ENSEMBLE PREDICTION OF WEATHER AND CLIMATE IN THE AGE OF PERTURBED PHYSICS

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WEDNESDAY 19 OCTOBER 2005

Aims and requirements of ensemble prediction at all time ranges – Dr Tim Palmer, European Centre for Medium-Range Weather Forecasts **tim.palmer- at -ecmwf.in**t
The scientific basis for ensemble prediction is discussed and some brief history behind the development of ensemble prediction systems, on timescales from days to centuries, given. The value of ensemble prediction for decision making will be discussed and quantified. The presentation will conclude with suggestions on how ensemble prediction system should be presented on the TV evening weather forecast.

Dealing with analysis error – initial condition perturbations - Dr Neill Bowler, Met Office
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Despite almost 13 years of operational use there are still a diverse range of methods for the generation of initial conditions for ensemble prediction. This diversity is borne out of the complexity of NWP models and the fact that there has been no best method identified.

A review is provided of the initial condition perturbation methods used by the major operational centres around the world - including singular vectors, error breeding, perturbed observations and the ensemble Kalman filter. Intercomparisons between these ensembles indicate no clear winner, with each system performing well on different measures.

The future of determining ensemble initial conditions is then discussed and the interactions between data assimilation and ensemble prediction are noted. We return once more to poor-man's ensembles and ask - "Why do they perform so well?"

Spurious numerical dissipation and stochastic convection - Dr Glenn Shutts, Met Office
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Two aspects of the representation of 'model error' will be discussed: kinetic energy backscatter from sub-grid to resolved scales and the statistical fluctuations of deep tropical convection. Some arguments are put forward to support the idea that the dissipation of kinetic energy in NWP and climate models associated with explicit diffusion and/or numerical smoothing is excessive. This has led to the use of a stochastic backscatter parametrization in ensemble prediction systems (EPS). Another source of model uncertainty comes from neglecting the underlying statistical fluctuations in traditional model parametrizations. A coarse-graining methodology has been applied to

some cloud-resolving model simulations of tropical convection to characterise the probability distribution functions of convective temperature tendency. These will be compared with the corresponding statistical behaviour of an aqua-planet simulation using the Met Office Unified Model. Time intermittency in convective parametrization tendencies appears to mimic the statistical fluctuations of simulated convection though only in a qualitative sense.

References:
ECMWF Tech. Memo: 449 "A stochastic kinetic energy backscatter algorithm for use in ensemble prediction systems."
pdf available at: http://www.ecmwf.int/publications/library/do/references/list/14

Dealing with model error – multi-model ensembles – Dr Tim Stockdale, European Centre for Medium-Range Weather Forecasts
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Prediction of weather and climate at various time-scales has to grapple with the problem of model error. However well we prepare our initial conditions, and however well we account for the uncertainty in the initial conditions by ensemble techniques, errors in today's numerical models will cause errors in the ensemble forecast.

A pragmatic approach to dealing with this problem is to use a number of different models to calculate a forecast, and to use the resulting 'multi-model' ensemble of results as the basis for issuing a forecast. In the context of seasonal forecasting, results show that such an approach is substantially helpful. However, multi-model ensembles give only a partial sampling of the impacts of model error. The translation of model outputs into a reliable forecast is still not straightforward, and the potential of seasonal forecasting is still substantially degraded by the errors in models. Multi-model ensembles are definitely a help, but they do not solve the fundamental problems of model error.

Model error in probabilistic climate forecasting – Dr Myles Allen, University of Oxford
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This talk will review the treatment of model error in both weather and climate forecasting, focussing on the climate problem because it raises the most obvious methodological issues. The fundamental problem is what to do when the relationship between the quantities we can observe and the quantity we want to forecast is non-linear, as in general it always will be. Naive, ostensibly Bayesian, approaches to probabilistic climate forecasting in this situation, such as simply sampling the distribution of the observable quantity that is consistent with our data and plotting the resulting distribution of the forecast, can result in the inadvertent introduction of information, potentially dominating the forecast in a a way that is utterly obscure to the forecast user. I will argue that the traditional statistical approach of trying as far as possible to separate out the respective contributions from prior assumptions and from data in determining the forecast has much to recommend it, in particular in that it is likely to provide much more robust and stable forecasts than the naive alternative. Since calling anything frequentist is unpopular, perhaps a more flattering name for this approach would be "transparent

Bayesian", or the phrase we have adopted, which is Stable Inference from Data, or STAID forecasting. I will use examples from the climateprediction.net project and other recent studies focussing on long-term climate change.

After the dealing's done: using ensembles of simulations from imperfect models – Dr Lenny Smith, University of Oxford and London School of Economics
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The ultimate goal of weather forecasting is forecasting the weather. While we must deal with analysis error, with model error, with perturbed physics and with ensemble formation, the ultimate evaluation of our efforts is determined by the ability to turn an ensemble of simulations into a forecast of some observed target, say, the temperature at London Heathrow.
After the dealing is done, we have to evaluate how well our forecasts do at predicting things we can measure, ideally things which are of interest either scientifically or for socio-economic decision support. But how are we to evaluate probabilistic forecasts? What scores should best quantify and communicate 'skill'? What properties should these scores have? How much information do our model simulations contribute to a weather forecast as a function of lead-time? These questions will be addressed. Limitations on making 'probability forecasts' will be noted, along with the fact that probabilistic forecasts need not imply the attempt to make probability forecasts. It is demonstrated that the value of current forecasts goes far beyond any "ensemble mean" (or "second moment" for that matter) and suggested that this evaluation is not only of interest to users, but can feedback into the modelling process and assist in dealing with resource allocation in operational centres.
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