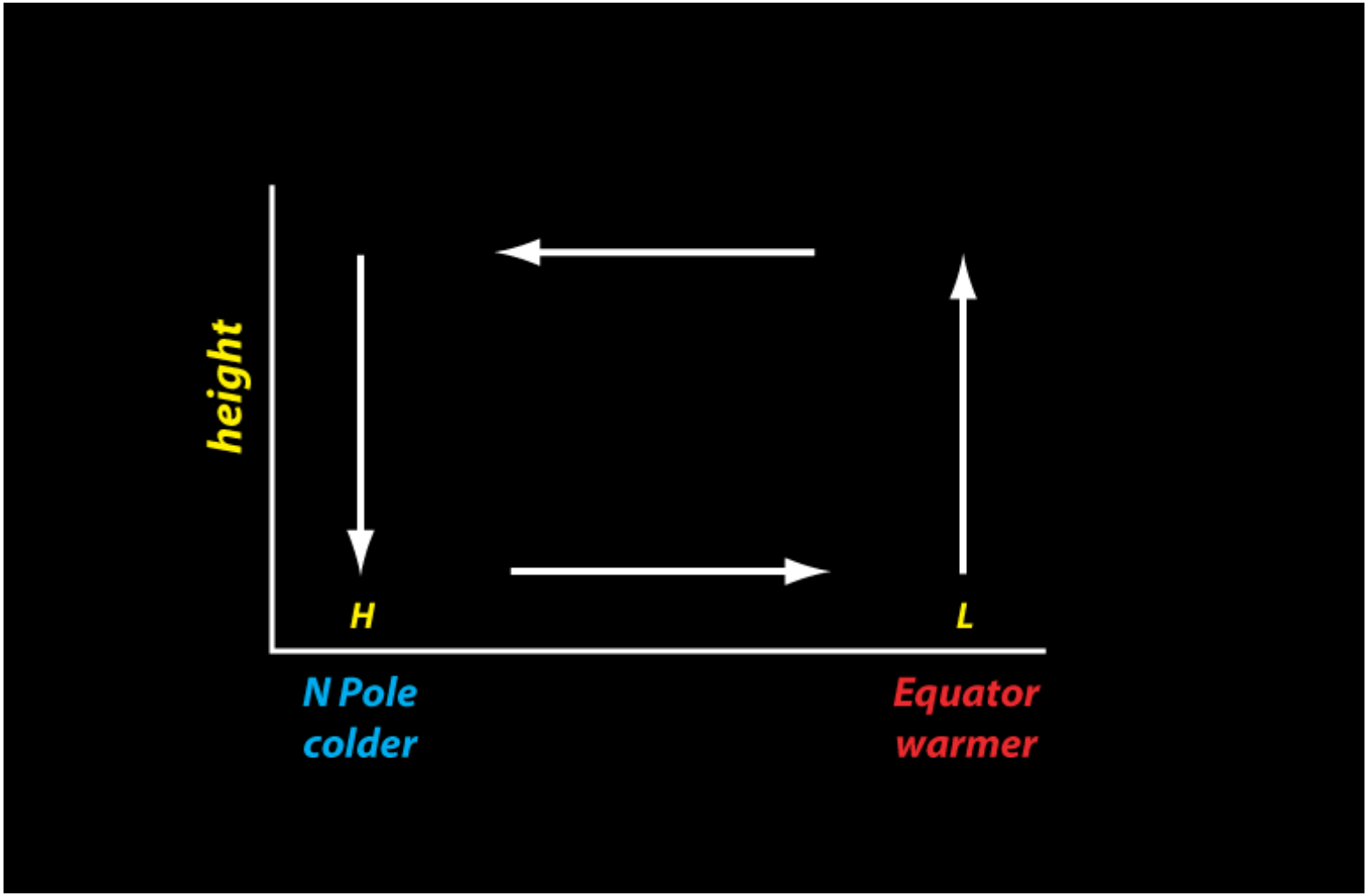
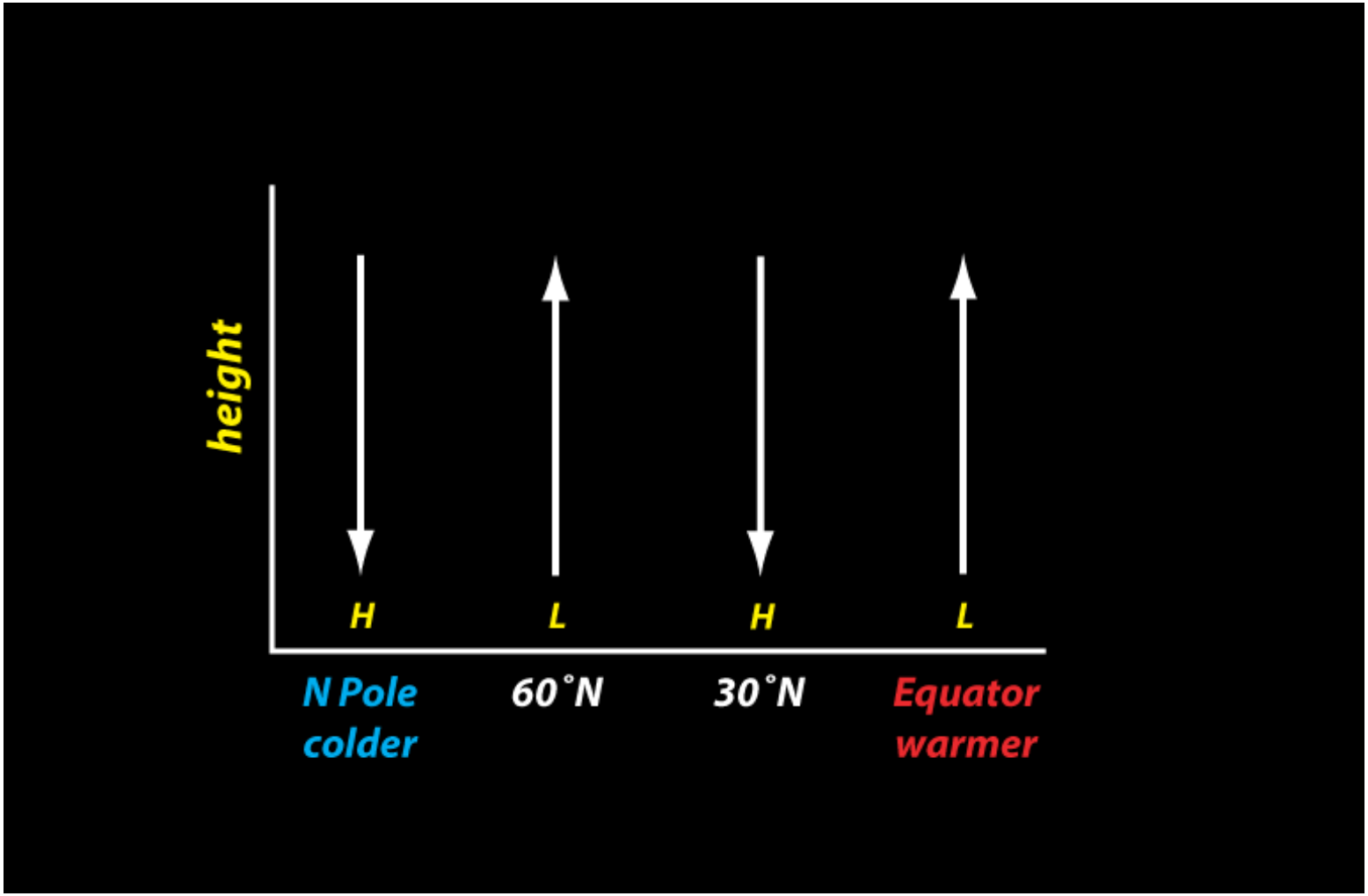
The elusive polar jet

ATM 210 -- Fall 2023 -- Fovell

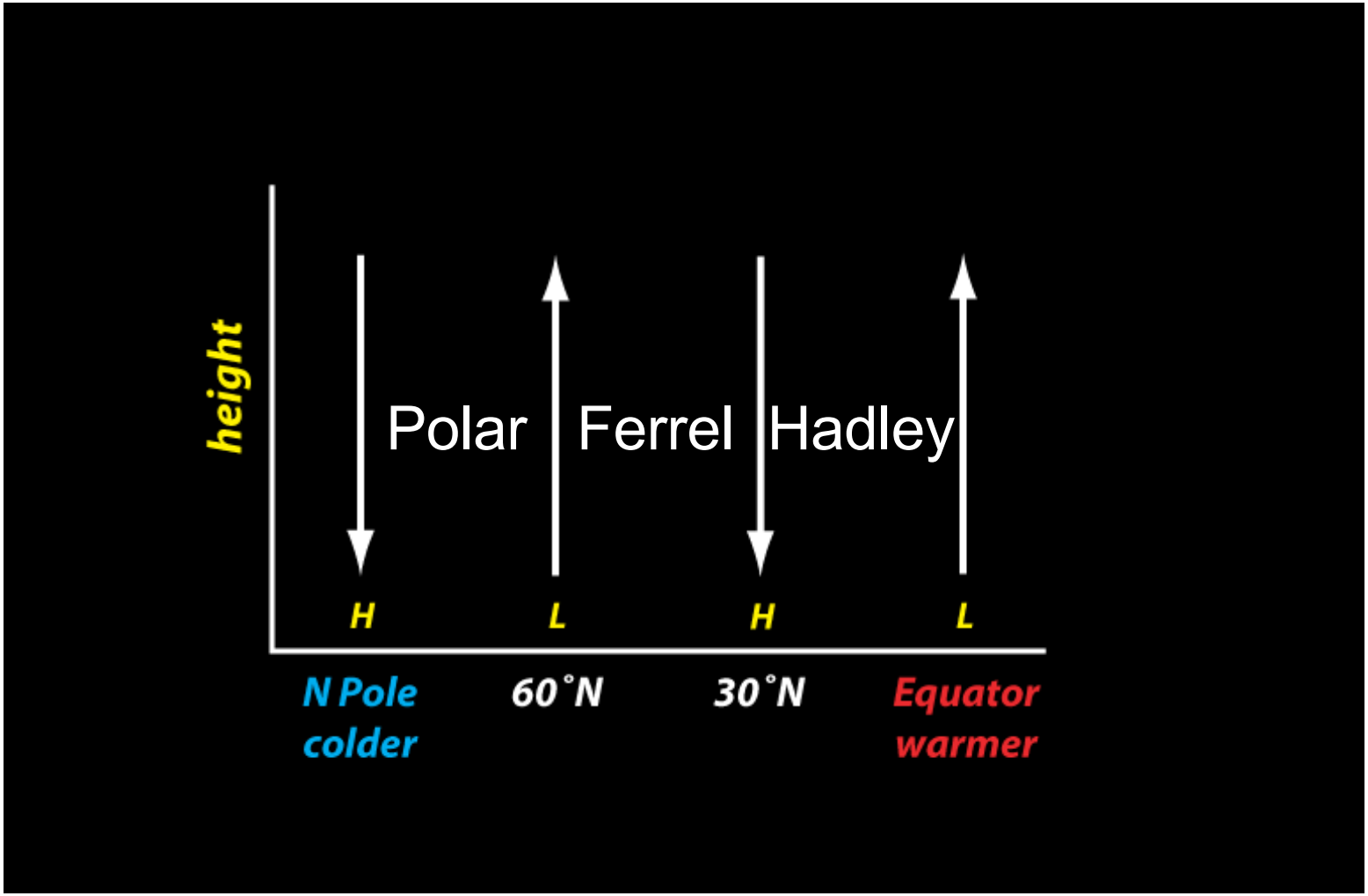
The one-cell model for hemispheric circulation **does not work**



