Satellite Products Guide

For the Mendoza Hail Suppression Project

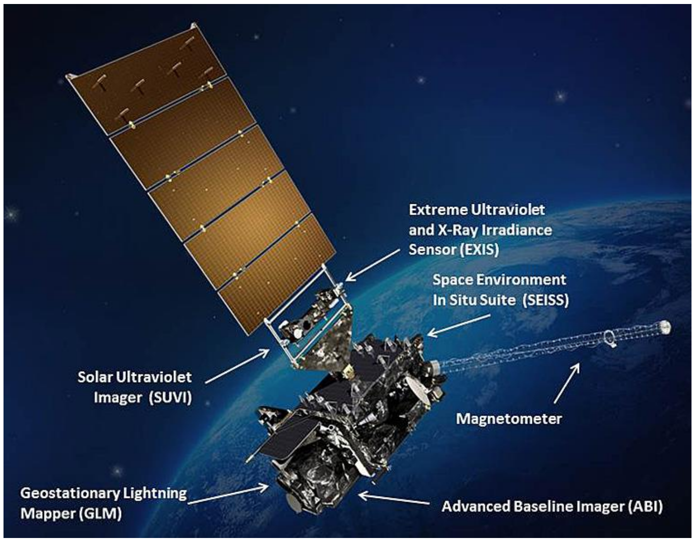
Revision 2: 20-Dec-2024

WEATHER MODIFICATION
INTERNATIONAL

Contents

GOES - ABI

Geostationary **O**perational **E**nvironmental **S**atellites (GOES) are multi-purpose satellites as part of collaborative program between the **N**ational **A**eronautics and **S**pace **A**dministration (NASA) and the **N**ational **O**ceanic and **A**tmospheric **A**dministration (NOAA). They monitor atmospheric weather through the **G**eostationary **L**ightning **M**apper (GLM) and **A**dvanced **B**aseline **I**mager (ABI), as well as space weather through other instruments. At WMI, ABI data is primarily processed, and as of summer 2024, in its native resolution. The ABI "sees" in 16 channels, or "bands", that have various resolutions and uses as shown in the table below.

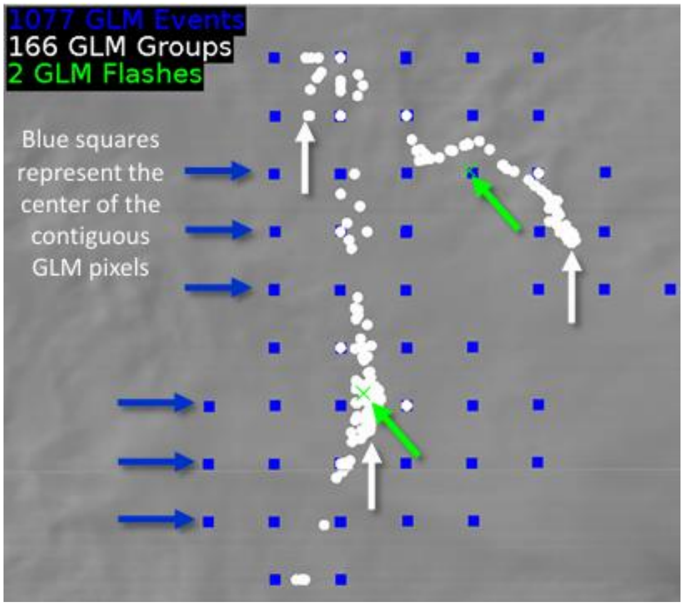


GOES ABI Summary Chart

Band	Central Wavelength (µm)	Type	Nickname/Use	Spatial Resolution (km)
1	0.47	Visible	Blue	1
2	0.64	Visible	Red	0.5
3	0.86	Near-Infrared	Veggie	1
4	1.37	Near-Infrared	Cirrus	2
5	1.6	Near-Infrared	Snow/Ice	1
6	2.2	Near-Infrared	Cloud particle size	2
7	3.9	Infrared	Shortwave window	2
8	6.2	Infrared	Upper-level water vapor	2
9	6.9	Infrared	Mid-level water vapor	2
10	7.3	Infrared	Low-level water vapor	2
11	8.4	Infrared	Cloud-top phase	2
12	9.6	Infrared	Ozone	2
13	10.3	Infrared	"Clean" longwave window	2
14	11.2	Infrared	Longwave window	2
15	12.3	Infrared	"Dirty" longwave window	2
16	13.3	Infrared	CO_2 longwave	2

