SERVICES & FACILITIES ANNUAL REPORT - FY April 2014 to March 2015

SERVICE	FUNDING	AGREEMENT	ESTABLISHED as S&F	TERM
NERC SCIENCE OF THE ENVIRONMENT NERC MST Radar Facility (MSTRF)	Block	SLA	1996	5 years

TYPE OF SERVICE PROVIDED:

The Mesosphere-Stratosphere-Troposphere (MST) Radar at Aberystwyth is the UK's most powerful and most versatile wind-profiling instrument. MST radars are unique in being able to provide continuous measurements of the three-dimensional wind vector over the approximate altitude range 2-20 km at high resolution (300 m in altitude and 5 minutes in time, in the case of the NERC Radar). They can also provide information about atmospheric stability, turbulence, humidity and rainfall. The NERC Facility additionally operates a number of auxiliary instruments and hosts guest instruments on behalf of other groups. There are no alternative sources of comparable data for many of the projects that the Facility supports.

The mission of the Facility is:

- To operate the MST radar on behalf of the UK atmospheric science community
- To operate, and host, instruments whose observations complement those made by the MST radar
- To participate in appropriate NERC-funded field campaigns
- To support facility users with analysis and interpretation of the data

Data from the Facility have demonstrable economic, social and practical impacts. They are used operationally for the purposes of numerical weather prediction by 5 European meteorological organisations: the Met Office (UK), Meteo France, Deutsche Wetterdienst (Germany), the European Centre for Medium-Range Weather Forecasts, and MeteoSwiss. This is undertaken through a commercial contract with the Met Office that provides 32% of the Facility's funding. The Facility is actively involved in public engagement schemes. During the 2014-2015 year its staff were responsible for three presentations to secondary school children, one for primary school children, and for the supervision of a work experience student.

ANNUAL TARGETS AND PROGRESS TOWARDS THEM

The MST Radar was in operation for 99.8% of the available time, exceeding the target of 98.0%.

SCORES AT LAST REVIEW (each out of 5)		Date of Last Review:		
Need	Uniqueness	Quality of Service	Quality of Science & Training	Average
4.5	5.0	4.5	4.0	4.5

CAPACITY of HOST ENTITY FUNDED by S&F	Staff & Status	Next Review (March)	Contract Ends (31 March)
% 68	0.85 FTE – David Hooper, Facility Manager 0.05 FTE – Jon Eastment, RF support 0.05 FTE – John Bradford, RF support 0.05 FTE – Alan Doo, computer support	?	?

FINANCIAL DETAILS: CURRENT FY						
Total Resource Allocation £k	Unit Cost £k			Capital Expend £k	Income £k	Full Cash Cost £k
	Unit 1	Unit 2	Unit 3			
139.5	User Support £3.1k	Guest instrument/campaign support £29.8k		0.0	63.0	244.67

FINANCIAL COMMITMENT (by year until end of current agreement) £k				
2014-15 : 139.5	2015-16 : 136.5			

STEERING COMMITTEE	Independent Members	Meetings per annum	Other S&F Overseen
RAG	5	1	CFARR and EISCAT

APPLICATIONS: DISTRIBUTION OF GRADES (current FY — 2014/15)													
	10	9	8	7	6	5	4	3	2	1	0	R*	Pilot
NERC Grant projects*													
Other academic													
Students													
TOTAL													

Two new PhD students have registered for "User Support" during the past year. These applications have not been graded.

