

Activity: Upper-Air Weather Maps

Educational Outcomes:

Weather as reported on surface weather maps provides us primarily with a two-dimensional view of the state of the atmosphere, that is, weather conditions observed at the Earth's surface. Atmospheric conditions reported on upper-air weather maps provide the third dimension, that is, conditions at various altitudes above the Earth's surface. Hence, for a more complete understanding of the weather, both surface and upper-air weather maps need to be consulted.

After completing this activity, you should be able to:

- Describe the topography of upper-air constant-pressure surfaces based on height contours, including the identification of Highs, Lows, ridges, and troughs.
- Describe the general relationship between height contours and the average temperature of the underlying atmosphere.
- Describe the relationship between the height contours and wind direction on upper-air maps.

Materials: Pencil

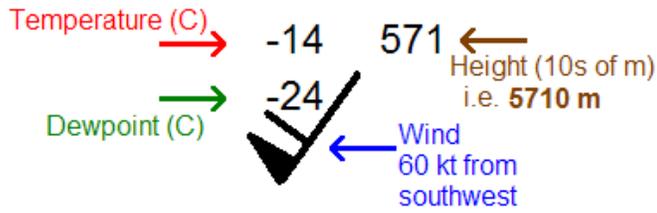
Investigations:

1. Upper-air weather maps differ from surface weather maps. Whereas surface weather conditions are plotted on a map of constant altitude (normally sea-level), upper-air weather conditions are plotted on maps of constant air pressure. The altitude at which the particular pressure is located is reported on these maps. Every twelve hours, upper-air maps are drawn for various pressure levels including, for example, 850 mb, 700 mb, 500 mb, and 200 mb. The 500-mb pressure level is about half way up in the atmosphere in terms of mass. Also, major weather systems tend to flow along the direction of the winds shown at 500 mb.

The data for these maps are obtained from rawinsonde reports. Rawinsondes are radiosondes which are tracked by Global Positioning System (GPS) positions to provide additional information on horizontal wind speeds and directions.

2. Plotted on upper-air maps are temperature (in °C), dewpoint (in °C), wind speed (in knots), wind direction, and coded height of the pressure surface above sea-level (in meters). Become familiar with the upper-air station model depicted below.

SAMPLE UPPER AIR STATION MODEL FOR 500 MB



3. **Figure 3** is the 500-mb map for 00Z 23 April 2012 (8 pm EDT of 22nd). The information is assembled from the 500-mb level of each station's reports at the same observation time. The 500-mb map is often employed by meteorologists because of its importance in revealing the direction of the steering winds, that is, the winds that steer weather systems across the Earth's surface.

