A global, 2-hourly atmospheric precipitable water dataset from IGS ground-based GPS measurements:

Scientific applications and Future needs

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Goals

1) To develop an analysis technique to derive atmospheric precipitable water (PW) using existing IGS tropospheric product (zenith tropospheric delay, ZTD) on a global scale;

2) To apply the technique to global ZTD data from 1997 to present to create a global, 2-hourly PW dataset, and make the dataset available to the public;

3) To use the data for various climate and weather studies:

   - To document and understand PW diurnal variations
   - To quantify time- and space-dependent biases in global radiosonde humidity records

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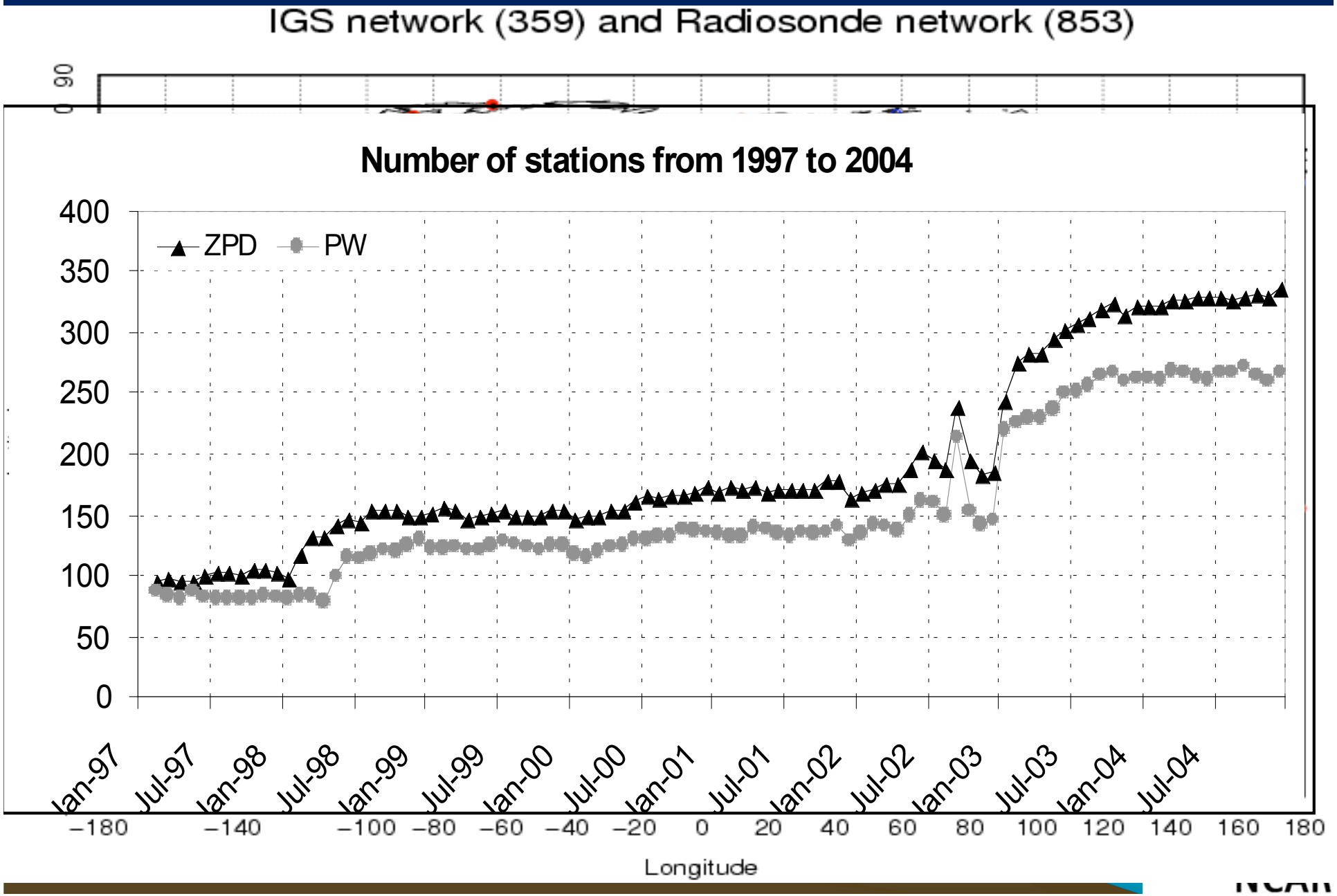
DATA: IGS ZTD data: ~340 stations, 1997-present, 2-hourly



Analysis Technique and Validations

Input:
ZPD = ZHD + ZWD

P_s from 3-hourly global surface synoptic observations with adjustment

$$ZHD = 2.2779 \times \frac{P_s}{f(\lambda, H)}$$

ZWD = ZPD - ZHD

$$T_m \equiv \frac{\int \frac{P_v}{T} dz}{\int \frac{P_v}{T^2} dz} \approx \frac{\sum_{i=1}^{N} \frac{P_{vi}}{T_i} \Delta z_i}{\sum_{i=1}^{N} \frac{P_{vi}}{T_i^2} \Delta z_i}$$

$$\frac{\Delta PW}{PW} = \frac{\Delta \Pi}{\Pi} \approx \frac{\Delta T_m}{T_m}$$

Tm from 6-hourly NCEP/NCAR Reanalysis with horizontal and vertical interpolation (Wang et al. 2005)

Output:
PW = ∏ * ZWD
∏ = f (Tm)

Comparisons with radiosonde, MWR and other data

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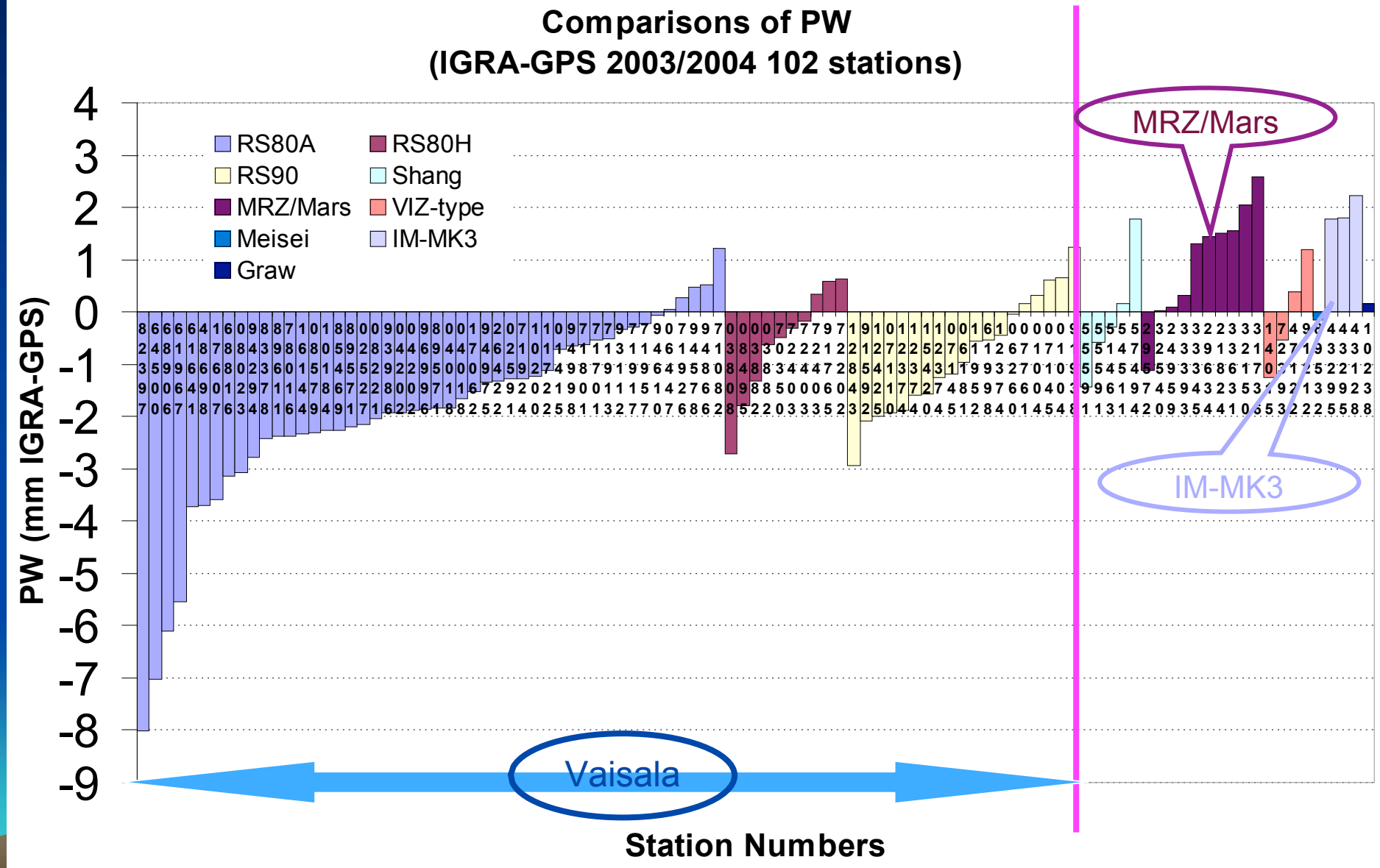
Comparison of GPS- and radiosonde-PW at 102 stations



