AMPS Precipitable Water Vapor Comparisons with GPS Observations in the McMurdo Region

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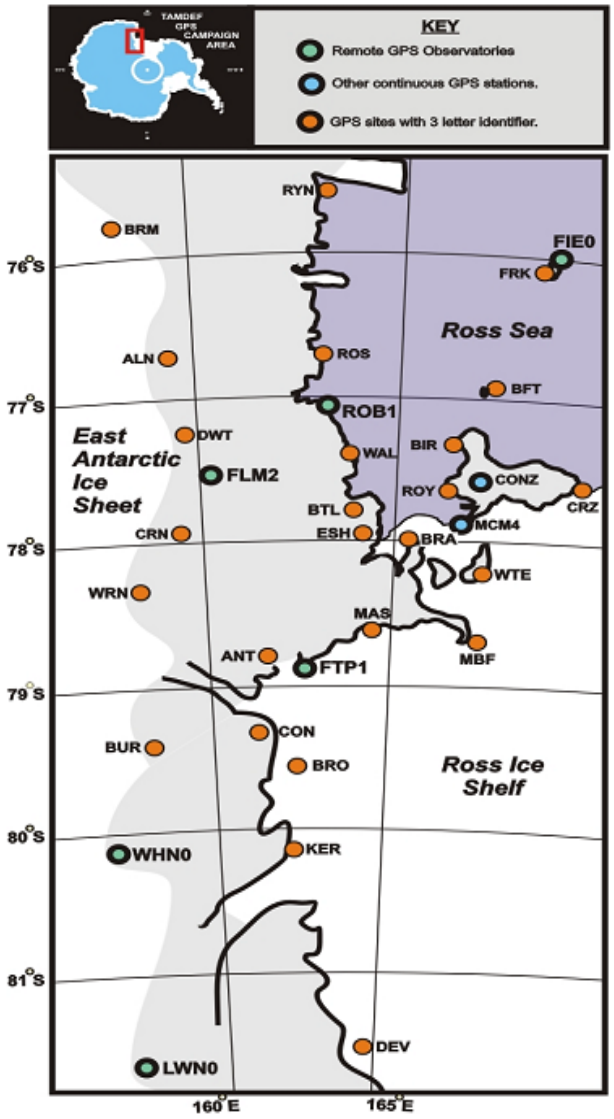
Background

- The observations from the McMurdo GPS, 2002-2005, are used here as a preliminary means of comparison to AMPS PWV
- A quick examination of the Cape Roberts GPS is also provided

The TAMDEF Network

- The Transantarctic Mountain Deformation Network (TAMDEF) consists of many sites within the McMurdo region
- Primarily used to monitor bedrock motion
- Comparing GPS-derived PWV with numerical weather prediction models is becoming more common in the literature



Extracting PWV from the GPS Wet Delay

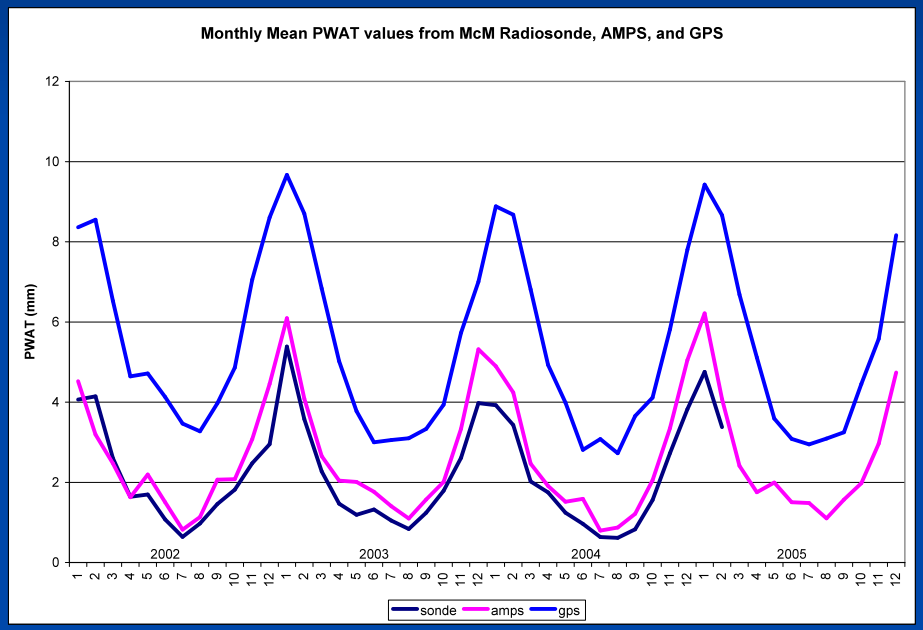
- GPS observations are post-processed to determine the wet part of the troposphere.
- Using the PAGES software developed at the National Geodetic Survey, the wet part is converted to atmospheric water vapor using the standard approach by Bevis et al. (1992).
- This method requires surface atmospheric pressure and temperature data for each site. The latter is used specifically to approximate the mean temperature of the troposphere, Tm.
- Bevis et al. (1994) show that Tm= 70.2 + 0.72 *Ts

  for the United States , where Ts is the surface temperature.

