A Global Tm Empirical Model based on NWM

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- **Background**
- **Data source**
- **Modeling method**
- **Accuracy validation**
- **Application**
- **Conclusion**

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Background

- Tm is vital in GNSS water vapor estimation

$$PWV = \prod^{-1} ZWD; \quad \prod = 10^{-6} \rho R_v \left[K_2' + \frac{K_3}{T_m} \right]; \quad T_m = \frac{\int \left(e / T \right) \mathrm{d}h}{\int \left(e / T^2 \right) \mathrm{d}h}$$

- Bevis - metrological data $T_m \sim T_s$: $T_m = a + bT_s$
- Radiosonde
- Empirical models: GPT2w, GWMT
- NWM (Numerical Weather Model)

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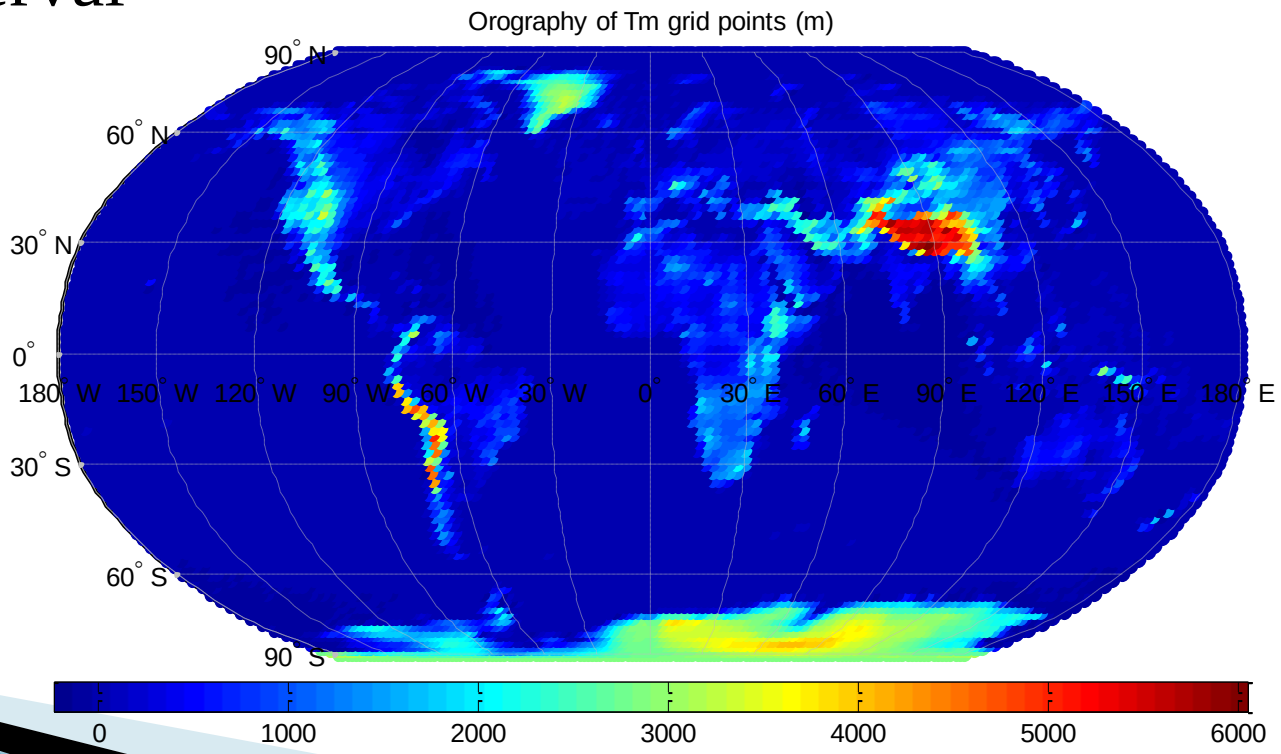
Data Source

- GGOS Tm grid data
- 2.0° ×2.5° latitude & longitude
- 6 hours interval
- 2005-2014



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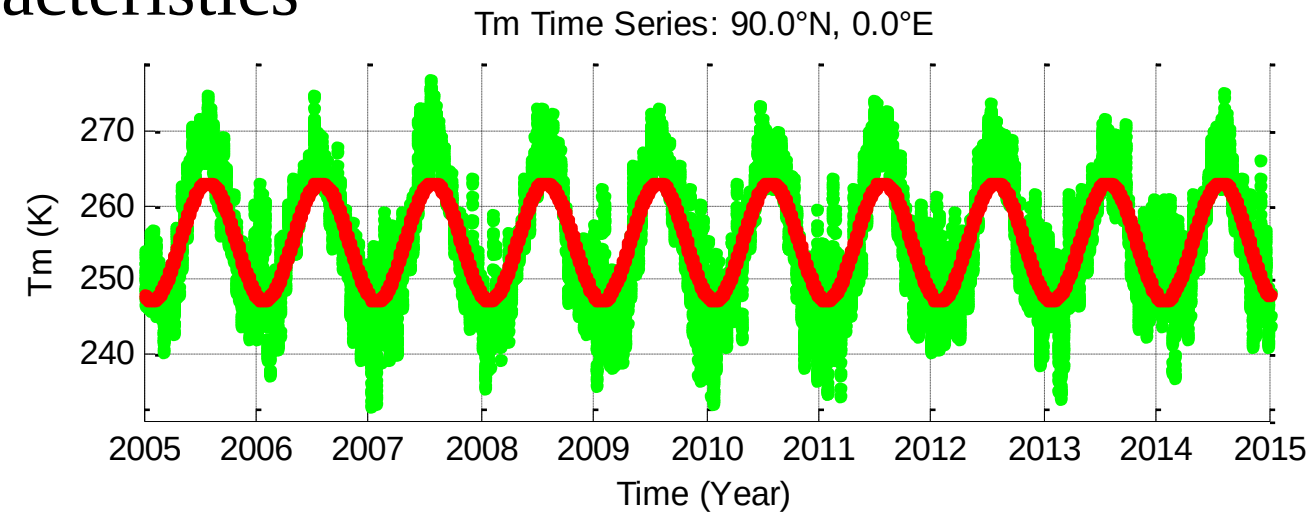
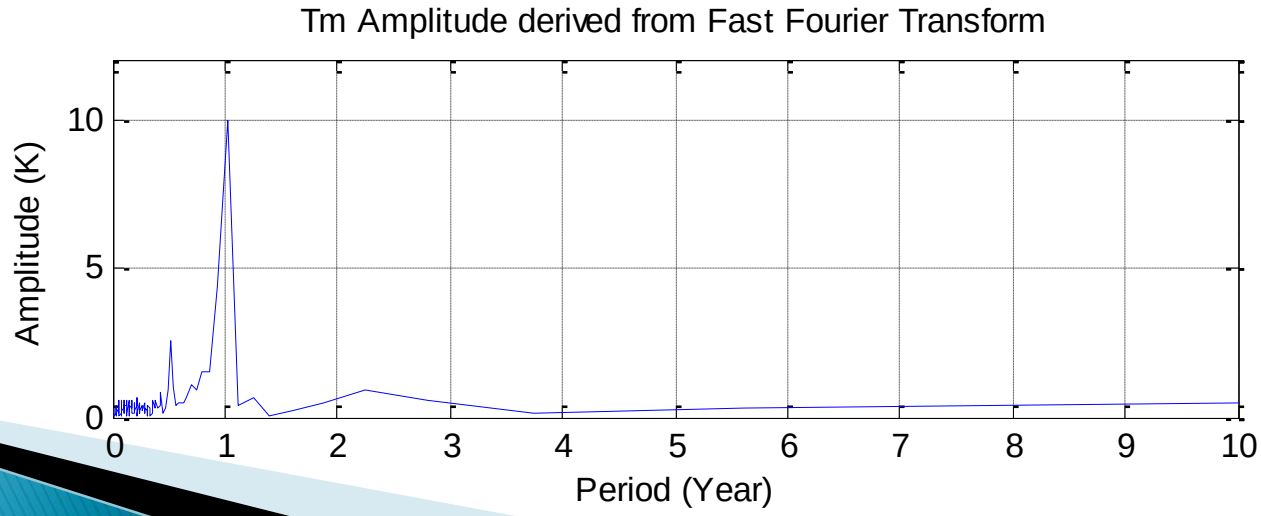
Modeling Method

- Tm characteristics





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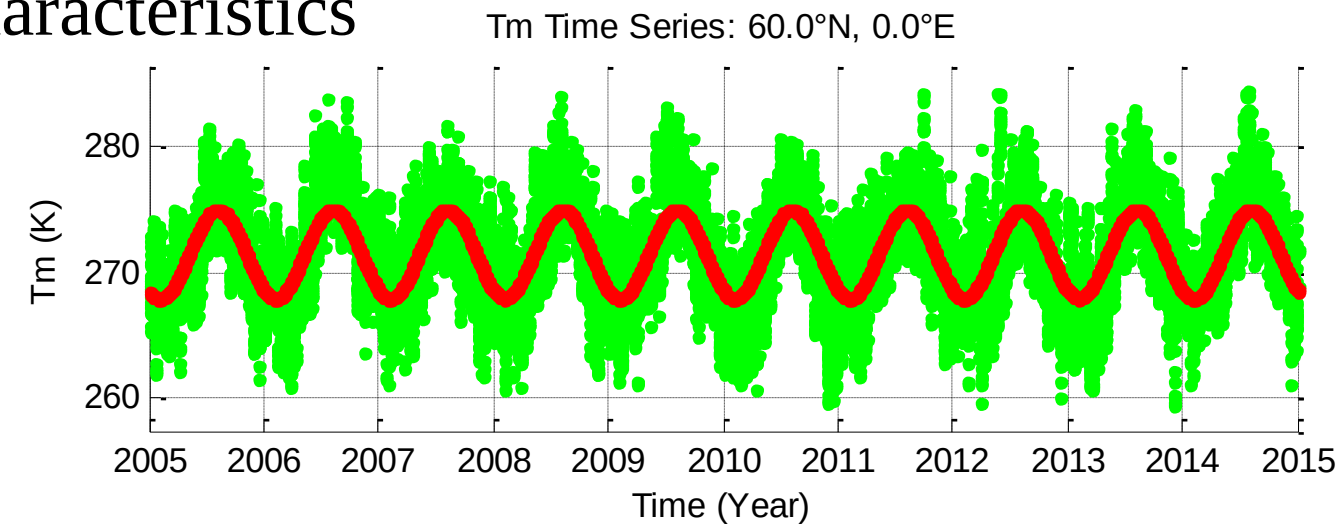

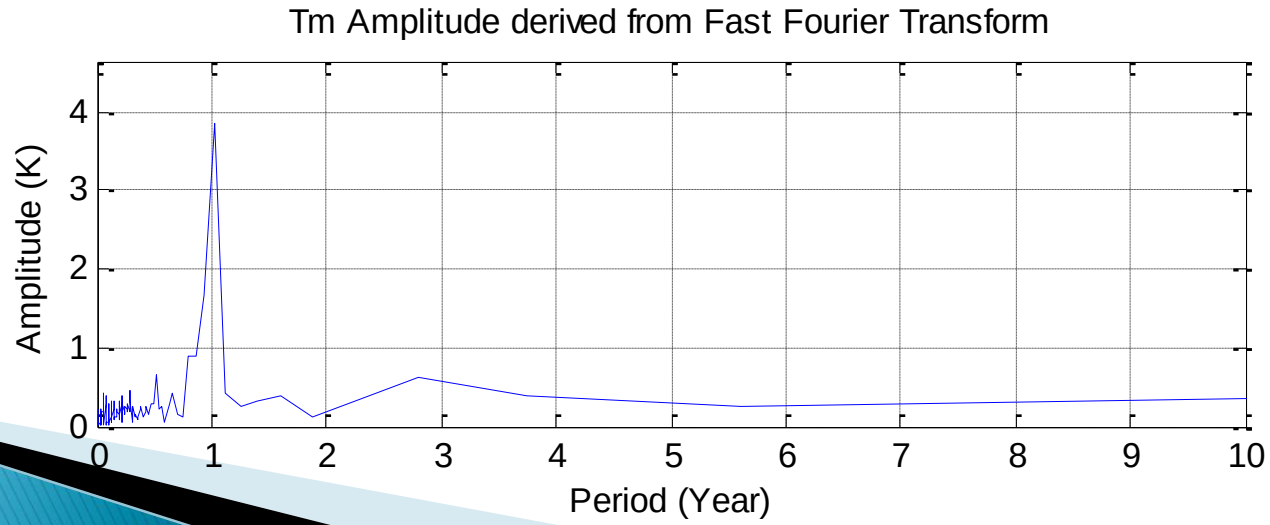

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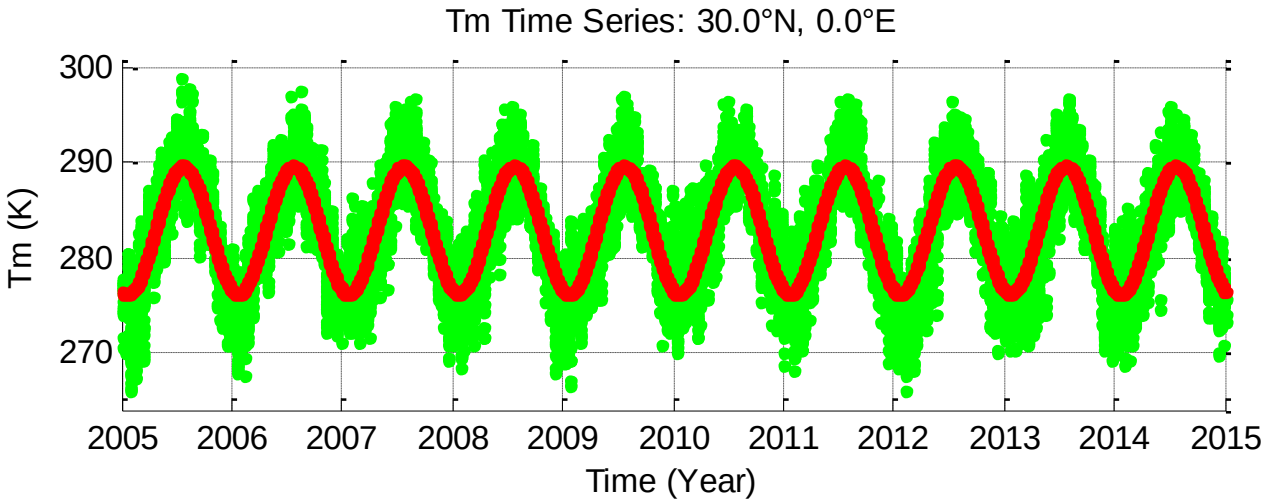

