

SERVICES & FACILITIES ANNUAL REPORT - FY April 2010 to March 2011

SERVICE  Science & Technology Facilities Council	Chilbolton Facility for Atmospheric & Radio Research	FUNDING Block	AGREEMENT SLA Ref. No. R8/H10/74	ESTABLISHED as S&F 1996	TERM 5 years
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TYPE OF SERVICE PROVIDED:

The Chilbolton Facility for Atmospheric and Radio Research (CFARR) occupies a sizeable, modern experimental site. It is particularly suitable for hosting large atmospheric science and remote sensing measurement campaigns that involve coordinated in situ aircraft measurements. The Facility operates a powerful combination of Doppler radars, lidars, radiometers, and supporting instruments; the CAMRa radar is mounted on the world's largest fully-steerable meteorological radar antenna. This combination of instruments, making detailed observations of precipitation, clouds, water vapour and aerosol, enables world leading research. (The Facility also has radiosonde and tethered balloon launch capability.) The science programme that is dependent upon CFARR



94 GHz cloud radar & 25m dish

measurements addresses four of the seven science themes in the current NERC strategy; (1) Climate System, (2) Natural Hazards, (3) Technologies, and (4) Environment, Pollution and Human Health. CFARR data provides invaluable training opportunities; it supported 14 PhD studentships during the year 2010/11. The Chilbolton Facility currently operates more than twenty major instruments, some continuously, while others are operated on demand. In summary these instruments consist of: (1) four Doppler radars that include the 3 GHz Chilbolton Advanced Meteorological Radar (CAMRa) on the 25m antenna, a clear air radar, and two cloud radars that when operated in tandem can be used to derive vertical profiles of cloud ice particle size and liquid water content; (2) four meteorological lidars that include a UV Raman lidar for high resolution (7.5m) profiles of humidity, a dual polarisation Doppler lidar that has the sensitivity to detect backscatter from aerosols, and has the capability to study turbulence within clouds and the boundary layer; a polarisation lidar making profile measurements of molecular, aerosol, and cloud particle backscatter; (3) a number of radiometers that include a multi-frequency radiometer for measuring cloud liquid water path and water vapour density profiles, a sun photometer for measuring aerosol optical depth, and broadband visible and infrared radiometers that measure downwelling flux. In addition there is a sonic anemometer & CO₂ / H₂O probe measuring surface fluxes of sensible & latent heat, momentum & CO₂, and disdrometers measuring the drop size and velocity of hydrometeors. Other instruments include cameras, and meteorological sensors. Adjacent to CFARR the Met Office operates a wind profiling radar, a lidar-ceilometer, and a multi-frequency microwave radiometer for atmospheric temperature, wind, and water vapour profiling. Measurements made at the Facility are quality assured prior to being archived at the British Atmospheric Data Centre.

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: (1) The polarisation lidar was unavailable from June onwards because the manufacturer had problems completing repairs; and (2) the ACROBAT radar is unavailable because a decision was taken, after consultation, not to fund the replacement of the power amplifier that has failed.

Target: To submit quality-controlled data from CFARR to the British Atmospheric Data Centre every quarter – achieved.

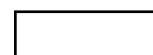
Target: Real time display of data on the Web - achieved.

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

CAPACITY of HOST ENTITY FUNDED by S&F	Staff & Status	Next Review (March)	Contract Ends (31 March)
86%	6.3 FTE drawn from 10 permanent STFC staff. [1.6 FTE @ Band F; 2.3 FTE @ Band E; 0.5 FTE @ Band D 1.9 FTE @ Band C]	2013	2014

FINANCIAL DETAILS: CURRENT FY									
Total Resource Allocation £k	Unit Cost £k						Capital Expend £k	Income £k	Full Cash Cost £k
	Dish radars (hr)	Data (Mb)	User Support (%)	Raman Lidar (hr)	Cloud Radars (day)	Lidars & Radiometer (day)			
649.09	4.29	0.0003	2.5	0.664	0.138	0.072	27.2	106	694.9
FINANCIAL COMMITMENT (by year until end of current agreement) £k									
2010-11:	649.09	2011-12:	658.09	2012-13:	671.91	2013-2014:	686.21	2014-2015	tbd

