An Overview of Transition of Research to Operations Activities: *Hyperspectral Infrared Sounder Retrievals in NOAA NWS Operations*

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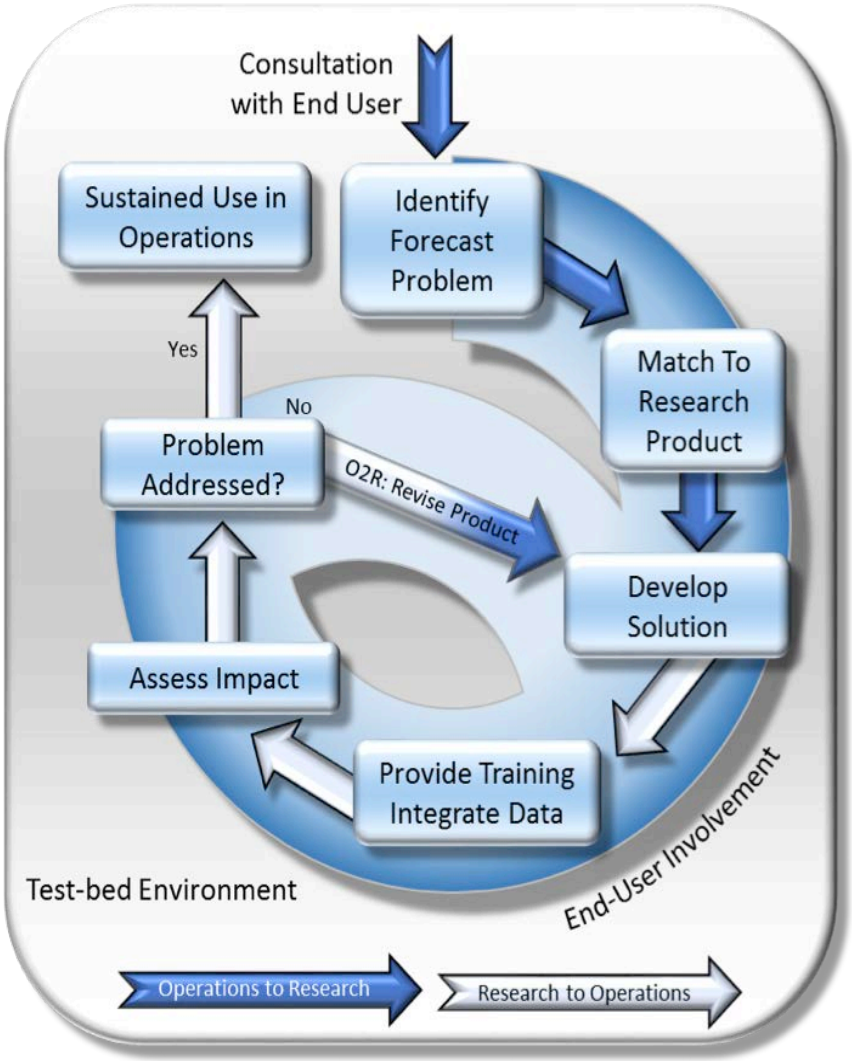
Outline

- Sounder Activities at NASA Short-term Prediction Research and Transition Center (SPoRT)
- Soundings in National Weather Service Operations
- Gridded Soundings in National Weather Service Operations
- Cold Air Aloft
- Pre-convective Environment
- New Applications
- Summary

SPoRT Mission and Paradigm

- The Short-term Prediction Research and Transition Center was established in 2002 for transitioning unique satellite observations and research capabilities to end users to improve short term forecasting and decision support
- Introduce experimental products to end users through a Research to Operations / Operations to Research Paradigm
- Concept has been used to successfully transition a variety of satellite datasets to operational users for 15+ years

