Meteorology – Lecture 16

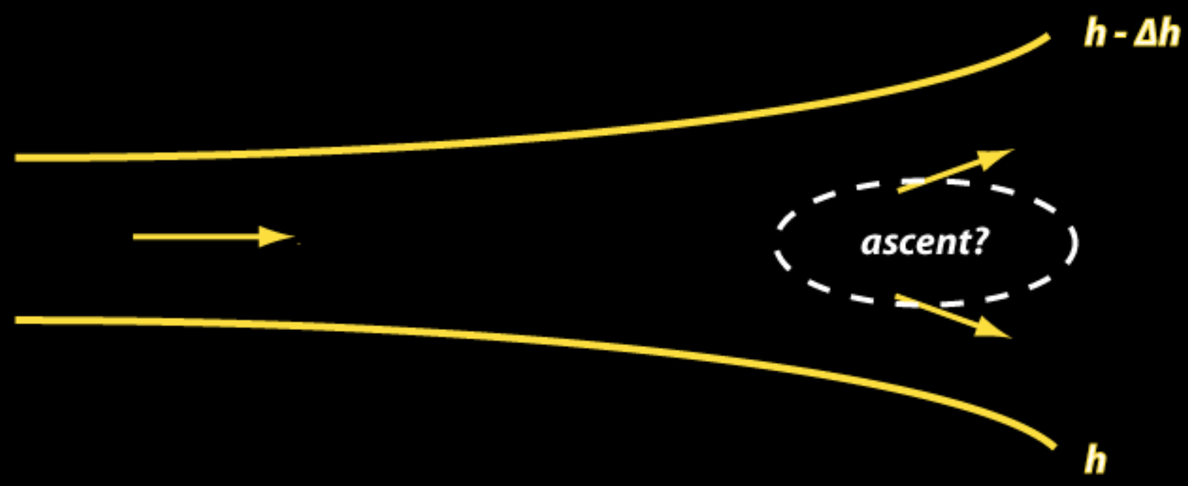
Robert Fovell

rfovell@albany.edu

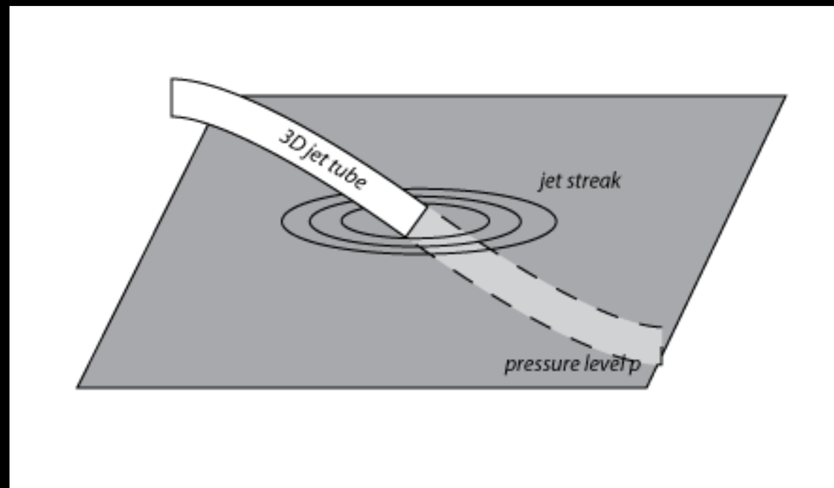
Important notes

- These slides show some figures and videos prepared by Robert G. Fovell (RGF) for his "Meteorology" course, published by The Great Courses (TGC). Unless otherwise identified, they were created by RGF.
- In some cases, the figures employed in the course video are different from what I present here, but these were the figures I provided to TGC at the time the course was taped.
- These figures are intended to supplement the videos, in order to facilitate understanding of the concepts discussed in the course. *These slide shows cannot, and are not intended to, replace the course itself and are not expected to be understandable in isolation.*
- Accordingly, these presentations do not represent a summary of each lecture, and neither do they contain each lecture's full content.

