Leveraging Satellite Imagery and Products on Severe Thunderstorm Days

Bill Line

NESDIS, Fort Collins, CO

Course Overview

Session 1: Geostationary Lightning Mapper Observations and Severe Weather Forecasting	Session 2: Leveraging Satellite Imagery and Products on Severe Thunderstorm Days	Session 3: Volcanic Eruptions as seen from Satellite	Session 4: Use of Satellite Data for Operational Tropical Cyclone Forecasting
Instructors: Joseph Patton (UMD/CISESS) and Scott Rudlosky (NESDIS/STAR)	Instructor: William Line (NESDIS/STAR)	Instructor: Scott Lindstrom (UW/CIMSS)	Instructors: Galina Chirokova (NWS/NHC/TSB) and Derrick Herndon (UW/CIMSS)
Tuesday, June 21st 1pm – 3pm EDT	Thursday, June 23rd 1pm – 3pm EDT	Tuesday, June 28th 1pm – 3pm EDT	Thursday, June 30th 1pm – 3pm EDT

GOES-R Series Advanced Baseline Imagery

- 16-channels
  - 2 visible (0.5 – 1 km), 4 near-IR (1-2 km), 10 IR (2 km)
    - From these, numerous multispectral and derived products (see below)
- 10-min Full Disk (Hemisphere), 5-min CONUS temporal resolution, plus two moveable 1-min 1000km x 1000km mesoscale sectors

East Conus	
Imagery Channels	▸
Derived Products	▸
Channel Differences	▸
RGB Composites	▸
RGB Composites Custom	▸
RGB Composites RAD	▸
Derived Motion Winds	▸
Vertical Temp/Moisture Profiles	??.????

Imagery Channels	
0.47 µm Blue Visible Band (Ch 01)	??.????
0.64 µm Red Visible Band (Ch 02)	??.????
0.86 µm Vegetation NIR Band (Ch 03)	??.????
1.37 µm Cirrus NIR Band (Ch 04)	??.????
1.61 µm Snow/Ice NIR Band (Ch 05)	??.????
2.24 µm Cloud Particle Size NIR Band (Ch 06)	??.????
3.90 µm Shortwave Window IR Band (Ch 07)	??.????
6.19 µm Upper-level Water Vapor IR Band (Ch 08)	??.????
6.93 µm Mid-level Water Vapor IR Band (Ch 09)	??.????
7.34 µm Low-level Water Vapor IR Band (Ch 10)	??.????
8.44 µm Cloud-Top Phase IR Band (Ch 11)	??.????
9.61 µm Ozone IR Band (Ch 12)	??.????
10.33 µm Clean Window IR Band (Ch 13)	??.????
11.21 µm Legacy Window IR Band (Ch 14)	??.????
12.29 µm Dirty Window IR Band (Ch 15)	??.????
13.28 µm Carbon Dioxide IR Band (Ch 16)	??.????

10.33 µm Clean Window IR Band (Ch 13) DegF	??.????

Derived Products	
Aerosol Detection Dust	??.????
Aerosol Detection Smoke	??.????
Aerosol Optical Depth	??.????
Clear Sky Mask	??.????
Cloud Optical Depth	??.????
Cloud Particle Size	??.????
Cloud Top Height	??.????
Cloud Top Phase	??.????
Cloud Top Pressure	??.????
Derived Stability Indices	▸
Fire/Hot Spot	▸
Fog and Low Stratus	▸
Land Surface Temperature	??.????
Total Precip Water	??.????
Turbulence Probability (UWSSEC)	??.????

Channel Differences	
CIRA GOES ProxyVis	??.????
Split Window (10.3-12.3 µm)	??.????
Split Window Rad (10.3-12.3 µm)	??.????
Split Window 2 (11.2-12.3 µm)	??.????
Split IR (10.3-11.2 µm)	??.????
Split Cloud Top Phase (11.2-8.4 µm)	??.????
Night Fog (10.3-3.9 µm)	??.????
Night Fog (11.2-3.9 µm)	??.????
Day Fog (3.9-10.3 µm)	??.????
Split Fire (2.2-1.6 µm)	??.????
Split Ozone (9.6-10.3 µm)	??.????
Split Water Vapor (6.19-7.3 µm)	??.????
Split Snow (1.6-0.64 µm)	??.????
Split Snow 2 (0.86-1.61 µm)	??.????
Vegetation (0.64-0.87 µm)	??.????
Norm Diff Vegetation Index (NDVI)	??.????

RGB Composites	
------ Simple ------	
Day Cloud Phase Distinction (10.35 µm, 0.64 µm, 1.61 µm)	09.1836
Day Cloud Type (1.38 µm, 0.64 µm, 1.61 µm)	09.1836
Fire Temperature (3.90 µm, 2.25 µm, 1.61 µm)	??.????
Day Land Cloud (1.61 µm, 0.87 µm, 0.64 µm)	09.1836
Day Cloud Convection (0.64 µm, 0.64 µm, 10.35 µm)	09.1836
Day Land Cloud Fires (2.25 µm, 0.87 µm, 0.64 µm)	09.1836
VIS/IR Sandwich	09.1836
Simple Water Vapor (10.35 µm, 6.19 µm, 7.34 µm)	??.????
------ Advanced ------	
Air Mass (6.19-7.34 µm, 9.61-10.35 µm, 6.19 µm)	??.????
Ash (12.30-10.35 µm, 11.20-8.50 µm, 10.35 µm)	09.1836
Day Convection (6.19-7.34 µm, 3.90-10.35 µm, 1.61-0.64 µm)	09.1836
Day Snow-Fog (0.87 µm, 1.61 µm, 3.90-10.35 µm)	09.1836
Differential Water Vapor (7.34-6.19 µm, 7.34 µm, 6.19 µm)	09.1836
Dust (12.30-10.35 µm, 11.20-8.50 µm, 10.35 µm)	09.1836
CIMSS Natural Color	09.1836
CIRA Geocolor	??.????
Nighttime Microphysics (12.30-10.35 µm, 10.35-3.90 µm, 10.35 µm)	09.1836
SO2 (6.95-7.34 µm, 10.35-8.50 µm, 10.35 µm)	??.????
------ Old RGBs ------	
Daytime Composite #1(0.64,1.61,11.20)	09.1836
Daytime Composite #5(0.64,0.87,0.64)	09.1836
Day Ocean Cloud Convection (0.87 µm, 0.87 µm, 10.35 µm)	??.????

Products Discussed Today

- Focus is on satellite products today. In reality, satellite used in concert with:
  - NWP, radar, lightning, UA, surface obs, webcams, human obs, etc
- Pre-convective Environment
  - Water Vapor Imagery Analysis
  - Split Window Difference
  - Derived Products – CAPE and TPW
  - Derived Motion Winds
  - NUCAPS
- Cumulus Cloud Field Analysis and Convective Initiation
  - VIS and IR imagery
  - Day Cloud Phase Distinction RGB
- Mature Convective Analysis
  - VIS and IR imagery
  - VIS/IR Sandwich Imagery
- Nighttime Convective Analysis
  - Nighttime Microphysics RGB
  - IR

Important to leverage meso imagery when available

Pre-Convective Analysis

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  - NWP, radar, lightning, UA, surface obs, webcams, human obs, etc
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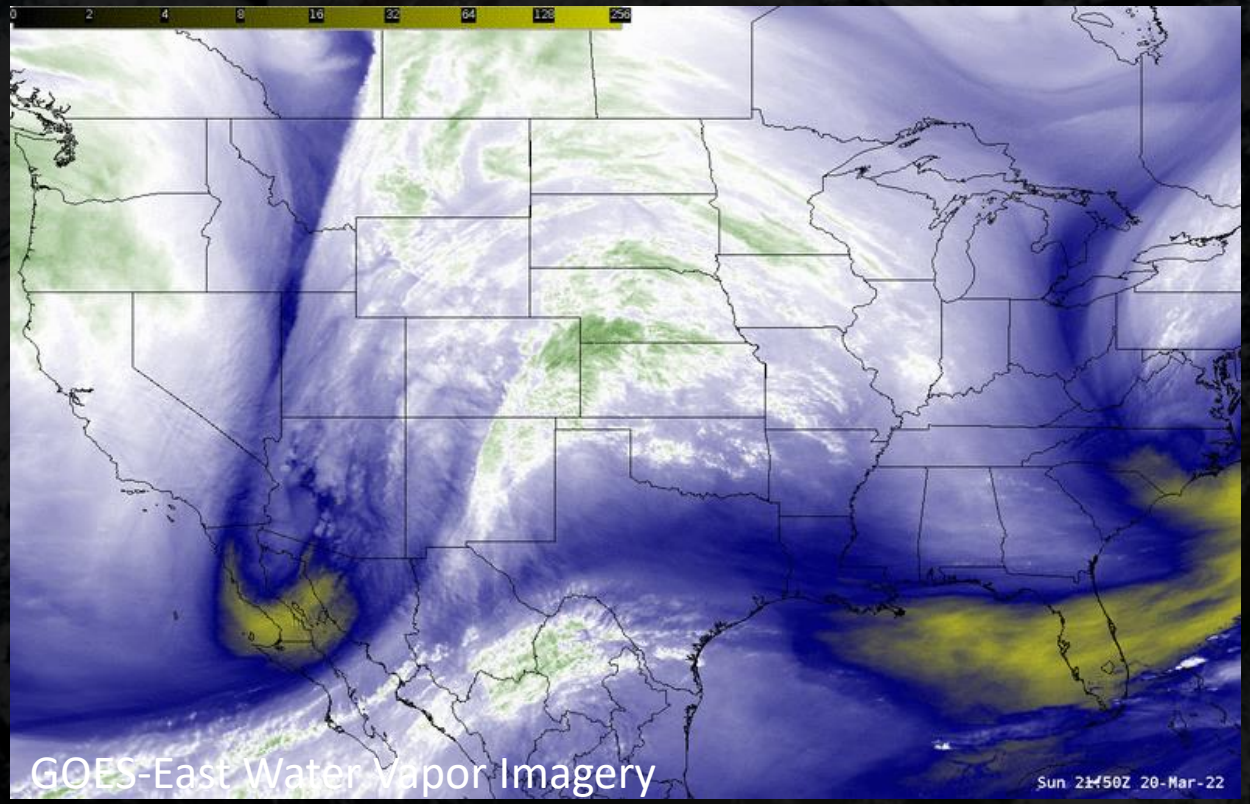
Water Vapor Imagery

- Diagnose broad trough/ridge pattern, shortwave troughs, jet streaks
- Recall:
  - Troughs are regions of cyclonic vorticity
  - (differential) positive vorticity advection yields divergence, which yields UVM
  - Upward motion is necessary for convective development
- 20 March 2022



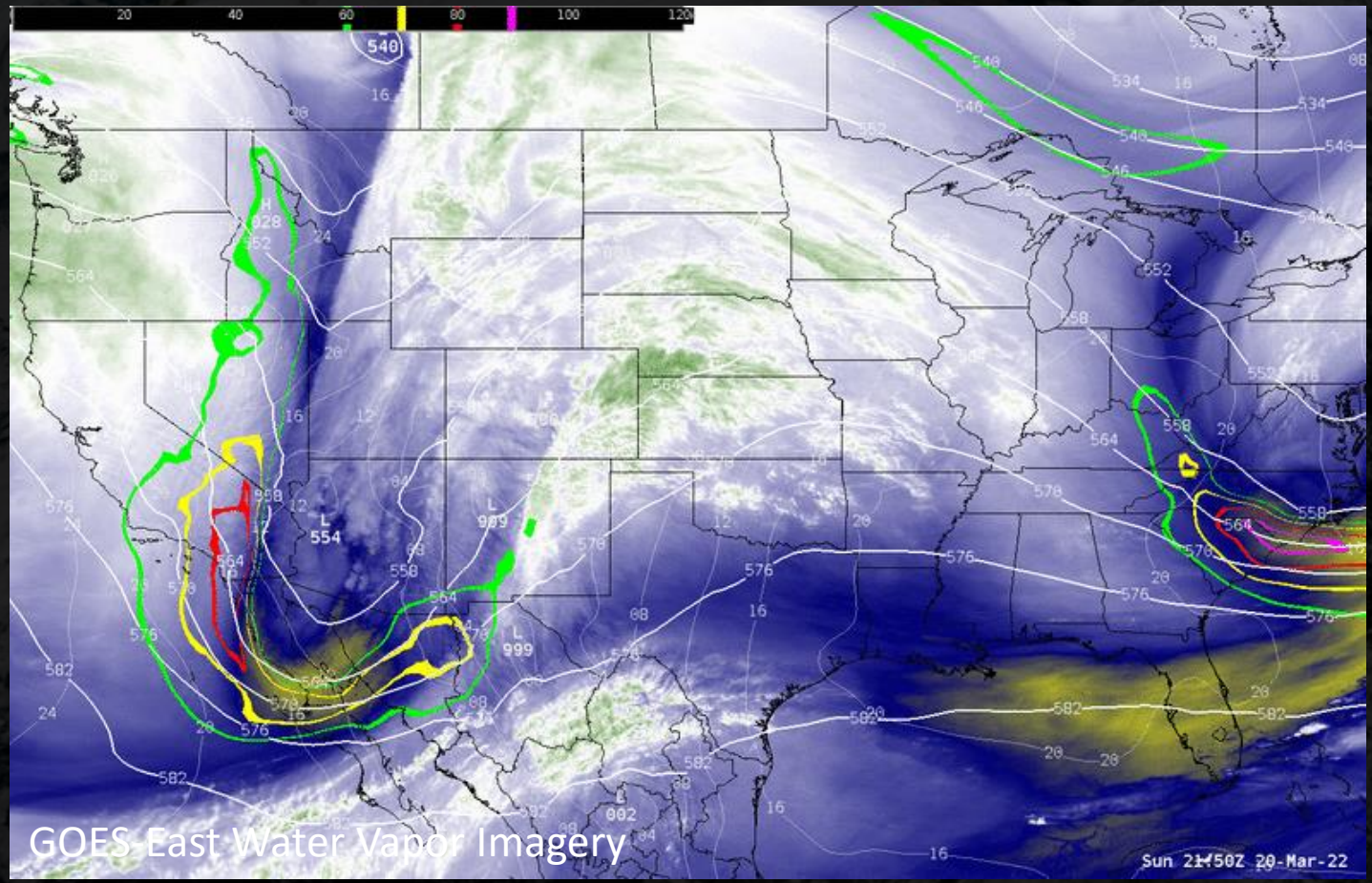
GOES-East Water Vapor Imagery

- Blue to warm colors represents warmer brightness temperatures, which implies drying/descending air
- Blue to white to green colors represents cooler brightness temperatures, which implies moistening/rising air
- Look for cyclonic motion, couplet of warm/cool BTs

https://satelliteliaisonblog.com/2022/03/18/mid-march-2022-blowing-dust-and-fires/

Water Vapor Imagery + NWP Analysis

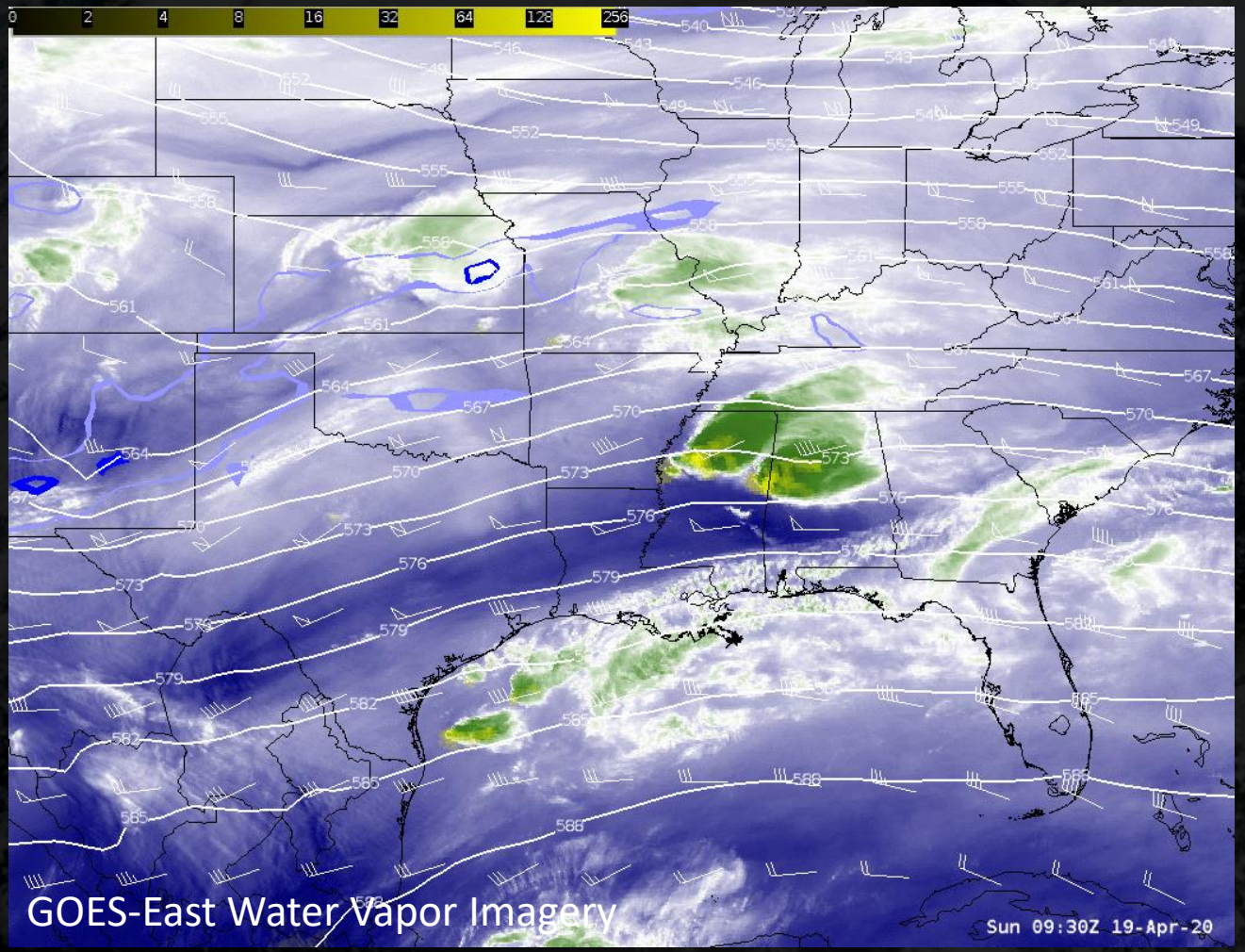
- 20 March 2022 GOES-East 6.2 um Water Vapor Imagery



https://satelliteliaisonblog.com/2022/03/18/mid-march-2022-blowing-dust-and-fires/

Water Vapor Imagery + NWP Analysis

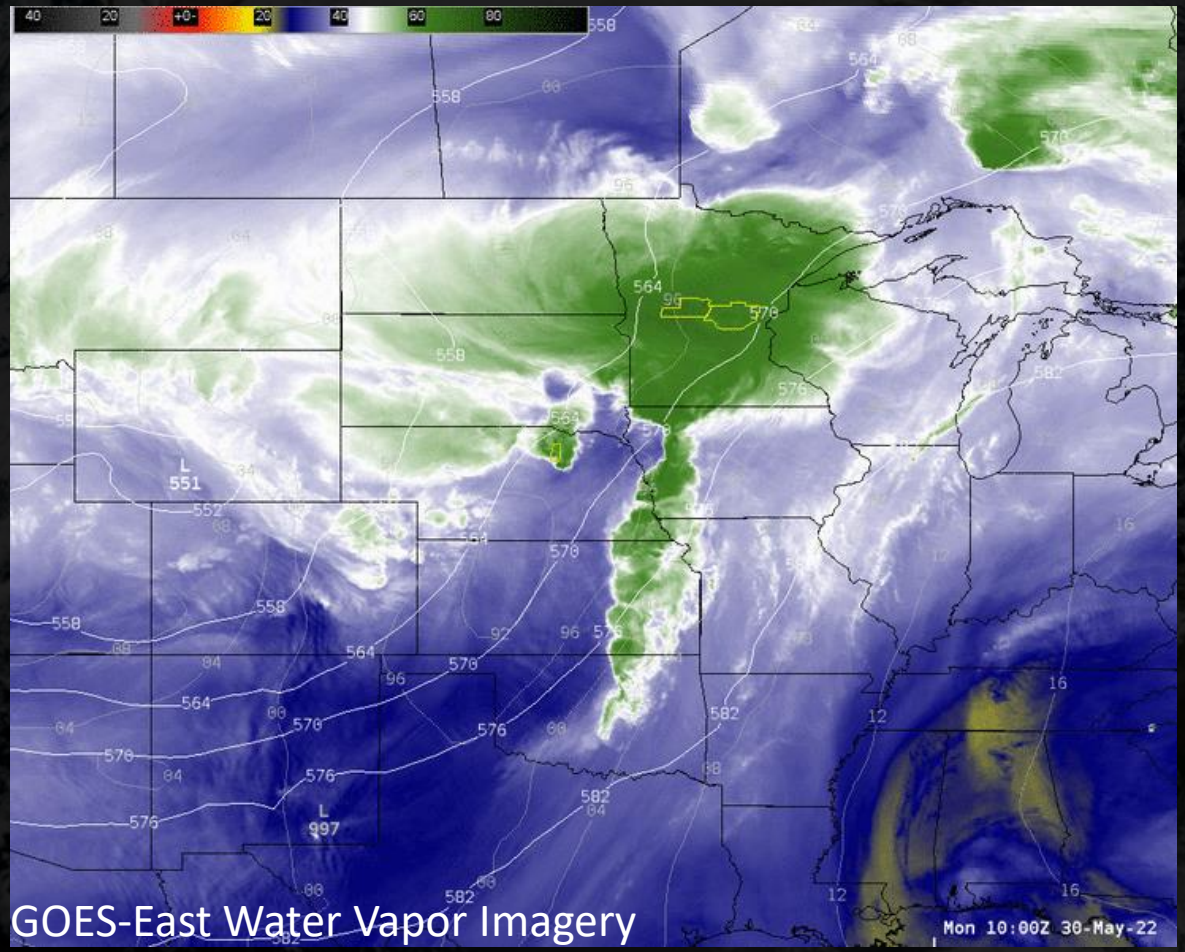
- 19 April 2020 GOES-East 6.2 um Water Vapor Imagery



https://satelliteliaisonblog.com/2020/04/21/using-goes-r-data-in-warning-ops-on-19-april-2020/

Water Vapor Imagery

- 30 May 2022 GOES-East 6.2 um Water Vapor Imagery

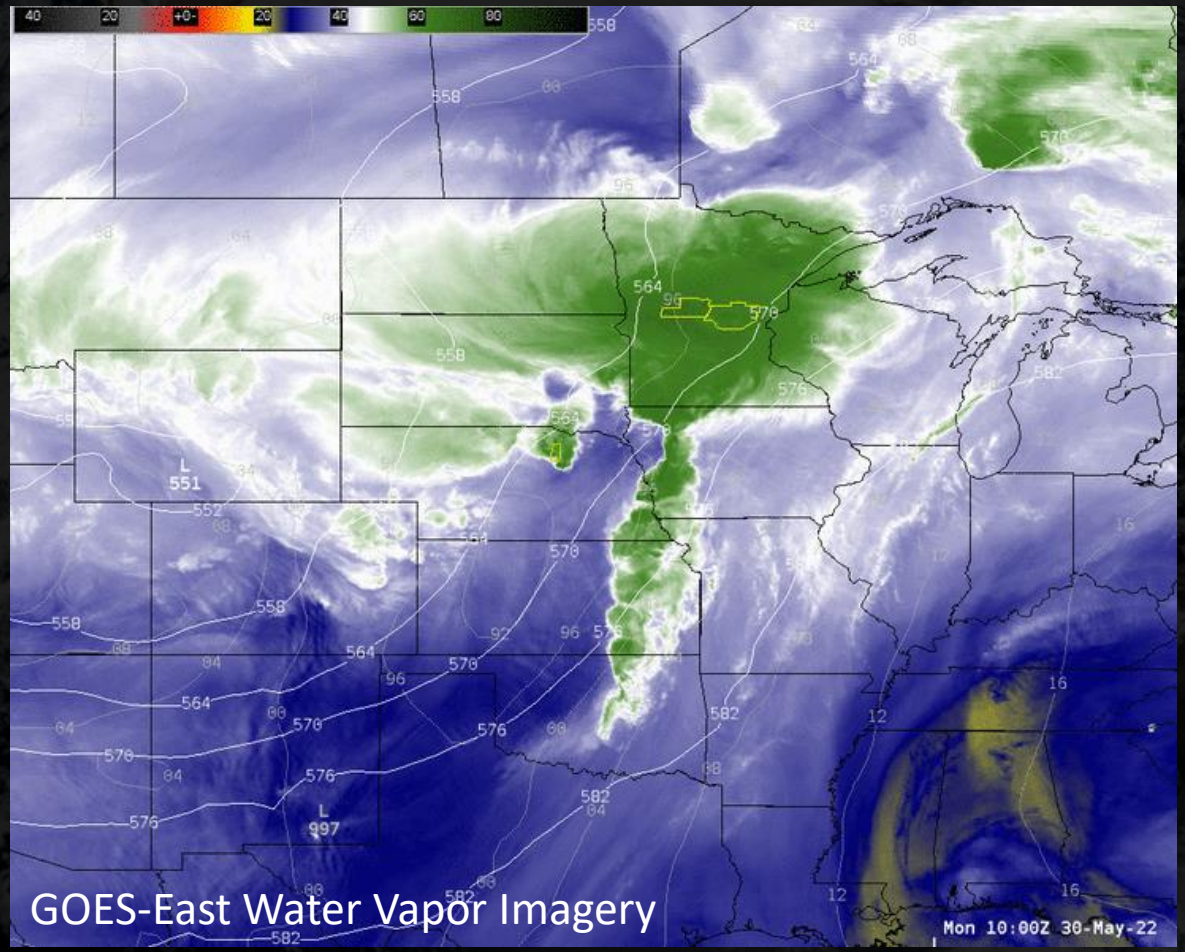


GOES-East Water Vapor Imagery

https://satelliteliaisonblog.com/2022/05/31/memorial-day-2022-severe/

Water Vapor Imagery

- 30 May 2022 GOES-East 6.2 um Water Vapor Imagery

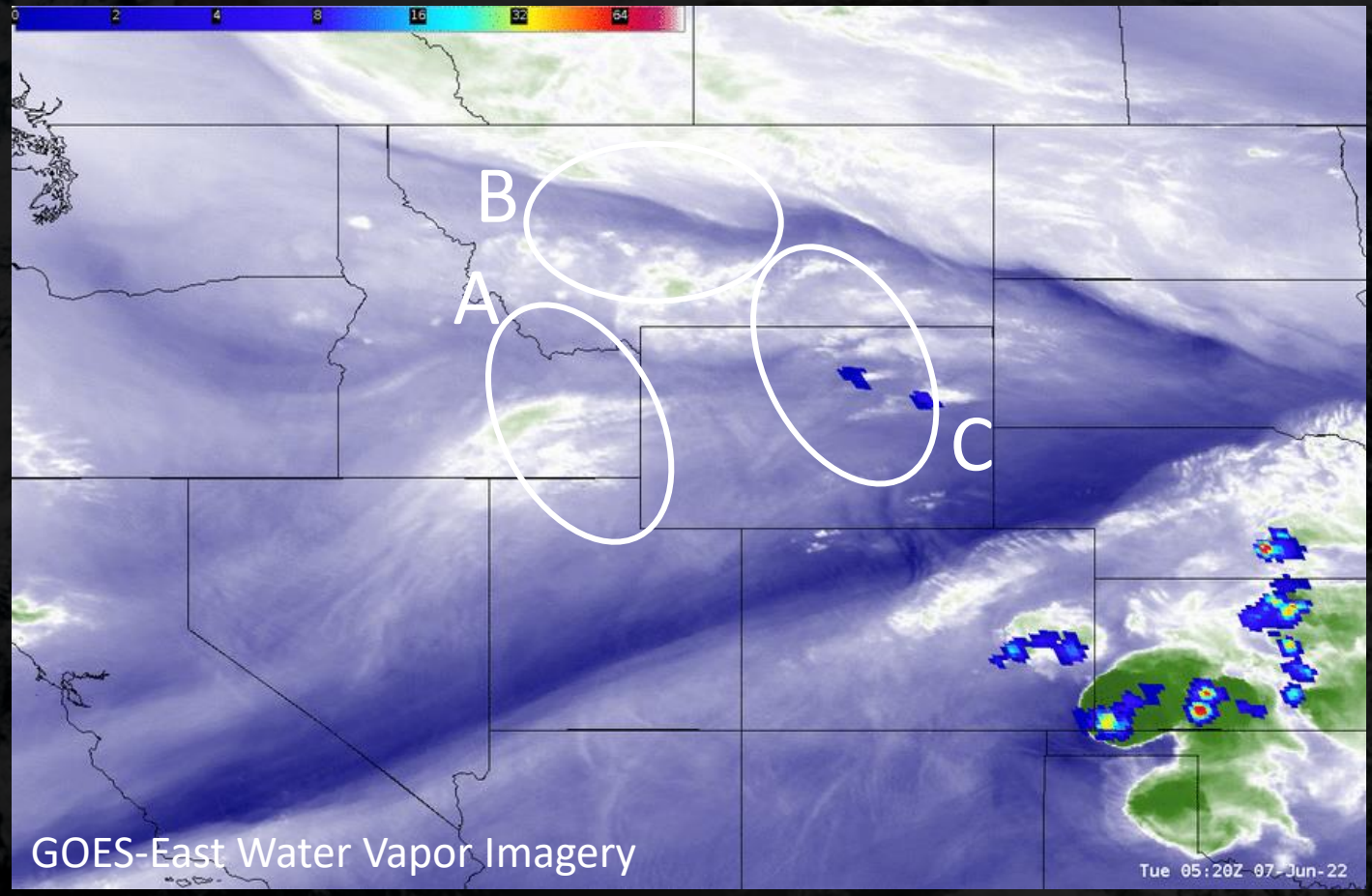


GOES-East Water Vapor Imagery

https://satelliteliaisonblog.com/2022/05/31/memorial-day-2022-severe/

Exercise: Where is convection most likely to occur given the presence of large-scale lift?

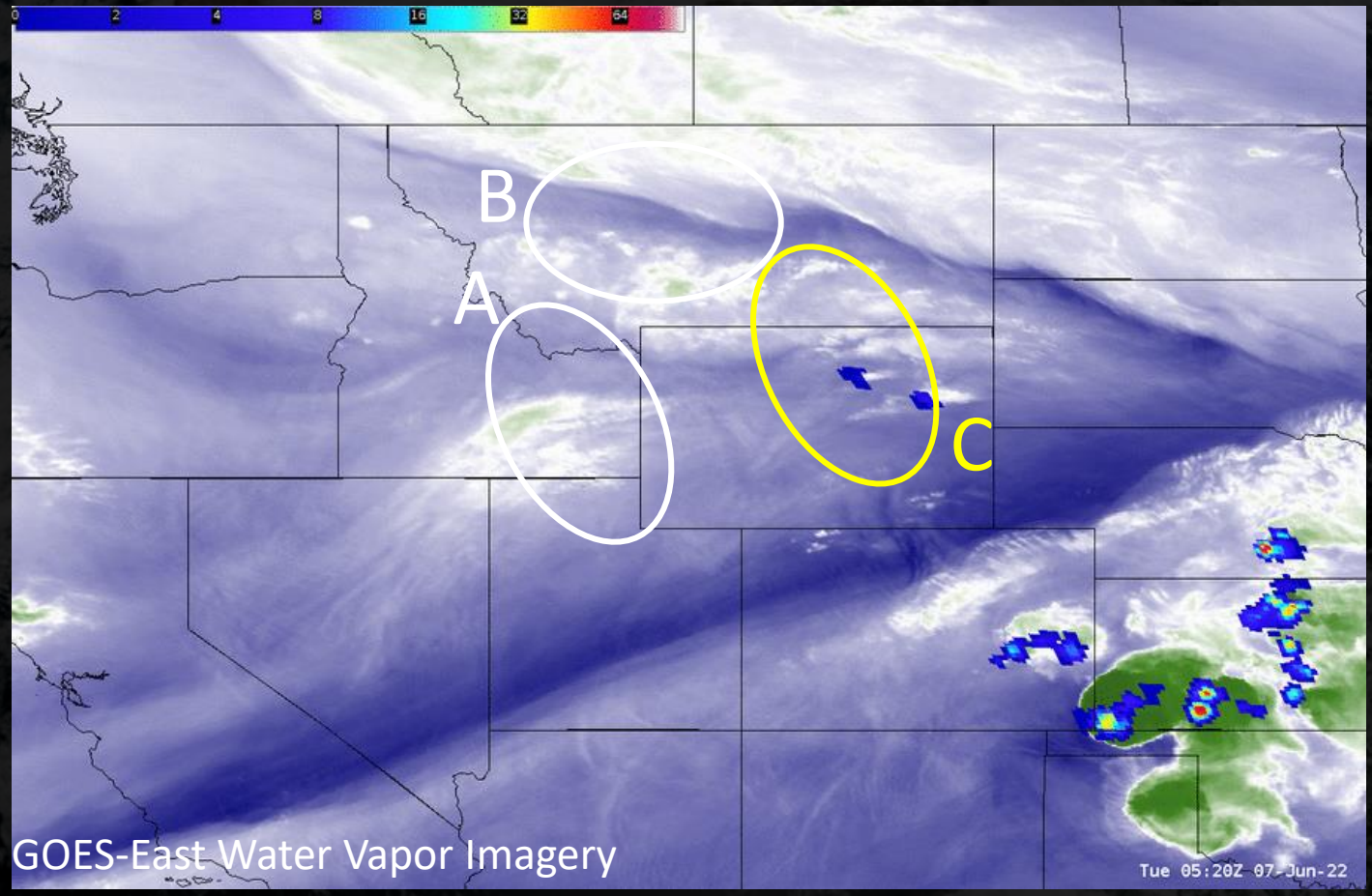
- 7 June 2022 GOES-East 6.2 um Water Vapor Imagery



Q1

Exercise: Where is convection most likely to occur given the presence of large-scale lift?

- 7 June 2022 GOES-East 6.2 um Water Vapor Imagery

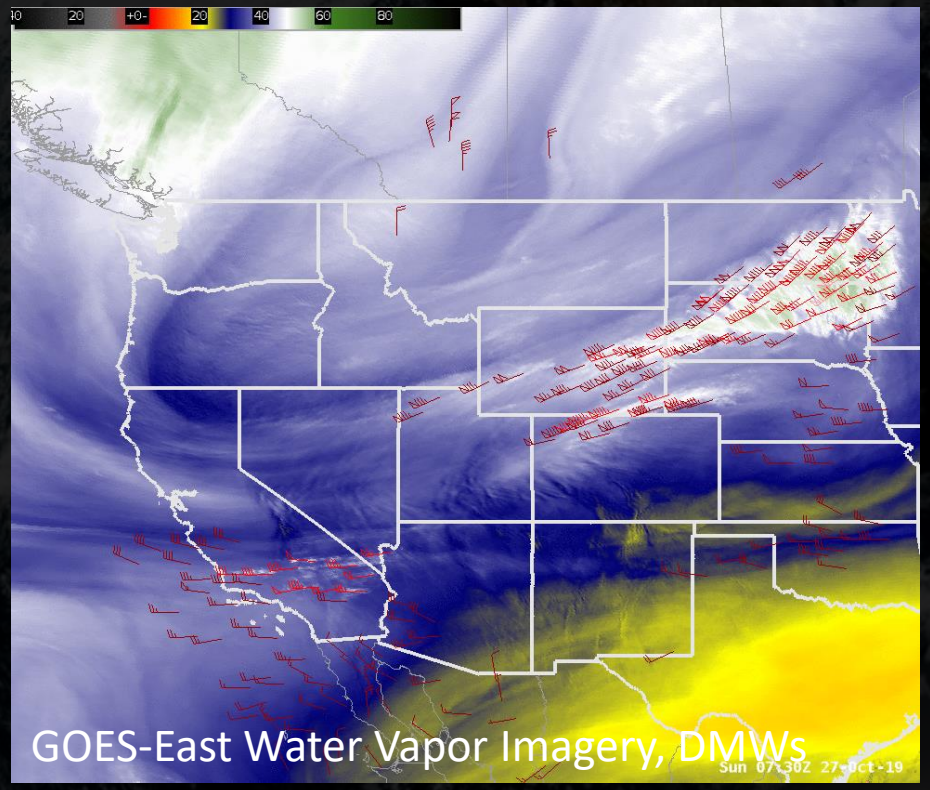


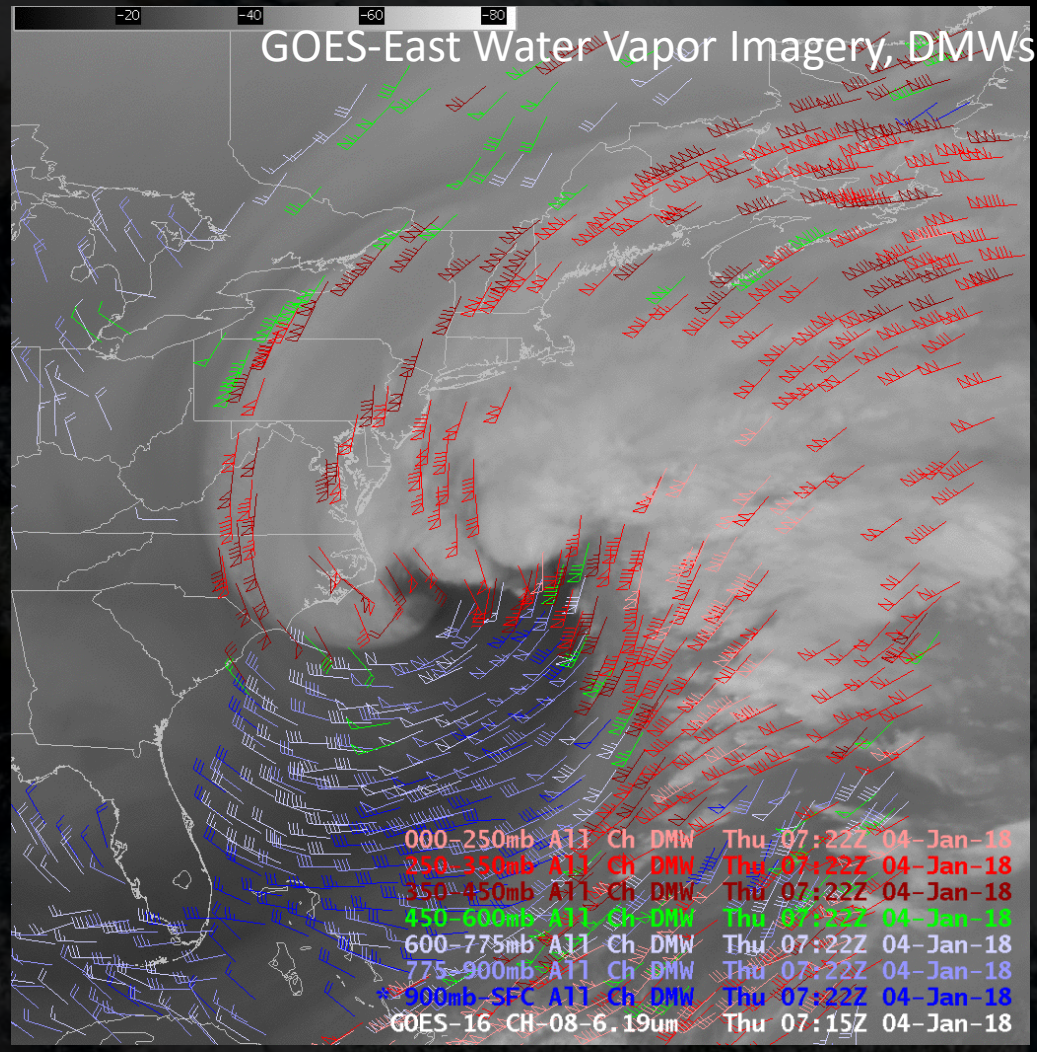
GOES-East Water Vapor Imagery

Q1 Answer

Derived Motion Winds

- Diagnose features not obvious (or misplaced) in models
  - Jet features (LLJ, jet streaks)
  - Trough/ridge, shortwaves, divergence/convergence
  - Mesoscale feaures
  - Vertical shear

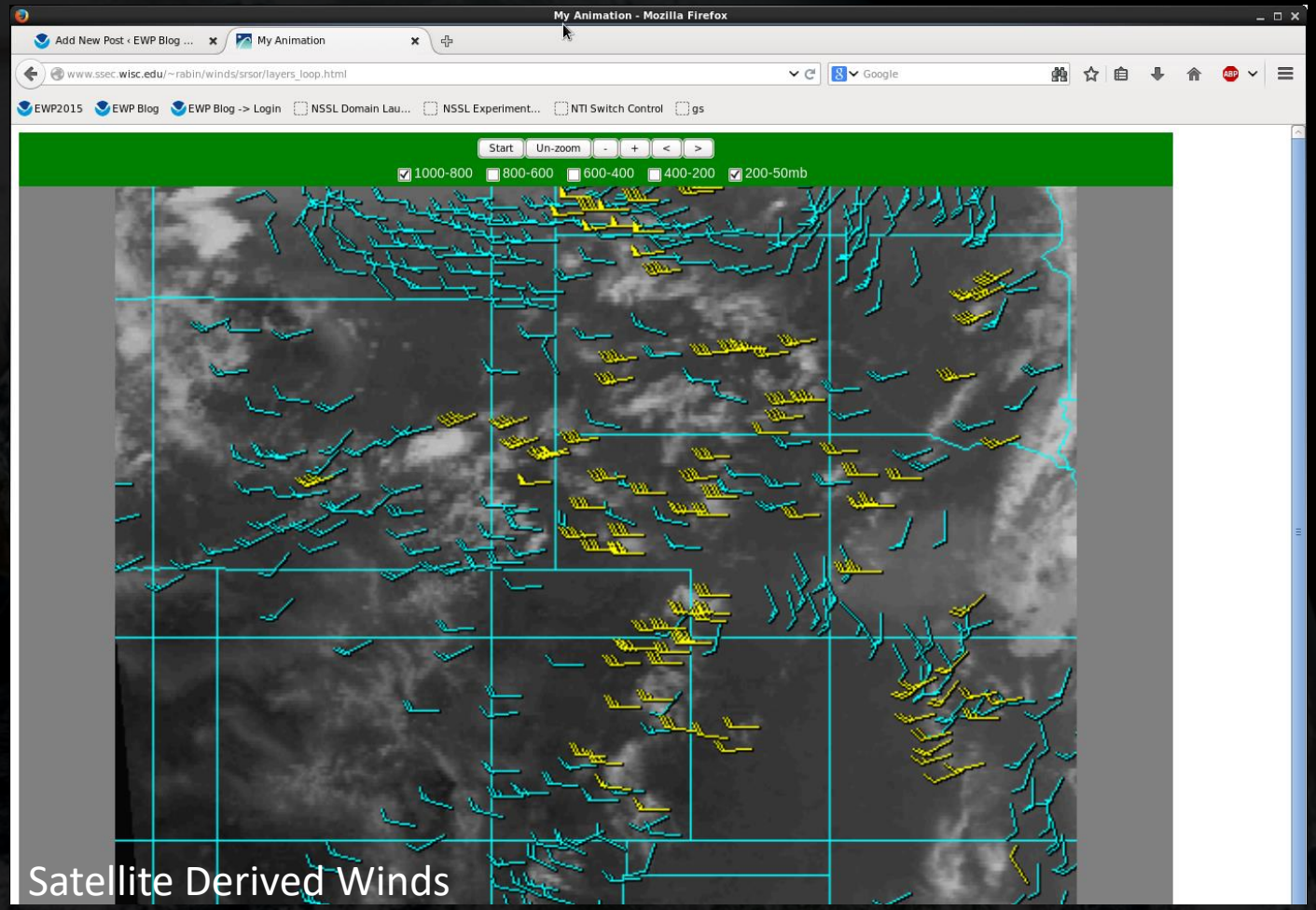




DMW Applications: Assess Model Output

02 June 2015 WY-NE Severe Convection

- Localized UL Jet not resolved correctly by models
- HWT early day: “There is a weak 50kt + jetlet moving across the cwa. This suggests that deep layer shear is larger than previous suggested by the RAP. As storms move to the east across the cwa, I’m expecting the storms to become more organized.”
- HWT post-event: “This data was a check to the models. The winds associated with this max increased the 0-6km shear to around 45 knots. I thought that the jetlet would cause the storms to become stronger and more supercell in nature until it moved out of the area. This in fact happened. This lead to a small window ~2 hours of supercells with large hail.”



