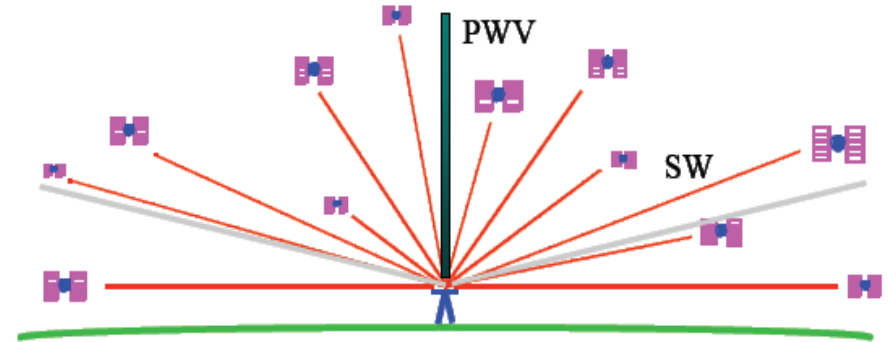




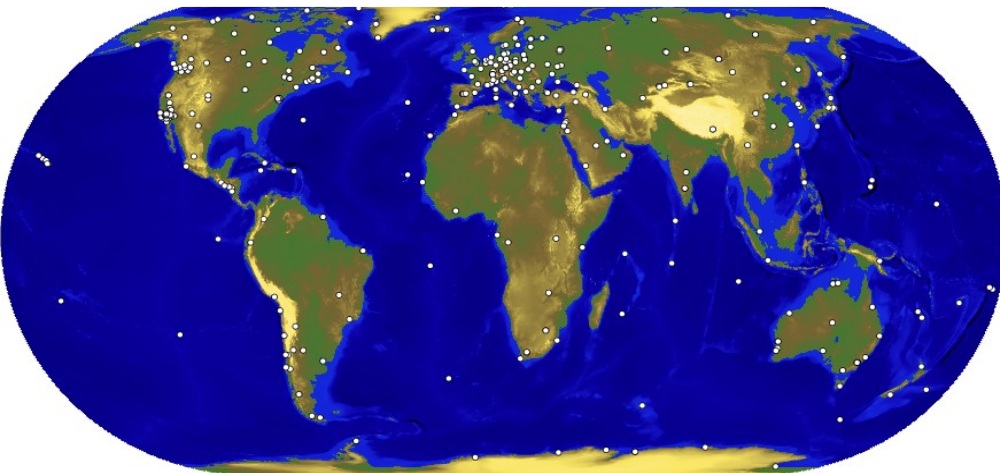
Contributions from John Braun, Tetsuya Iwabuchi, Teresa Van Hove  
COSMIC Program, UCAR  
June Wang, NCAR/EOL



International GNSS Service (IGS) GPS stations  
~380 stations, 1997-present, 5-min/2-hourly



**Total delay = Ionosphere + dry + wet**



- All weather
- Continuous measurements
- High temporal resolution
- High accuracy (~1-2 mm)
- Long term stability

