

Applications using Satellite Sounder Products at the NASA SPoRT Center

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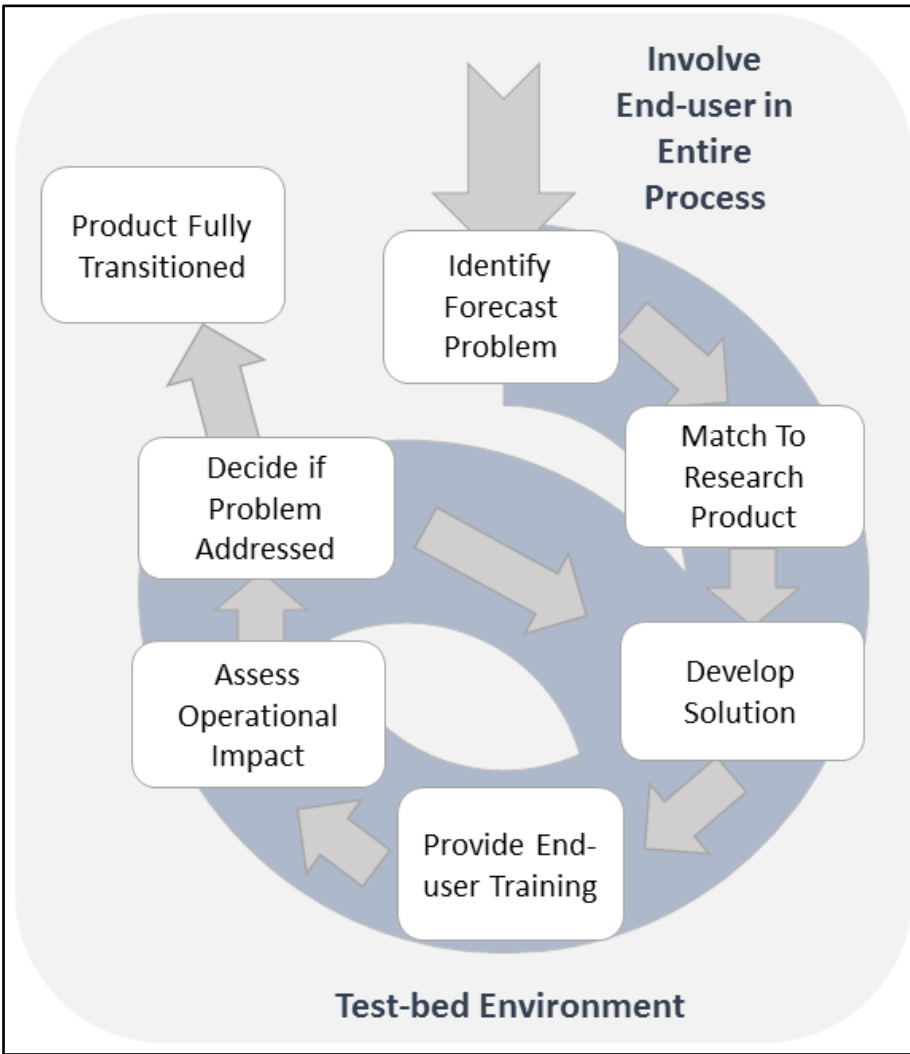
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STAR JPSS Annual Science Team Meeting
Soundings Breakout Session 7b
27 August 2015

Outline

- SPoRT Paradigm/Overview
- Situational Awareness Activities
- Data Assimilation Activities

SPoRT Mission and Paradigm



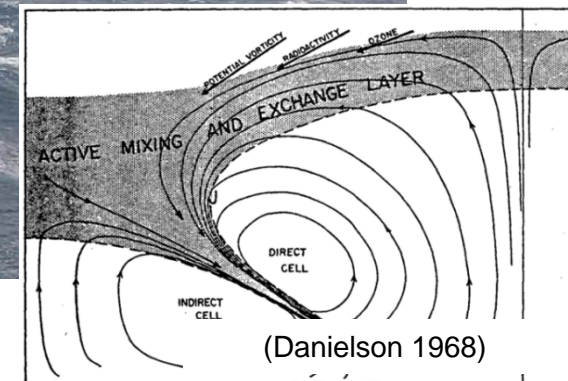
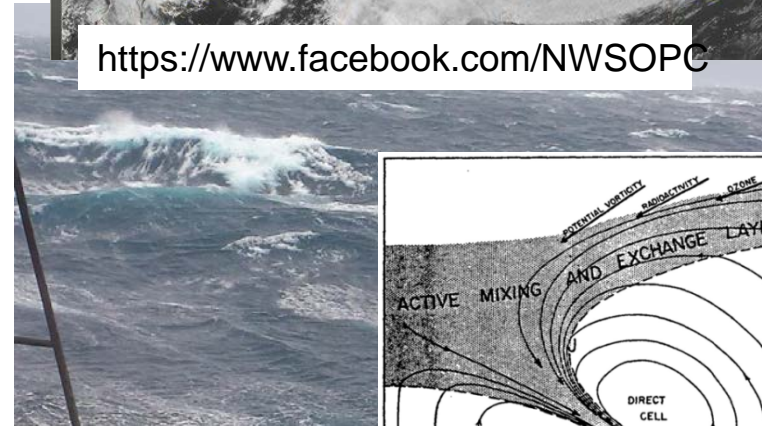
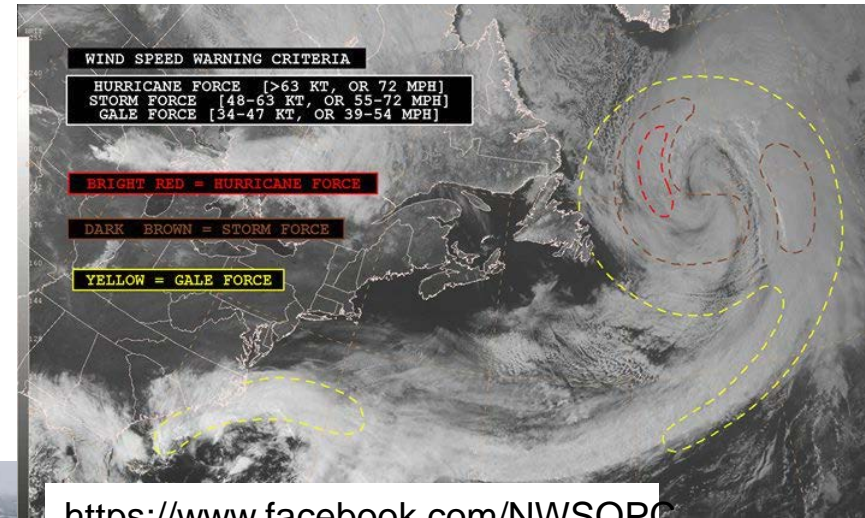
- *Apply satellite measurement systems and unique Earth science research to improve the accuracy of short-term weather prediction at the regional and local scale*
- Bridge the “Valley of Death”
- Can’t just “throw data over the fence”
 - Maintain interactive partnerships with help of specific advocates or “satellite champions”
 - Integrate into user decision support tools
 - Create forecaster training on product utility
 - Perform targeted product assessments with close collaborating partners
- Concept has been used to successfully transition a variety of satellite datasets to operational users for nearly 10 years

Outline

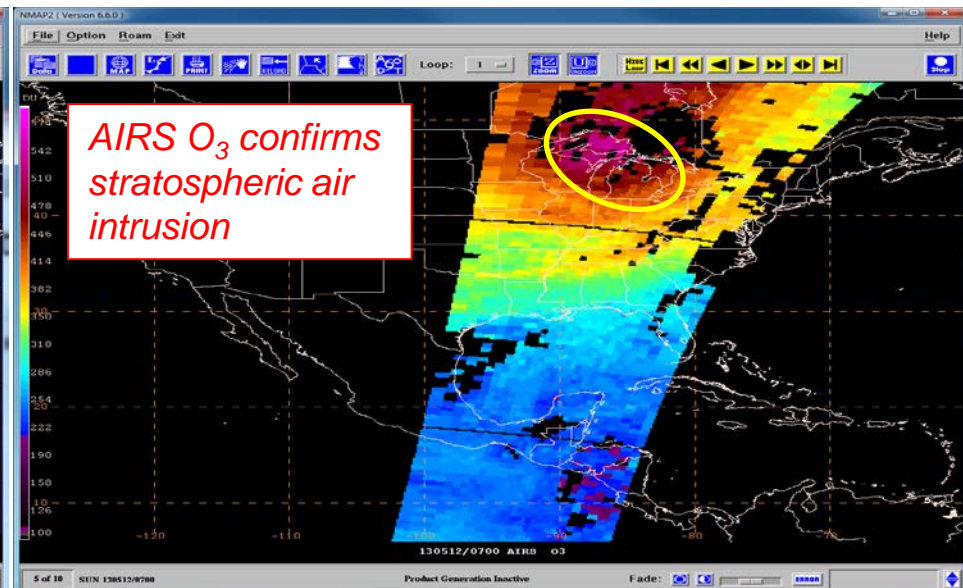
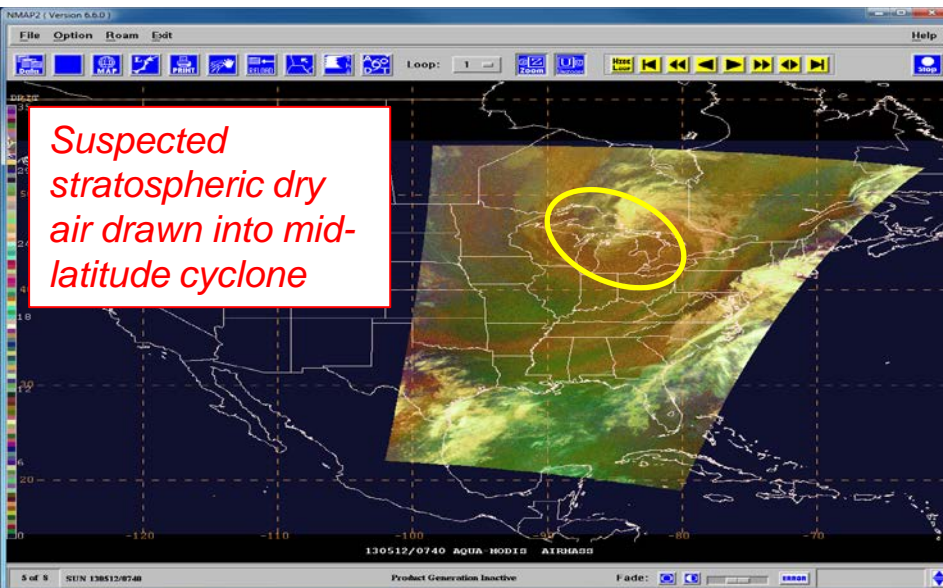
- SPoRT Paradigm/Overview
- **Situational Awareness Activities**
- Data Assimilation Activities

