

# **AIRS and IASI Precipitable Water Vapor (PWV) Absolute Accuracy at Tropical, Mid-Latitude, and Arctic Ground-Truth Sites**

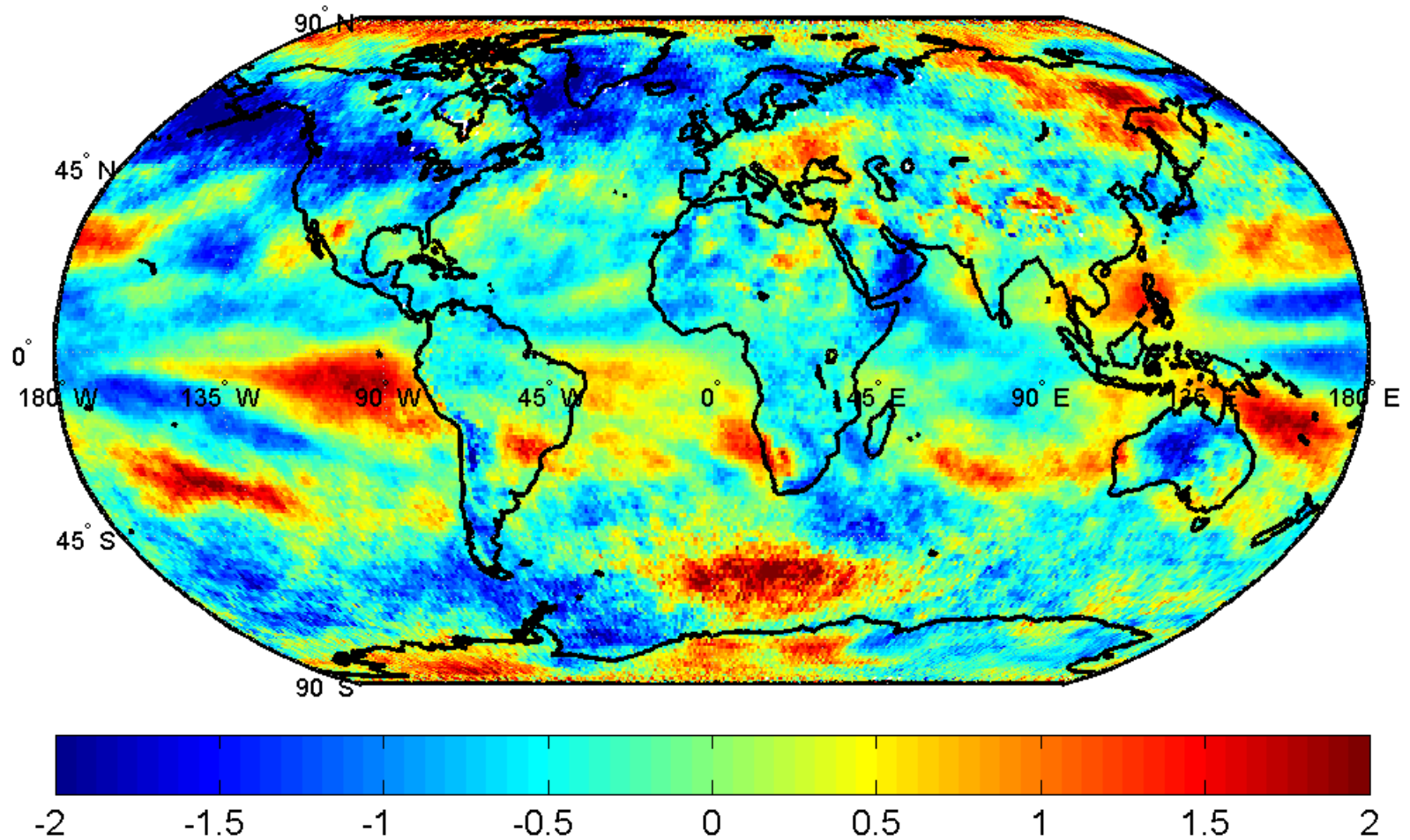
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Cooperative Institute for Meteorological Satellite Studies

# Why Validate Precipitable Water Vapor (PWV)?

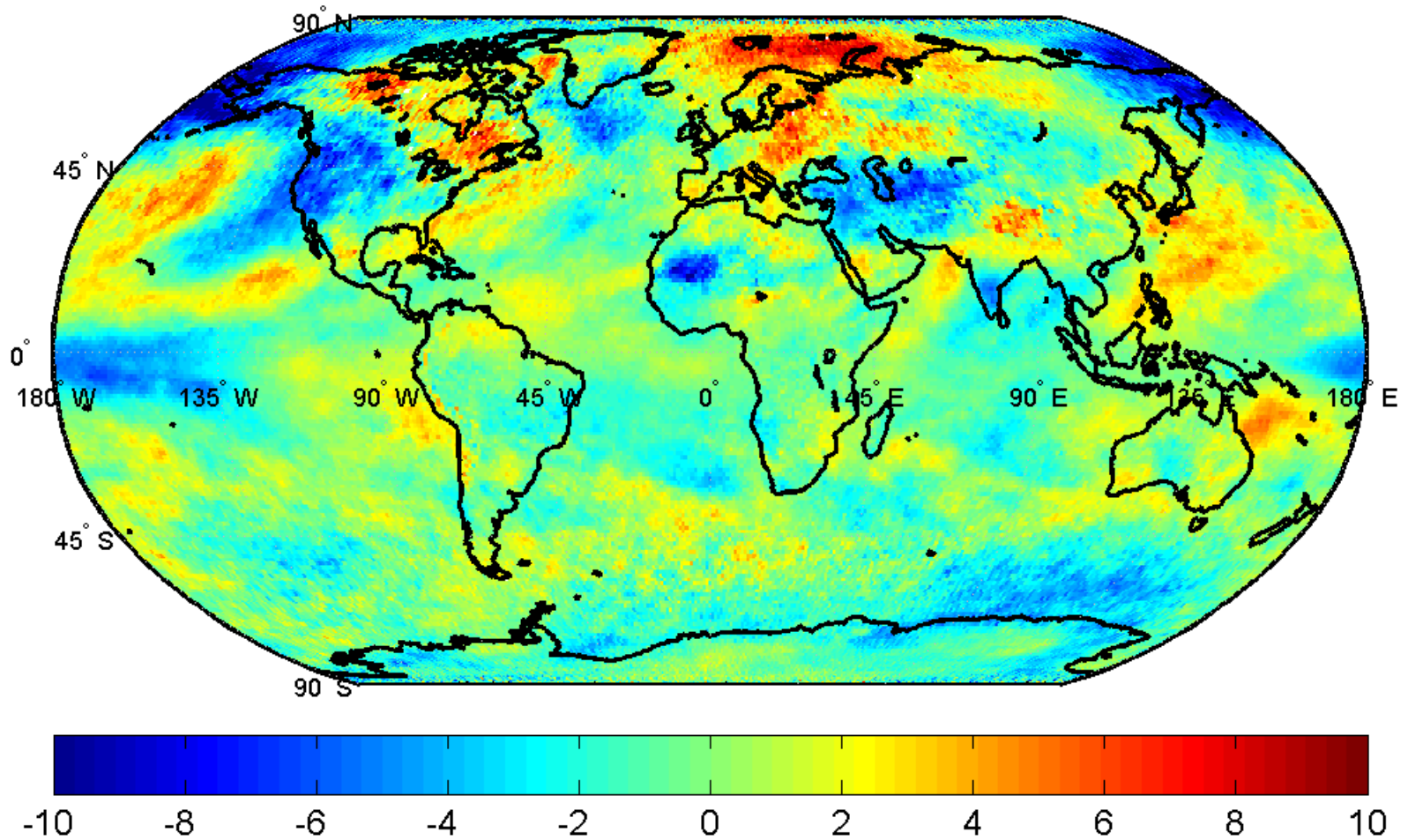
- Total column water vapor can be validated to a high percentage accuracy at selected ground sites (< 3% 2-sigma) using Microwave Radiometers operated by DOE ARM.
- Errors in the total column water vapor can be attributed to errors in the retrieved profile.
- Global warming implies an increase in the global atmospheric water vapor as warmer air is able to hold more vapor.
- In the future, can we use infrared sounders, e.g. AIRS, IASI, and CrIS, to accurately measure water vapor trends over both OCEAN and LAND?

