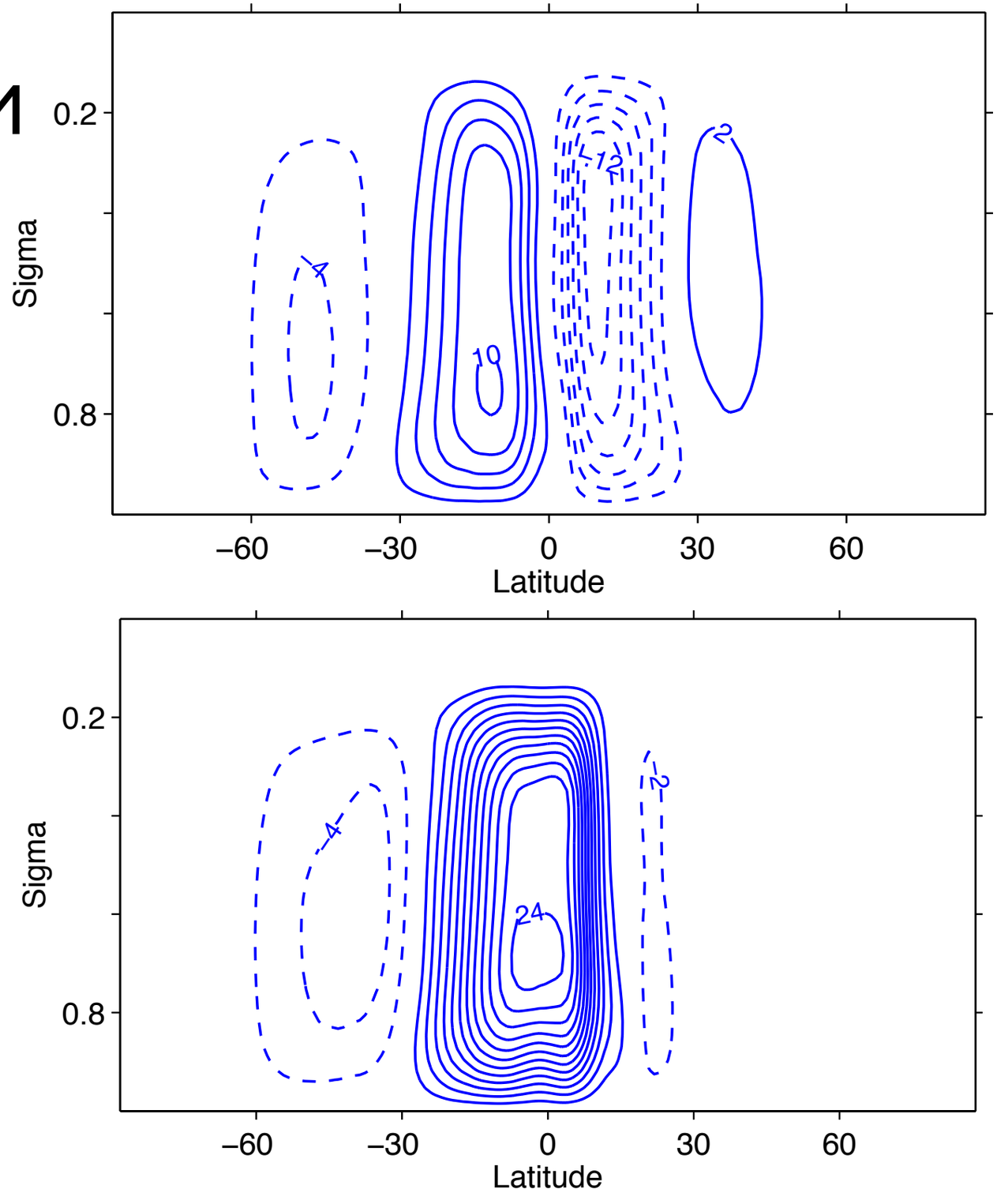
Course overview

- **Hadley-cell dynamics** for a zonally symmetric atmosphere and relation to monsoons
- **Internal gravity waves:** forcing by mountains, propagation, effect on mean flow
- **Quasigeostrophic dynamics:** potential vorticity, mechanism of Rossby waves, external mode and stationary waves, propagation of Rossby waves into the stratosphere
- **Wave activity and E-P fluxes:** relation to surface westerlies, necessary conditions for baroclinic and barotropic instability
- **Growth of disturbances**: Instability of African Easterly Jet, Eady model, PV perspective on cyclogenesis
- **General circulation:** Eddies and the midlatitude surface westerlies, isentropic circulation and tracer transport