The Forecast Challenge and Ozone Retrievals

- The National Centers (WPC/OPC/SAB) are tasked with providing outlooks that involve forecasting the development of synoptic scale systems and associated severe weather
- OPC especially focuses on forecasting cyclogenesis and the development of hurricane-force winds in the North Pacific and Atlantic oceans
- Identifying regions of stratospheric air and the potential for tropopause folding can enhance forecaster situational awareness of impending cyclogenesis and high wind events
- Stratospheric air can be identified by potential vorticity and warm, dry, ozone rich air

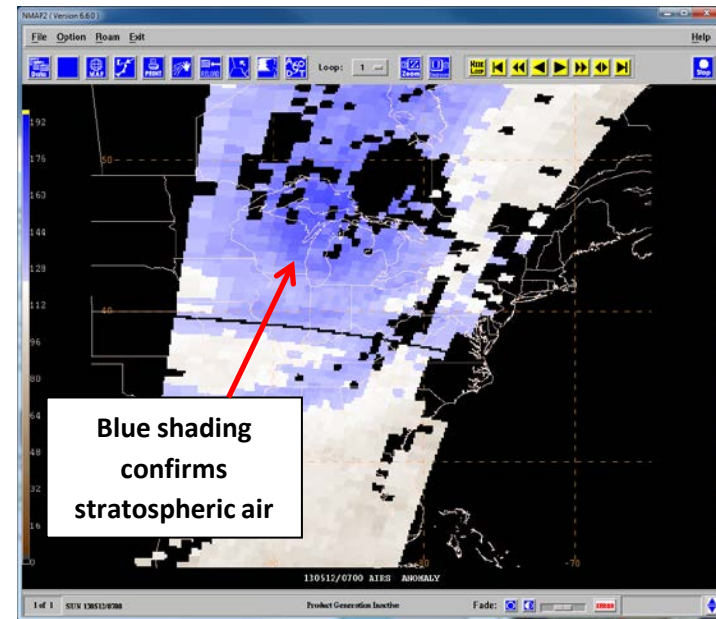
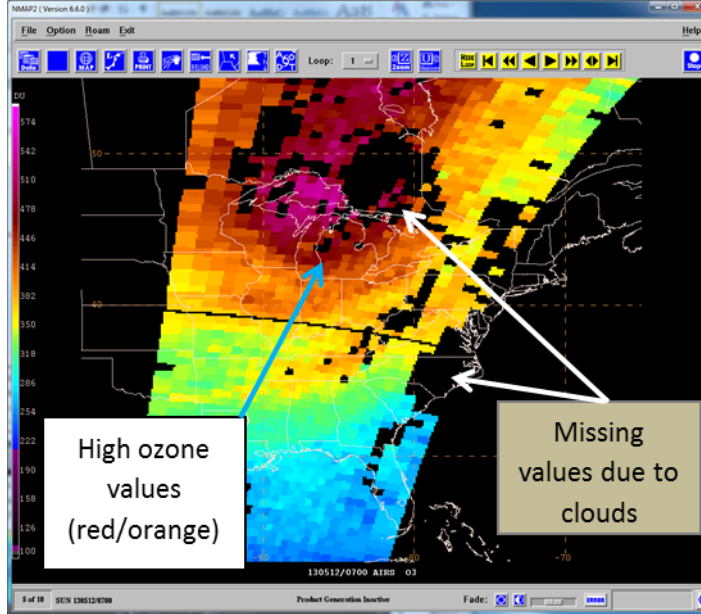


AIRS Total Ozone at WPC/OPC



- AIRS helps determine stratospheric intrusions associated with mid-latitude and extratropical cyclone strengthening and damaging non-convective winds
- Enhances interpretation of RGB products
- Full transition of product to Weather Prediction Center (WPC) and Ocean Prediction Center (OPC) in N-AWIPS decision support system

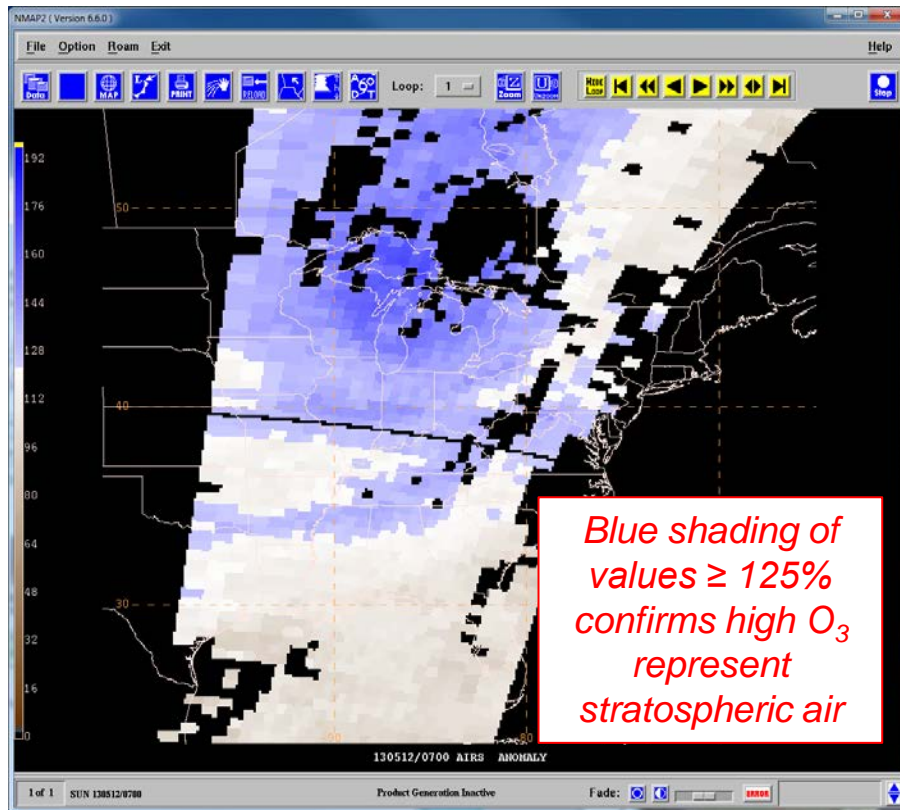
AIRS Total Ozone at WPC/OPC



- Numerous posts on SPoRT and NOAA Proving Ground blogs related to product
- Journal of Operational Meteorology paper on use at WPC/OPC
- Paper on development, application, and transition of SPoRT ozone products in publication for IEEE Transactions in Geoscience and Remote Sensing
- Anomaly product developed to confirm high ozone values are stratospheric and not just within the climatological range

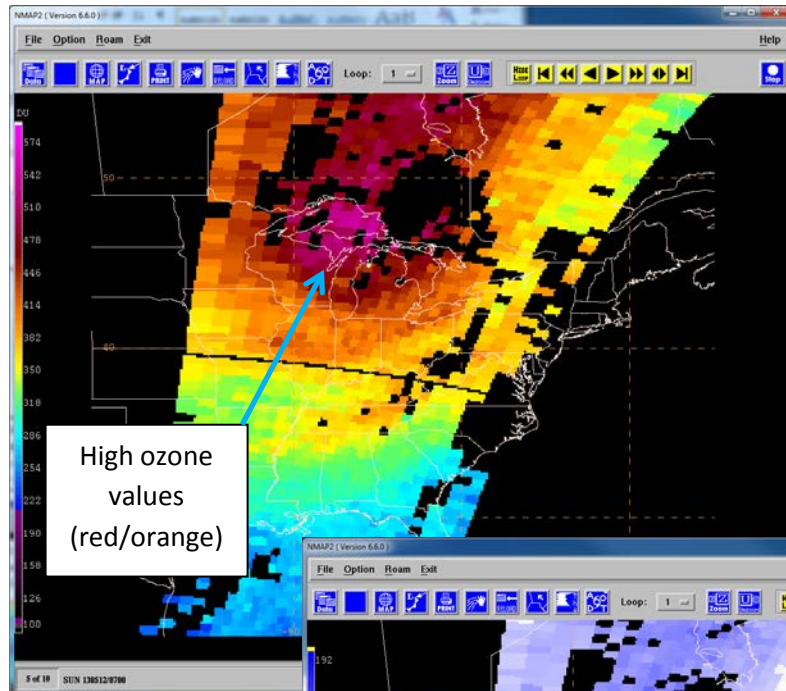
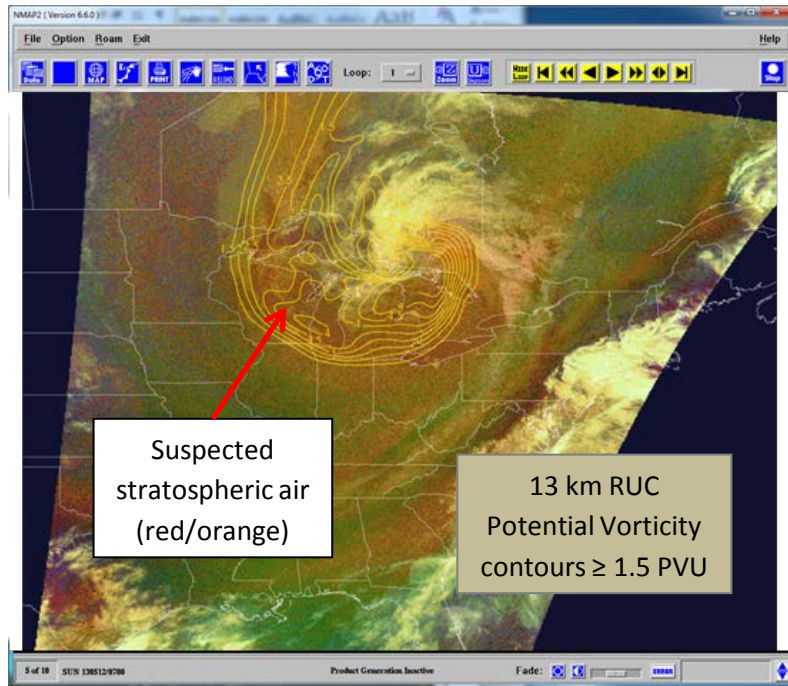
Ozone Anomaly Product