Satellite Derived Winds

https://goesrhwt.blogspot.com/2015/06/srso-data-vs-rap.html
https://goesrhwt.blogspot.com/2015/06/thoughts-on-1min-ssro-data-and-severe.html

DMW Applications: Synoptic Scale Feature Detection

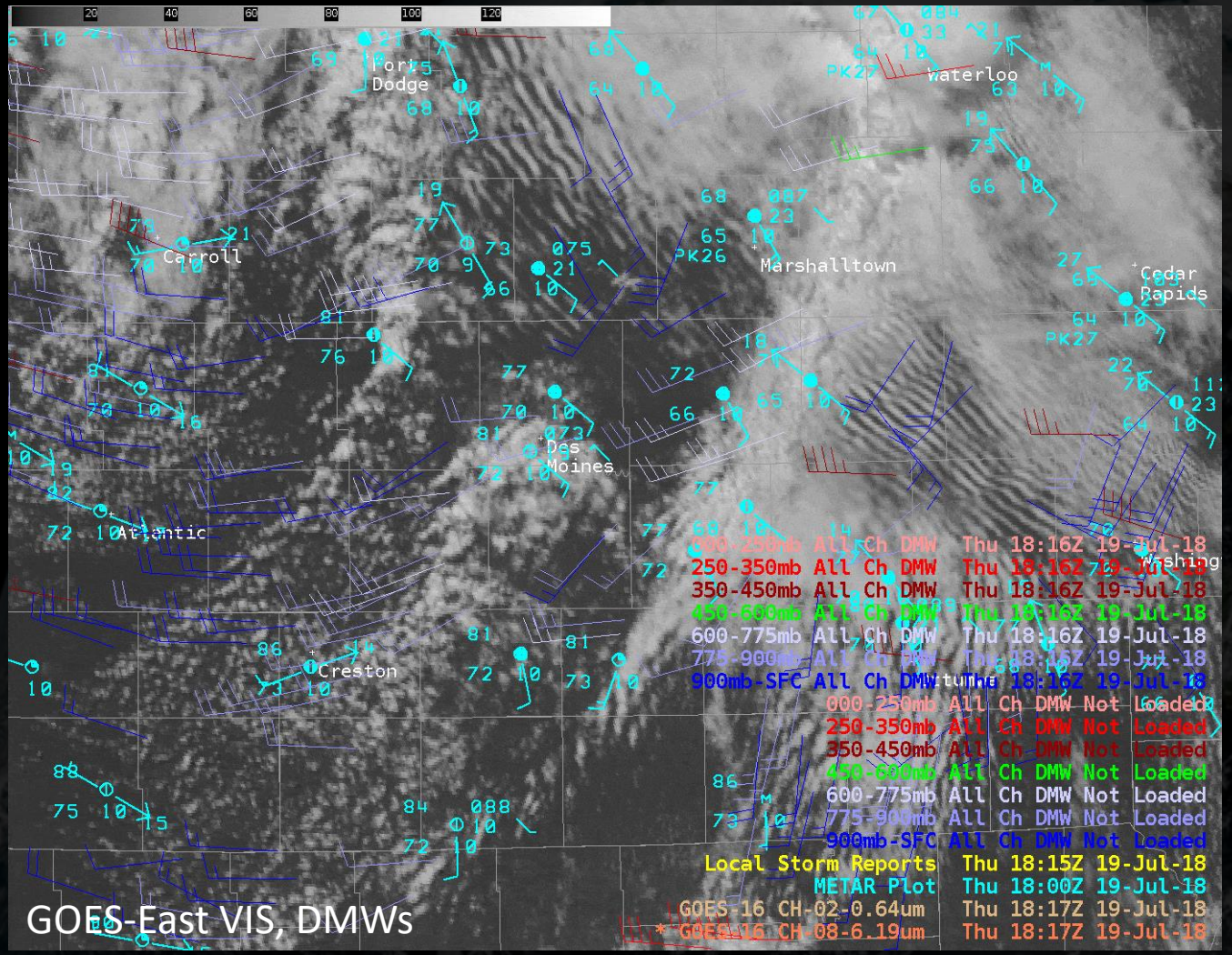
06 Sep 2018 Mountain Thunderstorms

- Localized jet apparent in UL DMWs enhances shear/lift over central CO; not captured in UL analyses
- Widespread showers/thunderstorms develop near and over burn scar, resulting in flash flooding

GOES-East Water Vapor Imagery, DMWs

https://courses.comet.ucar.edu/course/view.php?id=225

DMW Applications: Computing Bulk Vertical Shear



GOES-East VIS, DMWs

19 July 2019 C Iowa Tornado

- SFC METAR: 12 knots @ 160deg
- 1 km DMW: 16-20 knots @ 220deg
- 6 km DMW: 40-50 knots @ 275deg

➢0-1km Bulk Shear ~ 16 knots

➢0-6 km Bulk Shear ~ 49 knots

https://satelliteliaisonblog.com/2018/07/19/19-july-2018-iowa-tornados-goes-16-and-jpss/
https://www.meted.ucar.edu/training_module.php?id=10041#.XyCM3Z5KiUl

Split Window Difference – IR Combo

- Use: Anticipate cu development and future convective initiation from clear sky
- Ingredients
  - 10.3 um – 12.3 um Band Difference
  - 10.3 um Cold BT Overlay
- Interpretation
  - Greater + difference = more abundant moisture
  - Look for gradients, local max
- Caveats
  - Clear sky
  - Temperature decreasing with height
- Quick Guide

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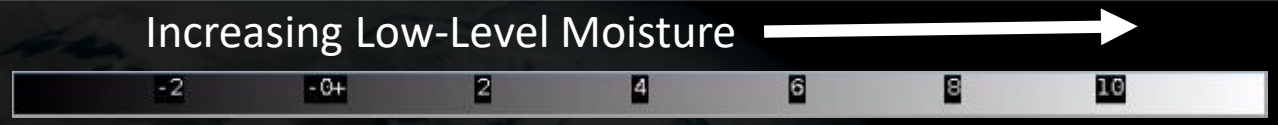

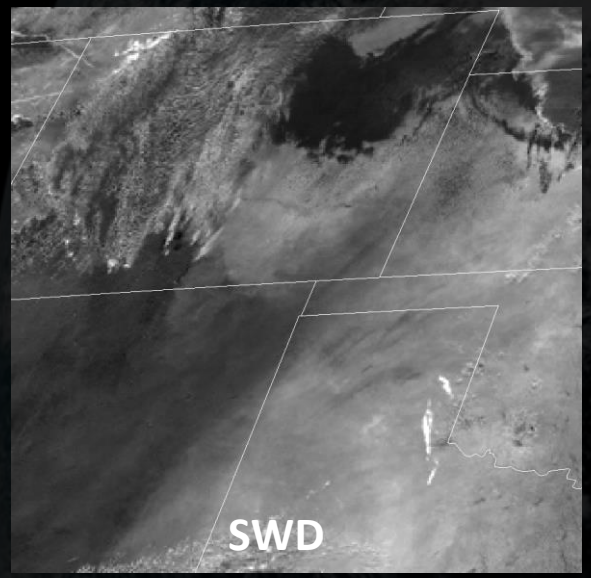

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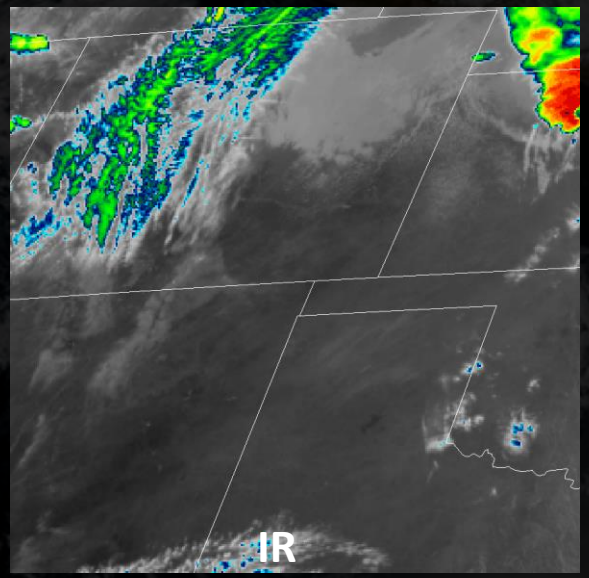

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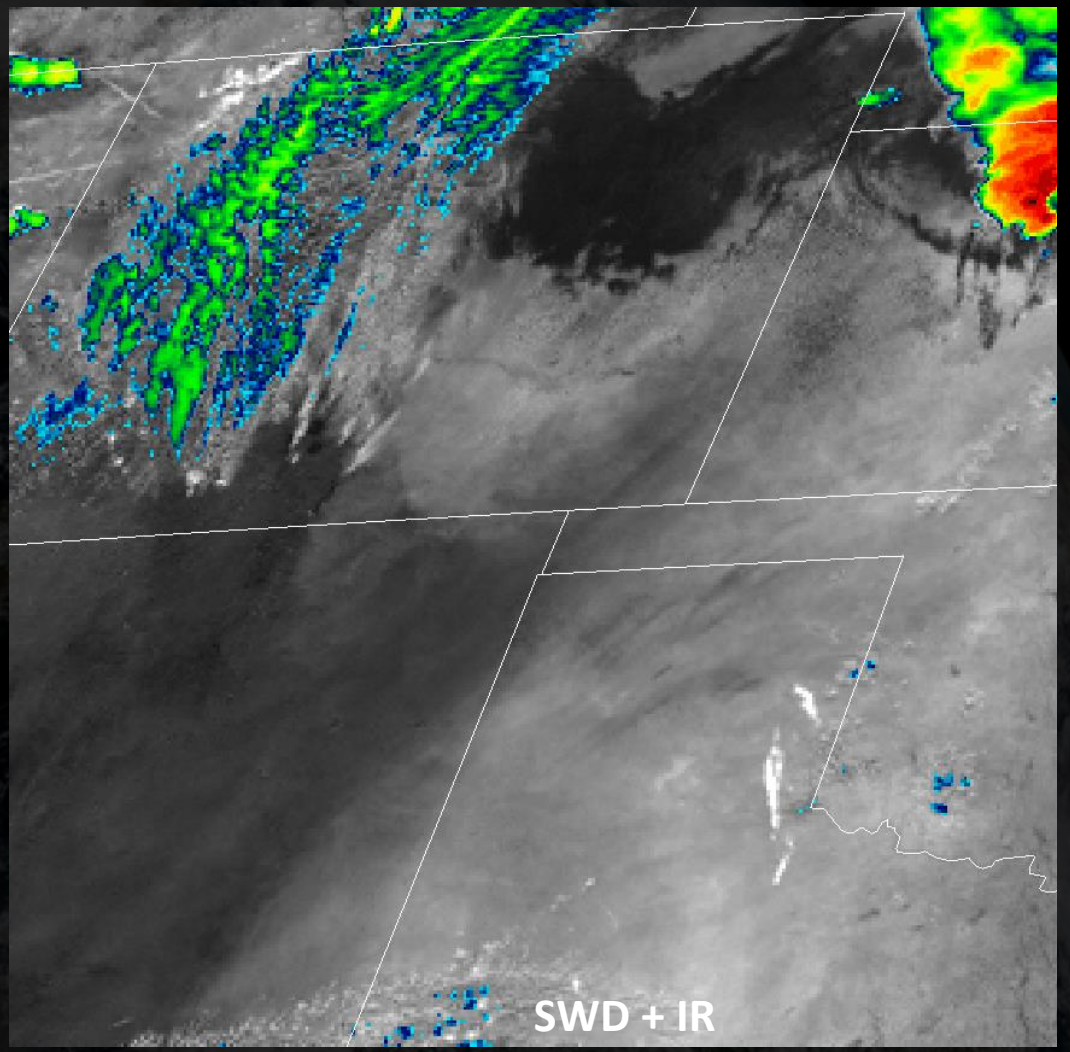
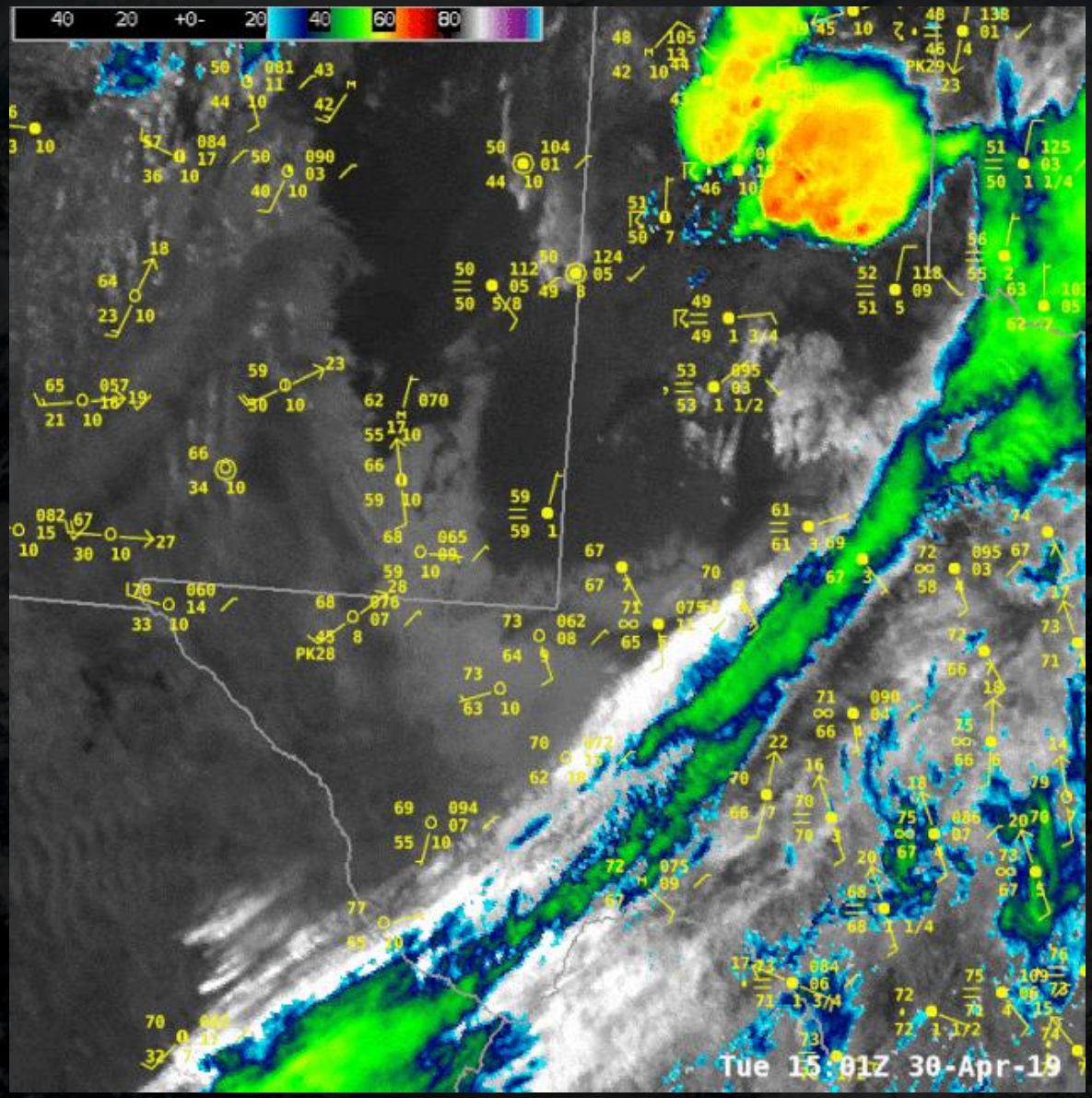
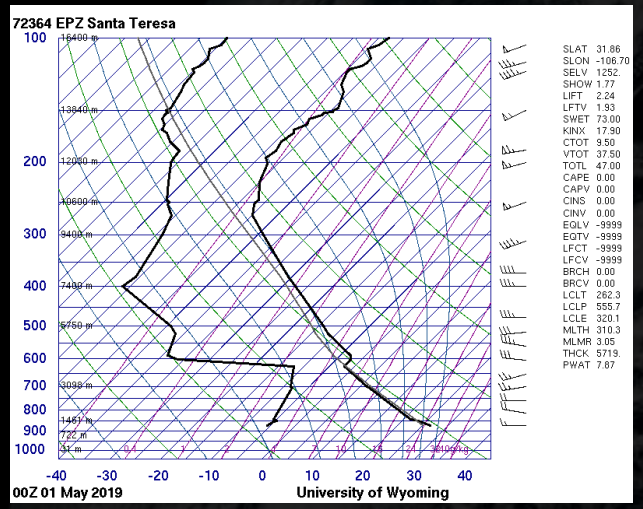
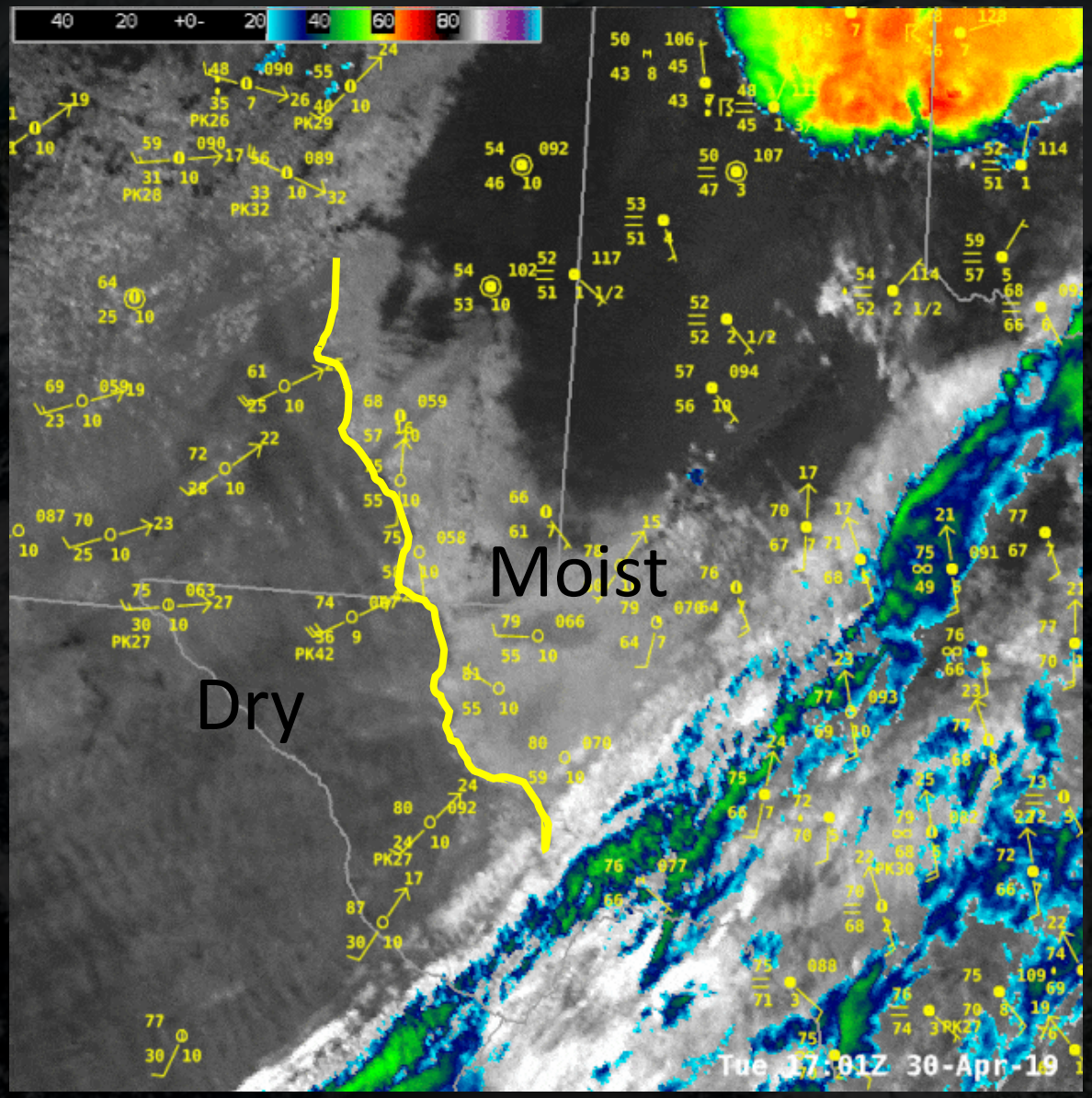


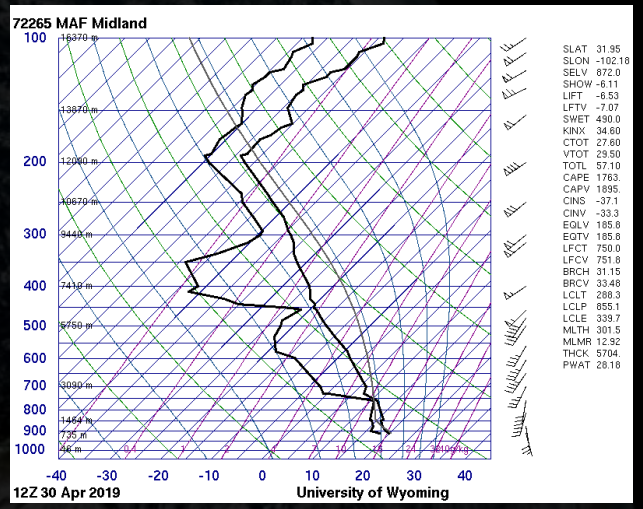
SWD-IR



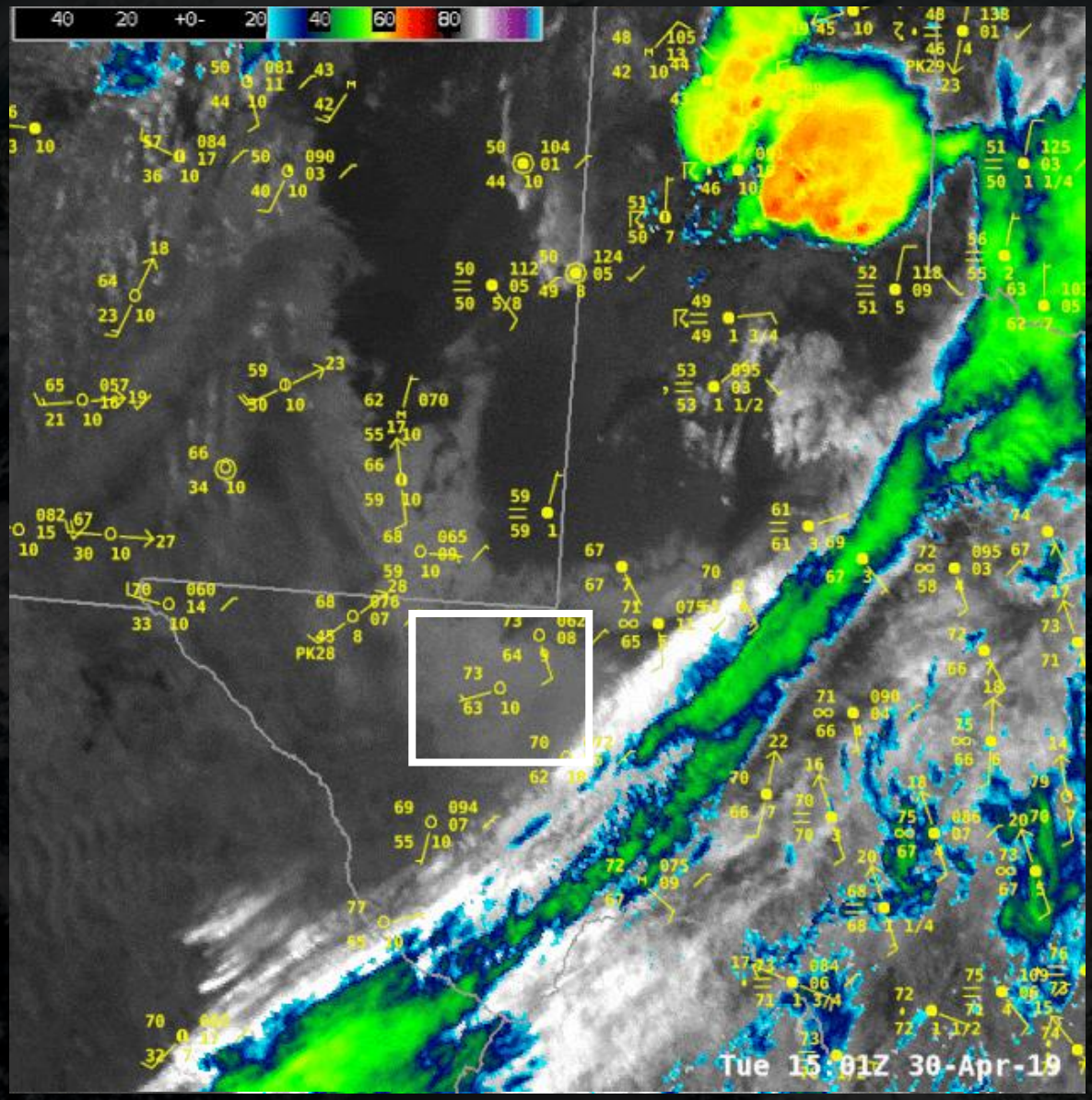
SWD-IR


72364 EPZ Santa Teresa
00Z 01 May 2019
University of Wyoming


Moist
Dry
Tue 17:01Z 30-Apr-19

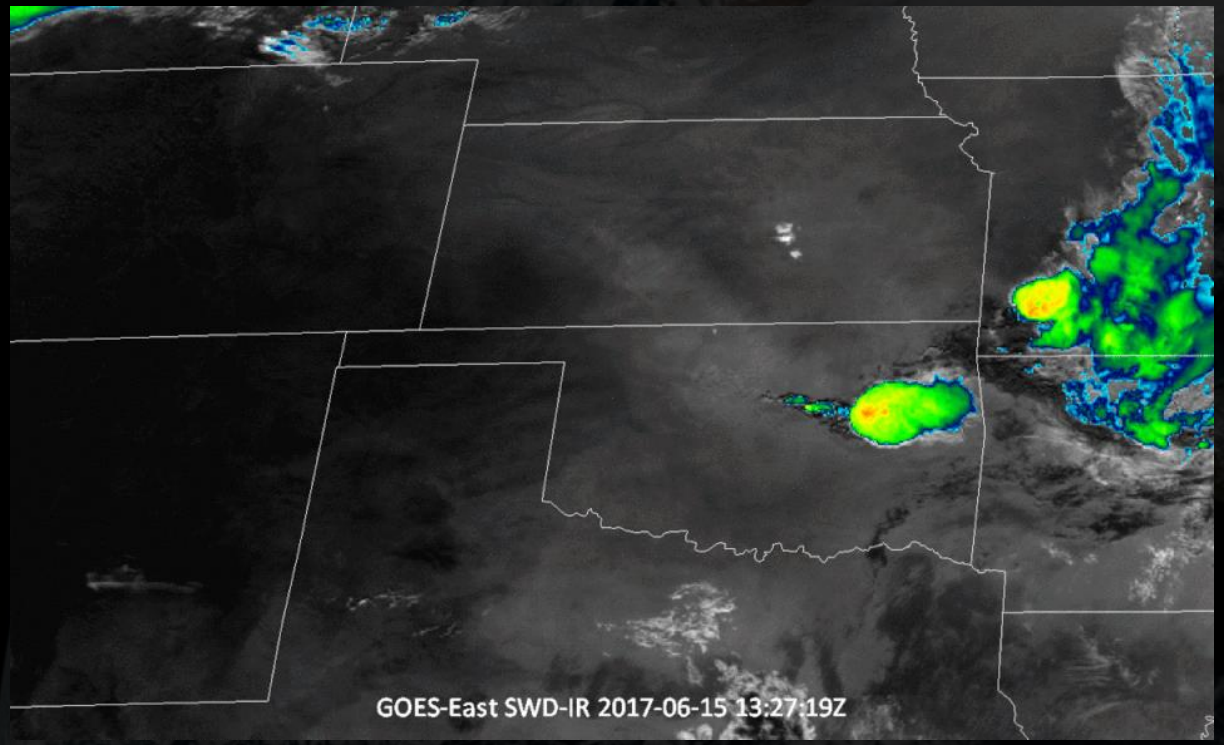

72265 MAF Midland
12Z 30 Apr 2019
University of Wyoming

SWD-IR

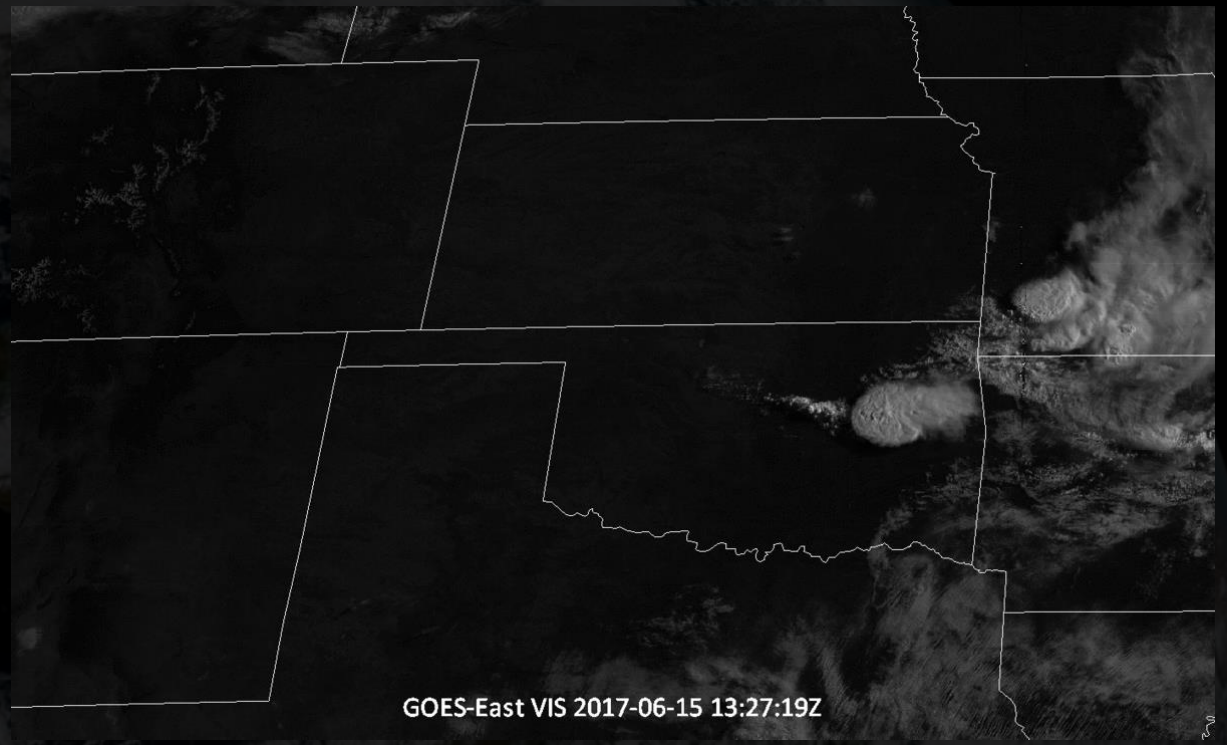


Where will cu field develop?

Split Window Difference with cold IRW Overlay



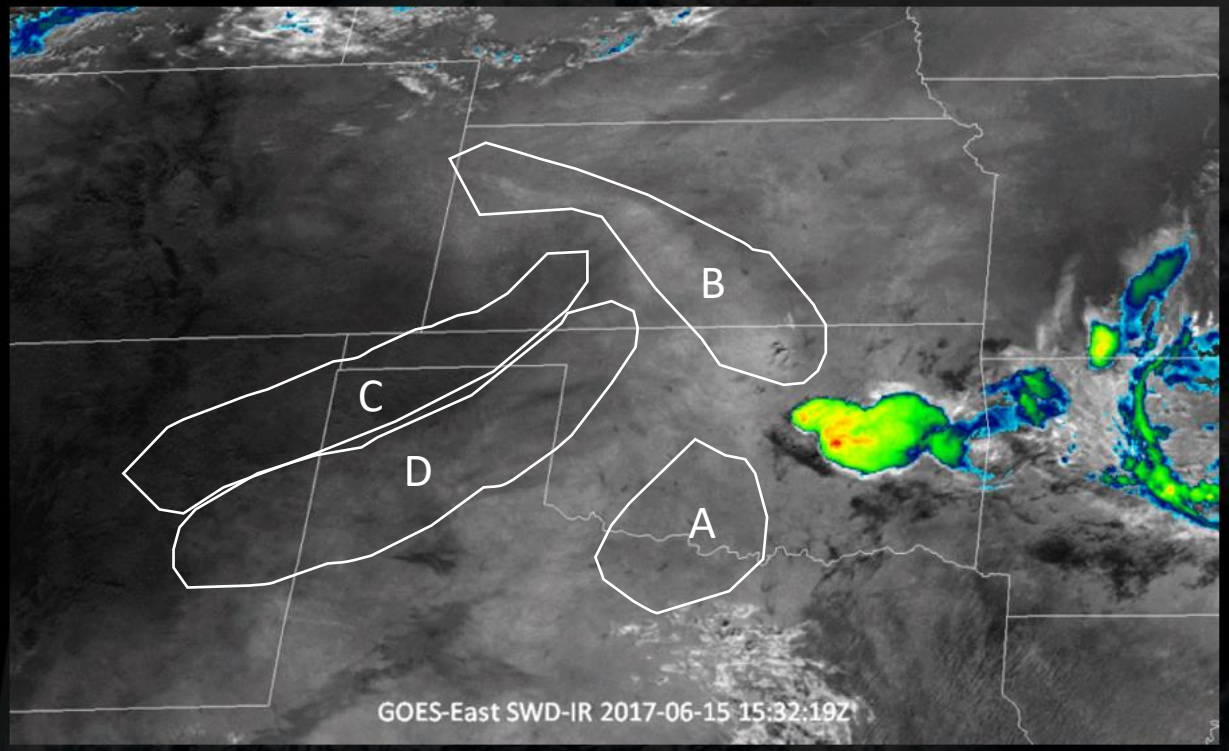
VIS



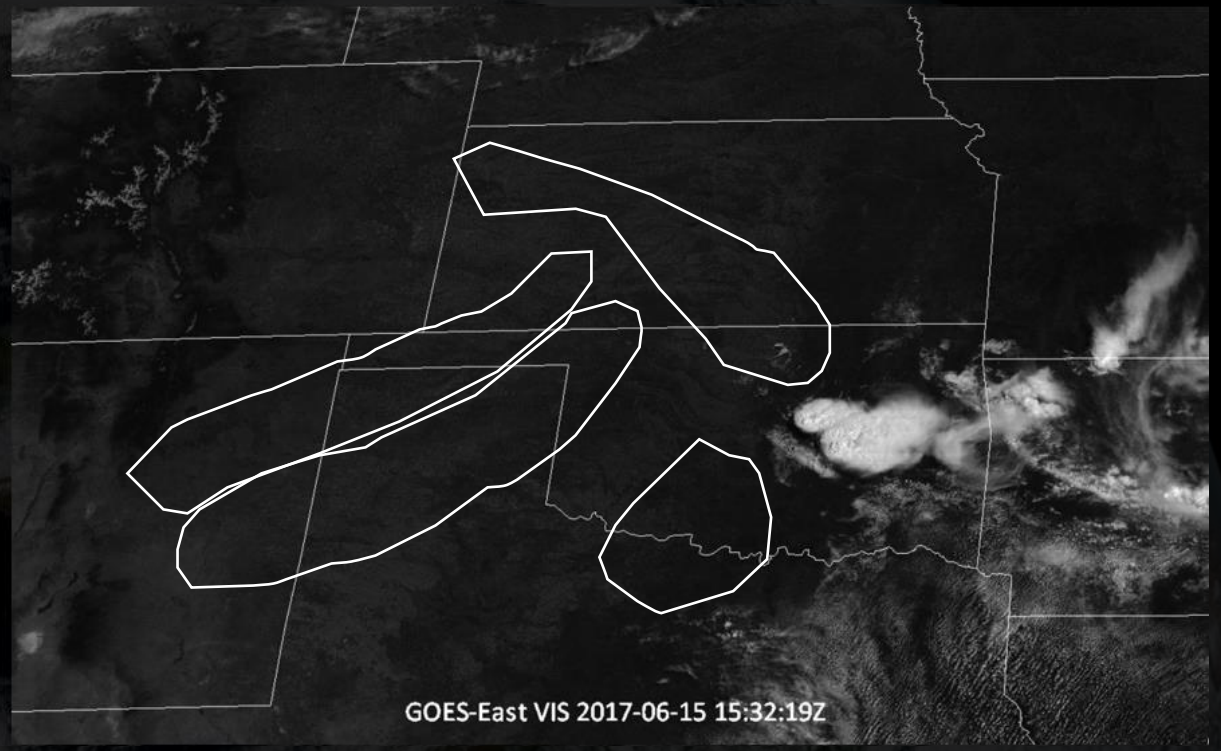
Q2

Where will cu field develop?

Split Window Difference with cold IRW Overlay



VIS



Q2

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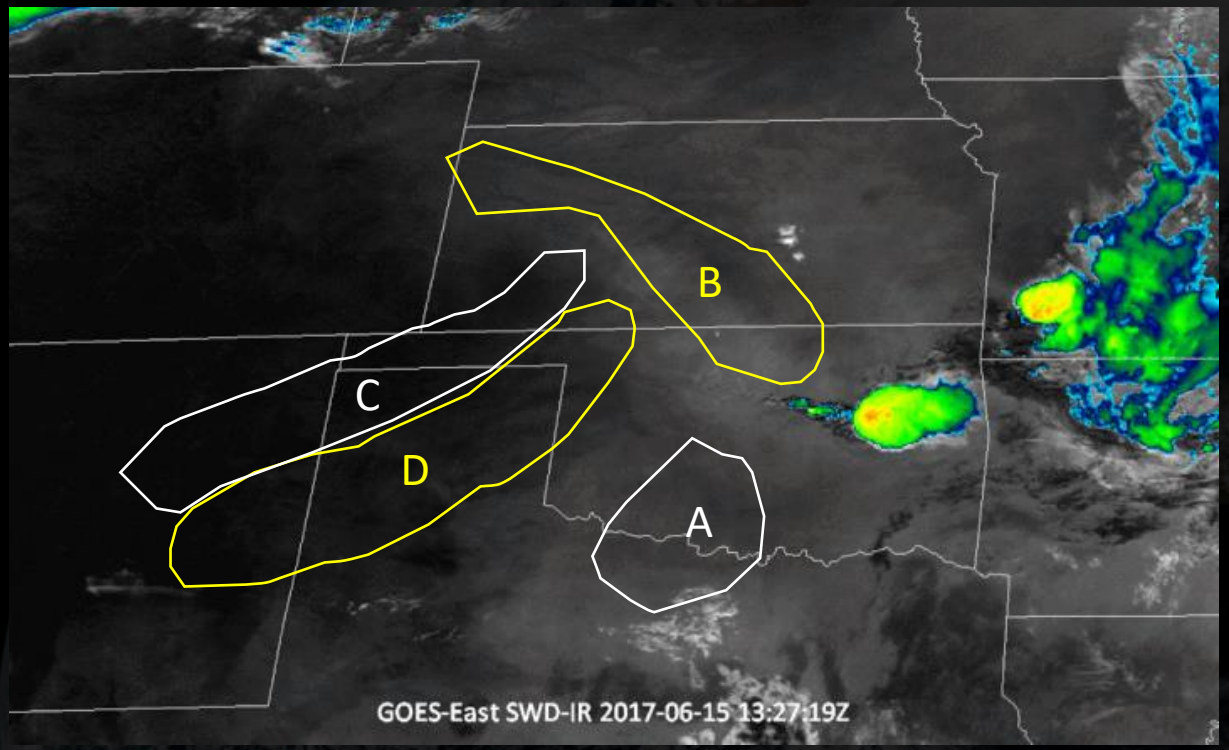
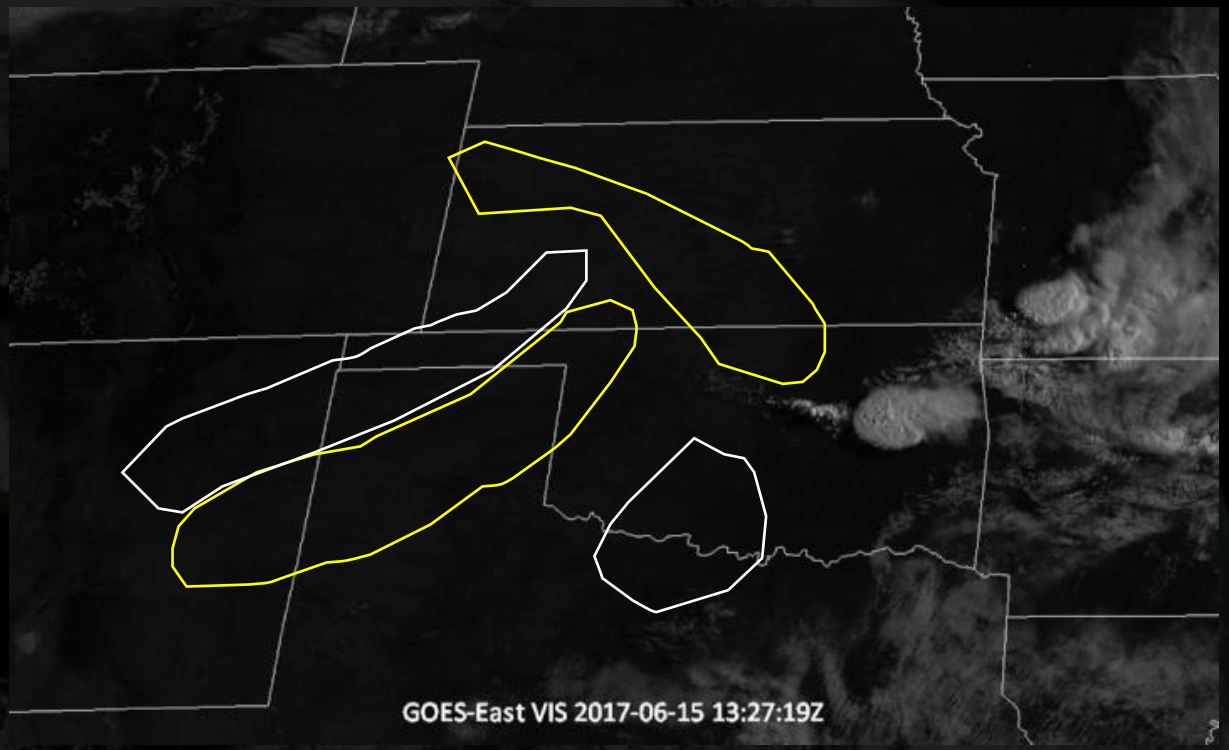


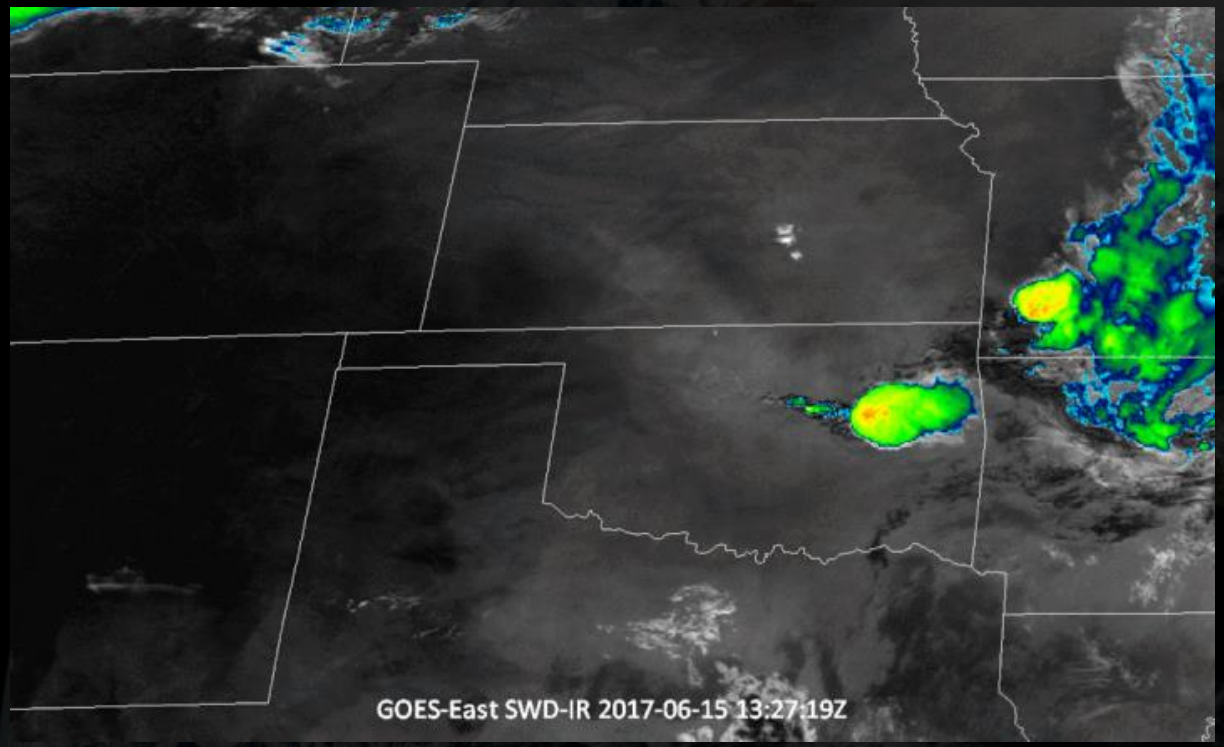
VIS



Q2 Answer

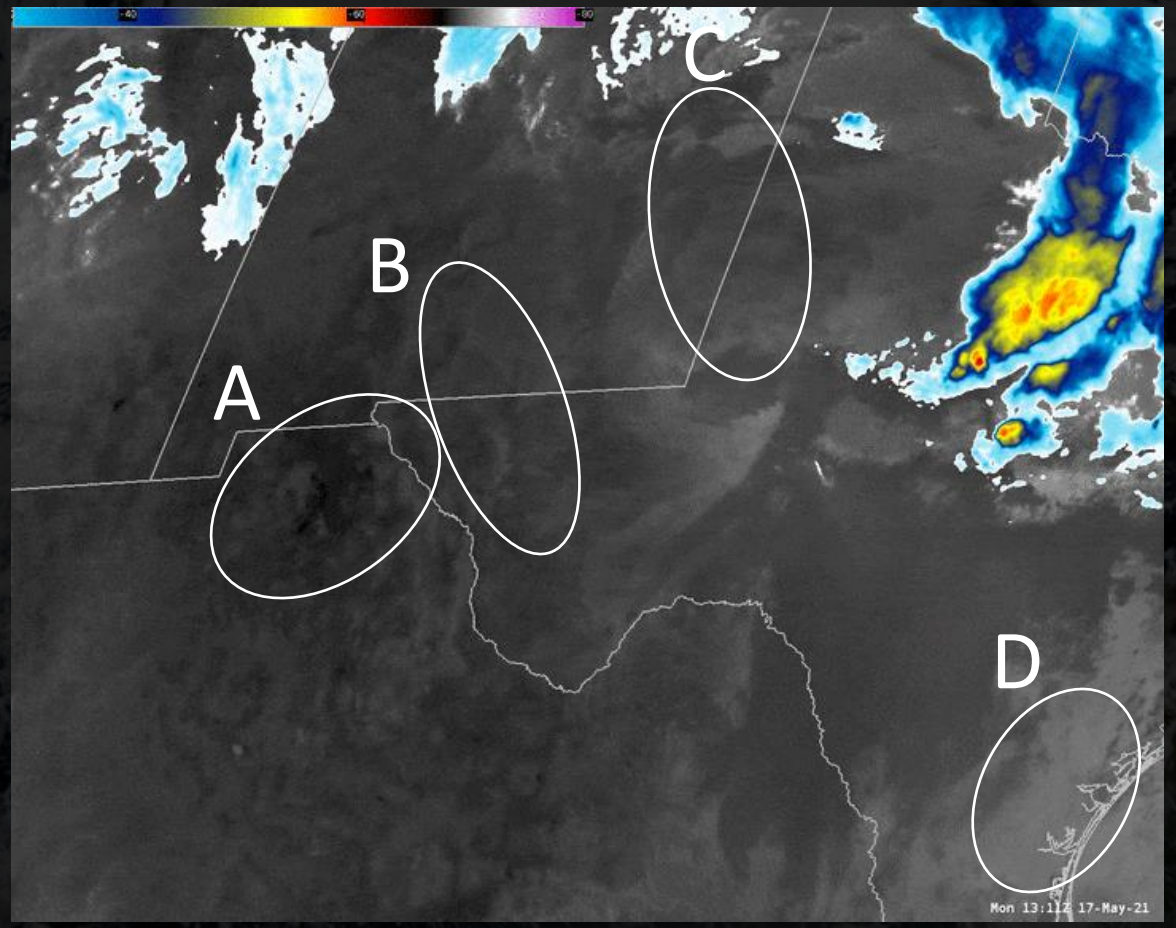
Where will cu field develop?

Split Window Difference with cold IRW Overlay



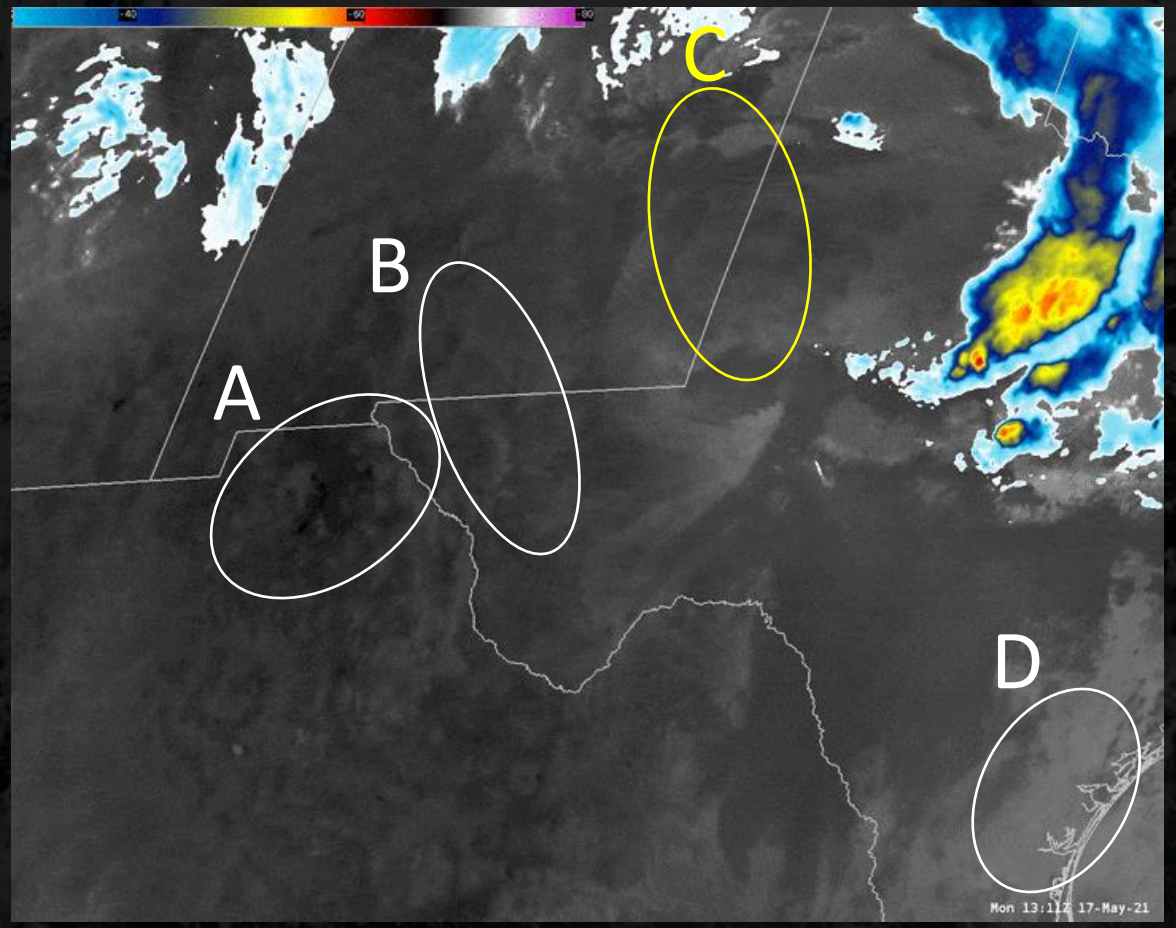
VIS

Where do you expect Convective Initiation in next few hours



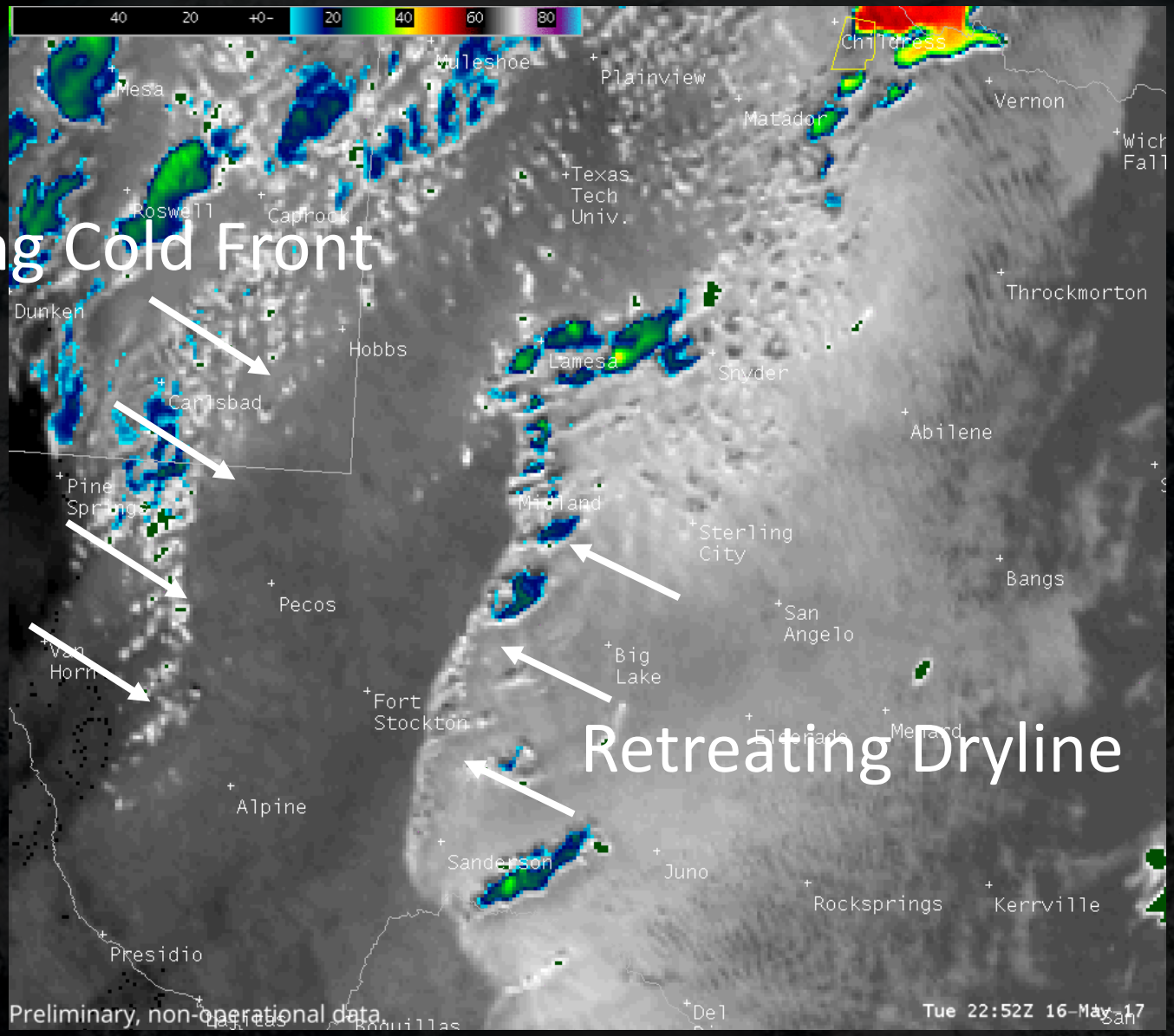
Q3

Where do you expect Convective Initiation in next few hours



Q3 Answer

Colliding Boundaries in SWD-IR Combo

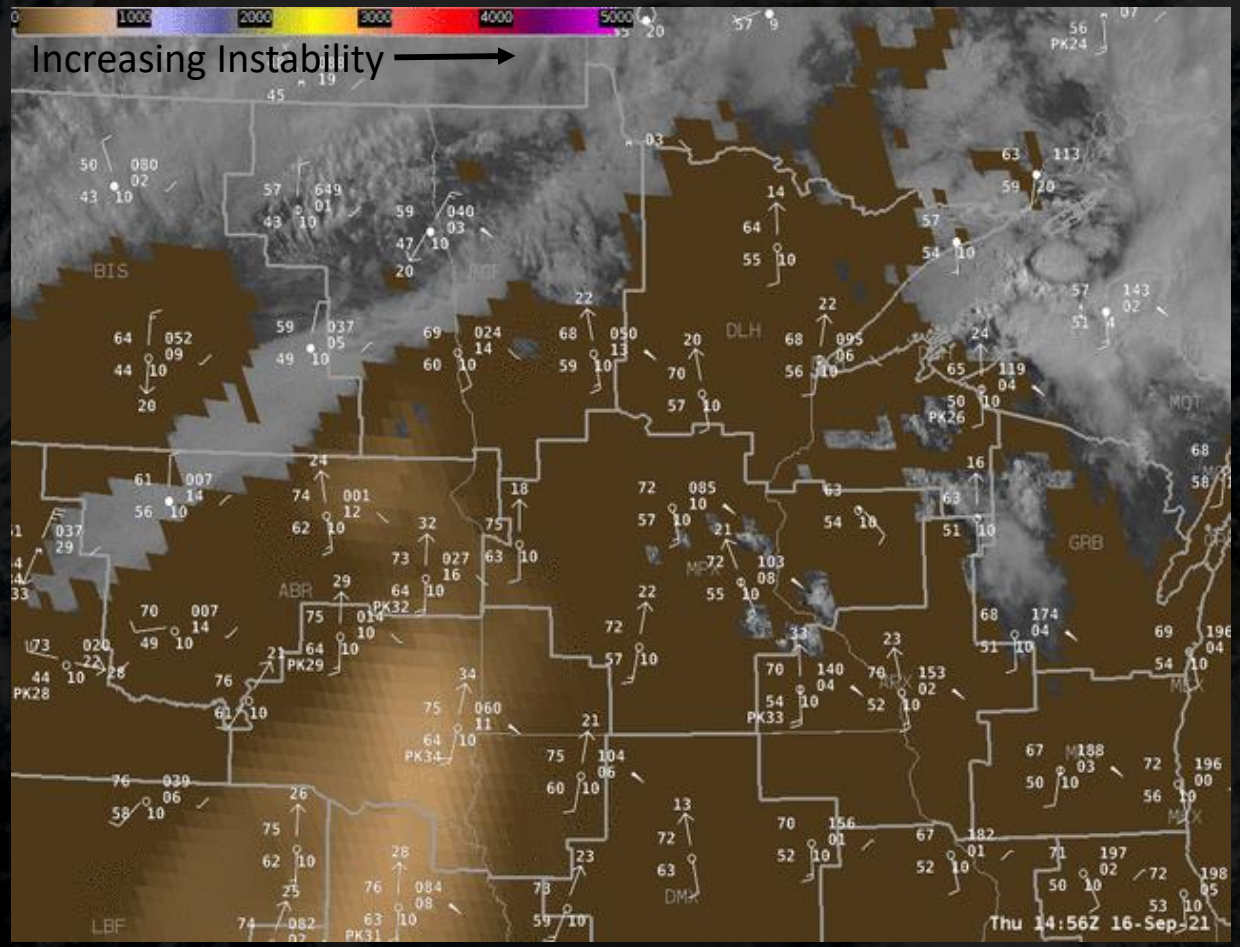


Advancing Cold Front

Retreating Dryline

GOES-R Derived CAPE CAPE

- Convective Available Potential Energy (CAPE)
  - Measure of amount of instability in the atmosphere
  - Look for: Increasing instability, boundaries, local max
- 16 September 2021 GOES-East Derived CAPE



