July 28, 2026

Finding Needles in a Haystack

Using a GOES Nowcasting Model to Forecast Convective Initiation

Ethan Campbell

Mentors: Kevin Yang, David John “DJ” Gagne, Charlie Becker

Image Credit: Tornado near Lincoln, Nebraska, April 26, 2024. Image courtesy of NOAA National Weather Service Forecast Office Omaha, Nebraska and Katie Wargowsky

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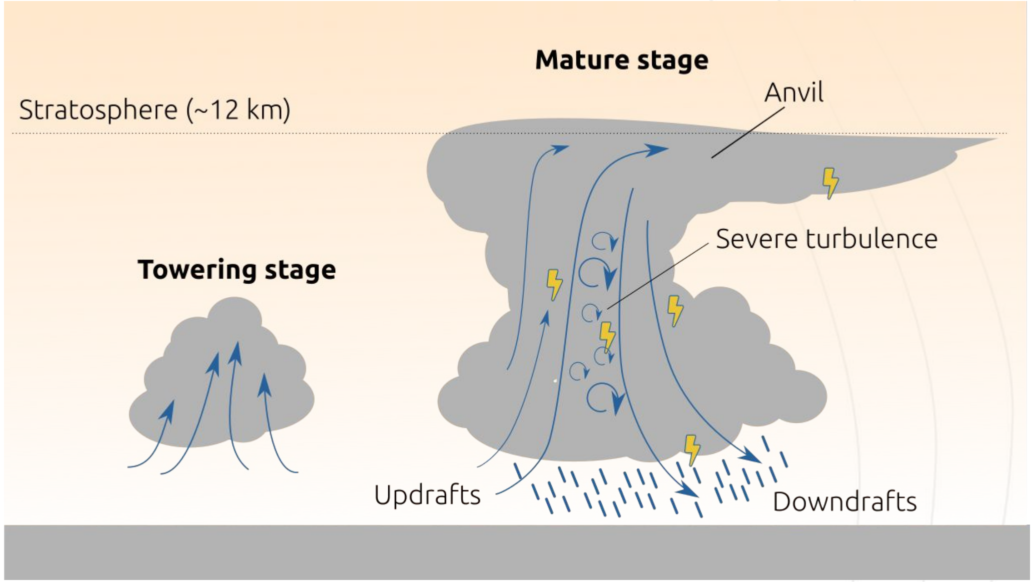
What is Convective Initiation?

Convective initiation is when thunderstorms are able to grow and form in the atmosphere.

Requires “SLIM”

- **S**hear
- **L**ift
- **I**nstability
- **M**oisture

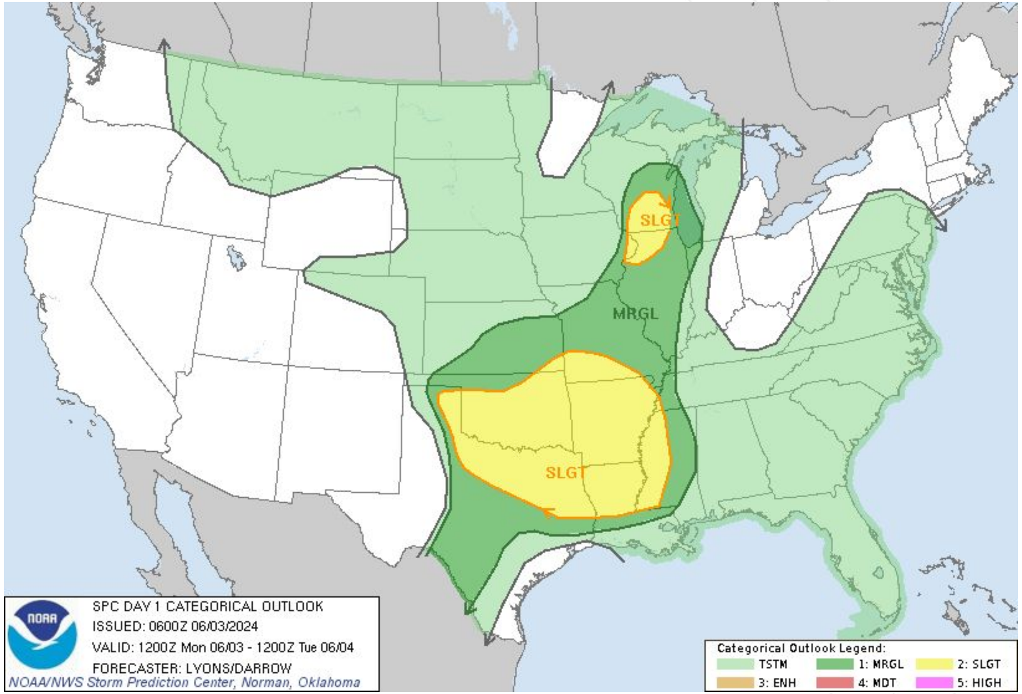


The Problem with Convective Initiation...

