Evaluation of the Impact of AIRS Radiance and Profile Data Assimilation in Partly Cloudy Regions

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Outline

Proposal funded through NASA ROSES10 A.24 entitled "Improved Impact of Atmospheric Infrared Sounder Radiance Assimilation in Numerical Weather Prediction"

- **NASA Short-term Prediction Research and Transition (SPoRT) Center Overview**
- **Project Background/Concept**
- **Experimental Setup**
- **Impact Difference Fields**
- **Comparison of Assimilated Data to MODIS**
- **Summary/Future Work**

SPoRT Background

Mission: Apply satellite 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, nowcasting, and NWP**
  - 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 (WFOs and regional HQs), NCEP, NESDIS (STAR, NDE), JCSDA, JPL, GOES-R PG, JPSS PG**
- **End Users: WFOs, other government organizations, private sector partners**

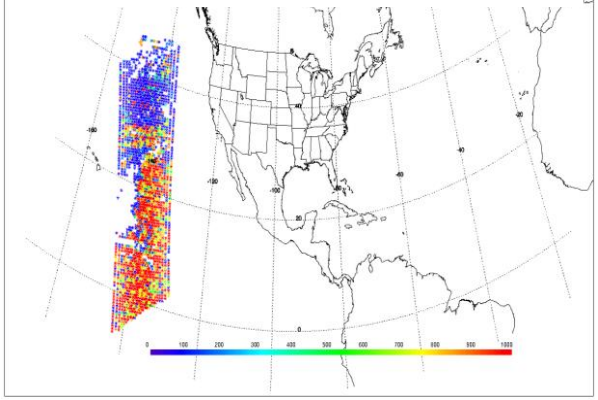
Keys to success

- ***Link data / products to forecast problems***
- ***Integrate capabilities into systems used in operations***
- ***Provide training / forecaster interaction & feedback***

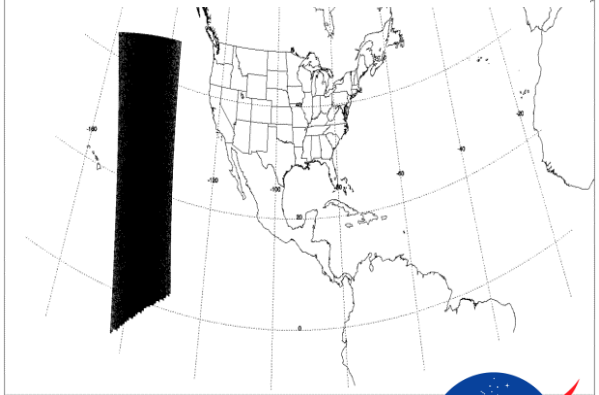
Project Concept

- **AIRS radiances currently assimilated operationally in GFS and NAM**
  - Cloud-free radiances from 281-channel subset
  - Cloud checks performed within GSI to determine which channels peak above cloud top
  - Inaccuracies may lead to less radiances assimilated or introduction of biases in cloud-contaminated radiances
- **Use AIRS L2 retrieved profiles to better understand the optimal three-dimensional distribution of AIRS radiances assimilated within GSI to engage the operational DA community regarding strategies for assimilating hyperspectral radiances**
  - Cloud contamination, channel reduction, spatial data reduction
- **Lowest extent of quality AIRS L2 profiles determined by quality indicators in preprocessing**
- **Use MODIS as an additional resource to determine cloud location and vertical extent**

