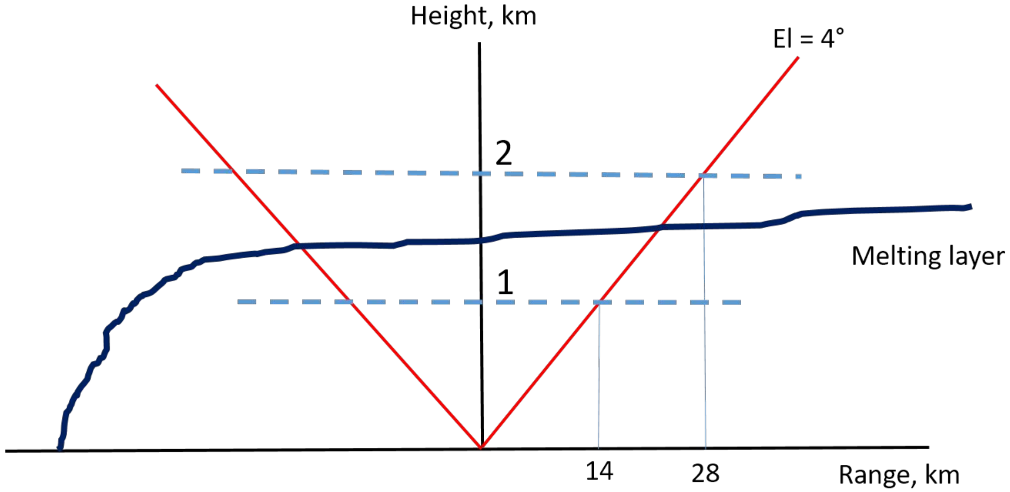
New Algorithm for Melting Layer Detection and Determination of its Height

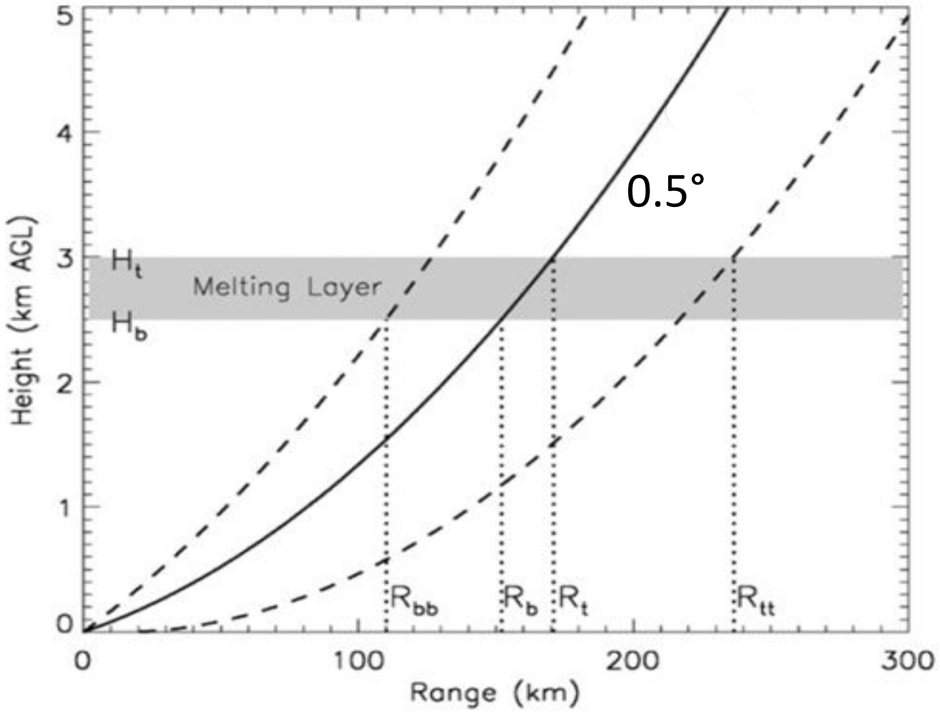
“New MLDA”

Alexander Ryzhkov, John Krause, and Heather Grams

TAC meeting, March 25, 2022

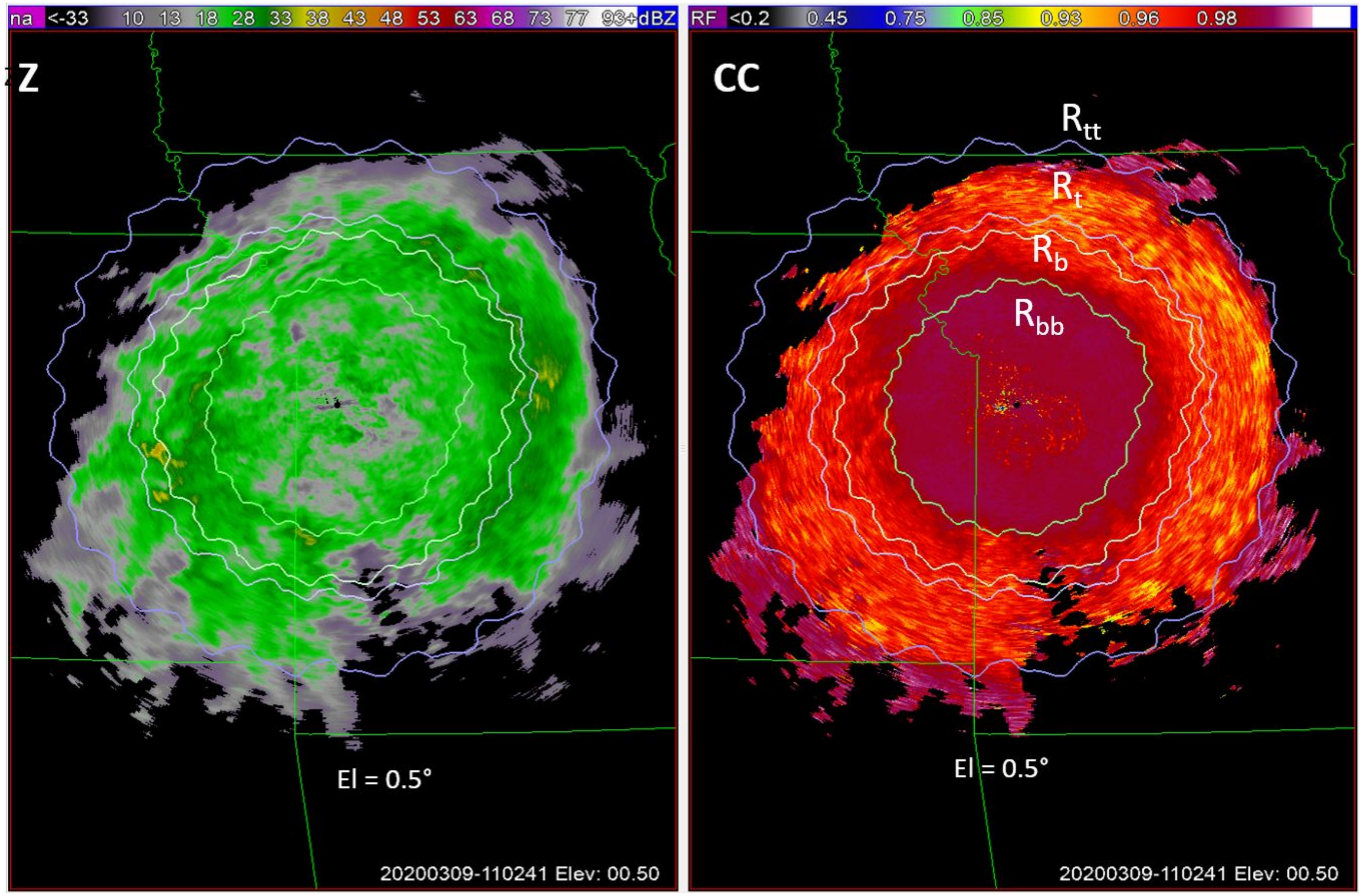
Problems with Existing MLDA





- It uses elevations exceeding 4°, therefore only the data from the close proximity to the radar are used for ML designation which is extrapolated to the whole field of view
- If the frontal boundary is far away from the radar, it is missed
- Existing MLDA estimates ranges Rbb, Rb, Rt, and Rtt at El = 0.5° and the corresponding quasi-circular contours are overlaid on the 0.5 elevation tilt
- *A map of real heights of the ML bottom and top is not generated*

