



Update on the validation status of the Aura Tropospheric Emission Spectrometer (TES) data

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Aura Science Team Meeting
November 8, 2005



TES Measurement Status

- Global Surveys (with limb scans) taken Sep 2004 – Apr 2005
 - 73 16-orbit Global Surveys acquired with limb data
 - Nadir targets $\sim 5^\circ$ apart along orbit track (2 nadir scans averaged)
- Global Surveys without limb scans started May 2005
 - 3x more nadir targets, $\sim 1.6^\circ$ separation, no averaging of scenes
 - Limb mode still available for special observations, but removed from the Global Survey mode to preserve instrument lifetime.
 - No data for June 2005 due to instrument in safe mode.
- Step/Stare, Stare and Transect modes used for special observations
 - AVE Oct 2004 – Nov 2004 & PAVE Jan 2005 – Feb 2005
 - S. Atlantic Sep 2004 – Oct 2004, Jan 2005 – Feb 2005
 - N. America July 31, 2005 – August 6, 2005
 - Lake Tahoe (Stare mode for geolocation, radiance validation) Aug 05 – Sep 05
 - S. America (biomass burning transects) Aug 2005 – Sep 2005

TES Data Availability

- L2 Products (v001) have been available since July 2005
- TES data available at the Langley Atmospheric Sciences Data Center (ASDC)
 - <http://eosweb.larc.nasa.gov/>
 - Nadir scenes only.
 - Global Surveys only.
 - Caveats listed for L1B calibration and L2 land retrieval issues.
 - Data in HDF-EOS5 Format
- TES data available at the Aura Validation Data Center
 - <http://avdc.gsfc.nasa.gov/>
 - Preliminary data for special observations and select global surveys (IDL "Save" format)
 - Data taken during AVE 04 available.
 - Subset of data taken during PAVE 05 available.

Data Quality of TES Data Products (v001)

- Level 1B:
 - TES L1B data products have systematic errors that will be fixed in v002 data.
 - Systematic errors are estimated after radiometric calibration and show an average radiance error of approximately 2% .
 - Errors specific to each target spectrum are available within the data products.
- Level 2:
 - TES L2 products that are ready for scientific use are nadir retrievals of **ozone, carbon monoxide, temperature, surface temperature** and **water**.
 - Caveats on TES L2 Products:
 - High altitude land scenes are reported but are not reliable due to a software bug.
 - TES L2 retrievals over some desert regions have problems with the a priori estimates of emissivity and should not be used.
 - Retrieved parameters poleward of 60 degrees latitude should be used with caution due to the low brightness temperatures associated with these scenes.
 - As a means of accounting for systematic errors in L1B radiances, current L2 profiles include the retrieval of a calibration scaling parameter.
 - The error estimates included in the L2 data products are meaningful based on the current validation analysis.

TES Data Availability (v001)

July - October 2005

TES Science Observations and Available Level 2 Products: 2005

Updated 11-04-05

July						
S	M	T	W	T	F	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
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24	25	26	27	28	29	30
31						

August						
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28	29	30	31			

September						
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October						
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30	31					

November						
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December						
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18	19	20	21	22	23	24
25	26	27	28	29	30	31

L2 Product Available: Blue = Global Survey Red = Step&Stare Green = Transect Magenta = Stare
 Dark Gray = L2 Product Not Available Orange = RunID for Global Survey Light Gray = Focal Plane De-Ice

TES Data Availability (v001)

January - June 2005

TES Science Observations and Available Level 2 Products: 2005

Updated 11-04-05

January						
S	M	T	W	T	F	S
						1 2463
2 2468	3	4	5	6	7	8
9 2476	10 2481	11 2486	12 2491	13 2496	14 2501	15
16 2496	17	18 2501	19	20 2506	21 2511	22
23 2535	24	25 2570	26	27 2584	28	29 2592
30	31 2597					

February						
S	M	T	W	T	F	S
		1	2	3	4	5
6 2630	7	8	9	10 2649	11	12 2654
13	14	15	16	17	18	19
20 2709	21	22	23	24	25	26 2749
27	28					

March						
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6 2771	7	8	9	10	11	12 2786
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27	28	29	30	31		

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29	30	31				

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26	27	28	29	30		

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TES Data Availability (v001)

July - December 2004

TES Science Observations and Available Level 2 Products: 2004

Updated 11-01-05

July						
S	M	T	W	T	F	S
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August						
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29	30	31				

September						
S	M	T	W	T	F	S
			1	2	3	4
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October						
S	M	T	W	T	F	S
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3	4	5	6	7	8	9
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December						
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			1	2	3	4
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19	20	21	22	23	24	25
26	27	28	29	30	31	

