Understanding Regional Climate Variations : GCM Validation and Assessment using PWV

Robert Knuteson, Jacola Roman*,
Henry Revercomb, William Smith, David Tobin

University of Wisconsin-Madison
Space Science and Engineering Center
**Department of Atmospheric and Oceanic Sciences*

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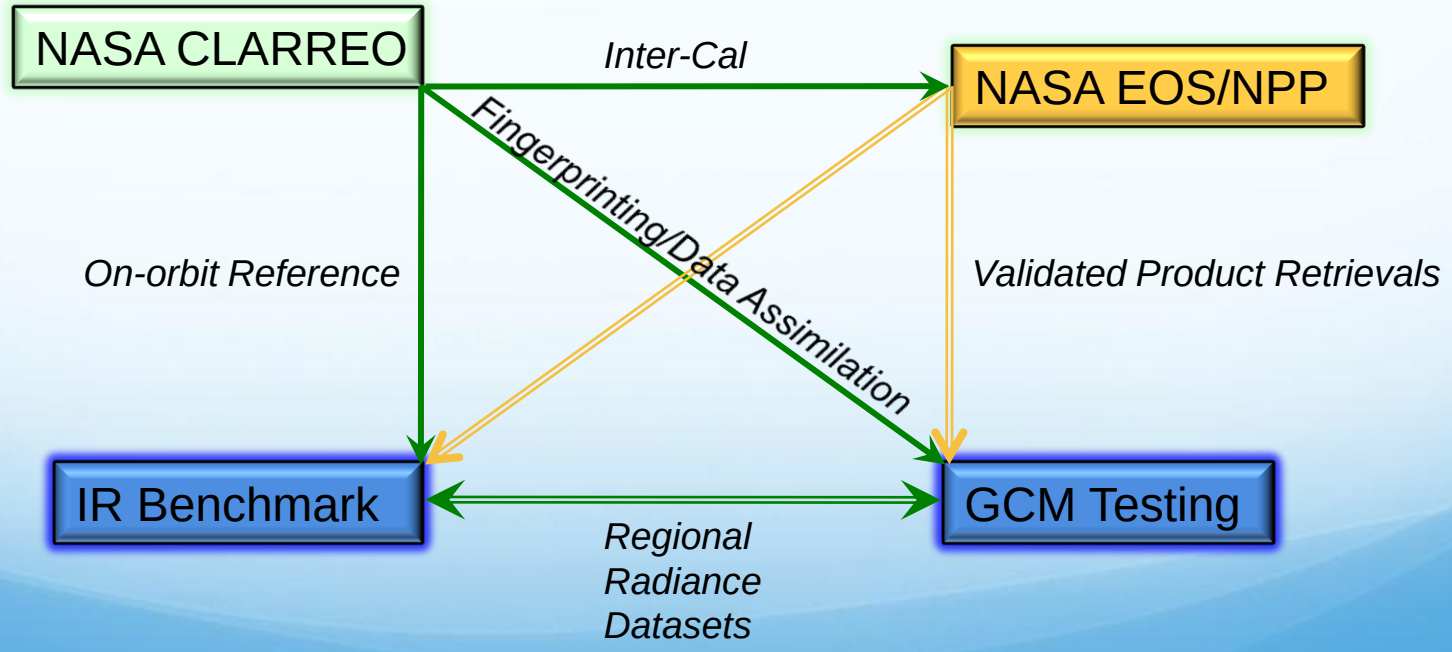
Introduction

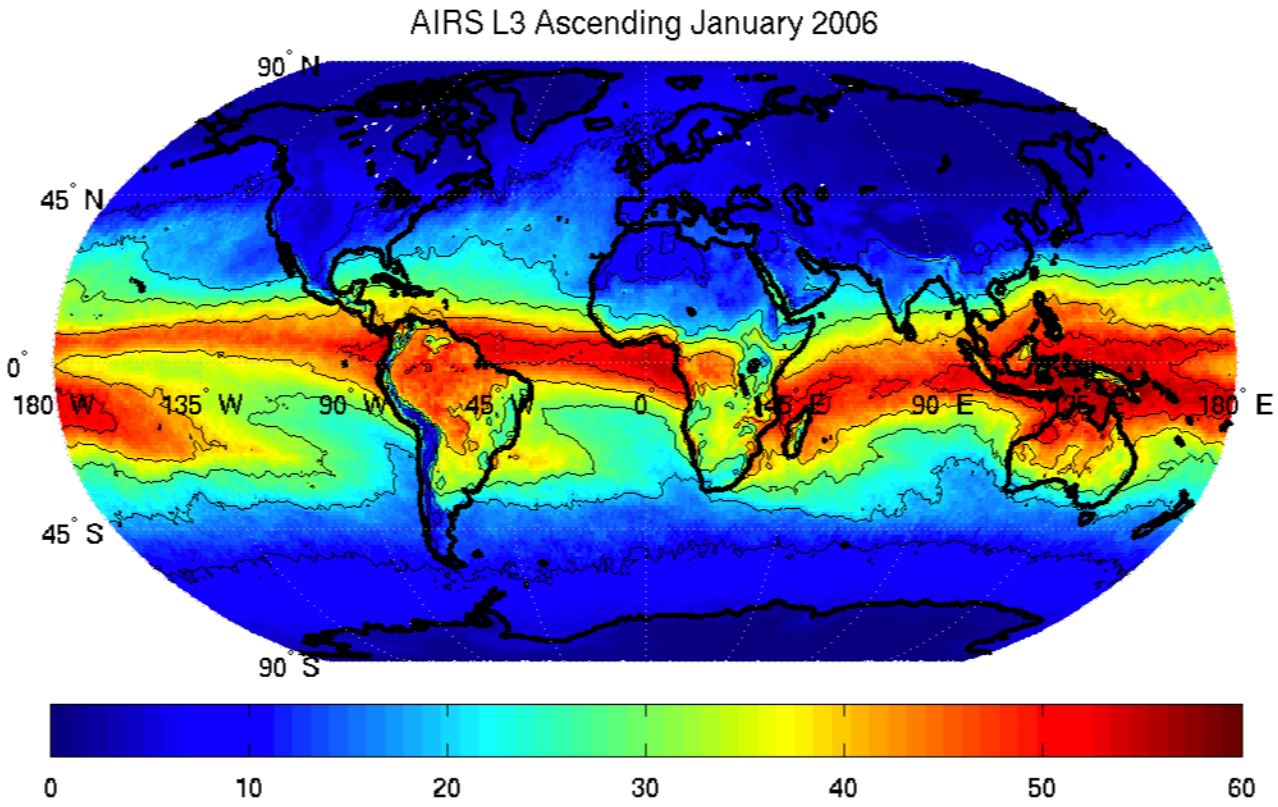
- The NASA CLARREO mission will provide
  1) a climate benchmark of IR radiance observations, and
  2) testing of global climate models (GCMs)

  with on-orbit verification.

- The NASA EOS & follow-on missions (e.g. NPP) will also contribute to these objectives tied to CLARREO via inter-cal.

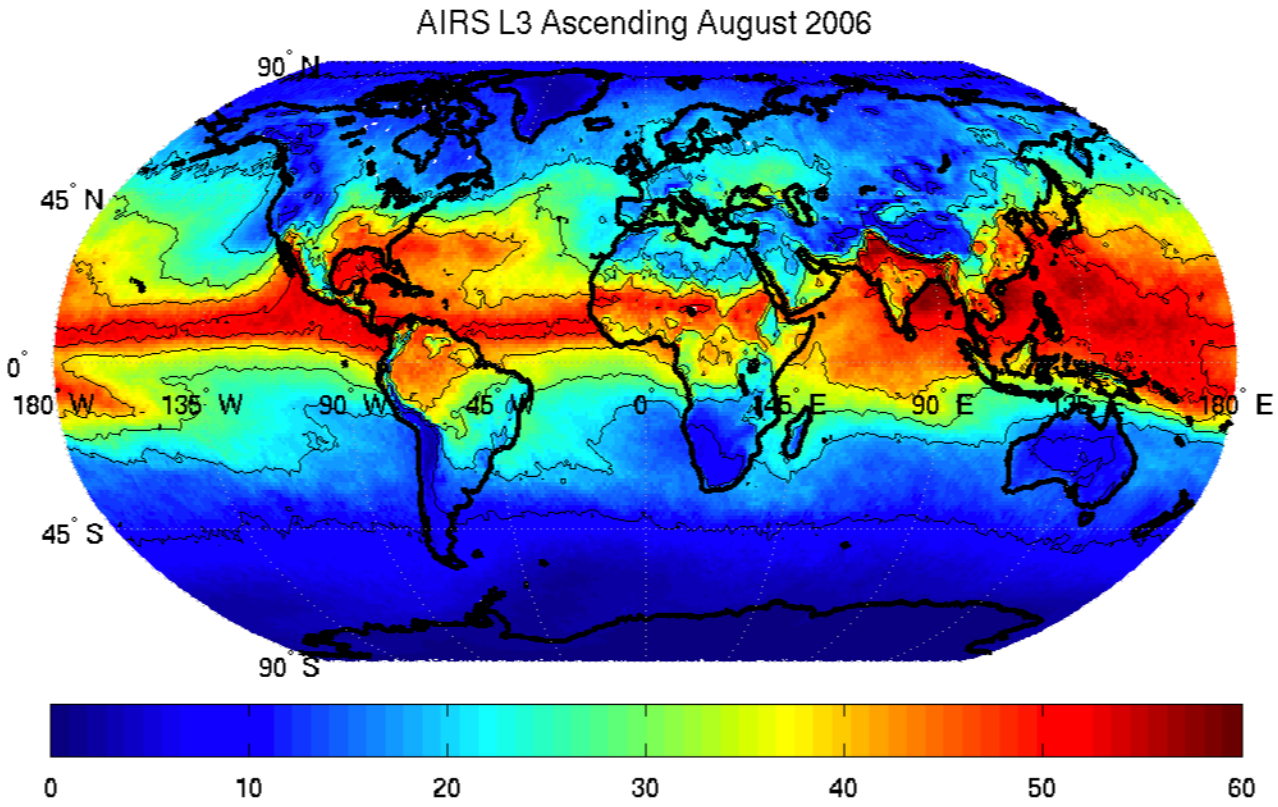


Use Precipitable Water Vapor (PWV) from NASA AIRS to Evaluate Regional and Seasonal Predictions of GCMs



