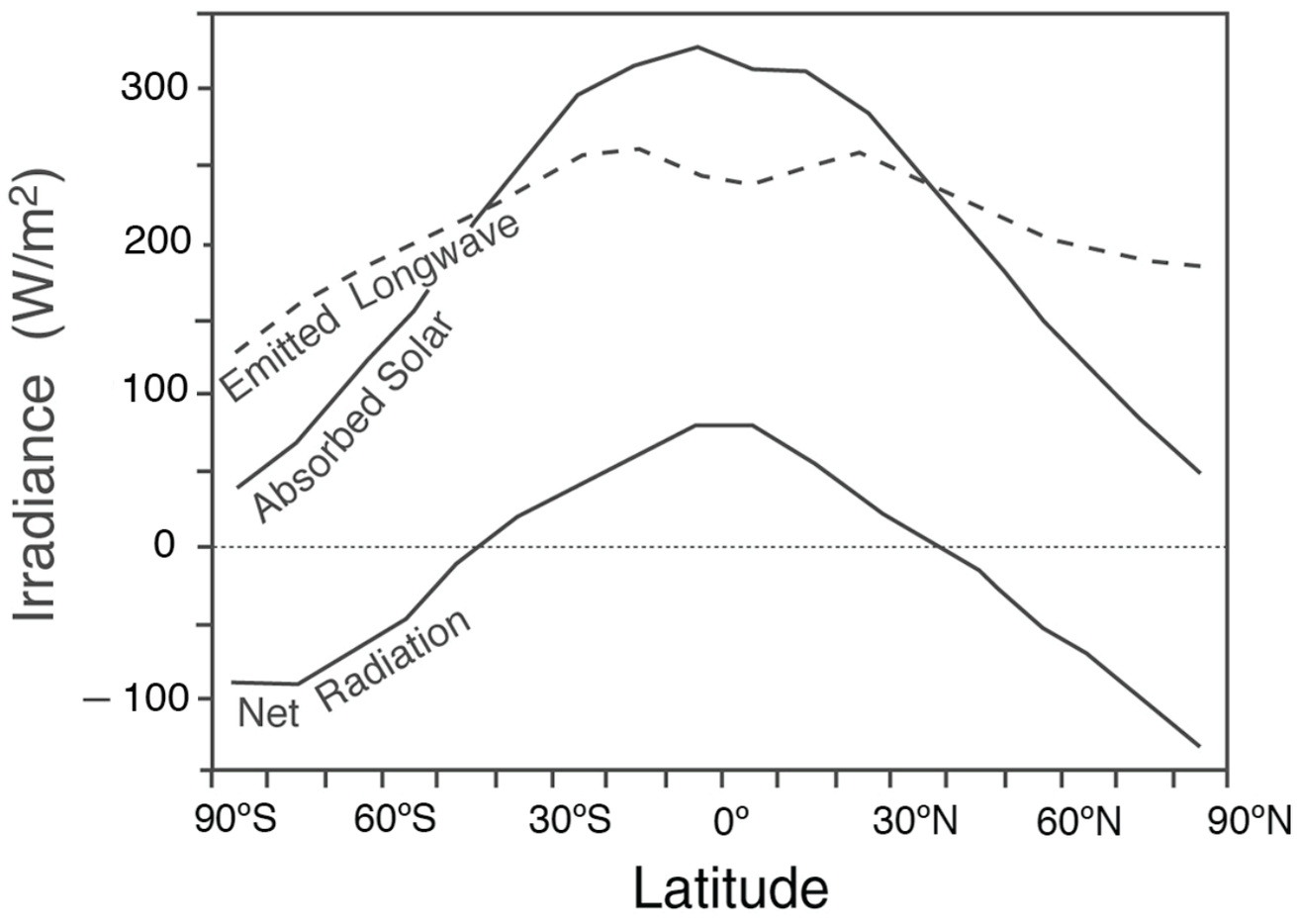
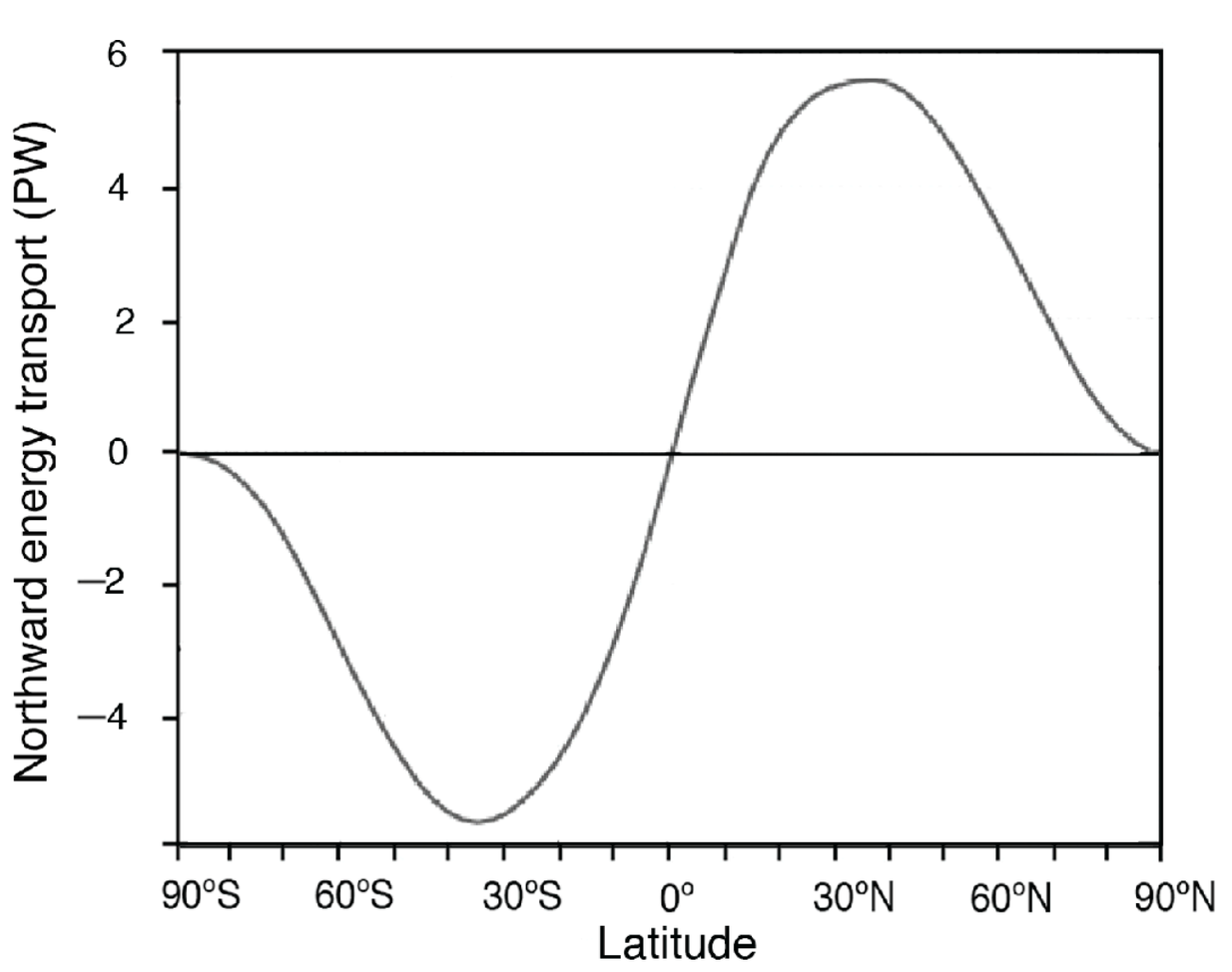
Chapter 5. Meridional structure of the atmosphere

