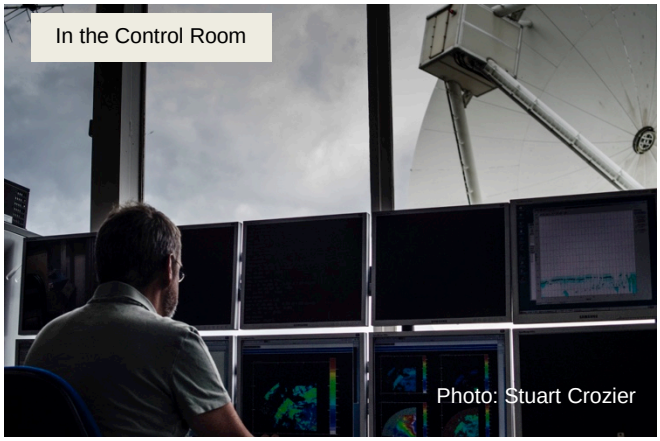
SERVICES & FACILITIES ANNUAL REPORT - FY April 2014 to March 2015

SERVICE	FUNDING	AGREEMENT	ESTABLISHED as S&F	TERM
Science & Technology Facilities Council Chilbolton Facility for Atmospheric & Radio Research	Block	SLA NERC-STFC RAL Space	1996	5 years

TYPE OF SERVICE PROVIDED:



The Chilbolton Facility for Atmospheric and Radio Research (CFARR) is hosted by the Science and Technology Facilities Council (STFC) at Chilbolton Observatory, a sizeable experimental site in rural Hampshire. It provides world-class capability for the study of clouds, rainfall, boundary-layer processes and aerosols, and has an established record for hosting large atmospheric science and remote-sensing campaigns that involve coordinated in-situ aircraft measurements. The Facility currently operates more than twenty major instruments, some continuously, while others are operated on demand. These include a powerful combination of Doppler radars, lidars, radiometers, and supporting instruments; the Chilbolton Advanced Meteorological Radar (CAMRa) is mounted on the world's largest fully-steerable meteorological radar antenna, and is able to probe clouds and storms with unparalleled sensitivity and resolution. The continuous round-the-clock operation of lidar and cloud radar instruments at CFARR is unique within the UK. There is also a 94-GHz cloud radar and high-power ultraviolet Raman lidar for use in case studies. The Facility operates a suite of meteorological instrumentation 24/7 including rain gauges, disdrometers, a sonic anemometer, LI-COR gas analyser and Grimm aerosol particle counter. There is also a multi-frequency microwave radiometer for measuring cloud liquid water path and water vapour density profiles. A multi-wavelength sun photometer provides continuous measurements of aerosol optical depth in clear skies, and CFARR is an AERONET site. The site also has clearance for the launch of radiosondes and experience with tethered balloon operations. Adjacent to CFARR is a Met Office compound, which includes a wind-profiling radar. Measurements made at the Facility are quality assured prior to being archived at the British Atmospheric Data Centre (BADC).

The science programme that is dependent upon CFARR measurements addresses two of the three major societal challenges in the current NERC strategy: (i) Resilience to Environmental Hazards, and (ii) Managing Environmental Change. CFARR provides invaluable training opportunities; it supported 7 PhD studentships during the year 2014/15. It also hosts annual MSc field trips, and data from CFARR are used regularly in undergraduate and postgraduate teaching. The user base is drawn mainly from across the UK atmospheric science, remote sensing and hydrology communities. Additionally, the freely available data archived by BADC and AERONET, together with the cloud products produced in Cloudnet/ACTRiS ensure that CFARR data are used by many more scientists worldwide.

ANNUAL TARGETS AND PROGRESS TOWARDS THEM

Target: To operate instruments at CFARR in support of NERC research areas – mostly achieved.

Progress: Most key instruments were available for all measurement campaigns. Problem areas: a decision has been made to withdraw the Leosphere UV polarisation lidar due to problems that could not be resolved with the manufacturer.

