



# MODIS MOD07 Collection 6 products: Impact of H2O/CO2/O3 spectral shifts



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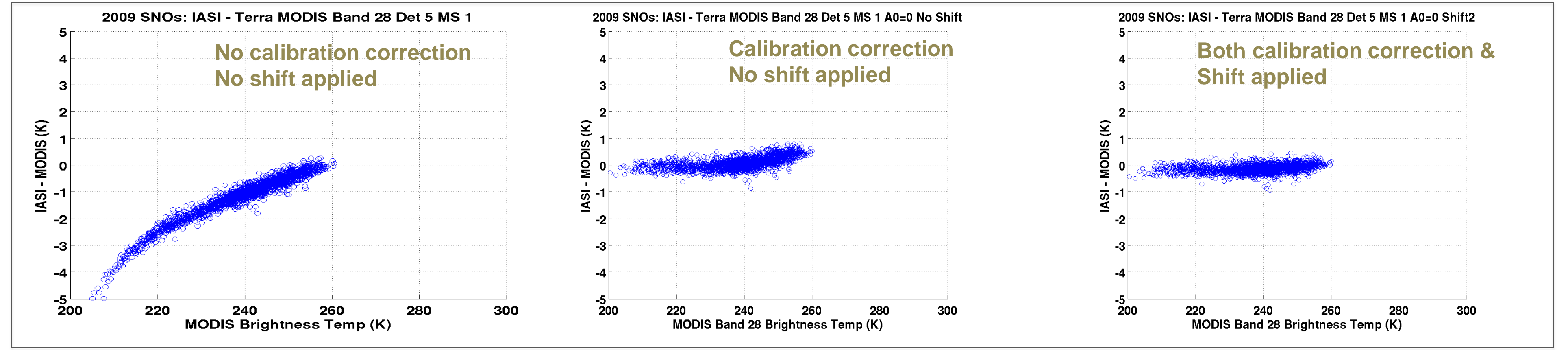
**Abstract:** The operational algorithm for retrieving temperature and moisture profiles and total column ozone and water vapor from infrared (IR) radiances observed by the NASA MODIS instrument is a clear sky synthetic regression retrieval algorithm called MOD07. MOD07 clear-sky radiances over land and ocean for both day and night from eleven MODIS infrared channels (25, 27-36). A new version of this algorithm (Collection 6) has been delivered and the products are available at <http://ladsweb.nascom.nasa.gov>. This poster introduces the new updates - focusing on the impact of the H2O/CO2/O3 channel spectral shifts - and offers local and global comparisons between the collection 5 and 6 products, using Southern Great Plains cart site measurements and the Atmospheric Infrared Sounder (AIRS) retrievals and Total Ozone Mapping Spectrometer (TOMS) products.

## The MOD07 algorithm updates for Collection 6

- Update the CRTM radiative transfer model in MOD07
- Apply zero bias adjustment in the radiative transfer calculation
- Apply H2O/CO2/O3 channel spectral shifts (Tobin et al., 2006, JGR, Tobin, Moeller and Quinn, 2011)
- Update NEdT for both Terra and Aqua
- Update surface emissivity spectra in the training database to the current version
- Make the Aqua and Terra DAAC code uniform
- Modify the TPW low and high products to be able to calculate 3 layer water vapor means. The new layers are: (low) sfc-680 and (high) 440-10 hPa
- Improve QA/QC flags - Confidence flag bug is fixed
- Output file updates: adding offset/scale factor usage, list of pressure levels, K-index valid range fixed, surface temperature changed to skin temperature, mixing ration profile added.

