ROYAL METEOROLOGICAL SOCIETY: AUSTRALIAN BRANCH MEETING

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Tropical Cyclone Modification: A Vortex Adjustment Problem

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The first part of this talk consisted of a review of Project Stormfury, the United States Government's tropical cyclone modification program. Satellite pictures and photos taken on aircraft penetrations into cyclones were used to illustrate the main structural features of tropical cyclones, and graphs of data taken on Stormfury research flights were used to define the major dynamical properties.

The bulk of the talk was a presentation of some of Dr Smith's own recent research relevant to the physical mechanisms of cyclone modification. The basic idea behind Stormfury is to seed with silver iodide to promote the growth of convective cloud in certain regions of the cyclone. The resultant latent heat release and mass redistribution changes the storm structure and correspondingly is hypothesised to reduce the maximum tangential wind speed.

Dr Smith investigates the theoretical background for such a process by considering the response of a simple one-layer model axisymmetric vortex to the presence of a constant mass sink. He uses the observed fact that in the cyclone (above the boundary layer) the tangential wind is to a good approximation in cyclostrophic balance with the radial pressure gradient.

Equations are set up for a constant density fluid with a free upper surface. Friction is set to zero, and an initial state is assumed with no radial motion but with a prescribed radial distribution of tangential velocity. Mass is extracted at a constant rate according to a distribution function $\rho\, S(r)\, dr$, and the response of the fluid is investigated under the constraint that hydrostatic and cyclostrophic balance be maintained. This problem has some similarities to the classical Rossby geostrophic adjustment problem. In the Rossby problem a system is perturbed to put it out of balance, and the primitive equations are used to investigate the adjustment back towards the balanced state. In the current problem, on the other hand, a perturbation is applied continuously but a balanced state is assumed right through the adjustment process.

The analytic solution shows that the tangential wind increases with time outside the radius at which mass is removed and decreases with time inside that radius. It also shows, however, that the effect inside the seeding radius is an order of magnitude or more smaller than the effect outside that radius.

The model is extended to two-layer and three-layer vortices with the same conclusion that the centrifugal stability of the flow inhibits radial motion inside the seeding radius. It is thus difficult to bring about a

significant radial adjustment of the cyclone's inner core region and, in particular, a significant change in the maximum tangential velocity by a stimulus (i.e. the removal of mass) outside the core.

Dr Smith pointed out that when the US Stormfury program was initiated in the early 1960s, it was based on a hypothesis all the physics of which are included in his analytical study. The results of his paper demonstrate, therefore, that such a modification strategy is unlikely to be effective in reducing the maximum wind speeds. The current strategy of the Stormfury project is to seed rainbands just outside the inner core region. This would cause the inflowing air to ascend at a larger radius, and thus by partial conservation of angular momentum would mean a reduced maximum tangential wind. Since the inflow near the inner core of a tropical cyclone is believed to be frictionally driven, the physics of this modified hypothesis are not included in Dr Smith's model. He hinted, though, that research on the extension to the frictional case is currently in progress.

J. McB.