

Atmospheric Soundings from JPSS - Retrievals for NWP Data Assimilation

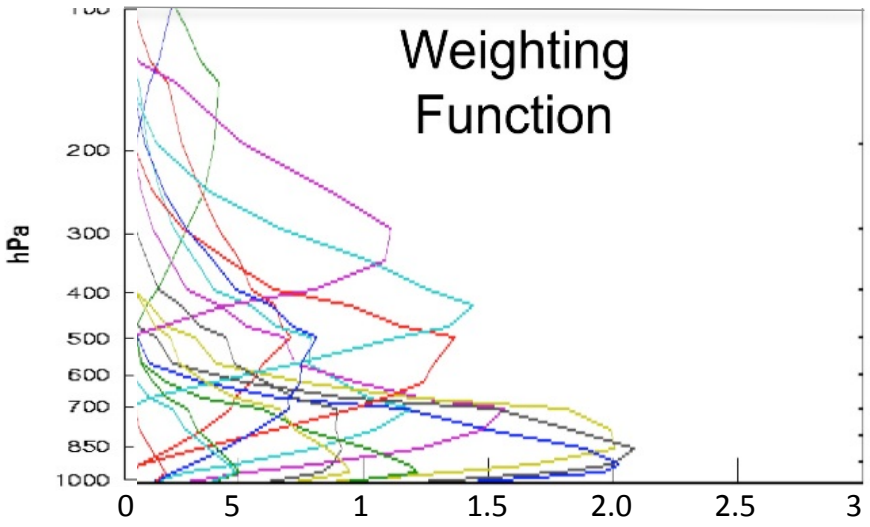
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University of Wisconsin Space Science and Engineering Center - Madison

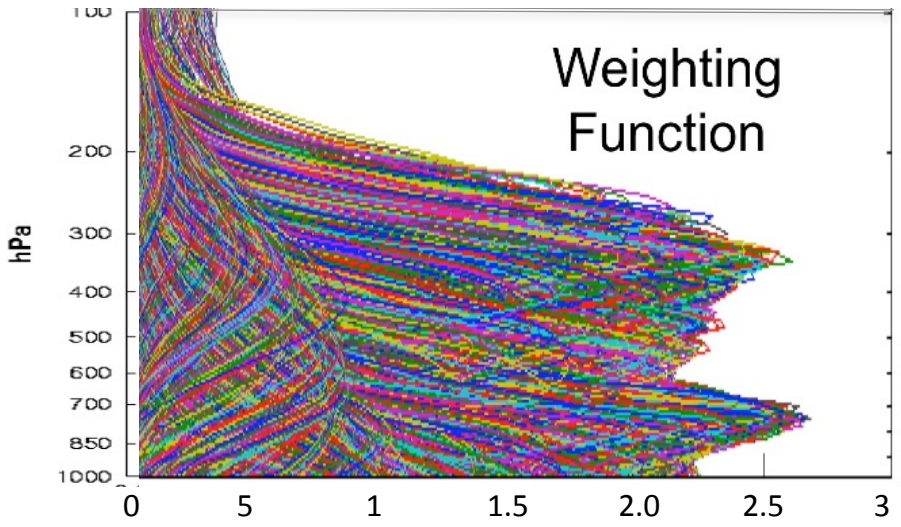
STAR JPSS 2015 Annual Science Team Meeting
24 – 28 August 2015
NCWP College Park, MD

Poor Sounding Vertical Resolution Causes Problem with Direct Assimilation of Satellite Profiles

Filter Sounders (e.g., HIRS)

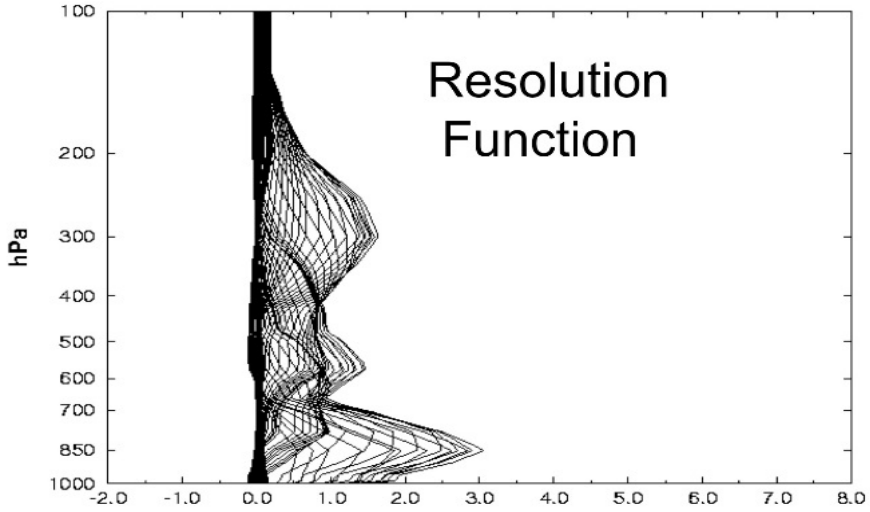


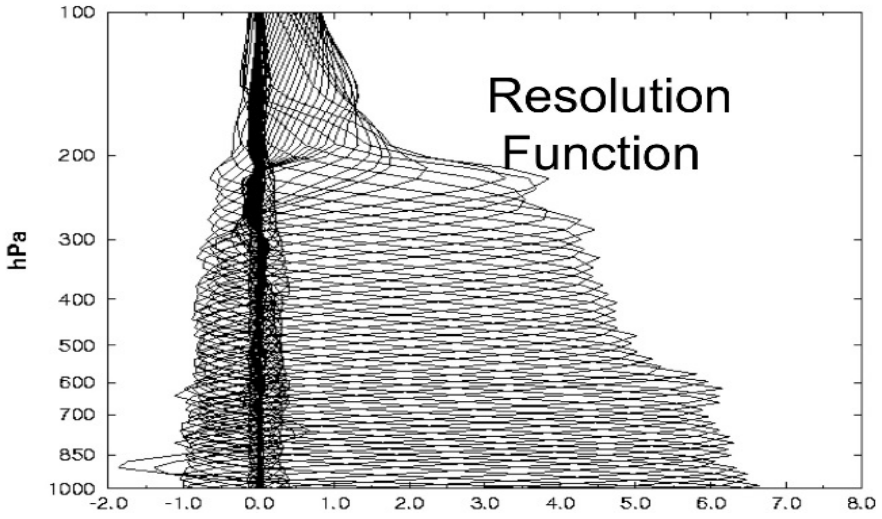
Interferometer Sounders (e.g.CrIS)



$\Delta\nu = 15.0\ cm^{-1}$

$\Delta\nu = 0.5\ cm^{-1}$

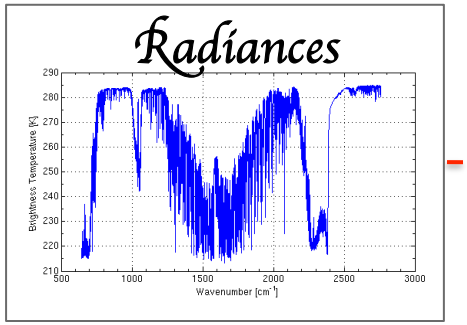




The Problem

- Satellite profile retrievals exhibit vertical structure biases toward the a-prior profile (i.e., either the initial guess profile or the mean of the statistics used for regression) due to the low vertical resolution (i.e., "null space") of the radiance observations
- This bias was large for retrievals from low spectral resolution filter radiometers (e.g., HIRS) causing vertical resolution aliasing when assimilated into NWP models causing negative impact.
- Direct assimilation of the radiances, rather than retrievals, was employed to avoid vertical resolution aliasing and to achieve positive impact.
- However, for hyperspectral sounding instruments, which contain thousands of spectral channels, radiance assimilation of all the spectral radiances is currently too time consuming for operational use. As a result, only a small subset of spectral channel radiances are assimilated limiting the vertical resolution, which is maximized by utilizing "ALL" the spectral channels in the retrieval process.
- Here, a simple and time efficient method for de-aliasing full spectral resolution hyperspectral sounding retrievals is presented

