How solar heating of the lower stratosphere influences tropospheric climate

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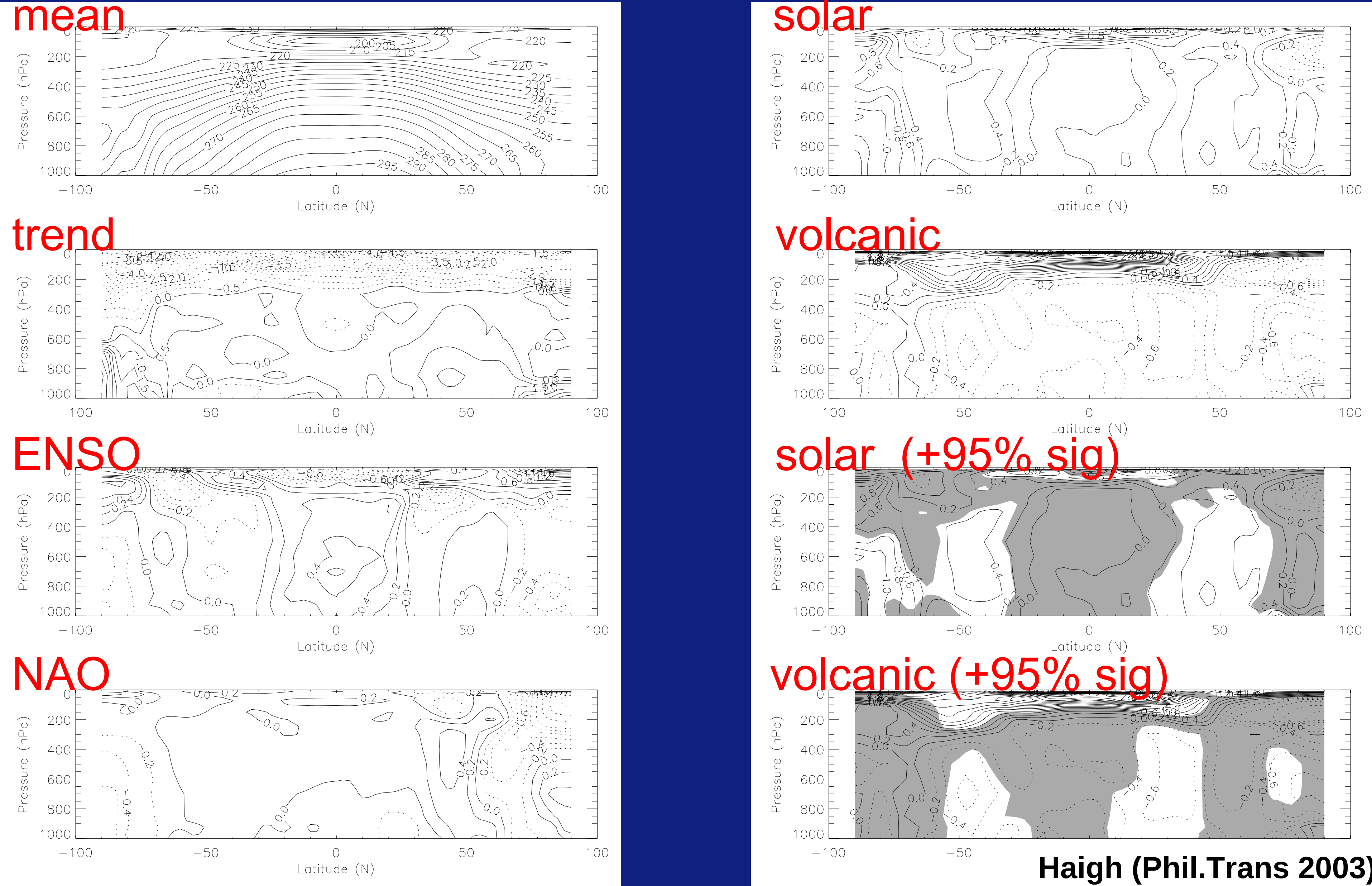
Multiple regression analysis: NCEP/NCAR zonal mean temperature



Haigh (Phil.Trans 2003)

Solar influence on zonal mean zonal wind

GCM simulation.

(a) Control run

(b) Difference between solar maximum and solar minimum.

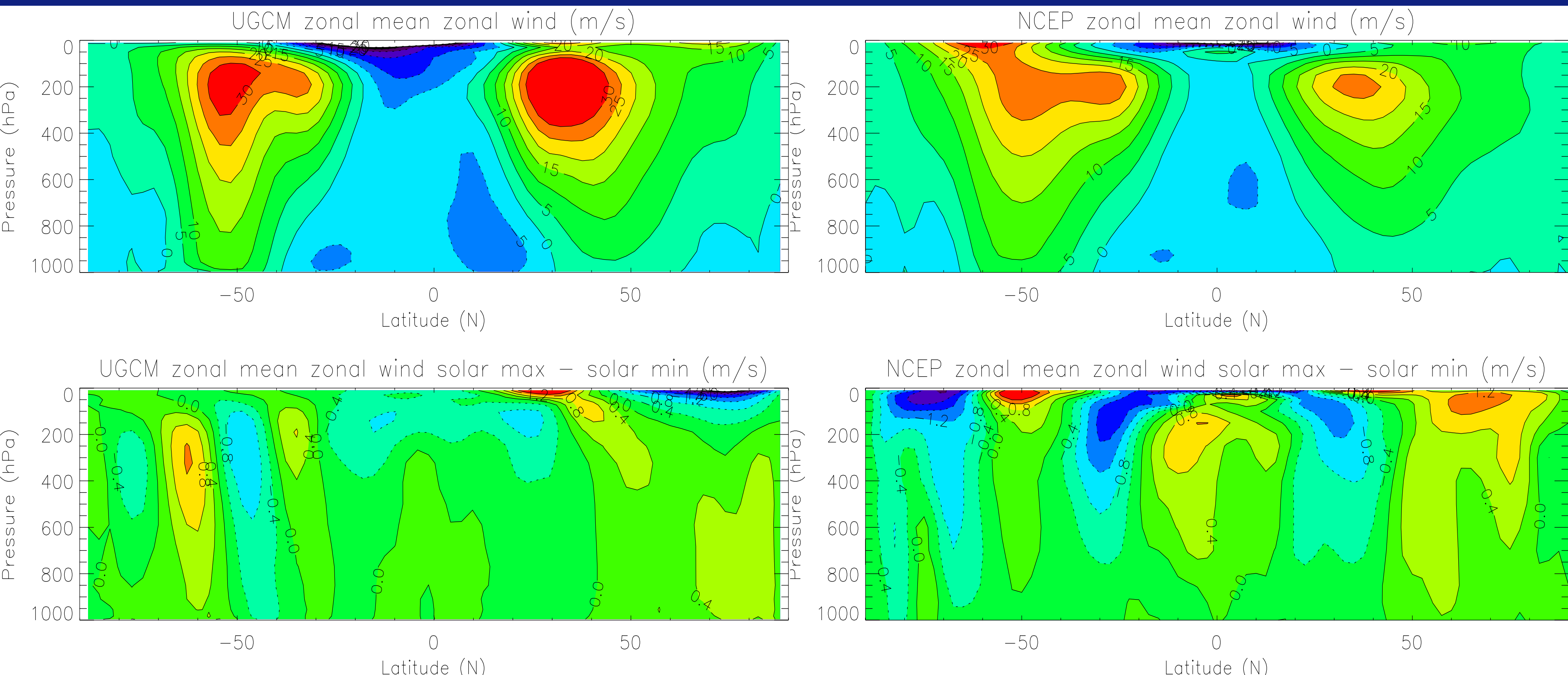
Haigh (*Science*, 1996)

