Evaluation of the Vienna APL corrections using reprocessed GNSS series

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G19. The Science and Technology of the Global Geodetic Observing System
San Francisco, CA, 05.-09. December 2011

The CODE analysis center

- CODE, Center for Orbit Determination in Europe, is one of the Analysis Centers of the IGS. CODE is formed as a joint venture of
  - the Astronomical Institute of the University of Bern (AIUB),
  - the Swiss Federal Office of Topography (swisstopo),
  - the Bundesamt für Kartographie und Geodäsie (BKG), and
  - the Institut für Astronomische und Physikalische Geodäsie of TU München (IAPG, TUM).

AIUB

Bundesamt für Kartographie und Geodäsie

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Technische Universität München

CODE reprocessing effort

Recent CODE reprocessing effort done by P. Steigenberger at TU Munich:

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	May 2003 – present	GPS+GLONASS solution

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Time interval:	January 1994 to May 2003	GPS–only solution
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- fully consistent with IGS08.ATX and IGS08.SNX
- following the IERS 2010 conventions
- based on existing screened observation files
- considering the CODE processing strategy from June 2011
  - ambiguity resolution for GLONASS according to the latest implementations at CODE
  - including a GPS/GLONASS antenna calibration bias
  - ...

APL as a topic for studies

- The CODE reprocessing has included the Vienna APL model (Wijaya et al. 2011) with scaling factors allowing to
  - validate the model from GNSS data,
  - easily compute two consistent solutions with/without APL corrections.

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- From all days in 2010 two days are selected

  21. January: most active APL in all stations of the network

  29. May: least active APL in all stations of the network

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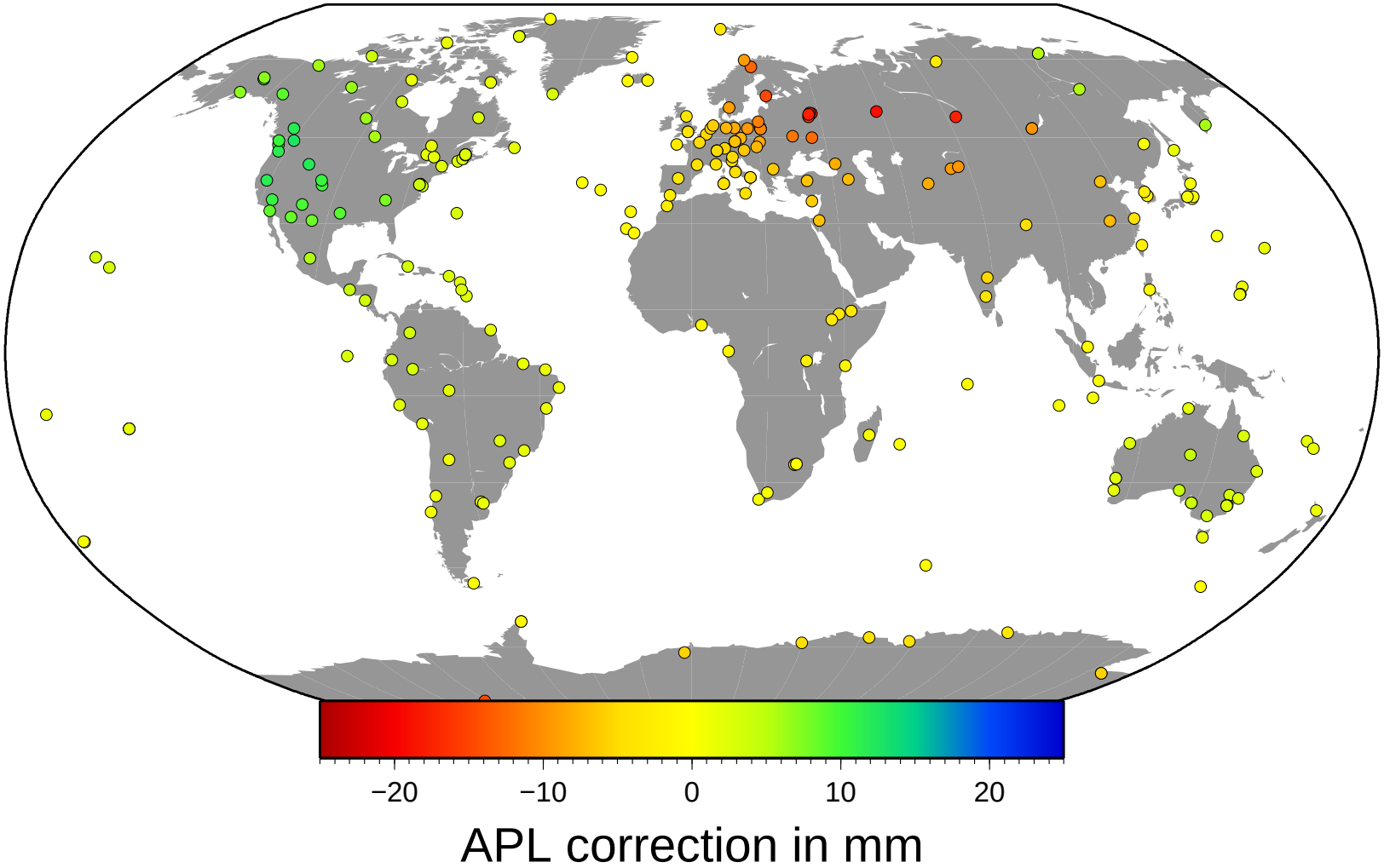
  29. May: least active APL in all stations of the network
- For these two days all APL corrections are summed in the processing program for each station.[1]

[1] Cannot be re–computed after data processing, e.g., from SINEX level!!

APL and GNSS–derived coordinates

Mean APL corrections for each station
extracted from Vienna model during data processing