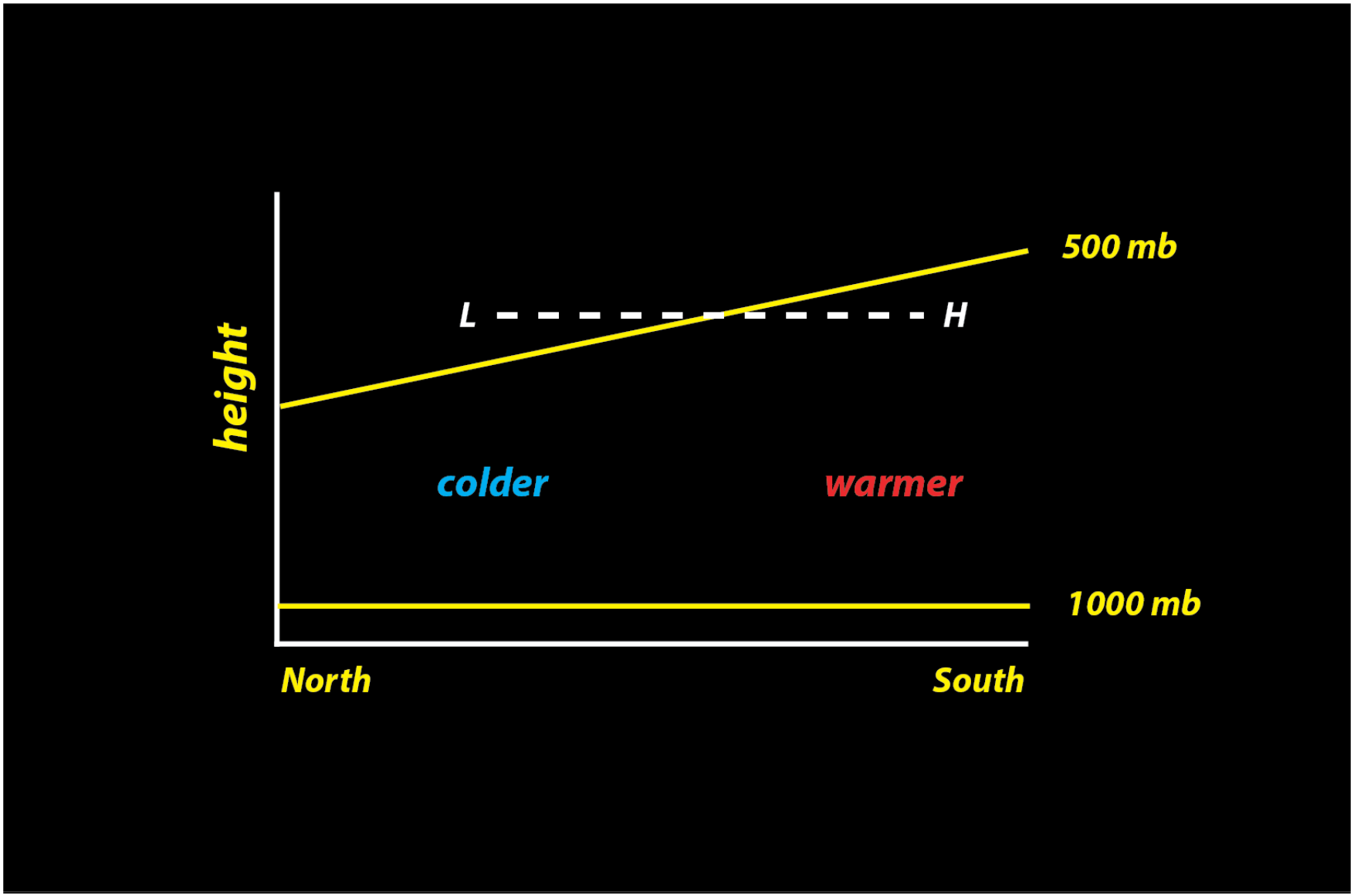
Earth rotation breaks it up into 3 cells per hemisphere, providing preferred latitudes for **storms** and **deserts**



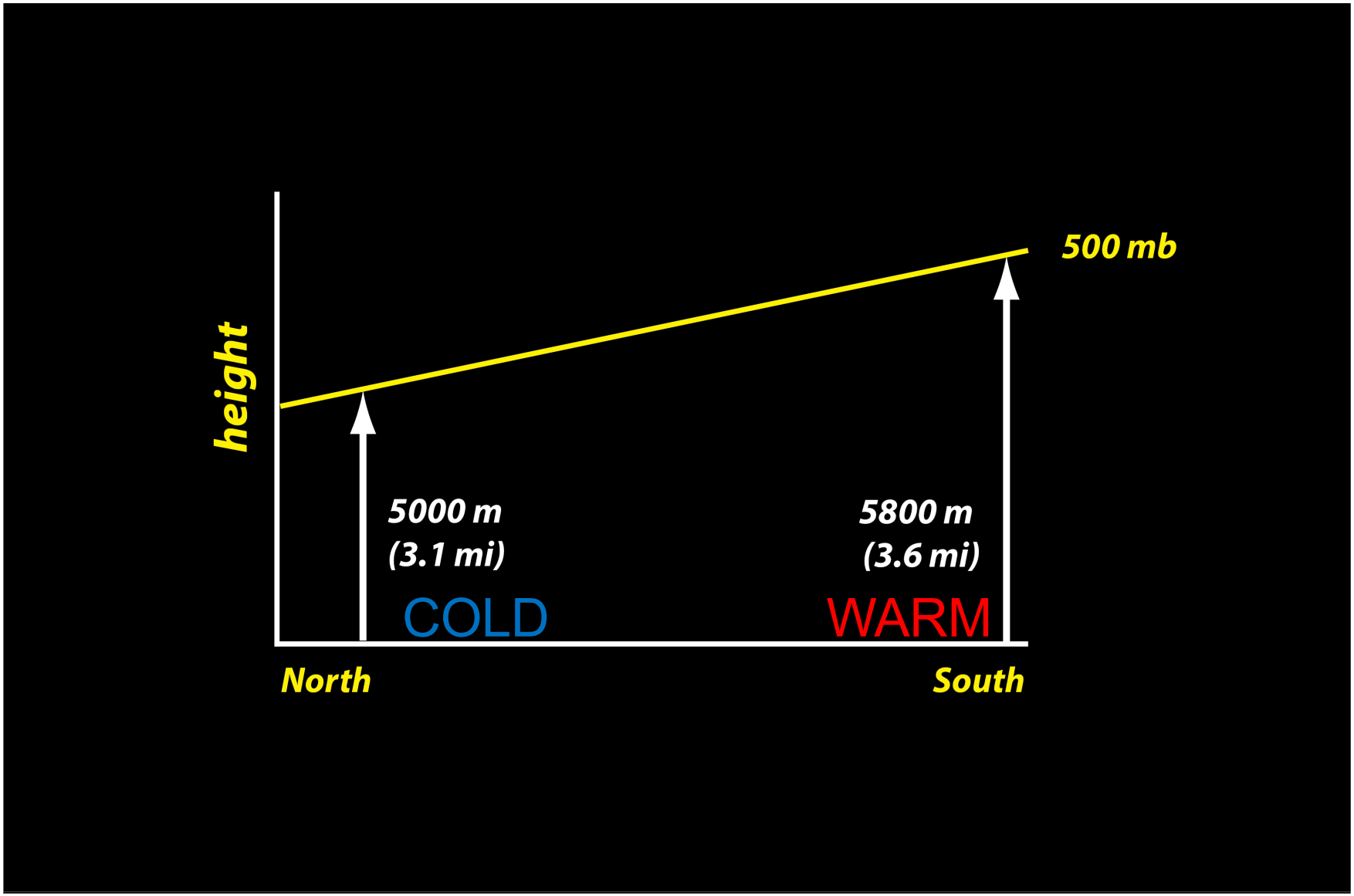
We call these cells Polar, Ferrel, and Hadley. The Ferrel is thermally indirect



