Evaluation of Atmospheric Loading Modeling Using GNSS Data

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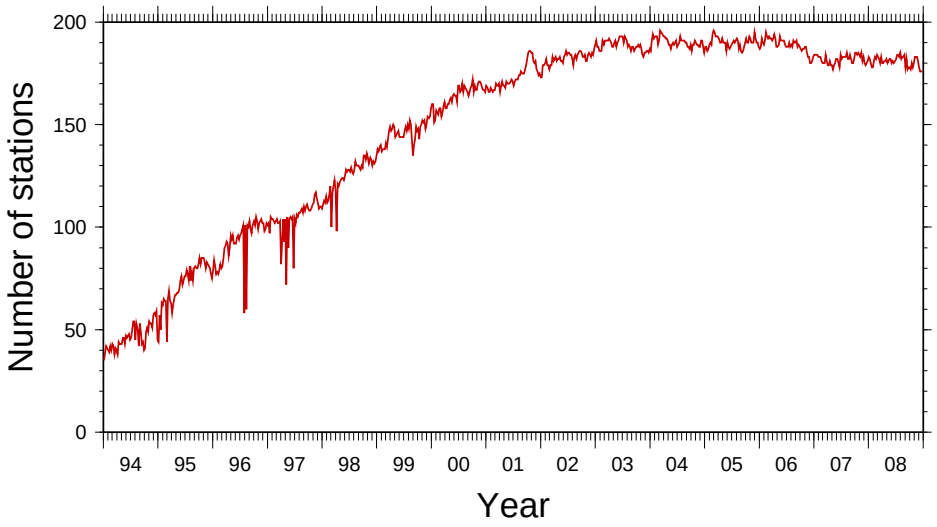
Outline

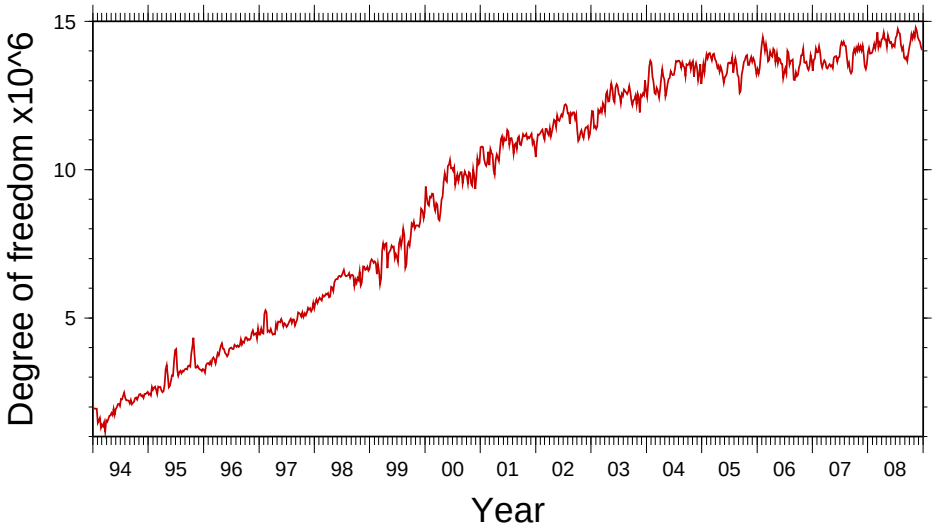
Evaluation of Atmospheric Loading Modeling Using GNSS Data

- Introduction: CODE contribution to the IGS reprocessing effort (repro1).
- Atmospheric pressure loading model: e.g., Petrov and Boy (2004)
- How to apply atmospheric pressure loading corrections?
  - based on weekly solutions, on observation level, or with a scaling factor?
- Validation of the model by estimating scaling factors.
- Conclusions and outlook

Generation of the GNSS solution

- starting with observation files from CO1 repro. (GPS–only)
- CODE standard processing is solving for CRD, TRP, ORB, ERP modeling: latest hardisp and troposphere VMF1/ECMWF
- daily solution → weekly NEQs
- cumulative solution from NEQs significant outliers and discont. using the FODITS–tool of BSW
- NNR–condition for coordinates and linear velocities on IGS05 reference frame sites





Pressure loading model: evaluation 1

Can atmospheric pressure loading explain seasonal variations in coordinate time series?

- Example: Atmospheric pressure loading model from Petrov and Boy, 2004

  consists of two components
  - S1/S2 tidal pressure loading coefficients
  - 2.5$\times$2.5 grids for the non–tidal component every 6 hours

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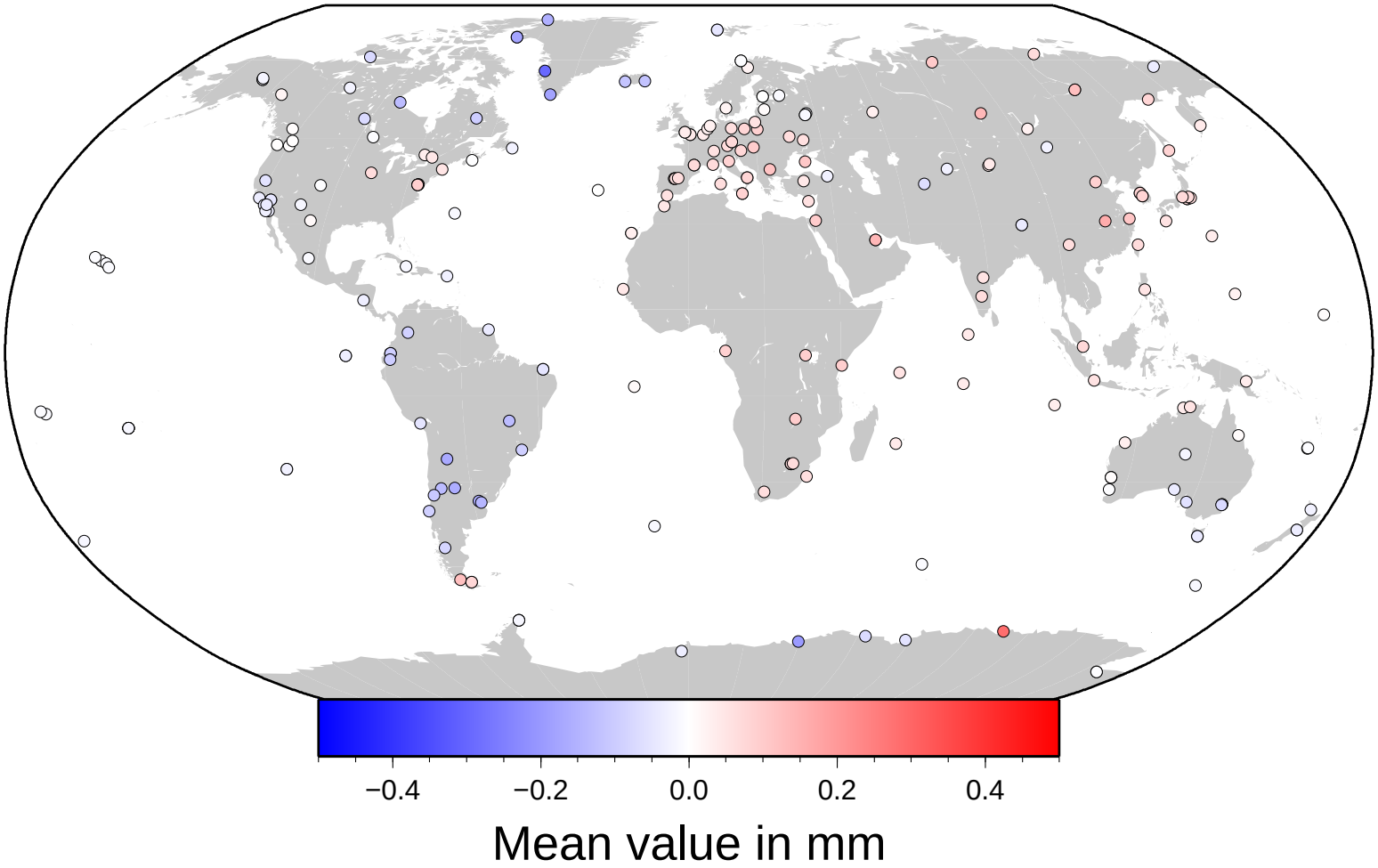
Evaluation 1:

- What impact on a GNSS solution can be expected from the model?