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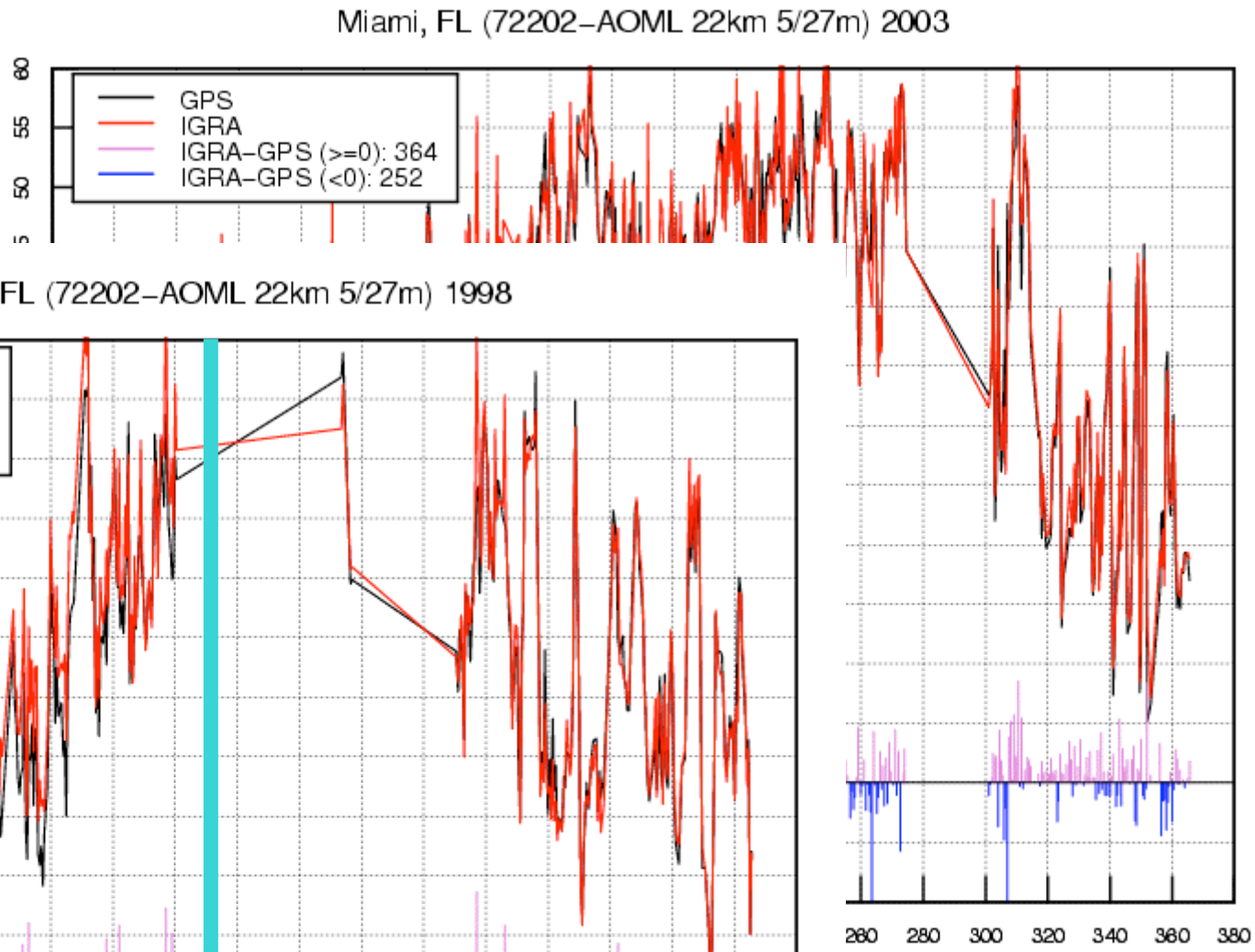
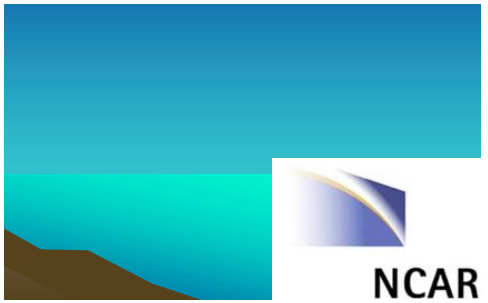
Miami, FL





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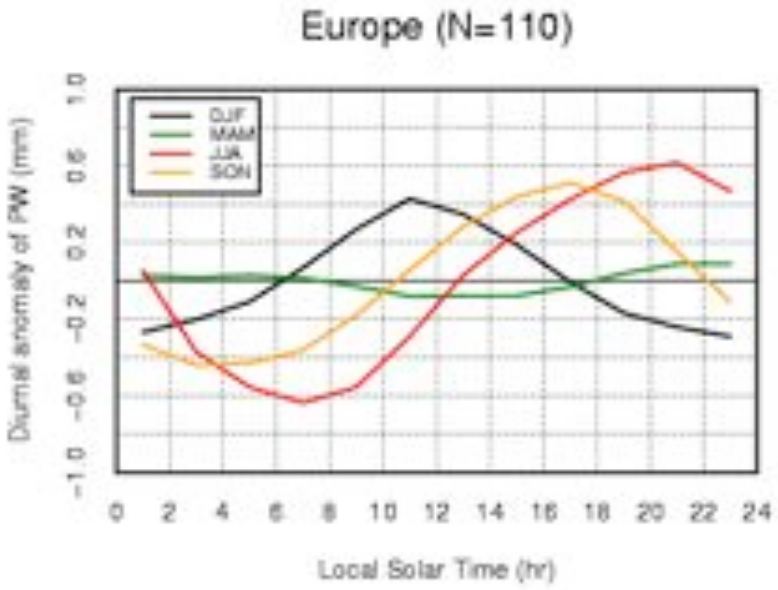
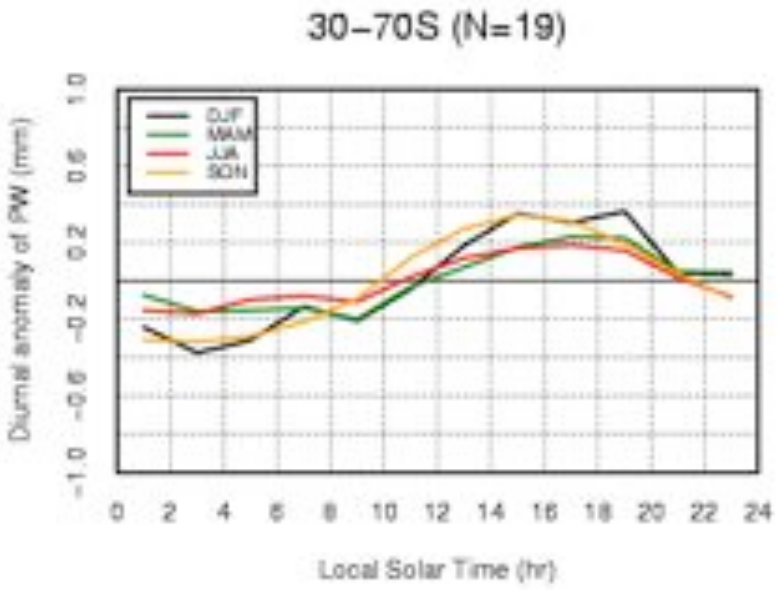
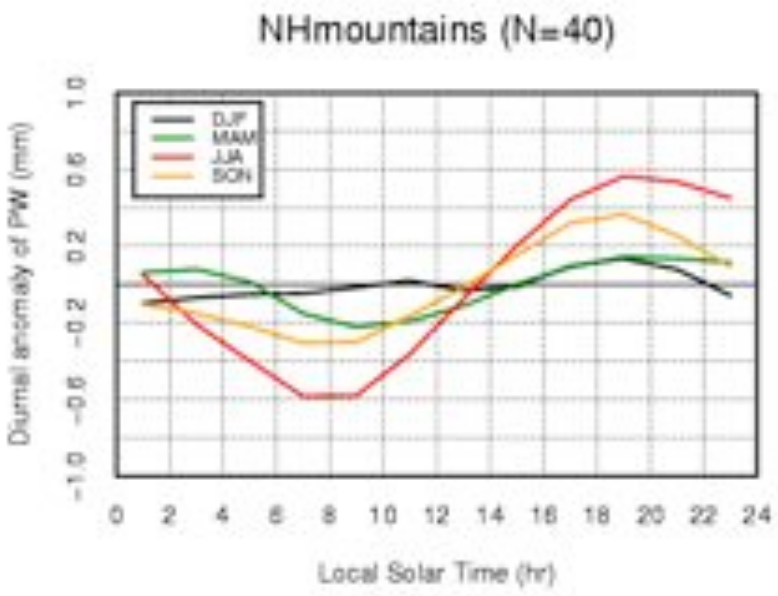
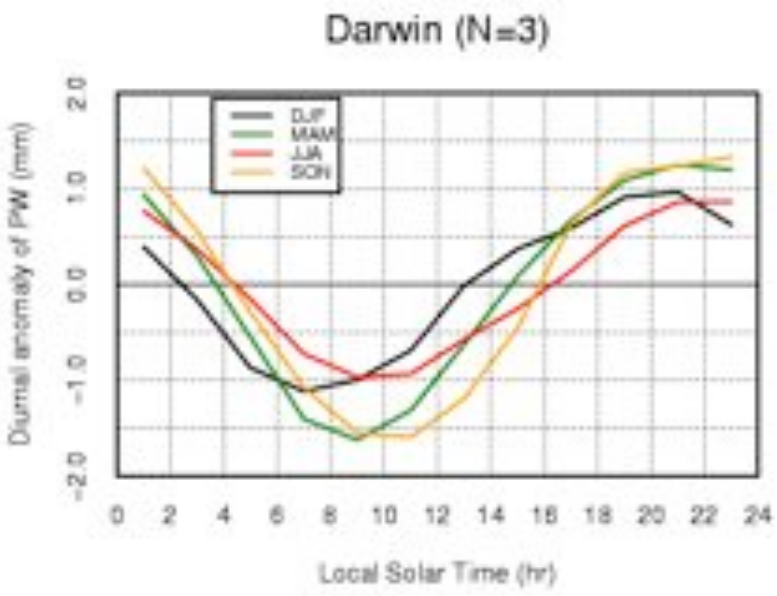
Diurnal variations of PW









Future Needs

Recommendations on improving future IGS products
Wish list

1. To maintain long-term stability and high quality of the ZTD product
2. To reduce diurnal biases in the ZTD product
3. To improve and increase sfc-met data
4. To co-locate with radiosonde stations
5. To increase the spatial and temporal coverage
6. To better document the IGS products

