Monitoring the quality of global radiosonde humidity data using ground-based GPS measurements

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GOALS

1) To develop an analysis technique for deriving a global, 2-hourly data set of atmospheric precipitable water (PW) using existing ground-based GPS measurements of zenith path delay (ZPD),

2) To use GPS PW data to monitor the quality of global radiosonde humidity data and estimate the diurnal sampling errors in twice-daily radiosonde humidity.

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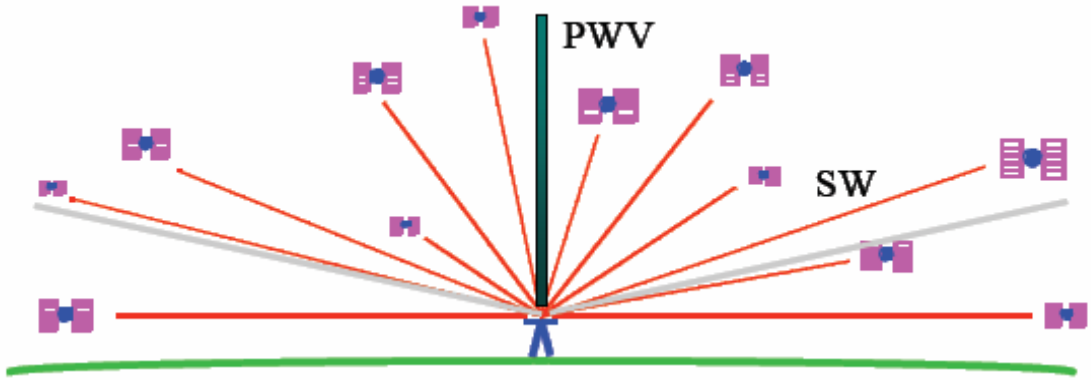
How does it work and Why using GPS data?



Total delay = Ionosphere + dry + wet

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

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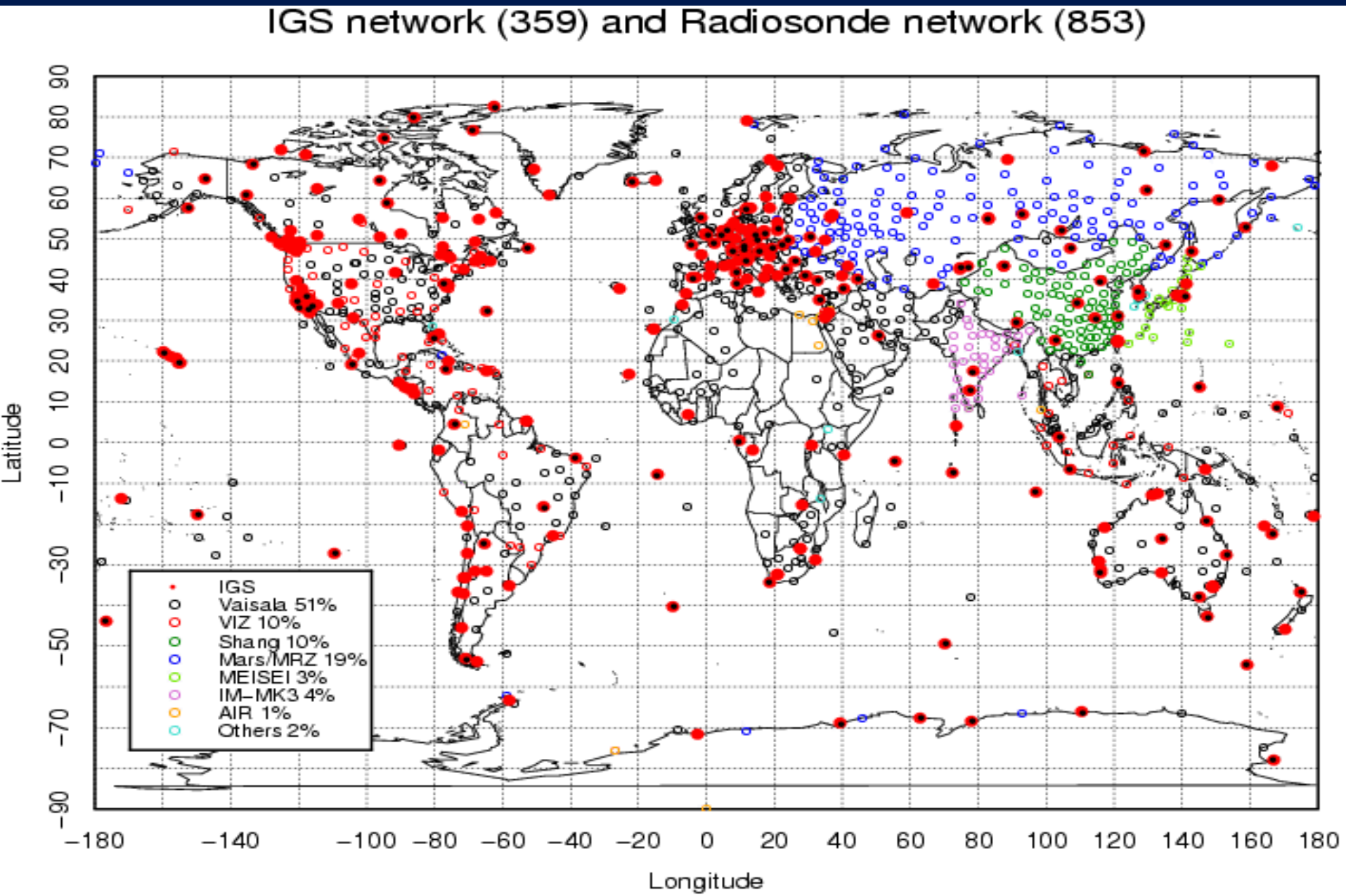
DATA: Global ZPD data: ~359 stations, 1997-present, 2-hourly



ANALYSIS TECHNIQUE AND VALIDATION

Input:
ZPD = ZHD + ZWD

P_s from GPS surface-met data

P_s from global surface synoptic observations with adjustment

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

ZWD = ZPD - ZHD

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

Tm from ERA-40 with horizontal and vertical interpolation

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

Output:
PW = Π * ZWD
Π = f (Tm)

Comparisons with radiosonde, MWR and others from field experiments for validations

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"Global Estimates of Water-Vapor-Weighted Mean Temperature of the Atmosphere for GPS Applications" (Wang et al. 2005)

1. **Radiosonde data:** The Integrated Global Radiosonde Archive (IGRA) from NCDC, 1938 to present.
2. **ERA-40:** ~1.125°X1.125° (TL 159), 60 vertical levels, 6-hourly, 1957-2002.
3. **NCEP/NCAR reanalysis (NNR):** ~1.875°X1.875° (T62), 28 vertical levels, 6 hourly, 1948-present.
4. **Bevis Tm-Ts relationship:** Tm = 70.2 + 0.72*Ts