Atmospheric loading model

Atmospheric pressure loading model from Petrov and Boy, 2004

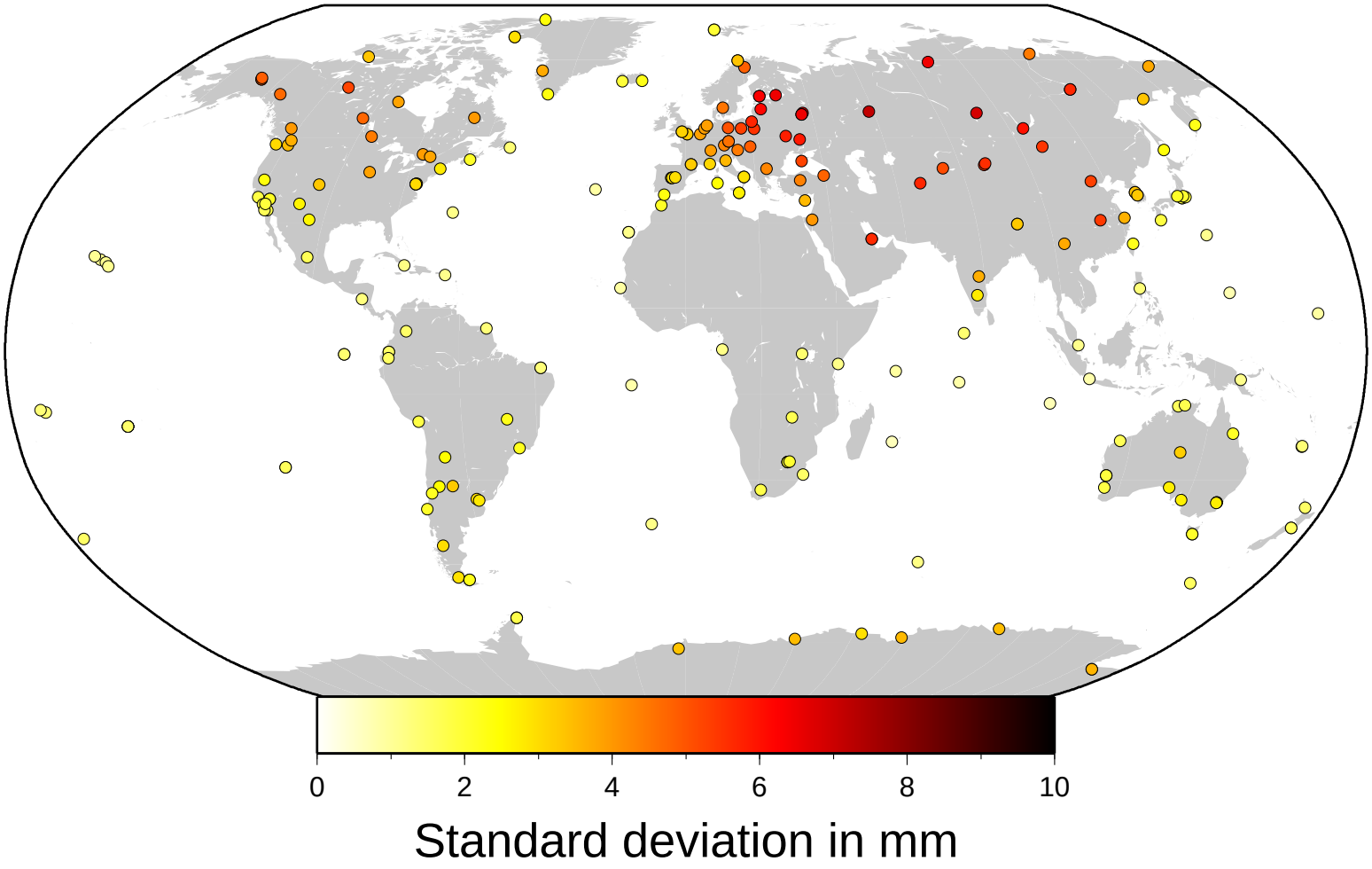
Mean non–tidal correction over 15 years



Atmospheric loading model

Atmospheric pressure loading model from Petrov and Boy, 2004

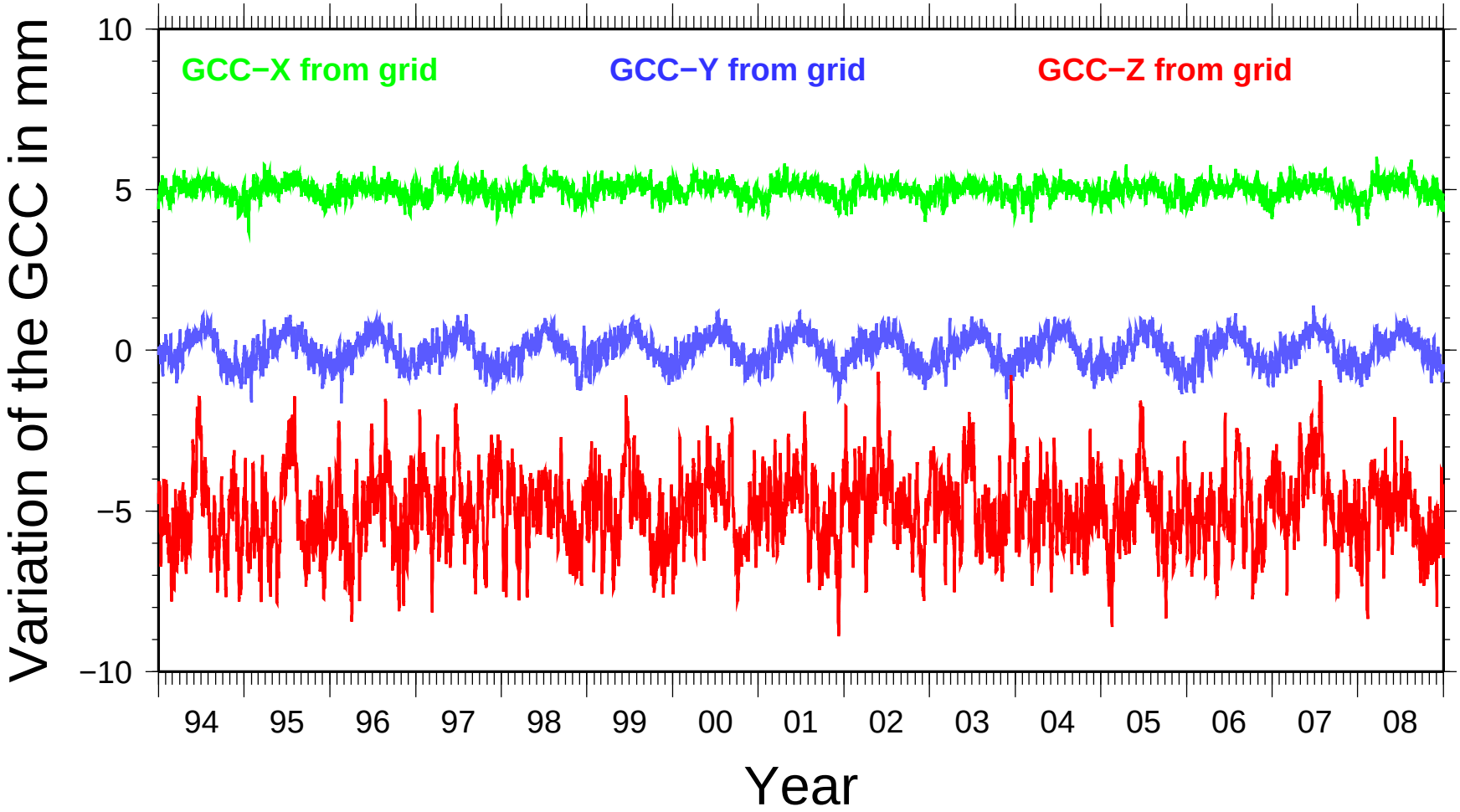
RMS of the non–tidal correction over 15 years



Atmospheric loading model

Atmospheric pressure loading model from Petrov and Boy, 2004

How does the pressure loading model translate into the geocenter?



Pressure loading model: evaluation 2

Can atmospheric pressure loading explain seasonal variations in coordinate time series?

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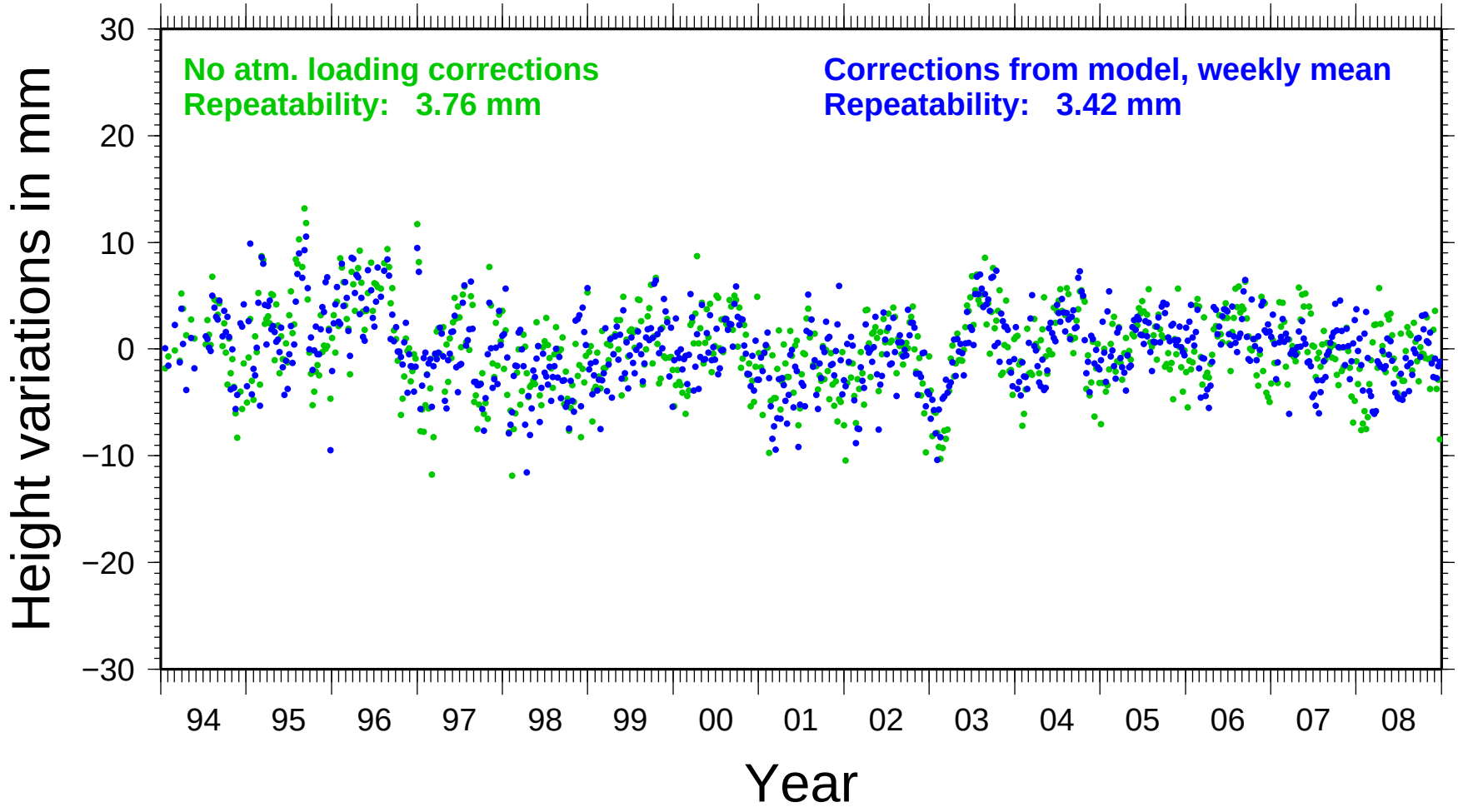
Evaluation 2:

- The non–tidal part is averaged for each station over one week
  if the station was available for this week.
- The correlation coefficients between the weekly mean effect from the model and the coordinate time series is evaluated.

