<u>**Synoptic Meteorology II: Frontogenesis Examples**</u>

The below images, taken from the 1200 UTC 17 January 2019 GFS forecast run, provide examples of the contributions of deformation and divergence to frontogenesis.

Using Fig. 1 below, we will evaluate frontogenesis in the Pacific Northwest, western Great Lakes, and southern Great Plains. Recall that isotherms on an isobaric surface are equivalent to isentropes due to Poisson's relation; p is constant everywhere, so θ is just a constant multiple of T.

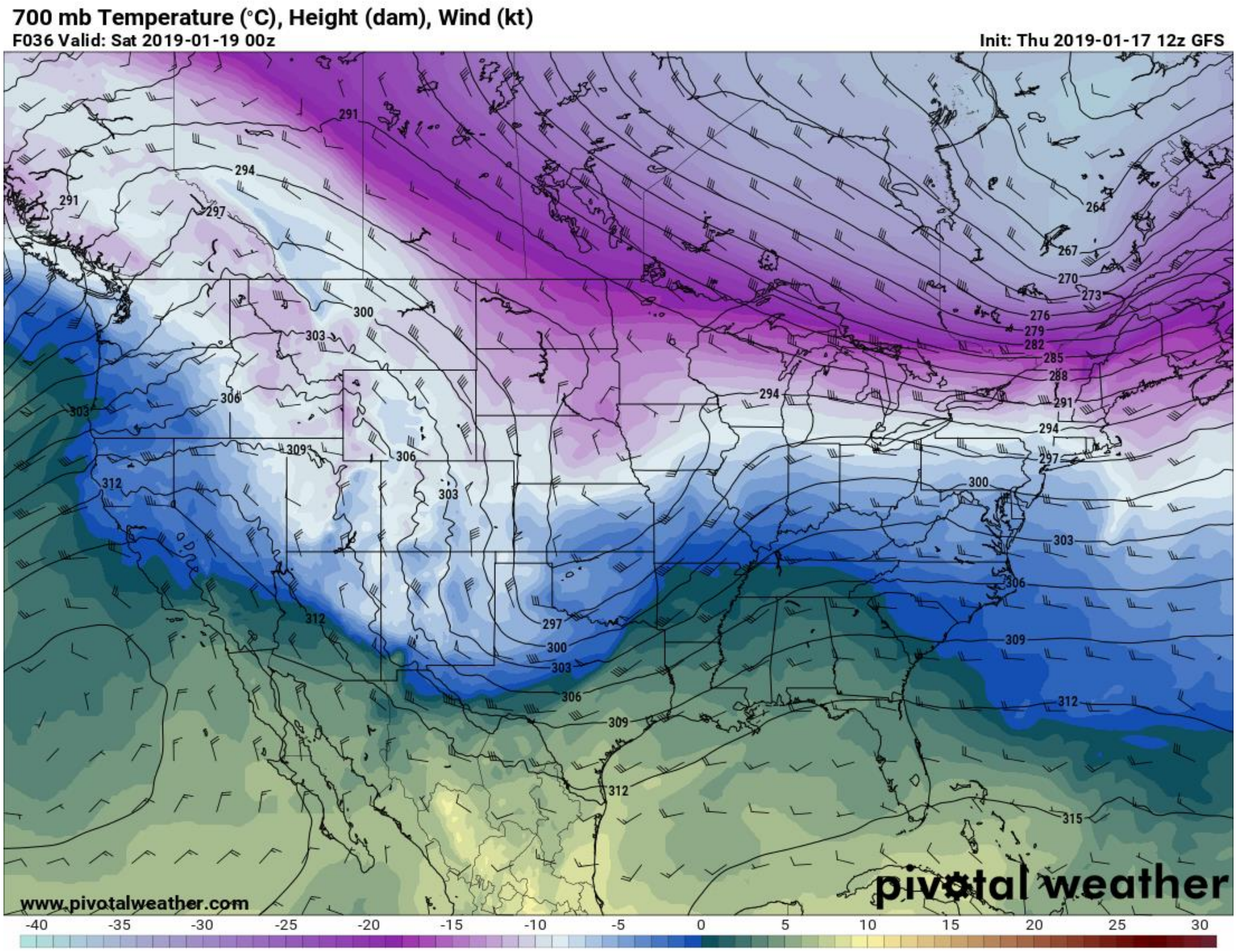

Figure 1. 700 hPa temperature (°C, shaded every 1°C per the color bar at bottom), wind (half-barb = 5 kt, barb = 10 kt, pennant = 50 kt), and geopotential height (m, contoured every 3 dam) from the 1200 UTC 17 January 2019 GFS forecast valid at 0000 UTC 19 January 2019 (f036).