Differences in Measurement Methods

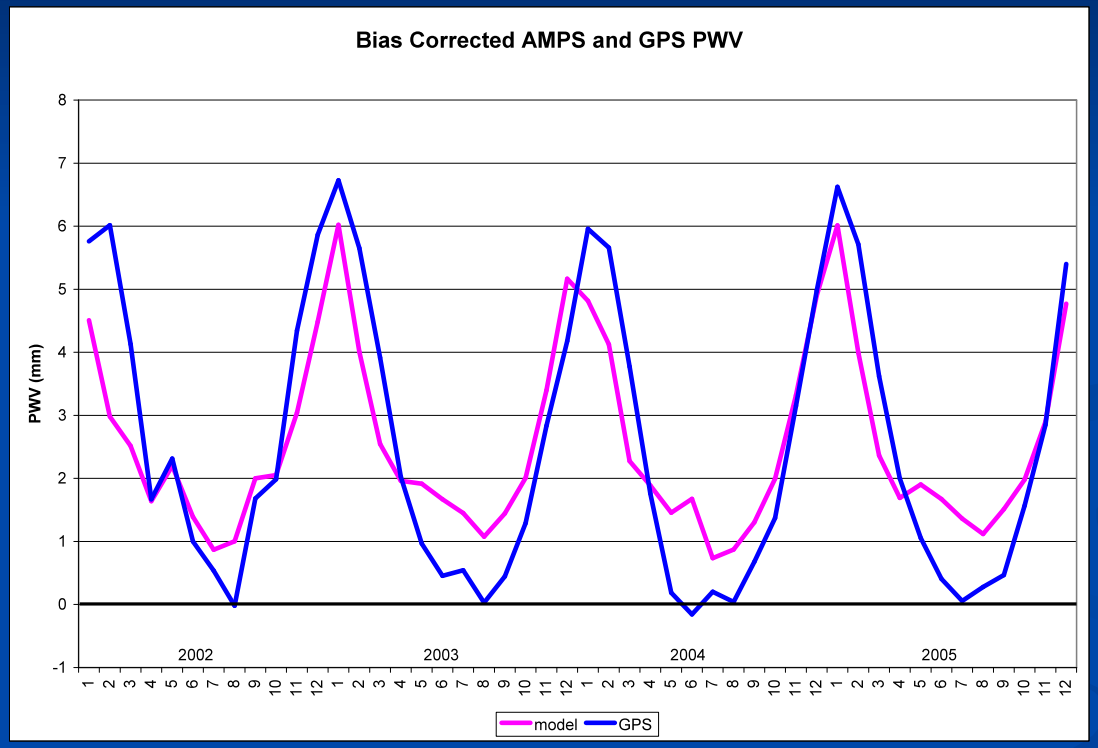
- There is a sharp spatial gradient in atmospheric moisture in the McMurdo Region from the Ross Sea to the Ross Ice Shelf and East Antarctica
- Thus, differences in the measurement methods can produce substantially different magnitudes of atmospheric moisture
  - Radiosonde data
    - Dependent on wind direction and speed
    - Can be too dry in winter due to cold temperatures
  - AMPS data
    - Represents the mean condition within the model grid box
  - GPS data
    - Dependent on satellite height / angle
    - Passes through a larger portion of troposphere and over-estimates PWV at low angles

Monthly Mean Comparisons



- Monthly mean comparisons between radiosonde (black), AMPS (pink), and GPS (blue) PWV values.
- The radiosonde and AMPS are closely related, while the GPS shows a persistent positive bias of ~3 mm.