Pressure loading model: evaluation 2

Repeatability of the weekly solutions considering atm. loading

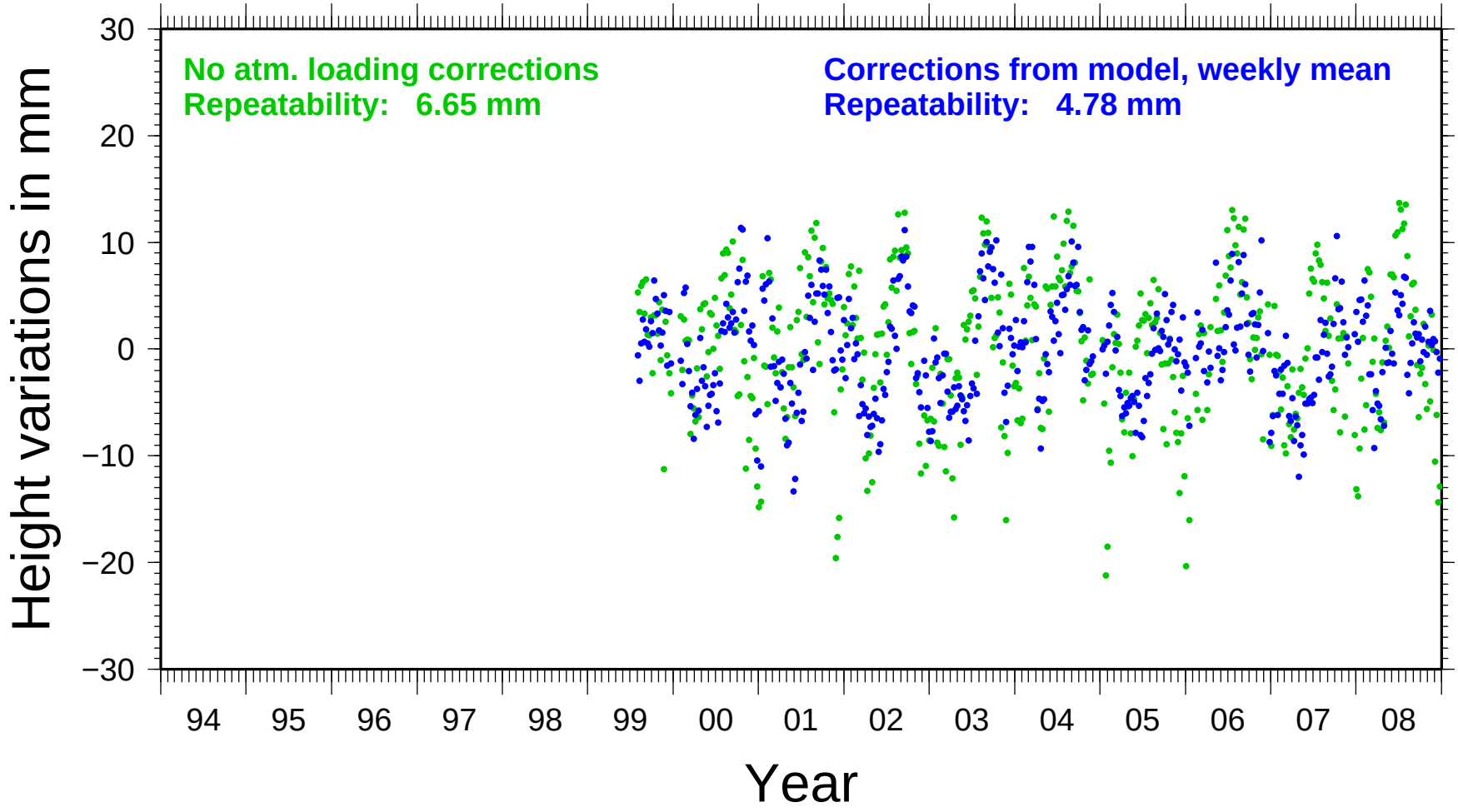
Example: Zimmerwald (ZIMM), Switzerland



Pressure loading model: evaluation 2

Repeatability of the weekly solutions considering atm. loading

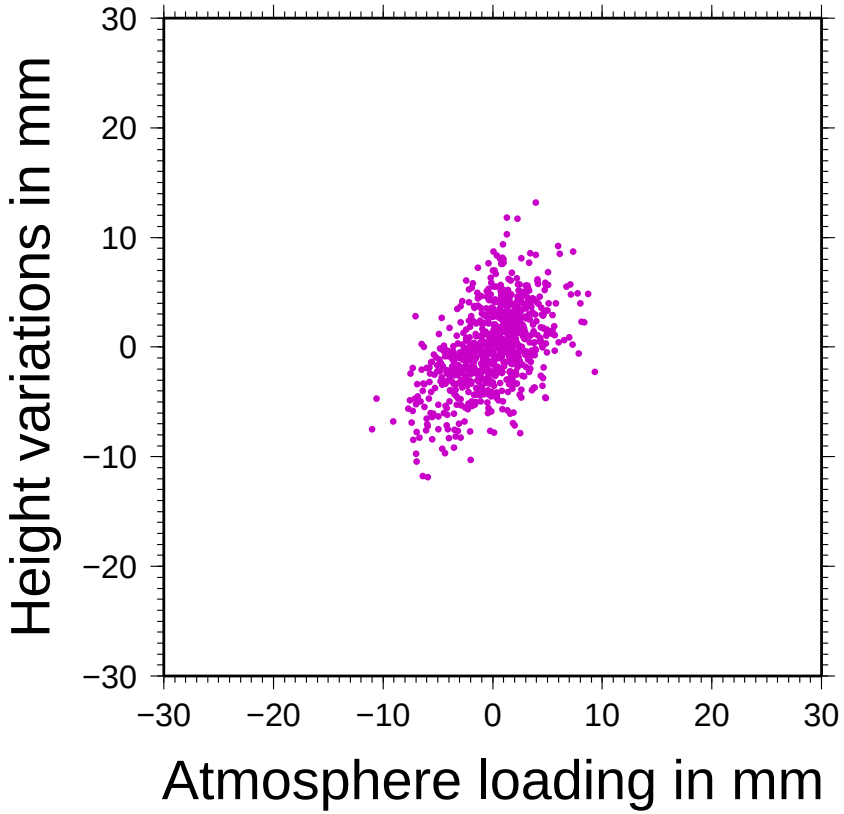
Example: Arti (ARTU), Russia



Pressure loading model: evaluation 2

Correlatogram between height variations and pressure loading

Zimmerwald (ZIMM), Switzerland



Regression coefficient: 1.30±0.04

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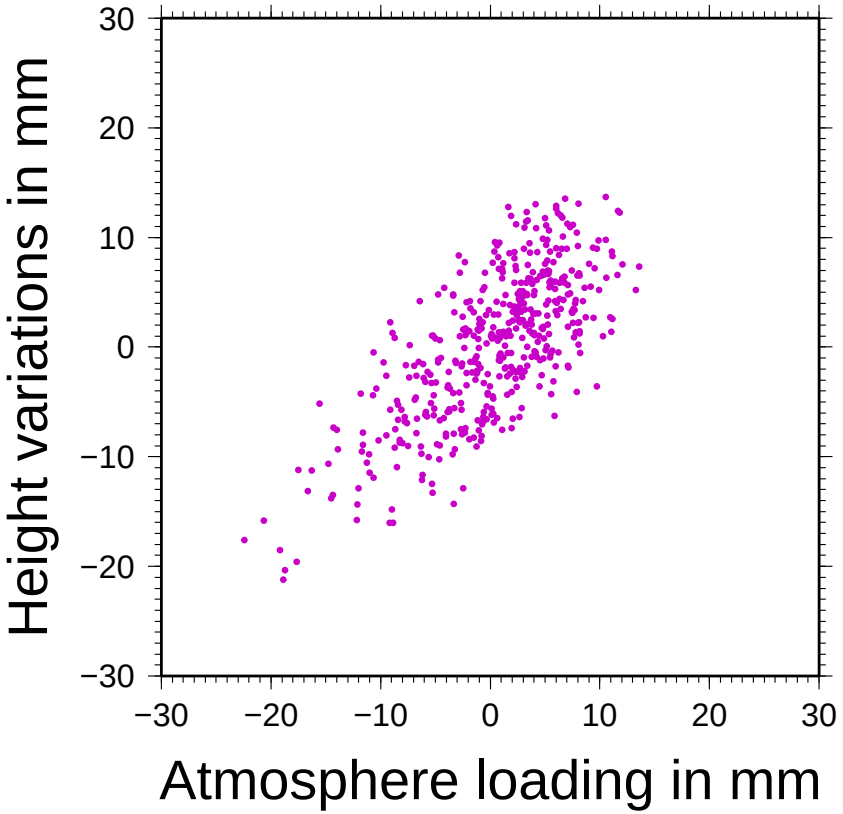

Regression coefficient: 1.27±0.03

Pressure loading model: evaluation 3

Can atmospheric pressure loading explain seasonal variations in coordinate time series?

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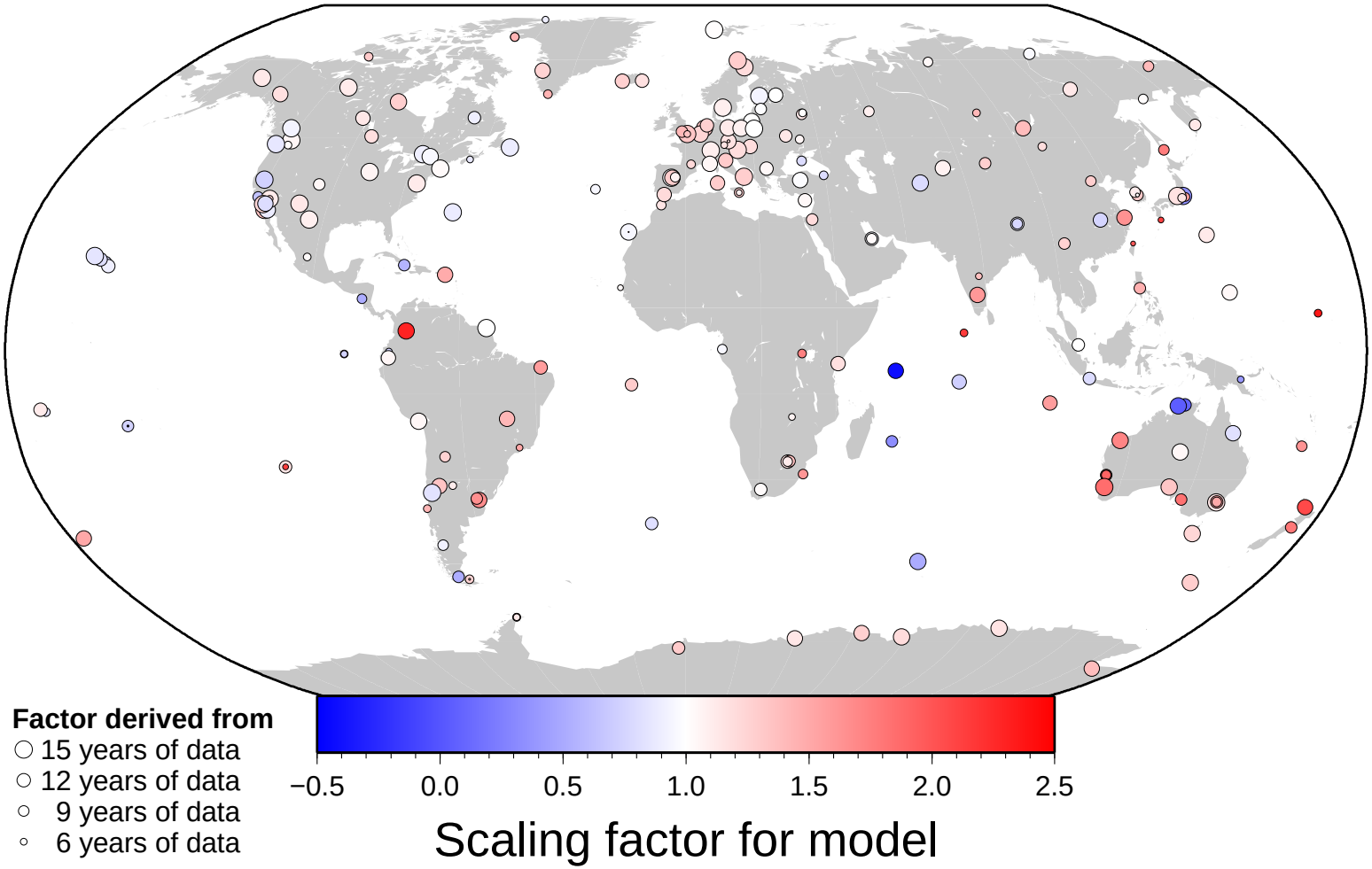
Evaluation 3:

- Tidal component is directly applied to the observations
- Evaluation of the non–tidal loading model by estimating scaling factors for each component and station
  - scaling factor of one: model is fully confirmed
- These scaling factors are introduced as “usual” parameters in the analysis process and stacked on NEQ–level in the cumulative solution.

