COLORADO STATE UNIVERSITY

Aviation-Relevant Satellite Research at CIRA

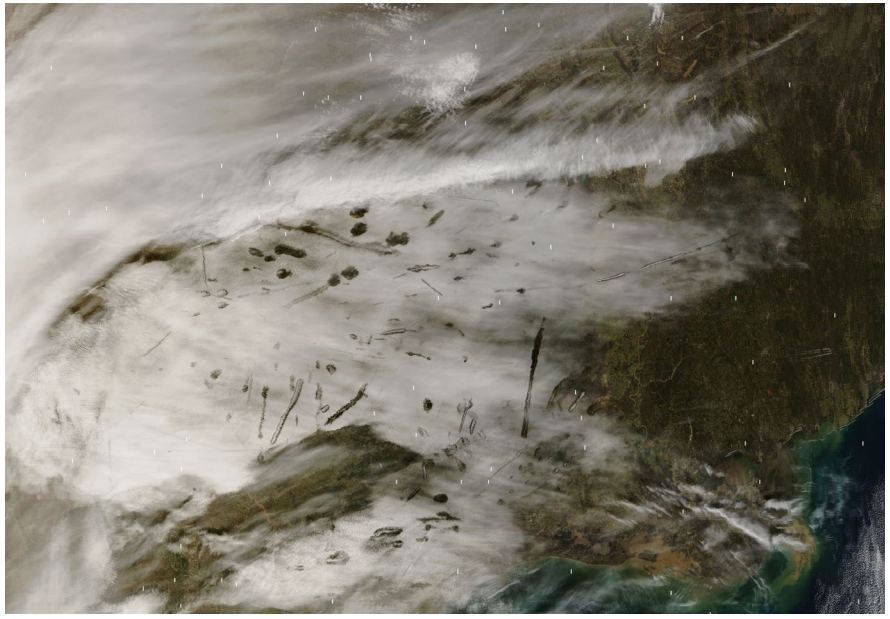
Steven D. Miller

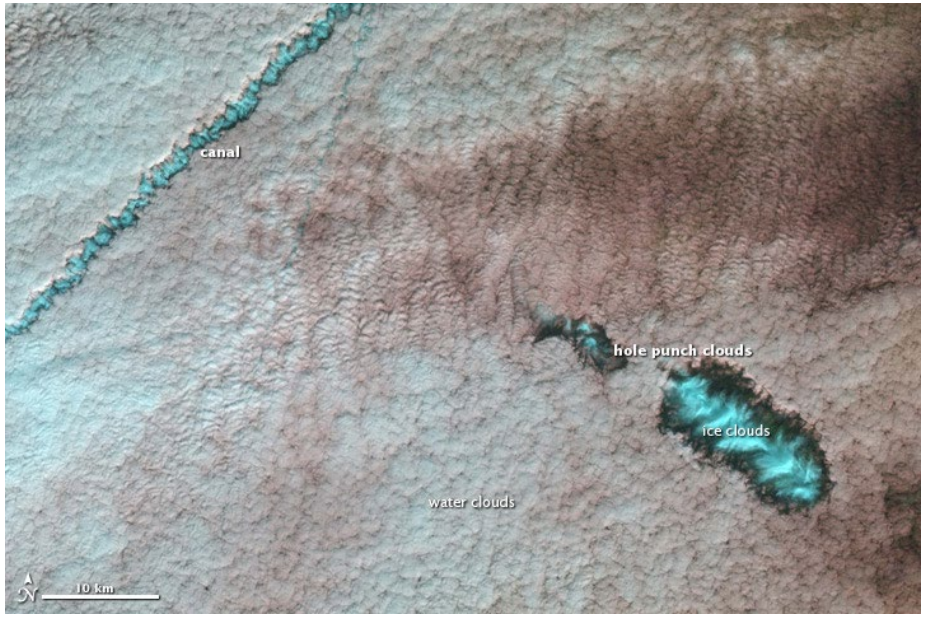
Cooperative Institute for Research in the Atmosphere (CIRA)

Clouds, Cloud Ceiling and Visibility (C&V) Technical Exchange Meeting

UCAR/NCAR, Boulder CO

13 July 2022





Cooperative Institute for Research in the Atmosphere

Topics

1. Brief CIRA Overview

2. Selected Satellite Applications bearing relevance to aviation

3. New technologies, techniques, and initiatives

Cooperative Institute for Research in the Atmosphere (CIRA)

Competitively Established in 1980

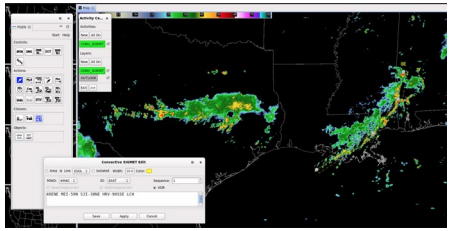
CIRA Serves as a Research and Development Arm of NOAA, Enabling High-Risk, High-Reward Atmospheric Science Applied Research

Mission: Connecting NOAA to Colorado State University Researchers, Faculty, and Students, aligning NOAA research needs with long-standing academic strengths of the University.

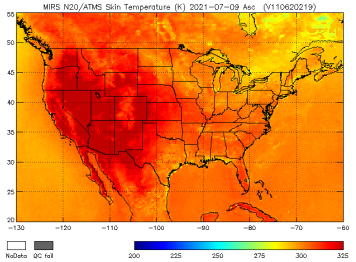
Vision: Realizing NOAA's societal benefit goals for a Weather and Climate Ready Nation via leadership in satellite remote sensing, forecast model and decision support, and model/observation connection.

CIRA
Cooperative Institute for Research in the Atmosphere

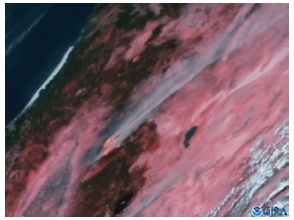
AWC/Kansas City

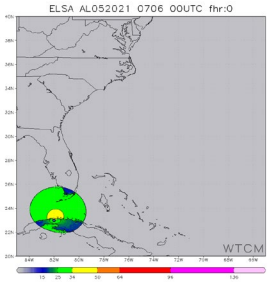


NCWCP/College Park



Colorado State University
RAMMB/Ft. Collins

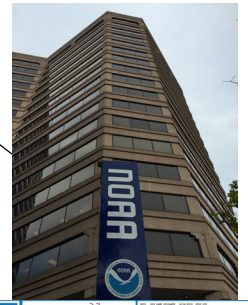




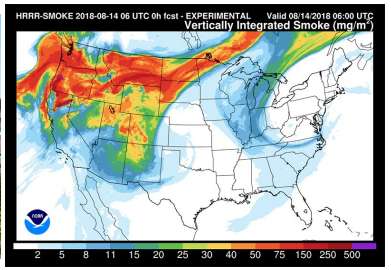
Staffing By Location

Location	Research	Admin	Total FTE
Boulder	40.2	1.1	41.3
College Park	9.0	0.2	9.2
Fort Collins	57.8	10.2	68.0
Kansas City	14.0	1.2	15.2
Miami	2.1	0	2.1
Silver Spring	11.0	0	11.0
Total	134.1	12.7	146.8

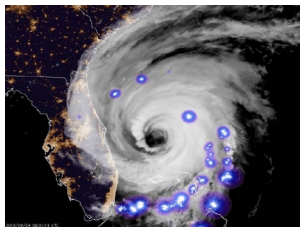
MDL/Silver Spring



ESRL/Boulder



NHC/Miami



CIRA Research Spans Multiple Themes

THEMES

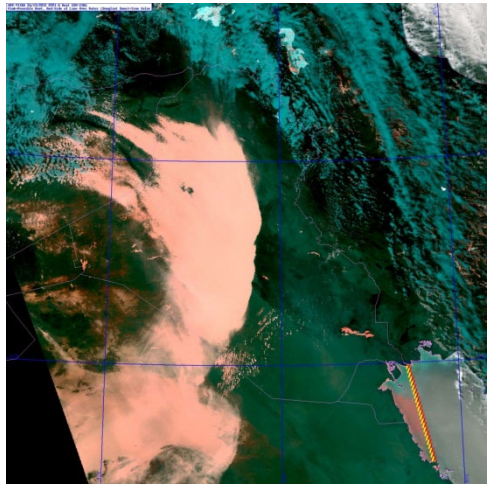
1. Satellite Algorithm Development, Training, and Education
2. Regional to Global Scale Modeling Systems
3. Data Assimilation
4. Climate-Weather Processes
5. Data Distribution

CORE CAPABILITIES

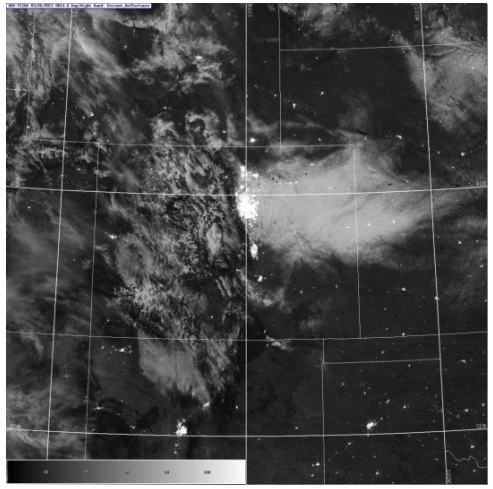
- Multi-satellite, multi-sensor, model-fusion
- Radiative transfer
- Machine Learning, Explainable AI
- Satellite Education, Training, and Outreach, R2O
- Forecaster tools, interfaces, model verification
- Societal and Economic Impact studies
- Connecting models and observations
- ***Faculty, grad student and postdoc involvement***