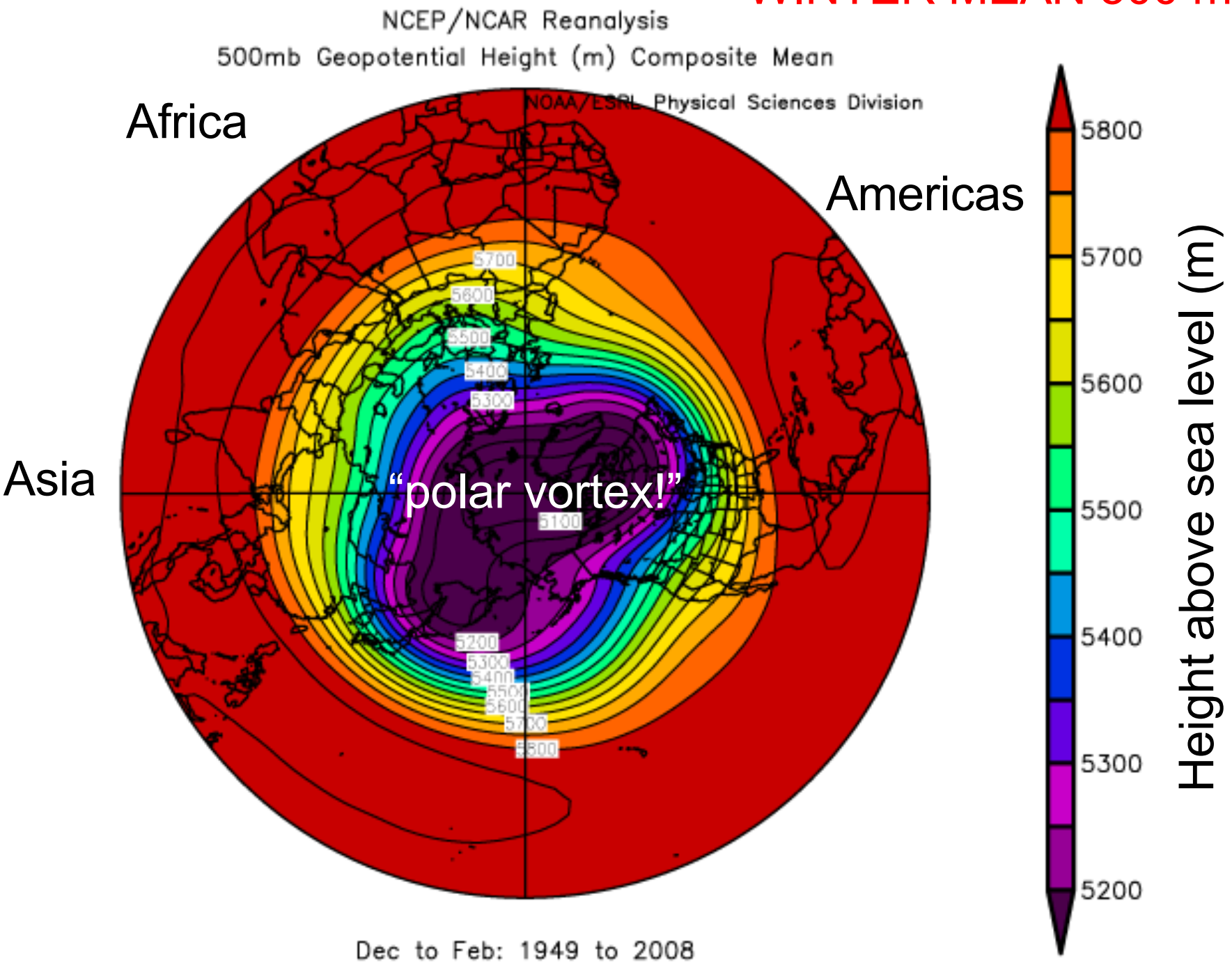
T gradient → p gradient → west to east geostrophic wind



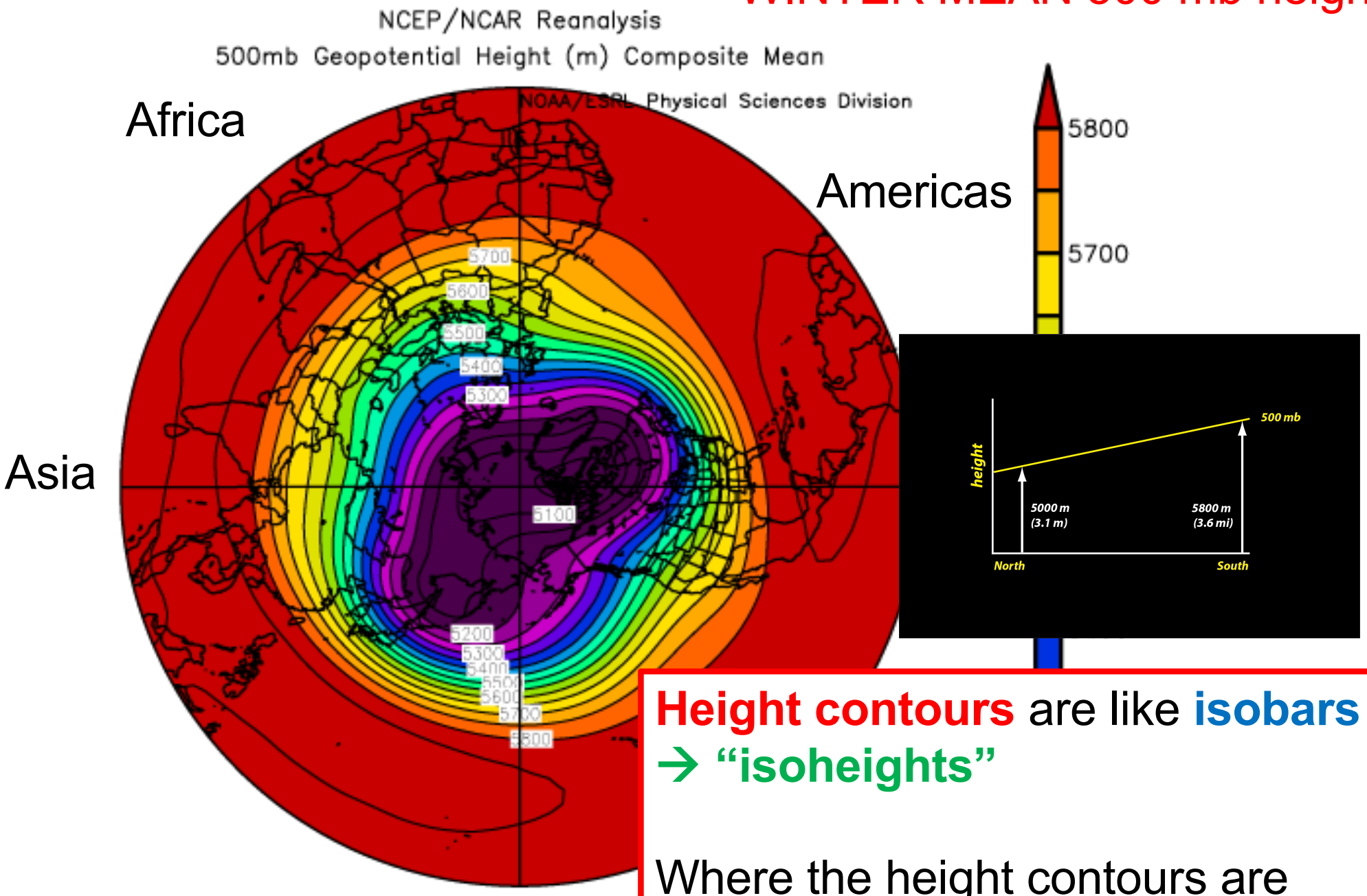
500 mb **isobaric surface** slants down towards cold pole