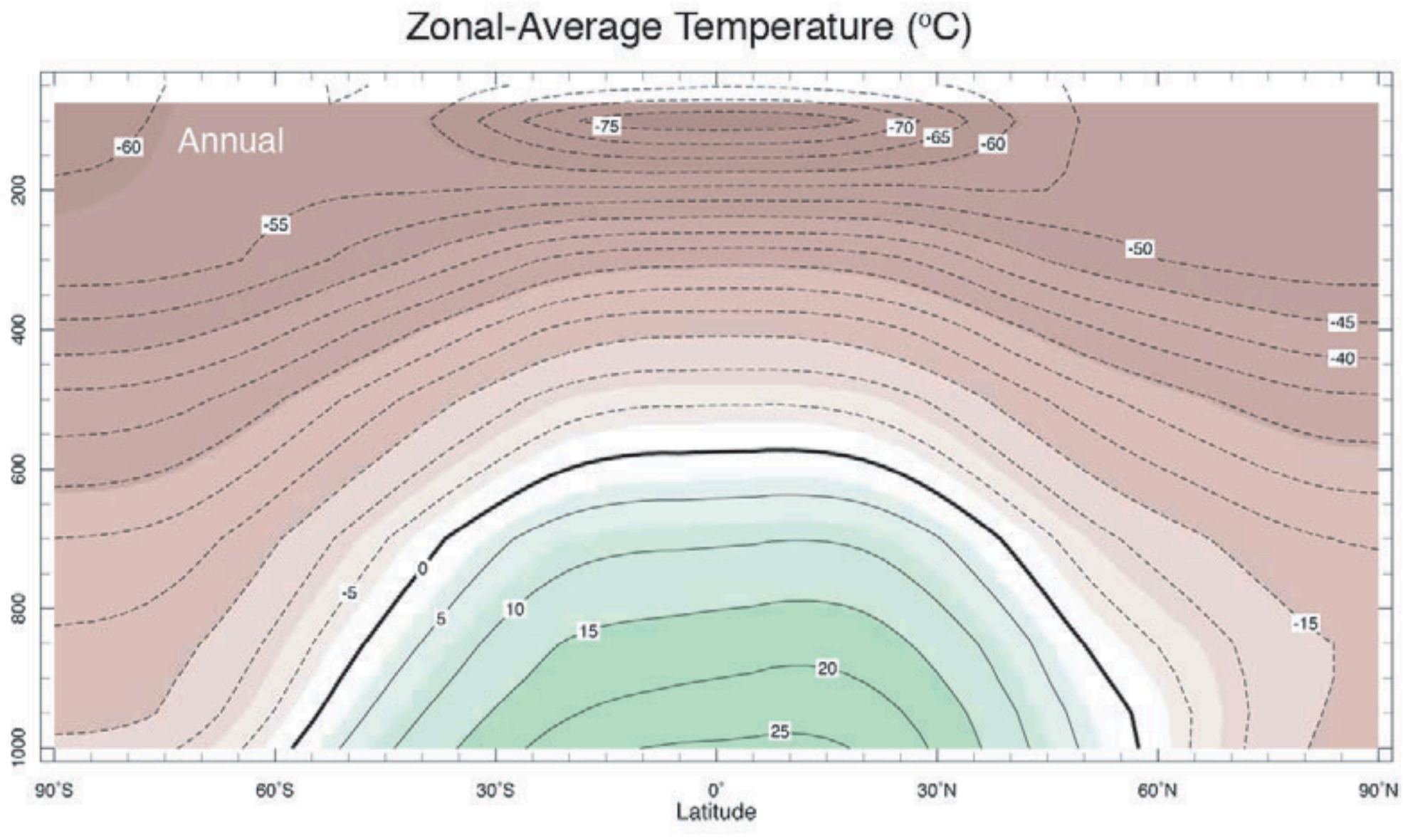
1. Radiative imbalance



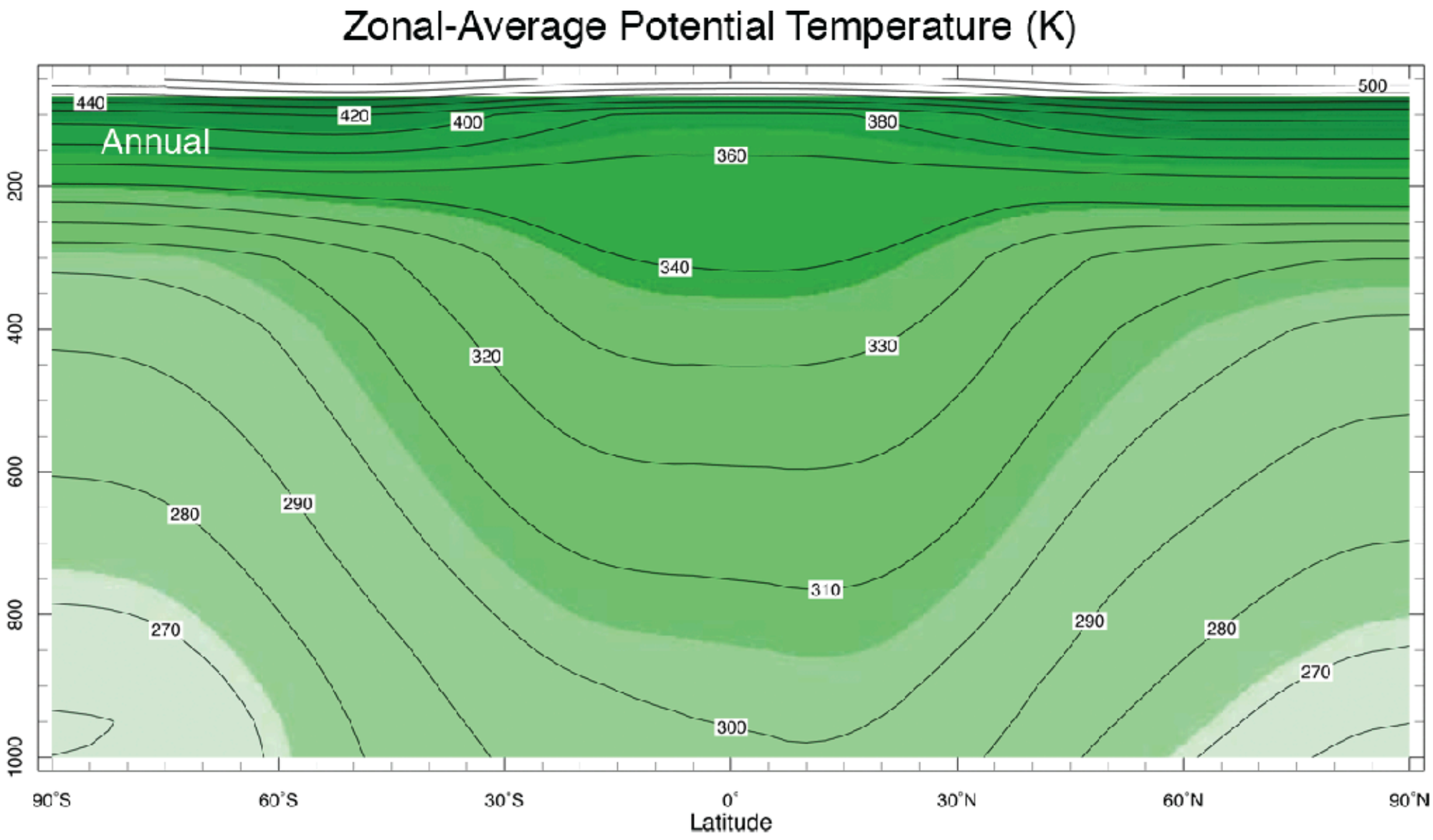


2. Temperature

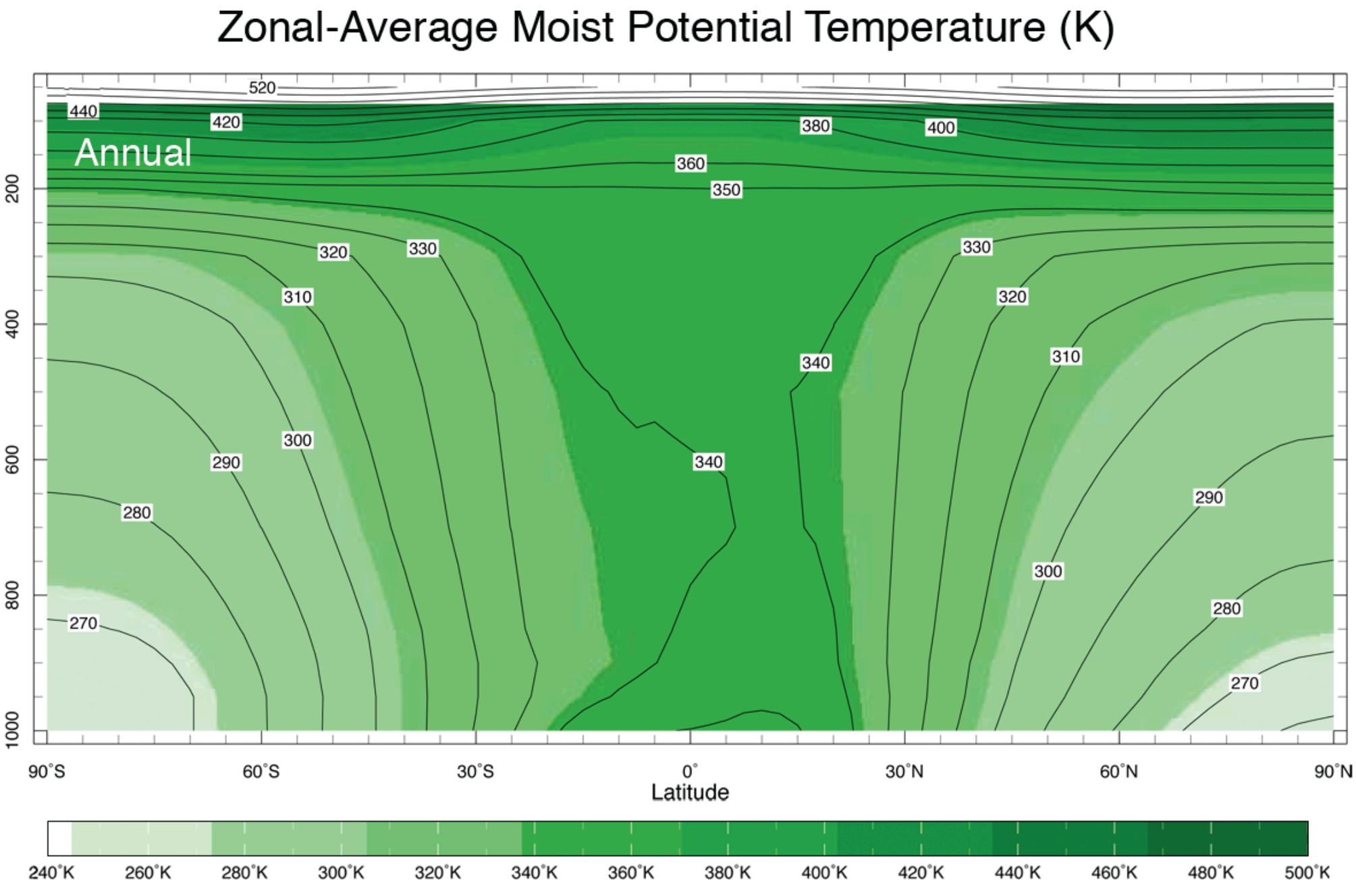
- See how the radiative imbalance shapes T



