STFC Environment Futures First Workshop Report

21 February 2011

Contents

1. Summary

This report records the outputs from the first Environment Futures Workshop held during November 2010. The workshop provided an opportunity for the STFC community to discuss how STFC's capabilities, within its laboratories and funded universities, could be applied to help provide solutions to the research challenges in environmental science. The workshop attendees were asked to produce a list of research priorities and matching capabilities, together with actions to help foster strong collaborative partnerships with the environmental research community.

Five priority areas were identified at the workshop: technology; climate change; sustainability and a low carbon economy; observing and dealing with pollutants in the environment and biogeochemical cycles; health. Two of these priorities have strong overlap with other Futures Programme areas, i.e. sustainability and a low carbon economy has elements in common with both energy and security, and health is a Futures area in its own right.

In all of these priority areas there are existing activities, and examples of these have been given in the main report and the annexes that describe the talks and posters that were presented during the workshop. However, the range of environmental research activities already happening across the STFC community is vast, and this report will not have captured every detail. Harder still is the process of identifying potential new areas where STFC could contribute, and much of what has been identified is very top level and requires detail to be added.

During the workshop there were clear messages about improving the processes by which environmental researchers can access STFC's capabilities, for example by extending the concept of facility access to skilled staff. There were perceived shortcomings in the way the research councils deal with cross-disciplinary research, and it was felt that there was sometimes an element of double jeopardy regarding facility access. A joined-up approach to allow projects access to multiple facilities was also requested.

The concept of a STFC Environmental Research Community Network was supported by the workshop. Whilst the primary purpose of the Network would be to enable the formation of challenge-led project teams, it was strongly felt that where appropriate this should be supported by the availability of proof-of-concept funding to kick-start new activities.

The next steps, following publication of this report, will start the process of adding detail to the top-level priorities and capabilities. This will begin with the Physical and Life Sciences (PALS) Committee review of STFC environmental science between March and June 2011. The review will be followed by a second Environment Futures Workshop to be held during October 2011, where the STFC and NERC communities will meet to begin the formation of collaborative partnerships.

2. Introduction

A two-day STFC Environment Futures Workshop was held at the Rutherford Appleton Laboratory on 11 and 12 November 2010. The workshop was attended by representatives from the STFC community, including laboratory staff, facility users, university-based researchers and other collaborators.

The workshop was held to address the following objectives of the Environment Futures Programme:

- showcase examples of previous, current and planned environmental research within the STFC community,
- forecast important environmental science challenges - drawing upon the strategies developed by the NERC and the Living With Environmental Change Programme - and consider how the STFC's unique capabilities can be harnessed to address these,
- explore how STFC can improve its interactions with environmental researchers; and
- initiate the formation of an STFC environmental research community for improved communication and the establishment of new, strong project teams to address the environmental challenges.

3. Workshop format

The workshop comprised plenary talks and breakout discussions interspersed with poster sessions and opportunities for networking. The workshop began with an introduction by the STFC Director of Science Programmes, Professor John Womersley. The introduction was followed by presentations from the NERC Head of Strategy, Dr Phil Heads, and the LWEC RCUK Theme Leader, Dr Dan Osborn. These talks identified some very top level priorities within the NERC and LWEC remits. A series of technical talks followed covering a range of environmental research topics that have made use of STFC facilities, expertise or technologies. These served to illustrate the breadth of environmental research that has already made use of STFC capabilities. At the end of the first day there was a conference dinner, during which a talk was given on some of the ethical issues surrounding the emerging topic of geoengineering of the Earth's climate.

Breakout discussion questions

There were two breakout sessions, one on each of the days. The first session identified scientific and technical priorities, whilst the second considered issues related to organisation and process. Facilitators and scribes guided the participants during the sessions and recorded the outputs.

Breakout session one

The questions in session one were posed after the participants had heard presentations about NERC strategy and LWEC objectives. In addition to relevant slides from the two talks, participants were provided with hard copies of the NERC strategy document. There were four breakout groups in session one and the following questions were posed:

Q1: Considering the research priorities identified by the NERC and LWEC what are the top three environmental science challenges that the STFC could/should support?

Q2: What technologies, facilities, skills and other capabilities does the STFC have within its laboratories and funded universities to address these challenges?

Participants were asked to create a ranked list in answer to question one, and then to assign capabilities to each of the priorities. The results from session one were fed back during a plenary discussion, and the priorities identified by each group were compiled into a single list with associated capabilities.

Breakout session two

Session two was held at the end of the workshop, after participants had learnt about the breadth of environmental science that STFC is already involved with, and had heard about some of the issues that need to be tackled in order to apply STFC capabilities more widely to address the research priorities identified during session one.

There were two breakout groups in session two. Each group considered one of the following questions:

Q1: What practical actions should the STFC take to better use its facilities, technologies and expertise to contribute more effectively to environmental science?

Q2: What form should an STFC environmental science community take and what opportunities and (organisational) challenges could the community address?

Participants produced a list of practical actions that the STFC should consider taking.

Feedback and discussion

Following the breakout sessions each group fed back their findings in plenary and discussion took place. This resulted in combined lists of priorities, capabilities and actions, and these are recorded in the following sections.

4. Research priorities and key capabilities

Breakout session one identified five priority areas that the STFC could support, these were:

1. Technology.
2. Climate change.
3. Sustainability and a low carbon economy.
4. Observing and dealing with pollutants in the environment and biogeochemical cycles.
5. Health.

The following sections list the STFC capabilities that could be deployed to address research challenges in each of the priority areas. Implicit in these lists is the idea that STFC capabilities include the technologies, skills and facilities within university departments that have been funded by STFC (or PPARC prior to April 2007), as well as those residing at the council's own laboratory sites. *There is no significance in the order that these priorities and capabilities are presented.*

One of the groups produced a matrix of challenges and the facilities and capabilities that could be relevant to climate change, sustainability and health. Since the group did not include experts from all of the relevant facilities, departments and university groups, *the matrices should be considered as a starting point for further debate at the PALS review and Second Environment Futures Workshop*.