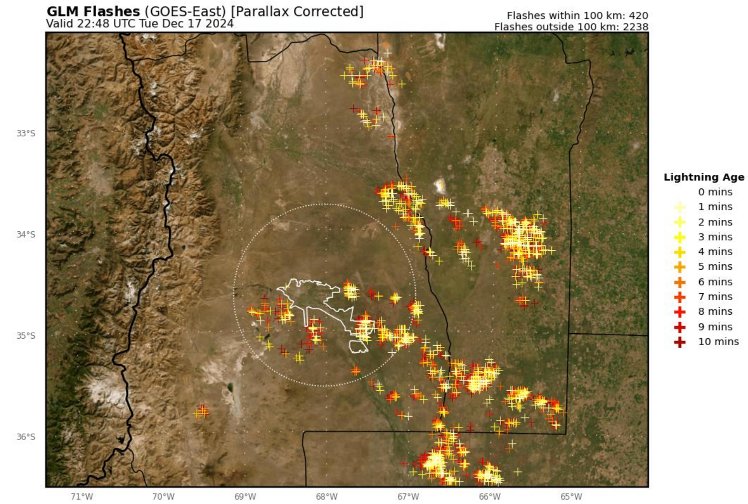
GOES - GLM

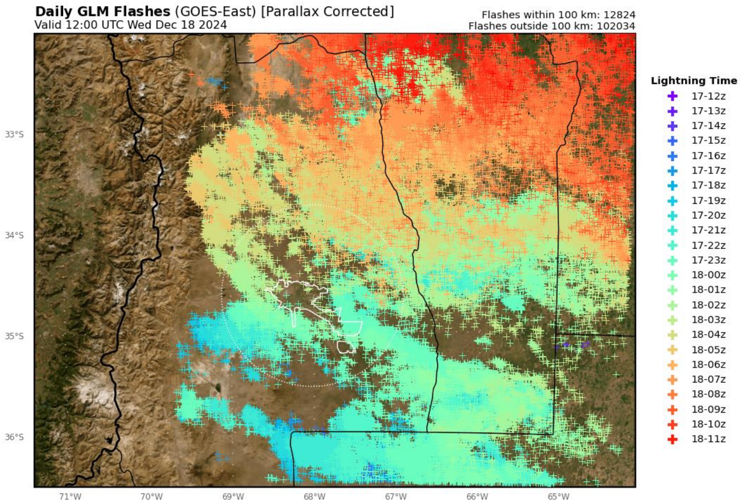
The **G**eostationary **L**ighting **M**apper (GLM) aboard GOES is an *imager* (not a detector) that is watching for brightness changes every ~2ms. It processes these pixels into events, then groups, then flashes. As such it has some caveats and isn't necessarily directly comparable to ground-based detection networks. The most obvious limitation is it is seeing mostly the tops of clouds. This means it may not "see" all cloud-to-ground strikes (CGs), and does not know the difference between in-cloud (IC) cloud-to-cloud (CC) and CG strikes. Because this is an imager on the satellite, it will suffer from parallax the same way all other imagery does. An initial form of parallax correction is attempted on the data, though there is always uncertainty in the exact placement of each flash.



