

SERVICES & FACILITIES ANNUAL REPORT - FY April 2005 to March 2006

SERVICE FSF	FUNDING Block	AGREEMENT Contract	ESTABLISHED as S&F 1988	TERM 3
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TYPE OF SERVICE PROVIDED:

The NERC Field Spectroscopy Facility (formerly NERC EPFS) is a unique world class facility supporting Earth Systems science. It comprises a collection of high quality modern field spectroradiometers and sun photometers, operating over the optical wavelengths, and associated calibration and support equipment. The Facility operates out of the School of GeoSciences, University of Edinburgh where it currently employs two personnel (an operations manager and equipment at 0.75 FTE each) and where it exploits synergies with other NERC facilities, notably the Geophysical Equipment Facility. FSF thus represents a financially and operationally efficient means of providing users with well maintained and calibrated instrumentation and with the training with which to use these instruments to best effect in order to facilitate and support high quality UK environmental science.

FSF is of strategic importance to NERC in underpinning both Thematic and non-Thematic research programmes and in contributing to the training of PhD students and new academics. FSF makes an important contribution across a broad range of NERC's Strategic Priority areas. FSF also provides support to NERC Centres of Excellence in Earth Observation, notably CTCD, CASIX and CLASSIC. The FSF also performs a vital strategic function in underpinning the use of data from airborne sensors, especially those flown by the NERC Airborne Research and Survey Facility.

The calibration of earth observation data is critical if we are to reliably attribute detected changes observed in satellite and aircraft data to real environmental changes occurring at ground level. Without calibration we are unable to rule out the influence of other factors such as instrument error or influences of the atmosphere. This problem is exacerbated by the myriad of sensors operated by multiple countries and organisations. *Calibration* allows the traceability of sensor data to the same physical standards and is routinely required as sensors decay throughout their lifetime in space. Calibration is critical to the compilation of reliable long-term data sets for studying the effects of climate change and the fluxes of carbon to and from the oceans and land. *Validation* refers to the independent verification of the physical measurements made by a sensor as well as of the derived geophysical variables. Validation allows for the verification and improvement of the algorithms used (e.g. for atmospheric correction and vegetation state). To achieve this, conventional, ground-based observations are required using calibrated and traceable field instrumentation.

The Facility provides training for postgraduate students and other researchers new to quantitative remote sensing. Training in instrument use is performed on a one to one basis, supplemented by a new two day Introduction to Field Spectroscopy course. On average 10 projects each year are associated with postgraduate PhD research including a significant number of NERC research studentships, frequently extending over two summer seasons.

Access to FSF resources is available free of charge to the UK research community, subject to expert peer review by the FSF Steering Committee. ~20 applications are received each year and the total requested loan time typically exceeds available capacity by ~10–20%. The science supported by the Facility is diverse and of high quality; this year papers were published in the *Journal of Geophysical Research*, *Continental Shelf Research* and *IEEE Transactions on Geosciences and Remote Sensing*.

ANNUAL TARGETS AND PROGRESS TOWARDS THEM

- User community increased through: upgrade and deployment of CIMEL sunphotometer deployed to CLRRRC, Chilbolton as part of AERONET network; funding for development of FTIR instrument covering wider spectral range (2-15 um); purchase of underwater housing for GER 1500 range of instruments. **More?**
- Training significantly enhanced through two day 'Introduction to Field Spectroscopy' training course for new PhD students;
- Continued developments in QA and calibration procedures to ensure rigorous and standardised
- Raise profile of the Facility through presentations at five national and international conferences and meetings
- Successful SRG review
- Active participation in NCAVEO knowledge transfer activities.

SCORES AT LAST REVIEW (each out of 5)		Date of Last Review: 2006		
Need 5	Uniqueness 5	Quality of Service 5	Quality of Science & Training 5	Average 4.88

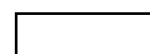
CAPACITY of HOST ENTITY FUNDED by S&F 100%	Staff & Status 1 x Director – 100% UoEdinburgh 1 x Operations Manager – 75% NERC 1 x Equipment Manager – 100% NERC	Next Review (January) 2009	Contract Ends (31 March) 2007
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FINANCIAL DETAILS: CURRENT FY									
Total resource allocation £k	Unit Cost £k						Capital Expend £k	Income £k	Full cash cost £k
	ASD FSPro	GER 3700	GER 1500 (D)	GER 1500 (S)	CIMEL	Micro-Tops			
£102	£283	£202	£256	£127	£55	£32	£48.6*	£6	£210.6