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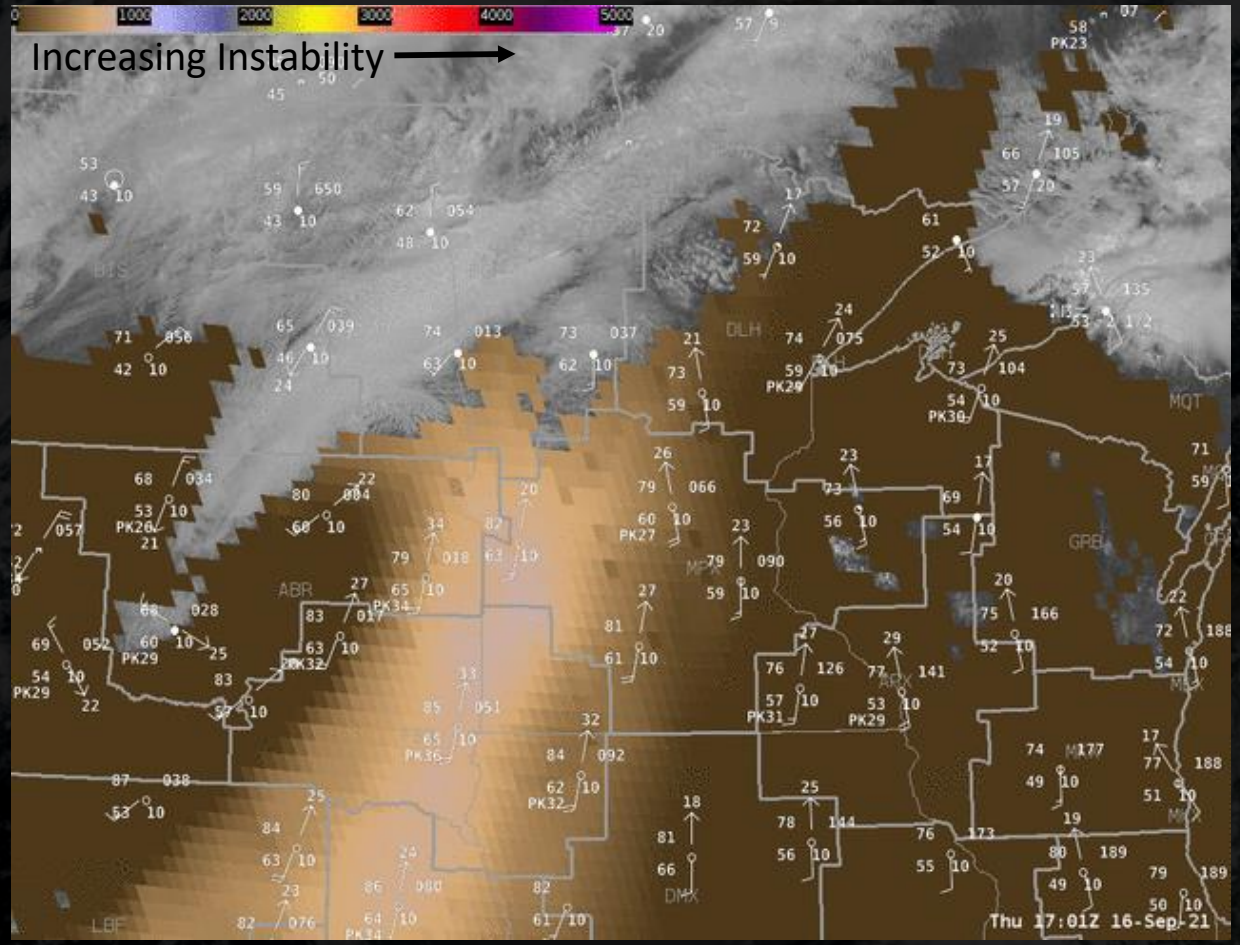
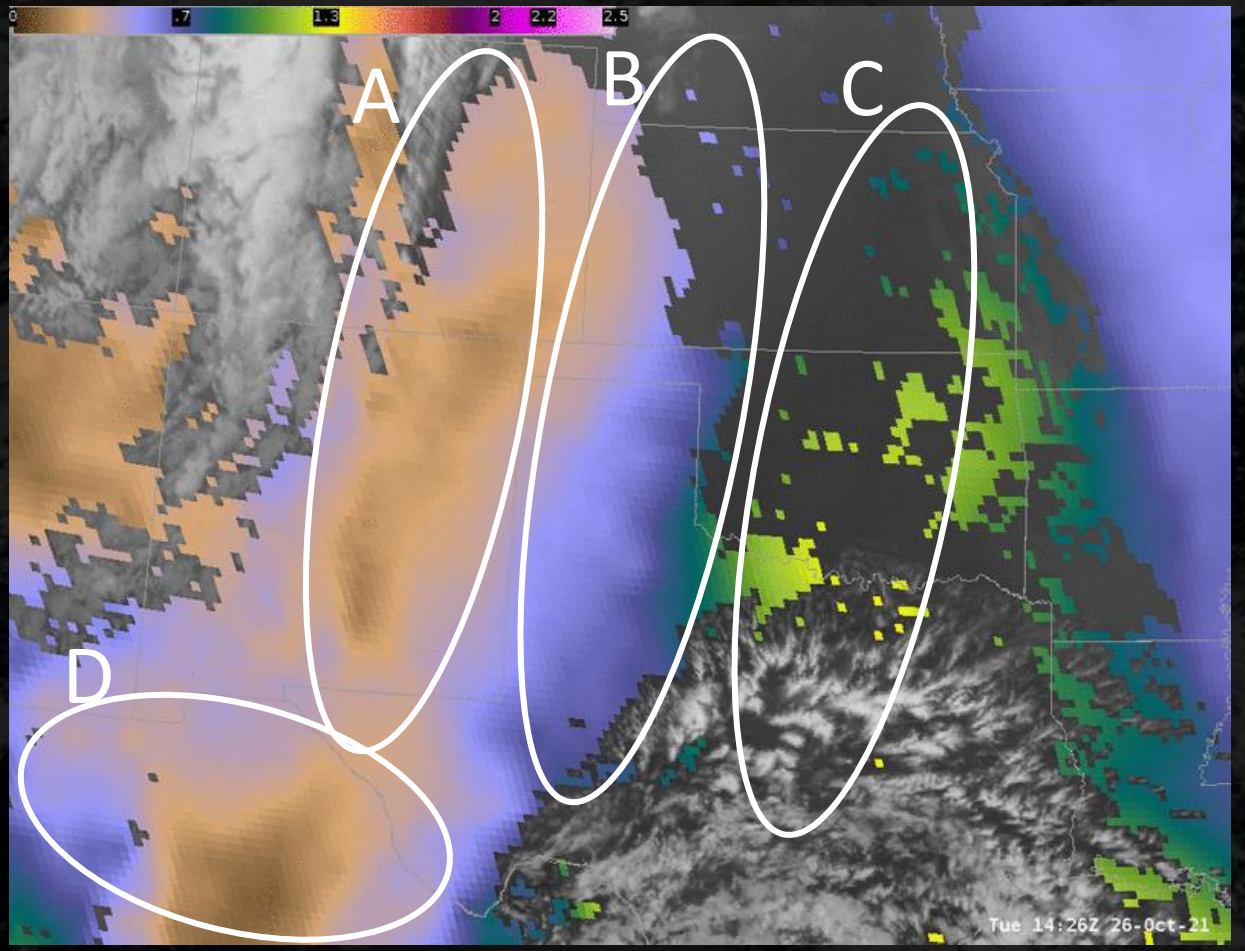


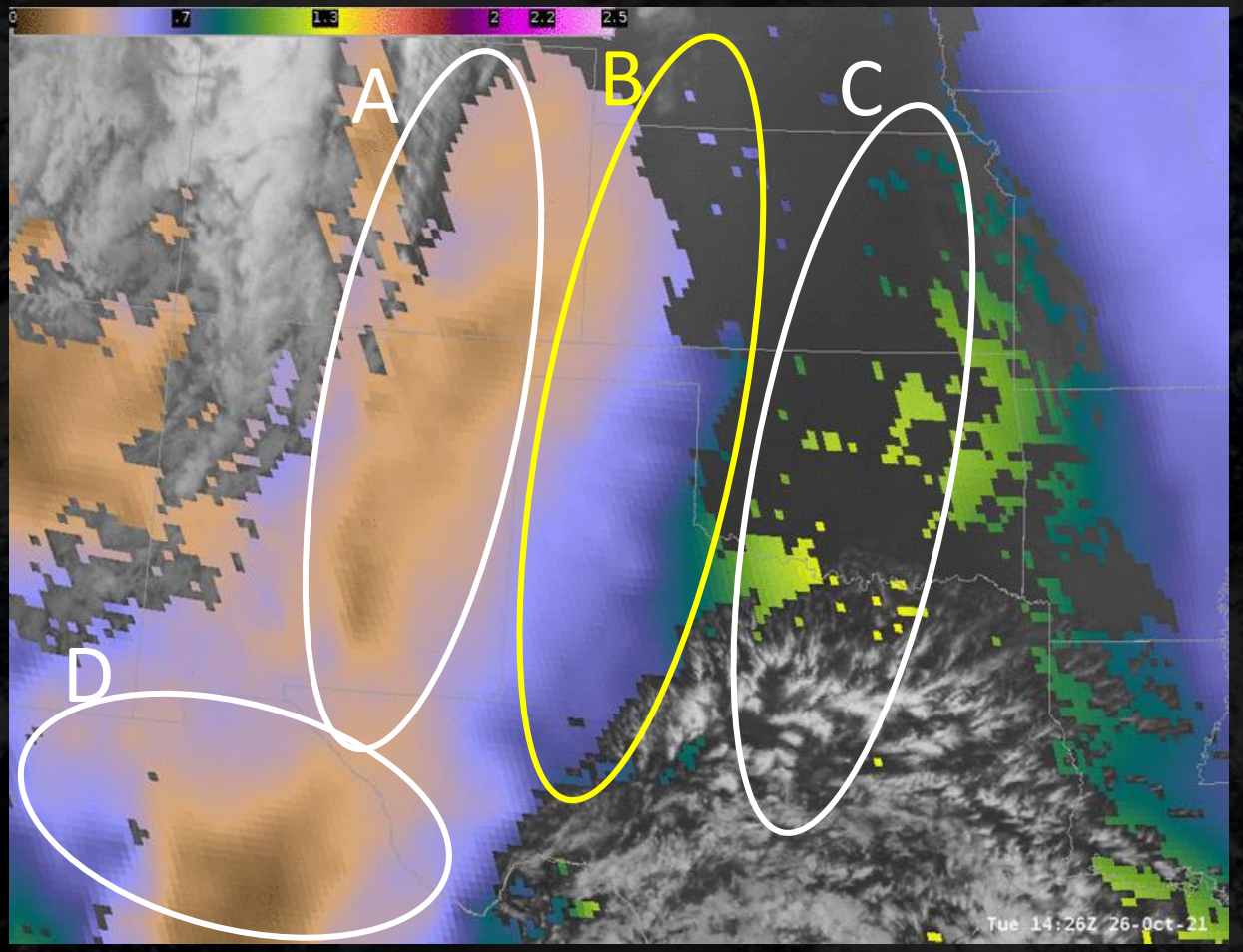
GOES-R TPW

- Total Precipitable Water (TPW)
  - Measure of amount of moisture in the atmosphere
  - Look for: Increasing moisture, boundaries, local max
- 16 September 2021 GOES-East Derived TPW



GOES-R TPW

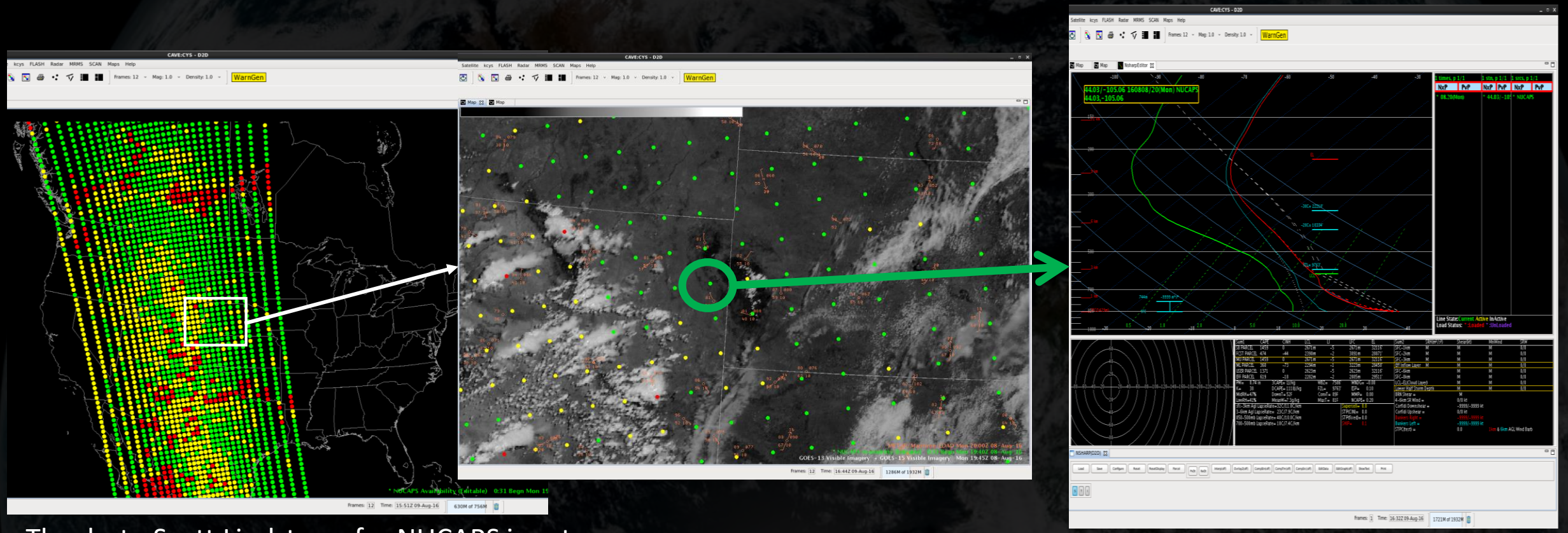
- Total Precipitable Water (TPW)
  - Measure of amount of moisture in the atmosphere
  - Look for: Increasing instability, boundaries, local max
- 16 September 2021 GOES-East Derived TPW



Q4 Answer

JPSS NUCAPS

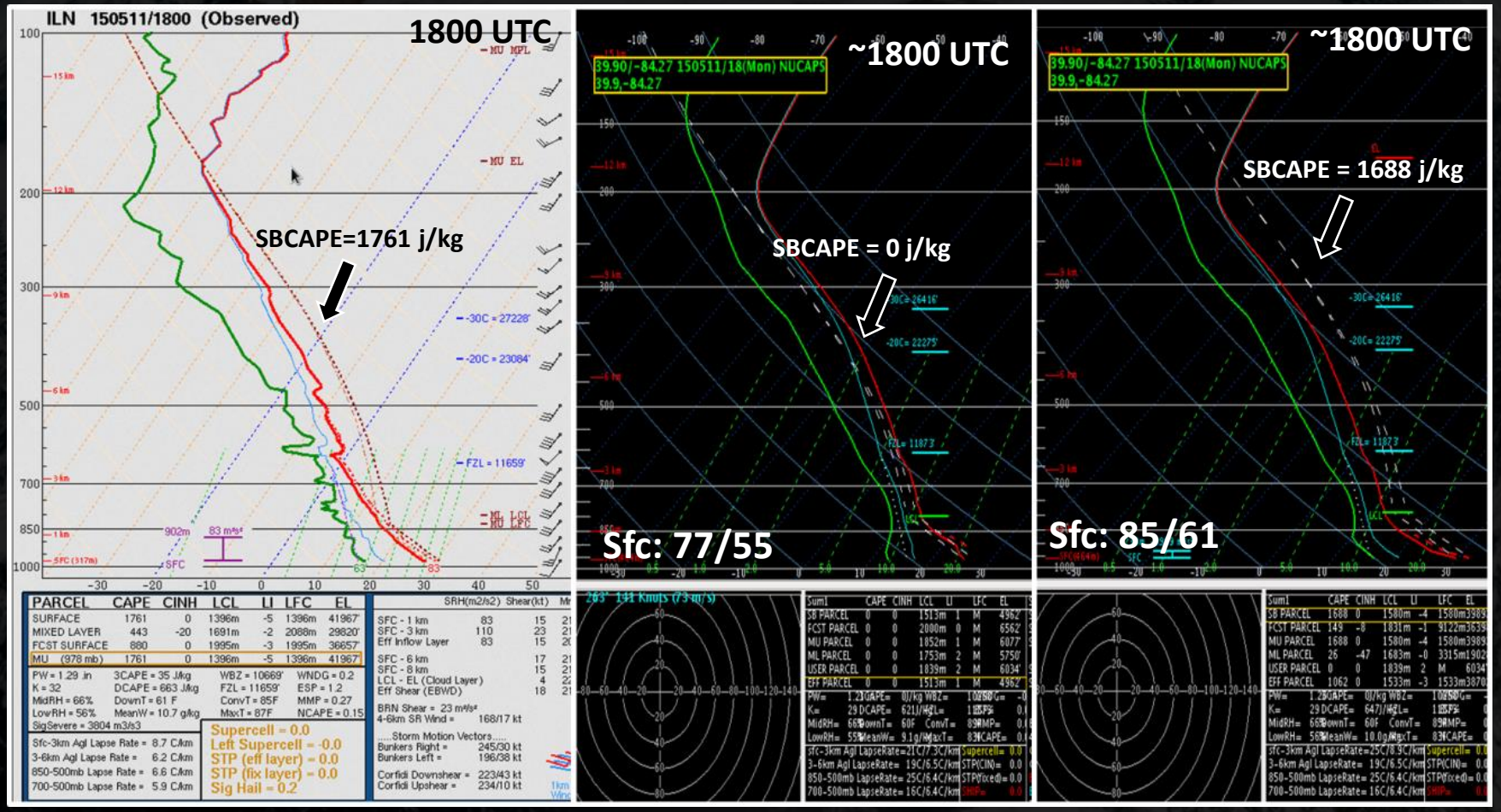
- **N**OAA-**U**nique **C**ombined **A**tmospheric **P**rocessing **S**ystem
  - Temperature and Moisture profiles derived from SNPP/JPSS CrIS and ATMS instruments
    - Also available in gridded, plan-view and cross-section format
  - SNPP and NOAA-20 provide data in early afternoon (and overnight), Metop in mid-morning
  - Use to asses environment prior to CI or ahead of ongoing convection



Thanks to Scott Lindstrom for NUCAPS input

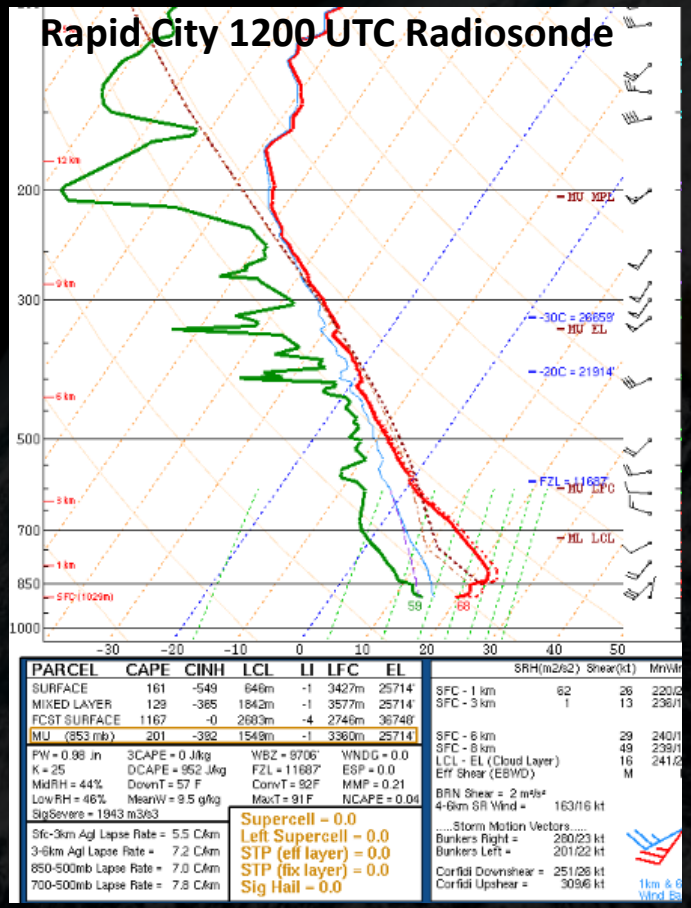
NUCAPS Comparison with Observed

ILN radiosonde (left), un-modified NUCAPS (middle), sfc-modified NUCAPS (right)

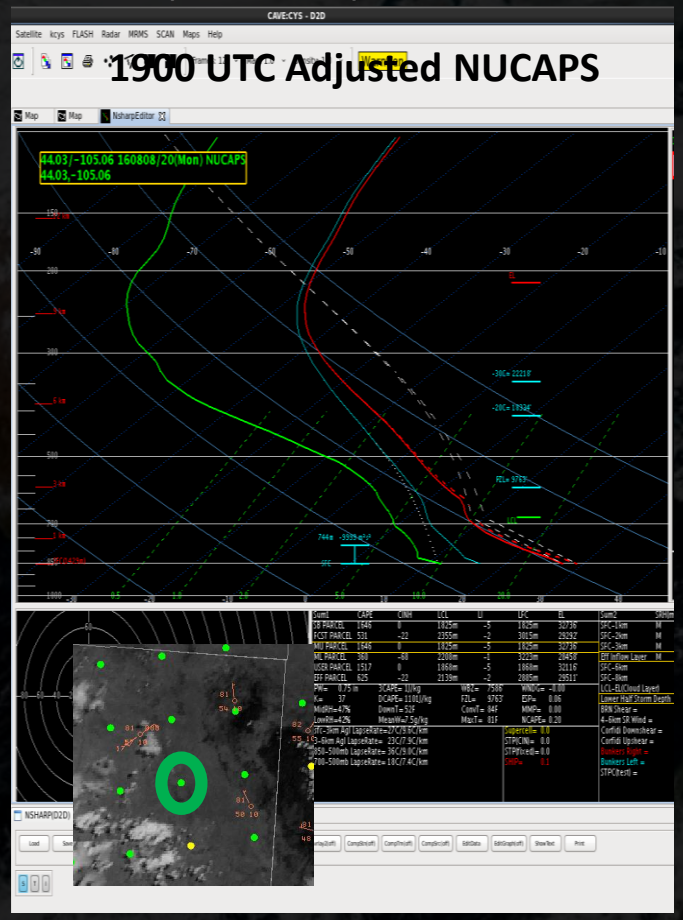


NUCAPS Example – Severe in N High Plains

- NUCAPS profile indicates potential for (severe) convection.

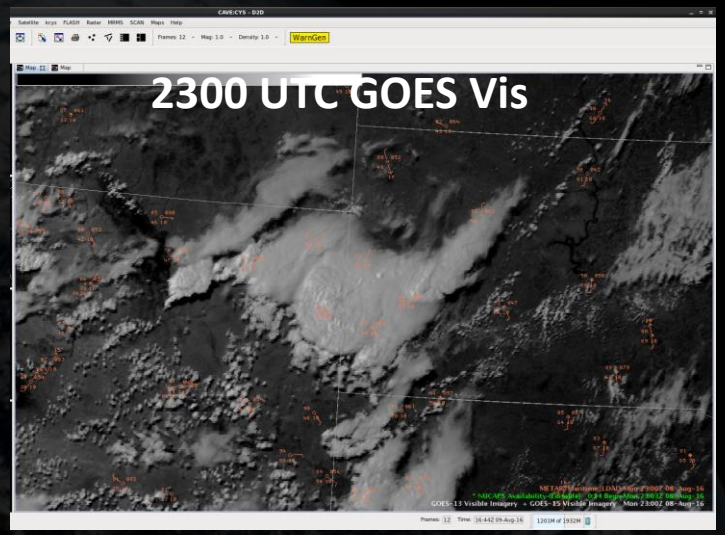


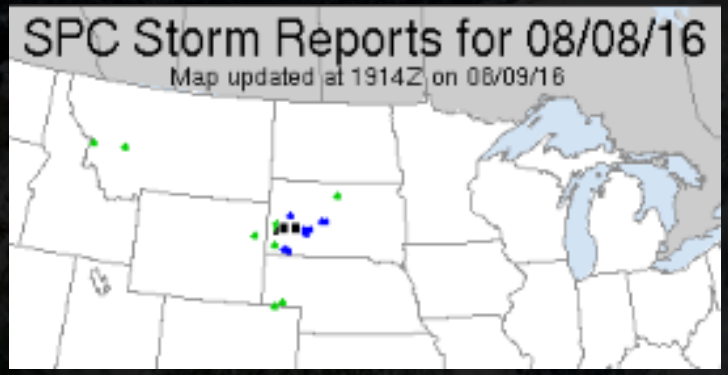
SBCAPE: 161 j/kg
3-6 km LR: 7.2 C/km
FL: 11,700 ft
-20C: 22,000 ft



Drying/cooling aloft
Heating surface

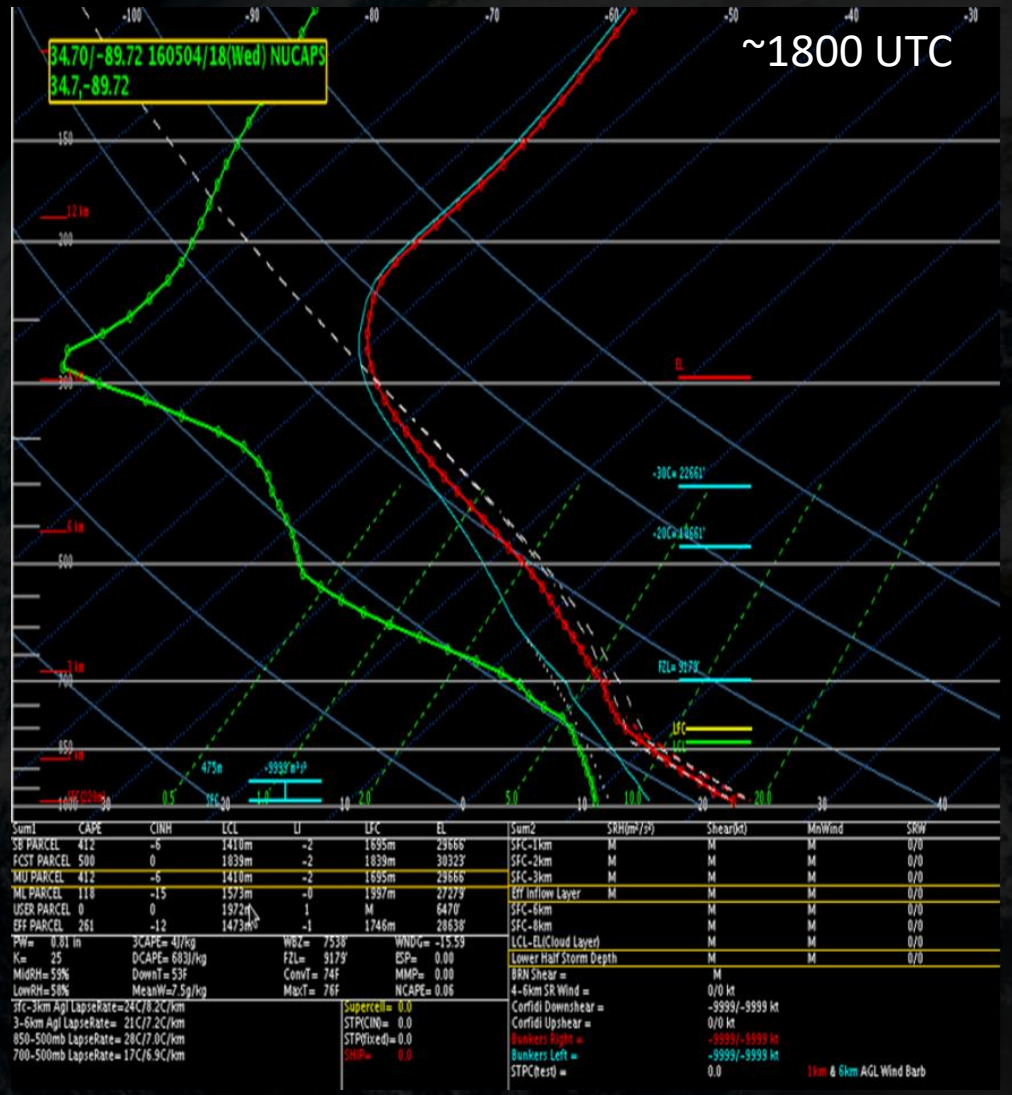
SBCAPE: 1650 j/kg
3-6 km LR: 7.9 C/km
FL: 9,800 ft
-20C: 19,000 ft

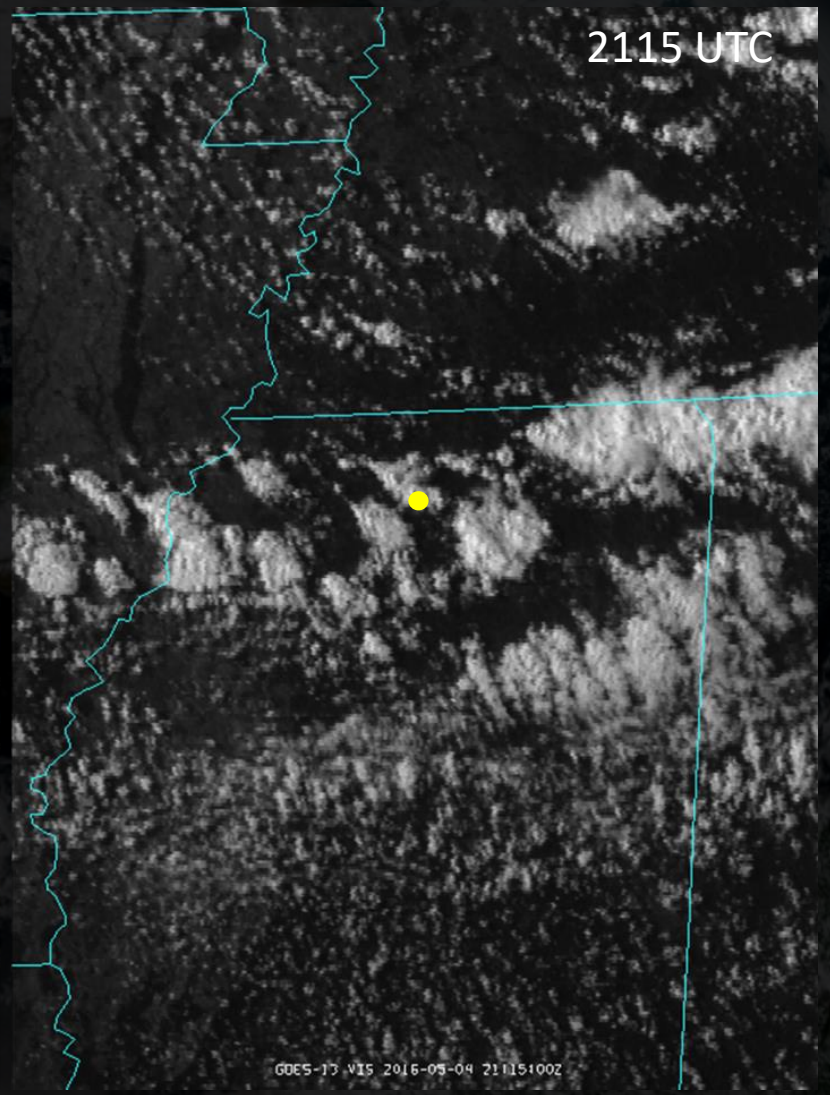




NUCAPS Example – Sub-Severe in N MS

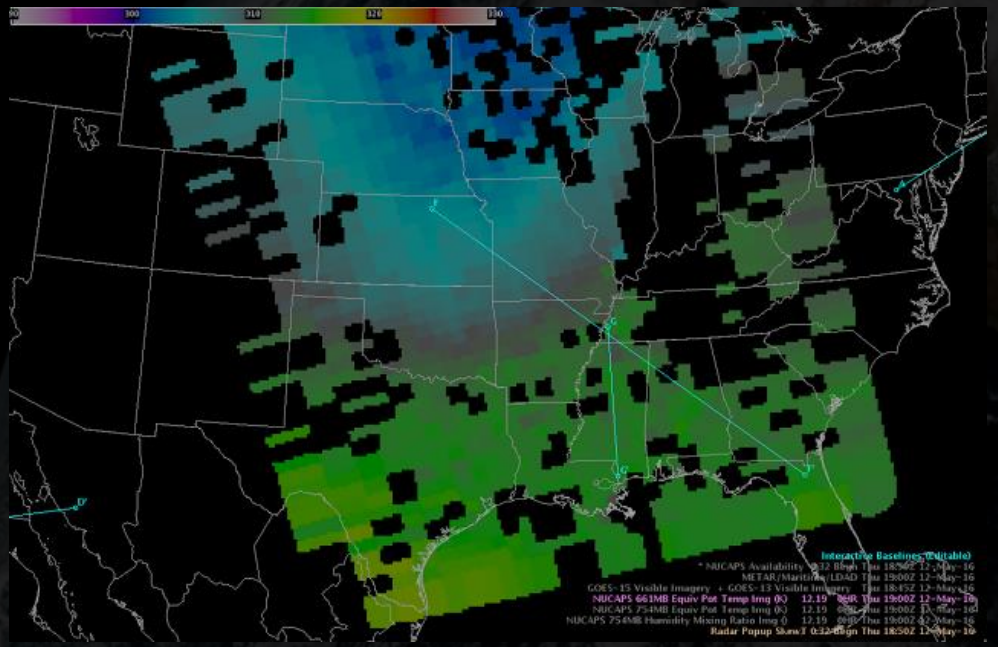
- NUCAPS profile indicates potential for (sub-severe) convection.

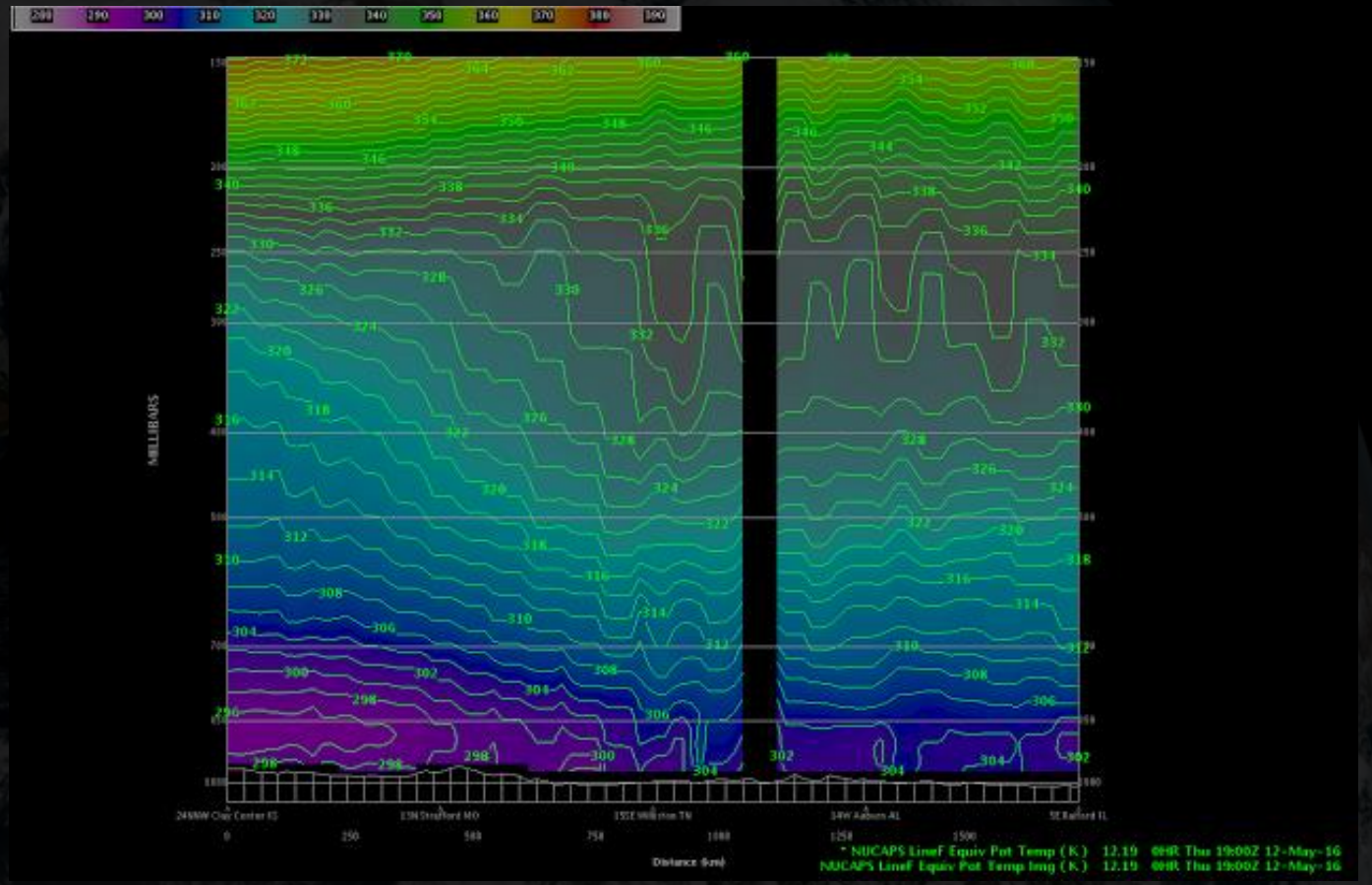




NUCAPS Plan View and Cross Section

- Equivalent Potential Temperature mid-level plan view and cross-section used to assess location of cold front both horizontally and spatially



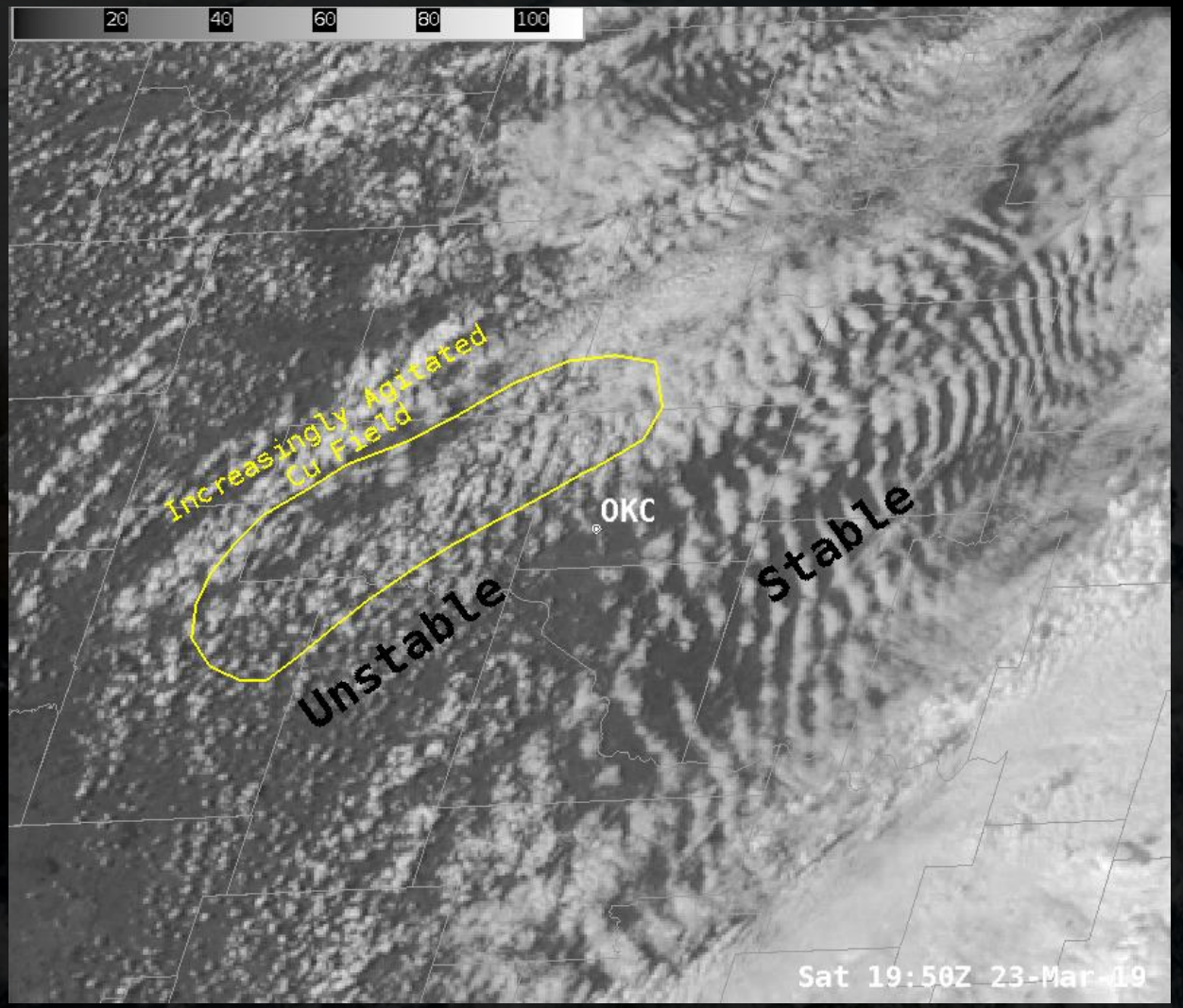


Cumulus Cloud Field Analysis and Convective Initiation

- Focus is on satellite products today. In reality, satellite used in concert with:
  - NWP, radar, lightning, UA, surface obs, webcams, human obs, etc
- Pre-convective Environment
  - Water Vapor Imagery Analysis
  - Split Window Difference
  - Derived Products – CAPE and TPW
  - Derived Motion Winds
  - NUCAPS
- Cumulus Cloud Field Analysis and Convective Initiation
  - VIS and IR imagery
  - Day Cloud Phase Distinction RGB
- Mature Convective Analysis
  - VIS and IR imagery
  - VIS/IR Sandwich Imagery
- Nighttime Convective Analysis
  - Nighttime Microphysics RGB
  - IR

Assessing the environment from cloud character

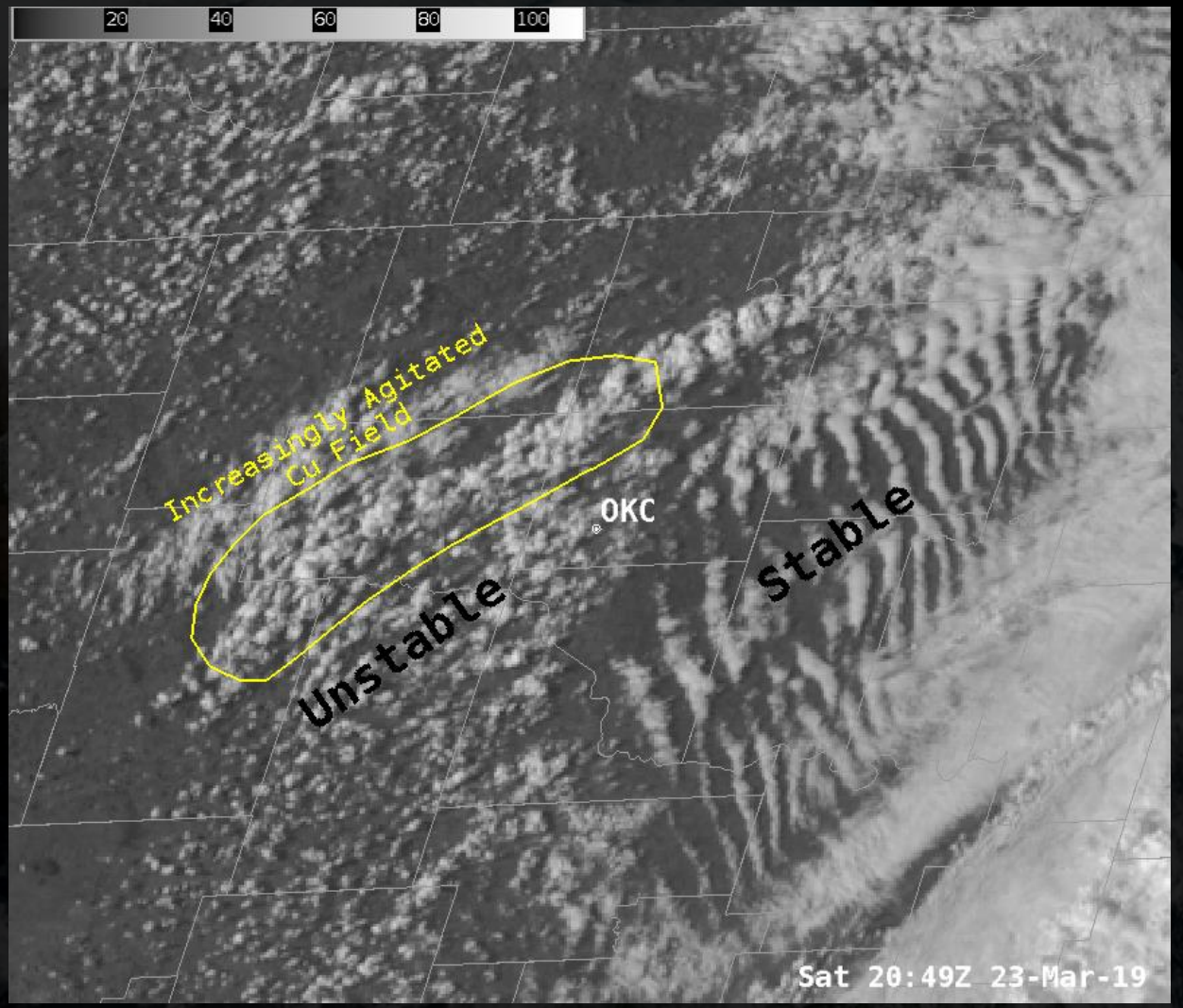
- Stable wave “Billow” Clouds
  - Oriented perpendicular to flow at top of stable layer
  - Smooth/flat appearance
  - Indicate a stable boundary layer
- Unstable Cumulus Cloud Streets
  - Oriented parallel to mean layer flow
  - Isolated, vertical growth appearence
  - Indicate an unstable boundary layer, with an inversion limiting further growth



https://satelliteliaisonblog.com/2019/03/24/satellite-views-of-23-march-2019-okc-severe-storm/

Assessing the environment from cloud character

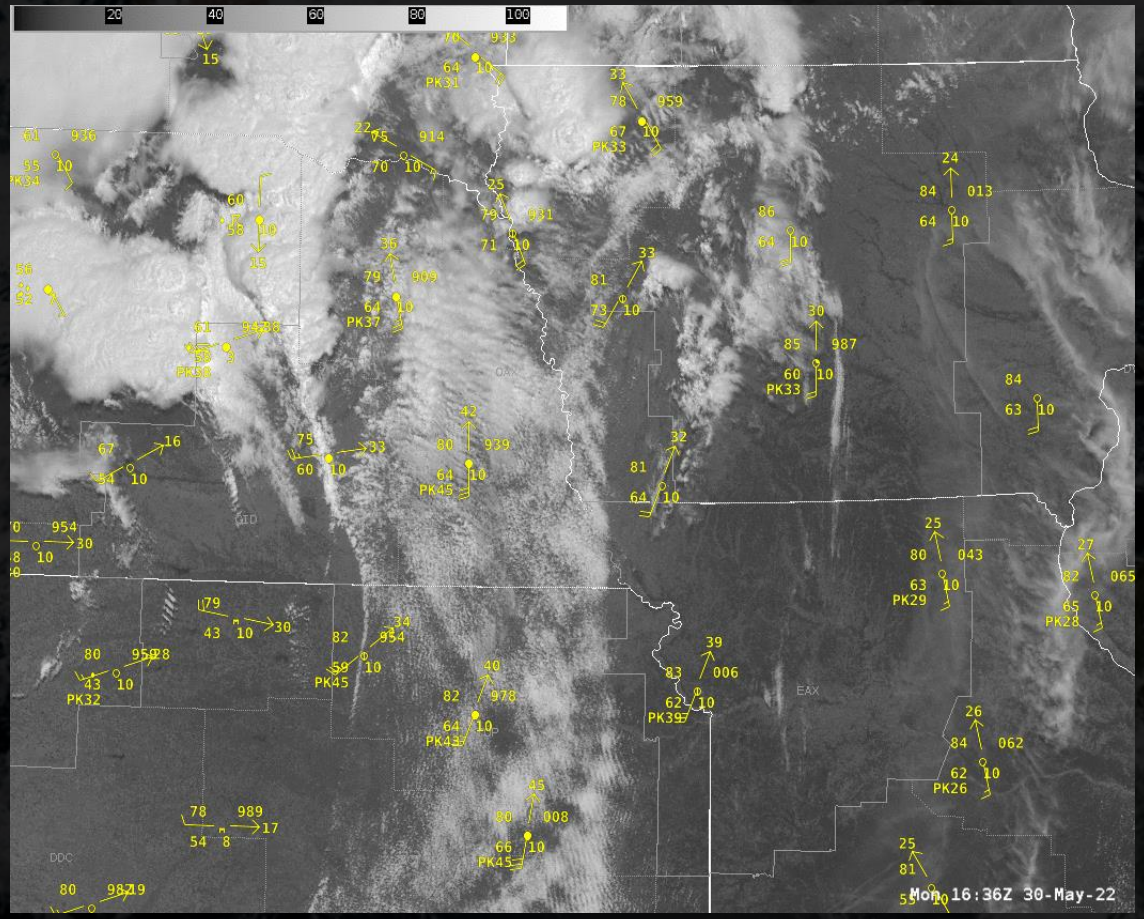
- Stable wave “Billow” Clouds
  - Oriented perpendicular to flow at top of stable layer
  - Smooth/flat appearance
  - Indicate a stable boundary layer, shear
- Unstable Cumulus Cloud Streets
  - Oriented parallel to mean layer flow
  - Isolated, vertical growth appearence
  - Indicate an unstable boundary layer, with an inversion limiting further growth



https://satelliteliaisonblog.com/2019/03/24/satellite-views-of-23-march-2019-okc-severe-storm/

Assessing the environment from cloud character

- Look for signs of boundaries, and organizing convection
  - Clumping or linear organization of cumulus clouds
  - No clouds in wake of linear organization



https://satelliteliaisonblog.com/2019/03/24/satellite-views-of-23-march-2019-okc-severe-storm/