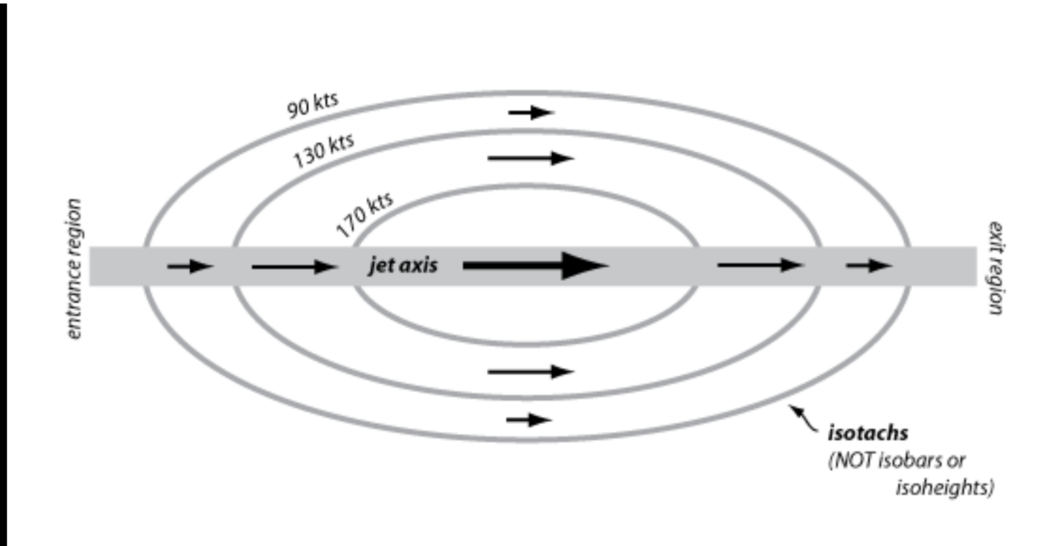
Jets



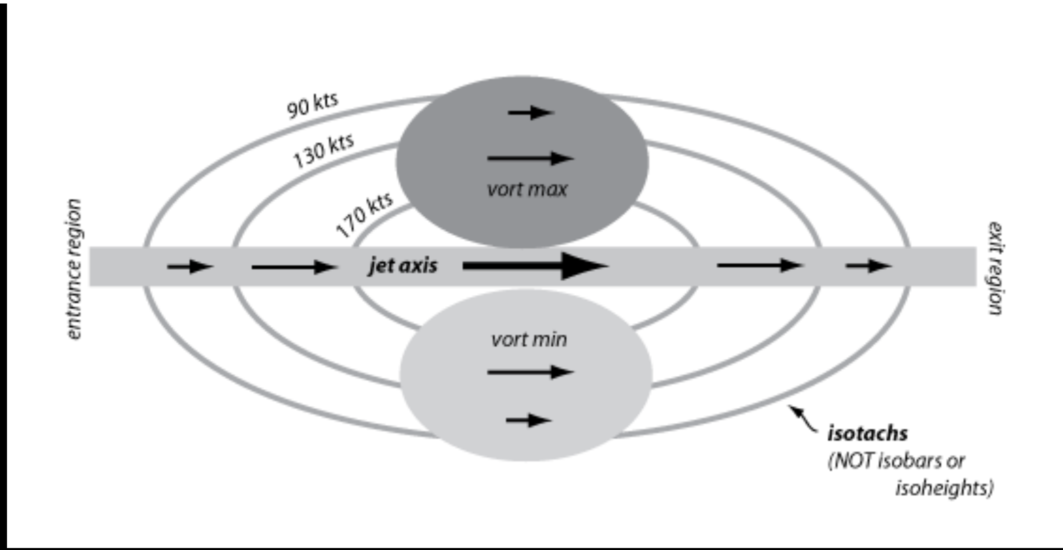
Based on this information alone, we cannot tell if we're seeing **divergence** or **diffluence**.



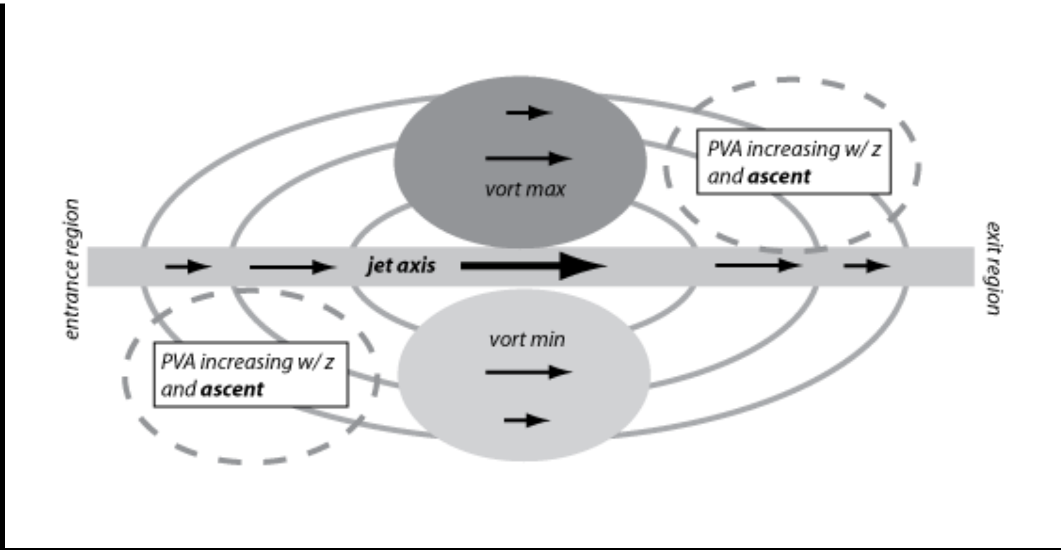
A **jet streak** representing a tube of high-velocity air intersecting an isobaric chart.



Take a look at the jet streak.
The wind is blowing left to right, increasing in speed upon entering the streak, decreasing on the other side.
We call these the jet ENTRANCE and EXIT regions.
The contours are **isotachs**.

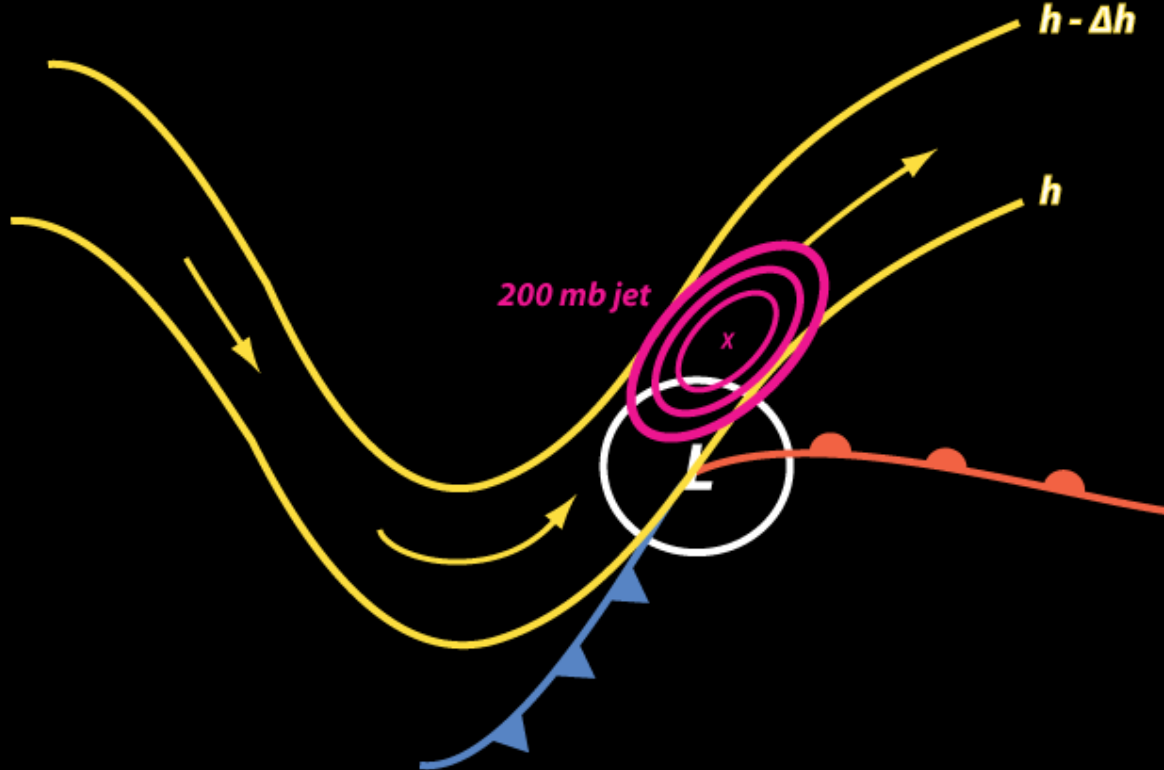


The horizontal shear is inducing CCW positive relative vorticity (vort max) on the north side of the jet streak, and CW negative relative vorticity (vort min) on the south side.