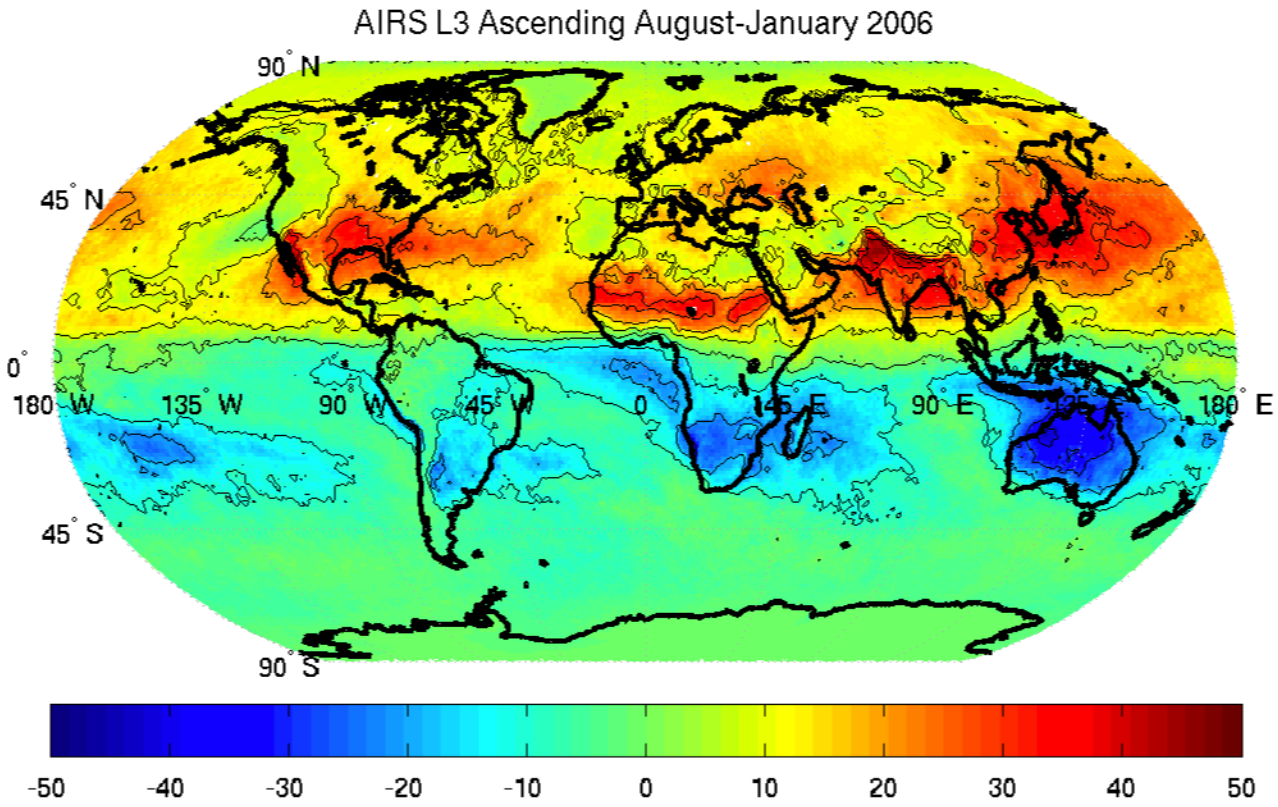
- AIRS Level 3 Gridded Product (Daytime): January 2006

Use Precipitable Water Vapor (PWV) from NASA AIRS to Evaluate Regional and Seasonal Predictions of GCMs



- AIRS Level 3 Gridded Product (Daytime): August 2006

Use Precipitable Water Vapor (PWV) from NASA AIRS to Evaluate Regional and Seasonal Predictions of GCMs



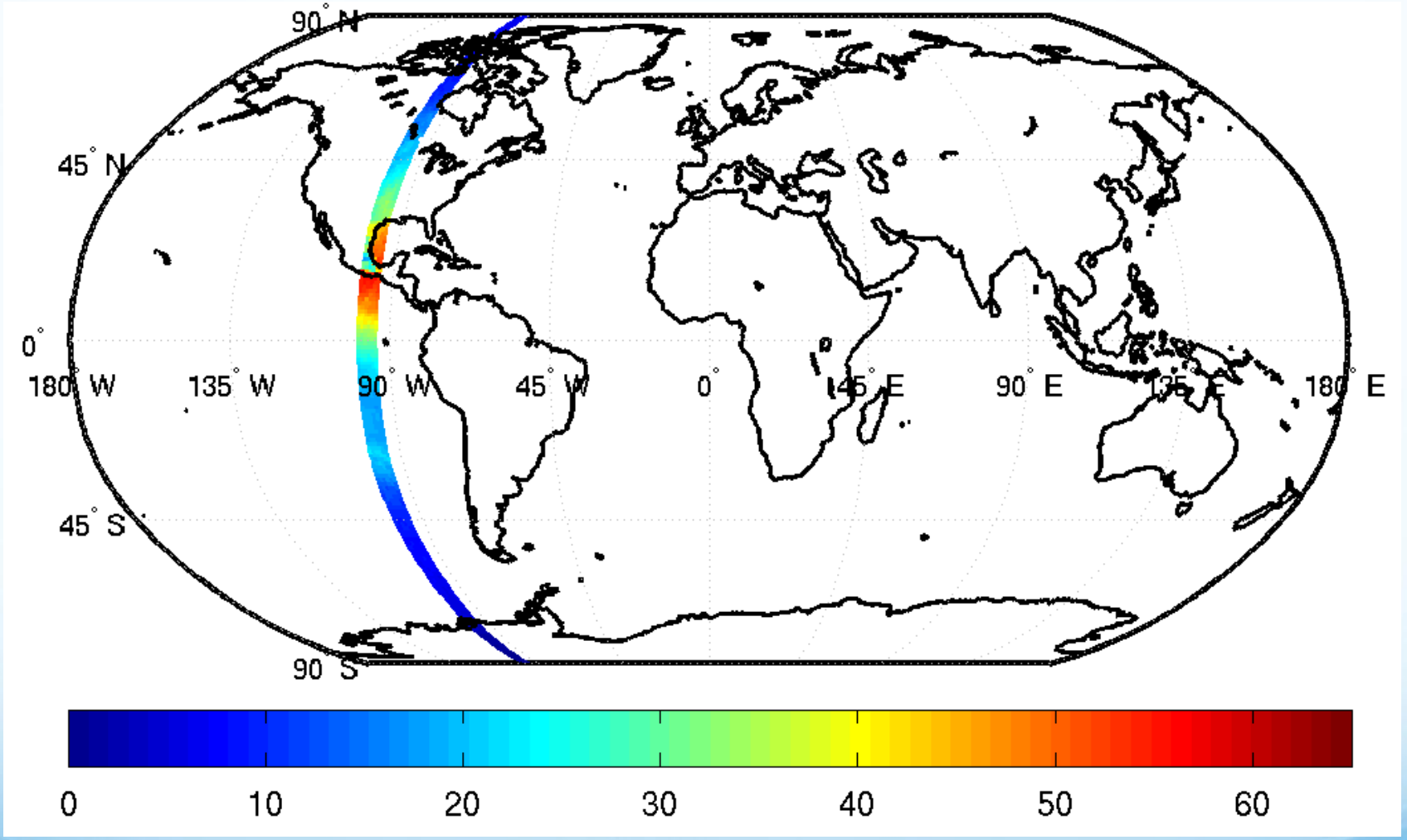
- August minus January 2006. ***Note the large seasonal moisture variation in the U.S. Great Plains region.***

Objectives of this Study

(Jacola Roman, UW-Madison AOS Master's Thesis)

- Investigate regional differences in total precipitable water vapor (PWV) among Global Climate Models (GCMs)
- Separate ocean/land effects from zonal averages of PWV
- Validation using ground-based GPS and IR satellites

