Outline

- **NASA Short-term Prediction Research and Transition (SPoRT) Center Overview**
  - Mission, Work, Partners, and End-Users
  - Data assimilation (DA) and Modeling Research
  - What does SPoRT mean by transition of DA/modeling research?
- **Overview of Past SPoRT AIRS Assimilation Projects**
- **Comparing AIRS radiance assimilation to AIRS profile assimilation**
- **Discussion of collaborative project with JCSDA to use AIRS profiles to better understand the impact of AIRS radiances assimilated within GSI**

The SPoRT Center:
Infusing NASA Technology Into Operational Forecasting

Mission: Apply NASA measurements and unique Earth science research to improve the accuracy of regional and local short-term weather prediction

- **Conduct focused research to evaluate products in a "testbed" mode**
- **Exploit satellite observations for diagnostic analyses and nowcasting**
  - Weather in data void regions
  - Cloud cover, visibility, fog, morning minimum temperatures (and its local variations)
  - Coastal weather processes; off-shore precipitation processes
  - Timing and location of severe weather
- **External Partners: NWS (national and regional HQs), NESDIS (STAR, NDE), NCEP, JCSDA, JPL, GSFC (GMAO), GOES-R PG**
- **End Users: WFOs, other government organizations, private sector partners**
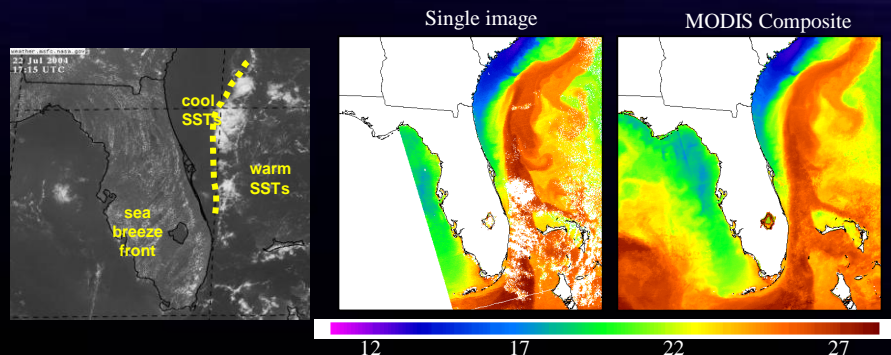
Keys to success
- *Link data / products to forecast problems*
- *Integrate capabilities into systems used in operations*
- *Provide training / forecaster interaction & feedback*

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Focused Data Assimilation and Modeling Research

Unique datasets

- High resolution MODIS / AMSR-E composite replaces RTG SST fields in regional forecast models leading to improved coastal weather forecasts – impact on tropical systems

Single image   MODIS Composite

0-10 cm Soil Moisture Diff (%, LIS – Control) 1200 UTC 6 May 2004

SPoRT/MODIS GVF (%) valid 17 JUL 2010

Improved description of soil moisture over Florida

Research model applications

- Coupled WRF / LIS replaces climatology land surface fields such as soil moisture/temperature, snow cover, and vegetation leading to improved convective forecasts

- Optimized microphysics WRF configurations for specific forecast challenges using CloudSat data

Innovations   Analysis Increments

Data assimilation approaches

- Assimilating AIRS radiances and profiles into WRF leads to regional forecast model improvements

- Lessons learned from regional DA studies can be applied to global

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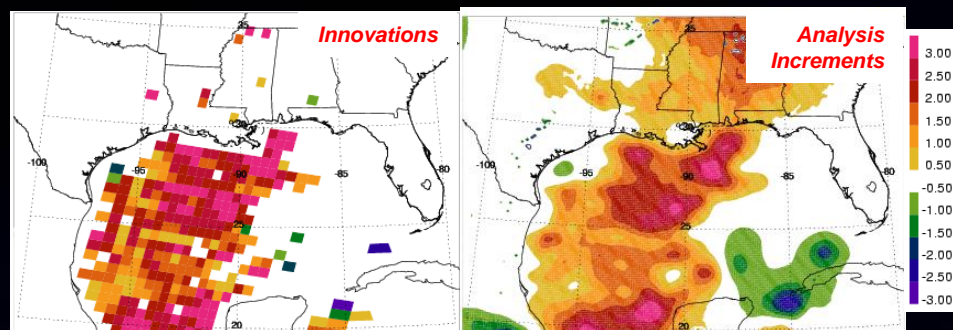
SPoRT Transitions Modeling and DA Research to Operations