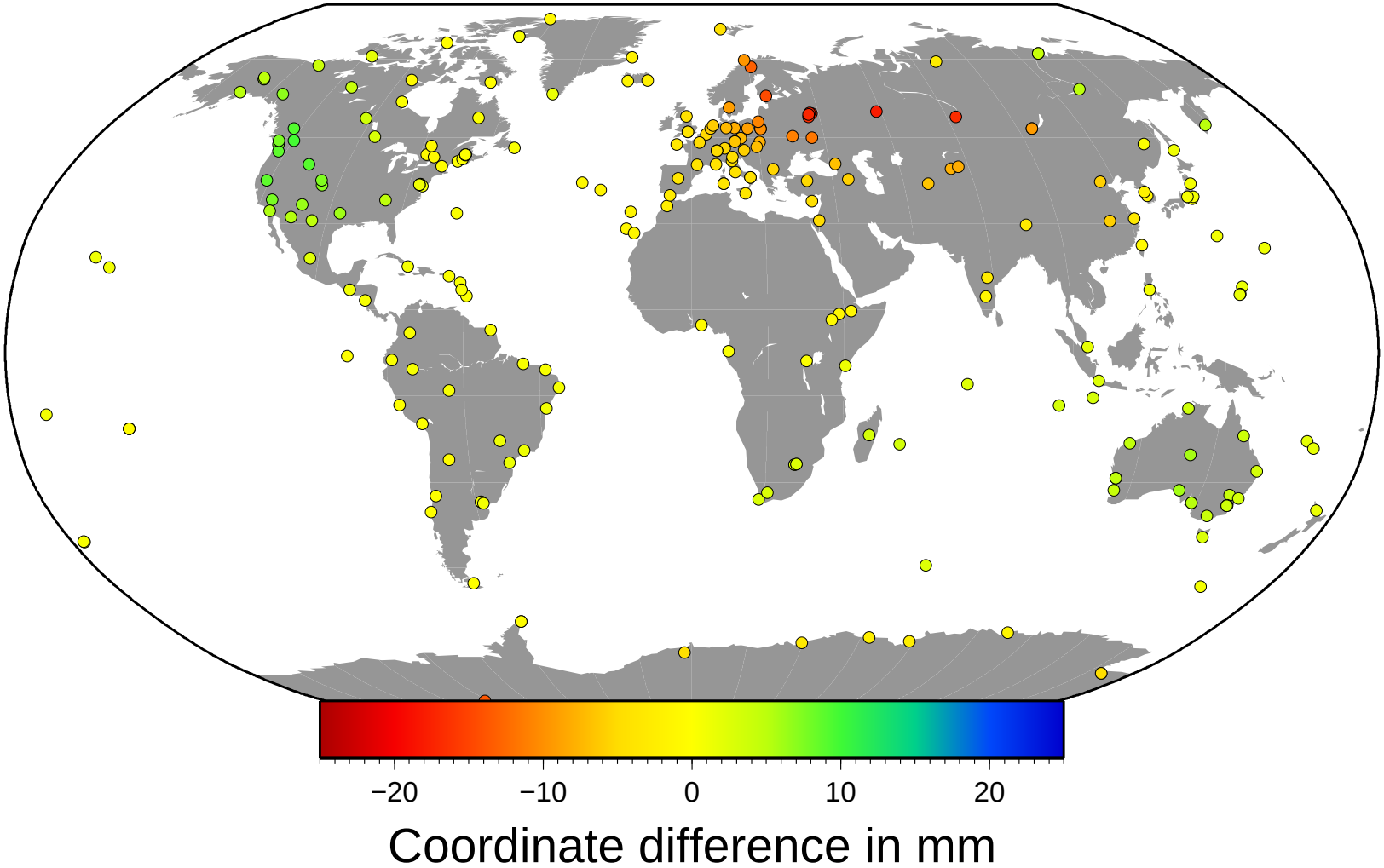


vertical component

21. January 2010

APL and GNSS–derived coordinates

Coordinate difference between solutions
applying/not applying APL corrections



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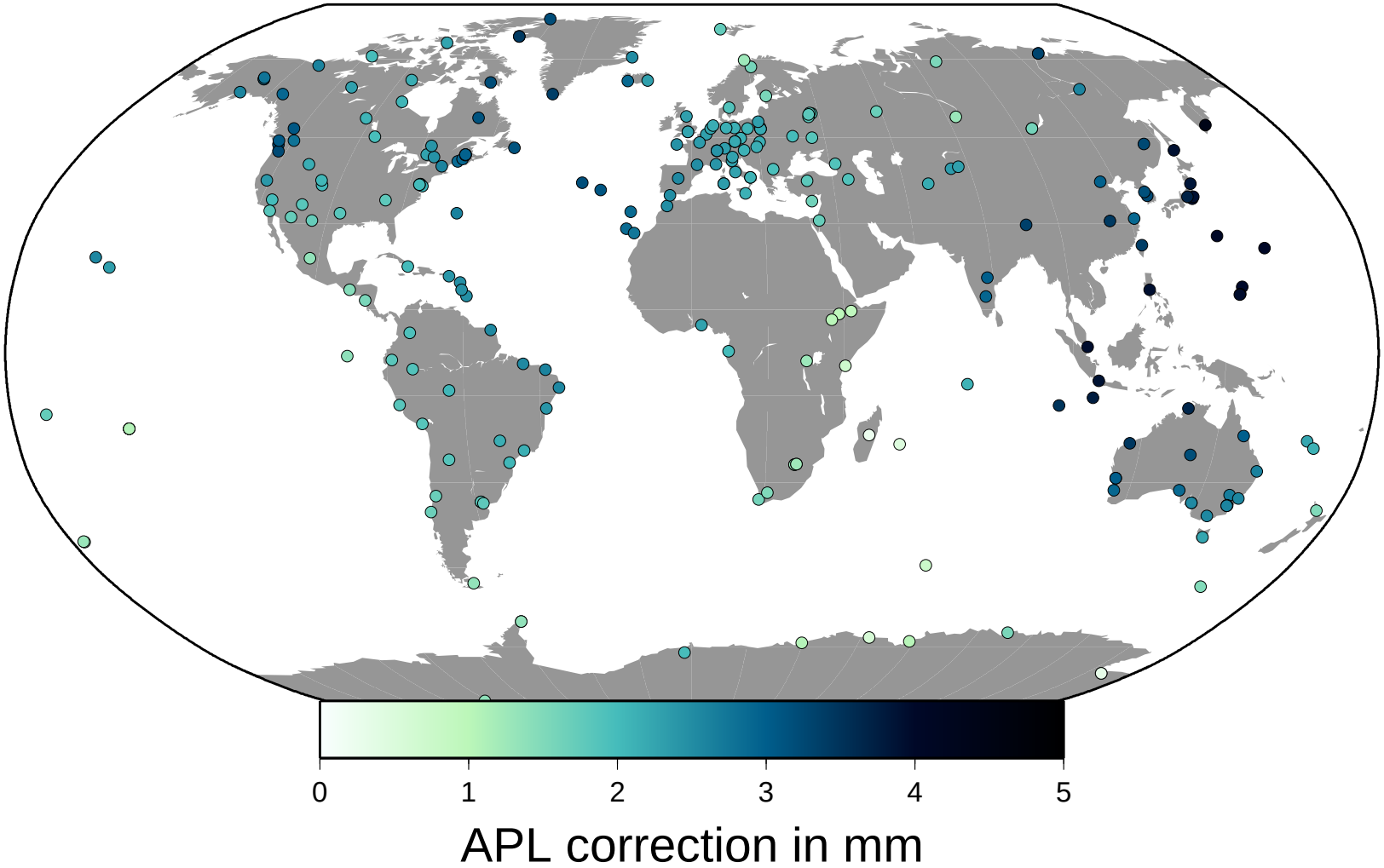

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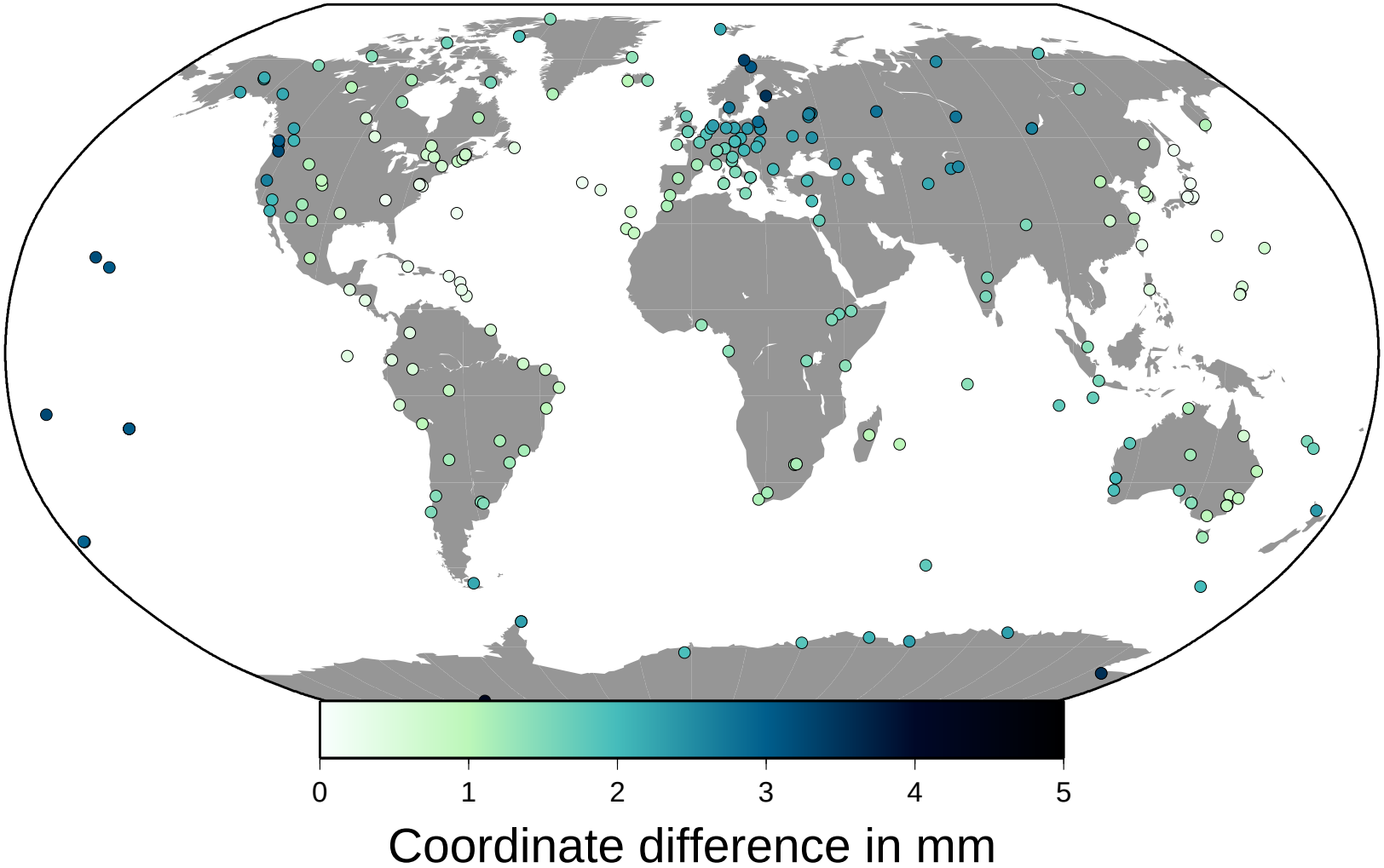
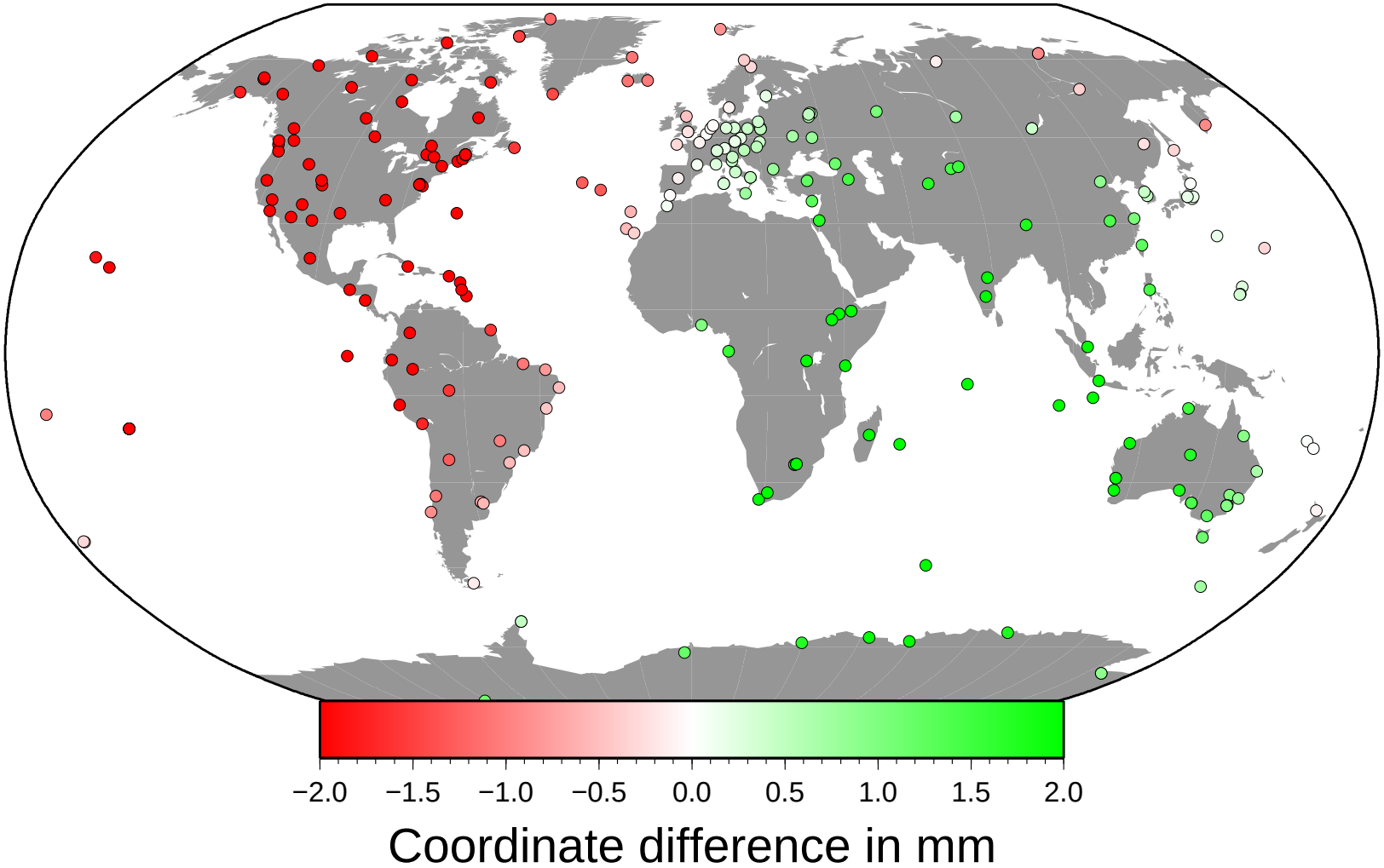


horizontal component

21. January 2010

APL and GNSS–derived coordinates

Coordinate difference between solutions
applying/not applying but correcting for APL effect



