The GOES Enterprise Cloud Product Suite: Convective Snow Nowcasting Applications in the Great Lakes Region

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NOAA/NWS: WFO Marquette, Gaylord, Buffalo

2023 Great Lakes Operational Meteorology Workshop, Madison, WI
25 May 2023

NOAA GOES-R

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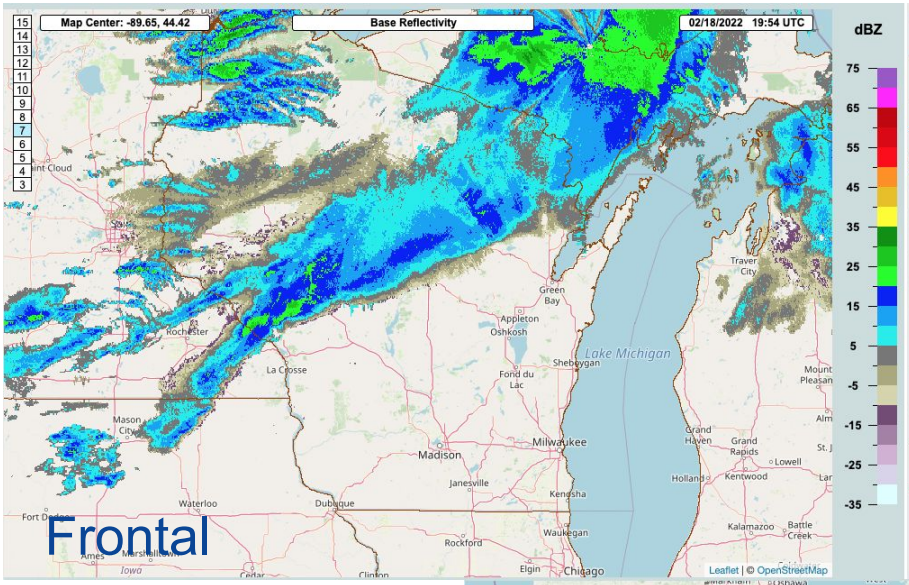
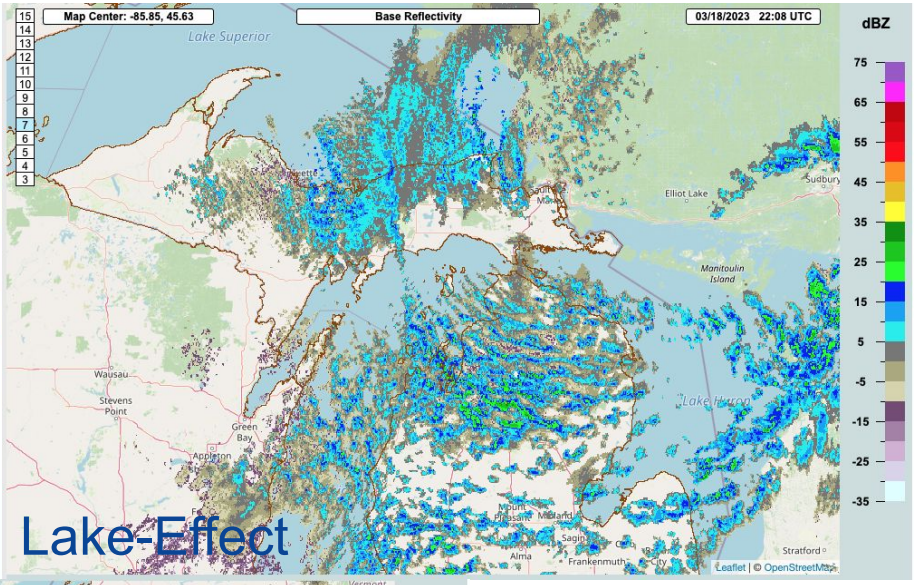
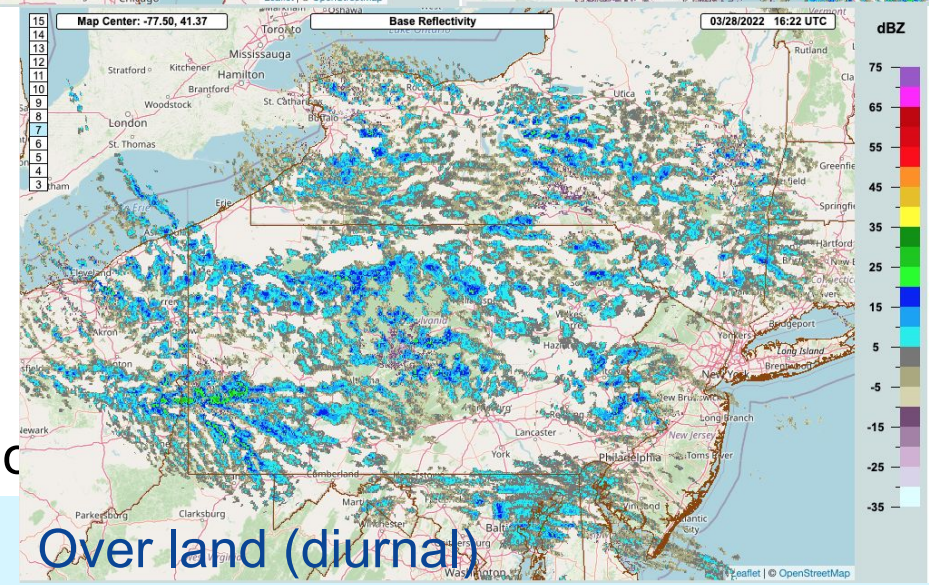
Motivation

- Convective Snow Squalls: Improve situational awareness
- GOES Cloud Products: Applications
- Snowfall Regimes: Understand physical processes

Convective Snow Squalls*







*Sho ent

The New York Times

Snow Squall Leads to 50-Car Pileup on Pennsylvania Highway

Several tractor-trailers were involved in the chain-reaction crash on Interstate 81, about 50 miles northeast of Harrisburg, Pa. The wreckage extended for about a mile, the authorities said.

Give this article 90

Sudden and blinding snow caused 80 vehicles to crash on Interstate 81 northeast of Harrisburg, Pa., on Monday. Two dozen people were taken to hospitals, the authorities said. Mike Nestor

By Neil Vigdor and Johnny Diaz

Published March 28, 2022

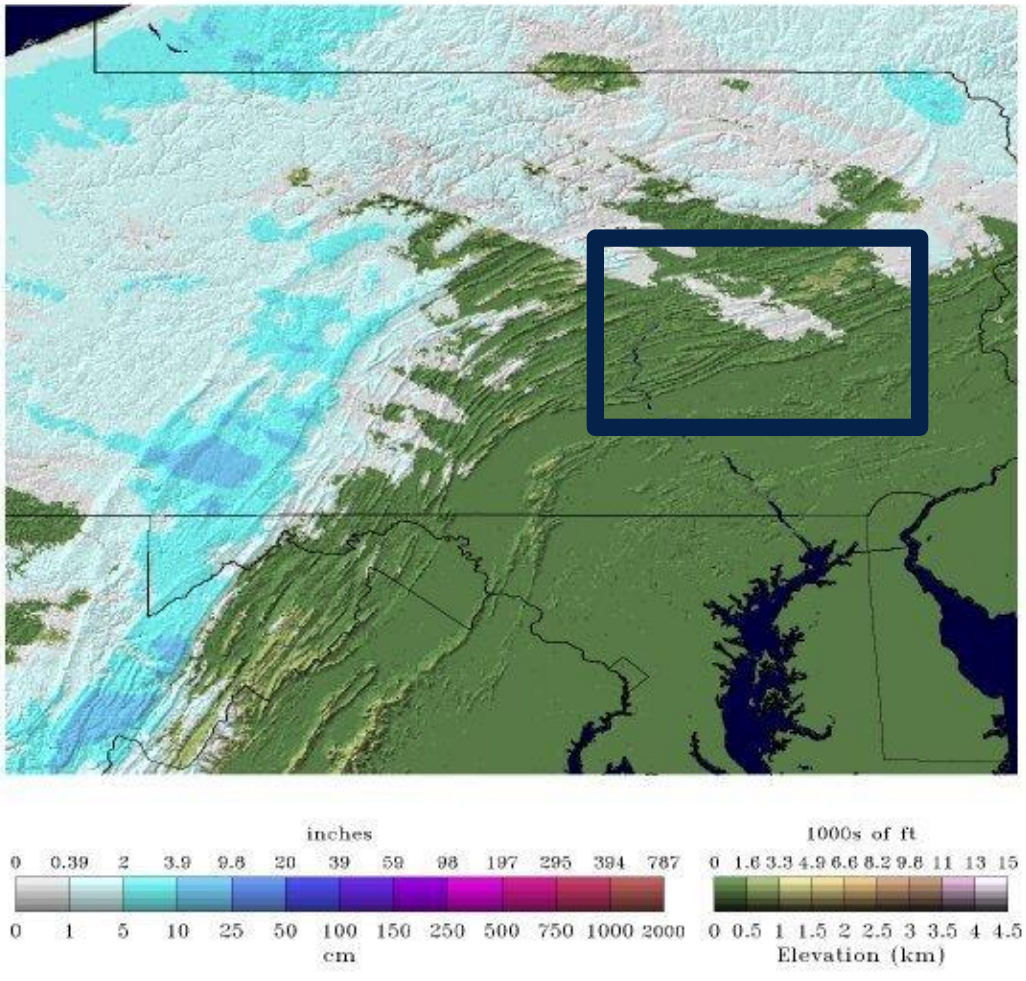
28 March 2022

National Snow Analysis

OWP | OFFICE OF WATER PREDICTION

Snow Depth

2022-03-28 06 UTC



National Snow Analysis

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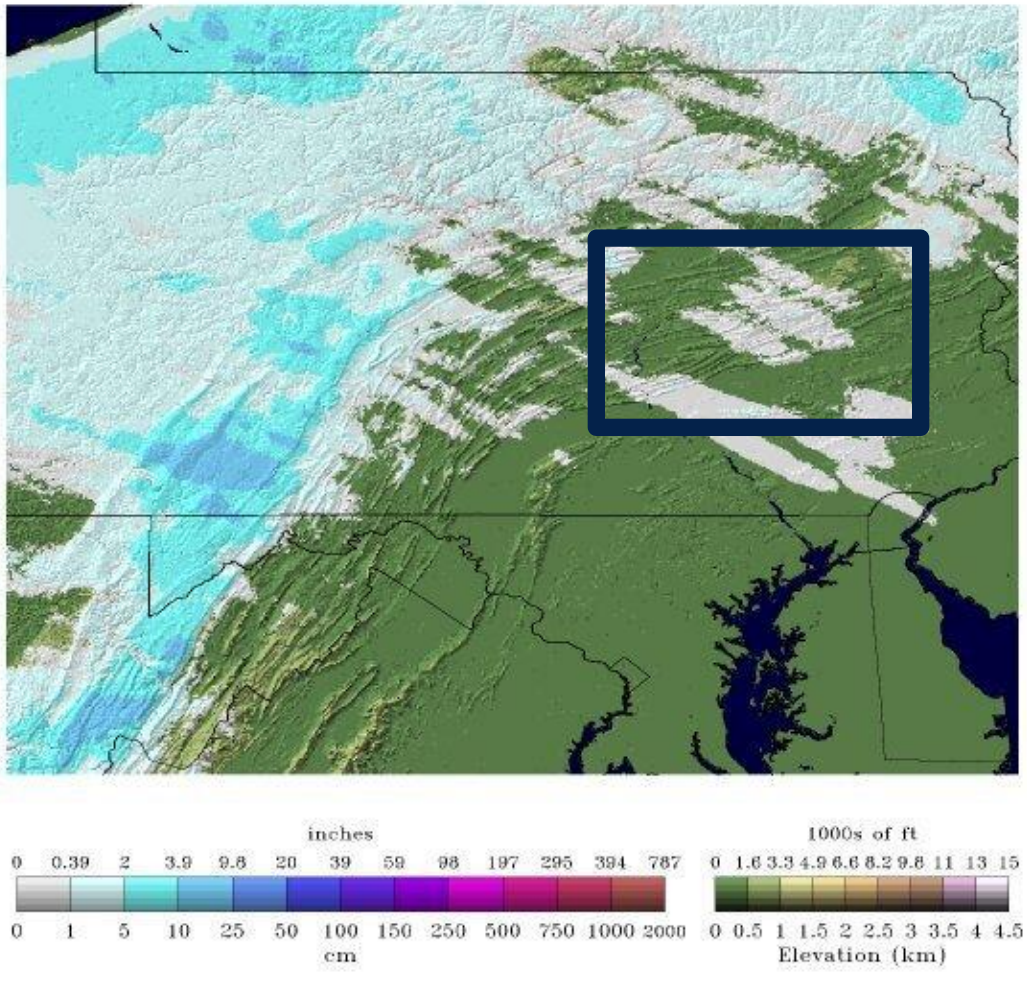
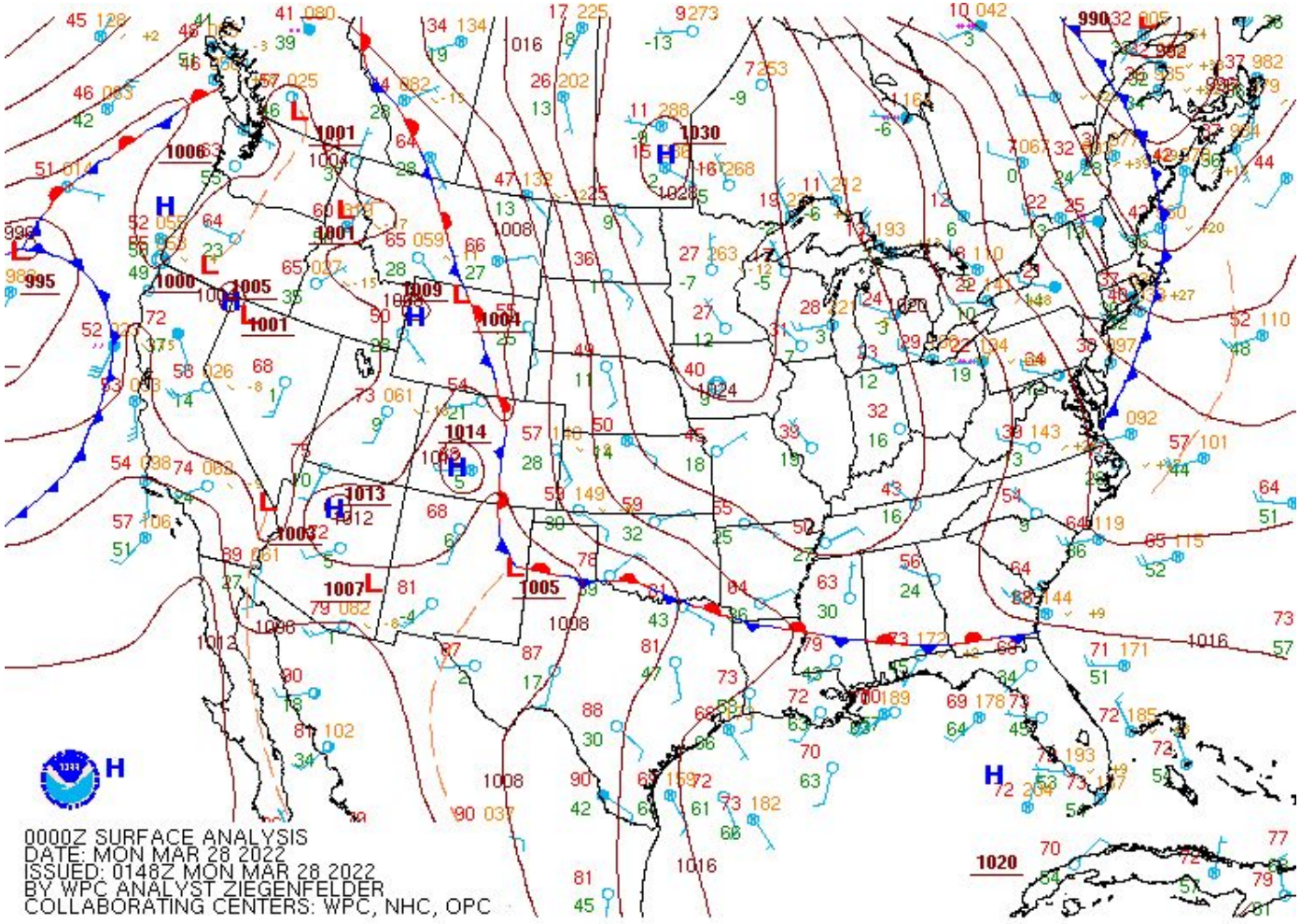
Snow Depth

