The Crystal Sandwich

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TAC Meeting

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Outline

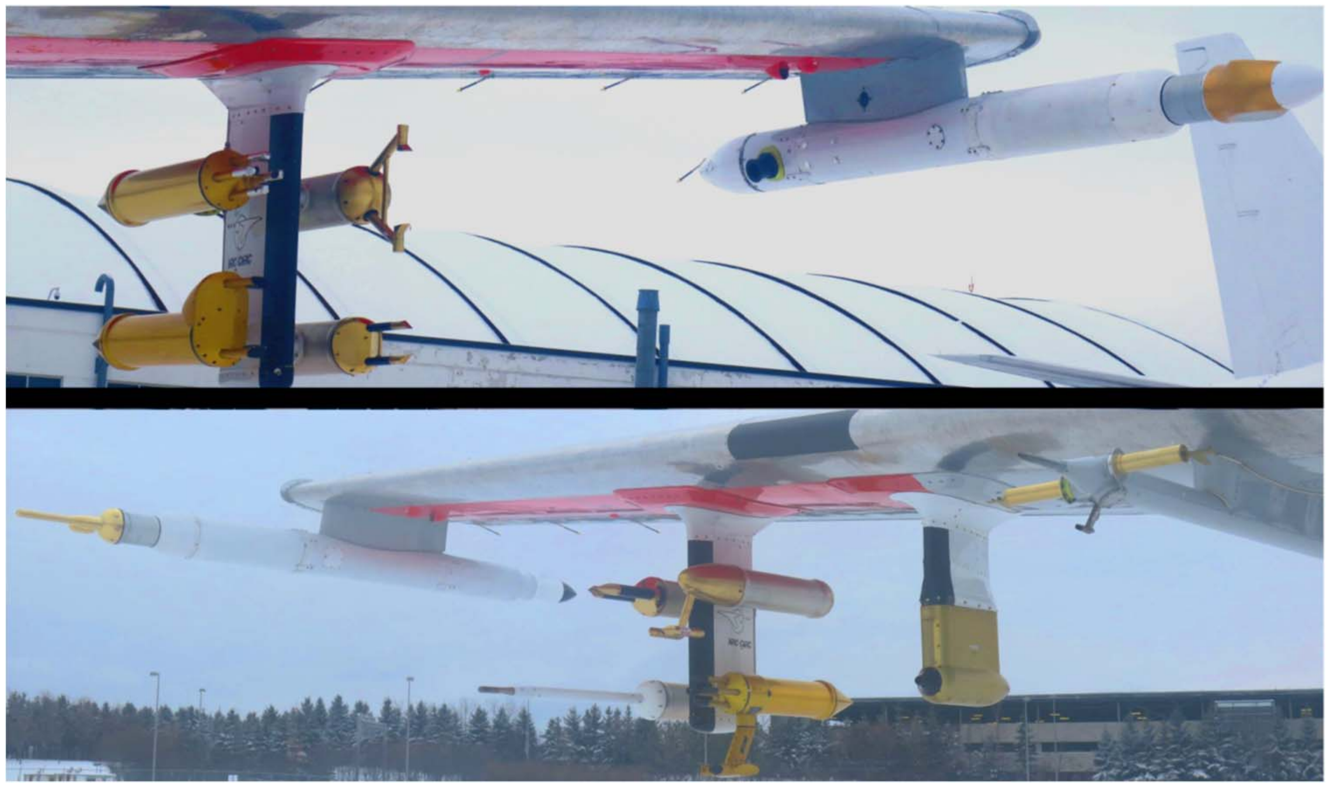
- Buffalo Area Icing and Radar Study (BAIRS)
- Definition of 'crystal sandwich'
- Strategy to identify dual polarimetric signatures linked with supercooled water
- Prevalence of dendritic and needle crystals in specific temperature ranges
- Differential reflectivity from dendrites and needles
- Linkage of both crystal types with water saturation
- Case studies
- February 28, 2013 (BAIRS I)
- January 10, 2017 (BAIRS II)
- AIRS-II campaign (Wolde, 2006)
- Miscellaneous NEXRAD examples

Buffalo Area Icing and Radar Study

(FAA-supported work on CONVAIR-580 validation of in situ icing conditions)

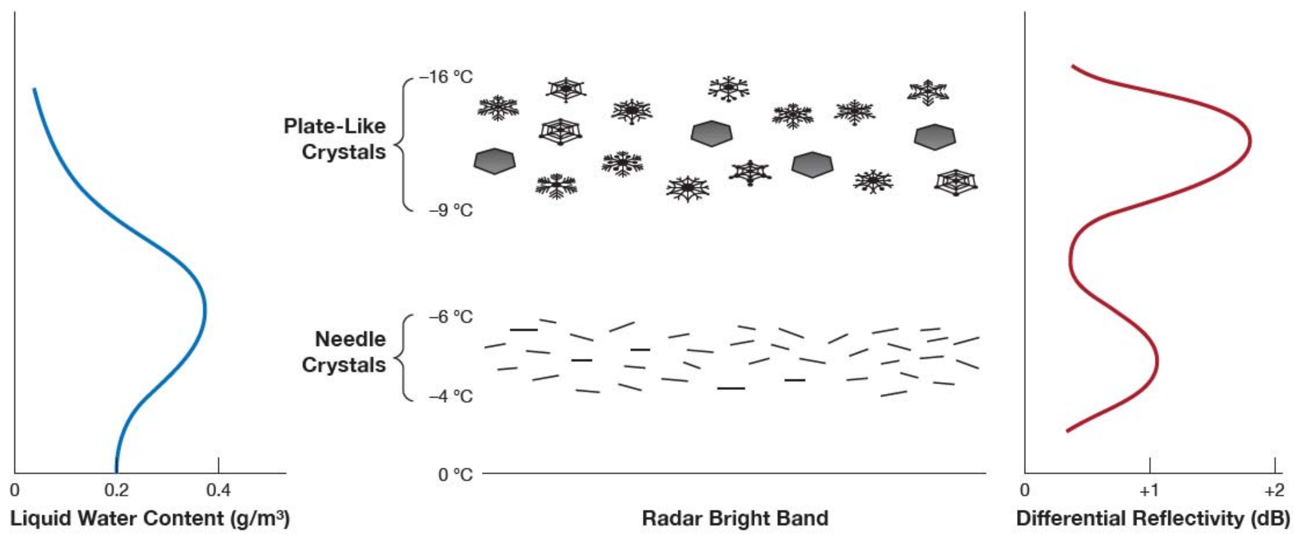
- **BAIRS I flights**
  - **February 19, 2013**
  - **February 26-27, 2013**
  - **February 28, 2013**

- **BAIRS II flights**
  - **January 10, 2017**
  - **January 24, 2017**
  - **February 7, 2017**
  - **March 24, 2017**
  - **March 25, 2017**

