DCOTSS

NASA Earth Venture Suborbital 3
Dynamics and Chemistry of the Summer Stratosphere

DCOTSS GOES Satellite Dataset Description

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DCOTSS GOES Dataset Overview

- **NetCDF-4 data from 5 July to 23 August GOES-16 and -17 have been delivered to the LaRC ASDC DCOTSS data archive. Dataset description document forthcoming**
- **A suite of multi-spectral and multi-instrument products provided, representing a variety of convection intensity and cloud-top height metrics developed based on years of experience at NASA LaRC**
- **10-minute imagery resampled to a fixed grid at ~2 km/pixel, extending from 12° to 52° North latitude**
  - Higher temporal resolution data available for almost all cases/regions upon request
  - 0.5 km visible data also available upon request for publications
- **GOES-16 data provided from 65° to 116° West, GOES-17 from 114° to 135° West**
  - GOES-16 favored due to GOES-17 sensor cooling issue that is especially problematic at night. Learn more about the GOES-17 issue here: https://www.star.nesdis.noaa.gov/goes/loopheatpipeanomaly.php
  - Users advised to merge data at 115° West, and overlap provided to enable parallax correction for each satellite across the 115° W boundary
  - Daily GOES-16 tar files: 4.5 Gb/Day, GOES-17: 1.8 Gb/Day
  - GOES data inputs downloaded from the University of Wisconsin-Madison Space Science and Engineering Center

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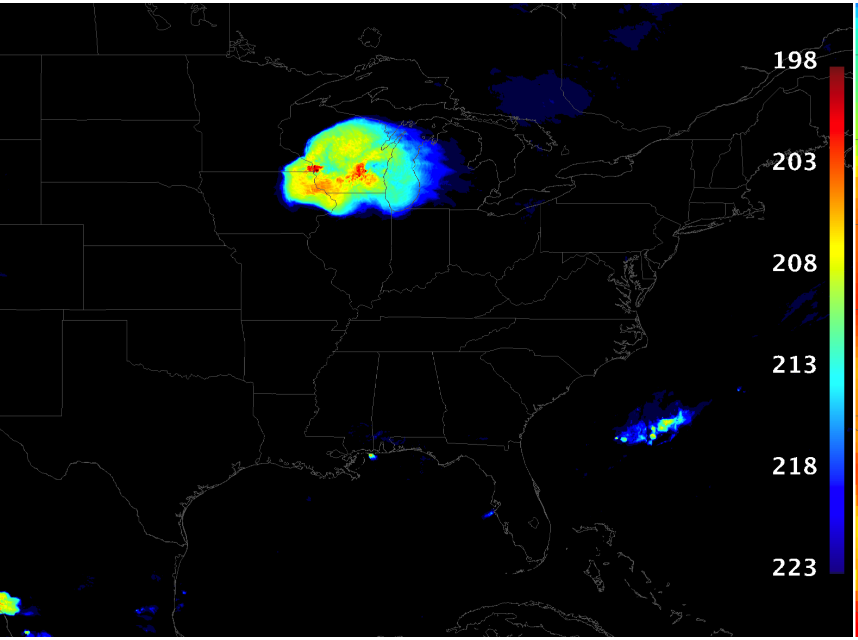
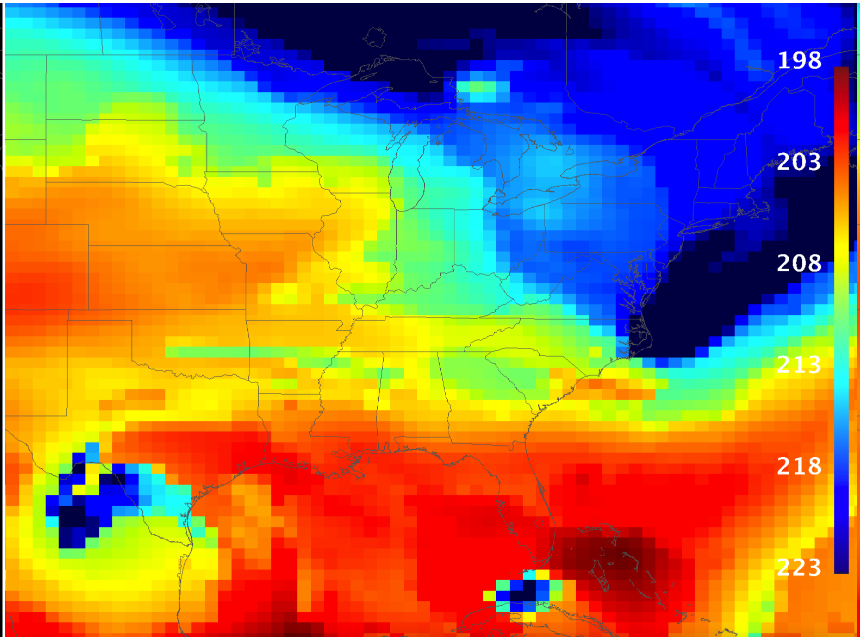
Tropopause Temperature Smoothing For GOES Overshooting Analysis

CHALLENGE: How do we determine what is ”overshooting” based on cloud-top infrared temperature measurements?
How should we handle spatial variance common to model tropopause temp reference data?
Are these variances “real”, and do the variances truly impact the altitudes/temperatures that storms achieve?