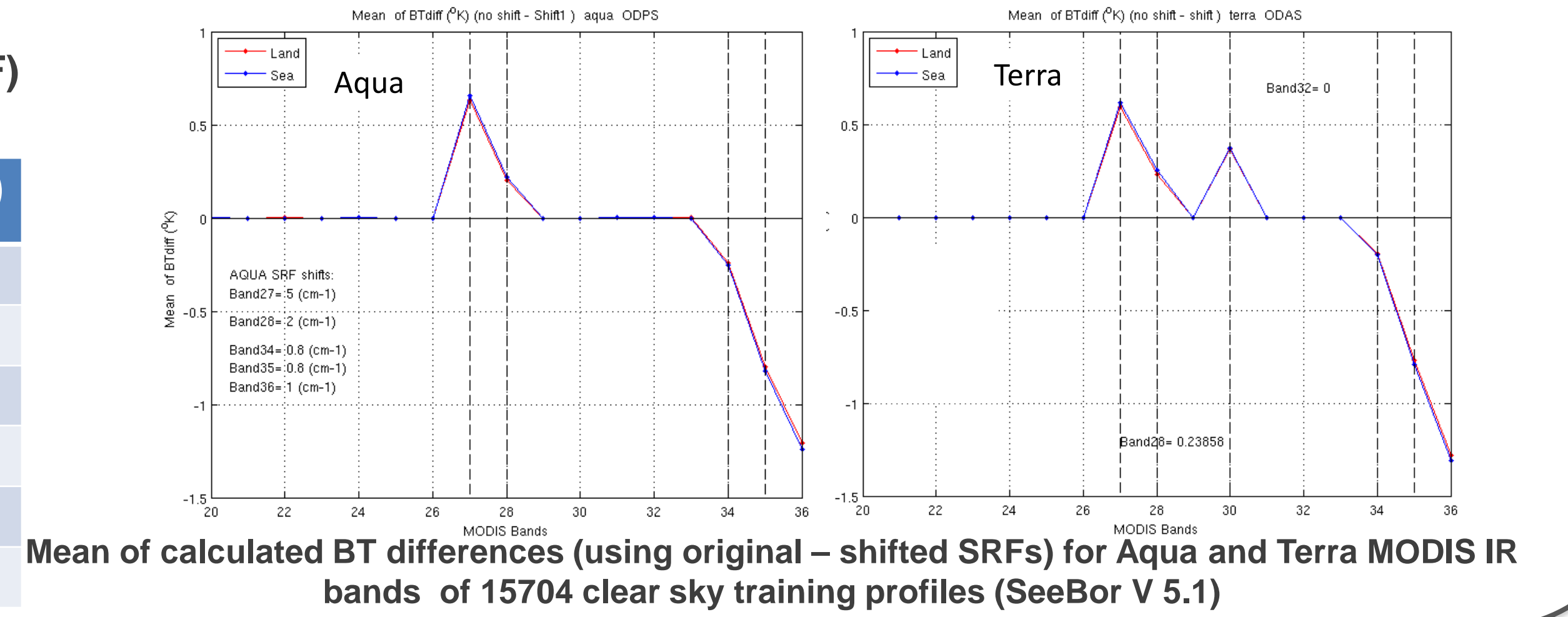
## The H2O/CO2/O3 channel spectral shifts

First, Tobin et al. (JGR, 2006) comparison between AIRS and MODIS radiances suggested the Aqua/MODIS H2O channels (27, 28) need to be more opaque and the CO2 channels (34-36) less opaque. Second, IASI and MODIS comparison study (Quinn et al. - <http://www.ssec.wisc.edu/~gregg/iasi-modis-2011-06/plots-shifted/plots.html>) for 2009 measurements showed that BT biases can be reduced by shifting the Spectral Response Functions for Terra/MODIS bands (20-30).



The following Spectral Response Function (SRF) shifts were applied in C6 MOD07 algorithm:

Band	Terra Shift (cm-1)	Aqua Shift (cm-1)
27 (H2O)	4	5
28 (H2O)	2	2
30 (O3)	1	0
34 (CO2)	0.8	0.8
35 (CO2)	0.8	0.8
36 (CO2)	1	1



## The effect of the H2O/CO2/O3 channel spectral shifts on TPW over the SGP ARM Cart Site

A database of clear sky cases at the ARM SGP site has been developed for evaluation of the MOD07 total precipitable water (TPW) product. This database includes 345 Terra and 317 Aqua overpasses determined to be clear during the period from launch through August 2005. MODIS sensor zenith angle was less than 50° to the Lamont, OK SGP site for all cases. These cases are readily reprocessed in-house to test any changes to the algorithm or training data. MOD07 TPW is compared with the ARM microwave water radiometer (MWR), radiosonde, and TPW from the GOES for all cases.