Assessing the environment from cloud character

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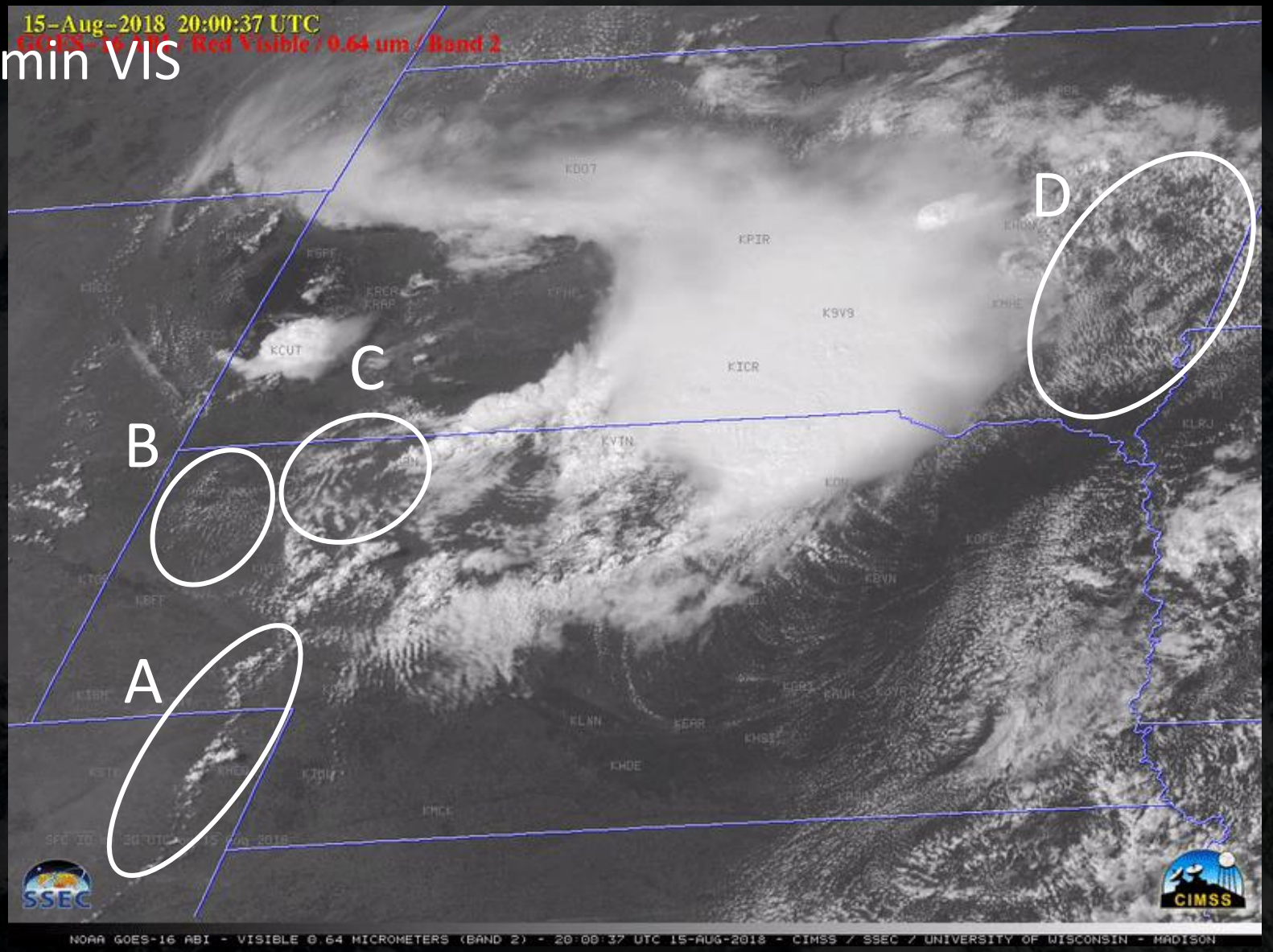
https://satelliteliaisonblog.com/2019/03/24/satellite-views-of-23-march-2019-okc-severe-storm/

Where is Convective Initiation LEAST Likely in next ~hour

- GOES-East 1-min VIS

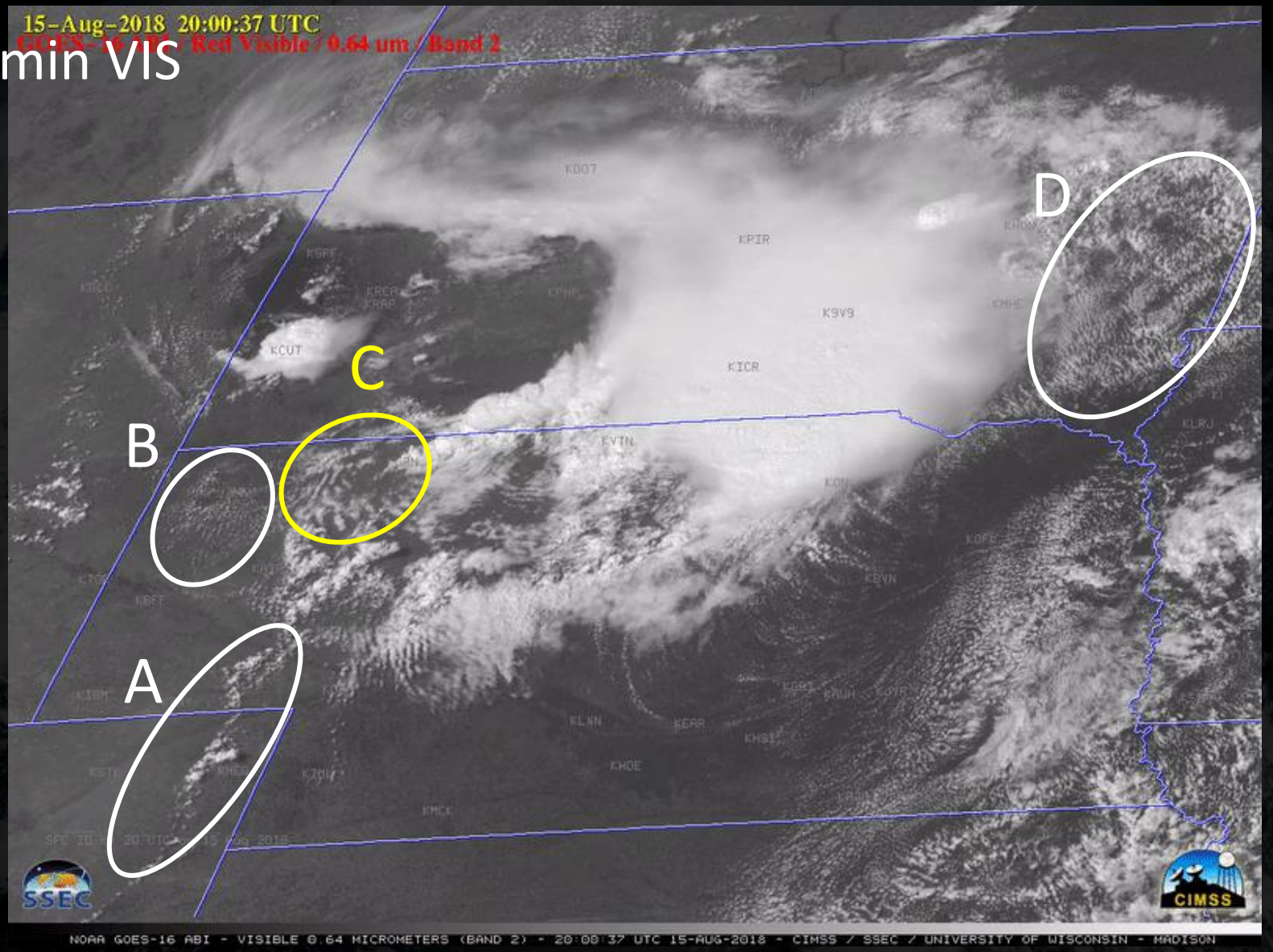


Q5

Image Credit: Scott Bachmeier (CIMSS) https://cimss.ssec.wisc.edu/satellite-blog/archives/29316

Where is Convective Initiation LEAST Likely in next ~hour

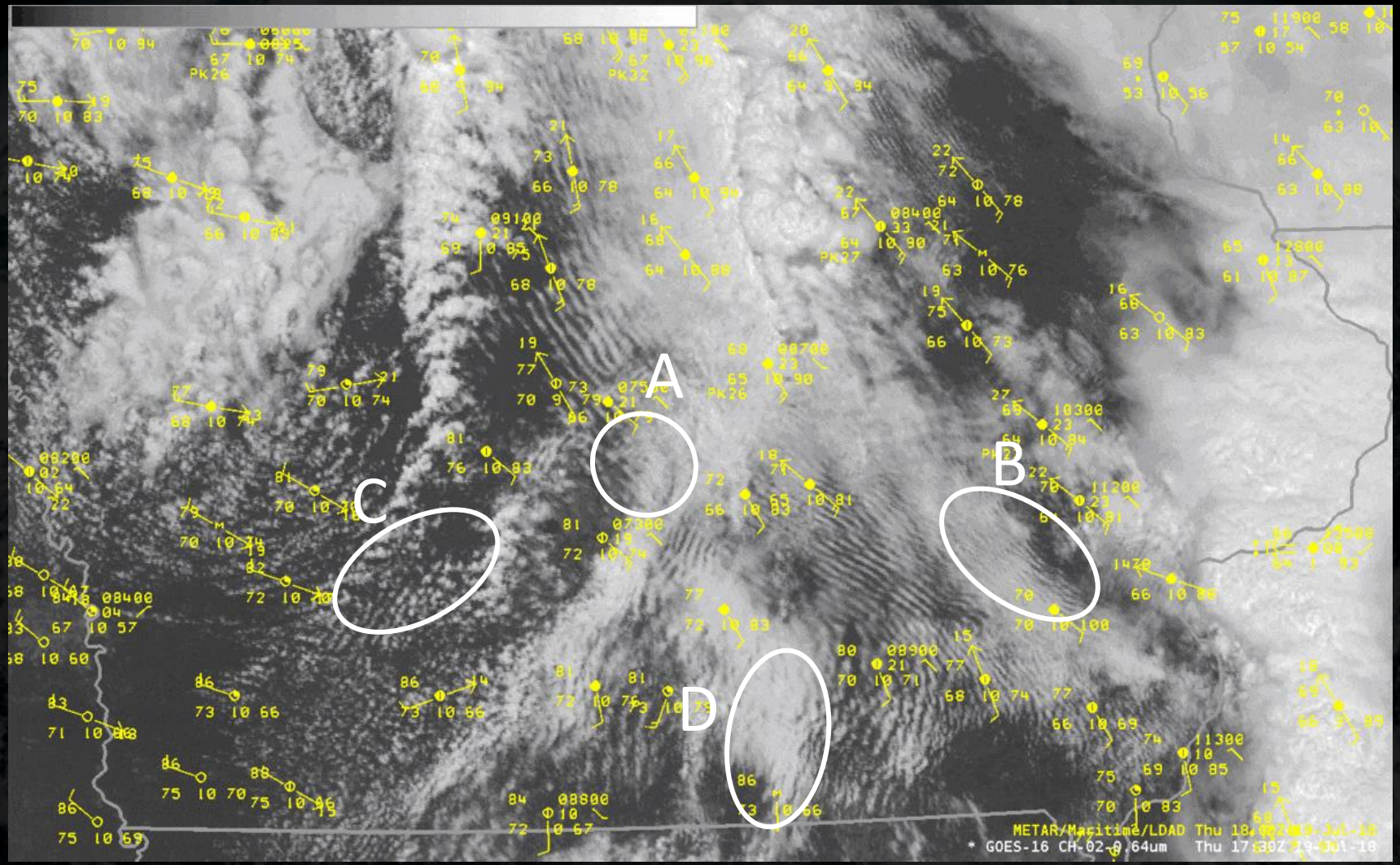
- GOES-East 1-min VIS



Q5 Answer

Image Credit: Scott Bachmeier (CIMSS) https://cimss.ssec.wisc.edu/satellite-blog/archives/29316

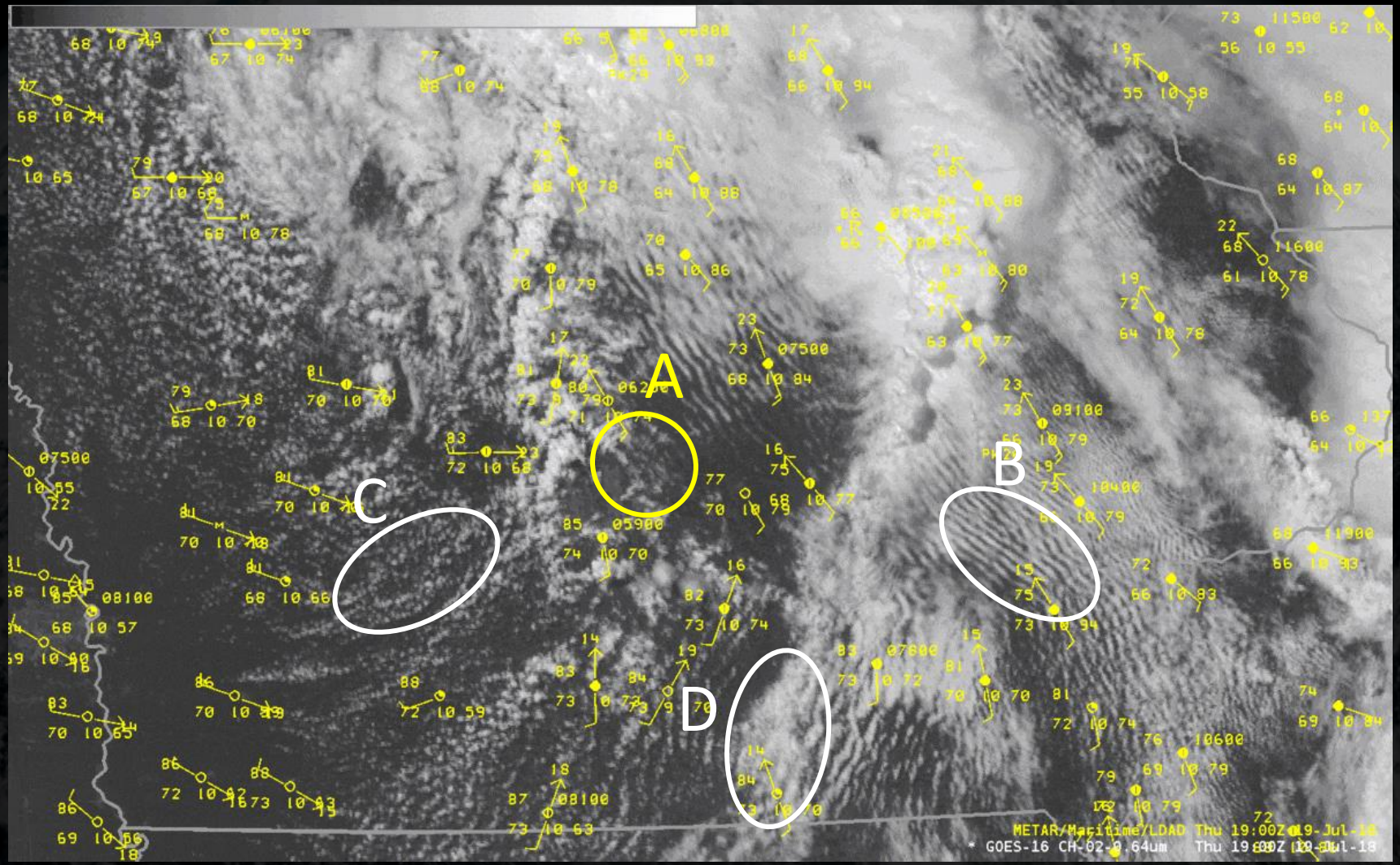
Where is Convection MOST likely to be present in next ~hour



Q6

https://satelliteliaisonblog.com/2018/07/19/19-july-2018-iowa-tornados-goes-16-and-jpss/

Where is Convection MOST likely to be present in next ~hour



Q6 Answer

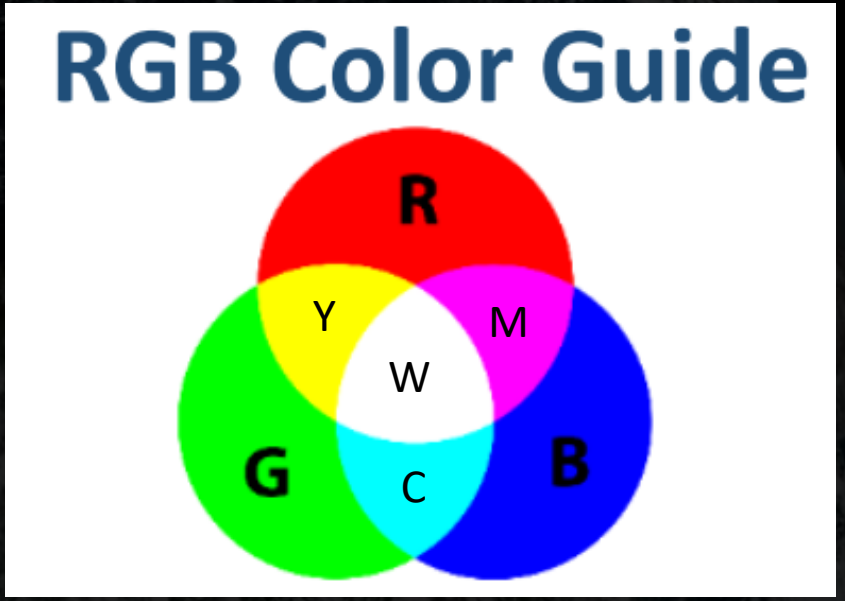
https://satelliteliaisonblog.com/2018/07/19/19-july-2018-iowa-tornados-goes-16-and-jpss/

What is an RGB

- What: Combines information from multiple (3) bands or band combinations into a single image.
- Why: Analysis of a single image, as opposed to multiple images, resulting in quicker/easier diagnosis of the feature at hand (low cloud, fire hot spot, volcanic ash, etc)
- Creation of an RGB
  - A single band, or band difference, is applied to each of the three Red-Green-Blue components that make up the RGB.
  - Maximum and minimum values (% or K) are applied to each of the three components
    - Values nearer the max for a given component will yield more of that color to the final product
  - A Gamma value is applied to each of the three components.
    - Gamma = 1 = constant contrast within range
    - Gamma > 1 enhances lower portion of the range
    - Gamma <1 enhances upper portion of the range

RED + GREEN + BLUE = RGB IMAGE

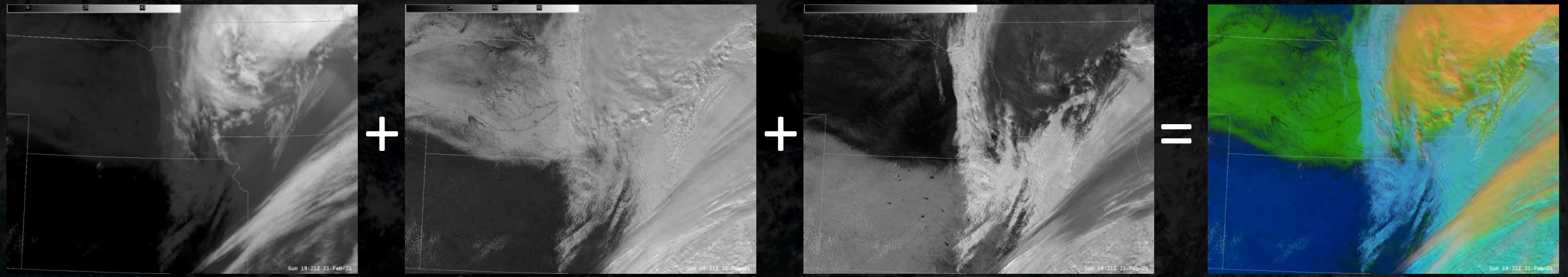
Band or band difference	Band or band difference	Band or band difference
Min	Min	Min
Max	Max	Max
Gamma	Gamma	Gamma



Day Cloud Phase Distinction RGB

- Use: Diagnose regions of most imminent convective initiation within the cu field during day
- Quick Guide

	RED	+	GREEN	+	BLUE	=	RGB IMAGE
Band or band difference	10.3 um Band "Clean Window IR"		0.64 um Band "Red Visible"		1.6 um Band "Snow/Ice"		
Min	7.5 K		0 %		1 %		
Max	-53.5 K		78 %		59 %		
Gamma	1.0		1.0		1.0		

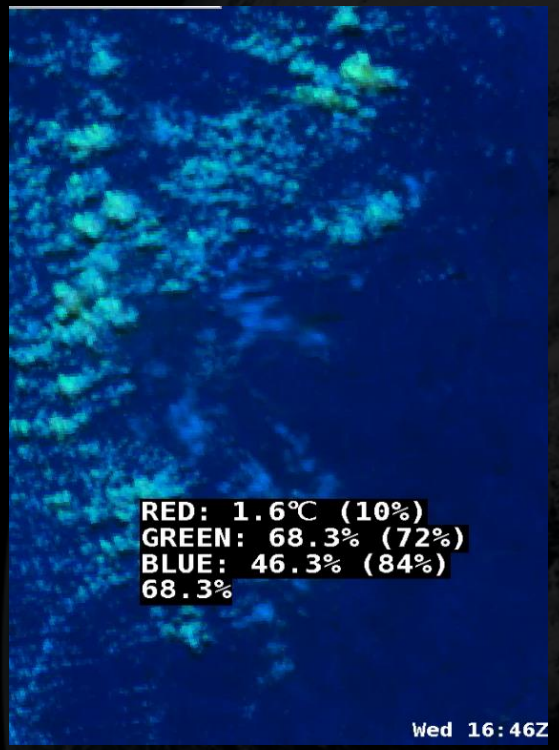


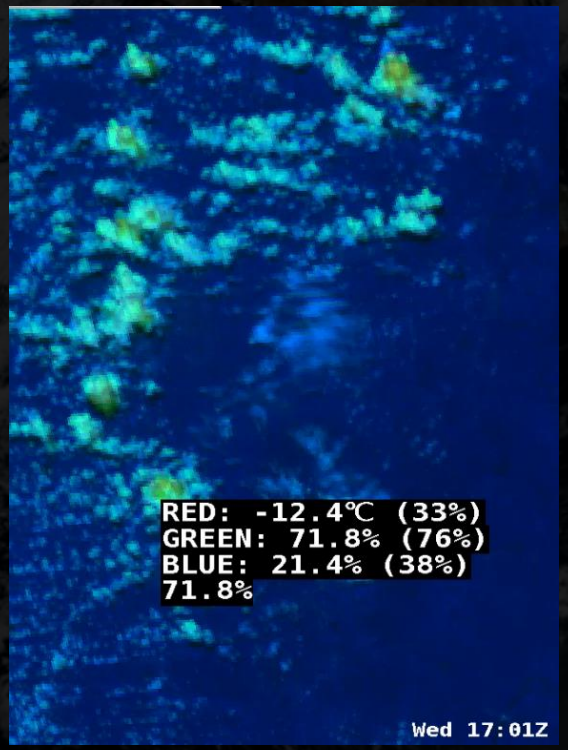
Day Cloud Phase Distinction RGB

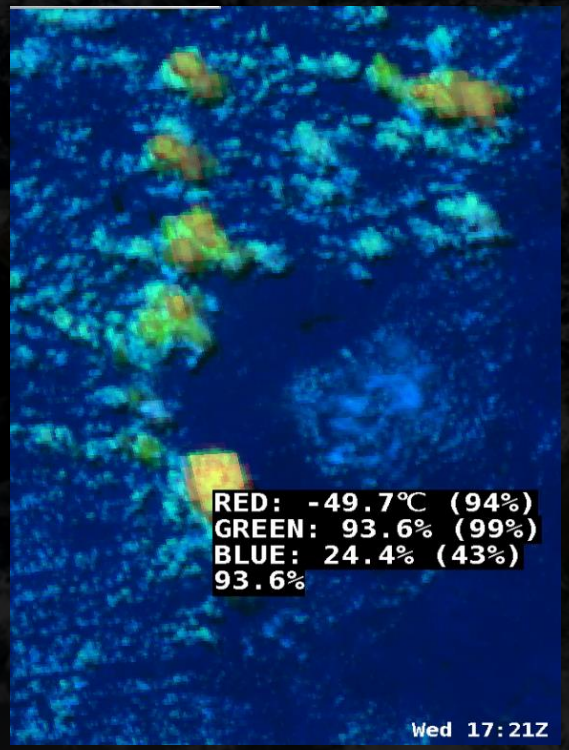
Band or band difference	RED	+	GREEN	+	BLUE	=	RGB IMAGE
	10.3 um Band "Clean Window IR"		0.64 um Band "Red Visible"		1.6 um Band "Snow/Ice"		
Min	7.5 K		0 %		1 %		
Max	-53.5 K		78 %		59 %		
Gamma	1.0		1.0		1.0		

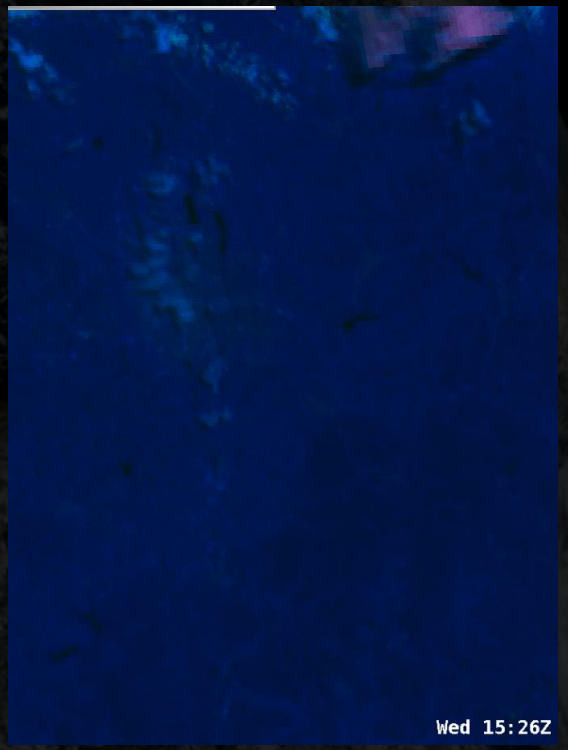
Glaciation/cooling = lose blue, gain red continued cooling = gaining red

CI: Cyan => Bright Green => Yellow

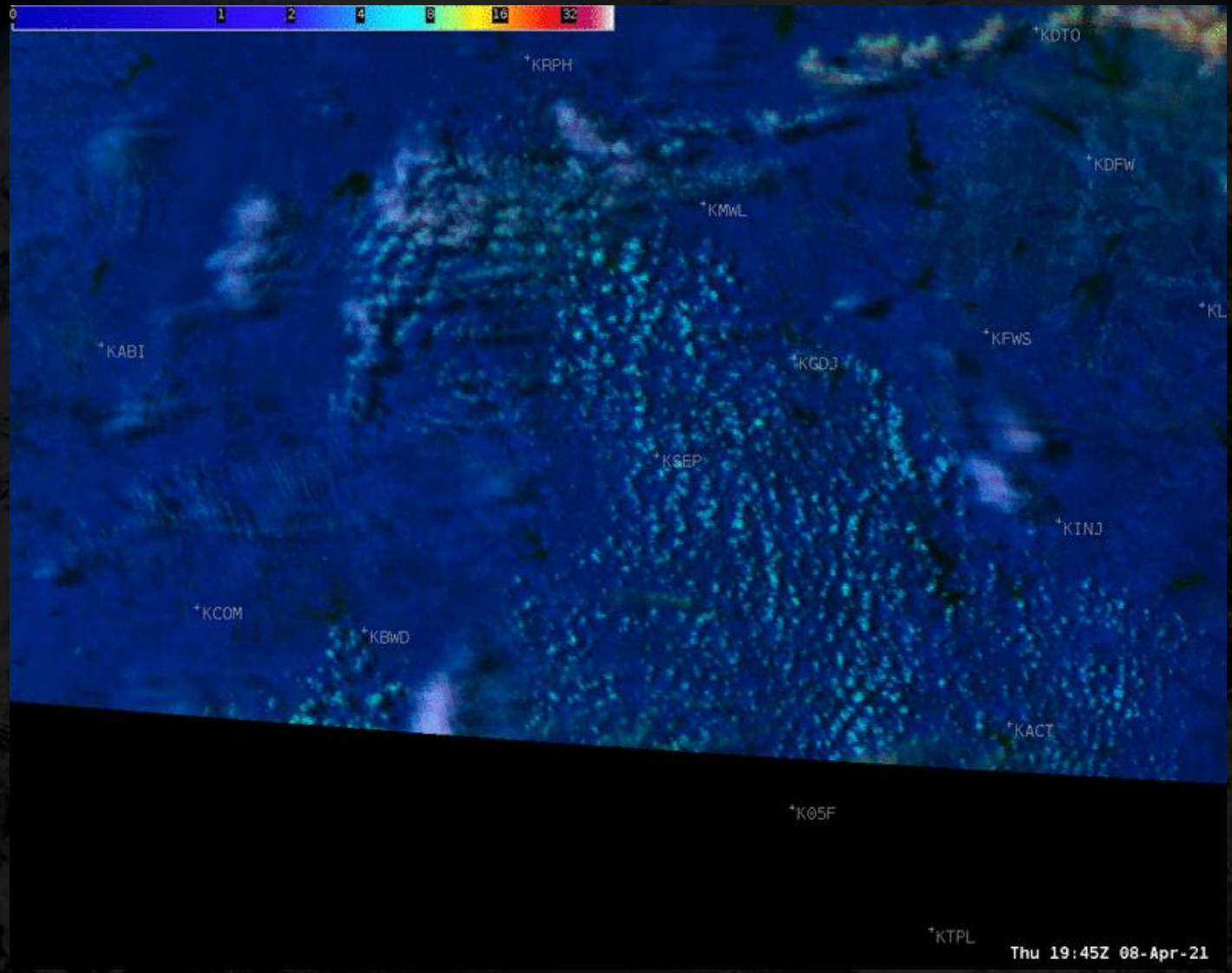






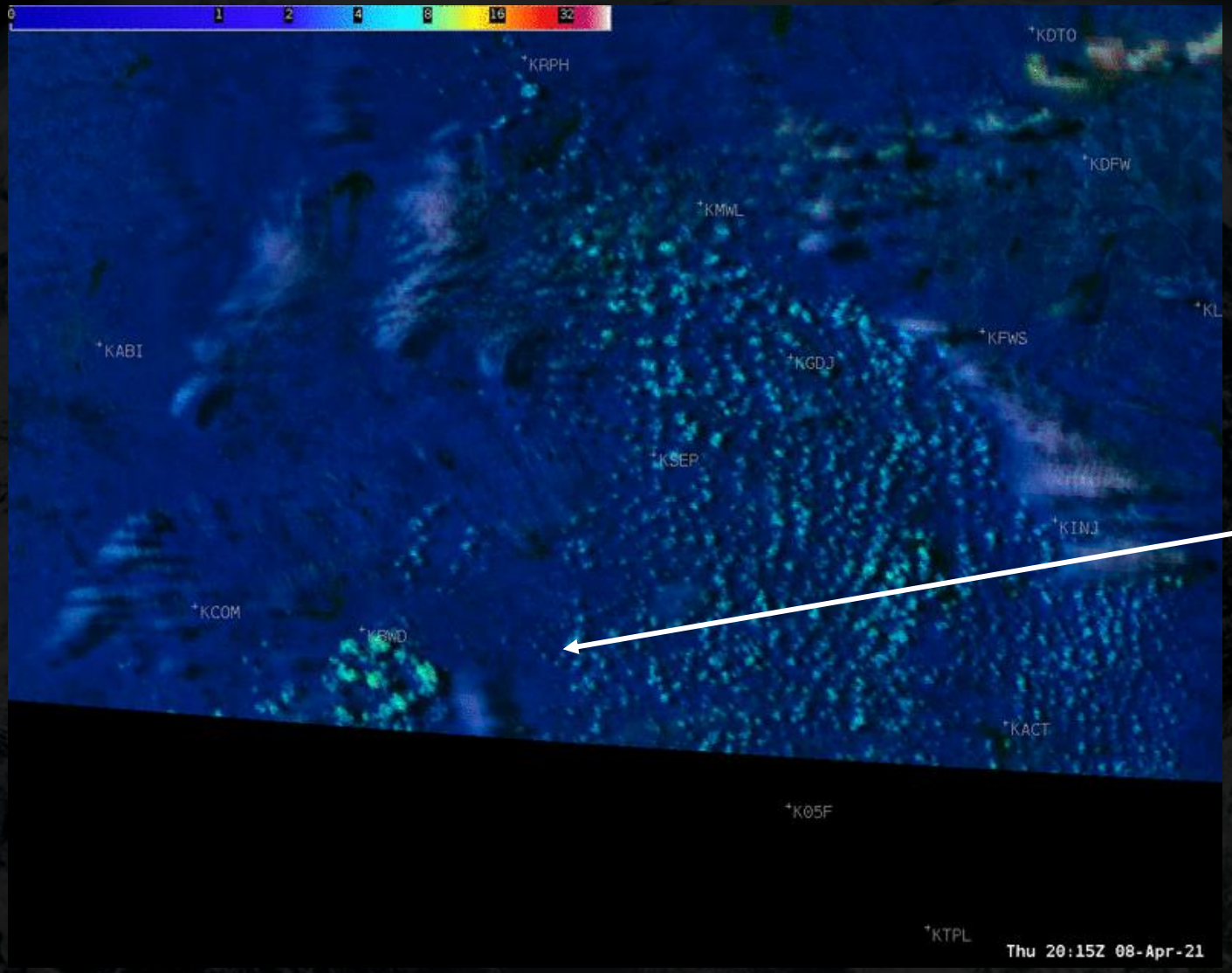


Using DCPD RGB to Anticipate CI



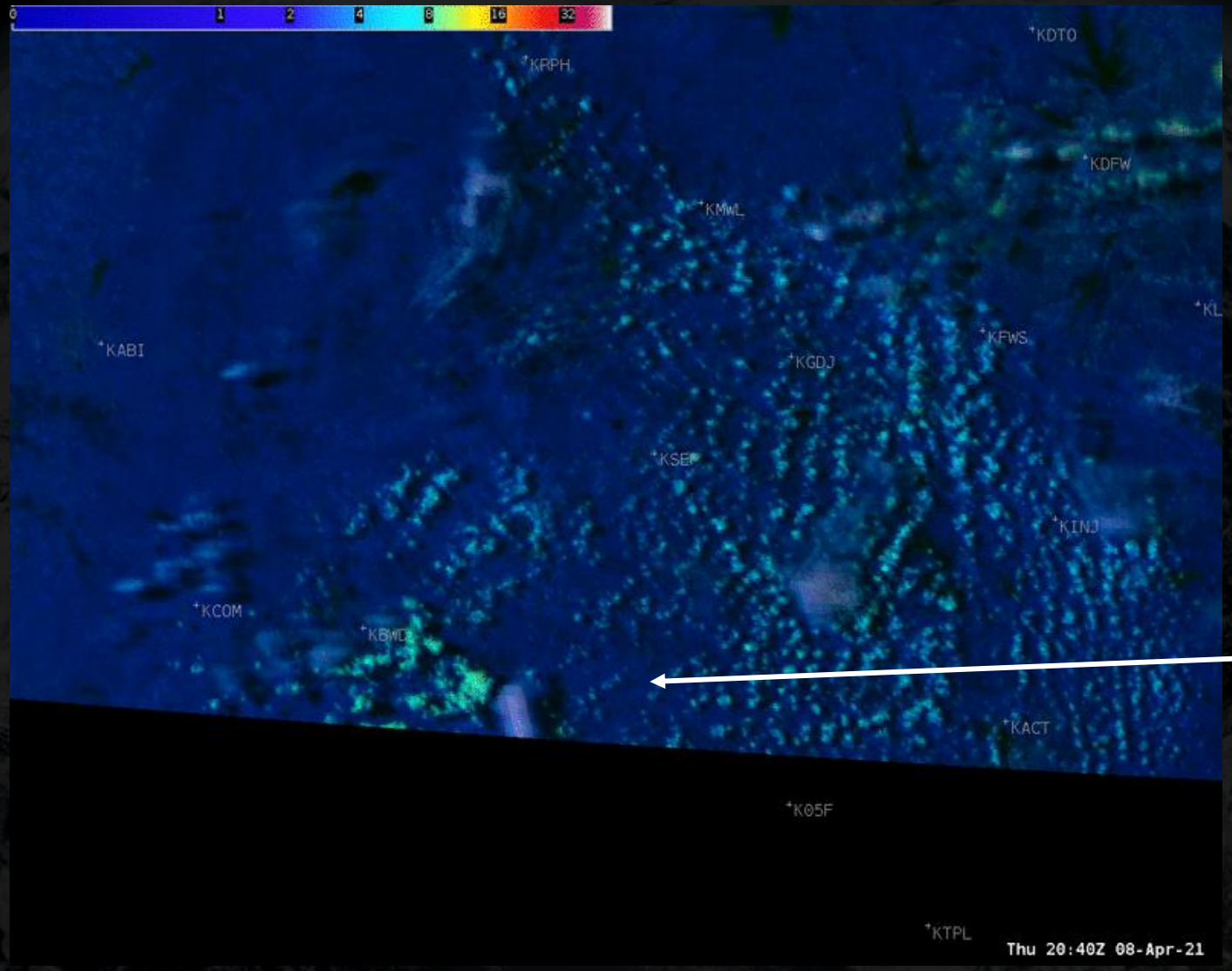
Pretty broad cu field with no obvious areas to note

Using DCPD RGB to Anticipate CI



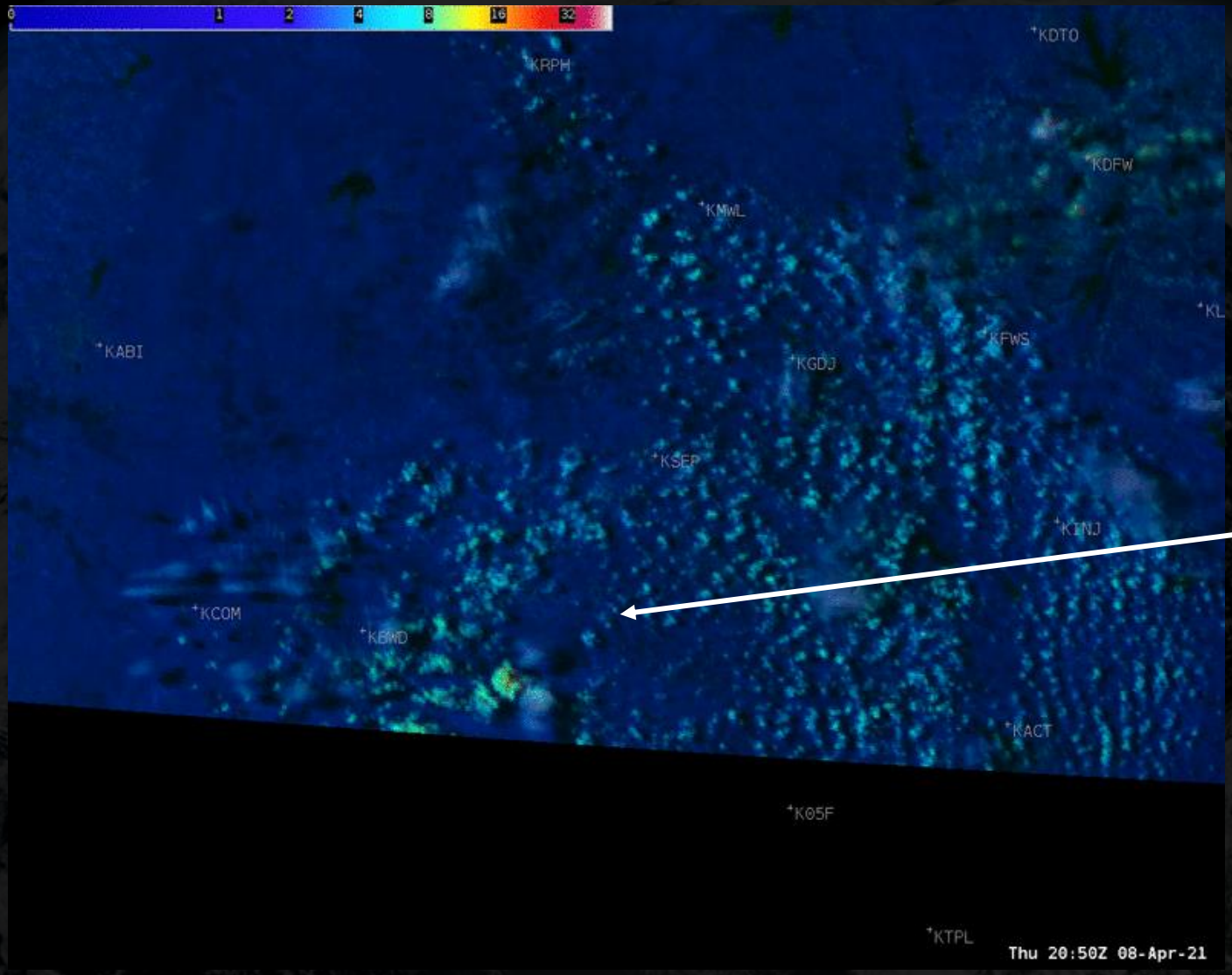
Clumping of cu with glaciation diagnosed

Using DCPD RGB to Anticipate CI



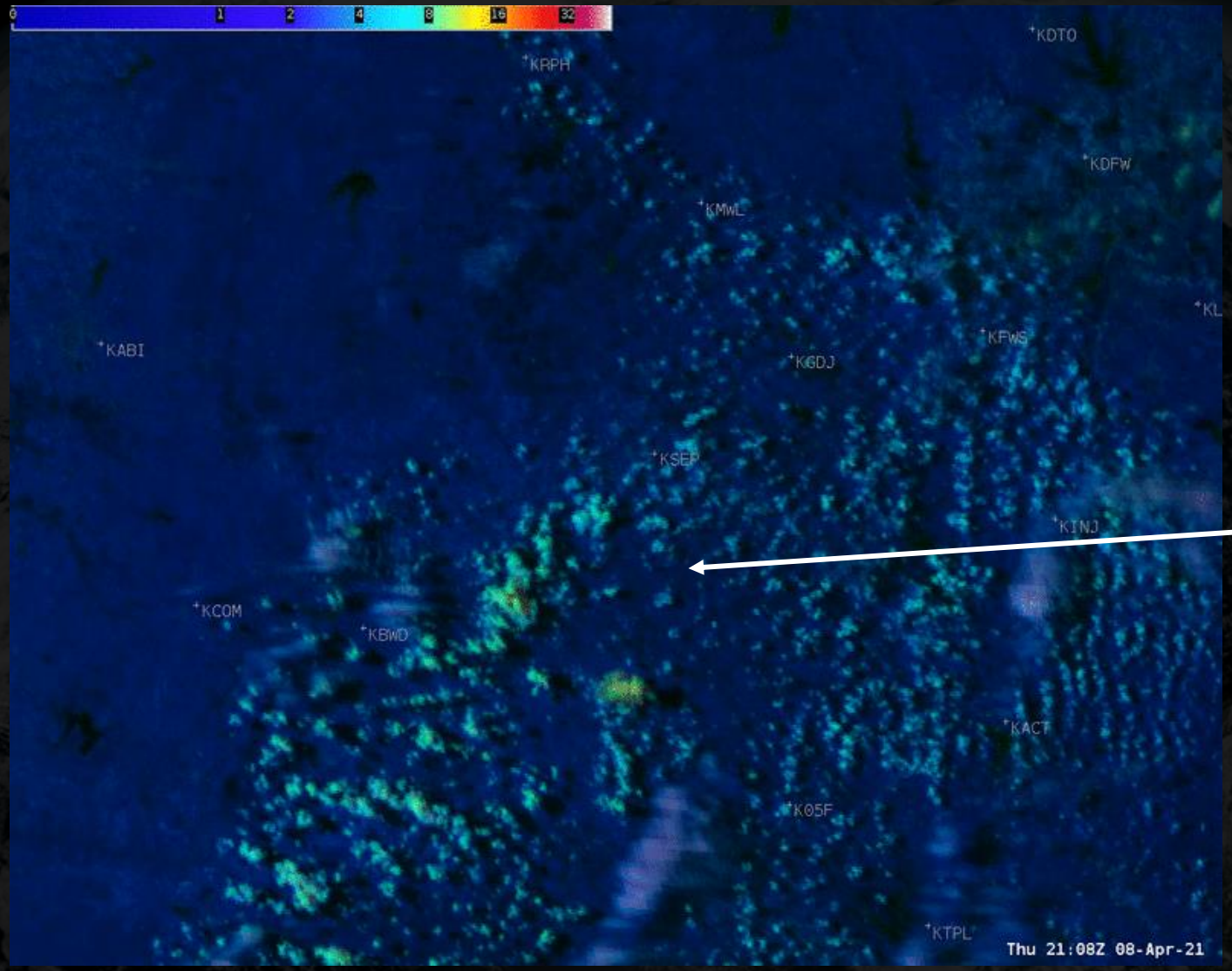
Orphan Anvil: Updraft has broken the capping inversion, but failed to sustain itself. A sign that the CAP is or may soon be gone, and convective initiation imminent

Using DCPD RGB to Anticipate CI



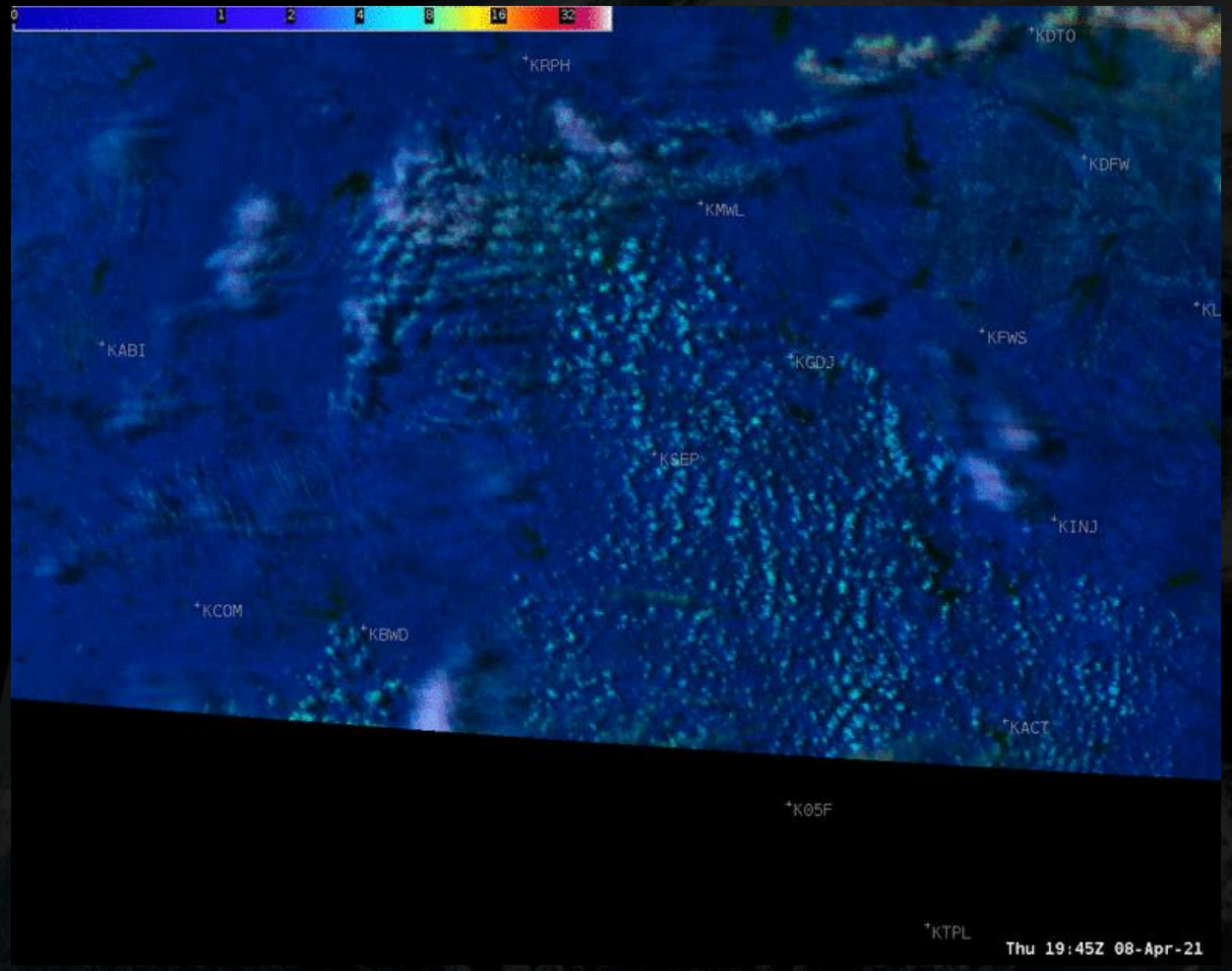
Additional vertical growth and glaciation nearby

