Advancements toward Fused Satellite, Radar, NWP, and in-situ Aviation Weather Decision Support

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Satellite-based Decision Support Fusion Overview

- New satellite-based hazardous weather decision support advancements
- Current and Future NOAA Operational Testbed Activities
- Fusion Pathways
- Conclusions

2010-2012 GOES-R Warning Product Set

The following list of products offers opportunity for near-real time Warning Related utility within various fusion pathways:

<u>Baseline Products:</u>
Volcanic Ash: detection & Height
Cloud and Moisture Imagery
Hurricane Intensity
Lightning Detection: Events, Groups & Flashes
Rainfall Rate / QPE
Total Precipitable Water
Fire/Hot Spot Characterization
Cloud phase/temperature/height/snow discrimination

<u>Option 2 Products:</u>
Aircraft Icing Threat
Convective Initiation
Turbulence
Enhanced “V” / Overshooting Top Detection
Low Cloud and Fog
SO_2 Detection

Satellite PG Testbed Demonstrations

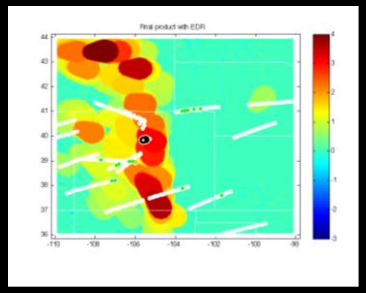
- HWT Spring Experiment at SPC/NSSL (2009 -)
- Aviation Weather Center (2011 -)
- Ocean Prediction Center/Hydrological Prediction Center and NESDIS Satellite Analysis Branch (2011 -)
- Pacific Region Demonstration (2011 -)
- Hurricane testbed (2010 -)
- High Latitude Testbed and Alaska Region (2010 -)
- NWS Operational Testbed (TBD, John Ogren)
- Local WFO Demonstrations
- Future field campaigns (DC3, Brazil Precipitation, ….)

Weather Decision Support Fusion Occurs at Multiple Levels

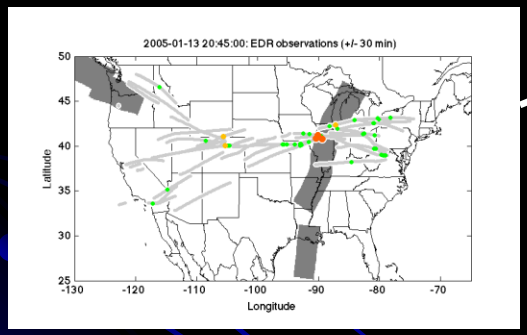
- Satellite decision support primarily not “stand-alone”, transition from GOES-R option 2
- Algorithm developers – NWP/in-situ used within satellite-based algorithms for turbulence, low cloud/fog, etc
- Subject matter multi-agency scientific experts – Satellite-based decision support flows to OU-CIMMS, MIT, and NCAR as additional input
- Operational forecasters – use AWIPS, N-AWIPS, and soon AWIPS-2 to fuse data

Fusion pathway for satellite turbulence-based inference decision support in NOAA AWC and NextGen:

Mountain wave



Tropopause folding



Overshooting Top

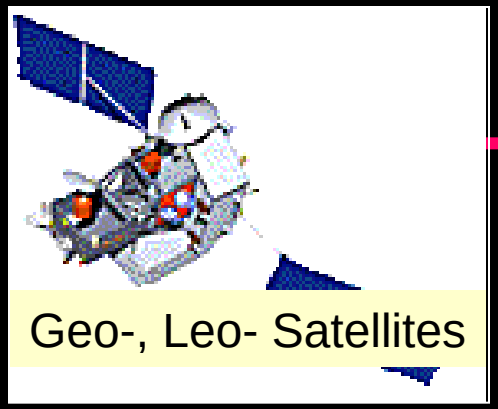
GTG-N → NextGen 4D cube

(NCAR Sharman/Williams PI)

Future, in development

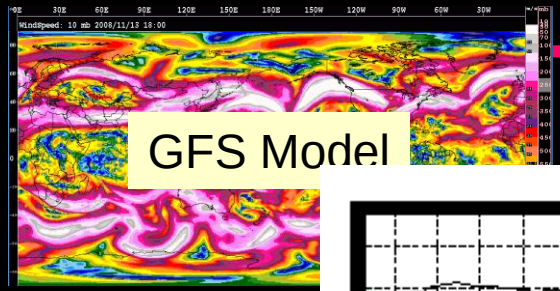
Rapid Anvil,
Transverse banding
Cloud top cooling

Flow Chart for Global GTG

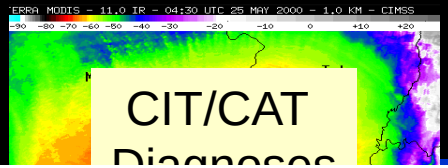


Geo-, Leo- Satellites

Convection Diag. & Now.



