SERVICES & FACILITIES ANNUAL REPORT - FY April 2014 to March 2015

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 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 of between 10 and 20 early career scientists annually through an internationally highly regarded 2 ½ day Introduction to Field Spectroscopy course, and to a further 10 to 12 early career scientists from across the EU during field training 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 Holuhraun volcanic eruption in Iceland in August 2014. 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 BAS **ARSF** hyperspectral imaging systems. **Economic impact and societal benefits** are further achieved by FSF working in collaboration with industry to develop optical sensors, such as the light-weight wirelessly controlled dual-field-of-view spectrometer system for UAV applications and "**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 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 observations.

ANNUAL TARGETS AND PROGRESS TOWARDS THEM

- FSF supported 14 peer reviewed international journals articles in the current year.
- A consistently high number of applications, 26 in total, were supported during 2014/15.
- A consistently high number of applications, 29 in total including 6 PAYG projects were received during 2014/15.
- The FSF 2 ½ Introduction to Spectroscopy course for early career researched and PhD students was again held during 2014/15.
- FSF continue to widen the user community. Two PIs not previously supported applied to FSF during 2014/15.
- Continue to supply well maintained, calibrated and more fully characterised spectrometers through emphasis on quality assurance, calibration procedures and instrument performance.
- Continued to develop cutting edge field spectroscopy instrument suites through development of external sensor for automated capture of measurement metadata.
- Continued development of state-of-the-art DFOV multi spectrometer system for sUAV platforms 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 science, and support the UK AERONET network.
- Continue to engage with the international field spectroscopy and optical Earth Observation communities through collaborations (U. of Wisconsin-Madison, USA; and CSIRCO, Australia) and representation in research networks (Dr Mac Arthur is Chair of COST Action ES1309 with 28 member countries and over 80 active scientists)

SCORES AT LAST REVIEW (each out of 5)		Date of Last Review:		
Need	Uniqueness	Quality of Service	Quality of Science & Training	Average
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 £191	**Unit Cost £k**					**Capital Expend £k**	**Income £k**	**Full Cash Cost £k**
	FTIR/ GRASS £0.295k	**Full wavelength spectrometer** £0.190	**CIMEL/OCRs & fluorometer** £0.075	**Micro-tops** £0.065	**CS support** £0.05	**£0**	**£10.9(net)**	**£230.4**

FINANCIAL COMMITMENT (by year until end of current agreement) £k				
2014-15 £192k	**2015-16 £192k**	**2016-17 £192k**	**2017-18 £192k**	**2018-19 £192k**

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		2	7										1
Other academic		3	1	3									2
Students	1	4	1	1									3
TOTAL	1	9	9	4									6*

* includes 6 PAYG projects

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

* includes 3 PAYG projects

Project Funding Type (current FY – 2014/15) (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**
		NERC	**Other**				**NERC**	**Other**		
26	3	5	2	7	6		1			2

Project Funding Type (per annum average previous 3 financial years - 2011/2012, 2012/2013 & 2013/2014)										
Grand Total	**Infrastructure**					**PAYG**				
	Supplement to NERC Grant *	**PhD Students**		**NERC Centre**	**Other**	**NERC Grant***	**PhD Student**		**NERC Centre**	**Other**
		NERC	**Other**				**NERC**	**Other**		
26.3	2.0	2.3	3.3	3.7	11.3	0.0	0.0	0.3	0.0	3.3

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 - 2011/2012, 2012/2013 & 2013/2014)				
Academic	**NERC Centre**	**NERC Fellows**	**PhD Students**	**Commercial**
17.7	6.7	0.3	11.0	3.0

OUTPUT & PERFORMANCE MEASURES (current year)										
Publications (by science area & type) (calendar year 2014)										
SBA	**ES**	**MS**	**AS**	**TFS**	**EO**	**Polar**	**Grand Total**	**Refereed**	**Non-Ref/ Conf Proc**	**PhD Theses**
0	10	2	4	8	16	14	**54**	14	34	6

Distribution of Projects (by science areas) (FY 2014/15)							
Grand Total	**SBA**	**ES**	**MS**	**AS**	**TFS**	**EO**	**Polar**
26	1	8	0	4	2	8	3

OUTPUT & PERFORMANCE MEASURES (per annum average previous 3 years)										
Publications (by science area & type) (Calendar years 2011, 2012 & 2013)										
SBA	**ES**	**MS**	**AS**	**TFS**	**EO**	**Polar**	**Grand Total**	**Refereed**	**Non-Ref/ Conf Proc**	**PhD Theses**
0.7	**6.6**	**7.4**	**5.6**	**2.6**	**7.7**	**9.4**	**40.0**	**16.6**	**20.0**	**3.4**

Distribution of Projects (by science areas) (FY 2011/2012 2012/2013 & 2013/2014)							
Grand Total	**SBA**	**ES**	**MS**	**AS**	**TFS**	**EO**	**Polar**
26.3	**1.0**	**5.7**	**1.6**	**3.1**	**4.3**	**8.2**	**2.5**