Investigate Regional PWV Over North America

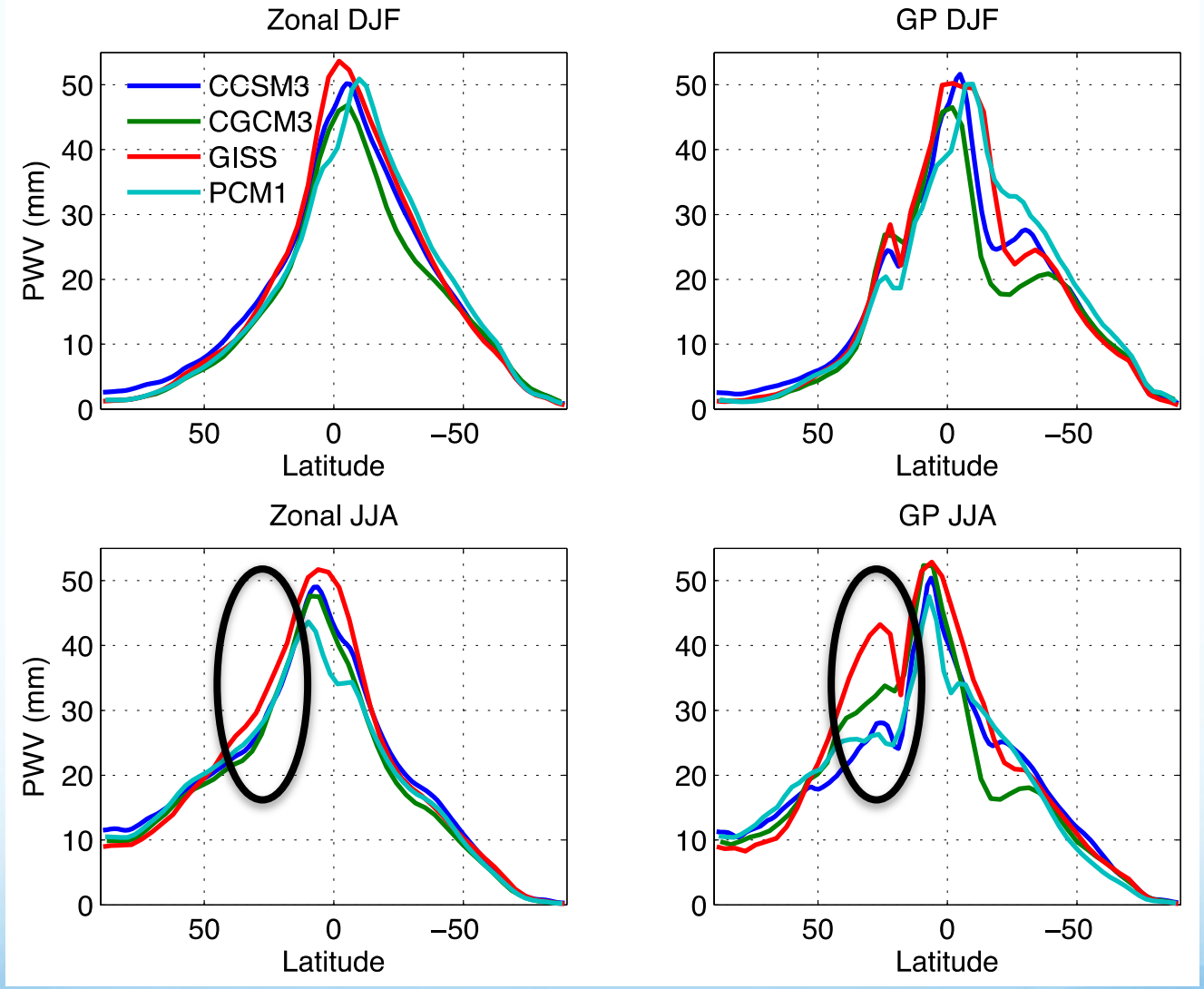


- Select latitude cross section of GCMs at longitude 100 W to 87 W

Four Models from the IPCC AR4 SRES A2 Scenario

DJF

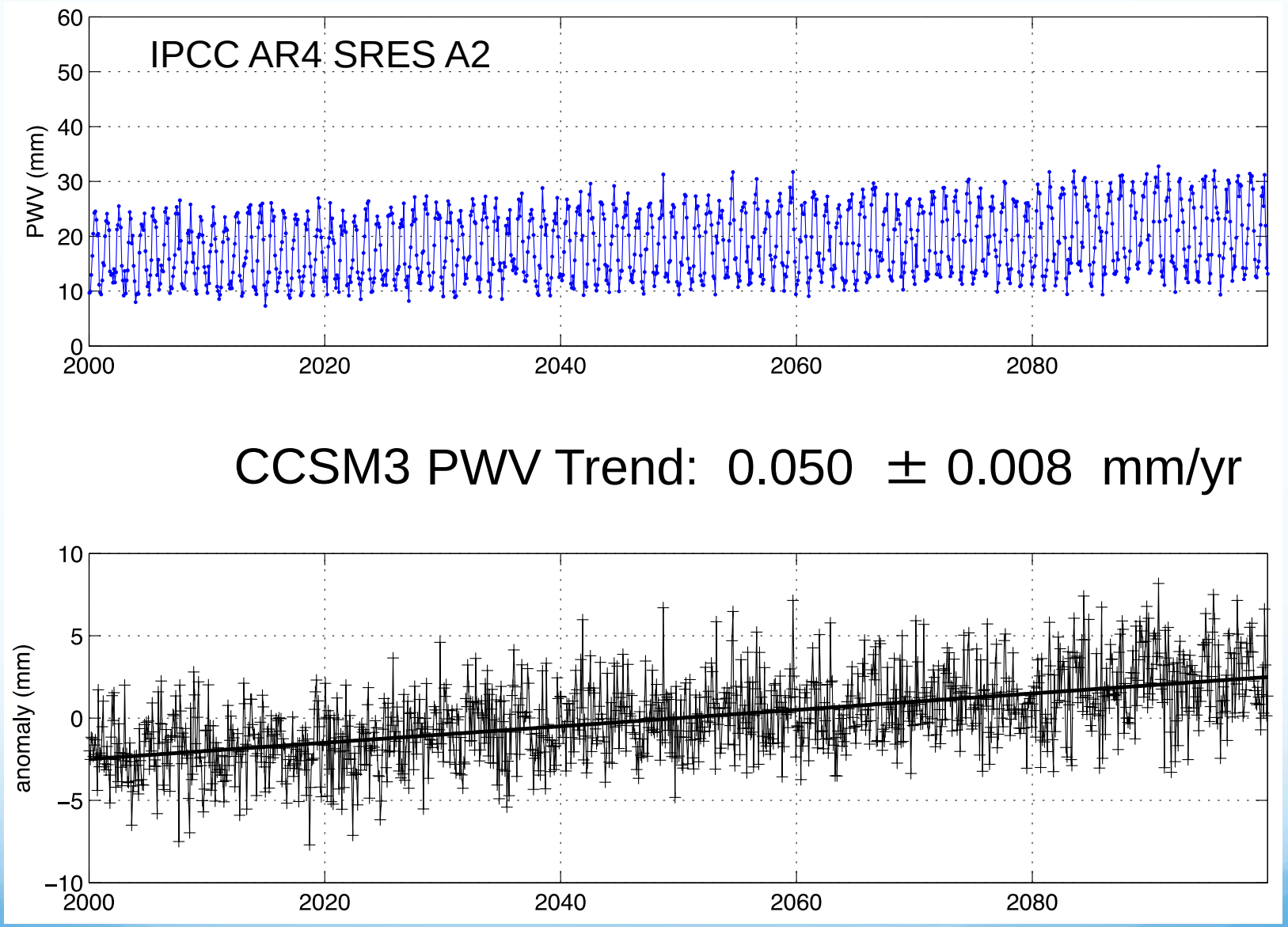
JJA



Zonal Average
(Ocean + Land)

Great Plains
(87 W to 100 W)

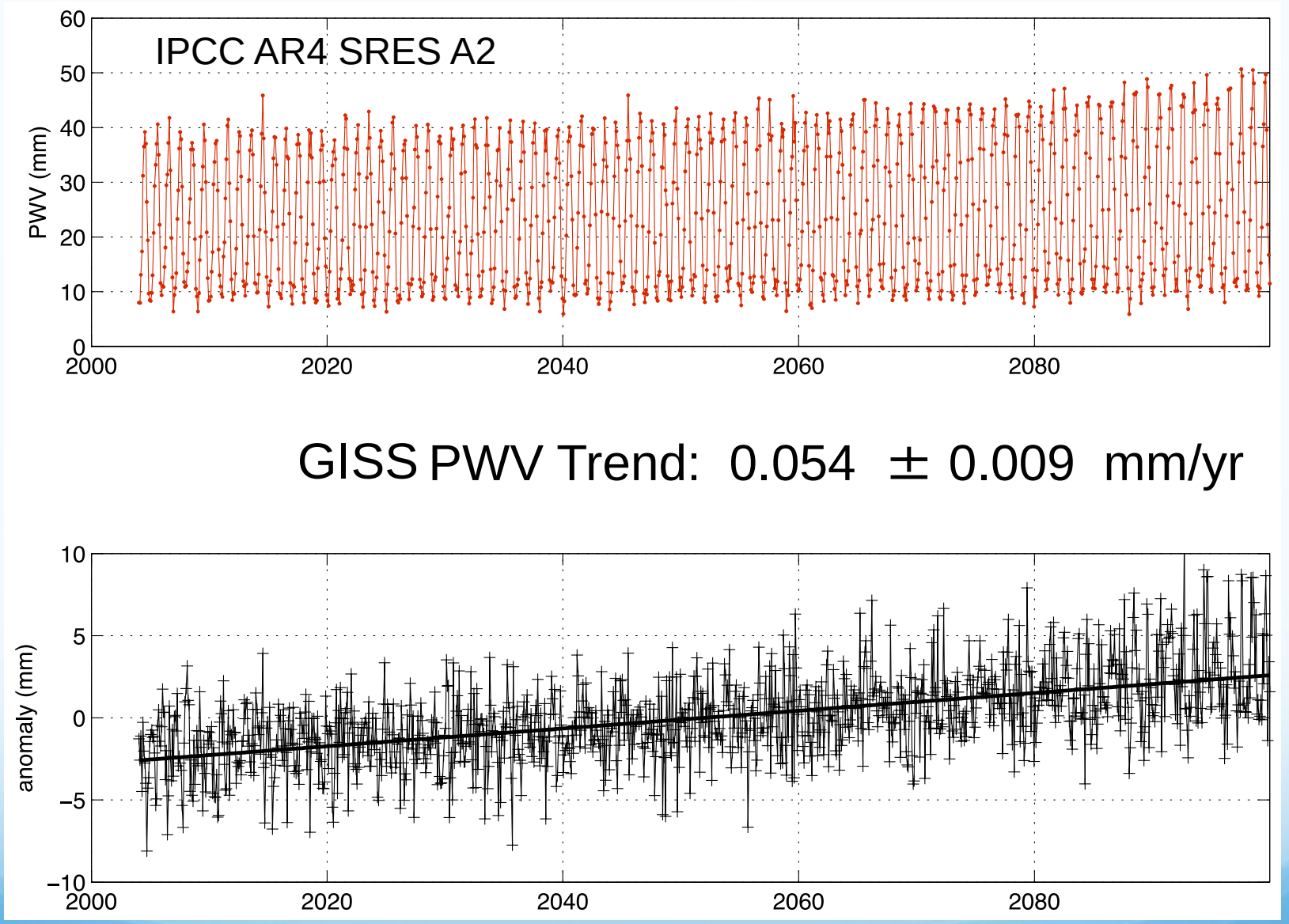
CCSM3 100 Year PWV Trend Oklahoma/Kansas Region



2000 2100

CCSM3 has reduced seasonal amplitude for entire 100 year time period 2000-2100.

GISS 100 Year PWV Trend Oklahoma/Kansas Region



2000 2100

CCSM3 and GISS 100 yr PWV trends (in mm/yr) are identical while Seasonal Amplitudes are very different!