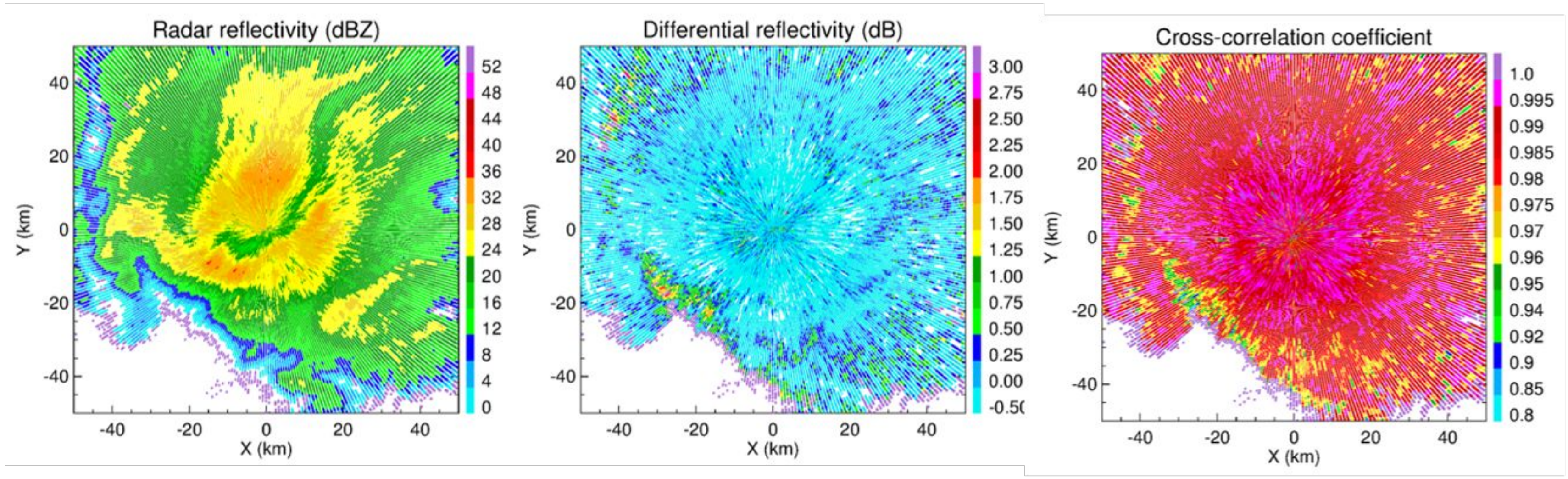
Example of existing MLDA output



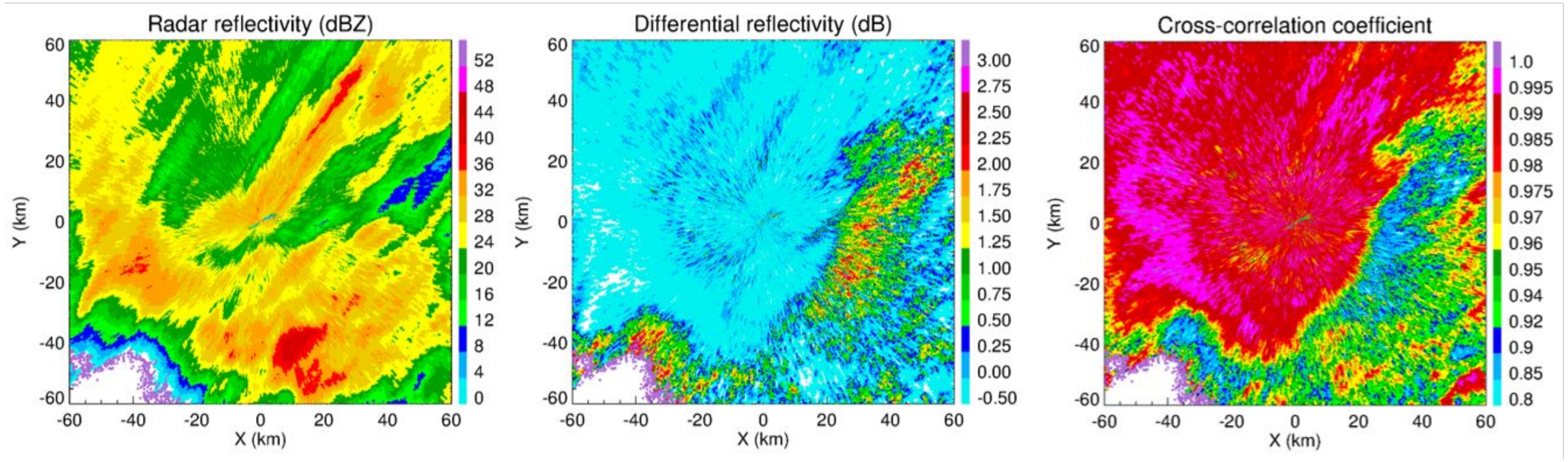
Contours of Rbb, Rb, Rt, and Rtt are overlaid on the maps of Z and CC at El = 0.5 deg

Some azimuthal modulation of the ML height is captured if it occurs in the close proximity to the radar

El = 4.0°



El = 1.3°



A frontal rain / snow boundary visible at El = 1.3° is missed at El = 4.0°

New MLDA concept

(1) A large number of radial profiles of CC for various intrinsic parameters of the ML (i.e., height of the ML bottom and the ML depth / strength) is generated for different elevations

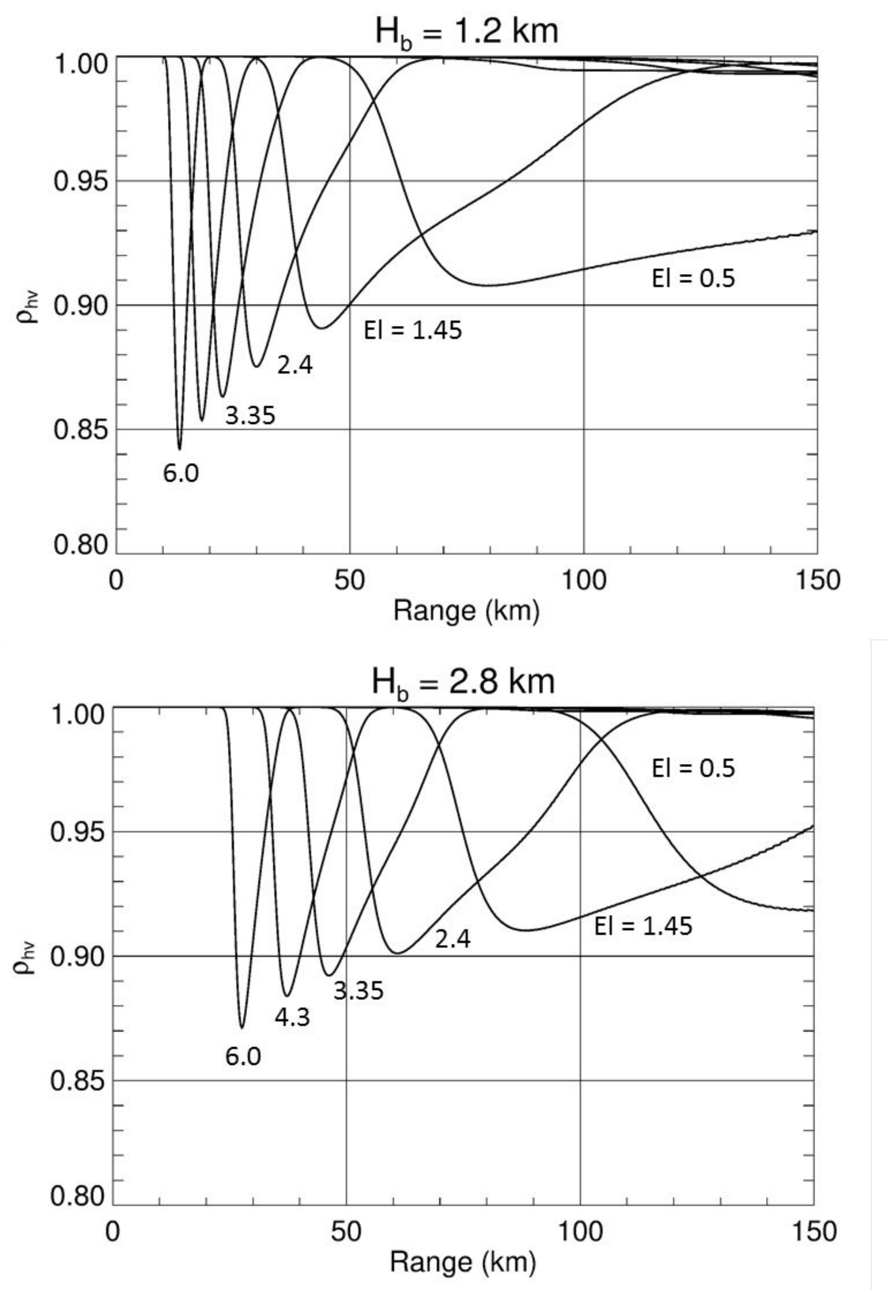
(2) The key parameters of the radial CC profiles such as the distance to the start of the CC dip and the depth / strength of the CC dip are stored in lookup tables for a multitude of ML heights, strengths, and antenna elevation angles

(3) The same parameters are estimated from the measured radial CC profiles

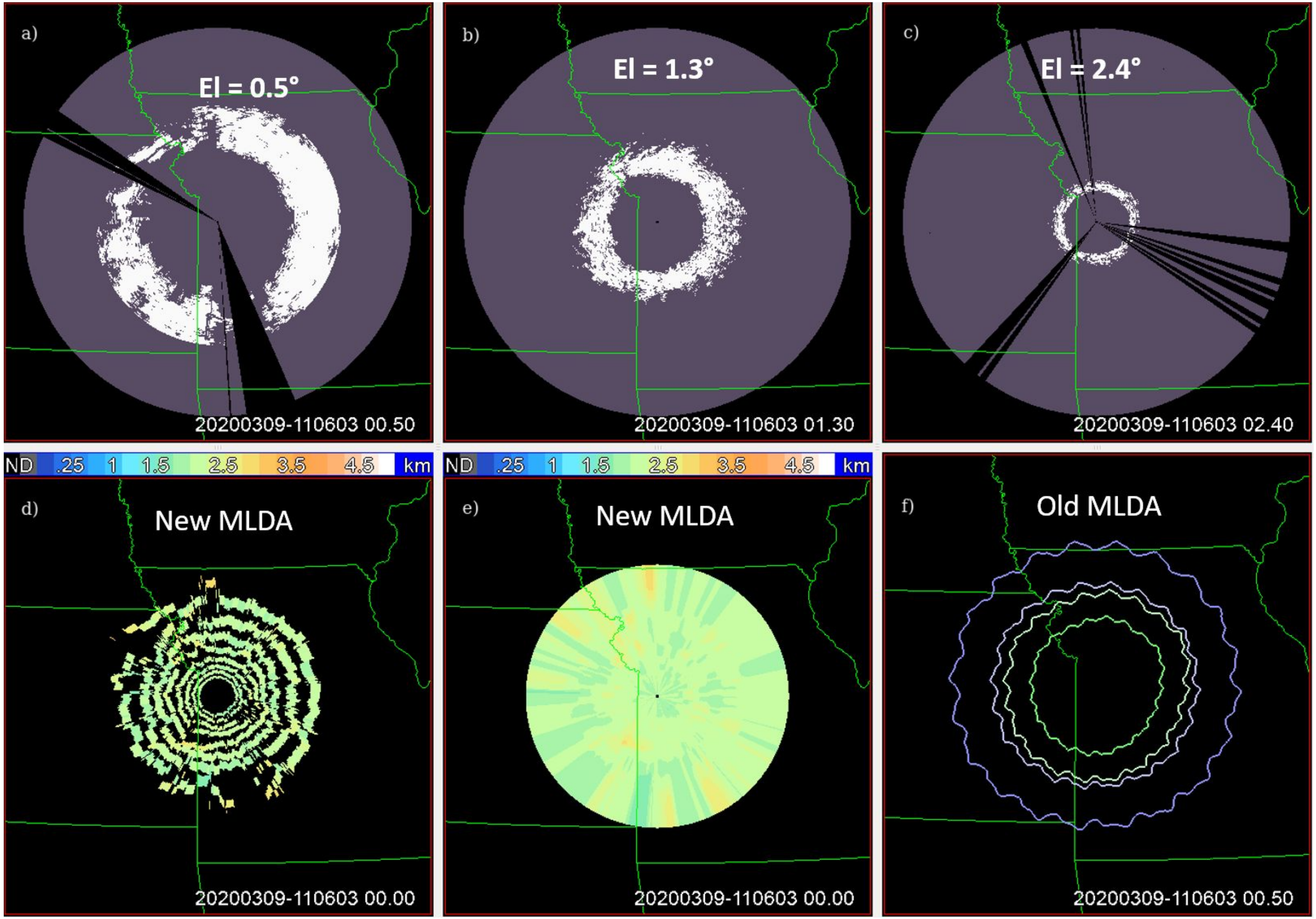
(4) The parameters of the measured CC profiles are compared to the model ones and the best match is identified from which the "true" heights of the ML bottom and top are determined