Two potential strengths of the STFC laboratory sites were identified during the discussions:

1. Environmental research often requires a combination of skills, technologies and facilities. Given the right mechanisms, the co-location of these at the laboratory sites could enable cross-disciplinary research to be undertaken in a highly productive way.
2. The proposed Centres could make STFC's capabilities and facilities more accessible to the environmental science community.

Technology

Technology underpins most of the strategic priorities of both the NERC and LWEC. However, technology has been identified by the NERC as a theme in its own right, and it is an area where STFC could potentially make a large contribution. There is clearly potential for additional economic and societal impact, as many technologies developed for environmental studies or monitoring will have applications elsewhere, e.g. novel chemical sensors for industrial processes.

A potential role for the STFC laboratories is retention of and training in specialist technological skills on behalf of the UK, with benefits for academic research and industry.

Many specific technologies are mentioned in the sections covering the other priority areas, therefore broad top-level examples of relevant capabilities are given here:

1. The design and build of instrumentation, sensors and detector systems drawing on skills in electronics, optics, cryogenics, etc.
2. The creation of bespoke software for instrument control, networking, data acquisition, data reduction and analysis.
3. Management of large and complex data sets and their long-term curation.
4. Data mash-up and visualisation of complex data sets to aid research, for public outreach and presentation to policymakers.
5. New methods for modelling and simulation that make use of the latest computing technology, e.g. massively parallel computing.
6. Facilities, including environmental testing of instruments, clean rooms, micro and nanotechnology, precision fabrication workshops, etc.

Climate change

This priority is strongly aligned to both NERC and LWEC strategic objectives. The STFC already makes a large contribution in this area by operating facilities and data centres on behalf of the NERC, some of which are part of larger NERC centres. For example, The British Atmospheric Data Centre (BADC, part of the National Centre for Atmospheric Science), the NERC Earth Observation Data Centre (NEODC, part of the National Centre for Earth Observation), the Chilbolton Facility for Atmospheric and Radio Research (CFARR), the Mesospheric-Stratospheric-Tropospheric (MST) Radar and the Molecular Spectroscopy Facility (MSF).

Within the STFC laboratories much of the obvious current activity relevant to climate change happens within RAL Space, however there are very significant areas of work within other departments and facilities. For example, the recent studies on wind-blown Saharan dust at DLS.

Through its data centre and modelling activities, the STFC has already established excellent links with the UK Met Office from RAL Space and Computational Science and Engineering Department (CSED).

Responsibility for solar-terrestrial physics (STP) until recently resided with the STFC. Although funding of STP activities has now moved to the NERC, the STFC retains expertise in this area.

Climate change and Earth observation are priorities for the new International Space Innovation Centre and the ESA Centre, both of which are located at Harwell.

Examples of relevant capabilities include:

1. Development and deployment of ground and aircraft-based in-situ and remote sensing technologies.
2. Development of satellite or spacecraft-based remote sensing technologies.

3. Development and provision of ground-based atmospheric remote sensing facilities, i.e. CFARR and MST Radar.
4. Ground station facilities for satellite mission control and reception of data, i.e. RAL Space Ground Station and proposed developments within ISIC.
5. Development and provision of laboratory facilities to determine the radiative properties of atmospheric trace gases and aerosols for climate modelling and Earth observation, i.e. the MSF.
6. Development and provision of laboratory facilities to understand the formation and evolution of aerosols and associated atmospheric chemical reactions, i.e. the Lasers for Science Facility and the MSF.
7. Development of systems to collate real-time data gathered from high-resolution sensor networks, Earth observation data, etc, to provide timely information about climate trends and their consequences.
8. Development of software tools to enable organisations to understand how climate change will affect their businesses, e.g. previous RAL Space involvement in UK Climate Impacts Programme, www.ukcip.org.uk.
9. Long-term climate data curation, data mining and fusion of data sets, i.e. the BADC and NEODC.
10. Data visualisation for research and public outreach, e.g. the planned hyperwall within ISIC, and the Imaging Solutions Centre.
11. Development of new climate modelling techniques at high spatial resolution that exploit advances in massively parallel computing, e.g. the joint development of next generation climate models between UK Met Office and STFC CSED.
12. Earth observation mission requirements studies, i.e. development of technical requirements for new EO instruments given desired measurement capabilities, e.g. the RAL Space PREMIER phase A study for a possible ESA Earth Explorer mission.
13. Modelling of measurement capabilities to investigate the feasibility of new observational technologies.
14. Exploitation of EO data to determine spatial distributions and radiative forcing of climate gases, air-quality pollutants, clouds and aerosols.
15. Exploitation of EO data to monitor land use and productivity.
16. Expert scientific and technical support and validation for long-term monitoring of sea surface temperature from space, i.e. the Along Track Scanning Radiometer series of instruments and the forthcoming Sea and Land Surface Temperature Radiometers.
17. Calibration of satellite-based spectrometers and radiometers used for remote sensing of the atmosphere.
18. Understanding how changes in solar activity and space weather affect the climate. Experts in solar physics within STFC laboratories and funded university groups could work closely with atmospheric modellers to enable a coherent space weather-Earth environment research programme.
19. Experimental studies of the influence of cosmic rays on aerosol and cloud formation using the low background radiation laboratory at The Boulby Deep Underground Science Facility (SKY-ZERO) and CERN (CLOUD).

Table 1. Climate change capability matrix

Challenge	ISIS	DLS	CLF	RAL Space & Universities	CSED & Universities	Technology	Boulby
Greenhouse gases			X	X	X	X	X
Aerosols	X	X	X	X	X	X	X
Land use	X	X		X	X	X	X
Solar activity				X	X	X	X
Ozone	X		X	X	X	X	

Sustainability and a low carbon economy

This priority aligns strongly with LWEC objectives and there is much potential for contribution across the board from STFC departments, facilities and funded university groups.

