   

Development and Application of a Satellite-based Cloud Object-Tracking Methodology

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Key Objectives…

- Overview of an independent, automated satellite-based cloud object-tracking framework
- Brief description of existing UWCI / CTC algorithm
- Application of object tracking methodology as an automated validation vehicle for UWCI/CTC and various radar fields
- Object tracking / Validation system can have any number of fields added allowing for an objective inter-comparison of a fused set of data types

Warning Decision Support System- Integrated Information (WDSS-II; Lakshmanan et al. 2007)

Robust *Satellite-based* Object Tracking

GOES Top of Troposphere

UWCI algorithm nowcasts and Cloud Top Cooling rates as well as NEXRAD radar fields are remapped to an equally spaced lat/lon grid matching the WDSS merged output

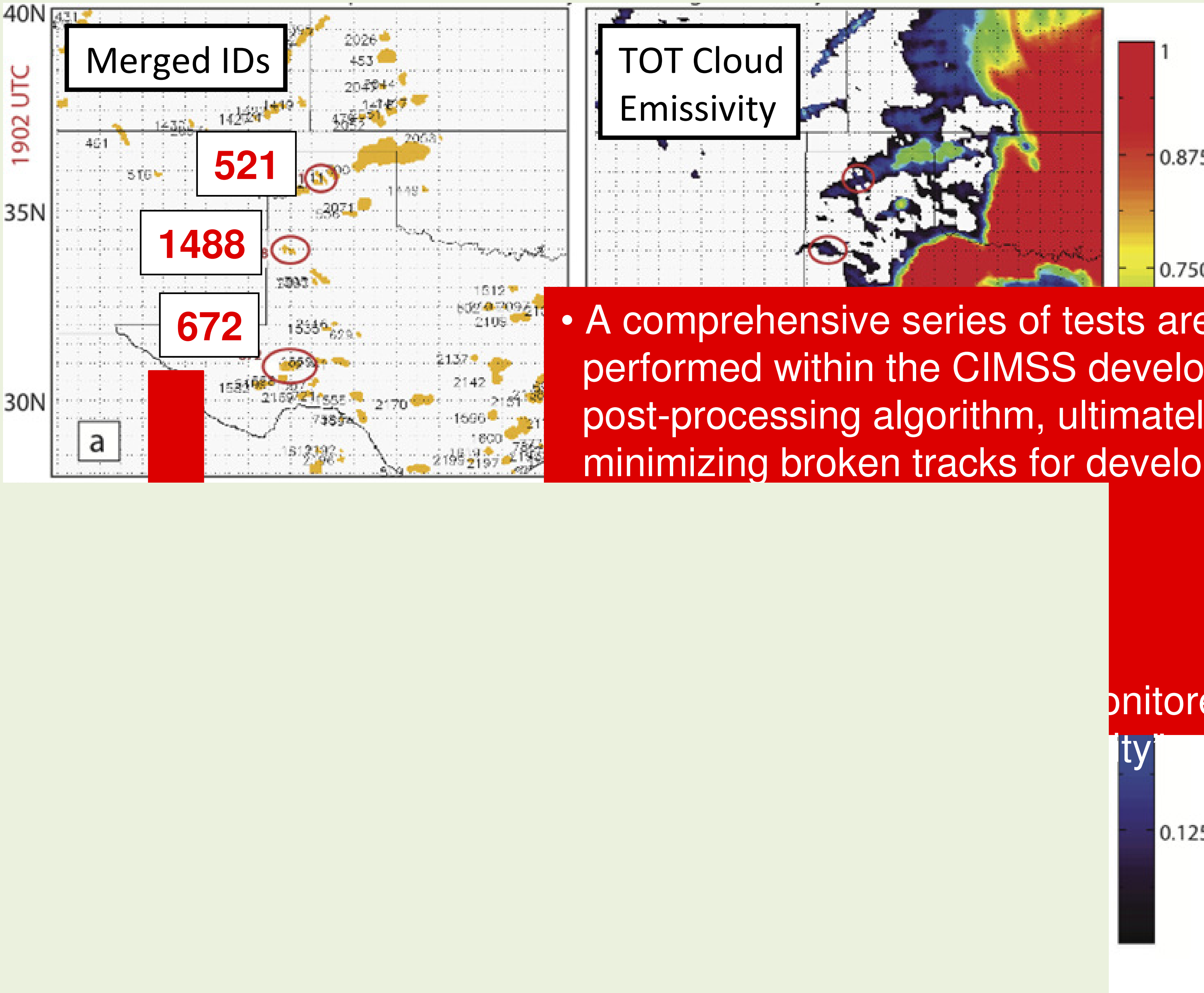
(WDSS-II)
Object Tracking

Provides an automated framework for validation of the UWCI/CTC algorithm vs. radar as well as a lead time analysis of different thresholds of CTC to various other radar field thresholds (i.e. VIL > 30 kg/m^2 or POSH > 50, etc.)