STEERING COMMITTEE	Independent Members	Meetings per annum	Other S&F Overseen
NARFSC	9	1	MSTRF & EISCAT



APPLICATIONS: DISTRIBUTION OF GRADES (current FY — 2010/11)												
	10	9	8	7	6	5	4	3	2	1	0	R*
NERC Grant projects*		1	2									
Other academic			1									
Students				1								
Pilot												
TOTAL		1	3	1								

PROJECTS COMPLETED (current FY – 2010/11)								
	α5	α4	α3	α2	α1	β	R*/Pilot	
NERC Grant projects*	2	2						
Other Academic								
Students		1						
Pilot								

Project Funding Type (current FY – 2010/11) (select one category for each project)										
Grand Total	Infrastructure						PAYG			
	Supplement to NERC Grant * PI/(Co-I)	PhD Students		NERC C/S	Other	NERC Grant*	PhD Students	NERC C/S	Other	
		NERC	Other				NERC	Other		
47	9/(12)	7	7	1/(2)	7/(2)					

Project Funding Type (per annum average previous 3 financial years - 2007/2008, 2008/2009 & 2009/2010)										
Grand Total	Infrastructure						PAYG			
	Supplement to NERC Grant * PI/(Co-I)	PhD Students		NERC C/S	Other	NERC Grant*	PhD Student	NERC C/S	Other	
		NERC	Other				NERC	Other		
47.66	10.33 / (12.33)	7	5	2/(3.66)	5.66					

User type (current FY – 2010/11) (include each person named on application form)				
Academic	NERC Centre/Survey	NERC Fellows	PhD Students	Commercial
29	3		14	1
User type (per annum average previous 3 financial years - 2007/2008, 2008/2009 & 2009/2010)				
Academic	NERC Centre/Survey	NERC Fellows	PhD Students	Commercial
14.33	3		11.33	2

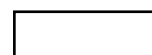
OUTPUT & PERFORMANCE MEASURES (current year)											
Publications (by science area & type) (calendar year 2010)											
SBA	ES	MS	AS	TFS	EO	Polar	Grand Total	Refereed	Non-Ref/ Conf Proc	PhD Theses	
			26	1	1		28	13	14	1	
Distribution of Projects (by science areas) (FY 2010/11)											
Grand Total	SBA	ES	MS	AS	TFS	EO	Polar				
32				28	3	1					

OUTPUT & PERFORMANCE MEASURES (per annum average previous 3 years)											
Publications (by science area & type) (Calendar years 2007, 2008 & 2009)											
SBA	ES	MS	AS	TFS	EO	Polar	Grand Total	Refereed	Non-Ref/ Conf Proc	PhD Theses	
			30.33	2	4.33		36.66	16	17.33	3.33	
Distribution of Projects (by science areas) (FY 2007/2008, 2008/2009 & 2009/2010)											
Grand Total	SBA	ES	MS	AS	TFS	EO	Polar				
30.65				28.33	0.66	1.66					

Distribution of Projects by NERC strategic priority (current FY 2010/11)							
Grand Total	Climate System	Biodiversity	Earth System Science	Sustainable Use of Natural Resources	Natural Hazards	Environment, Pollution & Human Health	Technologies
32	19			1	6	2	4

*Combined Responsive Mode and Directed Programme grants

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



OVERVIEW & ACTIVITIES IN FINANCIAL YEAR (2010/11):

New measurement capabilities at CFARR:

- **Li-Cor PAR sensor model LI-190 SA**

Photosynthetically active radiation (PAR) is an important variable in plant growth models and is a key parameter in global carbon flux models. A PAR sensor has been installed at CFARR by the University of Southampton to study how the relationship between PAR and broadband solar radiation varies with cloud cover and with season (air mass characteristics etc.). The installation will provide a time series of well-calibrated data which will be used to test this hypothesis. The deployment is for at least one year.