There is strong 700 hPa warm-air advection at this time near the Pacific Northwest coast. However, warm-air advection alone does not produce frontogenesis. Southwesterly wind prevails across this region but becomes much smaller in magnitude as you approach and cross the coastline from the southwest. Thus, there is strong speed convergence, contributing to strong frontogenesis. This is depicted in Fig. 2 below.

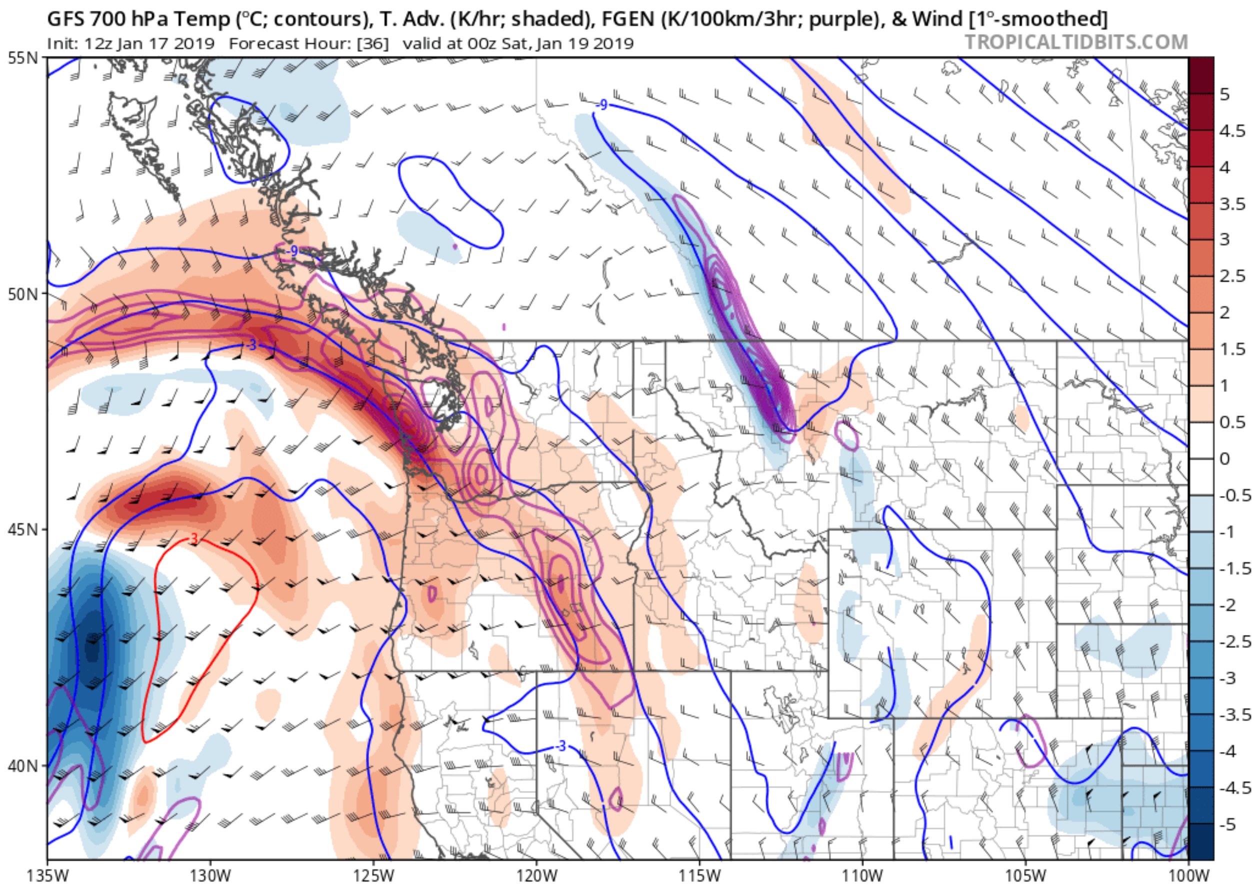

Figure 2. 700 hPa temperature (°C, blue contours every 3°C), wind (half-barb = 5 kt, barb = 10 kt, pennant = 50 kt), temperature advection (°C h^{-1}, shaded per the color bar at right), and frontogenesis (°C per 100 km per 3 h, purple contours) from the 1200 UTC 17 January 2019 GFS forecast valid at 0000 UTC 19 January 2019 (f036).