- Identification of stratospheric air based on high ozone values could lead to misinterpretation if the values actually range within climatology since the mean varies seasonally and spatially



- The AIRS Ozone Anomaly product clarifies the presence of stratospheric air based on:
 - Stratospheric air has ozone values at least 25% larger than the climatological mean (Van Haver et al. 1996)
 - Global and zonal monthly mean climatology of stratospheric ozone derived from the NASA Microwave Limb Sounder (Ziemke et al. 2011)

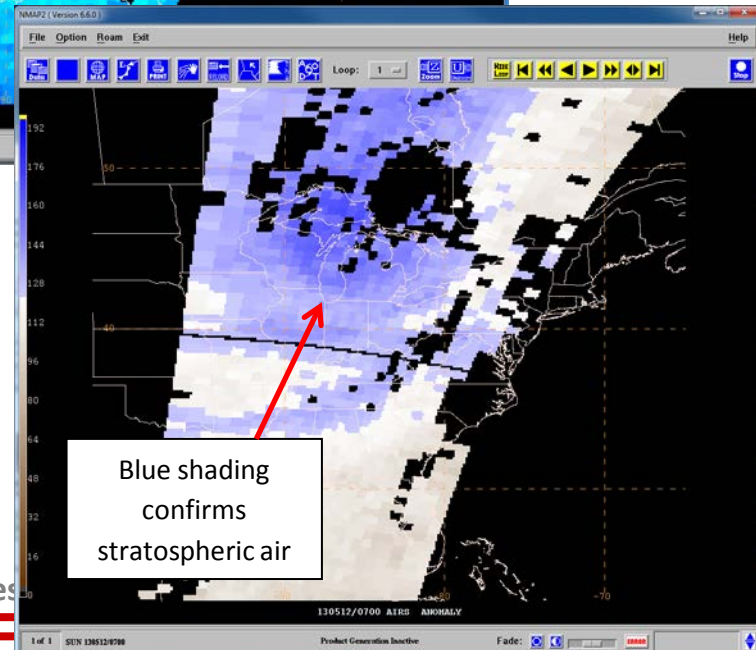
Example 12 May 2013



- SPoRT AIRS Ozone Anomaly product created as a percent of normal (0-200%)

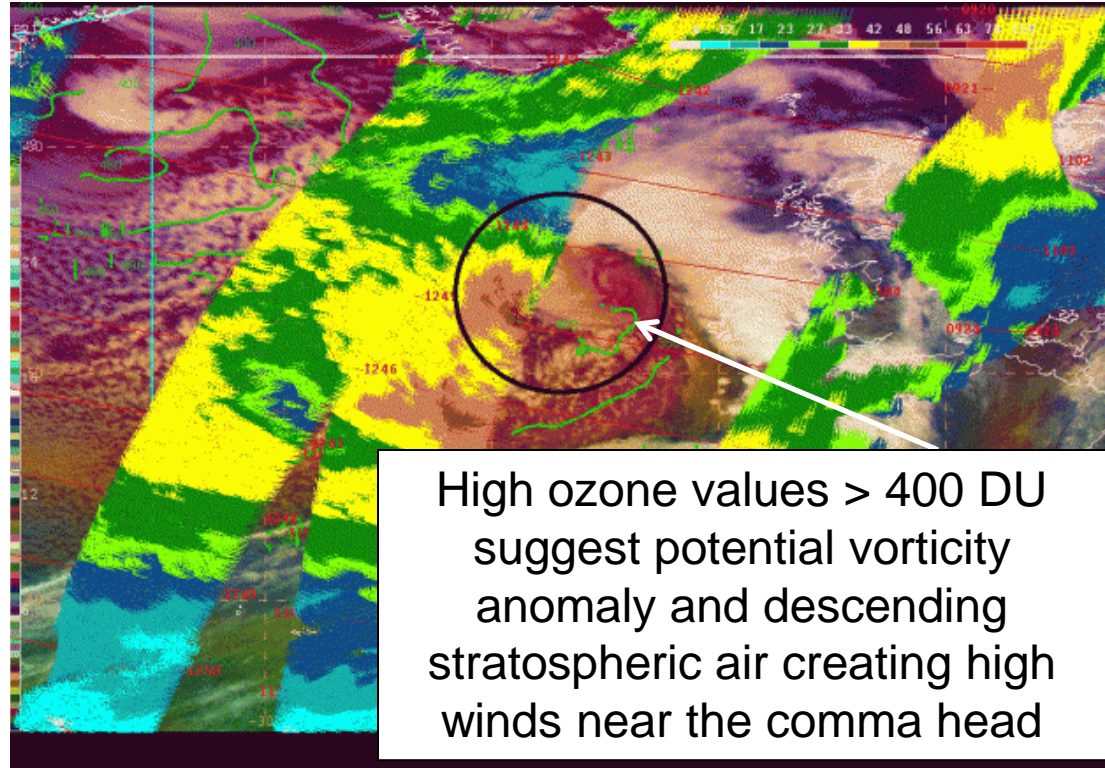
$$PON = \frac{TCO}{climo} \times 100$$

- Shades of blue represent stratospheric air (ozone values $\geq 125\%$)



Demonstration at National Centers

- AIRS ozone products evaluated at OPC, WPC, SAB winter 2013-2014
- Forecaster Feedback
 - “**Reinforce the evidence from RGB** of the descent of stratospheric air with tropopause folding.”
 - “This has allowed me to **have confidence in assessing the RGB Airmass product** and also in conjunction with gridded GFS output that a perceived PV anomaly is real or not.”



SEVIRI RGB Air Mass image, AIRS Total Column Ozone (green contours), and ASCAT winds valid at 1400 UTC on 12/18/13. The black circle highlights the descending stratospheric intrusion near the comma-head/bent back front. Image courtesy of Michael Folmer

Satellite Liaison at NOAA/NWS WPC/OPC/TAFB and NOAA/NESDIS SAB

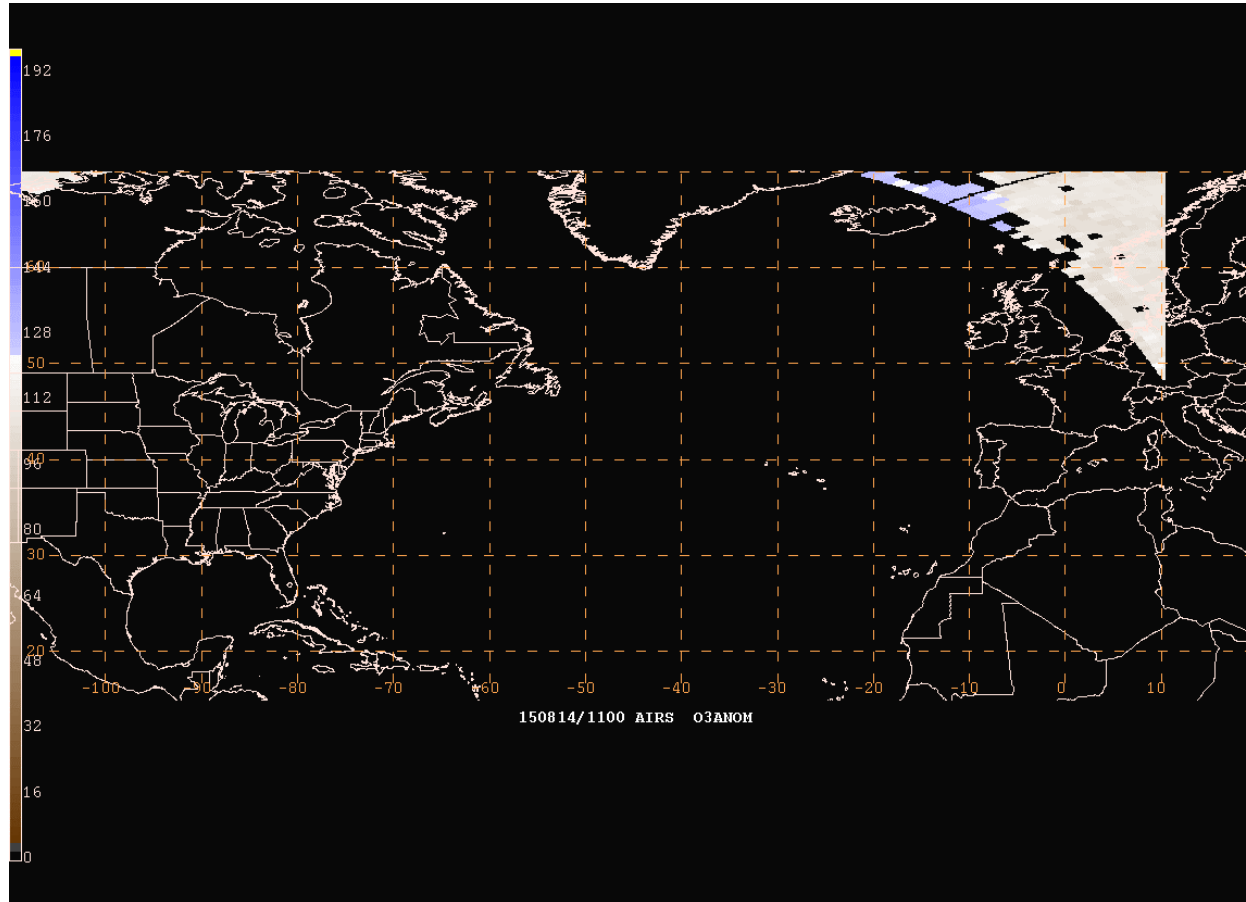
New Product Development

- Adjust product according to forecaster feedback from the winter 2014 product demonstration at OPC
- Expand the ozone products to other instruments
 - Increase temporal & spatial coverage by developing products from IASI and CrIS retrievals

“There may have been 1 occasion where 1 pass did line up over the US with the spot I was interested in. In that case, it was helpful in reaffirming my suspicions on whether stratospheric air was present. Otherwise, the passes were few and far between and not particularly timely. If there was greater coverage of passes and not as much of a lag, it would certainly be useful.”

