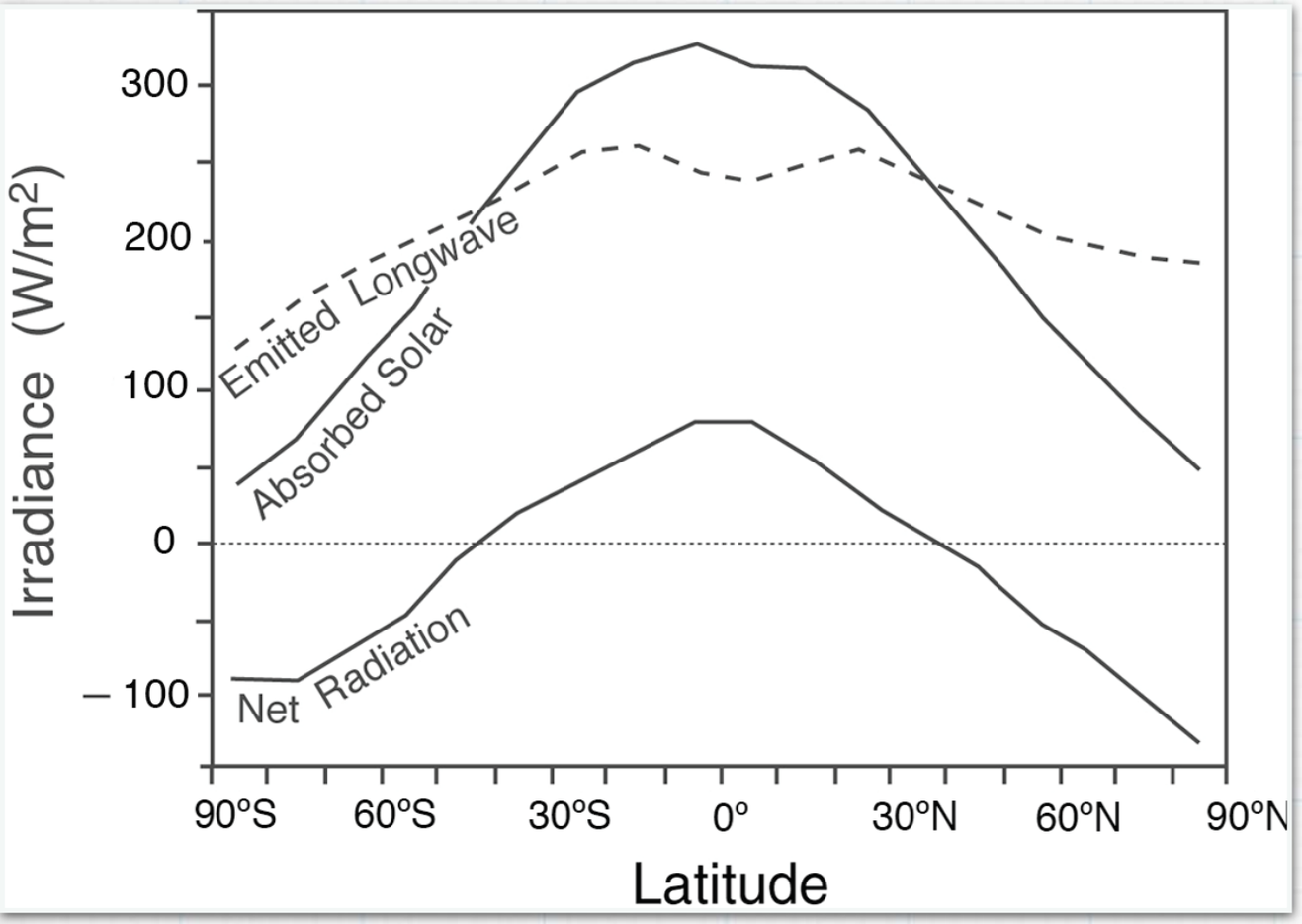
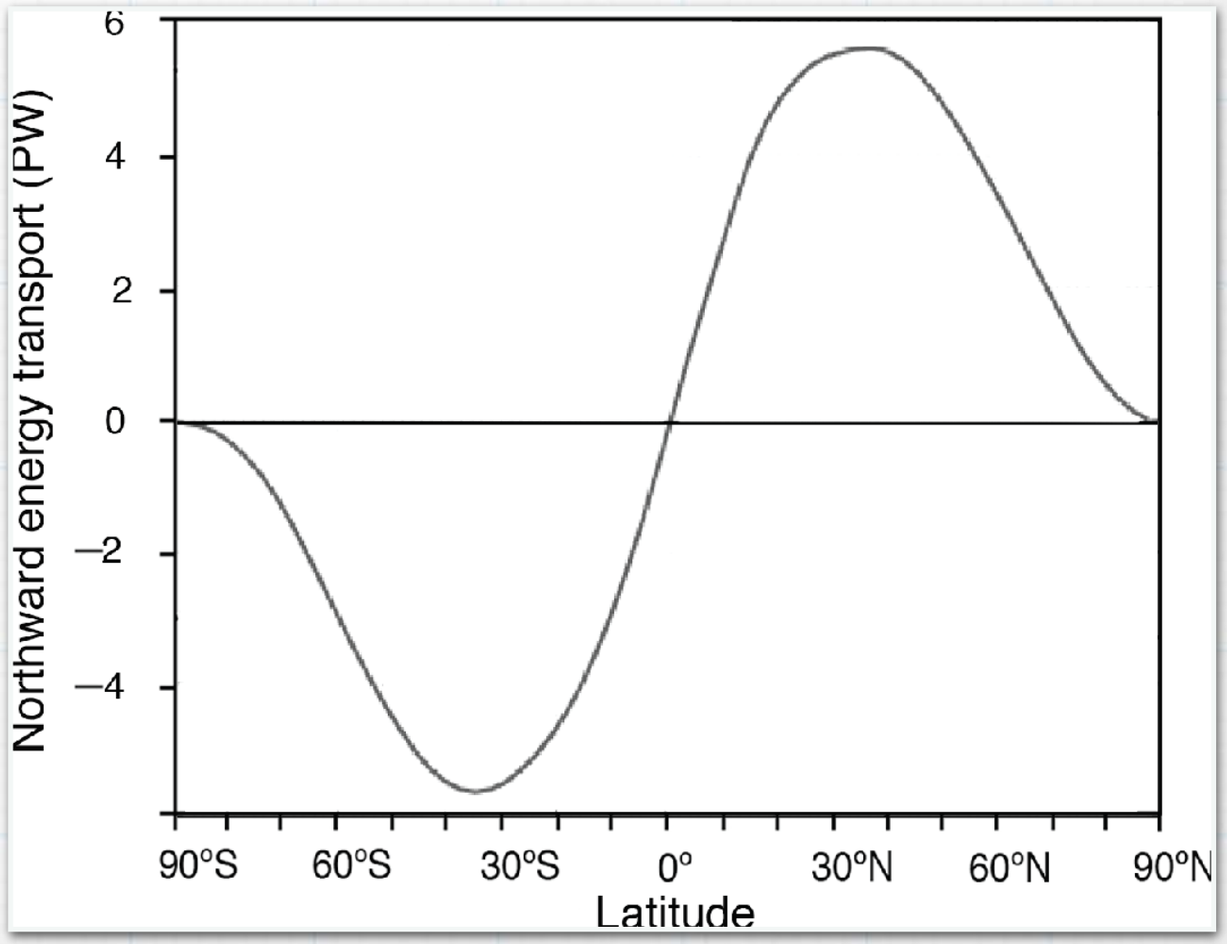
Atmosphere: #3 Observations

