S-HIS: The Dual Regression Profile Retrieval Algorithm Description

Bill Smith Sr., Elisabeth Weisz, Ray Garcia, Dave Hoese,

Hank Revercomb, Joe Taylor, Dan DeSlover

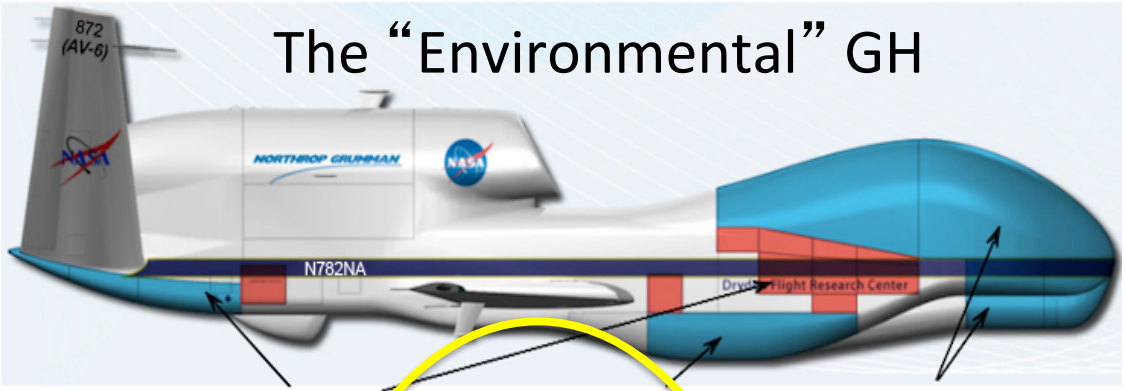
University of Wisconsin Space Science and Engineering Center

THE UNIVERSITY of WISCONSIN MADISON

Hurricane and Severe Storm Sentinel (HS3) Science Meeting
May 5 – May 7, 2015
NASA Research Park, Moffett Field, CA

SSEC

The "Environmental" GH



NASA Hurricane and Severe Storm Sentinel HS3

Airborne Vertical Atmospheric Profiling System (AVAPS)

89 Dropsondes / flight

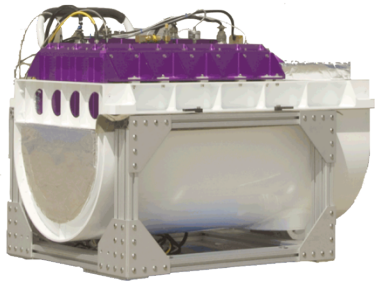
Temperature, Pressure, wind, humidity vertical profiles

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

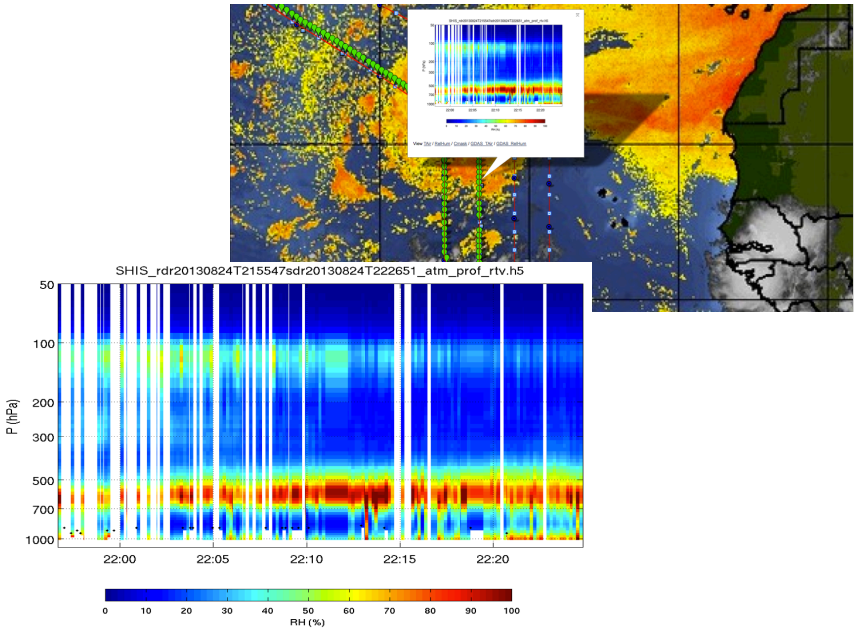
Cloud structure and depth

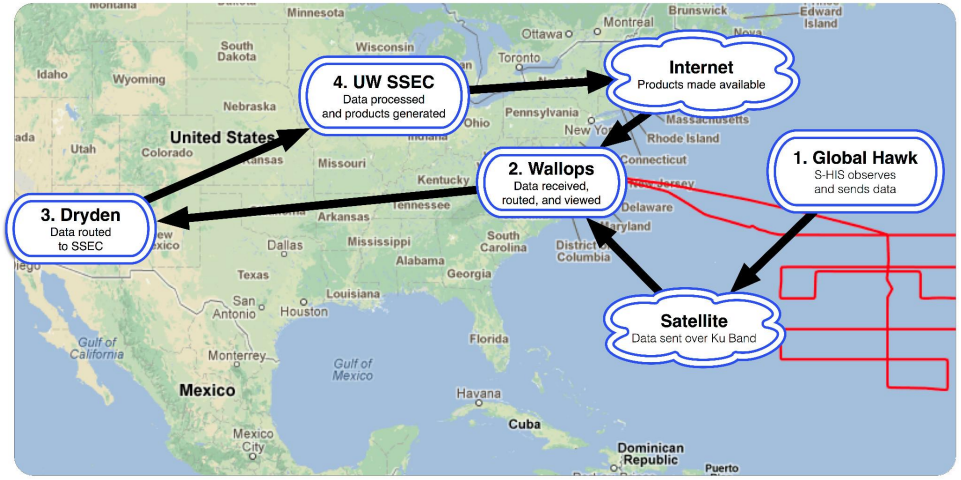
Real-time Data Collection, Downlink, and Processing

Real-Time Products
- Real time data processing software
- < 1 minute from data acquisition to delivery (MTS, website quick-looks)

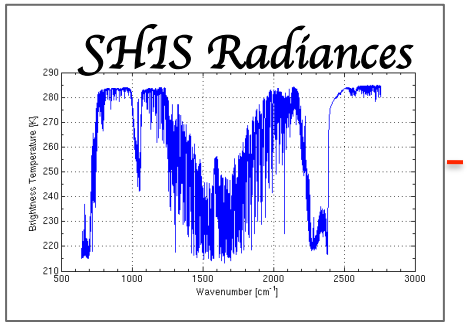
Near-Line Products
- Full data processing pipeline
- < 30 minutes from data acquisition to delivery (MTS, website quick-looks)

Final Products
- Full data processing pipeline
- Quality control, archived at SSEC, Delivered to NASA post-mission
- Preliminary (no QC) available within 8 hours post-flight





"Dual-Regression" Retrieval Algorithm* Overview



Global clear soundings

Radiances (clear FM)