GFS Model

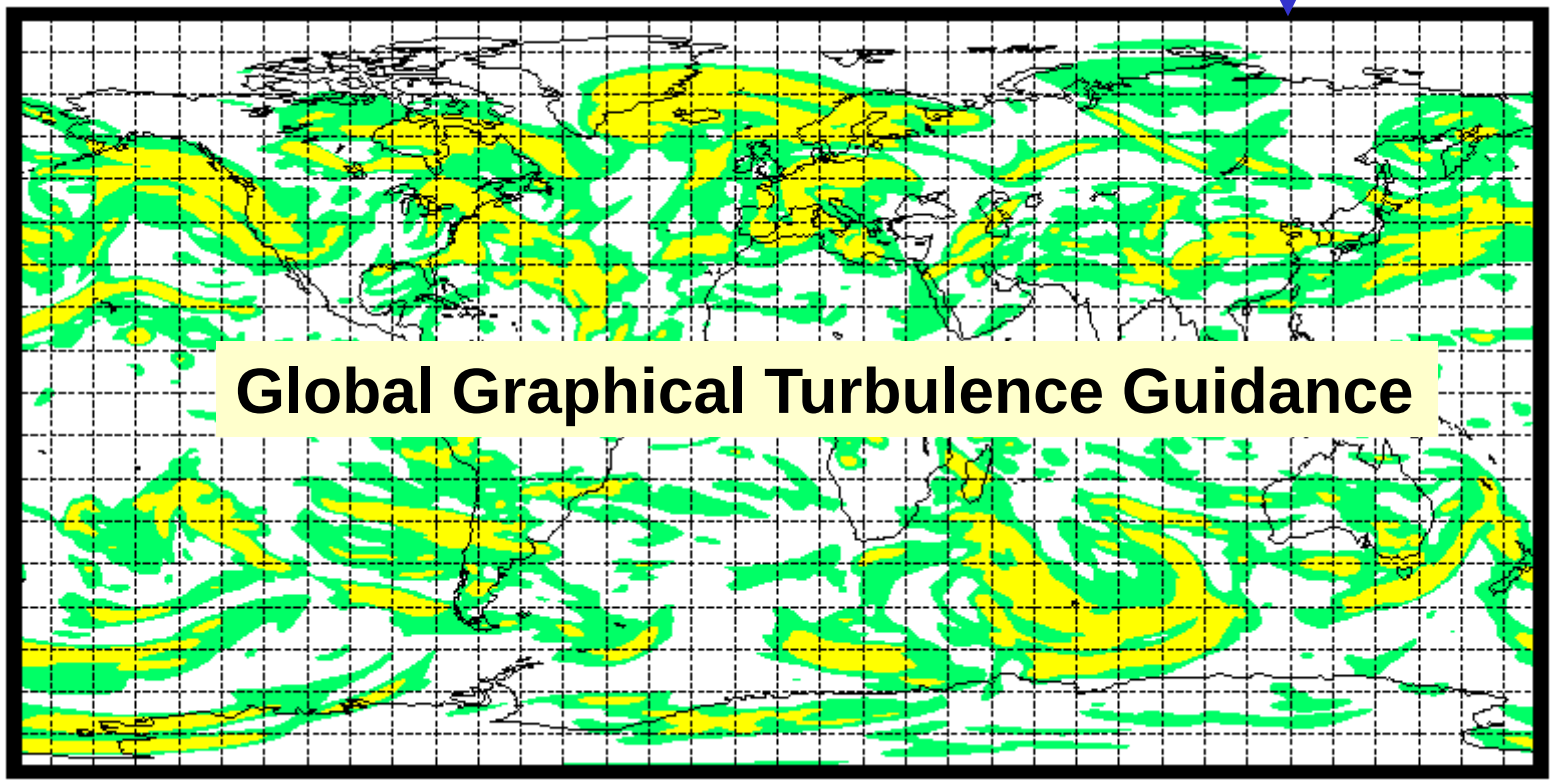


CIT/CAT Diagnoses

Credit:
J. Williams (NCAR)

