SERVICE	FUNDING	AGREEMENT	ESTABLISHED as S&F	TERM
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. 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. The Facility additionally operates a number of auxiliary instruments.

Data from the Facility are used to study a wide range of topics. During the past year, it has supported projects that address 6 of NERC's 7 priority themes: (1) Climate System, (2) Biodiversity, (3) Sustainable Use of Natural Resources, (4) Natural Hazards, (5) Environment, Pollution and Human Health, and (6) Technologies. There is no alternative source of comparable data for many of these projects.

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 4 European meteorological organisations: the Met Office (UK), Deutsche Wetterdienst (Germany), the European Centre for Medium-Range Weather Forecasts, and MeteoSwiss (Switzerland). This is undertaken through a commercial contract with the Met Office, which provides 32% of the Facility's budget. The Facility is actively involved in public engagement schemes. During the 2013-2014 year its staff were responsible for four presentations to school children, for the supervision of a work experience student, and for two presentations to amateur societies.

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:		2009
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%	Project Scientist: Dr David Hooper – 85% Site Technician: Mr Les Dean – 30%	?	2015

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			
131.0	User Support 2.7	Guest instrument/ Campaign support, 27.4		0.0	63.0	246.3

FINANCIAL COMMITMENT (by year until end of current agreement) £k				
2013-14: 131.0	2014-15 139.5	2015-16 ?	2016-2017 ?	2017-2018 ?

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

APPLICATIONS: DISTRIBUTION OF GRADES (current FY — 2013/14)

	10	9	8	7	6	5	4	3	2	1	0	R*	Pilot
NERC Grant projects*													
Other academic													
Students													
TOTAL													

There were 2 applications, which have not been graded. See next page for further details.

PROJECTS COMPLETED (current FY – 2013/14)												
	10 (α5)	**9**	**8 (α4)**	**7**	**6 (α3)**	**5 (α2)**	**4**	**3 (α1)**	**2**	**1 (β)**	**0 (Reject)**	**Pilot**
NERC Grant projects*		**1**			**2**							
Other Academic				**1**								
Students												**2**

Project Funding Type (current FY – 2013/14) (select one category for each project)										
	Infrastructure					**PAYG**				
Grand Total	**Supplement to NERC Grant ***	**PhD Students NERC**	**PhD Students Other**	**NERC Centre**	**Other**	**NERC Grant***	**PhD Students NERC**	**PhD Students Other**	**NERC Centre**	**Other**
10	**2**				**7**					**1**
Project Funding Type (per annum average previous 3 financial years - 2010/2011, 2011/2012 & 2012/2013)										
	Infrastructure					**PAYG**				
Grand Total	**Supplement to NERC Grant ***	**PhD Students NERC**	**PhD Students Other**	**NERC Centre**	**Other**	**NERC Grant***	**PhD Student NERC**	**PhD Student Other**	**NERC Centre**	**Other**
15.0	**2.67**	**3.33**	**1.67**		**6.0**					**1.33**

User type (current FY – 2013/14) (include each person named on application form)				
Academic	**NERC Centre**	**NERC Fellows**	**PhD Students**	**Commercial**
9				**1**
User type (per annum average previous 3 financial years - 2010/2011, 2011/2012 & 2012/2013)				
Academic	**NERC Centre**	**NERC Fellows**	**PhD Students**	**Commercial**
8.67			**5.0**	**1.33**

OUTPUT & PERFORMANCE MEASURES (current year)										
Publications (by science area & type) (calendar year 2013)										
SBA	**ES**	**MS**	**AS**	**TFS**	**EO**	**Polar**	**Grand Total**	**Refereed**	**Non-Ref/ Conf Proc**	**PhD Theses**
			7				**7**	**1**	**6**	

Distribution of Projects (by science areas) (FY 2013/14)							
Grand Total	**SBA**	**ES**	**MS**	**AS**	**TFS**	**EO**	**Polar**
10				**9.0**		**1.0**	

OUTPUT & PERFORMANCE MEASURES (per annum average previous 3 years)										
Publications (by science area & type) (Calendar years 2010, 2011 & 2012)										
SBA	**ES**	**MS**	**AS**	**TFS**	**EO**	**Polar**	**Grand Total**	**Refereed**	**Non-Ref/ Conf Proc**	**PhD Theses**
			7.33				**7.33**	**3.0**	**3.67**	**0.67**

Distribution of Projects (by science areas) (FY 2010/2011, 2011/2012 & 2012/2013)							
Grand Total	**SBA**	**ES**	**MS**	**AS**	**TFS**	**EO**	**Polar**
15.0			**0.11**	**14.44**	**0.11**	**0.33**	

Distribution of Projects by NERC strategic priority (current FY 2013/14)							
Grand Total	**Climate System**	**Biodiversity**	**Earth System Science**	**Sustainable Use of Natural Resources**	**Natural Hazards**	**Environment, Pollution & Human Health**	**Technologies**
10.0	**4.08**	**0.25**		**0.33**	**1.67**	**0.25**	**3.41**

