Institution: University of Reading (UoR)

Unit of assessment: UoA 7: Earth Systems and Environmental Science

a. Overview

The University of Reading (UoR) carries out a broad range of prizewinning research into Earth Systems and Environmental Sciences (relevant researchers received a total of 40 academic prizes in the last 5 years and the University was awarded the first ever Regius Chair in meteorology and climate science). This work is centred on the general theme of understanding environmental systems in the past, the present and the future and specialises in areas where we have a world-leading reputation and track record. The work is spread across several departments and UoR researchers contributing to UoA7 science are here collectively termed "the Unit". As well as pure curiosity-driven research into processes (including theory, observations, numerical simulation and prediction), we study how to apply knowledge gained to guide policy-making in environmental management and sustainable development and how to develop adaptation and mitigation strategies in response to environmental change. There are many productive collaborations between the Unit and other parts of UoR, including: the Schools of Construction Management & Engineering (SCME), Systems Engineering, Biological Sciences, and the Henley Business School, and the departments of Archaeology, Chemistry, Food and Nutritional Sciences, Law, Agriculture, and the Centre for Agri-Environmental Research. Our work is also highly collaborative with the broader community, two thirds of our publications being co-authored with other HEIs, government departments and agencies, and industrial partners, both in the UK and internationally (see section *e.i*).

The Unit comprises two main groupings which collaborate closely. Of the Unit's category A staff in this REF submission, 67 (contributing 60.0 FTE) are based in the Department of Meteorology (Met., which is part of the School of Mathematical and Physical Sciences, SMPS), and 14 (12.3 FTE) are from the Department of Geography & Environmental Science (GES, which is part of the School of Archaeology, Geography and Environmental Science (SAGES). In addition, 1 (1 FTE) is from Mathematics and Statistics (MaS, also part of SMPS) and there are 2 (1.5 FTE) category C staff employed by the Met Office and based in Met. There are four joint appointments: 2 Met-MaS, 1 Met-SCME, and 1 Met-GES.

The Unit is divided into a number of overlapping research groups that have evolved to cover core areas, to achieve certain tasks and/or to engage with specific stakeholders. Many staff are active in more than one grouping, but to give a rough guide to the size of each, we here give (in brackets) the number of the total of 274 researchers, including PDRAs and PhD students, for which each research group is their primary focus: Dynamical Atmospheric Processes (23); Data Assimilation (20); Soil Science (30); Mesoscale Meteorology (18); Tropical Meteorology (14); Boundary Layer and Urban Meteorology (12); Decadal Prediction (12); Space Weather and Atmospheric Electricity (11); Aquatic Systems Science and Biogeochemistry (26); Cloud Physics (11); Computational Modelling (10); Arctic and Sea Ice (10); Oceanography and Marine science (8); Africa and remote sensing of precipitation (8); Land Surface Remote Sensing (6); Land Processes and High Resolution Climate Modelling (6); Extratropical Meteorology (6); Aerosol-Climate Interactions (6); Global Water Cycle (6); Environmental e-Science (6); Radar Applications (6); Radiative Processes; (5); Stratosphere (5); Water Resources (5); Volcano and Solid Earth Science (4); Earth Observation from Space (4); Meteorology and Energy (3); Chemistry and Climate (2); plus the MetOffice@Reading group which carries out convective-scale modelling and research into advanced now-casting and climate change (21).

b. Research strategy

The Unit has a unifying mission – *to carry out world-leading curiosity-driven environmental and Earth-systems research and to use it to provide robust, focussed and timely science evidence to support policy and business development.*

The Unit's strategy is to focus on areas where it has recognised world-leading strengths and where there is a pressing need for applications outside academia. The wide variety of expertise within the Unit and elsewhere in UoR allow us to be leading participants in co-ordinated approaches to the grand challenges. Our approach to "blue-skies" research is different to that for "translational" research but we adhere to two key principles: (1) that the blue skies research is essential to the long-term quality of the translational research; (2) we must be pro-active in knowledge exchange, setting agendas for applied research in direct collaboration with intended beneficiaries, preferably with leveraged funding that improves the depth and quality of the

engagement.

The research groupings (see section *a*) are adapted to their individual foci, but share common vision, philosophies and goals: (1) to lead and take part in curiosity-driven Earth System and Environmental research; (2) to develop the next generations of facilities, models, platforms and observations that will be required for such research in the future; (3) to apply the expertise and knowledge gained to projects aimed at answering specific environmental questions and problems faced by governments and industries; (4) to train the next generation of environmental scientists for academia, government and industry; (5) to transfer the latest understanding and knowledge to governments, international bodies and industry; and (6) to be excellent and world-leading in all aspects of our work. These aims are complementary. Not all groups concentrate on all aims equally at any one time, but the Directors of Research, Heads of Department, and Steering Committee members meet regularly to ensure that the long-term balance is maintained.

b.i. Developments since RAE2008

Our stated strategy in RAE2008 was: (1) to maintain world-class and pre-eminent status in our key areas of expertise; (2) to increase our engagement with stakeholders; and (3) to broaden our competences as science and opportunities demand. We also stated that "The development of interdisciplinary and multidisciplinary links, which are critical to addressing many science questions and applications, will be based upon our core expertise in rigorous quantification of environmental processes. We will exploit our foundation in physical and mathematical science, and extend this rigour to multi-disciplinary collaborations." Progress towards these general goals has been achieved but they remain fully valid for the next 5 years and so are re-stated here. We have continued to grow and diversify our research income (section *d*) and have extended the areas of our national and international pre-eminence and indicators of our international and national esteem (section *e*) remain more numerous and significant. This has been achieved, in part, by merging Meteorology and ESSC (identified as a priority in RAE2008, see *b.ii*), by developing the collaboration with GES, by recruitment drives such as AIP (see *b.v*) and by studying and influencing funding agency strategies and themed programmes.

Increases in stakeholder engagement have been achieved by the mechanisms discussed in section (*b.iv*) and benefits have already accrued. A few of many examples are: a Chair, lectureship and fellowship funded by the Willis-Re re-insurance company as part of the Weather and Climate Hazards Laboratory (WCHL, launched in 2010); new PhD studentships funded by Lloyds and Hiscox; continued funding for a Chair by BMT; leadership of successful FP7 proposals (a recent example is CHARMe in collaboration with the space industry), the Walker Institute's alliance with the Queensland Government, and aquatic research projects funded by the Government departments, the Environment Agency, Forestry Commission, Natural England and the UK Water Industry (for example, the Defra-funded Demonstration Test Catchments programme, jointly led by the Unit which draws together over 50 academic, end-user and stakeholder groups). The Unit's skills and techniques are increasingly being applied to new research areas introduced into the Unit through horizon-scanning and new staff appointments. One example is space weather, of increasing interest to the Met Office because of its raised status in the UK's national risk register and the US-UK agreement to collaborate on mitigating the hazards in the 2011 Prime-Ministerial/Presidential summit.