.... is that it flips weather forecasting on its head.

Typical Weather:

- Slow-moving, large-scale features.
- Upper-atmospheric waves known as Rossby waves.
- Jet streams
- Cyclones
- Highly predictable through numerical weather models



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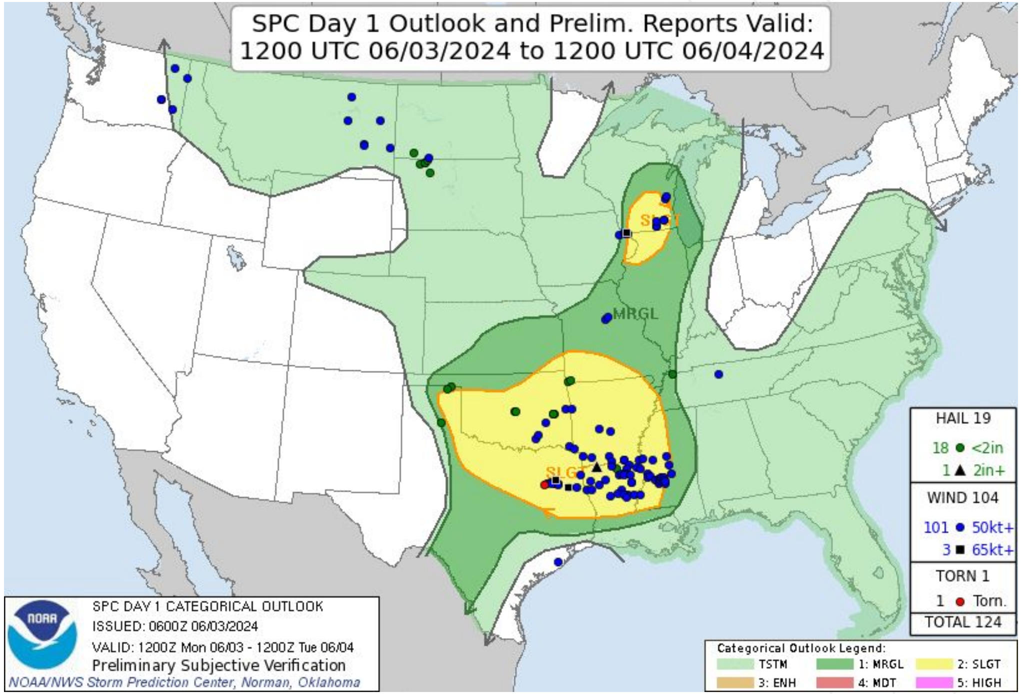
Convective Initiation:

- Inherently an unstable process
- Caused by individual cells of rising air punching through the atmosphere and forming storms.
- Highly localized and fast moving.
- Difficult for <u>any</u> model to predict with accurate timing and locations.



Objective

Evaluate a model that nowcasts GOES satellite imagery to predict convective initiation.

Why GOES Satellite Imagery?

- GOES satellites continuously monitor the western hemisphere.
- The sensors on-board has 16 channels: 2 visible, 4 near-infrared, and 10 infrared.
- Continental US data is available with a 5 minute temporal resolution, and a spatial resolution of at least 2 km.