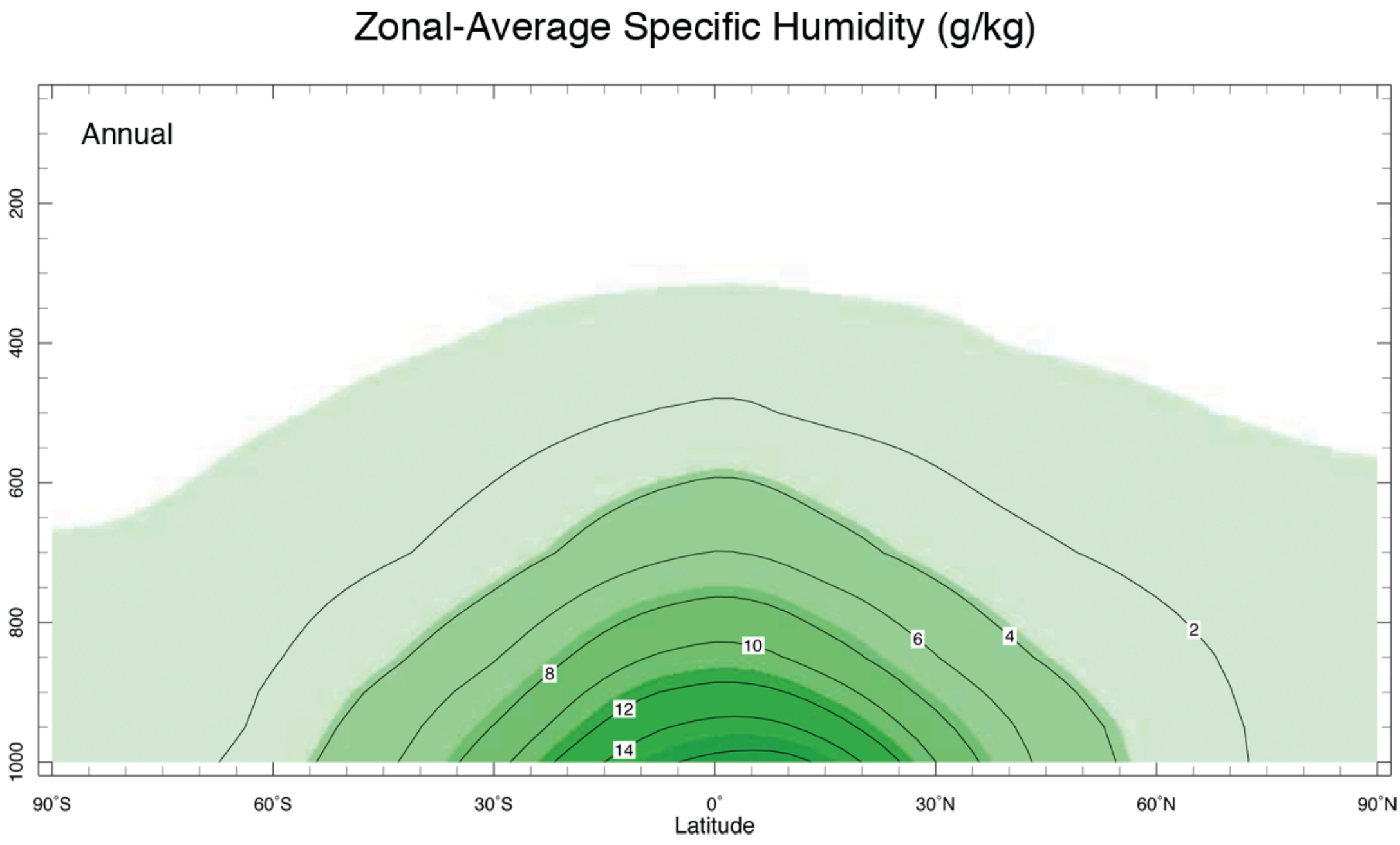
2. Temperature: potential temperature



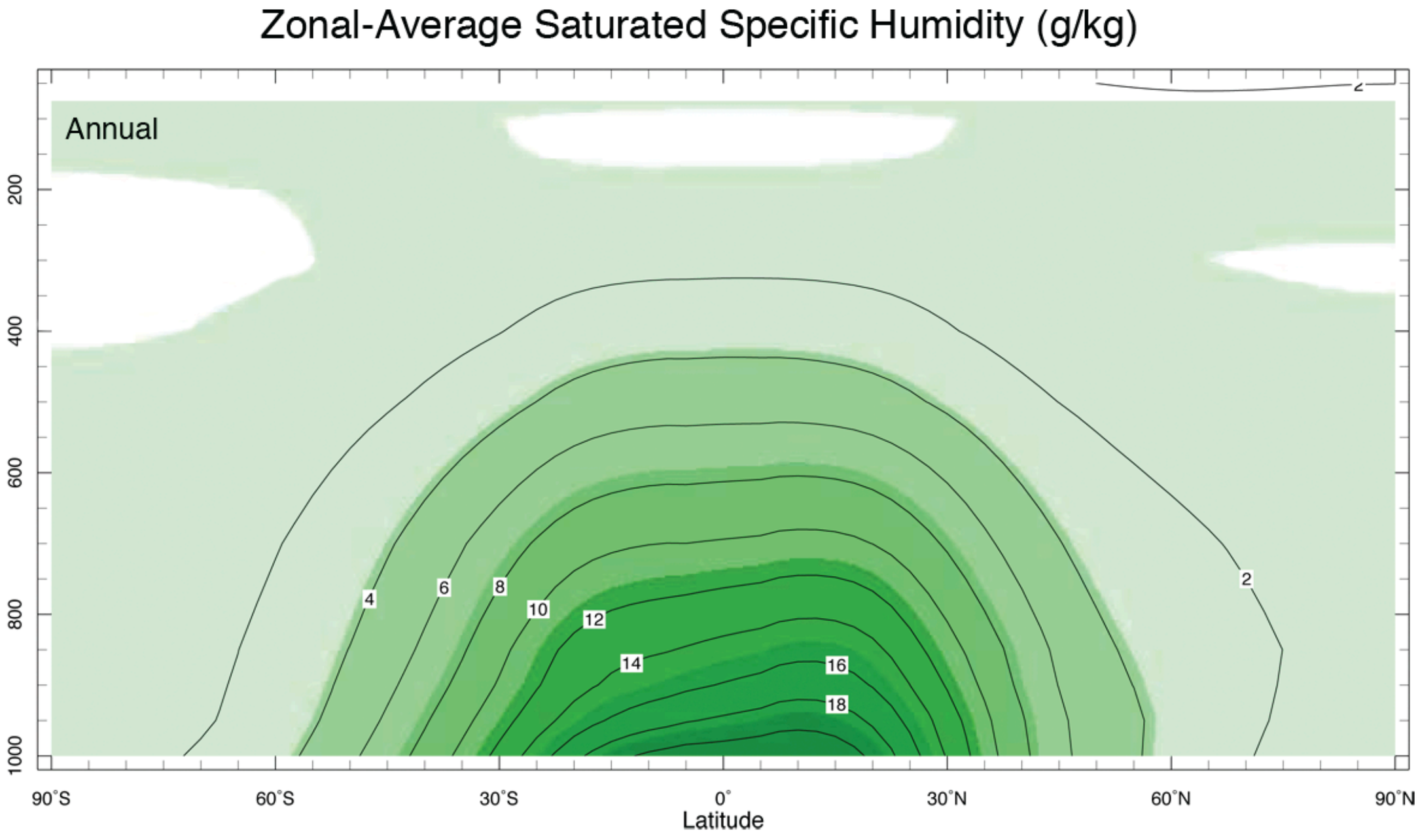
2. Temperature: equivalent potential temperature



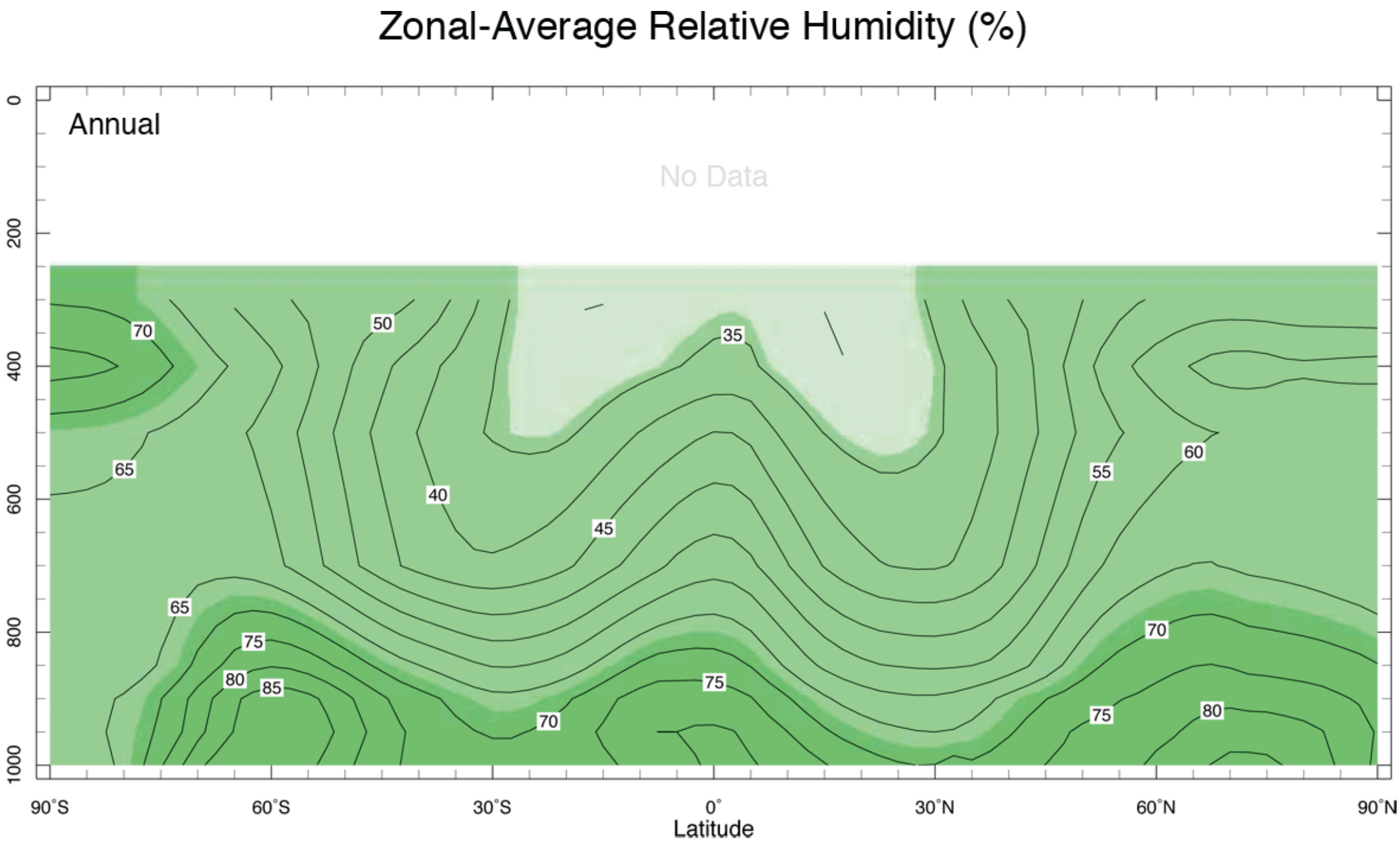
3. Humidity: specific humidity



3. Humidity: saturated specific humidity



3. Humidity: saturated specific humidity



Last time

- Saturated adiabatic lapse rate
- Equivalent potential temperature
- Convection
- Meridional structure of temperature
- Meridional structure of humidity

Today's topic

- Geopotential height
- Wind

4. Pressure / geopotential height

- From a hydrostatic balance and perfect gas law,

$$\frac{\partial z}{\partial p} = -\frac{RT}{gp}$$

$$z(p) = R \int_{p}^{p_s} \frac{T}{g} \frac{dp}{p}$$

- z(p) is called ***geopotential height.***
- If we assume that T and g does not vary a lot with p, geopotential height is higher when T increases.