GCM Validation using Ground-Based GPS

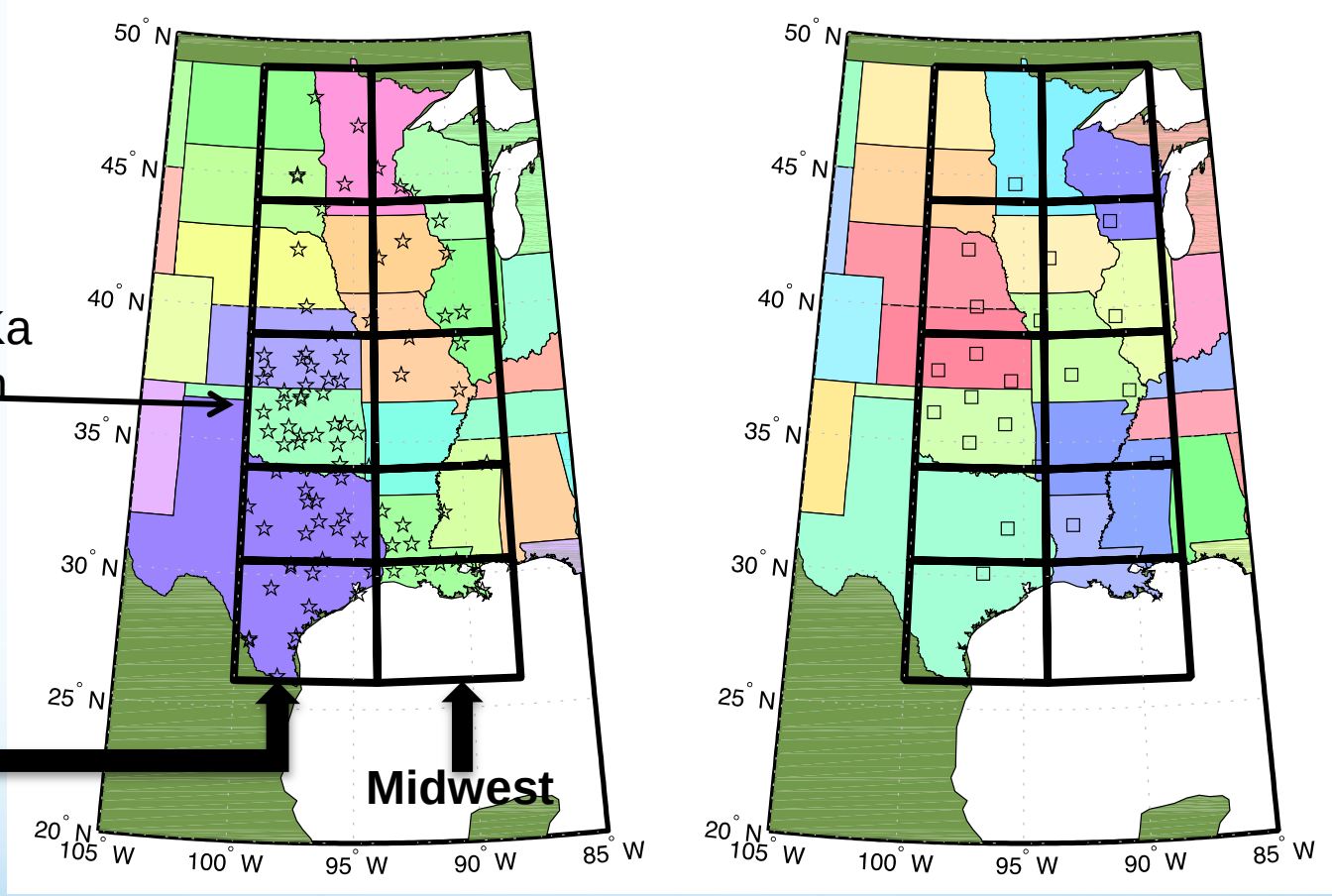
SuomiNet

Wind Profiler

Oklahoma/Kansas Region

Great Plains

Midwest



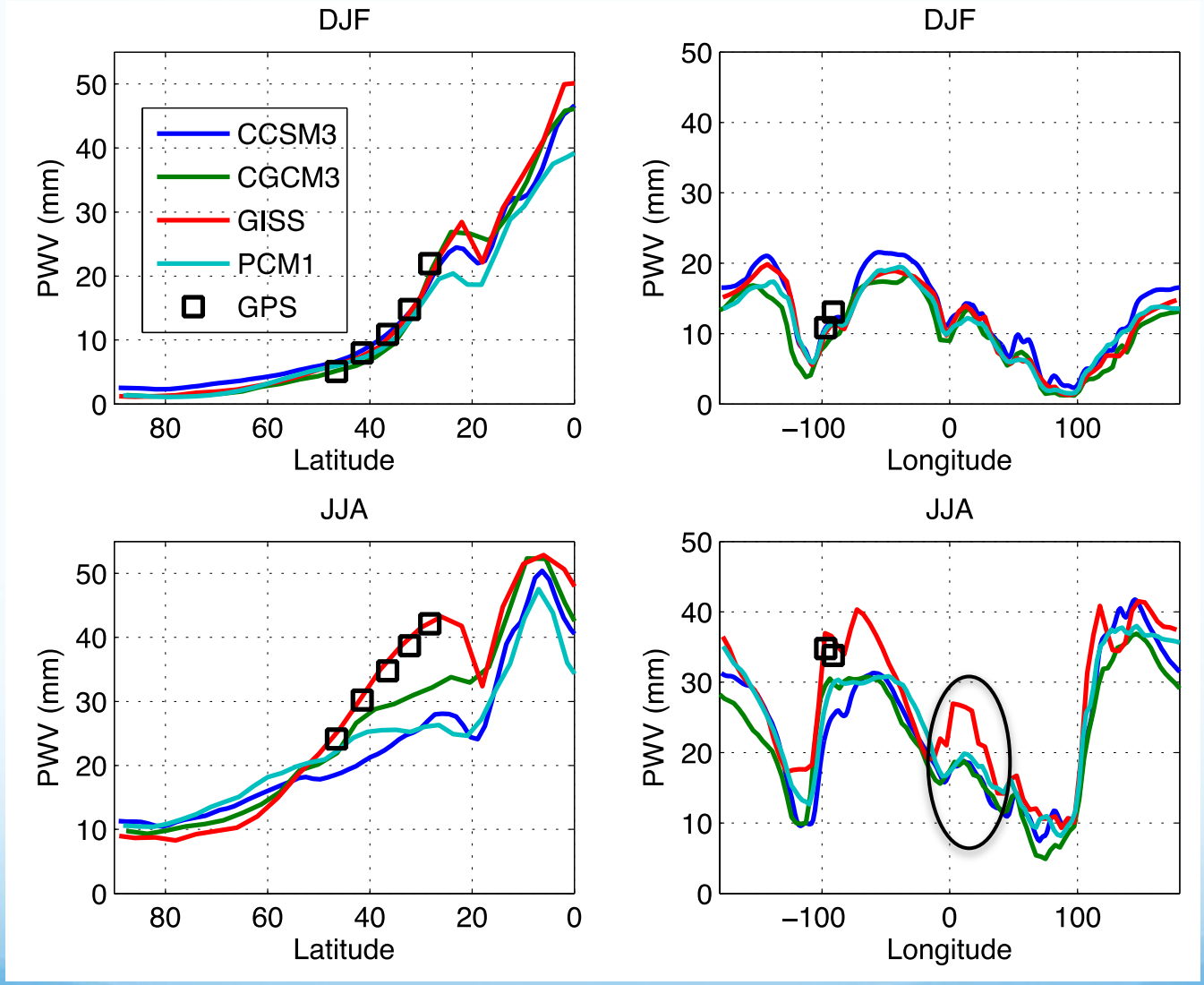
Ground-based networks of GPS receivers measure Total Column WV

- Growing networks provide increasing spatial coverage
- 30 minute time sampling provides continuous diurnal coverage

Models from the IPCC AR4 SRES A2 with GPS Observations

DJF

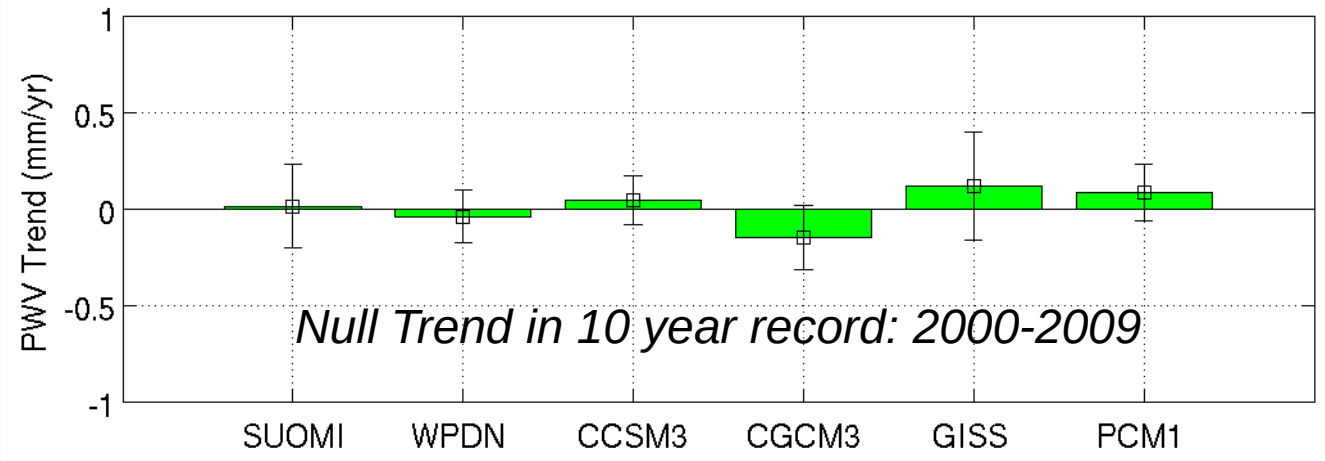
JJA



Great Plains
(Lon:100 W to 94 W)