WINTER MEAN 500 mb height



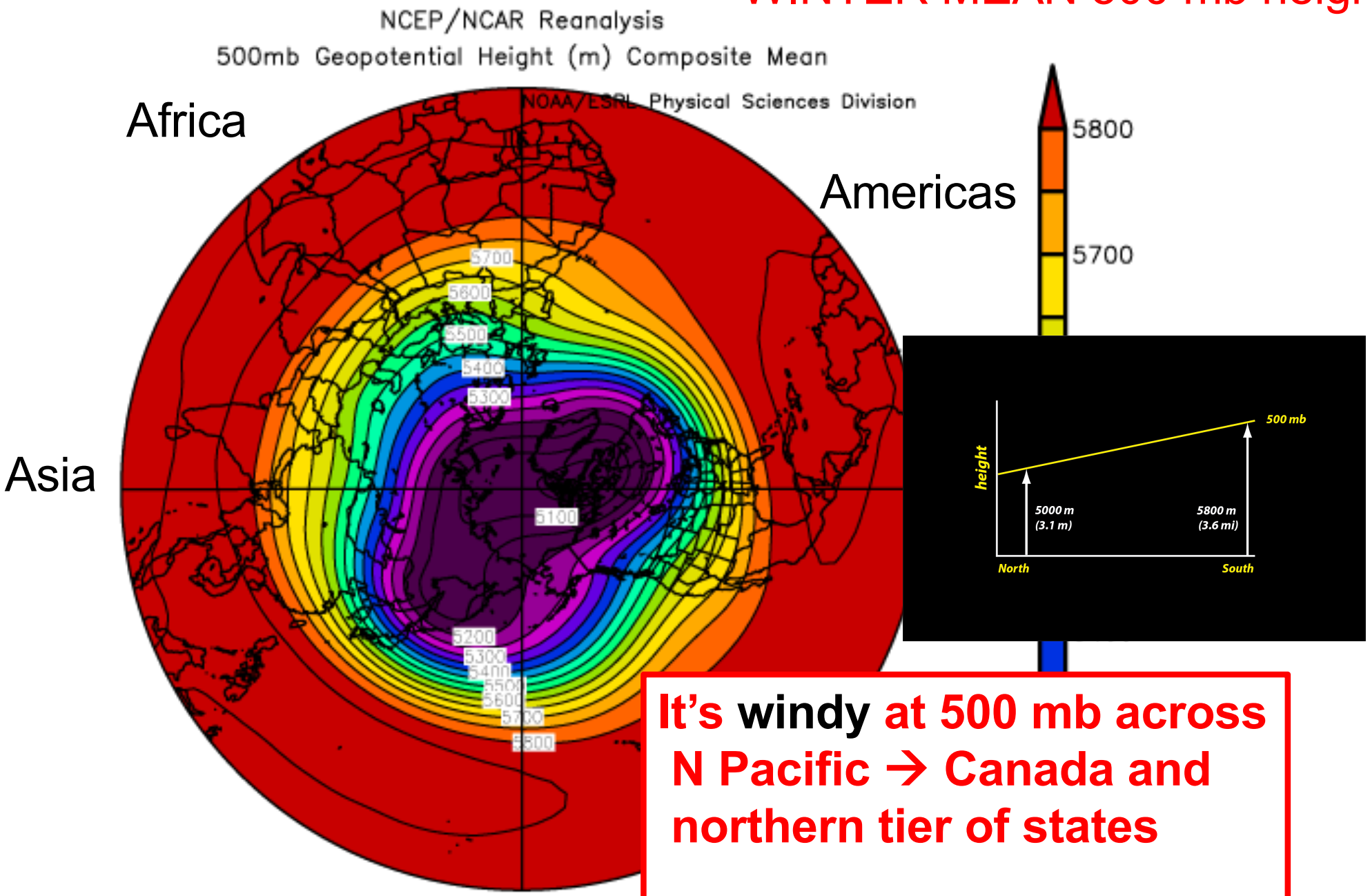
WINTER MEAN 500 mb height



Height contours are like **isobars**
→ **"isoheights"**

Where the height contours are **packed**, wind is **strong**

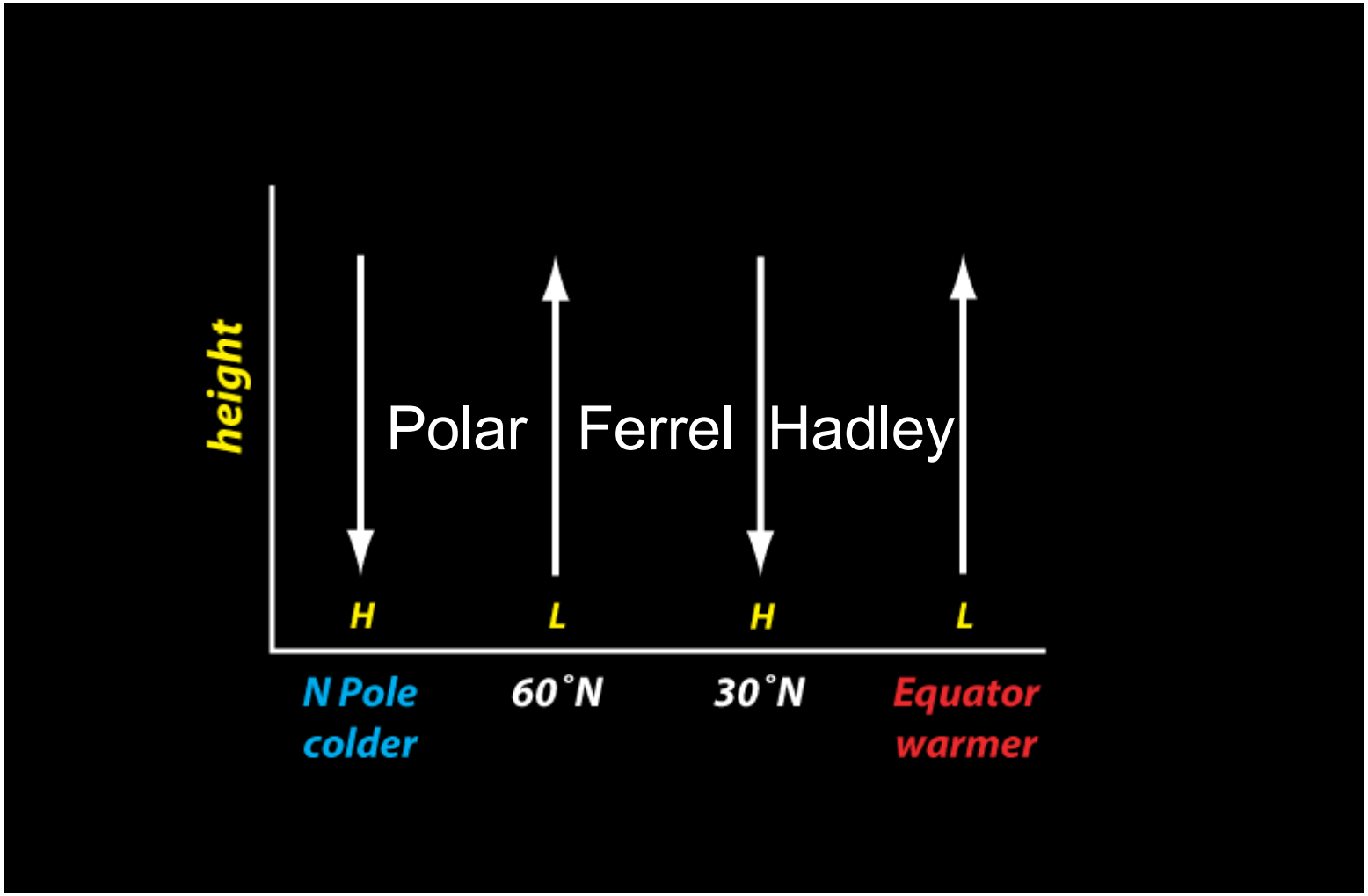
WINTER MEAN 500 mb height



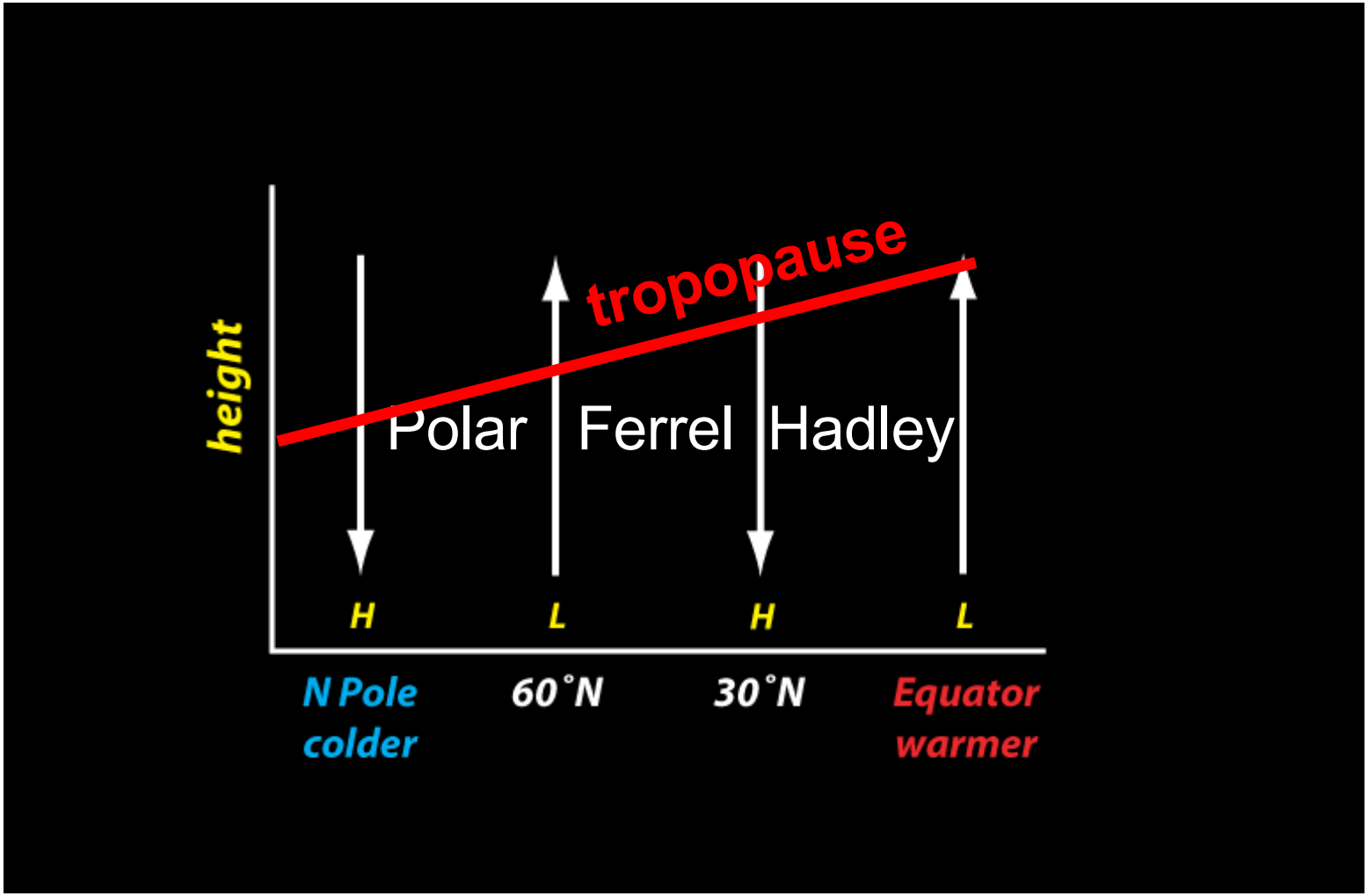
It's windy at 500 mb across N Pacific → Canada and northern tier of states