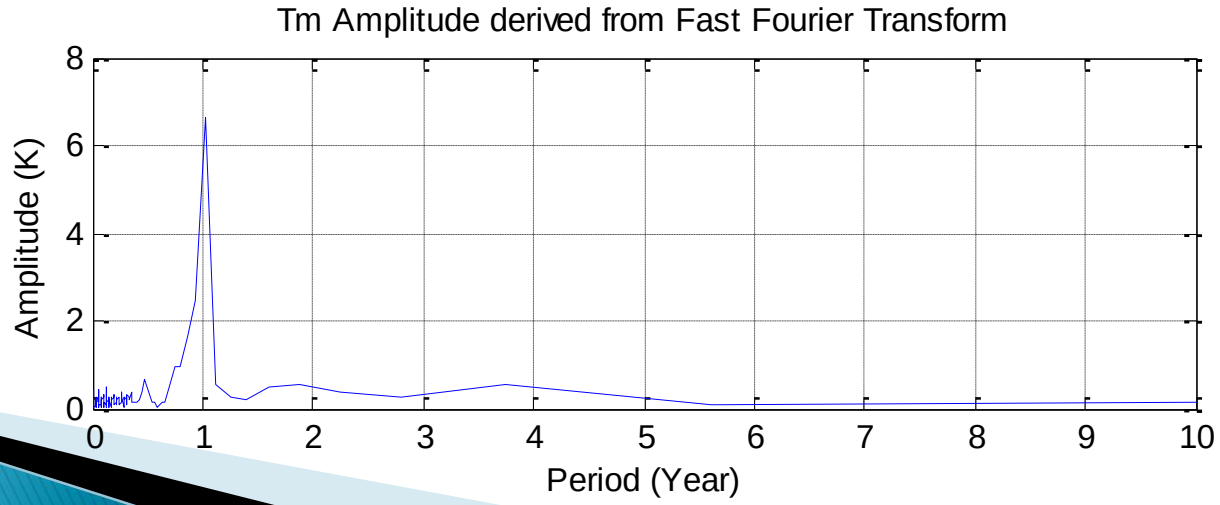

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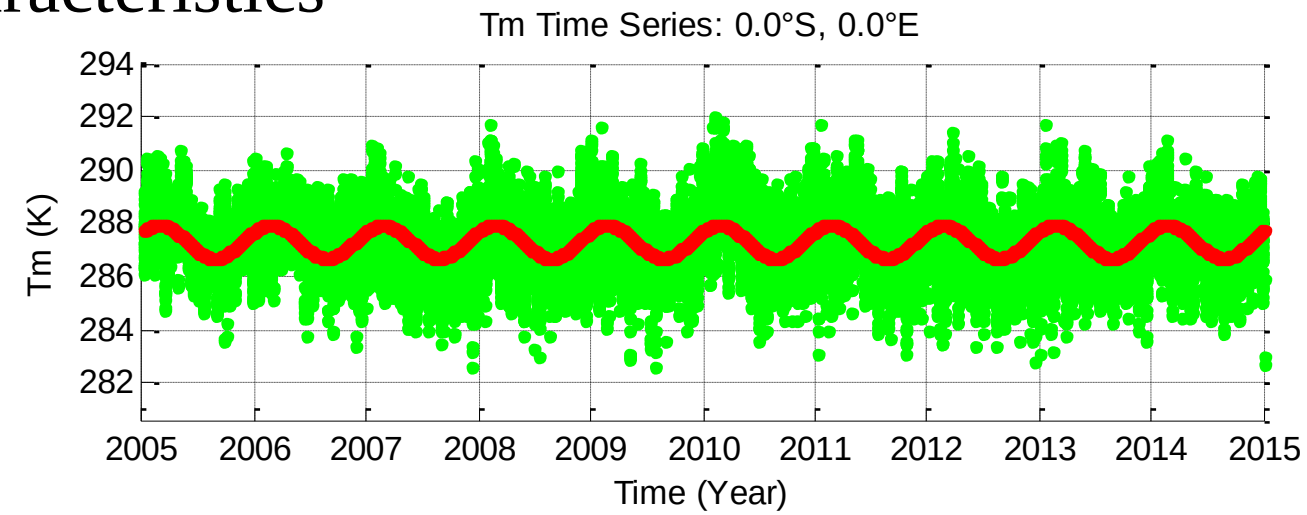

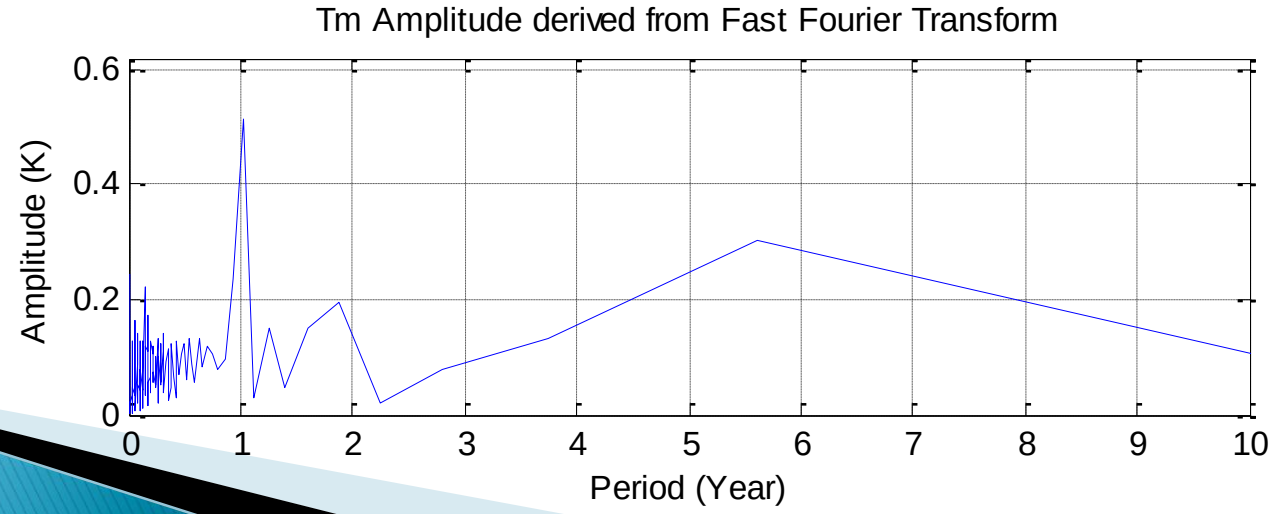

Modeling Method

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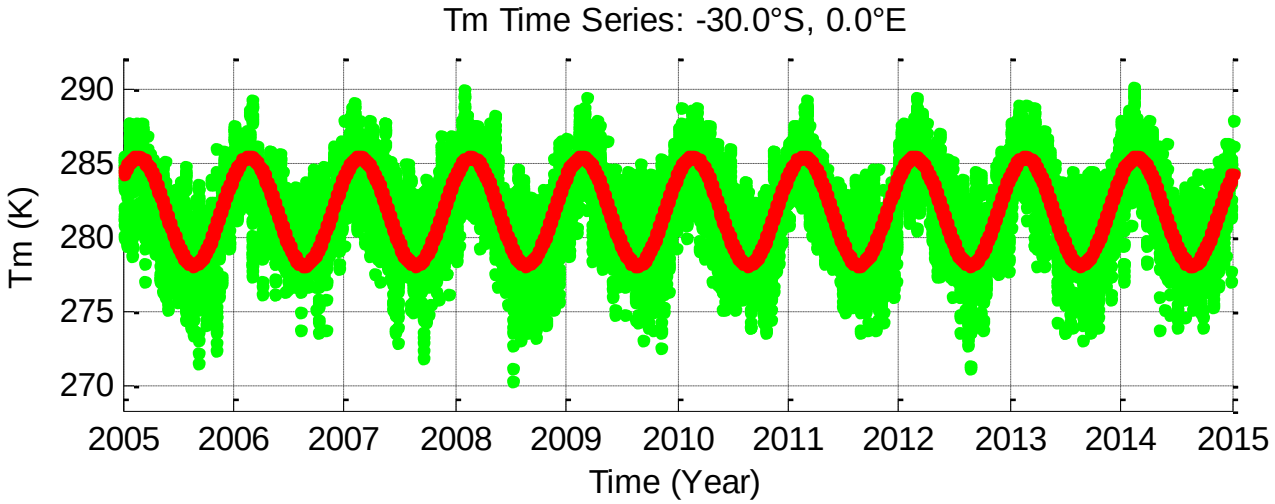

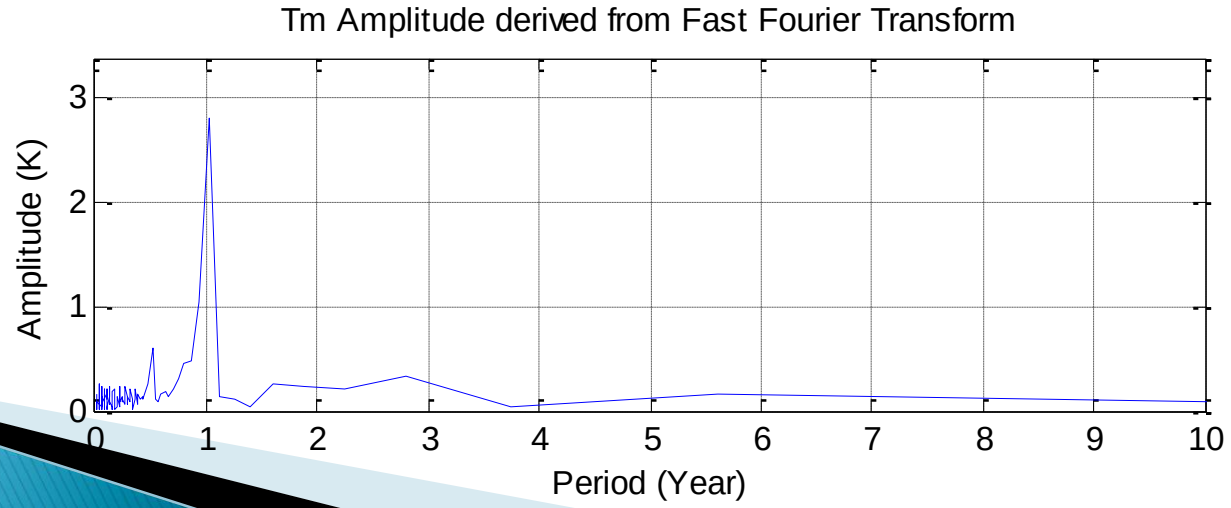

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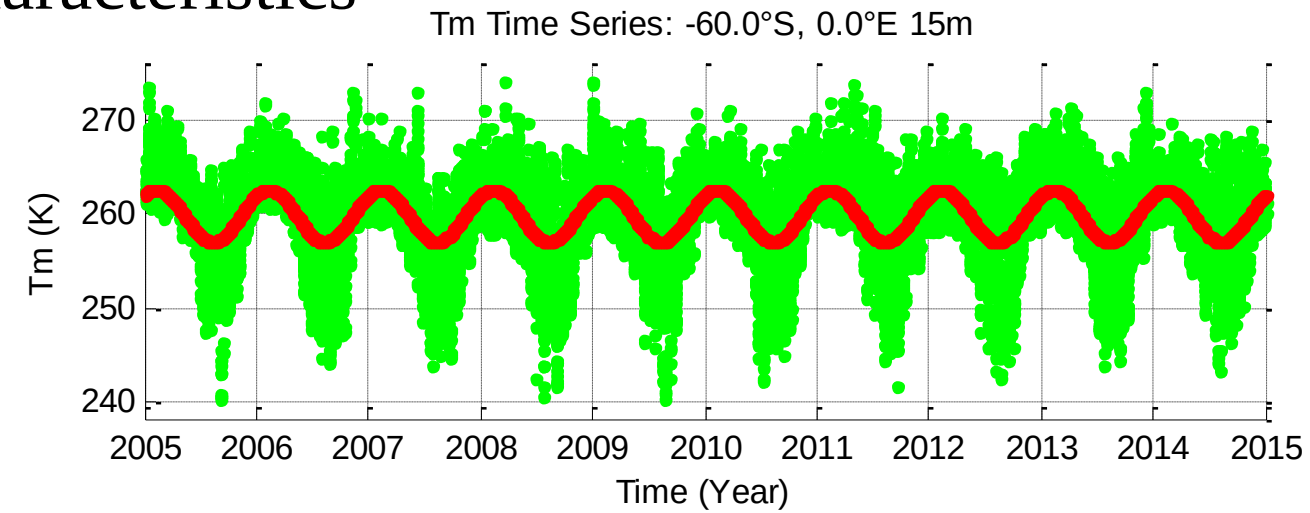

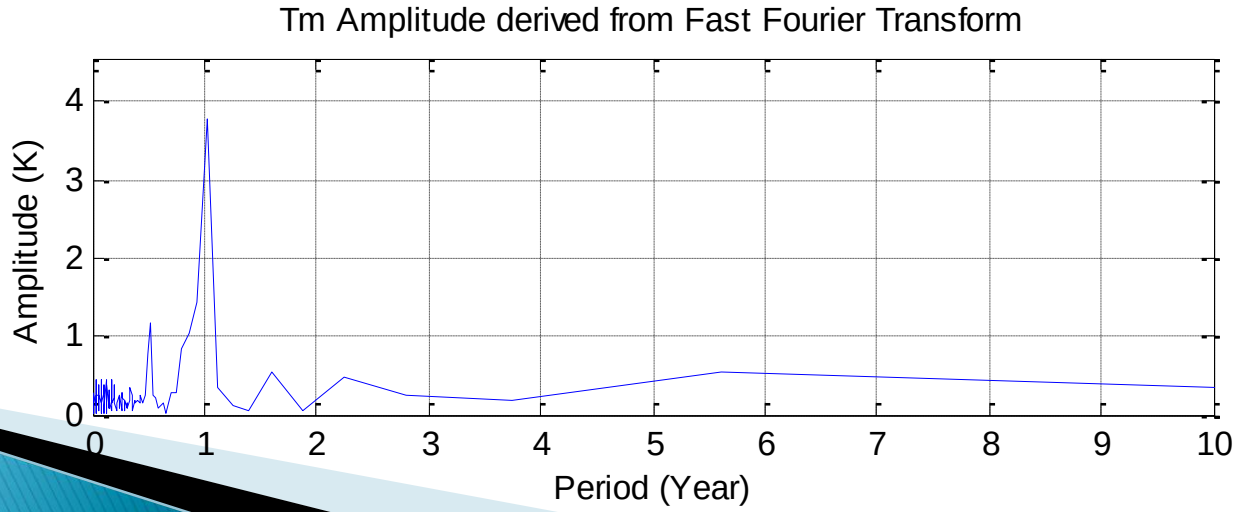

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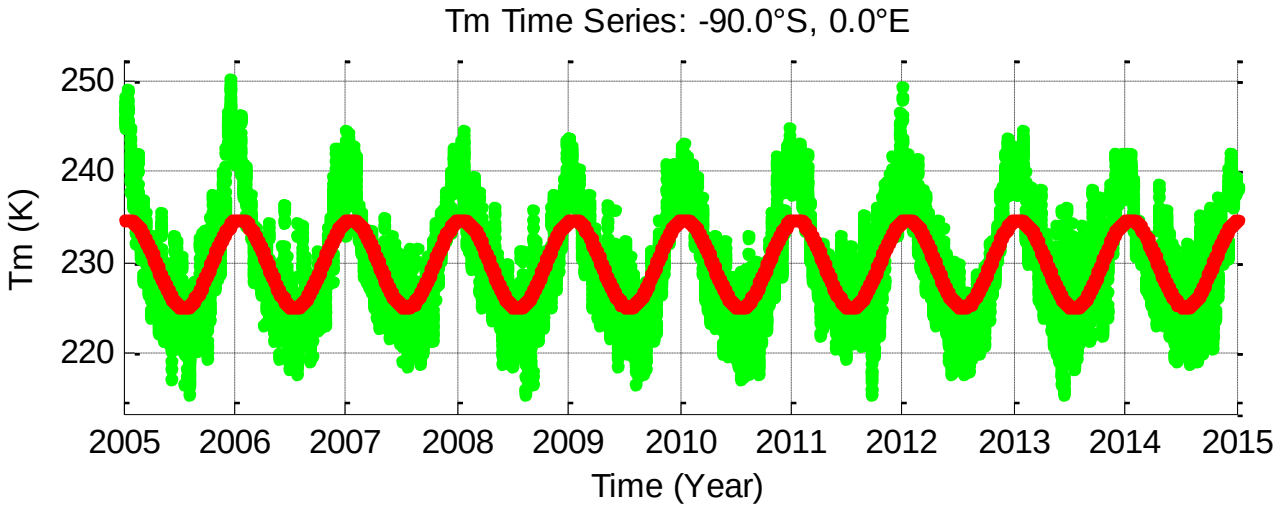