Multiple regression analysis of NCEP Reanalysis data 1979-2002.

(a) Mean

(b) Component associated with solar 11-year cycle.

Haigh et al (*J.Clim.*, submitted 2004)



Potential mechanisms

- Increased static stability weakens tropical upwelling and Hadley cells

- Changes in u affect growth/propagation of planetary waves

- Baroclinic lifecycles modified

Simplified GCM experiments

Dynamical core of University of Reading spectral model:

- Full dynamics T42 L20. No orography.
- Newtonian cooling (equinoctal radiative equilibrium temperatures).
- Rayleigh friction.

Run C	Control: T_e distribution of Held and Suarez (1994).	10,000 days
Run U1	Stratospheric T_e (ONLY) increased uniformly by 1K.	10,000 days
Run E1	Stratospheric T_e (ONLY) increased by 1K at the equator, decreasing with $\cos^2$(latitude) to 0K at the poles.	10,000 days
Run U5	5K uniform increase in stratospheric T_e	1,000 days
Run E5	5K $\cos^2$ (lat) increase in stratospheric T_e	1,000 days

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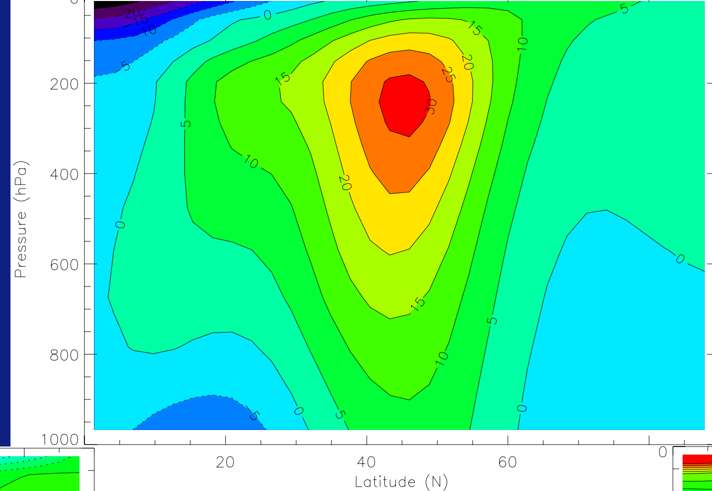
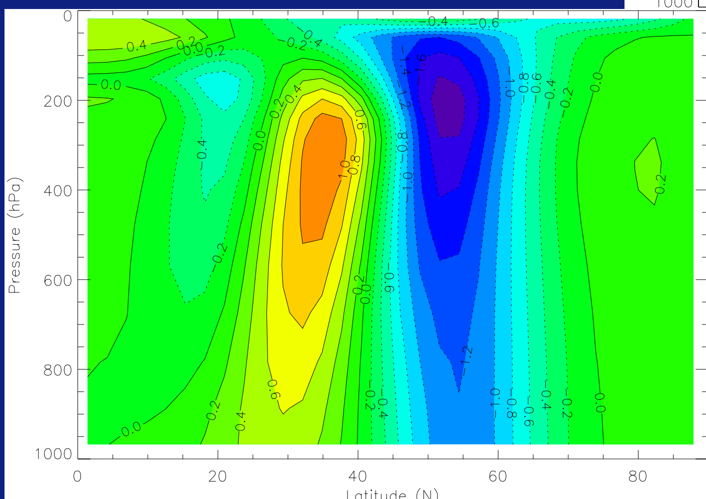
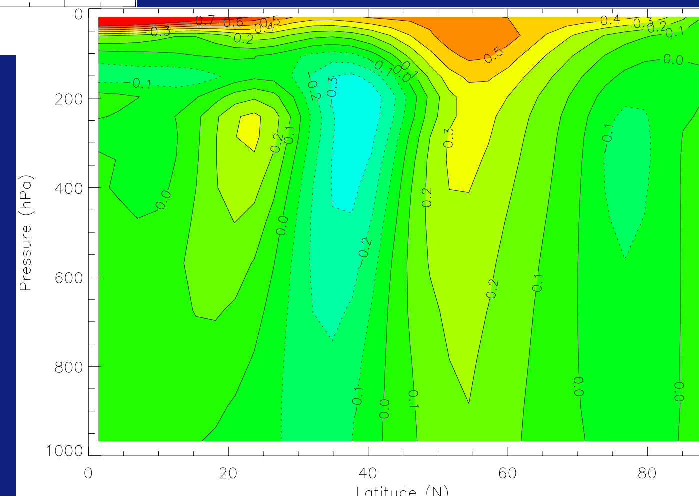
Simplified GCM experiments zonal wind