→ 40˚ to 60˚N latitude

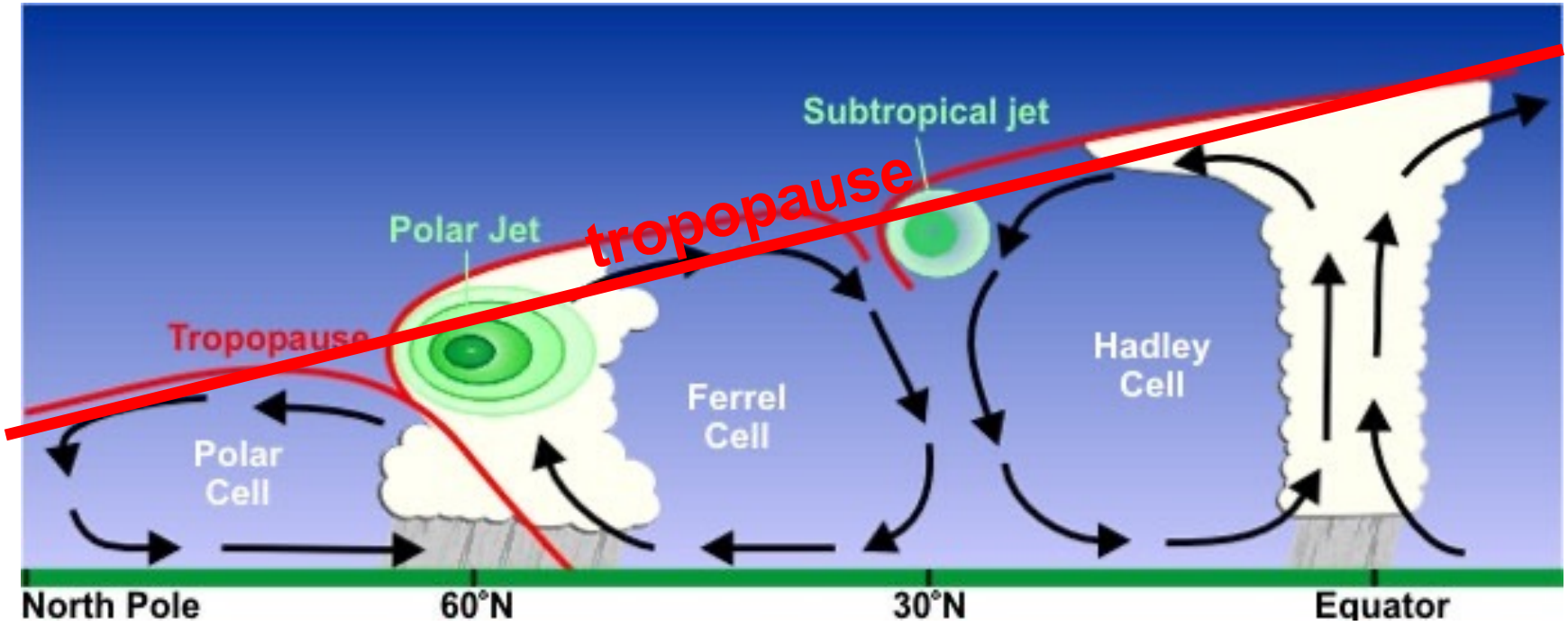
But this picture needs to be revised…



The **tropopause** also tilts down towards the cold pole



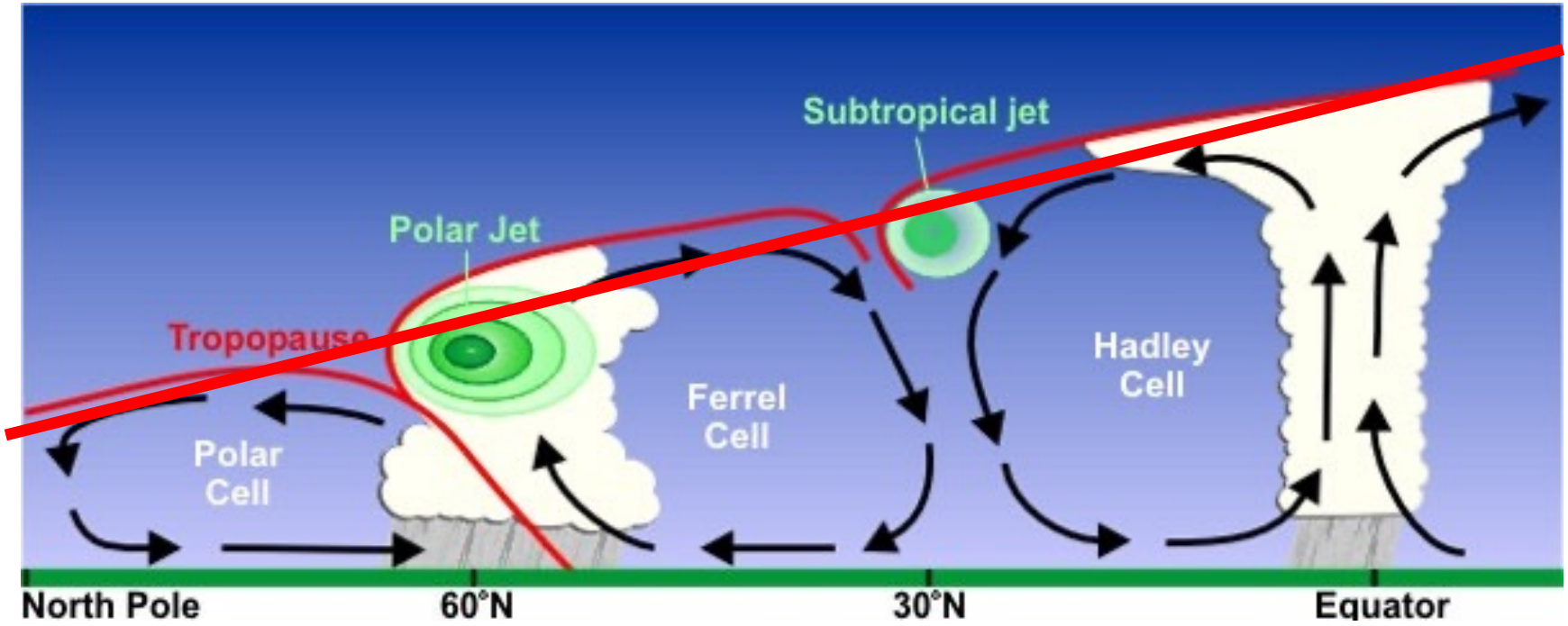
A more accurate view of the 3 cells



So the Polar cell is **shallower** than the Hadley cell

https://climate.ncsu.edu/images/edu/jetstream3.jpg

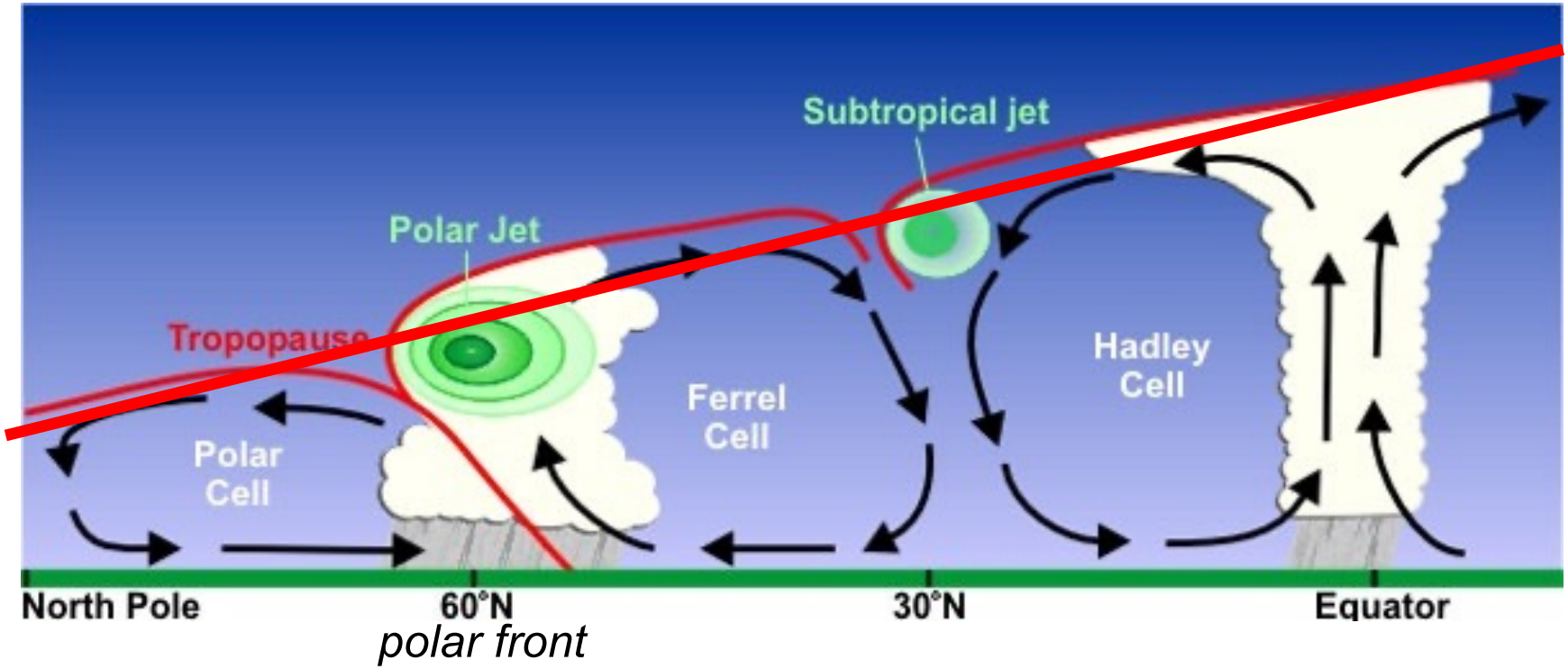
And there are **two jets**, one at 30˚N, the other at 60˚N