The challenge is to secure and make best use of natural resources including energy, food, water and minerals, whilst minimising pollution and carbon emissions. This will require the development of sustainable clean low carbon fuels, whilst protecting biodiversity and balancing the increasing pressures on land use. Clearly there are large areas of overlap between this priority and the Energy and Security Futures Programmes.

There is great potential here for the STFC to create impact by working with industry, in particular with the electricity suppliers and the increasing number of small to medium sized enterprises in the renewable energy sector. The Innovation and Technology Access Centre at Daresbury (and the proposed centre at Harwell) is already hosting a number of companies that are relevant to this theme.

1. Computer modelling to determine how changes in climate could affect the supply of food and water to different regions of the world.
2. Technology for smart grid and energy storage systems that enable more efficient use of existing energy supplies.
3. New technologies to assist with exploration for fossil fuel reserves, and more efficient extraction from existing oil and gas fields to limit the need for exploration in new environmentally sensitive areas.
4. Studies to find alternatives to minerals that have been over exploited, including experimental studies using the large facilities and computational studies to determine theoretical performance.
5. Earth observation technologies and data analysis to monitor changing land use, movement of populations and impacts on biodiversity, etc.
6. Technologies and modelling for renewable energy: wind (next generation turbine technology, power distribution, etc, for new offshore schemes, e.g. Irish Sea), tidal, wave, solar PV, energy storage solutions.

7. Design and study of new materials, e.g. for sequestration of carbon dioxide or for hydrogen fuel cells. Computational science and engineering could be applied to the theoretical modelling and identification of potential candidate materials. Beam lines at ISIS, DLS, CLF, ILL, ESRF, etc., and the expert staff in these facilities, could enable studies on the structures and behaviours of new materials.
8. Development of muon tomography techniques for long term monitoring of carbon storage sites. Relevant capabilities include detector and network technologies, and The Boulby Deep Underground Science Facility for development and testing.

Table 2. Sustainability capability matrix

Challenge	ISIS	DLS	CLF	RAL Space & Universities	CSED & Universities	Technology	Boulby
Food security	X	X	X	X	X	X	
Water security	X	X	X	X	X	X	
Pollution	X	X	X	X	X	X	X
Energy	X	X	X	X	X	X	X
Land use	X	X	X	X	X	X	
Biodiversity	X	X	X	X	X	X	X
Minerals	X	X	X		X	X	X

Observing and dealing with pollutants in the environment and biogeochemical cycles

This priority is closely aligned with the NERC Environment, Pollution and Human Health strategic theme.

In order to understand how humankind's activities impact on the environment research is required to identify the behaviour and fate of pollutants in the environment, how to remove them from the environment and how to prevent their release in the first place. This may include the development of techniques to identify and quantify sources of pollution for enforcement of regulations.

The STFC has a range of facilities that can study the cycle of chemicals in the environment from macroscopic to molecular scales. Examples of pollutants where the STFC has relevant expertise, technologies and facilities include gases, aerosols, chemicals in soils and water, nano-particulates and radioactivity. These capabilities have wider applicability to understanding the nutrient cycle whether from anthropogenic or natural sources, and include the study of how bacteria interact with nutrients.

Within the university community studies on astrobiology are relevant to the understanding of terrestrial life forms that survive in extreme environments, determining the limits of the biosphere and methods for life detection. This is an area where links between the STFC and NERC communities are already forming.

1. Exploitation and development of ultra-low background gamma spectroscopy capability at Boulby Underground Science Facility, enabling orders of magnitude improvement in sensitivity for various ongoing UK environment-related radioactivity studies.

2. Development of nanotechnology for decontaminating polluted water to minimise the release of pollutants to the environment and allow reuse.
3. ISIS, DLS and LSF already work with researchers funded by BBSRC and NERC. Expert STFC facility staff work closely with environmental scientists, who do not have expertise in neutron or x-ray science, to design new experiments, to make measurements and interpret data.
4. Exploitation of Earth observation data to track atmospheric pollution, and identify sources and sinks.
5. New EO technologies to increase the spatial resolution of observational techniques for improved identification of sources and sinks of pollutants.
6. Development of EO techniques to recognise damage to vegetation caused by pollutants.
7. Computer modelling of nutrient cycles.
8. Detector technologies.

Health

In addition to the challenges above, one group identified health as a priority area. Health is a separate theme within the Futures Programme, although there are clearly overlaps between Environment and all of the other global challenge areas.

Table 3. Health capability matrix

Challenge	ISIS	DLS	CLF	RAL Space & Universities	CSED & Universities	Technology	Boulby
Disease	X	X	X	X	X	X	
Infectious disease	X	X	X		X	X	
Natural hazards / disasters			X	X	X	X	
National security	X		X	X	X	X	X
Ageing society		X	X		X	X	
Urban environment		X	X	X	X	X	

Geoengineering

Geoengineering research was not identified as a separate priority area, probably because this area of research was in its infancy when the NERC and LWEC strategies were developed. However, a recent sandpit on geoengineering led by the EPSRC and NERC identified STFC facilities that could make significant contributions to this emerging area. One of the two projects funded by the sandpit will make use of the STFC Lasers for Science Facility and the NERC-funded STFC-hosted Molecular Spectroscopy Facility.

4. Organisational challenges

The results of breakout session two are recorded in Tables 4 and 5. It was interesting that, despite being posed different questions, many common issues emerged independently from the two groups. In particular the following common themes were apparent:

1. The STFC community and the environmental science community often have poor visibility of each other and speak a different language. Resource is required to enable these two communities to begin to work together effectively.
2. There should be a roadmap of environmental science activities within STFC and this should be developed in partnership with the NERC and LWEC.
3. Current RC arrangements for dealing with cross-cutting research proposals are not satisfactory, and there should be joint programmes between the RCs.

Table 4. Actions to improve interaction with the environmental science community.