Target: To submit quality-controlled data from CFARR to the British Atmospheric Data Centre every quarter – mostly achieved. Problem areas: further post-processing and quality control of a subset of radar data required.

Target: Real time display of data on the Web - achieved.

SCORES AT LAST REVIEW (each out of 5)		Date of Last Review:		2008
Need	**Uniqueness**	**Quality of Service**	**Quality of Science & Training**	**Average**
5	5	5	5	5

CAPACITY of HOST ENTITY FUNDED by S&F	Staff & Status	Next Review (March)	Contract Ends (31 March)
91%	5.3 FTE drawn from 9 permanent STFC staff Head C.J. Walden (0.9FTE@Band E) + 0.7@Band F (D.N. Ladd, J.D. Eastment); 1.4@Band E (J.L. Agnew, W.J. Bradford); 0.9@Band D (A. Doo); 1.4@Band C		

FINANCIAL DETAILS: CURRENT FY

Total Resource Allocation £k	Unit Cost £k				Capital Expend £k	Income £k	Full Cash Cost £k
	Dish Radars	On-demand instrument support (excl. dish)	User Support	Campaign/guest instrument support			
480.00	3.50	2.75	2.5	20.0	0	47.00	541.27

FINANCIAL COMMITMENT (by year until end of current agreement) £k

2014-15	2015-16	2016-17	2017-2018	2018-2019
480.00	468.00			

STEERING COMMITTEE	Independent Members	Meetings per annum	Other S&F Overseen
RAG	5	1	MSTRF & 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*			2	1									
Other academic				1									
Students													
TOTAL			2	2									

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	1.0	0.33									
Other academic				0.33									
Students			0.33										
TOTAL		0.33	1.33	0.66									

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*		1	1									
Other Academic												
Students				3								

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**		
13	4	4	3	1	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**		
15.6	3.7	6.3	4	0.3	1.3					

User type (current FY – 2014/15) (include each person named on application form)				
Academic	**NERC Centre**	**NERC Fellows**	**PhD Students**	**Commercial**
11	5		7	1
User type (per annum average previous 3 financial years - 2011/2012, 2012/2013 & 2013/2014)				
Academic	**NERC Centre**	**NERC Fellows**	**PhD Students**	**Commercial**
21	2		10.3	1

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**
			20	2	2		24	15	6	3

Distribution of Projects (by science areas) (FY 2014/15)							
Grand Total	**SBA**	**ES**	**MS**	**AS**	**TFS**	**EO**	**Polar**
13				12		1	

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**
			27.4	3.0	3.3		33.7	20.7	9.3	3.7

Distribution of Projects (by science areas) (FY 2010/2011, 2011/2012 & 2012/2013)							
Grand Total	**SBA**	**ES**	**MS**	**AS**	**TFS**	**EO**	**Polar**
15.7				14.3	0.3	1.1	

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**
13	3.9				4.9	0.2	4.0

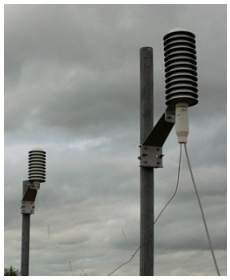
**Either Discovery Science (Responsive Mode) or Strategic Science (Directed Programme) grants*

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

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

Facility upgrades:

A new OTT Pluvio 200 weighing rain gauge has been purchased for use at CFARR. These rain gauges are increasingly being used in place of the widely deployed tipping bucket gauges for routine rain monitoring. They provide better rain accumulation resolution (0.1 mm vs. 0.2 mm) than the tipping bucket gauge and are described as low maintenance. They work by weighing the amount of rain collected. This purchase will allow CFARR to understand their performance compared with other types of gauge, including the high-resolution drop-counting gauges at the site.