In 2011 Reading became one of the 3 founding HEI members of the Met Office Academic Partnership, bringing together the Met Office with institutions who are amongst the leading UK Universities in weather and climate science. This formal collaboration is to advance the science and skill of weather and climate prediction. Because the Met Office is our largest collaborator (see section e), this has already become a major factor in forming strategy and directing research.

The staff changes detailed in (*c.i*) give 20.5 FTE new staff. In addition, the work of 15 other UoR staff (mainly from GES) has evolved to become most applicable to UoA7. The net result is that the 41 FTE submitted to the RAE2008 (UoA17) has grown to 76.15 FTE for REF2014.

We have identified the following increases over the past 5 years as evidence of the success of our strategy: the number of Unit papers published in higher impact factor (IF) journals (279 compared to 160 in the RAE2008 interval for the 34 journals with IF>3.5 that are the upper decile of the IF distribution for all relevant journals. (Note that these searches[1] required papers to have a UoR affiliation and so papers written by new staff before they joined the Unit are excluded even though they are REF-eligible: this is done to identify the success of our strategies, rather than of our recruitment); the total number of papers published per FTE of effort; the number of editor's

highlights awarded or news-and-views features triggered by the Unit's work; the numbers of downloads and citations; the number of press articles and TV/radio programmes about the Unit's research. A Web of Knowledge search[1] reveals that 314 FTE years of category A/C researcher staff effort in the Unit generated a total of 961 peer-reviewed papers published in 2008-2012, that were cited 8552 times in the same 5 years (an average of 8.9 times each and 27.2 citations per FTE). The same analysis applied in 2008 to the 52 researchers (contributing a total of 240 years FTE) entered by the Unit into RAE2008 yielded 622 journal papers cited 5230 times in 2003-2007(an average of 8.4 each and 21.8 per FTE). These, and other metrics, give us confidence that our research strategy is working to maintain and drive up research quality.

b.ii. Organisation and fit to strategy

The Unit is above "critical mass", allowing real progress to be made in key and difficult areas. However, to achieve this, the organisation needs to be right to ensure that the large number of scientists work effectively together. Our RAE2008 submission stressed the need for Meteorology and the Environmental Systems Science Centre (ESSC) to work more closely together. To facilitate this, the two units have subsequently been merged administratively. In addition, synergies between work on the changing hydrological cycle within SMPS and work on soil-vegetation-atmosphere interactions, flooding, drought, water quality and biogeochemical cycles within SAGES became increasingly apparent. The means to draw these together into an effective working relationship, the Walker Institute for Climate System Research (WICSR), was established in 2006 and has played a key role in developing this relationship through a suite of collaborative research ventures in the REF period. Examples include several projects funded in the REF period under the under the Ecosystem Services and Poverty Alleviation, Changing Water Cycle and Flooding From Intense Rainfall programmes, each involving staff from Meteorology, ESSC and SAGES in collaborative, interdisciplinary research.

The Meteorology department is unique in Europe in the range and depth of its world-leading research in atmospheric and oceanic physical sciences. Interests cover a broad range of spatial and temporal scales directed at understanding and improving prediction of weather, air quality and climate. It has a very close working relationship with the Met Office and this is greatly facilitated by hosting a long-standing unit of currently 21 Met Office staff on secondment (MetOffice@Reading). Meteorology also hosts the director (van Leeuwen, formerly O'Neill) and several scientists of the National Centre for Earth Observation (NCEO), the mission of which is to unlock the full potential of Earth observation data (from space, aircraft and the ground) to monitor, diagnose and predict climate and environmental change. The total number of individuals from the Unit contributing to the running and the science research of NCEO is 40. Much of NCEO's work involves cutting-edge data assimilation, which is used to understand, assess and develop quantitative prediction tools for the atmospheric, marine, terrestrial and near-Earth space environments. In addition, the Unit hosts the largest fraction of the staff of another distributed NERC centre, the National Centre for Atmospheric Science (NCAS). NCAS is a world-leading research consortium in atmospheric science studying: climate change (including modelling and predictions); atmospheric composition (including air quality); and weather (including hazardous weather). It also researches the technologies for observing and modelling the atmosphere and provides a number of national facilities. In total there are 130 NCAS staff, 58 of which are from the Unit, including the Director of Climate (Sutton) and the Director of Models and Data (Lawrence). NCAS and NCEO staff are funded by NERC (either core-funded from their "National Capability" line or from competitively-won research awards) but are employed by UoR and, like the MetOffice@Reading staff, are involved in planning and carrying out all of the Unit's activities.

GES has drawn together UoR's expertise in aquatic and soil systems and their interactions with the climate system. It was formed in 2011 through the merger of the Aquatic Environments Research Centre, and the departments of Soil Science and Geography. The group conducts multi-disciplinary research on the structure, function, problems, modelling and management of a range of aquatic and terrestrial environments. Much of its recent work has extended that knowledge to the prediction of function and responses to climatic drivers in estuarine and coastal waters in order to meet international policy needs and drivers. The group has expertise in aquatic environmental research in areas ranging from physical to chemical and biological sciences: it is one of the few soil science research groups in the UK and a key area of activity is its work on soil biology, soil and aquatic biogeochemistry and soil-vegetation-atmosphere transfer.

The WICSR helps to coordinate and develop research across the whole University into climate

change and its consequences, and to work with research groups to promote stakeholder engagement and drive KE activities. The Unit hosts the Walker Institute Director (Arnell) and core team, and Unit staff represent the bulk of Walker Institute associates. The Unit also flexibly forms and joins groupings that cut across other groupings to meet specific external drivers by bringing together the required mix of skills. For example, the Weather and Climate Hazards Laboratory (WCHL) is a multi-institute collaboration designed to ensure the benefits of our research for the insurance industry come to fruition.

