Poster #950

Elevated Convection in Snowstorms Using Aircraft and Remote Sensing Instruments During the IMPACTS Campaign

G. Heymsfield[1], C. Helms[1,2], M. McLinden[1], and S. Nicholls[1,3],
NASA-Goddard Space Flight Center[1], U. of MD/ESSIC[2], Science Systems and Applications, Inc.[3]

Objectives

- Characterize vertical motion, forcing, etc. for elevated convection (EC) on 25 January associated with a weak frontal system during early part of ER-2 flight over ocean
- Examine vertical velocities in generating cell/updraft regions
- Use gridded EXRAD scanning data to gain insights on distribution and magnitudes of convection off-nadir.
- Examine usefulness of cell motion estimation and vertical velocity estimation from scanning data.

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)
- Only EXRAD used in this presentation.

P-3 Observations

- Flight level data including TAMMS and WISPER
- Probe data
- Dropsondes

Surface, upper air, and buoy obs

All datasets available from: NASA EOSDIS Global Hydrology Resource Center DAAC http://dx.doi.org/10.5067/IMPACTS/DATA101

Methods

Horizontal winds:

- Comparison between HRRR, flight-level, VAD-derived, and dropsonde
- **VAD Wind Analysis** (Helms et al, 2020, Tian et al. 2015)

Vertical Velocity:

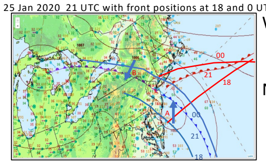
- Compared between flight-level, radar-derived, and dropsonde.
- BB detection and Hydrometeor ID
- Fallspeed estimation based on rain, snow, graupel, etc. (Heymsfield et al. 2009)
- Profile adjustment for mass continuity

3D winds:

- **Dual Doppler (Heymsfield et al. 1999) (not shown)**
- **3D Var (Guimond et al. 2016) (not shown.)**

Elevated Convection 25 January 2020

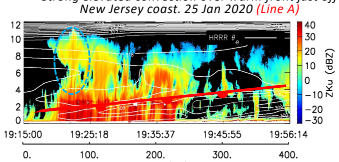
25 Jan 2020 21 UTC with front positions at 18 and 0 UTC



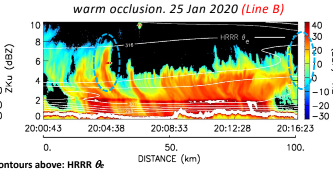
Warm occlusion over land with low along coast and warm front over ocean.

Northward movement of system from 18:00-00:00 UTC during aircraft flights - main rainband associated with this flight advanced similarly.

Strong elevated convection over warm front just off New Jersey coast. 25 Jan 2020 (Line A)

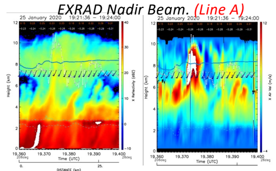


Elevated convection in New York State above warm occlusion. 25 Jan 2020 (Line B)



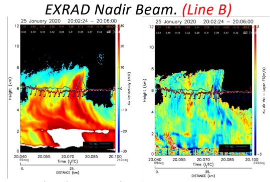
White contours above: HRRR θ_e

EXRAD Nadir Beam. (Line A)

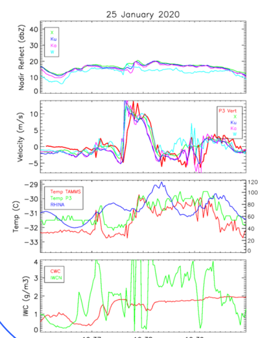


P-3 Altitude ~7.3 km, Temp ~ -30° C, IWC: 1.5 gm^{-3}

EXRAD Nadir Beam. (Line B)



P-3 Altitude ~5.8-6.1 km, Temp ~ -19° C, IWC: 2.8 gm^{-3}



P-3 insitu Compared with ER-2 EXRAD-derived Vertical Velocity for Line A

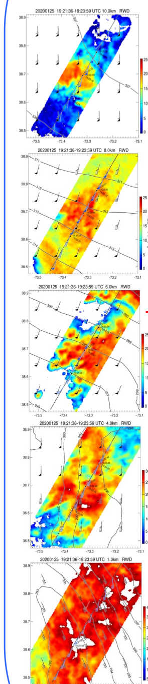
- P-3 underpass of ER-2 at ~7.4 km altitude
- Good correlation between P-3 measured updraft ~12 ms^{-1} updraft and that estimated from ER-2 at 4 frequencies.
- IWC ~1.5-2 gm^{-3} in core, ice particles (capped columns, minimal riming, etc.) were relatively small (few mm) with reflectivity ~15-20 dBZ at P-3 altitude.