Clear-trained regression coefficients

Global cloudy soundings

Radiances (cloudy FM)
Cloud height classes

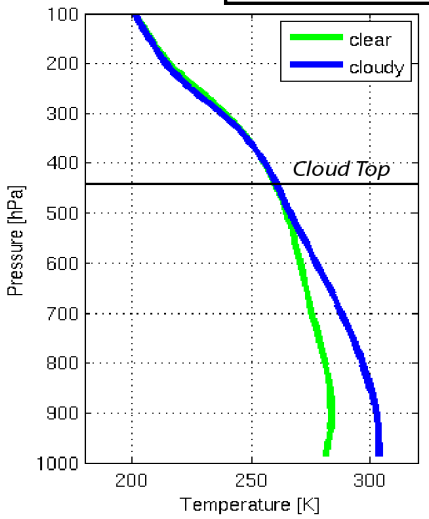
Cloud-trained regression coefficients

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

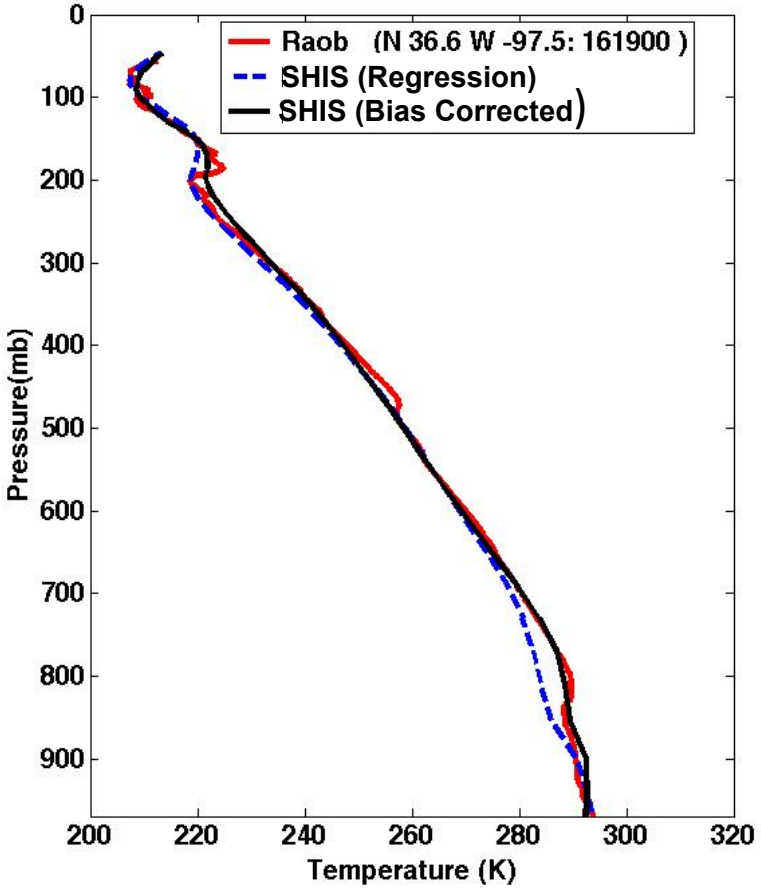
* Smith, W. L., E. Weisz, S. Kirev, D. K. Zhou, Z. Li, and E. E. Borbas (2012), Dual-Regression Retrieval Algorithm for Real-Time Processing of Satellite Ultraspectral Radiances. *J. Appl. Meteor. Clim., 51*, Issue 8, 1455-1476.

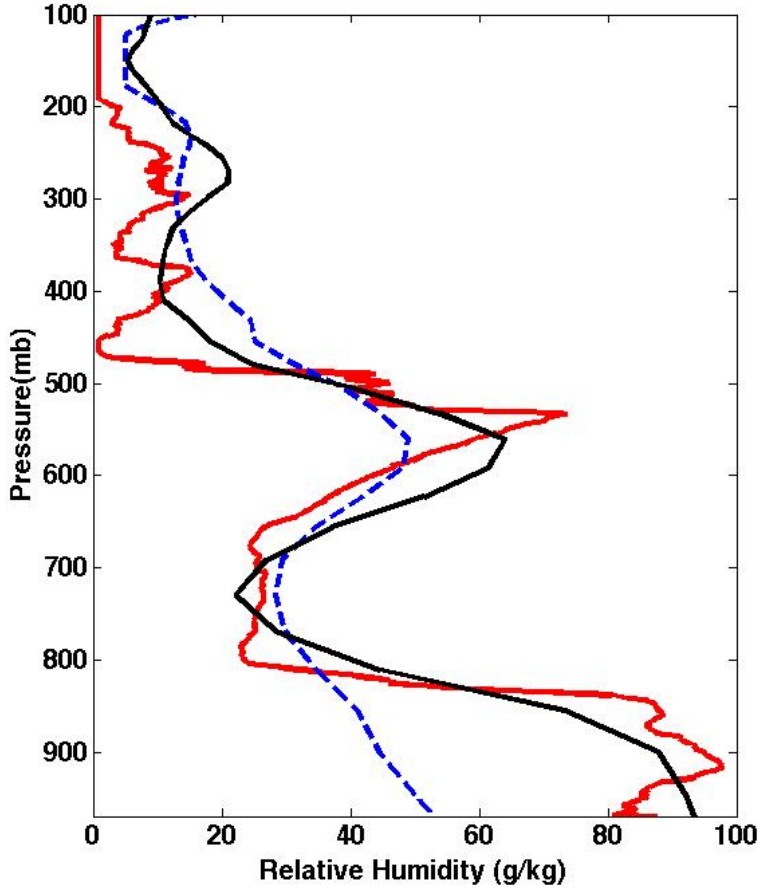
Physical Correction Using Forecast Model Profile

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

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

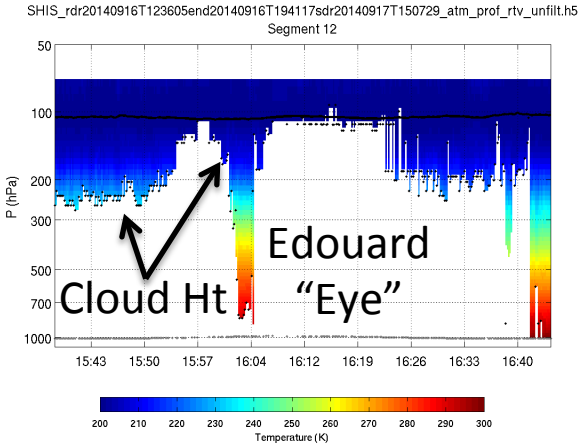
Statistical Bias = FP radiance Retrieval - FP