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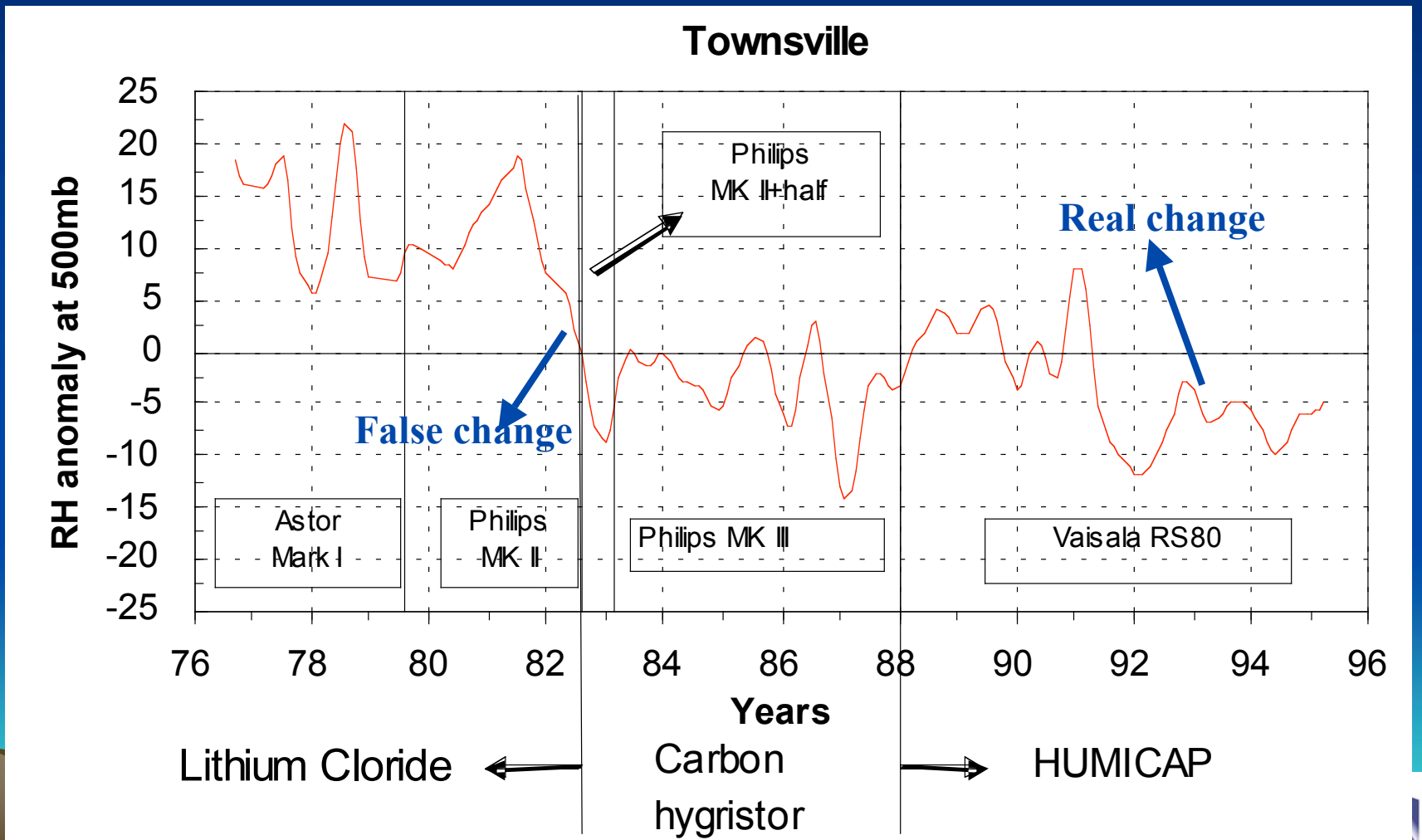
1. To maintain long-term stability and high quality of the ZTD product



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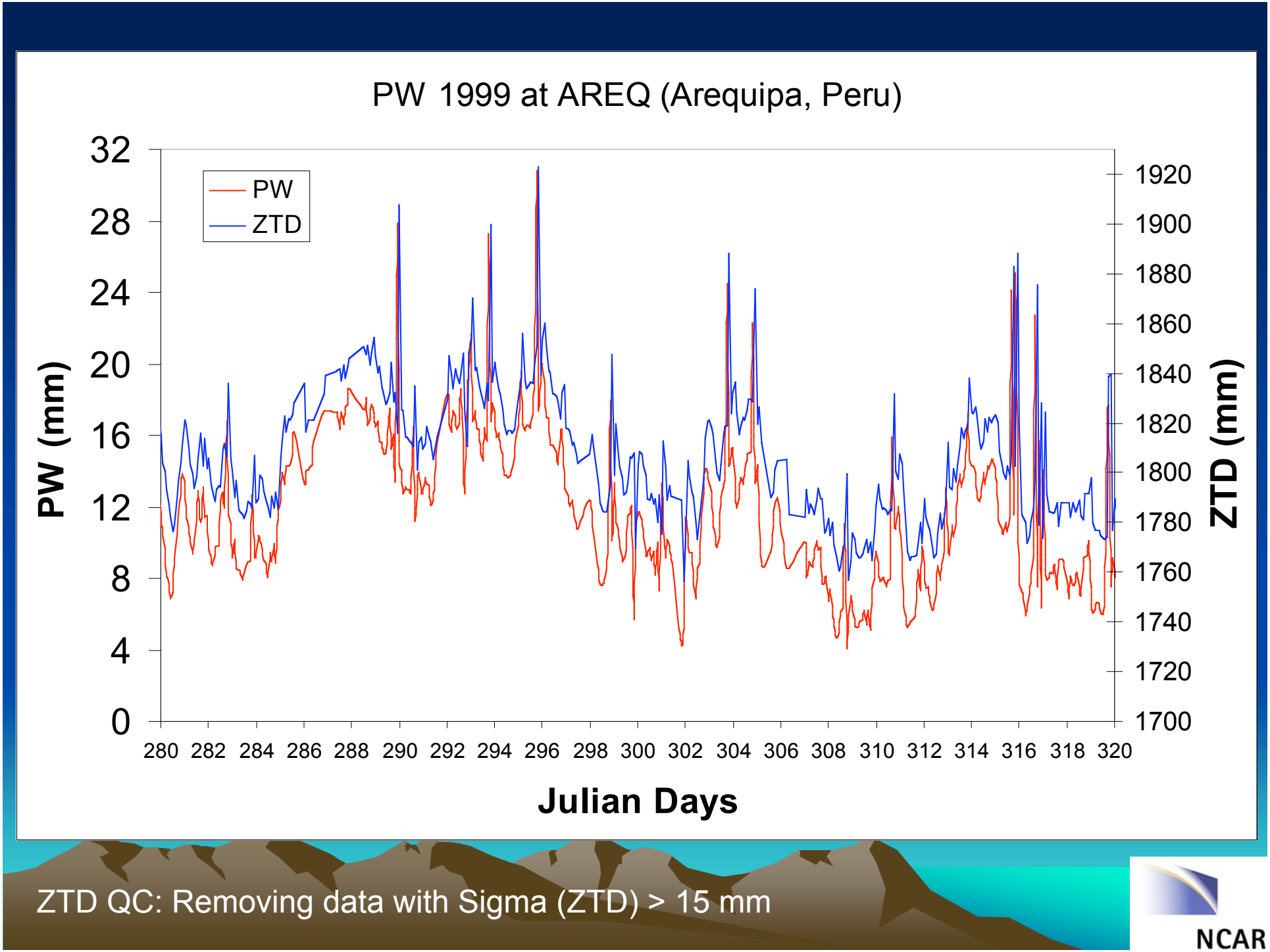

