

SERVICES & FACILITIES ANNUAL REPORT - FY April 2013 to March 2014

SERVICE Field Spectroscopy Facility	FUNDING Block	AGREEMENT Contract	ESTABLISHED as S&F 1988	TERM 5
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TYPE OF SERVICE PROVIDED:

The NERC Field Spectroscopy Facility (FSF) underpins NERC optical Earth Observation (EO) science. FSF provides fully calibrated and well-characterised spectroscopy instruments and integrated measurement systems for the ground validation and calibration of EO data and to further understand the interaction of light with terrestrial, aquatic/marine and atmospheric media. Access to this support is managed through the FSF SC peer review process. On average **30 projects are supported annually** of which 15 to 20 will have **PhD student involvement**. The Facility maintains a **nationally referenced optical instrument calibration service** and provides **expert advice on measurement methodologies** to NERC and wider UK research community. FSF provides **world class training in the theory and practice of field spectroscopy** through 1-2-1 training and to approximately 20 early career scientists annually through an internationally highly regarded 2 ½ day Introduction to Field Spectroscopy course, and to 10 to 12 early career scientists from across the EU during annual summer schools on a PAYG basis. The FSF also conducts ‘in-house’ research into the performance of, and develops state-of-the-art, spectrometer systems to support UK science.

Therefore the FSF underpins the NERC strategic goal of delivering “**world-leading environmental research at the frontiers of knowledge**” and provides “**high quality training that meets national skills needs**” (NERC Delivery Plan 2011-2015 Action 3). The **NERC Science Priority** areas routinely supported by FSF are: **Climate Systems; Biodiversity; Sustainable use of Natural Resources; Natural Hazards; Environment; Earth System Science; and Technologies**. FSF also supports **NERC National Capability (NC)** through its “**support of strategic and responsive research ... community access to essential facilities and ... response to national emergencies**” (NERC Delivery Plan 2011-2015 Sect. 2.2) as has been demonstrated by the swift response to events such as the Eyjafjallajökull eruption. FSF is integrated in NERC's NC through its support of instrumentation either owned, or borrowed from FSF, by **BGS, BAS, CEH, and NCEO** and provides technical and ground support for the NERC **ARSF** hyperspectral imaging systems. **Economic impact and societal benefits** are further achieved by FSF working in collaboration with industry to develop optical sensor networks for “**continuous observations**” (NERC Delivery Plan 2011-2015 Sect. 2.2).

The Facility is based in the School of GeoSciences, The University of Edinburgh, and employs a Facility Manager and an Equipment Manager at 1 FTE each. The Facility exploits synergies with the NERC Geophysical Equipment Facility, also based in GeoSciences, by drawing on their electronic and programming expertise. FSF represents a **cost effective and operationally efficient** means of providing NERC and the UK research community with **quality assured state-of-the-art** field spectroscopy instrumentation and expertise for optical Earth observation.

ANNUAL TARGETS AND PROGRESS TOWARDS THEM

- FSF supported 11 peer reviewed international journals articles and 2 book chapters published in the current year.
- A consistently high number of applications, 33 in total, were received during 2013/14.
- The FSF 2 ½ Introduction to Spectroscopy course for early career researched and PhD students had to be held twice during 2013/14 to satisfy increased demand
- FSF continue to widen the user community. Three new, and topical, sciences areas were supported in 2013/14.
- Continue to supply well maintained, calibrated and more fully characterised spectrometers through emphasis on QA, calibration procedures and instrument performance research.
- Continued to develop cutting edge field spectroscopy instrument suites through development of external sensor for automated capture of measurement metadata
- Developed state-of-the-art wireless DFOV multi spectrometer system for UAV platform and continuous logging deployment. NDA signed and route-to-market being sought with an environmental equipment manufacturer
- Continue to provide support for NERC RCs: BGS, CEH and BAS, and support the UK AERONET network

SCORES AT LAST REVIEW (each out of 5)			Date of Last Review:	
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 – 100% NERC; 1 x Equipment Manager – 100% NERC; 1 x ARSF support – 8.25% NERC	2014	2015

FINANCIAL DETAILS: CURRENT FY								
Total Resource Allocation £191	Unit Cost £k					Capital Expend £k	Income £k	Full Cash Cost £k
	FTIR/GRASS £0.275k	Full wavelength spectrometer £0.180	CIMEL/OCRs & fluorometer £0.075	Micro-tops £0.06	CS support £0.04			
					£75	£12(net)	£247.977	