2022-03-29 06 UTC

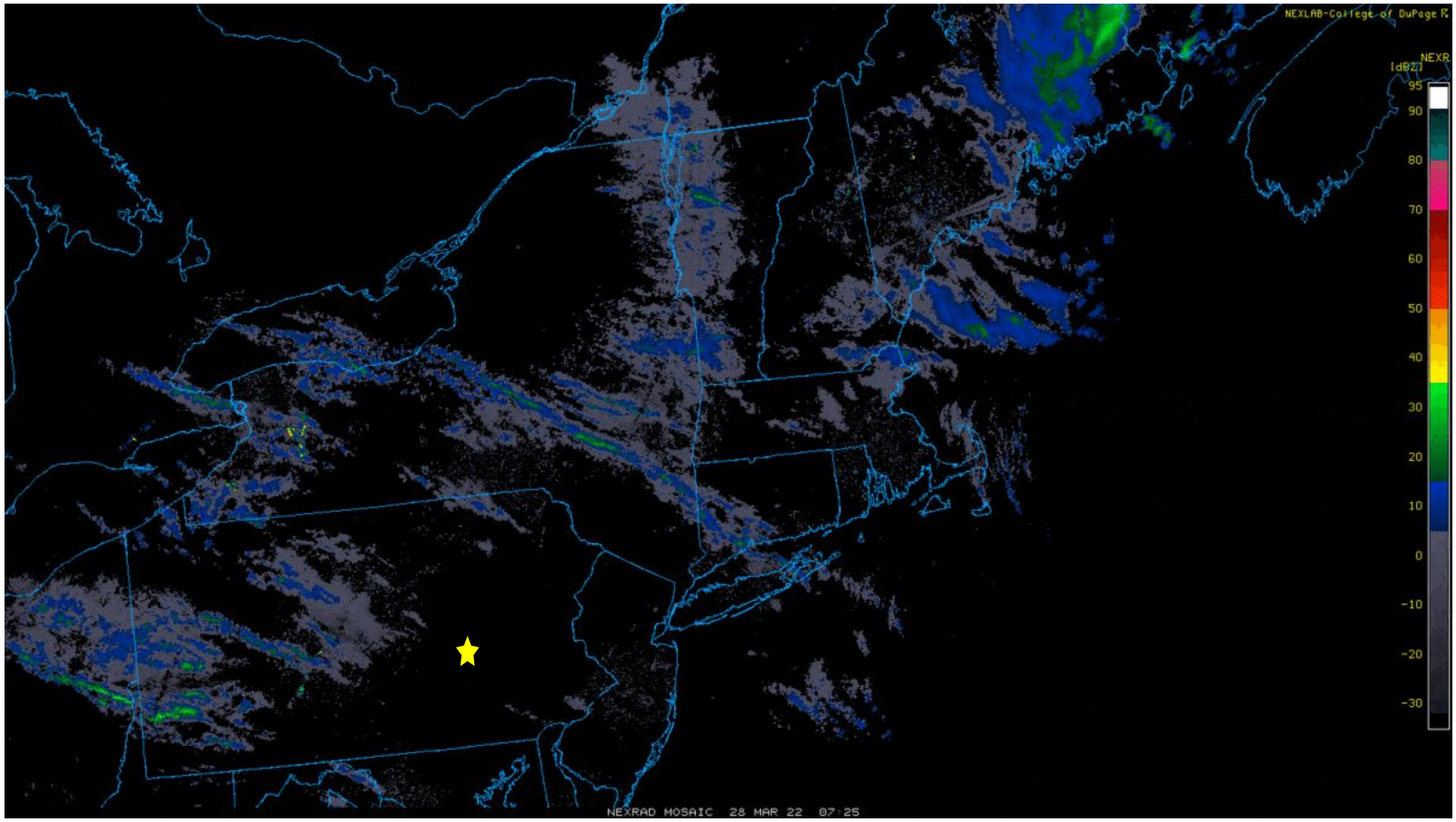


Postfrontal Environment



1800Z 28 March 2022

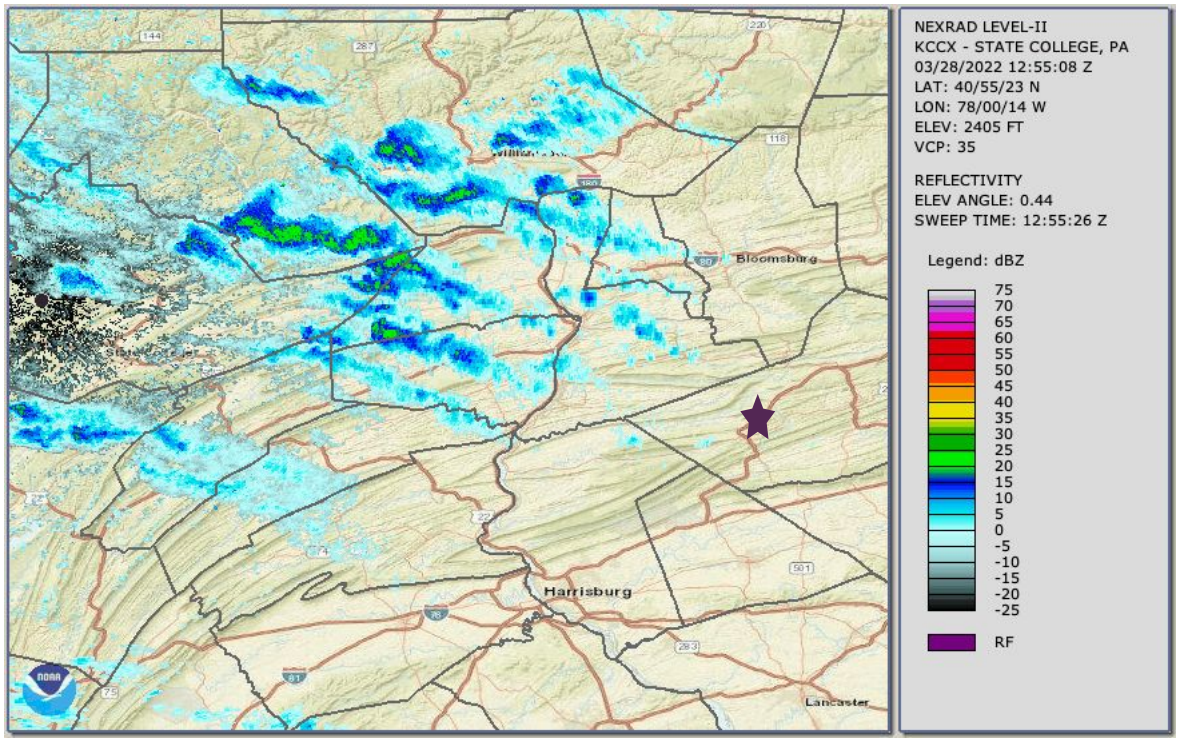
NEXRAD Composite



28 March 2022 (0730-2200 UTC)

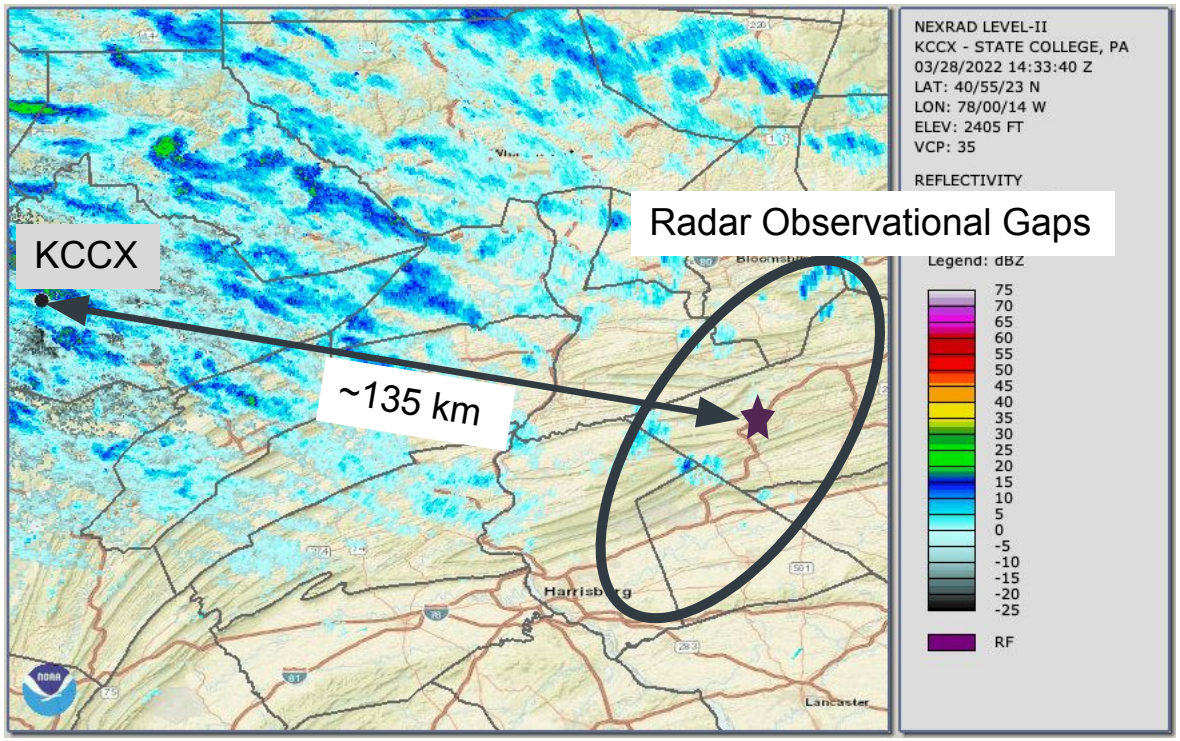
Transition: Banded lake-effect (early) to cellular (later) convection

KCCX Base Scan



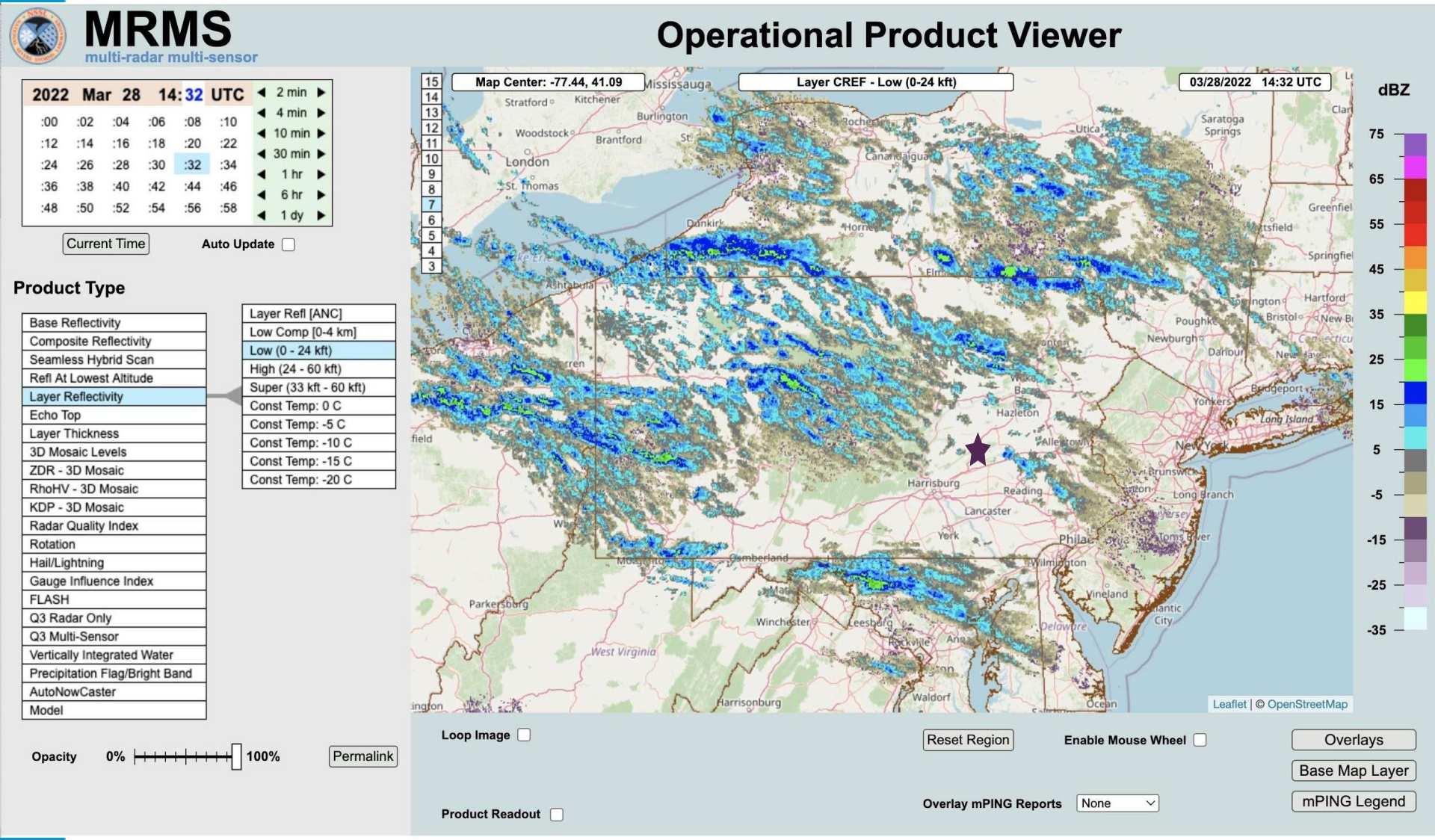
28 March 2022 (1255-1602 UTC)

KCCX Base Scan

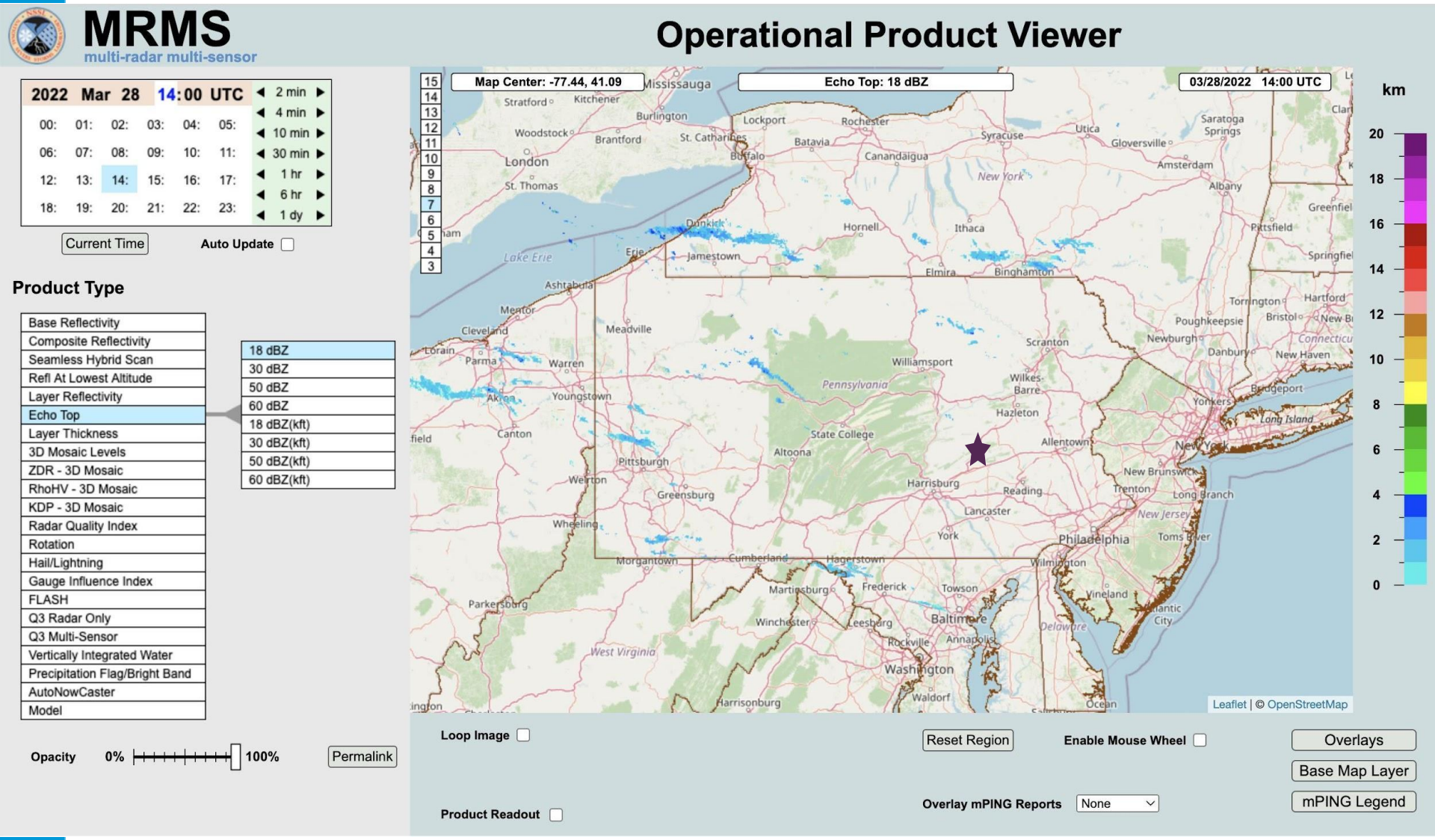


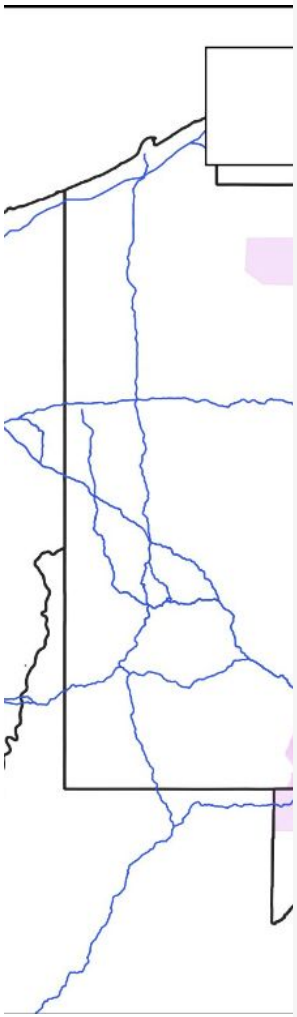
28 March 2022 (1430 UTC)

MRMS Merged Radar Reflectivity



MRMS 18 dBZ Echo Top Height





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795
WWUS51 KCTP 281500
SQWCTP

BULLETIN - IMMEDIATE BROADCAST REQUESTED
Snow Squall Warning
National Weather Service State College PA
1100 AM EDT Mon Mar 28 2022

PAC027-033-087-281600-
/O.NEW.KCTP.SQ.W.0009.220328T1500Z-220328T1600Z/
Centre PA-Clearfield PA-Mifflin PA-
1100 AM EDT Mon Mar 28 2022

The National Weather Service in State College PA has issued a

* Snow Squall Warning for...
  Southwestern Centre County in central Pennsylvania...
  Central Clearfield County in central Pennsylvania...
  North central Mifflin County in central Pennsylvania...

* Until noon EDT.

* At 1059 AM EDT, a dangerous snow squall was located along a line
  extending from S.B. Elliot State Park to Plymptonville to near
  Lecontes Mills to Moshannon to Milesburg, moving southeast at 15
  mph.

  HAZARD...Extremely poor visibility in snow and blowing snow. Wind
           gusts greater than 30 mph.

  SOURCE...Radar indicated.

  IMPACT...Dangerous life-threatening travel.

For those driving on Interstate 80, this includes areas between the
Dubois Route 255 and Snow Shoe exits, specifically from mile markers
107 to 144.

This includes Interstate 99 between mile markers 65 and 68...and from
mile markers 73 to 81.

