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

Robert Knuteson, Sarah Bedka,
Jacola Roman, Dave Tobin,
Dave Turner, Hank Revercomb

University of Wisconsin-Madison
Space Science & Engineering Center
Cooperative Institute for Meteorological Satellite Studies

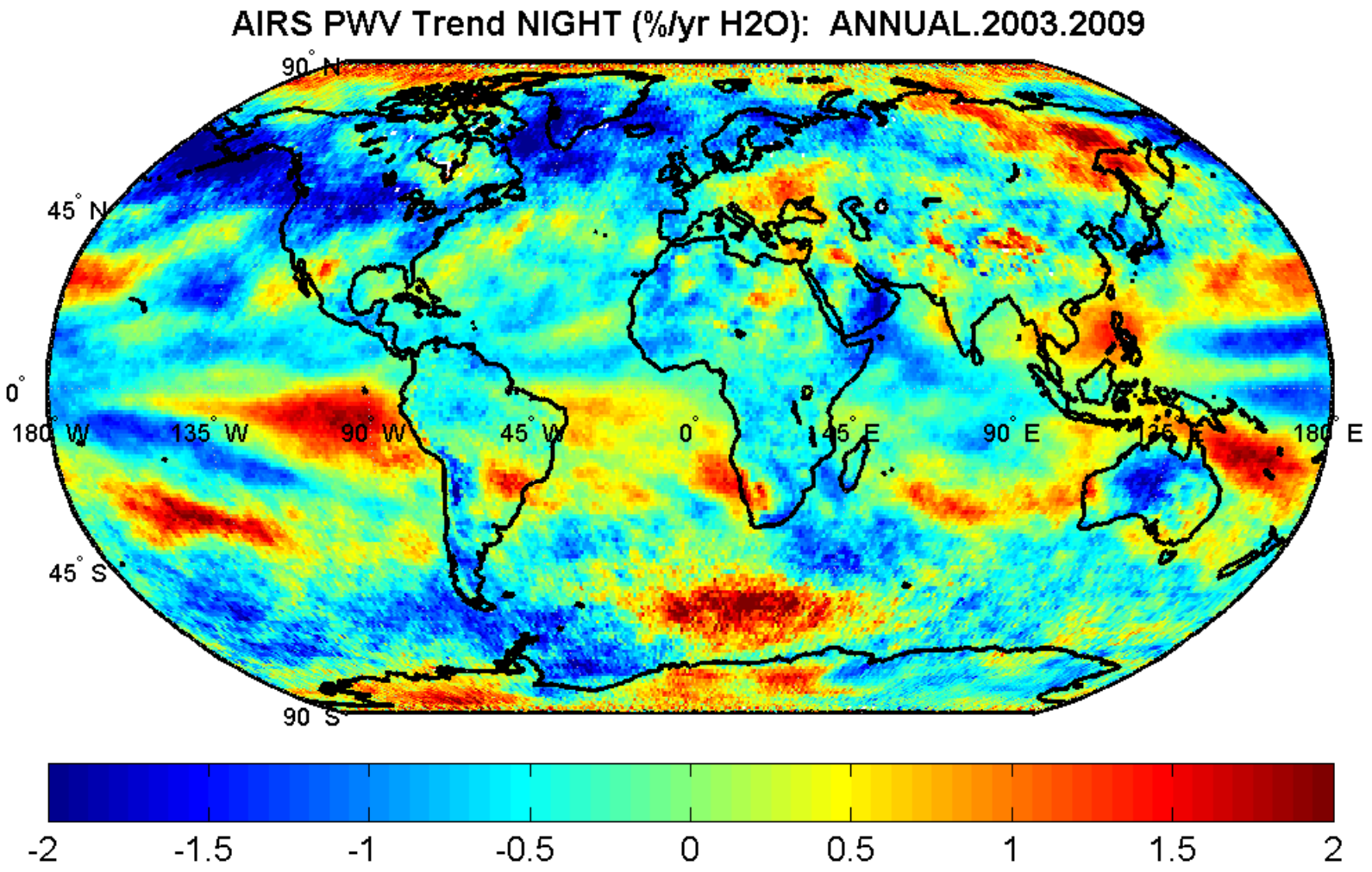
Why Validate Precipitable Water Vapor (PWV)?

• 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.

