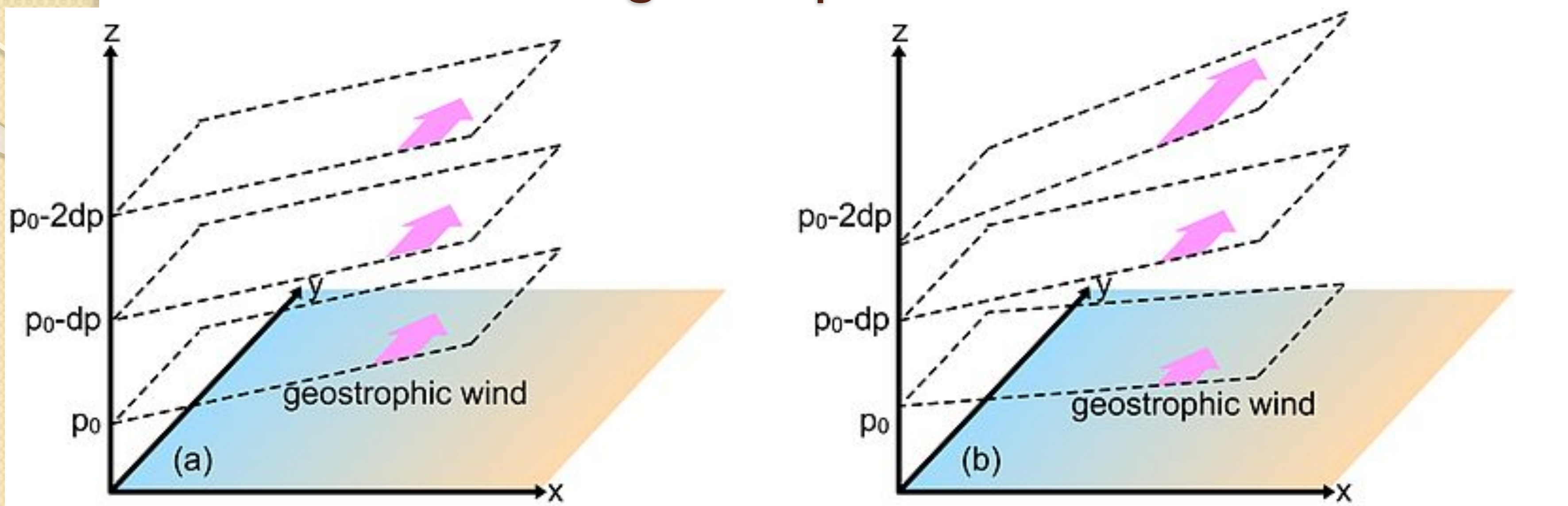
Thermal Wind: not a actual wind. It is a vector describing the **wind shear** of the geostrophic wind.



a) Barotropic (the density depends only on the pressure, therefore the isobar surfaces are parallel. The geostrophic winds at different levels are same)

b) Baroclinic (the density depends on both the temperature and the pressure, therefore, the slope of isobaric surfaces increases with height, causing the magnitude of geostrophic wind increase with height)

Derivation: Thermal Wind: combine the geostrophic wind equation and hypsometric equation

Applications (examples):