FINANCIAL COMMITMENT (by year until end of current agreement) £k												
2013-14	£272.88	2014-15	£280.179	2015-16	2016-2017	2017-2018						
STEERING COMMITTEE		Independent Members			Meetings per annum		Other S&F Overseen					
FSF SC		4			1		none					

APPLICATIONS: DISTRIBUTION OF GRADES (current FY — 2013/14)													
	10	9	8	7	6	5	4	3	2	1	0	R*	Pilot
NERC Grant projects*	1	0	6	1		0	0	0	0	0	0	0	0
Other academic	0	0	5	8	1	0	0	0	0	0	0	1	0
Students	0	1	7	0	0	0	0	0	0	0	0	0	2
TOTAL	1	1	18	9	1	0	0	0	0	0	0	1	2

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*	0	2	5	0	0	0	0	0	0	0	0	0
Other Academic	0	2	4	4	0	0	0	0	0	0	0	1
Students	0	0	6	0	0	0	0	0	0	0	0	0

Project Funding Type (current FY – 2013/14) (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
25	2			2	2	4	14	0	0	1	0	0
25												
Grand Total	Infrastructure							PAYG				
	Supplement to NERC Grant *			PhD Students		NERC Centre	Other	NERC Grant*	PhD Student		NERC Centre	Other
28.7	4.1			6.1	5.7	3.5	10.9	0	0	0	0	0

User type (current FY – 2013/14) (include each person named on application form)				
Academic	NERC Centre	NERC Fellows	PhD Students	Commercial
17	7	0	11	1
User type (per annum average previous 3 financial years - 2010/2011, 2011/2012 & 2012/2013)				
Academic	NERC Centre	NERC Fellows	PhD Students	Commercial
16.3	5.7	0.7	11.3	2.8

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	
2	7	2	2	20	5	6	43	11	31	1	
Distribution of Projects (by science areas) (FY 2013/14)											
Grand Total	SBA	ES	MS	AS	TFS	EO	Polar				
25	2	5.7	0	2.5	3.5	8.7	2.6				

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	
1	7.9	7.25	4.9	2.75	8.95	9.25	42	13.85	24	4.15	
Distribution of Projects (by science areas) (FY 2010/2011, 2011/2012 & 2012/2013)											
Grand Total	SBA	ES	MS	AS	TFS	EO	Polar				
27.4	0.7	6	1.7	3.5	5.1	9	1.5				

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
25	2.5	4.5	8	2	0	0	8

*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):

The impacts of FSF supported research

- Development of algorithms to assess the spatial and seasonal variability of freshwater lakes as sentinels of climate change.
- Reducing measurement uncertainties in the use of ice and snow fields as satellite sensor calibration validation targets.
- Use of atmospheric optical data to assess Met Office air quality models.
- Recommendation to the European ICOS network on making spectral measurements at carbon flux and water vapour research site for spatial extrapolation of data

Publicity

- Presentations were given on the services FSF provides at a COST Summer School in Sicily 2013 and at the ARSF-DAN workshop at PML in 2014.
- FSF staffed stands at the RSPSoc Annual Conference at the U. of Glasgow 2013 and at the ESA Living Planet symposium in Edinburgh 2013

Quality Assurance and calibration

- Mr MacLellan continued work with ARSF-DAN on calibration of the Eagle/Hawk and Fenix imaging systems.
- Mr MacLellan visited CSIRO in Perth and Canberra Australia and provided advice on QA and calibration of field spectroradiometers and reflectance panels.

Instrumentation

- A has received funding from Prof. J. Draper, U of Aberystwyth, for FSF to develop and provide integrated field spectrometer and webcam systems for continuous monitoring of vegetation canopies. Some of the integration work will be carried out by Dr M. Neal of U. of Aberystwyth. Dr F. Gerard of CEH is also a collaborator in this project.
- FSF are developing a lightweight thermal imaging system for UAV deployment to complement the instrumentation recently purchase by BAS for ARSF ground support.

