Evaluation of the VIIRS TPW algorithm with ground based measurements

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ABSTRACT

The goal of the Soumi 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 H2O absorption band and four channels within the 15 μm CO2 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 CrIS+ATMS water vapor product to compensate for the absence of VIIRS water vapor channels.

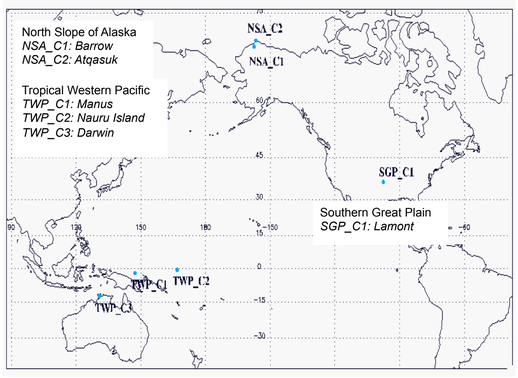
This poster presents a initial evaluation of the S-NPP TPW products with TPW data from the ground-based Global Positioning System (GPS) over the SOUMI network and from the Microwave Water Vapor Radiometer (MWR), RAOB and GPS over the Atmospheric Radiation Measurement (ARM) Cloud and Radiation Testbed (CART) sites at three different climate regions (Tropical Western Pacific, North Slope of Alaska, and Southern Great Plains).

DATA and SITES

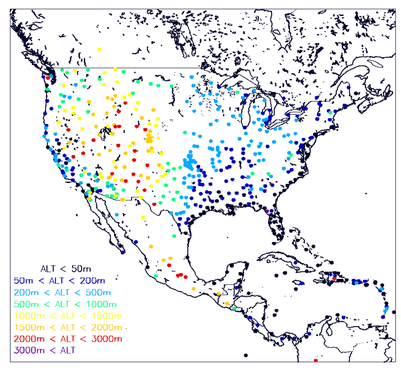
Ground based measurements:
- Microwave Water Vapor Radiometer (MWR) TPW
- GPS TPW measurements

Time period: Jan 2012 – July 2015

Airborne measurements:
- MODIS/MOD07 L2
- AIRS, AIRS+AMSU L2
- NUCAPS (CrIS+ATMS)
- VIIRS



Atmospheric Radiation Measurement (ARM) Cloud and Radiation Testbed (CART) sites at three different climate regions.



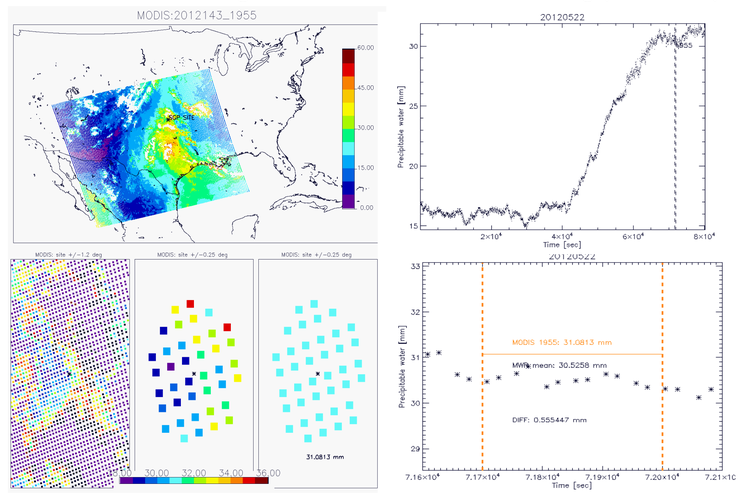
~500 GPS sites in North America from the SUOMI GPS Network (http://www.suominet.ucar.edu/; Ware et al., 2000)

Ware, R.H. D. W. Fulker, S. A. Stein, D. N. Anderson, S. K. Avery, R. D. Clark, K. Droegemeier, J. P. Kuettner, and J. B. Minster, 2000: Suominet: A real-time national GPS network for atmospheric research and education. Bulletin of the American Meteorological Society 81, 677-694.