Both jets are located at the tropopause

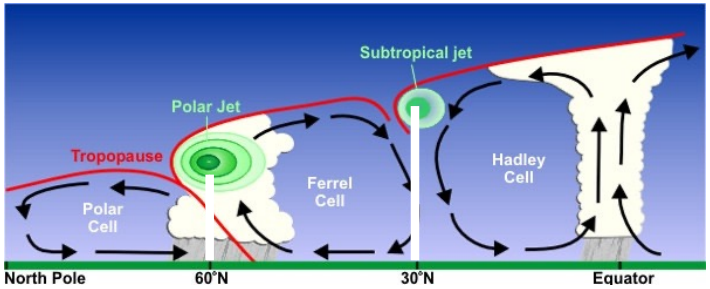
https://climate.ncsu.edu/images/edu/jetstream3.jpg

The **polar jet** is located at a lower altitude and is **much faster**



And it is located above the **polar front** at 60˚N:
Sharp N-S T gradient → **westerly vertical wind shear**

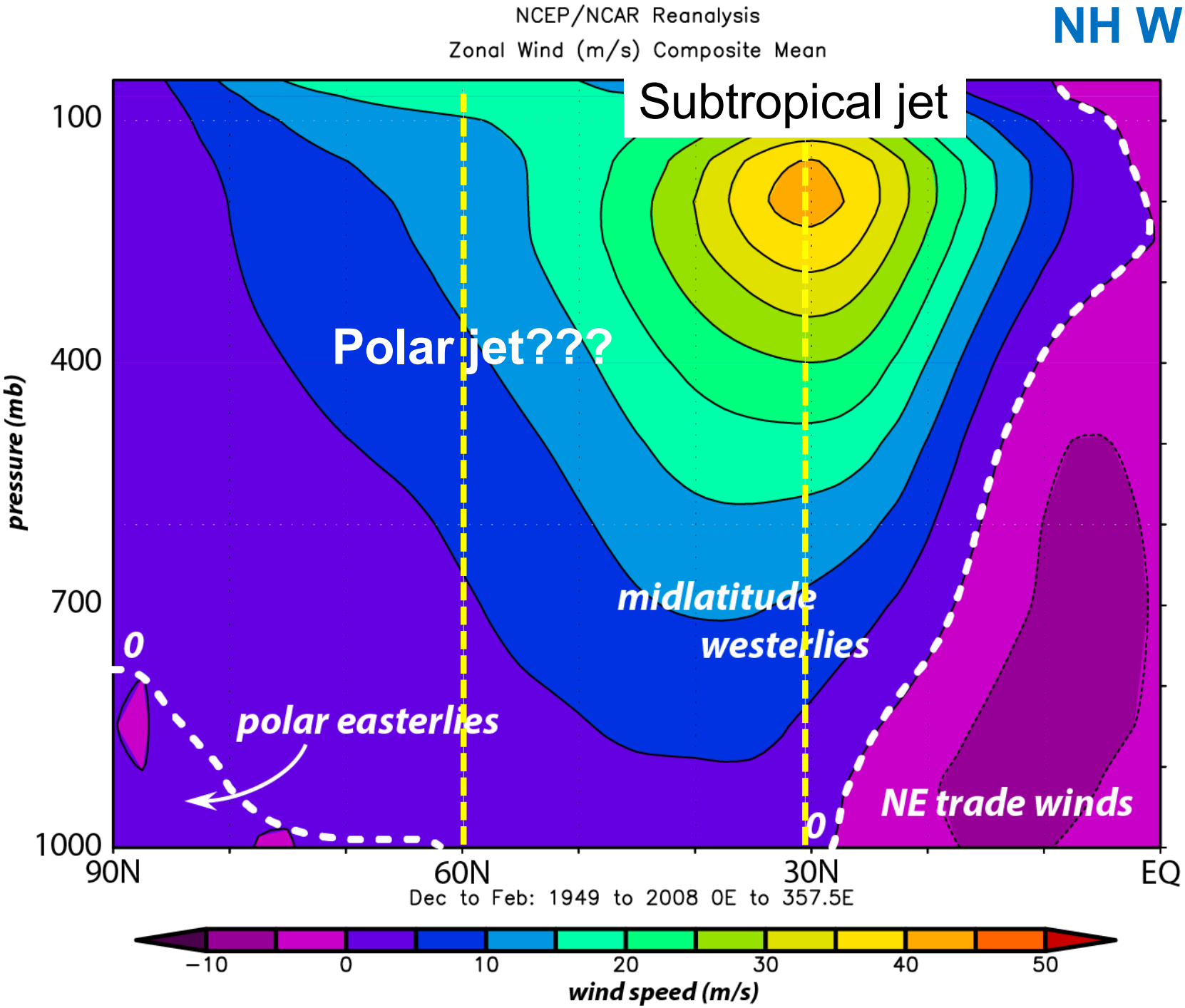
https://climate.ncsu.edu/images/edu/jetstream3.jpg



Two tropopause jets

- **Subtropical jet** (weaker; nominally above 30˚N)
  - Moderate horizontal T gradient [colder to N]
  - Moderate westerly vertical wind shear
  - Deeper tropospheric depth [warmer]
  - Jet max about 40 m/s (90 mph) in winter season composite
- **Polar jet** (stronger; nominally above 60˚N)
  - Very large horizontal T gradient [colder to N]
  - Substantial westerly vertical wind shear [above polar front]
  - Shallower tropospheric depth [colder]
  - Jet max in winter season composite…

NH WINTER



Where is the polar jet?????

The Case of the Missing Jet

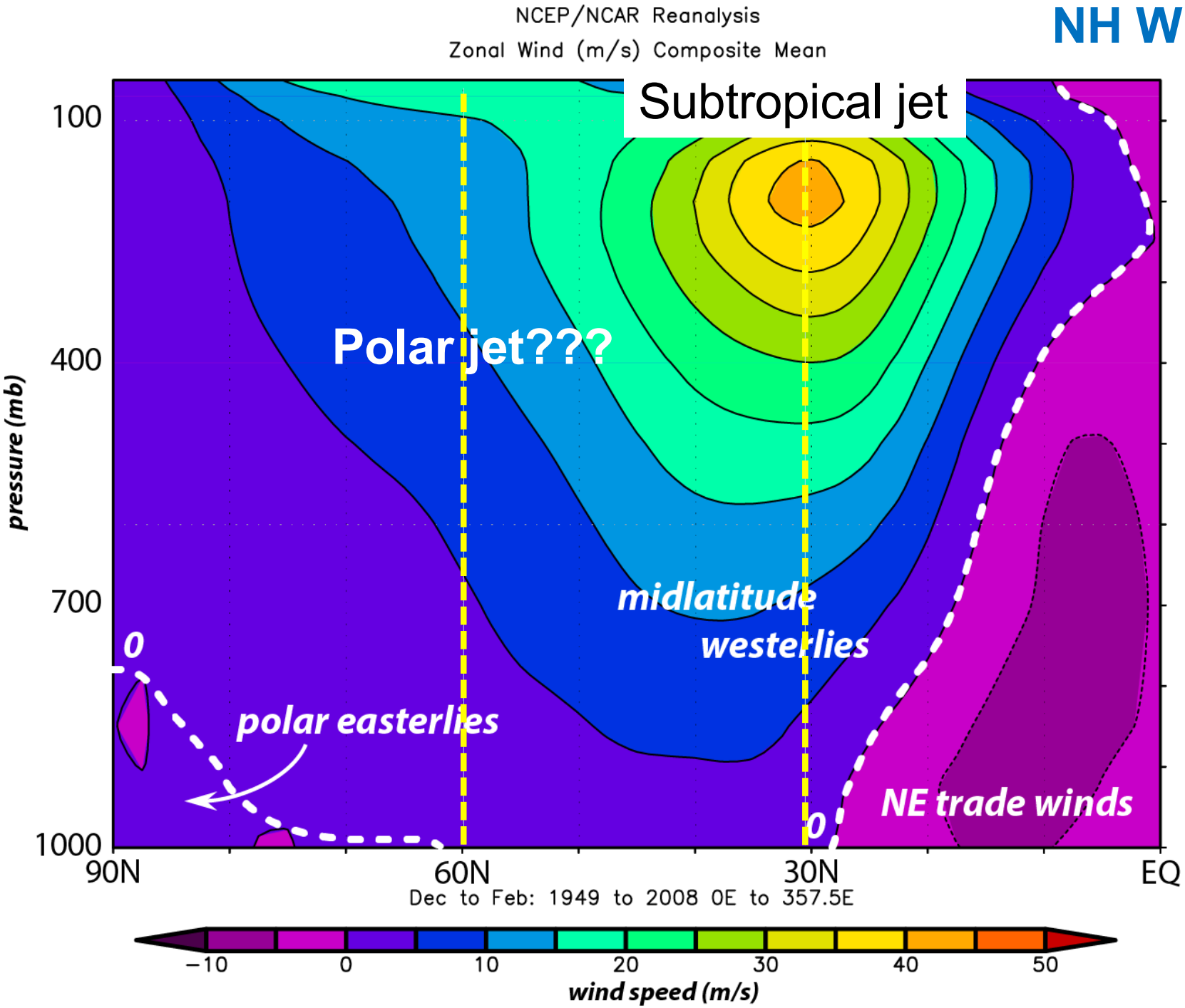
“A three-pipe problem?”

https://clipart-library.com/images_k/sherlock-holmes-silhouette-free/sherlock-holmes-silhouette-free-9.jpg