Challenge area	Actions and comments from the workshop
Communications	A survey of current environmental research activities is required. This should include minor areas of research and expertise, in terms of scale, that could have the greatest development potential. STFC should be represented on relevant panels and committees at the NERC, DEFRA, EA, Met Office, etc. STFC should be a full member of LWEC, thereby strengthening interactions with the twenty LWEC partner organisations. There needs to be publicity of STFC capabilities to the environmental science community, perhaps through roadshows or workshops. The NERC could perhaps increase awareness of STFC-funded facilities within their community, providing examples of how they have been used for environmental research in the past. Promote the existence of the Research Complex at Harwell to the environmental research community as a place to undertake research at the interfaces between the traditional scientific disciplines and the large facilities. STFC should ensure that the new strategy, in particular Solutions to Global Challenges, is widely known (including STFC review panels).
Funding	There needs to be funding to allow connections to be formed between the STFC and environmental science communities. Seedcorn programmes are required to progress new ideas, by providing funding for travel and a small amounts of staff time and equipment. There should be joint funding programmes with the NERC. Proposals submitted to joint funding programmes should be reviewed by a single peer-review panel. Follow-on schemes should be available for successful PoC studies to continue their development. There should be harmonisation of RC funding timetables.
Skills	The concept of facility access should be extended to skilled staff within STFC laboratories and STFC funded university groups, to enable environmental scientists to apply for expert support.

Facility access	It is *perceived* by the community that facility users experience double jeopardy: grant proposals that include facility time are reviewed once by the RC grant panel and then again by the facility review panel. Whether this perception is correct or not, it is an issue that was mentioned a number of times during the workshop by a number of different attendees and therefore needs to be addressed. There needs to be a holistic approach for one project to access multiple facilities.
Cross-cutting research	Research often cuts across RC boundaries. The composition of review panels does not always allow for effective assessment of cross-cutting research proposals. Sometimes a proposal will be rejected at the first stage because it is considered to be within the remit of another RC, although it is in fact cross-cutting. These are administrative issues for the RCs to address, and should not be a concern for academics when writing their proposals.

Table 5. STFC Environmental Research Community Network.	
Form	The STFC community should form a virtual network that can react quickly to opportunities. There should be a structure to the network. It should be represented by key individuals from the STFC community who will champion their facility, area of research, technology or expertise, and co-ordinate the network in its response to opportunities.
Role	The purpose of the network will be to form challenge-led collaborative relationships that make use of past, present and future STFC investments to enable environmental research or monitoring that addresses the strategic priorities of the NERC and LWEC. Network champions/co-ordinators will be responsible for representing the community at conferences, forums and seminars, to develop relationships and publicise the facilities and other capabilities that are available. The network will hold regular community workshops, where the network will interact within itself and the wider environmental science community. The network will be represented in meetings with NERC, LWEC and STFC to develop a roadmap and provide a focus for future investment and partnerships. The network should be able to call upon resources to fund pilot projects that have developed from interactions with the environmental science community. The network should provide advice to help determine the focus of specific STFC funding calls, e.g. CLASP rounds on environmental topics. The network should be able to request funds for visiting environmental scientists (to STFC laboratories or university departments) to work with facilities and skilled staff, to generate ideas and act as ambassadors for STFC within their own communities. The network should have access to concurrent design facilities (e.g. in ISIC and RAL Space) for the development of interdisciplinary project ideas with the environmental science community.

Specific challenges	To survey the whole of STFC's environmental research, technology and skills portfolio and produce a database (building on STFC Connections) that is available and understandable to environmental researchers. To create a single roadmap of interaction between the STFC and environmental sciences to provide focus. To create new links and develop relationships with the environmental research community. To identify environmental research requirements and then translate these so that other communities who are not expert in the field can understand them. To improve the ways in which cross-council research is assessed and funded by the research councils. To help secure resources for researchers to enable new challenge-led partnerships to flourish. To form collaborative relationships with the international environmental science community.

5. Next steps

The final version of this report will be provided to the STFC Physical and Life Sciences (PALS) advisory panel and the proposed STFC Futures Programme Panel. PALS will concentrate on the role of the facilities, and add detail to the top level priorities and capabilities identified in this report.

This report and advice from the panels will be used to help prioritise the allocation of resources from the Environment Futures Programme and provide advice regarding the direction of facility capacity towards environmental global challenges.

The report will also be used to help plan a further Environment Workshop to be held during October 2011. This second workshop will bring together the NERC and STFC communities to begin the process of information exchange, publicity of STFC capabilities and the formation of interdisciplinary partnerships.

Annex

List of talks presented during the workshop

Research challenges arising from the NERC strategy	Phil Heads, NERC Head of Strategy
Challenges identified by the Living With Environmental Change programme	Dan Osborn, RCUK LWEC Theme Leader
Cloud formation from the atmospheric oxidation of particulate matter using photons and neutrons	Martin King, Royal Holloway
Astrobiology: Where biology can bring together STFC and NERC	Charles Cockell, The Open University
Solute uptake at the mineral-fluid interface: case studies of synchrotron methods applied to molecular environmental science	Roy Wogelius, University of Manchester
Environment studies at the Boulby Mine Deep Underground Science Facility: Status, prospects and opportunities	Sean Paling, STFC Boulby Underground Laboratory
Millimetre-wave technology for environmental applications	David Matheson, RAL Space
Measuring the environment : re-using astronomy techniques	Andy Vick, STFC UK Astronomy Technology Centre
Geoengineering	Tim Kruger, Director Oxford Geoengineering
Nanomaterials in the Environment	Jamie Lead, University of Birmingham
The STFC Gateway Centres	Mike Curtis-Rouse, STFC Gateway Centres
The Hartree Centre	Mike Ashworth, STFC Computational Science and Engineering
Computing Challenges for Weather and Climate Modelling at the Met Office	Paul Selwood, The Met Office
Gas hydrates at high pressure - Applications from planetary atmospheres to carbon sequestration	John Loveday, University of Edinburgh

Slides from the talks are available from the Environment Futures Workshop web page at: http://www.stfc.ac.uk/Business+and+Innovation/Events/19491.aspx