Aqua/ Versions / FM/ TM	SRF shift	DRY (TPW<15mm)(228) Bias RMS	WET (TPW >=15mm)(89) Bias RMS	ALL (317 cases) Bias RMS
Col 5/pCRTM	No	-0.4 2.2	3.6 5.1	0.8 3.3
CRTM1.2/ODAS	No	-0.2 2.3	4.6 5.7	1.1 3.6
Col6 CRTM1.2/ODAS	Yes	-0.8 2.5	2.3 3.8	0.1 3.0

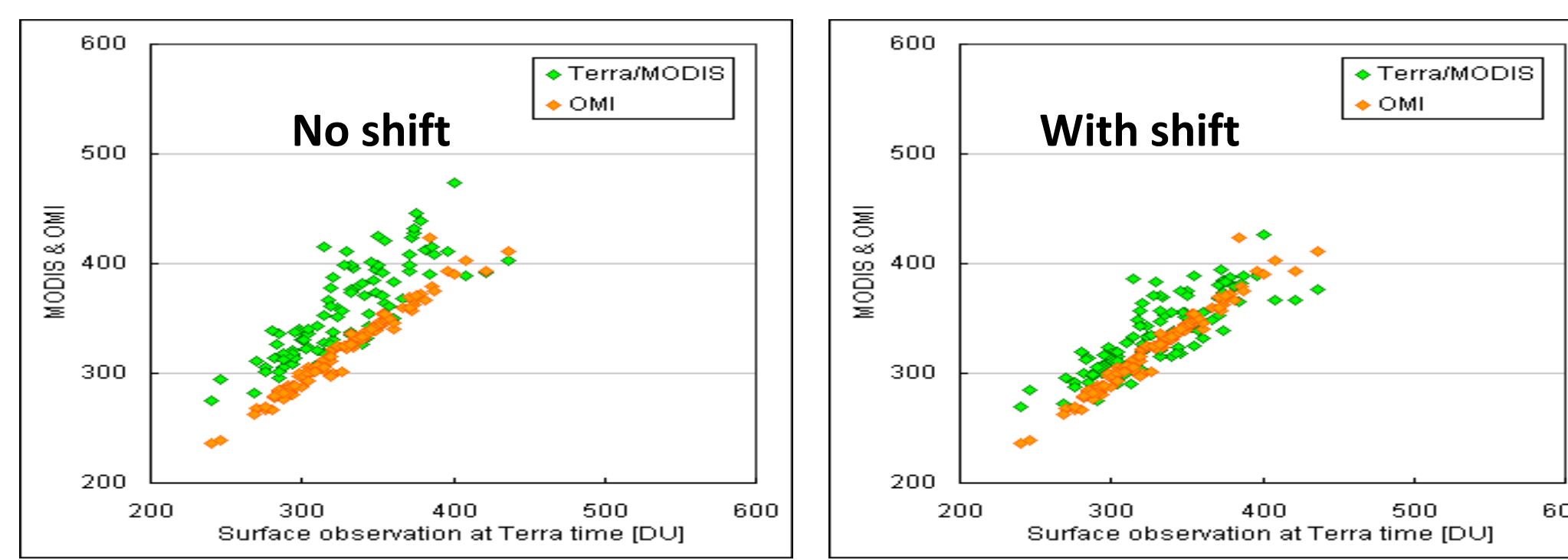
TERRA versions / FM/ TM	SRF shift	DRY (TPW<15mm)(217) Bias RMS	WET (TPW >=15mm)(128) Bias RMW	ALL (345 cases) Bias RMS
Col 5/pCRTM	No	-0.7 2.0	1.1 3.2	-0.04 2.5
CRTM2.0/ODPS	No	-0.8 2.1	2.0 4.2	0.2 3.0
Col6 CRTM2.0/ODPS	Yes	-0.3 2.0	2.8 4.5	0.9 3.2

TPW comparison at the ARM SGP site between MWR and MYD07 derived TPW. Dry and wet cases are separated. SRF shift (yes or no) is indicated in the second column.

