# GNSS homogenization

**Sibylle Vey**

GFZ Helmholtz-Zentrum Potsdam

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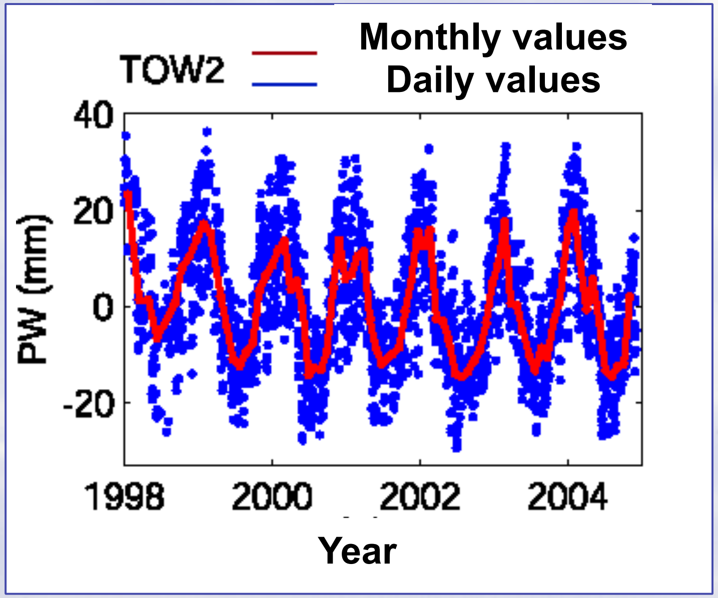
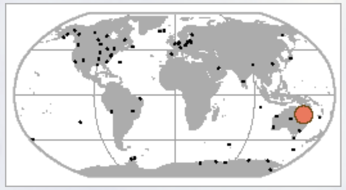
# GNSS homogenization

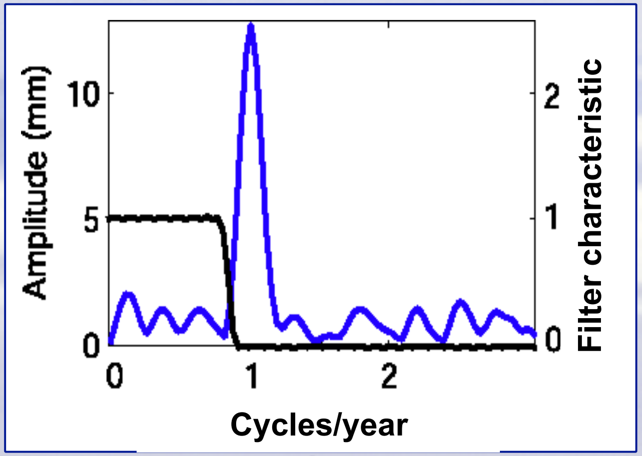
# Why is it important?