AIRS PWV Trend NIGHT (%/yr H<sub>2</sub>O): ANNUAL.2003.2009



- AIRS Total Column Water Vapor for 2003-2009 (All Months)

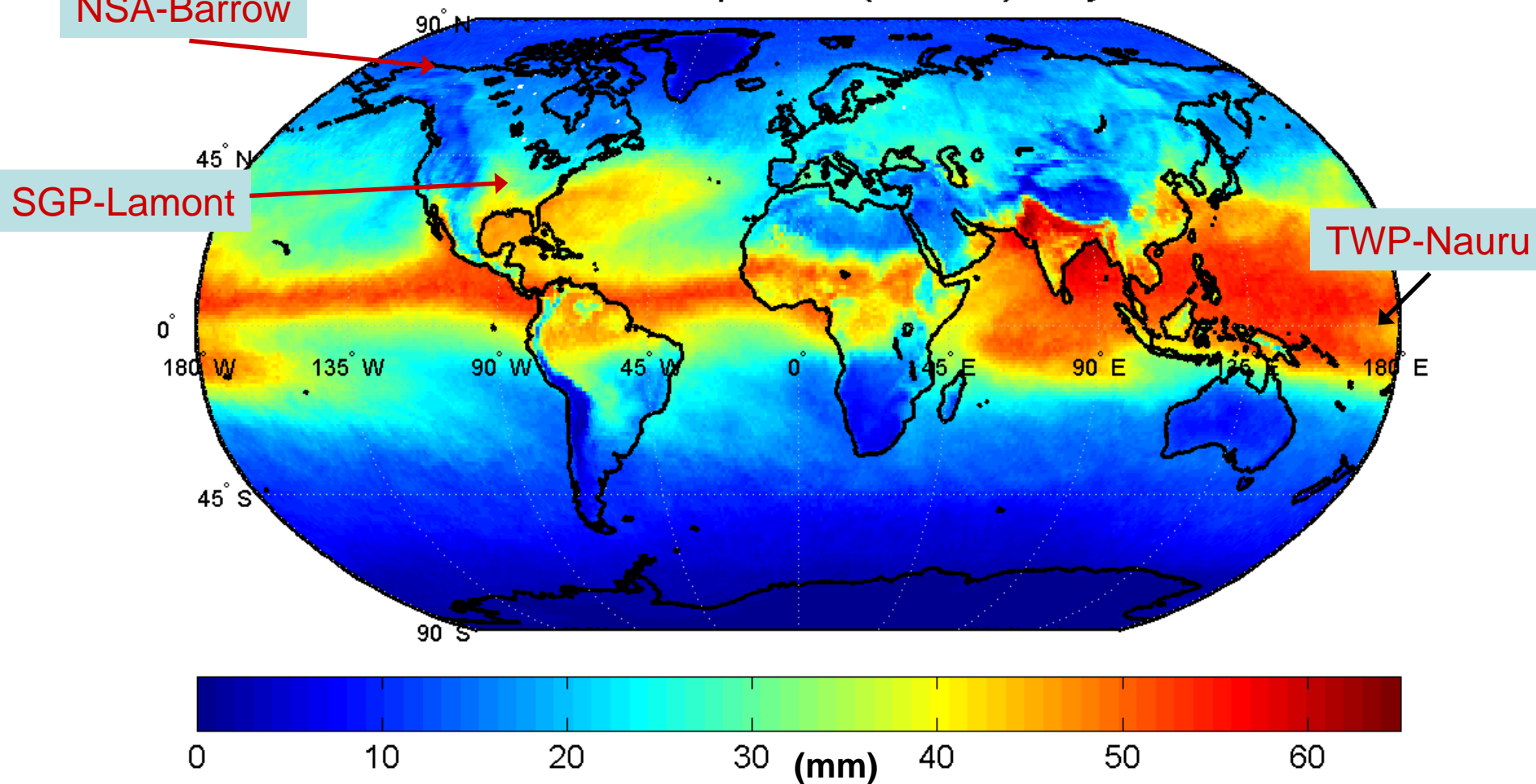
AIRS PWV Trend NIGHT (%/yr H<sub>2</sub>O): JANUARY.2003.2009



- AIRS Total Column Water Vapor for 2003-2009 (January)

# U.S. ARM Sites: SGP, TWP-Nauru, NSA-Barrow

AIRS Total Water Vapor DAY (mm H<sub>2</sub>O): July 2003



- We use ground-based observations from three ARM sites for validation in the Southern Great Plains, Tropical Western Pacific, and North Slope of Alaska