Integration

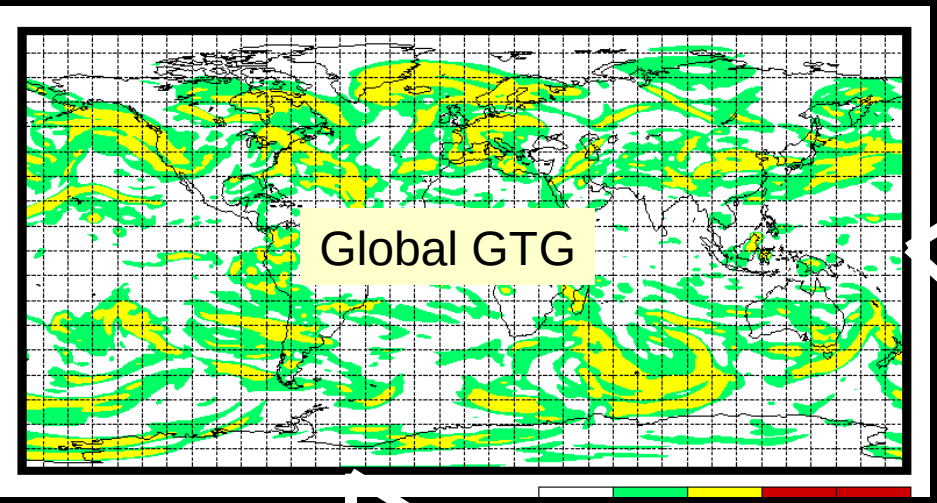
In Situ Obser
(tuning

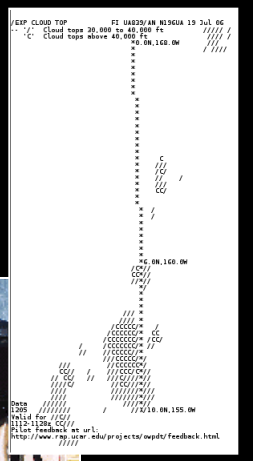


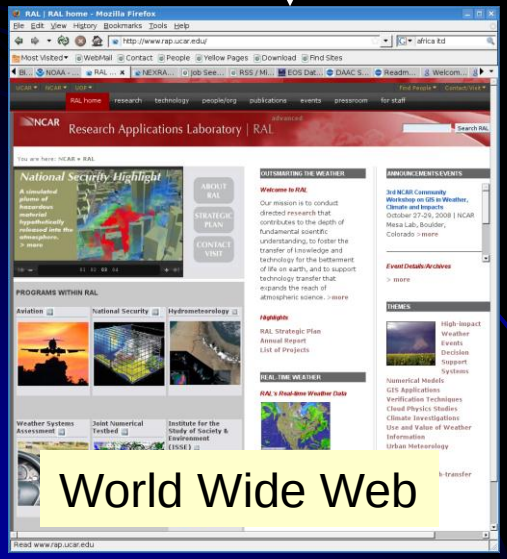
Global Graphical Turbulence Guidance

Global GTG Demonstration at NCAR

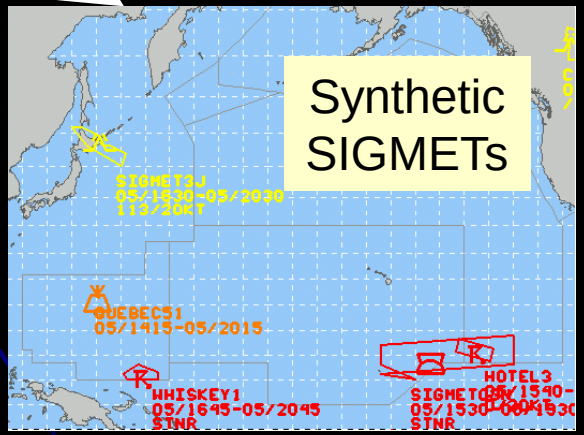
Credit:
J. Williams (NCAR)



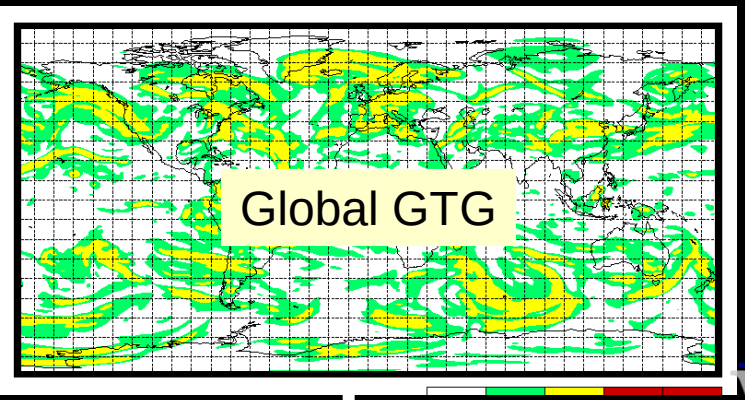




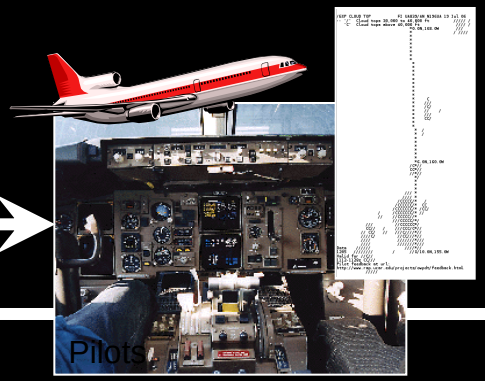
World Wide Web



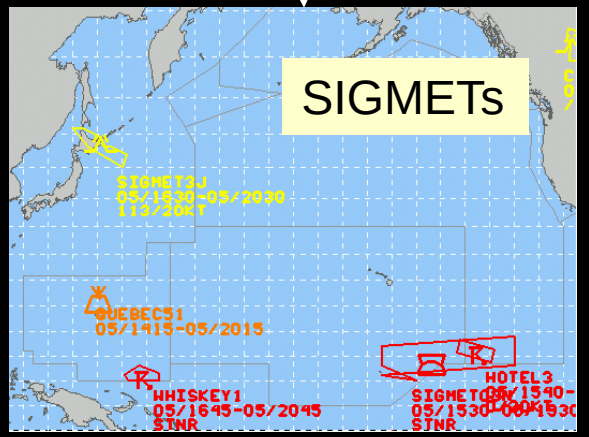
Future NEXTGen Use of Global GTG



SWIM



NEXTGen 4-D Data Cube

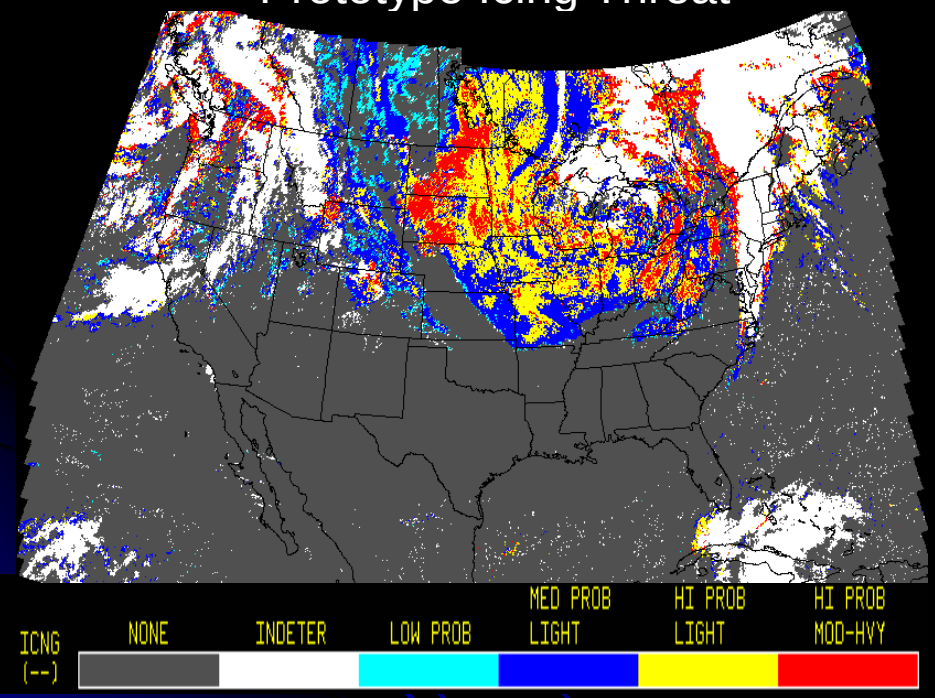


Credit:
J. Williams (NCAR)