- **SPoRT runs models in real-time for research purposes**
  - Possible due to "Weather in a Box" desktop supercomputers provided by NASA HQ
  - SPoRT researchers and operational partners can evaluate weather-of-the-day impact

- **Local/Regional (NWS offices)**
  - Provide real-time, NASA-enhanced analyses for local-scale applications
    - Diagnostic analysis product (CAPE, low-level moisture, etc.)
    - Initialize local WRF-EMS runs

- **Regional/National (SPC, NHC)**
  - Generate real-time SPoRT-WRF that incorporates NASA data and capabilities
   - Evaluated at HWT Spring Experiment

- **National/Global (NCEP/EMC)**
  - Assimilate conventional and satellite data using GSI to mimic operational DA/modeling configuration
    - Include AIRS profile (and eventually IASI and CrIS) in this configuration
    - Evaluate the potential impact of these data sets on the operational system


110427/1200V012 Updraft Helicity from 2-5 km AGL (m2/s2)
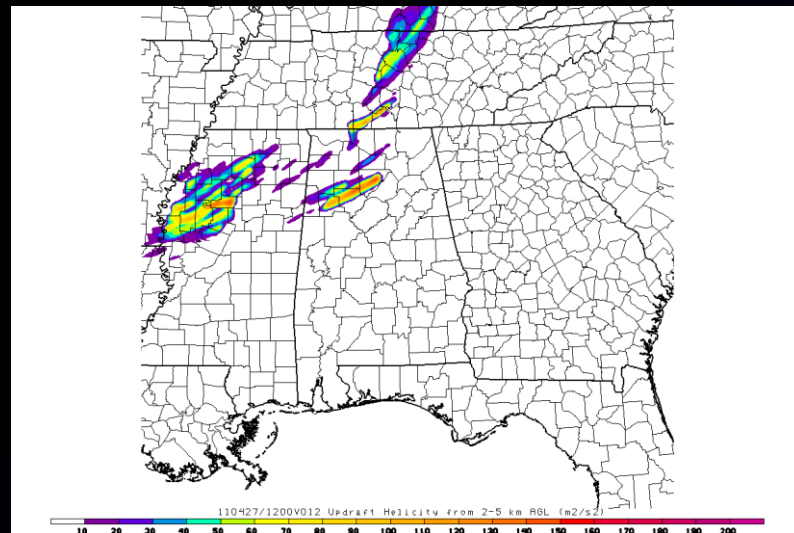
Brief History of AIRS Radiance Assimilation at SPoRT

- **Will McCarty collaborated with JCSDA to assimilate AIRS radiances using GSI**
  - Implemented CO_2 sorting technique as alternate approach to define cloud-free radiances
    - ○ Allows for additional radiances to be assimilated above low clouds that are removed using a masking approach
    - ○ Some cloud contamination still present at high latitudes
  - Showed analysis and forecast improvement with assimilation of AIRS radiances in the GSI/NAM including high-impact precipitation events
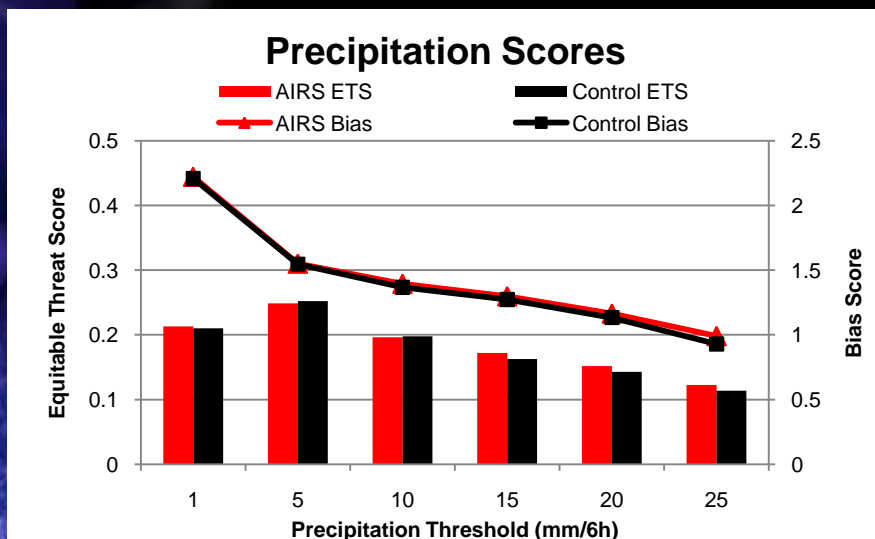
500 hPa Z anomaly correlation