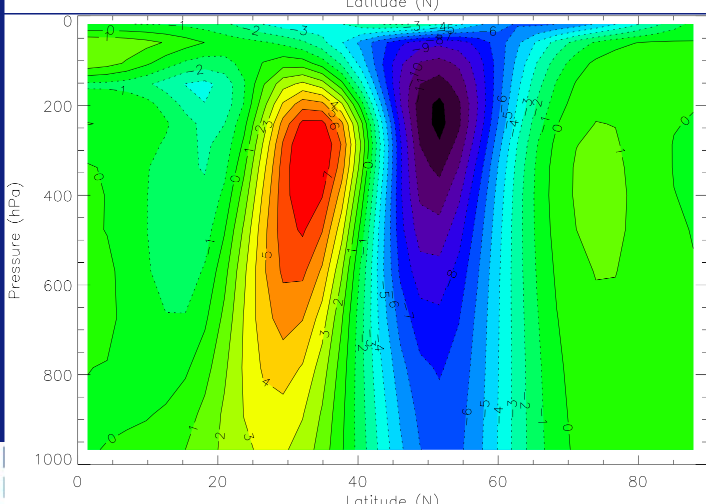
Run C



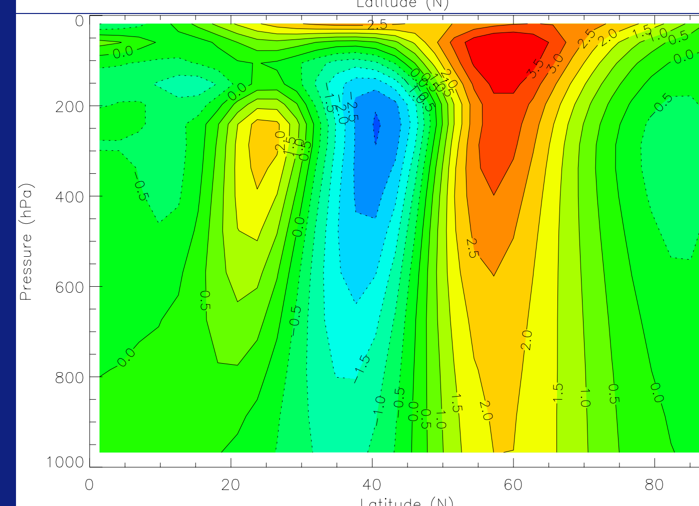
U1 – C



E1 – C



U5 - C

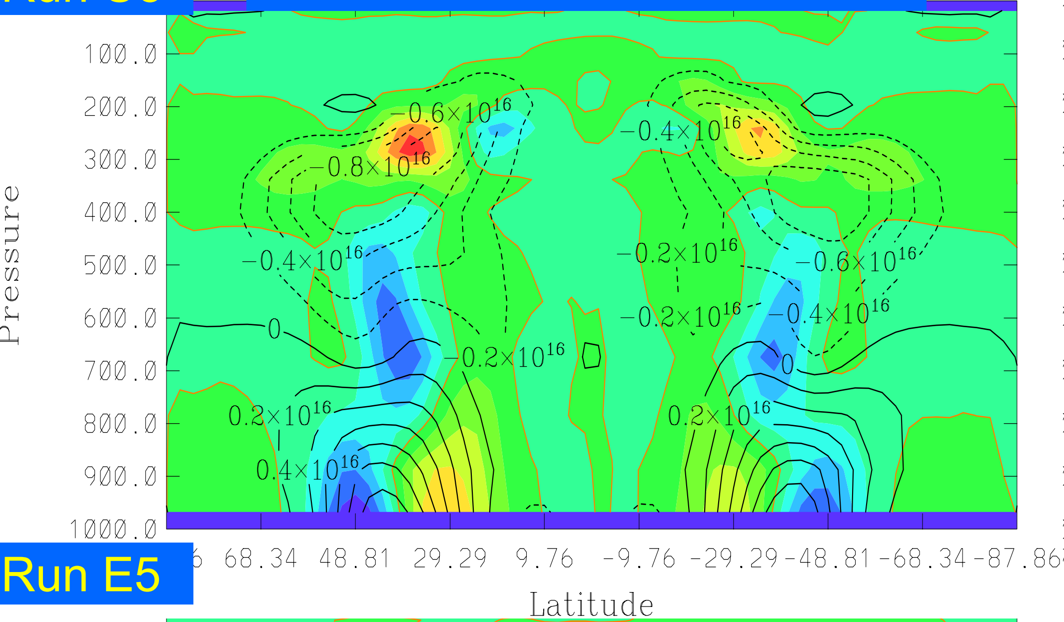


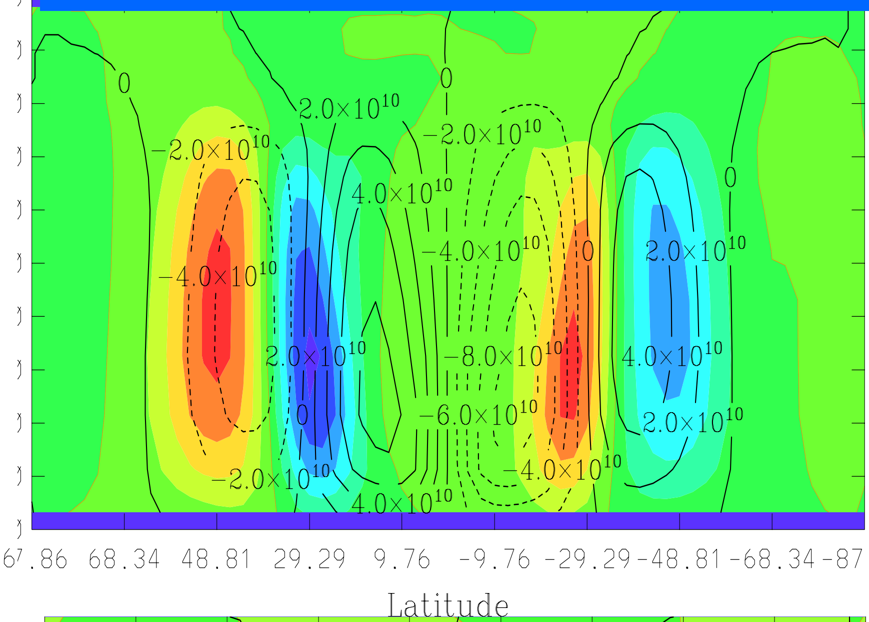
E5 - C

E-P flux divergence