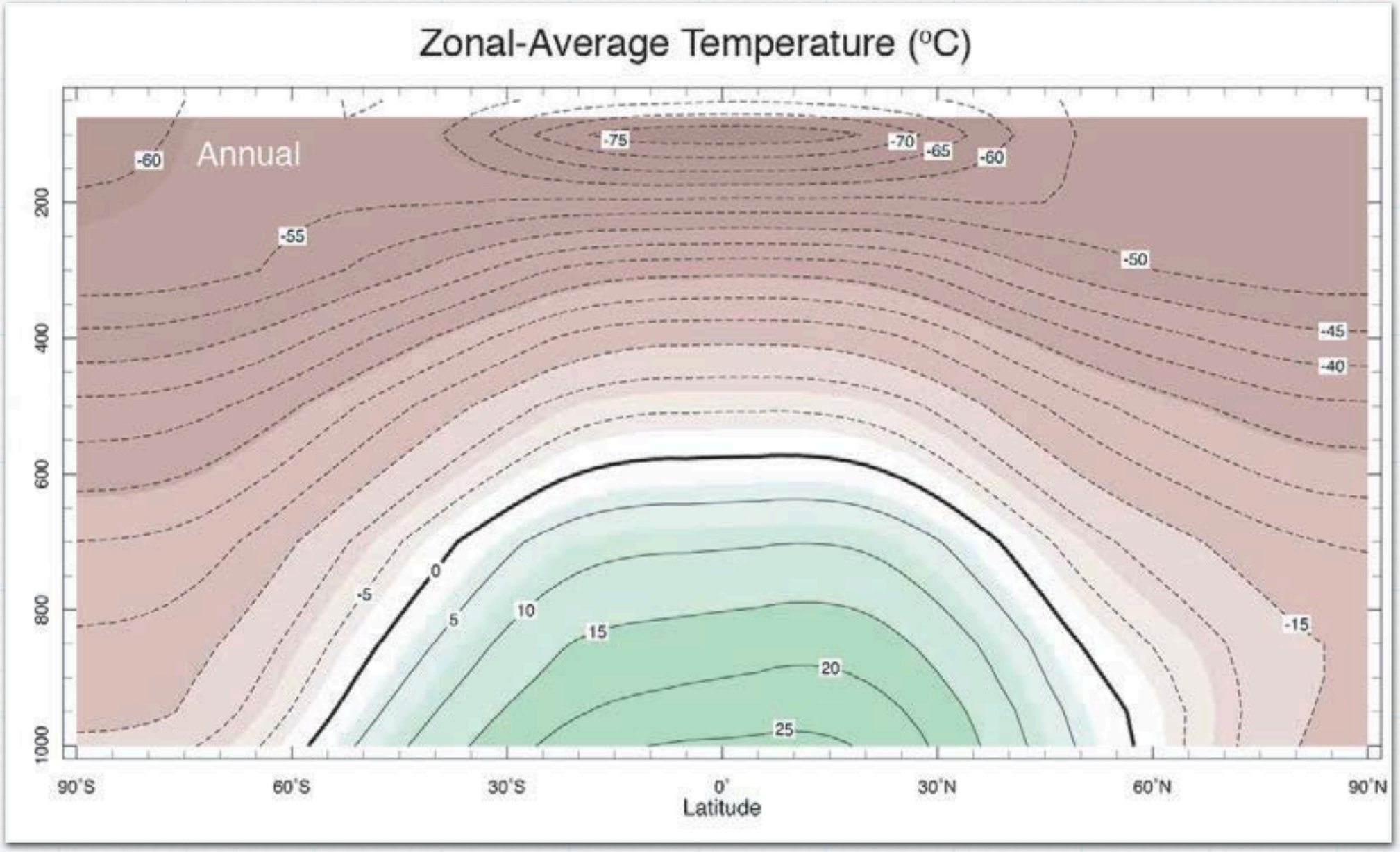
Radiative imbalance



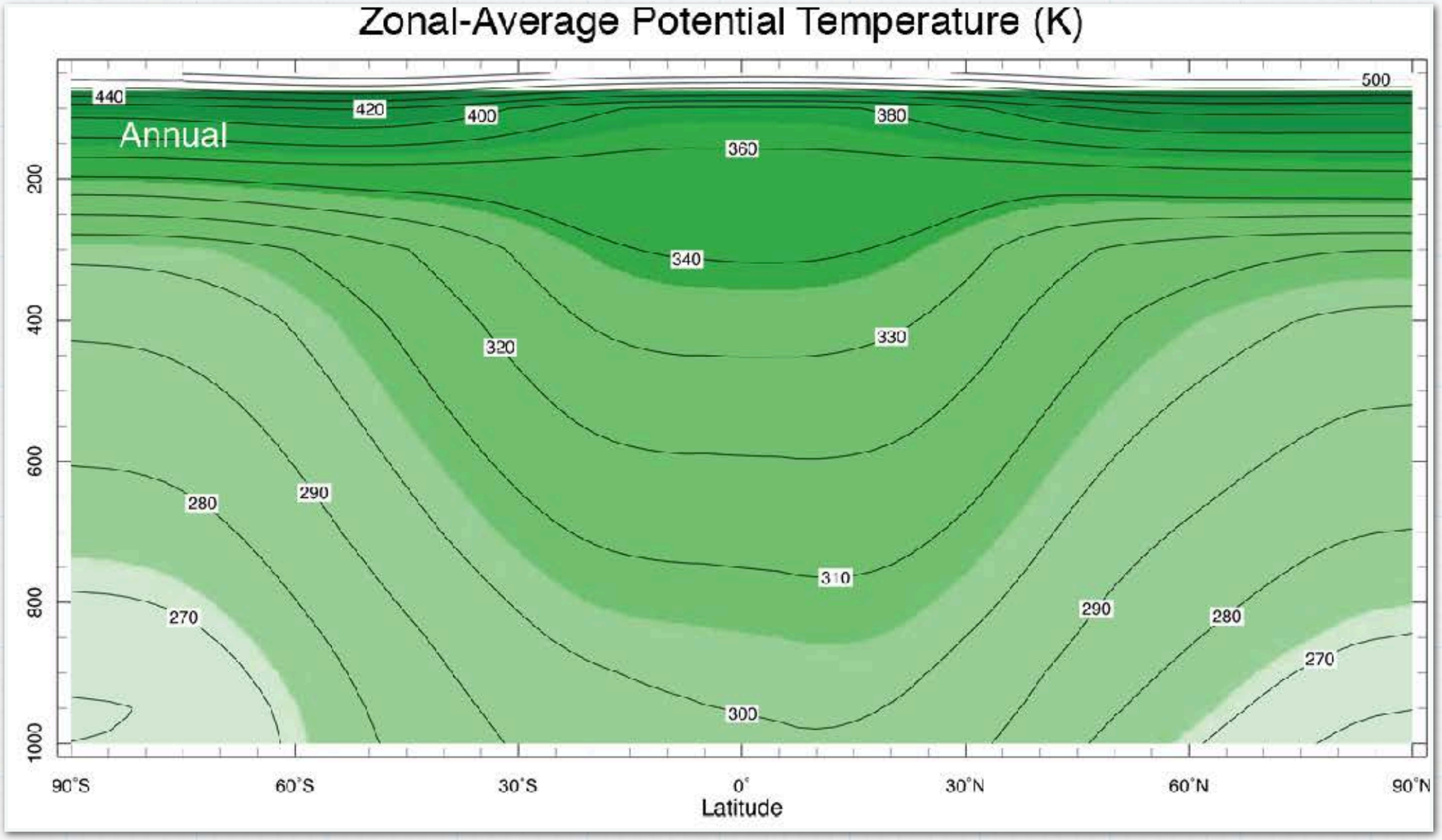


Temperature

- See how the radiative imbalance shapes T



Temperature: potential temperature



Pressure / geopotential height

- We are interested in $z(p)$, rather than $p(z)$
- 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.***

Pressure / geopotential height

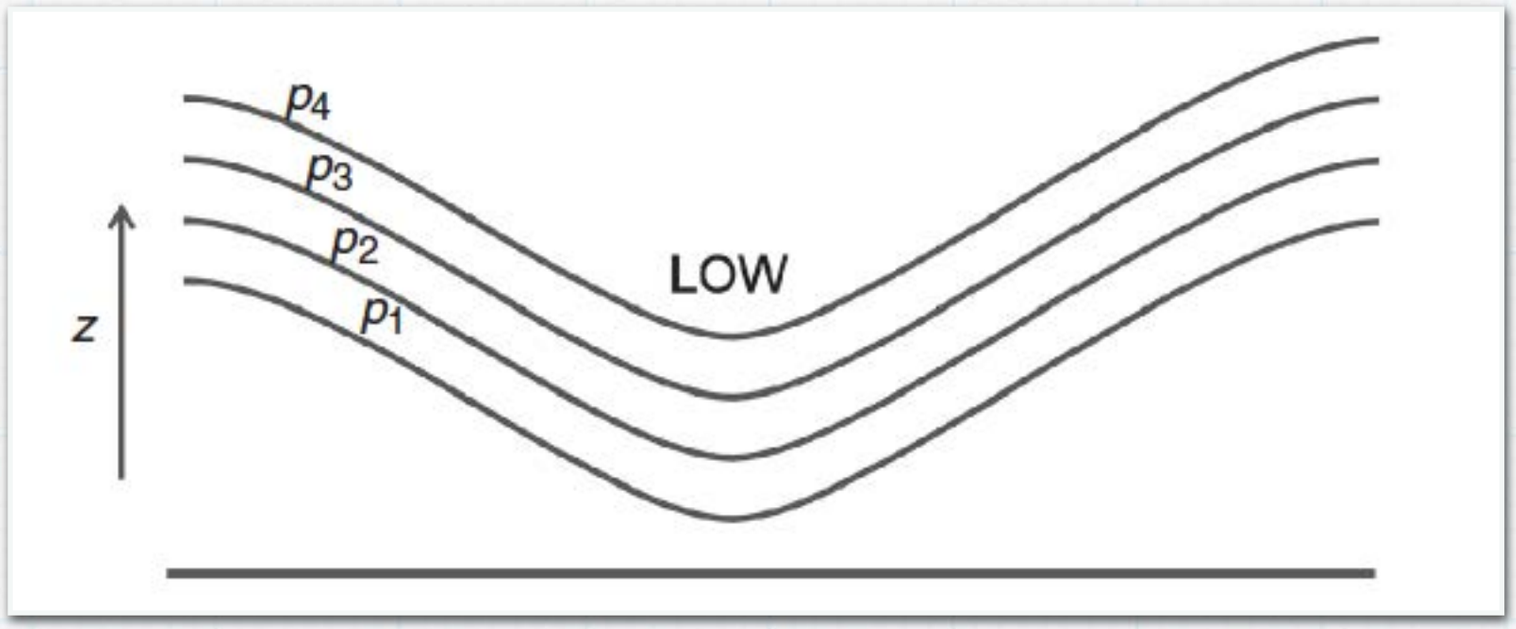
- If we assume that g and T do not vary a lot with p,