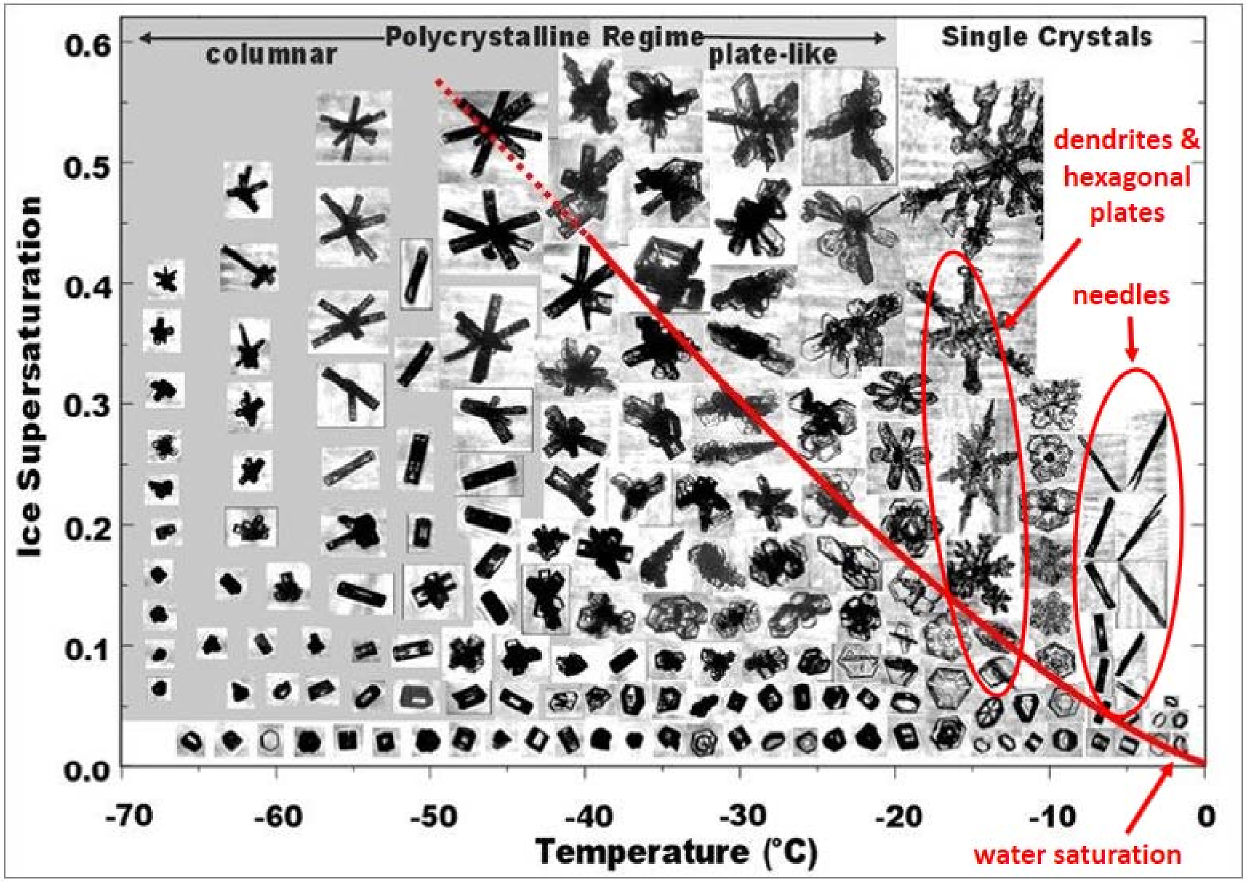


Crystal Sandwich

Target for NEXRAD Radar Differential Reflectivity
Indicator of In Situ Supercooled Water



Crystal habit versus temperature and water saturation condition (Bailey and Hallett, 2009)



Crystal habit depends on
- **Temperature**
- **Humidity**

Differential reflectivity of dendrite and needle crystals (Hogan et al., 2002)

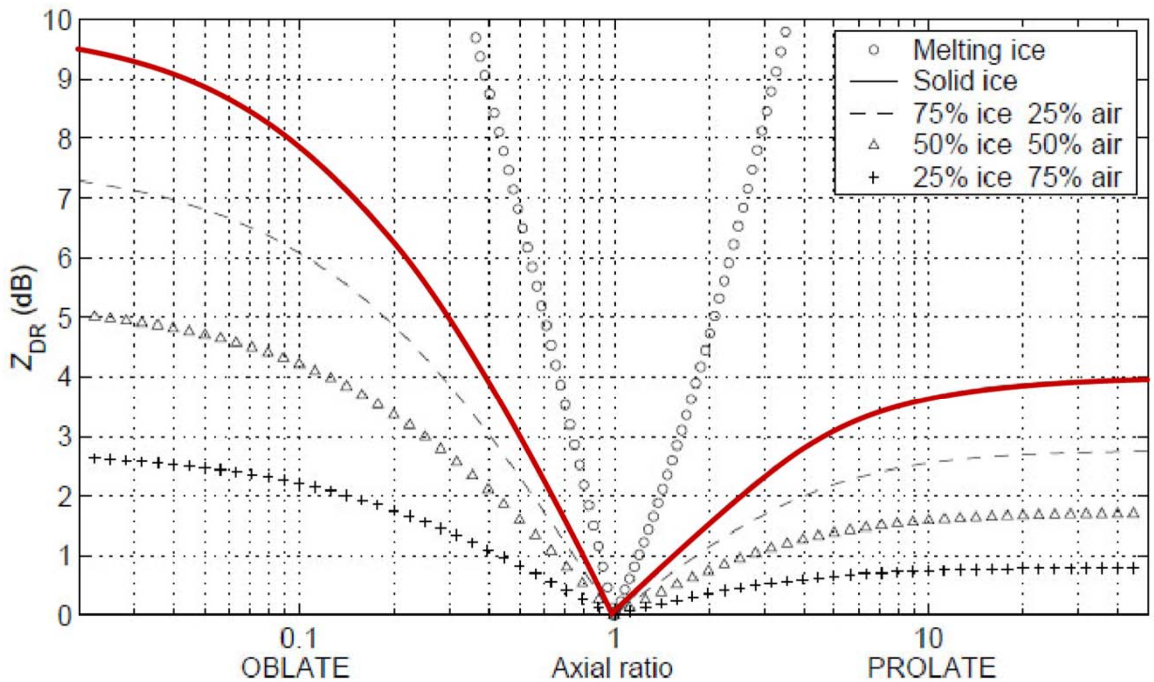
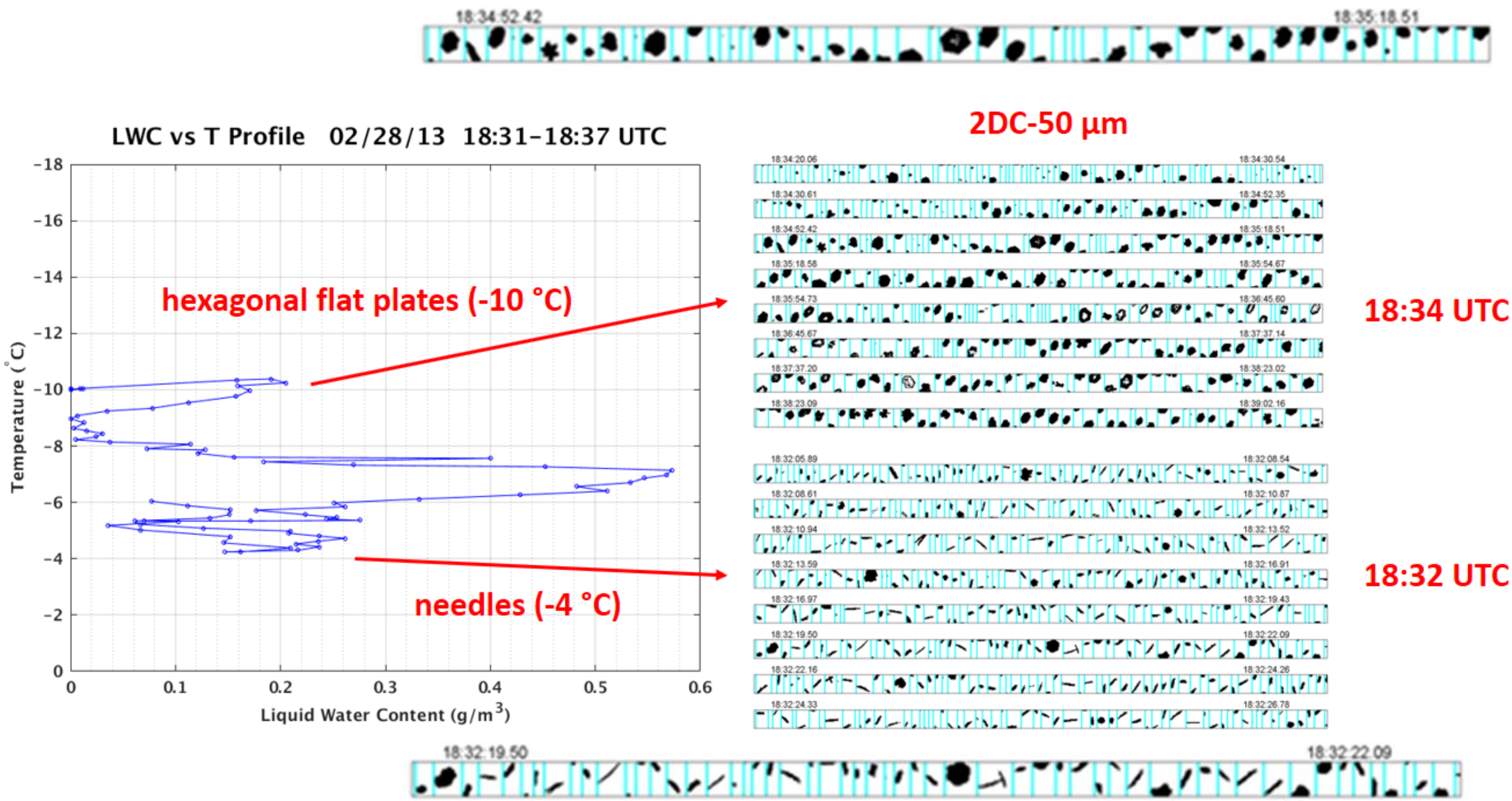
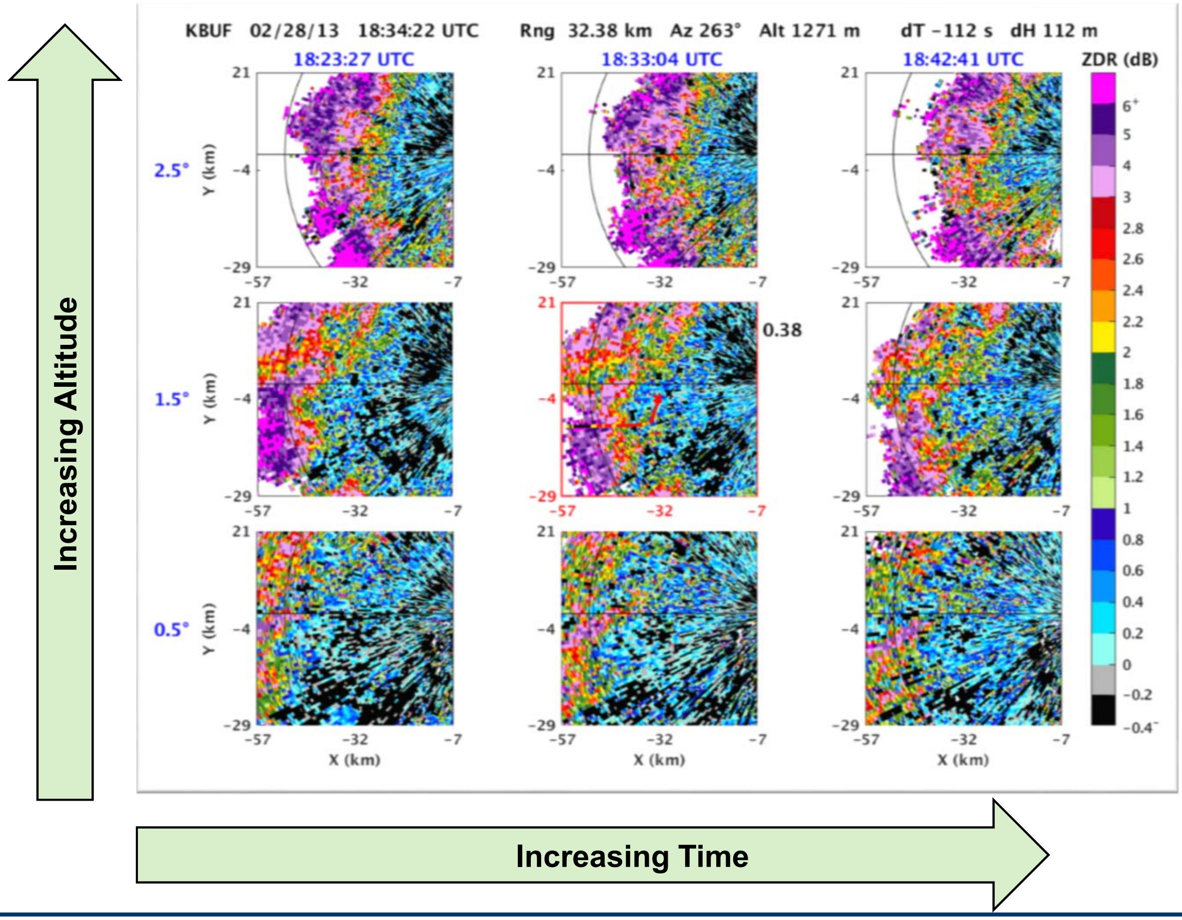