- **ClearfLo – gas measurements**

The NERC-ClearfLo project (Clean Air for London) is a collaborative scientific project designed to investigate boundary layer pollution across London. As part of the activity, the University of York is making routine measurements of CO and O₃ at Chilbolton which has been chosen as a 'rural background' site.

Facility upgrades:

- **Flux measurement compound**

Sensible heat, latent heat, and ground heat fluxes are measured at CFARR in a number of different ways. The eddy covariance technique is applied to sonic anemometer and rapidly sampled CO₂ / H₂O measurements to estimate surface vertical fluxes of sensible heat, latent heat, momentum and CO₂; a CNR1 net flux radiometer measures the energy balance between incoming short-wave and long-wave IR radiation versus surface-reflected short-wave and outgoing long-wave IR radiation; two soil heat flux plates measure the ground heat flux. A new compound has been established on the 500m range for these instruments; the grass beneath them is hand mown to maintain a near constant length. A horizontal beam has been attached to the existing tower to ensure that the radiation measurements are not affected by shadows. The 500m test range is often used for the testing and operation of scintillometers designed to measure heat fluxes over the length of the range.

- **LOFAR antenna arrays**

LOFAR-UK is a consortium of many universities plus STFC; they have built the first LOFAR (LOW Frequency Array) station in the UK at the Chilbolton Observatory. LOFAR is an aperture synthesis array radio telescope composed of phased array stations working at the lowest frequencies accessible from Earth (30-240 MHz). The UK station has been commissioned and is supplying data to the central processor in The Netherlands. In stand-alone mode, the Chilbolton station can be used to study the ionosphere as well as other aspects of solar-terrestrial physics.

- **CAMRa polariser and feed horn**

A new CAMRa radar feed horn was manufactured and installed to replace the combined CAMRa and ACROBAT radar feed horn; this should significantly improve the LDR measurement performance of CAMRa. Also a new stepper motor to drive the CAMRa polariser disk was installed. This has resulted in improved performance by fixing the rotational speed of the polariser.

- **94 GHz cloud radar transmitter**

A new EIKA amplifier power supply was purchased and then installed in the 94 GHz Galileo cloud radar by the CFARR radar engineer. Careful design ensured that the much larger power supply was fitted inside the existing housing so that the radar can still be mounted in the purpose built frame attached to the edge of the 25m dish, if required.

Experimental Campaigns:

- **SeptEx (NCAS/Met Office)**

CFARR supported three flights of the Facility for Airborne Atmospheric Measurements (FAAM) in the vicinity of Chilbolton during the SeptEx campaign by performing RHI scans with the CAMRa radar on the 25m dish to collect radar reflectivity measurements of clouds. Vertically pointing cloud radar and lidar data were also collected to help characterise the cloud above the facility. The FAAM flights were primarily designed to examine how ice forms in clouds.

- **EG-CLIMET - Water Vapour profiling (Met Office)**

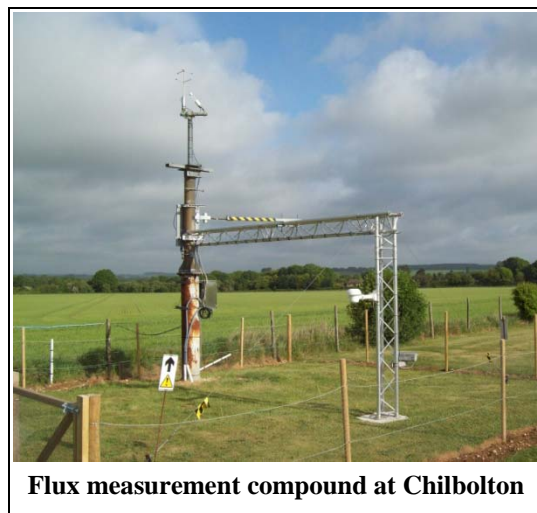
In June 2010 there was a campaign at CFARR designed to assess the ability of multi-frequency microwave radiometers to measure water vapour profiles. Water vapour profiles derived from measurements made using two HATPRO radiometers belonging to the Met Office, together with those derived from measurements made using a Radiometrics radiometer and a UV Raman lidar based at CFARR, and a series of radiosonde ascents, were compared over a period of 3 three weeks.

