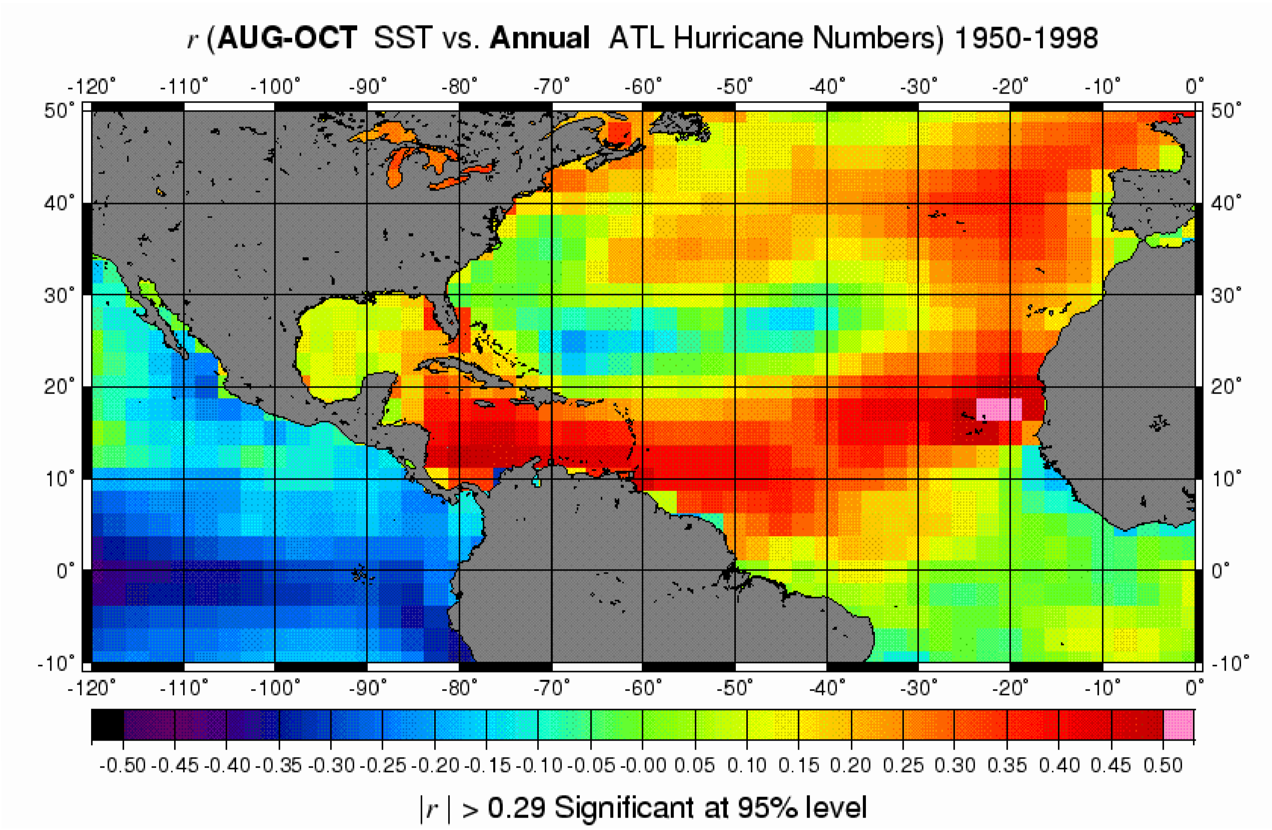
Statistical Predictability of North Atlantic Sea Surface Temperatures

Research Fellowship Funded by the NERC

Start Date: April 2000 or Earlier



Example of the importance of contemporaneous sea surface temperatures (SSTs) to US and European extreme weather. The plot shows the spatial correlation between the average August to October SST and the annual number of Atlantic hurricanes for 1950-1998. Large areas of the tropical north Atlantic and Caribbean are linked significantly to annual hurricane numbers.The seasonal predictability of these SSTs has received little prior attention. One objective of the project will be to examine the statistical predictability of these tropical SSTs with a view to benefitting seasonal hurricane forecasting.

Supervisor: Dr Mark Saunders

Benfield Greig Hazard Research Centre
Department of Space and Climate Physics
University College London

Post Summary and How to Apply

Applications are invited for the above 30-month NERC-funded research post commencing in April 2000 or earlier. Candidates should have, or expect to receive in 2000, a PhD in a relevant physical science. Knowledge of climate physics, scientific computing, and/or statistical analysis procedures would be an advantage.

