

**Earth Observing System (EOS)
Aura Spacecraft
Tropospheric Emission Spectrometer (TES)**



Level 3 (L3) Data/Plot User's Guide

Version 1.0

December 17, 2007



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Revision History

| Version | Date | Description/comments |
|----------------|----------------------|-----------------------------|
| 1.0 | Dec. 17, 2007 | Initial Version |

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1. TES Global Survey observations and Level 2 data

The Tropospheric Emission Spectrometer (TES) is one of four instruments on board NASA EOS (Earth Observing System) Aura satellite launched July 15, 2004. TES is an infrared, high spectral resolution Fourier Transform Spectrometer (FTS). It operates in both nadir and limb modes with the routine limb modes terminated May 2005. At Level 2 (L2) processing step, TES calibrated spectral radiances derived from the observed interferograms at Level 1B (L1B) are used to retrieve vertical profiles of atmospheric temperature and chemical species. These L2 data at the observation geolocations and times are used as the inputs to the TES Level 3 (L3) process. This document briefly describes the processing and products at L3 step, providing useful information for TES L3 data and image users in their analyses.

TES L3 process and data are only defined for Global Survey (GS) measurements. Special observation data, e.g., Step and Stare or Transect operated in a small portion of a satellite orbit, is available at L2 only. A single TES Global Survey is an operational mode that makes nadir/limb (Sept 20, 2004 to April 10, 2005) or nadir-only (since May 21, 2005) measurements continuously for 16 orbits (~26 hours). TES routine GS observations are conducted in one-day-on followed by one-day-off cycles for the main purpose of extending overall instrument lifetime. The optional Special Observations are scheduled on the GS off days. Figures 1-1 and 1-2 show examples of geolocations for nadir/limb and nadir-only GS observations.

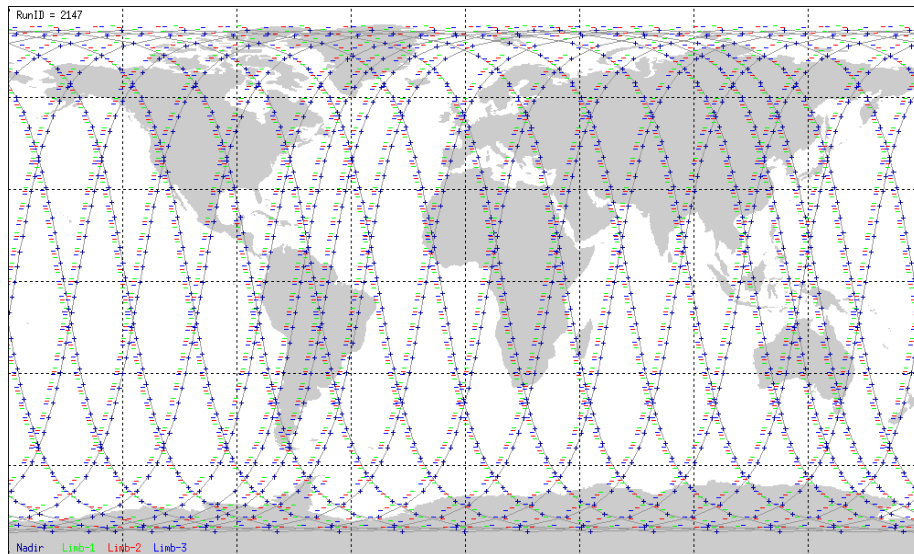


Figure 1-1. TES nadir/limb geolocations for September 20-21, 2004 (run 2147, ~26 hrs) observations, one Global Survey. This is an example for TES GS mode Sept 20, 2004 – April 10, 2005.