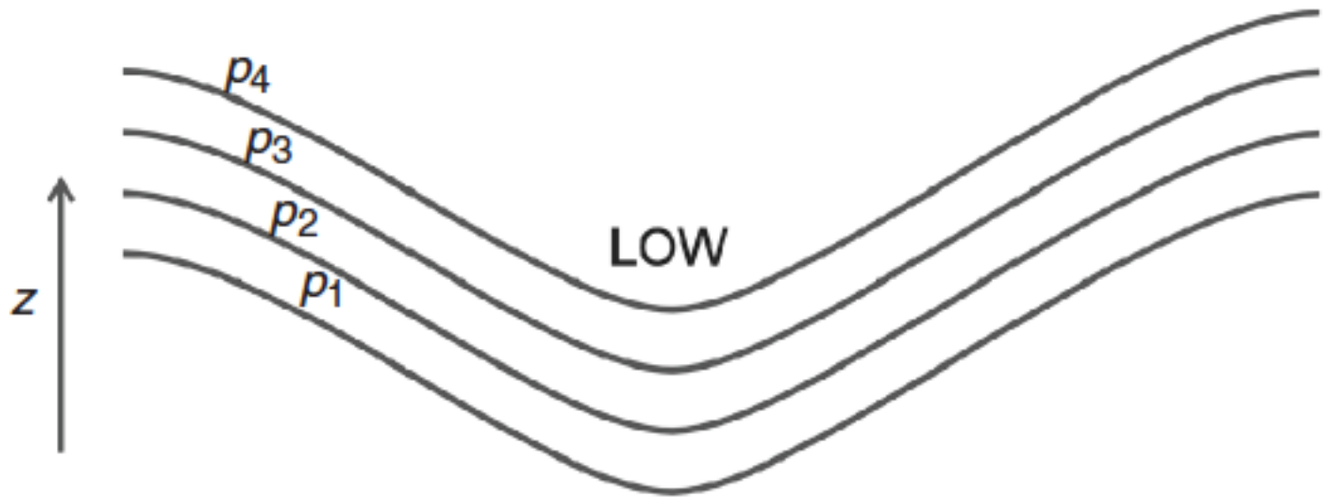
4. Pressure / geopotential height

- If we assume that *g* and *T* do not vary a lot with *p*,

$$z(p) = \frac{RT}{g}\left(\ln p_s - \ln p\right)$$

- *z* increases as *p* decreases.
- Higher T increases geopotential height.

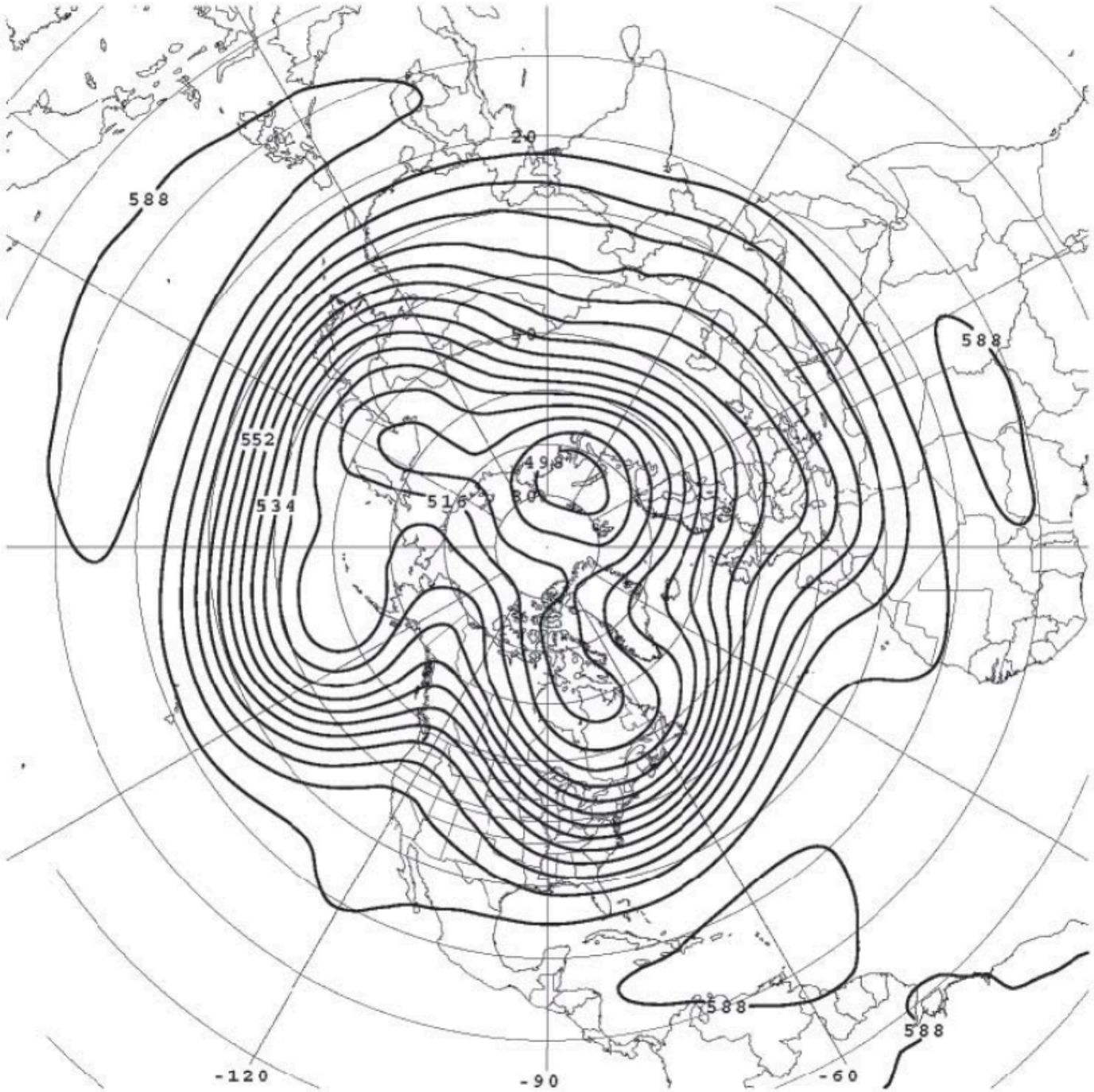
4. Pressure / geopotential height



- Geopotential height is lower at the low pressure system.
- Or the high pressure system corresponds to the high geopotential height.
- T tends to be low in the region of low geopotential height.

4. Pressure / geopotential height

The mean height of the 500 mbar surface in January , 2003



4. Pressure / geopotential height

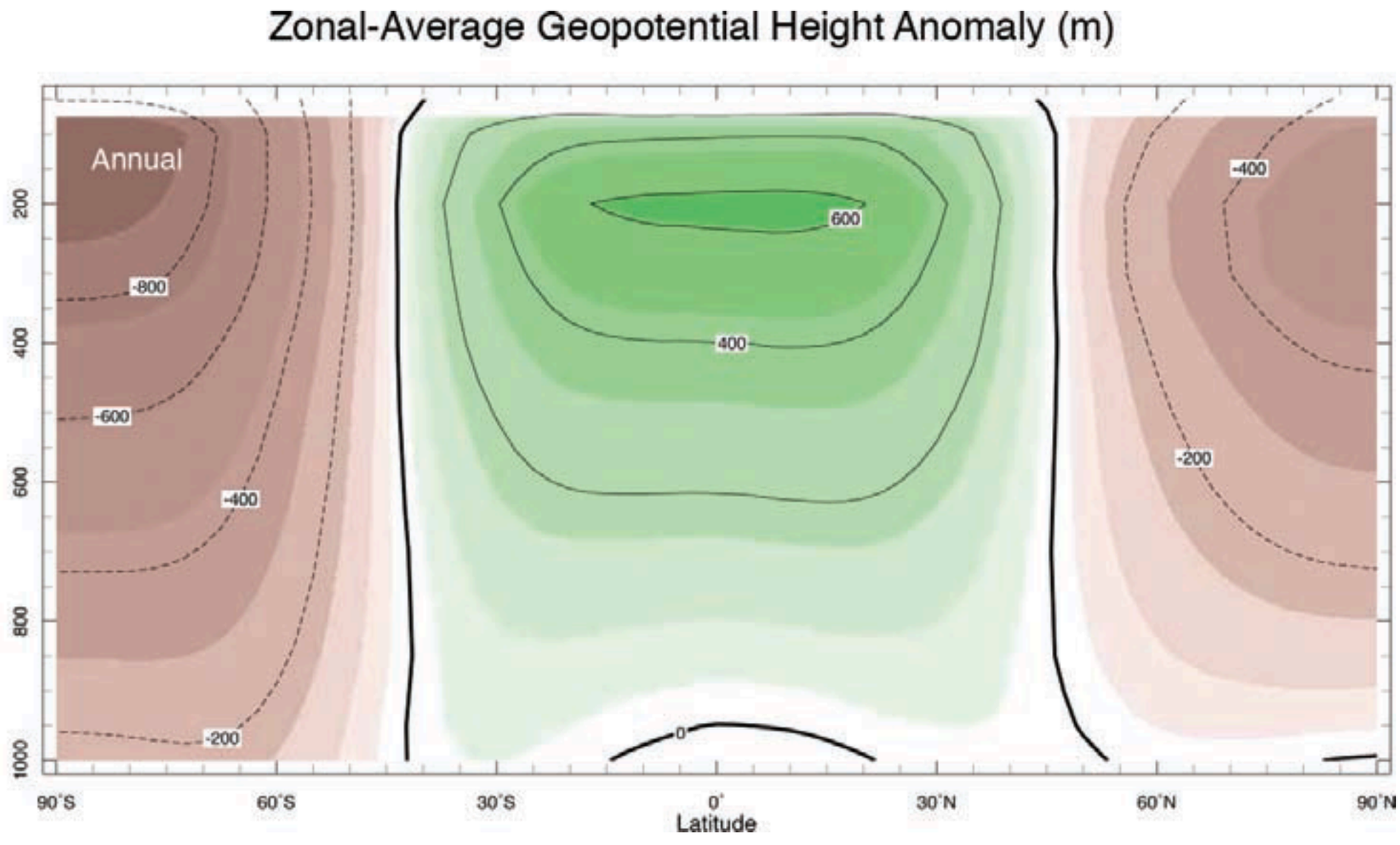
- We can discuss about the slope of the geopotential height if we know the temperature.