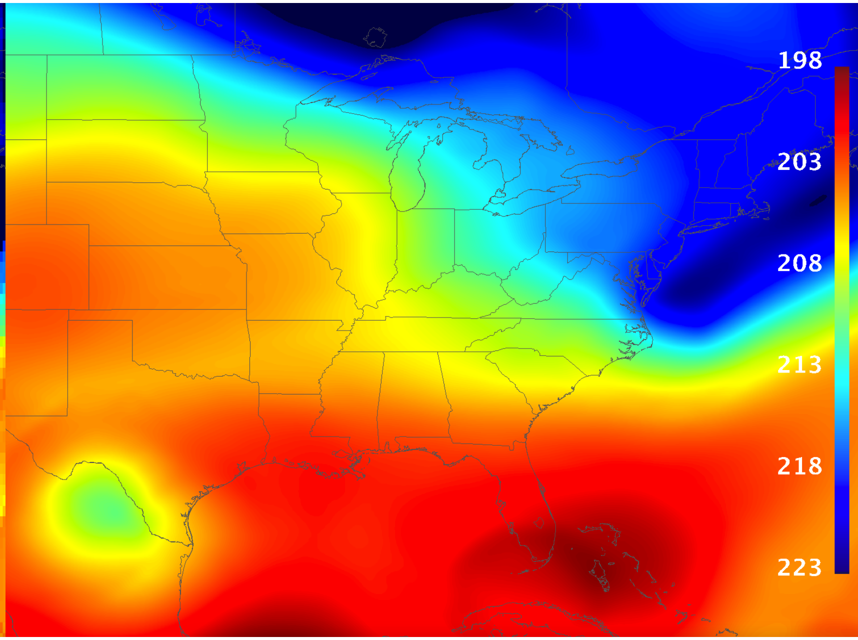
GOES IR Temperature Observations Of Convection
29 July 2021 at 0600 UTC



MERRA-2 TROPPT Tropopause Temperature
29 July 2021 at 0630 UTC



Spatially Smoothed, Temporally Interpolated
Tropopause Temperature: 29 July 2021 at 0600 UTC



Analyze tropopause temperature within 500 km averaging kernels

$$Trop_{smooth} = Trop_{orig\ mean} - 0.6 * Trop_{STDEV}$$

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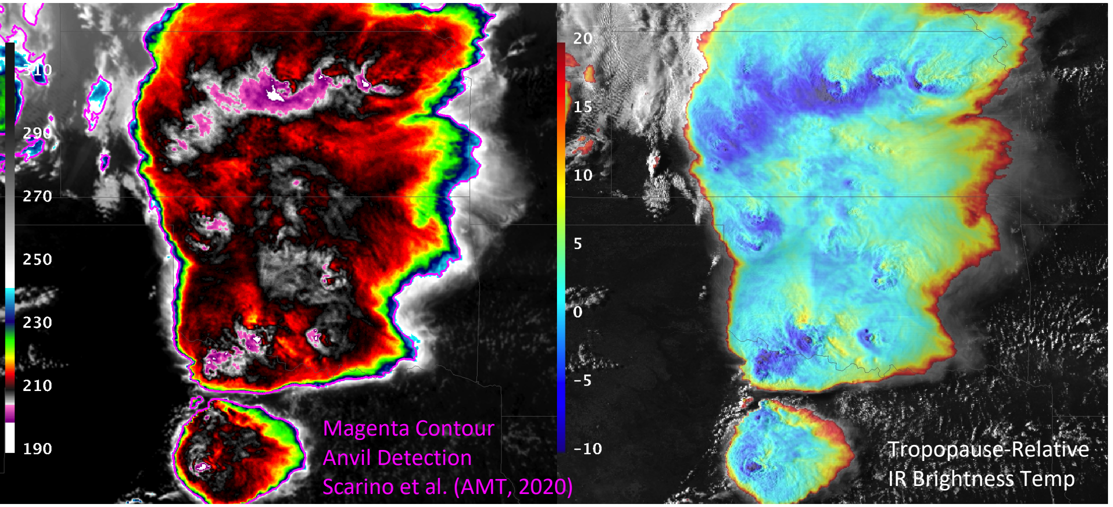
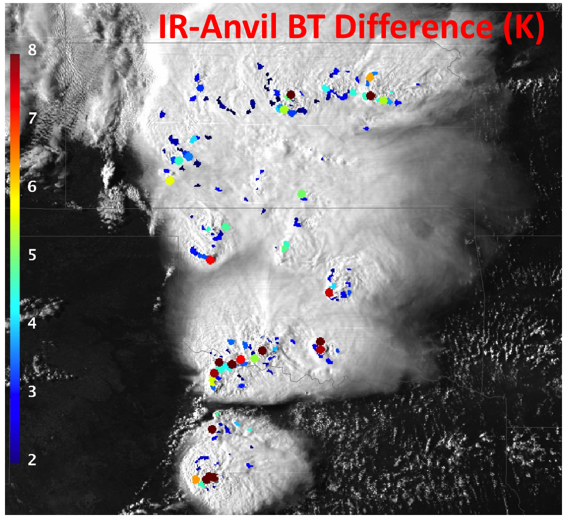
Automated Overshooting Cloud Top (OT) Detection and Validation