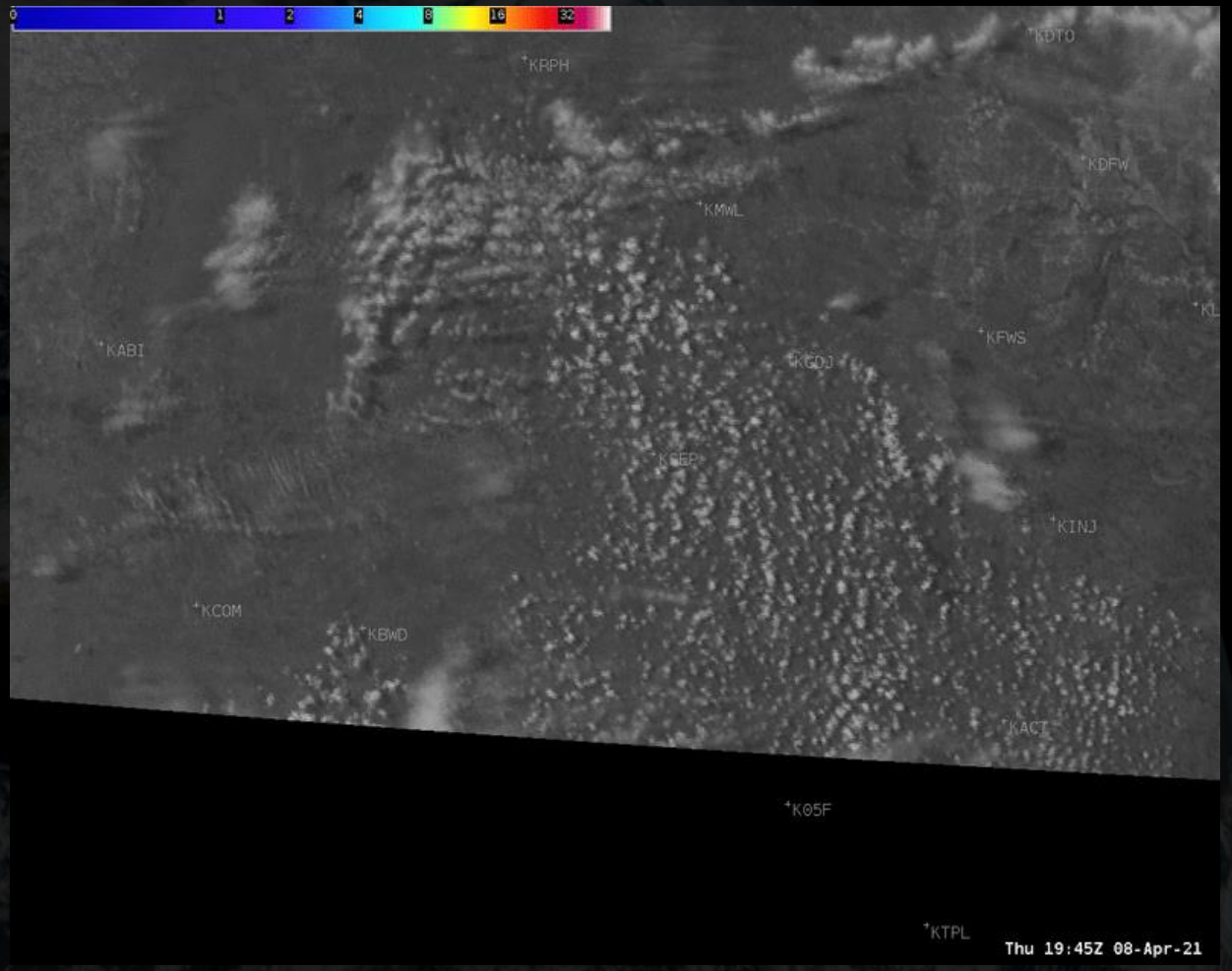
Using DCPD RGB to Anticipate CI



Continued initiation with first lightning flash

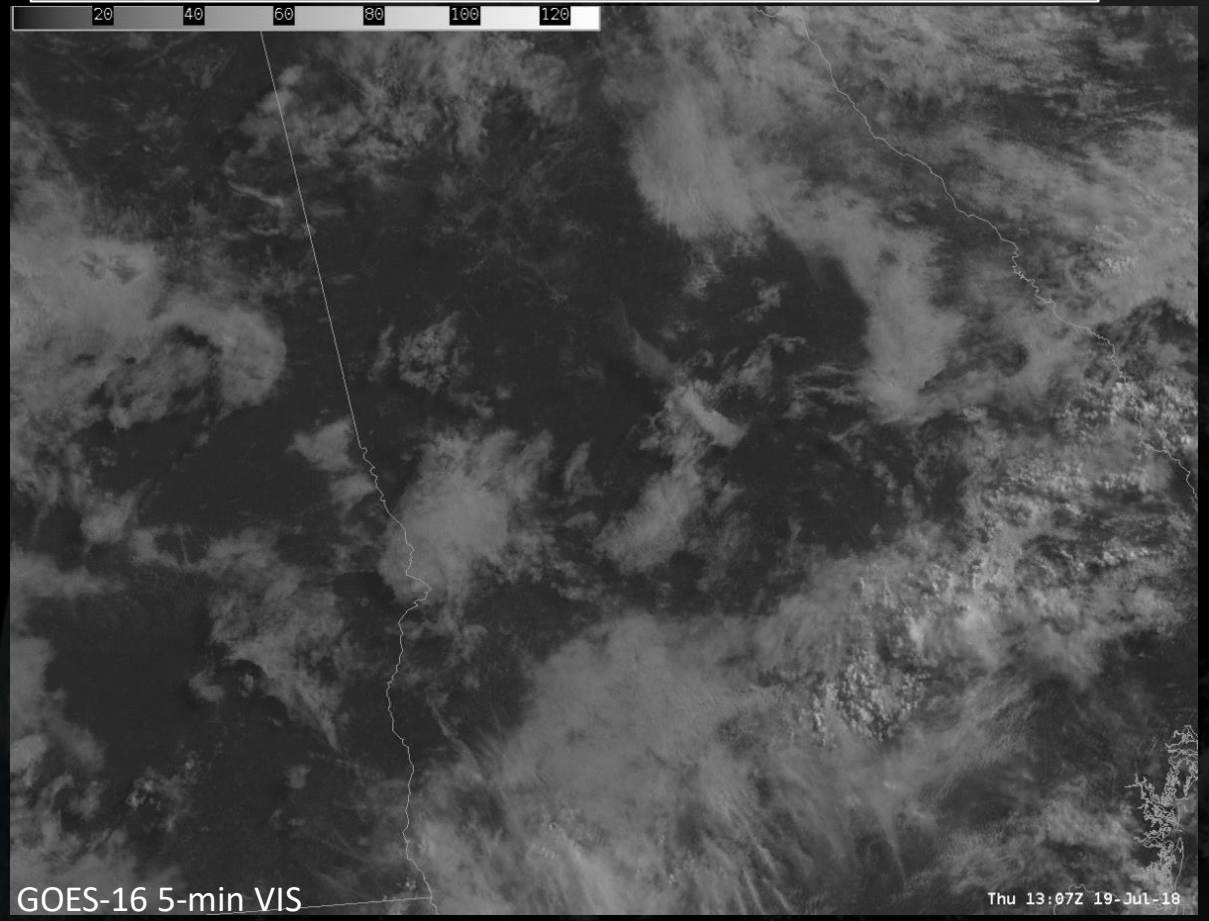
Using DCPD RGB to Anticipate CI



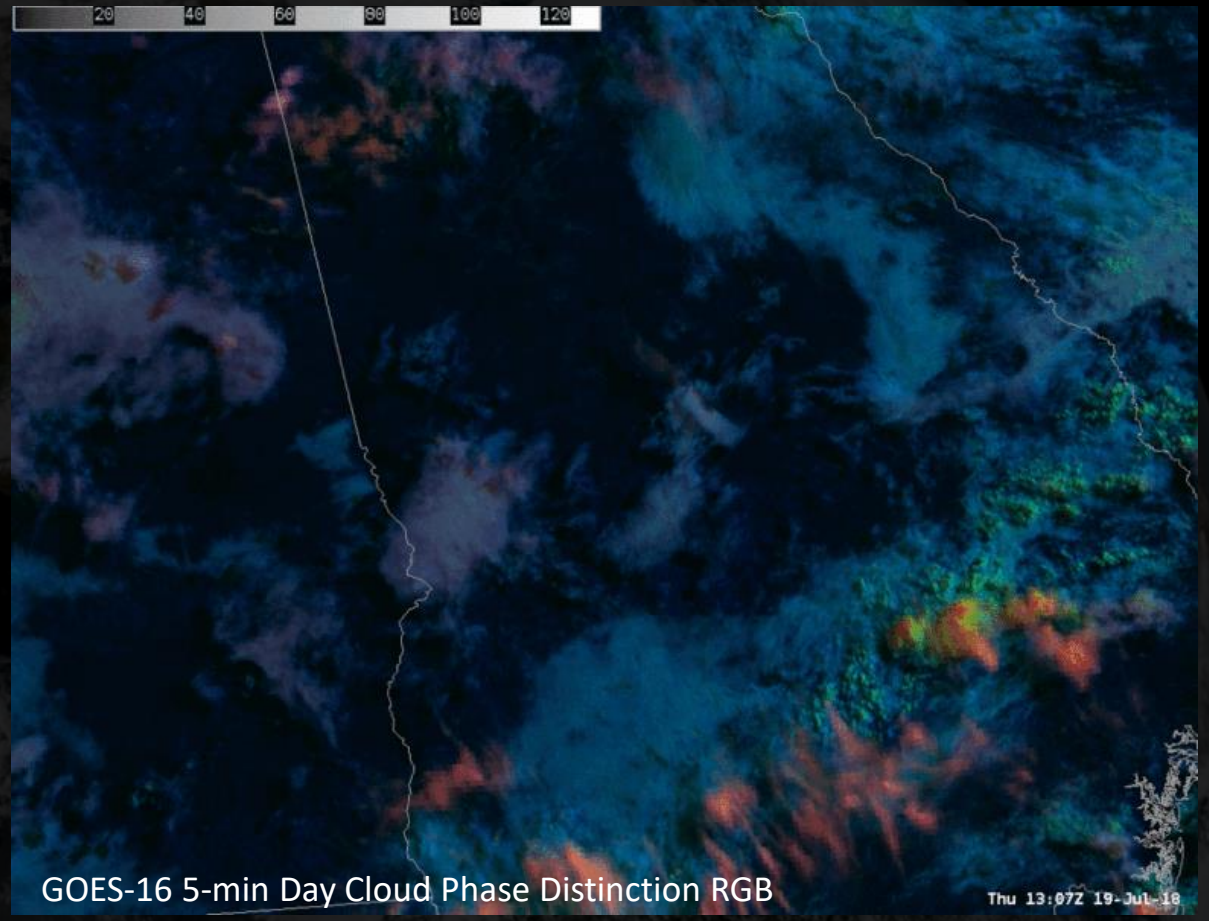


Do you expect convective initiation in the next 30-min?

Band or band difference	RED	+	GREEN	+	BLUE	=	RGB IMAGE
	10.3 um Band "Clean Window IR"		0.64 um Band "Red Visible"		1.6 um Band "Snow/Ice"		
Min	7.5 K		0 %		1 %		
Max	-53.5 K		78 %		59 %		
Gamma	1.0		1.0		1.0		



GOES-16 5-min VIS



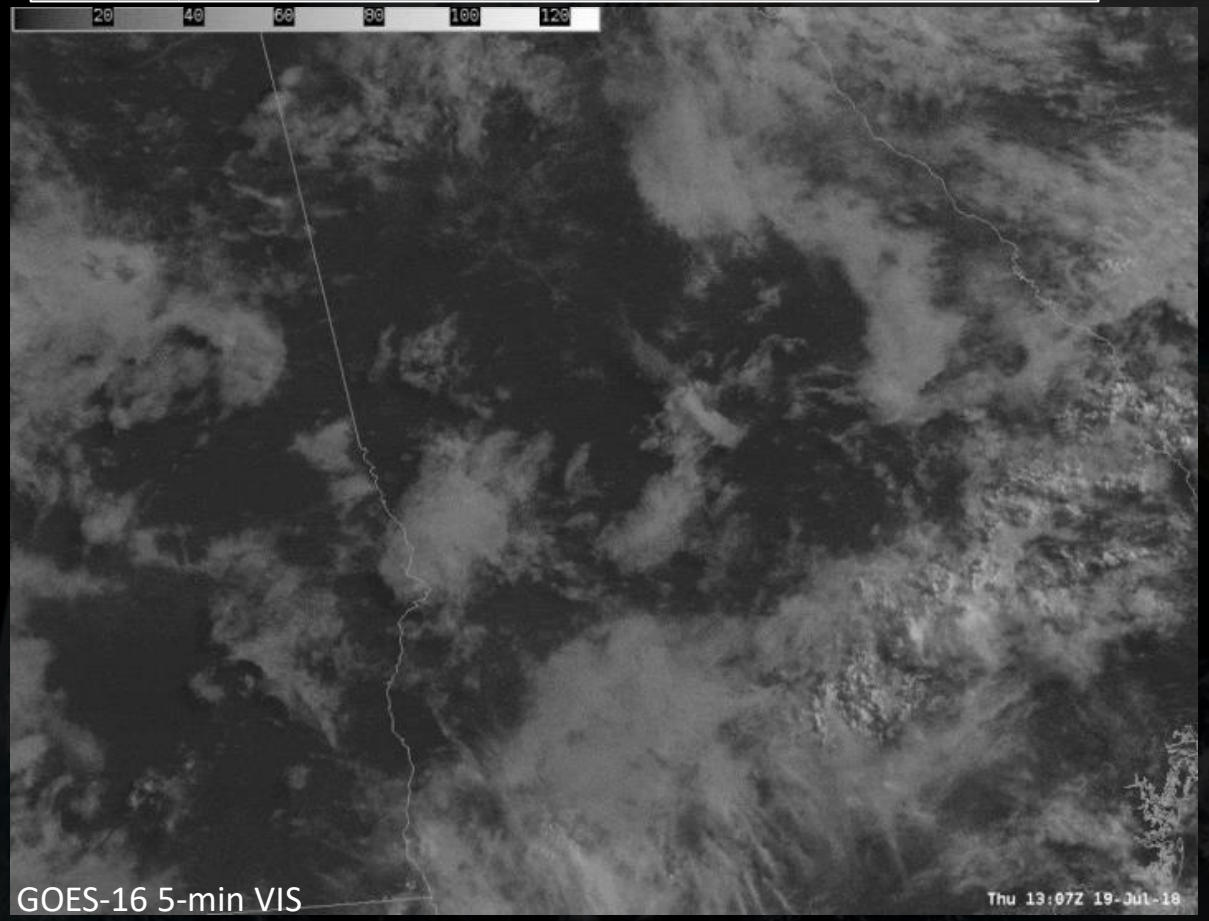
GOES-16 5-min Day Cloud Phase Distinction RGB

Q7

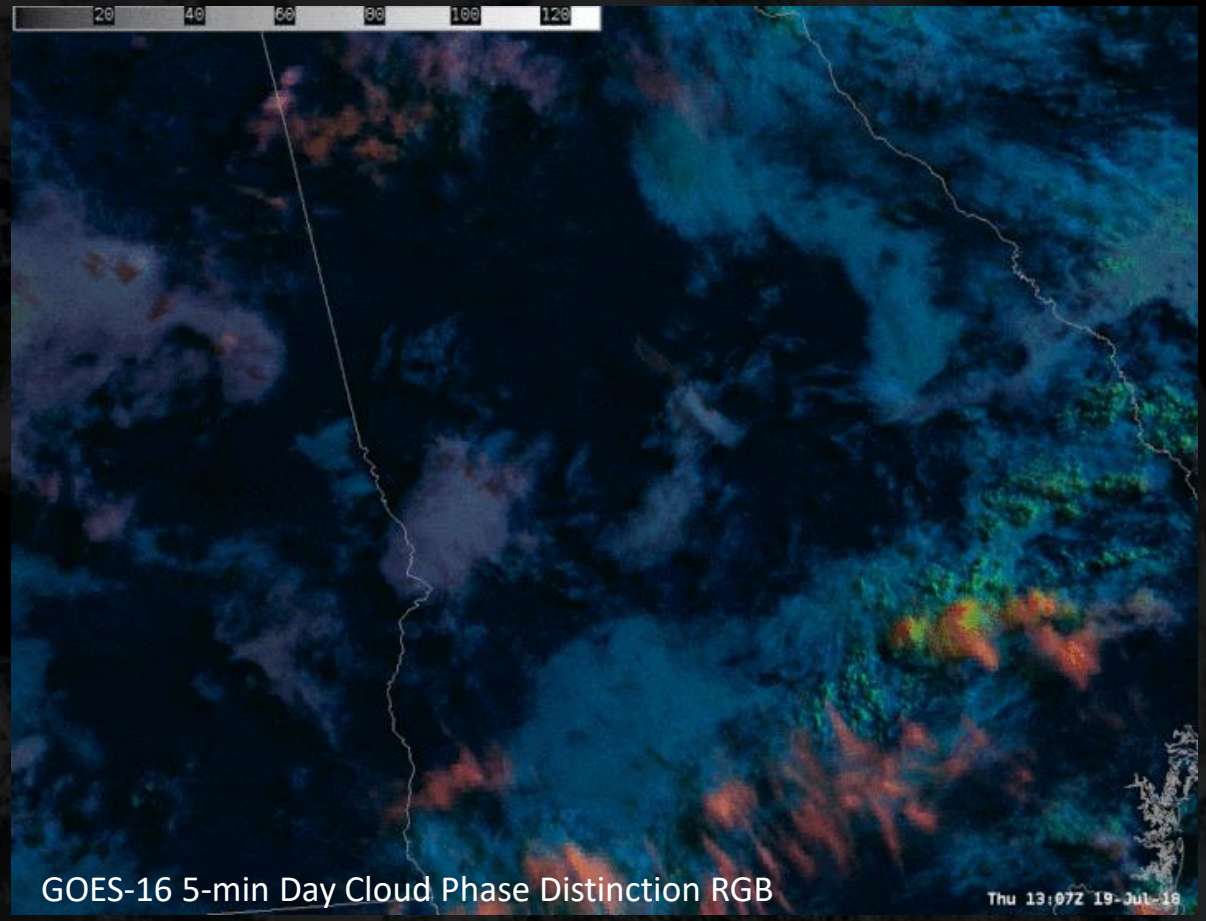
Yes, no

Do you expect convective initiation in the next 30-min?

Band or band difference	RED	+	GREEN	+	BLUE	=	RGB IMAGE
	10.3 um Band "Clean Window IR"		0.64 um Band "Red Visible"		1.6 um Band "Snow/Ice"		
Min	7.5 K		0 %		1 %		
Max	-53.5 K		78 %		59 %		
Gamma	1.0		1.0		1.0		



GOES-16 5-min VIS

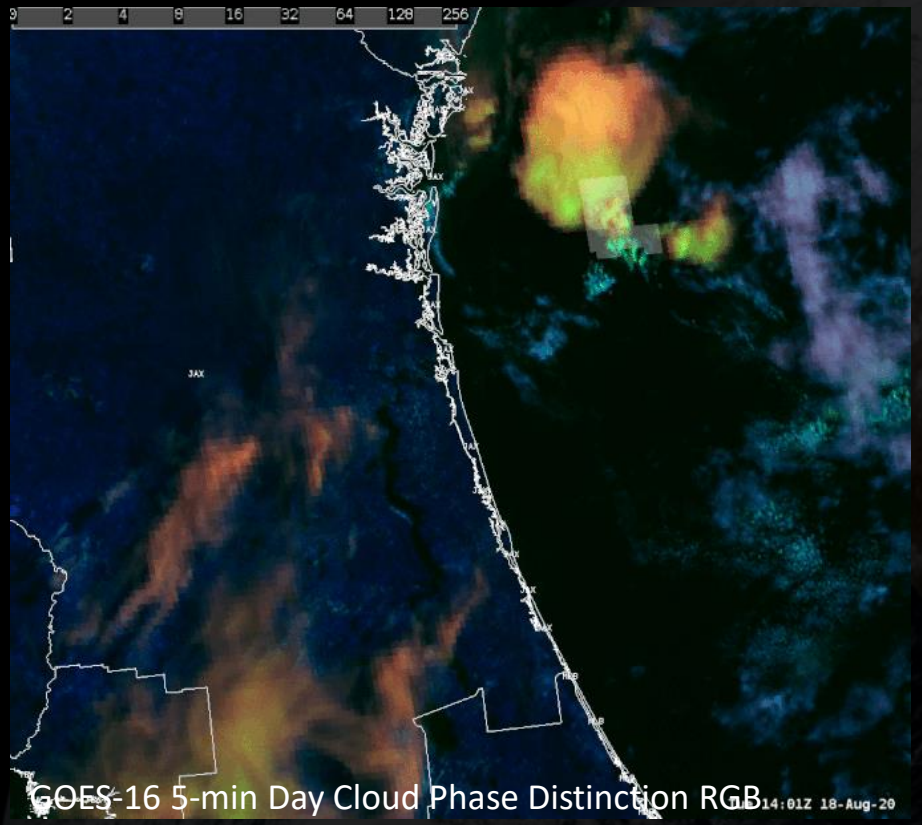


GOES-16 5-min Day Cloud Phase Distinction RGB

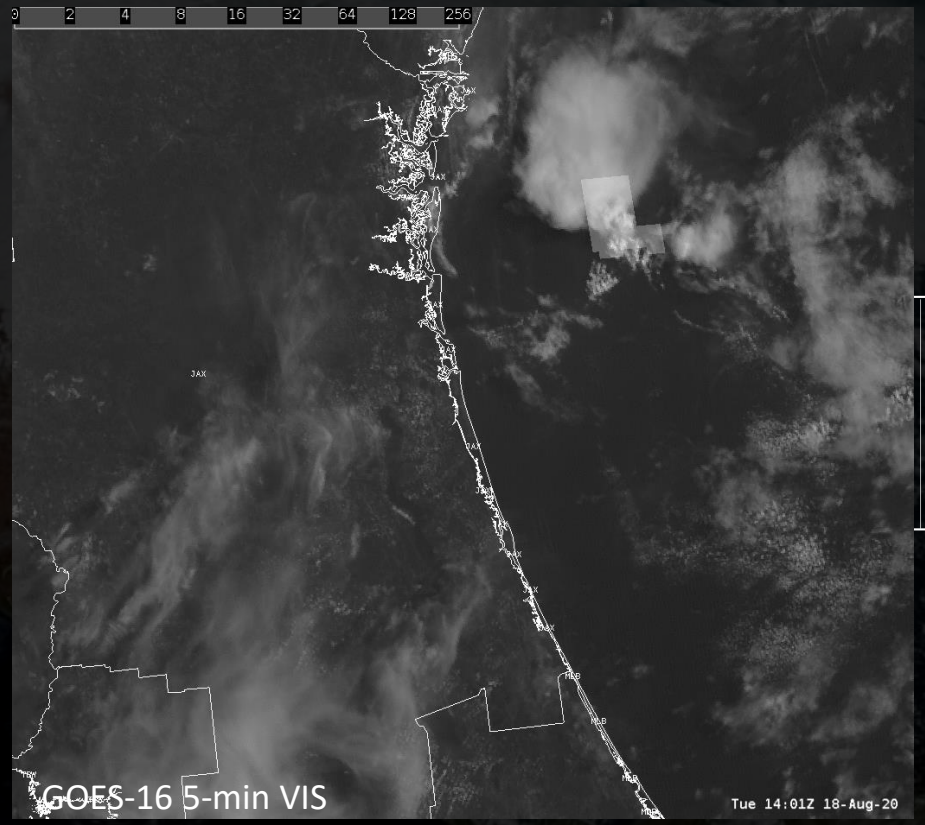
Q7 Answer

Yes, no

What Tweet text would be most appropriate for JAX to send now



GOES-16 5-min Day Cloud Phase Distinction RGB



GOES-16 5-min VIS

RED	+	GREEN	+	BLUE
10.3 um Band		0.64 um Band		1.6 um Band
"Clean Window IR"		"Red Visible"		"Snow/Ice"
7.5 K		0 %		1 %
-53.5 K		78 %		59 %
1.0		1.0		1.0

A. Aside from some cloud cover, it's a beautiful day! Enjoy the beach!

B. Hey beachgoers, sunny skies will give way to a few rain showers in the next hour

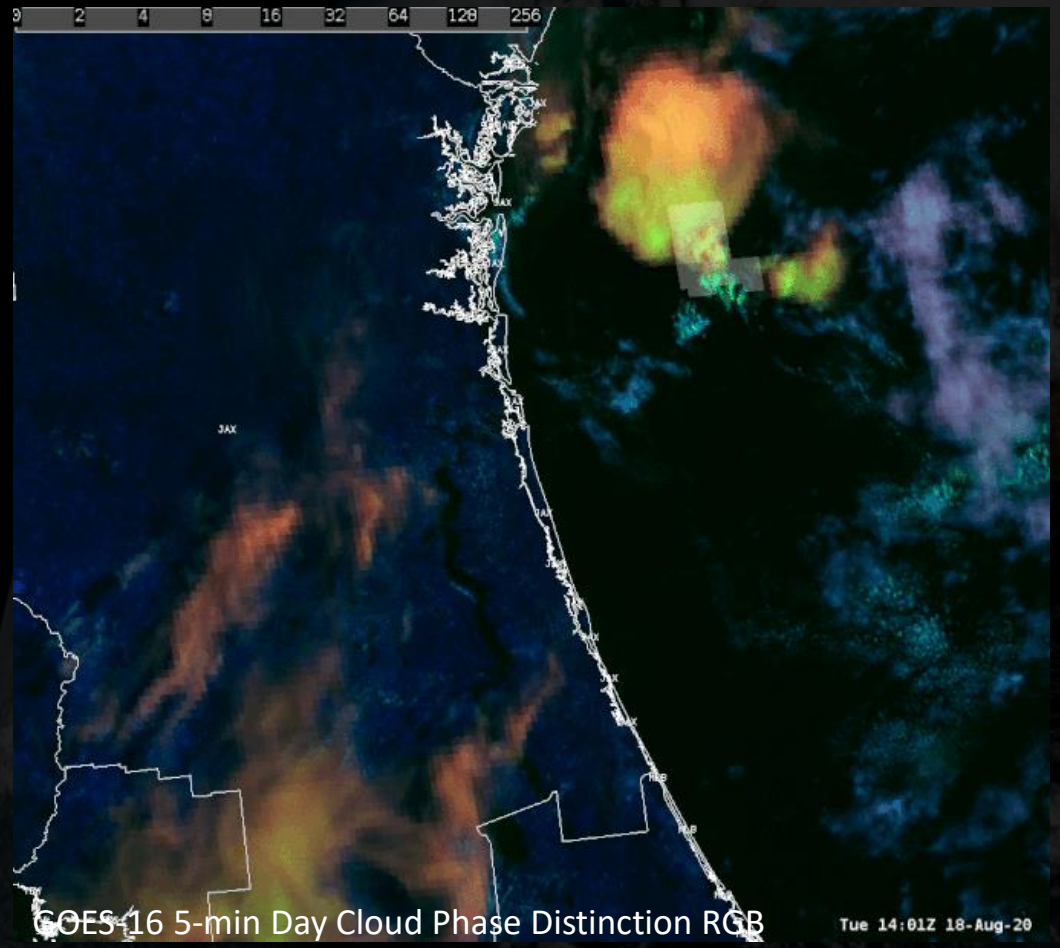
C. Lightning will be possible in the next hour. If at beach, monitor the weather closely and consider going indoors

D. T-storms with large hail possible in the next hour. If at beech, monitor the weather closely and consider moving indoors

Q8

What Tweet text would be most appropriate for JAX to send now

Band or band difference	RED + 10.3 um Band "Clean Window IR"	GREEN + 0.64 um Band "Red Visible"	BLUE = 1.6 um Band "Snow/Ice"	RGB IMAGE
Min	7.5 K	0 %	1 %	
Max	-53.5 K	78 %	59 %	
Gamma	1.0	1.0	1.0	



GOES-16 5-min Day Cloud Phase Distinction RGB

A. Aside from some cloud cover, it's a beautiful day! Enjoy the beech!

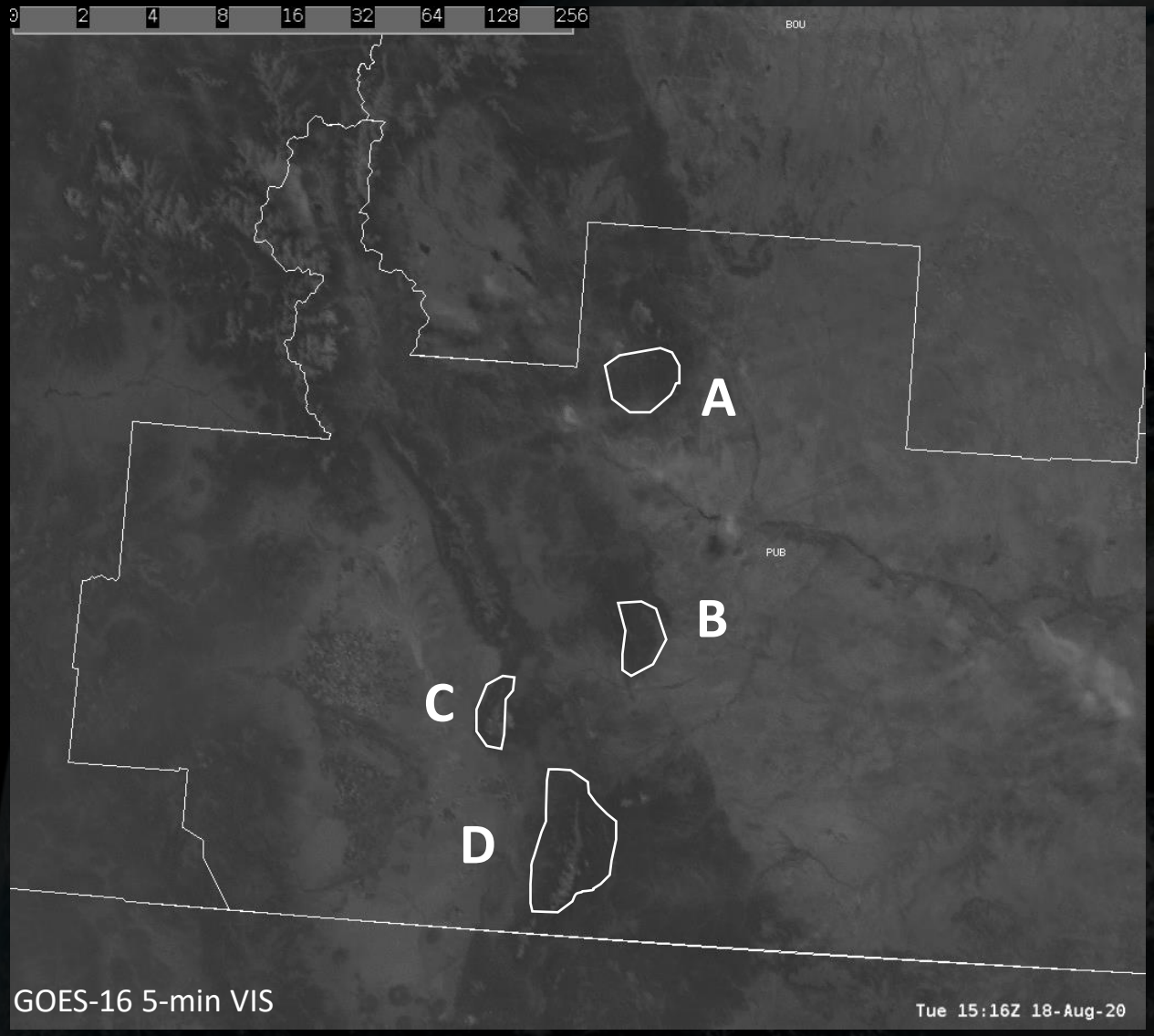
B. Hey beachgoers, sunny skies will give way to a few rain showers in the next hour

C. Lightning will be possible in the next hour. If at beach, monitor the weather closely and consider going indoors

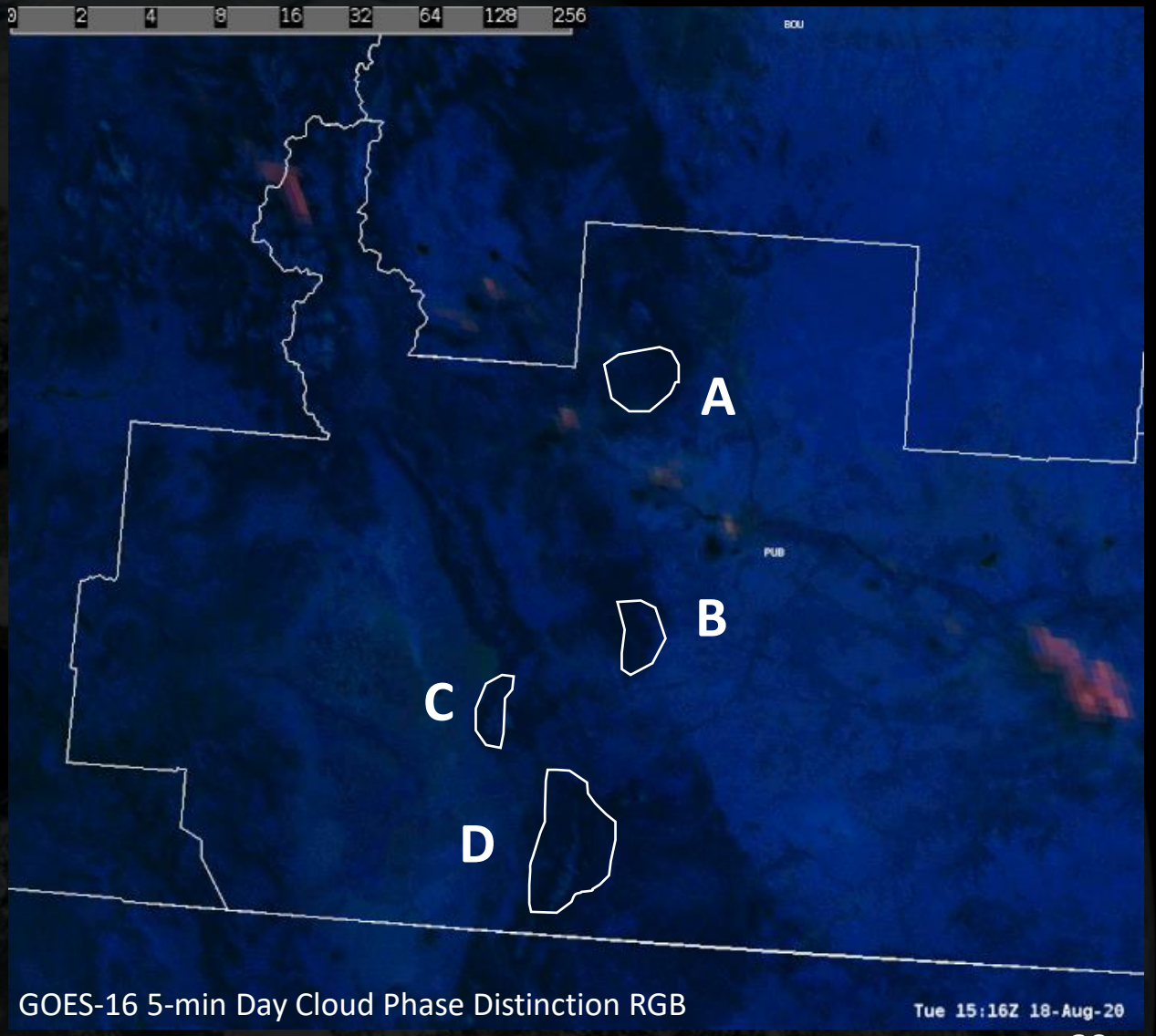
D. Thunderstorms with large hail possible in the next hour. If at beech, monitor the weather closely and consider moving indoors

Q8 Answer

Which (theoretical) burn scar should PUB send an alert regarding impending lightning and heavy precip potential?

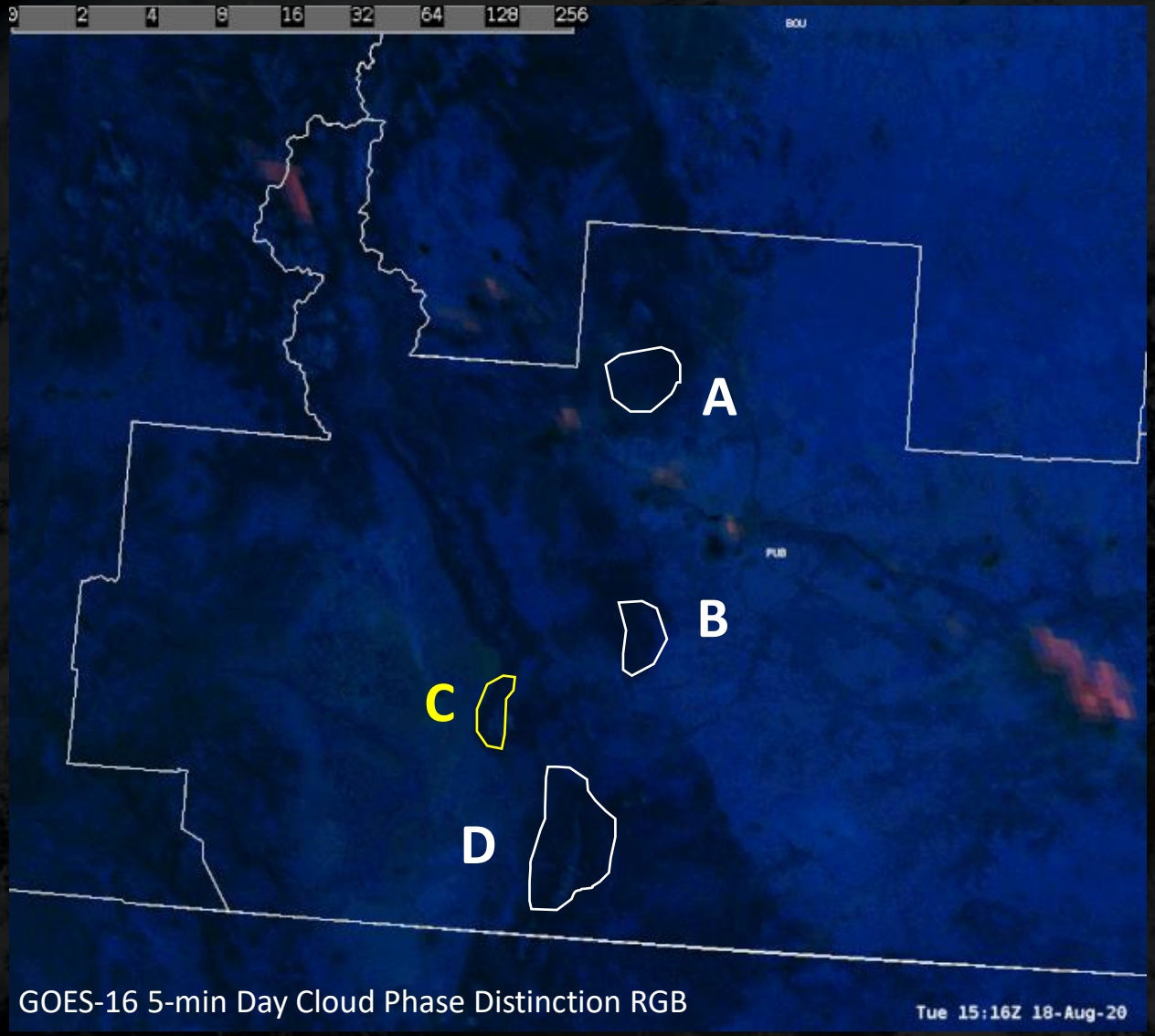


Q9



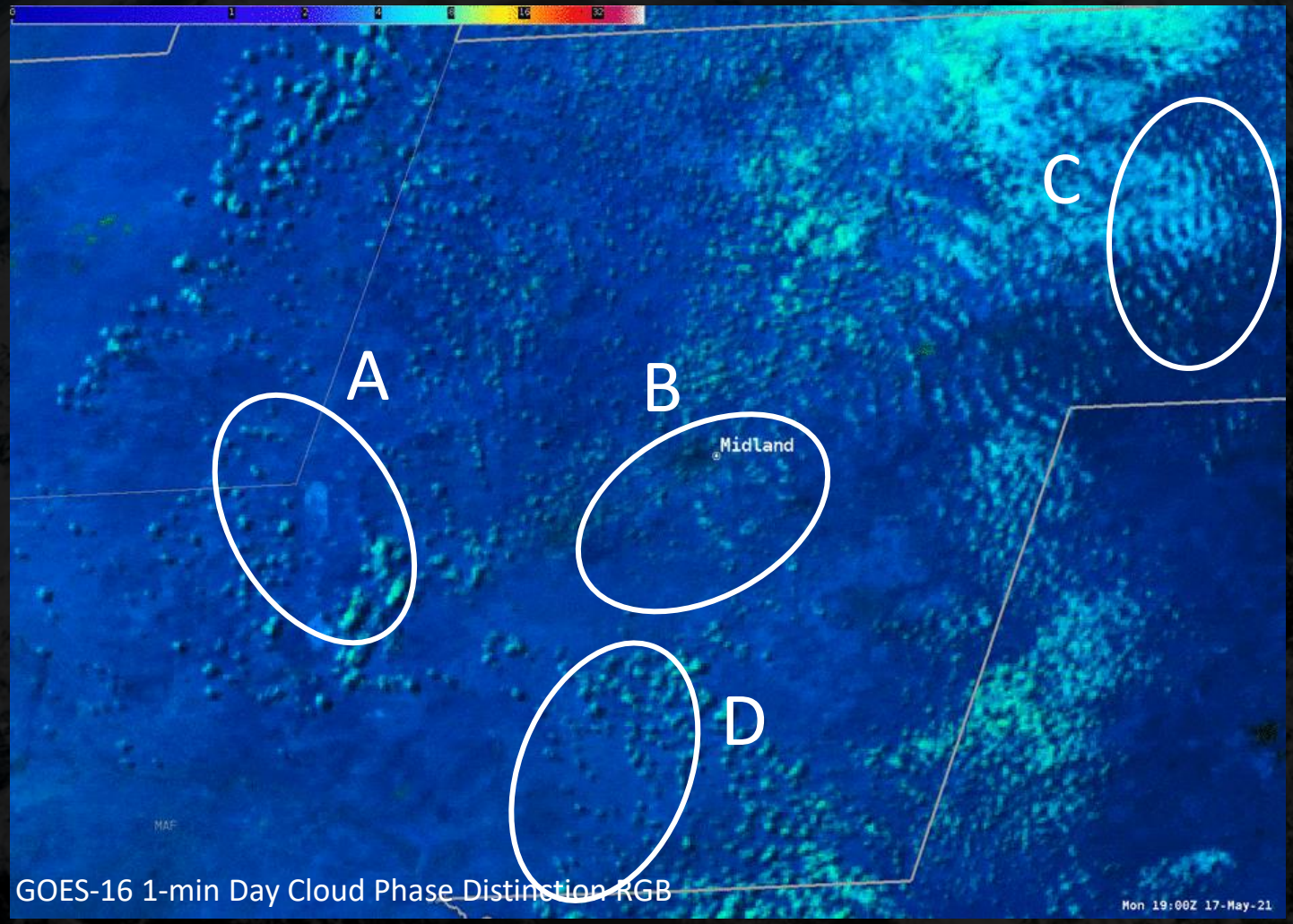
Q10

Which (theoretical) burn scar should PUB send an alert regarding impending lightning and heavy precip potential?



Q9+10 Answer

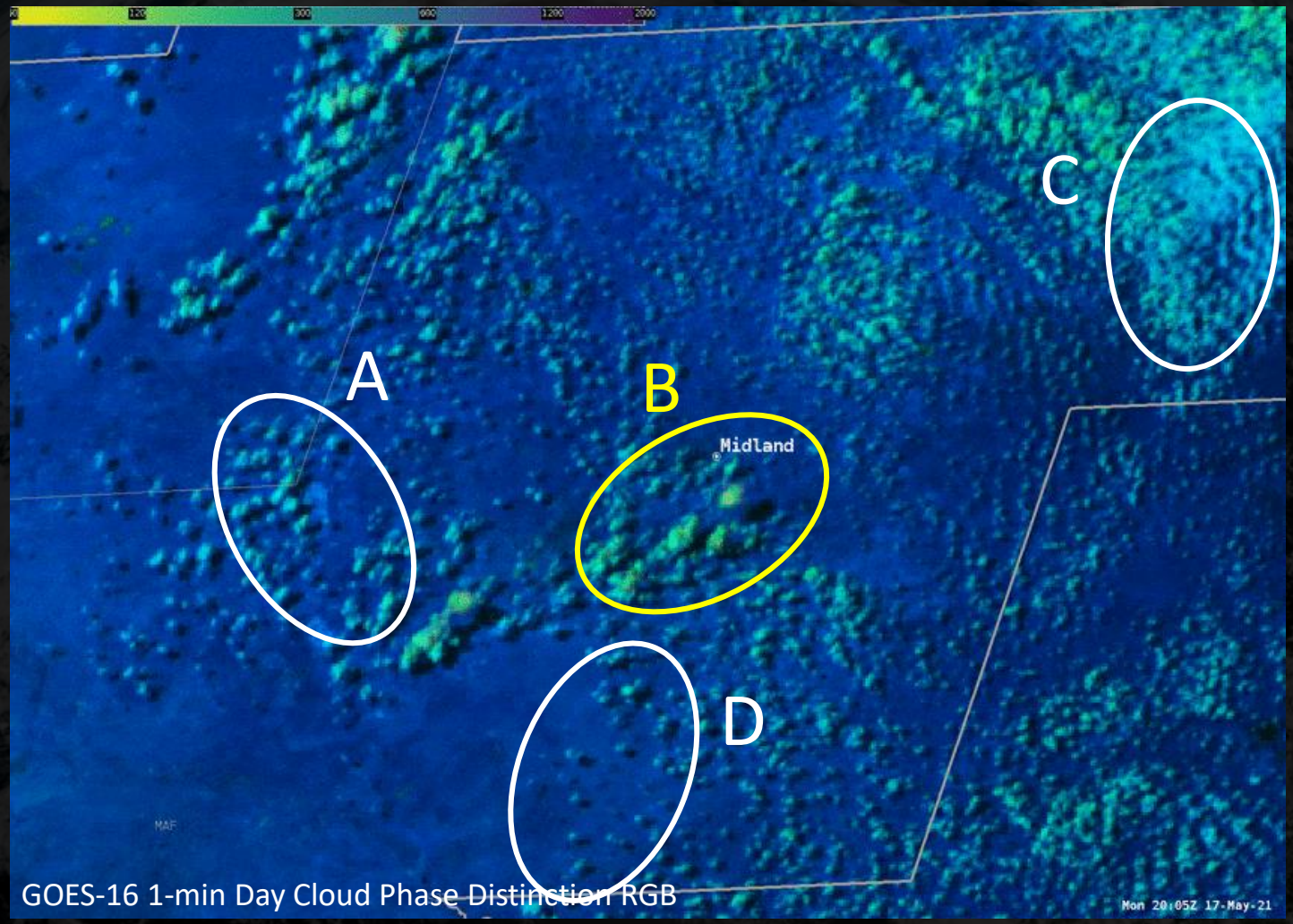
Where do you expect Convective Initiation in next 30-minutes



GOES-16 1-min Day Cloud Phase Distinction RGB

Q11

Where do you expect Convective Initiation in next 30-minutes



GOES-16 1-min Day Cloud Phase Distinction RGB

Q11 Answer

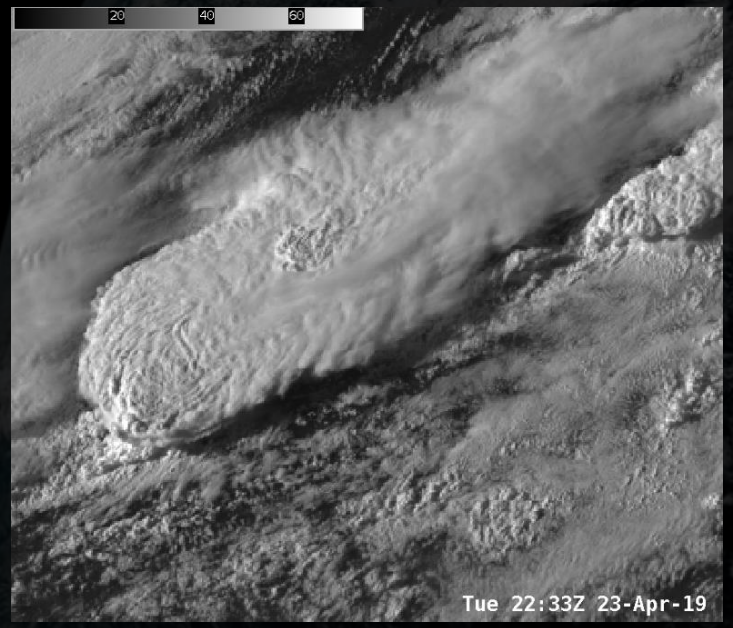
Mature Convective Analysis

- Focus is on satellite products today. In reality, satellite used in concert with:
  - NWP, radar, lightning, UA, surface obs, webcams, human obs, etc
- Pre-convective Environment
  - Water Vapor Imagery Analysis
  - Split Window Difference
  - Derived Products – CAPE and TPW
  - Derived Motion Winds
  - NUCAPS
- Cumulus Cloud Field Analysis and Convective Initiation
  - VIS and IR imagery
  - Day Cloud Phase Distinction RGB
- Mature Convective Analysis
  - VIS and IR imagery
  - VIS/IR Sandwich Imagery
- Nighttime Convective Analysis
  - Nighttime Microphysics RGB
  - IR

Sandwich RGB

- Use: Where is convection initiating? How intense is the convection? Where is convection strengthening? Weakening?
- Ingredients:

VIS + Semi-Trans Cold IRW Overlay = Sandwich Image



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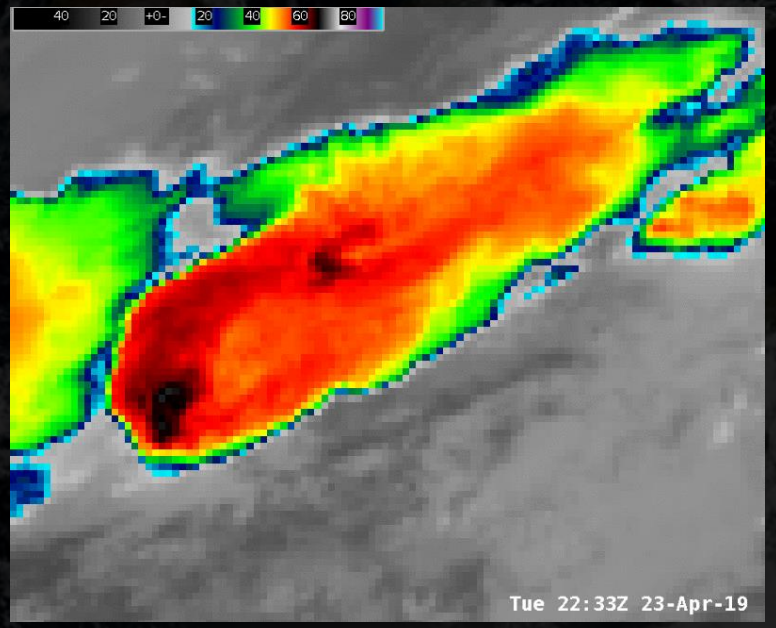

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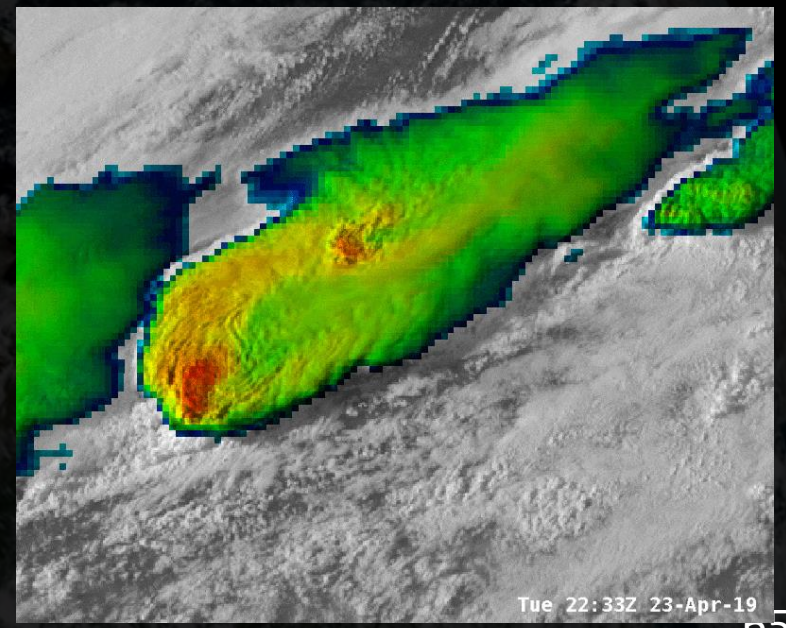
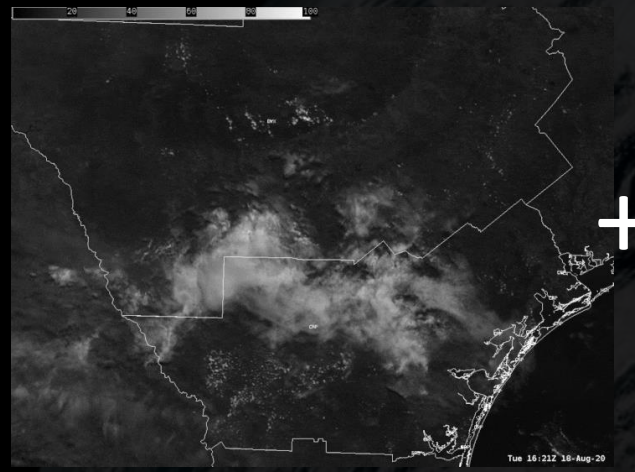


Sandwich RGB



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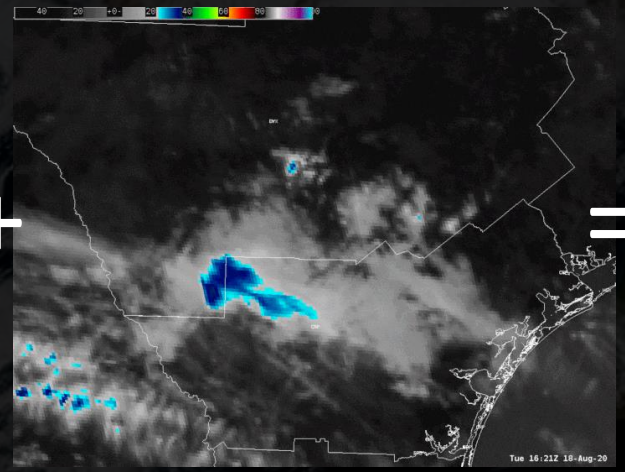

