RESEARCHER JOB DETAILS

Civil Engineering and Geosciences

Research Associate (INTENSE III) Grade: F Vacancy Ref: D1638R

Main Duties and Responsibilities

A successful candidate would be expected to:

1. Attend GEWEX/GHP meetings to contribute to the GEWEX/GHP sub-daily rainfall initiative/cross-cut which Prof Fowler leads.
2. Examine the dependence of daily and sub-daily precipitation, flooding, and daily extremes in other regions, on ARs and other circulation patterns, working with Prof. Richard Allan and his team at Reading University (short visits likely).
3. Explore how the frequency and magnitude of drought and heavy rainfall are linked through circulation variability.
4. Examine the role of the large scale atmosphere in modulating the local-scale thermodynamic dependencies working with Post 2 PDRA.
5. Fit more sophisticated statistical models, such as GEV or GDP models with non-stationary (time-varying) coefficients based on identified predictors (including local temperature and humidity from WP2).

Additional Information

Based at Newcastle University, you will carry out complementary research on the projects "INTENSE: INTElligent use of climate models for adaptatioN to non-Stationary hydrological Extremes" and SINATRA "Susceptibility of catchments to INTense RAinfall and flooding." You will be responsible for work in WP3 of the INTENSE project, in particular to examine the influence of large-scale circulation patterns on sub-daily and daily precipitation extremes around the globe using a new global sub-daily precipitation dataset being collected as part of the project. The role will involve working with Prof Richard Allan and his team at Reading University. A 3-month funded international research visit is also included as part of the role (negotiable). You should have a PhD or equivalent, with a proven record of achievement in a relevant research area and a creative approach to solving problems with an appropriate level of mathematical ability and prior use and knowledge of statistics. Experience in handing and manipulation of large datasets and computer programming skills are essential as are excellent written and oral communication skills and the ability to work both independently and as part of a team. It is desirable that you also have experience with precipitation datasets.

This is one of three posts being advertised to work on the INTENSE project. The post is tenable for 36 months from 1st December 2014 or as soon as possible thereafter. For further information and informal discussion of the role please contact Professor Hayley Fowler at h.j.fowler@ncl.ac.uk (0191 208 7113).

You will be employed by Newcastle University for the 3-year (36-month) post under the day-to-day supervision of Prof. Hayley Fowler. You will be responsible for work in WP3 of the INTENSE project, in particular examining the influence of large-scale modes of variability on sub-daily precipitation extremes around the globe. You will also be responsible for work in the SINATRA project which will examine the influence of large-scale modes of variability on sub-daily precipitation extremes in the UK (as a sub-set of the INTENSE analyses above)

The atmospheric and oceanic precursors of extreme precipitation are poorly understood, particularly for convective events. Large UK winter fluvial floods have been linked to “Atmospheric Rivers” (AR) (Lavers et al. 2011) which convey moisture from the subtropics to the mid-latitudes and cause extreme precipitation over daily or multi-day time-scales but it is uncertain how convective events, or other regions, are also affected by ARs. Recent work has shown that North Atlantic SSTs, monthly temperature range and the NAO are important drivers of UK daily precipitation extremes (Jones, 2012) and other modes such as El Nino will influence precipitation extremes in other regions. The added complication with hourly extremes is how large-scale and local thermodynamic processes interact to cause extreme precipitation, as local processes have a much greater effect at sub-daily time-scales. INTENSE will develop models accounting for non-stationarity in precipitation extremes from natural climate oscillations and global warming in different seasons and climate regimes using a hierarchy of statistical approaches.

You will be responsible in WP3 for the development and use of standard statistical techniques such as principal components or multiple-regression analysis to identify the “predictors” (e.g. synoptic circulation, sea-level pressure etc.) or circulation modes (e.g. North Atlantic Oscillation, El Nino variability, etc.) that influence the frequency and magnitude of sub-daily and daily precipitation maxima/POT in different regions. Atmospheric circulation variables will be extracted from reanalysis products (e.g. Compo et al., 2011). You will also use the algorithm from Lavers *et al.* (2012) which uses the spatial and temporal extent of vertically integrated horizontal water vapour transport to detect persistent “atmospheric rivers” (AR; lasting <18h) in reanalysis products. This was developed by a team led by Prof Richard Allan at Reading University and this part of the study will involve collaboration with him and his team and trips to Reading. The dependence of sub-daily extreme precipitation, and daily extremes in other regions, on ARs has not previously been investigated.