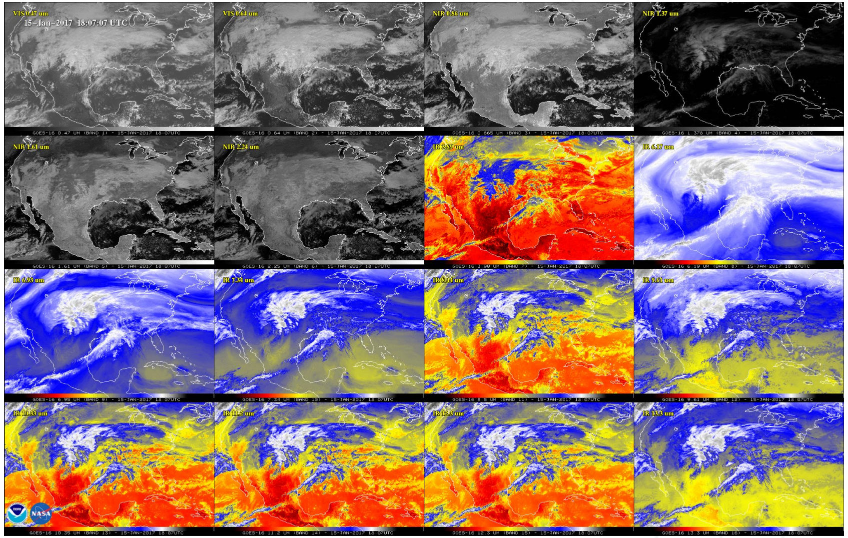
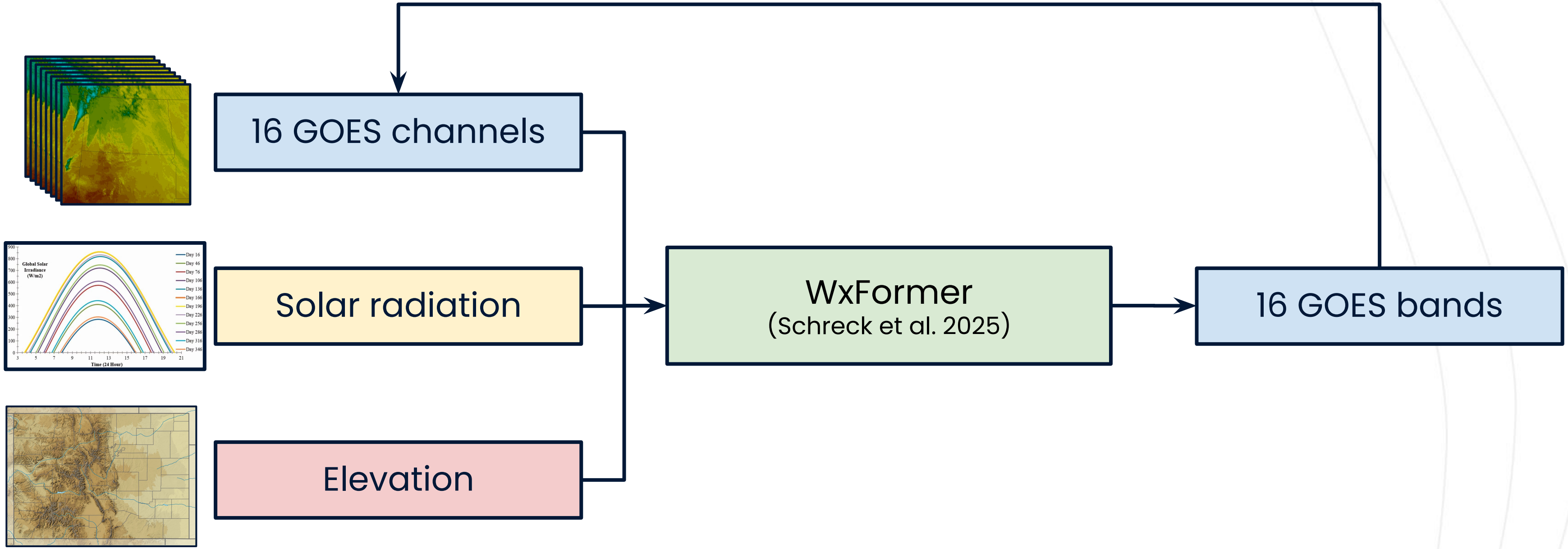