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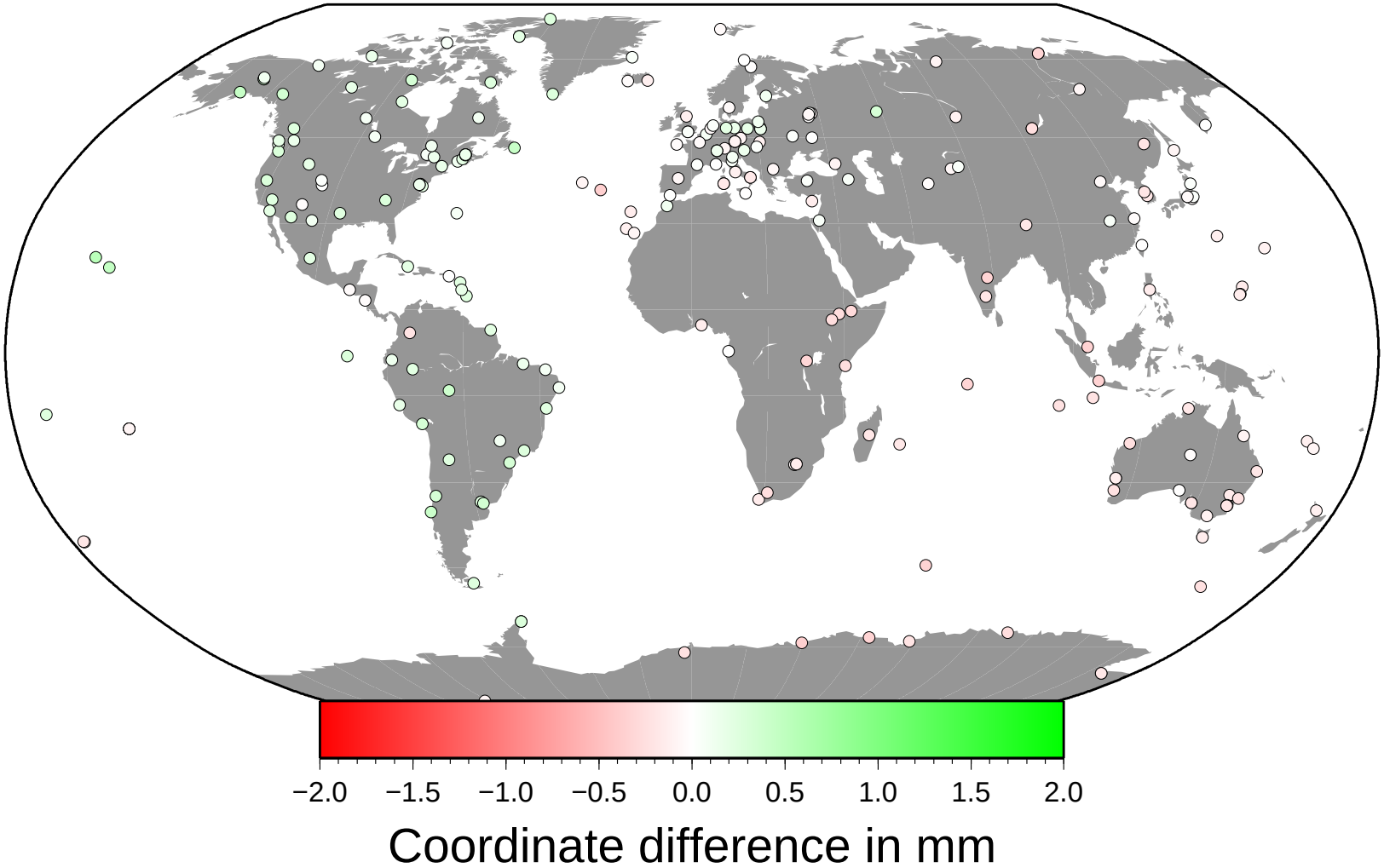
APL and GNSS–derived coordinates

Residuals of a Helmert–transformation between solutions applying/not applying but correcting for APL effect



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APL and GNSS–derived coordinates

RMS of coordinate comparison

APL and GNSS–derived coordinates

RMS of coordinate comparison

- Difference of the solution without applying APL corrections...

21. January 2010			29. May 2010		
RMS_N	RMS_E	RMS_U	RMS_N	RMS_E	RMS_U
$1.1\,\mathrm{mm}$	$1.4\,\mathrm{mm}$	$5.3\,\mathrm{mm}$	$0.6\,\mathrm{mm}$	$0.4\,\mathrm{mm}$	$1.5\,\mathrm{mm}$

...with respect to the solution applying the APL corrections on observation level.

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21. January 2010			29. May 2010		
RMS_N	RMS_E	RMS_U	RMS_N	RMS_E	RMS_U
1.8 mm	2.5 mm	1.7 mm	0.5 mm	0.4 mm	0.2 mm

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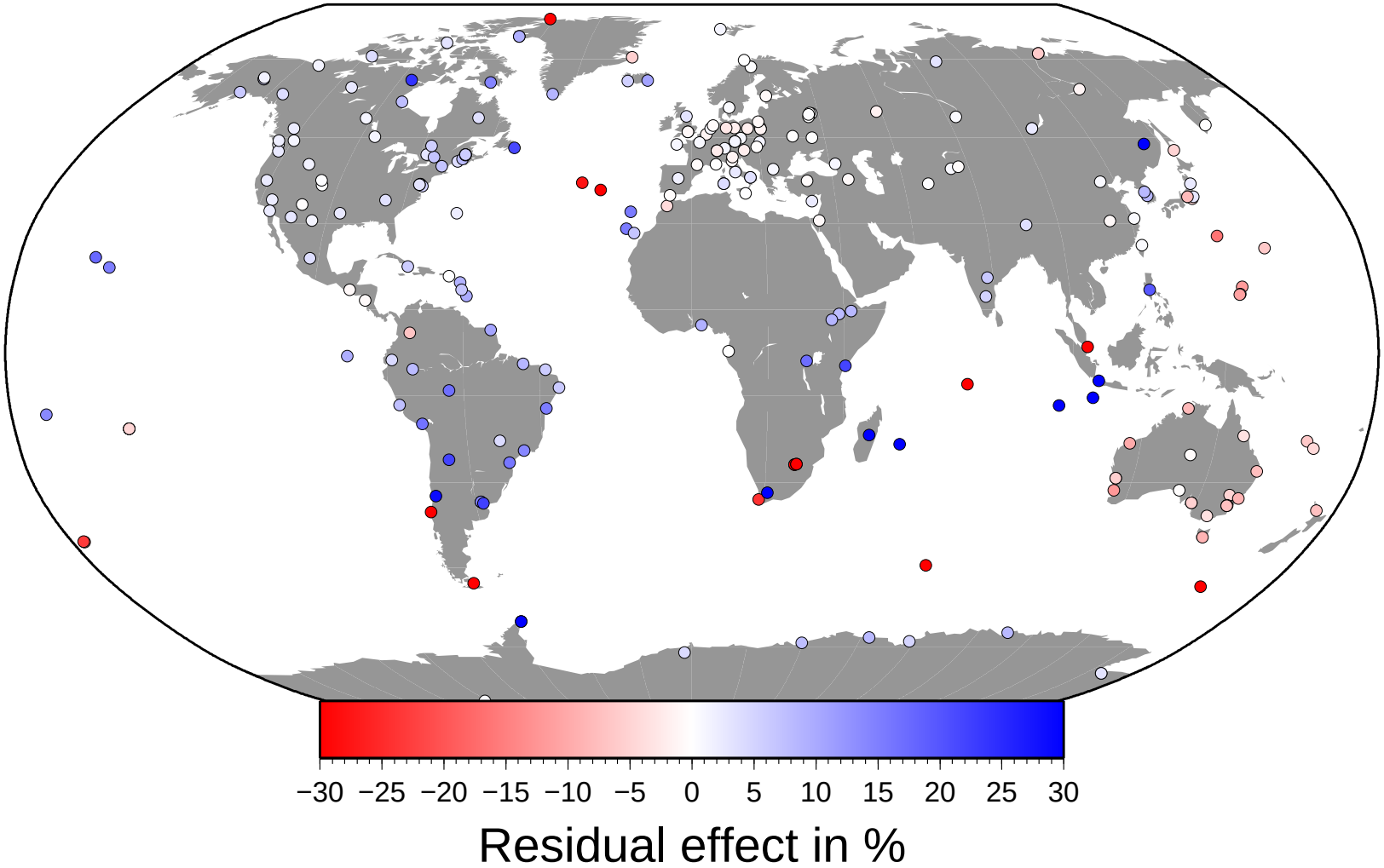

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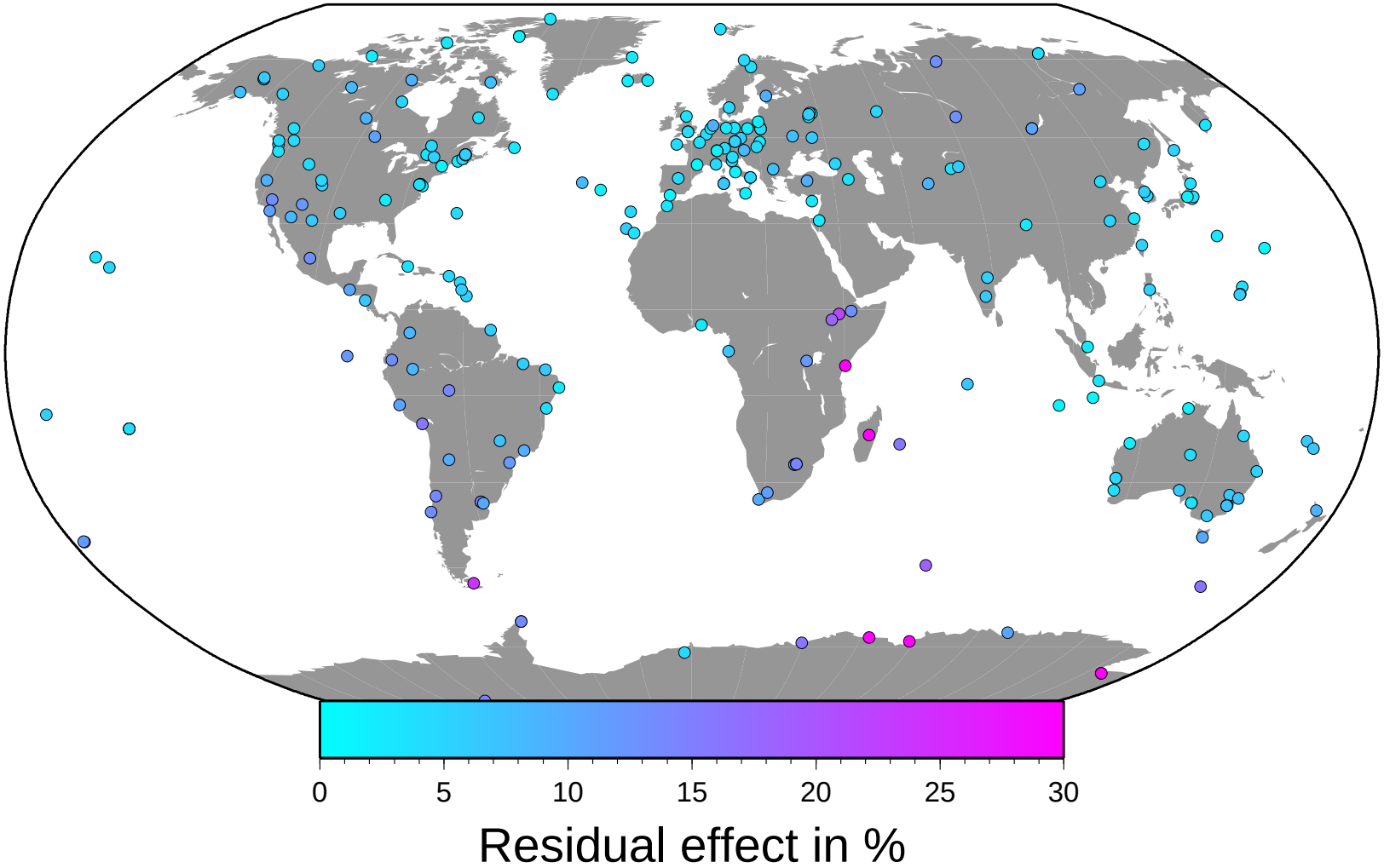