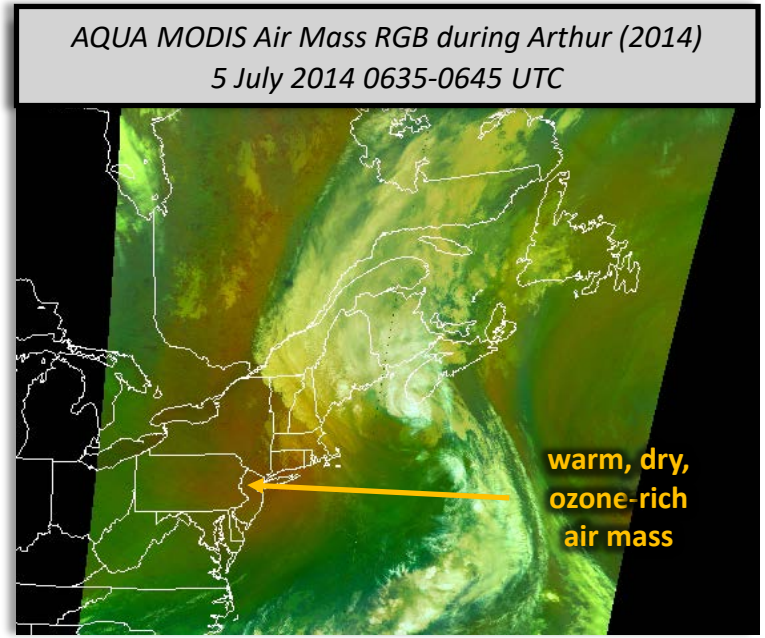


https://weather.msfc.nasa.gov/sport/

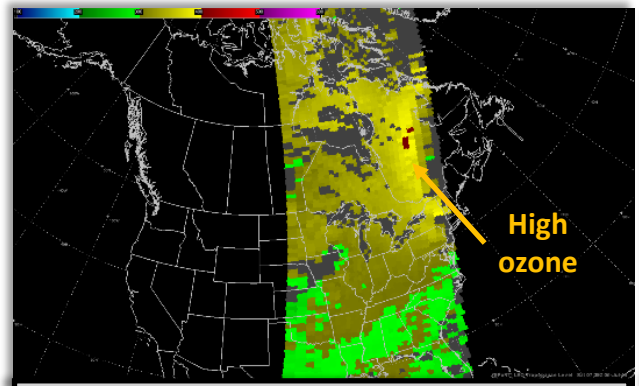
https://nasasport.wordpress.com

Sounder Activities at SPoRT

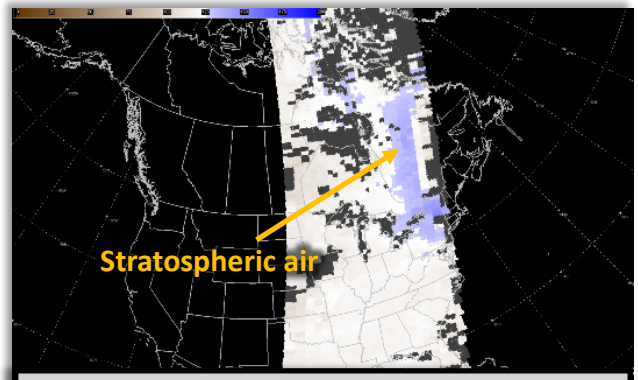
- Since 2013 SPoRT has provided AIRS ozone retrievals to NOAA NWS National Centers
- Identify stratospheric intrusions
  - rapid cyclogenesis and high wind events
  - hurricane tropical to extratropical transition
- Products from AIRS, IASI, and CrIS/ATMS available in the NWS display system
- Zavodsky et al. (2013), Berndt et al. (2016)



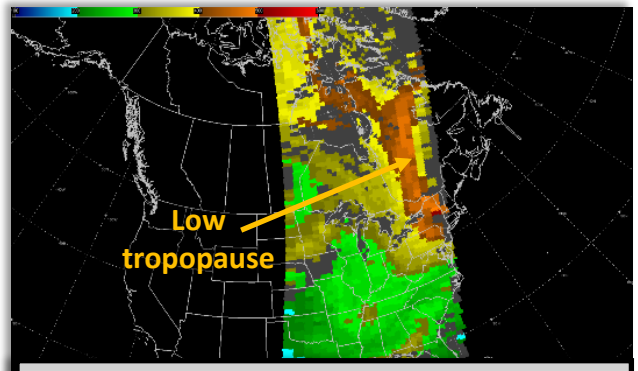
AQUA MODIS Air Mass RGB during Arthur (2014)
5 July 2014 0635-0645 UTC



Total Column Ozone (DU)



Ozone Anomaly (% of normal)

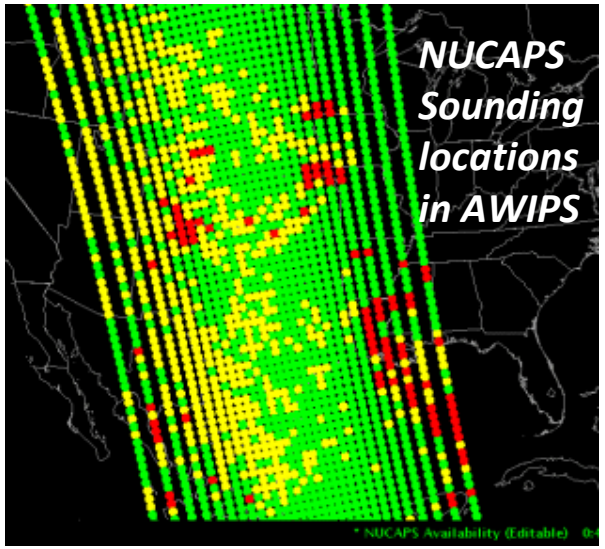


Tropopause Level (mb)