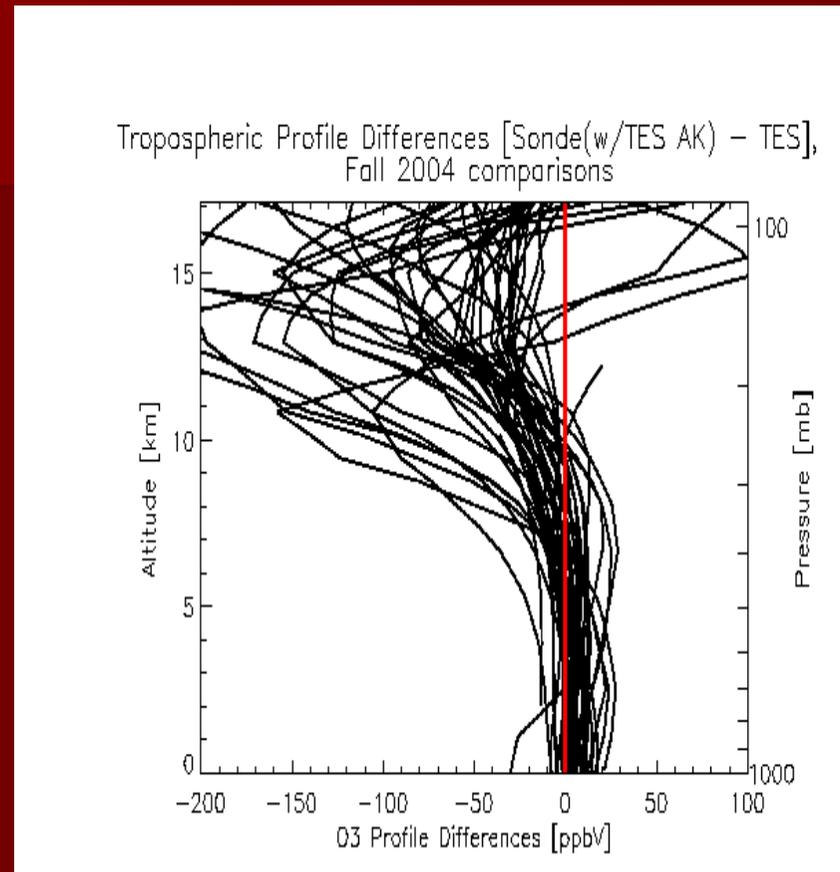
L2 Product Available: **Blue** = Global Survey **Red** = Step&Stare **Green** = Transect **Magenta** = Stare
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Ozone Validation (Launch + 14 Months)

Data Description	Instrument or Campaign	Contacts
Ozonesondes	SHADOZ, AVE, PAVE sondes	Helen Worden, Jennifer Logan
Satellite Total Ozone Column Comparisons	OMI, TOMS, SBUV, MLS	Greg Osterman
Models	GEOS-Chem	Qinbin Li, Line Jourdain, Lin Zhang, Daniel Jacob
In situ	FASTOZ, NOAA	Bob Herman, Ming Luo, Greg Osterman
Partial Ozone Column	CAFS	Greg Osterman
Lidar Profiles	DIAL, AROTAL	Greg Osterman, John Worden

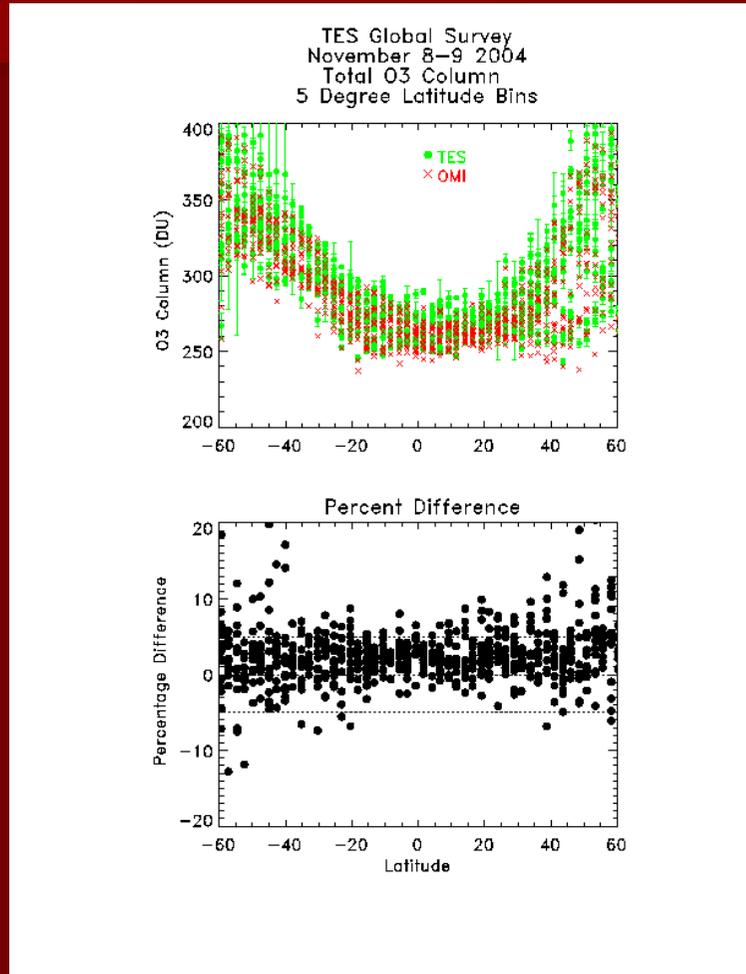
- Key Result: Comparisons with sondes show a consistent bias toward larger ozone concentrations in the upper troposphere measured by TES.