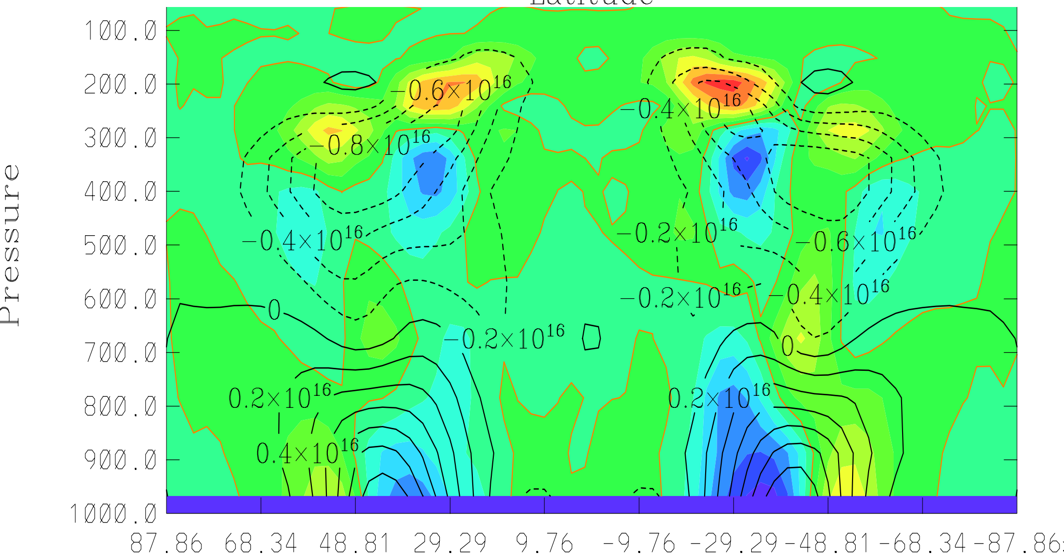
Mean meridional circulation

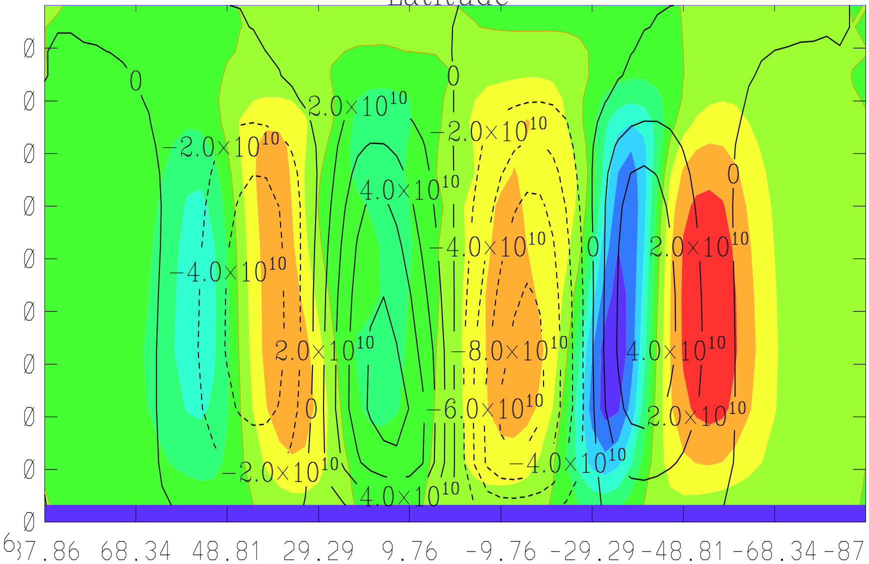
Run U5





Run E5





Contours: control run

Shading: anomaly

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