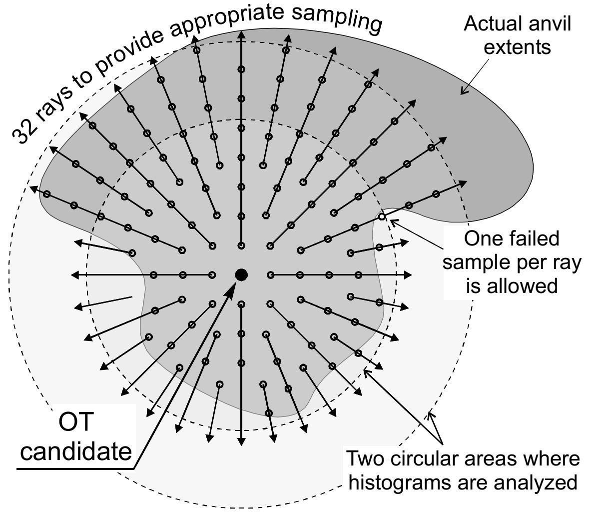
Khlopenkov et al., Cooney et al. (JGR 2021)

1) Normalize IR temperature using reanalysis tropopause temperature and identify convective anvil clouds

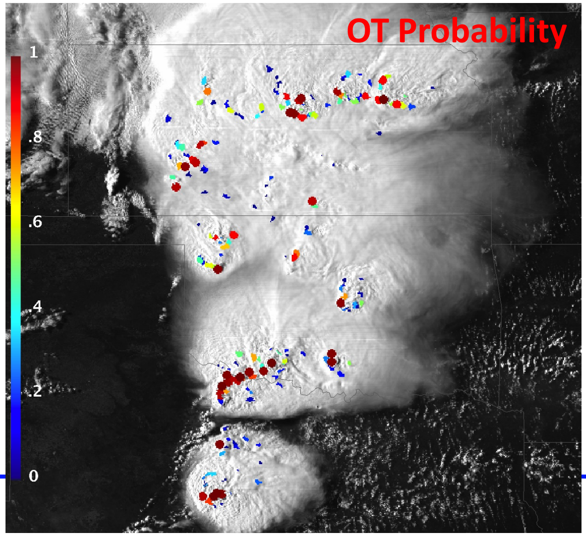


2) Identify cold minima embedded within anvils, and compute temperature difference relative to surrounding anvil

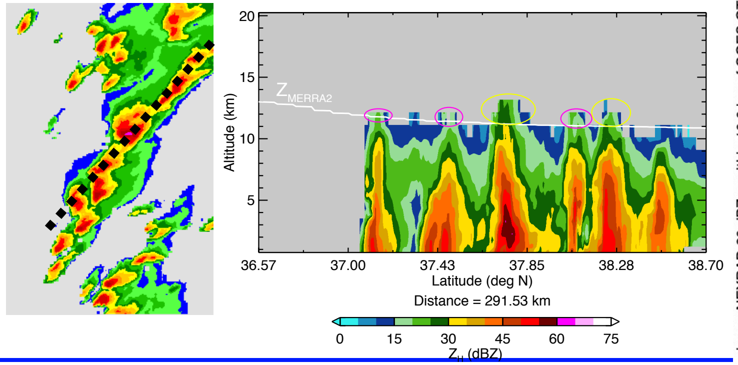


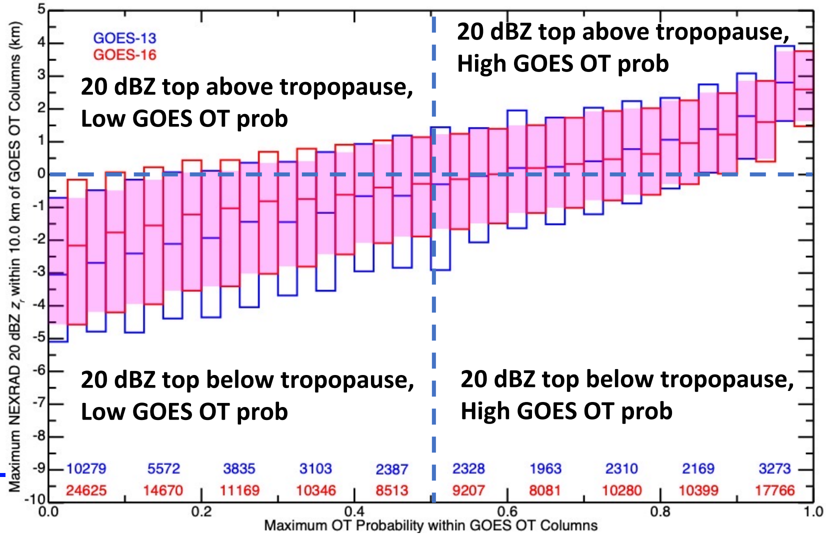


3) Use statistical functions based on human expert and NEXRAD OT identifications to combine IR-anvil, IR-tropopause, anvil area, and anvil spatial uniformity to derive OT Probability