# 22 GHz MWR Retrieval of TPW (built by Radiometrics, Inc.)

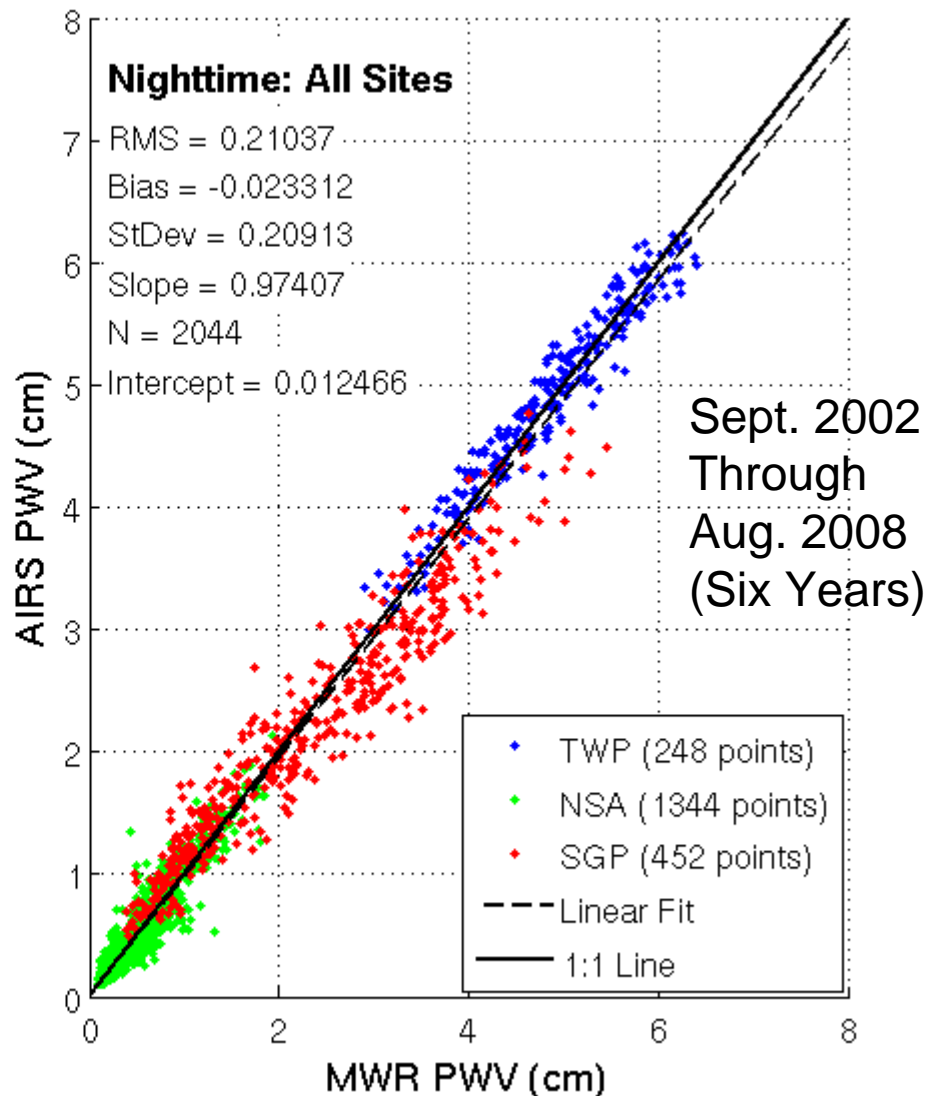
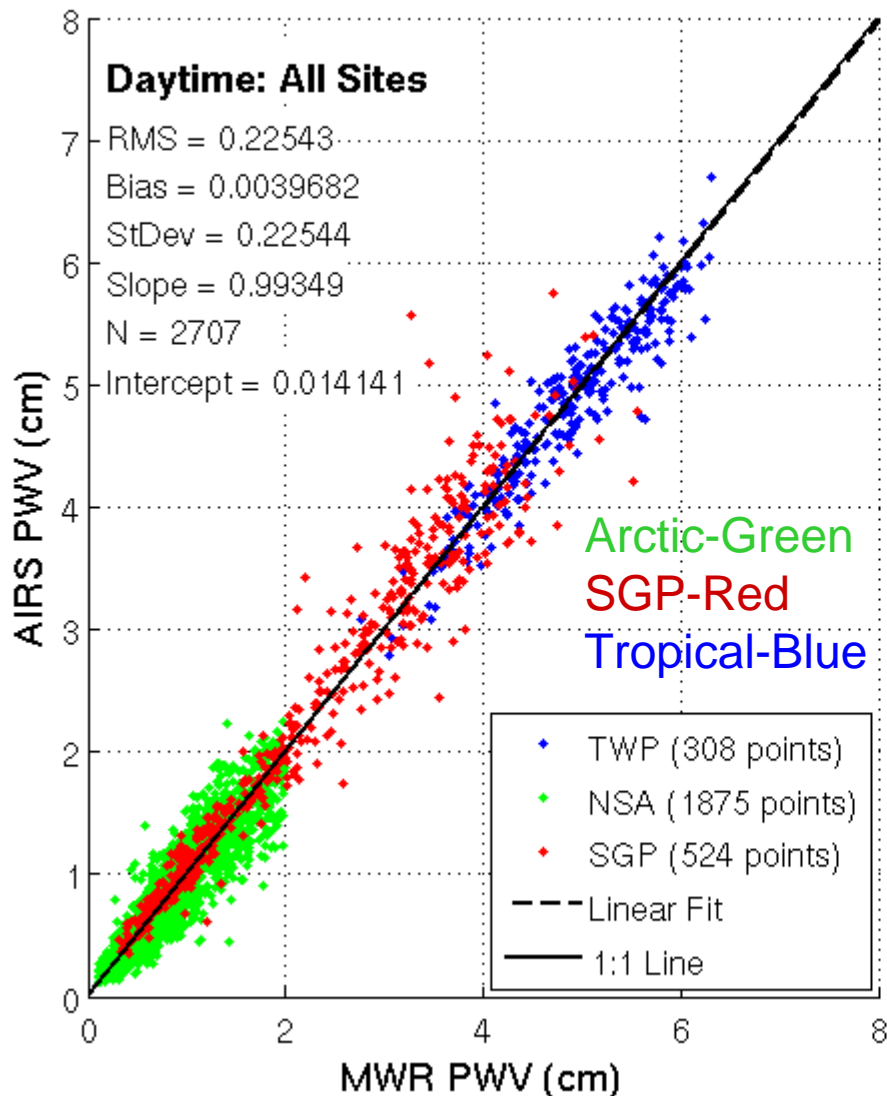


*PWV absolute accuracy is  
better than 3% (95% confidence)*

- 22 GHz line strength is known to high precision  
Clough, S. A., Y. Beers, G. P. Klein, and L. S. Rothman, “Dipole moment of water from Stark measurements of H<sub>2</sub>O, HDO, and D<sub>2</sub>O,” *J. Chem. Phys.*, vol. 59, pp. 2254-2259, 1973.
- Improved PW retrieval method by Dave Turner of UW-SSEC.  
*Turner, D.D., S. A. Clough, J. C. Liljegren, et al., 2007: Retrieving liquid water path and precipitable water vapor from the Atmospheric Radiation Measurement (ARM) microwave radiometers. IEEE Trans. Geosci. Remote Sens., 45.*
- MWR B.T. calibration accuracy estimated at < 0.3 K RMS.
- Verified MWR column using Raman Lidar/Chilled Mirrors (1%)  
*Revercomb, H.E., D.D. Turner, D.C. Tobin, et al., 2003: The Arm Program's Water Vapor Intensive Observation Periods. Bull. Amer. Meteor. Soc., 84, 217.*

