The Suomi-NPP VIIRS Total Precipitable Water Product

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Abstract

This poster presents the evaluation of the S-NPP TPW Level-2 and 3 products with TPW data from ground-based and satellite-based measurements. The goal of the Suomi NPP VIIRS Moisture Project is to provide total column water vapor (TPW) properties from merged VIIRS infrared measurements and CrIS plus ATMS water vapor soundings to continue the depiction of global moisture at high spatial resolution started with MODIS.

While MODIS has two water vapor channels within the 6.5 µm H_2O absorption band and four channels within the 15 µm CO_2 absorption band, VIIRS has no channels in either IR absorption band.

The VIIRS/CrIS+ATMS TPW algorithm being developed at CIMSS is similar to the MOD07 synthetic regression algorithm. It uses the three VIIRS longwave IR window bands in a regression relation and adds the NUCAPS (CrIS+ATMS) water vapor product to compensate for the absence of VIIRS water vapor channels.

Level-3 global 0.5° daily and monthly mean data products were developed by using a gridding software (called *Yori*) developed at UW-Madison SSEC. The development of Yori is framed by NASA VIIRS Atmosphere SIPS. The Level-3 products have been processed from May 2012 to December 2016.

Figure 1 TPW comparison on 15 October 2014 at ~08:50 UTC *(top left)* Aqua MODIS MYD07. *(top middle)* VIIRS only *(top right)* VIIRS plus NUCAPS retrievals, *(bottom left)* NUCAPS only *(bottom left)*, CFSR TPW analyses, *(bottom middle)* NUCAPS v1.1 TWP, *(bottom right)* quality flag.