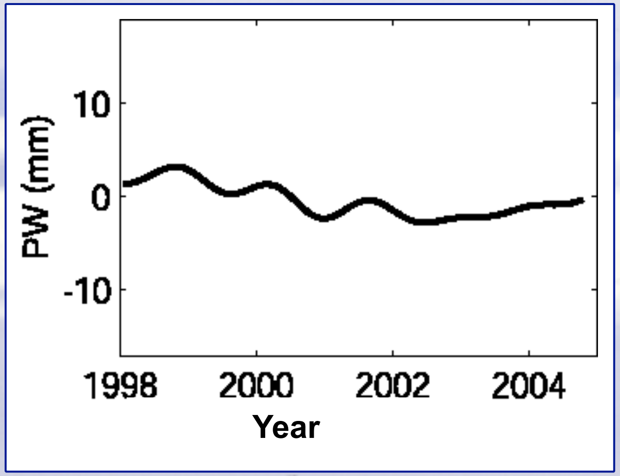


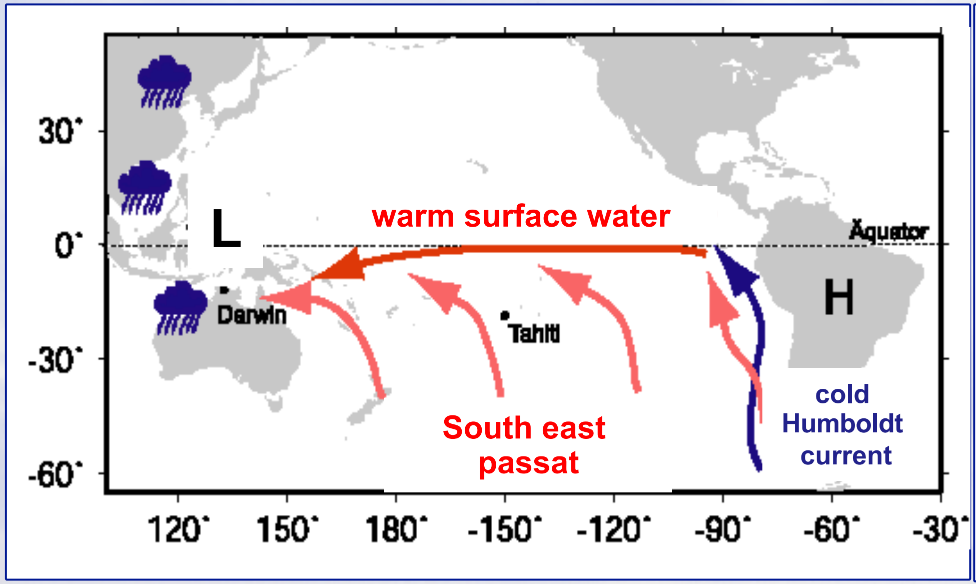
Station:
Cape Ferguson,
Australia

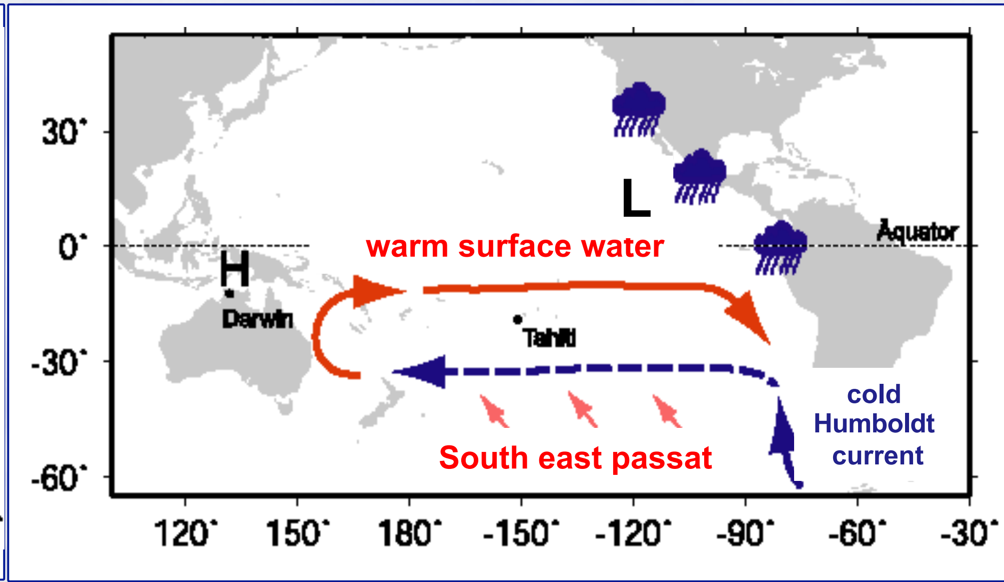
i(t) interannual component



# El Niño

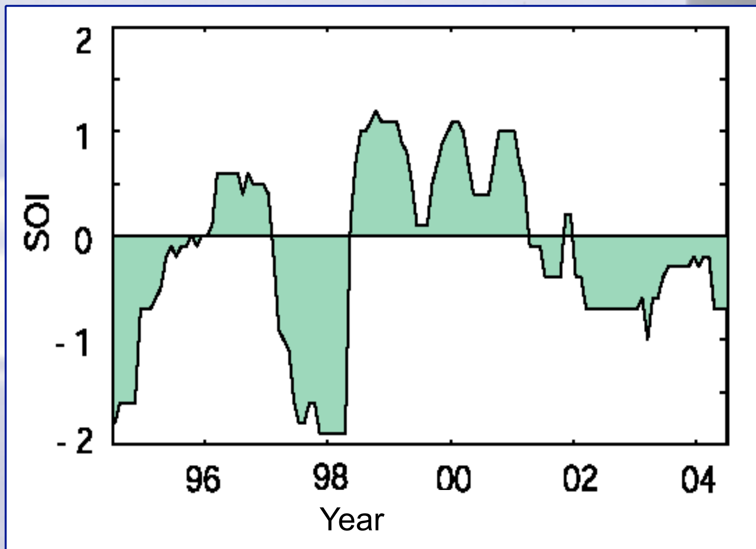



Southern Oscillation Index

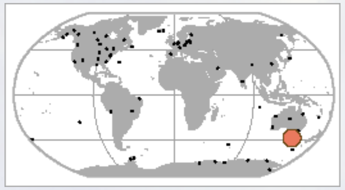
$$SOI = \frac{P_{Tahiti} - P_{Darwin}}{MSD(P_{Tahiti} - P_{Darwin})}$$

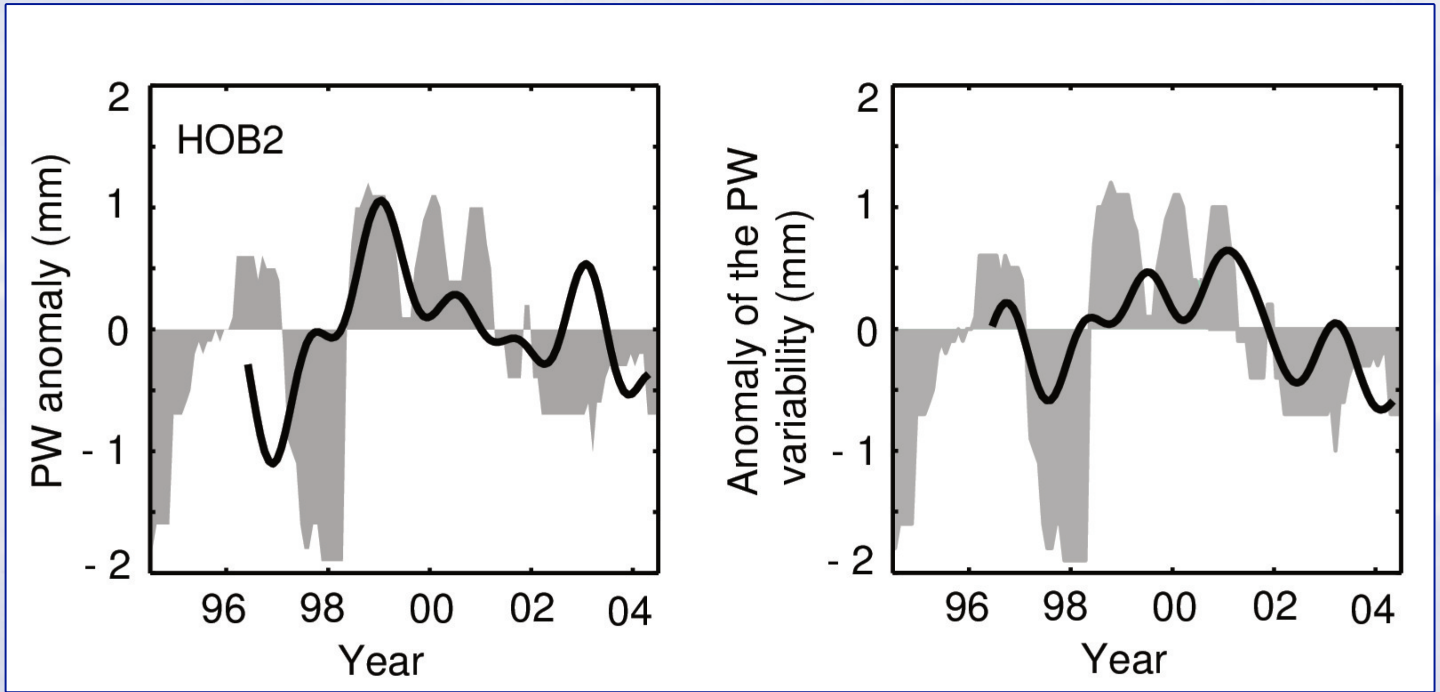
| | |
|---|---|
| $P$ | Air pressure at mean sea level |
| $MSD$ | Mean standard deviation |




Technische Universität Dresden
Institut für Planetare Geodäsie

# Influence of El Niño






Station:
Hobart
Australia

**The water vapor anomalies**

**- are in the order of 1-3 mm for most of the stations in Australia**

**- can be related to the influence of the Southern Oscillation**

# GNSS homogenization

**is important because**

the expected climate signals are in the same order than the effect of inhomogeneities

# What effects could cause inhomogeneities in ZTD time series?

# 1) GNSS processing related effects

**Modelling**

- Change of the mapping function
- Change of the antenna phase centre model (relative – absolute)
- Change of the ionospheric model (higher order)
- Change of the reference system

**Parameter Estimation**

- Change of the elevation cut-off angle
- Change of the number of estimated parameters (2-hourly ZTD, 15-min ZTD, gradients)

# 2) GNSS hard and software related effects

- Change of antenna/radom
- Change of the elevation cut-off angle

# 1) GNSS processing related effects

**Modelling**

- Change of the mapping function
- Change of the antenna phase centre model (relative – absolute)
- Change of the ionospheric model (higher order)
- Change of the reference system

**Parameter Estimation**

- Change of the elevation cut-off angle
- Change of the number of estimated parameters (2-hourly ZTD, 15-min ZTD, gradients)

