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) provides a fundamental service to the NERC and the wider UK academic research community through the provision of calibrated and well-characterised spectroscopy instruments, integrated spectral systems and ancillary equipment to support Earth observation through the NERC S&F peer review process. The Facility provides a nationally referenced spectrometer calibration and instrument characterisation service to NERC and the wider UK academic research community. FSF underpins the NERC strategic goal of delivering "**world-leading environmental research at the frontiers of knowledge**". 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** (see tables below and Annexes for details)**.** FSF also helps proved "**high quality training that meets national skills needs**" (NERC Delivery Plan 2011-2015 Action 3) through the provision of an internationally highly regarded **Introduction to Field Spectroscopy** course held annually and attended by scientists, post doctoral researchers and PhD students. In addition, FSF provides one-to-one field spectroscopy training to all Facility users. FSF also supports **NERC National Capability** (NC) through its **"support of strategic and responsive research … community access to essential facilities and ... respon(*se*) to national emergencies"** (NERC Delivery Plan 2011-2015 Sect. 2.2) as has been demonstrated by the swift response to the Eyjafjallajökull volcanic eruptions. FSF is fully integrated in NERC's NC through its support of optical instrumentation either owned or borrowed from FSF by **BGS**, **BAS**, **CEH,** and **NCEO** and provides technical support for the **ARSF** hyperspectral imaging systems. **Economic impact and societal benefits** are further achieved by staff from FSF working in collaboration with industry to develop cutting edge spectroscopy instrument systems and integrating these into 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, where it currently employs two personnel (Operations and Equipment managers at 1 FTE each) and exploits synergies with the NERC Geophysical Equipment Facility. 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 for Earth observation.

ANNUAL TARGETS AND PROGRESS TOWARDS THEM

- Continue to widen the FSF user community through provision of an increased range of hydrological optical instruments; more fully characterised state-of-the-art field spectroradiometers; field and laboratory spectro-goniometers; and a field portable open path FTIR with integral reference black bodies.
- Continuation to supply well maintained, calibrated and more fully characterised instruments through emphasis on QA, calibration procedures and instrument performance research.
- Continued to update and develop cutting edge field spectroscopy and laboratory instrument suites through capital allocation of ~£147k from NERC S&F during 2011/12
- Continue to support the NERC CIMEL AERONET network and field spectroradiometers held by BGS and NCEO.

SCORES AT LAST REVIEW (each out of 5)		Date of Last Review:		2009
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 – 17% NERC	2014	2015

FINANCIAL DETAILS: CURRENT FY								
Total Resource Allocation £k	Unit Cost £k*					Capital Expend £k	Income £k	Full Cash Cost £k
	FTIR/ GRASS	Full wavelength spectro-radiometers	CIMEL/ OCRs & fluorometer	Micro-tops	GER 1500s			
	£0.275	£0.180	£0.075	£0.025	£0.050	£142.000	£7.665	£326.410

FINANCIAL COMMITMENT (by year until end of current agreement) £k									
2010-11	£256.38	2011-12	£265.198	2012-13	£272.97	2013-2014	£272.88	2014-2015	£280.179

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

APPLICATIONS: DISTRIBUTION OF GRADES (current FY — 2011/12) Notes 1, 2 & 3													
	10	9	8	7	6	5	4	3	2	1	0	R*	Pilot
NERC Grant projects*			5	1									
Other academic		4	4	4	2								2
Students			3										
TOTAL		4	12	5	2								2

PROJECTS COMPLETED (current FY – 2011/12))* Notes 1 & 4												
	10 (α5)	9	8 (α4)	7	6 (α3)	5 (α2)	4	3 (α1)	2	1 (β)	0 (Reject)	Pilot
NERC Grant projects*	1	1	8	1								
Other Academic		4	2									
Students		1	4									

Project Funding Type (current FY – 2011/12) (select one category for each project)										
Grand Total	Infrastructure					PAYG				
	Supplement to NERC Grant *	PhD Students		NERC	Other	NERC Grant*	PhD Students		NERC Centre	Other
		NERC	Other				NERC	Other		
26	2	3	4	5	8	0	0	0	0	4
Project Funding Type (per annum average previous 3 financial years - 2008/2009, 2009/2010 & 2010/2011)										
Grand Total	Infrastructure					PAYG				
	Supplement to NERC Grant *	PhD Students		NERC	Other	NERC Grant*	PhD Student		NERC Centre	Other
		NERC	Other				NERC	Other		
28.3	9.7	6.3	6.0	2.7	9.7	0	0	0	0	0