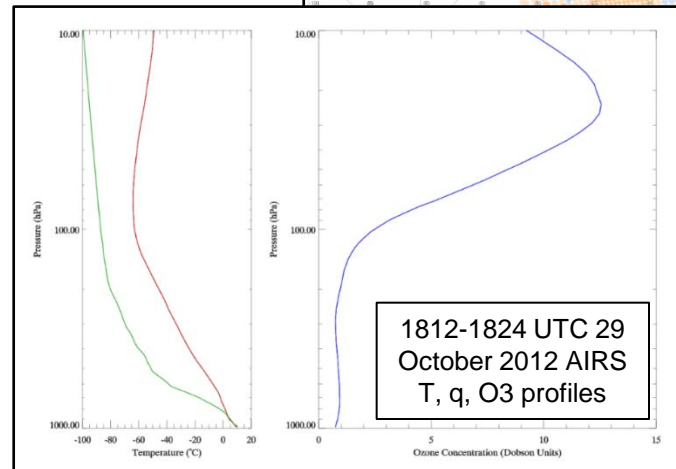
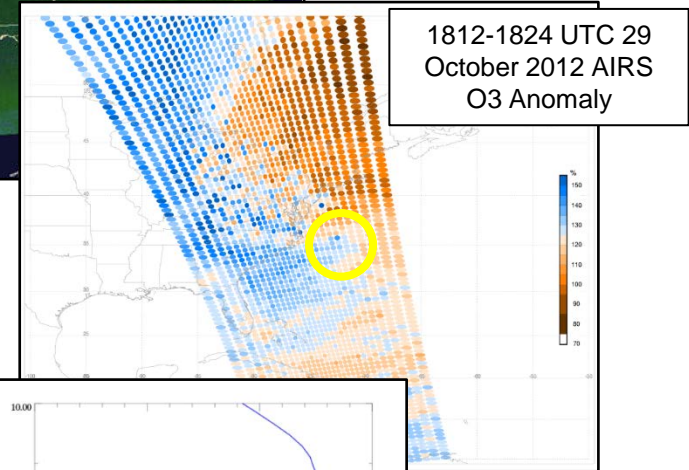
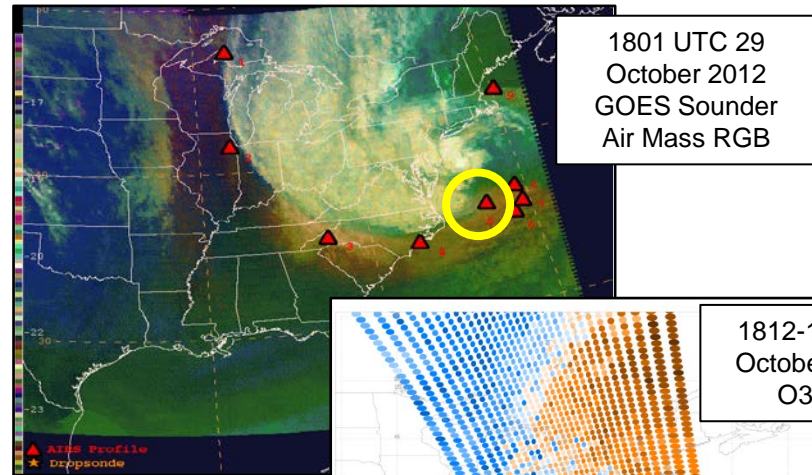
New Product Development

- Products from NUCAPS and IASI were develop in early 2015
- National Centers are receiving products from AIRS, IASI, and NUCAPS



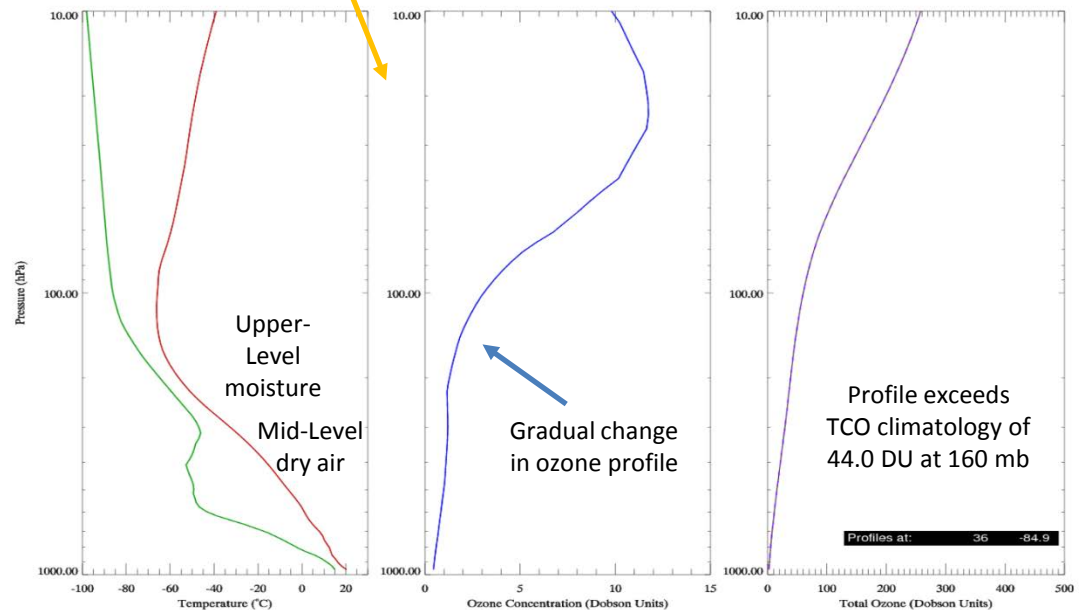
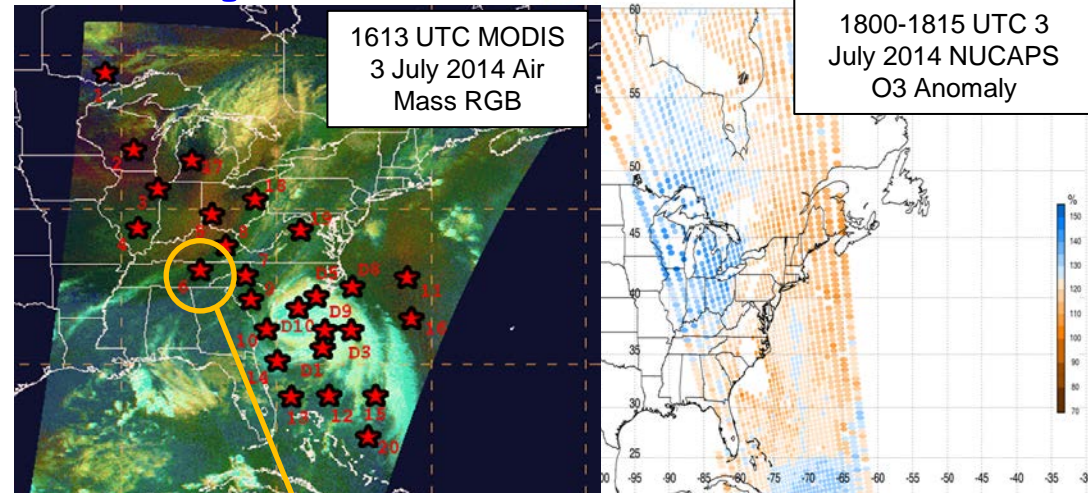
Hurricane Extratropical Transition

- National Centers' forecasters have GOES-R/JPSS Proving Ground proxy products, such as the Air Mass RGB, to assist in monitoring extratropical transition of hurricanes
- Air Mass RGB product provides an enhanced view of various air masses in one complete image to help differentiate between possible stratospheric/tropospheric interactions
- NUCAPS soundings can compliment the Air Mass RGB by providing insight about the vertical structure of the atmosphere
- Since NUCAPS soundings are already in AWIPS-II this projects investigates the utility of NUCAPS soundings for another unique forecasting challenge