Figure 1. Z_{DR} of spheroidal ice particles as a function of axial ratio and density. The particles are horizontally aligned but have random azimuthal orientation.

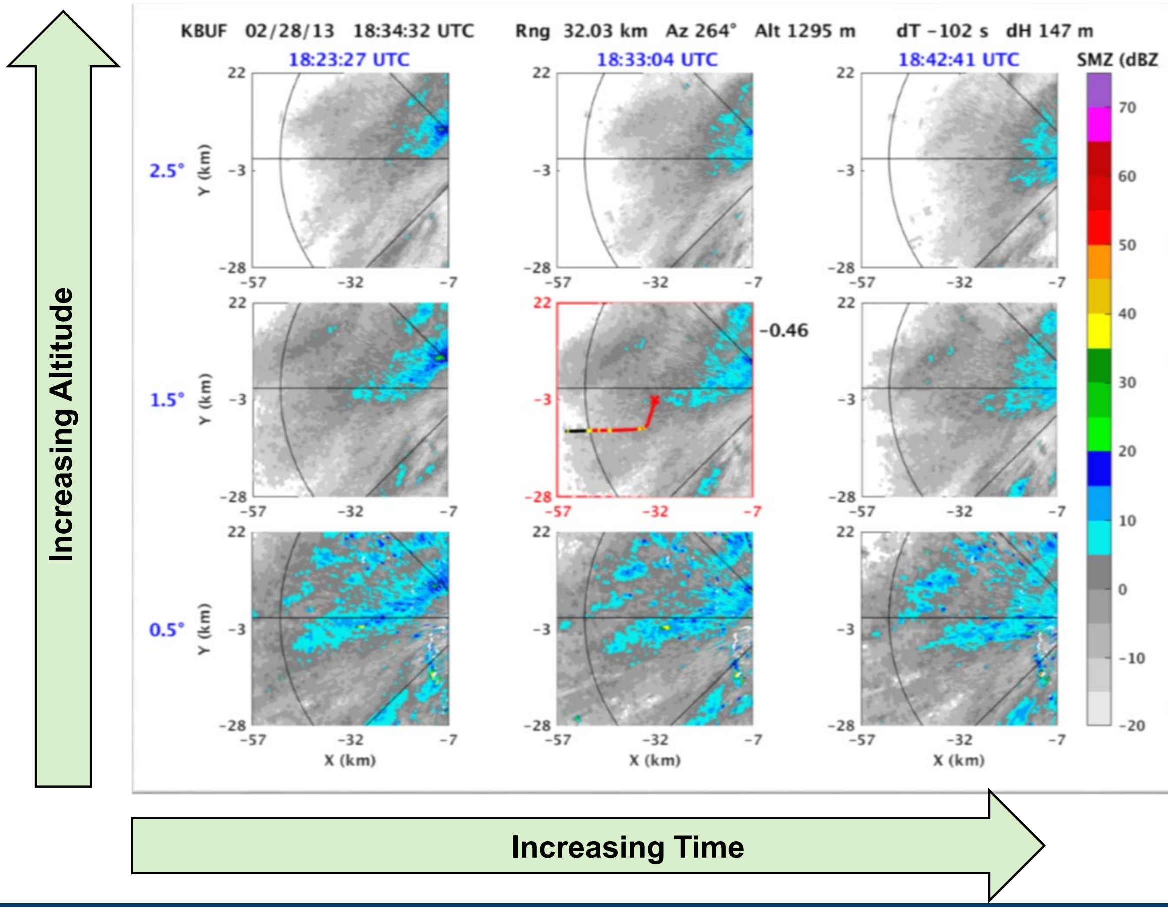
Hexagonal flat plates over needles (February 28, 2013)



