RISK SOLUTIONS

Hadley Centre Review 2006 Final Report

A report for Defra/MoD

March 2007

Executive Summary

Introduction

This review has been commissioned by Defra and the MoD, with the aim of examining all aspects of the operation of the Met Office Hadley Centre (referred to throughout this report as 'the Hadley Centre', or 'Hadley'), including:

1. the Hadley Centre's quality as a climate research and modelling establishment and as a source of advice on climate change
2. whether it is meeting the needs of its internal and external stakeholders

This review forms part of the comprehensive review of the Hadley Centre, in preparation for the introduction of new contracts in 2007. It was given a clear steer by Defra and MoD clients to focus on the future, rather than looking solely at past performance and to consider whether Hadley's reputation as a world-leading organisation remains justified and will continue into the future. This review makes recommendations for actions to take the Hadley Centre forward, maintaining its fitness for purpose until at least 2011.

The review was conducted by a study team led by Risk Solutions, with contributions from advisors Tony Taig and Tony Quigley. The University of Manchester conducted the review of the supercomputing provision, reported separately and summarised in this report.

Context of the Review

The review has taken place at something of a watershed in the history of the Hadley Centre:

There is increasing acceptance that climate change is occurring, that this can be attributed to human activities and that it presents a significant risk worldwide. Given this, policy makers' requirements from climate change research and modelling are changing.

Modelling has increased in complexity, with the addition of further physical and biochemical processes and feedbacks, and higher resolution models needed both for regional modelling and to capture some climate processes, for example ocean currents and North Atlantic storms. These create further challenges for modellers in balancing their resources.

Both Defra and the MoD have reviewed the way they are procuring climate change research from the Hadley Centre and are, as a result, changing contractual arrangements from 2007.

Key Findings

The findings of the review have focused around the following four key questions:

1. Is the Hadley Centre world leading?

The Hadley Centre is currently regarded as a world leading climate modelling centre. No other single body has a comparable breadth of climate change science, data analysis and modelling, or has made the same contribution to global climate science and current knowledge.

The UK Government's role in international climate change policy has been strongly supported by Hadley's world leading status and Hadley's stakeholders value this international standing.

2. Are Hadley's customers and stakeholders satisfied?

Hadley delivers high levels of customer satisfaction. The materials they provide are generally considered to be of a high standard and fit for purpose.

3. Is the Hadley Centre providing value for money?

This review has concluded that the Hadley Centre is providing value for money. We have qualitatively assessed alternative options for delivery and conclude that there is no other credible means of meeting the requirement as cost-effectively. We have identified some opportunities for efficiency gains for consideration by Hadley, although it has proved difficult to assess these formally.

4. Can the Hadley Centre continue to deliver into the future?

The new contractual arrangements should provide a framework within which the Hadley Centre can continue to meet its customer and stakeholder needs into the future. However there are a number of improvements and recommendations made in this report that we believe would be valuable to both the Hadley Centre and its customers.

The key risk to the continued successful delivery of policy requirements concerns supercomputing provision. The University of Manchester.[1] report concludes that

> *"the available supercomputing power limits both … science development and the application of this science (encapsulated in the models) to answer policy questions."*

While without this Hadley will be able to continue to do useful, though more limited, research they are very unlikely to be able to sustain their position at the forefront of climate change modelling, or provide effective policy advice in the medium to longer term.

Key Recommendations

We have made recommendations aimed at the Met Office, the Hadley Centre itself and at its key customers. The recommendations fall into the following areas:

1. Supercomputing provision

[1] Hadley Centre Review 2006 - Supercomputing Provision

2. Strategy and Planning
3. Leadership and Management
4. Delivery and Performance Monitoring
5. Communications
6. Features of the New Contracts
7. Governance

We outline some of the main recommendations of the report below. A fuller description can be found in Section 8 of the main report and the University of Manchester Report.

1. Supercomputing provision

The University of Manchester Report recommends that DEFRA, MoD and the Hadley Centre urgently form and promote the business case for a significant increase in supercomputing capacity. This should be considered in the context of the value the UK Government places on the Hadley Centre's world-leading science and status.

2. Strategy and Planning

We recommend that the Hadley Centre links its strategy and planning processes more closely to the policy outputs its customers require. This process is underway as part of the negotiation of the new contracts, and should be strengthened. The strategy should be linked to the modelling strategy and plans for delivery including a resourcing strategy, supercomputing resource plan and communications strategy.

Hadley has implemented processes to involve more junior members of staff in the strategy development process and we recommend that it explores ways to include outside experts in its strategic planning process to provide a challenge for its own staff's assumptions and world view.

We recommend that the Hadley Centre maintain its science strategy, modelling strategy and delivery plans as living documents, always clearly linked to the customer policy requirements.

3. Leadership and Management

We recommend that the Met Office and the Hadley Centre clarify the new management structure, particularly the roles and responsibilities of the Director of Climate Science and the Head of Climate Research, and that the effectiveness of these arrangements is monitored closely, as part of the contract monitoring provisions, and mechanisms developed to allow review and revision of the arrangements if necessary.

4. Delivery and Performance Monitoring

We recommend that the Hadley Centre's senior management team introduce more rigorous mechanisms to monitor activities, so links can be made directly with client deliverables and activities such as broader communications. The Hadley Centre should ensure that its mechanisms for prioritising work are transparent to the clients. There

are areas where the review team have concerns about staffing for future delivery. A human resource plan should be developed to address these.

5. Communications

While the Hadley Centre communicates effectively in many ways, we have made recommendations for improvements in areas of communication between Hadley and its customers, communications with staff and closer working with other parts of the Met Office, and communicating progress against milestones with some key stakeholders.

We recommend that Hadley and the Met Office develop a formal communications strategy with its key clients, and that the Met Office supports the branding of the Hadley Centre more tangibly, particularly with respect to the website which is part of its public face, where the Hadley Centre logo should be prominently displayed on all relevant web pages. Navigation within the Hadley Centre-specific part of the website should be improved, and it should have its own home page.

6. Features of the New Contracts

We recommend that design of the new contracts should address the key risks and critical success factors relating to delivery of the defined outputs and maintenance of the science base. These should be agreed with the customers, together with suitable controls and measures to monitor these.

The metrics used in the contract should be related to the purpose of the research. The most important metrics should relate to the primary purpose, while other metrics could relate to supporting activities that underpin the primary purpose.

7. Governance

We strongly recommend that Defra and MoD form a joint contract steering group. This group would help balance competing customer demands, critically assess the achievability of the science and modelling strategies, and monitor contract performance and key risks.

We recommend that a clear change control process is included in the contract, or supporting documentation, indicating who can authorise contractual changes and how this will be done.

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Customer	Defra/MoD
Customer reference	
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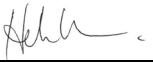
Risk Solutions
59-60 Russell Square
London
WC1B 4HP
United Kingdom
Telephone +44 870 850 4889
Facsimile +44 870 850 4895

Risk Solutions is a trading name of RiskSol Consulting Ltd

	Name	**Signature**	**Date**
Author	Eleanor Baker		12/03/07
Approved by	Helen Wilkinson		12/03/07

Contents

1 Introduction

The objective of the project was to undertake a review, on behalf of Defra and the MoD, of all aspects of the operation of the Met Office Hadley Centre (referred to throughout this report as 'the Hadley Centre', or 'Hadley'), including:

1. the Hadley Centre's quality as a climate research and modelling establishment and as a source of advice on climate change
2. whether it is meeting the needs of its internal and external stakeholders

1.1 Review Aims

The review aimed to assess:

a. the quality of the Hadley Centre's scientific enquiry and outputs when benchmarked with recognised international standards and customers' contractual requirements.

b. the strategic vision of internal and external stakeholders over five to twenty year timeframes, identifying strategic options to meet future needs of the Hadley Centre's clients.

c. the quality and value of the Hadley Centre's working relationship with its external collaborators including similar research establishments both nationally and internationally

d. the quality and value of stakeholder communication both internal and external with particular attention to the web-site.

e. customer satisfaction, how successful the centre is in meeting identified needs for scientific enquiry, information and services.

f. whether the current resourcing and IT provision provides value for money in enabling the delivery of high quality climate science evidence and advice, and the options for future provision – this part of the review is reported separately in "Hadley Centre Review 2006 - Supercomputing Provision".

g. whether, considering all these aspects, the Hadley Centre is meeting its customer requirements and delivering value for money and whether current governance and review mechanisms are appropriate.

The review was given a clear steer by Defra and MoD clients to focus on the future, rather than looking solely at past performance, and to consider whether Hadley's reputation as a world-leading organisation remains justified and will continue into the future.

This review forms part of the comprehensive review of the Hadley Centre.

1.2 Findings and Outcome of the Previous Review

The last review of the Hadley Centre, conducted by ESYS in 2000, was generally very positive. A number of issues were raised, however. These issues, and the Hadley Centre's descriptions of actions it has taken to address them, are shown in Table 1 below, along with our own comments (in italics).

Table 1: Hadley Centre Responses to Previous Review Recommendations

Recommendation	Hadley Centre Actions
Science	
The Hadley Centre should consider strengthening its work on atmospheric chemistry	The programme of developing chemistry modelling has been significantly enhanced, Met Office has committed extra effort to tropospheric modelling, although stratospheric modelling has decreased due to lack of funding. *This review noted that stratospheric modelling remains weak.*
The Hadley Centre should ensure a balance is maintained between the continuing focus on fundamental and policy driven work	The Hadley Centre considers it generates high quality science as well as policy relevant science, and this is reviewed in this report. *The quality and policy-relevance of Hadley's work has been assessed in this review.*
The Hadley Centre management, supported by the Science Review Group, should continue to ensure that an appropriate level of innovative underpinning science is maintained to provide the basis for future policy led work	The Hadley Centre has a strong commitment to this as is evidenced by the new policy relevant work that is coming on stream now that was in the early stages of development at the last review. Examples include - Quantifying Uncertainty, decadal forecasting. *This review has commented on the way the fundamental science is linked to policy outputs, in light of the new contracts being developed.*
There should be a detailed strategy for model development, making the model implementation more flexible and modular to facilitate the incorporation of external modules	The Hadley Centre has developed a modelling strategy. *This has been examined as part of this review.*
Management	
To ensure continuity, responsibilities for management and opportunities for scientific leadership should be devolved across a wider range of staff	There have been significant staff changes at senior levels with a knock on effect down the management chain, and the Hadley Centre has continued to produce high quality policy relevant science. Specific activities to promote opportunities include the following: ▪ Key strategic issues are debated at breakout groups at the Hadley Centre annual meeting, which all staff attend. ▪ These breakout groups are led by JL2s who then present the results and lead the

Recommendation	Hadley Centre Actions
	discussion at the Hadley Centre retreat which includes all JL1s and selected JL2s. ▪ Strategy and management have been thoroughly evaluated as part of this review
Collaboration	
Engage more widely with the UK and international scientific communities It is considered essential to the maintenance of the programme that the Hadley Centre further increases its level of collaboration with UK universities and research institutes	The Hadley Centre has significantly increased its collaborative work. *This is reviewed in this report.*
The increasingly multi-disciplinary nature of climate modelling means the Hadley Centre will need to address scientific problems for which they do not have in-house capability. To be able to cope with this, the Hadley Centre should establish more formal links with universities and other institutions to take advantage of developments	Specific joint Hadley Centre- NERC projects have been set up to address key issues. For example HiGEM (high resolution), UKCA (UK Chemistry and Aerosol modelling), JULES (Joint UK Land Environment Simulator). On an international level a European ocean modelling framework has been set up (NEMO) and discussions are underway for shared modelling with other countries such as Australia. *This review has examined the nature of Hadley's collaborations.*
Initiatives by the Hadley Centre, and other UK institutions, to establish a national partnership for climate research are endorsed. That will help ensure that planning is harmonised and research efforts are co-ordinated.	The strategy is to continue to build and develop much greater collaboration with outside organisations through strong partnerships. *This review has examined the nature of Hadley's collaborations.*
The Hadley Centre is also encouraged to improve its visitor and staff exchange programmes.	Hadley are increasingly targeting visiting scientists who will help them with specific goals, such as improving clouds, and involving Indian scientists in improving the monsoon in the climate model. *This review has examined this issue.*
Communication and Stakeholder Satisfaction	
A number of those consulted would appreciate a more regular and structured channel of information, covering for example the Hadley Centre's ongoing programme of work.	Highlights of Hadley Centre work are produced each year in a brochure, which is distributed widely. A new Hadley Centre information officer has been appointed since this review. She provides information to Defra and other users and works with the Met Office Media Centre to provide information etc to the media. *Communications have been thoroughly examined in this review.*
It was noted that the website is not used to its full potential as a tool for communication and dissemination of information and could fulfil a	The website has been improved since the last review.

Recommendation	Hadley Centre Actions
range of information requirements, currently handled individually.	*The website has been examined again as part of this review.*
There is no formal mechanism within the Hadley Centre for data distribution to the climate science community, nor are suitable data sets hosted externally. Answering these requests on a case by case basis is a drain on Hadley Centre staff time and resources.	More data is made available via BADC to address this issue. *This review has also looked at this issue.*
Computing	
It is envisaged that the next procurement, due to be operational in 2003, will provide a performance increase of between 30-70 times over the last procured machine. The computing performance needed to support resolution increases in the standard climate model, falls within this range.	The increase in computing power in 2003 was only a factor of 6 with a further doubling to a factor of 12 in 2005. Consequently the Hadley Centre is finding it difficult to adequately address the key modelling issues of resolution, complexity and uncertainty. *HPC provision is subject to a comprehensive review as part of the current exercise.*
Governance	
It is clear that the [Science Review Group] review mechanisms in place are effective in contributing to the excellence of science conducted by the Hadley Centre. They underpin the confidence that users have in its advice	The Science Review Group has an improved Terms of Reference which further enhances and improves its role. *This review has also looked at the role of the Science Review Group.*
Key Recommendations	
To continue the Climate Prediction Programme and the Public Meteorological Service Research & Development Programme at a level of funding at least equivalent to the previous 5 years.	Funding has increased in real terms since 2000. *This review has examined whether the Hadley Centre provided value for money.*
To maintain the Hadley Centre as part of the Met Office, with continued sharing of computing resources.	Hadley still benefits from integration *This review has looked at the relationship between the Hadley Centre and the wider Met Office.*
To endorse the recommendations made by the Scientific Expert Panel	Done
To re-establish the Science Review Group with more precise Terms of Reference and with a mechanism to rotate membership every 4-5 years.	Done

1.3 Structure and Content of this Report

This report contains the following sections:

Section 2: Context of the Review – this section describes the current global and UK context within which climate science is now conducted, and presents the context of review within the history of the Hadley Centre and Defra and MoD's future plans.

Section 3: Conduct of the Review – this section describes the review team, and the way in which the review has been carried out.

Section 4: Is the Hadley Centre World Leading? – this section presents the evidence for the quality of the science carried out by the Hadley Centre during the period of the review, 2000-2006

Section 5: Are Hadley's Customers and Broader Stakeholders Satisfied? – this section presents evidence on whether the Hadley Centre is meeting its customer and broader stakeholder requirements

Section 6: Is the Hadley Centre Value for Money? – this section considers the economy, efficiency, effectiveness and equity of the Hadley Centre and assesses the current arrangement with alternative mechanisms that might be used to deliver the climate advice required by Defra and MoD

Section 7: Can the Hadley Centre Continue to Deliver into the Future? – this section assesses the fitness of purpose of Hadley's systems, processes and people going forward identifying key success factors, risks and risk management measures.

Section 8: Conclusions and Recommendations – this section presents our conclusions and recommendations, including those specifically related to the development of the new contracts that Defra and MoD are currently negotiating with Hadley.

A number of Appendices provide supporting information to the report.

1.4 Acknowledgements

We are very grateful for the co-operation and assistance of the staff at the Hadley Centre, who have been very helpful throughout the conduct of this review. We would like to thank all the members of the Expert Panel, many of whom travelled long distances under very difficult travel conditions just before Christmas to assist with this work. This review would have been impossible without the assistance of all those individuals from customer and stakeholder organisations who made time in their busy schedules to take part in interviews. We have also depended on the co-operation of climate scientists and climate organisations from around the world, who completed questionnaires which have been essential to our analysis. Thank you to all those individuals who have participated in the conduct of this review. The timescales were very short, and without timely responses we would have been unable to fulfil our brief.

The Review Team, February 2007

2 Context of the Review

"Climate change is probably the greatest long-term challenge facing the human race. That is why I have made it a top priority for this government, at home and internationally"

Tony Blair, *Prime Minister, Climate Change the UK Programme, 2006,*

The Hadley Centre is primarily funded (approximately two thirds of the total) by the Department of the Environment, Food and Rural Affairs (Defra), through its Climate Prediction Programme (CPP) and ancillary projects, to the value of approximately £12.2 million in 2005/06. Approximately one third of total Hadley Centre funding comes from the MoD, via its Government Meteorological Research Programme (GMR).

The aim of these programmes is to carry out research relevant to the formulation of government policy. Since the last review of the Hadley Centre in 2000, important developments in the science and politics of climate change have taken place. These affect both customers' expectations and requirements from Hadley, and the centre's ability to deliver to these. They include the following:

1. **There is increasingly acceptance that climate change is occurring, that this can be attributed to human activities and that it presents a significant risk world wide**

   In 2001 the IPCC 3rd assessment report[2] concluded that:

   "There is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities"

   "Observed changes in regional climate have affected many physical and biological systems, and there are preliminary indications that social and economic systems have been affected".

   The 2006 Climate Change Programme[3] sets out the UK Government's belief that there is strong and indisputable evidence that climate change is happening and that man-made emissions are its main cause.

   Publication of the Stern Review on the Economics of Climate Change[4] completed in October 2006 supported this position, concluding that the scientific evidence that Climate Change presents a very serious global risk, and that it demands an urgent global response, is overwhelming.

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[2] Climate Change 2001, The Third IPPC Assessment Report, http://www.grida.no/climate/ipcc_tar/

[3] Climate Change - The UK Programme 2006, HMSO, March 2006. http://www.defra.gov.uk/environment/climatechange/uk/ukccp/pdf/ukccp06-all.pdf

[4] Sir Nicholas Stern, The Economics of Climate Change, Executive Summary, HMSO, October 2006. http://www.hm-treasury.gov.uk/independent_reviews/stern_review_economics_climate_change/sternreview_index.cfm

2. Given this growing acceptance, policy makers' requirements from Climate Change research and modelling are changing

While many fundamental questions remain to be answered the emphasis for policy makers is now moving away from establishing the evidence base for climate change and attribution to obtaining robust information to support policies in the areas of:

- Avoiding dangerous climate change,
- Adaptation to unavoidable climate change, and
- Negotiation of international agreements on mitigation[5].

In terms of the science outputs this means, for example, increased emphasis on:

- **Regional forecasting:** over a 30-40 year timeframe to support impacts and adaptation modelling.
- **Seasonal forecasting:** Developing a clearer understanding of the different weather patterns to be expected, on a seasonal basis, to help predict impacts including extreme events such as flooding, drought or heat waves.
- **Stabilisation, overshoot and mitigation:** Understanding the relationship between emissions scenarios, stabilisation levels and impacts
- **Reducing and quantifying uncertainty:** Including explaining the potential impacts of those factors that have not been included in the modelling.

3. Climate Change modellers face new challenges balancing the different demands on their resources

These new requirements, and developments in the underlying climate science, have lead to increasing demands for complexity and model resolution, including:

- Increased vertical and horizontal resolution, over both land and oceans
- Improved representation of the dynamics of the atmosphere, and of many processes in the atmosphere and oceans, inclusion of more physical processes
- Inclusion of interactions and feed back between constituent systems.

Increasing spatial resolution globally is proving essential to allow modelling of important ocean currents and weather systems such as monsoons and hurricanes. These can have far reaching impacts on global climate, allowing improved predictions of impacts at a regional or national level that would not otherwise be possible.

This and the need to quantify uncertainty through repeated (ensemble) model runs mean that climate centres around the world require increasing amounts of computer power, post processing and mass data storage. The Hadley Centre has illustrated the nature of this increased demand through a simple example[6]. They

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5 From interviews with policy makers carried out as part of this review (see Appendix 2 for a list of interviewees)

6 From "A Review of the Scientific Programme of the Hadley Centre, 2000 - 2006, 5 Year Strategy Document, 2006 – 2011", Hadley Centre

estimate that a modest increase in model capability would result in an increased requirement as follows:

- to double the resolution in all dimensions → a factor of 8 increase
- improved science and increased complexity (such as chemistry and earth system feedbacks) → a factor of 8 increase
- for ensemble predictions with a version of this model which has reduced resolution and complexity → a factor of 25 increase
- leading to a total increase of a factor of 1600
- or, if reduced resolution/complexity are used for ensemble modelling, to a factor of ~80.

That is, the science is readily able now to deliver customer benefits from a supercomputer up to 1600 times bigger than the current one. While modelling strategies enable best use to be made of the available computer resources, the demand has increased much more rapidly than was previously envisaged. At the time of the last review of the Hadley Centre in 2000 it was anticipated that the computing power available to the centre would increase by a factor of 30-70 in 2003. In fact it increased by a factor of 12 in 2004. A recent upgrade provided an additional increase of 20%; however the current resources clearly fall far short of what was anticipated or what could be used.

The upgrade plan, at the moment seeking approval from the Met Office Board, is to procure a machine that is approximately 8 times as powerful as the current one, at a level spend in real terms, in 2009.

A number of countries around the world are now investing considerable amounts of money in climate research, including investing in powerful supercomputers to run climate models. For example South Korea, China, Japan and the USA all have at least one, and in some cases several, supercomputers in the top 500 fastest in the world[7], dedicated to weather and/ or climate modelling. These countries are increasing their real terms spending on supercomputing, whereas the Met Office is planning a level spend in real terms, so even with its planned upgrade it will not enhance capability as quickly as others are doing.

Whilst supercomputing investment cannot be justified based purely on international competitors akin to an 'arms race', it should be recognised that with other climate research centres increasing their investment it will become increasingly difficult for Hadley to maintain its world leading position, even in the medium term, say beyond three years, with the indisputable link between supercomputing capability and science capability.

[7] As measured using the High Performance Linpack (HPL) benchmark

4. **Both Defra and MoD have reviewed the way they procure climate change research from the Hadley Centre and are, as a result, changing contractual arrangements from 2007**

   Previously the principal contracts between Hadley, Defra and MoD were managed as three year rolling contracts, reviewed annually. From 2007 these arrangements will be replaced by fixed price contracts planned to run for fixed time periods (currently 5 and 3 years respectively). The new contracts will specify high level outputs in outline and specific products that will be reviewed and updated on an annual basis. A new performance management regime will also be introduced with performance measures related to policy relevant outputs.

The Hadley Centre and its customers therefore find themselves at a pivotal point in terms of assessing the role of the centre in the future. This review makes recommendations for actions to take the Hadley Centre forward, maintaining its fitness for purpose until at least 2011.

3 Conduct of the Review

This section describes the review team and the activities undertaken.

Review Team

The review was carried out by a team led by Risk Solutions, an independent management consultancy specialising in applying risk thinking to strategic and management issues, across a range of public and private sector clients. The review team included a specialist team of supercomputing experts from the University of Manchester. Their full findings are presented in a separate report, but the key messages are incorporated into this document. The team was supported by two external expert advisors, Tony Taig who acted as an independent chairman for the Expert Panel element of the review, and Tony Quigley who provided advice to the study team on the conduct of the review and the findings. Short pen portraits of the review team are provided in Appendix 1.

Review Tasks

The review was divided into five main tasks:

1. Framing and preparation
2. Information gathering
3. Review of IT capacity
4. Analysis
5. Project management, reporting and communication

The activities we carried out as part of each task are described below.

Framing and Preparation

At the project initiation meeting, held on 19th October 2006 the focus of the review was discussed and Defra and MoD's priorities for the study were agreed. These were that the review should be forward-looking focused on the activities and actions necessary to ensure Hadley would be able to meet its customers requirements into the future. Defra and MoD also indicated that the Hadley Centre's status as a world class institution was important to them. Examining whether this status was being retained and could be sustained into the future was an important part of the review.

The review team developed an evaluation framework, agreed with Defra, to provide a structure for the information gathering task. The framework identified the areas of interest to the review, and classified them in terms of inputs, activities, outputs and outcomes of the Hadley Centre. The agreed evaluation framework is shown below.

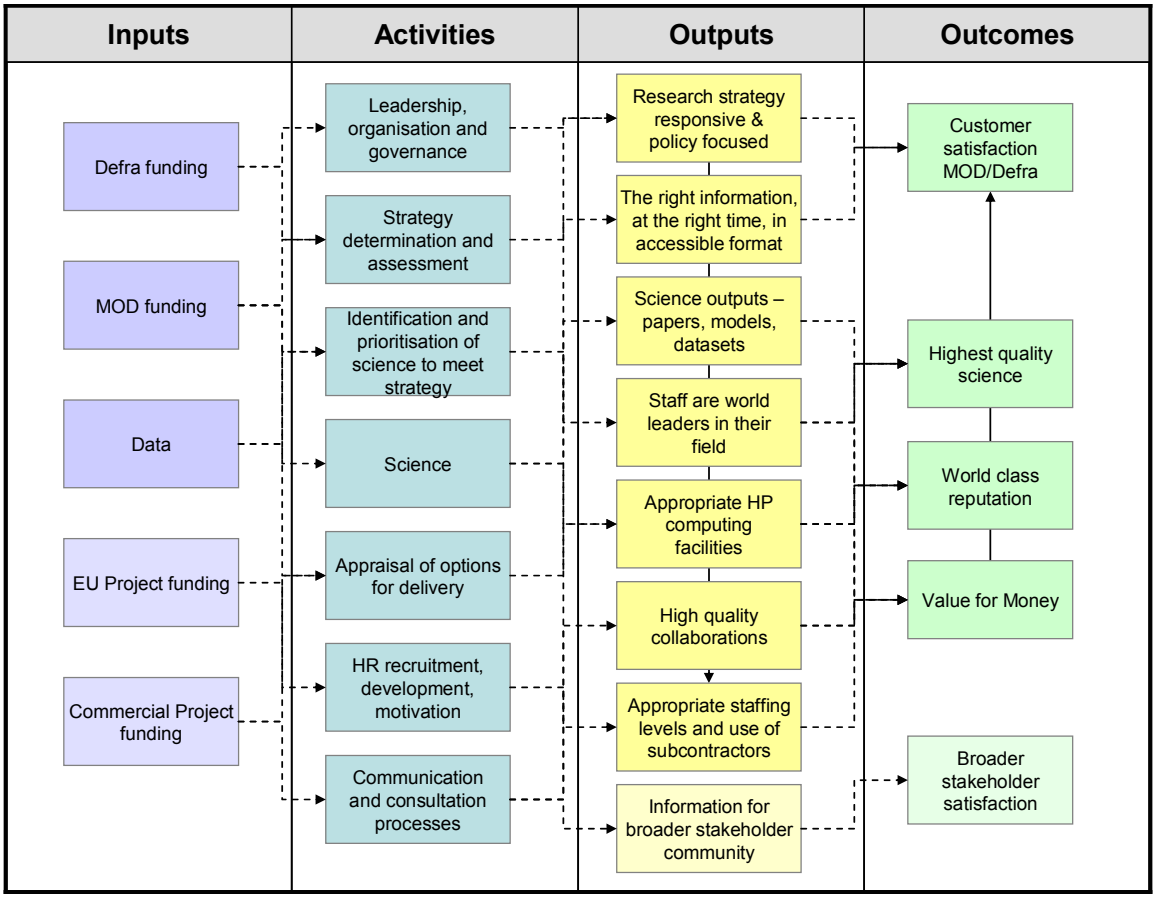


Figure 1: Agreed Evaluation Framework

Information Gathering

The purpose of gathering information was to allow us to assess:

- the quality of enquiry and research outputs produced to-date by the Hadley Centre
- the extent and quality of external collaborations
- the quality and value of stakeholder communications
- the performance of the centre in meeting identified needs for scientific enquiry, information and services
- the current mode of operation of the Science Review Group and quality and value of review mechanism

Information was obtained through a combination of consultation and survey and a review of written material.

A full list of people involved in the **consultation and surveys** is provided in Appendix 2 (Customers and other stakeholders) and Appendix 3 (Hadley staff). This involved the following groups:

- Customers – individuals from Defra and MoD who commission Hadley Centre work were interviewed to establish their requirements from Hadley, their levels of satisfaction and their perceptions of value for money.
- Hadley Centre staff – a staff workshop attended by approximately 30 staff, explored various aspects of the science and science management; face-to-face and

telephone interviews were carried out with all the senior staff, some key Met Office staff and some others with particular roles (e.g. the divisional accountant), and a large number of staff involved in collaborations.

- The Expert Panel - international climate science experts with a world class reputation, spent two days at the Hadley Centre examining the quality of science, their science management and organisation, and their plans for the future.
- Peer Reviewers – independent climate scientists reviewed a sample of the Hadley Centre's recent publications for quality of science (the papers were selected at random from papers published from 2004 onwards and indicated by Hadley Centre staff as representing their more influential work). The full list of papers subjected to this form of peer review is provided in Appendix 4.
- Collaborators – scientists involved in collaborative work with Hadley Centre staff were asked to comment on their experience of working collaboratively with Hadley. Collaborations were selected at random from the complete list provided by the Hadley Centre.
- Benchmarking organisations – other international organisations were asked to comment on Hadley's science excellence and also to provide examples of best practice in science management.
- Broader stakeholders – individuals within government departments, government agencies, the academic community and wider society including the media, who make use of or depend on outputs from the Hadley Centre.

Peer Reviewers, collaborators and benchmarking organisations were all sent electronic questionnaires containing sections tailored to the particular group and a section common to all groups that explored overall perceptions of the quality of science and Hadley's reputation worldwide.

Benchmarking organisations were additionally provided with a questionnaire prepared by the University of Manchester team requesting information about their supercomputing facilities which was followed up in a further consultation exercise.

We interviewed the majority of customers and broader stakeholders face to face, with a small number interviewed by telephone.

The Expert Panel spent two days at the Hadley Centre in Exeter they provided the review team with its own report of their findings (included as Appendix 5).

We reviewed the following **written information** provided by the Hadley Centre:

- draft strategy document
- a document detailing the Centre's achievements 2000-2006
- lists of all peer reviewed papers published since 2000
- all current collaborations, both formal and informal
- published brochures
- briefings provided to Defra and to ministers
- high level financial information on income and expenditure
- document: how do we measure our science output?, Science review working group, Met Office science review version 8
- briefing document, New CPP and DCRP Contracts

- draft project definition agreement for the Climate Prediction Programme

The brochures produced by Hadley for the scientifically literate general public (available via the website), and a selection of ministerial and Defra briefing papers were subject to critical review.

Defra also provided us with written information, including the previous review findings (ESYS, 2000) and minutes of the Science Review Group meetings, as well as the briefings they had received from the Hadley Centre during the review period.

Review of IT Capacity

This review was conducted by the University of Manchester team and is reported separately. The key findings of this part of the review will be included in the final issue of this report.

Analysis

We have structured our analysis of the information collected around four key questions:

1. Is the Hadley Centre world leading?
2. Are Hadley's customers, and broader stakeholders, satisfied?
3. Is the Hadley Centre providing value for money?
4. Can the Hadley Centre continue to deliver into the future?

We have used these questions as the headings for the next four sections of this report.

Project Management and Communications

After the initial kick-off meeting with the Defra and MoD key clients the review team has kept in close contact with the lead client at Defra, Chris Sear. The project team leader, Eleanor Baker, has discussed progress weekly with Chris Sear throughout the study period. We provided an interim report of the study findings in advance of the Expert Panel meeting, and these findings were presented at that meeting. A final presentation of the review findings will be held on 6th February 2007.

Key Constraints

Due to delays in the project start date the timescales of the project were necessarily very tight. Three and a half months were available from project initiation to reporting. This meant that a number of tasks were carried out in parallel, which would ideally have been consecutive, and we were unable to obtain and follow-up responses from the majority of the benchmark organisations. A number of key contract design documents were received towards the end of the review and while we have tried to review and include consideration of these in this report we have not been able to do this comprehensively.

4 Is the Hadley Centre World Leading?

"The Hadley Centre has the highest concentration of absolutely outstanding people who do absolutely outstanding work, spanning the breadth of modelling, attribution, and data analysis, of anywhere in the world."

Dr Susan Solomon, *NOAA Earth System Research Laboratory, Co-chair IPCC AR4 WG1: The Physical Science Basis*

Key Findings

- The Hadley Centre is widely acknowledged to be a world leader in climate research
- It continues to produce science and scientists of the highest quality
- Its models and datasets are used extensively across the research community both in the UK and abroad, and have made a significant contribution to the Intergovernmental Panel on Climate Change deliberations
- It is considered to be at the cutting edge of climate modelling in a number of key areas and to possess unique characteristics not available elsewhere.

4.1 Findings

The Expert Panel has concluded that:

"it is beyond dispute that Hadley occupies a position at the pinnacle of world climate science, and in translating that science into valuable policy advice."

This section briefly discusses some of the Hadley Centre's key achievements during the review period that support this conclusion and identifies some of the factors that have lead to its success

In the past, one of these key success factors has been Hadley's access, though the Met Office, to world class supercomputing resources; this is no longer the case, and current upgrade plans will not, we understand, fully address this. The supercomputing review carried out as part of this study[8] has stated that:

"world leading climate research is not sustainable over any reasonable period of time without continued access to supercomputers amongst the world's fastest."

This view is supported by the Expert Panel findings, which concluded:

"…*Hadley, even with the proposed Met Office investment in a new supercomputer in 2008, was falling behind and would continue to fall further behind other climate research organisations in*

[8] "Hadley Centre Review 2006 - Supercomputing Provision", University of Manchester report

computing resources. While in the short term Hadley would be able to retain their position and reputation because of the excellence of their staff, their leadership position could not be sustained longer term without computing capability and capacity comparable with those of their peers overseas."

We therefore also ask: "is it necessary for the UK to retain a world leading centre, delivering world leading science, for climate research?"

Key Achievements

Hadley has a world class reputation. It has been world leading in a number of areas, and its models and datasets are used extensively across the research community in the UK and abroad. The science is reviewed annually by the Hadley Centre Science Review Group (SRG) whose view is that Hadley science is often at the cutting edge of modelling developments. Key achievements include (a fuller description is provided in Appendix 6):

- **Monitoring Climate Variability and Change –** The observational datasets developed at the Hadley Centre have been widely used in IPCC AR4 and by Climate Centres world-wide and are considered by SRG and this review's Expert Panel to be very valuable and influential internationally, particularly for the recent US Climate Change Science Plan Report.
- **Quantifying Uncertainty in Model Predictions –** The Hadley Centre has pioneered a new approach to modelling uncertainty using the 'perturbed physics' approach. These probabilistic methods are being used to supply probabilistic predictions for the next UKCIP scenarios, UKCIP08, at a 25km scale across the UK for a range of impact-relevant variables.
- **Biogeochemical Cycles –** Hadley Centre research demonstrated that there are important interactions between climate change, the carbon cycle, ecosystems and atmospheric chemistry. The Hadley Centre, with IPSL, led a major intercomparison project, C4MIP, to compare eleven coupled climate-carbon cycle models. All the models showed a positive feedback, with climate change increased by the inclusion of the carbon cycle. This emphasised the importance of including carbon cycle processes in climate change projections.
- **Seasonal to Decadal Forecasting –** Seasonal and decadal forecasting has traditionally been very difficult, due to the natural variability of the weather (as compared with longer term climate). The Hadley Centre has used its observational datasets to show that the North Atlantic Oscillation (NAO) can be used to predict winter weather in Europe six months ahead.

  The Hadley Centre has also developed the world's first decadal prediction system, DePreSys, which takes account of natural variability in e.g. ENSO, THC as well as anthropogenic effects. The first experimental predictions from this system have recently been produced.
- **Changes in Climate Extremes –** The Hadley Centre has led the world in analysing observations of global weather extremes, and observed changes in extremes, and comparing these with modelled outputs.

Factors contributing to Hadley's success

The factors that have contributed to Hadley's success to date have been identified, by the staff themselves, by customers and stakeholders and by the Expert Panel, as:

- World class scientists – even the younger scientists were acknowledged by the Expert Panel as having world standing.
- Breadth of coverage – according to the Expert Panel members, no other organisation in the world combines as many aspects of climate science and modelling in one place as the Hadley Centre does. This breadth ensures that the developing models and advice are able to draw on a broad range of in-house expertise, including the leading edge observational datasets and analytical capability, as well as drawing on work with collaborators around the world.
- Linkage to the Met Office National Weather Programme – this provides major synergies, from the support of core science capability through to the unified model approach, and is a unique characteristic of the Hadley Centre.
- The direct link to those working on observations (both internal and external to the Met Office) – Hadley is one of few modelling centres with this direct link .
- Stability – continuity of staff and funding have enabled Hadley to develop and sustain longer-term research plans, which would be difficult in a grant-focused academic environment.
- Policy focus – staff and customers acknowledge that the focus of the Hadley Centre on producing policy-relevant outputs, rather than academic achievement, is a key factor in Hadley's success. It is also rewarding for staff to feel their work is being used to guide policy decisions.
- Access to world class computing facilities – although not currently the case Hadley's access to world class supercomputing resources in the past has also contributed to Hadley's success.

Is it necessary for the UK to retain a world leading centre, delivering world leading science, for climate research?

It could be argued that the challenge now in the UK is to develop adaptive capacity to improve the ability of business and organisations to adapt to changes in climate in a timely fashion. For the majority of such business decisions, at least in the shorter term, the information required to support this requirement is already available, or will be with the issue of UKCIP08. Based on this argument there would be little need for further, more sophisticated climate modelling and no real case for maintaining a world class facility in the UK.

There is, however, an important set of decisions for which more sophisticated data, requiring significant development in the models and science, are needed. There is also a continuing need to validate the information obtained using simpler models, and to consider the wider, global context. The majority of customers and senior stakeholders interviewed in the course of this review believe that there is still a need to develop the science and models, and that maintenance of Hadley's status as a world leading centre is extremely important. Reasons for this include:

- It will ensure that the UK has scientifically credible, independent advice on climate change, without depending on another country's or countries' resources, to support:
  - the UK Government's position in international negotiations on how to tackle climate change globally, where the UK is taking a leading role
  - capability building in developing countries
  - the successful promotion and implementation of effective domestic policies.
- It ensures a broader, diverse community of models across the world that can be compared with one another for validation – concentrating international effort in one model would be much less robust, as it is impossible to tell which of the models are best at predicting the future climate.

Ultimately it is for government to decide if Hadley should be maintained as a world leading centre, but if this is the case then this has important implications for supercomputing provision and, while we can explore options for delivery, ultimately for funding.

We have revisited options for delivery of the science in Section 6.1.1, including the option of abandoning maintenance of a world leading directed programme of research and instead obtaining advice on a more *ad hoc* basis from academia and overseas groups. The requirement for supercomputing resources and options for delivery are examined in the University of Manchester report.

4.2 Evidence

The evidence that the Hadley Centre is world leading is both qualitative and semi-quantitative, and draws on the expert opinions of a range of top climate scientists from around the world, analysis of the Hadley Centre's peer reviewed publications and collaborations, as well as the views of customers and other stakeholders who have participated in the review.

Findings of the Expert Panel

The Expert Panel concluded that, "it is beyond dispute that Hadley occupies a position at the pinnacle of world climate science, and in translating that science into valuable policy advice". They also stated that, "there is no other organisation in the world that has done as much across the breadth of modelling, detection/attribution, and observational analysis [as the Hadley Centre]".

The Hadley Centre Science Review Group

Examples of good science cited by SRG in 2006 included:

- valuable contributions to the IPCC AR4 in several areas including the non-temperature evidence of climate change work which was referred to as 'leading edge'
- analysis of observations carried out by Hadley was considered to have been very valuable and influential internationally, particularly for the recent US Climate Change Science Plan Report; the unique scientific capability of Hadley in the combined areas of modelling and the development of observational datasets was seen to be an important component of the report.
- the high proportion of papers published in high-impact journals, including Science and Nature.