Unit staff are distributed in various buildings of the University campus, the largest centre being the purpose-built Meteorology building where NCAS, MetOffice@Reading and the NCEO directorate are also housed. The science forms the coherence between different parts of the Unit who meet to discuss ideas and progress in a variety of meetings and workshops: the proximity of the Unit's scientists to researchers in other disciplines has often proved advantageous in developing cross-disciplinary themes. Research days and research planning meetings are also used to ensure research activities are coherent and support each other wherever possible. This organisation allows all the groupings to be effective in their specialist areas, whilst also benefitting from constant interaction with each other, thereby sharing expertise and knowledge.

b.iii. Pure Research Strategy

We aim to develop and employ numerical modelling (on a wide range of temporal and spatial scales), data assimilation, theory, remote sensing (from Earth's surface and from space), and laboratory and field observations to provide answers to the most important questions in Environmental and Earth-Systems sciences. A major new, and rapidly evolving, element of our strategy is the development of mechanisms to promote and facilitate multi-disciplinary research exploiting several of the research centres at UoR (such as The Centre for Integrative Neuroscience and Neurodynamics, the Institute for Cardiovascular and Metabolic Research and the Centre for Food Security). For pure blue-skies research, senior staff meet regularly to discuss "horizon scanning" activities that they have been involved in or know of, at either national or international levels. From these discussions, we identify where we can make significant and leading contributions in the future. These discussions are central to the annual research planning process of the University and underpin our recruitment activities. This also informs our choice of which programmes, collaborators and consortia we develop. The areas of activity in the Unit are, to some extent, shaped by the opportunities made available through the funding agencies; however, where appropriate, the schools' Directors of Research advise researchers against bidding for work which would deflect them from their personal long-term strategy (which is reviewed annually as part of their Staff Development Review, SDR). Because these personal research plans are informed by the needs and strategies of the funders, they are usually anyway well-aligned to the opportunities. However, it is important to stress that our approach is far from "top-down": it is the role of senior staff to facilitate collaborations and to advise and nurture younger researchers who are encouraged to set their own agendas and formulate their own proposals. This "bottom-up" philosophy, with advice from senior staff, ensures a vibrant research programme which never ossifies yet also learns from past experience.

b.iv. Translational Research Strategy

For more applied, strategic and translational research, our strategy evolves from discussions with a wide variety of government agencies and commercial companies, used to identify where the Unit's expertise could contribute to providing solutions to problems and questions that users have identified, and to search for new opportunities. We have developed mechanisms to ensure stakeholder engagement from the outset, including examples such as the Defra DTC programme (where stakeholders were actively engaged in the specification, selection and design of the research programme to ensure that the research platform and the activities undertaken by the research teams were fully aligned with their evidence and policy needs). A more general approach starts with stakeholder events and workshops run by the Walker Institute; these are very useful in establishing initial contacts, areas of opportunity and common interests. This has been followed up, in particular by the 4 NERC KE fellows and a KT Partnership Associate working on such stakeholder engagement. In addition, Unit staff have sat on external Scientific Advisory Committees (e.g. Defra, the Environment Agency, Centre for Ecology and Hydrology (CEH), WMO, ESA, UK Space Agency, Canadian Space Agency, BMT, Axa, Arup, Rolls Royce, Willis-Re, Plymouth Marine Laboratory, International Space Innovation Centre, NPL, and UK Airports Commission). A mechanism increasingly used to consolidate genuine working relationships is via

specific groupings such as WCHL (for working with the insurance and re-insurance industries), Space@Reading (for working with the Satellite Applications Catapult and the space industry), Global Satellite Sensing (GLOSS, working with NPL and Surrey Univ. to develop exploitation of new, small, lightweight and innovative satellites), the Aquatic Environments Research Centre (for working with water utilities and Government agencies concerned with water quality), the Soil Research Centre (for working with agri-environment, forestry and contaminated land agencies) and Afclix - Africa Climate Exchange (for working with African meteorological services, governments and aid agencies). Other contacts with stakeholders on specific issues lie with small groupings and specific individuals in the Unit. Examples include: working on the climate impact of and on aviation; on predicted demand and storm hazards with power utilities; on space weather hazards with satellite manufacturers and operators; on composting with the waste sector; on pesticide risk assessment with the agrochemicals industry; on data retrievals with remote sensing companies; on volcano monitoring with Government agencies; on volcanic ash with air traffic control agencies; on working with industry to develop systems to measure carbon emissions regionally and in cities, and on human exposure to pollutants with the environmental consultancy and health sectors. The large number of active collaborations between the Unit and stakeholders is evidence that the strategy is working well and we intend to continue to use it in future. However, we are aware that the Unit is able to carry out this translational research in an effective and cost-effective way because it is underpinned by the large and vibrant activity of pure research that maintains the Unit's techniques, skills, knowledge and models at the cutting edge of the global research activity.

The many pure and translational research groupings are complex, inter-related and tend to proliferate, and can make the organisation of the Unit difficult to describe. The most important element in our planning is to prevent "silos" of activities forming in which the work is done in isolation from other parts of the Unit and so fails to benefit from the cross-fertilisation of ideas and the sharing of techniques. To avoid this we encourage academic and research staff to be involved in as many activities as possible. (It is recognised there are limits to this and that over commitment would mean that the individuals' contributions to some, or even all, activities could become inefficient). The big advantage is that the Unit is flexible and can adapt rapidly to changing circumstances and requirements of the stakeholders.

b.v. Institutional Support

The Unit enjoys excellent support from the University which helps maintain and develop its research environment. This support takes a wide variety of forms beyond the obvious provision of office, laboratory, and observatory space, library and utility services and security and the fact that most academic and support staff in the Unit are centrally funded by the University (despite an increasing number of posts funded by external stakeholders such as NERC, BMT, the Met Office, Willis-Re and the Grantham Foundation). In 2012/13 the University invested in 50 new posts in its "Academic Investment Project" (AIP) and, because the effects of climate and environmental change impinge on so many of its research activities, 18 of these are wholly within the Unit (4 Professors, 5 Associate Professors, 9 lecturers) with a further 10 in closely-related areas such as food security, archaeology, sustainable technologies in the built environment and energy policy. This is a major and transformational expansion of the Unit, reinforcing its research portfolio and optimising the opportunities for the Unit's staff to undertake multi-disciplinary research to address the grand challenges facing society. In addition, we bid for new and replacement staff positions on a regular basis via our 3-year planning procedure. This allows us to have real control over our over-arching strategy and to ensure that we are at the forefront of setting agendas in key fields. Other ways in which the University supports the Unit are by offering Early Career Researchers a lectureship at the end of their fellowship and with half-funded PhD studentships, which are often used to attract commercial and other partners into co-sponsoring a student. UoR also funds maternity/paternity cover and returns a proportion of all research grant overhead, some of which goes directly to the PI, the rest of which helps to develop the Unit's research infrastructure. UoR has also invested strongly in a suite of shared research platforms including an £8m investment in the Chemical Analysis Facility (CAF) and Electron Microscopy Laboratory (formerly Centre for Advanced Microscopy, CfAM) extensively used to support our research in Earth Systems and Environmental Science. UoR's Human Resources office supports the recruitment and management of research staff and the Centre for Staff Training and Development provides extensive training opportunities and supports staff development courses within the Unit. Reading

was one of the first ten UK universities to receive the 'HR excellence in research' accreditation for adopting and implementing the European Charter for Researchers and the Code of Conduct for their Recruitment (re-awarded in 2012) and the Unit has benefitted greatly from the procedures developed. IT Services provide the core of the networking and email facilities on which our local computing infrastructure is built. UoR's Research and Enterprise Dept. and Finance Office also provide vital help in applying for and administering grants and fellowships and in 2009 embedded an expert advisor within the Unit.

c. People

The Unit is large, currently comprising a total of 275 researchers: 85 REF Category A/C staff (contributing 76.15 FTE), 91 PDRAs, 99 PhD students.

i. Staffing strategy and staff development

c.i. Staffing strategy

Our recruitment policy is determined by the strategy discussed above, but fit-to-strategy is not allowed to override excellence. Staff retention is regarded as very important and losses are minimised by the rigour and efficiency of our merit-based promotion procedures. Our promotion, rewarding staff, training, mentoring and annual review procedures are all exceedingly important in developing careers and maximising staff retention.