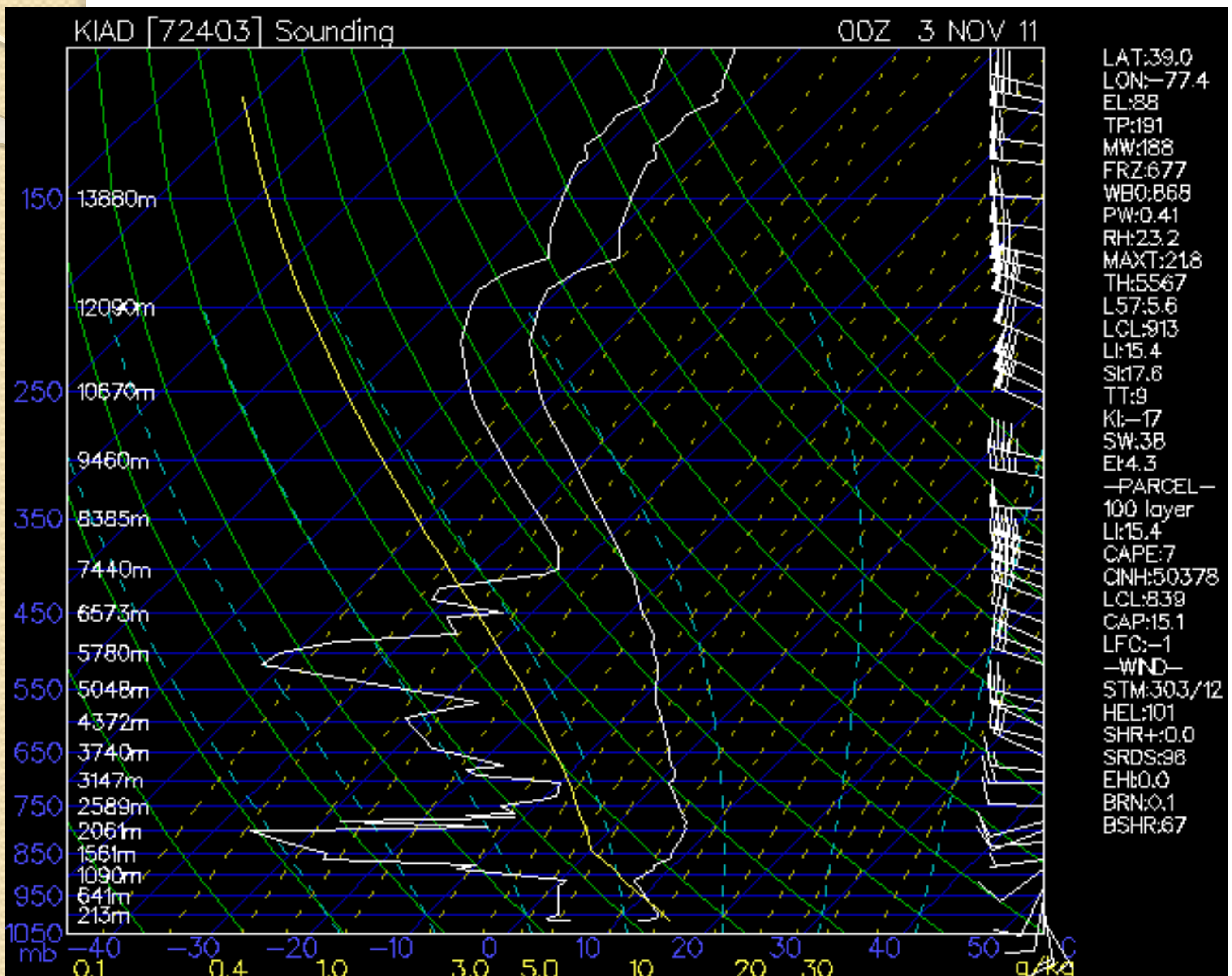
a) Determine temperature advection from sounding:

Backing (counter clockwise) wind → cold advection

Veering (clockwise) wind → warm advection

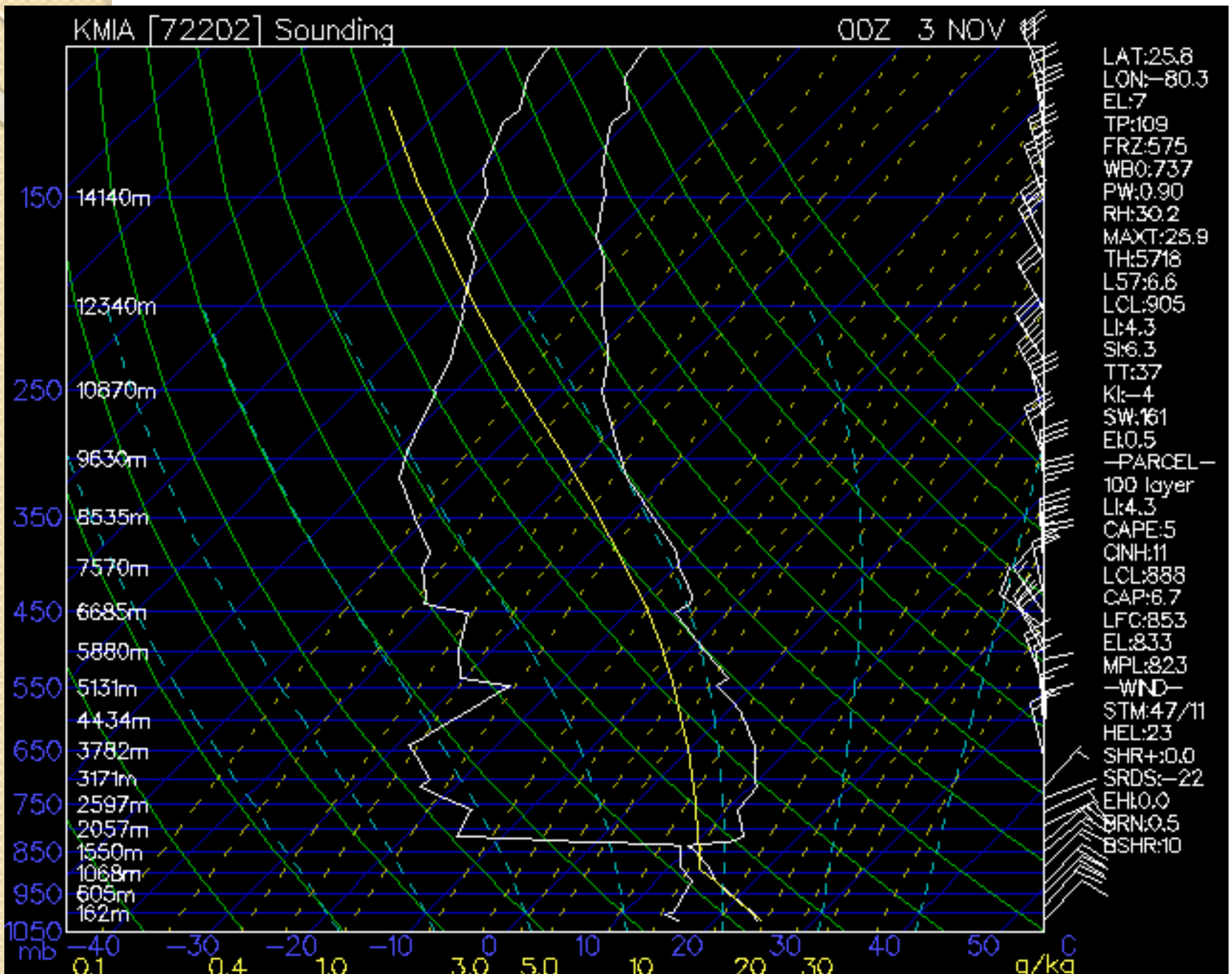
b) Jet Stream formation: Cold toward polar region and warm toward equator. This creates the thermal wind that causes the westerly geostrophic wind increases with height up until the tropopause, creating a strong wind known as the jet stream. The Northern and Southern Hemispheres exhibit similar jet stream patterns in the mid-latitudes.