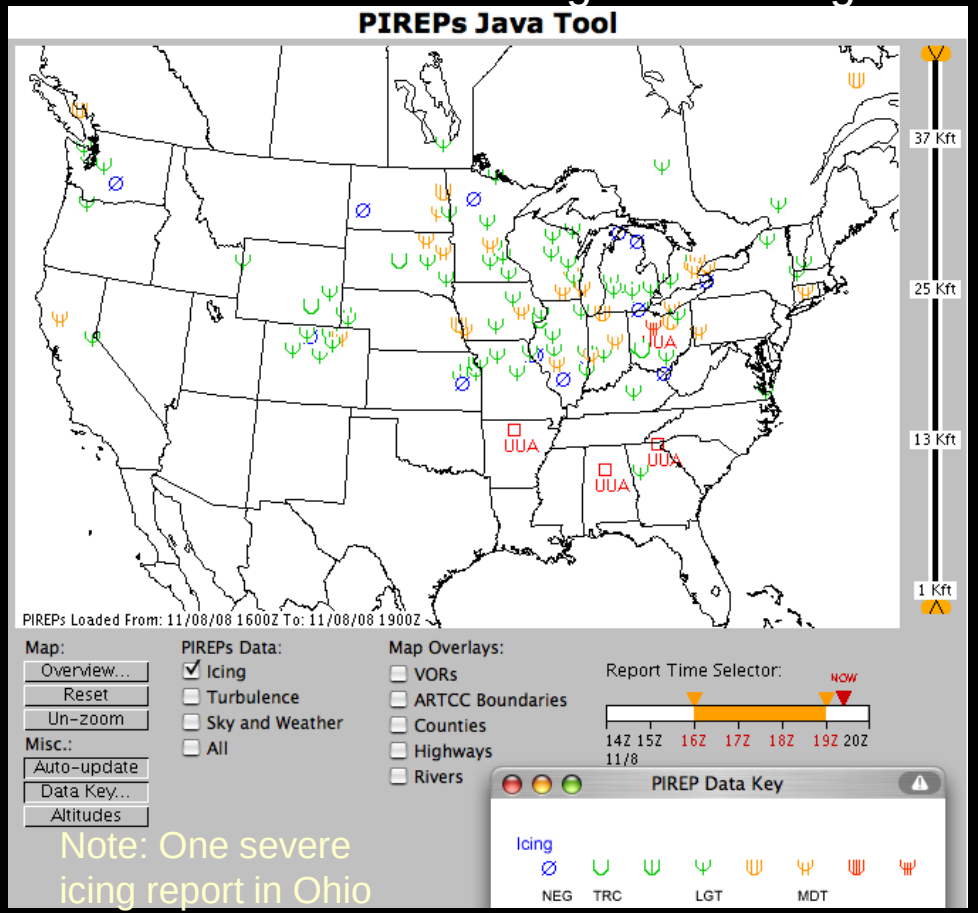
GOES-R FIT Algorithm Demonstration
Icing Severity from Current GOES

Nov. 8, 2008 (1745 UTC)