Satellite Algorithms & Applications

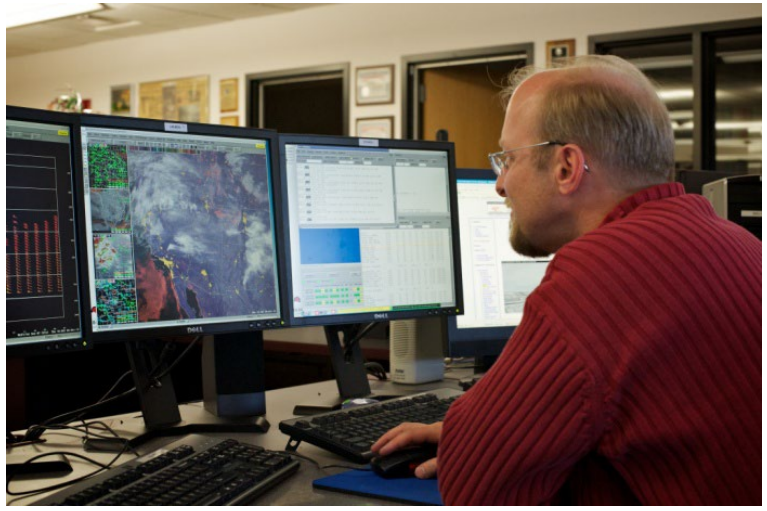
Dust Detection



Day/Night Band: Snow

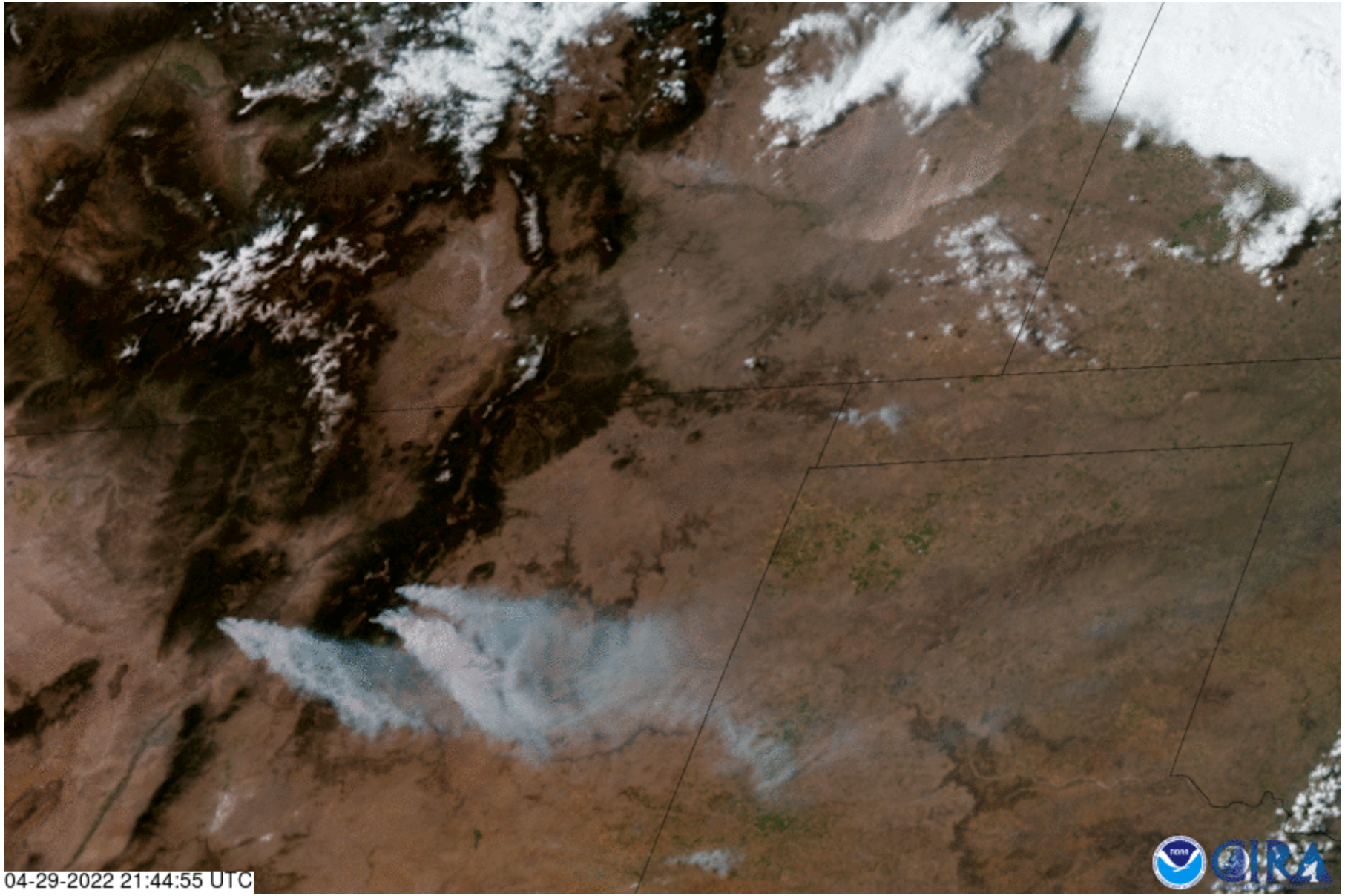


Connecting Products to Forecasters & Training



Advanced Satellite Imagery Applications

CIRA's GeoColor Imagery

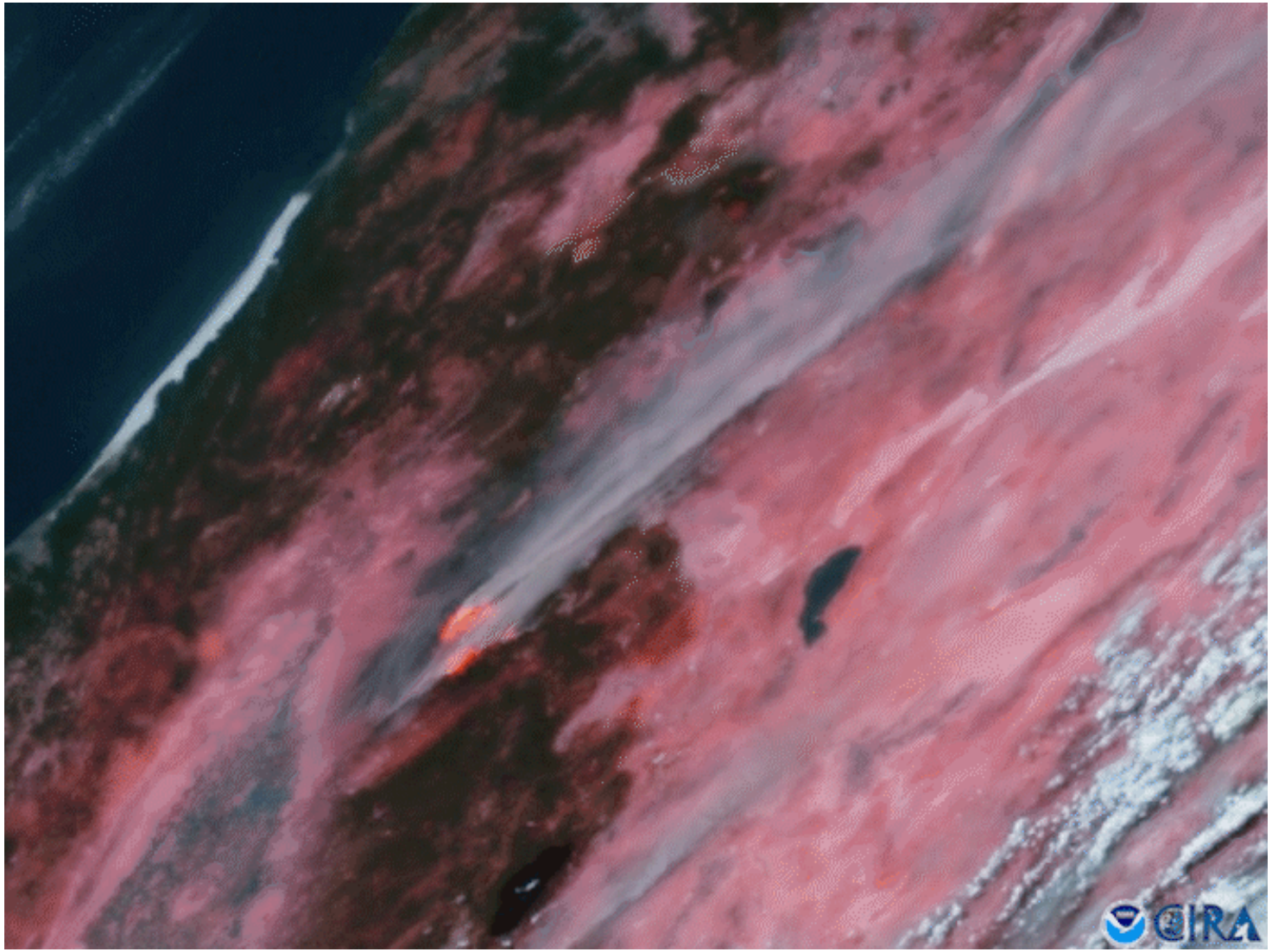


Dakota Smith, CSU/CIRA

Blended High-Dimensional RGBs

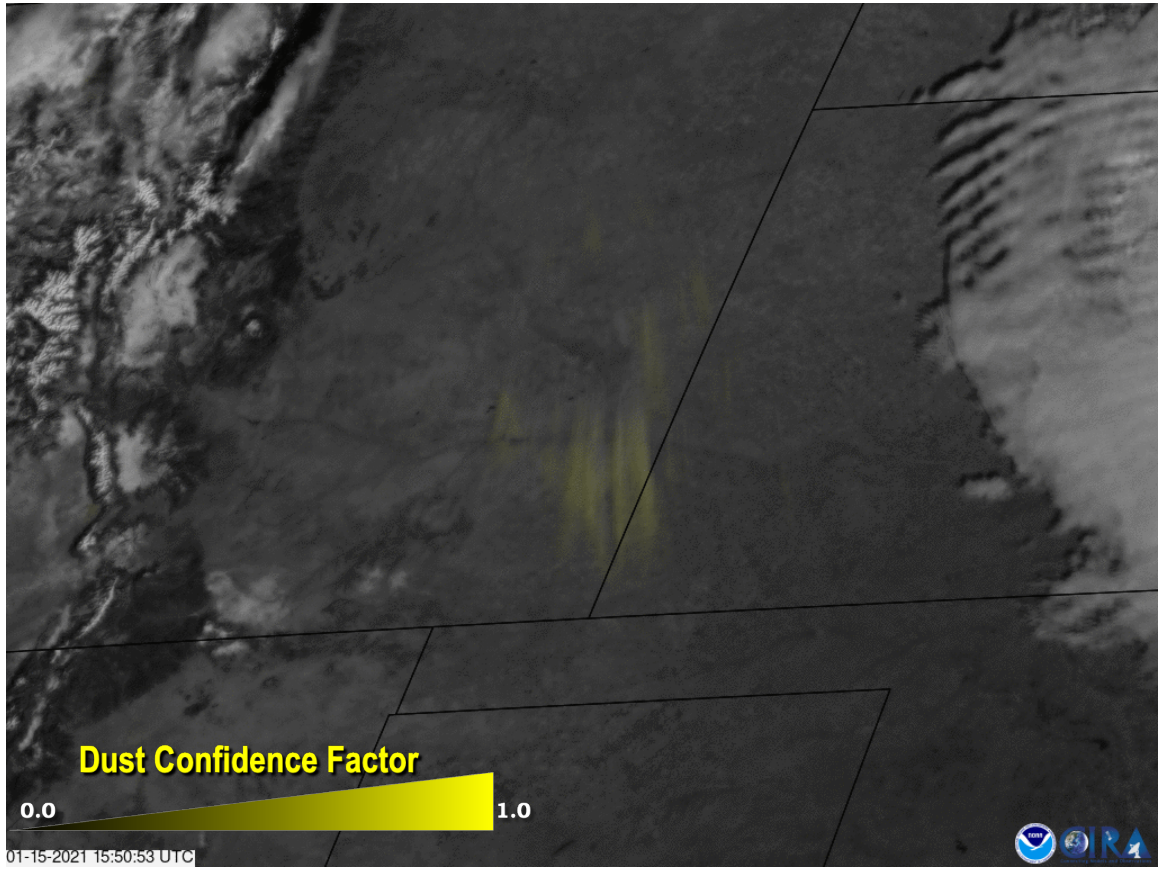
Curtis Seaman and Dakota Smith, CSU/CIRA