Set object tracking method:
OLDEST (age/centroid based)
see Lakshmanan et al. 2007
for full details

Additional mature convection WDSS-II configuration and UW-CIMSS post-processing allows for the continued tracking of anvil cores that are initially undetected in the infancy WDSS run. Mature objects are then remerged for additional times in the total object file to increase the likelihood of tracking the development of intense radar signatures of mature convective objects.

WDSS-II Object Tracking Example (29 April 2009)



- A comprehensive series of tests are performed within the CIMSS developed post-processing algorithm, ultimately minimizing broken tracks for developing

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UW Convective Initiation / Cloud Top Cooling (UWCI/CTC) Algorithm

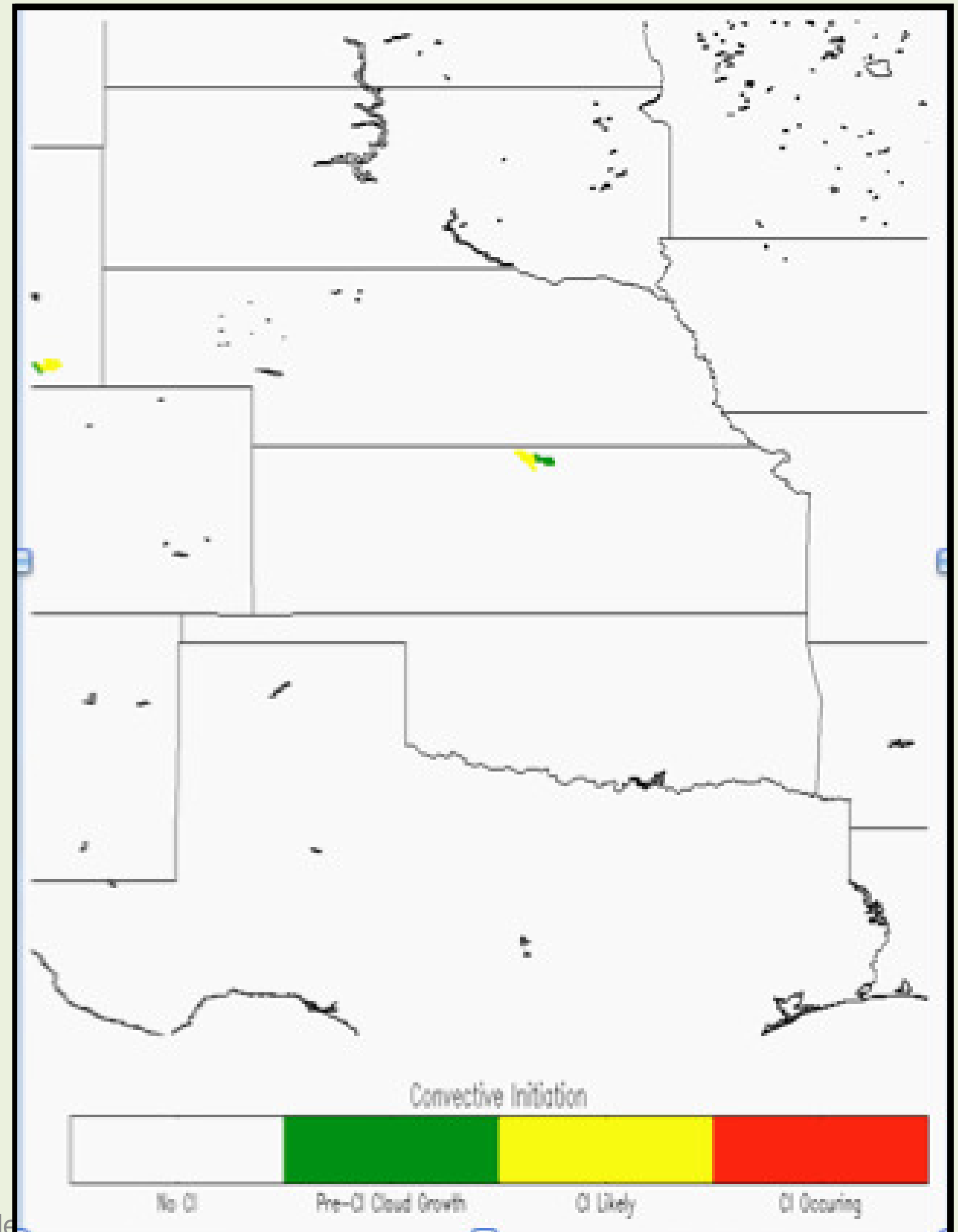
High-level algorithm overview

- Compute box-averaged 11 micron brightness temperature (**BT**) for current time and previous time, using specific categories from GOES Cloud Typing product