New MLDA utilizes the Z and CC data from ***all*** elevations including the lowest ones

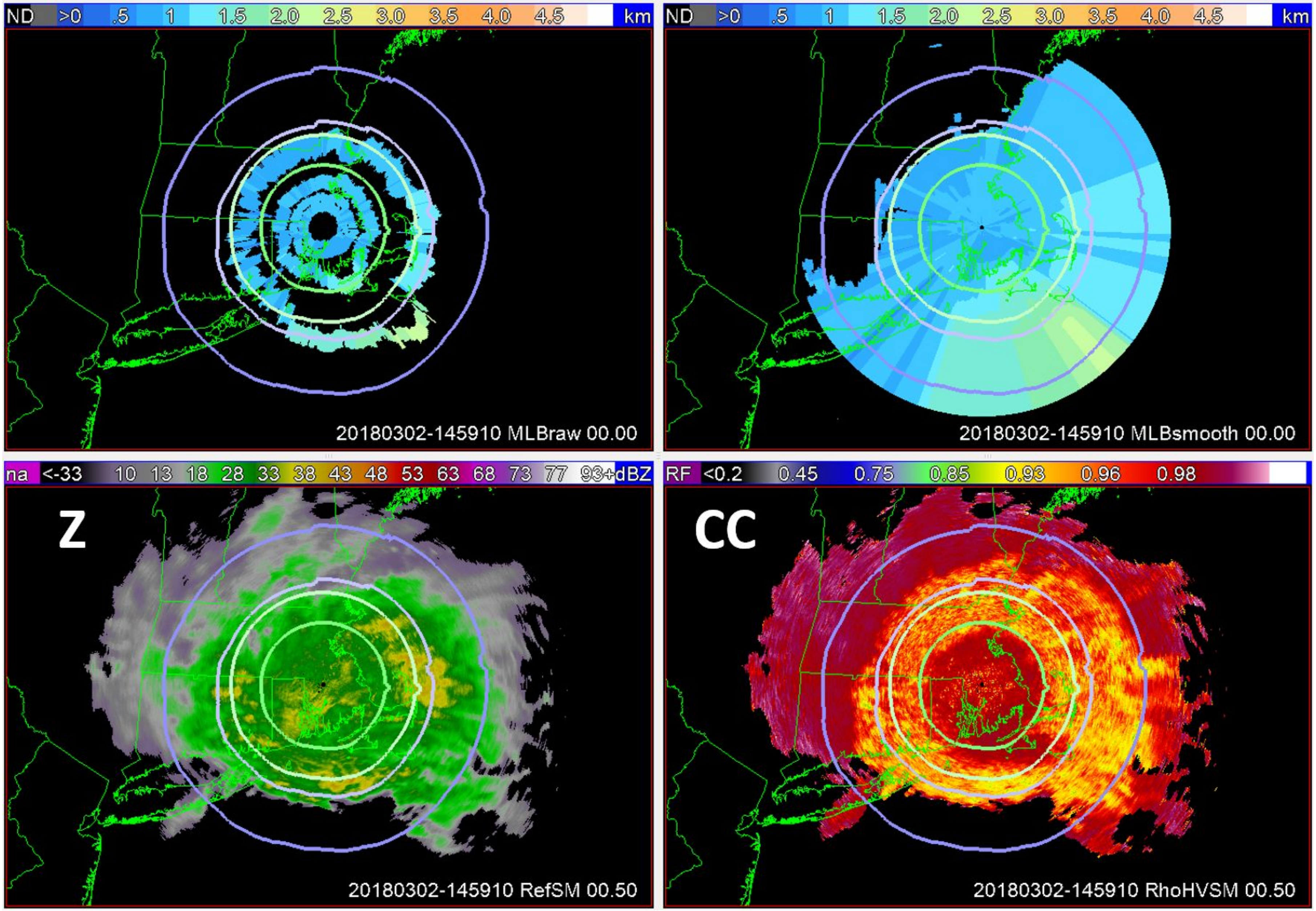
Model radial profiles of CC



ML construction demonstration (KEAX March 9th 2020 11z)



Example with gradually sloping ML in the land-ocean direction

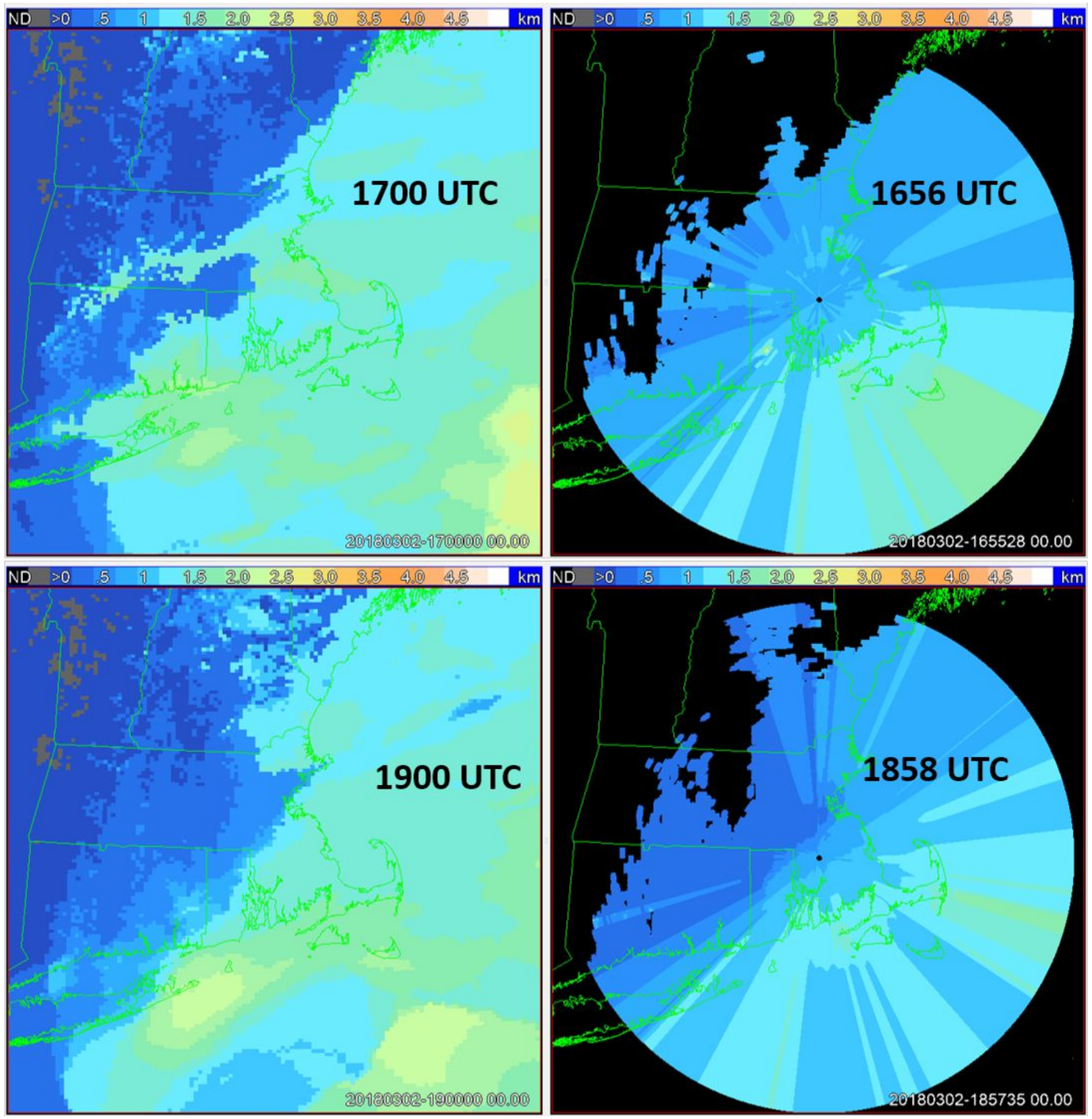


Left panels

2D maps of the height of the 0°C wet bulb temperature isotherm from the HRRR model

(a)

(c)