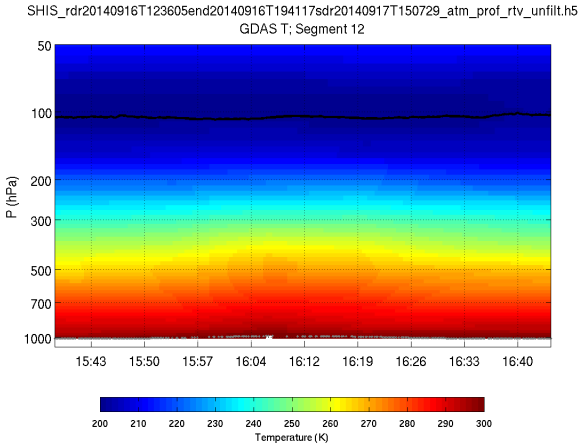


Bias Correction Enables Profile Retrievals Which Reveal NOAA Model Uncertainties

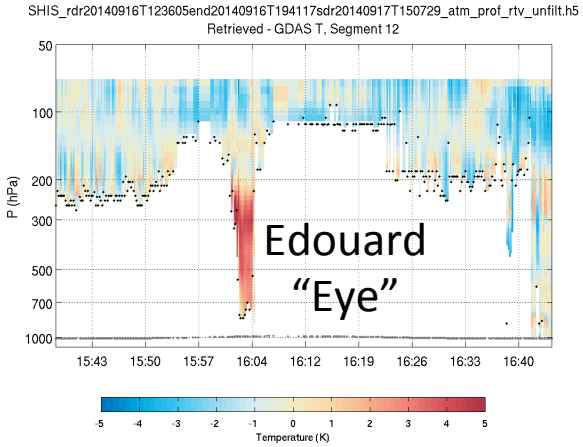
Retrieved Temperature



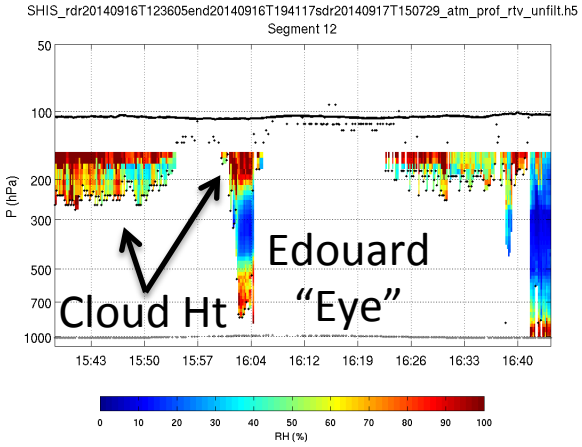
GDAS Temperature



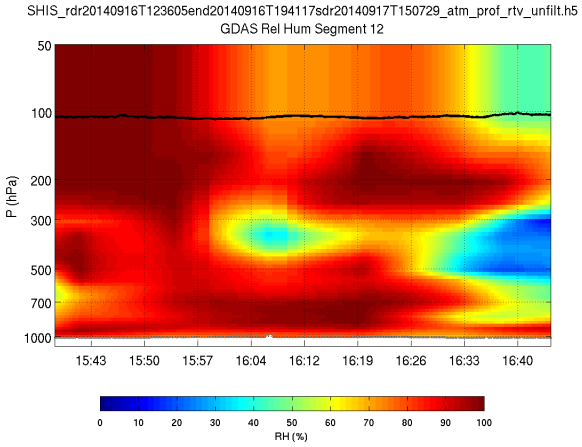
Retrieved - GDAS T



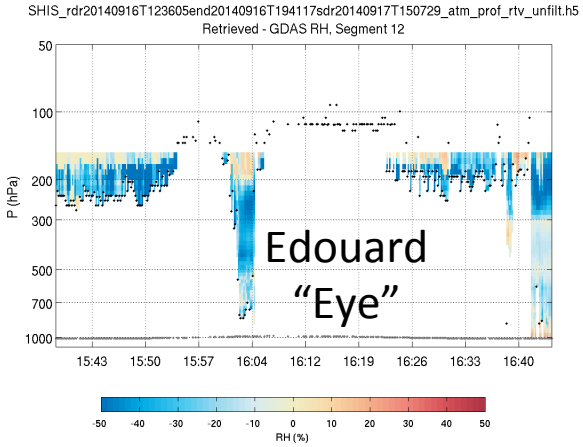
Retrieved RH



GDAS RH



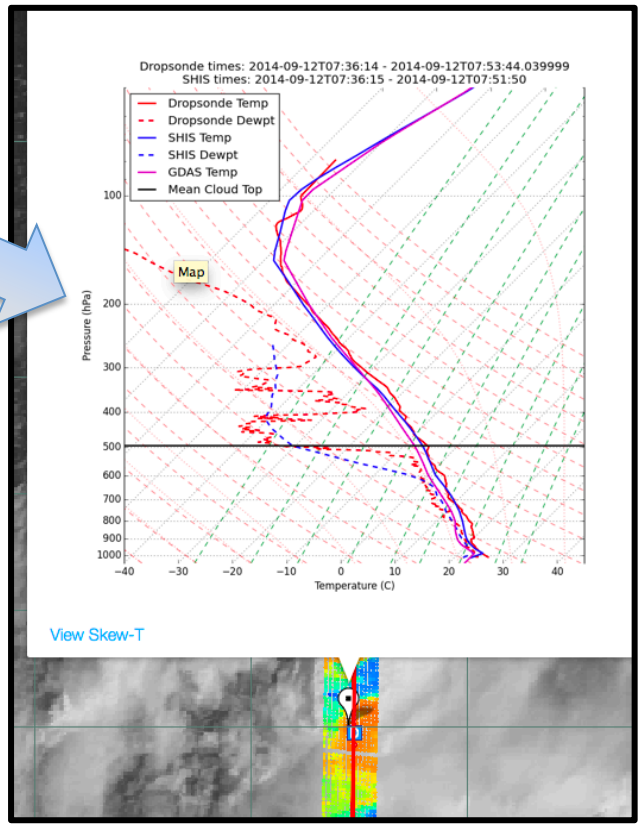
Retrieved – GDAS RH



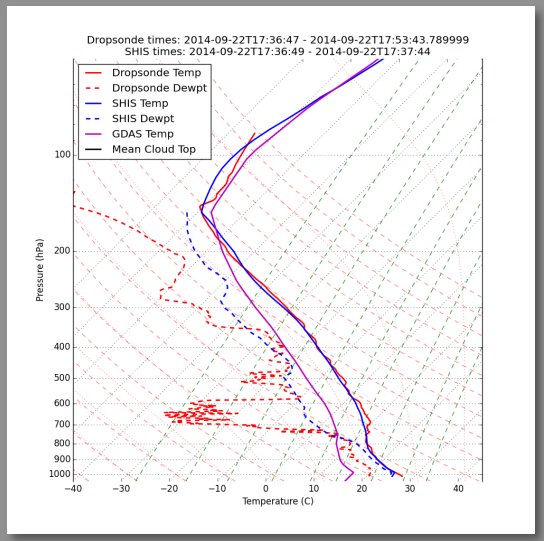
Real-time Data Collection and Processing
Added in 2014: SHIS/AVAPS Comparison Skew-T

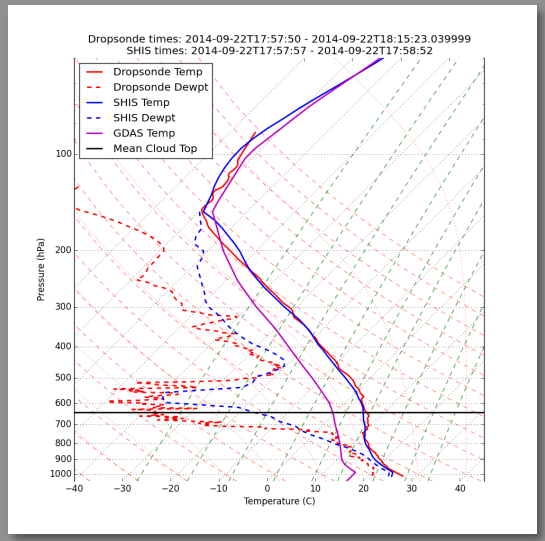
2014-09-12: "SHIS/AVAPS Comparison Skew-T" Plot added to MTS

- average of S-HIS retrievals from data collected during the sonde drop
- simple outlier rejection applied