- GOES-16 ABI GeoColor imagery with Fire Temperature RGB (3.9, 2.25, 1.61) overlay
- Depicting the Dixie Fire (N. California) on 22 July 2021.
- Applications to pilot visibility



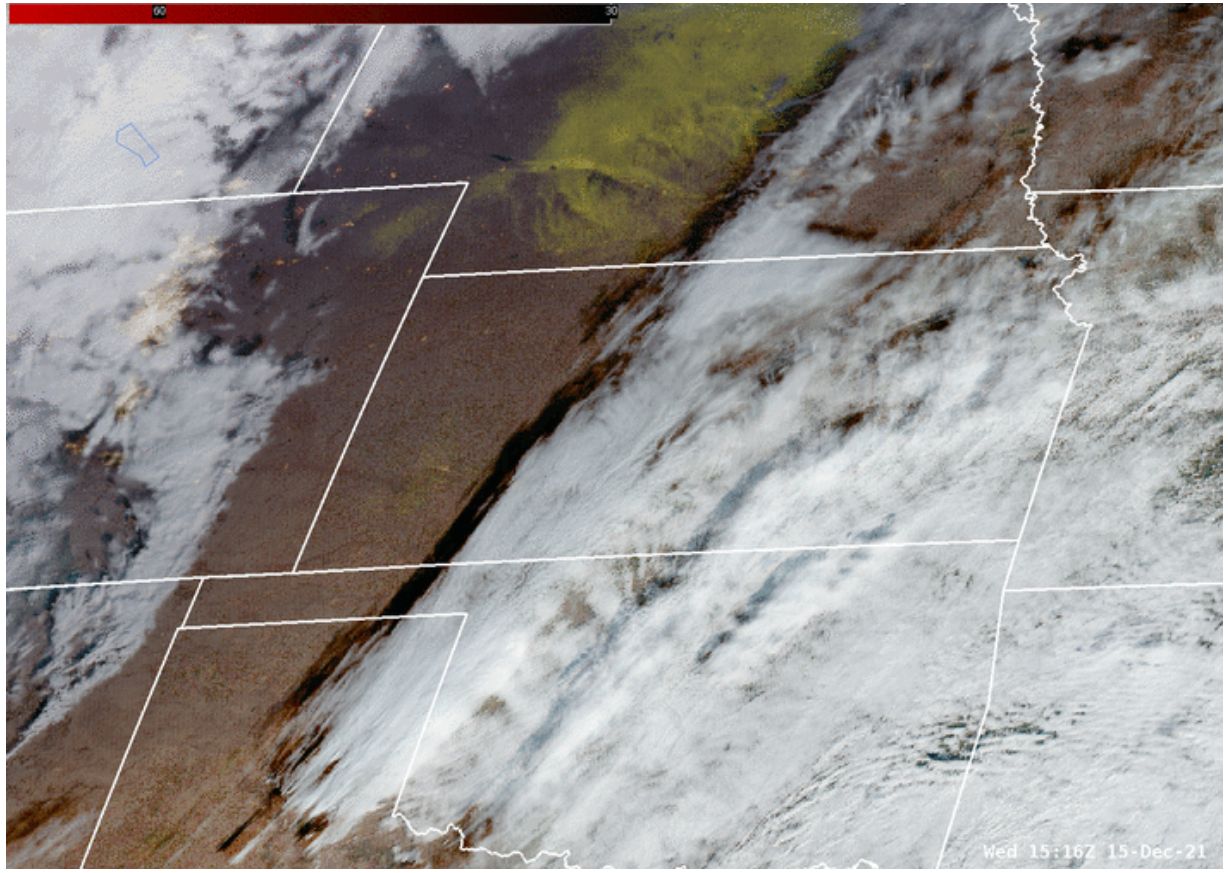
Multi-Spectral Lofted Dust Detection

DEBRA Flow-Following (GOES-R ABI)



Dakota Smith (CSU/CIRA)

GeoColor + DEBRA Merged (GOES-R ABI)

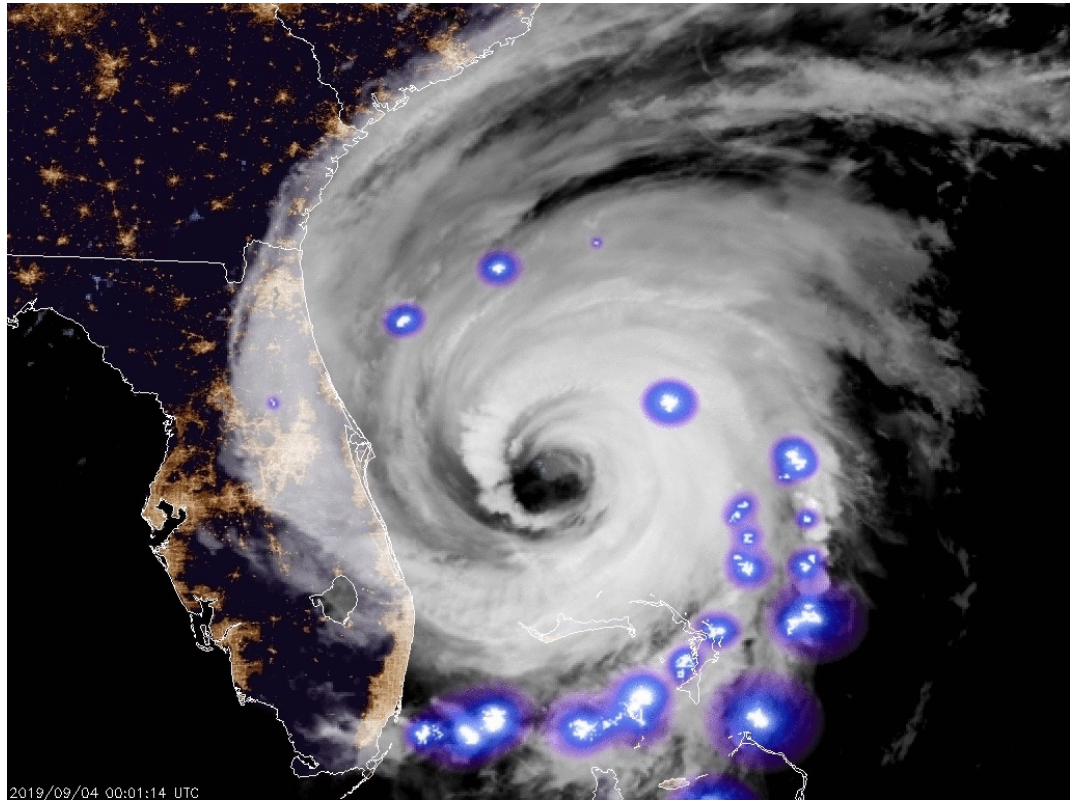


Bill Line (NOAA/NESDIS/STAR/RAMMB)