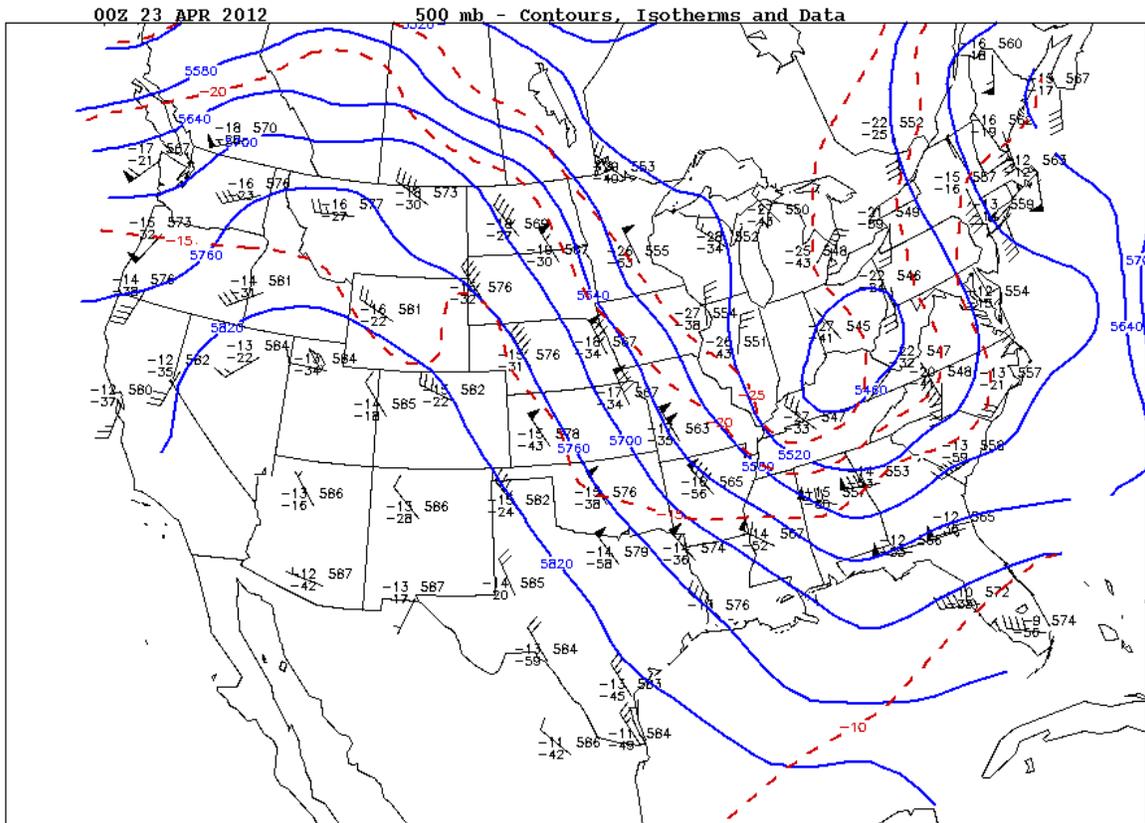


Figure 3. 500 mb upper air, constant-pressure map for 00Z 23 APR 2012 [NCEP/NOAA].

4. Solid lines on the 500-mb map display locations where 500-mb is at the same altitude. These lines, called *contours of height*, are drawn at intervals of 60 m. At 00Z, 23 APR 2012, the lowest reported height for a pressure reading of 500-mb was _____ meters, and the highest reported height was _____ meters.

5. The 500-mb map and other constant-pressure upper-air maps are similar to topographic maps. That is, the contour pattern reveals the “hills” and “valleys” of the constant-pressure surface. In general, the 500-mb surface (the surface where the air pressure is 500-mb) occurs at a **[(higher)(lower)]** altitude in southern Canada than in the southern United States.
6. Closed contour lines on constant-pressure upper-air maps identify topographic highs and lows. The closed 5460-m contour line on this map encloses **[(higher)(lower)]** 500-mb elevations. Therefore, the contour line encloses a topographic **[(Low)(High)]**. Place an appropriate large “H” or “L” on the map at the center of the area enclosed by the contour line.
7. The wave pattern of most contour lines consists of topographic ridges and troughs, that is, elongated crests and depressions, respectively. A broad **[(trough)(ridge)]** appears on the Figure 3 map in the eastern portion of the nation generally south of the closed contour. A **[(trough)(ridge)]** appears over western US.
8. A column of cold air is denser than a column of warm air. Hence, air pressure decreases more rapidly with altitude in cold air than in warm air. The height of the 500-mb surface is lower where the underlying air is relatively **[(cold)(warm)]** and higher where the underlying air is relatively **[(cold)(warm)]**. The air below the 500-mb Low in Figure 3 is **[(colder)(warmer)]** than the air below the surrounding higher 500-mb surfaces.
9. Dashed lines on the 500-mb map are isotherms. The interval between successive isotherms is 5 Celsius degrees. The general decline in temperature at 500 mb as latitude increases is accompanied by a(n) **[(increase)(decrease)]** in the altitude of the 500-mb surface.
10. Suppose that on 23 APR 2012 at 00Z you board an airplane and fly non-stop directly from Cincinnati Ohio, (on the Ohio-Kentucky border) to Tucson, Arizona (the southern station in the state). En route, the plane cruises along the 500-mb surface. Flying from Cincinnati to Tucson, the aircraft's cruising altitude **[(increases)(decreases)(does not change)]**. At the same time, the temperature of the atmosphere below the aircraft **[(rises)(falls)]**.
11. A relationship exists between the orientation of height contours and horizontal wind direction on 500-mb maps, especially at higher wind speeds. As seen in Figure 3, wind direction is generally **[(perpendicular)(parallel)]** to nearby contour lines.

Optional Upper-Air Map Activity

A physical, three-dimensional model depicting the relief of an upper-air map may be constructed by transferring the map to construction material of moderate thickness such as Styrofoam® or corrugated cardboard. The use of cardboard from boxes used to deliver pizzas is handy as it is thin and easily cut with scissors. The following procedure indicates how such a model can be assembled.

1. Enlarge the map in the Upper-Air Weather Maps activity by 175% using a photocopier. Make 6 copies of the enlarged map.
2. Glue the maps onto pieces of the construction material.
3. On one of the mounted maps, cut out the areas inside of the closed 5460-m and the looping 5520-m contour lines. Also note those same lines appear in the Pacific Northwest. Align and glue the map with the two holes onto an uncut copy of the map.
4. Cut out and discard the lower-altitude portions of successive mounted maps along 5580-, 5640-meter, etc. contour lines. Glue the remaining successive map pieces in sequence, one on top of the other, to produce a stepped relief map assembly.
5. Examine the assembled map from different angles, including looking straight down to see the full map. Turn to the Upper-Air Weather Maps activity and refer to the model as you answer or review your answers to the investigations. Be sure to compare the positions of the Lows, ridges, and troughs as they appear on the map and in the model.