AIRS and MWR PWV over SGP, TWP and NSA

AIRS

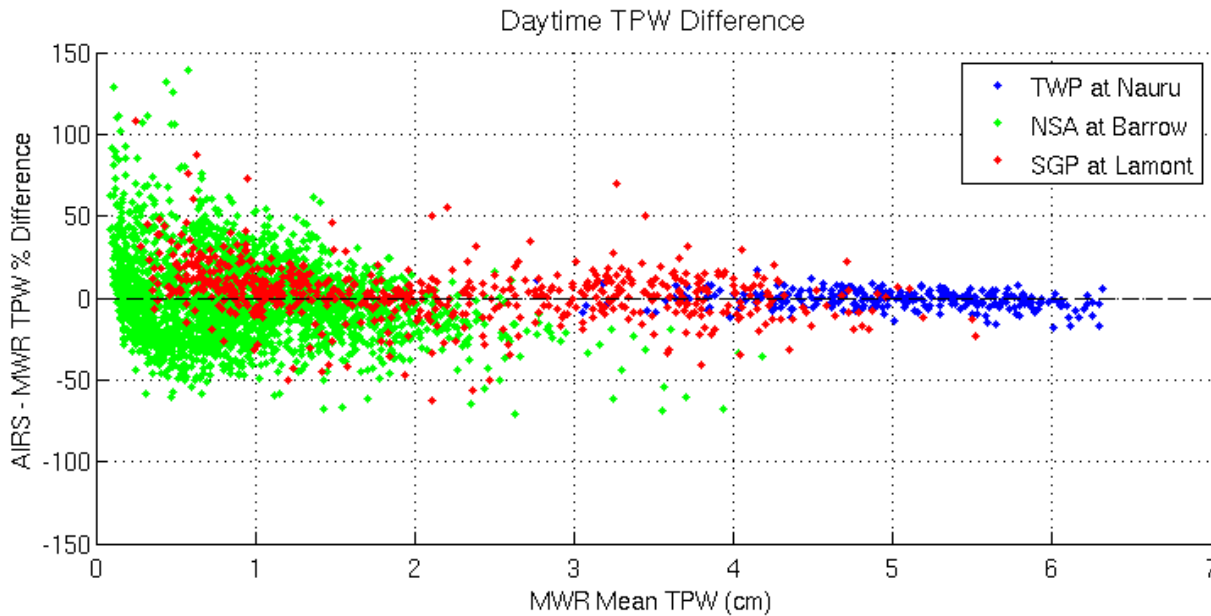


- Separate daylight and nighttime cases for independent analysis.

# AIRS

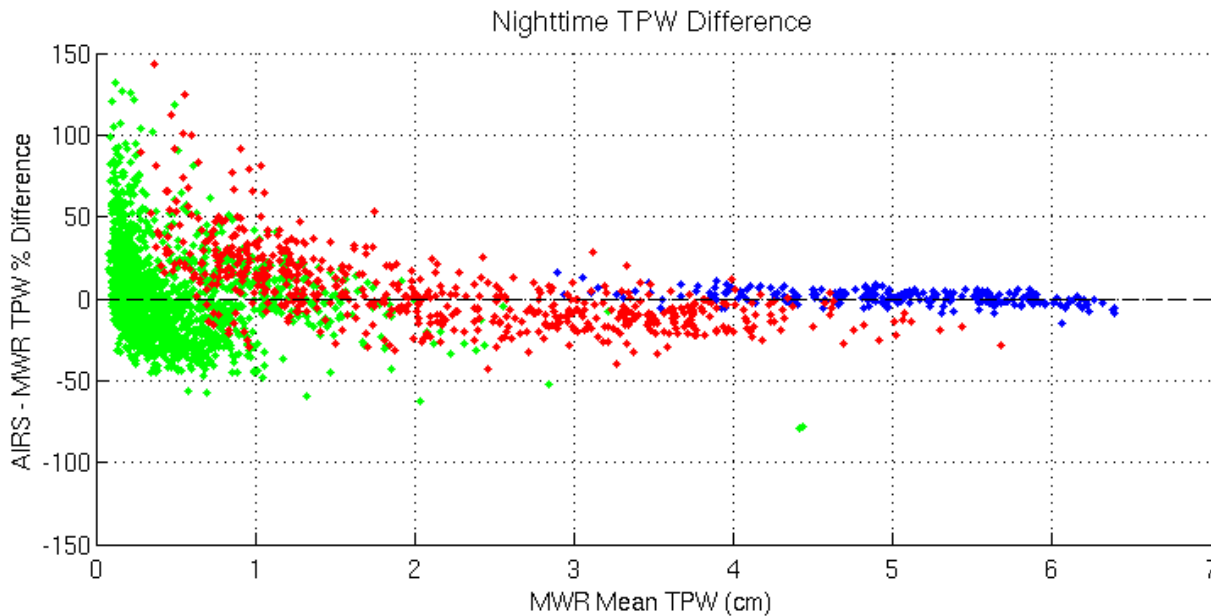
All the data from the period September 2002 to August 2008

**DAY**



**ARM MWR PWV (cm)**

**NIGHT**



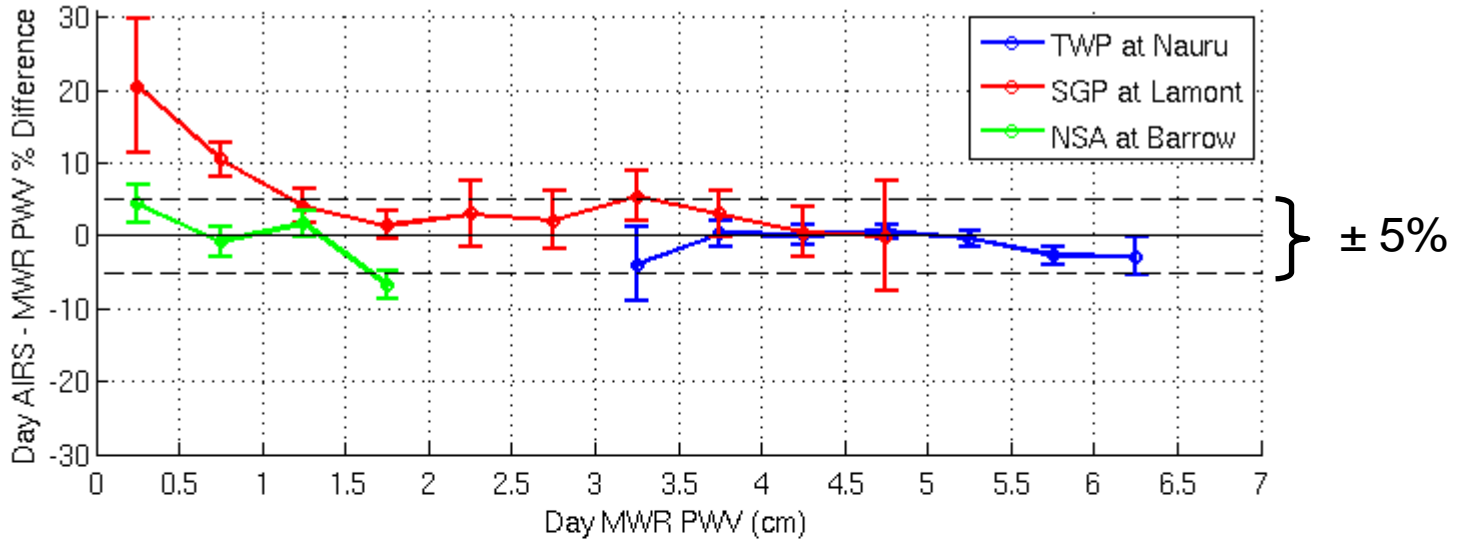
**ARM MWR PWV (cm)**

To quantify the bias we Estimate the Error in 0.5 cm PWV bins (next slide)