The project aims to quantify the statistical seasonal predictability of those sea surface temperature (SST) regions in the north Atlantic which are linked contemporaneously and most strongly to (a) hurricane landfalls on the USA and Caribbean, (b) winter windstorm impacts on the UK and northwest Europe, (c) monthly and seasonal UK temperature extremes, and (d) monthly and seasonal UK rainfall extremes. Leads of 1, 2, 3, 6, 9 and 12 months will be examined. Variants of three of the four most skilful ENSO SST statistical prediction models will be investigated and their skills inter-compared and assessed against persistence.

While ENSO SSTs are now predictable many months ahead, the seasonal predictability of north Atlantic SST anomalies has received little attention. Useful predictability of the latter would benefit the long-range forecasting of weather extremes and thus the risk management decisions made in many climate sensitive businesses (see http://forecast.mssl.ucl.ac.uk for details of the long-range weather forecasts we currently undertake for industry).

The post will be based in UCL's Climate Physics Group at Holmbury St Mary, near Guildford, in Surrey. The successful applicant will join an internationally competitive group researching seasonal forecasts of weather extremes and the Earth's changing climate system in general. Excellent computer facilities and climate data are available to support the work.

Starting salary will be in the range £18,185 - £19,869 (as at 1st April 1999). Opportunities will be available to enhance this through short-term commissioned work for industry.

Applications (comprising a detailed curriculum vitae and the names and addresses of two academic referees) should be sent to:

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The closing date for applications is Monday 31st January 2000.

For further information please see the following job description. In case of further queries please telephone 01483-204187 or e-mail: mas@mssl.ucl.ac.uk.

1. Principal Issues and Potential Benefits

The existence of seasonal weather prediction at many locations is well known (see reviews by Palmer and Anderson [1994], Hastenrath [1995] and Carson [1998]). Seasonal predictability arises from external forcing factors - that are predictable themselves - which alter the likelihood of the atmosphere at a remote location residing in a particular state. The forcing may be either contemporaneous or lagged, although sound physical explanations for the latter type of coupling are more difficult to prove. The primary source of external forcing at seasonal or interannual timescales is anomalous patterns of sea surface temperature (SST) (eg Palmer and Anderson [1994], Rowell [1998]). The impacts and predictability of ENSO SSTs on global climate have received considerable research in the last decade. The best performing ENSO models now achieve a correlation skill at a 9 month lead of ~0.5 (see reviews by Latif et al., [1998] and Barnston et al. [1999]). However, many of the weather extremes affecting the Atlantic basin, Europe, and the US eastern seaboard, are linked more strongly to contemporaneous north Atlantic SST anomalies than to ENSO (Davies et al. [1997], Saunders et al. [1997], Rowell [1998], Rodwell et al. [1999], Robertson et al. [1999], Colman and Davey [1999], Malmquist [1999], Sutton et al. [1999]). To date, the seasonal predictability of north Atlantic SSTs - both tropical and extratropical - has received little or no attention. The project will examine this predictability for key regions and seasons using a range of statistical forecast schemes. While dynamical forecast models should, in theory, eventually be superior to statistical models, this is not the case at present. Studies assessing current capabilities of the two model types show that the best statistical seasonal models are as good as, if not better, than the best dynamical seasonal models (Barnston et al. [1999], Anderson et al. [1999]). Furthermore this situation has not changed in the last 6 years. Hence we are confident that our statistical approach will provide a sound assessment of the potential SST predictability in the key Atlantic regions in question.

The project will enhance future opportunities for collaboration with UK and US industry. Weather affects the financial performance of 70% of business and industry. Examples are the insurance, power, construction, farming, tourism, retail, manufacturing and travel sectors (eg IQPC [1999], Malmquist [1999]). 'Skilful' forecasting of key Atlantic SST regions and patterns – and thus weather extremes - at leads of 1 to 12 months would benefit industry and commerce through the improved structuring of financial contracts used to hedge weather risk. By 'skilful' we mean correlation skills ≥ 0.4 which are significant at the 95% level or higher. In addition to benefitting industry the research is germane to the goals of major international and European research programmes including CLIVAR and PROVOST (eg Carson [1998]).