Precipitation Scores

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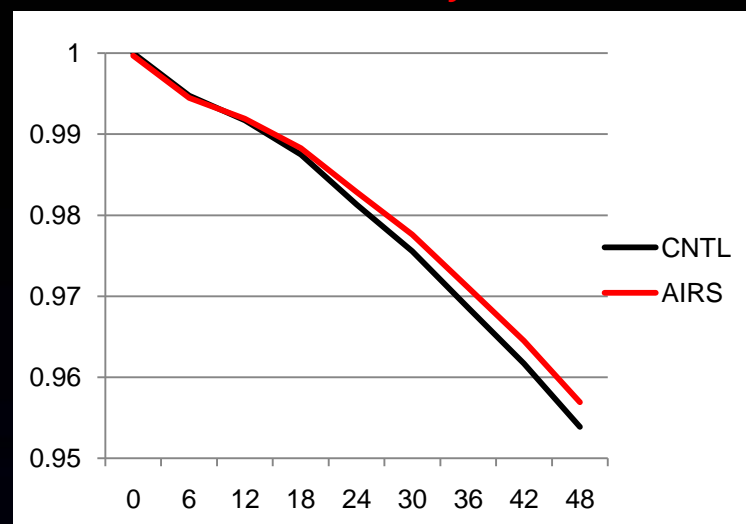
Brief History of AIRS Profile Assimilation at SPoRT

- **LAPS to initialize WRF but found it incorrectly handled moisture profiles**
- **Transitioned to ADAS but found long computational times and no dynamic adjustment to momentum fields which led to spin-up issues in WRF**
- **Next turned to WRF-Var**
  - Generated B matrix using control WRF forecasts and "gen_be" software
  - Altered source code to add AIRS profiles with separate land and water error characteristics
  - Found that AIRS profiles create a more unstable sounding improving precipitation statistics
- **Use GSI to replicate operational system**

