Growing our science
Met Office Academic Partnership
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What is it?

The Met Office Academic Partnership is a cluster of research excellence. It brings together the Met Office with the leading UK universities in weather and climate science through a formal collaboration to advance the science and skill of weather and climate prediction. The Met Office Academic Partnership is the Met Office, the University of Exeter, the University of Leeds, the University of Oxford and the University of Reading.

What are its aims?

- To draw together world-class expertise around a focused programme of joint research to tackle key challenges in weather and climate science and prediction.
- To maximise return on the UK’s investment in research and development in its leading institutions, to provide society with the best possible advice.
- To combine our strengths to secure the UK’s position in leading the world in weather forecasting and climate prediction.
- To build a cluster of research excellence that is instrumental in determining priorities for future funding and influencing the European Union Framework agenda.
- To provide an outstanding environment to develop the science leaders of tomorrow in this very challenging area of research and delivery.

Dr Jon Petch

Jon is the Head of Met Office Science Partnerships. He is responsible for the Met Office’s national and international relationships with other science organisations, including the Unified Model partnerships, relationship with the Natural Environment Research Council (NERC) through the Joint Weather and Climate Research Programme (JWCRP) and with the academic partnerships. Jon also continues to carry out research in areas related to atmospheric processes and parametrizations.

For further information please see: www.metoffice.gov.uk/research/partnership or email moap@metoffice.gov.uk
Challenges in weather and climate prediction

Data assimilation in complex models
- Improve and expand observations
- Clouds and the water cycle
- Cold weather, low-level clouds and fog
- More accurate weather and climate predictions

Improving projections of climate

Oceans and climate

Scale interactions in weather and climate

Polar regions

Probabilistic prediction of weather and climate

Professor Julia Slingo

Julia became Met Office Chief Scientist in 2009 and has responsibility for scientific research and development. Her personal research addresses problems in tropical climate variability, its influence on the global climate, its role in seasonal to decadal climate prediction and its response to climate change.

“Forecasting the weather, and understanding and predicting the future course of our climate, remain among the most socially important and scientifically demanding challenges of our age. No single institution can cover the breadth and depth of expertise to address these challenges. The Met Office Academic Partnership aims to bring the leading universities together with the Met Office to ensure that, together, we accelerate the pace of research to provide the answers that society increasingly asks of us, around the risks of extreme weather and the impacts of our changing climate.” Professor Julia Slingo, Met Office Chief Scientist
Achievements of the partnership

There is a constant effort to verify, calibrate and utilise information from prediction systems and to ultimately improve prediction systems to obtain more accurate forecasts. The University of Exeter has considerable expertise in environmental statistics that has been applied to verify and to quantify uncertainty in predictions on weather and climate timescales with an emphasis on rare and extreme events. The possibility of ‘tipping points’, where the response of the system is very much faster than the applied forcing, has been a feature of the collaboration. A recent success has provided a constraint on Amazon dieback based on the ability of models to reproduce interannual fluxes of CO₂, an example of a ‘process-based observational constraint’.

Case study

A major focus of the Exeter-Met Office partnership so far has been developing numerical techniques to improve weather and climate prediction. The ENDGame dynamical core of the Unified Model improves on the previous one in several ways: the optional use of a conservative transport scheme for mass and tracers; the use of a more stable time scheme based on an iterative approach; and the consistent inclusion of several switchable options for the geometric and dynamical approximations. ENDGame improves the model’s numerical accuracy, robustness and scalability and it is anticipated to become operational in early 2014.

The relative vorticity field from a numerical simulation of fluid (barotropic) instability using a shallow-water version of the ENDGame scheme.

Future directions for Exeter – Met Office

• The partnership will continue to improve weather and climate modelling and enhance our understanding of climate change using mathematical and statistical techniques.
• The concept of ‘process-based emergent constraints’, finding metrics of climate model processes that are correlated with future projections of different variables, will be further developed.
• University of Exeter will provide training for Met Office staff in numerical modelling techniques, climate science, environmental statistics and scientific writing.

Met Office Lead for Exeter, Nigel Wood
An important theme in our partnership is developing new models for atmospheric composition. Our small-scale research models are capable of representing the interactions of aerosols and chemical tracers with individual clouds, while our global models are able to scale such effects up to the Earth’s climate system. We are conducting new research into the assessment of uncertainty in such models of composition – analysis of uncertainty is necessary for the use of model results in decision-making.

Achievements of the partnership

The University of Leeds has a continuing history of leading major observational activities with the Met Office. Together, we have successfully used observations to develop theoretical understanding of the atmosphere, and to develop the next generation of weather and climate prediction models. Examples of such activities include a series of mountain-wave experiments conducted in Scotland and the north of England since the early 1990s, the Arctic Summer Cloud Ocean Study (ASCOS) in 2008, and the recent Cold-air Pooling Experiment (COLPEX) measuring night-time cold air in the valleys of Shropshire.