2. Specific Objectives

The project aims to quantify the statistical seasonal predictability of those SST regions in the north Atlantic which statistical field significance tests show are linked contemporaneously and most strongly to (a) hurricane landfalls on the USA and Caribbean, (b) winter windstorm impacts on the UK and northwest Europe, (c) monthly and seasonal US and UK temperature extremes, and (d) monthly and seasonal US and UK rainfall extremes. Leads of 1, 2, 3, 6, 9 and 12 months will be examined. Variants of three of the four most skilful ENSO SST statistical prediction models will be investigated, and their skills inter-compared and assessed against persistence. Principal attention will be given to the JASO months (hurricane landfalls and US summer weather/tropical north Atlantic) and to the DJFM months (European winter weather/tropical and extratropical north Atlantic). Other months and seasons will be examined depending upon progress.

3. Methodology

The project will employ global 2.5° gridded SST and climate data from the NCEP/NCAR Reanalysis for the 50-year period 1950-1999. The three statistical SST forecast models to be investigated are: (1) The Colorado State University ENSO Climatology and Persistence (CLIPER) multiple linear regression model (Knaff and Landsea [1997]). This is a simple statistical model based on the optimal combination of several timescales of SST persistence, month-to-month trends in recent observed SSTs, and SST climatology. It provides a baseline of skill, which is better than simple persistence, against which to compare more sophisticated models. There should be no difficulties in applying the CLIPER forecast methodology to the north Atlantic. (2) The University of Colorado, Boulder, linear inverse model (LIM) (Penland and Matrosova [1998]). LIM is a linear multivariate technique which employs the past history of the SST field to predict future SST anomalies. It is similar to principal oscillation pattern analysis but employs a much larger (~20) number of oscillation patterns, thereby enabling the SST anomaly field to be described in detail. Although the model is statistical, the technique assumes that the SST anomalies are driven by the stochastic linear dynamics of the atmosphere-ocean system. In applying LIM to predict the key north Atlantic SST regions the project will compare the relative importance of using tropical Atlantic SSTs, global tropical SSTs, north Atlantic SSTs, and global SSTs as predictors. This will be done by choosing an equal number of SST oscillation patterns in each case. Although technically demanding there should be no major difficulty in applying the LIM model. (3) Canonical Correlation Analysis (CCA) model as used extensively, for example, by the Climate Prediction Center at NCEP to forecast ENSO SSTs, global temperatures, and global precipitation (eg Barnston [1994], Barnston and Smith [1996], Barnston et al. [1999]). CCA is a sophisticated form of multiple linear regression which identifies linear relationships between preceding patterns in multicomponent predictor fields and the SST predictand. The predictor fields the project will investigate are global sea level pressure, northern hemisphere 700mb height, northern hemisphere sea ice coverage, the four SST predictors in (2) above, and the SST predictand itself, each covering consecutive 3-month (or 1-month) periods ending at the time of the forecast. To prevent overfitting by the weaker predictors, the SST predictand will be weighted double on entry to the analysis. All fields will be filtered separately using standard EOF analyses prior to the CCA, as done originally by Barnett and Preisendorfer [1987].

The skill of each model will be assessed by first performing a hindcast for the period 1980-1999. Constant predictor sets will be retained throughout, but only prior years will be used in recalculating the regression relationship for each future year to be forecast - ie the jack-knife method of cross-validation which can lead to skill inflation will not be employed. The hindcast values will be compared against verification and persistence, and the model skill quantified using standard measures including the ‘root-mean-square-error’ and ‘amount of variance explained’.

4. How is the Research Original, Technically Feasible, and Relevant?

The proposed work and its industrial application are totally original. Apart from the Penland and Matrosova [1998] LIM forecast for selected areas of the tropical Atlantic, no seasonal SST forecast currently exists for any north Atlantic region beyond 3 months. In the extratropical north Atlantic, current SST forecast leads are much less than 3 months. The proposed work will provide the first quantitative long-range forecasts of SST anomalies for those key north Atlantic regions which are statistically most important in forcing extreme weather. The development and inter-comparison of three different statistical SST forecast models is central to our proposal for it is preferable to have a variety of forecasts, based on different methods, available for review when deciding upon an SST predictand value.

The work programme is technically feasible. The three models the project will implement and adapt are among the best performing statistical models in forecasting ENSO SST conditions. Indeed during the 1997-98 El Niño episode and the 1998 La Niña onset the skill of these models matched that of the most comprehensive dynamical models (Barnston et al. [1999]). The theoretical basis for expecting that the models will perform in the tropical and extratropical north Atlantic is very good. Construction of the models is non-trivial requiring sound mathematical and statistical skills. However, we are confident that, for a qualified researcher, 30 months support is sufficient to build the models, optimise their performance, and assess their 20-year (1980-1999) hindcast skill for all the key regions.