**Either Responsive Mode or Directed Programme grants*

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

OVERVIEW & ACTIVITIES IN FINANCIAL YEAR (2013/14):

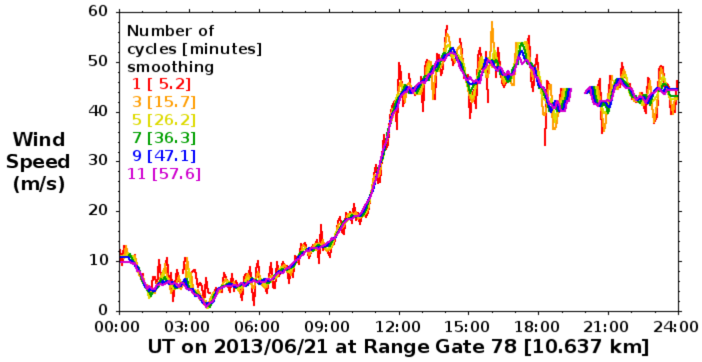
Changes to data access and an increase in the number of users

Prior to 2013, users were only granted access to the MSTRF's dataset once they had submitted an Application for Facility Support (AFS). In keeping with NERC's latest data policy, the dataset is now open-access. This means that it is automatically available to everyone with a British Atmospheric Data Centre (BADC) account. The BADC's download statistics indicate that this change has led to almost a doubling in the number of people who are accessing the dataset - 26 in 2013/2014 compared with 14 in the previous year. However, the 2013/2014 user statistics shown on the 2nd page of this report refer only to the 10 officially-registered users/projects, i.e. those for which an AFS has been submitted.

Responsibility for the MSTRF (and the other two NERC Atmospheric Radar Facilities) passed from NERC's Services and Facilities team to the National Centre for Atmospheric Science (NCAS) in April 2014. This led to the old NERC Atmospheric Radar Facilities Steering Committee (NARFSC) being replaced by a new Radar Advisory Group (RAG). At the time of writing this report, the RAG had not yet held its first meeting. Consequently there has been no opportunity to grade the 2 new AFSs that were submitted during the 2013/2014 year.

The representativeness of MST Radar winds

An in-house research project has gone back to the basics of the exact way in which wind-profile data are derived from the raw MST Radar measurements. This was prompted by the Met Office's of sporadic occurrences of rogue winds, i.e. those that are clearly inconsistent with their nearest neighbours in time and height, in the data that are sent to them. This was a surprise since the quality control software is typically very effective at removing outlying data points. In order to identify the source of the problem, which turned out to be a rarely-encountered software bug, it was necessary to analyse each stage of the signal processing in detail. Amongst other things, this raised the question of how much time-averaging should be applied to the wind data on a routine basis. The magnitude of the random errors associated with single-cycle winds, i.e. those derived from approximately 5 minutes' worth of observations, is a significant fraction of the mean speed. A statistical analysis of different levels of averaging has shown that the 30 minutes currently used for the Met Office's data stream is close to optimal for tropospheric data, i.e. for approximately the lowest 10 km of the atmosphere. However, 60 minute averaging gives better results for data from the lower stratosphere, i.e. for altitudes between 10 and 20 km. This work will be written up for publication.



The effect of different levels of time averaging on MST Radar wind speeds. A statistical analysis has shown that 30 minute averaging is close to optimal for tropospheric data whereas 60 minute averaging is better for lower stratospheric data.

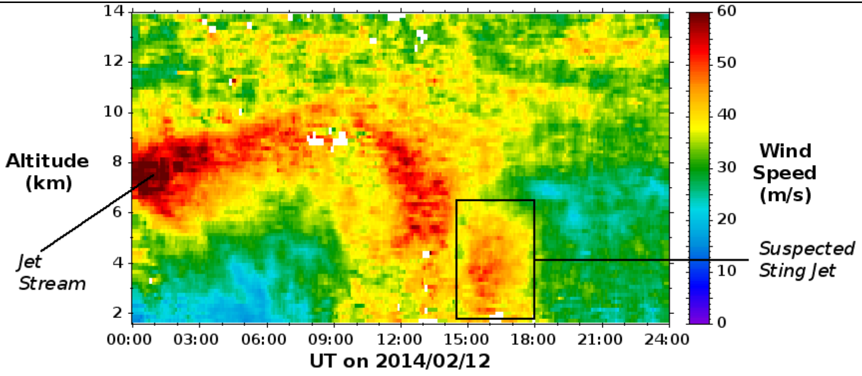
A separate project conducted by the Met Office has examined the impact of assimilating different data streams on the accuracy of their weather forecasts. Initial results have confirmed that the use of wind-profile data from the Aberystwyth MST Radar (as well from similar instruments in the UK and in Germany) has a positive impact. Although the impact per profile appears to be less than that for radiosondes (i.e. meteorological balloons), the radars typically produce 48 profiles per day whereas each radiosonde station produces only 2 or 4. The accumulated daily impact for wind-profiling radars is therefore higher than that for radiosondes.

