AATSR Principal Investigator

DEFRA Contract no: EPG/1/1/157

Final Quarterly Progress Report – March 2004 – June 2004

This report covers work done during the final reporting period of this contract, namely the period of March 2004 to June 2004 inclusive. DEFRA have agreed to extend the contract to the end of June 2004. Work done during this extension is described in this report.

(i) Summary of work performed during the reporting period

Some time was spent on early preparation for the SAG and on actions arising from the AATSR Quality Working Group, in preparation for the QWG meeting planned to take place after the SAG.

A meeting of the AATSR SAG was held at RAL on March 3

A meeting of the AATSR QWG was attended at RAL on March 4th.

A visit was made to Met Office and Hadley Centre at Exeter on March 5th. This was initially to have a meeting with Roger Saunders, Anne O'Carroll and James Watts about various technical issues concerning their buoy inter-comparisons. A number of issues were clarified.

It was also possible to meet with Nick Rayner, who explained how AATSR data are being evaluated and used in HadISST.

Nick Rayner had also arranged meetings with other users of AATSR data at the HC, which included introductory discussions held with David Rowell, who works on teleconnection patterns; with Doug Smith who works on decadal modeling; and with Mike Bell who works on data assimilation using FOAM and the NWP model.

These initial contacts were considered to be very important, because they give us an oversight of the HC's various interest in AATSR data and it was decided to visit the HC at least twice per year if possible in future, in order to maintain a good overview of AATSR-related work at the HC and thereby to ensure that there wee no serious obstacles to their use of the data.

While at the Met Office, the opening ceremony for the GHRSST project Office was attended and discussions held with several ESA personnel about future AATSR possibilities, primarily in the GMES programme.

During that week the second NERC EO Conference, at Plymouth, was attended. In addition to several posters from Leicester regarding AATSR validation and aerosol

measurements, DLJ gave a presentation on Climate change detection (work by S Lawrence, Leicester). This paper was very well received and stimulated a number of questions.

A particularly interesting paper was presented by Peter Cox of the Hadley Centre, who showed some global anomaly fields in vegetation cover (NDVI) which were correlated with el Niño events. This was particularly interesting because it showed manifestations of climate processes which were observable from land remote sensing, and, as the AATSR NDVI product eventually is validated, the possibility of examining el Niño related anomaly fields and other anomaly fields will be investigated (not under PI contracts)

On April 30th a meeting had been arranged at ESRIN, to include DLJ and Chris Mutlow, to discuss ESA's plans for archiving all ATSR data including AATSR. ESA also wished to discuss various AATSR promotional activities I preparation for the Salzburg symposium to be held in September. In the event, Alitalia cancelled the flight so that, following an abortive visit to Heathrow the previous evening, a 3-hour teleconference with ESA was held with the various parties. ESA want to find a way of getting access t the seamless archive so that they can make it available the wider user community. The way to achieve this was not decided.

ESA wished to produce a booklet, a movie and some sample level 3 (monthly average SST) data products. DLJ agreed to provide input for these and C Mutlow agreed t help with the booklet production.

Subsequently, on June 24th, CTM and DLJ met with ESA's contractors (Mike Wooding and Marie-Claire Greening of Remote Sensing Applications Consultants Ltd). The content, a pssible format foer the booklet was agreed; and it was also agreed that DLJ would draft most of the contents and CTM provide assistance with other material such as images. A significant amount of work was done in June and during the following contract period in supporting this activity.

From 18th to 21st May, a Meeting if the American Geophysical Union (AGU) General Assembly, at Montréal, was attended by DLJ to give invited presentations ob AATSR. These presentations covered recent validation results and the climate change detection work. This was in a special session on dual-view remote sensing organised by David Diner of JPL, who is the PI for MISR, a NASA-funded optical multi-angle sensor on the EOS-TERRA satellite.