User type (current FY – 2011/12) (include each person named on application form)				
Academic	NERC Centre	NERC Fellows	PhD Students	Commercial
18	8	1	11	4
User type (per annum average previous 3 financial years - 2008/2009, 2009/2010 & 2010/2011)				
Academic	NERC Centre	NERC Fellows	PhD Students	Commercial
13.8	3.0	0.6	11.0	0.0

OUTPUT & PERFO0.MANCE MEASURES (current year)									
Publications (by science area & type) (calendar year 2011)									
SBA	ES	MS	AS	TFS	EO	Polar	Grand Total	Refereed	Non-Ref/ Conf Proc	PhD Theses
0	6	3	10	3	10	4	36	20	15	1

Distribution of Projects (by science areas) (FY 2011/12)							
Grand Total	SBA	ES	MS	AS	TFS	EO	Polar
26	0	5	3	3	3	8	4

OUTPUT & PERFORMANCE MEASURES (per annum average previous 3 years)									
Publications (by science area & type) (Calendar years 2008, 2009 &2010)									
SBA	ES	MS	AS	TFS	EO	Polar	Grand Total	Refereed	Non-Ref/ Conf Proc	PhD Theses
1.0	8.8	3.5	5.5	6.2	22.3	2.5	49.0	9.0	35.3	4.7

Distribution of Projects (by science areas) (FY 2008/2009, 2009/2010 & 2010/2011)							
Grand Total	SBA	ES	MS	AS	TFS	EO	Polar
28.3	0.5	6.6	0.9	5.1	2.3	11.0	2.0

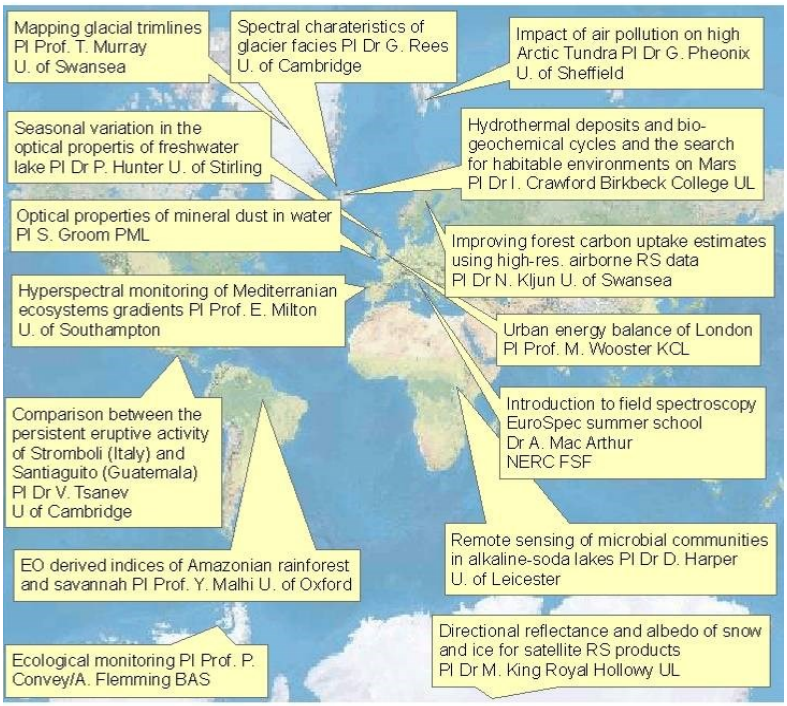
Distribution of Projects by NERC strategic priority (current FY 2011/12)							
Grand Total	Climate System	Biodiversity	Earth System Science	Sustainable Use of Natural Resources	Natural Hazards	Environment, Pollution & Human Health	Technologies
26	5.00	2.25	1.00	7.25	4.00	2.50	4.00