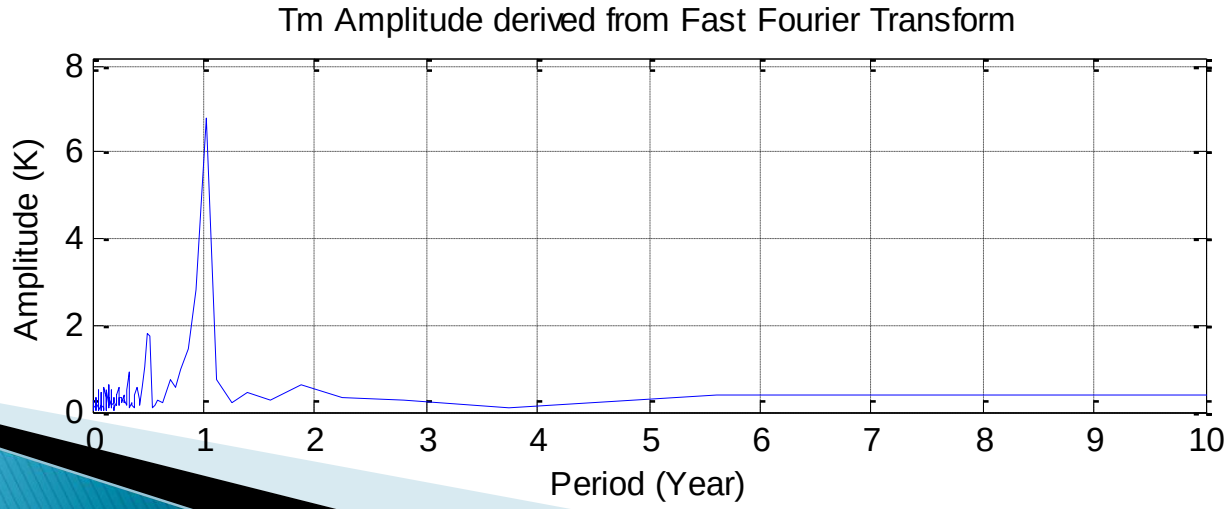

Modeling Method

- Tm fitting method of each grid point

$$T_m(doy) = a_0 \quad \cdots \text{annual mean value}$$

$$+ a_1 \cos\left[\frac{2\pi}{365.25}(doy - b_1)\right] \quad \cdots \text{annual terms}$$

$$+ a_2 \cos\left[\frac{4\pi}{365.25}(doy - b_2)\right] \quad \cdots \text{semi-annual terms}$$

- 5 parameters, $(a_0, a_1, b_1, a_2, b_1)$ at each grid point

User Method

- Tm of four grid points around the site

$$T_m(doy) = a_0 + a_1 \cos\left[\frac{2\pi}{365.25}(doy - b_1)\right] + a_2 \cos\left[\frac{4\pi}{365.25}(doy - b_2)\right]$$

- Reduction to the site height

$$T_m(H) = T_m(H_{GD}) - 0.0065 \times \beta_{Bevis} \times (H - H_{GD})$$

$$\beta_{Bevis} = 0.72$$

- Bilinear interpolation

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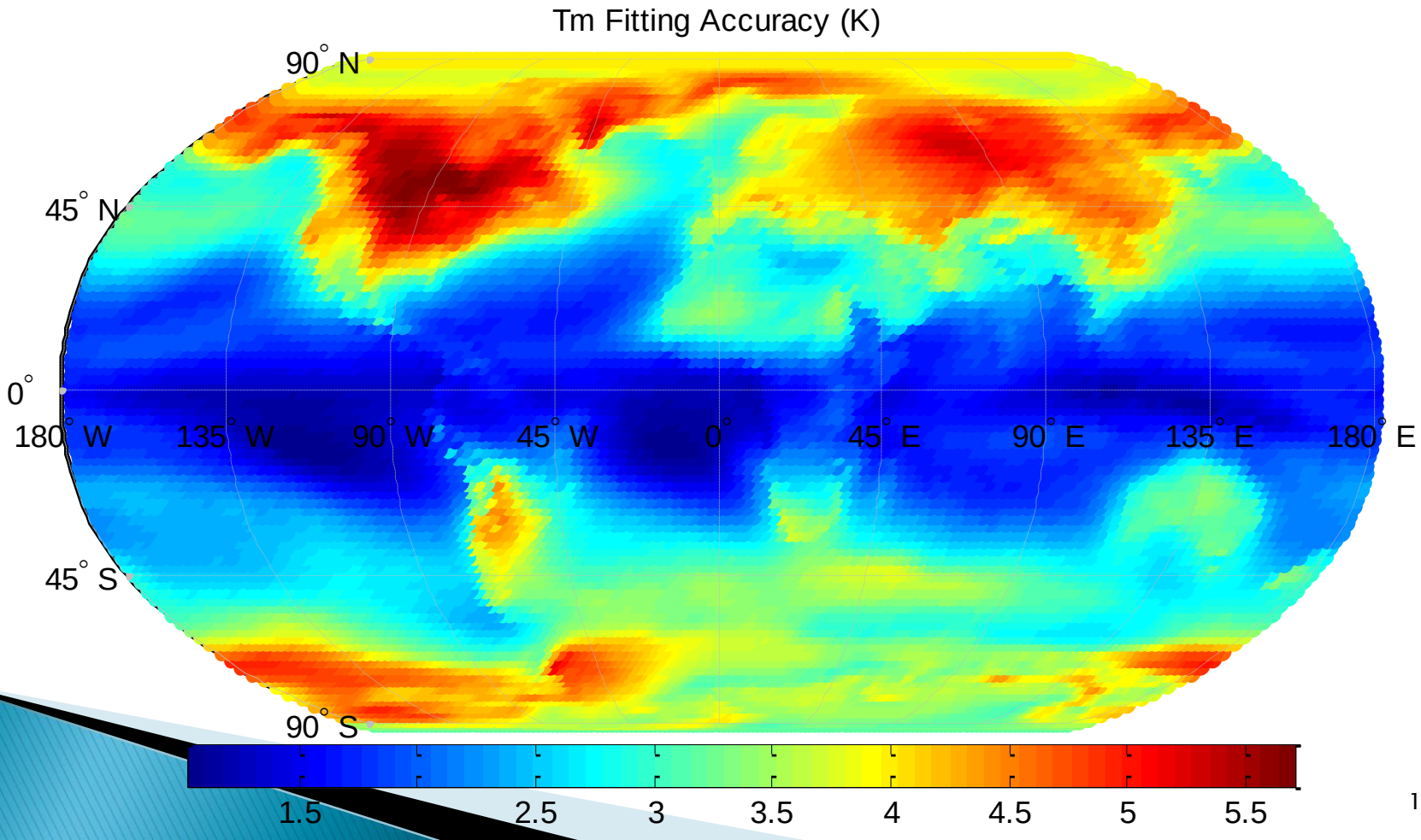
Accuracy validation

- NWM data – fitting error
- Metrological data – Bevis $T_m \sim T_s$ relationship
  - 70 IGS sites
  - 230 CMONOC sites
  - 1 year data (2014)

Accuracy validation

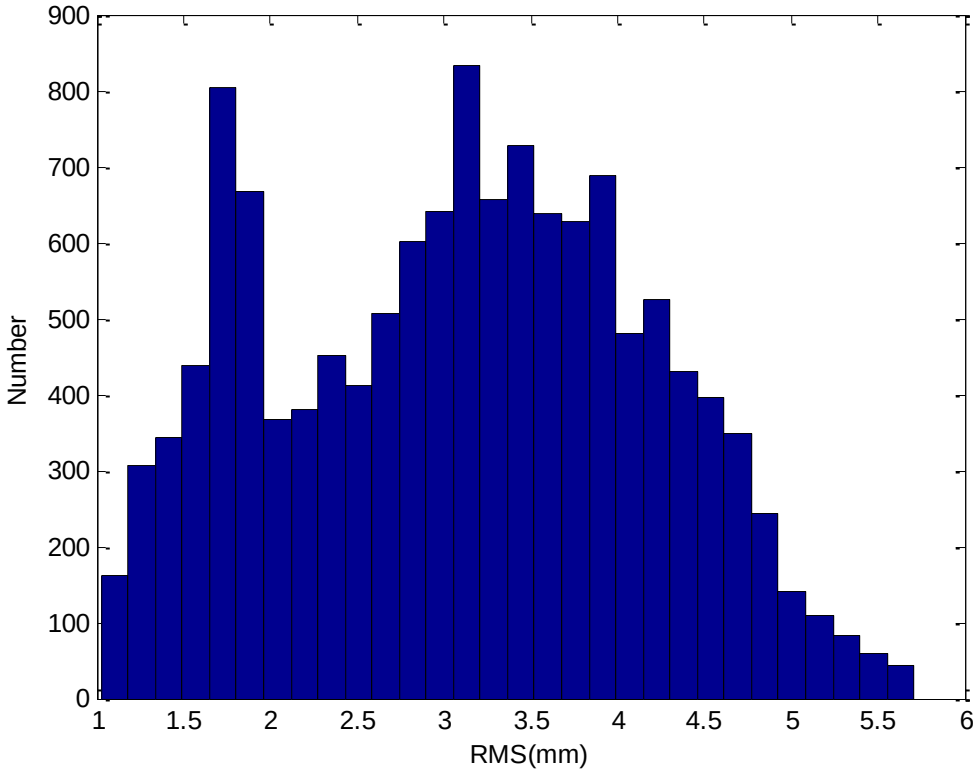
- Fitting accuracy of each grid point



Accuracy validation

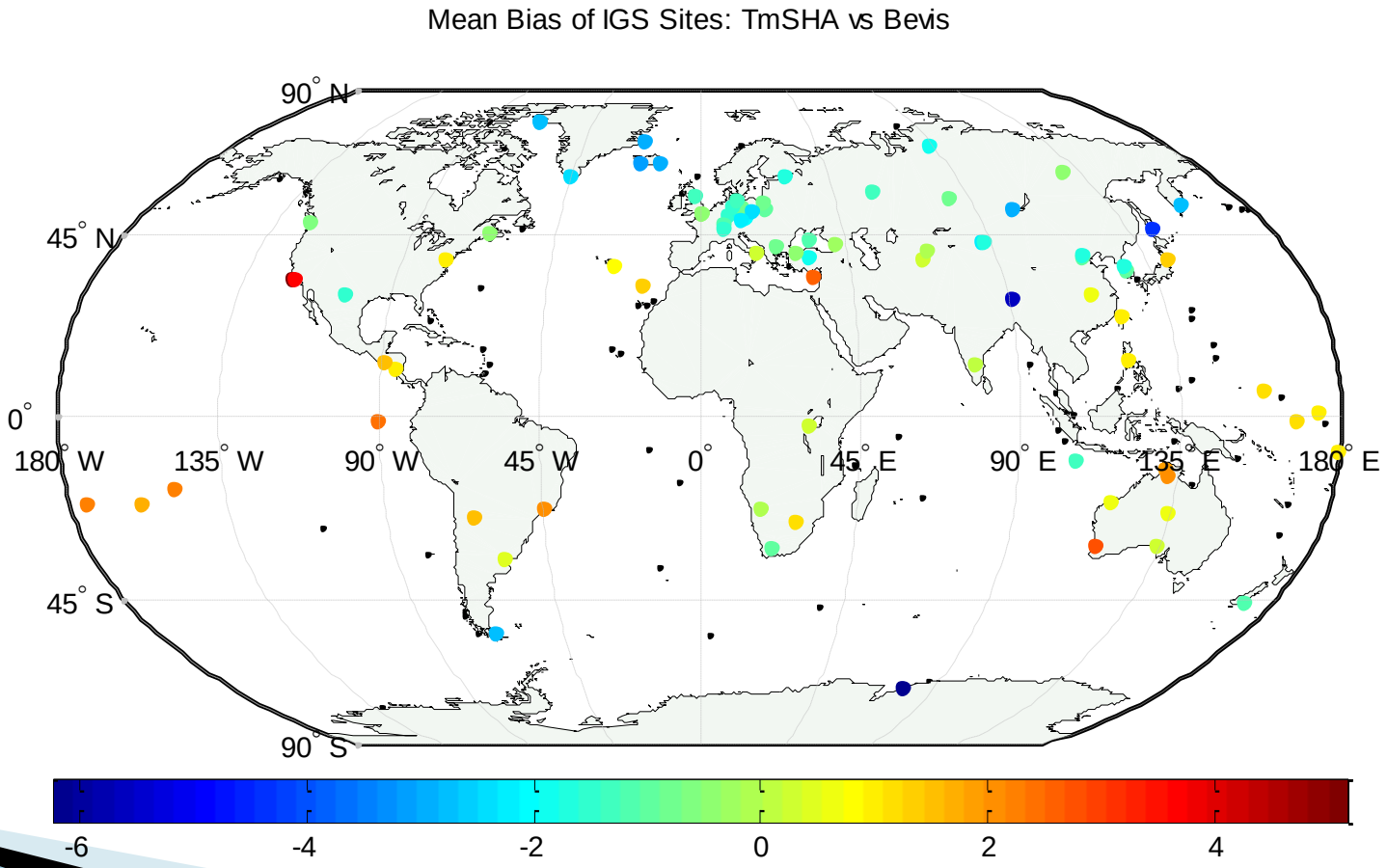
- Fitting accuracy of each grid point
- Statistics of fitting RMS (mm)