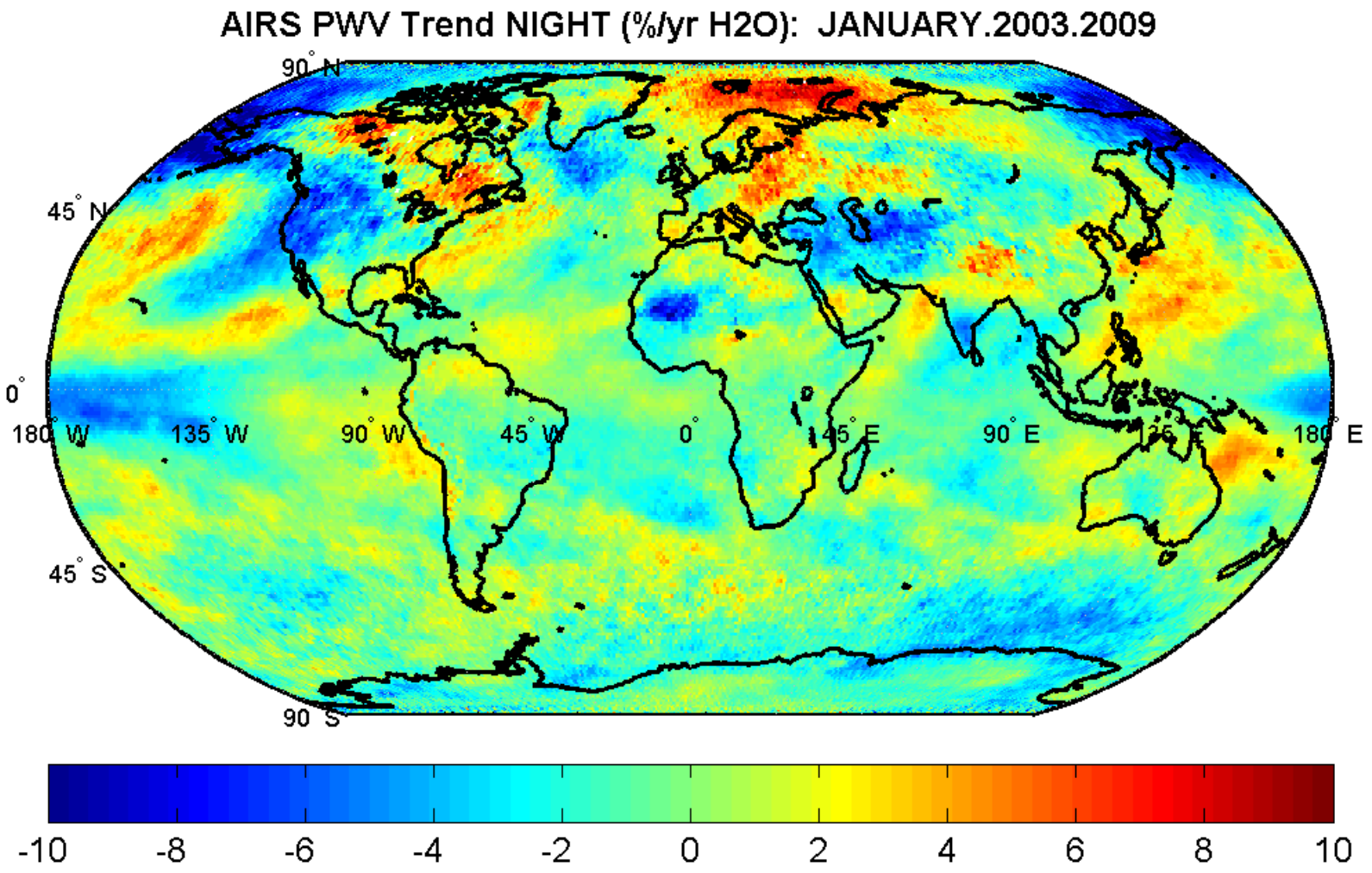
• Errors in the total column water vapor can be attributed to errors in the retrieved profile.

• 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?

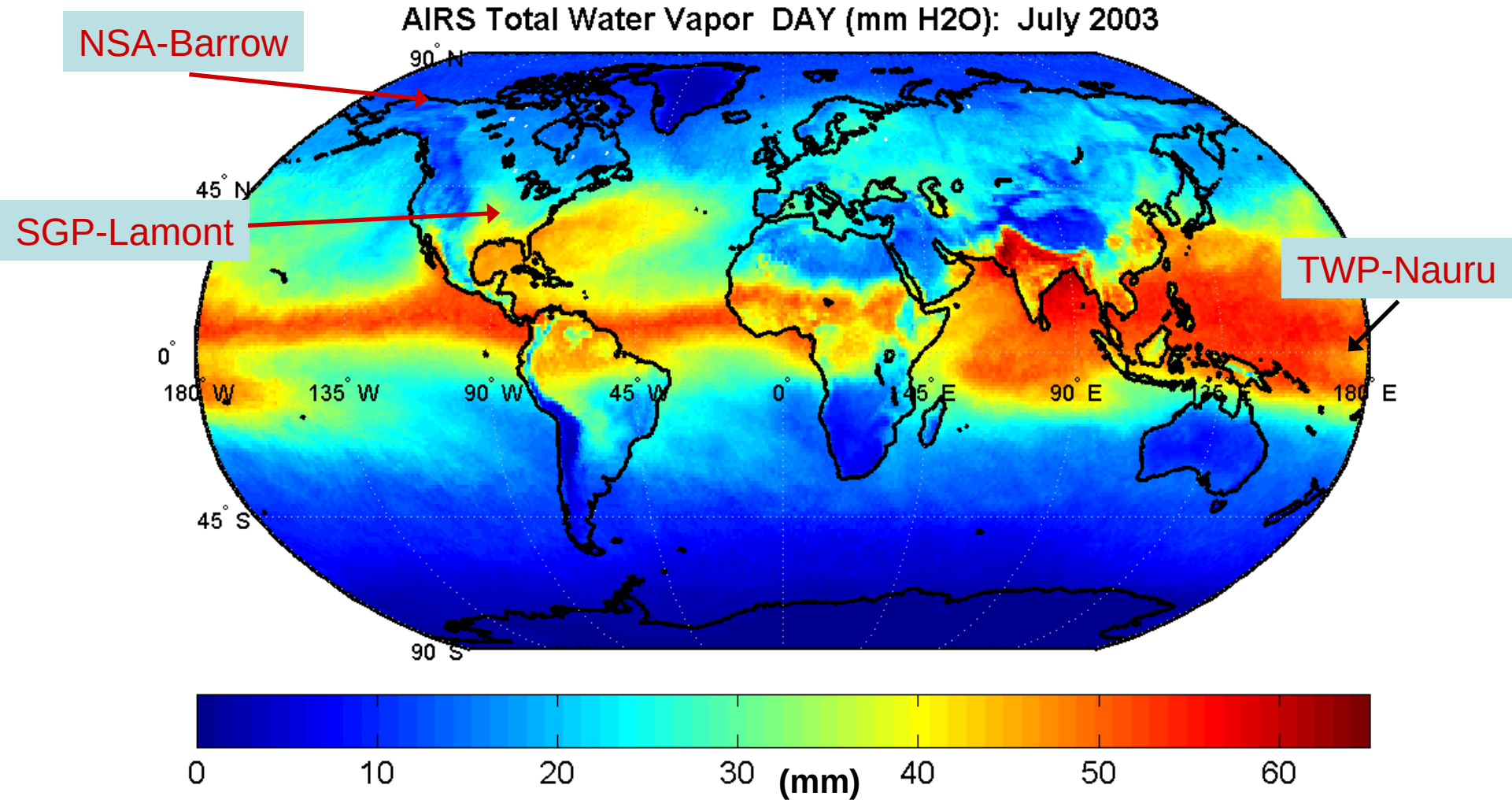


- AIRS Total Column Water Vapor for 2003-2009 (All Months)



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

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



- 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 H2O, HDO, and D2O," *J. Chem. Phys.*, vol. 59, pp. 2254-2259, 1973.