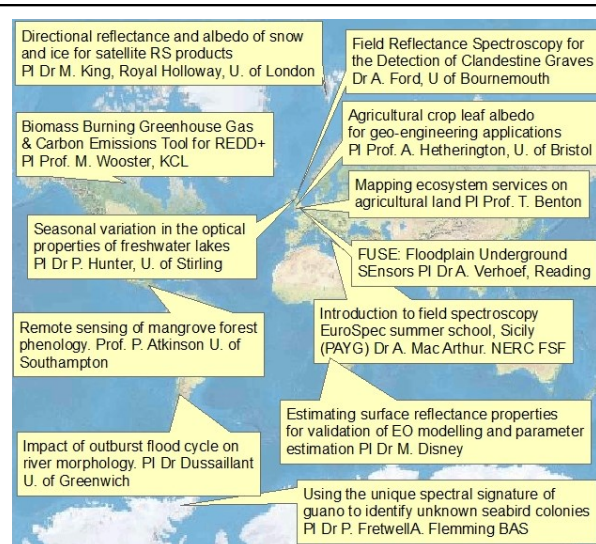
Research and development

- The Bluetooth interface for the SVC HR-1024 spectroradiometer has now been completed and this will allow continuation of the small sensor suite project for the HR-1024.
- NPL requested that FSF cost the project management and production of two GRASS instruments for possible resale to 3rd parties. This has now been completed and the 3rd parties are awaiting the outcome of their capital bids to the EU.

Science Highlights

Hunter P, Tyler A., Spyrakos, E. (U. of Stirling) Groom S, & Martinez V. PML Observatory of Lake Responses to Environmental Change (GloboLakes) NE/J024279/1. The world's freshwater ecosystems, and the biodiversity they support, are vital components of the global biosphere but are fragile and vulnerable to anthropogenic disturbance and climate change. To improve our understanding of lake responses to environmental change, the GloboLakes project is developing operational time-series satellite biogeochemical and lake surface water temperature products for more than 1000 of the world's largest lakes. In order to test and validate these products, an intensive field campaigns on large UK and European lakes is being undertaken to better constrain bio-optical algorithms for retrieval of lake biogeochemical constituents. During the 2013 sampling campaigns, measurements of the inherent and apparent optical properties at 82 stations on 7 lakes over a range of water optical types (Fig. 1) were made. This is complemented by data from a further 865 stations over 65 international lakes contributed by project partners. Preliminary results have revealed hitherto underestimated variability in the bio-optical properties of lake waters. These findings have clear implications for the applicability of bio-optical algorithms and are now being used to inform the development of an optical water classification scheme that will better enable dynamic selection of in-water algorithms for global-scale remote sensing of lake biogeochemical parameters.

Black, M. and Riley, T. NE/K50094X/1 – Investigating the potential of hyperspectral data for mapping in remote Polar Regions The Antarctic Peninsula is a long-lived continental margin arc that preserves thick sequences of intermediate-silicic volcanic rocks, arc-derived sediments and major plutonism. Although the geology of the peninsula is broadly understood, there are still significant areas where accessibility problems have prevented field-based investigation. Multispectral and hyperspectral remote sensing offers potential for providing new geological information in these regions but as yet has remained relatively underutilised due to the particular challenges that the peninsula presents for lithologic image analysis: these include the limited rock exposure, strong shadowing effects related to low solar elevation angles and mountainous topography,



General distribution of projects supported 2013/14



Fig 1. The FSF optics suite being used to measure the optical properties on Loch



Fig 2 Scientist carrying out a field spectroscopy survey at Southern Adelaide Island, Antarctica

and the difficulties in undertaking direct calibration and validation. However, the potential of multispectral Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) data for undertaking lithological mapping on the Antarctic Peninsula has recently been demonstrated. Through careful pre-processing and spectral analysis with reference to rock reflectance spectra, important lithologic information can be derived to support geological mapping. To further this analysis, an airborne hyperspectral campaign was conducted in 2011 and these data are being investigated through a NERC-funded PhD studentship to fully assess the potential of this method to support lithological mapping on the Antarctic Peninsula (Fig 2). The investigation of both spatially and spectrally higher resolution data will enable methods to be developed which may be scaled to work with existing multispectral (e.g. ASTER/Landsat/Worldview-2) and hyperspectral satellite instruments (e.g. Hyperion).