FINANCIAL COMMITMENT (by year until end of current agreement)									
2005-06	£102.26	2006-07	£90.90	2007-08	n/a	2008-09	n/a	2009/2010	n/a

*includes £11.95k spent on the FTIR instrument development

STEERING COMMITTEE	Independent Members	Meetings per annum	Other S&F Overseen
FSFSC	4	1 (2 in 2005-06)	None



APPLICATIONS: DISTRIBUTION OF GRADES (Current FY — 2005/06)								
	$\alpha 5$	$\alpha 4$	$\alpha 3$	$\alpha 2$	$\alpha 1$	β	R*/Pilot	Reject
NERC Grant projects	4	4					1	
Other academic	3	4						1
Students (NERC)	(1)	2 (3)	(1)					
Pilot		2						
TOTAL	8	15	1				1	1

APPLICATIONS: DISTRIBUTION OF GRADES (per annum average previous 3 years —21002/03 – 2004/05)								
	$\alpha 5$	$\alpha 4$	$\alpha 3$	$\alpha 2$	$\alpha 1$	β	R*/Pilot	Reject
NERC Grant projects	2.6	3.6	1					
Other Academic	0.6	6.3	5.3	0.6			0.3	0.3
Students	0.6(0.3)	4(2.3)	0.3					
Pilot								
TOTAL	4.3	16.3	6.6	0.6			0.3	0.3

PROJECTS COMPLETED (Current FY)								
	$\alpha 5$	$\alpha 4$	$\alpha 3$	$\alpha 2$	$\alpha 1$	β	R*/Pilot	
NERC Grant projects	5	4						
Other Academic	1	5						
Students (NERC)	1	2(2)	(1)					
Pilot	1							

USER PROFILE (current FY)										<i>*Combined non-Directed and Directed</i>			
Grand Total	Infrastructure					PAYG							
	Supplement to NERC Grant *	Student Total		NERC RC	Other	NERC Grant*	Student Total		NERC C/S	Other			
28	8	7	5	2	4					4			

USER PROFILE (per annum average previous 3 years)										<i>*Combined non-Directed and Directed</i>			
Grand Total	Infrastructure					PAYG							
	Supplement to NERC Grant *	Student Total		NERC RC	Other	NERC Grant*	Student Total		NERC C/S	Other			
32.5	8	9.6	3.6	3.3	8								

USER PROFILE (current FY)				
Academic	NERC RC	NERC Fellows	PhD	Commercial
22	2	1		1

USER PROFILE (per annum average previous 3 years)				
Academic	NERC RC	NERC Fellows	PhD	Commercial
13	2.6	1	11.3	0.6

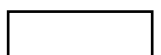
OUTPUT & PERFORMANCE MEASURES (current FY)										
Publications (by science area & type)										
SBA	ES	MS	AS	TFS	EO	Polar	Grand Total	Refereed	Non-Ref/ Conf Proc	PhD Theses
0	0	2	3	9	4	0	18	5	8	5

Distribution of Projects (by science areas)						
SBA	ES	MS	AS	TFS	EO	Polar
	1	3	3	5	10	1

OUTPUT & PERFORMANCE MEASURES (per annum average previous 3 years)										
Publications (by science area & type)										
SBA	ES	MS	AS	TFS	EO	Polar	Grand Total	Refereed	Non-Ref/ Conf Proc	PhD Theses
0	2	1.6	2.1	18	15	0	38.7	10.3	28	3

Distribution of Projects (by science areas)						
SBA	ES	MS	AS	TFS	EO	Polar
1	2.1	2.6	3.6	14.3	3	0.6

Distribution of Projects (by NERC strategic priority)				
Earth's Life Support Systems	Climate Change	Sustainable Economies	Underpinning Science	Specific Research
9	4	1	8	1



OVERVIEW & ACTIVITIES IN FINANCIAL YEAR (2005/06):

Loans, user training and support

- 28 loans of equipment supported (including 4 commercial loans). During the summer months the schedule was close to full with most instruments on loan throughout.
- A MicroTops sun photometer was supplied to Dr Tamsin Mather (Cambridge) under the urgency procedures to study the environmental effects of the Buncefield Oil Depot fire at Hemel Hemstead in December 2005. This support was highlighted in an article in the NERC Planet Earth publication.
- 11 new users have been trained one-to-one in the use of our instrumentation. Responses to the training received have been highly favourable. Telephone support has quickly resolved problems encountered in the field.
- A new training course entitled 'Introduction to Field Spectroscopy' was held for the first time on 19th and 20th December 2005. The course addressed the wider issues of methods in field spectroscopy which are not addressed when students attend for training in specific instrument use. The course was attended by 13 PhD students or RAs and the feedback highly positive.

