SERVICES & FACILITIES ANNUAL REPORT - FY April 2012 to March 2013

SERVICE	FUNDING	AGREEMENT	ESTABLISHED as S&F	TERM
Field Spectroscopy Facility	**Block**	**Contract**	**1988**	**5**

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 NERC S&F FSF SC peer review process. On average 30 projects are supported annually of which 15 to 20 will have PhD student involvement. In addition, the Facility maintains a nationally referenced optical instrument calibration service and provides expert advice on measurement methodologies to NERC scientists and the wider UK research community. The Facility provides world class training in the theory and practice of field spectroscopy through 1-2-1 training of applicants and to approximately 20 early career UK scientists through an internationally highly regarded 2 ½ day Introduction to Field Spectroscopy course, and to 10 to 12 early career EU scientists during annual summer schools on a PAYG basis. The FSF also conducts 'in-house' research into the performance of spectrometers 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 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 an Operations 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 16 peer reviewed publications in international journals in the current year.
- An exceptional number of applications, 37 in total, were received during 2012/13 including applications from NCEO, BAS, BGS and CEH scientists and 3 PAYG projects.
- Continue to widen the FSF user community. Three new, and topical, sciences areas were supported in 2012/13: crop albedo measurements for geo-engineering applications; optical measurements to support snow and ice mass balance measurements; spectral mapping of floristic diversity in agricultural landscapes for pollinator estimates.
- 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 instrument suite for automatic capture of measurement metadata and DFOV spectrometers for UAV platforms
- Continue to support spectrometers held by BGS and NCEO, collaborate with BAS in analysis of Antarctic spectral data and CEH in optical methods to measure forest canopy phenology and support the NASA AERONET network

SCORES AT LAST REVIEW (each out of 5)			Date of Last Review:	2009
Need	**Uniqueness**	**Quality of Service**	**Quality of Science & Training**	**Need**
5	**5**	**5**	**5**	**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	**Unit Cost £k**					**Capital Expend £k**	**Income £k**	**Full Cash Cost £k**
£191	**FTIR/ GRASS**	**Full wavelength spectrometer**	**CIMEL/OCRs & fluorometer**	**Micro-tops**	**CS support**			
	£0.275k	£0.180	£0.075	£0.06	£0.04	**£10.00**	**£9.10(net)***	**£247.977**

**no individual invoice exceeded £5k*

FINANCIAL COMMITMENT (by year until end of current agreement) £k				
2012-13 £265.198	2013-14 £272.88	2014-15 £280.179	2015-2016	2016-2017

STEERING COMMITTEE	Independent Members	Meetings per annum	Other S&F Overseen
FSF SC	4	1	none

APPLICATIONS: DISTRIBUTION OF GRADES (current FY — 2012/13)

	10	9	8	7	6	5	4	3	2	1	0	R*	Pilot
NERC Grant projects*		1	1										
Other academic			15	7	1							3	
Students		1	3										
TOTAL	0	2	19	7	1	0	0	0	0	0	0	3	

Note In addition, 5 commercial applications were received during 2012/13

PROJECTS COMPLETED (current FY – 2012/13)

	10 (α5)	9	8 (α4)	7	6 (α3)	5 (α2)	4	3 (α1)	2	1 (β)	0 (Reject)	Pilot
NERC Grant projects*		0	4	0								
Other Academic		1	4	5								
Students		1	4	1	1							1

Note In addition, 6 commercial projects, including 3 EU student STMS at FSF were supported during 2012/13

Project Funding Type (current FY – 2012/13) (select one category for each project)

Grand Total	Infrastructure					PAYG				
	Supplement to NERC Grant *	PhD Students NERC	PhD Students Other	NERC Centre	Other	NERC Grant*	PhD Students NERC	PhD Students Other	NERC Centre	Other
28	2	2	4	2	12	0	0	0	0	6

Project Funding Type (per annum average previous 3 financial years - 2009/2010, 2010/2011 & 2011/2012)

Grand Total	Infrastructure					PAYG				
	Supplement to NERC Grant *	PhD Students NERC	PhD Students Other	NERC Centre	Other	NERC Grant*	PhD Student NERC	PhD Student Other	NERC Centre	Other
27.7	1.5	5.0	6.0	3.7	10.0	0.0	0.0	0.0	0.0	3.0

User type (current FY – 2012/13) (include each person named on application form)

Academic	NERC Centre	NERC Fellows	PhD Students	Commercial
18	5	0	11	4

User type (per annum average previous 3 financial years - 2009/2010, 2010/2011 & 2011/2012)

