

SERVICES & FACILITIES ANNUAL REPORT - FY April 2008 to March 2009

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

The NERC Field Spectroscopy Facility is a unique world class facility supporting high quality Earth Systems science through the loan of high resolution, calibrated, and well maintained optical sensing equipment including high quality modern field spectroradiometers, sun photometers, an FTIR spectrometer and equipment for the measurement of underwater inherent and apparent optical properties. The Facility operates out of the School of GeoSciences, University of Edinburgh where it currently employs two personnel (Operations and Equipment managers at 0.75 FTE each) and exploits synergies with the Geophysical Equipment Facility. FSF represents a financially and operationally efficient means of providing users with well maintained and calibrated instrumentation and with the training to use the instruments to best effect.

Strategically, FSF underpins a wide swath of NERC science programmes, including Thematic and non-Thematic research programmes, and a broad range of NERC's Strategic Priority areas. It contributes to the training of PhD students and new academics and supports the NERC Centre for Earth Observation (NCEO). FSF also vitally supports the NERC Airborne Research and Survey Facility.

Calibration plays a key role in the Facility's operation and 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 where sustained observation is a key component of national capability. Emphasis is thus placed on the provision to users of calibrated equipment traceable to standards held by the National Physical Laboratory. This is key to minimising uncertainty if we are to reliably attribute detected changes observed in satellite and aircraft data to real environmental changes occurring at ground level, where the issues associated with the calibration of the space-borne sensors used to detect these changes is receiving increasing attention.

All new users are trained on a one-to-one basis in the use of Facility equipment. Additionally, an extended, highly rated, two and a half day *Introduction to Field Spectroscopy* training course is annually offered. 12 projects this year were 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 international journals such as *Journal of Geophysical Research*, *Journal of Geochemical Exploration*, *Optics Express* and *Geomorphology*.

ANNUAL TARGETS AND PROGRESS TOWARDS THEM

- Diversification of the user community achieved through: First full loans of the FTIR instrument during summer loan season 2008; Completion of the goniospectroradiometer development project and availability for loan during summer 2009 season. First loans of full integrated underwater AC-S/HYPER-OCR instrument suite during summer 2009 loan season. .
- Profile of the Facility raised through highly successful representation at RSPSoc 2008 meeting with lectures, demonstrations and displays of four new FSF instruments.
- Continued broad-base training in optical field measurement and analysis methods through a two and a half day 'Introduction to Field Spectroscopy' training course for 17 PhD students, post-docs and two academics held in April 2009;
- Continuation of well maintained and calibrated instrumentation through an emphasis on QA and calibration procedures.
- Purchase of two replacement full wavelength spectroradiometers with improvements to field measurement, and fields-of-view.
- Continuation of VNIR/SWIR and HR-1024 external sensor suite projects to improve instrumentation to better support field measurement.
- Trends towards higher graded loan applications supporting a wide range of NERC Science priorities, longer loans on instrumentation, and increased publication outputs.

SCORES AT LAST REVIEW (each out of 5)			Date of Last Review:		2009
Need 5	Uniqueness 5	Quality of Service 5	Quality of Science & Training 5	Average 5	

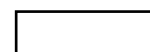
CAPACITY of HOST ENTITY FUNDED by S&F	Staff & Status	Next Review (March)	Contract Ends (31 March)
100%	1 x Director – 20% U of Edinburgh 1 x Operations Manager – 75% NERC 1 x Equipment Manager – 75% NERC	2014	2010

FINANCIAL DETAILS: CURRENT FY

Total Resource Allocation £k	Unit Cost £k									Capital Expend £k	Income £k	Full Cash Cost £k
	ASD FSPr	GER 3700	GER 1500 (D)	GER 1500 (S)	Cimel	Micro- Tops	FTIR	ASD FS3	ACS			
£183	£283	£220	£256	£127	£55	£32	£283	£256	£256	0	£0.7	£511.5

FINANCIAL COMMITMENT (by year until end of current agreement) £k									
2008-09	£183	2009-10	£187.6	2010-11	na	2011-12	na	2012-2013	na

STEERING COMMITTEE	Independent Members	Meetings per annum	Other S&F Overseen
FSFSC	4	1	None



APPLICATIONS: DISTRIBUTION OF GRADES (current FY — 2008/09)								
	$\alpha 5$	$\alpha 4$	$\alpha 3$	$\alpha 2$	$\alpha 1$	β	R*/Pilot	Reject
NERC Grant projects*	2	3					1	
Other academic	4	6					1	1
Students		4(4)						
Pilot								
TOTAL	6	17					2	1