Lowest extent of useable L2 profiles determined in preprocessing



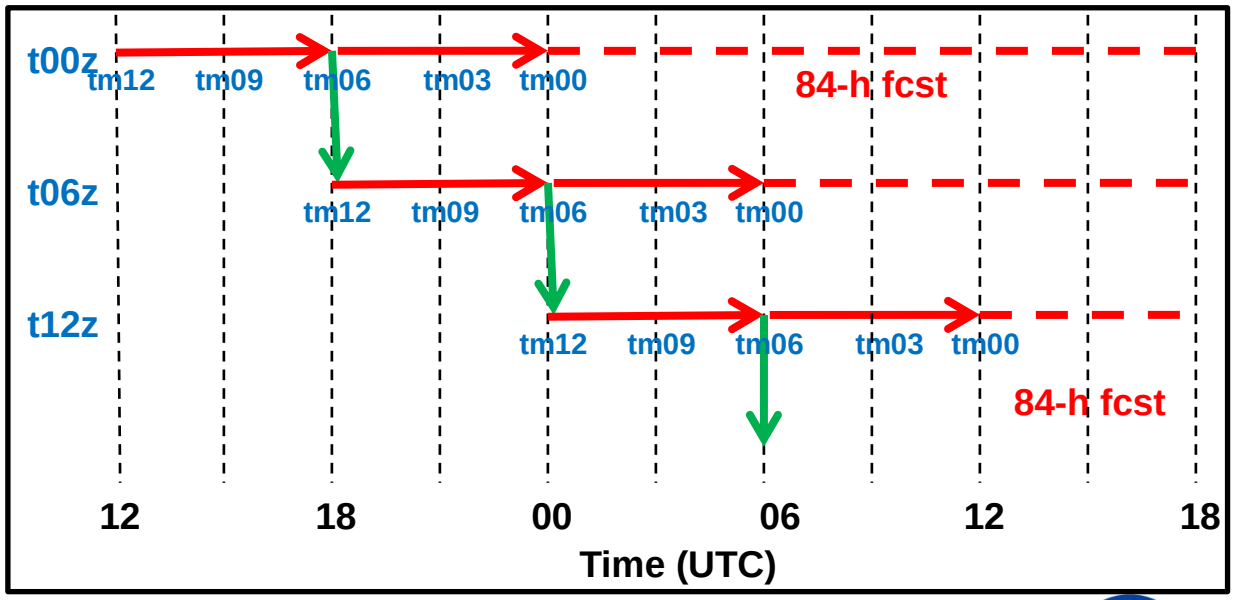
Lowest extent of useable L1B radiances determined within GSI