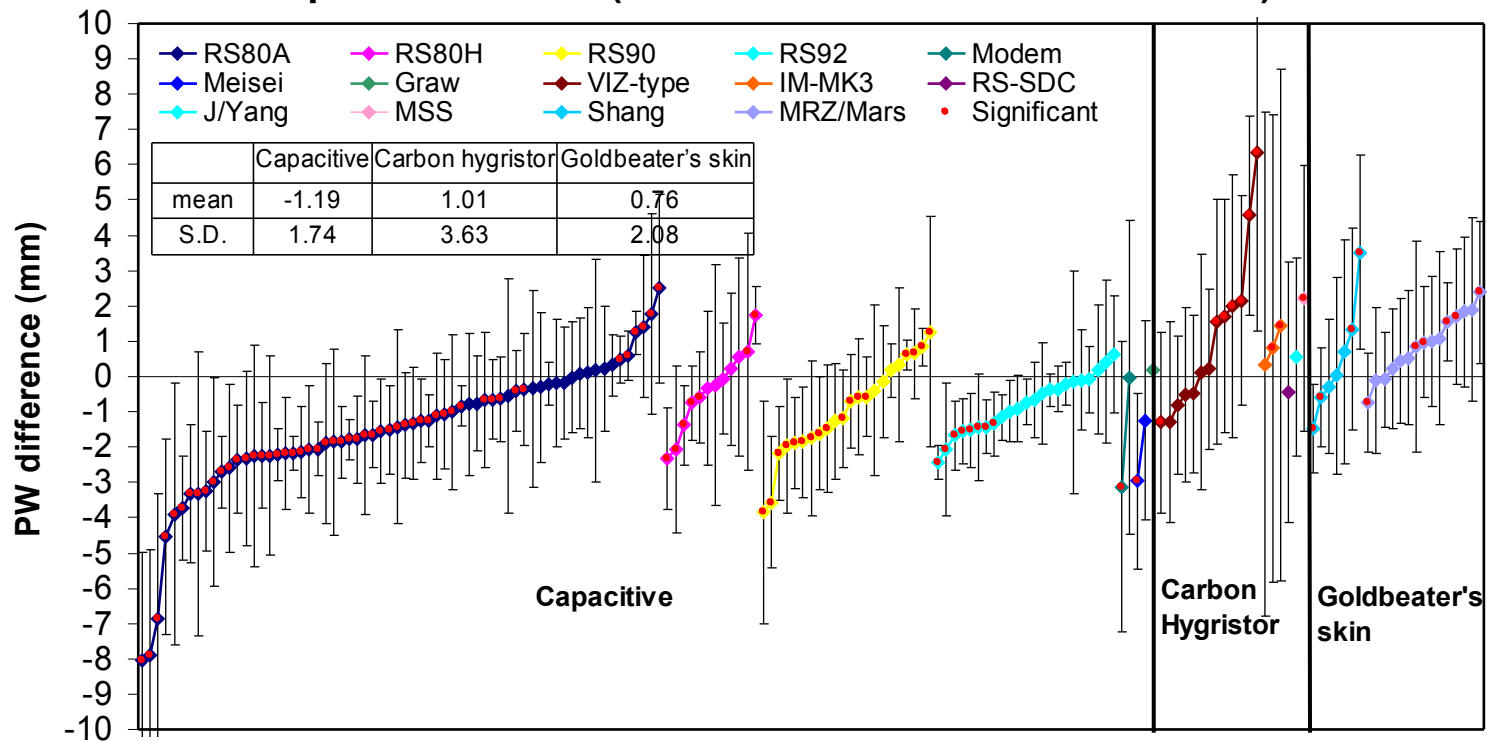


# Climate applications of GPS Precipitable Water (PW) estimates



- To validate global radiosonde and reanalysis humidity data
- To document and understand PW diurnal variations
- To potentially create a corrected global radiosonde PW dataset

Comparisons of PW (IGRA-GPS 1997-2006 169 stations)