Additional applications to pilot visibility, particularly under VFR

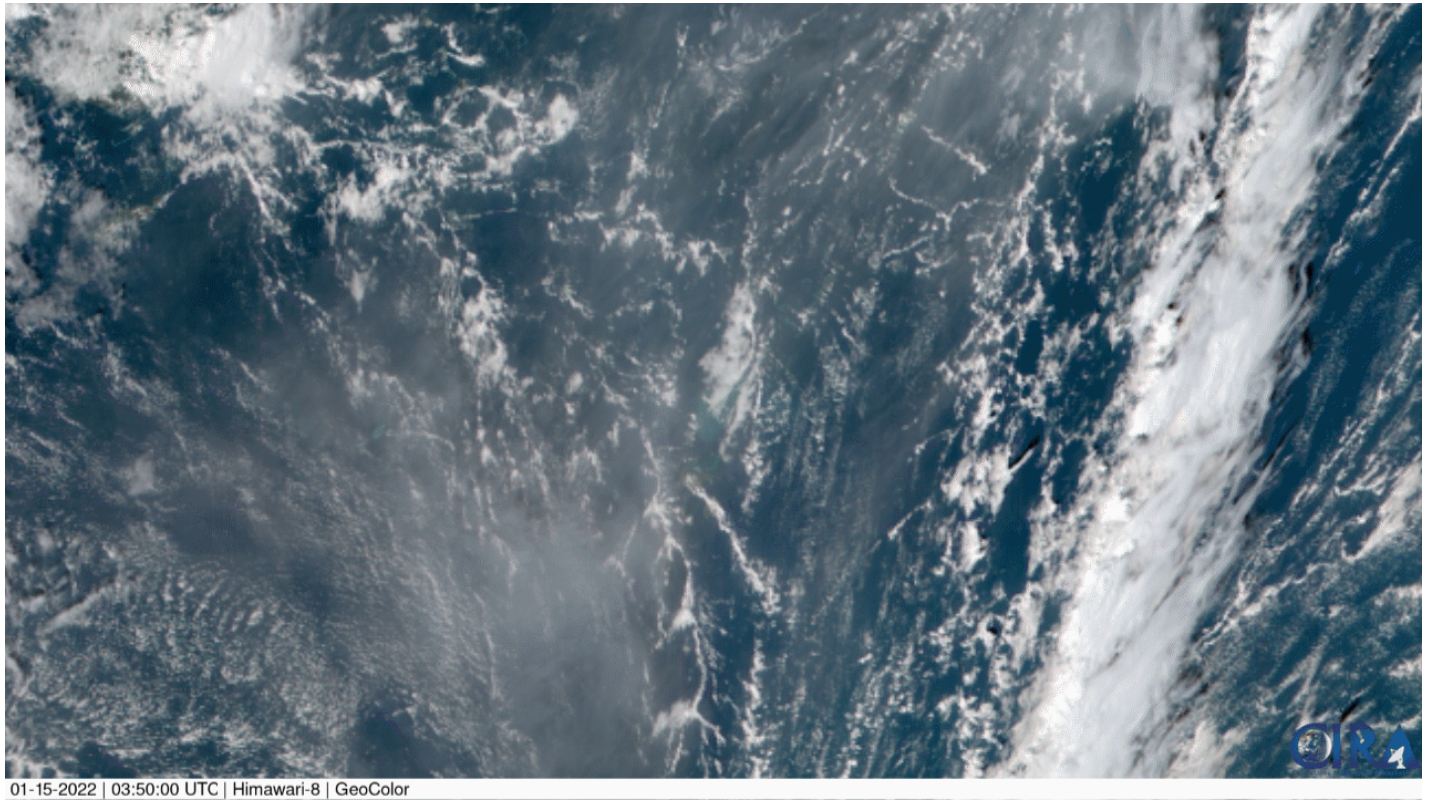
Monitoring Natural Disasters Worldwide

ABI/GeoColor + GLM: Hurricane Dorian
4 September 2019



YJ Noh, Kyle Hilburn, Dakota Smith, CSU/CIRA

Himawari-8/GeoColor: Hunga Volcano, Tonga
15 January 2022



Dakota Smith, CSU/CIRA

Monitoring aviation weather hazards at multiple space/time scales

Visit *SLIDER Web Page!*
https://rammb-slider.cira.colostate.edu

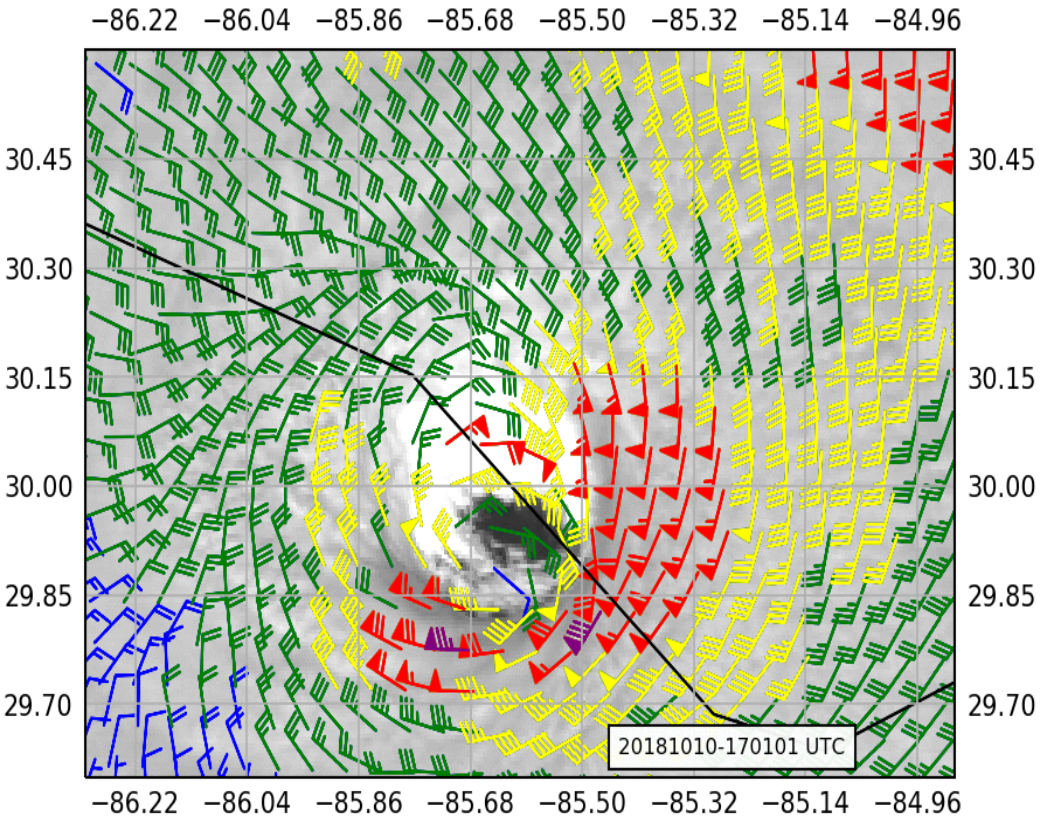
(Kevin Micke and Mattie Niznik, CSU/CIRA)

Quantitative Assessment of Cloud Dynamics

Optical Flow Motion Vectors & Imagery

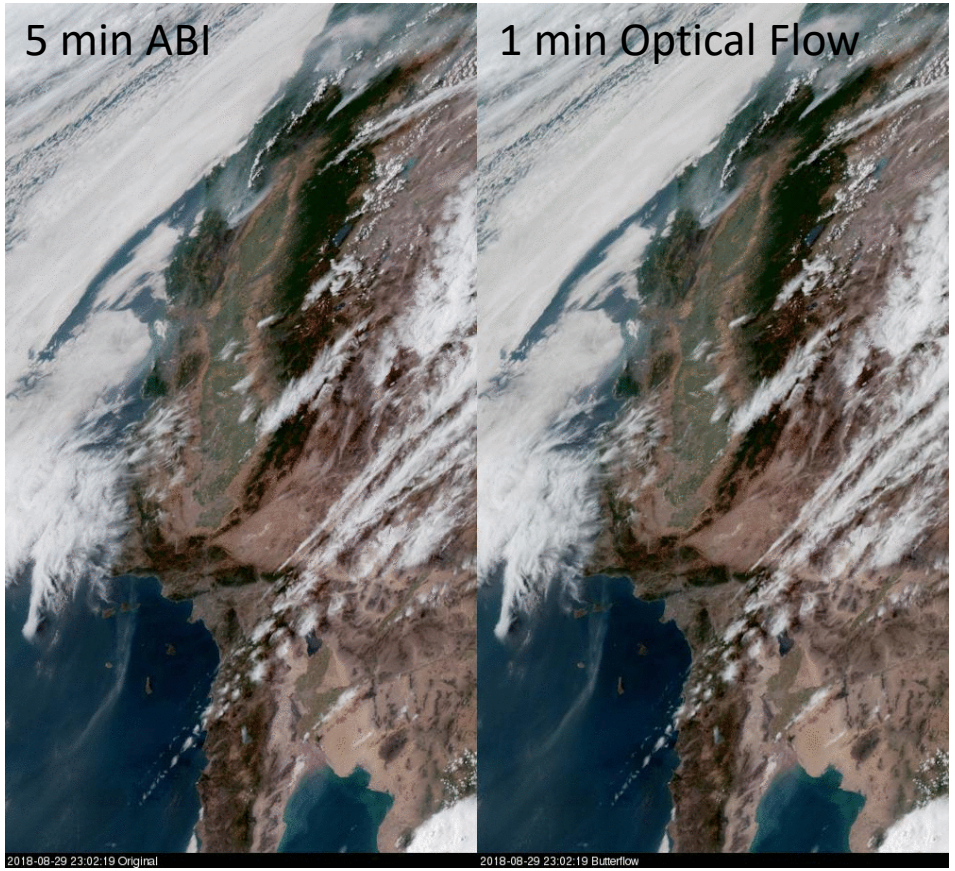
Jason Apke, CSU/CIRA

High-Density Wind Fields: Hurricane Michael



Pixel-resolved dense motion
Can stratify by retrieved cloud height to infer flight-level winds