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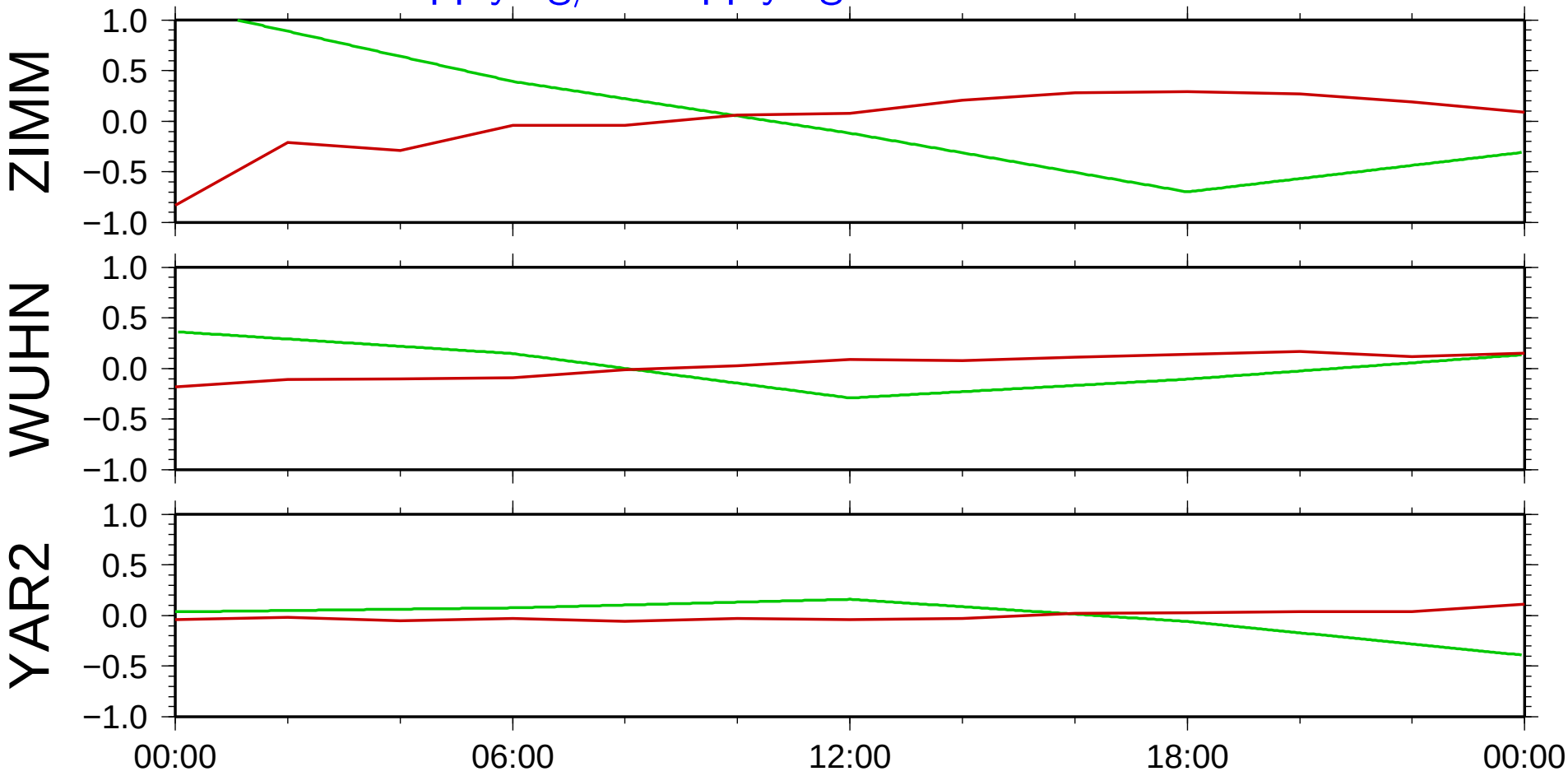
APL and GNSS–derived troposphere

Differences between troposphere estimates from solutions applying/not applying APL corections



units: mm

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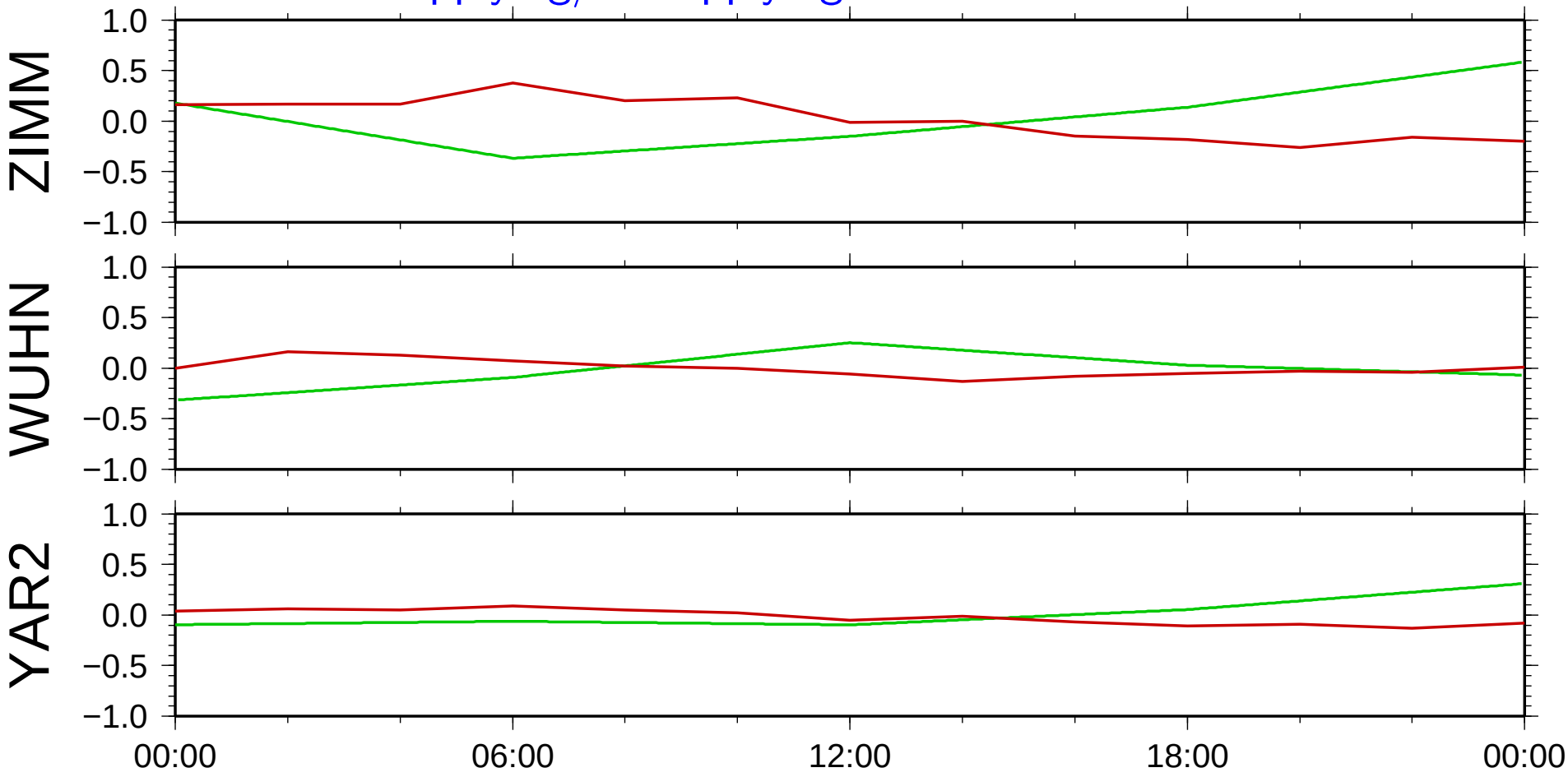

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APL and GNSS–orbits

RMS of Earth-fixed satellite positions

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RMS_X	RMS_Y	RMS_Z	RMS_X	RMS_Y	RMS_Z
$5.2\,\mathrm{mm}$	$14.5\,\mathrm{mm}$	$13.9\,\mathrm{mm}$	$2.0\,\mathrm{mm}$	$2.1\,\mathrm{mm}$	$2.1\,\mathrm{mm}$