- **24/7 Continuous measurements (NERC)**

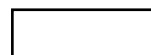
Throughout the period of the eruption from the Eyjafjallajokull volcano in April 2010, continuous measurements made at CFARR with a variety of instruments ensured that the Facility was able to collect important information about ash layers as they passed overhead. Depolarisation measurements made using two lidars, and ash particle size distributions derived from sun photometer measurements, were supplied directly to the Met Office and to the British Atmospheric Data Centre (BADC).

Prizes:

- The **Mason Gold Medal** was awarded to Professor A J Illingworth by the Royal Meteorological Society in May 2010; in part this was for his charismatic scientific leadership of the Chilbolton Facility.



Flux measurement compound at Chilbolton



SCIENCE HIGHLIGHTS:

• Volcanic ash characterisation

The eruption of the Eyjafjallajökull volcano in April 2010 resulted in severe disruption to aircraft flights over much of Europe. Instruments at CFARR detected evidence of ash clouds from 16th April onwards, and provided some of the first evidence for the size of the ash particles. Lidar depolarisation measurements can be related to the degree of asymmetry of the scattering particles, they proved extremely useful in identifying probable ash layers. Aerosol optical depth (AOD) computed from sun-photometer measurements of solar extinction provided a measure of the total amount of aerosol along paths through the atmosphere. In addition, sun-photometer radiance measurements were inverted to produce aerosol optical properties, including particle size distributions. Subsequent studies using those observations have established that a combination of sun-photometer and single-wavelength backscatter lidar data is best suited to retrieval of ash particle mass concentration and mean particle size. The data collected has been used to specify an optimum instrument set for a ground-based ash monitoring station.

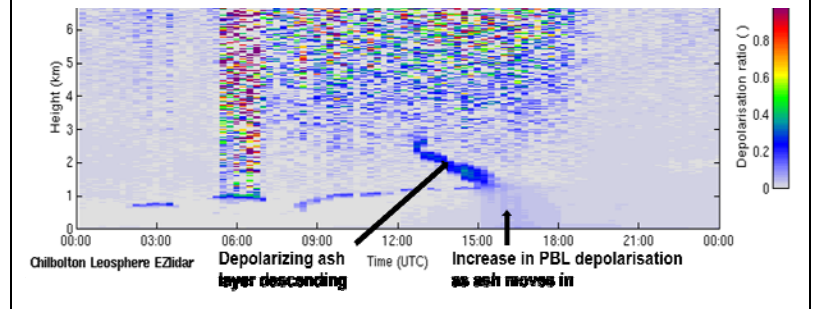
• Ice nucleation and formation of precipitation

Using 4 years of data from the Chilbolton cloud radars and the CT75K lidar, it is seen that at temperatures $>-20^{\circ}\text{C}$ essentially all ice clouds have liquid water at the top. The implication is that ice nucleation by direct deposition of water vapour onto aerosols is not important for clouds in this temperature range, and that it is the freezing of droplets which dominates the formation of ice in low- and mid-level clouds. This also has a knock on effect for formation of precipitation, since the crystals nucleated in such conditions (i.e. water saturation) grow at the maximum possible rate. At colder temperatures the number of liquid-topped ice clouds decreases monotonically, to 50% at -27°C , and 0% at -35°C . This is evidence that droplet-freezing may be an important ice-forming pathway, even in very cold clouds.