Note the better coverage and improved quality for VIIRS plus NUCAPS with holes filled compared with VIIRS alone, NUCAPS alone, and even MODIS.
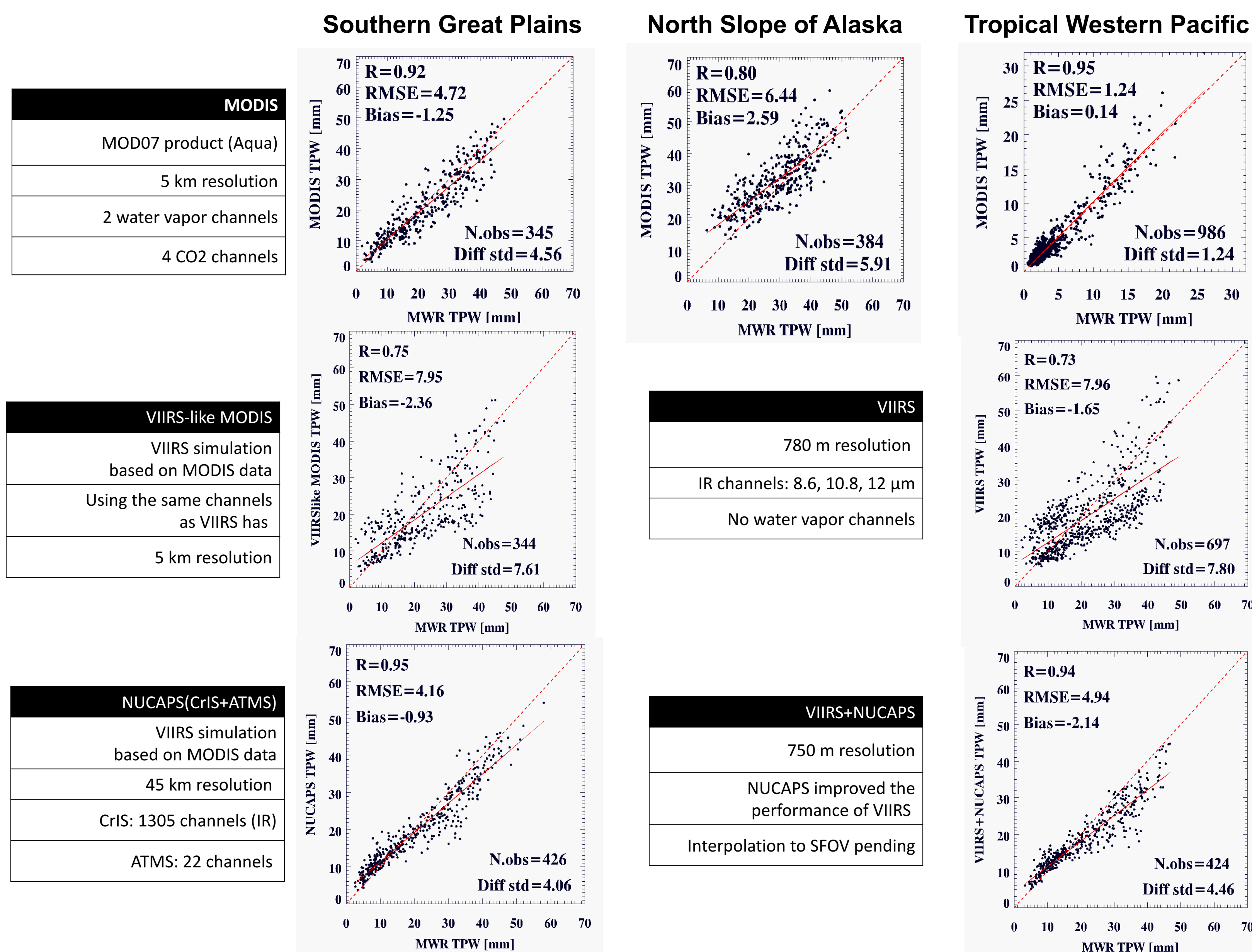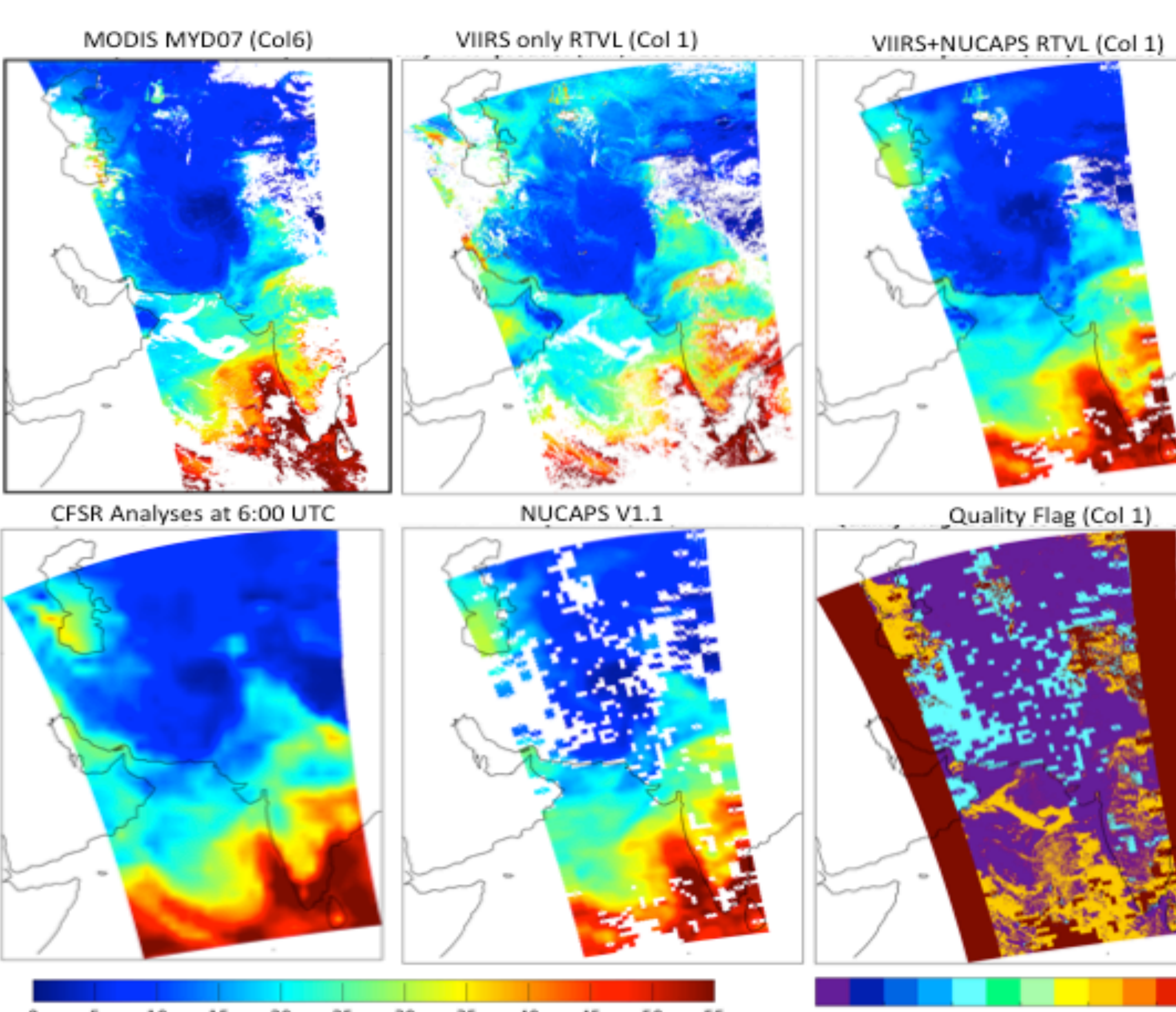
Table 1 Comparison of the characteristics of the Aqua MODIS (MYD07) and the VIIRS NUCAPS data products