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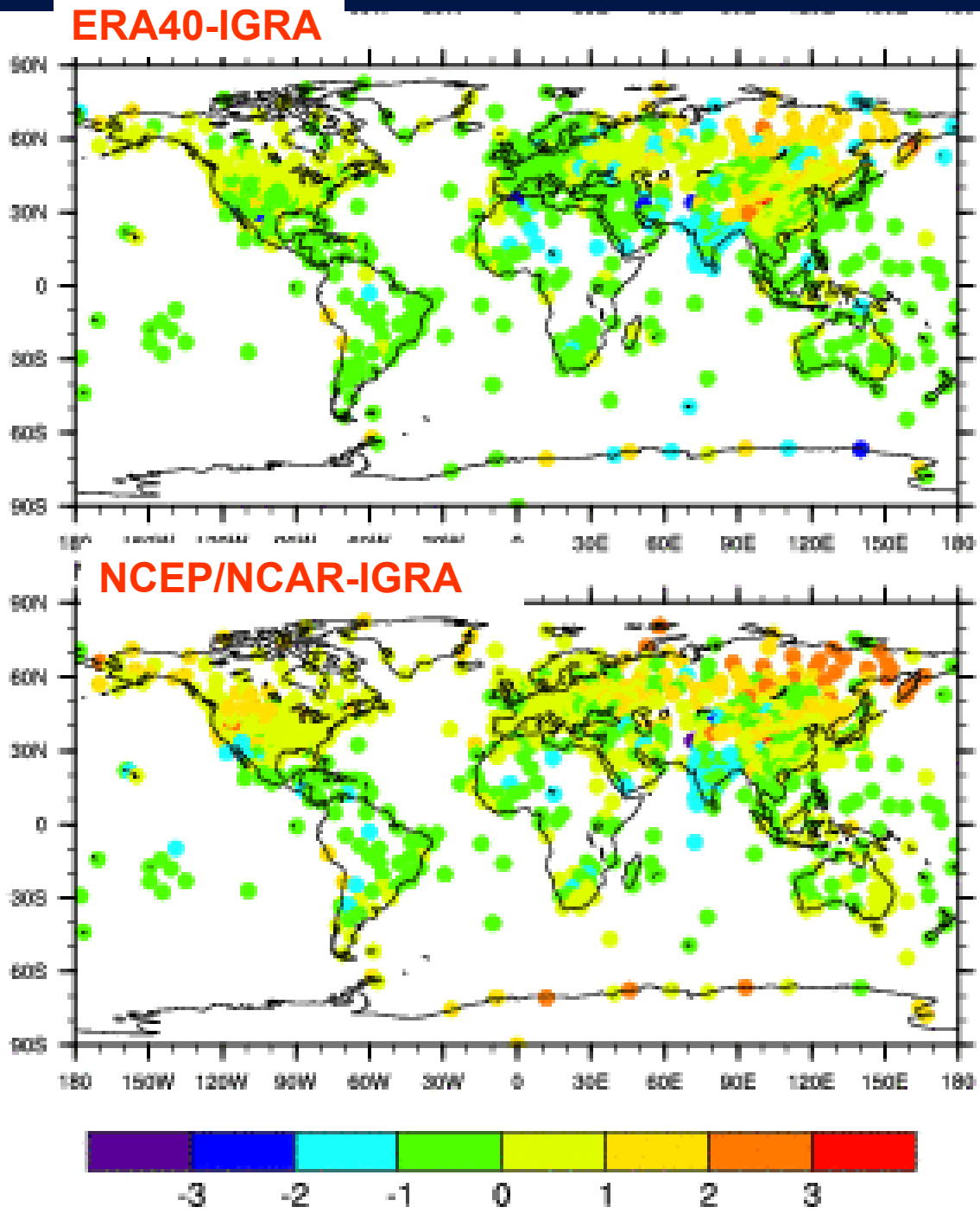
Annual mean Tm difference between reanalysis and IGRA

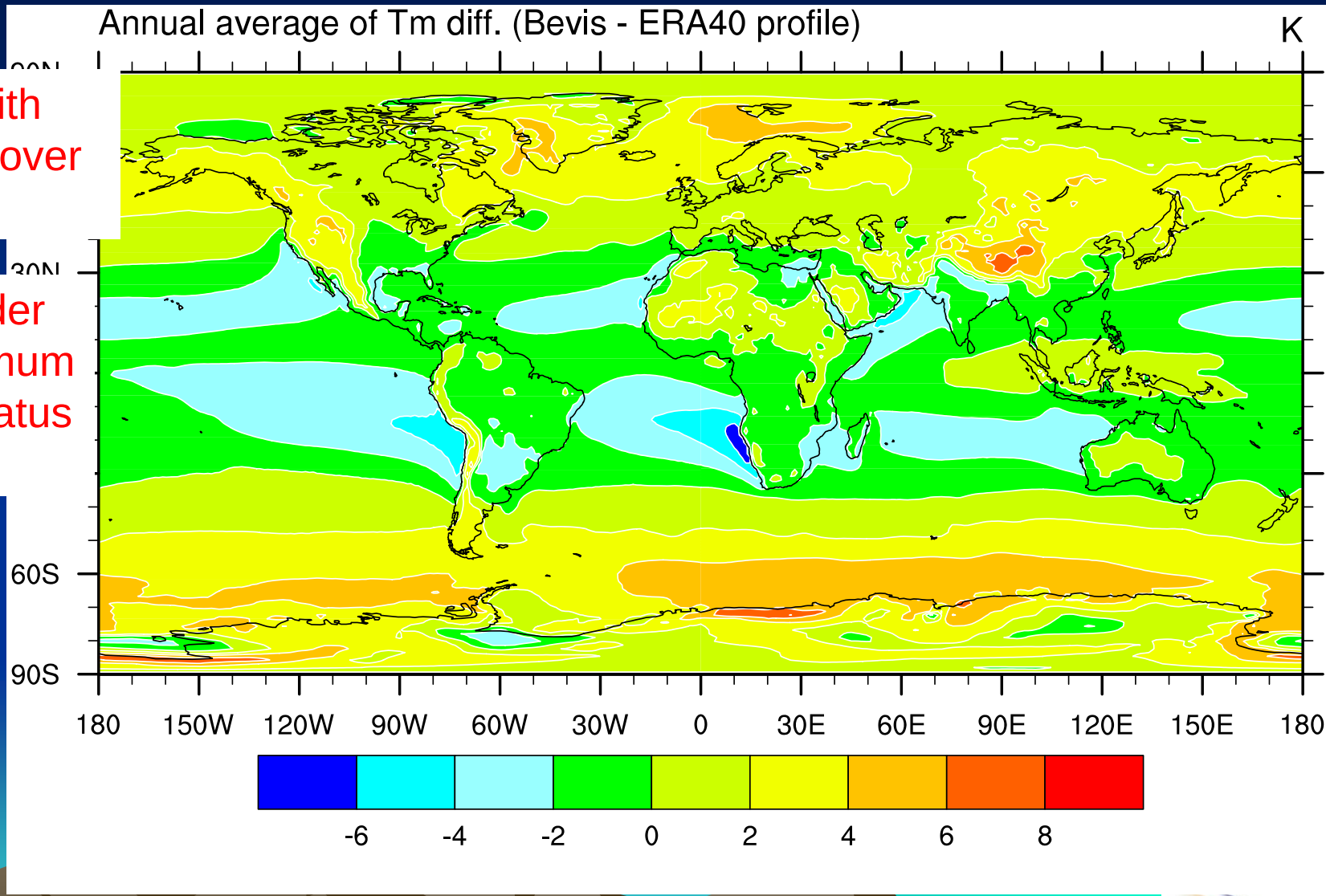
- **10% and 16% of stations with |ΔTm| < 2K for ERA-40 and NNR**
- **ERA40 better than NNR**
- **ERA40: a better option for global estimate of Tm**