APPLICATIONS: DISTRIBUTION OF GRADES (per annum average previous 3 financial years —2011/2012, 2012/2013 & 2013/2014)													
	10	9	8	7	6	5	4	3	2	1	0	R*	Pilot
NERC Grant projects*		0.33	0.66										
Other academic				0.33			0.33						1.33
Students				0.33	0.33								0.33
TOTAL		0.33	0.66	0.66	0.33		0.33						1.66

PROJECTS COMPLETED (current FY – 2014/15)												
	10 (α5)	9	8 (α4)	7	6 (α3)	5 (α2)	4	3 (α1)	2	1 (β)	0 (Reject)	Pilot
NERC Grant projects*			2									
Other Academic												1
Students												

Project Funding Type (current FY – 2014/15) (select one category for each project)										
Grand Total	Infrastructure					PAYG				
	Supplement to NERC Grant *	PhD Students		NERC Centre	Other	NERC Grant*	PhD Students		NERC Centre	Other
		NERC	Other				NERC	Other		
8		1	1	1	4					1

Project Funding Type (per annum average previous 3 financial years - 2011/2012, 2012/2013 & 2013/2014)										
Grand Total	Infrastructure					PAYG				
	Supplement to NERC Grant *	PhD Students		NERC Centre	Other	NERC Grant*	PhD Student		NERC Centre	Other
		NERC	Other				NERC	Other		
13.33	3.0	2.33	1.0		6.0					1.0

User type (current FY – 2014/15) (include each person named on application form)				
Academic	NERC Centre	NERC Fellows	PhD Students	Commercial
4	1		2	1

User type (per annum average previous 3 financial years - 2011/2012, 2012/2013 & 2013/2014)				
Academic	NERC Centre	NERC Fellows	PhD Students	Commercial
9.00			3.33	1.00

OUTPUT & PERFORMANCE MEASURES (current year)

Publications (by science area & type) (calendar year 2014)										
SBA	ES	MS	AS	TFS	EO	Polar	Grand Total	Refereed	Non-Ref/ Conf Proc	PhD Theses
			2	1			3	2		1

Distribution of Projects (by science areas) (FY 2014/15)							
Grand Total	SBA	ES	MS	AS	TFS	EO	Polar
8				8			

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

Publications (by science area & type) (Calendar years 2011, 2012 & 2013)										
SBA	ES	MS	AS	TFS	EO	Polar	Grand Total	Refereed	Non-Ref/ Conf Proc	PhD Theses
			6.0				6.0	2.33	3.0	0.66

Distribution of Projects (by science areas) (FY 2011/2012, 2012/2013 & 2013/2014)							
Grand Total	SBA	ES	MS	AS	TFS	EO	Polar
13.33			0.11	12.44	0.11	0.66	

Distribution of Projects by NERC strategic priority (current FY 2014/15)							
Grand Total	Climate System	Biodiversity	Earth System Science	Sustainable Use of Natural Resources	Natural Hazards	Environment, Pollution & Human Health	Technologies
8.00	3.33			0.33	2.16		2.16

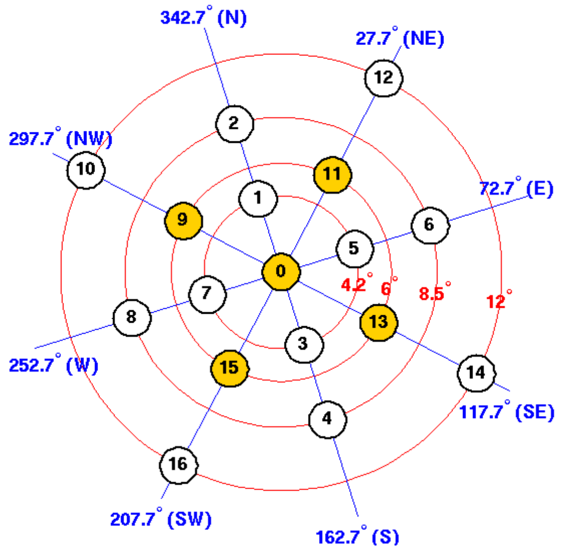
**Either Discovery Science (Responsive Mode) or Strategic Science (Directed Programme) grants*

NOTE: All metrics should be presented as whole or part of whole number NOT as a %

OVERVIEW & ACTIVITIES IN FINANCIAL YEAR (2014/15):