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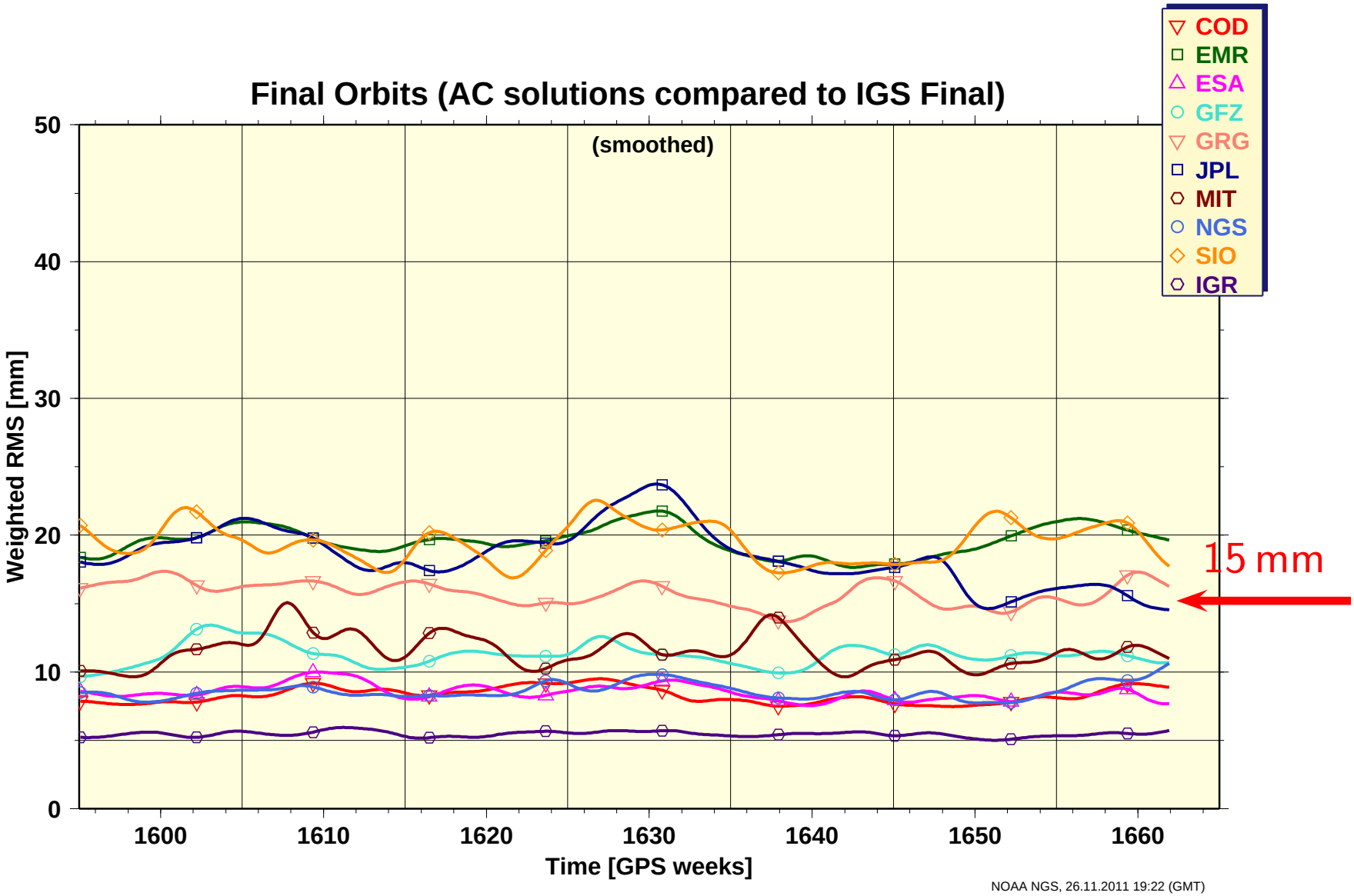
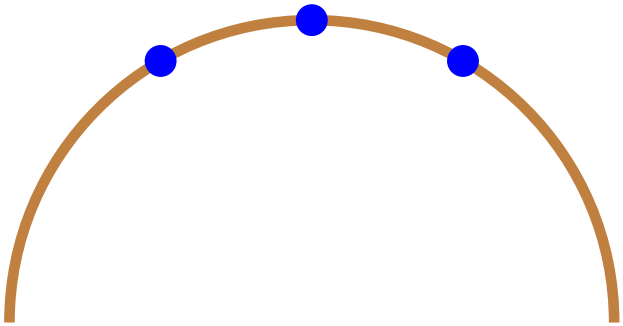


from `acc.igs.org`

How APL may mitigate into GNSS orbits?



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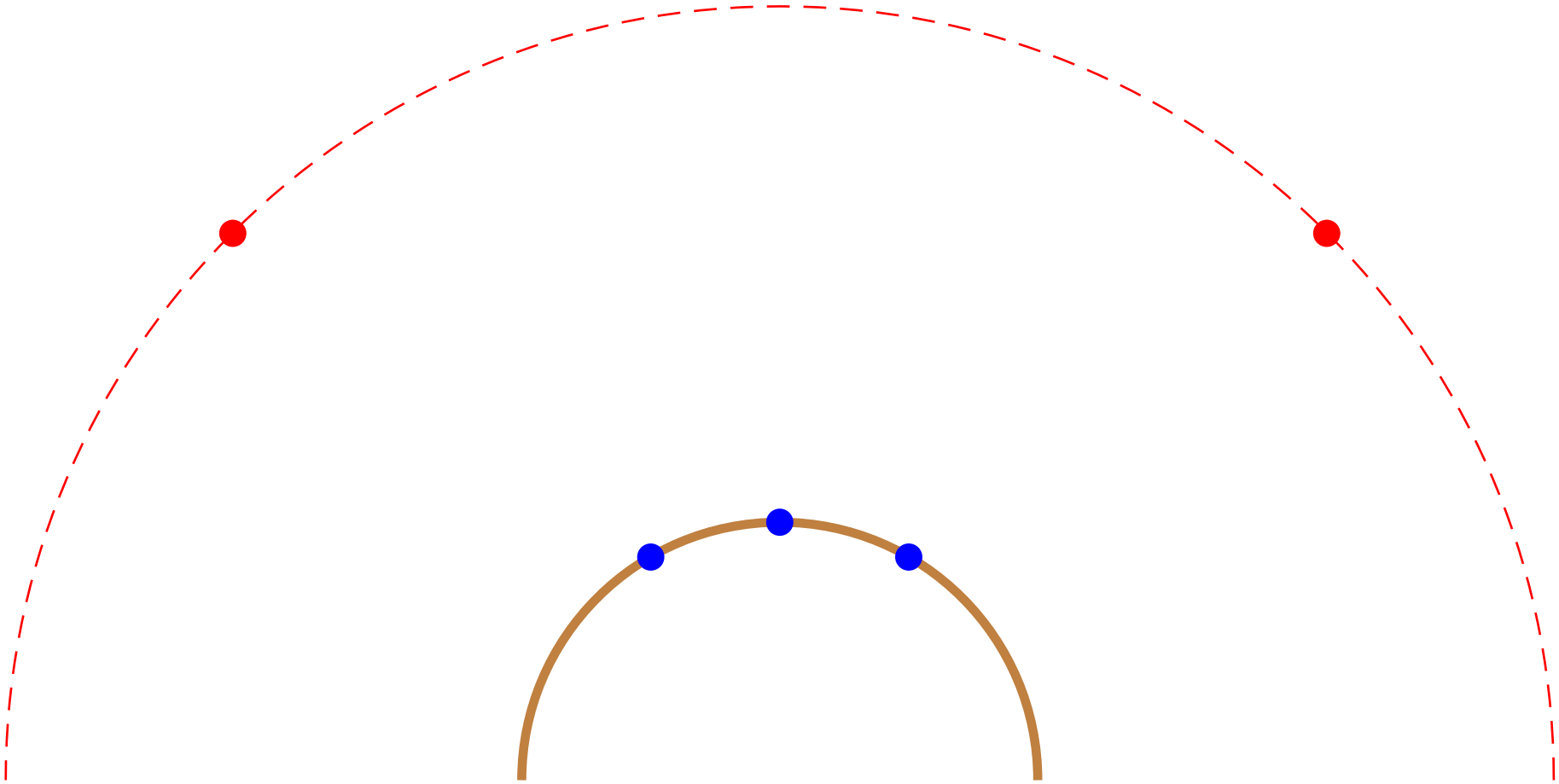

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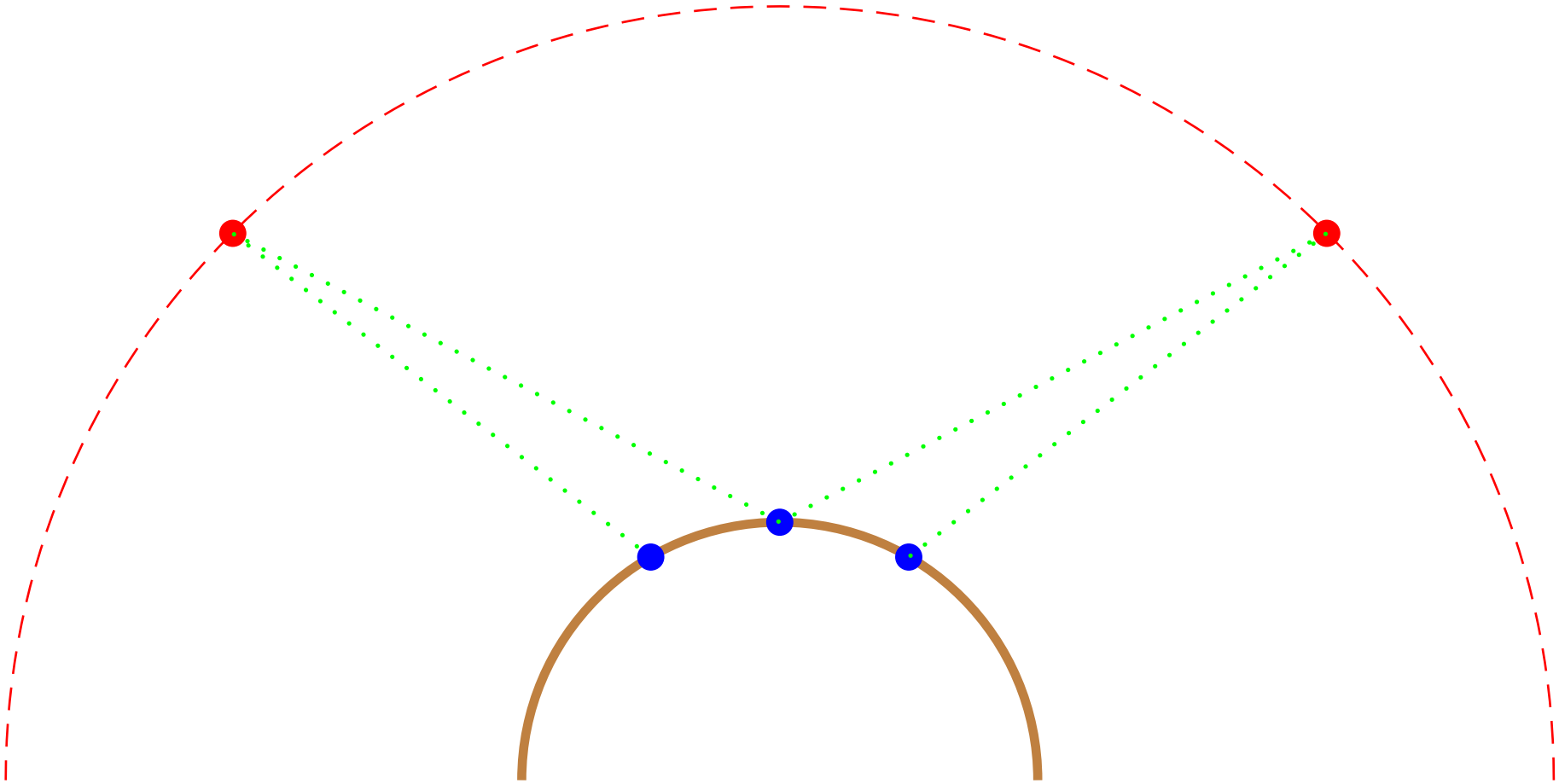

