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THE MAP ROOM

THE IMPACT OF A SPLIT-FRONT RAINBAND ON APPALACHIAN COLD-AIR DAMMING EROSION

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A split cold front is a cold front in the midtroposphere—usually centered near the 700-hPa level—that is located at least 200 km ahead of the surface cold front, creating a forward-tipped cold front structure. This structure has been shown to favor the development of convective precipitation along the upper-level cold front due to a thermally direct frontogenetical circulation that can provide the trigger for convective initiation. The split front is usually marked by a rapid decrease in moisture aloft during its passage, more so than temperature, so quantities such as 700-hPa equivalent-potential temperature (θ_e) or wetbulb potential temperature (θ_w) are best to use for identification of a split front. Due to the drier air and quasigeostrophic descent induced by cold advection aloft behind the split front, the eventual passage of the surface cold front is often dry in these situations. Therefore, the distribution of precipitation associated with a split front system or cold front aloft may differ significantly from that of the traditional Norwegian cyclone model, where precipitation would be concentrated along the surface cold front.

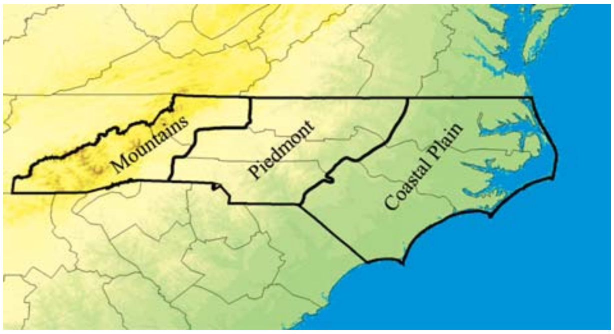

FIG. 1. Geographic features of North Carolina and surrounding areas.

The erosion of Appalachian cold-air damming (CAD) is a major concern for forecasters in the Carolinas and Virginia. Operational forecast models have been shown to erode the sensible weather effects of CAD too quickly, and this remains a problem faced by operational forecasters today. The presence of precipitation has traditionally been associated with the strengthening or initiation of a CAD event through evaporational cooling when precipitation falls into subsaturated air near the surface. However, in situations where the CAD airmass is already saturated when the rainband arrives, latent heat release (LHR) aloft is the dominant diabatic process. In *Weather and Forecasting* (**16,** pp. 35–56), one of us (Steven Koch) hypothesized that in such a case, focused LHR over the cold dome could lead to CAD erosion through hydrostatic pressure falls at the surface and a rapid inland movement of the coastal front, which marks the eastern boundary of the CAD airmass. The discussion of the following case will illustrate how precipitation-induced LHR associated with a split cold front interacted with a CAD event and a coastal front.

On 14 February 2000, a convective rainband associated with a split cold front moved over the central and southern Appalachian Mountains to the Atlantic Coast by 1200 UTC. As this rainband crossed the

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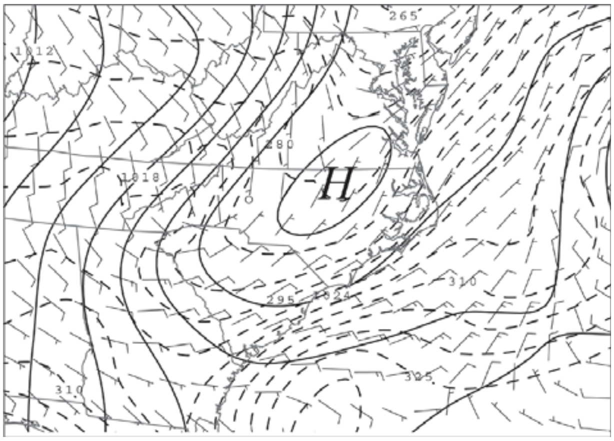

Fig. 2. Eta model analysis of sea level pressure (solid contours every 2 hPa) and 2-m equivalent potential temperature (dashed contours every 5 K), and 10-m wind (barbs, kt) valid at 1200 UTC 13 Feb 2000.

