S-HIS Dual Regression Analysis Relative to Dropsonde and Lidar Measurements During HS3

D. H. DeSlover, E. Weisz, J. K. Taylor, R. Holz, H. Revercomb, D. C. Tobin, R. O. Knuteson, W. L. Smith
Cooperative Institute for Meteorological Satellite Studies, Space Science and Engineering Center, University of Wisconsin-Madison

Abstract

The University of Wisconsin-Madison Scanning-High spectral resolution Infrared Sounder (S-HIS) is participating in the five-year Hurricane and Severe Storm Sentinel (HS3) mission. Its goal is to study processes that relate to hurricane genesis and development. We analyzed results from a dual-regression (DR) retrieval of S-HIS radiances, including temperature and water vapor profile retrievals, cloud top pressure and optical depth, from the inaugural 2012 campaign over the Atlantic Ocean basin.

Water vapor and temperature DR profiles (two-minute means) were derived corresponding to each Airborne Vertical Atmospheric Profiling System (AVAPS) dropsonde that was released during the mission. We present direct skew-T analyses and daily mean differences with respect to the dropsonde measurements. We also compare nadir DR retrieved cloud top pressure and optical depth to collocated Cloud Physics Lidar (CPL) measurements.

SHIS Dual Regression Retrieved T and RH profiles Relative to AVAPS Dropsondes

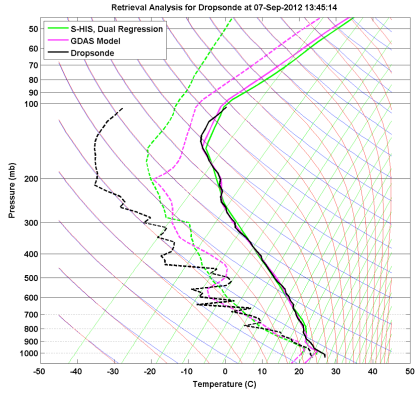
Methodology:

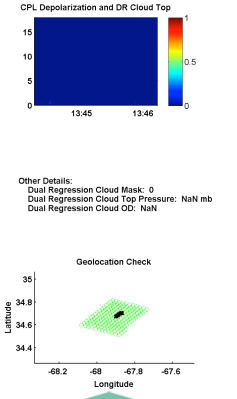
We performed a two-minute mean of S-HIS DR temperature and water vapor profiles. These data were plotted on a skew-T diagram for each AVAPS dropsonde during the 2012 HS3 campaign.

Example image from 7 Sept. 2012 HS3 sortie. A similar image was created for each AVAPS dropsonde during the campaign.

The left panel shows a skew-T diagram that includes the dropsonde (black), S-HIS DR mean retrieval (green) and GDAS model (magenta) profiles; where dashed-lines represent dewpoint temperature and solid lines indicate temperature.

The top right image shows the CPL depolarization for a two-minute window centered around the dropsonde time. Used to illustrate the nadir cloud conditions for the given dropsonde. This example was for a clear sky measurement, consistent with the DR retrieval shown in the skew-T.

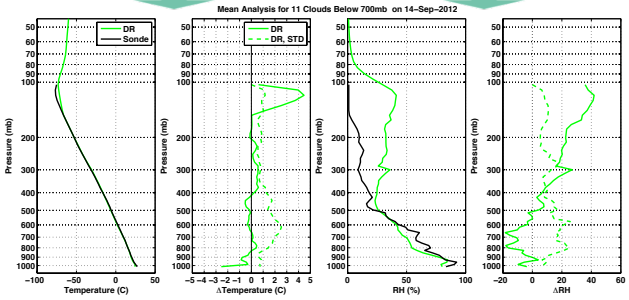




A daily-mean, four-panel image representing S-HIS DR retrievals relative to AVAPS dropsondes were created for each HS3 mission sortie. Data were compiled with respect to relative humidity (RH, shown below) and water mass mixing ratio (H2OMMR). Data were also filtered based on DR retrieved cloud top pressure limited to 700 mb.

Geolocation sanity check. Shows the S-HIS surface projected points (circles; green suggests no cloud while red specifies a positive cloud retrieval) and the dropsonde position during its descent (black x).

① The first panel shows the mean daily temperature profile for each dropsonde (black) and corresponding two-minute mean S-HIS DR retrieval (green);
② shows the ΔT difference from mean ($T_{DR} - T_{AVAPS}$) and its standard deviation;
③ same as (1) but showing relative humidity, note the significant dry bias in the dropsonde above 400 mb;
④ same as (2) but DRH difference from mean, and its standard deviation.