Publicity

- Poster presentations made at the RSPSoc Conference in Portsmouth (September) and at two NERC Regional Conferences in Edinburgh (May and Cardiff (June), to publicise the Facility and to highlight planned developments.

Quality Assurance and calibration

- Delays in calibration of our in-house standards by NPL impacted our ability to fully calibrate our instrumentation and to provide calibration services to others instrument holders. This situation is now resolved.
- A number of improvements in our QA and calibration procedures have been implemented to ensure greater rigor and more standardised procedures.

Instrumentation

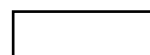
- The Facility's CIMEL sunphotometer was upgraded and recalibrated free of charge by NASA and installed at CLRRC Chilbolton in late 2005 where it now represents the UK's first official AEROSOL ROBOTIC NETWORK (AERONET) site. Data provided includes continuous observations of spectral aerosol optical depths, inversion products, and precipitable water at a UK site, and is supplied free of charge via the AERONET website.
- Upgrades to all our GER spectroradiometers were completed to allow interface to modern PCs, including upgrades to firmware, on board batteries, software and hardware. These should extend the lives of these instruments for several more years.
- Upgrades to the GER instrumentation necessitated the replacement of our post-processing software provided to users. The older DOS-based programs received following the transfer of the Facility from Southampton were augmented with a number of MS Excel templates with embedded Visual Basic macros. A single spreadsheet effectively replaces a number of DOS programs and allows users to process their data to absolute reflectance with minimal effort. Templates have been produced for each of the instruments and for different measurement modes (e.g. for reflectance or radiance data). User notes specific to each template have been provided along with the spreadsheets on the Facility's website.
- During 2005 the funding for the development of the FTIR instrument was confirmed and received. The specifications for the instrument were agreed and an order for the major items placed with Advanced Photonics (AP) from the USA. The instrument is due for delivery from the manufacturers, Midac, in August 2006, and acceptance testing will be undertaken at Midac's base in Durham, North Carolina. The instrument will only be transported to the UK when it has passed acceptance testing.

Research

- Plans were approved for the design of the goniospectroradiometer (jointly funded by NERC and DTI), developed as part of a PhD project of an NPL member of staff. The full system is currently being constructed and tested. It is anticipated that the device will be available for loan by users for the summer of 2007.
- To address the requirements and data processing issues of one user, the true field-of-view of the GER 3700 instrument was established. This reveals that the field of view is far from a uniform one, varying in size both spatially and with wavelength. A conference paper on the topic is in preparation.

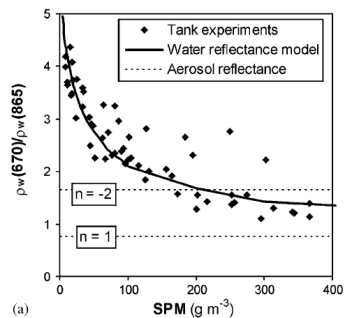
Other activities

- Near completion of formal procedures for all Facility activities, including loan applications and review, loan scheduling, training, and data processing.
- Full participation in NCAVEO (Network for calibration and validation of Earth Observation data) knowledge transfer activities
- FSF was part of a successful Accompanying Measures consortium funded by the EU Sixth Framework programme under the Research Infrastructures action. The programme, 'Hyperspectral Remote Sensing in Europe - Specific Support Actions' (HYRESSA), aims to investigate issues associated with the provision, accuracy, quality and conformity of hyperspectral remotely sensed data across Europe with the advent of the next generation of hyperspectral instruments. Edinburgh will lead the final work package aimed at developing a plan for future collaboration related to an EU-wide hyperspectral remote sensing research infrastructure. The programme will assess both imaging and ground based hyperspectral systems.
- In March, Dr Malthus visited instrument calibration facilities at CSIRO in Canberra, Australia.
- Application for renewal of the FSF contract submitted to S&F in December 2005.