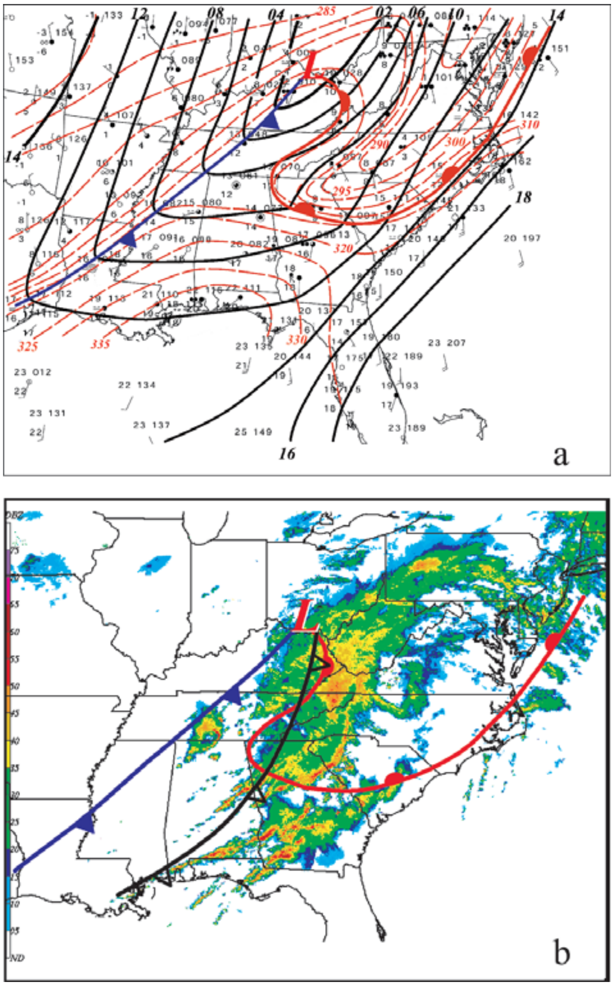

Fig. 3. (a) Manual surface analysis valid at 0600 UTC 14 Feb 2000. Isobars are thick solid-black contours every 2 hPa; thin red dashed lines are equivalent potential temperature every 5 K. Station reports and surface features are indicated by standard convention, with numerous reports omitted from the figure to make those shown legible. (b) Analyzed surface features and split front at 700 hPa (cold front with open barbs) overlaid with a mosaic of radar base reflectivity at 0600 UTC 14 Feb.

Carolinas and Virginia, a strong CAD event eroded in association with the rapid inland movement of a coastal front to the western Piedmont (Fig. 1). Surface temperatures rose 4°–7°C from east to west overnight as the coastal front moved westward through central North Carolina.

A strong CAD event was already underway across the Carolinas and Virginia by 1200 UTC 13 February 2000 (date and time will hereafter be referenced as DD/HH, e.g. 13/12 is 1200 UTC 13 Feb.), with analysis from the National Centers for Environmental Prediction (NCEP) Eta model showing a 1026-hPa high centered over northern North Carolina (Fig. 2). The characteristic "U-shaped" pressure ridge extends southward east of the Appalachians with cold advection produced by northeasterly surface flow extending through South Carolina. At 14/06, surface analysis shows a cyclone centered over the Ohio–Kentucky border with a cold front trailing southwest from the low center to southeast Texas (Fig. 3a). A warm front to the west of the Appalachians has pushed north into southeast Kentucky, but sags southward around the southern end of the Appalachian Mountain chain to the East Coast, marking the southern and eastern boundary of the residual CAD airmass as a coastal front. A large convective rainband extends from West Virginia southwest to the Gulf Coast at this time, well ahead of the surface cold front and closely aligned with the split front at 700 hPa (Fig. 3b). Data from the Eta model 6-h forecast valid at 14/06 shows a well-defined 700-hPa cold front in the θ_e field. Strong negative θ_e advection in the midlevels behind the split front is evident in the cross section from Amarillo, Texas, to east of Wilmington, North Carolina, as well as behind the surface cold front several hundred kilometers to the west (Fig. 4). At this same time, an objective analysis of surface observations shows that sea level pressure falls of 3–6 hPa (3 h)$^{-1}$ were occurring from south-central South Carolina to Virginia ahead of the split front (Fig. 5). These pressure falls induced an easterly or southeasterly isallobaric wind across the central and eastern Carolinas, west of the coastal front location.