MEAN	3.10
MEDIAN	3.17
MAX	5.71
MIN	1.02



Accuracy validation - vs Bevis

- IGS sites - metrological data



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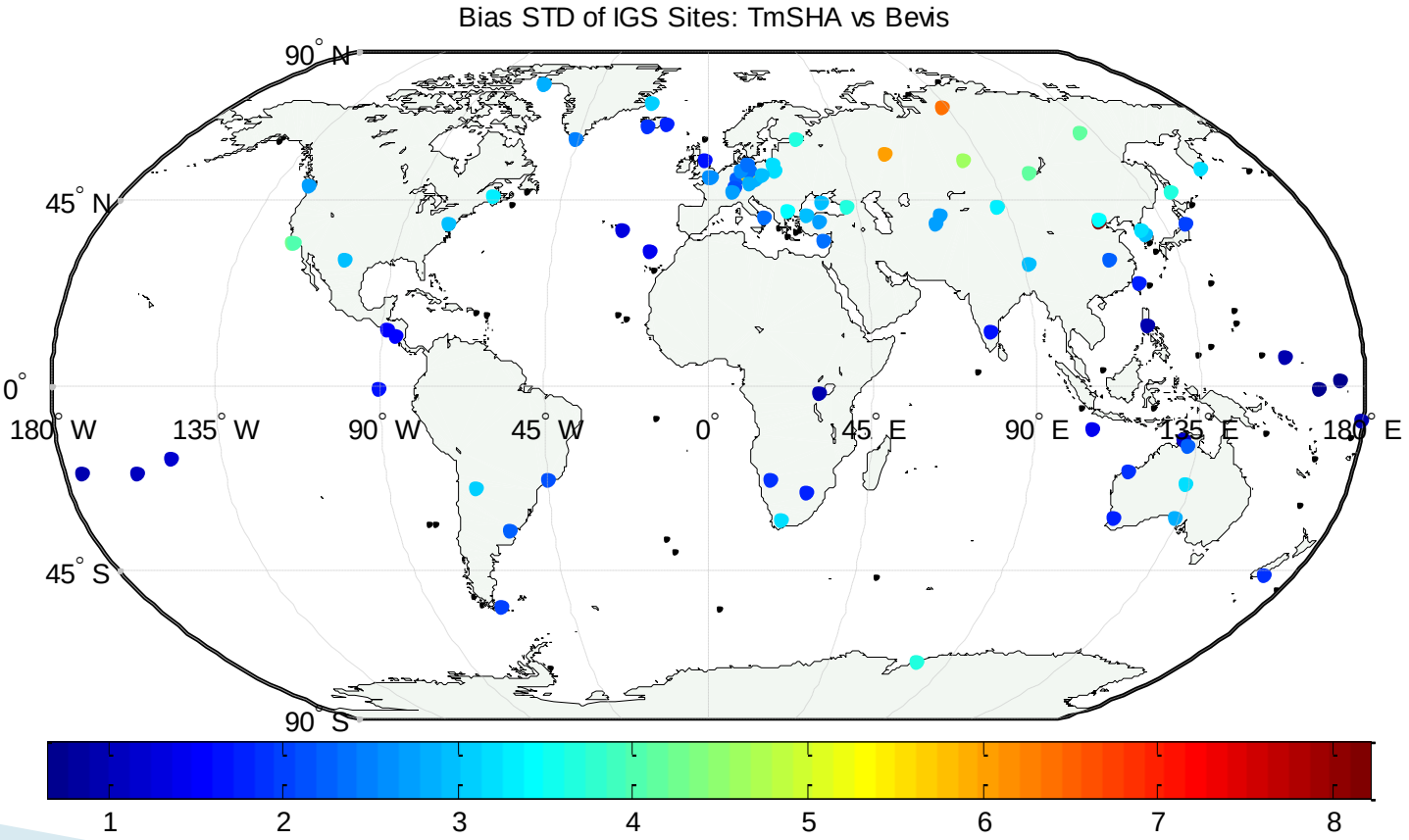

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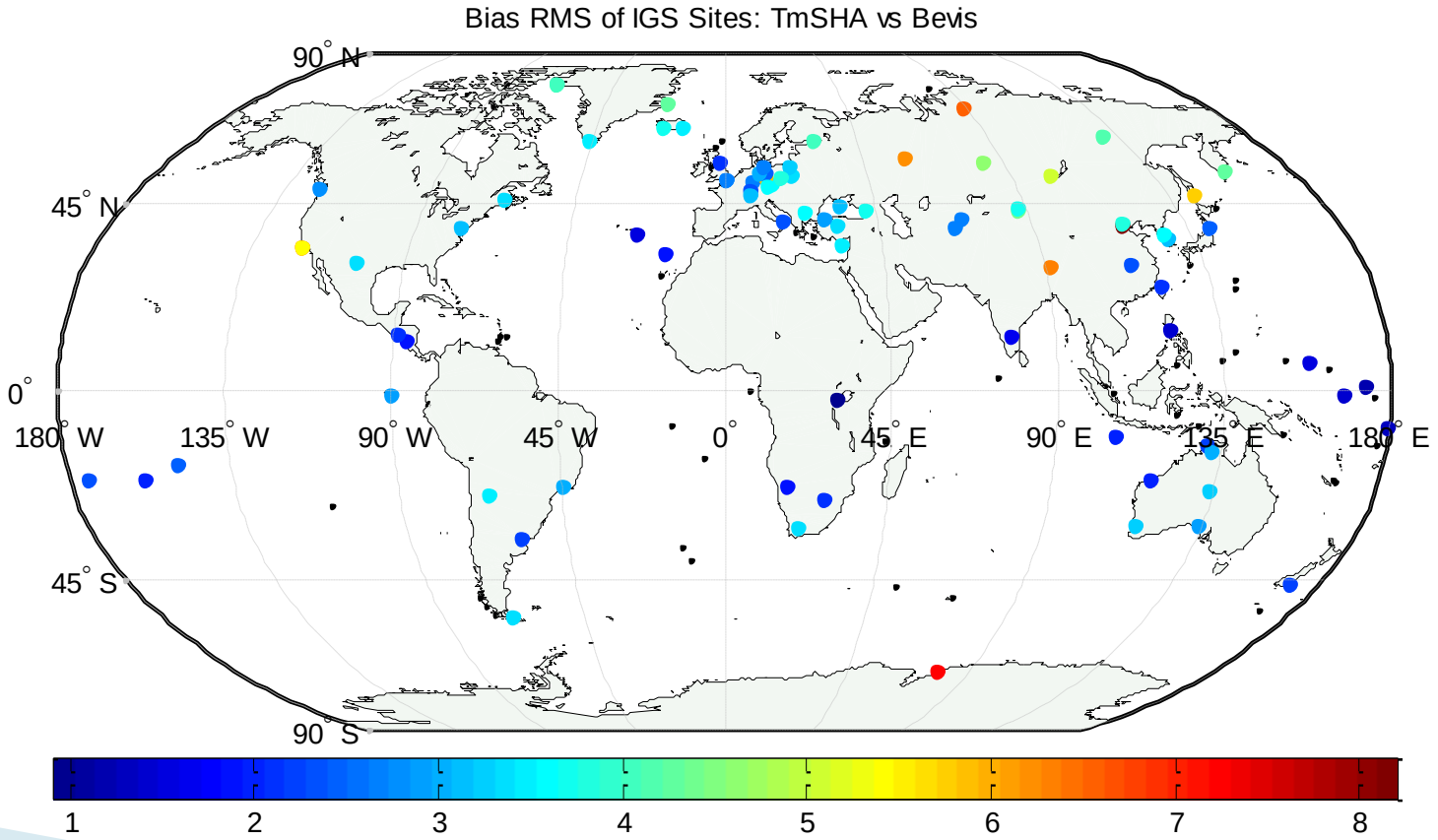

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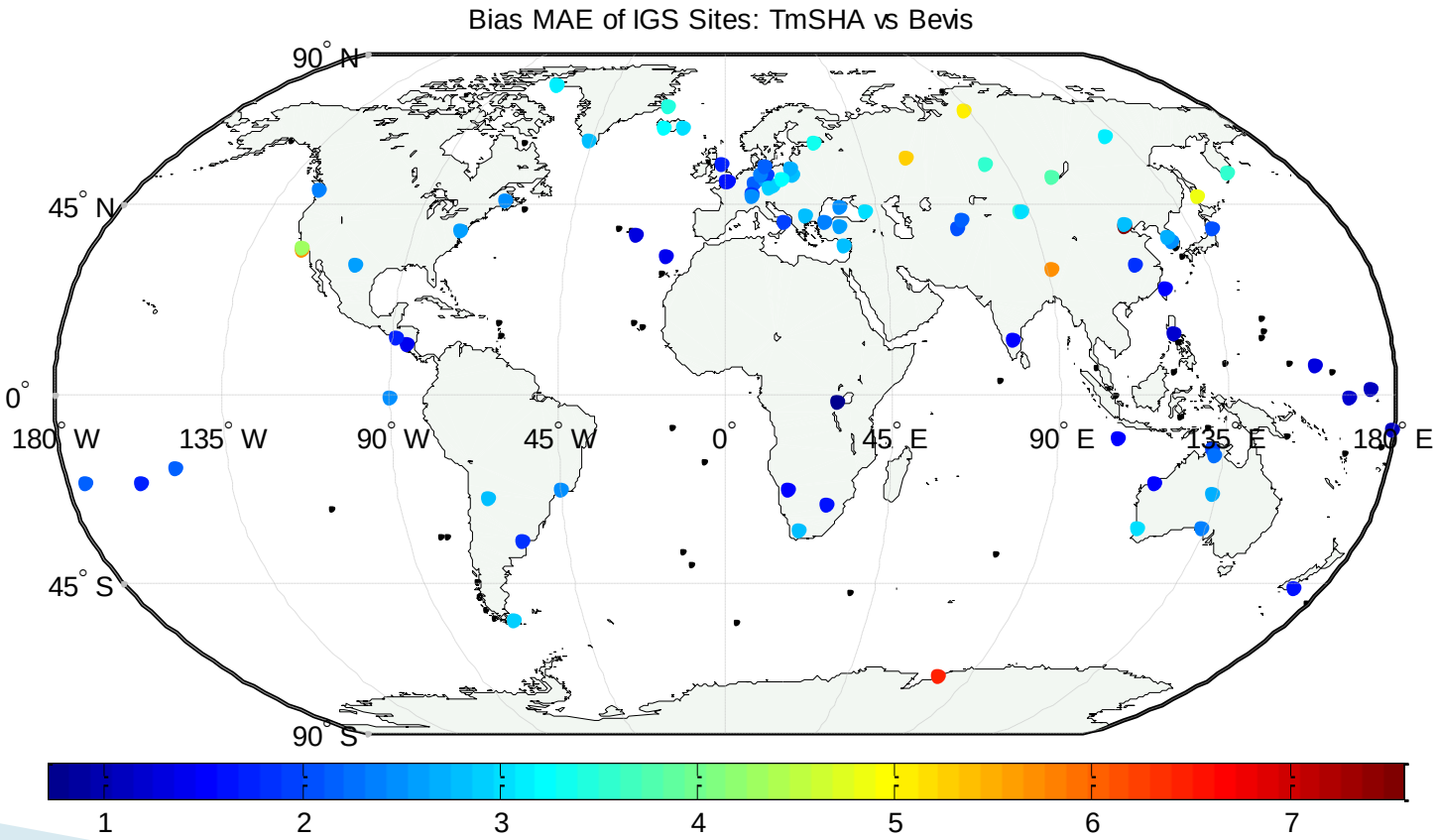

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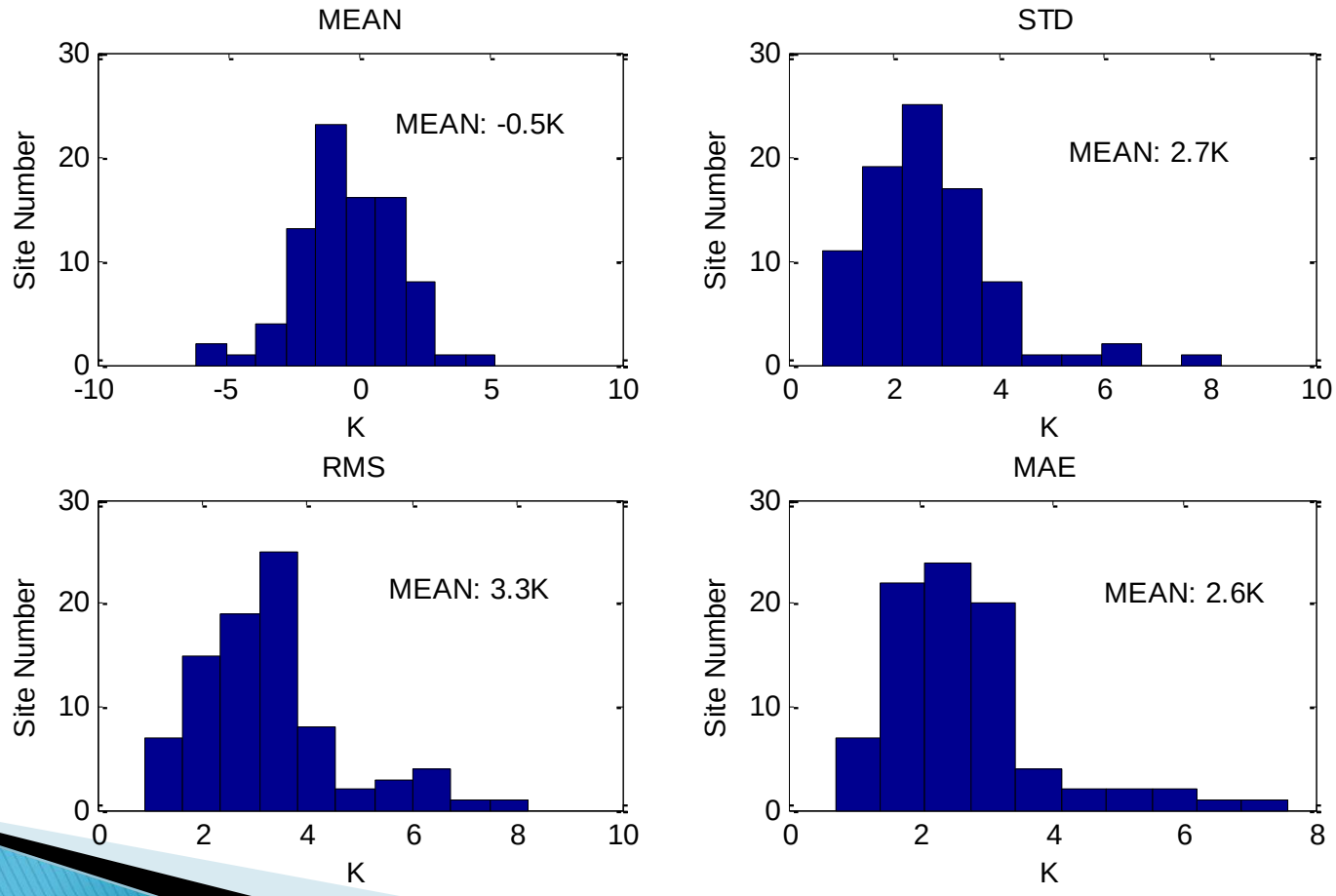
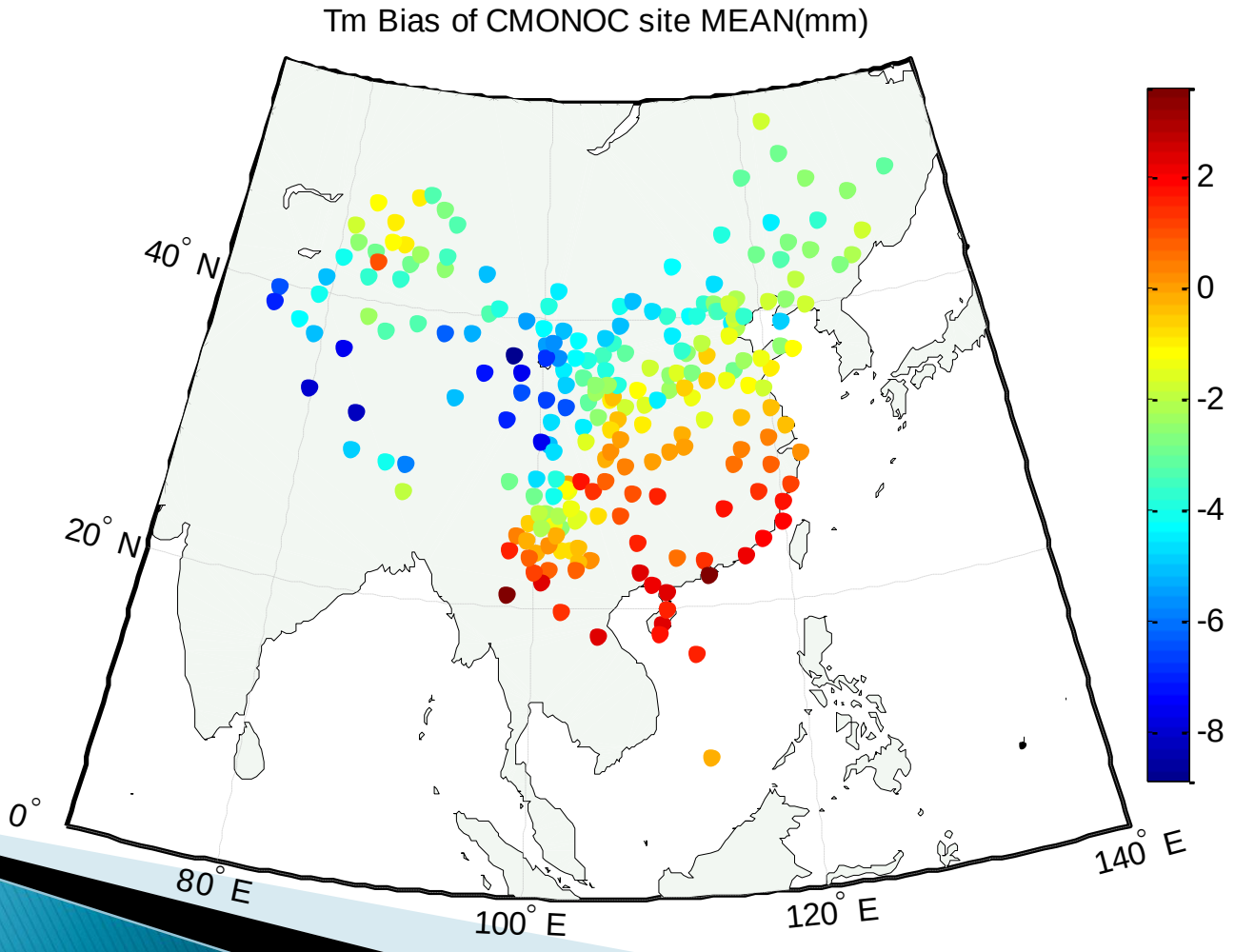