Weather and climate models have real problems in making accurate forecasts for many parts of Africa. The partnership is using field observations from major international field experiments, such as the African Monsoon Multidisciplinary Analysis (AMMA), to challenge and improve the models. Our results are benefitting various areas of the human environment in Africa, including the distribution and intensity of rainfall, its impact on crops, and the lifting of desert dust.

Future directions for Leeds – Met Office

- We will continue to lead and contribute to national and international observational programmes, and use these to challenge our mathematical theory and our predictive models.
- We are making a strategic effort to advance our understanding and modelling of cloud-aerosol interactions, from the cloud scale to the global scale.
- We are embarking on a joint effort in regard to the improved understanding and modelling of tropical continental water cycles.
Professor Peter Read

Peter is a climate physicist with research interests in the fundamental fluid dynamical processes in atmospheres and oceans that govern long-range transport and predictability. This entails studying complex turbulent motions in observations, numerical models and laboratory analogues of atmospheric circulation which he applies not only to the Earth’s atmosphere but also to the atmospheres of other planets. He began his career as a research scientist in geophysical fluid dynamics at the Met Office before moving to Oxford.

The three examples below highlight the interdisciplinary approach used to address key research areas such as ocean modelling and the interactions between weather, climate and climate change.

Representing uncertainty in weather and climate models

We are researching stochastic parametrization schemes to represent uncertainty in weather and climate models. Work ranges from proof-of-concept experiments in simple dynamical systems, to investigating new stochastic schemes for use in ocean models, to using global numerical weather prediction models to test improved stochastic parametrizations of convection. An exciting new research theme, involving collaboration between the Physics and Mathematics departments, explores using energy efficient stochastic computer hardware in atmospheric modelling.

Bias correction in ocean modelling

Researchers in the University’s Oceanography Group have worked with the Met Office to provide access to a wealth of detailed understanding of Southern Ocean circulation and dynamics. This enabled the Met Office to better account for the large warm sea surface temperature model bias in the Southern Ocean which was having an adverse impact on climate simulations, and in particular the representation of the globally significant heat/carbon uptakes that are known to occur in the Southern Ocean.

Climate-weather interactions

At the heart of existing collaborations on weather-climate interactions is understanding the weather as a chaotic system whose statistics, or the “shape of the chaotic attractor”, can be affected by external drivers like our changing sun, changing patterns of aerosol load in the atmosphere and rising greenhouse gas levels. Understanding and responding to changes in weather-related risks is at the heart of the new science of climate services and is greatly enhanced using our distributed computing network, climateprediction.net.

Future directions for Oxford – Met Office

- Continue to lead and contribute to advanced remote sensing methods to obtain key observations of atmospheric composition, clouds and aerosols.
- Develop a quantitative, multidisciplinary approach to model complex climate interactions between the atmosphere, ocean, cryosphere and land surface.
- Develop innovative ways of applying probabilistic and stochastic approaches to the prediction of weather and climate: used for attribution studies and assessing risks to water resources, ecosystems and infrastructure.

Met Office Lead for Oxford, John Eyre
Professor Peter Clark

Peter is a physicist and is particularly interested in the science behind the short-range forecasting of high impact weather. His research is primarily focused on how we represent complex turbulent flows, such as in thunderstorms and around urban areas, in mathematical models.

Achievements of the partnership

Weather and climate predictions are limited by our ability to accurately represent processes in our models and to challenge our models with accurate observations. At Reading we continually stretch the boundary of what is possible to model reliably. This ranges from very short-range forecasting of severe weather such as thunderstorms and flash floods, detailed prediction of urban heat islands, to climate predictions, which, for the first time, can represent the detailed structure of tropical and extra-tropical cyclones.

Case study

The accuracy of Met Office predictions of thunderstorms, and the extreme rainfall they can produce, depends on how well individual storms are modelled.

In the DYMECS (Dynamical and Microphysical Evolution of Convective Storms) project we used the Chilbolton high-resolution radar to make tens of thousands of measurements of the 3D structure of many different convective storms. These have been statistically analysed and compared with equivalent data from the operational 1.5 km UKV forecast model as well as research versions with grid-lengths as low as 200 m. This provides a rigorous test of the impact of improvements to the model’s treatment of cloud, precipitation and turbulence.

Future directions for Reading – Met Office

- The partnership will continue to improve the representation of basic processes in weather and climate models, including extending our models to forecast space weather.
- We shall develop advanced methods to make use of observations and hence improve our ability to forecast from hours to seasons and beyond.
- We are determining the role of anthropogenic emissions and natural processes in climate change and variability and continue to develop strategies for adaptation and mitigation.