Evolution of an Intense Warm Frontal Precipitation Band During the GPM Cold-Season Precipitation Experiment (GCPEx)

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Over the GCPEX study domain (Fig. 1) on 18 February 2012 a warm frontal precipitation band rapidly evolved from genesis, maturity, and decay from 0730 UTC to 1334 UTC 18 February 2012 (Fig. 2).

Narrow and intense bands have been well documented for cold fronts, but not for warm fronts. The conceptual model of a warm frontal band is fairly broad (~50 km wide), with a strong connection to generating cells aloft.

Questions:
What processes led to the rapid intensification and subsequent weakening of the warm frontal precipitation band?
What is the role of latent heating and cooling on the band evolution?
How did the ice and water amounts change within the band as it evolved?
How well can a mesoscale model predict this warm frontal band evolution?

Model Setup and Configuration

- The Advanced Research WRF (Weather Research and Forecasting; Skamarock et al. 2008) model version 3.5.1 was used for a 30-h run with a triple-nested grid configuration at 9-, 3-, and 1-km horizontal grid spacing (Fig. 3).
- Forecasts were initialized at 1800 UTC 17 February 2012 using initial and lateral boundary conditions from 6-hourly 13-km isotropic RUC analyses.
- All ice-phase particles in the P3 scheme are represented by four mixing ratio variables (total mass, rime mass, rime volume, and number) that freely evolve in time and space.

Microphysical Evolution

- At 1142 UTC, the ZDRs are near zero or slightly positive within the band, and the correlation coefficients are relatively high (~0.89, not shown), suggesting horizontally falling snow crystal and aggregates. The ZDRs are more negative to the south of the band and at ~1.25°C, indicative of graupel (Fig. 7).
- Aggregates of unimodal snow occurred within the band during early maturity, while more supercooled water and graupel occurred as the upward motion increased due to the frontogenetical circulation (Fig. 8-9).

Warm Frontal Band Development

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Summary

The band developed with low-level deformation and frontogenesis along the sloping warm frontal zone, and the vertical motions became large enough to produce graupel on the south side of the band. Embedded convective cells developed earlier in our GCPEX event, but the frontogenesis was weak then and banding was limited. As the deformation increased the stability also increased near the banding location (MMPx*1), which favored the development of single band. Through sensitivity studies (not shown) we found that latent heating helps increase the frontal circulations and resulting band development. Latent cooling also helps increase the frontogenesis giving the evaporative and sublimation cooling within the frontal precipitation.

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