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

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

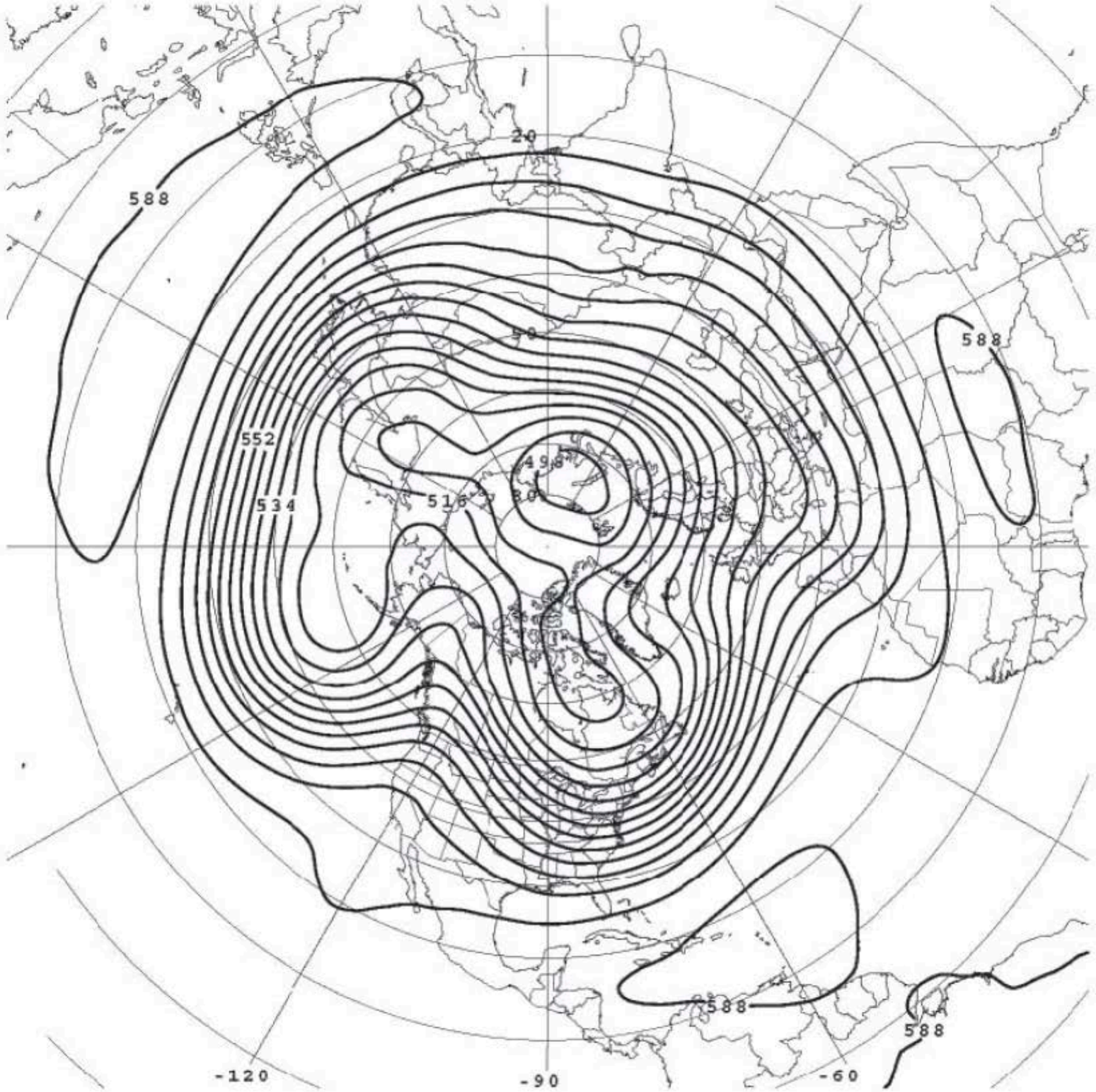
Pressure / geopotential height

- 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.