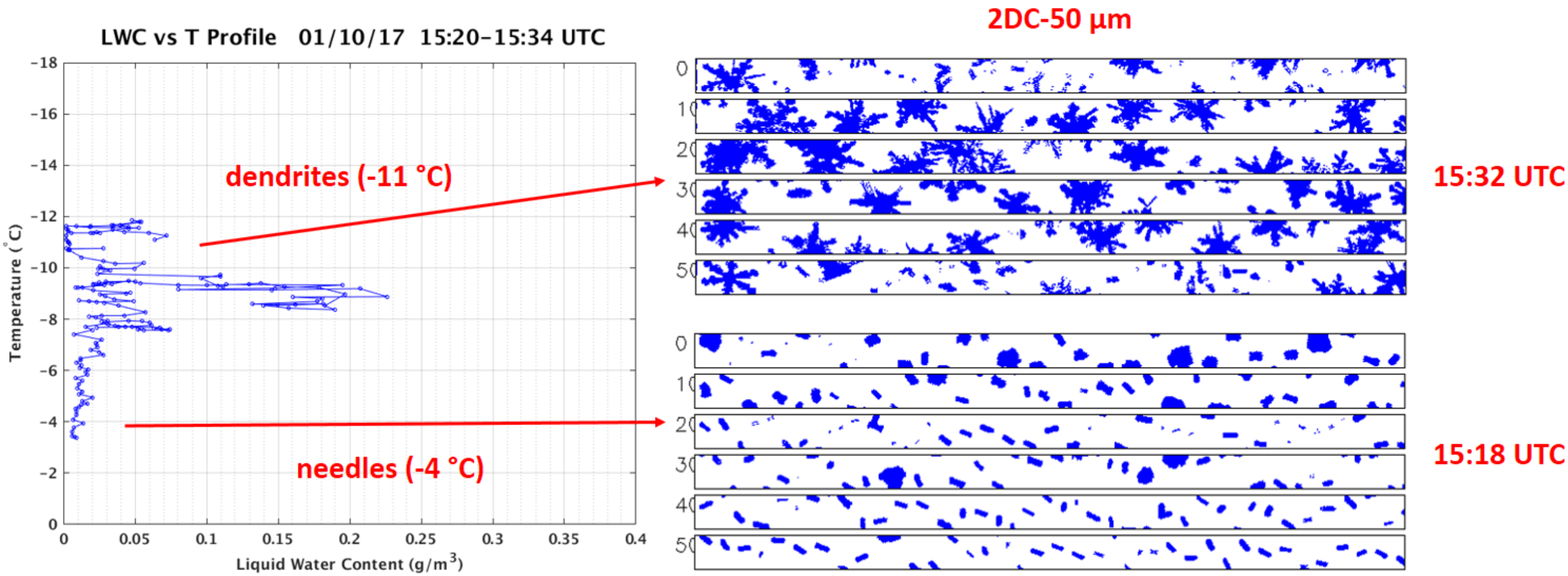
Differential reflectivity for hexagonal plates over needles (Feb 28, 2013)



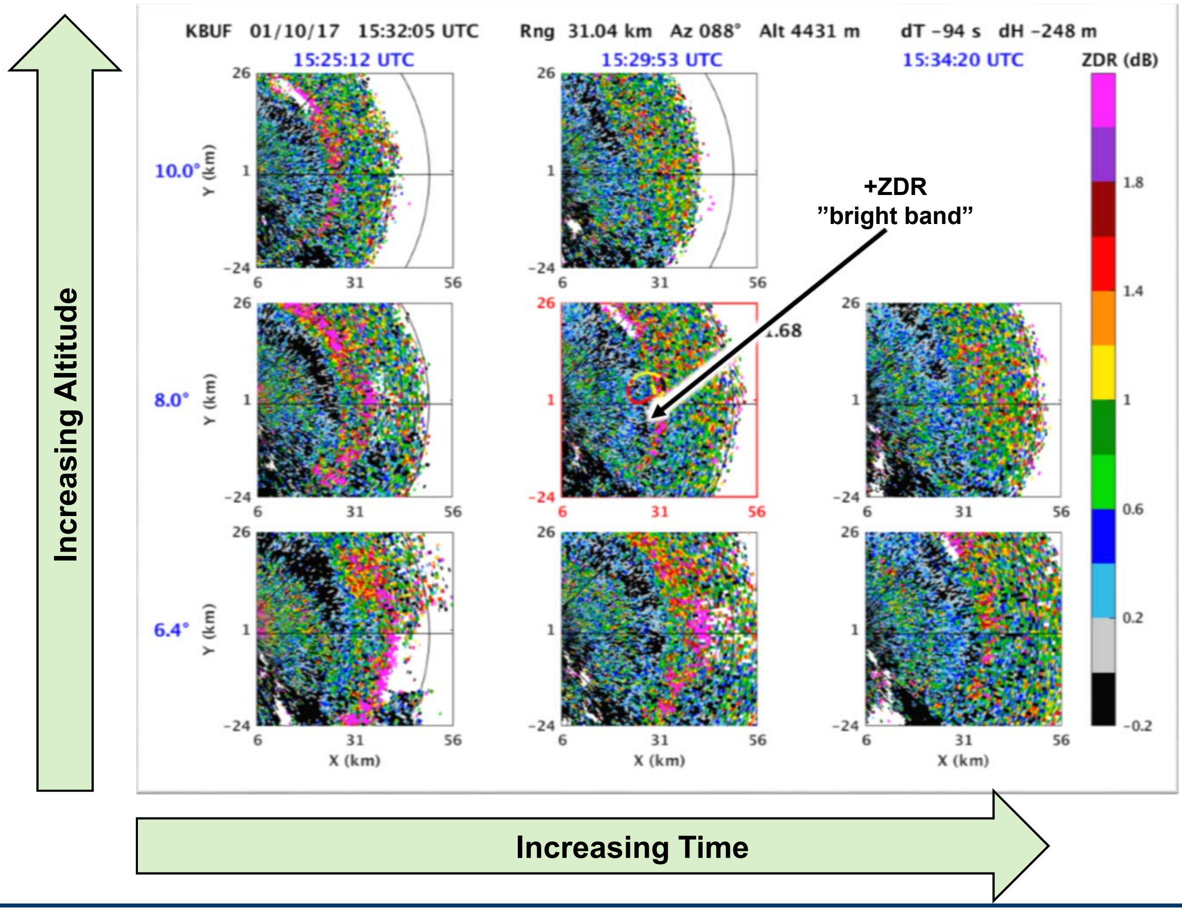
Reflectivity for hexagonal plates over needles