We strongly subscribe to the view stated by Sir Geoffrey Boulton[2]: "The prime function of leading-edge research is to develop new understanding and the creative people who will carry it into society". Hence when it does occur, loss of staff to key posts in industry and Government agencies is regarded positively and staff moving to other HEIs is useful in building collaborations. We recruit to replace senior staff on a like-for-like basis only when essential - more often we appoint at a more junior level which helps maintain career progression throughout the Unit. We also try to maintain continuity by maintaining a 20% FTE share with a joint appointment with the departing scientist's new institute which helps build or extend active collaborations.

We aim to recruit the best quality staff worldwide, and since RAE2008 we gained 10.13 FTE from other nations whilst 2.6 FTE left to work abroad. Recruited from outside the UK were: Prof. Theodore Shepherd (to the Grantham Chair for Climate Science and from Univ. Toronto); Prof. Peter van Leeuwen (to director of Data Assimilation, from Utrecht Univ.); Prof. Sandy Harrison (80% FTE from Macquarie University, Australia); and Doctors: J.-Y. (Christine) Chui (from Univ. Maryland); Jochen Bröcker (from MPI for the Physics of Complex Systems, Dresden); David Ferreira (from MIT); Michaela Hegglin (from Univ. of Toronto); Steffen Tietsche (from MPI for Meteorology, Hamburg); Miguel Teixeira (from Univ. Lisbon), Claire Watt (from Univ. Alberta) and Joaquim Pinto (33% FTE, from Univ. Cologne). Staff transferring to positions outside the UK were: Lucarini (to Univ. Hamburg, 20% FTE retained); Potthast (to German Met. Service, 20% FTE retained); Hanert (to Catholic Univ. Louvain). In addition, staff movements within the UK have been 15 incoming (Profs. Lockwood, Grimmond, Lawrence, Collins, Feltham, Clark and Merchant; and Doctors Quaife, Bellouin, Scott (formerly Davis), Cloke, Owens, Mayle, Singarayer and Roy) and 4.8 outgoing (Profs. J. Slingo to Met. Office Chief Scientist, Gray to Oxford Univ. (now both visiting fellows); Belcher to Head of Hadley Centre (20% FTE retained), Hodson to York Univ. and Woollings to Oxford Univ.). In addition, 6 of the Unit's research staff joined the academic staff (Doctors Brayshaw, Westbrook, Black, Weller, Woollings and Dacre). There have been 12 new fellowships, 6 retirements/career breaks (Ehrendorfer, Nortcliff, James, Futyan and Settle) and sadly the premature deaths of Prof A. Slingo and Dr D. Grimes.

The Unit is strongly committed to supporting equality and diversity. Meteorology holds an Athena Swan silver award and a GES (and UoR HR department) bronze award. We offer flexible working to all staff coming back from parental leave and all staff with small children. The Head of Department arrangement, whereby the administrative load is shared, typifies our efforts to make it possible for all staff members to participate in the decision making process without loading any single individual with a heavy time commitment. We also, whenever possible, hold meetings and seminars in designated core hours to make them accessible to all staff. We are committed to have all genders, ethnicities and backgrounds represented among the seminar speakers we invite, and monitor yearly the results of our commitment. Most importantly, we are committed to fairness and inclusiveness, and have conducted surveys on the working conditions. The result will also inform our application for renewal and upgrade of the Athena Swan awards.

Research groups meet regularly (usually bi-weekly or weekly) to discuss progress and to stimulate new ideas. We have cultivated a non-hierarchical ethos to create a cordial, relaxed

working environment, where young researchers are treated as equals with established academic staff. Social interactions between staff and young researchers are commonplace, and contribute to the friendly working environment. Social events are arranged after important seminars and PhD examinations and staff are encouraged to meet over morning coffee and afternoon tea as they give further opportunities to share problems, epiphanies and successes.

c.ii. Staff development

The University provides a wide variety of courses for academic staff and researchers through its Centre for Quality Support and Development (CQSD) as part of its enthusiastic adherence to the Concordat between the Funders and Employers of Researchers in the UK. The University has been recognised by the European Commission for its work in improving working conditions and career development opportunities for research staff. It was one of the first ten UK universities to receive the first 'HR excellence in research' accreditation for adopting the European Charter for Researchers and the Code of Conduct for their Recruitment. As part of this, the University had to demonstrate that it had undertaken an internal analysis to compare institutional practices against the Concordat to Support the Career Development of Researchers, and had implemented an action plan based on the results. The University also organises regular one-day conferences where research staff learn and discuss issues common to research in a variety of disciplines. We make extensive use of *Vitae* and the Researcher Development Framework (RDF) planner.

In addition to adhering to these University-wide standards, the Unit has a number of Quality Assurance procedures to develop the skills of both academic and PDRA researchers. The Schools underwrite the costs of promotions for researchers who are funded on grants, allowing merit to be the only consideration, independent of the financial implications and quotas. We hold biennial, 1-day PI and line manager workshops with presentations by CQSD and HR, Careers Advisors, School and Department Heads and Directors of Research and staff who have recently been promoted. In parallel, we hold equivalent workshops for PDRA research staff. Areas discussed in both series are: research ethics, line manager roles, feedback from research staff, career support responsibilities and good practice, career development advice, PI support and advice, mentoring, open access publishing, academic and non-academic impact, FOI and data availability, risk taking, flexible working and career breaks, generating successful grant applications, presentation skills, reviewing grant and fellowship opportunities, grant funding and demand management. Feedback was taken after each event which showed that the stated aims were achieved or exceeded in each case. Attendance has been high such that we are on target for all staff to attend either a researcher or a PI workshop in the planned 4-year cycle.

All staff take part in an annual or biennial Staff Development Review, SDR, with their line manager and prepare a personal research plan to help them take stock and guide research for the year ahead. Heads of School and School Directors of Research review them all within their School to ensure development is as expected and make appropriate interventions where needed. Early Career Researchers are encouraged to also complete a “Research Staff Development Prompter” form, uptake of which is very high (>85%), which invites them to identify activities that they feel would add to their CV and enhance future employment prospects in academia, government or industry. These are then matched to the opportunities for such work. All staff are invited to termly staff meetings. Athena SWAN focus groups have revealed that the Unit’s PDRAs see their SDR as a mentoring session and that they feel that the Unit’s academic staff are very supportive of them and that they feel comfortable in talking about problems.