- Improved PW retrieval method by Dave Turner of UW-SSEC.

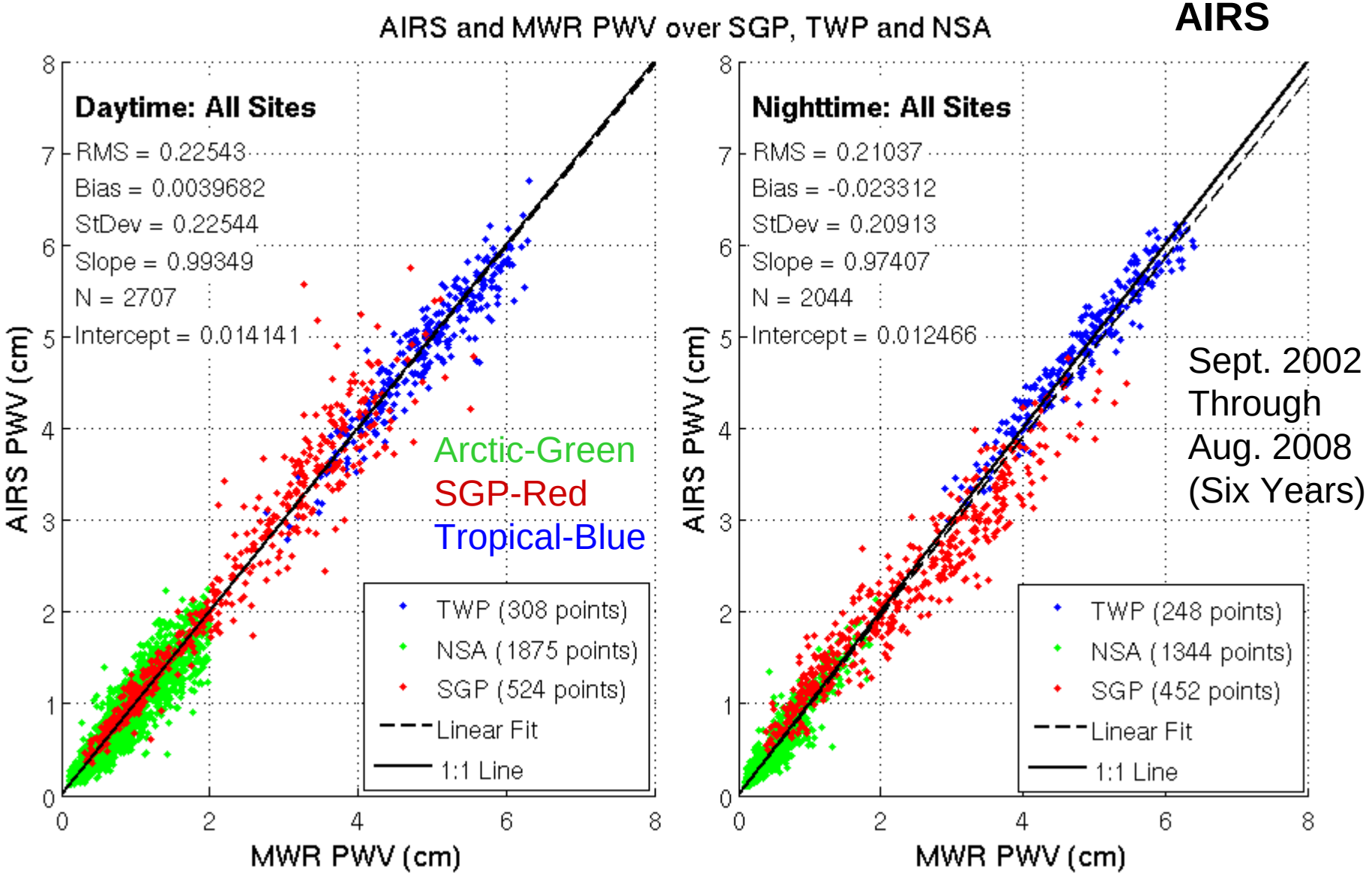
  *Turner, D.D., S. A. Clough, J. C. Liljegren, et al., 2007: Retrieving liquid water path and precipitable water vapor from the Atmospheric Radiation Measurement (ARM) microwave radiometers. IEEE Trans. Geosci. Remote Sens., **45**.*

- 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.*

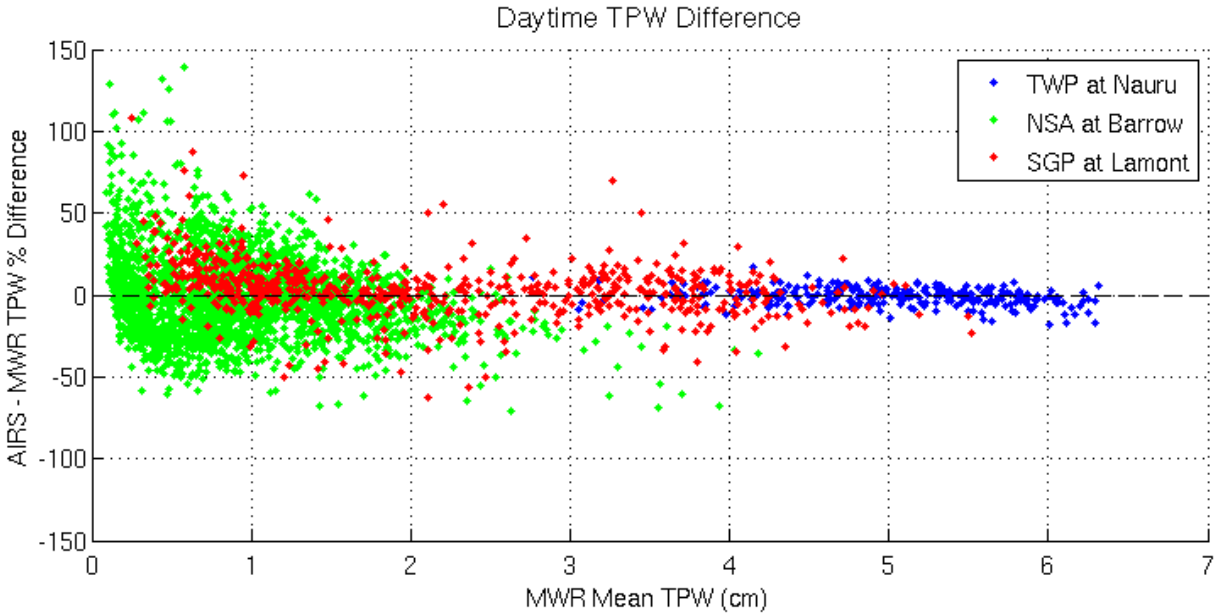
AIRS



Sept. 2002 Through Aug. 2008 (Six Years)