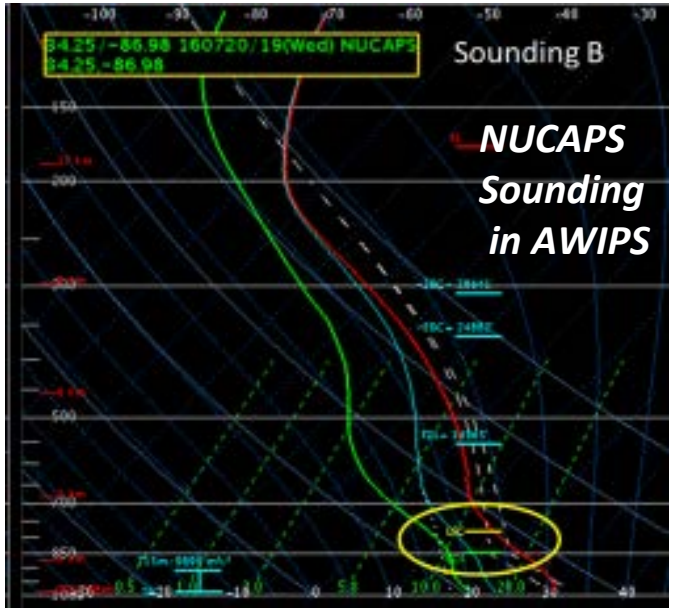
Ziemke et al. (2011) Van Haver et al. (1996) Thouret et al. (2006)

NUCAPS Soundings in NWS Operations

- Since 2014 S-NPP CrIS/ATMS NUCAPS Soundings have been operationally available to all National Weather Service forecasters through the Advanced Weather Interactive Processing System (AWIPS) as Skew-T plots
- NUCAPS Soundings have been valuable:
  - Where conventional observations lack
  - Between radiosonde launches
- Have been demonstrated as valuable for
  - Assessing the pre-convective environment
  - Cold Air Aloft aviation hazard
- The JPSS Sounding Initiative collaborated to develop the capability to visualize the data in plan view or cross section to maximize the benefits of NUCAPS data in AWIPS

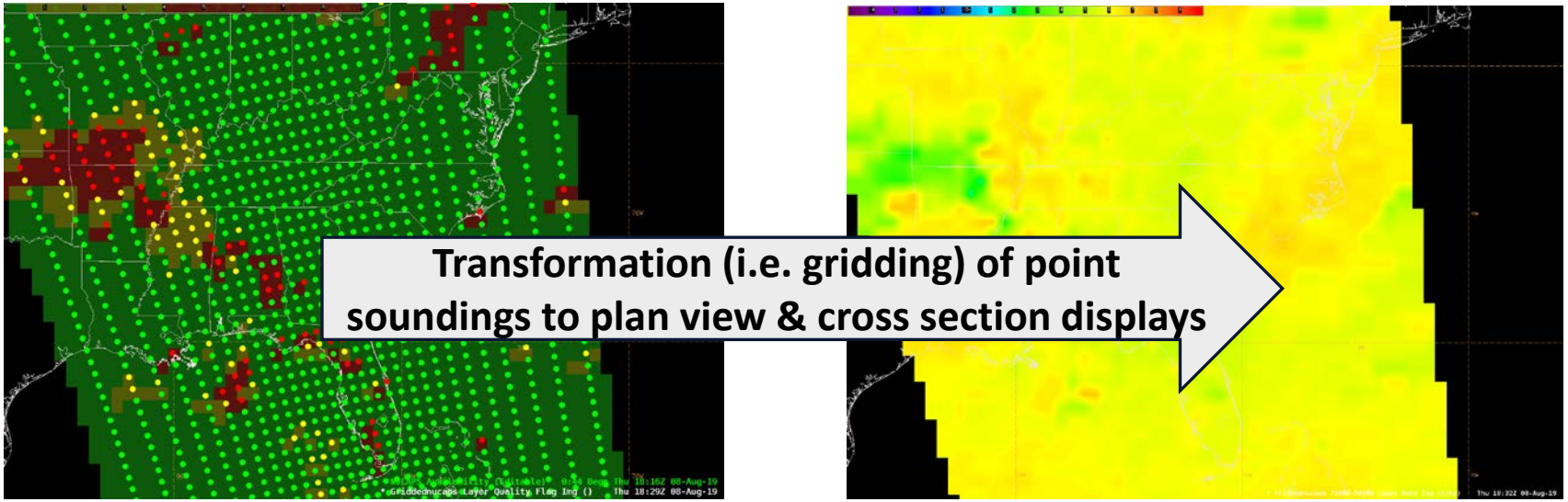


Images by Kris White (NWS HUN/SPoRT)