- Unfiltered Cloud Top Cooling (**CTC**) Rate is calculated by differencing box average 11 micron BT for current time from previous time

- Large/small box approach eliminates most of false CTC due to cloud motion (and additional checks reduce false cooling further)

- Combine cloud-top cooling information with cloud-top microphysical (phase/cloud type) transitions for convective initiation nowcasts

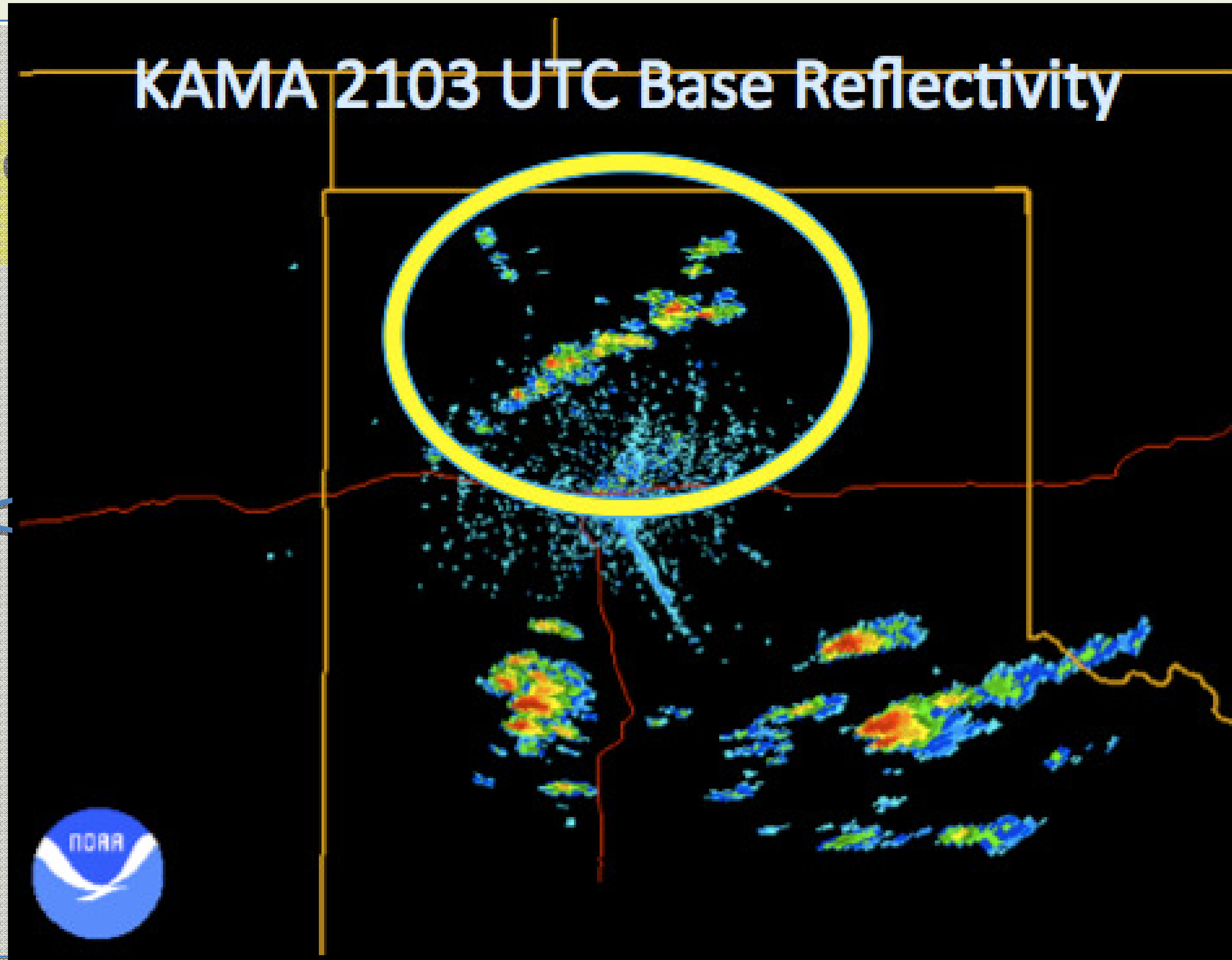


Reference: Sieglaff et al., 2011

UWCI/CTC Example: 29 April 2009 Texas Dryline Development

UWCI/Cloud Top Co
Signal at 2032 UTC

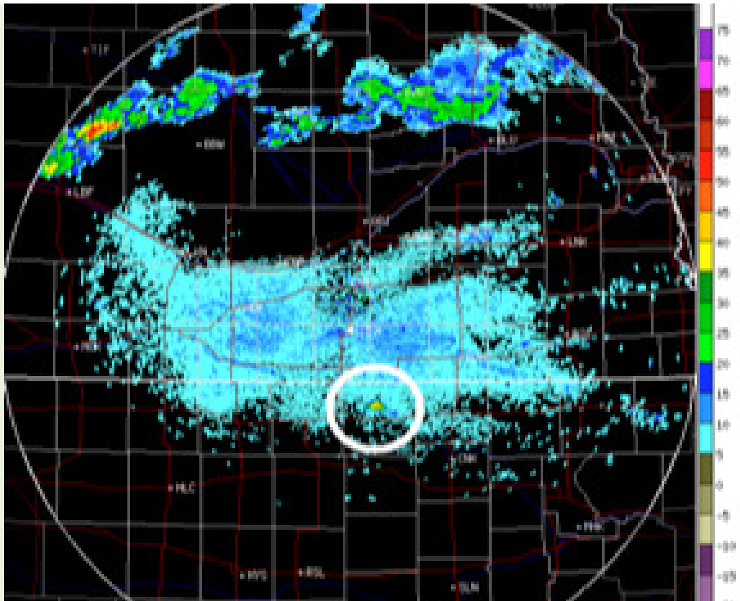
CI nowcast at 2015 UTC



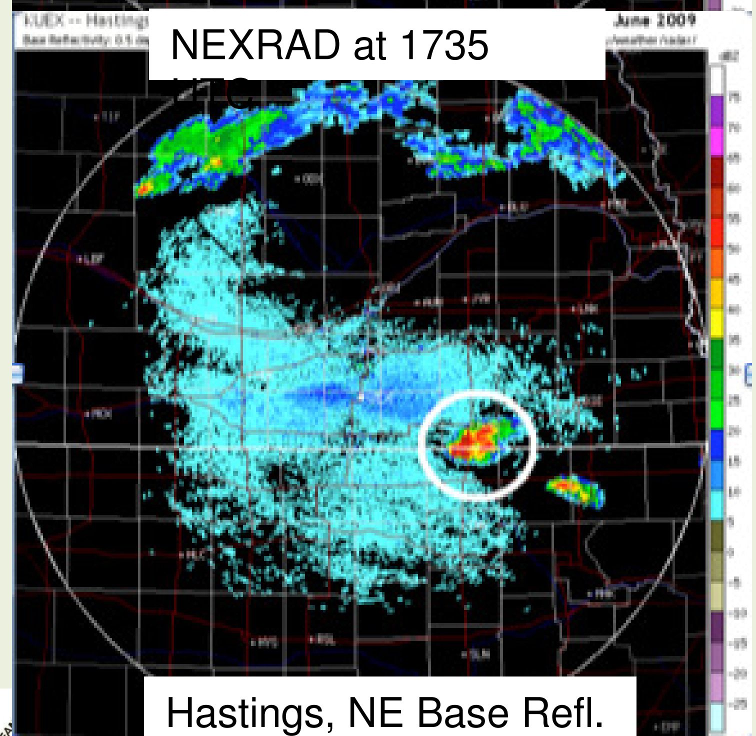
Example from June 17, 2009 over Northern KS