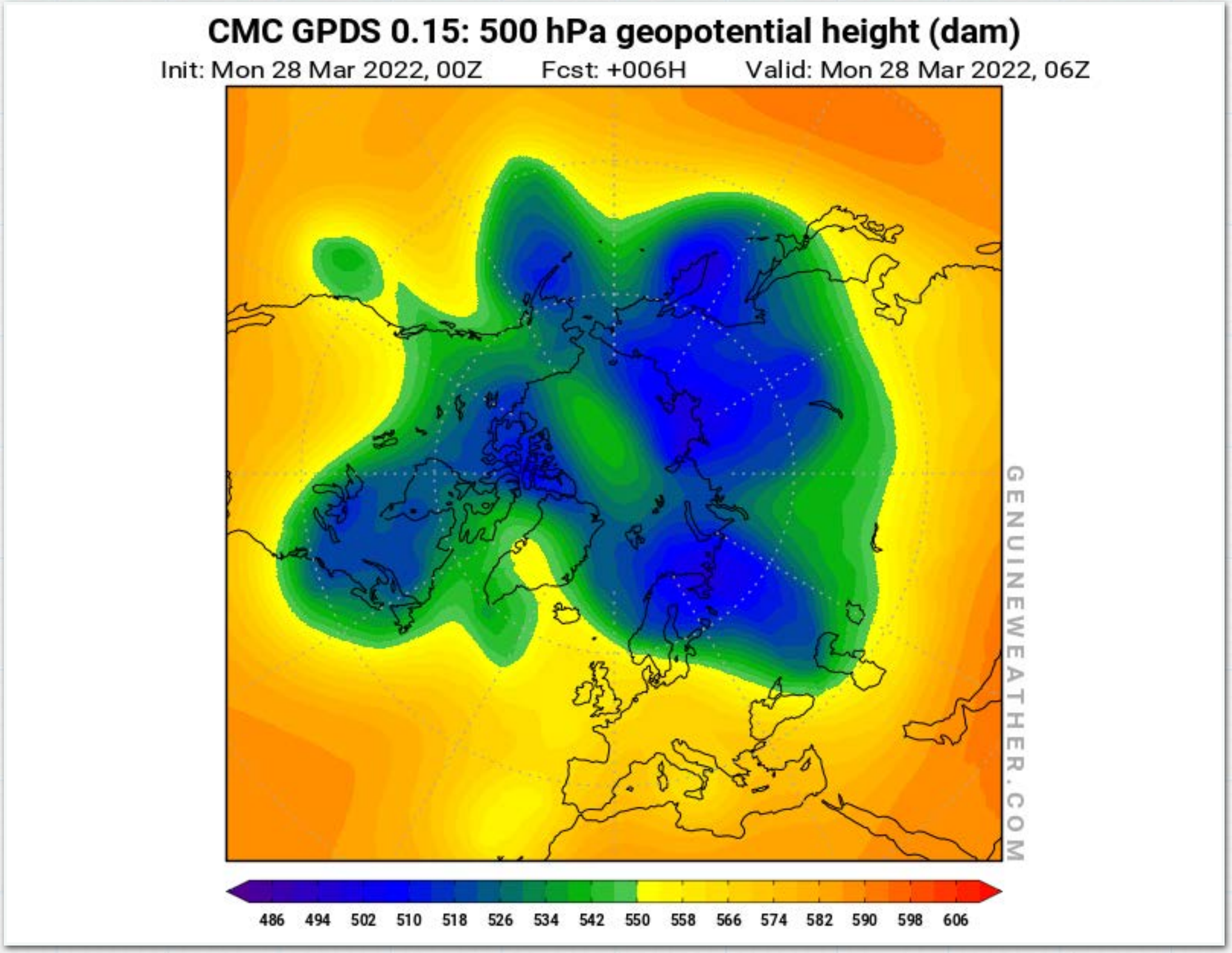


Pressure / geopotential height

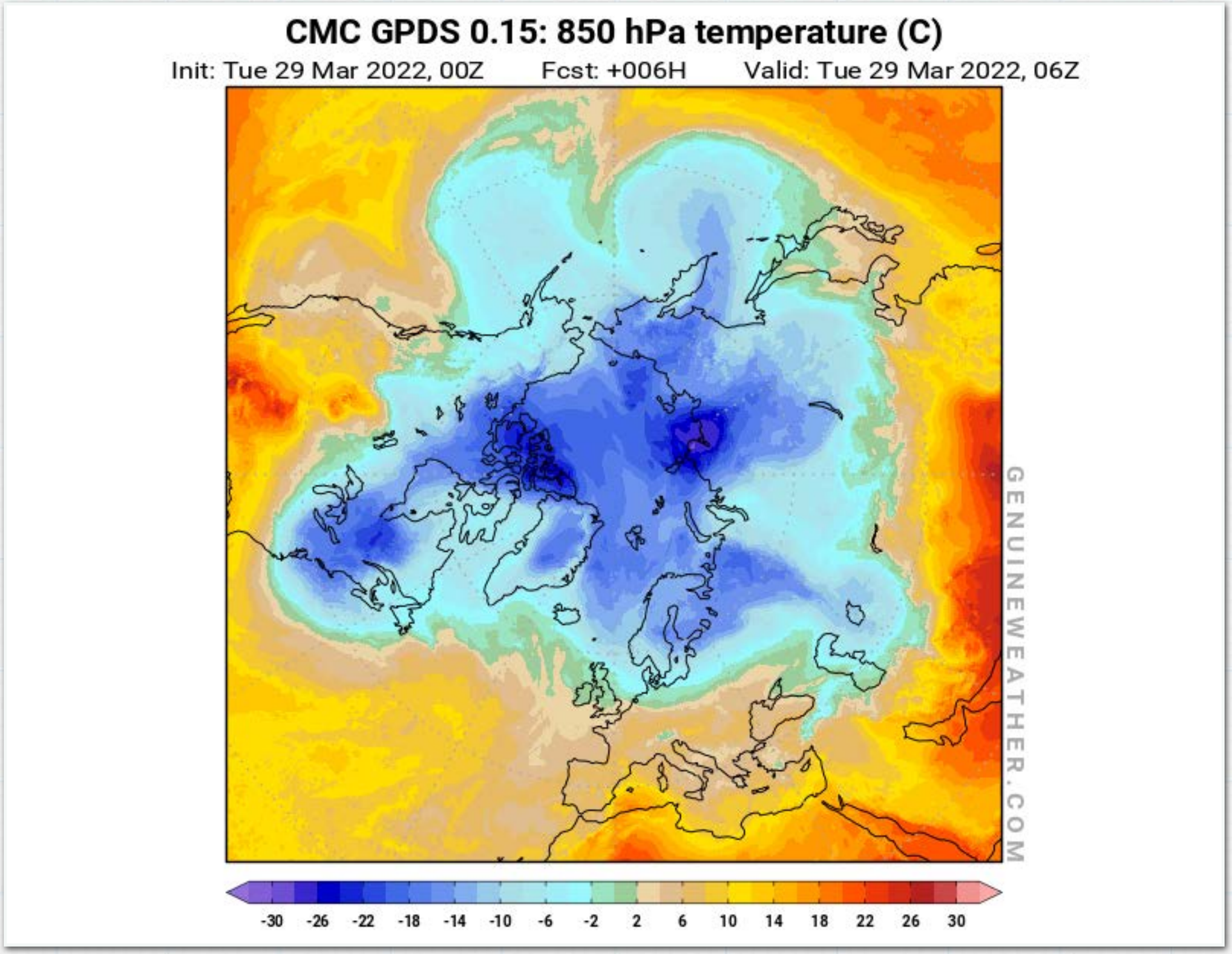
The mean height of the 500 mbar surface in January , 2003



Pressure / geopotential height



Pressure / geopotential height



Pressure / geopotential height

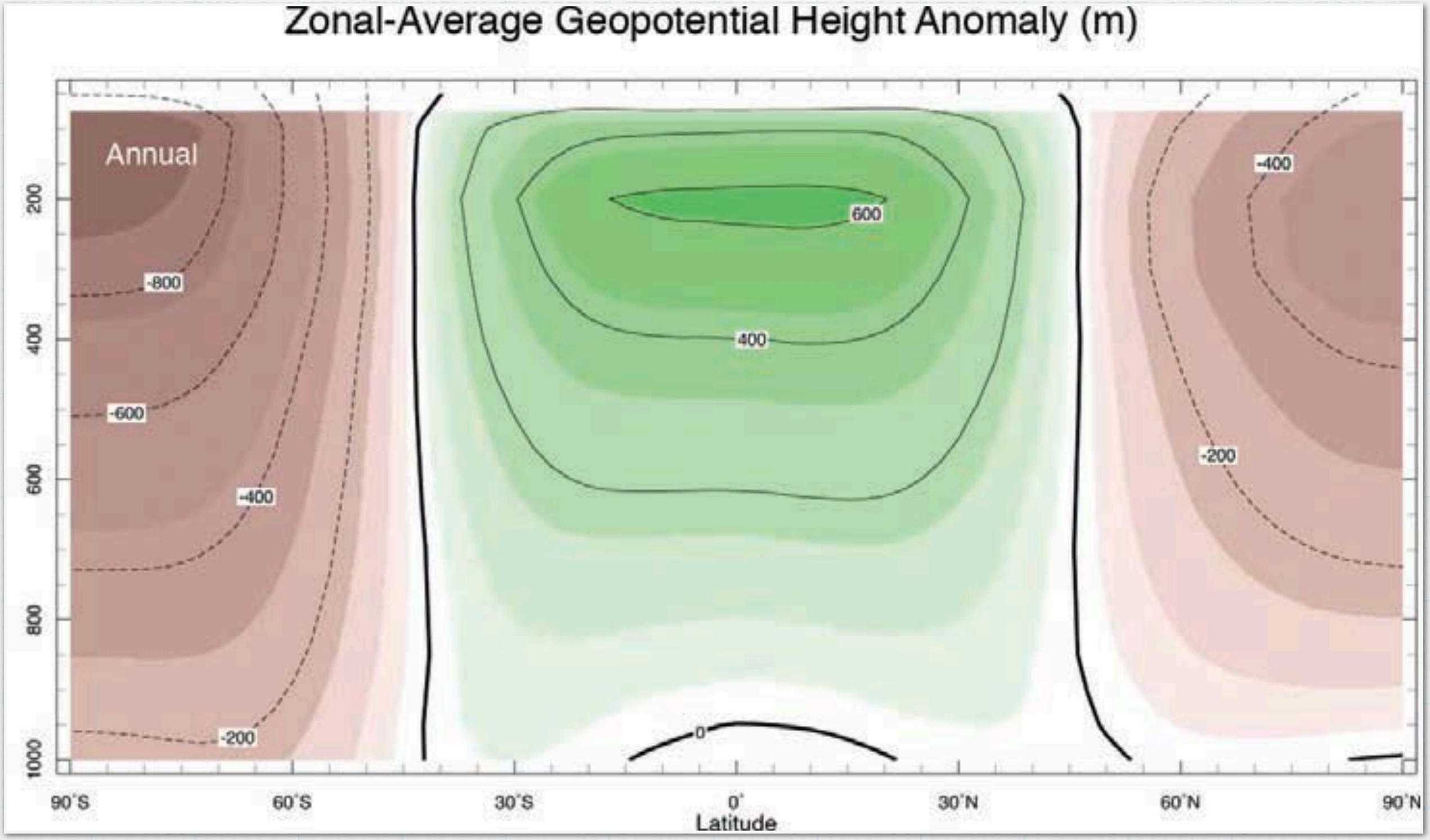
- We can discuss about the slope of the geopotential height if we know the temperature.

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

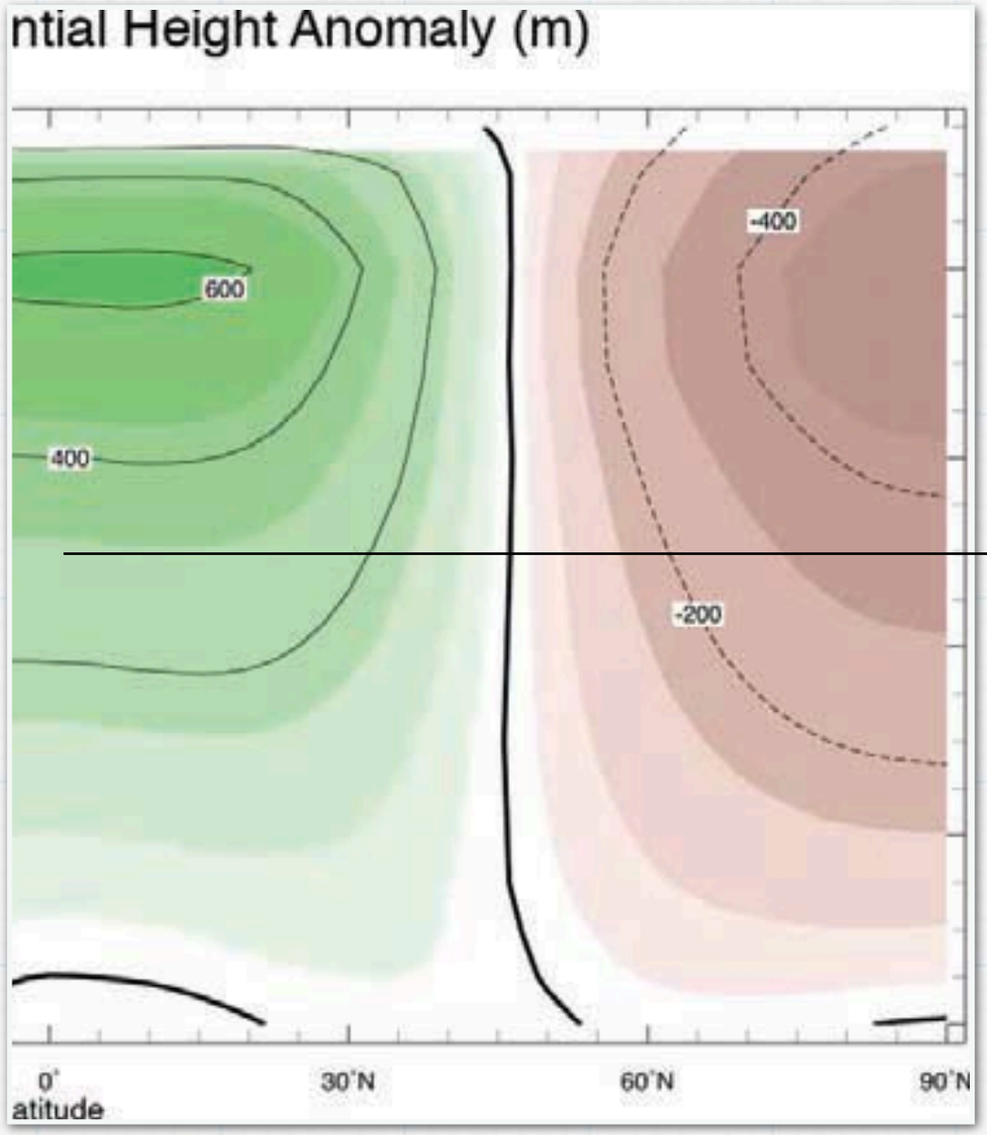
- We can also discuss about the thickness of an atmospheric layer if we know the temperature.