Veering or backing wind?
Washington DC sounding 00Z Nov. 3, 2011

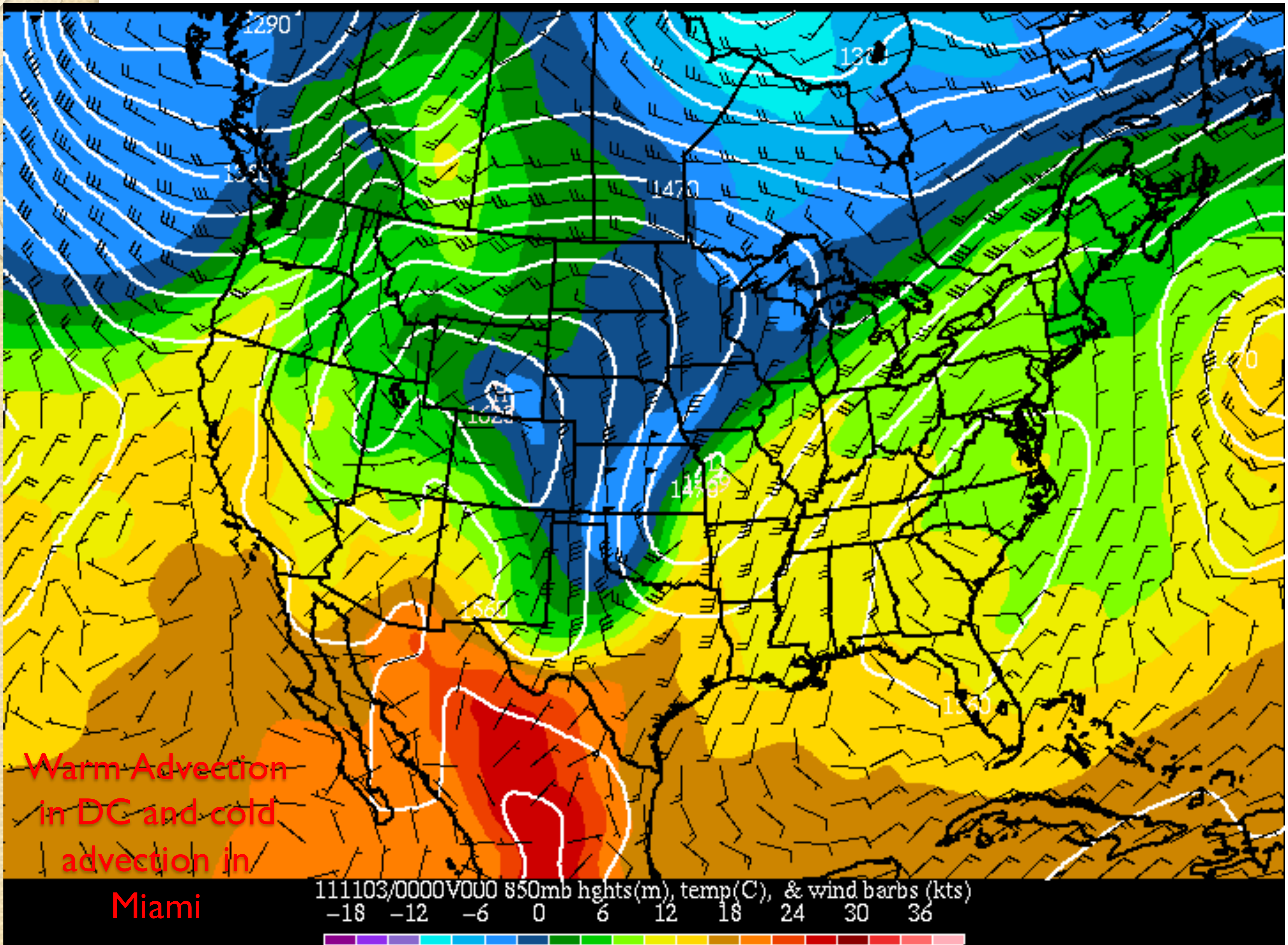