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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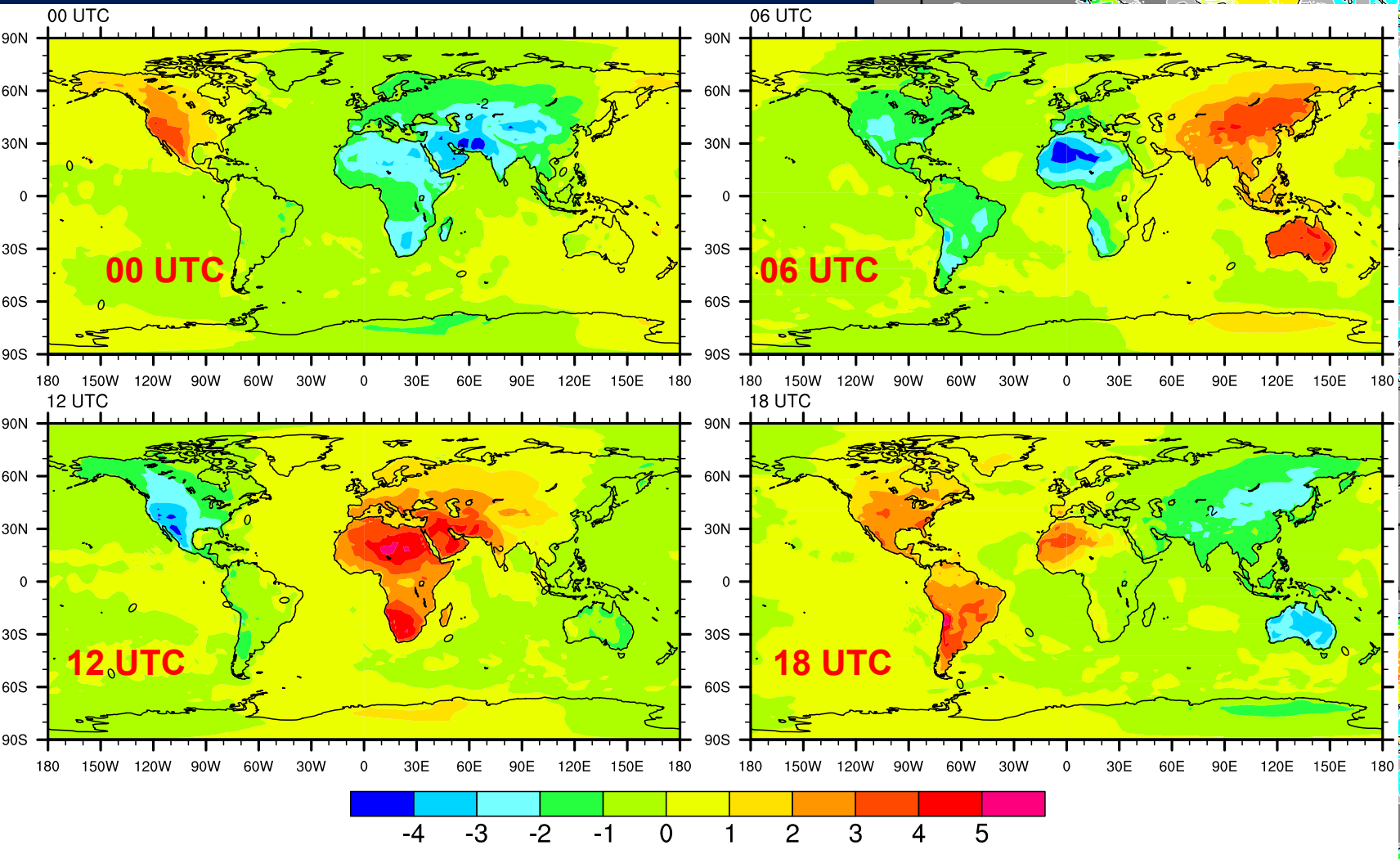
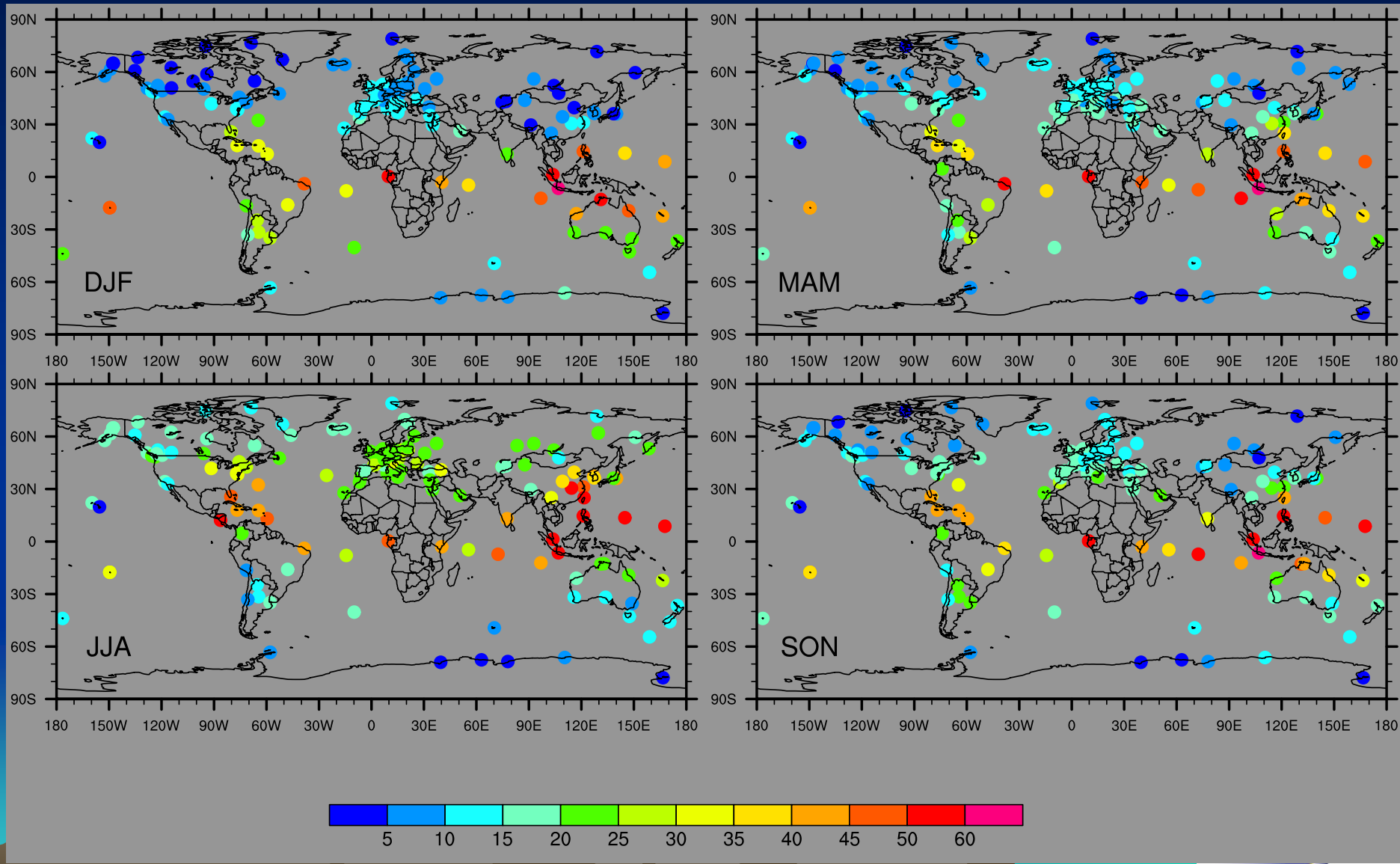
Diurnal biases in Tm_Bevis
Tm = 70.2 + 0.72*Ts