**-> Can be avoided when using reprocessed ZTD time series**

# 2) GNSS hard and software related effects

- Change of antenna/radome
- Change of the elevation cut-off angle

**-> Need to be considered !**

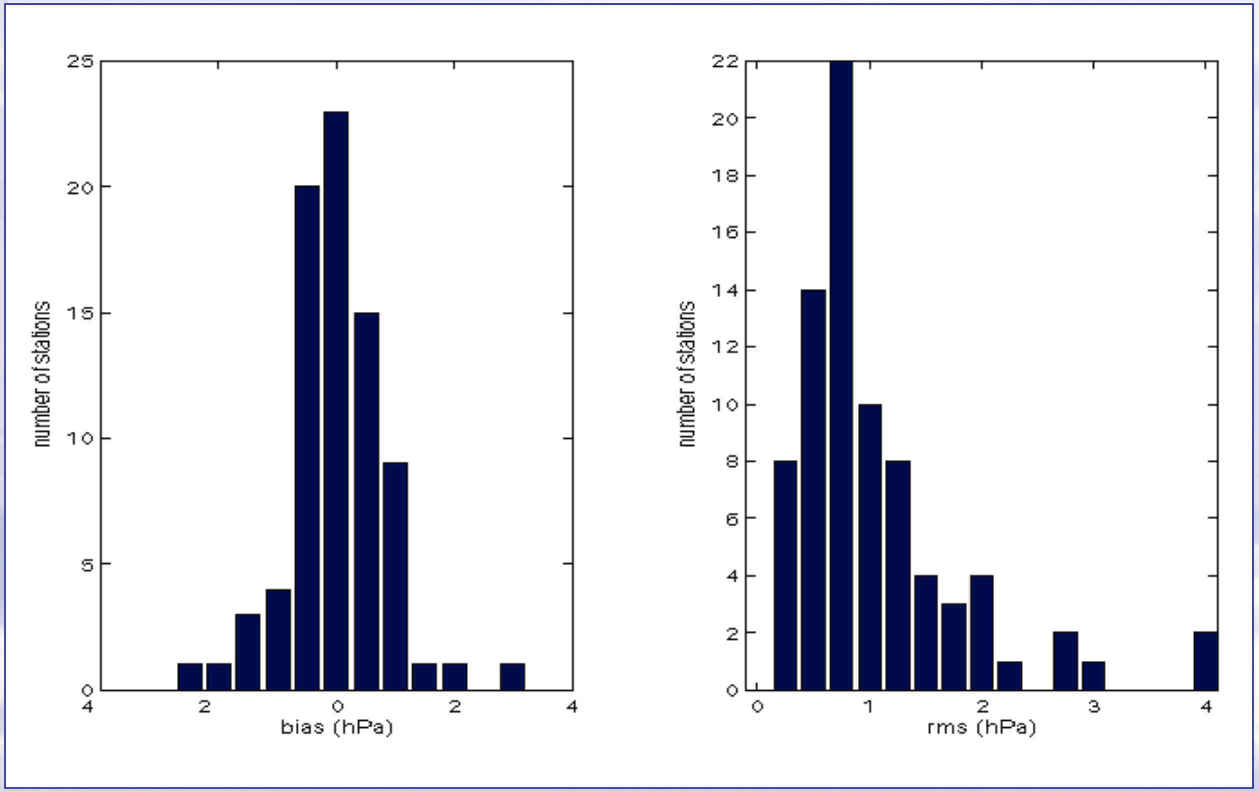
## 3) Effects of the conversion (ZTD-PW)

- Change/drift of pressure sensor
- Change in temperature sensor

**Pressure series** **Comparison of neighbouring IGS and WMO records**

- horizontal distance < 50 km, height difference < 500 m
- Jan. 94-Dec. 2004
- more than 100 days of common data

=> 62 stations

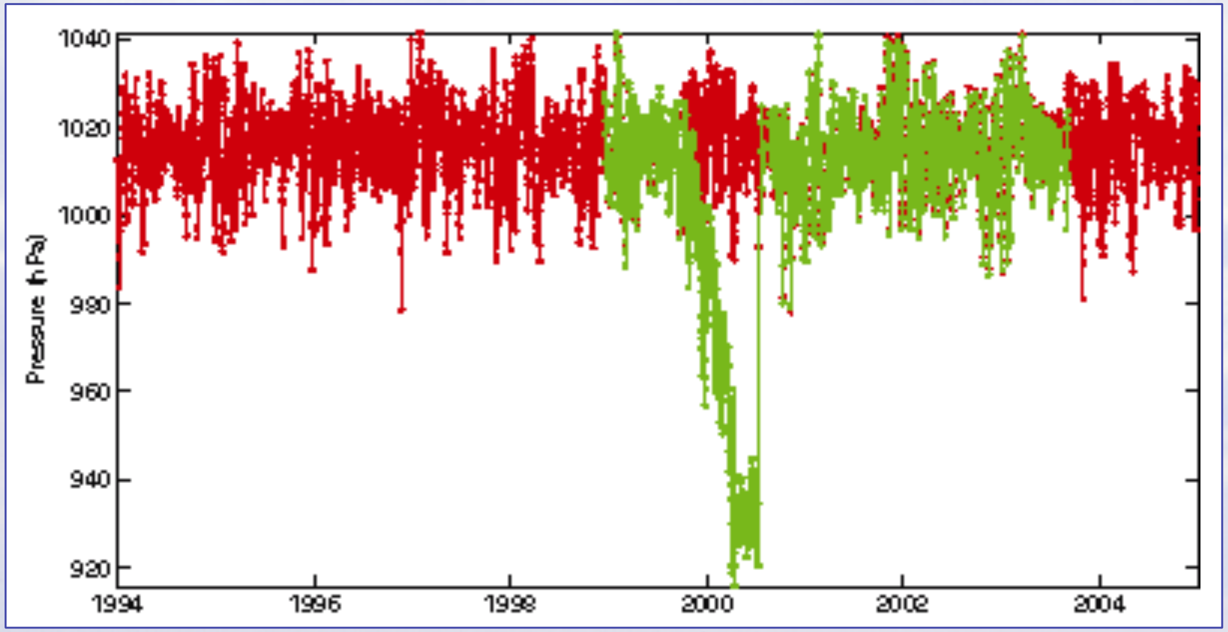



mean bias: -0.1 hPa
mean rms: 1.1 hPa

**=> In general good agreement between WMO and IGS pressure records**

# Homogeneity of pressure data

**BUT: some IGS pressure sensors show drifts**




Station: BRUS
(Brussels, Belgium)

red: WMO station
green: IGS sensor

**WMO pressure records:**

- **cover longer time periods**
- **contain less data gaps**
- **are more homogenous in time**

**=> are preferable in PW estimation for climatological application**

# Influence on PW

| Sources : | Effect | Influence on PW |
|---|---|---|
| (1) ZTD: | 10 mm | 1,5 mm |
| (2) Pressure: | 2 hPa | 0,6 mm |
| (3) Temperature : | 1 K | 0 ... 0,3 mm<br>(0,7 % of PW) |

## 1) GNSS processing related effects

-> Can be avoided when using reprocessed ZTD time series

## 2) GNSS hard and software related effects

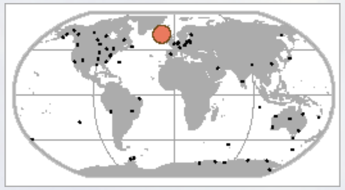
- Change of antenna/radome
- Change of the elevation cut-off angle