Hadley cells and monsoons

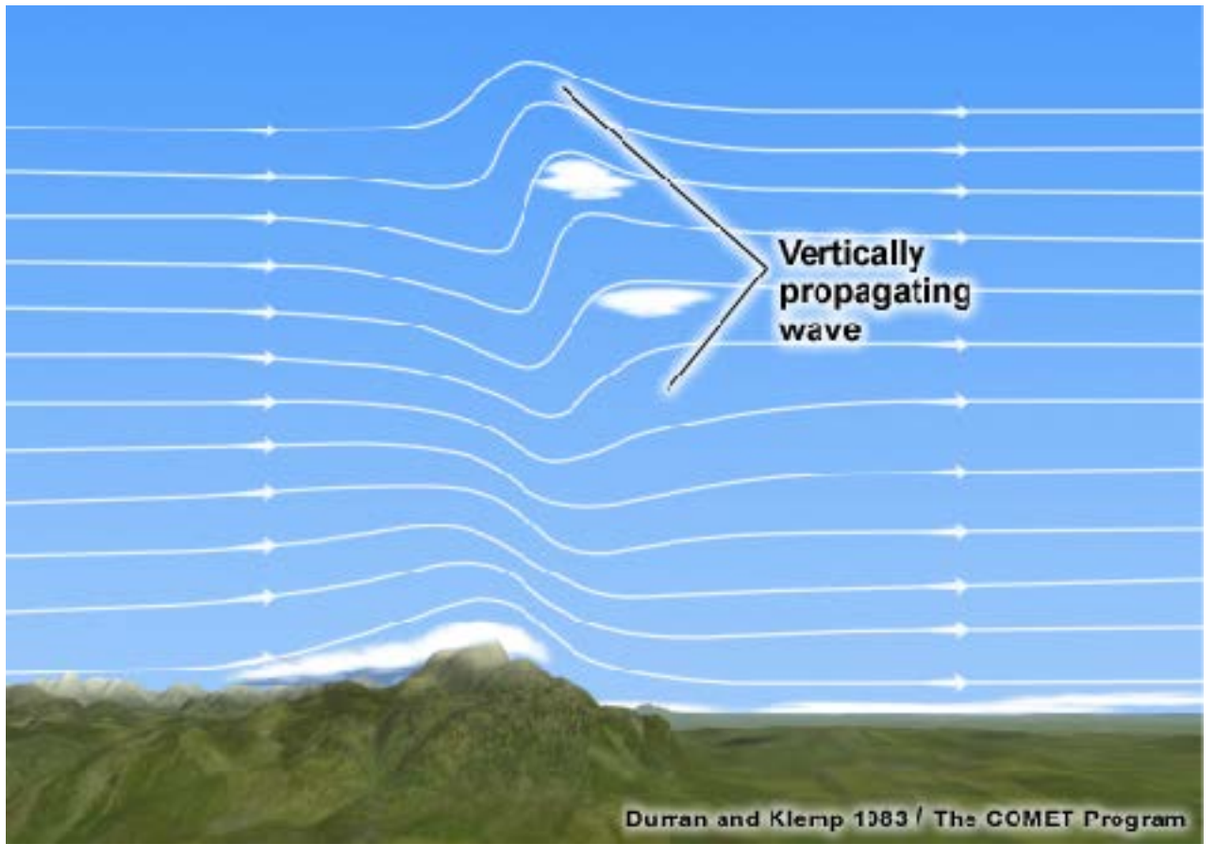
MAM



Hadley cell extent and strength constrained by angular momentum conservation and energy balance (eddies are also important)

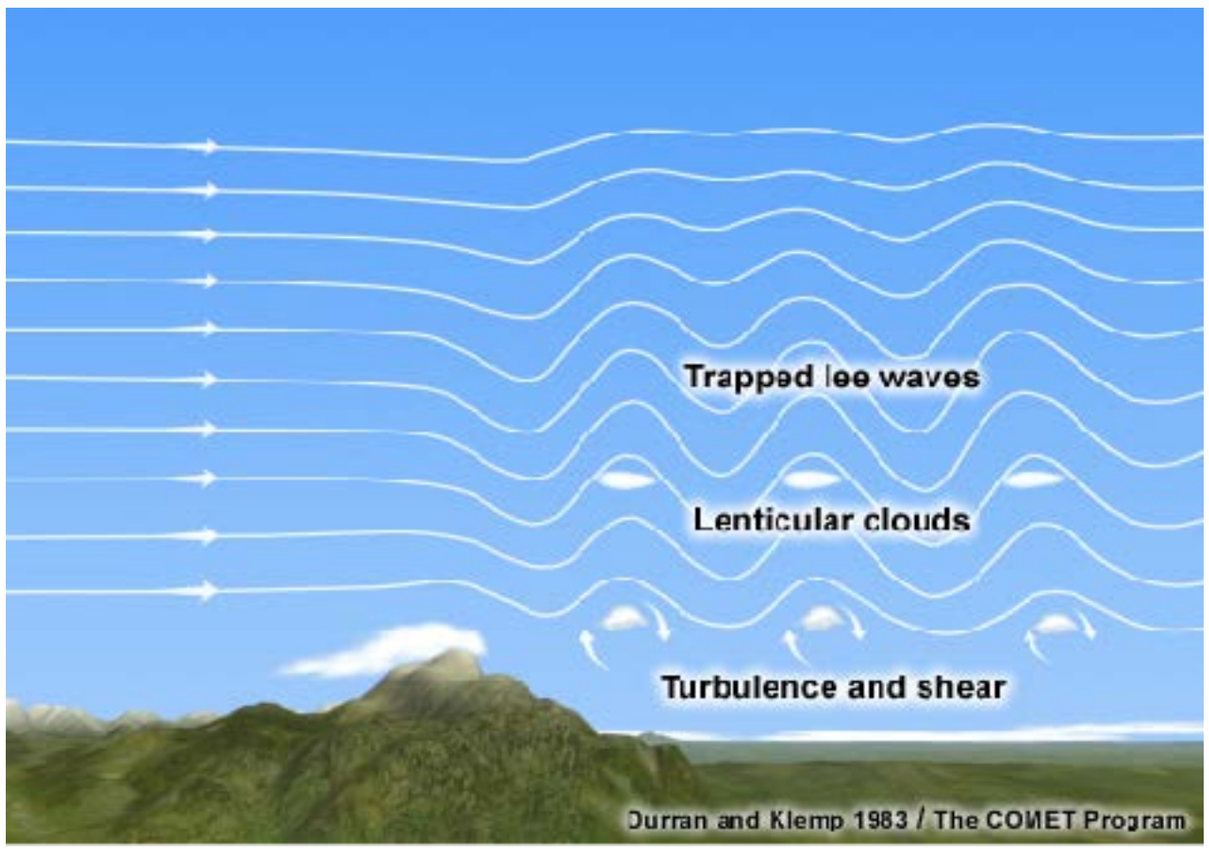
JJA

Difference between radiative equilibrium temperature and temperature implied by angular momentum
→ much stronger cross-equatorial cell



