8.2 GOES R Algorithm Working Group: Sounding Retrieval Algorithm – Jun Li

Proposed Work

Work proposed for year one of the Algorithm Working Group (AWG), as documented in Dr. Goldberg's letter dated 21 March 2006, focused on evaluation and development of Version 1 of Hyperspectral Environmental Suite (HES) retrieval algorithms. The content of Version 1 was to include:

- Direct cloudy sounding approaches,
- Advanced Baseline Imager/ Hyperspectral Environmental Suite (ABI/HES) cloud clearing approaches, and
- Efficient radiative transfer Jacobian computation.

Summary of AWG 2006 Accomplishments and Findings

Version 1.0 of clear and direct cloudy sounding software is ready for demonstration by the Algorithm Integration Team (AIT)

The single field-of-view (FOV) hyperspectral sounding algorithm version 1.0 uses an efficient statistical retrieval approach, and includes both clear sky sounding and above-cloud direct sounding approaches. Software and testing data are available to the AIT, and will be online very soon. A generic hyperspectral IR sounder instrument (650 – 2400 cm^{-1} with a spectral resolution of 0.625 cm^{-1}) is assumed in the version 1.0 algorithm. The algorithm has been applied to one day's full disk hyperspectral IR proxy data (generated by the CIMSS AWG proxy team) at 10 km spatial resolution and 1 hour temporal resolution. Output includes:

(1) clear sky derivation of temperature and moisture soundings at 101 vertical pressure levels (from the top of the atmosphere to the surface);

(2) partial cloudy derivation of effective cloud top pressure (CTP), cloud optical thickness (COT), and temperature and moisture soundings at 101 vertical pressure levels, when COT <1.0;

(3) cloudy derivation of CTP, COT, and temperature and moisture soundings above the CTP levels, when COT >1.0.

Figure 8.2.1 shows that the 500 hPa water vapor (g/kg) retrievals are close to the truth; and the hyperspectral IR radiances provide more retrieval coverage at 200 hPa than at 500 hPa (since there are less clouds higher than 200 hPa).

Figure 8.2.2 shows the temperature cross section (true and retrieved) along the 44^{o} latitude.

Figure 8.2.3 is the same as Figure 8.2.2 but for water vapor mixing ratio. The retrievals are close to "truth" in clear skies and in above-cloud regions.