"Dual-Regression" Retrieval Algorithm* Overview



Global clear soundings

Radiances (clear FM)

Clear-trained regression coefficients

Global cloudy soundings

Radiances (cloudy FM)
Cloud height classes

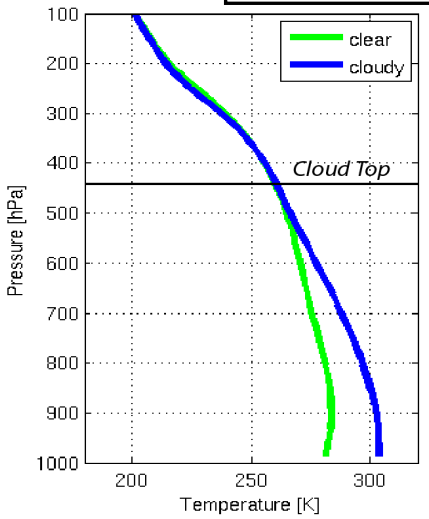
Cloud-trained regression coefficients

Theoretical Statistics

Radiance Observations

Clear-trained EOF regression retrieval

Cloud-trained EOF regression retrieval



Cloud Top Altitude
Level where $T_{cloudy} > T_{clear}$ for $p > p_{cld}$

Final Profile
from cloudy and/or clear retrievals

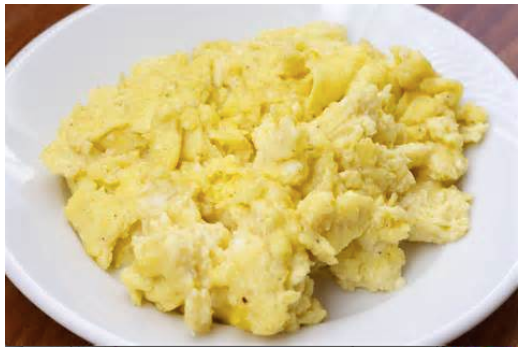
Temperature, Humidity and Ozone profiles, Surface and Cloud parameter at single FOV (0-2-km) resolution

* Smith, W. L., E. Weisz, S. Kirev, D. K. Zhou, Z. Li, and E. E. Borbas (2012), Dual-Regression Retrieval Algorithm for Real-Time Processing of Satellite Ultraspectral Radiances. *J. Appl. Meteor. Clim., 51*, Issue 8, 1455-1476.

How Can We Transform Radiances to Vertical Profiles?

Prof. Suomi provided the answer many years ago. He said the problem of satellite profile retrieval is similar to trying to separate the Yolk from the White in a scrambled egg.

The answer: Feed the scrambled egg back to the chicken





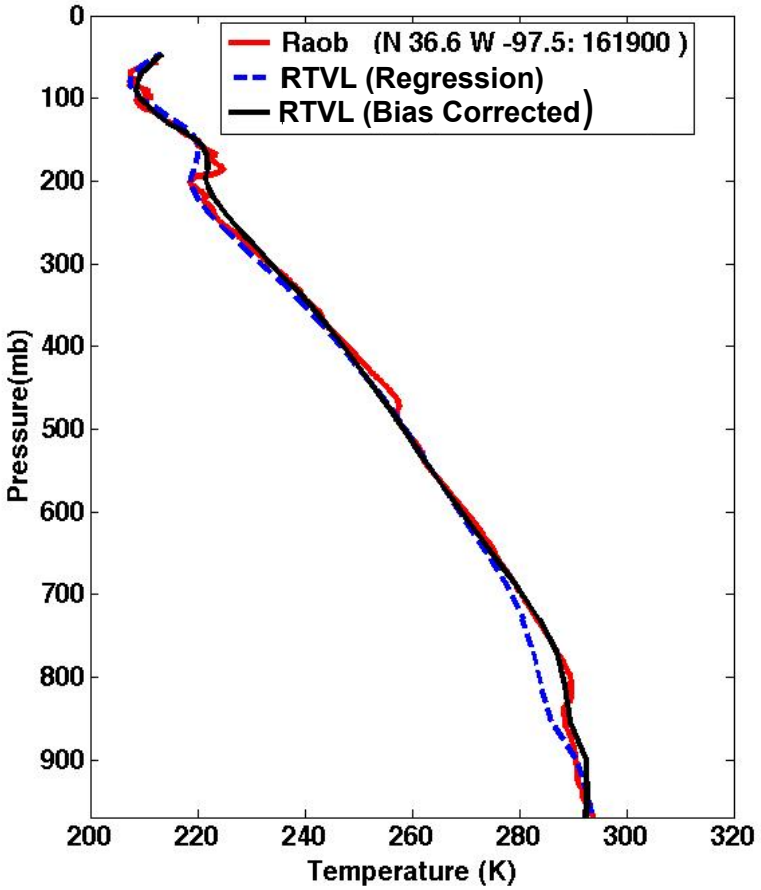
Spectral Radiances → Models → Vertical Profiles

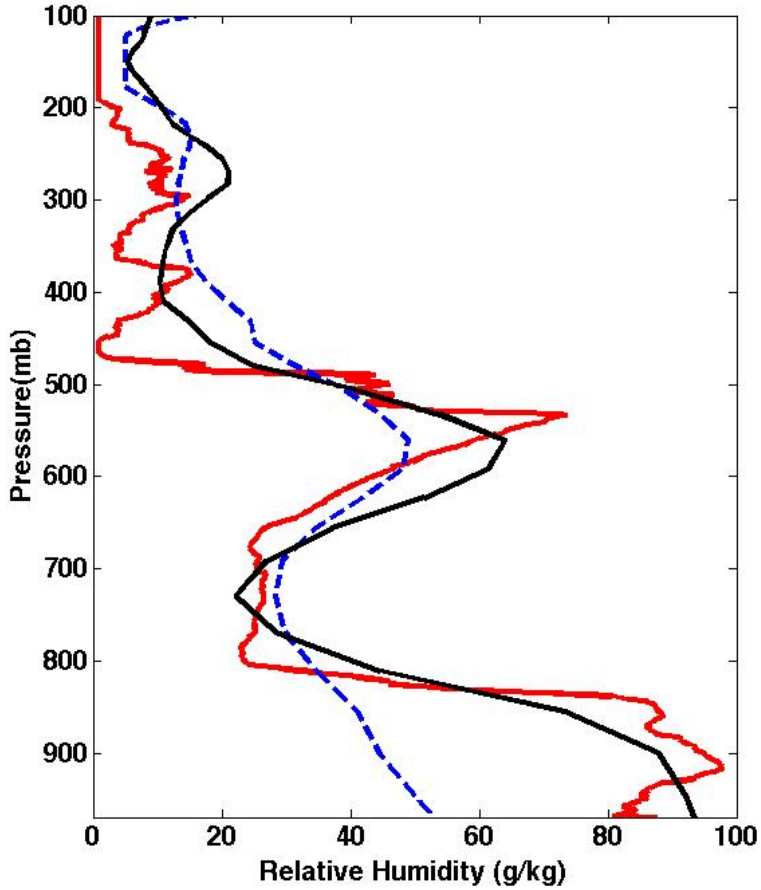
De-aliasing Using Forecast Model Profile

Problem: DR method uses a statistical training data set. Imperfect skill, due to lack of vertical resolution in radiances, leads to a vertical resolution alias.