ZTD QC: Removing data with Sigma (ZTD) > 15 mm

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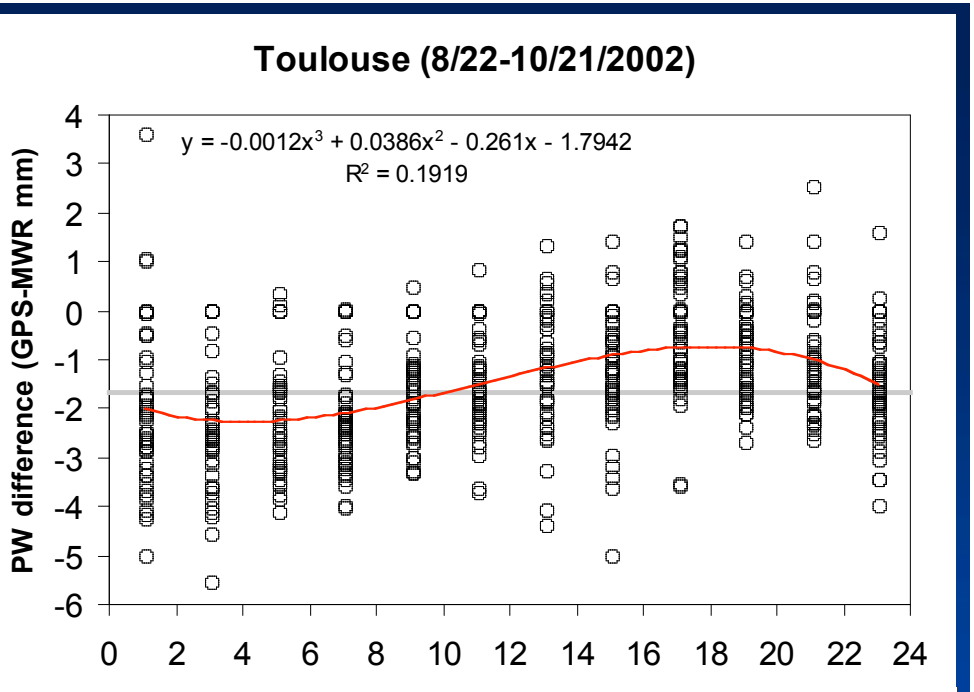
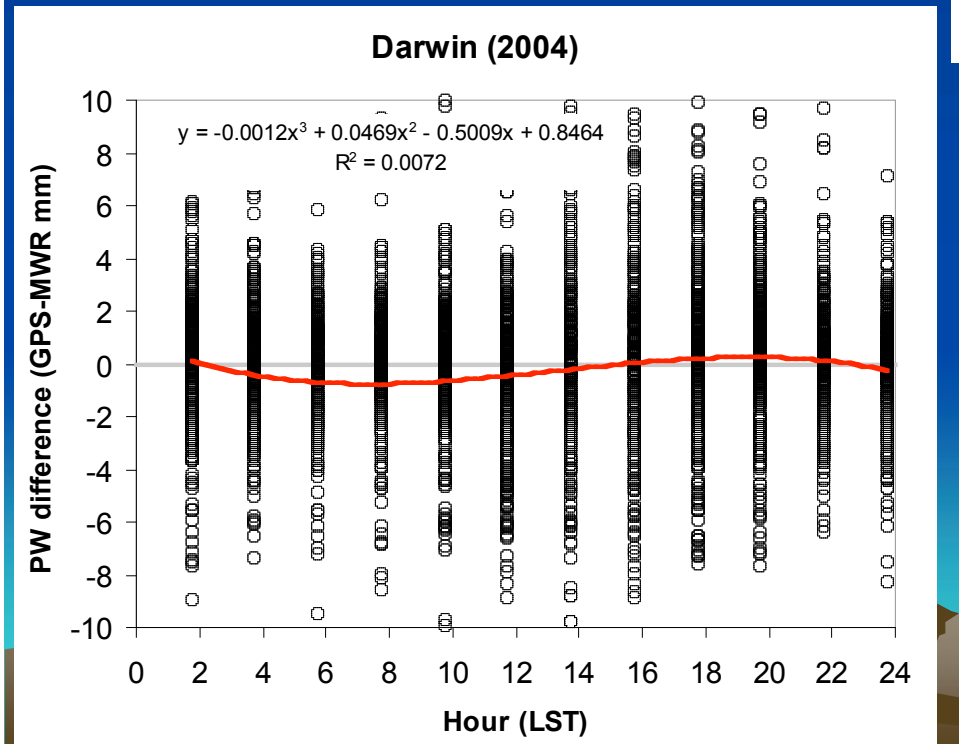
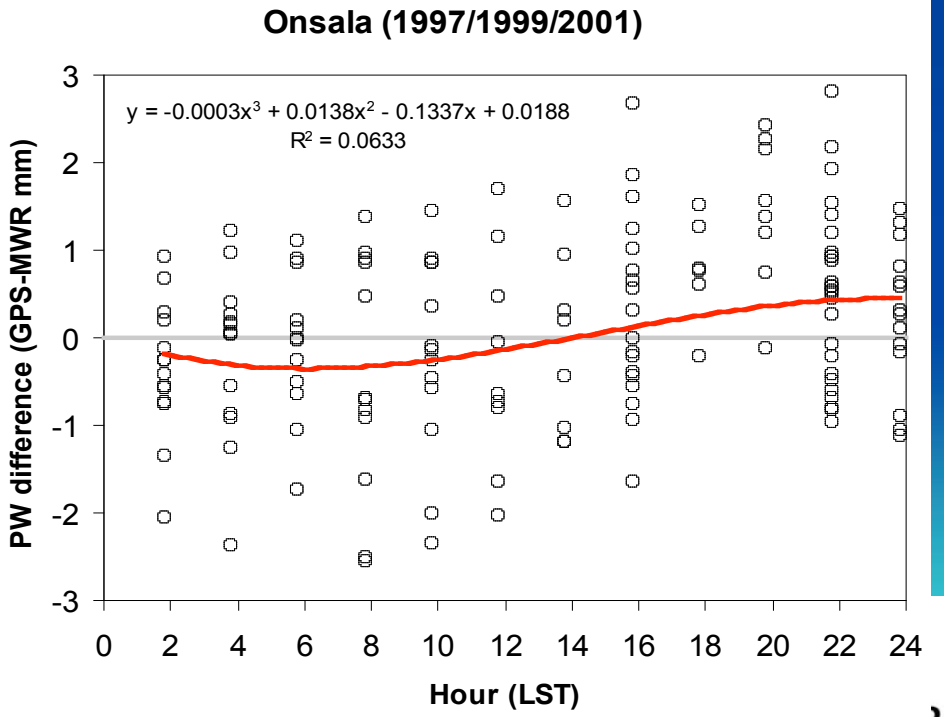
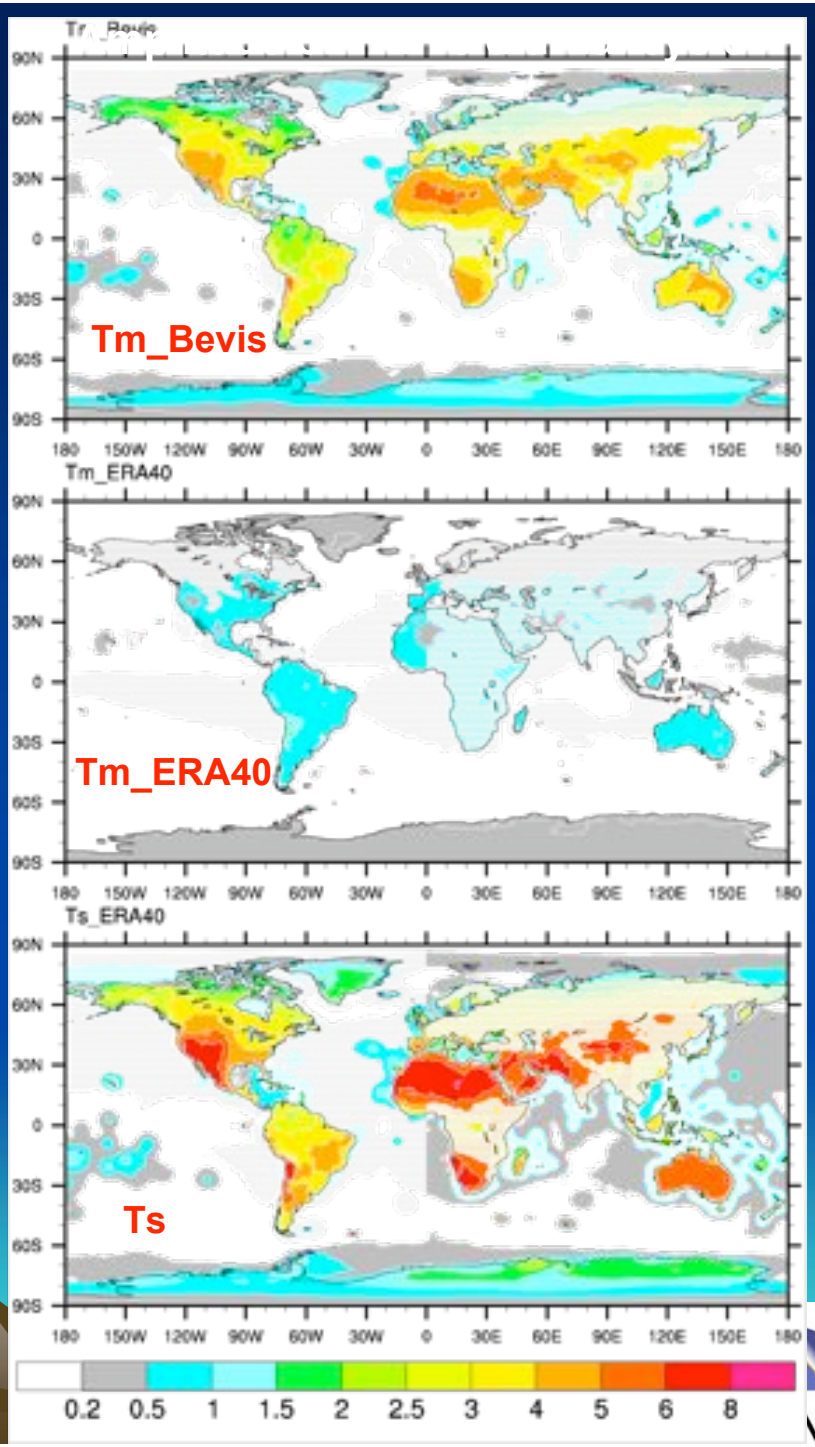
2. To reduce diurnal biases in the ZTD product







Diurnal biases in Tm_Bevis
Tm = 70.2 + 0.72*Ts



Wang et al. (2005)

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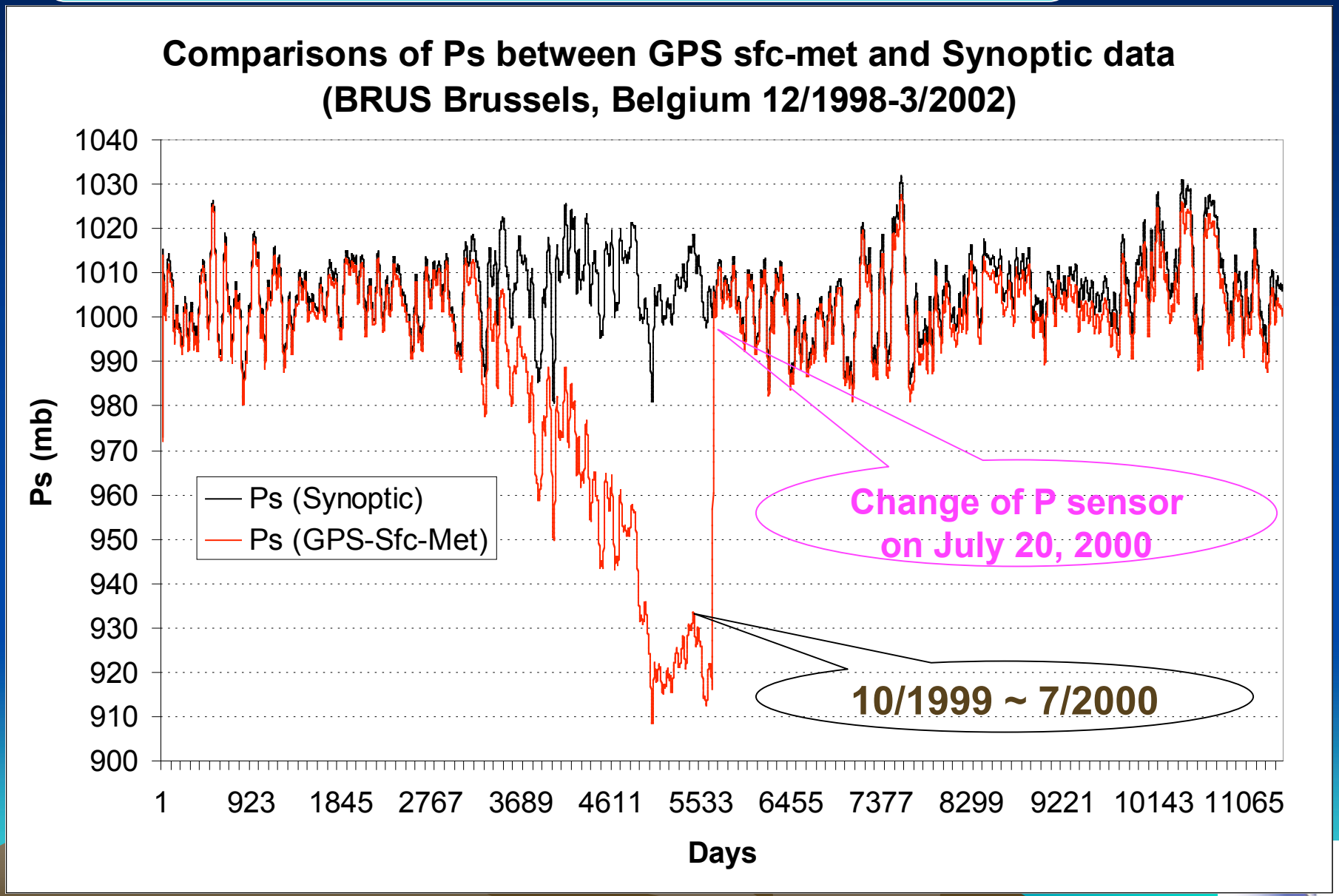
3. To improve and increase sfc-met data



