Understanding Regional Climate Variations: GCM Validation and Assessment using PWV

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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

- Zonal Average
  (Ocean + Land)

- Great Plains
  (87 W to 100 W)

DJF

JJA
CCSM3 100 Year PWV Trend Oklahoma/Kansas Region

IPCC AR4 SRES A2

CCSM3 100 Year PWV Trend: 0.050 ± 0.008 mm/yr

CCSM3 has reduced seasonal amplitude for entire 100 year time period 2000-2100.
CCSM3 and GISS 100 yr PWV trends (in mm/yr) are identical while Seasonal Amplitudes are very different!
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

Great Plains
(Lon: 100 W to 94 W)

Lat: 32 N to 37 N
Oklahoma/Kansas Region PWV Trend for 2000-2009

Null Trend in 10 year record: 2000-2009

Time to Detect Trend of 0.05 mm/yr

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

• DOE ARM SGP CF radiosondes (Vaisala RS92) confirm ground-based GPS PWV observations.
Validation of vertical profile at ARM SGP site (Lamont, Oklahoma)

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

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- Subsequent slides are preliminary results from our use of AIRS L3 PWV
PWV Difference (Suomi – AIRS) at SGP CF

- Quality control provided by SuomiNet.
Preliminary Results using AIRS version 5

GCMs  
SuomiNet  
and AIRS L3

Winter  
January 2005-December 2007

Summer  

100W-94W  
32N-37N

• AIRS L3 validates GISS model PWV.
North America Monthly Mean PWV for GCMs for January 2006

- 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

- Good agreement between GCMs and observations for North America in Winter.
North America Monthly Mean PWV for GCMs for August 2006

• 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.
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.