TES Ozone Validation



- Able to detect expected variability of ozone in the lower troposphere
- Bias in the upper troposphere (peaked at 200 - 150 hPa)

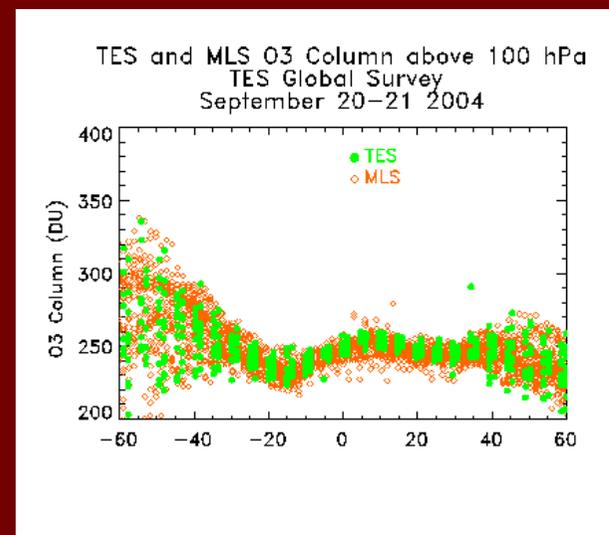
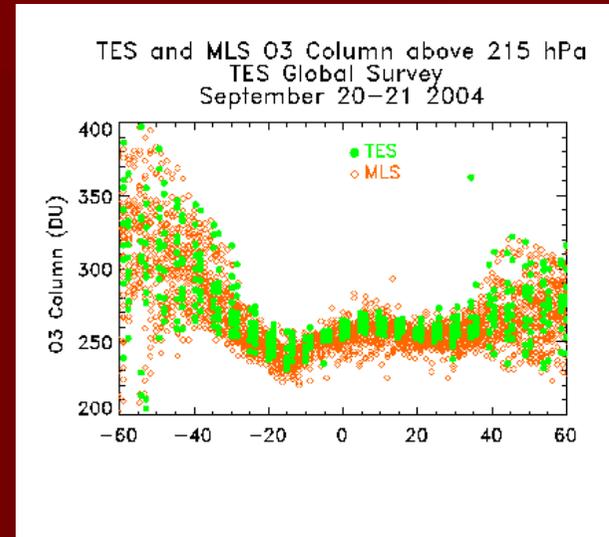
TES-OMI Comparison



- On average TES sees higher column values than OMI.
- Differences roughly in the 3-8% range between 60°N – 60°S
- Consistent for all Global Surveys from Nov 2004 and Jan 2005

Comparison with MLS

- TES measures ozone in the stratosphere
- Detailed statistics needed, but initial comparisons with MLS looks very promising
- Look at comparisons at different MLS levels



Carbon Monoxide Validation (Launch + 14 Months)

Data Description	Instrument or Campaign	TES Contacts
Satellite	MOPITT, ACE, MLS	Ming Luo
Aircraft	Argus, DACOM	Ming Luo
Models	GEOS-Chem	Qinbin Li, Line Jourdain, Nigel Richards

■ Key Results:

- Comparisons between TES and MOPITT at pressure layers where both instruments are most sensitive show that the retrievals agree to within roughly 10%
- Comparisons between TES and Argus agree to within the TES measurement error.
- GEOS-Chem and TES data show the same broad latitudinal structure in CO at all altitudes and consistent inter-hemispheric gradients.