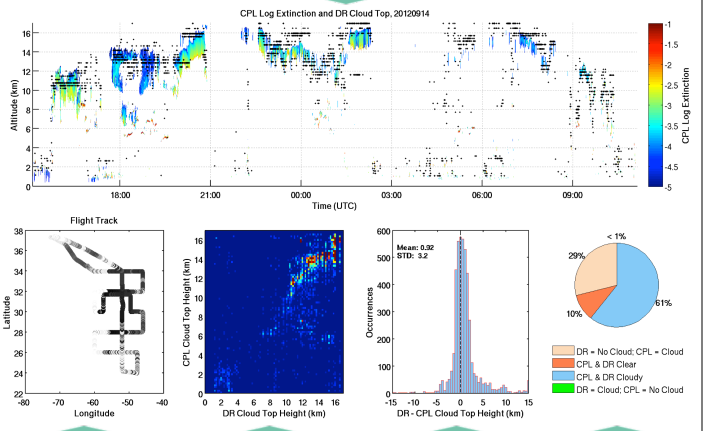
S-HIS Dual Regression Retrieved Cloud Heights Relative to CPL Measurements

Methodology: The DR retrieved cloud top pressures were converted to altitude by applying the GDAS model pressure as a function of geopotential altitude. This was performed for each individual DR retrieval (i.e., S-HIS footprint).

A collocation algorithm was used to determine the CPL measurements that coexisted for each nadir S-HIS footprint. The collocation yielded roughly 10-12 CPL measurements per S-HIS nadir footprint. These were averaged to yield a single CPL cloud height for each S-HIS DR retrieval cloud height.

Example quicklook image from 14 Sept. 2012 HS3 sortie. A similar image was created for each flight day for the campaign.

The top panel shows the CPL log-extinction as a function of time for the entire flight. The DR cloud top pressure was overlaid upon the CPL image with a black dot for each collocated DR cloud top that was retrieved.



Collocated flight track for the given sortie, where black indicates high cloud and white indicates low cloud (or clear sky).

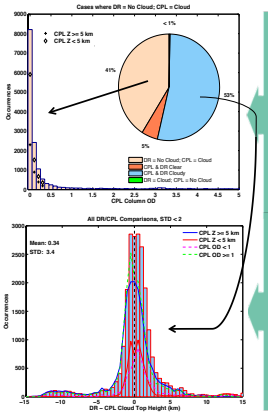
Density scatterplot showing the collocated DR cloud top heights relative to CPL. Data are filtered to exclude non-uniform scenes (i.e., CPL Z STD < 2 km).

Histogram showing the distribution of collocated DR – CPL cloud top height differences, applying the same non-uniform scene filter as density scatterplot.

Breakdown for all collocated DR and CPL measurements for the given sortie .

2012 HS3 Mission – S-HIS DR/CPL Cloud Top Statistics

We compiled the same statistics for the entire 2012 HS3 mission as shown in the daily quicklook image above. We extend the analysis to determine the effects of cloud optical depth for cases where the S-HIS DR did not discern the presence of cloud. Data was further broken down to clouds above (or below) 5 km. Mean collocated CPL data were used for both OD and cloud top height in this analysis.

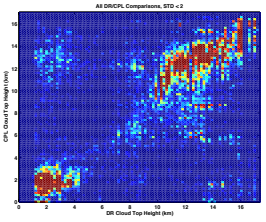


The pie chart shows a full breakdown of all collocated CPL and S-HIS DR obs for the 2012 HS3 mission. Note that:

- **Very few DR cloud cases exist where CPL saw clear.**
- **A large number (41%) of DR events indicated as clear but CPL observed as cloudy. Further analysis, shown in the adjacent histogram, indicates a majority were optically thin. While most of those (♦) are low (likely broken) clouds.**

The lower histogram shows the DR – CPL cloud top heights, resulting in a mean bias of 0.34 km with a STD of just under 3.5 km. The results are broken down further into distributions of:

- **high and low clouds, and**
- **optically thick or thin.**



Density scatterplot of S-HIS DR cloud top height with collocated CPL data for the 2012 HS3 mission (CPL STD < 2 km). Shows results from blue portion of pie chart/histogram as a function of cloud height. Decent agreement along diagonal. Clump of points in top left corner, according to histogram at left, are optically thick (CPL OD ≥ 1) that could be non-uniform within larger S-HIS FOV.

Contact Information: Daniel DeSlover, deslover@ssec.wisc.edu -- Data access: http://download.ssec.wisc.edu/files/hs3_shis/

Reference: Smith et al. 2012, Dual-Regression Retrieval Algorithm for Real-Time Processing of Satellite Ultraspectral Radiances, DOI: 10.1175/JAMC-D-11-0173.1