Internal gravity waves can be generated by flow over mountains

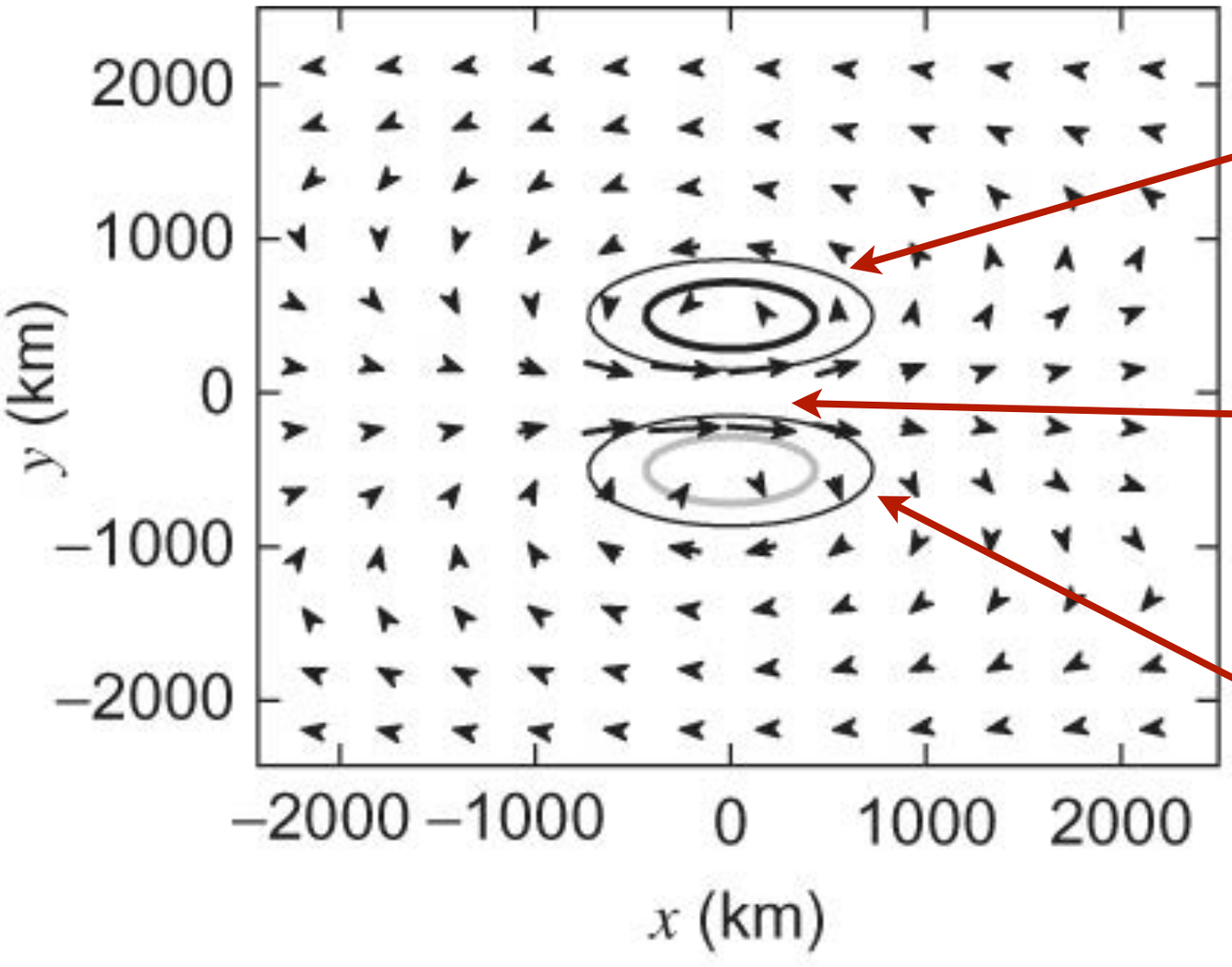
Propagate upwards if strong enough stratification, broad ridge, slow wind



Amplitude increases with height as density decreases

Interacts with mean flow when wave breaks and/or at critical level

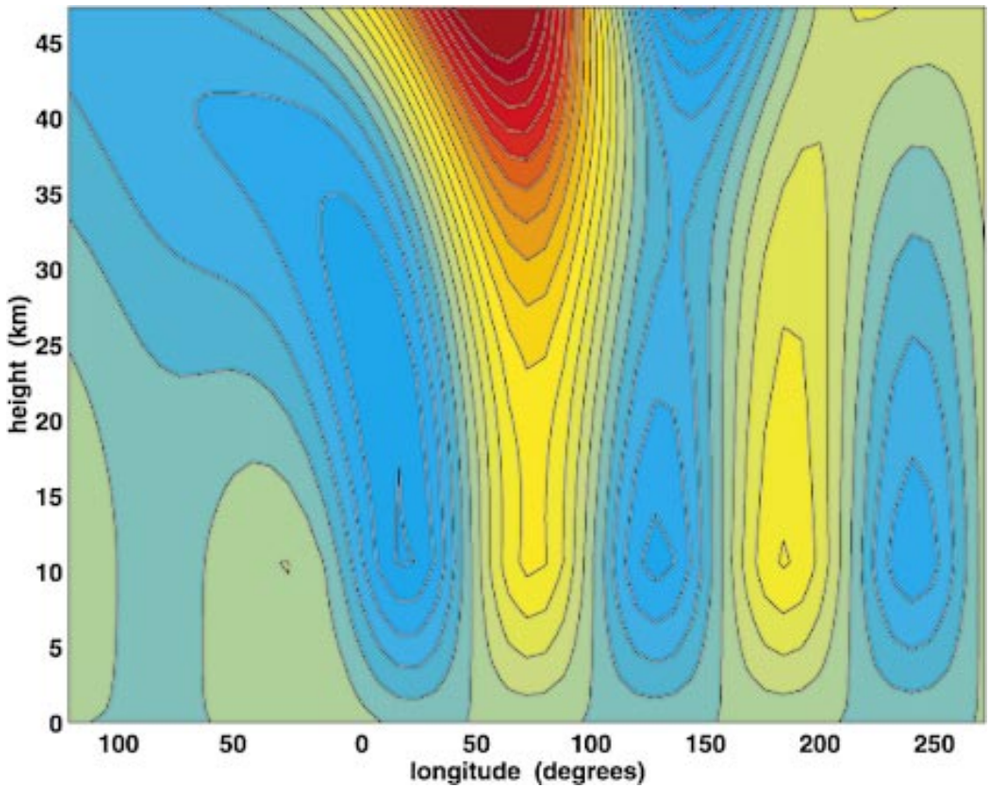
Use of potential vorticity to understand Rossby waves and jet streaks



