12.810 Dynamics of the Atmosphere

Vertically propagating and stationary Rossby waves

Zonal wind affects whether Rossby waves can propagate (Charney-Drazin filtering)

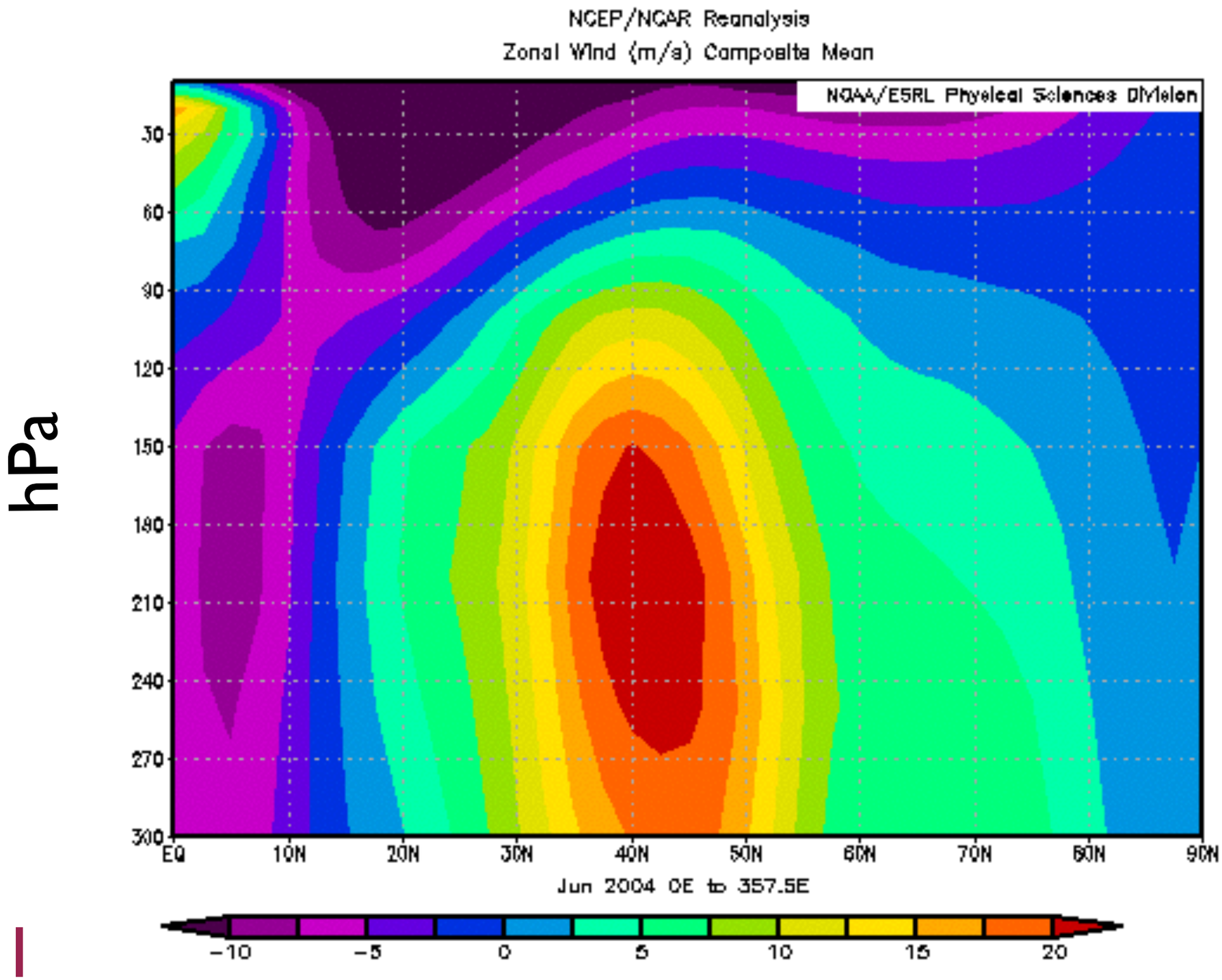
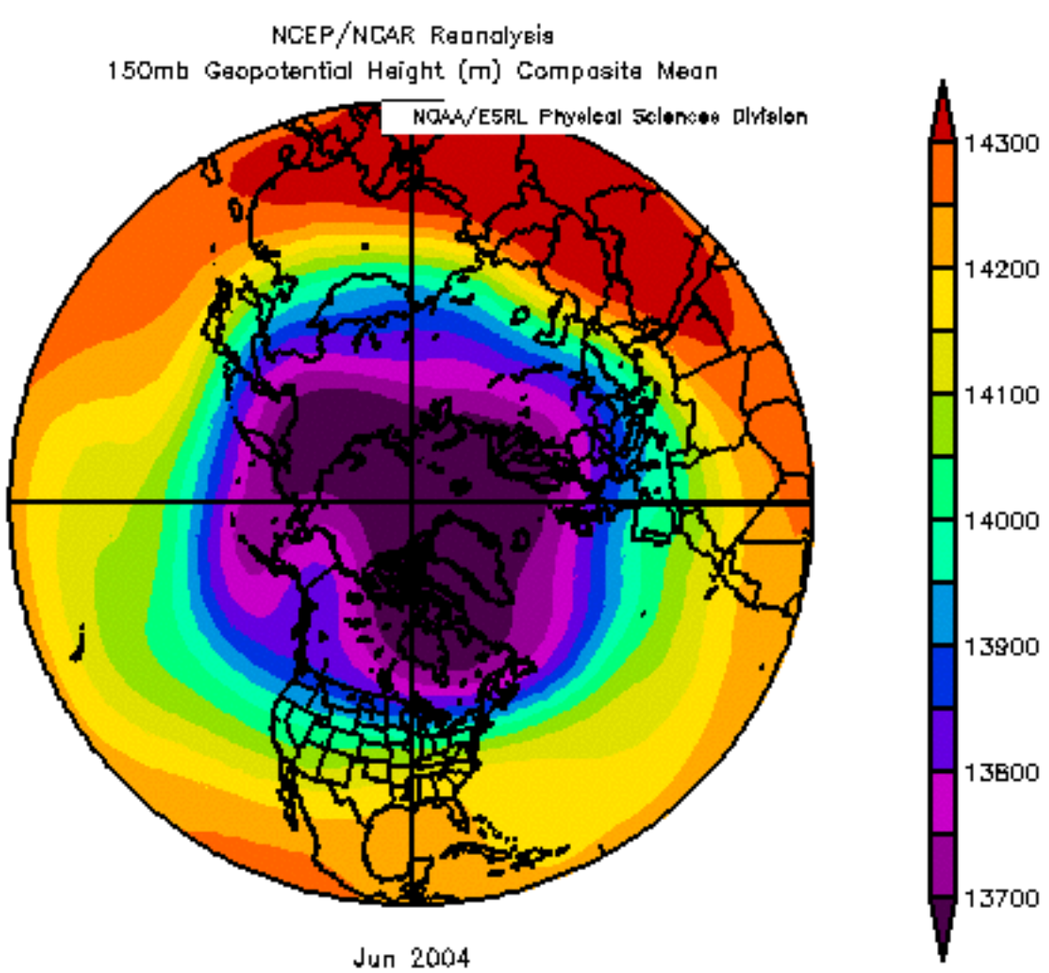


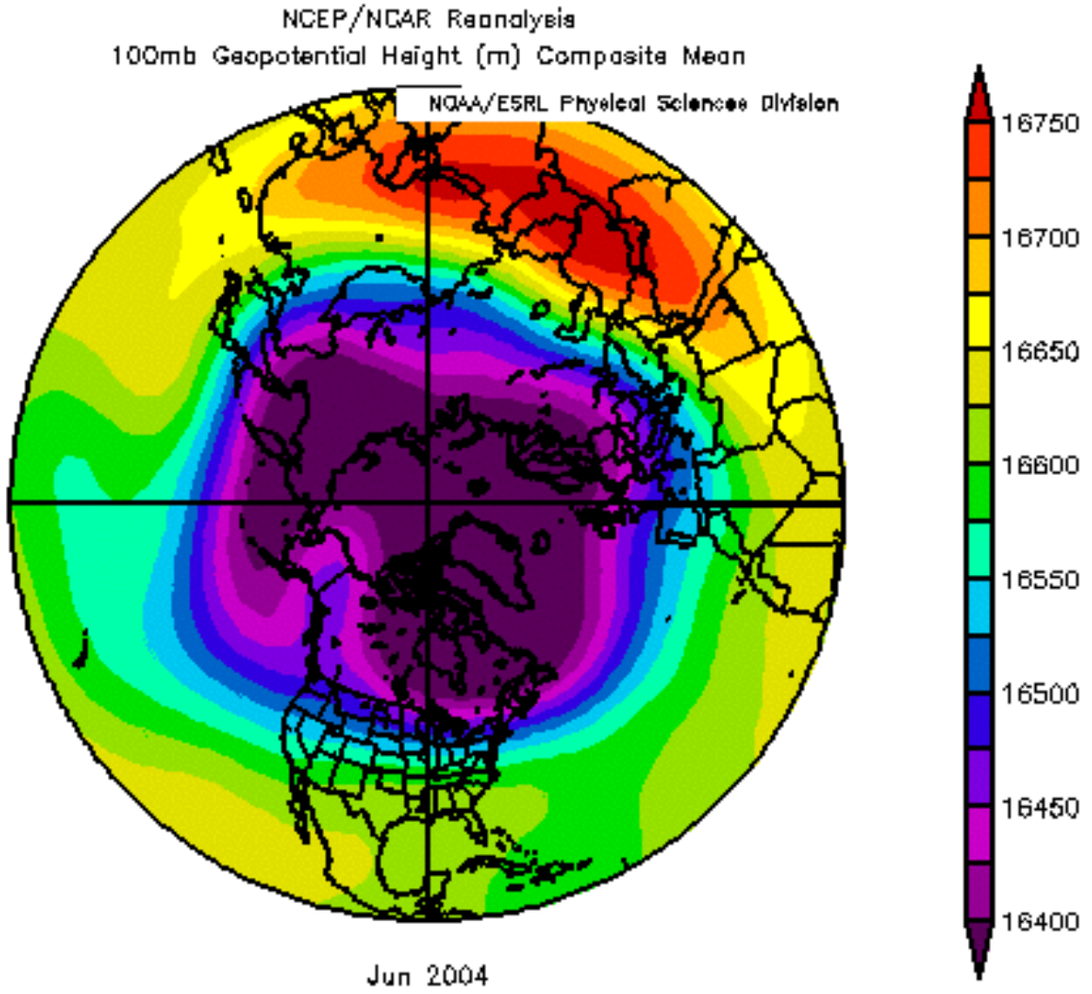
Fig. 1

Image courtesy of NOAA/ESRL.