Characteristics	MODIS (MYD07)	VIIRS (+CrIS/ATMS)
Spectral Bands	Uses 11 CO_2, H_2O, and IRW bands between 4.5 and 14.5 µm	Using bands M14, M15, M16 & TPW derived from CrIS/ATMS
Spatial Resolution	5km : 5x5 1km average	5km: 7x7 750m average
Spatial Coverage	Global (clear sky)	Global (clear sky)
Cloud Mask	MOD35 Cloud Mask	MVCM (750m)
Ancillary Data	GDAS (1° x 1° res)	CFSR (0.5° x 0.5° res)
Forward Model	CRTM V2.1	CRTM V2.1
Algorithm	Statistical Regression	Statistical Regression
Time Coverage	2000 -	2012 -

Comparison to MWR and GPS measurements

MODIS
- MOD07 product (Aqua)
- 5 km resolution
- 2 water vapor channels
- 4 CO_2 channels

VIIRS-like MODIS
- VIIRS simulation based on MODIS data
- Using the same channels as VIIRS has
- 5 km resolution

NUCAPS(CrIS+ATMS)
- VIIRS simulation based on MODIS data
- 45 km resolution
- CrIS: 1305 channels (IR)
- ATMS: 22 channels

VIIRS
- 780 m resolution
- IR channels: 8.6, 10.8, 12 µm
- No water vapor channels

VIIRS+NUCAPS
- 750 m resolution
- NUCAPS improved the performance of VIIRS
- Interpolation to SFOV pending

Table 2 Final statistics of the VIIRS algorithm

FINAL STATS	MODIS 5km		VIIRS 750m		NUCAPS 45km		VIIRS+ NUCAPS
	SGP MWR	GPS	SGP MWR	GPS	SGP MWR	GPS	SGP MWR
Number of obs.	345	63 565	697	169 927	426	66 705	424
bias	-1.25	0.89	-1.65	0.99	-0.93	-0.28	-2.14
RMSE	4.72	4.63	7.96	6.86	4.16	4.33	4.94
Std.dev	4.56	4.17	7.8	6.51	4.06	4.16	4.46

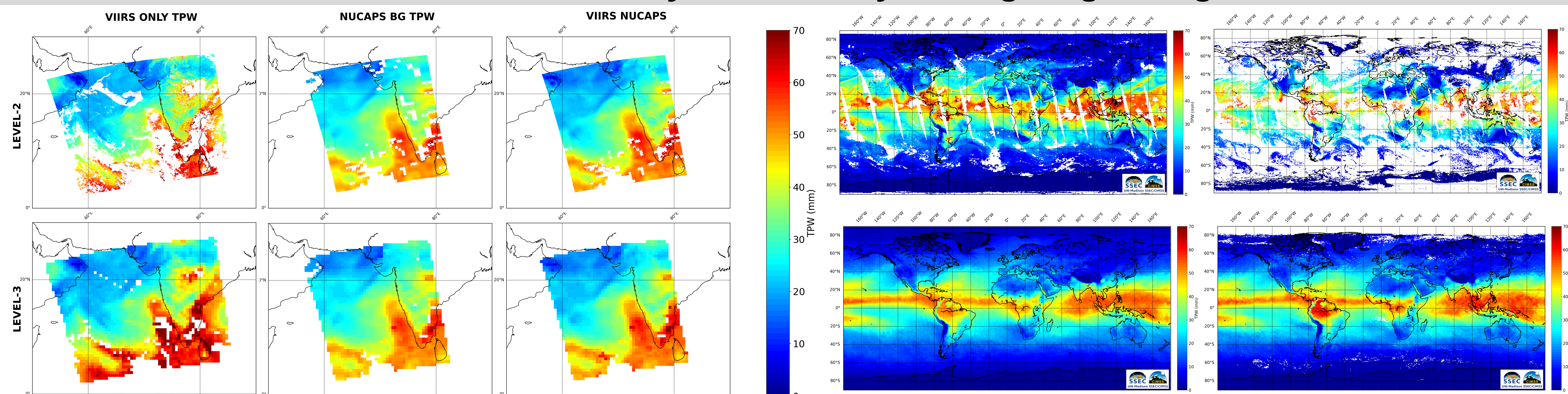## Level-3 Global daily and monthly 0.5 degree gridding

Figure 2 Processing a VIIRS TPW granule to a gridded granule (15 October 2014 at ~08:50 UTC).