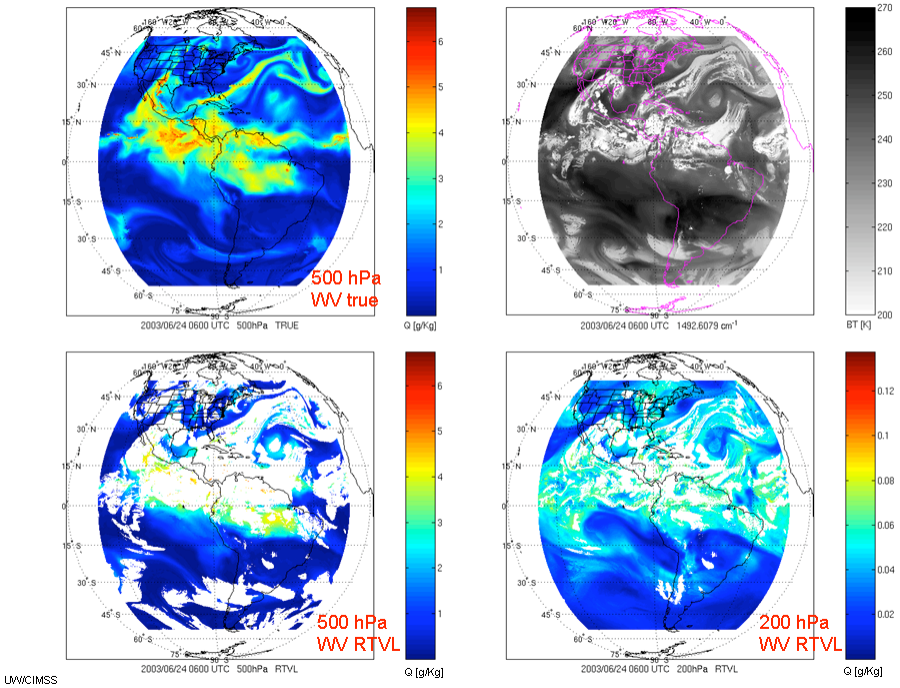


Figure 8.2.1: *Upper Left*: 500 hPa water vapor mixing ratio from the WRF model (truth); *Upper Right*: simulated BT image of an water vapor absorption channel; *Lower Left*: 00 hPa water vapor mixing ratio retrieval image; and *Lower Right*: 200 hPa water vapor mixing ration retrieval image.

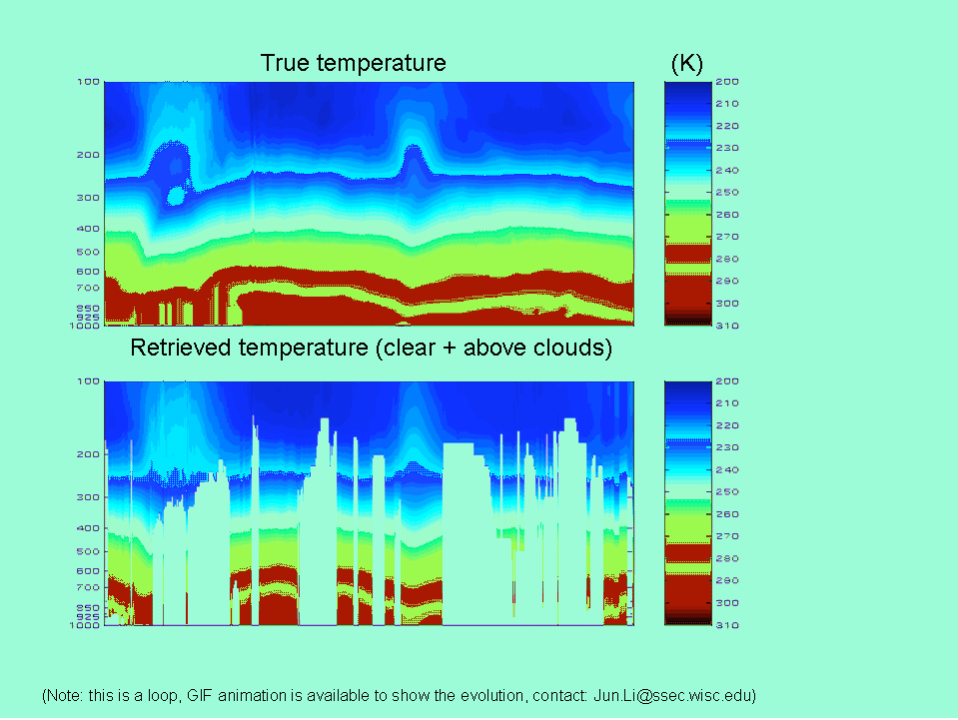
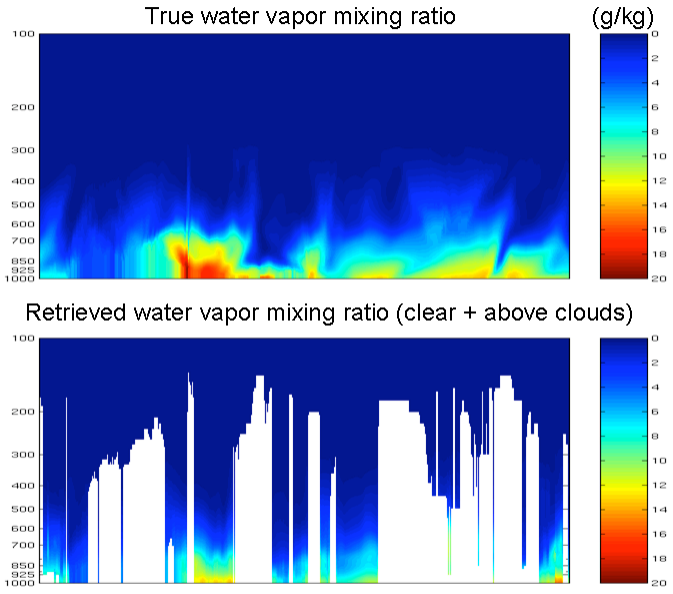