Stationary waves in the geopotential height at different pressure levels (June 2004)



150hPa

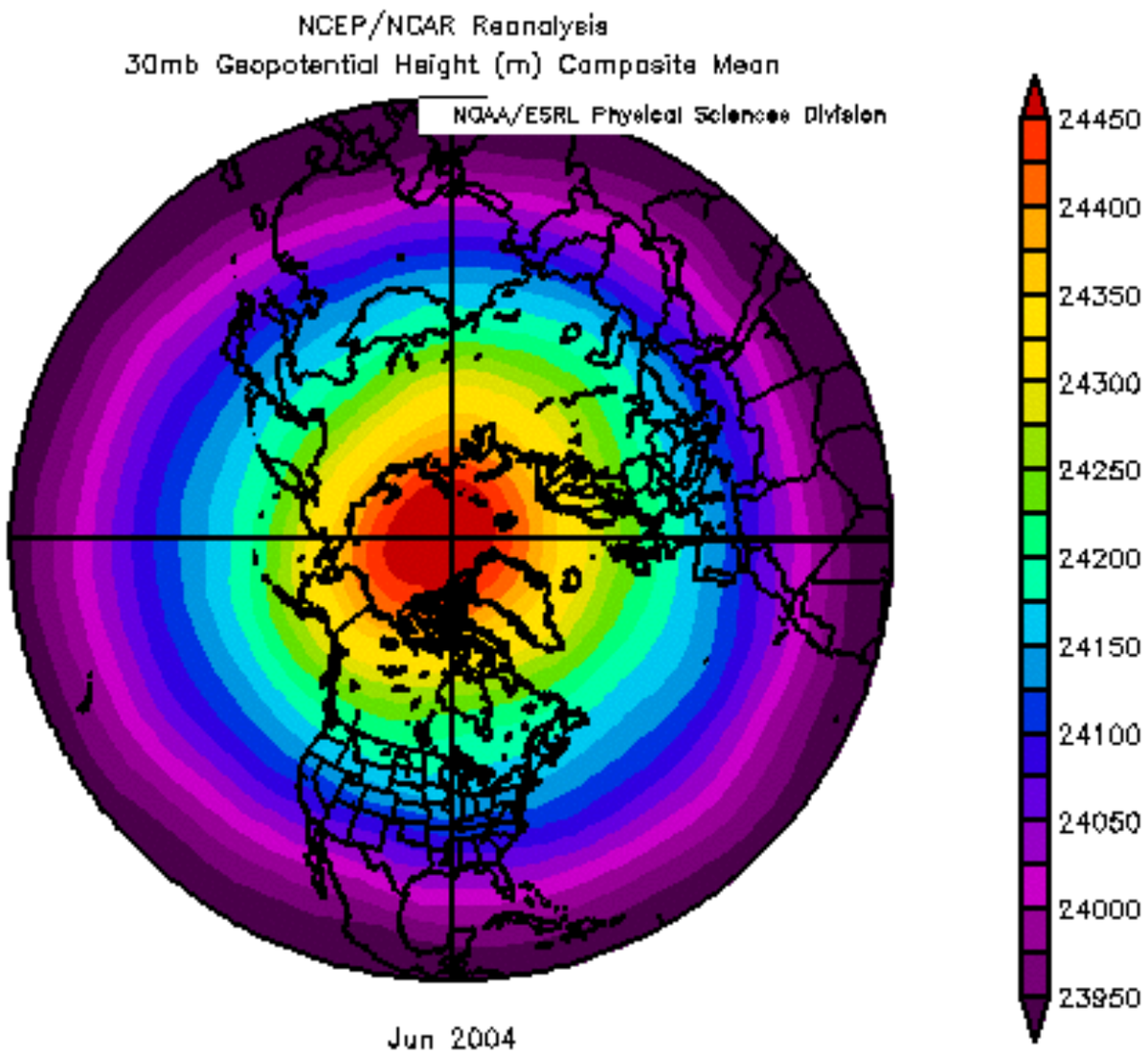


100hPa

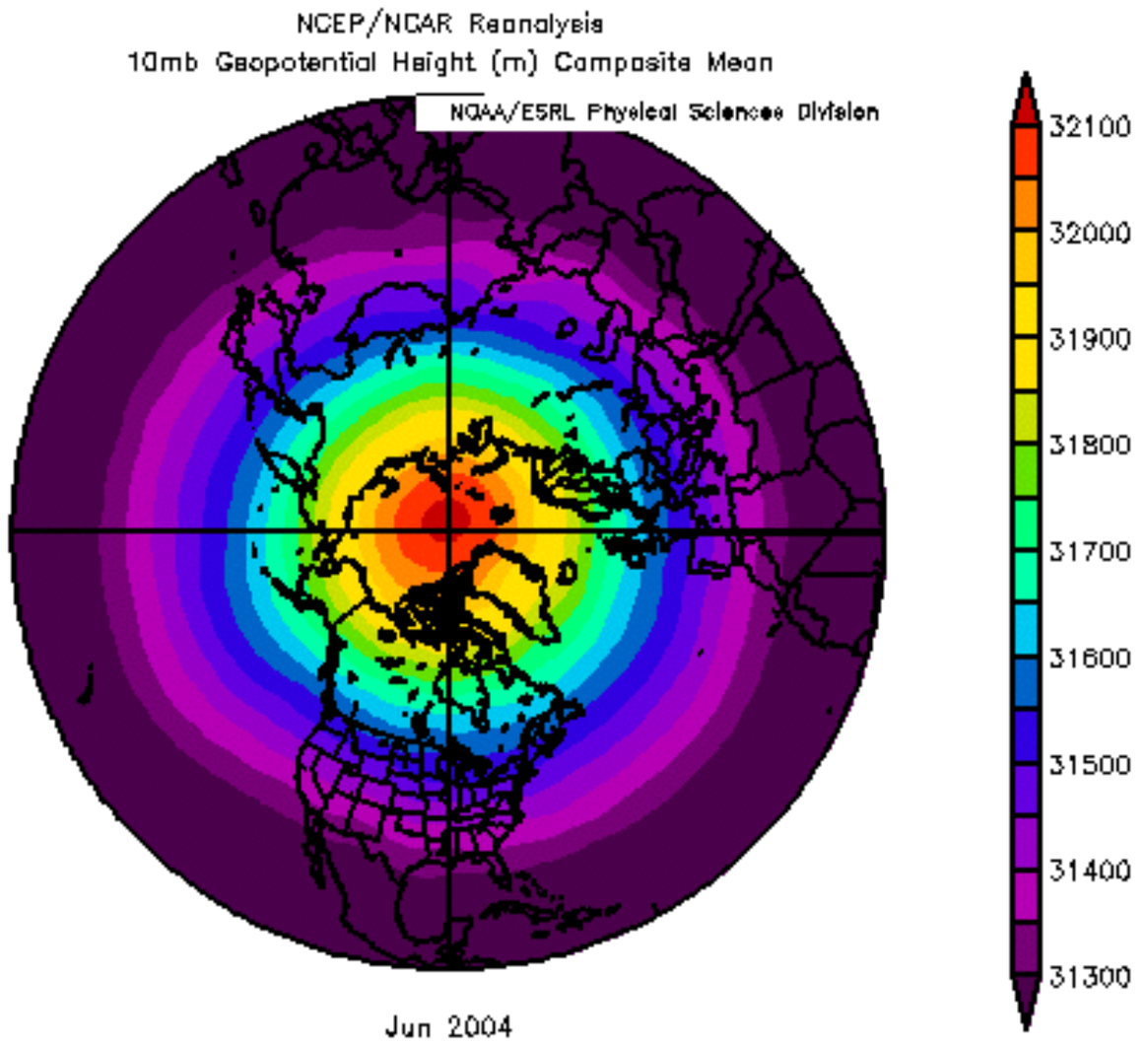
Fig. 2

Image courtesy of NOAA/ESRL.