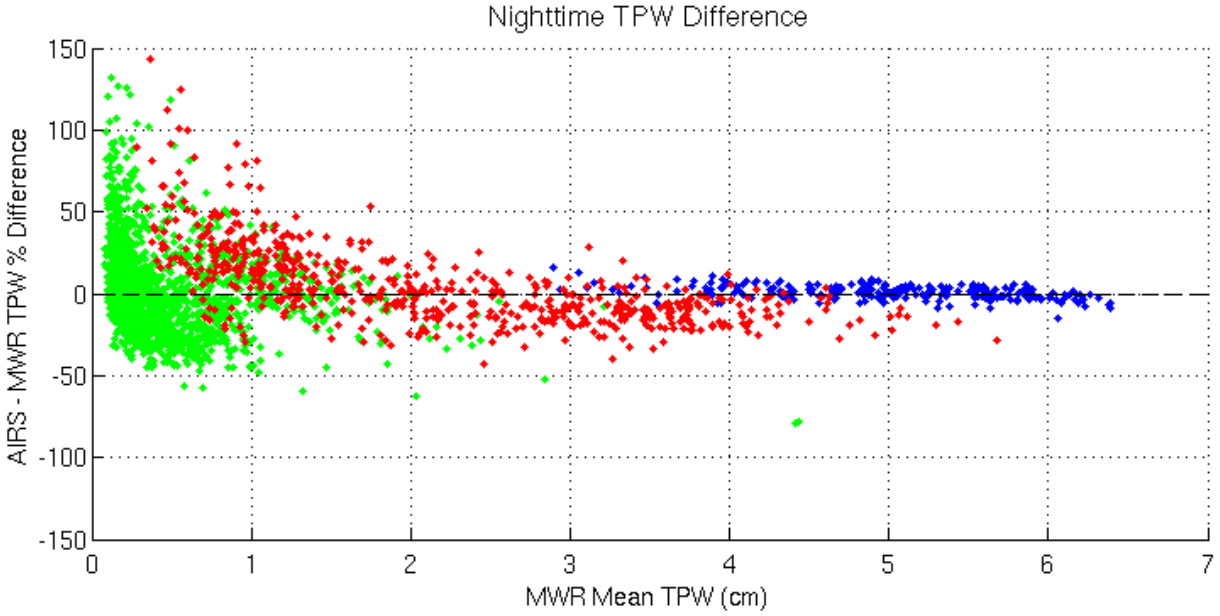
- Separate daylight and nighttime cases for independent analysis.

DAY



ARM MWR PWV (cm)

NIGHT



ARM MWR PWV (cm)