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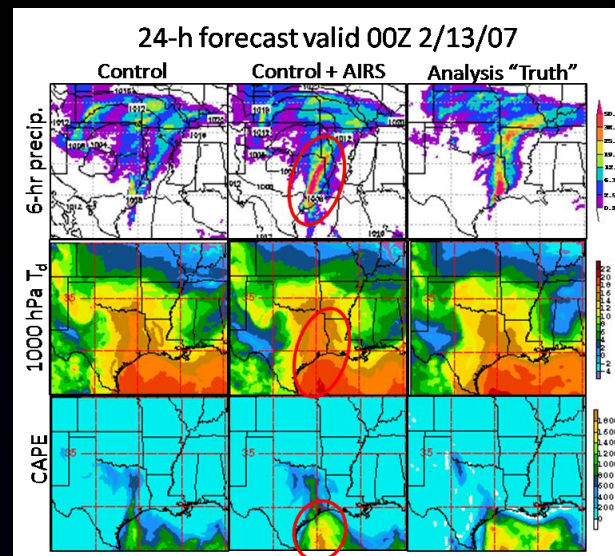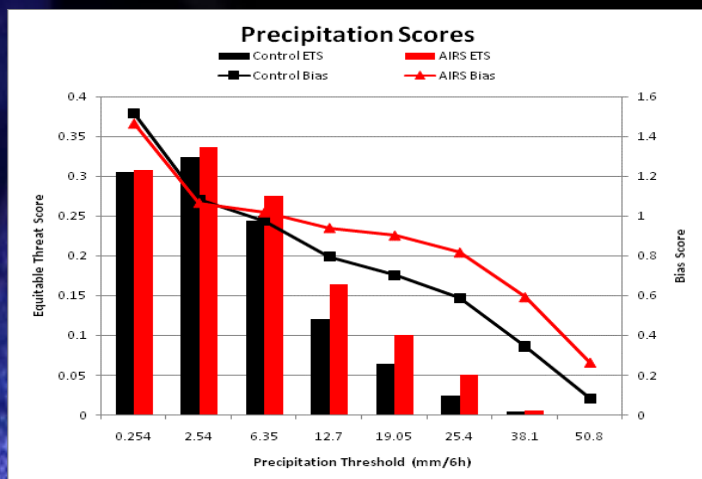
Assimilating AIRS Profiles to Understand Limitations of AIRS Radiance Procedures
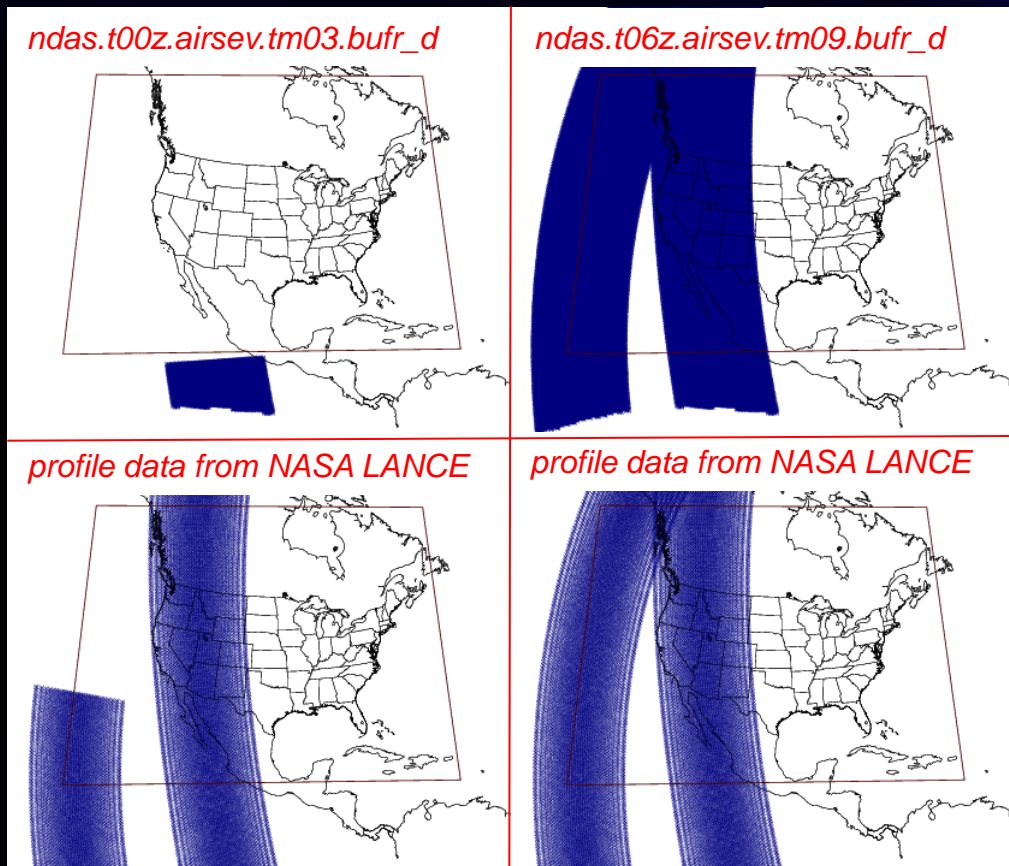
- **AIRS radiances currently assimilated operationally in GFS and NAM**
  - Cloud-free radiances from 281-channel subset
- **Larger impact of AIRS profiles has been demonstrated**
- **AIRS profiles do not contain the same limitations as previous profile data sets**
  - Hyperspectral nature of AIRS results in higher quality retrievals than previous sounders
  - Quality indicators define highest quality data
  - AMSU retrieval as first guess and for cloud-clearing
    - Aqua/AMSU radiances not assimilated
    - Large-scale model not used as retrieval first guess
- **Use AIRS profiles to better understand the three-dimensional distribution of AIRS radiances assimilated within GSI to engage the operational DA community in a re-assessment of assimilation methodologies to more effectively assimilate hyperspectral radiances**