4) Perform quantitative validation of geostationary OT detection using NEXRAD precipitation echo tops





GOES Cloud Top Height Retrieval For Overshooting Cloud Tops

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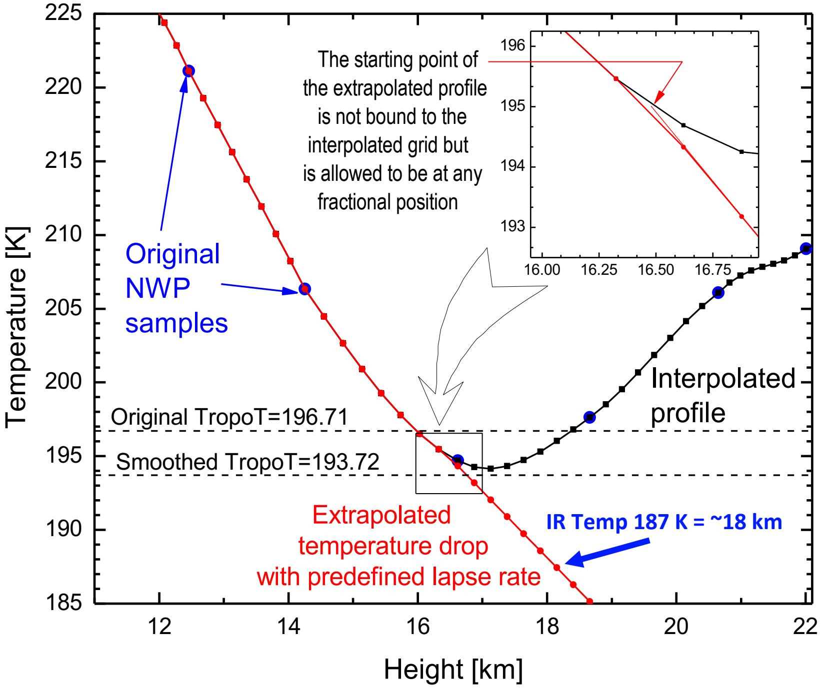

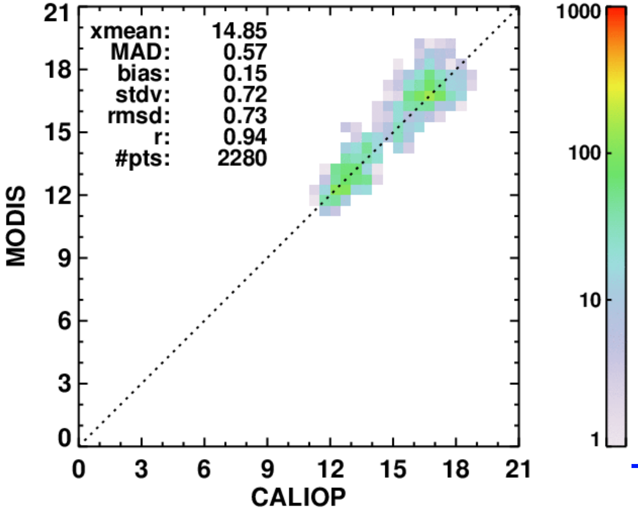

Overshooting cloud tops continue to cool as they ascend above the anvil. The magnitude of the cooling sensed by satellites is dependent on their image spatial resolution.

GOAL: Produce a high-resolution GOES pixel-scale cloud top height retrieval for deep convection, free of any spatial and model-grid-box induced artifacts

CHALLENGE: How can you assign a cloud top height if the IR temperature is colder than any temperature in a NWP/reanalysis profile?

PATH TO SOLUTION: 1) Perform careful spatio-temporal interpolation of reanalysis vertical temperature profiles, and spatial smoothing of lapse-rate tropopause to acquire values at each GOES 2 km pixel

2) Identify possible anvil clouds based on infrared temperature proximity to tropopause and spatial coherency (Scarino et al. 2020; Khlopenkov et al. 2021)

3) Identify inflection point in MERRA-2 temperature profile near to smoothed lapse rate tropopause temp

4) Modify stratospheric temperature profile to maintain cooling at 5.5 K/km, a lapse rate found to be appropriate for 2 km GOES-16/17 data

5) Match IR temperature to modified temperature and geopotential height profile to derive cloud height

6) Derive cloud top pressure and potential temperature

Initial validation of MODIS overshooting heights with CALIOP indicates minimal bias with ~0.75 km uncertainty