First UWCI/CTC cooling rate signal precedes NEXRAD 35 dBz signal by 37 minutes

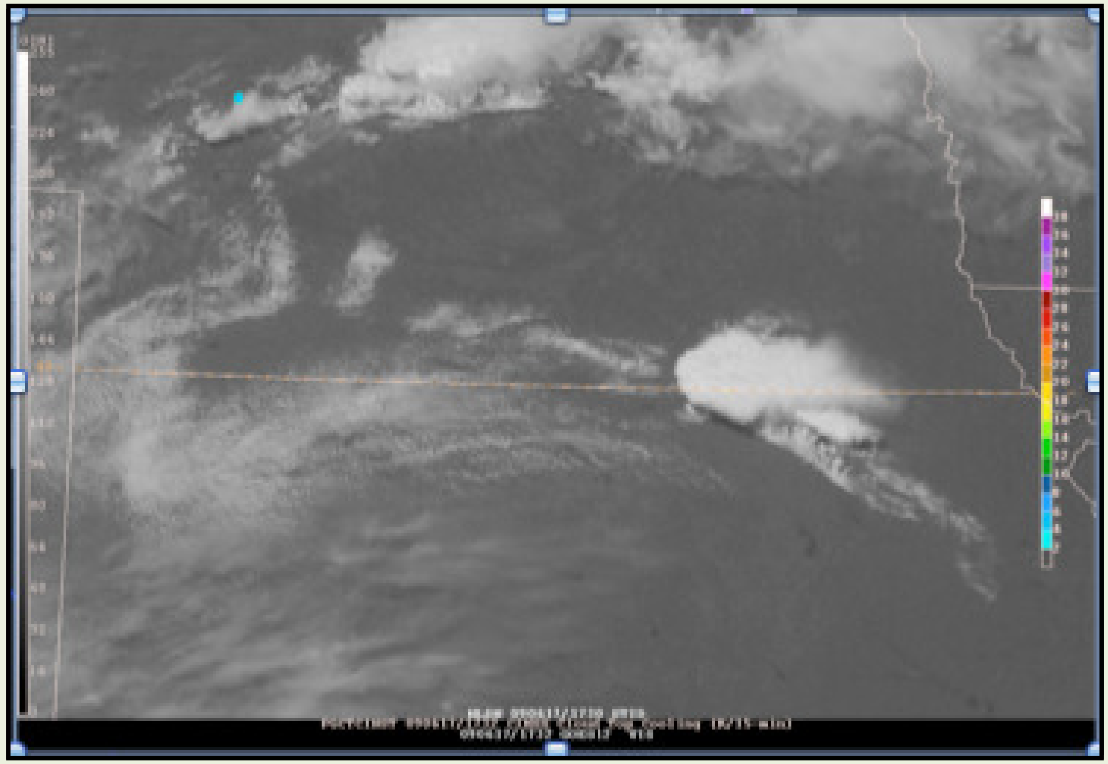
First NEXRAD 35+ dBz echo at 1622 UTC



NEXRAD at 1735 UTC



Hastings, NE Base Refl.



1732 UTC- Severe thunderstorm on radar

GOAL: To provide additional support and warning leadtime for NWS and aviation forecasters by addressing the following type of question:

"If the UWCI / CTC algorithm has a developing convective cloud with a cooling rate of -15 K / 15 min, how often will that developing storm achieve a VIL of 40 kg/m^2 ?

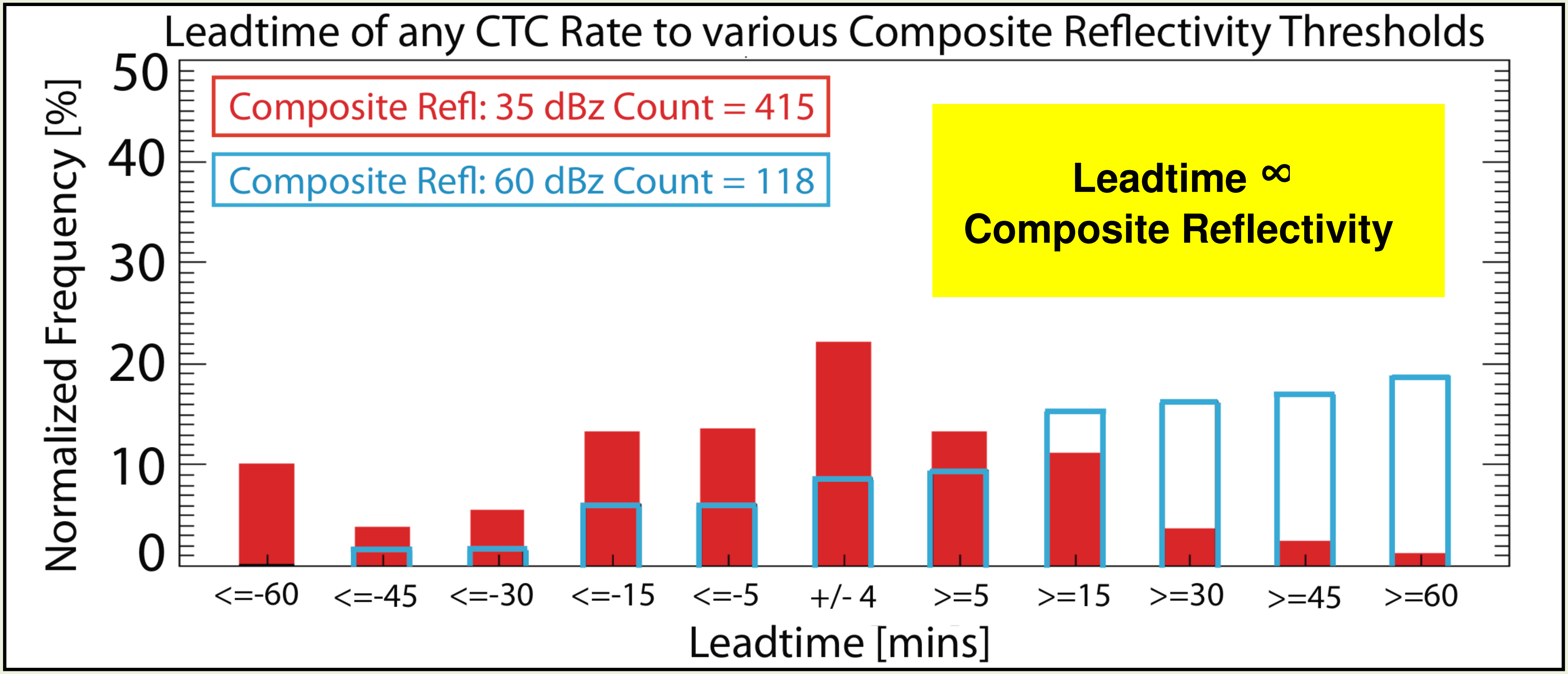
.. and just as importantly, with what lead time?"