Time-Interpolated Imagery: GOES-East

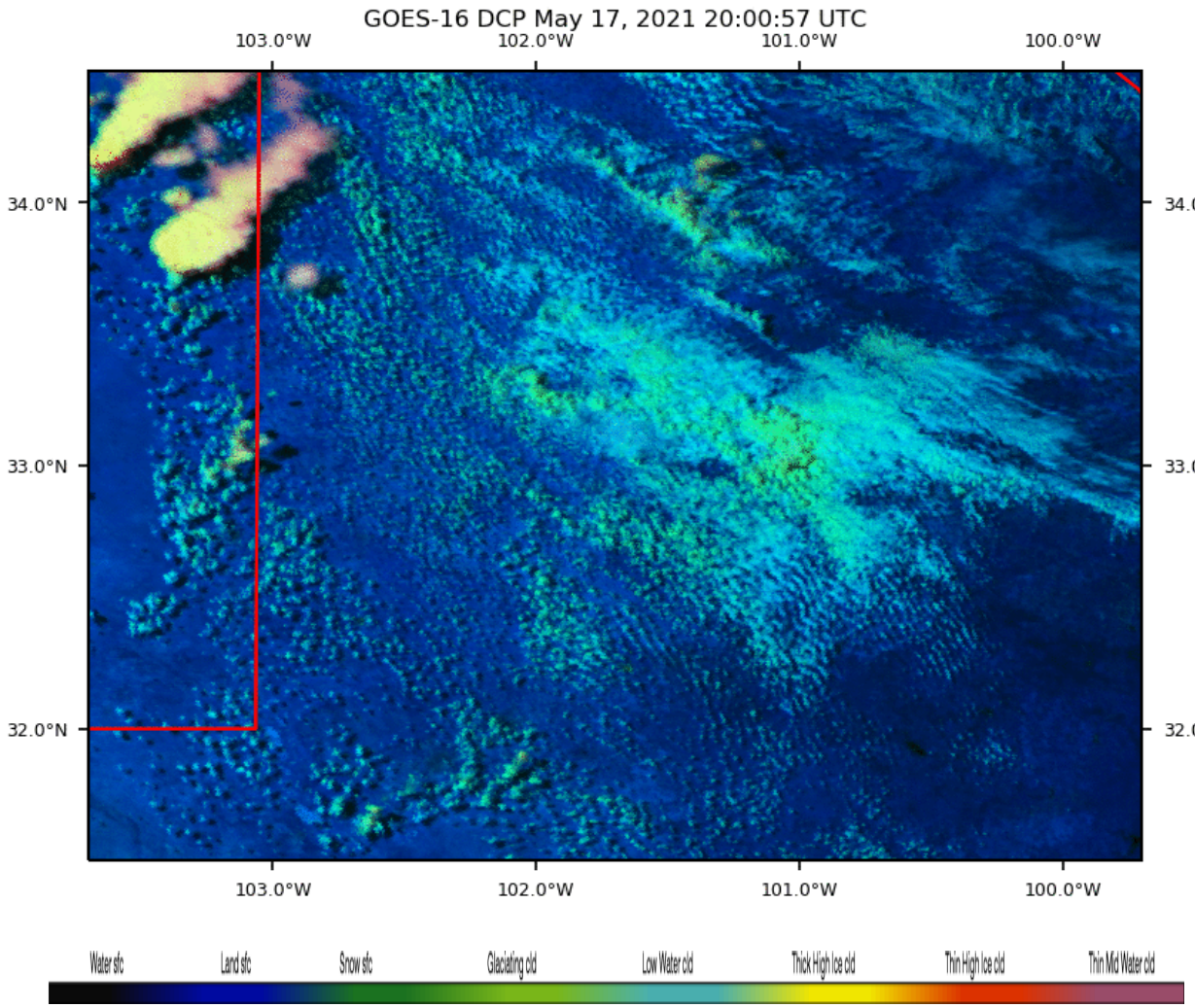


Can be used to time-interpolate imagery in a way that is far superior to conventional “fades,” filling imagery coverage gaps

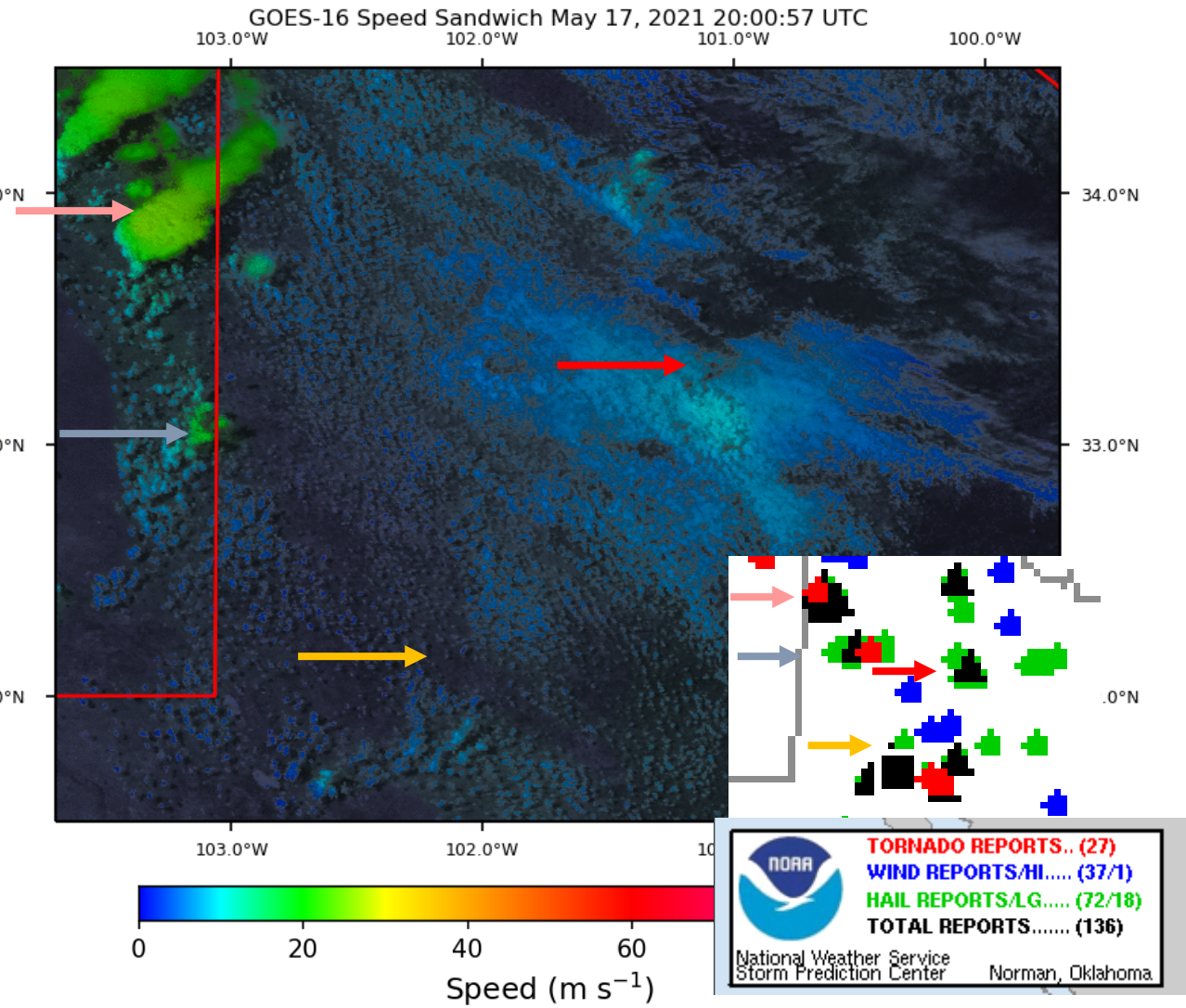
Optical Flow Enhanced Imagery

Jason Apke, CSU/CIRA

Day-Cloud Phase Distinction RGB (JMA)



DOF Speed/Visible "Sandwich"