The work lies firmly within the NERC mission of research into and predicting the environment. It is central to 'Environmental Risks and Hazards', one of the five Environmental and Natural Resource Issues on which NERC focuses its research activities. Through its objective of benefitting long-range extreme weather prediction, the proposed work has sound potential for creating new industrial partnerships and contributing to UK wealth creation, a key strategic NERC aim. The proposed work addresses the UK skills shortage of quantitative environmental scientists, and offers excellent opportunities for encouraging public interest in the environment.

5. References

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Saunders, M.A., & A.R.Harris, Statistical evidence links exceptional 1995 Atlantic hurricane season to record sea warming, *Geophys. Res. Lett.*, **24**, 1255-1258, 1997.

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6. Project Funding and Duration

Starting salary will be in the range £18,185 - £19,869 (as at 1st April 1999) on the Academic Research Fellow 1A scale. Opportunities will be available to enhance this through short-term commissioned work for industry. The post will commence in April 2000 or earlier, and have a duration of up to 30 months.

The project comes with a new Sun Ultra 10 workstation and a 21 inch monitor. Depending upon progress there will be good opportunities for international travel.

7. Person Specification

Candidates should expect to receive in 2000 a PhD in a relevant physical science. Knowledge of climate physics, scientific computing, and statistical analysis procedures would be an advantage, as would prior experience of working in or with industry. However, of more importance is that the Research Fellow should be hard working, reliable, and possess sound initiative. The work programme is demanding and technical, requiring commitment, scientific rigour, and dedication.

8. The Group and the Department

The post will be based in UCL's Climate Physics Group at Holmbury St Mary, near Guildford, in Surrey. The successful applicant will join an internationally competitive group researching seasonal forecasts of weather extremes (see http://forecast.mssl.ucl.ac.uk for details of the forecasts we undertake for industry) and the Earth's changing climate system in general. Excellent computer facilities, climate data and climate models are available to support the group's work.

The Department of Space and Climate Physics of University College London is based at Holmbury St Mary in the Surrey countryside about 30 miles from the centre of London. The Department houses around 130 researchers, PhD students and support staff, in a large mansion house with splended views

towards the South Downs. There are five main research groups: Astrophysics, Climate Physics, Detector Physics, Solar Physics, and Space Plasma Physics. A description of the Department's research activities and of life in general in the Department, can be obtained from viewing a 17-minute recruitment video which is available on request.

9. Career Prospects

Your career prospects on completing the Research Fellowship will be very good. Opportunities available to you will include:

a) Pursuing a University academic career.
b) Working in Research and Development in the rapidly growing Weather Risk Management Industry.
c) Working for the British, European or other weather/climate services.

With 70% of UK industry weather sensitive and with the recent explosion of interest in weather risk there will be no shortage shortage of jobs for talented and hard working scientific experts.

Dr Mark Saunders

Since 1997 he has built-up and established a research group specialising in the long-range statistical prediction of industry-sensitive extreme weather and climate events. These include (a) hurricanes, typhoons, and European windstorms, and, more recently, (b) rainfall, floods and droughts, and (c) temperature extremes. His expertise and skill in statistical seasonal forecasting may be judged from the facts that 5 major research projects are currently funded and, in the last year, he has completed promptly 12 commissioned contracts for industry, presented 20 invited talks and seminars, made 4 international press releases, and had over 30 media appearances and citations.

His publications in 1999 include:

1. Saunders, M.A. and S.E.George, Seasonal Prediction of European Storminess, Proceedings of Workshop on European Winter Storms and the North Atlantic Oscillation, Risk Prediction Initiative, Bermuda, 15pp, 18-19 January 1999.
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5. Saunders, M.A., Can We Forecast Hurricanes and Windstorms?, Proceedings of the Benfield Greig 1999 European Seminar, Paris, 21pp, 23-24 June 1999.
6. Saunders, M.A., Caribbean Hurricanes: Prospects for Long-Range Forecasting, Commissioned Report for Benfield Greig Hazard Research Centre, 4pp, June 1999.
7. Saunders, M.A., Hurricane Variability and Catastrophe Risk, The Insurance Institute of London Journal, 87, 16-23, 1999.
8. Saunders, M.A., Earth's Future Climate, Phil. Trans. Roy. Soc. Lond., Special Millennium Issue on 'Science into the Next Millennium', 21pp, in press, 1999.
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