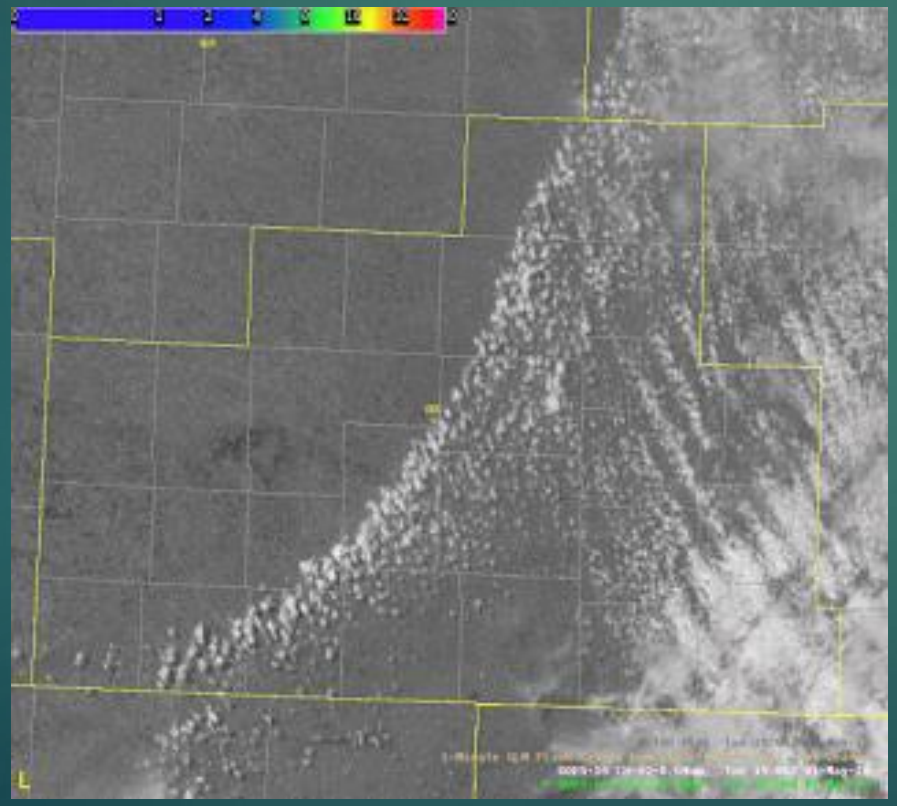
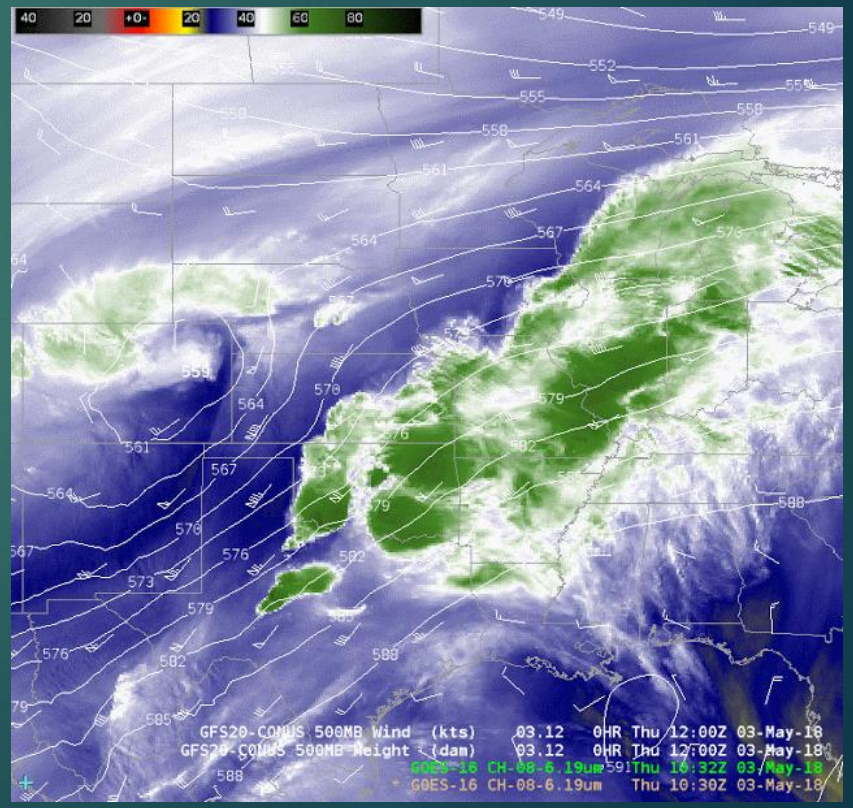
Severe Weather Applications: A SPC Perspective

GOES-R/JPSS PROVING GROUND/RISK REDUCTION SUMMIT

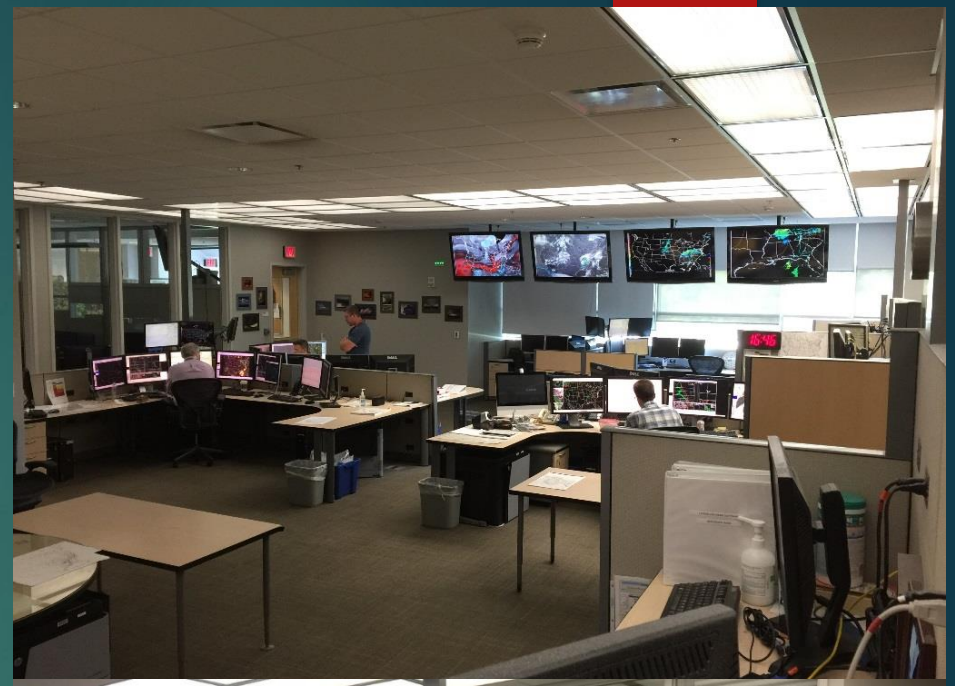
PRESENTER: MICHAEL BOWLAN, OU CIMMS & NOAA/STORM PREDICTION CENTER, NORMAN, OKLAHOMA

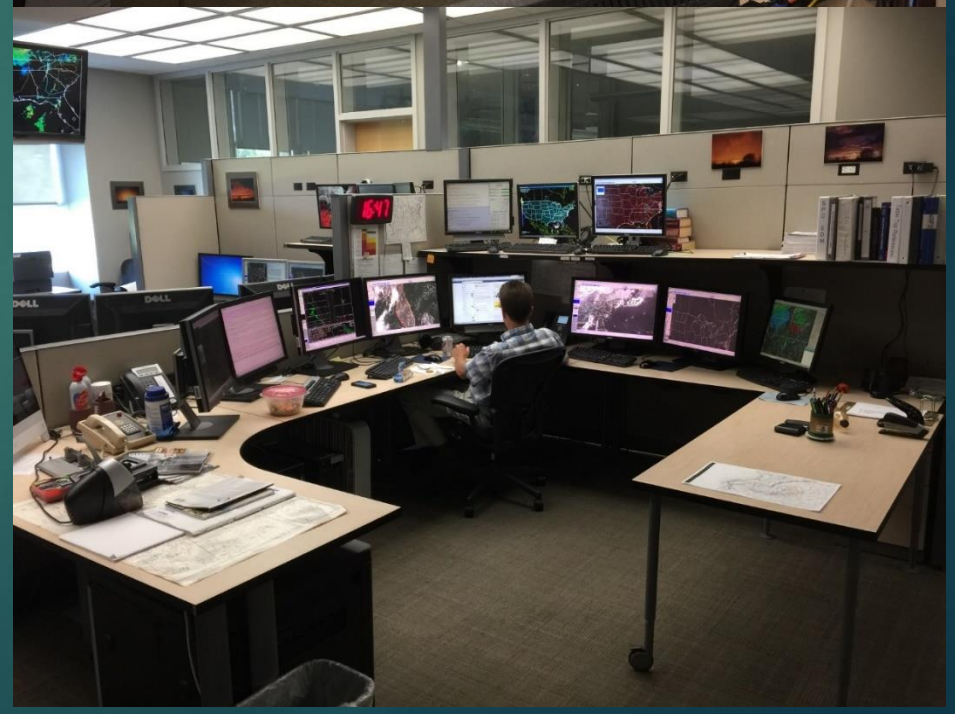




SPC Operations

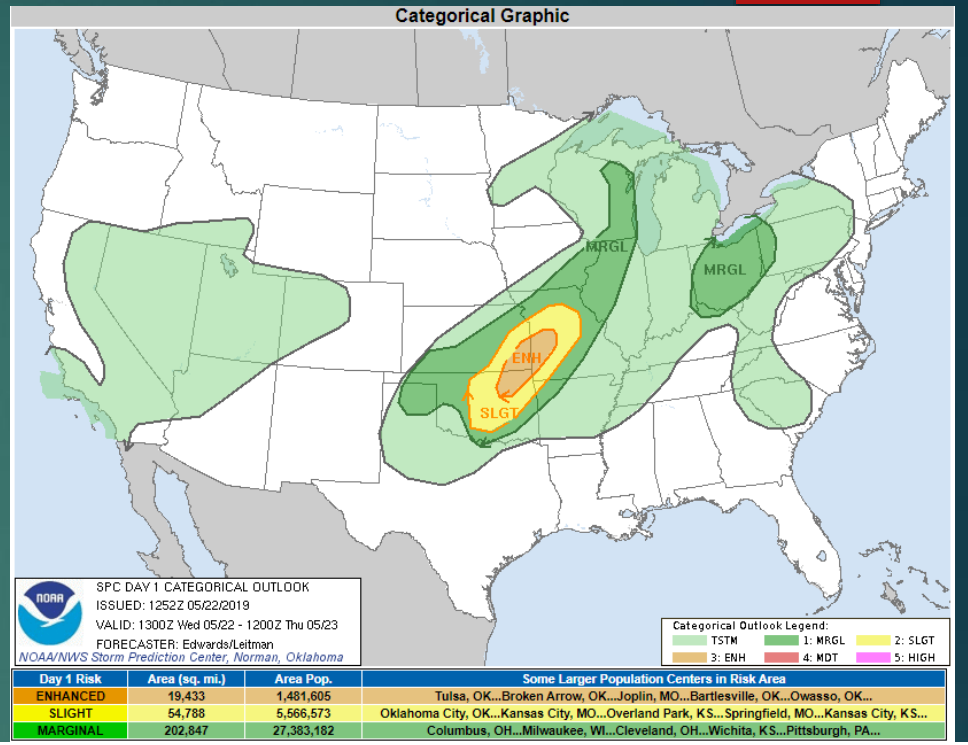
- Continuous Weather Watch over entire CONUS
  - Severe Weather Watches
  - Mesoscale Discussions
  - Convective Outlooks out to 8 days
  - Thunderstorm Outlooks
  - Fire Weather Outlooks out to 8 days
- Communicate the hazards to many partners: including WFOs, EMs, broadcast partners, and the public
- Use NAWIPS for data viewing and product issuance





Monitor the Large Scale Environment to Refine Convective Outlooks

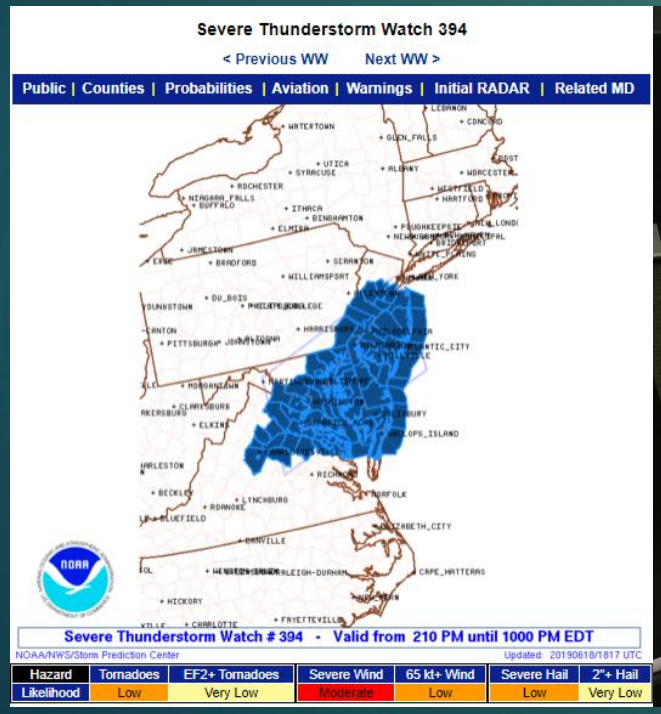
- Focus on large scale features
- Utilize Water Vapor Channels the heaviest here
- Compare CONUS and World Composites to upper air charts and model initializations to match obs to model
- NT Microphysics RGB has also aided in detecting low stratus overnight for initial Day 1 Outlooks

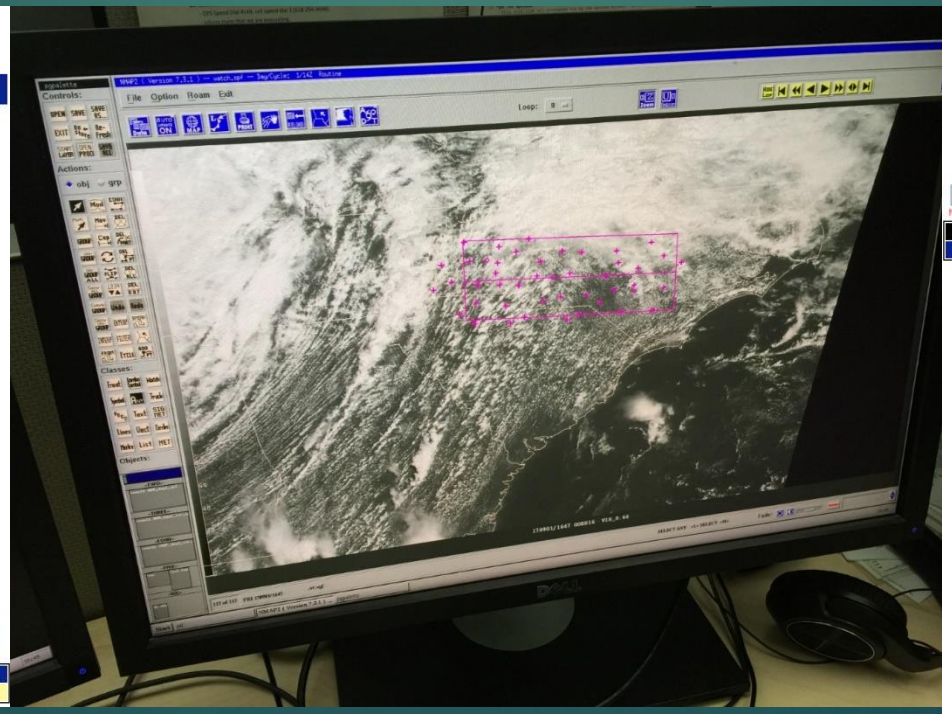


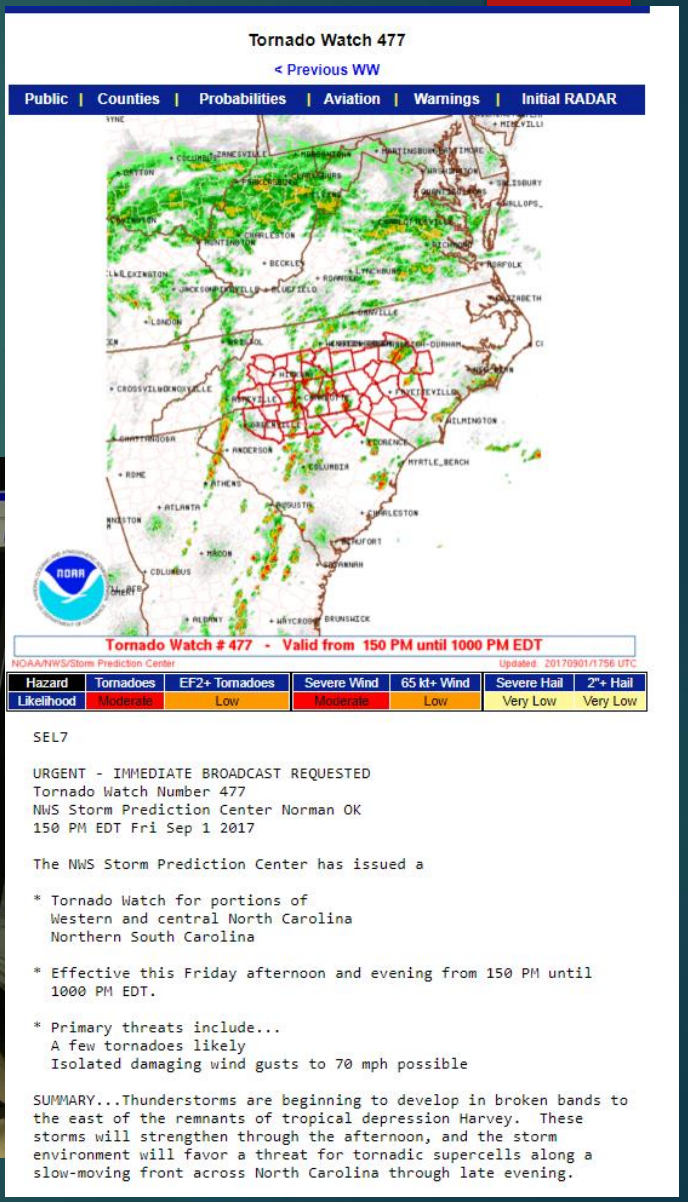
...Synopsis...
The period begins with a large area of mid/upper-level cyclonic flow covering most of the central/western CONUS, anchored by embedded lows initially evident in moisture-channel imagery over the north-central Plains and the Great Basin. The eastern of the two lows is occluded in low levels and nearly stacked, and is forecast to weaken while ejecting northeastward toward Lake Superior through 12Z. Meanwhile the western low should pivot slowly around the southern/eastern Great Basin, while assuming less-positive tilt. In between, shortwave ridging and height rises will build over the southern/central Plains.

Identify Areas Prime for Convective Initiation for Watch Issuance

- CONUS and Meso Sector VIS & IR
- Boundary detection
- Looking for glaciation







Identify Features on Small Spatiotemporal Scales for Mesoscale Discussion

Mesoscale Discussion 0922
NWS Storm Prediction Center Norman OK
0132 PM CDT Sat Jun 01 2019

Areas affected...Far Northeast NM...Western OK Panhandle...TX

DISCUSSION...Visible satellite imagery shows most of the low clouds present this morning over the TX Panhandle and vicinity have eroded, with deepening cumulus clouds now in place. Recent surface analysis places a outflow boundary from near the western border of the TX/OK Panhandles southwestward into western OK. Some surface troughing is also noted a bit farther west/northwest into northwest NM. Attempts at deep convection have been noted over the past hour with convective initiation now realized across the east-central TX Panhandle and over far northeast NM.

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- Monitor ongoing convective trends
- Look at cloud top temperature trends, especially for MCS maintenance and decay
- Look for interaction with boundaries
- Identifying unstable vs. stable air masses
- Cloud streets, billow clouds, gravity waves etc…
- Monitor for initiation prior to watch issuance

SPC Operational Challenges and Opportunities for Improvement

- Still using NAWIPS to issue products and many satellite products are not currently available on SPC NAWIPS or are degraded somewhat by limited color availability
  - Satellite Derived Winds, GLM Products, RGBs, TPW etc…
- Information overload can occur with many areas to monitor nationally
- Being able to see through or more easily detect multiple cloud layers
- Satellite soundings that adequately depict the boundary layer for data sparse regions to compare to model soundings
- Low-Level Water Vapor retrievals closer to the surface
- Cloud top delta T product tracking features
- Pre-cloud glaciation products

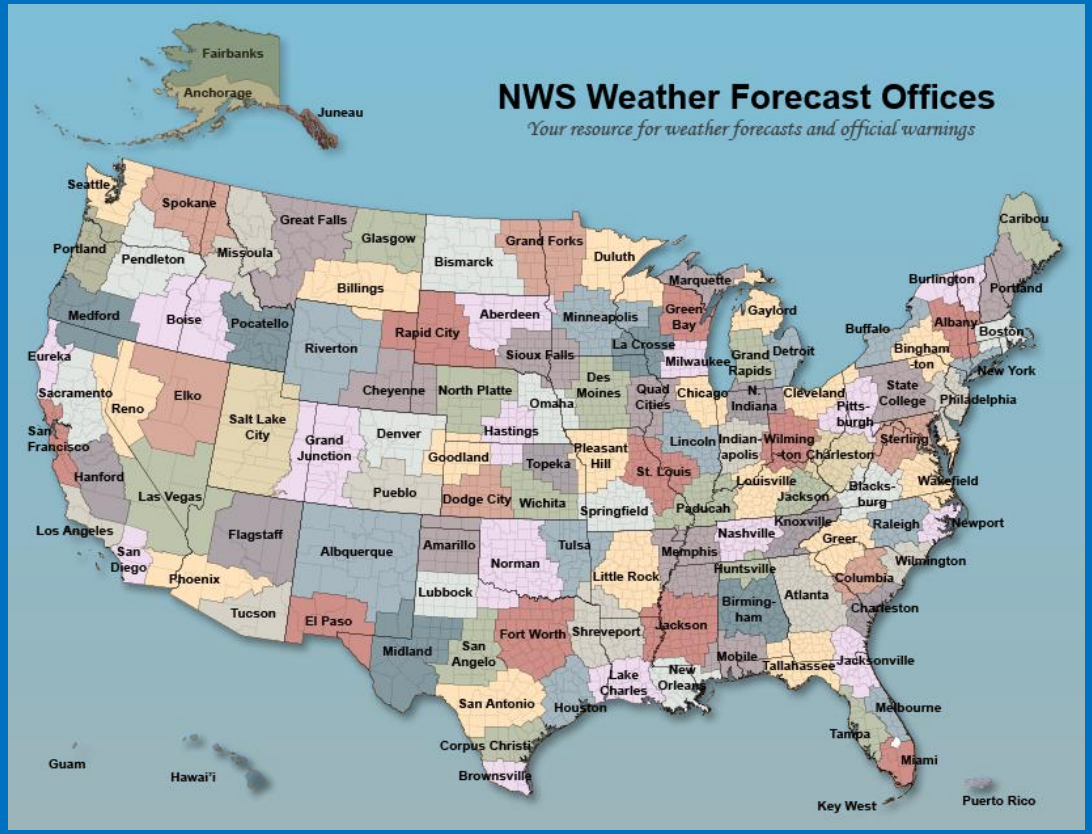
NATIONAL WEATHER SERVICE

NWS Regional Support of Integrating Satellite Data for Severe Weather

FEBRUARY 24, 2020 – Satellite Proving Ground Risk Reduction Summit

Presenter: Chad Gravelle, Tech Dev Met, NWS Southern Region HQ

NWS Southern Region Headquarters

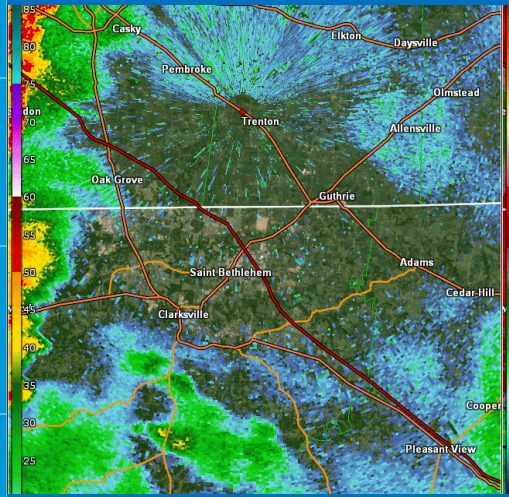


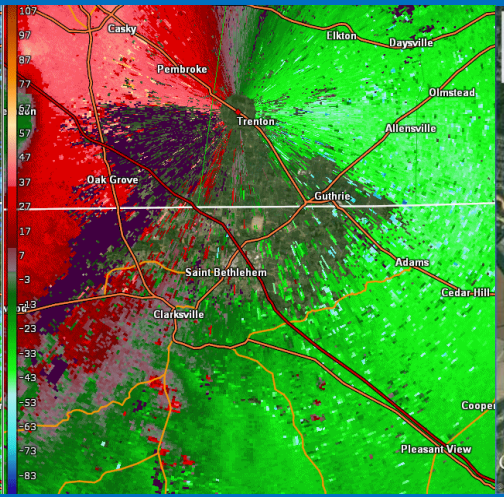
*Southern Region Headquarters provides both administrative and operational **support** to its field offices and manages the Region's programs, **scientific enhancements**, and staffing.*

