Aura-TES L2 Products: Version 3 Quality Description

Overview of Current Data Quality Status

The TES data products have undergone significant validation analyses. The version 2 L2 data nadir products ozone, carbon monoxide, water vapor, temperature, HDO and sea surface temperature are all validated and usable in scientific analyses. Details on the validation of the V002 data are available in the TES Validation Report v2.0. There also have been 13 papers submitted for inclusion in a future special issue of Journal of Geophysical Research - Atmospheres dealing with Aura validation. It should be noted that the TES nadir methane and all limb products are considered to be "beta" validated, meaning that data is basically useful for gaining familiarity with the TES products and the best way to use them.

A full description of the TES V002 L1B data product quality is available.

The following subsections give an overview of the current data quality of the TES V003 (F04_04) data products.

Data Quality and Validation Status for TES Level 2 Data Products

Nadir Ozone

Statistical comparisons of V002 TES ozone profiles to ozonesondes show that TES has a high bias of 3-10 ppbv in the troposphere. In particular, the bias in the lower troposphere ranges from 3.7-9.2 ppbv while in the upper troposphere the range is 2.9-10.6 ppbv. It is expected that the bias in TES ozone profiles compared to sondes is decreased in the upper troposphere for the V003 data. Comparisons of TES data to measurements from the NASA Langley Research Center DIAL lidar instrument show a similar high bias in the troposphere of between 5-15%. Comparisons of stratospheric ozone columns calculated from the TES data to similar columns from MLS ozone show good agreement with TES biased high by 2-5 DU.

Nadir Carbon Monoxide

Validation analyses of TES carbon monoxide V002 and V003 data products have been documented in the TES validation report and the publications. Few differences are found between TES V002 and V003 CO fields for the tropics and mid-latitudes. The major difference between the two versions is the larger variability seen in the V003 data at high latitudes due to relaxation of the *a priori* constraints.

Comparisons to the aircraft in-situ measurements during INTEX-B 2006, AVE 2004, and PAVE 2006 are performed to help assess the TES CO retrieval accuracy and to address the influences of tracer spatial/temporal variability to the comparisons. The agreement between TES CO profiles and data taken *in situ* is within 15%, less than the variability of the CO in TES and aircraft measurements.

Global comparisons between Terra MOPITT and TES CO measurements have been performed as well. The results show that for pressure layers where both instruments are most sensitive, the retrievals agree to within 10%. The global CO pattern observed by TES shows similar qualitative features to those seen by MOPITT. Comparison between TES CO data in the upper troposphere and those from the ACE instrument show an agreement of 7.4% at 316 hPa.

In early December 2005, an adjustment was made to the optical bench temperature that improved the quality of the TES CO product. Data taken after December 6, 2005 are of better precision and have better vertical resolution.

Nadir Atmospheric Temperature

The V003 TES temperature retrievals have been improved due to the use of the CO2 band with improved spectroscopy in the retrieval software. The V003 TES nadir temperature profiles now have 3 to 4 more degrees of freedom for signal as compared to V002. The predicted errors in temperature are reduced by ~0.1 K in the troposphere and ~0.5 K in the stratosphere. Comparisons to sondes show that TES V002 temperature retrievals are biased low by ~1K in the upper troposphere and stratosphere. This bias has been reduced to 0.5 K in the V003 data. The sonde comparisons also show a cold bias of 1 to 2 K at 400 hPa for both V002 and V003 data.

Nadir Water Vapor

Retrievals of water from TES show a wet bias throughout much of the troposphere when compared with radiosondes. The bias is on the order of 5-10 % below 700 hPa and 5-40% between 700 and 300 hPa. Definitive conclusions from the comparisons are difficult to obtain because of sampling issues, differences in sonde measurements and the inherent variability of water in the troposphere. The differences seen between TES and the sondes were fairly consistent for both V002 and V003 data. The TES water profiles have shown good qualitative agreement with in situ aircraft data. Comparisons of TES V002 data and AIRS total column water vapor is 10% drier than AMSR-E and AIRS. Comparison of the water vapor profiles from TES and AIRS show that most of the difference in the column is accounted for by the 700-900mb layer.

Nadir HDO

Comparisons of the TES HDO/H2O ratio to models, to the expected HDO/H2O ratio over oceans and to aircraft observations in the lower troposphere suggest that the HDO/H2O ratio is 5% too high. This bias is likely associated with either the H2O or HDO spectroscopy (or both) and/or with the TES calibration. Future co-located observations of in-situ observations will allow us to better understand this bias.

Because the problem of estimating HDO is highly non-linear, it is suggested that the data only be used when the sensitivity, as defined by the "DegreesOfFreedomForSignal" variable in the product files, has a value of 0.5 or higher. This is an ad-hoc threshold based on current analysis of the data and may be adjusted in the future.

Nadir Methane

TES methane retrievals should be considered as a "beta" product in the V003 data. We are currently working to characterize and validate the methane product. Preliminary comparisons utilizing very limited data sets have revealed a high bias in the TES methane product of ~5%. Preliminary comparisons with ground-based up-looking IR Fourier transform spectrometer data (available through from the international Network for the Detection of Stratospheric Change) show TES is higher by 0-10% in the total column amount (TES vertical sensitivity has not yet been folded into this calculation). Compared with a profiles obtained from in-situ data taken during the 2006 INTEX-B campaign, TES was often ~5% higher than the in-situ data in the 200-400 hPa range.

Nadir Surface Temperature (Sea Surface Temperature)

TES retrieves surface (skin) temperature as standard product. Over ocean this amounts to a sea surface temperature (SST). The TES SST compared to Reynolds Optimally Interpolated (daily) SST is within 1.2 K (RMS) and has a best fit gaussian width (done to eliminate a small set of cold/cloud contaminated outliers) of 0.6 K for target scenes with effective cloud optical depth less than 0.05. For all target scenes examined the TES SST is within 1.77 K (RMS) with a gaussian width of 0.7 K. For TES SST the master data quality flag eliminates about 20-25% of the target scenes, however the RMS and gaussian widths of TES vs. ROI are the same, 1.77 K (RMS) and 0.7 K.

Limb Ozone

Limb ozone compares well to TES nadir ozone when the averaging kernel is considered in the comparisons.

Limb Atmospheric Temperature

Limb temperature has been compared to sondes from the NCEP (National Centers for Environmental Prediction) data archive. For a TES global survey on September 20-21, 2004, the TES limb temperature shows a -0.15K bias (TES low) and 0.6 rms difference compared to the sonde values in the troposphere, and between 0 and 1.6K bias (TES high) with about a 1-1.5 K rms difference in the stratosphere.

Limb Nitric Acid

Limb nitric acid has been compared to data from in situ aircraft instruments, aircraft FTIR and other satellite instruments. Comparisons to these datasets show TES retrievals provide reasonable results above 100 hPa and the data shows expected global features, such as the stratospheric depletion in the southern polar winter.

Limb Water Vapor

Limb water and HDO in general show low sensitivity and are mainly used as interfering species when retrieving temperature, ozone, and nitric acid.