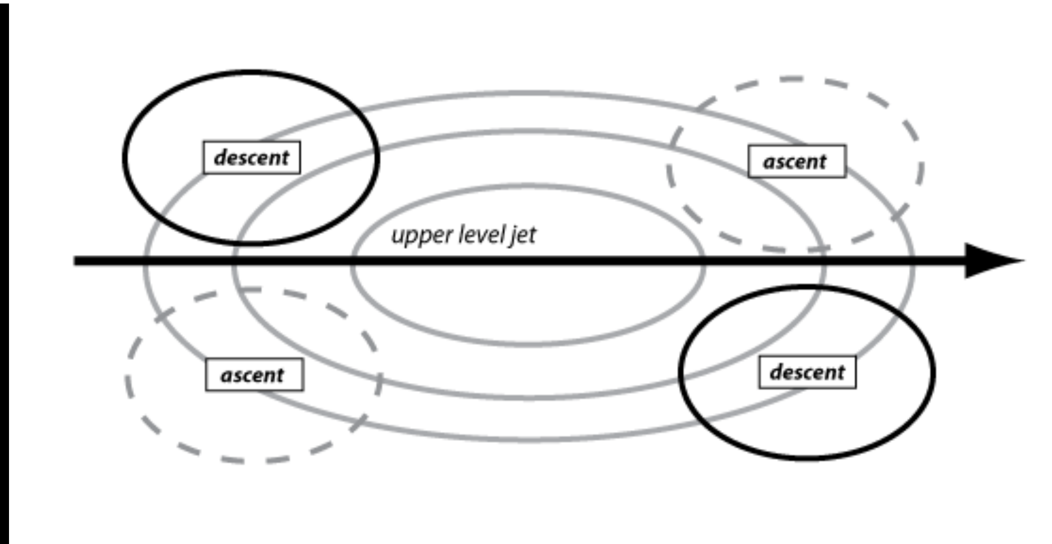
The wind can PUSH vorticity downwind. It can ADVECT it. So there is positive vorticity advection (PVA) at this level downstream of the vort max, in the **left exit region** of the jet.

It's less obvious why, but this also occurs at the **right entrance region**.

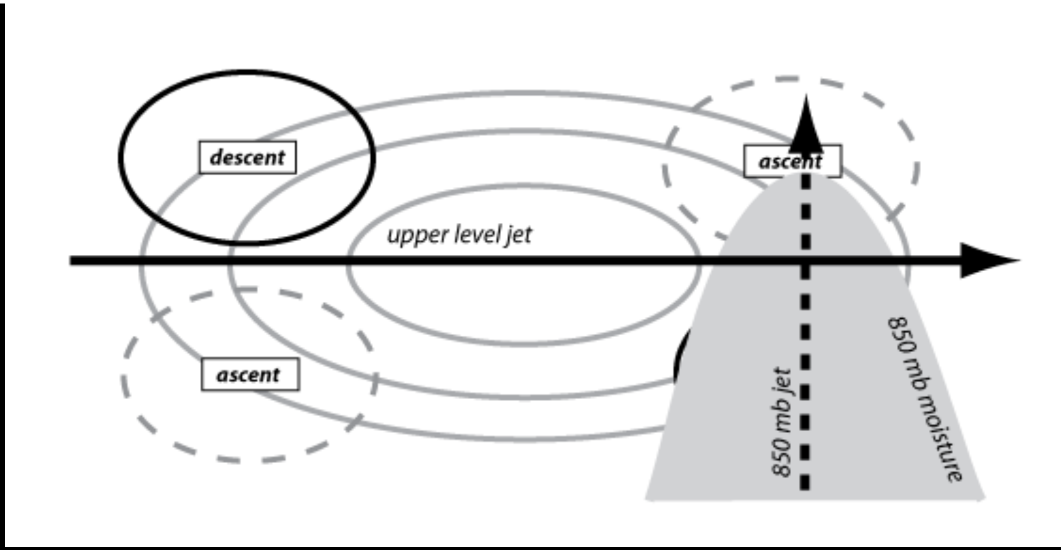


Remember our December 2007 snowstorm, with the surface cyclone that formed just east of the 500 mb trough? I've added the location of the 200 mb jet streak to this picture. The surface low resides beneath the right entrance region of the streak.

Another favorable indicator for development.



This pattern of rising and sinking motion shown will induce what we call a **secondary circulation**.
But this circulation is NOT of secondary importance.

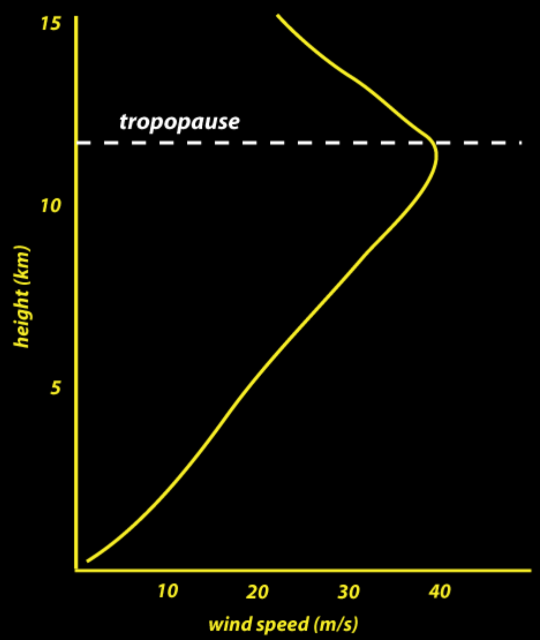


Focus on the exit region.