  - Real-time data constraints
  - Cloud contamination
  - Channel reduction
  - Spatial data reduction techniques
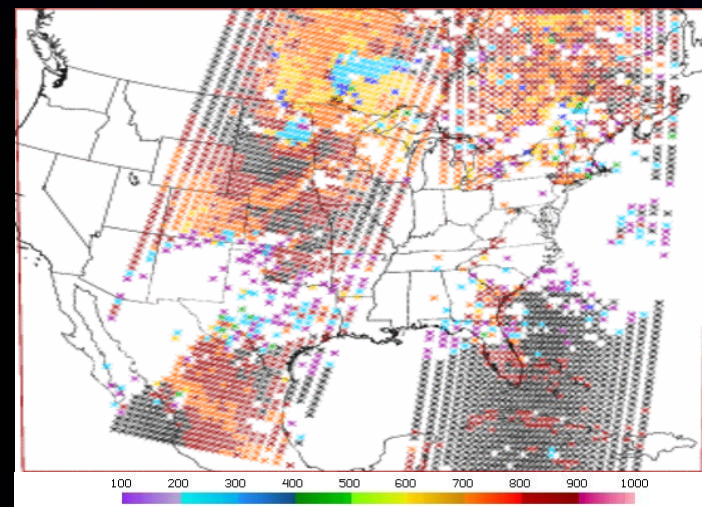
Real-Time Data Constraints

- **Nature of AIRS leads to data latency issues**
  - Huge volume of data to be downlinked
  - Non-continuous data downlink
- **NAM cycling mechanism does bring in all AIRS observations**
  - Are AIRS data used in a timely enough manner?
  - What might be the impact difference between assimilating AIRS data at t minus 3h instead of t minus 9h?
- **Possible to get real-time L1B AIRS observations from LANCE**
- **Need to revisit how AIRS L1B radiance data are obtained/preprocessed?**

Data valid at 2100Z 09 August 2011

ndas.t00z.airsev.tm03.bufr_d *ndas.t06z.airsev.tm09.bufr_d*

profile data from NASA LANCE *profile data from NASA LANCE*

Data available at 0000Z 10 Aug 2011 for 00Z cycle *Data available at 0540Z 10 Aug 2011 for 06Z cycle*