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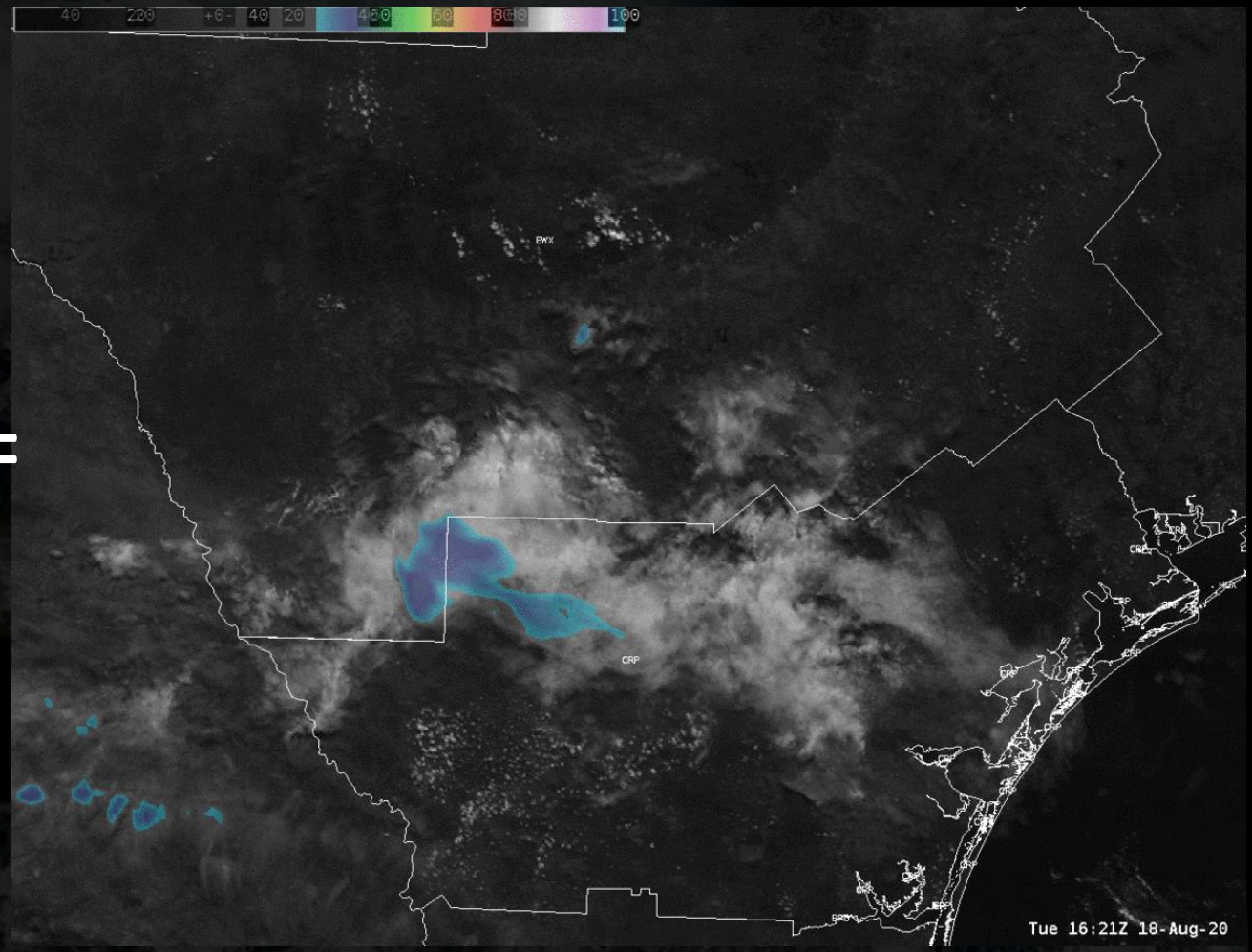
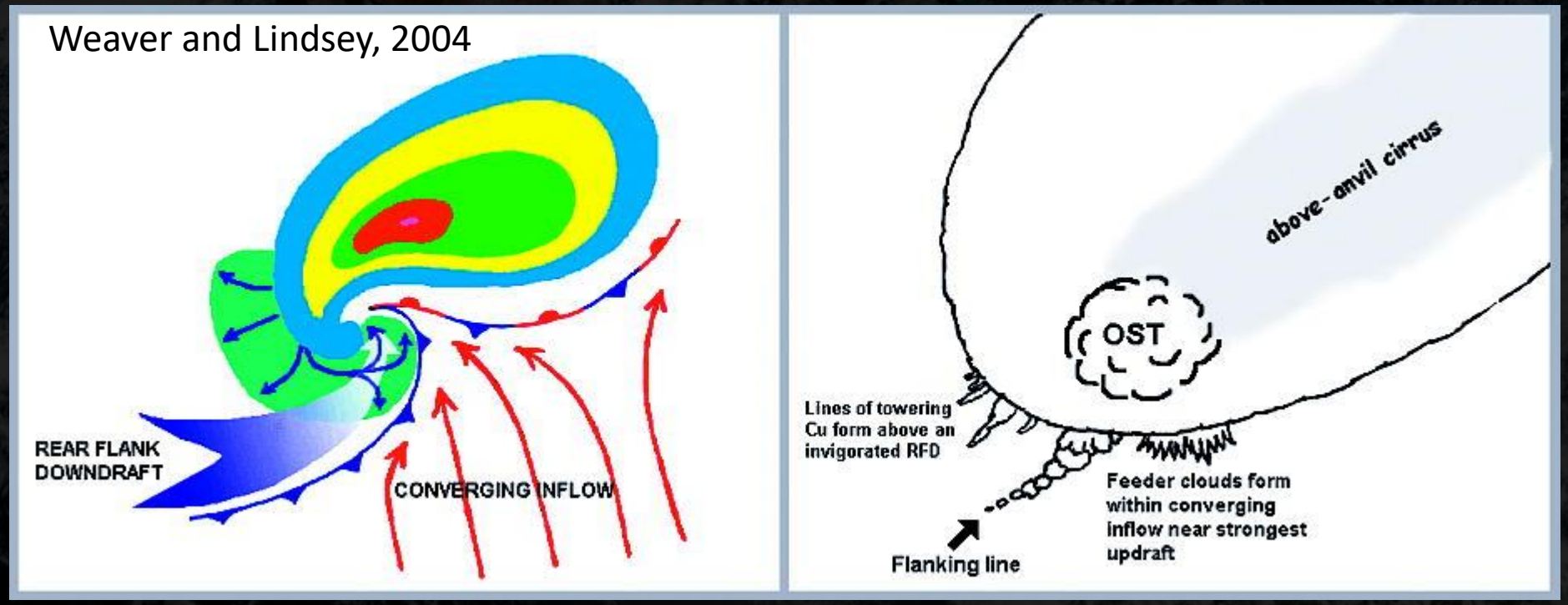


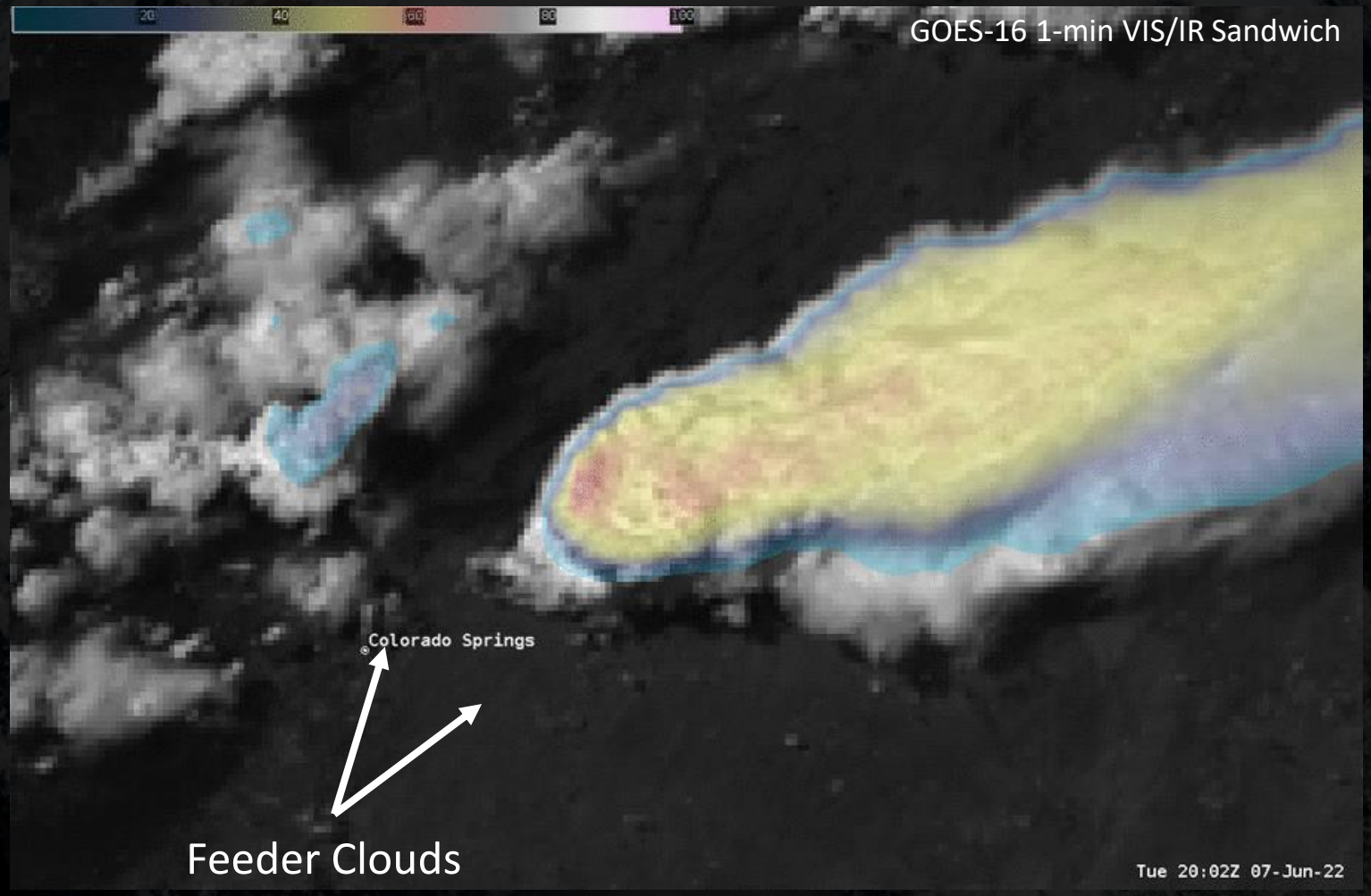
Characteristics of Strong-Severe Thunderstorms

- Inflow Feeder Bands/Clouds
- Overshooting Top
- Above Anvil Cirrus Plume
- Cold/cooling cloud tops



Inflow Feeder Bands/Clouds

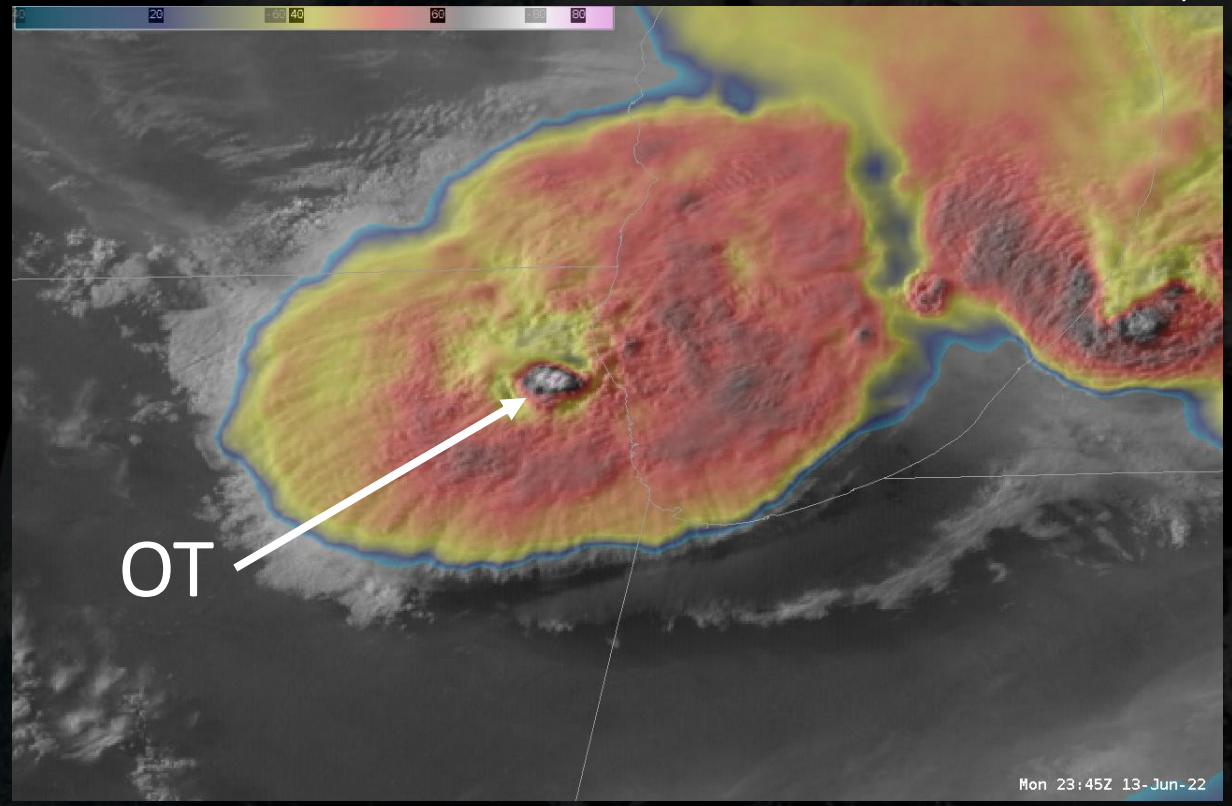
- Lines or bands of low-level clouds that move (feed) into the updraft region of a thunderstorm, parallel to the inflow (NWS)

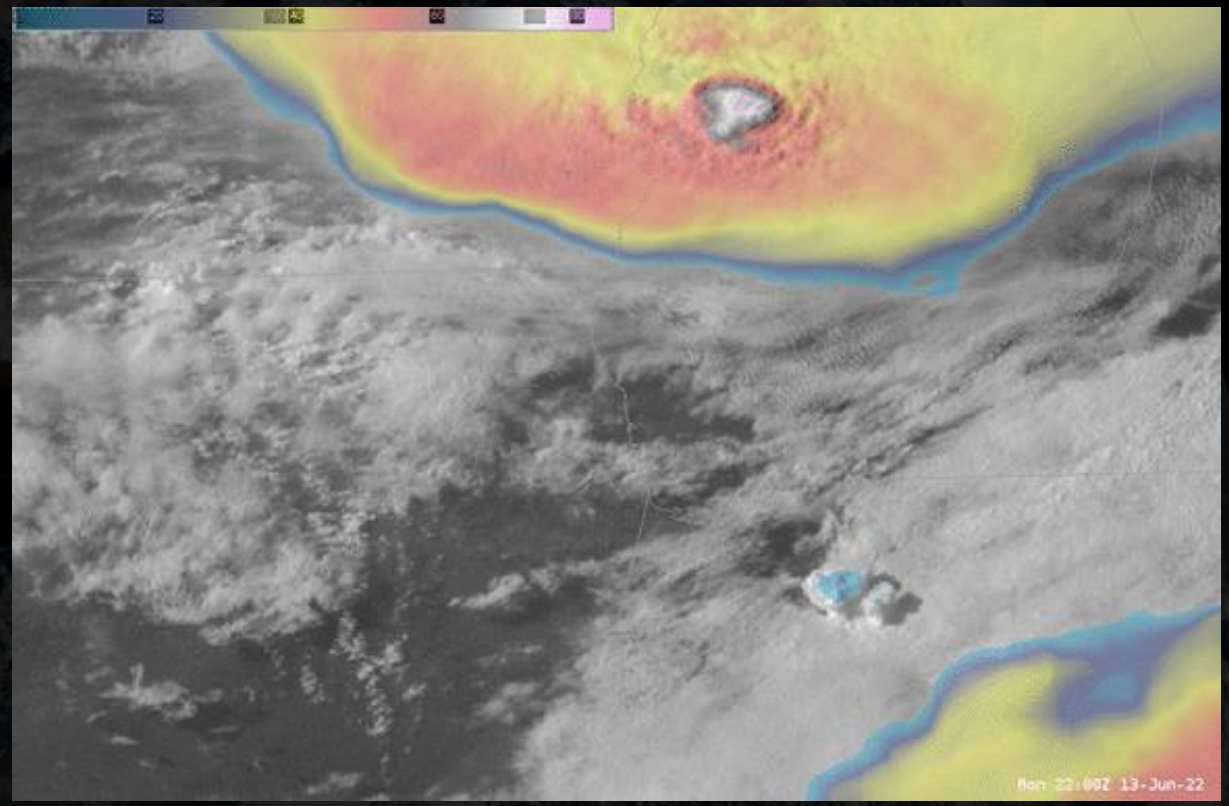


Overshooting Top

- A dome-like protrusion above a thunderstorm anvil, representing a very strong updraft and hence a higher potential for severe weather with that storm (NWS)
- ~Round, extends above anvil, typically cooler than surrounding

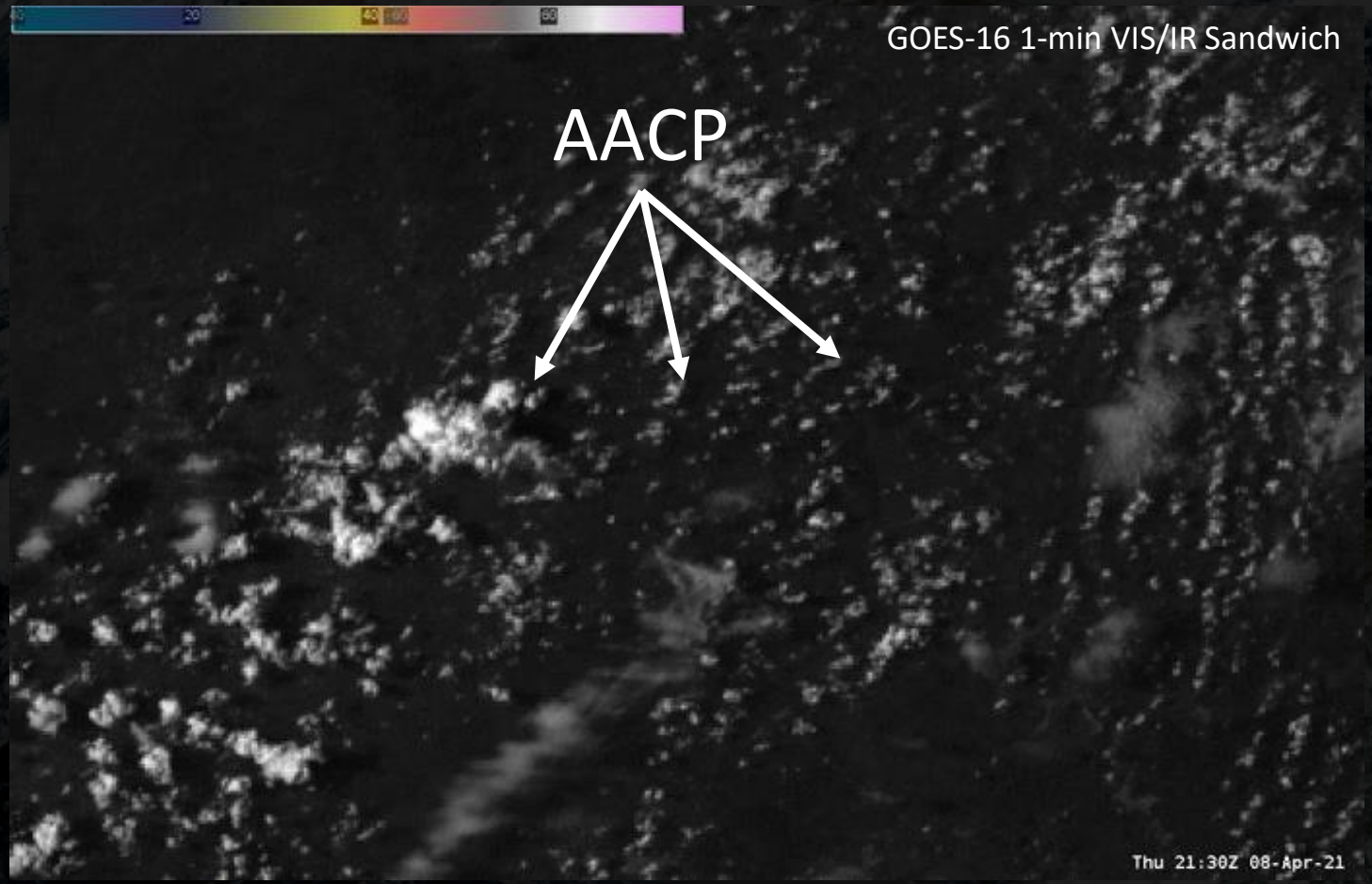
GOES-16 1-min VIS/IR Sandwich





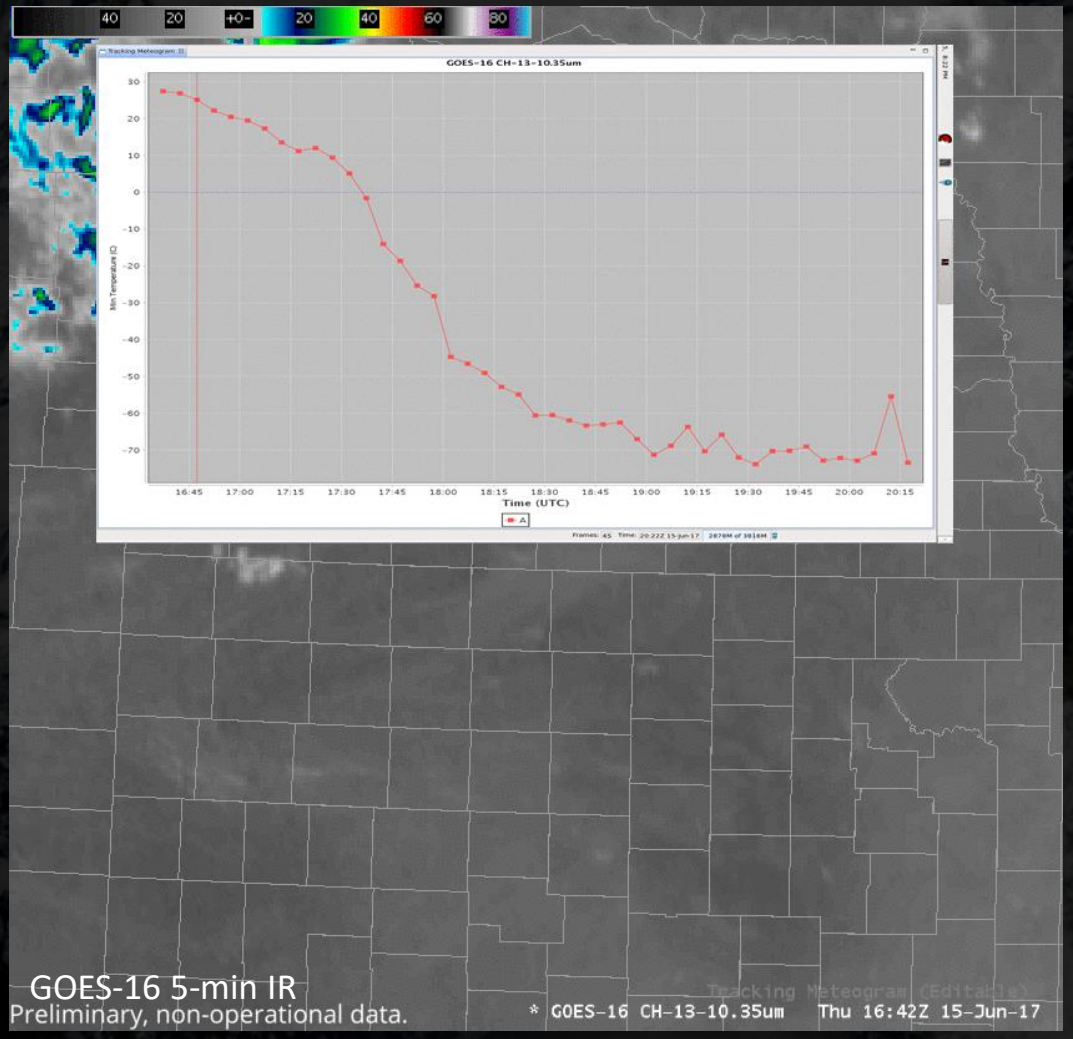
Above Anvil Cirrus Plume

- Intense tropopause-penetrating updrafts and gravity wave breaking generate cirrus plumes that reside above the primary anvil. (Bedka et al. 2018)
- Smooth texture, above anvil, typically warmer than surrounding anvil

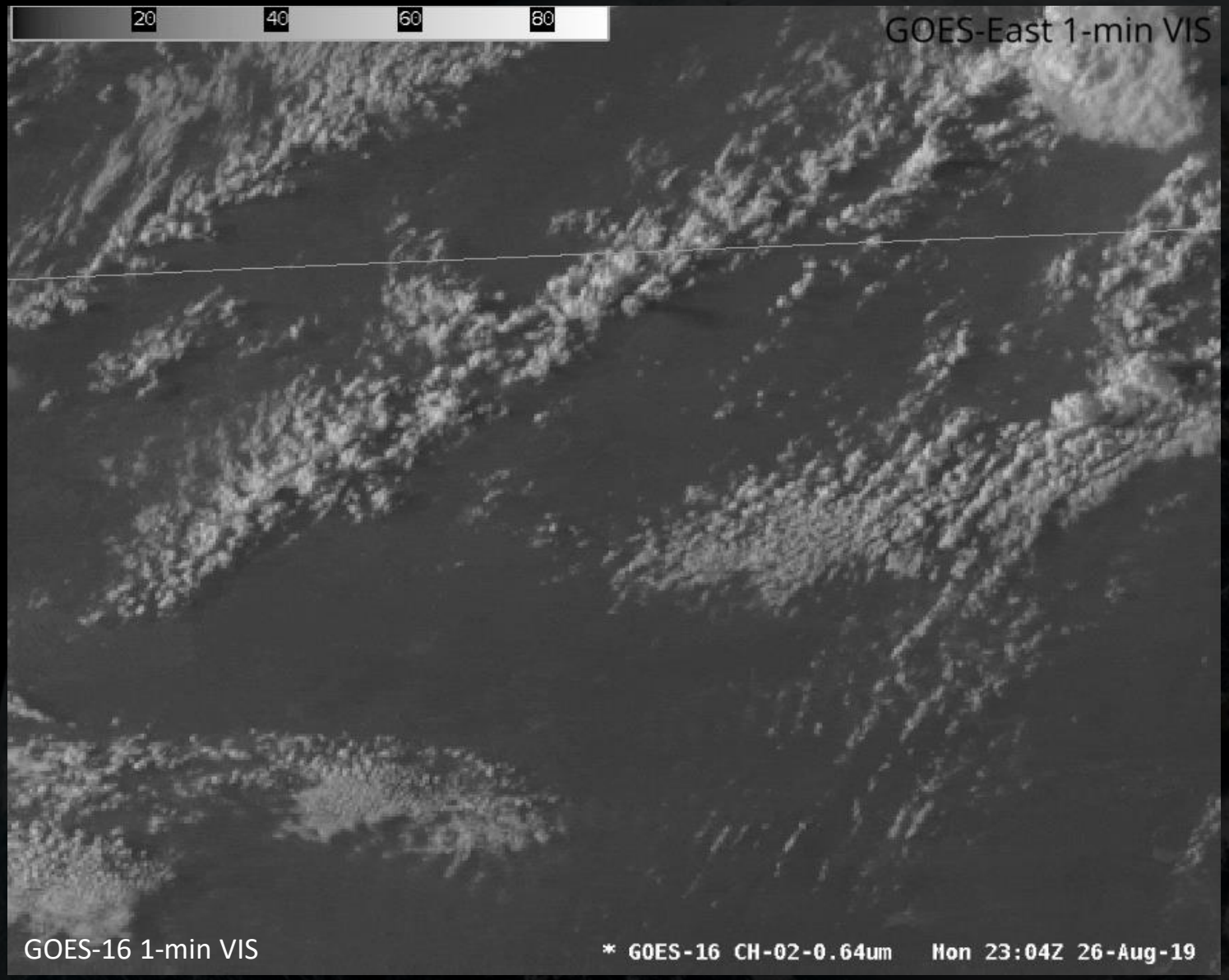


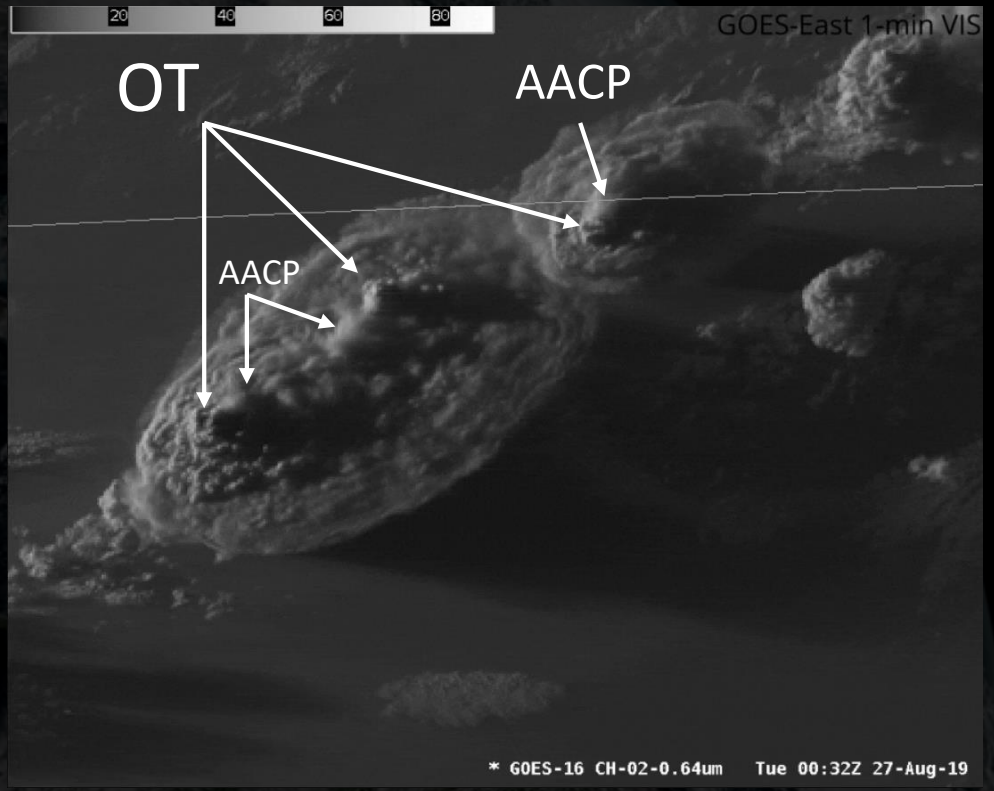
Rapidly Cooling Cloud Tops and Expansion of Anvil

- IR Brightness temperature decrease, and anvil expands, quickly

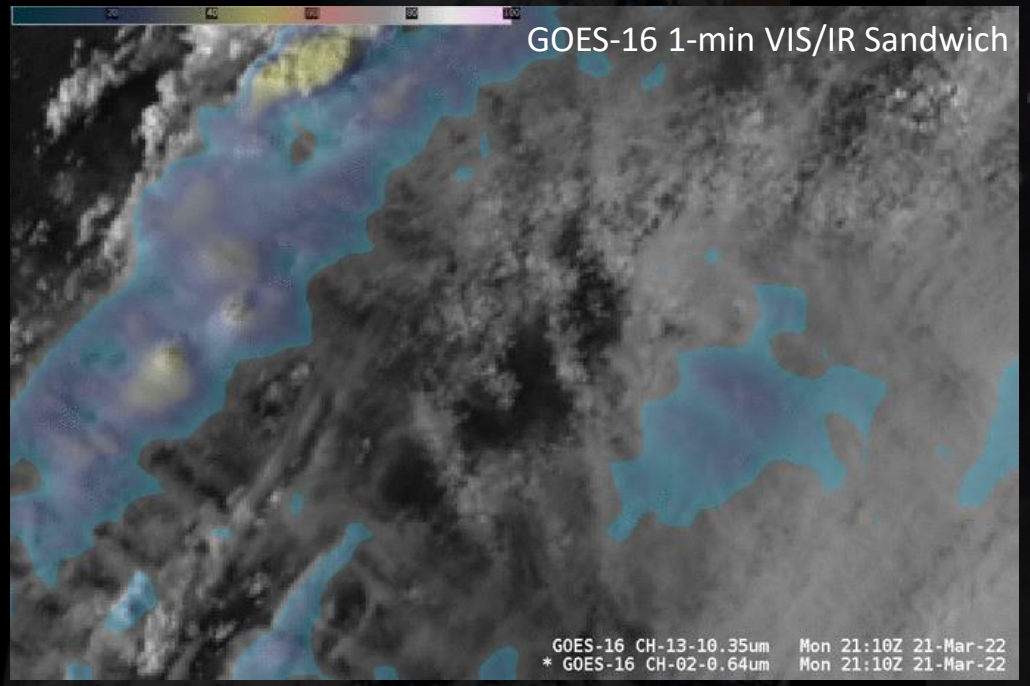


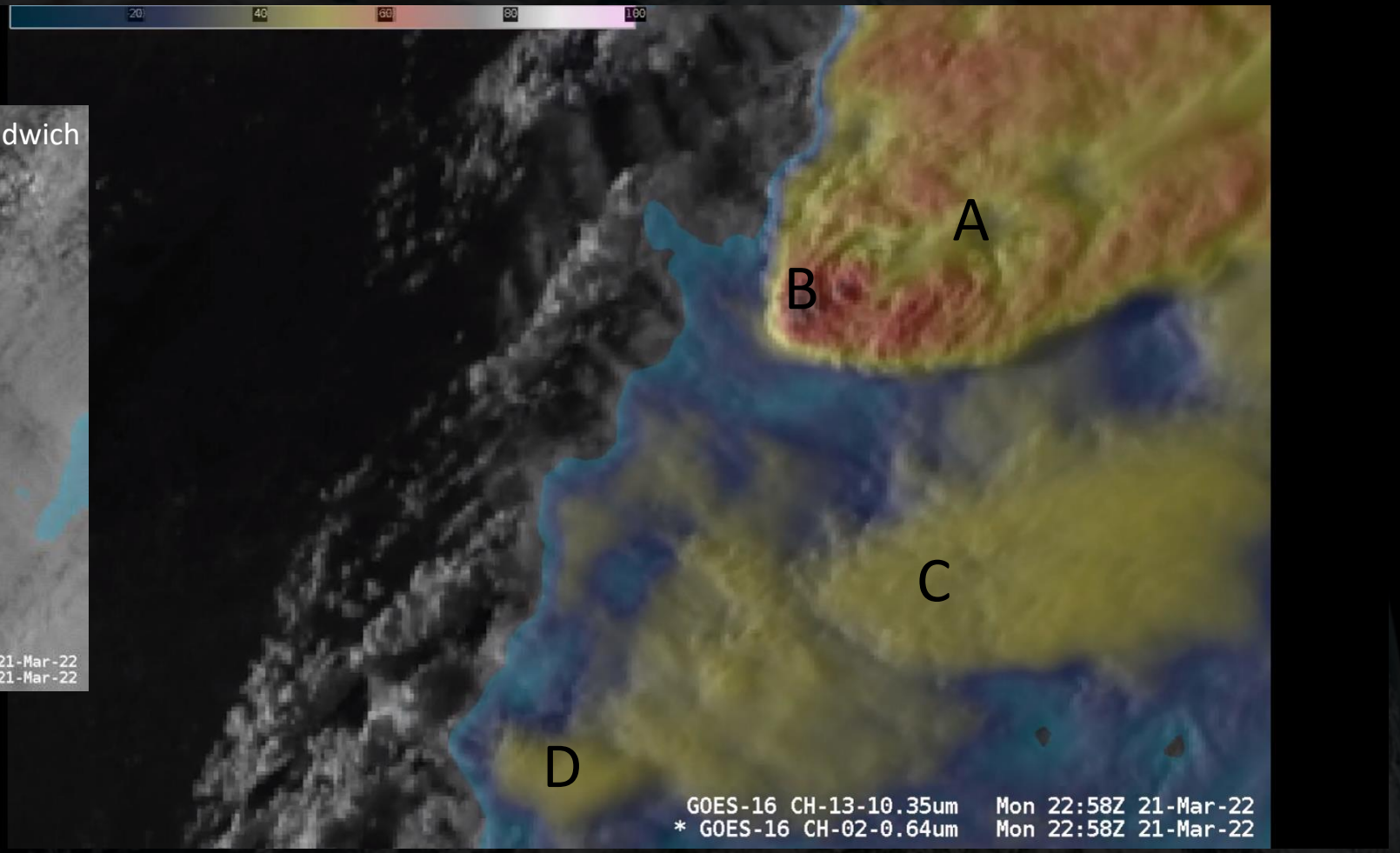
Pay attention to shadows as well





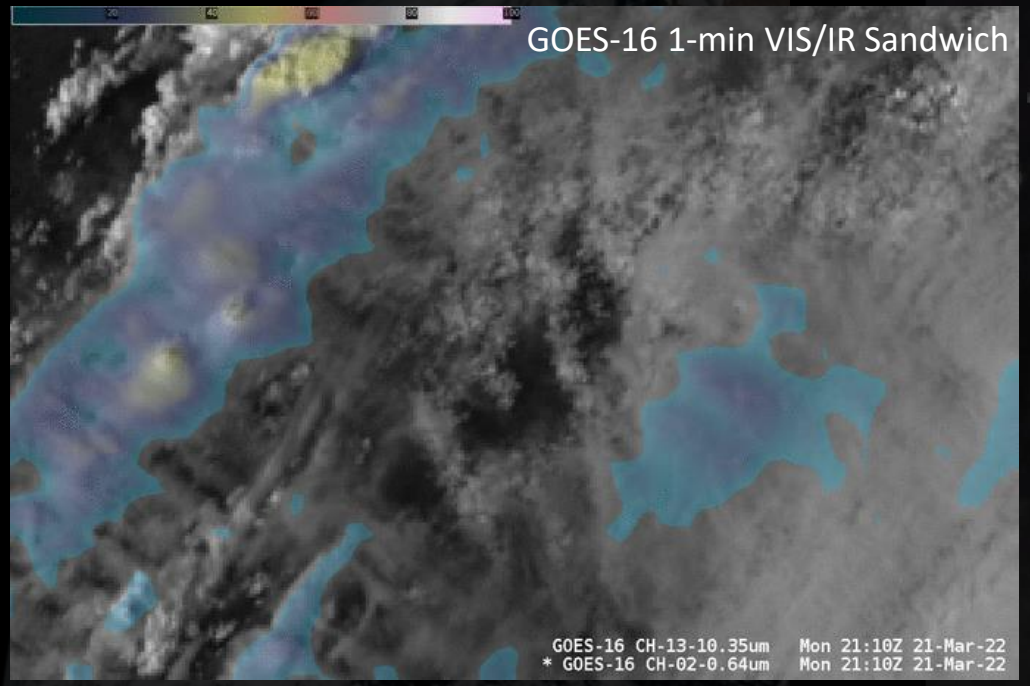
Where is the AACP?

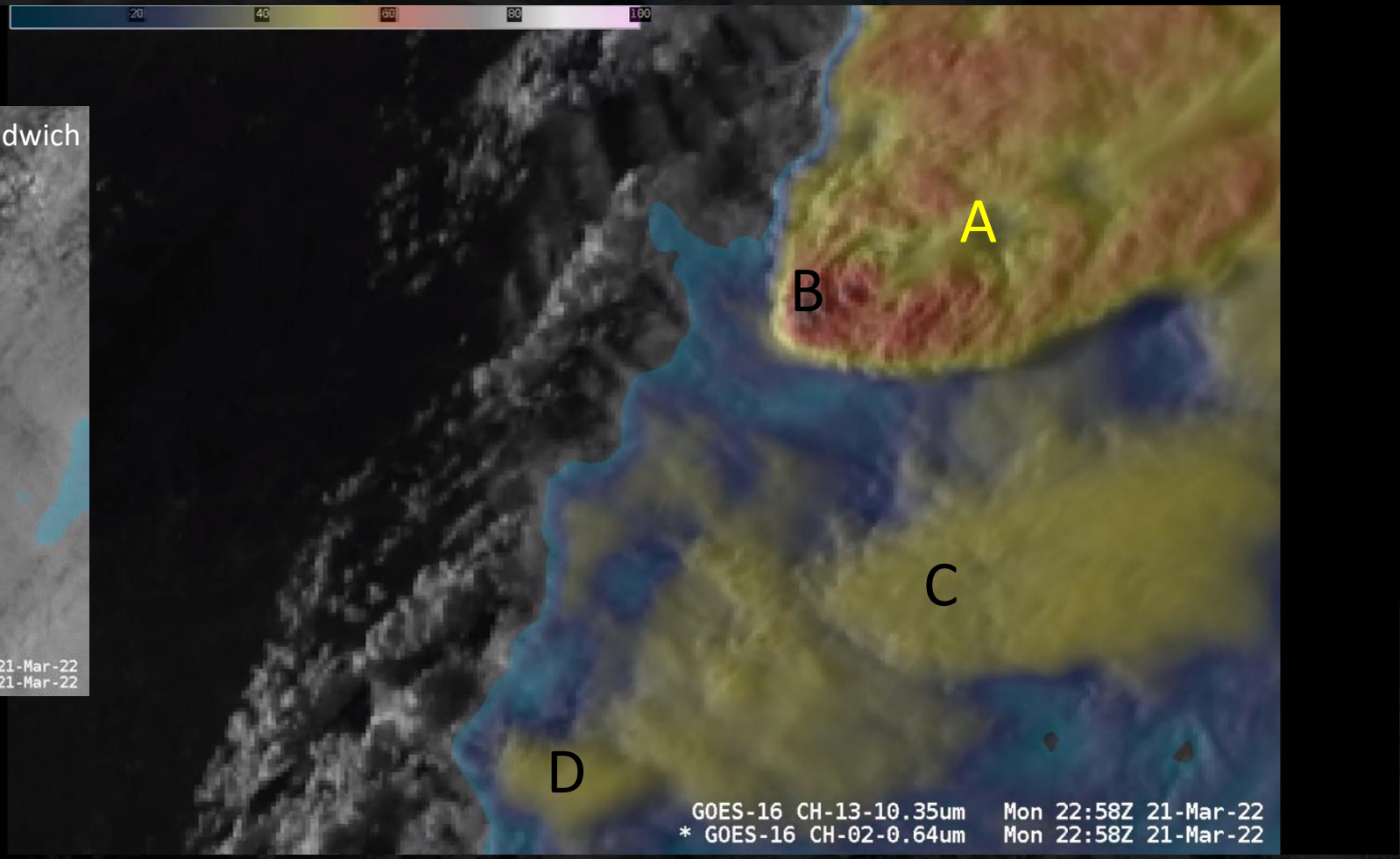




Q12

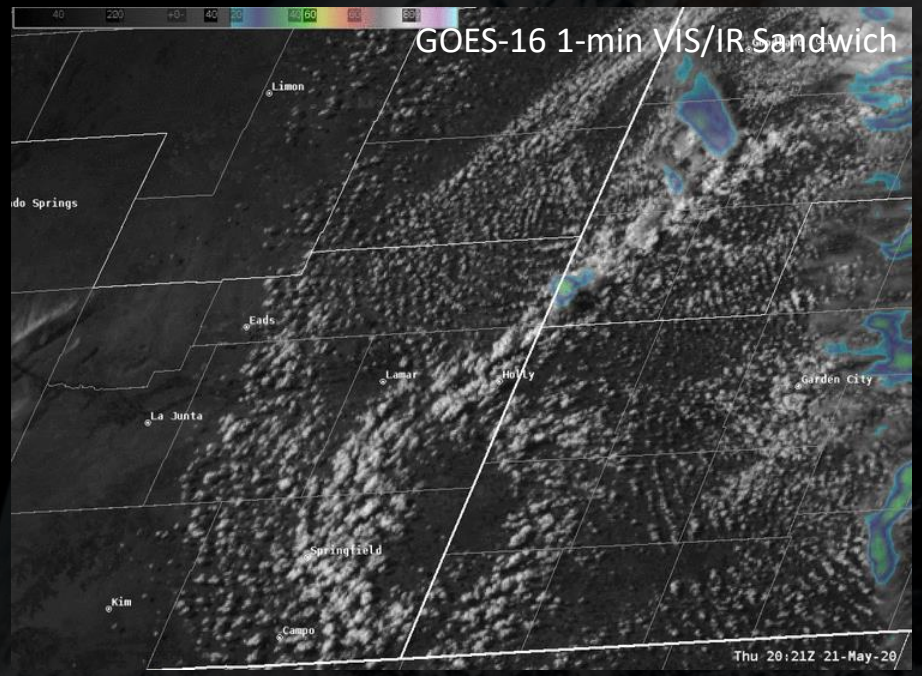
Where is the AACP?

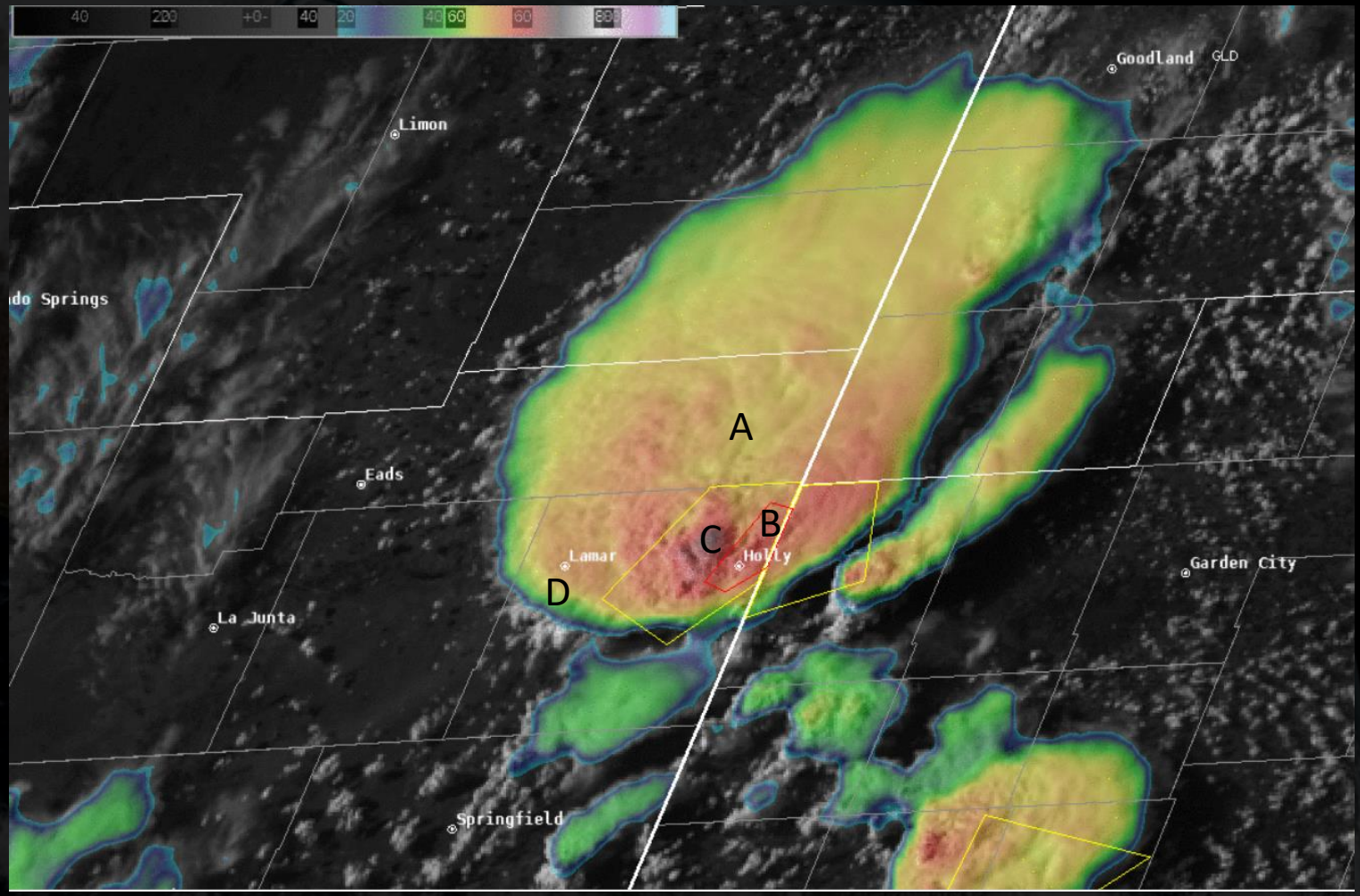




Q12 Answer

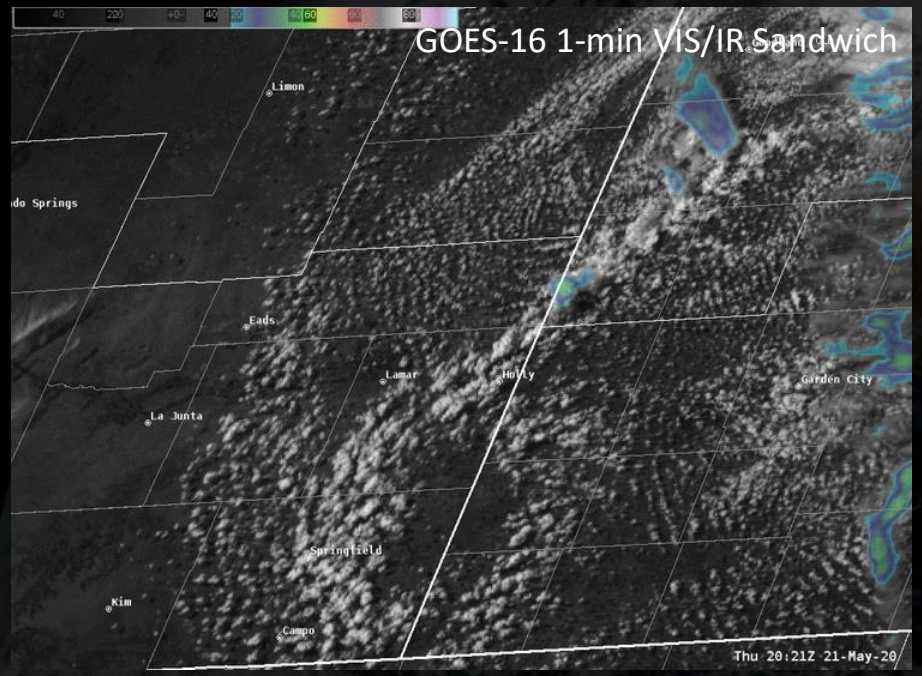
Where is the OT?