Prototype Icing Threat



PIREPS confirm significant icing

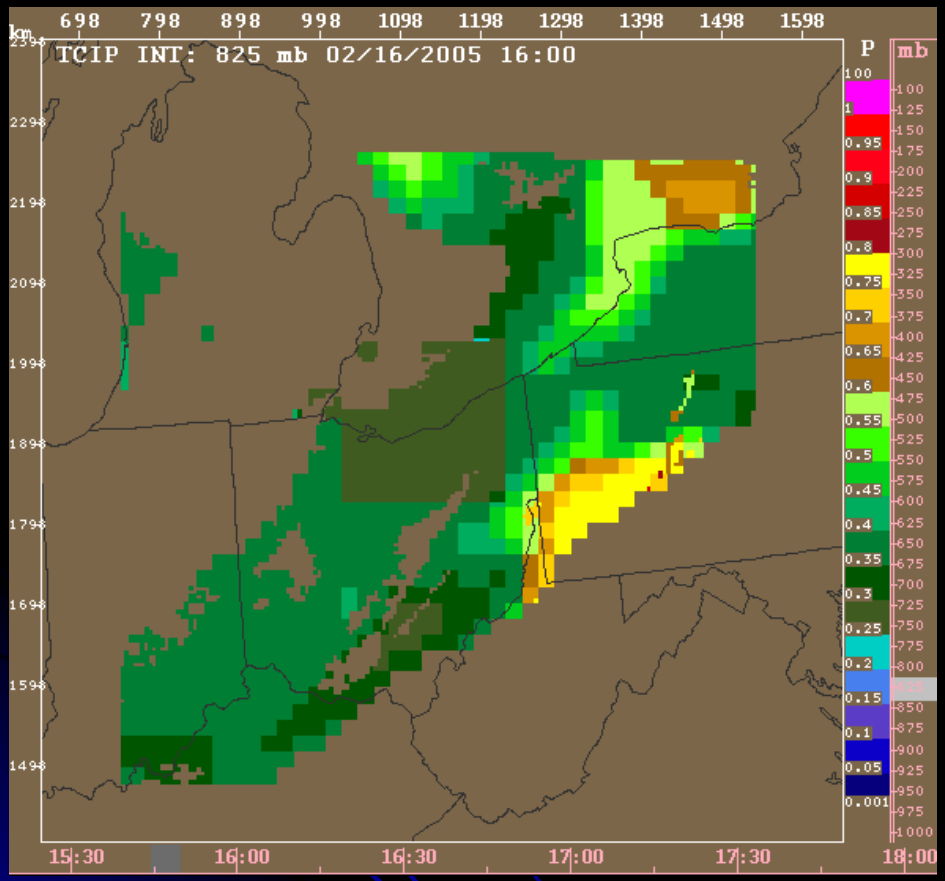


Note: One severe icing report in Ohio

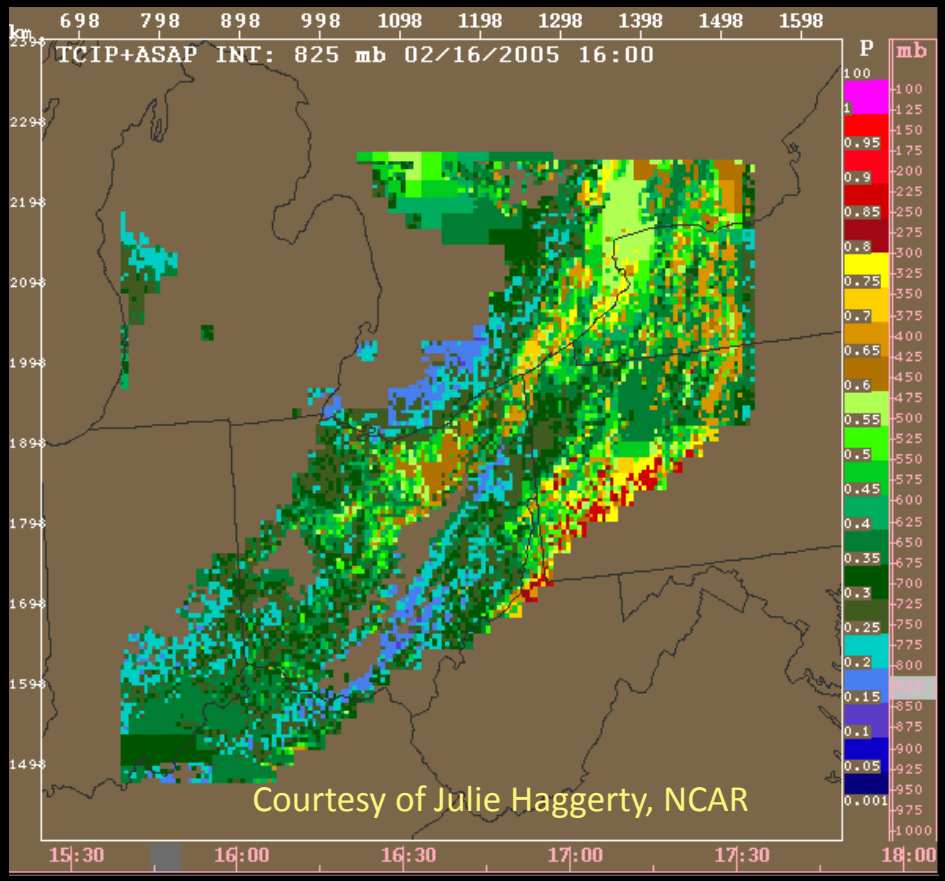
Credit:
W. Smith Jr. (NASA LaRC)

GOES Cloud Product Fusion Test with FAA-NCAR Current Icing Potential (CIP) Product

CIP without Satellite Products



CIP with Satellite Cloud Water Path

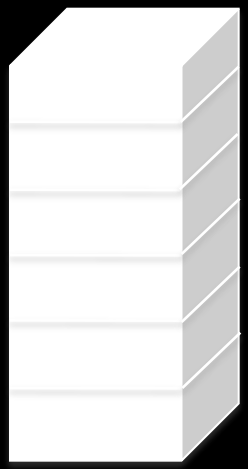


Courtesy of Julie Haggerty, NCAR

Credit:
W. Smith Jr. (NASA LaRC)

- Warmer colors imply higher icing potential
- Better definition of the field gives more options to pilots!
- Results validated against research aircraft flights from NASA GRC
- Improved CIP is on pathway to AWC and NextGen (M. Polotivitch)

Today



t = 30-60 min

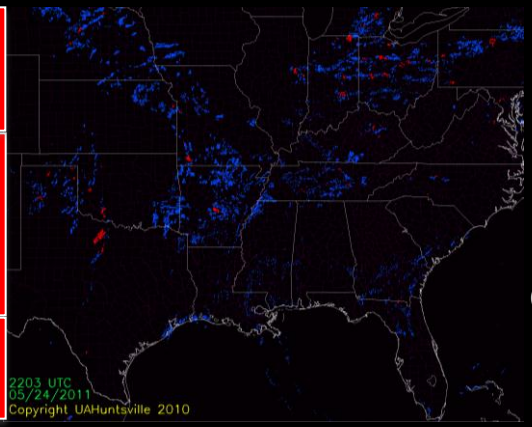
$t = t_3$

$t = t_2$

$t = t_1$

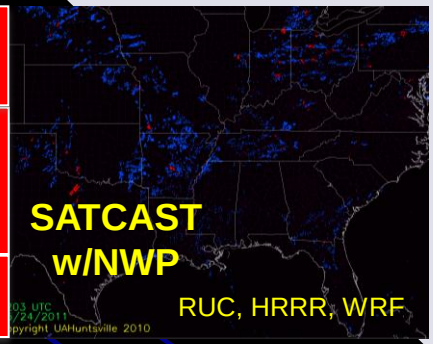
SATCAST 0-1 hr Nowcast

CCM MAMV OT



SATCAST is a satellite product, yet is constrained by NWP/RUC CAPE to limit CI Nowcasts to where there is instability