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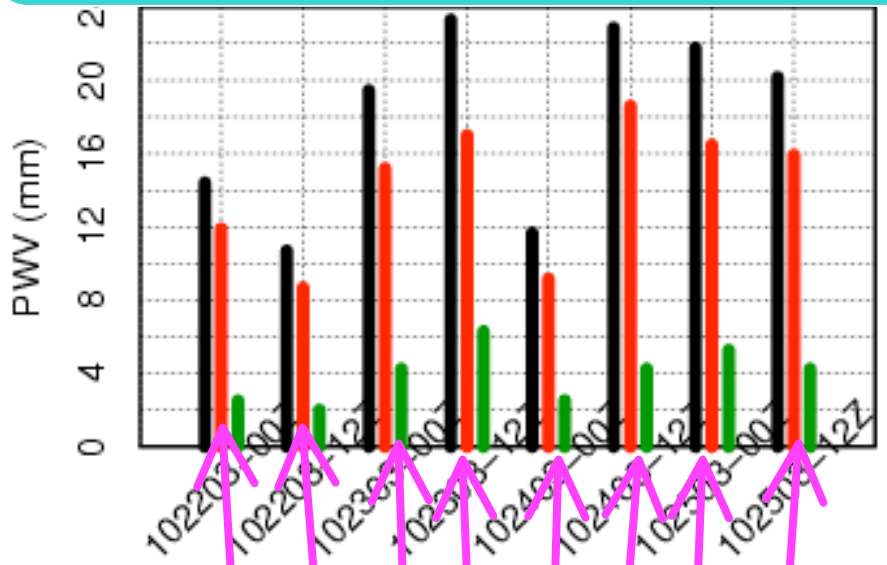
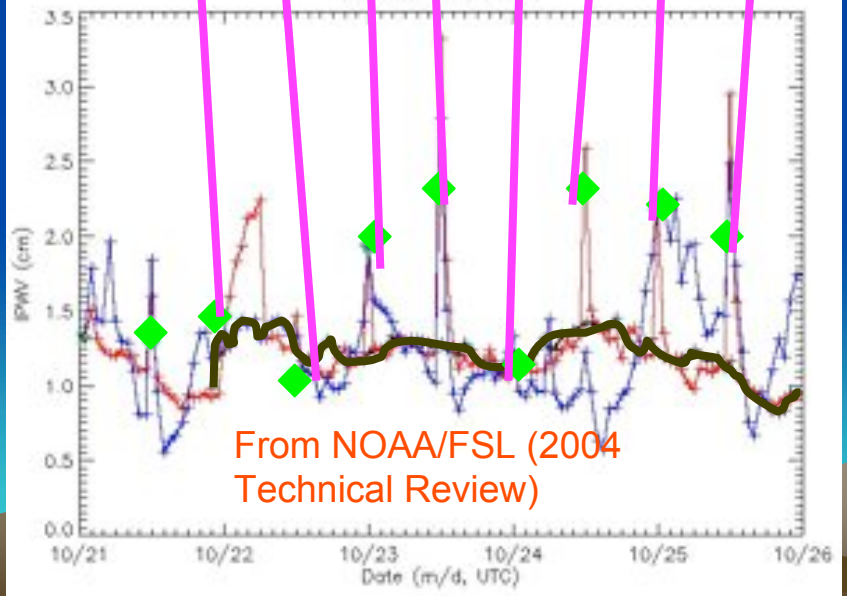
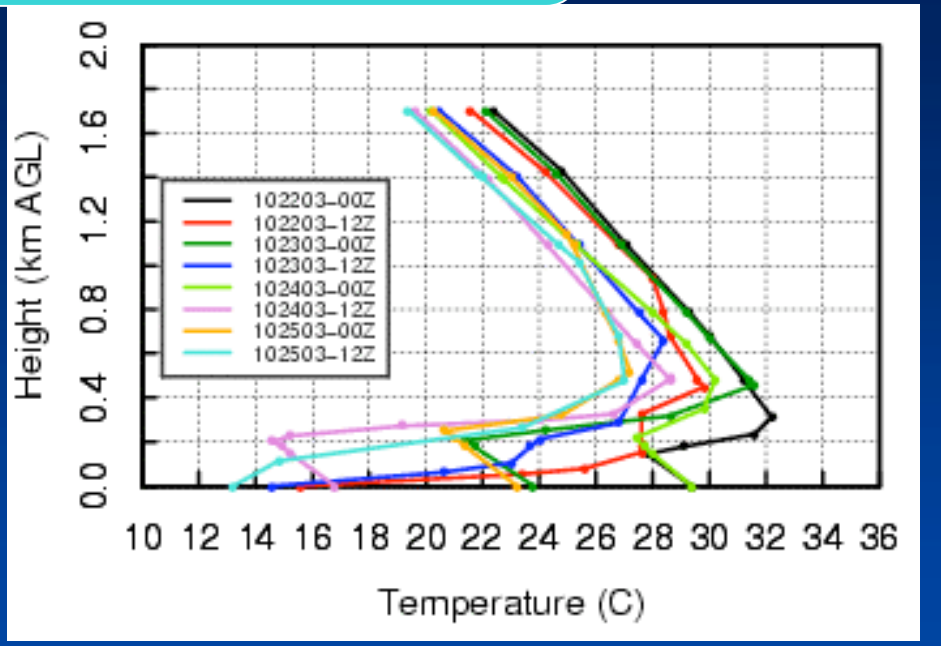
4. To co-locate with radiosonde stations

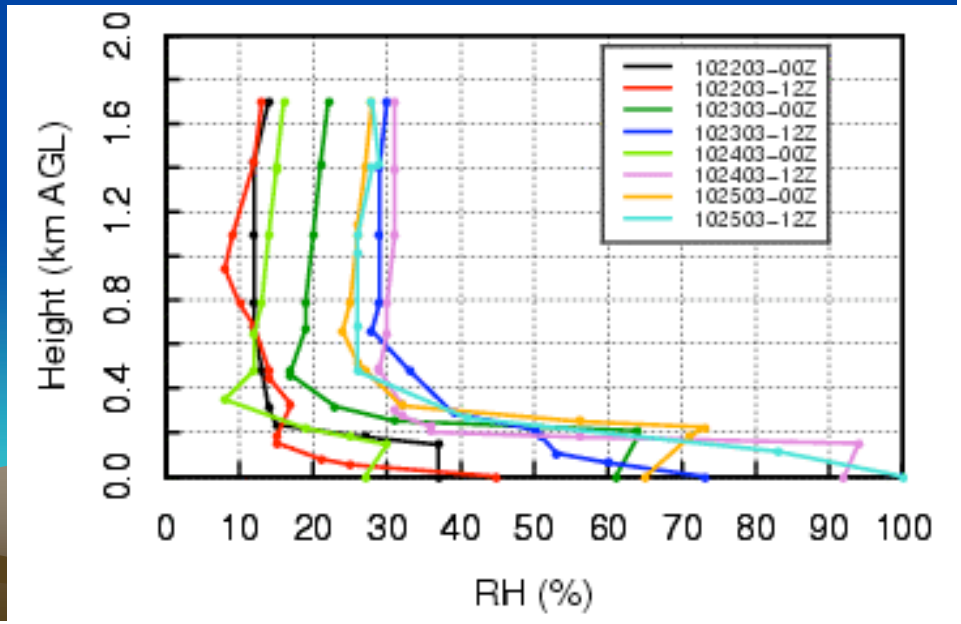


Comparisons of PW from GPS and radiosonde on Oct. 21-25, 2003 in La Jolla (9 km apart, 134/69 m elevations)



From NOAA/FSL (2004 Technical Review)

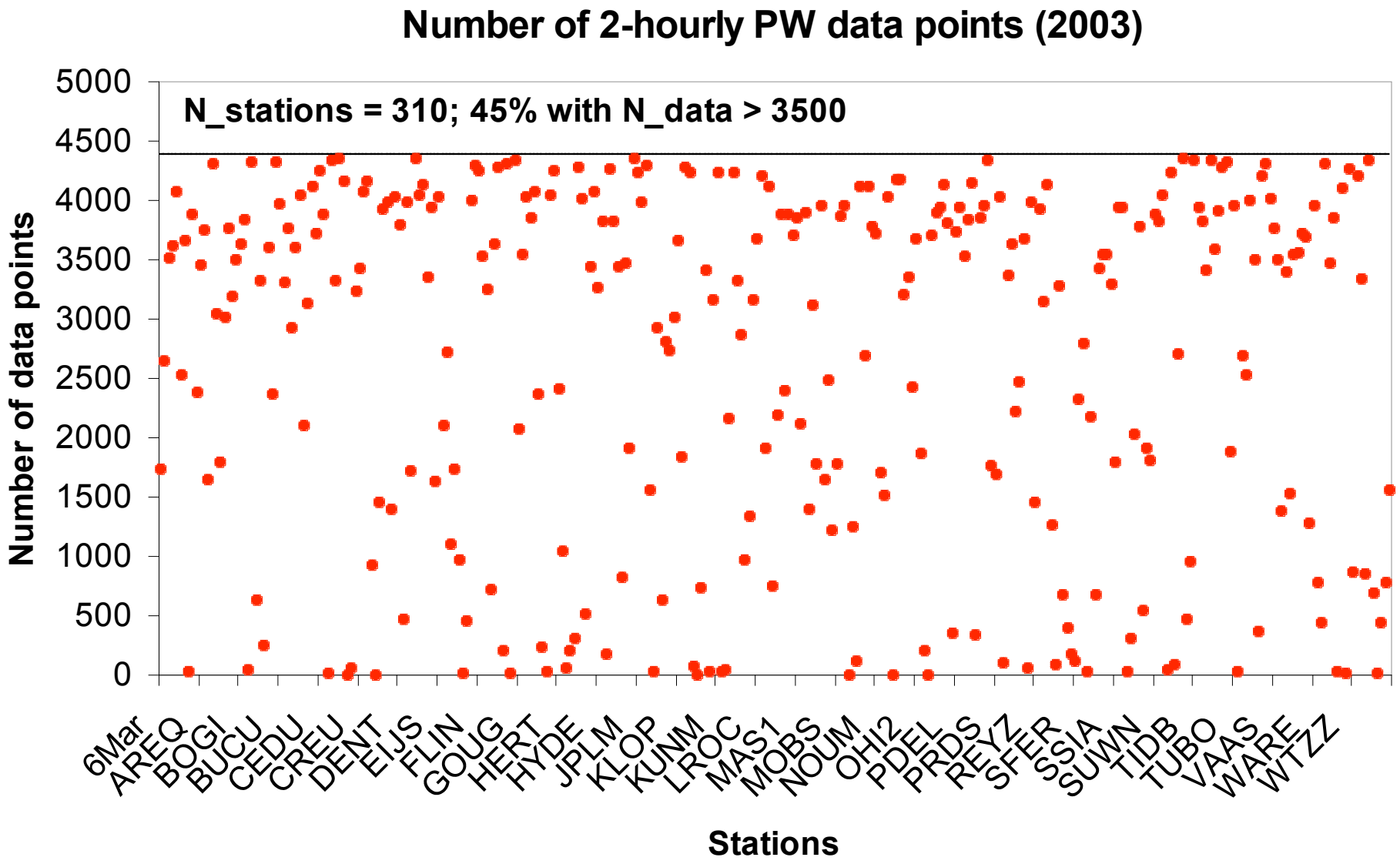




Global Upper-Air Reference Network

- Goals:
  - Provide long-term, high-quality climate records
  - Serve to constrain and calibrate data from more spatially-comprehensive global observing systems (inc. satellites)
  - Measure a larger suite of co-related climate variables than can be provided as benchmark observations
- It is initiated and led by WMO's Global Climate Observing System (GCOS) program
- It includes reference radiosonde system along with other instruments, such as GPS.
- 30-40 stations, every 2-4 days, 2/day, up to 5 mb, both ascending and descending profiles…
- Three workshops to define the network.

5. To increase the spatial and temporal coverage



6. To better document the IGS products

1. To include details on data characteristics and how they were derived
2. To maintain comprehensive meta data to document any changes in instruments, data processing and others, and to make it visible to users

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Summary

- **Dataset:** A near-global, 8-year, 2-hourly GPS-PW dataset is created using the IGS ZTD product.

