ASSIST II: Temperature, Water Vapor, and Greenhouse Gas Retrieval Algorithm

Introduction

This is a brief overview of the methodology for retrieving temperature, water vapor and the greenhouse gases and aerosol from the downwelling infrared radiance spectrum measured by ASSIST. The expected accuracy of the retrievals is presented.

The ASSIST-II

Figure 1. THE ASSIST II: A field deployable sounder for the atmospheric community.

The ASSIST-II (Figure 1) is a field deployable sounder which uses Fourier Transform technology. It is the latest development in ground based atmospheric sounding spectrometer. Its configuration is rugged, compact and can be adapted to various environment, such as ground and sea platforms. Thanks to its advanced software suite, it can be operated 24/7 to provide atmospheric profiles of various components at high temporal and spectral resolution as well as a wide choice of other applications.

The radiance spectrums measured with the ASSIST-II instrument are sensitive to atmospheric profile features caused by the absorption and re-emission of the radiation emitted by atmospheric gases. Figure 2 shows the regions of the spectrum measured by ASSIST-II that are optically active to the different gases. Most of the infrared spectrum observed with the ASSIST-II instrument provides useful information on the trace gases structure of the atmosphere. Its high sensitivity is essential for the study of the chemical and physical properties of the atmosphere column or any other target.

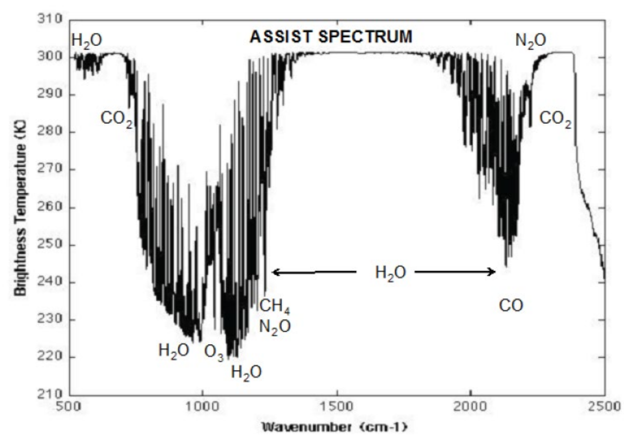

Figure 2. ASSIST-II Brightness temperature spectra showing the spectral regions where specific gases are optically active.

Gas Retrieval Algorithm

The methodology for deriving these vertical profile data is well established. Basically, a statistical database, based on the output of the Real-time Air Quality Modeling System (RAQMS), http://raqms-ops.ssec.wisc.edu, is used within a statistical regression retrieval algorithm to provide an initial estimate of the thermodynamic and greenhouse gas profiles. A final retrieval of these profiles is then achieved using a physical regression retrieval algorithm where the statistical bias in the initial regression profiles is determined by the comparison of a second statistical retrieval based on radiances simulated from real-time RAQMS model output for the time and location of the ASSIST measurements. The bias correction is simply the difference between the regression retrieval obtained from the simulated radiances and the RAQMS forecast profile used to simulate the radiance spectrum.

The elements of the retrieval procedure are summarized as follows:

1. An initial profile is obtained by optimal estimation using climatological covariance matrices produced by the global RAQMS dynamical chemistry model for eight different cloud height classes
2. Reference cloud-free radiance spectra are obtained from cloud attenuated spectra observed for broken cloud conditions using the well known “N* Method” used for operational processing of satellite data, applied to the time, rather than spatial, domain of the radiance observations. For cloud-overcast conditions, the reference cloud-cleared radiance spectra are obtained by radiative transfer simulation of the clear-sky radiance spectra from a real-time RAQMS profiles forecast for the ASSIST observation time and location.
3. The cloud height, and proper cloud class for the statistical retrieval, is defined as that one for which the RMSD between the clouded radiance retrieval and the reference “clear sky radiance” retrieval is a minimum
4. The statistical retrieval is then corrected for statistical bias (“Bias Correction”) using the difference between a real-time dynamical chemistry model profile and the retrieval obtained from a radiance spectrum simulated from the RAQMS profiles.