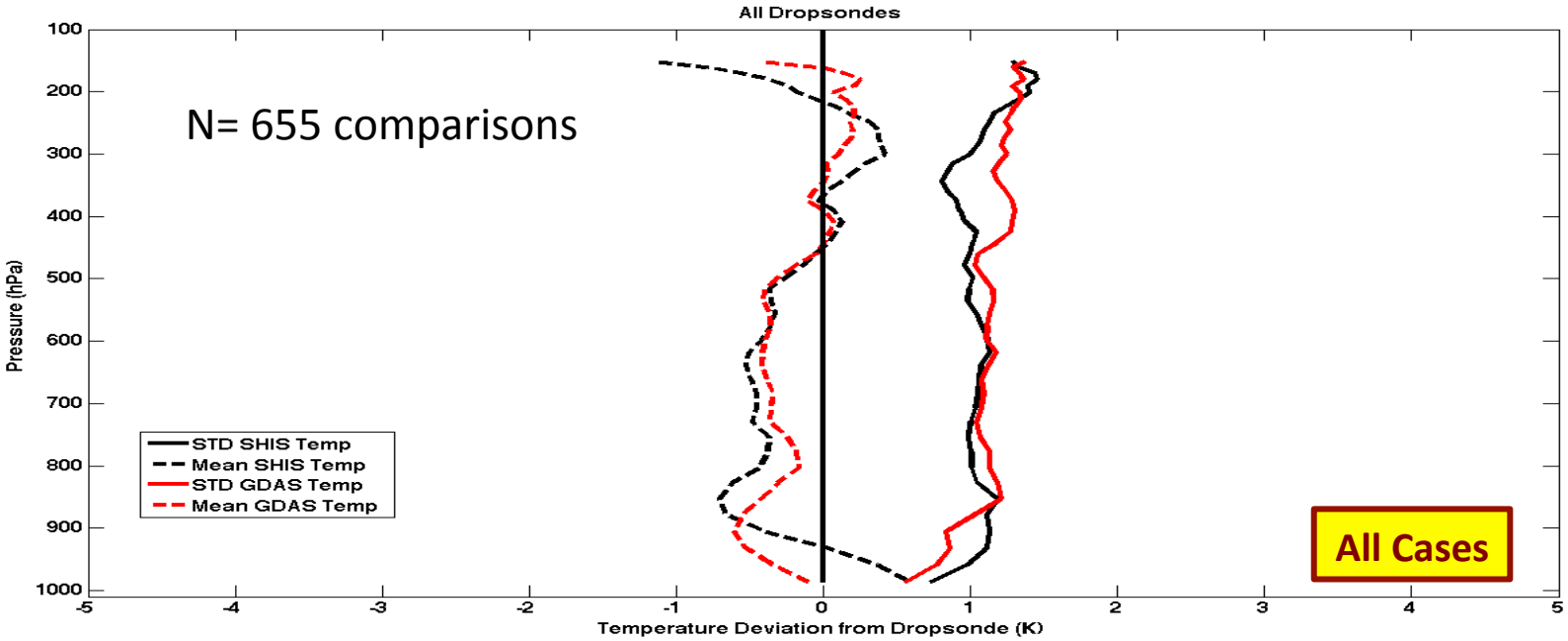
2014-09-22: Refined field of view averaging and selection algorithm applied to the S-HIS retrievals used in the AVAPS comparisons improved the temperature and dewpoint agreement