Over the Great Lakes, we see a complicated flow pattern, with a shortwave over the Missouri River valley to the west-southwest and a longwave trough over eastern Canada. Between the two features appears to be a deformation zone extending from southern Minnesota east to eastern Wisconsin. This deformation zone is aligned such that the axis of dilatation is nearly parallel to the isotherms. Thus, although deformation is weak, there is frontogenesis occurring in the western Great Lakes.

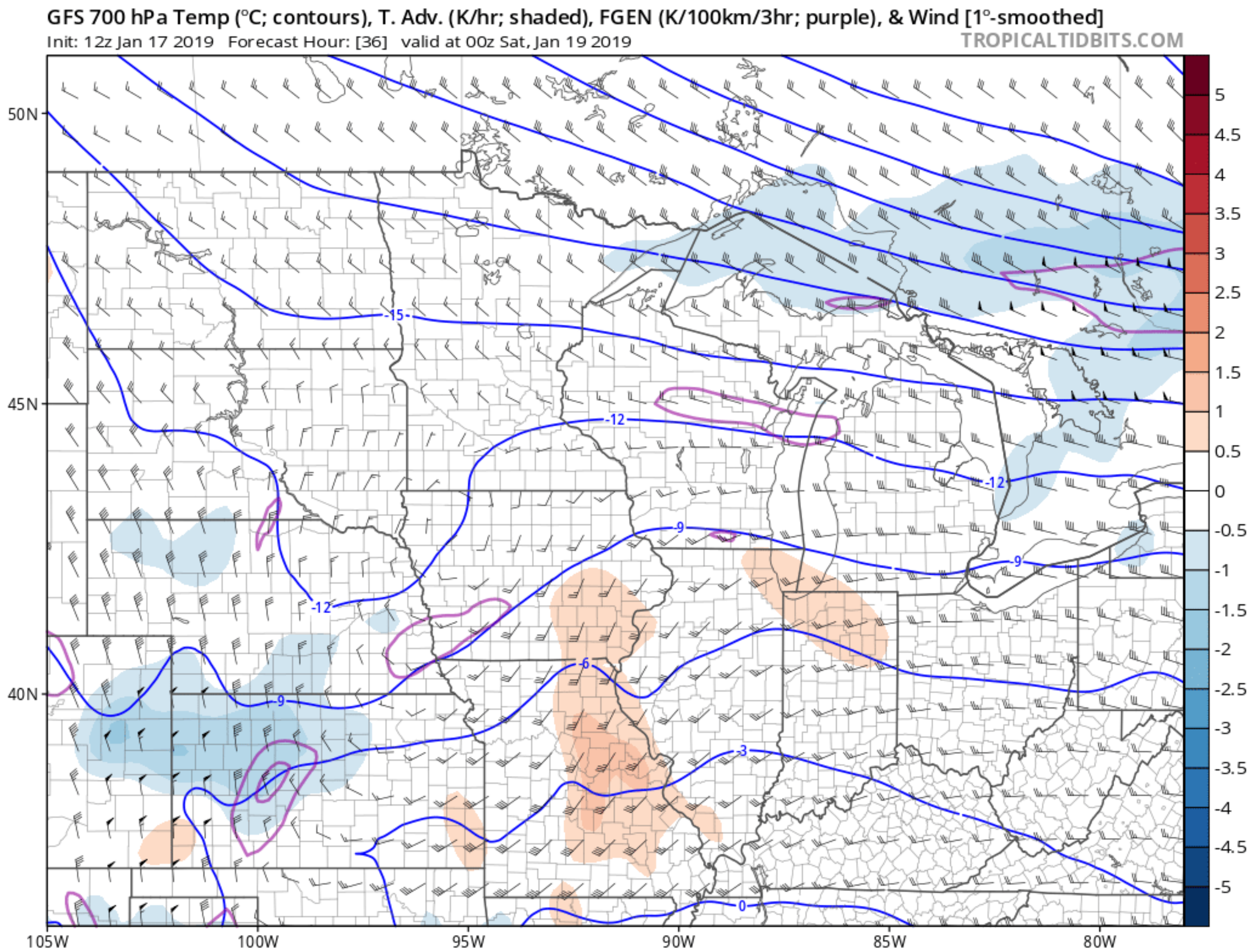

Figure 3. As in Fig. 2, except over the north-central United States.