Posters abstracts

1. Tropospheric profiling and meteorological measurement facilities at STFC Chilbolton Observatory
Judith Agnew, STFC Rutherford Appleton Laboratory
The STFC Chilbolton Observatory is home to the NERC-funded Chilbolton Facility for Atmospheric and Radio Research (CFARR). It houses a wide variety of atmospheric profiling and ground-based meteorological instruments, many of which provide continuous measurements. The site is well equipped to accommodate visiting scientists and instrumentation and has hosted many high profile field campaigns over recent years, including those for Aerosol Properties, Processes and Influences on the Earth's Climate (APPRAISE) and the Convective Storm Initiation Project (CSIP). In several campaigns measurements have been made in conjunction with research aircraft such as the NERC Facility for Airborne Atmospheric Measurements (FAAM). It is well-equipped to support a wide range of activities resulting from the STFC Environment Futures programme. The four radar systems based at the site are capable of profiling clear air features, precipitation and clouds. The four lidar systems provide cloud and water vapour profiling. Both the radar and lidar instrument suites provide polarimetric and Doppler data. A Radiometrics microwave radiometer produces continuous measurements of integrated water vapour, integrated liquid water and water vapour profile. A Cimel sunphotometer contributes measurements to AERONET. A wide range of meteorological sensors is also available. During the recent Eyjafjallajokull eruption the range of instruments, particularly the lidars and sunphotometer, were ideally suited to monitoring the evolution of the ash cloud over the site. Results from this and previous campaigns are displayed in order to highlight some of the capabilities.

2. TELIS – A Balloon-Borne Terahertz Observation of the Stratosphere
Brian Ellison (STFC-RAL), Manfred Birk (DLR), Gert de Lange (SRON) et al.
The poster will describe the TELIS balloon-borne atmospheric sounder instrument. TELIS (Terahertz and submm Limb Sounder) is a compact, lightweight, heterodyne spectrometer developed by a consortium of major European research institutes including RAL, UK, DLR (project leader), Germany, and SRON, Netherlands. The instrument is operated from a balloon platform simultaneously with an existing Fourier transform spectrometer (MIPAS-B) and has had three successful flights – one engineering and two scientific. Its purpose is to measure a variety of important atmospheric constituents within the stratosphere, including OH, HO2, O3, O2, H2O, NO, NO2 , CO, HCl, HOCl, ClO, and BrO, during long duration (~24 hour) flight campaigns carried out from northerly (e.g. Kiruna, Sweden) and lower latitudes (e.g. Brazil). The combined MIPAS-B/TELIS instrument is a standalone chemistry mission targeting the stratosphere, but also provides measurement complementary to existing and planned spaceborne instruments, e.g. ODIN, SMILES, Premier. The TELIS instrument comprises three signal channels operating at 500GHz (RAL), ~700GHz (SRON), and 1.8THz (DLR), and uses superconducting tunnel junction (SIS) and Hot Electron Bolometer (HEB) mixers at 4.2 K for sub-millimetre wavelength and THz channels respectively. Both the SIS and HEB mixers are 'pumped' by custom made solid-state local oscillators (the SRON channel uses an integrated flux-flow oscillator). A high-resolution digital autocorrelation spectrometer, previously demonstrated on ODIN but with an extended bandwidth of 4GHz for TELIS, provides the required spectral resolution. Implementation of a robust and lightweight instrument on an existing balloon platform has required careful mechanical and electrical design and optimisation, particularly with regard to the cryogenic system developed by RAL. Furthermore, robust instrument remote control and data handling systems have been developed that has been proven to survive the harsh environment associated with high-altitude flight conditions. Further flight campaigns of the instrument are being planned for 2011.

3. PREMIER -- ESA Earth Explorer-7 Candidate Mission

D Gerber, R Siddans, W J Reburn, C A Poulsen, B G Latter, A M Waterfall, G Miles, B J Kerridge. Remote Sensing Group, RAL Space.

PREMIER is one of three candidate missions in the final selection stage for the next ESA Earth Explorer Mission. The aim of PREMIER is to observe processes controlling atmospheric composition in the height range of particular importance to climate on a finer scale than previously accessible from space. This will be achieved by exploiting synergies between an FTIR limb-imager and a millimetre-wave limb sounder, together with collocated measurements by nadir-sounders on Eumetsat's MetOp satellite. RAL is co-ordinating preparatory scientific activities by an international team and is also developing critical mm-wave technology.

4. Satellite detection of volcanic ash during the Eyjafjallajokull eruption

Caroline Poulsen, Richard Siddans, Remote Sensing Group, RAL Space.

Gareth Thomas, Don Grainger, Elisa Carboni, AOPP, University of Oxford.

In April may this year the Eyjafjallajokul volcano erupted in Iceland and caused havoc over European air space. One of the actions out of the subsequent volcanic workshop as ESA was to develop quantitative ash products from satellite data that would not only show the location of the ash plumes but give information on the height and mass burden of the plume. The RSG group at RAL in collaboration with Oxford University has developed a retrieval scheme for the detection of ash clouds that is an extension of the ORAC (Oxford RAL retrieval of Aerosol and Clouds) retrieval scheme. The volcanic ash retrievals use ash optical properties measured at the RAL Molecular Spectroscopy facility to identify and measure the ash plumes properties. The algorithm has been applied to both polar orbiting AATSR data and the geostationary SEVIRI instrument results will be shown here.