## Effect of H2O/CO2/O3 spectral shifts on Total Ozone over Budapest, Hungary

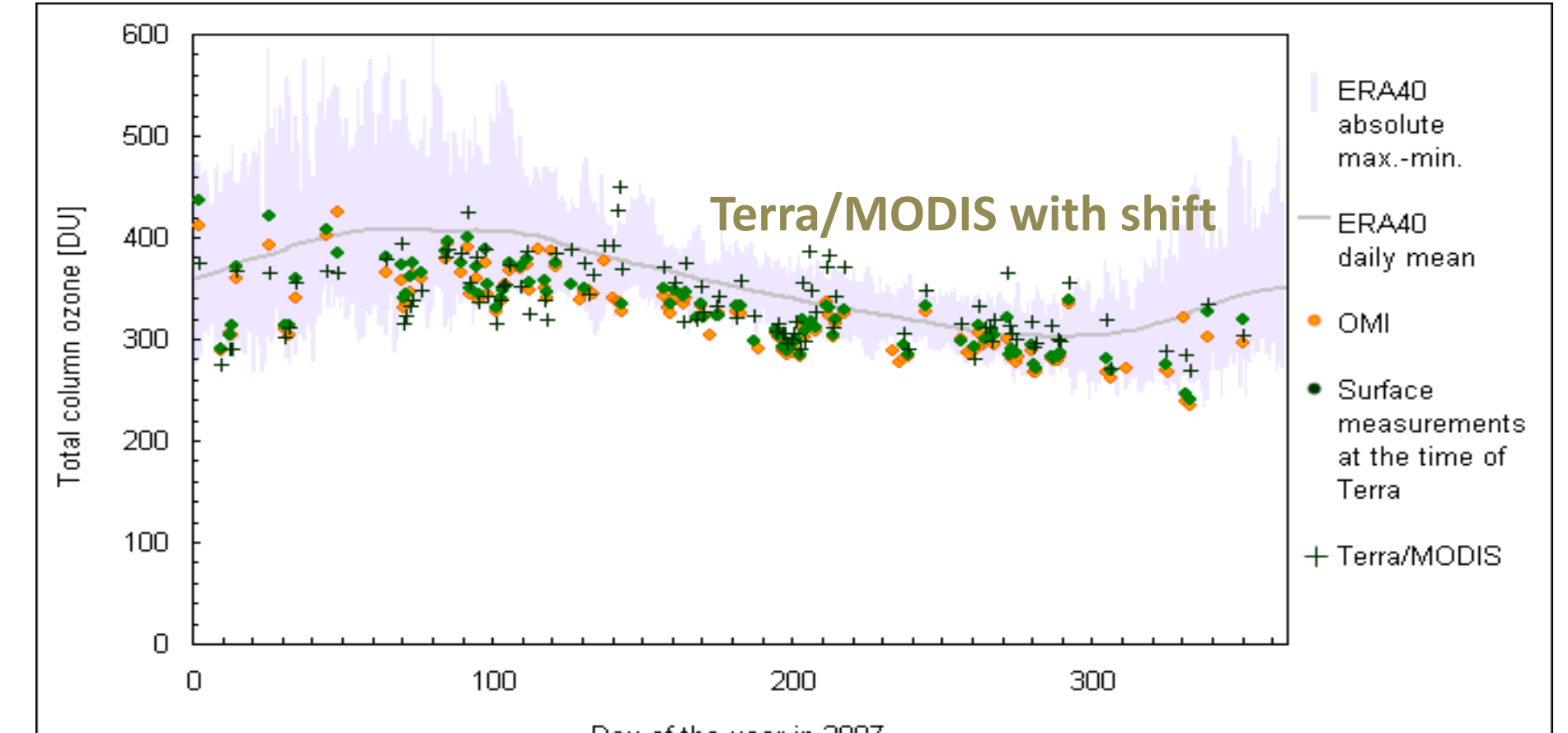
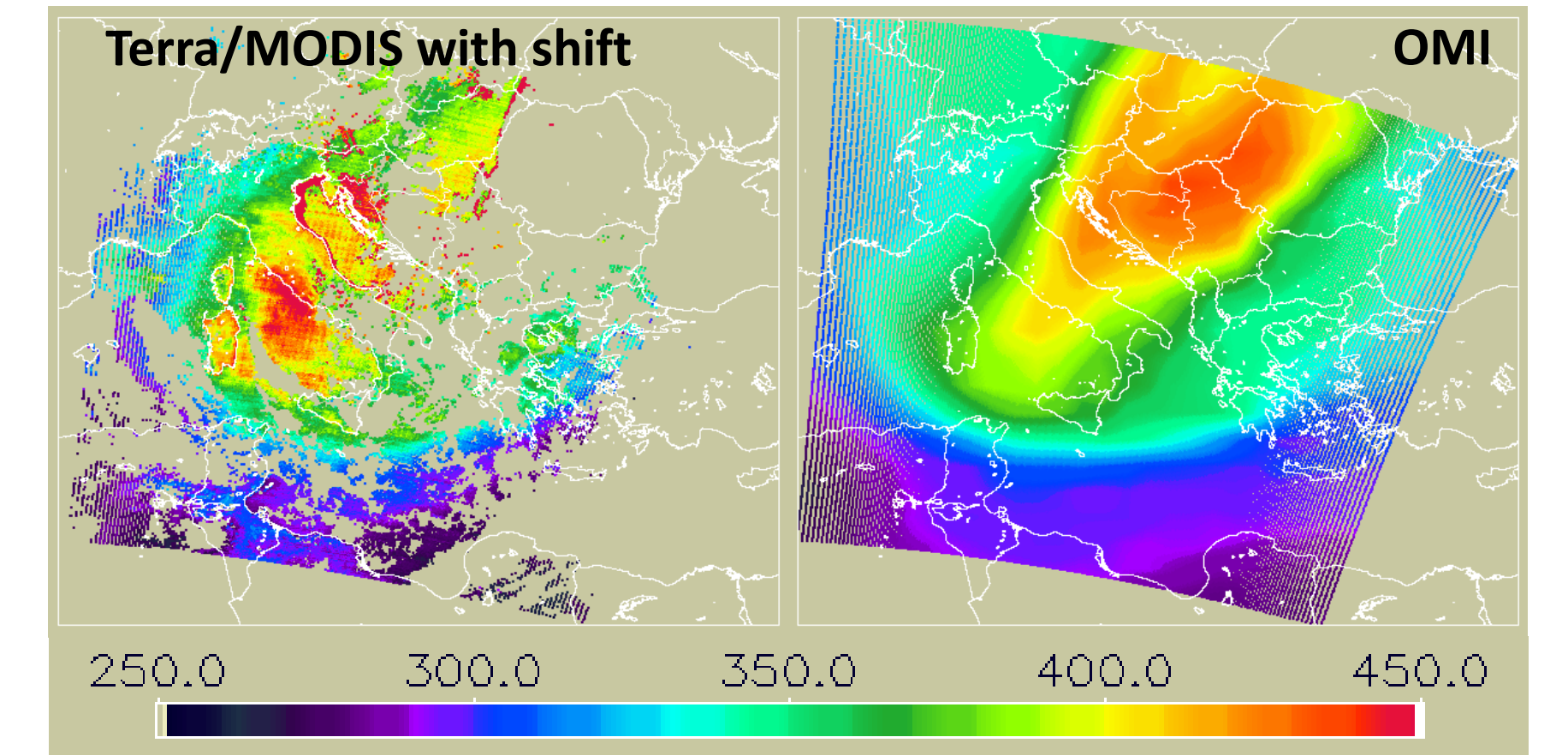
MOD07 total ozone data were compared to daily 1° × 1° horizontal grid resolution OMI data for Europe and surface Brewer measurements, representing the most accurate measurements of vertically integrated ozone values. The Brewer spectrophotometer is located in Budapest, the observation site of the Hungarian Meteorological Service (as the 152nd member of the Brewer Network). MODIS data were received by the receiving station of the Eötvös Loránd University, in Budapest, Hungary and processed using IMAPP software. Comparisons were performed for 102 and 41 mostly cloud free overpasses of Terra and Aqua, respectively, in the vicinity of Budapest and the Carpathian-Basin in 2007.