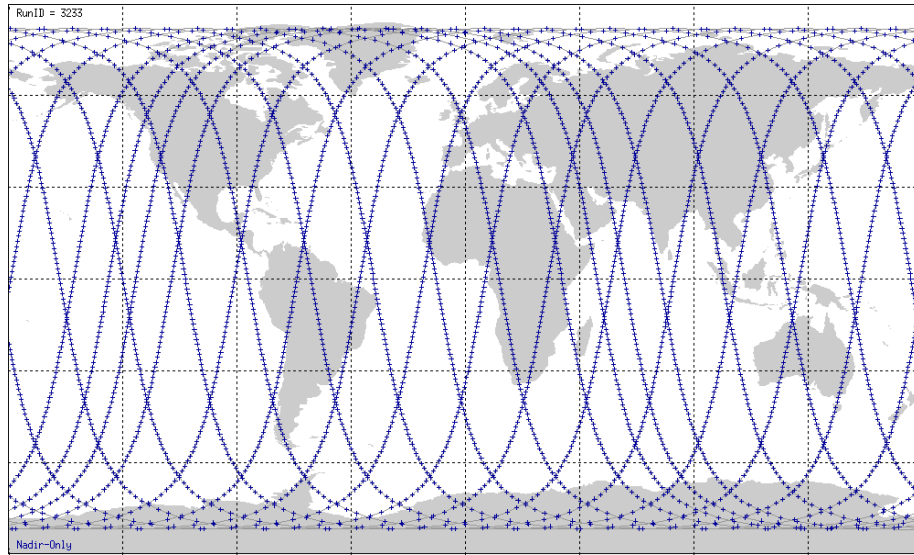


Figure 1-2. TES nadir-only geolocations for January 4-5, 2005 (run 3233, ~26 hours) observations, one Global Survey. This is an example for TES GS mode after May 21, 2005.

TES L2 profiles at these locations per-GS are used as inputs for deriving L3 **Daily** (per-GS) and **Monthly** (all GS in the calendar month) products. Table 1-1 lists the species names and viewing mode (nadir or limb) for L3 daily and monthly products. Other detailed information on L3 products is described in the following sections.

Table 1-1. L3 species and viewing mode.

| Species | Temperature | Ozone | CO | H ₂ O | HDO | CH ₄ | HNO ₃ |
|---------|-------------|-------|----|------------------|-----|-----------------|------------------|
| Nadir | x | x | x | x | x | x | |
| Limb | x | x | | x | x | | x |

2. Purposes and algorithms for producing TES Level 3 data and browse plots

TES Level 2 profile data for a given Global Survey measurements are located at either nadir or limb tangent along Aura orbits. Figure 2-1 left panel shows the CO distribution along the 16 orbit tracks at TES nadir locations for a GS time period of Sept 14-15, 2007. Evidences of enhanced CO due to biomass burnings or pollutions are seen in S Africa, S America, and E. Asia. However, there is a need to view the TES global distribution data more clearly by filling the gaps between the orbits. Figure 2-1 right panel shows the CO global distribution image generated from TES Level 3 data defined at uniform

latitude/longitude grids for the same GS. Compared to the dotted plot, this image is much improved in helping TES data users to view features in TES CO global distributions.