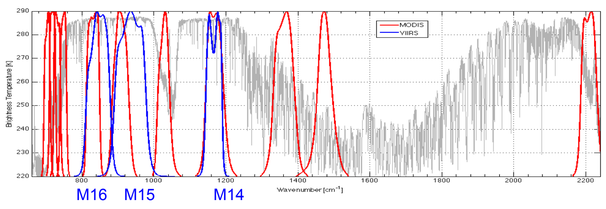
METHODS

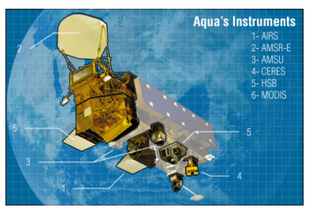
Collocations in space:
- MODIS, VIIRS: 20km around the site, if 90% clear
- AIRS, AIRS+AMSU, NUCAPS: closest pixel to the site

Collocation in time:
- MODIS, AIRS, AIRS+AMSU, VIIRS: closest pixel timing
- MWR: 5min average around the satellite data timing (~12 values)
- GPS: 60min average around the satellite data timing (~2 values)



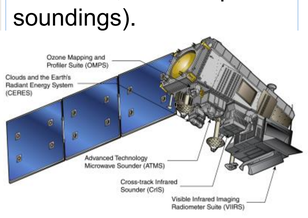
The main aim is to develop a VIIRS TPW algorithm for the continuation of the MOD07 product. MODIS: 5km resolution, has two water vapor channels. VIIRS: high spatial resolution (780 m) BUT has no IR absorption channels. It has IR windows at 8.6, 10.8 and 12 μm (low level moisture information)



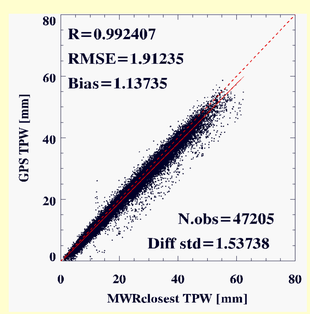


Characteristics	MODIS (MOD07)	VIIRS (+CrIS/ATMS)
Spectral Bands	IR only using CO2, H2O and IRW bands; between 4.5 and 14.5 μm (11 bands)	Band M14, M15, M16 TPW derived from CrIS/ATMS
Spatial Resolution	5km : 5x5 1km average	5km: 7x7 750m average
Spatial Coverage	Global (clear sky)	Global (clear sky)
Cloud Mask	MOD35 Cloud Mask	MVCM (750m)
Ancillary Data	GDAS (1^ox1^o res)	CFSR(0.5^ox0.5^o res)
Forward Model	CRTM V2.1	CRTM V2.1
Algorithm	Statistical Regression	Statistical Regressio
Time Coverage	2000-	2012-

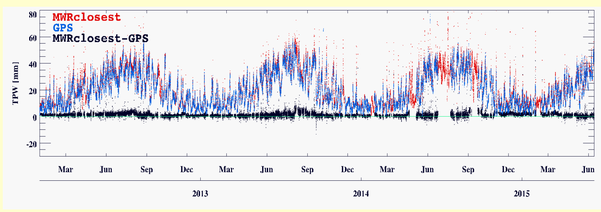
Try addition of CrIS + ATMS TPW retrievals (like NUCAPS: 45km resolution, water vapor soundings).



GPS and MWR measurements
SGP CART site

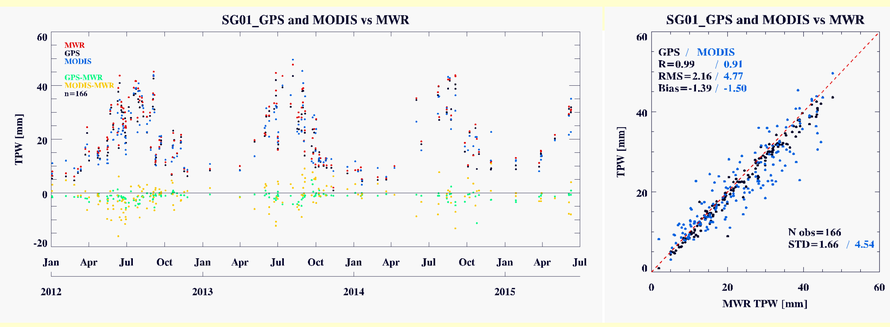


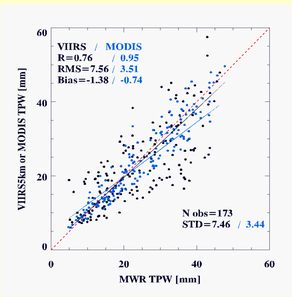
The closest MWR value in time was compared to the GPS measurement over the SGP CART site when both ground based TPW measurements were available.