APPLICATIONS: DISTRIBUTION OF GRADES (per annum average previous 3 financial years —2005/2006, 2006/2007 & 2007/2008)								
	$\alpha 5$	$\alpha 4$	$\alpha 3$	$\alpha 2$	$\alpha 1$	β	R*/Pilot	Reject
NERC Grant projects*	2.67	2.00					0.33	
Other Academic	2.00	5.00	0.67				0.33	0.67
Students	0.33	3(2.33)	(0.66)				0.33	
Pilot		1.00					0.67	
TOTAL	5.00	12.33	1.33				1.67	0.67

PROJECTS COMPLETED (current FY – 2008/09)								
	$\alpha 5$	$\alpha 4$	$\alpha 3$	$\alpha 2$	$\alpha 1$	β	R*/Pilot	
NERC Grant projects*	4	4						
Other Academic	3	4						1
Students	1	2(7)		1				
Pilot								1

USER PROFILE - funding type (current FY – 2008/09)										
Grand Total	Infrastructure					PAYG				
	Supplement to NERC Grant *	Student NERC	Student Other	NERC C/S	Other	NERC Grant*	Student NERC	Student Other	NERC C/S	Other
28	8	7	4	2	7	0	0	0	0	0

USER PROFILE - funding type (per annum average previous 3 financial years - 2005/2006, 2006/2007 & 2007/2008)										
Grand Total	Infrastructure					PAYG				
	Supplement to NERC Grant *	Student NERC	Student Other	NERC C/S	Other	NERC Grant*	Student NERC	Student Other	NERC C/S	Other
29.67	6.00	4.33	5.00	3.67	8.67	1.33	0	0	0	1.33

USER PROFILE – user type (current FY – 2008/09)				
Academic	Centre/Survey	NERC Fellows	PhD	Commercial
16.33	2	0.67	9	0

USER PROFILE - user type (per annum average previous 3 financial years - 2005/2006, 2006/2007 & 2007/2008)				
Academic	Centre/Survey	NERC Fellows	PhD	Commercial
11	6	0	11	1

OUTPUT & PERFORMANCE MEASURES (current year)											
Publications (by science area & type) (calendar year 2008)											
SBA	ES	MS	AS	TFS	EO	Polar	Grand Total	Refereed	Non-Ref/ Conf Proc	PhD Theses	
0	3	6	3	11	35	1	59	12	42	5	

Distribution of Projects (by science areas) (FY 2008/09)											
SBA	ES	MS	AS	TFS	EO	Polar					
0	15	2	8.5	2.5	26	2					

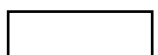
OUTPUT & PERFORMANCE MEASURES (per annum average previous 3 years)											
Publications (by science area & type) (Calendar years 2005, 2006 & 2007)											
SBA	ES	MS	AS	TFS	EO	Polar	Grand Total	Refereed	Non-Ref/ Conf Proc	PhD Theses	
0	0.67	1.17	2.67	9.33	9.83	0.33	24	7.33	14.33	2.33	

Distribution of Projects (by science areas) (FY 2005/2006, 2006/2007 & 2007/2008)											
SBA	ES	MS	AS	TFS	EO	Polar					
0.33	4.70	2.53	2.87	7.60	7.33	1.03					

Distribution of Projects by NERC strategic priority (current FY 2008/09)						
Climate System	Biodiversity	Earth System Science	Sustainable Use of Natural Resources	Natural Hazards	Environment, Pollution & Human Health	Technologies
5	6.5	13	0.5	1	1	1

*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 (2008/09):

Loans, user training and support

- 27 loans of equipment were supported. During the summer months the schedule was close to full with most instruments on loan throughout, including support to NERC ARSF campaign projects.
- One-to-one training of 7 new users 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.
- Fourth successful running of 'Introduction to Field Spectroscopy' training course held 1st to 3rd April 2009. The course addresses methods in field spectroscopy not addressed when users attend for training in specific instrument use. Attended by 17 PhD students and researchers, including two academics, with highly favourable feedback received.
- Continued development of User Guides to support users in their research.