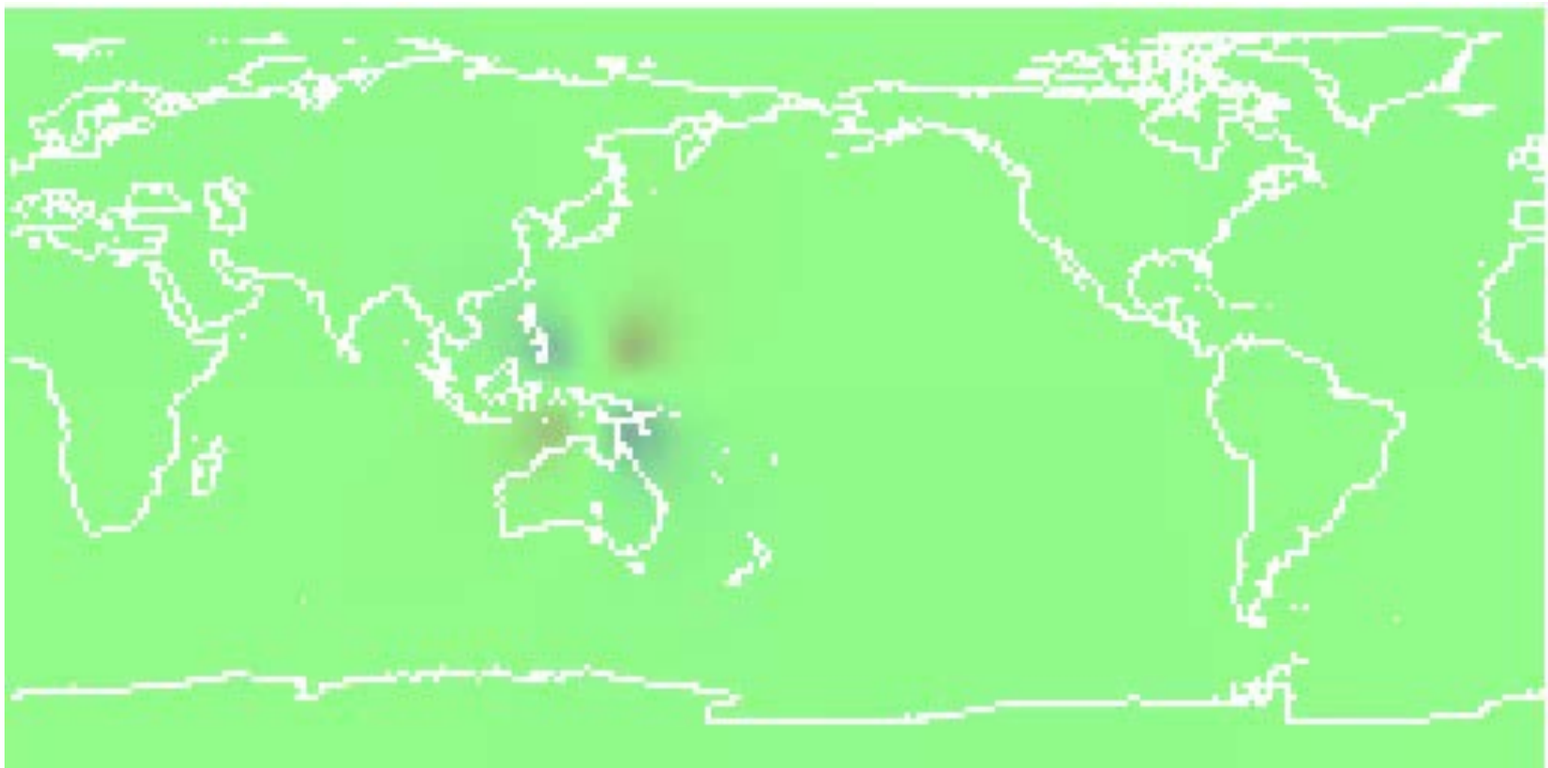
Arrows: wind induced by the PV anomalies
Lines: contours of PV

Holton and Hakim Fig 6.12

Stationary Rossy waves propagate upwards into stratosphere and also propagated horizontally in troposphere (external mode)