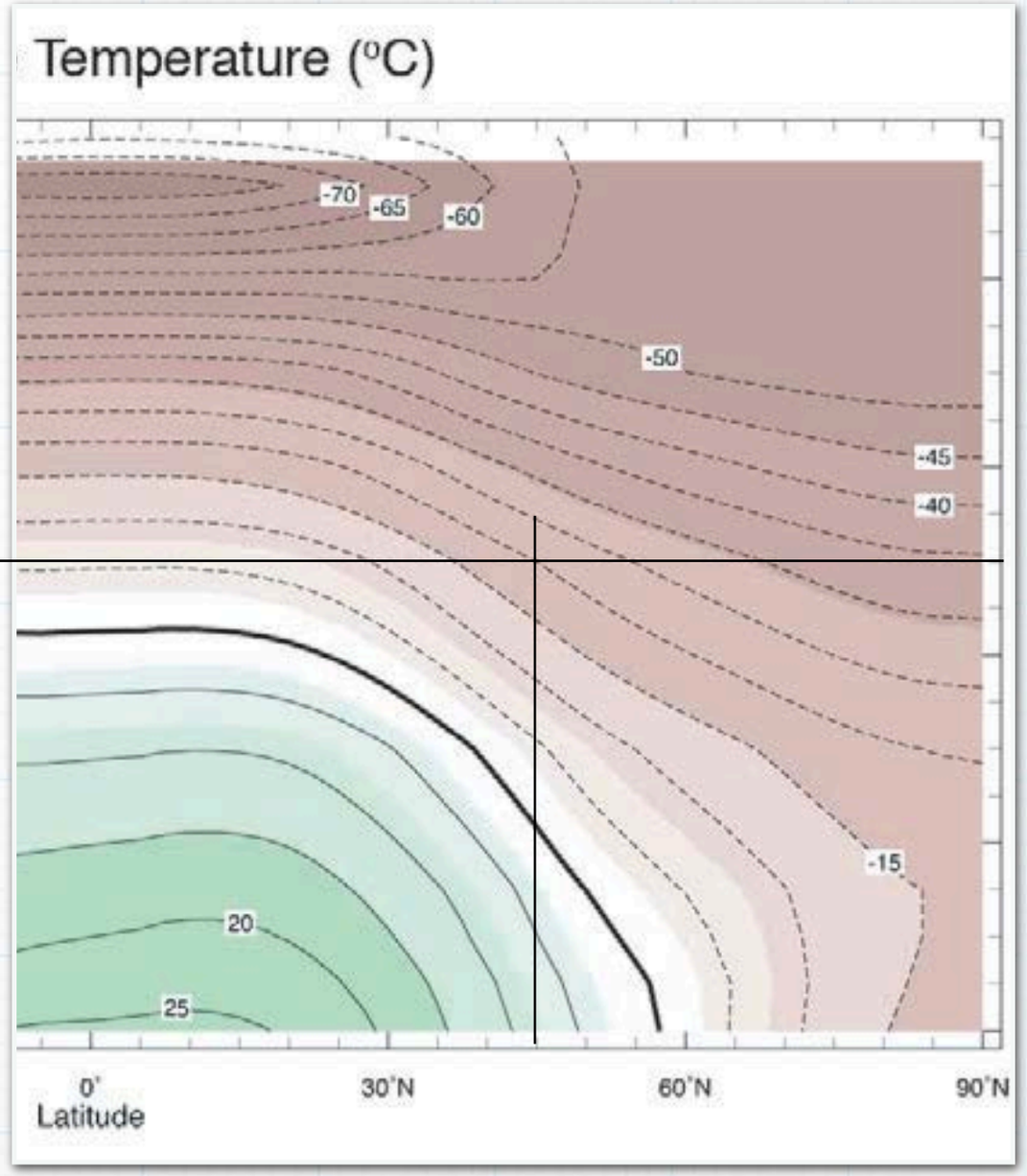
$$z_{p_1} - z_{p_2} = \frac{R\overline{T}}{g} \left(\ln p_2 - \ln p_1 \right)$$