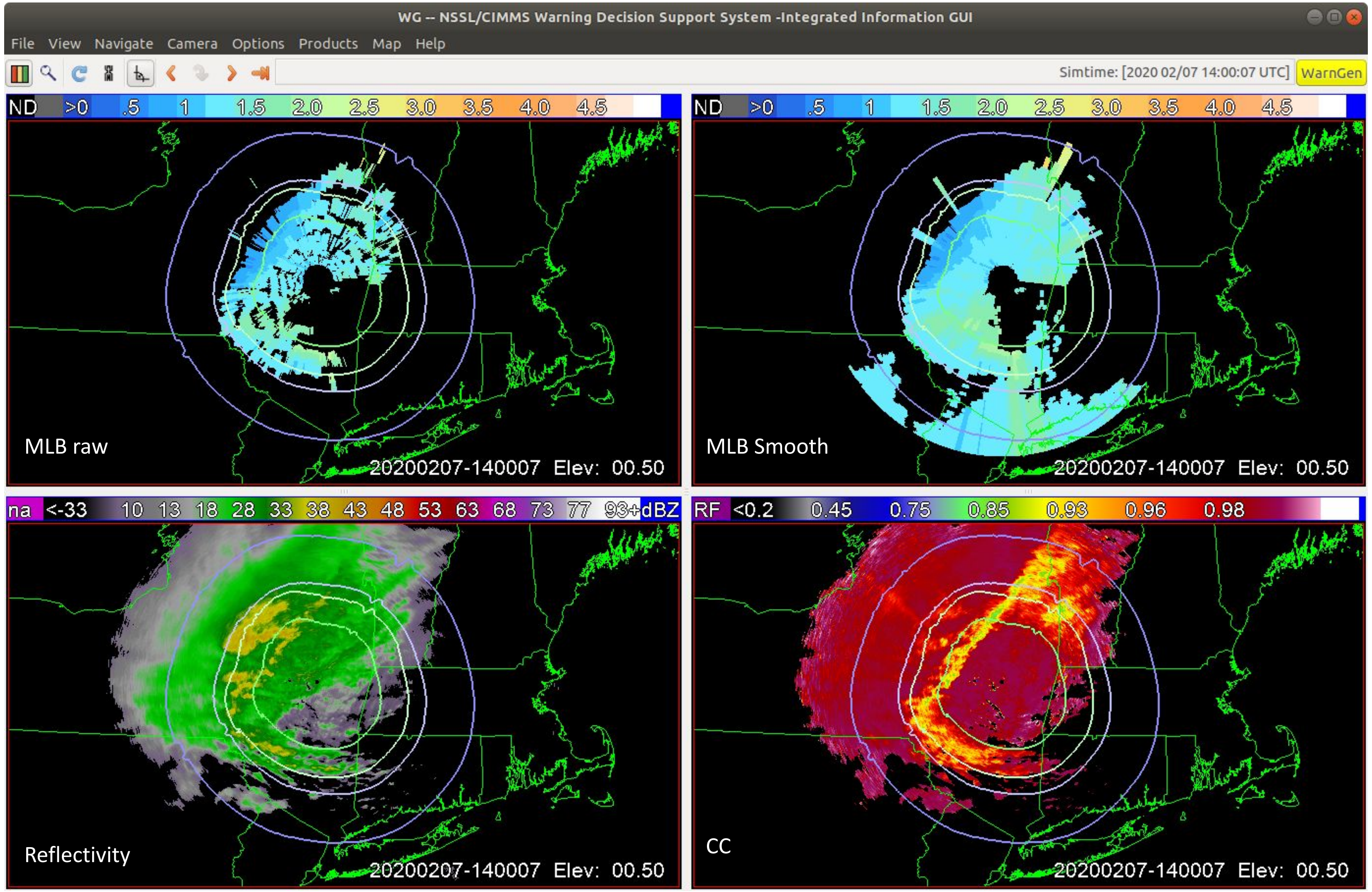
(b)

(d)

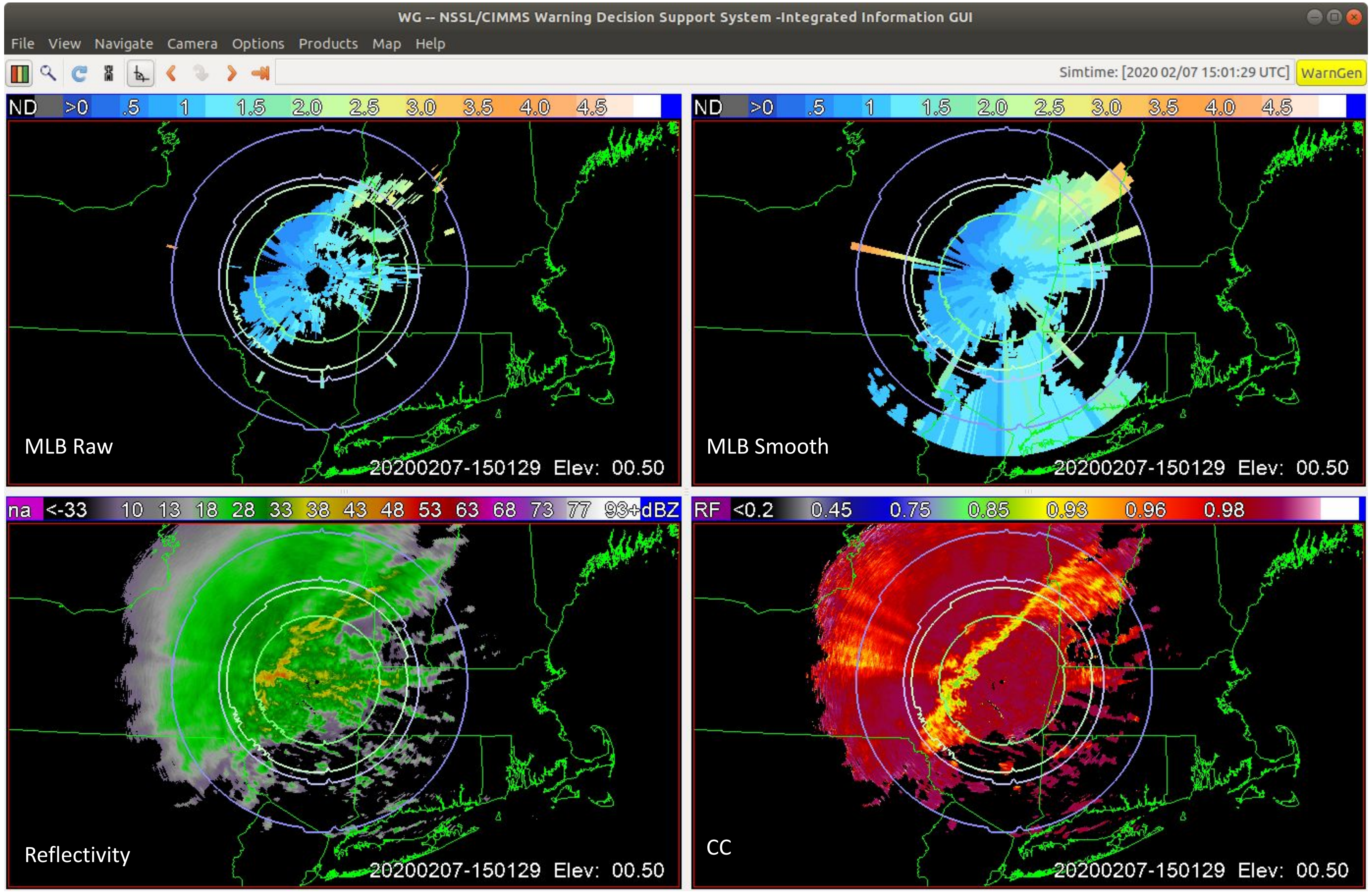
Right panels

2D maps of the height the ML bottom retrieved from the KOKX WSR-88D radar

Example of a sharp frontal boundary with rain / snow transition at the surface. Temporal evolution: 1401 UTC