A Vaisala HMP155A heated temperature and relative humidity sensor was purchased and is now in operation at CFARR. The decision to purchase this sensor arose from a networking meeting with Met Office staff held at Chilbolton in late 2014. Previous measurements of temperature and humidity at CFARR were made with a conventional unheated sensor, but the relative humidity sensor frequently failed due to repeated saturation in high humidity conditions. The new sensor uses gentle heating to prevent this happening, while a separate temperature sensor records the true, unheated conditions. It is expected that the new sensor will show greater reliability and require fewer sensor replacements than the previous system.

Drawing on in-house engineering expertise, the 94-GHz Galileo radar has undergone a number of upgrades in support of a CEOI-ST funded project to demonstrate the feasibility of making satellite observations of wind, rain and cloud. It is now able to transmit and receive twin closely spaced alternate H-V and V-H polarised pulse pairs with a long pair-repetition interval. Analysis of observations made with the upgraded system will allow estimation of cross-talk between the H- and V-channels, which could compromise the proposed technique. Although such pulse configurations are rather specialised, more conventional pulse trains are possible, and the key benefit is that CFARR users will now have access to dual-polarization capability at this frequency.


TMD PTX7610 Transmitter

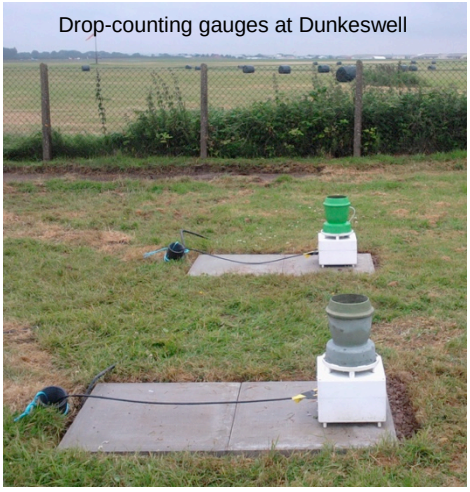
Photo: Stuart Feurtado

The Facility continues to benefit from complementary work at Chilbolton Observatory. Building on the use of the 3-GHz CAMRa radar to track objects in low Earth orbit as part of a programme in space situational awareness (SSA), a new TMD PTX7610 transmitter was procured. This has a travelling-wave tube amplifier (TWTA) suitable for pulse generation, with a 400-MHz bandwidth, capable of operation with the range 2.70 to 3.10 GHz. It can support pulse widths between 500 ns and 50 μs with a PRF between 75 Hz and 1 kHz. The nominal maximum power is 50 kW. This transmitter is now located in the base of the antenna tower and installation of the necessary waveguides has been taking place. In addition to its main role in SSA work, this instrument will be available to the atmospheric science community. Indeed, there are already plans to use it as part of a NERC Technology Proof of Concept grant on removing range side-lobe artefacts.

Discussions have been taking place to consider the possibility of Defra relocating its air quality monitoring station from Harwell to Chilbolton. As well as being part of the Automated Urban and Rural Network (AURN), and various other networks, Harwell is currently one of two UK EMEP “supersites”. EMEP is a Europe-wide programme of air monitoring under the UN Economic Commission for Europe's Convention on Long Range Trans-boundary Air Pollution. Although CFARR staff would have only minimal involvement in the day-to-day operation of station, the juxtaposition of this and CFARR instruments such as the 1.5-μm Halo Doppler lidar and sonic anemometer, which permit boundary-layer characterization, would offer attractive scientific opportunities, and provide an ideal location for field trials of new air quality instruments.

Experimental campaigns:

Forecasting Rainfall exploiting new data Assimilation techniques and Novel observations of Convection (FRANC)


Drop-counting gauges at Dunkeswell

Two CFARR drop-counting raingauges were installed at the Met Office’s Dunkeswell site, near Honiton, Devon, in June 2014. This is within the coverage areas of the Met Office radars at Cobbacombe and Wardon Hill, both of which have dual-polarisation capability. The data will be used to improve the accuracy of rainfall data produced by the Met Office radar network.