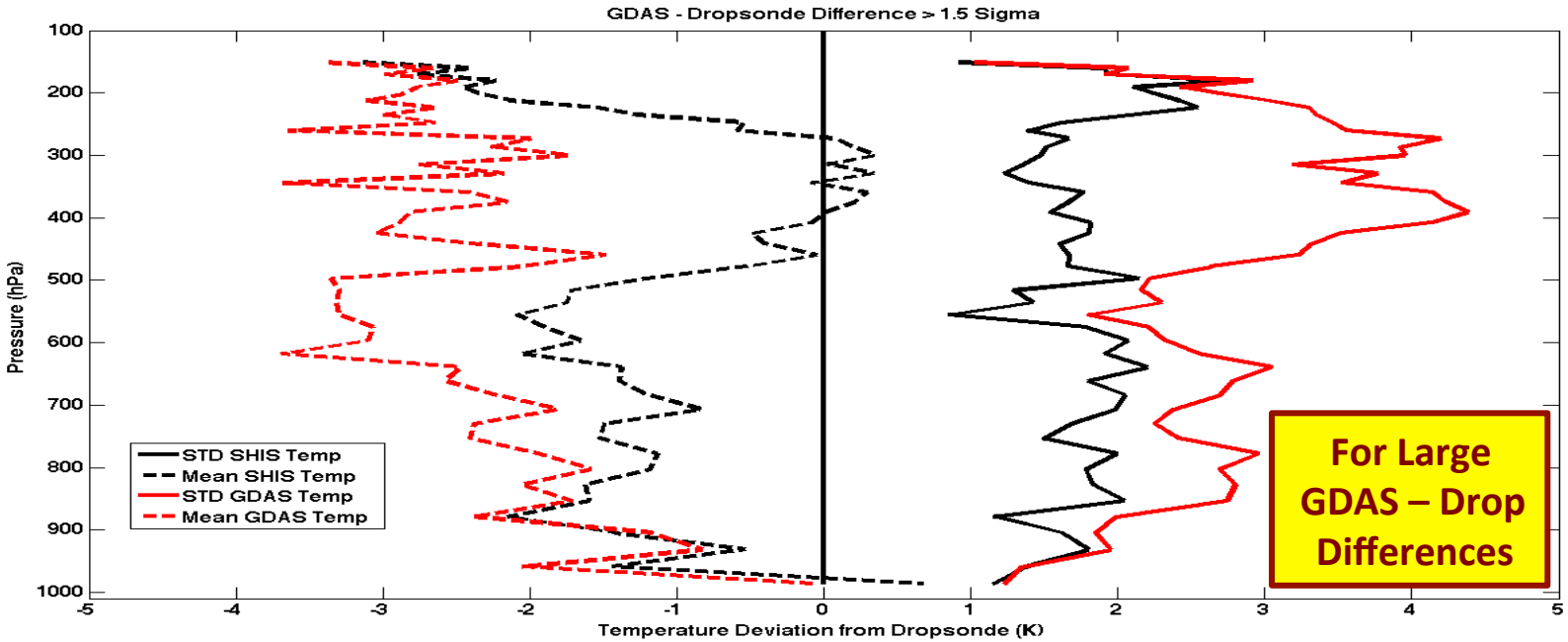




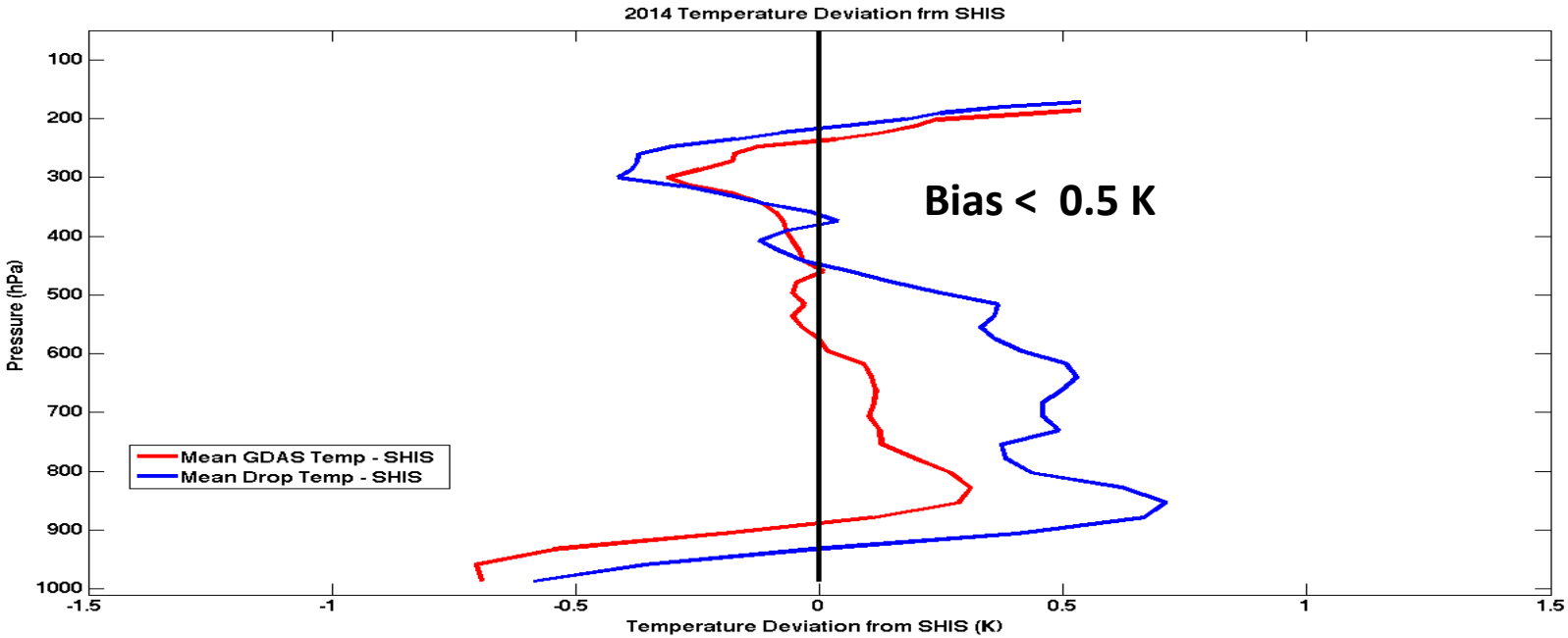
High Thin Cirrus Produced Cold Bias is Removed

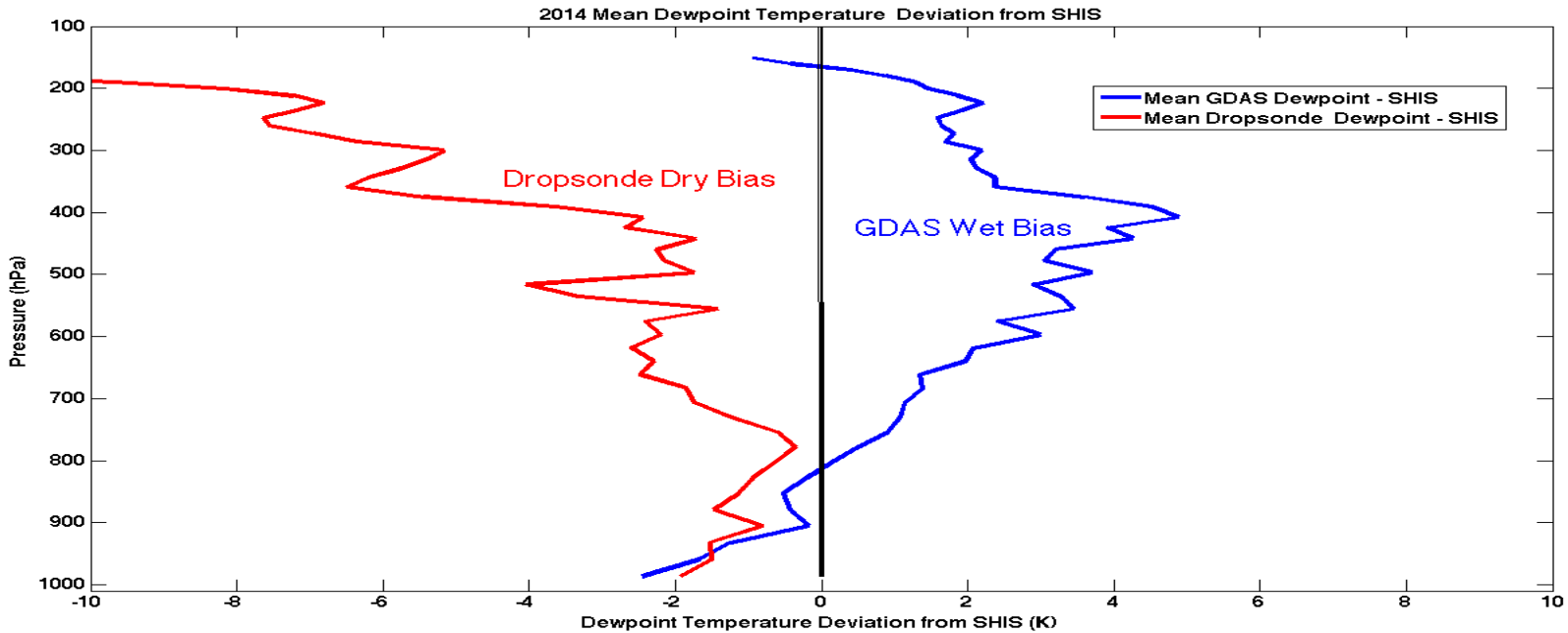
S-HIS Vs Dropsonde Statistics





Comparison With SHIS

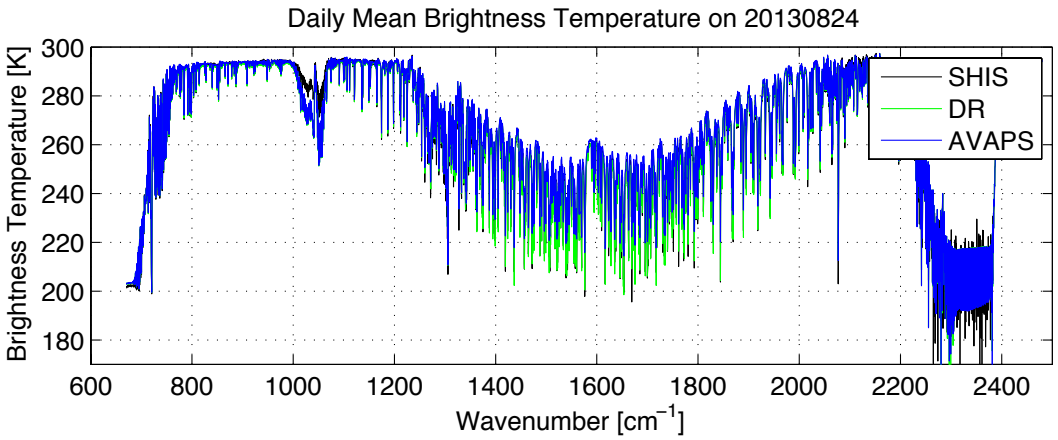




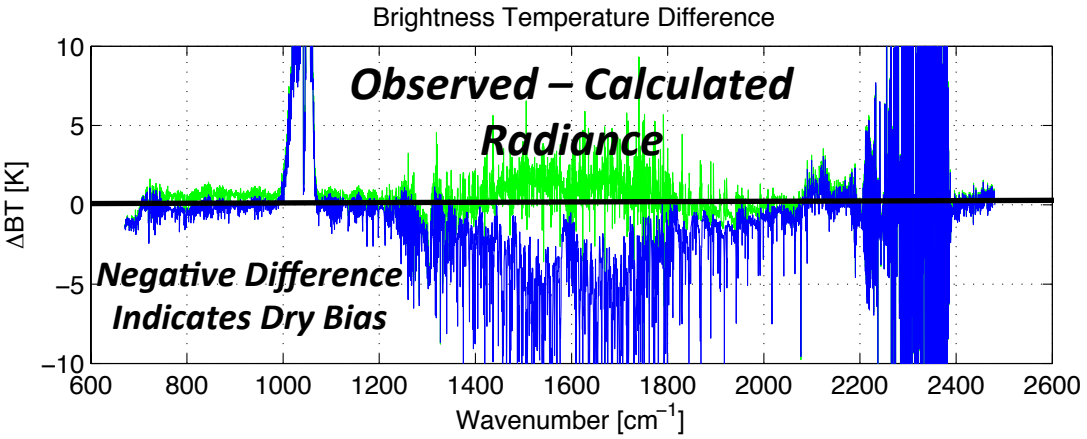
Radiative Closure Study to Confirm AVAPS Dry Bias *