Image Source: NOAA/NASA

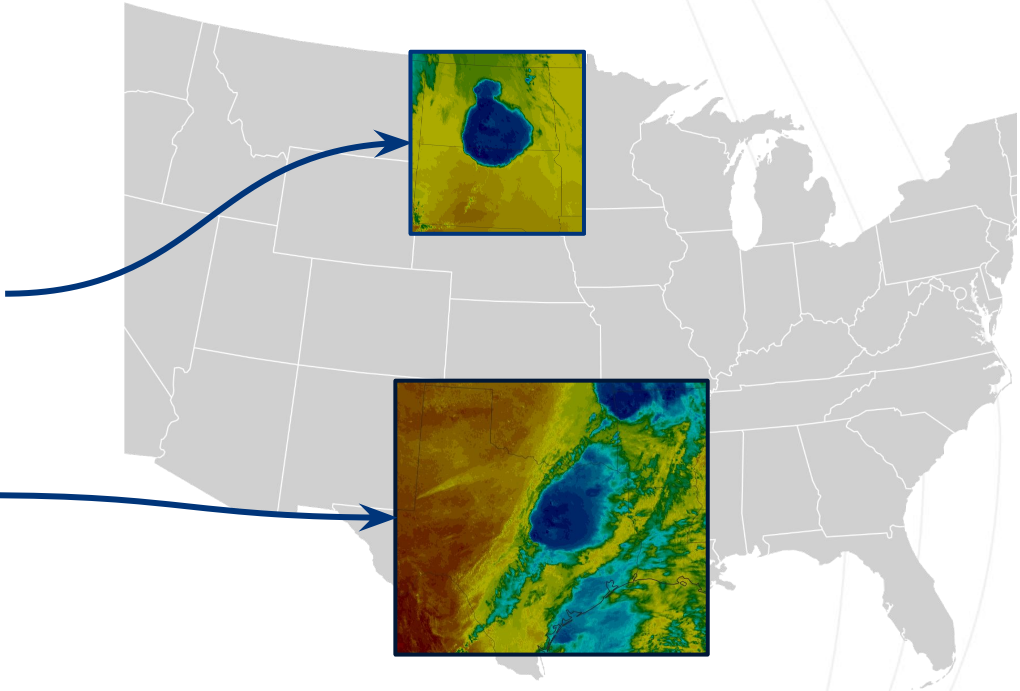
Machine Learning Architecture



Case Study Selection

Identify a representative sample of convective environments.

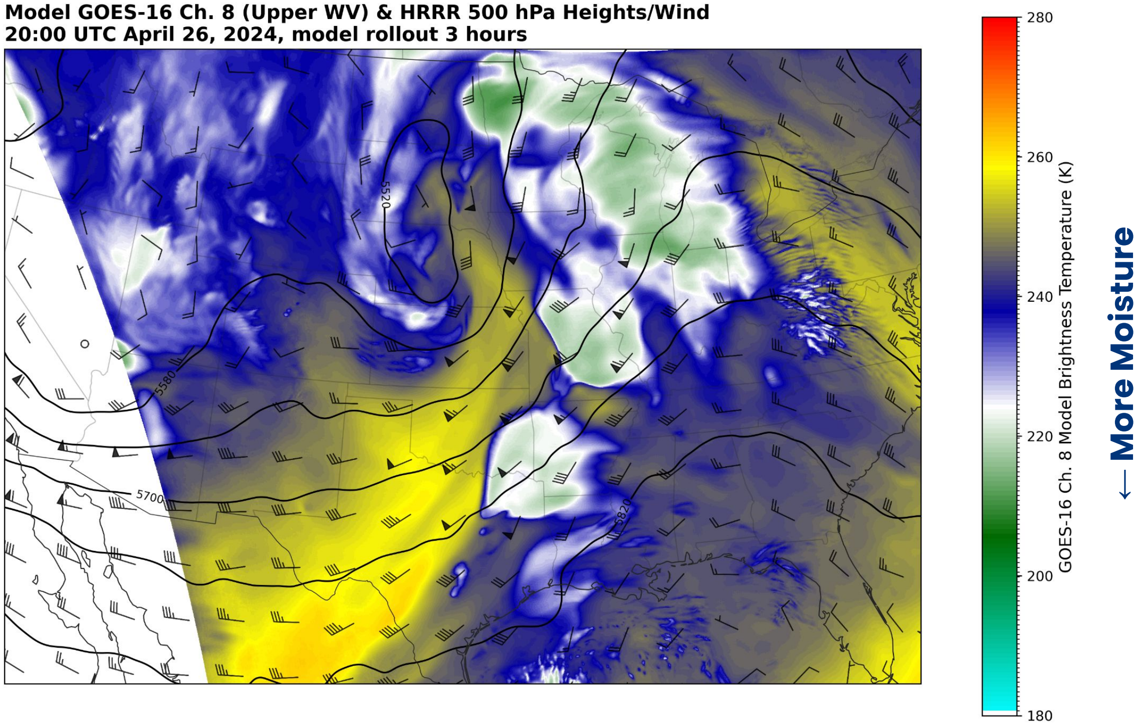
- Initiation over Dakotas
  - August 28, 2024
  - Two confirmed tornadoes
  - 35 wind reports
- Mid-latitude cyclone over the lower plains
  - April 26, 2024
  - 43 wind reports