Outreach:

As part of STFC’s outreach programme, Chilbolton hosted a Photowalk activity in July 2014. This was run in collaboration with the Royal Photographic Society, and provided an opportunity to raise awareness of the atmospheric science research conducted at CFARR. Some of the photographs taken that day have been included in this report.

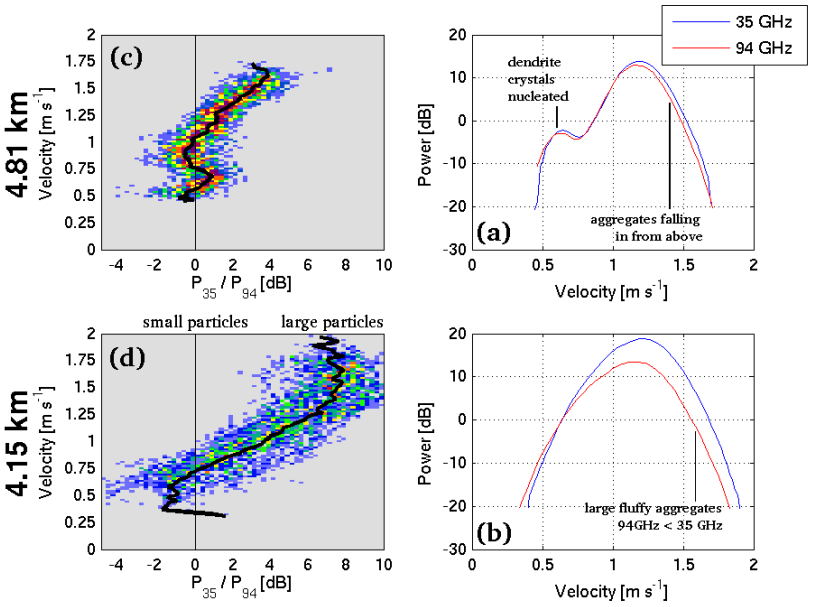

25-m dish service tunnel

Photo: Katherine Barnes

SCIENCE HIGHLIGHTS.

Evidence for highly efficient aggregation of ice crystals near -15°C *(Westbrook et al., Atmos. Chem. Phys., in preparation)*

Aggregation of ice crystals is fundamental to the development of precipitation, yet we know very little about it. Unique triple-wavelength Doppler spectra measurements made at CFARR are throwing a new light on this process. Profiles from a deep stratiform ice cloud on 17 April 2014 reveal a sharp transition from small (sub-mm) particles where the Doppler spectra at all frequencies are equal, to large (up to 1cm) aggregates with large differences between the spectra at different frequencies. Close examination of individual spectra shows that this rapid increase in particle size coincides with nucleation of dendritic ice crystals near the -15°C isotherm (panel a). Below this level the Doppler spectra change rapidly, and large differences between 35 and 94GHz spectra are observed (panel b): evidence for large aggregates. The relationship between the fall velocity of the crystals and this difference gives insight into the aggregate structure – panels (c,d) show that the size of the aggregates for a given fall speed increases significantly, which means that the particle geometry is changing to one which is more open and "fluffy". This supports recent laboratory work at Manchester (Connolly et al 2012) which found evidence for increased aggregation at -15°C. Our data shows that it is the formation of the dendritic ice crystals at this level that is critical for this process.