- **Scientific Applications:** Two examples, "Studying water vapor diurnal variations" and "Monitoring the quality of global radiosonde humidity data", are show here. More will be seen in the future.

- **Future work:**
  1. To explore the new 5-min ZTD product and possibly switch to it.
  2. To construct a corrected global radiosonde PW dataset for climate studies using the GPS-derived PW as a reference
  3. To apply the data for more climate and weather studies.

- **Future needs:**
  1. To maintain long-term stability and high quality of the ZTD product
  2. To reduce diurnal biases in the ZTD product
  3. To improve and increase sfc-met data
  4. To co-locate with radiosonde stations
  5. To increase the spatial and temporal coverage
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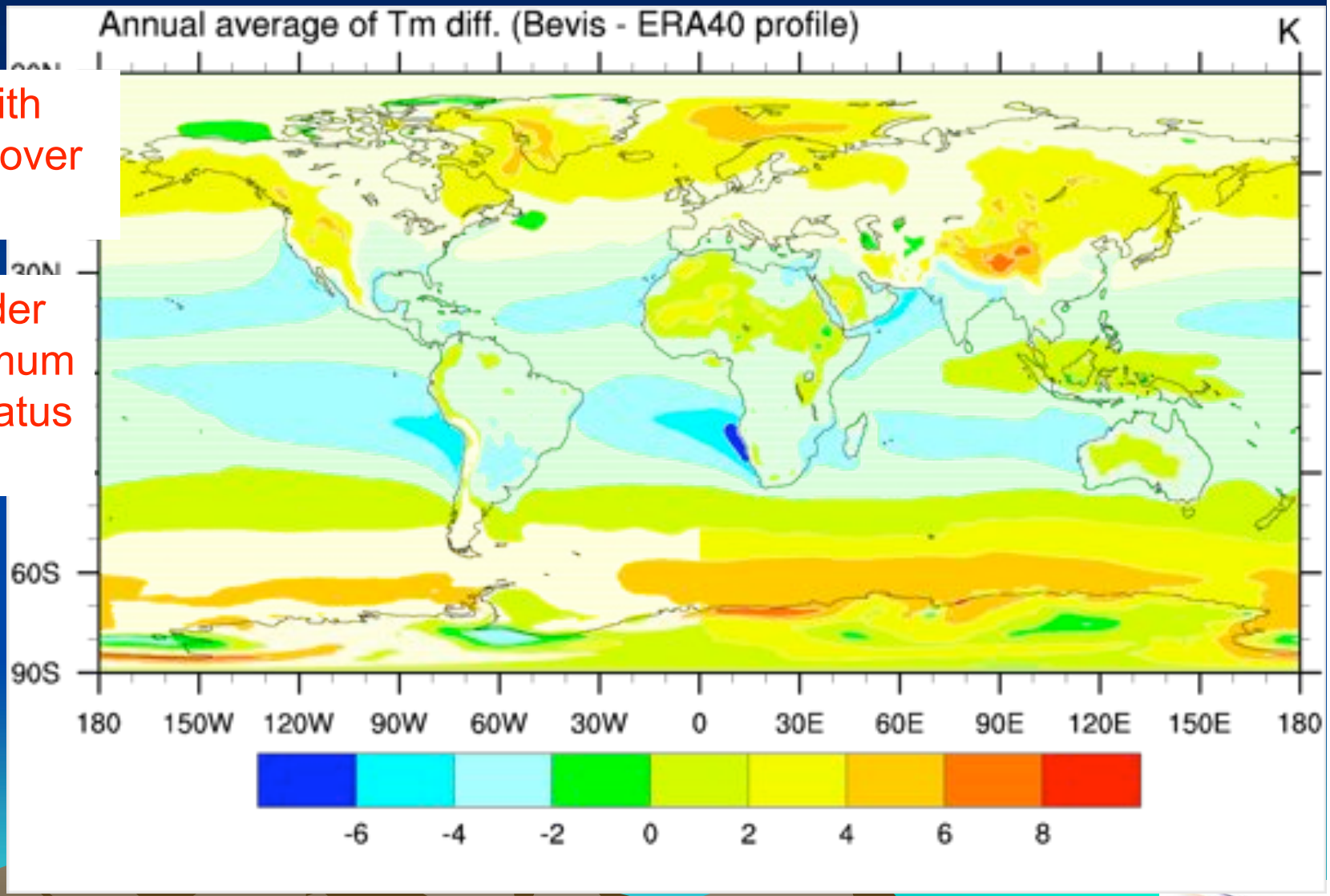
Annual mean Tm difference between Bevis and IGRA

Warmer with maximum over Mountains

~1-6K colder with maximum marine stratus regions



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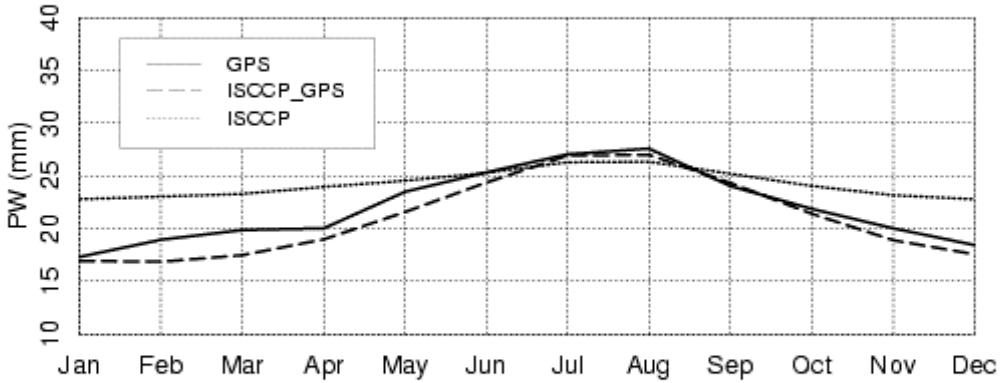
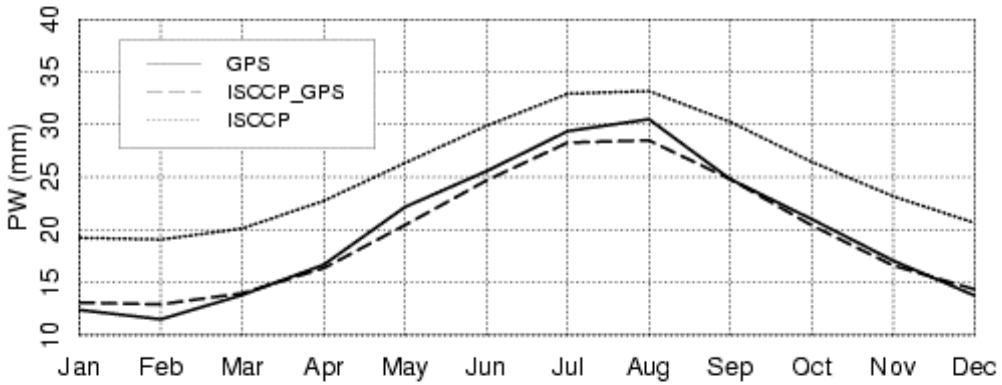
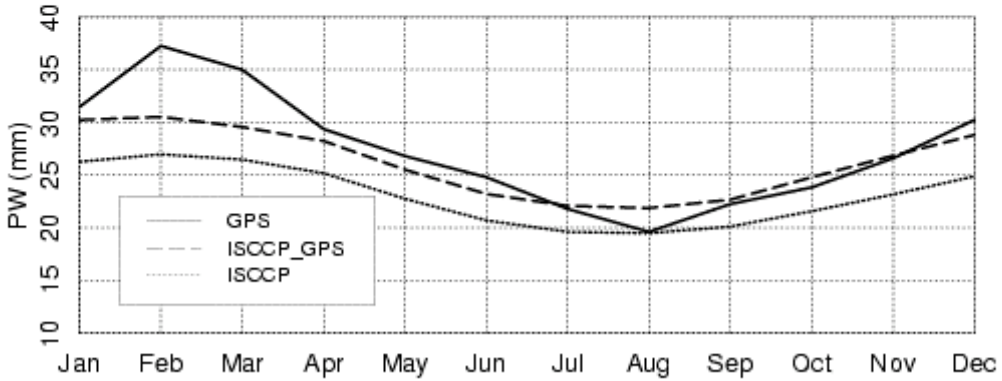
GLOBAL



Northern Hemisphere



Southern Hemisphere



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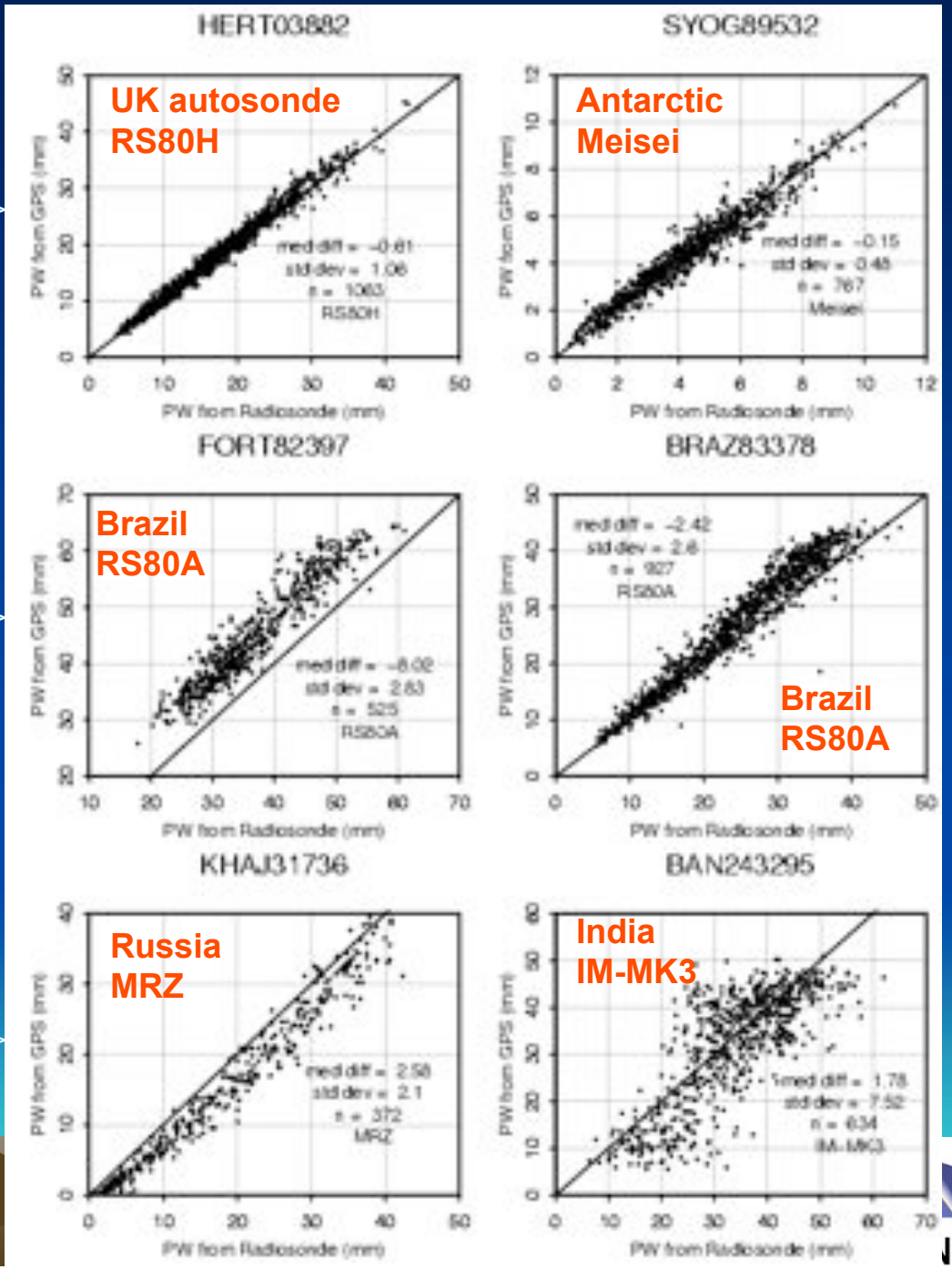
Good Agreements