For aviation purposes:

Since regions of cooling cloud tops indicate vertical cloud growth, a nowcast of CTC can help detect regions of elevated commercial passenger safety risk resulting from Convectively-Induced and Clear-Air Turbulence

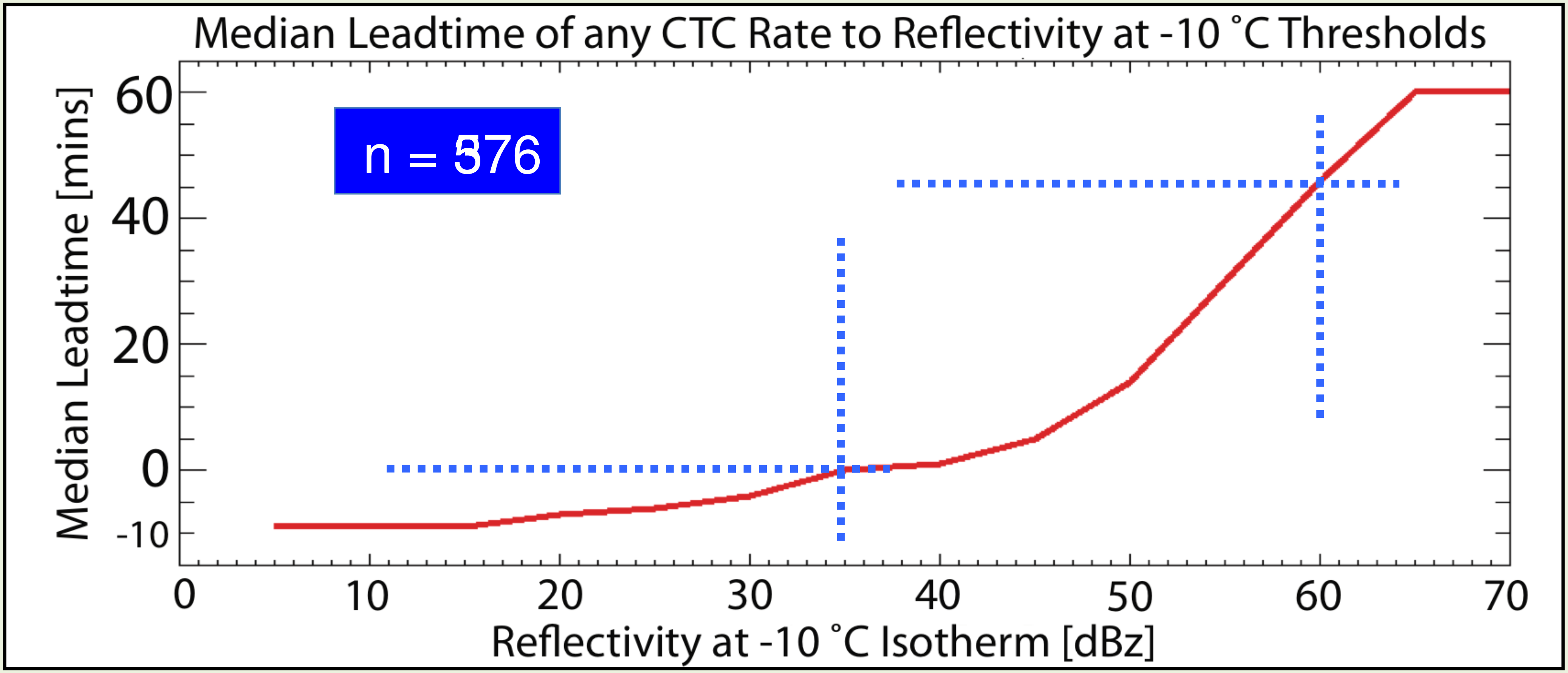
Various radar fields and thresholds to be studied are those most frequently observed with deep convection often producing severe hail, wind gusts and tornadoes.