$$z_{warm} - z_{cold} = \frac{R}{g} \left(T_{warm} - T_{cold}\right) \left(\ln p_s - \ln p\right)$$

- We can also discuss about the thickness of an atmospheric layer if we know the temperature.

$$z_{p_1} - z_{p_2} = \frac{R\overline{T}}{g} \left(\ln p_2 - \ln p_1\right)$$

4. Pressure / geopotential height



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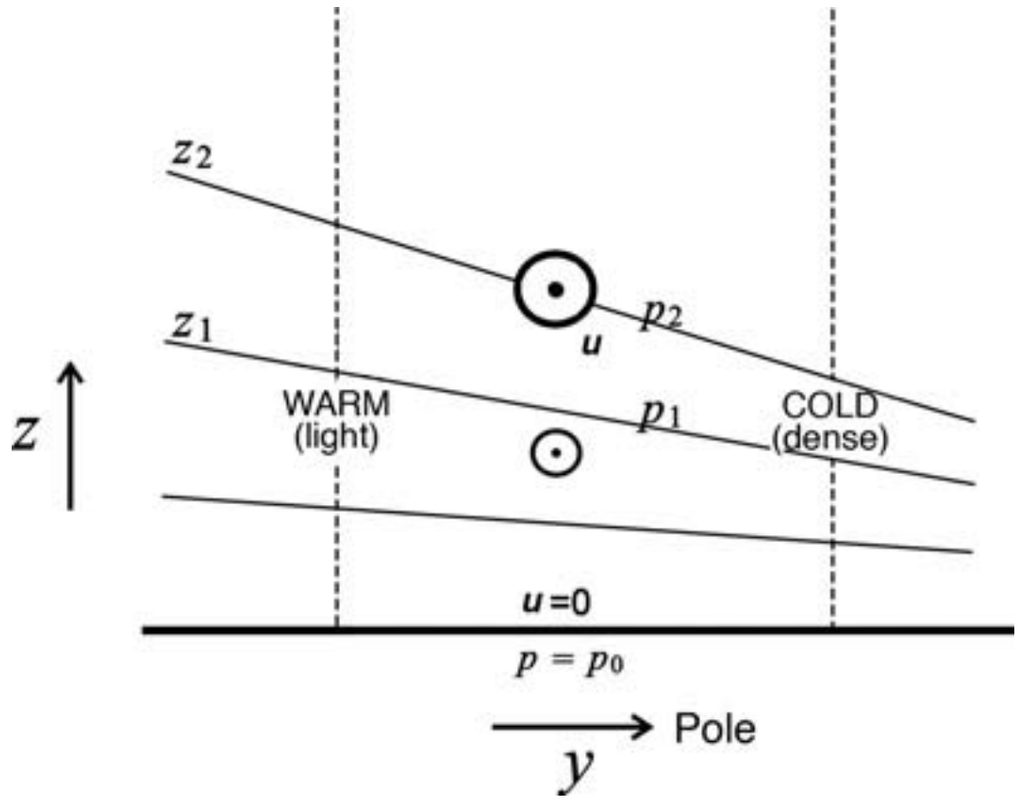