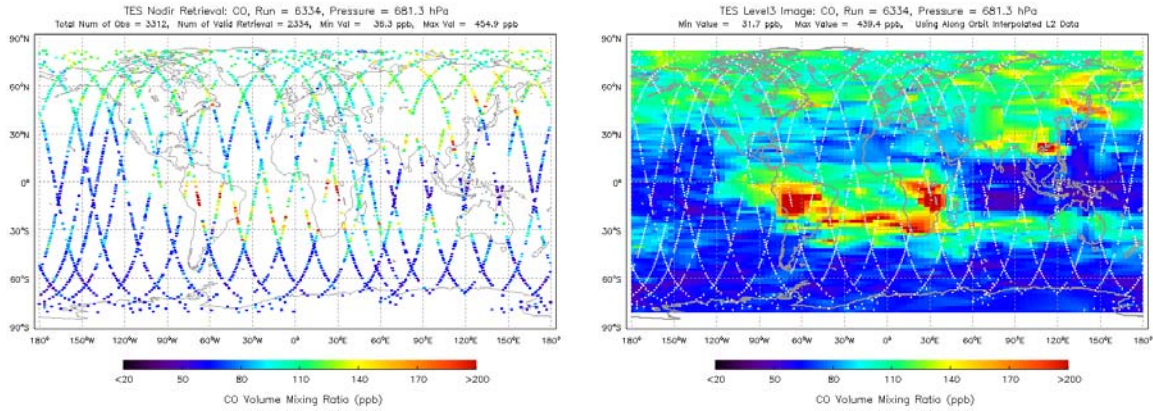


Figure 2-1. TES CO Volume Mixing Ratio (VMR) at 681.3 hPa derived from Global Survey observations taken on September 14-15, 2007. The colored dots in the left panel are CO VMRs at much enlarged footprints (the actual TES nadir footprint is ~5kmx8km). The left panel is the image from L3 data overlaid with nadir observation geolocations.

TES team provides Level 3 data for **Daily** (per GS) and **Monthly** (per calendar month) time periods. The corresponding L2 data are collected and screened with the L2 master quality flag before feeding to the L3 process. The algorithm for generating **Daily** L3 data is Delaunay triangulations on a latitude/longitude plane followed by 2-D interpolations for a fixed TES pressure level. The triangles across the poles are not used for interpolations at L3 points near the poles. The extrapolations are used instead for these points. The algorithm for generating **Monthly** L3 data is binning averages inversely weighted by distances between L2 and L3 locations and retrieval errors in L2 profiles. They are also done at a sub-set of L2 pressure levels, respectively.

It is important to note that the main advantage of TES L3 data and image is for data browsing. For the **Daily** products, horizontal interpolation is done to fill unknown data gaps and no time interpolation is considered. For the **Monthly** products, horizontal bin-average is done and there are unknown data gaps in time and location for the month. Most scientific analysis therefore should treat TES Level 2 data as the primary data source. In the next section, detailed information for deriving TES L3 V1.0 data and associated browse images is listed.

3. An overview of TES Level 3 data and browse plots

TES Level 3 process produces data and browse plots. Table 3-1 summarizes useful information on their contents. Data and plot file access information can be found in the next two sections.

Table 3-1. TES Level 3 data and browse plots overview

| | | |
|------------------------------|---|---|
| Data | Longitude and latitude ranges (degrees) | 0 - 360° and 82°S – 82°N |
| | Grid spacing in longitude and latitude (degrees) | 4° longitude X 2° latitude |
| | Number of longitudes, latitudes and pressures | 90 longitude X 83 latitude X 16 or 15* pressures * Monthly |
| | Pressure grids (hPa) | Surface*, 825.402, 681.291, 464.160, 316.227, 215.444, 146.779, 100.000, 68.1295, 46.4158, 31.6229, 21.5443, 14.6780, 10.0000, 6.81291, 4.64160 * Daily only |
| | Nadir species product list | Surface Temperature (day/night), Atmospheric Temperature (day/night), Ozone ^{1,2} , CO ¹ , CH ₄ ¹ , H ₂ O ¹ , HDO ¹ ¹ include total column ² include tropospheric column |
| | Limb species product list | Atmospheric Temperature, Ozone ^{1,2} , H ₂ O ¹ , HDO ¹ , HNO ₃ ¹ ¹ include total column ² include tropospheric column |
| | File format | 'he5', |
| | Filename example and explanation (Daily) | 'TES-Aura_L3-O3_r0000002147_F01_04.he5', where 'O3' is the species name, '0000002147' is the runID, 'F01_04' represent software version of V01 and data format version of V04. |
| Monthly Data Specific | Averaging binbox size: deltaFullLongitude X deltaFullLatitude (degrees) | 8° longitude X 4° latitude |
| | Statistical analysis per binbox | dataCount, maximum, minimum, stdDeviation |
| | Filename example and explanation (Monthly) | 'TES-Aura_L3-O3-M2007m10_F01_04.he5', where 'O3' is the species name, '2007m10' represent October 2007, 'F01_04' represent |