Views of Customers and Key Stakeholders

Customers at Defra and MoD are very satisfied with the quality of work conducted by the Hadley Centre. Leaders of NERC and NCAS endorse Hadley's reputation as a world class climate centre. Users including UKCIP are also of the opinion that the Hadley Centre is conducting world leading science and modelling work, and particularly support the probabilistic approach developed by the centre.

Involvement in IPCC Working Group I, Science

The IPCC process draws on the world's most authoritative and scientifically credible climate science, and lead authorship indicates that the individuals concerned are key figures in their fields. The Hadley Centre supplied three co-ordinating lead authors for the IPCC WGI third assessment report, and nine lead authors, as well as six review editors. For the fourth assessment report, Hadley has supplied one co-ordinating lead author, eleven lead authors and two review editors. It is supplying lead authors or co-ordinating lead authors for eight of the eleven chapters of the report, and also for the Technical Summary. By comparison, NCAR has four co-ordinating lead authors and six lead authors (although NCAR has a total staff of around 1000, whereas Hadley has 150). In total for the IPCC process (involving as many countries as possible), there are twenty-two co-ordinating lead authors, 118 lead authors and twenty-eight review editors.

IPCC Role, AR4 WGI	Hadley Centre staff (% of total)	Total
Co-ordinating lead author	1 (5%)	22
Lead author	9 (7%)	118
Review editor	2 (7%)	28
Total	**12 (7%)**	**168**

In total 34 countries are providing lead authors and review editors to the IPCC WGI. The representation by country is shown in the table below. This shows the UK punching significantly above its weight, with the UK's contribution driven substantially by the contribution of Hadley Centre staff, due to the strength of the Hadley Centre.

Country	Number of co-ordinating lead authors, lead authors & review editors for IPCC AR4	Country	Number of co-ordinating lead authors, lead authors & review editors for IPCC AR4
USA	38	Norway	5
UK	16*	Kenya	4
France	14	Argentina	3
Germany	10	Brazil	3
Canada	9	Italy	3
China	9	Mexico	3
Japan	8	Netherlands	3
Australia	7	New Zealand	3
India	6	Russia	3
Rest of the world			20

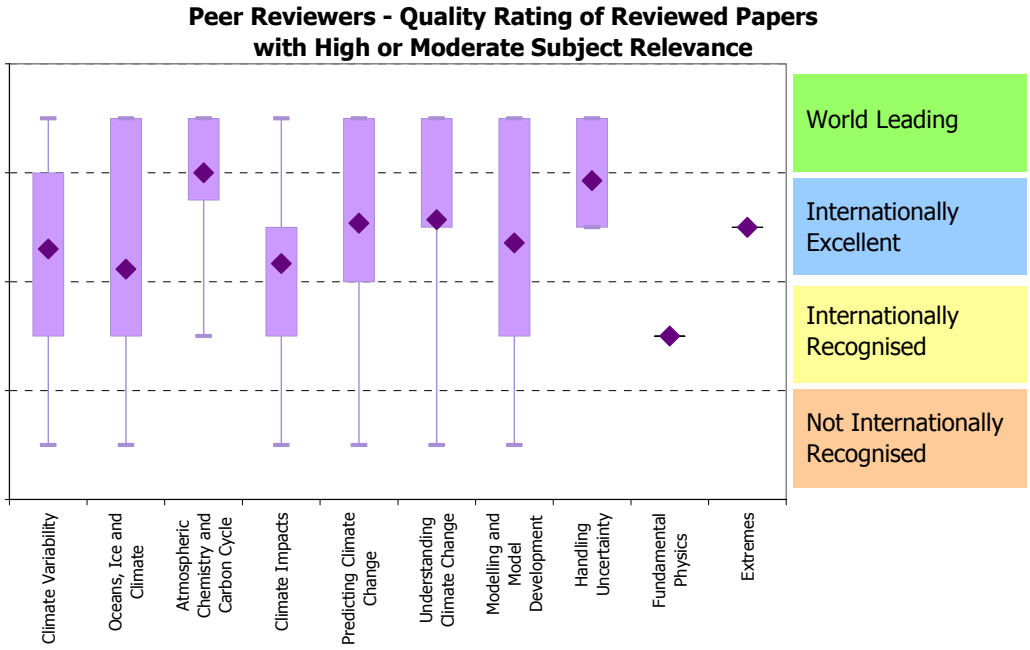
* Four from other UK institutions

Benchmark Organisations, Collaborators and Peer Reviewers

Results of the surveys carried out for this report show that the models and outputs of the Hadley Centre are held in high regard internationally for example when GFDL were developing the models used in the AR4 process (CM2.0 and CM2.1), they routinely compared there model results to those from the HadCM3 which they considered the "gold standard". The Unified Model is considered a great strength.

The full findings of the survey are presented in Appendix 7. The figures show some of the results.[9]

[9] It should be noted that the point indicating that 'Fundamental Physics' falls only into the 'Internationally Recognised' category should not be taken to imply that there is any problem with the quality of fundamental physics at Hadley, but relates to the results for only two assessed papers where fundamental physics was considered moderately relevant to the subject matter of the papers concerned. Doing fundamental physics is not the Hadley Centre's main focus of activity, so we would not expect very many of their papers to be scoring in this category.



Explanation of figures: The dark point shows the mean response, the ends of the whiskers the maximum and minimum responses and the box the 75% and 25% responses. Because the numbers of people surveyed was relatively small the results are subject to uncertainty, but are provided to give an indication of the range of responses.

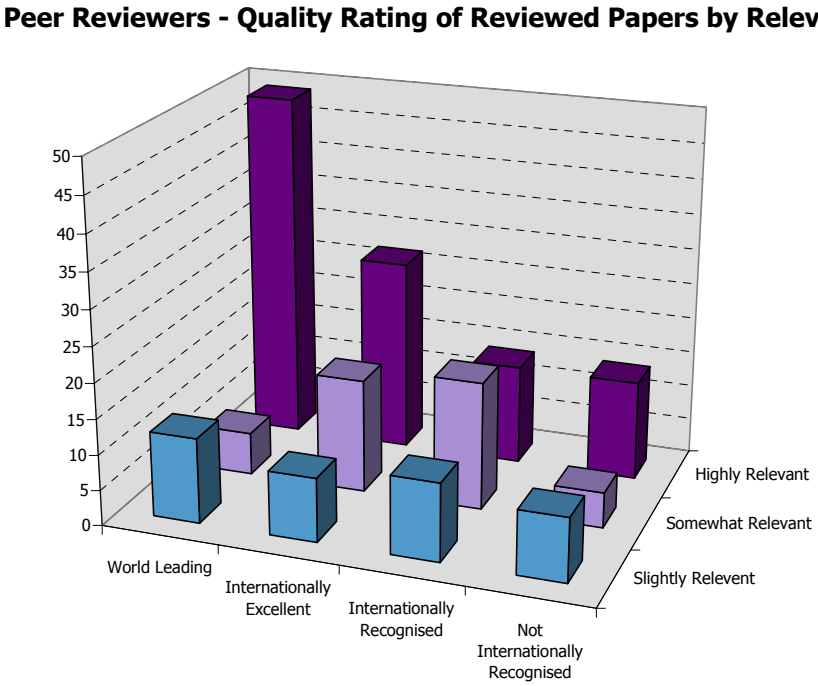


Figure 2: Results of the collaborators and peer review suveys

Collaborators and peer reviewers were asked to rate the quality of the Hadley Centre's scientific output compared to six other climate change centres. The following graphs show the average rating against each scientific area, for all responses where an opinion

was expressed. In these figures, points that fall in the green shaded area indicate that the respondents considers Hadley's performance in that field to be higher than the comparator organisation, points that fall in the cream shaded area indicate that the respondents considered Hadley's performance to be similar to the comparator organisation, and points that fall in the pink shaded area indicate respondents considered Hadley's performance to be lower than the comparator organisation.

The graph in Figure 3 indicates that the peer reviewers in general ranked Hadley as performing better in most fields than DKRZ, LMD, Max Planck, NOAA CPC and the Earth Simulator. NCAR CGDD is considered to perform as well as Hadley, and better in the areas of assessing adaptation strategies and impacts.

A similar assessment by collaborators, shown in Figure 4, indicates that on average the collaborators had an even higher opinion of the Hadley Centre's performance than the peer reviewers. In this case, only the Earth Simulator in Japan is considered to exceed Hadley's performance, and then only in efficient use of supercomputing facilities.

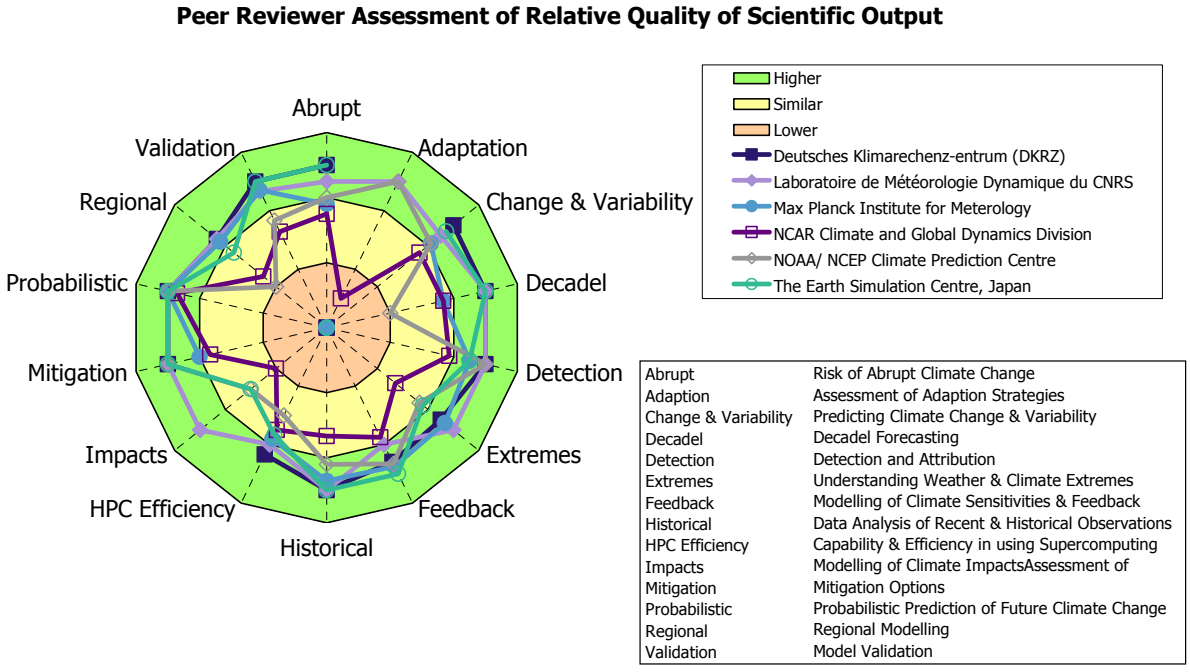


Figure 3: Assessment of relative merit – Peer Reviewers

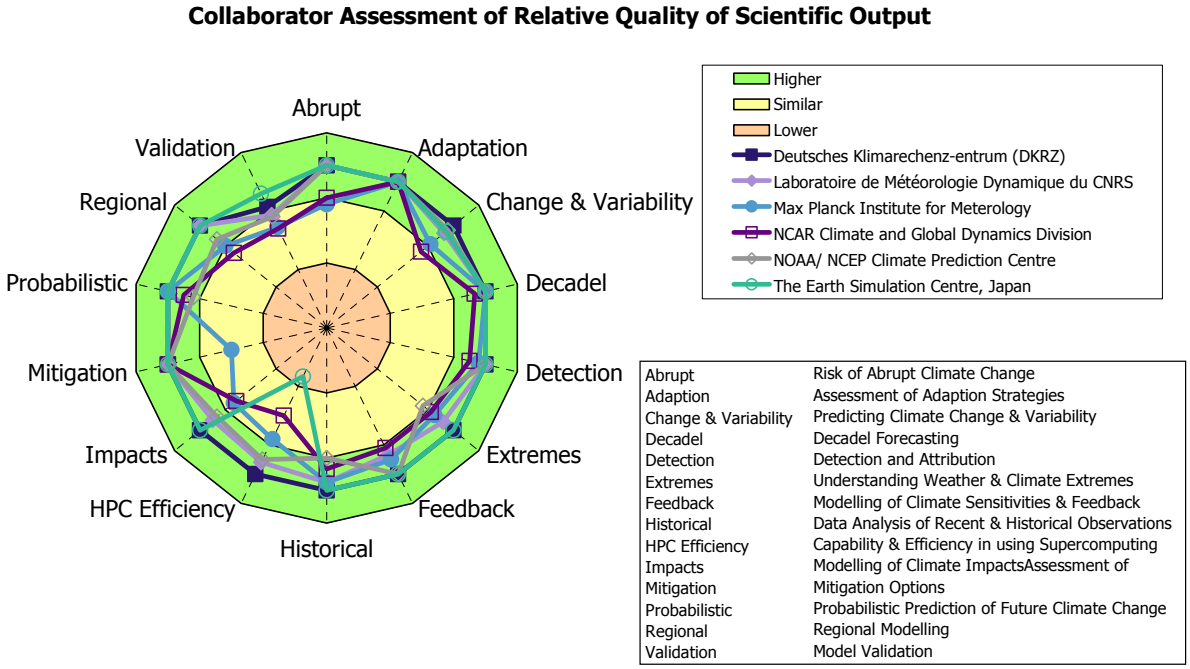


Figure 4: Assessment of relative merit - Collaborators

Citation analysis

There are a number of problems with citation count analysis as a measure of science "quality", the most important of which is the time lag inherent in the natural cycle of incorporating previously published work in papers and getting them published. We also note that citation statistics are not available for all the papers Hadley publishes (papers not in Web of Science are excluded from the analysis), and that a lot of Hadley's work does not lead to research papers, as it takes the form of Defra deliverables. Nevertheless some form of citation count analysis is a useful component of any attempt to benchmark the performance of the Hadley Centre.

The H-index analysis produced by Philip Brohan[10] is valuable and should be continued. The H index[11] is considered a better measure than average citations, because it takes account of any skewing that might be caused due to publishing a very small number of papers with a large number of citations, where the remaining published papers have very few citations. A higher H index would imply more papers with more citations. For example, an organisation that had a single paper with hundreds of citations, but where all its other papers had a small number of citations, would have a low H index. Figure 5 is drawn directly from Philip's paper, but there are other metrics that we have suggested that might give a complementary view. These

[10] Hadley Centre Five Year Strategy, Annex C: Review Citations.

[11] A group of N papers has index h if h of the papers have at least h citations each, and the other (N - h) papers have fewer than h citations each.

are described in detail in Appendix 8. In particular, it has proved possible to identify genuine comparator organisations from the citation count databases rather than using a hypothetical organisation constructed using random sampling. Examples of the findings are shown in the figures below (Figures 6-8).

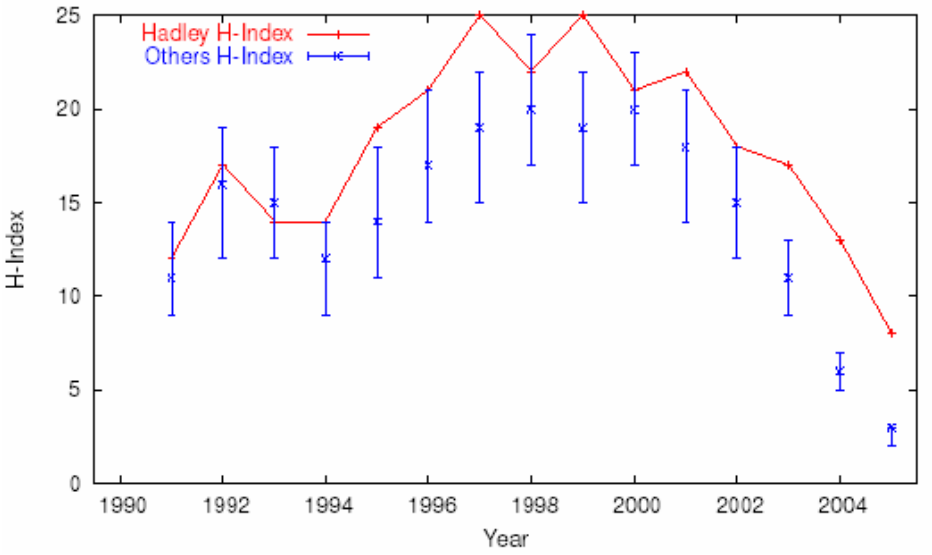


Figure 5: The H-index for the Hadley Centre compared with that for an imaginary sister organisation

The sister organisation was generated by randomly sampling from papers published in three specialist climate science journals. From the analysis by Brohan.

The H-index here is compared with an imaginary climate organisation, generated by sampling from all organisations that published in three climate science journals, and demonstrates that Hadley's performance is well above the average. Due to the time lag between publication of a paper and citation in future publications, the index falls off rapidly after 2000. We have concentrated our own analysis around this point. The three figures below show the full citation count distributions for three organisations, Hadley, NOAA and the Max Planck Institute, compared to that for "all papers" for 1999, 2001 and 2002.

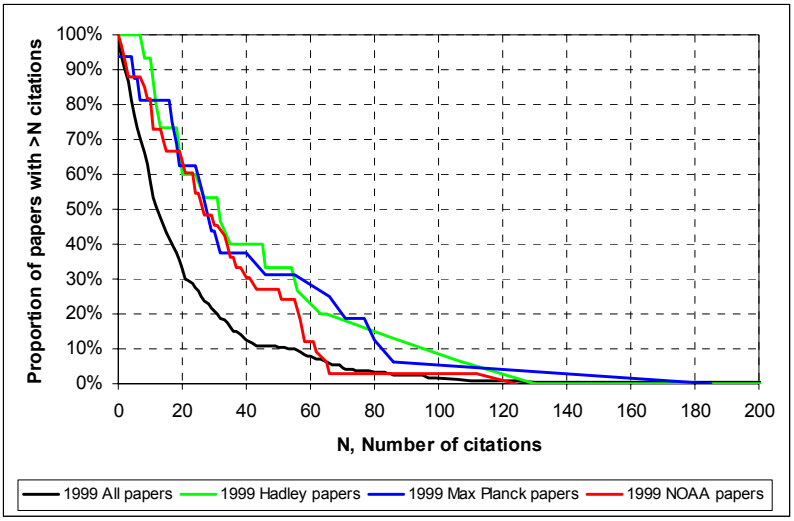


Figure 6: Proportion of papers with >N citations for papers published in three climate science journals in 1999.

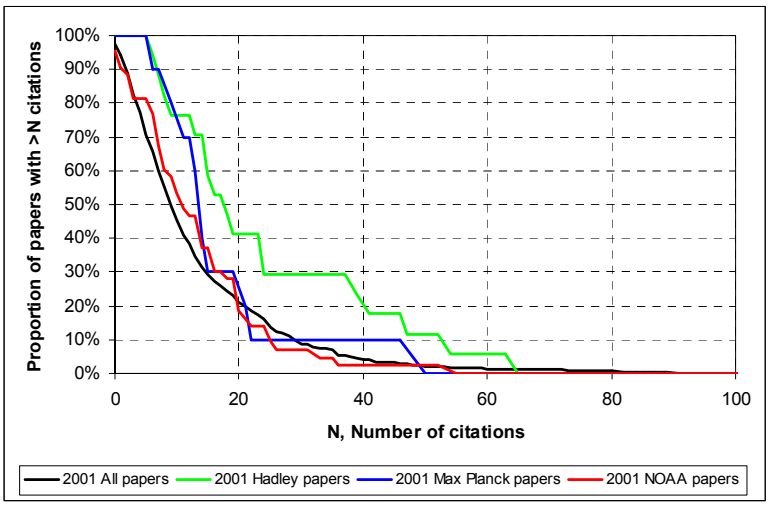


Figure 7: Proportion of papers with >N citations for papers published in three climate science journals in 2001.

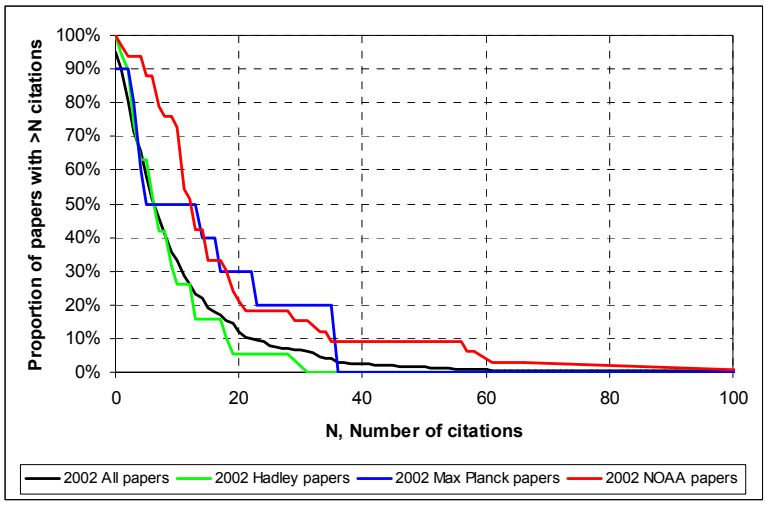


Figure 8: Proportion of papers with >N citations for papers published in three climate science journals in 2002.

Figure 6 shows that the papers produced by all three institutions in 1999 now have significantly higher citation counts than average, for example between 30% and 40% of their papers have more than 40 citations each compared to around 10% of papers on average. However the distributions for the three institutions are all quite close to each other until you reach the distribution tails (where the number of papers is small).

Figure 7 shows that the papers produced by the Hadley Centre in 2001 have had a particularly big impact, with the Hadley curve significantly separated from the other two institutions and from the average. It is possible that the considerable work that Hadley carried out in preparation for the IPCC Third Assessment Report contributed to this very strong performance at this time. Figure 8 shows that the Hadley Centre papers published in 2002 have had a much lower impact compared to the other institutions. The quantity of papers did not drop off in this year, so the effect is purely one of quality. It is possible that this is the first evidence of supercomputing limitations having an impact on the quality of papers produced by Hadley, but could simply the impact of the low numbers of citations on the statistical robustness of the calculation (an artefact of the time it takes for citation counts to build up).

From the analysis it would seem that the papers produced by the Hadley Centre and its true peers are indeed having a larger impact than the average, and this could be further refined if the size of the organisation (in terms of staff and funding) were taken into account. This would require a different sort of metric, based on numbers of quality papers per unit of money spent or per person employed, for example. Such metrics have been used to assess the UK science base as a whole, in the past, and the UK has been shown to perform very favourably against such measures, but as far as we are aware they have not explicitly been used to compare organisations with one another.

If Hadley wants to continue to claim to be one of the world's leading climate science institutions it should be benchmarking itself against genuine sister organisations on a regular basis and should not be content with simply comparing itself to the average. We would recommend that Hadley identify a set of such organisations that, between them, cover the range of activities performed by Hadley, and carries out a regular

analysis of citations against these organisations. Defra/ MoD should agree with Hadley which these organisations will be.

5 Are Hadley's Customers and Stakeholders Satisfied?

"The Hadley Centre has been invaluable in helping us to build a rigorous scientific base for our analyses"

Sir Nicholas Stern FBA, *Head of the Stern Review on the Economics of Climate Change*

Key Findings

Core customers

- The Hadley Centre is considered by its core customers to be unique in its ability to generate high quality, policy-relevant outputs, to the timescales that are needed by government. They are very responsive, providing briefing and presentations on request.
- Customers are generally very pleased with the quality of advice received, its relevance to policy, timeliness of delivery, and the breadth of knowledge available through Hadley. Some areas where improvements have been suggested include:
  - improving understanding of the policy making context
  - improving communications with customers
  - horizon scanning, and
  - timeliness of delivery for some deliverables.

Broader stakeholders

- A wide range of other people and organisations in the UK use Hadley's work, both directly and indirectly. These include other government departments and agencies such as the Environment Agency, and the academic community including the impacts community. Again these stakeholders record a high level of satisfaction with Hadley's outputs.
- The international climate change community relies heavily on Hadley's datasets and modelling outputs and also contribute to the development of the models. Hadley maintains a range of high quality collaborations both with the UK and international community to facilitate this work.
- Communications is again the main area where improvements could be sought.

5.1 Findings

Core Customers (Defra and MoD)

Hadley appears to possess, at all levels of the organisation, a policy focus that is unusual in research organisations. The staff at Hadley are proud of the policy relevance of their work and cite it as a key motivator. They have demonstrated an ability to reorganise teams to address emerging issues at short notice.

In general customers find Hadley highly responsive and capable of providing good quality, robust and timely advice:

- They have shown an ability to devise and deliver highly policy relevant science, for example the probabilistic outputs seen as increasingly vital to policy determinations
- Many of Hadley's staff have demonstrated an ability to communicate complex and uncertain information clearly to non-specialists
- Although briefing documents provided to Defra are often rewritten for ministerial consumption, the basic materials provided are considered timely and fit for purpose
- The brochures they produce appear to be particularly well received providing excellent and clear summaries of the latest climate change work
- Conference organisation and presentations are considered to be consistently of a high standard, well designed and delivered
- Their world class reputation is highly regarded and Hadley is considered a very valuable resource in diplomatic negotiations on climate change.

There are however a number of concerns largely relating to communication issues. We have discussed these in Section 5.2 below.

Broader Stakeholders

The broader stakeholder community also express satisfaction with Hadley's outputs and the quality of their work:

- **Collaborators:** Collaborators at the working level rate Hadley very highly in terms of the benefits received, working relationship and the quality of staff and the science carried out. The principal area where collaborators have encountered problems relate to Met Office security.
- **Broader climate change community and other customers**:
  - The UKCIP team, who will be the recipients of a major piece of modelling work Hadley is currently undertaking, are in general very pleased with their interactions with Hadley
  - The NERC community are happy with the Hadley Centre's quality of work, and emphasised their desire for further strategic collaborations.
  - The Tyndall Centre tends to work less directly with Hadley, as its work focuses more on the way society responds to and could manage climate

change, but the interactions it has are well-received – Hadley staff are described as very effective.
    - Environment Agency and MoD customers found the scientists at Hadley easy to deal with and responsive. Initial reports and presentations were sometimes found too technical or inadequately focused on the requirement.
- **The media:** Common themes raised by the journalists interviewed as part of this review were:
    - all reported that their interactions with the Hadley Centre are good and useful
    - ease and speed of accessibility to the right people was considered very important and was usually good, the journalists usually know who to contact. There was concern that this access may be replaced with a bureaucratic press office.
    - suggestions for improvements included: advance warning of research papers that are going to be published and providing a search facility on the website[12].
    - Other comments included, "I've never missed a deadline because of the Hadley Centre", "their world standing is important", "they do not make the most of their unique position".
- **The web-site:** The website has been upgraded during the conduct of the review. The new website works reasonably well, and provides a good entry into the climate science and modelling for an educated public. However there are aspects of it that could be improved (see below).

Suggestions for areas where Hadley could improve the quality of their offering again largely concern communication.

5.2 Areas for improvement

Understanding the policy making environment

Defra customers believe that Hadley could further improve their responsiveness and presentation of their work if they understood more about the environment within which policy decisions are made. It has been suggested by Defra and Met Office staff that this could be achieved by greater use of secondments between e.g. Defra and Hadley. However this solution has a number of drawbacks:

- Longer term (e.g. 6 months – year) secondments could require relocation of staff, due to the physical distance between Exeter and London. Staff who relocate may then choose not to return to their original employer at the end of the secondment period.
- Staff committed to their work may not be attracted by the opportunity of secondment.

[12] This has been implemented in the new website.

- Senior management may not want key staff to be seconded, because of their importance to e.g. Hadley Centre delivery programme.
- Funding for secondees would need to be by agreement between Defra and Hadley/ Met Office, and there is no clear, agreed framework for this at present.
- Short-term secondments might be a possible compromise, although it is unclear if e.g. a three month period would be long enough for the secondee to gain a thorough understanding of their new environment.

The barriers to successful secondment will only be overcome with genuine commitment from senior managers in both Met Office, the Hadley Centre and Defra. If this commitment is not forthcoming, there are other mechanisms whereby staff from both customers and Hadley can get a better understanding of the other organisation, for instance by instituting a series of regular seminars, going both ways, held alternately in London and Exeter, where staff share not only their recent achievement, but also discuss their working methods and the pressures that drive their performance.

Communication

- **Day to Day communications** - Day-to-day communications between Hadley and its core customers are primarily managed through regular contact, by email and telephone, between the Hadley contract managers (Vicky Pope for the Defra contract and Derrick Ryall for the MoD contract) and the client contract managers (Chris Sear for Defra and Bruce Callander for MoD).

  Defra customers believe that more direct contact with Hadley staff at lower management levels would bring a number of benefits:

  - It would help staff gain a more complete understanding of the requirement, the way in which their work will be used and the pressures that policy-makers operate under. Improvements in this understanding should help staff to prioritise work even more effectively, and to ensure all deliverables are timely and fully meet customer needs.
  - It would reduce the pressure on the very narrow conduit for communication.

  We believe that direct communication between clients and key scientific staff at Hadley should be encouraged, however care would need to be taken to ensure that requests for work were appropriately controlled. Also some Hadley staff are happy to engage with client representatives in this way, but others appear to be uncomfortable with such an approach.

  One of the principal methods of communication used is email. Hadley and Defra representatives need to work together to develop methods of identifying important or time-critical emails so there is no risk of them being missed by the intended recipient.
- **Communication of progress against milestones –** Hadley need to improve the communication of progress against project or programme milestones.
- **Communication of press releases and publications:** Defra is keen to ensure that it is kept aware of any Hadley Centre press releases or publications that may be result in press interest. Although published papers are Defra approved, there

is a delay between submission and publication. Defra will not be aware when a particular paper is due to be published, and would like more robust mechanisms in place to ensure they are alerted in advance of publication. Although this usually happens, it is not always the case. Greater political awareness amongst Hadley Centre staff would help create a better understanding of the likely impact of certain papers, and ensure that this Defra need is met more reliably.

- **Written communication and presentations –** While customers generally express satisfaction, the quality of some written materials and presentations can be variable, and not always matched to the audience or the requirement (for example briefing papers that don't always answer the question asked, presentations overly long or technical). Some of these may have been produced in very short timescales, but there is some room for improvement here.
- **Broader communication** – Many of the Hadley Centre's staff, including more junior staff, may be involved in communicating with the media, and with the broader public. It would be valuable to ensure all staff have at least some media training, to enable them to carry out these functions with confidence.
- **The web-site –** The web-site has been upgraded and is clearer and easier to use. However there is little information about the structure of the Centre, how it sits within the Met Office or how to contact staff about specific aspects of the science presented. There is also very little 'Hadley Centre' badging on the website, which is a page within the Met Office website, accessed through links to 'climate science' rather than to the Hadley Centre. Navigation specifically within the Hadley Centre area is also made more difficult because once the user moves away from the front page of climate science, return to it is not via a 'home' link (the 'Home' link sends the user to the Met Office home page). There is very little Hadley Centre branding used on the web pages. Although the Met Office is keen to promote its main brand, the Hadley Centre has a very strong brand worldwide, and it seems short-sighted for the Met Office not to seek to exploit this more effectively via the web.

Timeliness

Defra and MoD have both from time to time experienced difficulty with deliverables slipping in time. They have not always felt fully informed of potential delays. Slippages may occur because of the complex nature of the work, due to conflicting priorities, or because unrealistic expectations of what was possible developed. In some cases timing for policy-relevant work can be critical and therefore it is important that Hadley work closely with its customers to understand the requirement, agree realistic timescales and ensure that any risks are clearly understood.

The UKCIP team, have also experienced some slippage in delivery of the UKCIP08 scenarios. This has been due to the novelty and cutting-edge nature of the work being done. While the reason for the delays is understood and accepted, UKCIP would like some more visibility of the programme of work and progress against milestones than they have at present.

Horizon scanning

One further area which both customers and Hadley identified as one where improvements could be made was in horizon scanning, that is early identification of issues that might become matters of public, political or scientific interest.

5.3 Evidence

Evidence of customer and broader stakeholder satisfaction comes mainly from interviews. Appendix 2 provides a full list of people interviewed. We also surveyed collaborators and critically reviewed written communications.

Analysis of Written Communications

We analysed a series of brochures produced by Hadley for the scientifically literate general public (available via the website), as well as ministerial and Defra briefing papers. Based on the brochures and ministerial briefing papers we concluded that the Hadley Centre differentiates appropriately between the needs of different audiences when producing written communications, including: matching the nature of the final document content to the audience using differing formats, and planning and review processes. It produces external papers with good levels of clarity that are appropriate to their intended use. We have included a fuller report of this work in Appendix 9.

The Hadley Centre also produces a large number of briefing documents produced for Defra and MoD clients, including written answers to questions, longer papers and presentations. We have looked at a number of these. These documents tend to be far more variable in terms of presentation and clarity. We are aware that many of these are simply immediate responses to specific questions, however the original question may not always be included in the response (so it is difficult to understand its context). Presentations can sometimes appear to be over long or detailed, including pictures or text that are too small to be fully legible. While clients are generally happy with the responses they receive, and we understand that many of these are produced to very short timescales, there is an opportunity for even greater clarity.

Collaborators

As part of the survey of collaborators we investigated:

- The level of satisfaction reported by collaborators with the collaboration
- Their rating of potential problem areas
- Their rating of Hadley as collaborators

The results are summarised on the graphs shown below. The full results are included in Appendix 7. It can be seen that collaborators have indicated a high level of satisfaction. Met Office security is identified as the main problem area with data transfer the next most important.

In addition we carried out a thematic analysis of the comments noted on the collaborators' questionnaires and made in interviews of Hadley staff involved in the

same collaboration. These results are presented in Figures 10-12. In Figures 11 and 12 the dark point shows the mean response, the ends of the whiskers the maximum and minimum responses and the box the 75% and 25% responses. Because the numbers of people surveyed was relatively small (16 responses received) the results are subject to uncertainty, but are provided to give an indication of the range of responses.

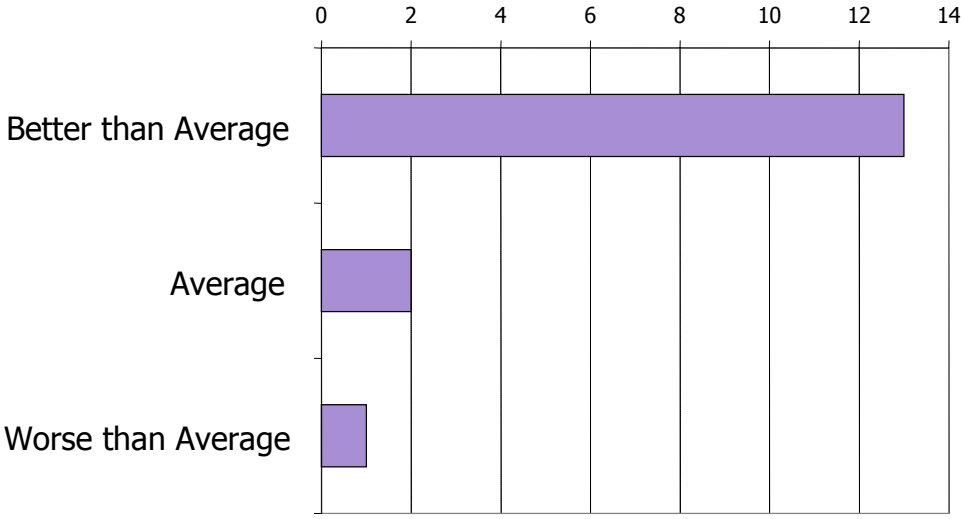


Figure 9: Collaborators' Rating of the Hadley Centre as an Organisation to Collaborate With

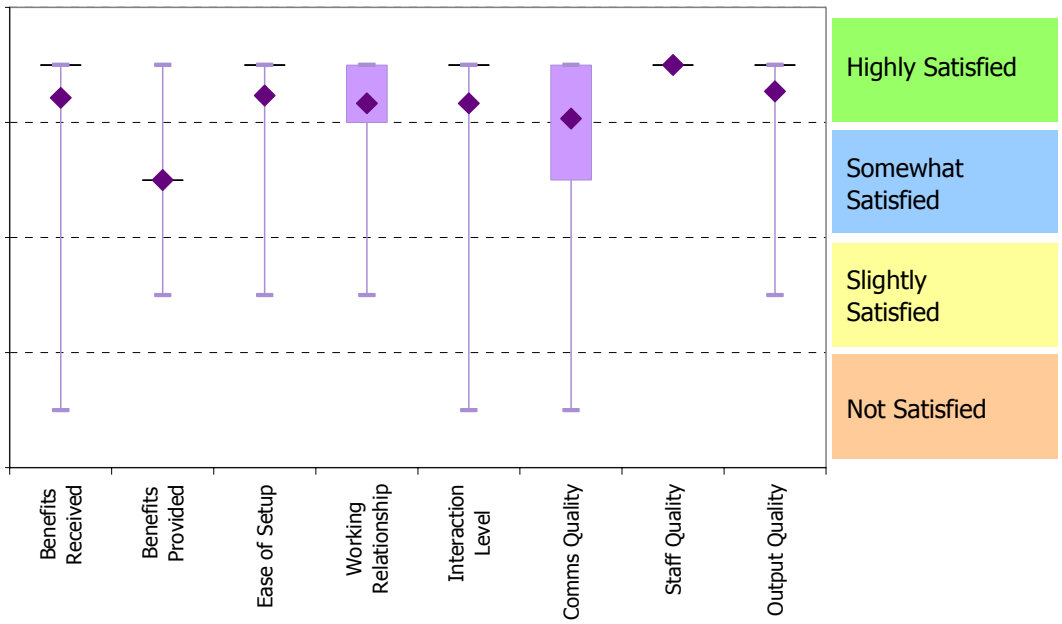


Figure 10: Collaborators' Satisfaction Rating of the Collaboration

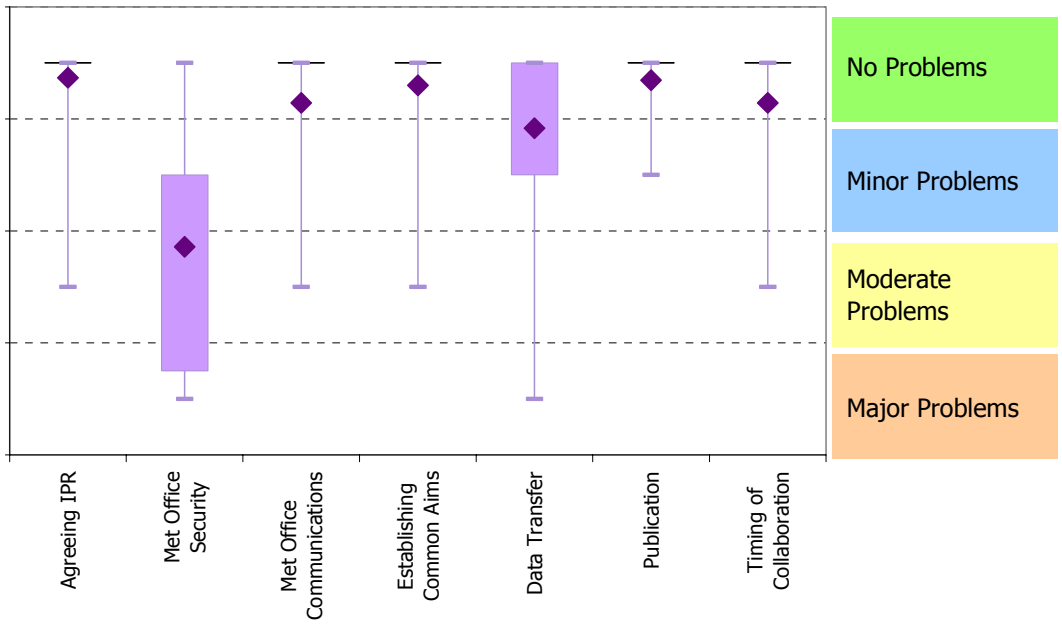


Figure 11: Collaborators' Rating of Potential Problem Areas

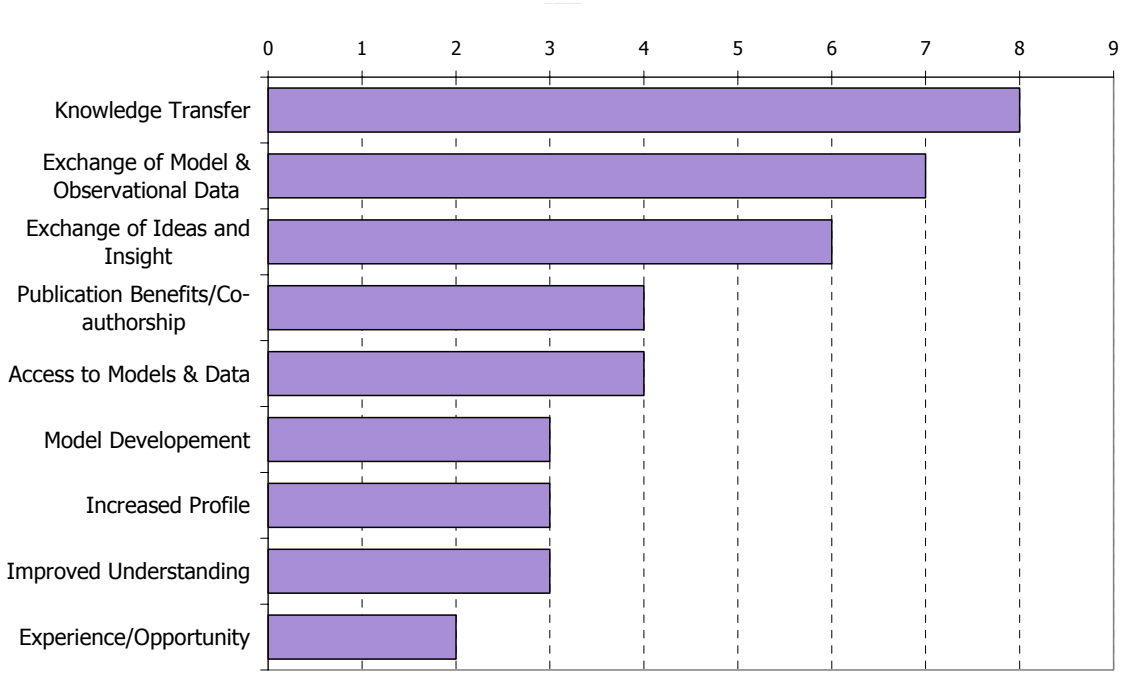


Figure 12: Benefits Cited by Collaborators as Achieved in Collaborating with the Hadley Centre (16 respondents)

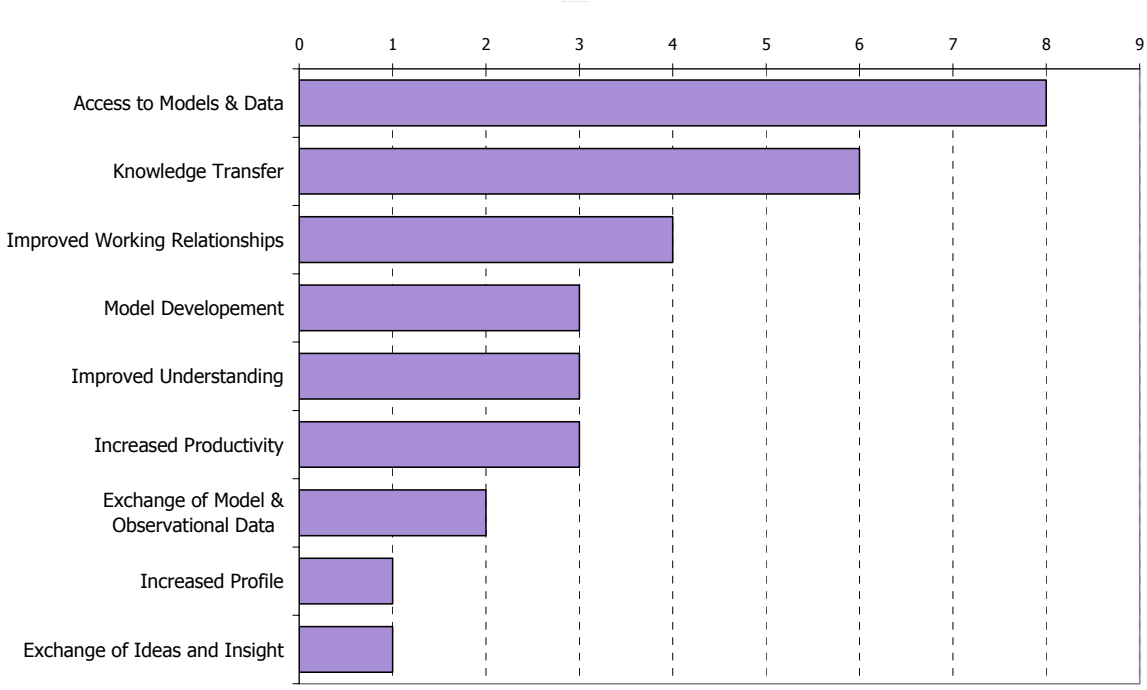


Figure 13: Benefits Cited by Hadley Centre Staff as Achieved in the Same Collaborations (10 respondents, covering 12 collaborations)

6 Is the Hadley Centre Value for Money?

The costs to the UK of … climate change could run to many hundreds of billions. Without better information on future climate and climatic extremes, the UK is likely either to lose or to waste many billions per year through under- or over-investment in adaptation.