- Apply the same data filter (S-HIS retrieved cloud top < 700 mb), then utilize AVAPS measured and S-HIS dual regression (DR) retrieved profiles to compute upwelling radiance at Global Hawk altitude.

Upper panel shows S-HIS measured upwelling brightness temperature (T_b) with AVAPS and DR calculations using Line-by-Line Radiative Transfer Model (LBLRTM)

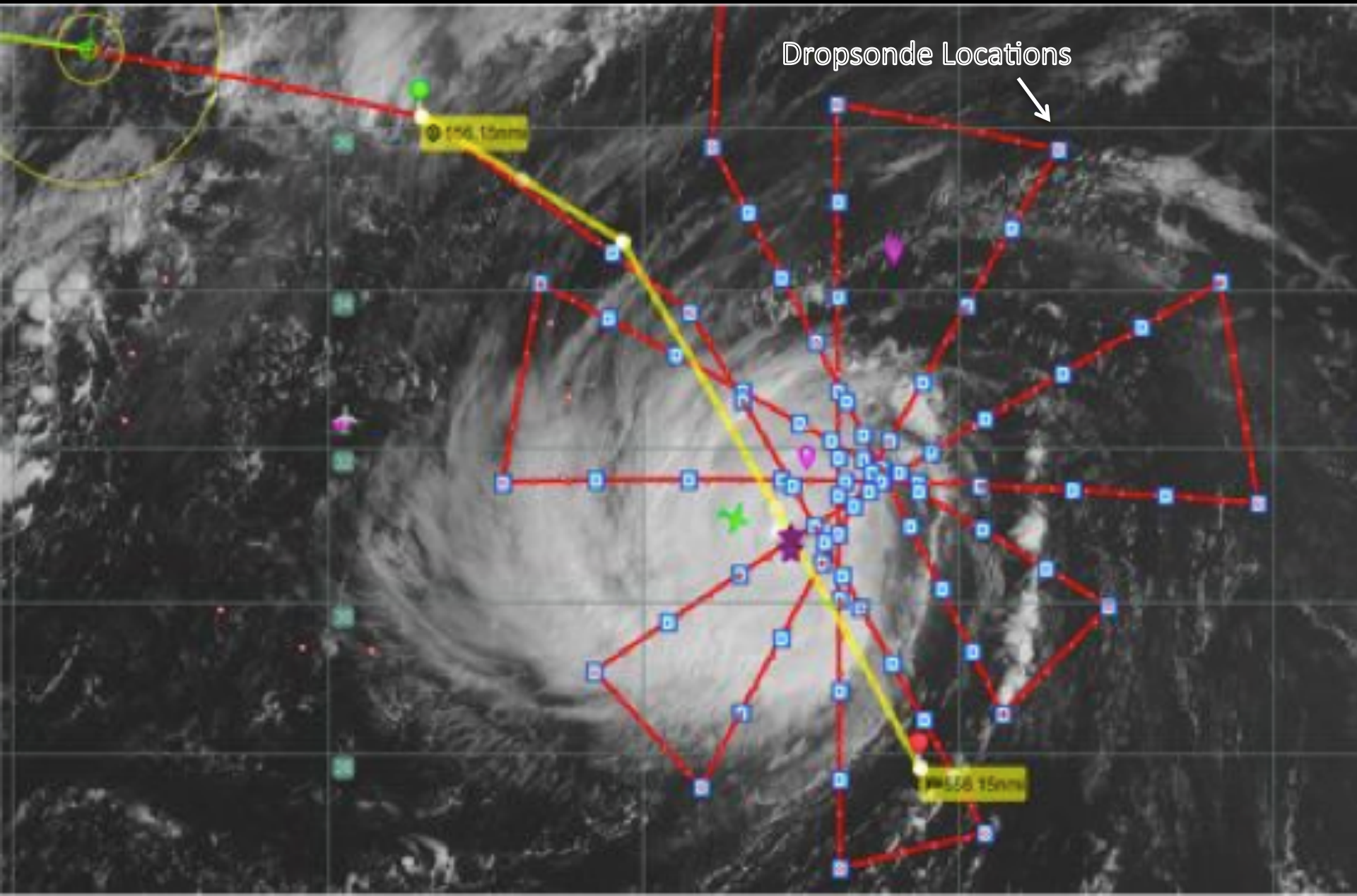


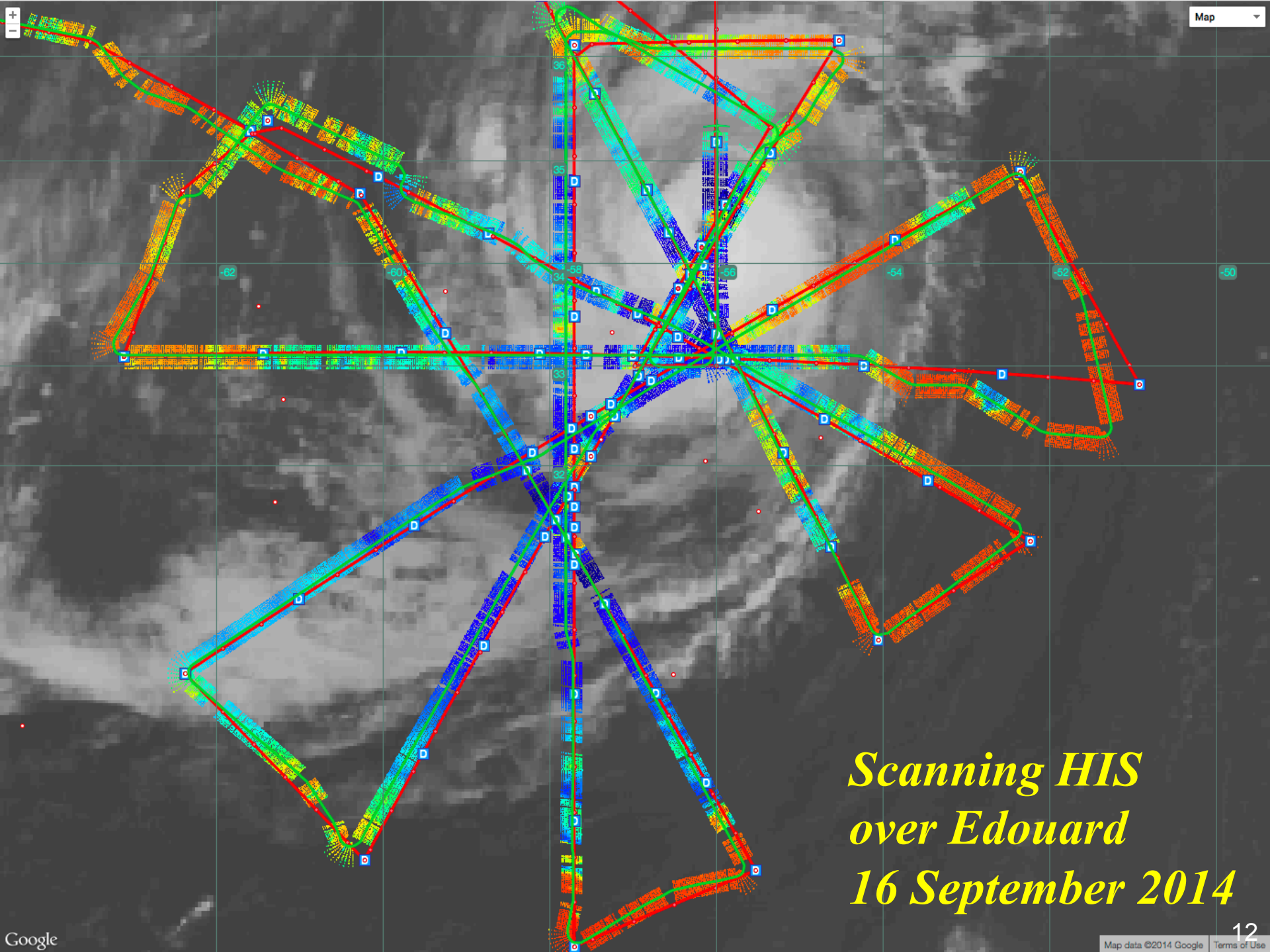
S-HIS T_b – LBLRTM calculations for both AVAPS and DR profiles. Strong negative bias for AVAPS between 1200 and 2000 cm^{-1} is indicative of an upper tropospheric water vapor deficiency.