Locations impacted include...
Clearfield, Bellefonte, Philipsburg, Boalsburg, Pleasant Gap,
Woodland, Lemont, Houserville, Hyde, Centre Hall, Plymptonville and
Chester Hill.
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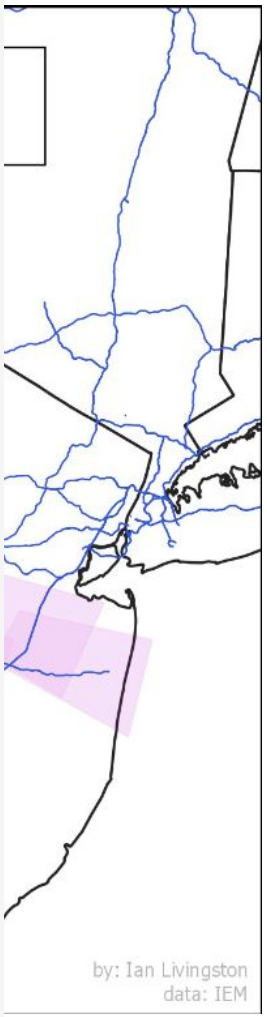
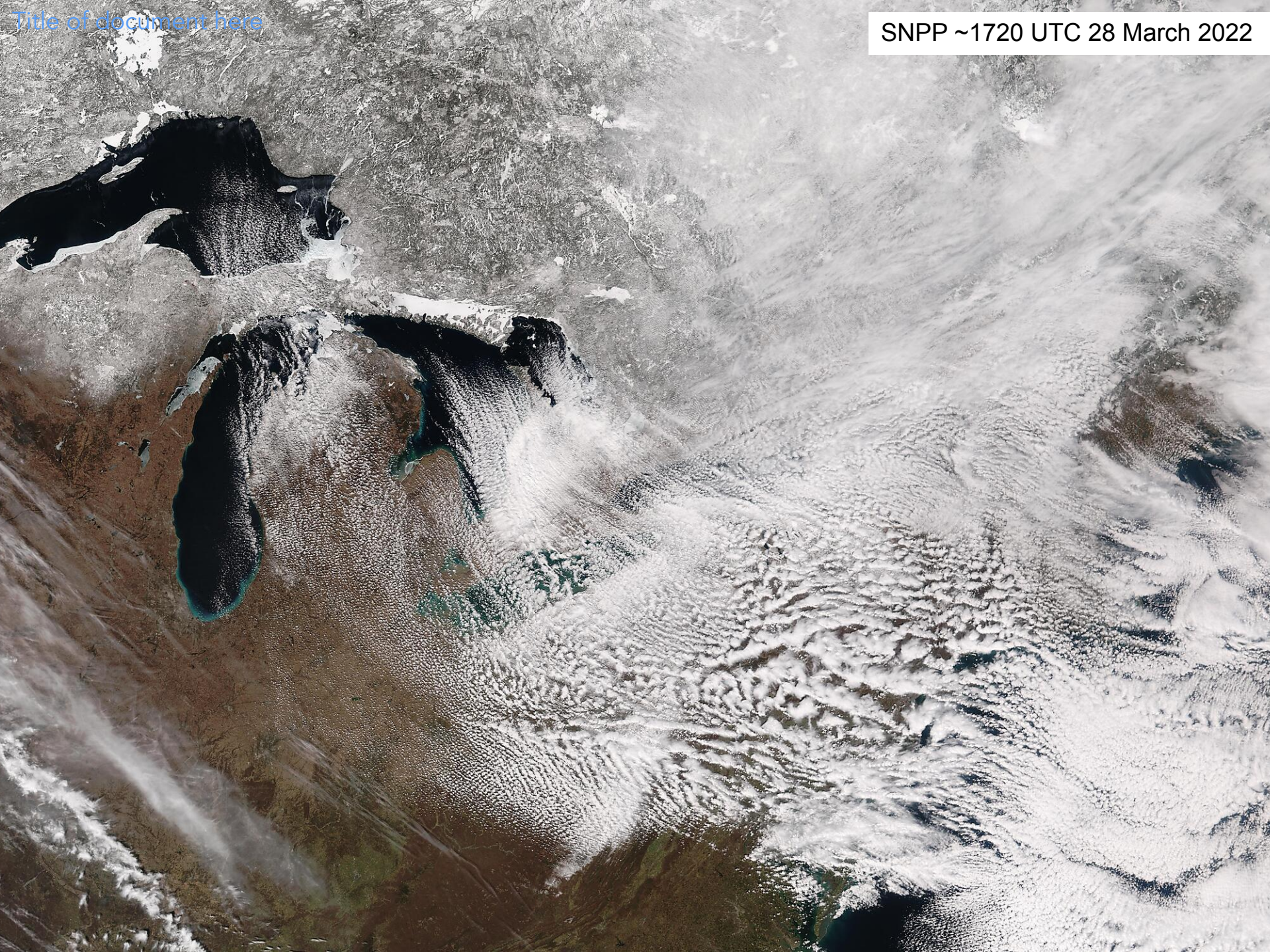
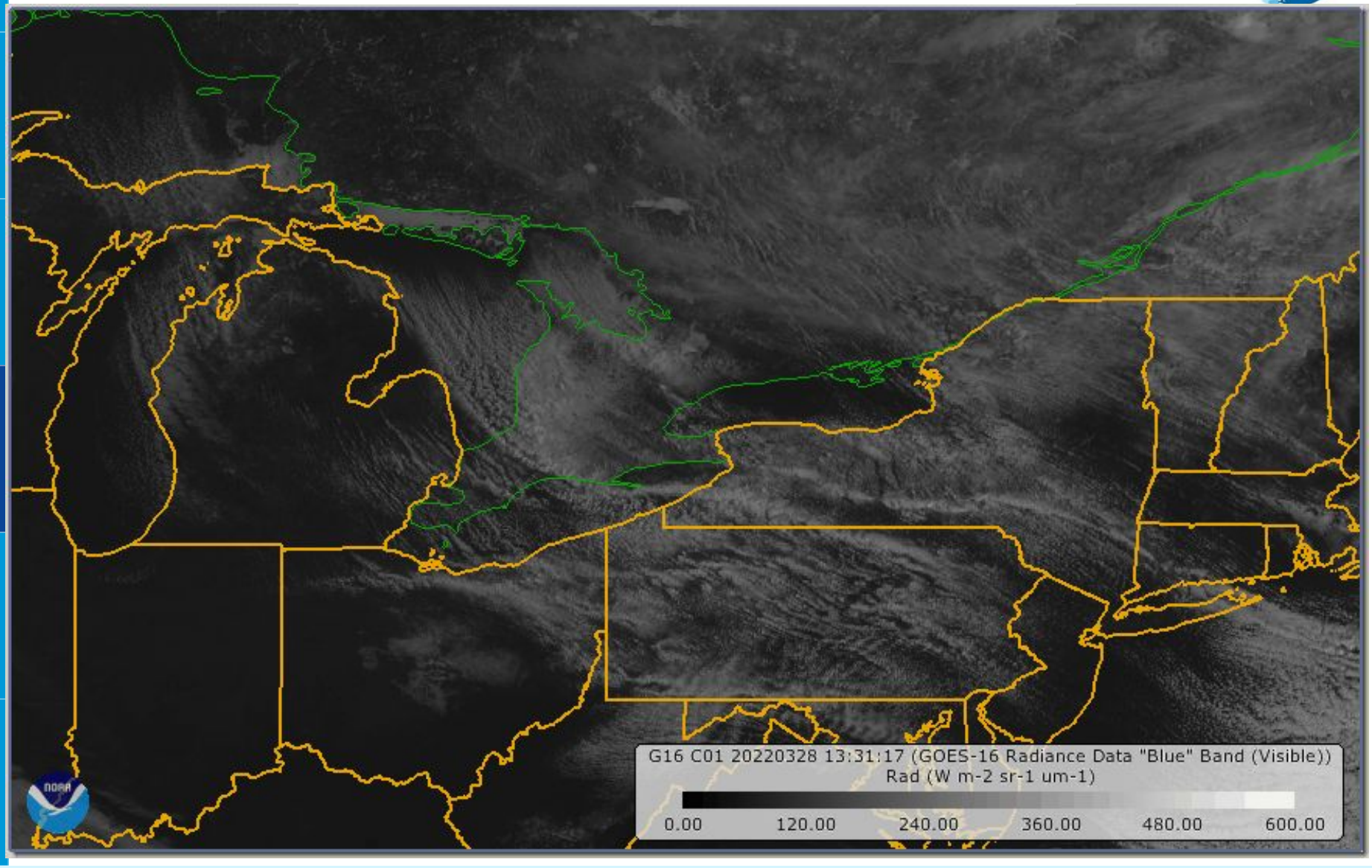


(28 March 2022)


SNPP ~1720 UTC 28 March 2022

GOES-16 1331-1531 UTC 28 March 2022



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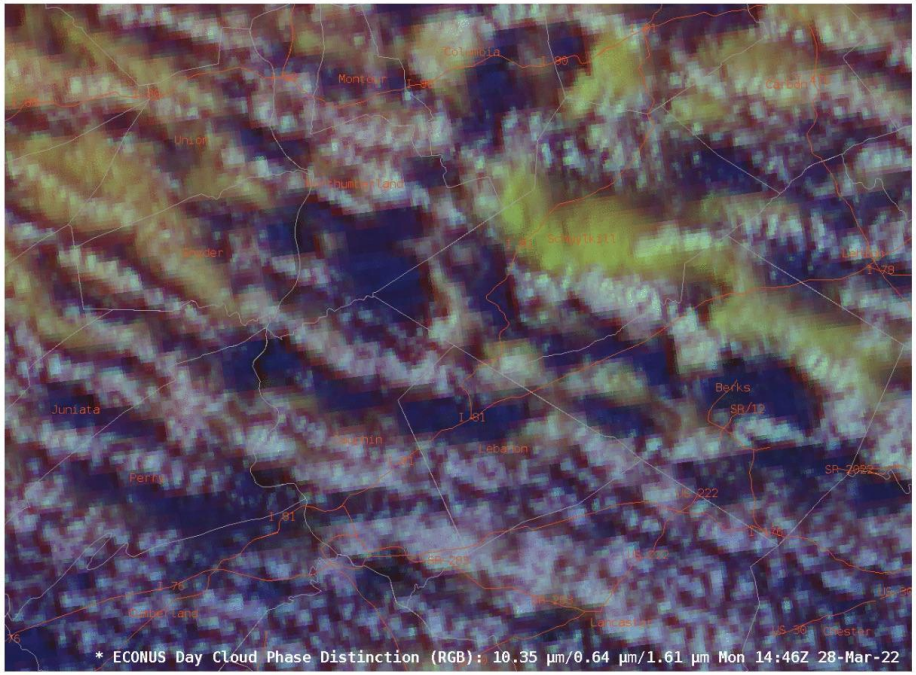
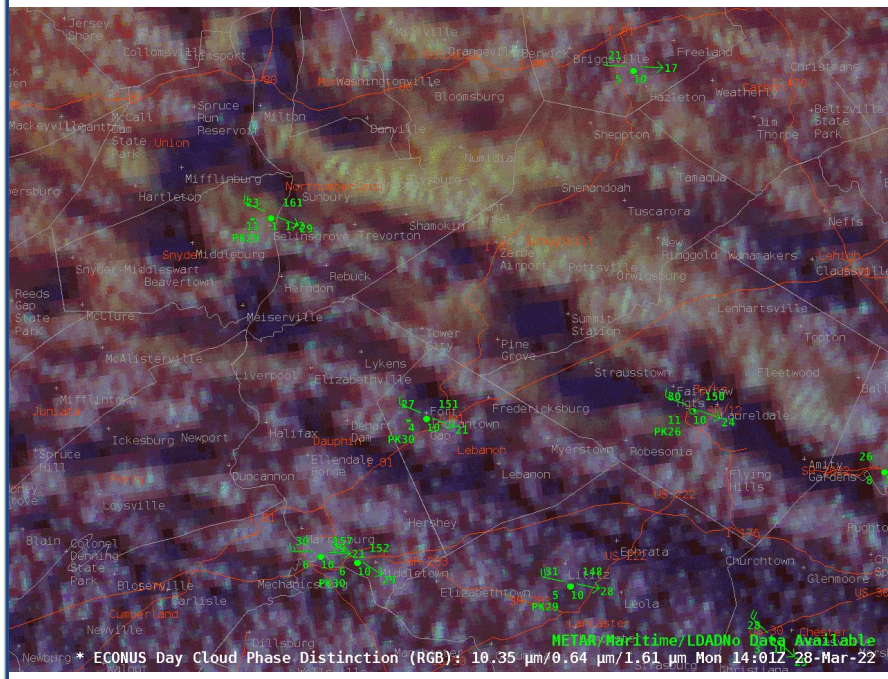
GOES-16 views of snow squalls associated with a multi-vehicle fatal crash in Schuylkill County, Pennsylvania

March 28th, 2022 | Scott Lindstrom



GOES-16 Day Cloud Phase Distinction RGB over Schuylkill County, 1401-1501 UTC on 28 March 2022
(Click to enlarge)

A 50- to 60-vehicle crash over central Schuylkill County (in Pennsylvania), with fatalities, on north-bound Interstate 81 occurred at around 11 AM EDT (TV news report; radio report), which is 1500 UTC. Day Cloud Phase Distinction, above shows the characteristic yellow/green/chartreuse shading that is associated with snow in cold air moving over I-81 in central Schuylkill County just before the reported time of the crashes. A longer animation below (with sparse surface observations — note no observations in Schuylkill County) during the day shows ongoing snow squalls during the course of the day.



https://cimss.ssec.wisc.edu/satellite-blog/archives/45461

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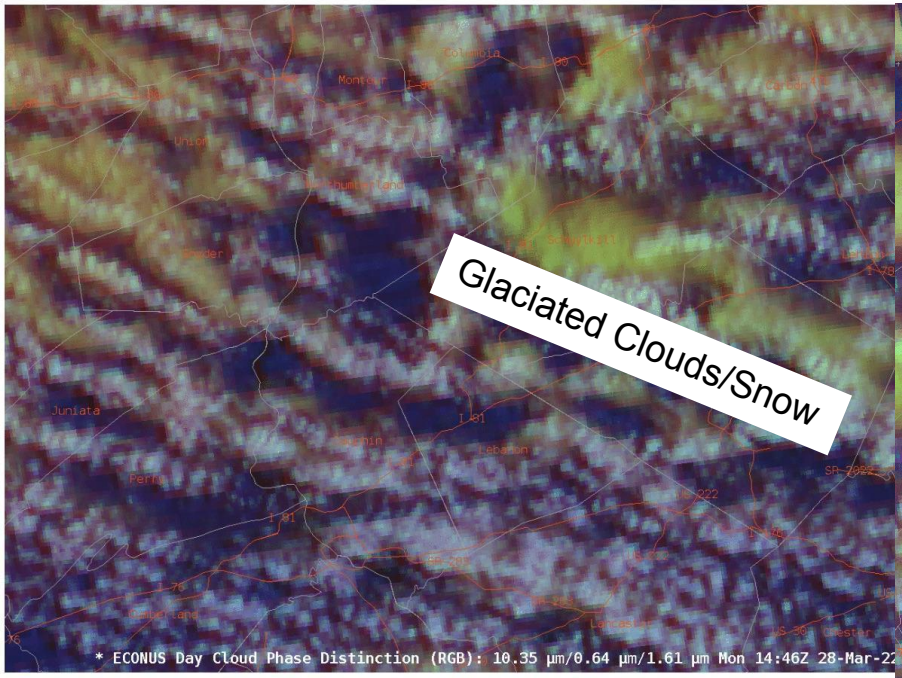

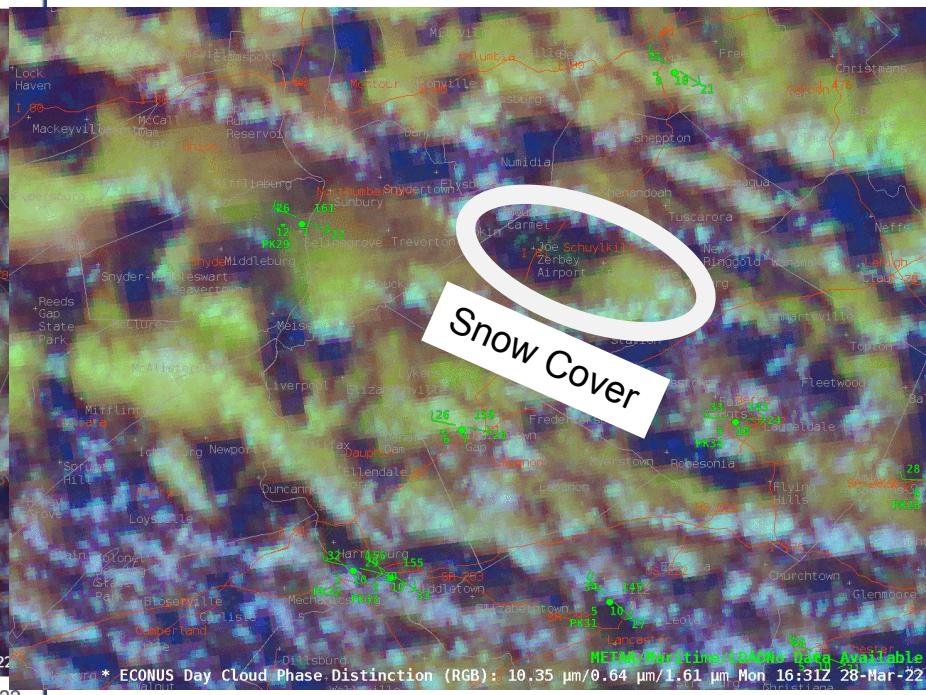

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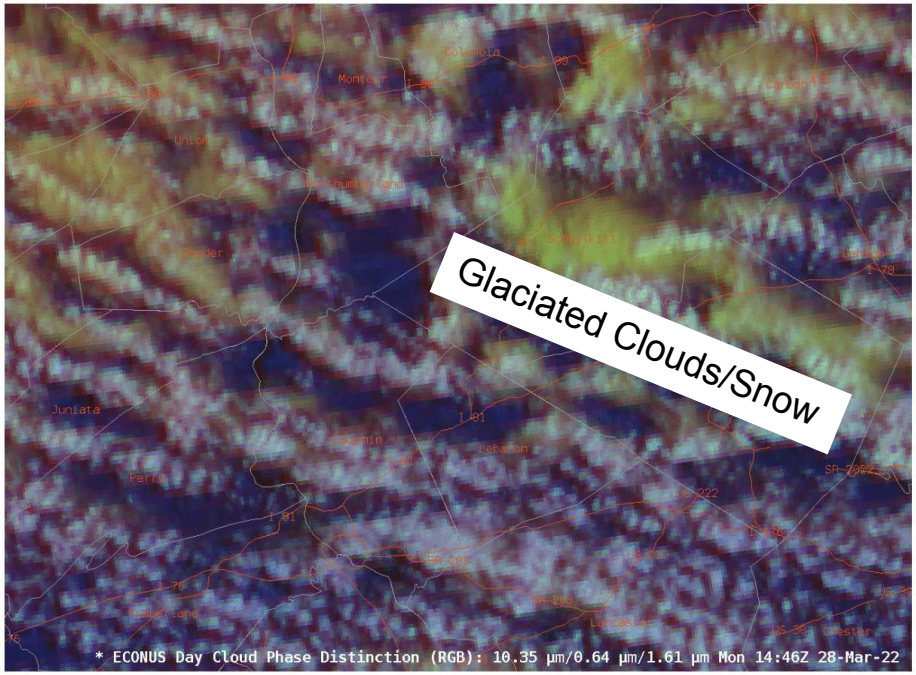
Quantitative guidance still needed!!