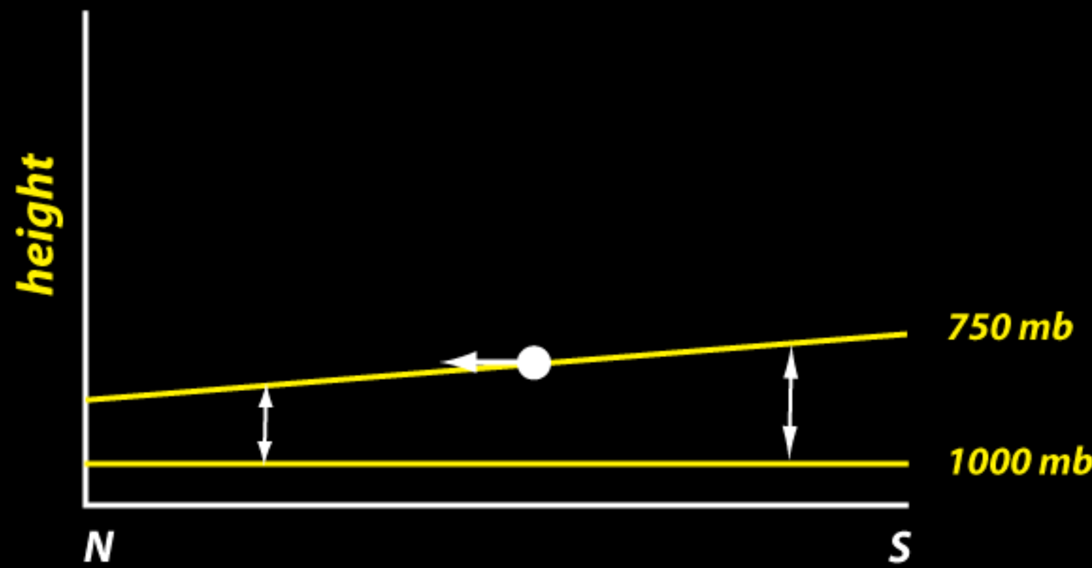
At the jet streak level, the ascent and descent should create flow heading south, out of the updraft and into the downdraft.

The secondary circulation loop is closed by realizing that has occur along with flow from S to N in the LOWER troposphere, which is what I'm showing here. That flow is important for severe weather.

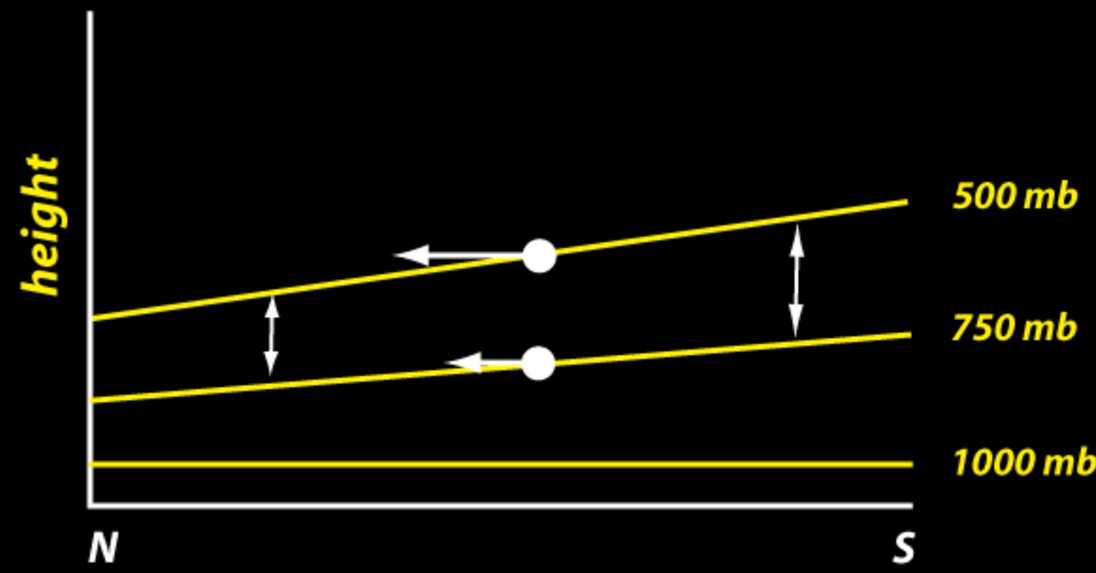
Vertical wind shear



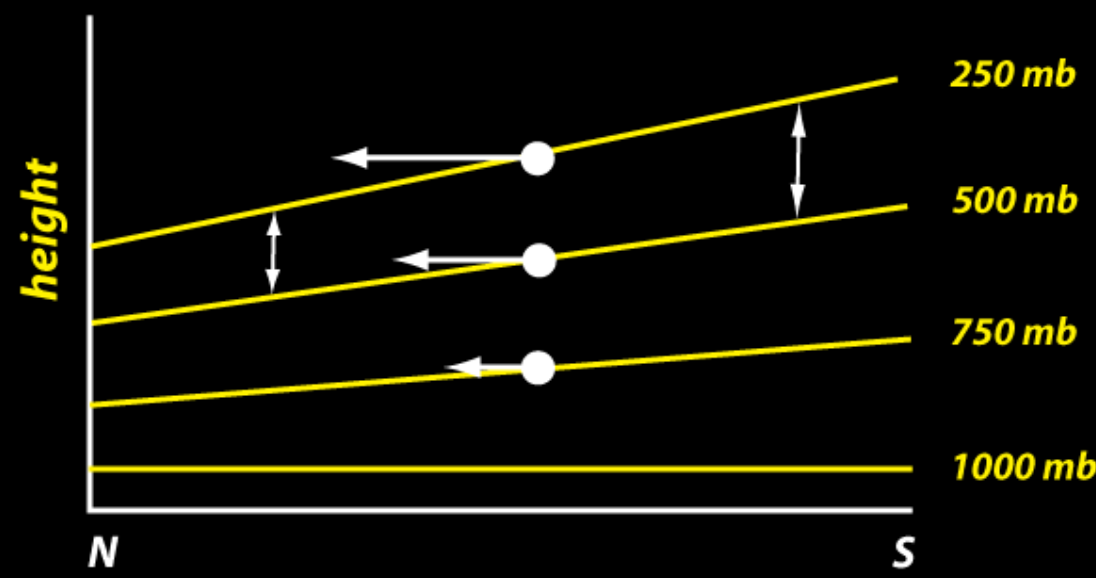
- Here is how the ZONAL WIND (west-east) varies with height at about 30N latitude during winter
- Speed increases with height to about 40 m/s (90 mph) at the tropopause.
- This very large shear very largely exists because it's **colder to the north**.



Look at a vertical cross-section, from cold N to warm S.
We're neglecting the surface wind for now.
Since it's colder to the N, the 750 mb level is tilted.
The geostrophic wind is into the page (westerly).