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
Note 3. 6 commercial applications were also received during 2011/12
Note 4. 4 commercial loans were also made during 2011/12

OVERVIEW & ACTIVITIES IN FINANCIAL YEAR (2011/12):

The impacts of FSF supported research

- Improvement of volcanic ash cloud modelling through provision of optical data to estimate atmospheric particulates
- Estimating primary productivity under the Arctic Ice to assess the effect of Climate Change on a vulnerable ecosystem
- Monitoring volcanic gas emission for assessment of their impact on human health
- Errors in the use of Antarctic ice sheets for satellite sensor calibration validation are being quantified
- An ecological survey was undertaken to monitor the long term impact of climate change in the Antarctic
- Work was undertaken to assess the impact of ocean acidification and temperature rise on cold water coral communities as a result of anthropogenic CO_2 emissions



Global distribution of projects supported by FSF during 2011/12

Publicity

- Presentations were given on the services FSF provides at a EU summer school in Italy; and the ARSF workshop at RSPSoc 2011; and hosted the EARSel Imaging Spectroscopy conference in Edinburgh during 2011.

Quality Assurance and calibration

- Continued development of 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 double monochromator was purchased to investigate spectrometer and multi-band sensor spectral response (FWHM).

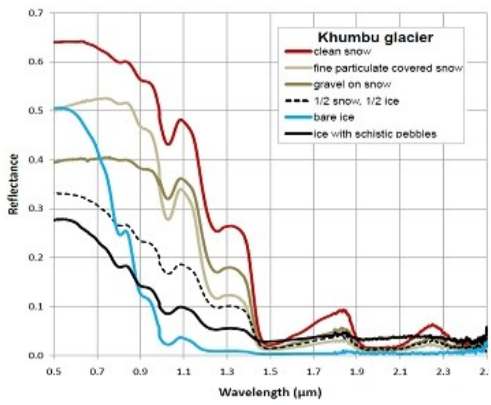
Research and development

- The temperature dependent performance characteristics of multi band sensors was investigated during a COST funded Short Term Scientific Mission.
- The laboratory goniometer was commissioned during 2011/12 and used to measure the cosine response of the Skydome spectrometer in a pilot project.

Science Highlights

The science supported by the Facility is diverse, of high quality and widely geographically distributed. This year papers were published in a wide range of highly regarded international journals. Three examples are **1) Casey *et al* (2011). Characterization of glacier debris cover via in situ and optical remote sensing methods: a case study in the Khumbu Himalaya, Nepal. The Cryosphere Discuss. 5. Impact factor 3.4** Field spectrometry and physical samples were collected from the ablation zones of Ngozumpa and Khumbu glaciers, Nepal during 2009. Field acquired spectral reflectances and mineral and chemical compositions of samples were used as ground data for comparison with satellite optical remote sensing data. Supraglacial debris was characterized by optical remote sensing methods and image-derived glacier velocity and theoretical supraglacial particle transport determined. Mass flux was estimated by false colour composites and glacier velocity displacement fields. Supraglacial temperatures were compared with mineral abundances, implying potential parameters to estimate differential melt. The glaciologic implications of debris cover characterizations applicable to glacier energy balance and glacial extent mapping were discussed. The methods developed can be used to improve supraglacial debris quantification and reduce errors associated with ice extent mapping, surface radiative properties, as well as debris covered ice mass flux and loss estimations.

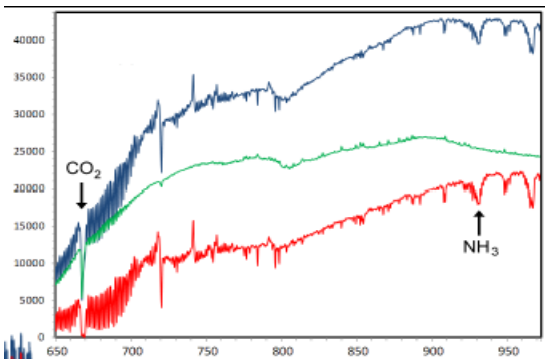

Debris strewn Khumbu Glacier, Nepal



Reflectance spectra of glacier surface with different debris compositions. Albedo estimated from integral of spectrum.