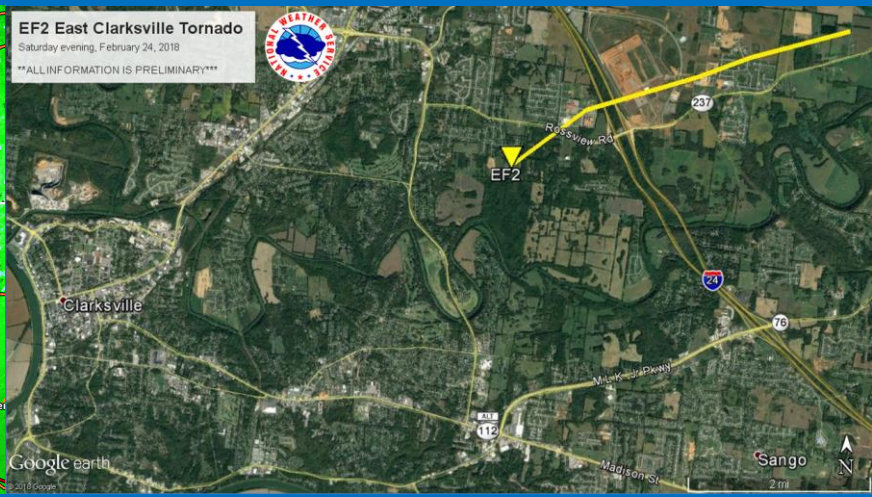
Mesoanalysis

February 24, 2018 – Clarksville, TN EF-2 Tornado

QLCS Tornado After Dark
Nearly 90 Homes Damaged
Zero Fatalities and Few Injuries

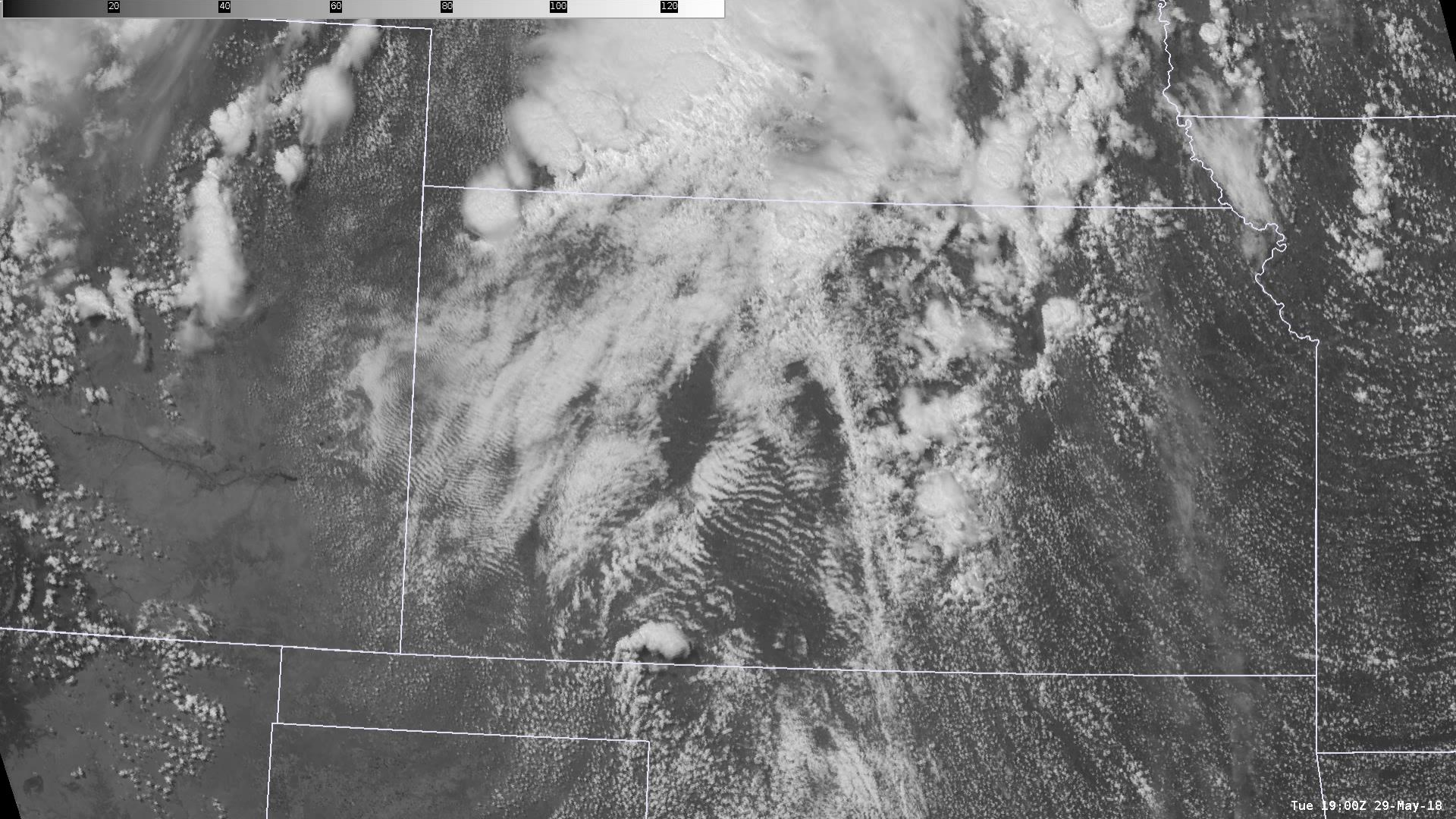






February 24, 2018 – Clarksville, TN EF-2 Tornado

"Many homes were destroyed and a few people sustained serious injuries, but the NWS warning gave most people time to take cover. ***There would have undoubtedly been fatalities had the warning not been issued so early.****"* - Montgomery County Emergency Manager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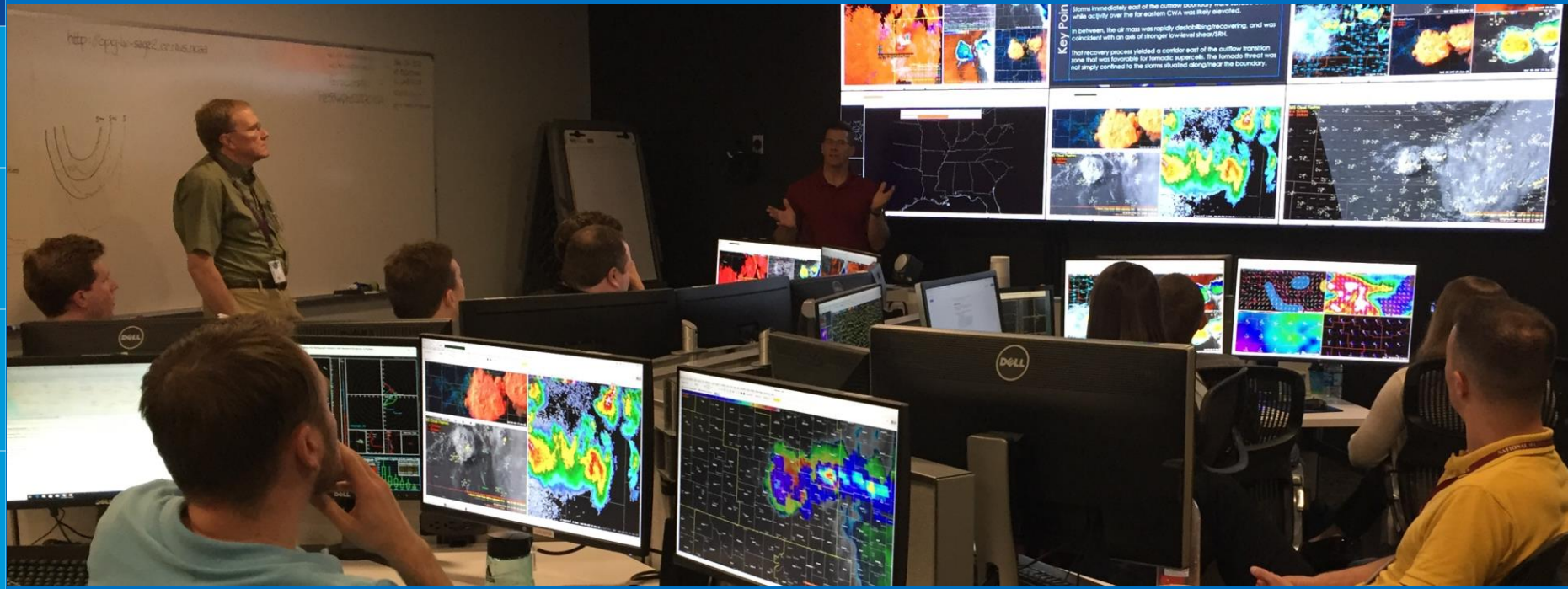
Operations Proving Ground Mesoanalysis Eval



"Use of satellite imagery to enhance understanding of ongoing physical processes." – Most common participant takeaway from OPG Report

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WFO Norman Hosting Sub-Regional Mesoscale Applications Webinars

posted Jan 29, 2020, 6:28 AM by NWS Insider Staff - NOAA Service Account

National Weather Service forecasters strive to provide the highest quality services possible. Opportunities for forecasters to add value to the forecast and warning process are most prevalent in the short-term periods. This was a focus of the Mesoanalyst Boot Camp held last summer at the Operations Proving Ground in Kansas City. To capitalize on expertise gained through the boot camp, WFO Norman has begun to host sub-regional seminars focused on applications of mesoscale meteorology. *"Mesoanalysis is the foundation of accurately communicating weather threats and encouraging protective action, so we want to discuss how to optimize our skills and provide a high level of service",* says WFO Norman forecaster and boot camp attendee, **Randy Bowers.**

To date, nine Mesoscale Application Discussions have been held since September. Topics have ranged from the use of GOES-16 imagery to diagnose the evolution of severe thunderstorms, to predicting banded heavy snowfall, to an After Action Review of impact-based decision support services provided during a wildfire outbreak. While the WFO Norman staff leads the discussions live in their conference room, as many as 11 other WFOs have participated remotely, as well as representatives from Southern Region Headquarters, the Storm Prediction Center, Oklahoma Forestry Services, and Texas A&M Forest Service. In all, 125 forecasters and core partners have directly been involved in the discussions so far, which have even been co-hosted with personnel from WFOs Wichita, Springfield, and Miami. Once the live discussions have ended, WFO Norman forecasters capture a summary of the conversations in a short video which can be easily shared via WFO Norman's Google intranet (here & here). WFO Tucson Meteorologist in Charge, **Marc Singer**, shared one such video with his staff and stated, *"there is value in sharing information across our agency" and that it provided "direct application on how to tackle future forecasting challenges".*

NWS Insider

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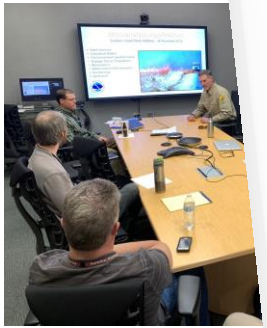
WFO Norman H

posted Jan 29, 2020, 6:28 AM by N



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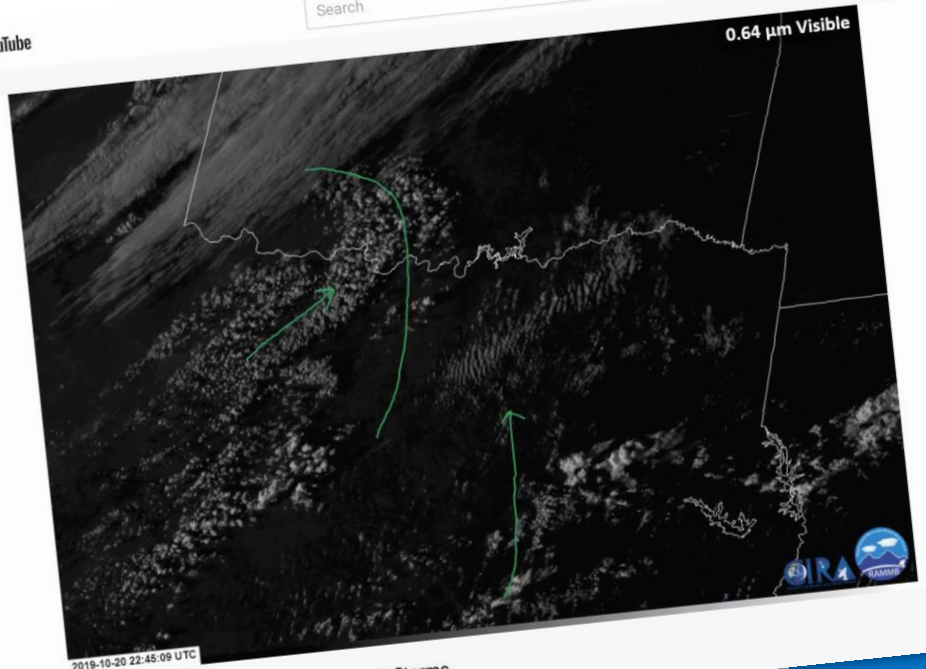
YouTube



Mesoanalysis Applications Talk - October 20th Severe Storms

Unlisted

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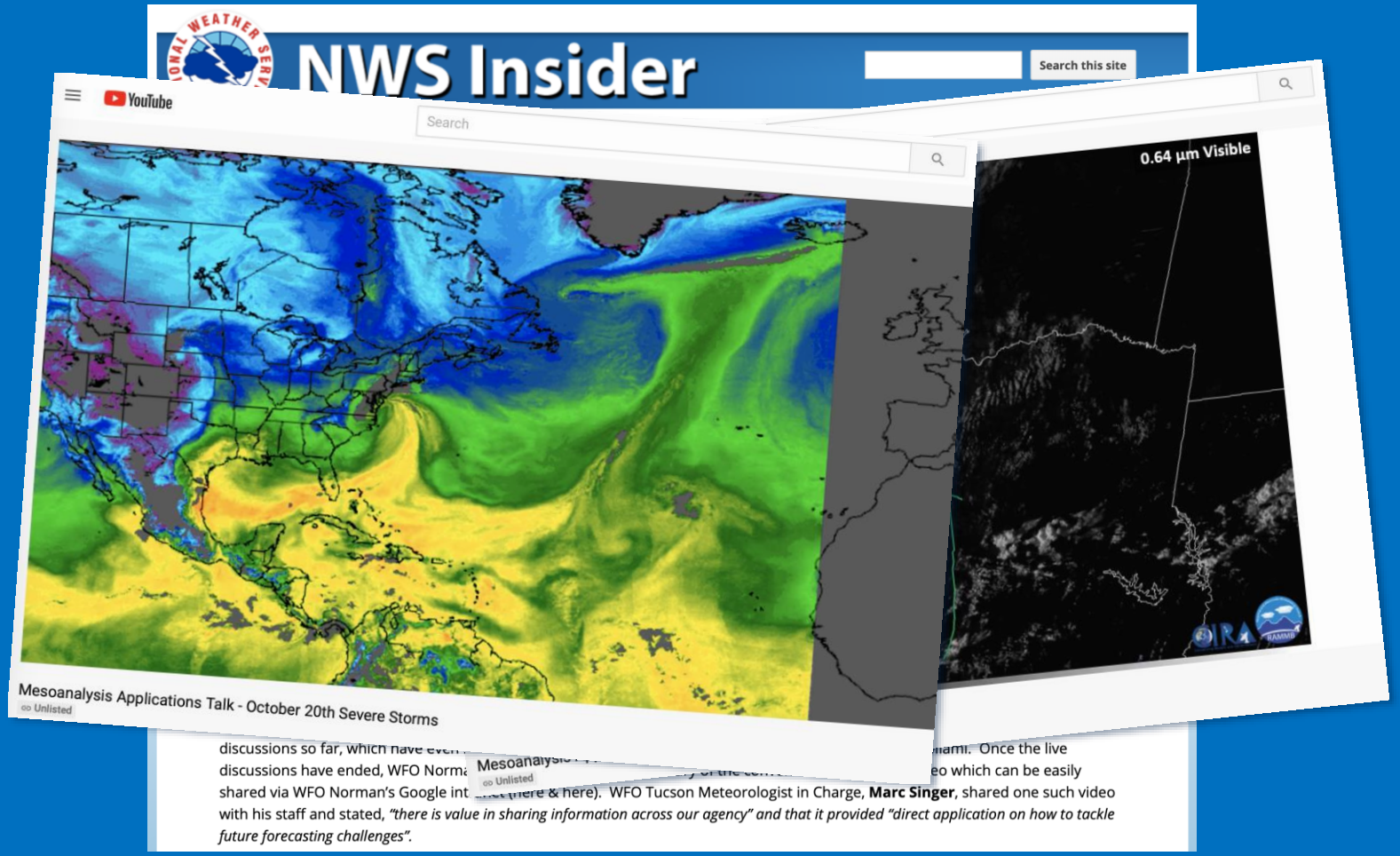
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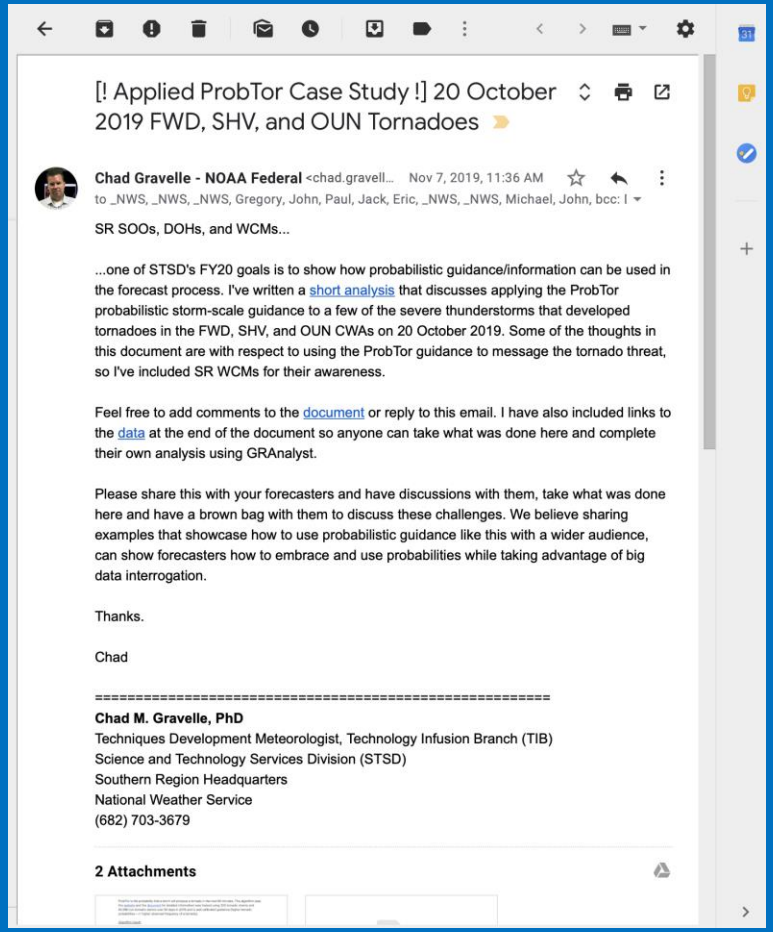
ProbSevere v2



[! Applied ProbTor Case Study !] 20 October 2019 FWD, SHV, and OUN Tornadoes

Chad Gravelle - NOAA Federal <chad.gravell... Nov 7, 2019, 11:36 AM
to _NWS, _NWS, _NWS, Gregory, John, Paul, Jack, Eric, _NWS, _NWS, Michael, John, bcc: I

SR SOOs, DOHs, and WCMs...

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Thanks.

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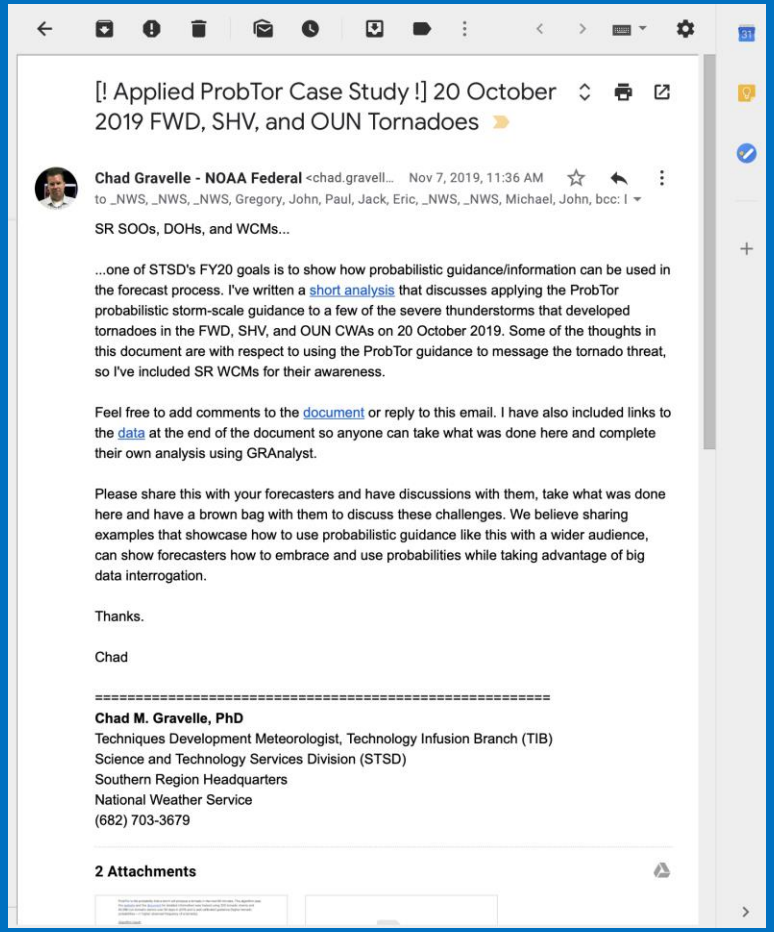

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ProbTor Applied Case Study
Chad Gravelle - SR STSD
20 October 2019 - FWD, SHV, OUN Tornadoes

ProbSevere v2, with individual hazard probabilities (ProbWind, ProbHail, ProbTor), is now available in AWIPS 19.2.1. This allows warning forecasters and mesoanalysts to integrate the probabilistic threat guidance directly into their decision making.

ProbTor Background

ProbTor is the probability that a storm will produce a tornado in the next 60 minutes. The algorithm (see this website and this document for detailed information) was trained using 325 tornadic storms and 45,586 non-tornadic storms over 60 days in 2016 and is well-calibrated guidance (higher tornado probabilities ---> higher observed frequency of a tornado).

Algorithm Inputs

MRMS Maximum 0-2km AzShear
MRMS 98th percentile 0-2km AzShear and 3-6km AzShear
Maximum Total Lightning Flash Density
RAP 0-1 km Storm Relative Helicity
RAP Effective Bulk Shear
RAP Mean Wind 1-3 km Above Ground Level
RAP MLCAPE and MLCIN

Known Caveats

1. ProbTor algorithm requires an identifiable object in radar and object identification can become more difficult in linear convection.

