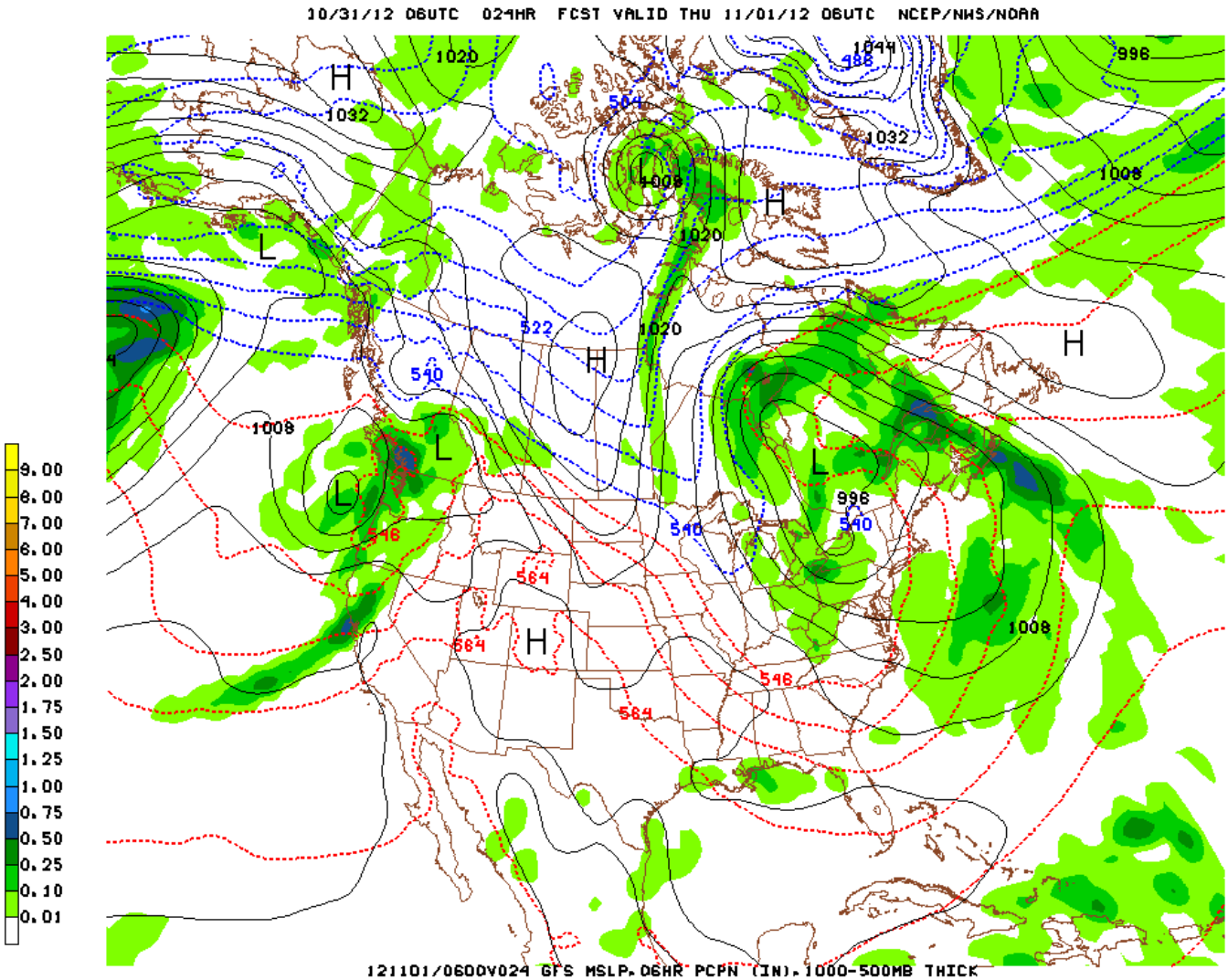
Explanation of the Combination Surface Pressure, 1000 to 500 mb Thickness and Precipitation Forecast Chart

The combination surface pressure, 1000 to 500 mb thickness and precipitation forecast chart includes three parameters: sea level pressure (black lines), 1000-500 mb thickness (blue and red dashed lines) and quantitative precipitation (color shaded contours).