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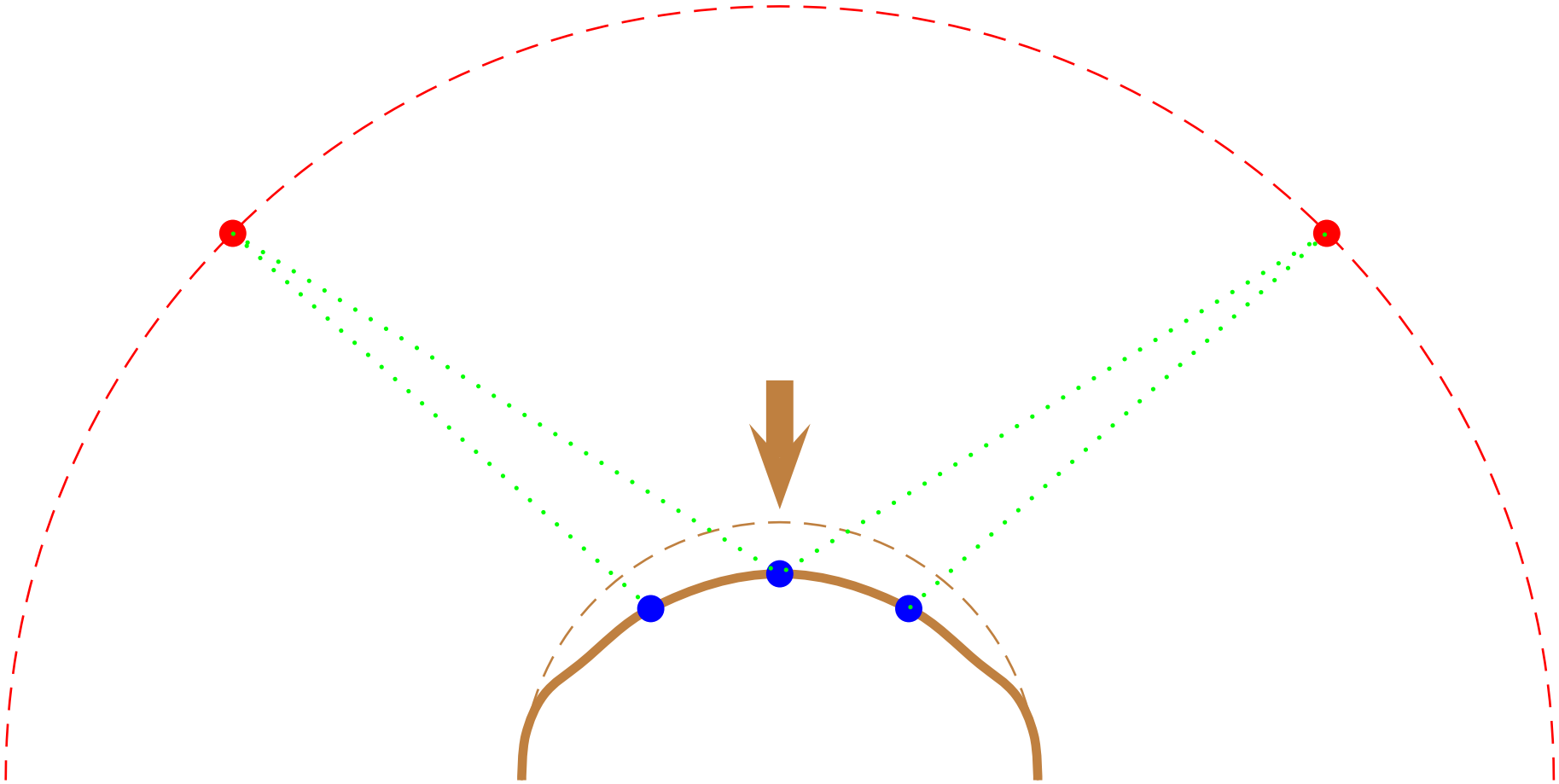

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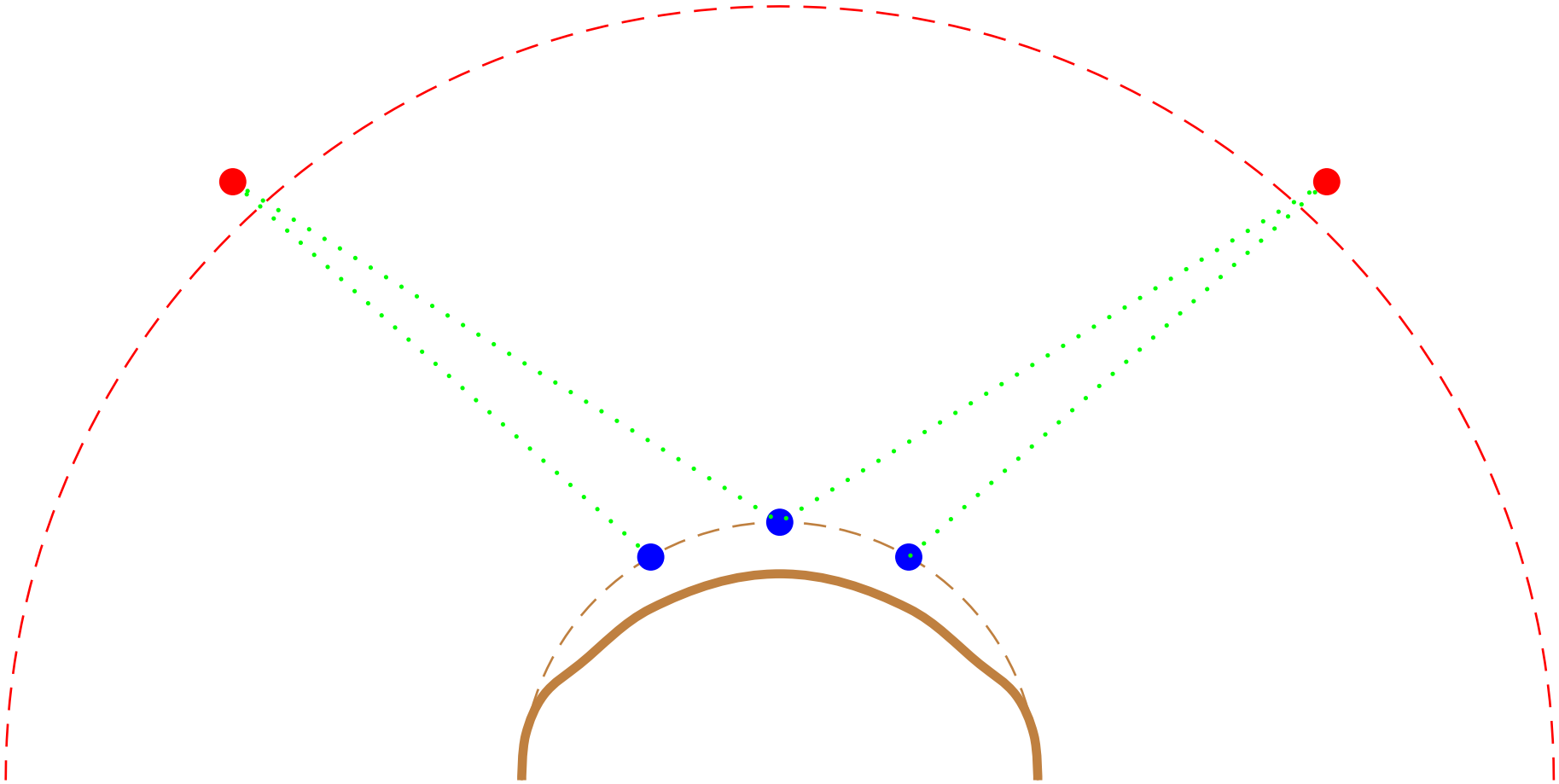

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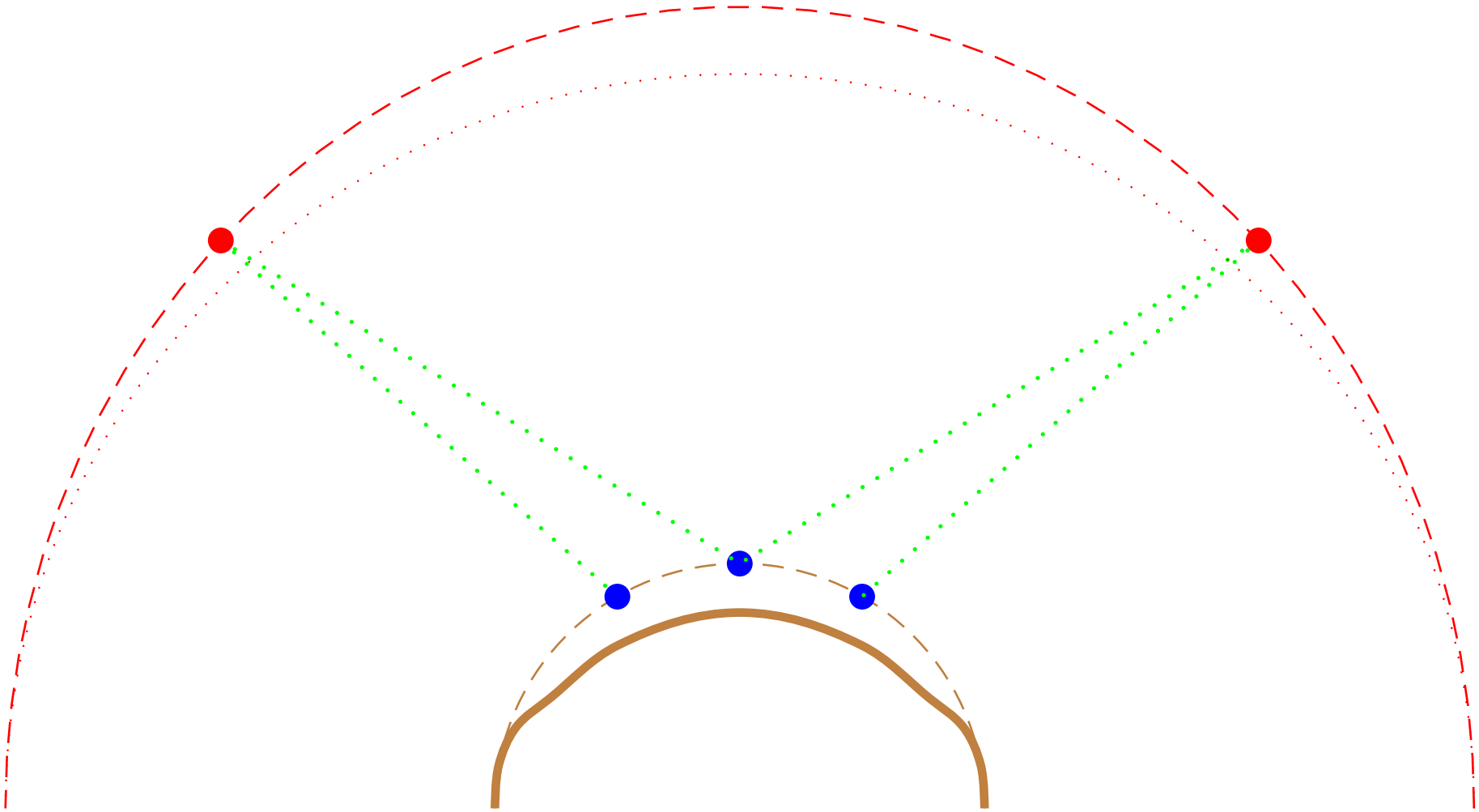

APL model for IGS(–like) processing

Conclusion: APL must be corrected on observation level
because an unmodelled APL-effect mitigates
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Resulting requirements:

1. High quality model is needed that corresponds to the quality of the state-of-the-art GNSS processing.
2. The model must consistently cover the time span from 1994 to present.
3. The model must be easily accessable by any user for any station (preferable grids).
4. The model is required at least for the final processing at the analysis centers (three days delay).

