SERVICES & FACILITIES ANNUAL REPORT - FY April 2007 to March 2008

SERVICE	FUNDING BLOCK	AGREEMENT	ESTABLISHED as S&F	TERM
The NERC MST Radar Facility at Aberystwyth http://mst.nerc.ac.uk		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 rainfall. 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 often 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

- The MST Radar was operated for 98.6% of the available time, exceeding the minimum target of 98.0%.
- A new air conditioning unit was installed in the radar control room in July 2007. High temperatures during the summer of 2006 had led to many instances of the radar operating in an unstable fashion.
- A new set of surface meteorological sensors were installed at the radar site in December 2007. These can be sampled at much shorter time intervals than was previously possible, which is vital for tracking short-lived but intense rain storms. This is directly relevant for a number of current scientific studies into clouds and rain.
- Construction of a new site shed was completed in June 2007 and the pre-existing shed was renovated in October 2007. The availability of weather-proofed out-buildings has proved to be invaluable for carrying out maintenance of UFAM instruments, which are often operated at the MST Radar site in-between campaigns.

SCORES AT LAST REVIEW (each out of 5)		Date of Last Review: 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	Contract Ends
77%	Project Manager: Dr Sam Pepler - 10% Project Scientist: Dr David Hooper – 100% Site Manager: Mr Tony Olewicz – 50%	(January) 2009	(31 March) 2010

FINANCIAL DETAILS: CURRENT FY						
Total Resource Allocation £k	Unit Cost £k			Capital Expend £k	Income £k	Full Cash Cost £k
	Unit 1 User Support	Unit 2 Guest instrument support				
120.8	£0.7k	£15.1k		6.0	47.5	154.8

FINANCIAL COMMITMENT (by year until end of current agreement) £k				
2007-08 121	2008-09 128	2009-10 136	2010-11 n.a.	2011-2012 n.a.

STEERING COMMITTEE	Independent Members	Meetings per annum	Other S&F Overseen
NARFSC	10	1	CFARR

APPLICATIONS: DISTRIBUTION OF GRADES (Current FY — 2007/08)								
	α5	**α4**	**α3**	**α2**	**α1**	**β**	**R*/Pilot**	**Reject**
NERC Grant projects		**2**						
Other academic		**3**	**2**					
Students (non PhD)								
Pilot	**2** (Applications in this category are not graded – the totals are shown in the Pilot column)							
TOTAL		**5**	**2**				**2**	
APPLICATIONS: DISTRIBUTION OF GRADES (per annum average previous 3 years —2004/2005, 2005/2006 & 2006/2007)								
	α5	**α4**	**α3**	**α2**	**α1**	**β**	**R*/Pilot**	**Reject**
NERC Grant projects		**1.00**	**0.33**					
Other Academic		**1.67**	**0.33**					
Students (non PhD)	**1.67** (Applications in this category are not graded – the totals are shown in the Pilot column)							
Pilot	**2.00** (Applications in this category are not graded – the totals are shown in the Pilot column)							
TOTAL		**2.67**	**0.67**				**3.67**	

PROJECTS COMPLETED (Current FY)							
	α5	**α4**	**α3**	**α2**	**α1**	**β**	**R*/Pilot**
NERC Grant projects		**3**					
Other Academic		**1**	**1**				
Students (non PhD)							
Pilot	**2** (Applications in this category are not graded)						

USER PROFILE (current FY)											**Combined non-Directed and Directed*
Grand Total	**Infrastructure**					**PAYG**					
	Supplement to NERC Grant *	**Student NERC**	**Student Other**	**NERC C/S**	**Other**	**NERC Grant***	**Student NERC**	**Student Other**	**NERC C/S**	**Other**	
25	**5**	**4**	**7**		**8**	**Supply of data to the Met Office (counts as 1 user) 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**	**Student Other**	**NERC C/S**	**Other**	**NERC Grant***	**Student NERC**	**Student Other**	**NERC C/S**	**Other**	
23.00	**7.0**	**2.33**	**2.00**		**9.33**	**Supply of data to the Met Office (counts as 1 user) under a commercial contract**					

USER PROFILE (current FY)				
Academic **16**	**Centre/Survey**	**NERC Fellows**	**PhD** **8**	**Commercial** **1**
USER PROFILE (per annum average previous 3 years)				
Academic **19.67**	**Centre/Survey**	**NERC Fellows**	**PhD** **2.33**	**Commercial** **1.0**

OUTPUT & PERFORMANCE MEASURES (current FY)										
Publications (by science area & type)										
SBA	**ES**	**MS**	**AS** **100 %**	**TFS**	**EO**	**Polar**	**Grand Total** **9**	**Refereed** **3**	**Non-Ref/ Conf Proc** **4**	**PhD Theses** **2**

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** **6.00**	**TFS**	**EO**	**Polar**	**Grand Total** **6.00**	**Refereed** **3.00**	**Non-Ref/ Conf Proc** **3.00**	**PhD Theses** **0.0**

Distribution of Projects (by science areas)						
SBA	**ES**	**MS**	**AS**	**TFS**	**EO**	**Polar**
			100%			