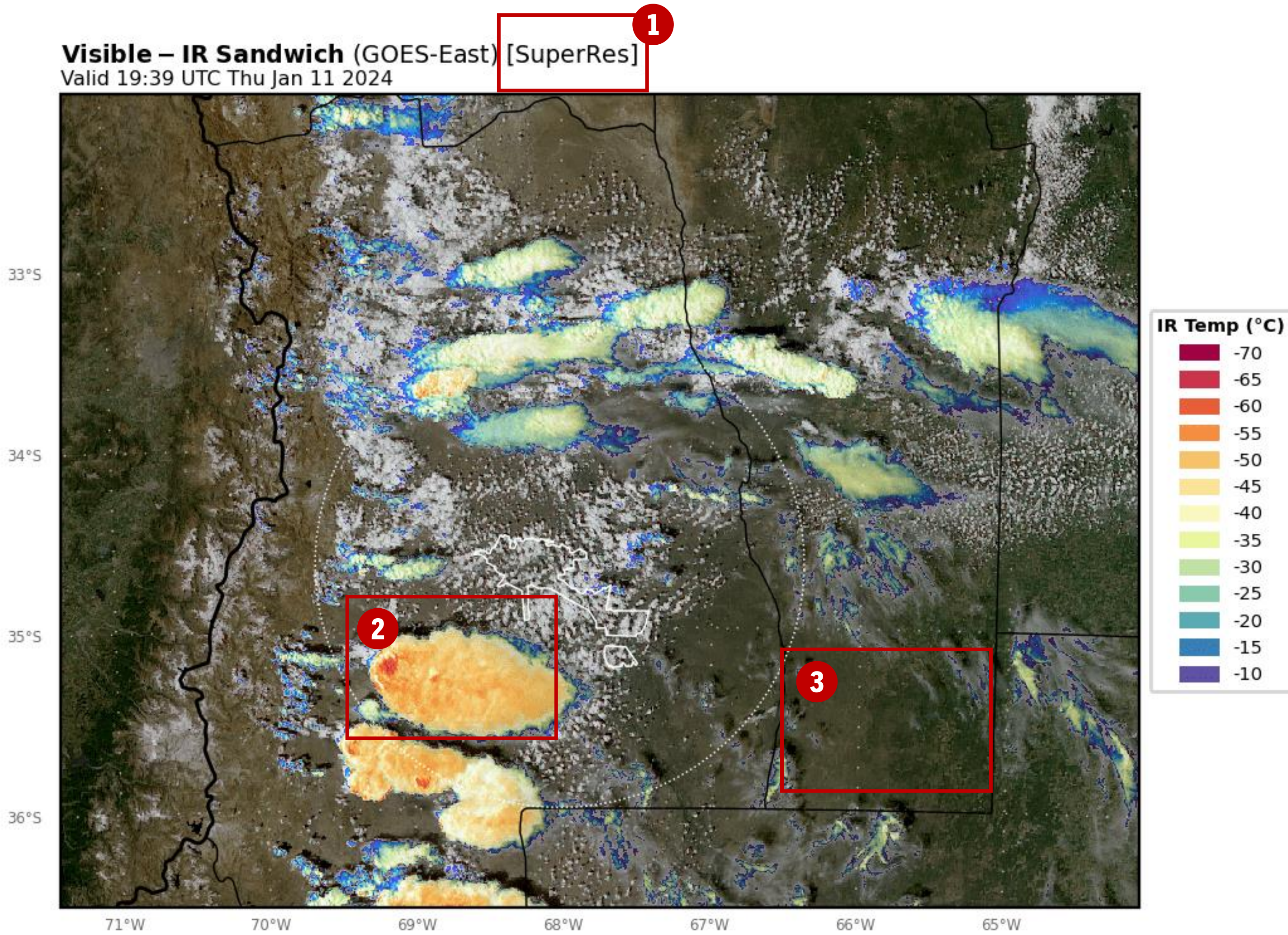
For this project, near-realtime flashes are plotted at a reasonable frequency (for example, 10 minutes of data ever 2 minutes – graphic below-left) in addition to a daily summary, going from 12Z-12Z (below-right). Flashes are counted within the plot domain both inside a 100km radius from the La Llave radar and outside this radius.