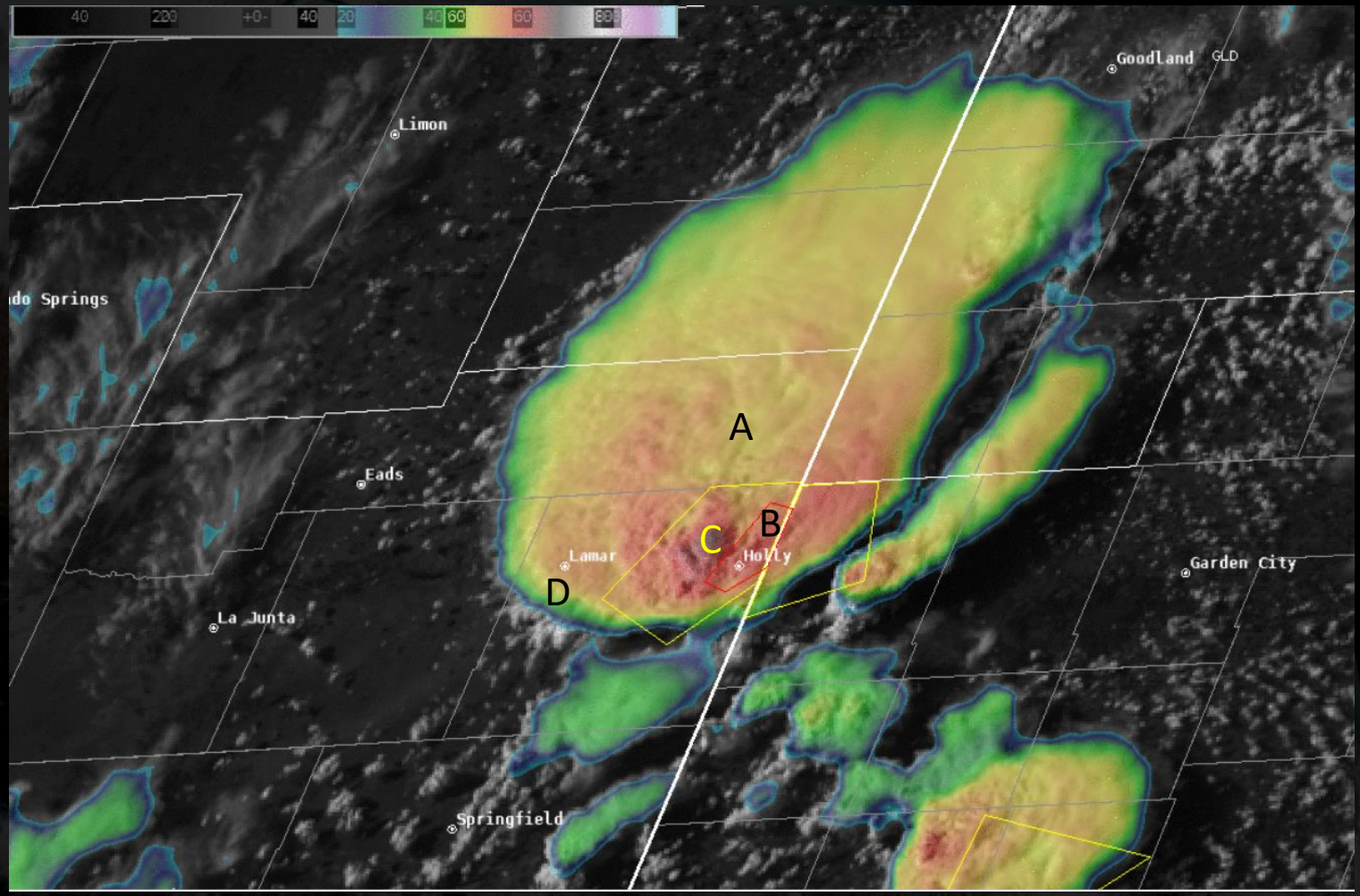




Q13

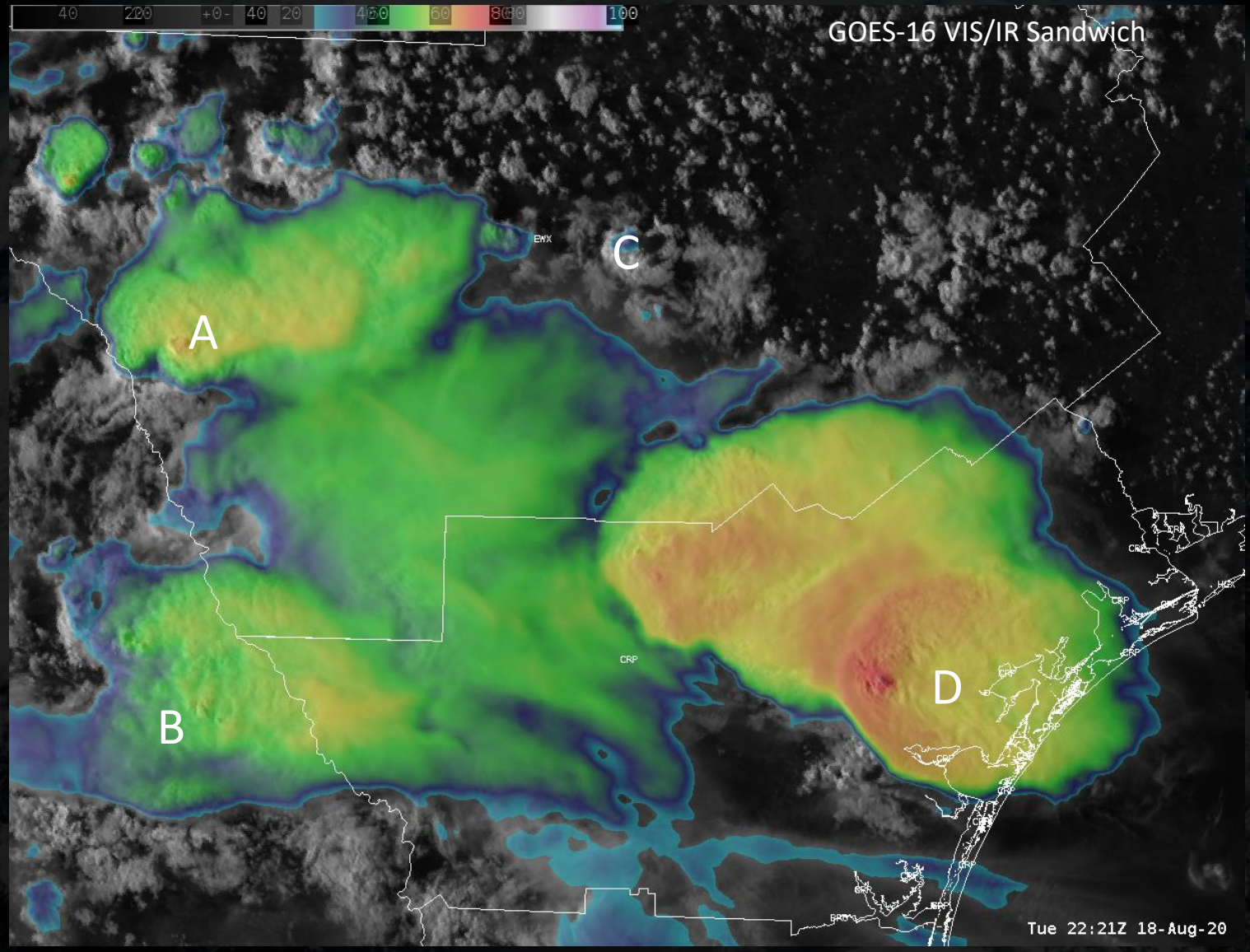
Where is the OT?





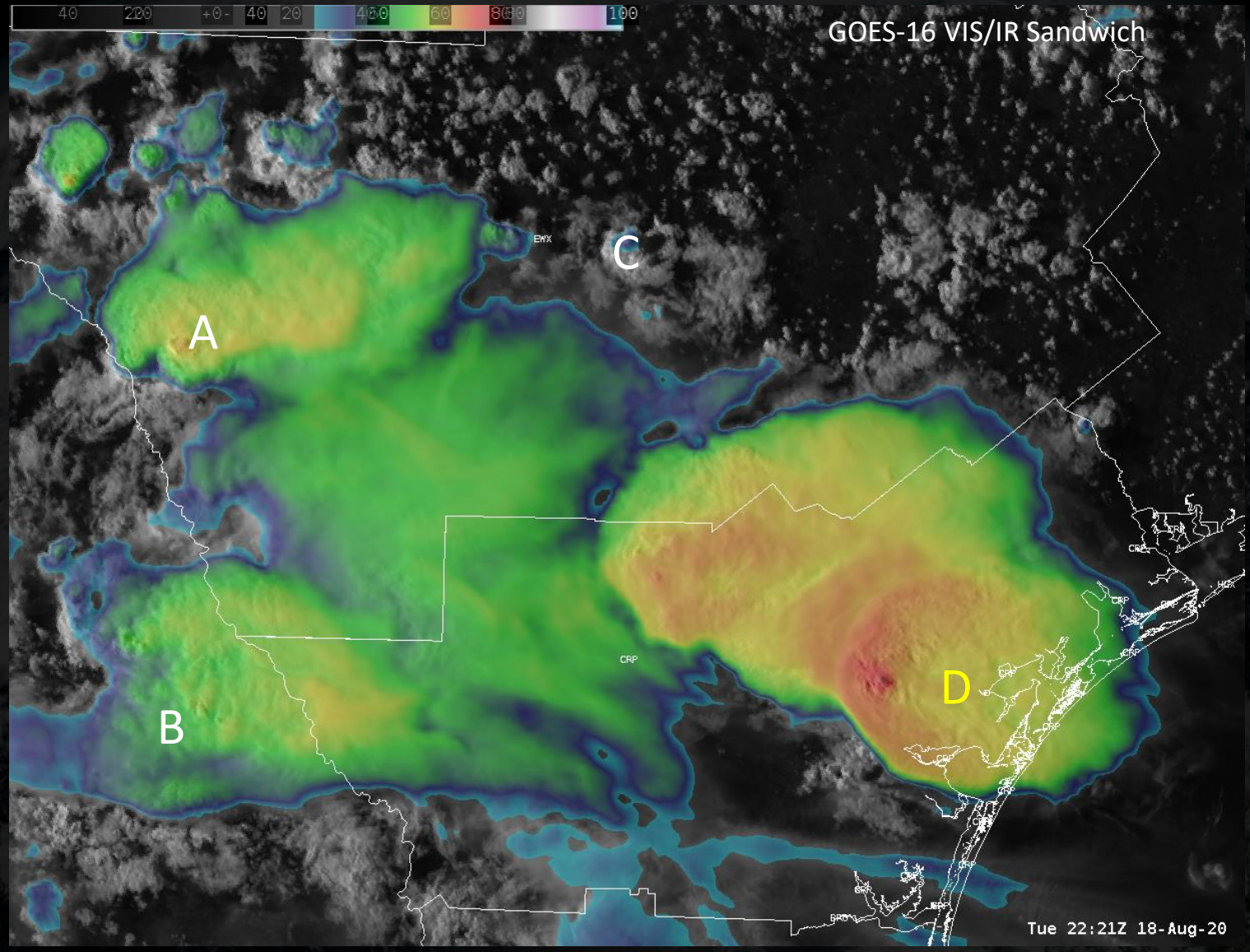
Q13 Answer

Which thunderstorm appears most intense?



Q14

Which thunderstorm appears most intense?



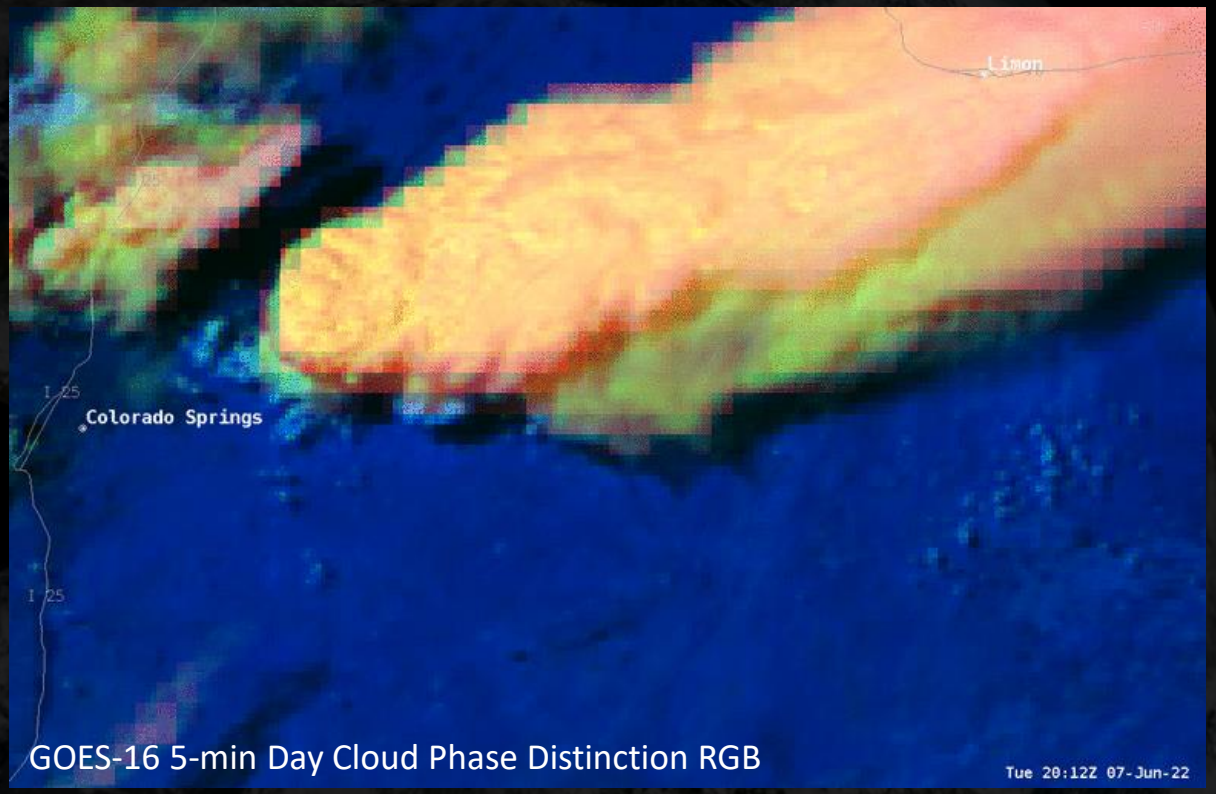
Q14 Answer

Hail Swaths

- Day Cloud Phase Distinction RGB
  - Hail at the surface appears like snow (Green)
    - Relatively warm (low red), low reflectance at 1.6 um (low blue), high reflectance at 0.64 um (high green)

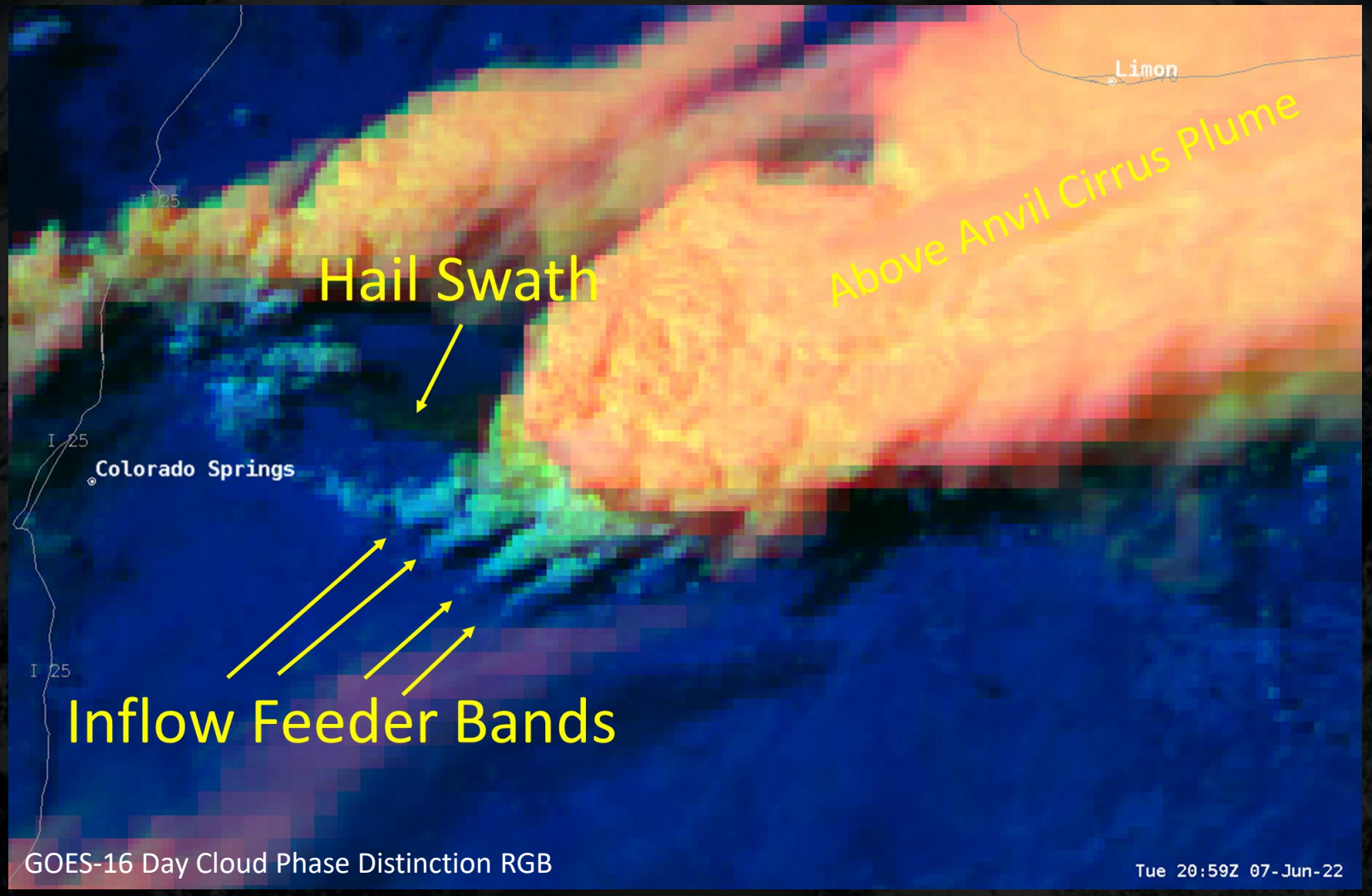
Band or band difference	RED	+	GREEN	+	BLUE	=	RGB IMAGE
	10.3 um Band "Clean Window IR"		0.64 um Band "Red Visible"		1.6 um Band "Snow/Ice"		
Min	7.5 K		0 %		1 %		
Max	-53.5 K		78 %		59 %		
Gamma	1.0		1.0		1.0		

GOES-East 1-min VIS



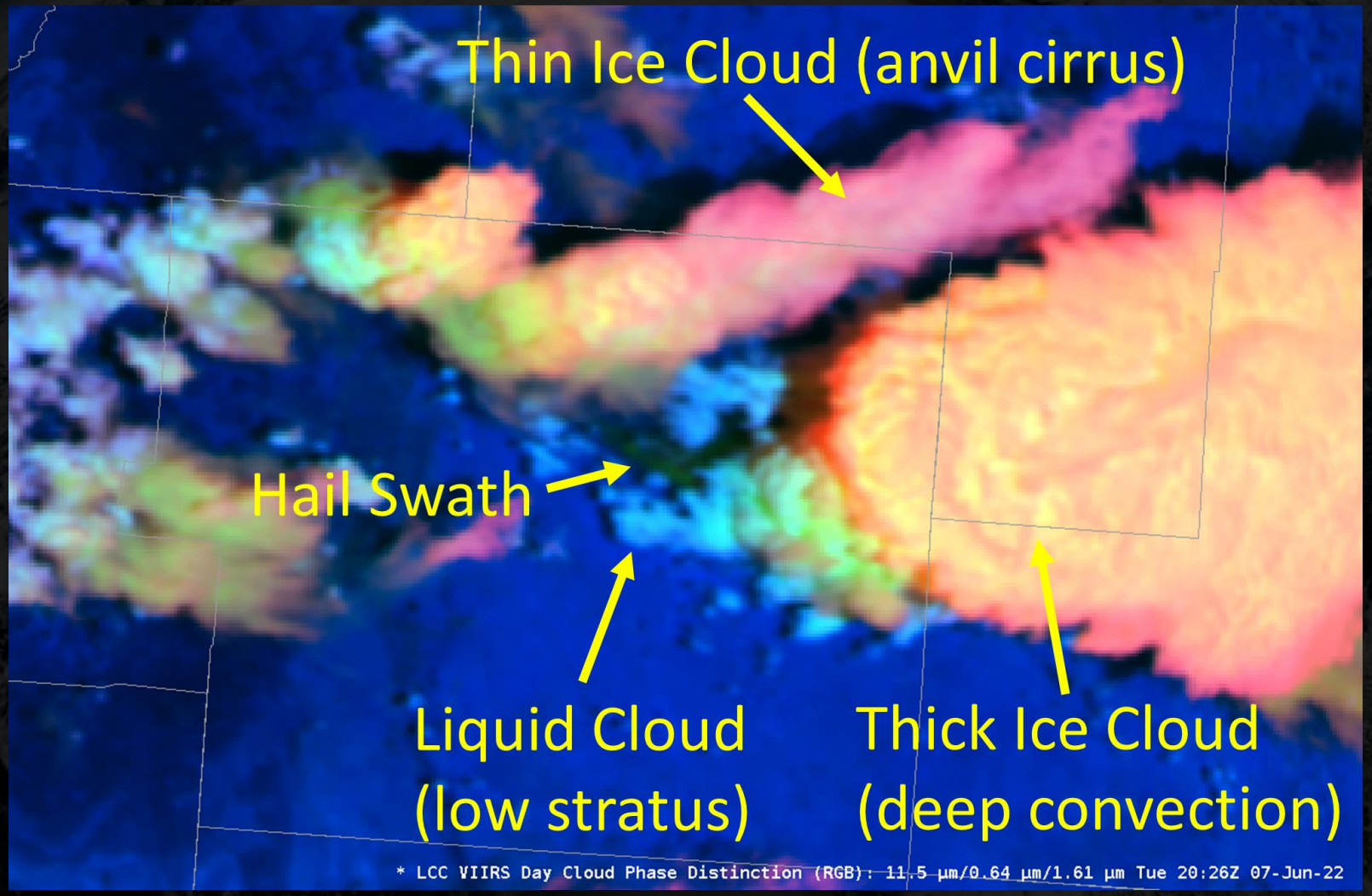
GOES-16 5-min Day Cloud Phase Distinction RGB

Hail Swaths and other Signatures



Hail Swaths

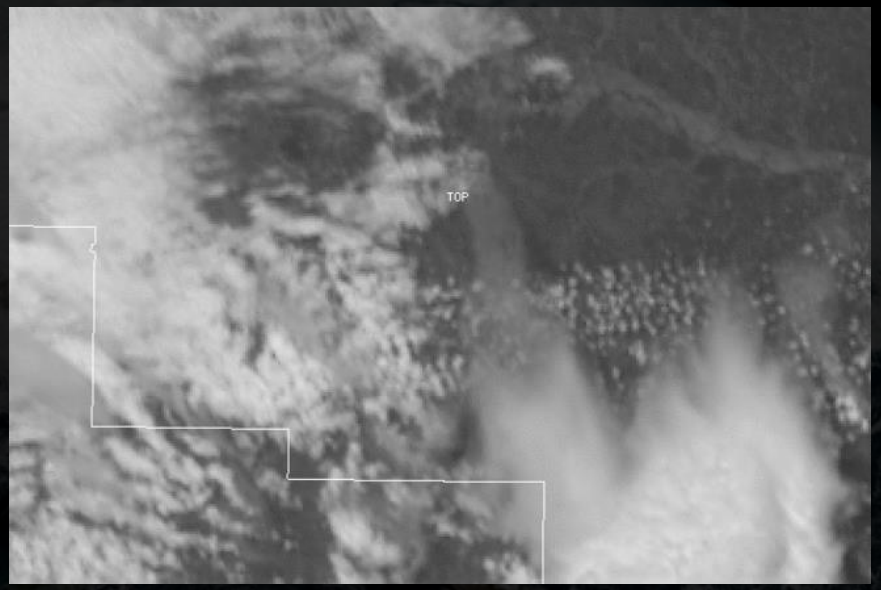
- VIIRS Day Cloud Phase Distinction RGB



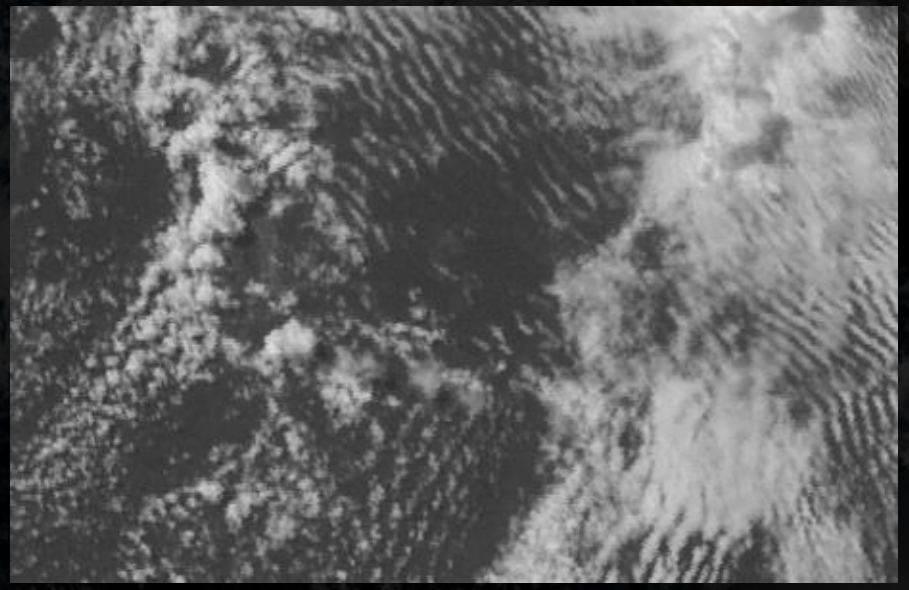
Which scene contains a thunderstorm that has a history of producing hail? Hint: Investigate at the path of the storm

A

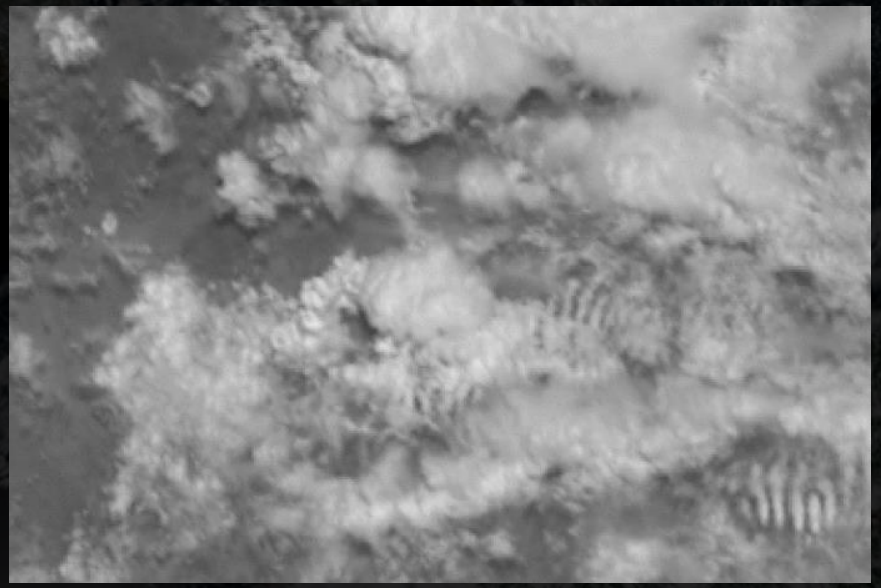
C



B



D

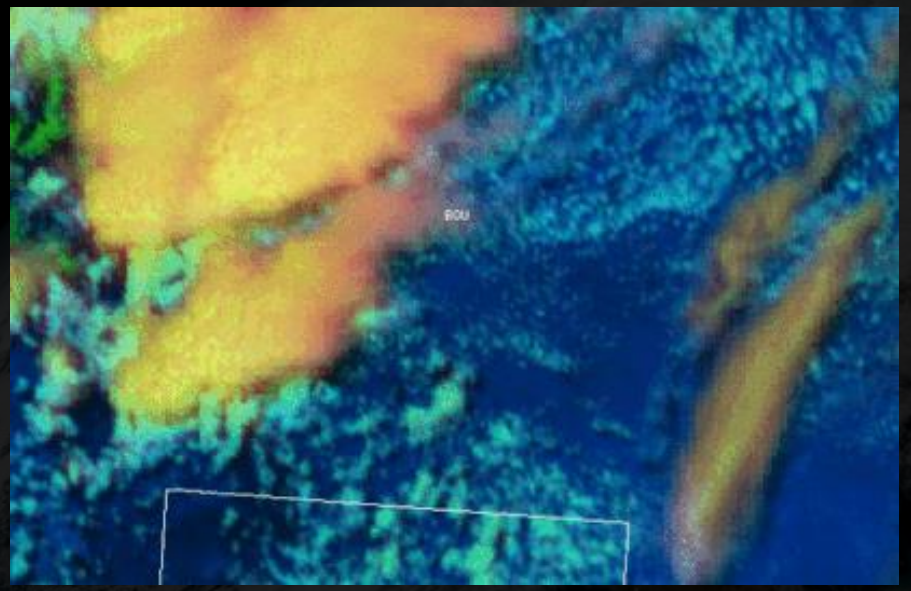


Q15

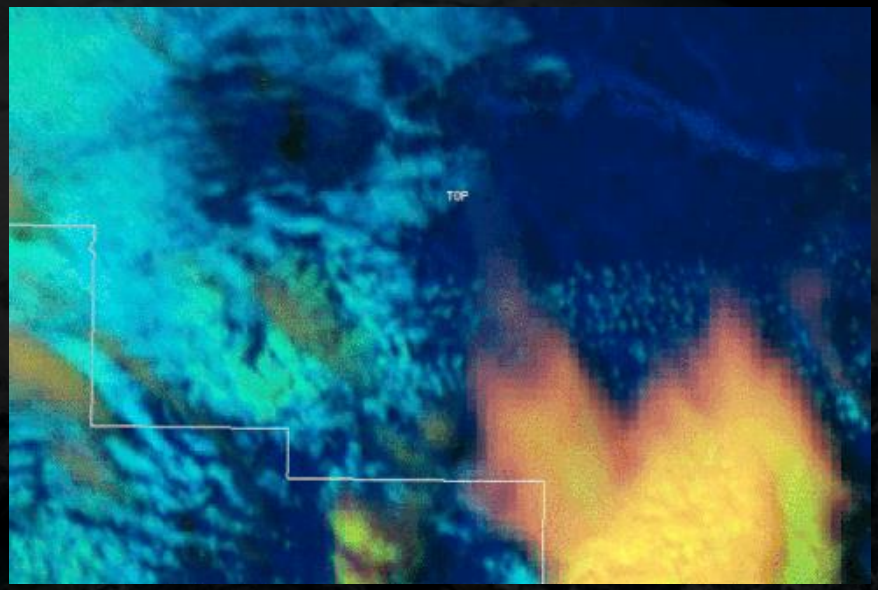
GOES-16 VIS

Which scene contains a thunderstorm that has a history of producing hail? Hint: Investigate at the path of the storm

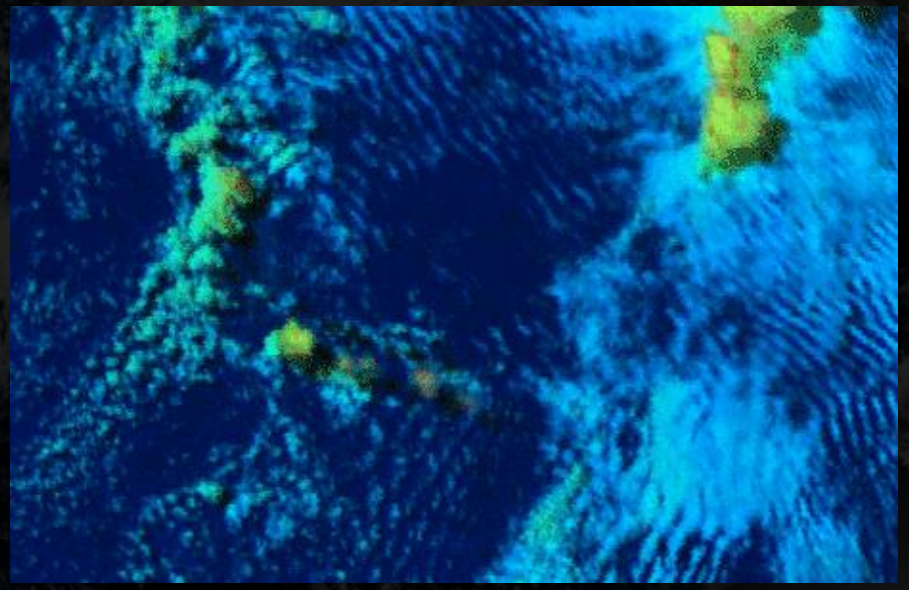
A



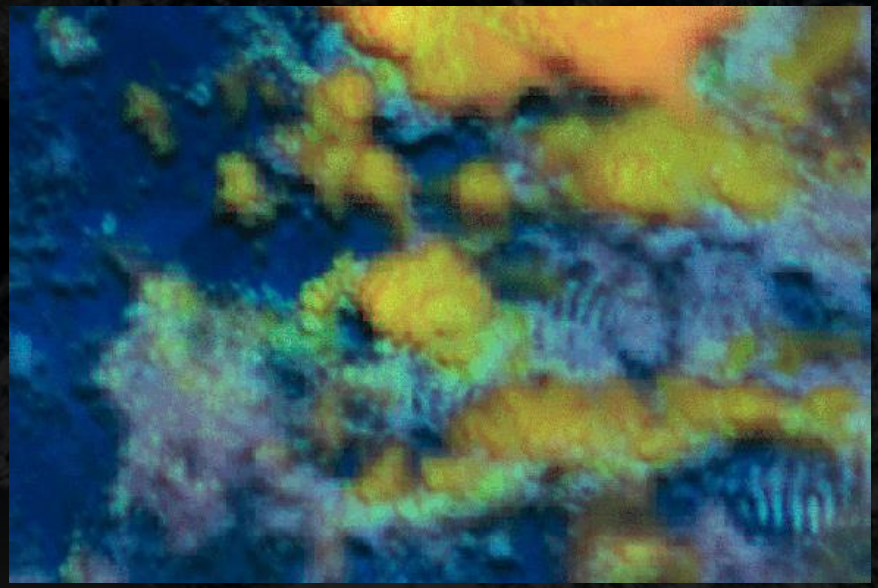
C



B



D

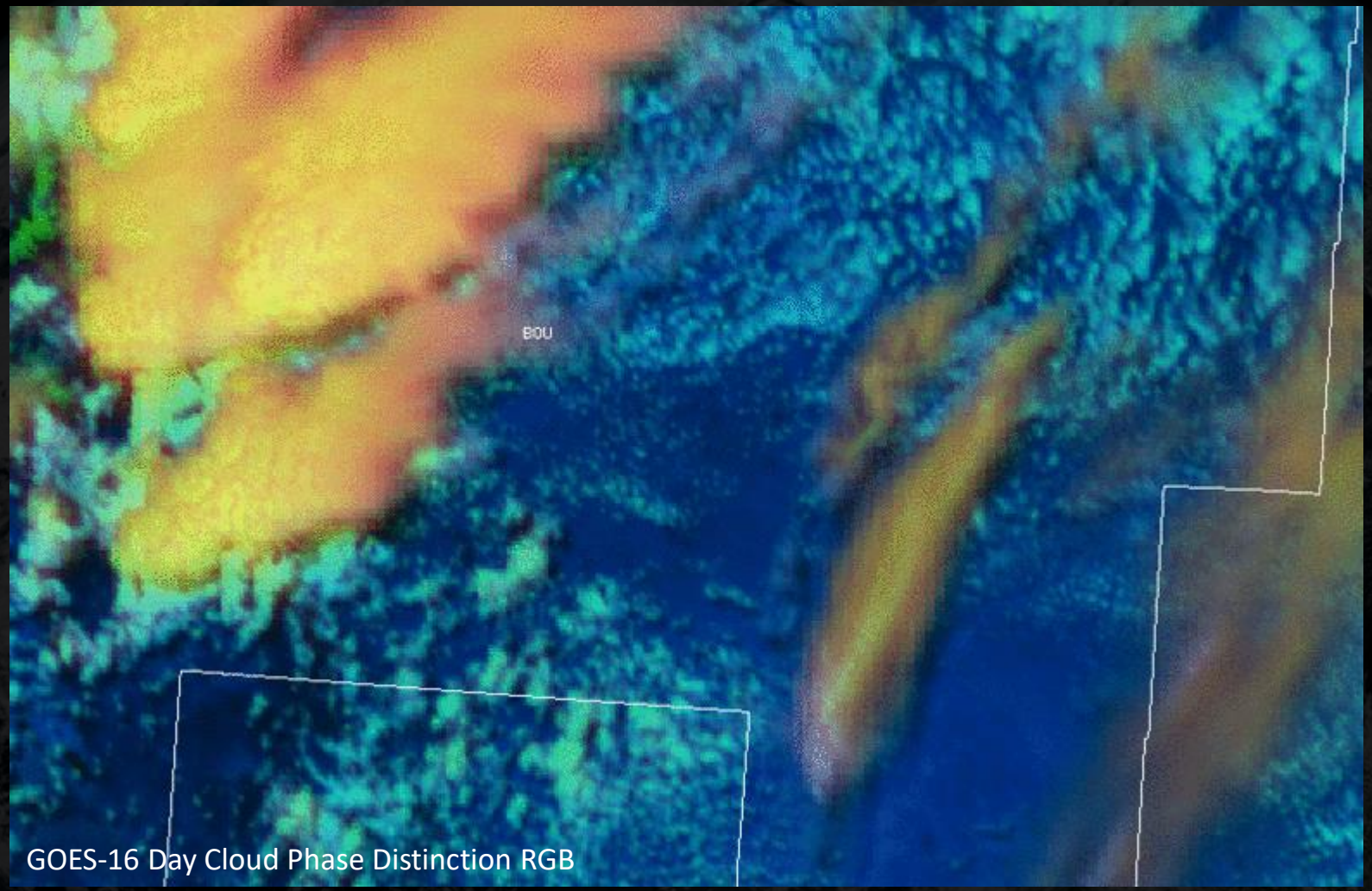


Q16

GOES-16 DCPD RGB

Which scene contains a thunderstorm that has a history of producing hail? Hint: Investigate at the path of the storm

A



GOES-16 Day Cloud Phase Distinction RGB

Q15+16 Answer

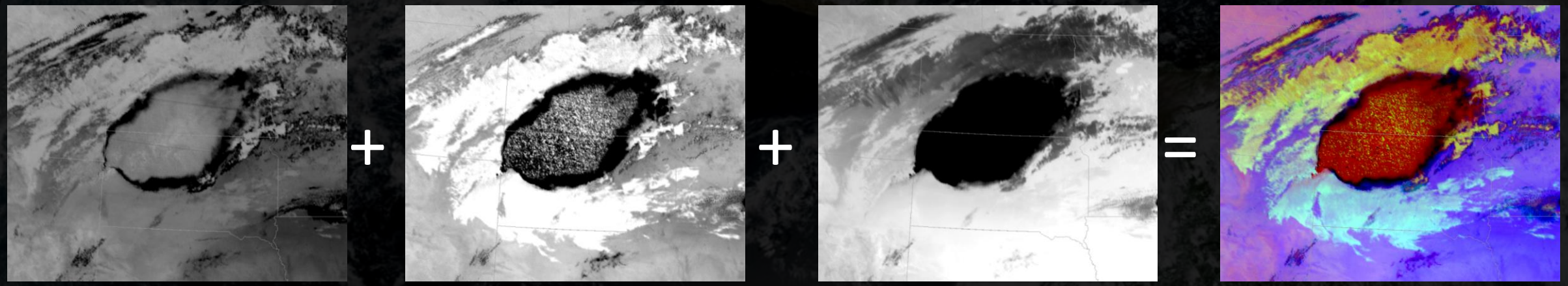
Nighttime Convective Analysis

- Focus is on satellite products today. In reality, satellite used in concert with:
  - NWP, radar, lightning, UA, surface obs, webcams, human obs, etc
- Pre-convective Environment
  - Water Vapor Imagery Analysis
  - Split Window Difference
  - Derived Products – CAPE and TPW
  - Derived Motion Winds
  - NUCAPS
- Cumulus Cloud Field Analysis and Convective Initiation
  - VIS and IR imagery
  - Day Cloud Phase Distinction RGB
- Mature Convective Analysis
  - VIS and IR imagery
  - VIS/IR Sandwich Imagery
- Nighttime Convective Analysis
  - Nighttime Microphysics RGB
  - IR

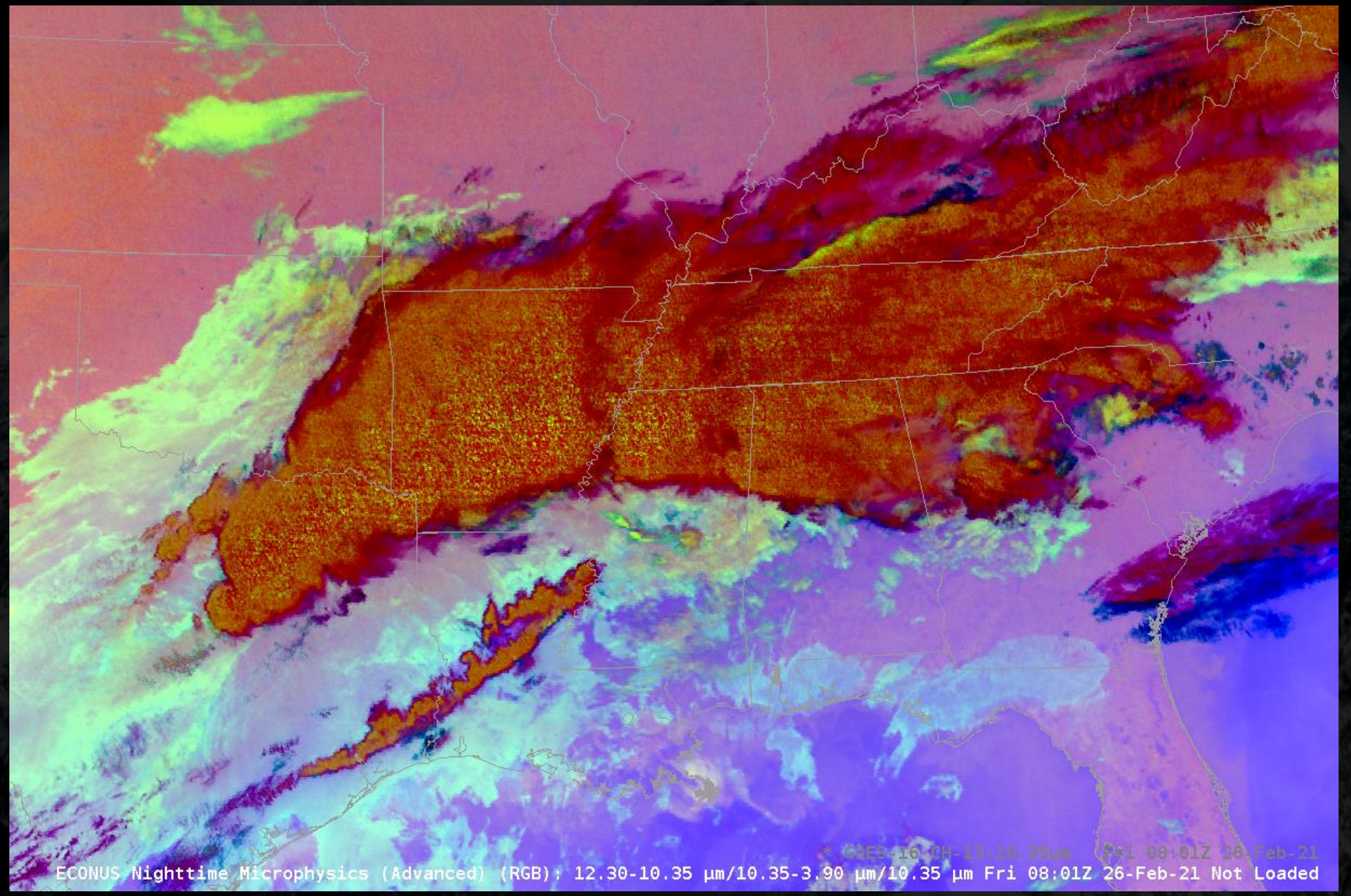
Nighttime Microphysics RGB

- Use: Diagnose regions of most imminent convective initiation overnight
- Quick Guide

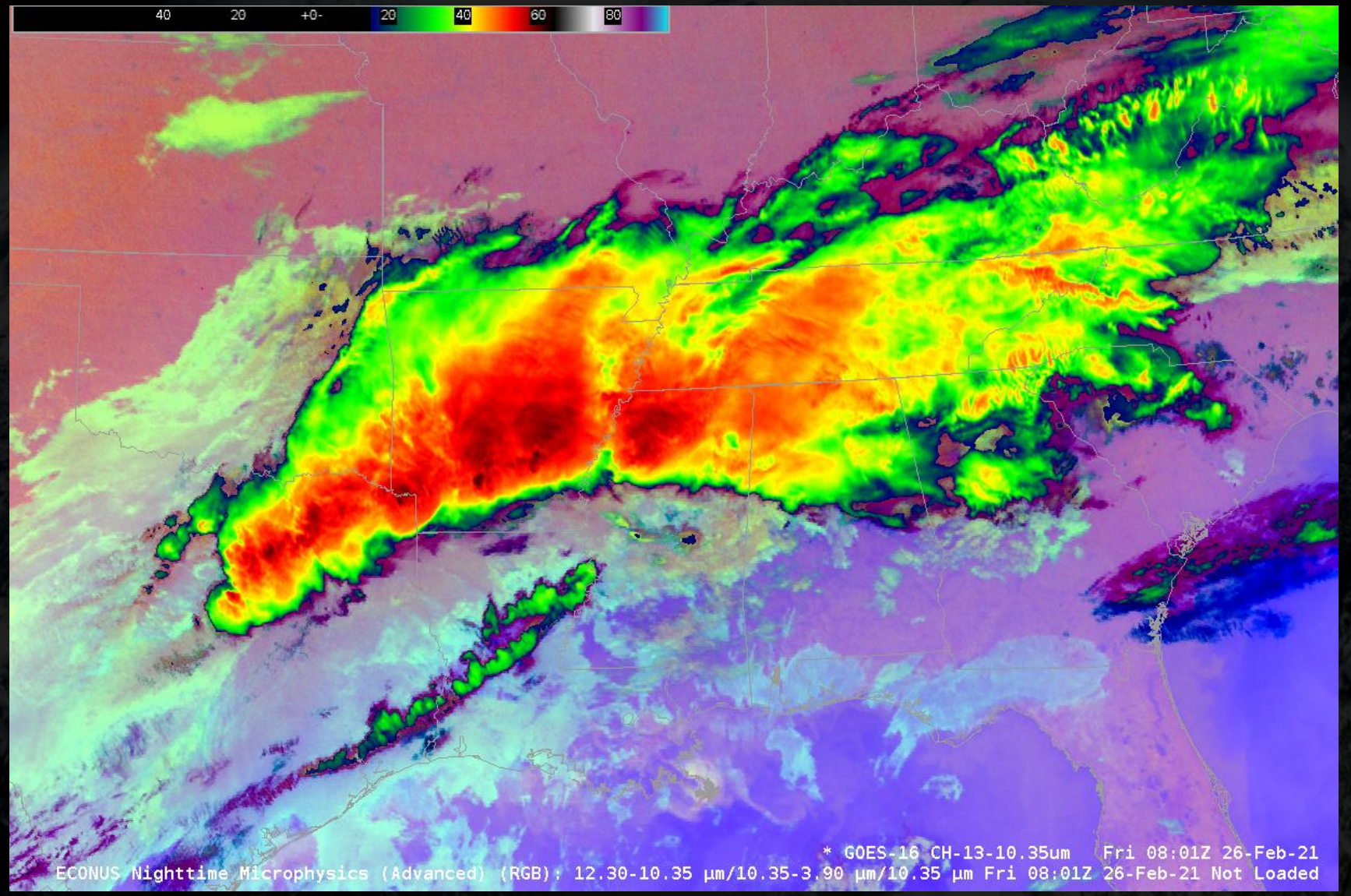
Band or band difference	RED 12.3 – 10.3 um "Split Window Diff"	+	GREEN 10.3 – 3.9 um "Fog Diff"	+	BLUE 10.3 um Band "Clean Window IR"	=	RGB IMAGE
Min	-6.7 K		-3.1 K		-29.5 K		
Max	2.6 K		5.2 K		19.5 K		
Gamma	1.0		1.0		1.0		



Nighttime Microphysics RGB – IRW Overlay

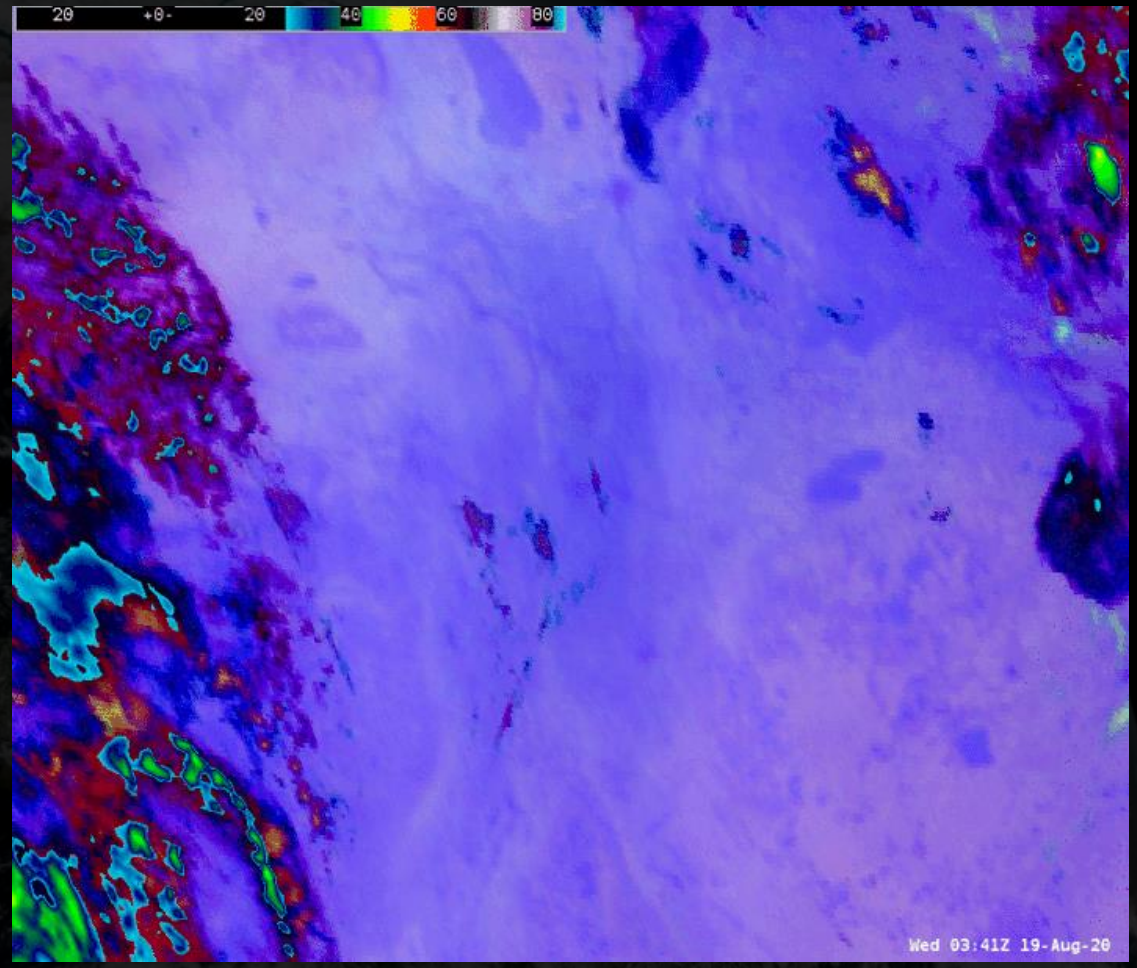


Nighttime Microphysics RGB – IRW Overlay



Nighttime Microphysics RGB – CI

Band or band difference	RED 12.3 – 10.3 um "Split Window Diff"	+ GREEN 10.3 – 3.9 um "Fog Diff"	+ BLUE 10.3 um Band "Clean Window IR"	= RGB IMAGE
Min	-6.7 K	-3.1 K	-29.5 K	
Max	2.6 K	5.2 K	19.5 K	
Gamma	1.0	1.0	1.0	