By 14/12, surface analysis indicates that the coastal front had moved well inland, stretching from western

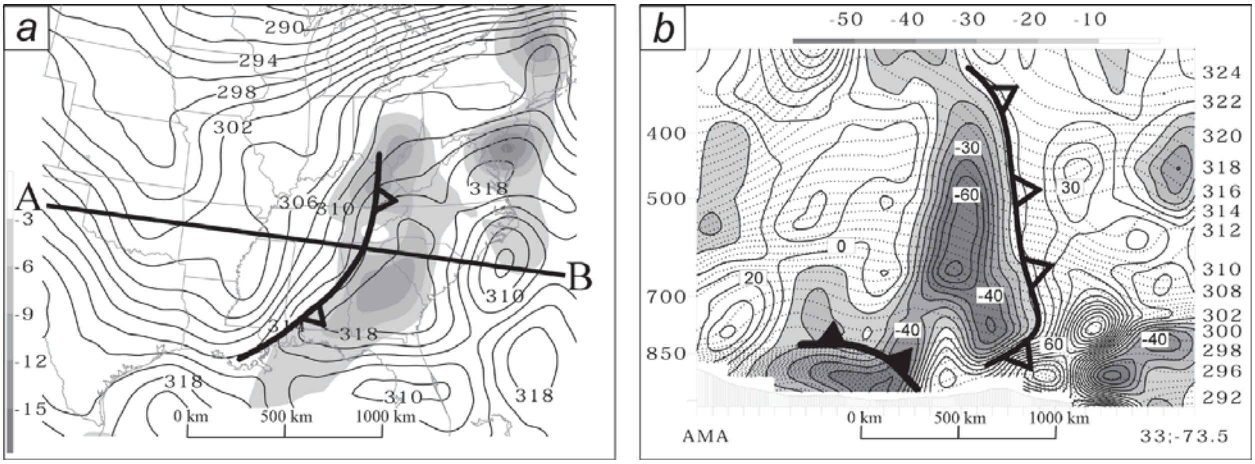

FIG. 4. (a) Eta model 6-h forecast of 700-hPa equivalent potential temperature (contoured every 2 K) and vertical velocity (μb s^{-1}, upward motion greater than 3 μb s^{-1} shaded) valid at 0600 UTC 14 Feb. (b) Eta model forecast advection of equivalent potential temperature (negative advection greater than 10 K day^{-1} shaded) and potential temperature (dotted lines every 1 K) valid at 0600 UTC 14 Feb. The line A–B in (a) depicts the cross section shown in (b).

South Carolina to central Virginia, as the rainband had moved to the coast with the split front, and the surface cold front was still west of the mountains (Fig. 6). Latent heat calculations from the Eta model forecast grids according to the methodology described in Emanuel et al. (1987) showed significant latent heat was released over the cold dome between 14/06 and 14/12. The level of maximum LHR was near 500 hPa at 14/06, which would lead to hydrostatic pressure falls at the surface and height rises above the level of maximum LHR (not shown).