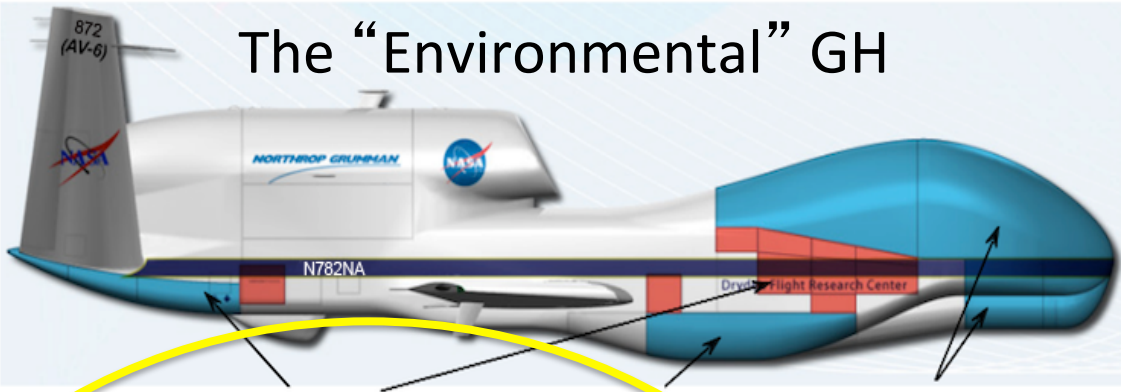
Solution: Calculate radiances from a Forecast Profile (FP) and perform DR retrieval using simulated radiances. Simulated Retrieval Error = Vertical Alias.

Vertical Alias= FP radiance Retrieval - FP





The "Environmental" GH



NASA Hurricane and Severe Storm Sentinel HS3

Airborne Vertical Atmospheric Profiling System (AVAPS)





89 Dropsondes / flight

Temperature, Pressure, wind, humidity vertical profiles

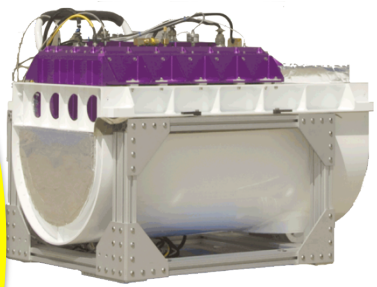
Scanning High Resolution Infrared Sounder (S-HIS)



Upwelling thermal radiation at high spectral resolution between 3.3 and 18 microns.

Temperature, water vapor vertical profiles

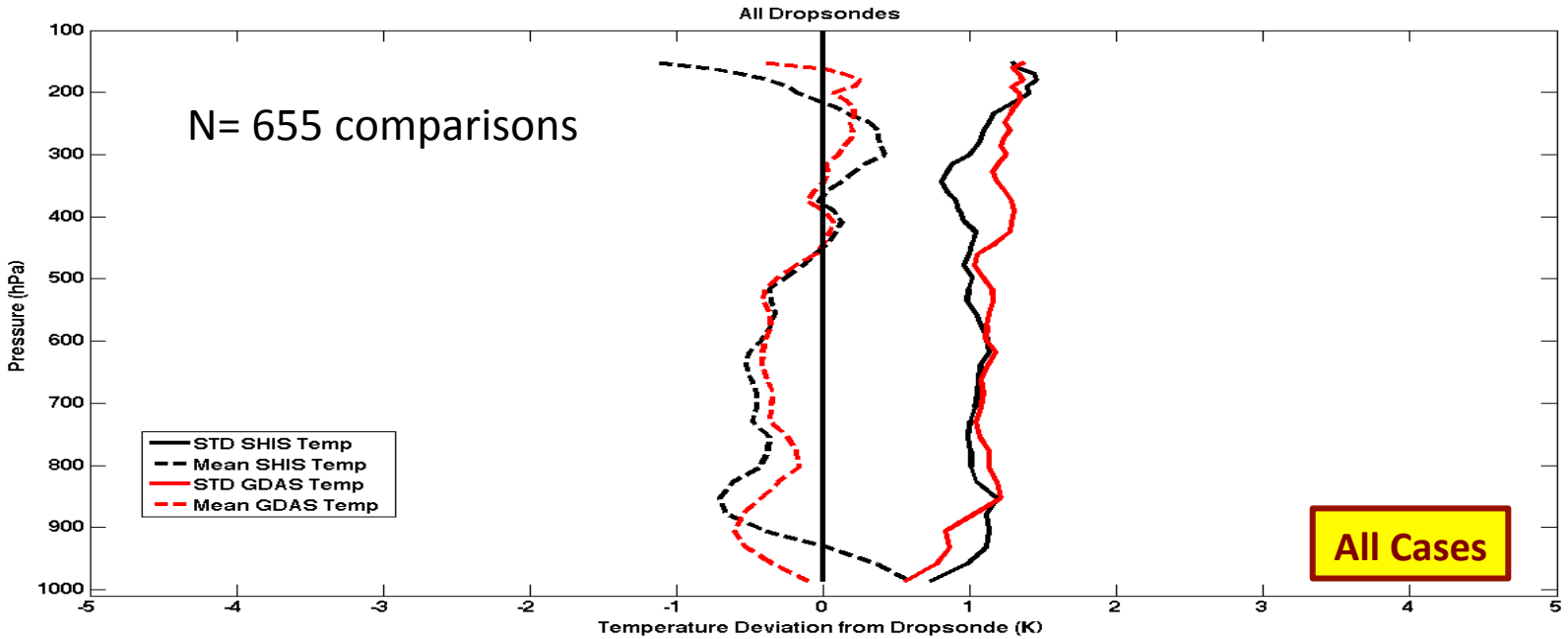
Cloud Physics Lidar (CPL)