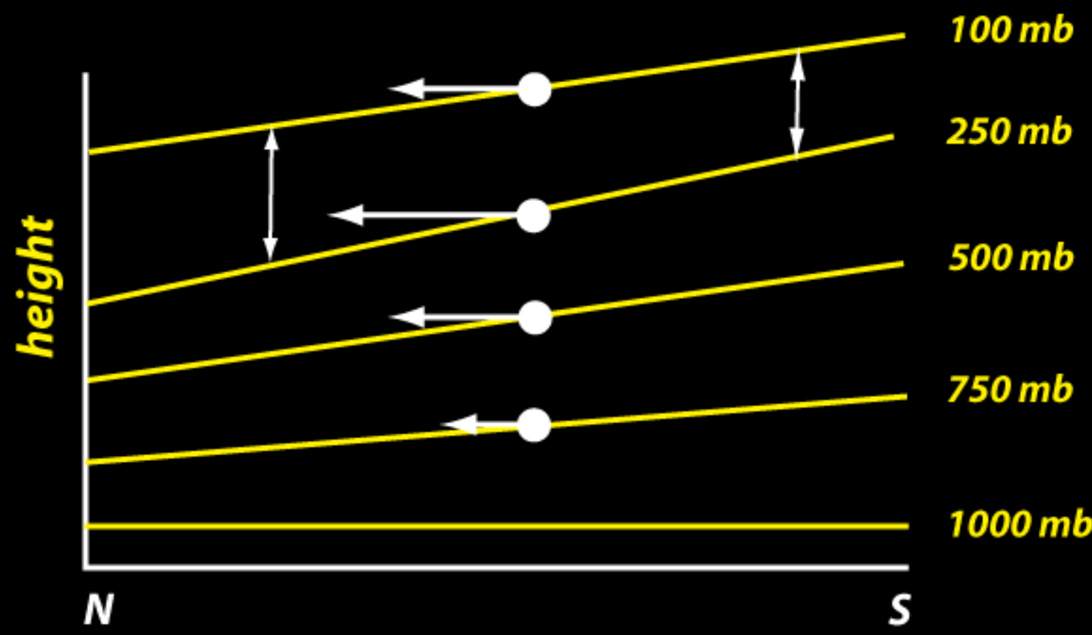


Now consider the 750-500 mb layer.
It's still colder to the north, so the thickness of this layer is still smaller there. We started with a 750 mb surface that tilted downward to the N, and now we get a 500 mb surface that has to tilt EVEN MORE.

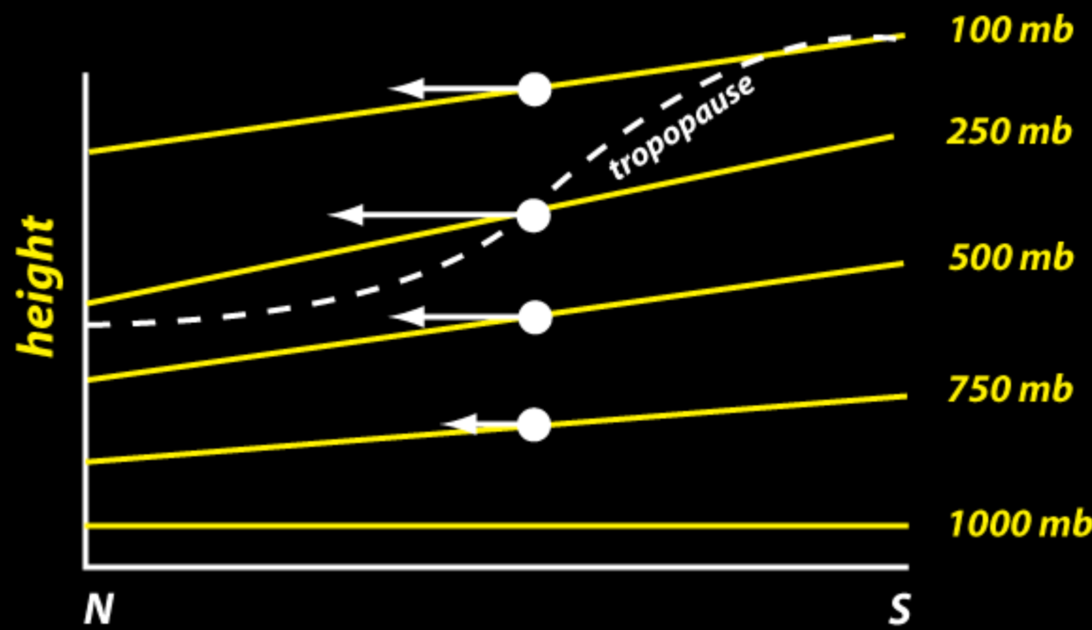


It’s STILL colder to the N in the 500-250 mb layer, so the 250 mb surface tilts even more, giving us an even stronger wind. **Westerly wind shear**.

Will this keep going? NO. We’re at the level of the subtropical jet, the maximum wind.

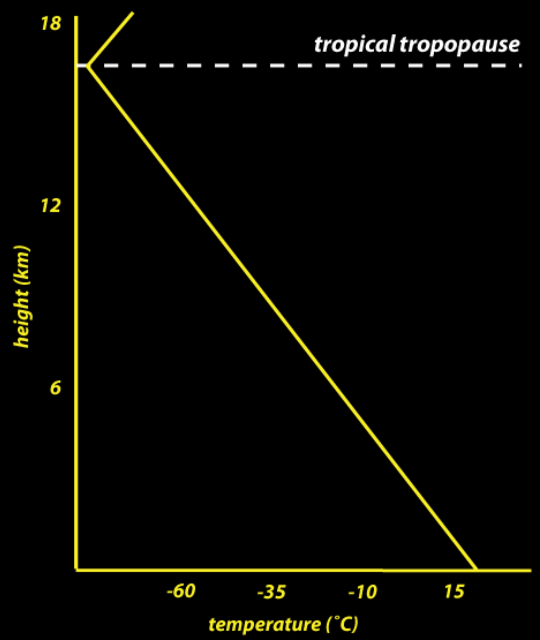


In the next layer up, the story finally changes. We've reached a layer in which it's actually WARMER in the N than in the S, EVEN in WINTER.
The 250-100 mb layer is thicker to the N, which means the isobaric surface at the layer top tilts somewhat LESS. The tilt hasn't gone away, but the wind is now getting weaker with height.