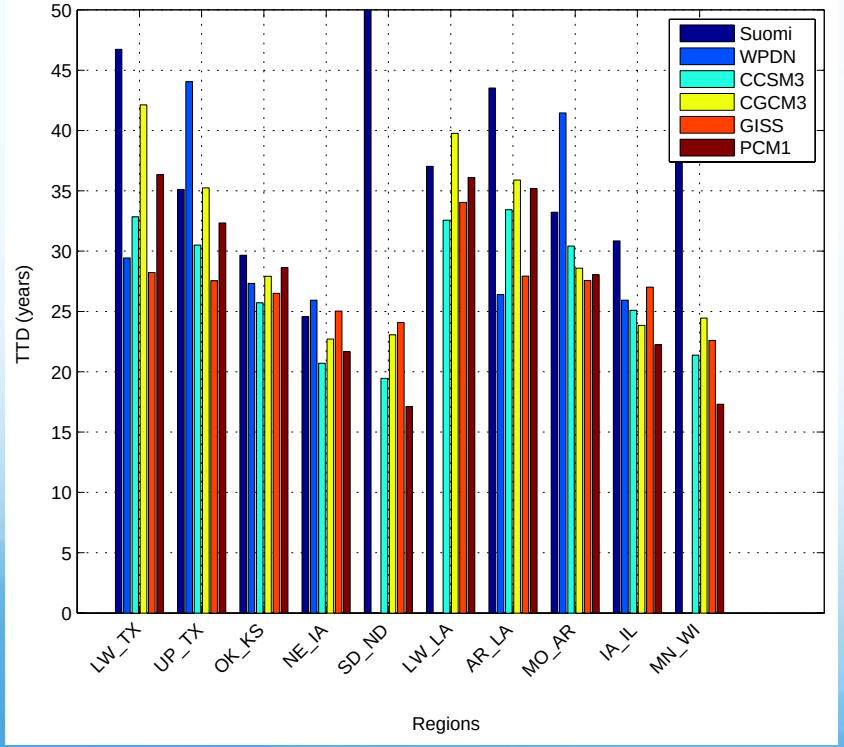
Lat: 32 N to 37 N

Oklahoma/Kansas Region PWV Trend for 2000-2009

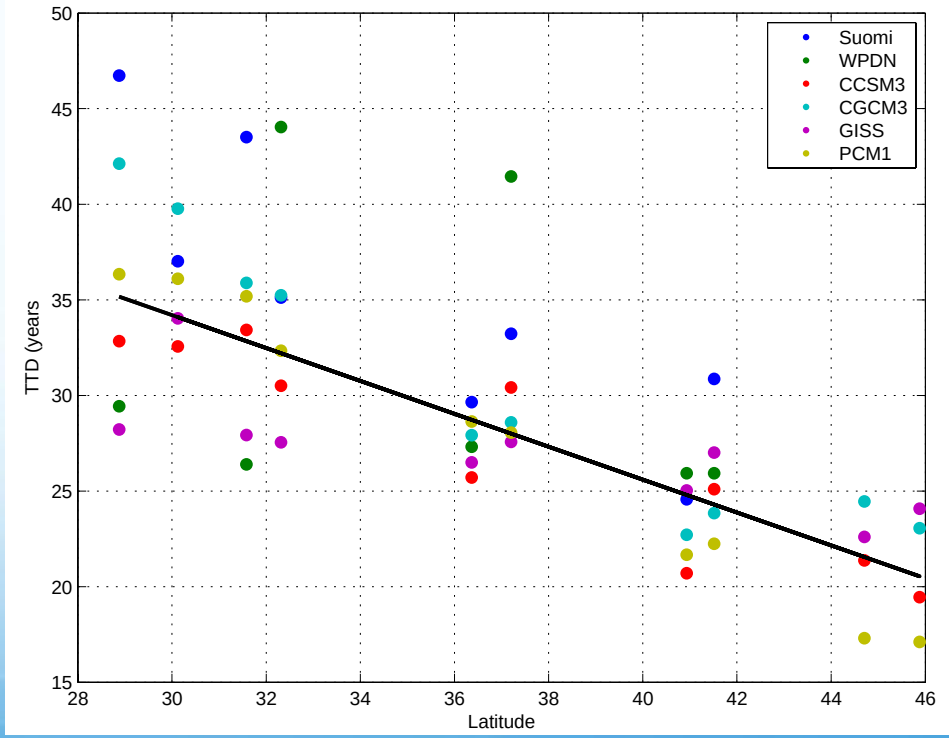


mm/yr Trend

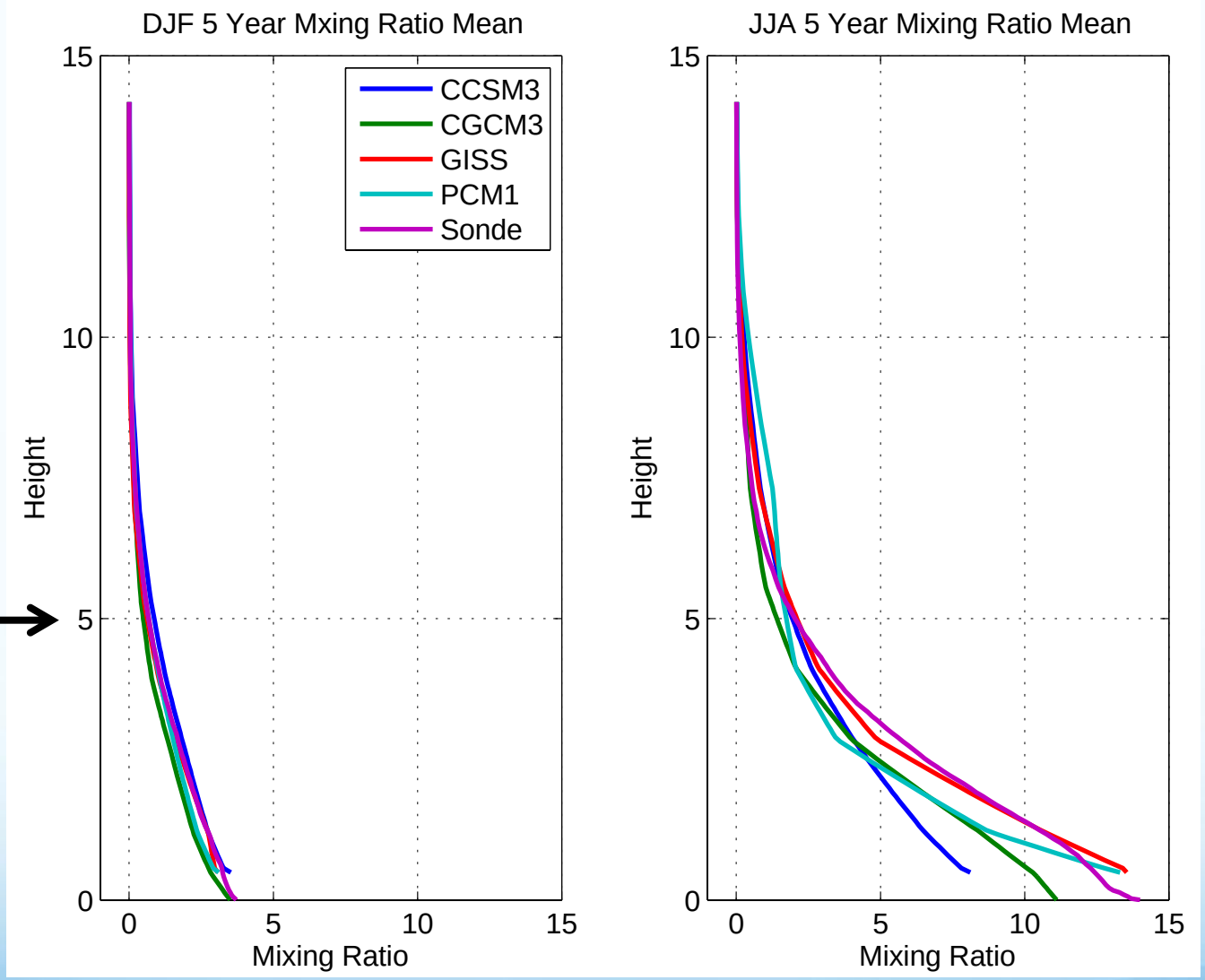
Time to Detect Trend of 0.05 mm/yr



TTD by Latitude



Validation of vertical profile at ARM SGP site (Lamont, Oklahoma)

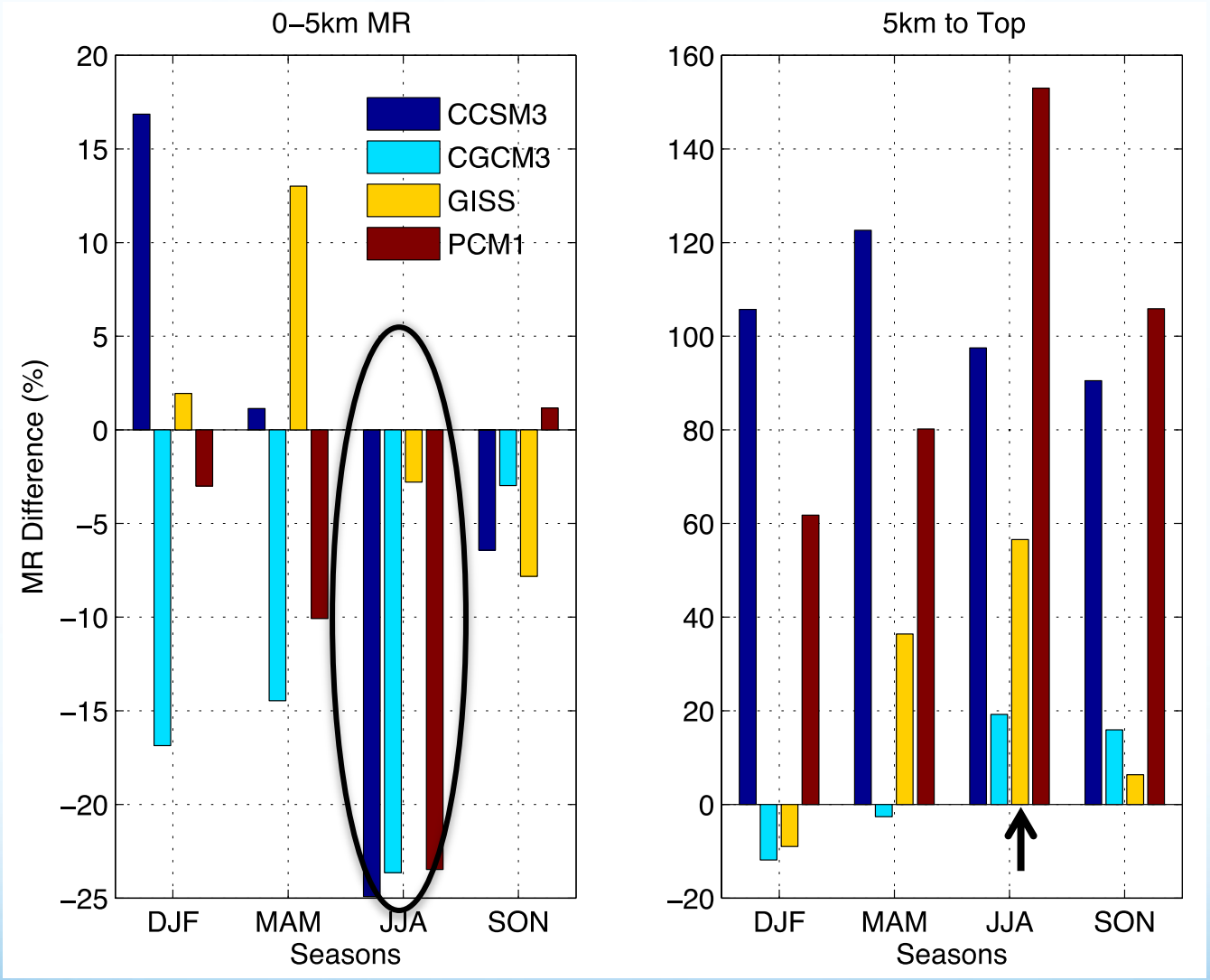


5 Km →

- DOE ARM SGP CF radiosondes (Vaisala RS92) confirm ground-based GPS PWV observations.

Validation of vertical profile at ARM SGP site (Lamont, Oklahoma)

< 5km



> 5 km

- GISS approximately 2.5% agreement with Sonde in summer < 5km.
- All others greater than 20% error in summer at SGP site < 5km.

