P2.28

Evolution of Hurricane-like Eyewall Structures Using a Divergent, Normal-Mode, Spectral Model

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The Model

Model based on shallow water equations in rotational form:

$$\frac{\partial u}{\partial t} - (f+\varsigma)v + \frac{\partial}{\partial x}\left[\phi + \frac{1}{2}(u^2+v^2)\right] = \mu\nabla^2 u$$

$$\frac{\partial v}{\partial t} + (f+\varsigma)u + \frac{\partial}{\partial y}\left[\phi + \frac{1}{2}(u^2+v^2)\right] = \mu\nabla^2 v$$

$$\frac{\partial \phi}{\partial t} + c^2\left(\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y}\right) + \frac{\partial (u\phi)}{\partial x} + \frac{\partial (v\phi)}{\partial y} = \mu\nabla^2 \phi$$

Solution Technique:

- Equations solved using the normal mode method presented in Guinn and Schubert (1993)
- Method allows easy partitioning of rotational and gravity-inertia modes

Model Details

- 600km x 600km doubly periodic domain
- 512 x 512 collocation points (170 modes)
- Ordinary diffusion with e-folding damping time of 60min for modes w/total wave number 170
- Undisturbed fluid depth of 2,000m giving $c \cong 140 \text{ms}^{-1}$
- $f = 5 \times 10^{-5} s^{-1}$, or ~20°N

Objective

Replicate classic non-divergent model hurricane-like eyewall simulations using a divergent (shallow-water), normal-mode model then partition linear terms into rotational and gravity-inertia modes to quantify the relative contribution of each.

Cases

Case 1: Ivan-like eyewall (Henricks et al, 2010)
Case 2: Annulus (Schubert et all, 1999)
Case 3: Kirchoff Vortex

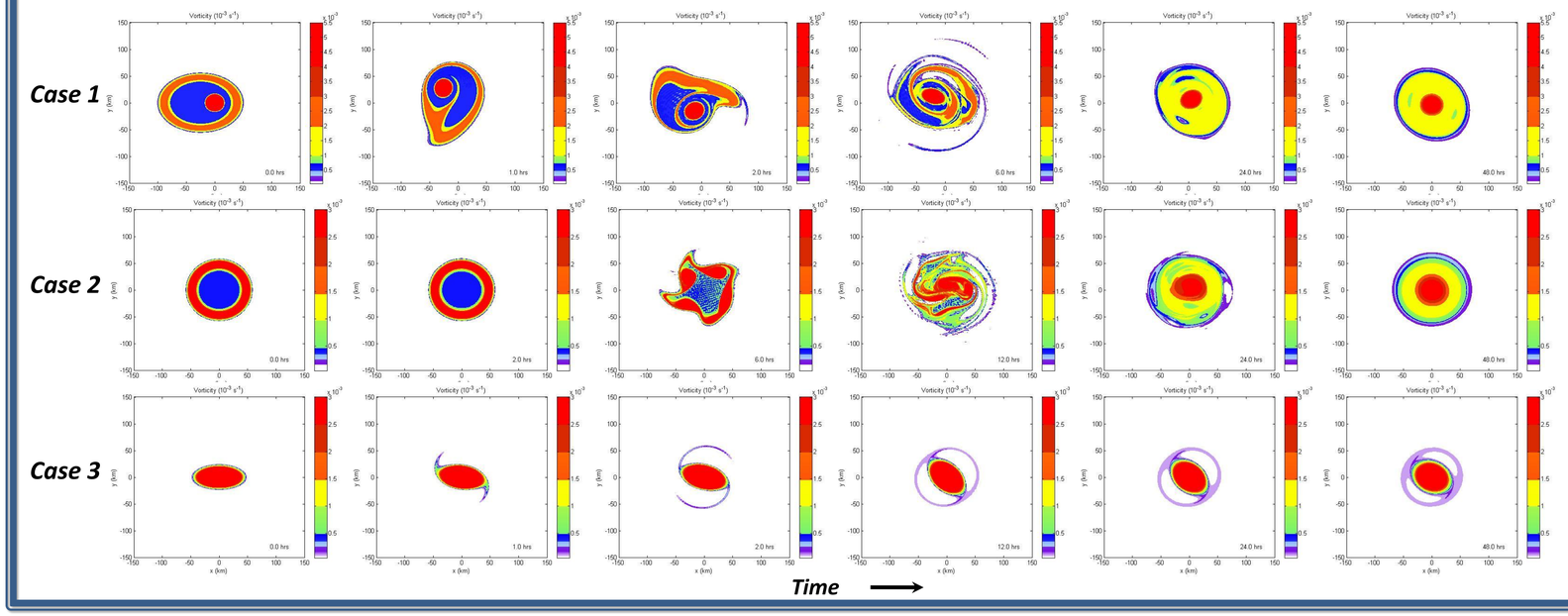
References:

Guinn, T.A., and W.H. Schubert, 1993: Hurricane spiral bands. *J. Atmos. Sci.*, **50**, 3380-3403.

Schubert, W.H., M.T. Montgomery, R.K. Taft, T.A. Guinn, S.R. Fulton, J.P. Kossin, and J.P. Edwards, 1999: Polygonal eyewalls, asymmetric eye contraction, and potential vorticity mixing in hurricanes. *J. Atmos. Sci.*, **56**, 1197-1223.

Hendricks, E.A., W.H. Schubert, S.R. Fulton, and B.D. McNoldy, 2010: Spontaneous-adjustment emission of intertia-gravity waves by unsteady vertical motion in the hurricane core. *Quart. J. Roy. Meteor.Soc.*, **136**, 537-548.

Vorticity 10^{-3} s^{-1}



Rotational/Gravity-Inertia Mode Contributions and Divergence