Expert Panel, *Hadley Centre Review, 2007*

Key Findings

- The Hadley Centre is considered to be good value for money by its senior customers and by external experts.
- The costs of the Hadley Centre are in line with comparator organisations, for the numbers of staff and the supercomputing facility they use, while the outputs produced are world-leading.
- It is highly unlikely that a similar calibre of directed research, focused on policy-relevant outputs and meeting the UK's strategic needs could be procured more cheaply through any other mechanism.
- The efficiency and effectiveness of Hadley's activities could be understood better, and perhaps improved, if better cost accounting methods were used to ensure that the costs of different types of activity could be monitored and managed.
- Areas where there may be scope for efficiency savings include:
  - Use and management of collaborations
  - Value of outreach staff
  - Value of the IPCC TSU
  - Maximising the value of links with the Weather Prediction Service
  - Time spent on broader communications and other activities.
- In order to ensure that resources are used most effectively Hadley needs to be able to demonstrate that they have effective processes for identifying and prioritising research activities.

6.1 Findings

In overview we found that the Hadley Centre is highly valued by its customers and stakeholders, both in the UK and in the rest of the world, and is considered very good value for money. It provides a high level of satisfaction amongst customers, produces

scientific outputs often at the very highest level in the world and is currently funded at a relatively low level, particularly in comparison with US or Japanese facilities.

We have tried to collect information on funding and staffing levels from similar organisations world wide, and to examine Hadley's own management information, to try to quantify these judgements. However, insufficient information was available to provide a sound basis for a fully quantified analysis. We have therefore carried out a systematic, but largely qualitative or semi-quantitative analysis examining four aspects of value for money:

- Economy: could the service be procured for less somewhere else?
- Efficiency: could Hadley produce more for the same money?
- Effectiveness: could Hadley produce better outputs for the same money?
- Equity: does the split of funding match the split of outputs?

6.1.1 Economy

The Hadley Centre has been funded primarily by MoD and Defra through two main programmes (GMR and CPP respectively). In considering whether there could be a more economical model for achieving the same deliverables we have considered the following alternative delivery mechanisms:

0. The Hadley Centre remains as it is now – 'Business as Usual'
1. The Hadley Centre is separated completely from the Met Office and becomes a NERC-style Centre of Excellence, perhaps attached to a University, funded through the research councils – this would require a transfer of funding from Defra/ MoD to NERC to support underpinning science. We assume that Defra and MoD would buy specific policy outputs.
2. The Hadley Centre becomes a virtual institute, similar to the Tyndall Centre, funded through the research councils.
3. The Hadley Centre is incorporated into a European climate centre. We assume, from our discussion with stakeholders, that this would be highly unlikely to be based in the UK so would essentially mean the closure of the Hadley Centre and the transfer of expertise to a European centre based in another EU country, funded through the EU.
4. The Hadley Centre is closed and the funds used to finance grants or contracts to the UK and overseas academic communities to supply the deliverables required by Defra and the MoD.

These are very similar to the choices considered by ESYS at the time of the last review in 2000. In assessing these options we have considered both the UK's strategic need for climate research and the likely impact on costs. An assessment of these options is provided in Appendix 10 and summarised in Figure 14 overleaf.

This assessment concludes that the current 'business as usual' option is the best. It is the only option that meets all the strategic needs, and also appears to be cost-effective. Lower cost options could not meet all the needs, and there is no other arrangement

that could genuinely meet all the requirements. This conclusion was also endorsed by the Expert Panel, who concluded that "Hadley is the only such organisation that could credibly provide such support to UK government" (Appendix 5).

There may well, however, be a choice of approach in delivering certain aspects of the overall programme which would provide for more efficient or effective use of resources, for example through strategic collaboration or subcontracting in areas where the Hadley Centre currently lack depth of expertise. This is discussed in the next section.

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Option	Strategic Needs						
	UK adaptation planning	Work with developing countries	Support for UK mitigation policy	Support for UK's international negotiations	Contribution to the IPCC process	Contribution to scientific expertise and prestige	Cost compared with current
0							
1							
2							
3							
4							

Key: Strategic Need

- Fully met
- Partially met
- Not met

Key: Costs

- Lower
- As now
- Higher

Figure 14: Strategic Needs and Costs Mapped Against Options for Delivering Climate Science

6.1.2 Efficiency and Effectiveness

While it is difficult to find appropriate international comparators for benchmarking purposes, the costs of the Hadley Centre do not appear to be disproportionate given the numbers of staff and the supercomputing facility they use, while the outputs produced are often world-leading. Table 2 provides some benchmarking information.

The keys to Hadley's productivity are:

- Focus on research, rather than dividing time between teaching and research.

- Focus on policy-relevant deliverables, rather than on publishing as many papers in peer reviewed journals as possible.
- Commitment of staff to delivering to customer requirements rather than pursuing their own research agendas.
- Stable funding, rather than reliance on time limited grant applications.
- Synergy between different areas of research, including with the Met Office NWP.

Centre	Description of Purpose	Number of staff (~ full time equiv.)	~ Funding (£M):		
			Total	Staff costs	Staff costs per person
Hadley Centre	The primary aim of the Hadley Centre is to carry out world-class research into climate change and variability which contributes to UK government policy objectives and to communicate the results to government and the public.	150	20	6	0.04
Earth Simulator Center, Japan	The primary objective of ESC is to promote the simulation science for predicting environmental changes with scientific reliability so as to contribute to human welfare and safety.	20	20	1.2	0.06
IPSL Modelling Group, France	LMD studies both modelling and observation of the atmospheric system. It is part of a wider institute, IPSL whose aim is to carry out transdisciplinary research (Earth System Modelling, IPCC-type simulations). The modelling group within IPSL is about 100 persons, and is the closest equivalent to the Hadley Centre in France	100	5	3	0.03
Climate Prediction Center, NOAA, USA	Climate Prediction Center (CPC) serves the public by assessing and forecasting the impacts of short-term climate variability, emphasizing enhanced risks of weather-related extreme events, for use in mitigating losses and maximizing economic gains.	50	2.5	2.5	0.05

Table 2: Some benchmarking information

Financial information is based on estimates provided by the institutes in national currency

There may be some areas where activities could be carried out more efficiently, reducing costs. However since activities by individuals are not monitored below contract level, it is difficult to identify areas that should be of particular concern, or to quantify the benefits of different options for delivery. We have discussed some areas of potential concern below where improvements may be possible, these are:

- Use and management of collaborations
- Value of outreach staff
- Value of the IPCC TSU
- Maximising the value of links with the Weather Prediction Service
- Time spent on broader communications and other activities

Looking forward, Hadley needs to be able to demonstrate that it has effective processes for identifying and prioritising research activities in order to ensure that resources are used most effectively. This and other areas for future consideration are discussed in Section 7.

Cost Effectiveness of Collaborations

At present the Hadley Centre is involved in a very large number of collaborations, both large and small in scale. They have often developed 'bottom up', i.e. through individual staff making links with others informally. These relationships may later be formalised through joint contracts or Memoranda of Understanding, but often remain informal. A number are very strategic in nature arising from a recognition that a particular need cannot be filled by Hadley from its own resources and skill base and that collaborations provide the best way of meeting the requirements.

These collaborations are often effective (see earlier analysis in Section 5.3), and provide Defra and MoD with opportunities to obtain better value from research being carried out in the broader academic community in the UK and the rest of the world. However, they also take time and resources to maintain properly. The focus must therefore be on those that bring most benefits for Hadley, or the wider community. There does not appear to have been much systematic 'top down' analysis and direction of collaborative focus to ensure that collaboration is used to best effect and is cost effective. It is important also to recognise the limitations of collaborations, the most significant of which are:

- Timing: collaborators may not be able to commit to the timescales required to deliver policy advice
- Met Office security and bandwidth (data transfer): these are quoted by collaborators as the most significant barriers to effective collaboration – it may be possible to address these in the planned supercomputing upgrade.

Outreach Staff – CEH Wallingford, Reading and the Earth Simulator Center

In addition to the main Hadley Centre, based in Exeter, there are a number of staff based in other locations. There are small numbers of staff based at CEH Wallingford, at Reading University and in Japan at the Earth Simulator Center. The staff at CEH Wallingford are embedded in an institute with expertise in land surface behaviour and the carbon cycle. These are two important areas where the Hadley Centre is developing its skills and expertise, and these feed directly into the main modelling work conducted by Hadley. The staff travel regularly to Exeter and this outpost appears to provide a valuable link into an area of expertise needed by Hadley.

The staff at Reading, although based in the University, do not appear to have such a close relationship with their host organisation. Efforts have been made by Hadley to ensure these staff feel a part of the Hadley Centre, and this has worked well, but the links to Reading have been less well developed. Although the Hadley Centre as a whole collaborates strongly with Reading University in a large number of areas, it is not clear that the staff posted at Reading are instrumental to this activity. This is an area that could be improved.

The staff in Japan are working on the Earth Simulator, a far more powerful computer than Hadley has access to at the Met Office. They are provided the time for free, and have used the Earth Simulator to test higher resolution modelling approaches, particularly for oceans, to understand the benefits that may be achieved by adopting higher resolution for the Hadley models. These experiments have proved very useful in developing and justifying Hadley's approach. This outpost appears to provide valuable, cost-effective input to the development of Hadley's modelling strategy.

IPPC TSU

The Hadley Centre hosts the Technical Support Unit (TSU) to Working Group II of the IPCC. This is supported by Defra funding, separate from the main Hadley Centre contract. The TSU supports IPCC Working Group II, currently co-chaired by Professor Martin Parry, which focuses on Impacts and Adaptations. The value to Hadley of hosting the TSU is the connection it provides to climate scientists around the world, and in particular to those working in the Impacts field where the Hadley Centre is hoping to develop expertise. To date, however, this link has not resulted in the successful recruitment of such an expert to Hadley. It is unclear whether the Hadley Centre is making optimal use of the opportunity to network provided by the TSU, although Hadley does collaborate widely.

Maximising the value of links with the Weather Prediction Service

Staff at the Hadley Centre are strongly of the opinion that the link with the Met Office's Weather Prediction Service and the Unified Model (UM) approach are invaluable to the quality of the climate change science they do. Indeed it is this close relationship with weather prediction modelling that is one of the unique features of the Hadley Centre compared with other climate research centres around the world. However while the UM is important, there are clearly different requirements for climate and weather prediction models, in terms of the processes included, the timescales over which they are run and the way the code is optimised. Hadley Centre staff expressed the opinion that the limited computation science and engineering expertise provided by NEC is sometimes more focused on optimising the supercomputing resource for weather prediction purposes than for climate modelling. There was also some feeling that model developments that address weather but not climate change are incorporated into the UM more quickly than those that address climate change but not weather, although it is recognised that Hadley derive a great deal of value from the work carried out on the UM by the NWP that addresses both weather and climate change..

These issues may become more acute as cuts to Met Office National Weather Programme take increased effect. We recommend that the processes that provide oversight of how the UM is developed are reviewed to ensure that resources are being fairly and appropriately distributed between the needs of climate science and those of weather prediction.

In addition to these model development issues, Hadley staff expressed the view that it is often more difficult to collaborate with the rest of the Met Office than with outside organisations. However closer links have been forged more recently through

developments of, for example, decadal and seasonal forecasting, which bridge the gap between climate and weather. We consider it would be valuable to improve the working relationship between the Hadley Centre and the rest of the Met Office. Opportunities to further strengthen these links should be sought where this will bring benefits.

Broader Communications and Other Non-core Activities

As well as having a dedicated Communications Officer, many of Hadley's scientists are also involved directly in communicating findings and climate science to the outside world, including the media and the general public. However we do not know *how much* of their time, on a weekly basis, is spent on this, and therefore whether or not this would be considered an appropriate proportion of time by their customers. A rough estimate provided by one manager was 10-15% of time, but there is no hard evidence for this. It is unlikely that Defra or MoD customers are fully aware of how much Hadley staff time is spent in such activities, and therefore will have been unable to give guidance on whether this is an appropriate level of time to be spending.

Similarly it is not possible to estimate how much time in total Hadley staff spend on administration, development and other activities not directly related to development and delivery of outputs and establish whether these are running at an appropriate level.

6.1.3 Equity

Lack of transparency results in all parts of the system being concerned that they are potentially cross-subsidising someone else. Defra is concerned about increasing margins, and that they are being overcharged by Met Office for supercomputing and so are cross-subsidising the NWP. MoD is concerned that its programme may subsidise commercial work. The Met Office has suggested that Hadley could increase value for money by increasing the level of commercial work they take on. We do not necessarily see that increasing commercial work would increase value for Defra/ MoD. We suppose that commercial work (paid for at commercial rates) could generate profits that could be used by Hadley to pay for some of the work done for Defra/ MoD and that some level of commercialisation could help pay for the overhead of dissemination of models and data to the wider community. However, there are material risks associated with attempting to increase commercialism which would have to be carefully managed. We have discussed these potential risks in Section 7.3.

Both MoD and Defra contracts are interdependent, but they have not previously worked together to define programme requirements, or defined their respective required outputs in their contracts, so it is not clear that the costs and benefits have been fairly distributed between the two. The new contracts need to be developed in partnership to address these issues.

The University of Manchester has examined distribution of computing costs in their report produced as part of this review.

6.2 Conclusions

While we have been unable to gather robust quantitative evidence of value for money, the qualitative evidence suggests that the Hadley Centre is delivering value for money and we can see no compelling reasons to move from the current delivery model. The key risk identified with any alternative model is the loss of policy focus. We do not believe that any of the alternatives considered could generate policy-relevant outputs, to the timescales needed by government.

There are some areas where there appears to us to be potential for more efficient, or effective use of resources, however lack of management information at an appropriate level of detail means it is hard to assess whether e.g. communications or management of collaborations is taking up a disproportionate amount of scientific staff time. The new contract is intended to provide a clearer demonstration of value for money in terms of procuring specific outputs and deliverables that can be measured.

7 Can the Hadley Centre Continue to Deliver into the Future?

"world leading climate research is not sustainable over any reasonable period of time without continued access to supercomputers amongst the world's fastest."

The University of Manchester, *Hadley Centre Review 2006 - Supercomputing Provision*

Key Findings

- The Hadley Centre is currently in the process of renegotiating new contracts with Defra and the MoD. As part of this process Hadley Centre have been working with its customers to more clearly define its remit in terms of an output specification.
- In developing their response to this requirement Hadley need to provide a clear business case for the various aspects of its operations linking its strategy and plans for delivery (HR, supercomputing, communications etc) to the output specification.
- The most significant risk to delivery in the future concerns supercomputing provision. We have also identified key risks and success factors in the areas of:
  - Planning
  - Delivery, and
  - Measuring, monitoring and governance.
- In general the Hadley Centres processes and systems for delivery appear effective. Hadley should ensure that they have visible and effective processes for planning and prioritisation.
- Particular risks relate to:
  - Critical resources: specifically computational science and engineering and observational analysis
  - Potential erosion of the organisations culture
  - Commercialisation issues
- Barriers to effective working include Met Office security and bandwidth issues
- We have identified a number of measures for strengthening governance and monitoring of the contract.

This section is concerned with looking forward to establish the key actions necessary to ensure Hadley can continue to deliver to customers needs into to the future. The focus here in on the next five years, however it is very important, given the complex

and evolving nature of climate science, that close attention is also paid to maintaining a sustainable science base, if high quality modelling outputs are to be provided beyond that date. We have discussed the risks and key success factors going forward in the following areas:

- Supercomputing provision
- Planning
- Delivery, and
- Measuring, monitoring and governance.

7.1 Supercomputing Provision

The underpinning contribution of the Hadley Centre to the UK government's leading role in the global climate change agenda critically depends on its ability to deliver policy advice, backed by leading climate science subjected to the highest standards of international scientific peer review. This science is developed through using supercomputers and observational data to continually test and enhance climate models. The available supercomputing power limits both this science development and the application of this science (encapsulated in the models) to answer policy questions.

Our review has concluded that the current business model, under which a single supercomputing service (which may deliver multiple technologies/architectures and a mix of capability and capacity services) is provided to both climate research and weather forecasting users, is highly likely to remain the best service delivery option for the foreseeable future. This core service should be supplemented by a range of external support/consultancy contracts where a critical mass of expertise is already established in external organisations and cannot be justifiably replicated internally.

The fundamental role of available supercomputing capacity in creating science, underpinning policy advice and sustaining international reputation, together with the economics of climate change as presented by the Stern Review, form the basis for a clear output-based business case for a multiple order of magnitude increase in supercomputing capacity for the Hadley Centre. Further, the UK's adoption of a high profile and leading role in the global climate change agenda should not be undermined by inadequate (supercomputer) support for the science underpinning this role.

We recommend that Defra, MoD and the Hadley Centre urgently form and promote an outputs-based business case for a significant increase in supercomputing capacity. These findings and recommendations are presented in more detail in the University of Manchester report.

7.2 Planning to deliver

Climate science is complex and being pushed forward now on many different fronts simultaneously. Hadley faces a formidable task prioritising the many research activities

in the light of developments in the science and the changing needs of policy. If most effective use is to be made of resources Hadley requires:

1. Strong and effective leadership
2. A flexible and responsive living science strategy document that is linked to clear statements of the policy requirement, and detailed modelling strategy and delivery plans including identification of where best value is obtained from in-house delivery and where Hadley can more effectively use collaborations or subcontractors.
3. Effective processes for prioritising work: Hadley needs to ensure that its work programme does not become too diverse to be manageable and that effective processes exist for prioritising work as new challenges emerge and in the face of existing requirements.

Hadley has put in place formal processes for developing their strategic vision and is in the process of developing its strategy and plans further in the context of the new contracts under negotiation with Defra and the MoD. We have discussed issues concerning strategy development and planning below, and explored a particular area of concern, which is the extent of Hadley's role in undertaking and leading impacts research.

Strategy and Planning

The original strategy document provided by Hadley did not set the strategy in the context of policy needs, nor did it show how the strategy could be achieved within the available resources. It provided an aspirational description of where Hadley would like to take its science and modelling to maintain its world leading position. In this respect it was considered a sound document by the Expert Group.

In the most recent documents we have seen, Hadley appears to have developed a considerably more focused articulation of the requirement placed on it by Defra. It is important that Hadley's science strategy is capable of meeting these requirements. Hadley has begun to articulate its work plans in terms of how they will contribute to the outputs required by Defra. They have stated their primary aim as:

> 'to carry out world-class research into climate change and variability which contributes to UK government policy objectives'.

According to the Expert Panel, the modelling strategy, culminating in the HadGEM3 family of models, will ensure Hadley maintains its world leading position in climate modelling and support ongoing policy requirements. There are major concerns, expressed by both the Expert Panel and others, over whether the current supercomputing upgrade plans will provide sufficient computing power to enable the models to deliver the science outputs required, once they have been developed. The Panel stated:

> 'to deliver the science strategy that Hadley proposes and the Panel endorses, the Panel agreed that both a higher specification new supercomputer, and appropriate computational support capability, would be needed.'

This issue is discussed further in the next section. The modelling strategy needs to identify the supercomputing (and other IT) resources required as a minimum to develop and run the models and to clearly describe the impact of any reduced provision both on the modelling strategy and:

- the customers' required outputs as described in the new contracts, and
- the sustainability of the programme and their leading position in the longer term.

This essentially means developing a business-plan based approach to strategy development. The strategy also needs to link to:

- a resourcing plan - this would cover:
  - Which skills are best retained in-house, and why, the criticality of these, the age and experience profile of staff in the delivery teams, overall numbers and staff turnover levels
  - Which areas Hadley should aim to supply through integrating knowledge generated elsewhere in the academic community, either within the UK or abroad
  - How any skills or knowledge gaps can best be filled, taking into account the costs and benefits of each option, either through recruitment, collaboration, sub-contracting, secondments etc.
- A communications strategy
  - Hadley has identified as one of it aims '...to communicate the results to government and the public'. While a clearer policy has been developed on communication between Defra and Met Office press offices relating to press releases and their policy implications, there is little as yet on a broader communication strategy regarding how the general public are to be engaged by the Hadley Centre, how much of Hadley's scientific staff time will be devoted to this activity, and how the success or otherwise of communications will be measured.
- Improved articulation of the benefits that the Hadley Centre's science and modelling will provide to policy makers. This needs to clearly set out:
  - why continuing specific areas of work will be essential to providing the outputs the customers want,
  - how the staff and supercomputing resources contribute to each area,
  - the benefits to the customer that can be achieved with the current planned level of resources and
  - the even greater benefits that could be achieved, for example, with increased supercomputing power.

  The benefits should draw on, for example, the critical uncertainties for policy makers, the likely costs of making poor decisions and the improvements to decision-making that could potentially be achieved with improved understanding of the climate uncertainties. This approach has been endorsed by the Expert Panel, who stated "The one area in which the Panel would wish to recommend change is that Hadley and the Met Office need to "raise their game" in

articulating the benefits of what they do to their core government customers, and in securing the investment that their work deserves."

Impacts Research

The focus of Government policy is now moving towards the need to understand the impacts of climate change and how the UK (and the rest of the world) can adapt to a world of changing climate. The Hadley Centre has already begun to incorporate into its models certain features that could be described as impacts, for example carbon cycle interactions with forestry. However, the term 'impacts' covers a very broad continuum, from impacts on ecosystems through impacts on agriculture and human health, to infrastructure, economic and social impacts.

There are many specialist researchers across the UK working in these very varied fields. For example CEH Wallingford, which models the detailed impacts of climate change on local water resources and water catchments, using the outputs of Hadley Centre models as their inputs. UKCIP takes outputs produced by Hadley and provides information to end users such as local government and businesses to help them make decisions on how to adapt to the expected effects of climate change, while the Tyndall Centre specialises in looking at how elements within society can respond to the challenges of climate change.

There is a strategic choice to be made as to whether to expand Hadley's remit to take a more leading role in some aspects of this research. The benefit would be that Hadley has a proven track record in focusing research to provide policy-relevant outputs, so this could be an efficient and effective route for directing impacts research. However the risk, as noted by the Expert Panel, is that opening up new work on the impacts front could detract from the resources that are needed to maintain existing priorities. Without a clear strategy for how impacts work will fit within Hadley's overall work programme it will also be hard to attract impacts scientists, as Hadley has already discovered.

7.3 Delivery

The review has identified a number of areas of immediate concern relating to delivery of the new contract(s), these concern:

- Staffing
- Organisation and management
- Organisational culture
- Reputation management and commercialisation
- Security, bandwidth and data transfer

Staffing

- **Critical resources:** The review has identified two immediate areas of concern:
  - Hadley does not have any significant or dedicated computational science and

engineering (CSE) resource. The University of Manchester has identified the need for CSE to re-architect the modelling code to run on the next generation of supercomputers, and to become a core part of the ongoing model development process, thus reflecting the underpinning role of supercomputing in the modelling. If these staff are to be funded from the Defra or MoD contract budgets, this will impact on other science areas. This is a critical requirement as without this re-architecting the codes will not run on the new computers, and this task must start as soon as possible.

- A succession plan is required for the team that carried out the observational data analysis work, used by Hadley and the rest of the world, as both Chris Folland and David Parker are due to retire shortly.

In the longer term there is a need for Hadley to ensure it has sufficient general scientists, as opposed to technical specialists, to retain the flexibility needed to respond to often rapidly evolving policy needs. In recent years there has been a focus on recruiting 'to post', rather than recruiting able junior scientific staff and training them in broad climate science, creating a less flexible workforce. Senior Met Office staff indicated that the Hadley Centre would be looking to recruit both specialists, perhaps at higher levels, and general scientists in future. We endorse this approach.

- **Recruitment and retention:** Hadley is concerned that retention may become more of an issue in the near future. There are several reasons for this:
  - Competition for top staff has been growing with the growth in climate science funded through NERC, although this has also increased collaborative opportunities.
  - Hadley has failed to attract an Impacts specialist of sufficient experience[13].
  - Recruitment of IT specialists is also a challenge, in part due to salary ranges but also because the type of work on offer is not necessarily appealing to ambitious young IT professionals (as it is based on Fortran, for example, and also because the Hadley Centre is not seen as a key IT specialist operator).
  - There is a perception that salaries, which in the past were ahead of those in academia, have fallen behind in recent years.

We have compared Hadley's pay scale with a typical academic pay scale in Appendix 11 and this analysis suggests that Hadley should not need to increase pay across the board to remain competitive, except perhaps for the most junior staff, where apparently there are no real recruitment difficulties at present. Looking more broadly, the Hadley Centre cannot provide comparable salaries with institutes in the US, but it can attract staff from other European countries.

[13] We note that at present Hadley's approach to impacts, and hence need for an impacts specialist, remains unclear. Due to the breadth of potential areas covered by 'impacts', finding a single individual with the right range of skills, of the right calibre, is difficult. In addition, without a clear brief for how impacts work will fit into the overall work of the Hadley Centre it is unlikely that a high-calibre individual would want to make the move.

This analysis should be treated with caution as academic scales can vary considerably and there are many other important factors in attracting and retaining the right calibre of staff. These include:

- The reputation of the Centre
- The working environment and culture
- The lifestyle associated with the South West of England

The move to Exeter resulted in a change to the staff structure, with some older and more senior staff members choosing to remain in the south east of England (due to family or other commitments). This provided an opportunity for younger people to be promoted into more responsible roles.

Despite Hadley's concerns, we do not recognise any particular cause for alarm. According to the Met Office's own staff attitudes survey, Climate Research staff are generally more satisfied with their situations that the rest of the Met Office staff. We would recommend that Hadley monitors staff turnover to provide an objective measure of any staff retention issue.

Organisation and Management

The Hadley Centre has recently undergone a change in leadership and leadership structure. David Griggs, formerly Director of the Hadley Centre, has been promoted to Director of Government Business for the whole Met Office. This initially left a leadership gap with no-one formally identified as leading the Hadley Centre. Customers expressed concern over these changes to the leadership of the Hadley Centre, both senior Defra and MoD customers, who felt they had little involvement and were not consulted in the making of this decision.

Since then a new post of Head of Climate Research has been created, to manage the science for Hadley and a new Director of Climate Science (for the whole Met Office) has also been created. We understand that the two posts responsible for managing the two main contracts (Head of the CPP and Head of the GMR) report to Dave Griggs as Director of Government Business as part of the Met Office's programme management organisation.

The management structure remains unclear – it is not yet clear where the boundaries of responsibility will lie between the Head of Climate Research and the Director of Climate Science, for example, which represents a form of matrix management for the Hadley Centre. There is still no 'Director of the Hadley Centre'.

It is unclear what mechanisms the Hadley Centre has in place for prioritising work when difficult decisions have to be made. In the past, the Director of the Hadley Centre would be the ultimate decision maker with regard to work priorities. With the new management structure this may be a collectively agreed process.

Staff expressed themselves much happier with the new arrangements than they had been on the initial change of David Griggs' role, when science leadership tangibly lost direction, it will remain to be seen how effective this new management structure is. Defra and MoD should ensure that the new contract allows them to monitor this aspect of Hadley performance and that they are consulted in any future changes to key personnel.

Culture

The identity of the Hadley Centre as an entity separate from the rest of the Met Office has been eroding since the amalgamation of the organisation into one building during the move to Exeter. Hadley Centre staff no longer have regular daily contact with all their colleagues, due to the design of the building they now inhabit. This has affected feelings of cohesion within the team, and must also impact on serendipitous exchanges. Some staff also find it difficult to work productively in an open plan environment and a simple recommendation would be to add IT facilities to the small meeting rooms, so that staff in need of a peaceful working environment for a short time could work effectively in these.

These feelings of loss of identify are now being compounded by the plan for managing the Hadley Centre as a virtual centre within the Met Office, with the matrix management approach described above. Concerns raised to the review team include:

- Some Hadley staff struggle to see the relevance of the Met Office's vision "Making our forecasts essential to everyone, every day" to their work
- There is concern about the perceived dilution of the Hadley Centre brand
- The Met Office corporate procedures and standards are considered more bureaucratic than previously and sub-optimal for delivery of a climate change research programme, which differs in many ways from the delivery of the Public Weather Service

The Met Office Employee Attitude Survey conducted by Accord Marketing and Research in March 2006 indicates that staff working in the Climate Research area are generally more satisfied with their work, the control they have over their work, their working environment, conditions and career prospects than other staff in the Met Office. This may be evidence that the Hadley Centre retains its own culture within the larger Met Office.

There is a risk however that the changing structure and environment will have a detrimental impact on the Hadley Centre's continued excellent performance. Met Office and Hadley Centre management need to be aware that the culture that has generated success could be damaged, and must manage this carefully.

Reputation Management

The Hadley Centre has an unparalleled reputation amongst climate scientists internationally as a world leading organisation, and is much admired. The review has examined the following aspects of reputation management:

- Making the most of Hadley's reputation: During negotiations with its government customers it has not capitalised on this position strongly enough, nor highlighted the risks to the standard of its work should future funding not be effectively secured. It needs to develop a more business led approach to presenting the benefits of the work it does, to the UK and to the wider world.
- This also applies to presenting itself internally to the Met Office – the reputation of the Hadley Centre should be something the Met Office is proud of and should promote, rather than (as it appears from the Met Office website) something it would rather remained 'just another part of the Met Office'.

- Risks to reputation:

  The uncontrolled use of Hadley Centre models by external academic organisations could potentially harm the reputation of the Hadley Centre, for example where someone publishes flawed results based on models that have been altered, or used parameters outside valid ranges, while quoting the Hadley Centre as the basis for the model. Hadley needs to develop appropriate management methods to control this risk.

  The Met Office is under considerable pressure to develop commercial work to support the reduction in its overall funding in real terms. This represents a real risk to the reputation of the Hadley Centre. For example the type of customer that Hadley takes commissions from could tarnish its reputation (e.g. the oil industry). We have presented a number of case studies in Appendix 12 that illustrate the risks which will need to be managed carefully.

Other Commercialisation Issues

At present commercial work is a small percentage of the overall work of the Centre, but it is growing rapidly. Hadley has set up a small separate team to manage this. However, while this team will manage the work they will draw on the scientific expertise of the rest of the Hadley Centre. We have identified a number of concerns in addition to the reputation risks identified above:

- It remains unclear how work will be drawn from the scientists and how Hadley will ensure that meeting commitments from commercial clients are never at the expense of meeting deliverable deadlines for its key customers.
- The management information systems will need to be developed in order to correctly account for time spent on commercial work, and appropriately allocate overhead costs.
- IP issues will need to be managed, a particular issue is if any US data or information might end up in a product or service being sold commercially. This would result in a draconian response from the US
- A serious commitment to the pursuit of commercial work requires considerable investment of staff time to the preparation of bids, with no guarantee of success. Could Hadley commit significant resource to bidding, let alone doing significant extra work? Their contracts make no provision for this, and if Defra and MoD do not perceive such work to be of direct benefit to them they should not be paying towards supporting it.

The Met Office needs to ask if the commercial work is to be marginal, is it worth the potential reputation risk for so small a return? If the intent is for substantial commercial operation, there needs to be a rethink of objectives and remit.

On the other hand, if their models are to be widely used there is an operational cost concerned with issuing software and updates, documentation, training, checking configurations etc. In these circumstances they could well put this on a semi commercial basis so as to recover the costs, lest their (capped) manpower gets too occupied on these functions. One way to do this is to license somebody to do the

supply. If, say, US data or models is included then a deal which has US licensees as well as UK/ROW might avoid the problem set out in Appendix 12

Security

Security issues have been mentioned as a barrier to recruitment, the visiting scientist programme, and to collaboration. This is usually attributed to the need for the Met Office supercomputer to operate in a specific secure environment, including against the risk of hackers interrupting the national weather forecasting service. It is possible that a new network architecture, deployed at the same time as the planned supercomputing upgrade, could reduce these constraints in some use cases.

Bandwidth and data transfer

The Hadley Centre is currently considerably constrained in sharing data with outside organisations, not only by the Met Office security issues but by narrow bandwidth connections to the outside world. Hadley has access to a low bandwidth SuperJANET connection but it does not, as a non-academic body, have free access to the SuperJANET high bandwidth academic network, although this could be purchased at a commercial rate. This lack of bandwidth has caused serious limitations for some collaborations and methods of facilitating exchange of data will need to be investigated as quantities of data are only forecast to increase.

7.4 Measurement, Monitoring and Governance

Performance Measurement

Hadley has begun to develop performance measures that will apply to the new contract. We have briefly reviewed the document "How do we measure our science output?" produced by the Science Review Working Group and find:

The principals proposed in the Recommendation appear sound. We recommend that the following are also added:

- The performance measures should relate to the primary purpose of the research, which needs to be clear and explicit – examples of what we mean by this are given in the box below.
- Bullet 1 – it helps to be clear what behaviours are desired
- The package of measures should be invulnerable to countermeasures (citation clubs and the like) or at the very least possible perverse behaviour should be identified and guarded against.

The proposed list of indicators needs more work and we assume is a first cut, for example:

- the *bibliometric* entry might usefully consider journal impact analysis
- *Staff turnover* should show a range, much less than 5% implies fossilisation, whereas much over 15% could indicate a real problem

- the *number of Unified Model* users and developers is suggested but we note that this can carry a considerable "support" overhead and risks to reputation.

Overhead costs as currently recorded include some support staff, office rental and a share of services such as HR, finance etc. There will be limited opportunity to drive these lower and indeed this may be counterproductive. This indictor does not measure the proportion of time spent directly delivering science rather than for example carrying out purely administrative tasks, attending training, attending management meetings or communicating with the broader stakeholder community, all of which may be necessary or valuable, but the proportion of time spent on them should be monitored and managed to ensure that it does not become excessive.

Box 1: Matching Metrics to the Primary Purpose

The primary purpose will shape the nature and balance of the review measures:

Bibliometrics can be very useful indicators. They are more directly useful the bigger the unit of assessment, institution (or even country). If the primary purpose is concerned with basic science, then science citations, publication in refereed journals or citation impact analyses might be suitable measures, for example. If the primary purpose is consultancy, then science citation measures are less relevant.

Patents can be popular indicators where the primary purpose relates to commercial aims (we know this is not the case for the Hadley Centre). However simple patent numbers can be dangerously misleading. Different sectors have a different propensity to patent, for example pharmaceuticals are strong on registering patents. On the other hand some electronics areas have rather less propensity and depend instead on speed to market for commercial advantage. For these organisations patent numbers are much less useful as a performance measure.

Governance

At present, governance of the Hadley Centre's outputs is assured through a range of processes. These include:

- the Met Office's internal processes
- links to key customers (contract managers),
- the Hadley Centre Science Review Group which meets annually to review the quality and direction of the science,
- MOSAC (the Met Office Science Advisory Committee, and
- Publication in peer reviewed journals.