| | | |
|---------------------|---|---|
| | | software version of V01 and data format version of V04. |
| Browse Plots | Plot types | ‘Dots’ at target locations (nadir or limb tangent) along Aura orbit from L2 data (.png files); ‘Image’ from L3 data (.png files or a combined .h5 file Daily or Monthly); ‘Google Earth overlay’ from L3 image (.kmz files) |
| | HDO plot specific | Delta-D = 1000(HDO/H2O/3.1e-4 - 1), per mil |
| | Nadir pressure levels (hPa) | Surface ¹ , 681.291, 464.160, 316.227, 215.444, 146.779, 100.000, total or tropospheric ² columns ¹ Daily only ² Ozone only |
| | Limb pressure levels (hPa): H ₂ O and HDO | 681.291, 464.160, 316.227, 215.444, 146.779, 100.000, total column |
| | Limb pressure levels (hPa): Atmospheric Temperature and Ozone | 681.291, 464.160, 316.227, 215.444, 146.779, 100.000, 68.1295, 46.4158, and total and tropospheric columns for Ozone |
| | Limb pressure levels (hPa): HNO ₃ | 215.444, 146.779, 100.000, 68.1295, 46.4158, 31.6229, 21.5443, 14.6780, 10.0000, and total column |
| | File format | ‘.png’ or ‘.kmz’ files. |

4. Web access to TES Level 3 browse plots

TES Level 3 Daily and Monthly browse plots (.png and .kmz files) are made available on-line via the TES public website, <http://tes.jpl.nasa.gov/gallery/level3Plots.cfm>. On the same webpage, browse plots for the Special Observations organized by observation campaigns are also available. The interfaces for displaying L3 image maps are easy to navigate. Figure 4-1 and 4-2 shows example Daily and Monthly web interface respectively. In the displaying window for the Daily plots, L2 dot plot and the corresponding L3 image plot for a given species and pressure level are always placed side-by-side, useful for data analyses.

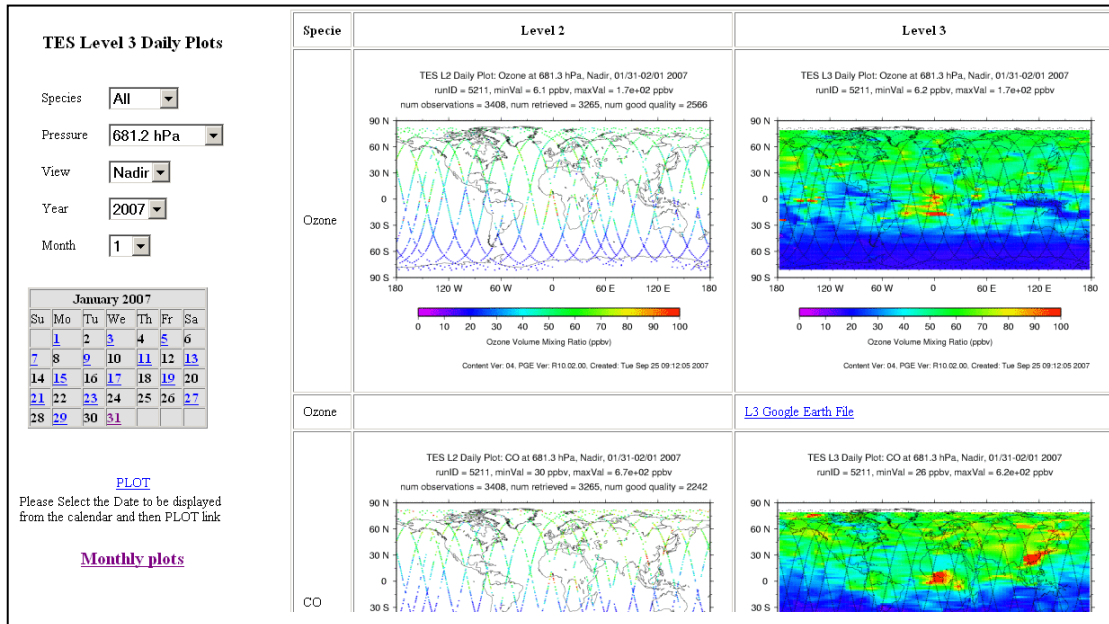


Figure 4-1. Example TES L3 Daily browse plots web-interface.