Over the southern Great Plains, north-northwesterly flow turns cyclonically across the baroclinic zone draped across Texas. On the cold side of the baroclinic zone, flow is pointed toward the front; on the warm side of the baroclinic zone, flow is pointed along the front. Thus, the flow converges (or, perhaps more accurately, is confluent) along this baroclinic zone, resulting in frontogenesis.

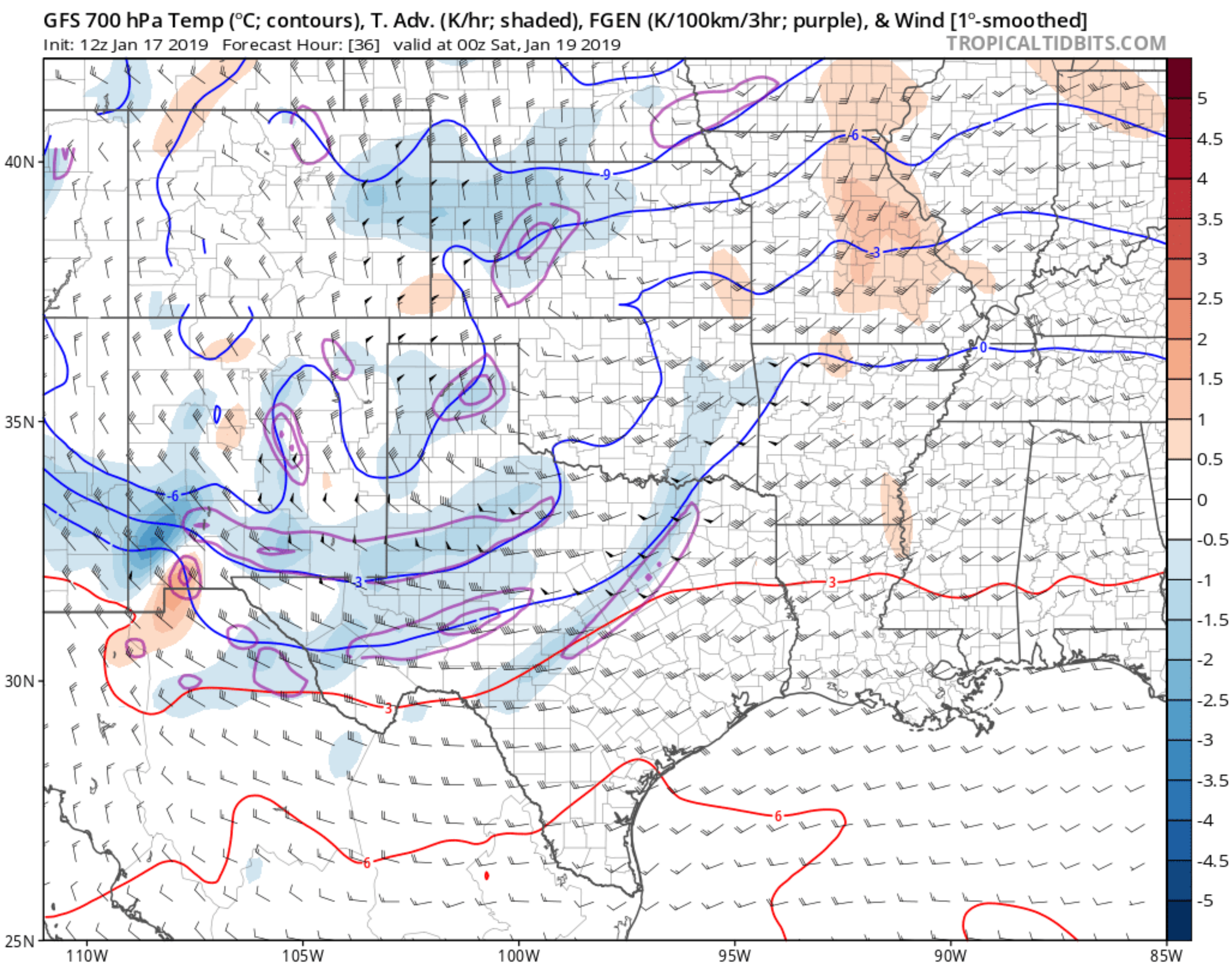

Figure 4. As in Fig. 2, except over the south-central United States.