Veering wind (clockwise with height) → warm advection

Veering or backing wind?
Miami sounding 00Z Nov. 3, 2011

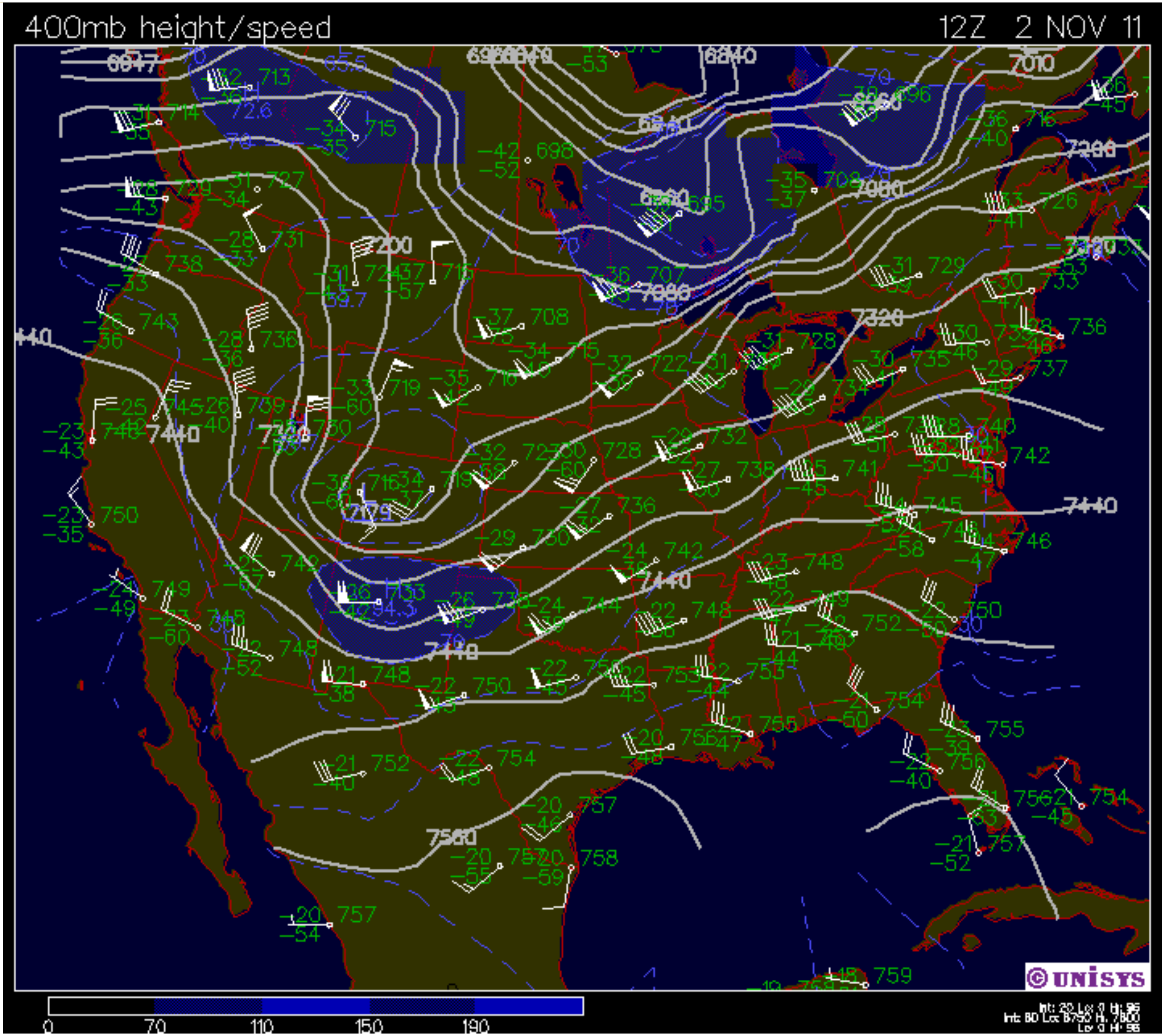