2. ProbTor interpretation can be more difficult in linear convection. Identifying the portion of a long convective line with the highest tornado threat is difficult since the the ProbTor object can be large. In addition, ProbTor can overforecast probabilities in linear convection due to strong MRMS AzShear that tends to occur in strong convective lines.

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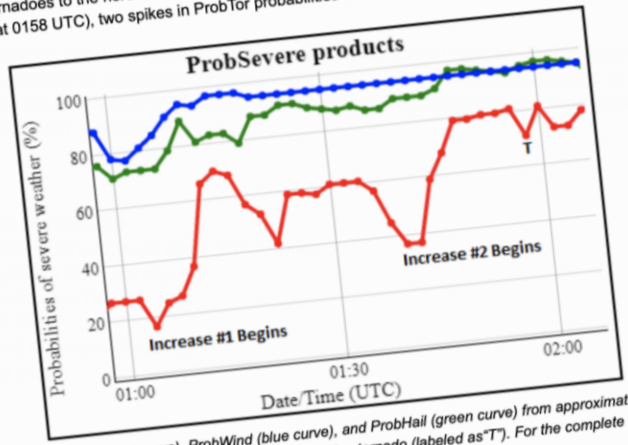
ProbTor Applied Case Study

The following examples will show how these can be applied during the convective decision making process.

1. Increasing Trends in ProbTor - North Dallas Tornado

First...it's important to note that the environment the EF-3 north Dallas tornado occurred in was conducive for tornadoes. There was 2600 J kg^{-1} ML CAPE, 20-30 J kg^{-1} ML CIN, 50 kts of Effective Bulk Shear, 30 kts of 0-1-km Mean Wind, and 300 m^2 s^2 0-1-km SRH. A SPC tornado watch was issued shortly after 0000 UTC.

Storms initially developed to the west of Fort Worth, split, and the two right turning supercells ended up producing tornadoes to the north and south of Dallas. In the hour leading up to the north Dallas tornado (developed at 0158 UTC), two spikes in ProbTor probabilities occurred.



Time series of ProbTor (red curve), ProbWind (blue curve), and ProbHail (green curve) from approximately 0100 UTC to 0200 UTC 21 October 2019 leading up to the North Dallas tornado (labeled as"T"). For the complete ProbTor input time series, see the interactive time series, these plots are available in real time.

The first upward trend occurred between 0104 and 0114 UTC as ProbTor increased from 17% to 70% in ten minutes. This spike was likely driven by two changes with the ProbTor inputs.

First, the MRMS AzShear inputs strengthened as strong low-level convergence was occurring in the developing supercell.

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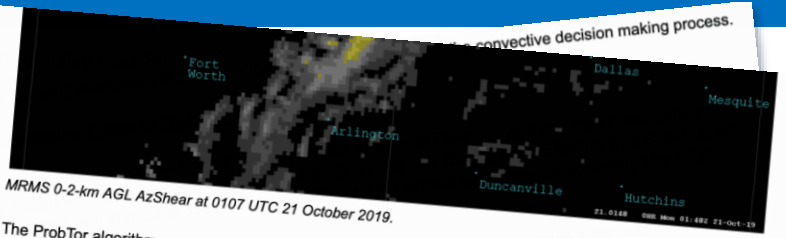

MRMS 0-2-km AGL AzShear at 0107 UTC 21 October 2019.

The ProbTor algorithm processes three MRMS AzShear fields and uses that information to assist with computing the tornado probabilities. This provides the warning forecaster with heightened situational awareness without having to interrogate high-resolution datasets in addition to base data. In the north Dallas tornado example, as low-level AzShear shear and ProbTor probabilities increased...the threat for tornadogenesis increased. This statement can be made because ProbTor is well calibrated and reliable...higher probabilities ---> higher observed frequency of occurrence.

2. To assist with adding the "Tornado Possible" tag in severe thunderstorm warnings.

In an environment favorable for tornadoes, trends in ProbTor may provide the warning forecaster with enough confidence to include the "TORNADO . . . POSSIBLE" IBW tag in severe thunderstorm warnings. As ProbTor increased to 70% between 0104 and 0114 UTC, adding the tornado possible tag could provide an additional level of DSS if forecaster confidence is not high enough to warrant a tornado warning.

3. To message tornado potential in NWSChat.

In addition to adding the "Tornado Possible" tag in severe thunderstorm warnings, trends in ProbTor can be messaged in NWSChat. For example, *"Experimental tornado guidance suggests the threat for tornadoes may be increasing with the supercell over northern Tarrant County. We are closely monitoring this storm for signals of increased rotation."*

2. Decreasing Trends in ProbTor - Southwest Shreveport Tornado

Trends in ProbTor probabilities were also observed with a supercell that produced two tornadoes across east Texas and western Louisiana; one EF-0 tornado west of Carthage, TX around 0036 UTC and one EF-1 tornado southwest of Shreveport, LA between 0142 and 0149 UTC. In the north Dallas tornado, increasing ProbTor probabilities were noted before both tornadoes occurred, the focus for the tornado southwest of

First, the MRMS AzShear inputs strengthened as

developing supercell.

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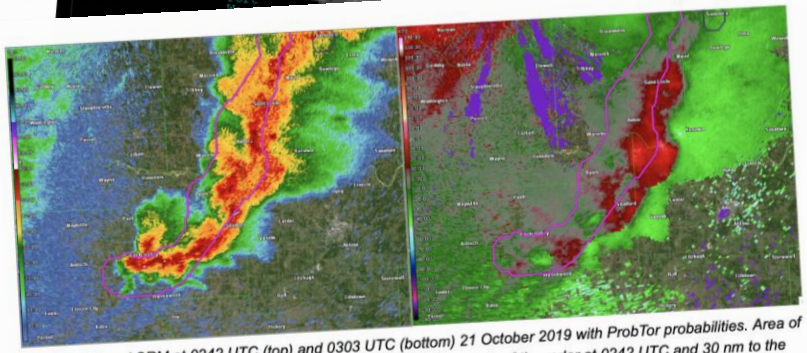


KTLX 0.4° Z and SRM at 0242 UTC (top) and 0303 UTC (bottom) 21 October 2019 with ProbTor probabilities. Area of strong convection near Paoli, OK was approximately 30 nm to the south of the radar at 0242 UTC and 30 nm to the southeast of the radar at 0303 UTC.

This example highlights one of the strengths (i.e., being able to efficiently focus the warning forecaster's attention) and one of the weaknesses (i.e., overforecasting probabilities in linear convection) of the ProbTor guidance. While ProbTor probabilities could have focused the warning forecaster's attention, it also showed the importance of human-driven base-data interrogation within the area of concern.

Final Thoughts

Even though ProbTor is well-calibrated storm-scale guidance, always use the ProbSevere products in conjunction with and to support base radar data interrogation. The analysis and ideas within this document are meant to show how ProbSevere products and probabilistic guidance can be used to assist with decision making in warning operations.

Thoughts and comments are welcome, feel free to add them within the document so we can all learn from them. If you would like to complete your own analysis of the examples presented, the WSR-88D Level 2 radar data and ProbSevere placefiles are located here. Just download the data, drag the radar files onto GRAnalyst, and load the ProbSevere placefiles on the radar data with the placefile manager. This will allow you to go through the document interactively.

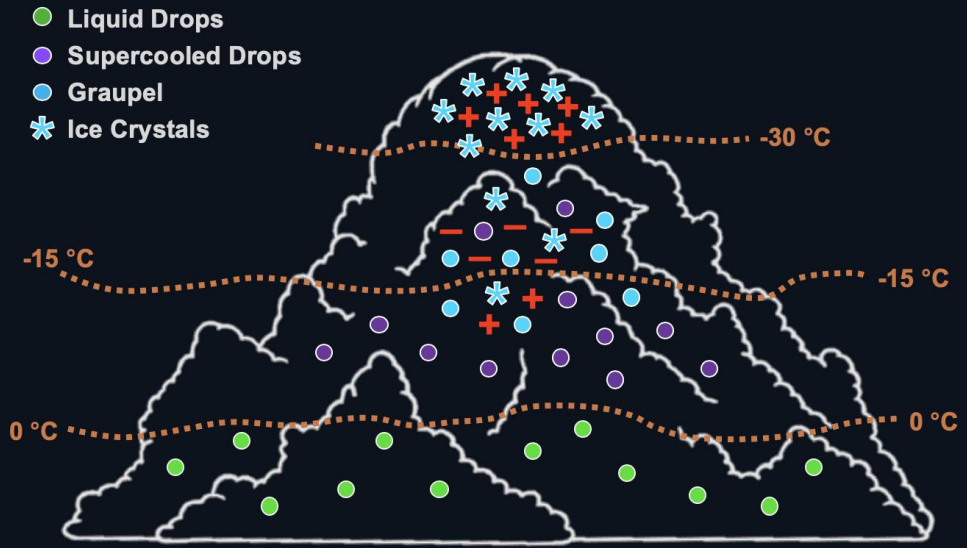
developing supercell.

Lightning Safety

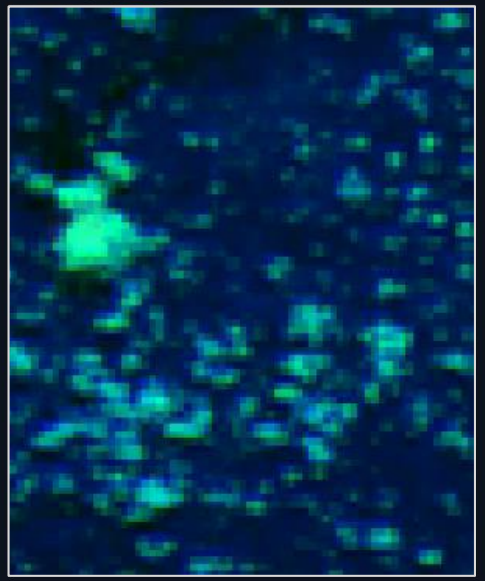
GOES-16 Day Cloud Phase RGB Composite

A Precursor for Lightning – Towering Cumulus (mixed)

Cloud Microphysics Conceptual Model



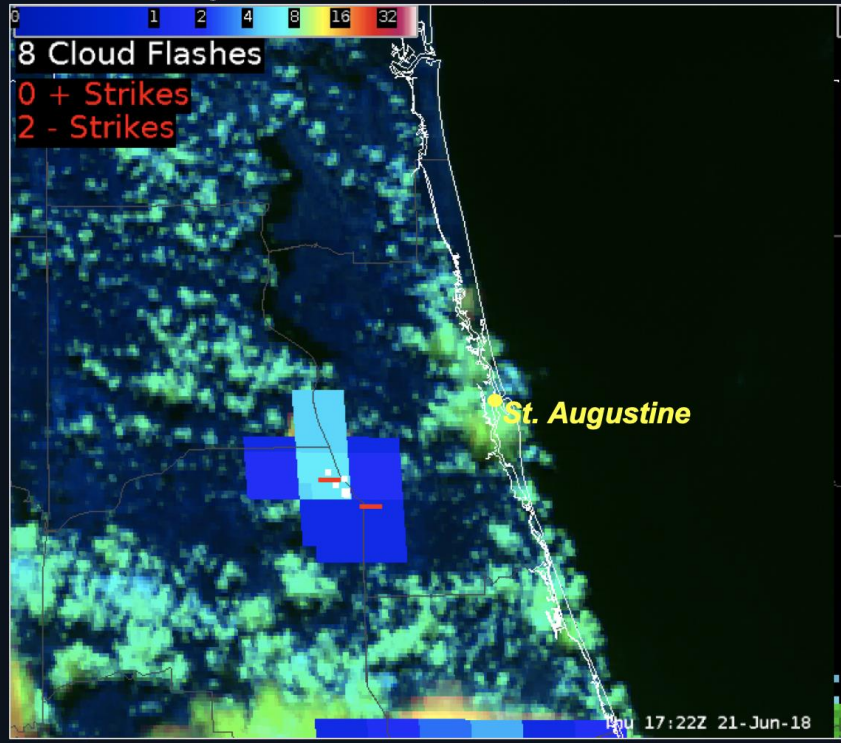
GOES-16 DCP RGB



Some Good Examples

21 June 2018 1722 UTC

GOES-16 Day Cloud Phase RGB, GLM, and ENTL IC/CG



MRMS Z at -10°C and ENTL IC/CG

NWS Jacksonville
@NWSJacksonville
Following

At the beaches this afternoon? Don't wait for the sound of thunder to go indoors. Lightning threat increasing for St Augustine & Vilano Beach. #flwx

12:24 PM - 21 Jun 2018

5 Likes

FORECASTERS' FORUM

Introducing Lightning Threat Messaging Using the *GOES-16* Day Cloud Phase Distinction RGB Composite

CYNTHIA B. ELSENHEIMER

NOAA/NWS Southern Region Headquarters, Fort Worth, Texas

CHAD M. GRAVELLE[a]

Cooperative Institute for Mesoscale Meteorological Studies, University of Oklahoma, Norman, Oklahoma

(Manuscript received 9 March 2019, in final form 1 July 2019)

ABSTRACT

In 2001, the National Weather Service (NWS) began a Lightning Safety Awareness Campaign to reduce lightning-related fatalities in the United States. Although fatalities have decreased 41% since the campaign began, lightning still poses a significant threat to public safety as the majority of victims have little or no warning of cloud-to-ground lightning. This suggests it would be valuable to message the threat of lightning before it occurs, especially to NWS core partners that have the responsibility to protect large numbers of people. During the summer of 2018, a subset of forecasters from the Jacksonville, Florida, NWS Weather Forecast Office investigated if messaging the threat of cloud-to-ground (CG) lightning in developing convection was possible. Based on previous CG lightning forecasting research, forecasters incorporated new high-resolution *Geostationary Operational Environmental Satellite (GOES)-16* Day Cloud Phase Distinction red–green–blue (RGB) composite imagery with Multi-Radar Multi-Sensor isothermal reflectivity and total lightning data to determine if there was enough confidence to message the threat of CG lightning before it occurred. This paper will introduce the Day Cloud Phase Distinction RGB composite, show how it can add value for short-term lightning forecasting, and provide an operational example illustrating how fusing these datasets together may be able to provide confidence and extend the lead time when messaging the threat of cloud-to-ground lightning before it occurs.

1. Introduction

The National Weather Service (NWS) has recorded fatalities due to weather-related hazards in the United States since 1940 (https://www.weather.gov/hazstat/) and, based on total fatalities, lightning is the leading cause of deaths. Currently, the 10-yr average is 27 deaths annually, which is ranked seventh and behind the two leading causes of weather-related fatalities: heat (10-yr average of 101 annual fatalities) and flooding (10-yr average of 95 annual fatalities). When lightning fatalities are ranked by state, they occur most frequently in Florida and coincide with the highest cloud-to-ground (CG) lightning flash densities in the United States (e.g., Huffines and Orville 1999; Rudlosky and Fuelberg 2010; Holle et al. 2016). Between 2008 and 2018, 54 lightning fatalities occurred in Florida—more than twice the number in Texas, which was the second most during the same period. Although Florida is susceptible to lightning fatalities year-round, they occur most often during the warm season (June–August) when convection and lightning flash densities are greatest due to diabatic processes and the development of sea-breeze convergence zones (Hodanish et al. 1997).

Overall, lightning-related fatalities in the United States have decreased dramatically since the 1970s and dropped an additional 41% after 2001 when the NWS increased lightning public awareness through the NWS Lightning Safety Awareness Campaign (Jensenius 2016). This is likely due in part to the "*When Thunder Roars, Go Indoors*" slogan that was developed to mitigate the threat of lightning by encouraging people to take shelter at the first sign a

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Corresponding author: Cynthia B. Elsenheimer, cindy.elsenheimer@noaa.gov

DOI: 10.1175/WAF-D-19-0049.1

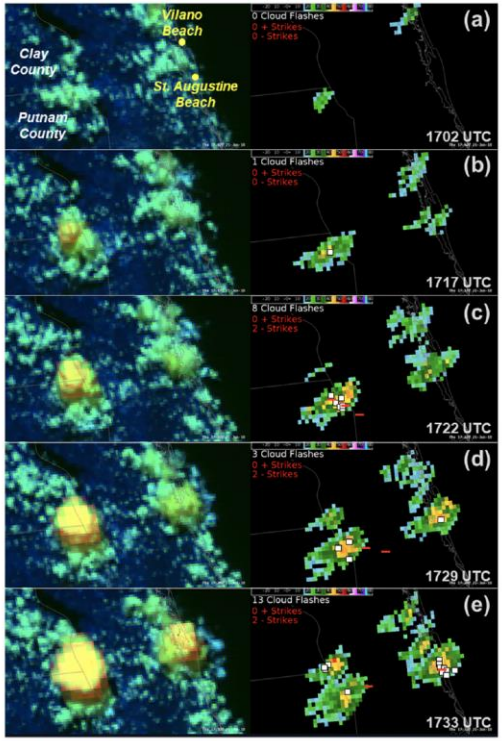
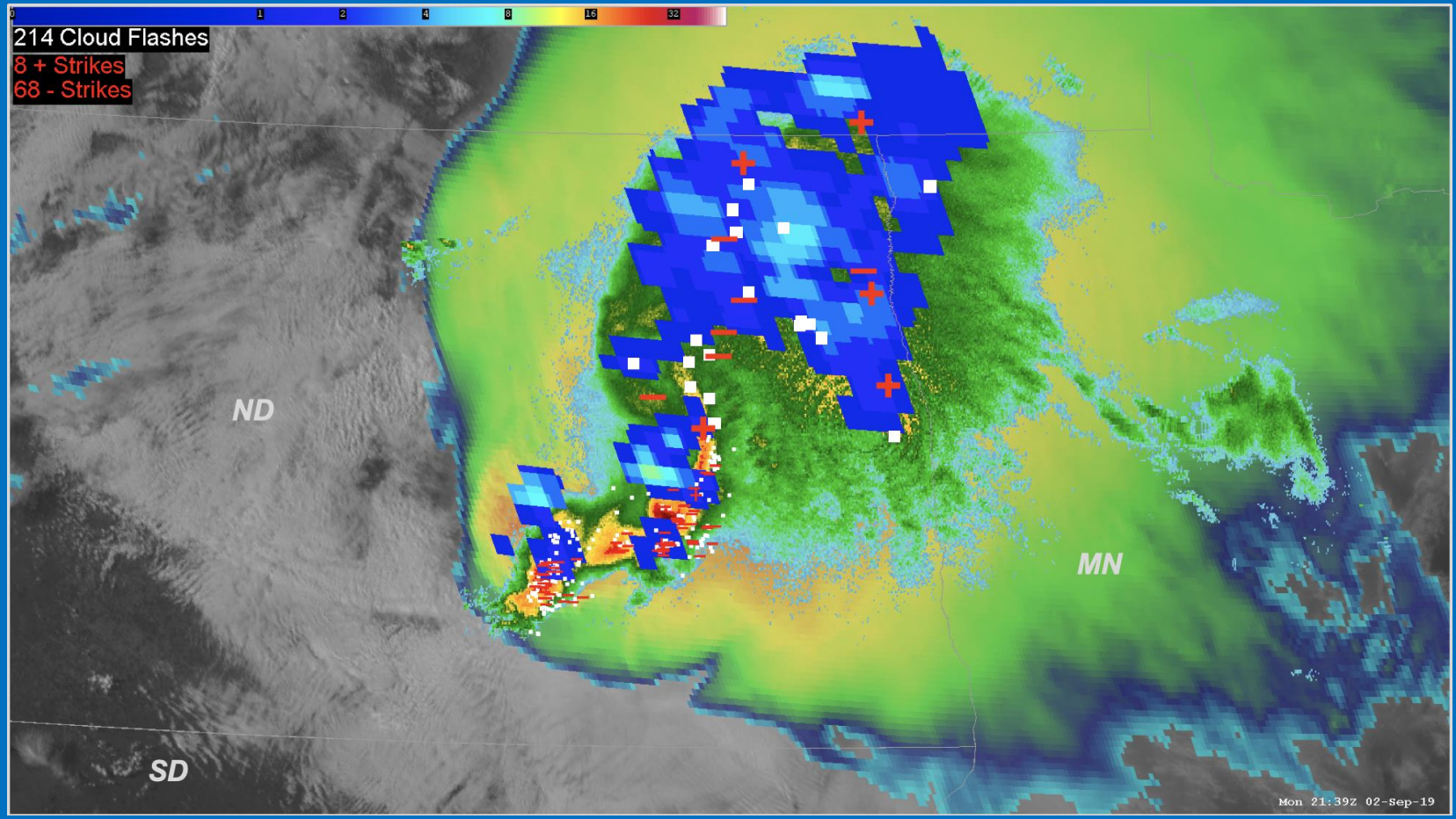
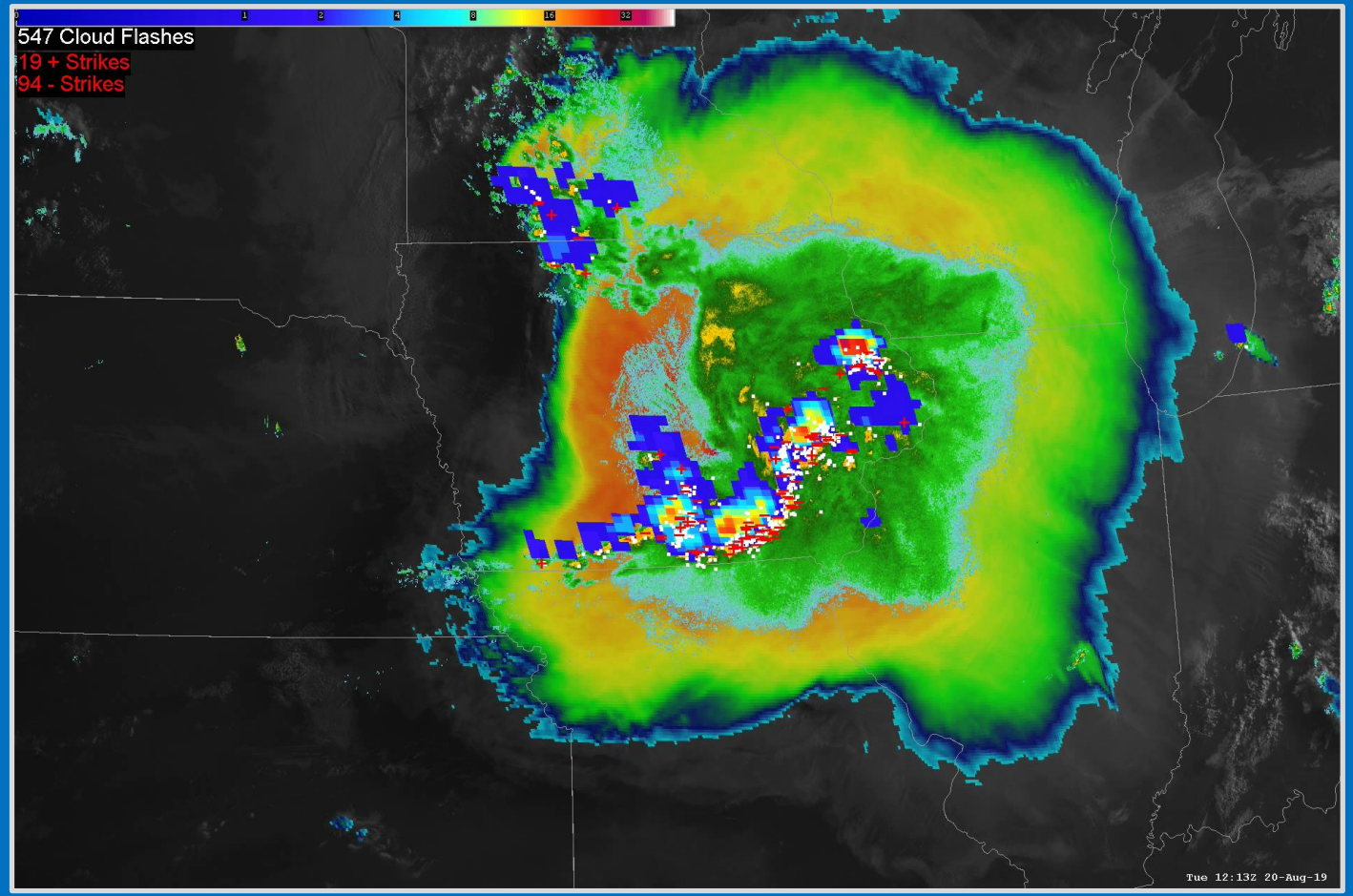


FIG. 6. (a)–(e) *GOES-16* Day Cloud Phase Distinction RGB composite on the left and MRMS −10°C isothermal reflectivity (dBZ; shaded according to scale) with ENTL IC (white squares) and ENTL CG (red positive and negative symbols) lightning observations on the right valid at (a) 1702, (b) 1717, (c) 1722, (d) 1729, and (e) 1733 UTC 21 Jun 2018.