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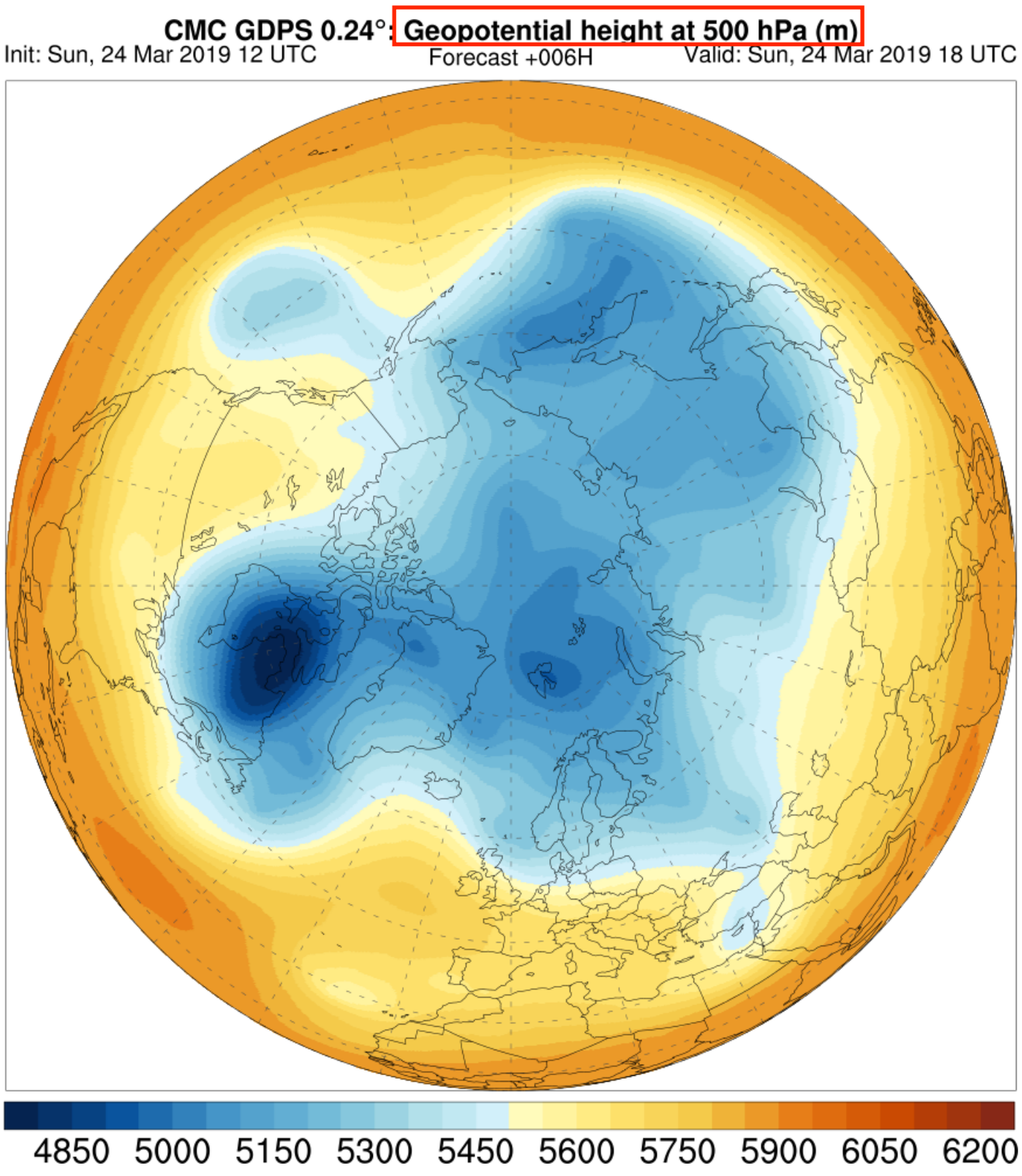
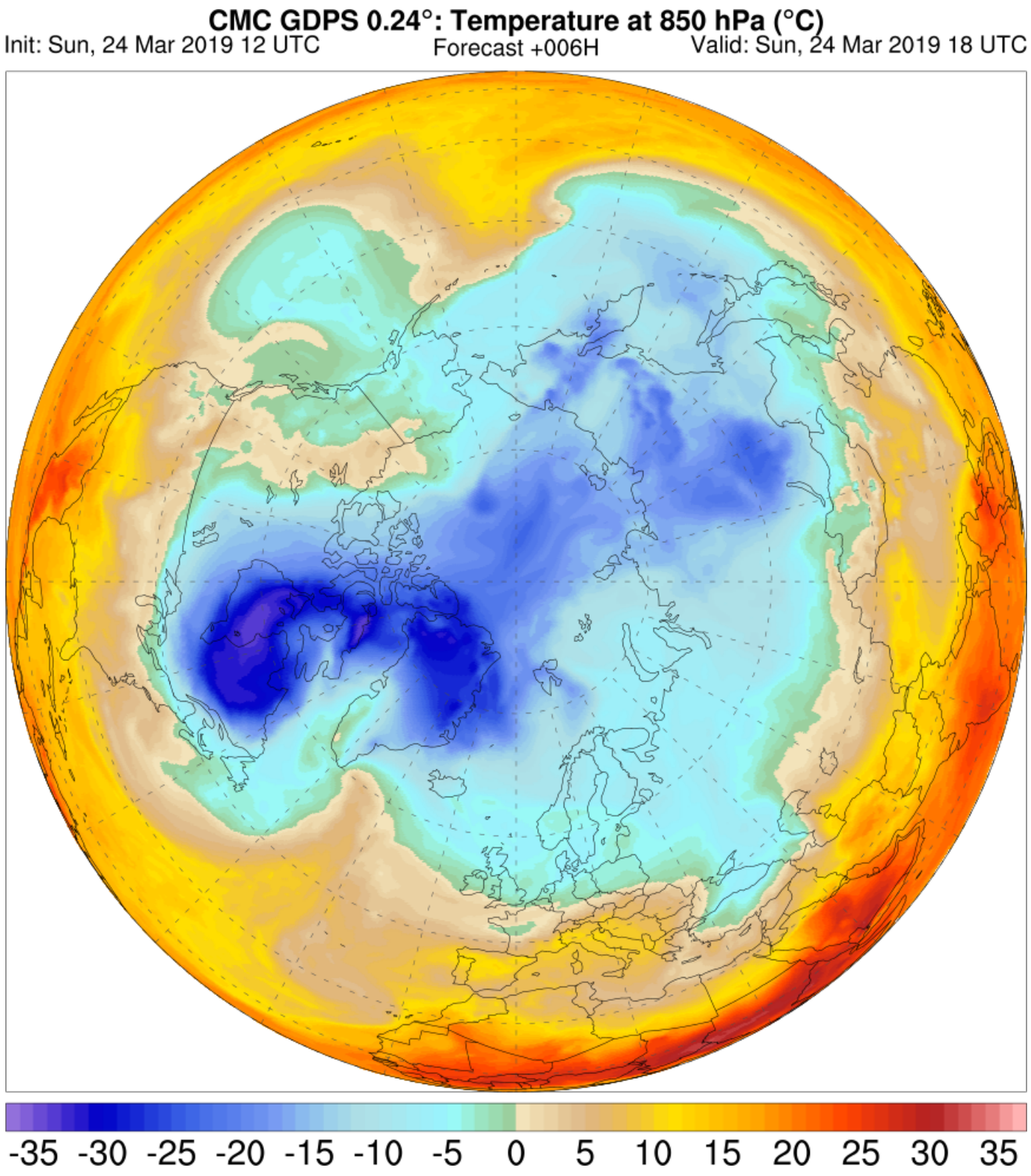


From http://www.genuineweather.com/?model=CMC-GDPS&run=12&zone=ART&type=G500&forecast=138

4. Pressure / geopotential height



T at 850 hPa

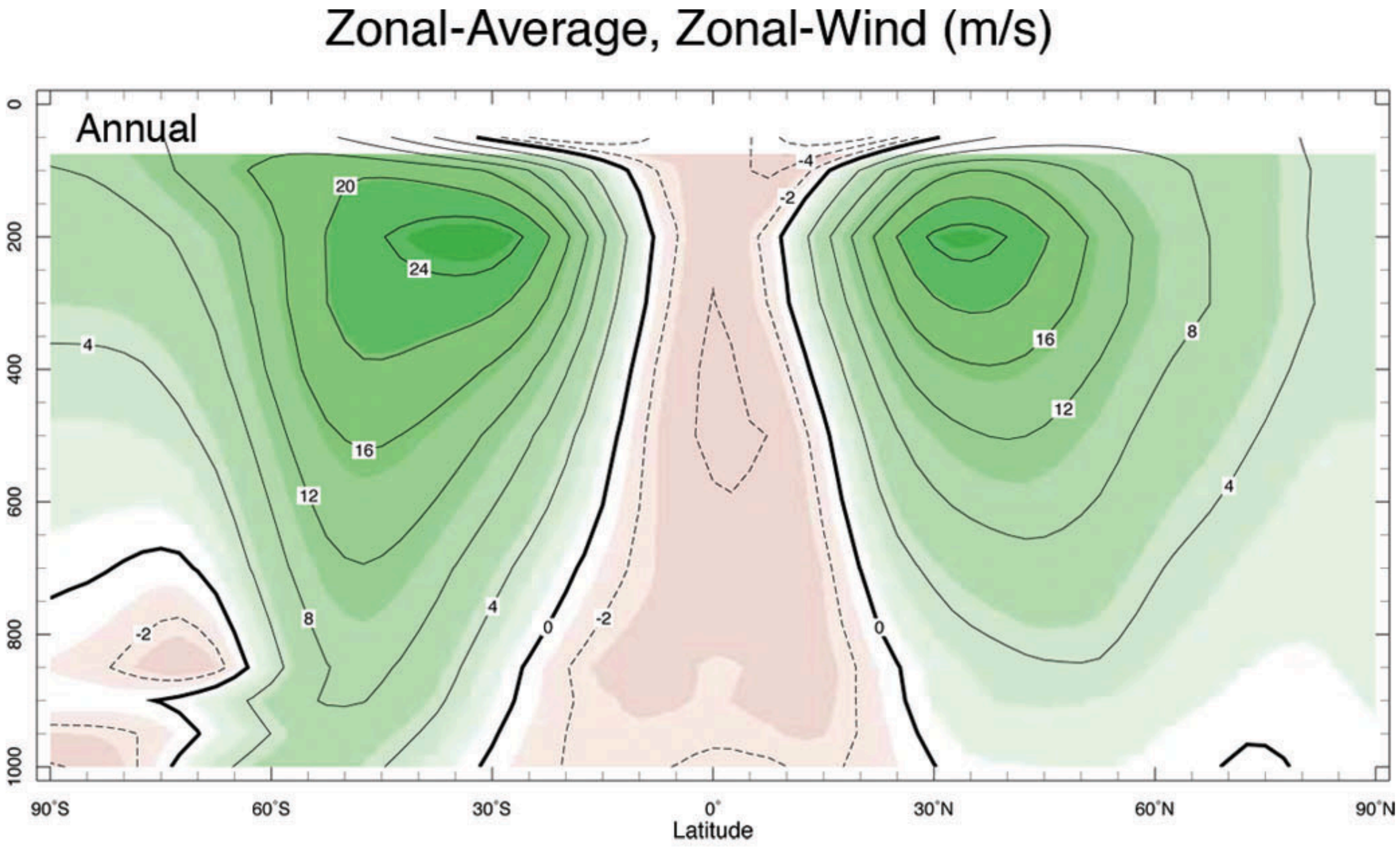
From http://www.genuineweather.com/?model=CMC-GDPS&zone=ART&type=T850