Publicity

- Poster and oral presentation made by FSF staff at the Fire Interdisciplinary Research in Ecosystem Services; fire and climate change in UK moorlands and heaths (FIRES) meeting in Edinburgh on 1st of April 2008; Research and Facility posters and an exhibitors stand at NERC-Natural England UKPopNet workshop Gregynog Hall, Wales, 9th – 10th December 2008. These publicised planned developments and research issues.
- Intensive presentations, demonstrations and an exhibitors stand at the RSPSoc Annual Conference, University of Exeter, Tremough campus, Cornwall, 15 – 17th September 2008. Separate demonstrations included: the FTIR instrument, approach to measurements and the retrievals of concentrations of common gases using the RTF code; ASD FieldSpec 3 instrument and the acquisition of field spectra; SVC HR1024 instrument and the acquisition of spectra; underwater optical properties instrumentation suite including a demonstration of measurement in a local lake; Headwall hyperspectral imaging spectrometer. The demonstrations for the latter four were presented jointly with the equipment manufacturers.



Demonstration of the AC-S underwater instrument suite, during RSPSoc Annual Conference 2008

Quality Assurance and calibration

- Continued development of in-house QA and calibration equipment, procedures and software to increase rigor and efficiency with which these are undertaken. Purchase of new integrating sphere to improve calibration of the NERC ARSF airborne optical instrumentation, notably the AISA Eagle/Hawk sensor.

Instrumentation



The Facility's new SVC HR-1024 full wavelength system, here with integrating sphere fitted.

- GRASS goniospectroradiometer project delivered to NPL for loan to users.
- Delivery of the new SVC HR-1024 full wavelength (400 – 2500 nm) spectroradiometer as replacement for aging GER 3700 instrument.
- Continuation of VNIR/SWIR research and development project to prototype stage.
- Purchase of new integrating sphere to improve calibration of the NERC ARSF airborne optical instrumentation, notably the AISA Eagle/Hawk sensor.
- Purchase of integrating sphere to improve the calibration of Spectralon reference panels.
- Successful capital equipment bids for new Diving PAM fluorometer (joint application with National Facility for Scientific Diving, Dunstaffnage), Cimel CE318 sunphotometer instrument, and to construct new hand-held, field portable V-SWIR

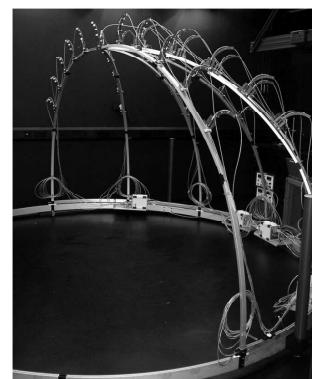
spectroradiometers as replacements for GER1500 instruments.

Research and development

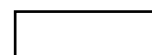
- The GRASS gonio-spectroradiometer instrument, developed by NPL, completed and field tested during 2008; it is now available for loan during the 2009 season.
- Continued instrument development project on novel designs to reduce uncertainties in measurement in the VNIR/SWIR region. Prototype fore-optics developed by Astronomy Technology Centre, Royal Observatory.
- Research into development of irradiance suite to support measurements obtained with the new SVC HR1024 spectroradiometer. To be completed during 2009.

Other activities

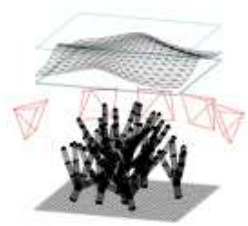
- Contribution to EUFAR Framework 7 Research Infrastructure project.
- Opinions of users sought on future equipment purchases. These show positive responses for the purchase of a ground-based imaging hyperspectral instrument and a thermal camera.
- SRG document submitted for renewal of the Facility's contract for 2010-2015.
- Application to British Council funded British-Israel Research and Academic Exchange Partnership (BIRAX) entitled "Calibration and validation for imaging spectroscopy" – to support further research into calibration of Specim AISA imaging spectrometers.
- Provision of host website space for key software routines developed by our user community. Includes: Microtops Inverse, developed by the University of Cambridge (allow the retrieval of columnar aerosol optical thickness, concentrated in plumes, from Microtops II); PlanarRad, an open-source C++ radiative transfer model for shallow-water environments (University of Exeter); establishment of a Field Spectroscopy Facility user forum, intended to provide useful software utilities.



The fully assembled goniospectroradiometer instrument in the laboratory.