But symmetric geopotential height at levels with easterlies



30hPa

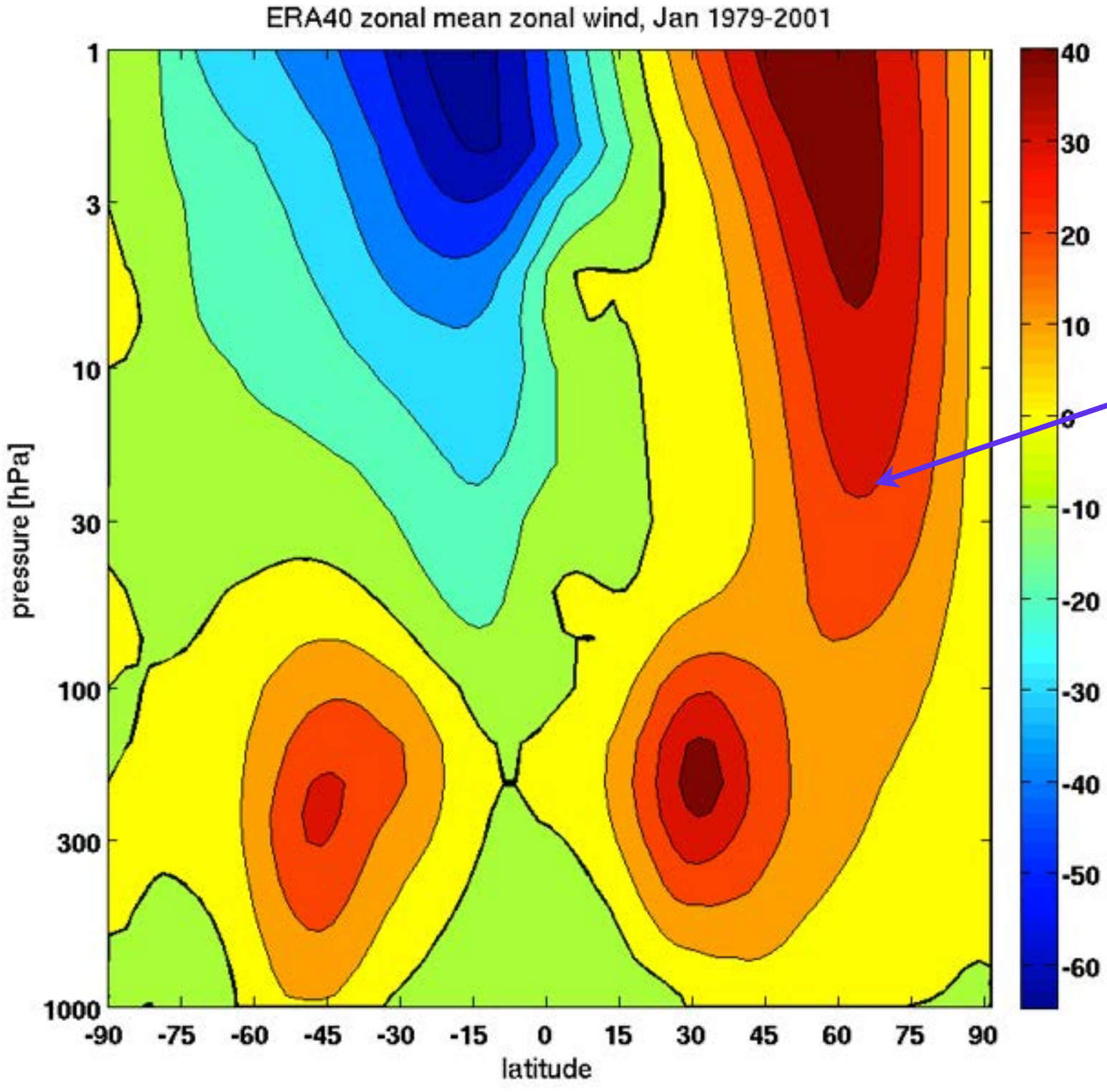


10hPa

Fig. 3

Image courtesy of NOAA/ESRL.

Effect of filtering for stratosphere: only planetary scale waves in winter, largely symmetric in summer



Westerlies allow for propagation of planetary scale waves

Fig. 4

Only planetary scale waves in winter (1/10/2006) at 30hPa

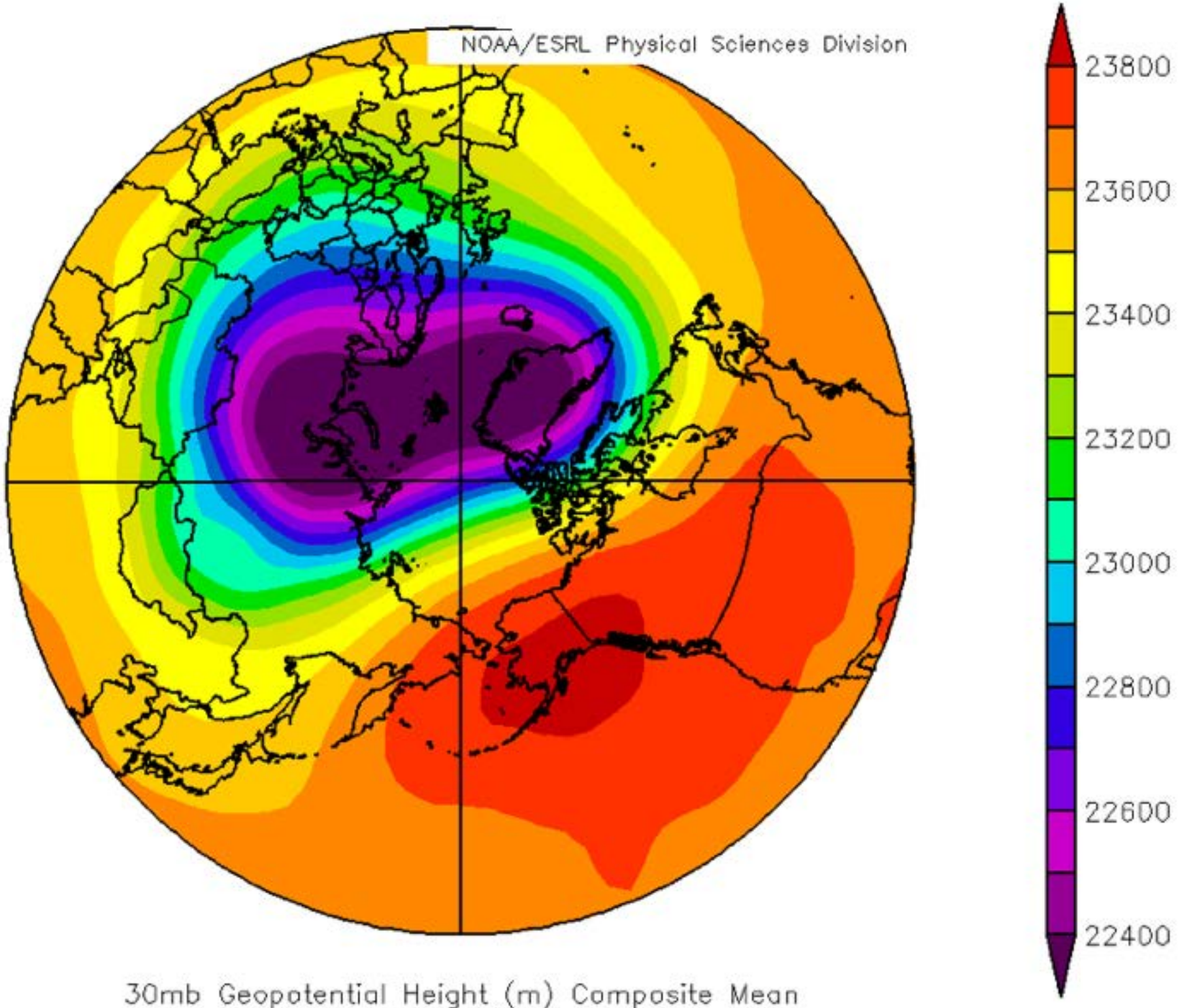


Fig. 5

Image courtesy of NOAA/ESRL.