Publication

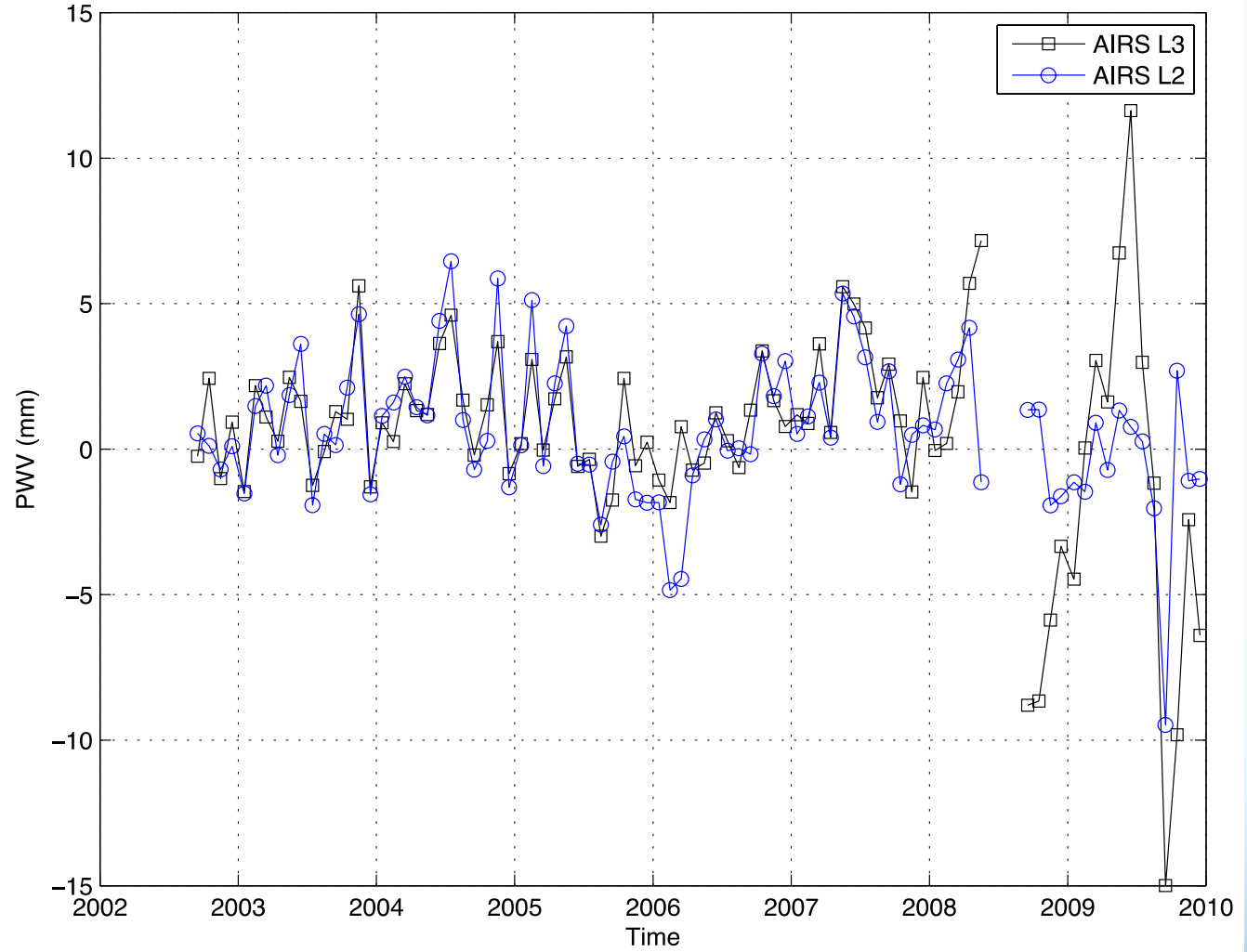
Validation of Regional Global Climate Model (GCM) Water Vapor Bias and Trends Using Precipitable Water Vapor (PWV) Observations from a Network of Global Positioning Satellite (GPS) Receivers in the U.S. Great Plains and Midwest

Jacola A. Roman, Robert O. Knuteson, Steven A. Ackerman, David C. Tobin, and Henry E. Revercomb

Submitted to Journal of Climate

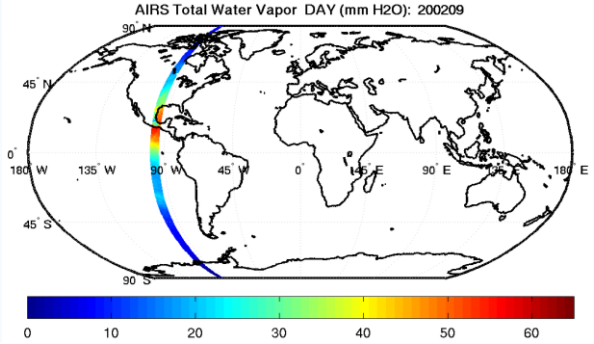
- Subsequent slides are preliminary results from our use of AIRS L3 PWV

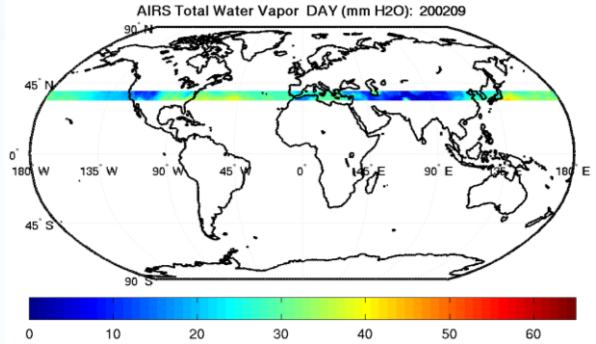
PWV Difference (Suomi – AIRS) at SGP CF



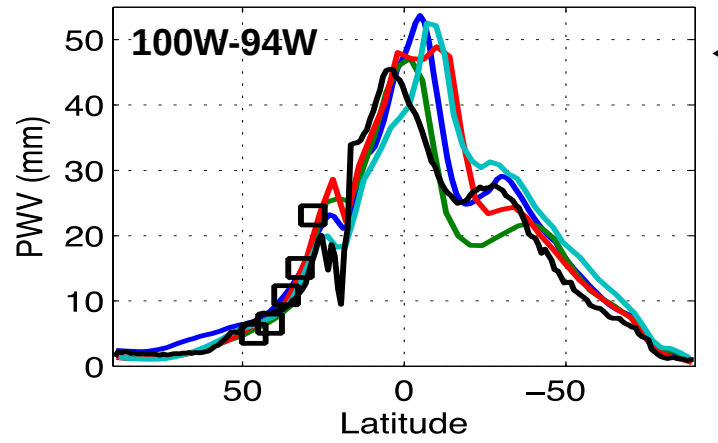
- Quality control provided by SuomiNet.
- Using AIRS L3 A January 2005-December 2007

GCMs SuomiNet and AIRS L3

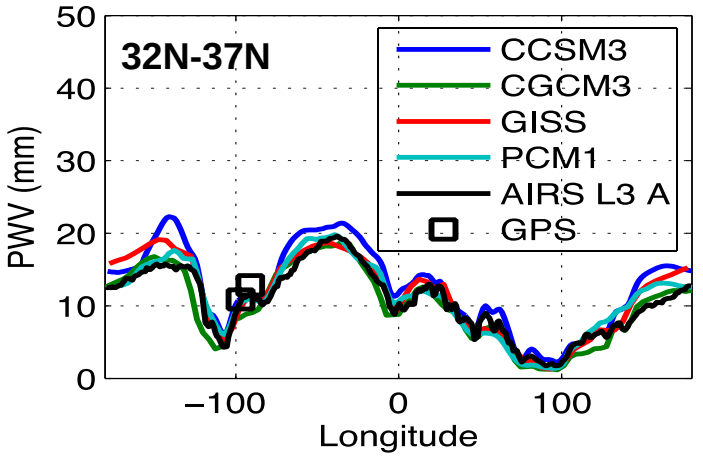




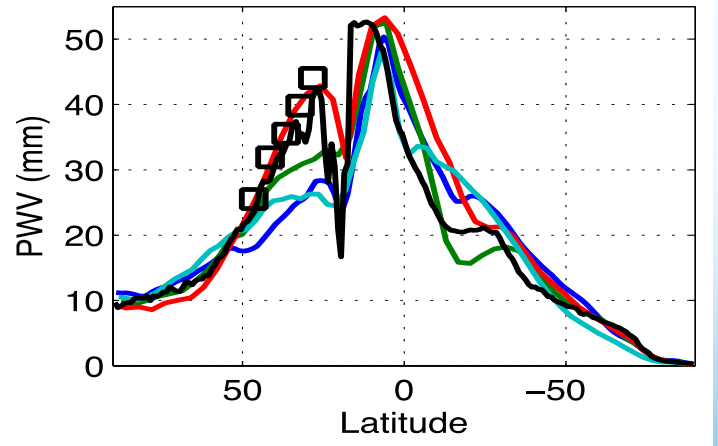
DJF



⟸ Winter ⟹

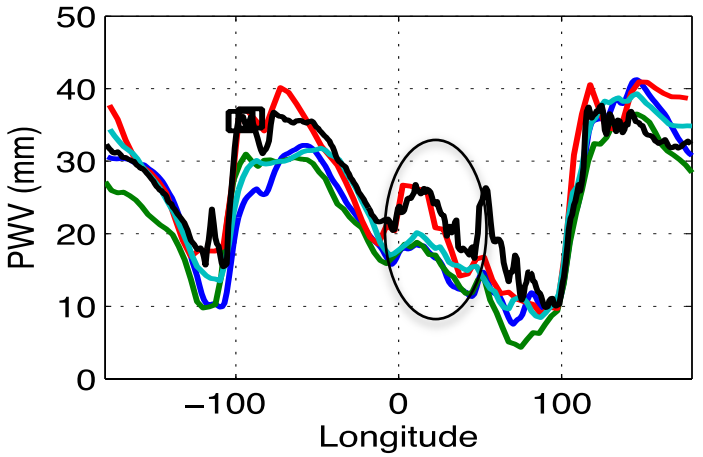


JJA



January 2005-December 2007

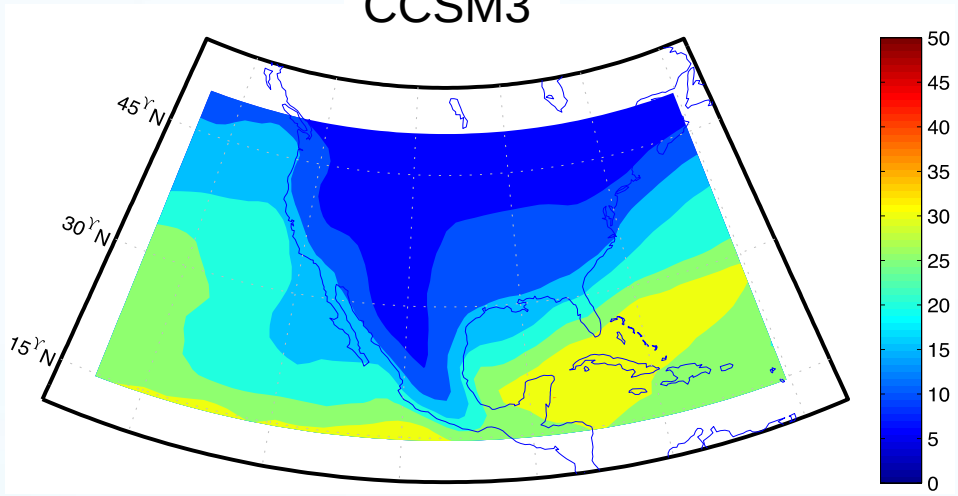
⟸ Summer ⟹



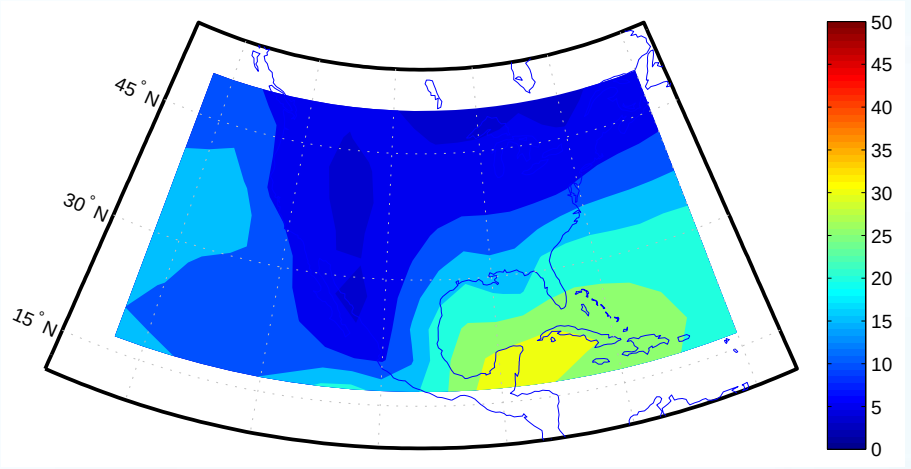
- AIRS L3 validates GISS model PWV.