Two Very Different Examples of Elevated Convection

- Convection highlighted for two cases
- Case A: Strong convection with base of convection rooted above warm front ~2 km altitude.
- Case B: 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)

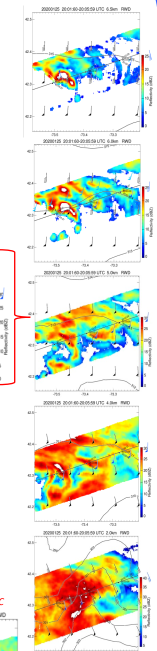
Cell Motion and Vertical Velocity from 3D Analysis

25 Jan 2020
19:21-19:24 UTC
Line A
Gridded EXRAD Data



- Left and Right Columns: *Reflectivity constant altitude plots derived from gridded EXRAD conical scan data for the RWD look. HRRR-derived θ_e contours and HRRR horizontal winds (black). Also winds from VAD analysis (blue barbs) and dropsonde (red barb) also shown.*

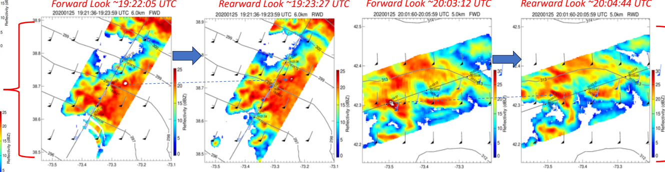
25 Jan 2020
20:02-20:06 UTC
Line B
Gridded EXRAD Data



Advection of Elevated Convection

- EXRAD's conical scanning data is partitioned into forward (FWD) and rearward (RWD) looks and then gridded (*panels below*).
- At any given 3D grid point, there is a time difference Δt ~90 seconds between the FWD and RWD looks.
- Reflectivity features advect with the horizontal winds during Δt providing an estimate of their speed and direction.
- Example of reflectivity tracked feature (black dashed): ~25 ms^{-1}
- Features generally advect with the environmental winds however stronger convective features are sometimes relatively stationary during Δt.

Forward Look ~19:22:05 UTC *Rearward Look ~19:23:27 UTC* *Forward Look ~20:03:12 UTC* *Rearward Look ~20:04:44 UTC*

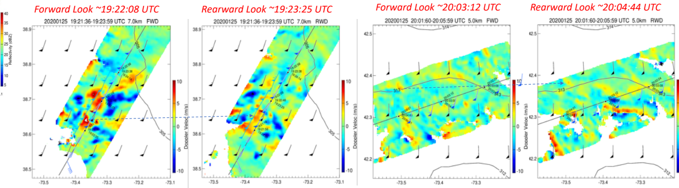


Barbs: HRRR Model (black), VAD-derived (blue), Dropsonde (red)

Vertical Motions Derived from Scanning Beam

- Vertical motion features are qualitatively derived from EXRAD scanning Doppler data.
- The VAD method is used to calculate the estimated winds & deformation for each 360° scan and for each range (Tian et al. 2015, Helms et al. 2020).
- The residual between the aircraft motion-corrected Doppler and the VAD profile provides an estimate of the vertical motion plus any variations of particle fall velocity over the scan circle.
- The residual is gridded (panels below) where red/blue shades are up/down motions.

Forward Look ~19:22:08 UTC *Rearward Look ~19:23:25 UTC* *Forward Look ~20:03:12 UTC* *Rearward Look ~20:04:44 UTC*



Barbs: HRRR Model (black), VAD-derived (blue), Dropsonde (red)

Summary & Future Work

- 25 January 2020 case has a variety of elevated convection (EC) events that that are often difficult to sample even with aircraft.
- Two EC examples shown initiate well above the boundary layer.
- EC cases presented have characteristics similar to previous studies of winter cyclones, but updrafts were significantly stronger and with significantly greater depth.
- EXRAD conical scan reflectivity and Doppler data were 3D gridded to provide additional information on distribution and structure of EC. EC features advect with environmental winds making them difficult to sample with only the nadir measurements. 3D gridded EXRAD data has highlighted some of these difficulties.
- Preliminary analysis from vertical velocity estimated from VAD analysis residuals have provided useful qualitative information but much more QC is required to eliminate bad data.

Acknowledgements: The authors would like to thank Peter Pantina/SSAI and Stacy Brodzik/U. Wash. for providing the interpolated HRRR analyses and NEXRAD mosaics, respectively. Lee Thornhill at NASA LaRC provided help with TAMMS data.