Figure 8.2.2: The temperature cross section along the 44^{o} latitude. (Top: "Truth"; Bottom: clear plus above clouds retrieval)



(Note: this is a loop, GIF animation is available to show the evolution, contact: Jun.Li@ssec.wisc.edu)

Figure 8.2.3: The water vapor mixing ratio cross section along the 44^{o} latitude. (Top: "Truth"; Bottom: clear plus above clouds retrieval)

The direct sounding approach in both clear and cloudy skies has been tested with Atmospheric InfraRed Sounder (AIRS) measurements. Additionally, preliminary simulation results using near global radiosonde observations with this version 1.0 retrieval algorithm were presented by Jun Li and Tim Schmit at the AWG GOES-R meeting on 13 September 2006 and AWG sounding telcon meeting on 04 December 2006. Both simulation and real AIRS testing show that the algorithm is reliable and a viable candidate for generating a hyperspectral IR sounding product.

An algorithm for simultaneously retrieving sounding data and the emissivity spectrum has been developed under GOES-R Risk Reduction. The AWG sounding software will be updated to include this new emissivity algorithm.

ABI/HES cloud-clearing approach studied

The ABI/HES cloud-clearing approach has undergone initial testing with MODIS/AIRS, and is ready for further demonstration with IASI/AHVRR (Infrared Atmospheric Sounding Interferometer/Advanced Very High Resolution Radiometer). In the future it can be applied to ABI and geostationary hyperspectral IR data processing. The MatLab version of imager/sounder cloud-clearing is available now, and it can be rewritten to Fortran if needed.

Improvement has been made on efficient Jacobian calculation

Improvements have been made to the efficient Jacobian algorithm (Li 1994) used for radiative transfer calculations. The new algorithm enables derivation of radiance or brightness temperature for a given IR spectral band with respect to profiles in temperature, moisture, and any trace gas; surface skin temperature; and surface emissivity. The boundary layer moisture retrieval is

improved by approximately 0.5% (mixing ratio) using the refined Jacobian. A manuscript on Jacobian improvement is under preparation.

ABI continuation of legacy GOES Sounder products

Since the ABI acquisition process starts earlier than the geostationary hyperspectral sounder acquisition process, it is important that legacy GOES Sounder products used by the NWS can be generated from ABI data. Many legacy products (radiances, TPW, LI, skin temperature, clouds, and winds) can be provided from ABI data, but temperature sounding information is limited because ABI has only one infrared CO2 absorption band. We are evaluating the combination of forecast radiances with ABI radiances to enable ABI production of current GOES-N sounder products. The operational MODIS (MoDerate Resolution Imaging Spectrometer) sounding algorithm (Seemann and Li 2003, JAM) was selected to demonstrate the feasibility of this approach for ABI moisture profile retrieval, and we have started testing of the ABI stand alone sounding algorithm.

Publications and Conference Reports

Jun Li; GOES-R Sounding Retrieval Algorithm Development; GOES-R Users' Conference, 1-3 May 2006 Broomfield, CO; Poster Presentation.

Jun Li and Tim Schmit; ABI Continuation of Current GOES Class Sounder Products, GOES-R AWG meeting, 13 September 2006, NOAA Science Center, Silver Spring, MD; Presentation

Jun Li; GOES Sounder Applications and Future Needs; International (A)TOVS Science Conference (ITSC-15), 4-10 October 2006, Maratea, Italy; Presentation.

- A proceeding paper on this presentation will be available.