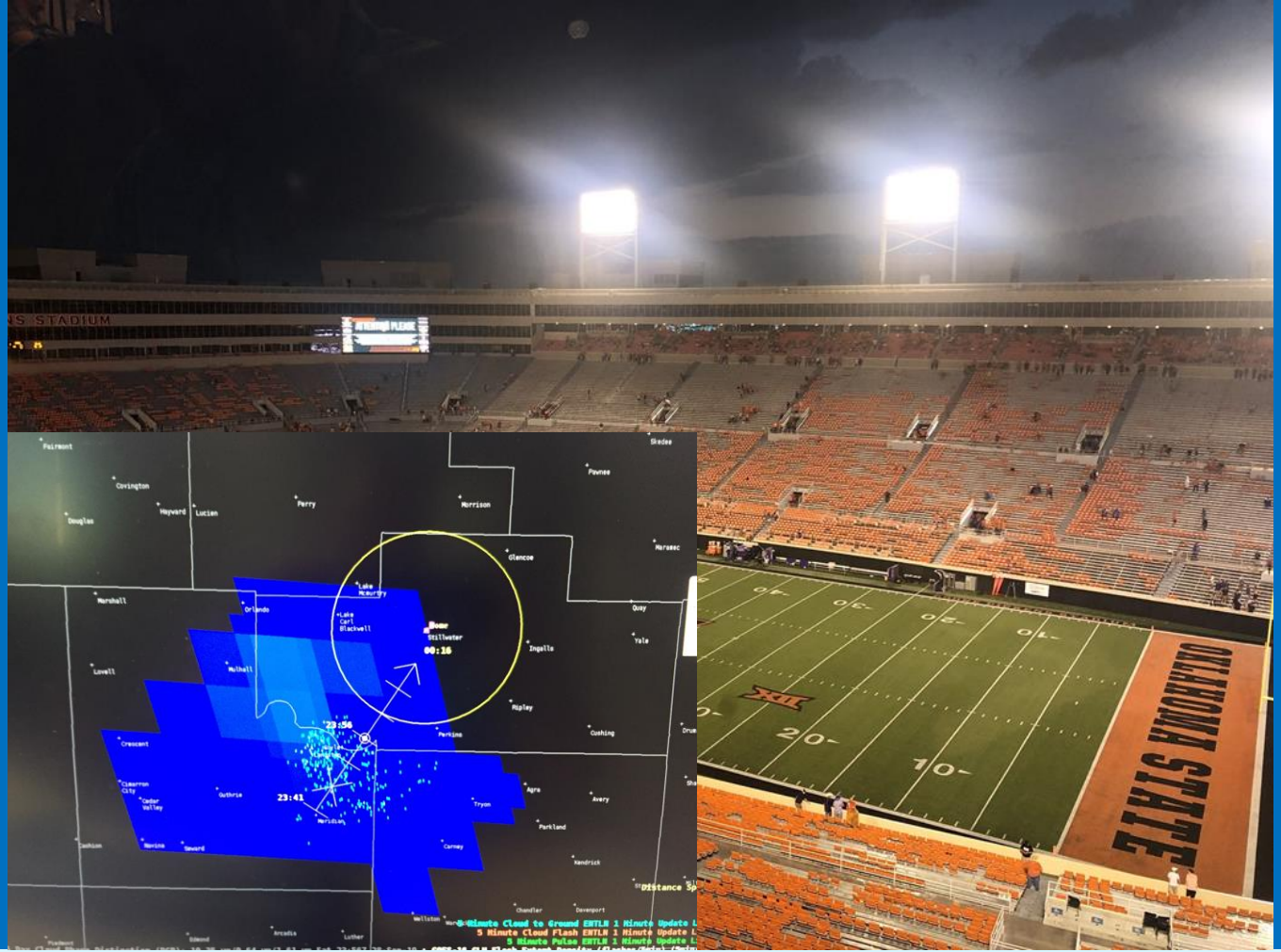
GOES-16 Red Visible and Clean IR Merge, MRMS 0℃ Z, GOES-16 GLM FED, and ENTL IC/CG



GOES-16 Red Visible and Clean IR Merge, MRMS 0℃ Z, GOES-16 GLM FED, and ENTL IC/CG



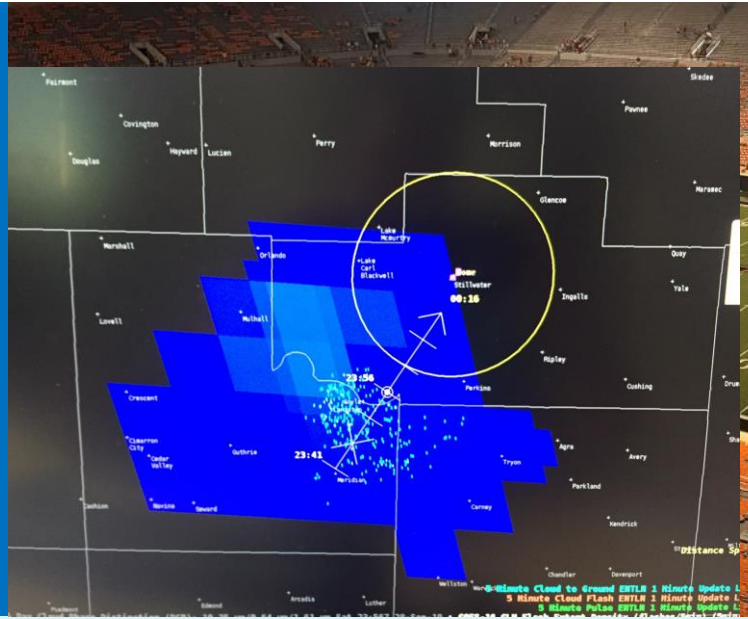

Simplified Long Flash Conceptual Model
Krehbiel 1986, Schuur et al. 1991, Stolzenburg et al. 1998, Carey et al. 2005, and others
Liquid Drops
Supercooled Drops
Graupel
Ice Crystals
Water-Coated Ice Crystals
Storm Motion
-30 °C
-15 °C
0 °C
100 km
75 km
50 km
25 km
0 km

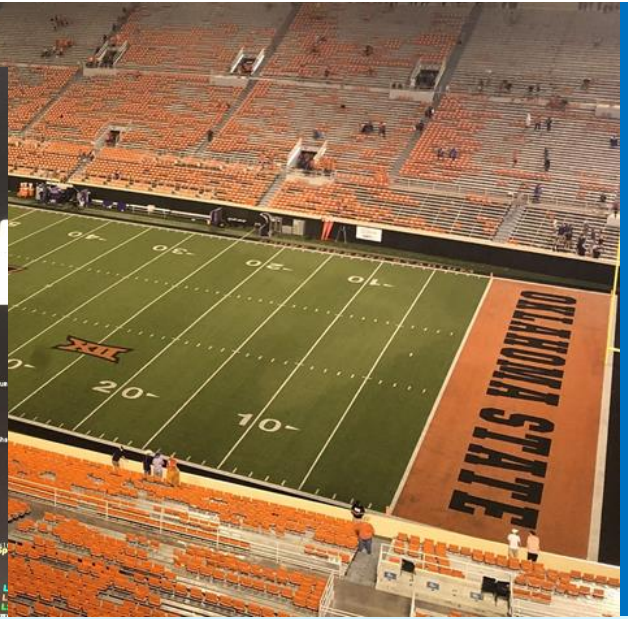

OKLAHOMA STATE
Fairmont
Covington
Douglas
Hayward
Lucien
Perry
Morrison
Pawnee
Skedee
Glancee
Marshall
Orlando
Lake Carl Blackwell
Stillwater
00:16
Quay
Yale
Lovell
Mulhall
Ingalls
Ripley
Cushing
Crescent
Cimarron City
Cedar Valley
Guthrie
23:41
Meridian
Tryon
Agra
Avery
Parkland
Mehan
Seward
Carney
Kendrick
Chandler
Davenport
Wellston
Arcadia
Luther
Edmond
Distance
5 Minute Cloud to Ground ENTLN 1 Minute Update
5 Minute Cloud Flash ENTLN 1 Minute Update
5 Minute Pulse ENTLN 1 Minute Update

When will lightning get inside the 8-mile circle?

(28 Sep 6:51 PM) nwsoun-randy.bowers: Rob, looks like about 10-15 minutes before the lightning strikes start to enter the 8 mile ring.

(28 Sep 6:52 PM) em-rob.hill: Thank you. We are beginning our notifications.





chad.gravelle@noaa.gov

NWS Southern Region HQ
Science Technology Services Division
Techniques Development Meteorologist

Severe Weather Applications: A WFO User Perspective

NATIONAL WEATHER SERVICE

JPSS/GOES-R Proving Ground / Risk Reduction Summit

Presenter: Chauncy Schultz, SOO, NWS Bismarck, North Dakota

Impact-Based Decision Support Services

WFOs communicate expected hazards, including via warnings

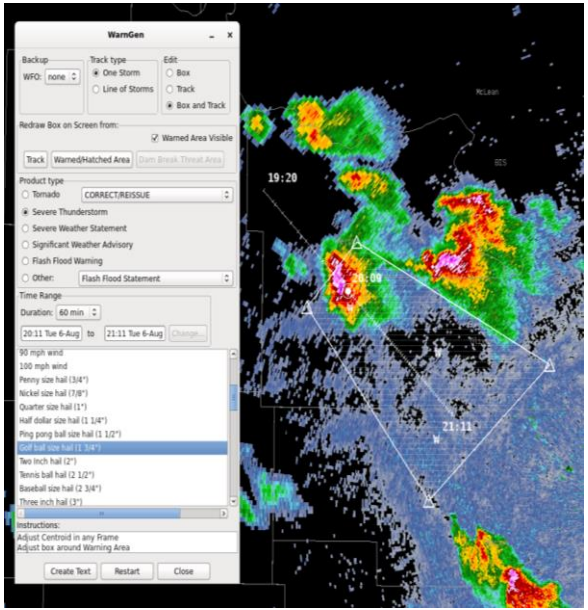
National Weather Service
Bismarck, North Dakota

Situation Report
Monday, July 8, 2019 8:19 AM

Severe Storms, Very Heavy Rain Today through Tuesday

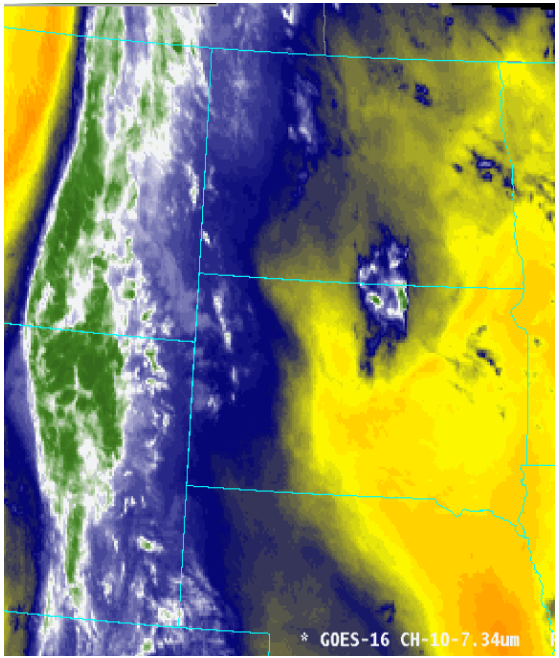
Message of the Day:

- Severe thunderstorms are expected across western and central North Dakota this afternoon through the evening.
- Storms may first form north of I-94 and east of Highway 83 by 3-5 pm CDT, with additional storms developing further west through the evening.
- Storms are expected to produce very heavy rain that could lead to localized flooding.

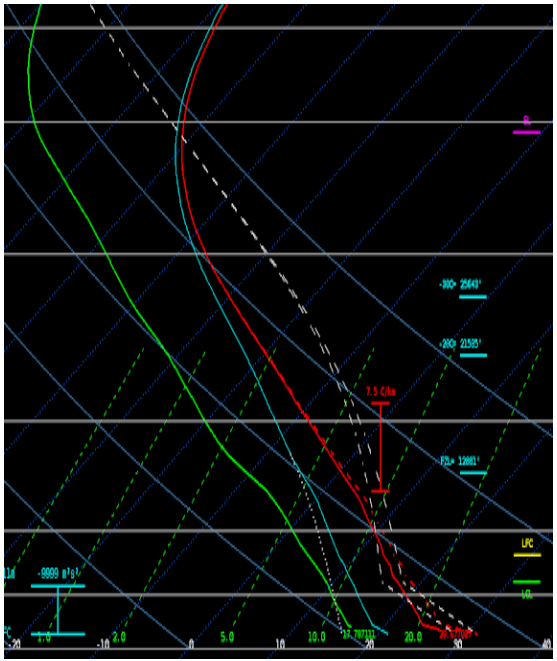


WFO Desired Outcome #1: Assess environmental "preconditioning" to collaborate/message risk

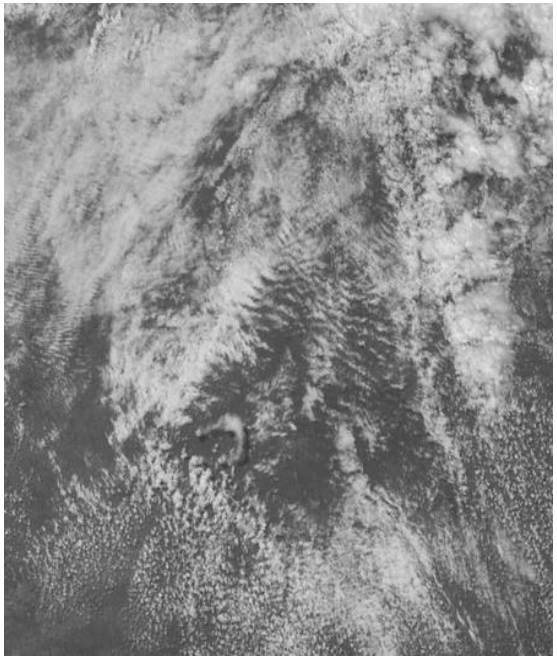
Water Vapor/ALPW Track EML



NUCAPS Confirms Capping



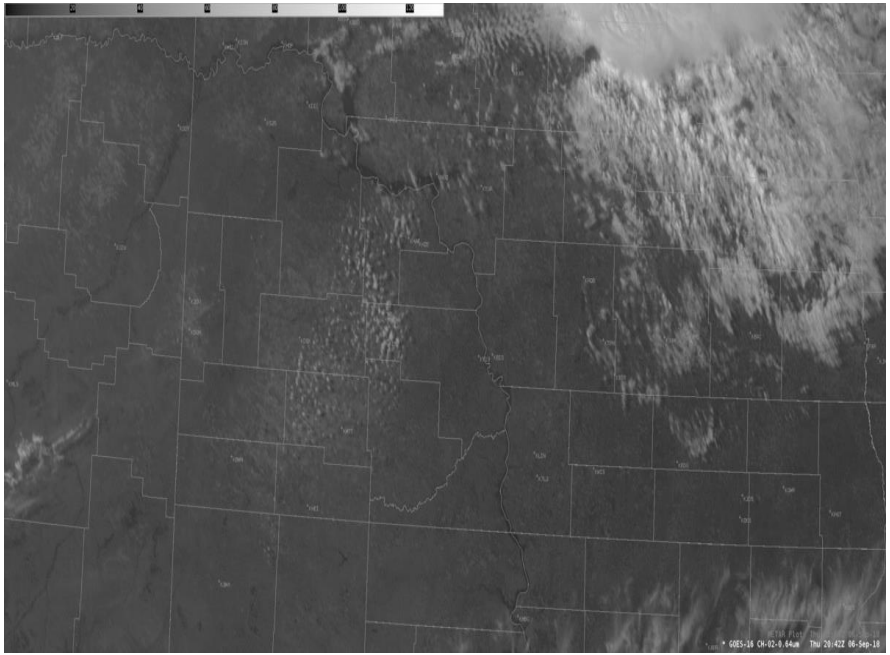
"Billow" Clouds = Higher BL SRH

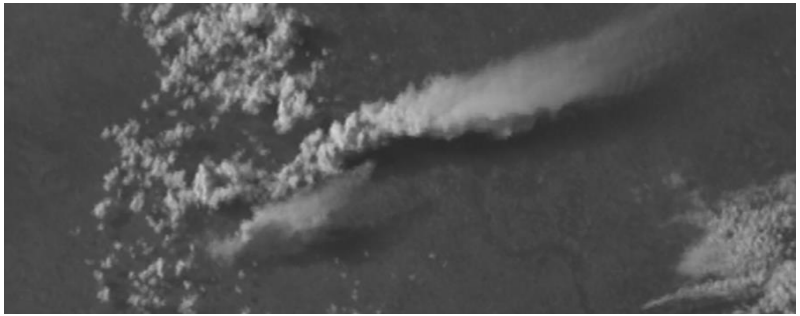


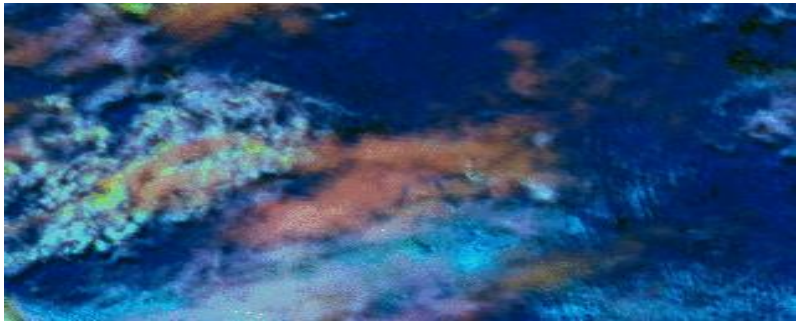
Operational Challenges: Data availability/integration, balancing with model simulations, identifying features

WFO Desired Outcome #2: Anticipate convective initiation at small spatiotemporal scales

Visible band and Day Cloud Phase RGB illuminate initiation elements, including orphan anvils



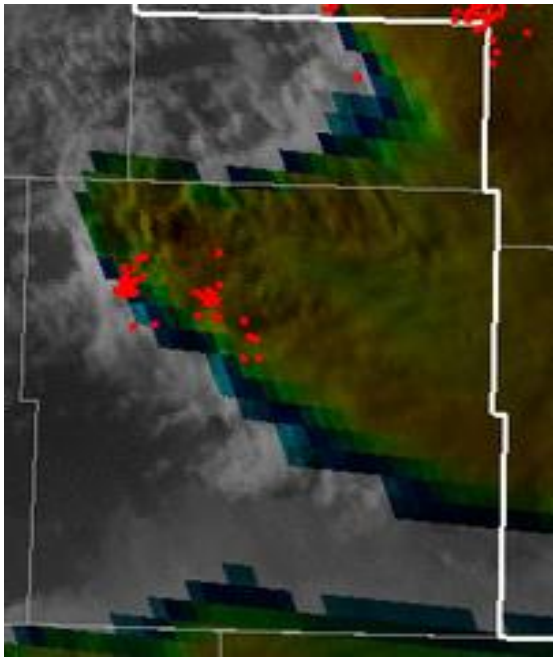


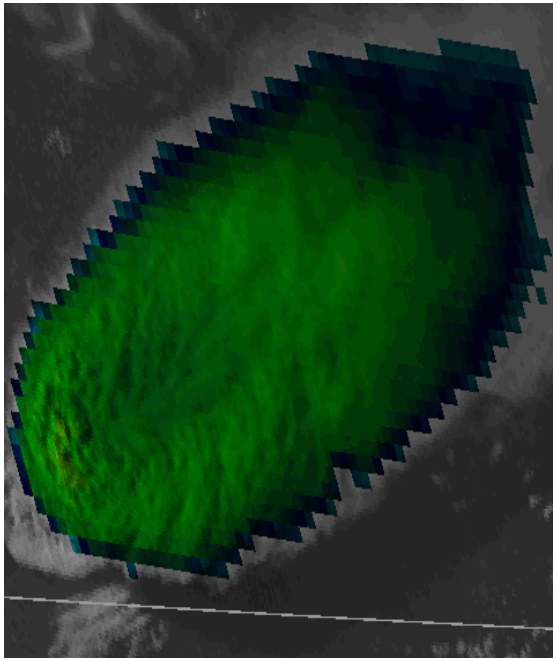


Operational Challenges: Identifying subtle features, multi-layer dependency, lack of pre-glaciation products

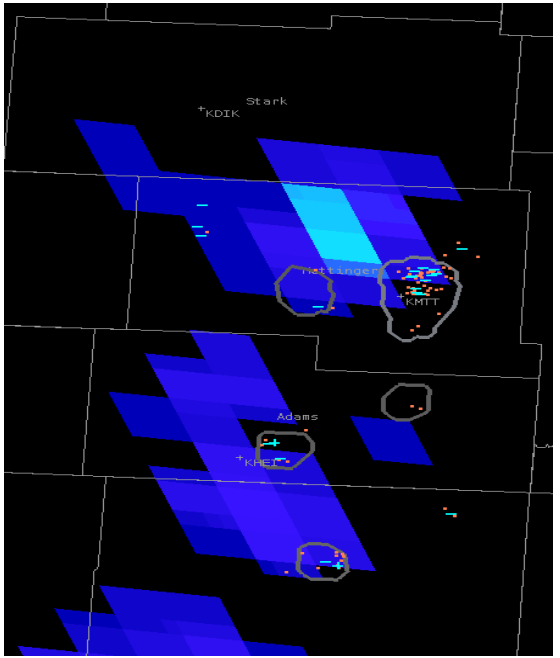
WFO Desired Outcome #3: Issue detailed severe thunderstorm and tornado warnings

Visible/Infrared Sandwich Product for Updraft Strength / Seeing AACPs





GLM for Updraft Strength/Trends

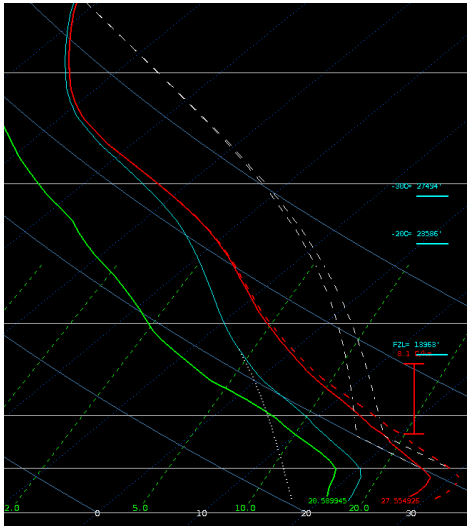


Operational Challenges: Data overload for warning teams, AWIPS memory, lack of trend tools/calibration

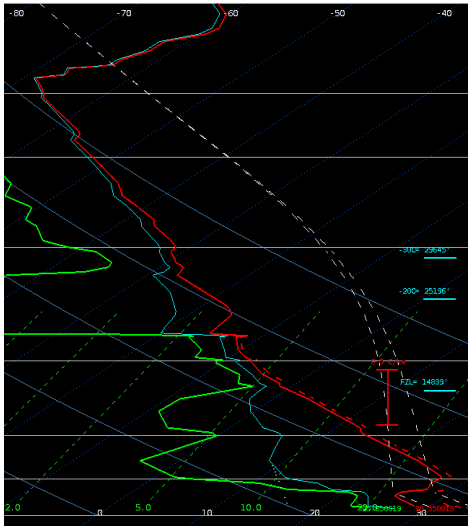
Opportunity: Improved Convective Initiation Tools

NUCAPS Moisture and PBL Sensitivity

NUCAPS ~19 UTC



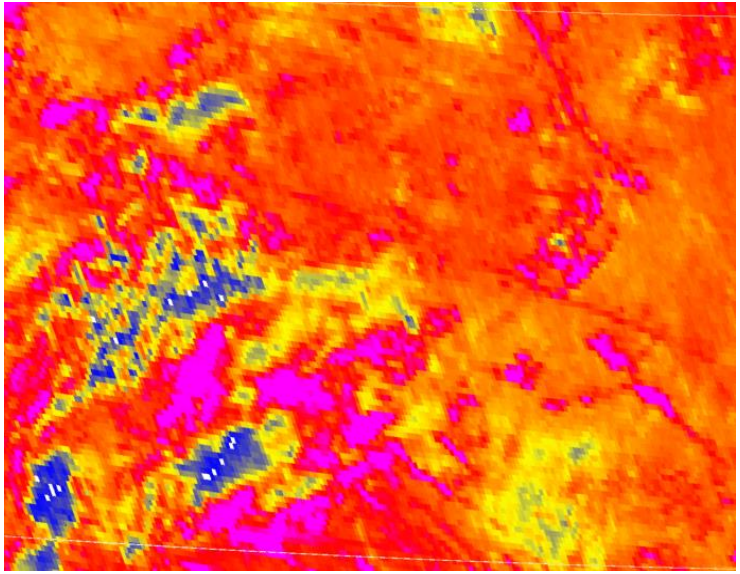
18 UTC KMPX RAOB



Ideas from the field:

- Can NUCAPS be paired/blended with RAP PBL data and/or surface observations automatically?
- Can GOES-R derived stability indices be improved?