Scaling factors for the model

Estimated scaling factors for the atmospheric loading model

Mean scaling factors over 15 years



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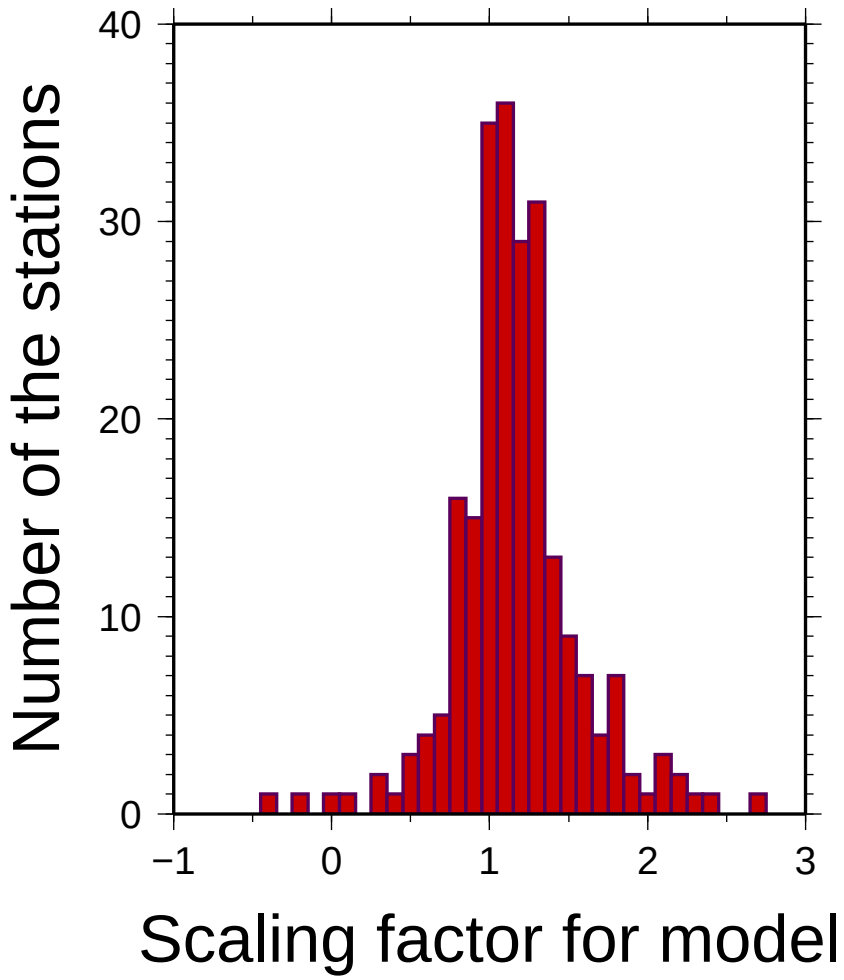

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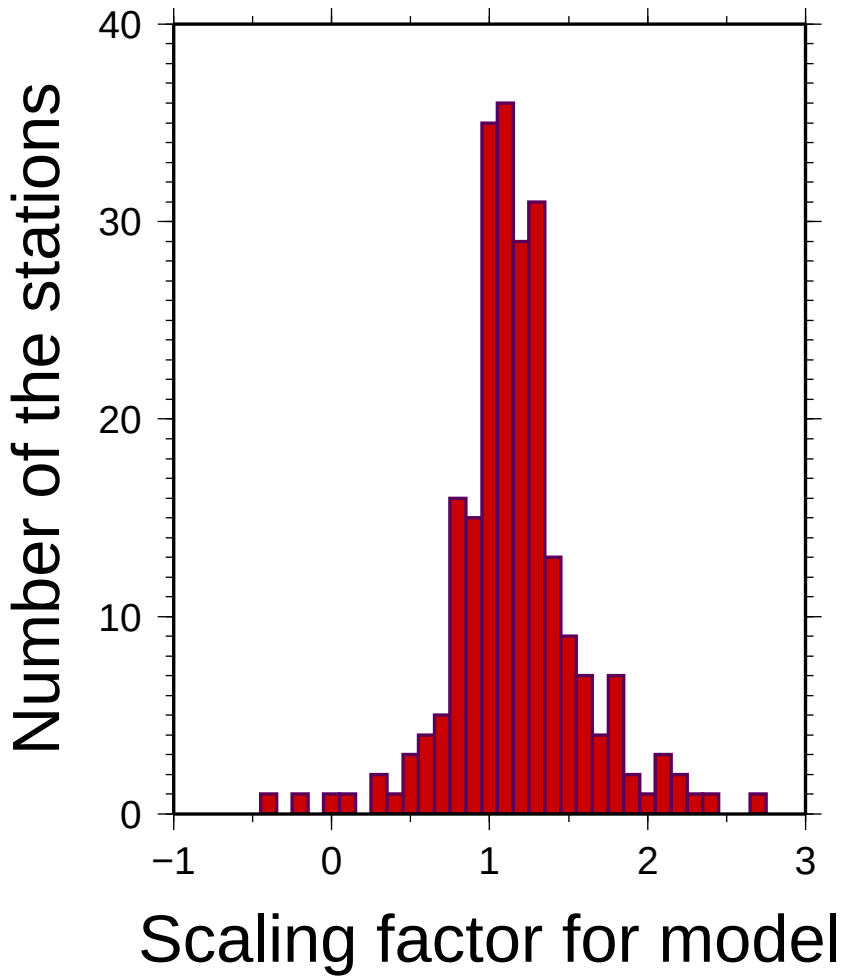
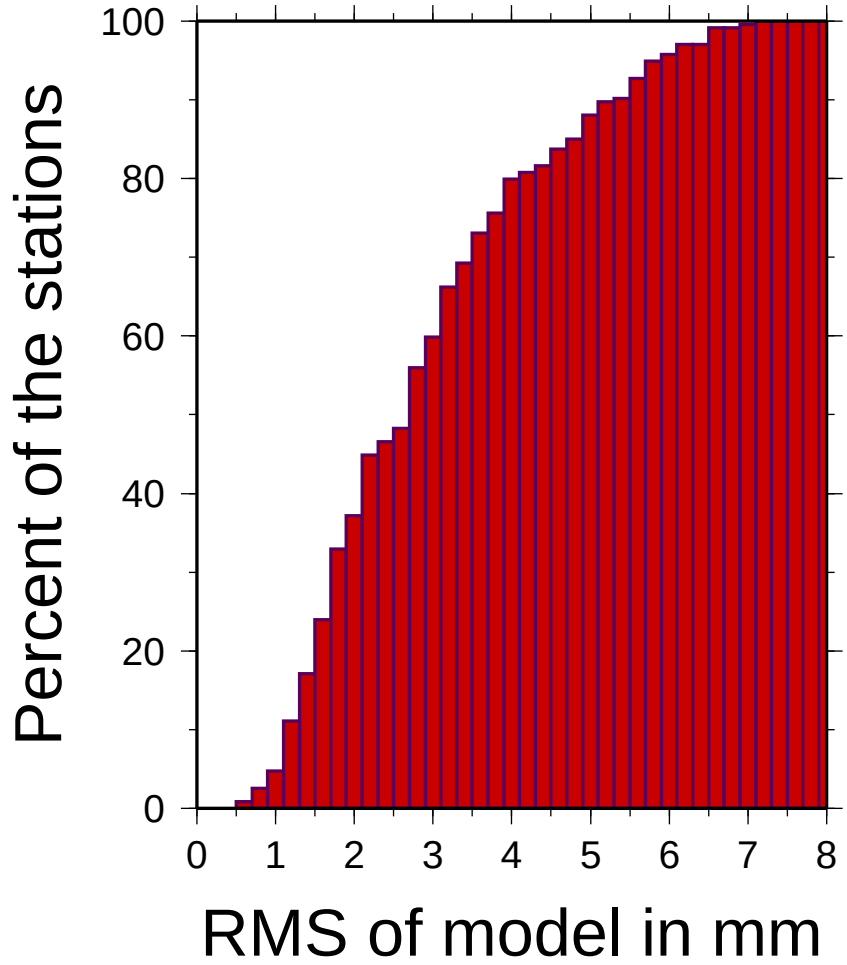