Resources: GLM_Quick_Guides_May_2019.pdf | GLM_FD_DQ_Quick_Guide_Dec_2020





Geocolor/IR Sandwich

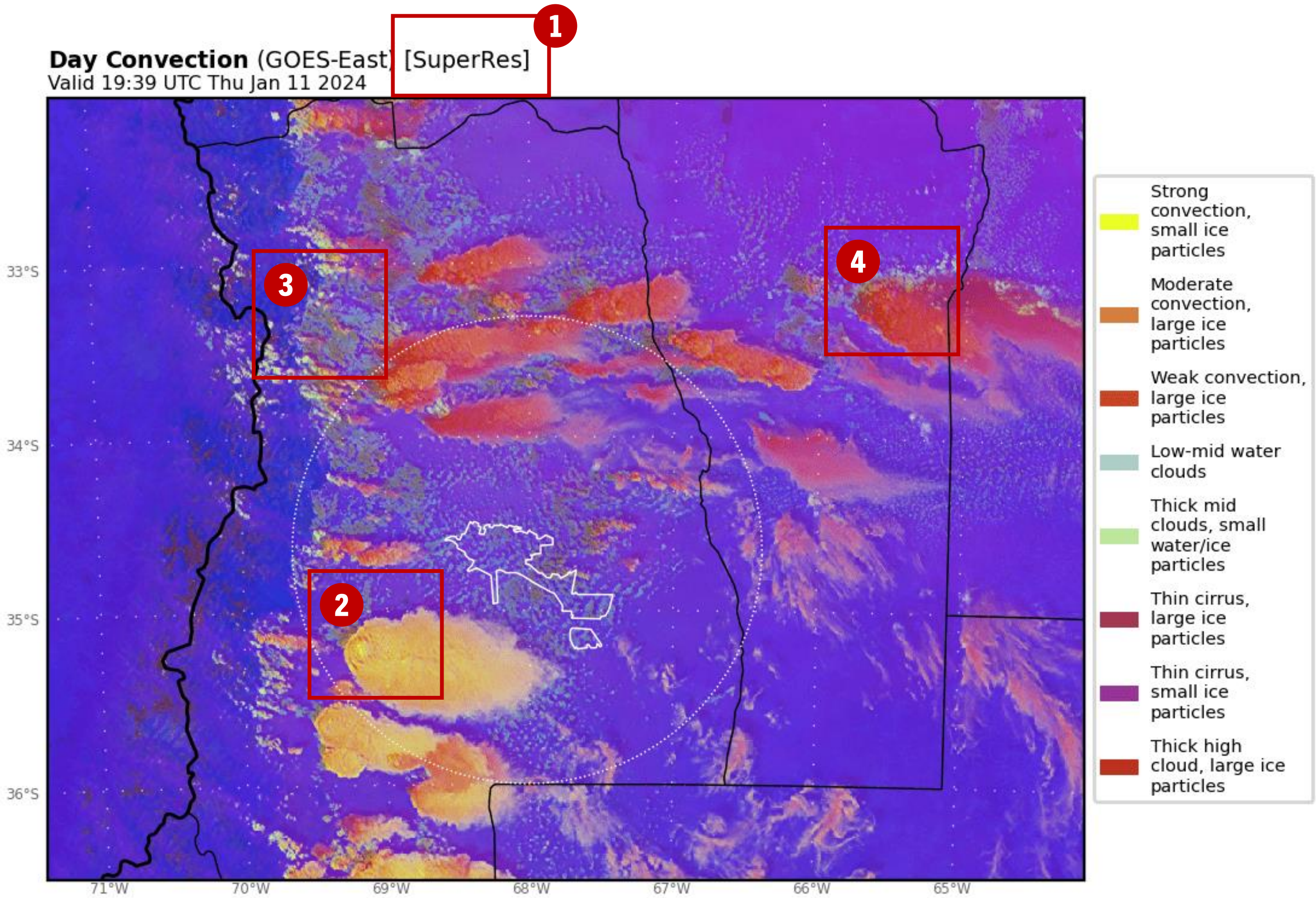


Modified "Geocolor" RGB composite with channel 13 overlaid for cloud-top temperatures.
QuickGuide_CIRA_Geocolor_20171019.pdf (noaa.gov)

Interpretation:

1) **SuperRes indicator.** Will show when SuperRes (page 8) product is active.
2) **IR Overlay.** Provides information on temperature (and height – since colder means higher) of cloud top.
3) **Bare ground.** Real-time true-color during the day, static "city lights" at night.