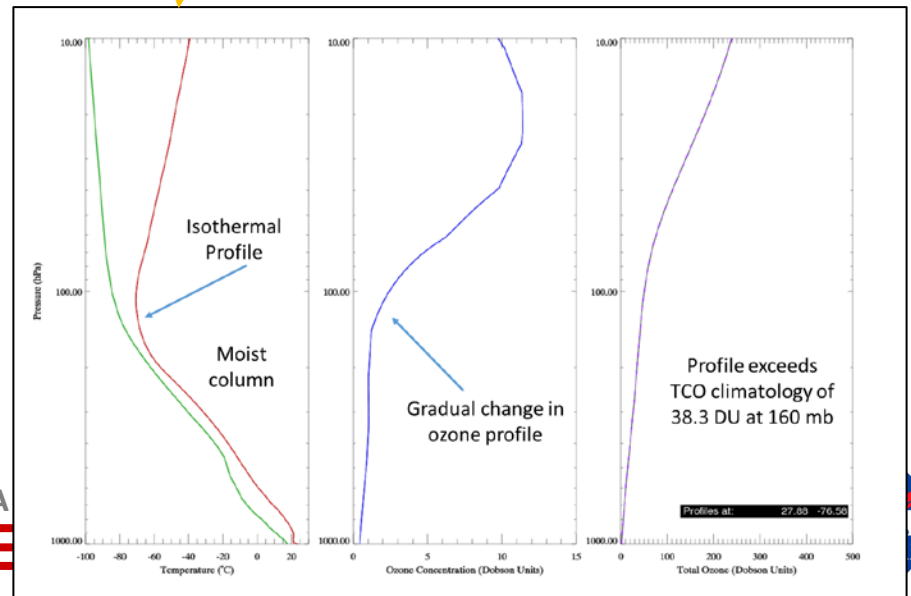
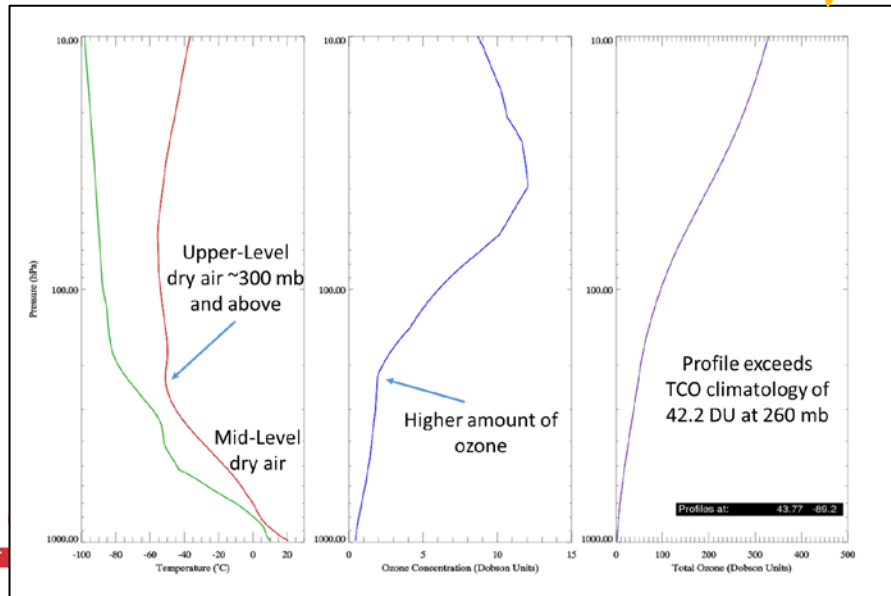
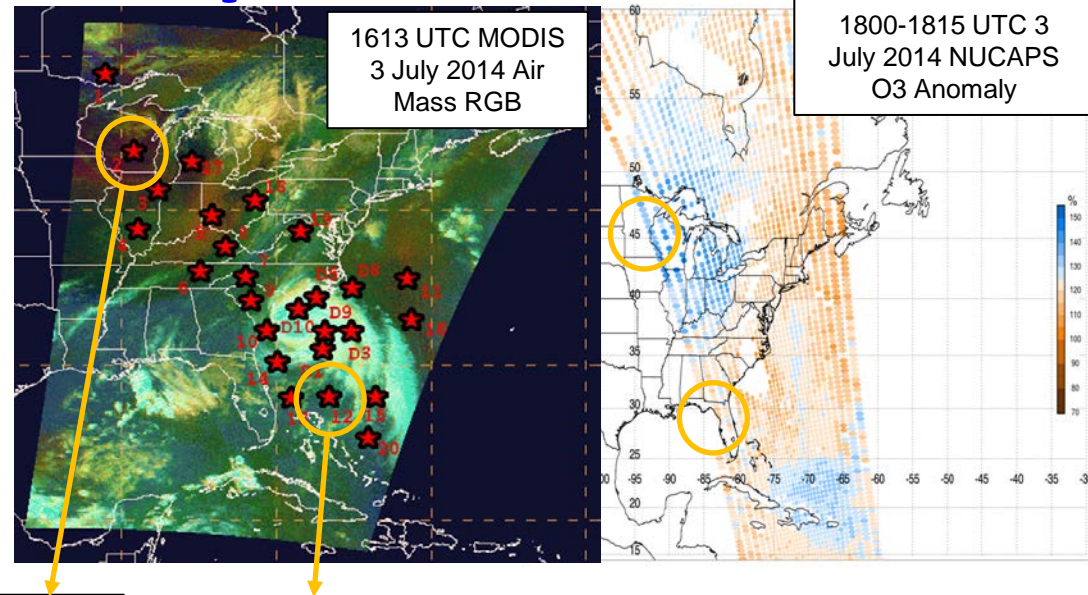
Hurricane Extratropical Transition

- Project will investigate 3 extratropical transition case studies
 - Arthur 2014
 - Sandy 2012
 - Nadine 2012
- Create a stratospheric depth product
- Create tailored training
- Conduct a product demonstration of NUCAPS soundings and stratospheric depth product with NHC, WPC, and OPC during 2016 hurricane season



Hurricane Extratropical Transition

- Profiles in red/orange regions confirm mid- and upper-level dry air and lower tropopause
- Profile near the storm in blue/green regions confirm a moist column, a gradual change in the ozone profile, and a higher tropopause

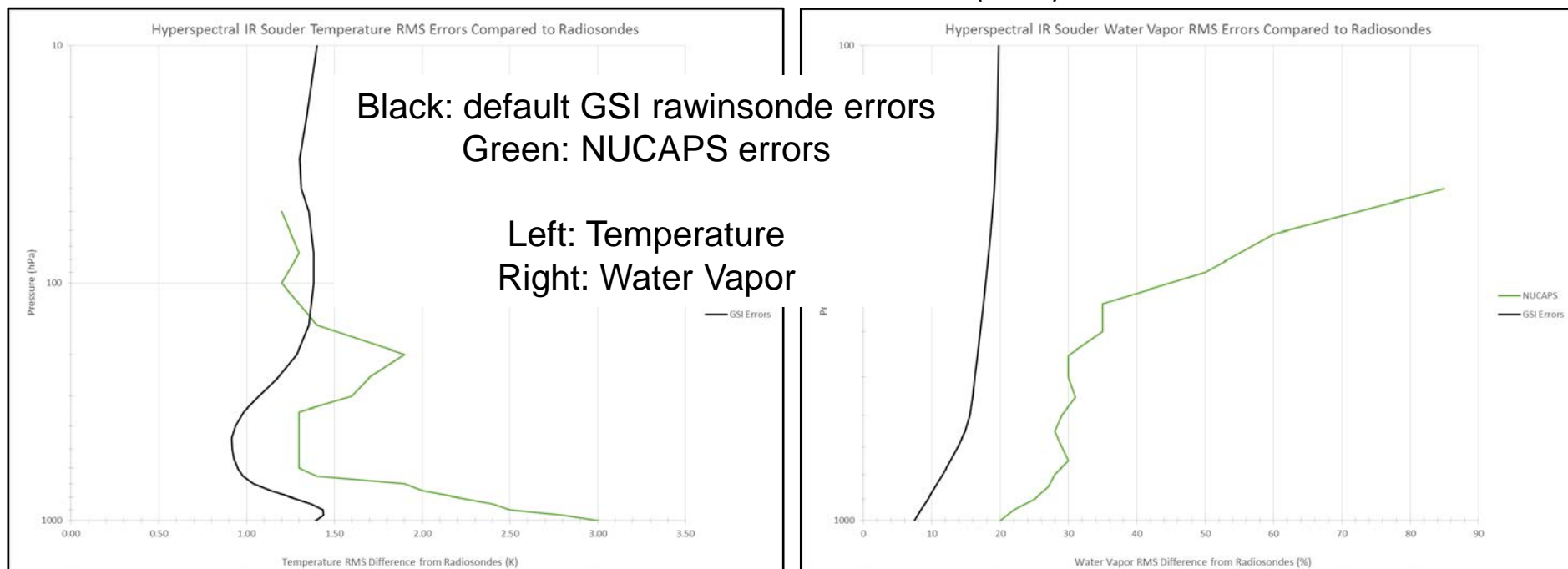


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Assimilation of NUCAPS Profiles

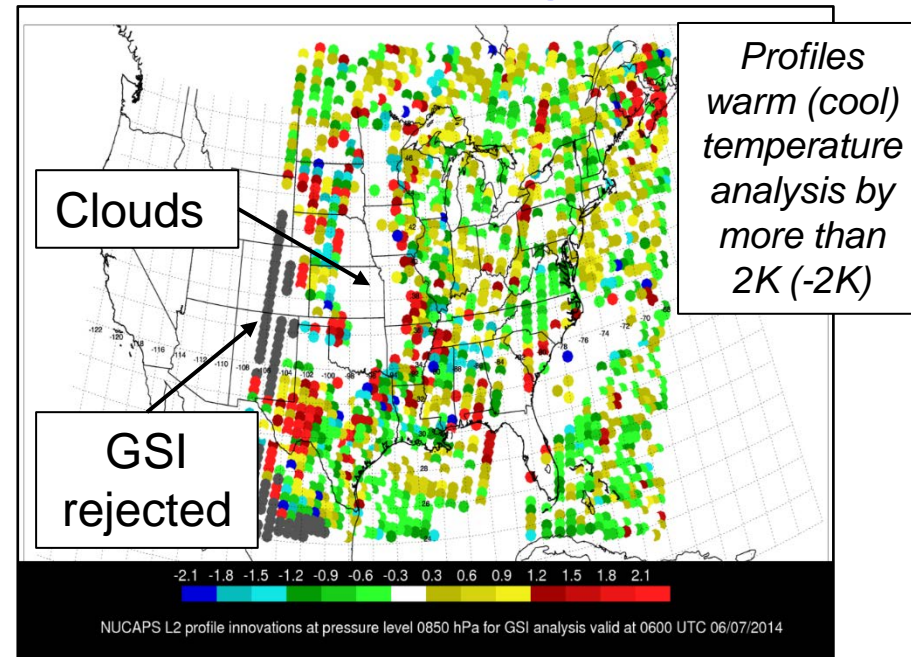
- Satellite profiles are traditionally assimilated as rawinsonde observations and assigned rawinsonde errors which are unrepresentative for satellite profiles
- Experiments were conducted to compare model runs
 - No profile assimilation + conventional observations
 - Profile assimilation with rawinsonde errors + conventional observations
 - Profile assimilation with NUCAPS errors from Nalli et al. (2013) + conventional observations



