SERVICES & FACILITIES ANNUAL REPORT - FY April 2004 to March 2005

SERVICE	FUNDING	AGREEMENT	ESTABLISHED as S&F	TERM
The NERC MST Radar Facility at Aberystwyth http://mst.nerc.ac.uk	BLOCK	SLA	1996	5 years - to March 2010

TYPE OF SERVICE PROVIDED:

The Mesosphere-Stratosphere-Troposphere (MST) Radar at Aberystwyth is the UK's most powerful and versatile wind-profiling instrument. It is unique in being able to provide continuous measurements of the three-dimensional wind vector over the altitude range 2-20 km at high resolution (typically 300 m in altitude and a few minutes in time). It can also provide information about atmospheric stability, turbulence, humidity and precipitation. It is therefore ideally suited for studying everything from small-scale atmospheric phenomena through to large-scale weather systems. Wind-profile data are supplied to the Met Office, for numerical weather prediction purposes, through a commercial contract. Upper-air input from the Aberystwyth area has been found to have a significant impact on improving longer range forecasts.

The Facility operates and hosts additional instruments whose observations complement those made by the MST radar. The Met Office operates a GPS water vapour receiver at the site, and has previously operated a boundary-layer wind-profiler there. The NERC Universities' Facility for Atmospheric Measurement (UFAM) boundary-layer wind-profiler and ozone lidar are operated at the site in-between campaigns.

The mission of the Facility is:

- To operate the radar on behalf of the UK atmospheric science community
- To operate, and host, instruments whose observations complement those made by the MST radar
- To facilitate the analysis and interpretation of the data

ANNUAL TARGETS AND PROGRESS TOWARDS THEM

1	Target	To upgrade the internet connection to the radar site from 56 kbps to 2 Mbps by 1st September 2004
	Progress	This work is in the hands of NERC's networking division and so the delay is beyond the control of Facility staff.
2	Target	To extend the new MST radar signal processing software to pick out multiple spectral peaks and to be able to reprocess archive data off-line by 1st September 2004.
	Progress	This has been achieved and work is underway to make the software operational.
3	Target	To install a laser ceilometer and sky-pointing camera at the MST radar site and to upgrade the radar control and data acquisition systems pending funding
	Progress	Capital funding has been awarded by NERC and delivery of the new instruments are expected in May 2005.
4	Target	To operate the MST radar for a minimum of 98% of the available time
	Progress	The instrument was in operation for 97.9% of the available time.

SCORES AT LAST REVIEW (each out of 5)		Date of Last Review: January 2004		
Need	Uniqueness	Quality of Service	Quality of Science & Training	Average
5.0	5.0	4.5	4.5	4.75

CAPACITY of HOST ENTITY FUNDED by S&F	Staff & Status	Next Review (January)	Contract Ends (31 March)
73%	Facility Manager: Dr Sam Pepler 25% (NERC funding for this position ceases after 2004-2005) Project Scientist: Dr David Hooper 100% Site Manager: Mr Tony Olewicz 100% (UWA contract)	2009	2010

FINANCIAL DETAILS: CURRENT FY

Recurrent Allocation £k	Unit Cost £k				Capital Expend £k	Income £k	Full cash cost £k
	Unit 1 NERC Specific	Unit 2 Non-NERC Specific	Unit 3 Pilot/Educational	Unit 4 Guest Instrument Support			
133.9	9.5	4.8	1.0	20	43	37.5	141.2

FINANCIAL COMMITMENT (by year until end of current agreement)

2004-05 133.9	2005-06 124.5	2006-07 128.9	2007-08 133.4	2008-09 138.1

STEERING COMMITTEE	Independent Members	Meetings per annum	Other S&F Overseen
NARFSC	5	1	CFARR