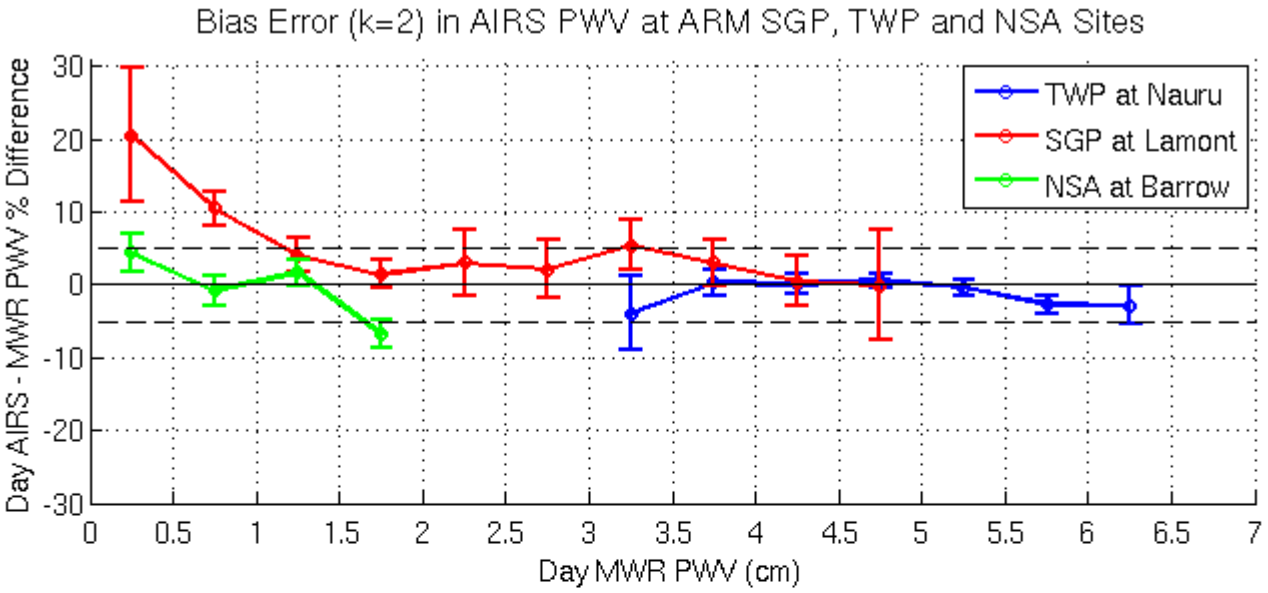
AIRS

All the data from the period September 2002 to August 2008

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

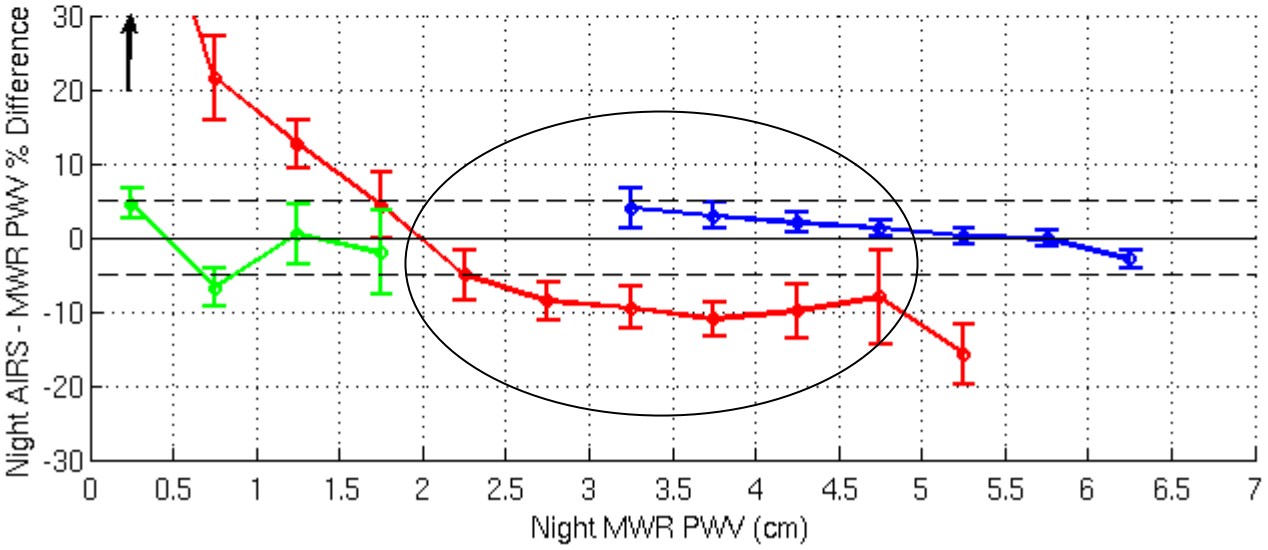
AIRS

DAY



± 5%

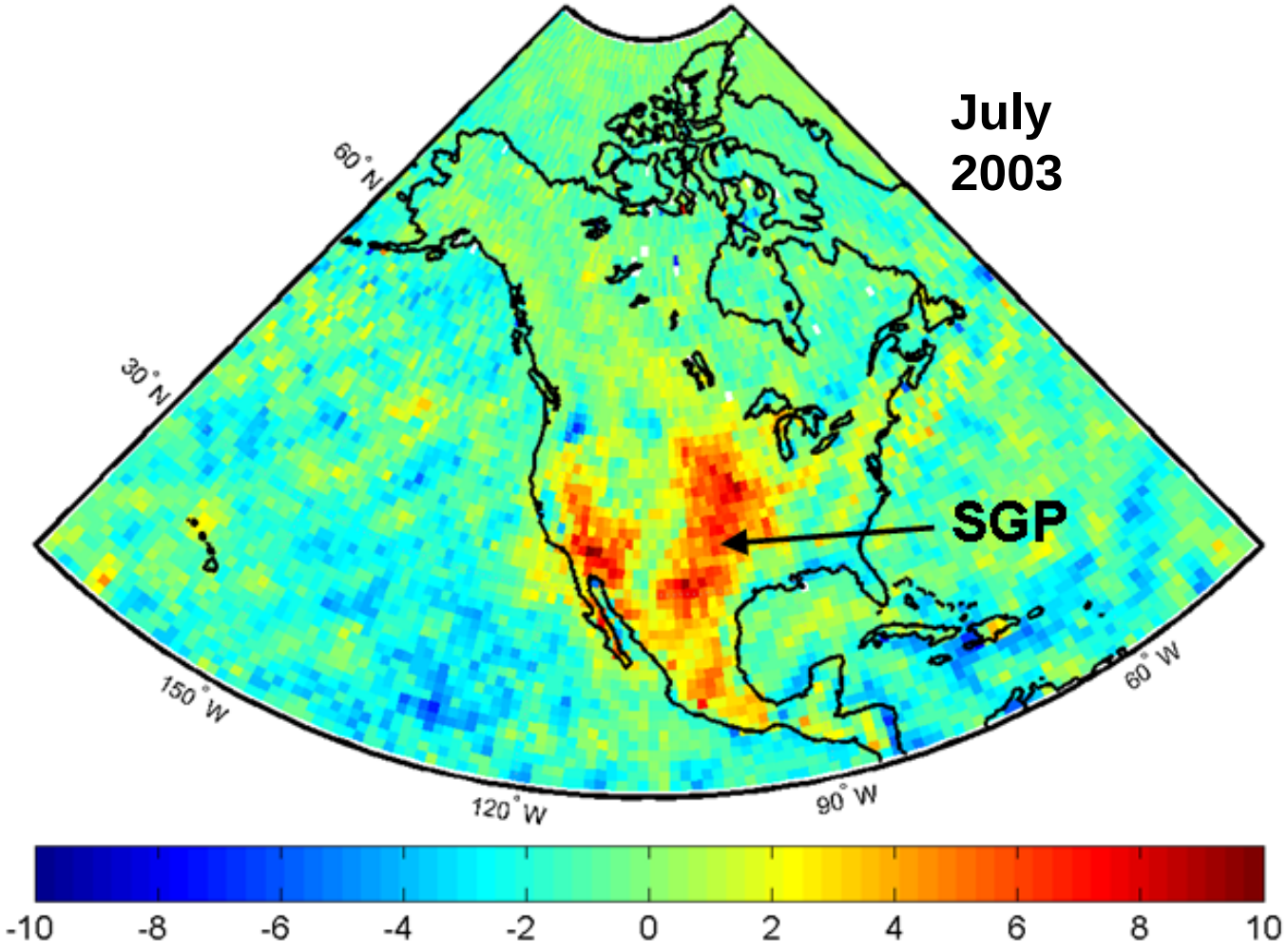
NIGHT



± 5%

ARM MWR PWV (cm)