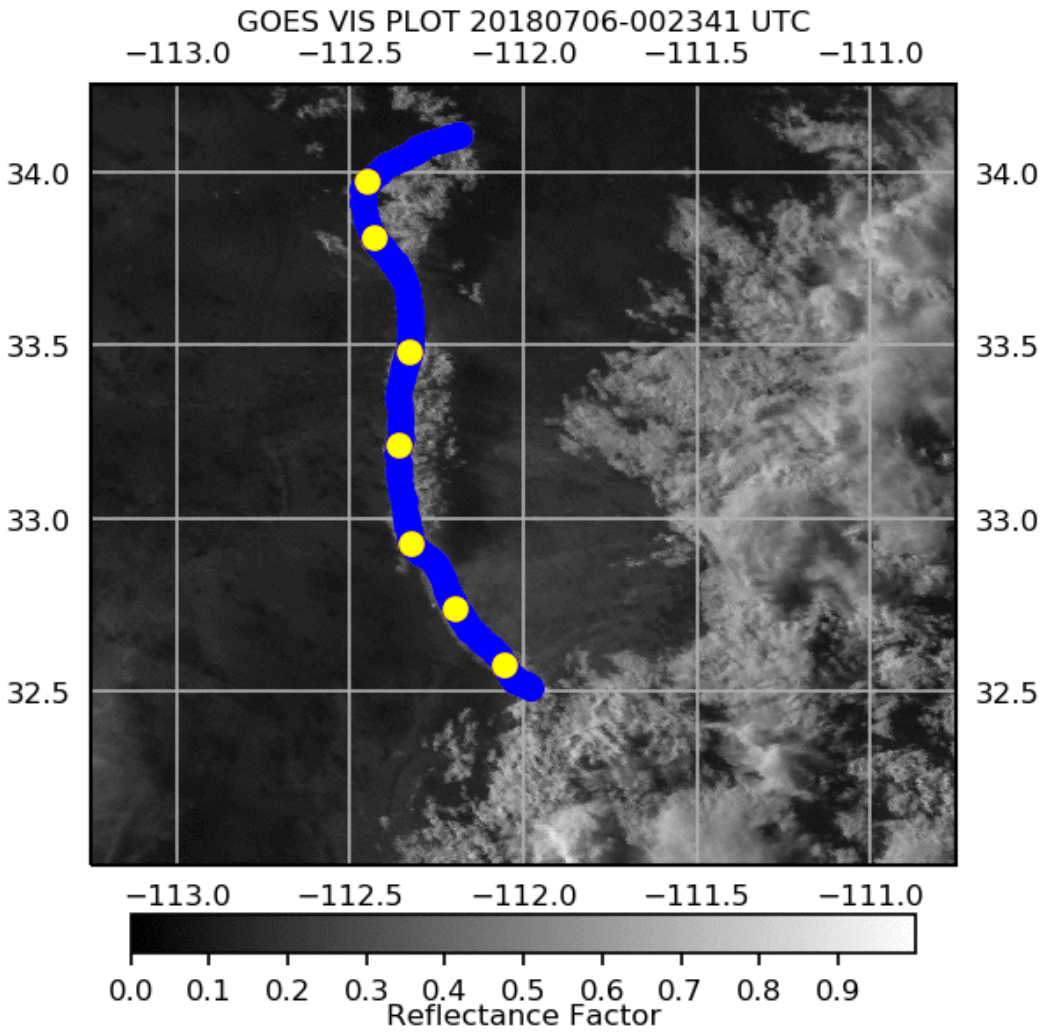


(*Left*) GOES-16 Day-Cloud Phase enhancement (from 0.64, 1.6, and 10.3 µm imagery) shown with (*Right*) Dense optical flow colored by wind speed with brightness indicating the 0.64 µm reflectance (the "OCTANE Speed Sandwich" product).

Optical Flow Dynamic Analyses

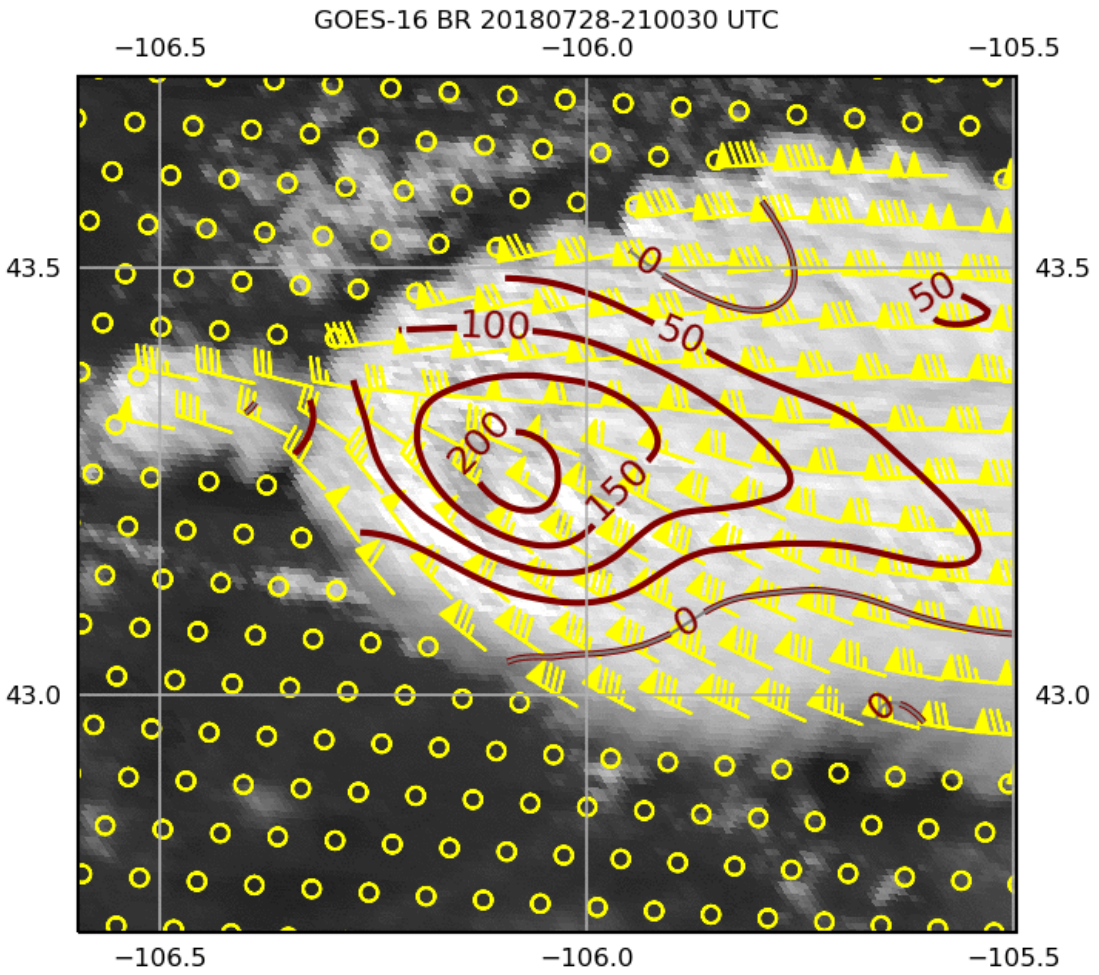
Jason Apke, CSU/CIRA

Convective Outflow Boundaries



Convective outflows near airfields…

Storm-Top Structure



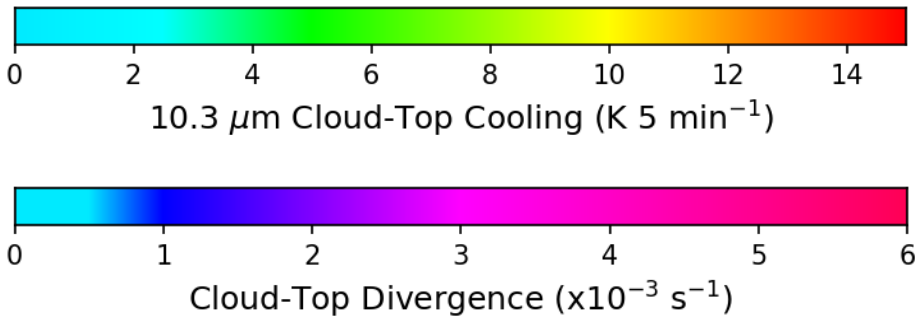
Clear air turbulence (gravity wave launching)…

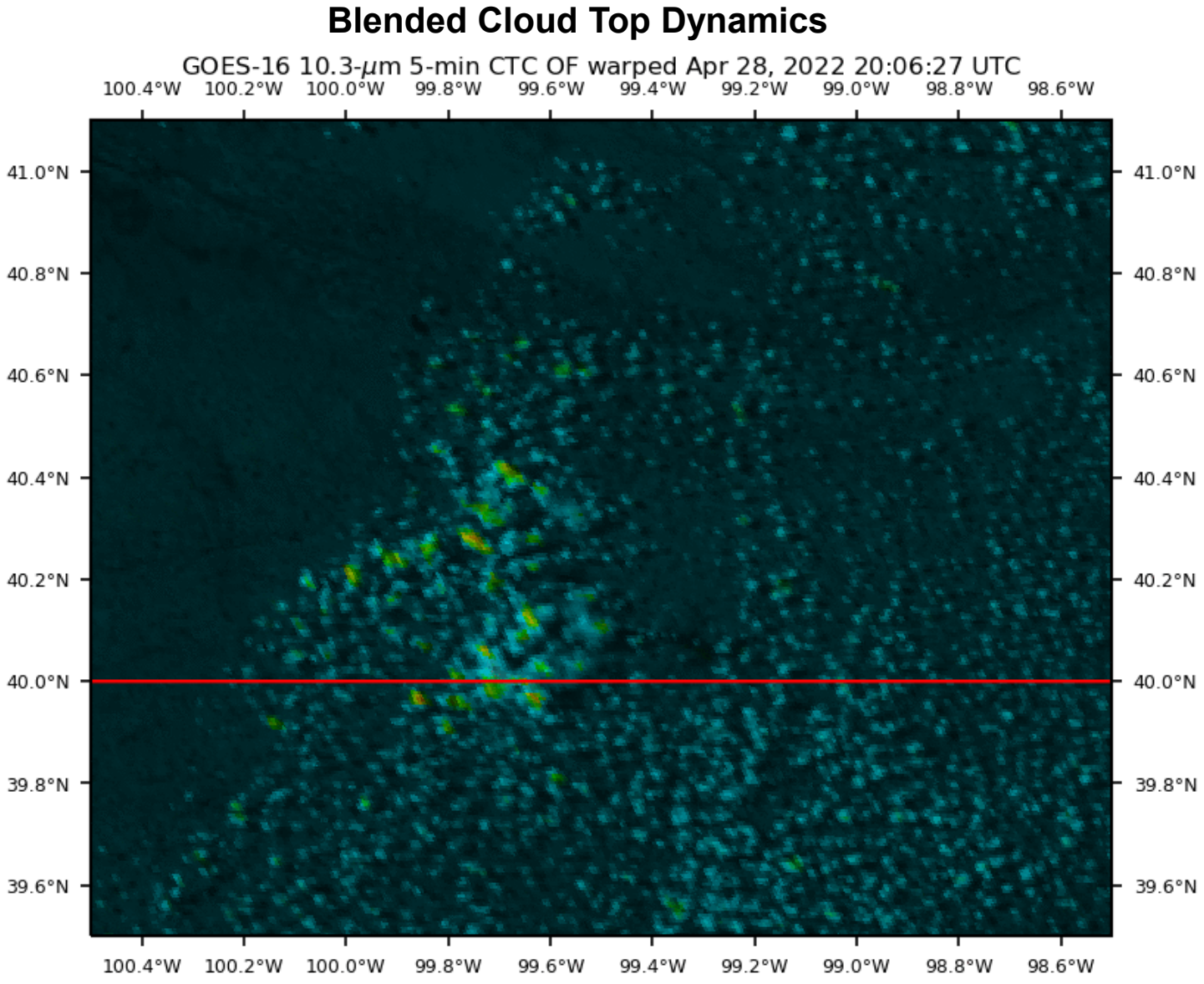
Optical Flow Blended-Product Imagery

Jason Apke, CSU/CIRA

- Cloud-top cooling (CTC) products can serve as early indicators for convection before they can be spotted on aircraft radar.