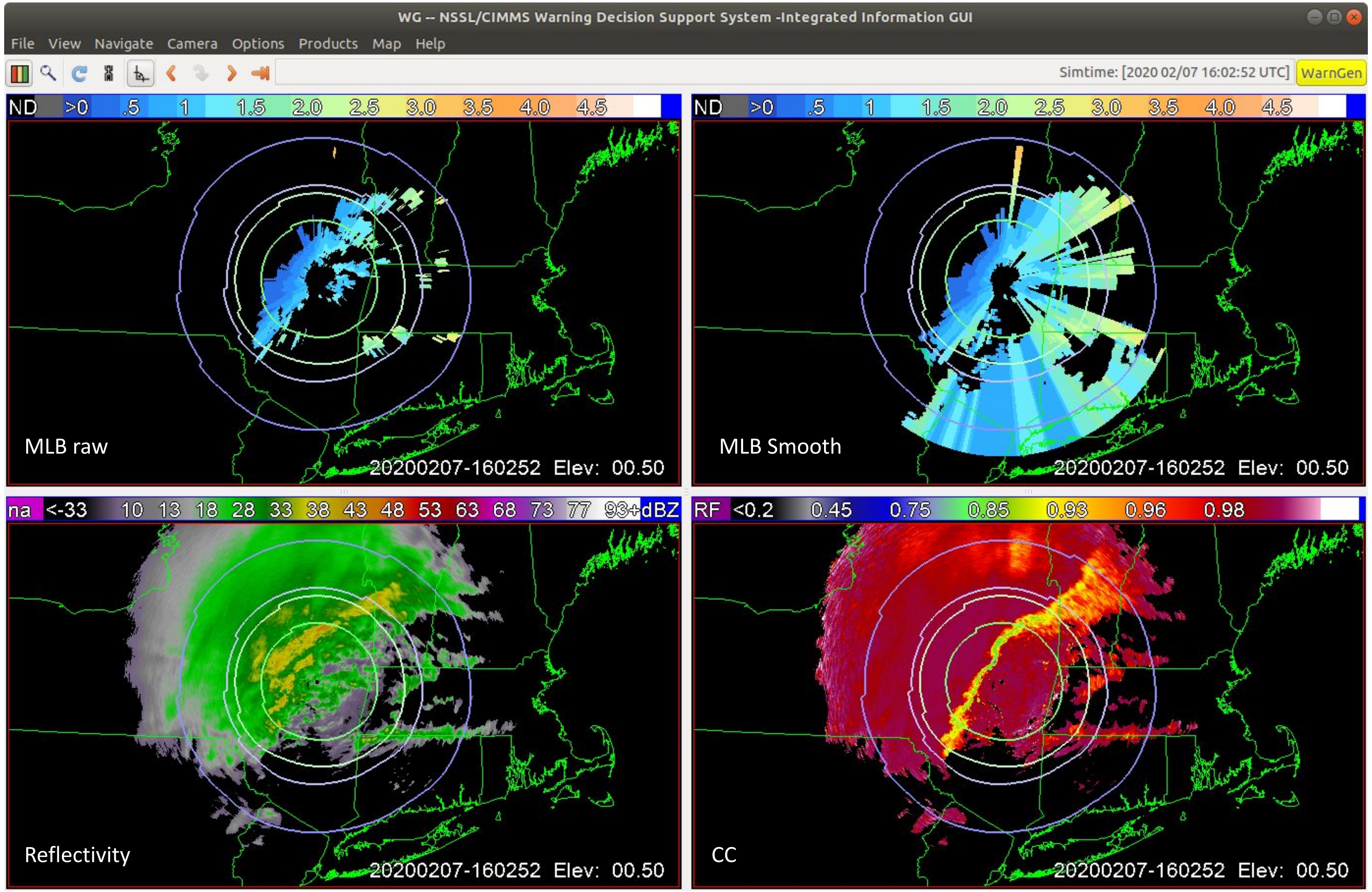
Temporal evolution: one hour later



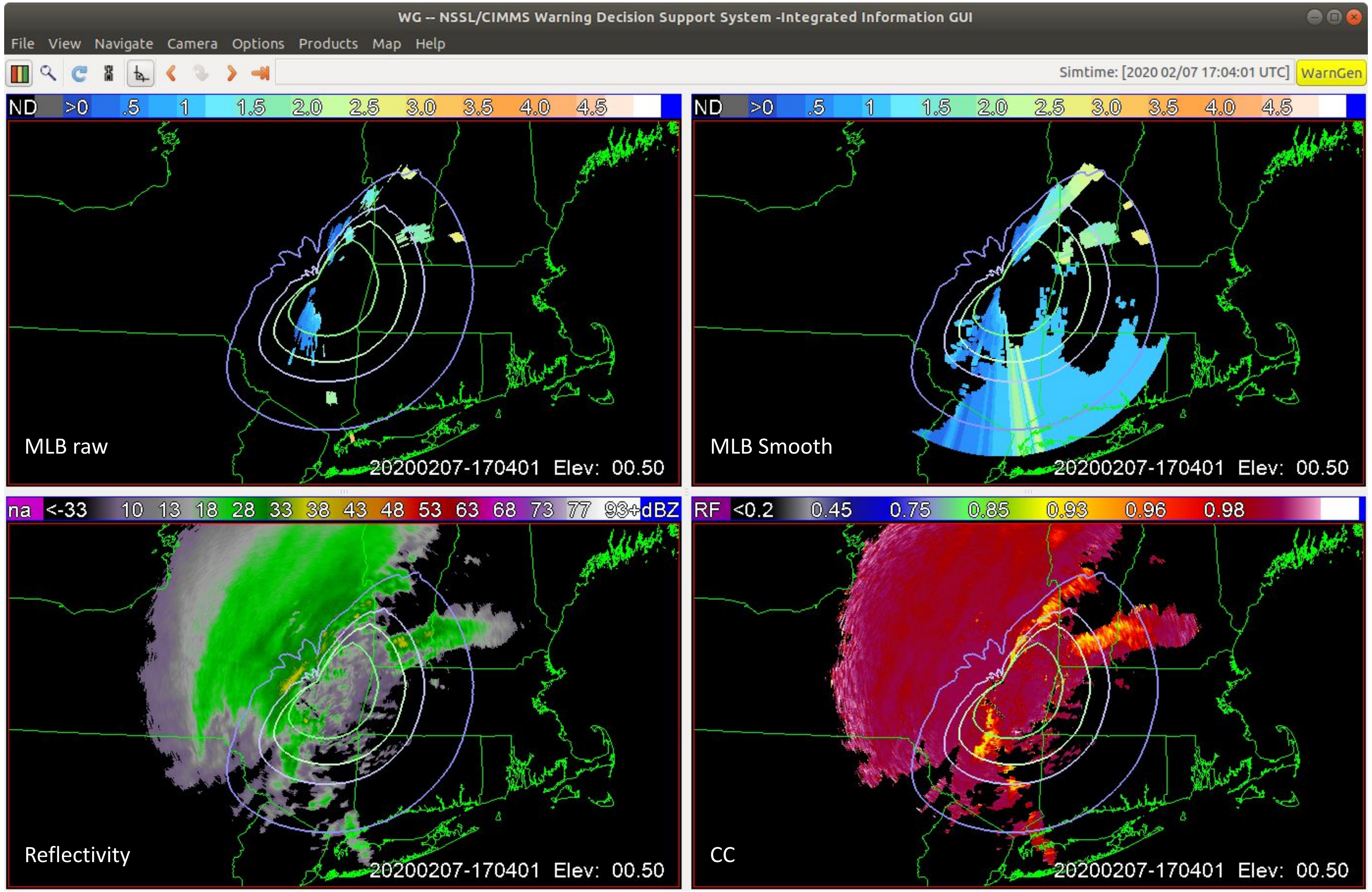
Note that in this image there is a false positive ML detection to the WNW. This error is due to the very strong depression of CC values, likely caused by dendrites, indicating very heavy snow in that region.

Significant effort has been applied to reducing dendrite contamination in the algorithm.