Experimental Setup

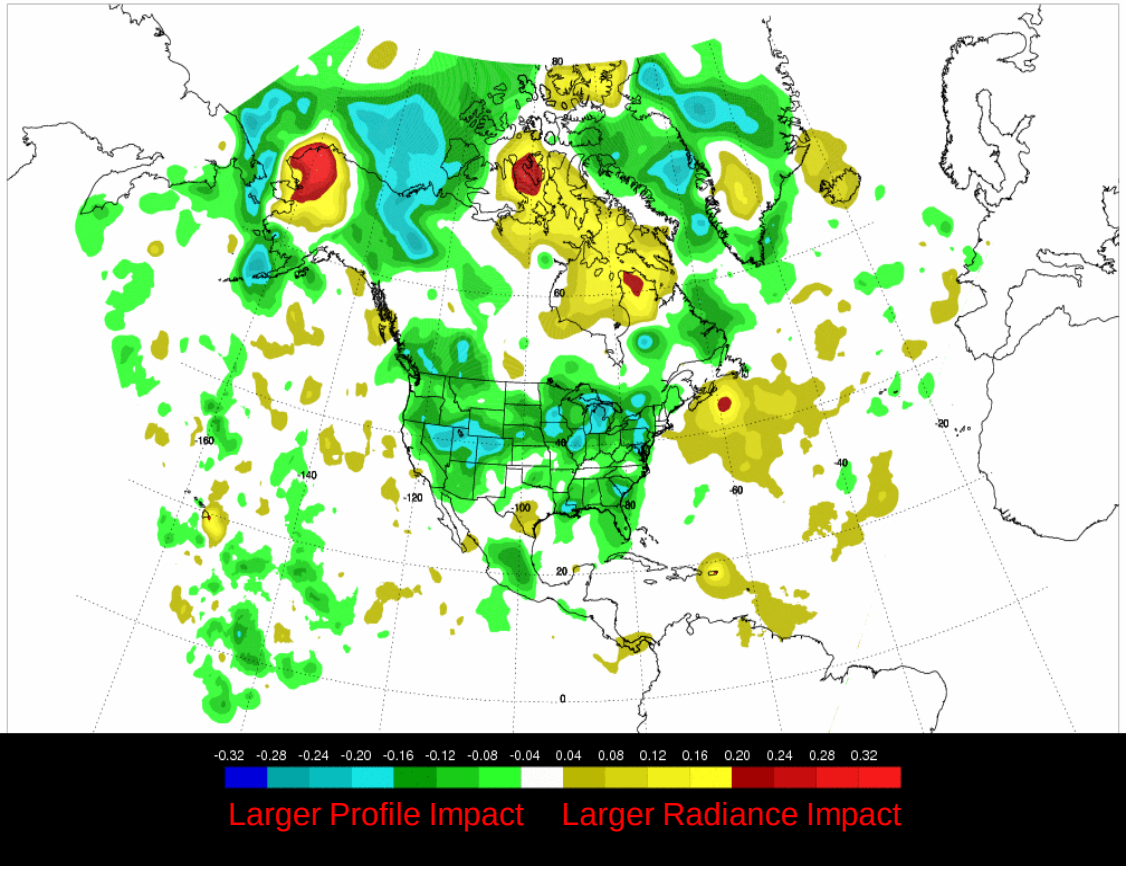
- **Developmental Testbed Center (DTC) GSIv3.0 and WRF-NMMv3.3 code configured in forecast cycling methodology that mimics the operational NAM**
- **Real-time BUFR files archived during assimilation period (4 Nov.–20 Dec. 2011)**
  - Satellite: AIRS, AMSU, HIRS, MHS, GOES Sounder, GPSRO, radar winds
  - Conventional: All observations used in EMC's Table 4
- **Two "parallel" 4-week experiments with 2-week spin-up:**
  - RAD
    - assimilate AIRS radiance data using operational procedures
  - PROF:
    - append PREPBUFR to include AIRS profiles as sondes ensuring consistency with real-time RAD swath locations
    - quality flag P_{best} to select data in the vertical to be assimilated
    - no observation thinning

Schematic for GSI scripts (DiMego, personal communication, 2011)



Overall Mean Impact Difference

Mean temperature (K) impact difference (ID) at σ=39 (≈500 hPa) for all 00Z analyses for 29 case studies days from 21 Nov-20 Dec 2011