To further quantify the impact of LHR on the CAD

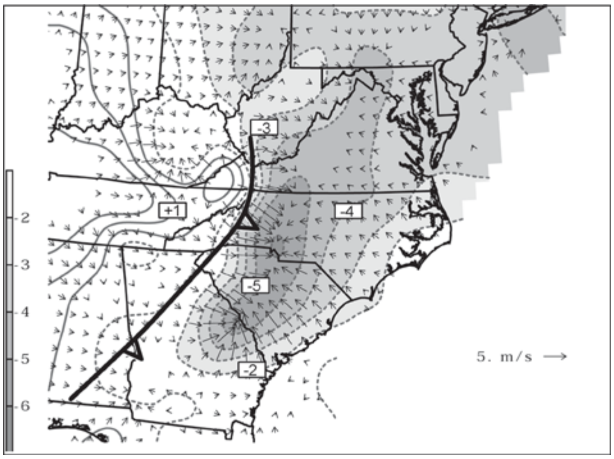

FIG. 5. Objective analysis of 3-h sea level pressure tendency (1-hPa contours, falls greater than 2 hPa shaded) and isallobaric wind with analyzed 700-hPa front position valid at 0600 UTC 14 Feb.

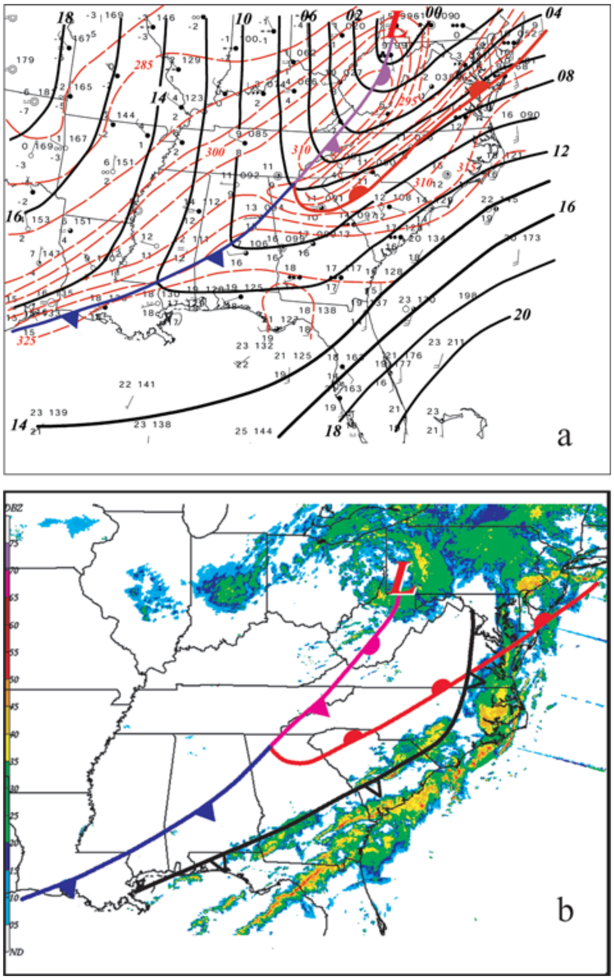

FIG. 6. As in Fig. 3, except for 1200 UTC 14 Feb.