Water Vapor Validation (Launch + 14 Months)

Data Description	Instrument or Campaign	TES Contacts
Satellite	AIRS, AMSR-E, MLS	Annmarie Eldering, Mark Shephard, Tony Clough, Karen Cady-Pereira
Aircraft	JLH, DLH, NOAA FP Hygrometer	Bob Herman

■ Key Results:

- TES total column water vapor is 10% drier than AMSR-E and AIRS.
- Most of the difference in the column is seen in the 700-900mb layer.
- Initial comparisons of TES water retrievals to aircraft instruments show good qualitative agreement.

Temperature Validation (Launch + 14 Months)

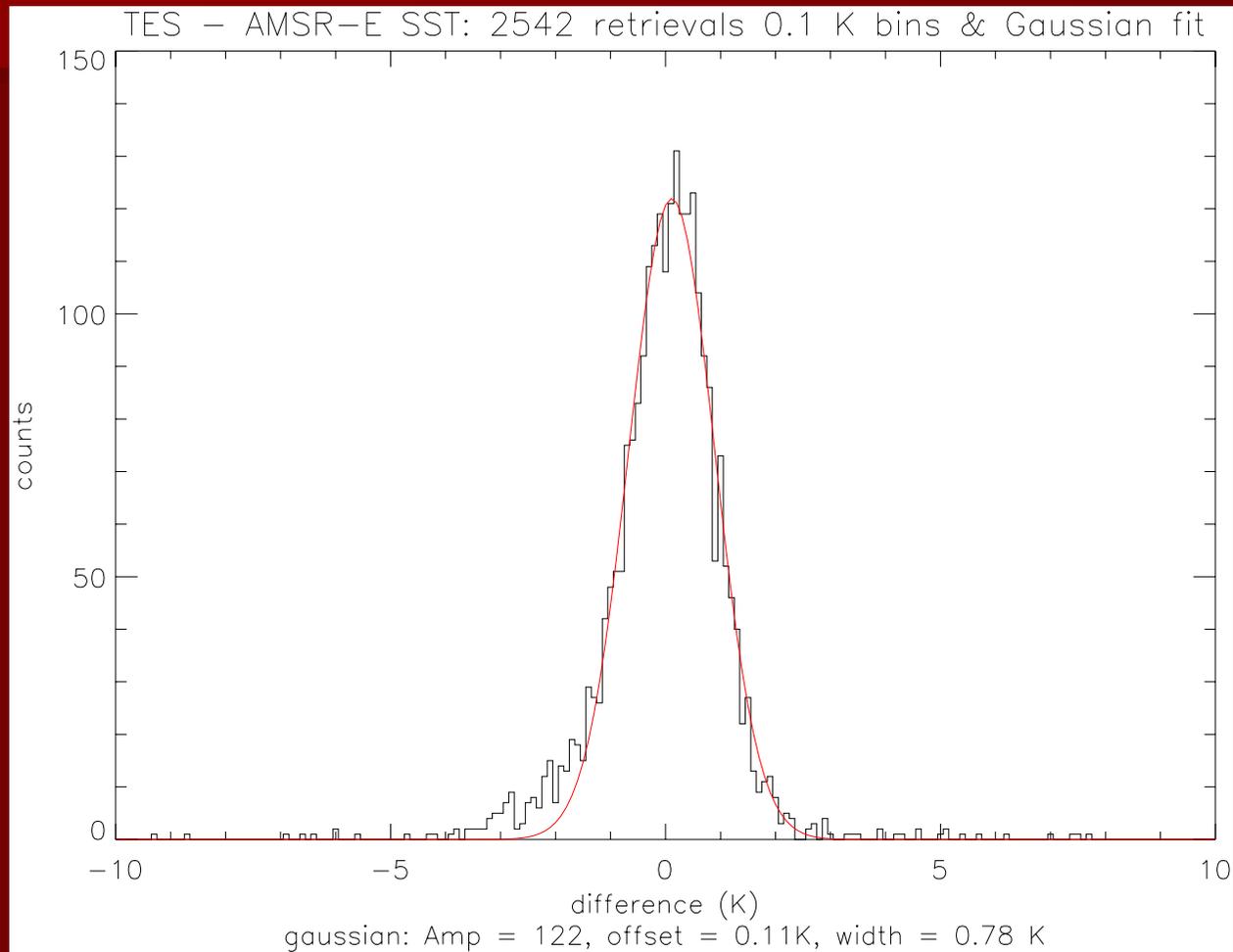
Data Description	Instrument or Campaign	TES Contacts
Satellite	AIRS, MLS	Annmarie Eldering, Mark Shephard, Tony Clough, Karen Cady-Pereira
Aircraft	AVE, MTP	Bob Herman
Surface Temperature	Reynolds Optimally Interpolated SST, AMSR-E	Michael Lampel

■ Key Results:

- Comparisons of AIRS and TES temperature data show that the temperature profiles agree to within 2K.
- The vertical structure of the difference between TES and AIRS profiles is consistent from day to day.
- Preliminary results show excellent agreement to Reynolds Optimally Interpolated SST with overall bias of $\sim 0.1\text{K}$.