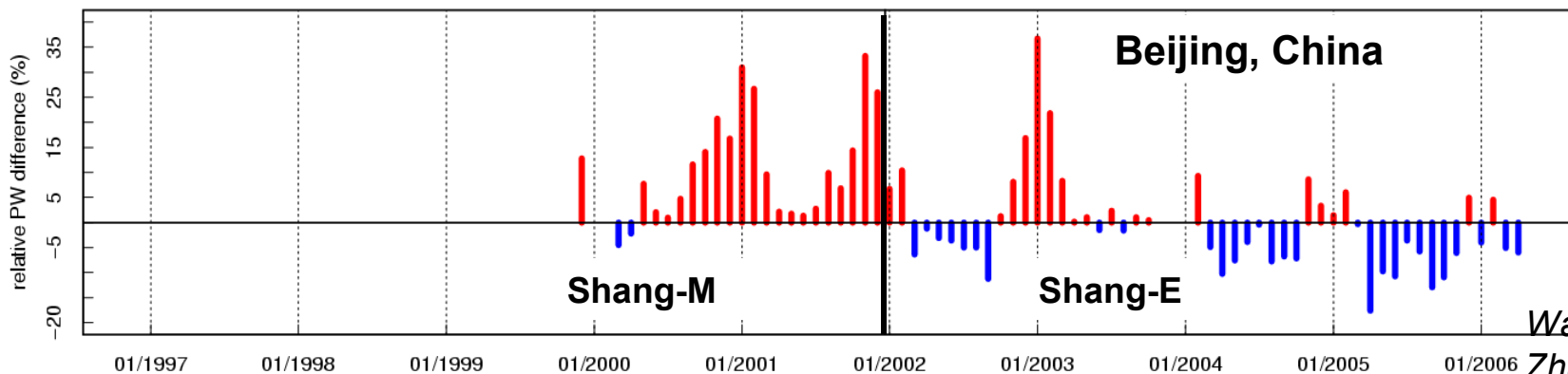
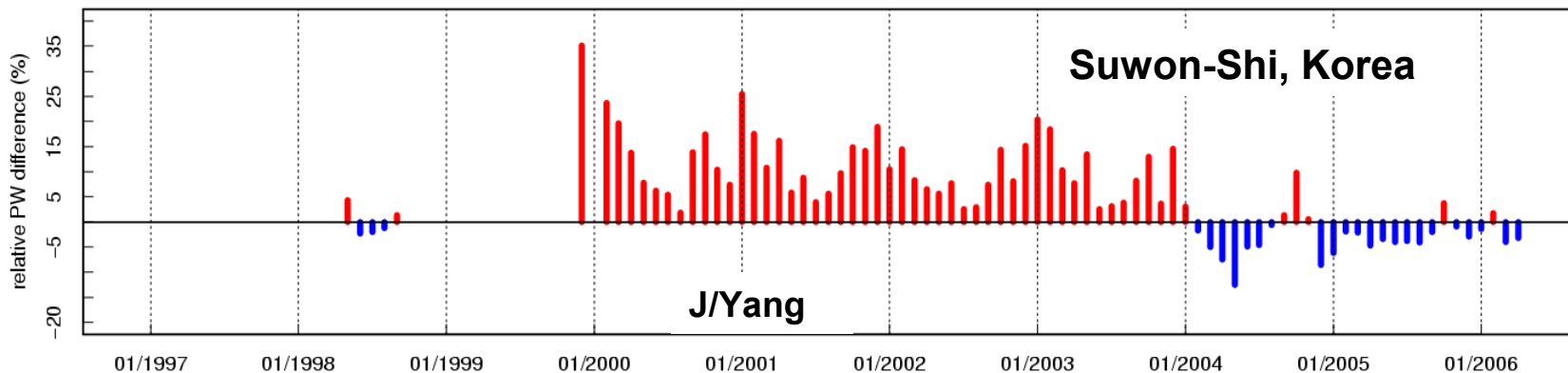
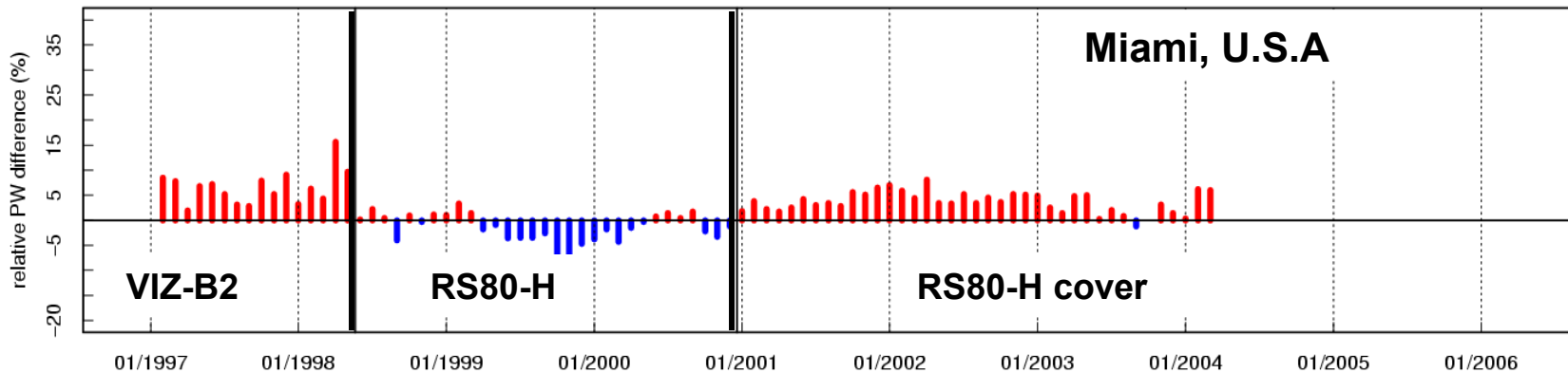
Wang and Zhang (2008)