**-> Need to be considered !**

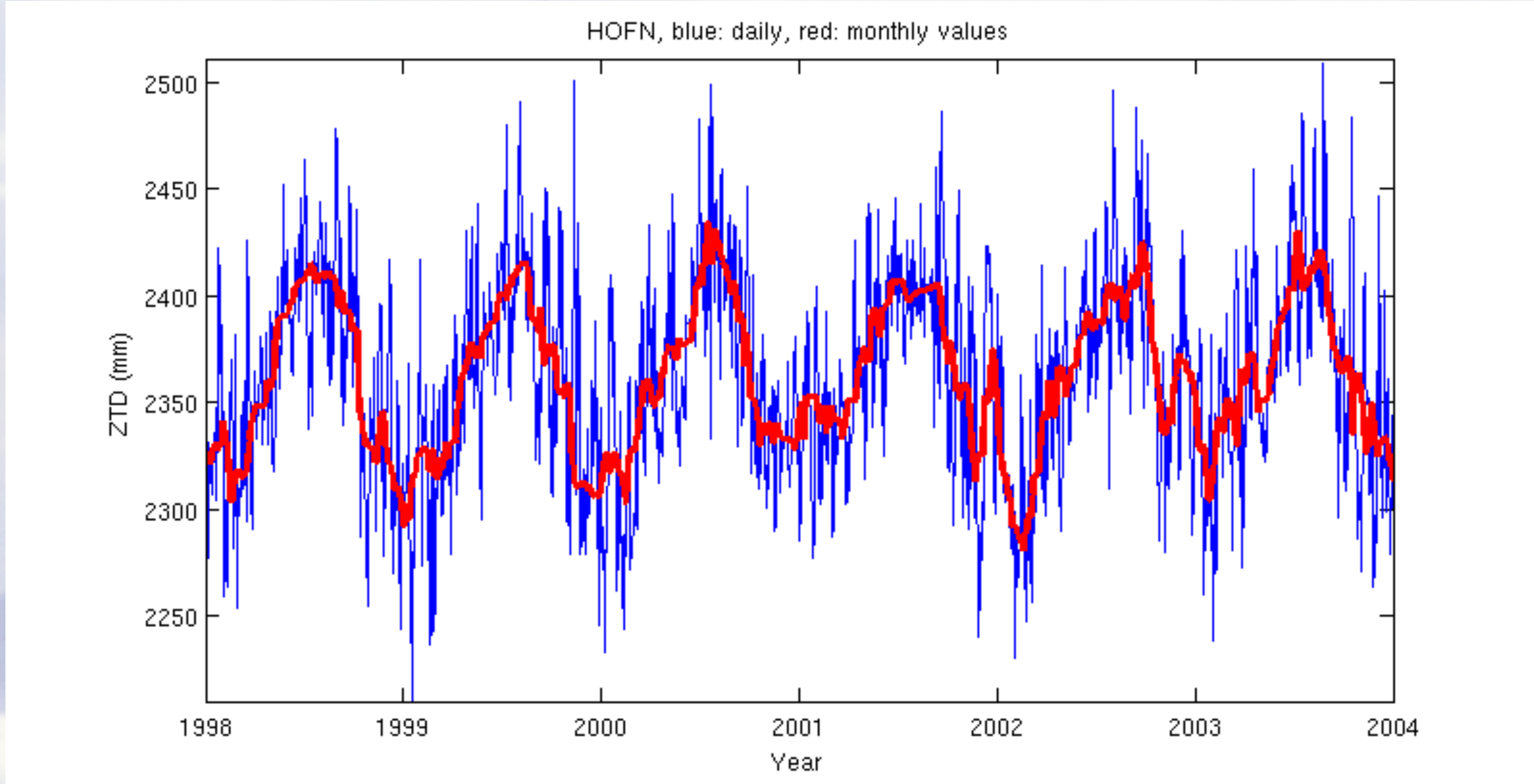
## 3) Effects of the conversion (ZTD-PW)

- > PW is very sensitive to pressure changes
  use of homogeneous pressure time series

# How can we detect hardware related effects ?

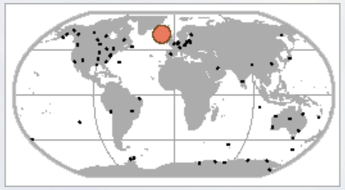


Stations:
Höfn (Island)




**ZTD time series from GFZ reprocessing**

# How can we detect hardware related effects ?



Stations:
Höfn (Island)

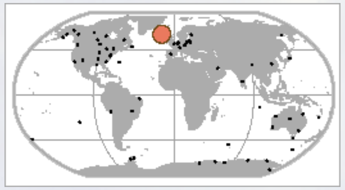
## Station logfile

**ftp://ftp.igs.org/pub/station/log/hofn_20140218.log**

4.3 **Antenna Type : TRM22020.00+GP DOME**
Antenna Radome Type : DOME
Antenna Cable Length : 30 m
Date Installed : 2000-05-25T13:45Z
Date Removed : 2001-09-21T18:00Z
Additional Information : TRIMBLE 24490-00 Prod Ass Ext Dome

4.4 **Antenna Type : TRM29659.00 NONE**
Antenna Radome Type : NONE
**Date Installed : 2001-09-21T18:00Z**
Date Removed : 2007-09-22T10:00Z
Additional Information :

# How can we estimate the effect of antenna/ radome change on the ZTD estimates?



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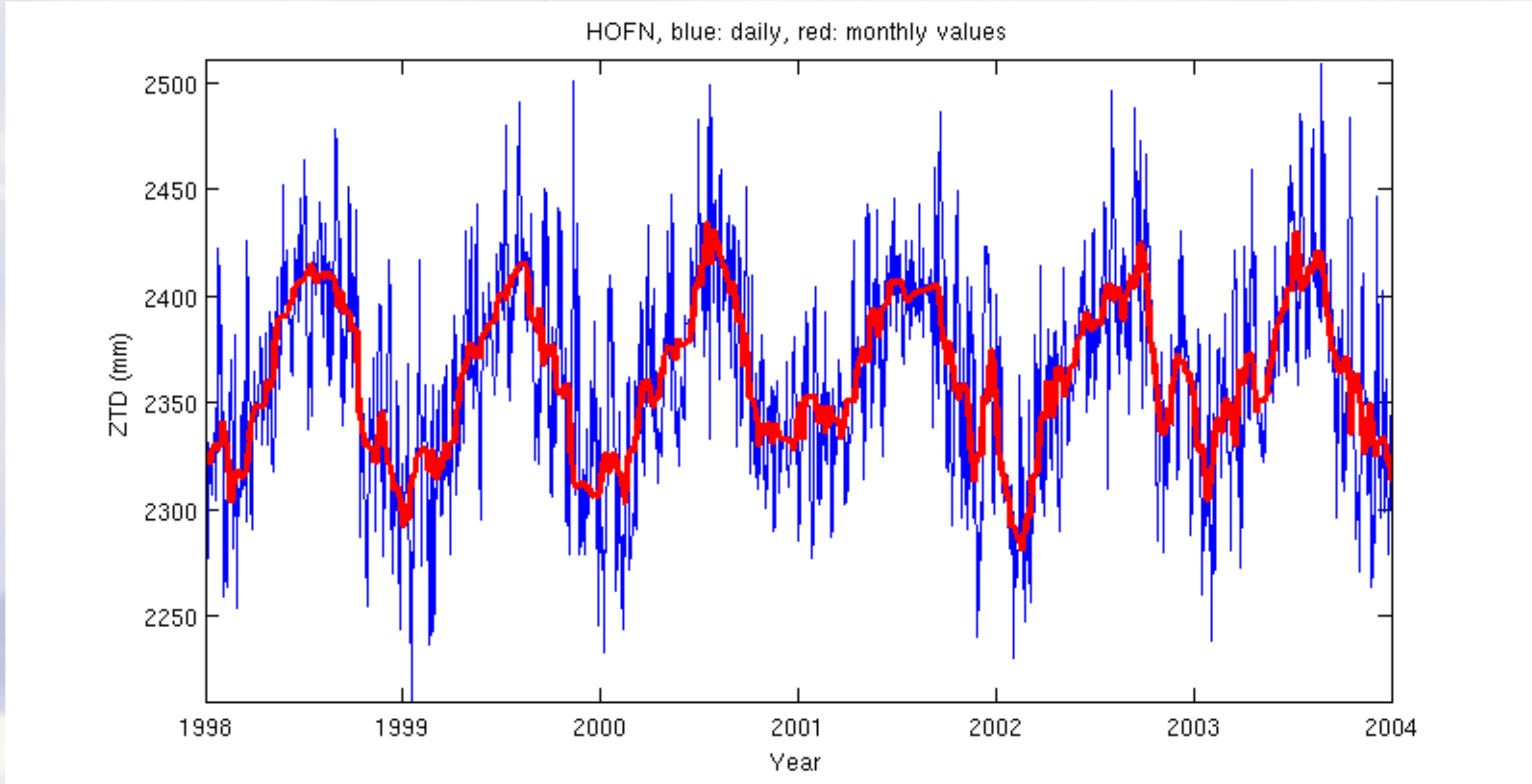