Largely symmetric in summer (7/1/2006) at 30hPa

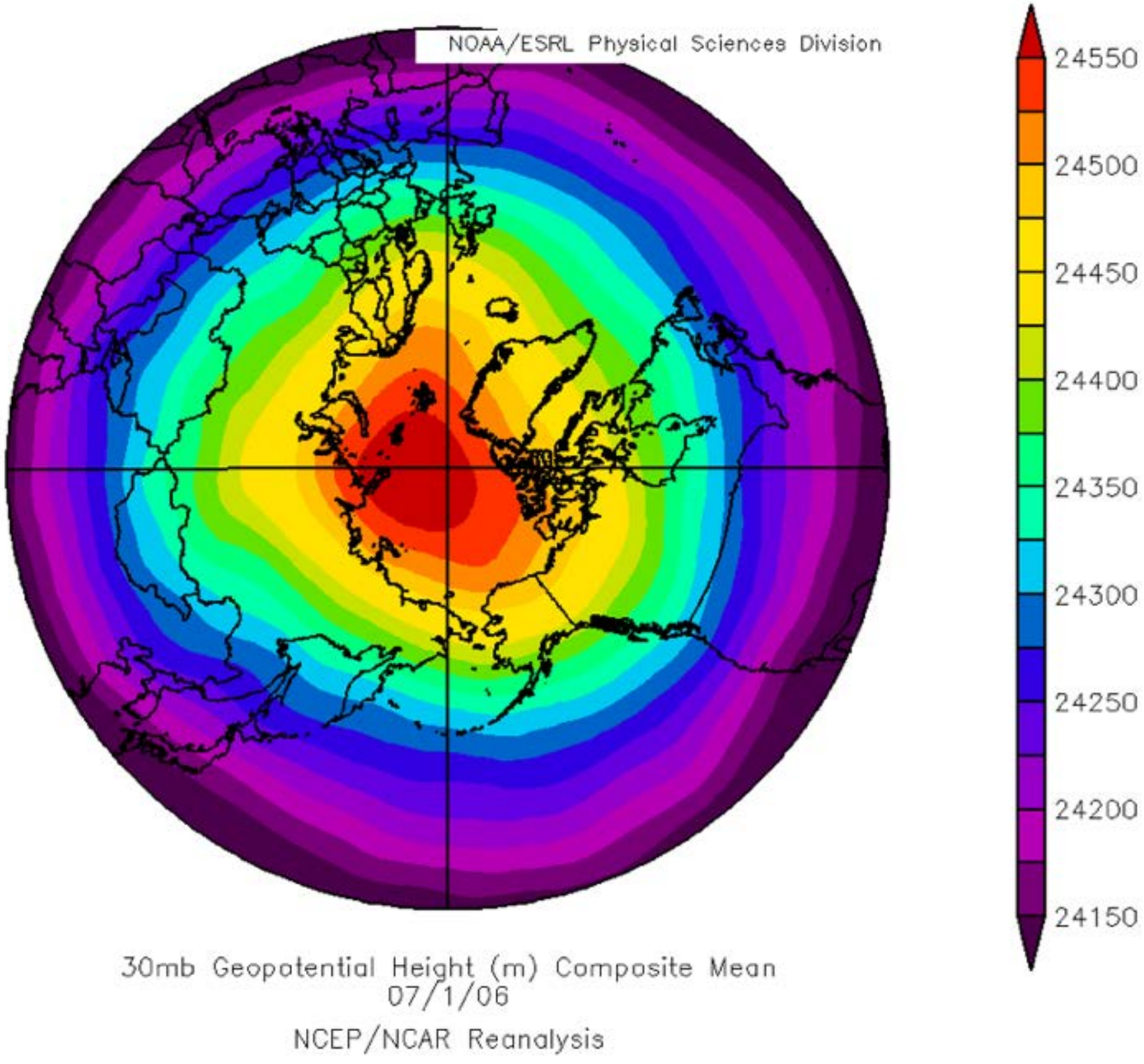


Fig. 6

Image courtesy of NOAA/ESRL.

Contrast with presence of synoptic waves in troposphere

1/1/2006 at 500hPa

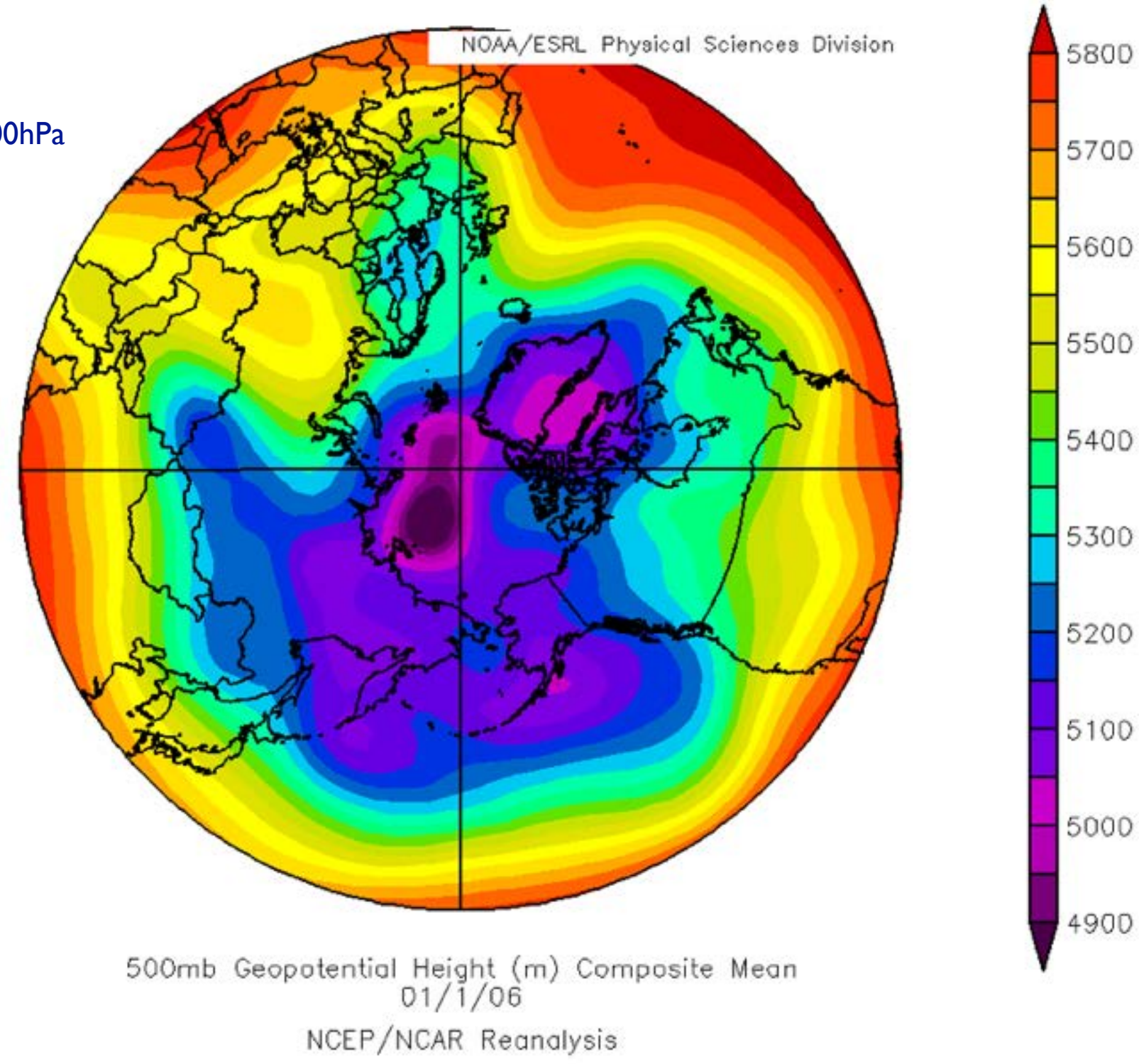


Fig. 7

Image courtesy of NOAA/ESRL.

Observed stationary waves in January climatology: Geopotential height at 300hPa

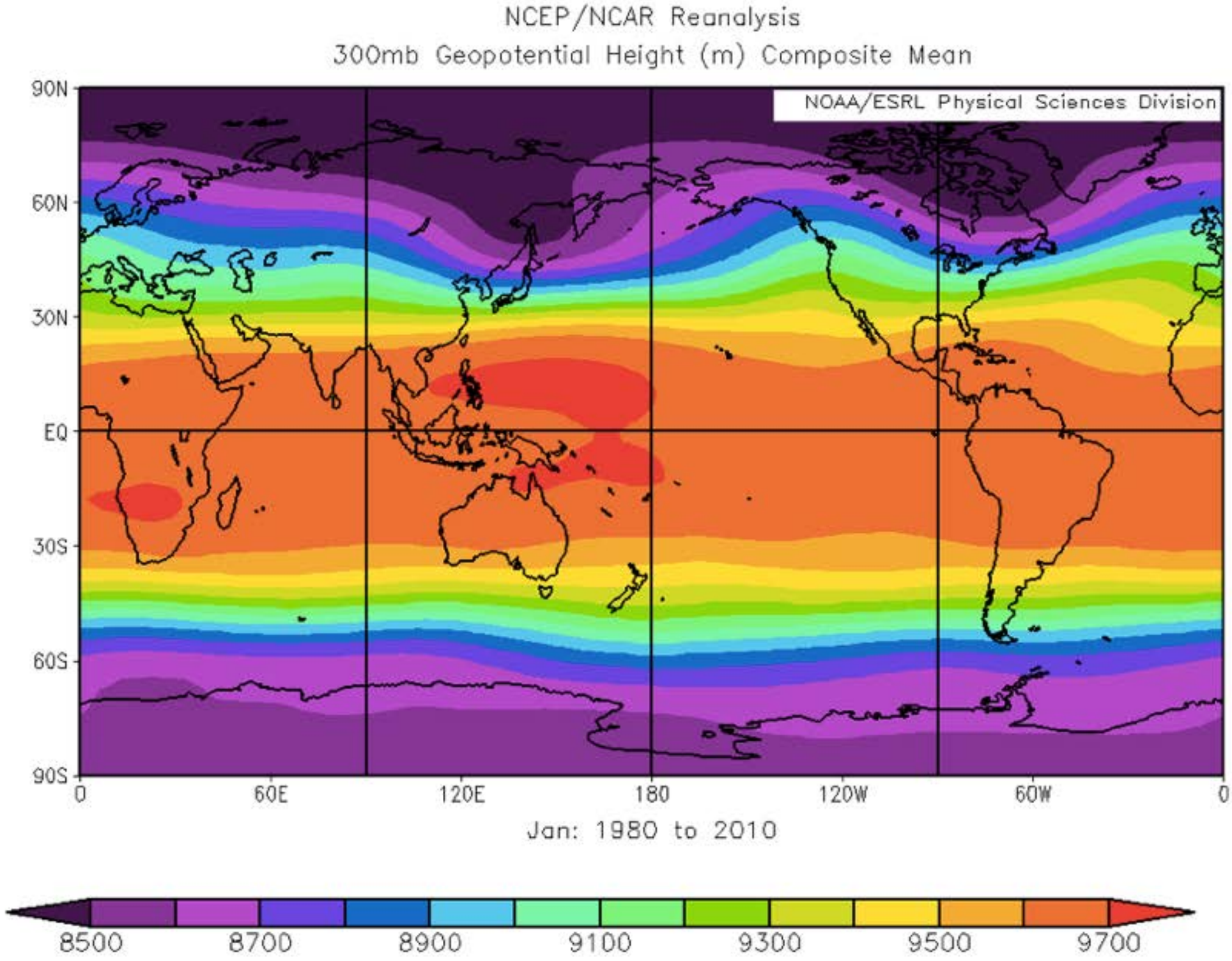


Fig. 8

Image courtesy of NOAA/ESRL.