The following discussion is a more detailed explanation of the lines and values of the GFS NWS Surface Pressure, 1000 to 500 mb thickness and quantitative precipitation chart shown below.



Sea level pressure

The sea level pressure field is defined by the solid black lines are pressure contours called isobars (lines of equal pressure). The isobars are drawn every 4 millibars. Surface winds are related to the packing (closeness) of the isobars. The tighter the packing (closer), the stronger the winds are. Direction can be found using the rule that winds flow clockwise around highs and counterclockwise around lows. (Buys Ballot Law: wind at your back lower pressure to your left.)

The surface pressure field can be used to find low and high pressure systems as well as the location of cold and warm fronts. The highs and lows can be located by the black H and L symbols on the map. Cold fronts will generally start from the center of an area of low pressure and follow a trough of low

pressure south and to the west of the low pressure center. Warm fronts will generally start from the center of an areas of low pressure and follow a trough of low pressure (usually less pronounced than the cold front trough so harder to find) east and to the south of the low pressure center. Precipitation and 1000 to 500 mb thickness pattern can also help define the fronts. Defined patterns of rain and/or snow are likely in the regions directly around the low, north of the warm front and along the cold front. Thickness line represent temperature patterns so thickness lines close together (rapid changes in temperature with distance) indicate fronts in the area.

Quantitative precipitation field

The quantitative precipitation field shows estimated 6 hour precipitation (liquid equivalent) for the 6 hour period prior to the valid time. The contours follow this scale to the left of the chart. Values are in inches.

In addition, the precipitation forecast can be used to estimate snow fall. A general 10 to 1 ratio can be used for snowfall based on the liquid equivalent shown in this chart. Using the 5400 m thickness line to determine whether the precipitation is snow or not, you take the precipitation total at a location and multiply it by 10 to get potential snowfall.

1000-500 mb thickness field

The 1000-500 mb thickness lines are ether blue or the red dashed lines. The thickness lines are drawn in 60 m interval. The dashed red and dashed blue line shown on the chart is the distances in deca-meters from the 1000 mb press level to the 500 mb pressure level. In meteorology we call the distance between vertical pressure levels "thickness" values. So the 546 line would represent a distance of 5460 meters between the 1000 and 500 mb pressure levels.

The distance between the pressure levels is inversely related to density and temperature. The colder the air the denser the air the lower values of the dashed lines. It turns out the 5400 meter (540 deca-meter) line is a good first approximation indicator of where the rain snow and 32˚ F line will be. So to make it easy they put the 540 line and lower in blue and the 546 line and higher in red. So a quick read of where the freezing line will be is to look at the location of where the blue and red lines are next to each other. One caveat is that the "540 rule" is a general guidance rule and will vary somewhat with season and terrain difference. For example the 32˚ F line will typically be associated with slightly higher thickness values in high elevation areas (e.g. 542 decameters). A table is provided in the next section to provide some guidance on the thickness and temperature values.

As mentioned in the surface pressure explanation above, thickness values and patterns can be used help to identify fronts. The location of close packing of thickness lines indicates the presence of the fronts. The values, wind flow and how the thickness move with time at can tell you the type of front. The direction and orientation of the packing will indicate whether the front is a cold or warm front. In general cold fronts are fairly easy to locate using the surface pressure and thickness lines. Warm fronts are more difficult to locate.