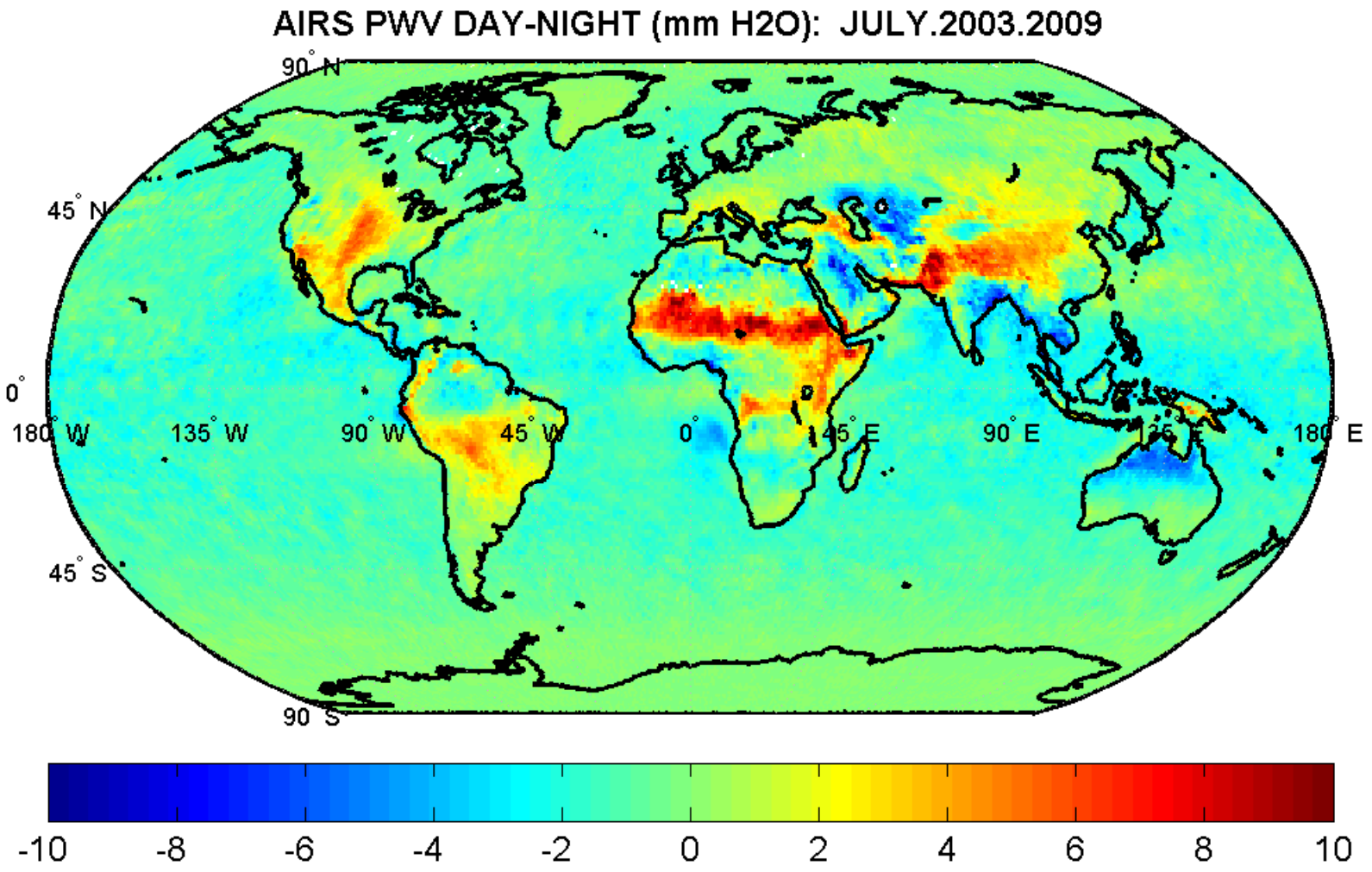
Diurnal PWV Error of AIRS Retrieval at the Southern Great Plains Oklahoma site?



AIRS Day minus Night Diurnal PWV in mm

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.



- 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)

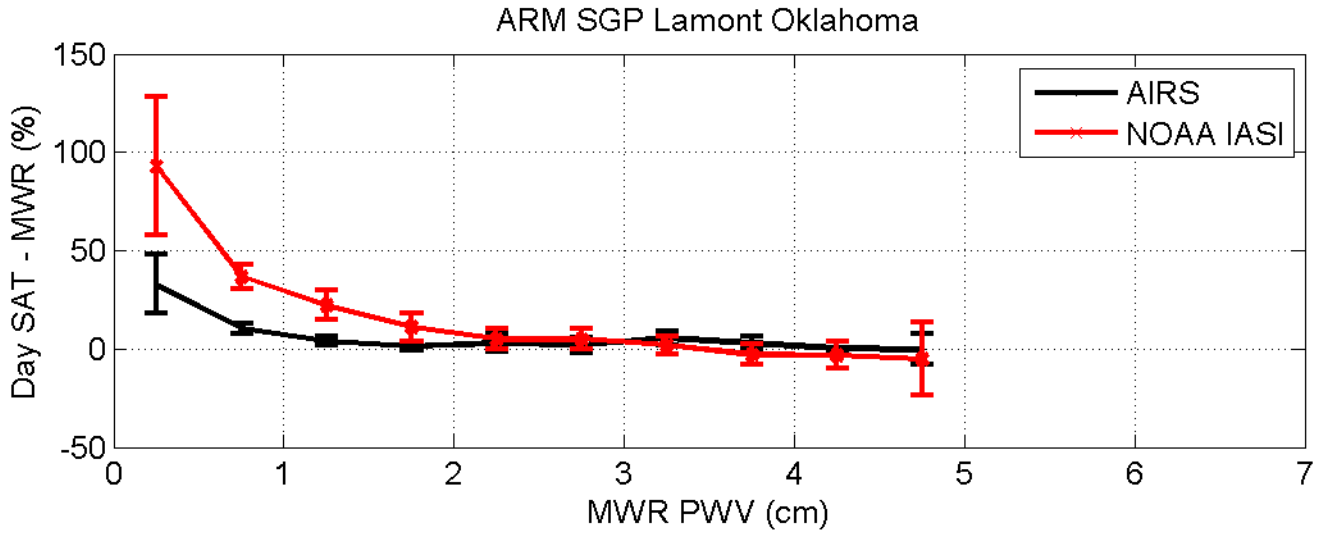
- AIRS V5 and NOAA IASI products use similar methods (e.g. cloud clearing) and radiative transfer models (SARTA). Statistical regression is used as a first guess to a physical iterative retrieval in both methods.