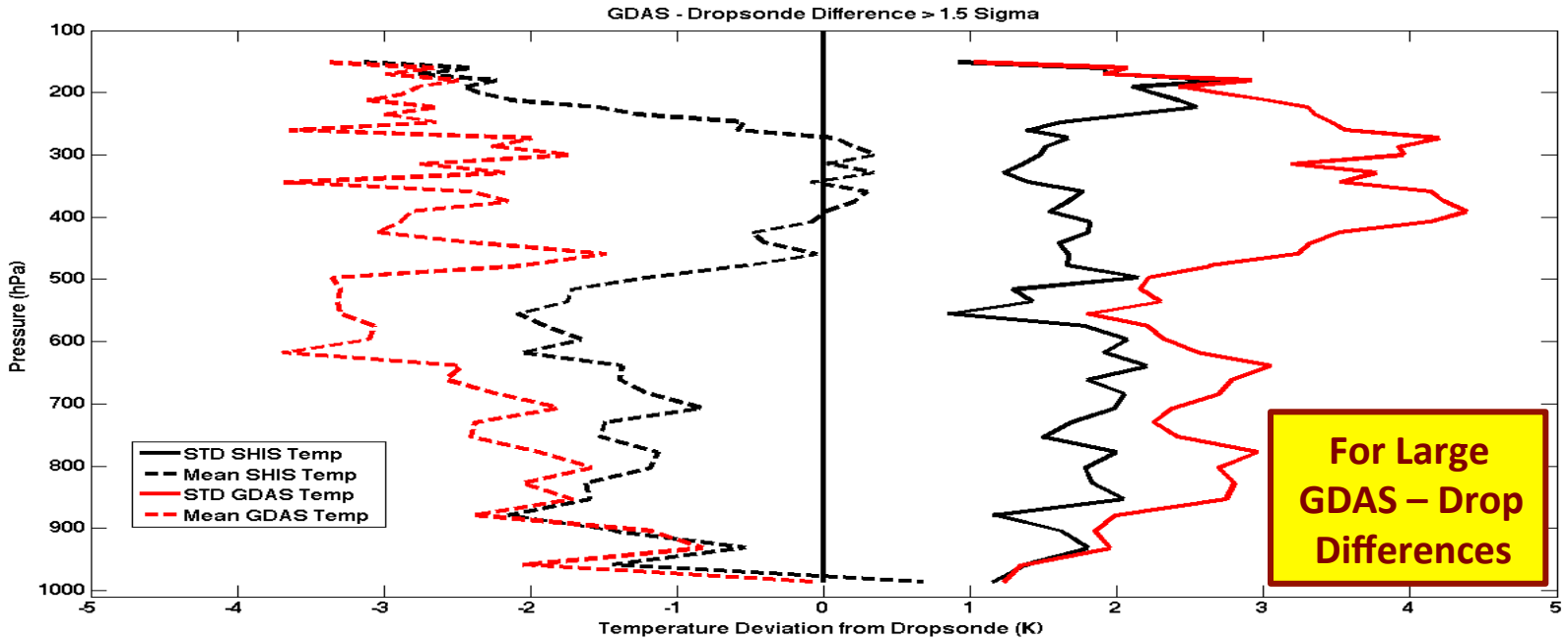


532/1064 nm Lidar Reflection

Cloud structure and depth

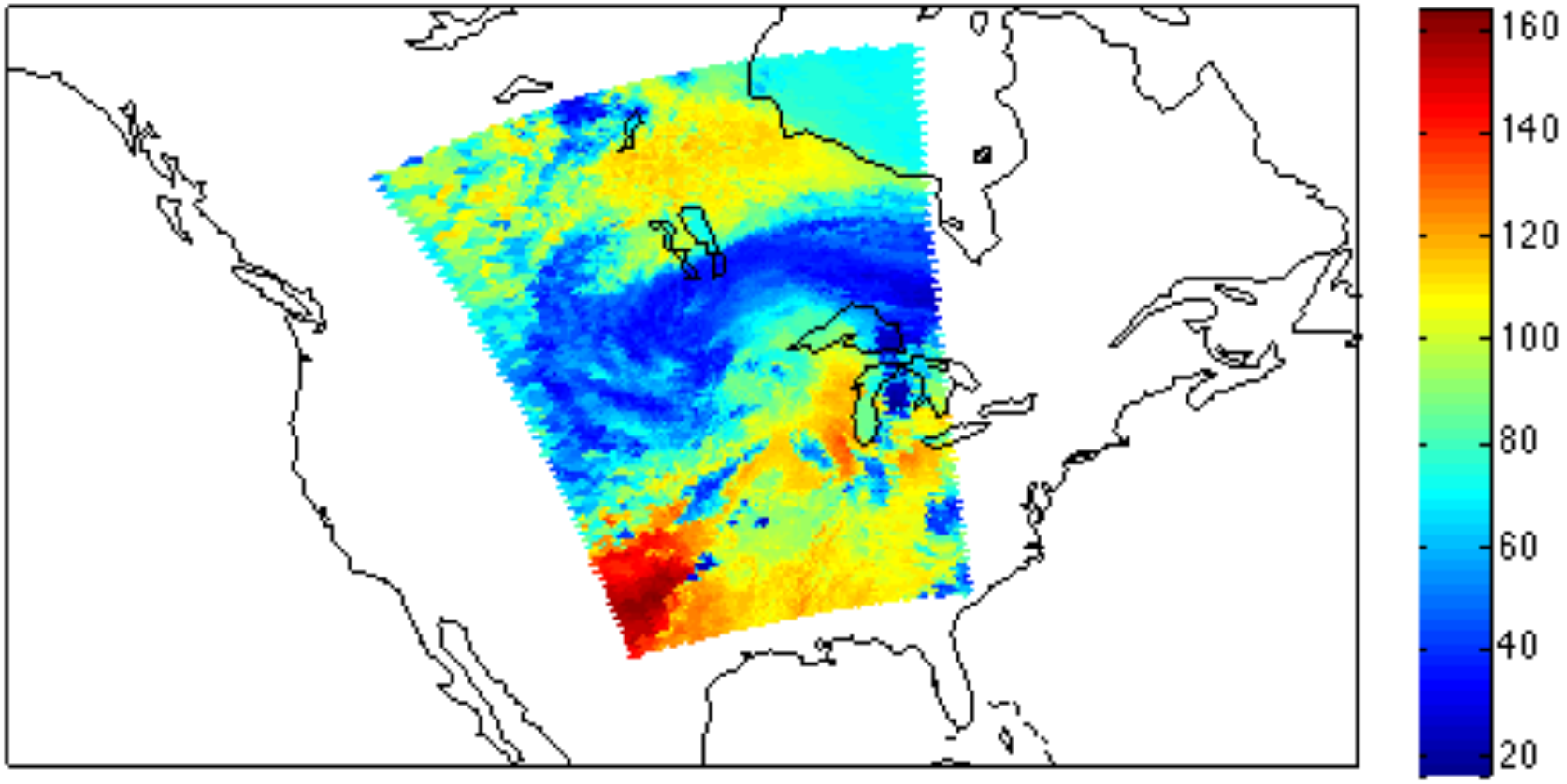
DA S-HIS Vs. Dropsonde Statistics (HS3-2014)



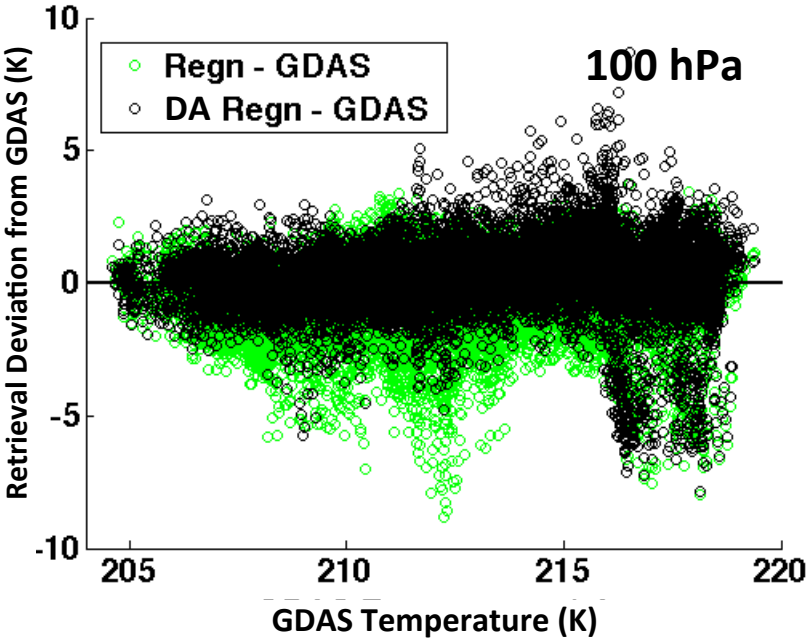


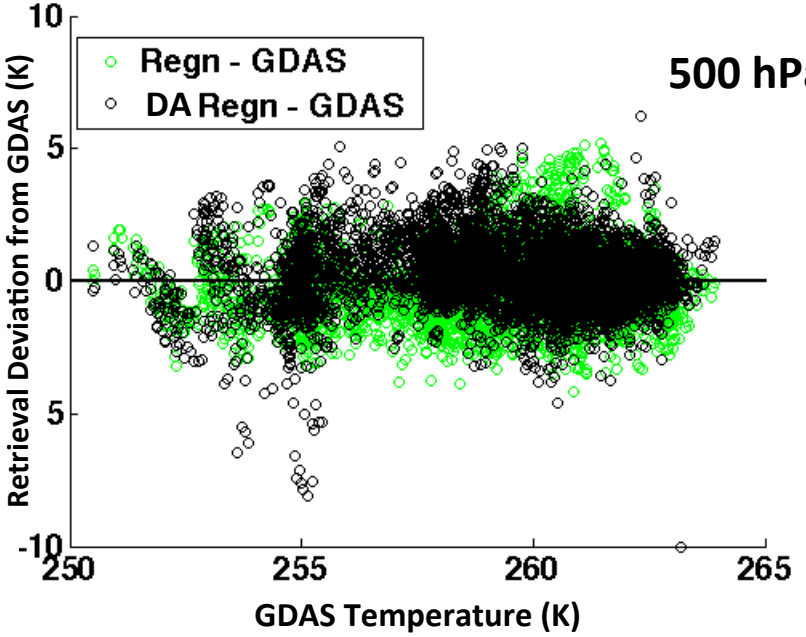
CrIS Coverage 19:08 UTC
S-NPP Cal/Val May 20 2013