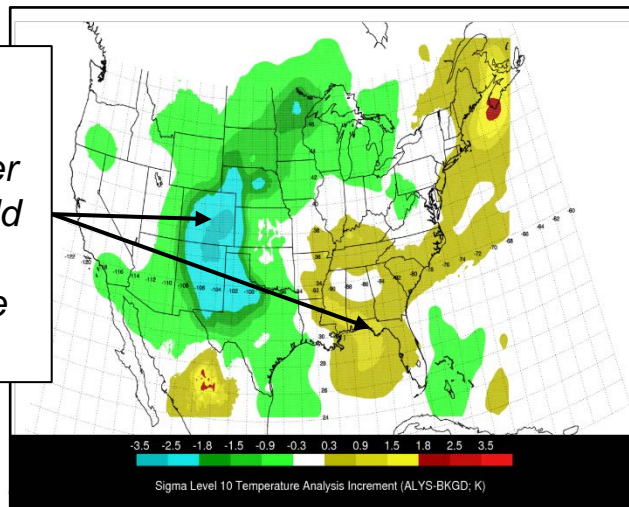
transitioning unique NASA data and research technologies to operations

Assimilation of NUCAPS Profiles

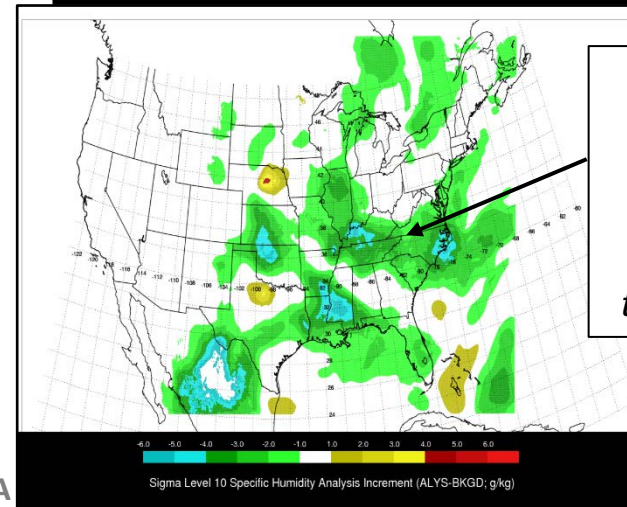
- Location and color coded innovations where NUCAPS profiles were assimilated at 850 hPa
- Yellow/red (green/blue) regions represent locations where individual profiles are warmer (cooler) than the final temperature analysis, gray locations were rejected by GSI
- Analysis increments show how much and where the background fields have been modified by assimilating observations



850 hPa
temperature
analysis cooler
behind the cold
front and
warmer in the
warm sector



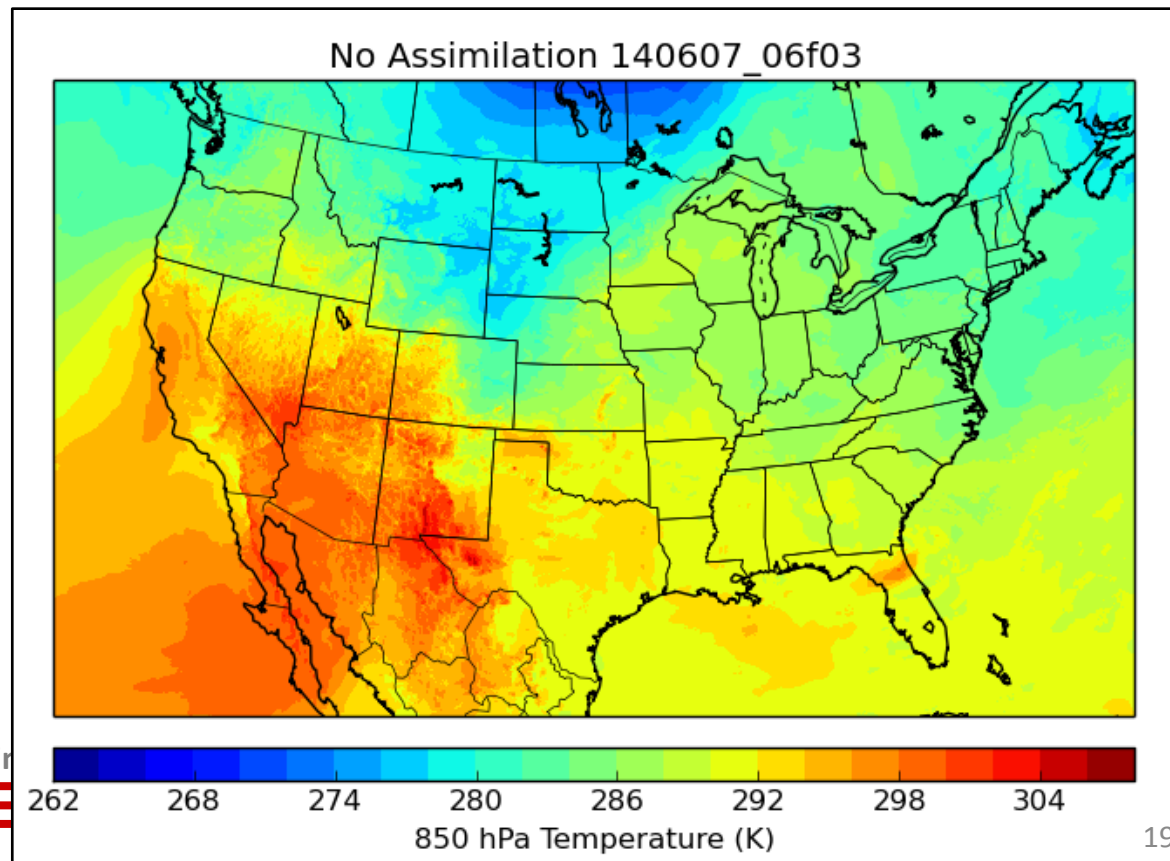
850 hPa
moisture
analysis
drier over
portions of
the domain



Assimilation of NUCAPS Profiles

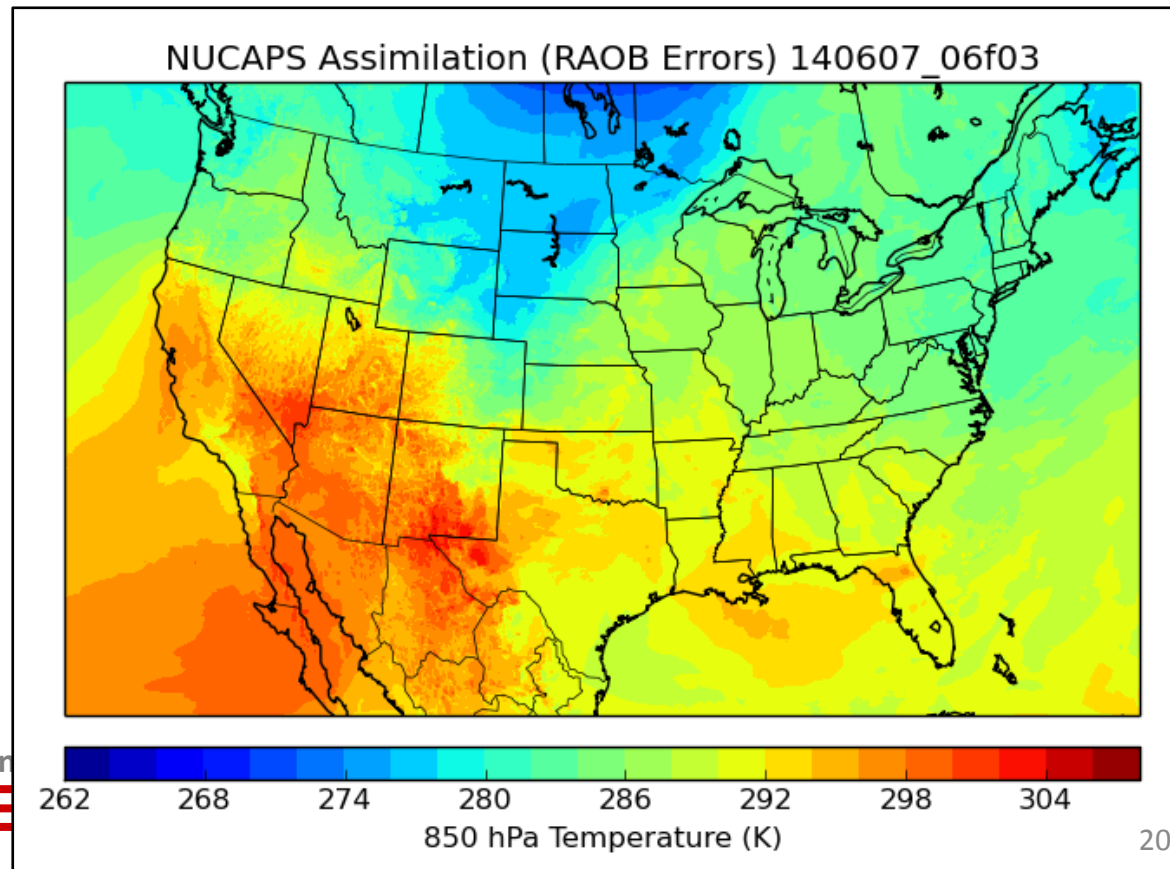
- Comparison of experiments show colder 850 hPa temperatures in the Upper Midwest and subtle warming in the Midwest and Southeast when NUCAPS profiles are assimilated