Cautionary notes: The physical relief map you have constructed has a greatly exaggerated vertical to horizontal scale. Also, the stepped relief presented in the model is contrary to the actual continuous sloping of the existing pressure surface.

Real World Applications

Upper atmospheric flow patterns exhibit wave-like motions as the air moves generally from west towards east around the globe. These waves have swirls like eddies in streams of water. Surface weather systems are formed from the flows of air aloft that result from atmospheric temperature patterns. As noted, the heights of constant pressure levels depend on the temperatures within the air below that level. Cold air columns produce lower heights of surfaces such as the 500-mb level. Warm air columns produce higher heights of 500-mb surfaces.

In turn, surface weather systems move warm and cold air masses generally eastward and influence the columns of air above the surface. The surface weather and upper air patterns are inextricably linked. Over the course of several days, patterns of upper air flows can change from situations shown in Figure 3 where circular eddies form and contours display closed loops to generally smooth west-to-east flows. Patterns having large north and south excursions as seen in Figure 3 are called *meridional* from their flow generally north and south along meridians of longitude. The opposite extreme of flow generally west-to-east would be called *zonal* from the flow along zones of latitudes.

Figure 4 is the 500-mb constant-pressure map for 12Z (7 am EST) 20 January 2012. Compare the flow pattern shown in Figure 4 to that of Figure 3.

1. The flow seen in Figure 3 would be termed **[(*meridional*)(*zonal*)]** while that of Figure 4 would be **[(*meridional*)(*zonal*)]**.
2. Compare the temperature patterns shown by the red, dashed isotherms plotted on each figure. The general decrease of temperature as latitude increases occurs more smoothly when the flow is zonal as shown in **[(*Figure 3*)(*Figure 4*)]**.

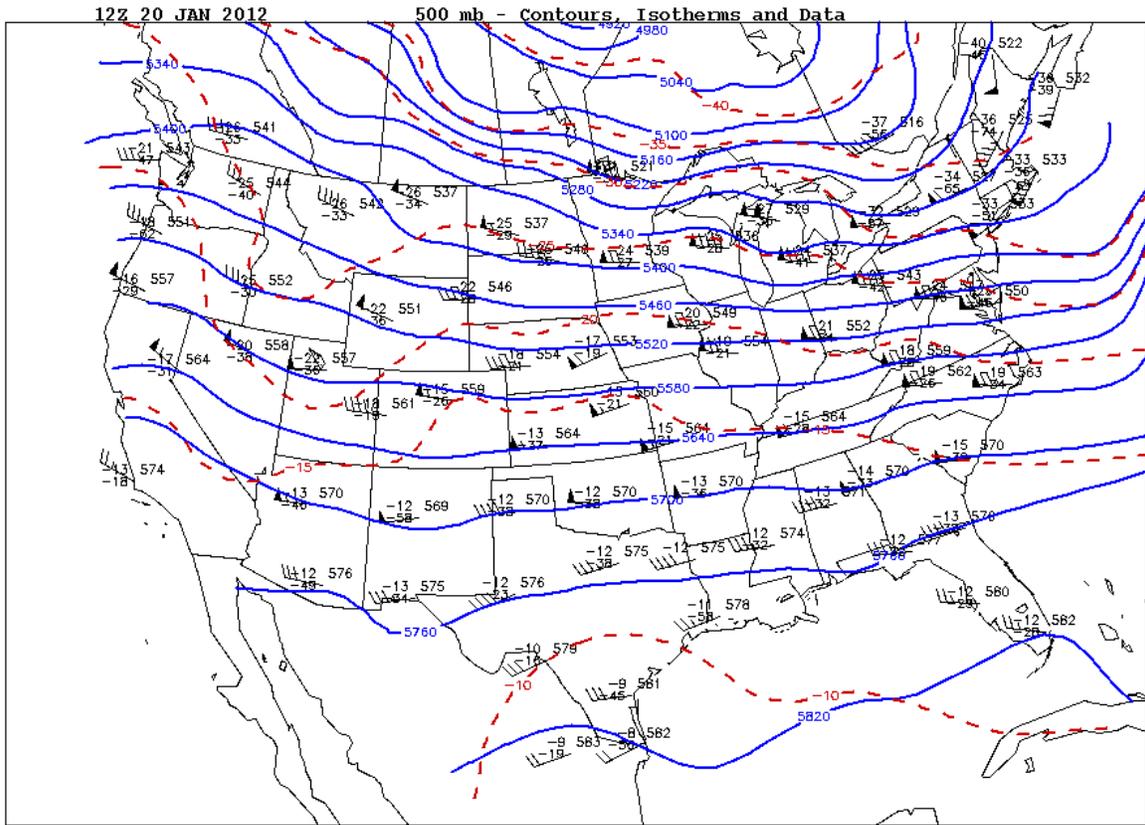


Figure 4. 500-mb map for 12Z 20 JAN 2012 [NCEP/NOAA].