Six-year (1997-2002) seasonal mean of PW (mm)



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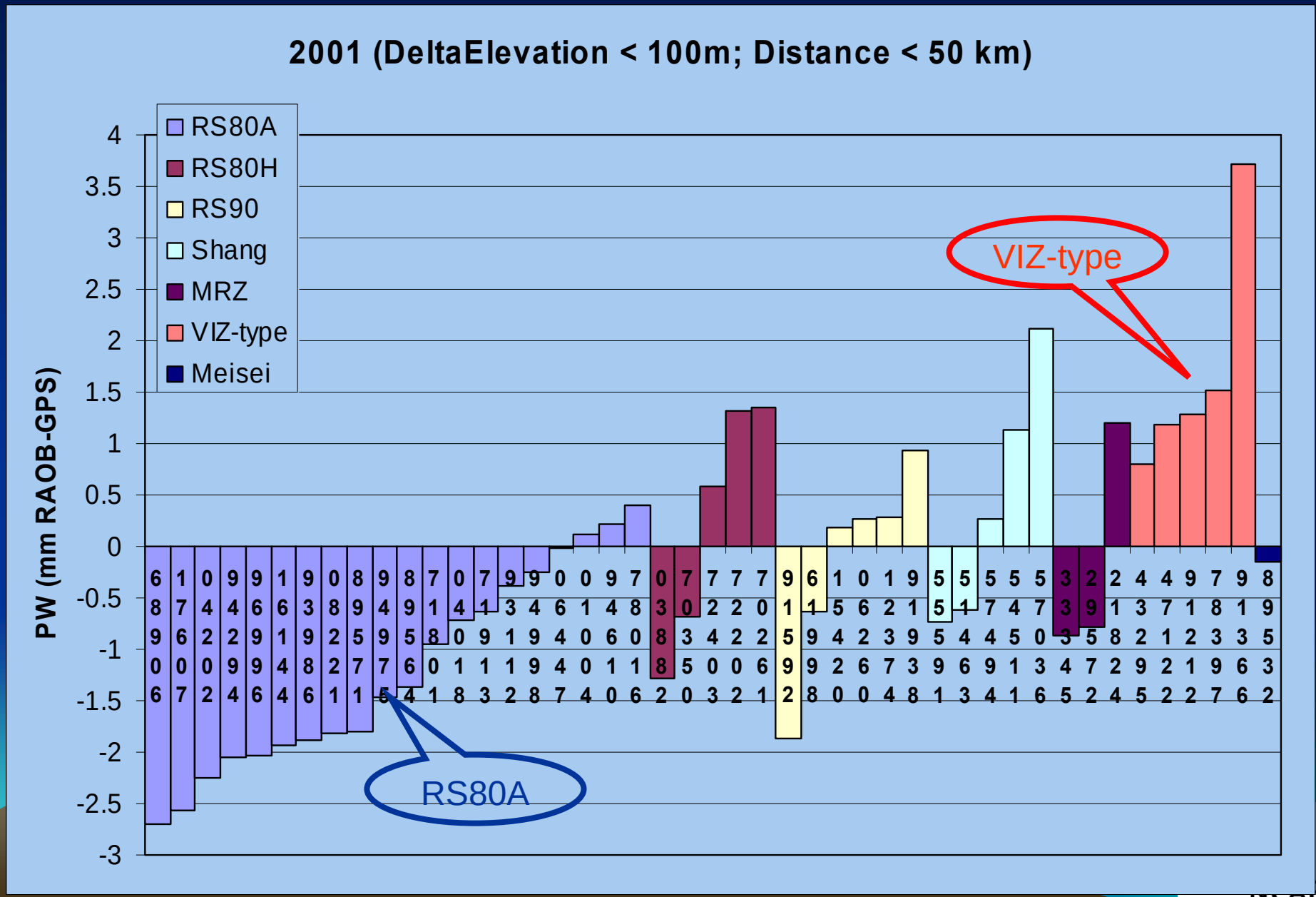
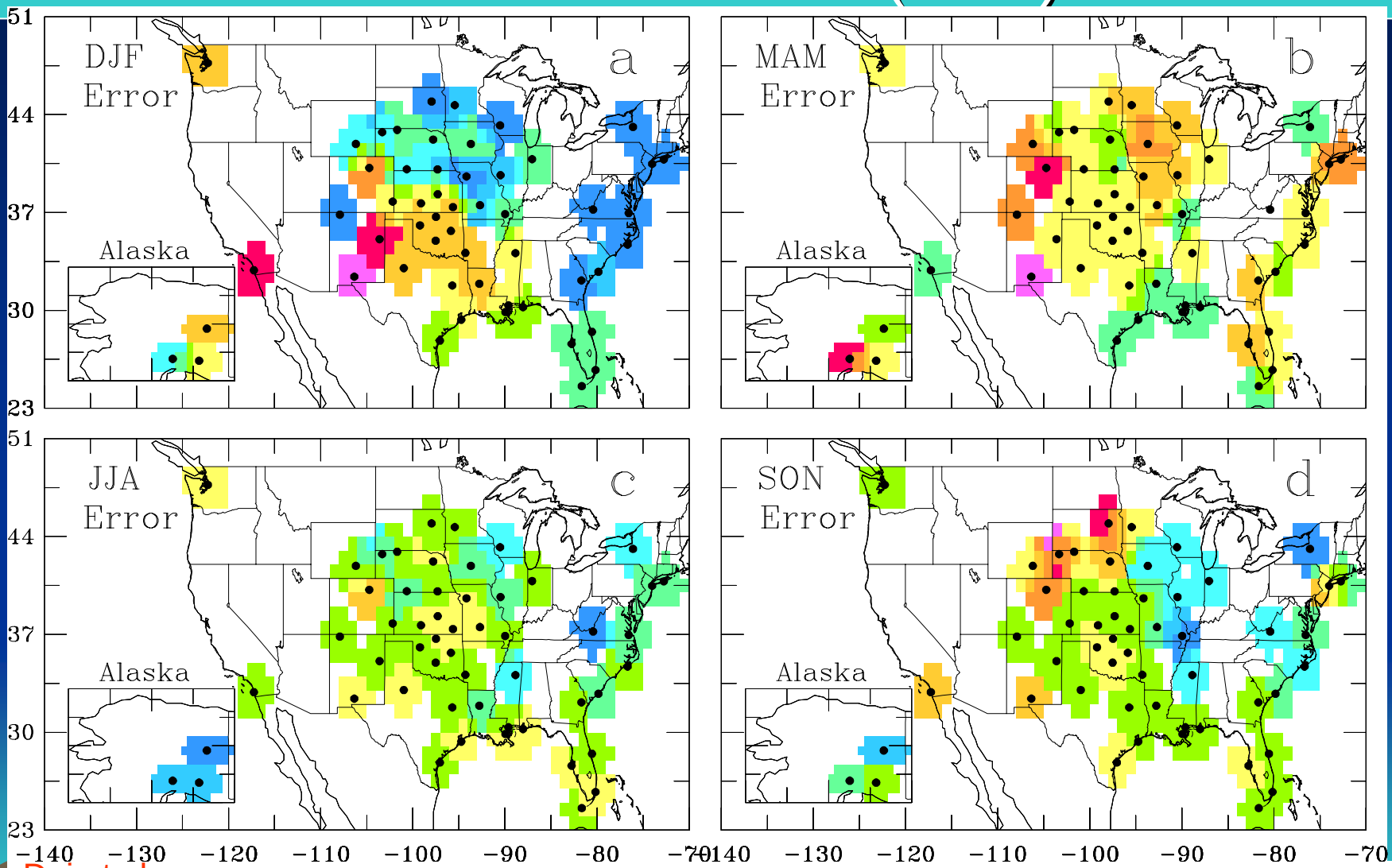
Monitoring of the “health” of global radiosonde humidity data