GOES-1 crash in

March 28th,

clues



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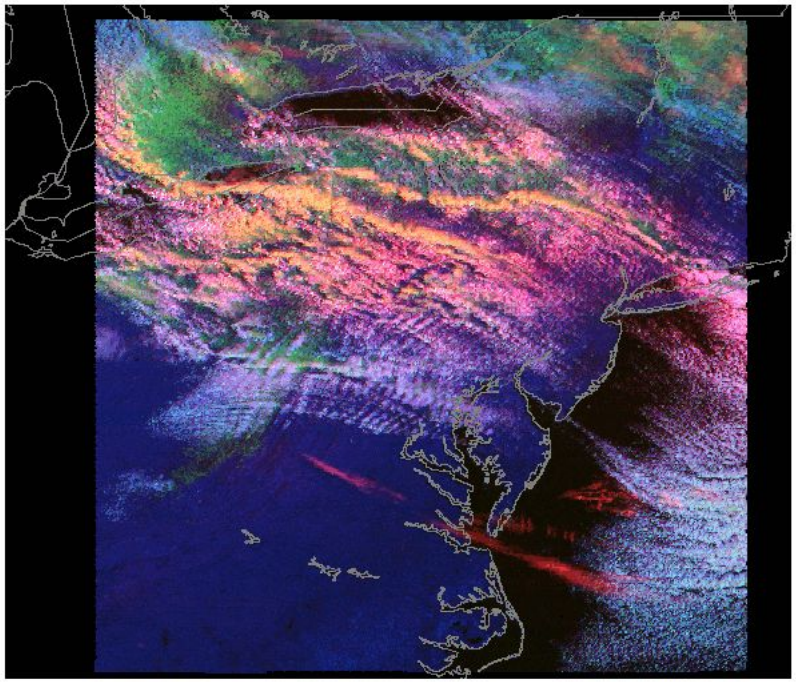
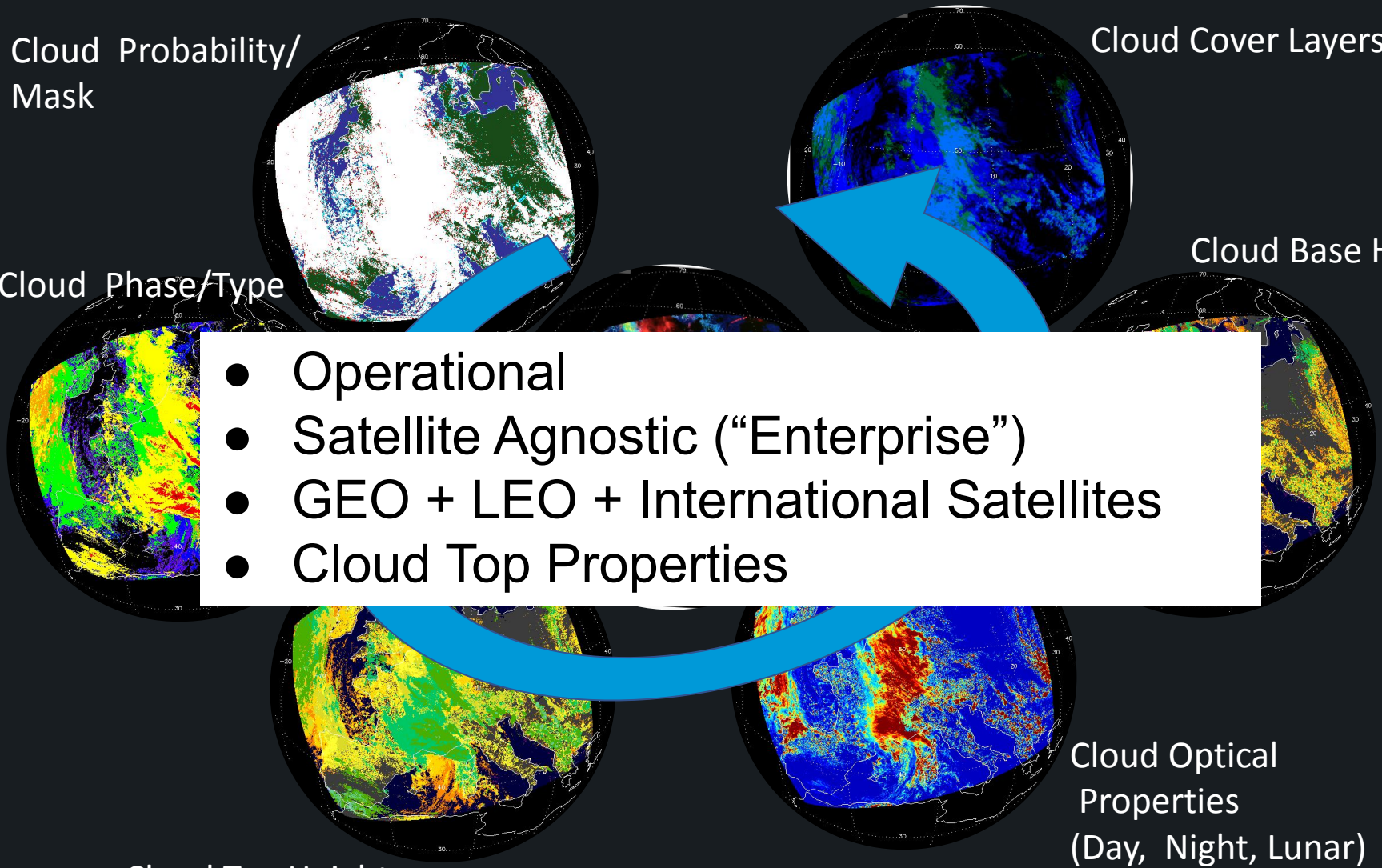


False Color Image

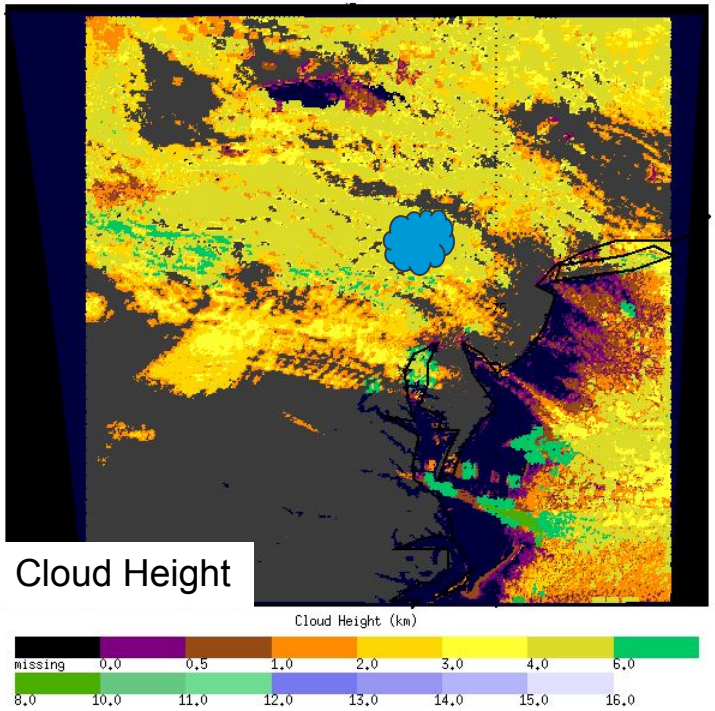
Red=1.38μm, Green = 0.65μm, Blue = 1.60μm

https://cimss.ssec.wisc.edu/satellite-blog/archives/45461

NOAA Enterprise Cloud Algorithms



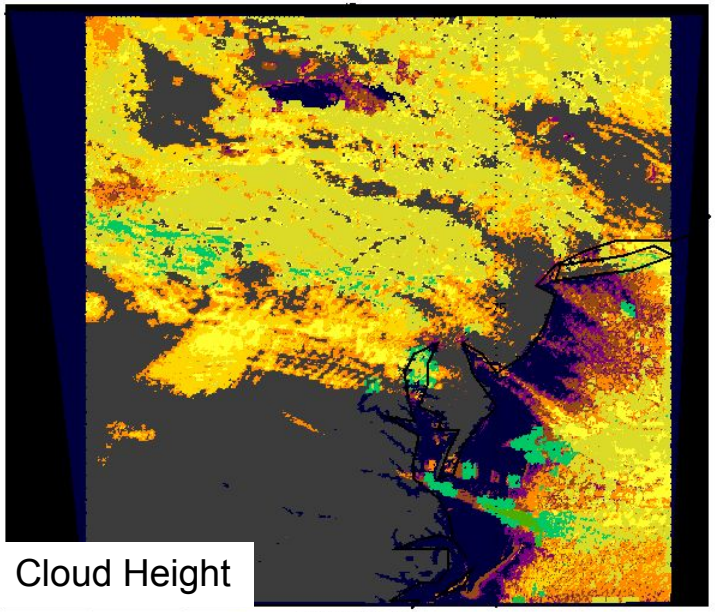
- Operational
- Satellite Agnostic (“Enterprise”)
- GEO + LEO + International Satellites
- Cloud Top Properties