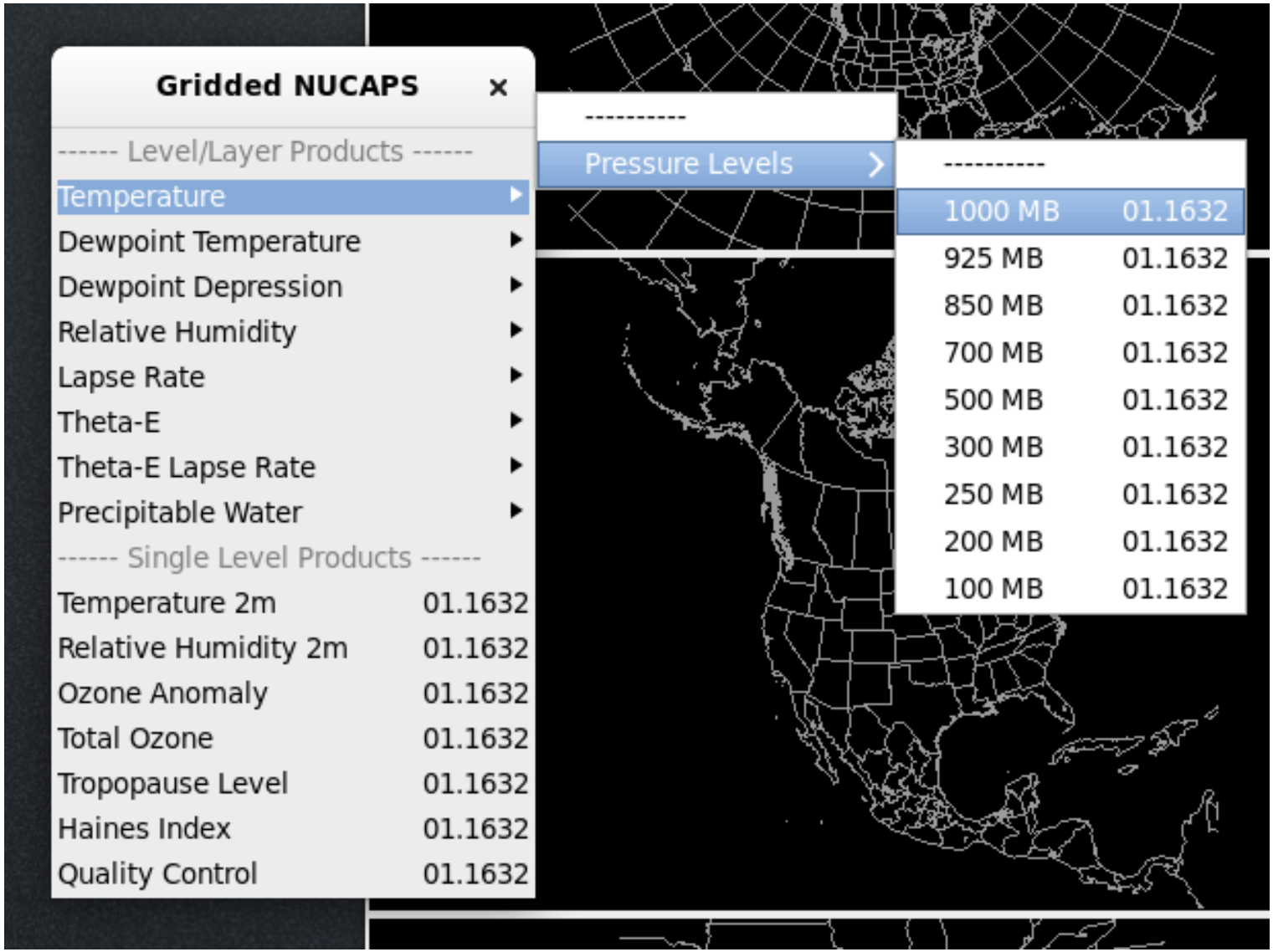


Gridded Soundings in NWS Operations

- An experimental gridding process was developed in 2015/2016 and introduced to NWS forecasters in a testbed environment
- The JPSS Sounding Initiative partnered the Meteorological Development Lab to develop the gridding capability within AWIPS
- Operational NWS-wide release was 3 Sept. 2019
- Minimal interpolation in the gridding process
- Temperature, moisture, and derived fields are available for display

