Water vapor variability from ground-based GPS measurements and reanalysis products

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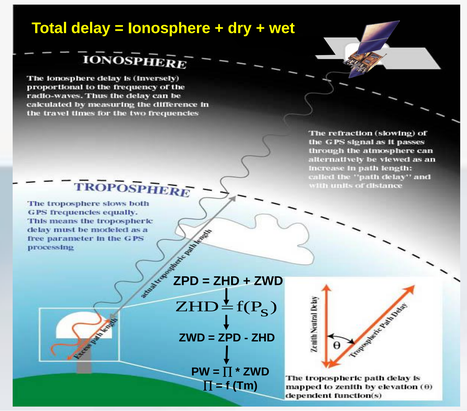
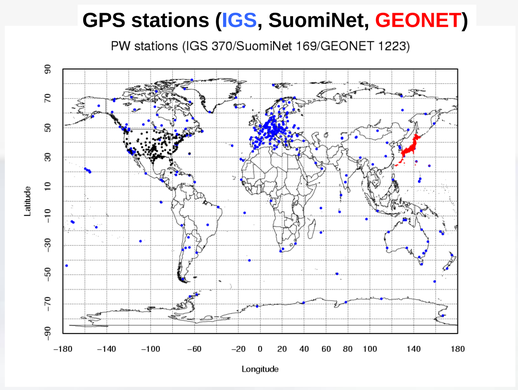
1.GOALS:

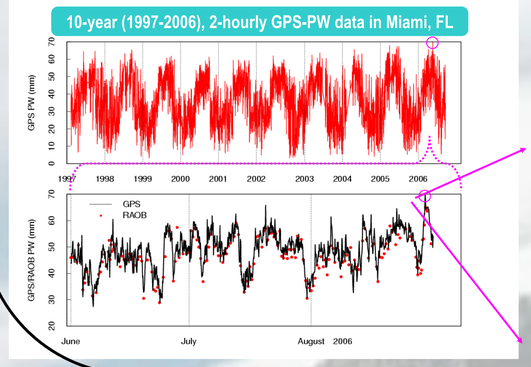
The goal is to utilize a global, 2-hourly atmospheric precipitable water (PW) dataset derived from ground based GPS measurements for the following applications:

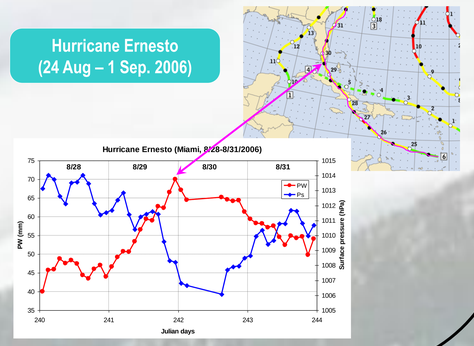
- **To document and understand PW diurnal variations**
- **To validate global atmospheric reanalysis products**
- **To study long-term PW trend**