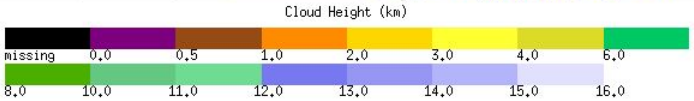
28 March 2022
1331-1531 UTC

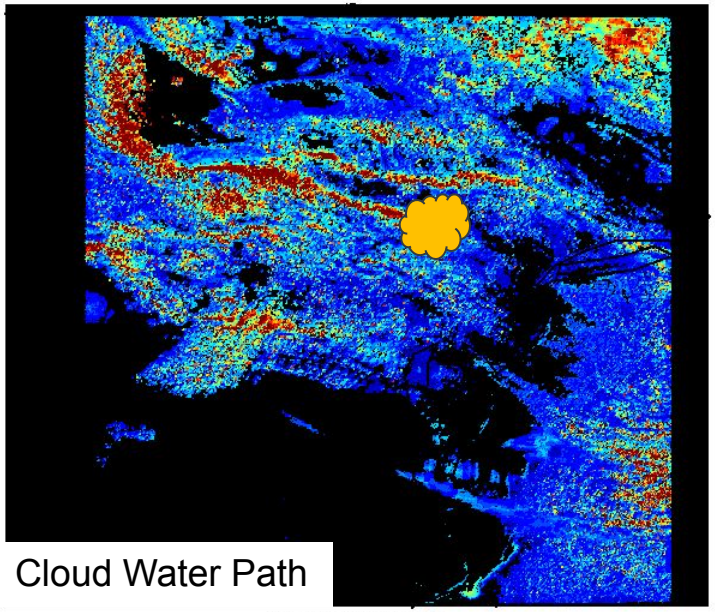
Max cloud top height: 4-6 km

28 March 2022
1331-1531 UTC

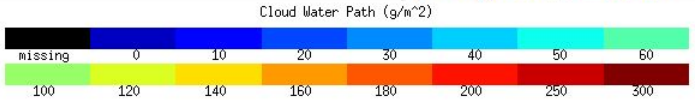


Cloud Height

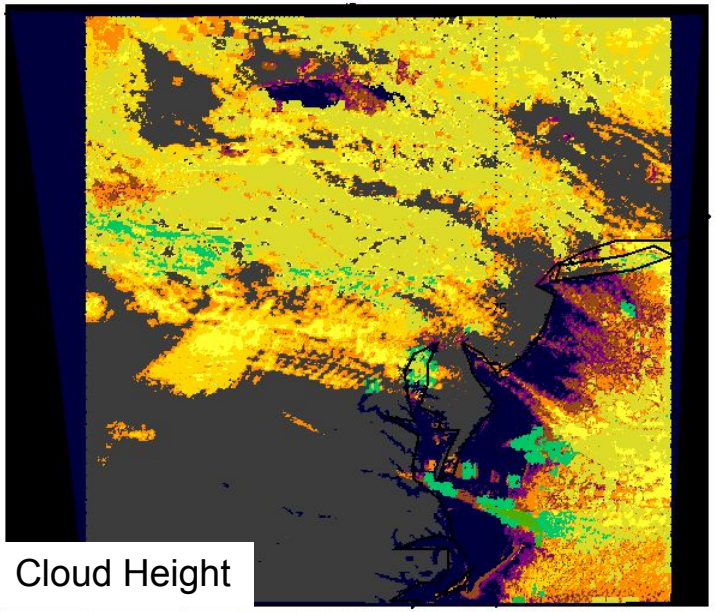




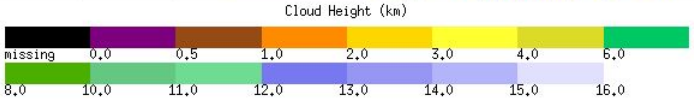
Cloud Water Path

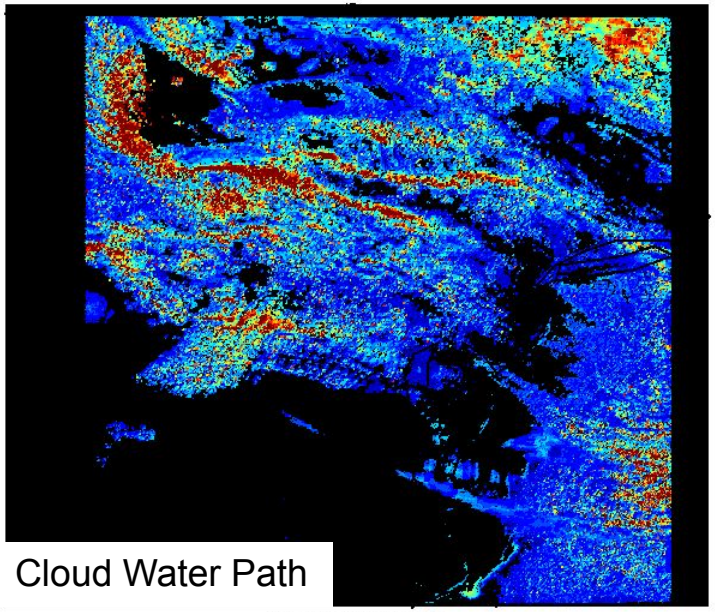


28 March 2022
1331-1531 UTC

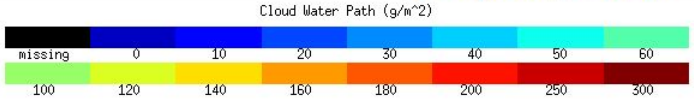


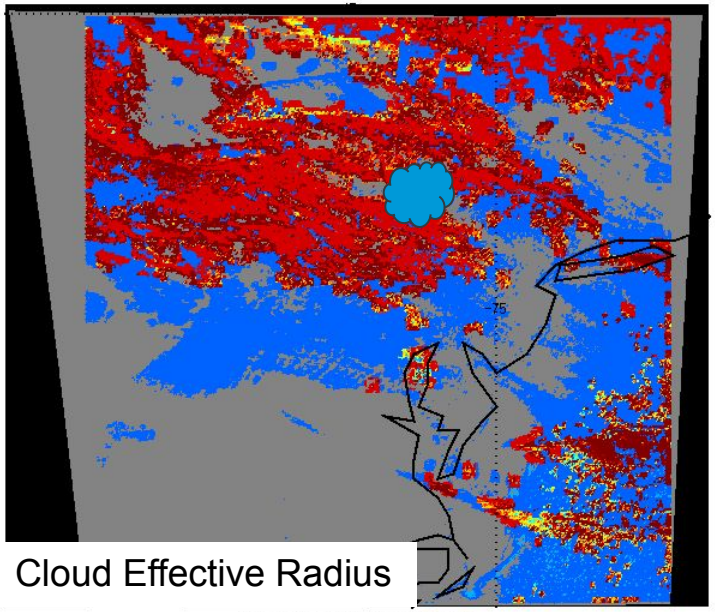
Cloud Height



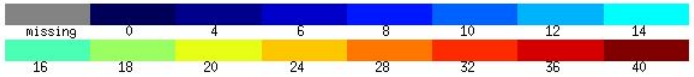


Cloud Water Path



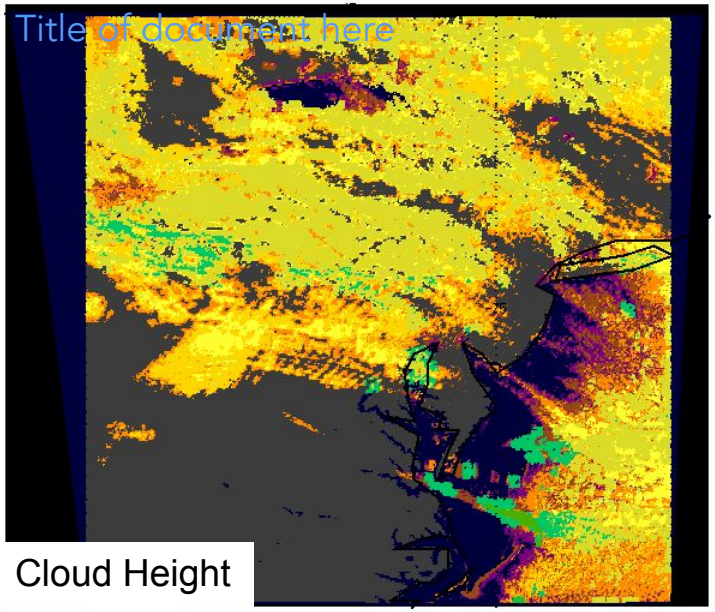


Cloud Effective Radius

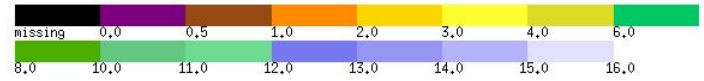


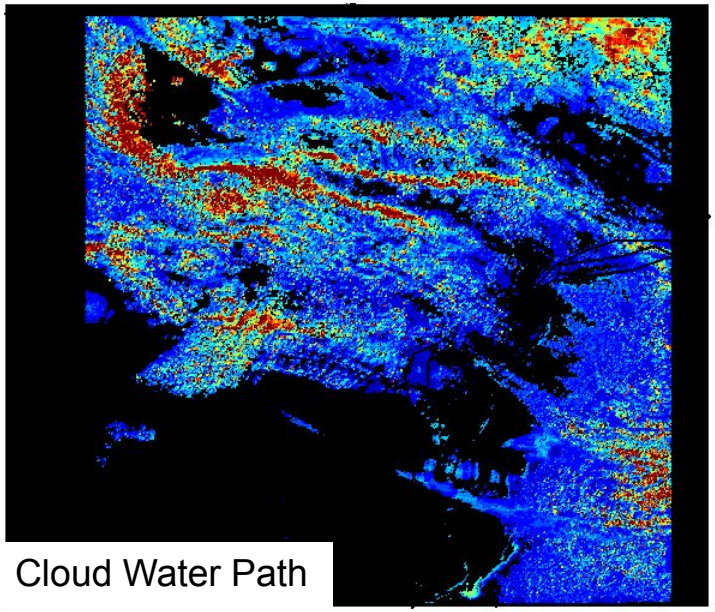
Available in AWIPS

28 March 2022
1331-1531 UTC

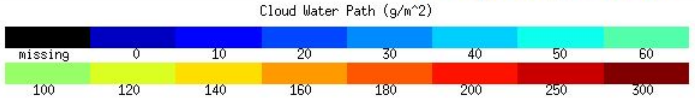


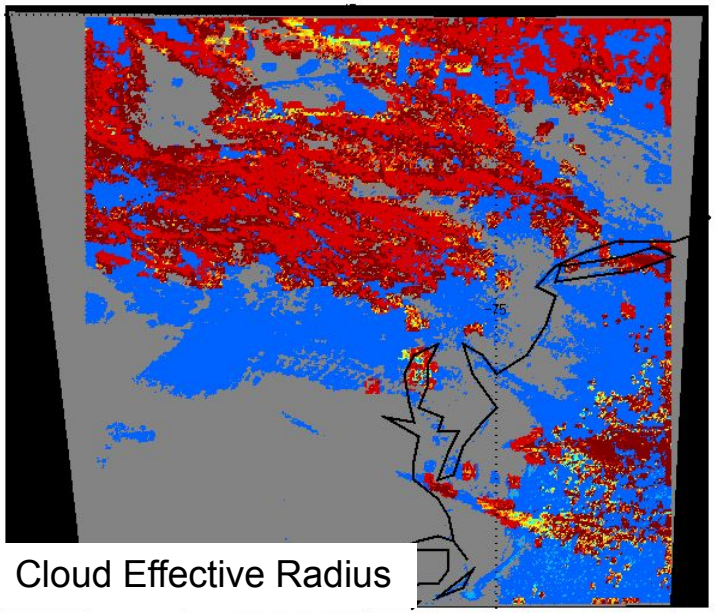
Cloud Height



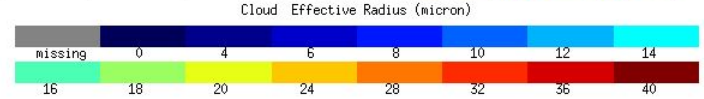


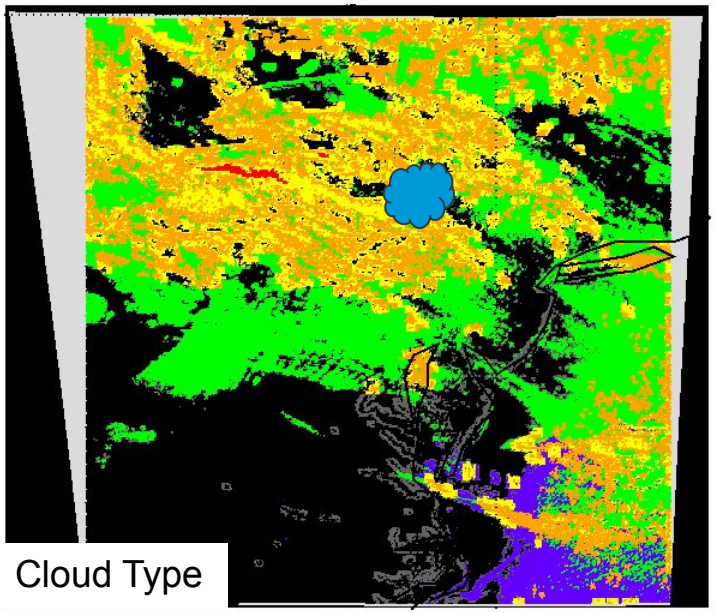
Cloud Water Path



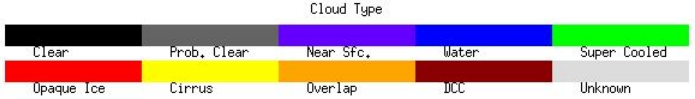


Cloud Effective Radius

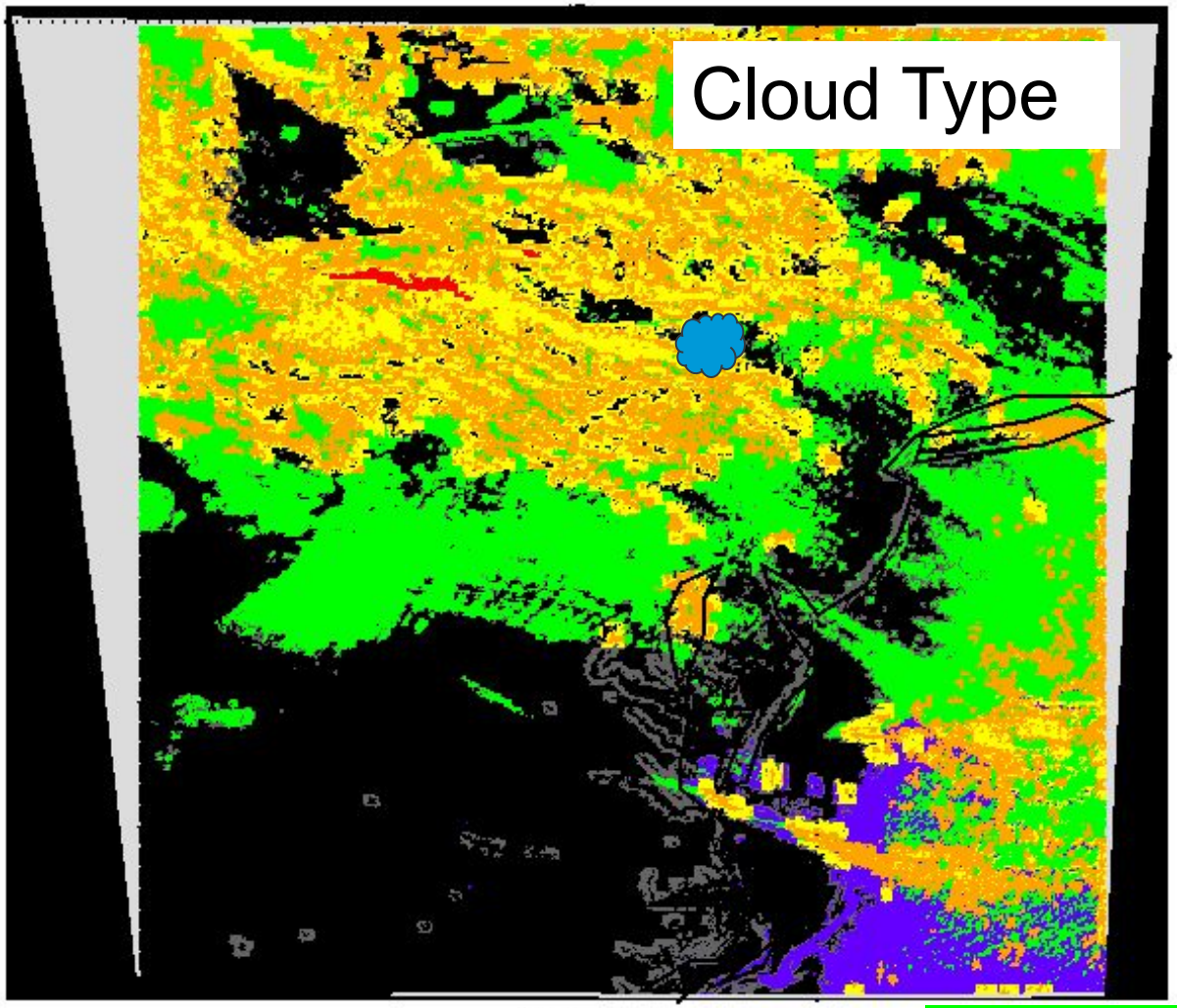




Cloud Type



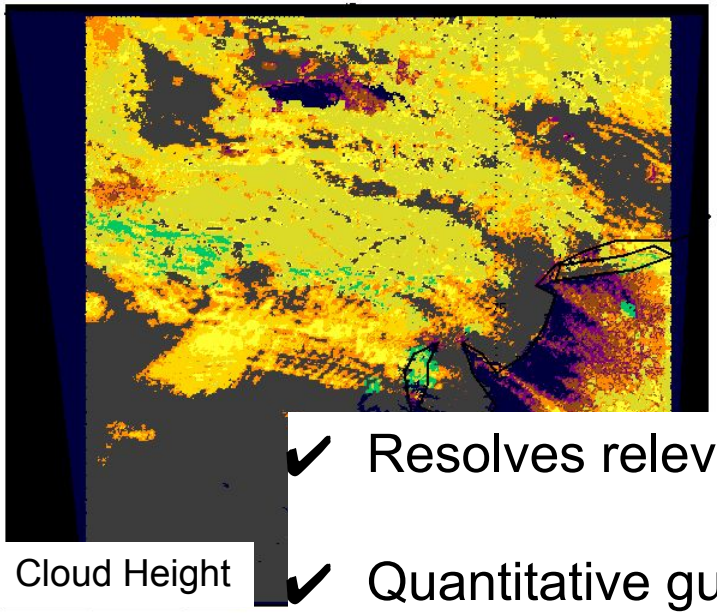
28 March 2022
1331-1531 UTC

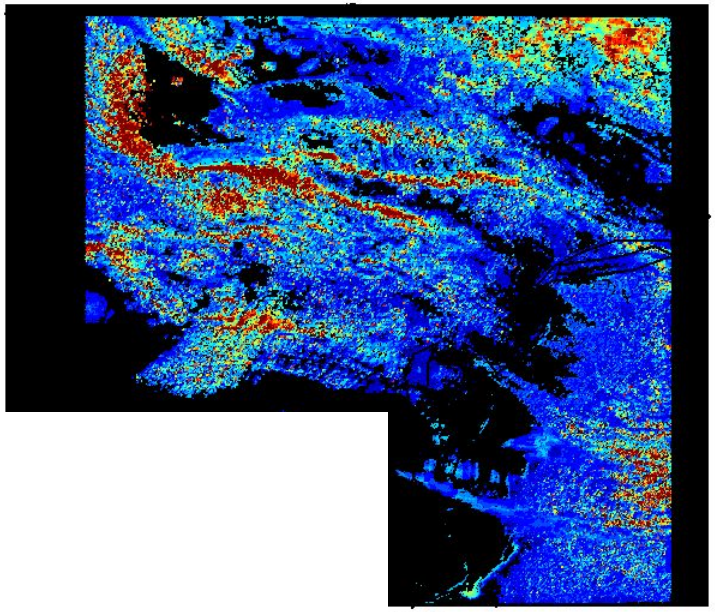


Supercooled

Opaque Ice | Cirrus | Overlap | Deep Conv

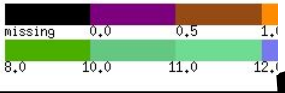
28 March 2022
1331-1531 UTC

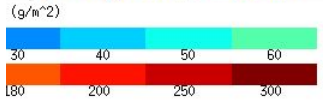


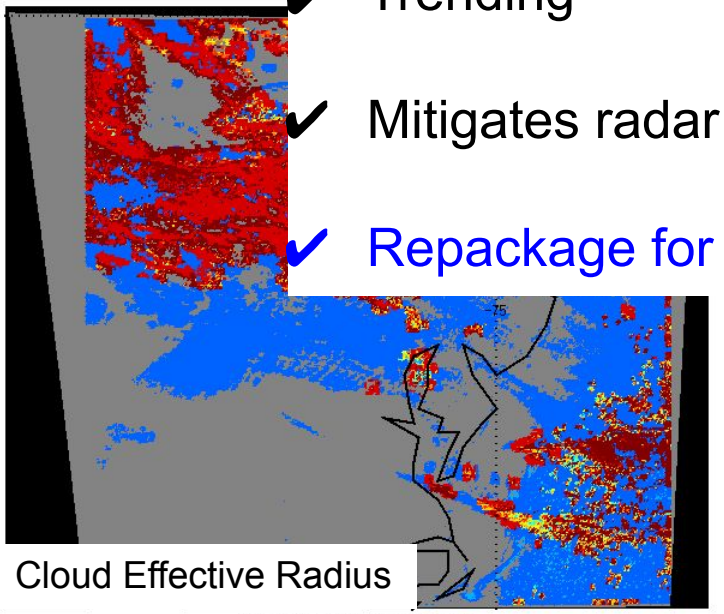


- ✔ Resolves relevant features
- ✔ Quantitative guidance
- ✔ Trending
- ✔ Mitigates radar coverage gaps
- ✔ Repackage for improved decision support?