Pressure / geopotential height



Pressure / geopotential height

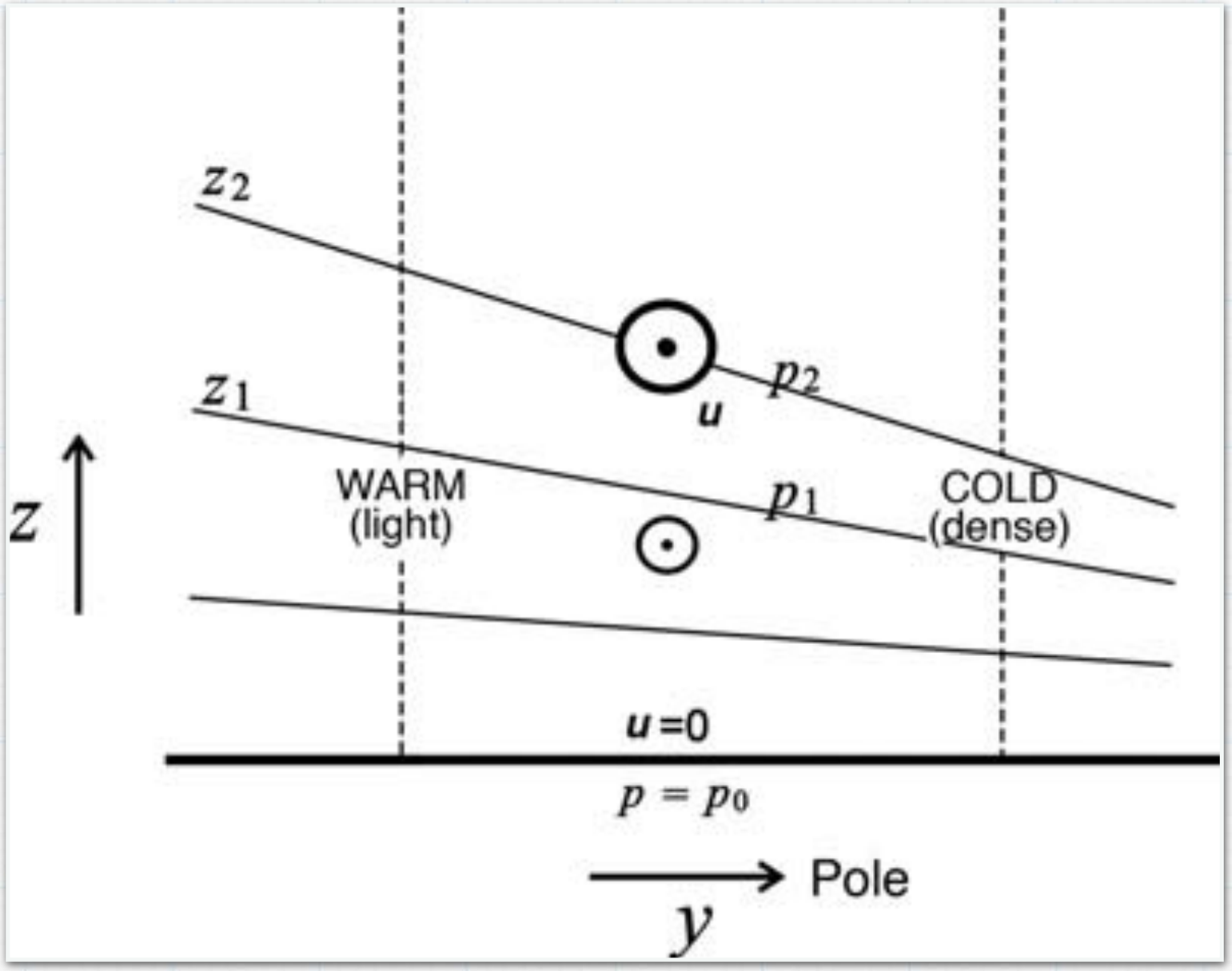




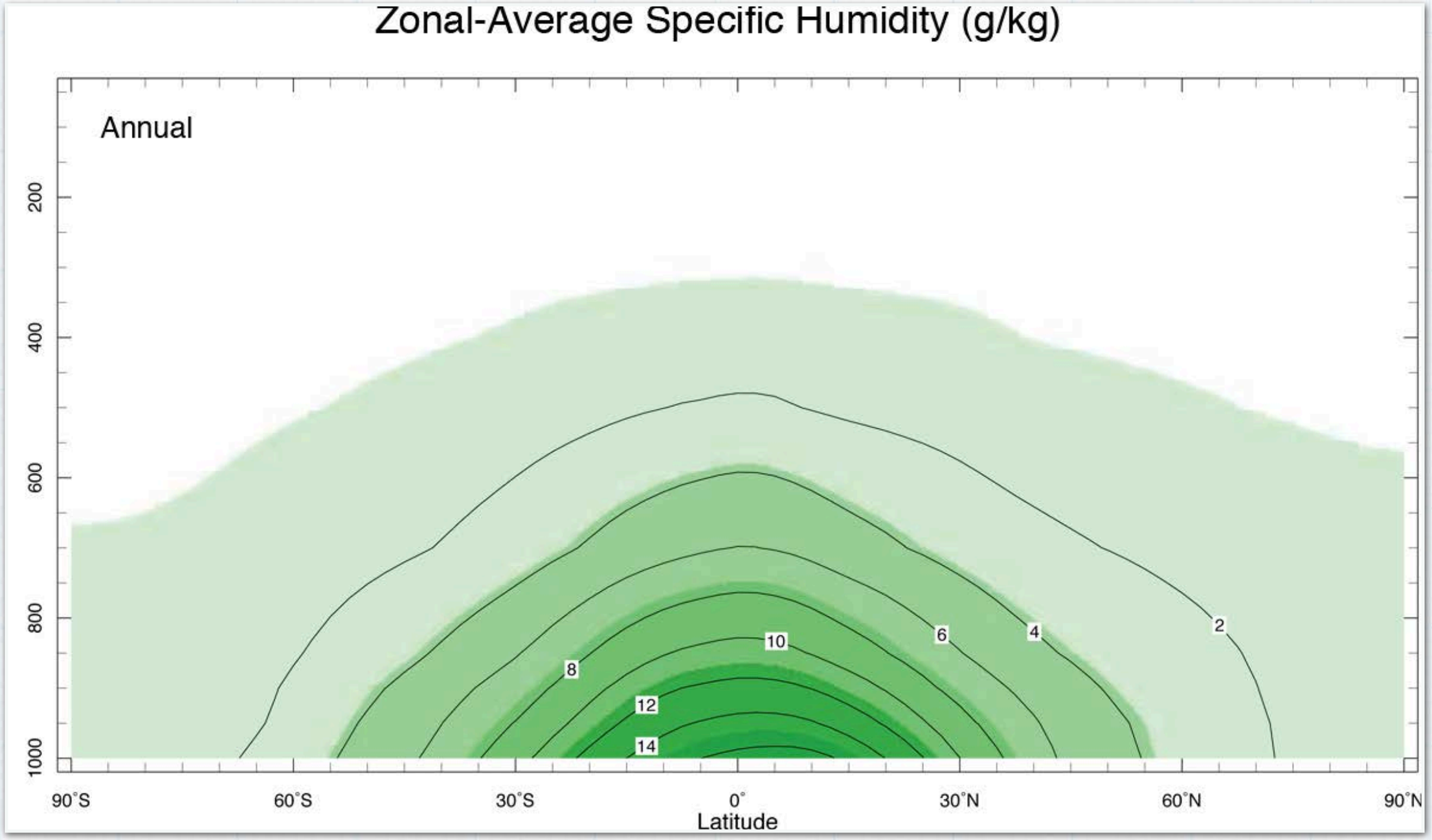
$$z_{warm} - z_{cold} = \frac{R}{g}\left(T_{warm} - T_{cold}\right)\left(\ln p_s - \ln p\right)$$

$$\approx \frac{287 \times 20}{10} \ln\left(\frac{1000}{500}\right) \approx 400$$