Improving the derivation of MST Radar Wind Speeds

An ongoing in-house research project has identified potential for improving some aspects of the way in which MST Radar winds are derived. This has recently focussed on the factor applied to the wind speeds in order to compensate for the effects of "aspect sensitivity", i.e. for the decrease in radar return signal power that is often seen when the beam is steered away from the zenith. Only 5 of the 17 available beam pointing directions (highlighted in yellow in the adjacent figure) are required in order to derive the basic wind-profile. A single additional beam pointing direction (number 7) is currently used in order to derive the aspect sensitivity compensation factor. The appropriateness of this approach has been tested using a unique dataset. A special observation format, which included all 17 beam pointing directions, was used for 6 weeks following the renovation of the radar in March 2011. The analysis has revealed that the existing compensation factor does not take into account variations in the radar return signal power as a function of azimuth angle. These are larger than expected. Secondly, the small separation in zenith angle between the main wind-profiling beams (6.0°) and the aspect sensitivity beam (4.2°) makes the compensation factor overly sensitive to small uncertainties in radar return power. The all-beam dataset is currently being used to establish a more-robust way of deriving the compensation factor.



The MST Radar's beam can be steered to point in any of 17 available directions. These cover a variety of azimuths (blue lines) and zenith angles (red circles). The 5 main beam pointing directions used for wind-profiling are highlighted in yellow.

During the twilight hours of the mid-summer months, the MSTRF operates an automatic camera with the aim of observing Noctilucent Clouds (NLCs). This activity is carried out in support of research into the Mesosphere Summer Echoes that are observed by the MST Radar. Both phenomena rely on the existence of ice crystals in the altitude range 80 – 90 km. In addition to observing NLCs on 9 occasions during the 2014 season, the camera observed lightning during the early morning of 18th July.

Owing to the fact that the northward view from the MST Radar site is blocked by the hills, the NLC camera is operated at the Chilbolton Observatory.

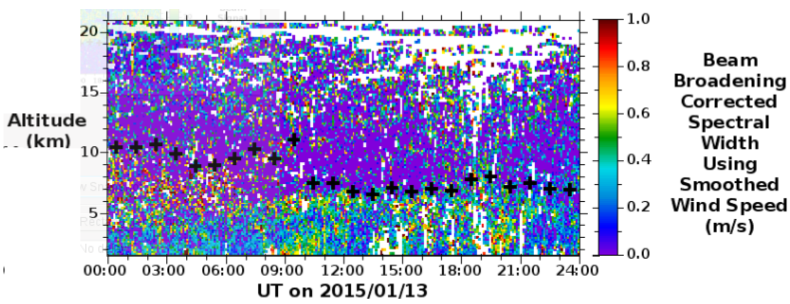
Improved internet connection to the radar site

The installation of a new broadband router at the radar site in early 2014 has led to the internet connection becoming significantly more reliable. This is important since near-real-time wind-profile data from the MST Radar are sent to the Met Office every 30 minutes. The data are operationally assimilated for the purposes of numerical weather prediction. The previous router was prone to dropping its connection and had to be power-cycled before data transfers could be resumed. Since the problem typically occurred during the middle of the night, outages generally lasted for at least several hours. It had been assumed that the problem was the result of the radar site being a long way from the nearest rural telephone exchange. Transfer speeds continue to be significantly lower than can be found elsewhere and exchange-level outages or line faults occur at least once a year. The new router has not needed to be power-cycled on a single occasion since it was installed. Moreover, based on this success, colleagues from the University of Manchester/Atmospheric Measurement Facility have switched to using the same model of router at a remote site. They had also been suffering from repeated dropped connections.