Together these provide, on the whole, a robust system of checks and balances. However, for any organisation that has been at the head of its field for any time, there is always a risk of complacency and a tendency to react defensively to challenge coming from outside the recognised community. This may be compounded by the fact that the climate science community is relatively small one. There is the possibility of 'groupthink', with even the SRG being drawn into the same commonality of thought. A particular issue to highlight here is the risk of modellers focusing on those things that it is possible to model at the expense of those that currently cannot. The contract steering group can play a role here, by requiring that conclusions and findings

are always reported in the context of the current state of the knowledge drawing on all sources of information.

To help manage these risks, it would be beneficial for the Hadley Centre to increase its exposure to genuine external challenge. For example the introduction of a non-climate scientist onto the SRG could mitigate the risks of groupthink and complacency and might be particularly beneficial as the Hadley work begins to rely on new disciplines as, for example, it continues to develop its approach to generating probabilistic outputs.

The new contracts will also introduce new challenges and it has been suggested to the review, and we agree, that a joint contract steering group should be appointed to oversee both the MoD and Defra contracts to help:

- balance competing customer demands, and provide direction for both the CPP and GMR programmes.
- Critically assess whether the science strategy can genuinely be met within current budgets and will meet the policy board
- Ensure that UM development balances climate modelling needs with those of the NWP as Met Office's budget comes under increasing pressure
- Monitor contract performance and key risks..

This steering group should include senior policy makers from both clients, and the Defra and MoD contract managers. We also recommend that this group includes suitable 'non-executive' members to provide a challenge function and help promote appropriate strategic relationships between the Hadley Centre and broader scientific community, for example a senior academic and a Chief Executive from another Trading Fund. The group should also actively make use of invited experts as appropriate e.g. when supercomputing is discussed, or when dealing with a new country etc.

Design of the New Contracts

The new contracts present both an opportunity and a risk. We believe that the introduction of longer term year fixed priced contracts, with well developed mechanisms for monitoring progress and managing changes will be beneficial. At this pivotal time for Hadley they present an ideal opportunity for Hadley to reassess with its customers its role and remit and to discuss and agree what can be delivered within the available resources. It will be important for Hadley to demonstrate how the various input activities relate to the outputs delivered to Defra and to demonstrate that their plans are credible and represent value for money (a business plan lead approach).

Hadley has provided two early drafts to inform the CPP contract design:

- A briefing document[14]:
- A draft Project Definition Agreement[15]

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[14] "Briefing Document: New CPP and DCRP Contracts, Vn. 1.0, 15 January 2007" (filename 'New Contract.doc') forwarded to us by Vicky Pope on 23/01/07

[15] Project Definition Agreement for the Climate Prediction Programme between the lobal atmosphere Division, Defra and the Hadley Centre, Met Office, DRAFT for discussion, Version 2.1, 2007-2012

We have provided some initial thoughts on these in Appendix 13. Our first impression is that they provide a considerably more focused articulation of the requirement placed on Hadley by Defra, but the briefing document requires more work to be persuasive. The draft project definition agreement looks like a reasonable output-based specification.

We recommend that the key risks and critical success factors for the new contract are identified and agreed, along with suitable controls and measures to monitor these. Issues addressed should include:

- Management and leadership, key staff, and the process by which they may be changed
- Important activities (e.g. PRECIS) that the client requires to be supported
- Key external inputs and activities (e.g. we are not certain whether funding for the Argo floats is secure, the impact of loss of these data on the programme should be examined)
- Relationships and communication mechanisms between customers and Hadley, as well as within Hadley.
- IPR issues, including obtaining datasets from external sources, use of outputs (e.g. UKCIP08), access by external users to Hadley-generated observational datasets etc.
- Governance including the processes by which variations to the contract will be agreed and managed (see above).

To-date the Defra and MoD programmes have been run as highly integrated programmes with well differentiated, complementary objectives. With both Defra and MoD now defining output specifications Hadley will need to ensure that they can effectively record effort spent on the different requirements accurately to ensure that there is no inappropriate cross-subsidisation. We recognise that this will be challenging and that it may be necessary to discuss and agree with the customers an appropriate way of allocating time spent on some of the common underlying science activities. There is also a far greater requirement for the customers to work together to ensure that Hadley aren't faced with reconciling competing objectives.

Beyond the New Contract

The current contracts being negotiated with Defra and MoD are for five and three years respectively. The underpinning science base, a key input to ensure the appropriate outputs are generated, will only be safeguarded through this period via clear links from these inputs to the outputs required by the customers. Hadley is currently developing the material to demonstrate how the science they conduct leads to the outputs needed. This is an important exercise to ensure that the output-based focus of the new contracts does not lead to any erosion of the quality of the underpinning science (often called 'insidious decline') during the lifetime of the contracts.

8 Conclusions and Recommendations

"My aim is that the following principles underpin our work: we are the best informed and researched Ministerial and official team in Whitehall, with an evidence basis at our fingertips faster, earlier and more focused than anyone else"

David Milliband, *Secretary of State for Environment Food & Rural Affairs*

The Hadley Centre holds a unique position in the world of climate science. No other single body has a comparable breadth of climate change science and modelling, or has made the same contribution to global climate science and current knowledge.

We are satisfied that Hadley is currently providing high quality, fit for purpose outputs focused on customers' requirements. The UK Government's current leading role in international climate change policy is strongly supported by Hadley's world leading status. The eminence of Hadley and the quality of science required to maintain this supports international negotiations and provides the detailed science required to underpin impacts and adaptation evaluation.

We have qualitatively assessed alternative options for delivering this strategic policy advice and conclude that there is no other credible means of meeting this need as cost-effectively. This conclusion was endorsed by the Expert Panel.

The key risk to the continued successful delivery of policy requirements concerns supercomputing provision. The existing resource is not capable of running the next generation of climate models. The upgrade to the Met Office supercomputer, planned for 2009, will deliver approximately 8 times the current supercomputing power. This will still result in serious resource constraints in terms of:

- running the more complex models being developed now, which are needed to answer questions about regional effects and broader impacts of climate changes
- exploring uncertainty through ensemble runs.

It will also leave the Hadley Centre far behind the current top climate research supercomputers, and even further behind where these are expected to be by 2009.

While without this they will be able to continue to do useful, though more limited, research they are very unlikely to be able to sustain their position at the forefront of climate modelling, or provide effective policy advice in the medium to longer term (beyond three years), without access to much greater supercomputing power.

Other key risks to sustaining the Hadley Centre's world-leading position are:

- Retaining a world class complement of staff across the breadth of science
- Maintaining the culture and stability of the organisation
- The increase in funding and commercialisation pressures being placed on the Met Office as a whole

We have made recommendations that address these aspects and some other additional areas where improvements could be made below. We believe that Hadley is, in the main, aware of the issues and is taking action to address them.

We have identified some areas where there may be potential for making efficiency savings, but suggest that most benefit will be gained from effective planning and prioritisation processes, and that these can be implemented as part of the planning and management of the new contracts.

8.1 Summary of findings against review aims

Review Aim	Conclusion
a. the quality of the Hadley Centre's scientific enquiry and outputs when benchmarked with recognised international standards and customers' contractual requirements.	Hadley is currently regarded as a world leading climate modelling centre, and in general is providing high quality, fit for purpose outputs focused on the customers' requirements. The UK Government's leading role in international climate change policy has been strongly supported by Hadley's world leading status *See Section 4*
b. the strategic vision of internal and external stakeholders over five to twenty year timeframes, identifying strategic options to meet future needs of the Hadley Centre's clients.	Hadley's stakeholders value Hadley's international standing and world class status. While there has been a shift in emphasis in terms of the outputs needed Hadley has recognised this and responded appropriately. Some uncertainty about the scope of their remit is now being resolved through the current contract negotiations. We have examined 5 strategic options for delivery and concluded that the current model is most appropriate in terms of delivering future requirements over the next five years, and as far as it is possible to judge, beyond this. However an important decision that needs to be taken now is whether Government wishes to maintain the Hadley Centre's capability to perform world leading science, as this has major implications for resources and supercomputing provision. *See Section 6*

Review Aim	Conclusion
c. the quality and value of the Hadley Centre's working relationship with its external collaborators including similar research establishments both nationally and internationally	Individual collaborations appear from our survey to be generally of high quality and of value to the Hadley Centre and wider community. Many of these are informal in nature, rely on networking by individual scientists and carry a low overhead. However, collaborations can take time and resources to manage properly and there is a concern now that Hadley may be putting to much effort into some collaborations for too little benefit. A more strategic, top-down approach to determining where to seek collaborations should ensure that effort is focused where it can bring most benefit. *See Section 5*
d. the quality and value of stakeholder communication both internal and external with particular attention to the web-site.	Internal communications are generally very good. Areas for attention include ensuring staff receive customer feedback on deliverables and feedback on decisions on the strategy. More junior staff should be given opportunities to interact with customers. External stakeholders are generally pleased with their interactions with Hadley. Hadley staff spend a significant amount of time communicating with the media, schools etc, This is valuable, but lack of monitoring of individuals' time below contract level means that it is not clear how much time is spent on these activities. The new web-site was only very recently launched but appears much improved. *See Section 5*
e. customer satisfaction, how successful the centre is in meeting identified needs for scientific enquiry, information and services.	Hadley delivers high levels of customer satisfaction. The materials they provide are generally considered to be of a high standard and fit for purpose. Improvements could be sought in the areas particularly of timeliness of some deliverables, communications and building a better understanding of the policy making context *See Section 5*
f. whether the current resourcing and IT provision provides value for money in enabling the delivery of high quality climate science evidence and advice, and the options for future provision	*See separate University of Manchester report, "Hadley Centre Review 2006 - Supercomputing Provision"*

Review Aim	Conclusion
g. whether, considering all these aspects, the Hadley Centre is meeting its customer requirements and delivering value for money and whether current governance and review mechanisms are appropriate.	This review has concluded that the Hadley Centre is meeting customer requirements and providing value for money. A lack of detailed management information makes it difficult to understand the real costs of activities. Although it is difficult to assess this formally, there are probably some opportunities for efficiency gains. *See Section 6* Governance of the science generally appears robust; we have made some recommendations for strengthening the arrangements further. The new contracts are providing a framework within which broader governance of the research programmes can be significantly improved. This includes encouraging a more business-plan based approach to developing strategy and planning and improving performance monitoring of the contracts (including more detailed financial monitoring). We have recommended a joint contract steering group is established to oversee both contracts. *See Section 7*

8.2 Recommendations

We have grouped our recommendations as follows:

- Recommendations for wider **Government** consideration
- Recommendations that would need to be implemented jointly by **Defra/ MoD and Hadley**
- Recommendations for **Hadley** senior management to consider
- Recommendations directed specifically at the **Met Office** senior management
- Recommendations that specifically address the development of the **new contracts**

8.2.1 Recommendations for Government

1. We conclude that maintenance of the Hadley Centre is the most appropriate way to deliver the strategic climate science policy advice currently required by the UK. The need for such strategic advice is expected to continue for at least the next five years.
2. The UK Government should take a strategic decision on whether it wishes the Hadley Centre to retain its world leading status. To do so would require considerably enhanced investment in supercomputing facilities, above and beyond the currently planned upgrades based on continued level funding.

8.2.2 Recommendations for Defra/MoD and Hadley

3. We recommend that DEFRA, MoD and the Hadley Centre urgently form and promote the business case for a significant increase in supercomputing capacity. This should be considered in the context of the value the UK Government places on the Hadley Centre's world-leading science and status. Other more detailed recommendations regarding supercomputer provision are provided in the University of Manchester report.
4. The relationship and mutual understanding between the Hadley Centre and its two key customers would be improved if broader communications between the organisations were enhanced. We recommend that Defra, MoD and Hadley consider the following possible approaches and select the ones that work best for them:
   - Secondments – in order for secondments to be made to work successfully, they would need to be supported by senior managers at the Hadley Centre, and the mechanism for funding of secondments would need to be agreed in advance between Defra, MoD and Hadley. Allowance for this could form part of the new contract. Shorter term secondments would probably be more acceptable to staff, although we recognise that they might add less value.
   - Defra, MoD and Hadley should consider instituting a series of two- or three-way seminars, where staff from both customer and supplier organisations are encouraged to share both current work and their experiences of working in their particular environment. These could be held alternately in London and Exeter.
   - Defra and MoD staff should have the opportunity for direct contact with a wider range of Hadley staff. This would enable more Hadley staff to have a better understanding of customer requirements, and to get direct feedback from customers on their work. (Contract managers should obviously retain the final say in how work is delivered to customers, and contract variations would always have to follow appropriate mechanisms.)
5. The quality of the science conducted by the Hadley Centre is overseen by the Science Review Group, as well as being subject to academic peer review when published. We recommend that the role of the Science Review Group be enhanced by recruiting a senior scientist from outside the field of climate change to provide external challenge, challenge complacency and reduce any risk of groupthink from within the climate change community.
6. The decision over how far the Hadley Centre should become involved in, or lead, climate impacts research is a strategic one. The benefits would be the directed nature and policy focus that Hadley could bring to such work. The risk would be that resources could be taken from other important areas of work. We recommend that Hadley, working with Defra and MoD, develops a clear business case for any expansion into this area.

7. We recommend that email communications between key Hadley Centre staff and key Defra and MoD clients be improved by mutually agreed prioritisation mechanisms.

8.2.3 Recommendations for Hadley Centre senior management

Strategy and Planning

8. We recommend that the Hadley Centre links its strategy and planning processes more closely to the policy outputs its customers require. This would improve its own business case for the various aspects of its operation. This process is currently underway, and is being developed as the new contracts are developing.
9. In considering its strategy, the Hadley Centre should be as open as possible to challenge and new ideas. We recommend that challenge from other parts of the scientific and broader stakeholder and client communities should be welcomed and treated constructively as part of the ongoing process of refining the strategy. Ways of incorporating this challenged earlier in Hadley's strategic planning process should be explored.
10. The Hadley Centre must link its overall strategy to its modelling strategy and plans for delivery, including a resourcing strategy, supercomputing resource plan and communications strategy:
    a. The modelling strategy should be improved with clearer articulation of the links between model design and the required customer outputs.
    b. The modelling strategy should be directly linked to the supercomputing resource plans, indicating what will be possible under the current planned upgrade and what additional benefits would accrue, specifically in terms of benefits to the policy-makers, with additional supercomputing power. This would provide the Hadley Centre with its business case for increased supercomputing investment.
    c. The human resourcing strategy should be articulated more clearly, indicating the skills needed to deliver the work programme, identifying any areas where capability needs strengthening and indicating the route for this strengthening, either through recruitment, collaboration or sub-contracts.
11. The Hadley Centre should ensure that its science strategy, modelling strategy and delivery plans are maintained as living documents, always clearly linked to the customer policy requirements. They should be regularly reviewed and updated as appropriate.

Delivery

12. The Hadley Centre must make its mechanisms for prioritising work transparent to the clients.
13. There are two key areas where there are current concerns regarding resourcing:
    - The Hadley Centre will need more computation science and engineering resource than it has at present to convert current modelling code to the new

supercomputing architectures that will be introduced with the next upgrade in 2009.

- Key staff members in the observational analysis area are due to retire. A succession plan will need to be put in place before this.

The Hadley Centre must show how it is going to address these concerns as part of its human resourcing strategy.

Monitoring and Performance Measurement

14. We recommend that the Hadley Centre's senior management team introduce more rigorous mechanisms to monitor activities by individuals, particularly in relation to the newly-defined customer deliverables, but also in relation to the broader activities that science staff are involved in that do not directly feed these deliverables, for example time spent on communications with the general public, administrative meetings, managing collaborators, travel etc. This would provide a better understanding of the real costs of such activities, and will help the Hadley Centre to demonstrate their business benefits and costs – important in building any business case.

Communications

15. Hadley should develop a communications strategy linked to its overall strategy and the policy need.

16. We recommend that the Hadley Centre improves the way it communicate its progress against agreed milestones with customers and broader stakeholders, particularly those outside the main Defra contract.

17. We further recommend that Hadley continues to work to improve communication internally, especially ensuring that feedback is provided to staff on strategy decisions and customer feedback.

18. The Hadley Centre should continue to encourage its staff, particularly more junior staff, to attend media training courses and gain confidence in engaging with the media directly.

8.2.4 Recommendations for the Met Office senior management

Leadership and Management

19. The Hadley Centre needs strong and effective leadership in order to maintain its focus on quality science and policy advice, and to balance the complex demands that are being place on it. We recommend that the Met Office and the Hadley Centre clarify the new management structure, particularly the roles and responsibilities of the Director of Climate Science and the Head of Climate Research and carefully monitor the arrangements.

20. The Hadley Centre has an extremely strong reputation and brand around the world, which reflects well not only on the UK as a whole, but also on the Met

Office of which it is part. We recommend that the Met Office supports the branding of the Hadley Centre more tangibly, particularly with respect to the website which is part of its public face. The Hadley Centre web pages should be clearly branded throughout. It should have its own branded home page that is easy to navigate to and from, with a clear logo showing, for example, 'The Met Office Hadley Centre' on each relevant page.

21. There is a risk that the changing structure and environment within the Met Office will have a detrimental impact on the Hadley Centre's continued excellent performance. Met Office and Hadley Centre management need to be aware that the culture that has generated success could be damaged, and must manage this carefully.

22. There is considerable value in the unique working relationship between weather prediction and climate change modelling provided through the Met Office's Unified Model. We recommend that the processes that provide oversight of how the UM is developed are reviewed to ensure that resources are being fairly and appropriately distributed between the needs of climate science and those of weather prediction.

23. We recommend that the Met Office formally seeks feedback on the Hadley Centre's performance from its key Government customers on an annual basis.

24. The Hadley Centre's reputation for independence and scientific excellence is essential to its continued success. The Met Office should ensure that commercial pressures do not result in the Hadley Centre's acceptance of contracts that could be a risk to this reputation or jeopardise delivery to Hadley's core customers.

25. The Met Office should actively look for ways to reduce the burden of its security requirements on the Hadley Centre. This may only be practical with the next supercomputing upgrade in 2009, but when this upgrade takes place the reduction of the security burden for Hadley should be a priority.

26. The Met Office should actively look for ways to increase the bandwidth available to the Hadley Centre, to improve its connectivity with the outside world and to ease the transfer of large datasets.

8.2.5 Recommendations for the New Contracts

27. We strongly recommend that Defra and the MoD develop and manage their new contracts in partnership to ensure there are no conflicting requirements placed on the Hadley Centre.

Key project requirements

28. Development of the contracts should include identification of the key risks and critical success factors relating to delivery of the defined outputs and maintenance of the science base. These should be agreed with the customers, together with suitable controls and measures.

29. Defra and the MoD should ensure that the contract makes explicit any consultation they require on changes to key personnel. These individuals should be named in the contract, together with their role.

30. As part of its requirements on communication of results, the Hadley Centre should be required to inform Defra not only when a paper has been submitted for publication but also when it is about to be published. There can be a significant timelag between the two and it is important for Defra to have advance warning of when papers that are of particular media interest are going to be published. Hadley and Met Office press offices should also be alerted to this.

31. The requirement for Hadley Centre to communicate its results to the broader public should be more explicitly detailed in the contract. A communications strategy for communicating results to the public should be prepared and fully costed, including all Hadley staff time not just the time spent by the Communications Officer.

Governance

32. We strongly recommend that Defra and MoD form a joint contract steering group, consisting of senior policy makers and contract managers from both clients, together with suitable senior 'non-executive' members from e.g. the academic community or another Trading Fund to provide external challenge. This group would help balance competing customer demands, critically assess the achievability of the science and modelling strategies, and monitor contract performance and key risks. The groups remit should be described in the contract documentation.

33. We recommend that a clear change control process is included in the contract, or supporting documentation, indicating who can authorise changes to both the contract and the work to be carried out, and how these changes will be made.

Contract monitoring

34. The most important metrics used in the contract should be related to the primary purpose of the research. In the case of the Hadley Centre the primary purpose is to provide policy advice, so we would recommend metrics that focus on this, for example measures of customer satisfaction, timeliness of responses and adherence to the planned programme. A suite of appropriate measures should be selected with regard to this primary purpose, the risks to its successful delivery and other subsidiary objectives. Cost effectiveness measures would also be useful (see earlier recommendations on planning and management information).

35. While the contracts are focused on the more immediate outputs needed by the clients, it is important to the longer term that the Hadley Centre maintains excellence in its underpinning science. Secondary measures such as bibliometrics would indicate how well the Hadley Centre is fulfilling the requirement to base its advice on sound and world leading science, and would demonstrate that the underpinning science is being maintained.

36. In terms of citations, we would recommend that the Hadley Centre continues to use the H-index, but seeks to compare itself on an annual basis with a small range

of individual world-class organisations, as well as with the average of all organisations publishing in the climate science field. These organisations should be agreed with Defra and MoD. A metric based on numbers of publications in certain prestigious journals, such as Science and Nature, could also be used and would have a shorter timelag than a citations-based measure, which is usually 5-7 years behind the current work. It should be noted that citations measures could potentially incentivise unwanted behaviours.

37. We would recommend that any measure of staff turnover used as a metric in the contract should include a minimum level (say 5%) as well as a maximum level (say 15%) to avoid stagnation of the organisation.

38. We recommend that the effectiveness of the new management arrangements for the Hadley Centre are monitored closely, as part of the contract monitoring provisions and mechanisms. The contract should allow review and revision of these arrangements if necessary, with the agreement of the client/s.

8.2.6 Action Plan

39. We recommend that an action plan is developed indicating the recommendations that are to be taken up, who will be responsible for implementing them and the date by which they should be in place.

Appendix 1: Review team members

Dr Helen Wilkinson,

Helen is a Partner in Risk Solutions, who has over 15 years experience of overseeing major consultancy and review projects. She has directed a number of high profile assignments on behalf of Defra including evaluation of foot and mouth disease control measures and review and development of a quality management standard for research, audit of management.

Eleanor Baker

Eleanor is one of Risk Solutions' most experienced consultants. During her eight year career with Risk Solutions, she has managed numerous projects, many involving large teams and multiple subcontractors, for a wide variety of clients in the public and private sector. Prior to joining Risk Solutions she worked as a researcher, developing tools and policy advice for the UK government and the EU on the impact of future transport technologies on the environment.

Tony Quigley

Tony has considerable experience with facilities mostly involving R&D, acquisition of technology or unusual risk. He is a Review Team Leader for OGC on Gateway Reviews (over 50 reviews and Healthchecks) of high-risk projects and has conducted similar reviews for other clients such as the SRA. He led peer reviews for the Atomic Weapons Establishment, reviewed work at the Central Laboratory for the Research Councils, and reviewed the high performance computing strategy for the UK Science Base. Tony has a unique blend of experience as someone responsible for delivering complex R&D programmes and also dealing with Ministers on high policy matters. He has worked at a senior level in the Cabinet Office (including chairing Cabinet Official Committees), the Ministry of Defence and in the Department of Trade and Industry. His last position in MOD carried responsibility for the scrutiny of all major defence projects and approval for those up to £400 million. This involved looking at the justification, value for money, risk, and ensuring that all procurement options were assessed. His team produced substantial savings (over £½billion in two years).

Tony Taig

Tony was one of the founding partners of Risk Solutions, and established his own consulting practice (TTAC Ltd) in 2001 to focus in particular on the interface between science and public policy. His work in New Zealand as well as the UK has made a major contribution to the use of scientific advice on large-scale natural hazards risks in the face of uncertainty. Of particular relevance to this review has been Tony's work with Defra, first to review the development and use of scientific advice in policy across

the whole of Defra, and more recently as one of the architects of Defra's new Evidence and Innovation Strategy and the process which developed it.

W T Hewitt

Terry is an international figure in supercomputing and is currently Director of Research Computing at the University of Manchester, leading the research support activity of Manchester Computing and provides strategic leadership of the research computing services at the University. His service role has been complemented by a diverse research and development programme that he has led, receiving funding from EPSRC, NERC, ESRC, DTI, EU and international companies. He is a Fellow of the Institute of Mathematics and its Applications, Chartered Mathematician and Chartered Scientist. He has been Chairman of an International Standards Working Group, Chairman of the European Association for Computer Graphics, and has lectured extensively throughout the world.

Andrew Jones

Andrew has over 10 years of experience of scientific research using supercomputing, with expertise in the challenges and application of supercomputing to scientific research, including technical, cultural and business issues associated with applying this successfully to real world problems. Andrew's career has spanned being an end-user, technical/CSE support, buyer and manager of supercomputing facilities, and has gained and applied this experience through work at academic, industry and government organisations.

In his current role at Manchester Computing Andrew is responsible for strategic developments in supercomputing and related activities. This includes developing the strategy for supporting computational based research (including supercomputing); developing relationships with other national and international centres using supercomputing, and with major supercomputing vendors; ensuring the supercomputing services and research programmes evolve and innovate in response to changing user needs and external technology/business changes; and acting as the lead for the outreach and promotion activities associated with the supercomputing services and research.

Zoe Chaplin

Zoe Chaplin has over 8 years experience of the UM on a variety of (supercomputing) platforms and for a number of different versions. She also has experience of performance optimisation and parallelisation of other scientific codes as well as application support for a variety of codes. Following her degree in Mathematics from the University of Bristol and a Masters in Fluid Dynamics from Cranfield University, Zoe worked in the New Dynamics and later UM Systems groups at the UK Met Office, developing a new dynamical core for the Unified Model (UM), with specific responsibility for the mesoscale model covering the UK and the implementation of the boundary conditions required to run this configuration and later implementing changes to the UM for new releases of the model.

Appendix 2: Stakeholders Engaged

The stakeholders engaged in the study fall into the following categories:

- Expert Panel members
- Peer reviewers
- Collaborators
- Benchmark organisations
- Customers
- Broader stakeholders:
  - Government departments
  - Government agencies
  - Academic community
  - Journalists

Expert Panel Members

All the Expert Panel members took part in a 2-day meeting at the Hadley Centre, Exeter, 20-21 December 2006.

Dr Sylvie Joussaume	*CNRS, IPSL/Laboratoire des Science de Climat et de l'Environnement, Gif sur Yvette, France*
Prof Dr Manfred Lange	*Institute for Geophysics and Centre for Environmental Research (ZUFO), University of Muenster, Germany*
Prof Hervé Le Treut	*Laboratoire de Météorologie Dynamique du CNRS, France*
Dr Ben Santer	*Program for Climate Model Diagnosis and Intercomparison, Lawrence Livermore National Laboratory, USA*
Prof Tony Slingo	*Environmental Systems Science Centre, University of Reading, UK*
Dr Susan Solomon	*NOAA Earth System Research Laboratory, Boulder, CO 80305 USA and co-chair IPCC WG1*
Tony Taig	*TTAC Ltd*

Peer Reviewers

The peer reviewers were provided with a list of papers to consider, and given a questionnaire to answer.

Dr Sandrine Bony	*LMD/IPSL, CNRS*
Dr Ken Caldeira	*Carnegie Institution, Dept. of Global Ecology*
Dr John Church	*CSIRO Marine and Atmospheric Research and Antarctic Climate and Ecosystems Cooperative Research Centre*
Dr Martin Heimann	*Max-Planck-Gesellschaft zur Förderung der Wissenschaften e.V., Institut für Biogeochemie*
Dr Thomas Knutson	*GFDL/NOAA*
Dr Thomas C Peterson	*NOAA's National Climatic Data Center*
Prof. Julia Slingo	*National Centre for Atmospheric Science; Walker Institute for Climate System Research*
Dr Ronald J Stouffer	*GFDL/NOAA*
Dr Karl E Taylor	*Program for Climate Model Diagnosis and Intercomparison, Lawrence Livermore National Laboratory*
Dr Claudia Tebaldi	*NCAR*

Collaborators

The collaborators were given a questionnaire to answer about their experiences of collaborating with the Hadley Centre on a specific project, selected at random from a list of all collaborations provided by Hadley.

Lisa Alexander	*Monash University*
Dr Seita Emori	*Center for Global Environmental Research (CGER), National Institute for Environmental Studies (NIES)*
Professor Lin Erda	*Institue of Environment and Sustainable Development in Agriculture (IEDA), Chinese Academy of Agricultural Sciences (CAAS)*
Dr Pierre Friedlingstein	*IPSL /LSCE*
Professor Gabriele Hegerl	*Duke University*
Dr Kevin Hodges	*Environmental Systems Science Centre, University of Reading*
Professor Ian Jolliffe	*Retired*

Professor Phil Jones	*Climatic Research Unit, UEA*
Dr Elizabeth Kent	*National Oceanography Centre, Southampton*
Dr Warwick Norton	*Walker Institute, University of Reading*
Dr Kamal Puri	*Australian Bureau of Meteorology*
Dr Rowan Sutton	*Walker Insitute; NCAS-Climate, University of Reading*
Professor Tuomi	*Imperial College*
Dr Russell S Vose	*National Climatic Data Center*
Dr Bruce A Wielicki	*NASA Langley Research Center*
Dr Zhou Tianjun	*State Key Laboratory of Numerical Modelling for Atmospheric Sciences and Geophysical Fluid Dynamics (LASG), Institute of Atmospheric Physics (IAP),Chinese Academy of Sciences*

Benchmark Organisations

The benchmark organistions were given a questionnaire to answer about their own organisation and a separate Supercomputing information request developed by the University of Manchester.

Climate Prediction Center, NOAA, US

Laboratoire de Météorologie Dynamique du CNRS, France

The Earth Simulator Centre, Japan

Customers

All customers were interviewed face-to-face.

Prof Sir Howard Dalton	*Chief Scientist, Defra*
Henry Derwent	*Director of Climate and Energy, Defra*
Dr Cathy Johnson	*CESA, Defra*
Dr Cinzia Losenno	*CESA, Defra*
Dr Chris Sear	*CESA, Defra*
Bill Stow	*Director General, Environment, Defra*
David Warrilow	*Head of CESA, Defra*

Prof Sir Roy Anderson	*Chief Scientist, MoD*
Dr Bruce A Callander	*Group Director (Information Superiority), Science, Innovation, Technology, MoD*
Dominic Wilson	*Director, Policy Planning, MoD*

Other Government Department Stakeholders

All stakeholders were interviewed face-to-face with the exception of those indicated with an asterisk (*) who were interviewed by telephone.

Keith Binfield	*Nuclear Pollution Inspectorate, Defra*
Dr Ian Davidson	*Environmental Science, Technology & EU, Defra*
Chris Dodwell	*Head of International Climate Change and Ozone, Defra*
Beth Greenaway	*Marine Environment Science Unit, Defra*
Sarah Hendry	*Livestock Division, Defra*
Paul Kiteley	*Procurement & Contracts, Defra*
Prof Paul Leonard	*Marine Environment Science Unit, Defra*
Diana Linskey	*Head, Marine Environment Science Unit, Defra*
Ralph Palmer	*R & D Contracts, Defra*
David Richardson	*Flood Management, Defra*
Andy Shaw	*Science Strategy – Earth Observation, Defra*
Dr Martin Williams	*Head, Air & Environment Quality, Defra*
Mark Ronald	*MoD*
Wing Commander Greg Underhill	*MoD*
Fergus Auld	*FCO*
Tom Burke	*FCO*

Government Agency Stakeholders

All stakeholders were interviewed face-to-face with the exception of those indicated with an asterisk (*) who were interviewed by telephone.

Anna Stainer *	*Science Team, UKCIP*

Roger Street *	*Technical Director, UKCIP*
Chris West	*Director, UKCIP*
Richard Westaway *	*Science Team, UKCIP*
Andy Deacon	*GLA*
Jonathan Brearley	*Office for Climate Change*
Tim Reeder	*Environment Agency*

Academic Community Stakeholders

All stakeholders were interviewed face-to-face with the exception of those indicated with an asterisk (*) who were interviewed by telephone.

Professor John Harries *	*Chairman SRG* *Space & Atmospheric Physics, Imperial College; Hadley Centre Science Review Group*
Professor Stephen Mobbs	*Director, NCAS; University of Leeds*
Professor Mike Hulme *	*Director, Tyndall Centre; University of East Anglia*
Professor Alan J Thorpe	*Chief Executive, NERC*

Journalists

All stakeholders were interviewed face-to-face with the exception of those indicated with an asterisk (*) who were interviewed by telephone.

Ian Sample *	*The Guardian*
David Shukman *	*BBC*
Mike McCarthy *	*The Independent*
Fiona Harvey *	*Financial Times*
Mark Henderson *	*The Times*

Appendix 3: Met Office Staff Engaged

We engaged with a large number of staff from the Hadley Centre, at a staff workshop, in face-to-face interviews with all the senior staff and also through face-to-face discussions with a large number of Hadley staff involved in collaborations. These individuals are listed below.

Workshop Attendees

Dr Helene Banks	*Oceans and climate*
Dr Alejandro Bodas-Salcedo	*Understanding Climate Change*
Ben Booth	*Climate Prediction*
Dr Philip Brohan	*Understanding Climate Change*
Dr John Caesar	*Climate variability*
Dr Robin Clark	*Climate Prediction*
Dr Bill Collins	*Climate, chemistry and Ecosystems*
Dr Mat Collins	*Climate Prediction*
Dr Richard Graham	*Oceans and climate*
Dr Jim Gunson	*Oceans and climate*
Dr Glen Harris	*Climate Prediction*
Dr David Hassell	*Climate Prediction*
Dr Debbie Hemming	*Climate, chemistry and Ecosystems*
Dr Chris Hewitt	*ENSEMBLES*
Dr Chris Jones	*Climate, chemistry and Ecosystems*
Dr Gareth Jones	*Understanding Climate change*
Dr Richard Jones	*Climate Prediction*
Dr Manoj Joshi	*Understanding Climate change*
Ann Keen	*Ocean and climate*
John Kennedy	*Climate variability*
Dr Jason Lowe	*Understanding climate change*
Matthew Palmer	*Climate Variability*
David Parker	*Climate Variability*
Dr Jeff Ridley	*Understanding Climate change*

Dr Mark Ringer	*Understanding Climate change*
Michael Saunby	*IT Applications*
Dr David Sexton	*Climate Prediction*
Dr Peter Stott	*Understanding Climate change*
Holly Titchner	*Climate Variability*
Dr Michael Vellinga	*Oceans and Climate*
Dr Keith Williams	*Understanding Climate Change*

Collaboration Interviewees

The following Hadley Centre staff were interviewed about their experiences of collaboration – the collaborators they work with were invited to answer a questionnaire about the collaboration.

Dr Rob Allan

Dr Alberto Arribas

Dr Helene Banks

Dr Simon Brown

Dr John Caesar

Dr Mark McCarthy

Dr Ruth McDonald

David Parker

Dr Mark Ringer

Dr Adam Scaife

Dr Cath Senior

Dr Peter Stott

Other Met Office/ Hadley Centre Interviewees

Dr Olivier Boucher	*Climate, Chemistry & Ecosystems, Hadley Centre*
Dr Chris Folland	*Climate Variability, Hadley Centre*
Dr Chris Gordon	*Head of Climate Research, Hadley Centre*
Dr Jonathan Gregory	*Understanding Climate Change, Hadley Centre (Reading)*
Dr David Griggs	*Head of Government Business, Met Office*

Mark Hutchinson	*Chief Executive, Met Office*
Dr John Mitchell	*Chief Scientist, Met Office; Head of Climate Science, Met Office*
Dr James Murphy	*Predicting Climate Change, Hadley Centre*
Dr Vicky Pope	*Head of the Climate Prediction Programme, Hadley Centre*
Derrick Ryall	*Head, Government Meterological Research, Met Office*
Dr Cath Senior	*Understanding Climate Change, Hadley Centre*
Dr Stephen Sitch	*Climate, Chemistry & Ecosystems, Hadley Centre (Wallingford)*
Fiona Smith	*Communications, Hadley Centre*
Terry Warner	*Divisional Accountant*
Dr Richard Wood	*Oceans & Climate, Hadley Centre*

Appendix 4: Peer Reviewed Papers

The following papers, already published in peer reviewed journals, were re-examined by the peer reviewers of this study. The papers were selected at random from sets of papers in each main area chosen by the Hadley Centre to represent their most influential work, and that had been published from 2004 onwards, so representing the more recent period of work. Authors working at the Hadley Centre at the time of publication are highlighted in **bold**.

Alexander, L., Tett, S. and Jonsson, T., 2005a: Recent observed changes in severe storms over the United Kingdom and Iceland. *Geophys. Res. Lett.*, 32, L13704. doi:10.1029/2005GL022371.

Banks, H. T. and J. M. Gregory (2006) Mechanisms of ocean heat uptake in a coupled climate model and the implications for tracer based predictions of ocean heat uptake, Geophys. Res. Lett., 33, L076208, doi:10.1029/2005GL025352, 2006.

Barnett D.N., S.J. Brown, J.M. Murphy, D.M.H. Sexton, M.J. Webb (2006) Quantifying uncertainty in changes in extreme event frequency in reponse to doubled CO_2 using a large ensemble of GCM simulations. Climate Dynamics 26, 489-511. Suggested reviewers: Jerry Meehl, Francis Zwiers, Claudia Tebaldi.

Betts, R.A, Cox P.M, Collins M, Harris, P.P., Huntingford, C. and **Jones, C.D.,** 2004: The role of ecosystem-atmosphere interactions in simulated Amazonian precipitation decrease and forest dieback under global climate warming. *Theoretical and Applied Climatology* **78**(1-3): 157-175

Clark R., S.J. Brown, J.M. Murphy (2006) Modelling northern hemisphere summer heat extremes using a physics ensemble of climate sensitivity experiments. J. Climate, 19, 4418-4435. Suggested reviewers: Jerry Meehl, Francis Zwiers, Claudia Tebaldi.

Folland, C.K., 2005: Assessing bias corrections in historical sea surface temperature using a climate model. *Int. J. Climatol.*. (Special issue, CLIMAR II Conference), **25**, 895 - 911.

Gedney, N., Cox, P. M., **Betts, R. A., Boucher, O.,** Huntingford, C. and **Stott, P.,** 2006: Detection of a direct carbon dioxide effect in continental river runoff records. *Nature*, 439, 835-838, doi:10.1038/nature04504.

P A Good, J A Lowe, 2006. Emergent behaviour and uncertainty inmulti-model climate projections of precipitation trends at small spatial scales. Accepted in J. Climate

Graham, R., M. Gordon, P.J. McLean, S. Ineson, M.R. Huddleston, M.K. Davey, A. Brookshaw, R.T.H. Barnes(2005) A performance comparison of coupled and uncoupled versions of the Met Office seasonal prediction general circulation model. Tellus, 57A, 320-339.

Gregory, J. M. and **Ingram, W. J.** and Palmer, M. A. and **Jones, G. S. and Stott, P. A.** and **Thorpe, R. B.** and **Lowe, J. A. and Johns, T. C. and Williams, K. D,** A new method for diagnosing radiative forcing and climate sensitivity, Geophys. Res. Lett., 2004, 31, L03205, doi = 10.1029/2003gl018747

J. M. Gregory and P. Huybrechts and S. C. B. Raper, Threatened loss of the Greenland ice-sheet, Nature, 2004, 428, 616

J. M. Gregory and K. W. Dixon and R. J. Stouffer and A. J. Weaver and E. Driesschaert and M. Eby and T. Fichefet and H. Hasumi and A. Hu and J. H. Jungclaus and I. V. Kamenkovich and A. Levermann and M. Montoya and S. Murakami and S. Nawrath and A. Oka and A. P. Sokolov and R. B. Thorpe, A model intercomparison of changes in the Atlantic thermohaline circulation in response to increasing atmospheric CO2 concentration, Geophys. Res. Lett., 2005, 32, L12703, doi = 10.1029/2005GL023209

Harris G.R., Sexton D.M.H. , Booth B.B.B., Collins M., Murphy J.M., Webb M.J. (2006) Frequency distributions of transient regional climate change from perturbed physics ensembles of general circulation model simulations. Climate Dynamics, 27 (4): 357-375. Suggested reviewers: Ben Santer, Claudia Tebaldi, Jerry Meehl.