RMS of the corrections over 15 years



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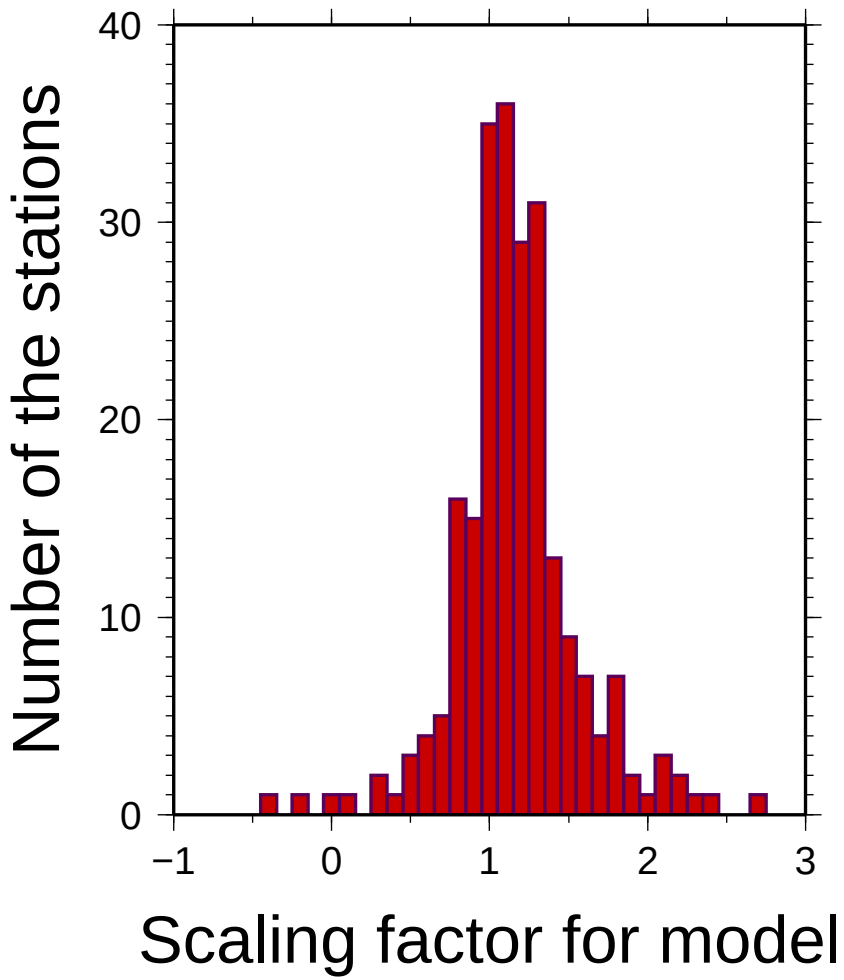
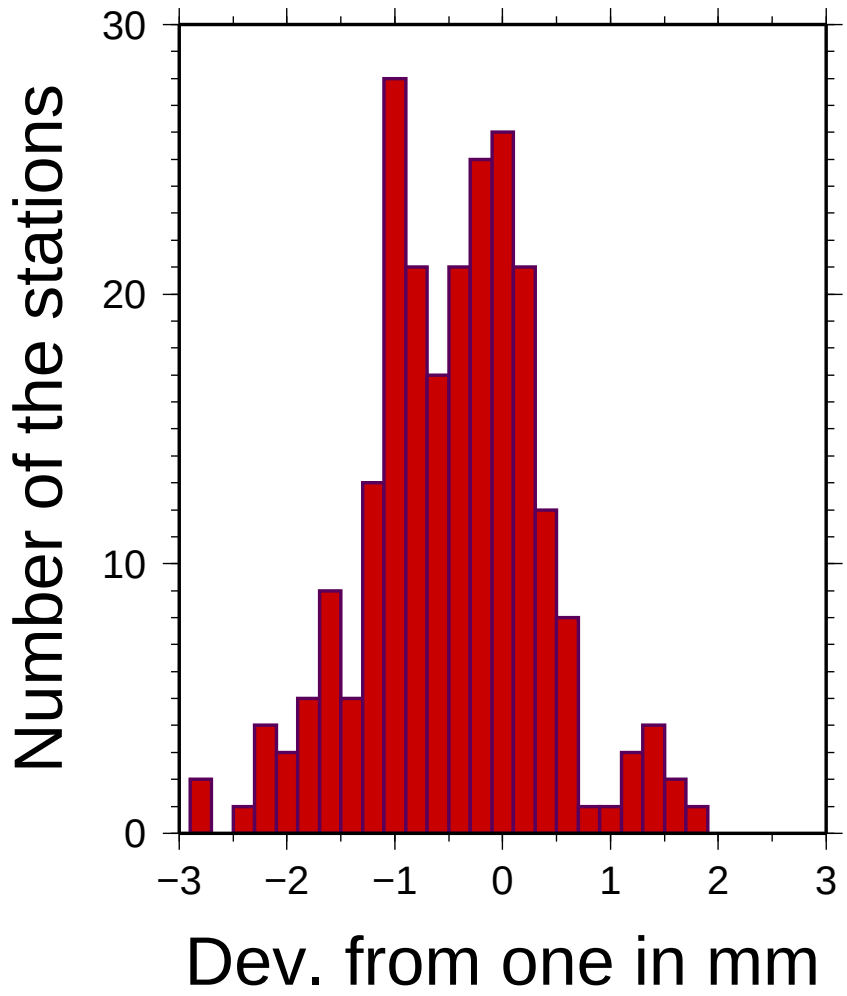


Dev. from one, norm. with RMS



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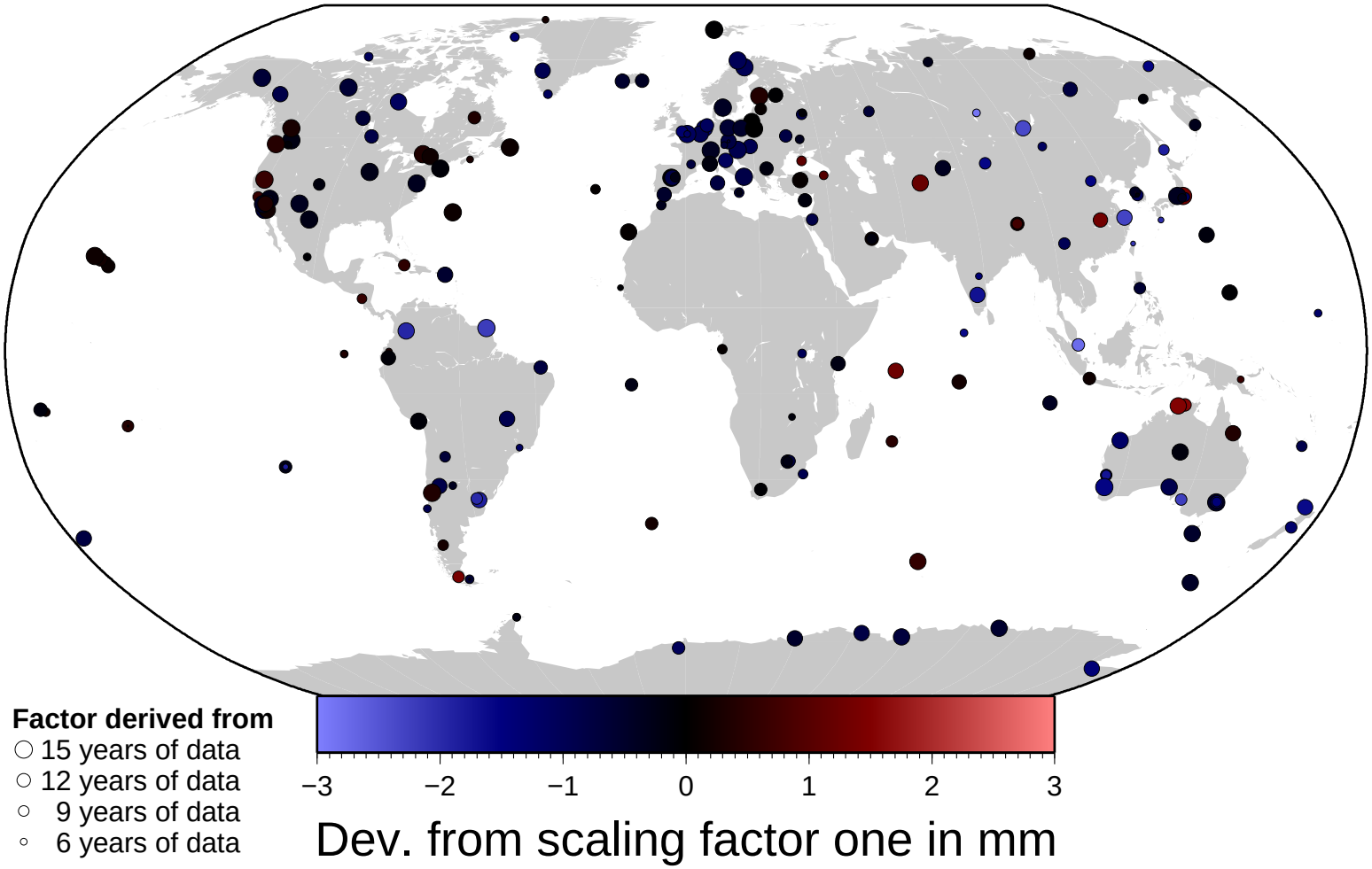
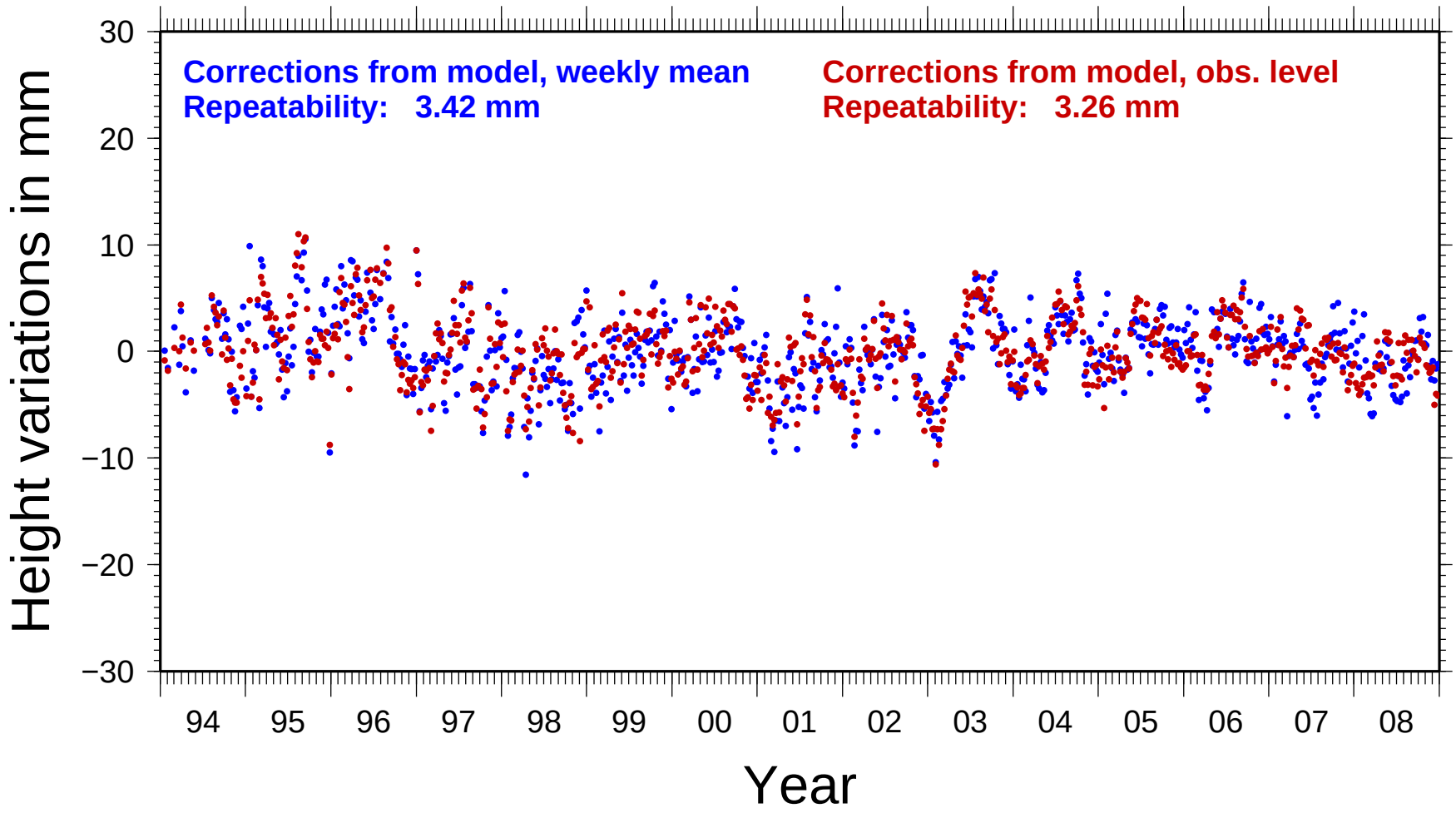