TES – AMSR-E

Sea Surface Temperature Histogram & Gaussian Fit



- χ^2 of Gaussian fit to histogram = 13.5
- Near Gaussian shape consistent with statistically independent measurements
- AMSR-E rms error is 0.5 K
- **Derived TES rms error: 0.6K**

Overall Validation Status of TES L2 Data (v001)

- The TES L2 nadir products have undergone an initial set of quality control and validation.
- The current TES L2 data products (v001) available to the public are considered a “beta” release and have been available starting in July 2005.
- The effort to validate the TES L2 products is in the process of being expanded and will provide more comprehensive comparisons in the near
- TES Validation Report – July 2005 (v001 data)
 - Available by email, contact Greg Osterman (Gregory.Osterman@jpl.nasa.gov)
 - Available soon at the TES website (<http://tes.jpl.nasa.gov/>)

TES L2 Data Version 2 (v002)

- Next data release in Spring 2006
 - L1B calibration improved substantially & validated
 - Will include limb retrievals (with HNO₃)
 - HDO product added for nadir views
 - Processing of special observations

Acknowledgements

- TES Science Team:
 - Kevin Bowman, Karen Cady-Pereira, Tony Clough, Annmarie Eldering, Brendan Fisher, Michael Gunson, Robert Herman, Daniel Jacob, Line Jourdain, Susan Kulawik, Michael Lampel, Qinbin Li, Jennifer Logan, Ming Luo, Inna Megretskaja, Gregory Osterman, Susan Paradise, Hank Revercomb, Nigel Richards, Mark Shephard, Dave Tobin, Solene Turquety, Helen Worden, John Worden, Lin Zhang and Reinhard Beer
- Rich McPeters
- Lucien Froidevaux, Yibo Jiang
- AVDC – Bojan Bojkov



Extra

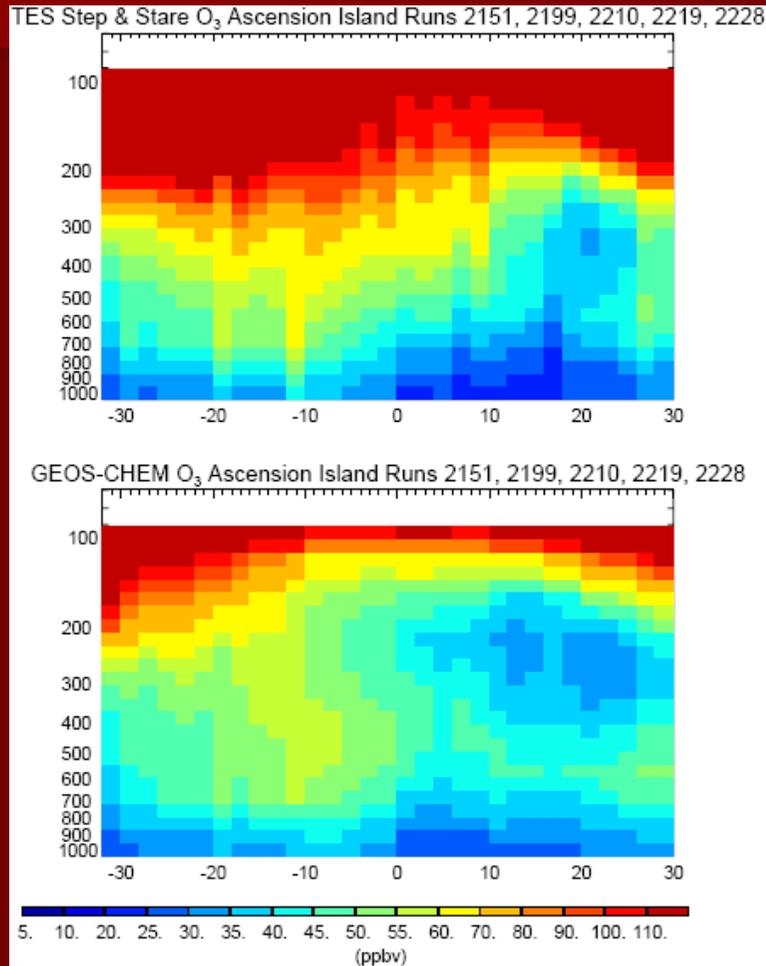


HDO Validation (Launch + 14 Months)

Data Description	Instrument or Campaign	TES Contacts
Aircraft	ALIAS	John Worden

- Key Results:
 - TES sensitive to HDO in the mid-upper troposphere.
 - Initial comparisons with ALIAS look very encouraging.