- Optical flow “follows” the convections in space/time, allowing for high-quality CTC calculations that minimize shift artifacts



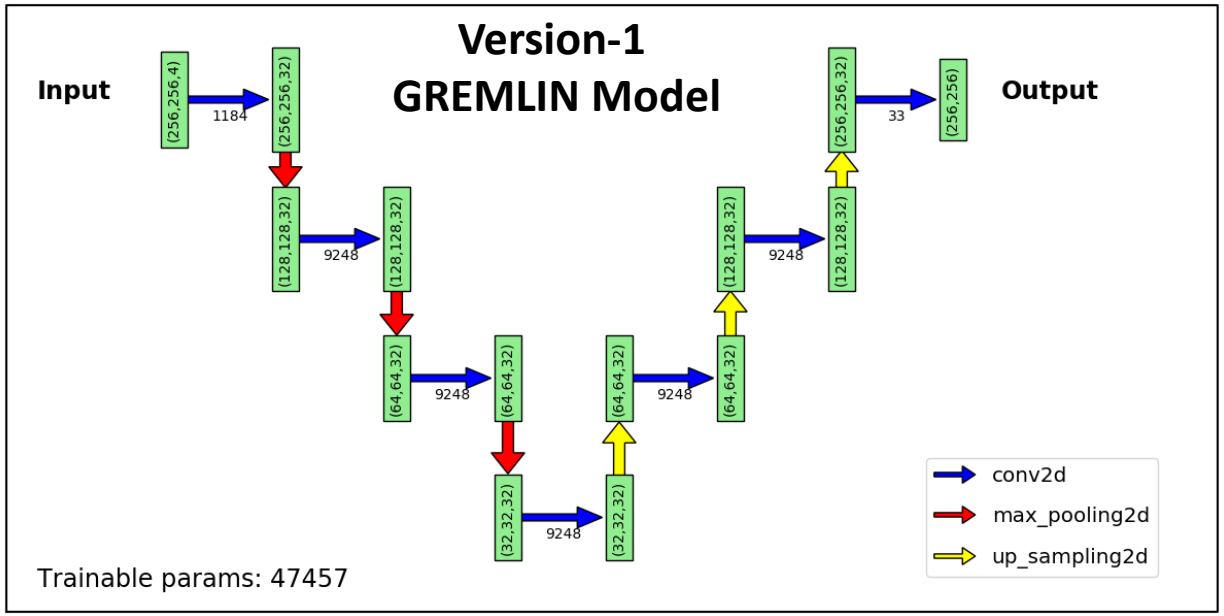


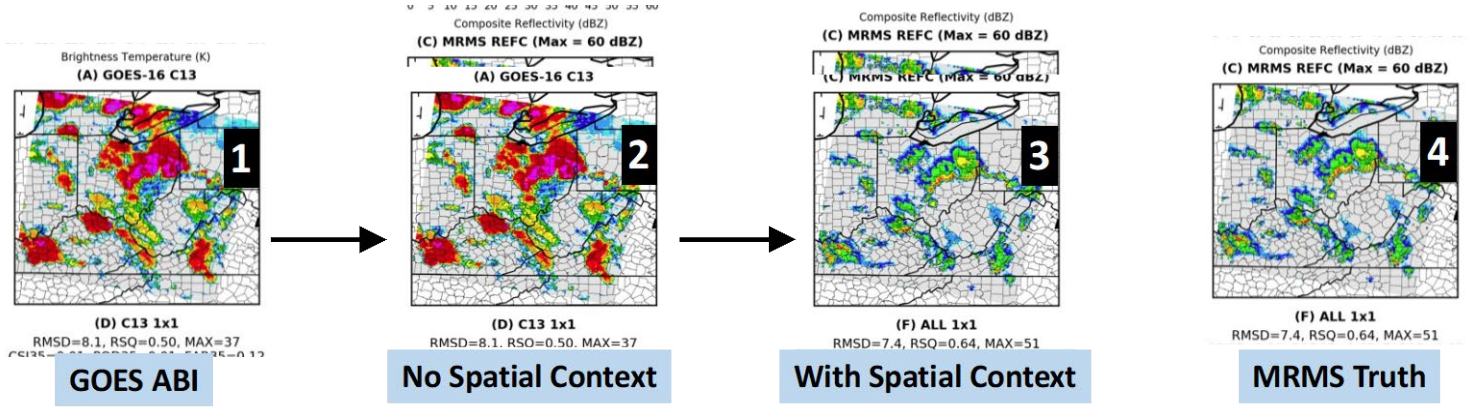
Pushing the Envelope of Remote Sensing Technology and Products

Machine Learning Initiatives at CIRA

Kyle Hilburn, CSU/CIRA

- Harnessing the power of Machine Learning (ML), GOES-R capabilities to provide "*radar everywhere*" for initializing convection in high-resolution numerical weather prediction (NWP) models
- Introducing (GOES Radar Estimation via Machine Learning to Inform NWP) → GREMLIN
- Convolutional neural network
  - Captures information content in spatial patterns with convolutional layers (blue arrows)
  - Captures multi-scale information with pooling and up-sampling (red, yellow arrows)
  - Leverages the power of spatial context provides a breakthrough improvement to skill!
- Image-to-image translation
  - Inputs: GOES ABI and GLM
  - Outputs: Multi-Radar/Multi-Sensor (MRMS) composite reflectivity