5. Neutron scattering to explore the fate of nanoparticles in aquatic environments: wastewater treatment.

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Through novel application of small-angle neutron scattering, we examined the fate of silica nanoparticles (SiO2NPs) during simulated primary wastewater treatment, by measuring, in real time, the colloidal behavior of SiO2NPs in wastewater (sewage). We examined the effects of surface functionality on SiO2NP fate in wastewater, by comparing both unfunctionalized (uncoated or "bare") SiO2NPs and SiO2NPs functionalized with a thin coating of a non-ionic surfactant (Tween 20), which is widely used in personal care and household product formulations containing engineered oxide nanoparticles. Our results show new evidence that the surface functionality of SiO2NPs plays a crucial role in their flocculation and sedimentation behaviour in wastewater, and thus the likely efficacy of their removal from the effluent stream during primary wastewater treatment. Uncoated SiO2NPs did not flocculate in wastewater over typical residence times for primary treatment. Conversely, surface-functionalized (Tween-coated) SiO2NPs underwent rapid flocculation in wastewater. Our results show that the surface-functionalized SiO2NPs are likely to be removed by sedimentation to sewage sludge (typically recycled to land), whereas uncoated SiO2NPs will

continue through the effluent stream. While nanoparticle design is driven by use purpose, this study shows new potential for exploiting surface functionalization of nanoparticles to modify their environmental pathways.

References:

[1] Jarvie, H.P., King, S.M., 2010. "Just scratching the surface? New techniques show how surface functionality of nanoparticles influences their environmental fate". Nano Today, 248-250.

[2] Jarvie, H.P., Al-Obaidi, H., King, S.M., Bowes, M.J., Lawrence, M.J., Drake, A.F., Green, M.A., Dobson, P.J., 2009. "Fate of Silica Nanoparticles in Simulated Primary Wastewater Treatment". Environmental Science & Technology, 43, 8622–8628.

6. SANS Studies of Natural Aquatic Colloids

Stephen King (STFC); Helen Jarvie (CEH)

Aquatic colloids (naturally-occurring, sub-micron sized, heterogeneous mixtures of mineral particles and organic ligands) are increasingly attracting the attention of water quality scientists and environmental regulatory authorities because of their potential ecological impact. Aquatic colloids act as vectors for the transport of nutrients, trace metals and organic micro-pollutants, and facilitate the biogeochemical cycling and bioavailability of pollutants. However, there are major gaps in our quantitative understanding of the structure and composition of natural aquatic colloids, and the significance of these properties for their chemical and biological reactivity.

In this poster we examine the potential of small-angle neutron scattering (SANS) for studying the structure and composition of these systems using a range of natural colloidal dispersions.

Reference

HP Jarvie; SM King, Env. Sci. Tech., 2007, 41, 2868-2873

Derived Publications

'Muddy Water Blasted With Neutron Beams', NERC Planet Earth, 2006, Winter, 33

'A Clear View Through Muddy Water', CCLRC Portal, 2007, 14, 16-17

'Tracking A River Of Nanopollution', The Telegraph, 2007, 15 January

ISIS Annual Report, 2007, 6

7. Optical Levitation of Aerosols at the STFC Central Laser Facility

Andy Ward, STFC Central Laser Facility, Research Complex at Harwell

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The optical trapping of single airborne liquid droplets using laser tweezers has been part of the Central Laser Facility capabilities, for UK and EU academics, since our first experiments on trapping hydrocarbon droplets in 2003. During this time iterations in experimental design, often arising from collaborative programmes, have led to the development of a portfolio of techniques for probing aerosol droplets.

8. Example Studies of Naturally Occurring and Enhanced Radioactive Materials in the Environment

P.H. Regan, D.A. Bradley, H.Al-Sulaiti, T.Santawamaitre, D.Malain, A. Habib (Department of Physics, University of Surrey, Guildford, UK)

9. Environmental Science on the Diamond Microfocus Spectroscopy beamline and other diamond spectroscopy beamlines
J FW Mosselmans, Diamond Light Source
The I18 beamline has been open for 3 years now, some of the recent beamline developments including new focussing mirrors, low energy opportunities and a new monochromator will be highlighted. Further some of the results from recent environmental science experiments on the beamline will be shown. These include: • the study of nickel in laterites from Cuba; understanding the mineralogy is a key in improving extraction techniques and thus reducing waste • the way lead is partitioned in calcium carbonate granules excreted from earthworms; earthworms cycle heavy metals in the environment affecting their availability to other lifeforms. I will also present experimental details of the two bulk EXAFS (extended X-ray absorption fine structure) beamlines that are opening at Diamond this year.

10. Climate Data from the BADC
Kevin Marsh, STFC
The BADC provides data support for numerous NERC climate related projects such as RAPID/RAPID-WATCH, QUEST, FREE, as well as national projects such as UKCP09, LINK and international projects like CMIP5, IPCC-DDC. In addition, there are climate datasests from the Met Office available (HadCM3, HadGEM, Gridded datasets, observations) and the CRU. The BADC also provide interfaces to the data to make more accessible to the user community.

11. The METAFOR project: providing community metadata standards for climate models
Sarah Callaghan STFC, Charlotte Pascoe STFC, Bryan Lawrence STFC, Eric Guilyardi IPSL and the Metafor project team
The results of climate models are now of more than purely academic interest: governments and the private sector also have a need to discover the results in order to prepare for and mitigate against the potentially severe impacts of global climate change. Climate modelling is a complex process, which requires accurate and complete metadata (data describing data) in order to identify, assess and use the climate data stored in digital repositories. The EU funded METAFOR project has developed a Common Information Model (CIM) to describe in a standard way climate data and the models and modelling environments that produce this data. To establish the CIM, METAFOR first considered the metadata models developed by many groups engaged in similar efforts in Europe and worldwide (for example the US Earth System Curator), explored fragmentation and gaps as well as duplication of information present in these metadata models, and reviewed current problems in identifying, accessing or using climate data present in existing repositories. The CIM documents the “simulation context and models”, i.e. the whys and wherefores and issues associated with any particular simulation. Climate modelling is a complex process with a wide degree of variability between different models and different modelling groups. To accommodate this, the CIM has been designed to be highly generic and flexible. The climate modelling process which is "an activity undertaken using software on computers to produce data" is described as separate UML packages. This fairly generic structure can be paired with more specific "controlled vocabularies" in order to restrict the range of valid CIM instances. METAFOR has been charged by the Working Group on Coupled Modelling (WGCM) via the Coupled Model Inter-comparison Project (CMIP) panel to define and collect model and experiment metadata for CMIP5. To do this, a web-based questionnaire will collect information and metadata from the CMIP5 modelling groups on the details of the models used, how the simulations were carried out, how the models conformed to the specific CMIP5 experiment requirements. The aim of the questionnaire is to document the climate models in