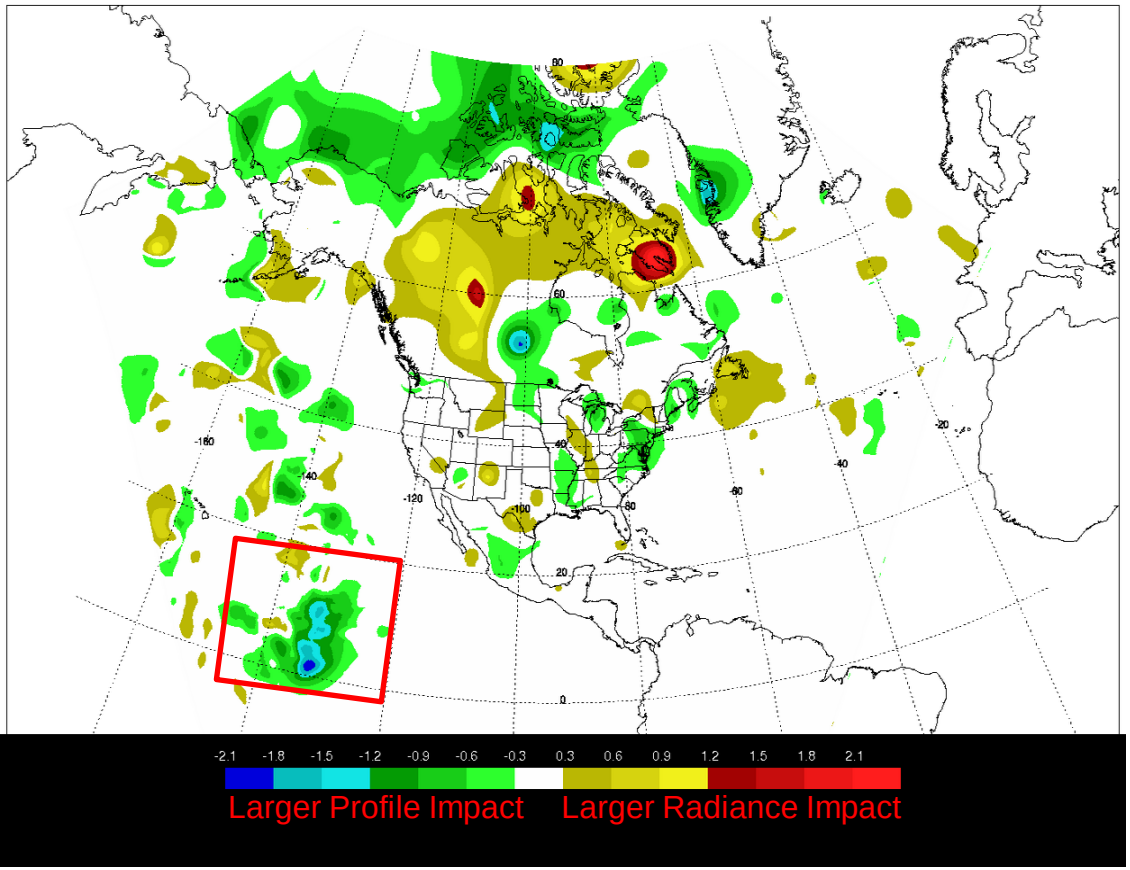
- Determine magnitude of differences between analysis impact from profile and radiance assimilation at each gridpoint by calculating impact difference (ID):

$$ID_{i,j} = |RADALYS_{i,j} - RADBKGDi_{,j}| - |PROFALYSi_{,j} - PROFBKGDi_{,j}|$$

- No determination of superior analysis or resulting forecast
- Areas of larger radiance impact in regions of climatological winter storm tracks and cloud contamination from previous studies
- Larger impact from profile assimilation over CONUS

Impact Difference for Select Case

Temperature (K) ID at σ=39 (≈500 hPa) for 00Z analysis on 19 December 2011

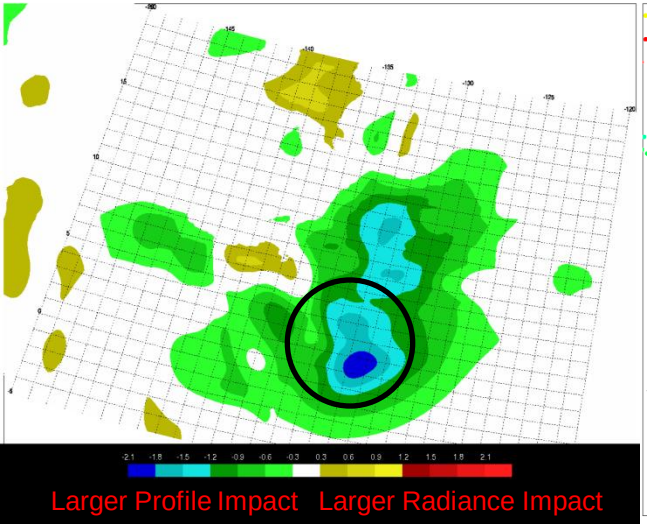


- ID was calculated for each 00Z analysis and interesting cases for further investigation were selected
- What follows is an example of the analysis being performed for a single case (19 Dec 2011)
- Larger radiance impact over Canada perhaps associated with cloud contamination
- Following slides examine comparisons between GSI diagnostics and MODIS cloud products for area over SE Pacific near the equator