Observed stationary waves in January climatology: Meridional wind at 300hPa

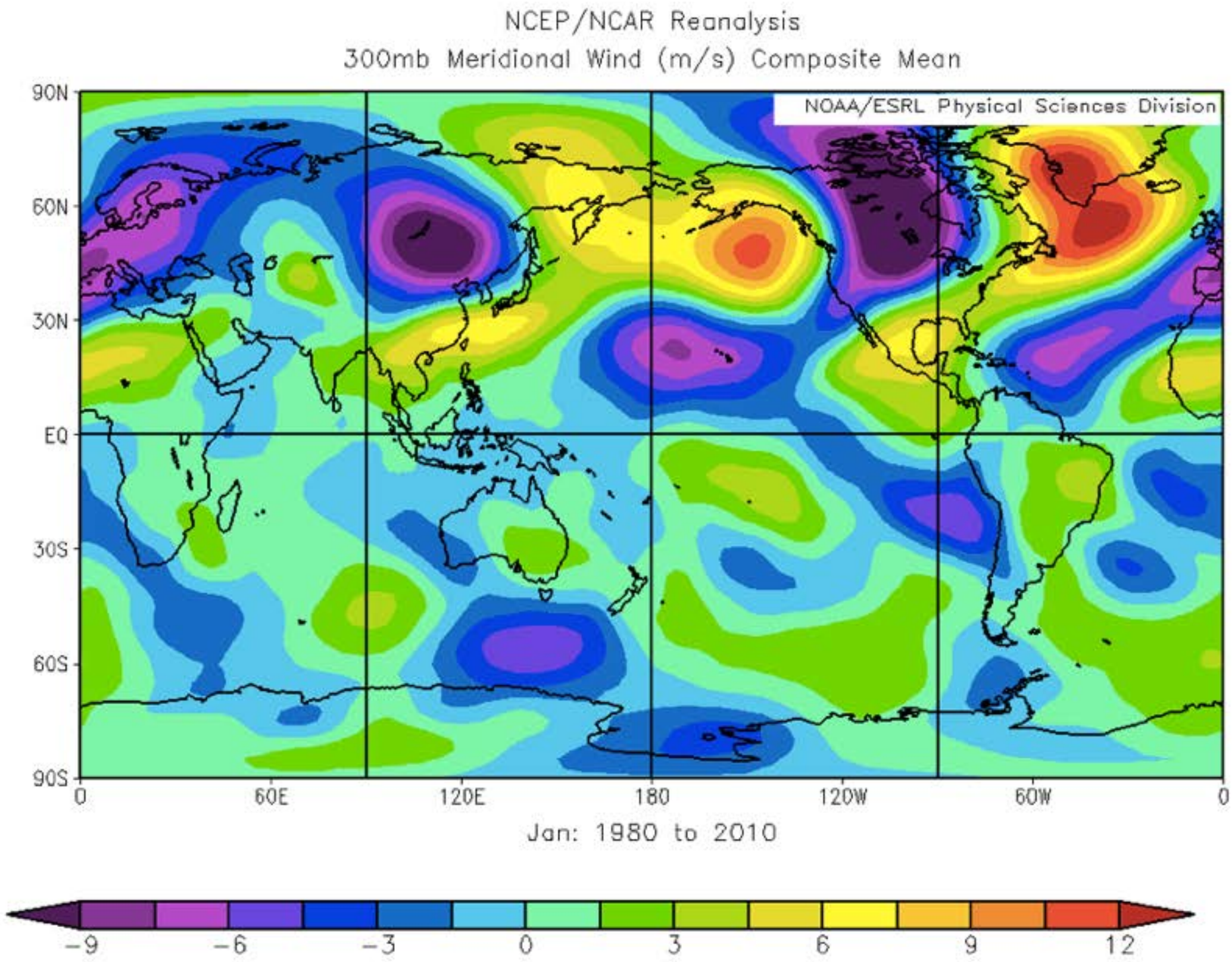
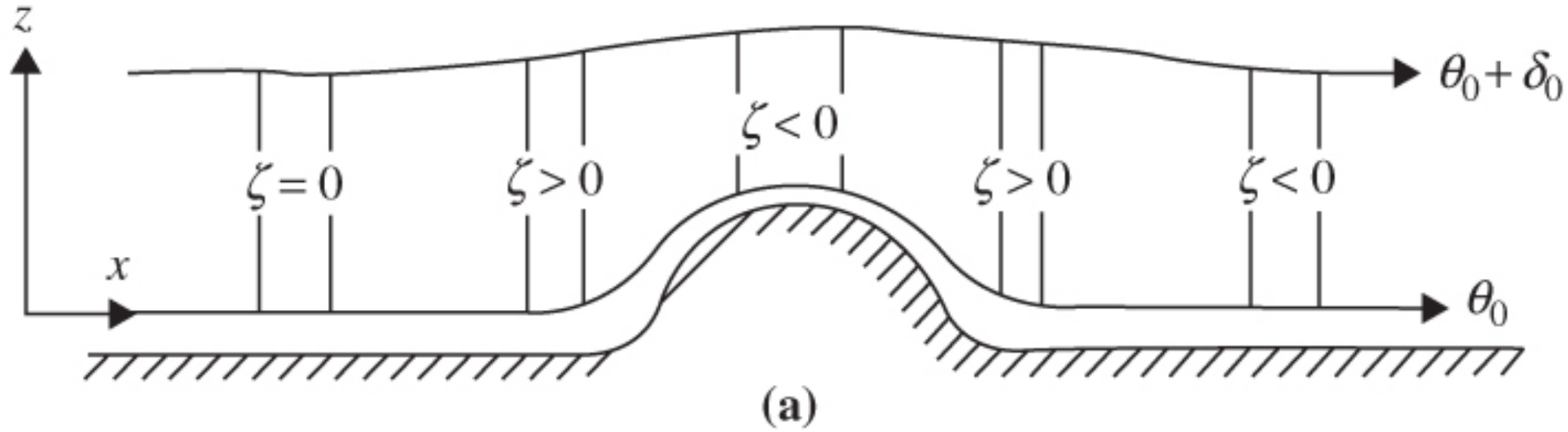


Fig. 8

Image courtesy of NOAA/ESRL.

Flow past a barrier: understanding the response using conservation of potential vorticity

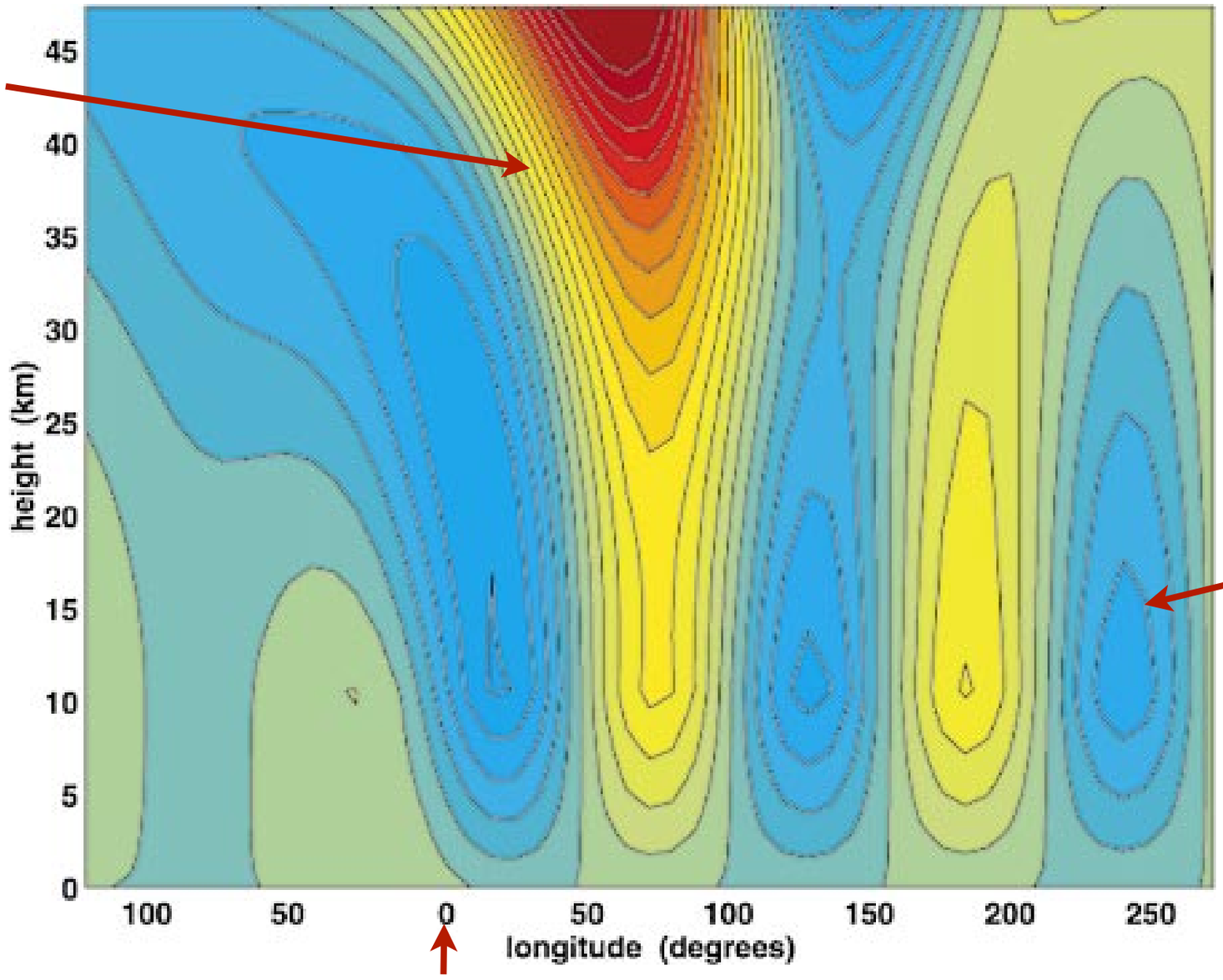


Holton and Hakim

Fig. 9 Schematic view of westerly flow over a topographic barrier: (a) the depth of a fluid column as a function of x and (b) the trajectory of a parcel in the (x, y) plane.