- AIRS Ver. 5 uses 3x3; NOAA IASI uses 2x2 FOVs.

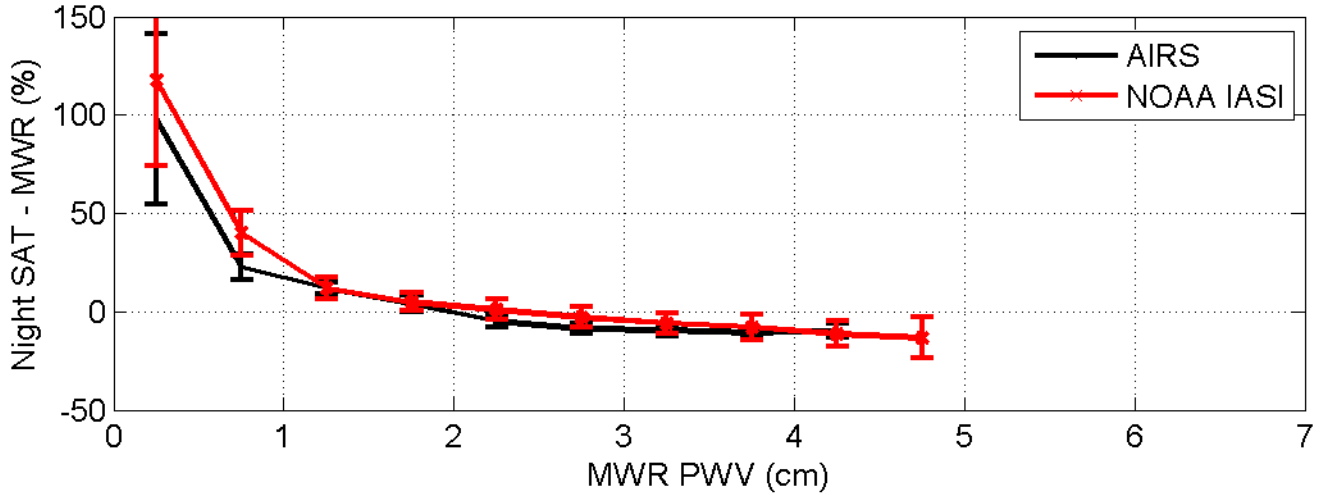
ARM South Great Plains Lamont, OK (in %)