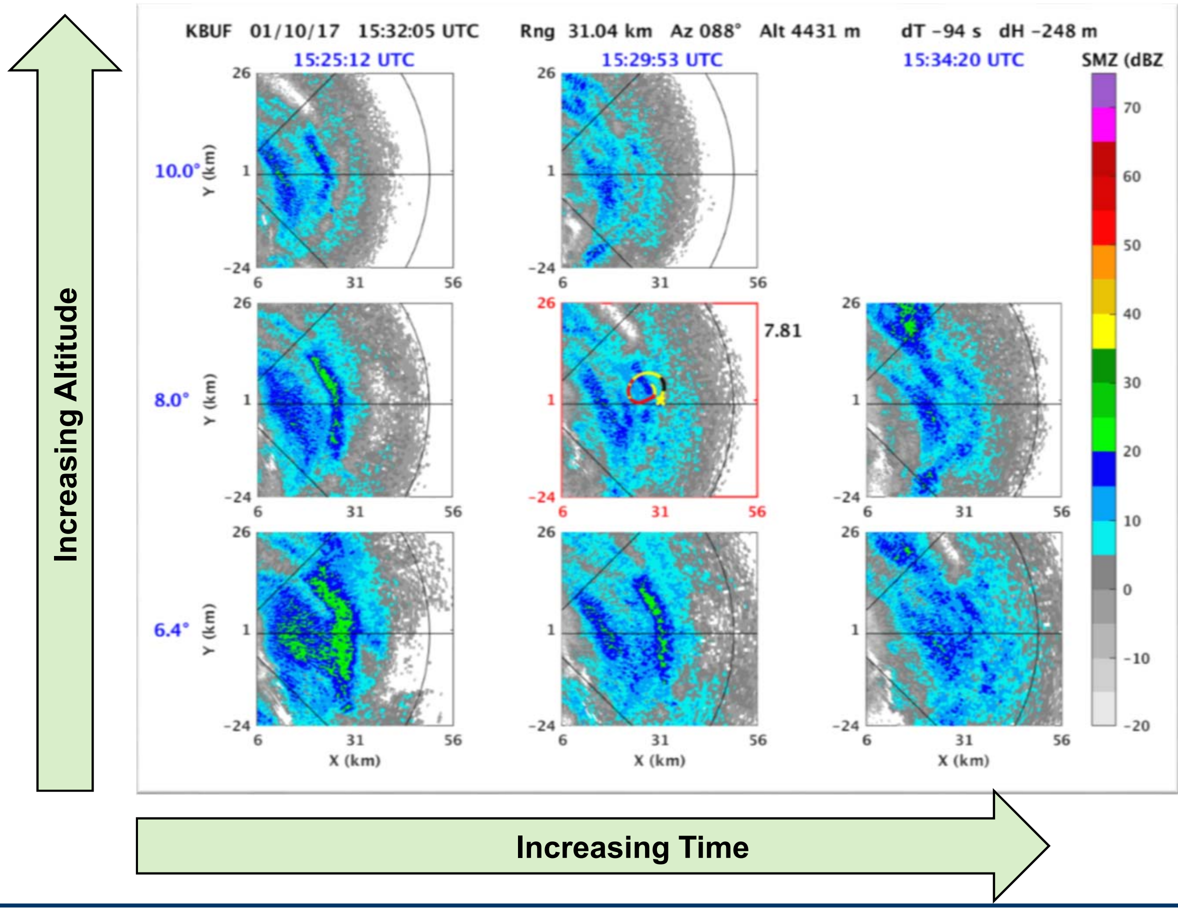
Dendrites over needles on January 10, 2017 (aircraft spiral ascent)



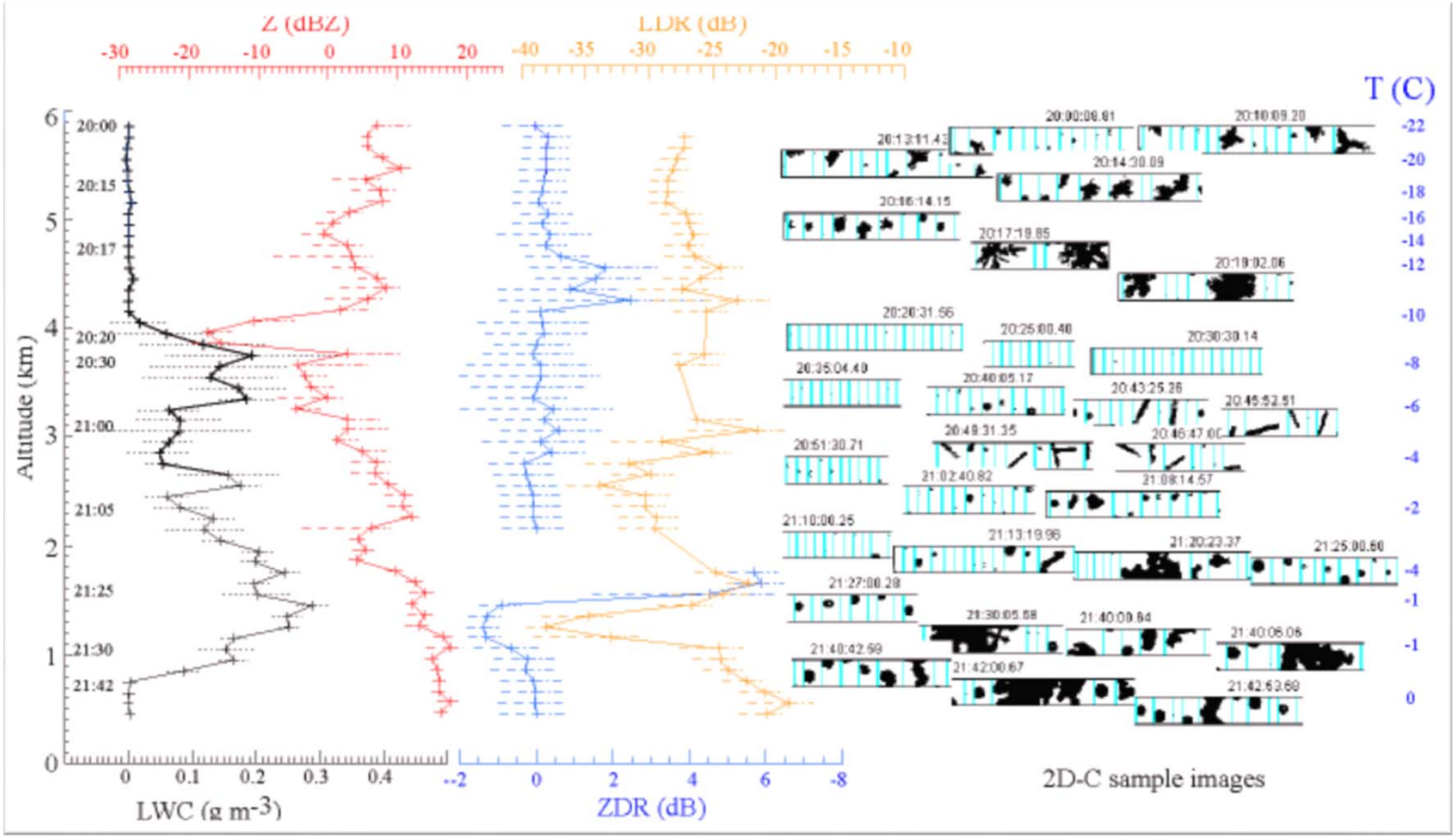
Differential reflectivity for crystal sandwich on January 10, 2017 (aircraft spiral ascent)