2. GLOBAL, 12-YEAR (1997-2008), 2-HRLY GPS PW DATASET:





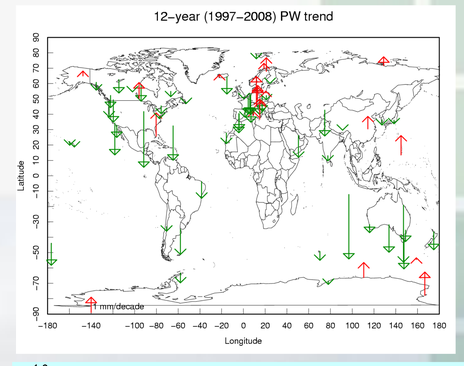


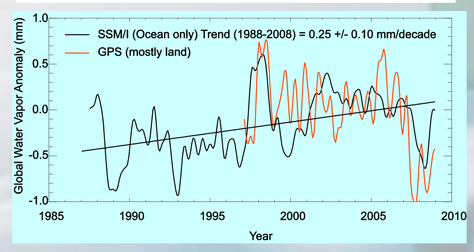


3. Reanalysis products:

	GPS-PW	NCEP/NCAR NCEP/DOE	ERA-Interium	JRA	NARR
Spatial coverage	~520 stations	gridded, globe	gridded, globe	gridded, globe	gridded, N.A.
Spatial resolution	Point	2.5°X2.5° 1.875°X1.875°	1.125°X1.125°	1.125°X1.125°	32 km
Temporal coverage	1997-2008	1948-present	1957-present	1948-present	1979-present
Temporal resolution	2 hours	6 hours	6 hours	6 hours	3 hours
WV data used	--	Radiosonde, TOVS/ATOVS	radiosonde, TOVS/ATOVS, SSM/I	radiosonde, TOVS/ATOVS, SSM/I	Radiosonde, dropsonde, TOVS-1b radiance, surface moisture

5. PW LONG-TERM TREND

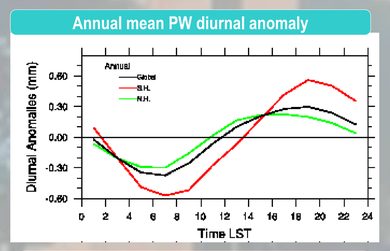




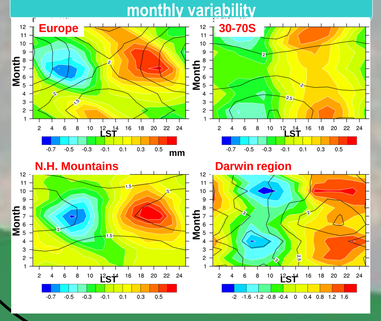
4. PW DIURNAL VARIATIONS AND COMPARISONS WITH REANALYSES in U.S.A. and Europe:

- **The diurnal cycle is less than 5% of annual mean PW**
- **Larger magnitude in summer than in winter**
- **Peak around late afternoon to early evening**
- **An order of magnitude smaller than seasonal variation**

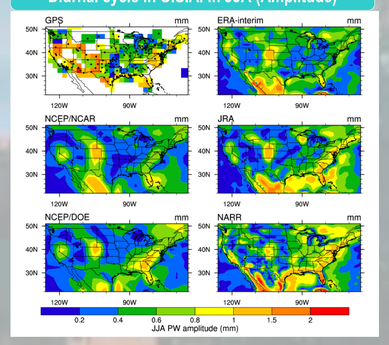
Annual mean PW diurnal anomaly



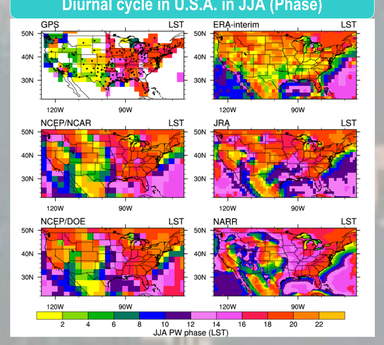
seasonal variations of PW diurnal and sub-monthly variability



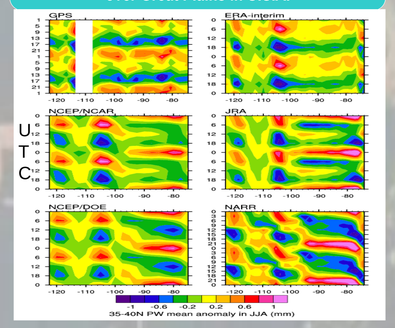
Diurnal cycle in U.S.A. in JJA (Amplitude)



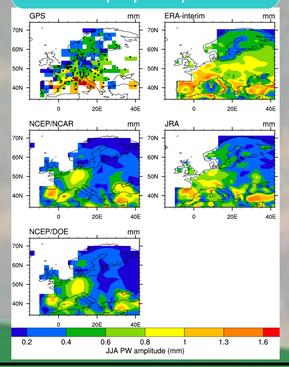
Diurnal cycle in U.S.A. in JJA (Phase)