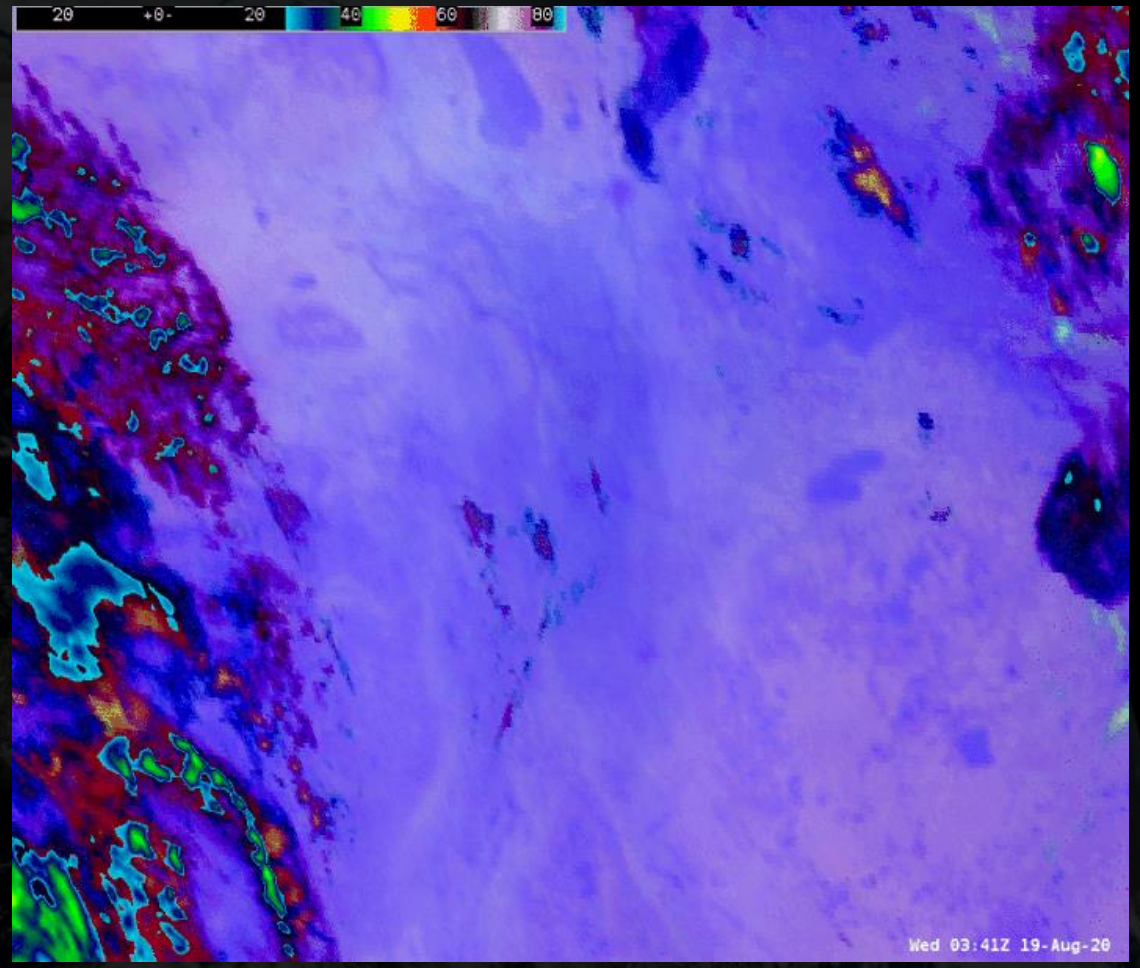
Convective Initiation:

Liquid cloud dev = adding green

Blue => Pale Cyan

Nighttime Microphysics RGB – CI

Band or band difference	RED 12.3 – 10.3 um "Split Window Diff"	+ GREEN 10.3 – 3.9 um "Fog Diff"	+ BLUE 10.3 um Band "Clean Window IR"	= RGB IMAGE
Min	-6.7 K	-3.1 K	-29.5 K	
Max	2.6 K	5.2 K	19.5 K	
Gamma	1.0	1.0	1.0	



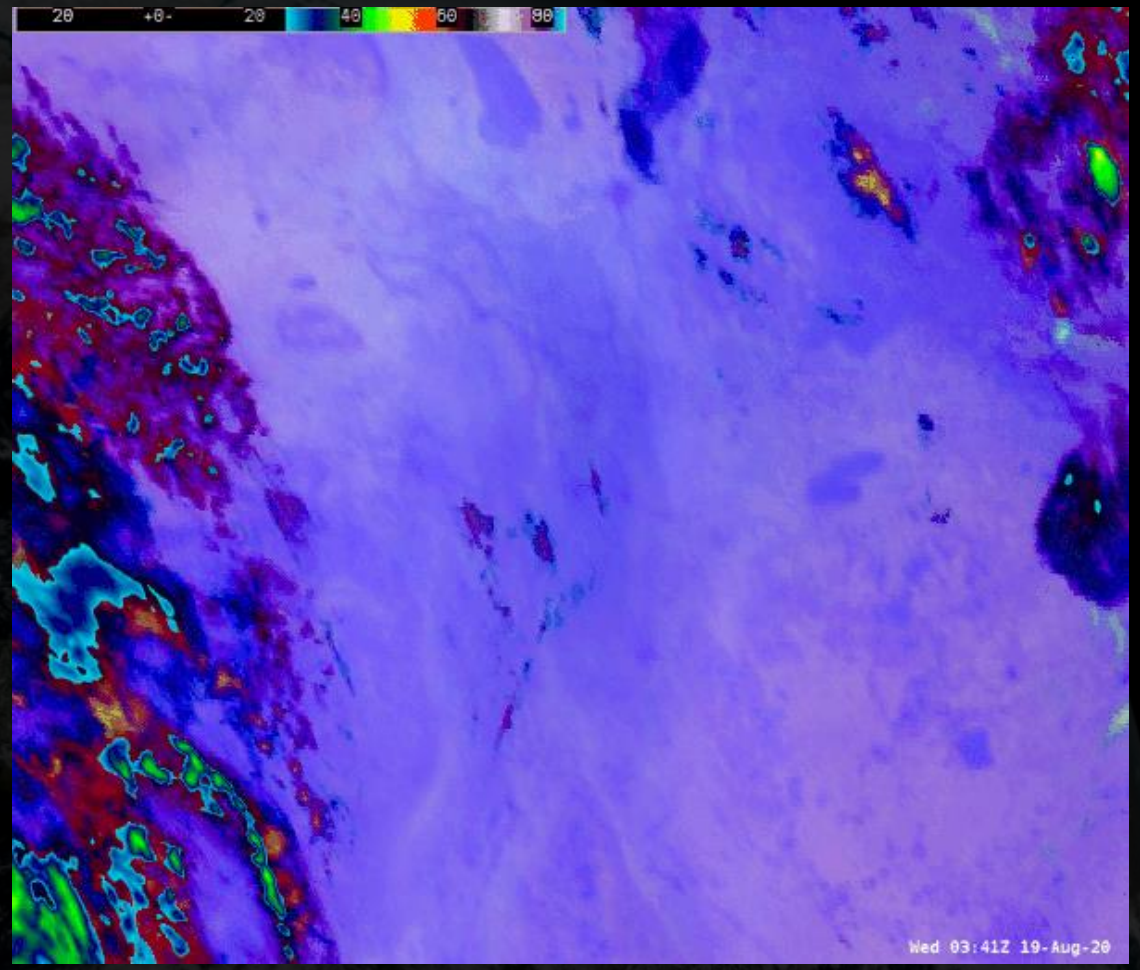
Convective Initiation:

Liquid cloud dev = adding green glaciation/cooling = losing green/losing blue

Blue => Pale Cyan => Red

Nighttime Microphysics RGB – CI

Band or band difference	RED 12.3 – 10.3 um "Split Window Diff"	+ GREEN 10.3 – 3.9 um "Fog Diff"	+ BLUE 10.3 um Band "Clean Window IR"	= RGB IMAGE
Min	-6.7 K	-3.1 K	-29.5 K	
Max	2.6 K	5.2 K	19.5 K	
Gamma	1.0	1.0	1.0	



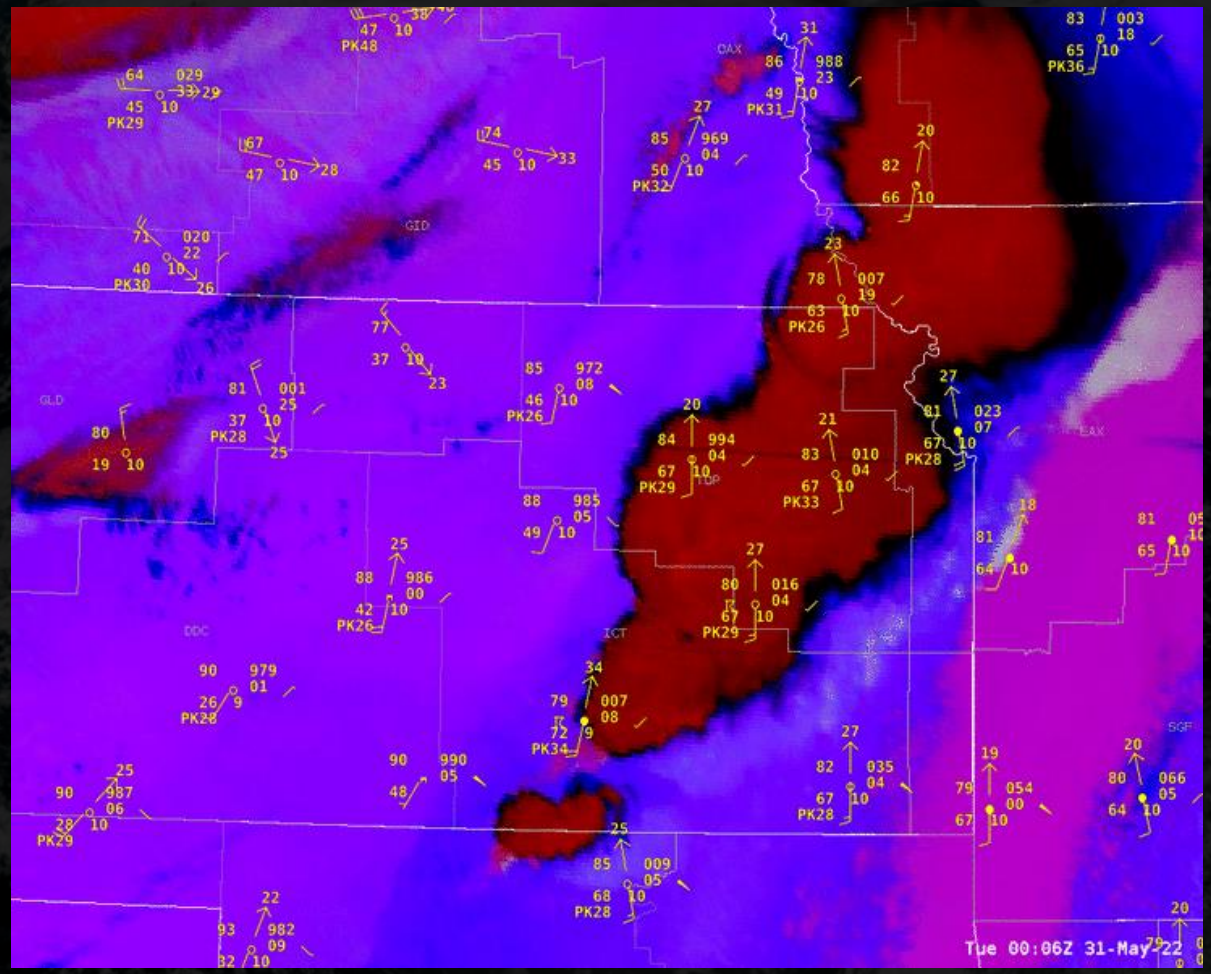
Convective Initiation:

Liquid cloud dev = adding green glaciation/cooling = losing green/losing blue Continued Cooling

Blue => Pale Cyan => Red => IRW Overlay

Nighttime Boundary Collision

- GOES-East Nighttime Microphysics RGB



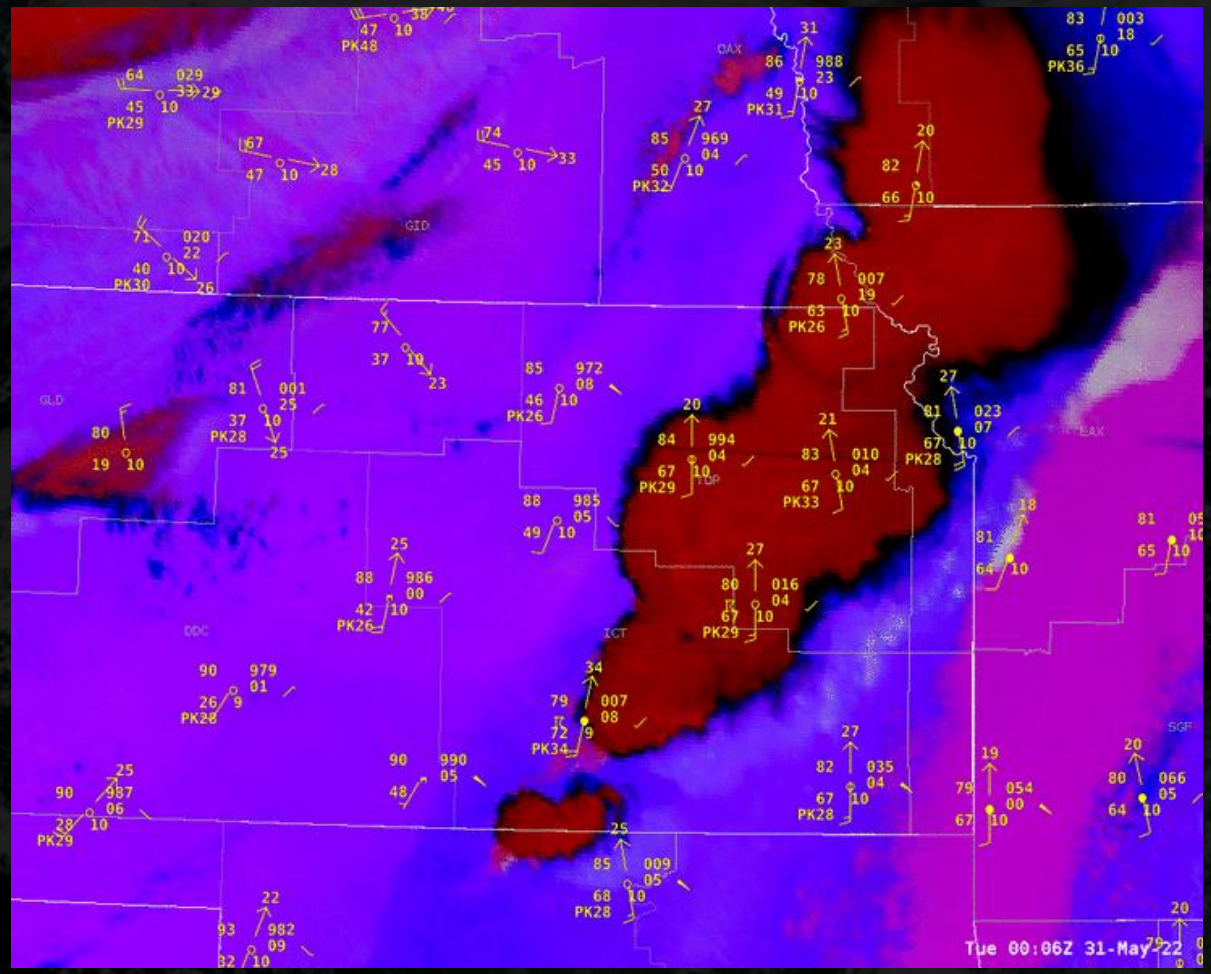
Convective Initiation:

Liquid cloud dev = adding green glaciation/cooling = losing green/losing blue Continued Cooling

Blue => Pale Cyan => Red => IRW Overlay

Nighttime Boundary Collision

- GOES-East Nighttime Microphysics RGB

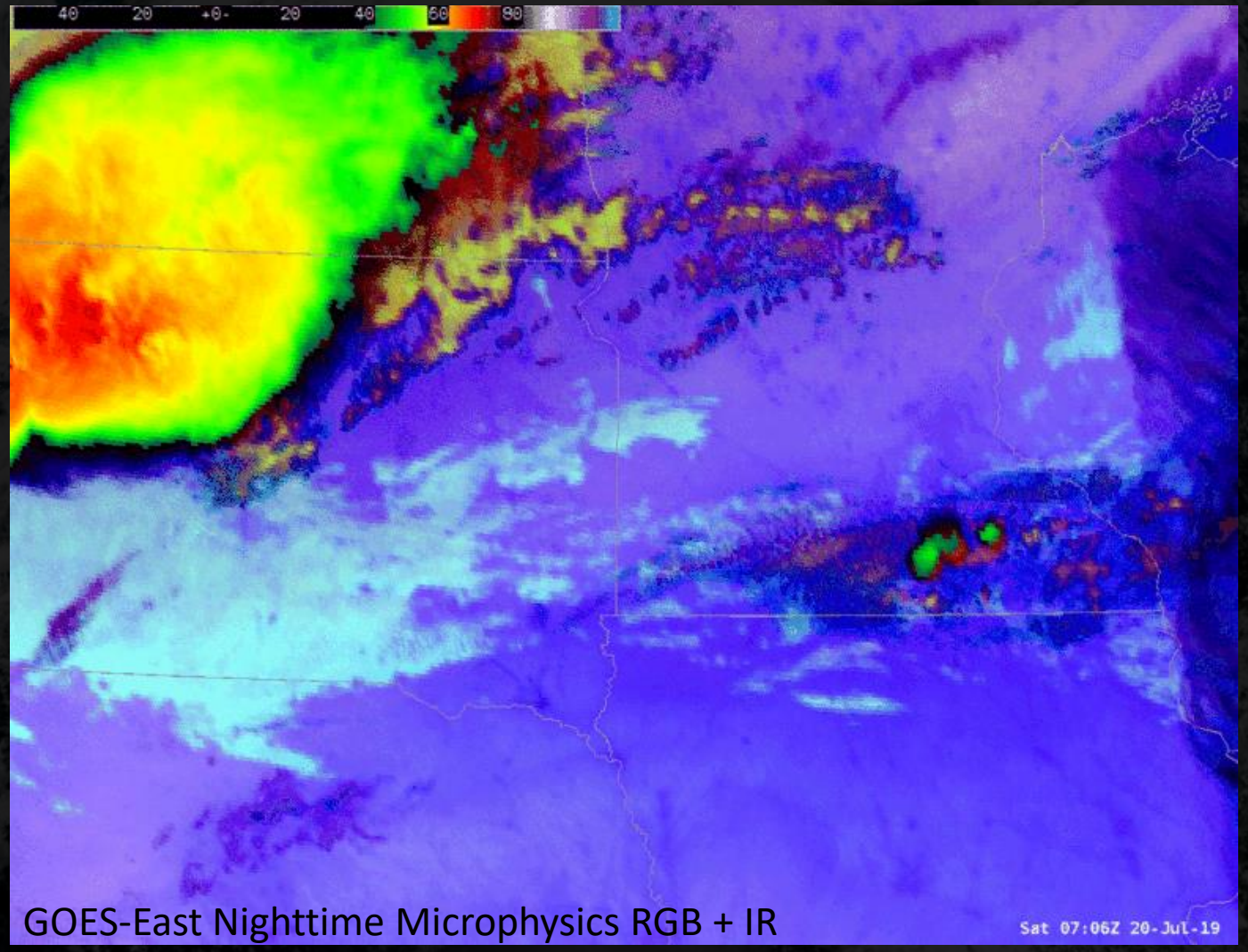


Convective Initiation:

Liquid cloud dev = adding green glaciation/cooling = losing green/losing blue Continued Cooling

Blue => Pale Cyan => Red => IRW Overlay

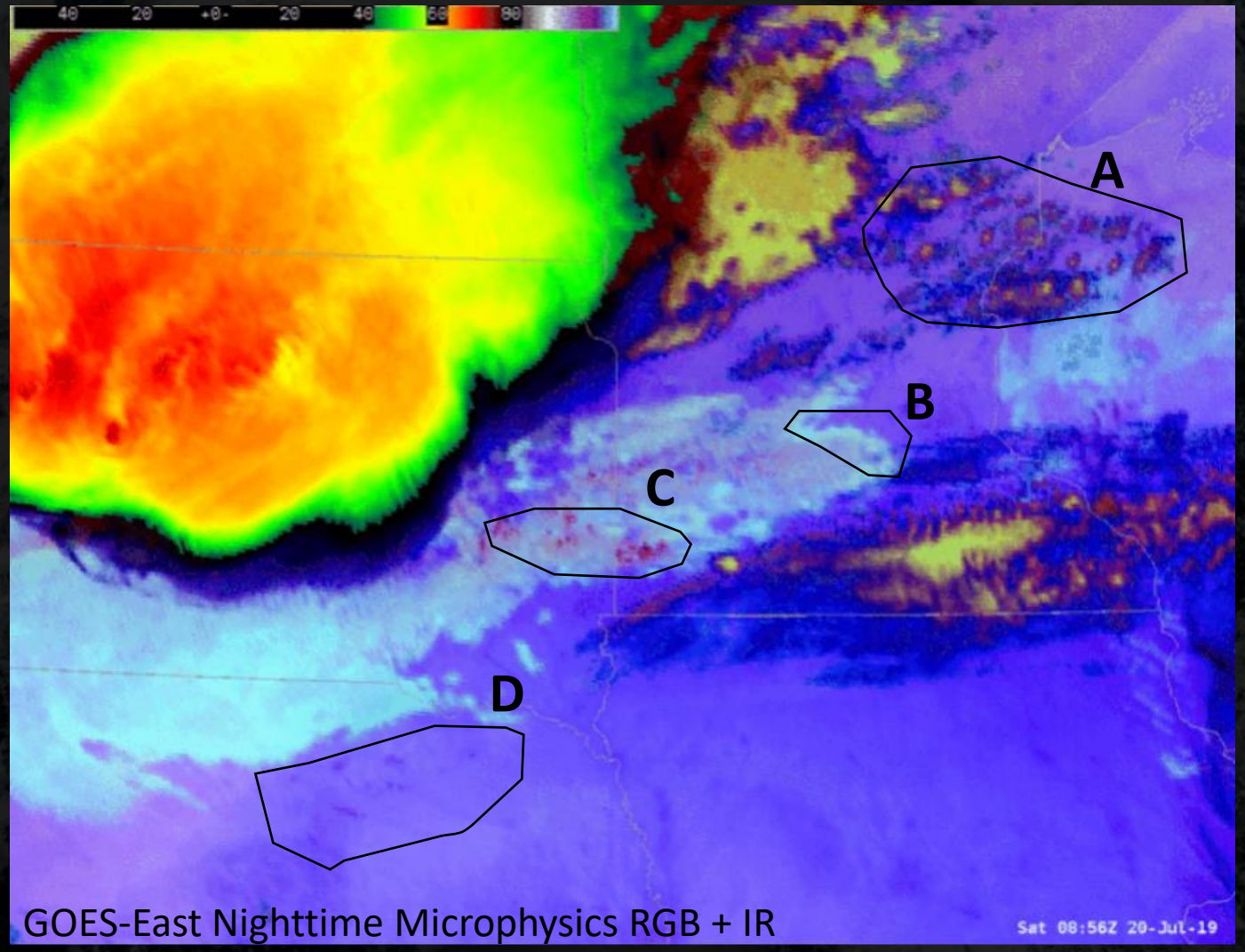
Where is CI most imminent (nighttime)?



GOES-East Nighttime Microphysics RGB + IR

Q17

Where is CI most imminent (nighttime)?



GOES-East Nighttime Microphysics RGB + IR

Q17

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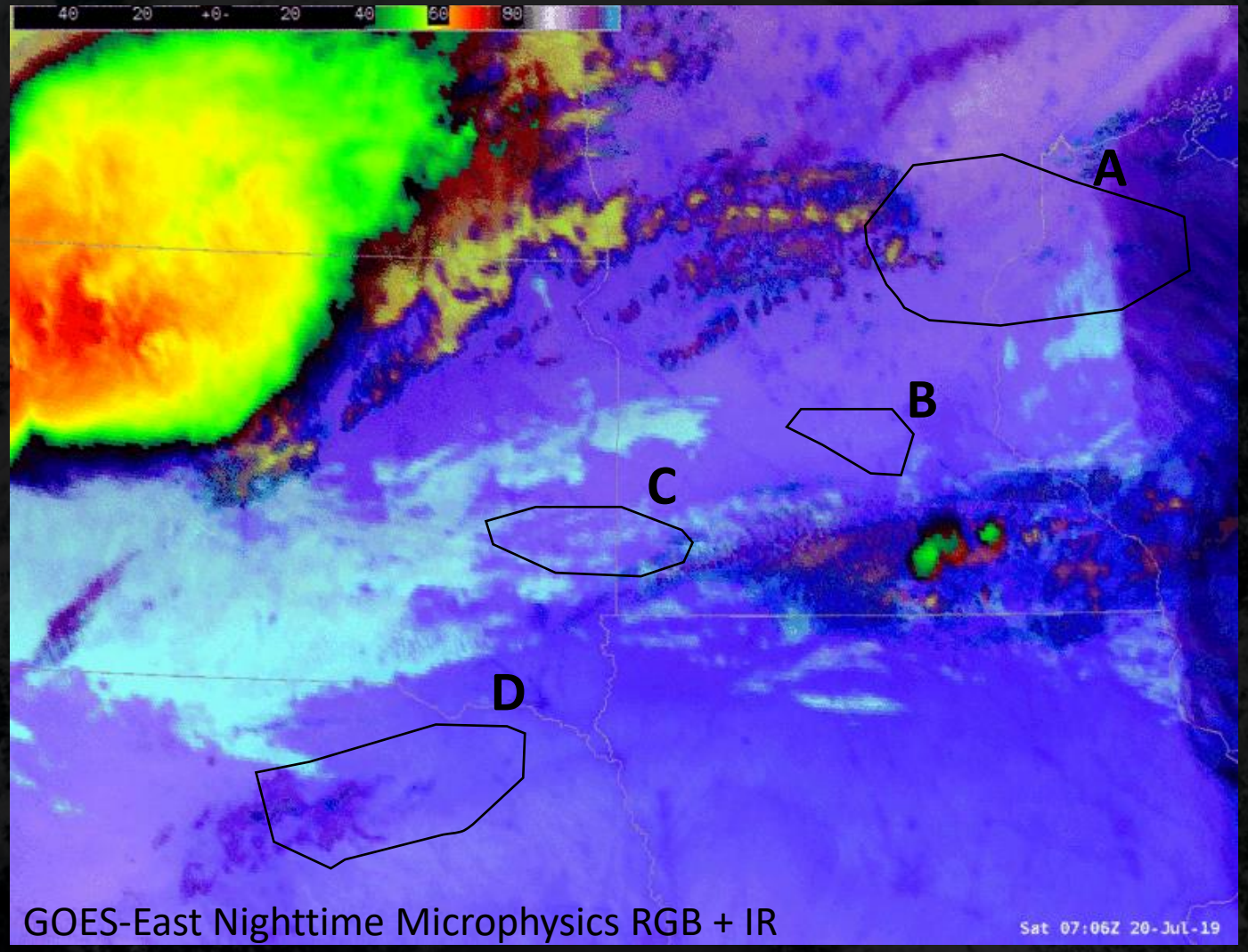

GOES-East Nighttime Microphysics RGB + IR

Q17

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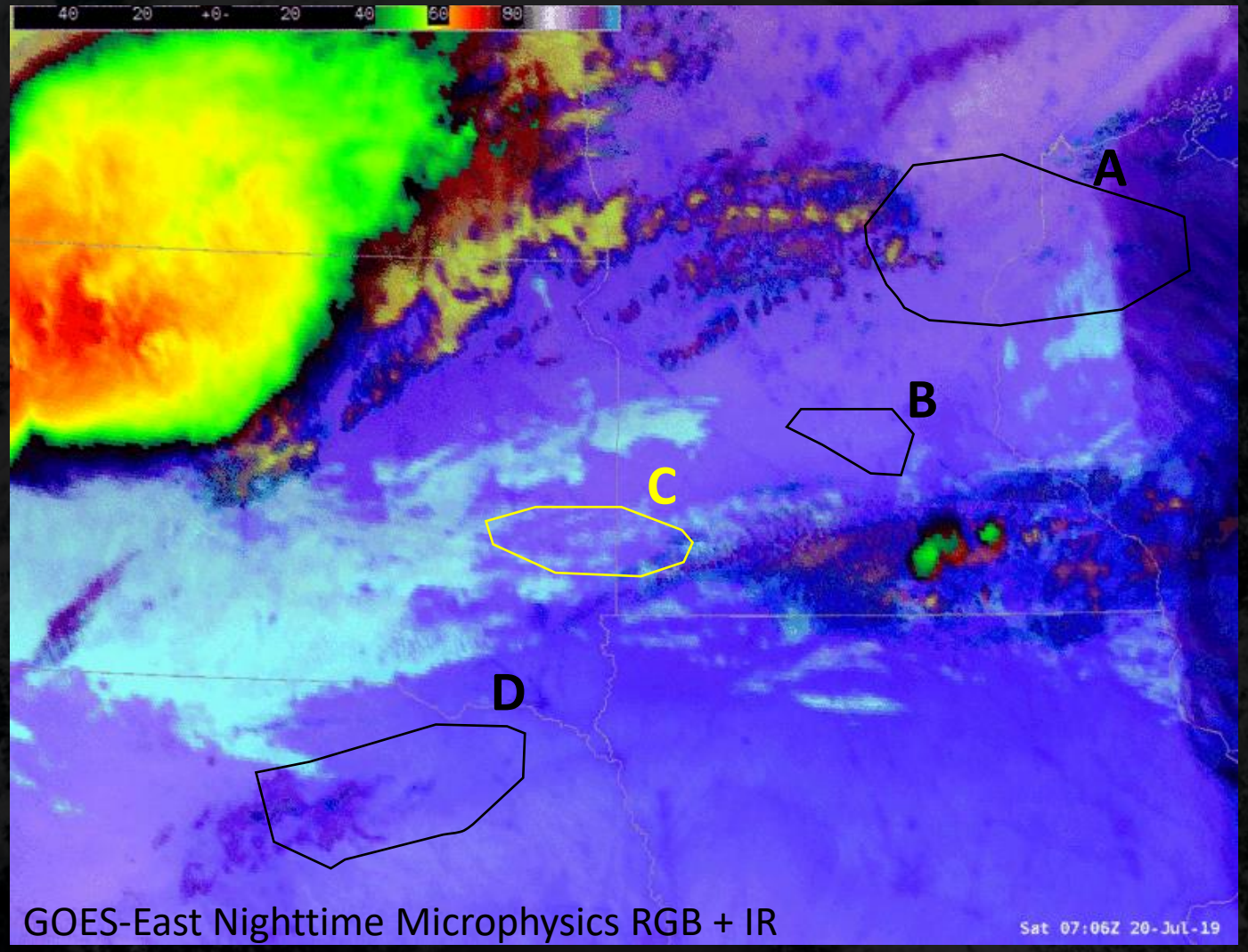
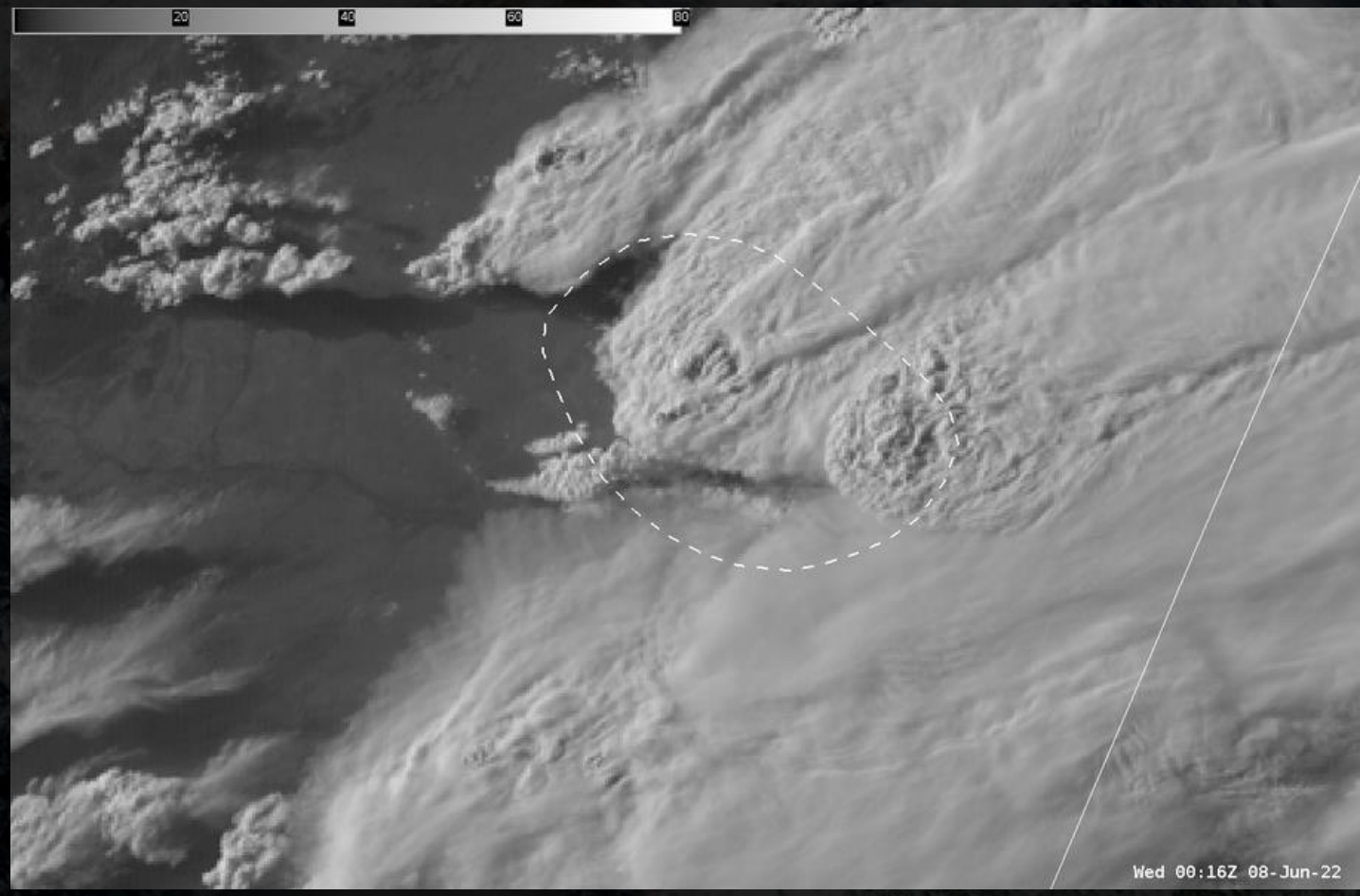


GOES-East Nighttime Microphysics RGB + IR

Q17 Answer

Hail Swaths at night

- Nighttime Microphysics RGB
  - Relatively Magenta compared to blue background
    - Cooler BT, less blue component
    - + vs – 12-10 um SWD, more red component



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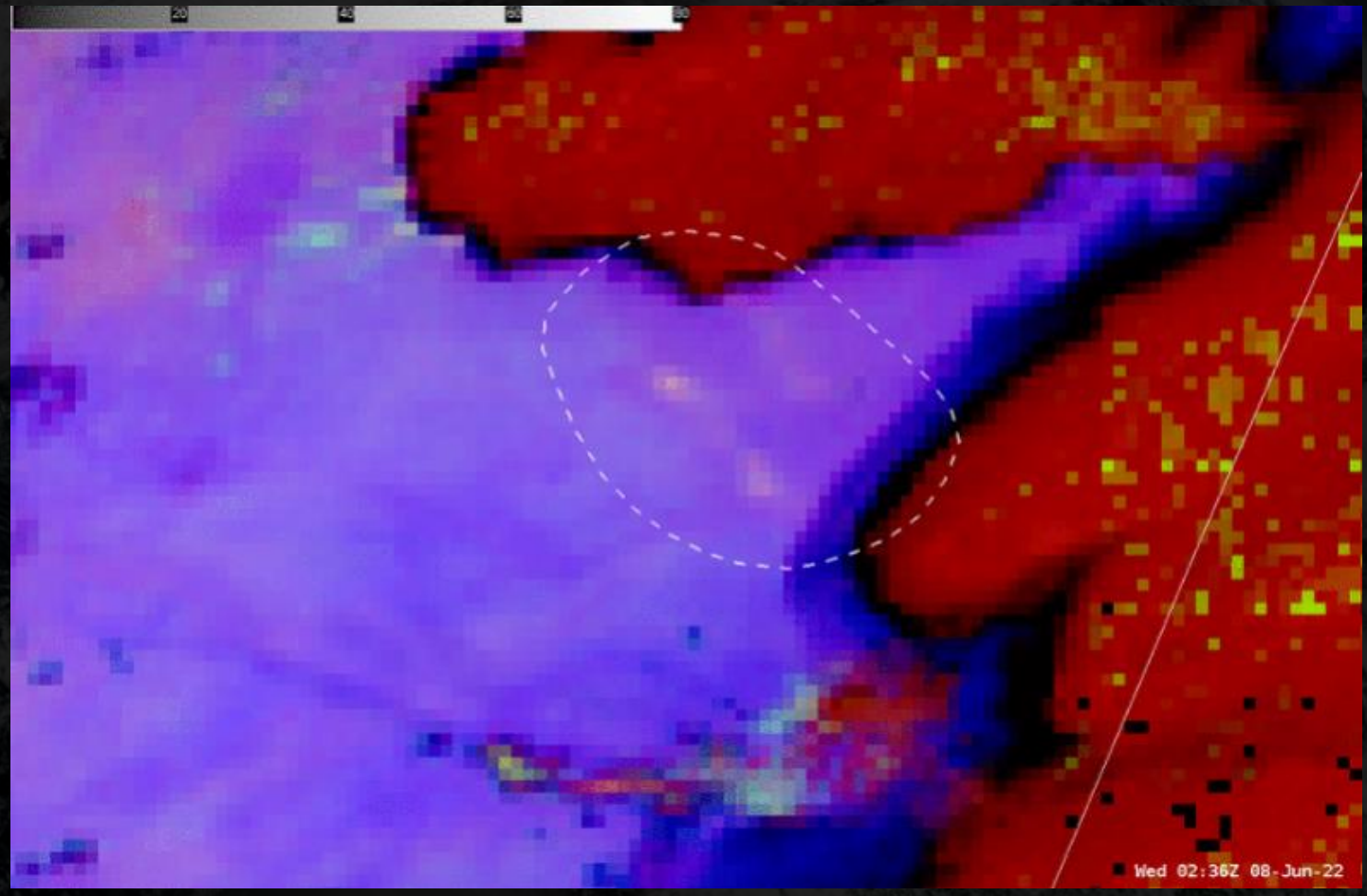
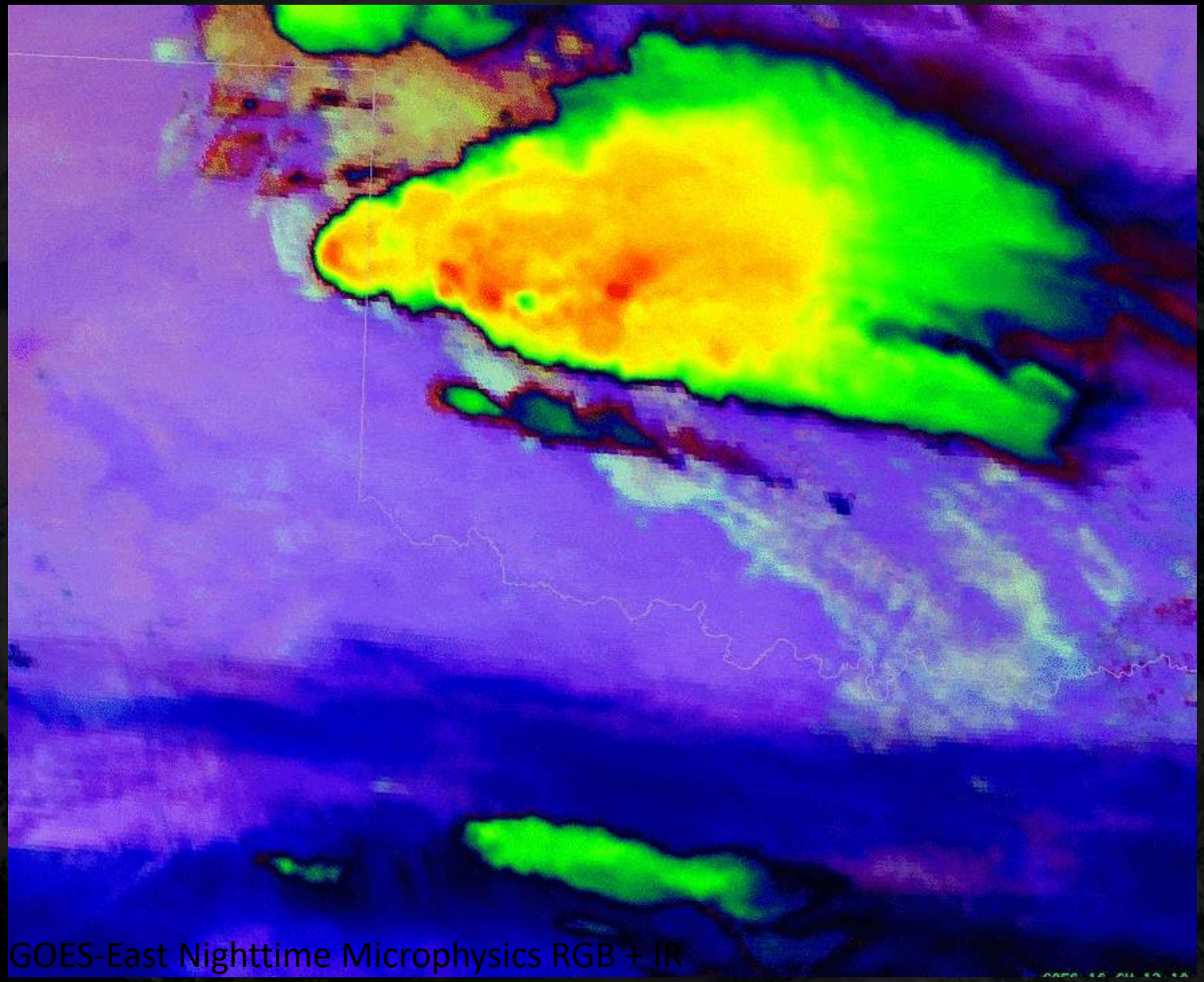
Band or band difference	RED 12.3 – 10.3 um "Split Window Diff"	+	GREEN 10.3 – 3.9 um "Fog Diff"	+	BLUE 10.3 um Band "Clean Window IR"	=	RGB IMAGE
Min	-6.7 K		-3.1 K		-29.5 K		
Max	2.6 K		5.2 K		19.5 K		
Gamma	1.0		1.0		1.0		



Which thunderstorm has a history of producing hail (nighttime)?
Hint: look at path of storm



GOES-East Nighttime Microphysics RGB + IR

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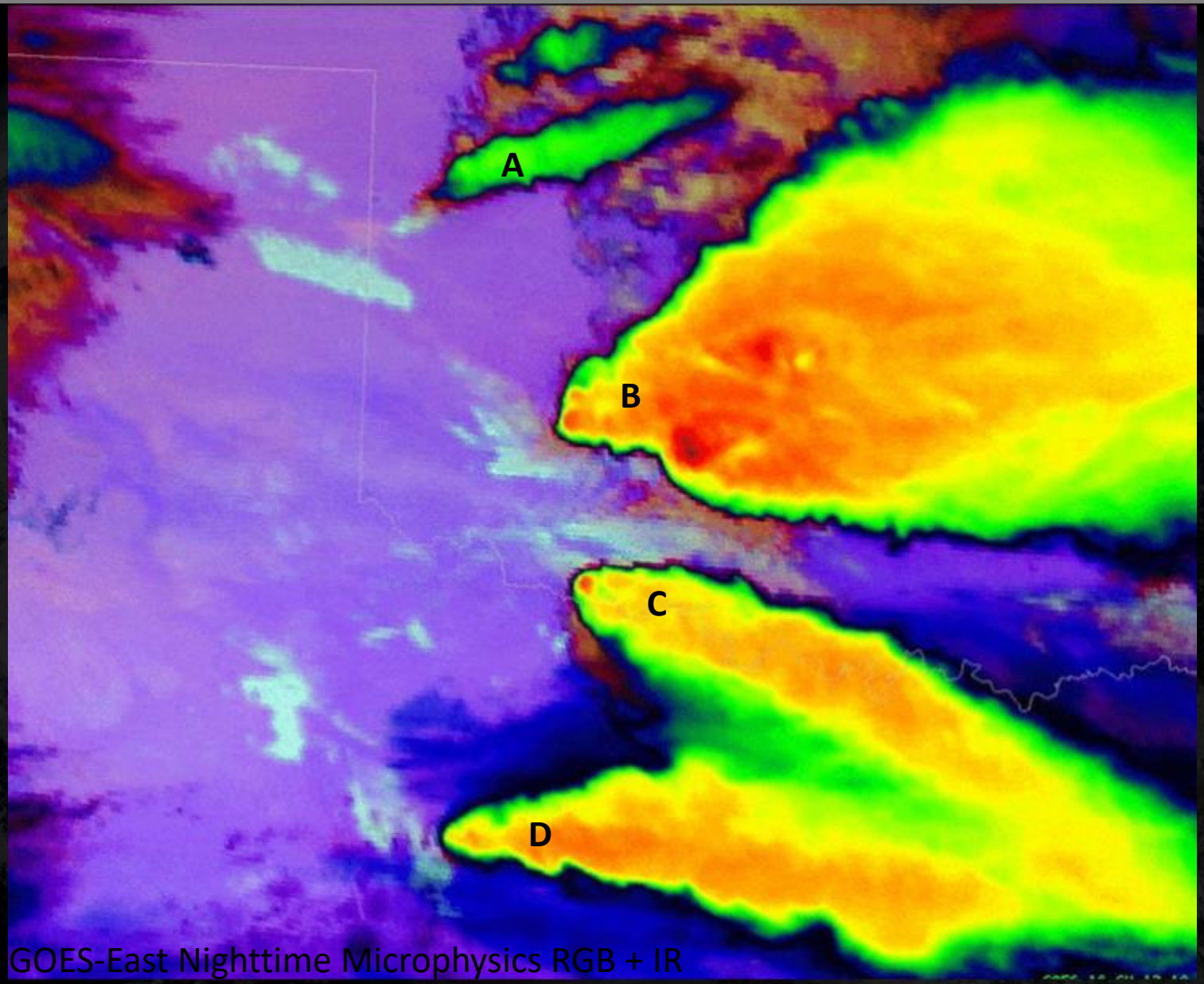
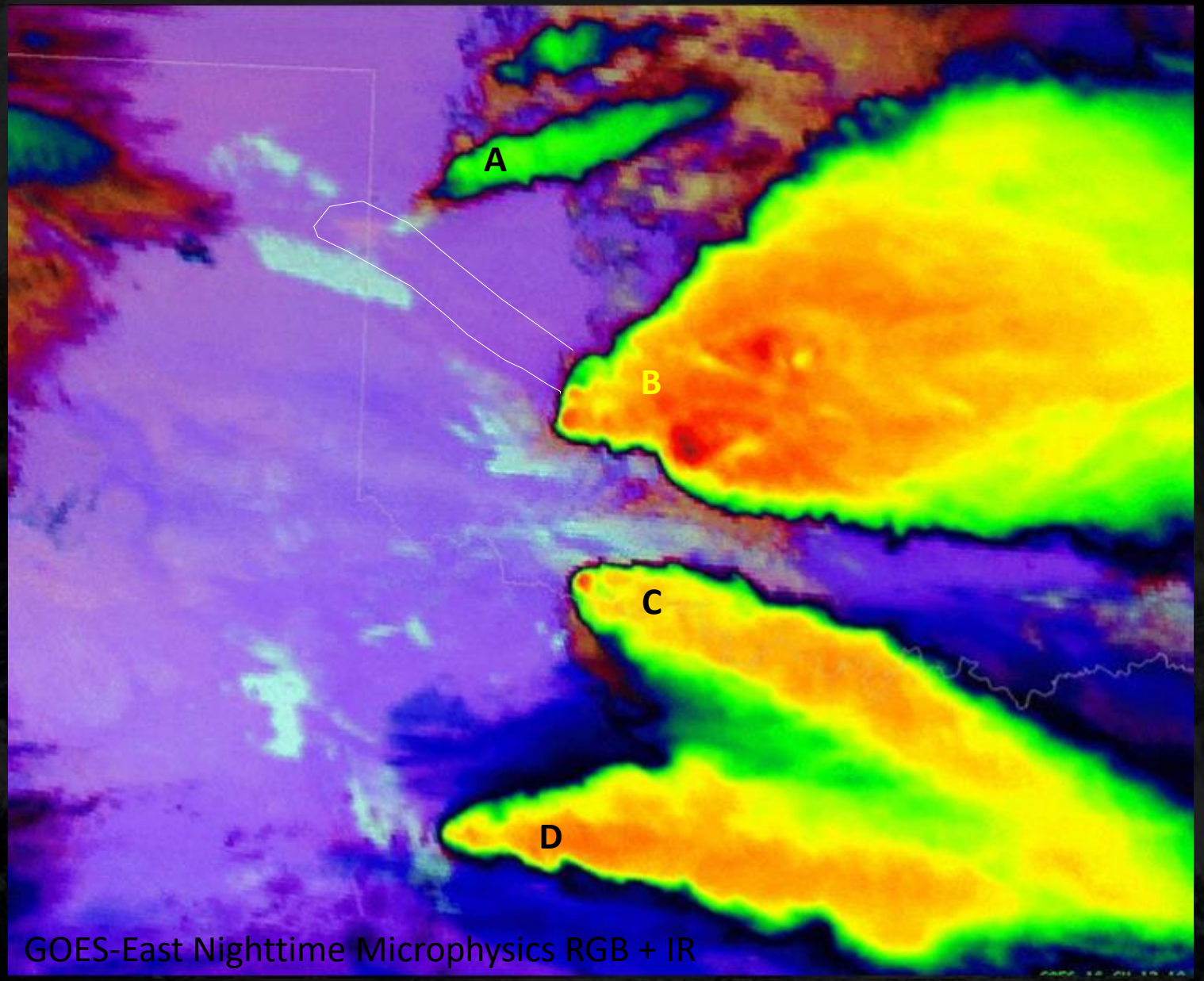


GOES-East Nighttime Microphysics RGB + IR

Q18

Which thunderstorm has a history of producing hail (nighttime)?

- Hail swath extends from Thunderstorm B
  - Relatively Magenta compared to blue background
    - Cooler BT, less blue component
    - + vs – 12-10 um SWD, more red component



GOES-East Nighttime Microphysics RGB + IR

Q18 Answer

Thank you!

- GOES-R Series ABI Imagery (single-band and multispectral) useful on convectively active days
  - Pre-convective analysis of forcing mechanisms and thermodynamic environment
  - Cu field analysis and convective initiation
  - Analysis of mature convection
  - Nighttime Convective Analysis

  - Satellite imagery and products are leveraged in concert with other observational and NWP products

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Many more examples: www.satelliteliaisonblog.com