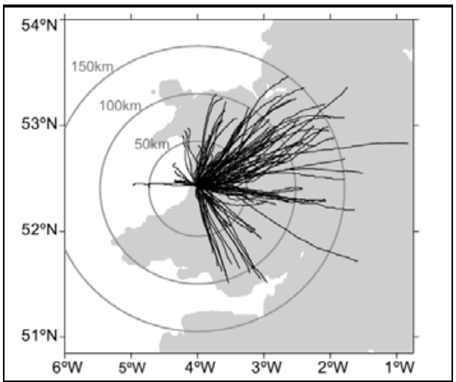
SCIENCE HIGHLIGHTS. ***To focus on economic and societal impacts and benefits where possible*:**

A Turbulence Measurement Campaign

Turbulence is a threat to safety for the airline industry as well as playing a key role for a wide variety of atmospheric processes. However, there are very few instruments that are capable of detecting it at altitude on a routine basis. Consequently airlines rely on their aircraft first encountering potentially-dangerous patches of turbulence before they can re-route subsequent flights to avoid these areas. If turbulence could be detected by weather balloons, which are already launched routinely from a world-wide network, there would clearly be a demand for the additional information. Researchers at the University of Reading are developing a balloon-borne sensor package that might allow this to be achieved. They conducted a campaign of launching these from the MST Radar site during the early part of 2015. Not only is the MST Radar capable of routinely detecting turbulence, thereby allowing the balloon-borne detection method to be validated, but its observations can reveal the underlying processes which give rise to the turbulence. Deep convection is a major cause for the region of the atmosphere up to the "tropopause" (which typically occurs at between 7 and 11 km above mean sea level). Turbulence at higher altitudes tends to be confined to layers of thin vertical extent and to be caused by atmospheric waves such as mountain waves – see below.



MST Radar observations from the first day of the turbulence campaign, which was characterised by deep convection (not shown). The large values of the beam-broadening-corrected spectral width (green, yellow, and red colours) indicate that the atmosphere was turbulent all the way up to the "tropopause" level (black crosses) for most of this day.



The flight tracks of 127 weather balloons launched from the MST Radar site. From Lee et al., 2014.

The Effects of Mountain Waves

Mountain waves are a ubiquitous feature of the atmosphere above the NERC MST Radar site. These are vertical fluctuations of the wind that are caused by flow over hilly/mountainous terrain. Since MST radars give a direct measure of the vertical wind velocity, they are particularly well-suited to studying these types of wave patterns. The waves also give rise to characteristic cloud shapes, which can often be seen in images from the MSTRF's sky-camera. A recent study by Lee et al. (2014) has revealed an unexpected effect of the waves: they seem to be the cause of slight differences between the horizontal winds measured by the MST radar and those measured by weather balloons that were launched from the radar site. The wave patterns remain locked relative to the topographical features that generate them. Since the MST radar is at a fixed location, it encounters a fixed "phase" of the waves. However, a weather balloon drifts over the landscape as it rises (see figure to the left). Consequently it encounters a different phase of the waves at each height. Owing to the fact that landscape is highly variable, the pattern of the waves depends on the direction from which the low-level wind is blowing.

Publications for the 2014 calendar year that were supported by the MSTRF:

- C. F. Lee, G. Vaughan, and D. A. Hooper. Evaluation of wind profiles from the NERC MST radar, Aberystwyth, UK. *Atmos. Meas. Tech*., 7(9):3113-3126, 2014. *[Journal Impact Factor 2.929/3.368 1 year/5 year]*
- J. P. McCalmont. Greenhouse gas balance in transition from semi-improved agricultural grassland to Miscanthus x giganteus bioenergy crop. PhD thesis, Aberystwyth University, 2014.
- R. M. Worthington. Boundary-layer effects on mountain waves: a new look at some historical studies. *Meteorol. Atmos. Phys*., 126(1-2):1-12, 2014. *[Journal Impact Factor 1.049/1.214 1 year/5 year]*

FUTURE DEVELOPMENTS/STRATEGIC FORWARD LOOK

During the latter part of the 2014/2015 year, a number of long-standing auxiliary instruments had to be replaced: the sky-camera, a surface met station, and the wind vane and anemometer mounted on a 10 m tower. Although all the new instruments have started to collect data, the appropriate metadata to accompany the files must be put together before the files can be released through the British Atmospheric Data Centre (BADC).