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Cloud Contamination

MODIS CTP

% Cloud-Free Radiances

MODIS VIZ

Profile P_{best}
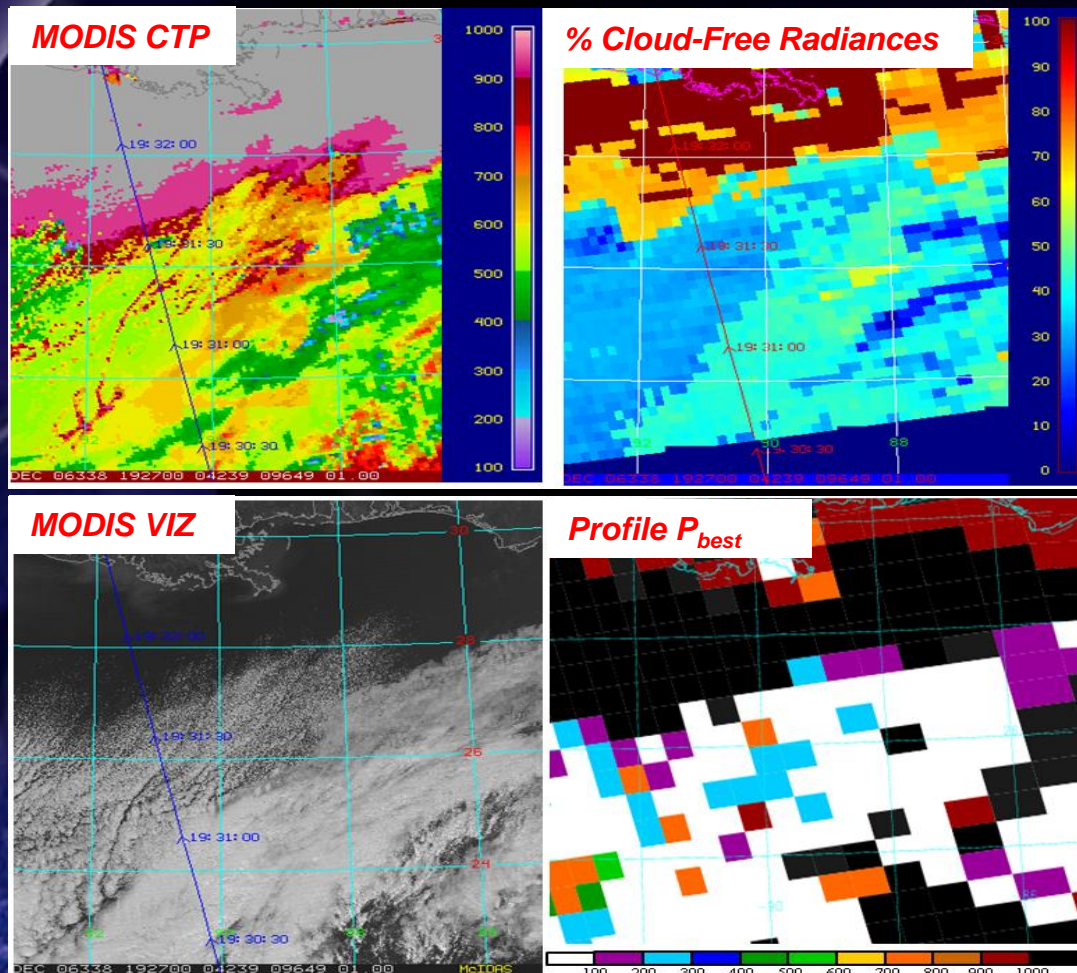
- **Multi-tiered cloud checking procedures are incorporated in GSI**

- **Cloud contaminated radiances can introduce unexpected biases**

- **Determine exactly which channels are being assimilated at each location**
  - Compare lowest vertical level of assimilated data with MODIS CTP
 - Compare to AIRS profile P_{best}