Boundary/Forcing Challenges

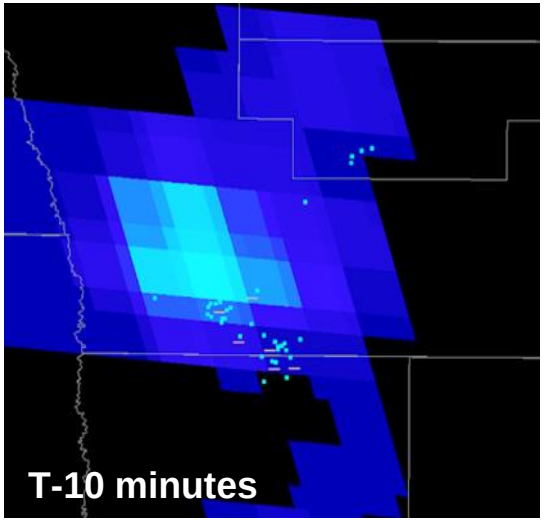


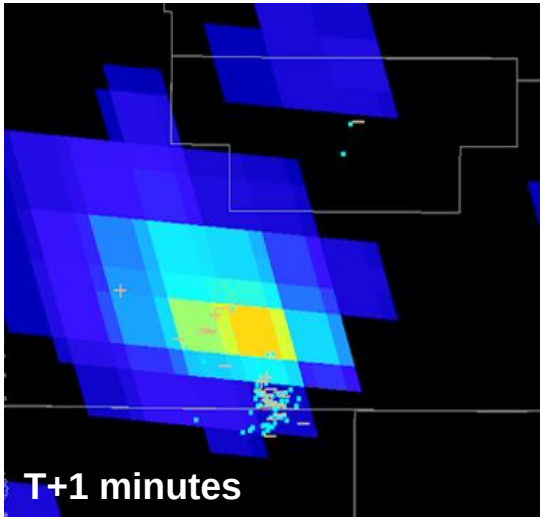
Ideas from the field:

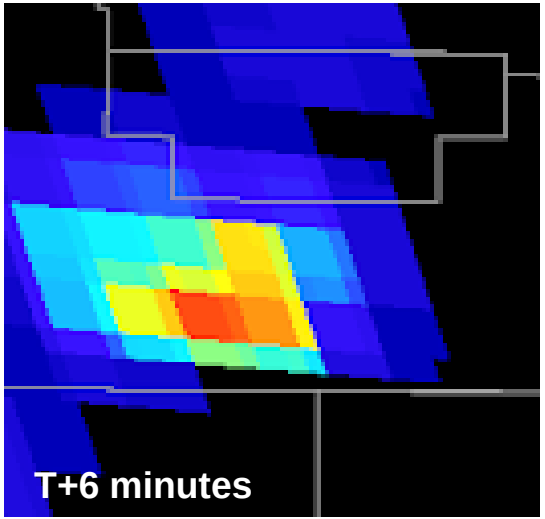
- Can a convective initiation algorithm be developed?
- Can the split-window product be improved?

Opportunity: GLM Tool Development

GLM Flash Extent Density Jump with Unwarned EF2 Tornado







Ideas from the field:

- Can a calibrated GLM lightning jump algorithm offer situational awareness? Could it be paired with baseline imager and/or RGB products for additional updraft strength/trend identification?
- Can GLM be refined/improved (or “bias corrected”) to offer consistent values no matter the storm type and geographic region?

Adapting Satellite Soundings for Operational Forecasting

Rebekah Esmaili (*and many, many others!*)
Science and Technology Corporation, Columbia MD

Sounding meetings/talks

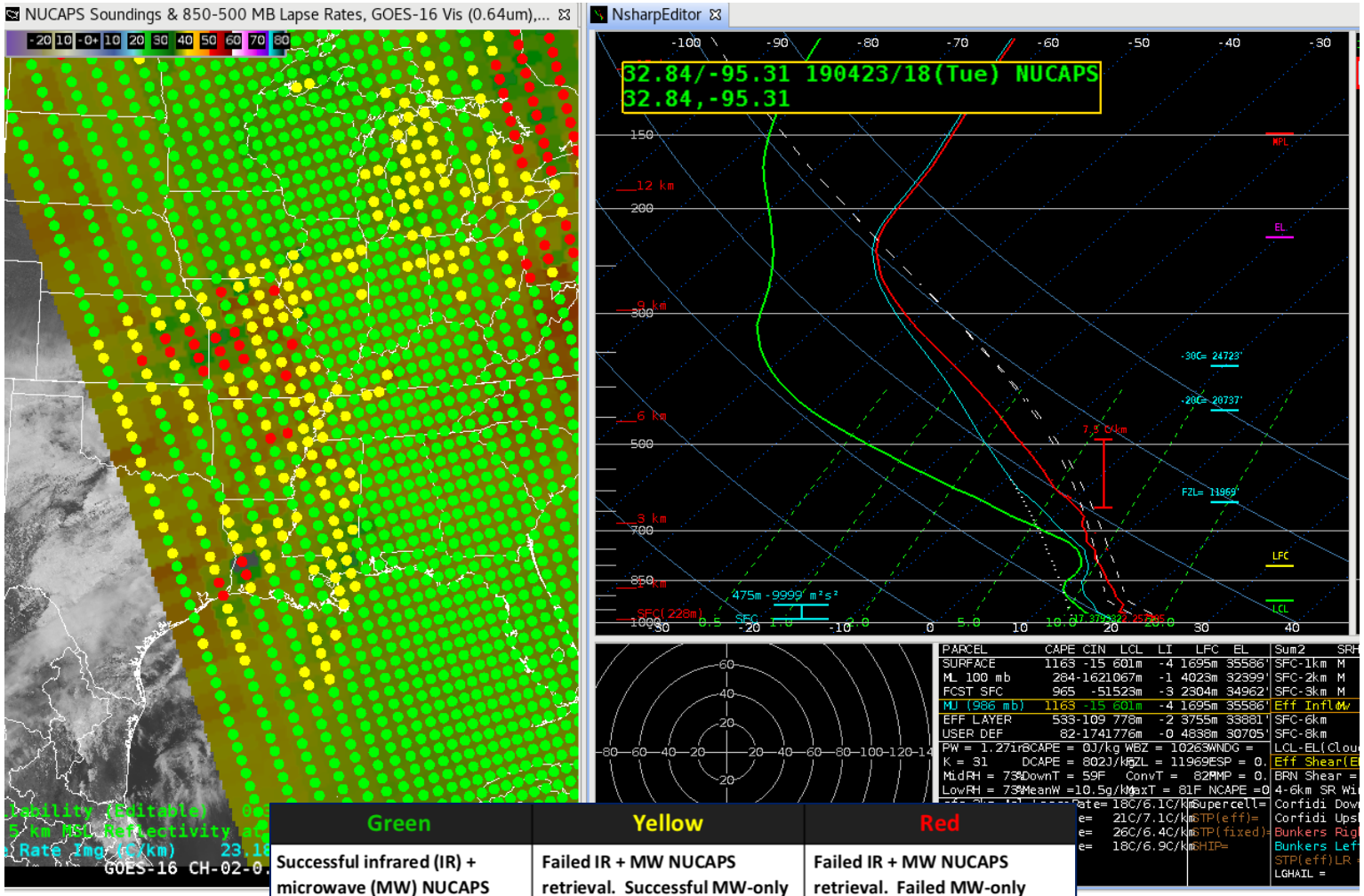
- **Sounding splinter session** *Tuesday* 12:15 – 13:15 (NCWCP Library, 1st floor)
- **Chris Barnet, Juying Warner: *Atmospheric Composition,*** *Thursday* 15:30 – 16:00
- **Jun Li*: Special Topics/Innovation,*** *Friday* 8:45 – 9:00

Forecasters use satellite soundings to visualize atmosphere in 3D

NUCAPS* soundings …

- Supplement radiosondes with wide swaths of soundings from JPSS satellites
- Retrieve vertical temperature, moisture, and trace gases
- Calculate stability indices
- Are available multiple times during the day
- Are model-independent

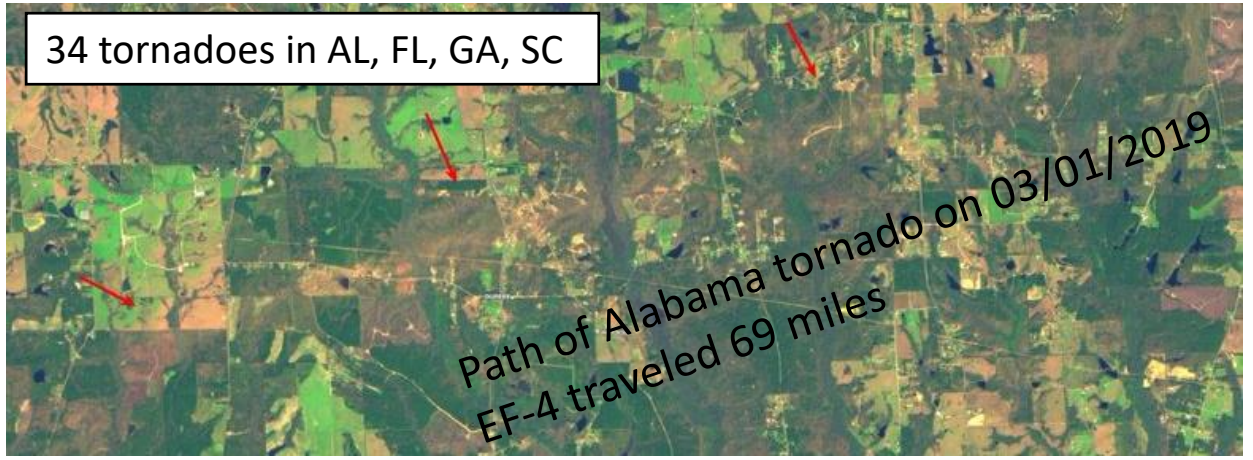
**NOAA Unique Combined Atmospheric Processing System*



Visit https://weather.msfc.nasa.gov/nucaps

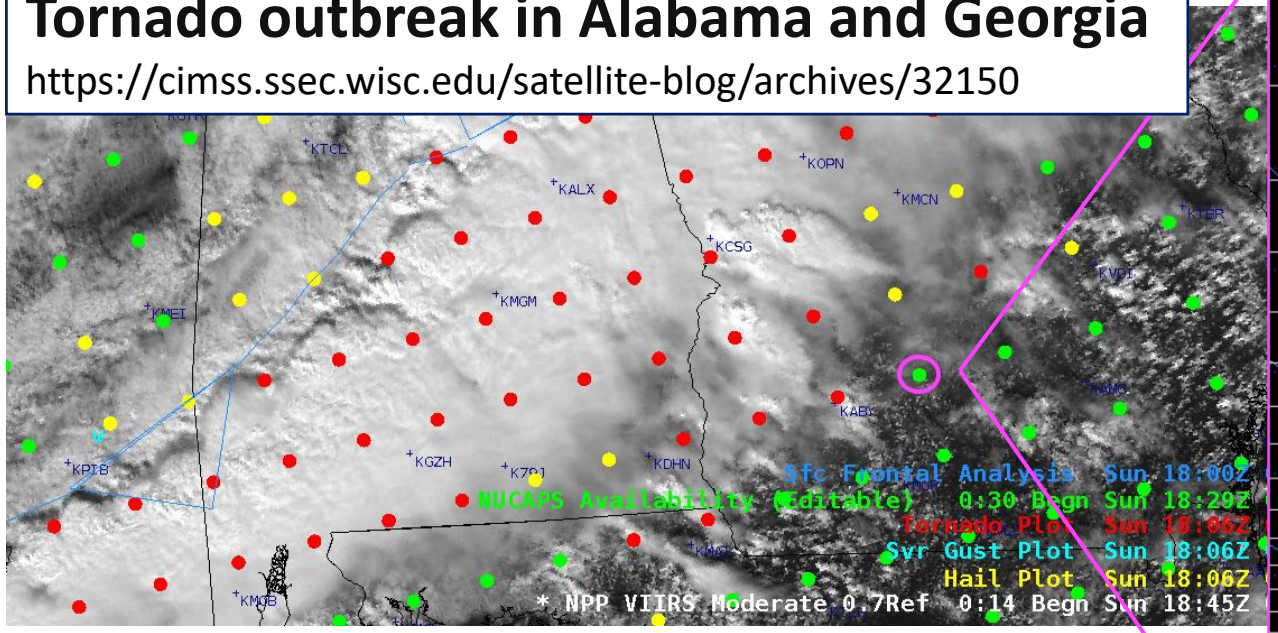
NUCAPS used to examine the pre-convective environment

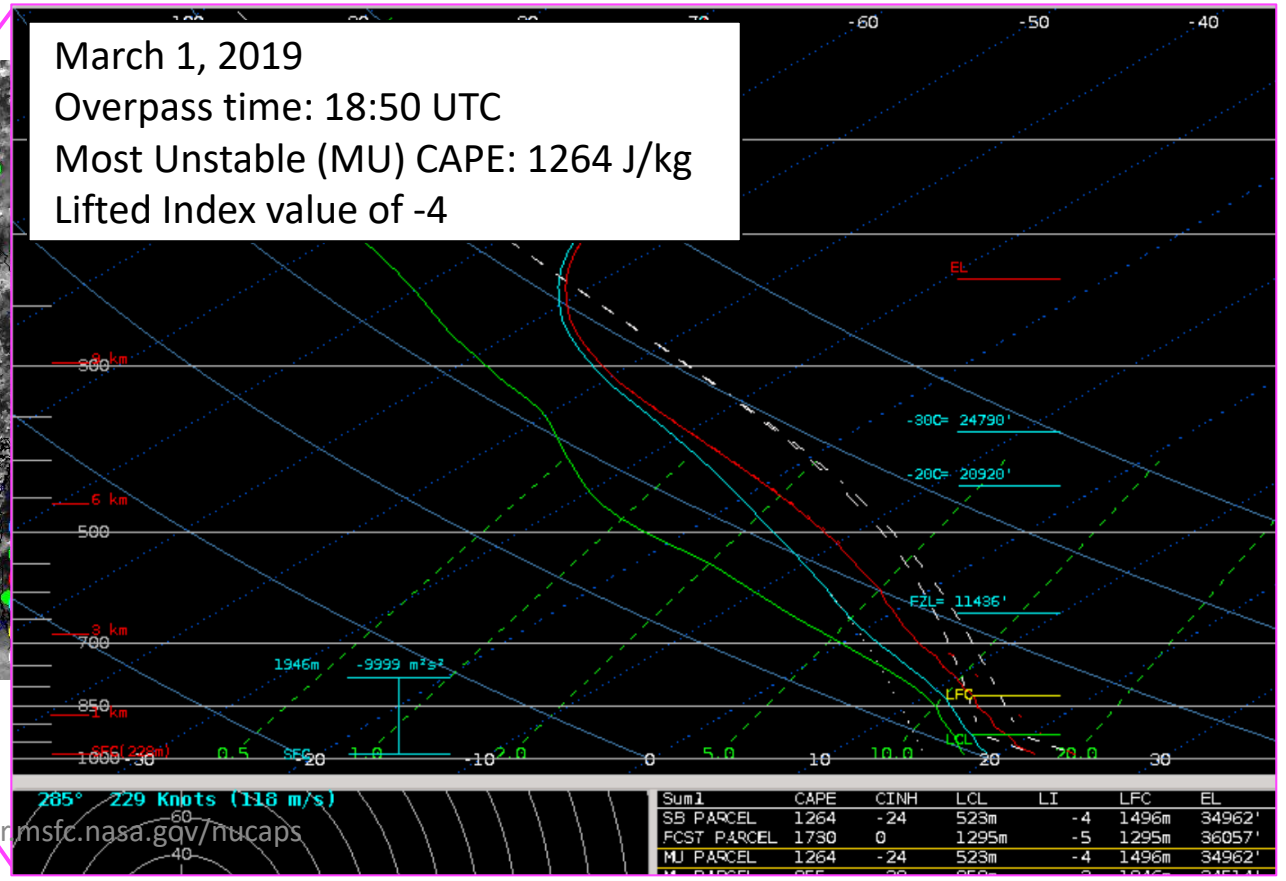
- Vertical thermodynamic state
- Spatial gradients
- Three-dimensional features



Tornado outbreak in Alabama and Georgia

https://cimss.ssec.wisc.edu/satellite-blog/archives/32150





Visit https://weather.msfc.nasa.gov/nucaps

NUCAPS evaluated by NWS forecasters in the Hazardous Weather Testbed (HWT) since 2015

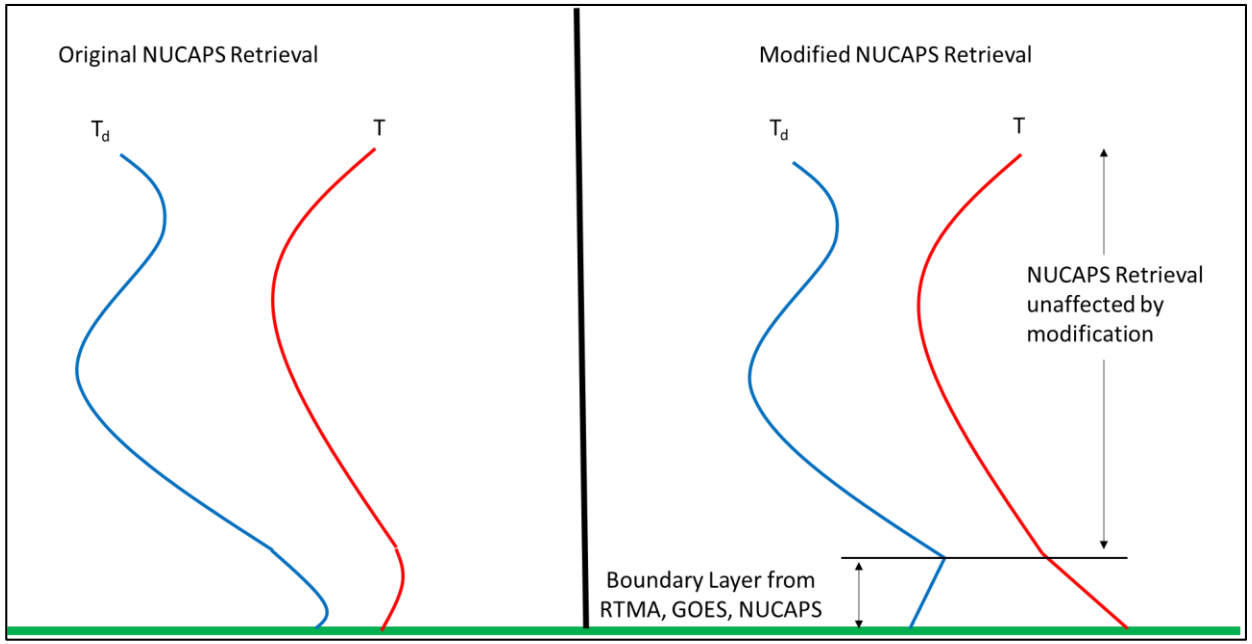
- Forecasters are provided with experimental products to issue warnings in an environment that replicates their operational workstations
- Researchers, developers, and subject matter experts are in the room with the forecasters

HWT Goals

- Train forecasters in new products/technology
- Evaluate new products ahead of their release in operations

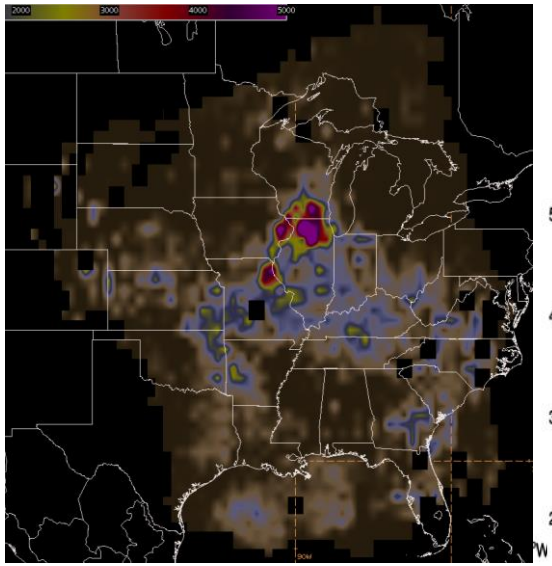
Incremental product development from forecasters feedback

Boundary layer modification



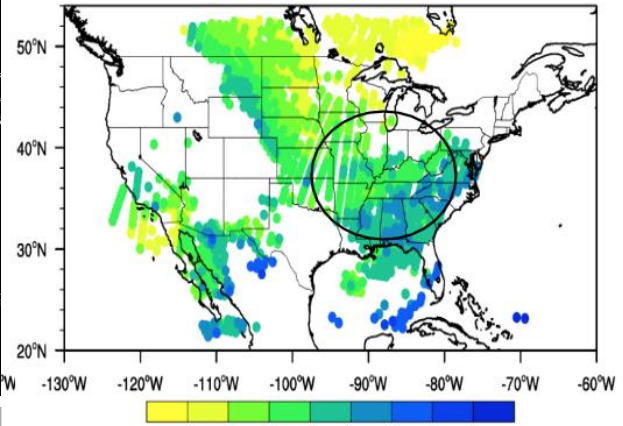
Courtesy of Jack Dostalek, CIRA

Data fusion with NWP models, ABI



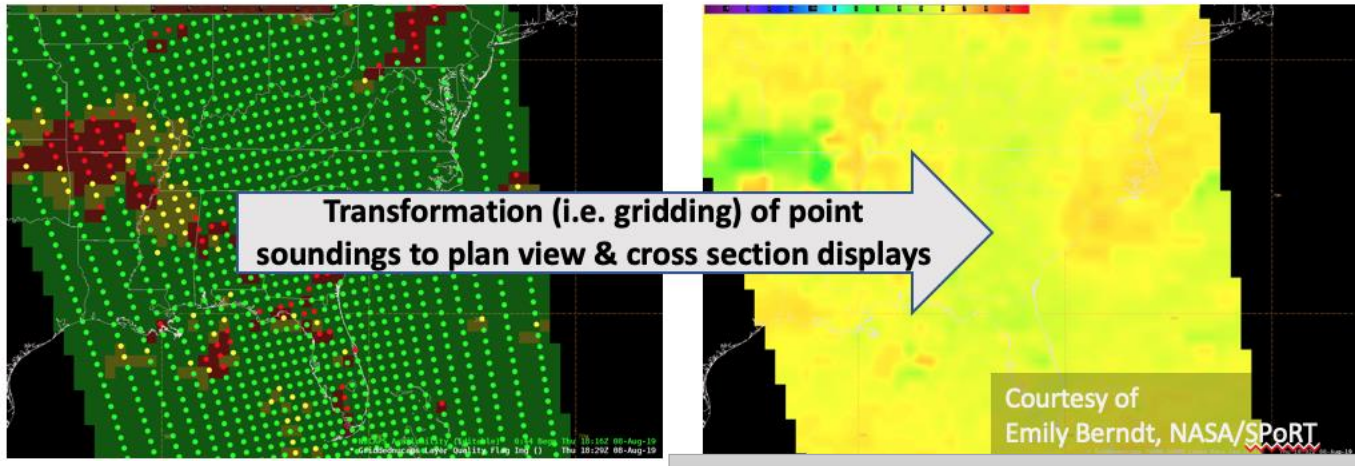
NUCAPS-Forecast CAPE (J/kg)

NUCAPS+ABI+Sfc Obs Water vapor MR@850 hPa shows good agreement w/reanalysis



Courtesy of Jun Li, CIMMS

Gridded NUCAPS: Plan-view/cross-section displays



Operational in AWIPS, Sept 2019!