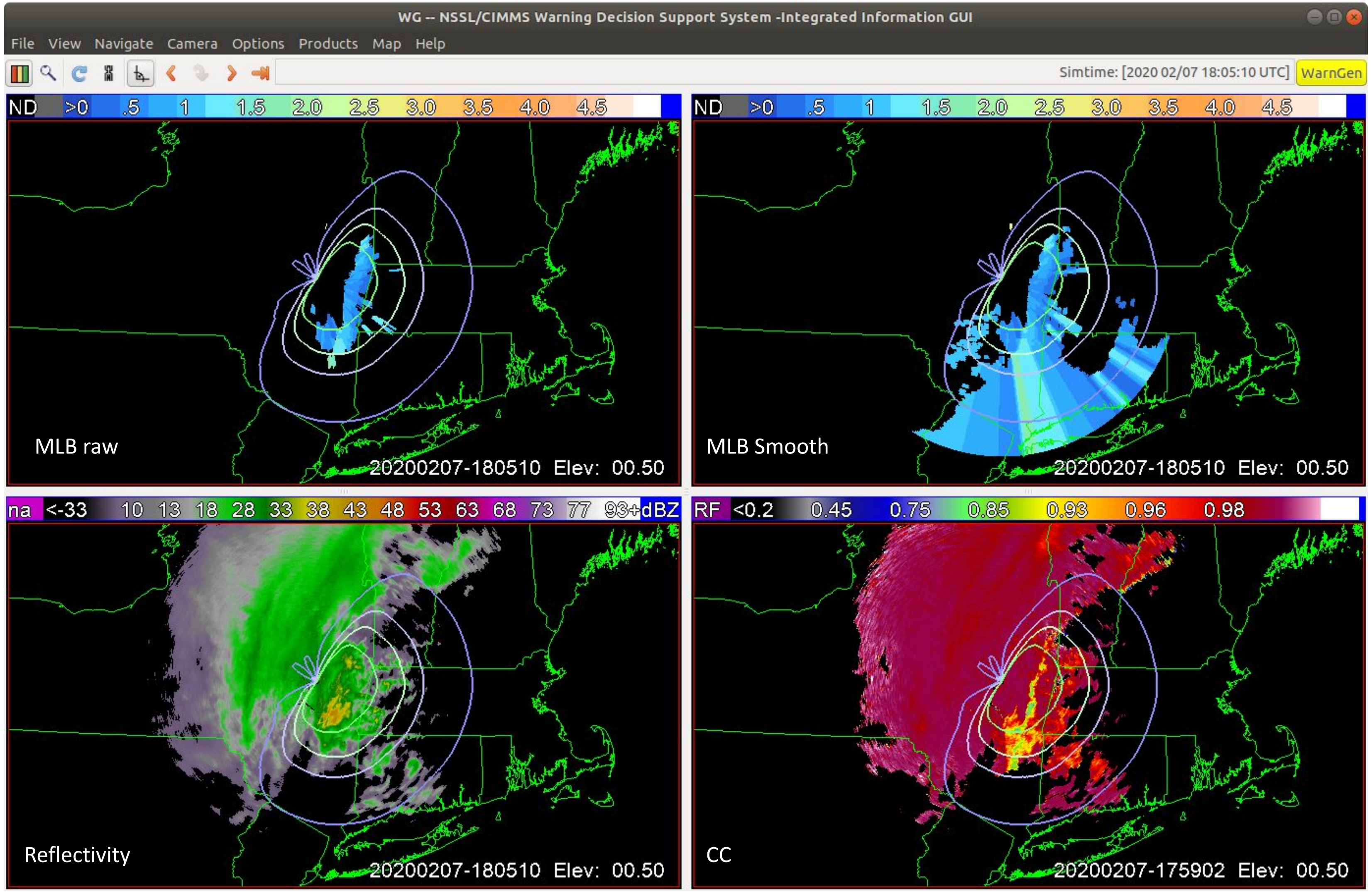
Temporal evolution: two hours later



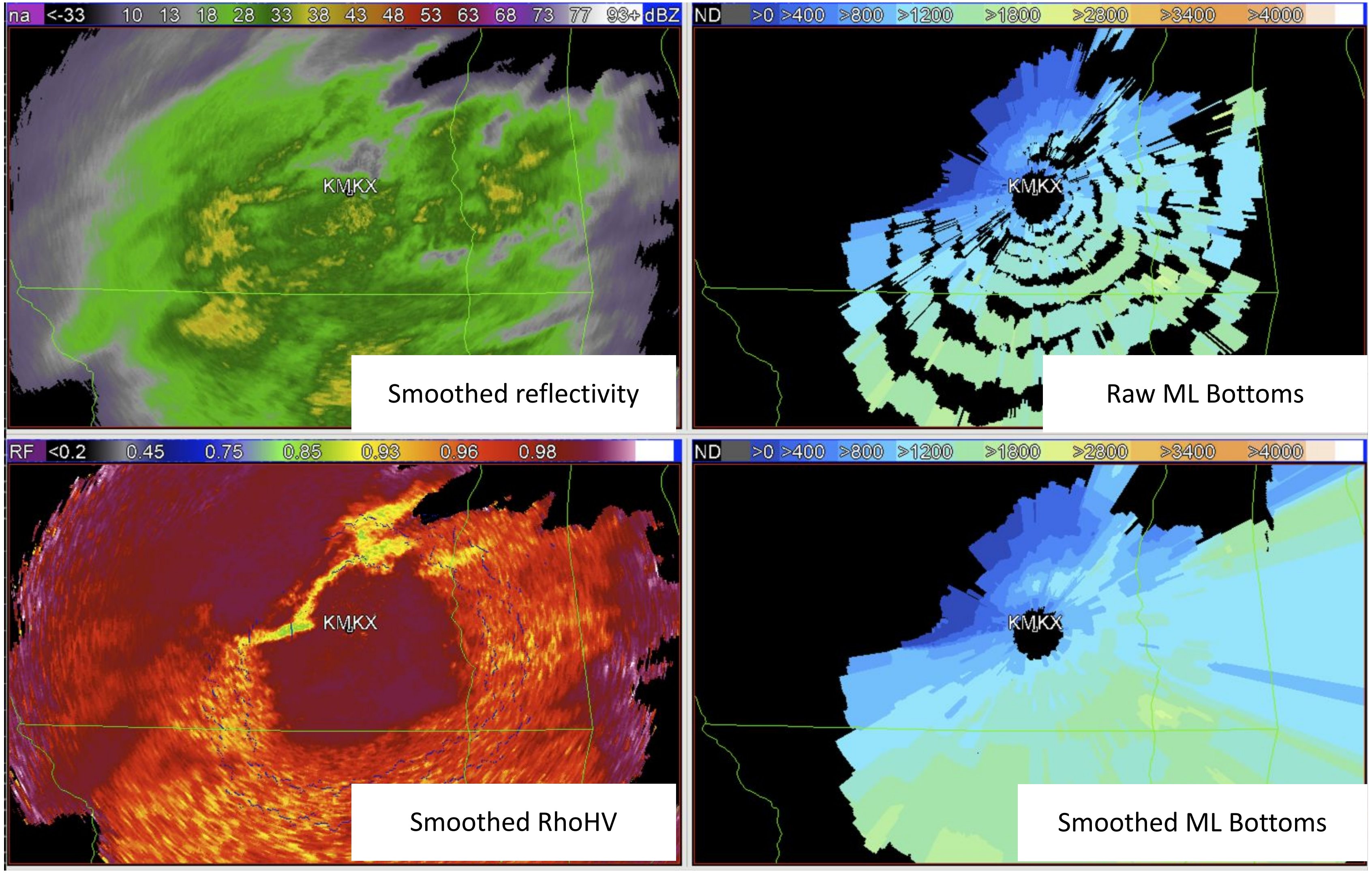
Temporal evolution: three hours later



Temporal evolution: four hours later

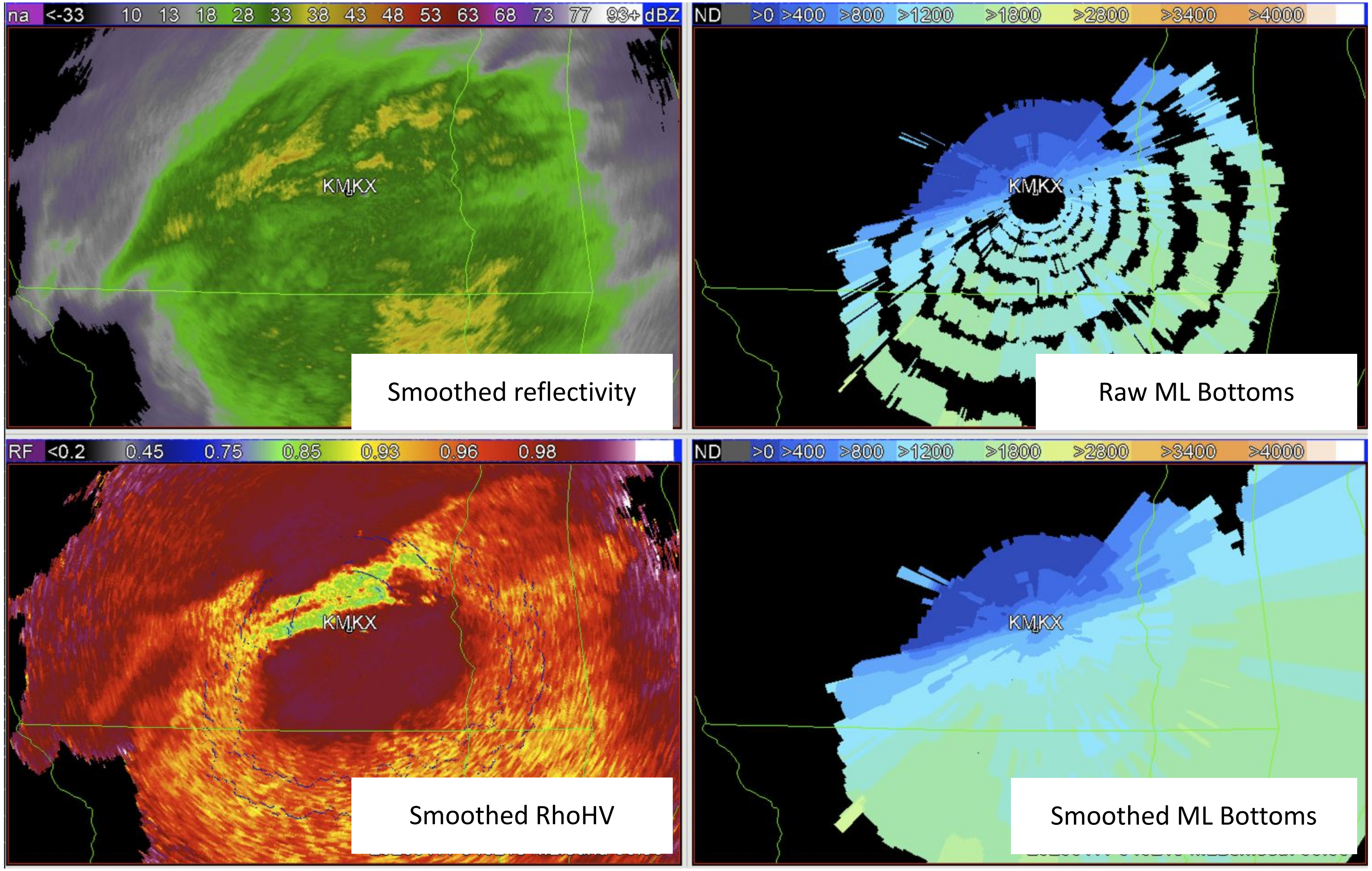


Example of a cold front with a rain/snow transition
KMKX 2020 Jan 11 0304 UTC

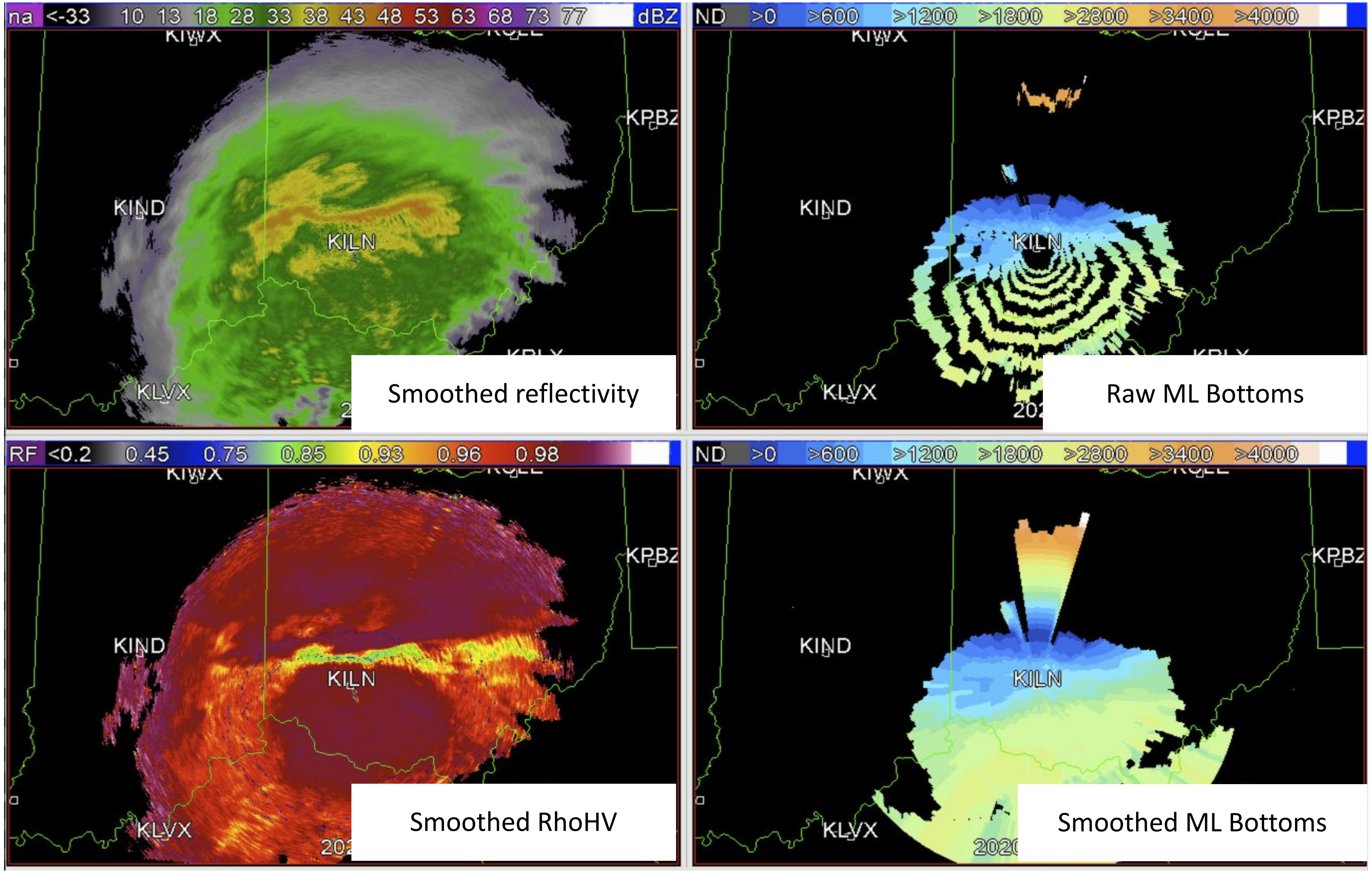


The sharp rain/snow transition is captured well.