The research-funded staff forum (RFSF) meets without academic staff to discuss issues and its chair is invited to sit on the departmental management boards. PDRAs are organised by research group under the direction of a principal investigator. Overall supervision is the responsibility of the Head of School or, where relevant, the Director of a NERC or Met Office Unit. All researchers have full access to the University’s training and review programmes and MSc modules. A prize committee of senior staff meets regularly and works with line managers to ensure that all appropriate candidates are nominated for awards and prizes (at all levels, but particularly for younger staff). Section *e.ii* lists the successful outcomes (i.e. prizes won).

We have recently upgraded our induction (which are run in addition to the University’s induction sessions), mentoring and probation procedures. These allow an open discussion with new staff about how they are managed, what they should expect from their line managers and from their SDR reviews. Staff are also introduced to our mentoring scheme, buddy system, the career development workshops as well as useful online resources for them. We have also

developed our promotion procedures to encourage impact and enterprise activities as well as academic output. For the fixed-term research staff we maintain a register of the end dates of all research grants and contracts, which we use to make staff nearing the end of their contract aware of likely employment possibilities within the Unit in a timely manner: PIs looking to recruit are also kept informed of who will be looking for a new post. This brokering activity helps us retain good research staff and give them a more stable career environment. In addition, all Early Career Researchers applying for fellowships or a job (either within the University or elsewhere) are offered advice and mock interviews. Personal research fellowships were won in the review period by Williams (Royal Society, 2009), Turner (NERC, 2009), K. Nicoll (Leverhulme, 2011), Cornforth (NERC KE, 2011), Froude (NERC KE, 2011), Osborne (NERC, KE joint with Agriculture, 2011), Holloway (NERC, 2010), Dacre (RCUK, 2008), Hawkins (NERC, 2010), Strachan (Willis-Re, 2010), Kutuzov (EU Marie Curie, 2009), Weller (NERC, 2009), Brayshaw (NERC, 2009) and Stephens (Leverhulme, 2013): 11 of these 14 Early-Career Researchers had been PDRAs within the Unit and these were given help and advice when preparing their proposal and presentation.

The University Research and Enterprise Department supply dedicated staff members to advise the Unit's research staff. This resource is used to identify sources of funding, advice on funder remits, pricing policies, eligibility, impact, planning, preparing and reviewing proposals, advice on consultancy and working with industry, costing proposals and institutional pricing policies and approvals. It is particularly valuable for PDRAs and Early Career Researchers.

An active sabbatical system is in place (one term in every nine in most parts of the Unit). To help provide sabbatical cover, the Schools fund three-month "lecturing fellowships" which have proven popular amongst recently-finished PhD students contemplating an academic career. Regular group meetings and the seminar programme promote research skills and increase the scientific maturity of young staff. New academic staff are allocated a mentor, in addition to a line manager, and are given funds for their own use (e.g. to support conference attendance), they also start with a reduced teaching load, normally achieving a full load by their third year.

ii. Research Students

c.iii. Research students: training

NERC provides the funding for most of our students but others have been funded by EPSRC, BBSRC, Defra, Environment Agency, Forest Research, Teagasc, Leverhulme, Petroleum Technology Development Fund, Marie Curie Career Integration Grants, University studentships, charitable trusts and industry. Recently, the Unit successfully bid to be the hub of NERC Doctoral Training Partnership (giving 12 studentships per year at UoR) in partnership with Surrey Univ., 8 national Laboratories, 7 companies and 3 international Universities, and a joint proposal with MaS and Imperial College to EPSRC was awarded 7.6 studentships per year at UoR. A total of 107 students were awarded PhDs in the review period (1.5 per FTE of submitted staff). On average for 2008-2012, the number of new PhD starts in the Unit per annum was 31, drawn from an average of 110 applicants. Hence the application success rate rose to 28%, pointing to a growing shortage of applicants with required mathematical/physics skills. Our MSc courses have been very important for PhD recruitment and we have established a new Environmental Physics undergraduate degree (first intake 2014) with PhD student recruitment partly in mind. Although the number of applicants from outside the EU is high, the number coming to the Unit is lower because most need to be self-funded. Just over 1.5% of students have been part time. All PhD students are required to complete 100 hours of appropriate training within the first two years, and before their registration as PhD candidates is confirmed. The individual training programme is agreed for each student at the beginning of their course of study by the supervisor(s) and the Director of Postgraduate Study. Students are funded, and encouraged, to attend both UK and international summer schools and attend at least one major international conference. P.-L. Vidale co-organised summer schools for both PhD students and PDRAs (both from the UK and international) at which many Unit staff gave lectures and ran practical sessions. Examples include E2SCMS (European Earth System and Climate Modelling School) with MPI, Hamburg and the biennial NCAS summer schools.

c.iv. Research students: monitoring

Students ordinarily meet supervisors at least once per week. To ensure that failures and setbacks in PhD projects are minimised, the Unit has for many years run a monitoring committee system, which has now been adopted by the University as a whole. Students report on progress 6 monthly (both on paper and orally) to the committee comprising at least two independent

academics, and the supervisor(s). The supervisor(s) independently provide a report on progress to this committee. Students are also given a chance to discuss problems confidentially with the supervisor(s) not present. Monitoring committees frequently place actions on both student and supervisors relating to both the research and the acquisition of transferrable skills. Students attend specialist lectures provided by the Unit, must present their work at a special conference in their second year and at a poster session in their third, and present a full seminar in year 3. They must attend courses on a variety of transferrable skills. They go through a formal confirmation process at the end of their 5th term. As part of their career development, paid demonstrating work is available, and funding is made available to support students in the post-viva period, to write up remaining un-published work for journals. Since 2011 the University-wide Graduate School, of which all PhD students are automatically members, has run the Reading Researcher Development Programme which provides core generic training to all PhD students and our students are required to attend a set number of training sessions.