There were some presentations relevant to the problem of atmospheric corrections for visible-wavelength land-surface remote sensing and as this area develops in the AATSR exploitation programme it will be important to maintain contact with the MISR Science Programme. It was agreed the interactions between the respective science teams should be organised in the future.

Throughout the reporting period there have, as usual, been frequent and regular interactions with others at ESA, DERA, RAL, NERC and various individuals involved in

the programme. There have also been regular discussions, several times per week, with the validation scientist about validation strategy, the interpretation of results and the development of the AATSR Science Exploitation Plan, which was discussed a the March Sag and which will be distributed with the minutes of the recent SAG held on September 16th.

Related work Outside this Contract

NERC required the final report on the ATSR 1 and 2 post-launch support Programmes. This was produced, largely by CTM, but with substantial input from DLJ and was presented to the NERC Earth Observation Experts' Group (EOEG) on June 24th. The EOEG wanted strong emphasis on the scientific output. In fact there have een about 370 refereed publications from the programme so far, plus a much larger number of conference and similar publications. A copy of the executive summary, which is being used to summarise the report to NERC senior boards, is appended to this document, because it contains some relevant background to the current programme.

(ii) Cumulative effort and expenses expended to 31 June, 2004

Heading	**No. of Days** *(if applicable)*	**Cost £**
Principal Investigator	50 days	27,885.00
Project Scientist (RAL) sub-contract	days	12,539.00
Travel		5,237.09
Consumables		3,456.91
	Total (excl. VAT)	**49,118.00**

ANNEX - Final Report to NERC on the ATSR-1 and ATSR-2 Programmes
Executive Summary

Introduction and Background

1) NERC has had responsibility for the first two Along-Track-Scanning-Radiometer space instruments, ATSR-1 and ATSR-2 ever since the Earth Observation part of the Research Councils' Space Research programme was transferred to NERC, following the White paper of 1993. This responsibility finished with the successful commissioning of the ENVISAT Satellite, which effectively continues the ATSR data-set under another funding umbrella, and the EOEG has received the report of the work carried out under the ATSR 1 and 2 Post-launch Support programme.

2) ATSR-1 was designed as an experimental instrument to measure global sea-surface temperature from space with the demanding levels of accuracy, of the order of $^{+}/_{-}$ 0.3°C globally, which was emerging as a strong requirement from the climate research community. This was in recognition of the importance of ocean-atmosphere heat transfer to major atmospheric processes which dominate climatic behaviour.

3) The first ATSR was launched into space in 1991, on-board ESA's ERS-1 satellite. The sensor was designed and built by a consortium consisting of RAL, Oxford University and University College, London's Mullard Space Science Laboratory (MSSL). It was funded by the then Science and Engineering Research Council, with additional contributions from DTI, Australia and France and supplied to ESA as a nationally provided payload element in response to an announcement of Opportunity.

The ATSR Programme

4) The ATSR concept is to combine a novel dual-angle viewing geometry with the technology of high-performance radiometry, together with the excellent skills and experience available in the UK atmospheric research community to retrieve an atmospheric correction of sufficient accuracy from the sensor's top-of-the-atmosphere radiance measurements.

5) The resultant sensor also incorporated two innovative technological developments from the proposing consortium, namely a newly developed closed-cycle cooler, to provide optimum detector performance, plus a highly innovative self-calibration system, leading to a near-ideal radiometer which produced 1 km resolution thermal and reflected infrared images of quite exceptional quality. The successor instrument ATSR-2, incorporated additional visible-wavelength channels with the extra objective of developing the use of along-track scanning for quantitative remote sensing of land surfaces in the visible and reflected infrared wavelength regions.

6) The ATSR post-launch support programme has been implemented continuously since the launch of the ERS-1 satellite in July 1991, until the successful commissioning of the AATSR sensor on ENVISAT in 2002. In 1994 under NERC, the ATSR PLS programme became funded through a service-level agreement between NERC and CLRC/RAL. After its launch in March 2002, AATSR, which is funded primarily by DEFRA with a contribution from NERC, became the prime source for the continuing data set.