Only subtle changes are apparent in 850 hPa temperature between experiments that assimilate NUCAPS profiles with RAOB error and NUCAPS errors



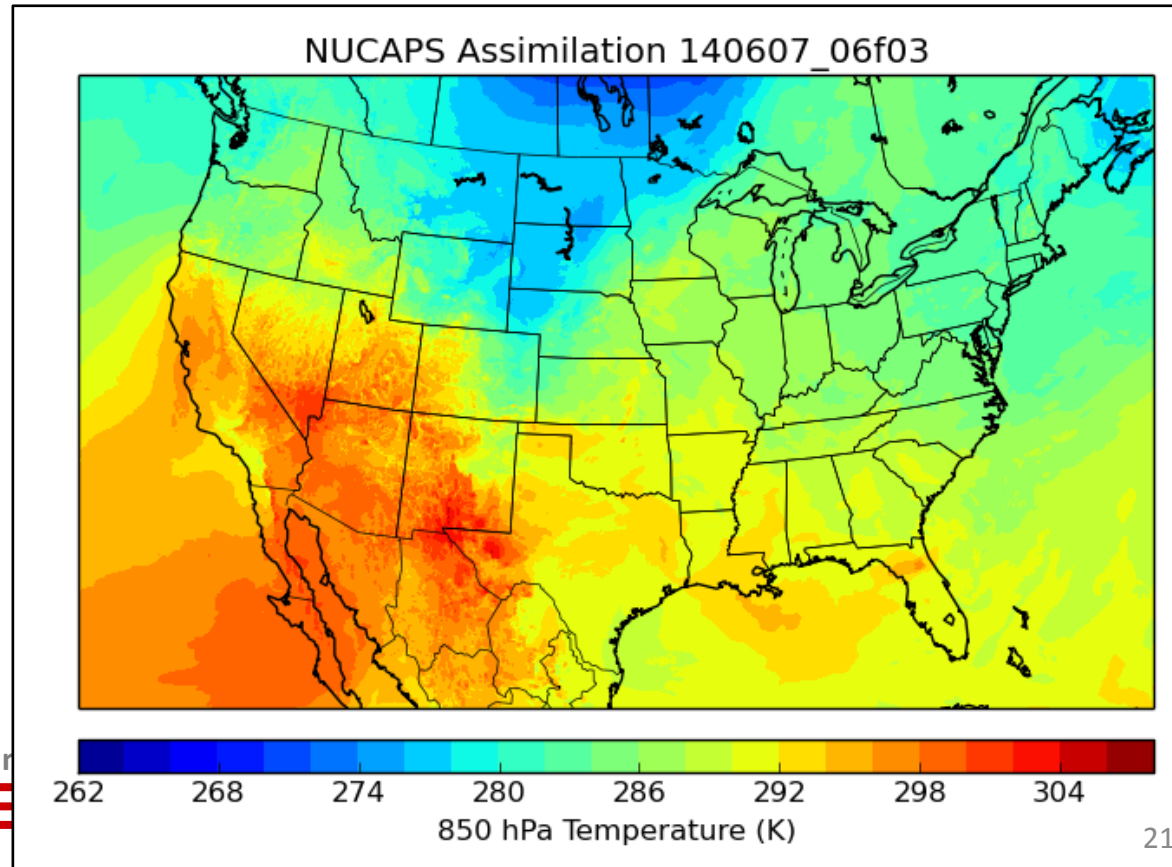
Assimilation of NUCAPS Profiles

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Assimilation of NUCAPS Profiles

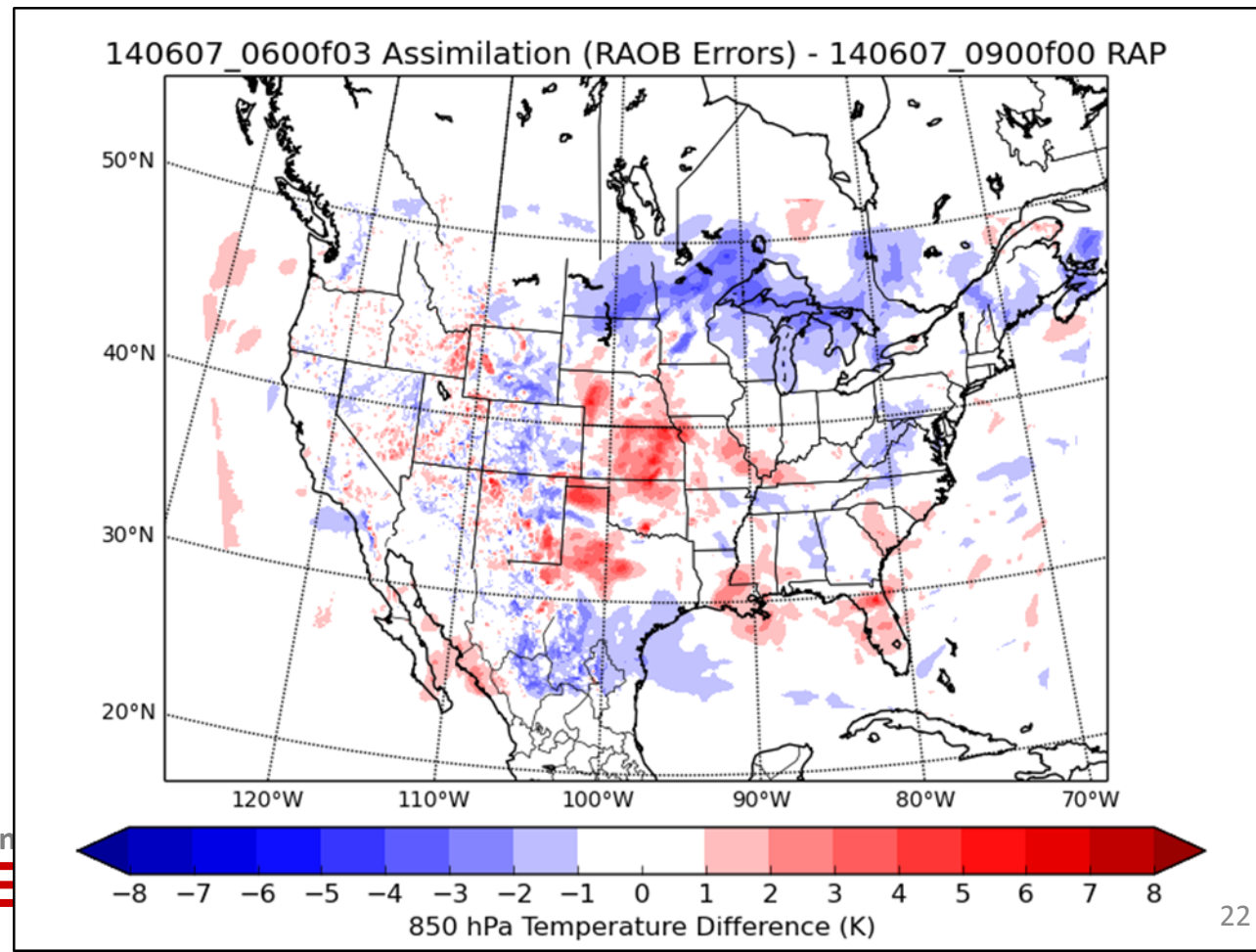
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Assimilation of NUCAPS Profiles

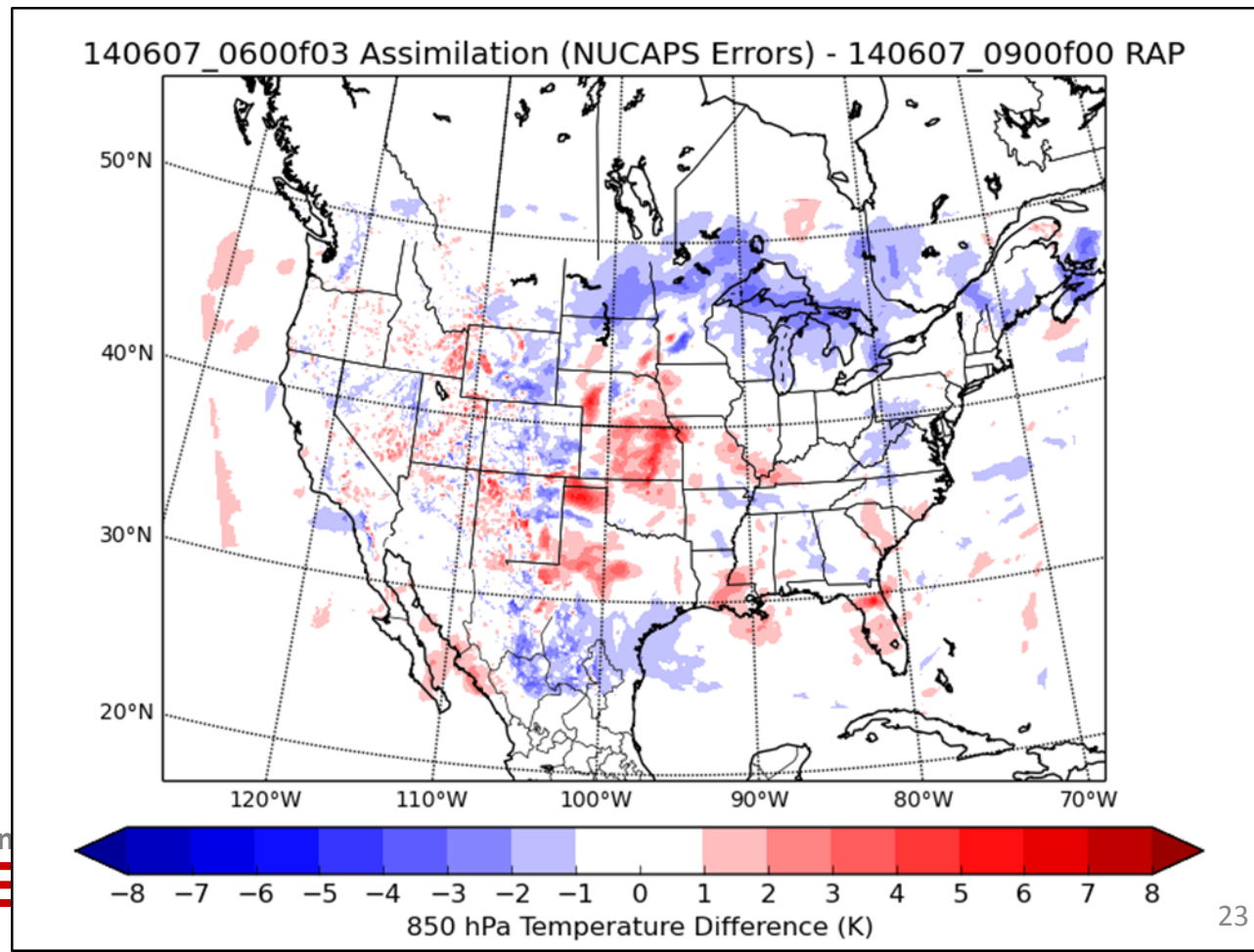
- Model output was re-gridded to 13-km and compared to the RAP analysis