Using Fig. 5 below, valid at 0600 UTC 20 January 2019 (or the 66-h forecast from the 1200 UTC 17 January 2019 GFS cycle), we will evaluate frontogenesis across the northeast United States.

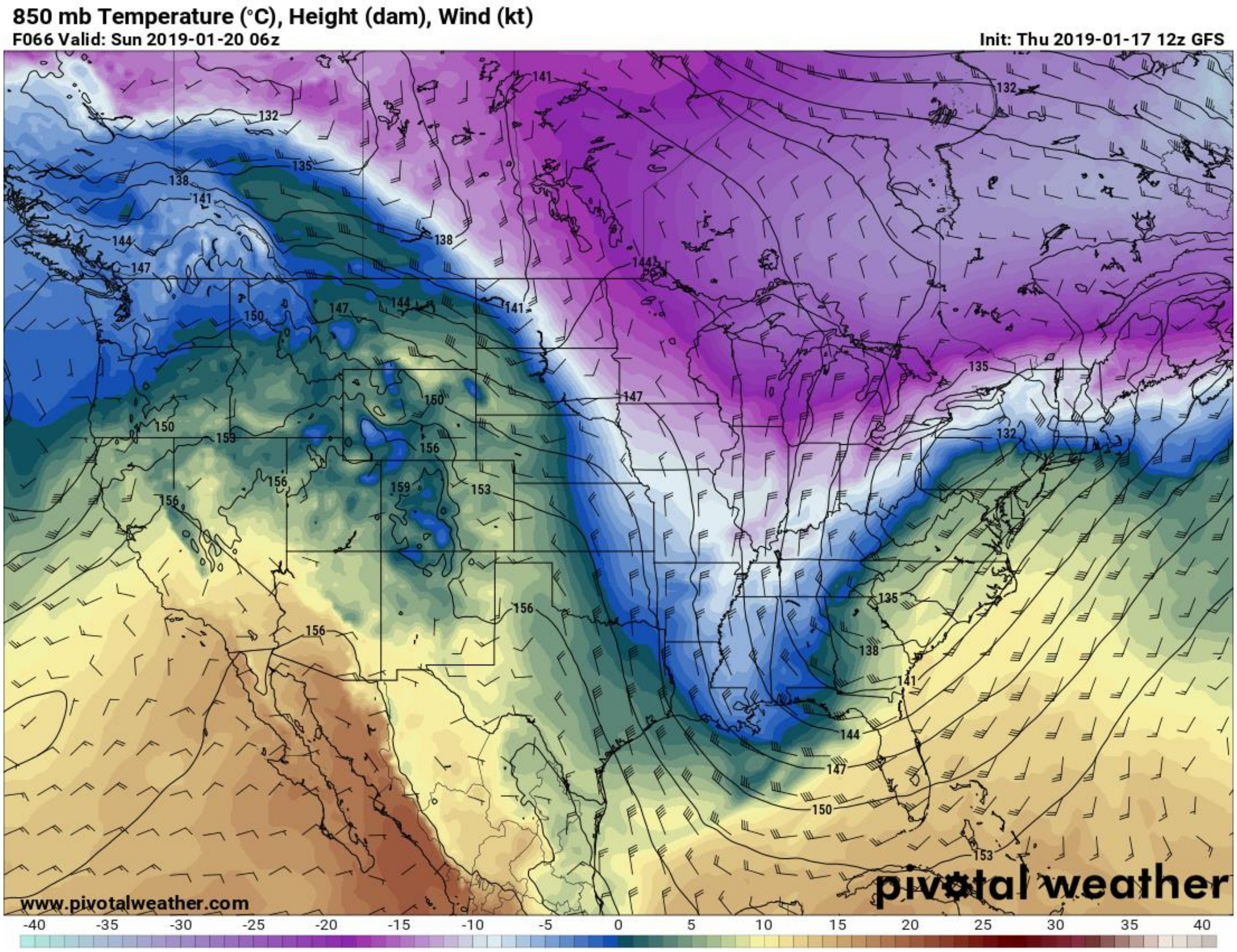

Figure 5. As in Fig. 1, except at 850 hPa and valid at 0600 UTC 20 January 2019.

Across the northeast United States at this time, we see a strong baroclinic zone draped east to west from the New York-Pennsylvania border eastward through southern New England to the western North Atlantic. On the warm side of this baroclinic zone, we see strong southwesterly flow of 50-65 kt. As in the first example, this example is also associated with strong warm-air advection. This flow becomes southeasterly, then southerly, across this baroclinic zone. Notably, the magnitude of this flow weakens substantially as it does so: to 10-20 kt at the Canadian border. In this case, we have a strong baroclinic zone (large temperature gradient) with strong convergence, resulting in strong frontogenesis.