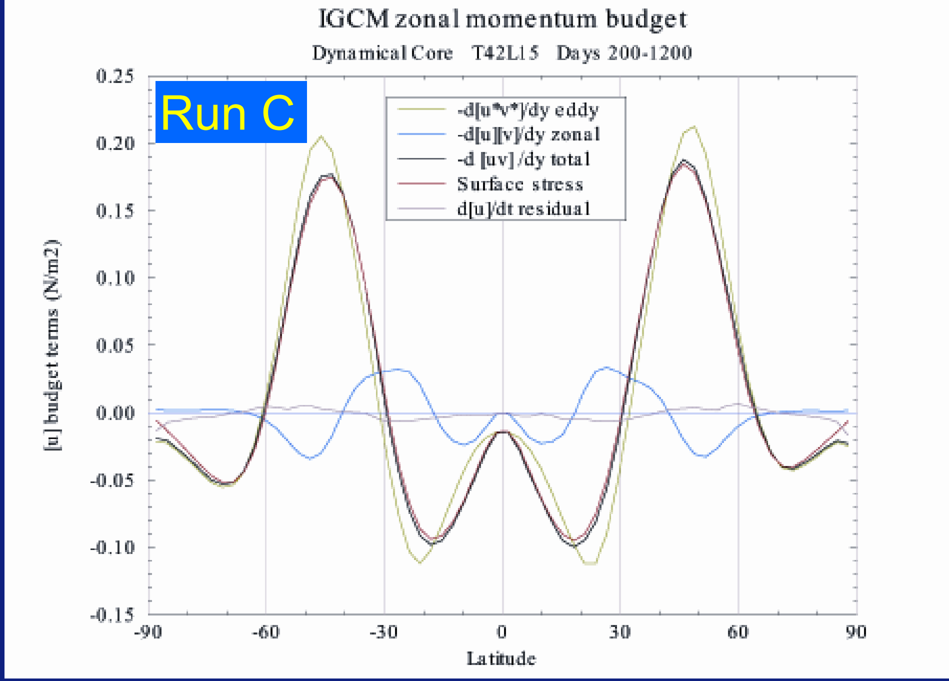
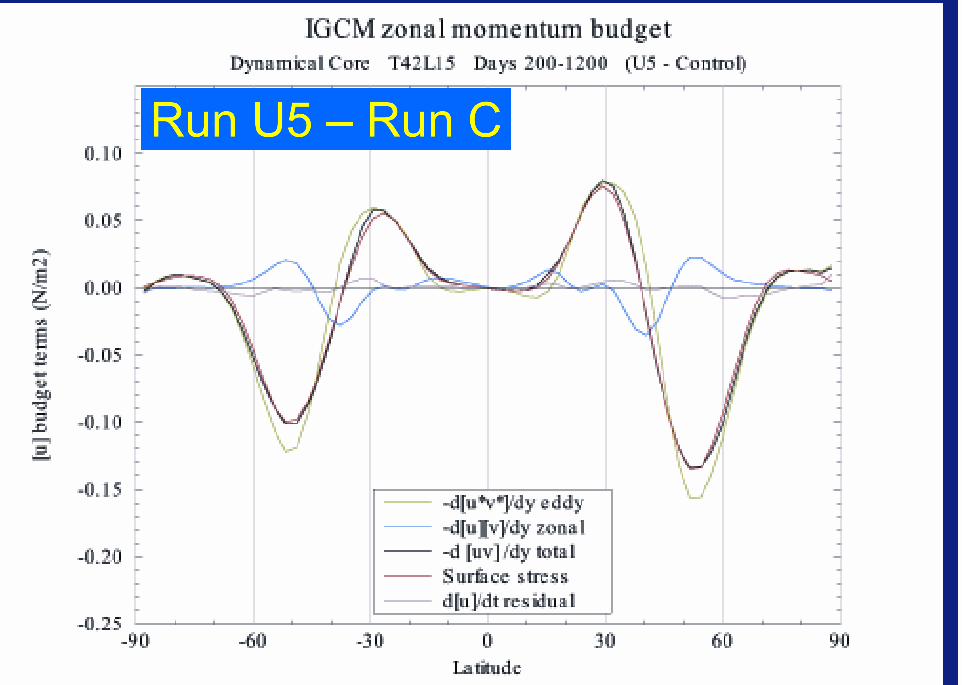
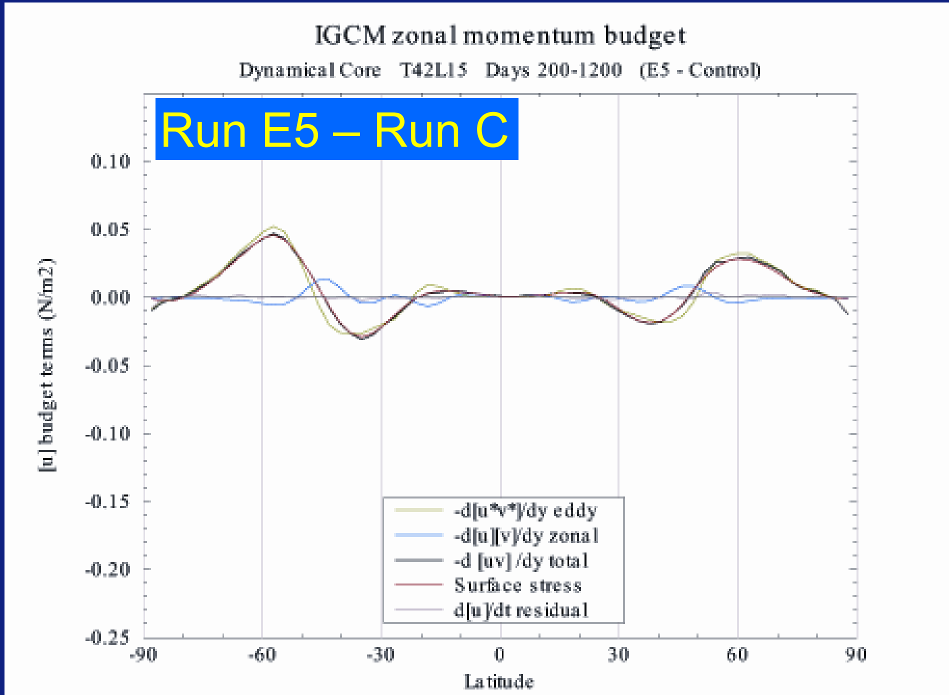
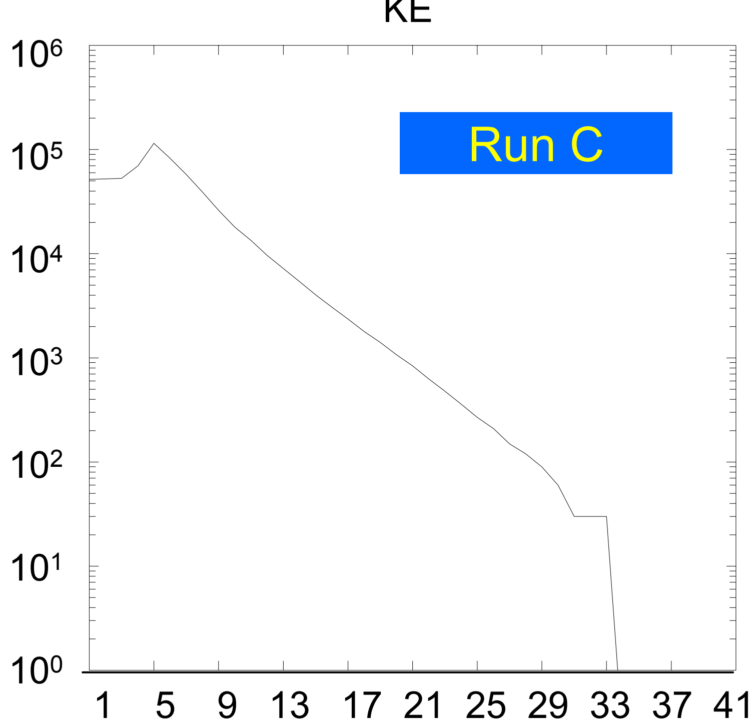
Vertically-integrated budget of zonal momentum