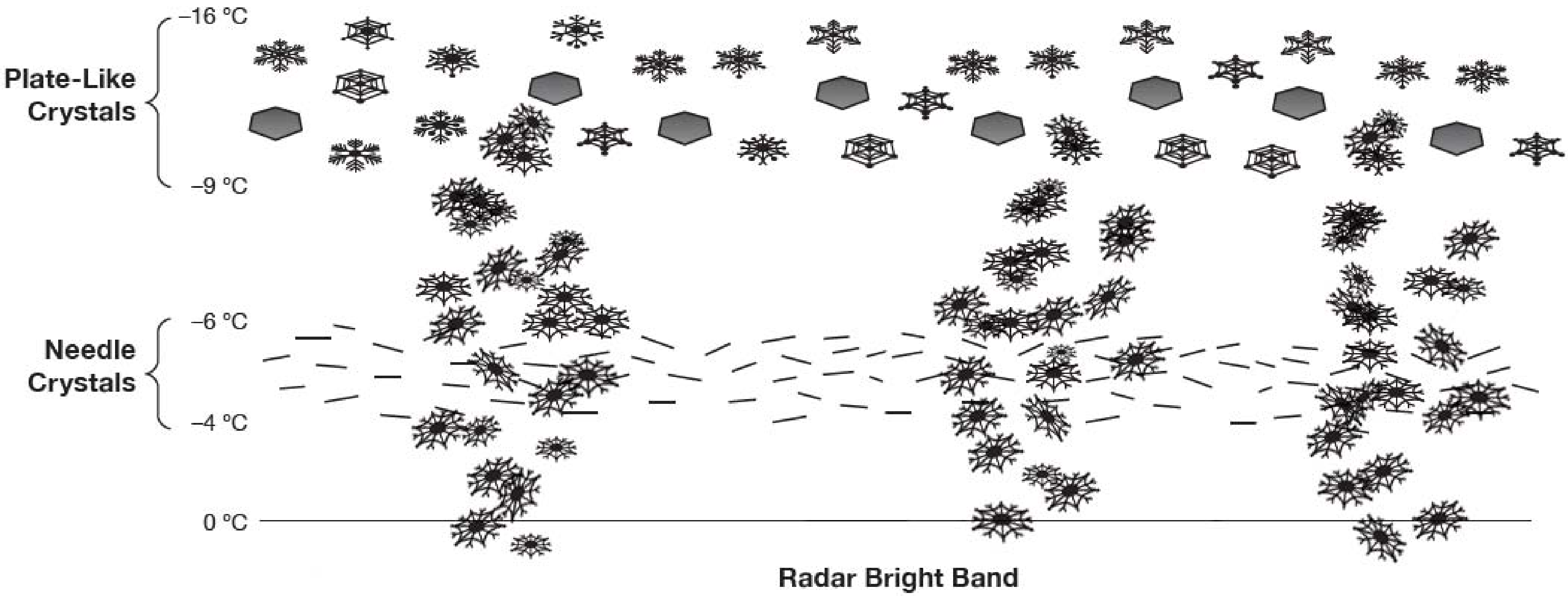
Reflectivity for crystal sandwich on January 10, 2017 (aircraft spiral ascent)



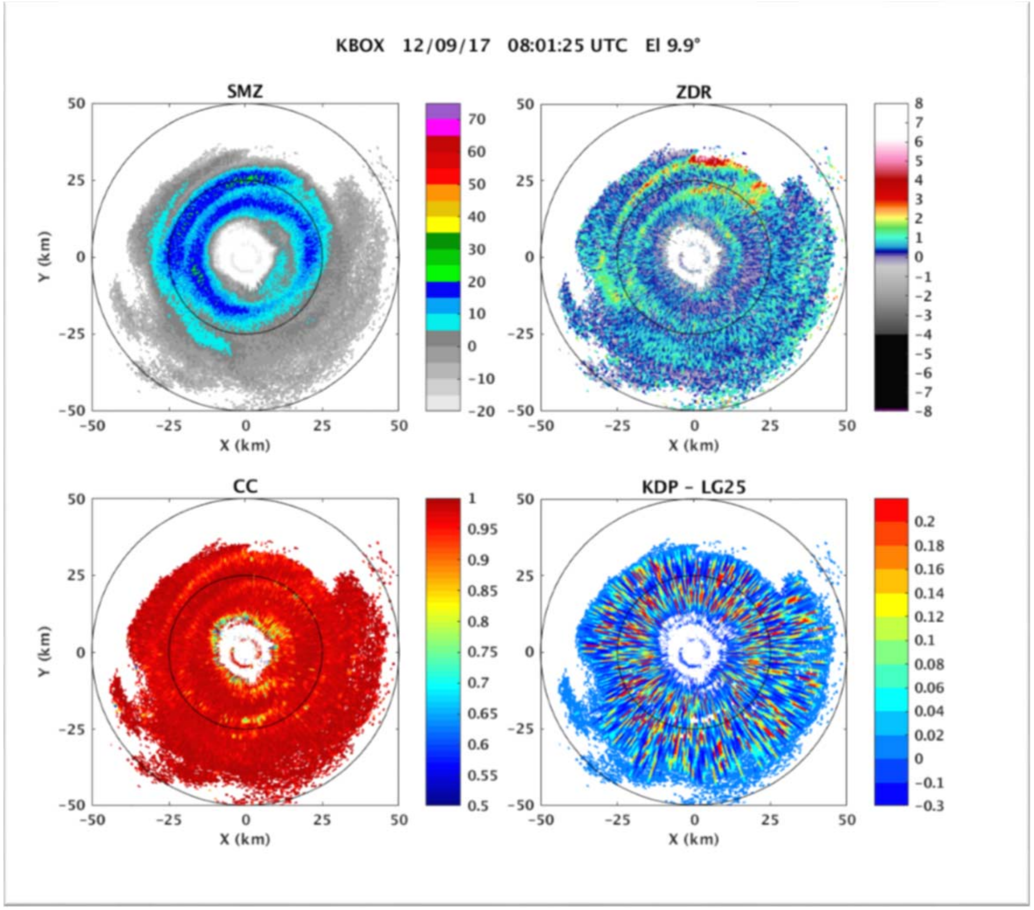
Further evidence for crystal sandwich from AIRS-II campaign (Wolde, 2006)