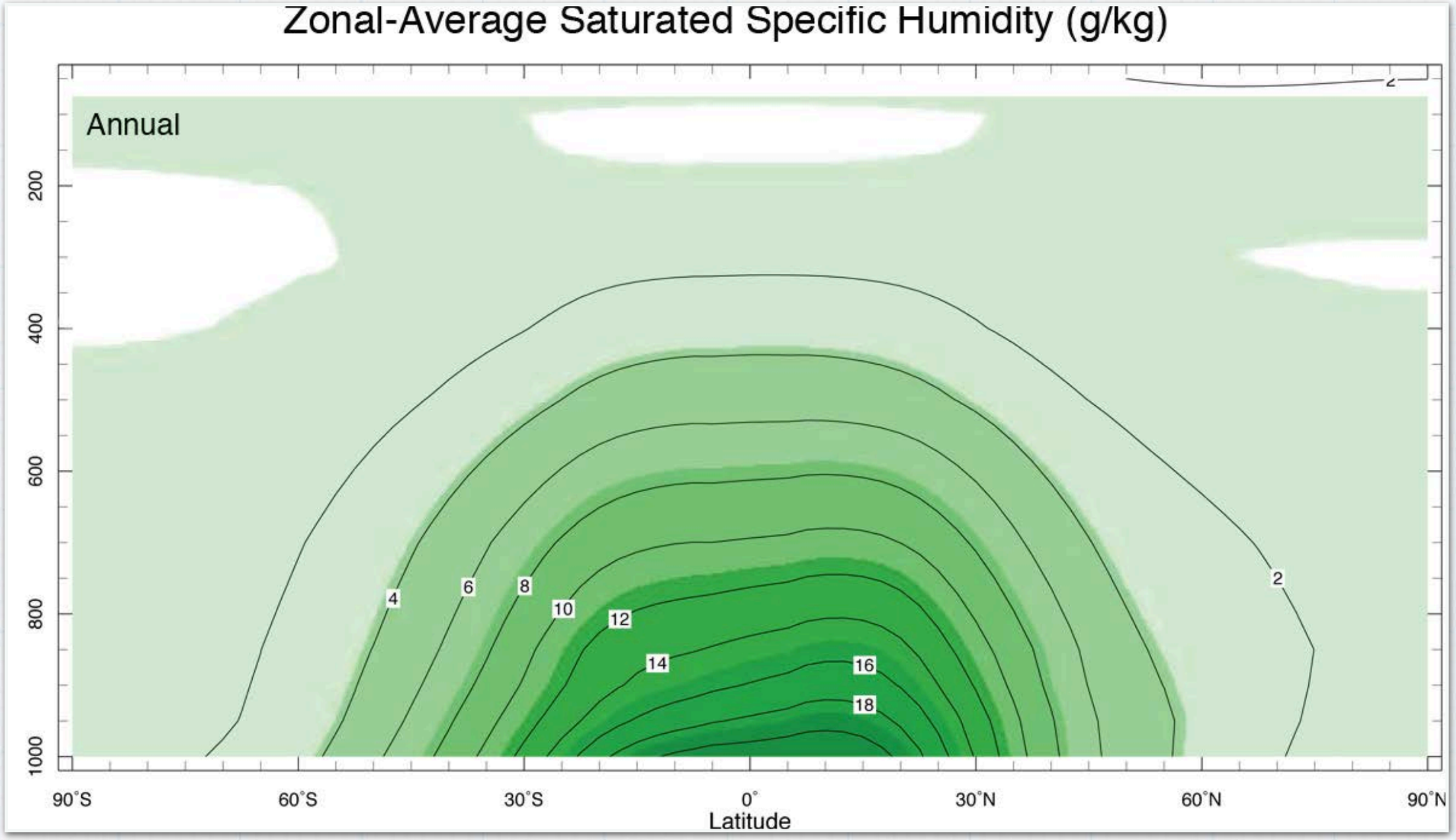
Pressure / geopotential height



Humidity: specific humidity



Humidity: saturated specific humidity



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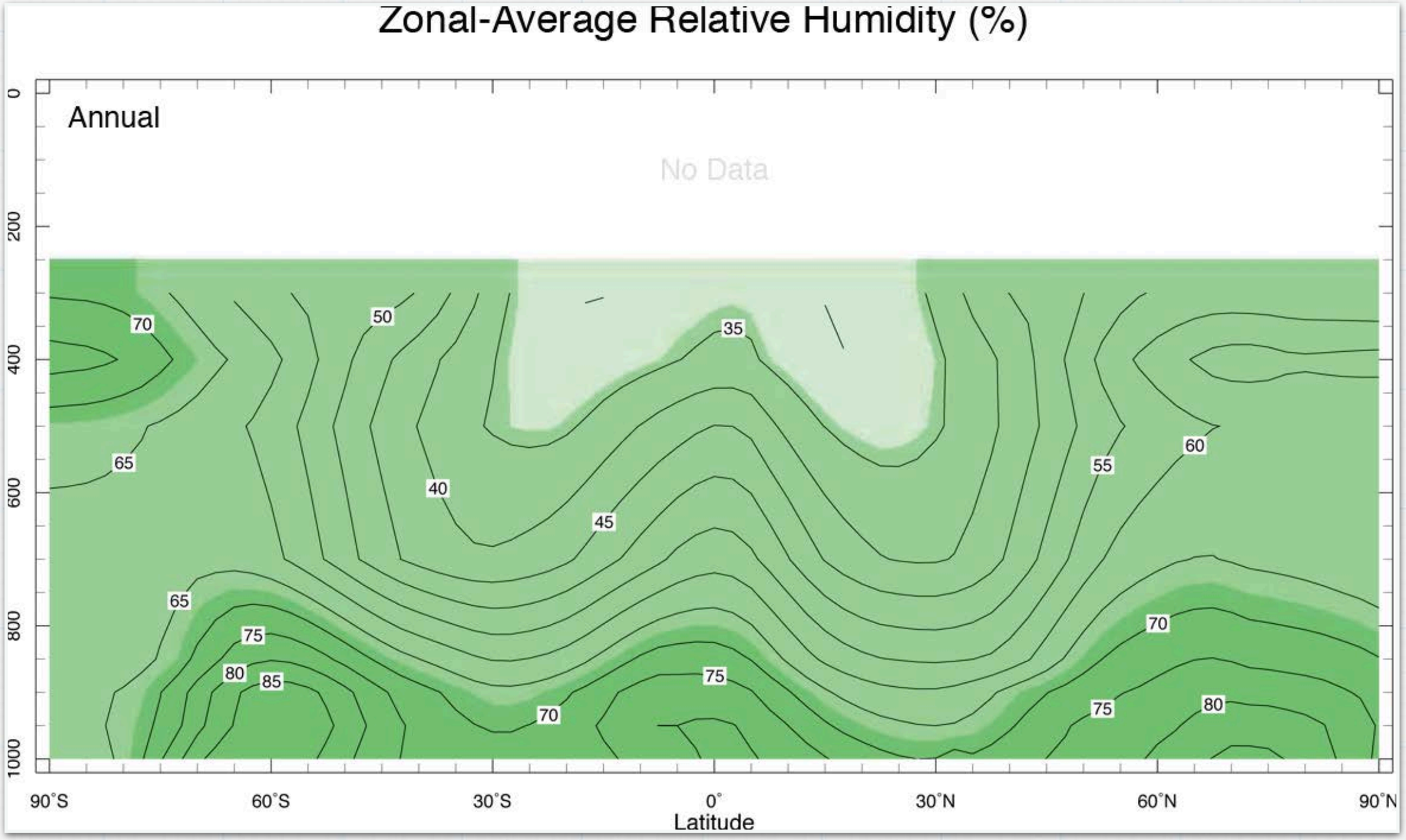
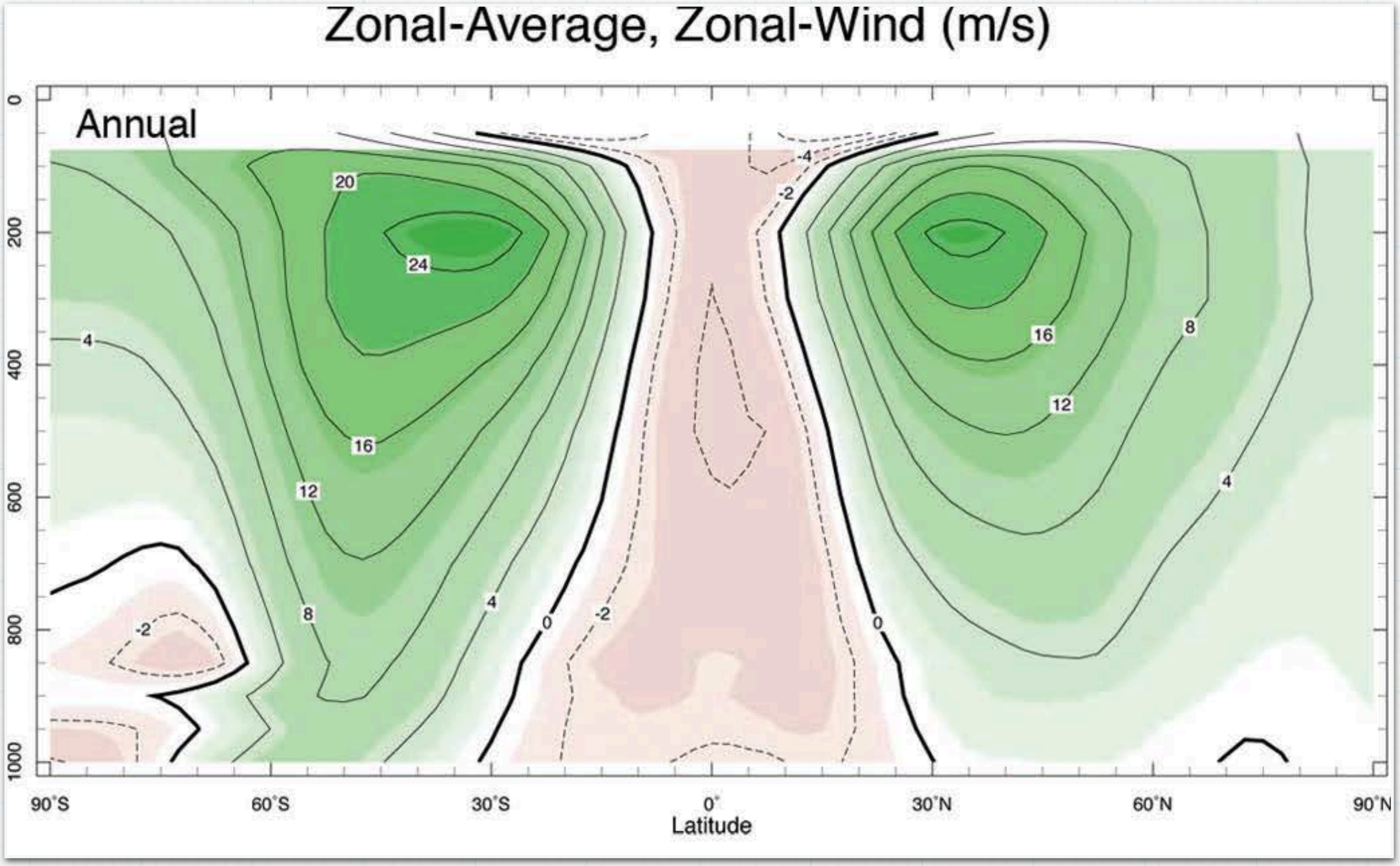


Wind

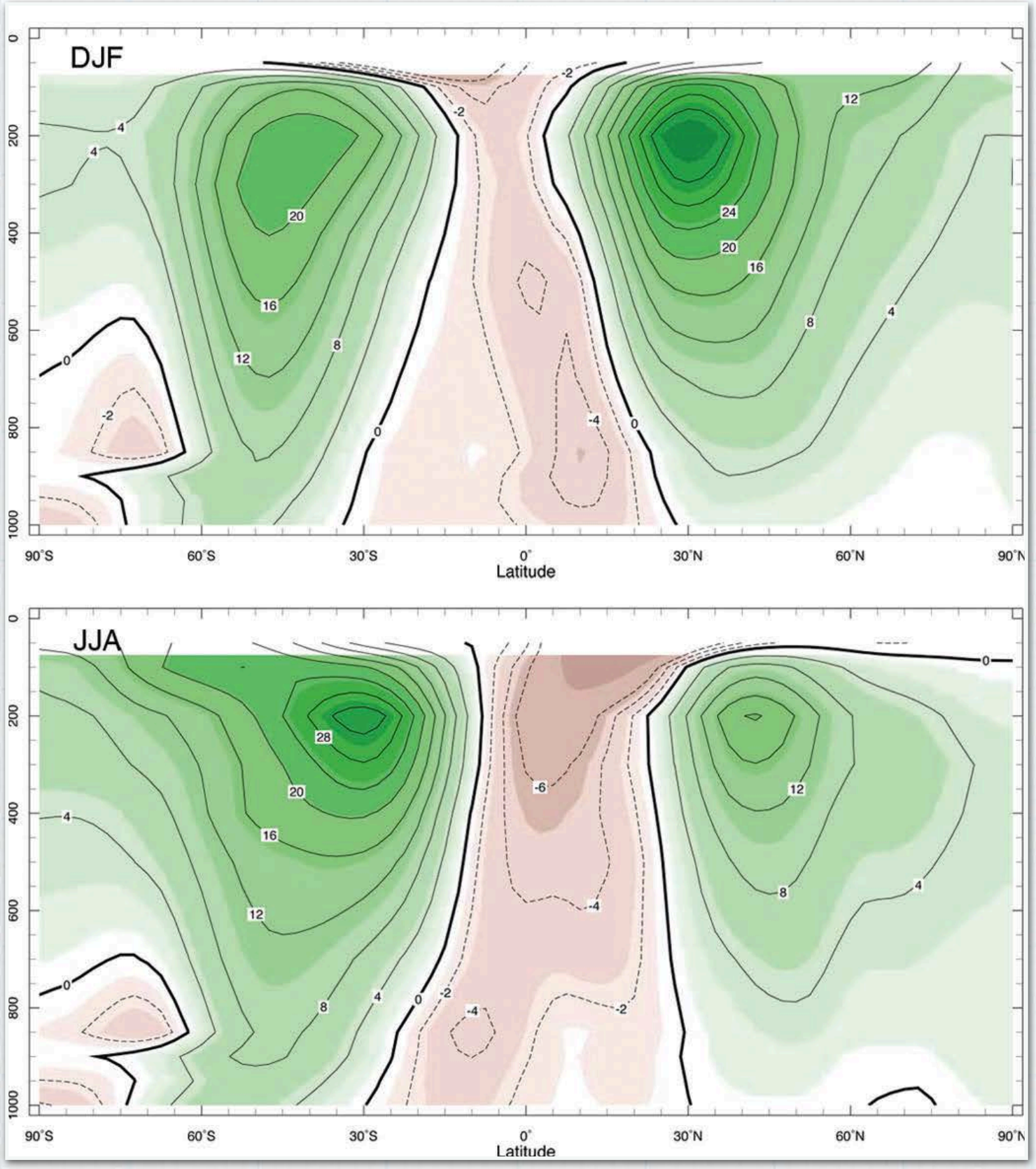
- There is a geopotential height slope from equator to pole
- We can expect that the pressure gradient force exists aloft.
- Wind has three dimensions: $\mathbf{u} = (u, v, w)$