TES Special Observations



- TES "Step & Stare" observations near Ascension Island (Oct 2004)
- Comparisons with GEOS-Chem model ozone.
- Both TES and GEOS-Chem show enhanced ozone concentrations in the middle and upper troposphere over tropical South Atlantic
- Both show lower values in the lower and upper troposphere around the ITCZ

Radiance Validation (Launch + 14 Months)

Data Description	Instrument or Campaign	Contacts
Satellite Comparisons	AIRS	Helen Worden, Kevin Bowman, Brendan Fisher
Aircraft Comparisons	Scanning-HIS	Hank Revercomb, Mark Shephard, Tony Clough, David Rider

■ Key Results:

- Comparisons between TES L1B radiance spectra and those from AIRS show that they agree to less than 1K in brightness temperature (improved for v002 data).
- Comparisons with AIRS and Scanning-HIS show biases due to systematic errors that are being investigated.

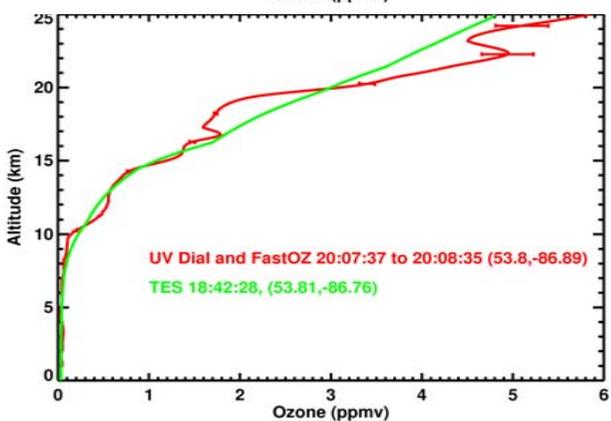
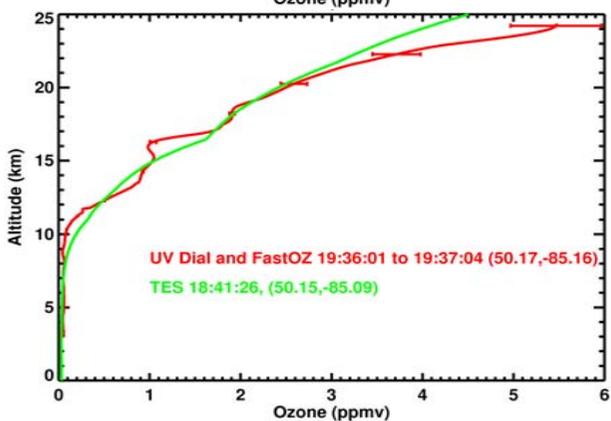
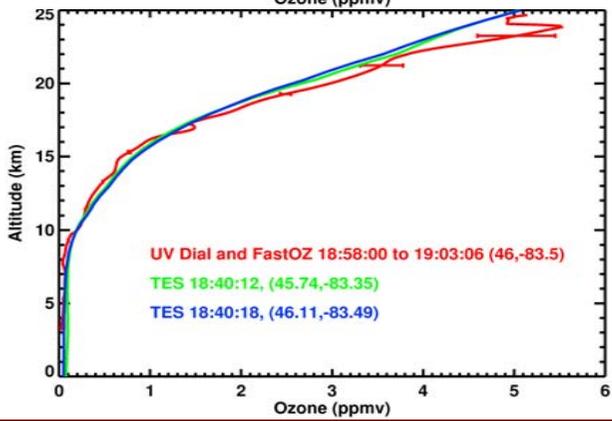
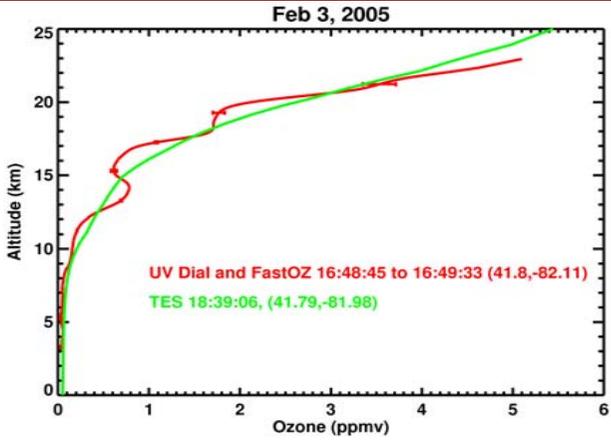
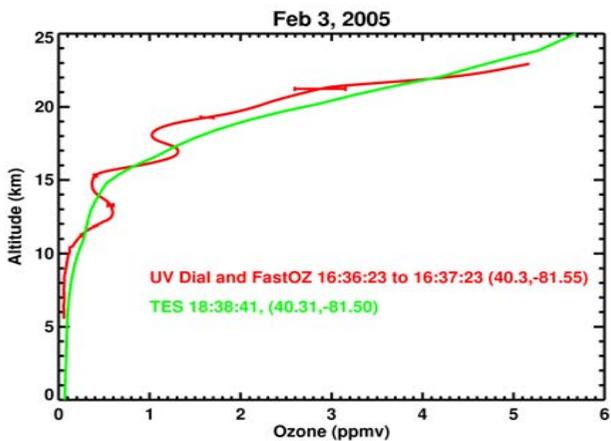
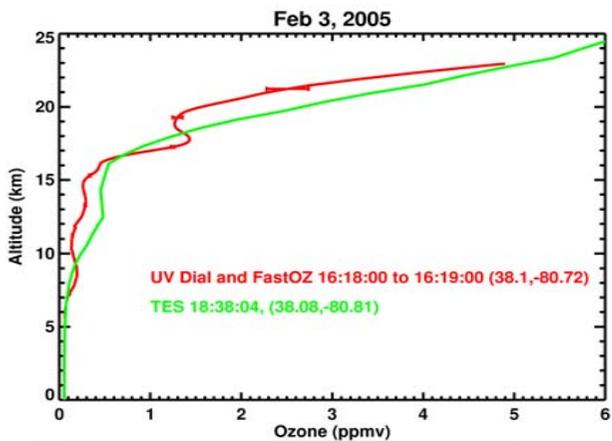
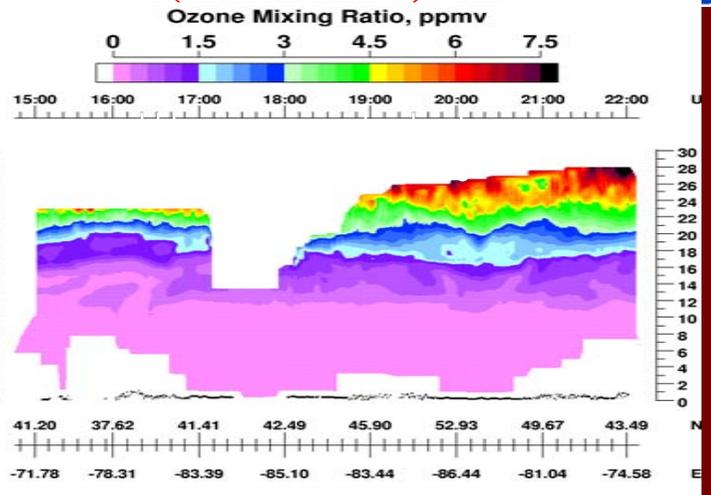
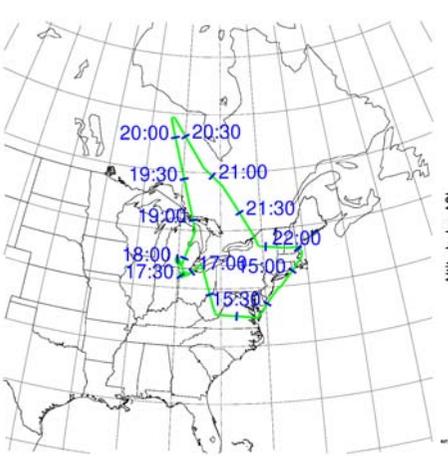
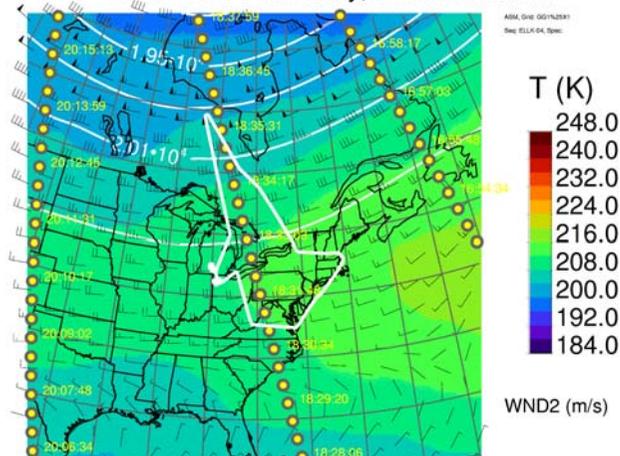
Primary TES L2 Issues (Next 12 Months)