Day Convection/Severe Storms



Day Convection/Severe Storms RGB to distinguish newer/stronger storms with microphysics diagnostics even when cloud top temperatures are similar.
QuickGuide_GOESR_DayConvectionRGB_final-1.pdf (colostate.edu)

Interpretation:

1) **SuperRes indicator.** Will show when SuperRes (page 7) product is active.
2) **Intense Updrafts.** These will have smaller ice crystals and appear yellow.
3) **Building cumulus.** Clouds that have not built sufficient depth for ice appear cyan or green.
4) **Old/Weak Updrafts.** These will have larger ice crystals, appearing red.

Satellite Parallax

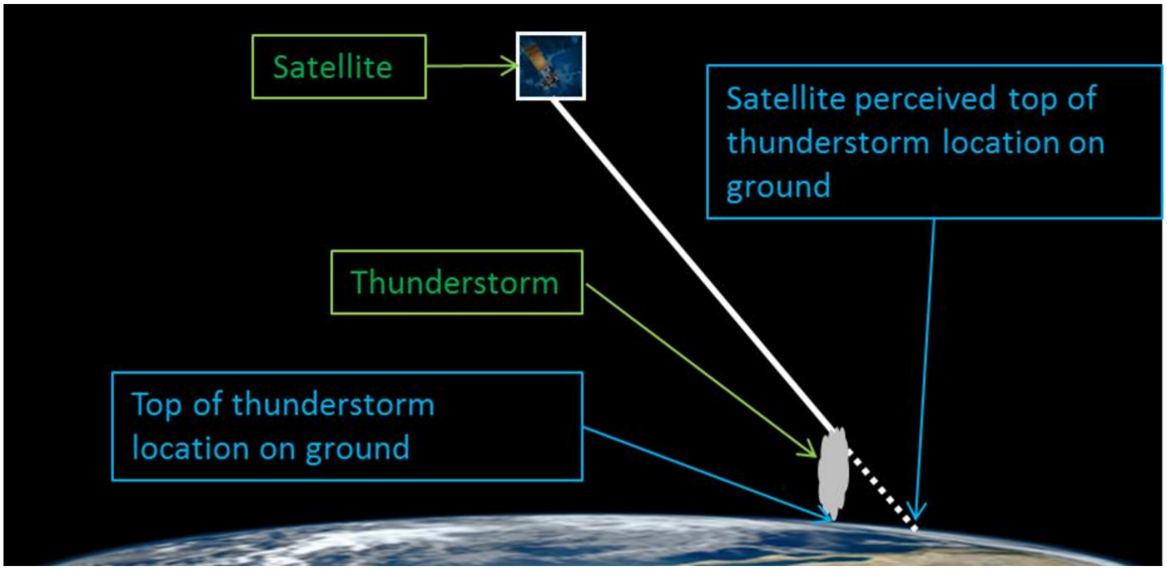
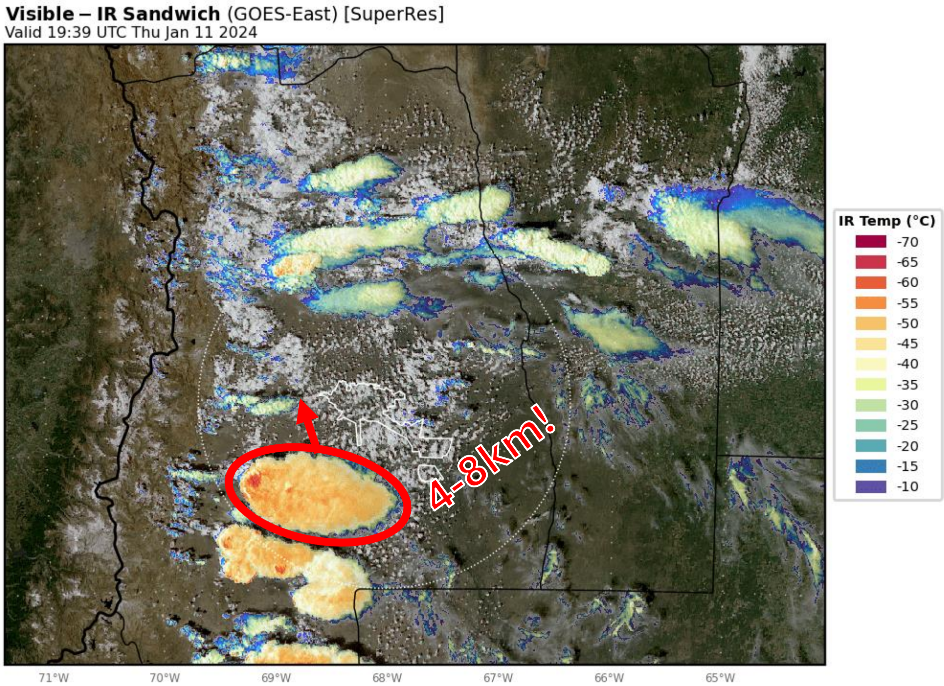