T.C. Johns, C.F. Durman, H.T. Banks, M.J. Roberts, A.J. McLaren, J.K.Ridley, C.A. Senior, K.D. Williams, A. Jones, G.J. Rickard, S. Cusack,W.J. Ingram, M. Crucifix, D.M.H. Sexon, M.M. Joshi, B-W. Dong, H. Spencer, R.S.R. Hill, J.M. Gregory, A.B. Keen, A.K. Pardaens, J.A. Lowe, A. Bodas-Salcedo, S. Stark, and Y. Searl, 2006. "The new Hadley Centre climate model HadGEM1: Evaluation of coupled simulations". Journal of Climate, 19, 1327-1353.

Jones, G. S., Gregory, J. M., Stott, P. A., Tett, S. F. B. and **Thorpe, R. B.,** 2005d: An AOGCM simulation of the climate response to a volcanic super-eruption. *Clim. Dyn.*, 25(7-8), 725-738. doi:10.1007/s00382-005-0066-8.

Martin, G.M., M. A. Ringer, V. D. Pope, A. Jones, C. Dearden and T. J.Hinton 2006. The physical properties of the atmosphere in the new Hadley Centre Global Environment Model, HadGEM1. Part I: Model description and global climatology J. Climate, 19, 1274-1301

McDonald R.E., Bleaken D.G., Cresswell D.R., Pope V.D., Senior C.A. (2005) Tropical storms: Representation and diagnosis in climate models and the impacts of climate change. Climate Dynamics, 25, 19-36.

Murphy J.M., Sexton D.M.H., Barnett D.N., Jones G.S., Webb M.J., Collins M., Stainforth D.A. (2004): Quantification of modelling uncertainties in a large ensemble of climate change simulations. Nature, 430, 768-772.

Murphy J.M., Sexton D.M.H., Barnett D.N., Jones G.S., Webb M.J., Collins M., Stainforth D.A. (2004): Quantification of modelling uncertainties in a large ensemble of climate change simulations. Nature, 430, 768-772.

Parker, D.E. and **Horton, E.B.,** 2005: Uncertainties in the Central England Temperature series 1878-2003 and some improvements to the maximum and minimum series. *Int. J. Climatol. ,* **25,** 1173-1188.

Rayner, N.A., Brohan, P., Parker, D.E, Folland, C.K., Kennedy, J.J., Vanicek, M., Ansell, T. and Tett, S.F.B., 2006: Improved analyses of changes and uncertainties in sea surface temperature measured *in situ* since the mid-nineteenth century: the HadSST2 data set. *J. Climate,* **19,** 446-469.

Ridley, J. and Huybrechts, P. and **Gregory, J. M. and Lowe, J. A.**, Elimination of the Greenland ice sheet in a high CO2 climate, J. Climate, 2005, 18, 3409-3427

Ringer, M.A., G.M. Martin, C.Z. Greeves, T.J. Hinton, P.M. James, V.D.Pope, A.A. Scaife, R.A. Stratton, P.M. Inness, J.M. Slingo and G.-Y.Yang, 2006. The physical properties of the atmosphere in the new Hadley Centre Global Environment Model, HadGEM1. Part II: Aspects of variability and regional climate. J. Climate, 19, 1302-1326

Roberts, M.J., H. Banks, N.Gedney, R. Hill, S. Mullerworth, A. Pardaens, R. Thorpe, R. Wood and G. Rickard (2004) Impact of an eddy-permitting ocean resolution on control and climate change simulations with a global coupled GCM. *J. Climate* **17**, 3-20.

Santer B.D, Wigley T.M.L., Mears C., Wentz F.J., Klein S.A., Seidel D.J., Taylor K.E., **Thorne P.W.**, Wehner M.F., Gleckler P.J., Boyle J.S., Collins W.D., Dixon K.W., Doutriaux C., Free M., Fu Q., Hansen J.E., **Jones G.S.**, Ruedy R., Karl T.R., Lanzante J.R., Meehl G.A., Ramaswamy V., Russell G., Schmidt G.A., 2005: Amplification of surface temperature trends and variability in the tropical atmosphere. *Science* **309** 1551-1556

Stainforth, D. A., T. Aina, C. Christensen, **M. Collins,** N. Faull, D. J. Frame, **J. A. Kettleborough**, S. Knight, A. Martin, **J. M. Murphy,** C. Piani, **D. Sexton**, L. A. Smith, R. A. Spicer, A. J. Thorpe, M. R. Allen (2005) Uncertainty in predictions of the climate response to rising levels of greenhouse gases. Nature, 433, 403-406.

Stainforth, D. A., T. Aina, C. Christensen, **M. Collins,** N. Faull, D. J. Frame, **J. A. Kettleborough**, S. Knight, A. Martin, **J. M. Murphy,** C. Piani, **D. Sexton**, L. A. Smith, R. A. Spicer, A. J. Thorpe, M. R. Allen (2005) Uncertainty in predictions of the climate response to rising levels of greenhouse gases. Nature, 433, 403-406.

Stark, S., R. A. Wood and H. T. Banks (2006) Can anthropogenic climate change be detected in Indian Ocean water masses?, J. Climate, Vol. 19, No. 16, pages 4075–4086.

P.A. Stott, G.S. Jones, J.A. Lowe, T.C. Johns, P.W. Thorne, and C.F.Durman, 2006. "Transient simulations with the HadGEM1 climate model: causes of past warming and future climate change". Journal of Climate,19, 2763-2782.

Stott, P. A., Kettleborough, J. A., Allen, M. R., 2006, Uncertainty in predictions of continental scale temperature rise. GRL, 33,doi:10.1029/GL024423.)

Stott, P. A., Stone, D. A., Allen, M. R., 2004. Human contribution to the European

heatwave of 2003. Nature, 432, 610-614.

Thorne, P.W., Parker, D. E., Tett, S. F. B., Jones, P. D., **McCarthy, M., Coleman, H. and Brohan, P**, 2005b: Revisiting radiosonde upper-air temperatures from 1958 to 2002. *J. Geophys. Res. (Atmospheres),* **110**, D18105, doi:10.1029/2004JD005753.

Webb, M. J. , C. A. Senior, K. D. Williams, M. D. H. Sexton, M. A. Ringer, B. J. McAvaney, R. Colman, B. J. Soden, N. G. Andronova, S. Emori, Y. Tsushima, T. Ogura, I. Musat, S. Bony, and K. Taylor (2006) On uncertainty in feedback mechanisms controlling climate sensitivity in two GCM ensembles. Climate Dynamics, 27 (1): 17-38.

Wood, R., Collins, M., Gregory, J., Harris, G. and **Vellinga, M.,** 2006: Towards a risk assessment for shutdown of the Atlantic thermohaline circulation. In: Schellnhuber, H.J., Cramer, W., Nakicenovic, N., Wigley, T. and Yohe, G. (eds.) *Avoiding Dangerous Climate Change* (Cambridge University Press), Chapter 6, 49-54.

Wu, P., R.Wood and P. Stott (2004) Does the recent freshening trend in the North Atlantic indicate a weakening thermohaline circulation? *Geophys. Res. Lett.,* **31**, L02204

Appendix 5: Hadley Centre Expert Panel Review 2006

Conclusions of the Expert Panel Meeting, Exeter, 20-21 December 2006

Summary

Risk Solutions and the University of Manchester (UoM) are reviewing all aspects of the Hadley Centre on behalf of the UK Department for the Environment, Food and Rural Affairs (Defra) and the Ministry of Defence (MoD). As part of this review, an international Expert Panel was convened to take an overview of the quality of the science at Hadley and of the fitness for future needs of the environment in which that science is carried out, and to comment on the emerging findings of the Risk Solutions/UoM review.

The panel members were

Dr Sylvie Joussaume	*CNRS, IPSL/Laboratoire des Science de Climat et de l'Environnement, Gif sur Yvette, France*
Prof Dr Manfred Lange	*Institute for Geophysics and Centre for Environmental Research (ZUFO), University of Muenster, Germany*
Prof Hervé Le Treut	*Laboratoire de Météorologie Dynamique du CNRS, France*
Dr Ben Santer	*Program for Climate Model Diagnosis and Intercomparison, Lawrence Livermore National Laboratory, USA*
Prof Tony Slingo	*Environmental Systems Science Centre, University of Reading, UK*
Dr Susan Solomon	*NOAA Earth System Research Laboratory, Boulder, CO 80305 USA and co-chair IPCC WG1*

The panel was chaired independently by Tony Taig. The panel review process involved

- short closed sessions to discuss the agenda and panel process
- longer open sessions with the review team and Hadley/Met Office staff, and
- a final session with the Risk Solutions/UoM review team to discuss the two-day review and develop the panel's conclusions.

The panel chairman will participate in the development of the review team report to ensure that the Panel's views are properly reflected and given due weight in that report, though the opinions in that final report will be those of the Review Team, which may not necessarily coincide in all respects with those of the Panel.

The Panel's conclusions were, in summary

1. Hadley's work and people are acclaimed globally as leading edge
2. Future needs for policy-relevant information have been well identified but without significant increases in planned funding and resources those needs cannot be met
3. Hadley's science strategy and modelling approach are excellent, bold, and appropriately ambitious, though could be better presented, and
4. There are significant risks to the sustaining and developing of Hadley's capability, which Hadley, the Met Office and government need to address.

These conclusions and their basis are expanded on in the following sections of this note.

1. On the Value of the Hadley Centre

The Hadley Centre is recognised by all the Panellists, and in the view of the Panel by the climate change community worldwide, as having made a unique and outstanding contribution to climate science and current knowledge. The particular qualities of Hadley for which it is most highly valued (not in priority order) are

a) Its **modelling capability**, which is at the leading edge in terms of ability to assimilate the many aspects of climate science, combine them into predictions, explore uncertainties and translate the outputs into policy advice

b) Its **observational analysis capability**, which is among the best in the world; the linkage of observational and modelling capability within Hadley greatly adds value to each

c) Its linkage to the Met Office **National Weather Programme**, which provides major synergies from the support of core science capability through to the unified model approach,

d) Its **stability**; continuity of staff and funding have enabled Hadley to develop amd sustain longer-term research plans. and

e) Its **world class scientists**, who are able to engage effectively with the scientific community worldwide and thus to ensure that leading edge science can be brought to bear in Hadley's work, both on their own and expanded through appropriate collaborations.

There are perhaps one or two other organisations in the world that might be argued to have made similar scale contributions to some of the specific aspects of climate science in the past 15 years, but there is no other organization in the world that has done as much across the breadth of modelling, detection/attribution, and observational analysis. Thus **it is beyond dispute that Hadley occupies a position at the pinnacle of world climate science, and in translating that science into valuable policy advice**.

2. On Future Customer Needs and Requirements of Hadley

The Panel welcomed many aspects of the work that has been done to clarify future customer needs of Hadley for information, including the increasing clarification by

Defra and Mod of their policy needs and of the science outputs required to support those needs.

On the other hand, the Panel was deeply concerned to hear of sentiments within UK Government that might threaten Hadley's core science funding, and that a growing role for Hadley in coordinating "impacts" work might be at the expense of current observational analysis, detection/attribution, modelling or prediction workstreams.

At the root of the Panel's unease in this respect was their concern that Hadley's climate change work and its excellence and continuing potential and value may not be fully recognised by those who determine Defra's and MoD's funding in this area. The Panel was deeply concerned to hear of sentiments in parts of UK government that, given there is now widespread acceptance that climate change is happening, the importance of research on the physical science of climate is now less, and the agenda should "move on" to impacts, adaptation, and mitigation. **The Panel did not view this as scientifically credible**.

While the Panel recognised the importance of enhancing current knowledge relevant to impacts and adaptation and the need to boost investment in these areas, the logical response to the acceptance that warming is happening should also be to INCREASE the value of (and investment in) broader climate change research. This is because, once it is accepted that climate change is happening and that its impacts will be large, the reduction of uncertainty surrounding the future climate becomes more critically important in informing any assessments of impacts and/or adaptation strategies. The Panel therefore regarded it as being of fundamental importance to sustain and if anything increase the resources available for climate change research.

The Panel further concluded that a key way for such investment to be channelled was through sustained or enhanced investment in a coherent programme with large-scale and long-term goals via an organisation with proven ability to meet deadlines and requirements. **Hadley is the only such organisation that could credibly provide such support to UK government**. In the Panel's view this approach is now well proven to be essential along with different approaches in which a portion of national funding is parcelled into numerous smaller pieces that are then competitively tendered.

3. On the Hadley Centre Science Strategy

The Panel endorsed the science strategy presented by Hadley staff, in particular Hadley's commitment to maintaining a centre of excellence in modelling, prediction and uncertainty evaluation, while strengthening collaborations to enable their predictive capability to take advantage of the best science emerging worldwide. The Panel noted that the quality of the presentations and discussion were significantly higher than that of the written strategy documents provided in advance.

The Panel noted that an excellent job had been done by Hadley in responding to previous reviews. Collaborations, including for example those with the UK modelling community and with European ocean modelling, had been further extended and enhanced. The Panel expressed some concern that, in view of the substantial resources required to build effective collaborations, Hadley should focus its collaborative efforts in areas where there are real benefits to be gained for their work

or for the wider climate science community. The PRECIS project for example, while excellent and effective, should logically receive targeted support for such international outreach from appropriate funding bodies. If future support (e.g., from the Foreign Office) is not forthcoming then this activity should not take up resources required for core science activities.

The Panel also supported Hadley's modelling approach, with the more pragmatic HadGEM-2 model focused on critical policy outputs in the short to medium term, and the parallel HadGEM-3 model being developed to take advantage of more state-of-the-art scientific models for parts of the earth system. The Panel considered that Hadley had the resources in its people to deliver this strategy, but would need computing resources beyond those currently planned to deliver it in full, as discussed in Section 4 below.

The Panel deliberated on the wisdom of extending Hadley's scope to include a greater role in the coordination of climate change impacts work. On the one hand, the Panel shared Defra's recognition of the need in this area, and of the value of introducing a substantial, coherent programme led by a respected organisation with a strong track record – for which Hadley is a uniquely well-qualified UK candidate with an unparalleled track record in the Panel's view. Opening up to new communities could have many benefits. On the other hand, the Panel was concerned that opening up new ambitions on the "impacts" front should not detract from the resources that are needed to maintain other work. Indeed, improved physical modelling and detection/attribution studies including boundary/initial conditions and smaller scales are essential underpinning for such an effort.

It was not considered that any of the current areas of work were weak, nor that they could be cut significantly without severe loss to international and UK science and essential input to policy advice.

In light of these considerations, the Panel concluded that

a) Defra and MoD should recognise that any extension of Hadley's scope of work (for example into climate change impacts) must involve additional resources, and should not be at the expense of the areas where Hadley is already at the leading edge (earth observation analysis, climate modelling, detection/attribution and the supporting science), and where the value of further advances is extremely high in relation to the costs of such work, and

b) Hadley and the Met Office should seek low-risk opportunities to begin entry into new areas such as climate change impacts work (e.g. should short-term budget opportunities arise, they might engage high calibre temporary or consulting staff to help scope out what needs to be done on this challenging problem, formulate a programme and start building relevant capability and capacity within Hadley).

4. On Sustaining and Developing Hadley's Capability

The Panel considered it fundamental to Hadley's future success that they should be able to attract, retain and motivate people of equivalent calibre to their current staff,

and that they should have access to appropriate resources such as computer capability and capacity. In the Panel's opinion there are significant risks to these fundamentals.

The Panel agreed with the interim finding of the UoM reviewers that Hadley, even with the proposed Met Office investment in a new supercomputer in 2008, was falling behind and would continue to fall further behind other climate research organisations in computing resources. While in the short term Hadley would be able to retain their position and reputation because of the excellence of their staff, their leadership position could not be sustained longer term without computing capability and capacity comparable with those of their peers overseas.

To deliver the science strategy that Hadley proposes and the Panel endorses, the Panel agreed that both a higher specification new supercomputer, and appropriate computational support capability, would be needed. Hadley does not need to be ahead of the rest of the world in computational resources, but it needs to be comparable.

As regards the people and working environment at Hadley, the Panel was particularly concerned about threats to core science at Hadley, and to the working environment for Hadley staff, as it and the Met Office change and develop[16]. The ability to combine excellence in the underlying science with policy-focused applied work has been fundamental to Hadley's success in the view of the Panel. While endorsing Hadley's strategy increasingly to collaborate with others so as to maintain leading edge science input to its work, the Panel considered that such a collaborative approach could only be effective while Hadley maintained its own scientific excellence and key staff. The Panel was therefore concerned that funding for core science appears to be under particular threat, in being squeezed

a) by the expansion of policy interest in climate change and thus of new types of outputs sought by Defra and MoD

b) by the threat to climate science funding if there were to be government sentiments that the agenda could "move on" to impacts and adaptation and

c) by cuts to the much larger Met Office National Weather Programme, which has always supported a great deal of the fundamental science base within the Met Office on which Hadley relies.

The Panel formed the impression that Hadley and the Met Office are at something of a watershed, which may have important future implications for their culture and working environment. Of particular relevance here are

a) the increasing focus on commercial exploitation of the Met Office's and Hadley's capabilities, and

b) the strengthening of the Met Office corporate branding of Hadley.

The Panel recognises that both of these issues involve opportunities as well as threats, and the second has been significantly mitigated by the current plan to establish John

[16] The Panel were also made aware of concerns that pay at Hadley and the Met Office generally is slipping behind that available for "comparable" work in academia. We did not have the evidence against which to test this claim and recommend that Risk Solutions should explore this farther in their review.

Mitchell in a new role as Director of Climate Science with particular responsibility for Hadley. Similarly, the growth of commercial business will create new opportunities for the many staff at Hadley who derive as much satisfaction from seeing their work applied to make a difference in the world as from advancing science. The source of the Panel's concerns is that what Hadley has is very precious, has taken a great deal of effort to build, and could be relatively quickly undermined. Many other organisations attempting to commercialise their scientific excellence and rebrand themselves have suffered as a result, and the Panel are keen that Hadley and the Met Office should not follow them. The Panel has too much respect for the Hadley and Met Office management to recommend that they backtrack on change to adapt to circumstances, but do recommend that particular efforts are warranted to safeguard against unintended effects of these changes.

Underpinning many of the Panel's concerns for the future of Hadley was the surprise with which Panellists learnt of the possible mismatch between what the Panel see as the value of both Hadley's and the Met Office's work, the recognised value and success of UK climate science at the ministerial and indeed prime-ministerial levels, and the existence of government sentiments that the policy agenda should "move on" from climate science to impacts and adaptation (with the associated threats to Hadley's climate science funding).

To the Panel, the business case for sustained and indeed increased national investment in climate and weather prediction is overwhelming. This is not a case of others from outside the UK advocating that UK taxpayers' money should be spent for the benefit of the rest of the world. The costs to the UK of adapting its basic infrastructure – water, flood and coastal defences, energy, transport, communications – to climate change could run to many hundreds of billions. Without better information on future climate and climatic extremes, the UK is likely either to lose or to waste many billions per year through under- or over-investment in adaptation. Climate and extreme climatic events top any rational list of risks to the UK in terms of their likelihood and impact.

It would be easy to place the blame for mismatched perceptions as to the value of Hadley's work at the door of government, and the Panel has indeed recommended that government (through Defra and MoD) should be sustaining or increasing Hadley's funding.

The Panel also considered, though, that Hadley and the Met Office could articulate the benefits of their work and of their proposals for the future more clearly. The Panel noted that the current written version of the science strategy document did not do justice to the strategy as explained by the managers involved. By and large the Panel have the greatest of respect and admiration for all that the Met Office and Hadley have achieved, and are wary of making recommendations as to how they go about their business. The one area in which the Panel would wish to recommend change is that Hadley and the Met Office need to "raise their game" in articulating the benefits of what they do to their core government customers, and in securing the investment that their work deserves.

Tony Taig, Panel Chairman, 31 January 2007

Appendix 6: Summary of key achievements

During the period covered by this review The Hadley Centre has made significant progress in all the key areas of its research. These are briefly summarised below.

Input to the IPCC process

The Hadley Centre has also contributed significantly to the IPCC process. As well as the input of its scientific findings and supplying lead authors for various chapters of the IPCC Assessment Reports, during the first part of the review period the Hadley Centre continued in its role of hosting the IPCC TSU for Working Group I, which at that time was jointly chaired by Sir John Houghton. Since the chairmanship of the Working Groups changed in 2002 this role ceased, but Hadley now hosts the TSU for Working Group II.

Monitoring Climate Variability and Change

The observational datasets developed at the Hadley Centre are critical to understanding natural climate variability and for detection and attribution of climate changes to human actions, and to testing the performance of climate models over time. The datasets have been widely used in IPCC AR4. Datasets on sea-ice, sea surface temperatures and land surface temperatures have been improved and updated with novel assessments of biases and uncertainties in the data measured historically using a number of different techniques and tools (including satellites), to create longer consistent datasets. A new blended global surface temperature dataset has been created, extending back to 1850. New observational dataset of sub-surface ocean temperature and salinity have been developed, based on observations from tools such as the argofloats.

Building Capacity and Reducing Uncertainty

The major models that the Hadley Centre develops and uses are its key tool for exploring the future climate and uncertainties. The HadCM3 model has been extremely successful and very influential worldwide. Hadley has now produced a new model, HadGEM1, which represents a major step in incorporating more complex details of the physical processes that determine climate. It includes better representation of physical processes, better coupling between physics and dynamics and increased horizontal and vertical resolution. These developments have led to significantly more realistic simulations of many processes.

The plan is to build new processes, such as an interactive carbon cycle and atmospheric chemistry, as modules that can be incorporated into the model to create HadGEM2. Hadley has also been working with other modelling groups, such as the NERC-led project HiGEM and the UJCC project using the Earth Simulator Center in Japan, to explore the potential of increasing modelling resolution even further.

The modelling of clouds and cloud feedbacks has been significantly improved within the HadGEM1 model, which now simulates present-day cloud regimes well in comparison with other models. This is important because cloud radiative feedbacks are an important source of variability between climate models.

Simulating Past and Future Climate Change

Hadley Centre research has identified significant human influence on temperature changes on individual continental regions, rather than purely on a global basis. The HadCM3 model has been used to reproduce observed changes with all known forcings, and comparing this with the evolution of the climate without anthropogenic emissions across 16 sub-continental scale regions. The behaviour of the Greenland ice sheet has been investigated through the addition of a fully coupled, high resolution Greenland ice sheet model within HadCM3. A large number of HadCM3 model simulations have been run and the results have been made available to external scientists who have been able to carry out further and more detailed analyses and use the outputs as inputs to further downstream studies.

The newer HadGEM1 model has been used to run policy-relevant scenarios for inclusion in IPCC AR4. Model runs at a regional level have also been used to examine issues such as drought in Europe.

The PRECIS model, which is a regional climate model developed by the Hadley Centre for use on a PC has been distributed to users in developing countries to allow them to explore climate change and its impacts for their own region. Hadley Centre staff have supported this activity.

Quantifying Uncertainty in Model Predictions

The Hadley Centre has pioneered a new approach to modelling uncertainty using the 'perturbed physics' approach. They have create ensemble model runs in which physical parameters are perturbed away from their standard values and the models then used to build towards a time-dependent probability density function of climate change at large regional scales under specified scenarios. These probabilistic methods are being used to supply probabilistic predictions for the next UKCIP scenarios, UKCIP08, at a 25km scale across the UK for a range of impact-relevant variables.

Changes in Climate Extremes

Understanding how extreme weather may change as the climate changes is of crucial importance to decision making both by Government and private sector e.g. the insurance industry. The Hadley Centre has led the world in analysing observations of global weather extremes, and observed changes in extremes, and comparing these with modelled outputs. Attribution of extreme events has focused on some key variables: the warmest and coldest days and nights of the year, the start of spring, the length of the growing season and the level of drought. Anthropogenic effects have been detected in the warming of the warmest night of the year, the increase in the length of the growing season since 1950 and patterns of global drought. Hadley has also investigated the impact of the climate on storms, both on number of storms and intensity. This indicates an increase in tropical storm intensity due to climate change.

Probabilistic techniques have been used to assess the robustness of future projections of extreme events and their likelihood.

Oceans and Climate

The Hadley centre has used HadCM3 to assess the effect of climate change on the influential Atlantic thermohaline circulation (THC). A complete shutdown of the THC, considered a low probability, high impact event, would have a catastrophic effect on the UK's climate. The Hadley Centre has modelled the impact of such a shutdown and has used probabilistic techniques to estimate its likelihood. Hadley has also used its climate models to assess which observations would be most valuable in detecting changes to the THC and to ocean salinity, and has fed results into key ocean observing programmes such as Argo and the NERC RAPID programme.

The Hadley Centre has begun work on a new state-of-the-art ocean model, NEMO, developed in collaboration with the National Centre for Ocean Forecasting and European partners. This model will form a component of the HadGEM3 model, and will be used for seasonal and decadal as well as longer term climate forecasts.

Biogeochemical Cycles

The Hadley Centre has developed models of the carbon cycle and atmospheric chemistry in order to predict changes in greenhouse gases. These models are coupled to climate models, and research has shown that there are important interactions between climate change, the carbon cycle, ecosystems and atmospheric chemistry. The Hadley Centre, with IPSL, has led a major intercomparison project, C4MIP, to compare eleven coupled climate-carbon cycle models. All the models showed a positive feedback, with climate change increased by the inclusion of the carbon cycle. This emphasised the importance of including carbon cycle processes in climate change projections.

The Hadley Centre has greatly expanded its modelling of the ocean carbon cycle. This has shown that the predicted increasing levels of CO_2 dissolved in the surface ocean will significantly impact ecosystems through the acidification of the water.

The Hadley Centre has also investigated a number of feedbacks and interaction between the atmosphere composition, climate, ecosystems and aerosols.

Impacts of Climate Change

The Hadley Centre has pioneered a new approach to assessing the impacts of climate change, driven primarily by the need to incorporate key feedbacks and interactions to improve the overall climate modelling. Two main areas of focus have been terrestrial ecosystems and hydrology. For example, modelling of the Amazonian forests shows that not only does the forest respond to climate change, it plays a direct role in affecting the climate at regional levels. Forest die-back leads to loss of precipitation, which in turn leads to further loss of the forest. Model simulations show that by the end of the 21st century this feedback may lead to desertification. Hadley has also used their dynamic vegetation model to examine the impacts of reforestation on

atmospheric CO_2. Hydrological impacts have been found to be affected by the direct response of vegetation to CO_2 changes as well as by the effects of climate change.

Seasonal to Decadal Forecasting

Seasonal and decadal forecasting has traditionally been very difficult, due to the natural variability of the weather (as compared with longer term climate). The Hadley Centre has used its observational datasets to show that the North Atlantic Oscillation (NAO) can be used to predict winter weather in Europe six months ahead. Simulations have allowed Hadley to separate out the effects of the NAO from anthropogenic climate changes. The Hadley Centre is also investigating other oscillation effects that may be useful over decadal timescales, particularly the Atlantic Multidecadal Oscillation, which may also have an impact on the El Niño Southern Oscillation.

The Met Office's Long-Range Forecast group uses GloSea a version of HadCM3 adapted specifically for seasonal forecasting, with higher ocean resolution and improved ocean-atmosphere coupling. Seasonal forecasts are used by meteorological and hydrological services worldwide. The UK/ Europe winter forecast for 2005/06 received considerable publicity. A new version of the model, based on HadGEM, will be brought in over the next two years.

The Hadley Centre has also developed the world's first decadal prediction system, DePreSys, which takes account of natural variability in e.g. ENSO, THC as well as anthropogenic effects. The first experimental predictions from this system have recently been produced.

Appendix 7: Analysis of Collaborator and Peer Review Questionnaires

Collaborators' Survey

We invited 22 people to take part in a survey of the views those who are, or have recently been, involved in collaboration with the Hadley Centre. Of these 16 replied.

Collaborators were asked to provide their views in three key areas:

- What their organisation did and how it similar it was to the Hadley Centre
- The quality of collaborations with Hadley
- The quality of Hadley's scientific staff, science and outputs.

The collaborators were asked to fill in survey forms, which allowed them to provide a mixture of open-ended and semi-quantitative responses.

Examples of the three sections of the survey form are shown below.

Section A: About you and your organisation

Your name	A N Other
Job title	Climate Change Scientist
Name of your organisation	Climate Change Research Organisation
Please briefly describe your organisation's vision, objectives and scope of work related to climate science and climate change issues?	

Aims

The purpose and aims of the UK Met Office's Hadley Centre are shown below. Please indicate below which of these aims also apply to your organisation by typing **X** in the appropriate column:	Similarity to your organisation's aims: Very similar	Somewhat similar	Slightly similar	Not similar
Provide its government clients with scientific evidence, in support of policy development concerned with climate science and climate change issues		X		
Understand physical, chemical and biological processes within the climate system and develop state-of-the-art climate models which represent them			X	
Use climate models to simulate global and regional climate variability and change over the last 100 years and to predict changes over the next 100 years	X			
Monitor global and national climate variability and change		X		
Attribute recent changes in climate to specific factors	X			
Understand, with the aim of predicting, the natural inter-annual to decadal variability of climate		X		

Figure 15: Example Collaborator's Survey Response – Section A

Section B: Quality of Collaborations with Hadley

Please describe the nature of this collaboration	
What formal or informal arrangements were put in place?	

Please describe:

The benefits you obtained (or expect to obtain) from the collaboration	The benefits you believe Hadley received (or will receive) from the collaboration
My Benefit 1	Hadley Benefit 1
My Benefit 2	Hadley Benefit 2
My Benefit 3	

Satisfaction level

Please indicate how satisfied you would say you are with the following by typing **X** in the most appropriate column:	Highly satisfied	Somewhat satisfied	Slightly satisfied	Not satisfied	Comments
The benefits you obtained from the collaboration	X				
The benefits you believe you were able to provide to Hadley		X			
The ease with which the collaboration was established	X				
The working arrangements once the collaboration was put in place		X			
The level of interaction with Hadley staff	X				
The quality of the communications with Hadley staff	X				
The quality of the staff you worked with	X				
The quality of the outputs	X				

Problems

Did you encounter any problems with the following? Please indicate by typing **X** in the most appropriate column:	No problems	Minor problems	Moderate problems	Major problems	Comments
Agreeing intellectual property rights	X				
UK Met Office Security				X	
Communications with the UK Met Office (as opposed to Hadley)	X				
Establishing a common understanding of the aims of the collaboration		X			
Data transfer			X		
Publication of results	X				
Timing of the collaboration within your own work programme	X				

	Better than average	Average	Worse than average
How would you rate the Hadley Centre as an organisation to collaborate with? (Please type **X** in the most appropriate column)		X	

Please describe how, in you opinion, Hadley could improve their collaborations	

Figure 16: Example Collaborator's Survey Response – Section B

Section C: Quality of Hadley's Scientific Staff, Science and Outputs

Staff quality: Using the quality rating system provided, how would you rate the quality of the staff in the following research areas? Please indicate by typing **X** in the most appropriate column.

	Quality Rating				
	4	3	2	1	Cannot comment
Climate Variability		X			
Oceans, Ice and Climate			X		
Atmospheric Chemistry and Carbon Cycle					X
Climate Impacts	X				
Predicting Climate Change		X			
Understanding Climate Change, including Detection and Attribution	X				
Modelling and Model Development	X				
Other, please specify up to two:					
<enter research area>					
<enter research area>					

Quality rating system

Science and output quality: Using the quality rating system provided, how would you rate the quality of Hadley's scientific research and outputs in the following research areas?
Please indicate by typing **X** in the most appropriate column.

	Quality Rating				
	4	3	2	1	Cannot comment
Climate Variability	X				
Oceans, Ice and Climate					X
Atmospheric Chemistry and Carbon Cycle		X			
Climate Impacts			X		
Predicting Climate Change	X				
Understanding Climate Change, including Detection and Attribution	X				
Modelling and Model Development	X				
Other, please specify up to two:					
<enter research area>					
<enter research area>					

Quality rating system

Datasets: How would you rate the accessibility, suitability and usefulness of the data sets produced by Hadley?
Please indicate by typing **X** in the most appropriate column:

Temperature datasets:	Extremely	Very useful	Some use	No use	Cannot comment
HadSST2			X		
HadISST		X			
HadNMAT					X
CRUTEM3		X			
HadCRUT3			X		
HadAT	X				
Pressure datasets:					
HadSLP			X		
HadESP					X
NOA (North Atlantic Oscillation)				X	
Extremes datasets:					
HadGHCND			X		
HadEX		X			
HadCET	X				
HadUKP			X		

Please explain how the usefulness of the datasets could be improved:	

Finally, for each of the areas listed below, how would you rate the quality of the Hadley Centre's scientific output among the climate change centres listed? Please answer a, b, c, ns or na as defined below. You may type in your answers or use the in-cell drop-down list.

a Hadley Centre output is of higher quality **b** Hadley Centre output is of similar quality **c** Hadley Centre output is of lower quality **ns** Not sure how Hadley Centre output compares **na** Not applicable: centre does not do work in this area	Deutsches Klimarechenz -entrum (DKRZ)	Max Planck Institute for Meterology	Laboratoire de Météorologie Dynamique du CNRS	NCAR Climate and Global Dynamics Division	NOAA/ NCEP Climate Prediction Centre	The Earth Simulation Centre, Japan
Predicting climate change & variability	b	b	a	a	b	b
Modelling of climate sensitivity & feedbacks	ns	ns	ns	ns	ns	ns
Capability / efficiency in using supercomputing resources	b	b	a	a	b	c
Regional modelling	b	b	ns	ns	b	ns
Model validation	b	b	ns	a	b	ns
Probabilistic prediction of future climate change	ns	c	na	na	ns	ns
Data analysis of recent and historical observations	b	b	b	a	b	ns
Decadal forecasting	na	ns	na	na	ns	na
Understanding weather and climate extremes	b	b	b	a	a	ns
Risk of abrupt climate change	ns	ns	ns	ns	ns	ns
Detection and attribution	ns	ns	ns	ns	ns	ns
Modelling of climate impacts	b	ns	ns	na	b	ns
Assessment of Mitigation options	ns	ns	ns	ns	ns	ns
Assessment of Adaptation strategies	ns	ns	ns	na	ns	ns

Figure 17: Example Collaborator's Survey Response – Section C

A selection of Hadley Centre staff, involved in the same collaborations, were invited to answer a similar series of questions as part of a structured interview. We have reported their findings here alongside the collaborators' responses, to allow the reader to compare the views of participants on each side of the collaboration.

Peer Reviewers' Survey

We asked 10 climate change experts to carry out peer reviews on a total of 42 papers and publications produced by the Hadley Centre.

Peer reviewers were asked to provide their views in three key areas:

- The nature of their expertise and any relationship with the Hadley Centre
- The relevance and scientific quality of each paper reviewed against a predefined set of climate change research areas
- The quality of Hadley's scientific staff, science and outputs.

The peer reviewers were asked to fill in survey forms, which allowed them to provide a mixture of open-ended and semi-quantitative responses.

Examples of the three sections of the survey form are shown below.

Section A: About you

Your name	A N Other
Please briefly describe your area of expertise related to climate science and climate change issues	
Name of your organisation	
Please briefly describe the nature of any formal or informal links you have had with the Hadley Centre for Climate Change over the last 5 years or you expect to have in the near future	

Figure 18: Example Peer Reviewer's Survey Response – Section A

Section B: Review of documents

These questions refer to the documents you have been asked to review. There is a set of questions for each document.
At the end of each set you may click the button to proceed to Section C if you have no further document reviews to record.
If you wish to complete Section C and then return to Section B, simply scroll back up the sheet.

Document 1: Title of paper or document under review	**Hadley Centre Paper on some issue of Climate Change Science**

Please indicate below the research areas covered by the document, and the extent to which they are relevant to the document.
(Please type an X in the appropriate column)

Research Area	Highly relevant	Somewhat relevant	Slightly relevant	Not relevant
Climate Variability		X		
Oceans, Ice and Climate				X
Atmospheric Chemistry and Carbon Cycle				X
Climate Impacts	X			
Predicting Climate Change	X			
Understanding Climate Change, including Detection and	X			
Modelling and Model Development	X			
Other, please specify up to two:				
Extreme events in future climate	X			
Uncertainty quantification in climate change projections	X			

Using the quality rating system, how would you rate the quality of the work presented in the paper?

Quality rating system
click here to view

	Quality Rating			
Research Area	4	3	2	1
Climate Variability		X		
Oceans, Ice and Climate				
Atmospheric Chemistry and Carbon Cycle				
Climate Impacts			X	
Predicting Climate Change	X			
Understanding Climate Change, including Detection and		X		
Modelling and Model Development			X	
Other:				
Extreme events in future climate	X			
Uncertainty quantification in climate change projections		X		

Figure 19: Example Peer Reviewer's Survey Response – Section B

Section C: Overview of Hadley Centre's Outputs

Staff quality: Using the quality rating system provided, how would you rate the quality of the staff in the following research areas? Please indicate by typing **X** in the most appropriate column.

	Quality Rating				
	4	3	2	1	Cannot comment
Climate Variability		X			
Oceans, Ice and Climate	X				
Atmospheric Chemistry and Carbon Cycle			X		
Climate Impacts		X			
Predicting Climate Change	X				
Understanding Climate Change, including Detection and	X				
Modelling and Model Development					
Other, please specify up to two:					
<enter research area>					
<enter research area>					

Quality rating

Science and output quality: Using the quality rating system provided, how would you rate the quality of Hadley's scientific research and outputs in the following research areas? Please indicate by typing **X** in the most appropriate column.

	Quality Rating				
	4	3	2	1	Cannot comment
Climate Variability	X				
Oceans, Ice and Climate	X				
Atmospheric Chemistry and Carbon Cycle		X			
Climate Impacts		X			
Predicting Climate Change	X				
Understanding Climate Change, including Detection and		X			
Modelling and Model Development			X		
Other, please specify up to two:					
<enter research area>					
<enter research area>					

Quality rating

Finally, for each of the areas listed below, how would you rate the quality of the Hadley Centre's scientific output among the climate change centres listed? Please answer a, b, c, ns or na as defined below. You may type in your answers or use the in-cell drop-down list.

a Hadley Centre output is of higher quality **b** Hadley Centre output is of similar quality **c** Hadley Centre output is of lower quality **ns** Not sure how Hadley Centre output compares **na** Not applicable: centre does not do work in this area	Deutsches Klimarechenz -entrum (DKRZ)	Max Planck Institute for Meterology	Laboratoire de Météorologie Dynamique du CNRS	NCAR Climate and Global Dynamics Division	NOAA/ NCEP Climate Prediction Centre	The Earth Simulation Centre, Japan
Predicting climate change & variability	a	b	b	ns	a	a
Modelling of climate sensitivity & feedbacks	b	a	b	ns	ns	b
Capability / efficiency in using supercomputing resources	b	ns	a	a	ns	a
Regional modelling	b	ns	b	a	b	a
Model validation	b	a	b	a	b	a
Probabilistic prediction of future climate change	b	a	a	a	b	b
Data analysis of recent and historical observations	b	a	ns	b	b	b
Decadal forecasting	a	a	ns	b	a	b
Understanding weather and climate extremes	a	b	a	b	a	b
Risk of abrupt climate change	a	b	b	a	a	a
Detection and attribution	b	b	b	b	b	a
Modelling of climate impacts	a	ns	b	b	b	a
Assessment of Mitigation options	b	ns	b	b	a	b
Assessment of Adaptation strategies	b	ns	ns	b	a	b

Figure 20: Example Peer Reviewer's Survey Response – Section C

Survey Analysis Methods

A number of the questions used in the surveys of Collaborators and Peer Reviewers required the respondent to select from a number of pre-defined options.

For example:

Science and output quality: Using the quality rating system provided, how would you rate the quality of Hadley's scientific research and outputs in the following research areas?
Please indicate by typing **X** in the most appropriate column.

	Quality Rating				
	4	3	2	1	Cannot comment
Climate Variability	X				
Oceans, Ice and Climate	X				
Atmospheric Chemistry and Carbon Cycle		X			
Climate Impacts		X			
Predicting Climate Change	X				
Understanding Climate Change, including Detection and		X			
Modelling and Model Development			X		

Figure 21: Example of Scientific Quality Rating Survey Question

When we analysed the results we assigned a numerical value to each response. In this example a quality rating of 4 would have produced a numerical score of 4.