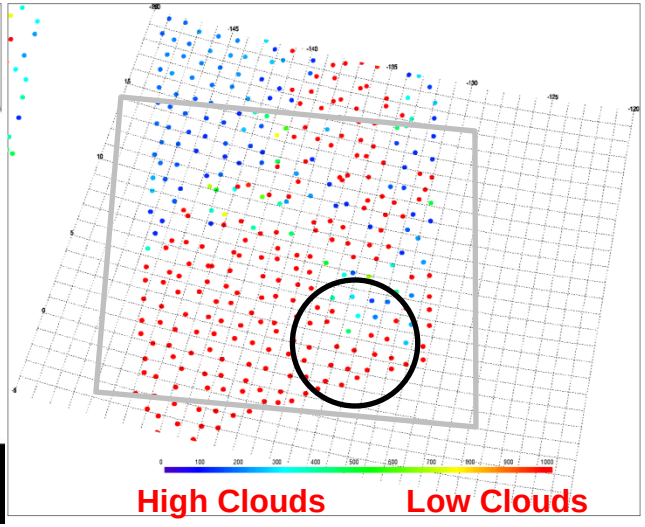
Comparison to MODIS CTP

- Overall, GSI does a good job of determining cloud top pressure (CTP)
- For region of largest profile impact differences (, GSI detects CTP of <400 hPa
- However, Aqua MODIS CTP valid at concurrent time as AIRS observation indicates CTP is ≥950 hPa
- ≈2K larger analysis impact in profile analysis near 0ºN, 130ºW

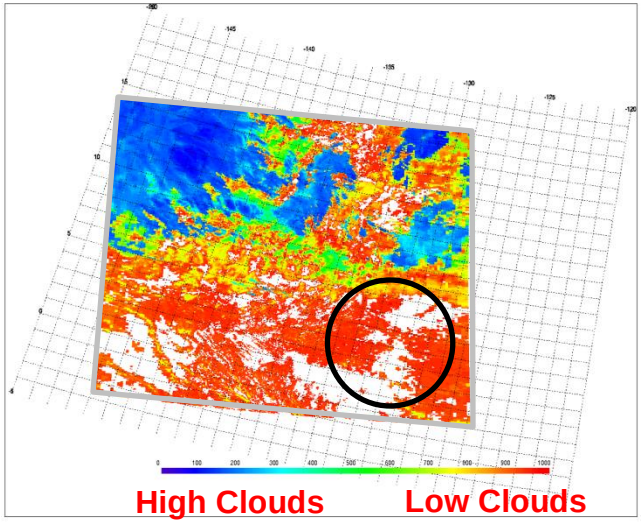
T (K) ID at σ=39 (≈500 hPa) for 0000 UTC analysis 19 December 2011



GSI CTP for 0000 UTC analysis on 19 December 2011



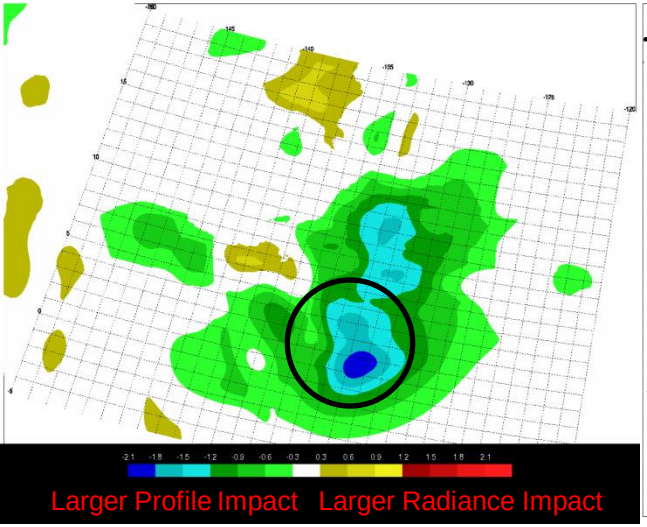
MODIS CTP valid 2240 UTC on 18 December 2011