Figure 3 Daytime Daily (Oct 15, 2014, top panels) and monthly (Oct 2014, bottom panels) mean 0.5 degree gridded VIIRS/NUCAPS (left) and AQUA/MODIS MYD07 (right) TPW products.

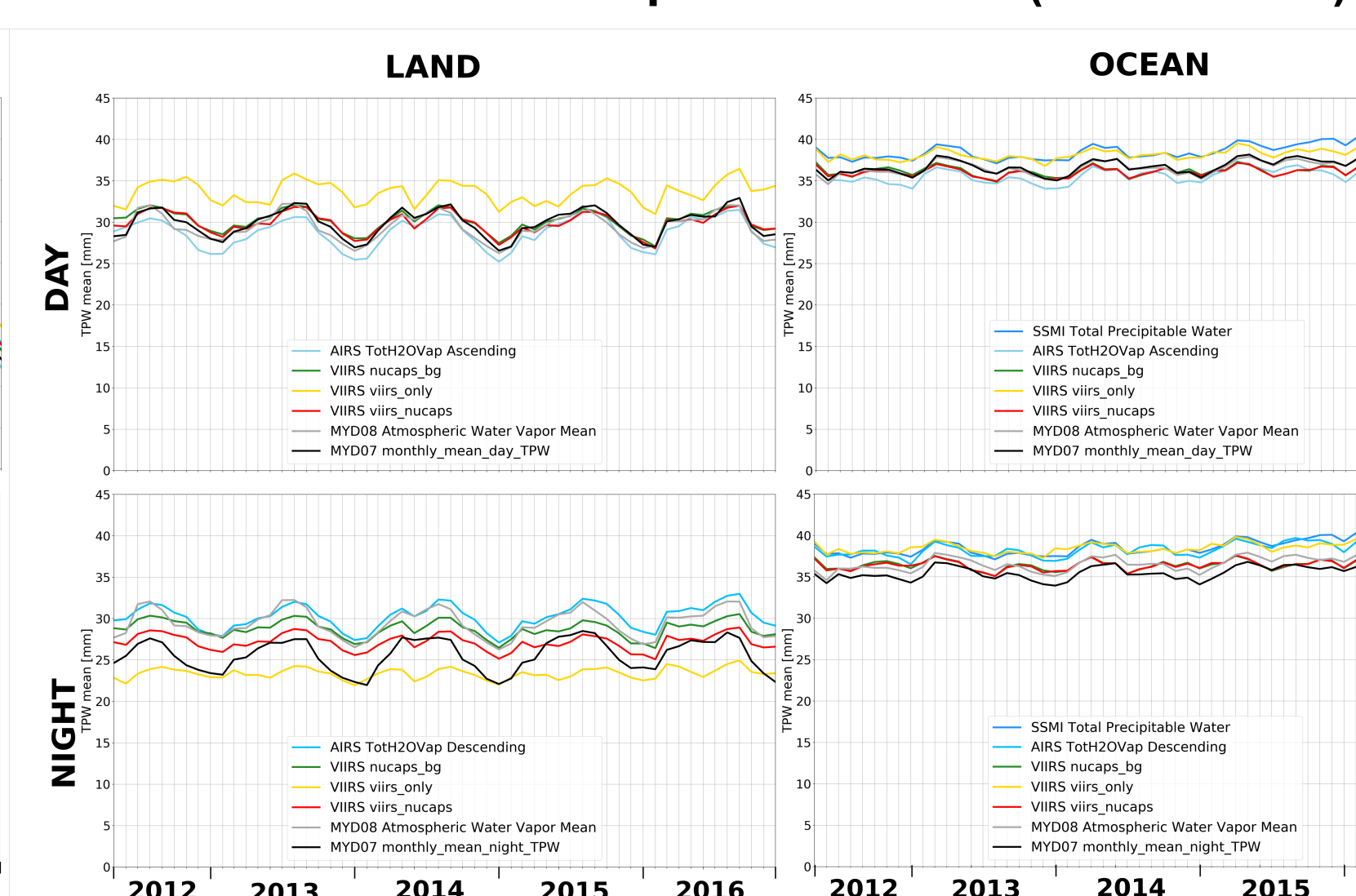## Zonal monthly mean cross-comparisons of different TPW products

