ATM S 442/504: Atmospheric Motions II

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FEB 7, 2014
Eady Model

Growth rates (imaginary part of frequency)

Stable for large wavenumbers, unstable for small wavenumbers

Wave speeds (real part of frequency divided by k)

Phase speed for unstable modes = mean flow speed at midtroposphere.
Eady Model of Baroclinic Instability

Most Unstable Mode (Growing)

Height (contours) & theta (colors)

Vorticity (contours) & w (colors)

Most Unstable Mode (Decaying)
Heat fluxes

Growing mode has heat flux poleward

Decaying mode has equatorward heat flux (upgradient!)
Observed Cyclogenesis
Observed Phase Tilts

Fig. 3. Pressure/longitude section showing trough positions of Atlantic low at 6-hourly forecast intervals up to hour 60 for the forecast from 1200 UTC 27 January 1994. Also shown are the surface pressures at the center of the low at 12-hourly intervals.
Cyclone Structure
Idealized Cyclogenesis

Rotunno et al. (2000)

\( \bar{u}, z/\varepsilon + \Theta \)

Isotachs

Isentropes
Idealized cyclogenesis
Non-QG Effects

Nonlinear baroclinic instability simulations with a QG model and with a primitive equations model

Stretching of relative vorticity amplifies cyclones and weakens anticyclones

(this is a non-QG effect – cyclones and anticyclones are symmetric in QG)