AIRS & IASI

DAY



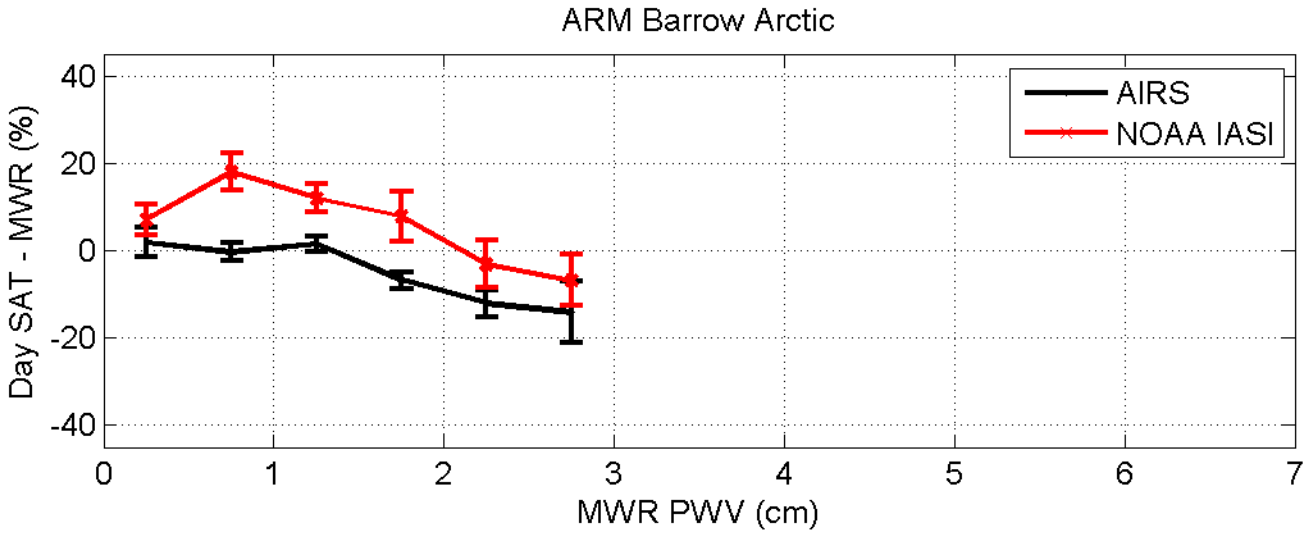
NIGHT



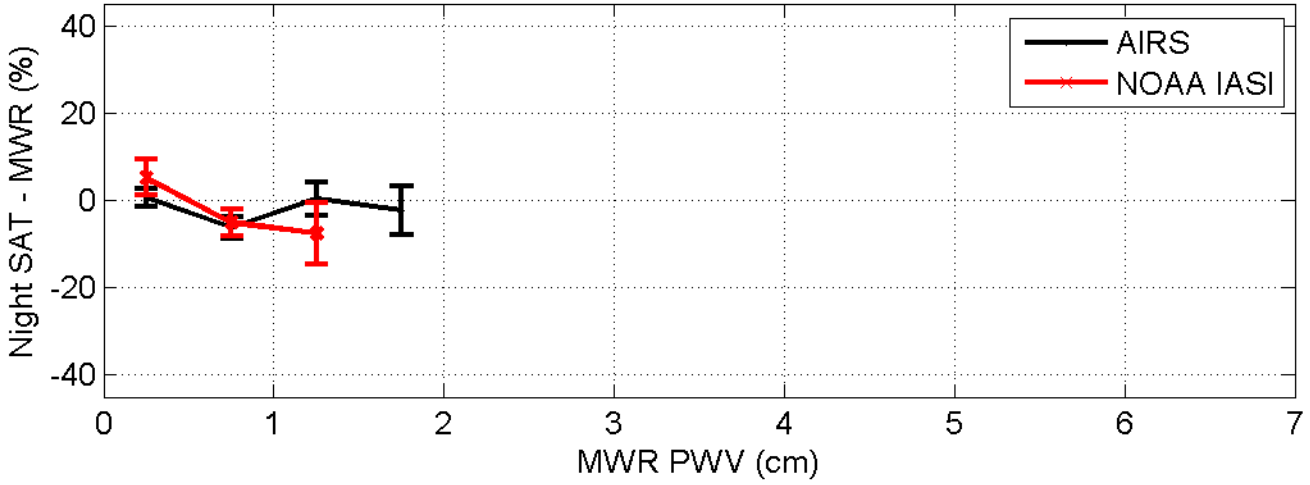
ARM NSA Barrow, Alaska (%)

AIRS & IASI

DAY



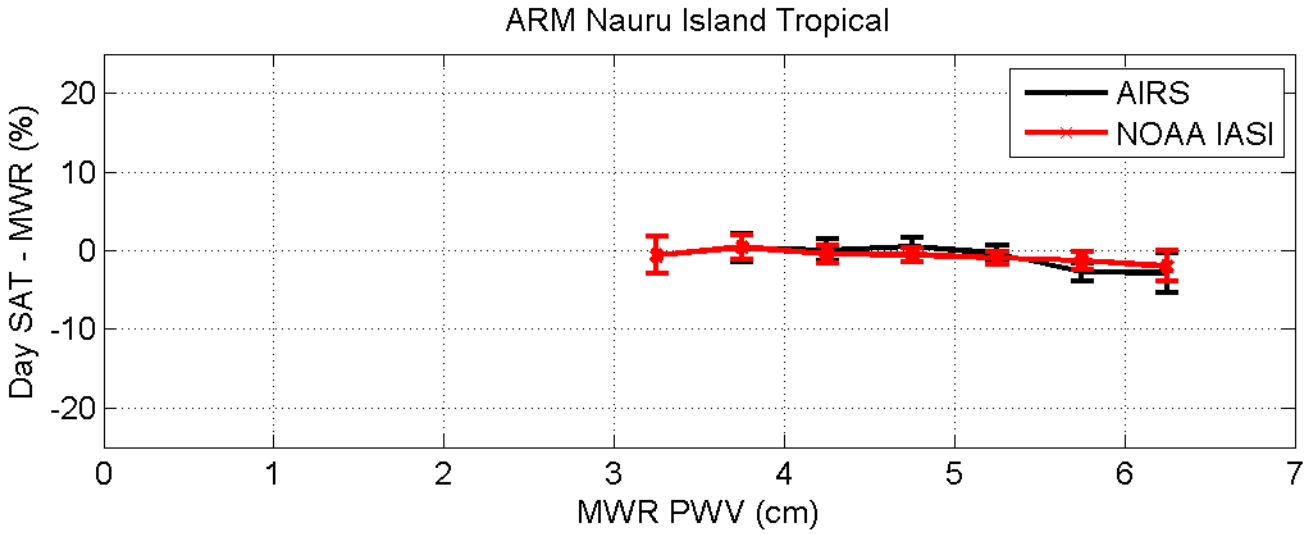
NIGHT



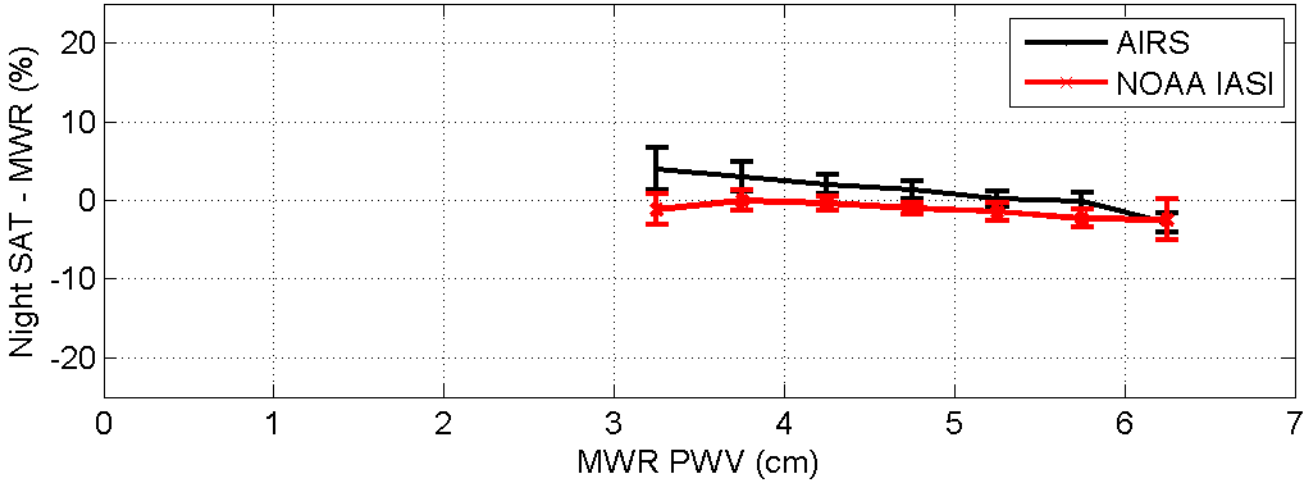
ARM Tropical Western Pacific Nauru Island (%)

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