Diagram from Bill Line, *Why is my GOES-16 Imagery Displaced? Parallax!*

The GOES-East satellite we utilize on project orbits over 22,000 miles above the earth at 75.2 degrees west longitude over the equator. This means not only is the satellite looking at an angle to see the project area, but the earth is also curving away from the satellite! This results in features appearing to be displaced to the south and east of where they actually are relative to the ground on the satellite image. And this effect grows with height. A cloud at a height of 15,000 ft (~4.5 km) above sea level will appear displaced ~4 kilometers to the south/southeast in satellite imagery. A cloud at 30,000 ft (~9.1km - like thunderstorm tops), will be displaced by about 8 kilometers!

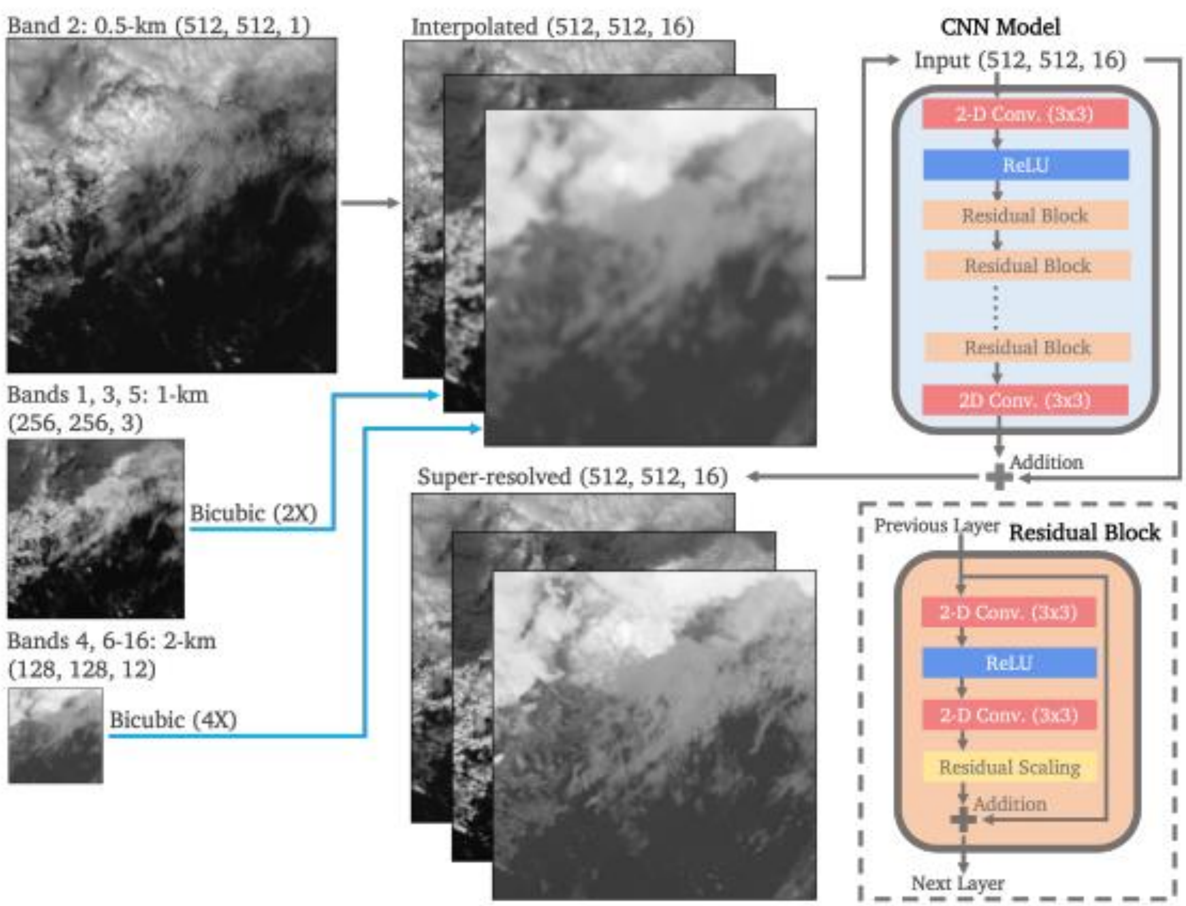
Explore the effects of parallax (wisc.edu)



ABISR (SuperResolution)