Destruction of Crystal Sandwich by Aggregation of Dendrite Crystals

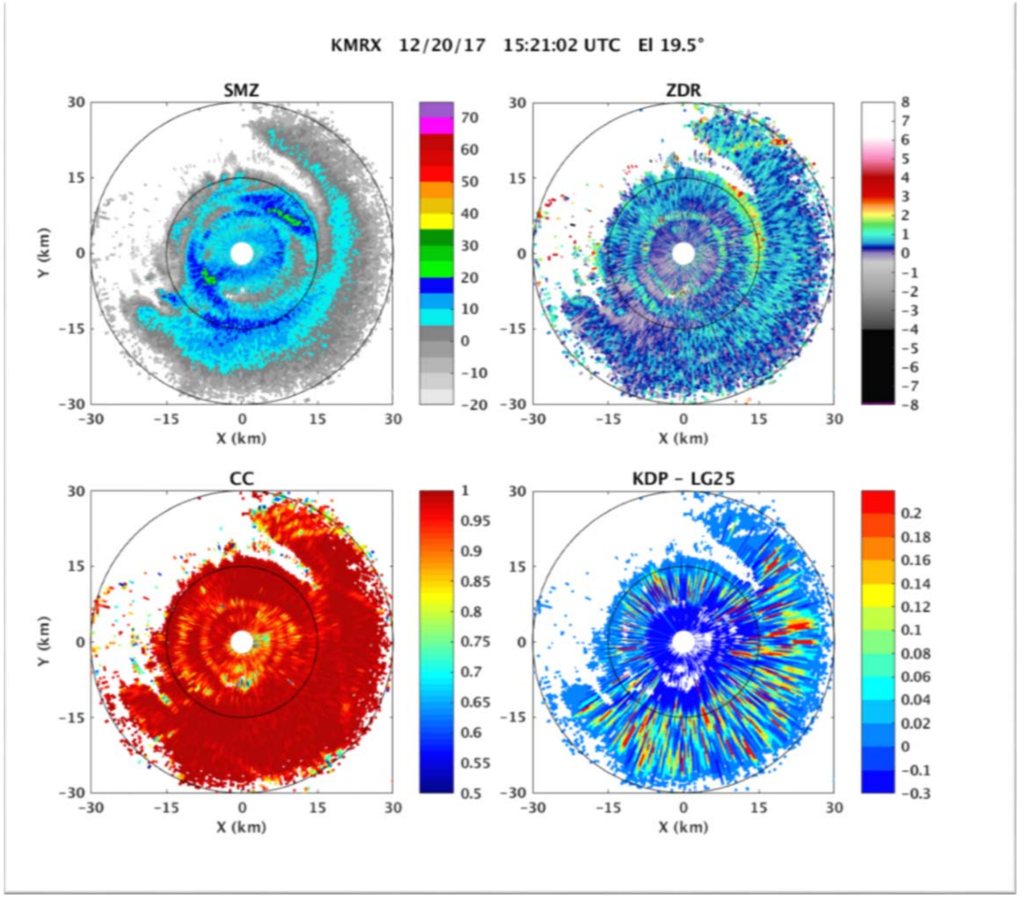


KBOX radar
December 9, 2017



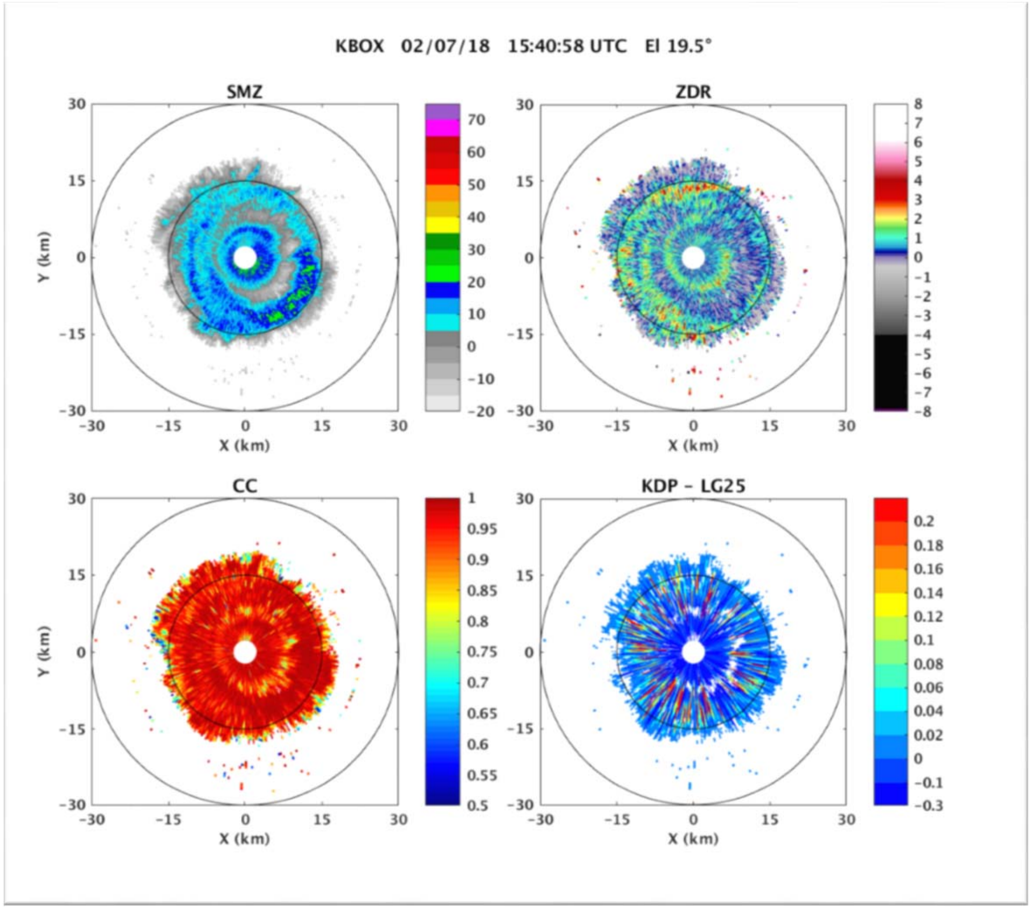
ZDR evidence for:
- **Dendrite 'bright band'**
- **Needle 'bright band'**
- **Conventional bright band**

KMHX radar
December 27, 2017



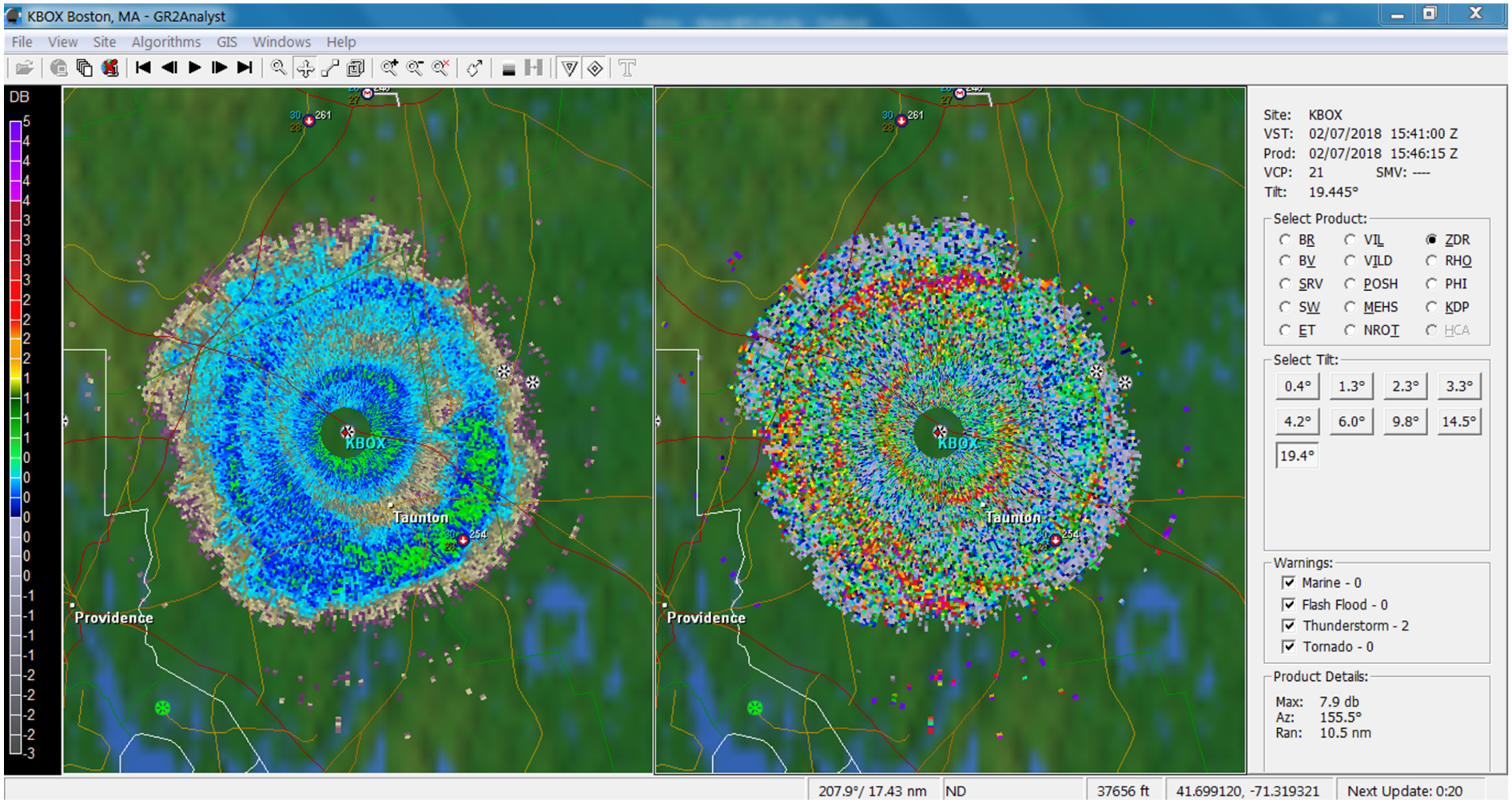
ZDR evidence for:
- **Dendrite ‘bright band’**
- **Needle ‘bright band’**
- **Conventional bright band**

KBOX radar
February 7, 2018



ZDR evidence for:
- **Dendrite 'bright band'**
- **Needle 'bright band'**
- **Conventional bright band**

KBOX radar
February 7, 2018



ZDR evidence for:
- **Dendrite ‘bright band’**
- **Needle ‘bright band’**
- **Conventional bright band**