- Ozone in the Upper Troposphere
 - Understand and mitigate the bias currently seen in TES profiles and total column
- Carbon Monoxide
 - More profile comparisons with data under a wider range of CO mixing ratios to better understand TES retrievals
- Water Vapor and Temperature
 - Better understanding of water vapor retrievals in the middle troposphere
 - Reasons for 2 K bias seen in comparisons with AIRS
- Nitric Acid
 - Initial validation of limb nitric acid profiles

Validation Priorities (Next 12 Months)

- INTEX-B (March-May, 2006)
 - Aircraft measurements for ozone, carbon monoxide and nitric acid with primary emphasis being the troposphere
 - Higher number of tropospheric profiles for comparisons
- Maximize the number of ozonesonde launches coincident with Aura overpasses
 - Dedicated ozonesonde campaigns
 - Launches for a variety of geographic and seasonal conditions (improved statistics)
 - Special observations at ARM sites
- MOZAIC Data Analysis for Ozone and Carbon Monoxide
- Continue Analysis of AVE, PAVE data sets
- Support of Field Campaigns:
 - AVE – Costa Rica (January-February, 2006)
 - MONA 2006 (Summer 2006)
 - Texas Air Quality Study/Gulf of Mexico Atmospheric Composition and Climate Study (Summer 2006)

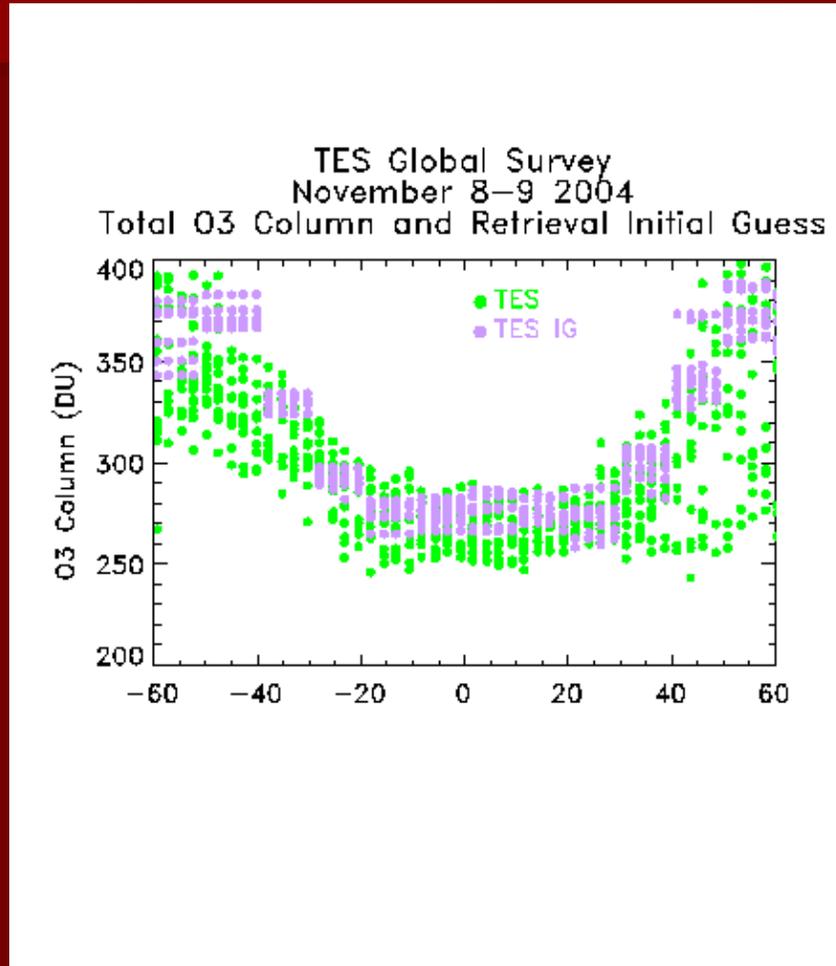
18 UTC on 3 February, 2005 at 50.0 mb



Documents

- TES Validation Report
 - Available by email, contact Greg Osterman (Gregory.Osterman@jpl.nasa.gov)
 - Soon available at TES External Website
- Data Product Specification (DPS)
 - <http://eosweb.larc.nasa.gov/PRODOCS/tes/DPS/> or
 - http://tes.jpl.nasa.gov/publications/documents/Data_Product_Spec_R7.doc
- TES L1 Algorithm Theoretical Basis Document (ATBD)
 - Link
- TES L2 ATBD v2.0
 - Link

A Priori



- TES does move away from the a priori.
- Does the TES initial guess contribute to any possible bias?

TES Nadir Ozone Averaging Kernel

- TES retrievals get 3.5-5.0 degrees of freedom of signal for the entire ozone profile.
- Sensitivity up to ~3 hPa at the top
- Sensitivity down to just above boundary level