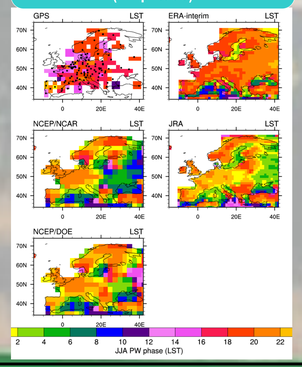
Diurnal PW anomaly Hovmoller diagram over Great Plains in U.S.A.



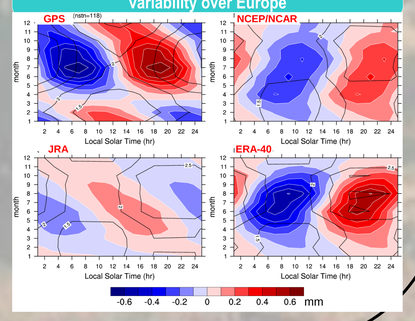
Diurnal cycle in Europe in JJA (Amplitude)



Diurnal cycle in Europe in JJA (Amplitude)



Seasonal variations of diurnal and sub-monthly variability over Europe



6. SUMMARY:

- **Dataset:** A global, 12-year, 2-hourly GPS-PW dataset is created for various scientific applications and will be continuously updated. You are welcome to use it.
- **Diurnal variations:**

1. The PW diurnal cycle is small, but significant. Global, N.H., S.H. annual mean peak-to-peak amplitudes are 0.66, 0.53 and 1.11 mm, respectively. On global and hemispheric average, PW peaks from late afternoon to mid-night.
2. Seasonal variations of diurnal cycle in different regions are shown. The sub-monthly variability of PW has much larger magnitude than the diurnal cycle.
3. The PW diurnal cycle in reanalyses is compared against the GPS data over U.S.A. and Europe. Over U.S.A., NARR performs best. It is not clear whether it is due to its high resolution or assimilation of surface moisture data. Over Europe, ERA performs better than others.

- **Long-term PW trend:** The 12-year (1997-2008) PW trends are derived from GPS PW data at 71 GPS stations where continuous data are available. Most of stations show negative trends (drying) except at some European stations and in Polar regions. The local maxima in 1997-1998 associated with ENSO events and local minima in 2007-2008 due to La Nina partially contribute to such drying trends. Globally averaged PW time series were also derived from the SSM/I data and the GPS data at these 71 stations. In spite of incomplete spatial coverage of GPS data, it shows quite similar features as the SSM/I data.
- **More information:**

- Wang, J., and L. Zhang, 2009: Climate applications of a global, 2-hourly atmospheric precipitable water dataset from IGS ground-based GPS measurements, J. of Geodesy, 83, 209-217.
- Wang, J., and L. Zhang, 2008: Validation of Atmospheric Precipitable Water in Three Reanalysis Products using Ground-based GPS Measurements, extended abstract for *Third WCRP International Conference on Reanalysis*, Jan. 28 – Feb. 1, 2008, Tokyo, Japan.
- Wang, J., and L. Zhang, 2008: Systematic errors in global radiosonde precipitable water data from comparisons with ground-based GPS measurements. *J. Climate*, 21, 2218-2238.
- Wang, J., L. Zhang, A. Dai, T. Van Hove and J. Van Baelen, 2007: A near-global, 8-year, 2-hourly atmospheric precipitable water dataset from ground-based GPS measurements, *J. Geophys. Res.*, 112, D11107. doi;10.1029/2006JD007529.
- Wang, J., L. Zhang, and A. Dai, Global estimates of water-vapor-weighted mean temperature of the atmosphere for GPS applications. *J. Geophys. Res.*, 110, D21101, doi:10.1029/2005JD006215, 2005.

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