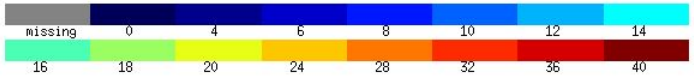
Cloud Height

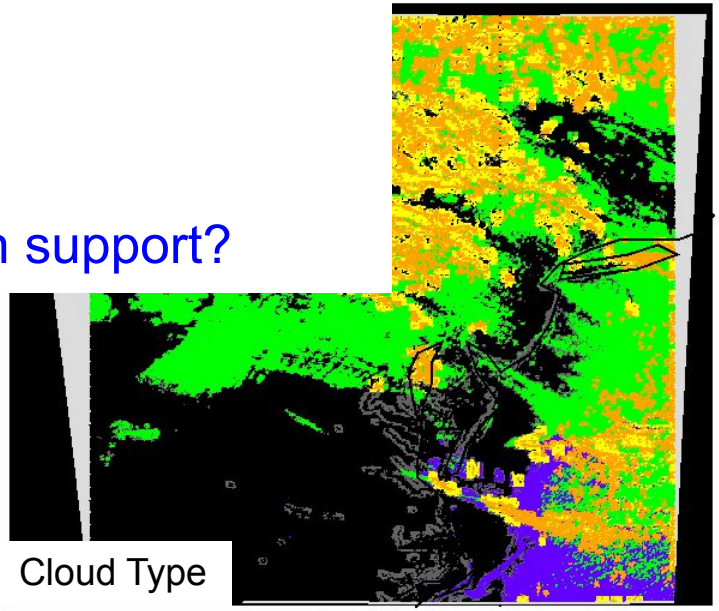




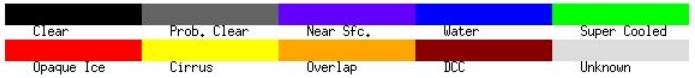


Cloud Effective Radius

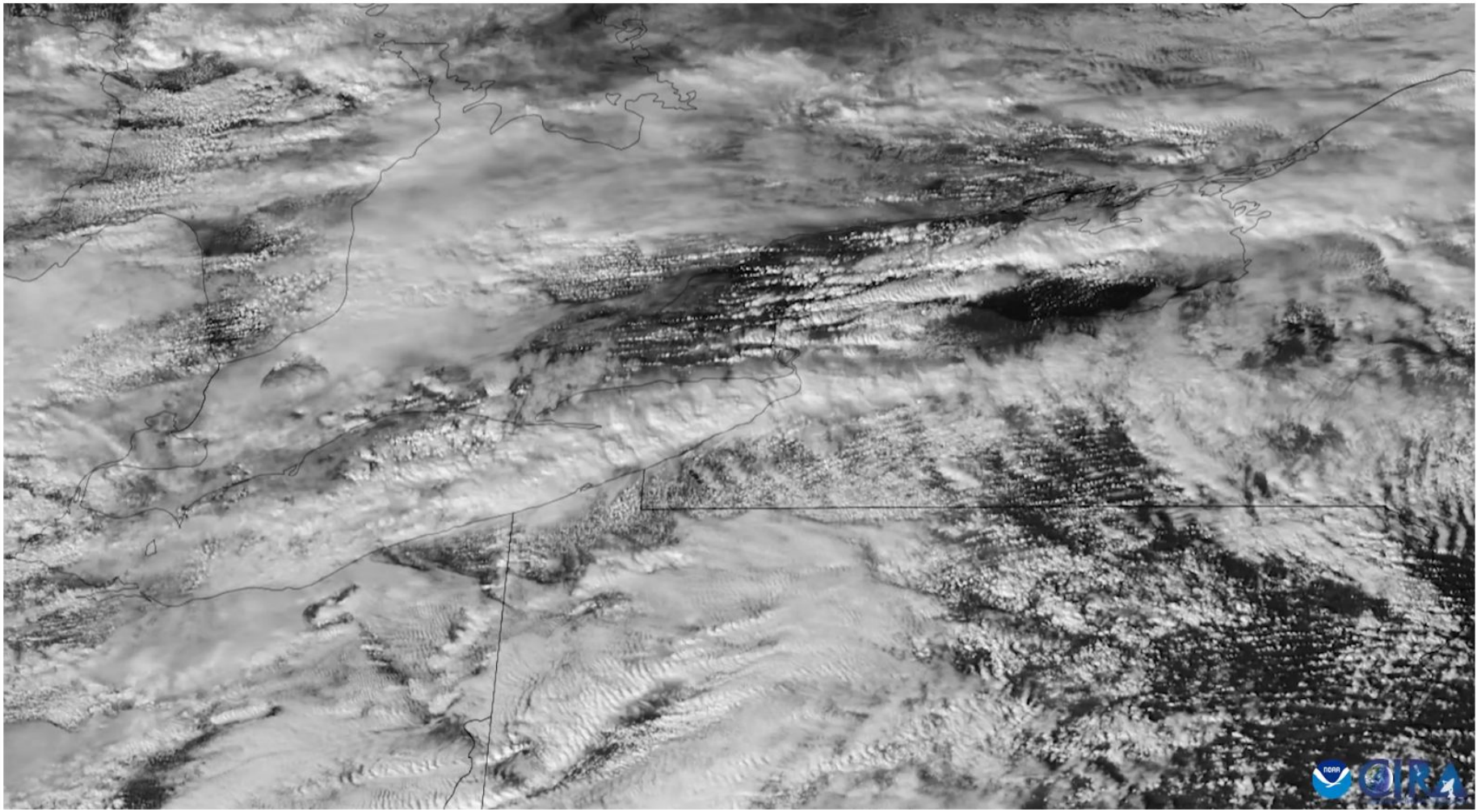




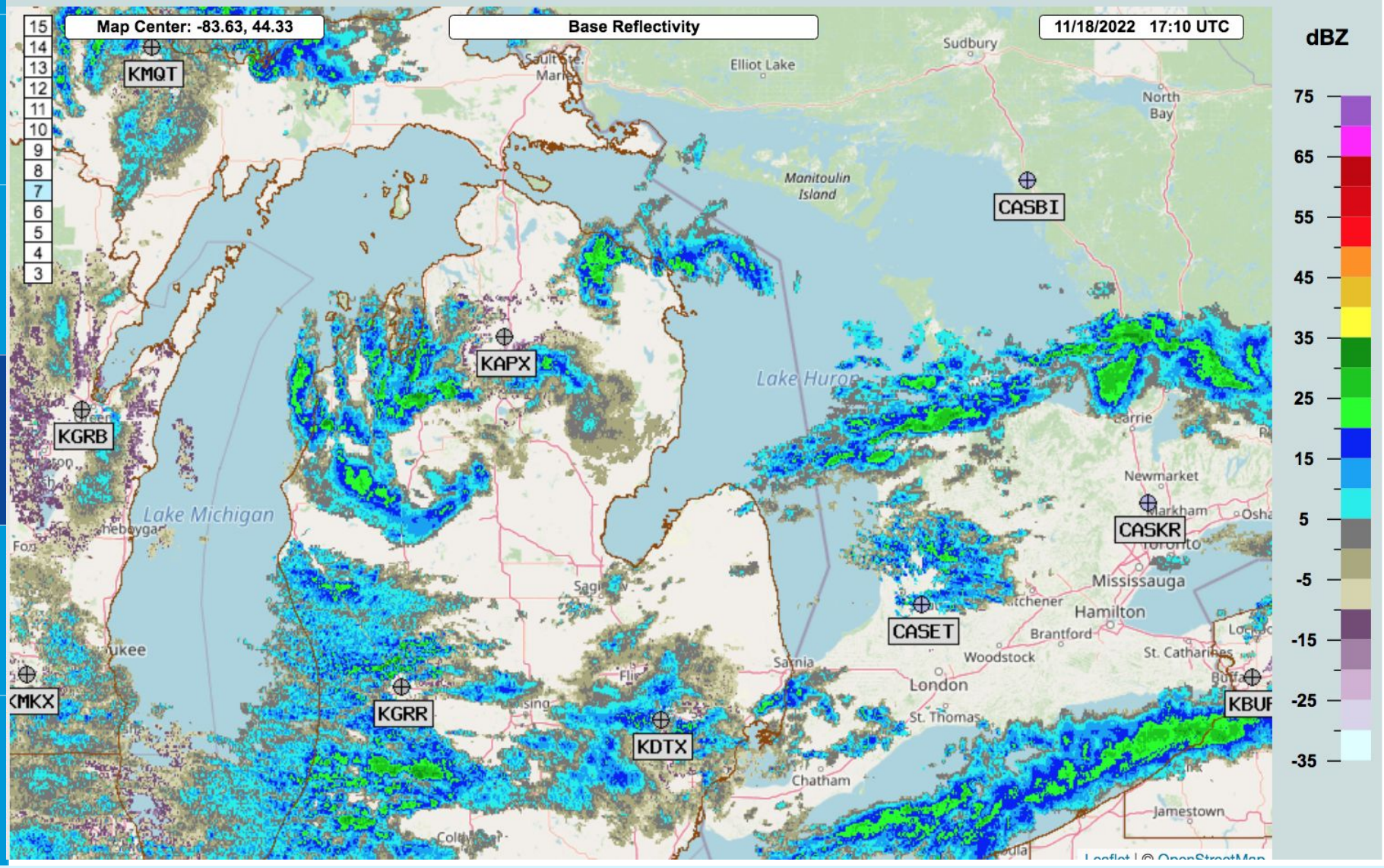
Cloud Type



Lake-Effect Event (18 November 2022)

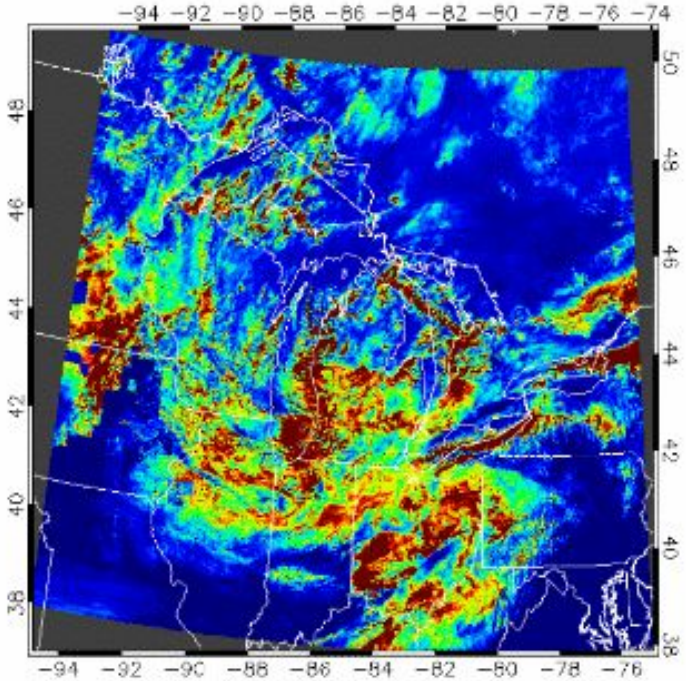


Lake-Effect Event (18 November 2022)



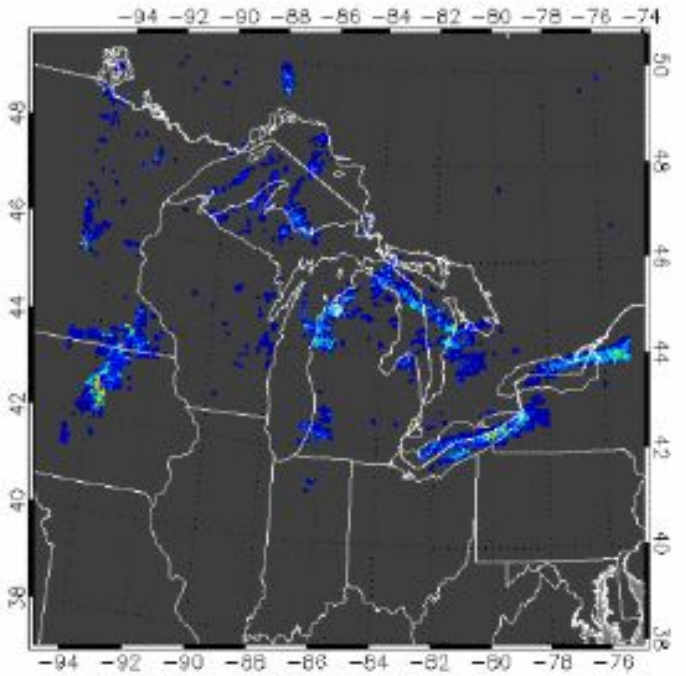
Lake-Effect Event (18 November 2022)

Cloud Optical Depth



s20223221501

Precip Rate



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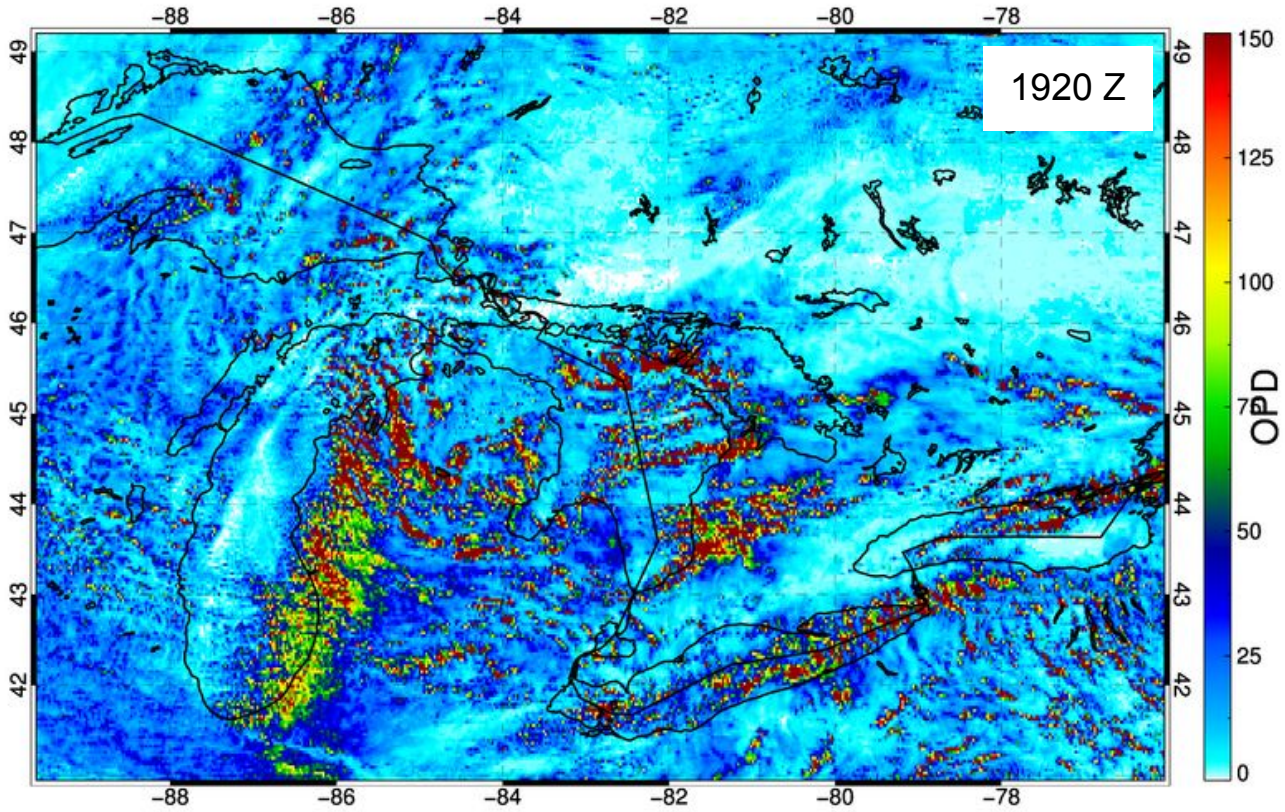
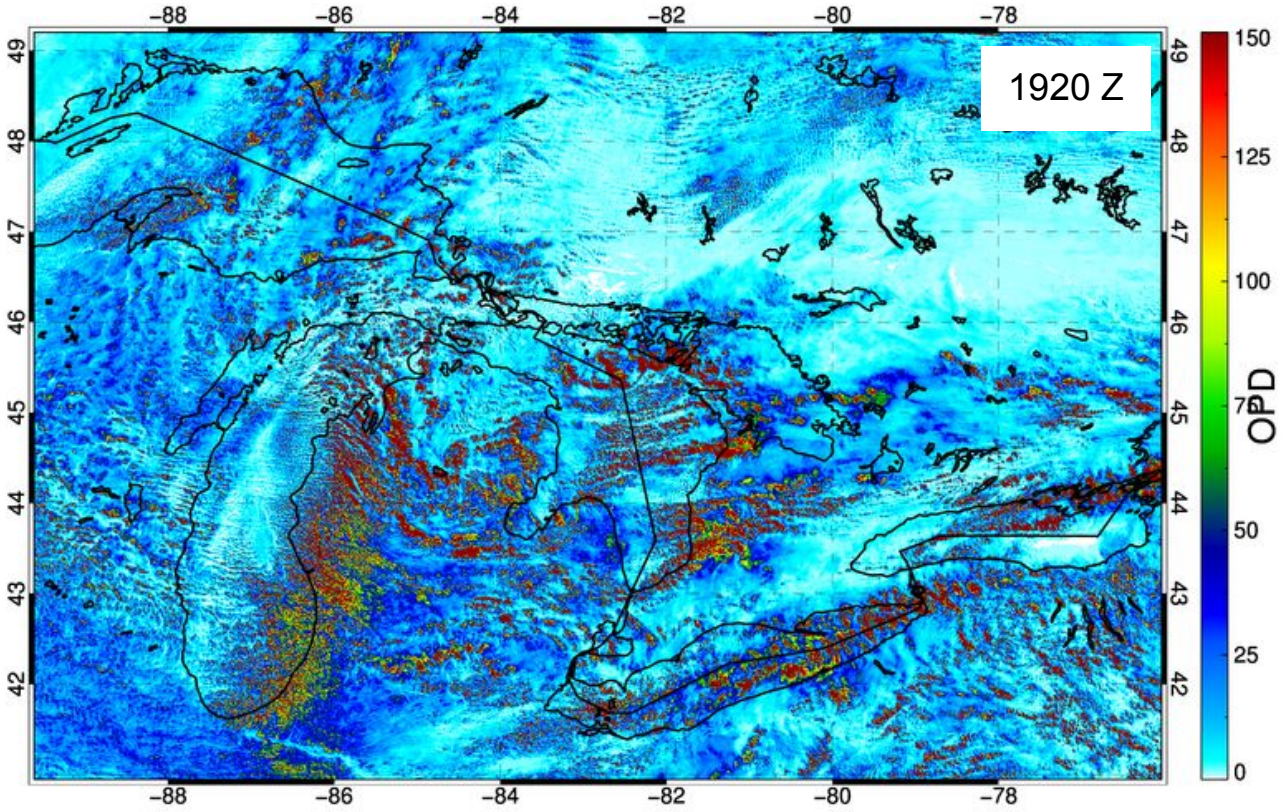


Current Operational Resolution (2 km)

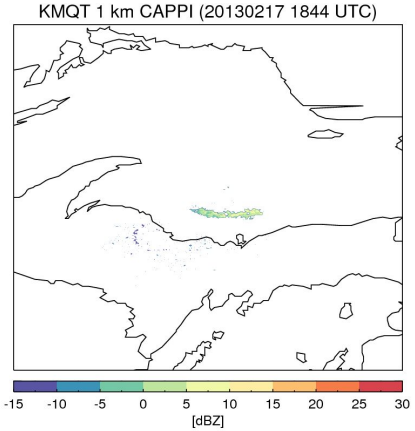
Lake-Effect Event (18 November 2022)



Experimental Super Resolution (500 m)

Experimental Lake-Effect Snow QPE Product

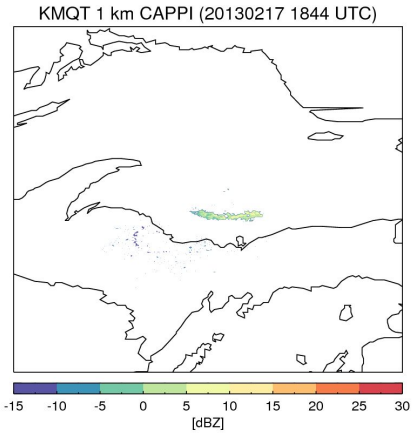
VIS



KMQT Radar

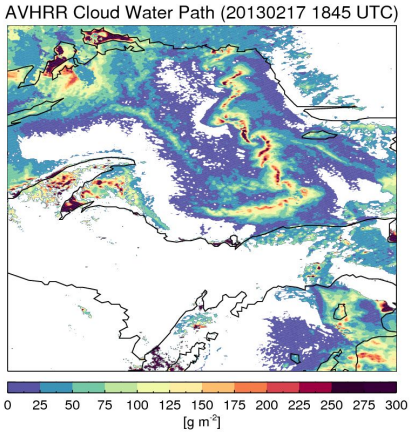
Experimental Lake-Effect Snow QPE Product