Satellite-based TOZ vs. Surface Brewer Measurements (Brewer - MODIS)	Bias [DU]	Stdev [DU]	RMSE [DU]
OMI at Terra overpass times	6.8	6.9	9.7
Terra Col5/pCRTM	-16.8	20.0	26.1
Terra Col6/CRTM2/ODPS no shifts	-35.5	26.7	44.4
Terra Col6/CRTM2/ODPS with shifts	-9.6	21.6	23.6
OMI at Aqua overpass times	0.6	7.5	7.6
Aqua Col5/pCRTM	6.0	20.8	21.6
Aqua Col6/CRTM1.2/ODAS no shifts	-1.2	17.6	17.7
Aqua Col6/CRTM1.2/ODAS with shifts	4.0	16.0	16.5



Scatter plot of Terra/MODIS and OMI Total Ozone vs ground-based Brewer measurements for 2007 at Budapest, Hungary

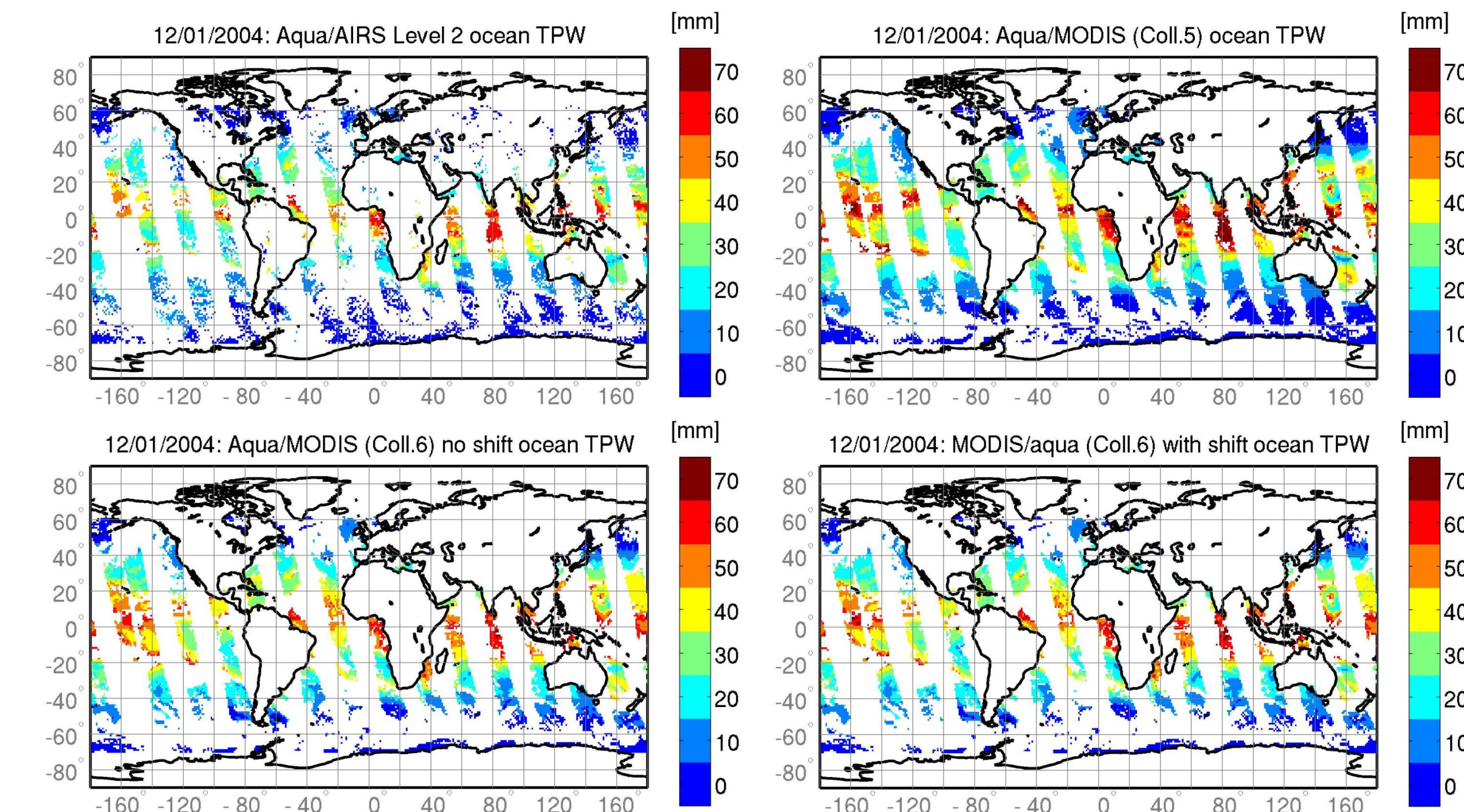
## Total Ozone on April 14 2007 at 09:50 UTC



Time series of Total Ozone observations for 2007 over Budapest, Hungary.

