Independent Nadir Retrievals from the Tropospheric Emission Spectrometer (TES)

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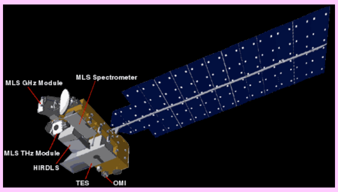
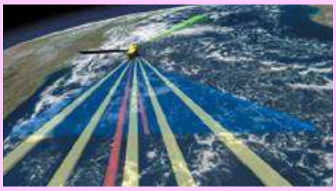
INTRODUCTION

The Tropospheric Emission Spectrometer (TES) was launched on NASA's EOS AURA satellite in July 2004. TES is a high-spectral resolution infrared-imaging Fourier transform spectrometer developed, built, tested and operated by NASA's Jet Propulsion laboratory (JPL). TES has a spectral range from 3.2μm to 15.4 μm and is capable of performing both nadir and limb observations. TES routinely measure temperature, concentrations of O_3, H_2O, CH_4, CO, HNO_3, NO_2 and provide global maps of tropospheric ozone and the chemicals which can form ozone.
Global maps of ozone are required for the monitoring of the ozone layer in the stratosphere and ozone concentration in the troposphere where it acts as a pollutant. Here the results of an initial joint retrieval of surface temperature, ozone, water vapour and atmospheric temperature are shown along with the microwindow selection.





[http://aura.gsfc.nasa.gov/spacecraft/index.htm] [Image produced by Jesse Allen (ssai)]

The figure on the left shows the location of each instrument on the AURA satellite. The field of view of each instruments on AURA are shown in the figure on the right (red = TES, blue = OMI, yellow = HIRDLS and green = MLS).

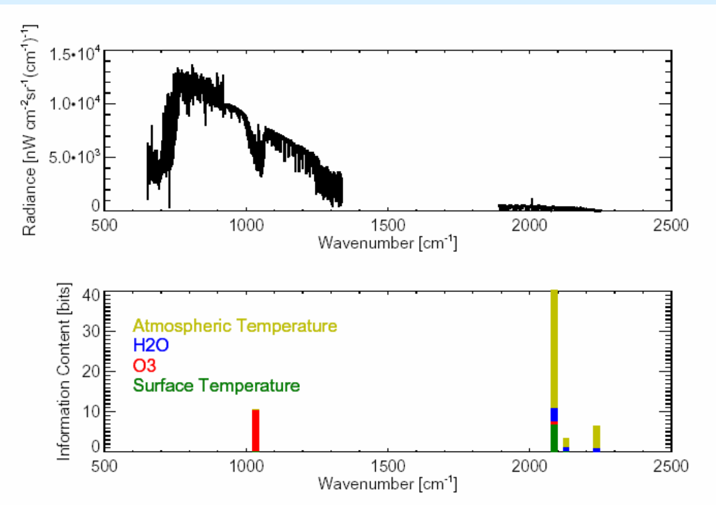
MICROWINDOW SELECTION

It is conventional to use narrow spectral intervals, known as microwindows, when using high resolution spectra. This process reduces the processing time required for a retrieval, with little loss in information.

In this case TES spectra were split into microwindows three wavenumbers wide. The information content for each species was calculated for each microwindow using the equation below and the four microwindows with the largest total information were selected.

$$\text{Information content} = -0.5 \log_2 (|\mathbf{S}_x| / |\mathbf{S}_a|)$$

Where $\mathbf{S}_x$ and $\mathbf{S}_a$ are the covariances of the state vector and the *a priori* respectively.



The top plot shows the TES nadir spectrum for run 2026 sequence 232 scan 2. The bottom plot shows the information content of the selected microwindows for a joint retrieval of surface temperature, ozone, water vapour and atmospheric temperature profiles. The width of the microwindows has been increased by ± 10 cm^{-1} from the central point for this plot.