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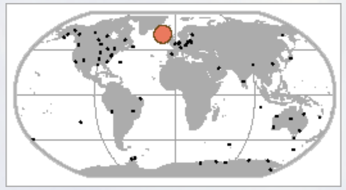
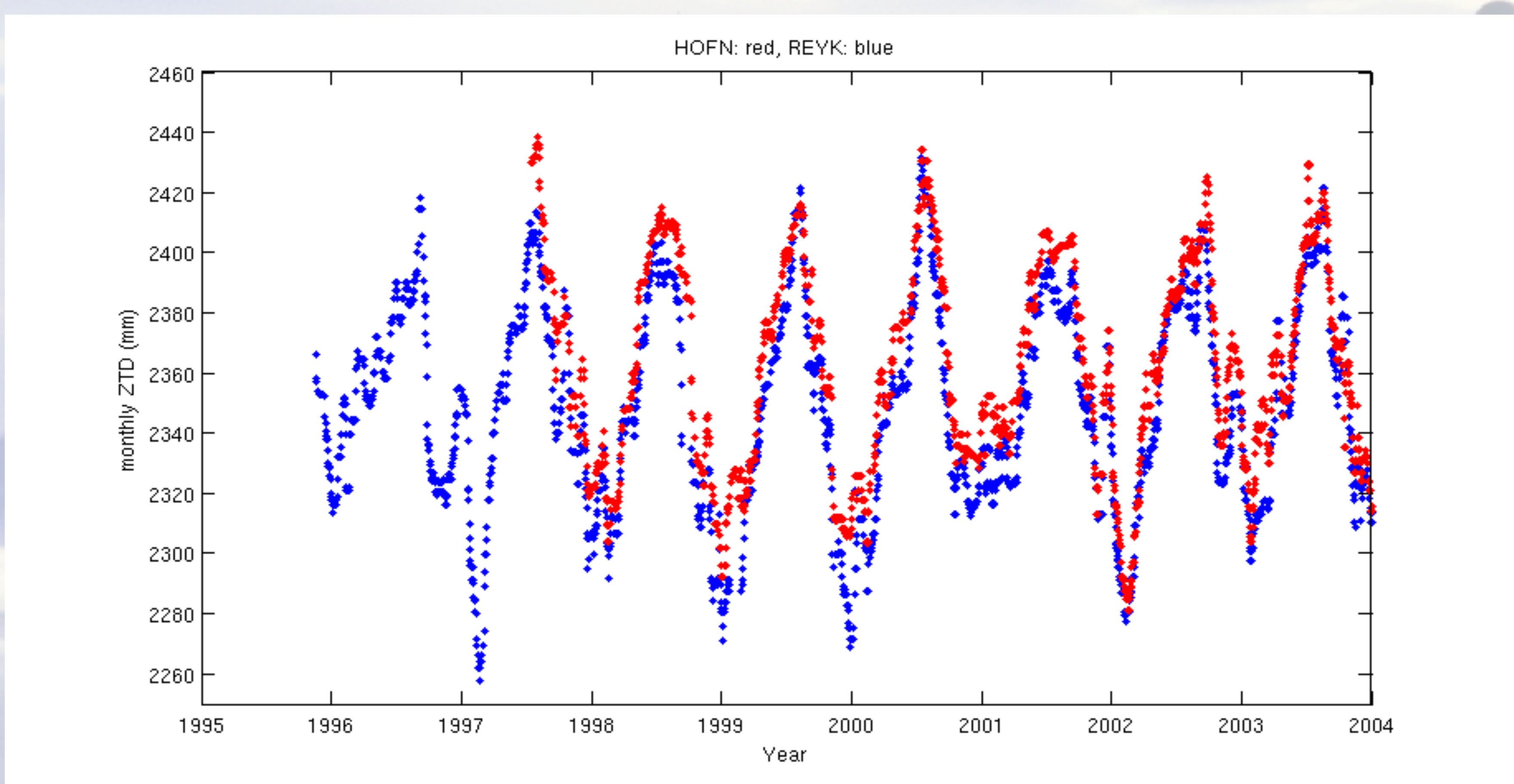
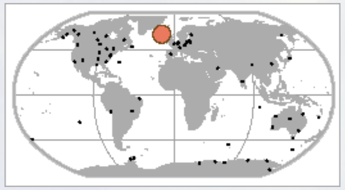


Stations:
Höfn, Rekjavik
(Island)

**Calculation of the difference with an homogeneous ZTD time series with similar seasonal signal**



# Practical



Stations:
Höfn, Rekjavik
(Island)

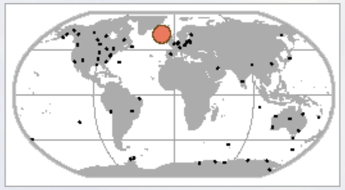
1) **Calculate and plot the ZTD difference time series of HOFN-REYK**