Dry bias in RS80A

Moist bias
in MRZ and IM-MK3



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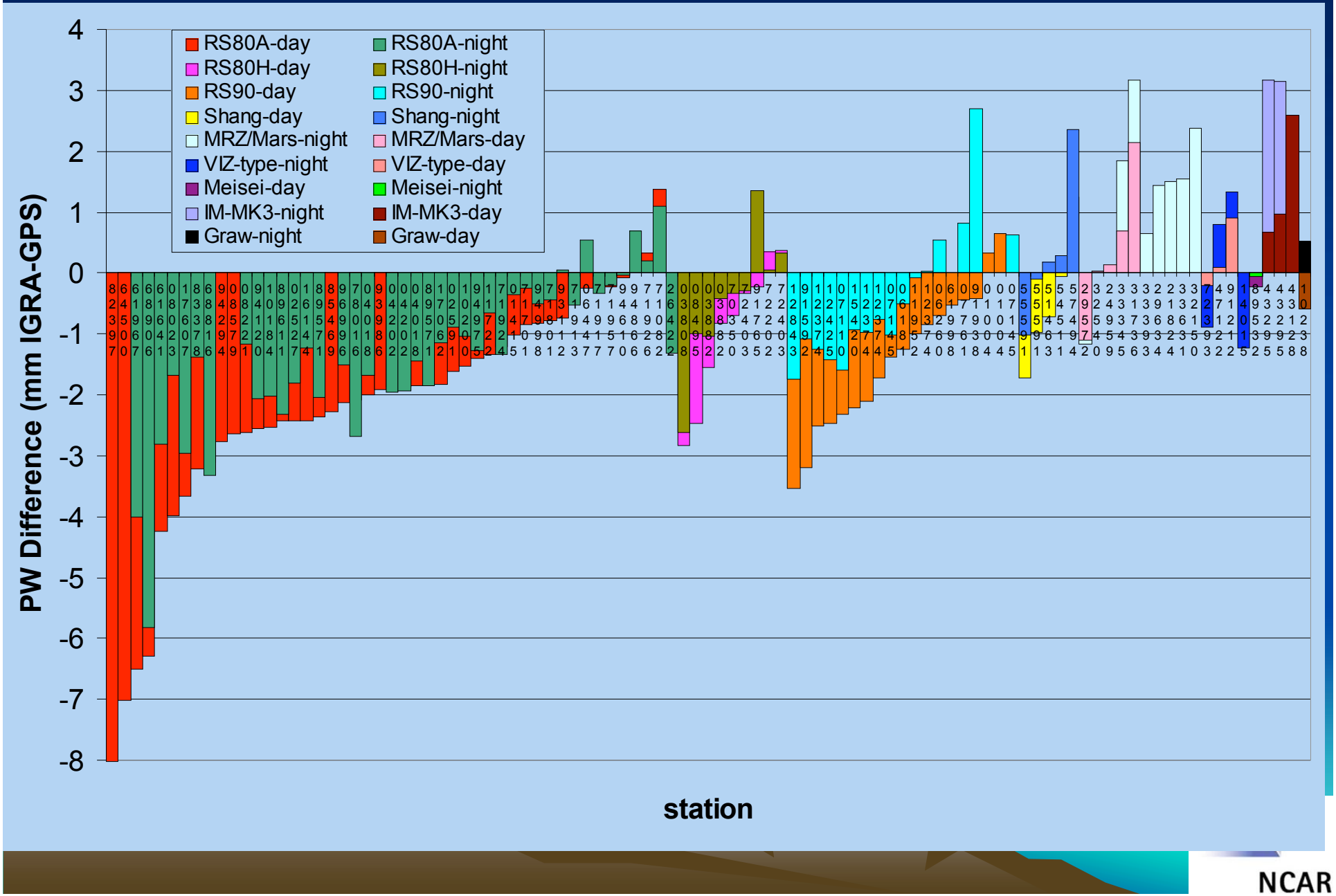
Day/Night Differences



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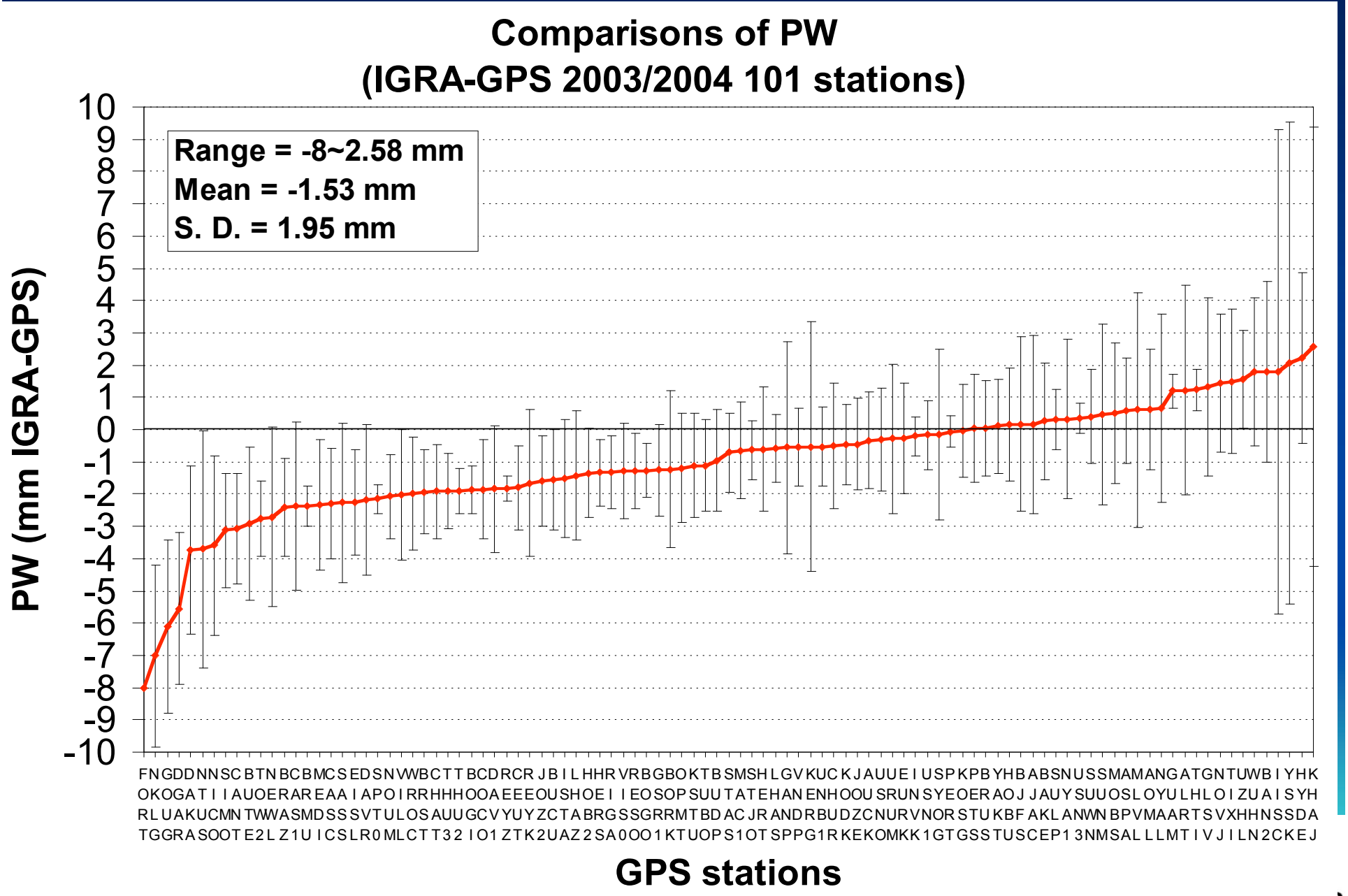
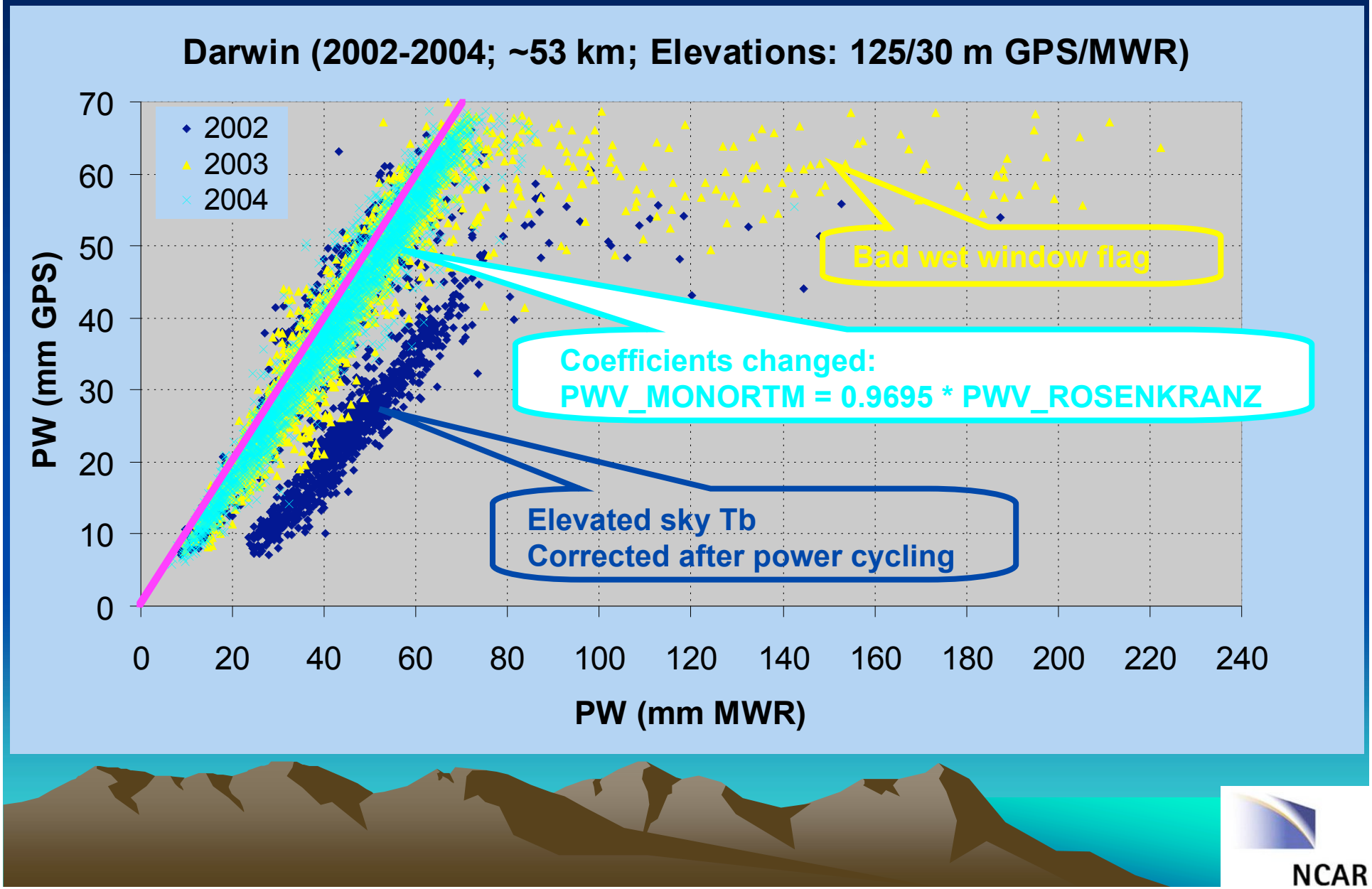
Comparisons of GPS and Integrated Global Radiosonde Archive