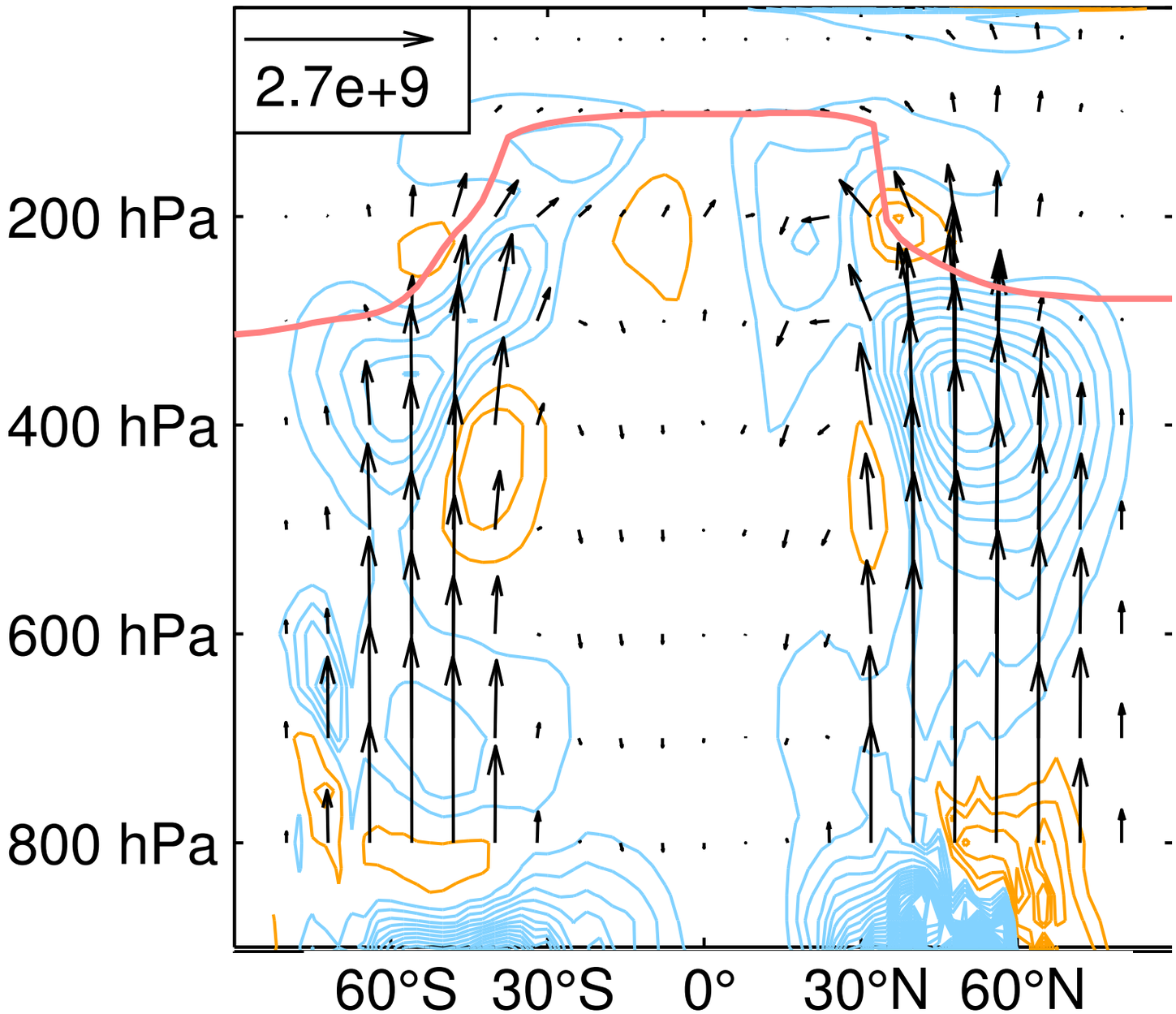
Held et al J. Climate 2002



Isaac Held blog

Image courtesy of Isaac Held. Used with permission.

Eliassen-Palm fluxes show propagation and sources/sinks of wave activity



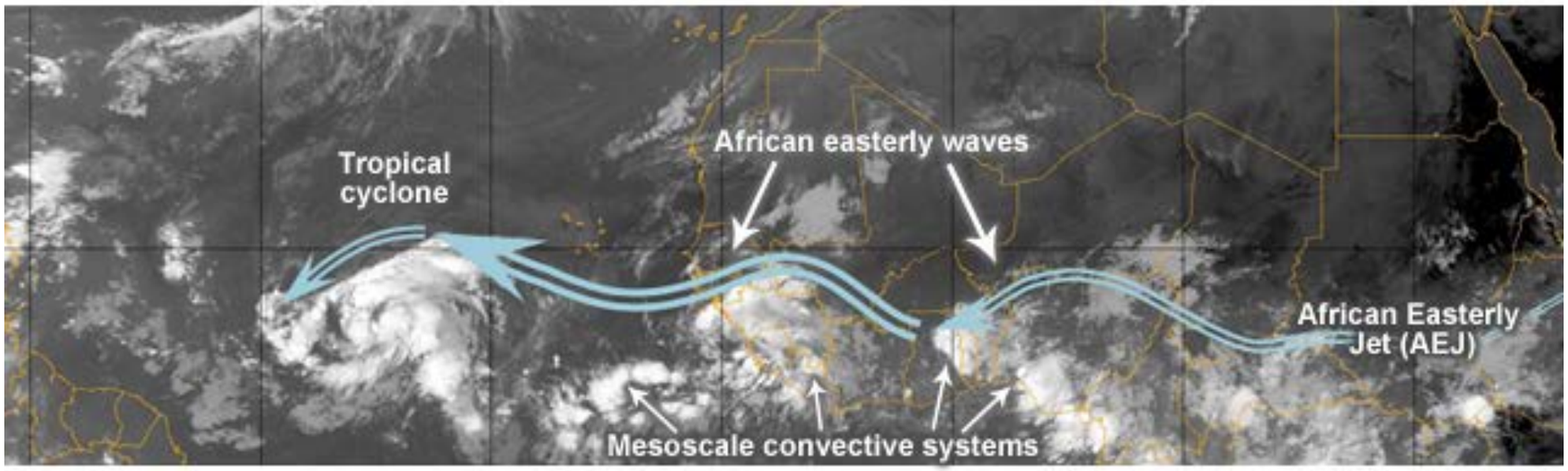
EP fluxes (arrows); orange is divergence, blue is convergence