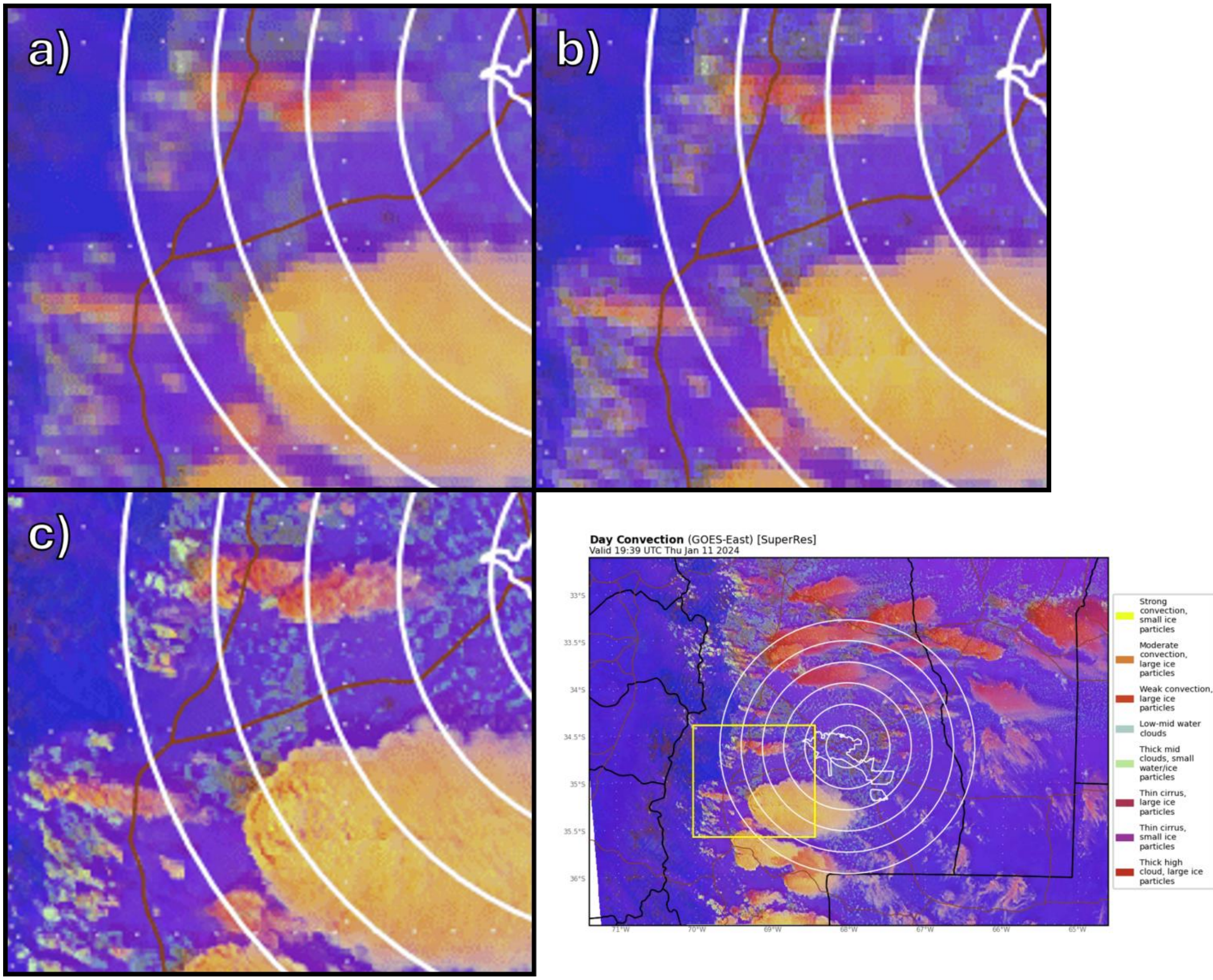
Recall from the section on GOES (page 3), that each of the 16 bands/channels on the satellite can have different resolutions. The red visible channel (channel 2) has the highest resolution, with 0.5km pixels. While each channel is sensitive to slightly different things in the atmosphere, they aren't completely independent and do have some correlation. We can utilize these relationships plus data from higher-resolution (but less frequent) satellites to train Artificial Intelligence to upsample all channels to this 0.5km resolution! Doing so greatly aids in satellite resolution of convective structures between 0.5km and 2km scale, resulting in **more detail, crisp gradients, and restoration of minima/maxima** that were lost in the courser channels!

Since this is based on the red/channel 2 data, this will only run during the daytime, and will do so automatically, appending [SuperRes] to the title of each image it successfully runs on! This technique was developed by Charles White and others at the Cooperative Insititute for Research in the Atmosphere (CIRA). See more below.



Superresolution of GOES-16 ABI Bands to a Common High Resolution with a Convolutional Neural Network in: Artificial Intelligence for the Earth Systems Volume 3 Issue 2 (2024) (ametsoc.org)

ABISR (SuperResolution)



SuperResolution greatly aides in convective diagnosis and nowcasting. Because the Severe/Day Convection RGB ingests some of the coarser bands of data, the product loses effective resolution and can't resolve details like overshooting tops or cumulus fields very well. By using ABISR, we are able to recover such details, allowing better nowcasting and prioritization of hail suppression operations before infrared signals alone, and even sometimes before radar signatures!

The above figure compares uniform 2km resolution Level 2 data (a), native-mixed-resolution Level 1b data (b), and SuperResolution data processed through ABI to a common 0.5km resolution (c).

Plots of 10-minute data can be found at
WMI Argentina Web Interface (wmiradar.com)

Questions? Visit www.weathermodification.com or email
info@weathermodification.com

WEATHER MODIFICATION
INTERNATIONAL

Satellite Products Guide for the Mendoza Hail Suppression Project
Revision 2: 20-Dec-2024