Leadtime: CTC Rate to thresholds of Composite Reflectivity



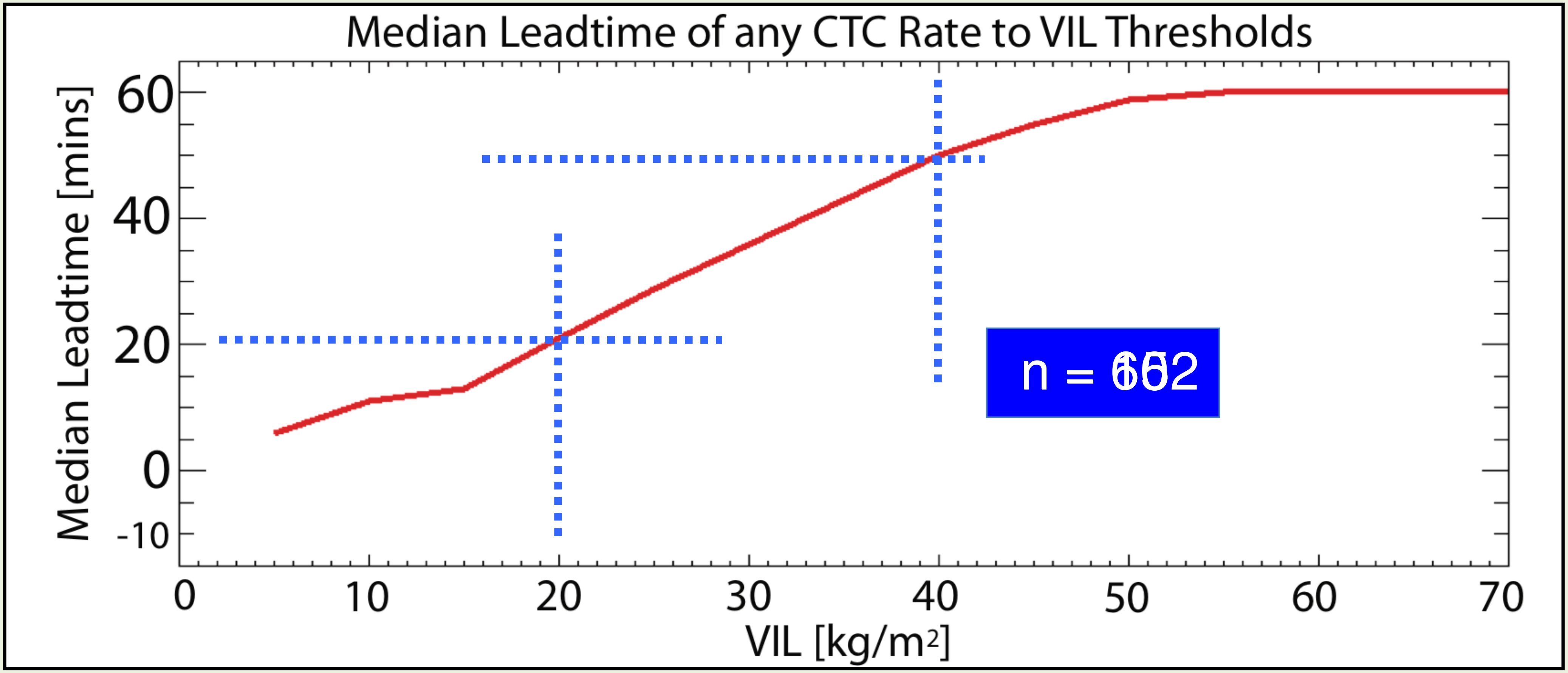
There is a direct proportionality between the amount of leadtime in minutes and intensity of composite reflectivity for clouds cooling at a rate faster than -4 K / 15 min

Median Leadtime: CTC Rate to various thresholds of Reflectivity at -10 ℃ Isotherm

