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NERC SCIENCE OF THE ENVIRONMENT

Cold Surges over Western Europe: Mechanisms Underlying Variability and Change (Ref IAP-16-59)

Durham University, Department of Geography

In partnership with School of Geography, Politics and Sociology, Newcastle University

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Key Words	**1. Cold surges** **2. Temperature extremes** **3. Atmospheric processes** **4. Climate diagnostics** **5. Climate variability and change**

Overview

Associated with the spectre of human induced climate change is an increase in extreme climate events such as temperature extremes. Comparatively, high temperature extremes have received more attention in the academic literature than their low temperature counterparts. Notwithstanding projected decreases of cold extremes as a result of climate change (Kharin et al., 2007; Meehl et al., 2016), cold spells are likely to remain a feature of the climatology of middle to high latitude locations throughout the 21st century (Kodra et al., 2011). Indeed the recent severe winters of 2009/10 and 2010/11 experienced across western Europe are testament to the fact that low temperature extremes and extended cold spells continue to present significant risks and costs to society and ecosystems (Cattiaux et al., 2010; Palin et al., 2016). For example the Centre for Economic and Business Research estimate that extreme cold weather has lowered quarterly GDP growth in the UK by 0.6 percentage points since 2005 (Cebr, 2015).

To date much research on low temperature extremes has focused on climate change projections related to cold day/cold spell occurrence. Further and importantly, studies of observed changes in cold extremes have largely paid attention to temperature minima and frost days mainly as static or statistical phenomena rather than the outcome of atmospheric processes. Such studies have concluded that as a result of observed and projected warming the number of cold days and cold spells will decrease. This is problematic from two viewpoints. Firstly as the mean and variance are essentially independent statistical properties it does not necessarily follow that an increase of the mean temperature and an associated positive shift in the normal temperature curve will simply result in cold days becoming less frequent. Therefore the prospect of increased temperature variability and thus increases in cold extremes is a real one under climate change. Secondly from a societal impacts point of view, cold days may not be totally satisfactory as an indicator of risk because a number of societal impacts arise from wind chill as opposed to straight chill, Therefore surges of cold air or cold surges and associated rapid changes in temperature brought about by intense cold air advection are potentially more hazardous than innocuous cold spells.

Because cold surges are a result of the day to day variability in atmospheric conditions as manifest via the interaction of a range of climate fields, they are fundamentally different to cold days. This is often overlooked in the scientific literature with the result that little attention is given to cold surges as a severe winter weather phenomenon. Accordingly there has been little research on the observed variability and change in cold surges, especially from a climate dynamics view point. Given this the overall aim of the proposed research is to understand the mechanisms underlying cold surge development, variability and possible change. In relation to this we are particularly interested in investigating the role of land-atmosphere and ocean-atmosphere interactions in the generation of cold surges, for example the importance of Arctic sea ice changes (Screen and Simmonds, 2010; 2013) and the so-called Artic Amplification (Serreze and Barry, 2011) as well as possible tropical-extra-tropical interactions (Jung et al., 2010). In addition to the scientific justification for this study is that related to the need for science informed climate risk management. Research findings will provide knowledge to improve decision making and action in a range of sectors of the economy (e.g. from the oil industry to human health) related to managing risk, building resilience and reducing vulnerability to and preventing major impacts from cold surge events.

Methodology

Methodology will broadly follow an environment to circulation approach (Yarnal, 1993) in that traditional temperature and wind speed based criteria, in addition to variables that describe atmospheric dynamics, will be applied to the identification of cold surge events and characterisation of their intensity, duration and spatial coverage so that further analyses on the identified events can be undertaken, The primary data sets to which the cold surge criteria will be applied will be observation data from the network of climate stations across Western Europe as well as a number of atmospheric re-analysis data sets (Lindsay et al., 2014; Reanalysis.org, 2016). Once the time series of cold surge events has been identified variability and trend analyses will be undertaken related to a range of cold surge diagnostics at an array of temporal and spatial scales. The cold surge time series will also be investigated following a circulation to environment approach (Yarnal, 1993) via exploring the extent to which intra-seasonal to inter-annual variability of cold surge occurrence may be related to a number of modes of large scale ocean-atmosphere circulation variability. A selection of at least two cold surge events will be made for in depth analyses of cold surge dynamics, using reanalysis climate fields in order to understand cold surge origin/life cycle and the extent to which a number of candidate hypotheses such as tropical-extra-tropical interactions, Arctic Amplification and sea-ice extent may account for cold surge formation. Modelling and visualisation software will be applied to assist the interpretation and description of cold surge life cycles. Three different reanalysis data sets will be used for the analysis, modelling and visualisation. These will be obtained from the ECMWF (European Centre for Medium-range Weather Forecast), NCEP (National Center for Environmental Prediction) and Japan Meteorological Agency (JMA). Undertaking the analyses based on more than one reanalysis product will facilitate an inter-comparison of events as portrayed by the three reanalyses with the expectation that we will find a commonality amongst the reanalysis products and events themselves which will serve to highlight the fundamental characteristics of cold surge events. An outcome of this methodology will be insights into how reanalysis models, assimilation techniques and forecasting can be improved in relation to cold surges. Because of the nature of the project it will necessarily be computer processing intensive.

Timeline

Activity	Yr/Quarter (start Oct)
R&T Needs Analysis	1/1
Research Training	1/2 – 1/3
Lit. Review; Aim & Objectives	1/1 – 1/3
1st Yr PG Conf. Talk	1/3
Data Assemblage	1/3 – 2/2
Data Processing	1/4 - 2/3
2nd Yr Prog. Rep	2/1
Continuation Review	2/3
Data Analysis	2/1 – 3/1
Intl Conference	3/1
Journal Paper 1, 2 & 3	1/3, 2/3, 3/2
3rd Yr Prog. Report	3/1
3rd Yr PG Conf. Talk	3/2
Thesis Writing & Submission	3/2 – 4/2

Training & Skills

Generic training in the 1st year will be provided in (a) research skills and techniques, (b) research environment, (c) research management, (d) personal effectiveness, (e) communication skills, (f) networking and team-working, (g) career management. The student will also take the Department of Geography taught course “Implementing Research Design” during their first year. Additionally research topic specific training and skills development will be in (a) conceptual modelling, (b) large data set management, manipulation and processing, (c) advanced statistical techniques, (d) model-based data comparison and specialist tools for three-dimensional data visualisation and (e) academic journal paper preparation.

References & Further Reading

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Further Information

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