* See Poster By DeSlover et. al.,

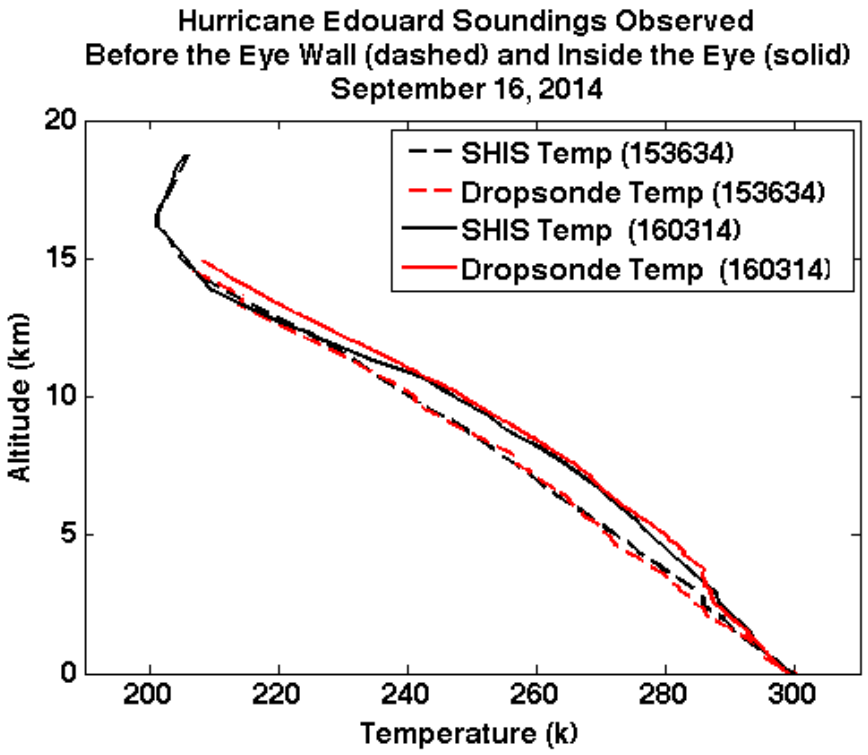
HS3 Global Hawk Flight Track (9/16/2014)



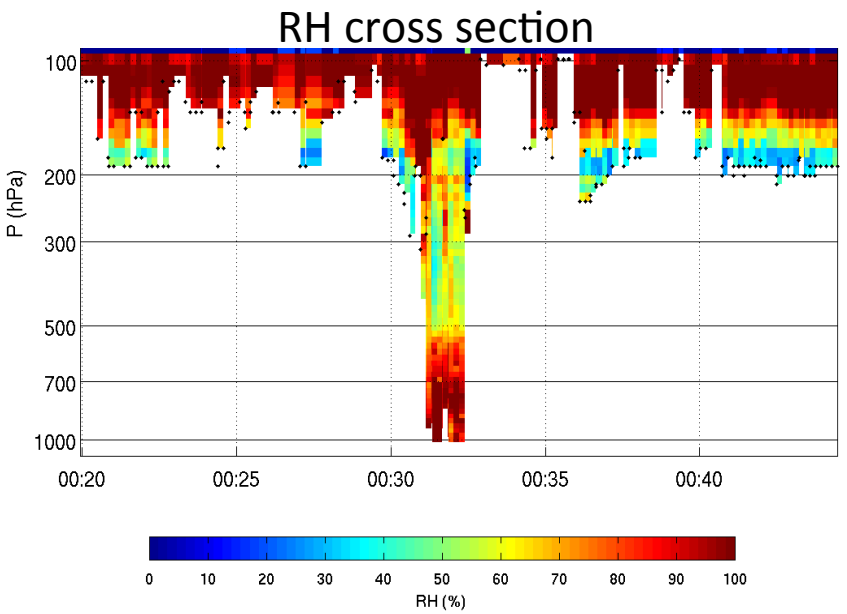

Map
Scanning HIS
over Edouard
16 September 2014
Google
Map data ©2014 Google
Terms of Use

S-HIS Sounds in the eye of Edouard

- **Example S-HIS real-time retrieval display of the eye of Hurricane Edouard:**



Soundings to the surface!