Vertical structure of response to flow over an isolated mountain

Vertically propagating wave



Wave with fixed structure in z (external mode)

FIG. 4. Streamfunction response to orography in a QG model on a β plane with uniform Brunt–Väisälä frequency, in which the mean zonal flow is linear in height below the tropopause (at 10 km) and uniform above the tropopause. The orography and the solution are assumed to be independent of latitude. The orography is centered at 0° lon.

Fig. 10

Held et al J. Climate 2002

Climatological stationary wave pattern for January: no phase tilt with height

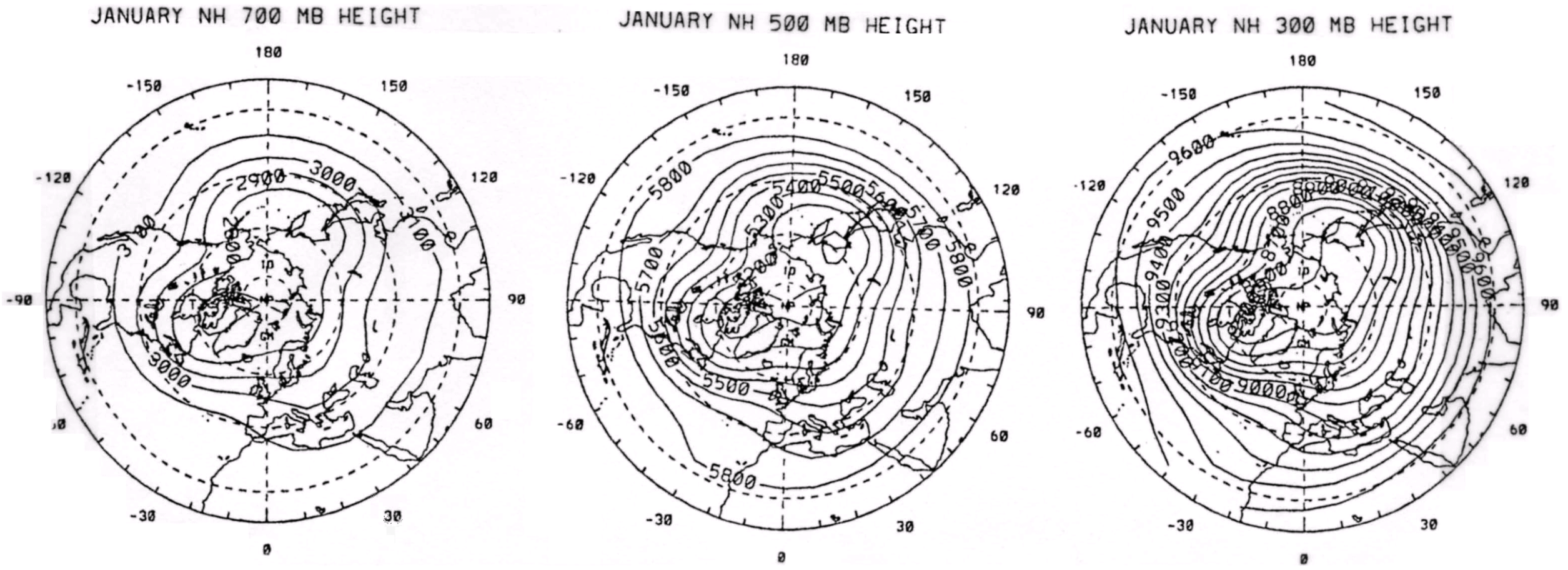


Fig. 11

Alan Plumb notes

Vertical structure of external mode

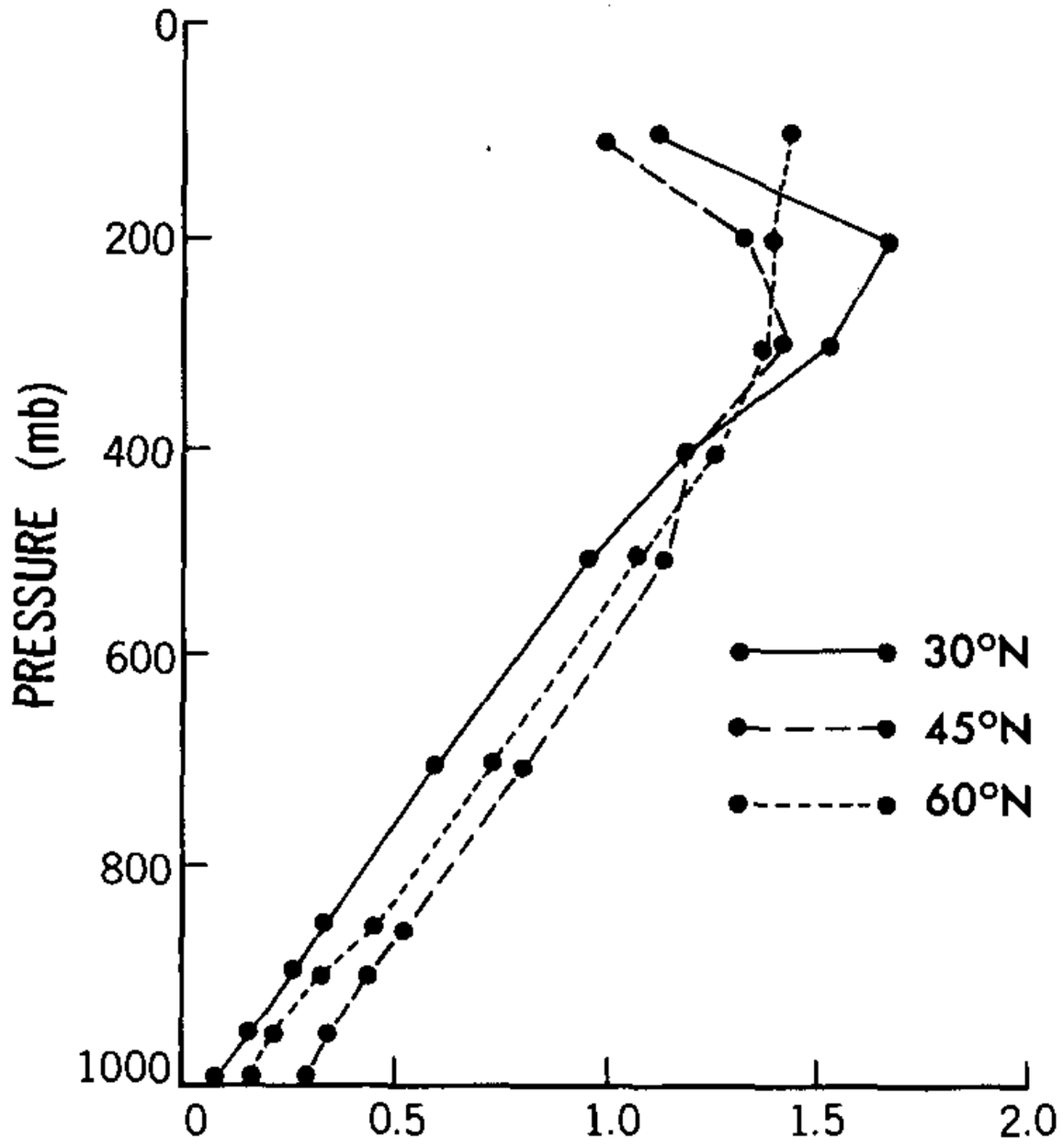


FIG. 12. Vertical structure of the stationary external mode geopotential in the finite-differenced model described in the text, using observed Northern Hemisphere zonal winds and static stabilities, at three different latitudes.

Fig. 12

Held et al, JAS, 1985

Animations of stationary waves

"This animation is the response of a two-dimensional flow on the surface of a rotating sphere to a source that mimics stationary localized heating centered on the equator. The loop covers about 40 days, but the pattern is fully set up in less than half that time. The continental outlines are just meant to help orient the viewer; the surface in this model is featureless. At the start of the animation the flow is purely zonal and the forcing is turned on instantaneously and then maintained."