GPS v.s. MWR



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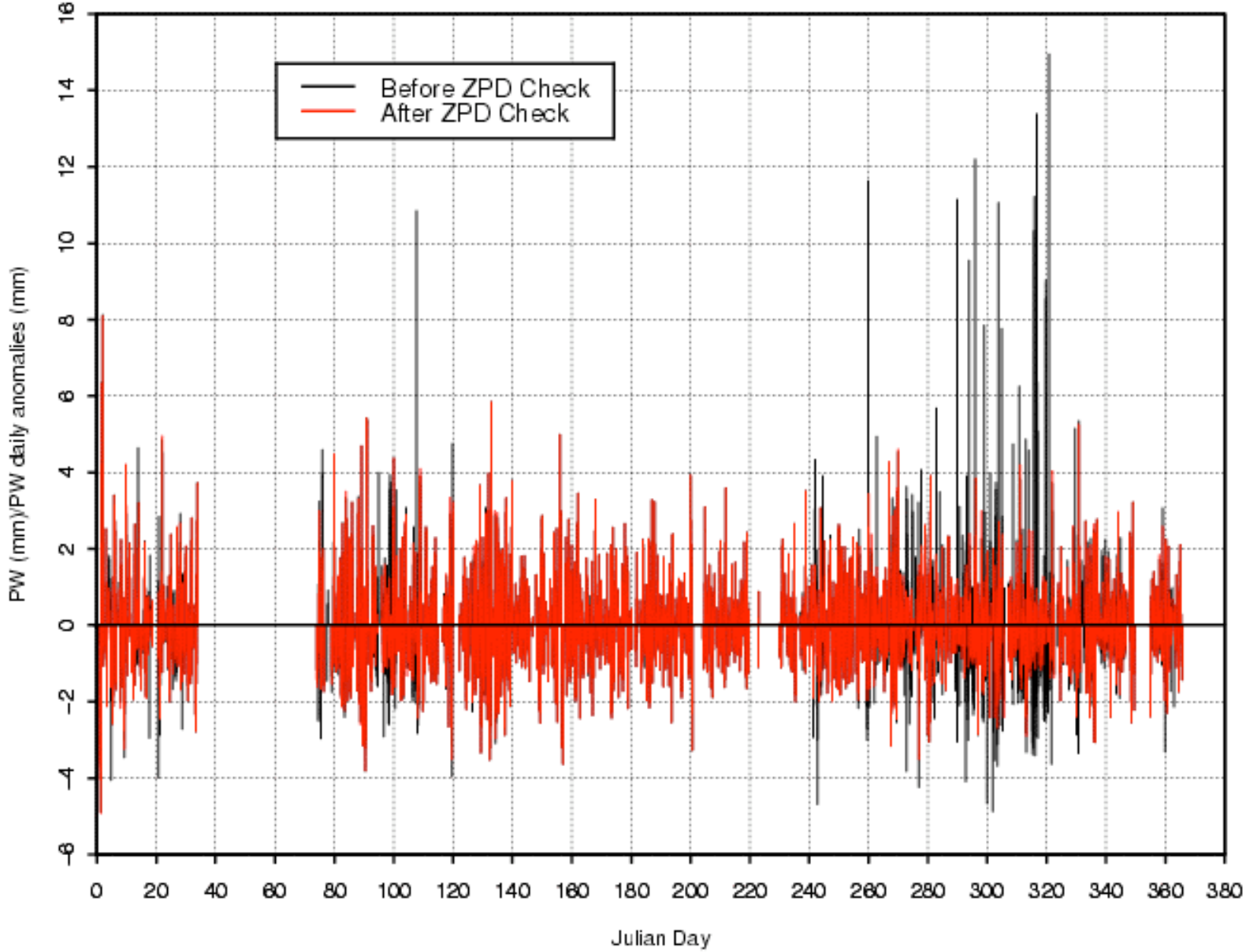
AREQ.1999
Before ZPD Check
After ZPD Check
PW (mm)/PW daily anomalies (mm)
16
14
12
10
8
6
4
2
0
-2
-4
-6
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
Julian Day

6. better document the IGS products

1. **To include details on data characteristics and how they were derived**
2. **To maintain comprehensive meta data to document any changes in instruments, data processing and others and to make it visible to users**

********** IGS Electronic Mail
31 Jan 04:51:24 PST 2000 Message Number 2691
****

The problems reported previously with the station BRUS have been resolved thanks to a receiver change : the AOA SNR-12 ACT receiver has been replaced by a ROGUE SNR-8000. Data are again available since DOY 027. The updated site log is available the IGS Central Bureau.

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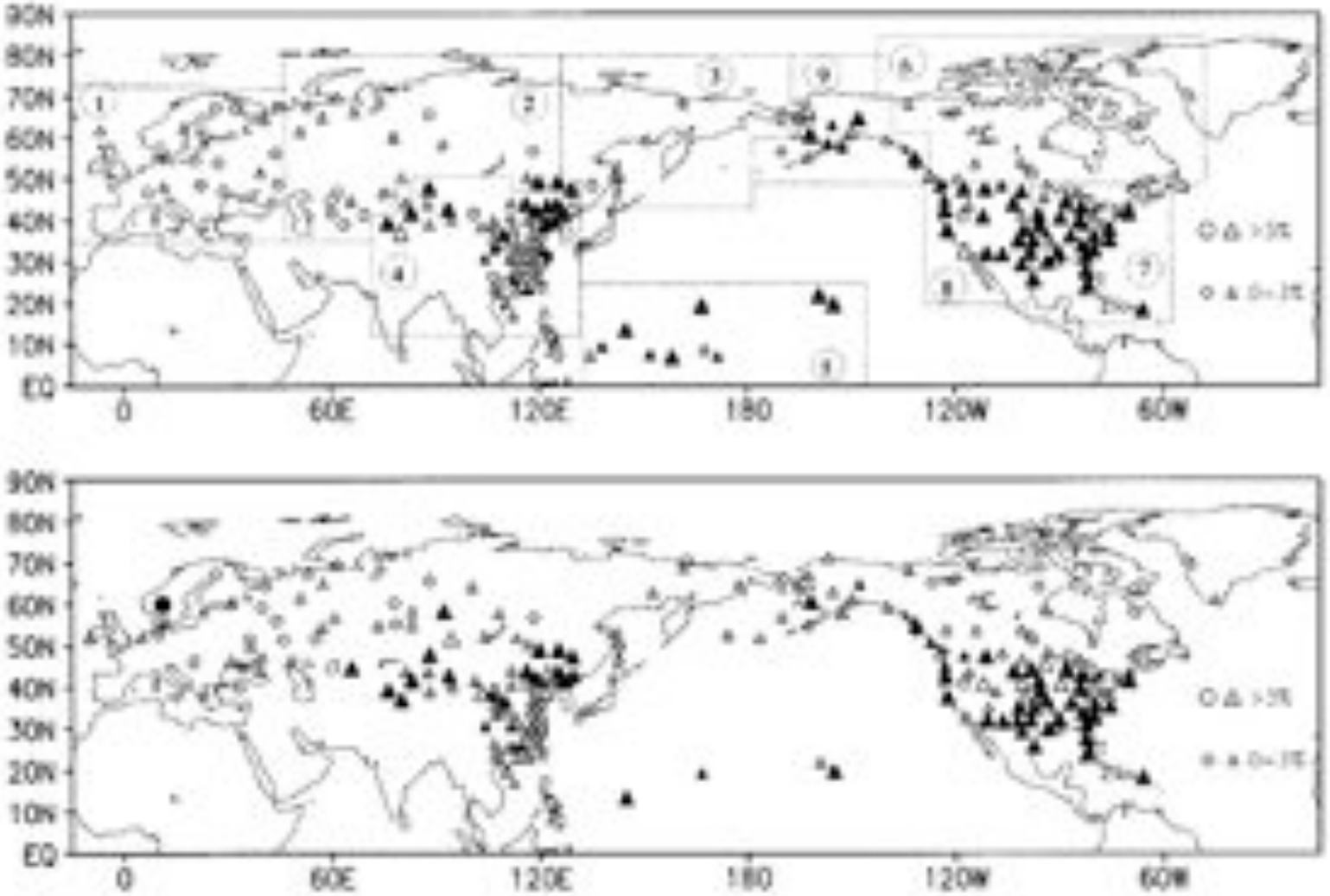

FIG. 2. Annually averaged trends in W (% decade^{-1}) at (top) 0000 and (bottom) 1200 UTC for the period of 1973–95. Positive trends are indicated by triangles and negative trends by circles. Filled symbols indicate the trends were statistically significant at the 5% level according to the Spearman test. The small symbols indicate trend magnitudes of 0%–3% and the large symbols denote trend magnitudes greater than 3%. The numbered regions delineated in the top panel are used in Table 2 and Figs. 5 and 7.

Ross and Elliott (2001)

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