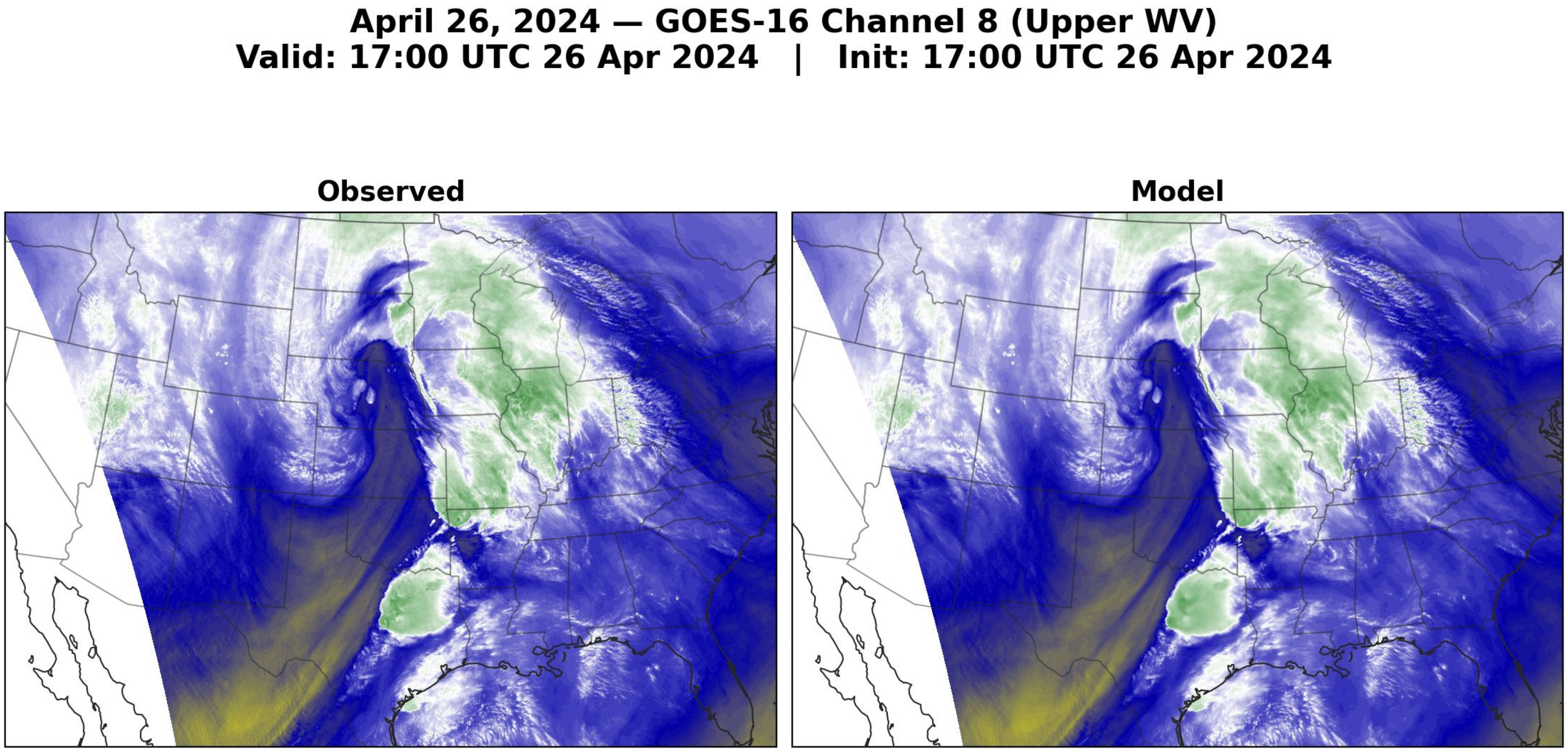
Large-Scale Features

At 3 hours, the model still shows skill modeling broad-scale dynamics.

- Appropriate movement of cloud patterns
- “Learned” how to model cyclone rotation without explicit programming
- Creates features from off-map