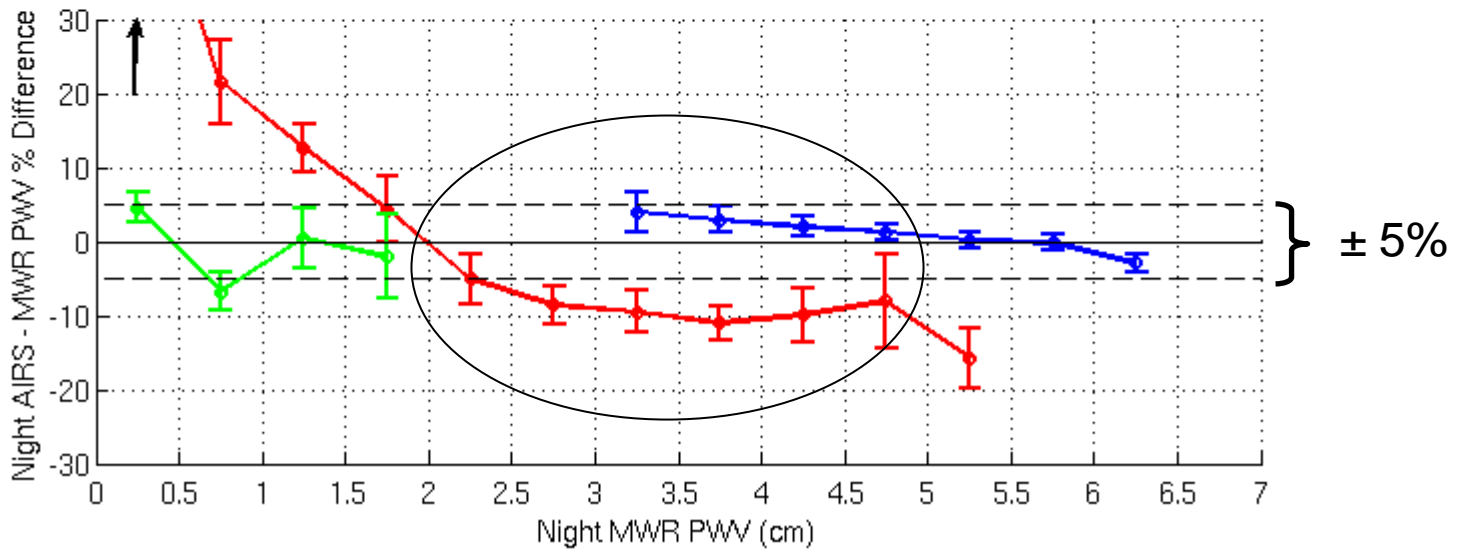


Bias Error (k=2) in AIRS PWV at ARM SGP, TWP and NSA Sites

**DAY**

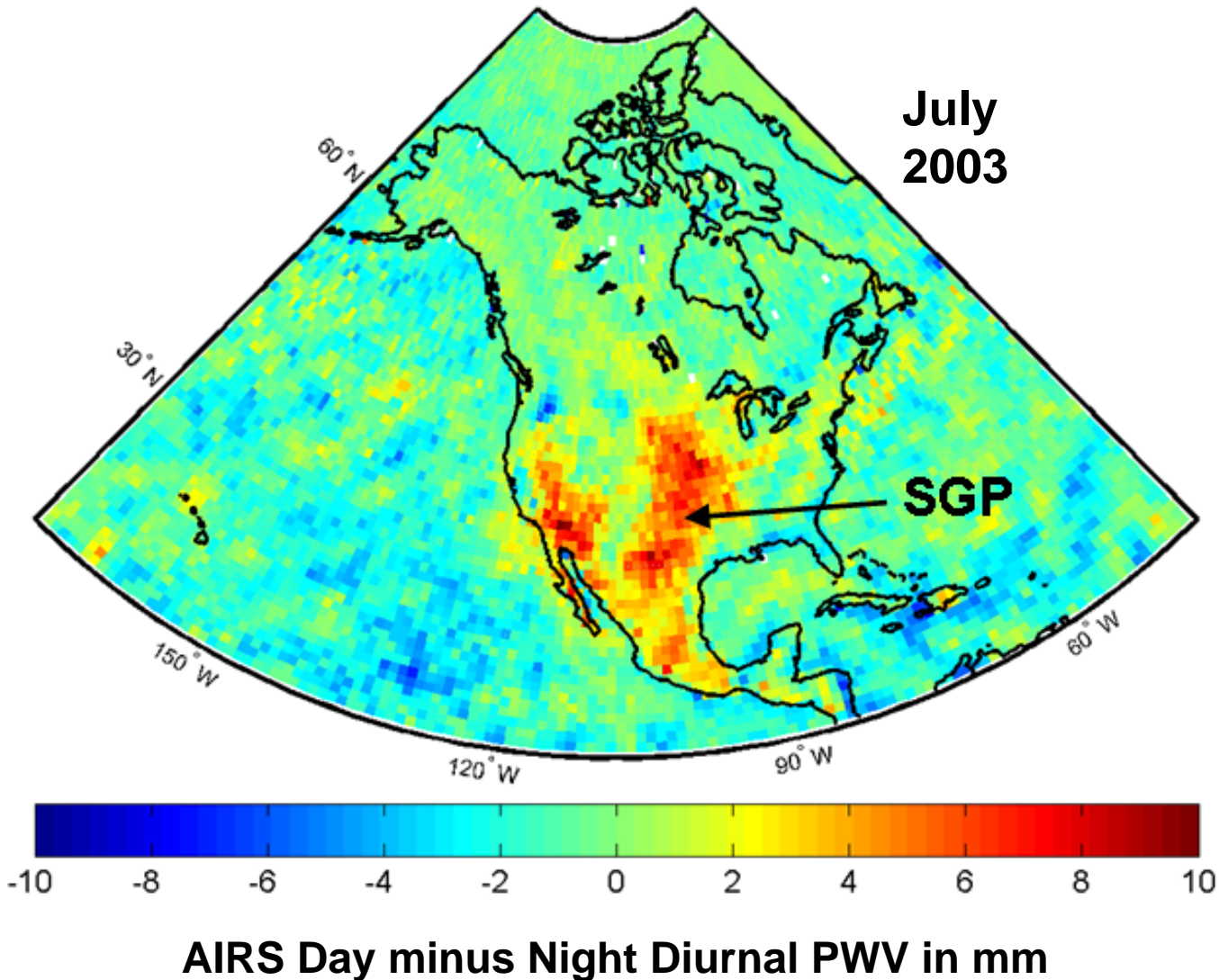


**NIGHT**



**ARM MWR PWV (cm)**

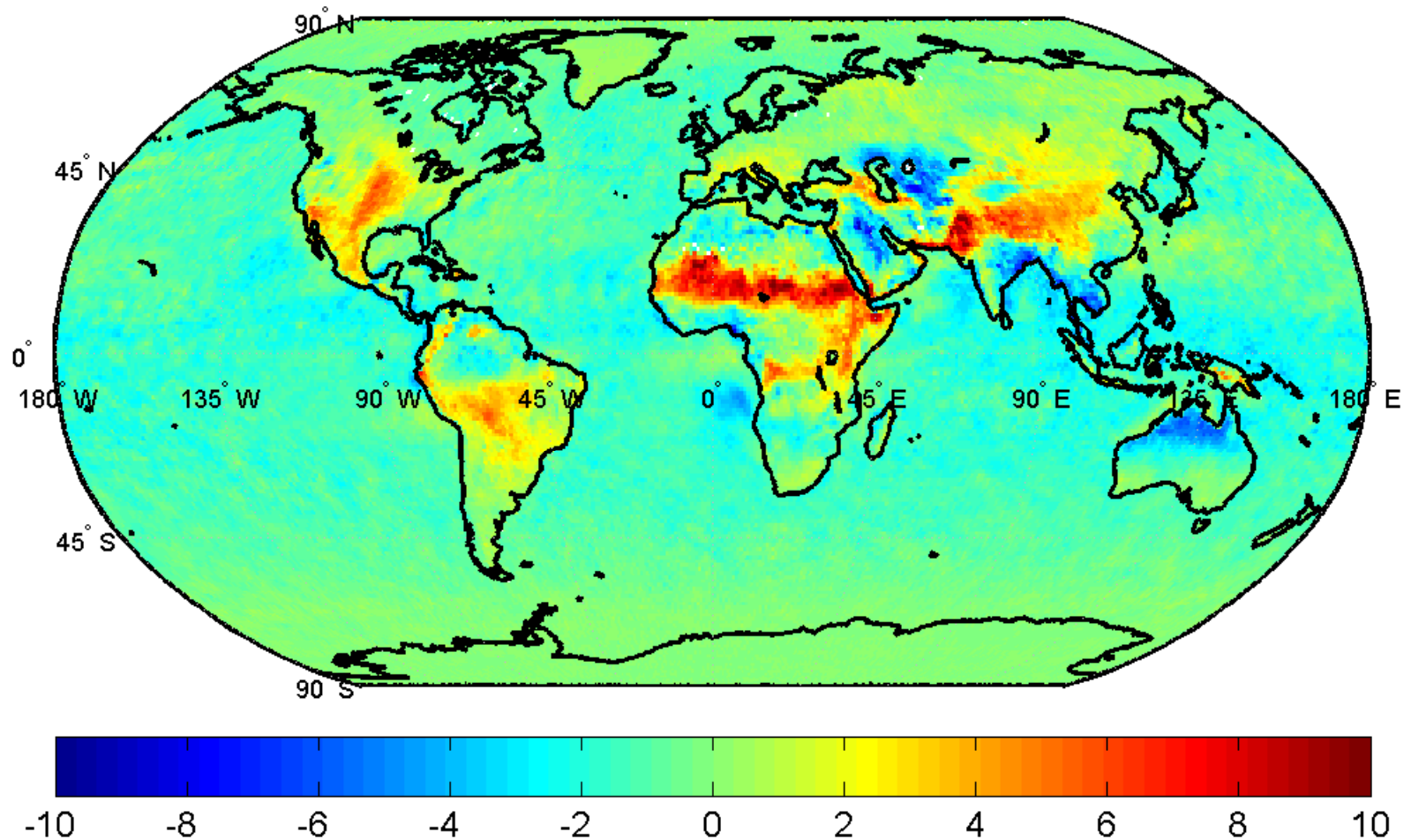
# Diurnal PWV Error of AIRS Retrieval at the Southern Great Plains Oklahoma site?



AIRS v5 Level 3 product exhibits a large day minus night difference for the monthly means during each summertime throughout the U.S. Great Plains and in the Desert Southwest.

This diurnal difference is a **retrieval artifact**.

AIRS PWV DAY-NIGHT (mm H<sub>2</sub>O): JULY.2003.2009



- This diurnal issue in AIRS v5 also appears in other regions.

## U. Wisconsin Validation of AIRS V5 Total Water

- **AIRS PWV is within the stated 5% accuracy:**
  - NSA < 5% ( 1 – 25 mm pw)
  - SGP < 5% (10 – 50 mm pw; daytime only)
  - TWP < 5% (35 – 65 mm pw)
- AIRS 10-30% too wet for pwv < 1 cm for Southern Great Plains LAND site both day and night.
- AIRS 10% too dry for pwv > 1 cm for the Southern Great Plains LAND site at nighttime only.

*[Bedka et al., An Assessment of the Absolute Accuracy of the Atmospheric Infrared Sounder (AIRS) v5 Precipitable Water Vapor Product at Tropical, Mid-Latitude, and Arctic Ground-Truth Sites: September 2002 through August 2008, JGR, 2010, in press]*