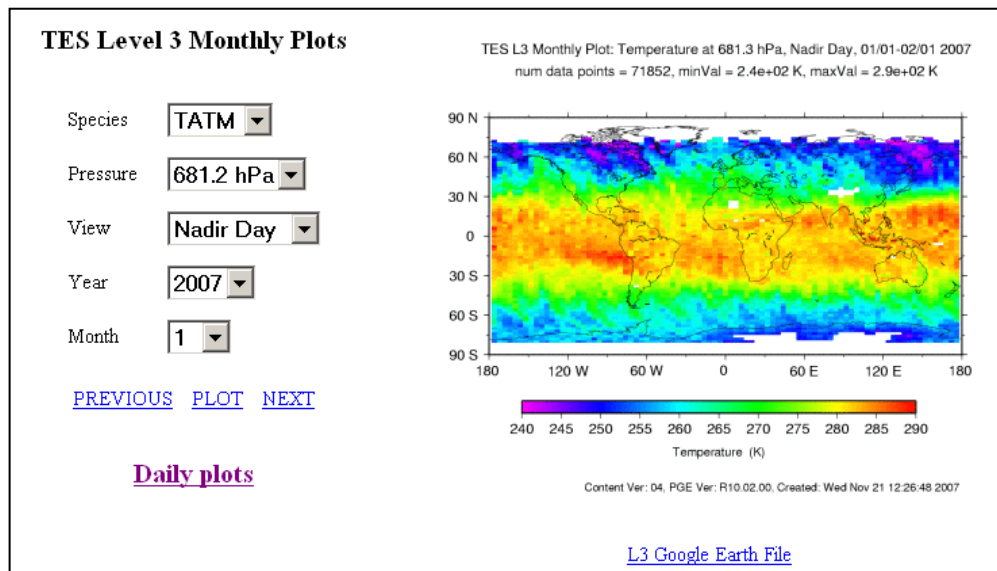


Figure 4-2. Example TES L3 Monthly browse plots web-interface.

5. References

The following **TES documents** controlled, defined, described or useful to the developments and applications of TES Level 3 data products and browse plots.

Tropospheric Emission Spectrometer: Science Objectives & Approach, Goals & Requirements. JPL D-11294, Version 6.0, April 1999.

Tropospheric Emission Spectrometer: TES Level 3 Algorithms, Requirements, and Products, JPL D-26534, Version 2.0, April 2005.

Tropospheric Emission Spectrometer: TES Level 3 Software Requirements, JPL D-37019, Version 1.2, November 2006.

Tropospheric Emission Spectrometer: Science Data Processing Standard and Special Observation Data Products Specifications, JPL D-22993, Version 10.13, April 2007.

Tropospheric Emission Spectrometer: Level 2 Algorithm Theoretical Bases Document. JPL D-16474, Version 1.1, October 1999.

Tropospheric Emission Spectrometer: Level 2 (L2) Data User's Guide, JPL D-38042, Version3.0, May 2007.

Tropospheric Emission Spectrometer: Data Validation Report, JPL D-33192, Version3.0, November 2007.

The following list of **web pages** provides links for obtaining TES L3 data, plots, and papers with TES data applications.

TES page at NASA Langley Atmospheric Science Data Center (ASDC) consisting links for ordering/accessing data, documentations, and IDL data file reader routines:

http://eosweb.larc.nasa.gov/PRODOCS/tes/table_tes.html#data.

To order TES L3 data and quick look browse plots at EOS Data Gateway:

<http://redhook.gsfc.nasa.gov/~imswww/pub/imswelcome/plain.html>.

The 'headquarter' for TES L3 Daily and Monthly browse plots on the TES public website: <http://tes.jpl.nasa.gov/gallery/level3Plots.cfm>.

To relate calendar dates with a TES runID: <http://tes.jpl.nasa.gov/science/dataCalendar.cfm>.

The **publication list** on the TES website consists papers published on the peer reviewed journals: <http://tes.jpl.nasa.gov/docsLinks/publications.cfm>.