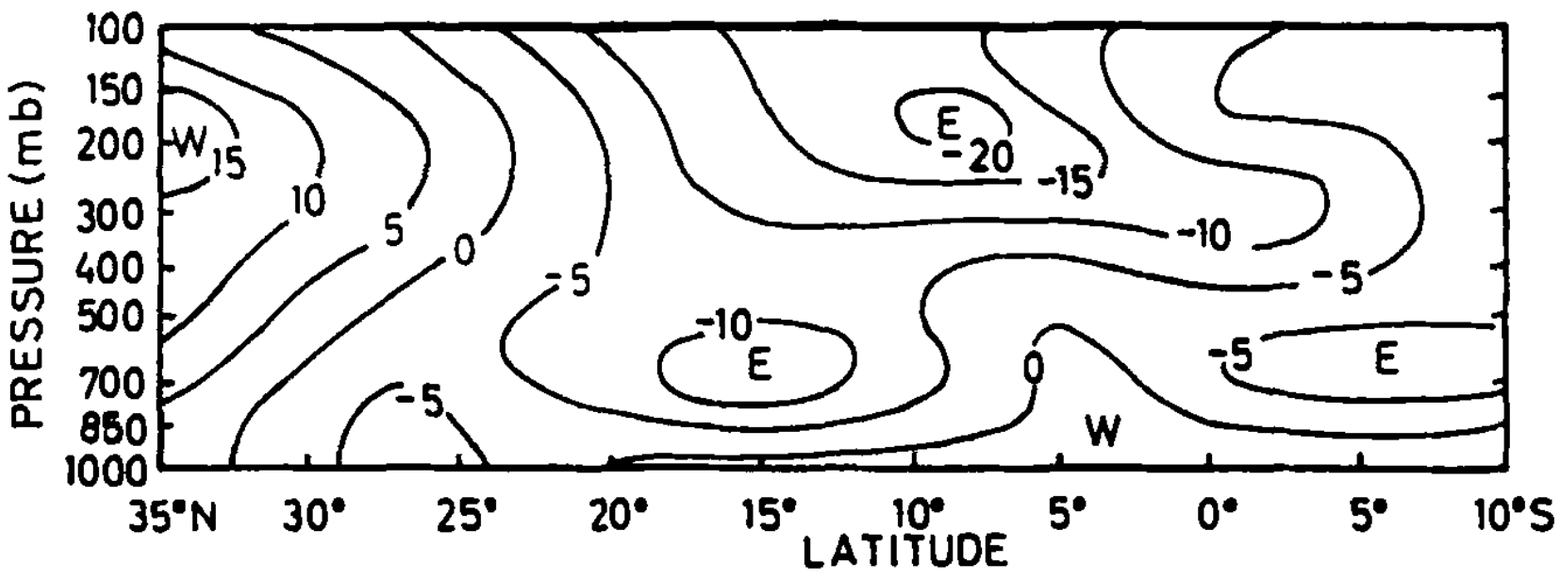
The reference arrow has units m^3s^{-2}. The contour interval is 75 m^2s^{-2}.

Red line is the tropopause. Based on ERA-interim 1980-2013. Figure courtesy John Dwyer.

Necessary condition for instability: change in sign of PV gradient or surface wind shear has same sign as PV gradient

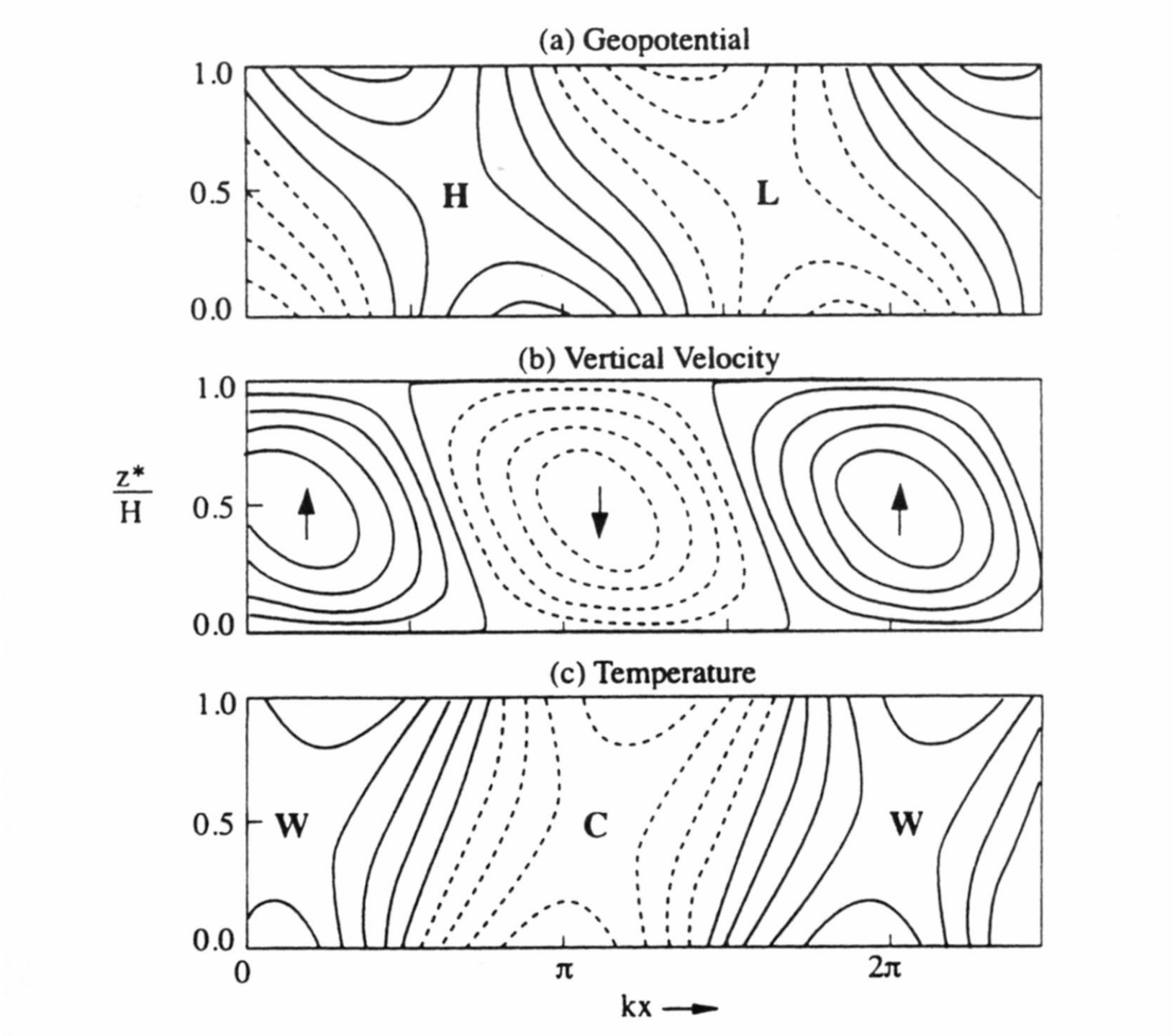
Instability of the African Easterly jet





Mean zonal wind at 5 degrees East in August
Hoskins & Thorncroft 1994

Baroclinic instability at midlatitudes: mechanism can be understood as interaction of counterpropagating Rossby waves (or edge waves)