Table 3 TPW Products used for the zonal cross comparison

TPW data product		Res.
VIIRS	VIIRS ONLY (day / night)	0.5 °
CrIS + ATMS	NUCAPS BG (day / night)	0.5 °
VIIRS + CrIS + ATMS	VIIRS NUCAPS (day / night)	0.5 °
AIRS3STM	TotH2OVap_A, TotH2OVap_D	1 °
MYD08_M3	Atm. Water Vapor	1 °
MYD07_L3	TPW (day / night)	0.5 °
SSMI	TPW	1 °
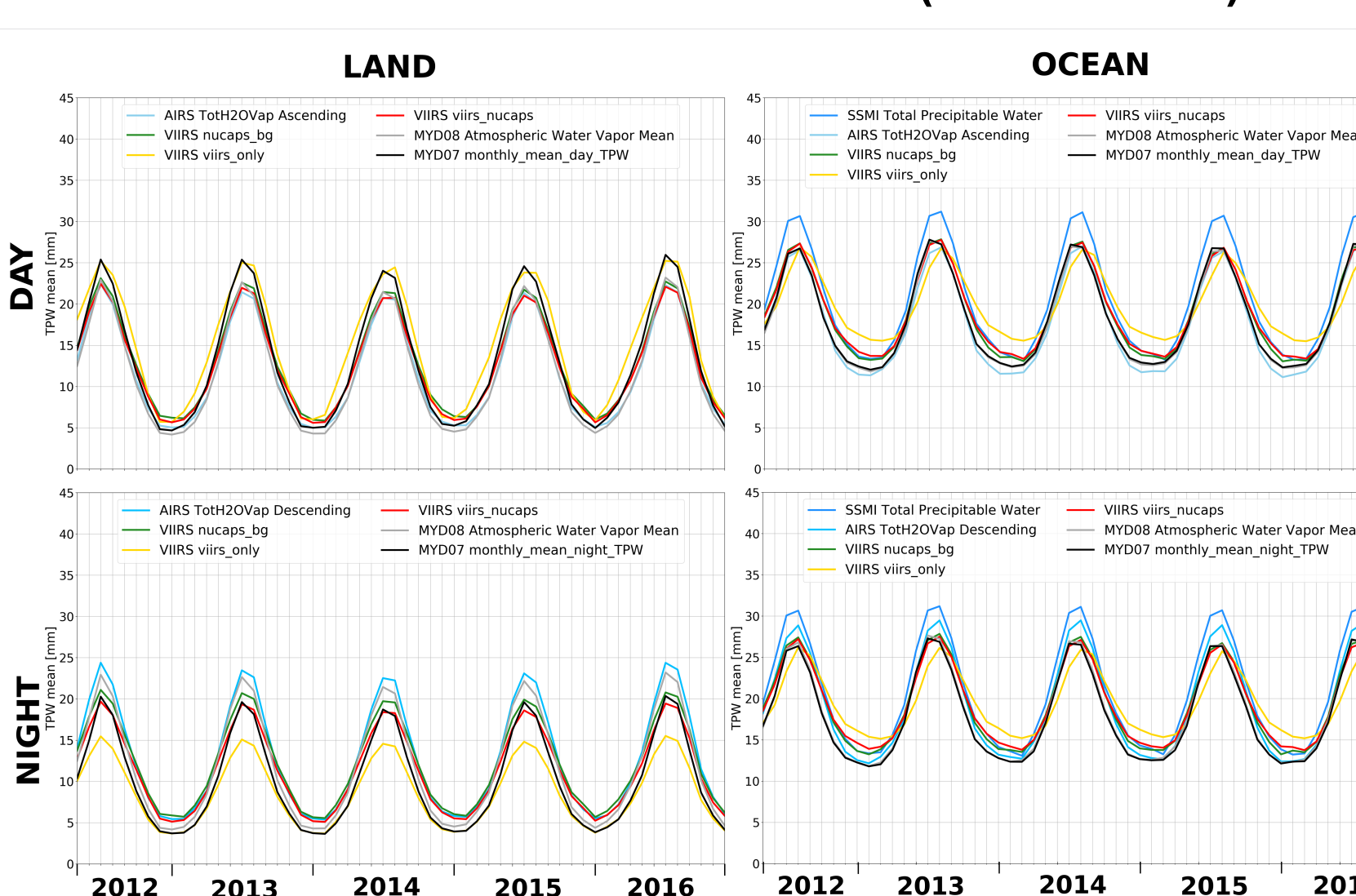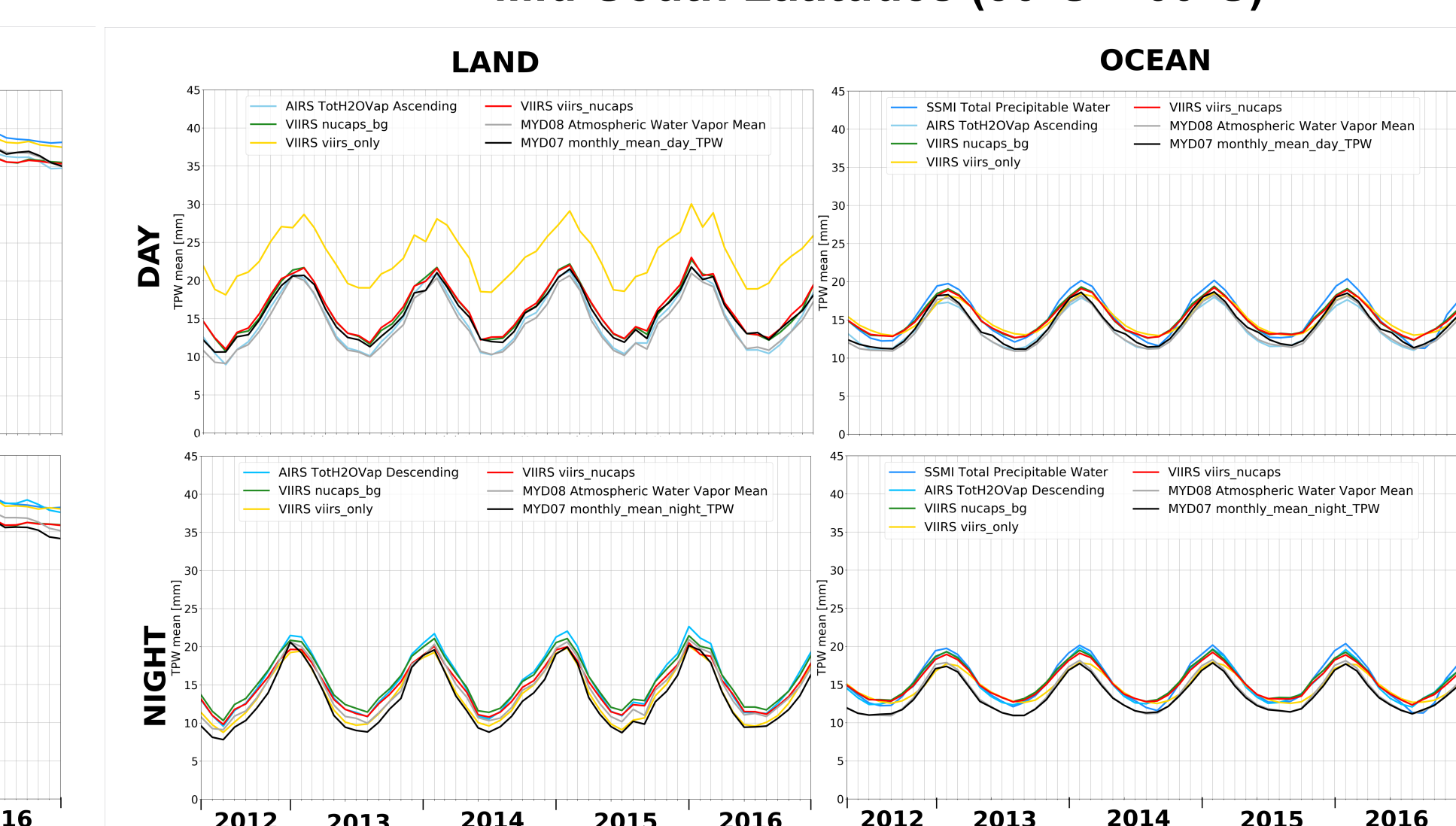
Comparing to MODIS/Aqua (MYD07 day/night)