Distribution of Projects by NERC strategic priority (current FY 2014/15)							
Grand Total	**Climate System**	**Biodiversity**	**Earth System Science**	**Sustainable Use of Natural Resources**	**Natural Hazards**	**Environment, Pollution & Human Health**	**Technologies**
26	4.5	6	8	0.5	1	1	5

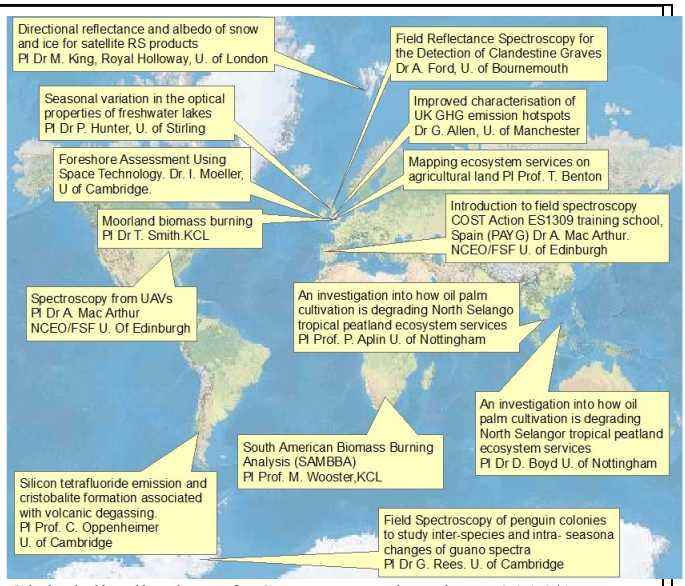
**Either Responsive Mode or Directed Programme grants.*

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

OVERVIEW & ACTIVITIES IN FINANCIAL YEAR(2014/15):

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.
- Recommendations to be published on making spectral measurements at carbon flux and water vapour research site for satellite EO cal/val and the spatial extrapolation of data



Global distribution of FSF supported projects 2014/15

Publicity

- Presentations were given on the services FSF provides at a COST Summer School in Spain in 2015.
- FSF held a one day workshop and staffed stands at the RSPSoc Annual Conference at the U. of Aberystwyth 2014

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

- FSF continued to develop an integrated field spectrometer and webcam systems for continuous monitoring of vegetation canopies for Prof. J. Draper, U. of Aberystwyth. 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.

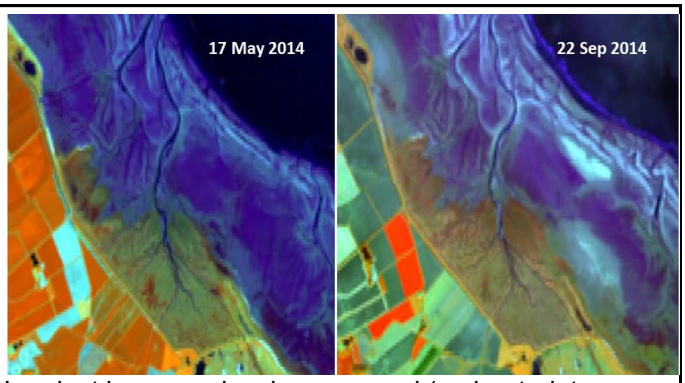
Research and development

- FSF are currently testing the lightweight DFOV double spectrometer system developed for logging and sUAV deployment.
- FSF are developing near-ground thermal airborne EO validation methods in collaboration with ARSF and NCEO

<u>Science Highlights:</u> A. Pope and G. Rees U of Cam. (2014) Impact of spatial, spectral, and radiometric properties of multispectral imagers on glacier surface classification. RSE v141, p1-13. **Loan 614.1110.** Glaciers are key to understanding the world's hydrological cycle as well as regional and global climate change. Through each melt season, glacier surfaces develop a range of zones which have implications for surface energy balance and can be used as a proxy for a glacier's mass balance. Multispectral images (in particular Landsat data) have been extensively used to delineate and study glacier surfaces, but not to classify glacier zones. Therefore, this study used full-spectrum in situ surface reflectance data from Midtre Lovénbreen (Svalbard) and Langjökull (Iceland) which are combined with Landsat ETM+ imagery to inform and explore glacier surface classification. A new classification scheme was based upon principal component analysis of measured spectra. It was determined that Landsat's ETM+ has sufficient spectral resolution to classify clean glacier surfaces, but not glaciers with ash or other significant debris cover. Field spectra and this new classification scheme were then applied to investigate classification success with a range of multispectral sensors**. A. Kukui, … , M. D. King, J. L. France, *et al.* (2014) Measurements of OH and RO2 radicals at Dome C, East Antarctica. Atmos. Chemistry and Physics. 14 12373-12392.** Measurements of OH and RO2 radicals at Dome C, East Antarctica: Concentrations of OH radicals and the sum of peroxy radicals were measured in the boundary layer for the first time on the East Antarctic Plateau at Dome C, 75.10° S, 123.31° E during the Southern Hemisphere Summer 2011/2012. The median concentrations of OH and RO2 radicals were comparable to those observed at the South Pole, confirming that the elevated oxidative capacity of the Antarctic atmospheric boundary is not restricted to the South Pole but common over the high Antarctic plateau. Concurrent measurements of O3, HONO, NO, NO2, HCHO and H2O2 demonstrated that the major primary source of OH and RO2 radicals at Dome C was the photolysis of HONO, HCHO and H2O2, with the photolysis of HONO contributing ~75% of total primary radical production. However, photochemical modelling with accounting for all these radical sources overestimates the concentrations of OH and RO2 radicals by a factor of 2 compared to field observations. Neglecting the OH production from HONO in the photochemical modelling results in an underestimation of the