DCOTSS GOES-16 Product Examples, 10 August 2021 at 2000 UTC

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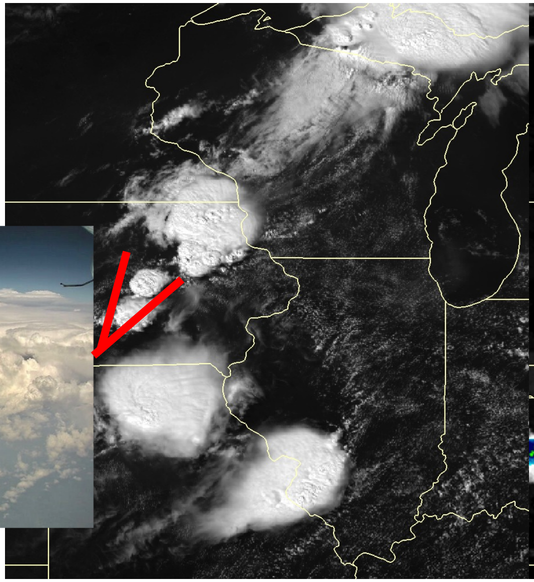
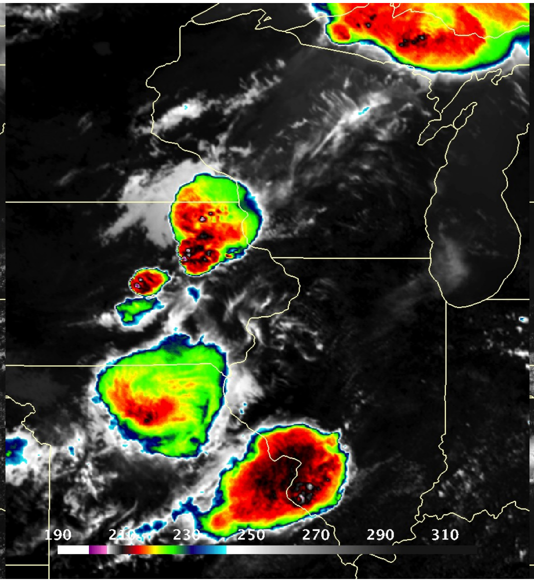
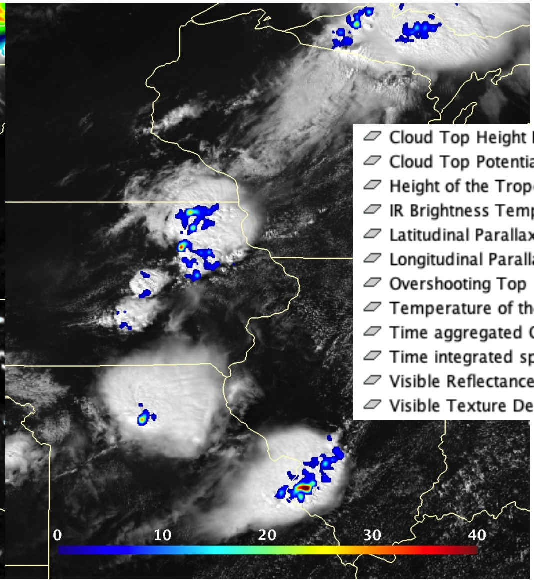
GOES-16 Visible Reflectance