Hard to measure

Wind - zonal wind (u)

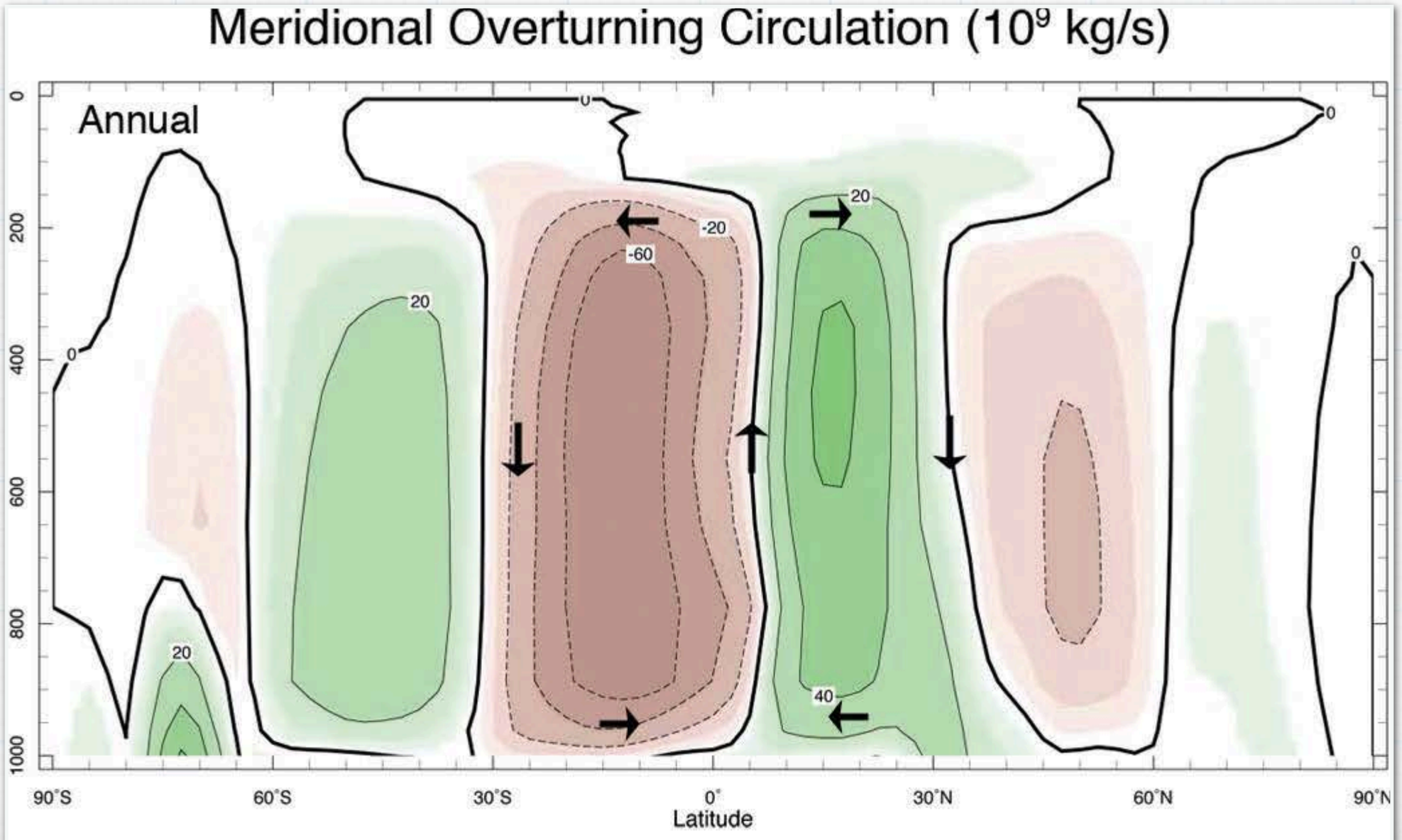


Wind - zonal wind (u)



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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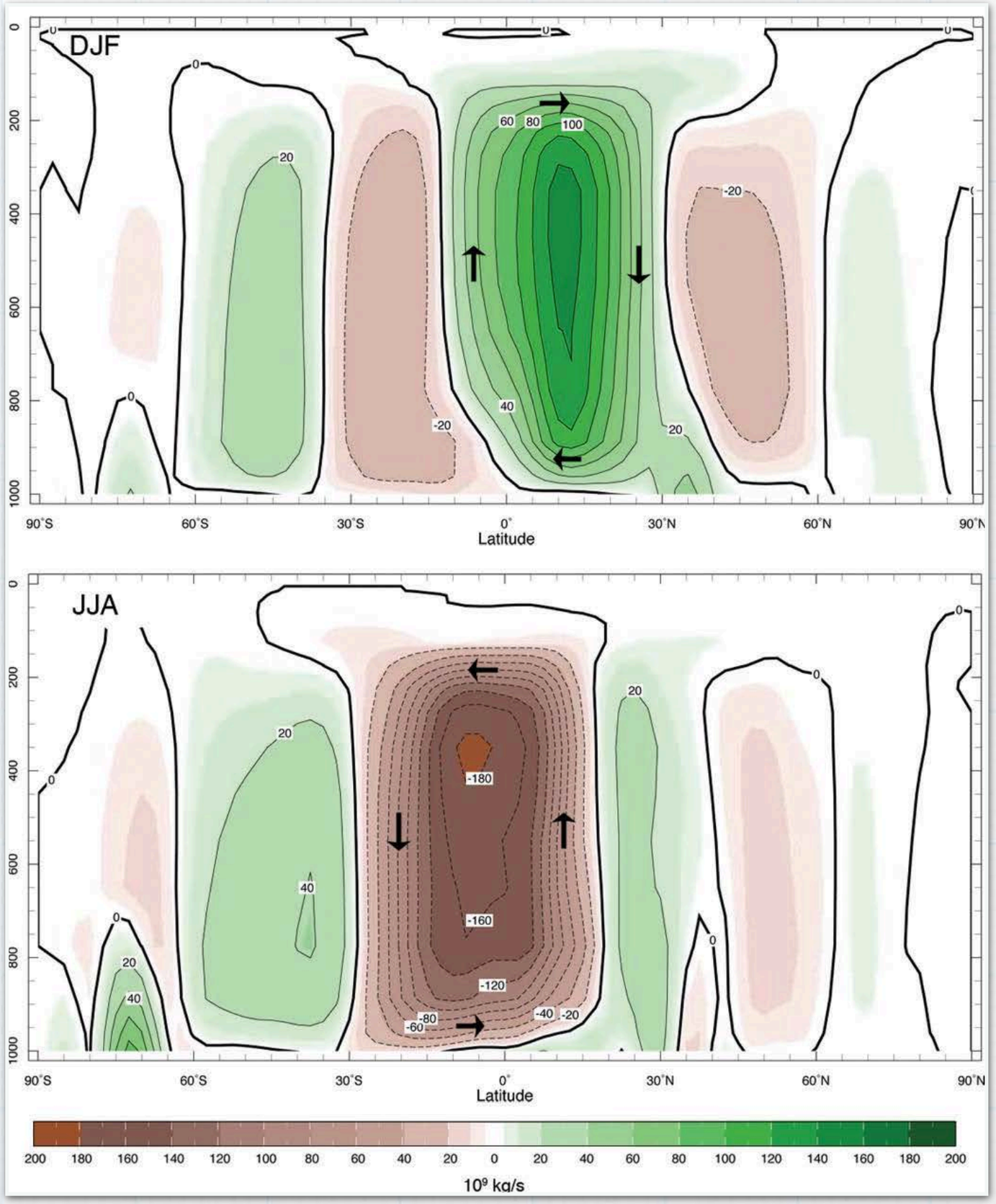

Eddies and waves