Academic	NERC Centre	NERC Fellows	PhD Students	Commercial
12.3	3.3	0.5	12.3	3.0

OUTPUT & PERFORMANCE MEASURES (current year)

Publications (by science area & type) (calendar year 2012)

SBA	ES	MS	AS	TFS	EO	Polar	Grand Total	Refereed	Non-Ref/ Conf Proc	PhD Theses
1	6	12	2	2	4	15	42	16	21	5

Distribution of Projects (by science areas) (FY 2012/13)

Grand Total	SBA	ES	MS	AS	TFS	EO	Polar
28	1	6.25	1.75	3.75	6.25	8	1

OUTPUT & PERFORMANCE MEASURES (per annum average previous 3 years)

Publications (by science area & type) (Calendar years 2009, 2010 & 2011)

SBA	ES	MS	AS	TFS	EO	Polar	Grand Total	Refereed	Non-Ref/ Conf Proc	PhD Theses
1.0	9.8	2.5	7.8	3.5	13.9	3.5	42	11.7	27.0	3.3

Distribution of Projects (by science areas) (FY 2009/2010, 2010/2011 & 2011/2012)

Grand Total	SBA	ES	MS	AS	TFS	EO	Polar
26.8	0.3	5.8	1.7	3.3	3.9	9.9	2.0

Distribution of Projects by NERC strategic priority (current FY 2012/13)

Grand Total	Climate System	Biodiversity	Earth System Science	Sustainable Use of Natural Resources	Natural Hazards	Environment, Pollution & Human Health	Technologies
28	3.5	1.5	9	2	2.5	1	8.5

*Either Responsive Mode or Directed Programme grants

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

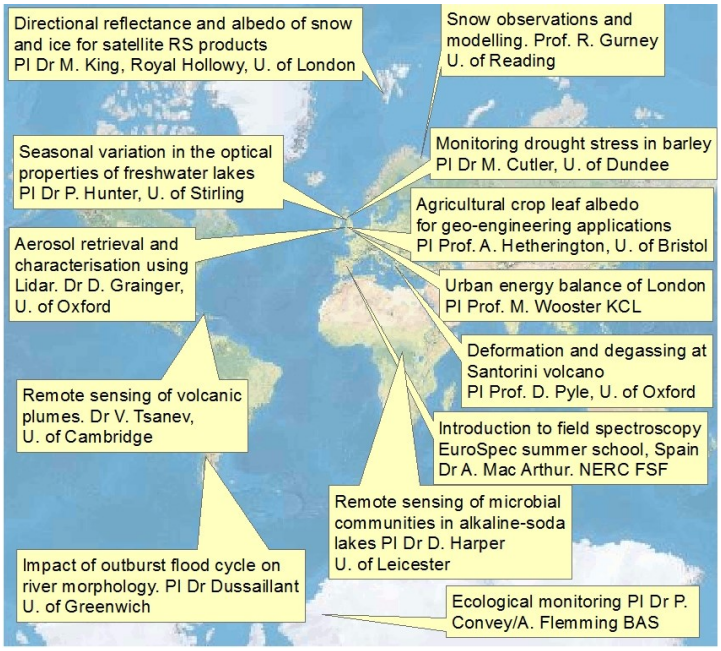
Note 1. Either Responsive Mode or Directed Programme grants.

Note 2. SC members have been excluded from the review of any loan application with which they may be perceived to have a vested interest

OVERVIEW & ACTIVITIES IN FINANCIAL YEAR (2012/13):

The impacts of FSF supported research

- Monitoring volcanic gas emissions for assessment of their impact on human health
- Improvements in the use of ice and snow fields as satellite sensor calibration validation targets.
- Monitoring the spatial and seasonal variability in the inherent optical properties of freshwater lakes as sentinels of climate change.
- Developing methods to measure photosynthesis of micro-phytoplankton, being assessed as a potential source of carbon neutral bio-fuel.



Global distribution of a selection of projects supported - 2012/13

Publicity

- FSF organised a joint NERC Facilities stand at the NCEO annual conference, Nottingham, 2012. Dr Mac Arthur gave a key-note presentation at the CEOI Challenges workshop, RAL 2012. Mr MacLellan gave a presentation at ACEAS TERN workshop, Brisbane, 2012. Presentations were given on the services FSF provides at a EU Summer School in Spain 2012; at the ARSF-DAN workshop, PML 2013; and at a EU COST workshop, Edinburgh, 2013.
- **Quality Assurance and calibration**
- Continue develop in-house QA and calibration procedures to increase integrity with which these are undertaken.
- Continued work with ARSF-DAN on calibration of the Eagle/Hawk imaging system.