Distribution of Projects (by old NERC strategic priority) (as whole or part of whole number NOT as a %)				
Earth's life support systems	**Climate Change**	**Sustainable Economies**	**Underpinning Science**	**Specific Research**
0.0	**2.5**	**6.5**	**10.0**	**6.0**

Distribution of Projects (by new NERC strategic priority) (as whole or part of whole number NOT as a %)						
Climate System	**Biodiversity**	**Earth System Science**	**Sustainable Use of Natural Resources**	**Natural Hazards**	**Environment, Pollution & Human Health**	**Technologies**
2.5	**0.0**	**8.0**	**3.25**	**8.0**	**3.25**	**YES**

OVERVIEW & ACTIVITIES IN FINANCIAL YEAR (2007/08):

Automated operations

The Facility's site manager, who had overseen operations since the radar was built in 1989, (semi) retired in February 2007 [1]. Consequently during the 2007-2008 year, for the first time, equipment was often left running unattended for up to several weeks at a time. The fact that instrument up-times were maintained at the high levels set during previous years is a testament to the Facility's on-going efforts to improve automation and remote monitoring. For example, Uninterruptible Power Supply (UPS) units are now used for all equipment. These are highly effective are smoothing out the fluctuations of the incoming mains voltage, which are relatively common at the Facility's rural location. Such fluctuations had previously been one of the most significant causes of equipment malfunction. Quick-look plots for all instruments are now generated automatically on a daily basis. This means that any problems are soon identified and corrective action can rapidly be initiated. One of the most effective innovations has proved to be the deployment of webcams at strategic points around the Facility. Being able to see, for example, oscilloscope traces and flashing lights on panels can provide the most useful information for diagnosing a problem. Even more importantly, webcams have played a vital role in carrying out repairs remotely. On a number of occasions over the past year, University of Manchester staff (who are often on site) have been able to carry out simple repairs whilst being relayed instructions over the telephone. The webcams make this process highly effective since they allow Facility staff to monitor progress.

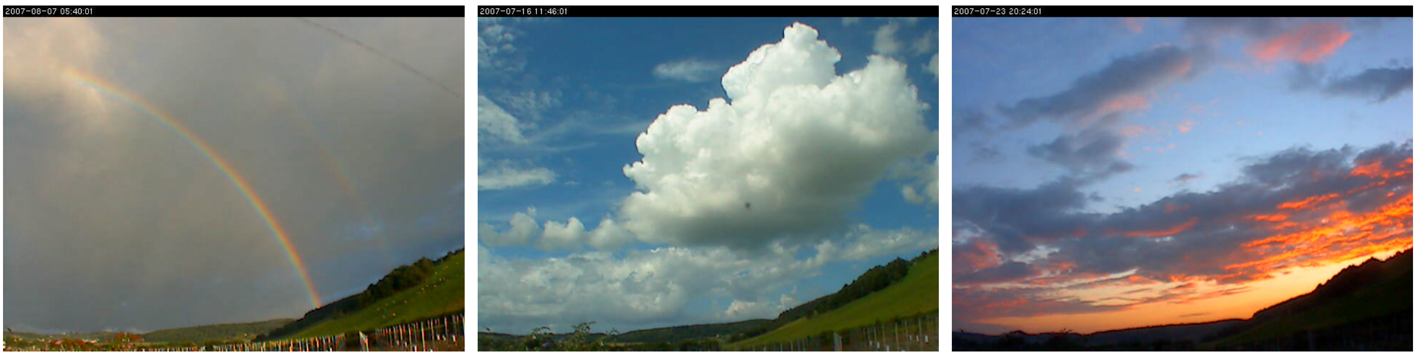
[1] This, together with other cost savings implemented by the Facility over the past few years, has resulted in the 2007-2008 resource allocation from NERC being 10% below the 2004-2005 level.

Documentation

Clear documentation is essential for ensuring the long-term scientific usefulness of a dataset. Unless users know how the measurements were made, how they were processed, and something about their reliability and accuracy, they may not have the confidence that the data are appropriate for their intended purpose. It is difficult to predict how data will be used in the future - the Facility already has a tradition of scientists using the data for unexpected applications. The Facility has recently prioritised increasing the levels of documentation available. There is now an on-line event-log, which records specific problems with instrument performance and data reliability. Data files for all instruments now contain a verbose description of the measurement principles and techniques. Most importantly, a paper has just been written on the latest version of the MST radar signal processing software. This contains details about the possible sources of contamination, about the quality control algorithms, and about the statistical measures of data accuracy. No such document was ever produced for the previous version of the signal processing software, which was in operation for over 15 years.

Sky-camera images

Sometimes the best way to understand the state of the atmosphere is to simply look out of the window. With this in mind, the Facility began to operate a "sky-camera" in April 2007. This is, in fact, a security camera which has been directed to capture sky conditions to the west of the radar site. The images are recorded at one minute intervals on a continuous basis. They can be particularly useful for scientists trying to understand the measurements made by the other instruments at the site. Animations of these images have proved to be a powerful tool for revealing the presence of phenomena, such as convection, whose motions are too slow to be obvious to a real-time observer. They have also revealed that the nearby Welsh mountains play a far greater role in local cloud formation than can be appreciated from static images. Two work experience student placements have been used to generate an event-log of interesting observations. These, together with the animation software, are available to user scientists through the Facility's website.