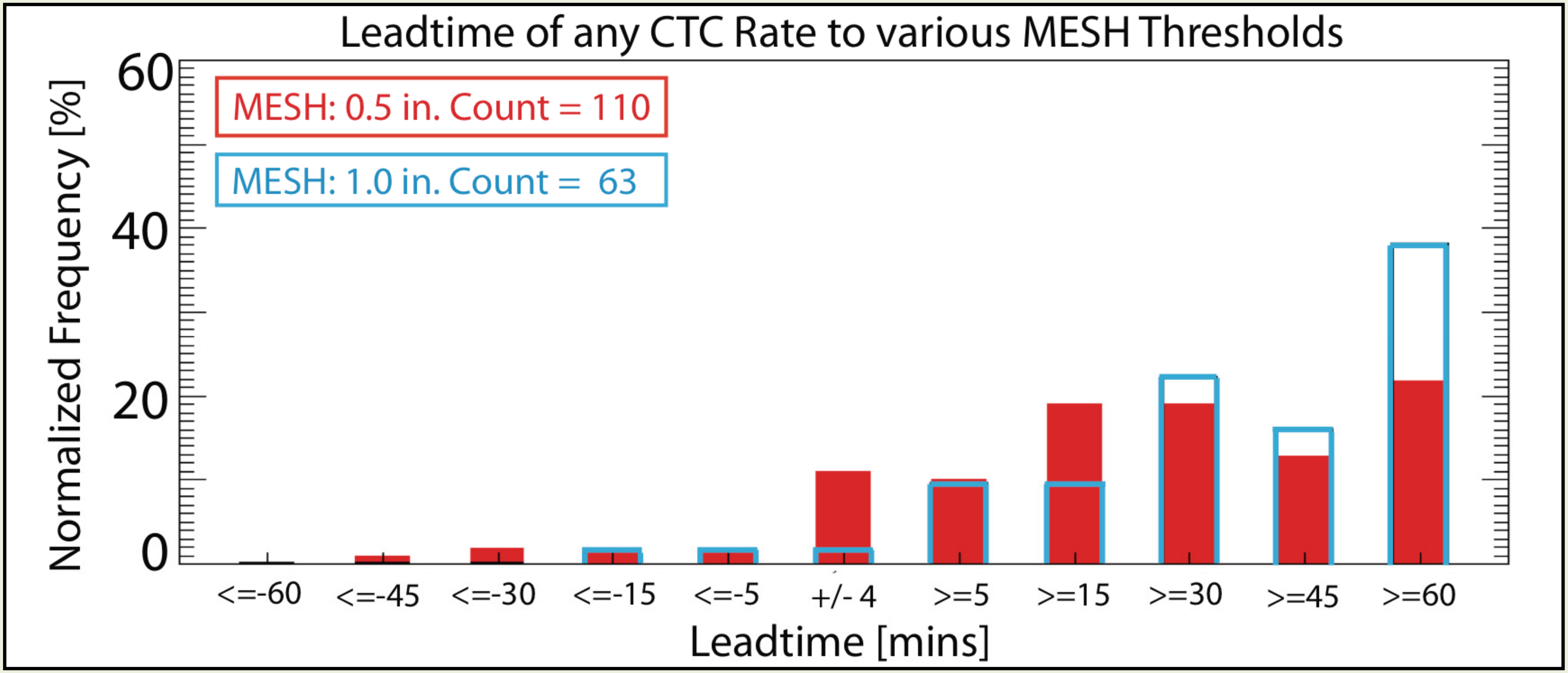


Reference: Gremillion and Orville, 1999

Median Leadtime: CTC Rate to various thresholds of Vertically Integrated Liquid (VIL)



Leadtime: CTC Rate to thresholds of Max Expected Hail Size (MESH)



A median leadtime of 15+ minutes prior to a MESH of 0.5” hail and 30+ minutes before a MESH of severe hail was observed in 80% of cooling objects, respectively

Wrap-up…

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- Monitoring cloud top cooling rates (a proxy for the intensity of vertical cloud growth) has diagnostic potential for identifying regions of elevated CAT / CIT aviation risk

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- Although designed for radar object tracking, WDSS-II also provides a robust framework for satellite-based cloud object tracking
- This framework utilizes an independent data field to generate objects and is therefore an ideal validation and analysis tool for various satellite, radar and model fields
- Monitoring cloud top cooling rates (a proxy for the intensity of vertical cloud growth) has diagnostic potential for identifying regions of elevated CAT / CIT aviation risk
- Preliminary results indicate that clouds exhibiting a cloud top cooling rate faster than -4 K /15 min tend to precede significant radar signatures by 20+ minutes (a more in-depth breakdown of CTC rates vs radar is underway)

Next steps…

- Conduct automated validation of UWCI / CTC algorithm against reflectivity on -10℃ isotherm using robust satellite-based cloud object-tracking methodology

- Further break down CTC thresholds to extract various leadtime statistics for radar fields as a function of *intensity* of vertical cloud growth

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