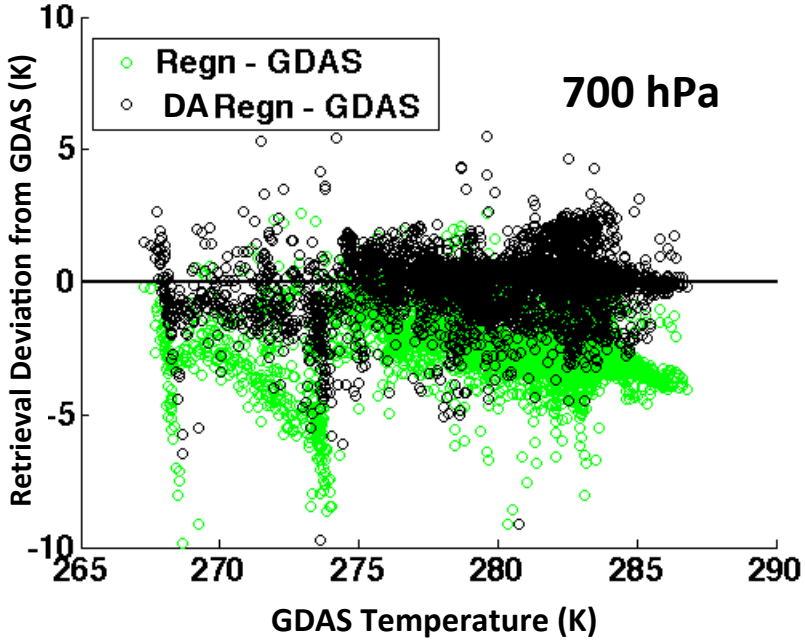
11 micron (i.e., 900 cm^{-1}) Radiance

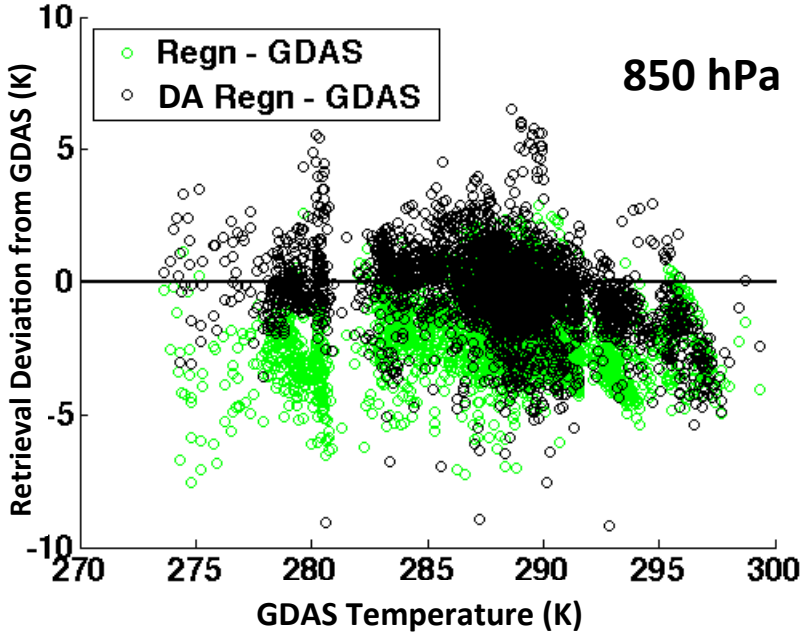


Deviation from GDAS (All, N = 12,880)