User Feedback from 2019 HWT

How often would you use NUCAPS in the future?

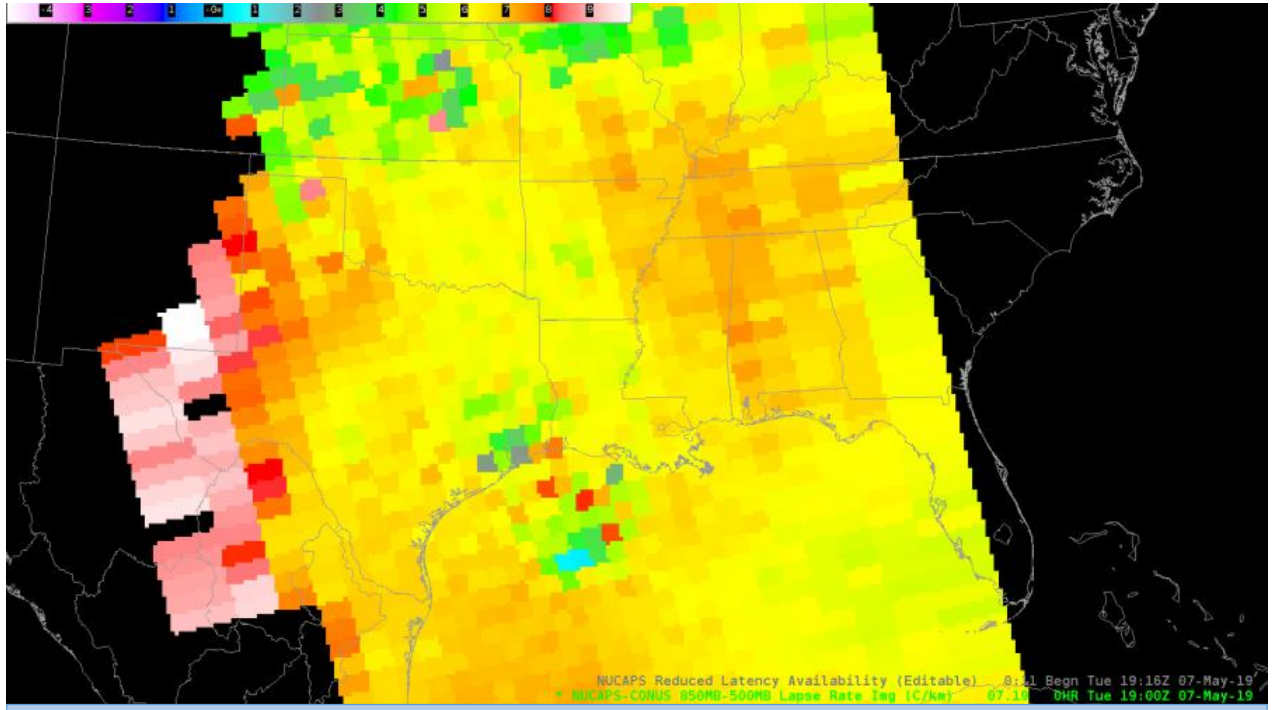
60% of HWT 2019 responses: “sometimes”, “usually”, or “always”

How can NUCAPS products could be more useful in the future?

50% of respondents indicated more satellite overpasses would be helpful

Ranked as important/very important:

1. Better boundary layer representation (and by extension, CAPE values)
2. More observations (e.g. having two satellites available in AWIPS)

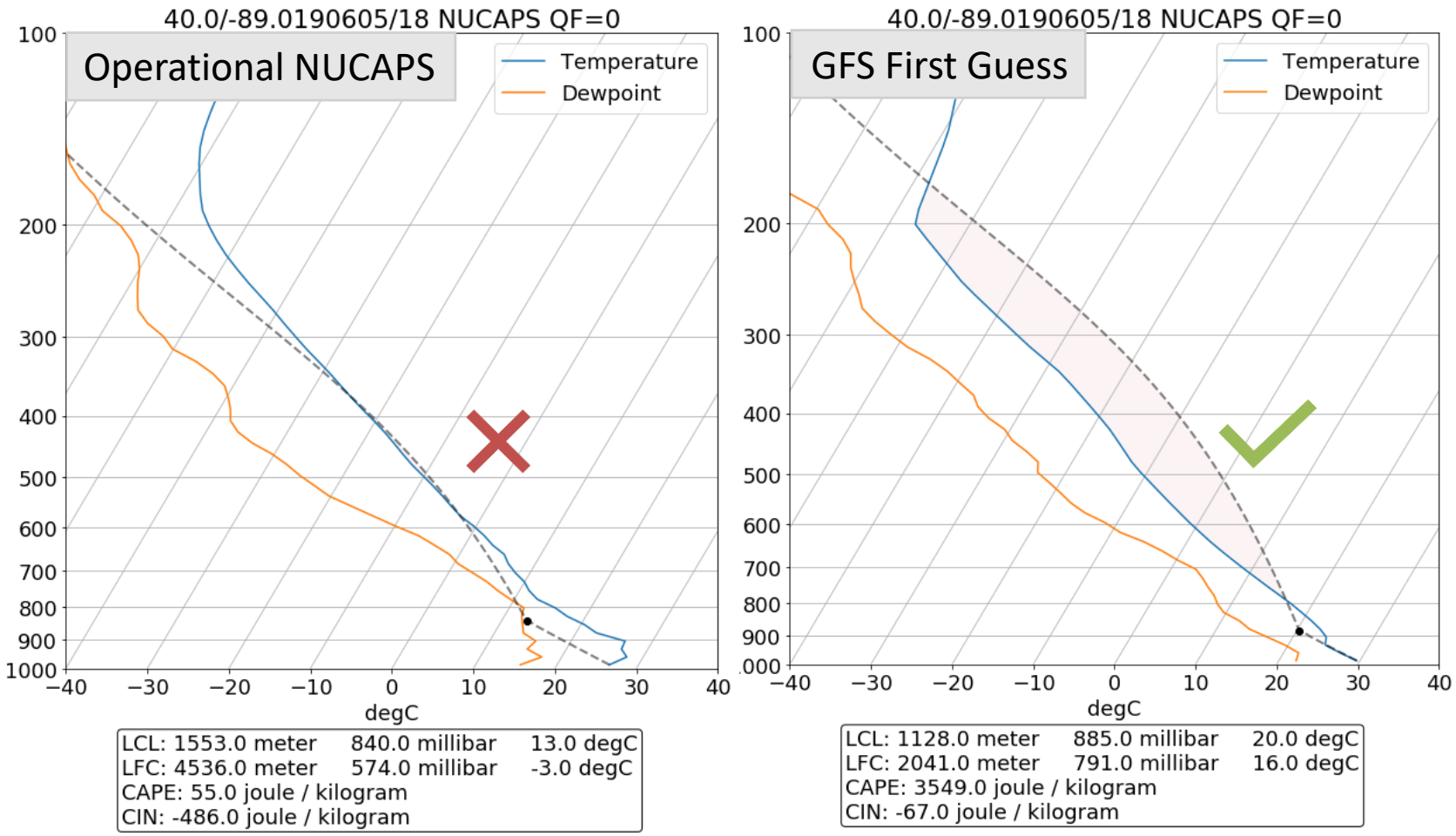


As an operational forecaster, I like to compare model output, real-time obs, and any additional derived data. ***This image from the NUCAPES H85-H5 Lapse Rate can potentially help boost one’s confidence in particular synoptic situations.*** For example, suppose you were expecting a dryline to emerge east across W Texas, but guidance indicated otherwise and sfc METARS were unavailable, ***using the NUCAPS Lapse Rate products can help determine the location of the dryline (for this particular setup). In this image, values reflect the drier air advancing east leading to steeper lapse rates***.

-- HWT Forecaster 2019

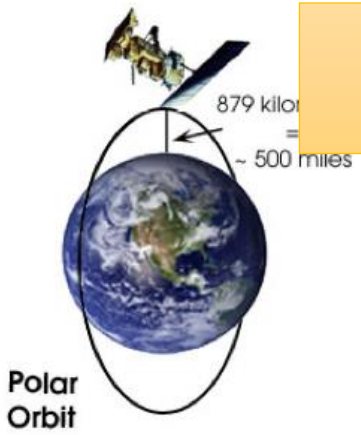
Future Improvement: **Better boundary layer**

- CAPE values too low in left retrieval
- Re-ran retrieval with GFS as the first guess
- → CAPE values significantly improved due to more realistic boundary layer



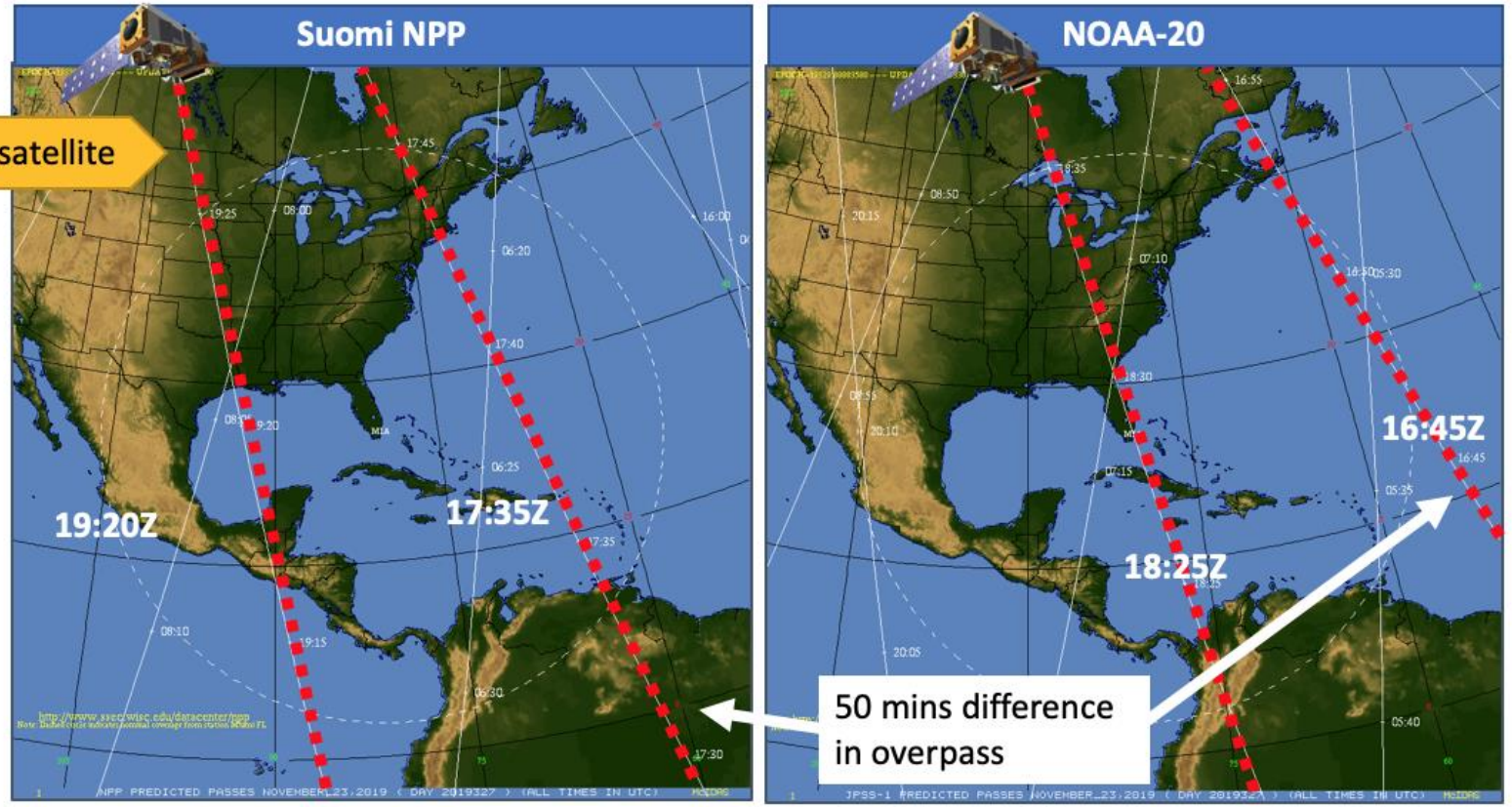
1835 to 1845 UTC (N20) 5 June 2019; Springfield, IL

Future Improvement: **More sounding data**



~2x daily observations per satellite

- Only NOAA-20 NUCAPS is available to operational forecasters via SBN
- Adding additional sounders (e.g. Suomi-NPP) to allows forecasters to see **changes in space and time**
- Increase ROI of existing sounding assets

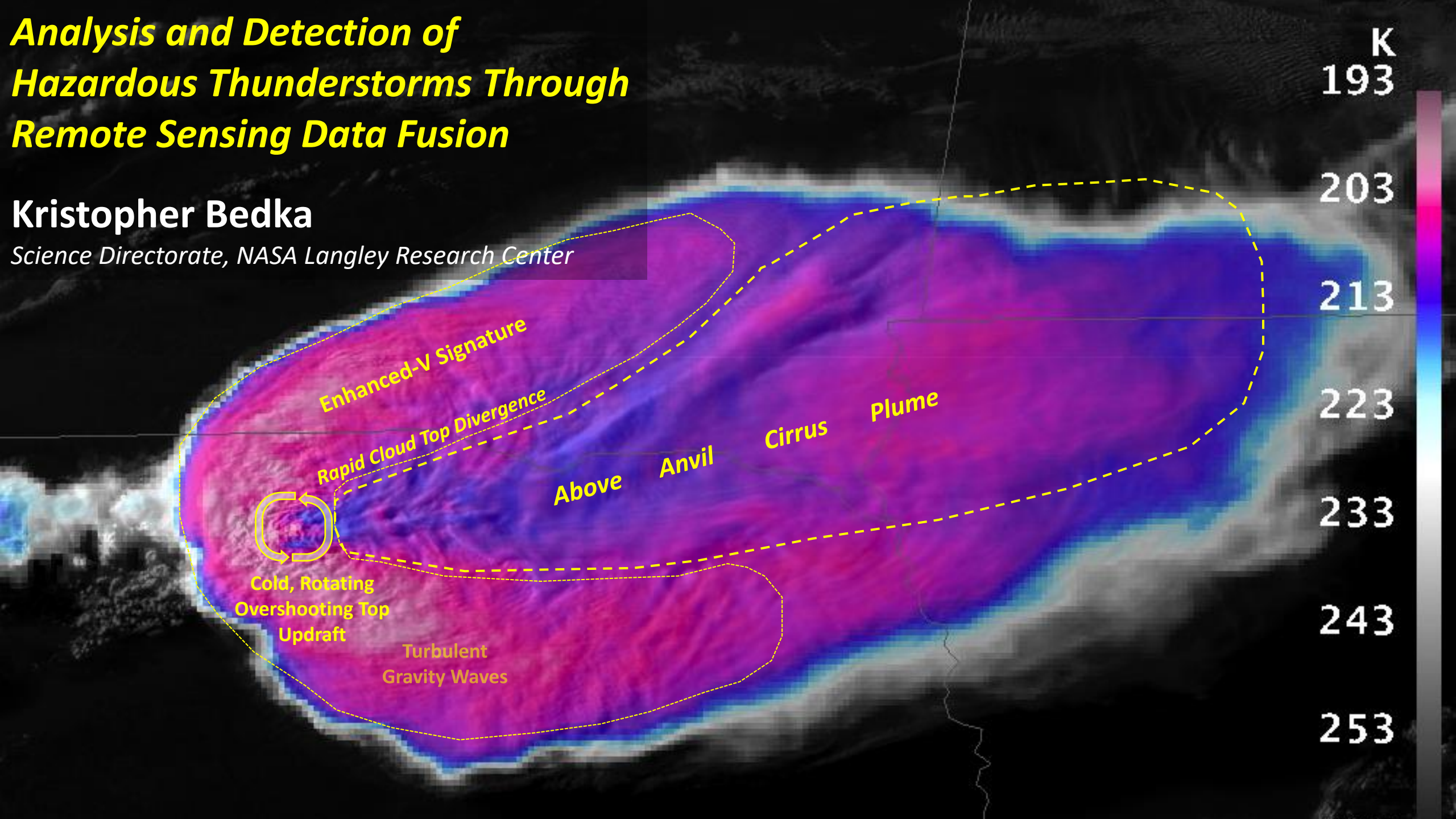


Satellite	Equator overpass (local time)
NOAA-20, S-NPP, AQUA	1:30AM/PM
Metop (A, B, C)	9:30AM/PM

Analysis and Detection of Hazardous Thunderstorms Through Remote Sensing Data Fusion

Kristopher Bedka

Science Directorate, NASA Langley Research Center



Introduction

A 2017 National Academies Earth Science Decadal Survey *Most Important* Question:

"Why do convective storms, heavy precipitation, and clouds occur exactly when and where they do?"

Over the last 10+ years, NASA, NOAA, and other agencies/industry have supported NASA Langley and partners to analyze geostationary (GEO) data and a variety of other datasets to better understand, detect, and predict hazardous storms

GEO imagery/products at up to 30-sec frequency, and historical LEO/GEO data are being used to:

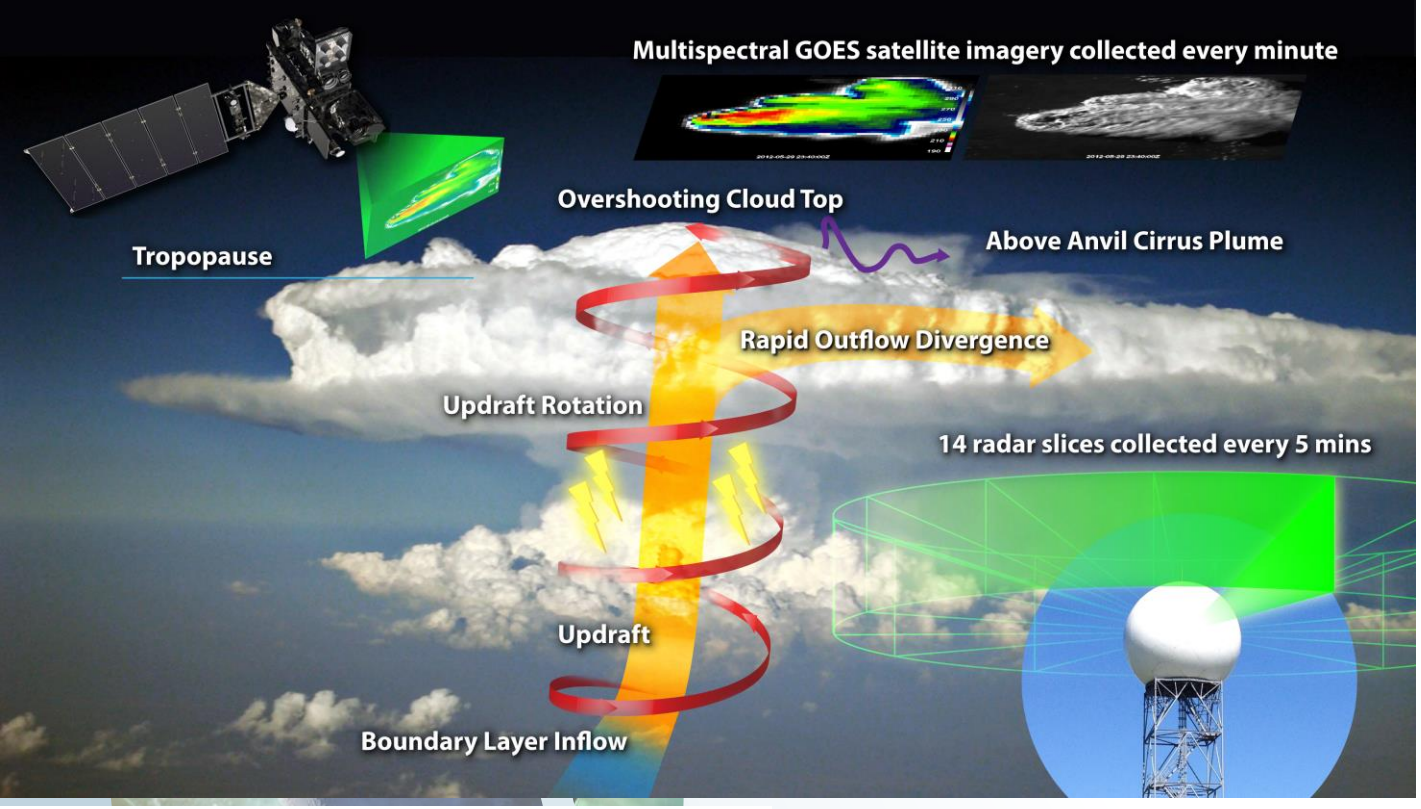
1) Characterize storm evolution and recognize unique signatures that occur in advance of hazardous weather such as *hail, tornadoes, damaging wind, ice crystal icing, and aviation turbulence*

2) Develop and demonstrate state-of-the-art derived products and analysis methods that could improve hazardous storm detection and forecast lead-time

3) Perform climatological hailstorm analysis to characterize hail frequency/risk in regions with limited radar data, and the assess the capability of satellites to observe hail damage

4) Better understand how intense convection impacts upper troposphere – lower stratosphere composition

Remote Sensing Data Fusion For Hazardous Storm Analysis



Data Fusion: The process of integrating multiple, diverse datasets for combined analysis

Radar-based storm tracking is used to integrate:

1) GOES storm updraft detection/characterization, and cloud-top wind flow data

2) Radar-observed wind flow, storm vertical structure and microphysics data

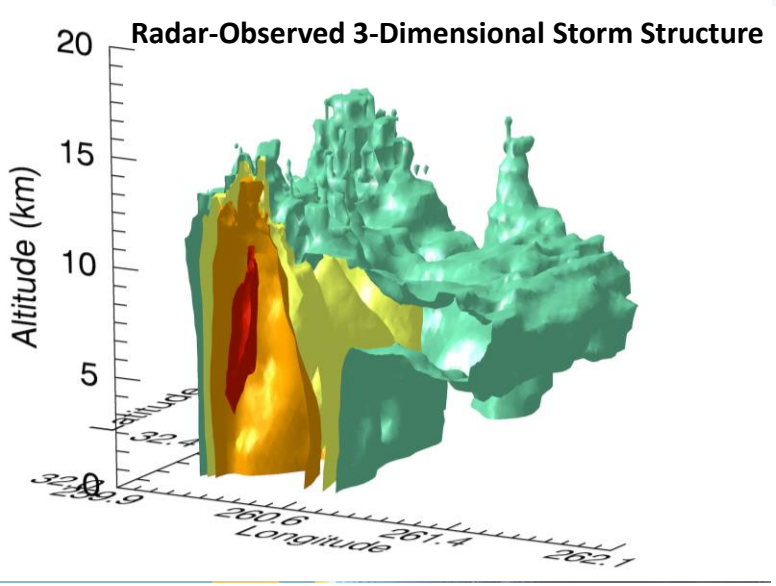
3) Ground- and GOES-based lightning detections