   function unique
   function interpol1

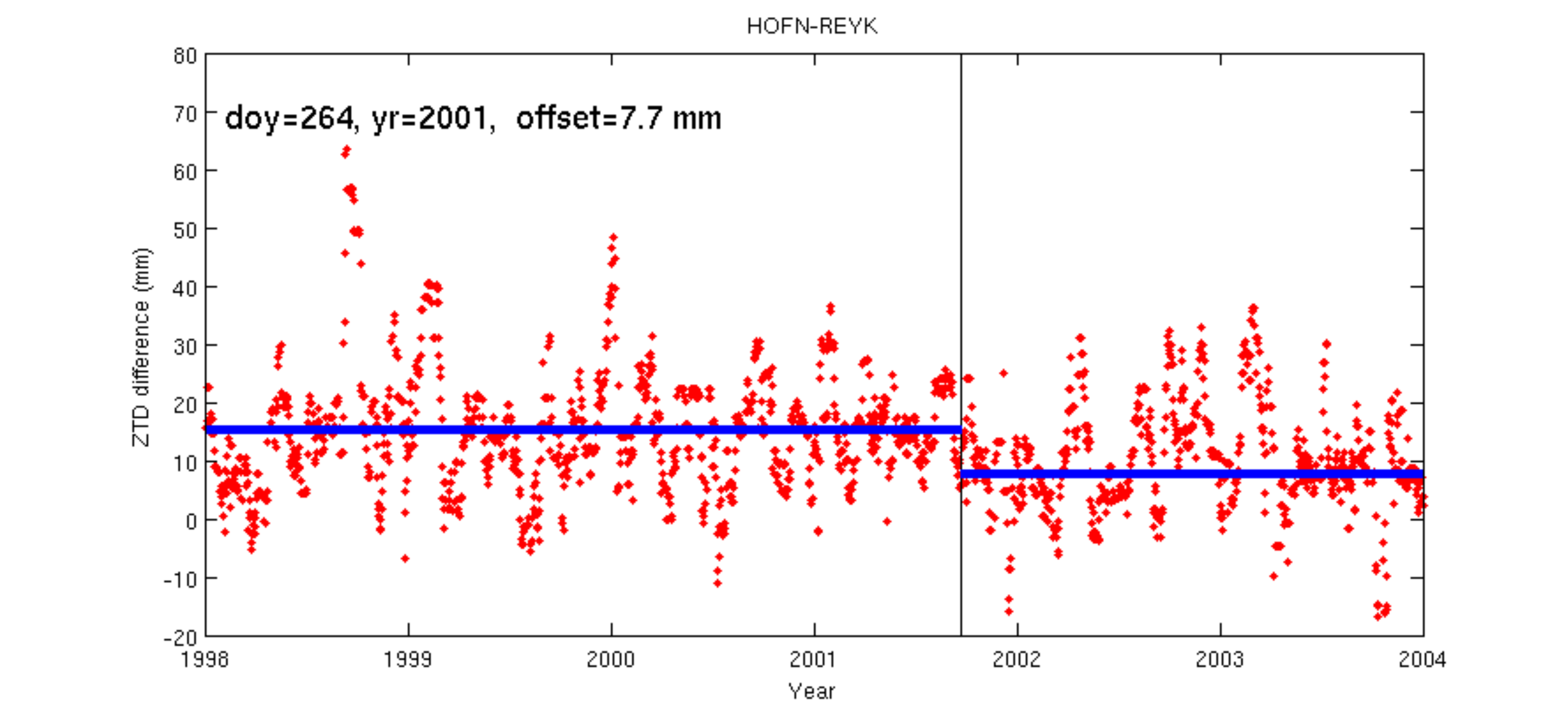
2) **Calculate the offset in the ZTD difference time series due to the antenna/radome change on September 21th 2001 (doy 264)**

   mean of ZTD before and after doy 264/2001

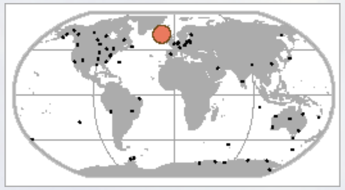
# Practical



Stations:
Höfn, Rekjavik
(Island)



# Precipitable Water (PW)



Stations:
Höfn, Rekjavik
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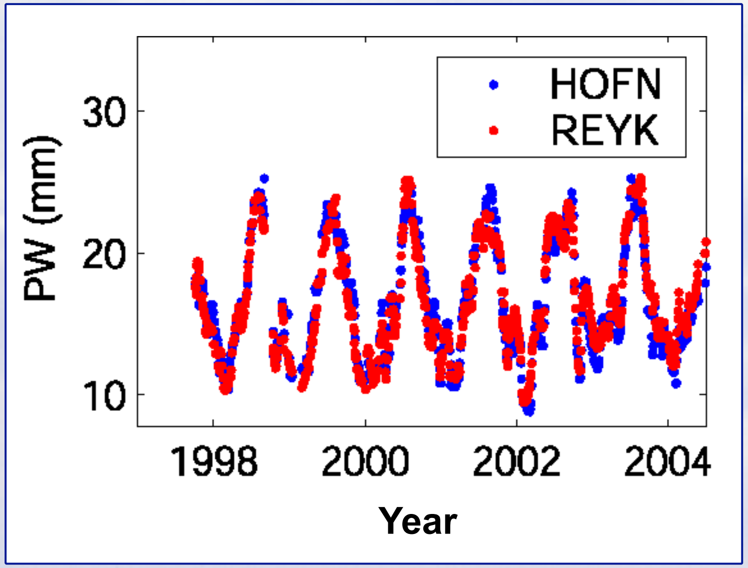
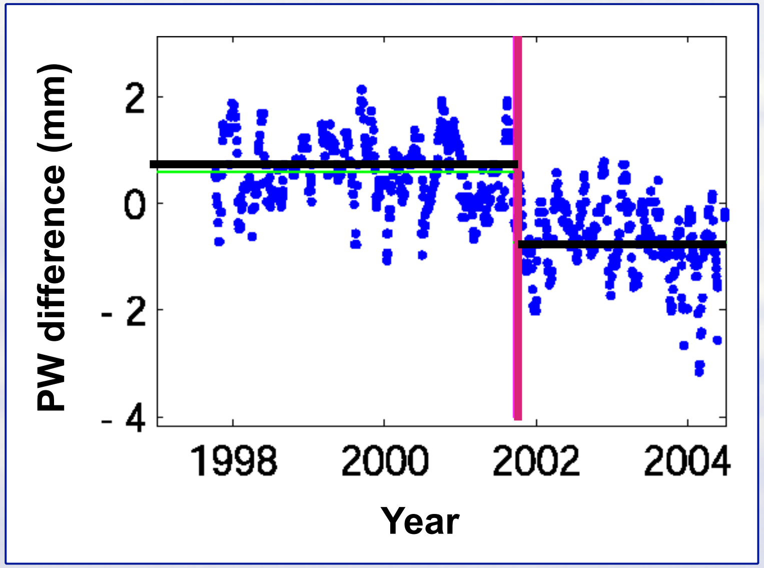
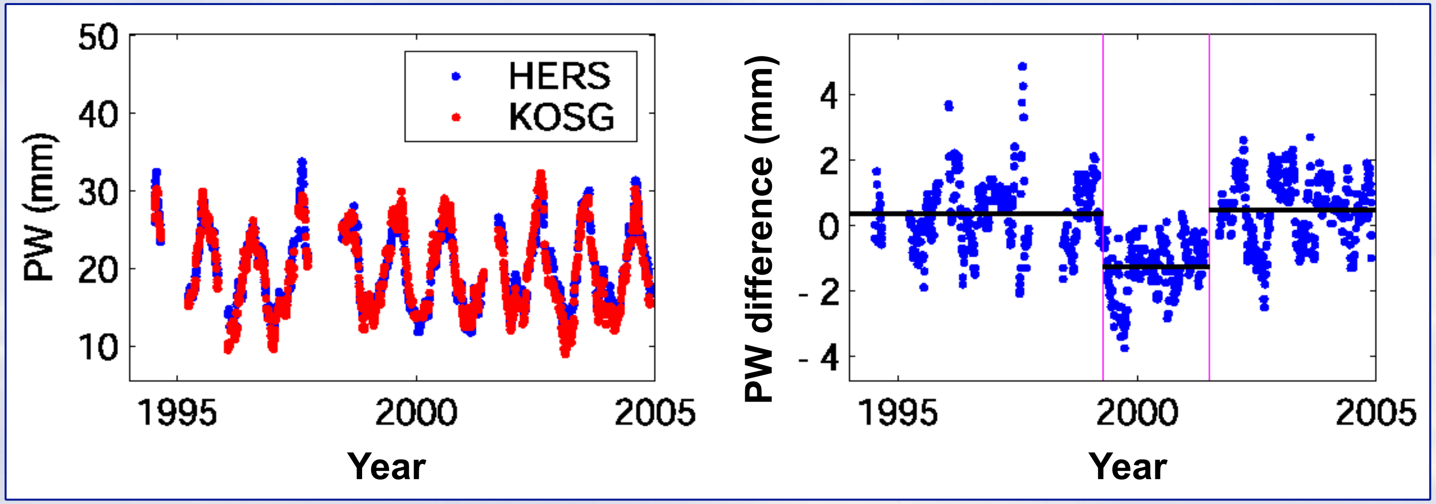