Fig. 13

Isaac Held Blog post 57

Animations of stationary waves

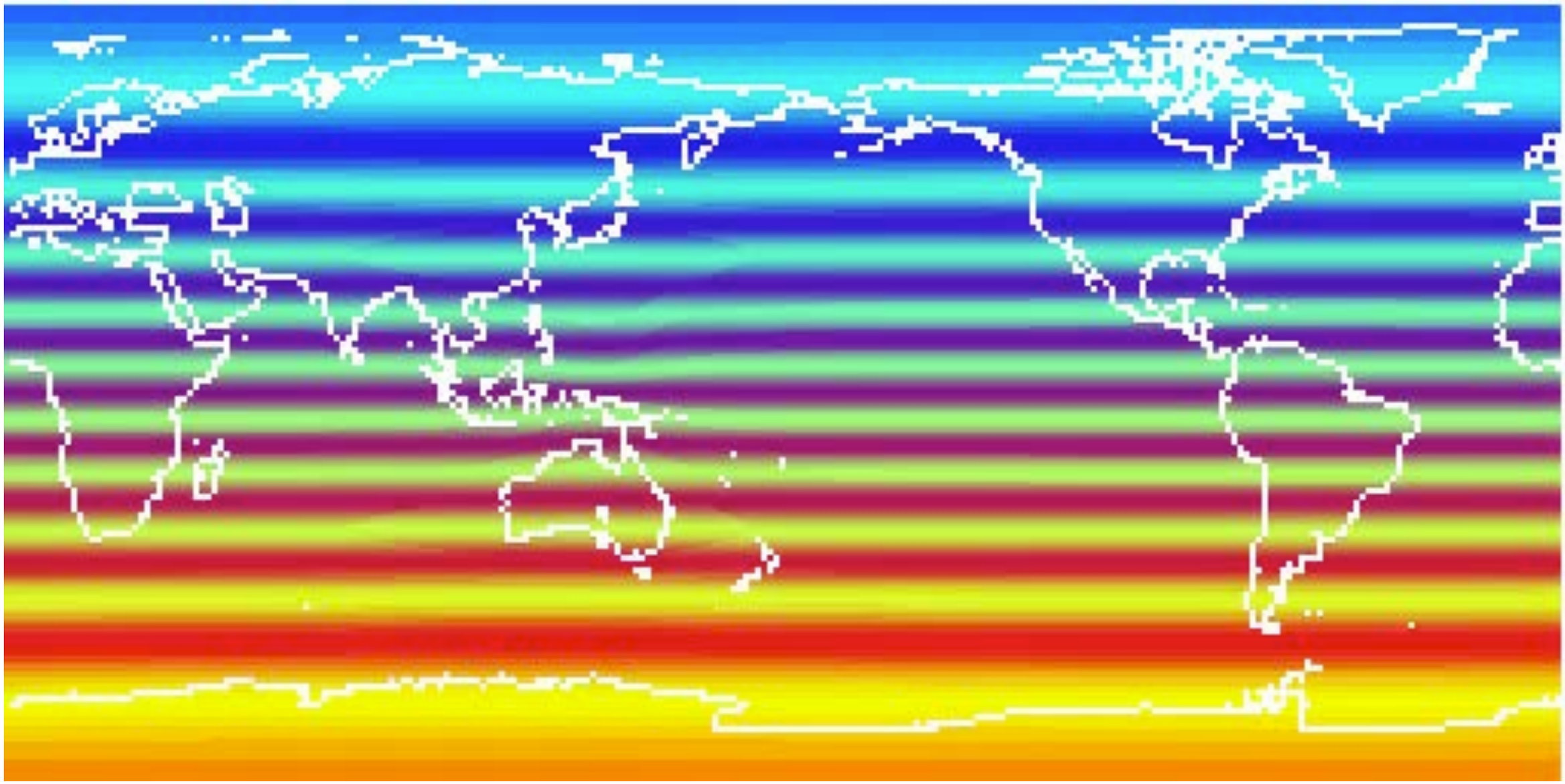


Fig. 13

Streamfunction of the total horizontal flow

Isaac Held blog

Image courtesy of Isaac Held. Used with permission.

Animations of stationary waves

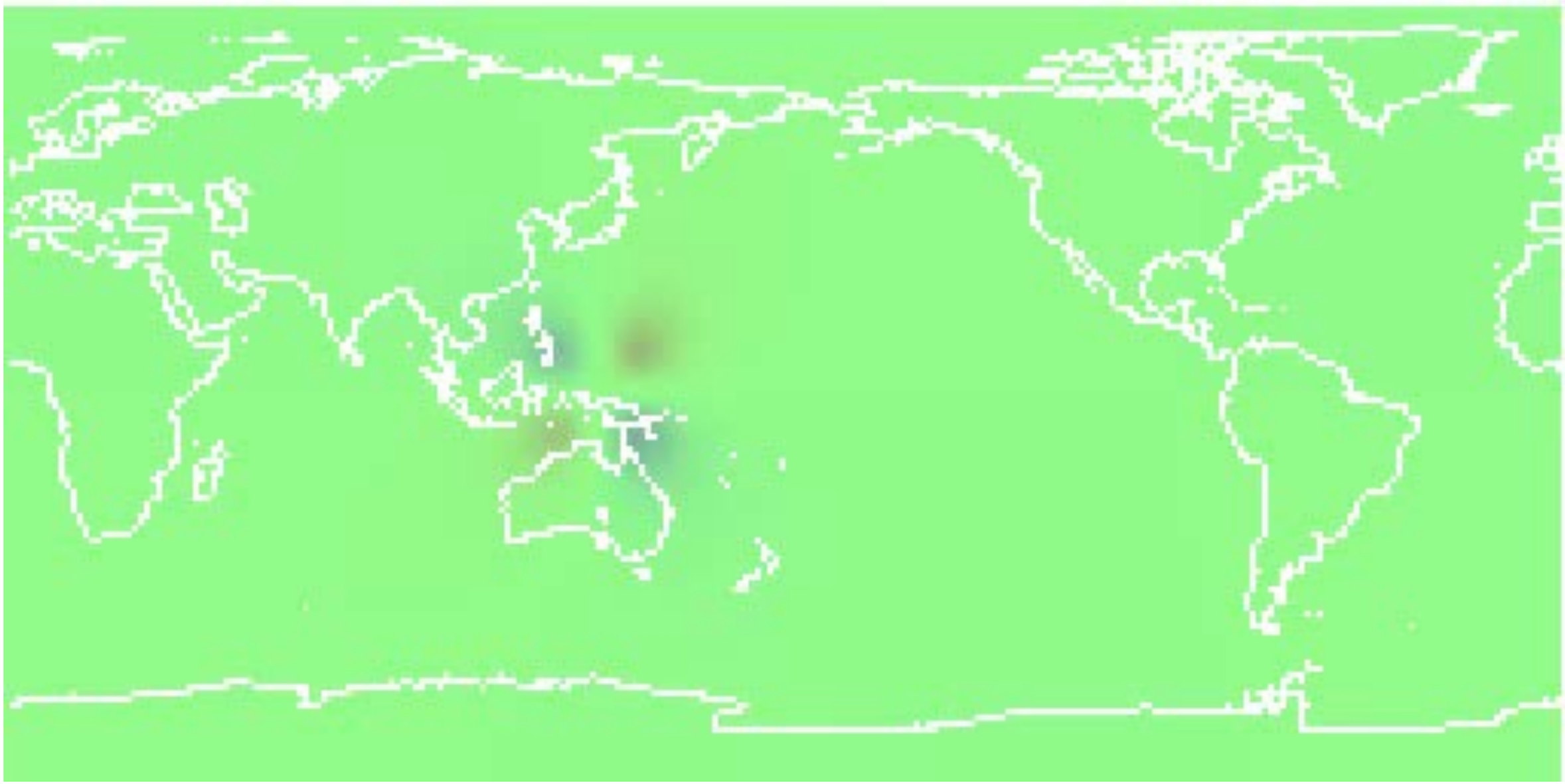
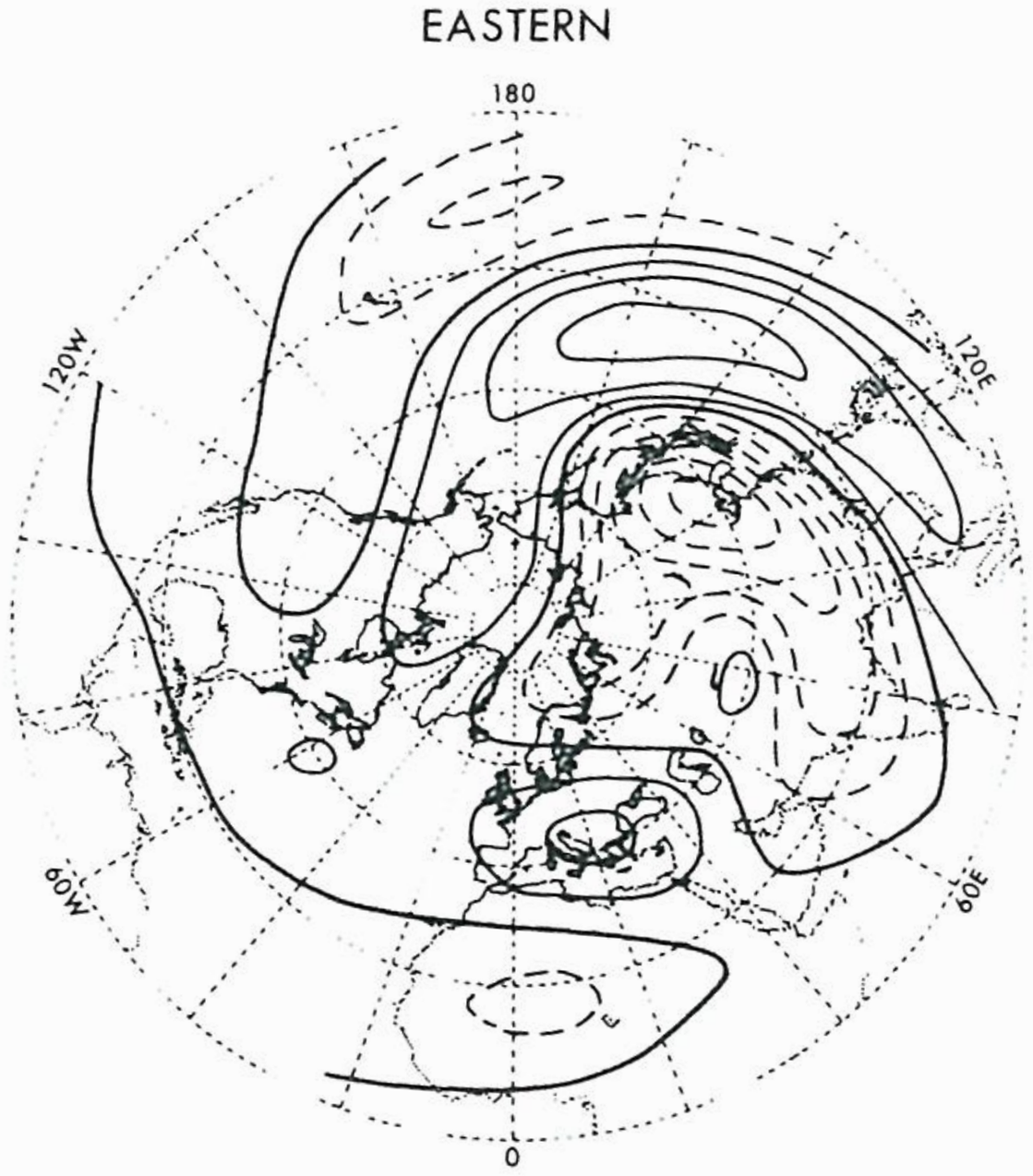