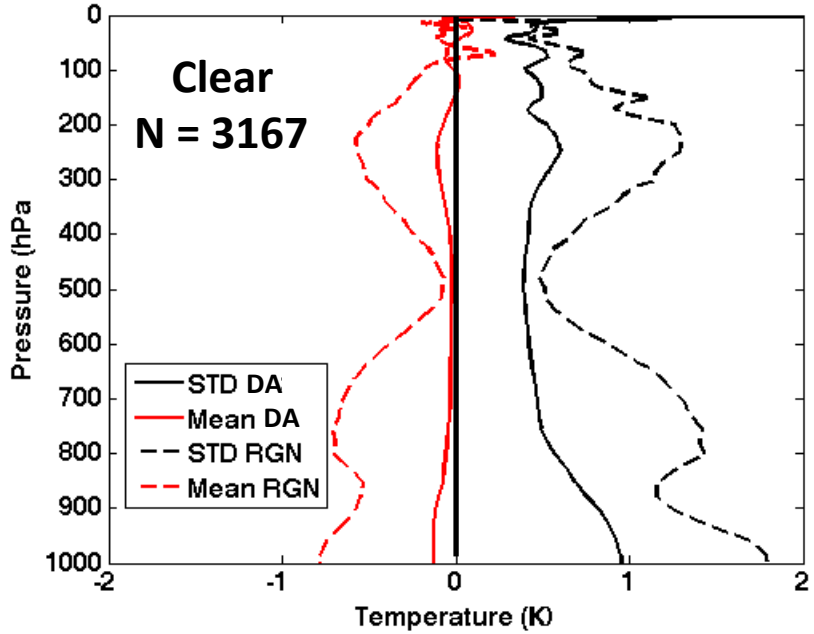


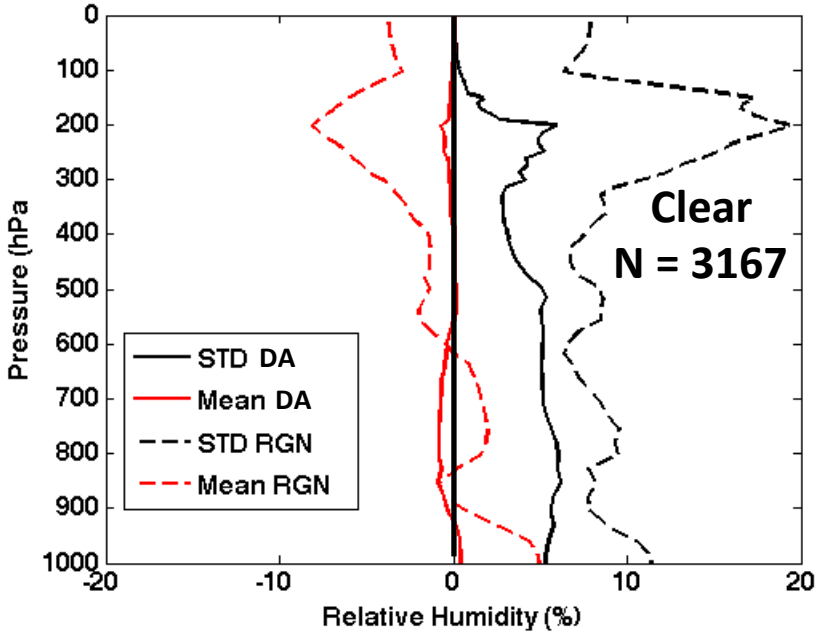


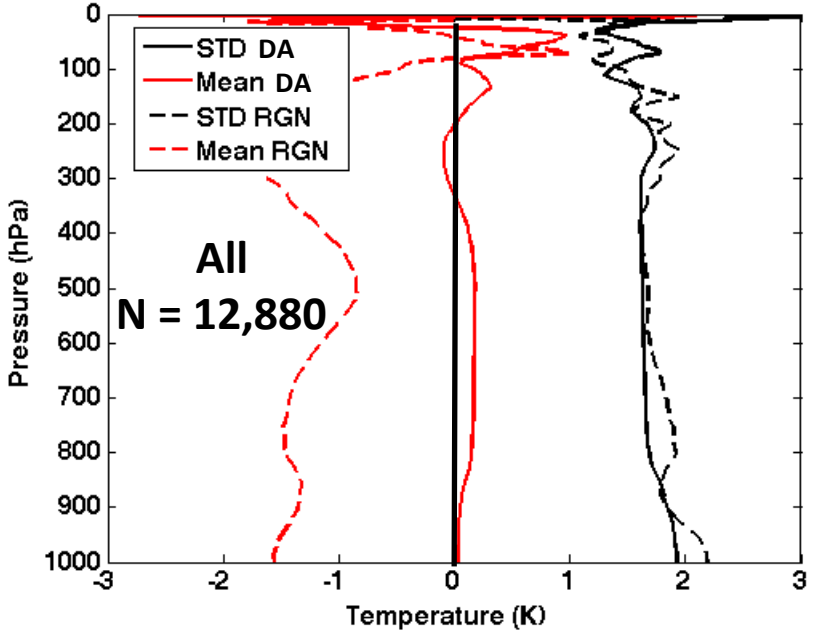


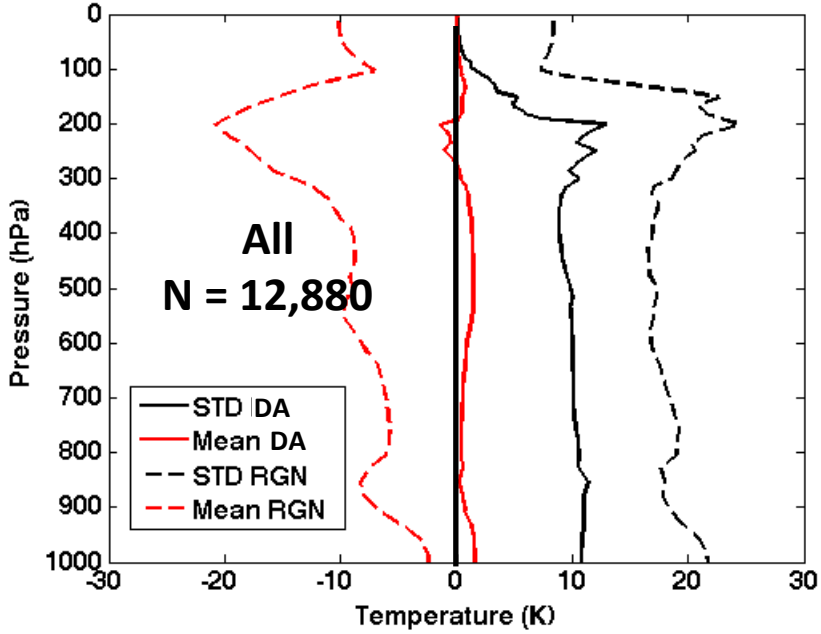


Mean and Standard Deviation from GDAS

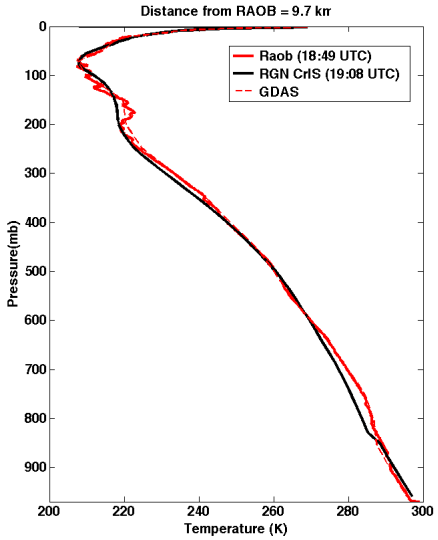


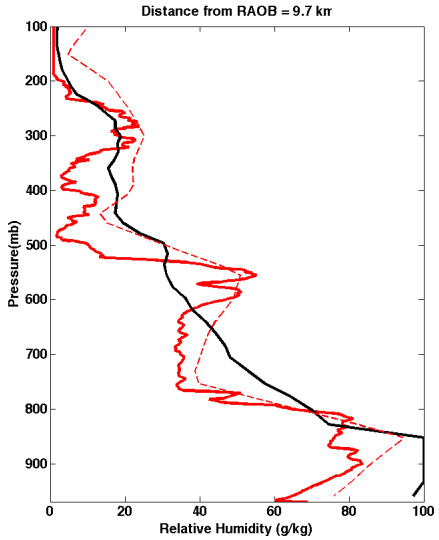


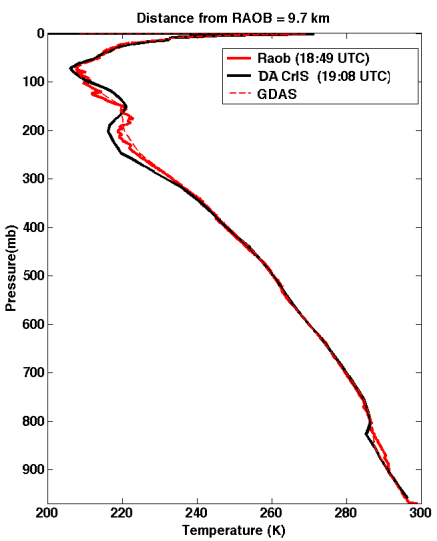


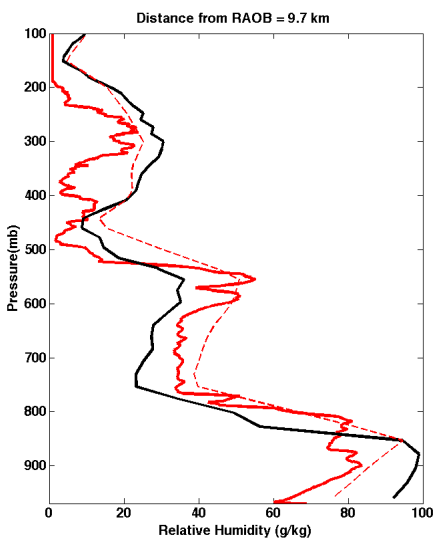


Regression and De-Aliased CrIS Retrievals Vs. ARM-site Radiosonde (May 20, 2013)