Example of a cold front with a rain/snow transition
KMKX 2020 Jan 11 0402 UTC - one hour later



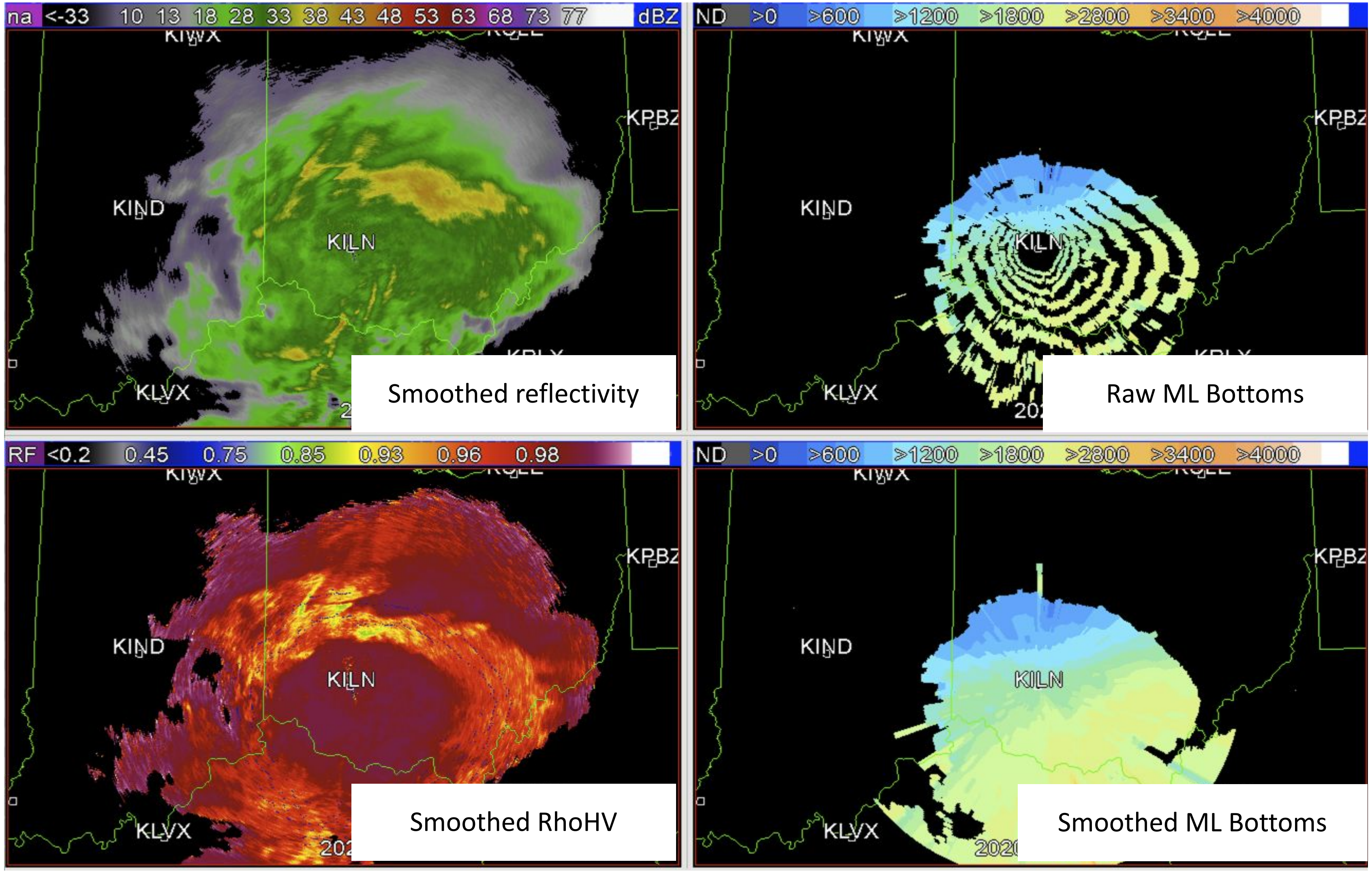
Example of a stationary front with a rain/snow transition
KILN 2020 Feb 13 0006 UTC



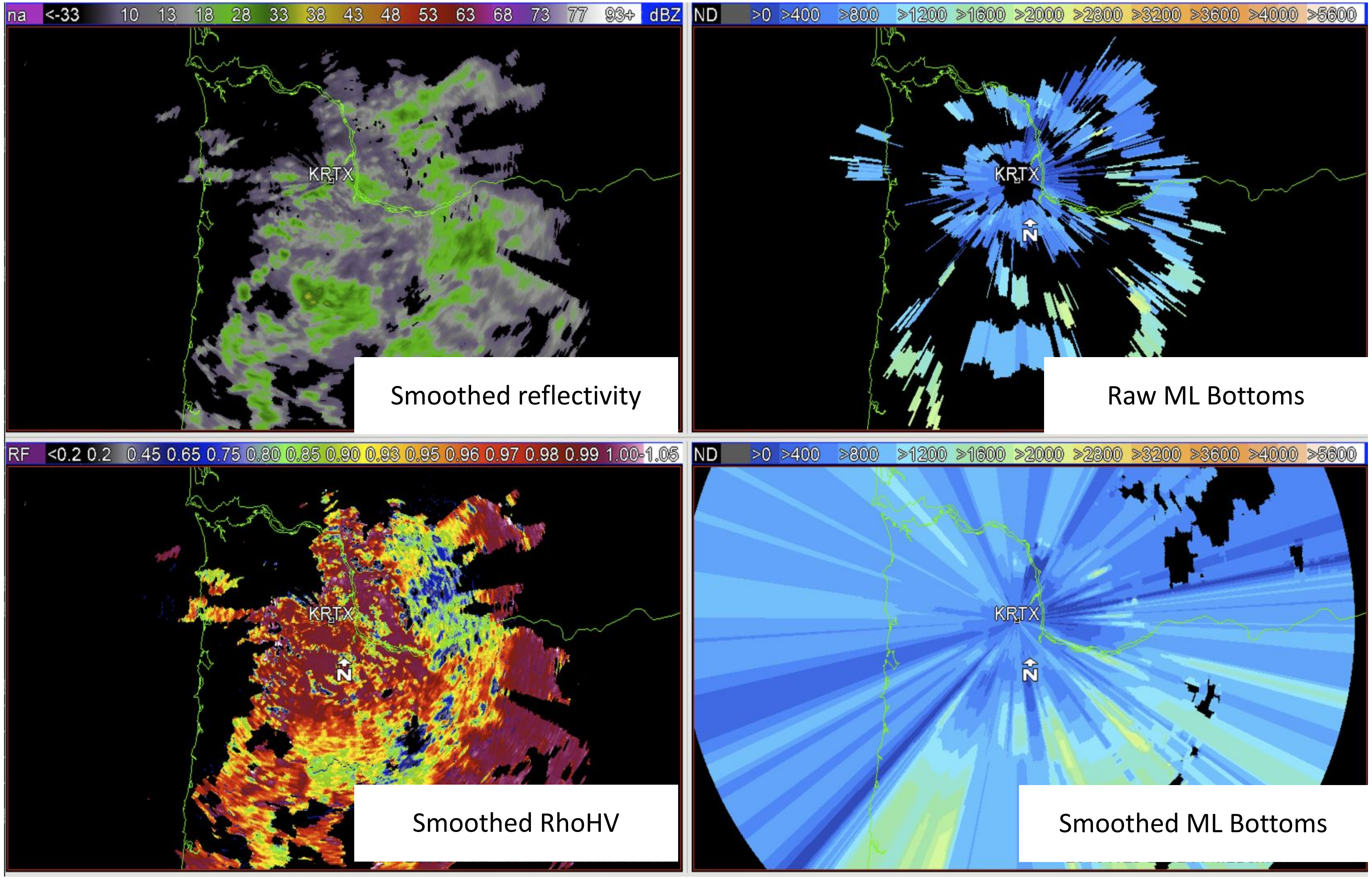
The false detection to the north of KILN is caused by dendrites.

Otherwise, the gently sloping melting layer and sharp rain/snow transition are captured well.

Example of a stationary front with a rain/snow transition
KILN 2020 Feb 13 0100 UTC - one hour later

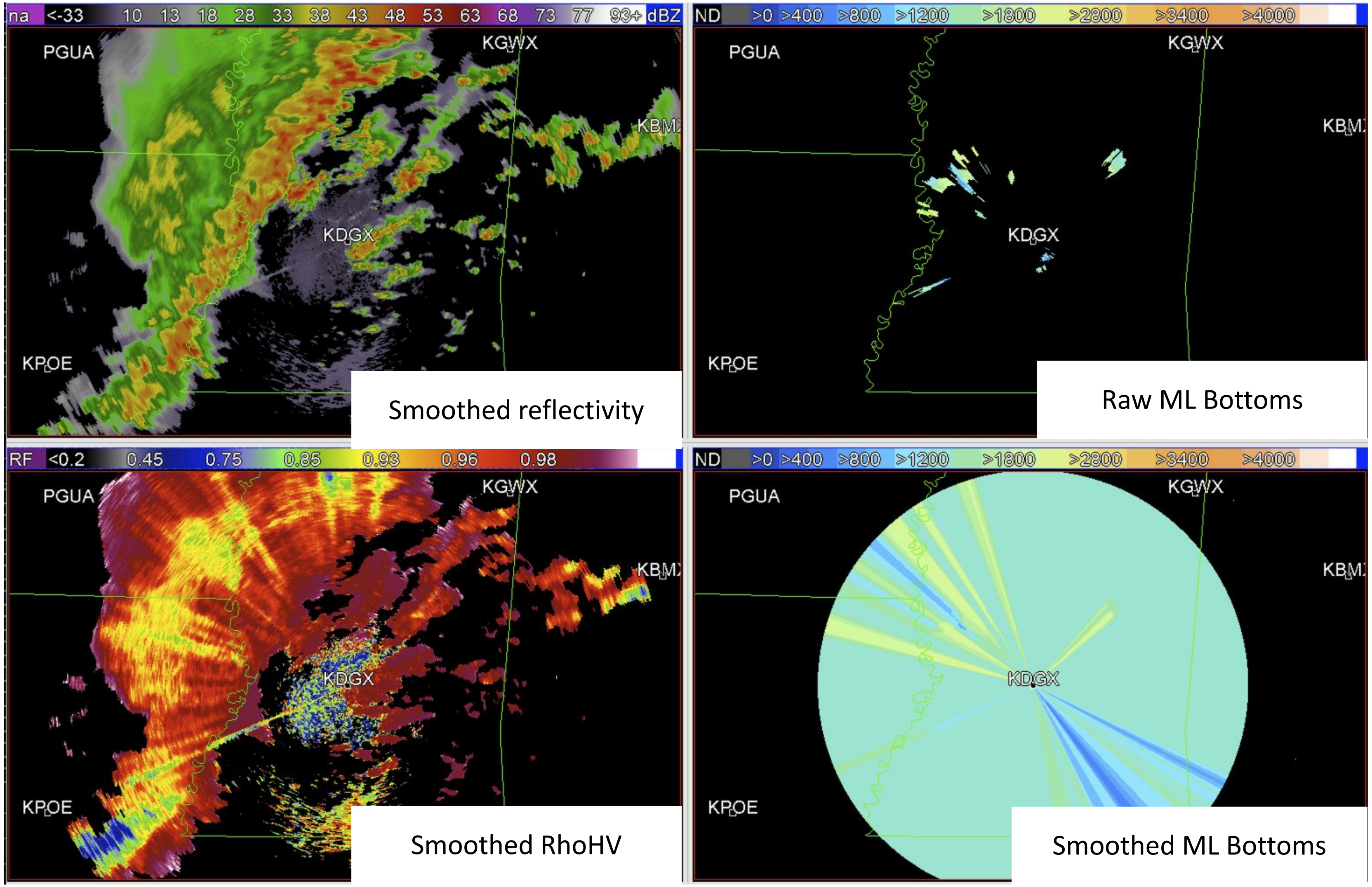


Example of a light and broken precipitation KRTX 2016 Nov 11 2232 UTC



Despite the broken nature of the light precip and complex terrain, a fairly consistent melting layer is detected.