In the case of less quantitative response options we still used a numerical scoring system, with a positive response being assigned a higher number. In the example below, a Highly Relevant response would have been rated as a 4, Not Relevant as a 1.

Research Area	Highly relevant	Somewhat relevant	Slightly relevant	Not relevant
Climate Variability		X		
Oceans, Ice and Climate				X
Atmospheric Chemistry and Carbon Cycle				X
Climate Impacts	X			
Predicting Climate Change	X			
Understanding Climate Change, including Detection and	X			
Modelling and Model Development	X			
Other, please specify up to two:				
Extreme events in future climate	X			
Uncertainty quantification in climate change projections	X			

Figure 22: Example of Research Area Relevance Survey Question

Using this approach we were not only able to generate a distribution of answers across all respondents, but to produce an average score and some indication of the distribution of the responses using a box and whisker plot.

Box and whisker plots provide a concise way of indicating the distribution of results. The whiskers represent the limits of the distribution, while the box represents the 25th and 75th percentiles. Finally the mean score across the distribution is indicated by the diamond.

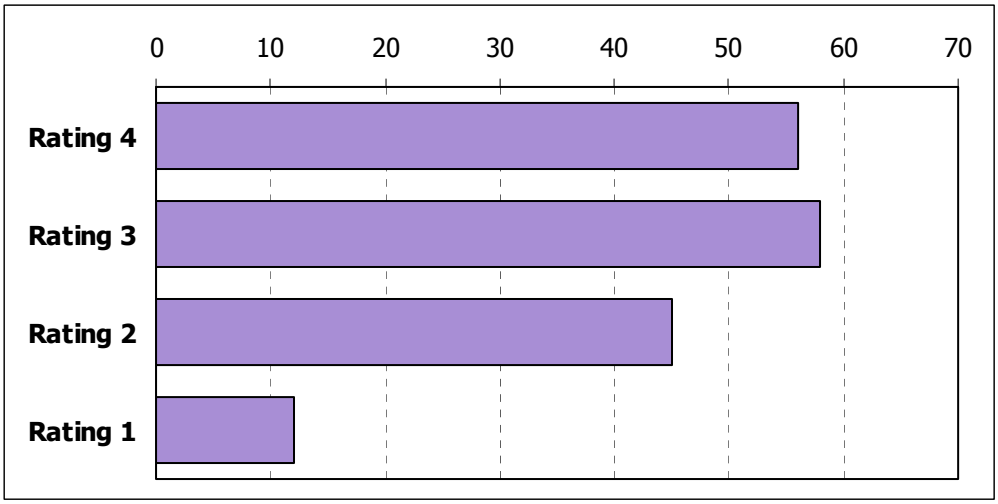


Figure 23: Example distribution of responses to a question with 4 possible answers

In order to show the box and whisker plots correctly against the initial survey response categories the left hand axis is offset by 0.5. Thus an average score of 3 would produce a diamond that fell in the middle of the Rating 3 category. The example shown below indicates that the average score was actually 2.5 (i.e. half way between rating 2 and rating 3).

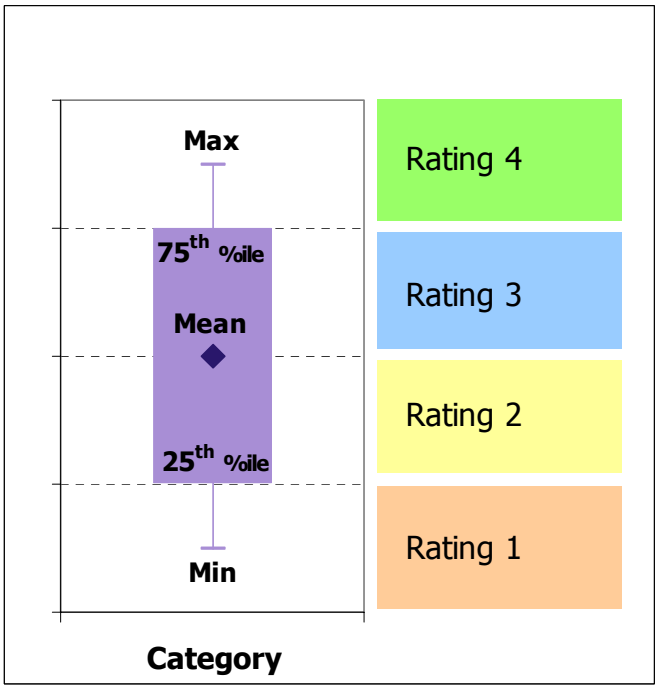


Figure 24: Example of Box & Whisker Plot

Survey Results

This section contains a complete set of the analyses carried out on the survey responses. A number of the graphs shown here are reproduced in the main report as well.

Here, we provide an explanation for each graph, explaining the question asked and the way the responses have been analysed.

A standard quality rating system was used throughout the surveys.

Quality rating system

4 **World Leading in terms of originality, significance and rigour, that is:**

- agenda setting
- leading or at the forefront of the research area
- great novelty in developing new thinking, new techniques or novel results
- major influence on a research theme or field
- developing new paradigms or new concepts for research
- major changes in policy or practice can be traced to research results

3 **Quality that is internationally excellent in terms of originality, significance and rigour but which nonetheless falls short of the highest standards of excellence. Evidence that the output produced:**

- makes important contributions to the field at an international level
- contributes important knowledge, ideas and techniques which are likely to have a lasting impact, but are not developing new paradigms or leading to fundamental new concepts
- significant change to policies or practice can be traced to research results

2 **Quality that is recognised internationally in terms of originality, significance and rigour. Evidence that the output produced:**

- provides useful knowledge to the field but lacks the potential for lasting impact
- involves incremental advances which might include new knowledge or model calculations, using established techniques or approache, which conform to existing ideas and paradigms
- research results have influenced policy or practice

1 **Below quality indicated in 2, above**

The graphs summarise these as:

4: World Leading

3: Internationally Excellent

2: Internationally Recognised

1: Not Internationally Recognised

Collaborators' Quality Rating of Staff

Collaborators were asked to rate the quality of Hadley scientific staff in 7 predefined research areas. They were also able to rate them against two further user defined research areas.

Two collaborators provided ratings in two additional research areas ("Handling Uncertainty" and "Use of Observation").

Rating was done using the 4 predefined quality rating categories, plus a fifth category of "Could not comment".

All blank responses or responses of "Could not comment" have been excluded from the analysis.

The results show that overall collaborators rate Hadley staff very highly, across all areas of climate change research.

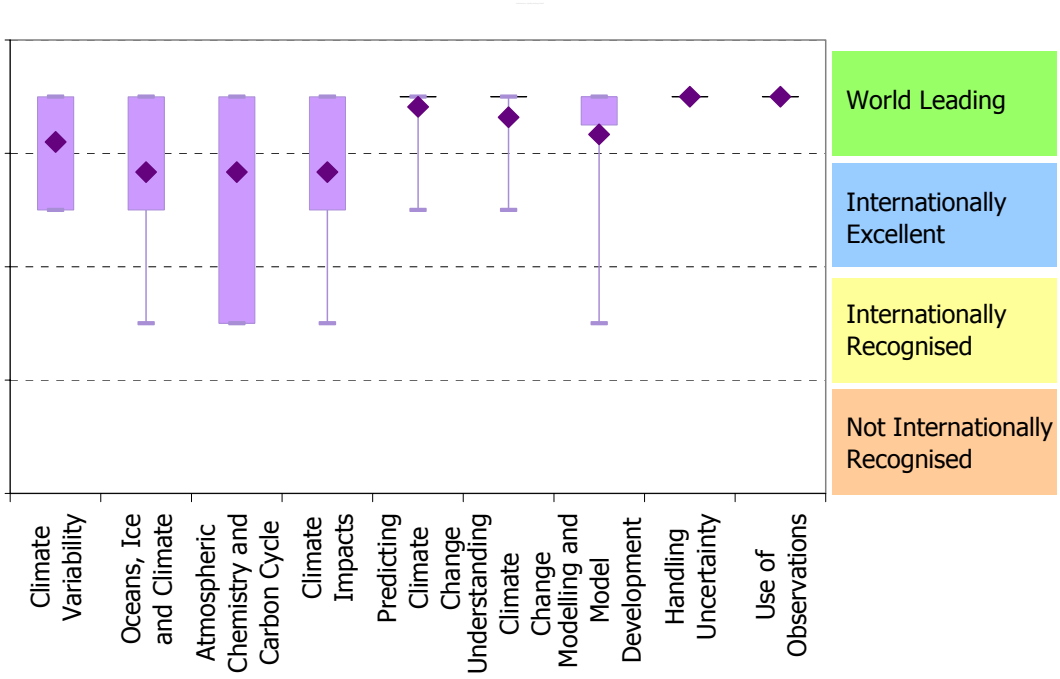


Figure 25: Collaborators' Quality Rating of Hadley Scientific Staff

Collaborators' Quality Rating of Scientific Output

Collaborators were asked to rate the quality of Hadley scientific output in 7 predefined research areas. They were also able to rate them against two further user defined research areas.

Two collaborators provided ratings in two additional research areas ("Handling Uncertainty" and "Use of Observation").

Rating was done using the 4 predefined quality rating categories, plus a fifth category of "Could not comment".

All blank responses or responses of "Could not comment" have been excluded from the analysis.

The results show that overall collaborators rate Hadley scientific output very highly, across all areas of climate change research.

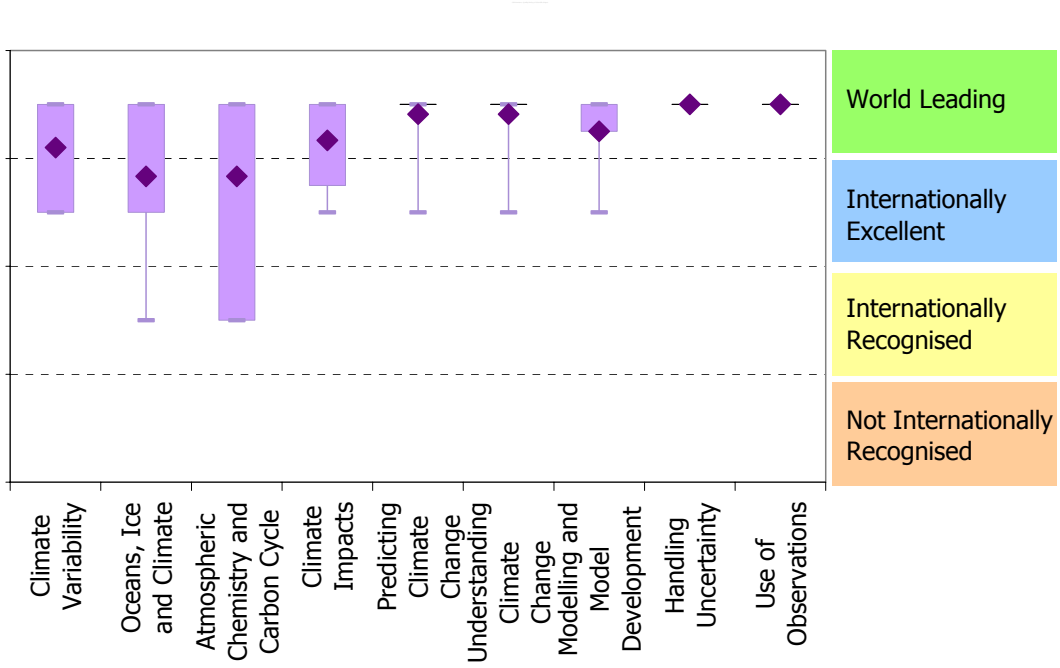


Figure 26: Collaborators' Quality Rating of Hadley Scientific Output

Peer Reviewers' Quality Rating of Scientific Output

Peer reviewers were asked to rate the quality of Hadley scientific output in 7 predefined research areas. They were also able to rate them against two further user defined research areas.

One peer reviewer provided ratings in two additional research areas ("Fundamental Physics" and "Handling Uncertainty").

Rating was done using the 4 predefined quality rating categories, plus a fifth category of "Could not comment".

All blank responses or responses of "Could not comment" have been excluded from the analysis.

The results show that overall peer reviewers rate Hadley scientific output highly, across all areas of climate change research, although not as highly as collaborators do. Performance in the area of Climate Impacts is considered to be slightly weaker than other areas.

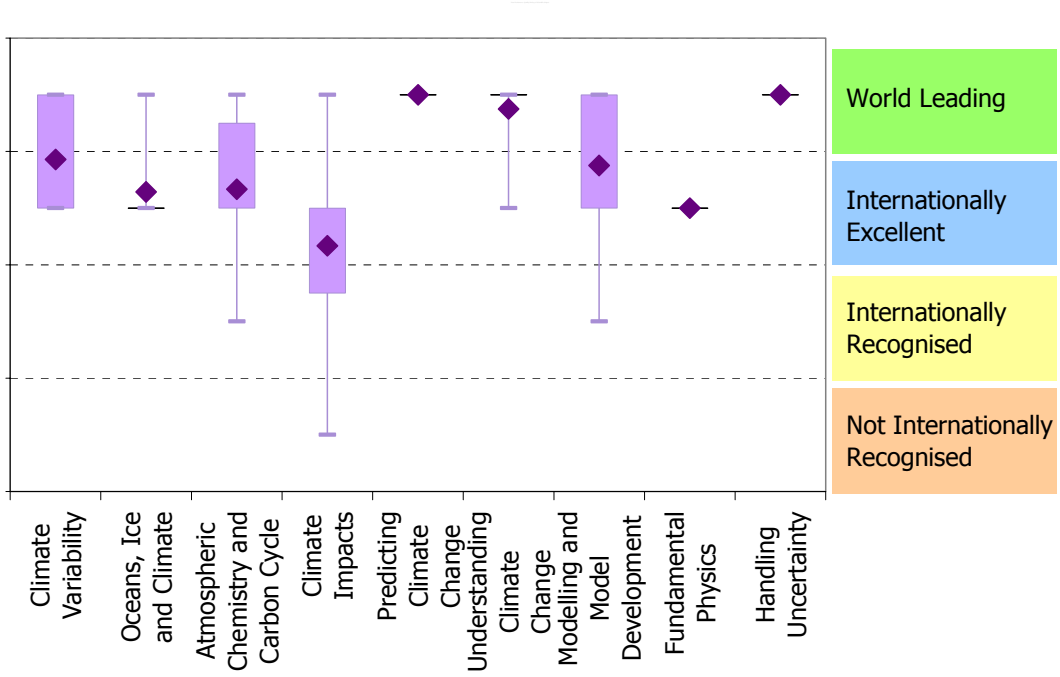


Figure 27: Peer Reviewers' Quality Rating of Hadley Scientific Output

Peer Reviewers' Quality Rating of Reviewed Papers

Peer reviewers were asked to rate the quality of a number of papers that had been published by Hadley staff in peer-reviewed journals. Reviewers were asked to assess each paper's relevance in 7 predefined research areas, plus two further user-defined research areas. They were then asked to rate the scientific quality using the 4 predefined quality rating categories, plus a fifth category of "Could not comment".

Three additional research areas were suggested ("Handling Uncertainty", "Fundamental Physics" and "Extremes").

All blank responses or responses of "Could not comment" have been excluded from the analysis. In addition we did not include ratings when the reviewer indicated that the paper was not relevant to those research areas.

The results show that overall peer reviewers rate Hadley scientific output highly, across all areas of climate change research. However, the results do indicate that there are elements of the published work that is not rated that highly. This is due to the inclusion of quality ratings in research areas for which the papers were considered to only be slightly relevant.

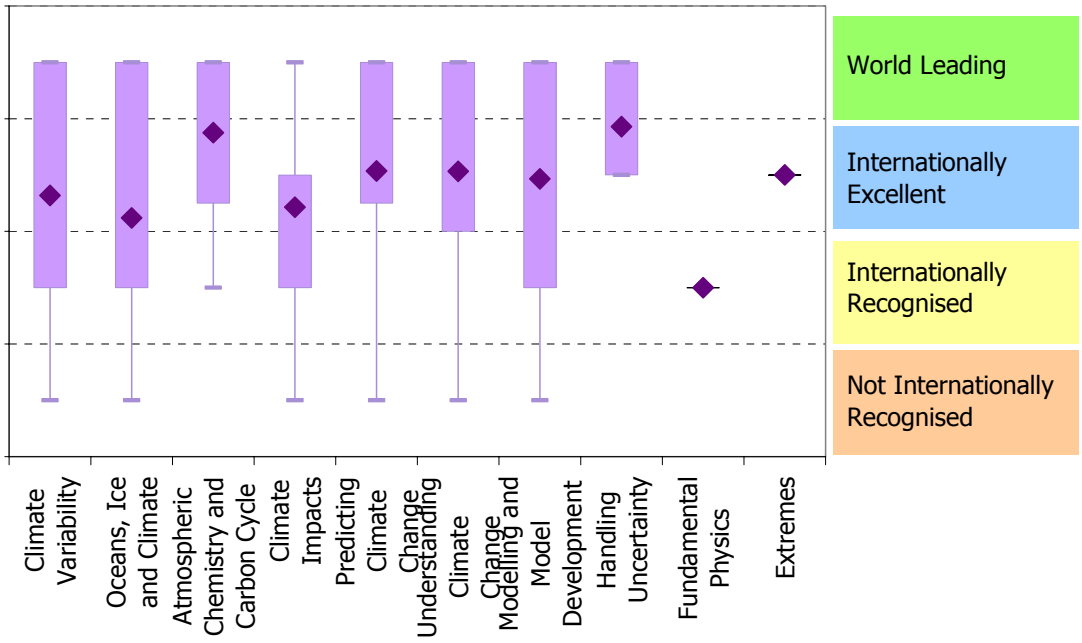


Figure 28: Peer Reviewers' Quality Rating of Reviewed Papers

Analysis of the quality rating against subject relevance indicates that where the subject is highly relevant to the paper (presumably where that subject is the main subject of the paper) the research is generally considered to be internationally excellent or world leading.

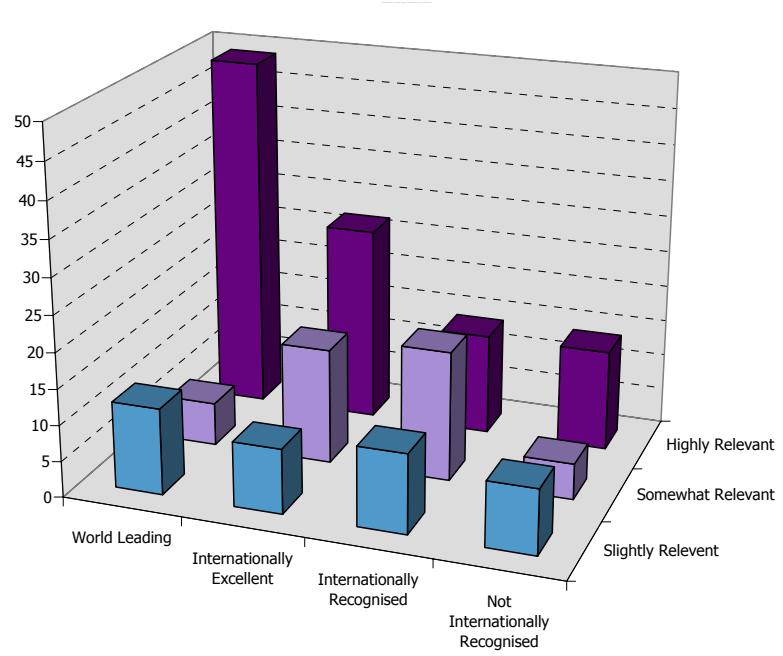


Figure 29: Peer Reviewers' Quality Rating of Reviewed Papers by Relevance

The graphs below show the increase in overall quality rating when results from less relevant research areas are removed from the analysis.

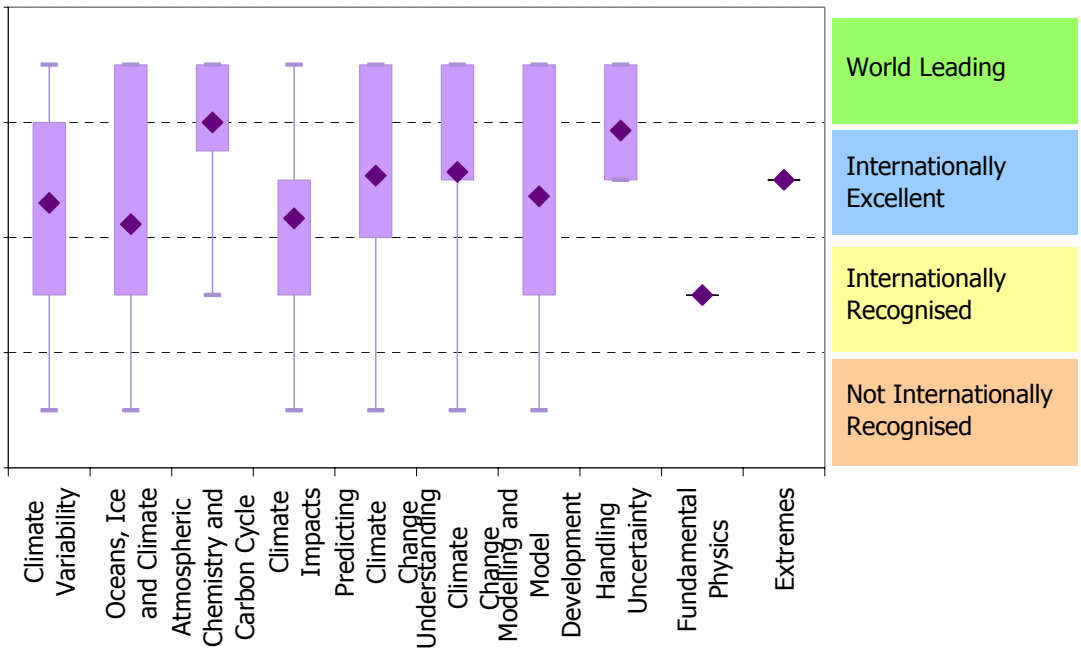


Figure 30: Peer Reviewers' Quality Rating of Reviewed Papers with High or Moderate Subject Relevance

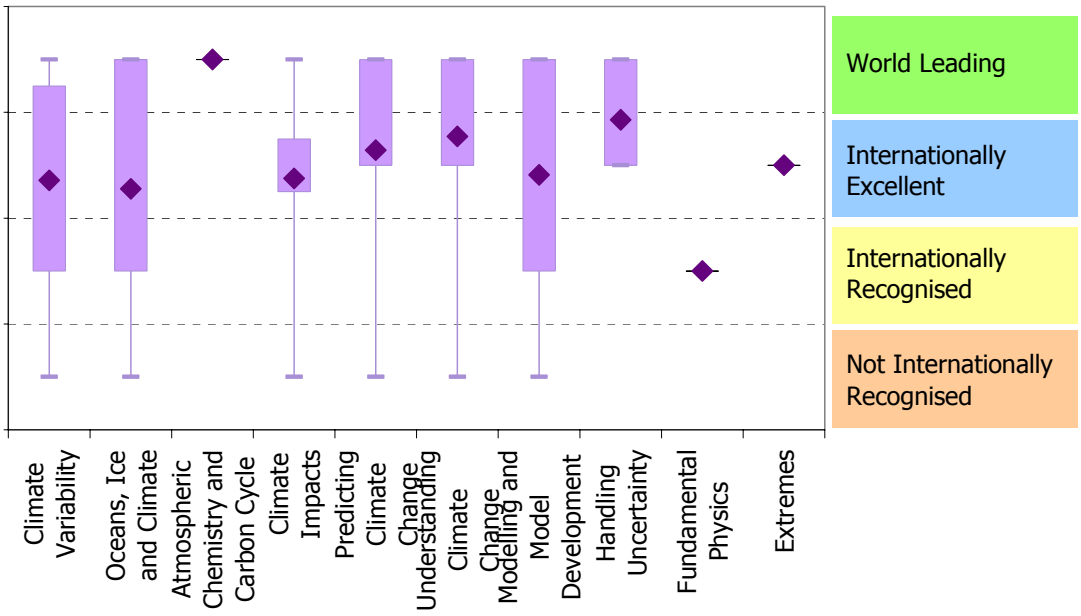


Figure 31: Peer Reviewers' Quality Rating of Reviewed Papers with High Subject Relevance

Peer Reviewers' Quality Rating of Non Peer Reviewed Journal Papers

Peer Reviewers were asked to rate the quality of a number of brochures that had been published by Hadley staff but had not been submitted to peer-reviewed journals. Reviewers were asked to assess each paper's relevance in 9 predefined research areas.

They were then asked to rate each area using 4 predefined categories. The categories were specific to each area as follows:

Area	Description	Rating 4 (Excellent)	Rating 3 (Good)	Rating 2 (Adequate)	Rating 1 (Poor)
Purpose Clear	Was the purpose of the document clear?	Very Clear	Somewhat Clear	Not very clear	Not at all clear
Key Message Clear	Were the key messages clear	Very Clear	Somewhat Clear	Not very clear	Not at all clear
Matched to Target Audience	Was the document matched to the target audience	Very	Somewhat	Poorly	Very poorly
Information Clear	Was the information presented clearly	Very Clear	Somewhat Clear	Not very clear	Not at all clear
Information Attractive	Was the information presented in an attractive manner	Very attractive	Somewhat attractive	Not very attractive	Not at all attractive

Area	Description	Rating 4 (Excellent)	Rating 3 (Good)	Rating 2 (Adequate)	Rating 1 (Poor)
Material Correct	Was the material correct given the current understanding of the science	Completely	Mostly	Partly	Not at all
Open to Misinterpretation	Was the information open to mis-interpretation	Not at all	Some could be	Most could be	All could be
Uncertainties Presented	Were uncertainties in the data properly presented	Completely	Mostly	Partly	Not at all
Aims Achieved	Did the document achieve its aims	Completely	Mostly	Partly	Not at all

For the purpose of this analysis, each category level has been considered to be equivalent. All blank responses have been excluded from the analysis.

The results show that overall Peer Reviewers rated the brochures highly, although there is some indication that the attractiveness of information presentation could be improved.

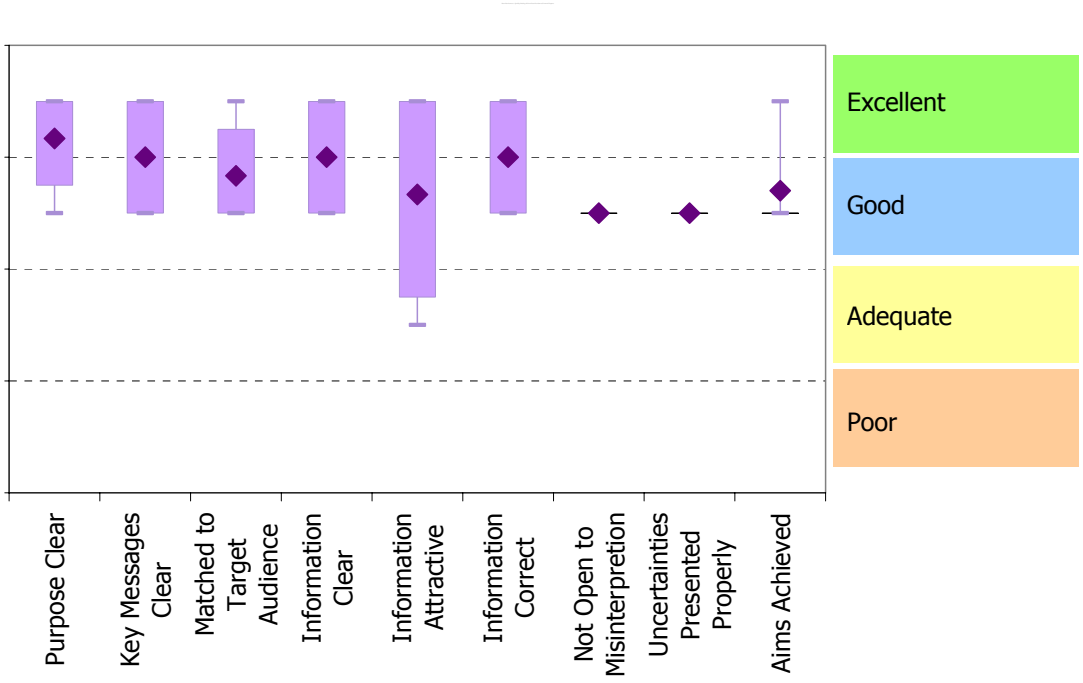


Figure 32: Peer Reviewers' Quality Rating of Non Peer Reviewed Jouranl Papers

Collaborators' Satisfaction Rating of Collaboration

Collaborators were asked to indicate how satisfied they were with their collaborations with the Hadley Centre in 8 predefined areas. They were also able to provide further comments about these areas.

Rating was done using 4 predefined satisfaction categories, with blank responses excluded from the analysis.

The results show that overall collaborators are highly satisfied with the collaboration, although some level of dissatisfaction has been expressed in 3 areas.

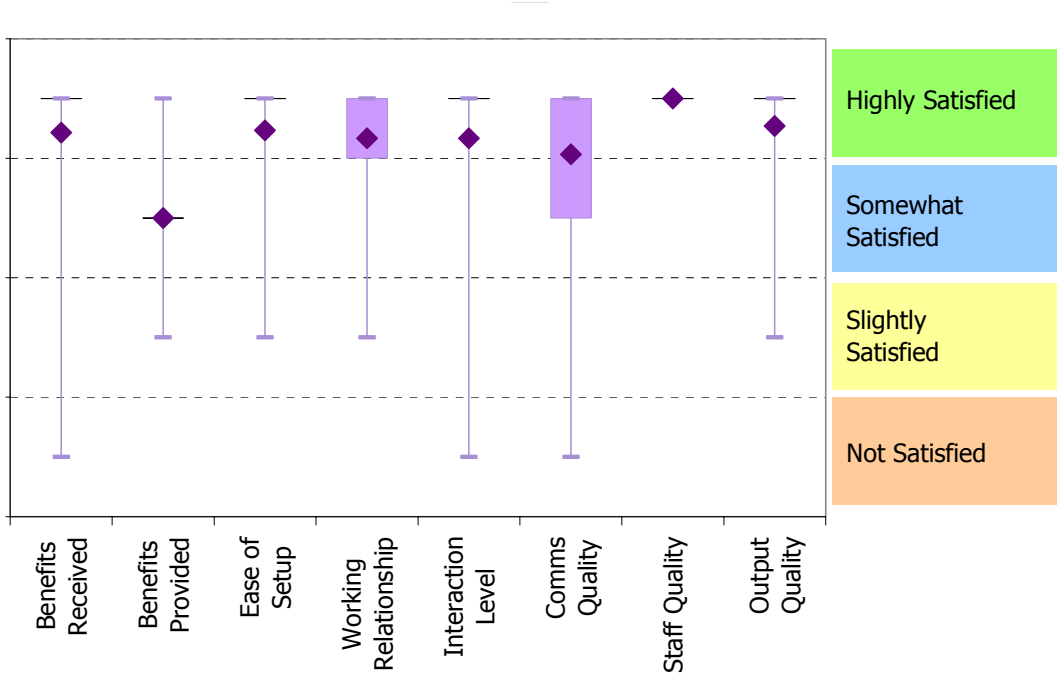


Figure 33: Collaborators' Satisfaction of Rating of Collaboration

No relevant comments were recorded against the satisfaction areas.

Collaborators' Rating of Collaboration Problem Areas

Collaborators were asked to indicate whether they had encountered problems in 7 predefined areas. They were also able to provide further comments about these areas.

Rating was done using 4 predefined Problem categories, with blank responses being excluded from the analysis.

The results show that Collaborators did encounter problems in two areas, namely issues associated with Met Office Security clearance and Data Transfer.

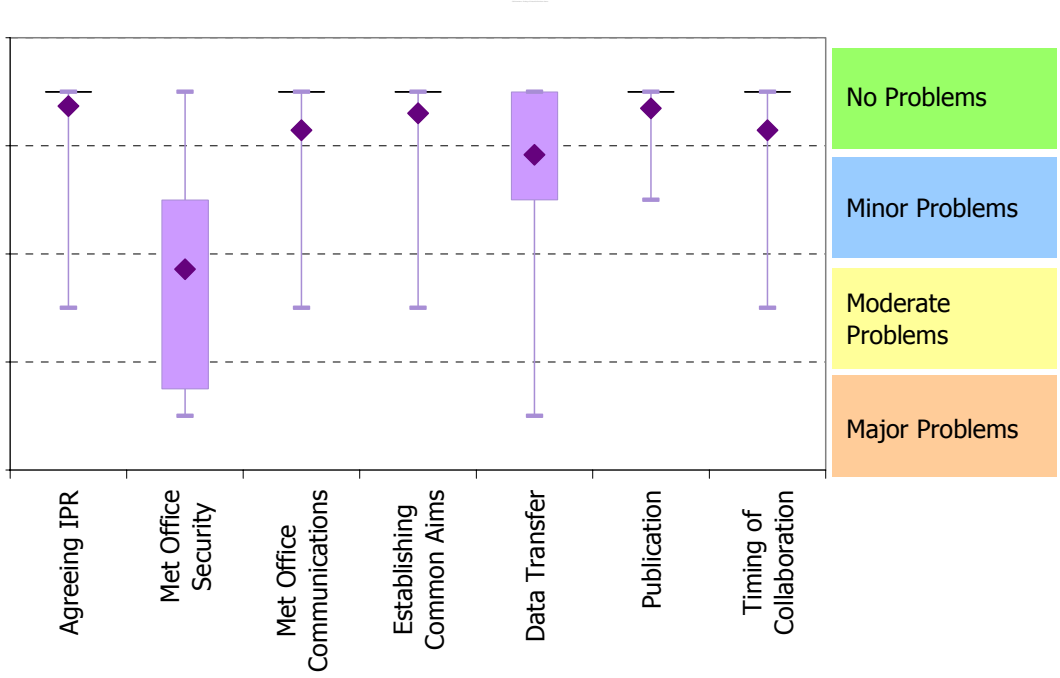


Figure 34: Collaborators' Rating of Collaboration Problem Areas

The following table details the specific comments that were received about observed problems encountered in each specific problem area.

Table 3: Specific Comments Made by Collaborators About Problems Encountered

Area	Problem
Agreeing intellectual property rights	This particular contract was OK, but a recent smaller contract was held up by IPR issues
	No discussion of this BUT this is a major issue
UK Met Office Security	Met Office security is by a wide margin the most annoying and off putting aspect of Hadley Centre collaboration
	Some difficulties due to delay of my security clearance.
	Access to canteen difficult in orange+ security (that was in bracknell)
	Lack of easy access to Hadley centre machines.
	Met Office removed access to MO computers a year into the project
	Wireless internet access at UKMO would help!
Communications with the UK Met Office (as opposed to Hadley)	Contracts office was somewhat slow to act
Establishing a common understanding of the aims of the collaboration	No Comments
Data transfer	Very slow connections to the rest of the world.
	It is still difficult to transfer data between the Met Office and the Universities because of MO security and MO not being on JANET
Publication of results	Have not published anything yet but there are some issues regarding crown copyright when publishing with Met Office authors. There can be a delay in publication because Met Office staff cannot sign over copyright to scientific journals.
	Page charges would be nice, but this is extremely minor.
Timing of the collaboration within your own work programme	No Comments

Hadley staff working on collaborations were also asked about specific problems they had encountered in setting up or during the collaboration. The table below details the specific comments that Hadley staff made about problems encountered in each problem area.

Table 4: Hadley Cited Problems

Area	Problem
Agreeing intellectual property rights	IPR has been a huge and ongoing issue, but is being negotiated.
	IPR is always an issue, but dealt with in normal way
	IPR - some issues surrounding the raw data, which had to be kept separate and Hadley couldn't use themselves.
UK Met Office Security	Clearance took a long time to come through and decisions had to be made re: flights and accommodation before knowing when this would come through. As a result, the collaborator arrived before they got clearance, and had to spend a month working from internet cafes or on own laptop, as not allowed access to system.
	Security can be a nuisance, people need to be cleared well ahead of time especially for IT access.
	Security: when someone comes for a working visit it takes a long time to get clearance
	Security a minor problem, slight hindrance as the people who could visit to work at Hadley were limited to those who had already got security clearance. HiGEM uses the ACCESS grid for teleconferencing, so Hadley couldn't participate in these although it is not clear what the issue is that is blocking this and whether it would be possible to remove this.
	Security is an issue but hope to work it through parallel collaborations with universities and web pages outside the firewall. Also need to get their people through security clearance - have already started this as it takes so long.
	Now there would be security system access problems, as dial-up wouldn't be possible.
	Admin effort was associated with setting up the dial-in facility
Communications with the UK Met Office (as opposed to Hadley)	No Comments
Establishing a common understanding of the aims of the collaboration	Establishing common aims has been worked on v hard and also to establish common working practices - included in formal agreements
	Common understanding of aims may be an issue.
	Mismatch in aims: now the universities are coming to the end of their grant they are looking for the follow-on, so are hurrying to deliver something to meet grant needs.
	Mismatch between priorities and objectives between the two organisations has prevented more fruitful collaboration (BAS more focused on Southern Ocean & ice shelves and this level of detail is too deep for Hadley when there are bigger issues to worry about with the model.
Data transfer	Data transfer was accomplished in the end by DVD transfer.
	Data transfer was initially a problem, but wih the new Met Office ftp server this is improved.
	Data transfer can be a problem, for a lot of data, due to the firewall. Have set up own web-server, independent of Met Office, which works very well, and allows people to have free access to a lot of good data. This is important to the reputation of the Met Office as results generated by others should be based on good data.
	Data transfer - plan is that people will transfer between the centres, not necessarily data, but for daily NWP this may be a problem
	Data transfer logistics have been a minor issue to make sure Rob had access to all the data.
	Data transfer works OK due to long established relationship with Reading, and also technological improvements which make storage and transfer of large amounts of data easier.
	Data transfer can be a problem, but the new ftp server may have solved this.
	Some data transfer problems, especially between UK and Japan.
	Data: not always freely exchanged, people are jealous of it particularly if it is high res or daily data, and want to sell rather than give.
	Data transfer was a major problem before BADC, and now only a limited period of data is available.
Publication of results	No Comments
Timing of the collaboration	Timing of EU projects e.g. finishing at end of FY when they are very busy writing future research plans is a problem - it would be better if these could be staggered so they don't all end at the same time.
	Timing - this is an ongoing issue, but have tried to write plans for them to fit in with deliverables into the agreements.

Collaborators' Cited Benefits Achieved by Collaborating

Collaborators were asked to indicate what benefits they have received by collaborating with the Hadley Centre. They were able to describe up to 4 benefits in free text boxes.

In order to analyse these responses we consolidated the free text responses into a number of themed categories.

The categorisation we used is shown overleaf in Table 5.

We then grouped the responses into these categories to highlight the most common observed benefits.