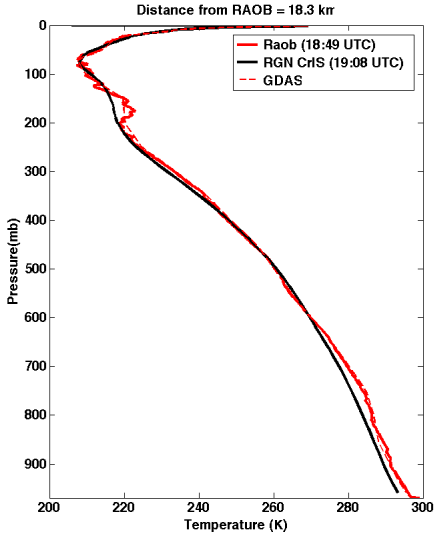


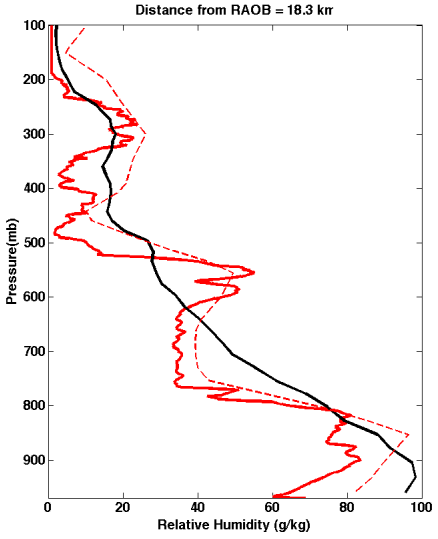




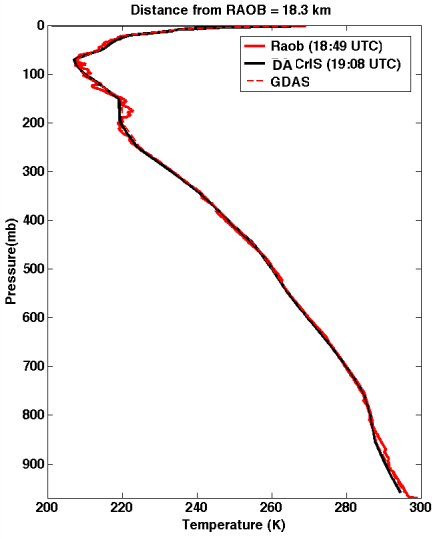


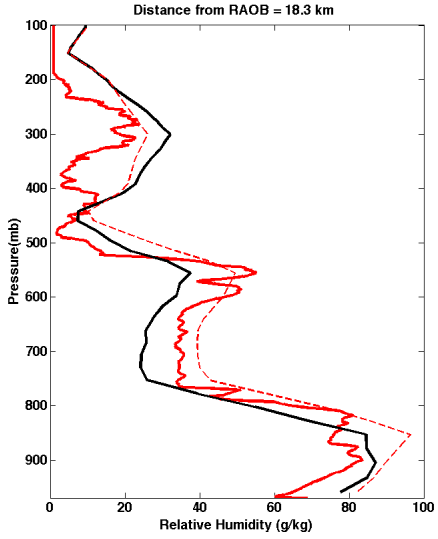
Regression Retrievals



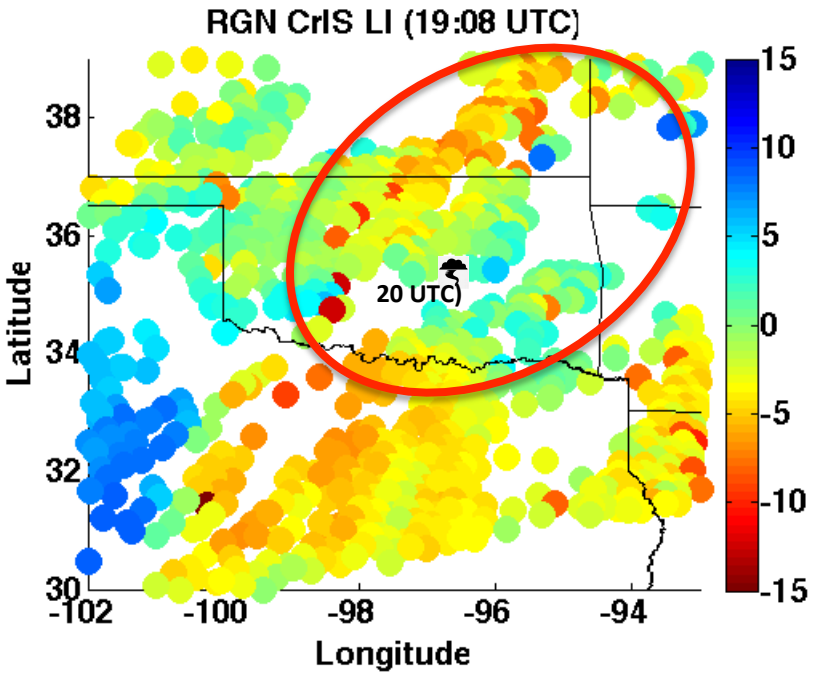


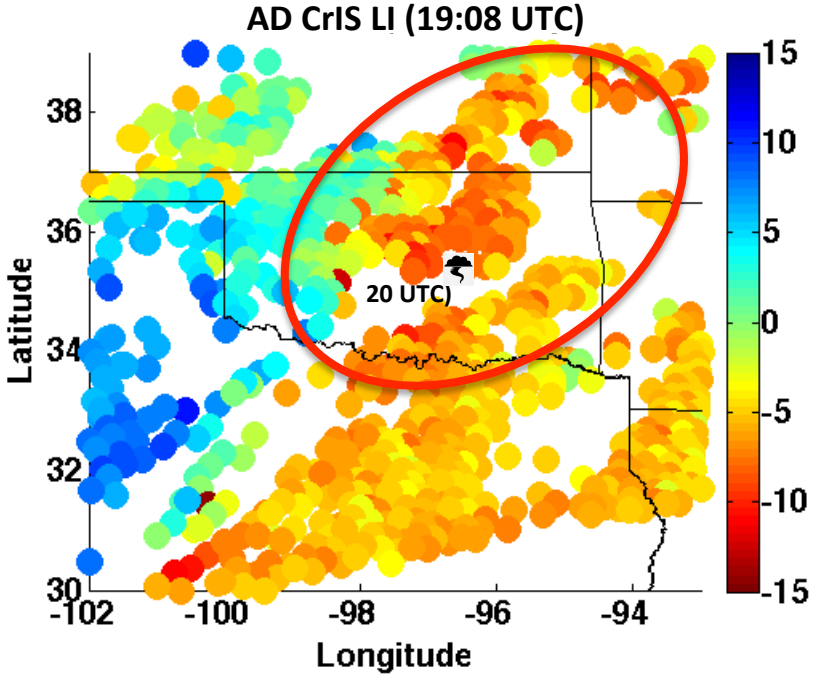
De-aliased Retrievals

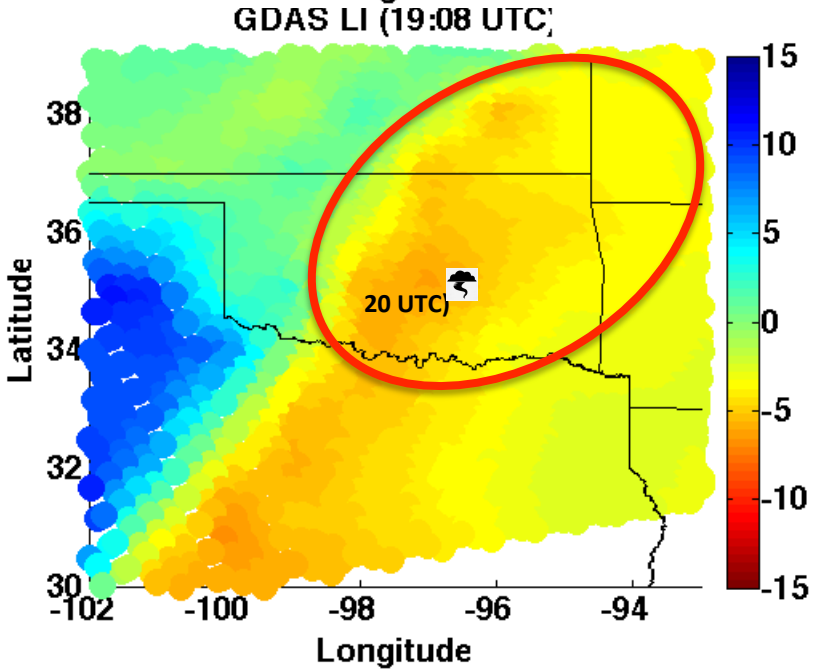


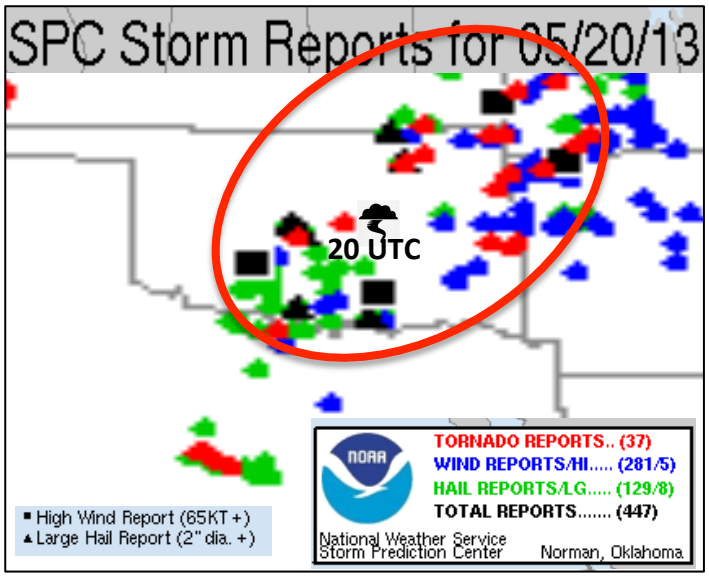


Regression Vs. De-aliased Vs. GDAS Lifted Index (May 20 2013)