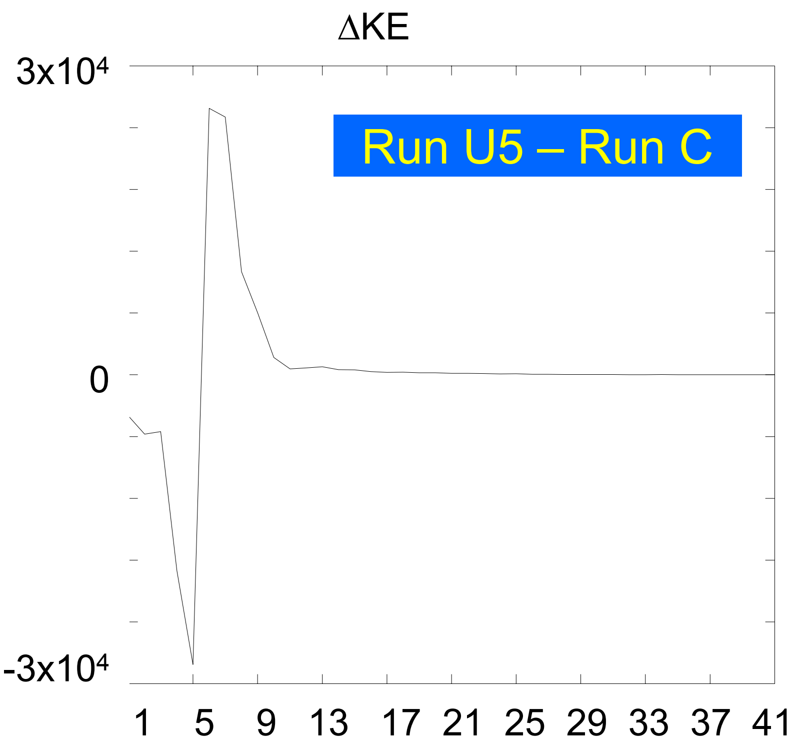


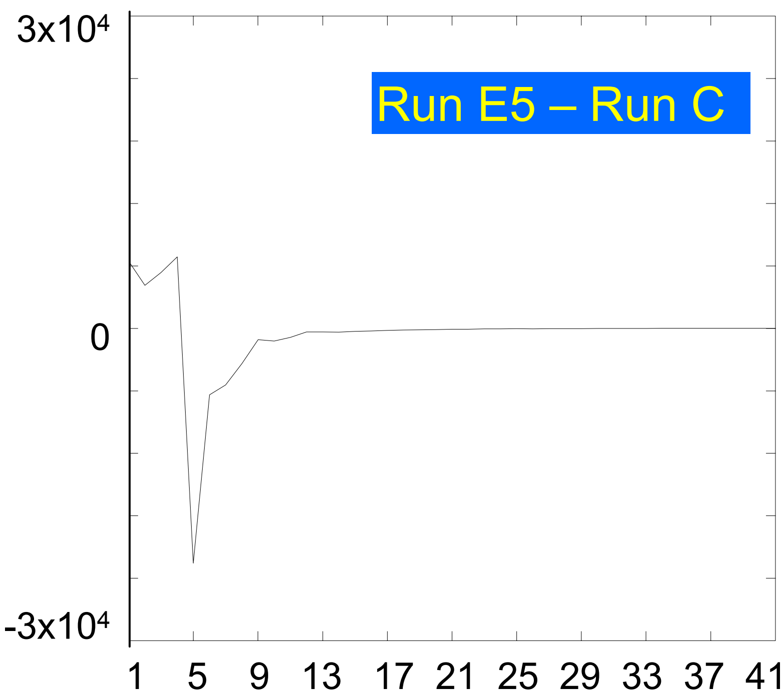




Spectrum of kinetic energy as a function of zonal wavenumber



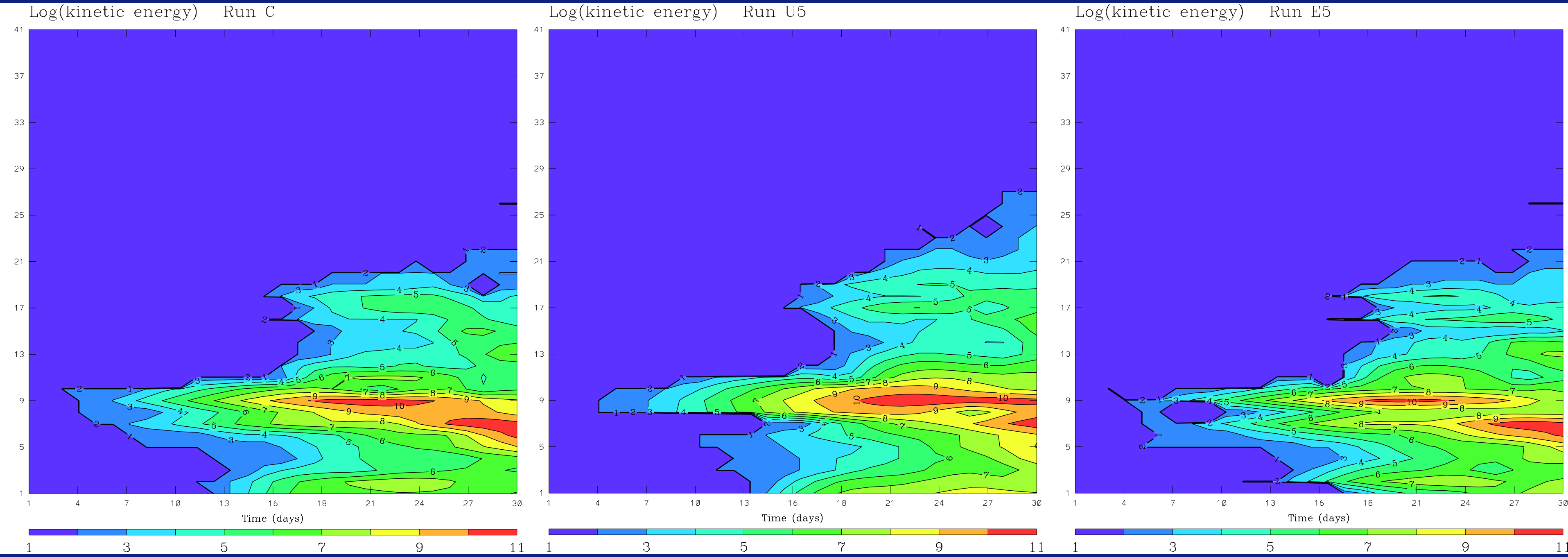




Baroclinic lifecycle experiments

Log$_e$(kinetic energy) as a function of time (days) and wavenumber during an adiabatic baroclinic lifecycle running under background conditions of:

Run C | Run U5 | Run E5



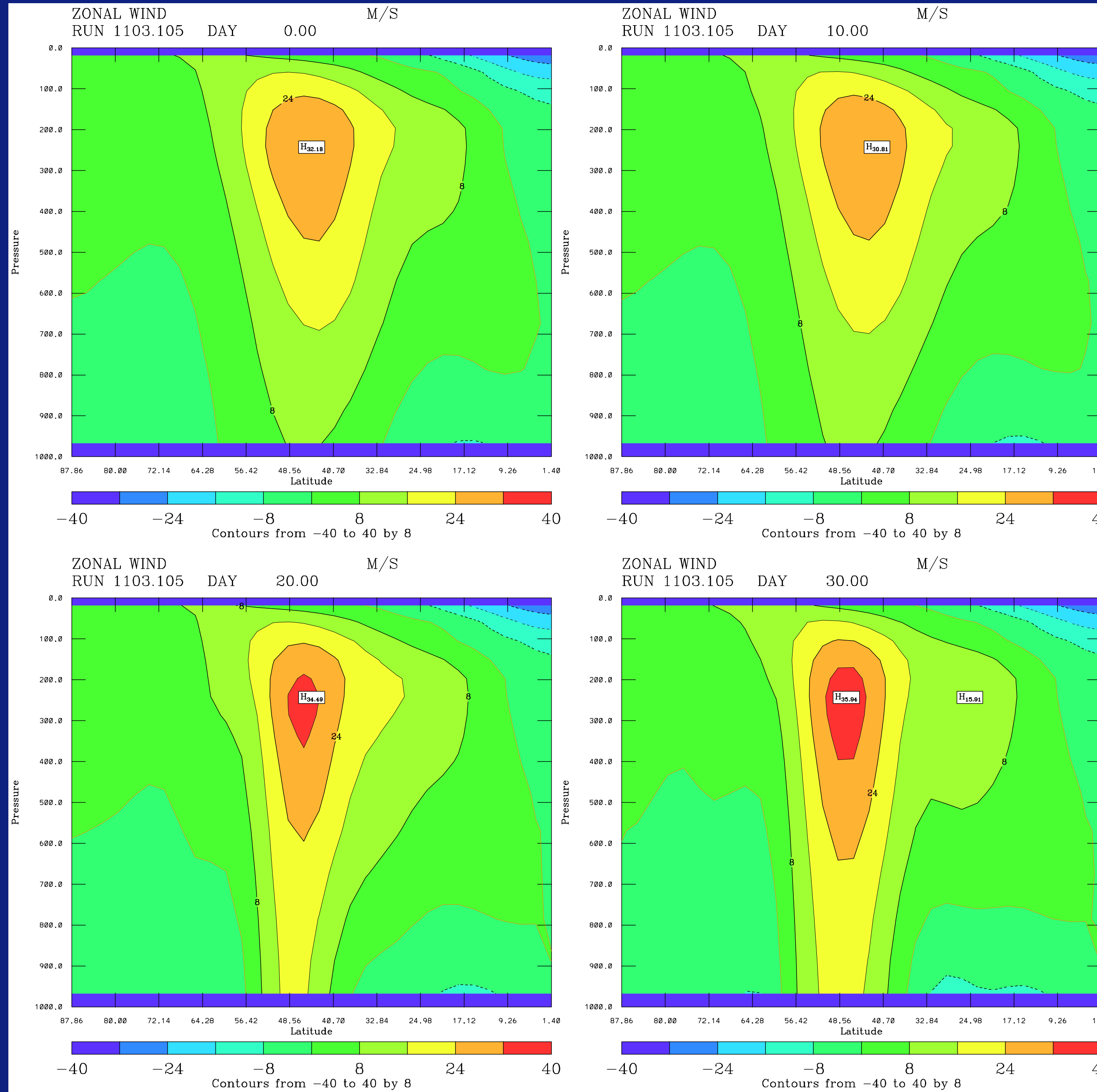
Zonal wind evolution during baroclinic lifecycle

Zonal mean zonal wind

(N. Hemisphere only)

at days 0, 10, 20, 30

under the background conditions of Run C.



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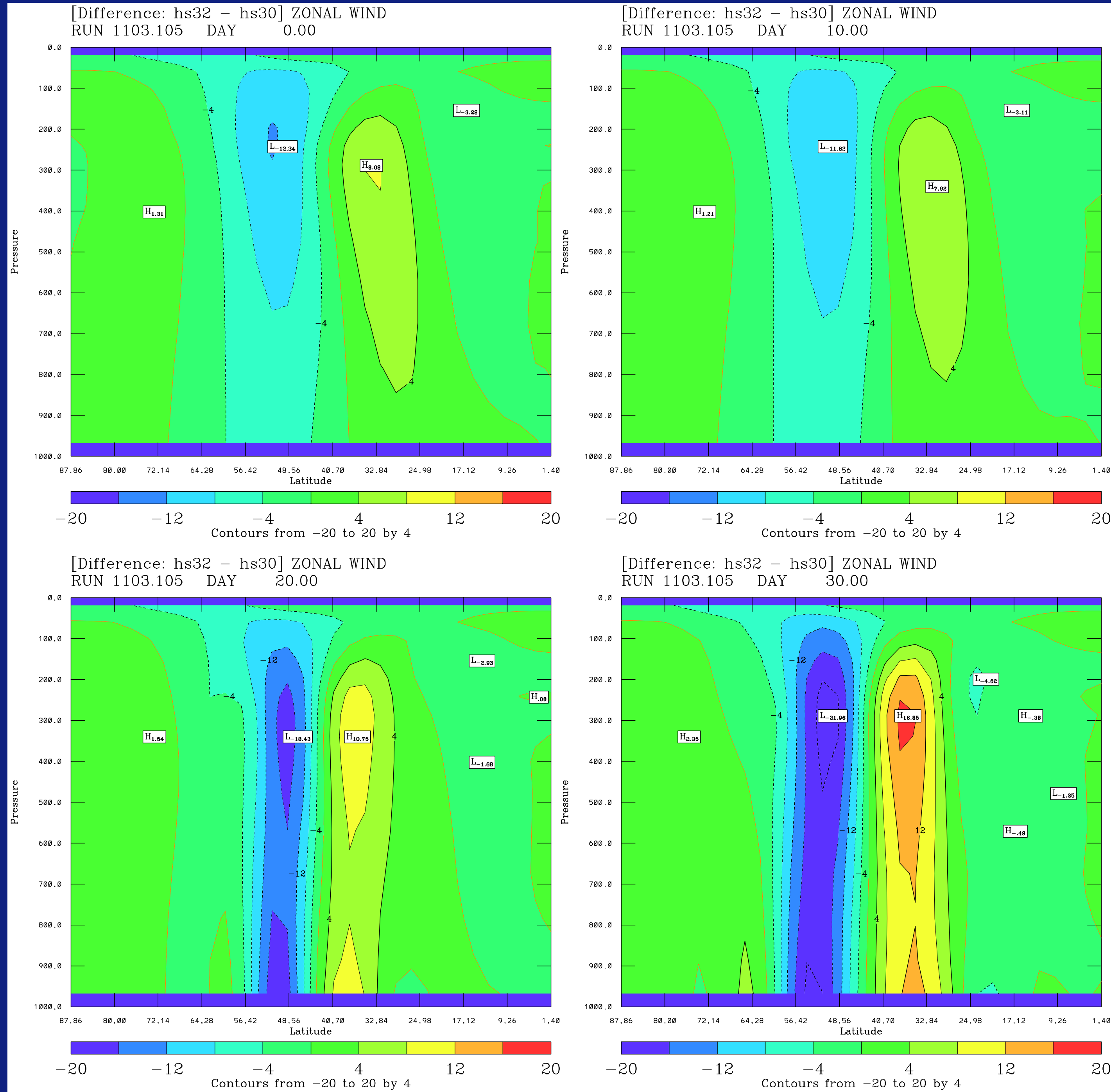
Zonal wind