North America Monthly Mean PWV for GCMs for January 2006

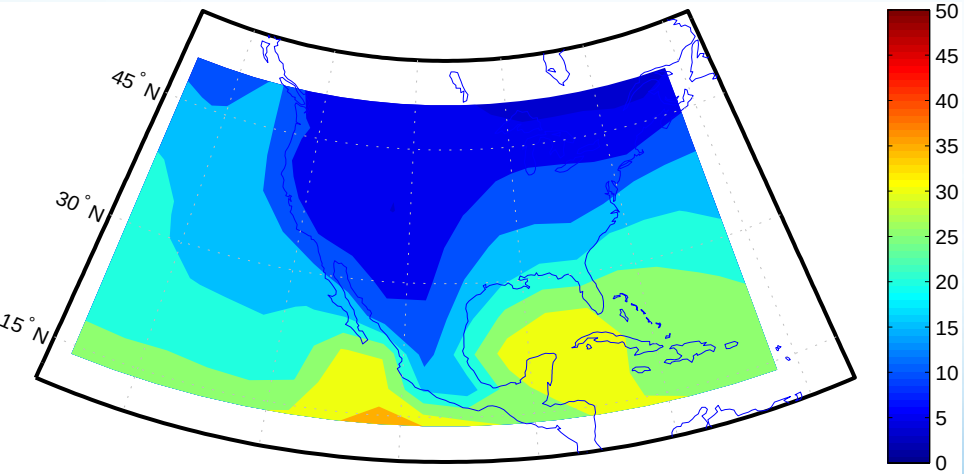
CCSM3



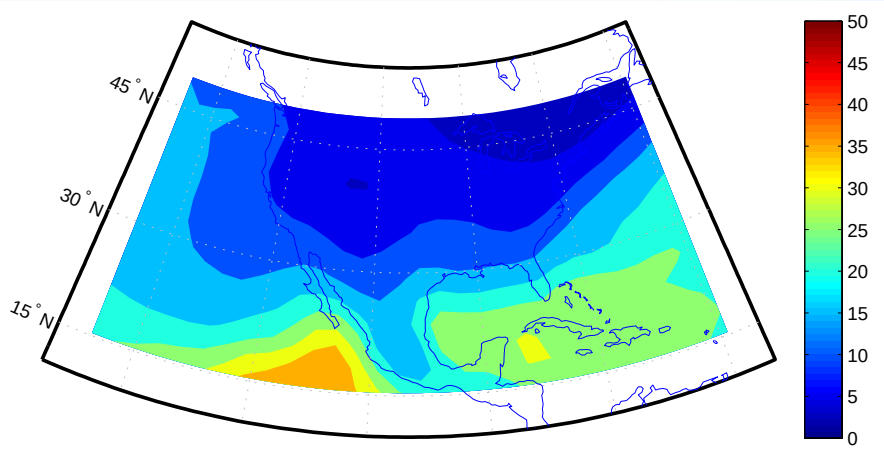
CGCM3



GISS



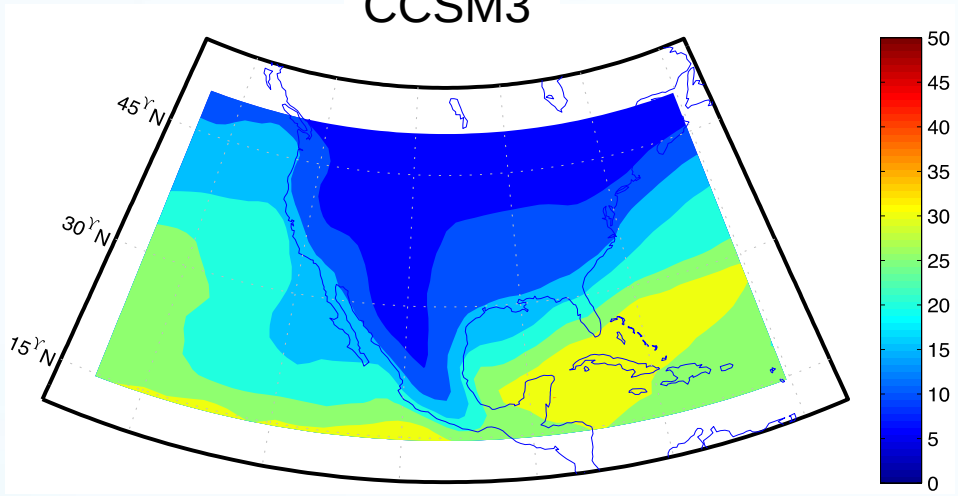
PCM1



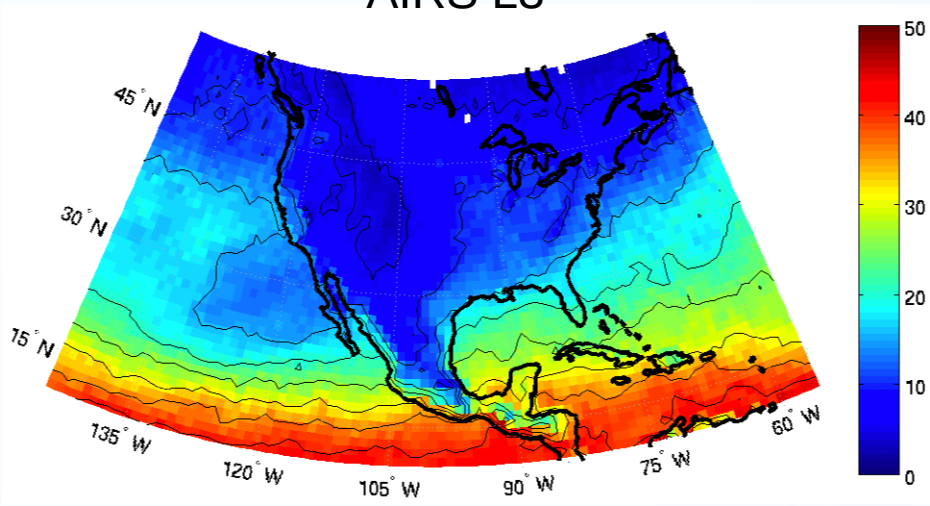
- Good agreement among all four GCMs for North America in Winter.

North America Monthly Mean PWV for GCMs, AIRS, and North America Regional Reanalysis (NARR) for January 2006

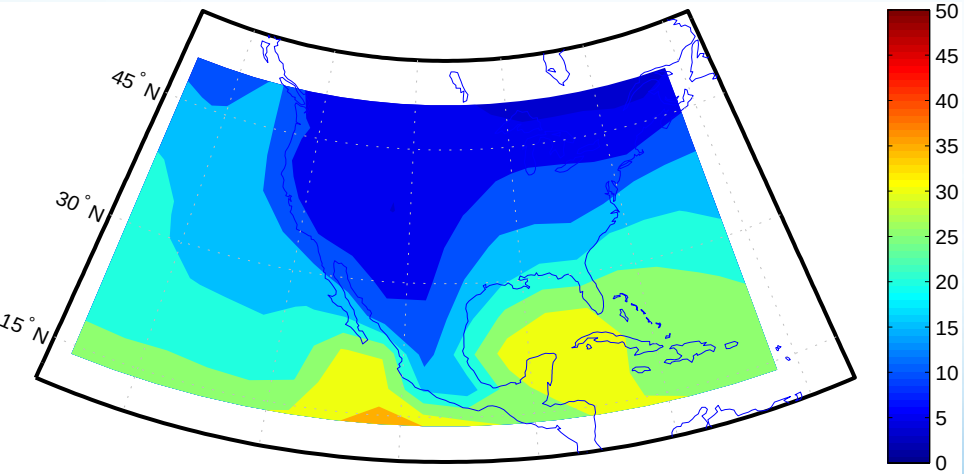
CCSM3



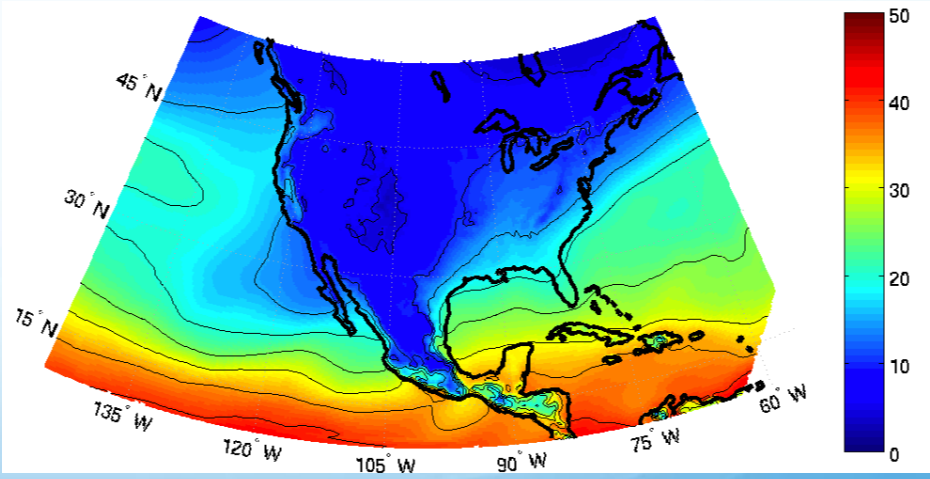
AIRS L3



GISS



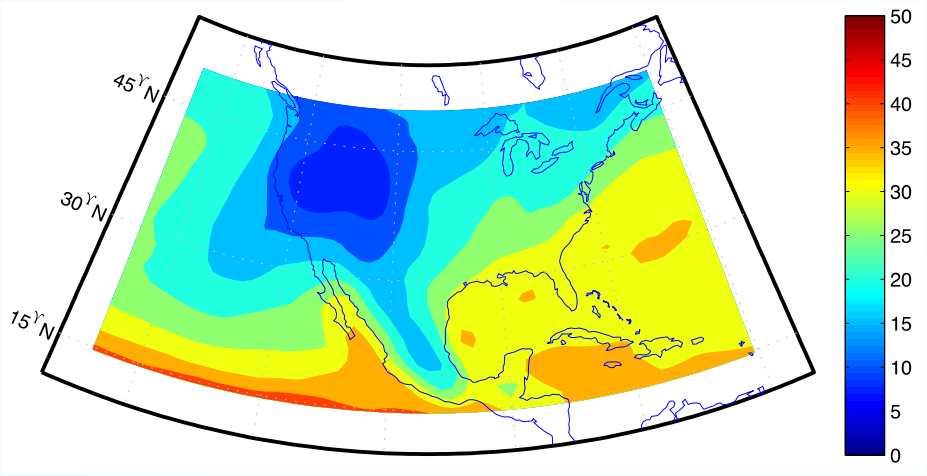
NARR



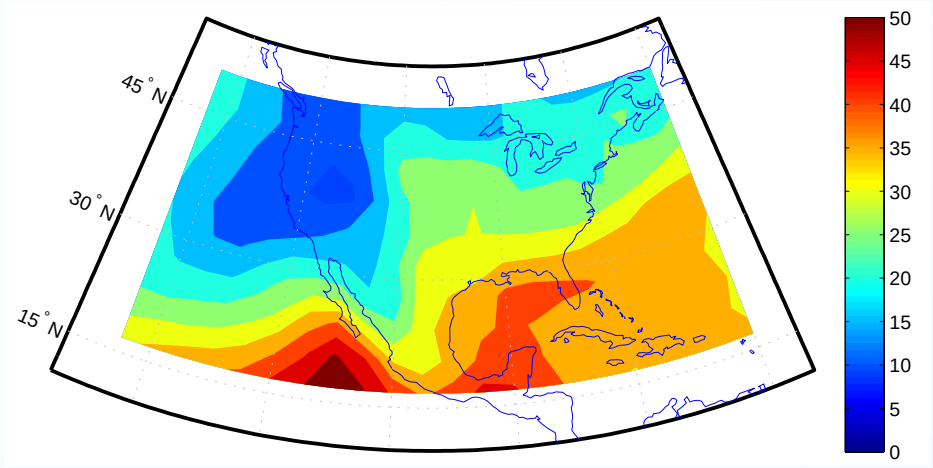
- Good agreement between GCMs and observations for North America in Winter.