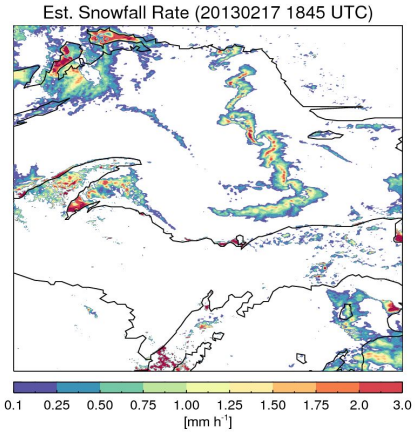
VIS



KMQT Radar

CWP

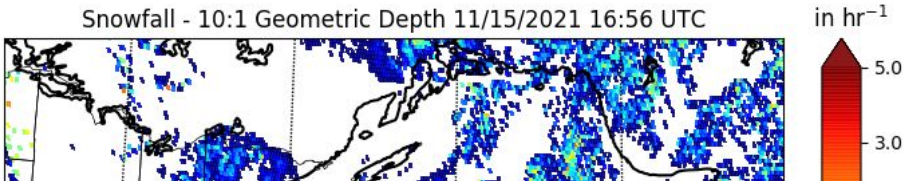




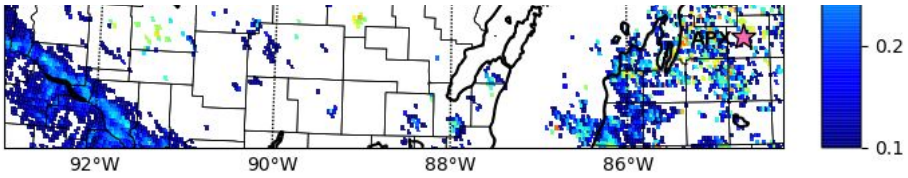
Satellite-derived snowfall rate
(Radar obs used as training dataset)

Experimental Lake-Effect QPE Product

- Improve situational awareness (GOES-16)
- 5-10 minute product latency
- Augment NEXRAD observations (especially over mid-lake)
- GOES QPE



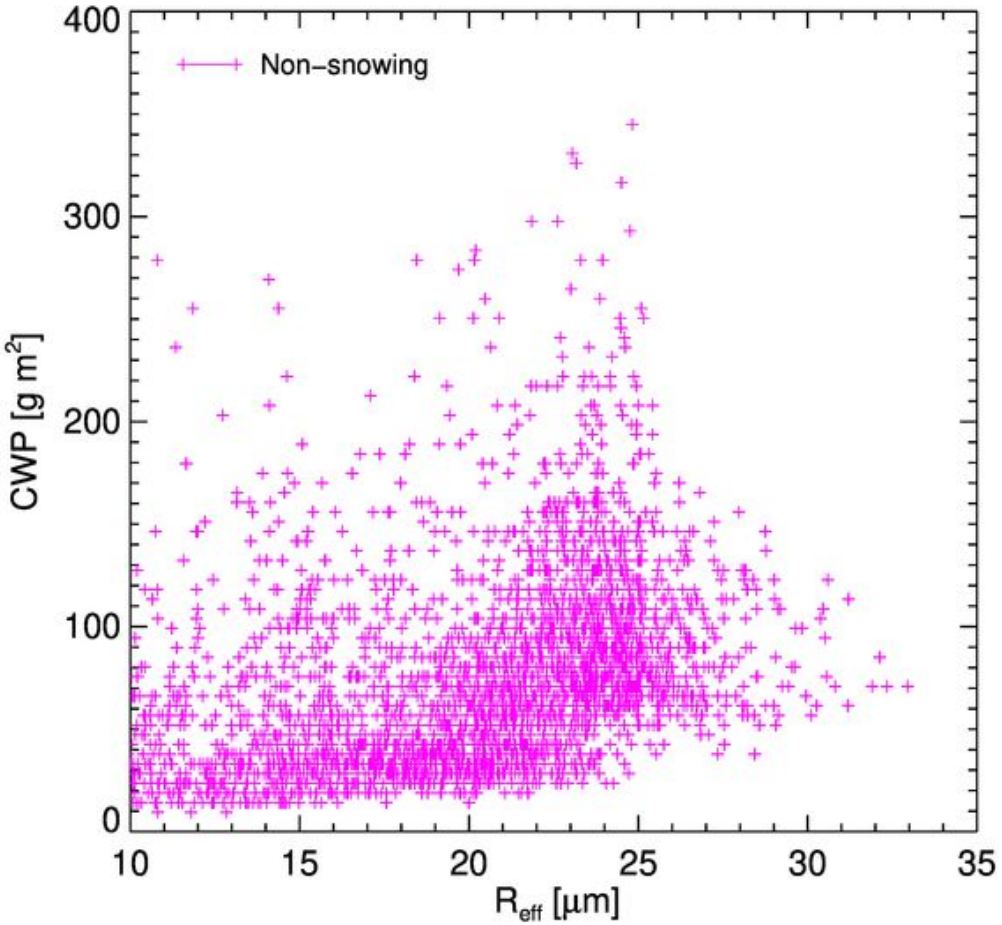
Currently no logic applied to create the product (i.e., no distinction between lake-effect or synoptic events)



https://www.ssec.wisc.edu/les-goes16/image-viewer

Improve Nowcasting Tool: Multivariate Input

Spatiotemporally match NEXRAD QPE and Cloud Products



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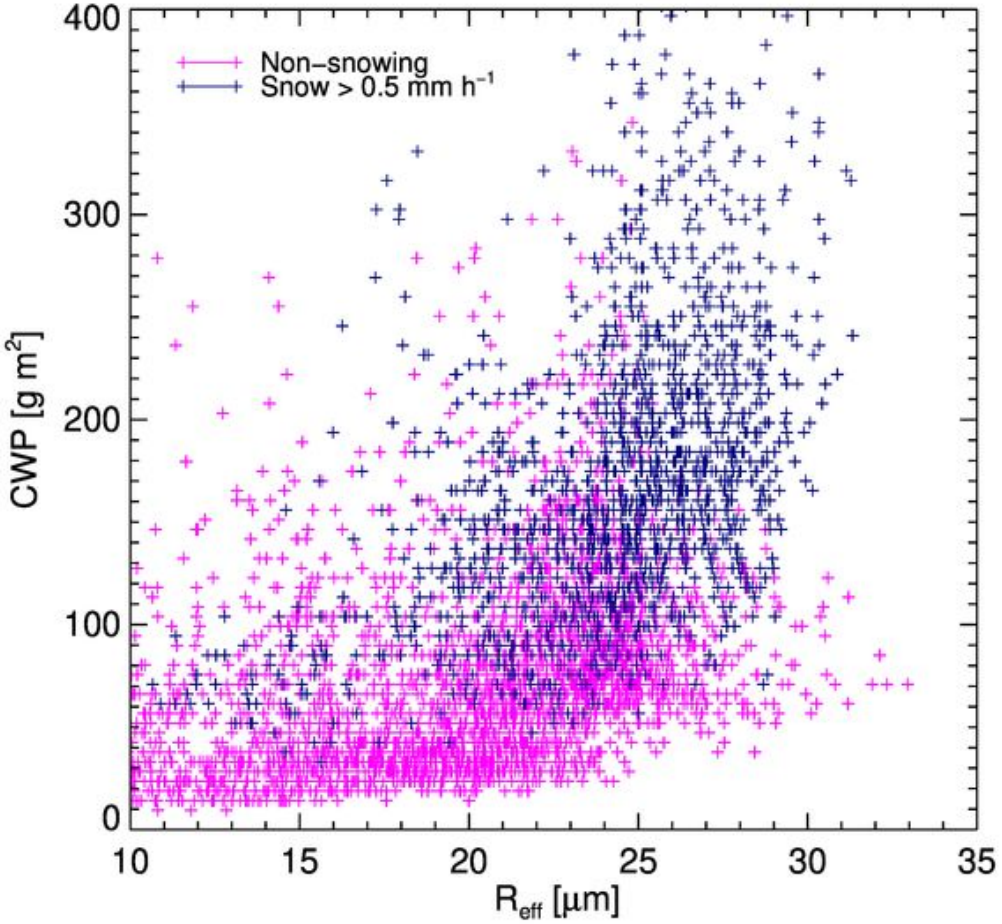

The Path Forward (Product Development)

- Snow Squalls: Value-added QPE/threat level product
  - GOES + NEXRAD (MRMS)
  - NWP
  - Surface Obs
  - Multivariate input: AI/ML tool (new proposal just funded!)

The Path Forward (Product Development)

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  - NWP
  - Surface Obs
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- Complications: Training and validation datasets
  - Improve NEXRAD QPE
    - MQT, APX, & BUF microphysics + profiling radar obs

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  - Storm reports (mPING?)

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- Fused satellite-radar product

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  - Surface Obs
  - Multivariate input: AI/ML tool

- Complications: Training and validation datasets
  - Improve NEXRAD QPE
  - Instantaneous snowfall rate observations lacking
  - Storm reports (mPING?)

- ProbSevere-like infrastructure
- Fused satellite-radar product
- Nighttime capabilities

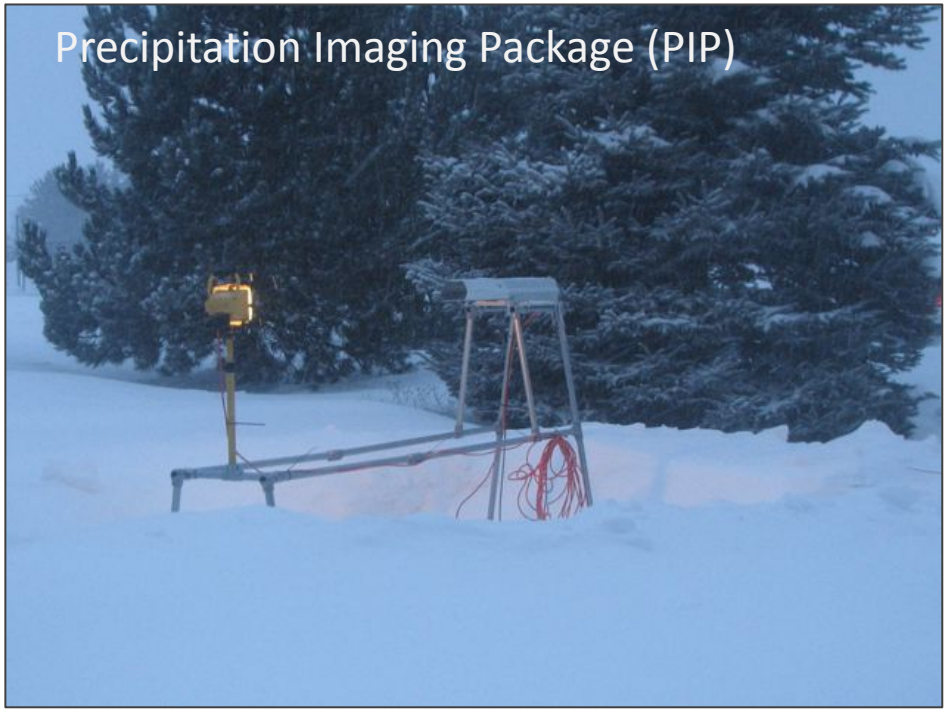
User Input Needed!

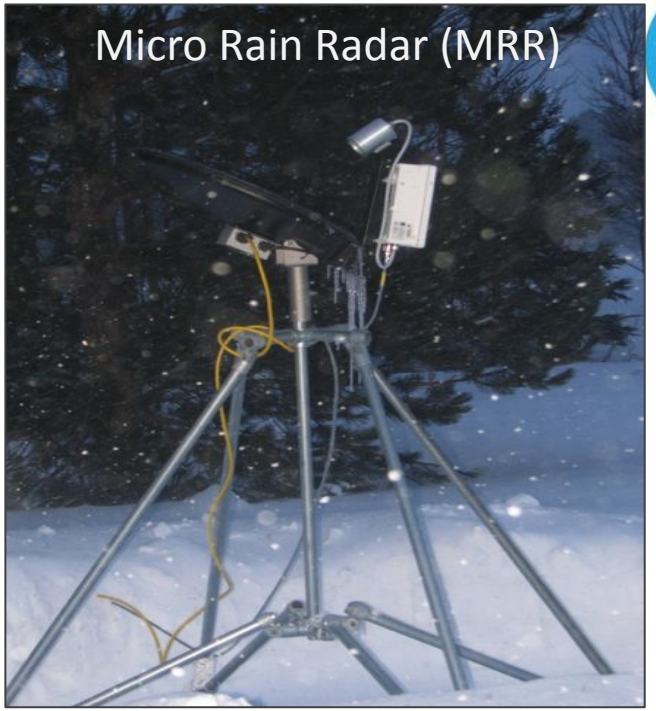
- Worth pursuing?
- QPE vs. threat-level % (or both)?
- Optimal display (non-AWIPS)
- Environmental variables?
  - Lake snow parameter
  - DGZ
  - Wind speed/direction
  - Air/lake surface temp difference
  - Synoptic dynamics

The Path Forward (Science)

- Lake-effect versus over-land convective snow

MQT Snowfall Observatory





Dataset Duration:
January 2014 - Present

MQT Snowfall Observatory

The Precipitation Imaging Package: Assessment of Microphysical and Bulk Characteristics of Snow

A Composite Analysis of Snowfall Modes from Four Winter Seasons in Marquette, Michigan

CLAIRE PETTERSEN,[a] MARK S. KULIE,[b] LARRY F. BLIVEN,[c] ARONNE J. MERRELLI,[a] WALTER A. PETERSEN,[d] TIMOTHY J. WAGNER,[a] DAVID B. WOLFF,[c] AND NORMAN B. WOOD[a]

[a] *Space Science and Engineering Center, University of Wisconsin–Madison, Madison, Wisconsin*
[b] *Advanced Satellite Products Branch, NOAA/NESDIS/Center for Satellite Applications and Research, Madison, Wisconsin*
[c] *NASA Goddard Space Flight Center, Wallops Flight Facility, Wallops Island, Virginia*
[d] *NASA Marshall Space Flight Center, Huntsville, Alabama*

(Manuscript received 29 April 2019, in final form 15 October 2019)

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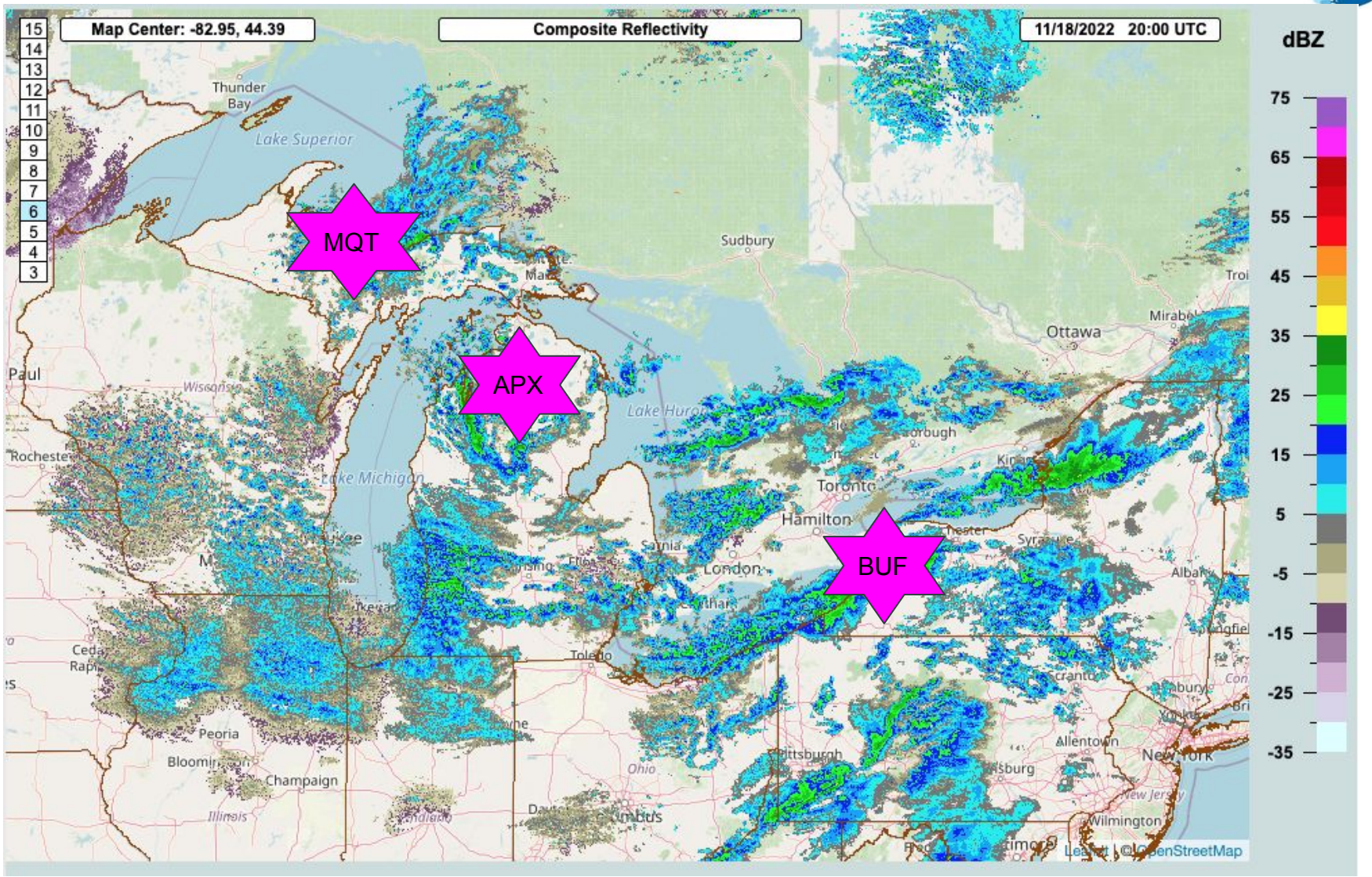
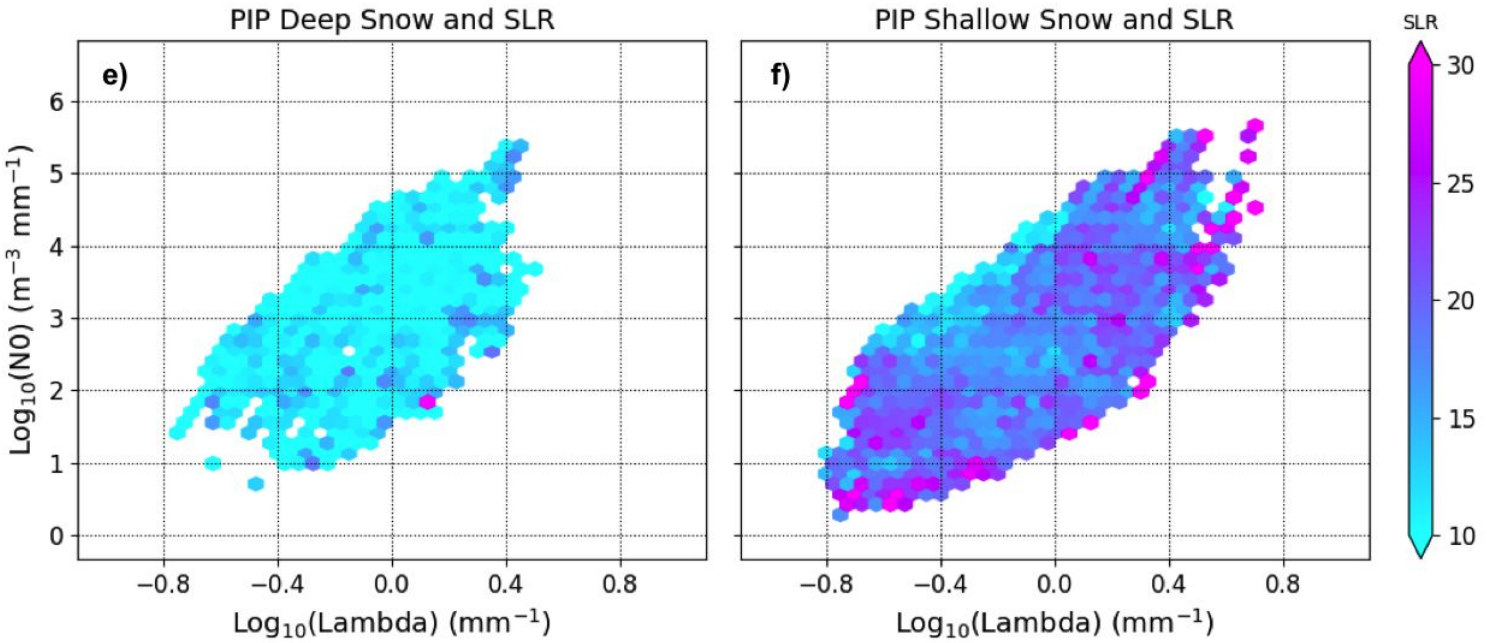
Remote Sens. **2021**, *13*(11), 2183; **https://doi.org/10.3390/rs13112183**