Monthly Mean Comparisons: Bias Correction



- Removing the long-term average bias (2.82) shows that the GPS observations have a larger annual cycle than AMPS, and occasional differences in phasing

Statistics by Season

Bias (mm, AMPS- GPS) and Percent Error (based on AMPS values)

	annual	MAM	JJA	SON	DJF
2002	-3.37 (141%)	-3.41 (161%)	-2.24 (206%)	-3.13 (132%)	-4.07 (84%)
2003	-2.52 (93%)	-2.98 (139%)	-1.77 (126%)	-2.06 (90%)	-3.39 (72%)
2004	-2.68 (109%)	-2.86 (153%)	-1.76 (161%)	-2.35 (107%)	-3.63 (73%)
2005	-2.72 (104%)	-3.06 (154%)	-1.69 (122%)	-2.32 (109%)	-3.45 (72%)
overall	-2.82 (111%)	-3.08 (152)%	-1.86 (150%)	-2.47 (110%)	-3.63 (75%)
	correlation	0.90	0.18	0.91	0.36

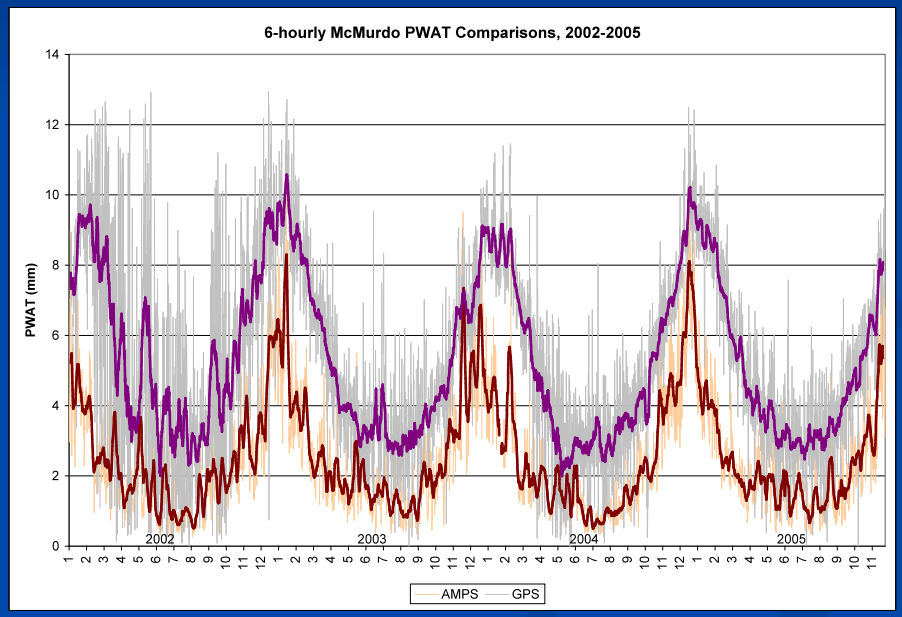
- The percentage error is largest in fall and winter, and lowest during summer
- 2002 has considerably larger biases than the other years
- The strong correlation only in fall and spring demonstrate that the GPS observations capture the transition between the solstices, but are less similar at the solstices themselves
- Due to the differences in measurement methods and their limitations, it is difficult to discern which is more accurate

Advantages of the GPS Observations

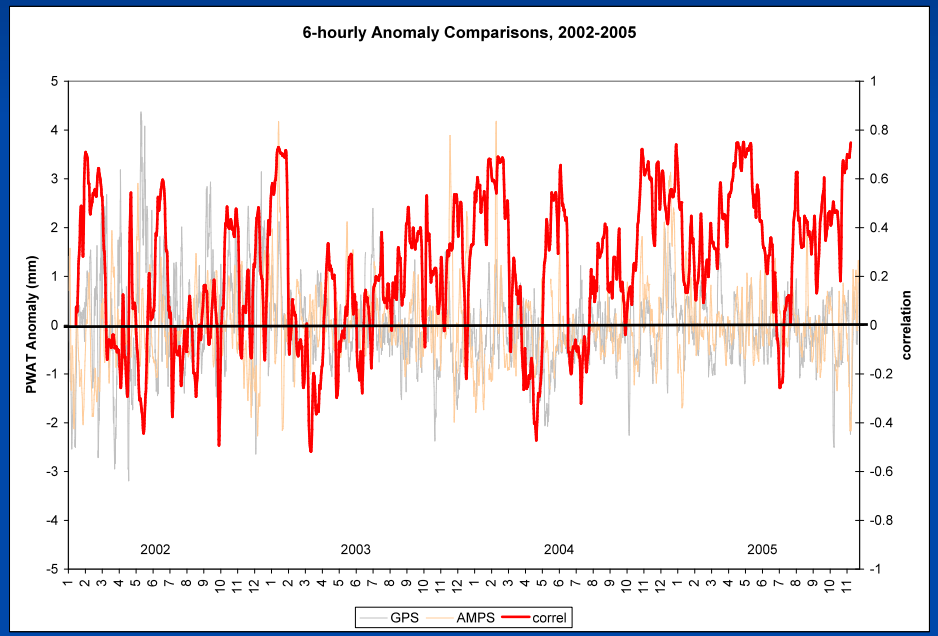
- More locations in meteorologically diverse regions.
  - AMPS does not display a sharp spatial gradient of atmospheric moisture, even on the 3.3 km resolution
- Temporal resolution (hourly observations) is much greater than the measurements from the McMurdo radiosonde
  - Allows for better depiction of the moisture variability in mesoscale cyclones and other high-frequency phenomena that are common in the region.
- The second point is examined in more detail using 6-hourly observations from the McMurdo GPS and AMPS.