North America Monthly Mean PWV for GCMs for August 2006

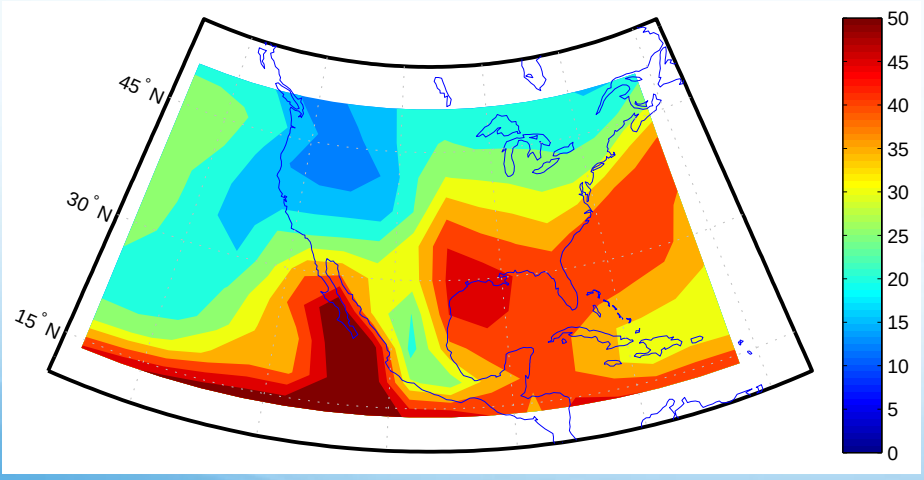
CCSM3



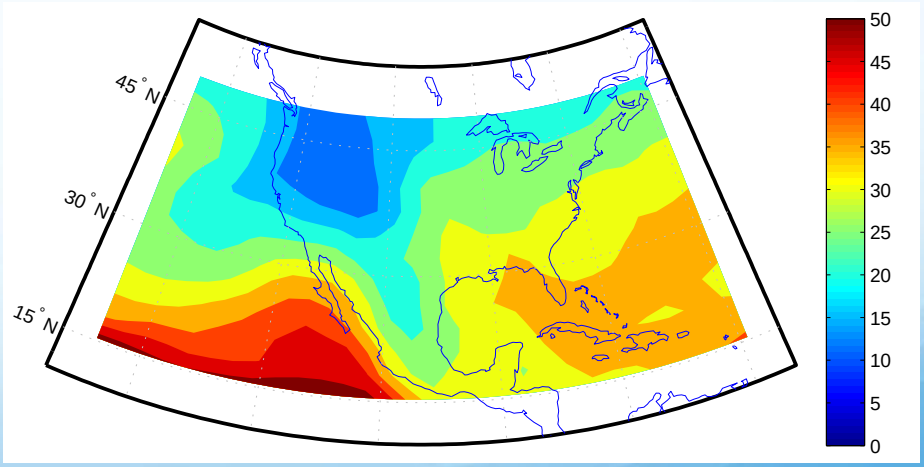
CGCM3



GISS



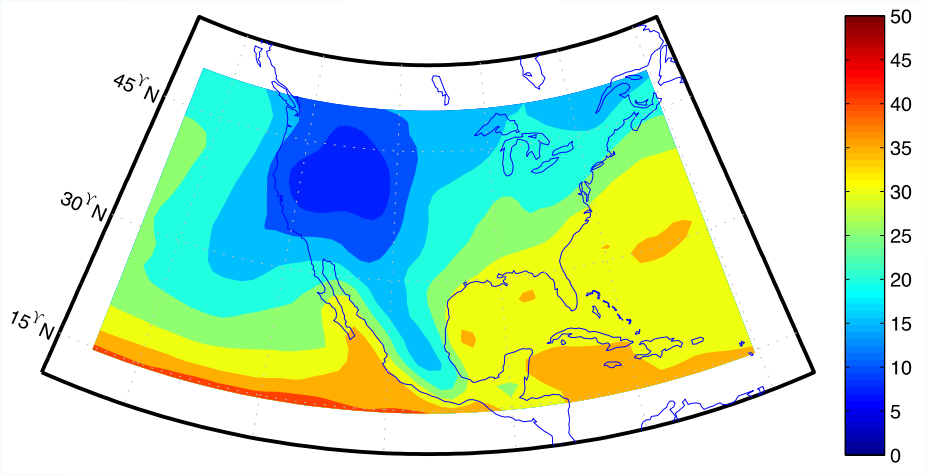
PCM1



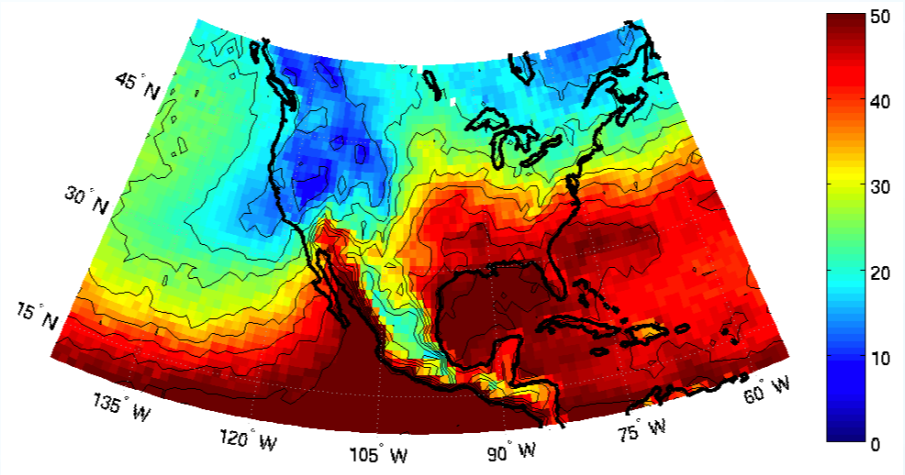
- Only GISS captures the moisture flux from the Gulf of Mexico into the Great Plains and Midwest. Note also enhanced PWV in the Gulf of California.

North America Monthly Mean PWV for GCMs, AIRS, and NARR for August 2006

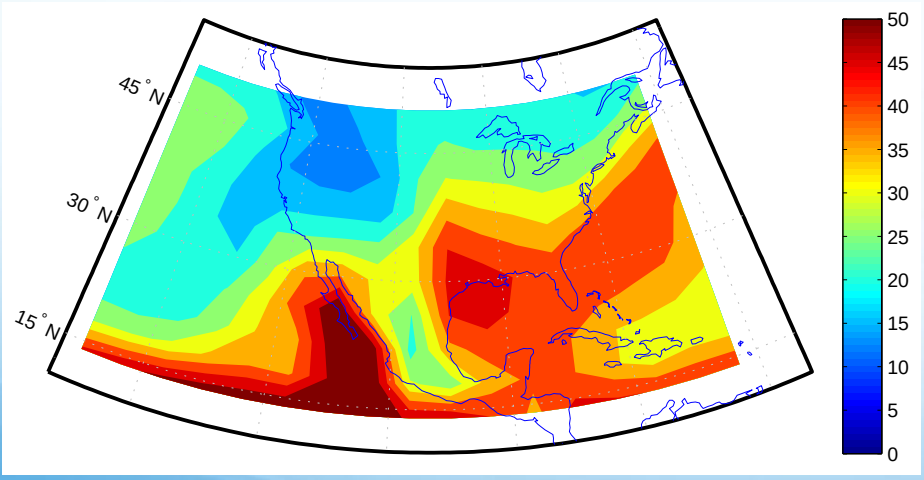
CCSM3



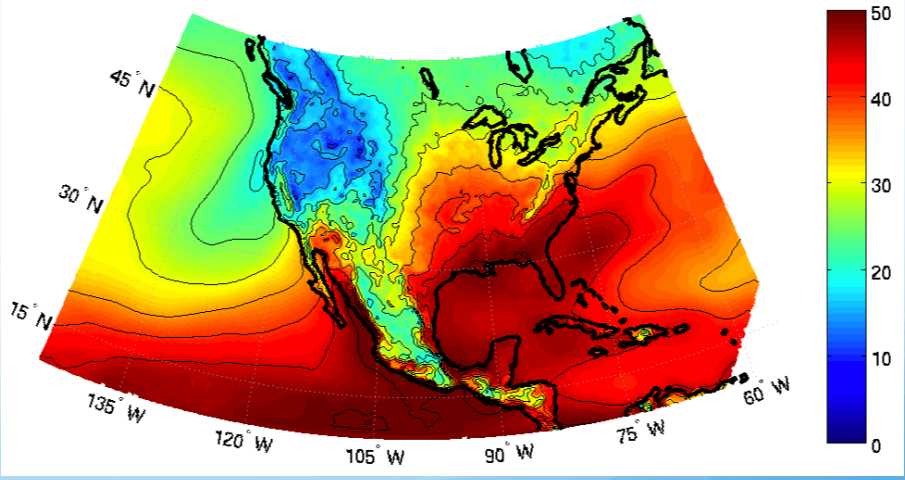
AIRS L3



GISS



NARR



- GISS agrees with observations in US Great Plains and Midwest in summertime.

Preliminary Results using AIRS version 5

Conclusions

- Used NASA satellite water vapor from AIRS v5 along with independent validation of the total column amount to test the seasonal and regional accuracy of GCMs from IPCC AR4

- We will work with Bill Smith to demonstrate that CLARREO mission design will provide the radiance signal required to achieve similar results on regional and seasonal scales.