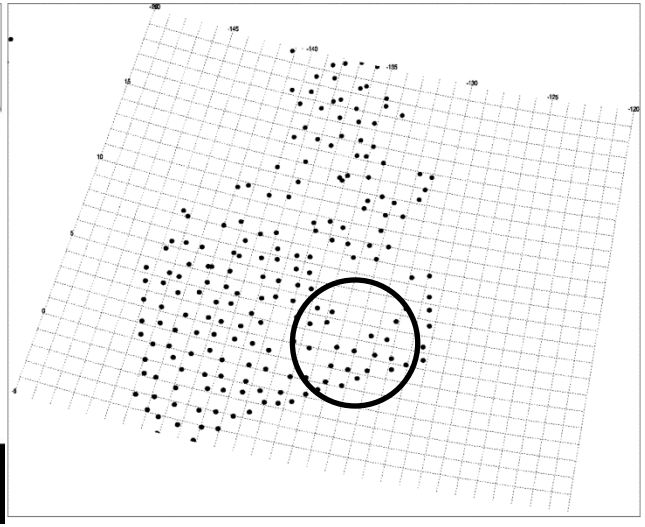
Location of Assimilated Data

- **Limited radiance assimilation around 500 hPa in area of largest profile impact**
- **A number of observations retained in the thinning process are not used in the analysis due to CTP in GSI being at a higher elevation**
- **Locations of retrieved L2 profiles are larger in number (no data thinning) but also provide more data in regions where CTP is lower than 500 hPa**

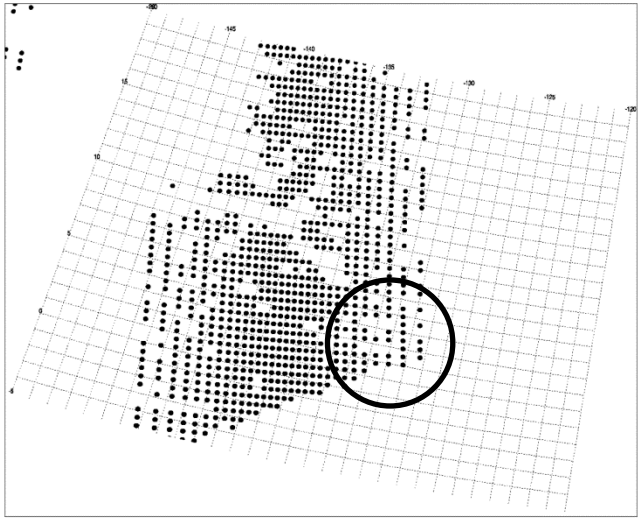
T (K) ID at σ=39 (≈500 hPa) for 0000 UTC analysis 19 December 2011



Assimilated AIRS Radiance Locations at 722cm^{-1} (≈501 hPa)



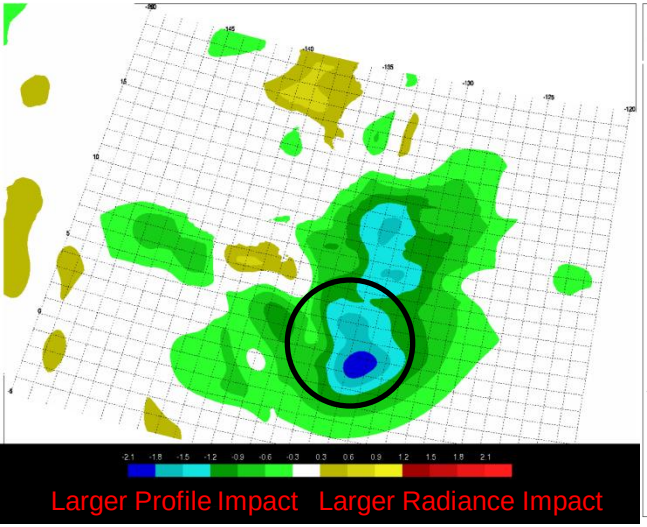
Assimilated L2 Profile Locations at 500 hPa