APPLICATIONS: DISTRIBUTION OF GRADES (Current FY — 2004/05) –								
	α5	α4	α3	α2	α1	β	R*/Pilot	Reject
NERC Grant projects			1					
Other academic		1					2	
Teaching/Educational	Applications in this category are regarded as Pilot and not graded						1	
Pilot	Applications in this category are regarded as Pilot and not graded						1	
TOTAL		1	1				4	
APPLICATIONS: DISTRIBUTION OF GRADES (per annum average previous 3 years —2001/2002, 2002/2003 & 2003/2004)								
	α5	α4	α3	α2	α1	β	R*/Pilot	Reject
NERC Grant projects		4.00						
Other Academic		2.33	0.67					
Teaching/Educational	Applications in this category are regarded as Pilot and not graded						3.67	
Pilot	Applications in this category are regarded as Pilot and not graded						3.00	
TOTAL		6.33	0.67				6.67	

PROJECTS COMPLETED (Current FY) – NOT APPLICABLE FOR THIS FACILITY							
	α5	α4	α3	α2	α1	β	R*/Pilot
NERC Grant projects							
Other Academic							
Teaching Educational							
Pilot							

USER PROFILE (current FY) **Combined non-Directed and Directed*

Grand Total	Infrastructure					PAYG				
	Supplement to NERC Grant *	Student		NERC C/S	Other	NERC Grant*	Student		NERC C/S	Other
		Total	NERC				Total	NERC		
22	7	5	2		9	Supply of data to the Met Office under a commercial contract				

USER PROFILE (per annum average previous 3 years) **Combined non-Directed and Directed*

Grand Total	Infrastructure					PAYG				
	Supplement to NERC Grant *	Student		NERC C/S	Other	NERC Grant*	Student		NERC C/S	Other
		Total	NERC				Total	NERC		
24.67	4.00	6.33	2.67		11.67	Supply of data to the Met Office under a commercial contract				

USER PROFILE (current FY)				
Academic	Centre/Survey	NERC Fellows	PhD	Commercial
19			2	1
USER PROFILE (per annum average previous 3 years)				
Academic	Centre/Survey	NERC Fellows	PhD	Commercial
15.33		1.33	3.33	1.00

OUTPUT & PERFORMANCE MEASURES (current FY)

Publications (by science area & type)

SBA	ES	MS	AS	TFS	EO	Polar	Grand Total	Refereed	Non-Ref/ Conf Proc	PhD Theses
			6				6	3	3	

Distribution of Projects (by science areas)

SBA	ES	MS	AS	TFS	EO	Polar
			100%			

OUTPUT & PERFORMANCE MEASURES (per annum average previous 3 years)

Publications (by science area & type)

SBA	ES	MS	AS	TFS	EO	Polar	Grand Total	Refereed	Non-Ref/ Conf Proc	PhD Theses
			100 %				9.67	7.33	1.67	0.67

Distribution of Projects (by science areas)

SBA	ES	MS	AS	TFS	EO	Polar
			100%			

Distribution of Projects (by NERC strategic priority)

Earth's life support systems	Climate Change	Sustainable Economies	Underpinning Science	Specific Research
1	13	8	3	4

OVERVIEW & ACTIVITIES IN FINANCIAL YEAR (2004/05):

Much of the Facility's staff effort over the past year has been linked directly to the science projects. In particular preparations have been made for a number of new instruments (both purchased by the Facility and hosted on behalf of other groups) to be operated at the radar site. These activities will consequently be dealt with in the following two sections.

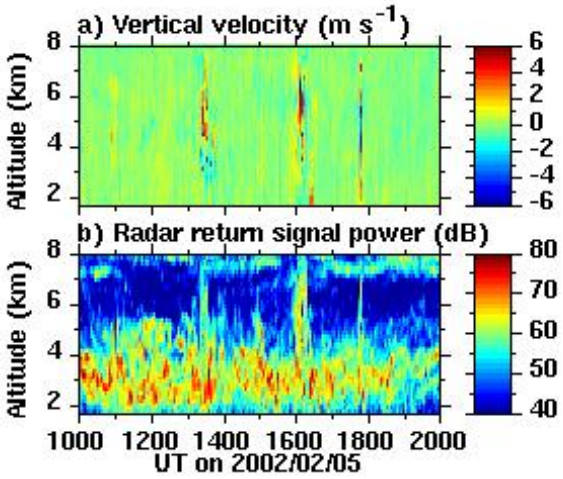
Re-organisation of the Facility's data archive. There have been large changes to the way in which MST Radar observations are made, since operations began in 1990, and to the ways in which the data are used. Nevertheless, the structure of the data archive on the British Atmospheric Data Centre (BADC) had never been updated to reflect these changes. The archive had consequently become difficult to navigate. Notable components of the restructuring included:

- Retrospectively assigning signal processing version numbers so that particular data products could be uniquely identified.
- Completely rewriting the Facility's data web pages, which now clearly describe the different file types, their contents and formats, and highlighting known problems with the different versions of signal processing.
- Reprocessing the entire data archive using both the original and current versions of the signal processing.
- Producing quick-look plots for the entire observation archive.

SCIENCE SUPPORTED IN FY (2004/05):

As described below, the MST Radar Facility is currently supporting projects which address all four key challenges identified by the NERC Centres for Atmospheric Science (NCAS) for the UK atmospheric science community: to increase knowledge of the interaction between atmospheric composition, weather and climate, to increase knowledge of the small-scale physics and dynamics of the atmosphere, to improve climate predictions, and to develop the fundamental underpinning technologies for observing the atmosphere.

Convection. Until recently it was not realised that the MST radar was capable of observing the vigorous vertical motions of convection or the atmospheric mixing that it causes. A new MST radar observation format was introduced in June 2004 to allow the convective up- and down-drafts to be measured at much higher time resolution than previously – at intervals of just 46 s, compared to 230 s (over three and a half minutes). A surprise result from these observations was that updrafts as strong as 10 m s^{-1} can sometimes be seen. The old format gave snapshots of this motion and peak velocities of only a few m s^{-1} had been detected. Moreover, it is now clear that the vertical velocities can change by several m s^{-1} in the 46 s intervals. An important consequence of this fact is that the corresponding radar-derived horizontal winds have considerably reduced reliability: an implicit assumption of the wind-profiling technique is that the wind field remains constant over the time scale required to make observations in a number of radar pointing directions. This knowledge is being exploited by the Facility's Project Scientist to improve the data reliability flagging, which will be of benefit both to academic researchers and to the Met Office.



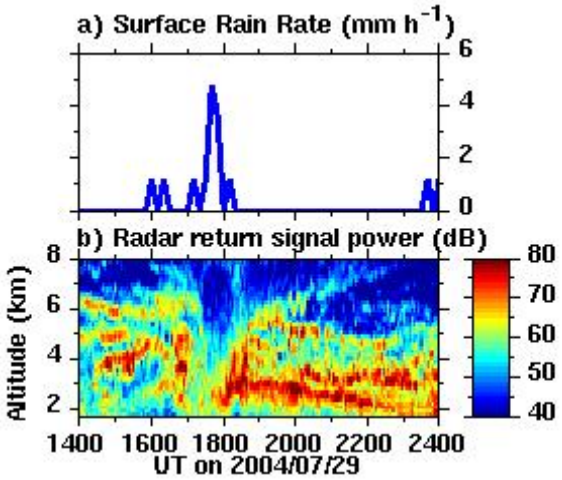
Convection, which is characterised by vigorous up- and down-drafts, gives rise to abnormally large radar return powers.

Convection also gives rise to abnormally large MST radar return signal powers. A comparison with instrumented balloon measurements has shown that these signals can be as much as a hundred times (20 dB) above expected levels. It is speculated that this is a result of mixing between the in-cloud and surrounding air. Since the same mechanism would also redistribute man-made chemicals (released at the ground and transported upwards through the convective cloud) into the upper-level air, a better understanding of this observation could have a positive impact on another current MST radar project within NERC's Polluted Troposphere thematic programme.