SCIENCE HIGHLIGHTS:



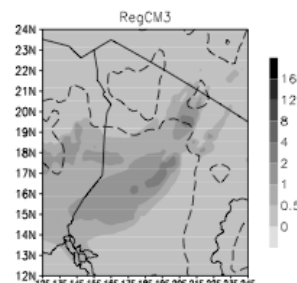
FSF underwater equipment was used to validate a new geometric optical model for three-dimensional radiative transfer for shallow water environments with complex benthic structures. The model discretizes surfaces and volumes into patches and voxels and establishes the radiative transfer relationship between pairs of elements. Model errors were less than 1% for two examples simulated. Potential applications in remote sensing include forward-modeling of structural effects and spatial patterns in water leaving radiance to inform inversion methods, remote sensing of benthic photobiology, BRDF functions for the total water column or below-water structures and influences of shading by boats and other

structures on measurements. (Hedley 2008, *Optics Express*, 16: 21887-21902)

Todd et al. (2008) compared five regional atmospheric coupled climate-aerosol models for the quantification of dust fluxes and associated climate impacts, focusing on a 3-day dust event over the Bodele depression in northern Chad, the world's single most important dust source.

Simulations were compared to satellite data and in situ observations, including measurements using FSF Microtops sunphotometers. The models reproduced key features of the meteorology and the dust plumes but there was an order of magnitude range in model estimates of key quantities including dust concentration, dust burden, dust flux, and aerosol optical thickness.

There remains considerable uncertainty in model estimates of the dust cycle and its interaction with climate. (Todd et al. 2008, *J. Geophys. Res.*, 113, doi:10.1029/2008JD010476).



The variation with depth of chemicals such as nitrate trapped in Antarctic ice cores potentially provides the strongest evidence available for past climate and climate change events, but deciphering the chemical signals present in the ice cores is a major challenge. UK researchers have developed a method by which the nitrate concentration depth profiles in ice cores can be used to obtain mixing ratios of atmospheric gases ($\text{NO}_2 + \text{NO}$) in past atmospheres and thus the palaeo-atmospheric oxidizing capacity. FSF GER1500 spectroradiometers and Microtops instrumentation were used to measure the optical properties of snow at Dome C, to help calculate and measure atmospheric and in-snow photolysis rates of nitrogen oxides and nitrate. Optical properties of the snowpack showed large heterogeneity with some of metamorphosed snow having penetration depths of 12-15 cm and the old wind-packed snow having penetration depth of 4 cm, Albedo was extremely high (0.95 to 0.98). Radiative-transfer calculations based on the photochemistry show that the heterogeneity is key in controlling the light photochemistry. (France et al. 2007, *Atmos. Environ.*, 41, 5502-5509).

Spectroradiometric measurements and laboratory analyses were used to assess the nature and degree of contamination at the Rodalquilar mine, Spain, using a range of spectrometric analyses. The resulting mineral maps identified that tailings material with significant amounts of hematite with minor jarosite, ferrihydrite and goethite, and clays, primarily alunite and kaolinite, with minor smectite and illite, had been dispersed along the length of the Rodalquilar river. These results improve understanding of the erosion and remediation history of the Rodalquilar mine and show the potential of field-based reflectance spectroscopy, integrated with GPS and digital mapping, as a real-time tools enabling immediate, accurate characterisation of the nature and scale of tailings material dispersion. (Ferrier et al. 2009; *J. Geochem. Explor.*, 100, 11-19)

FUTURE DEVELOPMENTS/STRATEGIC FORWARD LOOK

New science areas supported

- First full loans of FTIR equipment by users during summer 2008. First loans of GRASS goniospectroradiometer in summer of 2009.

Planned hardware developments to support science areas

- Continuation of VNIR/SWIR instrumentation research project to test prototype in laboratory and field.

Other developments planned to meet mission objectives

- Continued profile raising through joint meeting with MSF planned for 2009, and presentations at other national and international meetings.
- Opportunities for closer integration of FSF activities with wider EO research activities through closer ties with the NCEO.
- Emphasise training with repeat of introductory training course.
- Further enhance the Facility's website through the development of a formal website strategy.

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

User satisfaction questionnaire shows high standard of support and satisfaction with FSF (Annex 10 for further results). The quality of service reported by users is either excellent or good, as is the training offered either as one-to-one or the Introduction to Field Spectroscopy Facility. Comments from users included: "Support from the facility has been first class"; "I have been very happy with the service, training and equipment provided by the FSF. This really is an excellent service..."; "The support from the FSF is critical to our work, they are always helpful and accommodating and we couldn't complete our work, without their hard work"; "Have always received prompt and excellent support from the Facility".