Characteristics and Origins of Frontal Convection During the IMPACTS 25 January 2020 Case

G. Heymsfield[1], C. Helms[1,2], S. Guimond[1,3], A. Heymsfield[4], and A. Bansemer[4]
NASA-Goddard Space Flight Center[1], NPP Postdoctoral Fellow[2], UMBC/JCET[3],NCAR[4]

Objectives

- A warm-occlusion frontal system moved across the Northeast U.S. on 25 January bringing widespread clouds and precipitation across the region. Precipitation was primarily rain in most areas with embedded convection and some freezing rain/snow in higher terrain in the northern regions.
- Characterize the elevated convection on 25 January 2020.

- Focus on two flight lines:
  - Strong convective cell during early part of flight over warm front with rain at the surface and over ocean
  - High-reflectivity feature aloft over land above warm occlusion.

Datasets

ER-2 Radars
- Ka-band – HIWRAP (35.5 GHz)
- Ku-band – HIWRAP (13.6 GHz)
- W-band – CRS (94 GHz)
- X-band – EXRAD (9.4 GHz)

P-3 Observations
- Flight level data including TAMMS and WISPER
- Probe data
- Dropsondes

Surface and upper air observations
- Buoy data

Methods

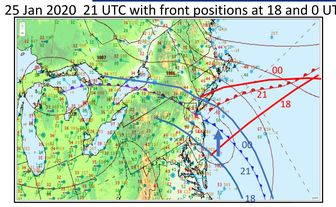
Vertical motion and horizontal winds

Vertical motions
- BB detection and Hydrometeor ID
- Fallspeed estimation based on rain, snow, graupel, etc. (Heymsfield et al. 2009)
- Profile adjustment for mass continuity

VAD analysis (Helms et al, 2020)
Dual Doppler (Heymsfield et al. 1999)

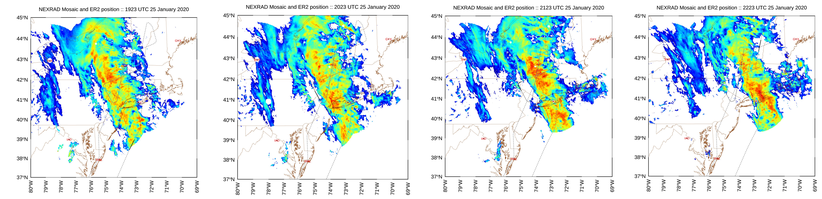
Flight Background

25 Jan 2020 21 UTC with front positions at 18 and 0 UTC

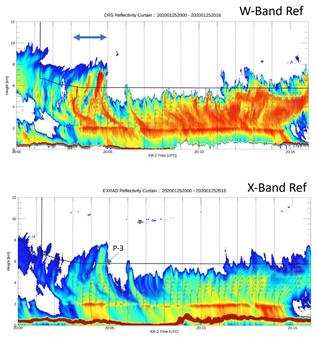


Warm occlusion over land with low along coast and warm front over ocean.
System advanced northward during aircraft flights - main rainband associated with this flight advanced similarly.
Early part of flight encountered strong convection over data sparse ocean region where two dropsondes were launched.

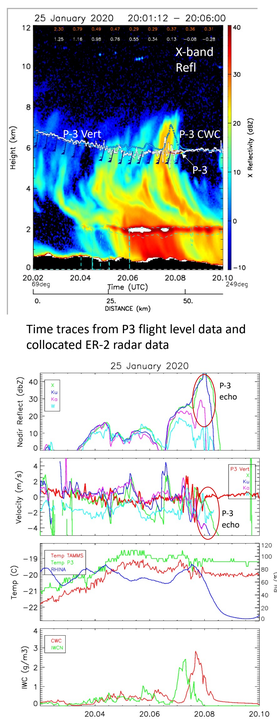
88D Composite from 19:23-22:23 during ER-2/P-3 flights



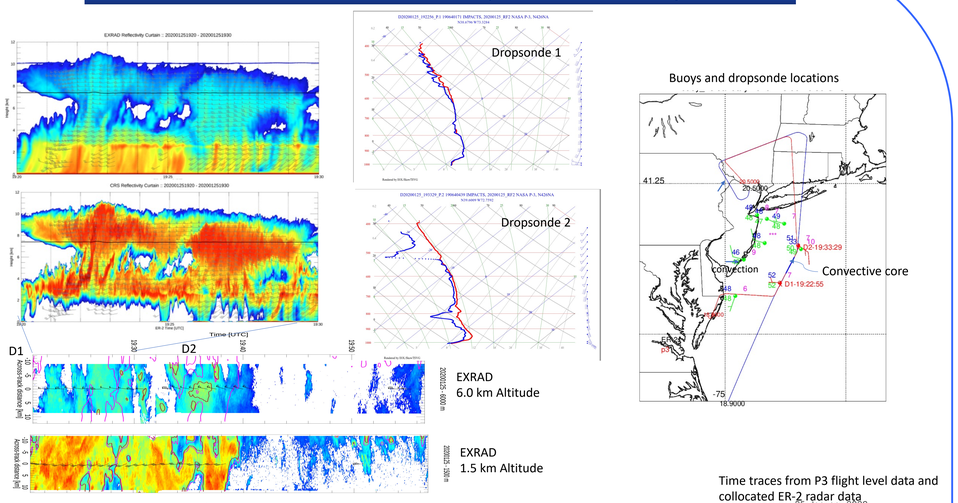
Elevated Convection (~20:00 UTC)



Time traces from P3 flight level data -> and collocated ER-2 radar data



Elevated Convection (~19:22 UTC)



Discussion of Figures

- Convection highlighted for two cases
- Case 1 [Right Panel]: Strong convection with base of convection rooted above warm front ~2 km altitude.
  - P-3 underpass of ER-2 at ~7.5 km altitude
  - Good correlation between P-3 measured updraft ~12 ms^{-1} updraft and that estimated from ER-2.
  - IWC ~1.5-2 gm^{-3} in core, ice particles (capped columns, minimal riming, etc.) were relatively small (few mm) with reflectivity ~15-20 dBZ at P-3 altitude.
- Case 2 [Left Panel]: Convection aloft above warm occlusion
  - Roots of convection appear to be high above 4 km
  - High reflectivity core (~20-25 dBZ at 6 km), updraft ~2-4 ms^{-1}, and large rimed ice (5 mm)

Summary & Future Work

- 25 January 2020 case has complex frontal structure with warm front over ocean and warm occlusion over land.
- Elevated convection over warm front has strong vertical motions for wintertime, but it is probably being fed by warm moist air that originated from the Gulf Stream.
- Strong generating cells over land were associated with the occlusion, and they contain relatively strong updrafts and relatively high reflectivities for generating cells.
- Future work: Continue on radar-derived structure of the examples shown and other flight lines on this day.