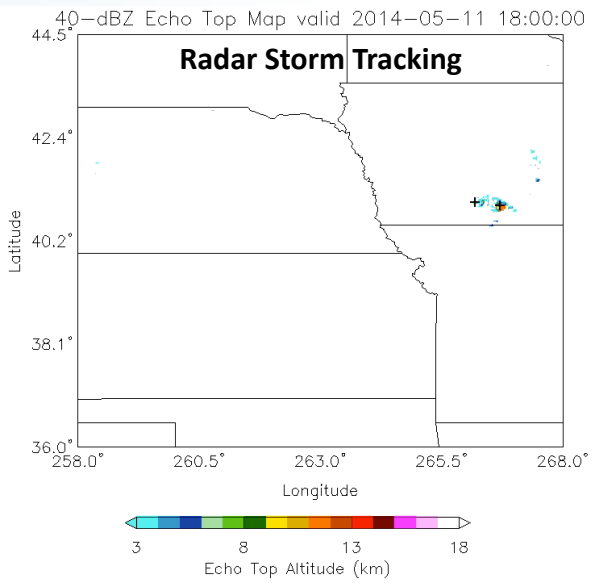
4) Weather prediction and reanalysis model data

5) Severe weather reports

6) National Weather Service severe weather warnings

to better understand and predict storm hazards





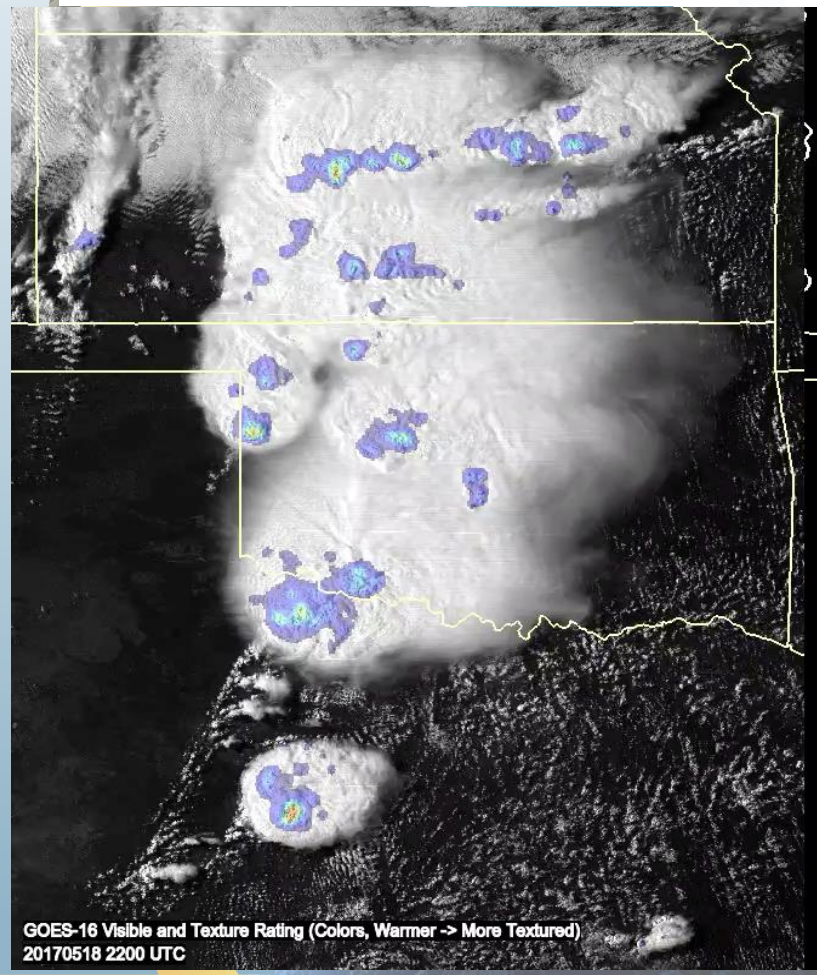
Radar data and images courtesy of Cameron Homeyer, University of Oklahoma. Learn more at: http://www.gridrad.org

Photograph By: Roland Welser (DLR) over Northern Texas on 29 May 2012 during the DC3 Field Campaign
Storm is producing 2.5 inch diameter hail at the time of the photo
Graphic Designed By Timothy Marvel, Kristopher Bedka (NASA LaRC) and Cameron Homeyer (University of Oklahoma)

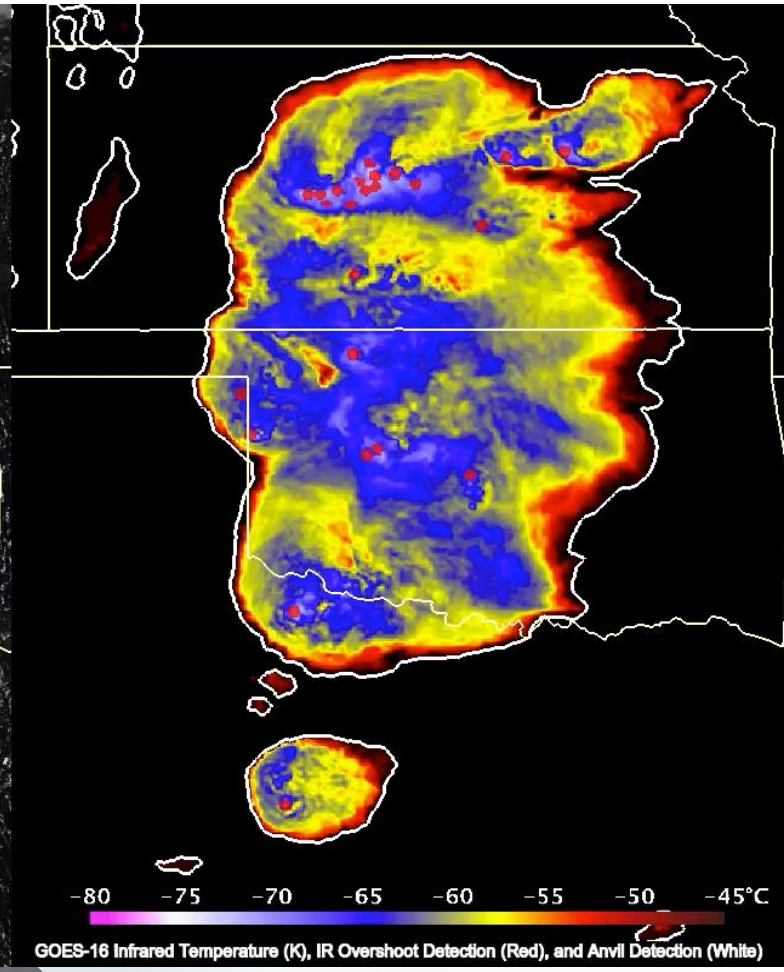
Automated Hazardous Storm Detection From LEO or GEO Visible and IR Data

- Overshooting Top and Enhanced-V Detection was an "Option 2 / Future Capability" product requirement for GOES-R, and detection algorithms were delivered to the GOES-R Aviation Algorithm Working Group in 2011
- Based on user feedback within the NOAA Hazardous Weather Testbed and other studies, recent research has greatly improved our ability to detect and characterize storm updrafts using VIS and IR data. These products have been used in over 20 publications

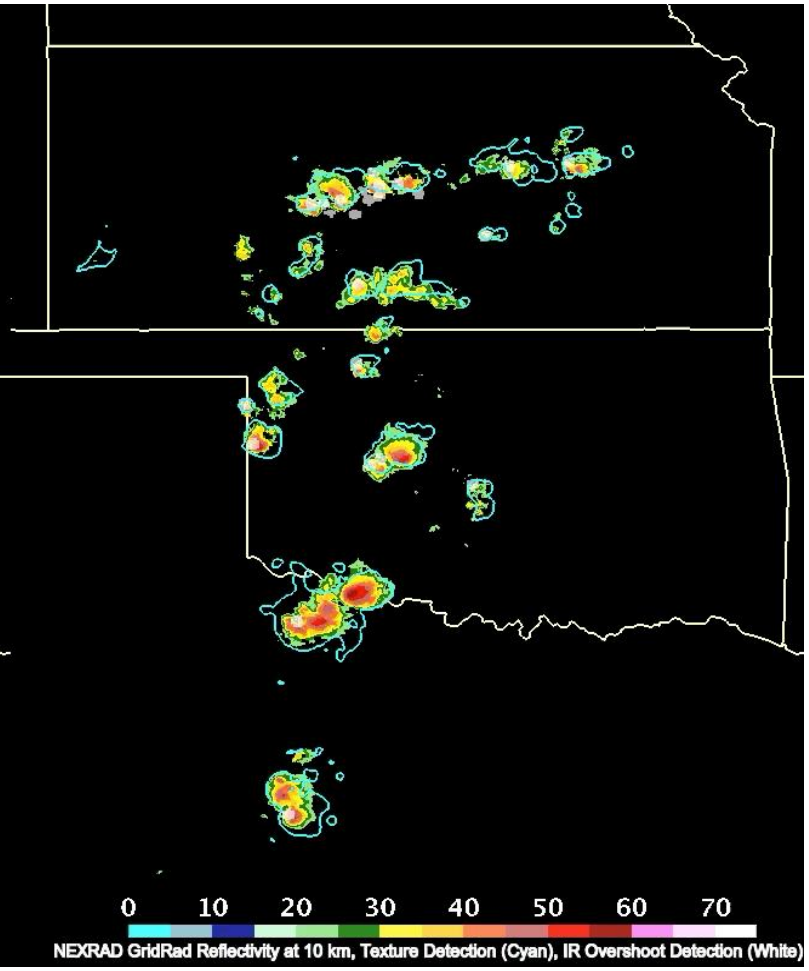
GOES-16 Visible and Texture Detection



GOES-16 Infrared, Overlaid With Detections of Embedded Overshooting Top Updraft Regions



Visible Texture and IR Overshooting Detection Overlaid On Radar Reflectivity At 10 km Altitude

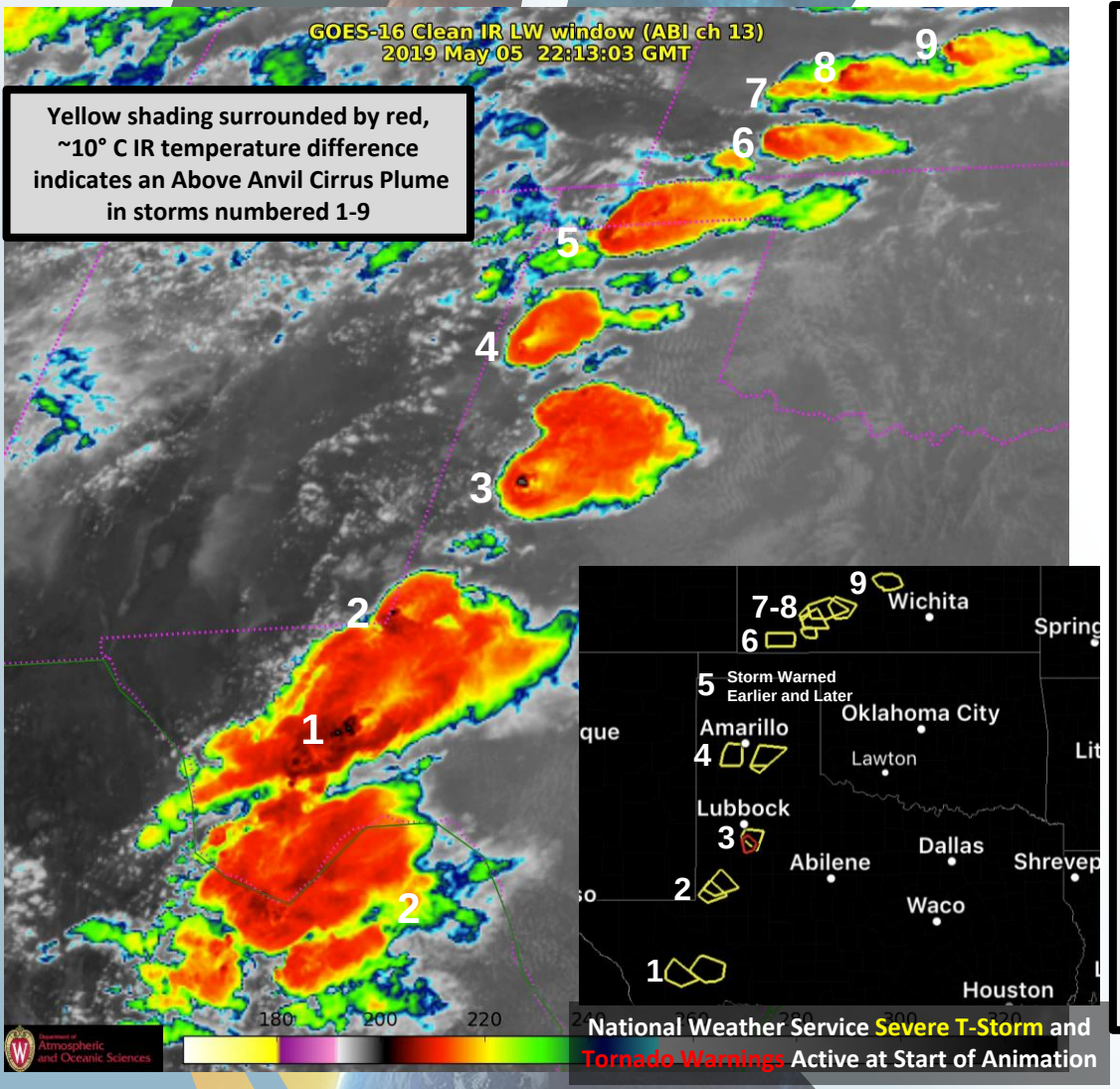


Key Findings From Recent Research

- Analysis of over 8000 storms revealed that, on average, tornadic storm updrafts are more intense than those within other storm types based on almost every radar, lightning, and satellite-derived metric (Sandmael et al. 2019)
- Storm top divergence and rotation can be retrieved from 1-min GEO data, and these properties are closely linked to storm updraft evolution and severity (Apke et al. 2016, 2018)
- Quantification of visible texture is better linked to above-anvil radar echo penetration than IR temperature patterns (Bedka and Khlopenkov 2016; Sandmael et al. 2019)
- The combination of tropopause-relative IR temp, storm-top divergence, above anvil cirrus plume presence, and ENTLN lightning flash rate combined with NEXRAD-derived indicators can improve severe storm detection beyond NEXRAD alone (Mecikalski et al. 2020)
- Assimilation of GOES cloud water path retrievals within the NSSL WRF model improved severe storm forecasts (Jones et al. 2016; Skinner et al. 2018)
- Aircraft ice crystal icing (ICI) conditions most often occur in cold, optically thick cloud within 40 km of an overshooting cloud top (Yost et al. 2018; Bedka et al. 2019). Automated overshooting top and ICI detection products were very well received by NOAA Southern Region CWSU forecasters during an evaluation conducted in Spring 2019 by NASA SPoRT.
- Overshooting top climatologies derived from GEO data have been extremely useful for determining regions most often impacted by hazardous storms across the world (Punge et al. 2017; Thiery et al. 2017; Bedka et al. 2018)
- Based on analysis of 1-min GOES-14/16 data, nearly 60% of storms that generated an above anvil cirrus plume were responsible for reported severe weather (Bedka et al. 2015, 2018)

Above Anvil Cirrus Plumes

An Indicator of Intense Updrafts, Ice Injection Into the Stratosphere, and an Extremely Severe Storm



National Weather Service Severe T-Storm and Tornado Warnings Active at Start of Animation

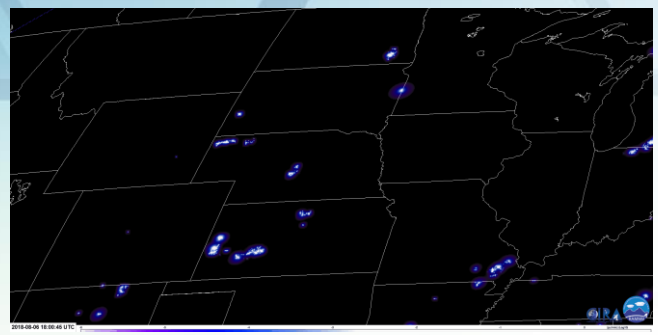
- **Intense thunderstorm updrafts inject plumes of cirrus into the stratosphere, where cirrus plumes become warm** (see left)
- **The above-anvil cirrus plume is the strongest indicator of a severe storm ever quantified in visible/IR satellite imagery** (Bedka et al. 2018)
  - Analysis of over 4500 storms showed that plume storms produced 14 times more severe weather per storm than storms without plumes
  - Over 85% of 2+ inch hail and EF-2+ tornado events were generated by storms with plumes
  - Plume-producing storms often exhibit supercell characteristics
  - On average, plumes appeared 30 minutes before the first severe weather was generated by a storm
- **Plume identification can augment severe storm warning and help forecasters identify severe storms in areas without radars**
- **The NASA DCOTSS airborne campaign seeks to sample plumes and overshooting top outflow with the ER-2 aircraft to understand how these storms impact stratospheric composition**

LEARN MORE: https://climate.nasa.gov/news/2782/severe-storms-show-off-their-plume-age/
https://satelliteliaisonblog.com/2019/06/24/use-of-goes-16-imagery-during-colorado-severe-weather-event-on-26-may-2019
https://doi.org/10.1175/WAF-D-18-0040.1

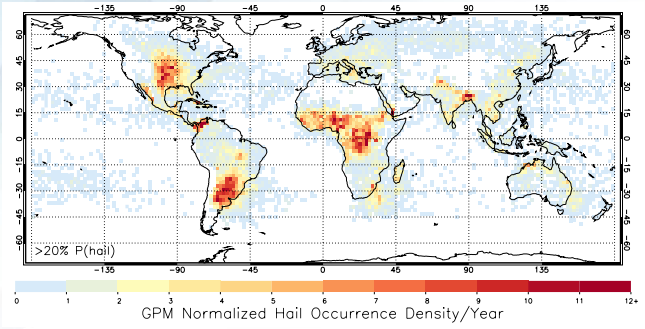
Hail Storm Risk Assessment Using Space-Borne Remote Sensing Observations and Reanalysis Data

PI: Kristopher Bedka (NASA LaRC)

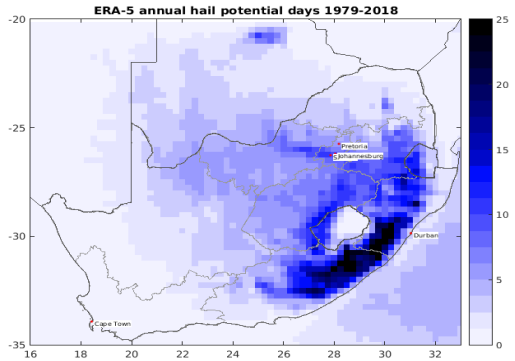
Geostationary Lightning Flash Rates and Flash Characteristics Consistent With Hailstorms

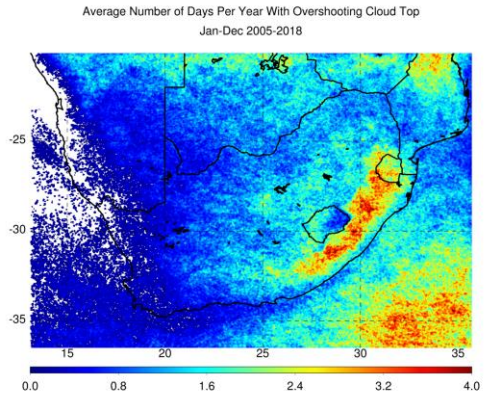


Up to 30-Year Duration Global Passive Microwave Hailstorm Database

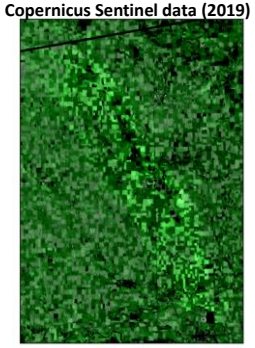


Hailstorm Environment Climatologies From Reanalyses





Optical Imager (e.g. LandSat-8) and SAR (e.g. Sentinel-1) Observations of Hail Damage Swaths



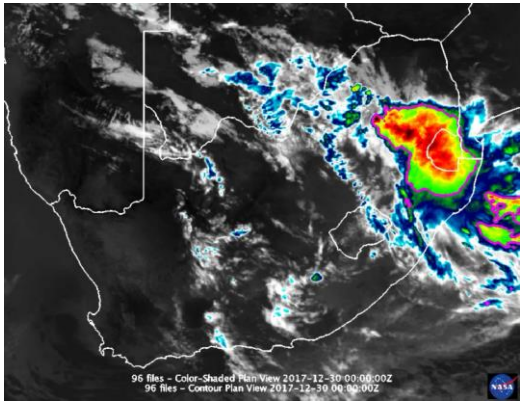
Demonstrate Use of High Resolution Optical Imager and SAR Data To Identify Hail Damage Swaths For Post-Event Response and Insurance Claim Analysis

Develop the Highest Possible Resolution and Longest Duration Satellite and Reanalysis-Based Hail and Severe Storm Climatologies, Tested and Validated With Spotter Reports, Doppler Radar Hail Detection, and Insured Losses

Use Climatologies To Develop Reinsurance Hail Catastrophe Models, Improve Understanding of Hailstorm Distributions at High Spatio-Temporal Resolution, and Address Important Decadal Survey Science Questions

Provide Near-Real Time Geostationary Products To Aid Severe and Aviation Weather Forecasting

Visualize and Provide Data to The International Community With GIS-Based Tools

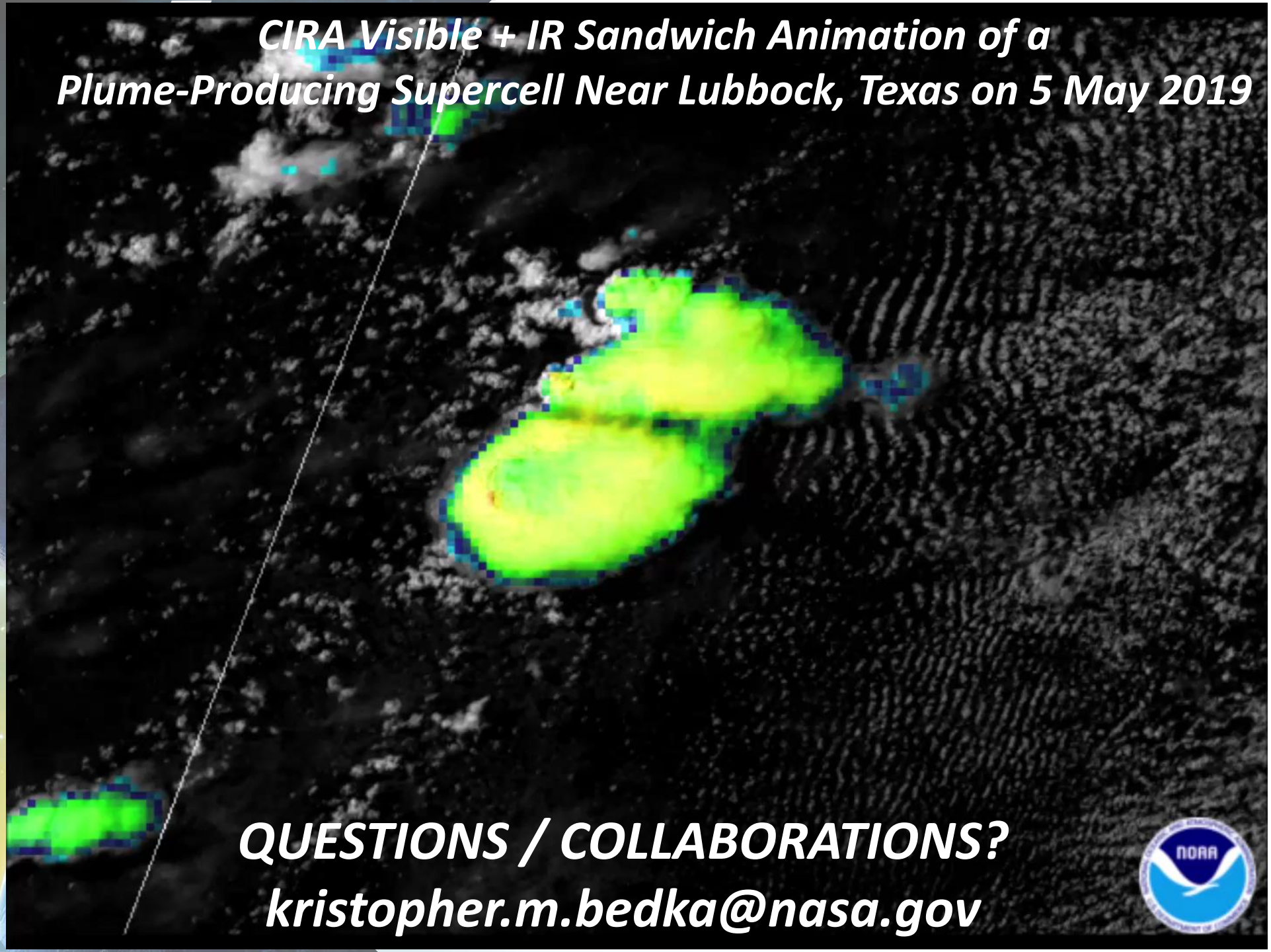


Up to 25 Year Duration, ~4 km and 10-30 min Resolution Regional GOES and Meteosat Visible and Infrared Detections of Hailstorm Clouds