Facts at hand

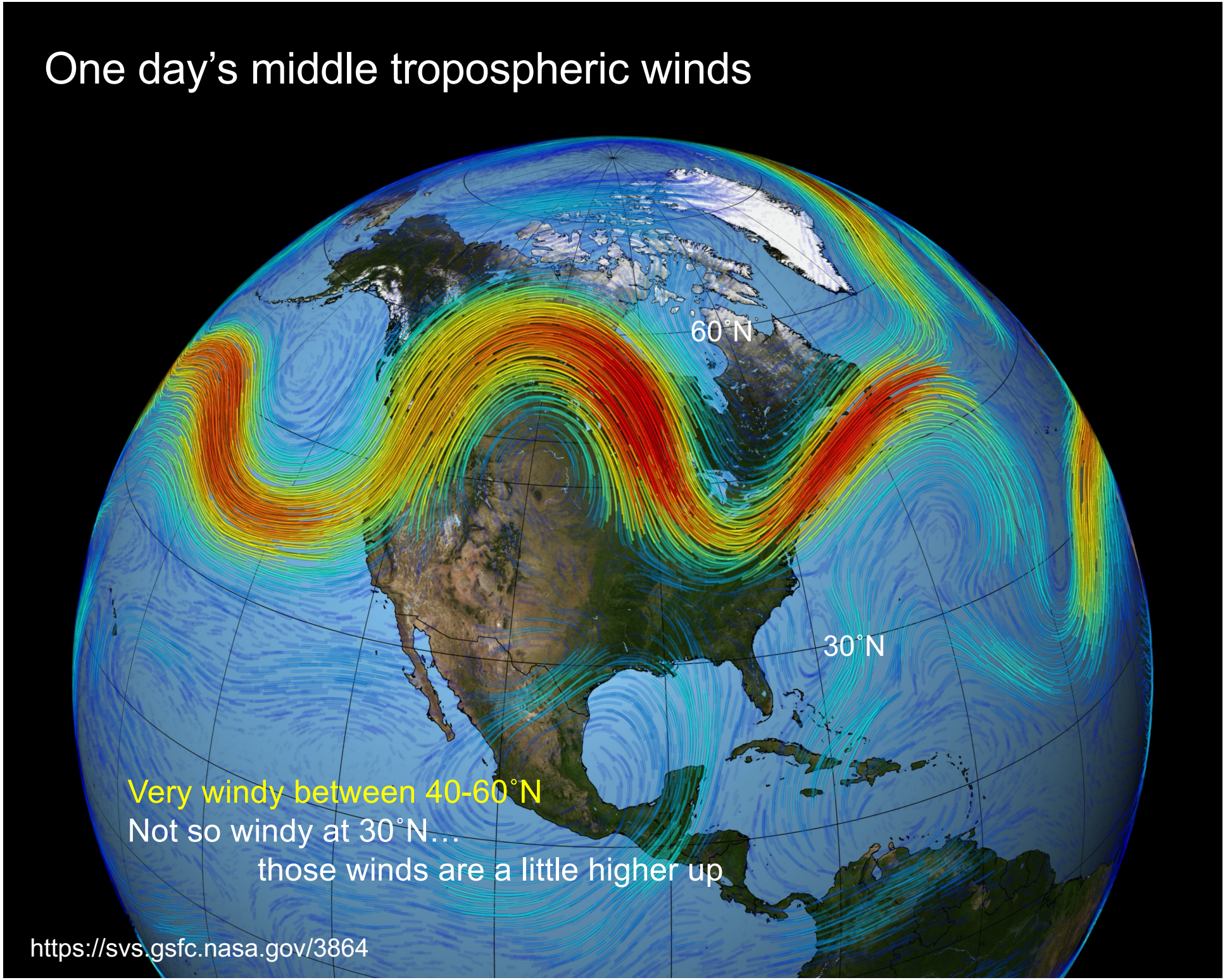
- **Two** jets – both at **tropopause**:
  - Subtropical jet above 30˚N [slower]
  - Polar jet above 60˚N [faster]
- Tropopause tilts down towards the cold pole
  - Polar jet has a lower physical altitude above sea level
- Although slower, the subtropical jet shows up very well in seasonal composites while the **polar jet is nearly absent!**