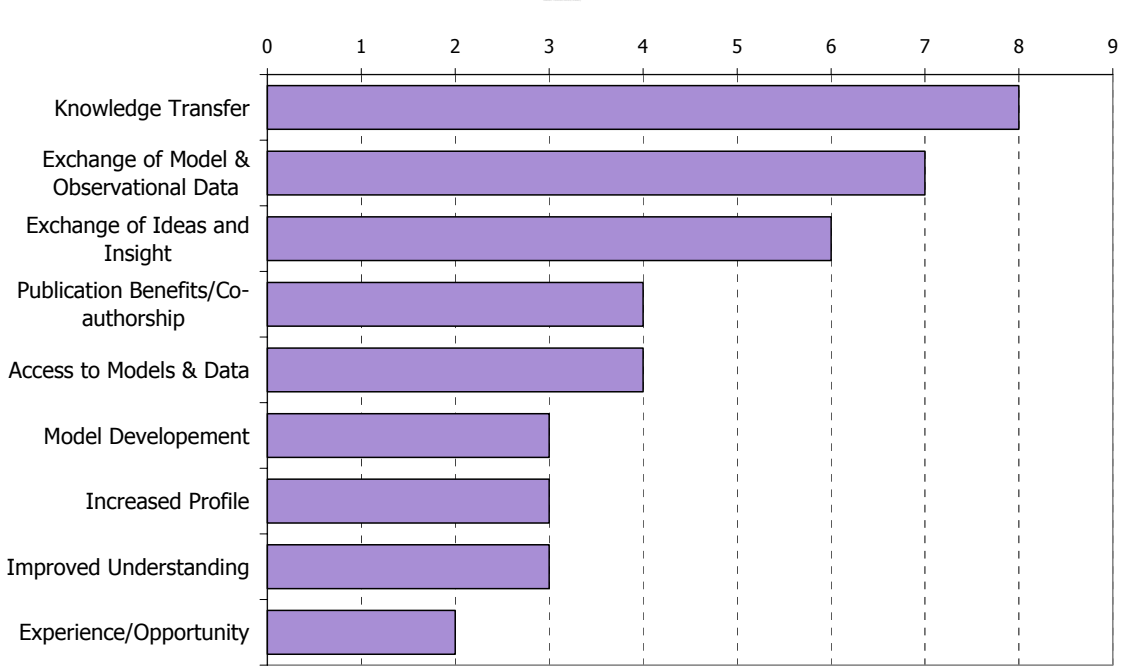


Figure 35: Collaborators - CitedOwn Benefits Achieved by Collaborating

Table 5: Collaborator BenefitOwn Benefits Classification

Collaborator Cited Benefits for Themselves	Benefit Classification
Being able to construct high-resolution (50km in horizon) SRES climate change scenarios in the 21st century over China.	Model Developement
Access to climate data	Access to Models & Data
Access to expertise at the Hadley on developing earth system models.	Exchange of Ideas and Insight
Access to models and data	Access to Models & Data
Access to the HadGEM1 code and subsequent model developments.	Access to Models & Data
Acknowledgements and citations on publications.	Publication Benefits/Co-authorship
Availabilitiy of HC's model data	Access to Models & Data
Better understanding of the coupled climate-carbon cycle system over the 20th and 21st century	Improved Understanding
Capacity buiding has been strenthened from the collaboration. More data could be received from the Hadley Centre.	Knowledge Transfer
Coauthorship of papers	Publication Benefits/Co-authorship
Contributing to Assessments of the IPCC starting with the Fifth Assessment	Publication Benefits/Co-authorship
Demonstration of the value to operational prediction of the results of our research	Increased Profile
Development and maintenance of a world class Earth System Model	Model Developement
Development and maintenance of a world class weather forecasting system	Model Developement
Exchange of data	Exchange of Model & Observational Data
Exchange of ideas and insight	Exchange of Ideas and Insight
Exchange of ideas.	Exchange of Ideas and Insight
Exchange of model data	Exchange of Model & Observational Data
Exchange of observational data	Exchange of Model & Observational Data
Experience of work at a world-top climate centre and friendship with some people there	Experience/Opportunity
Greater profile for our work	Increased Profile
I am now planning to do a similar study for southern Australia using these techniques.	Knowledge Transfer
Improved understanding of climate observation system requirements for future observations	Improved Understanding
Improved use of new satellite observation capabilities in understanding the climate system and its prediction	Improved Understanding
Involvement in interesting research problems. Small amount of income.	Exchange of Ideas and Insight
Meeting government policy requirements in natural resource management and related fields	Knowledge Transfer
Networking	Increased Profile
New gridded dataset	Exchange of Model & Observational Data
new ideas through discussion	Exchange of Ideas and Insight
Several well-regarded journal papers	Publication Benefits/Co-authorship
The collaboration will promote valuable two-way knowledge transfer between NCAS-Climate and the Met Office in the area of seasonal prediction	Knowledge Transfer
The funding received allowed me to revive an area of work that I was very interested in but local pressures were moving me away from. This was very successful and analysis of the marine in situ network and dataset development are now a NOCS core activity.	Knowledge Transfer
The global climate model(GCM)-projected climate change results based on SRES assumptions and PRECIS system were provided	Exchange of Model & Observational Data
The interactions that developed as part of the project have been sustained and are extremely productive. The approach to analysis at the two centres is quite different and so the results obtained are very complementary.	Knowledge Transfer
The opportunity to be involved in the scientific output of one of the world's leading climate centres.	Experience/Opportunity
These data had been applied in the impacts aseessments of climate change on Chinese agriculture.	Exchange of Model & Observational Data
To address the NAO-related climate anomalies over East Asia	Knowledge Transfer
To share the idea from Hadley Centre scientist	Exchange of Ideas and Insight
To share the model and observation data	Exchange of Model & Observational Data
Wider use of our objective weather system tracking and diagnostic software.	Knowledge Transfer

Collaborators' Cited Benefits for Hadley Achieved by Collaborating

Collaborators were asked to indicate what benefits they thought that the Hadley Centre had received by collaborating with them. They were able to describe up to 4 benefits in free text boxes.

In order to analyse these responses we consolidated the free text responses into a number of themed categories.

The categorisation we used is shown overleaf in Table 6.

We then grouped the responses into these categories to highlight the most common observed benefits.

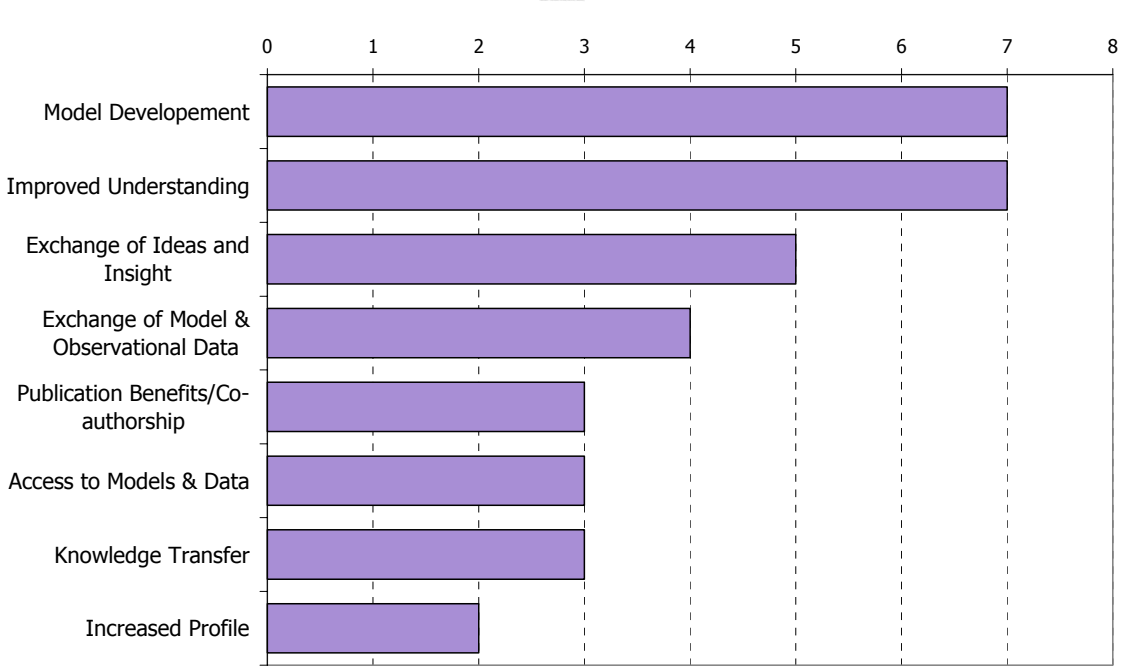


Figure 36: Collaborators - Cited Benefits for Hadley Achieved by Collaborating

Table 6: Collaborator Cited Hadley BenefitBenefits Classification

Collaborator Cited Benefits for Hadley	Benefit Classification
Access to expertise in the NERC community in earth system models.	Model Developement
Access to software and support.	Access to Models & Data
Access to some climate data we have received	Access to Models & Data
Active research being maintained beyond the contract in a key area of interest	Improved Understanding
Analysis of their data and model runs	Access to Models & Data
Bug fixes and improvements to the HadGEM model arising from the development of HiGEM	Model Developement
Coauthorship on papers	Publication Benefits/Co-authorship
Contributing to Assessments of the IPCC starting with the Fifth Assessment	Publication Benefits/Co-authorship
Development and maintenance of a world class Earth System Model	Model Developement
Discussion of data issues/ homogeneity	Exchange of Ideas and Insight
Exchange of data	Exchange of Model & Observational Data
Exchange of data and results from processing and analysis performed in ESSC.	Exchange of Model & Observational Data
Exchange of ideas and insights	Exchange of Ideas and Insight
Exchange of ideas.	Exchange of Ideas and Insight
Feedbacks of using PRECIS to the Hadley Centre for PRECIS further development.	Improved Understanding
I have reformatted data and supplied code already for this project.	Model Developement
Improved ability to determine the uncertainty of climate predictions	Improved Understanding
Improved ability to prioritize future climate model improvements required.	Improved Understanding
Improved interaction with NOCS	Model Developement
Improved statistical underpinning of methodology used in various projects.	Model Developement
Improvements in the simulation by running at increased resolution (e.g. in the simulating El Nino)	Model Developement
Keeping a good relationship with the Japanese climate modelling community, which has the Earth Simulator	Increased Profile
Meeting government policy requirements in natural resource management and related fields	Knowledge Transfer
My several years experience in working with the data have highlighted the data problems that are likely to be encountered with the newly digitised data. Rob has been able to seek my advice on these pitfalls and ask for my scientific opinion.	Improved Understanding
Networking	Increased Profile
New gridded dataset	Exchange of Model & Observational Data
New ideas through discussion	Exchange of Ideas and Insight
Several well-regarded journal papers	Publication Benefits/Co-authorship
The collaboration will promote valuable two-way knowledge transfer between NCAS-Climate and the Met Office in the area of seasonal prediction	Knowledge Transfer
The project has only just started. When completed it will deliver specific recommendations for improvements to the seasonal prediction system, including an assessment of priorities	Improved Understanding
To extend the discussion of NAO-related climate anomalies from Atlantic domain to Far East	Exchange of Ideas and Insight
To perform coordinated numerical model experiments and make multi-model inter-comparisons	Improved Understanding
To share the model and observation data from Chinese side	Exchange of Model & Observational Data
Training staff	Knowledge Transfer

Hadley Centre Cited Benefits Achieved by Collaborating

Hadley Centre staff involved in the collaborations were asked to tell us what benefits they have received by collaborating. We consolidated the verbal responses into a number of themed categories for analysis.

The categorisation we used is shown overleaf in Table 7.

We then grouped the responses into these categories to highlight the most common observed benefits.

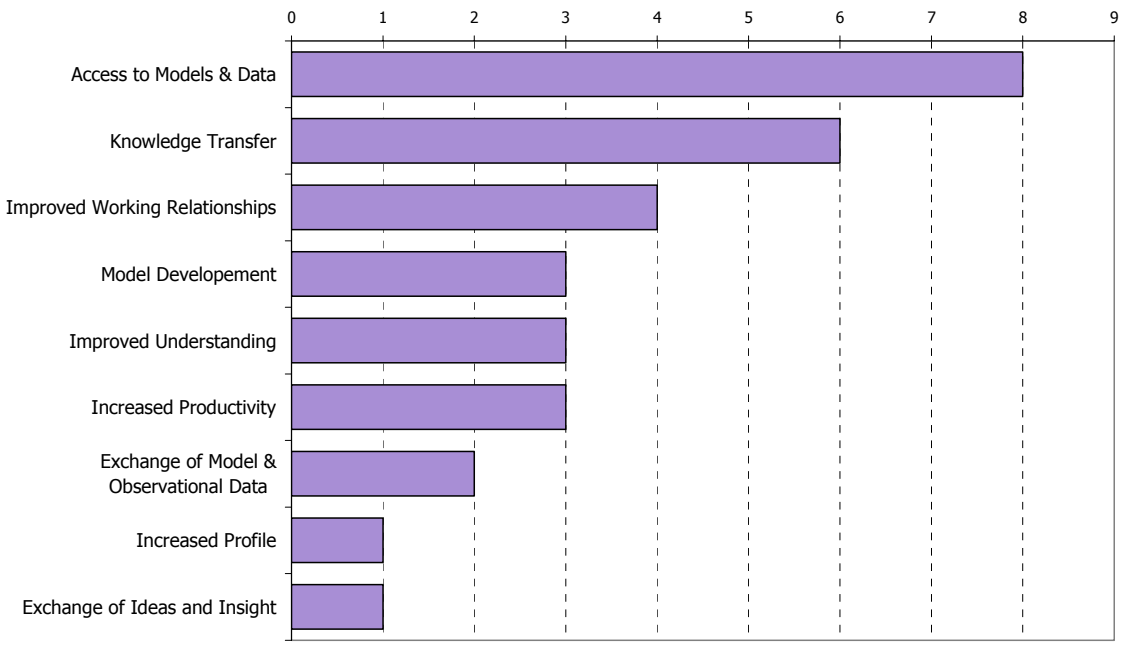


Figure 37: Hadley Centre Staff Own Benefits for Hadley Achieved by Collaborating

Table 7: Collaborator Cited Hadley Benefits Classification

Hadley Cited Benefits for Themselves	Benefit Classification
Increase in staff resources and expertise in the new research discipline	Knowledge Transfer
Being informed of all work going on in the field and therefore being at forefront of what's happening.	Improved Working Relationships
Sharing of expertise, which allows work to be done that otherwise wouldn't happen.	Exchange of Ideas and Insight
Sharing of observational and model data.	Exchange of Model & Observational Data
Access to data that would otherwise not necessarily be freely available (Met Office not signed up to International Data Exchange, because it charges for some of its data, so is not given access to US data freely, and data therefore can't simply be obtained via internet).	Access to Models & Data
Good to work with the people who generate the data, as can get updates on future developments and can influence the way the data is collected, e.g. have already been involved in improving quality controls.	Improved Working Relationships
Access to better quality observational data	Access to Models & Data
Improved contact with general Earth Observation community, so easier to access other things.	Improved Working Relationships
Increased expertise in the use of the data.	Knowledge Transfer
Increased expertise in tropical meteorology	Knowledge Transfer
Improvements in model performance over time.	Model Developement
Very prestigious.	Increased Profile
Improved outcomes due to having a much longer dataset.	Exchange of Model & Observational Data
This will set the foundations for looking at wider issues, and taking forward with US and European partners. Could develop into a bigger product.	Improved Understanding
Access to all groups results.	Access to Models & Data
Homogeneous satellite dataset that could be used for model validation (against simulated satellite radiances from model)	Access to Models & Data
Access to historical data that will help reduce uncertainty in prediction.	Access to Models & Data
Access to expertise in analysis of atmospheric variability and in seasonal forecasting,	Knowledge Transfer
Development of the model in seasonal forecasting, both technical and scientific work.	Model Developement
The model generates too much data for Hadley to be able to analyse it all alone.	Increased Productivity
Increased speed of analysis which saves time.	Increased Productivity
Gain a software package and support, and comparisons of results.	Access to Models & Data
Imrpovements to model estimation methods	Model Developement
Access to more historical data	Access to Models & Data
Experience of how the model would perform at higher resolutions.	Improved Understanding
Collabroator input into ECMWF re-analysis project	Improved Understanding
Allowed Hadley to work very effectively and generate a lot of science and work with a lot of University people.	Increased Productivity
Closer engagement in day-to-day working practises, and much closer working relationships.	Improved Working Relationships
Useful exchange of expertise	Knowledge Transfer
Access to rainfall data.	Access to Models & Data
Access to specific expertise not otherwise available.	Knowledge Transfer

Hadley Centre Benefits Assumed for Collaborators Achieved by Collaborating

Hadley Centre staff involved in the collaborations were asked to tell us what benefits they consider their collaborators have received by collaborating. We consolidated the verbal responses into a number of themed categories for analysis.

The categorisation we used is shown overleaf in Table 8.

We then grouped the responses into these categories to highlight the most common observed benefits.

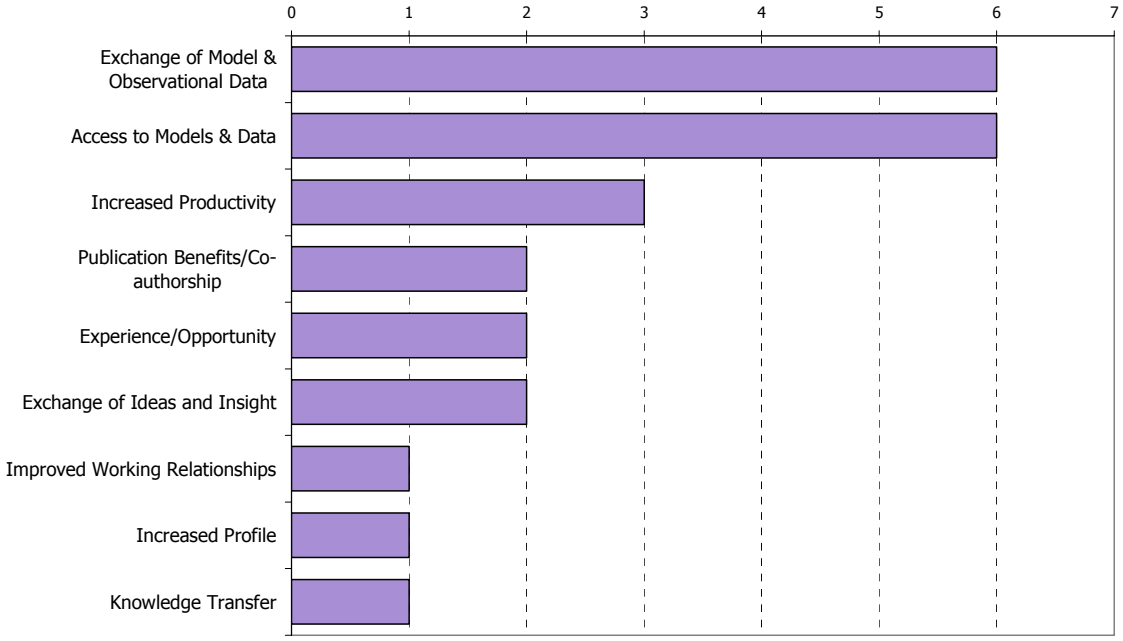


Figure 38: Hadley Centre Staff Assumed Benefits for Collaborators Achieved by Collaboration

Table 8: Hadley Assumed Benefits for Collaborators Classification

Hadley Cited Benefits for Collaborators	Benefit Classification
Gained new experience of and an insight into the Hadley 'model of success'.	Experience/Opportunity
Gained kudos from being involved with Hadley	Increased Profile
Being informed of all work going on in the field and therefore being at forefront of what's happening.	Improved Working Relationships
Sharing of expertise, which allows work to be done that otherwise wouldn't happen.	Exchange of Ideas and Insight
Sharing of observational and model data.	Exchange of Model & Observational Data
Additional resources to develop the grid method	Increased Productivity
Greater use made of their data.	Exchange of Model & Observational Data
Demonstration that collaborators observations are useful, so can justify their funding.	Publication Benefits/Co-authorship
Collaborators got involved in new areas of work.	Experience/Opportunity
Collaborators got status from publication.	Publication Benefits/Co-authorship
Gain access to a much better model straight away.	Access to Models & Data
Collaborator can continue work despite moving to Australia.	Increased Productivity
Each group had access to all others' results.	Exchange of Model & Observational Data
Access to processed data, which has other applications as well e.g. in atmospheric physics.	Access to Models & Data
Experience and input into ECMWF re-analysis project	Exchange of Ideas and Insight
Increased speed of analysis which saves time.	Increased Productivity
Access to modelling work and the newer HadGEM modelling capability.	Access to Models & Data
Their software is more widely used.	Exchange of Model & Observational Data
There is value in all researchers using the same code as it allows better cross-comparisons between groups.	Exchange of Model & Observational Data
Collaborator's data analysis methods are utilised to make better use of existing datasets.	Exchange of Model & Observational Data
Help in developing the infrastructure for modelling	Knowledge Transfer
Access to the model code for further development.	Access to Models & Data
Access to data and expertise.	Access to Models & Data
Access to data	Access to Models & Data

Collaborators' Rating of Hadley Datasets

Collaborators were asked to indicate how useful they considered each of the 13 Hadley Centre climate change datasets to be.

Rating was done using 4 predefined usefulness categories, plus a fifth category of "Cannot comment".

All blank responses or responses of "Cannot comment" have been excluded from the analysis.

The results show that overall collaborators consider the datasets to be very useful, although most areas have at least one response that indicated that the dataset was no use. It is not clear whether this indicates that the dataset was simply not relevant to the particular collaborator, or some deeper underlying problem.

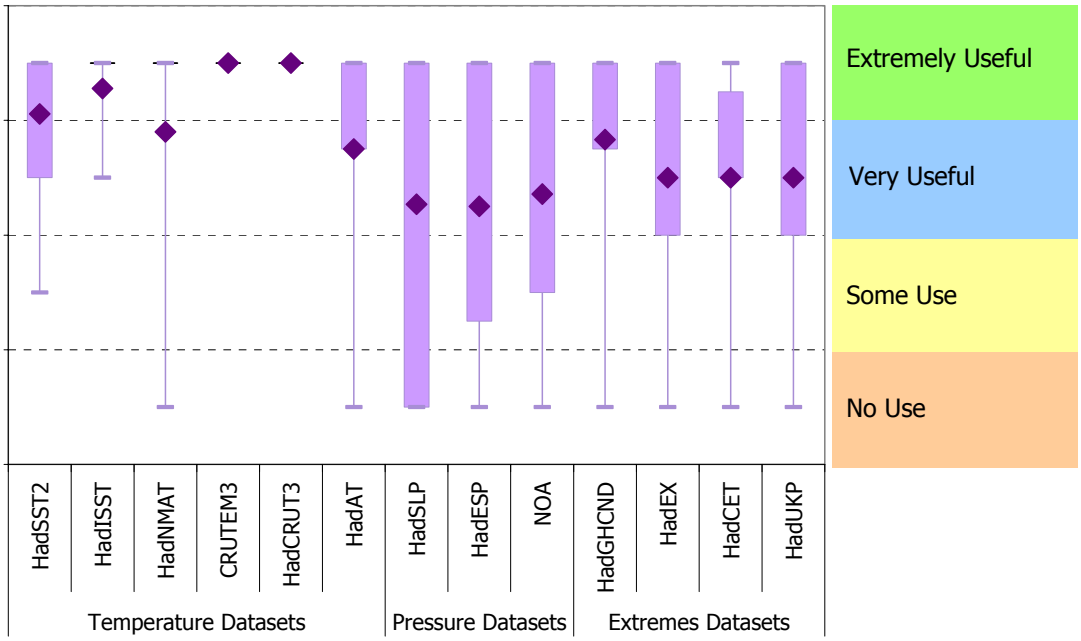


Figure 39: Collaborators' Rating of Hadley Centre Datasets

Collaborators' rating of the Hadley Centre as an Organisation with which to Collaborate

Collaborators were asked to indicate how they would rate the Hadley Centre as an organisation to collaborate with.

Rating was done using 3 predefined categories:

- Better than average
- Average
- Worse than average

All blank responses have been excluded from the analysis.

Almost all respondents concluded that the Hadley Centre was better than average as an organisation to collaborate with.

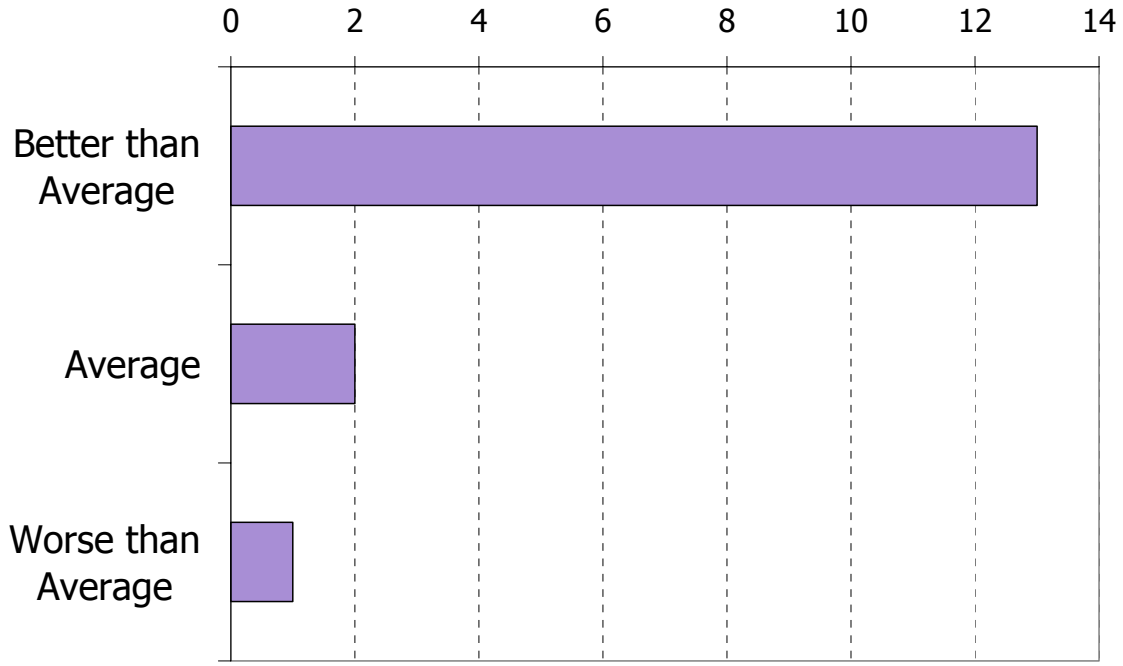


Figure 40: Collaborators' rating of Hadley Centre as an organisation to collaborate with

Comparison with Other Climate Change Centres

Collaborators and Peer Reviewers were both asked to rate the quality of the Hadley Centre's scientific output compared to six other climate change research centres, in 14 research areas.

Rating was done using 5 predefined comparison categories:

- Higher: The quality of Hadley Centre scientific output is considered to be higher than that of the other climate change research centre.
- Similar: The quality of Hadley Centre scientific output is considered to be similar to that of the other climate change research centre.
- Lower: The quality of Hadley Centre scientific output is considered to be lower than that of the other climate change research centre.
- Not sure: Respondent was not able to make a judgement
- N/A: Respondent did not consider a comparison to be possible.

The following graphs show the average rating against each factor, for all responses where an opinion (Higher, Similar or Lower) was expressed.

Figure 41 indicates that the peer reviewers generally consider the Hadley Centre to produce scientific outputs of higher quality that the other six climate change centres, other than NCAR. Adaptation, Decadal, Impacts and Regional modelling are the only areas in which the Hadley Centre was consider to have significant competition that was considered to be better.

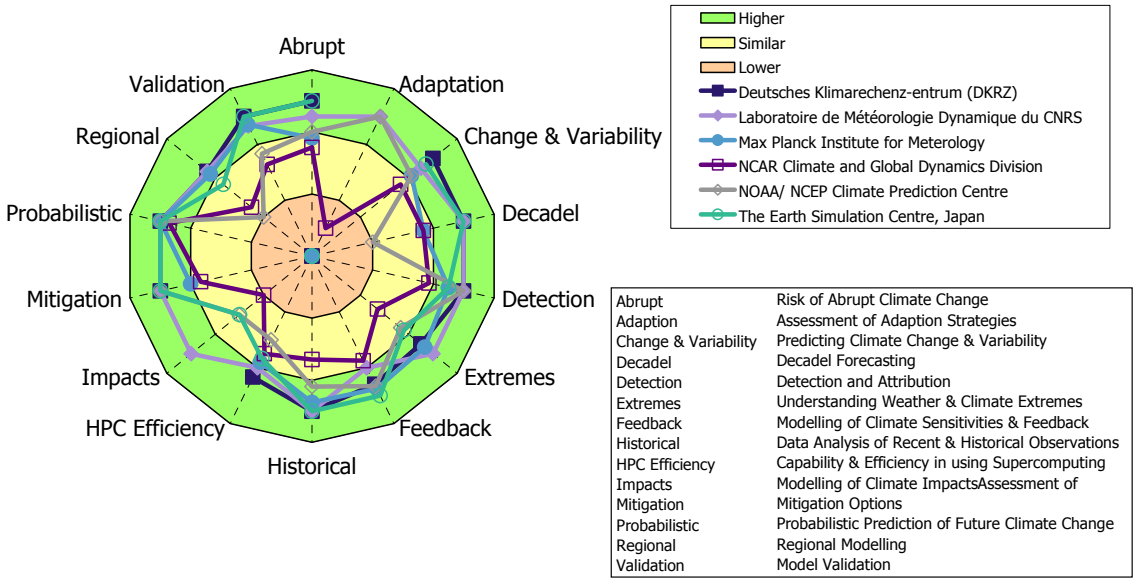


Figure 41: Peer Reviewer Assessment of Relative Quality of Hadley Centre Scientific Output

Figure 42 indicates that the collaborators generally consider the Hadley Centre to produce scientific output of higher quality that the other six climate change centres. Only Hadley's supercomputing capability was considered to be behind when compared with the Earth Simulation Center.

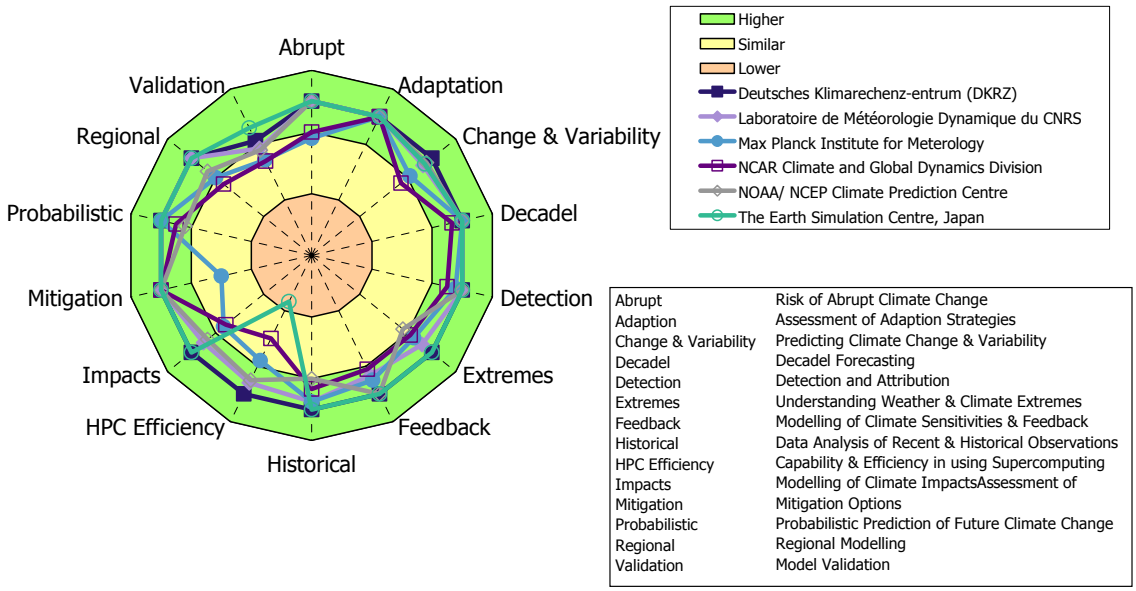


Figure 42: Collaborator Assessment of Relative Quality of Hadley Centre Scientific Output

Appendix 8: Citations Analysis

This Appendix both discusses the citations analysis provided by the Hadley Centre and presents some further analysis carried out by Risk Solutions.

Introduction

One of the documents provided to the Risk Solutions review team summarised a citation count analysis produced by Philip Brohan[17]. The conclusion from his analysis was that Hadley Centre papers published in journals indexed in the Web of Science system have significantly higher citation counts than those published by other climate centres.

A commonly used metric for assessing the "quality" of research is the average number of citations per published paper, see Figure 1 (taken directly from Brohan's summary).

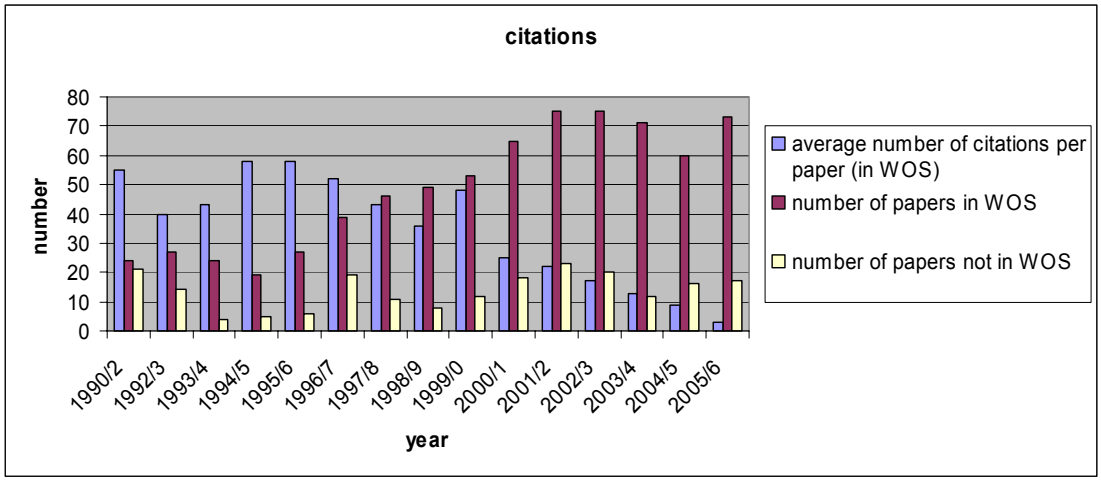


Figure 1: The number of Hadley Centre papers in the Web of Science (WOS) in each year, together with the average number of citations of these papers. The number of papers not in WOS is also given. From the analysis by Brohan.

The fall in citation index after 1999/2000 is believed to be a reflection of the time it takes for new papers that cite these papers to appear in the published literature. Before that date, it can be seen that the average number of citations per paper varies between approximately 30 and 60.

However Brohan argues that this is not a very good description of a typical paper because the distribution of citation counts among papers is very skewed: most papers have few citations but a small number of papers are very heavily cited. He has

[17] Hadley Centre Five Year Strategy, Annex C: Review Citations.

therefore calculated the H-index[18] for all Hadley papers, and has produced an estimate of how Hadley's H-index compares to that of a hypothetical sister organisation by randomly sampling from other papers published in three peer reviewed climate-only journals (International Journal of Climatology; Journal of Climate; Climate Dynamics), see Figure 2. The initial rise in H-Index goes with the rise in the number of papers published, the fall in the last few years reflects the fall in the number of citations seen in Figure 1. It was the relative position of the Hadley curve compared to the hypothetical organisation's curve that led to his conclusion concerning Hadley's higher than average citation count.

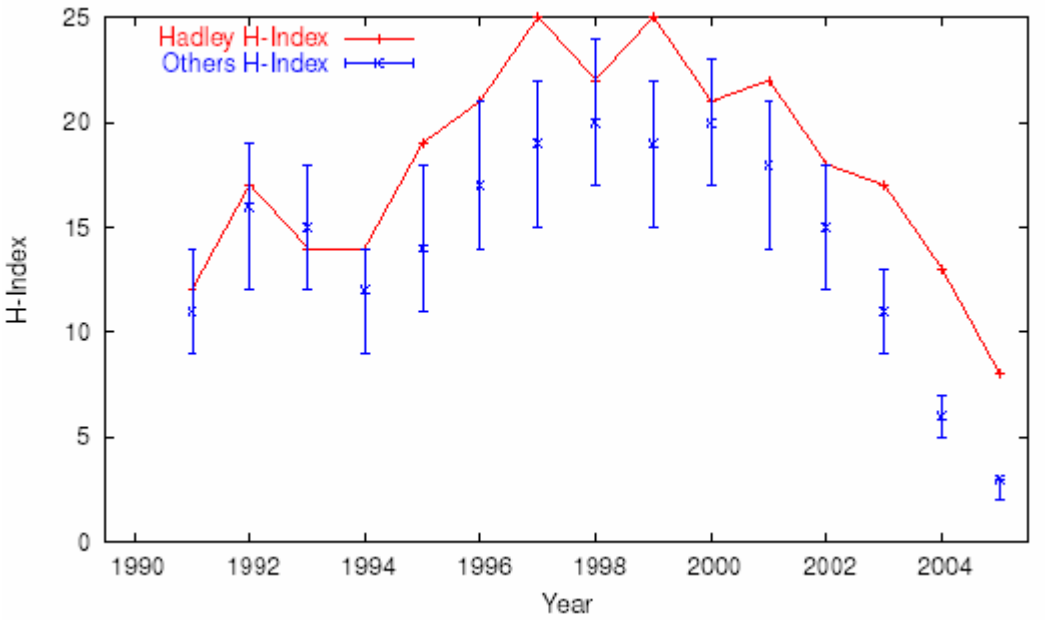


Figure 2: The H-index for the Hadley Centre compared with that for an imaginary sister organisation, generated by randomly sampling from papers published in three specialist climate science journals. From the analysis by Brohan.

Observations

As Brohan noted:

- Citations are not a perfect measure of the quality of a research paper, and there is a time lag of several years between a paper being first published and significant numbers of other papers citing it
- Citation statistics are not available for all the papers Hadley publish (papers not in Web of Science are excluded from his analysis)
- A lot of Hadley's work does not lead to research papers

[18] A group of Np papers has index h if h of the papers have at least h citations each, and the other (Np - h) papers have fewer than h citations each.

Nevertheless, we agree that citation analysis can give some useful insights into the quality of science being produced by an organisation. But we also feel that some more analysis is necessary before we can confirm Brohan's overall conclusion. In particular:

1. Is it true that the three climate science journals chosen by Brohan represent an unbiased sample to compare against Hadley's papers? For example if a paper is more likely to be highly cited if it appears in Nature or Science, the presence of these papers in the H-index calculation for Hadley versus the absence of such papers in the H-index calculation for the hypothetical sister organisation might explain the difference between the two curves.
2. Is a random sample of all papers a true surrogate for a "sister organisation"? For example if Hadley's citation count was directly compared against that for a genuine sister organisation, would Hadley's performance still stand out?
3. Are there other measures of citation count that could be calculated using the same set of data? The H-index is somewhat esoteric, and its value depends on the number of papers published as well as their individual "quality", so it is difficult to compare organisations of differing sizes that publish significantly different numbers of papers each year.

These three questions are addressed in Section A5.3 below.

Additional citation analysis

The additional analyses described in this section were carried out by Risk Solutions on the same raw data used by Philip Brohan, kindly supplied by him in January 2007.

Check for sample bias

Table 1 shows the total number of papers published, the total citation count, and the average number of citations per paper for the Hadley Centre papers indexed in Web of Science.

Journals	Time period								
	1998/99 to 2005/06			1999/00 only			2000/01 only		
	No. of papers	No. of citations	Avg. citations per paper	No. of papers	No. of citations	Avg. citations per paper	No. of papers	No. of citations	Avg. citations per paper
All journals in Web of Science	519	10432	20.1	52	2517	48.4	65	1607	24.7
Nature only	23	1450	63.0	2	253	126.5	3	437	145.7
Science only	9	439	48.8	2	118	59.0	1	132	132.0
Climate Dynamics only	61	1682	27.6	8	816	102.0	6	139	23.2
Journal of Climate only	64	1271	19.9	5	163	32.6	5	110	22.0

Journals	Time period								
	1998/99 to 2005/06			1999/00 only			2000/01 only		
	No. of papers	No. of citations	Avg. citations per paper	No. of papers	No. of citations	Avg. citations per paper	No. of papers	No. of citations	Avg. citations per paper
International Journal of Climatology only	12	305	25.4	2	92	46.0	1	28	28.0
Clim. Dyn.; J. Clim; and Int. J. Clim.	137	3258	23.8	15	1071	71.4	12	277	23.1

Table 1: Citation data for Hadley papers

Two full years have been selected, 1999/00 and 2000/01. These fall either side of the "cliff edge" observed in Figure 1, i.e. relatively few papers published between 2001 and 2005 will have been able to reference papers published in 2000 due to the time taken to write the paper and get it accepted and published in a peer reviewed journal. Also shown is the average over the period 1998/99 to 2005/06. The table shows that papers published in the most prestigious journals such as Science and Nature do indeed generate higher citation counts on average. However, the average citation count for the three journals selected by Brohan is comparable to the average citation count for all journals, so the potential skewing effect of the Nature and Science papers does not seem to be significant.