CCM MAMV OT



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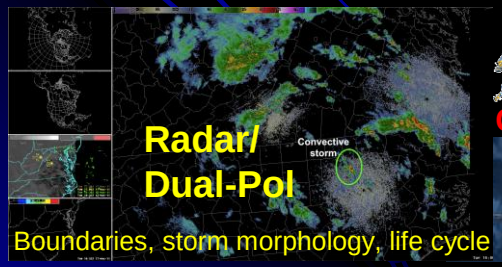

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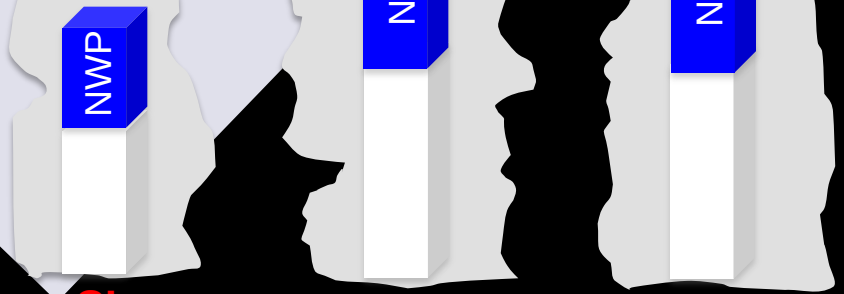
Data Fusion:

Towards a product that uses multiple sensors to solve a challenging forecast problem.



21 Sept 2011

Where we are headed…

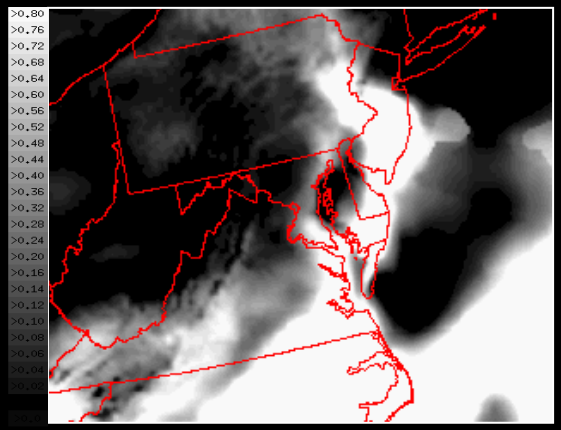
UAHuntsville
THE UNIVERSITY OF ALABAMA IN HUNTSVILLE

J Mecikalski
Sept 2011

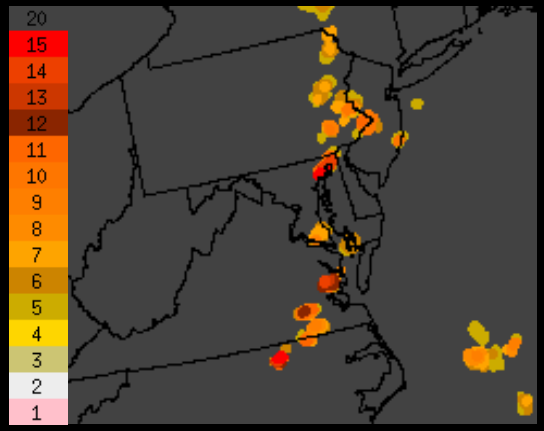
Fusion of Satellite, Radar, and NWP Data for Convective Initiation Forecasts in the FAA's CIWS System