Diurnal PW sampling errors in twice-daily radiosonde data (U.S.)



Dai et al. (2002)

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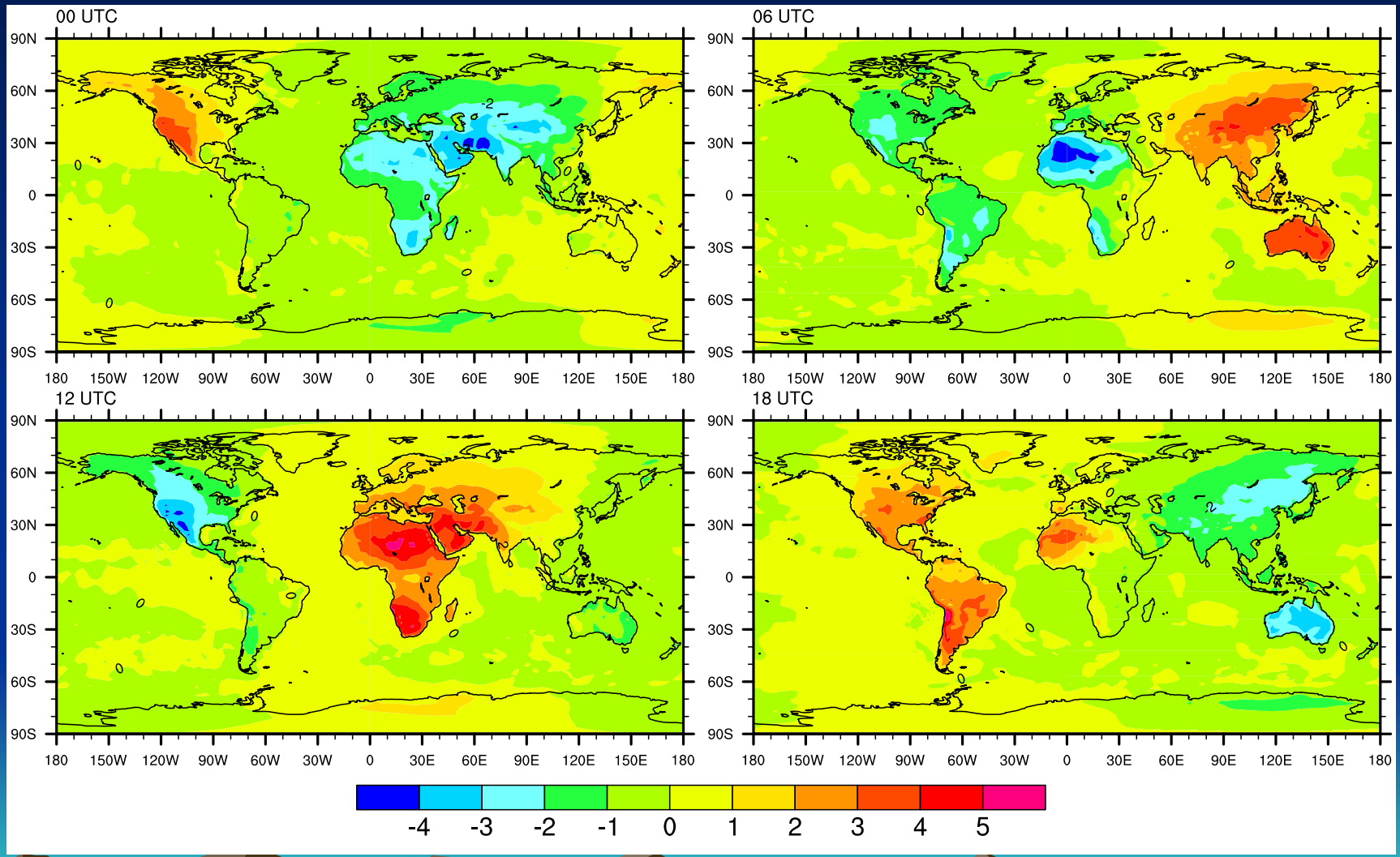
CONCLUSIONS AND FUTURE WORK