Channel Reduction Due to Clouds or Surface Emissivity

MODIS CTP

% Cloud-Free Radiances

MODIS VIZ

Profile P_{best}
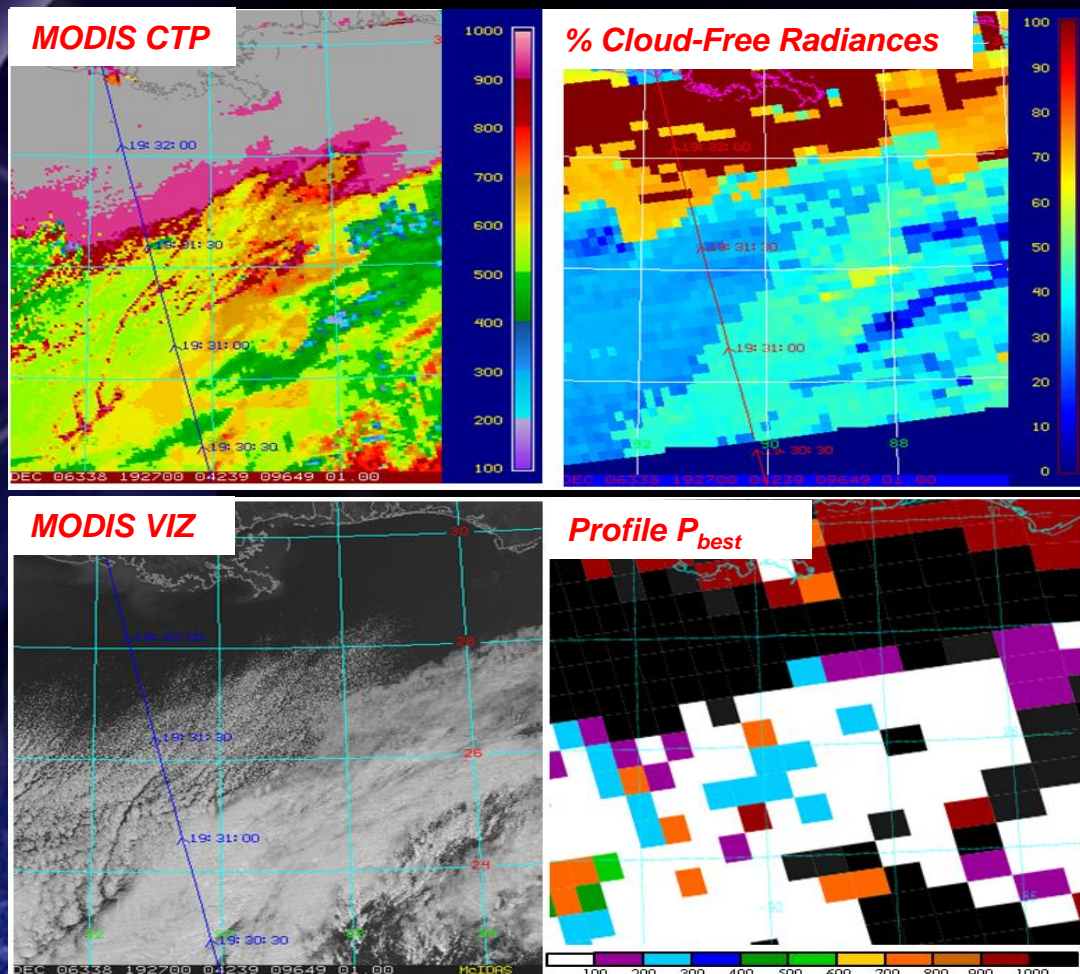
- **Meteorologically significant regions may not be sampled by AIRS radiances**
  - Low clouds on storm periphery
  - If cloud checks are too conservative, useable data may be lost

- **Determine exactly which channels are being assimilated at each location**

- **Surface emissivity checks in GSI may remove some near-surface channels**
  - Compare rejected low-level channels in clear sky conditions over land and water
  - Compare to P_{best}

Spatial Data Reduction Techniques

- **Currently, 1 in 64 AIRS radiances are used due to operational constraints**
  - Subsampling methodology does not take into account interesting weather features
- **Profile assimilation allows for larger number of observations to be used**
- **Removal of cloudy radiances increases data reduction to 100s of kilometers spacing**
  - Use 1 in 9 radiances to match resolution of using all profiles
  - Systematically add radiance observations around clouds

Operational

Proposed
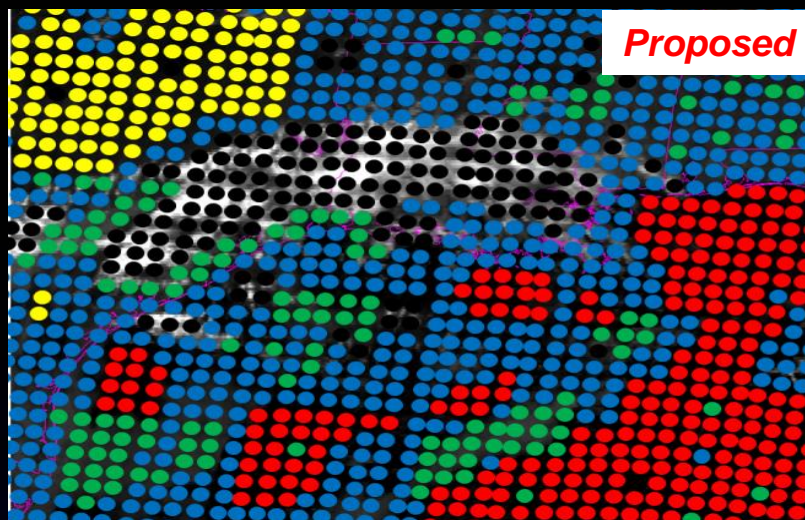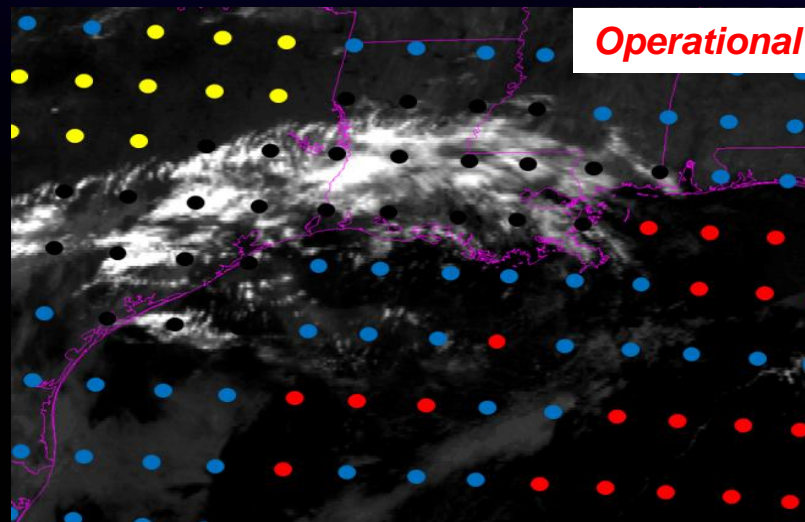
- ● Clear
- ● Cloudy
- ● Lower levels impacted by emissivity
- ● Clear channels above cloud
- ● Additional channels available above cloud