Scaling factors for the model

Repeatability of the weekly solutions considering atm. loading

Example: Zimmerwald (ZIMM), Switzerland



Scaling factors for the model

Evaluation of the scaling factors for the atm. loading model

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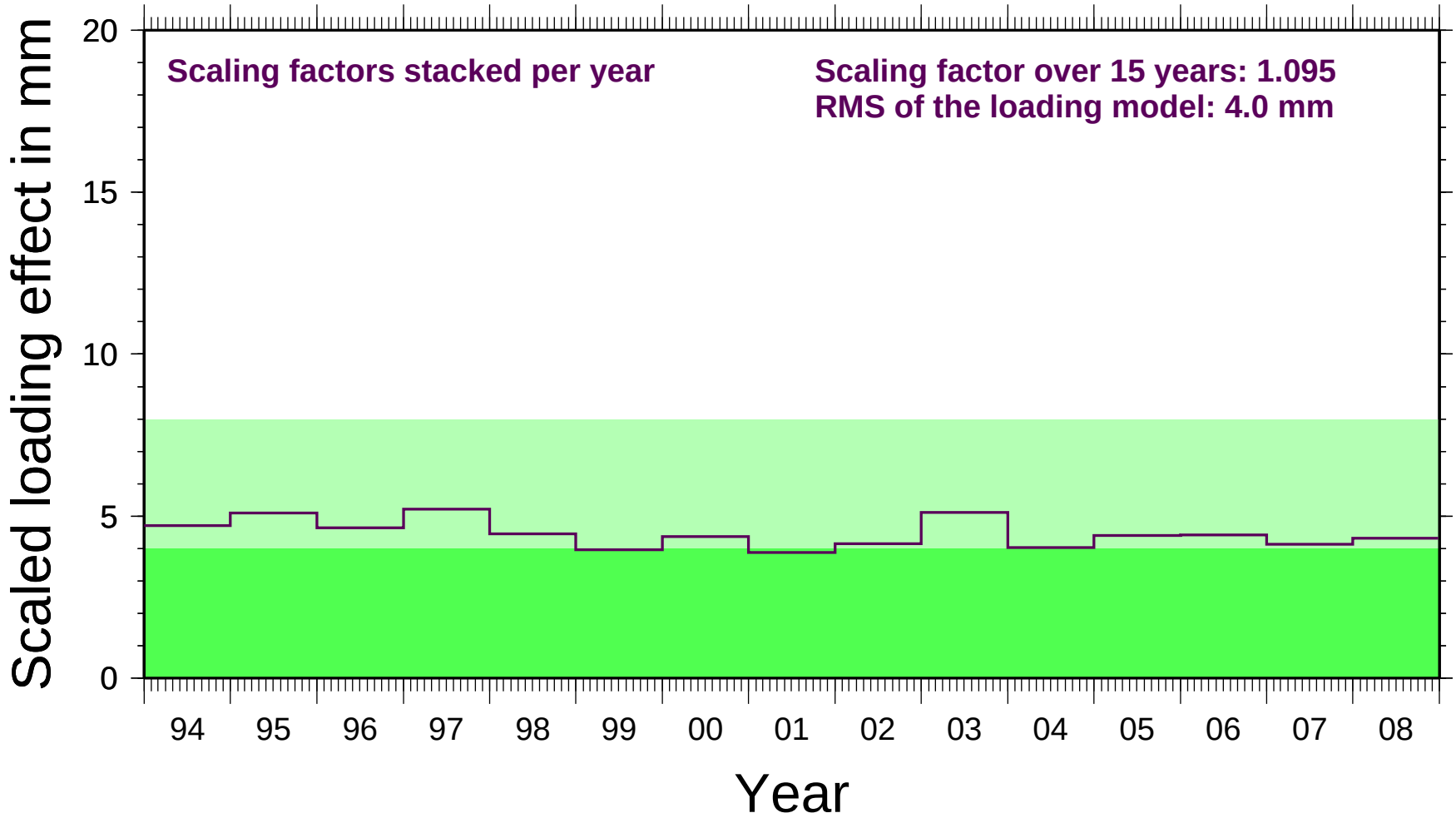

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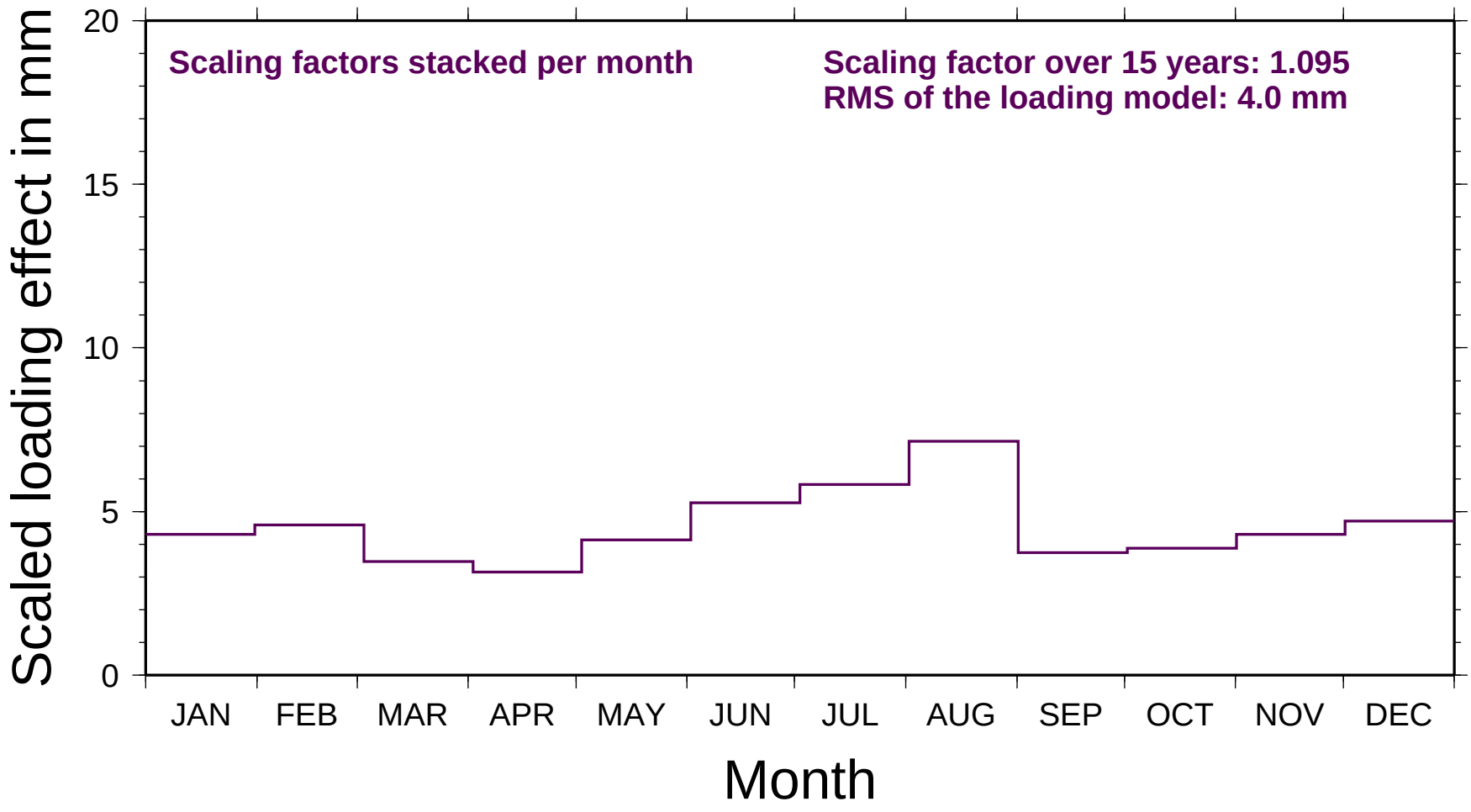

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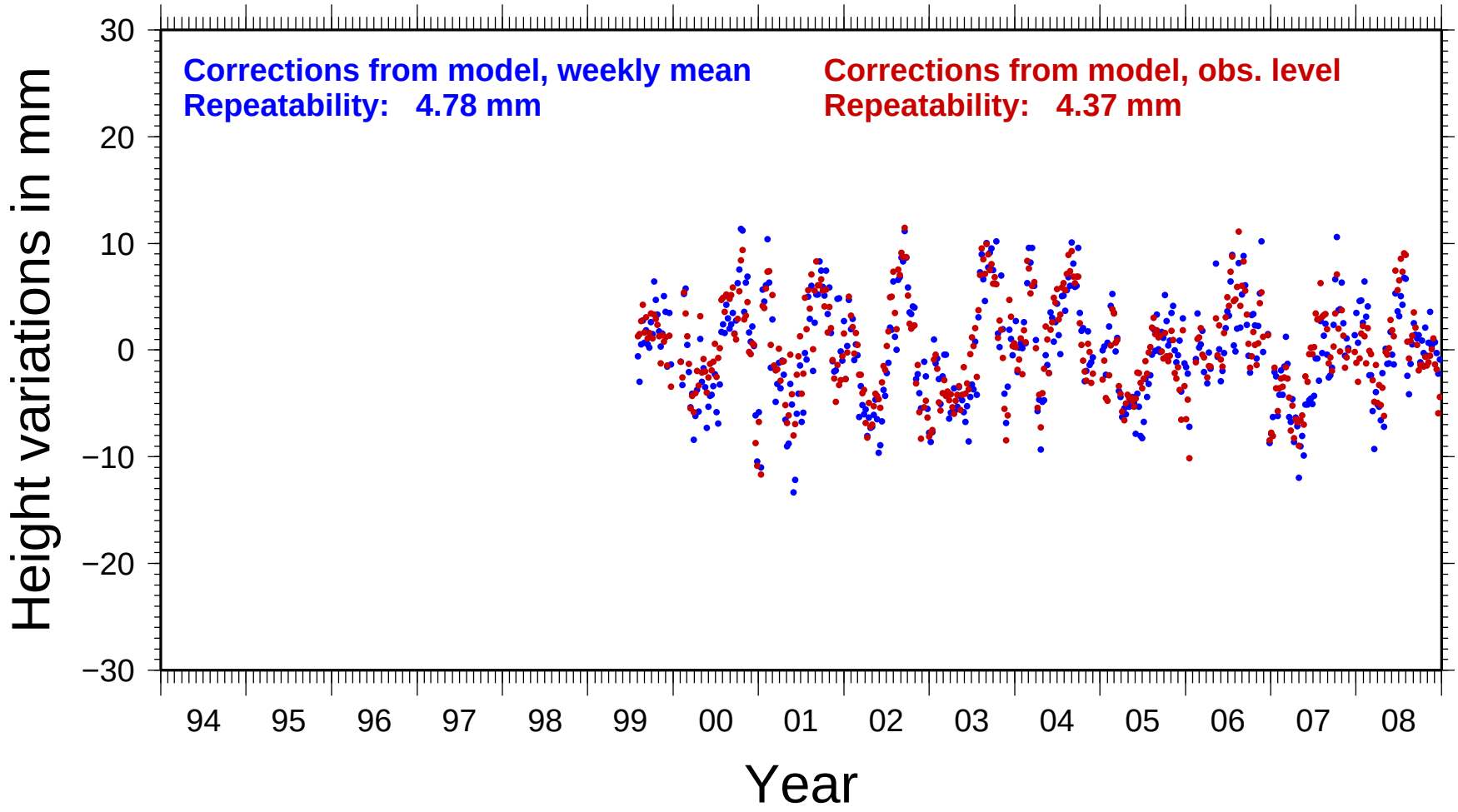