A survey of outcomes for 2008-2012 shows the fraction of PhDs completed is 98%, with 78% within 4 years. 10% are successful at the first attempt, 80% at the first attempt after minor revisions, 7% at the first attempt after major revisions and 1% (1 case) at the second attempt. There were 2 studentships (2%) that resulted in an MPhil degree.

c.v. Visiting Scientists and Seminar Programme

In addition to 16 regular visiting appointments of UK scientists, since 2008 the Unit has run a Student Visitor Programme. PhD students nominate and vote for an eminent scientist to invite. This initiative has led to visits from eminent scientists such as Heini Wernli (ETH Zurich), Kerry Emanuel (MIT), Susan Solomon (formerly NOAA and IPCC WG1 co-chair, now MIT), Kevin Trenberth (NCAR) and Isaac Held (NOAA, Princeton). In 2011 a similar program was started by the Early Career Researchers via the RFSF and has already resulted in a visit from David Randall (Colorado State University) with others planned for the future. Visitors are given administrative, financial and computing support, office space, a seminar slot, help with domestic arrangements and a "buddy" to ensure they interact with PhD students and PDRAs as much as possible as well as with senior staff. In 3 years this has brought 157 visitors (136 from outside the UK) to the Unit.[5] Seminars with external speakers and lunchtime seminars with internal speakers run weekly during term time in both SMPS and SAGES and the NERC Units also run seminar series.

d. Income, infrastructure and facilities

d.i. Income

The research grant spend in the Unit rose from £10.4M in 2008/9 to £11.6M in 2012/13, the 5-year total (£55.55M) corresponding to just over £0.8M per submitted staff researcher. Research Council (RC) grants yielded 74% of the total, international sources 9%, in-kind contributions 10%, and the commercial sector 4%. The NERC-funded distributed National Capability Centres embedded in Meteorology, NCEO and NCAS, gave total average annual incomes to the Unit of £1.69M and £1.87M, respectively (together, roughly 30% of the total). NERC remains the largest source of funding for Meteorology's research, but sources have diversified considerably since RAE2008, with funders including: EPSRC, DECC, Defra, DfID, Environment Agency, Leverhulme Trust, ESA, Royal Society, EC FP7 (including the ERC), ERC, the private sector (Willis-Re Ltd, Lloyds Insurance, Lloyd's Banking, Google Earth, Deloittes), the Grantham Foundation, TSB (via the Satellite Applications Catapult Centre), and the European Institute of Innovation and Technology via the Climate "Knowledge and Innovation Community" (KIC). The Unit's policy is to continue to diversify sources and, in particular, to seek international funding (for example, Shepherd was recently awarded a new €2.5M ERC Advanced Grant which is not included the above spend figures). Work in GES is funded by NERC, EPSRC, BBSRC, STFC, EU FP7, Leverhulme and Marie Curie Fellowships, Government departments (Defra, BIS, DfID) and agencies (EA, Forestry Commission, Natural England, Countryside Council for Wales, Teagasc), ERC, and a range industrial sponsors (e.g. UK Water Industry Research, Syngenta) and charities (Royal Horticultural Society, Game and Wildlife Conservation Trust, The Rivers Trust, The Lawes Trust, Institution of Occupational Medicine). Although non-RC sources of funding have increased in number the rise in their total value was by the same fraction as the overall rise and so the RC grant funding has stayed constant at close to 74% throughout. Our strategy for the future is to increase the fraction of non-RC funding by exploiting the wider range of sources we have established. Our aim to increase the total research income whilst increasing the international and commercial components has been a factor in our recent appointments.

Typically over 150 projects are running at any one time. Grants vary from of order £5k for small travel grants up to over £1M. Awards exceeding £1M (UoR share) in the review period included ACTUAL (for urban meteorology monitoring) from EPSRC, SEACHANGE (prediction of sea level rise) from the ERC, DIAMET (mesoscale phenomena in extratropical storms) from NERC and the NCAS-Climate core contract from NERC. Yet to start are SINATRA (£1.05M on effects on catchments of intense rainfall and flooding) and DOMAINE (£0.95M on dissolved organic matter in freshwaters) both from NERC. Unit staff have had a number of consultancies with the power, transport, insurance, building, waste, retail, water and marine sectors. We are also giving CPD training, for example, for the energy sector with EDF.

d.ii. Infrastructure and Facilities

All Unit researchers receive a fully supported desktop terminal connected to a centralised server system. Because numerical modelling is such a key element of our work, access to very large high performance computing (HPC) facilities and large data storage capacity is vital. NCAS CMS (Computational Modelling Services) is hosted by the Unit and administers the atmospheric science HPC allocation provided by NERC. It provides centralised support for models, data and tools on all the central HPC systems for the entire UK academic atmospheric science community (as well as NCAS staff). It also provides centralised support for models, data and tools on all the central HPC systems for all NCAS users, as well as assistance in optimising the models on HPC systems, currently the HECToR service (operated by Univ. Edinburgh, NAG and Cray) and the joint supercomputing service MONSooN for NERC and Met Office collaborative projects. Unit researchers also have several projects underway with ECMWF allowing direct access to their operational model and data assimilation HPC infrastructure. Using UoR funding and research grant income, the Unit has recently built its own flexible and easily expandable centralised Linux based HPC system, with large scale storage capabilities, currently around 1.5 petabytes, to allow all the Units researchers, including students, to process, visualise and interpret model output and other large environmental data sets such as satellite data. The Unit has built and maintained operational services, in particular TAMSAT which now provides rainfall estimates for all Africa based on satellite observations, with time-critical delivery to a large group of users in Africa and beyond. The Unit has played a key role in the NERC Environmental Virtual Observatory pilot, developed using cloud computing infrastructure, bringing together data from disparate sources, and providing a variety of web-enabled data management tools to support simultaneous integrated data interrogation and modelling activities. This facility enhances the storage, interrogation and management capacity for environmental data for all the Unit's research.

In addition, the Unit provides the leadership for the development and deployment of the new national data analysis facility (JASMIN), which will exploit recent research developing the NERC Environmental Virtual Observatory. This work using cloud computing infrastructure, and bringing together data from disparate sources, is providing a variety of web-enabled data management tools to support simultaneous integrated data interrogation and modelling activities for both the research and impact communities.

The Unit is supported in its environmental chemistry, biogeochemistry and ecological research through access to a range of shared research platforms within the University of Reading, representing significant investments in research infrastructure at Reading since RAE2008. These include The Electron Microscopy Laboratory (EMlab, formerly the Centre for Advanced Microscopy, CfAM) and the Chemical Analysis Facility (CAF). The EMLab facility enables members of the Unit to investigate details of structures from the atomic through the nano up to the macroscopic scale. CAF provides our researchers with access to a state-of-the-art instrument suite comprising NMR spectroscopy, Mass Spectrometry, X Ray Diffraction and Scattering, Optical Spectroscopy and Thermal Analysis facilities. We are further supported through investment in a suite of in-house state of the art laboratory facilities located in SAGES, comprising advanced analytical facilities for the analysis of soil, sediment, water and biological materials (ICP-MS, ICP-OES, IR-MS, AAS, Skalar San++ autoanalyser, Shimadzu TOC Analyzer, Organic Elemental Analysis suite, Gas Chromatography, Fluorescence and UV-Visible spectrophotometry, HPLC, Dionex, Microwave Digestion Unit, Coulter Laser Diffraction Particle Size Analyser, X-Ray Diffraction, X-Ray Fluorescence, Scintillation Counting, Fluorescence-activated cell sorting and a molecular microbial ecology equipment suite), a Sediment Magnetic Characterisation Laboratory, Spectroscopy Laboratory (housing a GER Spectroradiometer) and as well as a full range of field equipment for field based research including geophysical survey equipment, automatic water and

soil solution sampling equipment, high specification telemetered laboratories, and novel wireless sensor network platforms deployed in remote and/or inaccessible sub-surface environments.