Summary

- **NASA's SPoRT Center collaborates with operational partners of different sizes and operational goals to improve forecasts using targeted projects and data sets**

- **Modeling and DA activities focus on demonstrating utility of NASA data sets and capabilities within operational systems**

- **SPoRT has successfully assimilated AIRS radiance and profile data**

- **Collaborative project is underway with the JCSDA to use AIRS profiles to better understand the impact of AIRS radiances assimilated within GSI in hopes of engaging the operational DA community in a re-assessment of assimilation methodologies to more effectively assimilate hyperspectral radiances**

  - Use MODIS CTP and AIRS P_{best} to investigate how well cloud-free radiances are determined in GSI

  - Use AIRS P_{best} over land and water to investigate impact of surface emissivity

  - Use higher resolution AIRS radiance data and AIRS profiles data around cloud edges to investigate impact of data subsampling

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SPoRT Future DA Work/Collaboration with JCSDA/EMC

- **SPoRT would like to assist with current DA/forecast problems recognized by operational centers related to remotely-sensed observations**
  - With expertise in both areas, SPoRT can assist in regional scale applications of both radiance and profile projects
  - Regional scale applications (in the right context) can be applied to global problems

- **Use results from this work to perform an "apples-to-apples" forecast impact study of AIRS radiance assimilation and profile assimilation**
  - Use AIRS profiles to supplement AIRS radiance assimilation in partly cloudy scenes
  - Use averaging kernels to assimilate satellite profiles as vertically-correlated observations

- **Use data mining techniques developed at UAHuntsville to pursue new methods of detecting cloudy radiances or to improve data reduction**

- **Apply lessons learned to IASI, CrIS, and future hyperspectral sounders**

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Thank you for the invitation to speak

Questions? Comments?

For more information about SPoRT, visit our website at http://weather.msfc.nasa.gov/sport

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The SPoRT-WRF (Back-Up Slide)

- **Desktop supercomputing systems acquired from NASA HQ enable SPoRT to perform more rigorous modeling projects**

- **SPoRT-WRF merges SPoRT DA and modeling projects into one real-time system for testbed evaluation by operational forecasters**
  - Identical configuration to National Severe Storms Laboratory WRF used by SPC
  - NASA data sets address forecast challenges of convection in NWP models
    - daily 1-km SPoRT SST composite product
    - daily 1-km LIS surface characterization
    - daily 1-km MODIS GVF composite product
    - AIRS retrieved thermodynamic profiles

- **Evaluated at this year's Hazardous Weather Testbed Spring Experiment**
  - Tendency to under-forecast convection
  - Cooled and dried lower levels

- **Version 2 development under way**
  - Improved GVF product
  - Cycling assimilation methodology using GSI to bring in more satellite and conventional observations and remove start/stop of model forecast