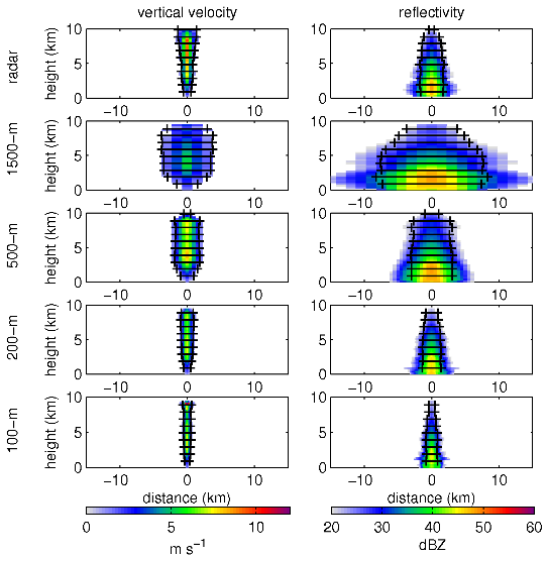


Improving convective rainfall forecasts (*Nicol et al., Q. J. R. Meteorol. Soc.*).

Convective updraughts are fed by the energy released as water vapour condenses into cloud droplets. Under the right conditions, these develop to produce heavy rainfall. When the updraught size is not correctly modelled, the number and frequency of these updraughts are also not well forecast. Accurate and timely forecasts of localised heavy rainfall are essential to better predict flash-flooding.

A new technique was developed to derive the vertical air motion from Doppler wind measurements made with the Chilbolton advanced meteorological radar. The exceptionally narrow beamwidth of this radar (1/4 of most weather radars) allowed accurate estimates of updraughts even to a distance of 100 km. The characteristic size and strength of convective updraughts was systematically compared with model forecasts as a function of model gridlength and the subgrid turbulent mixing length. Updraught velocity averaged over 100s of storms from radar observations and model forecasts and corresponding reflectivity profiles (a proxy for rainfall) are shown.

In current operational forecast models (1500-m gridlength), these updraughts are many times larger than those observed. By reducing the horizontal resolution (or *gridlength*) of the forecast model down to 200 m, the size of the updraughts and associated rainfall closely match observations. The updraught size becomes sensitive to the subgrid turbulent mixing length at shorter gridlengths; good agreement was found with value of 40 m.



Four high impact publications during the year (ranked by journal impact) were:

- Nicol J, Hogan R, Stein T, Hanley K, Clark P, Halliwell C, Lean H, Plant R. 2014. Convective updraught evaluation in high-resolution NWP simulations using single-Doppler radar measurements. *Quart. J. Royal Met. Soc.* doi: 10.1002/qj.2602.
  5-year impact factor: 5YIF(2014): 4.682
- Lloyd, G., Dearden, C., Choularton, T.W., Crosier, J. and Bower, K.N., "Observations of the origin and distribution of ice in cold, warm, and occluded frontal systems during the DIAMET campaign", Mon. Weather Rev., **142**, 4230-4255, 2014. doi: 10.1175/MWR-D-13-00396.1 **5YIF(2014): 3.600**
- Dunbar, T., Barlow, J. and Belcher, S., "An optimal inverse method using Doppler lidar measurements to estimate the surface sensible heat flux", Boundary-Layer Meteorology, **150**, 49-67, 2014. doi: 10.1007/s10546-013-9858-2 **5YIF(2014): 2.590**
- Wilson, R., Milton, E. and Nield, J., "Spatial variability of the atmosphere over southern England, and its effect on scene-based atmospheric corrections", Int. J. Remote Sens., **35**, 5198-5218, 2014. doi: 10.1080/01431161.2014.939781 **5YIF(2014): 1.859**

FUTURE DEVELOPMENTS/STRATEGIC FORWARD LOOK

The role of CFARR in providing long-term measurements is of international importance, particularly through the profiled Cloudnet products derived from its cloud radars, ceilometer and microwave radiometer. It is now formally part of ACTRiS (Aerosol, Clouds and Trace Gases Research Infrastructure). The possibility of also hosting Defra air quality measurements alongside CFARR at Chilbolton would mean the site could simultaneously address multiple areas of interest within this Europe-wide research infrastructure. Plans for CFARR to act as the home site for a new field-deployable AMF (Atmospheric Measurement Facility) scanning cloud radar will further cement its role within NCAS.

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