Example of Learned Dynamics



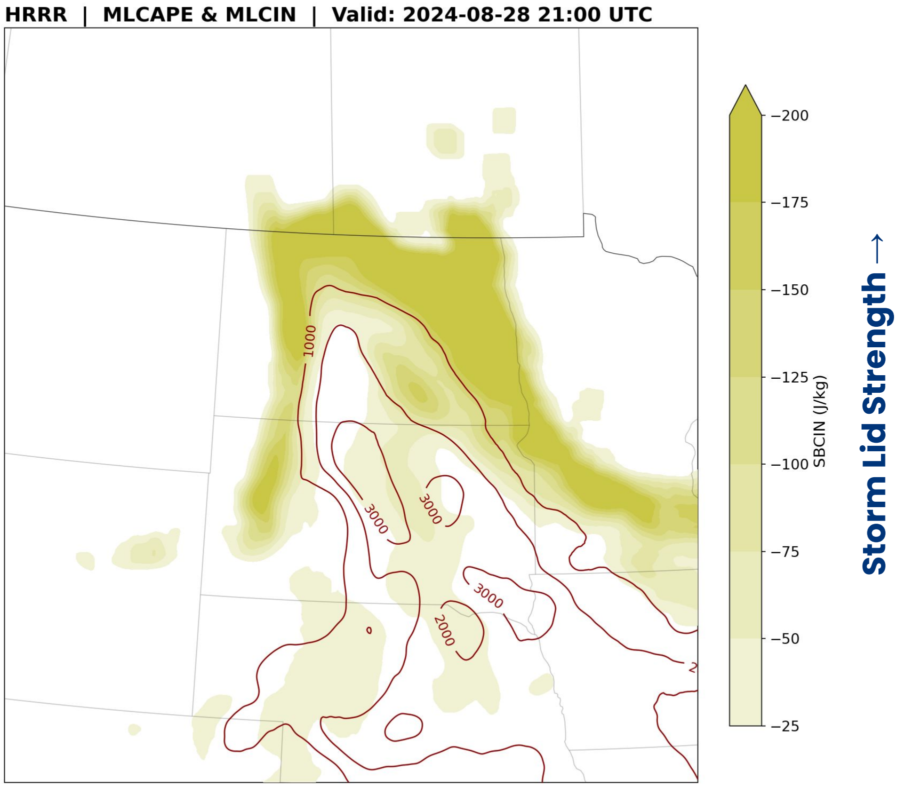
Case Study: Northern Plains Supercell

Case Facts

- Initiation over the Dakotas.
- August 28, 2024 2pm – August 29, 2024 12am
- Two confirmed tornadoes
- Baseball sized hail

Meteorological Environment

- Significant energy for storms
- Upper-level trough
- Cold front progressing eastward
- Shear supporting discrete thunderstorms