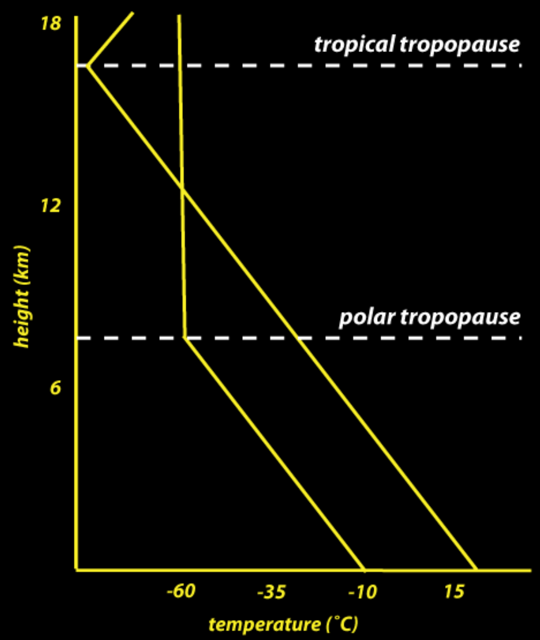


How can it be warmer at the pole than equator ANYWHERE during winter, given the pole doesn't even receive any sunlight for a whole 6 months?
Here's a hint: T decreases with height only in the TROPOPSHERE. It INCREASES with height in the stratosphere… or, at the very least, it stops decreasing quite so quickly.

Tropical vs. polar tropopause height

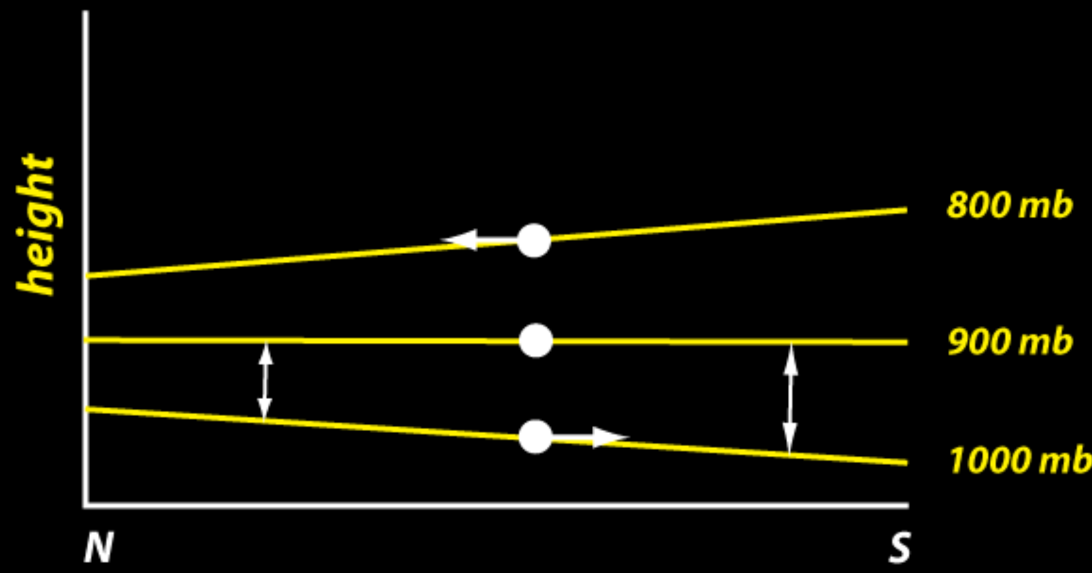


- Here’s how T varies with height in the tropics, on average.
- The tropical tropopause is located around 17 km above sea-level, with a T there of -80C or -112F

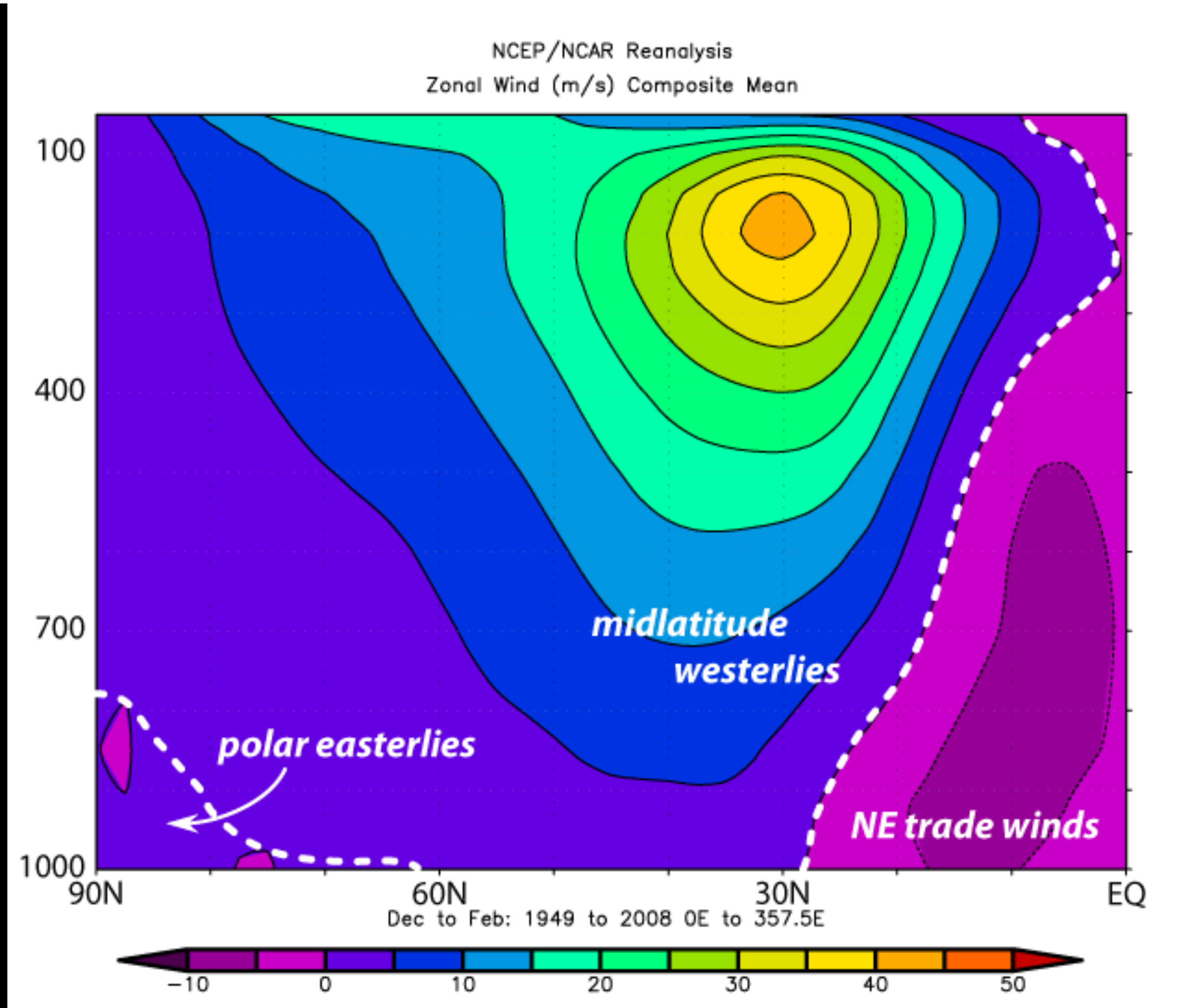


- Tropical tropopause is about 17 km above sea level.
- Polar T does start out a lot colder at the surface, and though it cools with height at about the same rate… the polar tropsphere is SHALLOW because it's cold
- At 12 km or so, equator and pole are same T! **That's where the jet is**.