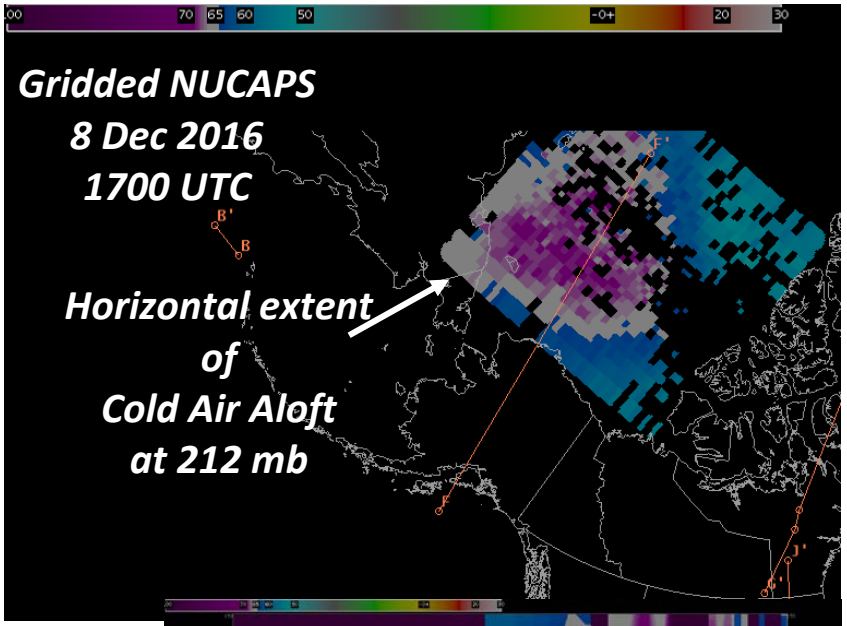


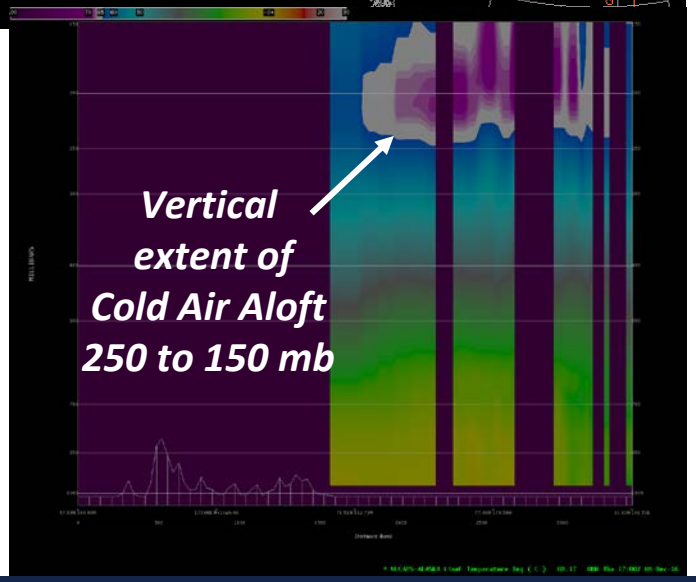
Gridded Soundings in NWS Operations



Cold Air Aloft

- Gridded NUCAPS was initially developed to address Cold Air Aloft
- Cold Air Aloft (≤ -65°C) events can freeze airliner fuel and regularly occur at flight levels in the arctic
- The Anchorage Center Weather Service Unit (CWSU) provides Meteorological Impact Statements (MIS) to Air Traffic Controllers to direct flights around the 3D air features
- In data sparse Alaska, forecasters have relied on analysis and model fields and limited radiosonde observations to guess the 3D extent of the Cold Air Aloft
- Use of satellite observations provides an opportunity for forecasters to observe the 3D extent of the Cold Air Aloft in real-time
- NUCAPS Soundings and Gridded products have been operationally adopted into the Anchorage CWSU operations
- Weaver et al. (2019)





Pre-Convective Environment

- Since 2015 NUCAPS has been assessed by NWS forecasters at the Hazardous Weather Testbed Spring Experiment
- This has led to incremental product development and ideas for new areas of applied research
  - Boundary layer modification
  - Improved latency
  - Data Fusion

Examples on the HWT blog

http://goesrhwt.blogspot.com/search/label/NUCAPS

https://blog.nssl.noaa.gov/ewp/tag/nucaps/

Boundary Layer Modification

- Automatic Boundary Layer modification by Jack Dostalek at CIRA
- Real-time GOES-16 and RTMA (Real-time Mesoscale Analysis) data are used to find the surface temperature and mixing height
- The lower portion of the profile is replaced with new information and delivered to the Hazardous Weather Testbed

$$z_{i+1} = \left[z_i^2 + \frac{2}{\gamma} C_H |\boldsymbol{V}| (\theta_{Skin} - \theta_{Air}) \Delta t \right]^{\frac{1}{2}}$$

Stull, *Introduction to Boundary Layer Meteorology*

z: height of boundary layer
Θ_{Skin}: Potential temperature of surface skin (GOES-16 11/12 µm)
Θ_{Air}: Potential temperature of surface air (RTMA)
$|\mathbf{V}|$: Wind speed (RTMA)
γ: Lapse rate of free atmosphere (NUCAPS T profile)
C_H: Bulk heat transfer coefficient

Apply equation to get boundary layer depth as function of time.