Case Study: Northern Plains Supercell

Case Facts

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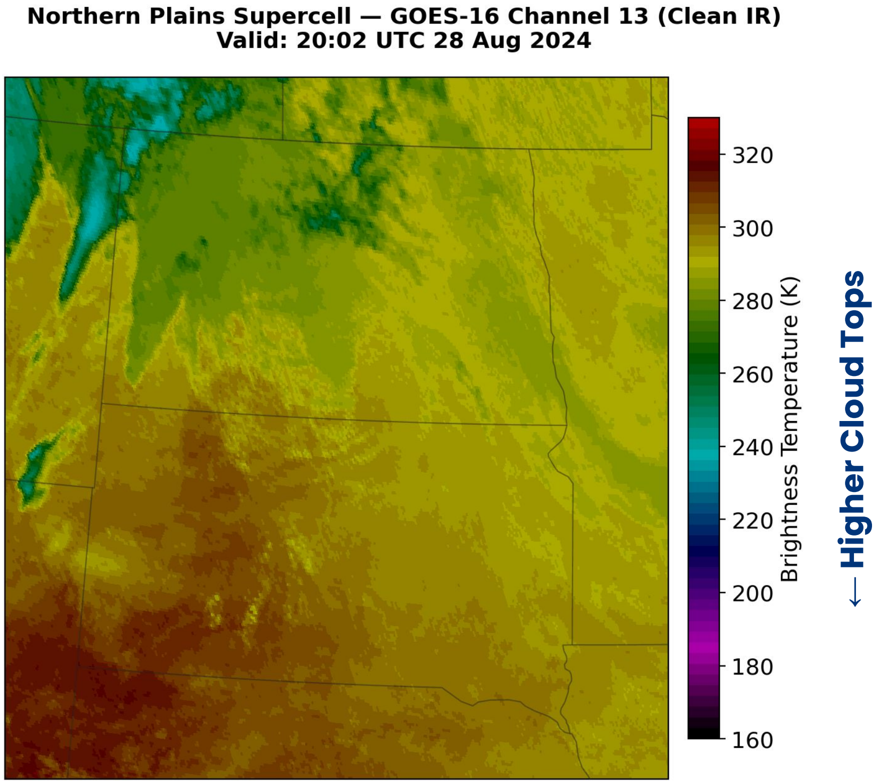
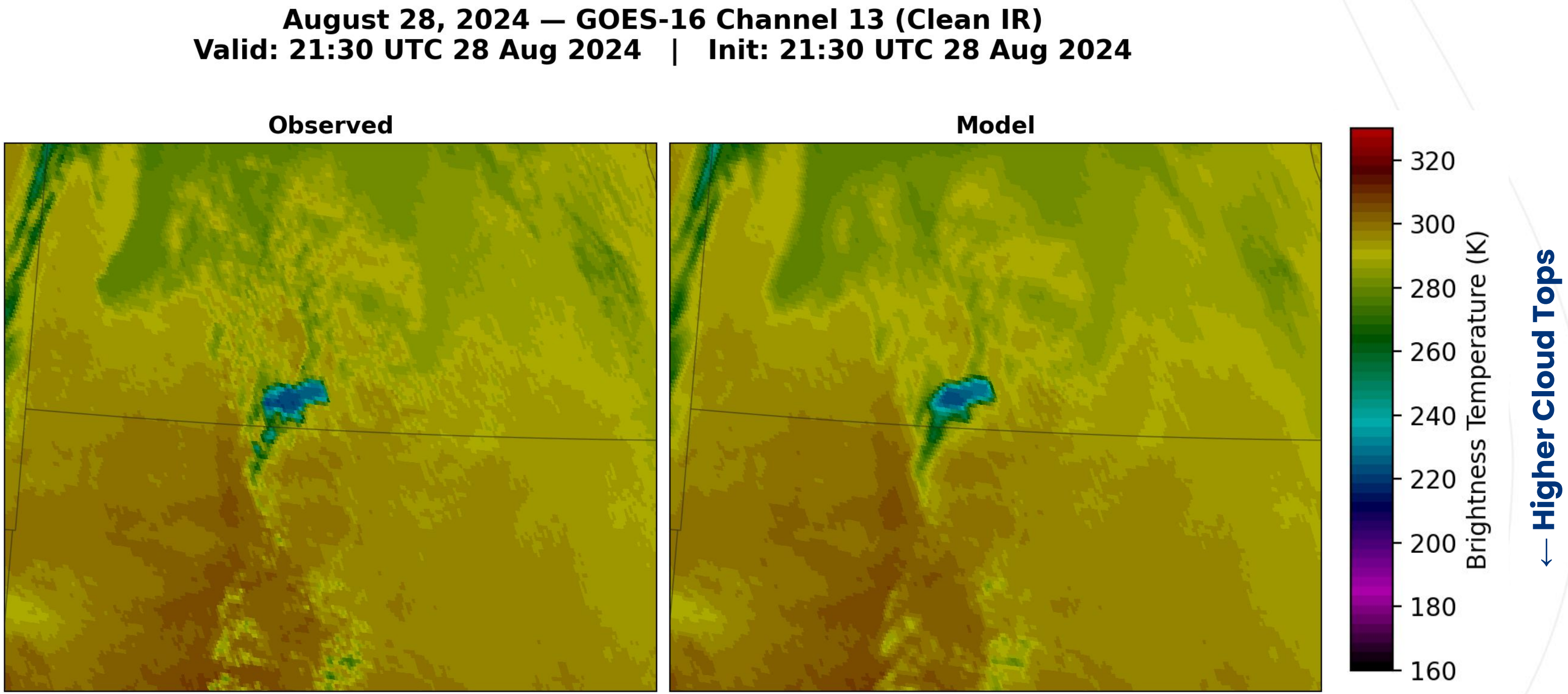
Hypothesis: given a substantially clear environment, the model will struggle to initiate new convection