Accuracy validation - vs Bevis

- CMONOC sites - metrological data



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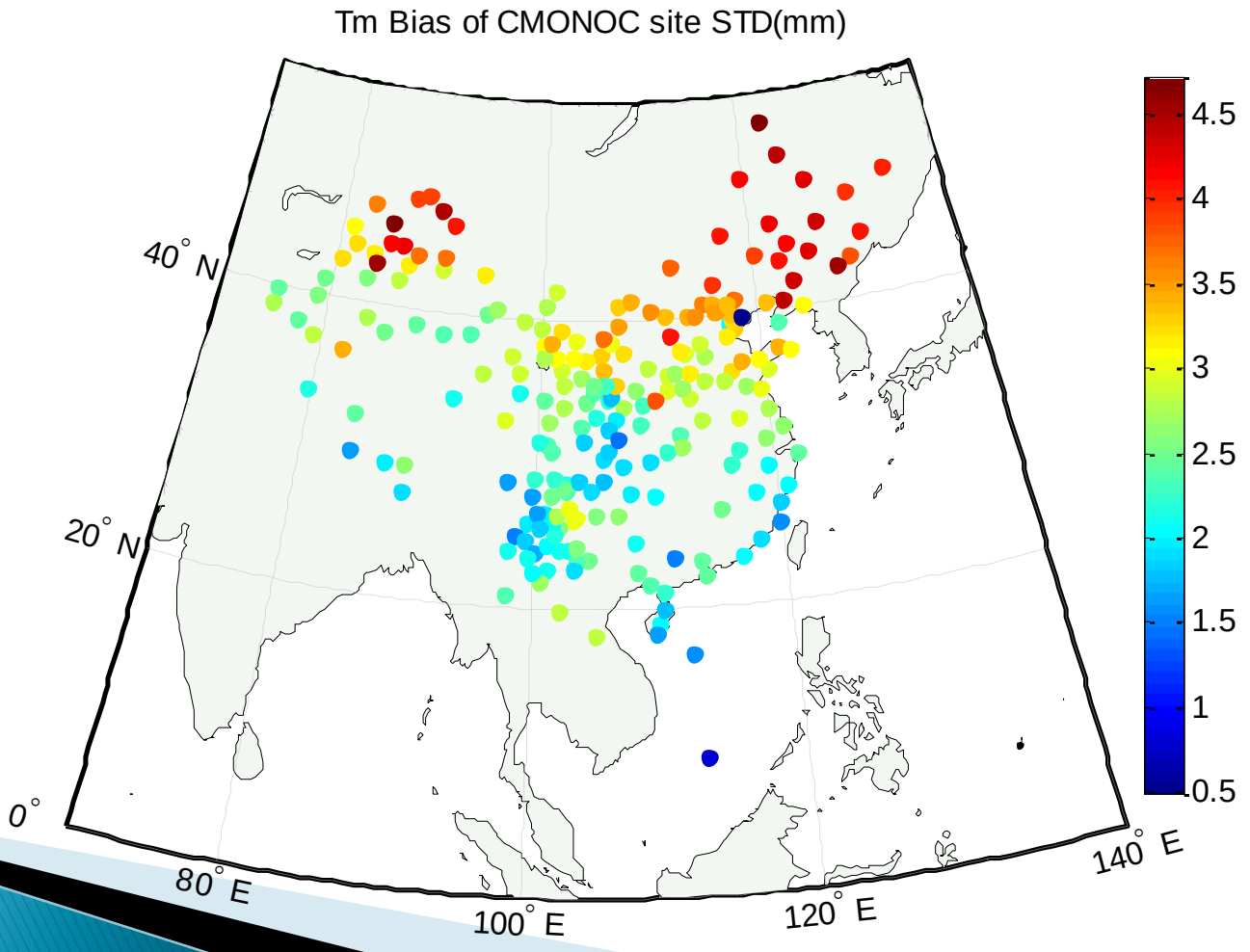

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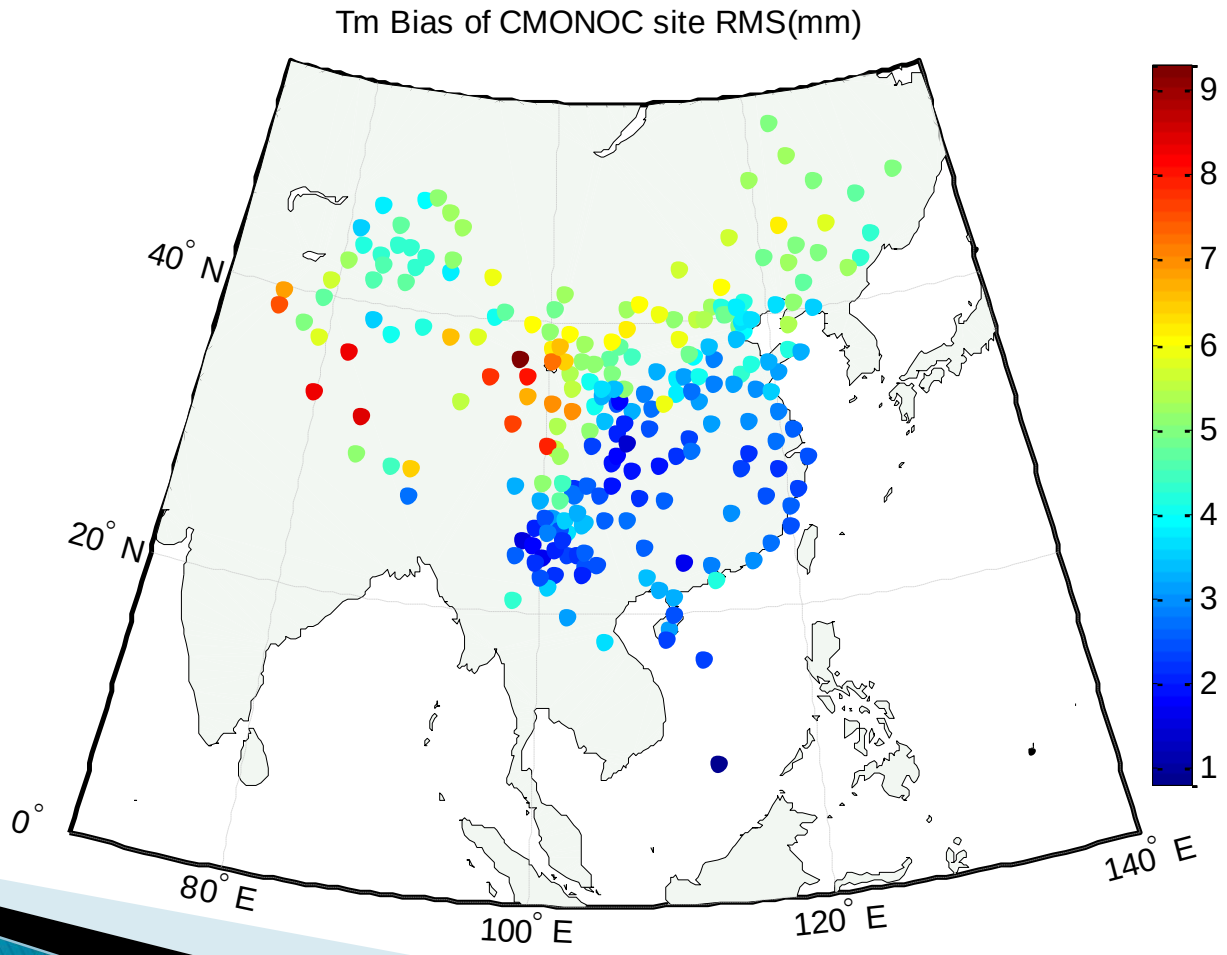

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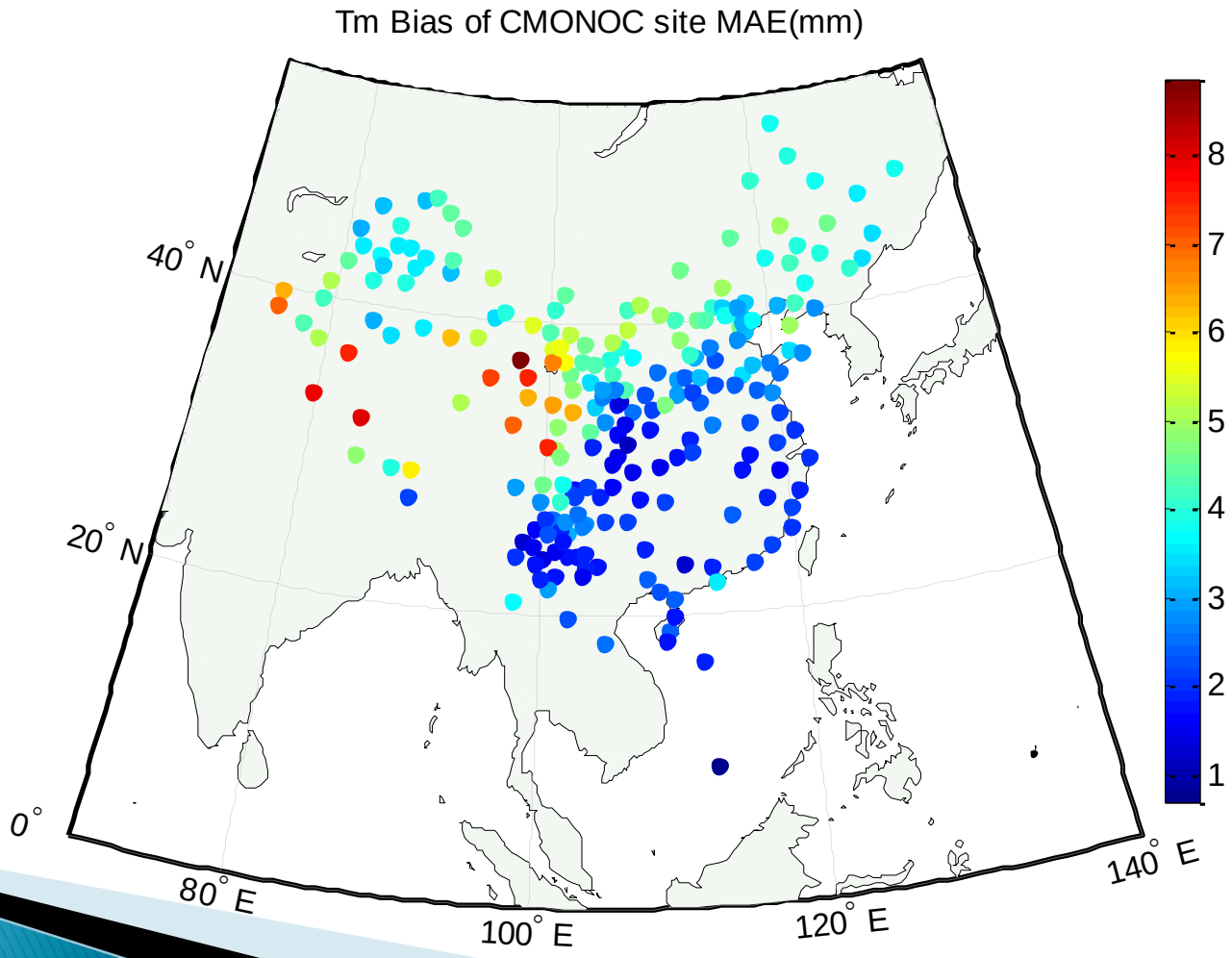

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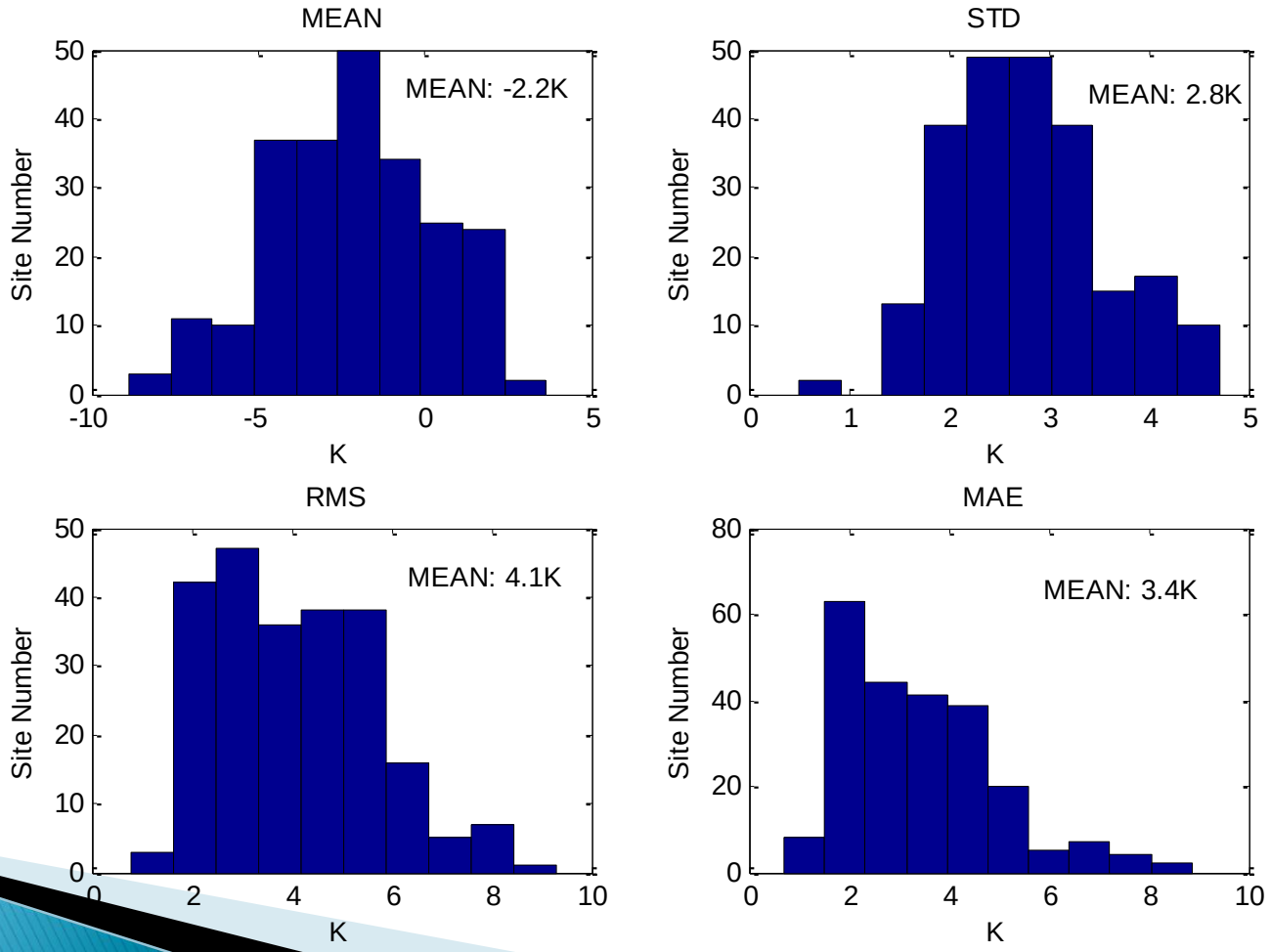