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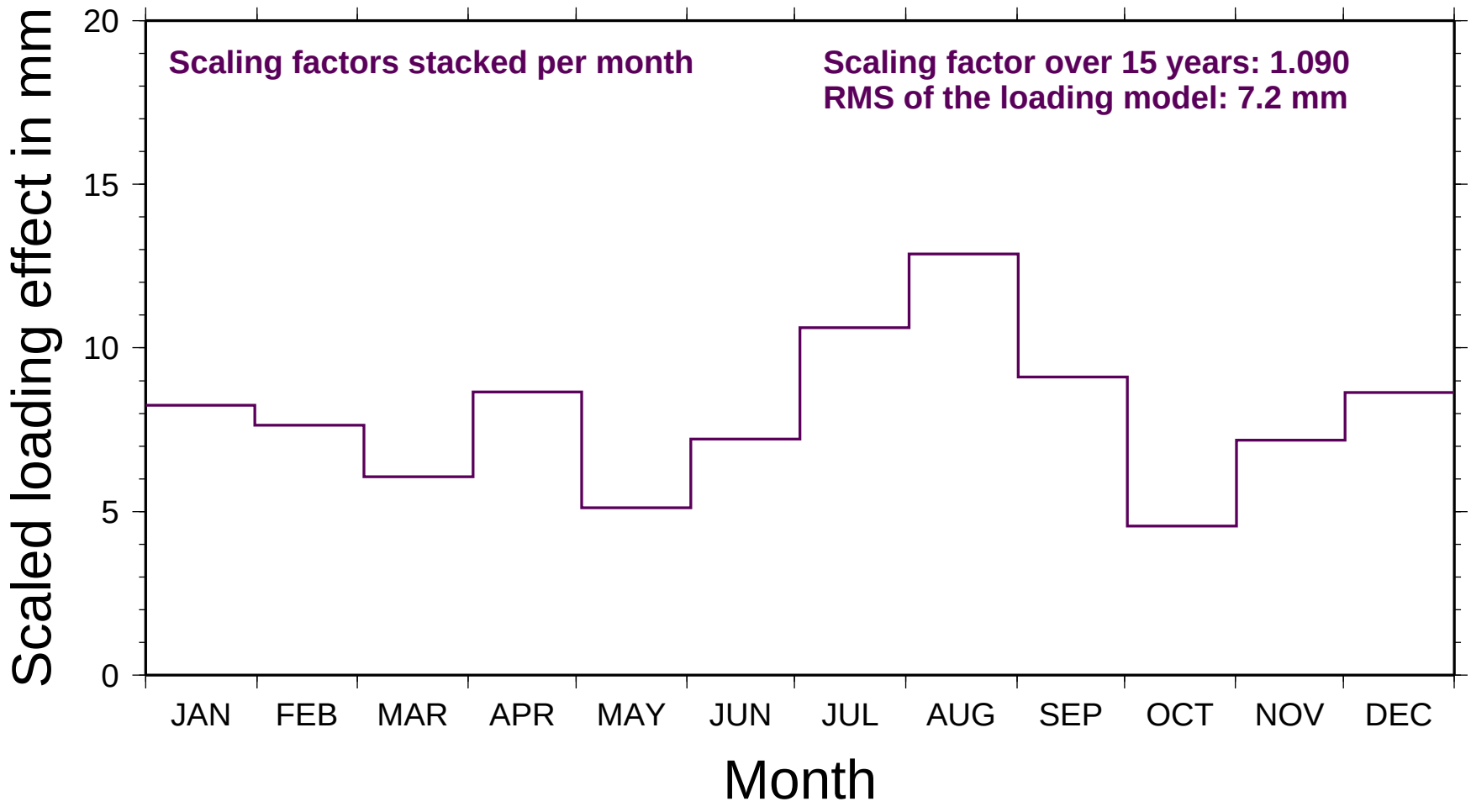

Repeatability of the coordinate solution

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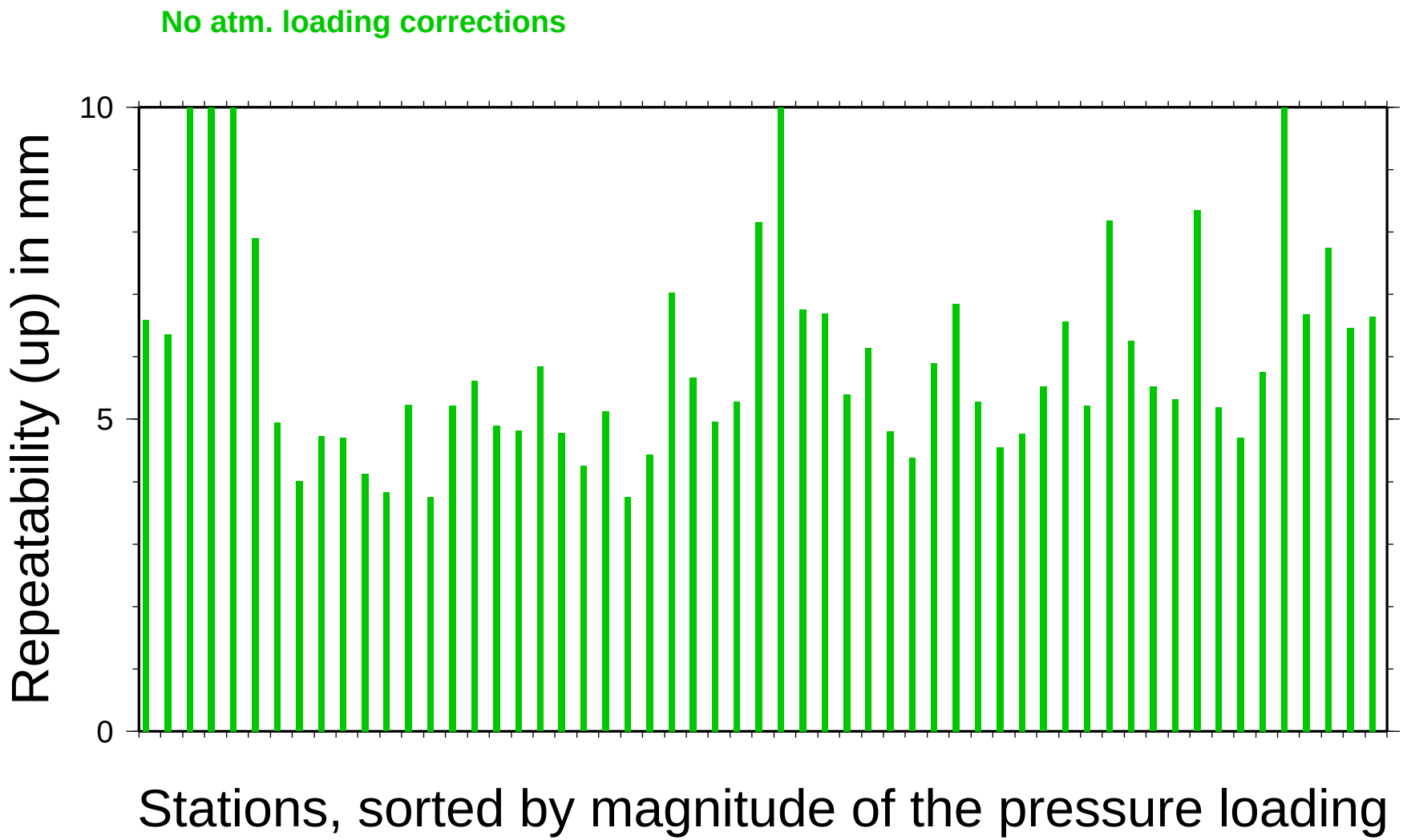