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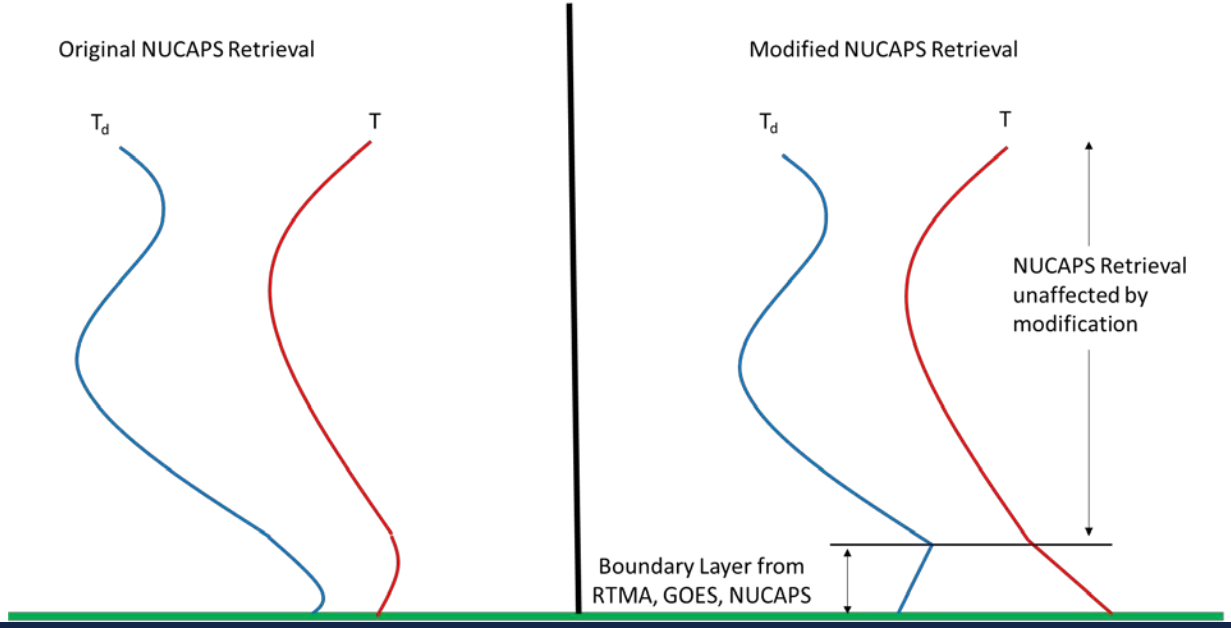
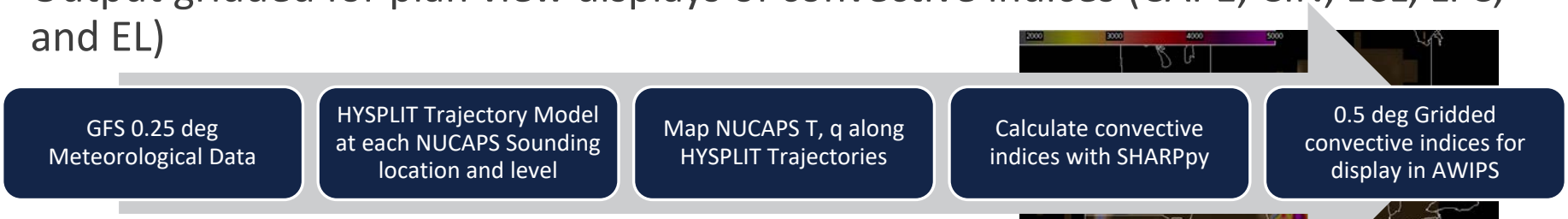


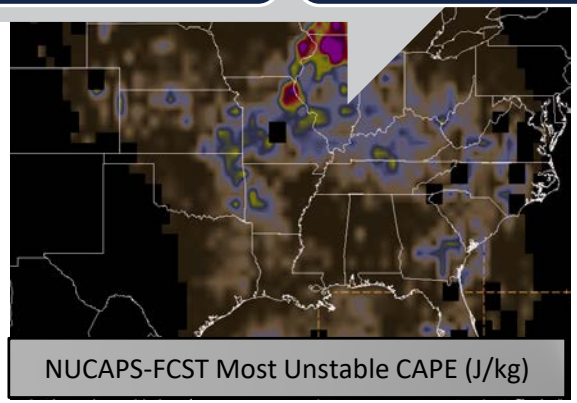
Data Fusion

- NUCAPS Soundings are advected forward in time (NUCAPS-Forecast)
  - Developed by Peter Kalmus & Brian Kahn at JPL (Kalmus et al. 2019)
  - assuming adiabatic parcel theory with the HYSPLIT trajectory model
  - 1 hour increments for a total of 6 hours
- SPoRT operationalized research code to use near-real time NOAA-20, GFS model, development of multi-node parallel processing to deliver AWIPS-compatible files to HWT in ~60 minutes after the overpass
- Output gridded for plan view displays of convective indices (CAPE, CIN, LCL, LFC, and EL)