# Temporal inhomogeneity of radiosonde PW data



NCAR

## Relative PW differences (% Radiosonde-GPS)



Wang and Zhang (2008)



# Essential GPS Equipment



GPS Receiver/Antenna	Geodetic quality dual frequency carrier phase observations are needed for any GRUAN site.
Surface Observations (pressure and temp.)	Pressure accurate to $<0.5$ hPa to remove hydrostatic delay. A 0.5 hPa error in surface pressure $\sim 0.2$ mm error in PW.
Internet	Data need to be provided to analysis center(s) in timely manner to ensure that are included in routine processing.
Station Monumentation	GPS antenna should be installed in a manner that conforms to IGS standards.
Cost of Station	A research quality site can be installed for approximately \$10K US.



- GRUAN site data should be included to IGS network
  - » Ensures data will be analyzed in a timely basis.
  - » Sites will automatically be included in any global reanalysis projects.
- Monumentation and Installation Recommendations
  - » Great care needs to be made to document any changes with GPS equipment (especially antennas and antenna covers). The IGS has standardized logs to document these changes.
  - » Information sources regarding GPS site installation:
    - <http://igscb.jpl.nasa.gov/network/monumentation.html>
    - <http://igscb.jpl.nasa.gov/network/netindex.html>
    - <http://www.unavco.org/>
    - <http://www.ngs.noaa.gov/CORS/>