GOES-16 10.3 micron Temp

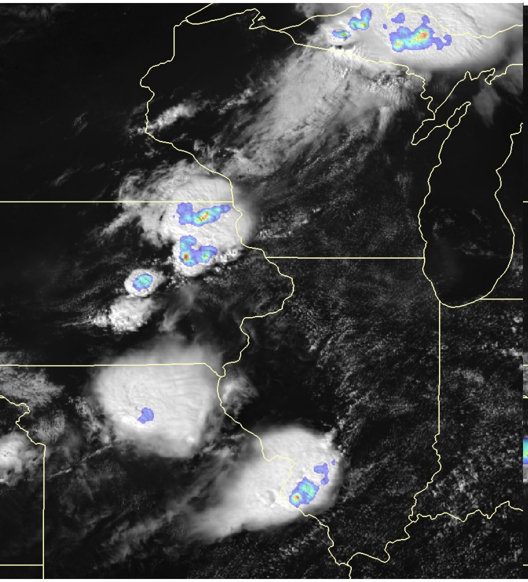


GLM 10-min Flash Point Density

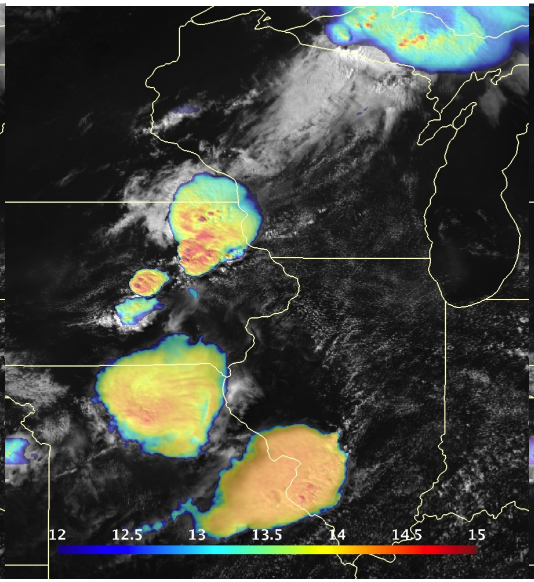


- Cloud Top Height Retrieved from MERRA-2 Reanalysis
- Cloud Top Potential Temperature Retrieved from MERRA-2 Reanalysis
- Height of the Tropopause Retrieved from MERRA-2 Reanalysis
- IR Brightness Temperature Image
- Latitudinal Parallax Correction Based On Cloud Top Height Retrieval
- Longitudinal Parallax Correction Based On Cloud Top Height Retrieval
- Overshooting Top Probability
- Temperature of the Tropopause Retrieved from MERRA-2 Reanalysis
- Time aggregated GLM flash counts interpolated to the ABI grid
- Time integrated spatial evolution of lightning influence based on GLM counts
- Visible Reflectance Image
- Visible Texture Detection Rating