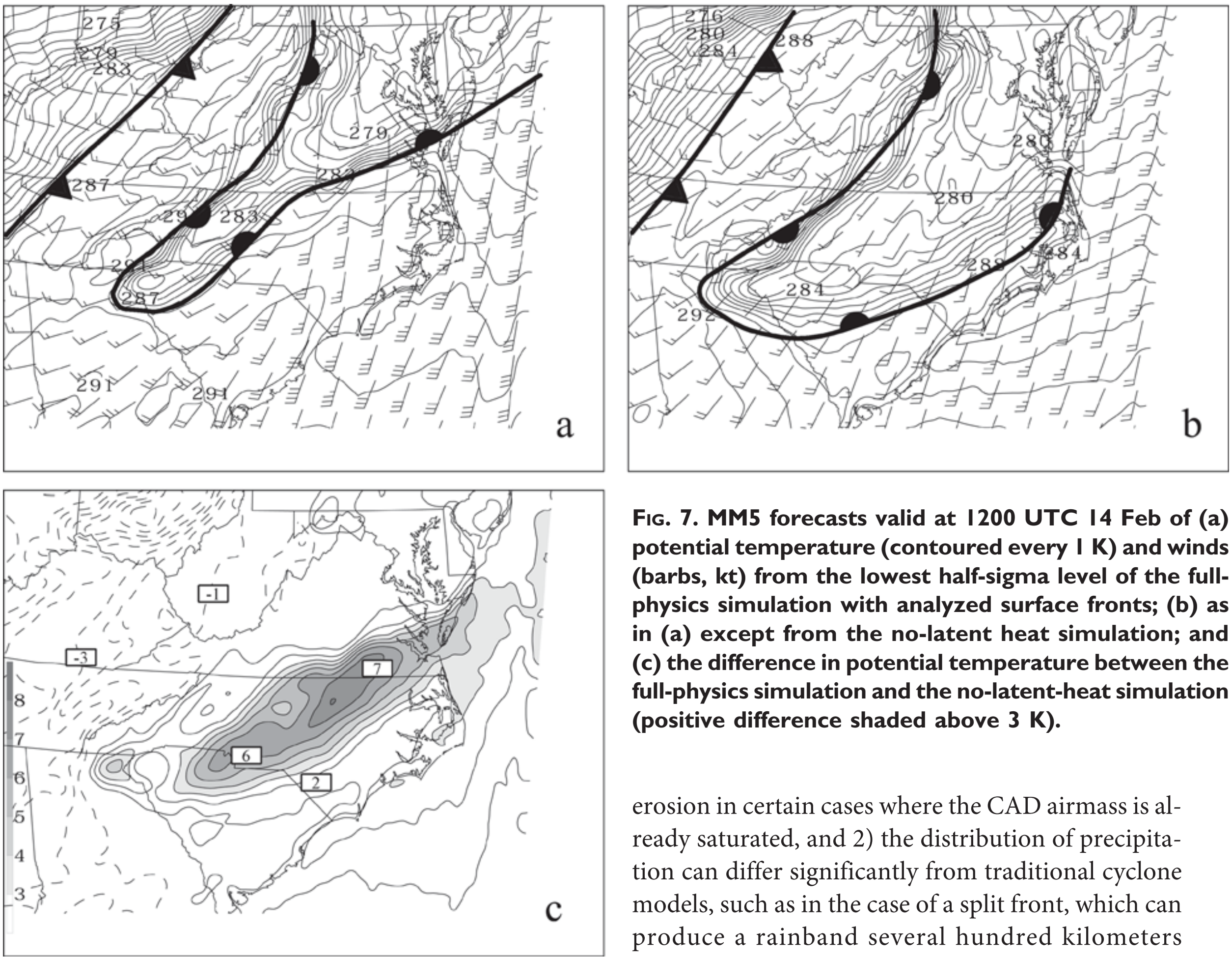

Fig. 7. MM5 forecasts valid at 1200 UTC 14 Feb of (a) potential temperature (contoured every 1 K) and winds (barbs, kt) from the lowest half-sigma level of the full-physics simulation with analyzed surface fronts; (b) as in (a) except from the no-latent heat simulation; and (c) the difference in potential temperature between the full-physics simulation and the no-latent-heat simulation (positive difference shaded above 3 K).

erosion, a sensitivity test was performed using the MM5 mesoscale model. The effects of LHR were withheld in the model's explicit precipitation and cumulus parameterization schemes, and the output was compared to a control simulation with full model physics. At 14/12, a comparison of the simulations shows that the control simulation has pushed the coastal front well inland, in agreement with observations, while the simulation without latent heating shows the cold dome largely intact, with the coastal front extending from central South Carolina to northeastern North Carolina (Fig. 7a,b). Surface potential temperatures in the control simulation are up to 7 K warmer in North Carolina when compared to the no-LHR simulation (Fig. 7c). For further details and analysis of this case, see our article last year in *Weather and Forecasting* (pp. 712–731).

The two main operational points from this case are: 1) during a CAD event, precipitation cannot only act to enhance CAD, but appears to contribute to its erosion in certain cases where the CAD airmass is already saturated, and 2) the distribution of precipitation can differ significantly from traditional cyclone models, such as in the case of a split front, which can produce a rainband several hundred kilometers ahead of the surface cold front and lead to a dry surface frontal passage.

FOR FURTHER READING

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