You will then work with other members of the INTENSE team to explore how the frequency and magnitude of drought and heavy rainfall are linked through circulation variability using simple methods such as correlation analysis or multiple-regression models – the work on drought will be performed by another member of the team, Dr Selma Guerreiro.

Finally, you will fit more sophisticated statistical models, such as GEV or GDP models with non-stationary (time-varying) coefficients based on identified predictors (including local temperature and humidity from WP2). This will allow analysis of changes to within-year clustering of extreme events which has not been previously examined for global regions.

This role also links to the GEWEX/GHP sub-daily rainfall initiative/cross-cut which Prof Fowler leads and a successful candidate would be expected to contribute to this initiative.

The INTENSE Project

The post is funded by a European Research Council funded project led by Professor Hayley Fowler, INTENSE: INTElligent use of climate models for adaptatioN to non-Stationary hydrological Extremes. The project is large and exciting – with a number of research staff working together on different aspects based at both Newcastle

University and our main project partner, the UK Met Office Hadley Centre Regional Climate Modelling team led by Dr. Elizabeth Kendon. The project also has many international project partners including Princeton University, NCAR and Washington State University (US), KNMI (Netherlands), SMHI (Sweden), CSIRO, UNSW, Adelaide University (Australia) and Reading University (UK) and funding is available for extended stays to work with international research teams within the project budget.

The key challenges to the climate change impacts community with regards to precipitation extremes are: (i) a paucity of studies on sub-daily extremes and the lack of a comprehensive global assessment of changes; (ii) an incomplete understanding of the relationship between atmospheric temperature and moisture and extreme precipitation; (iii) an incomplete understanding of how large-scale atmospheric and oceanic modes and local thermodynamics influence extreme precipitation; (iv) statistical and climate modelling approaches that fail to represent the key features, non-stationarities and continuum nature of precipitation extremes, features that are likely essential in adequately representing the response to global and local change.

INTENSE will use a novel and fully-integrated data-modelling approach to provide a step- change in our understanding of the nature and drivers of global precipitation extremes and change on societally relevant timescales. Extreme precipitation is increasing globally and theory suggests it will continue to increase with global warming: however, results based on opportunistic datasets indicate that sub- daily precipitation extremes will intensify more than is anticipated based upon theoretical considerations. Determining the precise response of precipitation extremes is hampered by coarse climate models which cannot adequately resolve cloud-scale processes and a lack of sub-daily observations which are vital in advancing the theoretical knowledge necessary for improved regional prediction. INTENSE will comprehensively analyse the response of precipitation extremes to global warming by constructing the first global sub-daily precipitation dataset, enabling substantial advances to be made in observing current and past changes and in providing the physical understanding of processes relating to precipitation extremes necessary for improved regional prediction. This will be used together with other new observational datasets and high-resolution climate modelling to quantify the nature and drivers of global precipitation extremes and their response to natural variability and forcing across multiple timescales. Specifically the project will examine the influence of local thermodynamics and large-scale circulation modes on observed precipitation extremes using new statistical methods which recognise the non-stationary nature of precipitation, and use these to identify climate model deficiencies in the representation of precipitation extremes. The recurrence of extreme hydrological events is notoriously hard to predict, yet successful climate adaptation will need reliable information which better quantifies projected changes. INTENSE will provide a new synergy between data, models and theory with which to tackle the problem using a process-based framework; isolating the precursors for extreme precipitation and intelligently using detailed modelling as a tool to understand how these extremes will respond to a warming world and the implications for adaptation strategy. This is hoped that this approach will provide improved projections of precipitation extremes.

This will be based around six key research questions:

i) How has sub-daily maximum precipitation changed over the last century, across continents, climate regimes and seasons?

ii) How does precipitation at different time-scales vary with atmospheric temperature and atmospheric moisture as the atmosphere warms?

iii) How do large-scale atmospheric and oceanic features influence or modulate the observed changes in precipitation extremes, the clustering of extremes and the variability between ‘drought’ and ‘flood’ periods, in different climate regimes and seasons?

iv) What is the influence of climate model resolution and structure on the simulation of precipitation extremes for different climate regimes and seasons?

v) What is likely the response to warming of precipitation and precipitation extremes at different time- scales across different climate regimes?

vi) How can we use information from both high-resolution and coarse-resolution climate models in a more intelligent way to inform climate change adaptation decision making to better manage extreme hydrological events?