**Radom + antennen change**

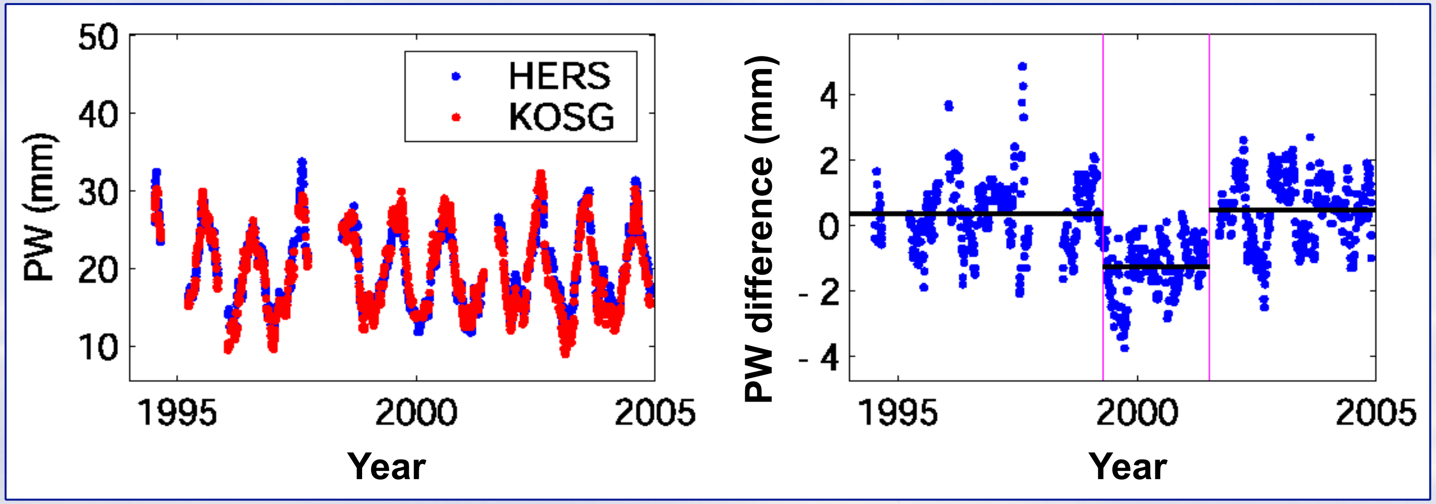
**=> offset of 1,3 mm in PW at the station Höfn**

**Reasons: Deficits in the modelling of the antenna phase centres (the influence of radoms is not considered)**

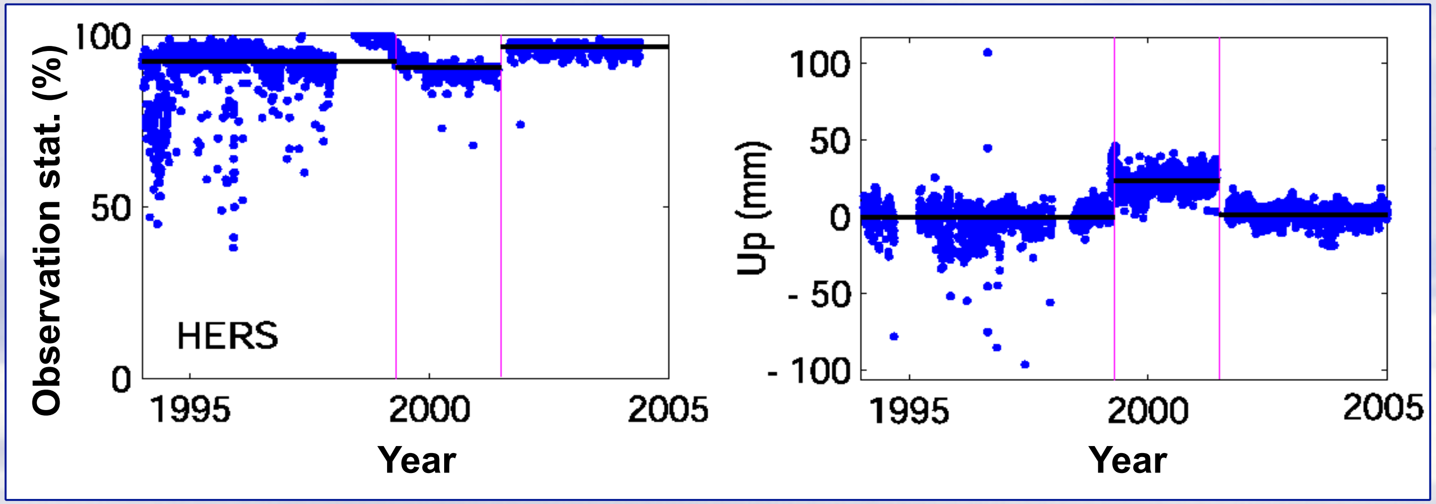



Stations:
Hailshaim (England)
Kootwijk (Netherlands)