6-hourly GPS and AMPS PWV Comparisons

- 6-hourly values for AMPS (light pink) and the GPS (gray). Overlain is the 7-day running mean (brown-AMPS, purple-GPS).
- There are a few periods when the variability is well-aligned (early 2004).
- Overall the GPS shows much more variability, especially during winter, which explains the low correlation during this season.
  - Given the exponential dependence of water vapor on temperature, even small changes in the temperature can produce large changes in the water vapor, thus the increased variability in the GPS during winter is plausible.



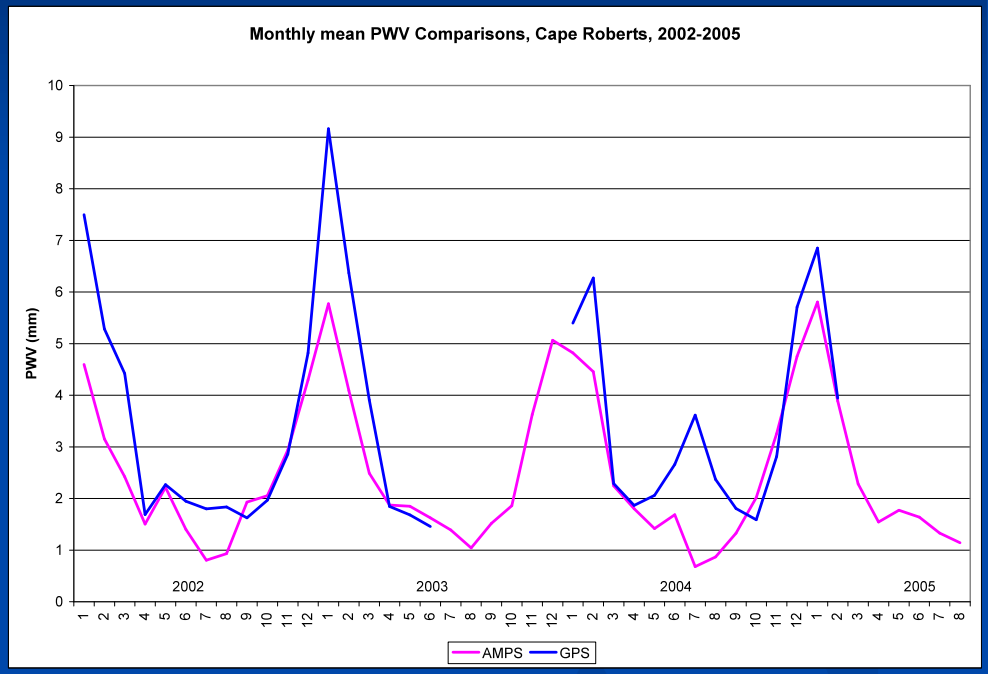
Anomaly Comparisons, 6-hourly data



- 6-hr anomalies from the long-term monthly means (2002-2005) were calculated, and then smoothed with a 3-day running mean.
- Also plotted is the 30-day running correlation; there is moderate correlation through much of the period. Correlations on raw (unsmoothed) anomalies are lower.

Cape Roberts GPS

- A quick look at the monthly means from another continuous station situated north and west of McMurdo (a more marine environment) provides an additional viewpoint of the PWV variability in AMPS.
- Although the data are better aligned (mean bias is -0.84 mm, largest in summer) they were extracted using a different method than the McMurdo data.
- It is not yet understood why different extraction methods between Cape Roberts and McMurdo are required to produce reasonable results at each location.



Suggestions for Better Agreement

- We are still working on tuning the methodology of extracting the PWV values.
  - Employing coefficients specific to Antarctica in the Tm=a + b*Ts relationship will likely help to reduce the bias.
- Quality control, data filtering, and site-specific corrections need to be conducted on the GPS data to tune the measurements, which will improve the correlation and overall bias.
- Thus, the results here are preliminary, but certainly encouraging.

Conclusions

- The GPS observations can provide a unique set of moisture data, a field that is challenging to forecast accurately
- The data are at higher temporal and spatial resolutions than any available data
- The preliminary results are encouraging, suggesting that these could be valuable tools for forecasting
- However, it is too early to discern yet if they are worth the time and effort to assimilate into the AMPS system