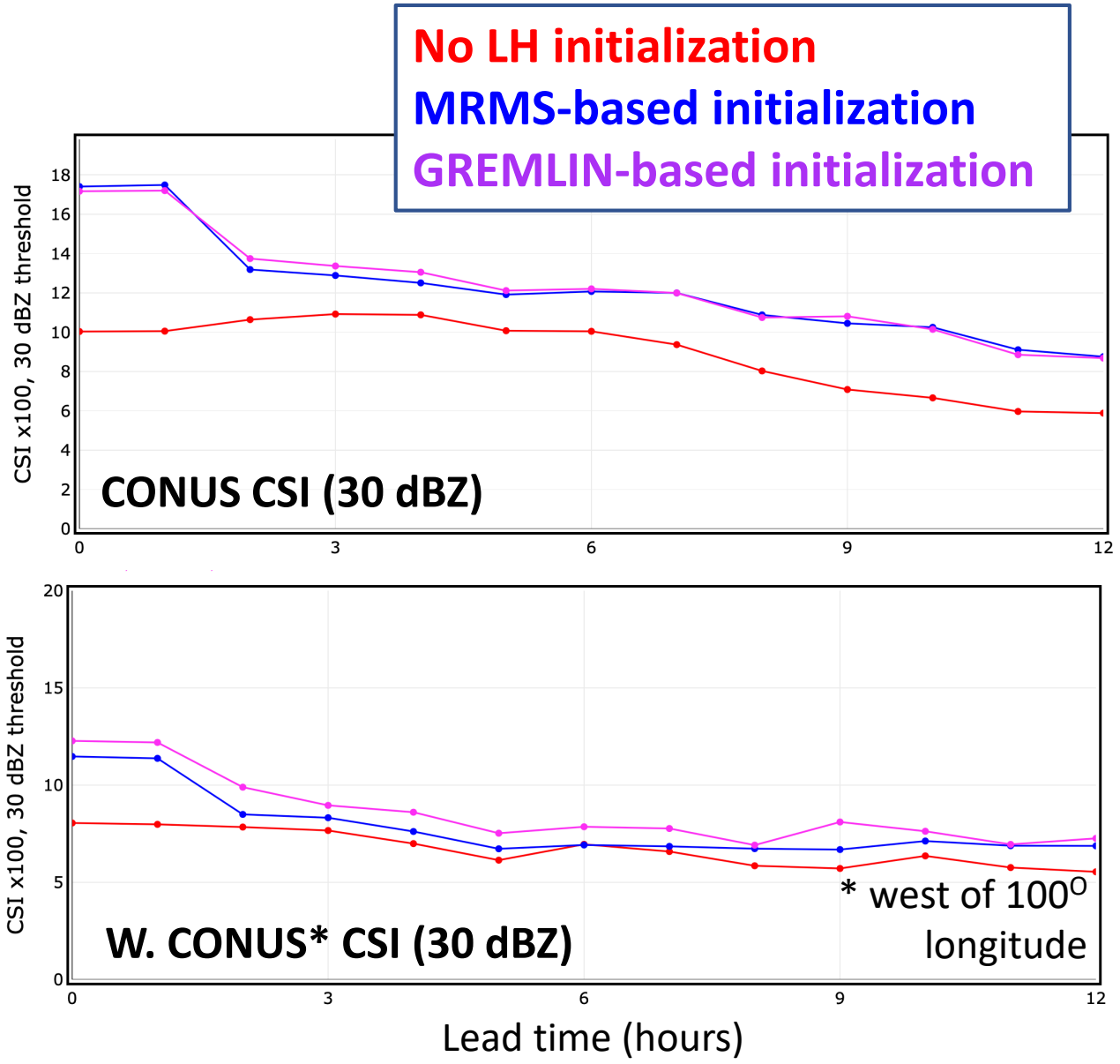




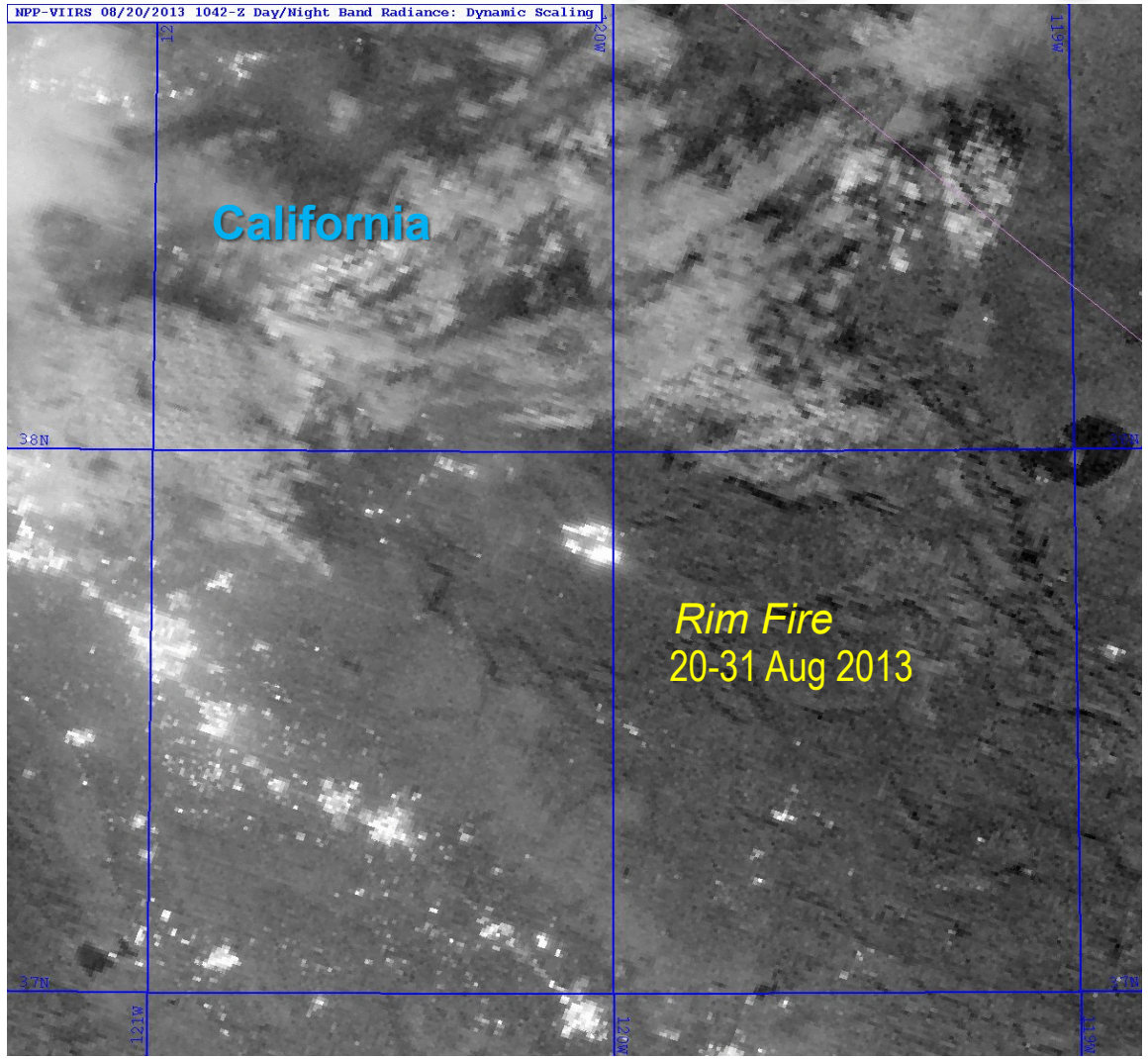
Machine Learning Initiatives at CIRA

Kyle Hilburn, CSU/CIRA

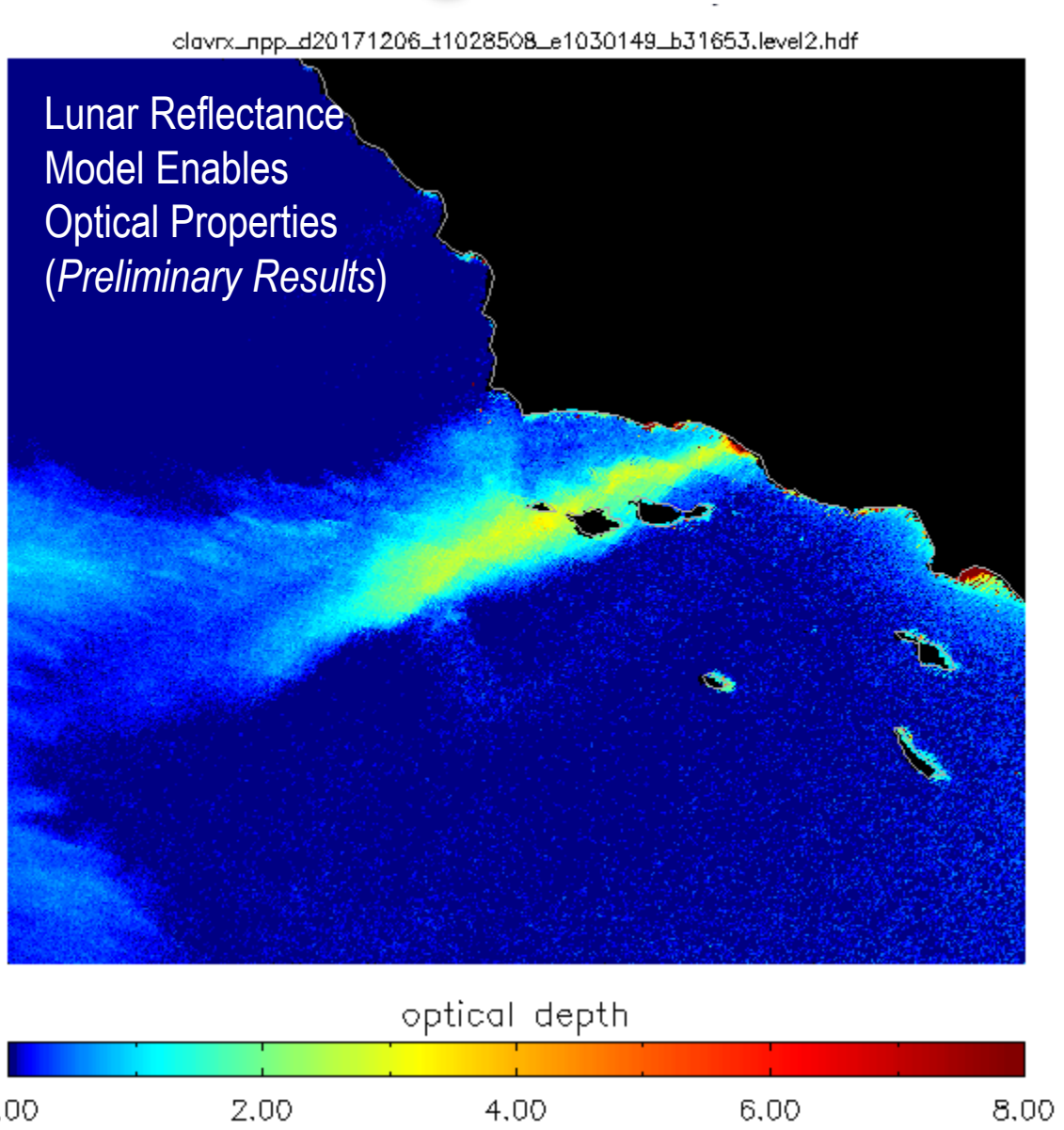
- A 1-week experimental period was conducted, GREMLIN-assimilated data to assess NWP skill impact…
- Critical Success Index (CSI, higher = better) vs. forecast lead time assessed →
- Initializing the RRFS with GREMLIN *outperformed MRMS* over the the entire CONUS domain, and the Western U.S. where radar coverage is limited!
- **Aviation:** *"Deterministic Convective Initiation"* (when and where the nascent convection is observed) is key to predicting convective outflow structures/interactions near airfields!



Helping to Fight Fires at Night?



→ Smaller fires and smoke detection can complement infrared observations



Courtesy of Andy Heidinger (NOAA/NESDIS) and Andi Walther (UW/CIMSS)

On the Horizon: "OVERCAST" Initiative

- Sponsored by the Office of Naval Research (ONR)
- Generate quantitative global, near real-time three-dimensional (3D) satellite cloud analysis based on:
  - ***Cloud Geometric Thickness estimation***
  - Hidden layer estimation
  - Ice/Water profile estimation
  - Potentially expand to other cloud/environmental fields
- Global cloud analysis rendered via:
  - Geostationary + polar-orbiting satellite sensors (ABI, AHI, SEVIRI, VIIRS, AVHRR), blended at seams
  - Rooted in NOAA Enterprise processing (CLAVR-x)
- These products can be leveraged by the FAA and other users for near real-time flight planning (YJ Noh's talk)
- Project kicks-off this summer!

Summary

Multi-Agency Partnerships

Transition-Oriented Research

Academic Enrichment

Interdisciplinary Science

Thanks!
Time for Questions?

Extra Toppings

Cooperative Institute for Research in the Atmosphere

Multi-Spectral Lofted Dust Detection