Atmospheric Profile Soundings from the Scanning High-resolution Interferometer Sounder

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Physical Retrieval Method

• A physical iterative retrieval method was implemented to simultaneously solve for atmospheric temperature, water vapor, ozone profiles and skin temperature from the Scanning-HIS upwelling radiances (Antonelli).

• The retrieval uses the Bayesian optimal estimation technique known as the Maximum A Posteriori (MAP) method (Rodgers).

• A line-by-line forward model (AER LBLRTM v10.3+) was used to minimize the observed minus calculated radiances along with analytic jacobians (Clough).

• A priori climatology was created at UW-CIMSS from a multi-year set of radiosonde observations augmented with ozone profiles (Woolf). The domain of the climatology (approx. 6000 profiles) is shown below.

• The Newton-Gauss method was implemented to find the zero of the derivative of the joint probability distribution (pdf) corresponding to the optimal solution. The actual form is

$$x = x_a + (K^T S_e^{-1} K + S_a^{-1})^{-1} K^T S_e^{-1} * [R - F(x) + K^*(x - x_a)]$$

where R is the observation, F(x) the forward model, K is the jacobian dF/dx, and S is the covariance where "a" refers to the a priori climatology and "e" to the measurement error covariance.

Radiosonde Climatology

☐ Radiosonde launch sites
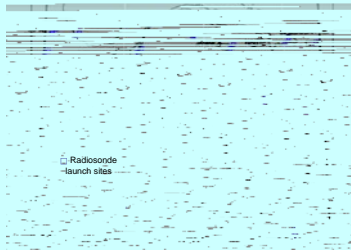
Regression Retrieval Method

• A "physical regression" retrieval algorithm has been adapted for the S-HIS observations following approaches developed previously for the NPOESS Atmospheric Sounder Testbed-Interferometer (NAST-I) by Zhou and Smith et al.

• Clear sky TOA radiances are computed with an LBLRTM based fast transmittance model for the sonde climatology (above).

• Computed radiances are regressed against the input profiles

• Products include:
• Temperature and water vapor profiles
• Surface temperature and emissivity
• CO and O3 profiles

• Further work is underway to include the NAST-I cloudy sky methodology in the S-HIS retrievals.

▪ Zhou et al., Thermodynamic product retrieval methodology and validation for NAST-I, *Appl. Opt.*, **41**, 6957-6967, 2002.
▪ Zhou et al., Thermodynamic and cloud parameter retrieval using infrared spectral data, *Geophys. Res. Lett.*, **32**, 2005.
▪ Zhou et al., Physically retrieving cloud and thermodynamic parameters from ultraspectral IR measurements, *J. Atmos. Sci.*, **64**, 969-982, 2007.

Summary

This poster presents recent work to apply atmospheric profile retrieval methodology to observations obtained by the Scanning High-resolution Interferometer Sounder (S-HIS), a high altitude aircraft based high spectral resolution infrared spectro-radiometer. Two complimentary retrieval approaches are under development: an optimal estimation physical retrieval and a physical regression retrieval. An introduction to the S-HIS, descriptions of the retrieval methodologies, and sample results for recent field observations are presented. At this stage of the investigations, we find reasonable performance of the retrievals for clear sky conditions when comparing with collocated in-situ observations. Future work involves further development of the retrieval algorithms and more quantitative performance evaluations.

The Scanning High-resolution Interferometer Sounder (S-HIS)

• 1 cm MaxOPD plane mirror interferometer
• 580-3000 cm^{-1} coverage with 3 spectral bands
• 100 mrad FOV (~2 km diameter from 20 km)
• programmable cross track downward and zenith viewing
• 1998 to present on NASA ER-2, Proteus, and NASA WB-57
• In-field calibrated spectra w/ 3-sigma absolute uncertainty of < 0.2K
• Applications:
• Radiances for Satellite Validation and Radiative Transfer Development
• Temperature and Water Vapor Profile Retrievals
• Cloud Radiative Properties
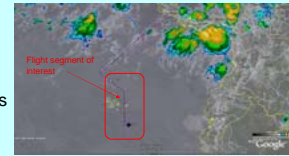• Surface Emissivity and Temperature
• Trace Gas Retrievals
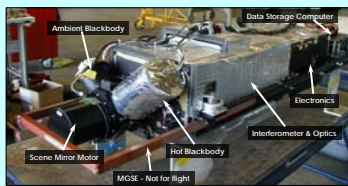
Sample nadir viewing clear sky observation
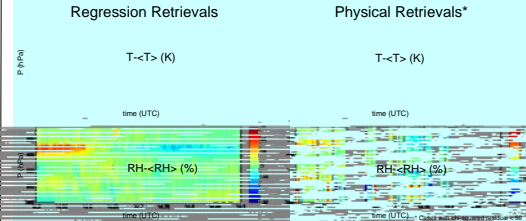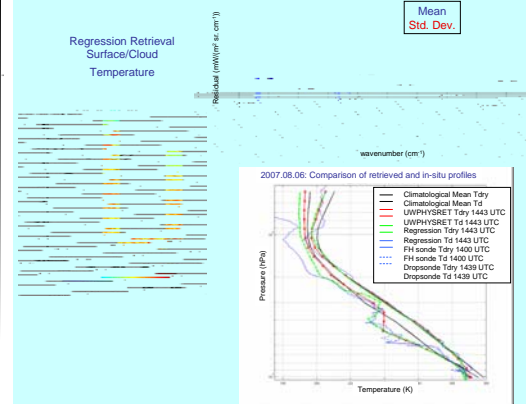
Past Deployments
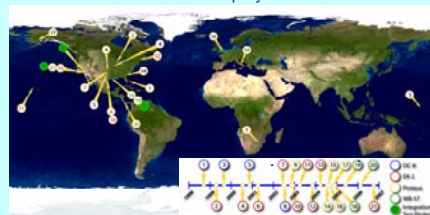
2007.08.06 Galapagos Flight

• NASA Tropical Composition Cloud and Climate Coupling (TC4) campaign
• S-HIS on ER-2 at ~20 km
• Low clouds over ocean
• Coincident with dropsondes from DC-8 and frost point sonde launch (Vömel) from San Cristobal island.

Comparison of Retrieval Results
Cross section of difference from mean profile

Regression Retrievals	Physical Retrievals*
T-<T> (K)	T-<T> (K)

Physical Retrieval Spectral Residuals*

Regression Retrieval Surface/Cloud Temperature

2007.08.06: Comparison of retrieved and in-situ profiles

2007.07.19 Saharan Air Layer Flight

Physical Retrieval; Single Iteration (quicklook) Retrieval

Effect of iteration on convergence