21 NOVEMBER 2001 : DYNAMICS OF THE ATMOSPHERIC CIRCULATION: CLASSIC PAPERS AND THEIR MESSAGE FOR TODAY

Prof A Thorpe, NCAS, University of Reading - The Origins of Circulation, Vorticity and Potential Vorticity in Meteorology - a.j.thorpe@reading.ac.uk

Two lines of thinking concerning fluid rotation - using either vorticity or circulation - emerged from the work of Helmholtz (1858) and Kelvin (1867) respectively. Vilhelm Bjerknes introduced an extension of Kelvin's ideas on circulation into geophysics. In this talk an historical perspective will be given on what has become known as the "Bjerknes Circulation Theorem". Vilhelm Bjerknes wrote several papers on this topic, the first being in 1898. As Bjerknes noted, a Polish physicist Ludwik Silberstein had previously published an equivalent result concerning vorticity generation in 1896. In his 1898 paper Bjerknes describes many possible applications of the theorem to meteorology and oceanography including to extratropical cyclones, a subject that made his "Bergen School" famous. The connection to the introduction of potential vorticity by Rossby and Ertel will also be discussed.

Dr A Simmons, ECMWF - Rossby, C-G (1945) on the Propagation of Frequencies and Energy in Certain Types of Oceanic and Atmospheric Waves - J Meteor, 2, 187-204 - naa@ecmwf.int

Rossby's 1945 paper discusses how a localized perturbation of the atmosphere can be expected to give rise to an increasing number of new waves to the east of the seat of the initial disturbance. It identifies a process by which a disturbance generated by baroclinic instability may weaken and trigger downstream development of new baroclinic waves, and by which error in the initial conditions of a numerical weather forecast may spread downstream and likewise be amplified by baroclinic instability. Generalizations of Rossby's barotropic wave theory have provided further insights into the behaviour of baroclinic waves in the growing, mature and decaying stages of their life cycles, and identified barotropic as well as baroclinic processes as fundamental limiters of deterministic predictability in middle latitudes. Conversely, barotropic wave propagation away from a region of anomalous tropical forcing provides a mechanism for anomalous and potentially predictable mid-latitude conditions on the seasonal timescale. The presentation will introduce Rossby's paper, discuss its initial impact and subsequent theoretical advances, illustrate the basic downstream development process, and present examples of how today the ideas stemming from the paper are still applied in explaining atmospheric behaviour and in helping to improve atmospheric prediction.

Dr D Andrews, University of Oxford - Propagation of planetary waves: Charney and Drazin, forty years on - andrews@atm.ox.ac.uk

The paper "Propagation of Planetary-Scale Disturbances from the Lower into the Upper Atmosphere" by J. G. Charney and P. G. Drazin (1961) (J. Geophys. Res., 66, 83--109) pioneered the study of the vertical propagation of planetary (Rossby) waves. It also

introduced or clarified several other important ideas in atmospheric dynamics, and has been the starting-point for numerous further studies of planetary-wave propagation, wave-mean interaction and troposphere-stratosphere coupling. It still receives large numbers of citations in the literature. The present talk will outline the main ground-breaking points of the paper and will mention various extensions that have been carried out over the past 40 years, including some of topical interest.

Dr I James, University of Reading - Negative Viscosity and the Global Circulation: The Influence of the Victor Starr School - i.n.james@reading.ac.uk

In the mid-twentieth century, the transport properties of a turbulent flow were often thought of as essentially diffusive, and attempts to parametrise turbulence in terms of an 'eddy viscosity', by analogy with the kinetic theory of gases, became widespread. Victor Starr and his co-workers used this language to analyse the newly available global upper air data, and to interpret the processes maintaining the atmospheric global circulation. They realised that transports of angular momentum in many geophysical and astrophysical contexts were often up-gradient rather than down-gradient. Starr coined the term 'negative viscosity' and began to see it as a ubiqitous phenomenon in the atmosphere, on the Sun and even on the galactic scale. We no longer use the language of eddy viscosity. But we do recognise the fundamental role of transient eddies in the global circulation, and we have developed some ideas of how the paradigm of Rossby wave propagation can lead to up-gradient transports of momentum and angular momentum. But the Starr dream of parametrizing these effects in a simple formula has proved elusive, and we have to acknowledge that understanding, rather than merely simulating, the dynamical transports by transient eddies is still an unachieved aim.

Prof S Mobbs, University of Leeds - Gravity Waves and Rotors - stephen@env.leeds.ac.uk

Although early ideas (theoretical and laboratory) concerning gravity waves date back to the 19th century, real appreciation of their existence in the atmosphere only began during the 1930s, with the exploration of lee waves using gliders. During the 1930s and in the early post-war years, study of gravity waves included a wide range of related phenomena of practical interest, including rotors which have significant implications for flight safety. Curiously, since the 1950s, almost no advances have been made in the understanding or prediction of rotors. Only in the last few years has attention been turned back to research into rotor phenomena. In the intervening 40 or more years, much of the early physical insight has been neglected. This talk will show how in spite of huge advances in observational and computational technology, the rotor studies from the 1930s and 1950s can still have a significant role in modern studies. Some ideas as to why gravity-wave studies turned away from rotor phenomena will also be discussed.

Dr P Read, University of Oxford - Laboratory Experiments On Sloping Convection and the General Circulation: a 'Philosophers' Stone' or a 'Storm in a Teacup'? - p.read@atm.ox.ac.uk

For more than 120 years (starting with the intriguing and far-sighted early experiments of Prof. Dr Vettin of Berlin in the 1880s), laboratory experiments on thermal convection in a rotating, differentially-heated fluid have been a source of insight and inspiration in the study of fluid motion in atmospheres, oceans and planetary interiors. Such experiments came into their own in the late 1940s and lent significant credibility to the early work of Eady and Charney on the linear stability of baroclinic jets. They were also a major source of inspiration to workers such as Ed Lorenz in the 1960s and 1970s in their pioneering development of prototypical models of low-dimensional periodic and chaotic behaviour (as may be seen, for example, in Lorenz's recent book 'The Essence of Chaos').

In this presentation we will review some of this early work and discuss its most significant findings in the light of contemporary developments in the theory of baroclinic instability, atmospheric predictability and the general circulation. The talk will conclude with a brief outlook on more recent work (which has concentrated e.g. on understanding mechanisms for low-dimensional chaotic motion and validating numerical modelling techniques) and outstanding questions for the future.