Understand individual cyclogenesis events using potential vorticity

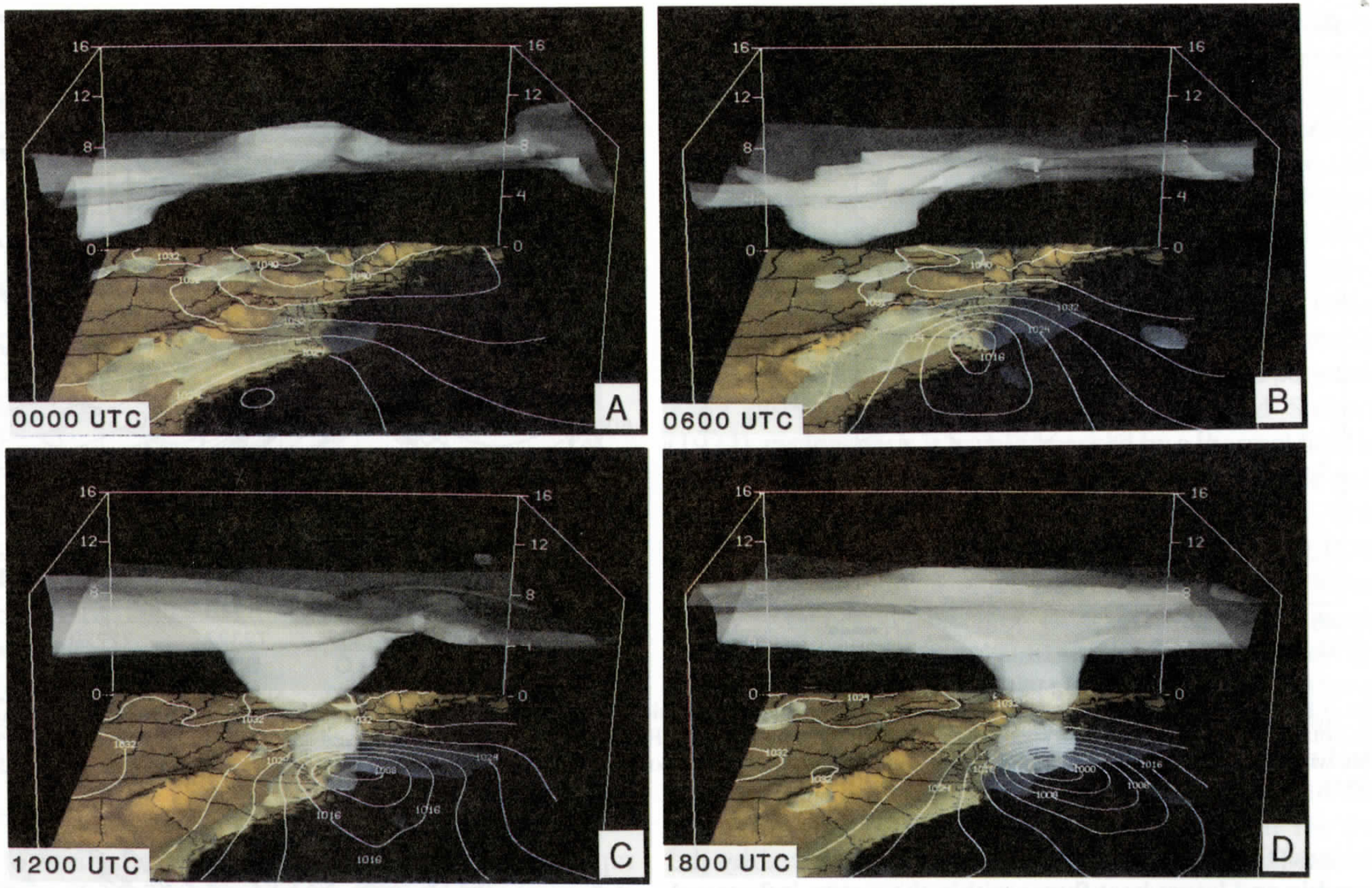
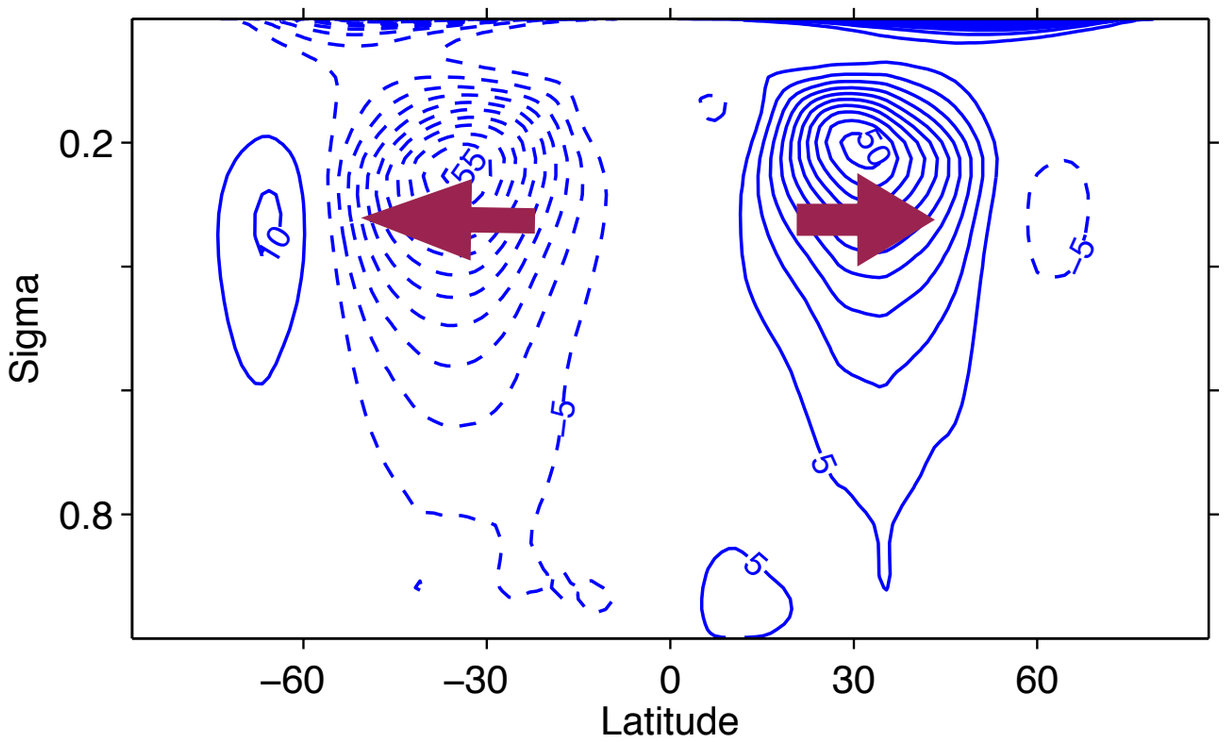
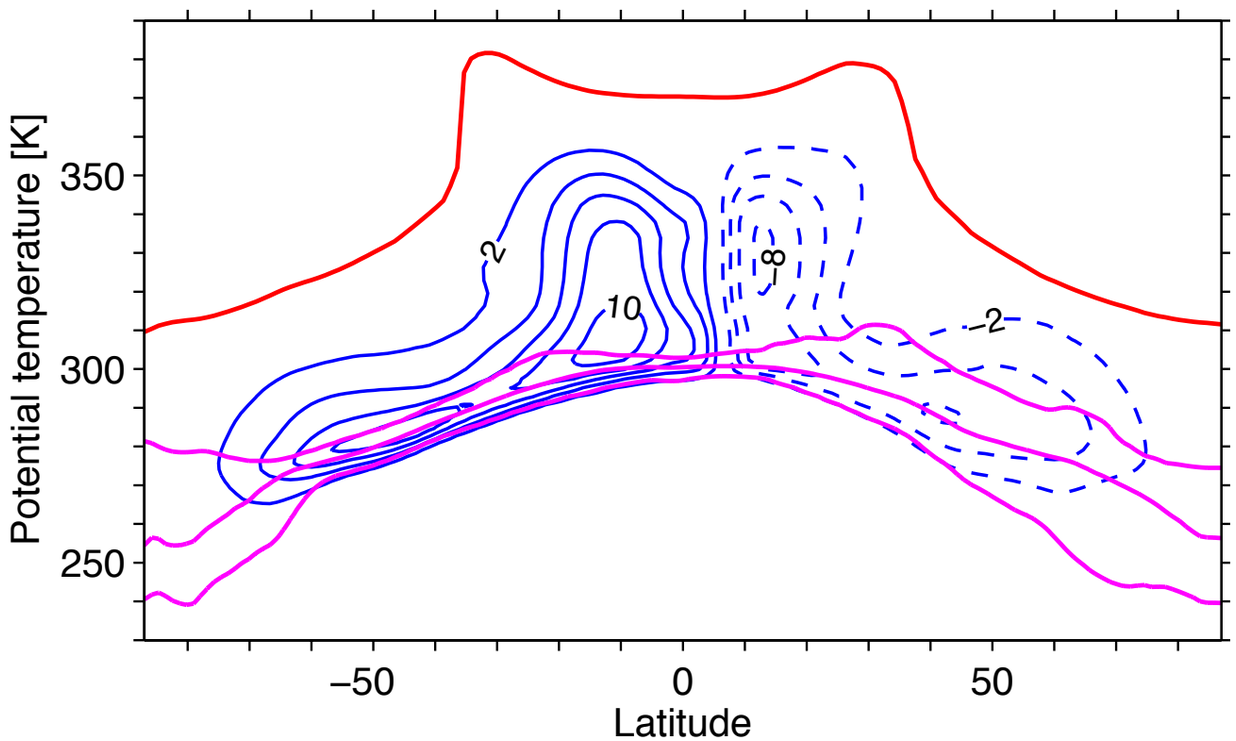