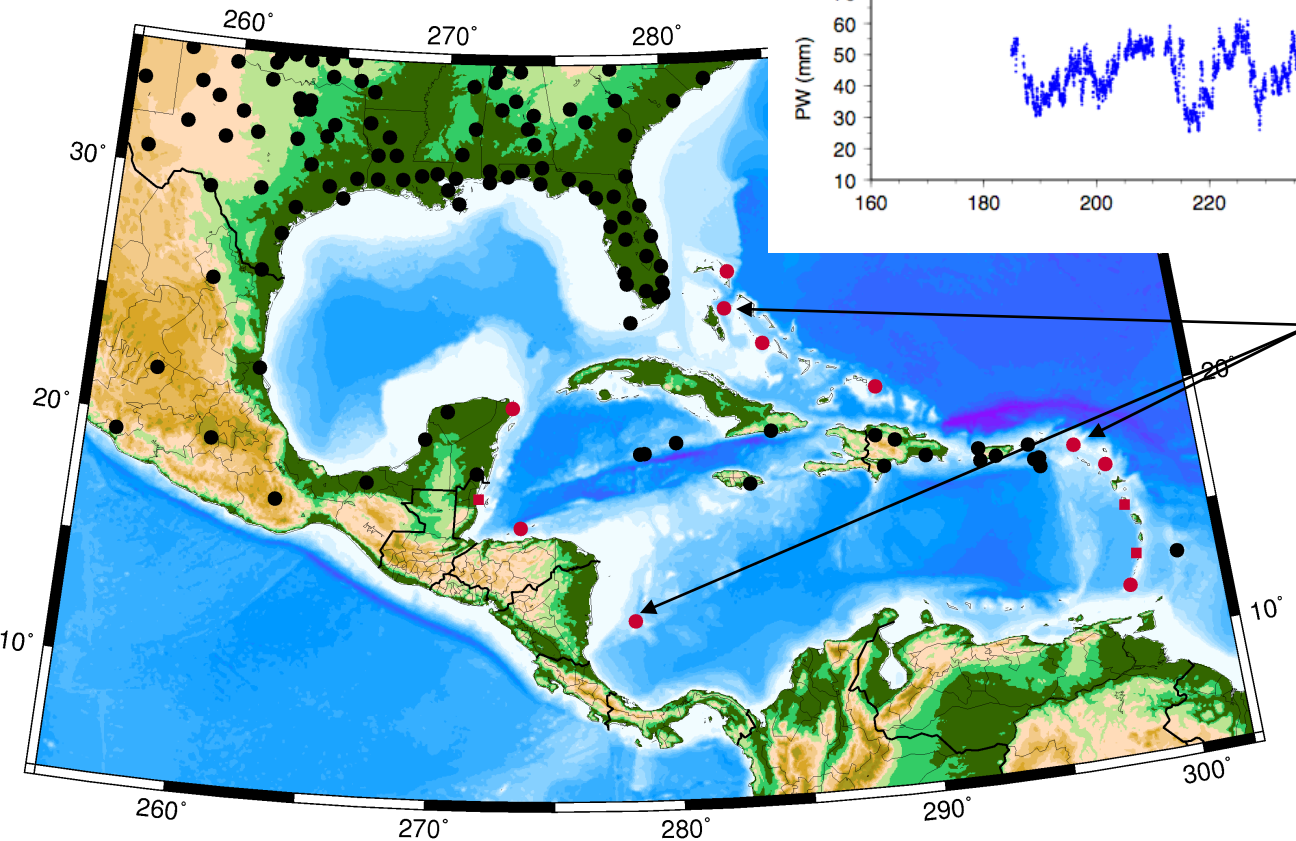
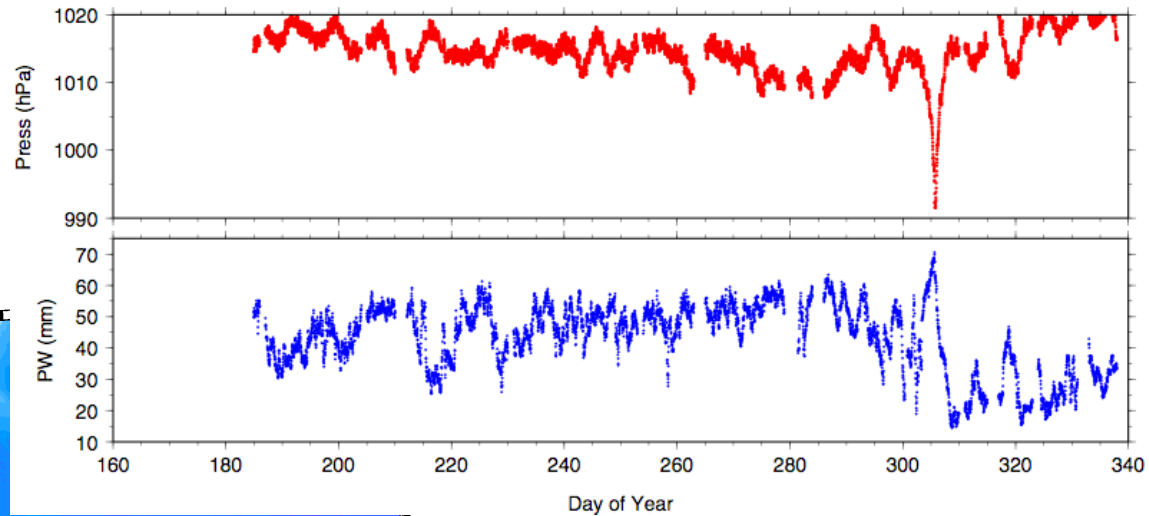




# Caribbean Network



NASO



Potential GRUAN Sites:  
Nassau, Bahamas  
Isla de San Andres, Columbia  
St. Marteen

These sites may need some financial support.