1) An analysis technique is developed to create a global, 2-hourly PW dataset. The technique needs to be validated and improved if necessary.
2) Preliminary analysis of PW differences between GPS and radiosonde data at 45 stations around the globe shows dry biases at most of Vaisala stations, but moist biases at all stations using carbon hygristor. This type of comparisons will be done to multi-year data, and more analyses are needed.
3) Errors in seasonal mean humidity due to under-sampling the diurnal cycle with twice-daily synoptic sounding are small (within ±2%) over the globe. More careful and detailed analyses will be done to quantify the error and its spatial and temporal distributions. The sampling error of once-daily sounding will be also estimated.

Diurnal biases in Bevis Tm



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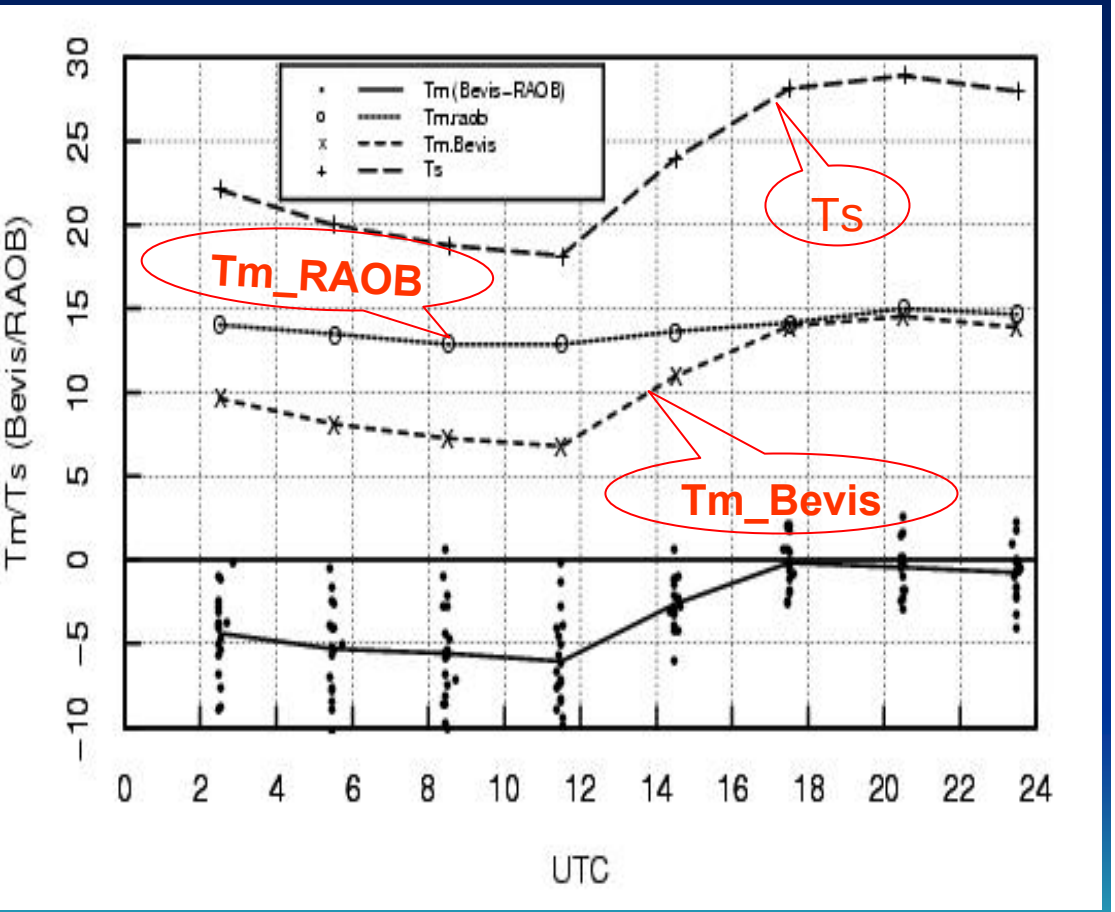
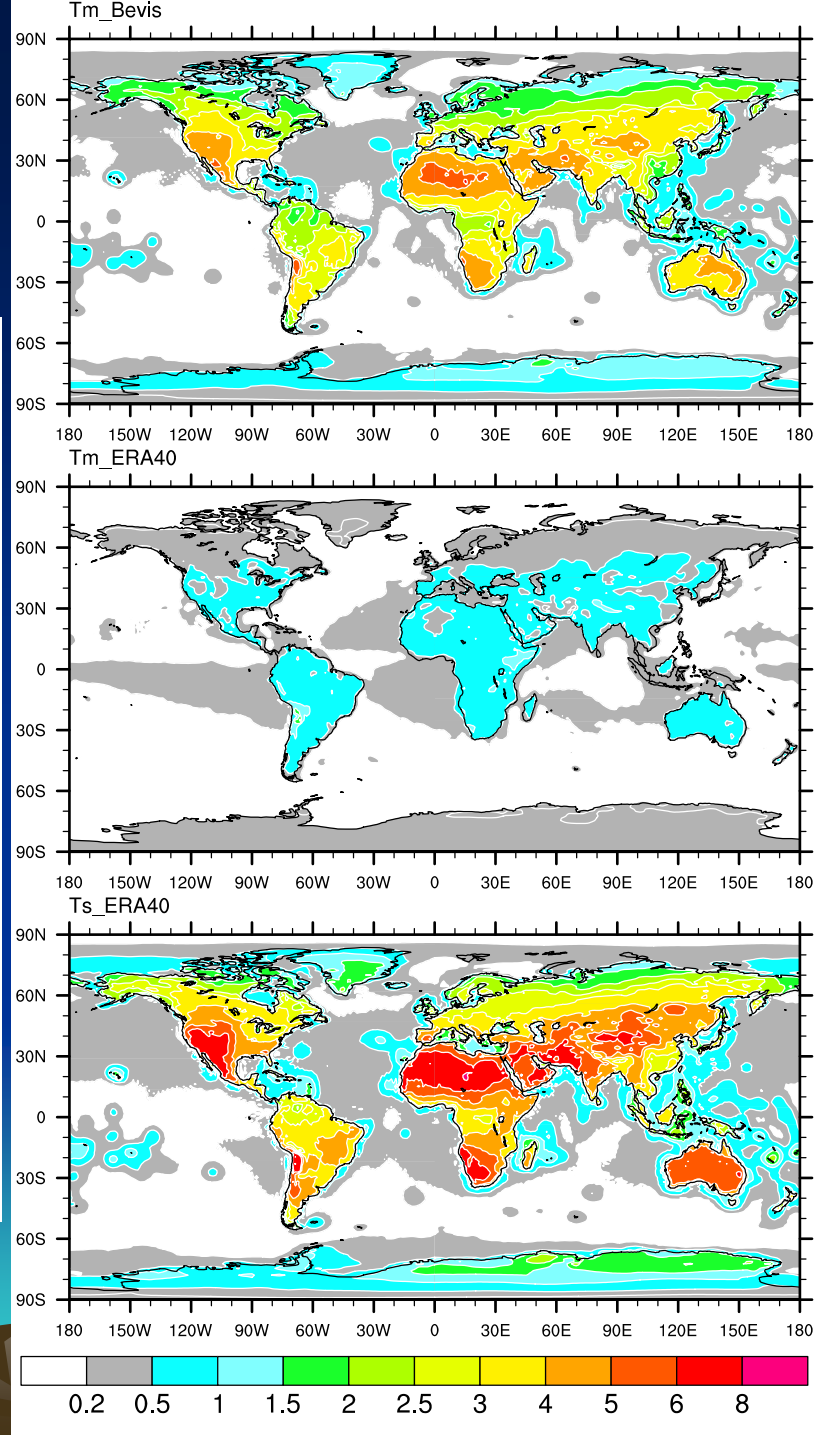
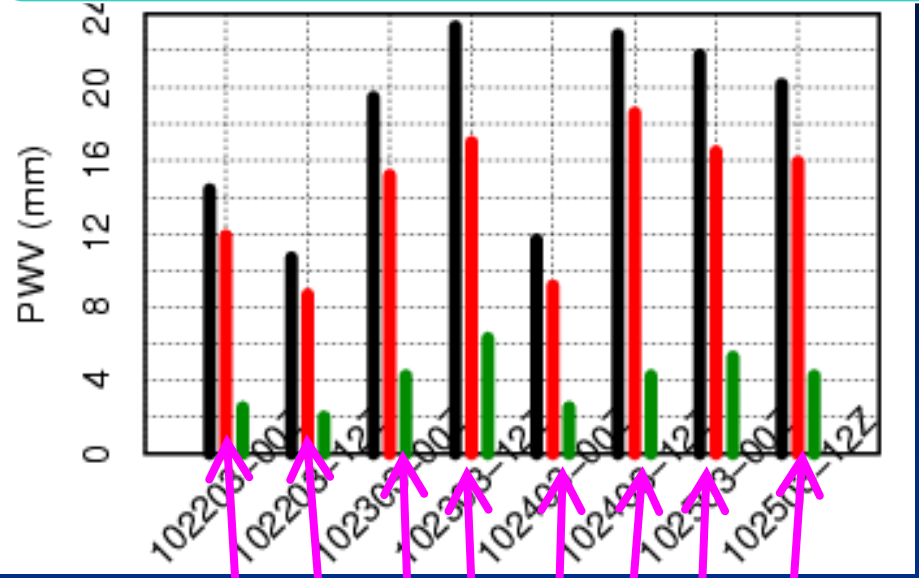
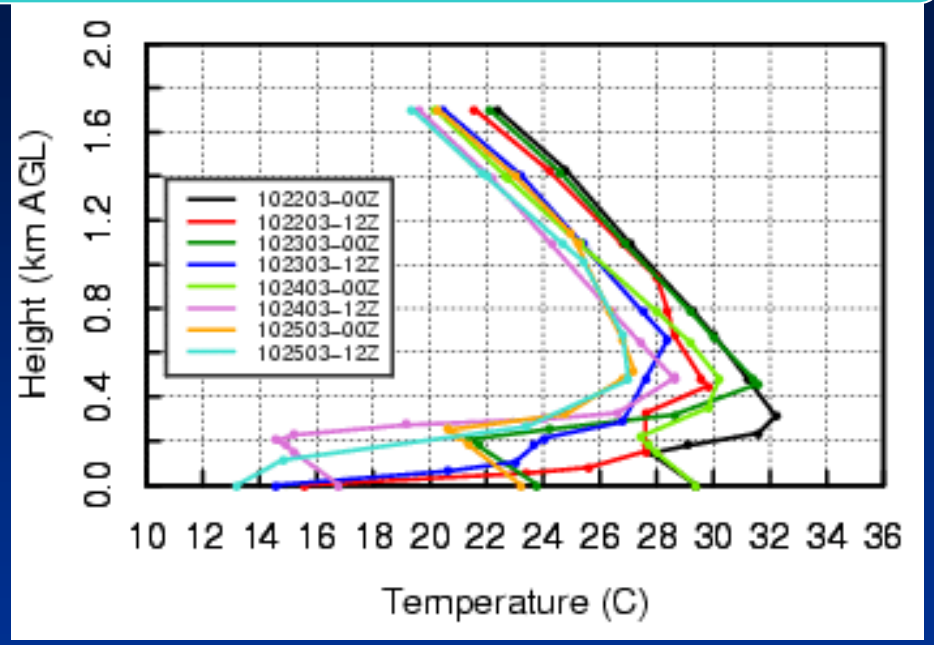
Amplitudes of Tm diurnal cycle