FIG. 6.12. Three-dimensional perspectives, as viewed from the south, of the 2×10^{-5} K mb^{-1} s^{-1} IPV surface, and sea-level pressure isobar pattern (mb) derived from the numerical simulation of the Presidents' Day cyclone of Whitaker et al. (1988) for (a) 00 UTC, (b) 06 UTC, (c) 12 UTC and (d) 18 UTC 19 February 1979. The three-dimensional perspectives were derived by William Hibbard using the University of Wisconsin, Space Science and Engineering Center, three-dimensional McIDAS system.



Zonal and time mean of $u'v'\cos(\text{lat})$ in m^2/s^2

Poleward eddy momentum fluxes lead to Ferrel cell and surface westerlies and also affect Hadley cell



Dry-isentropic mean meridional streamfunction (10^{10} kg s^{-1})

Different mean circulation in isentropic coordinates which has implications for tracer transport

Upcoming classes

12.901 (Fall 2023): Papers, Proposals, and Pathways

This seminar will build skills for writing scientific proposals and papers and facilitate investigation of career pathways. Topics covered include peer review process, scientific writing and graphics, proposal writing for grants and fellowships, and exploration of academic and non-academic careers.

Units: 2-0-3 (P/D/F)

Upcoming classes

12.901 (Fall 2023): Papers, Proposals, and Pathways

Student comments from previous years:

- Overview of writing and communicating in a scientific context (e.g., for making better papers and applications to grants) as well as better understanding of career options.

- A very good class that fills in some of the gaps on the practicalities of writing grants and considering jobs with an Atmospheric Science degree

- You talk about academic skills and topics, I found it very useful.

- I have a more thorough understanding of potential future career paths

- Lots of practical skills that I'm already using.

Please remember to do your class evaluations
(and have a great summer!)

12.810 Dynamics of the Atmosphere

Spring 2023