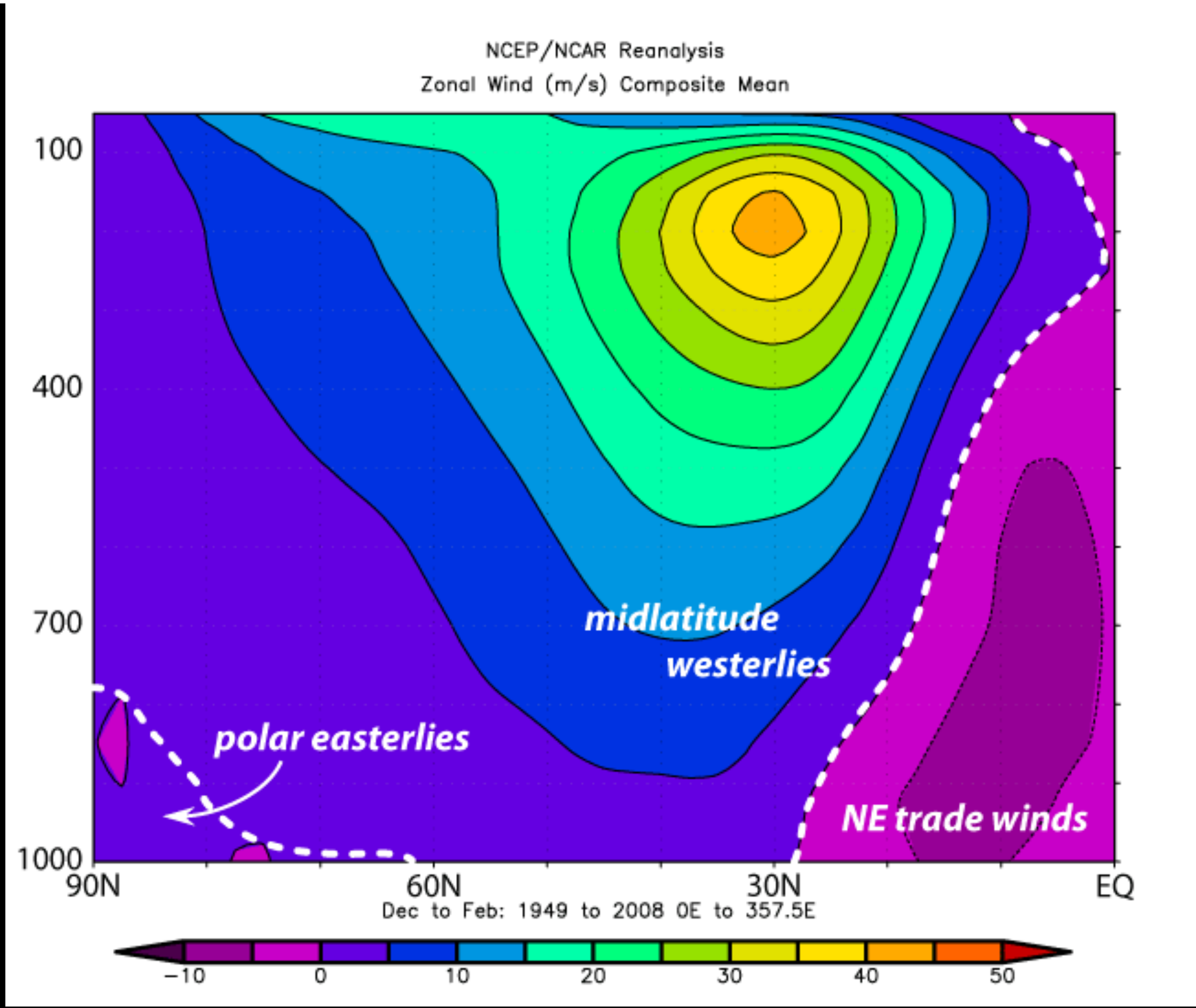
Revisit the 3-cell model



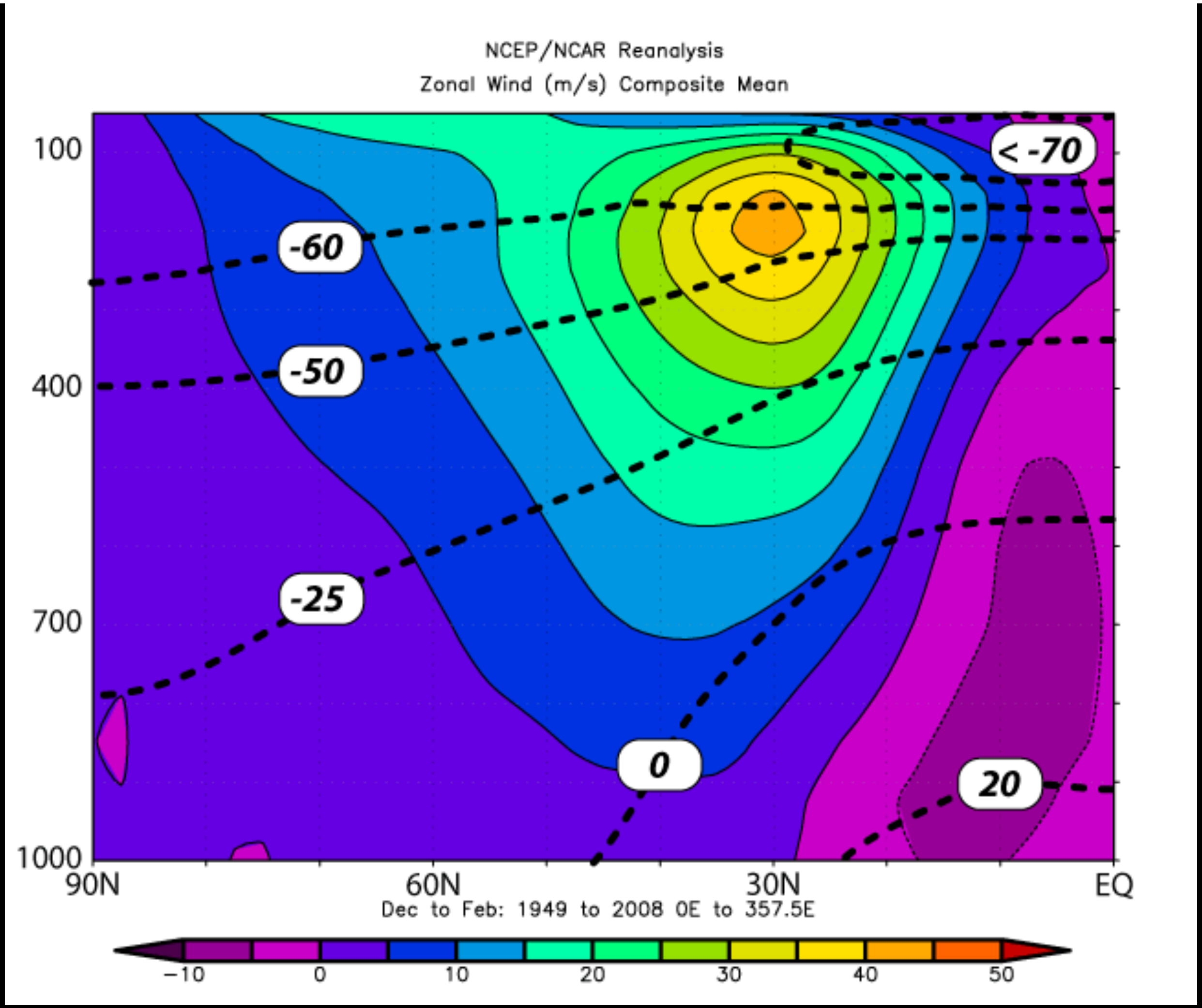
Situation in which T decreases to the N, but surface wind is easterly. Note the easterly wind vanishes with height, and turns to westerly. It's still westerly shear, because it's colder to the north. This applies to the surface polar easterlies.