**March 1999 to June 2001**
**PW offset of 1.4 mm**



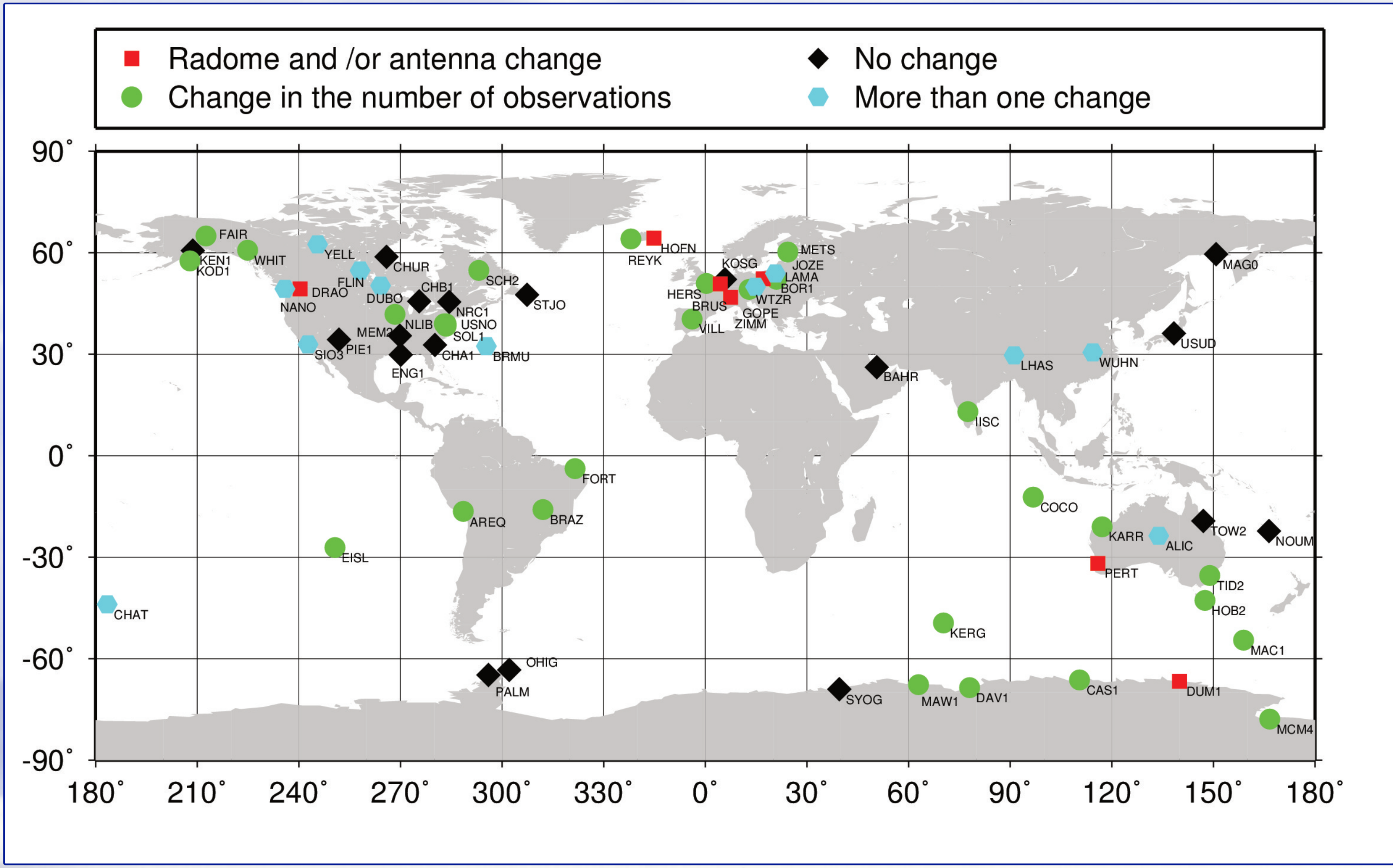

Stations:
Hailshaim (England)
Kootwijk (Netherlands)




**Offset of 1.4 mm due to a reduced number of observations**

**Reasons: deficits in the mapping function and modelling of the antenna phase centre variations**

# Homogeneity




**- Homogenous time series for 19 stations**

**- For all other stations offset correction necessary**

**- Accuracy of offset correction : 0,01 … 0,4 mm PW**

# Take home

- Climate studies should be based on
  - reprocessed ZTD time series
  - homogenous pressure und temperature data

- Effects of hard and software changes
  - are in the same order than inter-annual variations
  - need to be corrected

## References

**Vey, S., Dietrich, R., Rülke, A., Fritsche, M., Steigenberger, P. und Rothacher, M. (2010).** Validation of precipitable water in NCEP using global GPS observations from one decade, Journal of Climate, DOI: 10.1175/2009JCLI2787.1

**Vey, S., Dietrich, R., Fritsche, M., Rothacher, M., Rülke, A., and Steigenberger, P (2009).** On the homogeneity and interpretation of precipitable water time series derived from global GPS observations, Journal of Geophysical Research, 114, D10101, doi:10.1029/2008JD010415.

Vey et al. 2009 (JGR) & Vey et al. 2010 (JoC)

# Thank you!

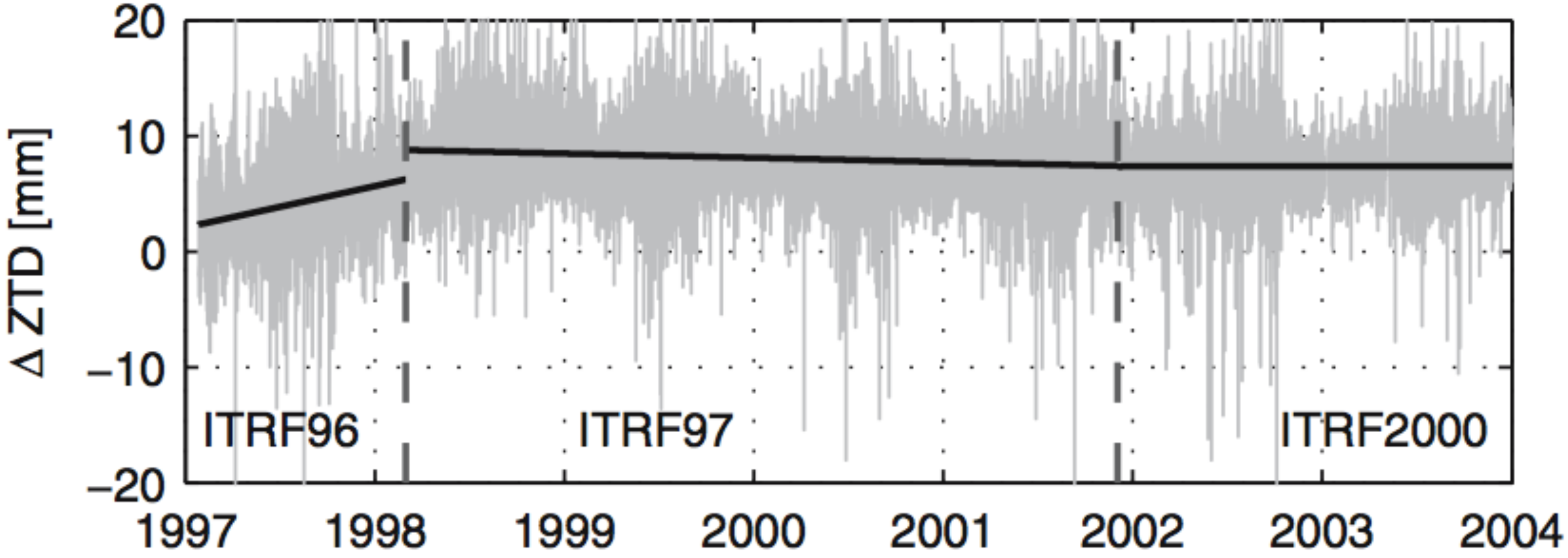



**Fig. 1** Differences between IGS and reprocessed zenith total delay (2-hourly) for Algonquin Park (ALGO). The different drift behavior of the three time periods coincides very well with the different reference frame realizations (marked by *dashed vertical lines*): ITRF96: 3.6 mm/year, ITRF97: –0.4 mm/year, ITRF2000: 0.0 mm/year

**Steigenberger et al. 2007 (JoG)**