The Unit also makes extensive use of Research Council facilities, such as the Chilbolton and EISCAT radars, the NERC FAAM aircraft, the Molecular Spectroscopy Facility and a wide variety of spacecraft instrumentation. The Unit has specialist workshops for preparing instrumentation (for example: radiosondes; high specification environmental sensors for soil, wetland and aquatic deployment; equipment for remote monitoring systems; and space and radar hardware). The Unit maintains a dedicated Atmospheric Observatory on the University site which was refurbished in 2012, hosting a growing range of meteorological instruments, e.g. a new Cloud Lidar, and it is extensively used by both students and research personnel. It also holds, and makes regular use of, a licence to release research balloons, and to handle and conduct research using soil and vegetation and contaminated materials from outside the EU. The Unit recently acquired an atmospheric monitoring site atop the BT tower in London and other urban meteorology monitoring equipment are available to the Unit as part of research consortia.

The biggest item of planned future investment is support to move ECMWF from its currently restricted site in Reading onto the campus in close proximity to Meteorology. Negotiations are complex and involve many parties but this will represent investment of upwards of £50M. Connected to this is a plan in its early stages to add a wing to the Meteorology building to bring the Weather and Climate research together again in one building. We are also making plans to establish an Environmental Technology and Innovation Centre, part funded by HEFCE and involving a partnership with industry, to translate research into environmental applications and services for the public and private sectors. The University is currently investing £0.25M for upgrading the Unit's computing and observatory infrastructure particularly to guarantee our students continuing access to the latest research facilities.

d.iii. Scientific and Technical Support

Technicians (12) support laboratory and field research activities on the Atmospheric Observatory, on the field research platforms, and in laboratory experiments and infrastructure, field instrument installation and maintenance, and the conduct of field experiments/campaigns. Dedicated librarians (2) manage the relevant journal and book purchases, and their electronic access. Ten computer staff help install, run, maintain and upgrade computer hardware, back up data files and set up computer networks, as well as providing programming support for running models and transferring and analysing data. The IT team also has a wide range of other expertise, including, for example interactive web pages, collaborative platforms, video-conferencing, graphics processing unit (GPU) programming and other parallel programming techniques. These skills are supplemented by members of the Reading e-Science Centre (ReSC), hosted by the department since 2003, who bring expertise in areas such as web services, interactive visualisation of environmental data, software version control and rigorous Open Source design and development techniques. ReSC staff have consistently won external funding from NERC, EPSRC, TSB, JISC, ESA, and the EU, for technical innovation projects, many with industry connections, and they help to maintain a cutting edge competence in technical collaborations, as well as training for other Unit researchers and students.

As discussed in section (*b.v*), the Unit enjoys excellent support from the University which helps maintain and develop its research environment and train both its research and academic staff. To provide individuals with scientific advice and encouragement, groups meet regularly (usually bi-weekly or weekly) to discuss progress and to stimulate new ideas.

e. Collaboration and contribution to the discipline or research base

e.i. UK and International Research Collaborations

The Unit provides distinct and unique elements to the UK's research base which are genuinely world-leading. As a result, it leads, or is an active member of, a great many collaborations. A W-o-S search[1] reveals that in 5 years the Unit had 886 "collaborators" (here defined as institutes or HEI departments) in 64 different countries giving 2449 "collaborations" (here defined such that *p* peer-reviewed publications co-authored with *c* collaborator institutes is $p \times c$ collaborations). Out of the total of 961 publications, 319 (33.2%) had only UoR authors, and 268 of the 642 papers with collaborators had a first author from the Unit. The average number of collaborator institutes per collaborative publication was 3.8 and so, were leadership to be equally shared, we would expect (100/3.8) = 26.2% of these papers to be led by Unit staff: the fact that the actual figure was 41.7% is one demonstration of the Unit's discipline-leading status on a global basis. The top ten

collaborators were: 1. Met Office Hadley Centre (104 joint papers); 2. other Met Office departments (74); 3. National Center for Atmospheric Research (NCAR), Boulder, USA (46); 4. ECMWF (42); 5. Rutherford Appleton Laboratory RAL Space (37); 6=. Univ. Leeds, Institute of Climate & Atmosphere Science (35); 6=. Univ. Oxford, Physics Dept., (35); 8. Univ. Manchester, Centre for Atmospheric Science (33), 9. Imperial College London, Grantham Institute (28); 10. Centre for Ecology and Hydrology (CEH) Wallingford (26). There were 221 collaborators in the UK giving 984 collaborations, compared to 665 internationally which gave 1465. The top ten other nations were: 1. USA (197 collaborators 511 collaborations); 2. Germany (49, 143); 3. France (61; 66); 4. Netherlands (29; 59); 5. Australia (18; 58); 6.Japan (22; 57); 7. Canada (25; 52); 8. Norway (18; 49); 9. Switzerland (20; 38); and 10. P.R. China (16; 37). From this analysis, the formal Met Office collaboration is clearly central to the Unit's work and a key long-term goal is that we retain the ability to meet the specified roles and requirements of this partnership. Our collaboration with nearby ECMWF is less formal and tends to be via a variety of joint EC projects. Nevertheless it is developing and influences our strategic aims, as do the research councils (NERC in particular) and the Governmental/RCUK "grand themes". Our collaborations with the Centre for Ecology and Hydrology, British Geological Survey, Forest Research and Rothamsted Research are developed through a wide range of research activities, from jointly funded PhD studentships through to collaboration in a suite of large, high profile, multi-disciplinary research programmes. Because climate, weather and water resources impinge on so many other areas of research, collaborators are often from other academic disciplines. From the survey, at least 20% of the Unit's collaborations are with groups working entirely outside the UoA7 remit: however, this is a conservative estimate of the fraction of the work that is interdisciplinary for a number of reasons (for example, collaborations with UoR departments outside the Unit are also interdisciplinary). Our collaborations formed in a variety of ways: from discussion at workshops and conferences; from visits to and by Unit staff, and from correspondence to and by Unit staff over specific problems and requirements. Some collaborations are long-standing, others formed recently. We always look to develop and build on our most successful collaborations.

e.ii. Leadership and Esteem

The Unit enjoys exceptional esteem among the international academic community. The most important element of this is the large number of national and international research consortia that we are invited to join and, more importantly, lead (see section *e-i*). These are funded to carry out research on a specific topic by NERC, RCUK, Defra, EU, ESF, and the COST intergovernmental framework for European Cooperation, the European Space Agency and many others.