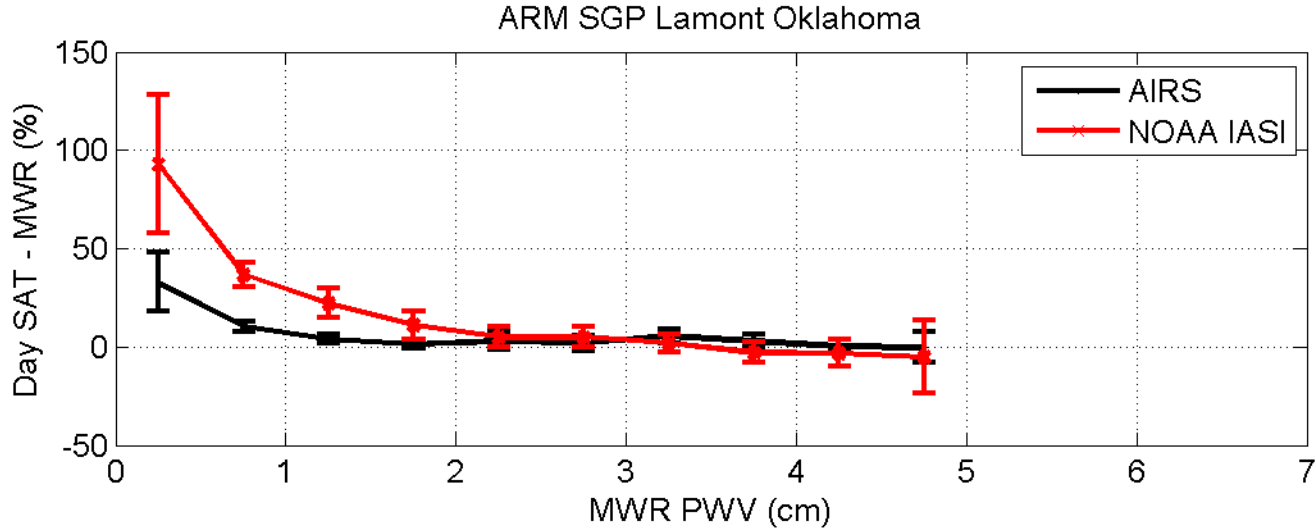
# AIRS and NOAA IASI Comparison

- AIRS Ver. 5 PWV  
using six years of measurements (Sep 2002 - Aug 2008)
- NOAA IASI PWV  
using two years of measurements (Jan 2008 - Dec 2009)
- AIRS V5 and NOAA IASI products use similar methods (e.g. cloud clearing) and radiative transfer models (SARTA). Statistical regression is used as a first guess to a physical iterative retrieval in both methods.
- AIRS Ver. 5 uses 3x3; NOAA IASI uses 2x2 FOVs.

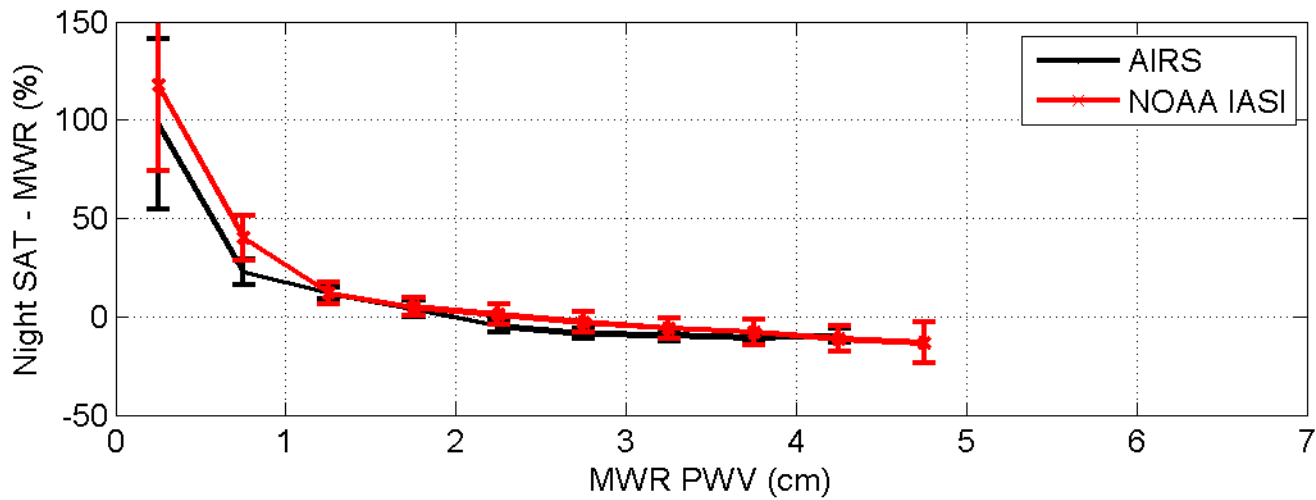
# ARM South Great Plains Lamont, OK ( in % )