NH WINTER



This plot represents an average around the latitude circles

One day's middle tropospheric winds

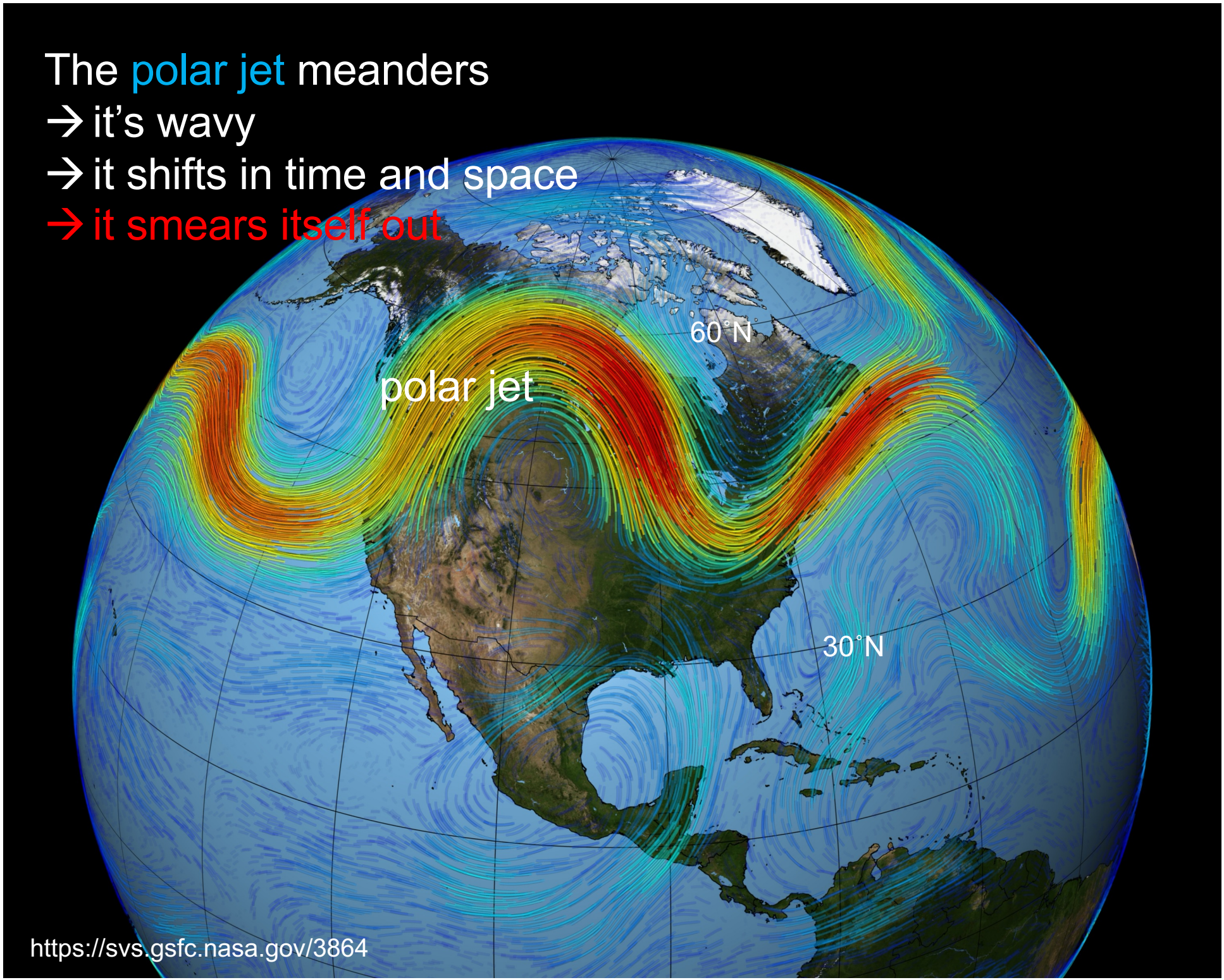


The polar jet meanders

→ it's wavy

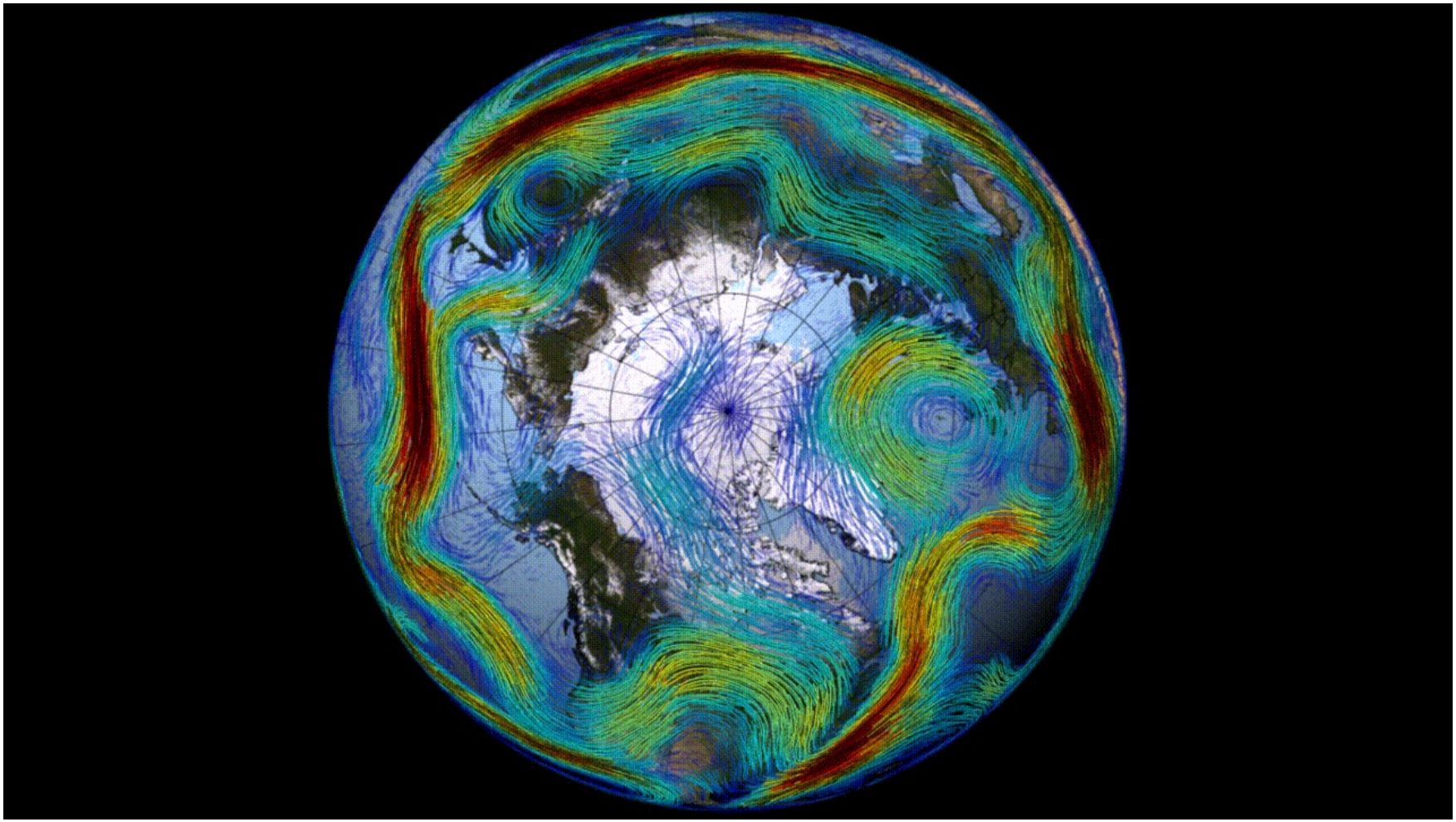
→ it shifts in time and space

→ it smears itself out



https://svs.gsfc.nasa.gov/3864

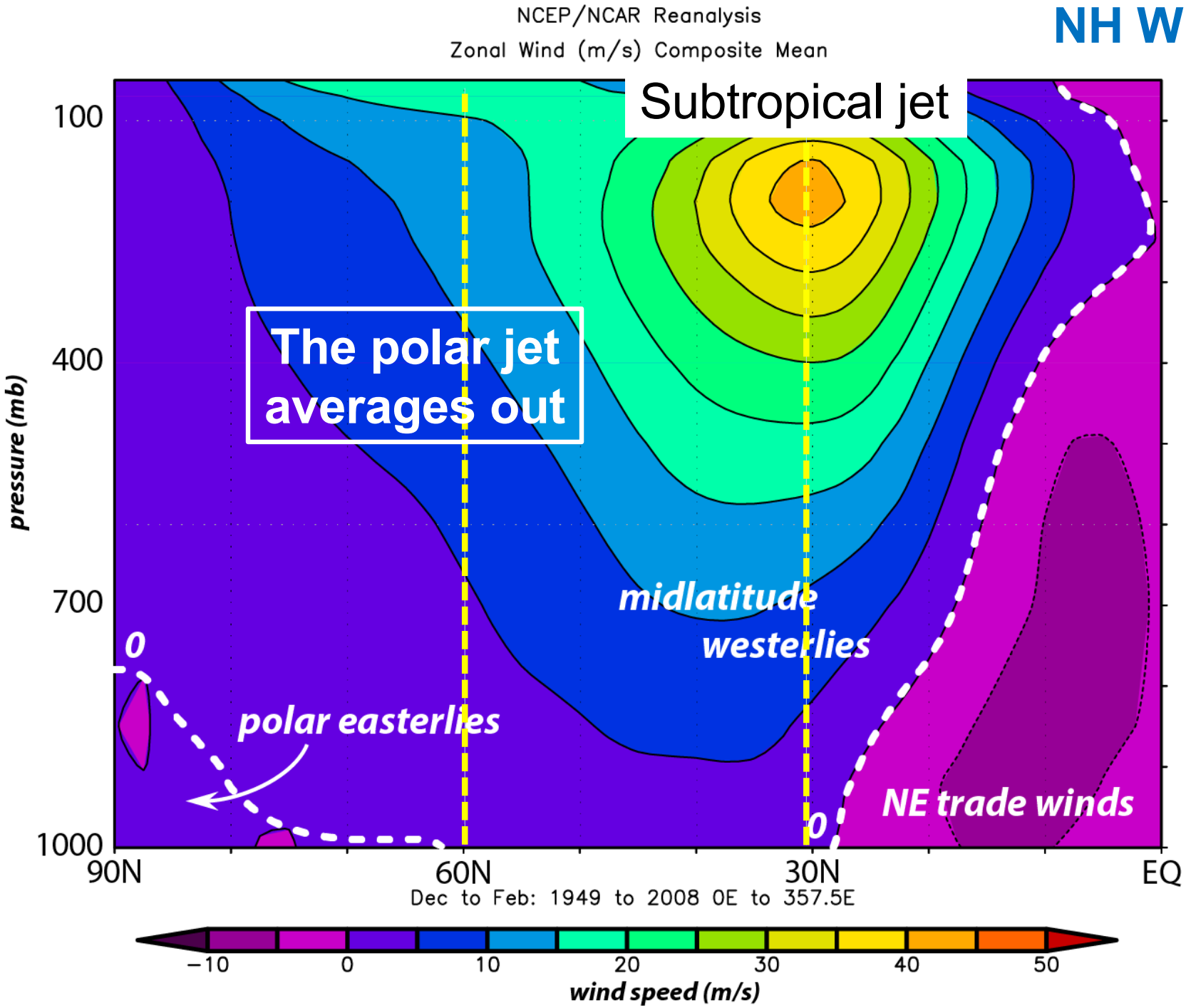
A month-long animation



And if we average all this along latitude circles…

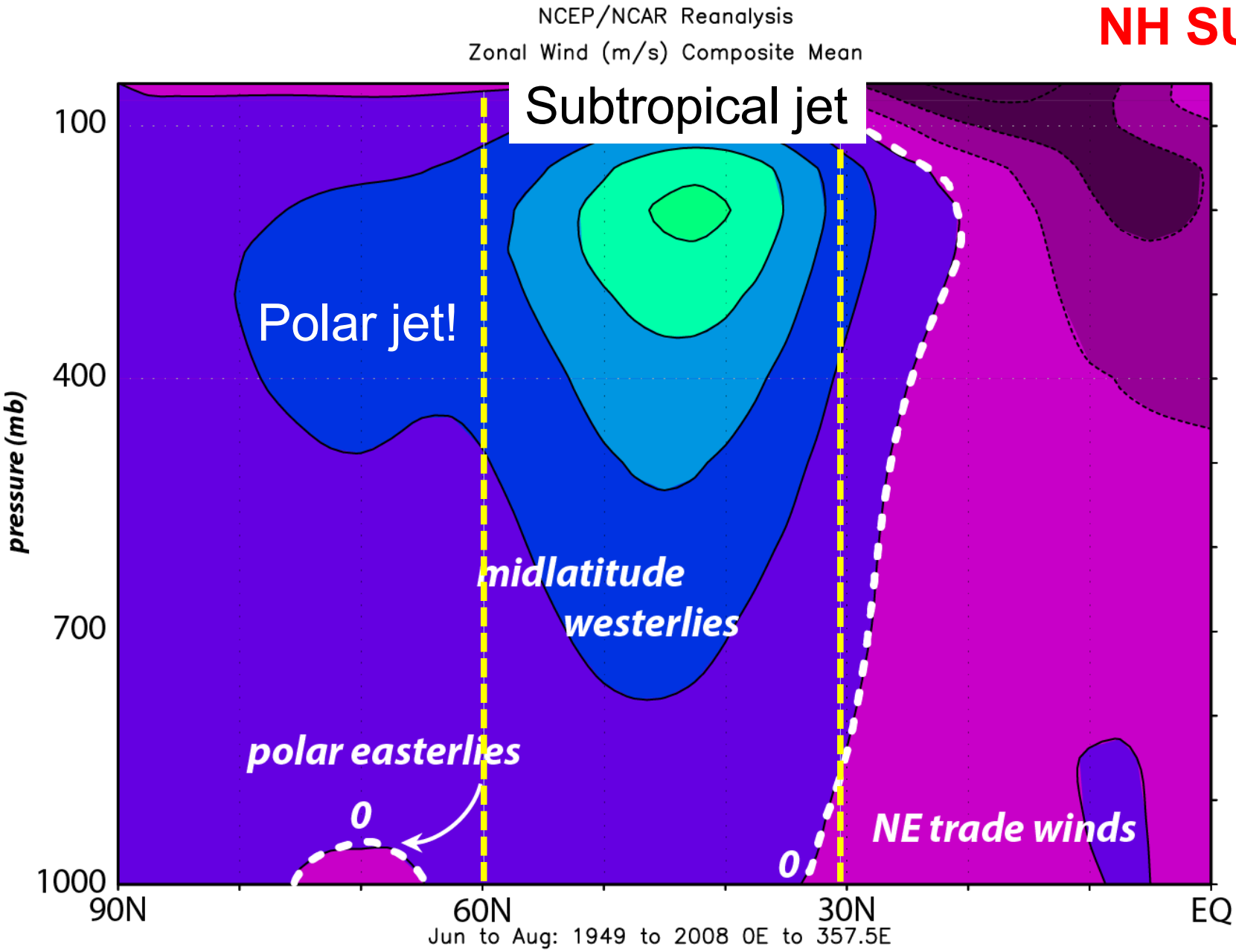
https://svs.gsfc.nasa.gov/3864

NH WINTER



The subtropical jet meanders less

NH SUMMER



We can see some of the polar jet in the summer!

It is weaker and shifted N but **does not meander quite as much.**

The **means** are important
but so are the **variances**

And the **variances** are the **weather**

[case closed]