Differences are smaller and the forecasted field is closer to the RAP analysis when assimilating profiles with NUCAPS errors



Assimilation of NUCAPS Profiles

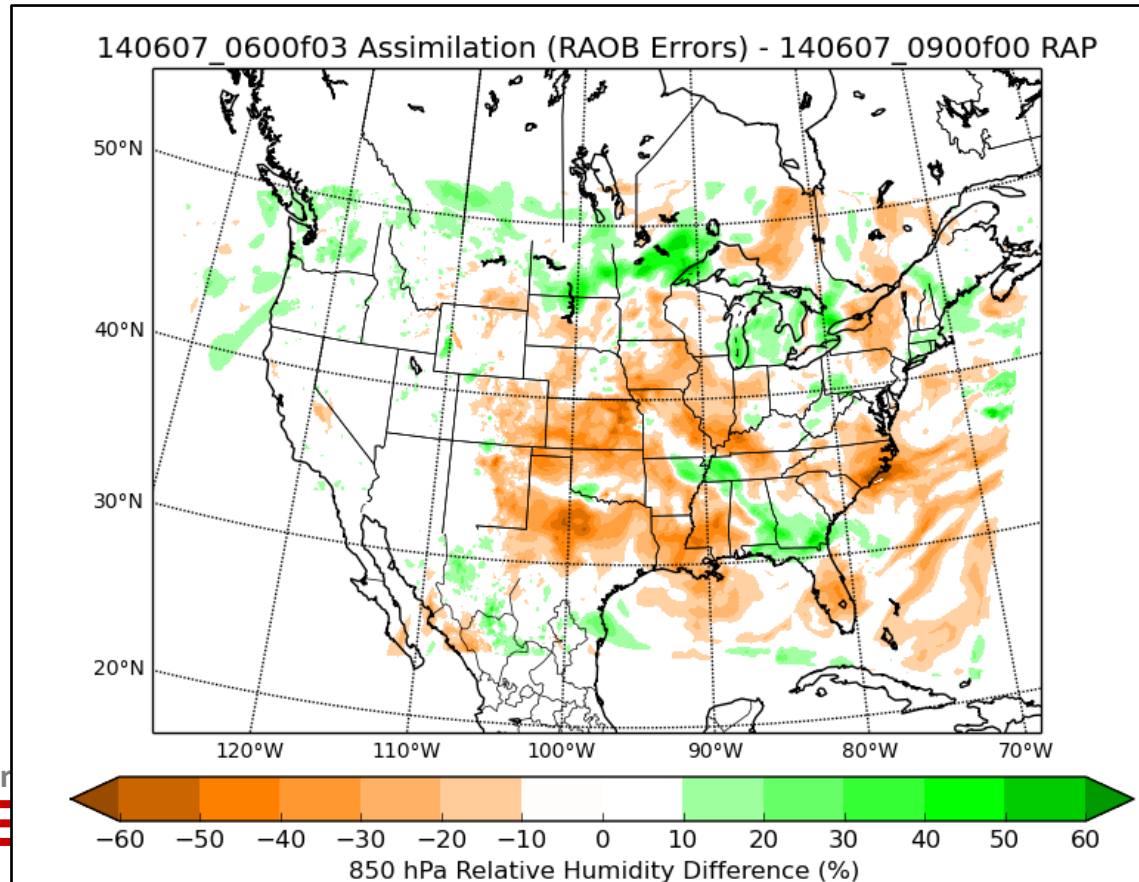
Differences are smaller and the forecasted field is closer to the RAP analysis when assimilating profiles with NUCAPS errors



Assimilation of NUCAPS Profiles

- 850 hPa Relative Humidity Figures are not shown, but more drying occurs at low levels when assimilating NUCAPS profiles with subtle differences between assimilating profiles with RAOB and NUCAPS Errors

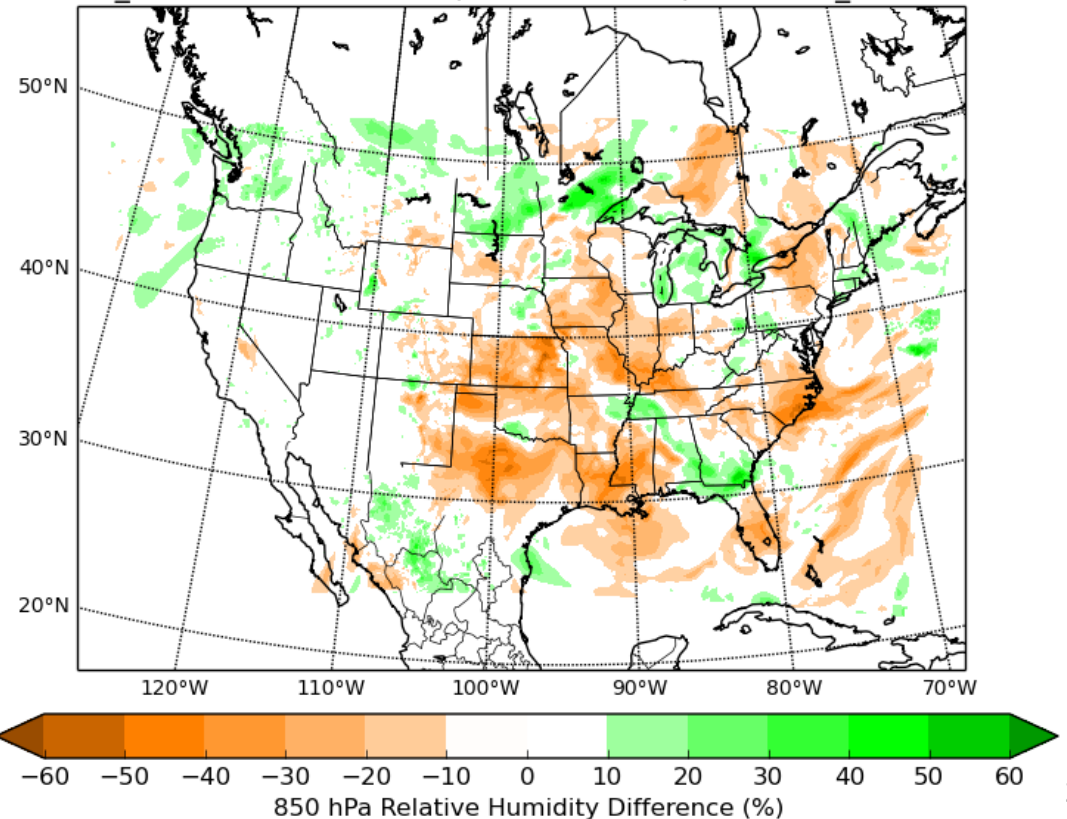
Less drying occurs (relative to 13-km RAP analysis) when profiles are assimilated with NUCAPS errors.



Assimilation of NUCAPS Profiles

*Less drying occurs
(relative to 13-km RAP
analysis) when profiles
are assimilated with
NUCAPS errors.*

140607_0600f03 Assimilation (NUCAPS Errors) - 140607_0900f00 RAP



Assimilation of NUCAPS Profiles

- NUCAPS profiles can be assimilated in GSI as a separate observation other than rawinsondes with only changes to tables in the fix directory
- Assimilation of profiles does produce changes to analysis fields and evidenced by:
 - Innovations larger than ± 2.0 K are present and represent where individual profiles impact the final temperature analysis
 - The updated temperature analysis is colder behind the cold front and warmer in the warm sector
 - The updated moisture analysis is modified more in the low levels and tends to be drier than the original model background
- Differences relative to 13-km RAP analyses are smaller when profiles are assimilated with NUCAPS errors
- Next steps include assimilating profiles over a longer period of time and assessing the impact on the forecast

Summary

- SPoRT is a proven community leader for transitioning satellite products to operational end users and is working to bring data from hyperspectral infrared sounders to forecasters
- SPoRT products using AIRS, IASI, and NUCAPS data are currently available at National Centers: WPC, OPC, SAB
- SPoRT is continuing to investigate the utility of NUCAPS profiles for other applications such as Extratropical Transition
- SPoRT also assimilates NUCAPS profiles into regional models and is investigating the influence on summer-time convection forecasts