Difference between baroclinic lifecyle runs under conditions of Run U5 and Run C



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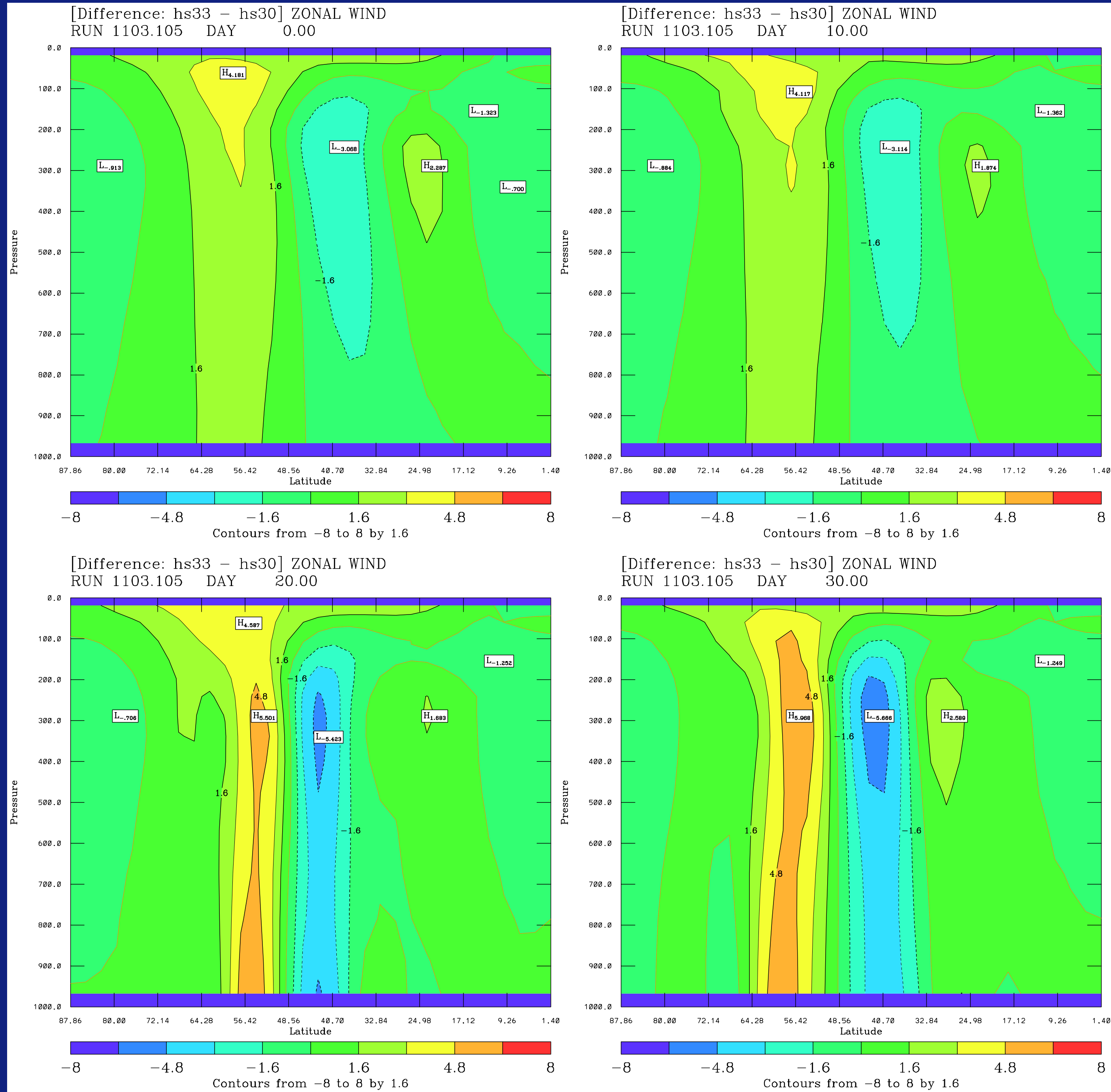
Zonal wind

Difference between baroclinic lifecyle runs under conditions of Run E5 and Run C



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Conclusions

- Analysis of NCEP zonal winds reveals that when the sun is more active the sub-tropical jets are weaker and positioned nearer the poles.

- This signal is qualitatively similar to the results of GCM simulations with enhanced solar UV (and ozone).

- In a simplified GCM imposed stratospheric warming, and associated lowering of the tropopause, weakens the jets and storm-track eddies.

- Equatorial stratospheric warming displaces the jets polewards while uniform or polar warming displaces them markedly equatorwards.

- Baroclinic lifecycle runs show that baroclinic waves reinforce the zonal wind anomalies.