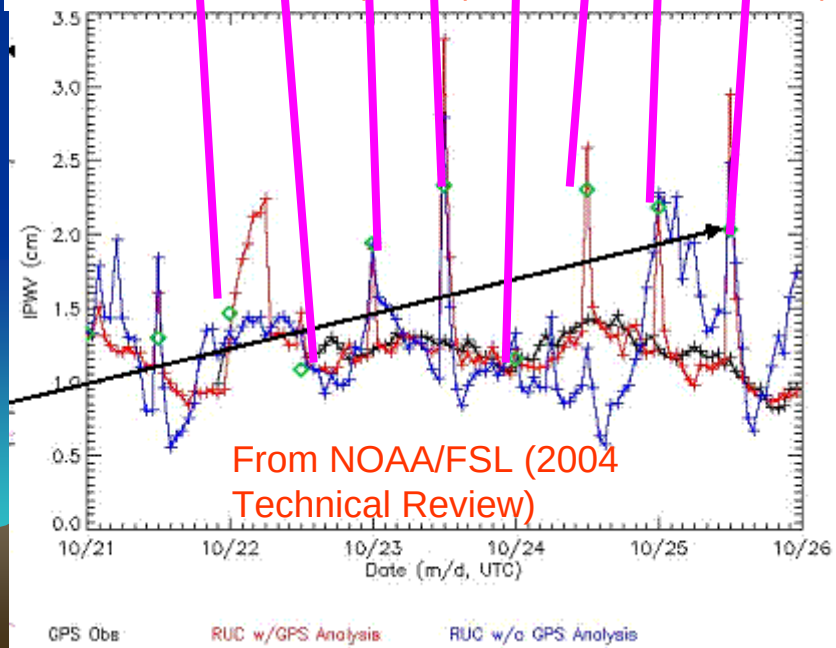


8. Monitoring of the quality of radiosonde humidity data for NWP

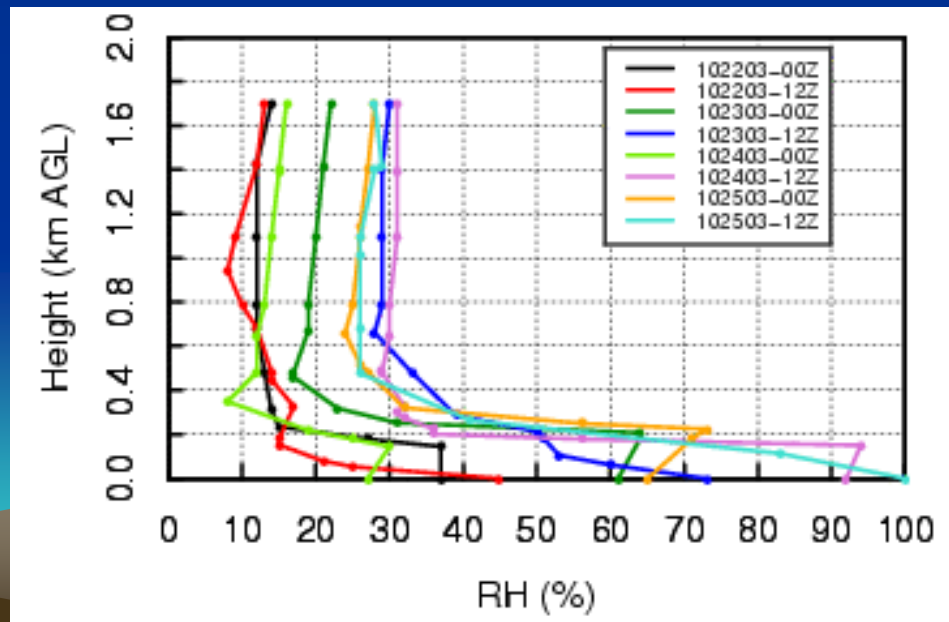




Comparisons of PW from GPS and radiosonde on Oct. 21-25, 2003 in La Jolla (9 km apart, 134/69 m elevations)



From NOAA/FSL (2004 Technical Review)



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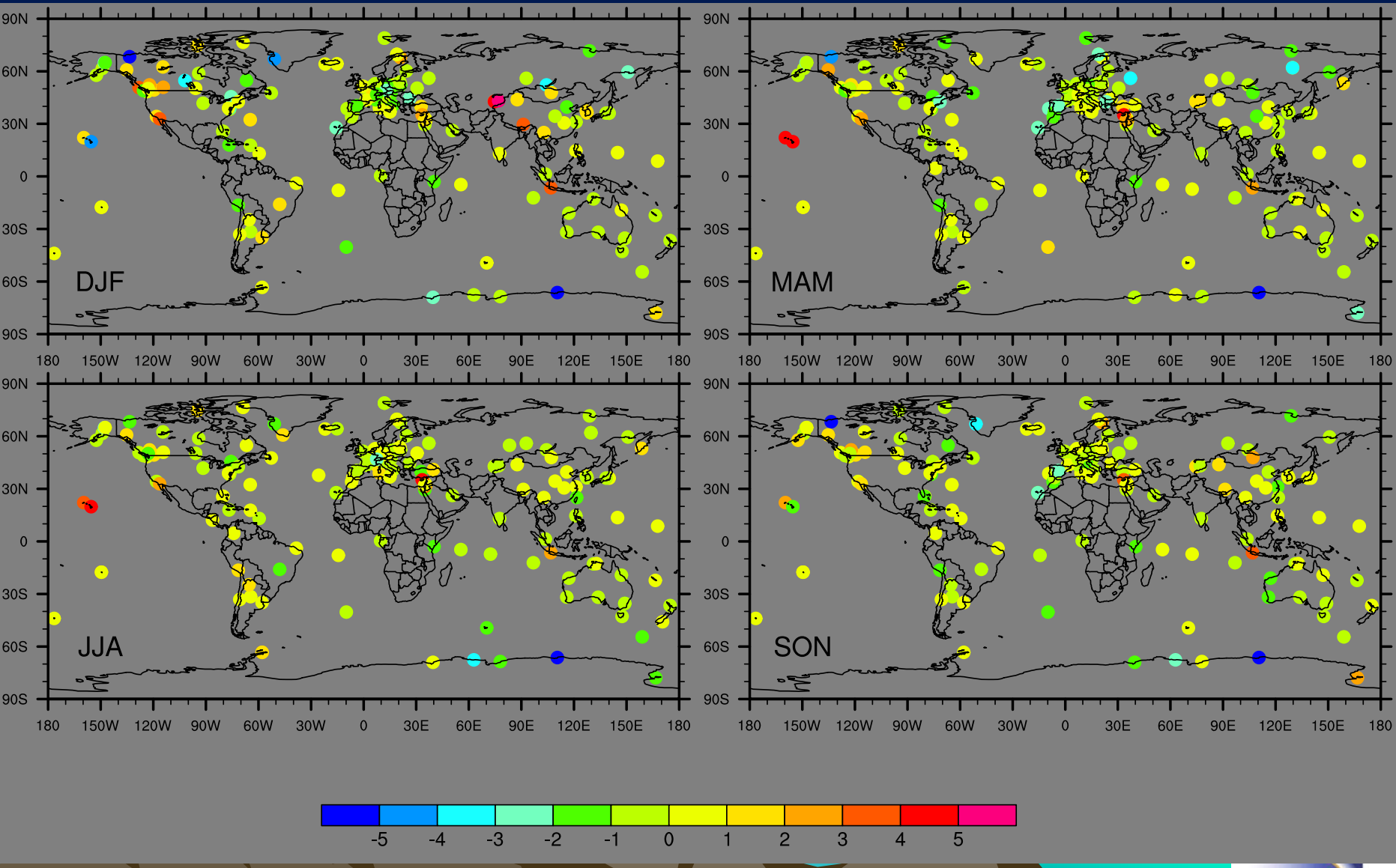
Six-year (1997-2002) seasonal mean of diurnal sampling errors



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Diurnal sampling errors (%) of twice daily radiosonde data