# UCAR Participation in GRUAN



- UCAR (COSMIC) has previously collaborated with other groups (ARM, NOAA and others) to established GPS stations (SGP, Nauru, Manus, Barrow). UCAR is willing to help pursue funding sources for additional GRUAN sites.
- Can provide advice/recommendations for site installation, equipment specifications, analysis procedures, etc.
- UCAR/COSMIC has established analysis capabilities and is constantly evaluating possible ways to improve analysis strategies.
- Can help with site identification, installation, and analysis.
- NOAA/ESRL has similar capabilities.



## Climate applications of GPS Precipitable Water Vapor (PW) estimates

- **To validate global radiosonde humidity records and reanalysis data**
- **To document and understand PW diurnal variations**
- **To create a corrected global radiosonde PW dataset**

- Wang, J., L. Zhang, and A. Dai, 2005: Global estimates of water-vapor-weighted mean temperature of the atmosphere for GPS applications. *J. Geophys. Res.*, 110, D21101, doi:10.1029/2005JD006215.
- Wang, J., L. Zhang, A. Dai, T. Van Hove, J. Van Baelen, 2007: A near-global, 2-hourly data set of atmospheric precipitable water from ground-based GPS measurements. *J. Geophys. Res.*, **112**, D11107. doi:10.1029/2006JD007529.
- Wang, J. and L. Zhang, 2008: Systematic errors in global radiosonde precipitable water data from comparisons with ground-based GPS measurements. *J. Climate*, in press.
- Wang, J., and L. Zhang, 2007: Climate applications of a global, 2-hourly atmospheric precipitable water dataset from IGS ground-based GPS measurements, *J. of Geodesy*, submitted.