Precipitation (i.e. rain, snow and hail). Again, until recently it was not realised that the MST radar could detect precipitation. It is designed to detect the "clear air" radar returns which give wind-profiling information. However, unusually intense rainfall associated with convective conditions, such as that experienced around Boscastle Harbour in August 2004, can give rise to radar return signals which are much stronger than those associated with the clear air. Again, the Facility's Project Scientist is exploiting this new information to improve the radar signal processing. On the one hand, not accounting for the fact that precipitation is being observed leads to contamination of the wind-profiles. On the other

hand, the precipitation returns are being exploited as a source of new data products. It turns out that even under conditions of less intense rain, precipitation has an indirect signature: it reduces the strength of the corresponding clear-air radar returns. This phenomenon can give an indication of the altitude of precipitating clouds. Surface rain measurements give no such information.

Climatological studies. Two NERC-funded MST radar projects have exploited the quasi-continuous data archive, which stretches back to 1996, in order to establish the patterns of occurrence of atmospheric phenomena. One is looking at atmospheric waves, which are currently poorly represented in circulation models and which are known to have an impact on climate. The other is looking at sting-jets – regions of intense winds which can have significant economic impact through structural damage.



Precipitation has the indirect effect of reducing the clear-air radar return signal power.

Other Projects. The Facility has additionally supported projects looking at the humidity structure of the atmosphere, the ducting of radio signals (which can affect the performance of wireless links), the validation of satellite observations, new signal processing schemes, and the effects of meteorology on bat feeding habits. One unusual study has used radar wind data to predict the power requirements for an airship designed to make long-term flights at altitudes of up to 20 km. No other sources of high time-resolution wind data at these altitudes exist within Europe.

FUTURE DEVELOPMENTS/STRATEGIC FORWARD LOOK

Installation of new instruments. A number of new instruments are due to be installed at the radar site in the early part of 2005-2006. These will primarily be of importance for the areas of humidity, convection and precipitation research.

- **A guest 78 GHz cloud radar.** This radar has been developed within the Millimetre Wave Technology Group at the Rutherford Appleton Laboratory. An earlier incarnation of the instrument was operated at the MST radar site in the late 1990s. Since then it has undergone considerable development and the Met Office (who have funded much of the work) are sufficiently impressed with the current model to want to commission a purpose-built prototype.
- **A laser ceilometer.** This is used (primarily) for the detection of the cloud base altitude, but can also give an indication of boundary layer height. It is already known that the observations made by such an instrument can help in interpreting those made by the cloud radar.
- **Sky-pointing cameras.** A visual record of conditions above the radar site represents the simplest, but potentially most useful, source of complementary information. It is already known that cloud-radar returns can fluctuate rapidly under patchy cloud conditions - as individual clouds pass into and then out of the radar beam. It remains to be established how the MST radar returns respond to the presence of individual clouds.

The Convective Storm Initiation Project (CSIP). Observations made by the MST radar will contribute to this major NERC/Met Office campaign being conducted during the summer of 2005.

Reintroduction of Mesospheric observations. Scientists from both the atmospheric science and space science communities have agreed on the need to raise the priority of studies of the much-overlooked mesosphere – the region of the atmosphere between approximately 45 and 85 km altitude which marks the transition between the interests of the two communities. It is too high to be reached by aircraft and too low to be traversed by satellites. MST radars are one of the few tools available which can provide any information. However, the radar returns from this region tend to be weak, sporadically occurring, and from layers of thin vertical extent. Consequently the NERC MST radar has been operated predominantly in the ST-mode (covering the approximate altitude range 2-20 km) for which the radar returns are much stronger and continuous in both time and altitude. No M-mode observations have been made since 1999. Even at the peak of interest in the mesosphere (in the early 1990s), M-mode observations were made, at most, for a few hours each day on arbitrarily selected days. A new observation format was introduced on 6th April 2005 to allow continuous M-mode observations to be interlaced with the standard ST wind-profiling mode. For the first time ever with this radar, it will be possible to build up a complete picture of when, and from which altitudes, mesospheric radar returns are observed. Proposals for a new cross-council mesospheric research programme have been submitted to both NERC and PPARC.

Non-Mandatory Facility-specific OPMs: utilisation, allocation of capacity etc