Instrumentation

- A dual-field-of-view VNIR spectrometer is being developed in collaboration with a commercial partner.
- The development of a dual-field-of-view VNIR/SWIR1 spectrometer is under discussion with another potential commercial partner. A NDA has been signed by both parties.
- **Research and development**
- A laboratory inter-comparison experiment was carried out using multiband and hyperspectral field spectrometers used at eddy covariance flux sites. This furthered the field comparison work by Anderson, K., Mac Arthur, A., *et al* 2012.

Science Highlights

The science supported by the Facility is diverse, of high quality and widely geographically distributed. Highlights include: **A. Mac Arthur, MacLellan, C. and Malthus, T. (2012) The fields of view and directional response functions of two field spectroradiometers TGRS, 50(10) 892-3905. Impact factor 2.895.** Accurately determining field-of-view has rarely been considered in field spectroscopy where specifications for fore optics used are limited and the influence of the spectroradiometer rarely considered. The issue can be compounded with full wavelength spectroradiometric systems where the size and alignment of the viewing optics and technology adopted to transfer light from the fore optic to individual spectrometers may cause significant non uniformity of spectral response across measurement support. In addition, this support may not align with that assumed from the specification supplied. When recording spectra from heterogeneous earth surface targets, it is important to have the support accurately defined as individual reflecting surfaces may be present in varying proportions within this area, and these proportions need to be determined to relate spectral reflectance to state variables or target classifications being considered. The areal extent of support and the spatial and spectral responsivity of the spectroradiomneters have been determined by measuring the directional response function of each instrument (Fig. 1 and 2). This research highlighted several areas of concern and made recommendations for the improvement of field spectroradiometers and field spectroscopy methodologies.

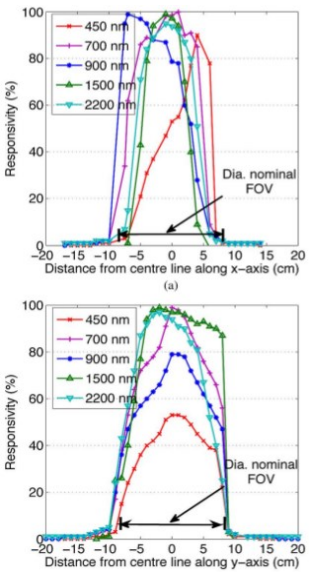


Fig. 2 Responsivity of GER3700 #1008 with 10 º FO

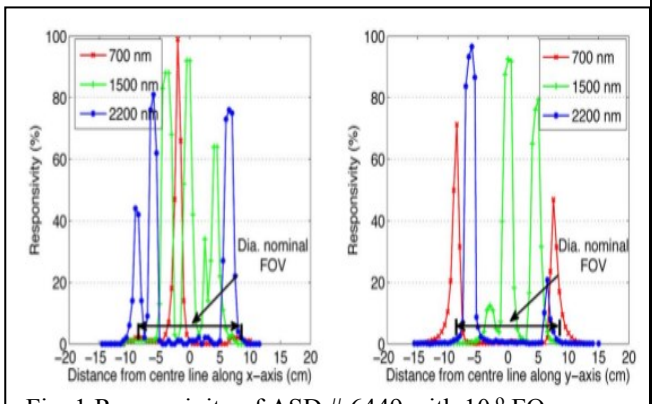


Fig. 1 Responsivity of ASD # 6449 with 10 º FO.

S. Hamylton, *et al.* (2012) Spatial modelling of benthic cover using remote sensing data in the Aldabra lagoon, western Indian Ocean. Marine Ecology Progress , 460, 35-47. Impact factor 2.711