APL model candidates for IGS(–like) processing

Petrov and Boy, 2004:

+ Is already in use by other IAG services.
+ Good experience with previous studies.
− Bases on NCEP final products — sometimes too late for the final processing.

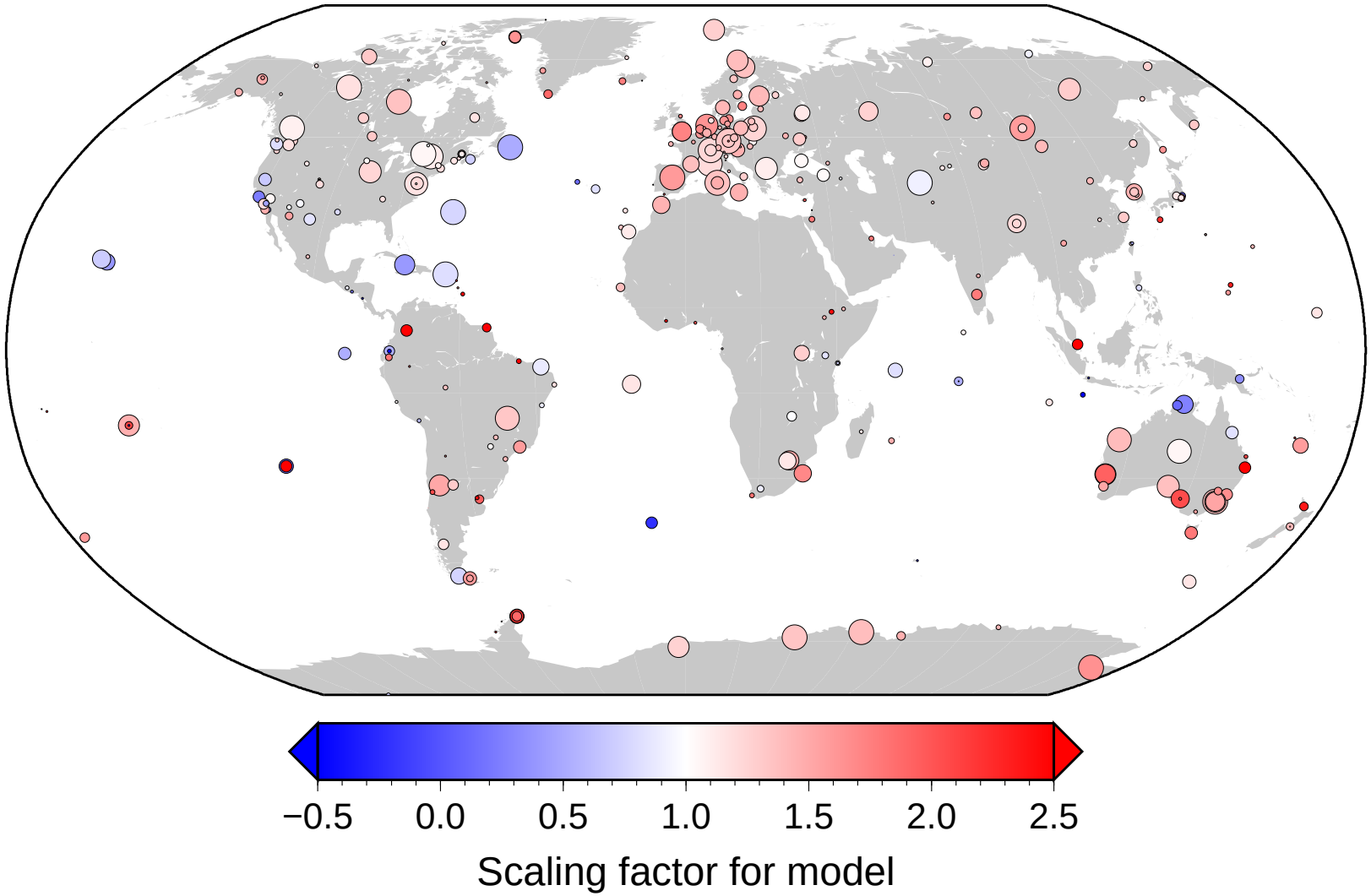
Wijaya et al., 2011:

+ Using the same source as the VMF–correction → optimal consistency.
+ Latency is not an issue because a version based on predicted pressure is available.
± A new model on the market: not well established yet.

Scaling factors for the Vienna APL model: vertical

Estimated scaling factors for the atmospheric loading model

Mean scaling factors over 15 years



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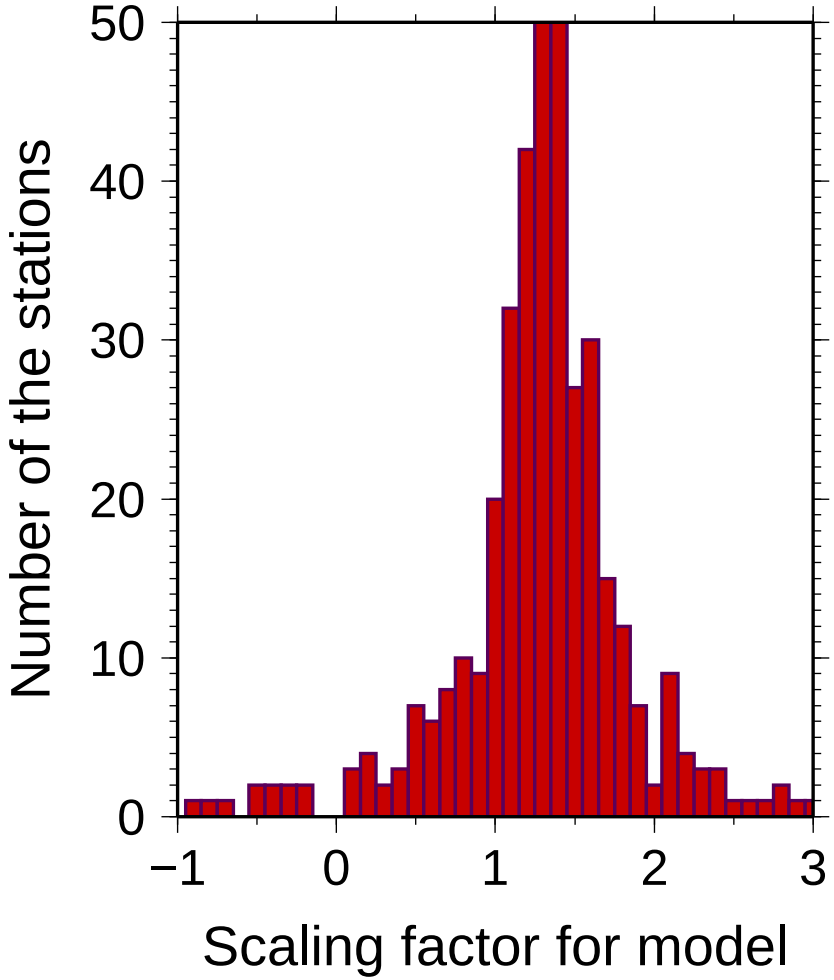

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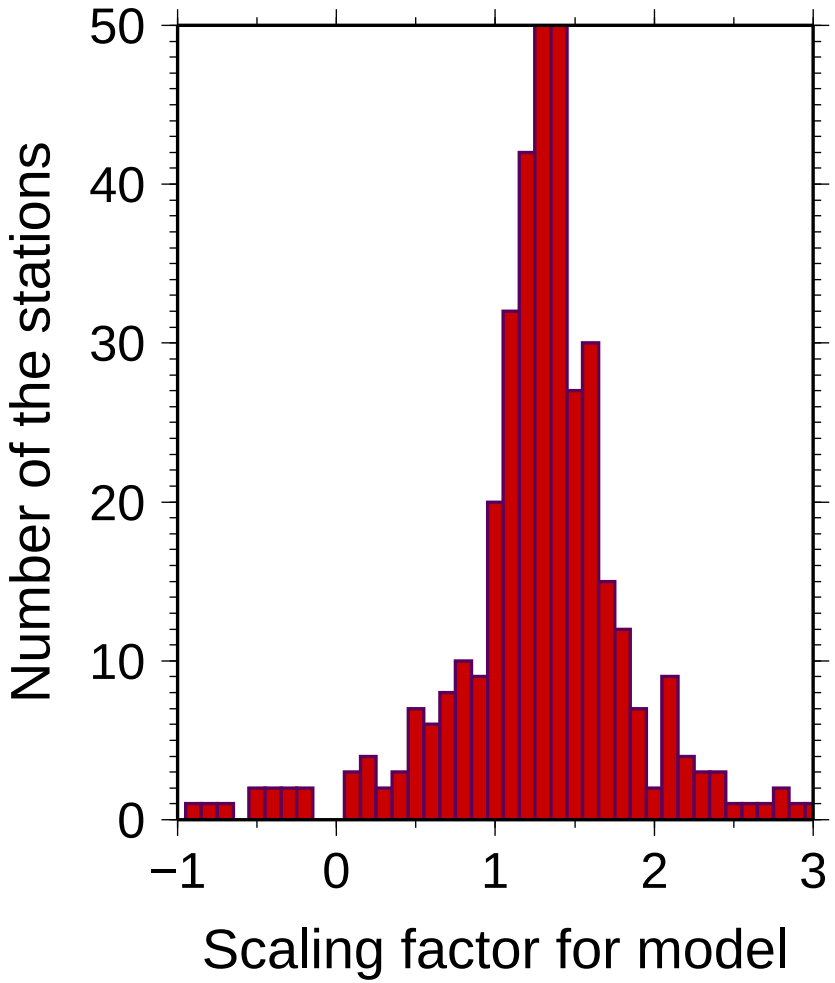
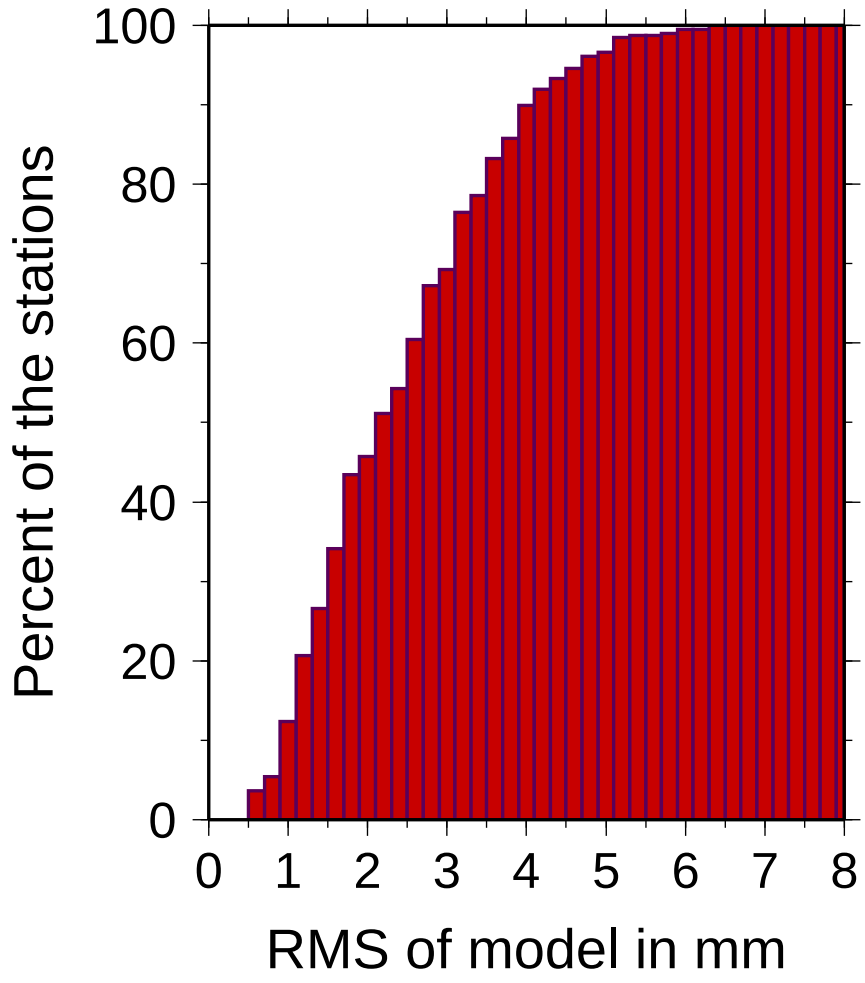