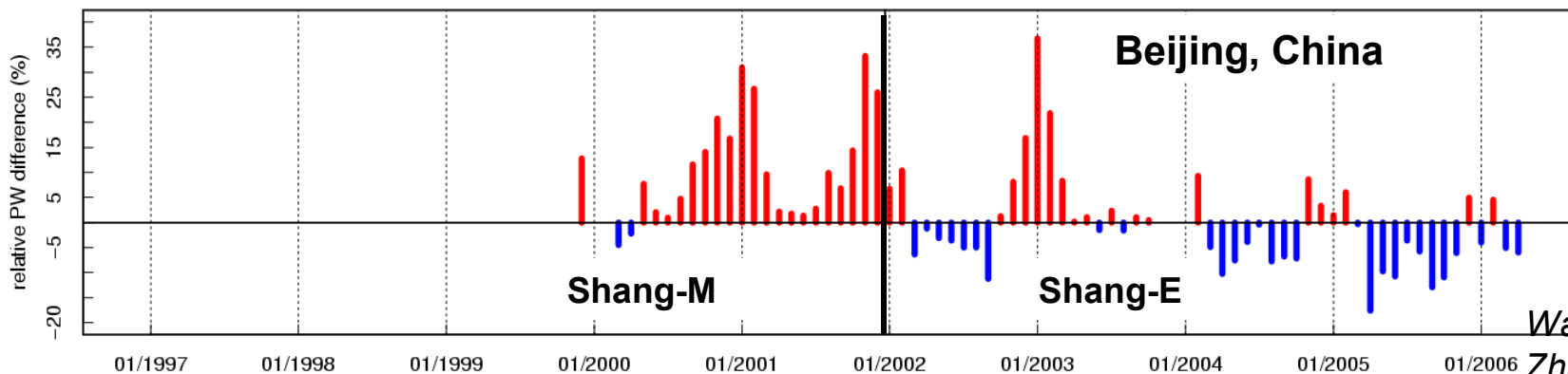
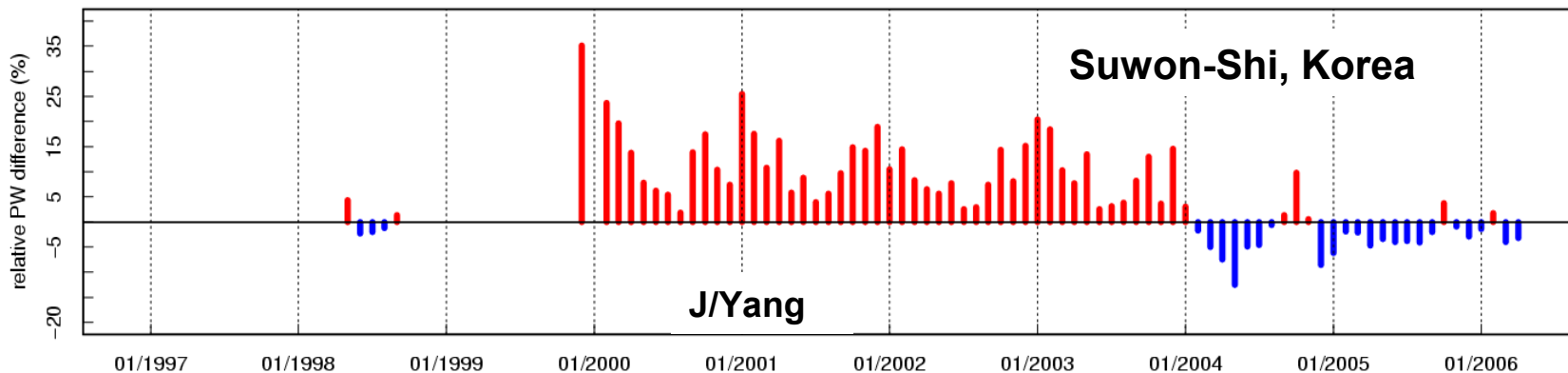
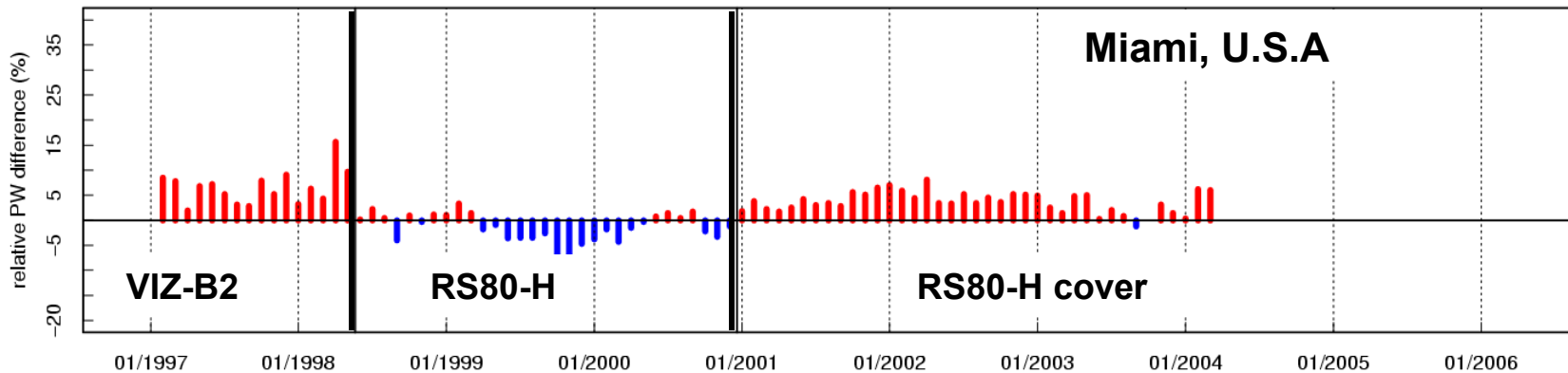


# Temporal inhomogeneity of radiosonde PW data



NCAR

## Relative PW differences (% Radiosonde-GPS)



Wang and Zhang (2008)

# Seasonal variations of diurnal and sub-monthly variability in Europe