7) Since autumn 2002, RAL has been completing the ATSR-1/2 UBT data archives and its transfer to NEODC under SLA funding, and has continued ATSR-2 flight operations under a direct contract from ESA.

Output of the Programme

8) Since the beginning of the programme there has been substantial scientific output, comprising over 370 published papers in the refereed literature and a significantly larger number in conference proceedings and similar publications.

9) The scientific highlights are numerous and particularly diverse, involving many of the NERC science areas, particularly Marine, Atmospheric and Terrestrial Science, as well as some polar applications and include several investigations of climate change. . Some of the highlights are identified below.

10) Of the scientific highlights, possibly the most important is the quantitative detection of global change through the examination of an 8-year time-series of global SST measurements from ATSR-1 and -2. Advanced mathematical techniques were used to identify and remove the stronger effects of natural variability, both cyclical and stochastic, to isolate a trend in global SST. One interesting result of the work is that ATSR-1 and ATSR-2 were found to show remarkable consistency in their ability to detect and quantify small anomalies and trends. This work is of lasting importance because, not only is it a quantitative measurement that can be compared with model output, it has been achieved from the preliminary examination of 8 years of a data-set that is now over 12 years in duration and is likely to extend to at least 15 years in duration.

11) A particularly important aspect of the ATSR sensors is that they provide a high-definition sea-surface temperature field. Already, these sensors have allowed global patterns of climate change to be detected in a way that was not possible previously. Further investigations will undoubtedly lead to a better and fuller characterisation of climate changes across the globe and the processes that drive those changes, thereby enhancing climate predictability. Other scientific highlights, in the various NERC science areas, include:

Marine Science

- Tropical Instability Waves and their phase relationship to westerly wind-bursts
- Observation of thermal signature of Rossby Waves and their latitude dependence

Atmospheric Science

- Retrieval of quantitative information about global Aerosols and clouds
- Derivation of Total Atmospheric Water Vapour fields on a global basis

Terrestrial Science

- Enhanced atmospheric correction from dual-angle view, which enables quantitative estimates of photosynthetic activity and other aspects of land-cover to be made
- Global fire atlas generated by ESA

Current Situation

12) Today, the ATSR data set continues to be acquired through the AATSR sensor and the data are demonstrably the most accurate SST measurements currently being obtained from space. NERC, in partnership with DEFRA, who are funding the continued data acquisition through AATSR, are setting up a new and seamless archive of (A)TSR data, uniformly processed and formatted, which will be a major and unprecedented asset to the UK climate research community and those carrying out quantitative research on large-scale, long time-scale processes in the Marine, Atmospheric and Terrestrial Sciences. The full value of the data set is almost certainly still to be realised, as the length of the data set extends well into a climatically significant duration in excess of 10-15 years and as our skills in the interpretation of the radiance measurements continue to develop.

Some additional points

i) The funds used for the ATSR programmes were largely 'new money' for Earth Observation, not funds that were taken away from other NERC areas. The original funding for ATSR1 was bid for out of the SERC Astronomy and Space Research (ASR) Budget in competition with competing projects, mainly in the astronomy area. Later, additional funds for ATSR-2 were obtained directly from Central government in response to a PES bid made by SERC. Thus, in addition to the lasting scientific benefit, this programme has led to significant increases in the UK spending on Natural Environmental Research.

ii) The programme has also provided a model for technology transfer and knowledge transfer to industry, in that the production of an experimental observing system has now been transferred from academia to industry

iii) The ATSR programme has also achieved transfer of responsibility for continuation of the series to a user-department of government, namely DEFRA, which is the first time that such a transfer has been achieved. This meets a major current objective of BNSC.

iv) AATSR data are gradually being evaluated by operational data-users and climate analysis schemes, particularly in the UK Met Office and Hadley Cenre.