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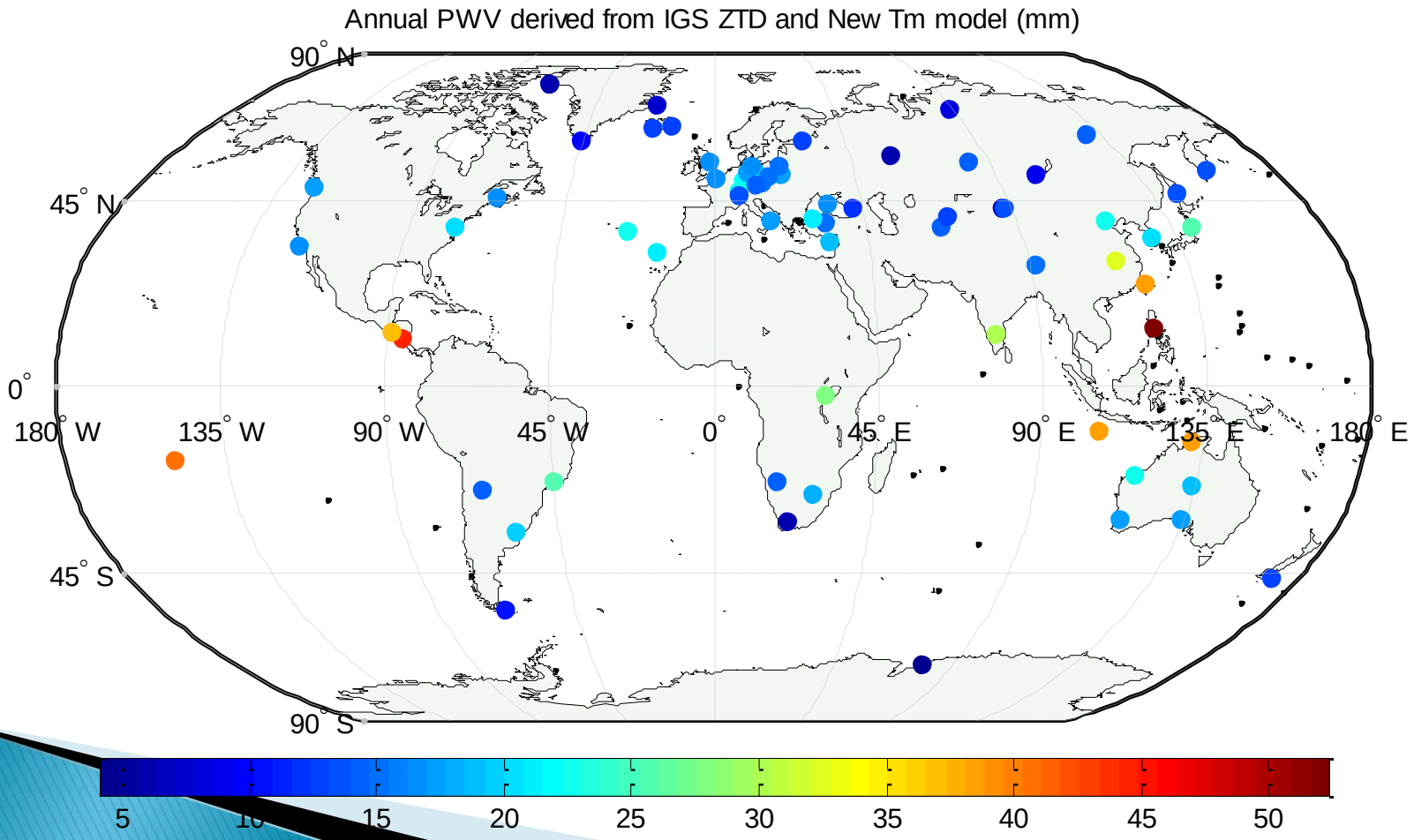
Application

- PWV derived from GNSS ZTD
- Using new Tm model and Bevis Tm-Ts relationship
  - 70 IGS sites
  - 230 CMONOC sites
  - 1 year data (2014)

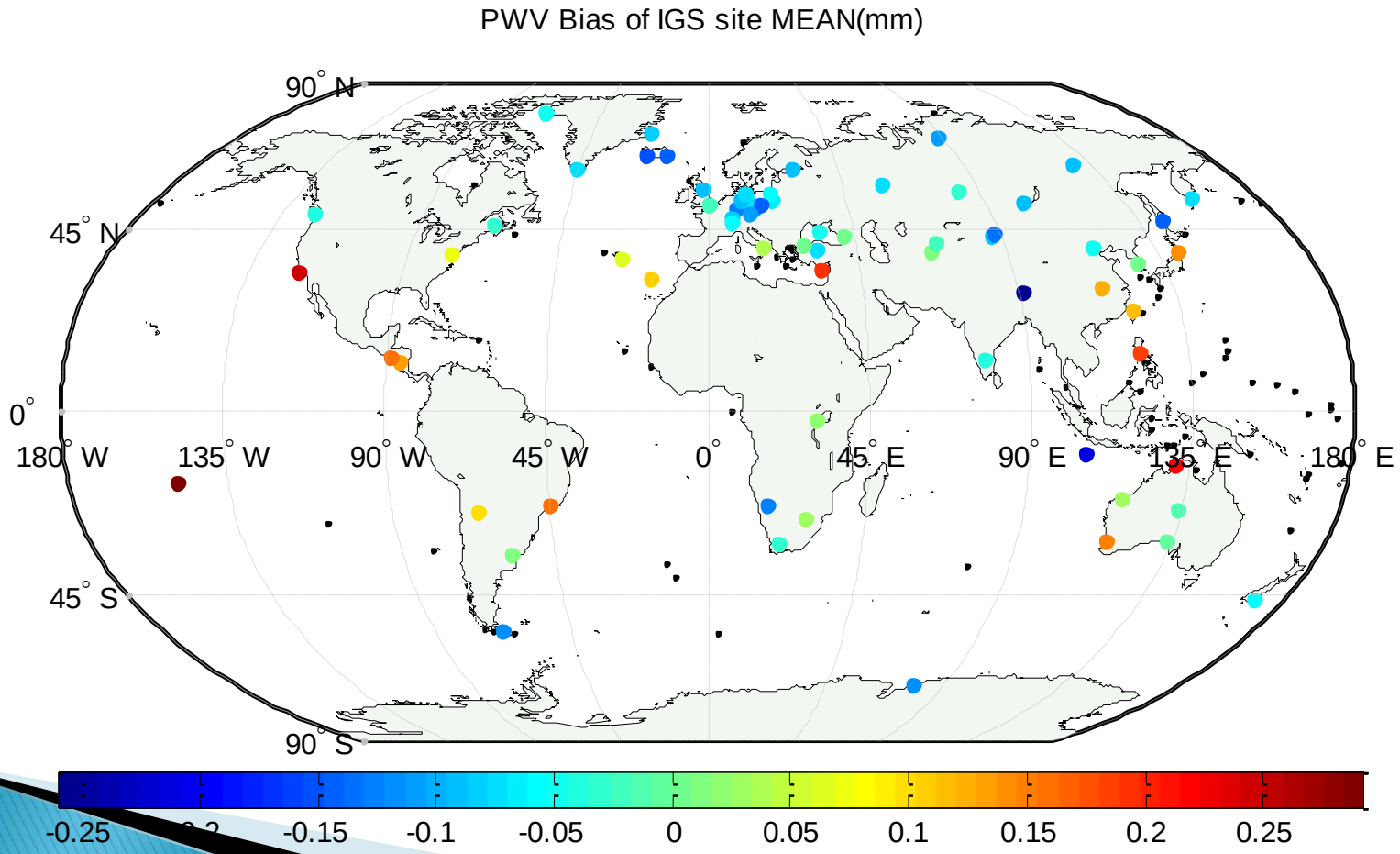
Application – PWV of IGS sites

- PWV derived from IGS ZTD and New Tm model



Application - PWV Bias vs Bevis

- IGS sites – vs Bevis using metrological data



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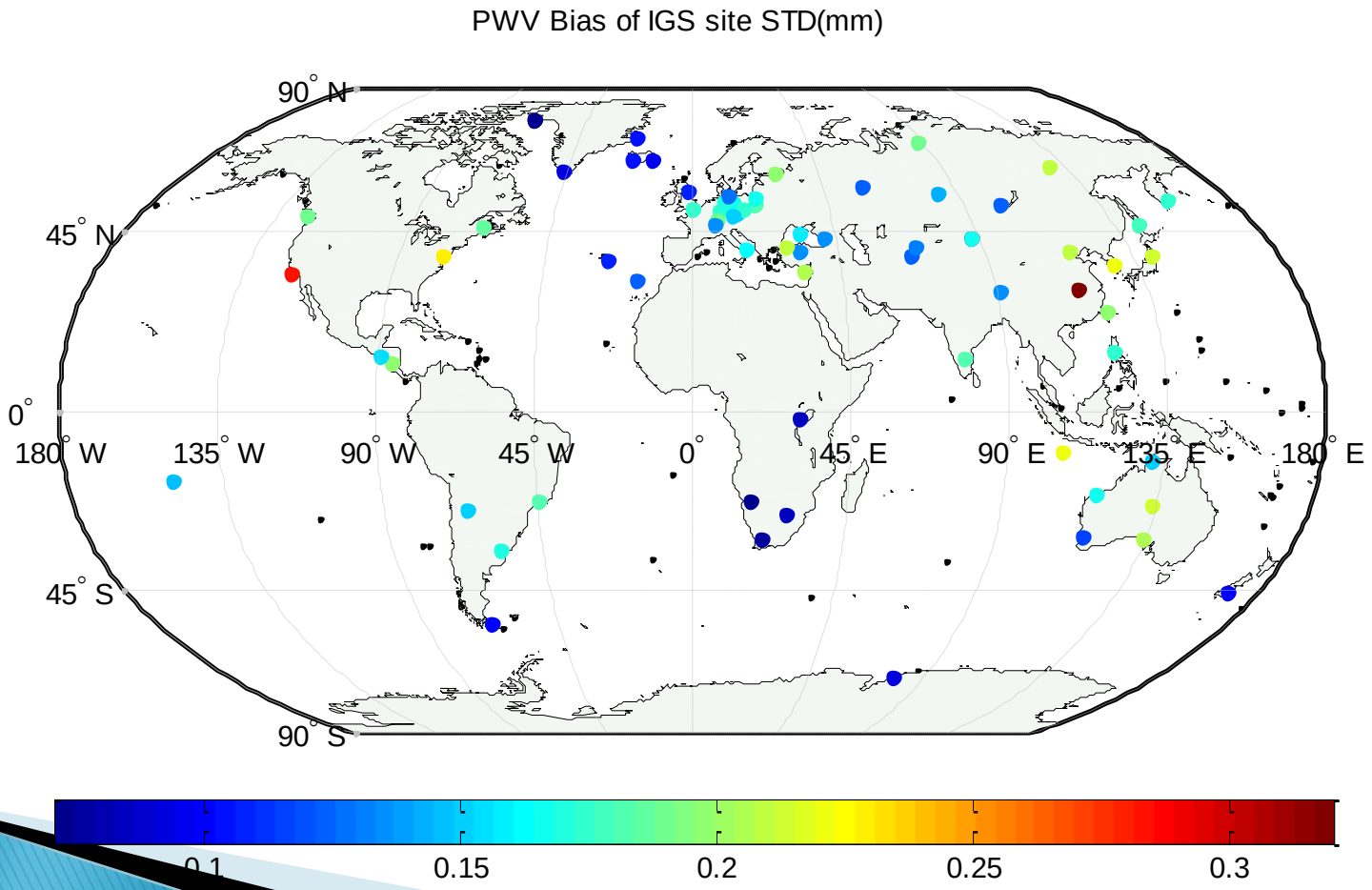

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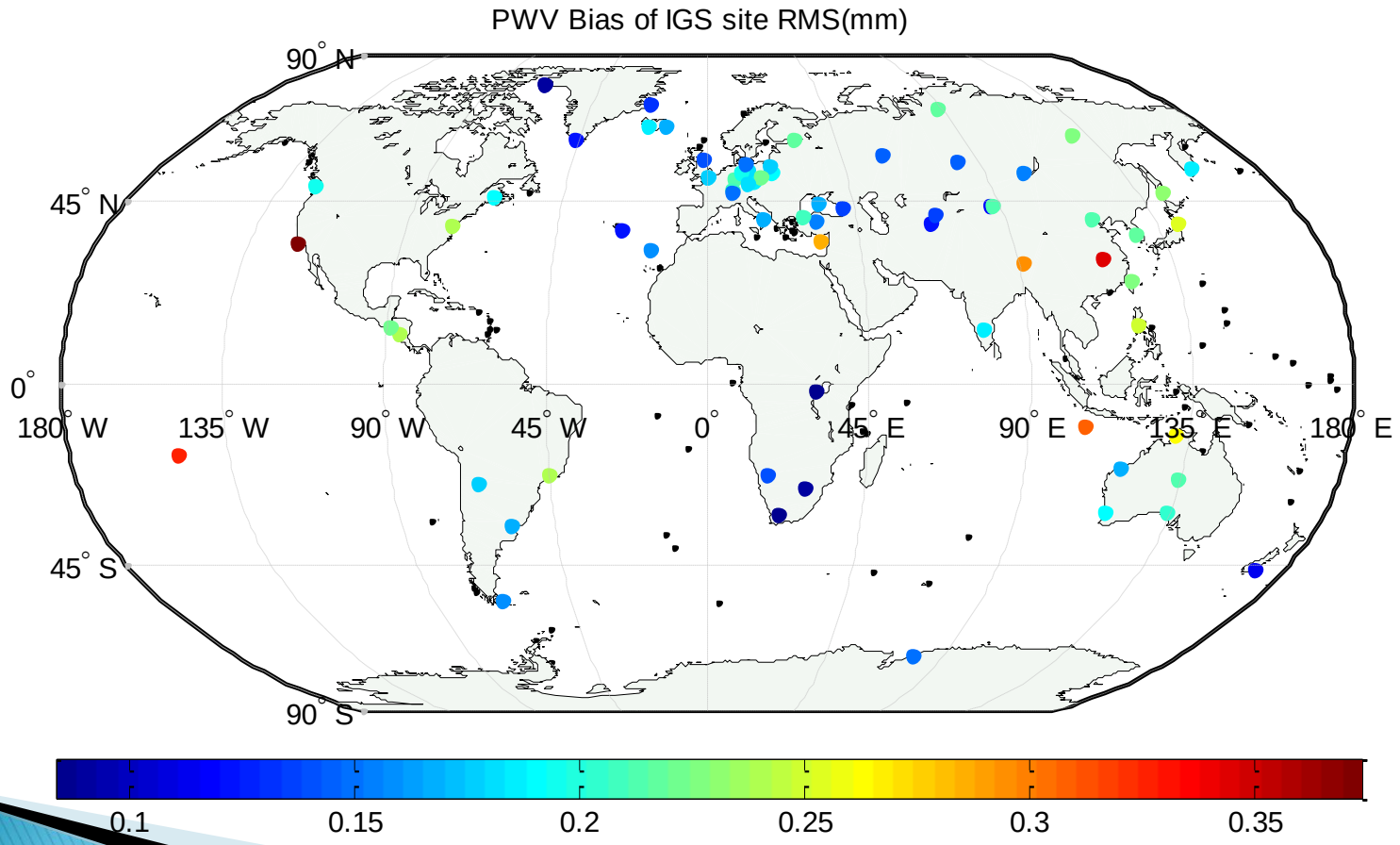