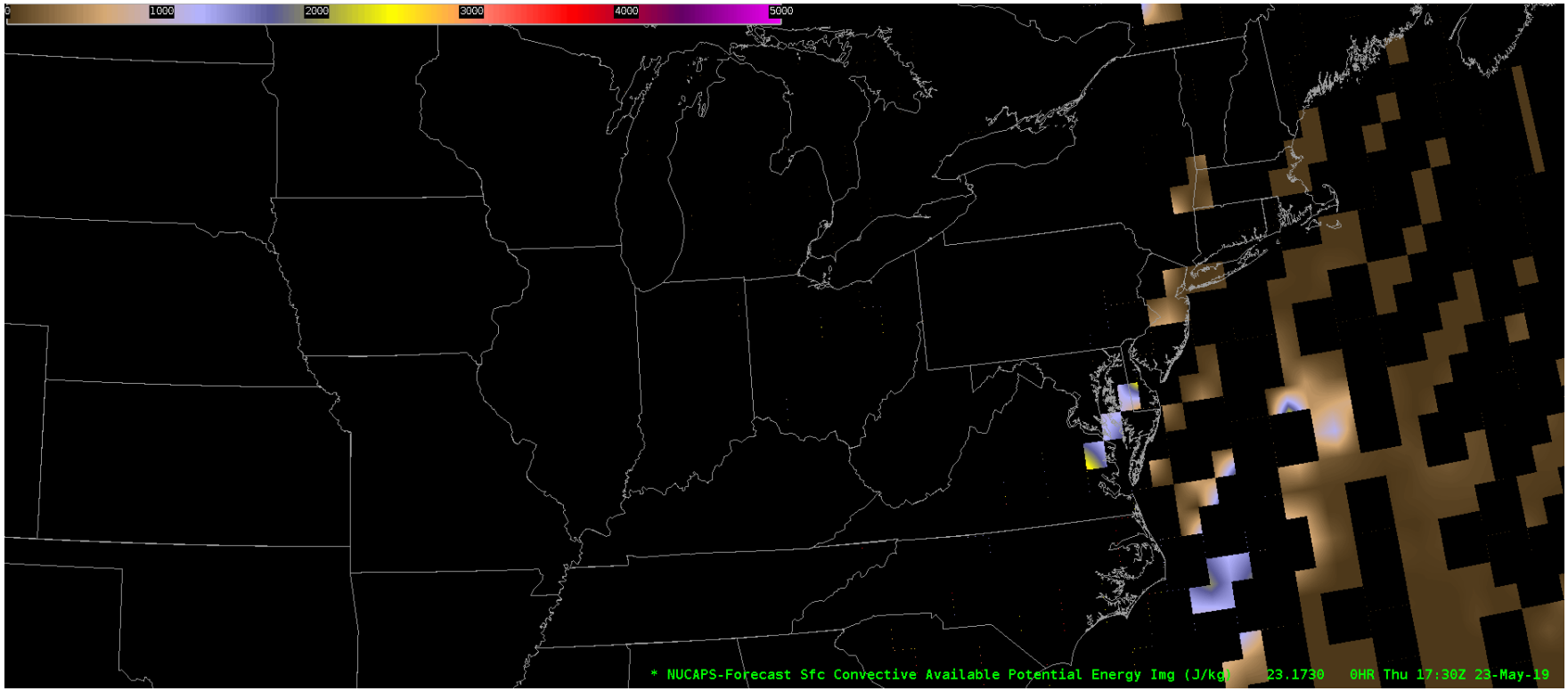


…some enhancement of CAPE in NUCAPS-FCST over Oklahoma for the 19Z swath. Lo and behold, at some point this afternoon, SPC upgraded from categorical to marginal severe over Oklahoma. We should keep note of the model runs and see if they miss time changes in convective parameters that NUCAPS-FCST might be able to get further in advance. ~forecaster HWT 2019

The gradients of CAPE are essential to diagnosing where convective initiation takes place. NUCAPSFCST not only provides gradients in space but also in time. ~forecaster HWT 2019


NUCAPS-FCST Most Unstable CAPE (J/kg)

Data Fusion


1000
2000
3000
4000
5000
* NUCAPS-Forecast Sfc Convective Available Potential Energy Img (J/kg) 23.1730 0HR Thu 17:30Z 23-May-19

Product Life-Cycle

- Through the Hazardous Weather Testbed Spring Experiment the JPSS Sounding Initiative has had the opportunity to introduce Hyperspectral Infrared Soundings (S-NPP, NOAA-20, MetOp-A/B) to NWS forecasters
- Products have been tailored to meet the needs of the operational environment
  - Boundary layer modification has given forecasters more confidence in the lower portion of the retrieval
  - Providing Soundings through CSPP direct broadcast has increased the data availability to less than 60 min to diagnose the pre-convective environment
  - Data fusion and trajectory modeling has increased the temporal and spatial resolution
- *A consistent message from forecasters is the need for more satellite soundings delivered with low latency*