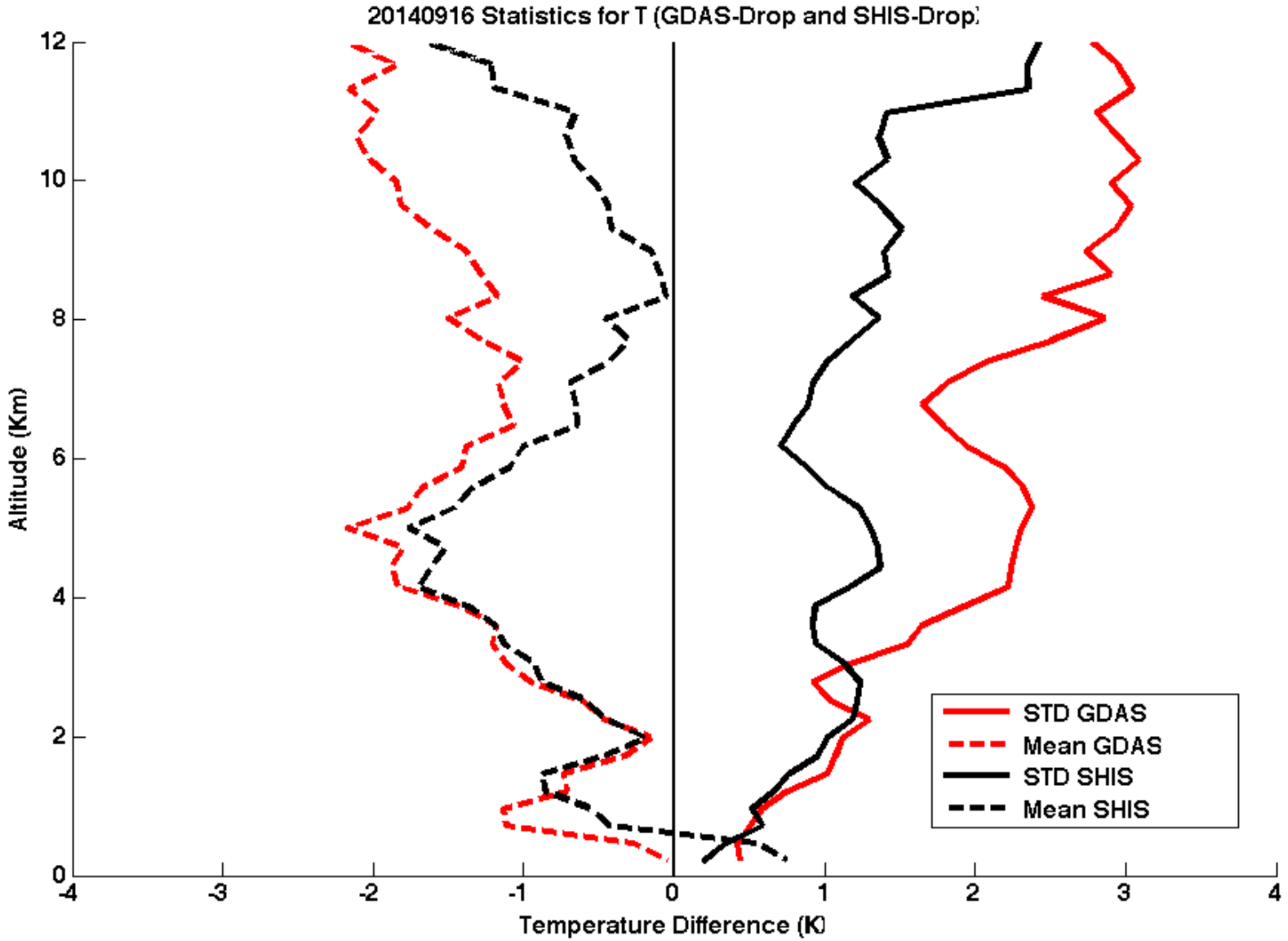


Summary

- ***S-HIS provides a dense coverage of atmospheric profiles whose accuracy has been validated using coincident dropsonde measurements***
  - *Generally more accurate than NOAA GDAS analyses*
  - *Significantly more accurate than NOAA GDAS for extreme situations (e.g., hurricane warm "eye" anomaly)*
  - *Improves absolute accuracy of upper tropospheric humidity observed from Global Hawk*
  - *Fills gaps in sounding coverage by AVAPS*
  - *Fill off-nadir gaps in cloud top altitude coverage provided by CPL*

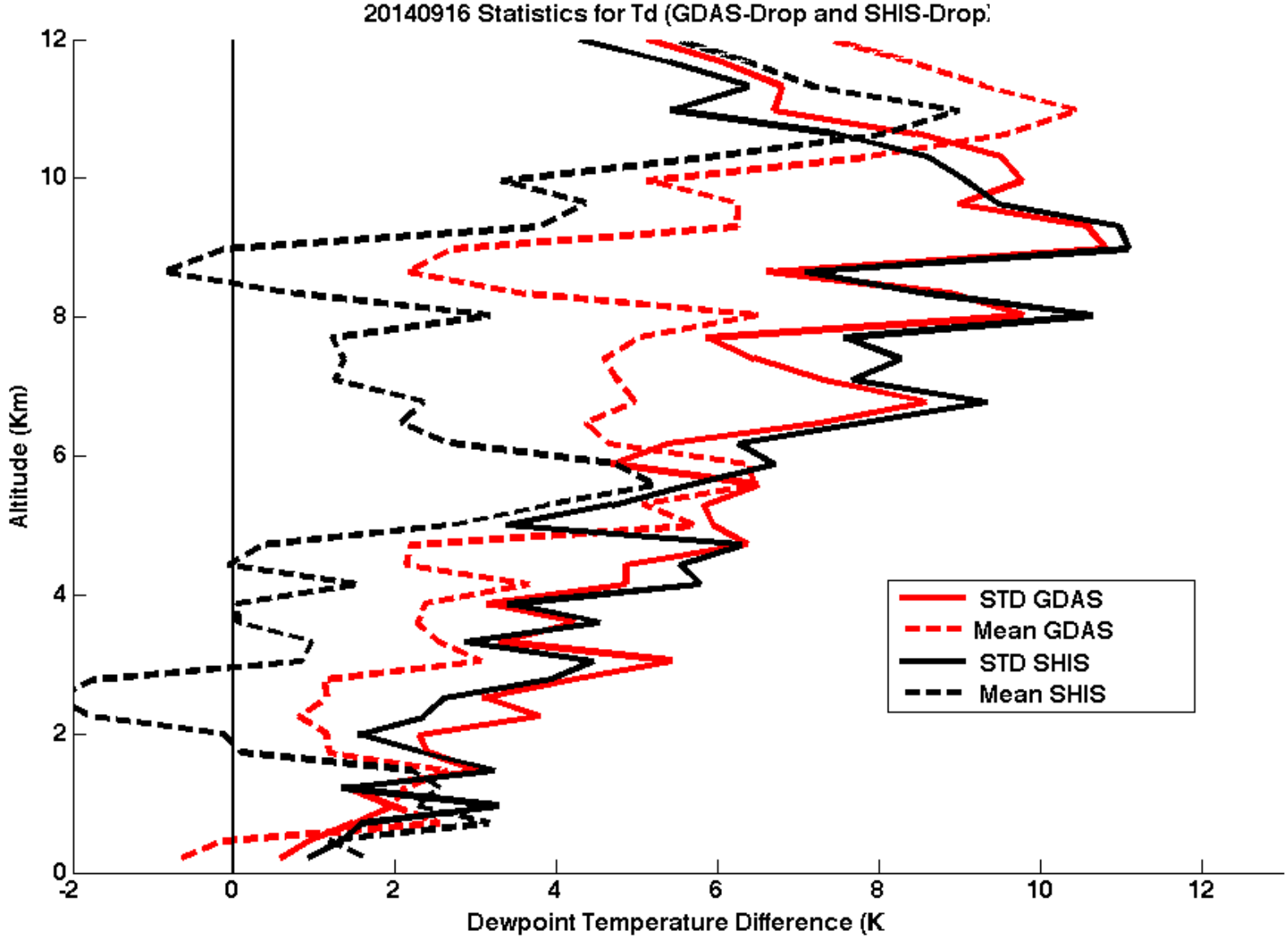
Back-up Slides

Dropsonde Comparison Statistics (Sept. 16, 2014)



- *SHIS retrievals compare closer to the dropsondes than does the NOAA GDAS Analyses*
- *Dropsondes are generally warmer than SHIS and GDAS*

Dropsonde Comparison Statistics (Sept. 16, 2014)



Dropsondes exhibit a dry bias which decreases with decreasing altitude