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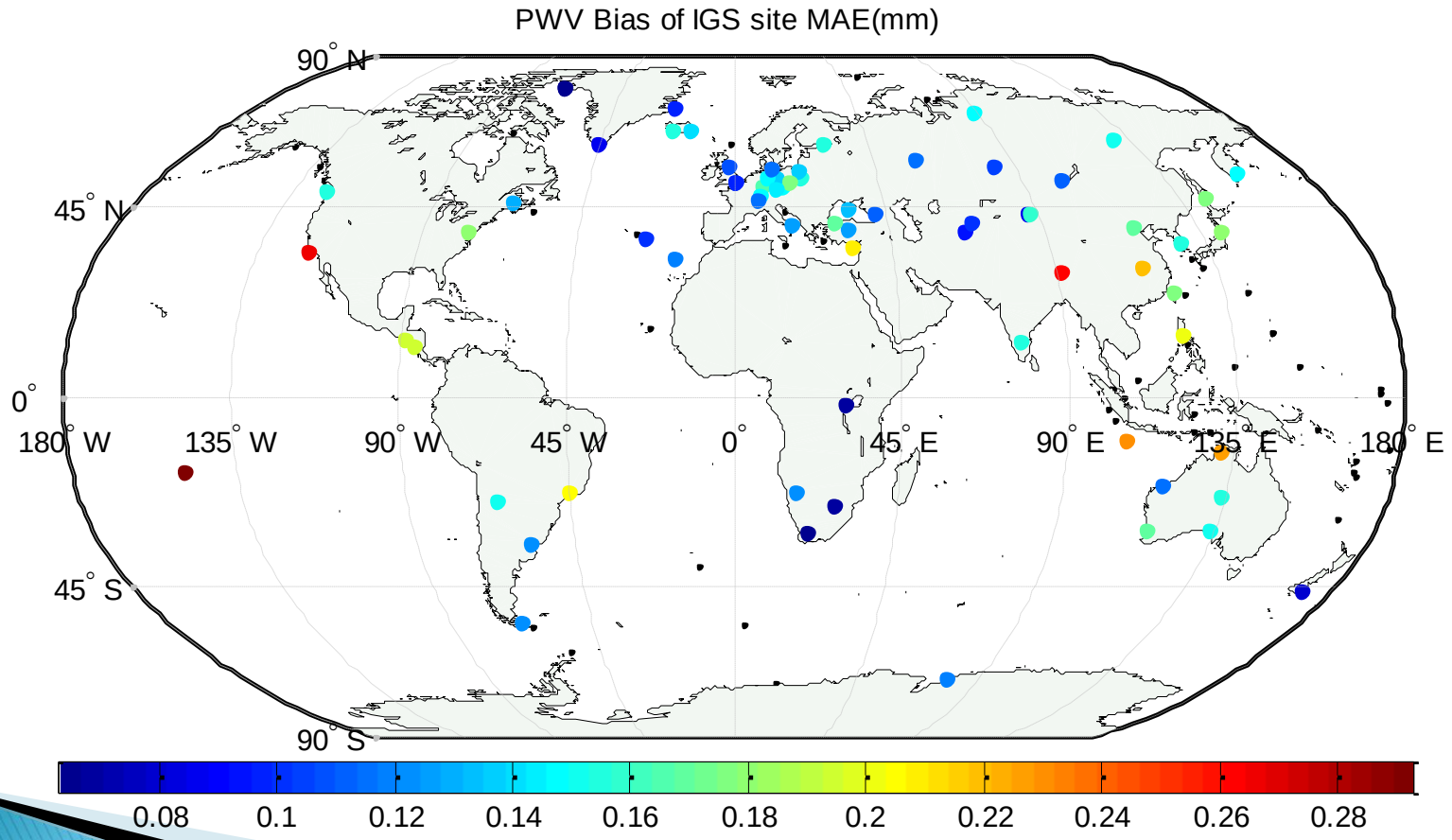

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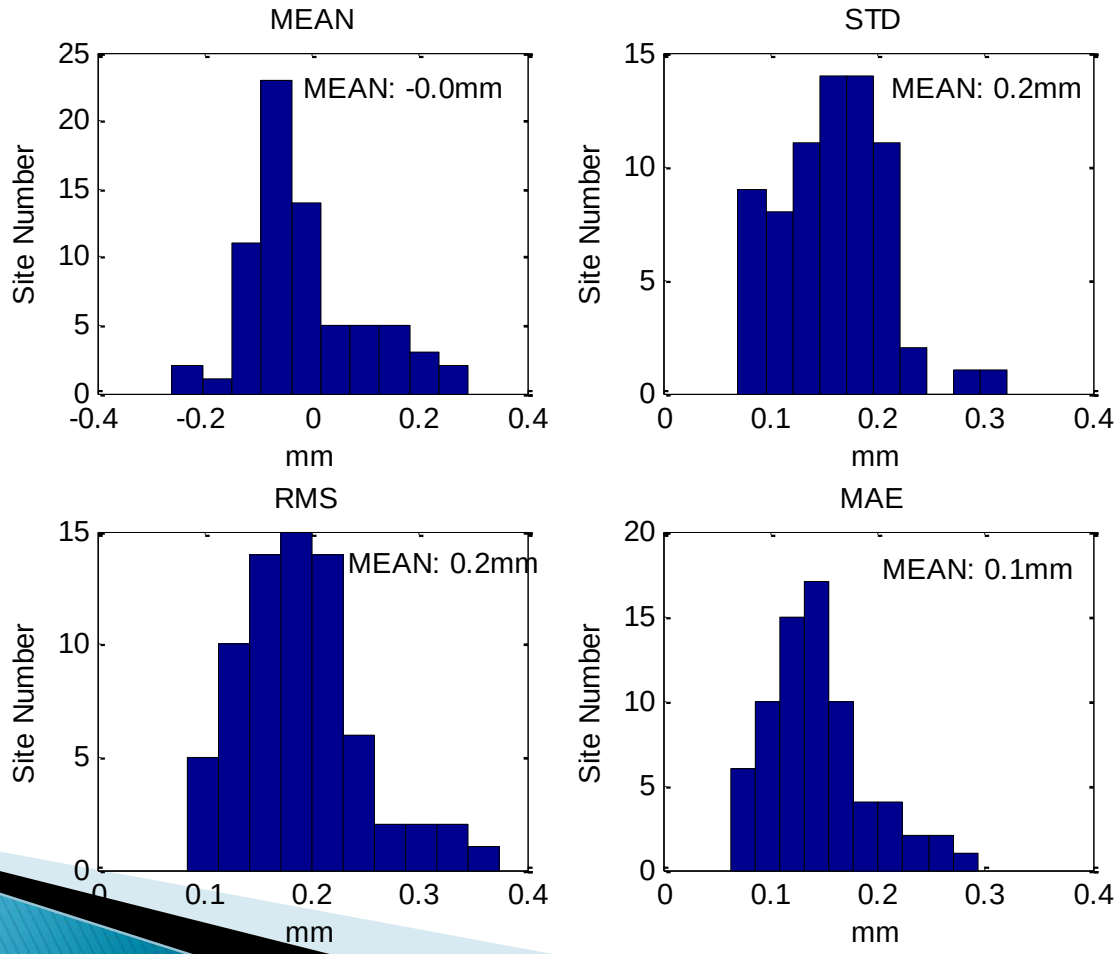
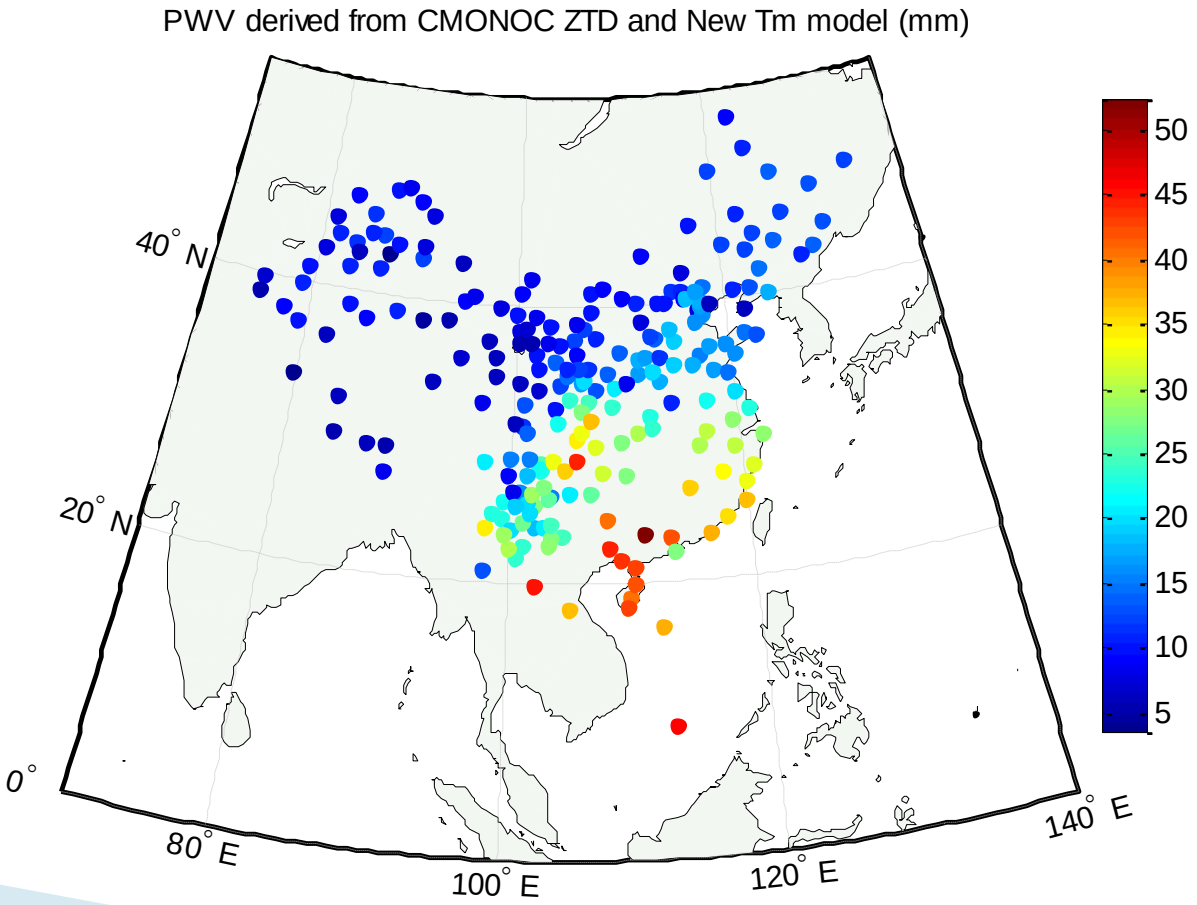


Application - PWV Bias vs Bevis

- CMONOC sites – vs Bevis using metrological data



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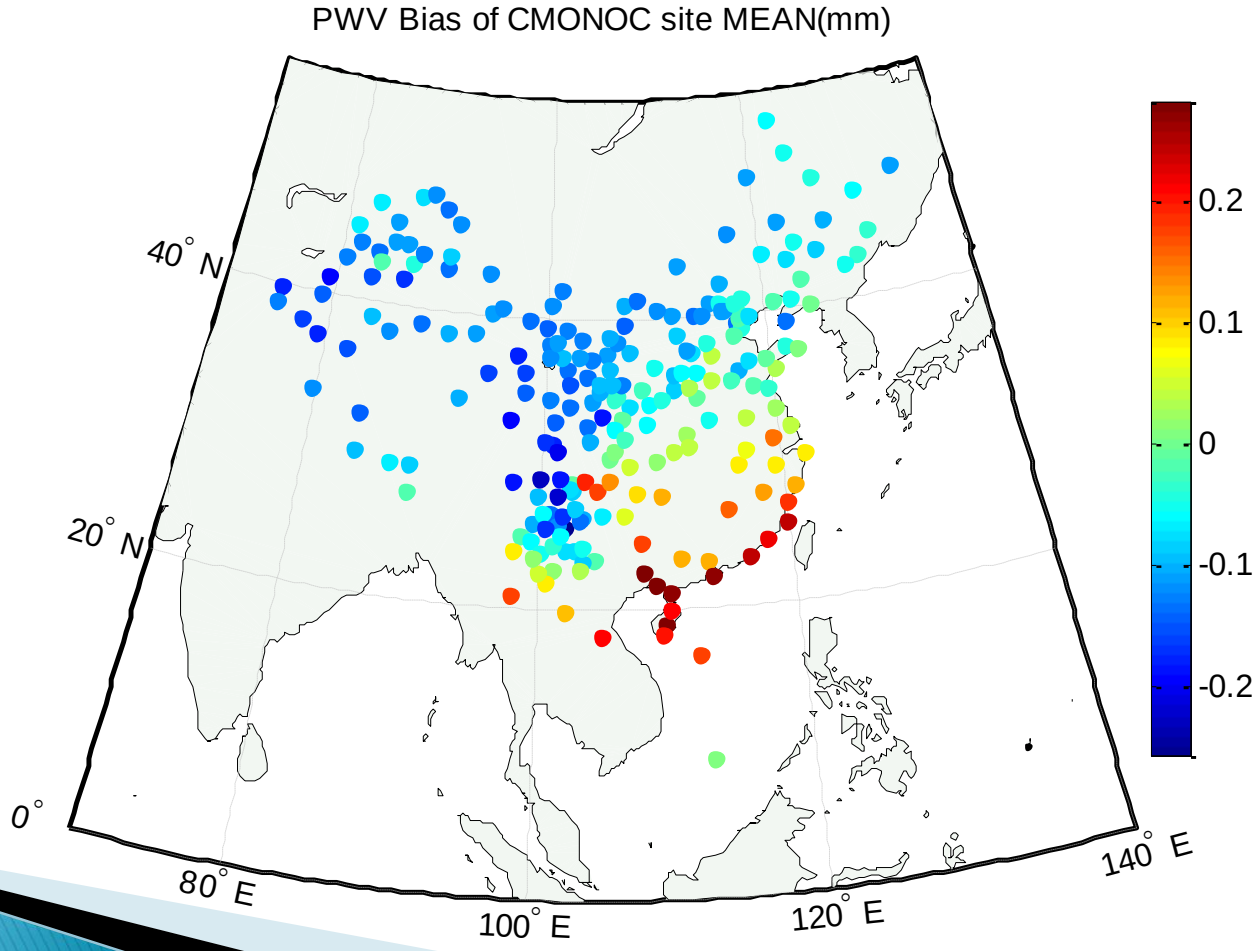