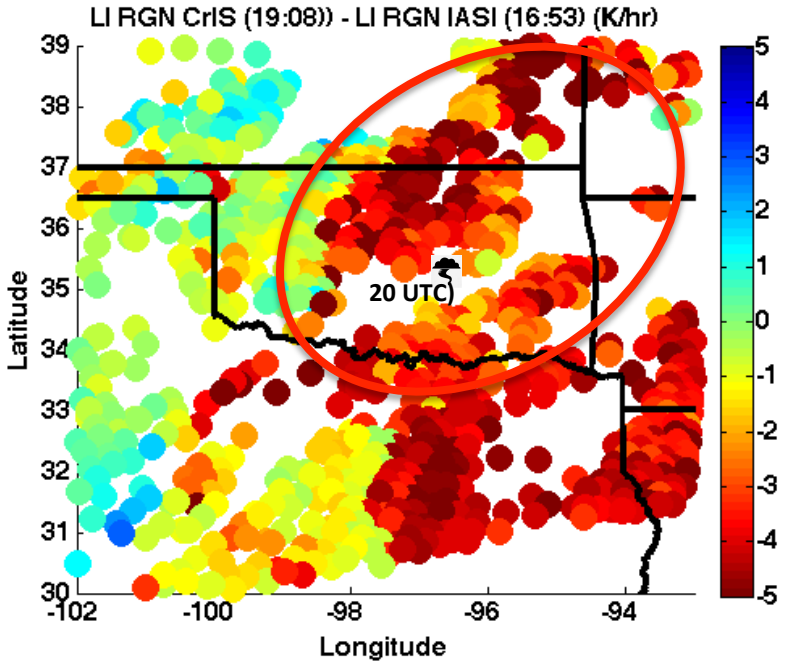


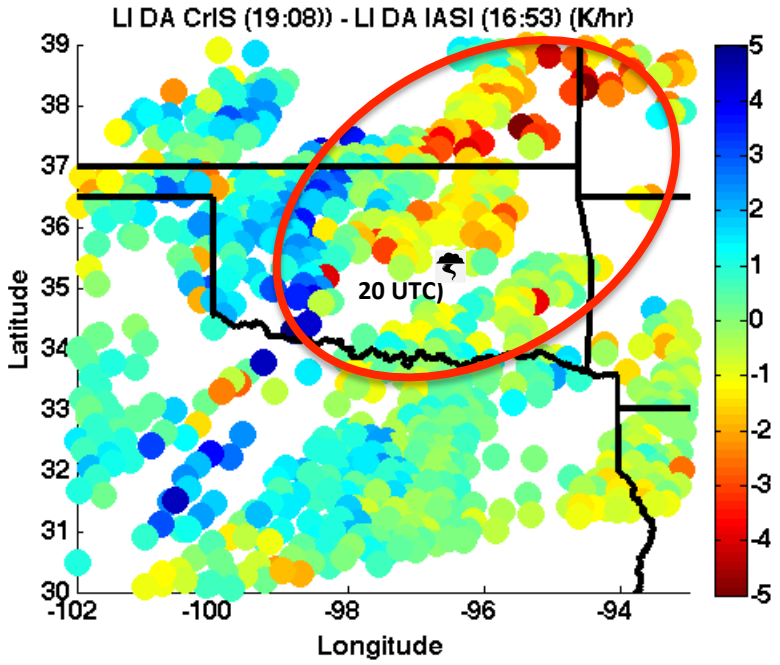


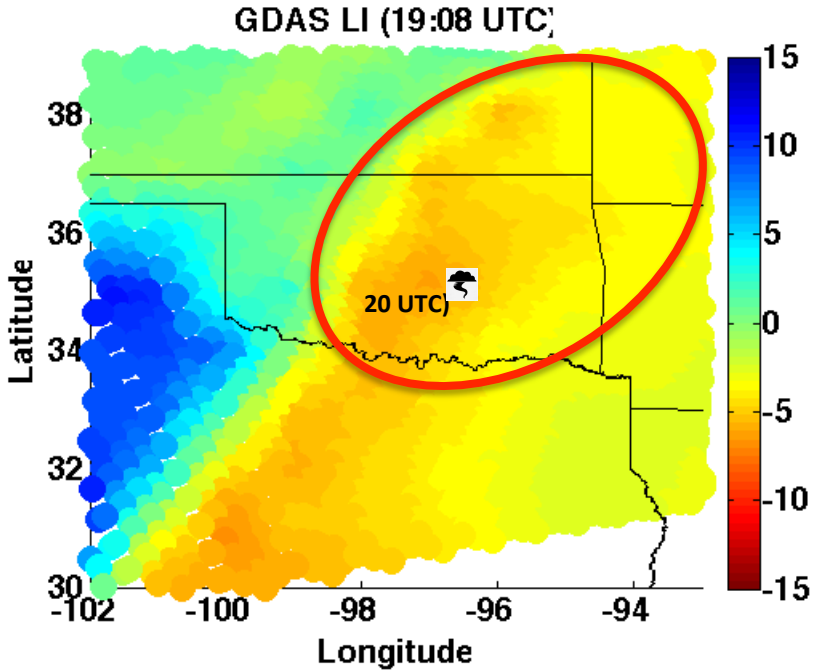


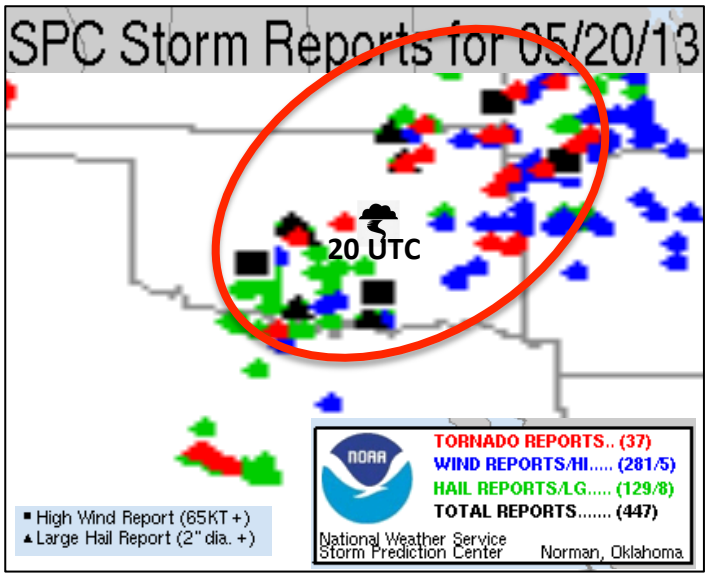


Time Tendencies of Lifted Index (May 20 2013)









Summary

- Poor vertical resolution of satellite soundings can cause a vertical alias within the NWP models that assimilate them
- The vertical alias can be determined using NWP simulated radiances and removed from the real radiance retrieval
- It is shown that the de-aliased profile retrieval is an improvement of the model profile that was used for the de-aliasing process
- Analyses of time consecutive (2-hr interval) satellite retrievals (i.e., from Metop-B IASI and S-NPP CrIS), antecedent to a Tornadic storm outbreak, indicates that the assimilation of de-aliased satellite profile retrievals will improve the forecast of the location and timing of severe weather events.
- This hypotheses now needs to be proven through the time assimilation of de-aliased hyperspectral soundings obtained from the system of Metop-A, Metop-B, S-NPP, and Aqua satellites.