Figure 7 (right) The Land/Water and the Latitudinal Zones used for the cross-comparison. The Land/Water Mask used for the zonal subsetting was derived from the SSMI dataset.
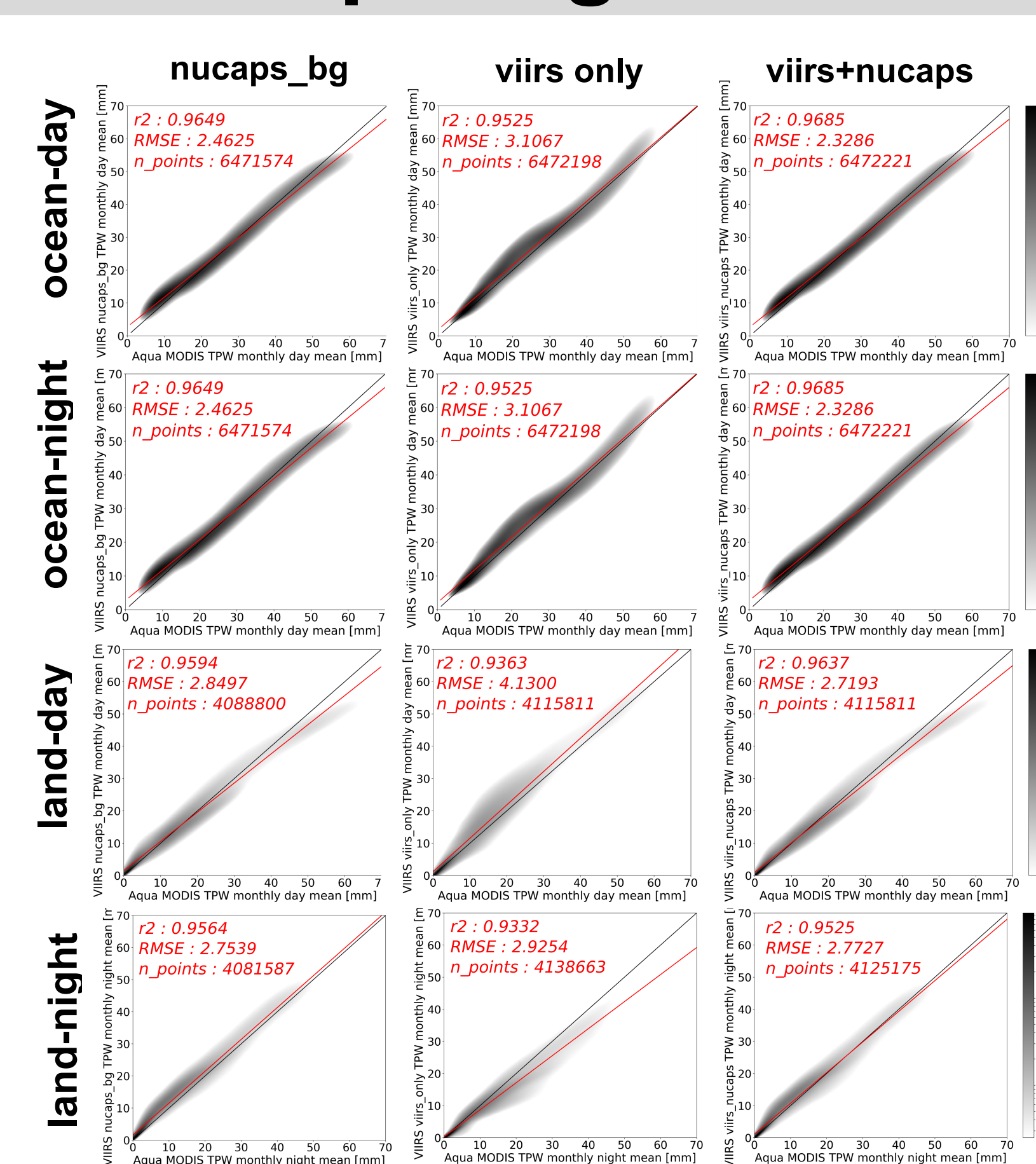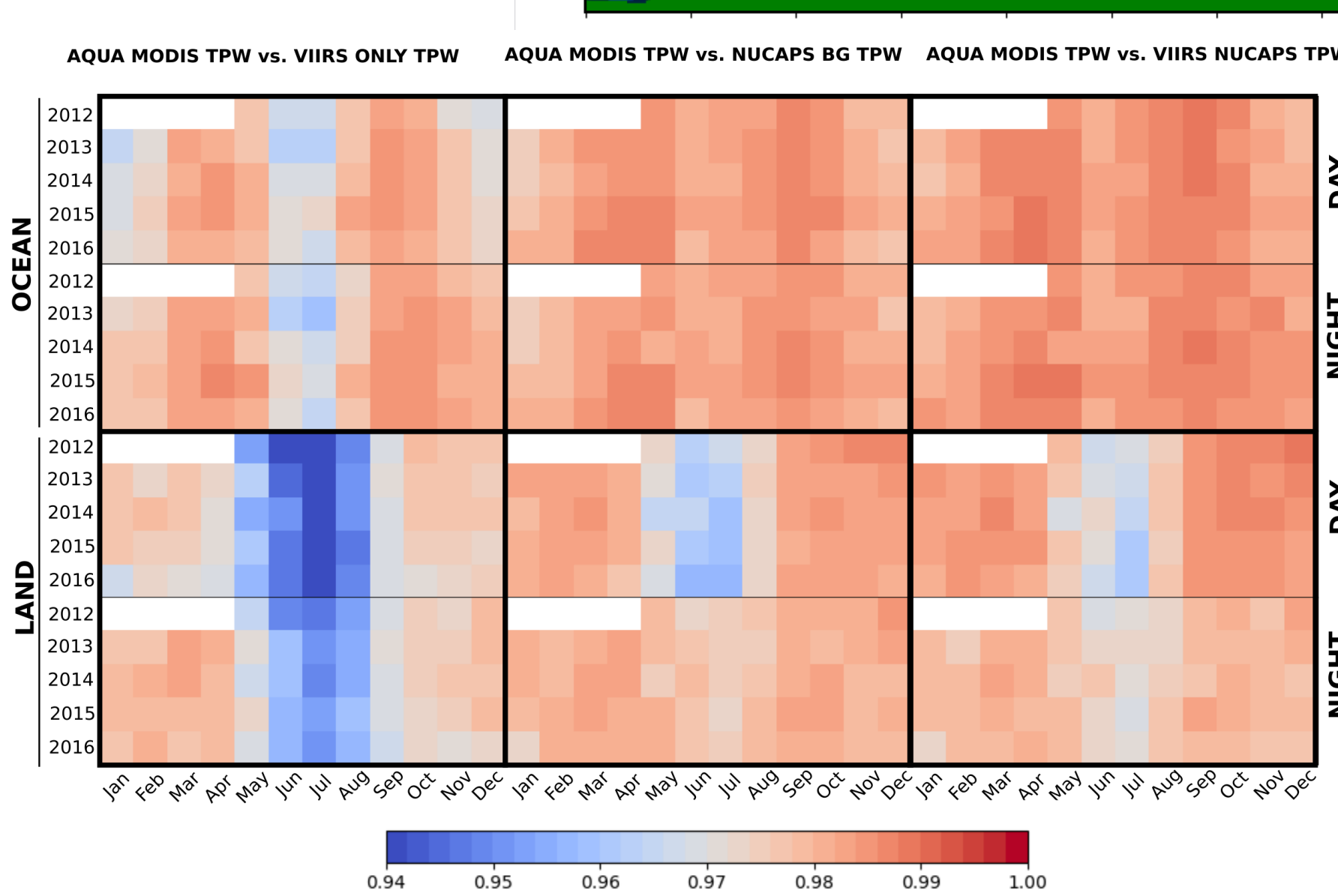