The research questions outlined above will be addressed through 5 work-packages which each have a research associate working on them who will also work together as a larger project team. Additionally, Dr. Geert Lenderink from KNMI, Netherlands will work 20% FTE on WP2 during the project lifetime. Posts are advertised for PDRA’s to work on WP1, WP2 and WP3 of the project.

WP1: Sub-daily precipitation data collection and trend analysis: collect sub-daily precipitation data over four continents, quality check, analyse the global climatology of sub-daily precipitation and extremes (including the diurnal cycle), process to extract indices and quantify recent regional and global trends.

WP2: Influence of local thermodynamics: global analysis of precipitation (extremes) and temperature and humidity scaling for sub-daily data from WP1 and existing global daily datasets: exploring the influence of local environment, storm dynamics and cloud-process feedbacks using observed datasets.

WP3: Influence of large-scale atmosphere-ocean modes: regional analyses of precipitation (extremes) and temperature or humidity datasets linking changes/cycles to clearly defined atmosphere-ocean modes of natural variability, i.e. NAO, ENSO using non-stationary statistical methods.

WP4: Influence of climate model resolution and structure: global analysis, using case-studies of nested RCMs and high-resolution GCMs, to explore model inadequacies in simulation of local thermodynamics and the influence of large-scale atmosphere-ocean modes on extreme precipitation for different climate regimes.

WP5: Intelligent, process-based, downscaling: developing new downscaling methods accounting for non- stationarity in precipitation extremes from natural climate oscillations and global warming, using observed process-understanding from WP2-3 and better understanding of model inadequacies from WP4; explore how this alters the projected response of precipitation and precipitation extremes to global warming.

The SINATRA Project

Flooding from Intense Rainfall (FFIR) has caused widespread disruption and damage across Britain over recent years. Such flooding arises from complex, hydrological, hydrodynamic and hydro-morphological processes whose dynamics and non-linear interactions challenge conventional approaches both to short-term forecasting for warning and emergency response and to longer term assessments of risk for spatial planning and climate change adaptation policies. There are fundamental challenges to understanding process operation and interactions under (often highly localised) extreme rainfall, which can give rise to different types and mixes of flooding (e.g. debris flows, rapid in-channel flood waves, pluvial runoff, water table rise) under different conditions. Further challenges arise in predicting how FFIR then translates through related hazards, such as debris flow, into loss of life and other societal impacts that depend on poorly understood vulnerability and exposure characteristics of particular catchments and communities.

In particular, the underlying evidence-base about the frequency, intensity, spatial distribution, and impacts of past FFIR events is poor, and few, if any, systematic data collection studies during such events have been attempted. Short duration, high intensity rainfall events challenge the ability of Numerical Weather Prediction models, while their Land Surface components fail to route intense rainfall runoff correctly. Hydrologic and hydraulic modelling tools to predict FFIR impacts at both local and catchment scales have fundamental limitations, and models to predict debris transport and erosion during extreme floods are currently over-simplistic in terms of the flow physics they include. Yet during major flood episodes the flood damage associated with intense rainfall can account for up to two thirds of all losses and cause billions of pounds of damage (Pitt Review, 2008). New approaches and parameterisations are therefore urgently needed to simulate these spatiotemporally variable process dynamics, to assess the validity and uncertainty of the resulting predictions, and provide the support needed by decision-makers to reduce the risks of damage and loss of life from surface water and flash floods.

Rationale for research: With the Pitt Review (2008) and the 2010 Flood and Water Management Act, the focus of the Government's flood risk management strategy has expanded beyond the comparatively well-defined hazards posed by fluvial and coastal flooding to address the more complex, variegated, and multiply determined risks of FFIR. The joint Flood Forecasting Centre (FFC) was established to improve coordination between the previously separate severe weather warnings issued by the UK Met Office (UKMO) and flood warnings from the Environment Agency (EA) and Scottish Environment Protection Agency (SEPA). However, significant challenges remain in the forecasting of convection and other atmospheric drivers of intense rainfall and in linking those events through the full chain of dynamic, non-linear, hydrological and hydro-morphological processes which initiate, extend and intensify risks of FFIR for particular catchments and the people and places within them. As well as better predictions of the probability, location, timing, and intensity of intense rainfall and FFIR, emergency responders are also demanding information about the likely impacts of severe weather to inform more proportionate and risk-based responses.