## The effect of the H2O/CO2/O3 channel spectral shifts on Global TPW and Total Ozone

MODIS Total Precipitable Water (TPW) and Total Ozone (TOZ) retrievals from Collection 5 and Collection 6 MOD07 algorithms are compared globally against AIRS and TOMS products for three days for both Aqua and Terra. TOMS measurements are from the Earth Probe platform (Version 8 products) or the OMI platform (Version 3 products) depending on the study date. Version 5 Level 2 standard retrieval AIRS products (AIRSX2RET) are used. The UW space-time gridding algorithm (Smith et al., 2013) was used for projecting data from their unique instrument domain to a uniform space-time domain. The instrument observations (or retrievals) are first snapped into nearest neighbor clusters then the clusters are averaged into single grid cell values. The result is a uniform equal-angle latitude-longitude grid. The space-time algorithm was used here to create daily averages on 1° × 1° grids of TPW and TOZ retrievals from both Terra and Aqua MODIS, AIRS on Aqua, and OMI on Aura.



Global clear-sky TPW [mm] retrievals on 1 December 2004. Results represent daytime retrievals over ocean resampled and averaged to a 1° × 1° latitude-longitude grid.

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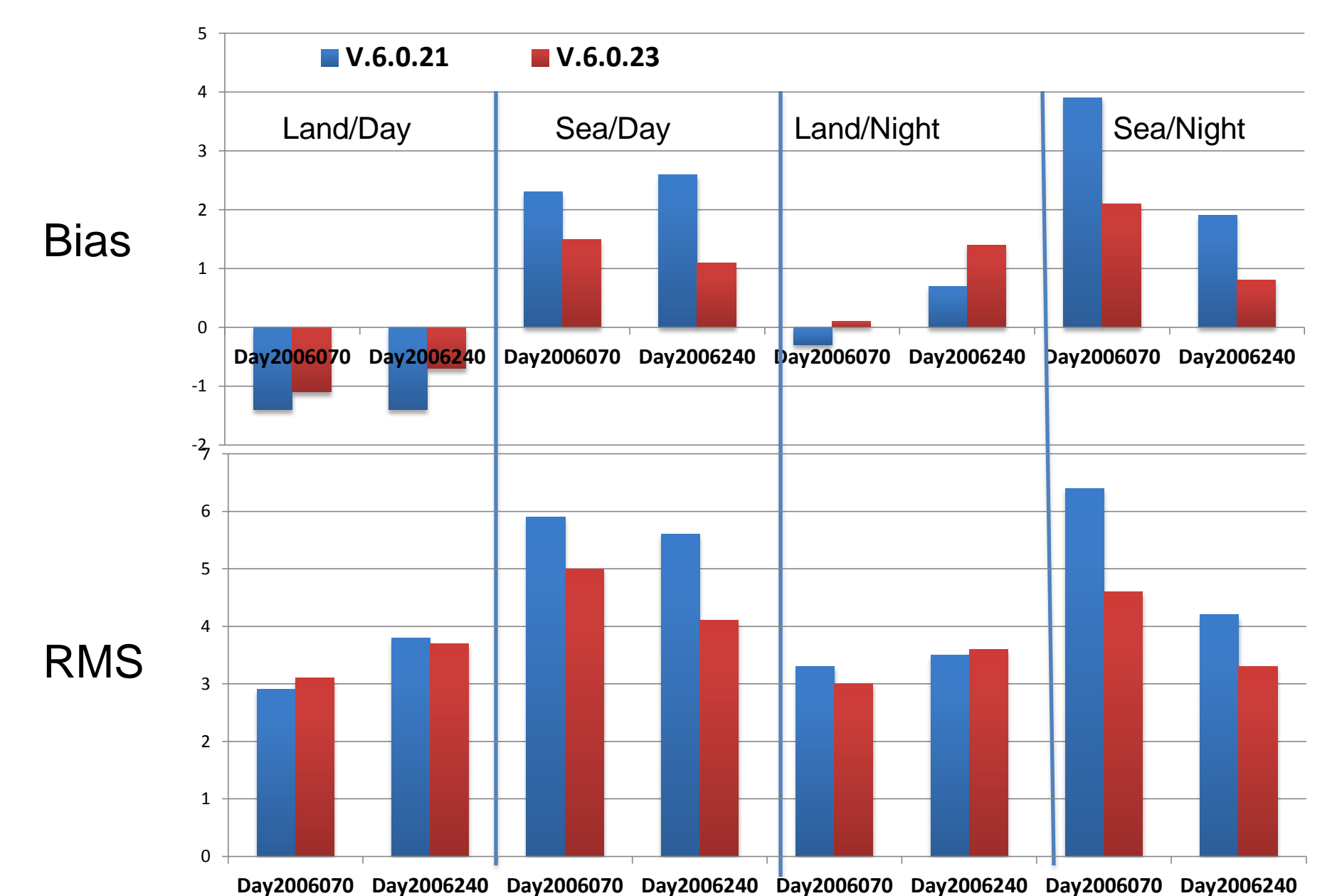
## Total Ozone global comparison