Example images from the new sky-camera showing (left panel) a rainbow, (centre panel) a cumulus cloud, which indicates convective conditions, and (right panel) a sunset.

SCIENCE HIGHLIGHTS:

A turbulence measurement campaign

An instrumented meteorological balloon being launched from the MST Radar site as part of the turbulence measurement campaign. Image courtesy of David Hooper.

Turbulence plays a number of important roles within the Earth's atmosphere. For example, it can pose a hazard for aircraft (and passengers) and it can accelerate the dispersal of man-made gases. However, it cannot be routinely detected with standard atmospheric monitoring instruments (airlines rely on pilots' reports in order to give hazard warnings to aircraft which subsequently follow the same routes). The spectral-widths of echoes observed by wind-profiling radars - such as the MST Radar and the UFAM boundary-layer wind-profiler – are broadened by turbulent activity. However, owing to the paucity of intercomparisons with more direct measurements of turbulence, the quantitative value of the radar technique is currently unknown. A campaign was conducted at the MST Radar site, during March 2008, in order to address this issue. The UFAM boundary-layer wind-profiler was operated alongside the MST radar in order to remotely-sense the atmosphere. Meanwhile, instrumented meteorological balloons and the NERC (Airborne Research and Survey Facility) Dornier aircraft (which carried an AIMMS turbulence probe) flew overhead in order to make in-situ measurements. This was the first time that meteorological balloons had been launched from the radar site itself (in the past they had to be launched from a location 3 km to the west). The results have been very encouraging with data regularly being collected up to the balloon burst altitude of around 20 km.

The representativeness of Aberystwyth wind-profile data

There is no doubt that the MST Radar provides the most detailed set of wind-profile measurements for a location in the British Isles. However, how representative are these measurements for other parts of Britain? This was a question addressed by a recent climatological study of winds measured by the Met Office's instrumented balloon network. Broadly-speaking, the wind distributions changed only slightly between the extremes of north, south, east and west across the British Isles and were close to that of the radar-derived data. Nevertheless, there was a qualitative difference between the balloon and radar distributions. This is attributed to the fact that the MST radar captures a much fuller picture of the atmosphere. It can be operated under all weather conditions and provides wind profiles at intervals of less than 5 minutes. By contrast, balloons cannot be launched under conditions of strong low-level winds (for safety reasons) and wind-profiles are seldom available at intervals of less than 6 hours. Consequently they are less likely to capture small-scale extreme events. The Met Office are currently reviewing their observation requirements for the forthcoming decade. They will need increasingly high-resolution measurements to match the advances in the numerical weather prediction model resolution. Wind-profiling radars are clearly well-suited to fulfil this requirement. The Facility continues to work closely with the Met Office in order to improve the flexibility of the data delivery system. It is in a position to provide higher-time-resolution data as soon as the Met Office are ready to assimilate them (they currently use 30 minute averages).

A climatology of atmospheric waves

The atmosphere (above the lowest few kilometres) responds to vertical displacements in a similar way to water which has a stone thrown into to – by generating waves which propagate away from the disturbance. Although the wave motions are relatively unimportant in the lowest 10 km of the atmosphere, where weather patterns dominate, they play an increasingly significant role with increasing altitude above this. For example, through wave breaking, they determine the rate at which CFCs and other man-made chemicals are transported through the stratosphere. A recent study has exploited 8 years of quasi-continuous MST radar derived winds in order create a climatology of these atmospheric waves. Long period waves turn out to be ubiquitous at altitudes above 10 km, being observed for 70% of the time. However, their generation mechanism remains something of a mystery. One theory was that they were associated with the jet stream – a narrow, high-altitude region of fast-flowing air. However, their occurrence shows only a weak correlation with the jet speed or direction and there is very little variation during the course of the year.

Three refereed publications for the 2007 calendar year:

1. G. Vaughan and R. M. Worthington. Inertia-gravity waves observed by the UK MST radar. *Q. J. R. Meteorol. Soc.*, 133:179-188, 2007.
2. R. M. Worthington. Aircraft measurements of asymmetric temperature microstructure causing azimuth variations of VHF radar echo power. *J. Atmos. Sol.-Terr. Phys.*, 69(12):1331-1343, 2007.
3. T. G. Reynolds, L. Ren, and J.-P. B. Clarke. Advanced noise abatement approach activities at a regional UK airport. *Air Traffic Control Quarterly*, 15(4):275-298, 2007. [this work was highlighted in the 2006-2008 report]

FUTURE DEVELOPMENTS/STRATEGIC FORWARD LOOK

The current cycle of funding comes to an end in March 2010. Consequently a priority for the forthcoming year is to prepare a funding renewal application. The Facility has reduced its costs and its staffing levels over the past few years. Some capital investment in new radar hardware will be necessary in order to allow the Facility to move forwards.