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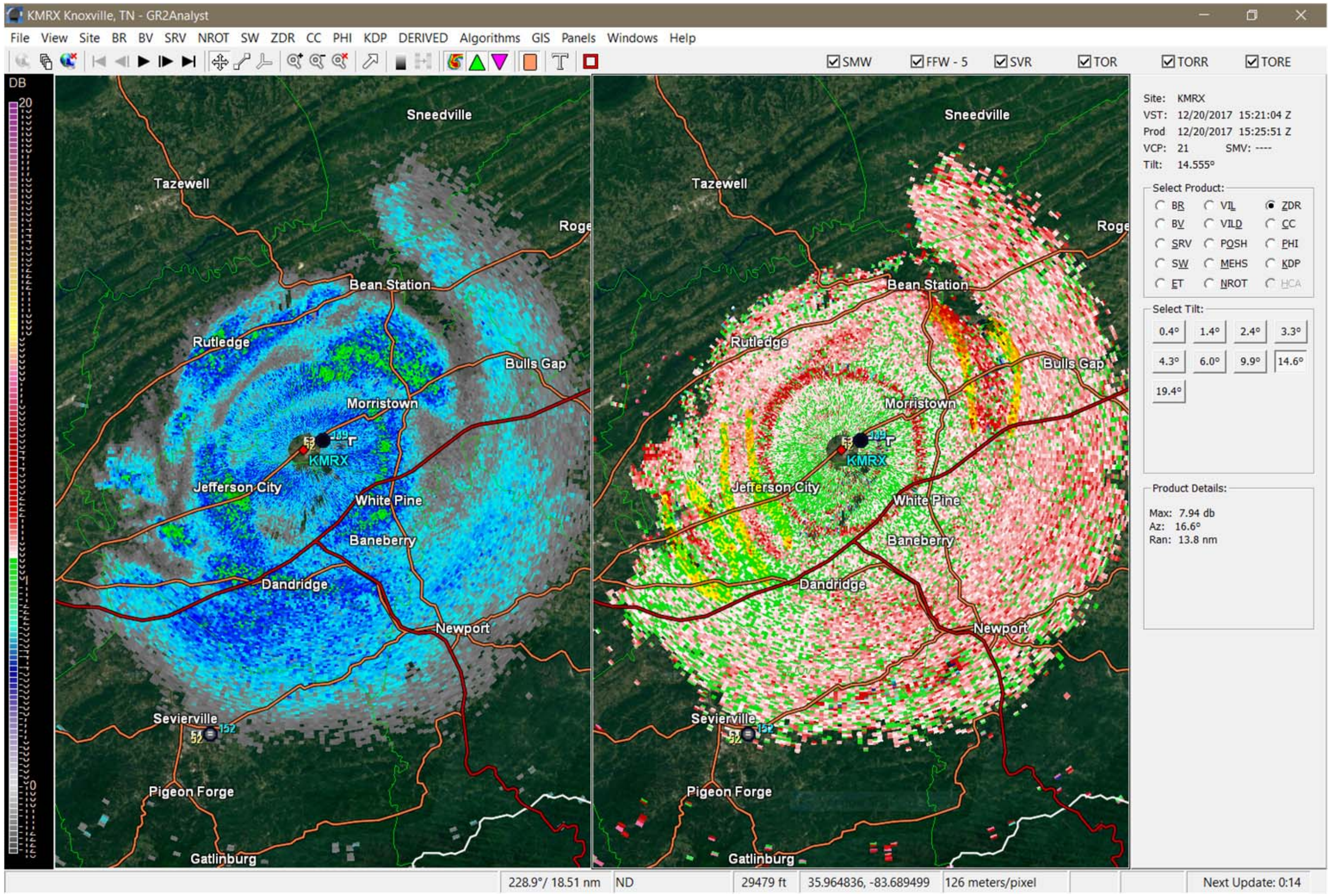
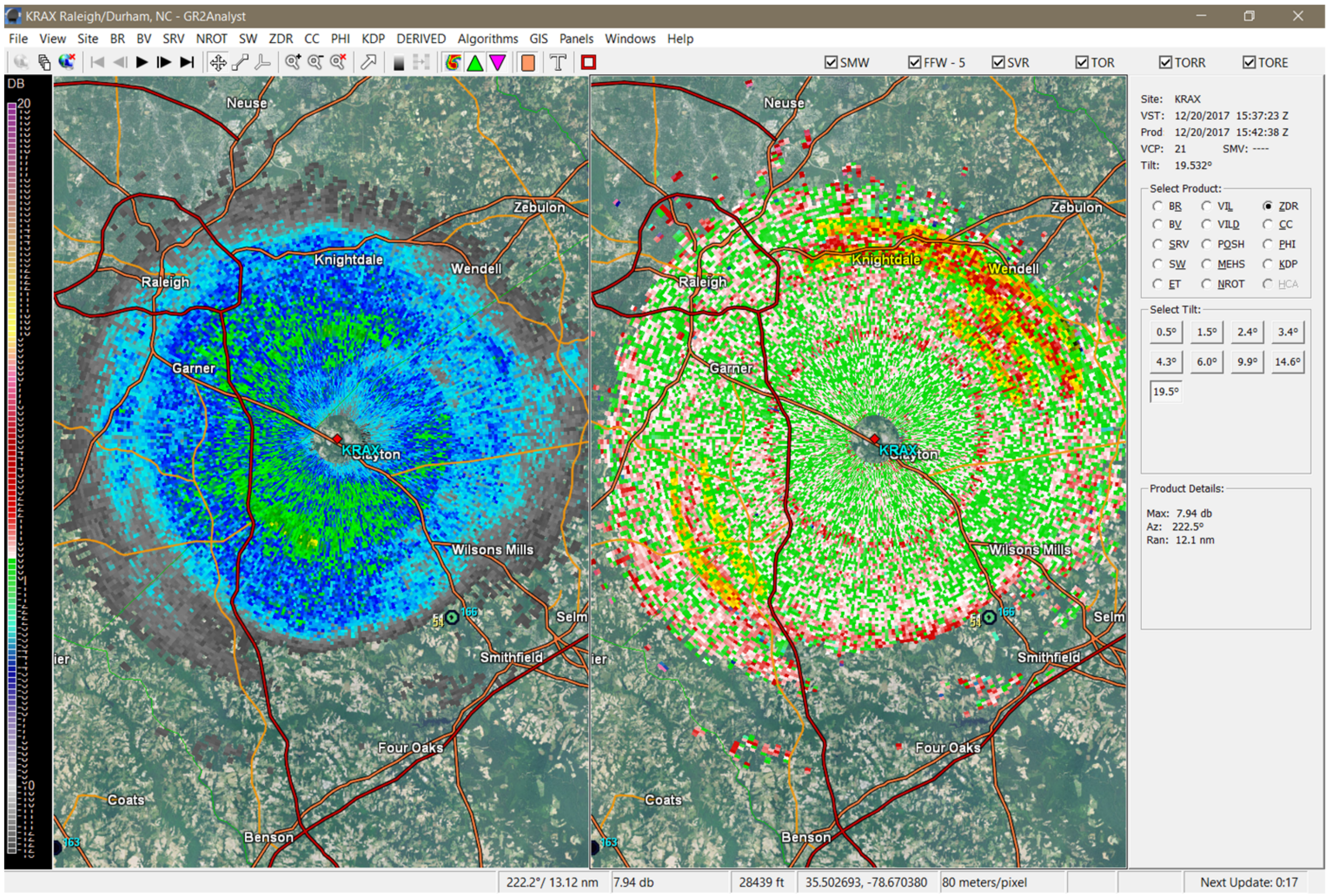
KMRX radar
December 20, 2017



ZDR evidence for:

- Dendrite 'bright band'
- Needle 'bright band'
- Conventional bright band

KRAX radar
December 20, 2017



ZDR evidence for:
- **Dendrite 'bright band'**
- **Needle 'bright band'**
- **Conventional bright band**

Conclusions

- The crystal sandwich with dendrites over needles is a prevalent structure in winter storms characterized by weak vertical ascent
- A layer of supercooled water is often found as ‘filling’ for the sandwich
- Deep spiral ascents/descents are best method for documenting this sandwich structure
- Aggregation of dendrites and their descent is destructive of simple sandwich structure