Field work in Iceland

concentrations of OH and RO2 radicals by a factor of 2. To explain the observations of radicals in this case an additional source of OH equivalent to about 25% of measured photolysis of HONO is required. Another major factor leading to the large concentration of OH radicals measured at Dome C was large concentrations of NO molecules and fast recycling of peroxy radicals to OH radicals **I. Moeller, U of Cam. Foreshore Assessment using Space Technology. Loan 711.1114.** Marine foreshores are currently not included in flood and coastal erosion risk management approaches. There is mounting scientific evidence for the Flood and Coastal Erosion Management ecosystem services provided by foreshores and floodplains. Increasing sedimentation, reducing erosion and attenuating waves, are some of those services. All of these mitigate flood risk by improving sea defence stability and lifetime. This project is developing a new web-based service supporting the use of Copernicus and Sentinel 2 products in the coastal zone and allowing users to gain easy access to information on foreshore stability and the effect of a foreshore on water levels and waves. Measurements of wave reduction and erosion/deposition are collected alongside ground observations on vegetation cover, biomass, and structure and ground surface spectra. The project thus has the objective of 1) Linking data from satellite images to the biophysics of foreshores and flood plains by ground referencing in salt, brackish and fresh water systems; 2) Developing generic algorithms for classification of foreshores and floodplains characteristics on satellite images; 3) Linking biophysical characteristics of foreshores and floodplains to wave and/or flow attenuation and erosion/deposition patterns for different water levels and wave heights/flow speeds through field measurements. Translating effects of foreshores and floodplains on waves/flow and stability into i**m**pacts on engineering requirements for flood safety infrastructure; 5) Developing a prototype user-friendly software tool where linkages between biological and morphological features of foreshores/floodplains and requirements for flood safety infrastructure are automated; 6) Ensuring end-user commitment and involvement in a user-driven approach to product design and implementation, relying on inter-active consultation and regional workshops; and 7) Dissemination of results via a wide range of channels (academic publications, media, web-based platforms etc). Through the FSF loan it has been possible to acquire a full set of reference measurement for the range of seasonally changing surface conditions to support the calibration and validation of remotely sensed (RS) imagery via ground reference measurements in regions of interest. The seasonal field spectrometry can then be related to a series of vegetation and sediment characteristics that are being captured by direct measurement. Reflectance spectra will also be used within supervised classification of RS images and aid in the validation of atmospheric correction procedures and RS-derived biophysical products.



Landsat imagery showing seasonal (spring-to-late-summer) changes on the intertidal foreshore

Burdett, H et al: Investigating the photophysiology of Maldivian coral reefs under changing enviromnental conditions. The Maldives, in the eastern Indian Ocean, consists of 1200 atoll islands, each one surrounded by a coral reef, yet very little research has been conducted on this vitally important marine ecosystem. The Maldivian economy is almost entirely dependent on the long-term survival of their coral reefs; 43% of the country's GDP comes from the fishing and tourism industries. Coral reef macrophytes (e.g. corals, coralline algae, seagrass) are highly susceptible to environmental change (e.g. long-term climate change or anthropogenic perturbations such as a pollution event). The ability for these organisms to maintain photosynthesis in the face of environmental change is key to their survival. In a multi-institution field campaign (with researchers from the U. of St Andrews, Heriot-Watt and Glasgow), we investigated the photophysiological response of coral reef macrophytes (corals, coralline algae and seagrass) in Lhaviyani atoll, mental conditions compared to their 'normal' location (e.g. increased light or temp.) and their photophysiological response monitored over time. PAM fluorometry measurements were conducted in situ to assess changes in photosynthetic rate; net photosynthetic rate was determined by complementary dissolved oxygen measurements. Preliminary results suggest that Maldivian reef macrophytes are able to quickly acclimate to new environmental conditions, perhaps explaining their sustained success over time.


Conducting PAM fluorometry measurements on a coral reef

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
- Draft a review paper on field spectroscopy measurement configurations and measurement descriptions to incorporate mathematical description of empirically derived directional response function anomalies