sufficient detail so that the CMIP5 data can be located and compared by a wide and diverse community, including those researchers with an interest in the impacts and adaptations of climate change (e.g. IPCC's WGII). A new set of "controlled vocabulary" was devised to describe in a standard and structured way the dynamics, physics, numerical schemes and other parameterisations of the several components (ocean, atmosphere, land surface, sea ice, atmospheric chemistry, etc.) of the earth system models used in CMIP5. The CMIP5 model documentation questionnaire is an ambitious metadata collection tool. It will provide the most comprehensive metadata for a climate model inter-comparison project yet and plans for the community governance of its associated standards and now being organised. The questionnaire's close ties with the CIM will ensure that the metadata for the CMIP5 model runs will be stored in a standard way, enabling the development of tools to search for and compare CIM documents, and hence different climate models

12. The MOLES-v3 Information Model: Metadata Objects for Linking Environmental Sciences

Spiros Ventouras STFC, Bryan Lawrence STFC, Simon Cox CSIRO

The Metadata Objects for Linking Environmental Sciences (MOLES) model has been developed within the Natural Environment Research Council (NERC) DataGrid project [NERC DataGrid] to fill a missing part of the 'metadata spectrum'. It is a framework within which to encode the relationships between the tools used to obtain data, the activities which organised their use, and the datasets produced. MOLES is primarily of use to consumers of data, especially in an interdisciplinary context, to allow them to establish details of provenance, and to compare and contrast such information without recourse to discipline-specific metadata or private communications with the original investigators [Lawrence et al 2009]. MOLES is also of use to the custodians of data, providing an organising paradigm for the data and metadata. The work described in this paper is a high-level view of the structure and content of a recent major revision of MOLES (v3.3) carried out as part of a NERC DataGrid extension project. The concepts of MOLES v3.3 are rooted in the harmonised ISO model [Harmonised ISO model] - particularly in metadata standards (ISO 19115, ISO 19115-2) and the 'Observations and Measurements' conceptual model (ISO 19156). MOLES exploits existing concepts and relationships, and specialises information in these standards. A typical sequence of data capturing involves one or more projects under which a number of activities are undertaken, using appropriate tools and methods to produce the datasets. Following this typical sequence, the relevant metadata can be partitioned into the following main sections – helpful in mapping onto the most suitable standards from the ISO 19100 series. • Project section • Activity section (including both observation acquisition and numerical computation) • Observation section (metadata regarding the methods used to obtained the data, the spatial and temporal sampling regime, quality etc.) • Observation collection section The key concepts in MOLES v3.3 are: a) the result of an observation is defined uniquely from the property (of a feature-of-interest), the sampling-feature (carrying the targeted property values), the procedure used to obtain the result and the time (discrete instant or period) at which the observation takes place. b) an 'Acquisition' and a 'Computation' can serve as the basis for describing any observation process chain (procedure). The 'Acquisition' uses an instrument – sensor or human being – to produce the results and is associated with field trips, flights, cruises etc., whereas the 'Computation' class involves specific processing steps. A process chain may consist of any combination of 'Acquisitions' and/or 'Computations' occurring in parallel or in any order during the data capturing sequence. c) The results can be organised in collections with significantly more flexibility than if one used the original project alone d) the structure of individual observation collections may be domain-specific, in general; however we are investigating the use of CSML (Climate Science Modelling Language) for atmospheric data The model has been tested as a desk exercise by constructing object models for scenarios from various disciplines. References NERC DATAGRID: http://ndg.nerc.ac.uk LAWRENCE ET. AL., Information in environmental data grids, Phil. Trans. R. Soc. A, March 2009 vol. 367 no. 1890 1003-1014 ISO HARMONISED MODEL: All relevant ISO standards for geographic metadata from the TC211 series (eg. ISO 19xxx), and is harmonised within a formal UML description in the 'HollowWorld' packages available at https://www.seegrid.csiro.au/twiki/bin/view/AppSchemas/HollowWorld

13. The CEDA OGC Web Services Framework

Stephen Pascoe STFC, Ag Stephens STFC, Dominic Lowe STFC

The CEDA OGC Web Services framework (COWS) emphasises rapid service development by providing a lightweight layer of OGC web service logic on top of Pylons, a mature web application framework for the Python language. This approach gives developers a flexible web service development environment without compromising access to the full range of web application tools and patterns: Model-View-Controller paradigm, XML templating, Object-Relational-Mapper integration and authentication/authorization. We have found this approach useful for exploring evolving standards and implementing protocol extensions to meet the requirements of operational deployments. This paper outlines how COWS is being used to implement customised WMS, WCS, WFS and WPS ser- vices in a variety of web applications from experimental prototypes to load-balanced cluster deployments serving 10-100 simultaneous users. In particular we will cover 1) The use of Climate Science Modelling Language (CSML) in complex-feature aware WMS, WCS and WFS services, 2) Extending WMS to support applications with features specific to earth system science and 3) A cluster-enabled Web Processing Service (WPS) supporting asynchronous data processing. The COWS WPS underpins all backend services in the UK Climate Projections User Interface where users can extract, plot and further process outputs from a multi-dimensional probabilistic climate model dataset. The COWS WPS supports cluster job execution, result caching, execution time estimation and user management. The COWS WMS and WCS components drive the project-specific NCEO and QESDI portals developed by the British Atmospheric Data Centre. These portals use CSML as a backend description format and implement features such as multiple WMS layer dimensions and climatology axes that are beyond the scope of general purpose GIS tools and yet vital for atmospheric science applications.