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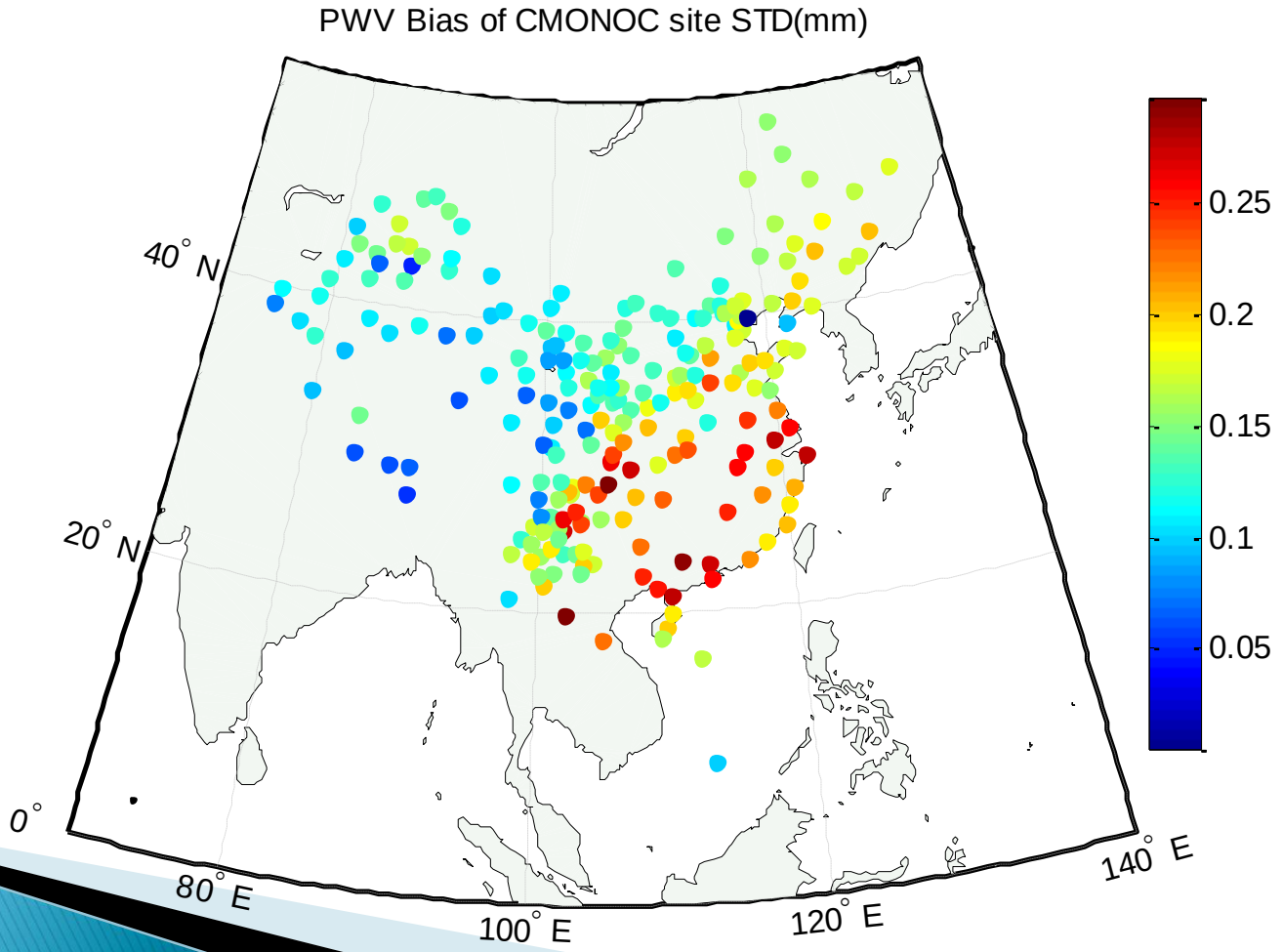

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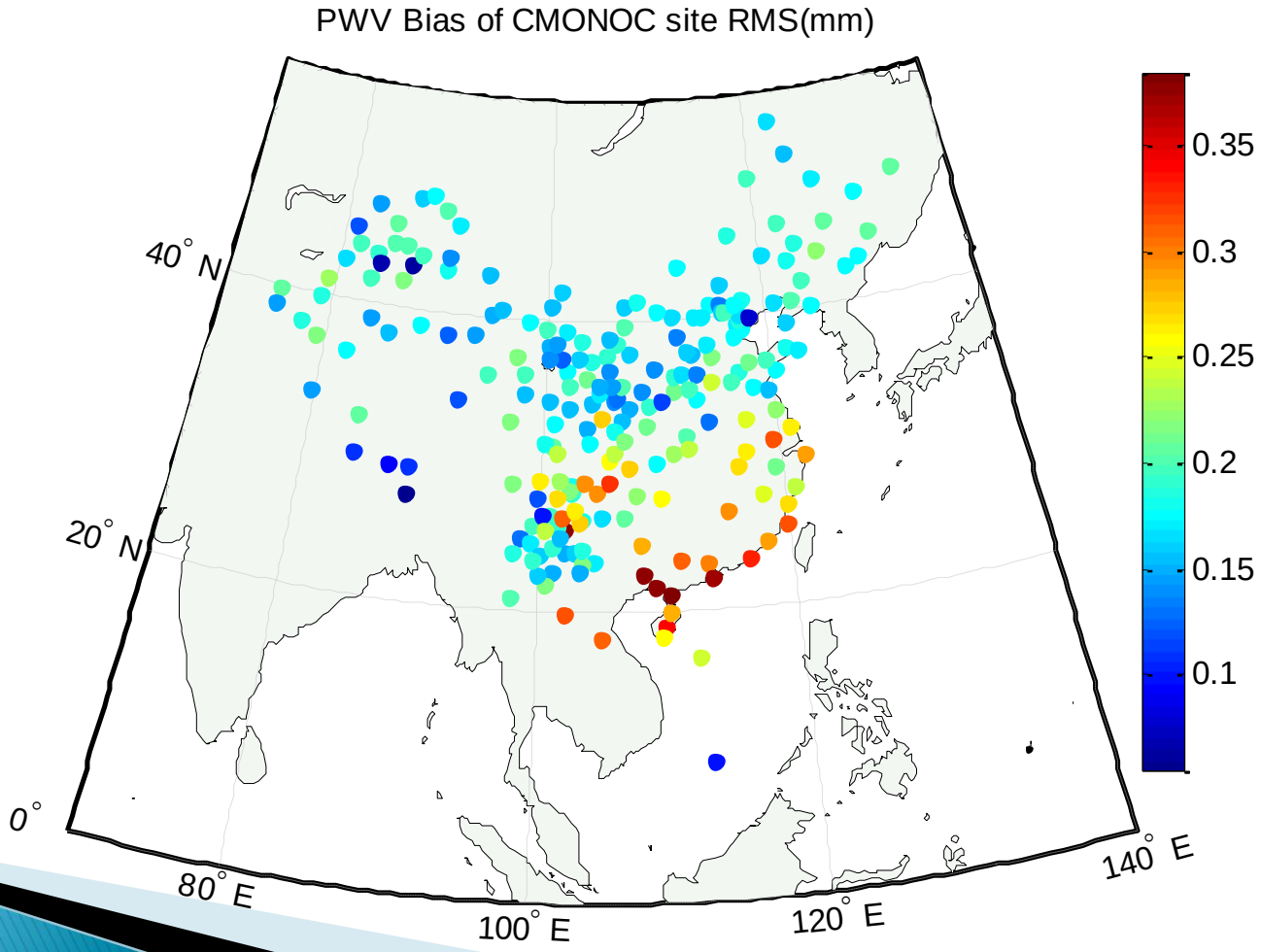
- CMONOC sites - metrological data



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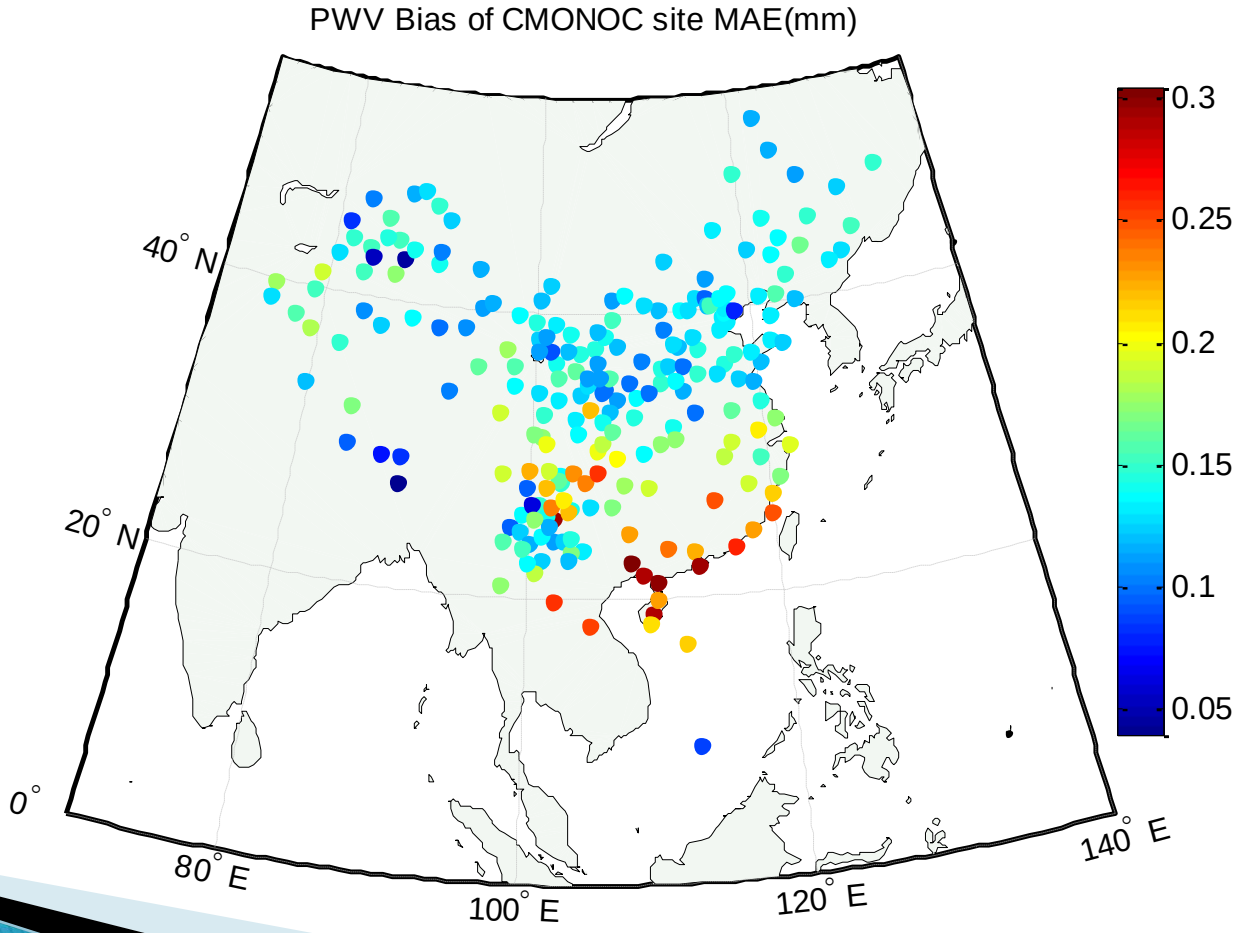

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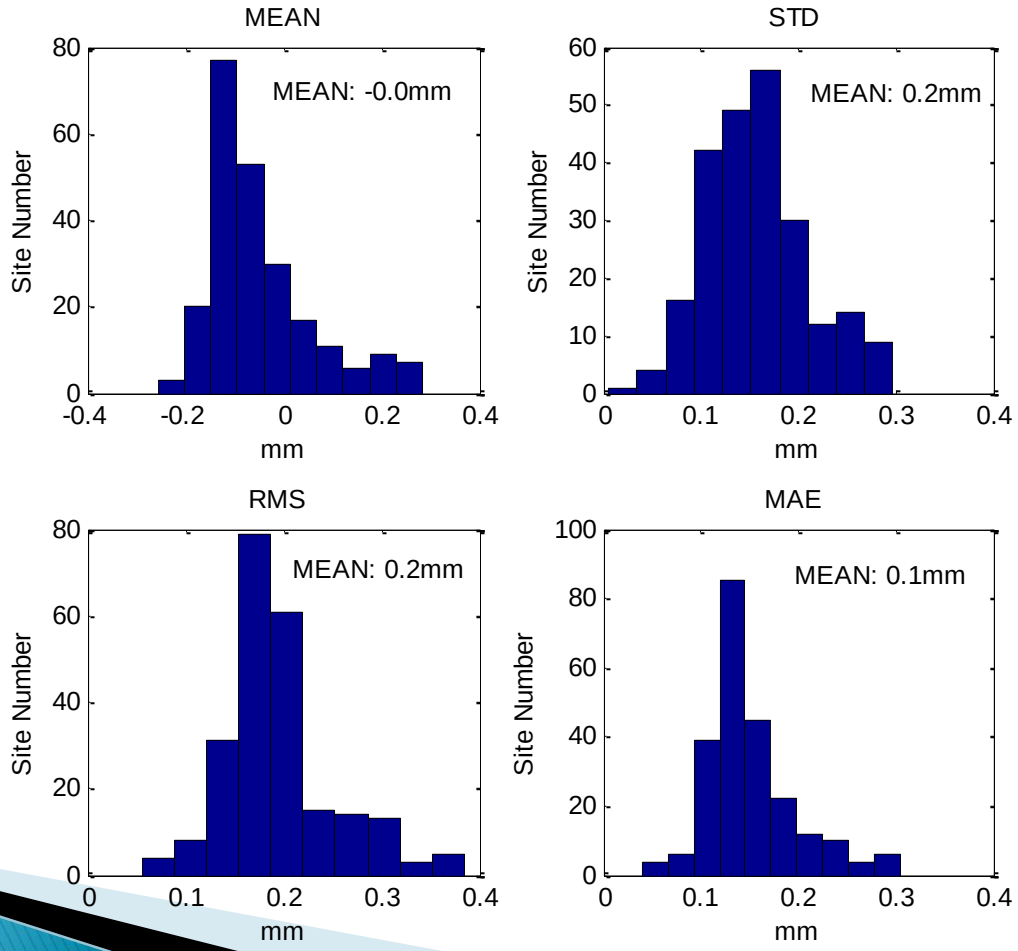

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Conclusion

- New Tm empirical model based on NWM data
- High accuracy

- More validation (radiosonde)
- Optimizing of hydro tropospheric delay calculation – without using meteorological data

THANKS
FOR YOUR ATTENTION

Many Thanks to
CPGPS
CMONOC, GGOS, IGS, SHAO