[d] *Space Science and Engineering Center, University of Wisconsin–Madison, Madison, Wisconsin*
[e] *NOAA/NESDIS/Center for Satellite Applications and Research, Madison, Wisconsin*
[f] *Department of Physics, University of Helsinki, Helsinki, Finland*
[g] *Wallops Flight Facility, NASA Goddard Space Flight Center, Wallops Island, Virginia*

~~MQT~~ Great Lakes Snowfall Observatory



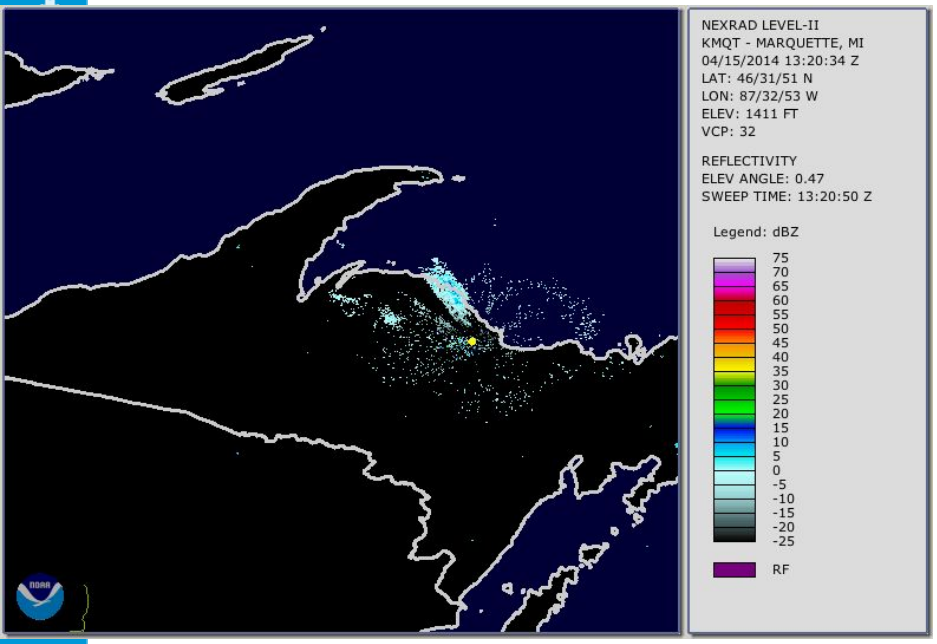
~~MQT~~ Great Lakes Snowfall Observatory



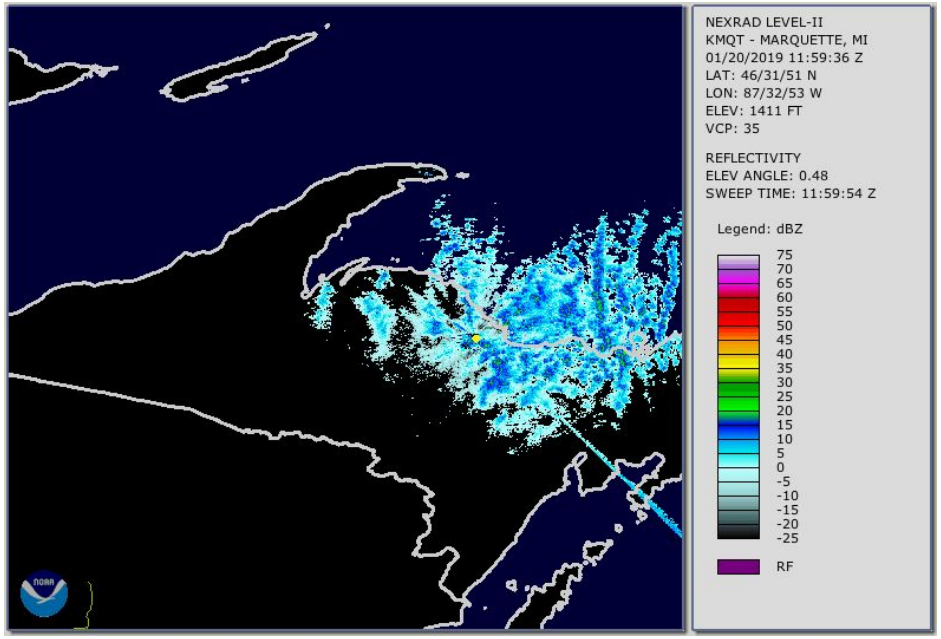
MQT snow-to-liquid (SLR) variability

1 minute sampling

The Path Forward (Science)



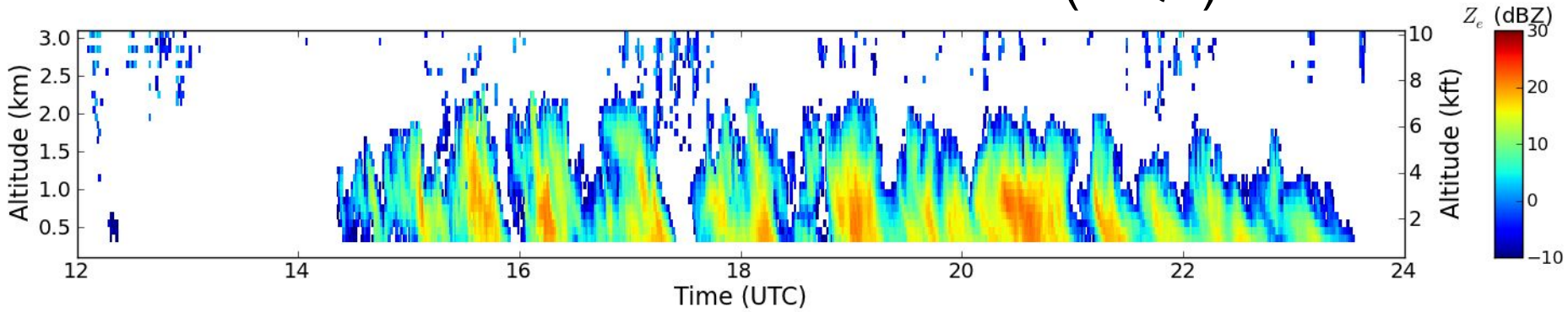
Overland Convective Snow (15 Apr 2014)



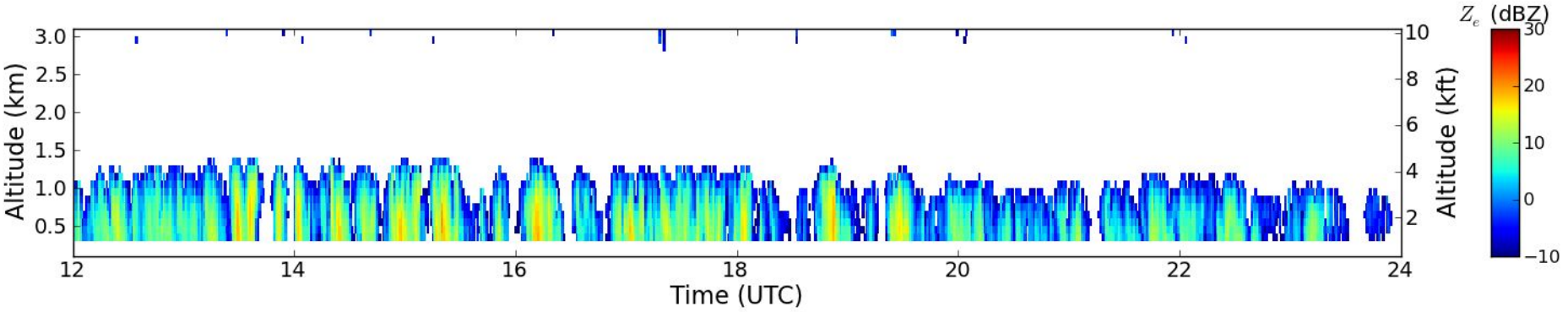
Lake-Effect Snow (20 Jan 2019)

The Path Forward (Science)

Micro Rain Radar Observations (MQT)



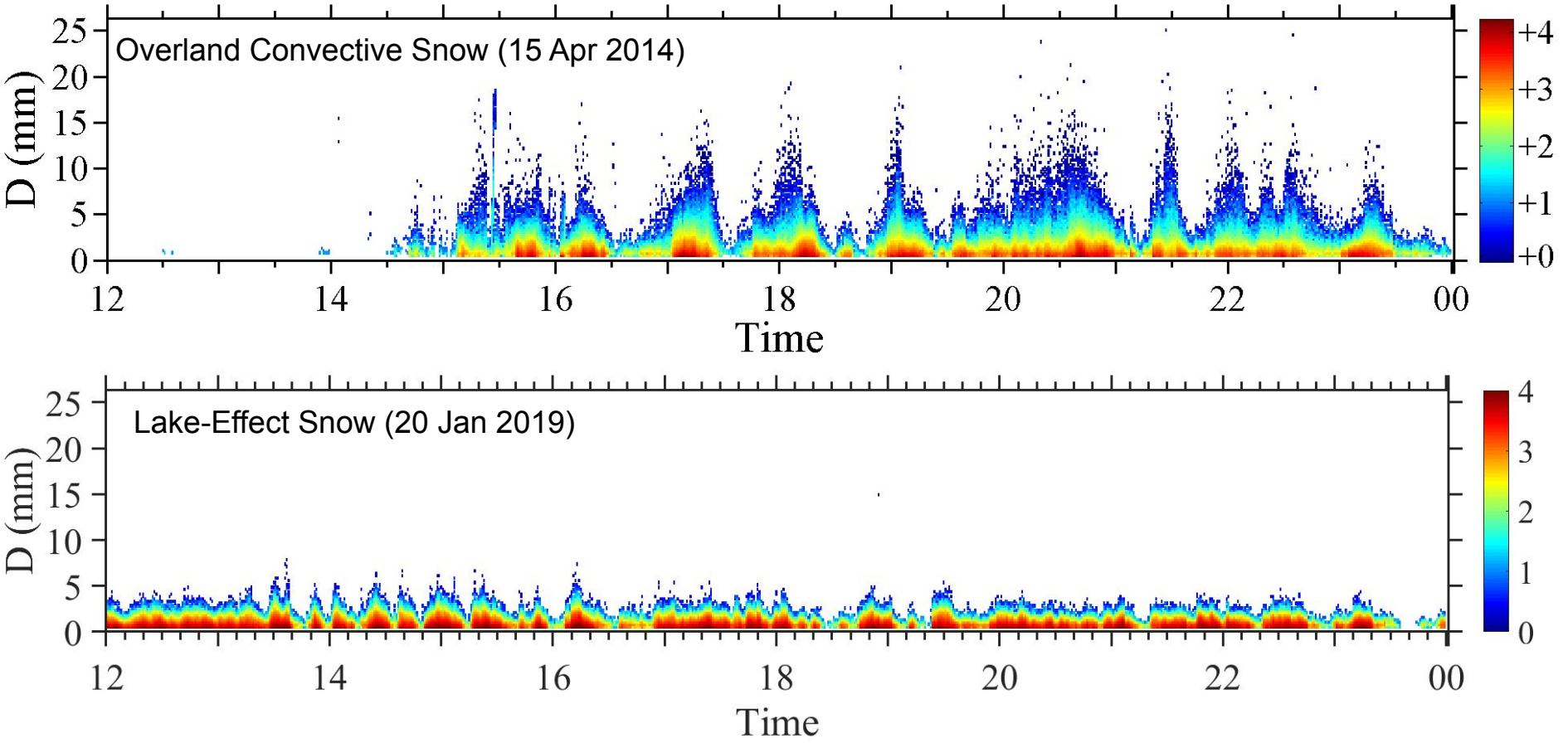
Overland Convective Snow (15 Apr 2014)



Lake-Effect Snow (20 Jan 2019)

The Path Forward (Science)

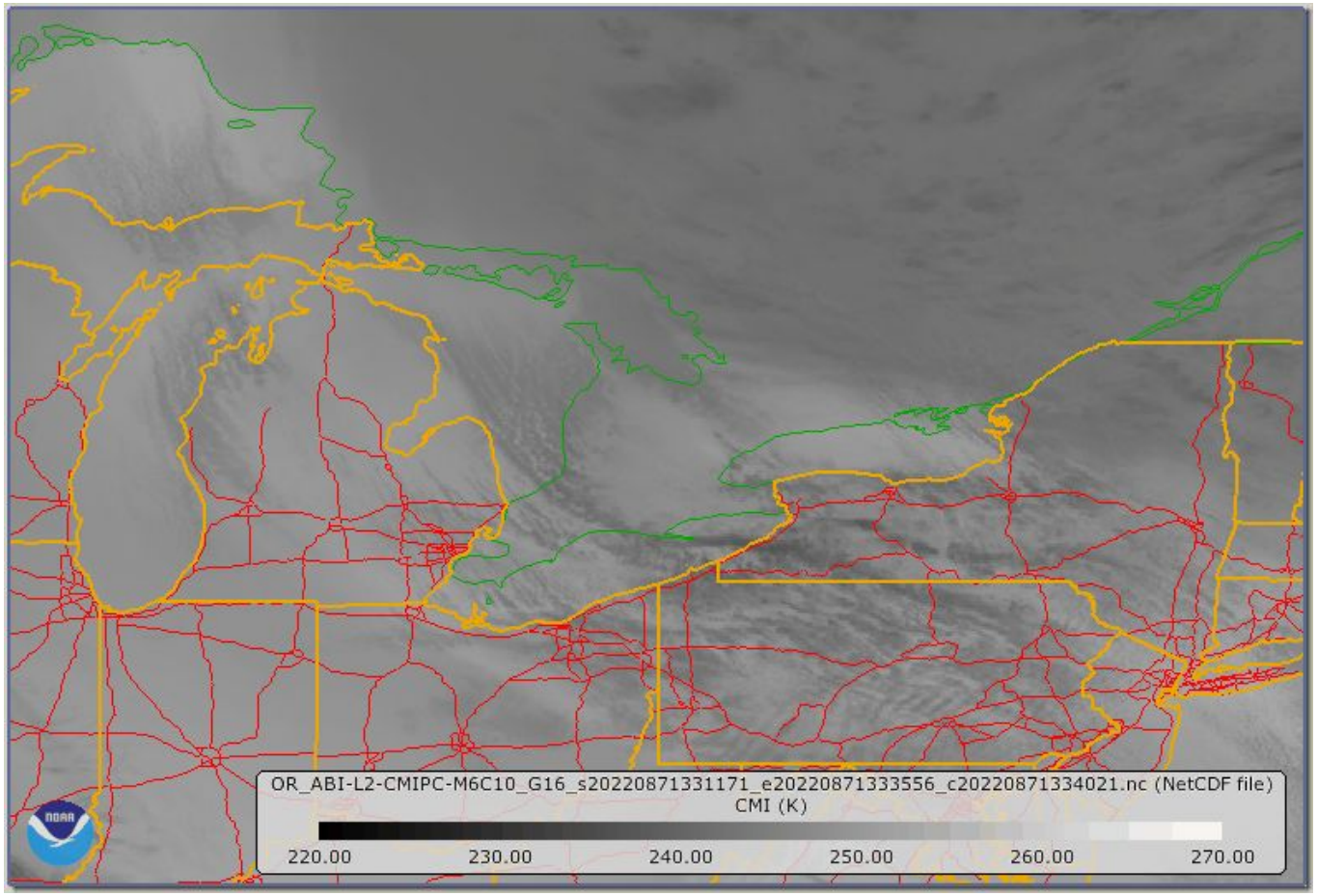
Precipitation Imaging Package Observations (MQT)



Remote sensing + microphysics observations: Nowcasting tool development, improve NWP, etc.

The Path Forward (Science)

- Lake-effect versus over-land convective snow
- Great Lakes influence



Summary

GOES Cloud Products: Snow Squall Situational Awareness

- Useful, especially if optimized for nowcasting purposes
- Augment NEXRAD obs
- Future snow squall QPE/threat level product development
- Expand scientific knowledge

Great Lakes Working Group

- Contact me if you are interested in joining!
- mark.kulie@noaa.gov