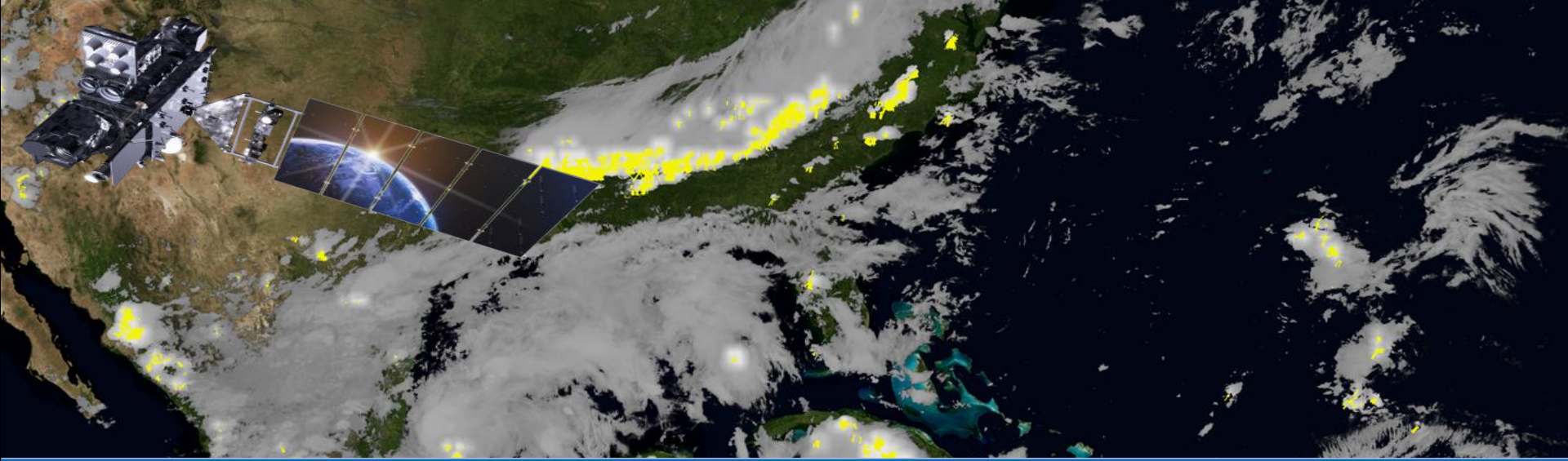
Project Partners

NASA LaRC and MSFC, U. Alabama in Huntsville, Willis Towers Watson, Karlsruhe Institute of Technology, University of Buenos Aires, Brazil National Institute for Space Research CPTEC, National Meteorological Service of Argentina, University of Pretoria, Insurance Institute for Business & Home Safety

CIRA Visible + IR Sandwich Animation of a Plume-Producing Supercell Near Lubbock, Texas on 5 May 2019



QUESTIONS / COLLABORATIONS?
kristopher.m.bedka@nasa.gov



Geostationary Lightning Mapper Update and Applications

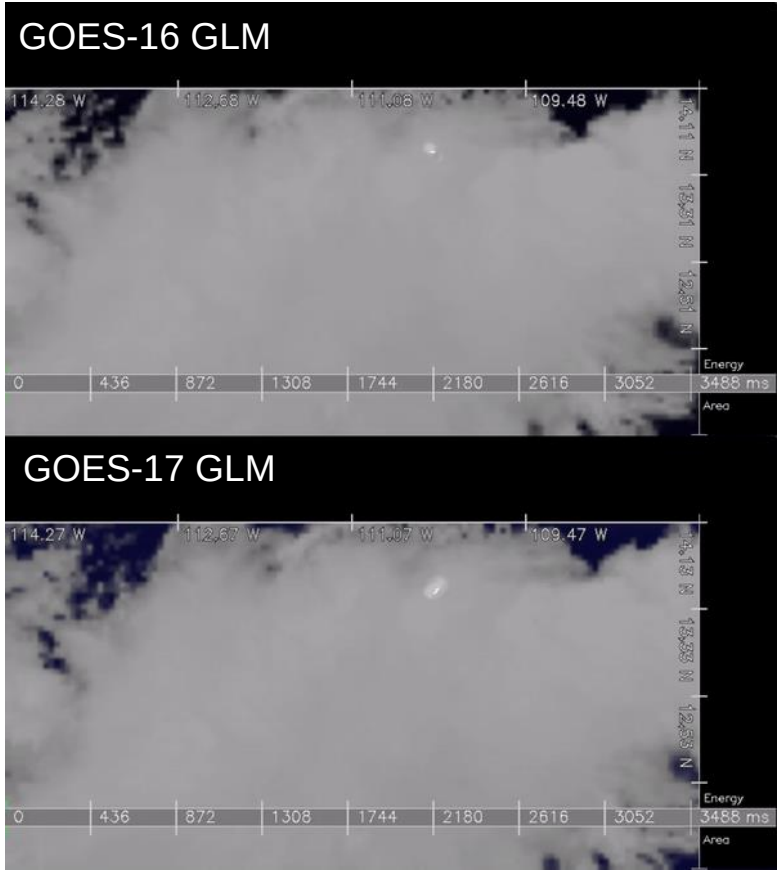
Scott Rudlosky (NOAA/NESDIS/STAR)

GOES-R JPSS Summit (24 February 2020)

https://lightning.umd.edu/glm/
https://vlab.ncep.noaa.gov/web/geostationary-lightning-mapper/

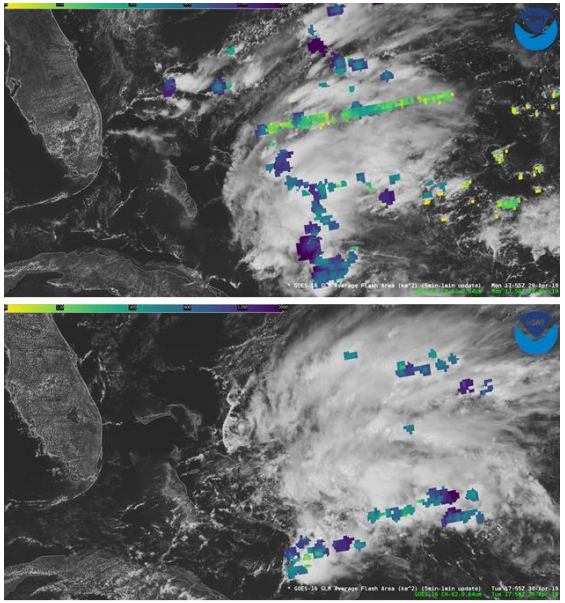
Geostationary Lightning Mapper

- First of its kind instrument, discovering new things daily, two product lines
- Clearly a lightning imager rather than a detector (very fine temporal resolution)
- Have only scratched the surface in terms of instrument capabilities
- The TRMM Lightning Imaging Sensor (LIS) could require up to 35 years to sample the diurnal cycle for the equivalent of the 257 days (~9 months) studied by Rudlosky et al. (2019)



GLM L2 Product Status

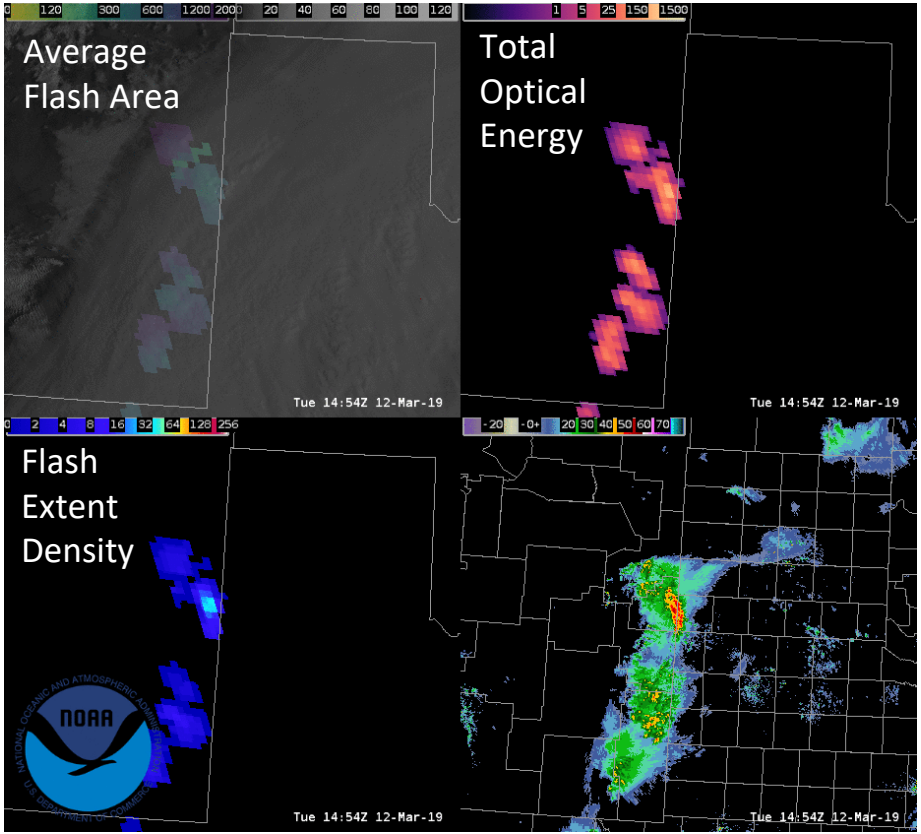
- **https://lightning.umd.edu/documents/GS_Status/**
  - ***GLM_GS_Status_8_21_19.pdf*** **- lists all known GLM-related changes to the Ground System (GS) software since initial deployment**
  - ***GOES16_GLM_FullValidation_ProductPerformanceGuide.pdf*** **summarizes key performance metrics and existing issues of the GOES-16 GLM L2 data product found on November 1, 2018**
- **Variable performance still must be better documented, understood, and communicated**
  - **With time, as the onboard settings and GS processing evolve**
  - **Within the FOV (i.e., diurnal, regional, and storm-scale variability)**



Bahama Bar Before and After

GLM in the National Weather Service

- **The GLM observations fundamentally differ from the ground-based lightning data most familiar to forecasters**
- **Collaborative effort developed a new suite of gridded GLM products tailored to NWS operations**
- **Gridded products presently produced and distributed via experimental channels (AWC – CRH – Other RHs – WFOs)**



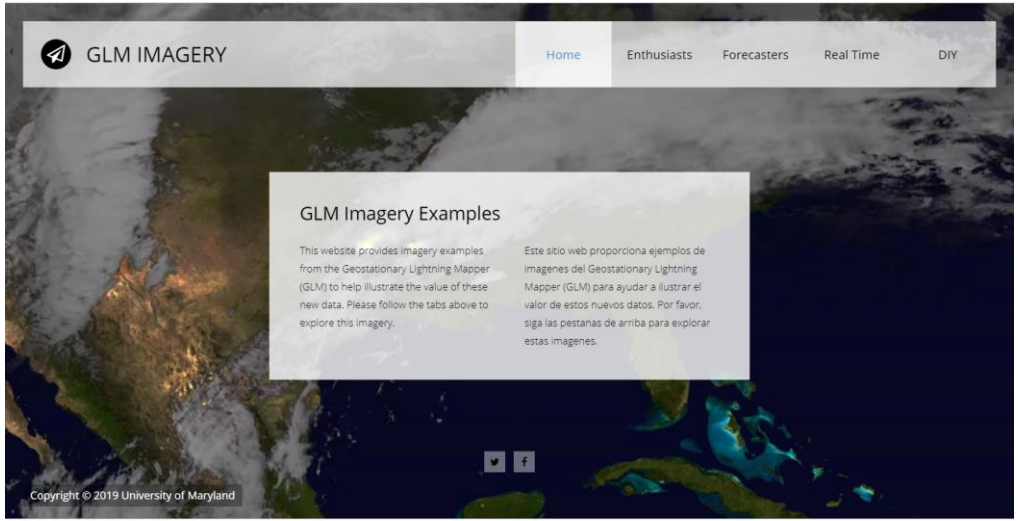
GLM Path Forward

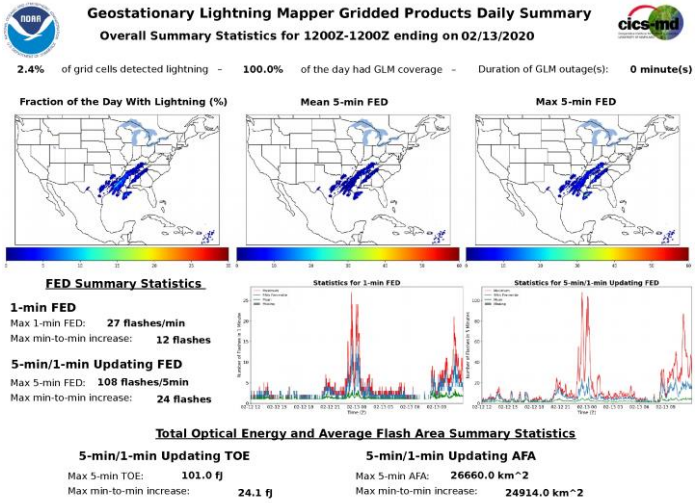
- Experimental distribution results in product downtime (and sub-optimal latency) which discourages operational use
- Must accelerate hardening of this product path to encourage forecaster use and best advise deliberations on next generation architecture
- Proposed path forward:

1. Include the x, y, lat, lon, and pixel ID in the L2 data to drastically simplify derivation of the gridded products [FY20]
2. Develop much simpler image processing codes in the CSPP-GEO to compute official GLM gridded products at each GRB site [FY20]
3. Transfer CSPP-GEO decoder to the GOES Ground System to broaden availability of the gridded products (e.g., SBN, GEONETCast) [FY21]

GLM Outreach

- **Aim to promote proper use and interpretation (e.g., new visualization website)**
  - **https://lightning.umd.edu/glm/**
- **NWS VLab Webpage**
  - **https://vlab.ncep.noaa.gov/web/geostationary-lightning-mapper**





GLM Application

Message: Knowing the complete lightning channel path aids forecasters during IDSS

1. Video illustrates one flash producing two ground strikes ~10 miles apart during fireworks in Jacksonville, FL
2. Radar and ground based lightning networks were not indicative of lightning threat between these weakly electrified storm cores
3. GLM depicts long channels connecting distant convection

Case contributed by Chad Gravelle (NWS SRH)
Summarized by Scott Rudlosky (NESDIS STAR)

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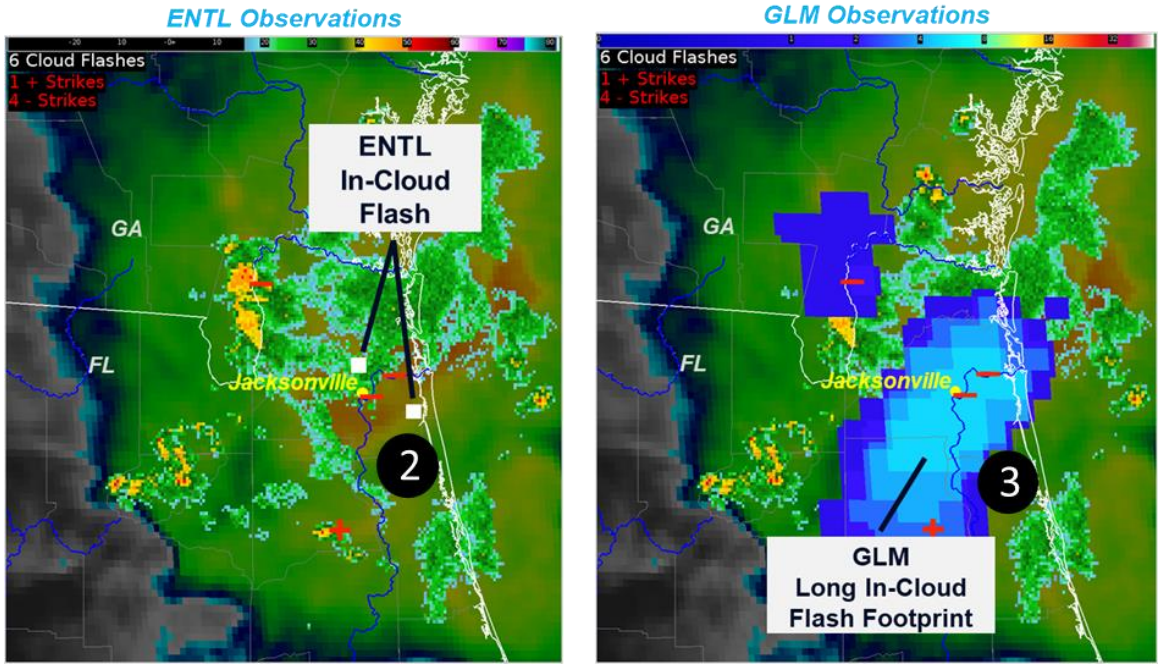

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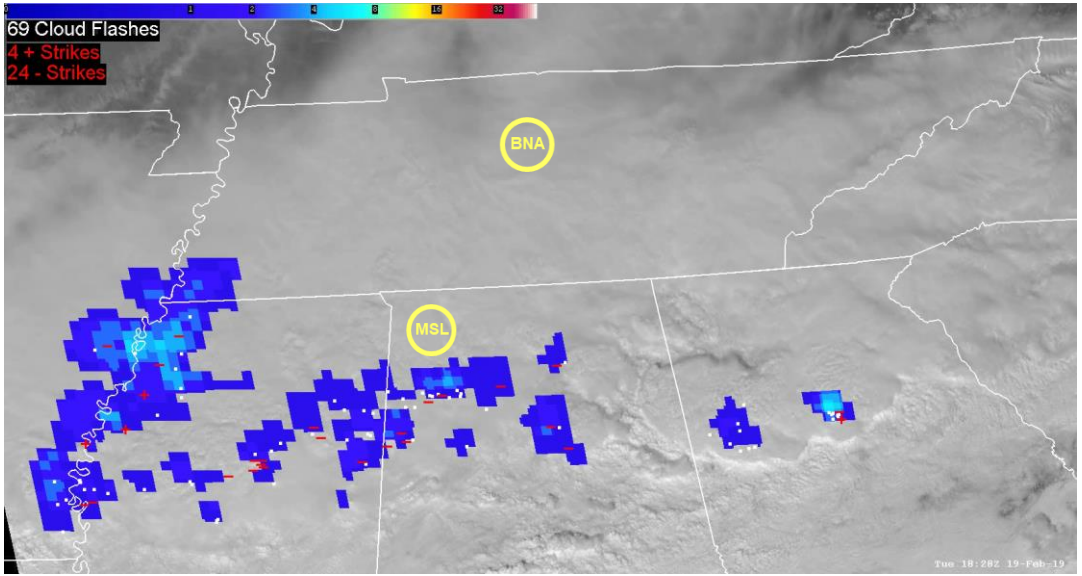
GLM Application

Message: Lightning travels far from deep convection, observing extensive anvil/stratiform flashes provides lead time before the threat becomes more obvious

Cases contributed by Chad Gravelle (NWS SRH) and Brian Carcione (NWS/HUN)

- GLM observations connect the widespread cloud and cloud-to-ground lightning reports, indicating flash source and destination



- Video illustrates lightning flashes traveling hundreds of km north of the main convective line

GLM Application

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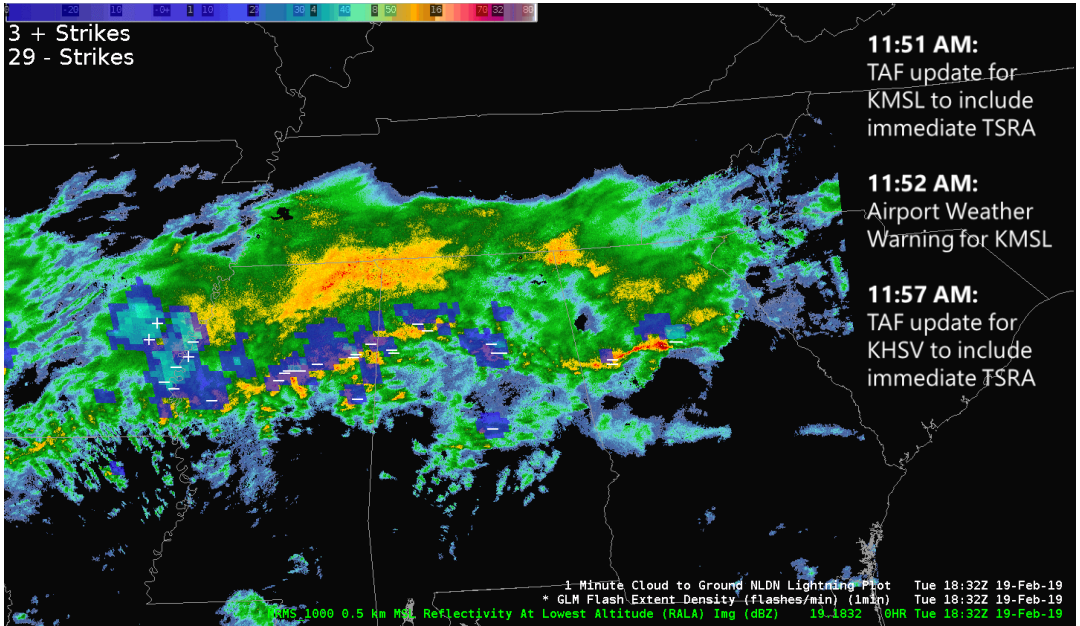
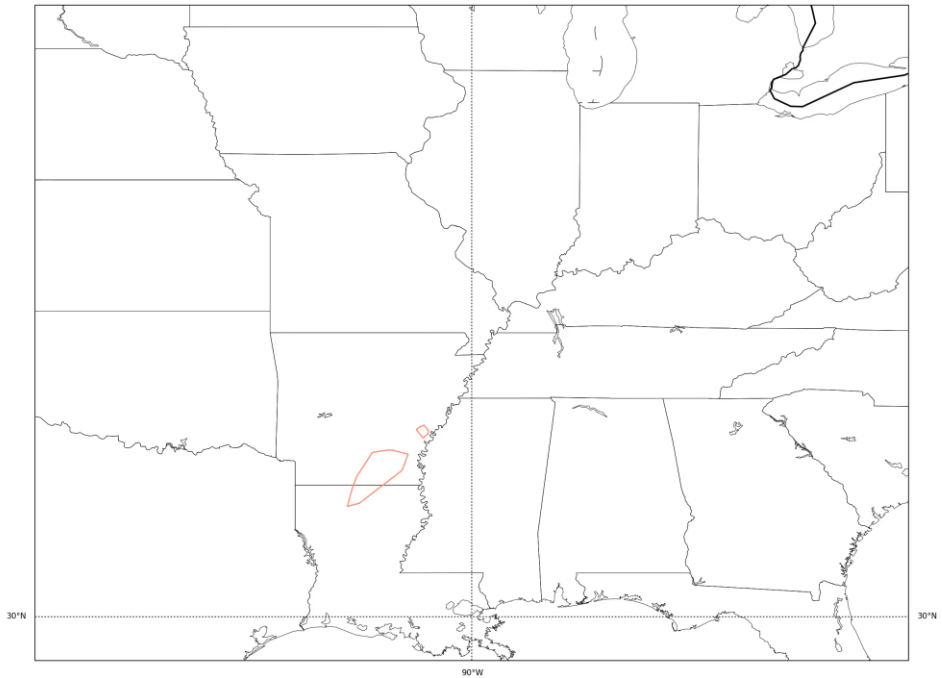


- NWS HUN issued airport weather warnings with increased lead time using GLM and NLDN observations

Thank you for your attention



Experimenting with GLM Storms