Figure 8 The scatter plots show the day, night, ocean and land separated relationship between the Level-3 MYD07 (x-axis) and the Level3 NUCAPS, VIIRS-only and VIIRS NUCAPS data products.

Figure 9 The correlation table shows the relationship between the Aqua MODIS and VIIRS-only(left blocks), NUCAPS(middle blocks) and VIIRS+NUCAPS (right) monthly mean Level-3 data products, separated by day, night, ocean and land.

Conclusions and Future Plans

- The Level-2 6-minutes and 750 m spatial resolution VIIRS TPW product file includes the collocated NUCAPS background TPW, the VIIRS-only TPW, and VIIRS+NUCAPS TPW with a quality flag.
- The Level-3 VIIRS TPW products are daily and monthly means aggregated to 0.5 degree spatial resolution separated by day and night.
- The Level-3 products have been processed for data between May 2012 and December 2016.
- The Level-2 and Level-3 comparison with Aqua MODIS showed that VIIRS+NUCAPS TPW quality is better than VIIRS or NUCAPS alone. Values missing in the NUCAPS alone due to surface emissivity issues are filled by using VIIRS alone values. Values missing in VIIRS and MODIS alone due to interference by non-precipitating clouds are filled by using smoothed NUCAPS values.
- The VIIRS+NUCAPS combined TPW algorithm is producing near-MODIS quality TPW in the comparison between 2012-2016 with r2 values greater than 0.95 over land and ocean both day and night.

In the future, we are planning to
- improve the VIIRS TPW by radiance fusion form CrIS or product fusion (Weisz et al., 2017) and
- making some refinements like updating the forward model form CRTM to RTTOV; increasing viewing angle categories; Investigate the retrieval noise occurring over land at cloud edges. update the IR emissivity data base (from UW BFemis to CAMEL) .