Fig. 13 Meridional wind. Red is northward. Blue is southward

Isaac Held blog

Wavetrains from topography in Eastern and Western hemispheres



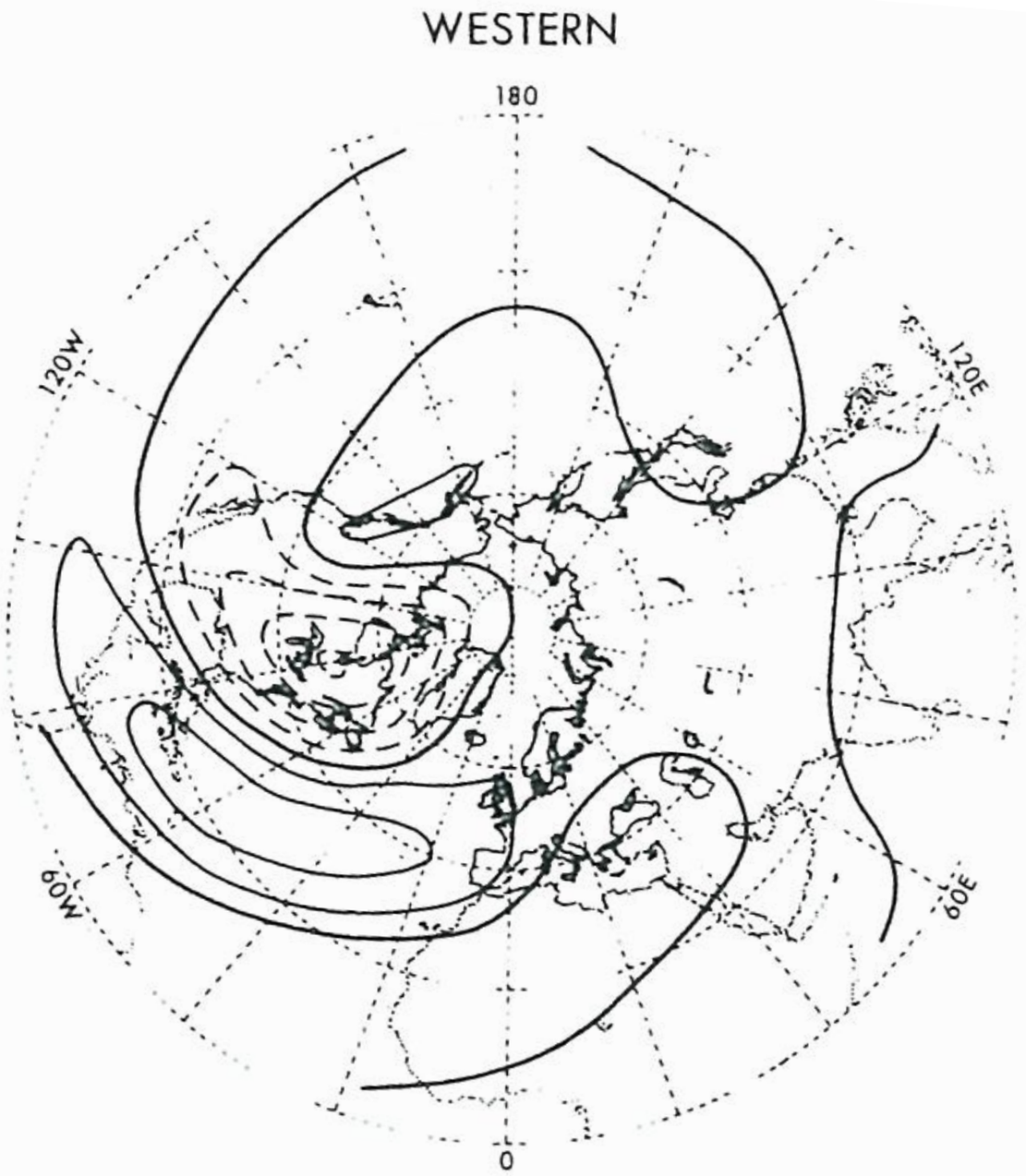


Fig. 14 Streamfunction response in a numerical model split into response to topography in the Eastern (Tibet, Alps) and Western (Rockies) hemispheres. Eastward propagating wavetrains are damped out on a timescale of 20 days.

Two wavetrains emanating from mountain at 30N

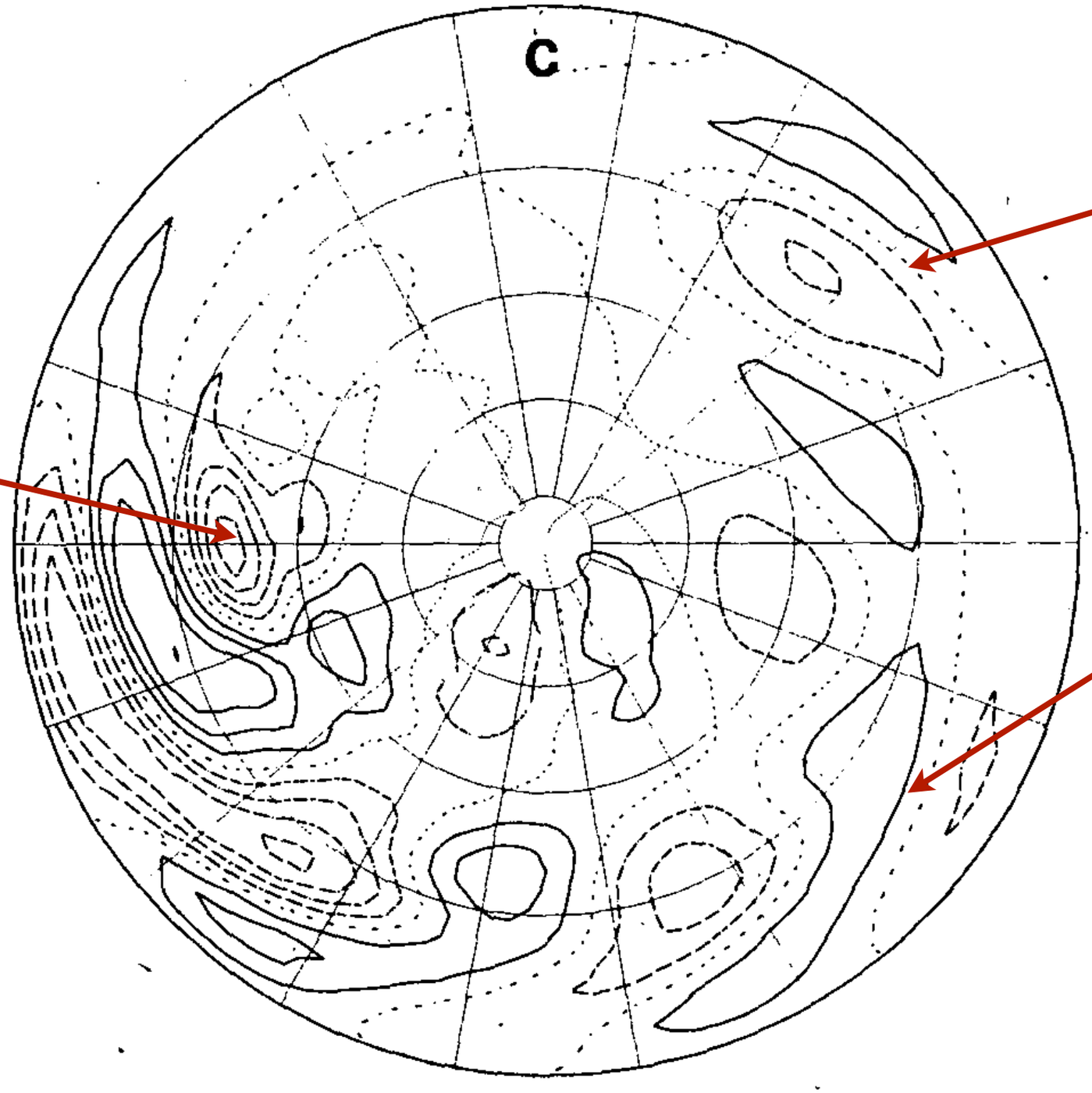


Fig. 15

Linear stationary wave response to circular mountain at 30N
Shown is the vorticity perturbation at 300hPa
Base flow is NH winter

Hoskins and Karoly 1981

12.810 Dynamics of the Atmosphere

Spring 2023