2) Asmat, A. *et al* (2011) Empirical correction of multiple flightline hyperspectral aerial image mosaics. RSE 115. Impact factor 4.6 Aerial survey provides users with great flexibility in terms of the geometry of sensing and the timing of measurements, but mosaicking individual aerial images to produce an extensive coverage remains a problem. Empirical methods based on normalising individual images to a common standard are widely used to create visually acceptable mosaics. However, the effect of these methods on quantitative estimation of land surface properties is unknown. An existing method for atmospherically correcting an aerial image mosaic involves fitting a regression model using pixels from the overlapping edges of adjacent flightlines. A new method of atmospherically correcting an aerial image mosaic, based on use of an additional orthogonal flightline was presented. The two methods were compared by using the two image mosaics to calculate vegetation indices (NDVI, SAVI, ARVI), which were then used to predict leaf area index, which was known in detail from ground survey. The second method was found to have lower uncertainty for all three vegetation indices tested. ARVI was found to be the most robust of the three when applied across multiple flightlines, regardless of the method of atmospheric correction. **3) Wooster *et al* (2011) Field determination of biomass burning emission ratios and factors via open-path FTIR spectroscopy and fire radiative power assessment: headfire, backfire and residual smouldering combustion in African savannahs. Atmos. Chem. Phys. 11. Impact factor 4.3** Biomass burning emissions factors are vital to quantifying trace gases releases from vegetation fires. In this paper the emissions factors for a series of savannah fires in Kruger National Park (KNP), South Africa using ground-based open path Fourier transform infrared (FTIR) spectroscopy are examined. Though FTIR spectroscopy can detect many different chemical species present in vegetation fire smoke, analysis here focuses on five key combustion products released during the pyrolysis (CH_2O), flaming (CO_2) and smoldering (CO, CH_4 NH_3) processes. It was demonstrated that well constrained emissions factors for these gases can be derived for the backfire, headfire and residual smouldering combustion (RSC) stages, from which stage specific emission factors can then be calculated. Headfires and backfires often show similar emission ratios and emission factors, but those of the RSC stage can differ substantially. The fire averaged emission factors for CO_2 and CH_4 agree well with those from prior studies. Analysis also concurred with past suggestions that emission factors for CH_2O in this environment appear substantially underestimated but no evidence to support suggestions of a major overestimation in the emission factor of ammonia was noted. However, somewhat higher CO and NH_3 emission factors than usually reported for this environment were noted. Finally, these results suggest that the contribution of burning elephant dung can be a significant factor in the emissions characteristics of certain KNP fires.

FTIR in open path mode measuring fire emissions



FTIR measurement viewing IR source. Geen -smoke filled optical path; blue – 'ambient'; red- difference used to estimate NH_3

On-going research - Dr N. Kamenos, University of Glasgow. The impacts of ocean acidification on marine biogenic carbonates. The photosynthetic characteristics of red coralline algae are not well understood. This study comprised of controlled laboratory and field measurements using a Diving-Pulse Amplitude Modulation fluorometer (PAM). The PAM provides detailed information on the photosynthetic characteristics of plants and algae and can be used underwater. Field measurements were taken at 6 m depth using SCUBA, following a dive-plan agreed with NERC SDF. This research is primarily focused on the effect of environmental change (e.g. ocean acidification) on marine algal assemblages including coralline algal beds and coral reefs. A photosynthetic study on free-living red coralline algae has been conducted in Loch Sween, Scotland and at the Suleman reef, Sinai Peninsula, Egypt. Following this work Dr Kaminos' team have been awarded an EU FP7-ASSEMBLE Marine grant to conduct further work on maerl and kelp beds.

Using Diving PAM to measure photosynthesising activity of coral

FUTURE DEVELOPMENTS/STRATEGIC FORWARD LOOK

- Spectral and spatial response characterisation of the NERC ARSF and Airborne Geosciences imaging spectrometers and a range of multi band spectrometers will begin during 2012/13 for spectral and spatial scaling studies.
- Investigation into the spectral dependencies of the FWHM resolution of field spectroradiometers and the creation of Spectral Libraries in ENVI User Guide will begin during 2012/13.
- A survey of the views of users on the service and instruments provided by FSF will be undertaken during 2012/13