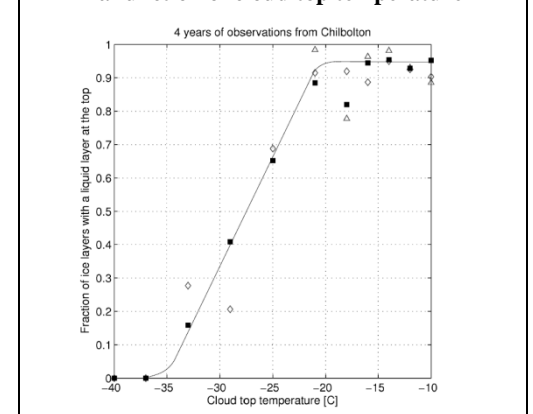
Four publications ranked by journal impact factor during the year were:

- Westbrook, C. D., Illingworth, A. J., O'Connor, E. J. and Hogan, R. J., "Doppler lidar measurements of oriented planar ice crystals falling from supercooled and glaciating layer clouds", *Q. J. Roy. Meteor. Soc.*, **136** (646), 260-276, 2010. [doi: 10.1002/qj.528] **IF(2010): 2.977** **5YIF(2010): 3.557**
- Browning, K. A., Marsham, J. H., Nicol, J. C., Perry, F. M., White, B. A., Blyth, A. M. and Mobbs, S. D., "Observations of dual slantwise circulations above a cool undercurrent in a mesoscale convective system", *Q. J. Roy. Meteor. Soc.*, **136** (647), 354-373, 2010 Part B. [doi: 10.1002/qj.582] **IF(2010): 2.977** **5YIF(2010): 3.557**
- Bouniol, D., Protat, A., Delanoë, J., Pelo, J., Piriou, J., Bouyssel, F., Tomkins, A. M., Wilson, D. R., Morille, Y., Haefelin, M., O'Connor, E. J., Hogan, R. J., Illingworth, A., Donovan, D. P. and Baltink, H., "Using continuous ground-based radar and lidar measurements for evaluating the representation of clouds in four operational models", *J. Appl. Meteorol. Clim.*, **49**, 1971-1991, 2010. [doi:10.1175/2010JAMC2333.1] **IF(2010): 1.918** **5YIF(2010): 2.218**
- O'Connor, E. J., Illingworth, A. J., Brooks, I. M., Westbrook, C. D., Hogan, R. J., Davies, F. and Brooks, B. J., "A method for estimating the turbulent kinetic energy dissipation rate from a vertically pointing Doppler lidar, and independent evaluation from balloon-borne in situ measurements", *J. Atmos. Ocean. Tech.*, **27**, 1652-1664, 2010. [doi: 10.1175/2010JTECHA1455.1] **IF(2010): 1.860** **5YIF(2010): 1.959**

Lidar depolarisation ratio measurements show an ash layer descending over Chilbolton on 16th April 2010



Fraction of ice-phase clouds which have supercooled liquid water droplets at the top as a function of cloud top temperature



FUTURE DEVELOPMENTS/STRATEGIC FORWARD LOOK

1. Work with the manufacturer of the 1.5 μm dual polarisation Doppler lidar to restore lost sensitivity. (Jul'11)
2. EG-CLIMET/ Upper Air measurements – exploit the synergetic use of multiple profiling microwave radiometers at Chilbolton. (Oct'11)
3. Ensure that the manufacturer of the 355nm polarisation lidar completes the servicing and upgrading of the instrument and returns it to CFARR as soon as possible. (Jun'11)
4. 35 GHz cloud radar – build a replacement RF unit controller to reduce radar down time when IC components fail. (Aug'11)
5. Purchase a new cavity magnetron tube for the CAMRa radar – required as a spare for the radar's existing tube. (Nov'11)
6. Take delivery of, and install, a new travelling wave tube (TWT) power amplifier for use with the CAMRa radar. (Feb'12)
7. Complete implementation of a new web-based system for recording all upgrades, repairs, and calibrations of facility instruments. [Delayed from last year.] (Jul'11)
8. Complete repair of water leaks in the focus cabin on the 25m dish. [Delayed from last year due to cold weather.] (Jul'11)
9. Install and commission the new data acquisition system for the meteorological instruments on the 500m test range. (Jun'11)
10. Support NERC grants requiring access to CFARR – two bids are currently being reviewed. (Mar'12)
11. Participate in, and support, bids to NERC for funding of research activities requiring the use of CFARR. (Mar'12)
12. Contribute to "Living with Environmental Change" programme. (Mar'12)