Fuzzy Logic CI Nowcast Model

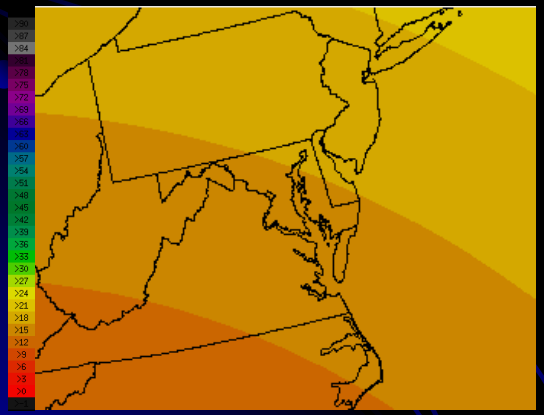
RUC/STMAS Instability



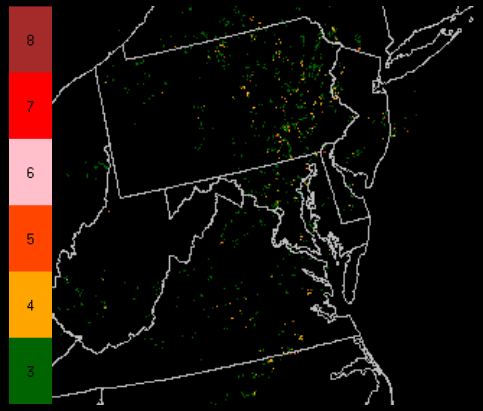
NEXRAD Radar Growth



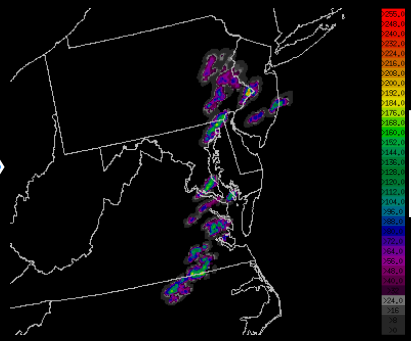
GOES Solar Angle



# of SATCAST CI Indicators



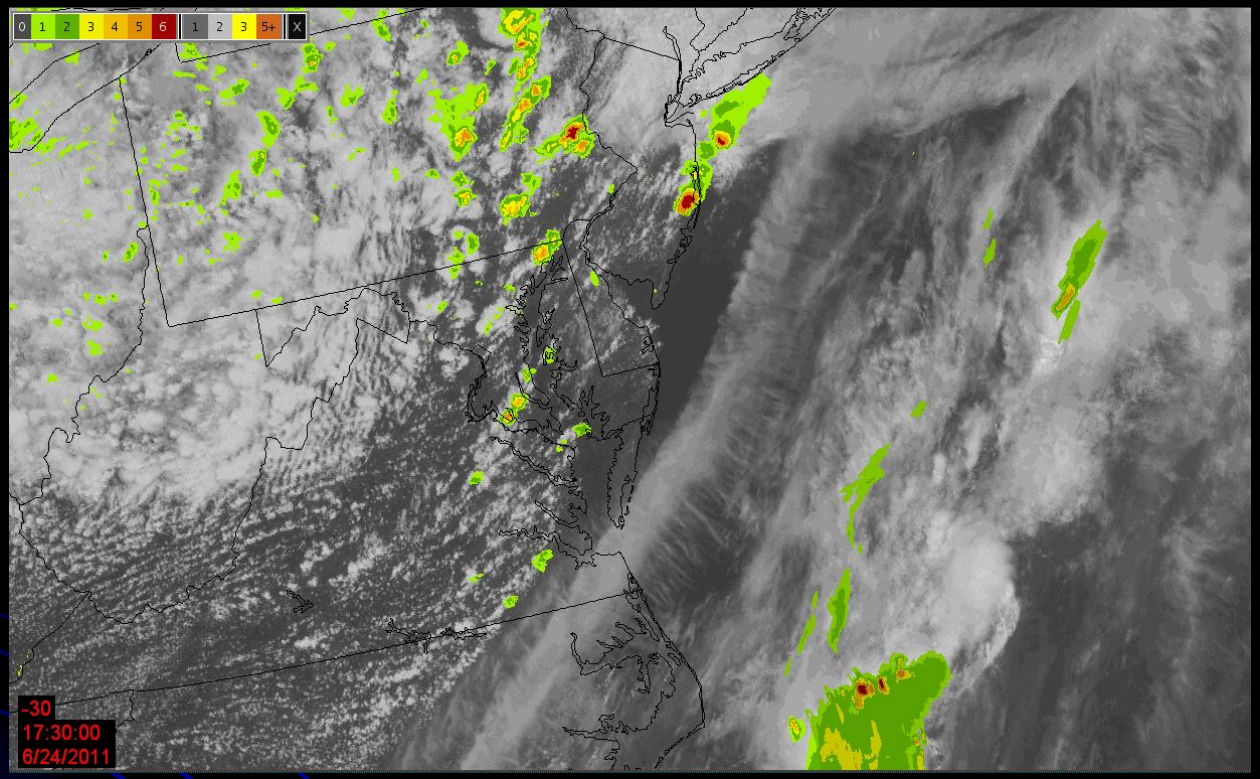
CI Interest



CIWS Forecast Engine

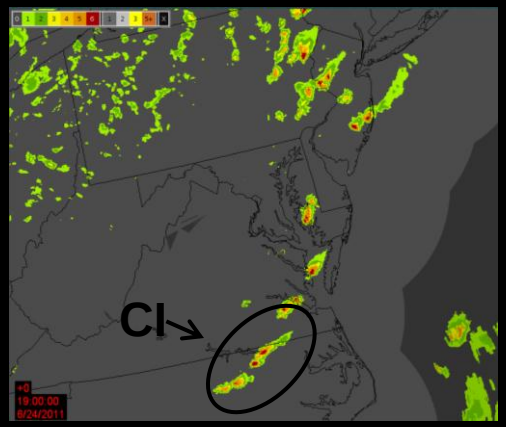
Credit: Haig Iskenderian MIT Lincoln Laboratory