Model Output During Initiation

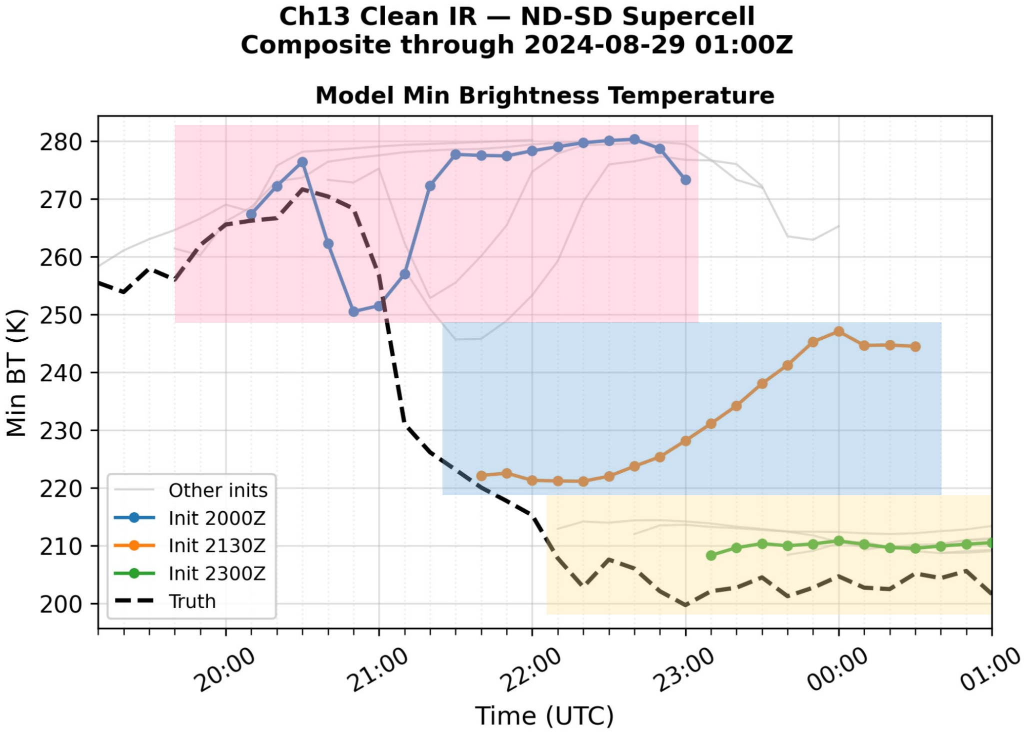


Brightness Temp. Comparisons to Observations

Model runs during initiation fail to meaningfully deepen the storm.

Model run during initial deepening failed to capture maximum strength and prematurely weaken storm.

Model runs during maturation capture the storm's magnitude relatively well.

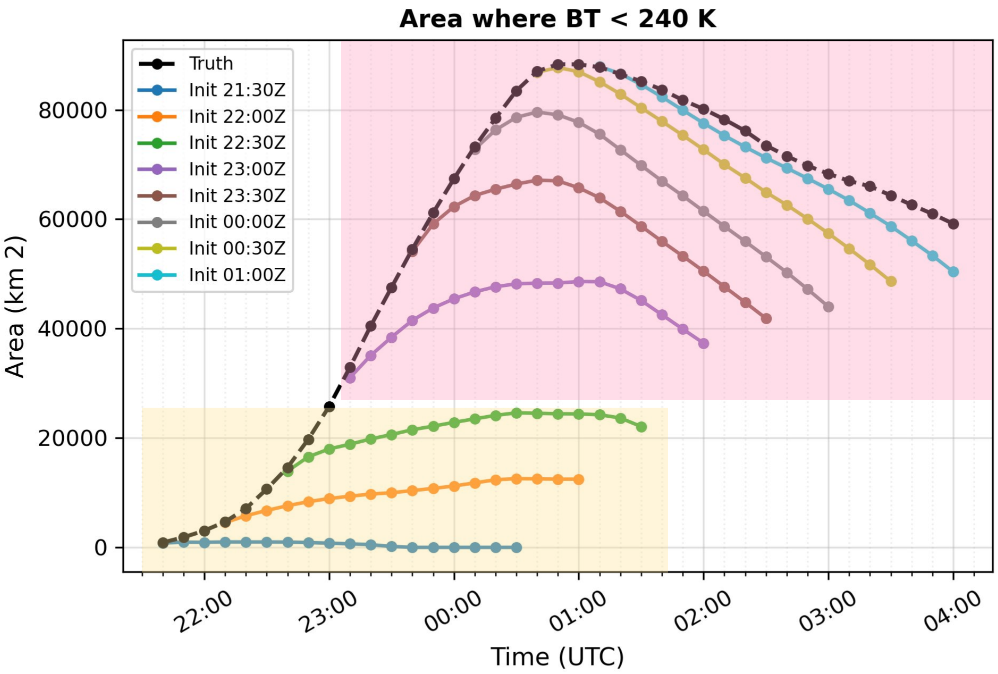


Comparison of Model & Observations Extent

Model also prematurely decays the storm and decays more quickly than the observational data.

During initiation & growth stages, model persistently underestimates the full extent both spatially and strength-wise.

Cold-cloud area (Ch13 Clean IR)



Conclusions & Future Work

Conclusions

- The model shows general skill in terms of handling broad-scale dynamics.
- Convective initiation is still a major problem for the model.
- Additionally, spatial extent and premature decay of existing storms is often exhibited.

Future Work & Next Steps

- Re-training the model using a multistep approach to reduce errors.
- Incorporating more meteorological variables to add context to the model.
- Resample the training data to include more examples of convective initiation.

Questions?

Contact Information

Email: ecampb34@charlotte.edu

LinkedIn

Poster