SGP CART site

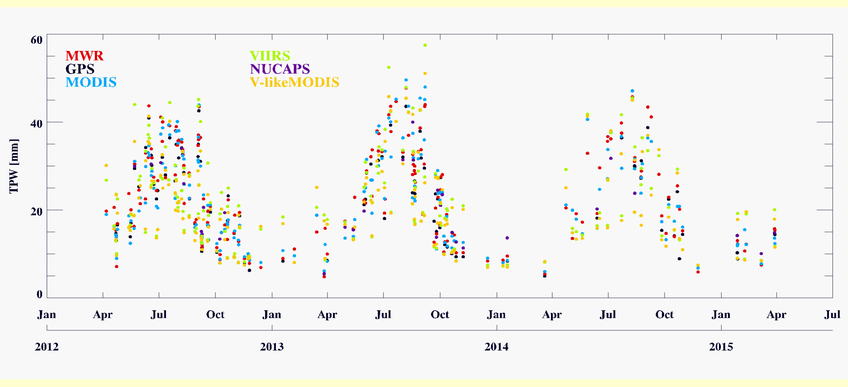
Comparison of MODIS, GPS, and MWR
MWR measurements are considered as 'truth'.





Left: MODIS-MWR and VIIRS-MWR Collocations
Max time difference: 1hour
Filtering: if MODIS-MWR too high (>1/3*MODIS)

Below: Collocations of MWR / GPS / MODIS / VIIRS-like MODIS / VIIRS / NUCAPS for 3 yrs
Max time difference: 1hour
Filtering: if MODIS-MWR too high (>1/3*MODIS)



RESULTS

AIRS
Advanced IR Sounder
- 50 km resolution
- 2378 TIR, 6 VIS bands

AIRS+AMSU
Advanced IR Sounder
Advanced Microwave Sounding Unit
- 50 km resolution
- AIRS: 2378 TIR, 6 VIS bands
- AMSU: 15 MW channel

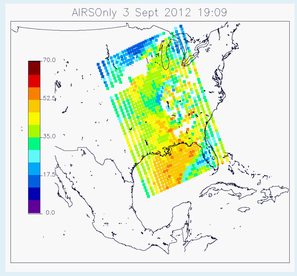
MODIS
Moderate Resolution Imaging Spectro-radiometer
- MOD07 product (Aqua)
- 5 km resolution
- 2 water vapor channels
- 4 CO_2 channels

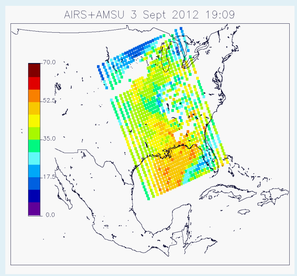
NUCAPS(CrIS+ATMS)
Cross track Infrared Microwave Sounding Suit
Advanced Technology Microwave Sounder
- 45 km resolution
- CrIS: 1305 channels (IR)
- ATMS: 22 channels

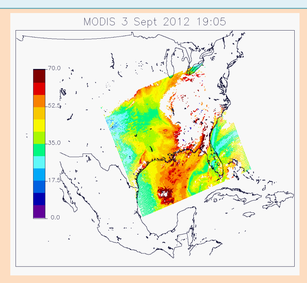
VIIRS
Visible Infrared Imaging Radiometer Suite
- 780 m resolution
- IR channels: 8.6, 10.8, 12 μm
- No water vapor channels

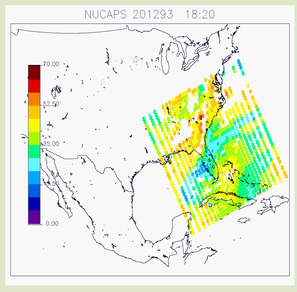
VIIRS-like MODIS
- VIIRS simulation based on MODIS data
- Using the same channels as VIIRS has
- 5 km resolution

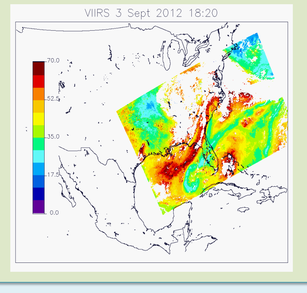
Total Precipitable Water [mm]