New Applications

- With Gridded NUCAPS now available to forecasters across the NWS the community can be engaged to broaden the applications of Soundings in the operational environment
- NOAA-20 data are delivered operationally to NWS offices and the JPSS Sounding Initiative is working on a solution to provide additional Soundings in real-time

- Assessing the thermodynamic conditions for fire weather is one example
- Temperature, moisture, and derived fields such as precipitable water and Haines Index are used to assess fire potential

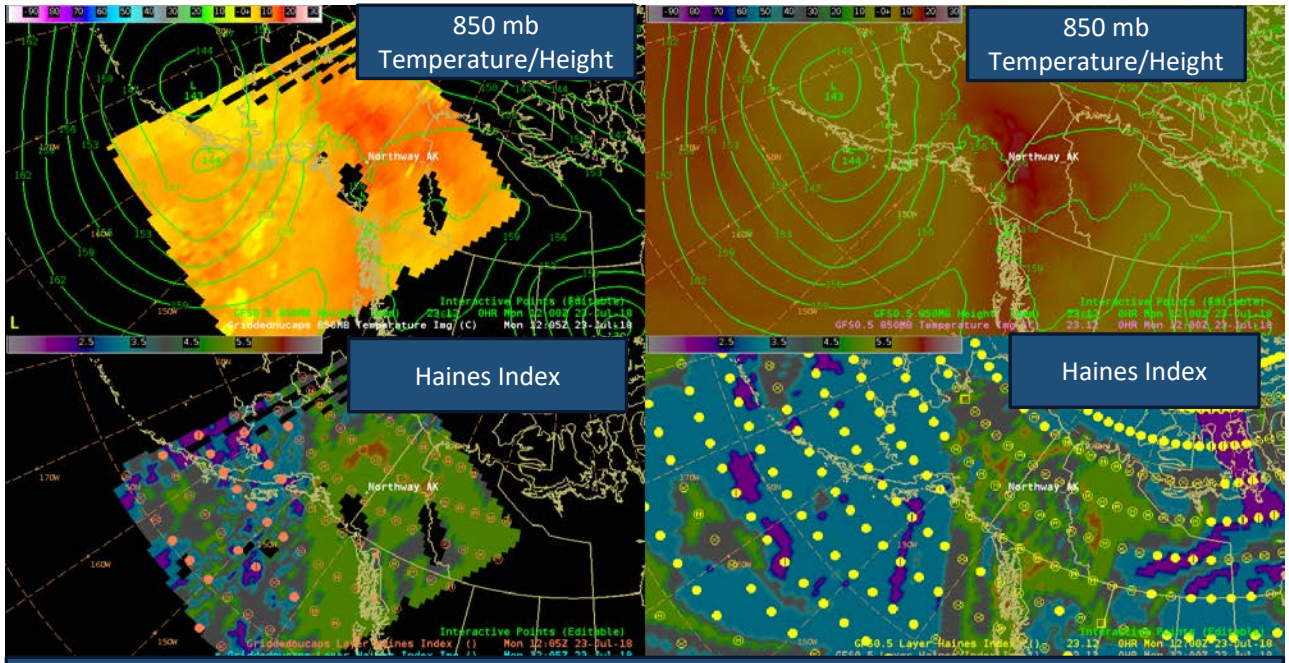


Fig. 17 1025 UTC 23 July S-NPP Gridded NUCAPS and *0.5 degree GFS Analysis* 1200 UTC 23 July

https://vlab.ncep.noaa.gov/web/nasa-sport/gridded-nucaps

Summary

- Since 2013 SPoRT has provided AIRS ozone retrievals to NOAA NWS National Centers to assess high impact storm development and associated high winds
- Since 2014 S-NPP CrIS/ATMS NUCAPS Soundings have been operationally available to all National Weather Service forecasters as Skew-T plots
- Soundings have been evaluated by NWS forecasters at the Hazardous Weather Testbed since 2015 which has led to product modifications and development to meet the needs of the operational environment
- Activities with Cold Air Aloft and the Pre-convective Environment have led to the availability of Gridded Soundings across the NWS for plan-view and cross-section display
- The JPSS Sounding Initiative is continuing to engage with NWS forecasters regarding Hyperspectral Infrared products to continue to test new ideas, find new applications and applied research, and operationally introduce more soundings from additional satellite platforms to the operational environment

Acknowledgements

Much of this work was funded by the NOAA Joint Polar Satellite System Proving Ground/Risk Reduction Program, directed by Dr. Mitch Goldberg and This work was supported by the NASA Research and Analysis Program as part of the Short-Term Prediction Research and Transition Center (SPoRT) project at the Marshall Space Flight Center.

Questions?

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Additional Presentations

Aerospace America Feature Article "Danger In the Air"

Virtual Alaska Weather Symposia

JPSS Science Seminar

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