Tebbs, E.J., J.J. Remedios *et al*, Remote sensing of chlorophyll-a as a measure of

cyanobacterial biomass in Lake Bogoria, a hypertrophic, saline-alkaline, flamingo lake, using Landsat ETM+, RSE (2013)

Lake Bogoria is a saline-alkaline lake in the Kenyan Rift Valley, known for supporting dense

blooms of cyanobacteria and large flocks of up to 1 million Lesser Flamingos (*Phoeniconaias minor*). An algorithm for the remote sensing of chlorophyll-a (Chl-a), as an indicator of cyanobacterial biomass, has been developed using a time series of Landsat images and in situ measurements (Fig. 3). In situ measured reflectance spectra were resampled to Landsat bands, and the near infrared (NIR) band, R835, was found to be well represented by a linear relationship to Chl-a ($R^2 = 0.847$) for concentrations up to $800 \mu\text{g l}^{-1}$. The band ratio R835/R660 also showed a strong linear relationship with Chl-a ($R^2 = 0.811$). Similar relationships were derived using Landsat satellite imagery and monthly in situ Chl-a data for the period Nov 2003–Feb 2005. The NIR:Red ratio gave a better fit to Chl-a than a single NIR band algorithm when applied to satellite imagery, and the ratio performed best when based on top of atmosphere (TOA) reflectance rather than atmospherically corrected data. Hence an algorithm for Chl-a was derived based on the TOA Landsat reflectance ratio, R835/R660, which showed a strong fit against Chl-a ($R^2 = 0.801$). Lesser Flamingos feed on cyanobacteria in saline-alkaline lakes, therefore the algorithm can be used to monitor changes in their food supply, providing valuable information for their future conservation. The study also allowed characterisation of the optical properties in Lake Bogoria and provides insight into the changes occurring during cyanobacterial bloom and die-off events.

Cousins, C., Crawford, I. *et al.*, "Glaciovolcanic hydrothermal environments in Iceland and implications for their detection on Mars", Journal of Volcanology and Geothermal Research (2013)

Volcanism has been a dominant process on Mars, along with a pervasive global cryosphere. Therefore, the interaction between these two is considered likely. Terrestrial glaciovolcanism produces distinctive lithologies and alteration terrains, as well as hydrothermal environments that can be inhabited by microorganisms. This group provide a framework for identifying evidence of such glaciovolcanic environments during future Mars exploration, and provide a descriptive reference for active hydrothermal environments to be utilised for future astrobiological studies. Remote sensing data were combined with field observations and chemical and structural analysis into characterise samples from two areas of basaltic glaciovolcanism: Askja and Kverkfjöll volcanoes in Iceland. Active hydrothermal environments at Kverkfjöll include hot springs, anoxic pools, glacial meltwater lakes, and sulphur- and iron-depositing fumaroles, all situated within ice-bound geothermal fields. Temperatures range from $0 \text{ }^\circ\text{C}$ – $94.4 \text{ }^\circ\text{C}$, and aqueous environments are acidic-neutral (pH 2–7.5) and sulphate-dominated. Mineralogy of sediments, mineral crusts, and secondary deposits within basalts suggest two types of hydrothermal alteration: a low-temperature ($< 120 \text{ }^\circ\text{C}$) assemblage dominated by nanophase palagonite, sulphates (gypsum, jarosite), and iron oxides (goethite, hematite); and a high-temperature ($> 120 \text{ }^\circ\text{C}$) assemblage signified by zeolite (heulandite) and quartz. These mineral assemblages are consistent with those identified at the Martian surface. In-situ and laboratory VNIR (440–1000 nm) reflectance spectra representative of Mars rover multispectral imaging show sediment spectral profiles to be influenced by Fe²⁺/³⁺-bearing minerals, regardless of their dominant bulk mineralogy. Characterising these terrestrial glaciovolcanic deposits can help identify similar processes on Mars, as well as identifying palaeoenvironments that may once have supported and preserved life.

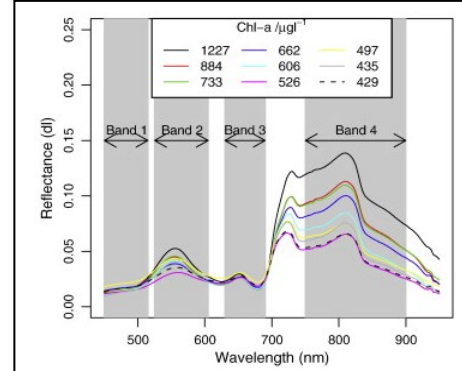


Fig 3 Reflectance spectra of *A. fusiformis* matched to Landsat bands

DEVELOPMENTS/STRATEGIC FORWARD LOOK

- Continue collaborating with an environment monitoring equipment manufacture to identify route-to-market for lightweight DFOV multi spectrometer system.
- Develop a near-ground thermal imaging measurement validation methodology in collaboration with Prof. Wooster of King's College, U. of L.
- Publish a spectrometer etaloning correction procedure to enable the latest back-thinned CCD spectrometers to be used to measure chlorophyll fluorescence in field studies