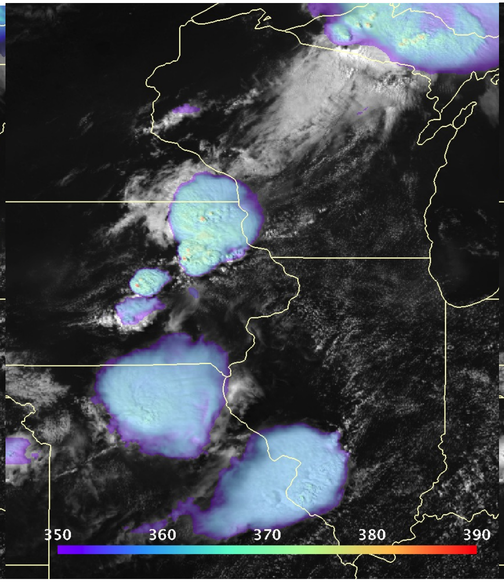
Visible Texture Rating



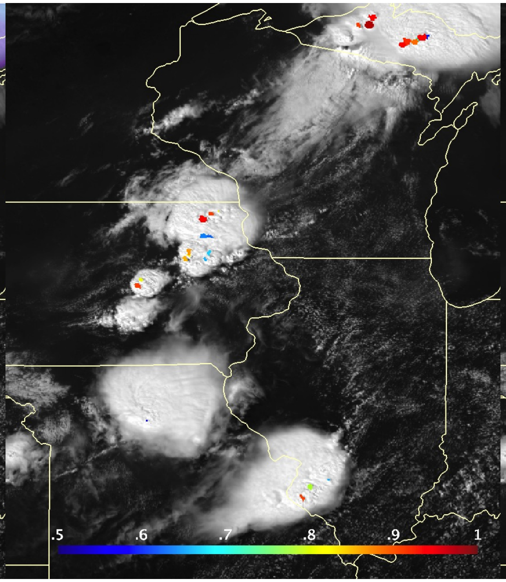
Anvil Cloud Top Height



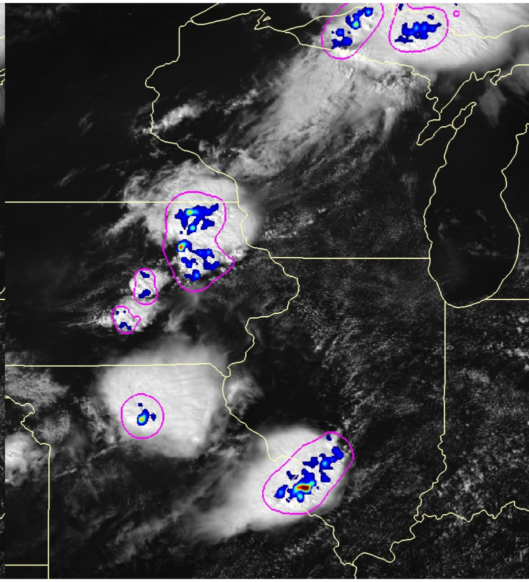
Anvil Cloud Potential Temp



Overshooting Probability



GLM Flash Density and Lightning Influence



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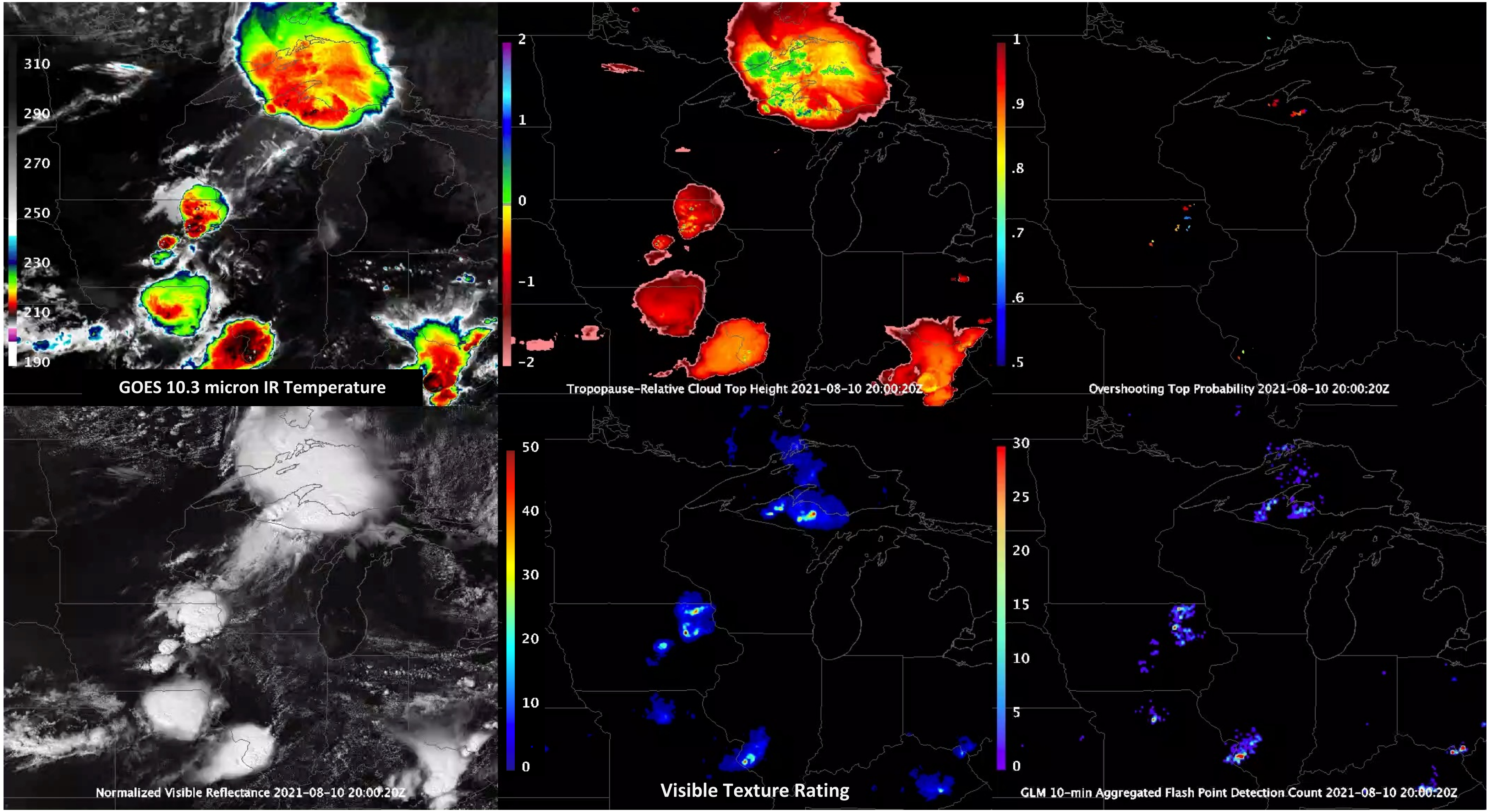
GOES-16 DCOTSS Convection Product Examples