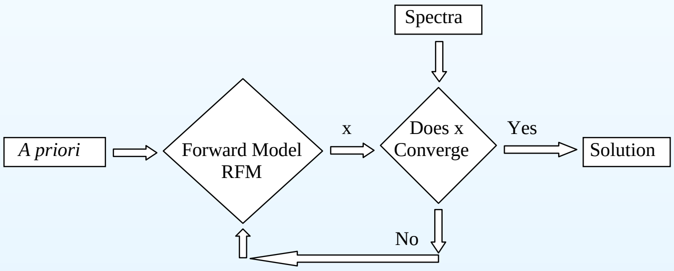
RETRIEVAL METHOD

An optimal estimation method using the Oxford Reference Forward Model (RFM) was used for a retrieval of surface temperature, ozone, water vapour and atmospheric temperature profiles. This constrained the solution to be close to an *a priori* solution, in this case a standard equatorial atmosphere. The solution is found by minimizing the cost function χ^2.

$$\chi^2 = (\mathbf{y}-\mathbf{F}(\mathbf{x}))^T \mathbf{S}_y^{-1}(\mathbf{y}-\mathbf{F}(\mathbf{x}))+(\mathbf{x}-\mathbf{a})^T\mathbf{S}_a^{-1}(\mathbf{x}-\mathbf{a})$$

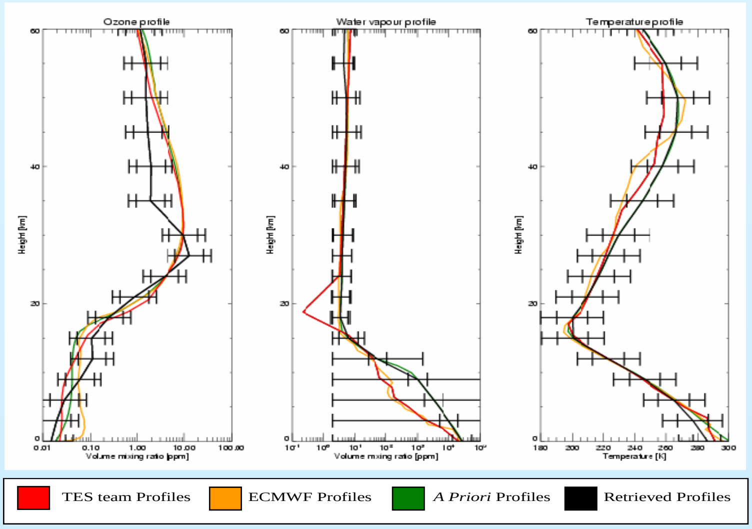
Where $\mathbf{F}(\mathbf{x})$ is the forward model estimate, $\mathbf{x}$ is the retrieval state vector, $\mathbf{y}$ is the measured spectrum, $\mathbf{a}$ is the *a priori* estimate and $\mathbf{S}_y$ and $\mathbf{S}_a$ are the covariances of $\mathbf{y}$ and $\mathbf{a}$ respectively.

This method is less sensitive to noise than other methods, but can introduce an *a priori* bias into the profiles. The flow chart below shows the mechanism of the retrieval process.



RETRIEVED PROFILES

Ozone , water vapour and atmospheric temperature profiles where produced using this retrieval method and the four selected microwindows. Pressure is assumed to be fixed as a function of the altitude. The plot below shows a comparison between these profiles, the *a priori* profiles, the ECMWF profiles (provided by Niels Bormann) and the profiles obtained by the TES team (provided by Susan Sund Kulawik). The outer error bars are that which would be seen if only the *a priori* was being retrieved and the inner error bars are the actual errors for this retrieval.



CONCLUSIONS

- The microwindows with the largest combined information content for surface temperature, ozone, water vapour and atmospheric temperature are located within the spectral range of the 1A and 1B detector arrays.
- The errors show that the retrieval is improving slightly on the *a priori* estimate but adding more microwindows should improve the retrieval further.
- An average noise for each detector array was used in this retrieval, which may account for some of the deviations from the other profiles.