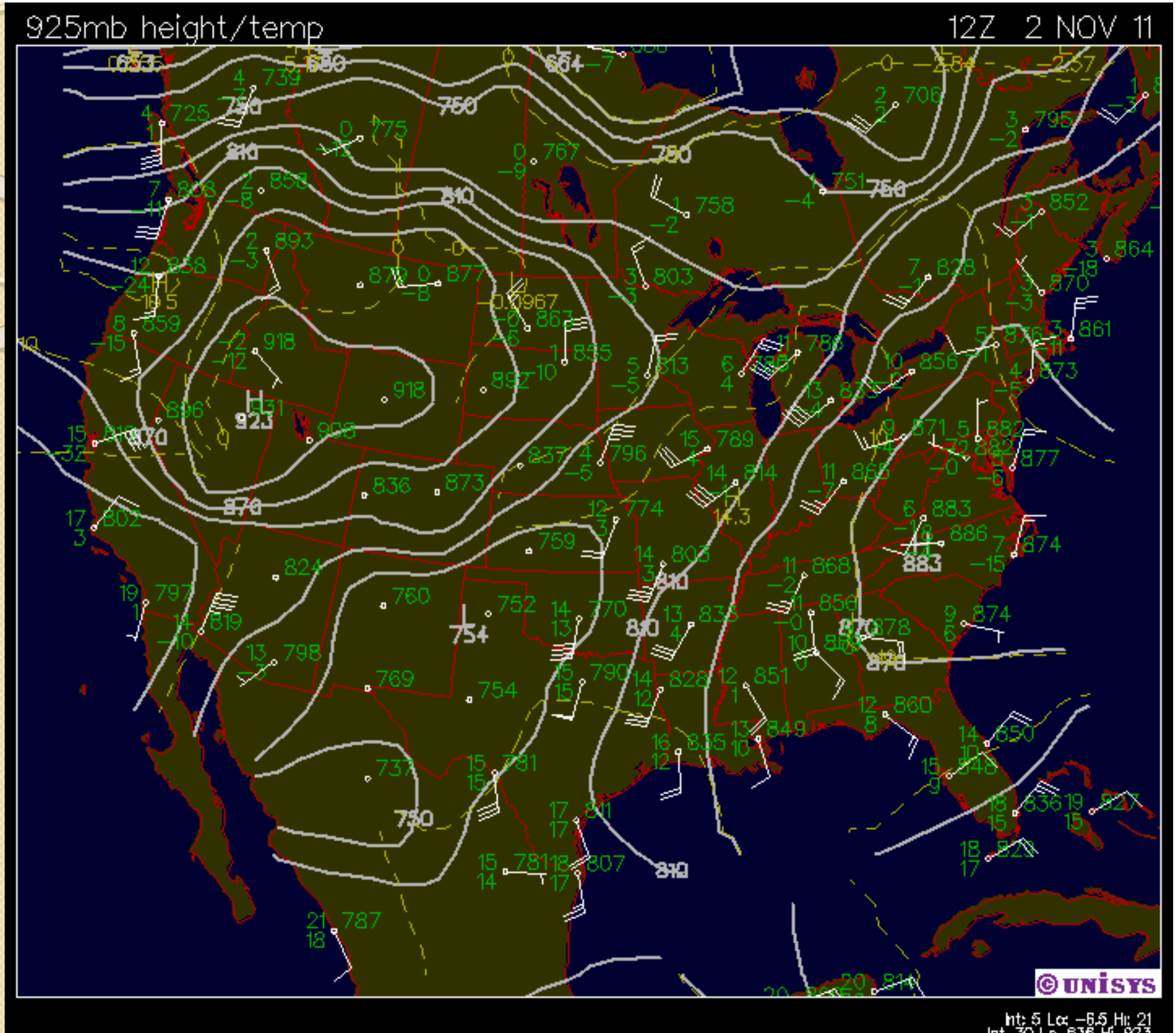
backing wind (counter-clockwise with height)→ cold advection