Hadley compared to true sister organisations

A careful analysis of the research address and reprint address fields in the citation database records has enabled us to identify a good sample of papers from the three climate journals (Clim. Dyn.; J. Clim; and Int. J. Clim.) with either the Hadley Centre, the Max Planck Institute and/or NOAA[19] listed as one or more of the contributing authors. Many papers have multiple authors, some from different institutions, with up to twenty five authors listed for some papers – a paper in the database with authors from more than one of these three organisations will therefore appear in the statistics more than once. The total number of papers in the samples, their citation count, and the average number of citations per paper is summarised in Table 2.

[19] The database search was able to identify papers produced by NOAA as a whole, but not by its separate sub-divisions such as NCEP, GFDL etc, due to differences in spellings and inconsistent address listing styles.

	All papers in the three journals			Hadley Centre papers		
	No. of papers	No. of citations	Avg. citations per paper	No. of papers	No. of citations	Avg. citations per paper
1999	391	8370	21.4	15	663	44.2
2000	468	9813	21.0	17	833	49.0
2001	492	6738	13.7	17	420	24.7
2002	445	4561	10.2	19	168	8.8
2003	495	3149	6.4	19	186	9.8
2004	577	1475	2.6	11	68	6.2
2005	520	228	0.4	19	7	0.4
	NOAA papers			**Max Planck papers**		
	No. of papers	No. of citations	Avg. citations per paper	No. of papers	No. of citations	Avg. citations per paper
1999	33	1079	32.7	16	716	44.8
2000	43	839	19.5	14	349	24.9
2001	43	585	13.6	10	175	17.5
2002	33	638	19.3	10	142	14.2
2003	39	432	11.1	13	125	9.6
2004	50	183	3.7	14	52	3.7
2005	43	24	0.6	19	3	0.2

Table 2: Citation data from three journals: International Journal of Climatology, Journal of Climate, and Climate Dynamics. Average citation count for all papers and for the Hadley Centre, NOAA and the Max Planck Institute.

Table 2 shows that the Hadley Centre and the Max Planck Institute are publishing a comparable number of papers each year in these journals, with NOAA publishing approximately twice as many. All three institutions show the same fall-off in citation count for more recent papers due to the time lag effect discussed above. There is some slight evidence that the citation count for Hadley is falling off faster than for the other two organisations, although it is too soon to say whether this is a significant difference or a statistical fluctuation due to the lack of stability in the "average number of citations per paper" metric. Figures 3a to 3c therefore show the full citation count distributions for the three organisations compared to that for "all papers" for 1999, 2001 and 2002.

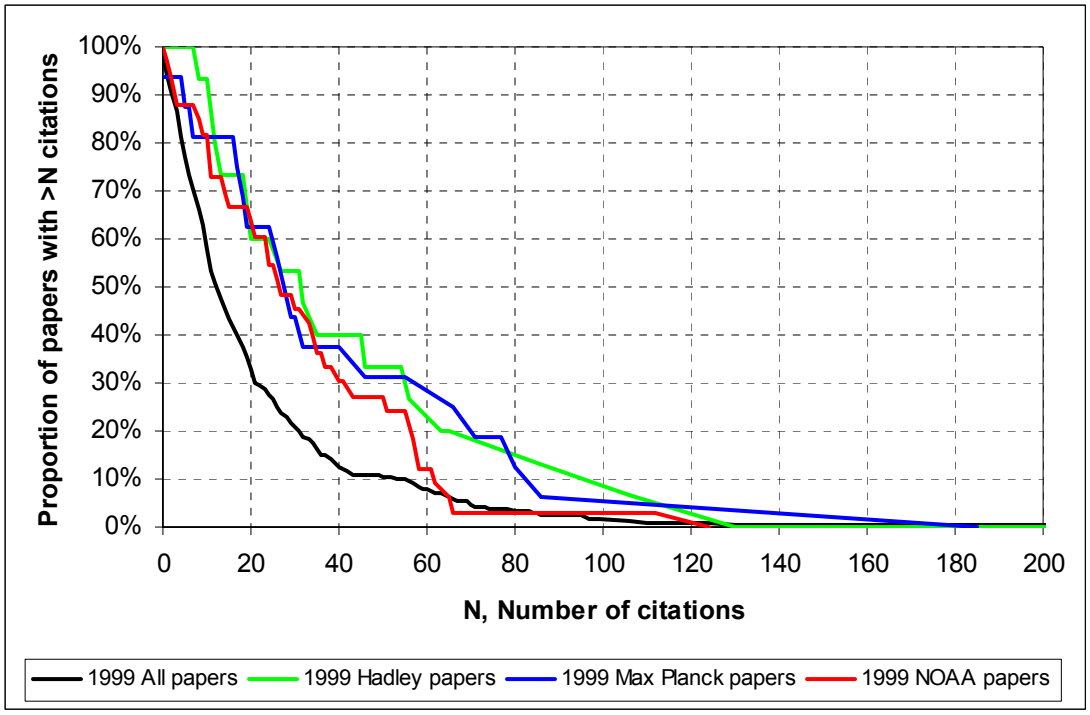


Figure 3a: Proportion of papers with >N citations for papers published in three climate science journals in 1999.

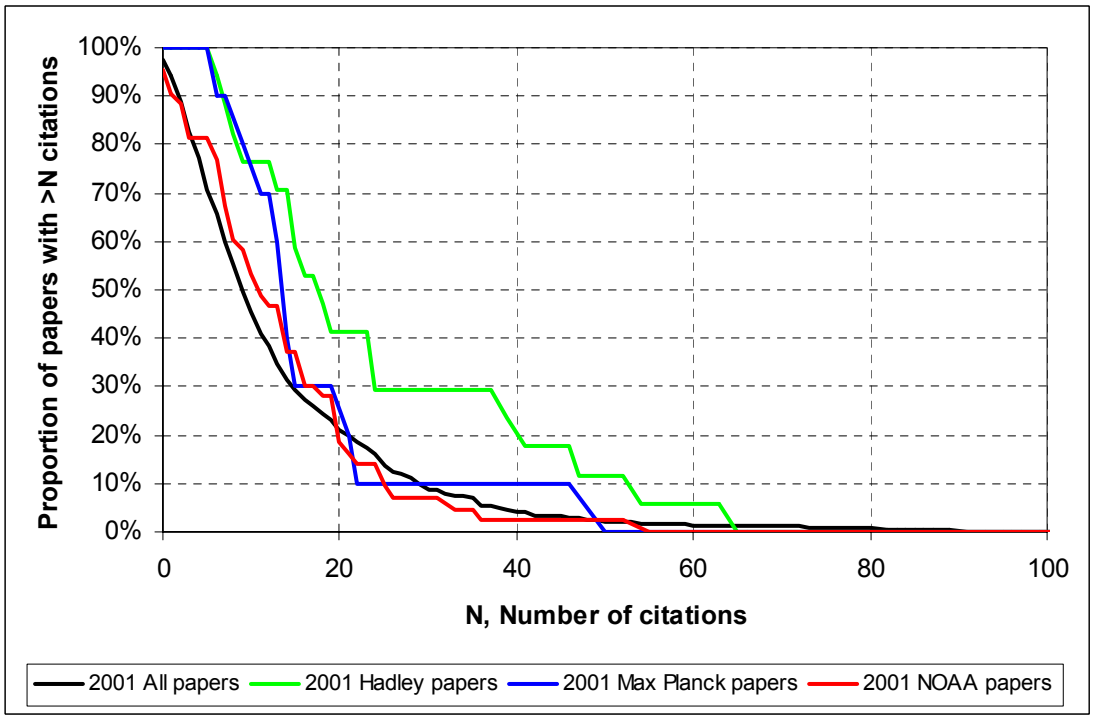


Figure 3b: Proportion of papers with >N citations for papers published in three climate science journals in 2001.

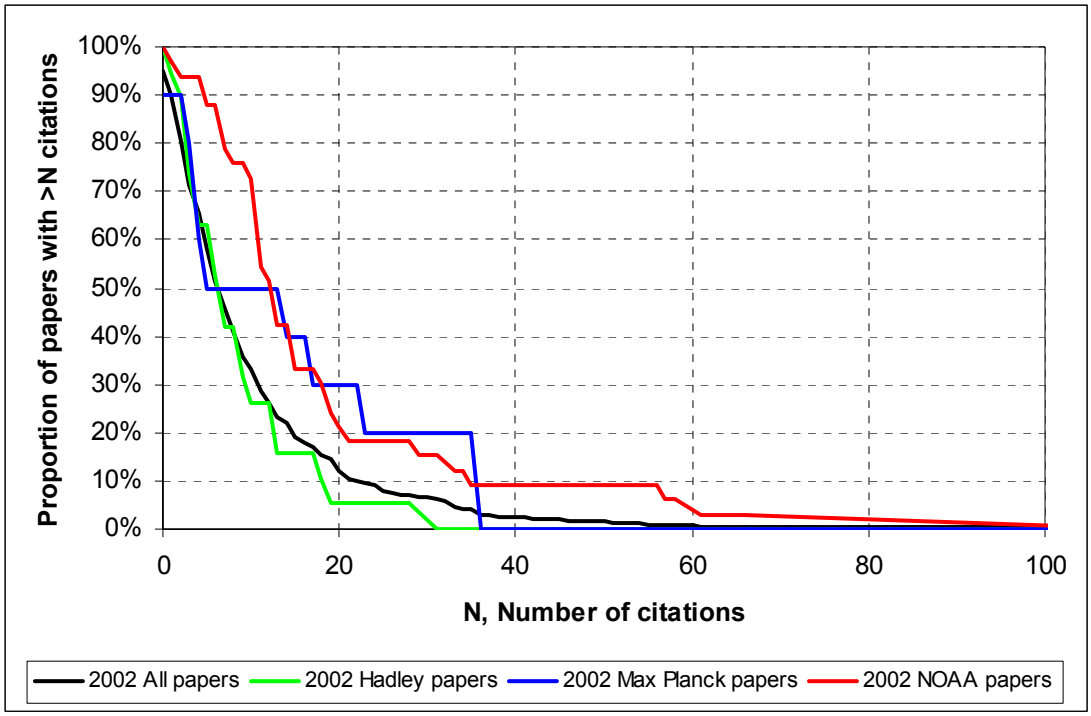


Figure 3c: Proportion of papers with >N citations for papers published in three climate science journals in 2002.

Figure 3a shows that the papers produced by all three institutions in 1999 now have significantly higher citation counts than average, for example between 30% and 40% of their papers have more than 40 citations each compared to around 10% of papers on average. However the distributions for the three institutions are all quite close to each other until you reach the distribution tails (where the number of papers is small).

Figure 3b shows that the papers produced by the Hadley Centre in 2001 have had a particularly big impact, with the Hadley curve significantly separated from the other two institutions and from the average.

However, Figure 3c shows that the Hadley Centre papers published in 2002 have had a much lower impact compared to the other institutions. This may be an artefact of the time it takes for citation counts to build up, so we recommend that Hadley repeats this analysis each year as a useful benchmarking exercise.

Alternative citation metrics

The Office of Science and Technology PSA Metrics[20] include a number of citation measures that are relative, i.e. normalized for the effect of number of papers published. Table 3 below summarises those that we thought were potentially the most useful.

[20] Department of Trade and Industry, Office of Science and Technology: PSA target metrics for the UK research base, December 2005.

PSA Metric	Definition
3.01	(Sum of citations of Hadley papers / Sum of citations of all papers)
3.04	(Sum of citations of Hadley papers / Sum of citations of all papers) minus (Total number of Hadley papers / Total number of all papers)
3.05	(Total number of uncited Hadley papers) / (Total number of all uncited papers)
3.06	(Total number of Hadley papers with >1 citations) / (Total number of all papers with >1 citations)
3.07	(Total number of Hadley papers in the top 10% of papers by citation count) / (Total number of all papers in the top 10% of papers by citation count)[21]

Table 3: PSA Metrics

In fact relatively few papers have no citations, so metric 3.05 is not very informative. Figures 4a to 4d show the other metrics for the Hadley Centre, Max Planck Institute and NOAA using the three climate science journals as before.

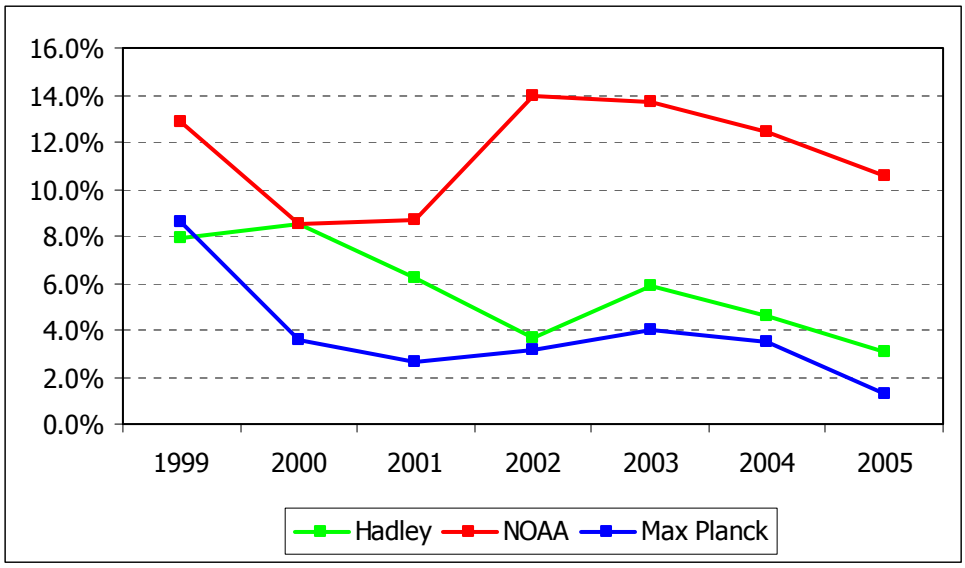


Figure 4a: Metric 3.01: (Sum of citations of Hadley papers / Sum of citations of all papers) across three climate science journals, and similar for NOAA and the Max Planck Institute

[21] The original PSA Metric 3.07 uses the top 1% of papers, because it is calculated on a national basis. We have changed this to the top 10% of papers because our sample sizes are that much smaller.

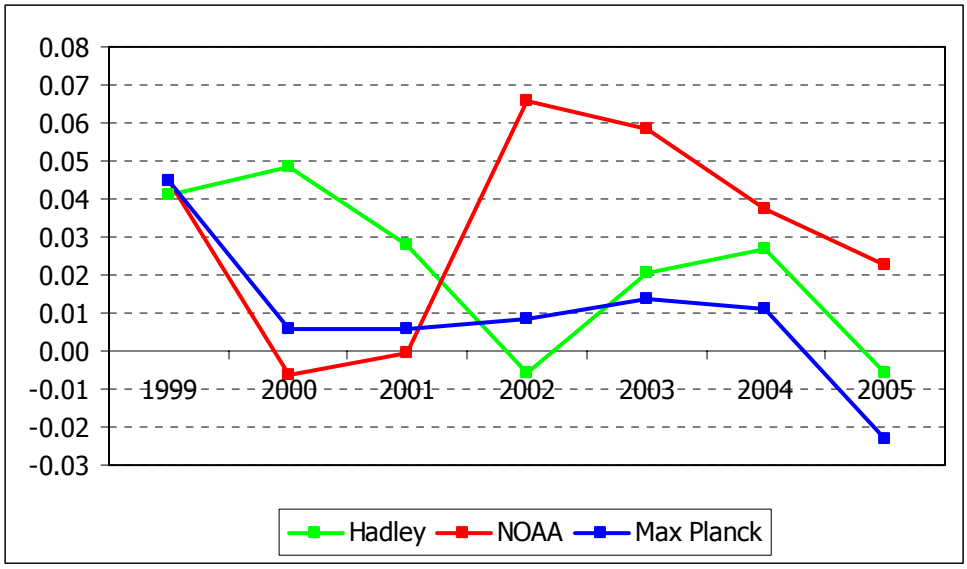


Figure 4b: Metric 3.04: (Sum of citations of Hadley papers / Sum of citations of all papers) minus (Total number of Hadley papers / Total number of all papers) across three climate science journals, and similar for NOAA and the Max Planck Institute. A value of greater than zero signifies that the organisation is achieving a greater share of citations than would be expected based on its share of published papers.

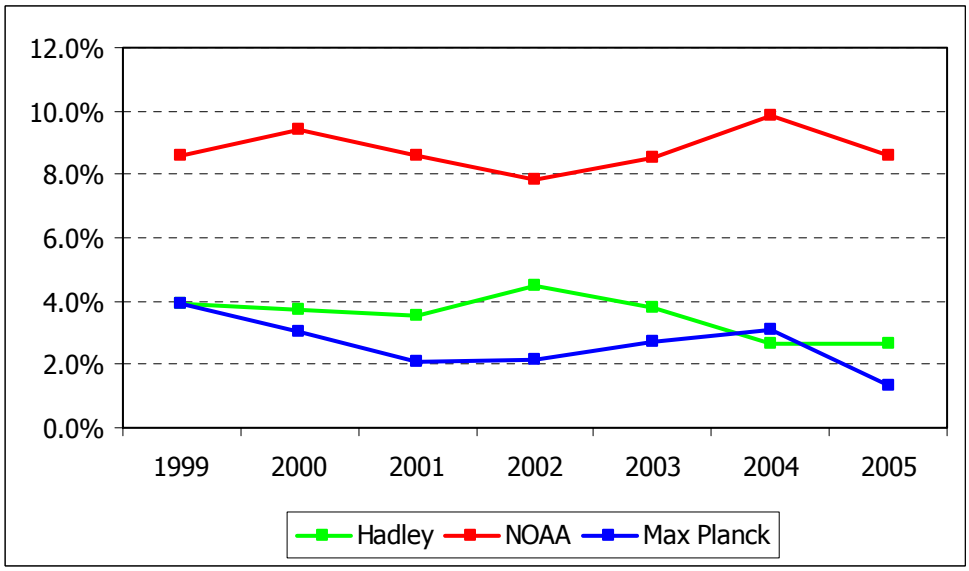


Figure 4c: Metric 3.06: (Total number of Hadley papers with >1 citations)/ (Total number of all papers with >1 citations) across three climate science journals, and similar for NOAA and the Max Planck Institute

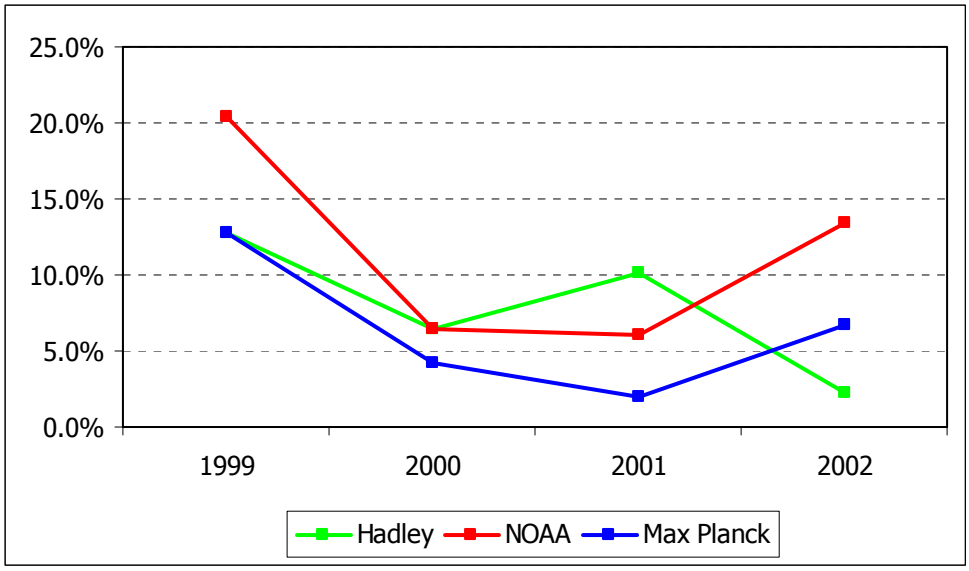


Figure 4d: Metric 3.07: (Total number of Hadley papers in the top 10% of papers by citation count) / (Total number of all papers in the top 10% of papers by citation count) across three climate science journals, and similar for NOAA and the Max Planck Institute. The citation count statistics are insufficient to calculate this metric for papers published after 2002.

Recommendations

There are a number of problems with citation count analysis as a measure of science "quality", the most important of which is the time lag inherent in the natural cycle of incorporating previously published work in one's own work, and then getting it published. Nevertheless some form of citation count analysis is a useful component of any attempt to benchmark the performance of the Hadley Centre. The H-index analysis produced by Philip Brohan is valuable and should be continued, but there are other metrics that we have suggested here that might give a complementary view. Also, it has proved possible to identify genuine sister organisations from the citation count databases rather than using a hypothetical organisation constructed using random sampling. From the analysis presented here it would seem that the papers produced by the Hadley Centre and its true peers are indeed having a larger impact than the average, but if Hadley wants to continue to claim to be one of the world's leading climate science institutions it should be benchmarking itself against genuine sister organisations on a regular basis and should not be content with simply comparing itself to the average.

Appendix 9: Written Communications Analysis

This review aimed to assess the Hadley Centre's written outputs in terms of their communications, as opposed to scientific, quality. The review built on a structured Communications Benchmark developed by Risk Solutions and tailored to the information available on the Hadley Centre outputs.

We reviewed four brochure publications plus thirteen ministerial and DEFRA briefing papers.

For the briefing papers, we considered the clarity of presentation of each paper's subject, objectives and key messages. We also considered the appropriateness of the writing style and document format to the target audience.

For the brochures, we additionally considered the planning and review process, the distribution channels used and feedback.

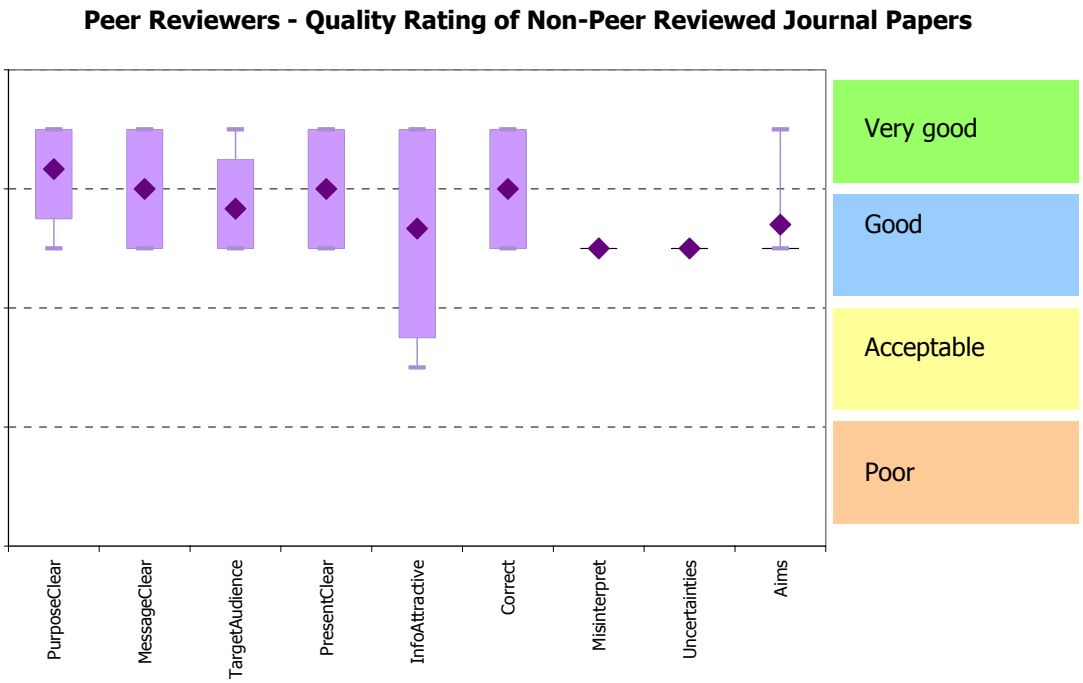
The brochures were also reviewed by the peer reviewers who carried out the review of published papers. Their conclusions have been incorporated into this report.

Brochures

The brochures were all of a high standard, being well presented, clear, and informative and in a style appropriate to the intended broad audience. Each contained a summary relating to the theme of the document followed by underpinning articles presenting the relevant Hadley Centre research. These articles were well written and the use of technical phraseology was minimised with necessary terminology and concepts mostly well explained. These aspects are important as while some recipients had relevant scientific knowledge, others were intelligent lay people. The text was supported by appropriate use of colour graphics and illustrations. This was all presented in a brochure style that in total made the publications clear, interesting and informative, and can be expected to achieve the goal of informing and educating a wide spectrum of recipients.

Three of the brochures reviewed were also given a high profile launch, in addition to being distributed at a key annual event and being made available to a wider and more general audience subsequently (including via the website). In these cases the Hadley Centre has made good use of opportunities to inform and educate relevant audiences about its work and results. The resultant range of enquires following distribution of these publications, while not a robust assessment, indicates the publications are effective in informing and educating a wide spectrum of people, which is their aim.

A graph summarising the peer reviewers' assessment of these brochures on a semi-quantitative basis is shown below.



The peer reviewers in general considered that the purpose of the brochures was very clear, the messages were clear, they were reasonably well aimed at the target audience and were well presented. The broadest range of opinion was over whether the information was attractively presented, which is a somewhat subjective measure. The content was largely considered to be accurate, although the opportunity for misinterpreting it and the handling of uncertainties in the findings could have been better presented. Overall, the peer reviewers considered that the brochures generally met their aims.

Briefing Papers

Similarly, all five ministerial briefing papers reviewed were found to be clear and concise, addressing the question asked and used non technical terminology. They were presented in a predefined ministerial briefing format. Overall they seem appropriate to the intended audience and purpose.

The seven Defra briefing papers that were reviewed are understood to have been written in response to specific questions from individuals in Defra that had scientific knowledge. We also understand that it is these individuals who would have been responsible for putting the information into a form for onward use. Given this, while the papers were found to be very variable in their quality (for example we found it difficult to determine the key messages and question being addressed in some), it is quite possible they were appropriate to their intended use. Without detailed knowledge of the original question and the intended use of the response, it was not possible to make an informed judgement on this. Therefore, while the papers were assessed using the same methodology as the other papers, we have not presented any overall results or conclusion drawn as to the appropriateness of the Defra briefing papers.

Conclusion

Based on the brochures and ministerial briefing papers we have reviewed we conclude that the Hadley Centre differentiates appropriately between the needs of different audiences, including using differing formats, and planning and review processes, and the nature of the final document content. It produces external papers with good levels of clarity that are appropriate to their intended use.

Briefing notes and documents intended to answer questions asked by scientifically literate Defra clients tend to be of more variable quality. It is unclear to us how far these meet the client needs, although Defra clients have expressed themselves as generally happy with the support and advice they receive.

Appendix 10: Analysis of Options for Delivering Strategic Climate Change Advice

The following options were considered in this analysis:

0. The Hadley Centre remains as it is now – 'Business as Usual'
1. The Hadley Centre is separated completely from the Met Office and becomes a NERC-style Centre of Excellence, perhaps attached to a University, funded through the research councils – this would require a transfer of funding from Defra/ MoD to NERC to support underpinning science, although assumes that Defra and MoD would buy specific policy outputs.
2. The Hadley Centre becomes a virtual institute, similar to the Tyndall Centre, funded through the research councils.
3. The Hadley Centre is incorporated into a European climate centre, possibly based outside the UK, funded through the EU.
4. The Hadley Centre is closed and the funds used to finance grants or contracts to the UK and overseas academic communities to supply the deliverables required by Defra and the MoD.

Option	Strategic Needs						
	UK adaptation planning	**Build capability in developing countries**	**Support for UK mitigation policy**	**Support for UK's international negotiations**	**Contribution to the IPCC process**	**Contribution to scientific expertise and prestige**	**Cost compared with current**
0	Hadley provides a UK-focused, probabilistic input into UK plans e.g. UKCIP08	Hadley supports climate research in developing countries with PRECIS and via collaborations.	Hadley provides modelling support for understanding emissions scenarios and impacts on climate	Hadley's world-leading status provides key credibility to UK negotiators (see FCO).	Hadley has made major contributions to the IPCC, on science and in leading authorship	Hadley has a strong international reputation which reflects well on the UK as a whole.	Level funding is planned for the future.
1	Could provide UK-focused inputs into plans, although may focus more on publications and other activities such as completing PhDs	Could continue to collaborate with developing countries, providing can lead to publications, or is directed to do so through a specific funded project.	Could provide modelling support for understanding emissions scenarios and impacts on climate	Could continue to support UK's position	Could continue to support the IPCC process – risk if focus too much on publication	Could maintain strong international reputation	Would need to have its own dedicated support services, e.g. human resources, finance etc, which would probably cost more than using Met Office systems, although could use NERC systems and support instead – depends how Met Office overheads are charged to Hadley at present.
	Defra and MoD would pay for specific outputs, NERC would support underpinning science. Funds would need to be transferred from Defra/ MoD to NERC. Potentially less flexible and unable to respond as quickly as at present to changing policy needs or urgent policy requirements. Overall less policy focused.						

Option	Strategic Needs						
	UK adaptation planning	**Build capability in developing countries**	**Support for UK mitigation policy**	**Support for UK's international negotiations**	**Contribution to the IPCC process**	**Contribution to scientific expertise and prestige**	**Cost compared with current**
2	Staff will be less focused and will have other priorities e.g. teaching and publishing their own work.	Could collaborate, but without a central focus this is likely to be more difficult. Would need to be specifically funded.	Staff will be less focused and will have other priorities e.g. teaching and publishing their own work.	Centre may have less kudos as a virtual organisation, and will be less tangible to the outside world.	Less likely to have the synergy of the current organisation. Individual scientists may still make strong contributions.	Centre may have less kudos as a virtual organisation, and will be less tangible to the outside world.	Shorter term funding through grants likely to reduce efficiency in the longer term. Less synergy possible due to distribution of staff. Staff are likely to work less efficiently or effectively due to other academic commitments.
	Less flexible and unable to respond as quickly as at present to changing policy needs or urgent policy requirements. Overall less policy focused. No 'one-stop shop' for Defra policy makers to rely on.						
3	Unlikely for work to focus specifically on the UK's needs, particularly for regional modelling.	Collaboration would be possible, but the UK would not be in control of this.	Unlikely for work to focus specifically on the UK's needs, particularly for regional modelling.	UK would lose the kudos of having the Hadley Centre on which to rely for its negotiating position – would be in the same position as European partners.	The new institute could provide inputs into the IPCC process, but the UK would have less influence than present – would be shared with other European partners.	UK scientists are likely to be attracted to the new institute, but would compete with European colleagues. Much less prestige accorded to the UK.	The UK would be providing only part of the funding for the institute, which would be shared with European partners. Direct costs would be much less, although there are likely to be increased costs within Defra as staff make up the policy deficit.
	The EU would not necessarily have the same approach to science quality as the UK, perhaps focusing more on EU cohesion and national representation to drive staffing and leadership.						

Option	Strategic Needs						
	UK adaptation planning	Build capability in developing countries	Support for UK mitigation policy	Support for UK's international negotiations	Contribution to the IPCC process	Contribution to scientific expertise and prestige	Cost compared with current
4	The Expert Panel concluded that the policy-focused outputs required by Defra could not be supplied on an *ad hoc* basis by the academic community.	Collaborations would need to be established between existing institutions and developing countries, but without a central focus this is likely to be more difficult. Would need to be specifically funded.	The Expert Panel concluded that the policy-focused outputs required by Defra could not be supplied on an *ad hoc* basis by the academic community.	A dispersed resource would not provide the credibility and recognition that the UK negotiators rely on from the Hadley Centre.	Scientists from across the UK could provide inputs into the IPCC process, but the UK is likely to have less influence as the Hadley Centre provides a concentration and synergy of expertise that feeds the IPCC.	Scientists would develop expertise and prestige individually. This would not necessarily reflect on the UK as a whole.	Shorter term funding through grants likely to reduce efficiency in the longer term. Less money would be available to research as Defra would need more in-house staff to manage the various projects and to bring the results together into policy-relevant advice.

Key: Strategic Need

- Fully met
- Partially met
- Not met

Key: Costs

- Lower
- As now
- Higher

Appendix 11: Comparison of Pay Scales

Anecdotally Hadley Centre staff and senior management are of the opinion that pay is falling behind the academic competition. This would mean that Hadley is paying less for the staff it has, but may also mean it is uncompetitive in attracting and retaining the best staff on which it relies for its world class reputation.

We have been provided with broad salary ranges for the different grades of Hadley Centre staff. These are shown in Table 1 below, together with, as far as possible, the academic equivalent grade ranges as at the most recent (2006) pay agreements for universities.

Hadley Grade	Pay range (£k)	Academic Grade equivalent	Pay range (£k)
JL4 (entry grade)	18-25	Entry level researcher	22-30
JL3 (3-6 years experience)	25-35	Expected progression for researcher	31-40
JL2 (senior scientist)	35-45	Senior level researcher	41-48
JL1 (senior manager)	45+	Professor	50+
Director	60+		

Table1: Comparison of Hadley Centre pay scales with that of the Academic Community in the UK

From this table we can see that while the grades used at the Hadley Centre do not precisely match those used in the academic sector, pay rates do not appear to be very far removed. It may be that where a particular individual has been targeted e.g. for a Chair at a university, they may be offered an attractive salary to encourage them to move. Academic pay scales, while nominally common across universities and other institutions, actually vary considerably between them as individual universities negotiate the points on the common pay spine that apply to different grades. Academic pay is also far more structured, with staff moving up a 'spine point' each year, whereas at the Hadley Centre pay is slightly more flexible, and may include a performance element. From this comparison table it does not appear that the Hadley Centre needs to materially increase its salaries across the board to maintain competitive salaries, apart from perhaps at the most junior grade.

Appendix 12: Case studies – culture and commercialisation

The following case studies demonstrate some different aspects of how commercialisation can be inimical to the culture and success of an organisation.

Tobacco Companies and Research Institutes

In 1996 the MRC's Neurochemical Pathology Unit sought additional external funds to avoid redundancies. They took a contract from a tobacco company which led to accusations of conflict of interest, the risk of biased science etc. The MRC had to step in and ensure there was a contractual clause that meant the Unit could publish without clearance by the client.

Also in 1996 the cancer research charity CRC sought to cut funding to Cambridge University which had accepted research funding from BAT (British American Tobacco). CRC eventually relented but then issued a code of conduct to ensure the situation could not recur.

The key point in these examples is that the commercial work brought vocal complaint from stakeholders and risks to other funding streams. We might consider that the problem with a medical research institute entering into a relationship with a tobacco company would be an obvious one, but where else could such a company get respectable science done? Nobody would believe results from their own labs (if they had any). The possible analogue is for Hadley to get funding from a large company known to be sceptical about climate change.

DERA

The Defence Evaluation and Research Agency (DERA) had a remit to seek commercial exploitation of its intellectual property. Relations with the US Department of Defence and its labs were excellent until it became clear that DERA was to move from being a Trading Fund into a Government-Owned Company with a view to eventual privatisation.

The US authorities took the view (which they always have) that they would freely exchange information on a Government-to-Government basis but they would not do so where commercial interests were present. This created a fuss with the outcome that the potential privatisation was modified, with DERA being split into QinetiQ as a private company, and Dstl which remained as a Government body. The US were still concerned and pending detail as to exactly what was to happen, DERA staff were no longer welcome at DOD facilities and information flow stopped. The DoD insists that all leaders of collaboration are Government employees, so QinetiQ staff who had been the UK lead were shut out. The US is very open with the UK on a Government-to-Government basis but will be very protective of US interests as soon as commercial interests are present. Information sharing has to be kept separate from exploited data.

The House of Commons Defence Committee wrote in June 2000:

"*In the meantime, damage has been done to the MoD's relations with industry, DERA's personnel and the US Department of Defense. The DoD, in particular, appears to be some way from finishing its assessment of the implications of the latest proposals, and already it appears that the flow of collaborative research work may have been impeded because of US misgivings about the status of its chief collaborative partner.*"

This could have been a disaster for the UK.

The possible analogue with Hadley is where commercial exploitation might be seen to be in conflict with information or other exchanges provided freely by overseas partners. In these cases, perception matters as much as the reality and once trust is dented, its restoration can be a difficult process.

CCLRC

The Council for the Central Laboratory of the Research Councils (CCLRC), following its formation in 1994, had a remit to generate a growing proportion of its income from commercial activity. At this time, its income was primarily from Research Council grants paying for use of CCLRC facilities. The difficulty was that they had no control over rates charged and were not able to recover capital costs - they could only cover operating costs and had to seek separate funding for capital expenditure. Their clients (researchers) could at the same time make use of international deals whereby use of other countries' facilities would be free and researchers in those countries could use UK facilities for free. The latter caused some complex bartering where overseas researchers used CCLRC facilities, but the outcome was that CCLRC was in a precarious position. Worse, in order to take on commercial work, it needed to be able to take risk in the form of extra resource not only to do the work, but also to bid for it, with a significant risk of losing any bid. But they had no reserves and were not allowed to borrow. There were also strong limits on the rate at which they could accumulate reserves. It is no surprise that they never met the commercial target. Fortunately the arrangements changed somewhat in later years.

The commercialisation requirement had never been thought through - not just the money, but where priorities should lie in delivering the service. As the equivalent of a Trading Fund receiving grant-in-aid, they were not entitled to take risks with their money; hence any commercial work will be marginal unless they were able to build reserves that could be risked.

How does the Hadley Centre compare in this? They are very small and could not commit significant resource to bidding, let alone doing significant extra work. Their contracts make no provision for this. They would need a central pot of seed corn investment money provided by the Met Office. This is an issue for the Met Office to consider if it is serious about developing commercial work. It should not come from the Defra/ MoD contracts, for example, unless supporting this commercial development is important to Defra and MoD (which we do not believe it is).

Appendix 13: Initial comments on the draft contract documents

Hadley has prepared two early documents relating to the CPP document:

- A briefing document[22]:
- A draft Project Definition Agreement[23]

Briefing Document

We assume this is intended as a response to the clients to show how their needs will be responded to.

There is an apparent inconsistency in the opening of the document:

Para1 - The requirements from Defra and MoD have substantially changed…

Para2 - … much of our focus will need to remain unchanged

At first glance these cannot both be true. What can be deduced form reading further is that the client has made clear the areas where output will be required so as to inform policy. The response should be that this will refocus the programme but that the underpinning basic science has to be there. The Hadley Centre should aim to express this clearly and transparently link the science plan with the required policy outputs.

In section 3 there is mention of supercomputing with the assessment that the new requirements call for significantly improved modelling systems which in turn call for much higher resolution. It then goes on to say that the new investment will deliver 6-8x current computing power and that this "*will be insufficient to run models at much higher resolution*…" This makes the investment sound pointless. Hadley needs to develop the case showing what can be done with this amount of investment and what more could be achieved with higher powered computers.

The narrative in sections 1-4 needs to be much more convincing.

Project definition agreement

This looks like a reasonably clear early draft of the agreement. Reference is confused slightly by the strange change of paragraph numbering from page 9 onwards.

Broadly speaking this looks like a reasonable output-based specification. Much will turn on the Hadley Centre response which will flesh it out.

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22 Briefing Document, New CPP and DCRP Contracts Vn. 1.0 15 January 2007

23 Project Definition Agreement for the Climate Prediction Programme between the lobal atmosphere Division, Defra and the Hadley Centre, Met Office, DRAFT for discussion, Version 2.1, 2007-2012

There should be a section on governance. This should include change control (who authorises changes and how) which matters with an alleged fixed price contract. It should also include the steering group we discussed.