14. The CMIP5 Archive Architecture: A system for petabyte-scale distributed archival of climate model data

Stephen Pascoe STFC, Luca Cinquini NASA-JPL, Bryan Lawrence STFC

The Phase 5 Coupled Model Intercomparison Project (CMIP5) will produce a petabyte scale archive of climate data relevant to future international assessments of climate science (e.g., the IPCC's 5th Assessment Report (AR5) scheduled for publication in 2013). The infrastructure for the CMIP5 archive must meet many challenges to support this ambitious international project. We describe here the distributed software architecture being deployed worldwide to meet these challenges.

The CMIP5 architecture extends the Earth System Grid (ESG) distributed architecture of Datanodes, providing data access and visualisation services, and Gateways providing the user interface including registration, search and browse services. Additional features developed for CMIP5 include a publication work flow incorporating quality control and metadata submission, data replication, version control, update notfication and production of citable metadata records. Implementation of these features has been driven by the requirements of reliable global access to over 1Pb of data and consistent citability of data and metadata.

Central to the implementation is the concept of Atomic Datasets that are identifiable through a Data Reference Syntax (DRS). Atomic Datasets are immutable to allow them to be replicated and tracked whilst maintaining data consistency. However, since occasional errors in data production and processing is inevitable, new versions can be published and users notified of these updates. As deprecated datasets may be the target of existing citations they can remain visible in the system.

Replication of Atomic Datasets is designed to improve regional access and provide fault tolerance. Several datanodes in the system are designated replicating nodes and hold replicas of a portion of the archive expected to be of broad interest to the community. Gateways provide a system-wide interface to users where they can track the version history and location of replicas to select the most appropriate location for download.

In addition to meeting the immediate needs of CMIP5 this architecture provides a basis for the Earth System Modelling e-infrastructure being further developed within the EU FP7 IS-ENES project.

15. Atmospheric Monitoring for Ground-based Gamma-ray Telescopes

P.M. Chadwick, S.J. Nolan & C.B. Rulten, Durham University

Ground-based gamma-ray astronomy is unique in that it uses the atmosphere as part of its detector. The next generation of ground-based gamma-ray telescopes seek an energy threshold of some 10's of GeV whilst minimising systematic uncertainty in derived flux and energy. To achieve this, detailed study and measurement of atmospheric quality is required. We present a simulation studies using an array comprising 97 telescopes, folded with real lidar data, to show the effect of changing atmospheric quality on gamma-ray results and consider future atmospheric monitoring requirements. This work forms part of the design study performed by the atmospheric and calibration working group of the Cherenkov Telescope Array consortium.

16. SKY-ZERO: Study of Aerosol nucleation in an ultra-low ionisation environment

Jens Pedersen, Martin Enghoff, Henrik Svensmark – Technical University of Denmark

Sean Paling – STFC & Sheffield University

The formation of ultrafine particles by nucleation from trace gases occurs frequently in the atmosphere and the resulting aerosols affect the energy budget of the Earth climate system both directly, by reflecting and absorbing shortwave solar radiation, and indirectly, by acting as cloud condensation nuclei. The uncertainty in aerosol radiative forcing is currently equivalent to a significant part of the effect of increasing greenhouse gases. An improved understanding of the mechanisms behind aerosol nucleation from the gas phase would reduce the uncertainties, but the experiments and observations suffer from the problem that several mechanisms of nucleation are likely to be active simultaneously and difficult to distinguish. In particular the role of atmospheric ions has been controversial and whereas laboratory experiments have indicated that ions have an significant effect, both field studies and modelling work have suggested much smaller effects of ions in the real atmosphere. Here we show that ions dominate the nucleation of small sulphuric acid–water clusters under conditions that resemble the Earth's atmosphere. The measurement were performed in the Boulby Deep Underground Science Facility where the role of ions can be distinguished from neutral nucleation because the background ionisation levels can be reduced by about 3 orders of magnitudes compared with surface laboratories. Our results suggest that ions play a dominant role in aerosol nucleation over the Earth's oceans.

17. Satellite based Sea Surface Temperature (SST) measurement validation using the SISTeR (Scanning Infrared Sea Surface Temperature Radiometer) instrument from the Queen Mary 2

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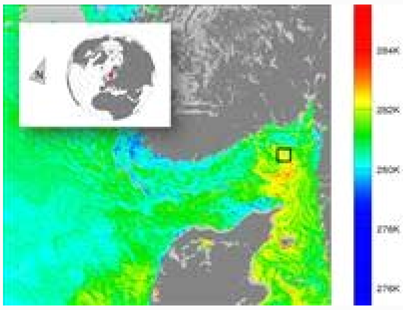
Sea surface temperature (SST) is considered one of the essential climate variables and is critical in the understanding of how oceans exchange energy with the atmosphere. Not only are SST's important in understanding climate change but they are also used as input parameters to the meteorological models which are in turn used to generate accurate weather forecasts.

Queen Mary 2 with SISTeR on starboard bridge

A partnership between the Science and Technology Facilities Council (STFC) and the Carnival Group UK

(Cunard's parent company) has culminated in an instrument developed by RAL Space being installed on the Queen Mary 2. The Sea Surface Temperature monitoring instrument, SISTeR (Scanning Infrared Sea Surface Temperature Radiometer), is a project aimed at validating satellite measurements and improving climate records.



An AATSR Sea Surface Temperature map indicating the position of SISTeR at the time of inter-comparison. Recorded on 21st April 2008 at 20:35.21 UTC. Location: latitude 58.53 °N Longitude 10.30 °E

Global measurements of SST are performed by satellite borne radiometers that detect the thermal radiation emitted from the "skin" of the sea. To ensure that the satellite measurements are accurate, SISTeR is used to provide a calibrated validation. The ground truthing is provided when the satellite and SISTeR measurements coincide and the SST is recorded at the same location by both instruments.

The Queen Mary 2 is the largest ocean linear in the world and provides the ideal platform from which to perform these measurements. SISTeR is positioned at the prominent vantage point, high on the starboard bridge wing, giving a perfect view of unbroken water. The mixture of transatlantic crossing, (from Southampton to New York) and tropical round the world cruises give an ideal combination of hot and cold water measurements which can be used to validate satellites over the wide variety of Sea Surface Temperatures.