5. Wind

- There is a geopotential height slope from equator to pole
- We can expect that the pressure gradient force exists aloft.
- Wind has three dimensions: $\mathbf{u} = (u, v, w)$

  Hard to measure
-

5. Wind - zonal wind (u)



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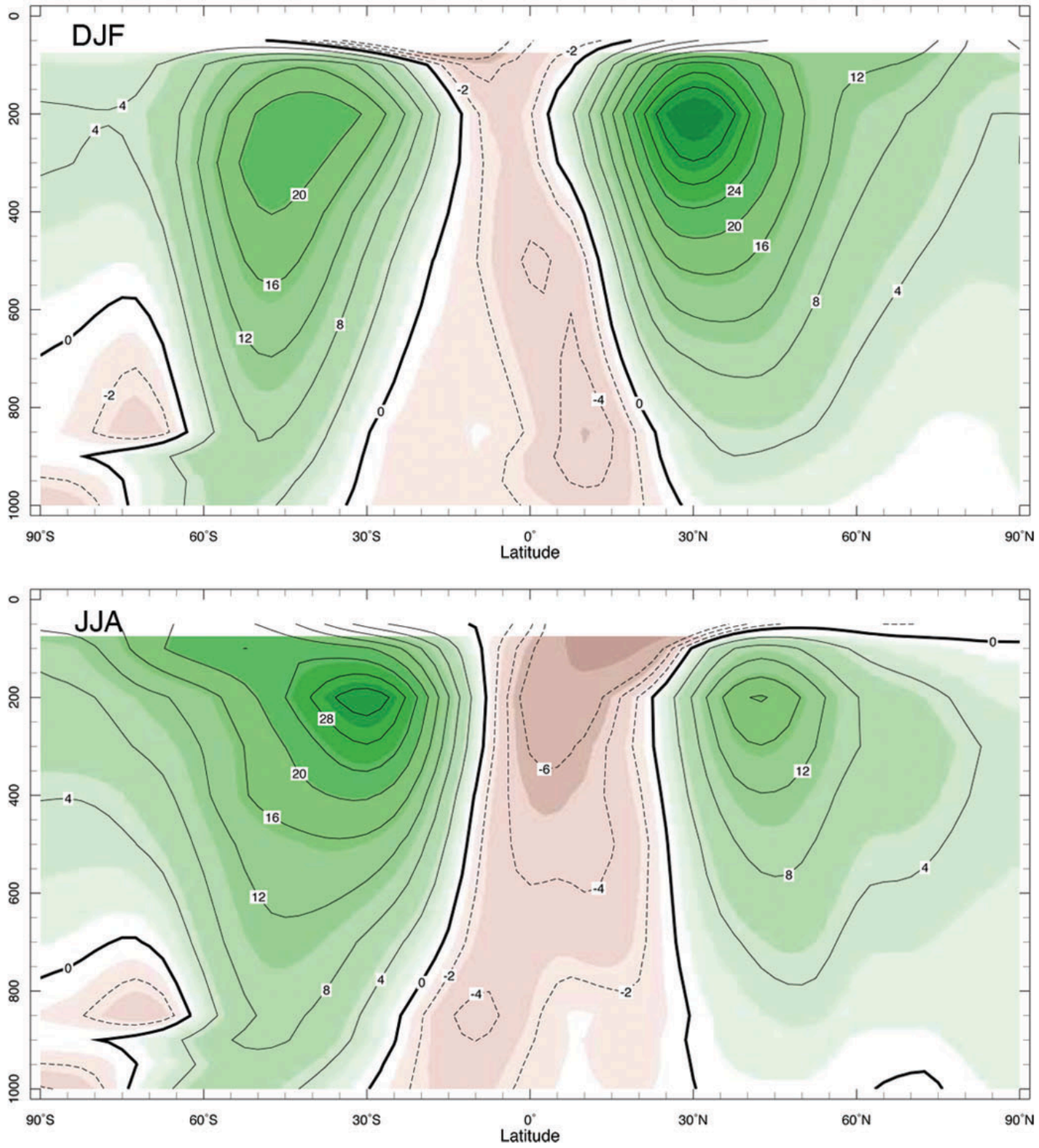
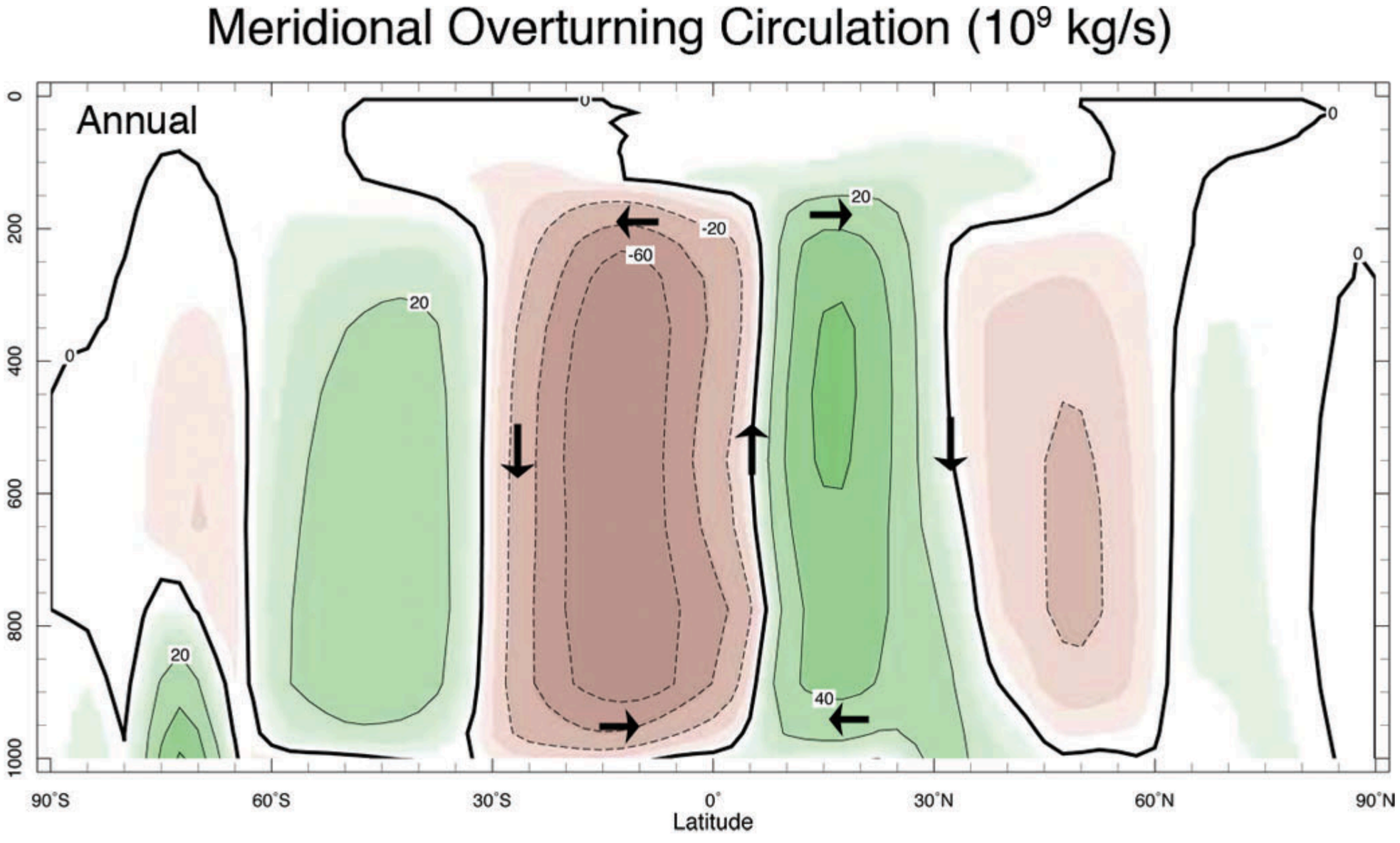


5. Wind - meridional wind (v)

$$v = -\frac{1}{\rho a \cos\phi}\frac{\partial \Psi}{\partial z} \qquad w = \frac{1}{\rho a^2 \cos\phi}\frac{\partial \Psi}{\partial \phi}$$



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