More Details about Theory of Thickness

(1) Thickness Defined

(For a derivation of the following see: http://en.wikipedia.org/wiki/Hypsometric_equation)

Thickness is the vertical distance between two constant-pressure surfaces as defined by the hypsometric equation expressed as:

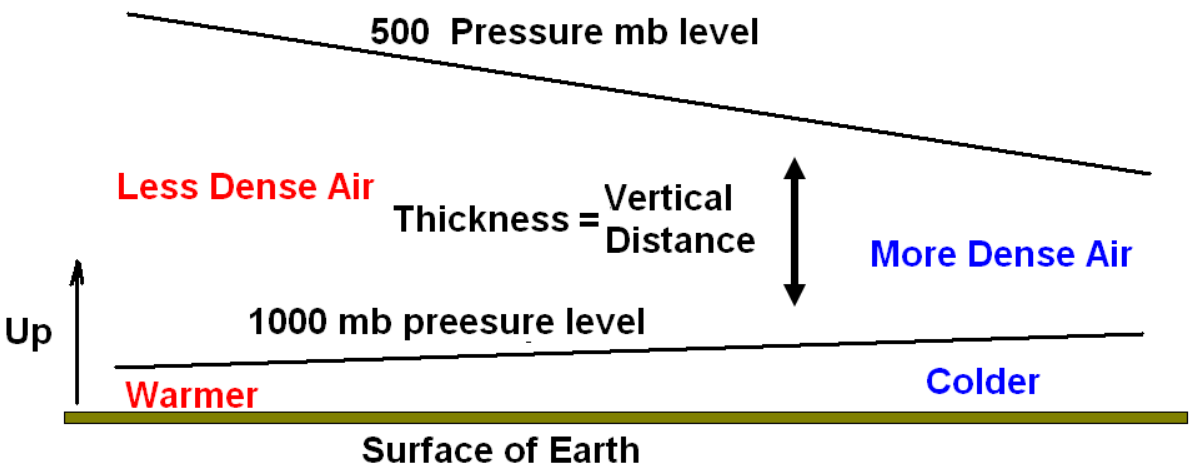
$$h = z_2 - z_1 = \frac{R \cdot T}{g} \cdot \ln\left[\frac{P_1}{P_2}\right]$$

Where:

h= thickness of the layer [m]
z= geopotential height [m]
R= specific gas constant for dry air
T= temperature in Kelvin [K]
g= gravitational acceleration [m/s^2]
P= pressure [Pa]

In meteorology $P_1$and P_2 are isobaric surfaces and T is the average temperature of the layer between them.

In diagram form for a P1 = 1000 mb and P2 - 500 mb:



So from the hypsometric equation and diagram we can see that the thickness of a column of air is proportional to the mean virtual temperature of the layer. The warmer the column, the higher is its thickness. The colder the column, the lower is its thickness. Although moisture content affects the thickness of a column, we normally associate thickness with temperature. While we can compute thickness using any two constant-pressure surfaces, we usually work with the 1000- 500-mb thickness levels (combined with surface pressure chart).

Thickness is directly related to temperature; as thickness decreases, so does temperature. Thickness is a measure of mean temperature in a layer of the atmosphere and ranges from 4900m in cold wintertime atmospheres to 5900m in warm summertime atmospheres. Precipitation type can also be estimated from the thickness field with the 5400 meter thickness serving as the rain/snow line. Snow falls where thicknesses are below 5400 and rain occurs where they are greater.

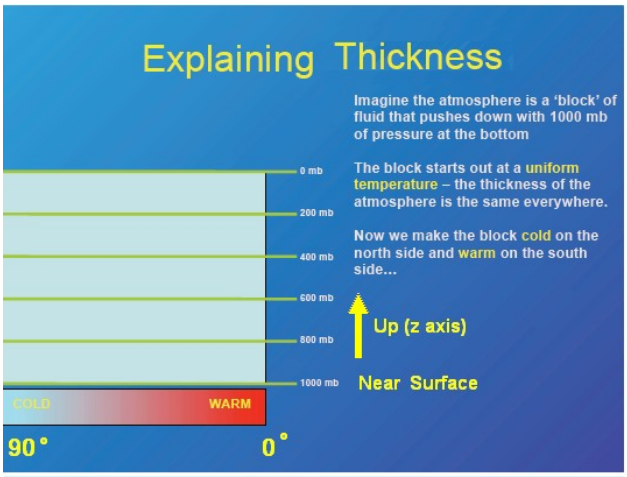
The heights can also be used to estimate surface temperatures since height of a pressure surface is related to the mean temperature of the air below it. Here is a rough estimate of temperatures based on color. The variability is on the order of +-10 degrees F:

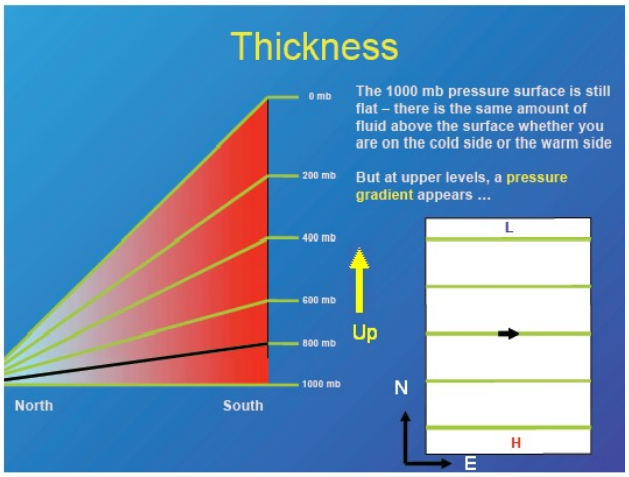
Basic 1000 - 500 mb Thickness to Temperature (F) Relationship			Modify Basic Relationship by Condition	
Height	**Color**	**Hi Temp**	**Type of conditions**	**Modify Thick by (in m)**
5940-6000	Red	~90	Deserts	+20 m
5880-5940	Red Orange	~84	Mid Summer	+10 m
5820-5880	Orange	~78	Tropics	+5 m
5760-5820	Yellow Orange	~72	Spring/Fall	0
5700-5760	Yellow	~66	Cloud cover	-5 m
5640-5700	Greenish Yellow	~60	Rainy areas	-10 m
5580-5640	Yellowish Green	~54	Near Low Press	-10 m
5520-5580	Green	~48	Wintertime	-10 m
5460-5520	Cyanish Green	~42	Snow cover	-10 m
5400-5460	Greenish Cyan	~36	Arctic Winter	-20 m
5340-5400	Cyan	~30		
5280-5340	Blueish Cyan	~24		
5220-5280	Blue Cyan	~18		
5160-5220	Cyanish Blue	~12		
5100-5160	Blue	~6		
5040-5100	Magentaish Blue	~0		
4980-5040	Blueish Magenta	~-6		
4920-4980	Magenta	~-12		
4860-4920	Medium Magenta	~-18		
4800-4860	Dark Magenta	~-24		

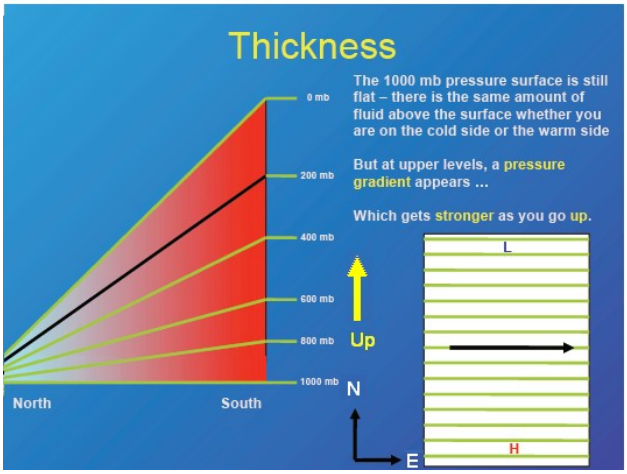
The surface presue/1000 - 500-mb product is useful for determining the mean temperature advection in the 1000- 500-mb layer. We can estimate the mean temperature advection by advecting (estimate horizontal motion) of the 1000- 500-mb thickness isopleths (lines of equal thickness values) with the surface isobars. Warm air advection (WAA) occurs in regions where the wind (isobaric flow) advects higher thickness values into a region presently occupied by lower values. Cold air advection (CAA) occurs in regions where the wind (isobaric flow) advects lower thickness values into a region presently occupied by higher values.

