

## **WEDNESDAY 16 APRIL 2003: NOT JUST NUMBERS, BUT INSIGHT: THE ROLE OF MATHEMATICS IN METEOROLOGY**

### **David Stephenson: Lies, damned lies, and climate statistics**

Where would climatologists be without the concept of correlation? Climate talks are full of (rather dubious) correlations purporting to represent causal links in the climate system. This talk will present the discovery of correlation by Sir Francis Galton in 1888 and its introduction into climate research by Sir Gilbert Walker in 1908. A plea will be made for more probability model-based approaches to the statistical modelling of climate

### **Julian Hunt: Complex flows in meteorology from synoptic to turbulence scales**

Storm systems, fronts, clouds, turbulent eddies are examples of self organised structures on a wide range of scales. From Howard and Lamarque's cloud classification to current modelling of tropical cyclones and coherent eddies in turbulence these structures have played a central role in our understanding and prediction of weather and even climate. Examples will be given in this talk of how mathematical ideas and techniques provide insights into the geometrical and stochastic description of these structures and, through dynamics and statistics, into their internal structure and mutual interactions with the background fields and with each other. These approaches should lead to improved modelling and explanations where current models can mislead. Arguably human forecasters should continue to play a critical role because they are rather good at spotting and understanding patterns!

### **Ross Bannister: Two 'wrongs' can make a 'right' - Combining models and data**

We learn about the behaviour of the atmosphere through observations on the one hand and models on the other. Even though there is an extensive observation network, observations on their own do not give a complete picture of the atmosphere. Increasingly, the atmosphere is being sensed remotely and such observations contain only indirect information of meteorological quantities. Models provide a more complete coverage of the atmosphere and allow us to make predictions, but they will stray from reality due to their imperfections and their chaotic dependence on initial conditions.

Data assimilation combines the desirable features of each source of information, as well as 'unpicking' meteorological information from indirect observations. The data assimilation process can be thought of as either one of 'keeping models on the rails' or of 'filling voids between the observations'.

This talk is an introduction to atmospheric data assimilation from a historical perspective. In its humble beginnings, it was little more than interpolation of observations to a model's grid. The recent deployment of four dimensional variational analysis takes the form of a sophisticated inverse model of the atmosphere and of the observing system.

### **Andy White: Mathematics and the foundations of numerical weather prediction**

To meteorology, as to all other sciences, mathematics offers a discipline for the construction and interpretation of reliable theoretical and numerical models. It can also be seen as a vast store of knowledge, accumulated over 2,500 years, on the appreciation and solution of physical problems. Maths plays a crucial role in four areas of Numerical

Weather Prediction:

- (i) deciding which continuous flow equations we would like to solve;
- (ii) choosing and implementing a discretization for numerical computation;
- (iii) avoiding spurious instabilities and exploiting real ones;
- (iv) diagnosing and interpreting results.

These four areas will be surveyed. If time allows, a case study involving Poisson's differential equation and related elliptic forms will be presented, emphasising their ubiquity and the conceptual value of solution methods which are mathematically well-established but novel in meteorology.

**Ian Roulstone: Computation, chaos and geometry**

Despite the inherently quantitative nature of numerical modelling, dynamical meteorology and oceanography are subjects that make extensive use of qualitative concepts, many of which are derived from conservation laws and asymptotic approximations, to advance our understanding of the mechanisms behind weather and climate. During the last 150 years, mathematicians have made an increasing use of geometry to quantify the qualitative behaviour of dynamical systems. In this talk, I shall review the history of the interplay between calculus and geometry in the development of the theory of dynamical systems, and I shall go on to describe how we use geometry in data assimilation, and in ensemble forecasting, to incorporate qualitative concepts into quantitative numerical models.