

# ROYAL METEOROLOGICAL SOCIETY: AUSTRALIAN BRANCH MEETING

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## Air Parcel Trajectories over the Oceanic Tropics

A. H. Gordon

Mr Gordon began with a brief history of his involvement with Lagrangian ideas, including recollections of a memorable quote by Scorer:

No theory is so sacrosanct that it cannot be challenged,  
No idea is so outrageous as to be discarded out of hand.

He then continued with a digest of various Eulerian methods of assessing balance between wind and pressure, proceeding rapidly from the geostrophic equation through the use of the vorticity equation to quasi-geostrophic theory.

Returning to Lagrangian coordinates, Mr Gordon outlined a model for determining parcel trajectories over the tropical oceans. This is essentially an analytical model that assumes a constant synoptic pressure pattern, Coriolis force, and coefficient of friction in its derivation, then uses a numerical time stepping procedure to allow some variation of these parameters. Major restrictions on the model include the maintenance of a constant pressure field and constraint of all trajectories to horizontal surfaces.

A further interesting constraint obtained from the analytical solutions was the conservation of so-called ageostrophic K.E., i.e., given an initial ageostrophic component  $u_0' v_0'$ , then  $u'v'$  at any time was constrained such that

$$u'^2 + v'^2 = u_0'^2 + v_0'^2.$$

Mr Gordon followed with a presentation of some of his results, examples of constant level balloon trajectories over the Indian Ocean, and a preview of some results from a P.E. trajectory model treatment of the Indian summer monsoon at NCAR. He also described how a number of synoptic events, such as the summer monsoon rainfall of India and Australia, could be explained using Lagrangian techniques.

In summary, Mr Gordon stated that the major use of Lagrangian techniques was that they provide information on the actual air flow, its upstream history, and response to the pressure field, and claimed that their use could give a valuable insight into many atmospheric processes in the tropics.

Opening the question time, Dr Zillman commented that he had been fascinated by the work of Johnson and McRth some ten years ago, which had been branded heretical by some but had nevertheless given some understanding of particle flow in the tropics. Mr Gordon agreed that the technique was interesting but criticised it for being too qualitative in nature.

While supporting the use of Lagrangian techniques Mr Bell considered that, since the model assumed a constant pressure field, a streamline analysis would give the same results. Mr Gordon replied that streamline analyses were too inaccurate and could not duplicate trajectories because of initialisation. Mr Clarke commented that there were well developed objective streamline analysis techniques. Mr Clarke also questioned the need for such a crude estimate of friction in the model, especially since one can go straight to numerical methods, without the necessity for an analytical model.

Dr Smith and Mr Holland expressed reservations that pressure observations in the tropics were accurate indicators of pressure fields on a synoptic scale, especially in poor data areas, and commented that sea breezes, diurnal effects, and even local cumulus can cause pressure variations of the same order as the normal gradient

Answering a question by Dr Wells, Mr Gordon agreed that the main reason for the poor performance of numerical models in the tropics lay in the difficulties of initialisation and balance.

Returning to the maintenance of a constant pressure field, Dr Zillman commented that the pressure must adjust to the wind field as well as vice versa and questioned incorporation of such a severe restriction. Mr Gordon replied that it was possible both to change the pressure field at each time step or to incorporate a variable pressure gradient in the primitive equations in the form of any tractable analytical function desired, but this had not yet been attempted. Mr Holland then referred to the restriction of horizontal flow, especially in the region of the monsoonal trough, and asked if an isentropic analysis might not be more suitable. In reply Mr Gordon noted that it was difficult to get sufficient observations for an isentropic analysis, a technique that was unreliable due to diabatic effects.

G.J.H.