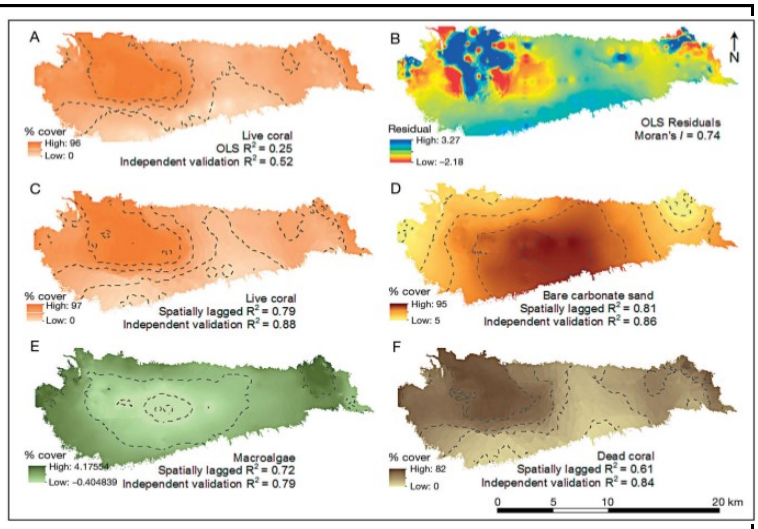


Fig. 3 Model output for the different lagoon benthic coverages

Spatially explicit ecological modelling was used to predict the distribution of 4 benthic components (live coral, carbonate sand, macroalgae and dead coral) inside the Aldabra lagoon, southern Seychelles. Both classic ordinary least-squares and spatial auto-regression techniques were used on spatially referenced data set and satellite remote sensing images to define an empirical relationship between local environmental conditions (water depth and water level variation) and benthic cover. This relationship was then used to generate a synoptic model of the spatial cover and distribution of each benthic component at the landscape (i.e. whole lagoon) scale. Environmental conditions were estimated from satellite remote sensing data (water depth) and using GIS techniques. By drawing on species−environment relationships applicable to many lagoons, continuous records of percentage benthic cover were derived for the extensive lagoon at a high measurement level for use in conservation and resource management applications. This analysis (Fig. 3) adds a spatially explicit and statistically rigorous approach to the growing body of bottom-up models used for upscaling local field data to spatially continuous landscapes in an ecologically meaningful manner. **H. Beine, …, M. King, *et al*, (2012) Soluble chromophores in marine snow, seawater, sea ice and frost flowers near Barrow, Alaska, JGR, 117. Impact factor 3.465** This team measured light absorption in marine snow, sea ice, seawater, brine, and frost flower samples collected during the OASIS field campaign. Samples represented multiple sites between landfast ice and open pack ice in coastal areas approximately 5 km west of Barrow, Alaska. They found that chromophores that are most commonly measured in snow, H_2O_2, NO_3, and NO_2, on average account for less than 1% of sunlight absorption. Instead, light absorption is dominated by unidentified "residual" species, likely organic compounds. Light absorption coefficients for the frost flowers on first-year sea ice are, on average, 40 times larger than values for terrestrial snow samples at Barrow, suggesting very large rates of photochemical reactions in frost flowers. The residual spectra are similar to spectra of marine chromophoric dissolved organic matter (CDOM), suggesting that CDOM is the dominant chromophore in our samples. The team expect that CDOM is a major source of OH in their marine samples, and it is likely to have other significant photochemistry as well. Given that both bacteria and extracellular polysaccharides are elevated in frost flowers and brines compared to the underlying ice surfaces the photoformation of OH from CDOM and other chromophores likely leads to significant oxidation of these organics and, perhaps, release of volatile organic compounds to the boundary layer. **Ongoing research. Y. Mali, U. of Oxford, F. Gerard and C. Chavana-Bryant of CEH** The phenological dynamics of terrestrial ecosystems reflect the response of the Earth's biosphere to inter- and intra-annual dynamics of the Earth's climatic and hydrological regimes. A number of studies in the tropics have used satellite based time-series of observations of Leaf Area Index as evidence of tropical forest resilience to drought. However there is a distinct possibility that the seasonal variation in vegetation indices (VI) is driven by the leaf aging as well as by the shedding or appearance of new leaves. This study is investigating the influence that age related variation in the spectral reflectance properties of leaves may have on apparent VIs of a tropical forest canopy. The work combines ongoing measurements of vegetation phenology at two sites in French Guiana and Peru, with to measurements of leaf reflectance, physical and physiological properties of large samples collected to represented different leaf ages and leaf canopy positions. Preliminary results reveal an interesting shift in reflectance with leaf age and distinctly different reflectances between sunlit leaves and shaded leaves. A high quality video, filmed by J. Bryant and narrated by C. Chavana-Bryant for the general public, is available from < http://vimeo.com/46676651 >.


Fig. 4. Climbing in the Amazon forest canopy to make spectral measurements

FUTURE DEVELOPMENTS/STRATEGIC FORWARD LOOK

- Spectral and spatial response characterisation of the NERC ARSF and Airborne Geosciences imaging spectrometers and a range of field spectrometers will begin during 2013/14 for spectral and spatial scaling studies,
- Investigation into the FWHM of field spectrometers and the creation of Spectral Libraries in ENVI User Guide will continue.
- Development of spectrometer system to record field spectroscopy metadata and a UAV spectrometer will continue
- Opportunities for FSF to provide an EU wide calibration and instrument inter-comparison facility to support EU carbon flux research sites, on a PAYG basis, will be sought.