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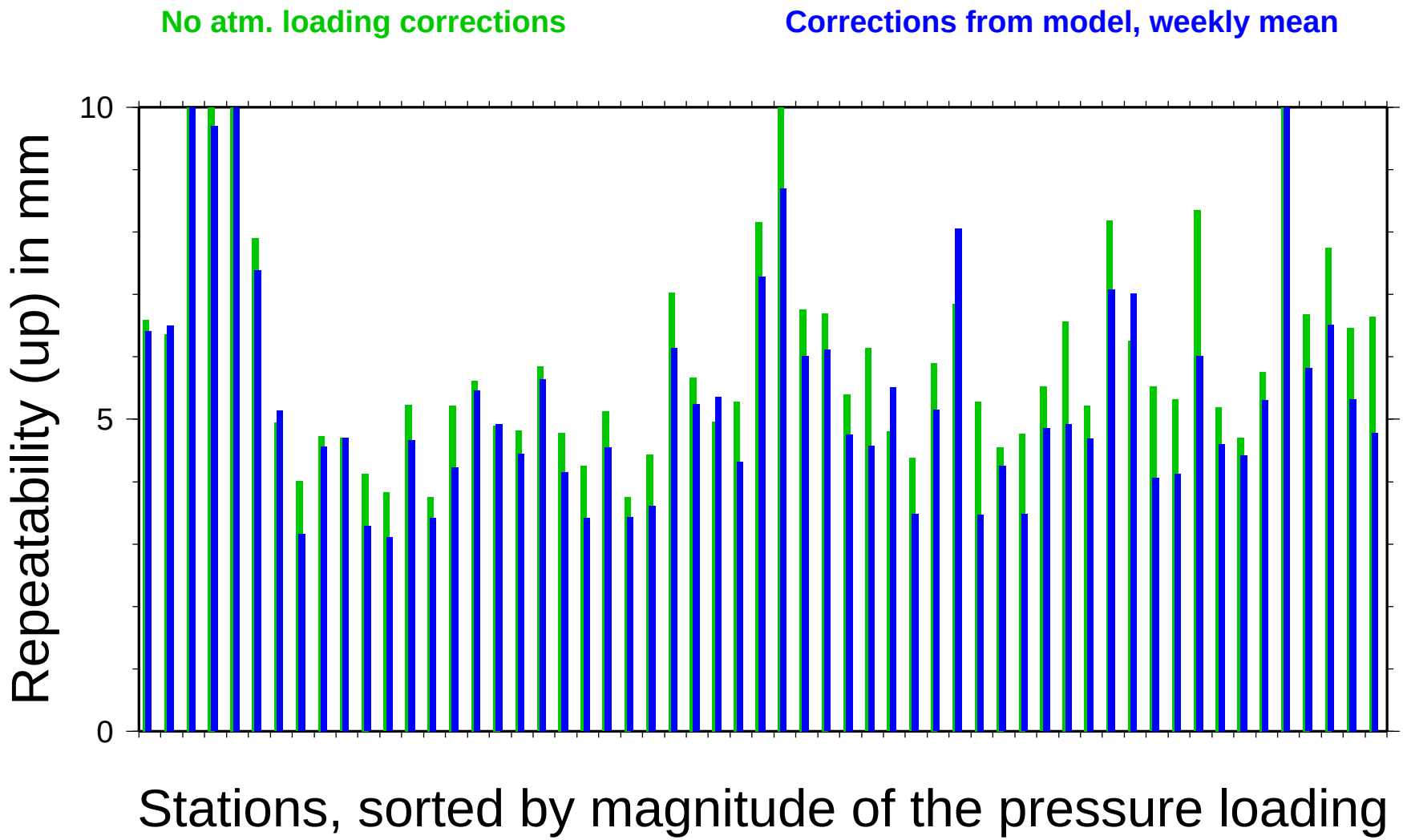

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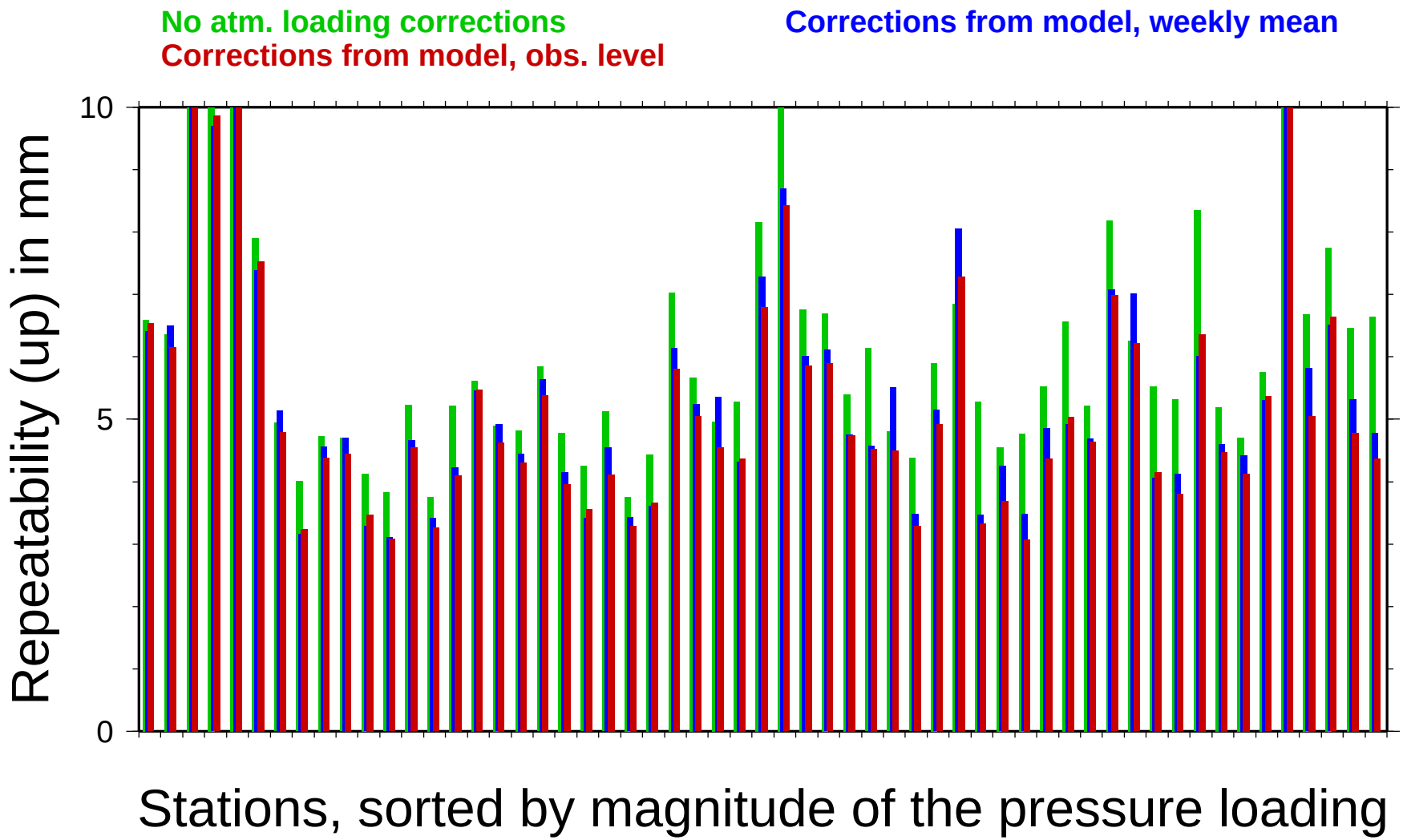

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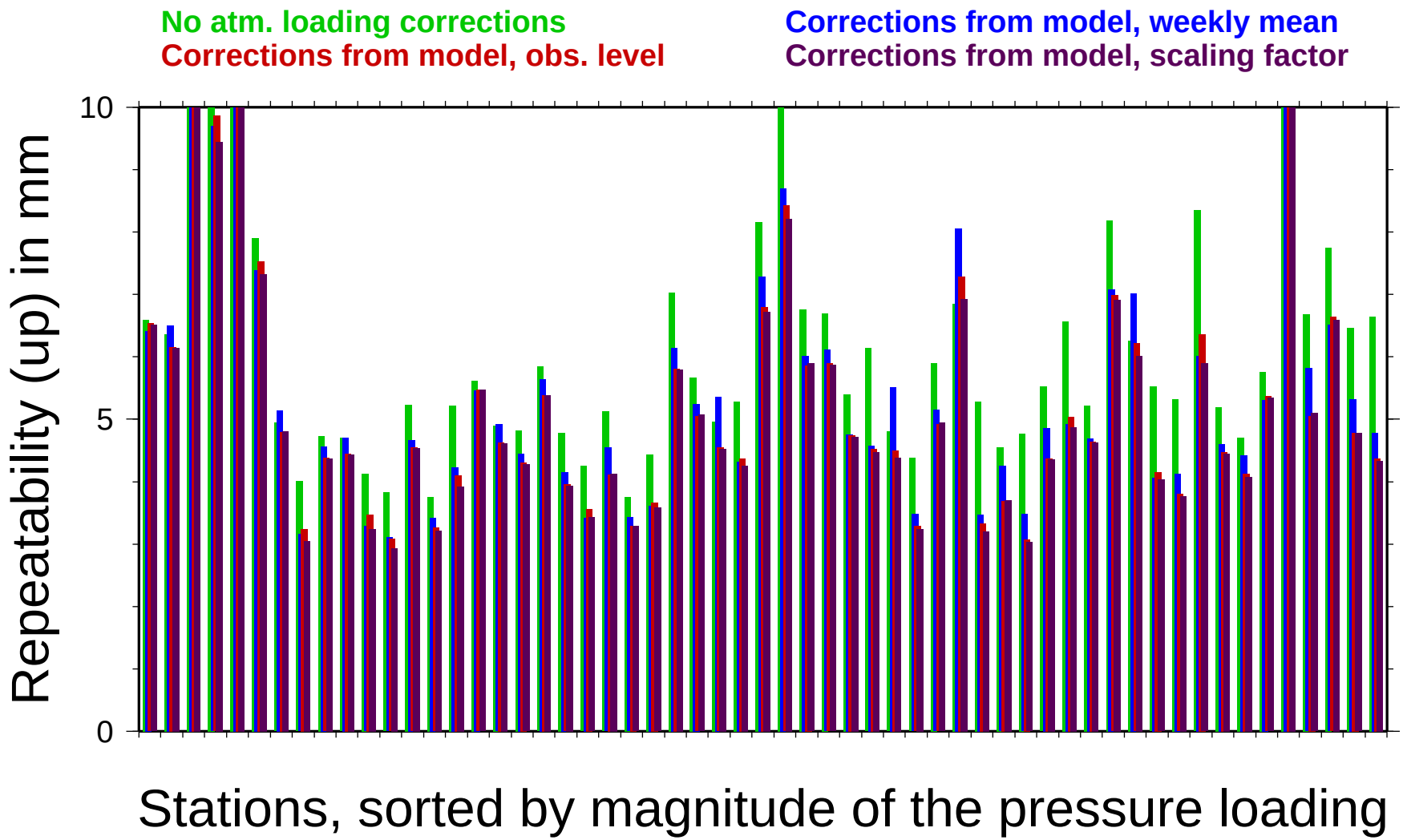

Conclusions and outlook

- The effect of atmospheric loading can be clearly seen in GPS–derived coordinate time series (weekly solutions) and need to be corrected for to generate a reference frame (compatibility between the solutions/techniques).
- Atmospheric loading models can be used to correct for this effect — an improvement of the repeatability of up to 20% can be achieved.
- The correction has to be preferably done at the observation level (at least a weekly coordinate solution is a too long interval).
- To apply corrections from an atmospheric loading model is preferable versus the estimation of correlation coefficients between local pressure and site displacement (which is still better than no correction).
- The atmospheric loading model from Petrov and Boy (2004) has been confirmed by the estimation of station–wise scaling factors within the expected uncertainty range.
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  (There seems to be seasonal variations of the scaling factors.)
- An extension of this study to other atmospheric loading is appreciated.

Conclusions and outlook

What does it mean for the IERS?

- If the optimal correction is achieved by correcting at observation level, a full consistency of inner– and inter–technique loading corrections is necessary. The loading bureau of the IERS should provide such “standard” corrections.
- A future reprocessing (e.g., in frame of an IGS repro2) shall be supported with such corrections.
- In future the loading corrections need to be in place according to the IGS final schedule (three days after the observations).
- A redundancy for the provision (computation?) is appreciated.
- An extension on other geophysical effects (e.g., ocean non–tidal loading) shall be studied.