The role of biological particles in cloud formation

During the past year the MSTRF has hosted in-situ air-sampling instruments on behalf of two University groups. One of the aims of the associated NERC-funded project was to study the role of biological particles such as pollen, fungal spores, and bacterial cells in cloud formation. Water vapour typically requires the presence of microscopic particles known as cloud condensation/ice nuclei in order to condense/freeze out of the atmosphere. In their absence, the relative humidity can considerably exceed 100% without condensation/freezing taking place. Consequently they play an important role in determining exactly where and when clouds form and therefore in the patterns of rain. A wide range of materials including sea salt, dust, and soot can act as cloud nuclei, albeit with varying efficiencies. The reason for the interest in biological cloud nuclei is that they are particularly efficient in allowing ice crystals to form at relatively warm (sub-zero) temperatures. Their ubiquity in rain samples indicates that they have a widespread role. Nevertheless, there is a great deal of uncertainty regarding the seasonal and geographical variations in their atmospheric concentrations. This was one of the questions being addressed by the 10 month deployment of two instruments at the MST Radar site. An additional aim of the deployment was to inter-compare two completely different measurement techniques. One relied on analysing the air as it passed through the instrument by means of laser-induced fluorescence. The second relied on collecting air samples and returning them to the laboratory for DNA sequencing of any biological material present. The data are already being used to support four MPhys student projects and three NERC grant/fellowship applications. There are plans for at least two papers for peer-reviewed journals.

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

The MST Radar observes a rare, extreme-wind phenomenon



Wind speeds in excess of 50 m/s (red colours) are typically confined to the Jet Stream, which is an upper-air phenomenon. They are extremely destructive when they reach ground level, e.g. in the form of a Sting Jet .

The British winter of 2013/2014 will be remembered primarily for its relentless rain and widespread flooding. However, it was also notable for its gale force winds. Twelve major storm systems affected the country during the period between December and February. The one that crossed Wales (and north-west England) on 12th February 2014 was one of the most destructive to have affected the region in recent decades. Numerous trees were uprooted and tens of thousands of homes were left without electricity. The exceptional nature of this storm is thought to have been the result of a rare meteorological phenomenon known as a Sting Jet. This is a narrow tongue of particularly strong winds that can develop within a rapidly-deepening low pressure system. It is so narrow – perhaps just 50 km across – that numerical weather prediction models have only recently begun to be routinely run at sufficiently high resolutions to be able to represent such a feature. However, model resolution has not been the only limiting factor and an improved understanding of the driving factors is still required. The MST Radar is one of the few instruments that is capable of providing upper-air observations against which the model fields can be compared. Even so, the Sting Jet must pass directly over the radar and so very few examples exist. The 12th February 2014 case was the clearest one in over a decade. It has been identified by researchers at the University of Reading as a suitable candidate for detailed model analysis.

Multiple frontal bands seen by MST Radar

Although the classical model of a frontal zone between different air masses suggests a single region of wind shear at the interface (corresponding to a single sharp horizontal gradient in temperature), a number of studies have shown that multiple bands can exist. A study by Lawson et al. (2013) has shown that there can often be corresponding multiple bands in MST Radar return signal power (sometimes as many as three). These tend to be associated with sharp vertical gradients in potential temperature and/or in specific humidity. Most of the power and shear bands were found to be associated with warm fronts (cold fronts are less easily identifiable in MST Radar observations). These results add to the evidence that frontal zones can be more complex than suggested by simple conceptual models.

Details of 3 publications from 2013 that were supported by the Facility

1. Bogdan Antonescu, Geraint Vaughan, and David M. Schultz, 2013.A five-year radar-based climatology of tropopause folds and deep convection over Wales, United Kingdom. Mon. Wea. Rev., 141:1693-1707. [*Journal impact factor 3.616*]
2. J. M. Chagnon, S. L. Gray, and J. Methven, 2013. Diabatic processes modifying potential vorticity in a north atlantic cyclone. Q. J. R. Meteorol. Soc., 139(674):1270–1282. [*Journal impact factor 5.131*]
3. John Lawson, David M. Schultz, Geraint Vaughan, and Daniel J. Kirshbaum, 2013. Multiple bands near fronts in VHF wind-profiling radar and radiosonde data. Atmos. Sci. Lett., 14(3):146-152. [*Journal impact factor 3.206*]

Note that the first 2 publications have not contributed to the statistics shown on the second page of this report. They were counted in the 2012-2013 report when they had been published electronically but not in hard copy.

FUTURE DEVELOPMENTS/STRATEGIC FORWARD LOOK

Oversight for the Facility was handed over from NERC to the National Centre for Atmospheric Science (NCAS) in April 2014. This is expected to lead to a number of subtle changes to the way in which the Facility is managed. However, it should not have any impact on the ways in which existing user scientists interact with the Facility. It is hoped that the change will lead to better opportunities for attracting new user scientists.