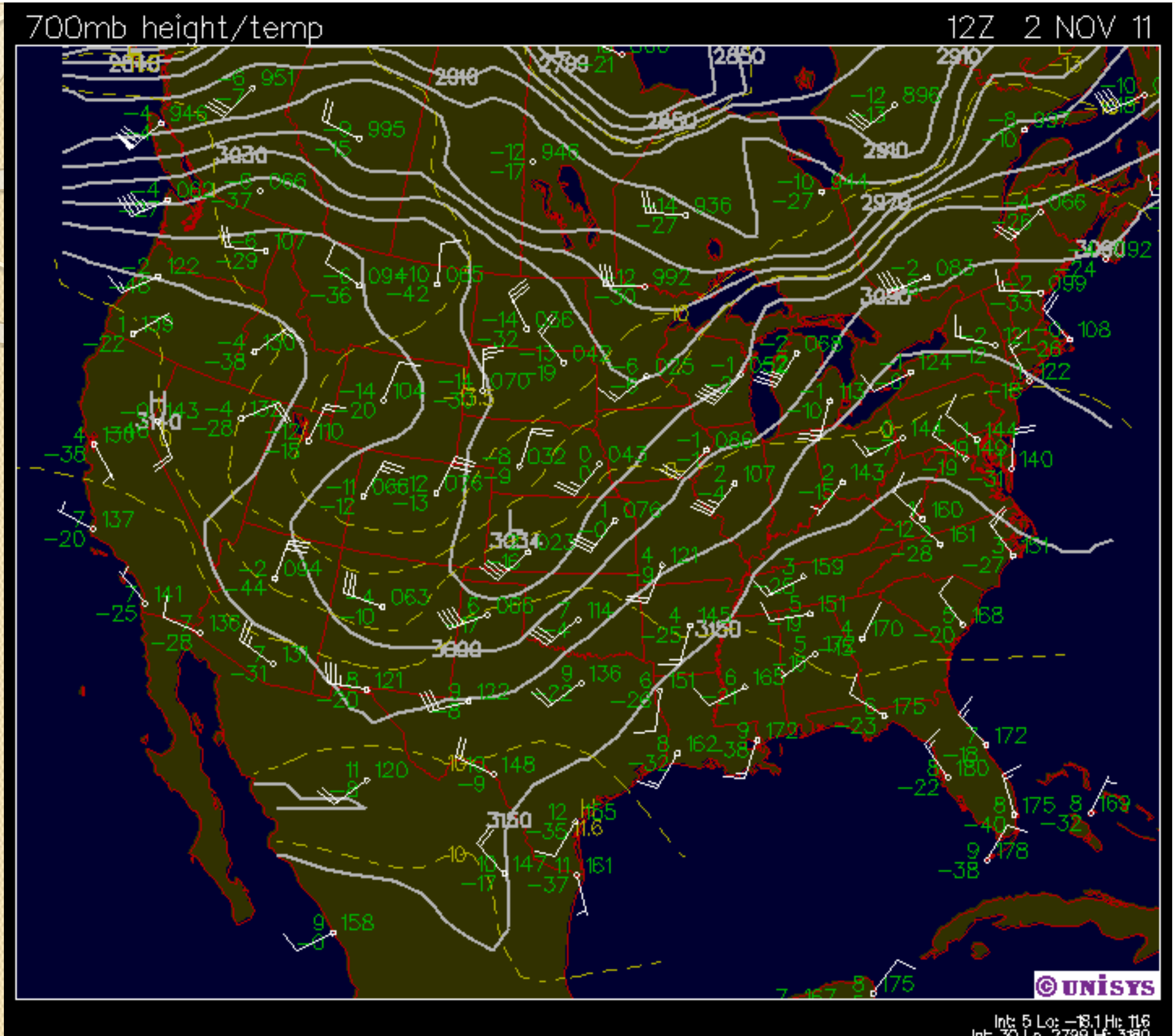


Warm Advection in DC and cold advection in Miami

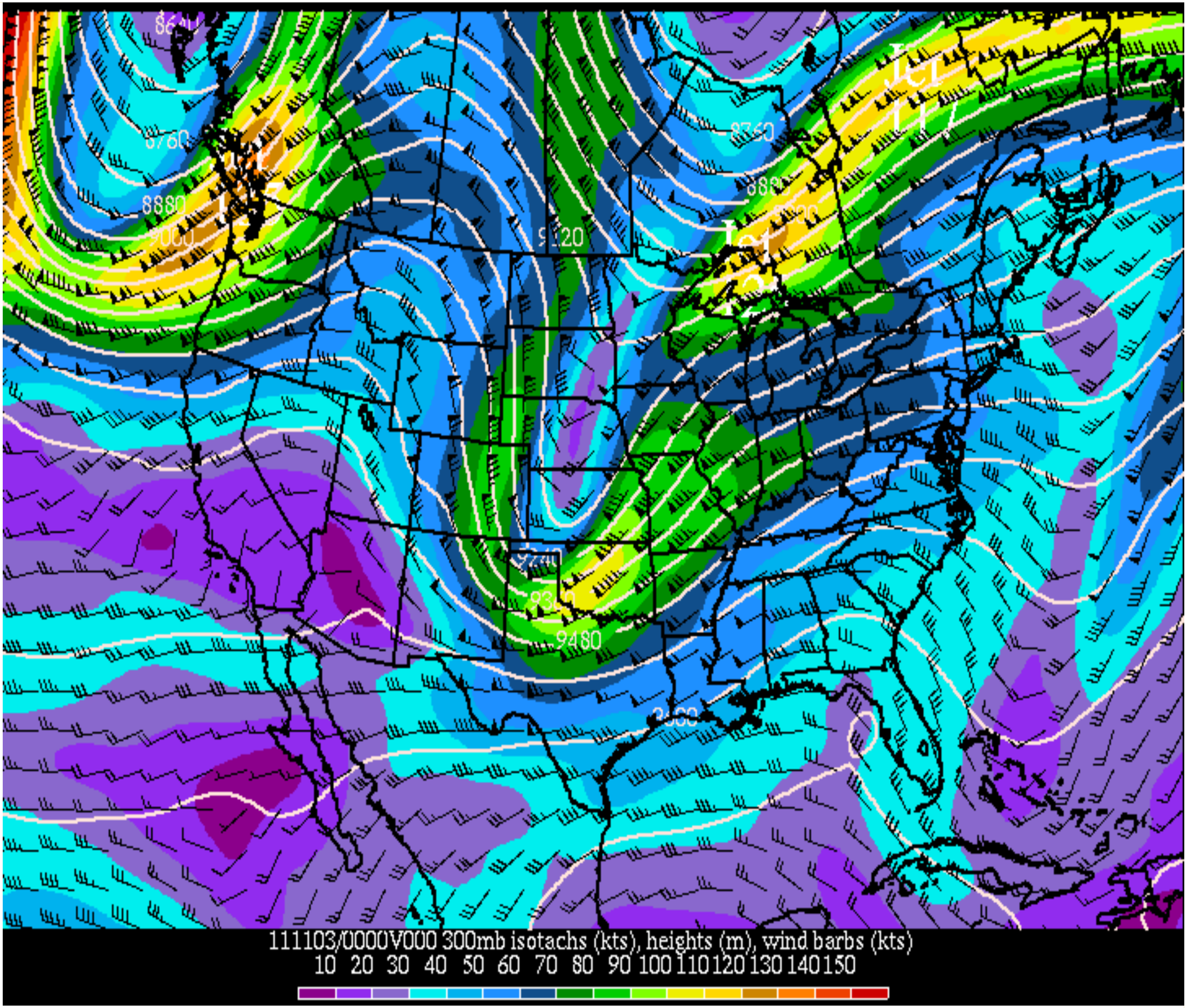
Hypsometric Equation: small thickness, colder mean temperature




925mb height/temp
12Z 2 NOV 11
© UNISYS
Int: 5 Lo: -6.5 Hi: 21
Int. 30 Lo. 636 Hi. 923


700mb height/temp
12Z 2 NOV 11
© UNISYS
Int: 5 Lo: −18.1 Hi: 11.6
Int: 30 Lo: 2799 Hi: 3180

Geostrophic wind; Gradient Wind



Curvature Vorticity & Shear Vorticity