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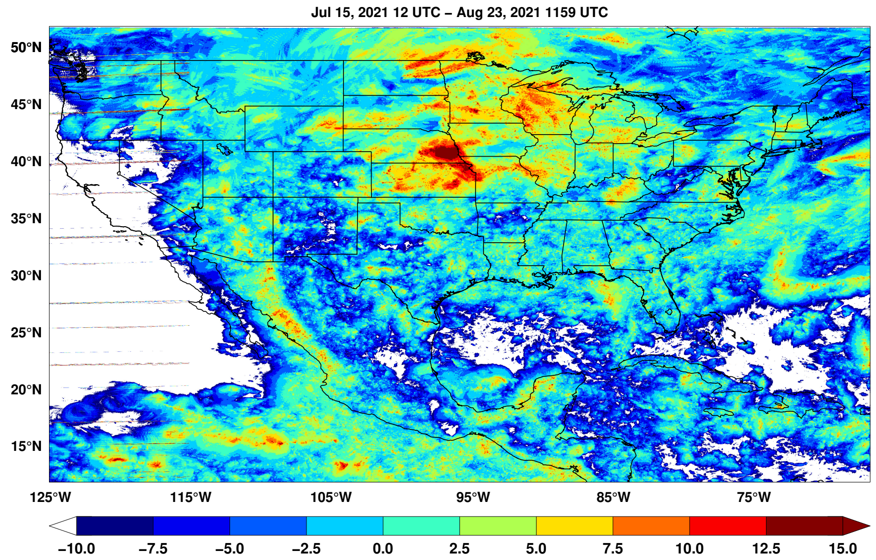
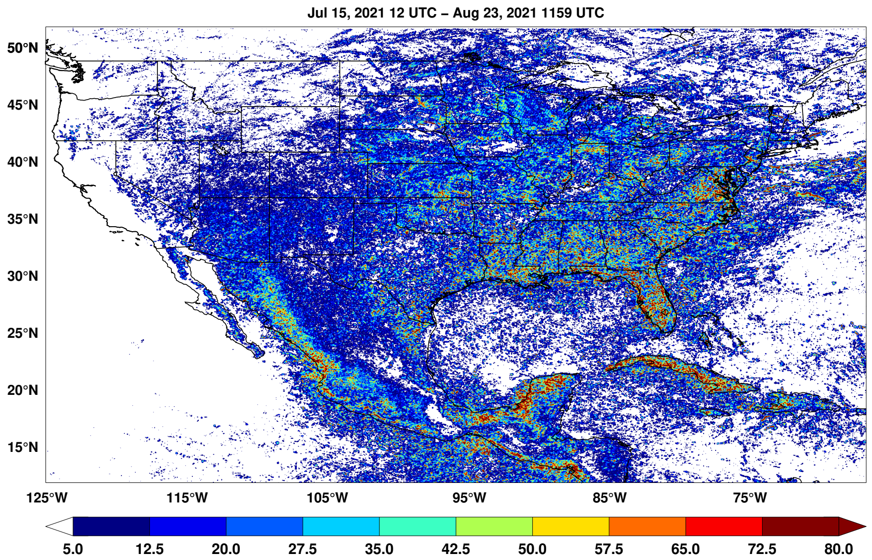
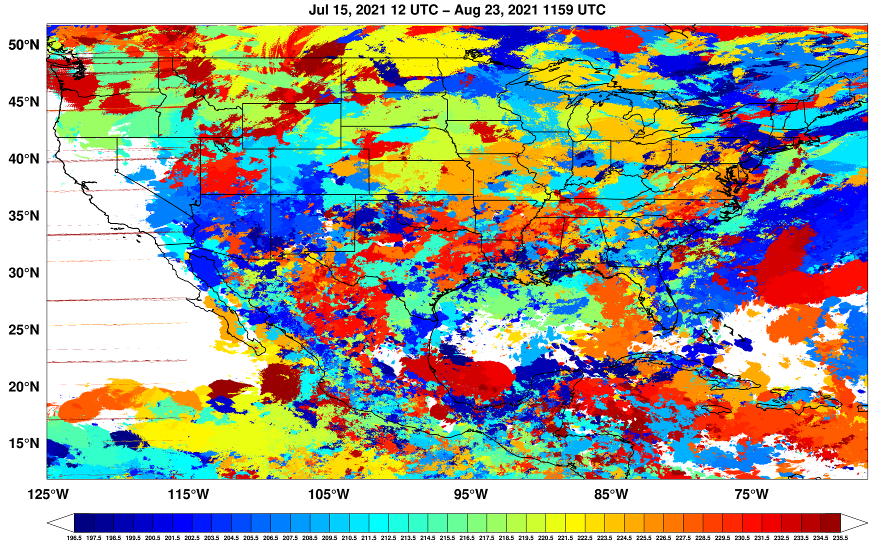
Initial GOES Analysis of Overshooting Convection During DCOTSS

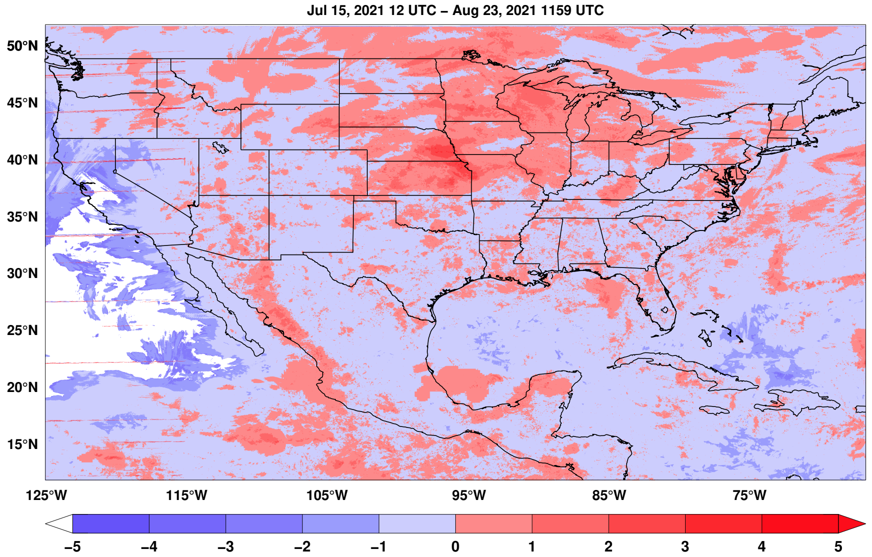




Maximum Tropopause Temperature – IR BT (K)

Maximum GLM Flash Point Density (flashes/10 min)





Day of Maximum Intensity (Fractional Day)

NASA Langley Research Center

Maximum Tropopause Relative Cloud Top Height (km)

References

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