Further to the north, in southern Quebec, the flow is deformative, with an axis of dilatation nearly parallel to the isotherms. This results in frontogenesis here as well, with a different forcing from that to the south. The frontogenesis chart below highlights this well.

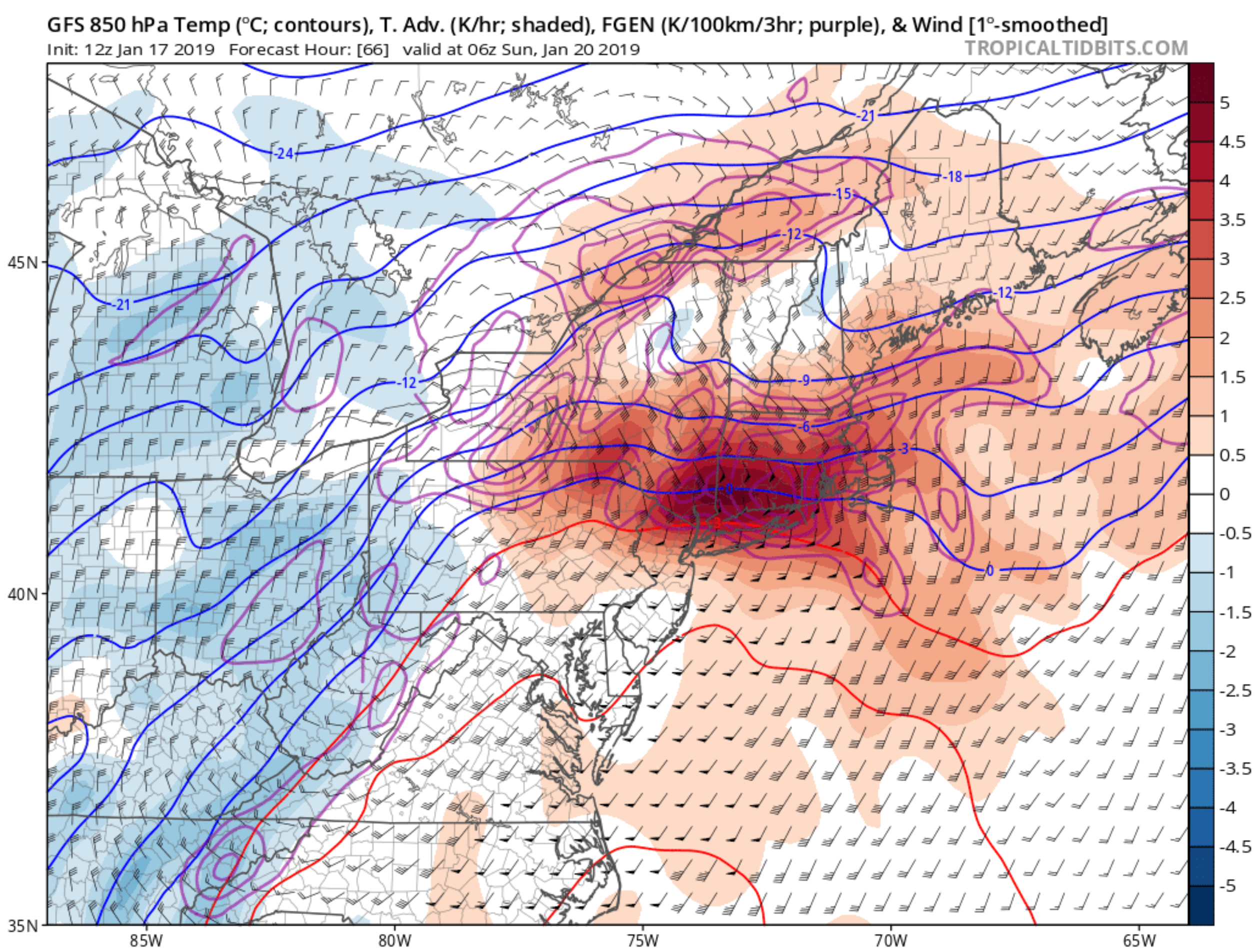

Figure 6. As in Fig. 2, except at 850 hPa and valid at 0600 UTC 20 January 2019 over the northeast United States.