CIWS 1 Hour Convective Initiation Forecast



24 June 2011

1 Hour Truth



Credit: Haig Iskenderian MIT Lincoln Laboratory

Satellite-based Object Tracking Motivation – Why? WDSS-II – OU-CIMMS/UW-CIMSS

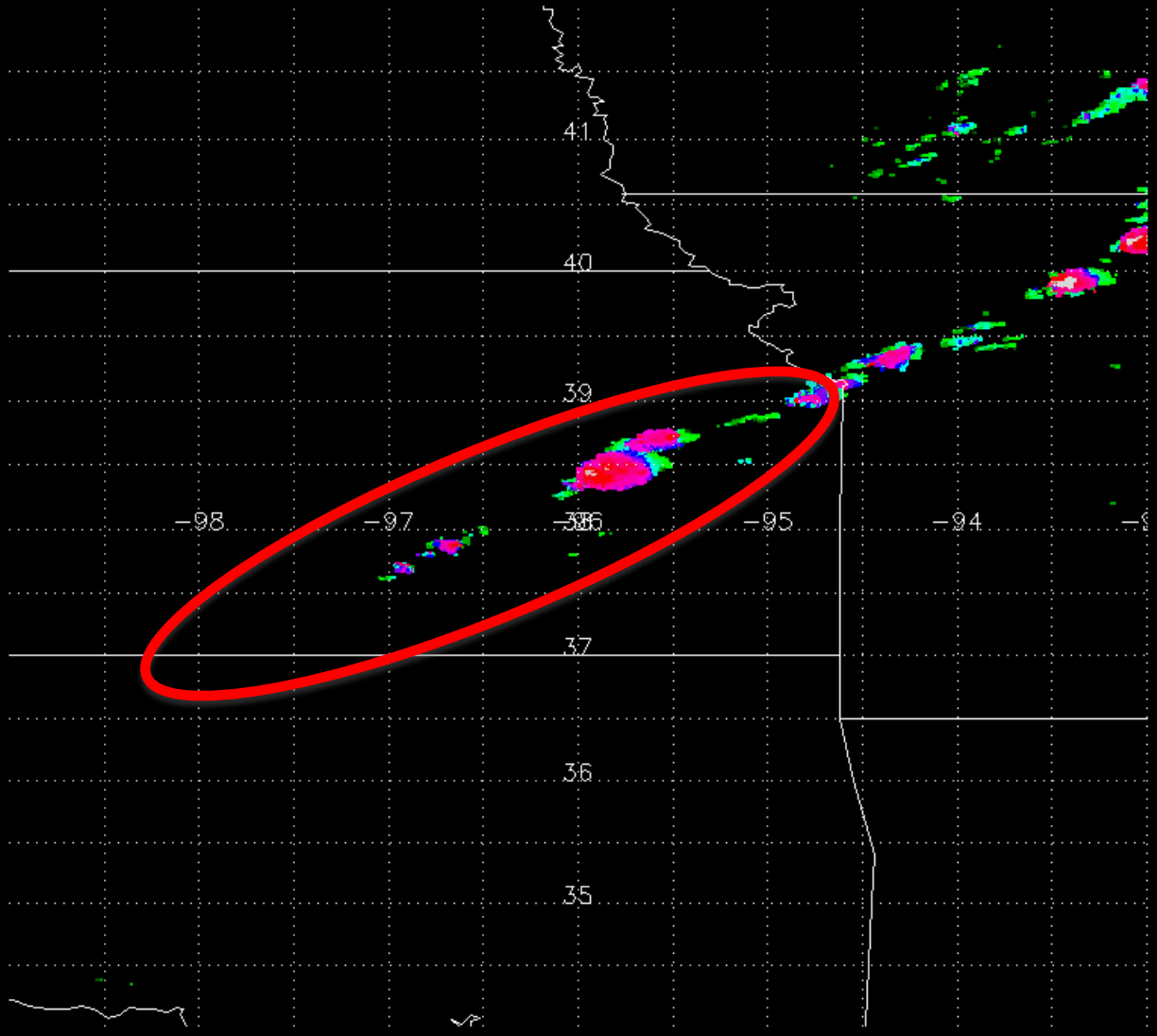
1) As a validation tool (Satellite-based convective decision support vs Radar)

2) Fusion of any number of data fields from any sensor type (satellite, satellite algorithm output, radar, lightning, NWP model, surface and upper air observations, etc.) into a single framework for 0-1 hour nowcasting relationships

All these quantities are used in cloud object space, not single pixel space, allowing for easy monitoring of temporal as well as spatial trends

- A continuously (not discrete) changing field is key, in this case: Top of Troposphere Cloud Emissivity (Pavolonis, 2010)

30 dBZ Echo Top Height:20090513-2216



GOES R – Why are WFO forecasters excited?

- Ability to sync satellite, radar, lightning, profiler, and ASOS/mesonet observations every 5 minutes (regional with highest fidelity resolution data)
- Potential to change analysis standard (RTMA) from hourly to 5 minute by 2020? (Draft of NWS S&T Roadmap)

Credit: Jeff Craven SOO Milwaukee/Sullivan -WFO

Satellite-based Future Capabilities Fusion Bottom-line

GOES-R/JPSS satellite-based weather decision support are or will fused systematically at developmental, subject matter expert, and operational venues:

- Satellite-based future capability science team
- Turbulence (T. Wimmers CIMSS)
  - AWC/NextGen Graphical Turbulence Guidance – N (John Williams/Bob Sharman NCAR/RAL PI)
- Icing (William Smith Jr NASA Langley)
  - Cloud Icing Product (Marcia Politovich NCAR/RAL PI)
- Convective initiation (J. Mecikalski UAH)
  - AWC/FAA/NextGen CoSPA (Haig Iskendarian MIT PI)
- National/Regional/ and WFO operational level

Satellite-based Future Capabilities Fusion Bottom-line

- GOES-R algorithm development has fostered new decision support applications with current imager technology (expected launch of GOES-R in 2015) and new JPSS PG:
  - Convective Initiation, Overshooting-top, Volash, SO2, Fog/low cloud, Cloud typing, Fires
- Vested interest in fused satellite-based decision support products (AWG to Proving Ground connections)
- Very exciting interaction and process has shown new ways to uses Polar and Geostationary data fusion for NOAA decision support guidance and will occur at multiple stages within research to operations process

NPP Launch

- JPSS will be particularly valuable over northern (Alaska) and polar regions where multiple overpasses should provide near geostationary-like capabilities and therefore compliment GOES-R
- VIIRS will provide low-light imaging capability, new uniform nadir to limb horizontal resolution and improved temporal latency, all important for aviation applications
- CrIS will provide an additional hyperspectral platform for monitoring atmospheric stability, flight level temperature for fuel conservation purposes, polar wind information, and improved high latitude volcanic ash monitor (US to China routes are expected to increase rapidly in the near future)

Reference: National Polar-orbiting Operational Environmental Satellite System (NPOESS): New Capabilities for Supporting Aviation Applications, NASA Tech Report 2008, Wayne Feltz and David Johnson