SCIENCE HIGHLIGHTS (including four most impactful outputs):

(1) FSF equipment was used in a field and modelling study of the optical properties of wet mid-latitude mountainous snow (Cairngorms). UV penetrated to greater depths than polar (tundra) snowpacks, suggesting that the snow has fewer absorbing impurities than snow from the Arctic. Mid-latitude snow may thus release more NO₂ gas to the atmosphere due to photolytic destruction of nitrate anions in the snowpack. **Fisher et al. (2005). *Journal of Geophysical Research*, 110; d21301.**

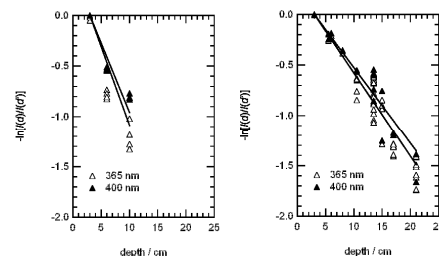


(a) NIR and aerosol reflectance ratios as a function of SPM for the ratio 670/865nm. A comparison of measured and modelled results.

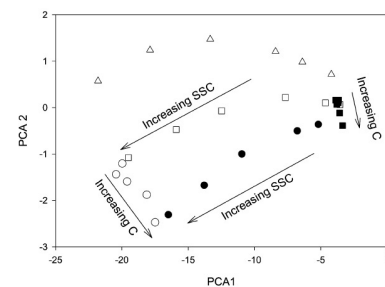
(2) Case II surface waters typically have high reflectance at near infra-red wavelengths which invalidates “dark pixel” atmospheric correction methods where negative reflectances are often given. A laboratory-based tank experiment using FSF equipment, complemented by coupled ocean-atmosphere modelling and validated against test images from Europe, characterised NIR reflectances of different concentrations of suspended sediments representing diverse sediment mineralogies. The modified atmospheric correction methods led to significant increases in normalised water leaving-radiances across the whole spectrum and to fewer negative water leaving radiances. **Lavender et al. (2005) *Continental Shelf Research*, 25:539–55.**

(3) Wetland systems are fragile and highly dynamic ecosystems which are affected by degradation processes as a result of anthropological influences, such as overexploitation of groundwater for agriculture and associated land use. Field reflectance and hyperspectral image spectra of surface components were used to define endmembers in a site-specific spectral library; the information was extrapolated to a temporal series of broadband multispectral imagery with spectral unmixing analyses performed to detect changes in the wetlands over time. The results indicate the significant impact of anthropogenic impact, but that natural seasonally-induced fluctuations confuse the changes detected. Water regulation and agricultural practices directly influences the salinity of the soils and therefore the nature of the hygrophytic vegetation. **Schmid et al. (2005) *IEEE Transactions in Geoscience and Remote Sensing*, 43:2517-2525.**

(4) In situ reflectance measurements in Lake Balaton were supplemented by controlled tank experiments to characterize the influence of suspended sediment (SS) and Chl a on spectral reflectance and simulated Landsat satellite responses. These confirmed that Chl a could not be estimated directly from Landsat data in waters characterized by heterogeneous suspended matter. However, principal component analysis indicated that a spectral linear mixture modelling approach combined with a multivariate regression analysis could be used to provide estimates of Chl a concentrations, independent of SS concentrations. **Svab et al. (2005) *International Journal of Remote Sensing*, 26: 919–928.**



Log plot of relative light penetration at two wavelengths versus snow depth at one site on days 3 and 53.



PCA scatterplot Landsat simulation with location of end-members identified.

FUTURE DEVELOPMENTS/STRATEGIC FORWARD LOOK

New science areas supported

- Support to marine and freshwater sciences enhanced with arrival of beam attenuation and absorption instrument in mid 2006.
- Atmospheric and solid surface environmental science applications extended through the development of instrumentation covering a wider spectral range to extend from the optical into the thermal range.

Planned hardware developments to support science areas

- Continued phased development of the field portable FTIR spectrometer covering the spectral region 2 – 20µm.
- Arrival of Wetlabs AC-S instrument for the measurement of underwater absorption and beam attenuation.
- Purchase of one VNIR/SWIR spectroradiometer to replace existing aging stock.
- Application to purchase further optical instrumentation for underwater use to complete suite of underwater capabilities.

Other developments planned to meet mission objectives

- Raise profile of the Facility through presentations at national and international conferences and meetings.
- Continued growth of the user base through supporting wider areas of NERC science outlined above
- Continued emphasis on training with repeat of introductory training course.
- Introduction of calibration services for non-NERC owned spectroradiometric equipment.
- Provision of calibration services to ARSF.
- Further developments in QA and calibration procedures aimed ultimately at NPL accreditation.
- Continued developments to website and databases to improve Facility functioning.
- Continued active participation in NCAVEO knowledge transfer activities.

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

NERC Planet Earth winter publication highlighted FSF's rapid-response contribution of MicroTops instrumentation to support research of impacts on the atmosphere of the Buncefield fuel depot fire, on 11th of December 2005 (Annex 10).