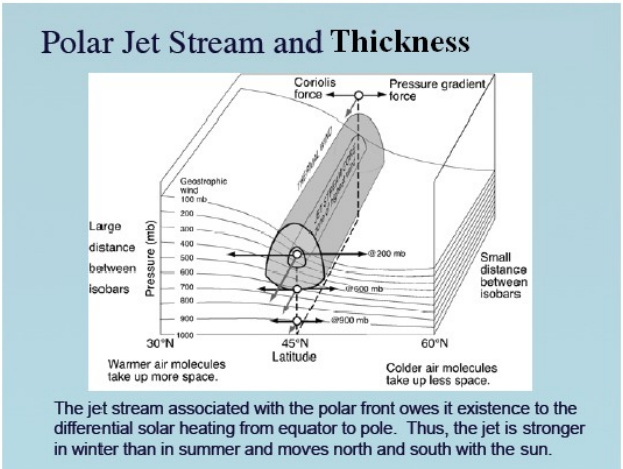
(2) Additional Theory:

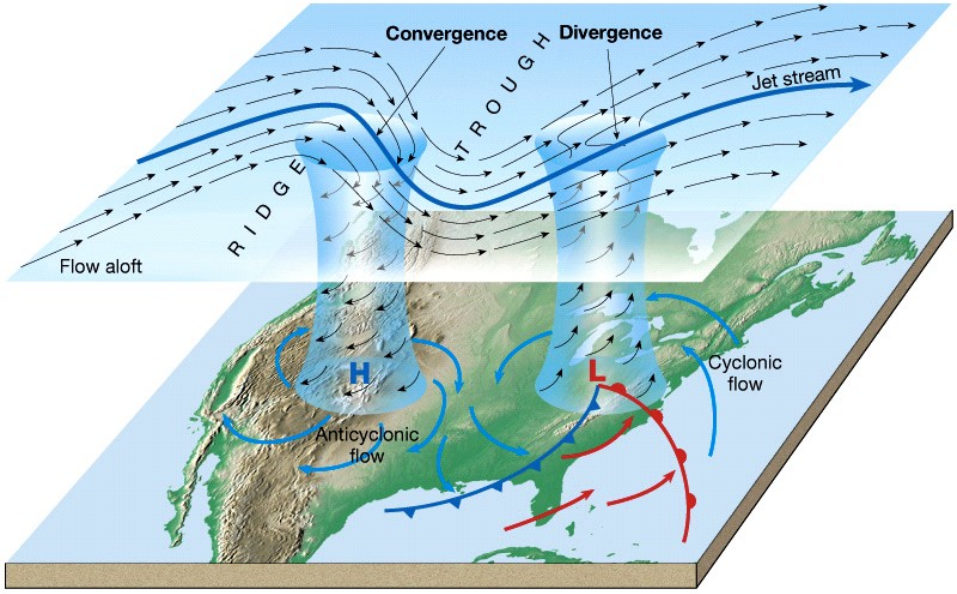
The following diagrams show how thickness differences form and impact the strength of pressure (height) system wind speeds.











For more details of thickness theory go to: http://weatherfaqs.org.uk/node/152
http://lukemweather.blogspot.com/2010/11/closer-look-at-critical-thickness_14.html
http://weather.unisys.com/upper_air/ua_cont.php?plot=thi&inv=0&t=cur
http://weather.unisys.com/model/details.php#press
http://www.nwas.org/digest/papers/1996/Vol21No1/Pg21-Billingsley.pdf