Improved understanding of the incidence and impacts of FFIR is also needed for longer-term planning and climate change adaptation. The EA is continuing to seek best practice in characterising rapid response catchments and mapping hazard zones for surface water flooding to support Local Authorities in assuming lead responsibility under the 2010 Flood and Water Management Act. Nationally, there is also increasing concern with improving preparedness and resilience to FFIR, which features prominently in the National Risk Register of Civil Emergencies. The new cross-government Natural Hazards Partnership (NHP) plans to use the case of surface water flooding to pilot development of an all-hazards impact model to support impacts-based warnings and the Cabinet Office review of natural hazards in the National Risk Assessment. More research is needed to underpin government efforts to respond to the calls of the Pitt Review (2008: vii) for "*a step change in the quality of flood warnings*" and in the capacity to anticipate and manage FFIR. The UK Flood and Coastal Erosion Risk Management Research Strategy recognises that the drivers of FFIR, and the processes shaping catchment susceptibility to it, are poorly understood.

These knowledge gaps create a number of well recognised problems with the operational tools used in real-time flood forecasting and incident management and for longer term preparedness planning and adaptation. For example, catchment hydrology models are implemented for flood forecasting without full consideration of the uncertainties introduced by process representation, parameterisation and by the nature of extreme rainfall itself, which can lead to poor prediction of FFIR. Additionally, techniques used to map likely surface water flooding, such as those used by the EA, are based on assumptions about rainfall that do not reflect its spatial and temporal heterogeneity or the hydrodynamic processes controlling catchment susceptibility to FFIR. In both cases the relationship of the flood hazard to its likely impact is also very poorly understood, and so the scientific challenges in understanding and predicting FFIR are multiple and interconnected.

The SINATRA project capitalises on recent ground-breaking work in this area by its team of leading researchers and aims to develop tools which allow *(i) characterization of catchments prone to FFIR events*; *(ii) collection of critical data sets using within and post event forensic analysis*; (iii) development of models which better represent the complexity of catchment response during extreme events; and (iv) the generalization of these findings to provide national scale strategic analyses and forecasting tools. Such work requires skills, tools, techniques and data sets that are uniquely available to the SINATRA team and without which its scientific impact cannot be delivered. These include state-of the-art models for hazard impact assessment and Land Surface Modelling, debris flow, surface water hydraulics and national scale hydrological characterization, benchmark data sets which will allow these models to be refined specifically to deal with the unique needs of FFIR, and novel uncertainty analysis techniques to support optimal decision making in the face of limited knowledge.

Research Role Profile

As part of our commitment to career development for research staff, the University has developed 3 levels of research role profiles. These profiles set out firstly the generic competences and responsibilities expected of role holders at each level and secondly the general qualifications and experiences needed for entry at a particular level. It is unlikely that any single member of staff will be applying all these competences at any one time but he or she would be expected to display most of them over a period of time.

Please follow this link to our Research Role Profiles

Person Specification

Knowledge (inc. qualifications)

Essential

- A good degree (2.1 or above) in mathematics, statistics, climate or atmospheric sciences, engineering, physics or related subject
- A PhD (or almost completed PhD or equivalent research experience) in a relevant physical science
- Appropriate level of mathematical ability and prior use and knowledge of statistics

Skills (professional, technical, managerial, practical)

Essential

- Excellent written and oral communication skills
- Ability to work both independently and as part of a team
- Ability to work to deadlines and manage competing priorities
- High level of analytical and problem solving capability
- Ability to co-ordinate own work with that of others, deal with problems which may affect the achievement of research objectives and contribute to the planning of the project

Desirable

- Detailed subject knowledge in the area of research

Experience and Achievements (paid or unpaid)

Essential

- Good knowledge of high level programming languages such as C or Fortran, IDL, R, Python etc.
- Experience in handling, manipulation and analysis of large datasets
- Experience in analysis of precipitation or atmospheric data
- Published high quality research papers commensurate with level of experience
- Presenting research findings at conferences

Desirable

- Experience of extreme value statistics
- An appreciation of the wider issues related to climate impacts analysis and decision-making
- Contributed to/written research proposals

For additional details about this vacancy and essential information on how to apply, visit our Job Vacancies web page at http://www.ncl.ac.uk/vacancies/