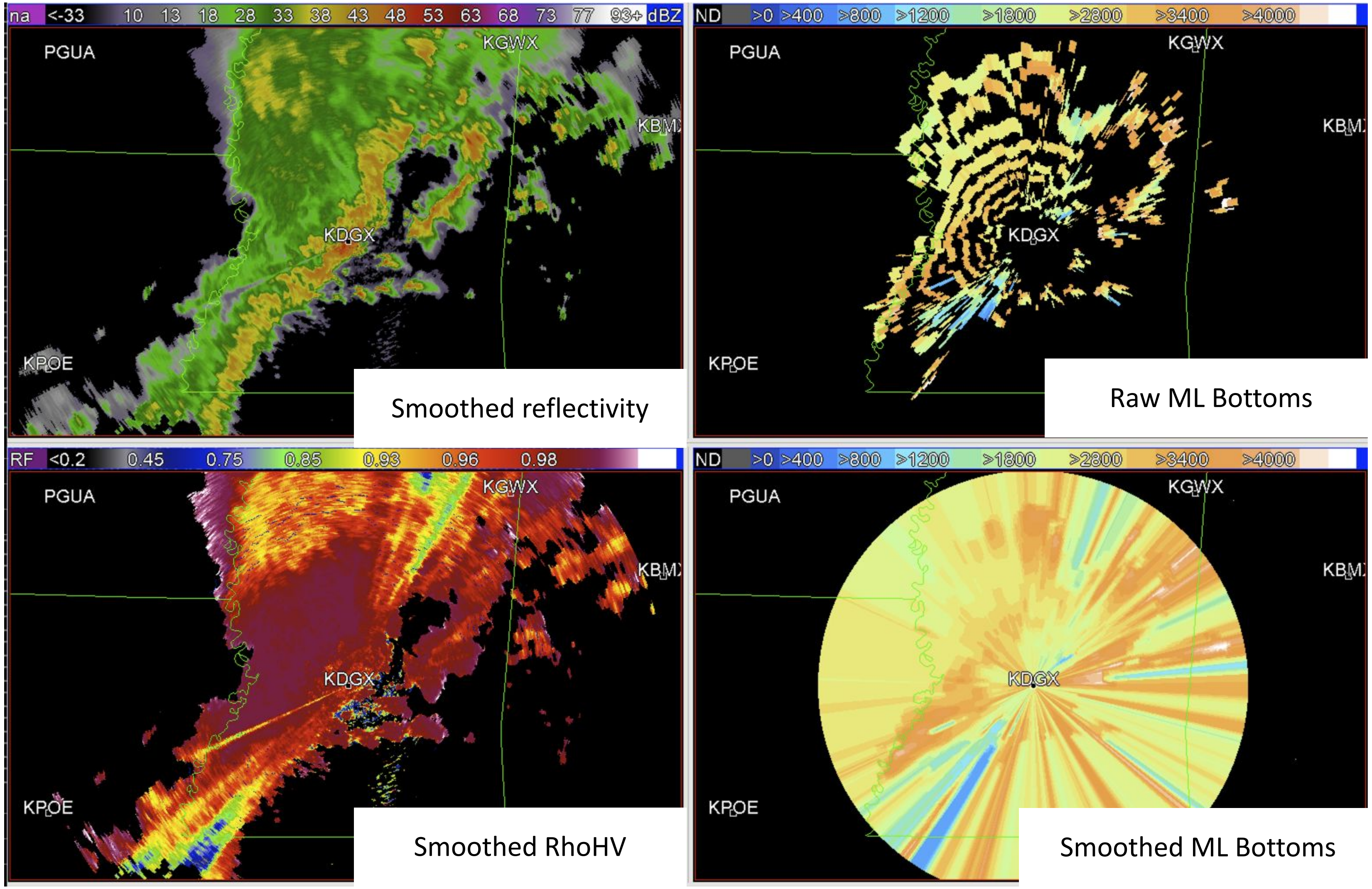
Example of warm season convection
KDGX 2021 May 04 1905 UTC



An MCS with a well defined melting layer was moving towards KDGX

Due to range constraints of 150 km on the New MLDA, no melting layer was detected at this time.

Example of warm season convection
KDGX 2021 May 04 2005 UTC - one hour later



Smoothed reflectivity

Raw ML Bottoms

Smoothed RhoHV

Smoothed ML Bottoms

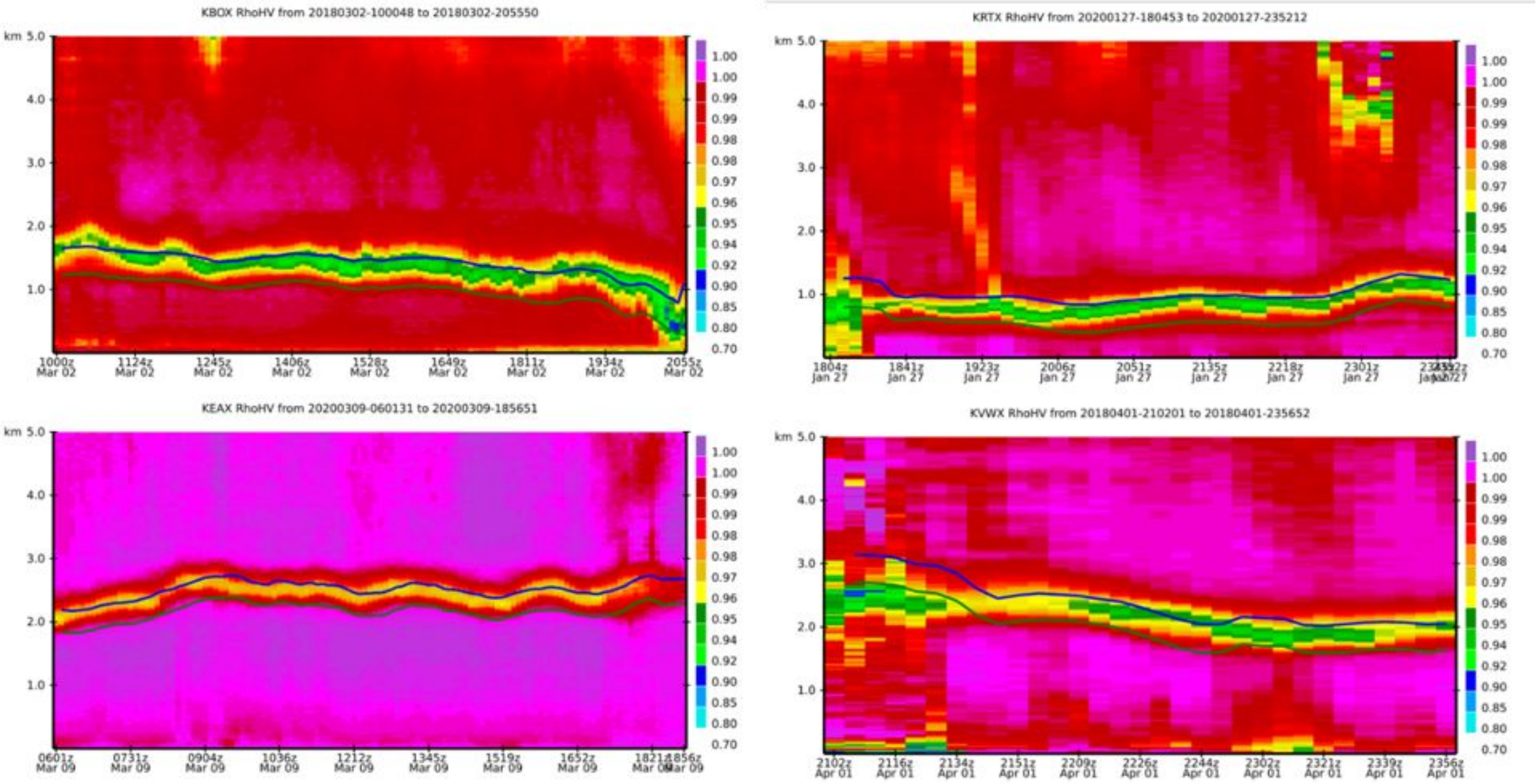
An MCS with a well defined melting layer was moving towards KDGX

Once the MCS got closer, a melting layer was detected.

There are a few errors associated with hail cores, though most of the product is accurate.

Validation using QVPs

RD-QVPs of CC for 4 events with the new MLDA estimates of H_b and H_t depicted as overlaid green and blue lines respectively



ORPG implementation

The newMLDA algorithm was wrapped and run on a build 20 ORPG.

Identifies any algorithmic performance issues when using ORPG specific radar and model data.

Identifies the CPU and memory footprints

Gives the formal Technology Transfer process a reference point to work from.

Builds confidence in output by allowing the testing team to run cases independently of the developer.

Challenges

- Mild underestimation of the ML height is occasionally observed
- The underlying model of the ML and radial CC profiles is not valid in areas of deep convection. Some pre-classification should be done in the presence of deep convection.
- Our goal is to generate the map of the ML height in a 150 km radius area centered on a particular radar and we need to find an optimal solution for merging the radar and model data in the echo free zones
- Can we make the algorithm all-seasonal? It currently works in the ML height interval from 0 to 5 km.

Conclusions

- A principally novel algorithm for melting layer detection and determination of its height has been developed
- For the first time, the maps of the heights of the ML top and bottom are generated at the distances up to 150 km from the radar
- Initial version of the new algorithm is implemented in C++ and was tested on a large number of cases with different degree of spatial nonuniformity
- The new MLDA exhibits robust performance and passed the test on the spatial and temporal continuity
- The MLDA output was validated using the model data and QVP products.