Terra Time TOZ [DU] DAYTIME	AIRS-MOD07 (Col. 6) bias±stdev	
	Land	Ocean
2006070: no shifts	-36±77 (ns=92)	-10±53 (ns=1972)
: with shifts	7±56 (ns=92)	7±34 (ns=1972)
2006240: no shifts	-14±33 (ns=134)	-6±29 (ns=1980)
: with shifts	2±30 (ns=134)	9±29 (ns=1980)
Terra Time TOZ [DU] NIGHTTIME	AIRS-MOD07 (Col. 6) bias±stdev	
	Land	Ocean
2006070: no shifts	-59±82 (ns=60)	2±29 (ns=1614)
: with shifts	-20±57 (ns=60)	13±23 (ns=1614)
2006240: no shifts	-4±18 (ns=56)	-13±25 (ns=1911)
: with shifts	9±15 (ns=56)	-2±28 (ns=1911)

Globally gridded TPW (above) and TOZ (right) comparison of MODIS with AIRS separated by sea / land and day / night time. (MODIS min(obs) = 10 angle (viewing angle < 42))

## Total Precipitable Water Global Comparison

Two tests are shown below for two global days: (V6.0.21) using CRTM1.2 / ODAS (old MODTRAN-type transmittance model) without any SRF shifts and (V6.0.23) using CRTM2.0 / ODPS (new RTTOV-type transmittance model) with H2O/CO2/O3 SRF shifts separated by day and night and land and ocean. MOD07 TPW products are compared to Aqua AIRS TPW L2. Terra overpass is between 10 am and noon, while Aqua overpass is between 1 pm and 3 pm.; time differences in the comparisons are between 1 and 5 hours. Application of Terra/MODIS H2O/CO2/O3 band SRF shifts for MOD07 TPW products show significant improvement globally for both days.



## Conclusions

- TOZ: Overall, application of Terra spectral shifts shows **significant improvement** (reduced bias and rms) for MOD07 TOZ products in both the local (Budapest, Hungary) and global validation studies. The Aqua MOD07 TOZ is also positively effected on the global scale by the H2O/CO2 spectral shifts.
- TPW: Aqua spectral shifts for Bands 27 & 28 (using CRTM V1.2/ODAS) produced a **significant positive improvement** for the Aqua/MODIS TPW over the SGP Cart site. Comparing C6 to C5, the dry bias for wet cases has been reduced by 1.1mm!
- TPW: Terra spectral shifts show a positive impact over the SGP Cart site for the dry cases (the wet bias is reduced by 0.5 mm), but have a negative impact for the wet cases (overall 0.7 mm bias increase). The overall rms differences were not changed significantly. Improvement after SRF shifts is more evident in two global day cases.