An example of the results of the retrieval procedure, for 37 N and 77 W 19-21 April 2012 is shown in Figure 3 below. The left-hand column is the result of the initial statistical regression retrieval whereas the middle column is the result after “Bias Correction”. The right column is the real-time RAQMS model prediction for the location of an ASSIST instrument, which was used for the bias correction. One can see that from Figure 3 that the ASSIST plus RAQMS (middle column of Figure 3) captures the information content of both the ASSIST radiance measurements and the RAQMS forecast profiles.

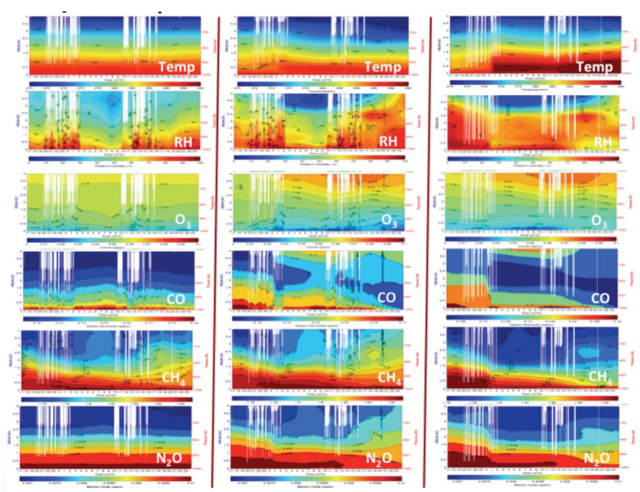

Figure 3. Thermodynamic (i.e., temperature and water vapor) and greenhouse gas (O3, CO, CH4, and N2O) profile cross-sections. The left hand column is the result of the initial statistical regression retrieval from ASSIST radiance spectra whereas the middle column is the result after “Bias Correction”.

The right column is the real-time RAQMS model prediction for the location of the ASSIST instrument.

The theoretical expected accuracy if the retrieved profiles has been determined by comparing retrieved profiles with “True” profiles used to simulate the ASSIST radiance spectra from a regional set of RAQMS model-based profiles. Figure 4 below shows the results. The three curves shown illustrate the bias error of the retrieval (dashed black line), the random error of the retrieval (solid black line), and the standard deviation of the sample set used for the simulations (solid red line). It should be noted that the skill of the retrievals is measured by the distance between the red and black curves, with no skill being when the two curves coincide. As can be seen, the skill is greatest near the surface and then decreases fairly rapidly with altitude. Useful skill is shown for temperature and the mixing ratio of all the gases within the Planetary Boundary layer up to an altitude of about 3-Km, with the exception of ozone where the skill is actually increasing with altitude with useful skill found well beyond the 4-km level. One can also see that the poorest skill is for the measurement of carbon dioxide.

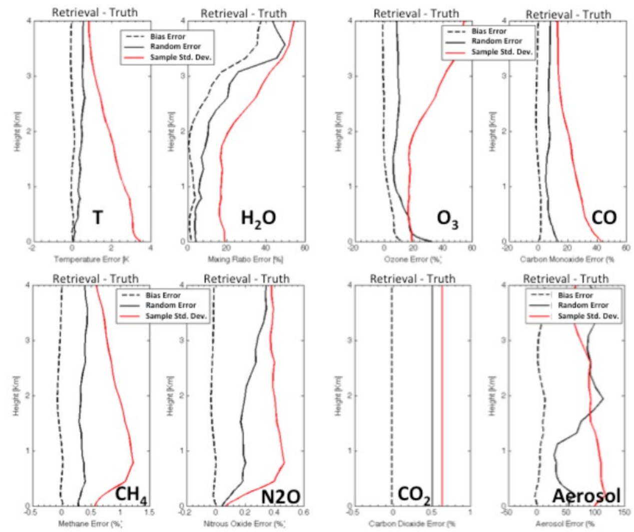

Figure 4. Accuracy of temperature, water vapor, and greenhouse gas retrievals for the surface to 4-km layer.

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