**AIRS  
&  
IASI**

**DAY**



**NIGHT**

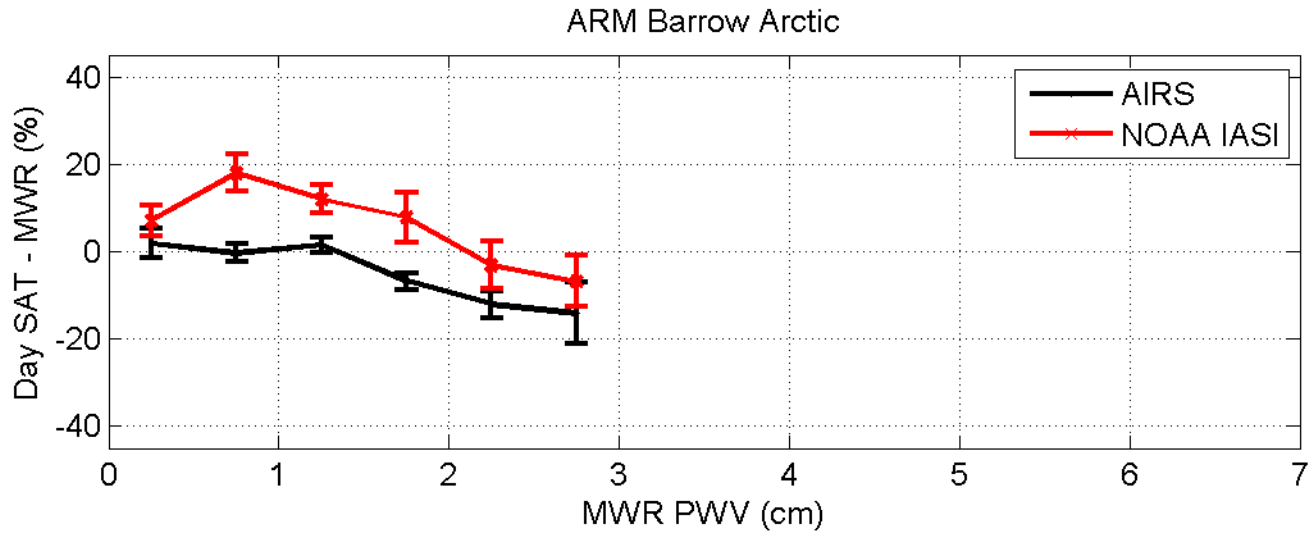




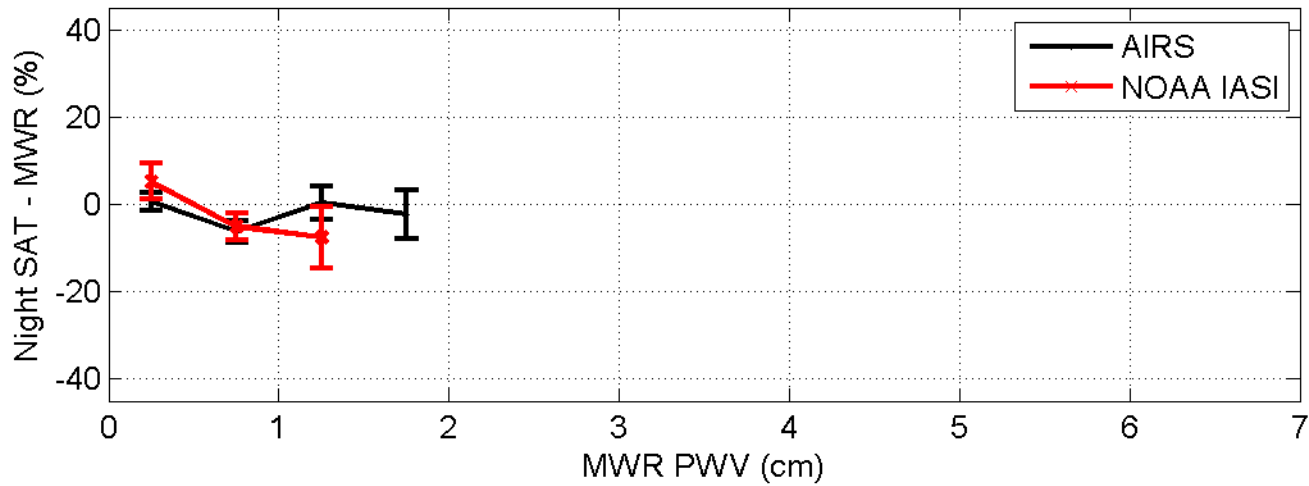
# ARM NSA Barrow, Alaska ( % )

**AIRS  
&  
IASI**

**DAY**



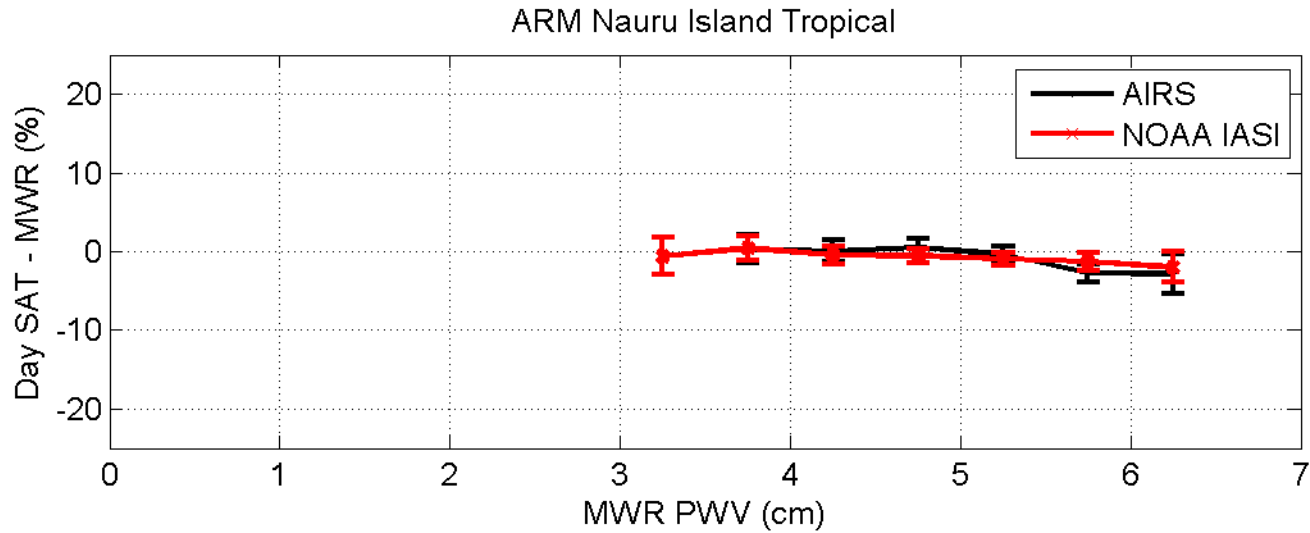
**NIGHT**



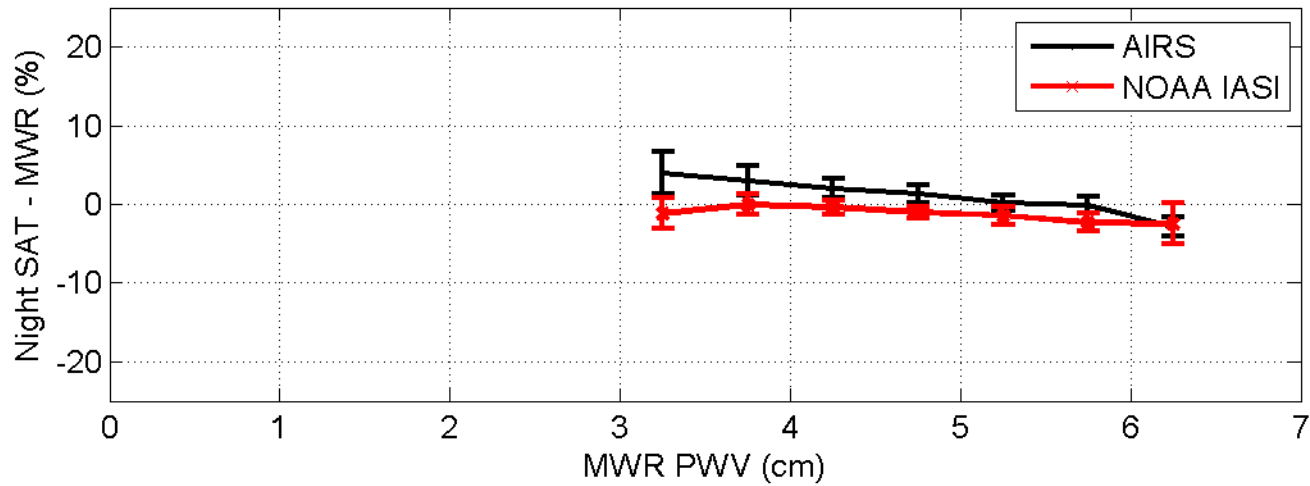
# ARM Tropical Western Pacific Nauru Island ( % )

**AIRS  
&  
IASI**

**DAY**



**NIGHT**



# Preliminary Conclusions of the AIRS and IASI PWV Validation

- We were able to validate total column water vapor to 3% accuracy for nearly the entire range of terrestrial water vapor column amounts using the ARM sites for both AIRS and IASI sensors.
- *The AIRS v5 algorithm is performing well (<5%) over a wide dynamic range but with some significant diurnal biases over land which warrant further investigation.*
- **IASI NOAA processing using a similar algorithm to the AIRS processing gives validation results similar to the AIRS results.**
- Future work will make use of the groundbased GPS network to extend the analysis from point site measurements to a regional analysis.

# Backup Slides

International TOVS Study Conference, 17<sup>th</sup>, ITSC-17, Monterey, CA, 14-20 April 2010.  
Madison, WI, University of Wisconsin-Madison, Space Science and Engineering Center,  
Cooperative Institute for Meteorological Satellite Studies, 2011.