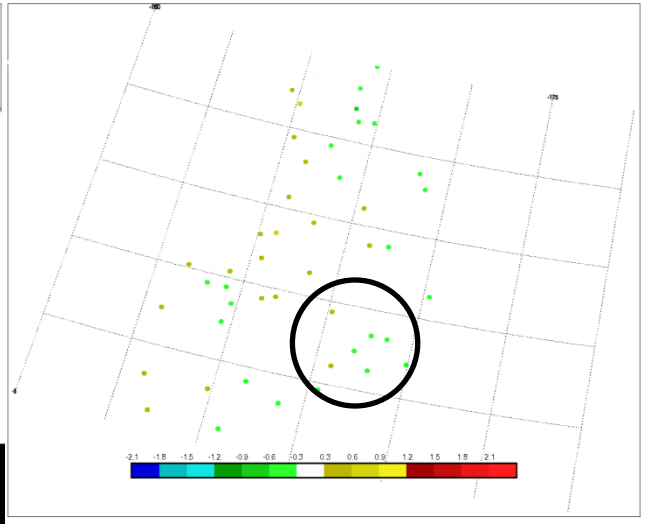
Temperature Innovations

- **Unrealistic innovations not the cause of large analysis impact from the profiles in this region**
- **Combination of radiances removed due to cloud check and spatial thinning are the likely causes for analysis differences**
- **Further investigation into positive or negative analysis and forecast impact**

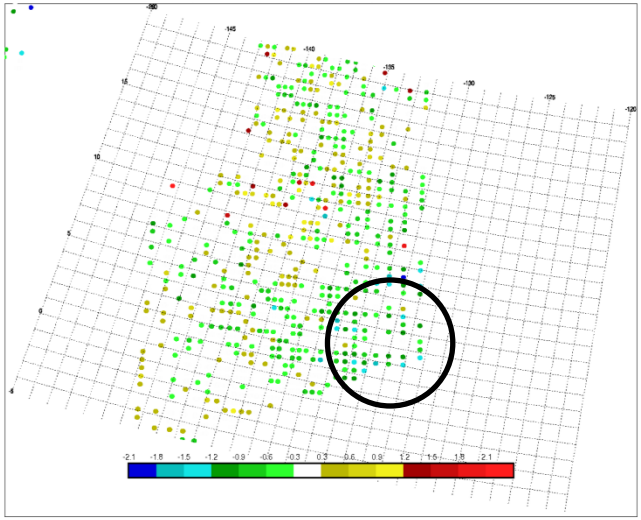
T (K) ID at σ=39 (≈500 hPa) for 0000 UTC analysis on 19 December 2011



AIRS Radiance T (K) Innovations (OB-BG) at 722cm^{-1} (≈501 hPa)



AIRS L2 Profile T (K) Innovations (OB-BG) at 500 hPa



Summary/Future Work

- **Summary**
  - Parallel experiments using AIRS L1B and L2 retrieved profiles were run for 29 case study days for early Winter 2011
  - Overall analysis increments show that profiles yield larger impact except in areas of climatological cloud cover and storm track during case study period
  - Initial results indicate that GSI does a good job on the whole of determining cloud-free radiances there are some areas coincident with areas of larger profile impact that are misrepresented (compared to MODIS) that may result in reduced analysis impact
- **Future Work**
  - Quantitatively evaluate analysis and forecast impact over entire case study period using forecast comparisons to cycled analyses and external analyses along with analysis impact using independent satellite observations
  - Investigate regions where AIRS radiances have larger impact for possible cloud contamination affects
  - Produce quantitative statistics comparing GSI CTPs with MODIS CTPs
  - "Turn knobs" within GSI to determine analysis/forecast impact from different cloud detection, quality, and spatial thinning options

Thank you for the opportunity to present!

Are there any questions?

Please contact me with further questions or ideas for collaboration

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