Zonally-averaged zonal wind varies with latitude during winter, from NH pole to equator.
Warm colors represent fast westerly winds. The subtropical jet is at the 200 mb level, above 30N. Wind speeds up to 100 mph.

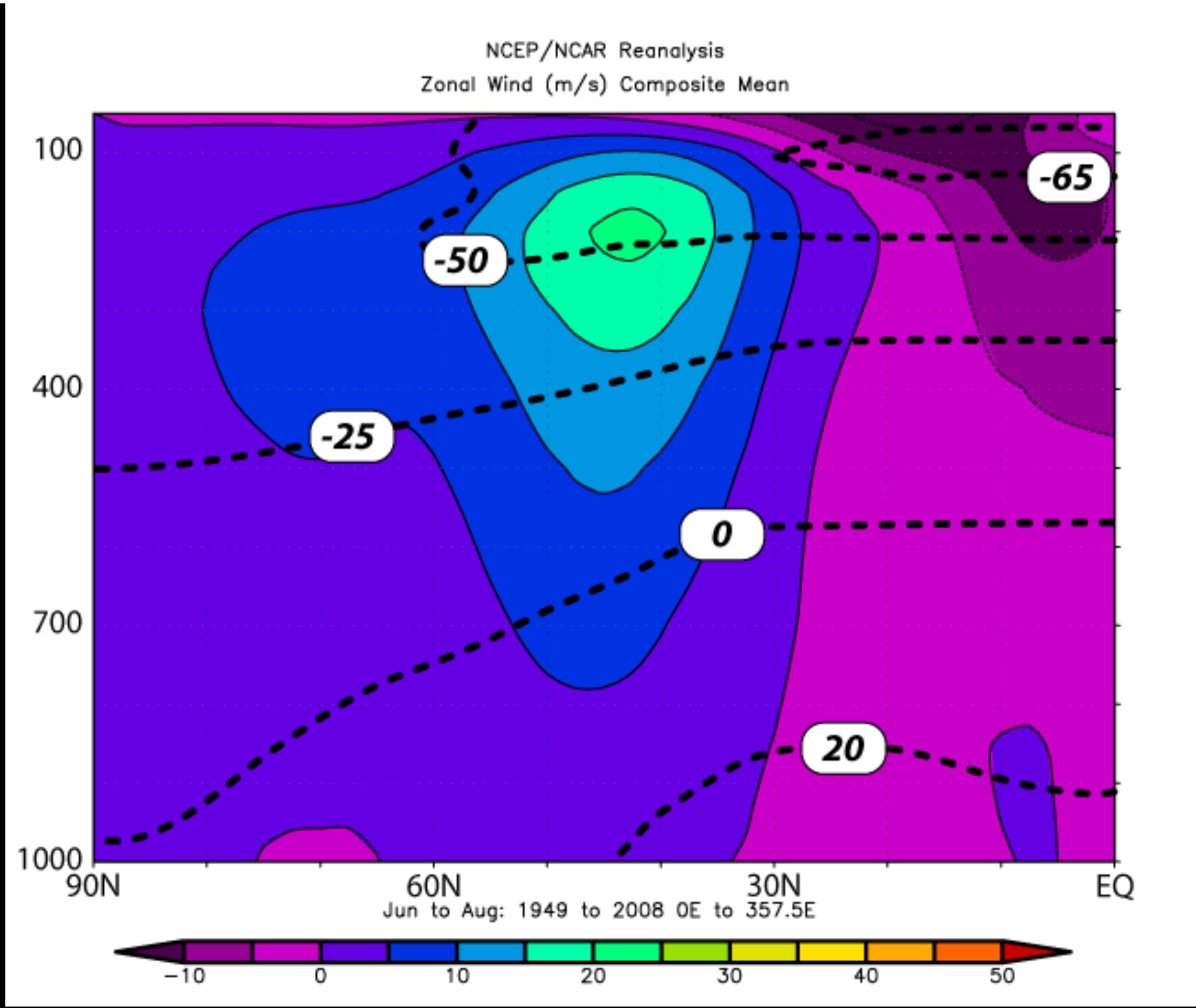


In midlatitudes, between 60 and 30N, there are westerly winds at all levels, from the surface to the top of the figure, which is 50 mb. That level is in the stratosphere everywhere on Earth. The polar easterlies are very shallow, and there's little vertical shear in the tropics.



I've added isotherms – lines of equal temperature – in degrees C. Observe how the horizontal T variation changes with altitude.

This is still **winter**.



Now for **summer**. Everything is slower, smaller, because the pole to equator T difference is smaller.

[end]