The Unit has 4 Fellows of the Royal Society (Hoskins, Shine, Mitchell and Lockwood). Hoskins is also a member of the U.S. National Academy of Sciences and a Fellow of the American Association for the Advancement of Science. The Unit continues to win academic prizes at all levels; awards to Unit staff since RAE2008 have included: the Royal Meteorological Society (RMS) Mason Gold Medal (Illingworth, 2009); RMS Symons Gold Medal (Hoskins, 2009, Mitchell, 2011); American Meteorological Society (AMS) Helmut E Landsberg Award (Grimmond, 2009); Royal Society Wolfson Research Merit Award (Shepherd, 2012); Julius Bartels Medal of the European Geophysical Union (Lockwood, 2012); AMS Henry G. Houghton Award (Hogan, 2014); IBM Prize of the RMS, (Millford, Dugdale and Grimes[3], 2010); Remote Sensing and Photogrammetry Society Award (Gurney, 2013); American Geophysical Union Fellowship (Shepherd, 2010); the Philip Leverhulme prize from the Leverhulme Trust (Williams, 2012; Owens 2013); Fowler Award from the Royal Astronomical Society (Owens, 2012); RMS L.F. Richardson Prize (Westbrook, 2008, Turner, 2009; Woollings[3], 2013); the International Association for Urban Climate's Luke Howard Award (Grimmond, 2010); University of Łódź Amico Medal (Grimmond, 2008); CSIRO Ernest Frolich Fellowship (Grimmond, 2012); the Gordon Manley Weather Prize of the RMS (Pinto and colleagues, 2008); Lloyd's Science of Risk Prize (Gray, 2012); NOAA Outstanding Scientific Paper Award (Stott, 2008); RMS Quarterly Journal Editor's Award (Van Leeuwen, 2012); EGU Hydrology and Earth System Sciences Outstanding Editor Award (Cloke, 2012); Saudi Arabian Govt. Prize for Environmental Management (White, 2013); US National Oceanographic Partnership Programme Excellence in Partnering Award (Merchant, 2008); RMS Michael Hunt Award for excellence in science communication (Williams, 2012). In addition, Unit staff won 12 outstanding poster/paper/presentation awards and 2 Honorary doctorates. Stott is named in Foreign Policy magazine's list of Leading Global Thinkers for 2013. C. Davis' collaboration with RGO on the "Solar Stormwatch" citizen science programme won the Museums

and the Web "Best of the Web" Innovation/Experimental Award in 2010. In 2013 the Unit was awarded the Regius Professorship for Meteorology and Climate Science, one of twelve new Regius Chairs to mark HM The Queen's Diamond Jubilee. Shine has been appointed to the post. Unit staff gave 119 named, prize and keynote lectures over the last 5 years. Gregory, Arnell, Shine, Sutton, Shepherd, Collins, Guilyardi and Stott are IPCC 5th Assessment Report lead authors and/or review editors and the Unit also provided many expert reviewers and contributing authors. Johnes was a lead author on the European Nitrogen Assessment, and provided input to the Gothenburg Protocol re-negotiation under the International Convention on Long-Range Transboundary Air Pollution as a member of the UNECE Task Force for Reactive Nitrogen. Hegglin was a coordinating lead author on the 2010 WMO/UNEP Ozone Assessment, and Shepherd is on the Steering Committee of the 2014 Ozone Assessment. Unit staff are frequently invited to plan and participate in many national or international workshops and conferences.

Within the REF period Unit staff have served on 87 UK and 96 international panels, including: NERC's Council (Lockwood), Science and Innovation Strategy Board (Belcher and Lockwood), Executive Board (O'Neill), Peer Review College Pool of Chairs (Johnes), and 20 members of the Peer Review College. Shine is chair of Royal Society Sectional Committee 5 and Lockwood served on Sectional Committee 2. Others include: HEFCE REF Sub-Panel 7 and Impact Pilot Study (Shine); UK Space Agency Earth Observation Advisory Committee (Merchant, O'Neill), Defra UKCP09 Science and CCRA Review Panels (Arnell) and international grant-awarding panels including the national academies and research councils in Norway, Finland, Sweden, Iceland, Austria, Germany, Netherlands, France, EC/FP7 (including ERC), USA, Canada, Australia. Scott (formerly Davis) is a member of STFC's Solar System Advisory Panel. Other positions of responsibility include: Hoskins is chair of the Met Office Scientific Advisory Committee; Sutton was theme leader for the NERC Climate Research Programme; Johnes was executive director of HYDRA (the HYDrosciences Research Associations comprising CEH, BGS ICL, QMC, UCL, UoR and Oxford), Chair for the Academy of Finland Research Council for Biosciences and Environment panel, and is a member the IAHS International Commission on Water Quality and of 3 expert panels advising UNECE; O'Neill is chair of the European Space Agency's Earth Science Advisory Committee; Highwood is a Vice-President of Roy. Met. Soc.; R. Gurney is chair of the Science Advisory Committee for the EPSRC Basic Technology Programme, a member of the EPSRC e-Science Science Advisory Committee, has also represented NERC on the RCUK e-Science Advisory Committee, been chair of the British National Space Centre's Earth Observation Programme Board and is a member of the Space Leadership Council of the UK Space Agency's Space Action Network. Harrison (S.) is President of the Palaeoclimate Commission of the International Quaternary Association, and Co-chair of the Palaeoclimate Modelling Intercomparison Project and Global Palaeofire Working Group; Wadge is chair of the FCO Scientific Advisory Committee on Montserrat Volcanic Activity and sits on the Government's Chairs of Scientific Advisory Committees and Chief Scientific Advisers group. Unit staff also sit on a large number of external Scientific Advisory Committees (Defra, EA, WMO, Axa, ESA, Rolls Royce, Arup, BMT, NPL, Plymouth Marine Lab., Willis-Re). Sutton is NCAS Director of Climate, Lawrence NCAS Director of Models and Data and van Leeuwen (previously O'Neill) Director of NCEO. In the last 5 years, the Unit has provided: 111 external examiners (53 in the UK, 58 international) for PhD awards and academic promotions; 73 reviewers for non-UK programmes; 44 Full, Guest and Associate Editors of journals; and 33 journal Editorial Board members. Unit staff hold 29 Visiting Honorary Chairs/Readerships/Lectureships at other HEIs.

[1] *Web of Science (accessed 23/3/2013) search for: 2008-2012, all REF2014-submitted Unit staff and a UoR affiliation (outputs by appointments, published before joining Unit, are not included). Corresponds to category A and C staff effort of 314 years FTE in the Unit.*

[2] *Boulton, G. (2010). Harvesting talent: strengthening research careers in Europe, League of European Research Universities (LERU), January 2010.*

[3] *Prizes awarded for work done at the Unit to staff who have subsequently left the Unit. Milford and Dugdale (now Visiting Fellow) have retired; Woollings moved to Oxford University in 2013; Grimes died in 2011.*