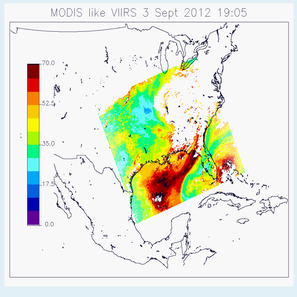








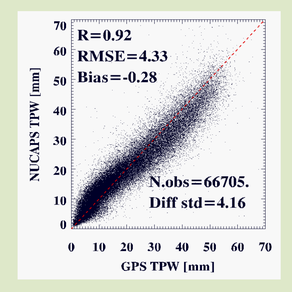


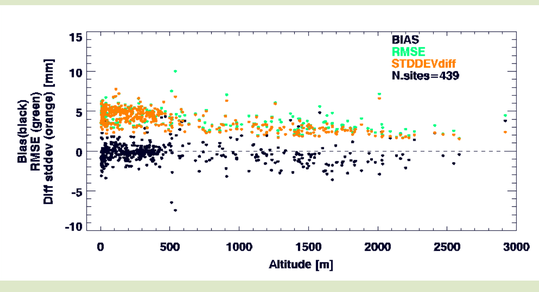


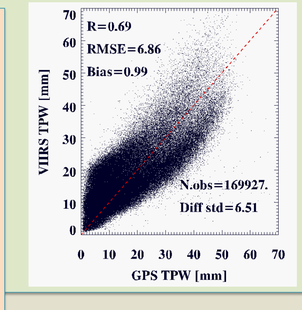
Comparison to MWR measurements

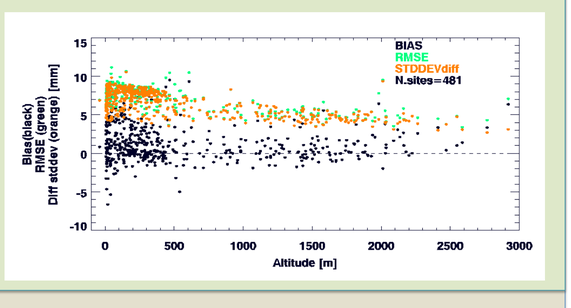
	Southern Great Plains	Tropical Western Pacific	North Slope of Alaska
AIRS	R=0.96 RMSE=3.92 Bias=-1.23 N.obs=548 Diff std=3.72	R=0.93 RMSE=6.10 Bias=-2.00 N.obs=359 Diff std=5.77	R=0.94 RMSE=2.41 Bias=-0.74 N.obs=1226 Diff std=2.29
AIRS+AMSU	R=0.95 RMSE=3.98 Bias=-1.17 N.obs=524 Diff std=3.81	R=0.91 RMSE=6.20 Bias=-1.53 N.obs=352 Diff std=6.02	R=0.93 RMSE=2.38 Bias=-0.72 N.obs=988 Diff std=2.27
MODIS	R=0.92 RMSE=4.72 Bias=-1.25 N.obs=345 Diff std=4.56	R=0.80 RMSE=6.44 Bias=2.59 N.obs=384 Diff std=5.91	R=0.95 RMSE=1.24 Bias=0.14 N.obs=986 Diff std=1.24
NUCAPS	R=0.95 RMSE=4.16 Bias=-0.93 N.obs=426 Diff std=4.06	R=0.94 RMSE=5.15 Bias=-1.76 N.obs=315 Diff std=4.85	R=0.93 RMSE=2.62 Bias=-0.29 N.obs=345 Diff std=2.60
VIIRS	R=0.73 RMSE=7.96 Bias=-1.65 N.obs=697 Diff std=7.80		
VIIRS-like MODIS	R=0.75 RMSE=7.95 Bias=-2.36 N.obs=344 Diff std=7.61		

Comparison to GPS measurements



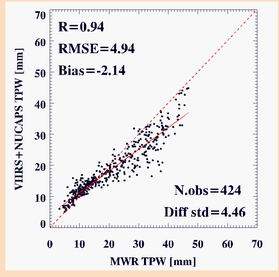






VIIRS+NUCAPS

- 750 m resolution
- NUCAPS improved the performance of VIIRS



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

Future Plans:

- Finalize the VIIRS+NUCAPS combined algorithm
- Apply the Space Time Grid software (Smith et al, 2014) to build global daily / monthly VIIRS/NUCAPS L3 gridded TPW products
- Compare VIIRS/NUCAPS TPW L3 global products to MOD07 L3, AIRS L3 and SSMI TPW products

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