Structural Evolution of a Warm Frontal Precipitation Band During GCPEX

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Previous Warm Frontal Band Studies

Instability/generating cells aloft

Low-level deformation/frontogenesis

Hobbs 1978 and Matejka et al. (1980)

Banacos (2003)

Browning (1986)
Global Precipitation Mission (GPM) Cold-season Precipitation Experiment (GCPEx 1/15/2012 - 2/29/2012)
Motivation:
• There has been limited analysis of warm frontal precipitation bands.
• What processes led to the rapid spinup and evolution of the intense band? (See A.Naeger talk 10.6 for microphysical details)
### NASA-Unified-WRF configuration

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<td>Cumulus scheme</td>
<td>Grell-Freitas, Turned off, Turned off</td>
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1200 UTC 18 February 2012

700 hPa Analysis

WPC Surface Analysis
Figure 1. (left) WRF model domains and the GCPEX field location site (red dot). (right) 11-h WRF forecast (at 1100 UTC 18 February 2012) showing SLP (every 2hPa), surface temperature (shaded) and surface winds (full barb = 10 kts).

Obs 0700 UTC -- Genesis
Obs 0900 UTC -- Genesis P2
Obs 1100 UTC -- Mature

WRF: surface winds; 2-m Temp (red)
3-km WRF cross section: dBZ, circulation vectors, and Miller 2-D frontogenesis – red)
Precipitation band over D3R Dual Pol radar at 1200 UTC 18 Feb

Cloud top generating cells – similar to Plummer et al. (2015)
CARE site

WRF Profiles Within Band

$\theta_E$ and $\theta_E^*$

RH wrt water and ice

Aircraft sounding via a spiral at 1130 UTC

Moist neutral near cloud top

Theta and $\theta_E^*$

Relative Humidity (%)
WRF (Genesis Stage)
0700 UTC 18 Feb

WRF cross section: dBZ, circulation vectors, theta, and Miller 2-D frontogenesis, top - red)

WRF cross section: MPV* shaded, horiz winds, and thetaE*
WRF Profile Just South of Band

\[ \theta_e \text{ Saturation } \theta_e \text{ (K)} \]

\text{thetaE and thetaE*}

WRF Profile Within Band

\[ \theta_e \text{ Saturation } \theta_e \text{ (K)} \]

Weak CI

Weak PI

RH wrt water and ice
WRF (Genesis Stage P2)
0900 UTC 18 Feb

WRF cross section: dBZ, circulation vectors, theta, and Miller 2-D frontogenesis, top - red)

WRF cross section: MPV* shaded, horiz winds, and thetaE*
WRF (Mature Stage)  
1200 UTC 18 Feb  
WRF cross section: dBZ, circulation vectors, theta, and Miller 2-D frontogenesis, top - red)

WRF cross section: MPV* shaded, horiz winds, and thetaE*
Decay Stage

Frontogenesis/deformation weakens, and less instability towards band
Summary

- A warm frontal precipitation band developed over a few hours 50-100 km to the north of a surface warm front. The 3-km WRF was able to realistically simulate band development, although the model is somewhat too weak.

- Band genesis was associated with weak frontogenesis (deformation) in the presence of weak potential and conditional instability feeding into the band region, while it was closer to moist neutral within the band.

- As the band matured, frontogenesis increased, while the stability gradually increased in the banding region. Cloud top generating cells were prevalent, but not in WRF (too stable).

- The band decayed as the stability increased upstream and the frontogenesis (deformation) with the warm front weakened.

- The WRF may have been too weak and short-lived with the band because too stable and forcing too weak (some micro issues as well).