RMS of the corrections over 15 years



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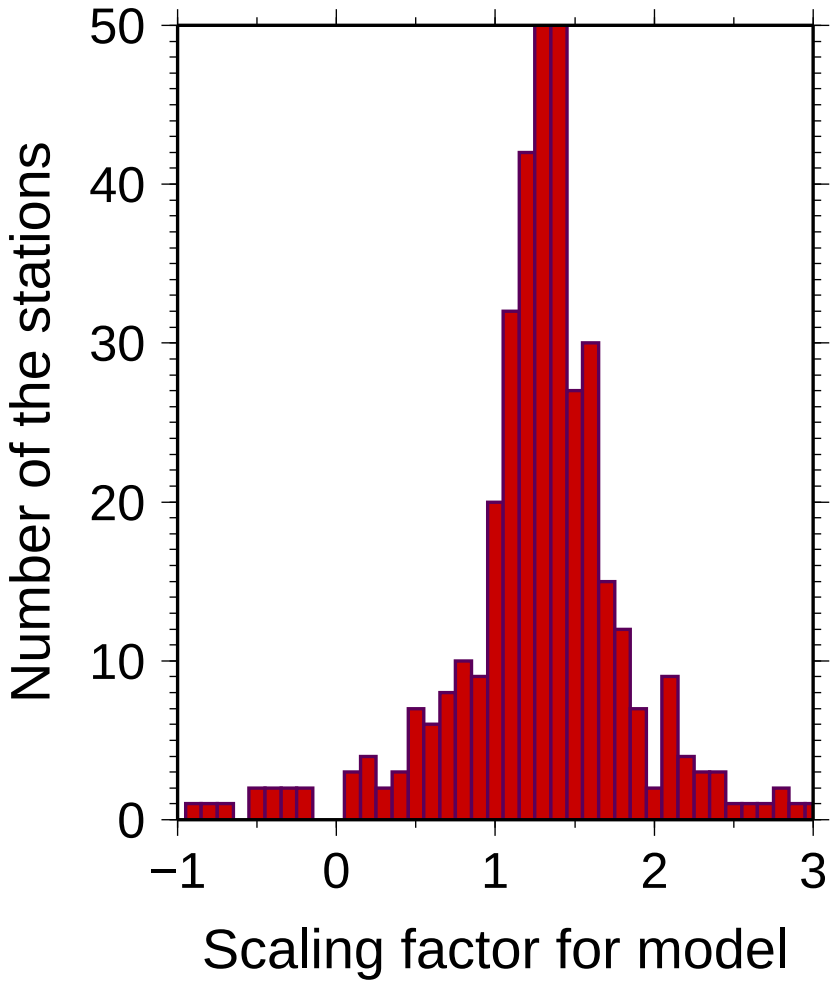
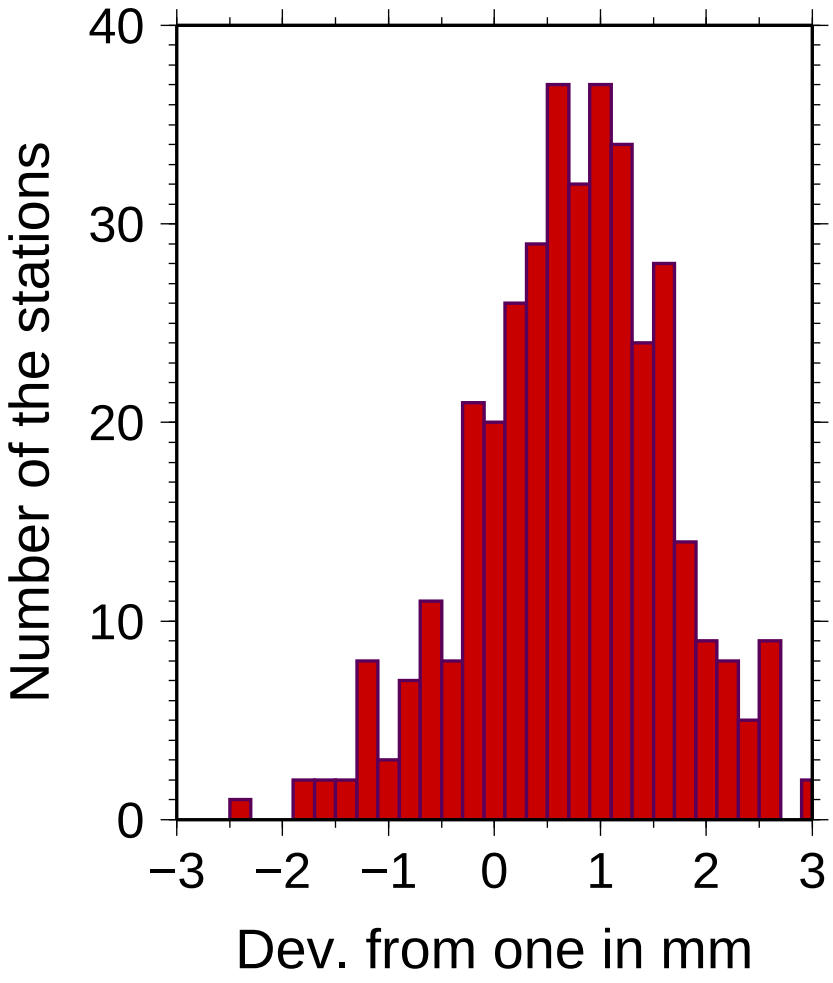


Dev. from one, norm. with RMS



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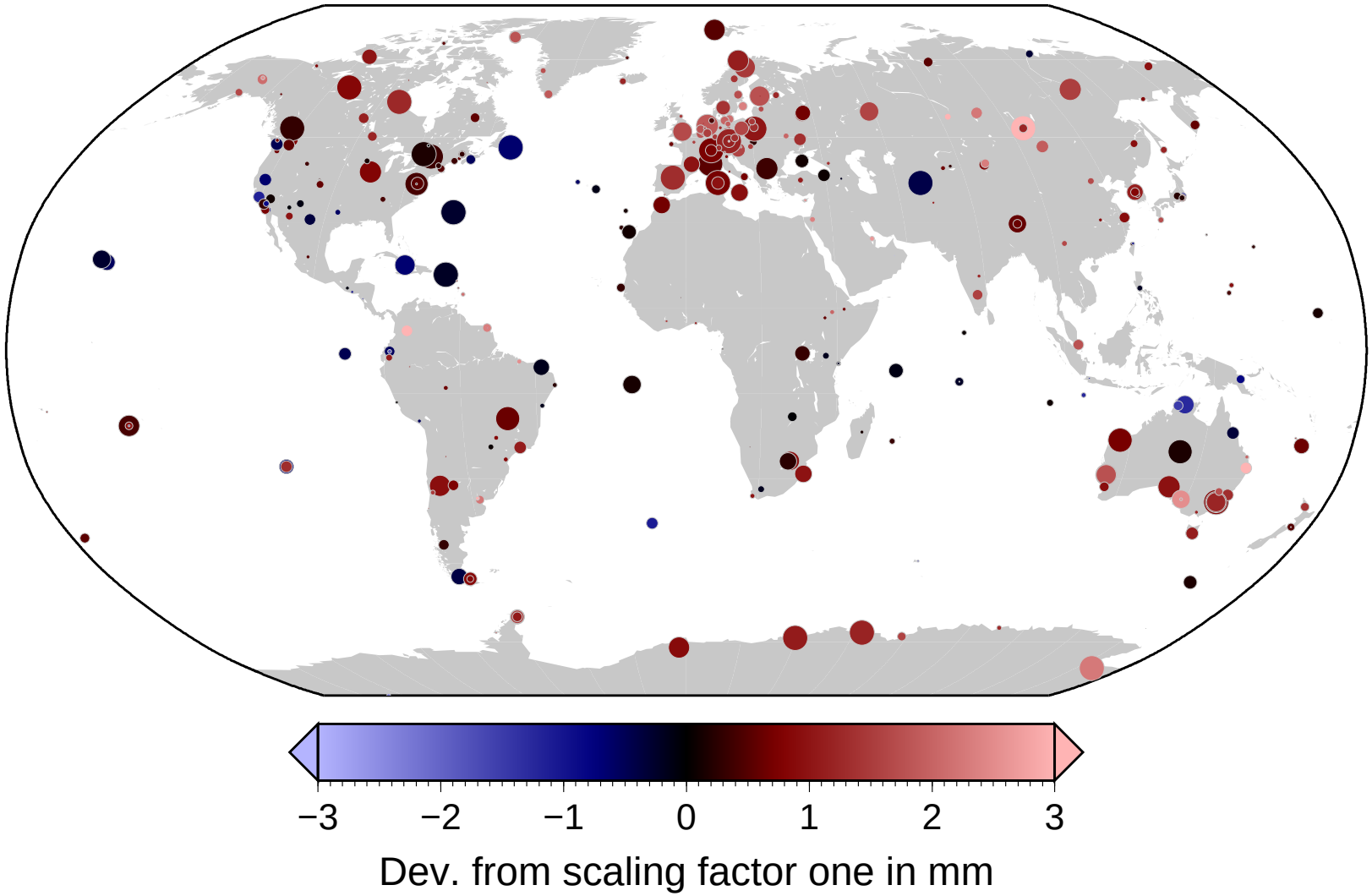
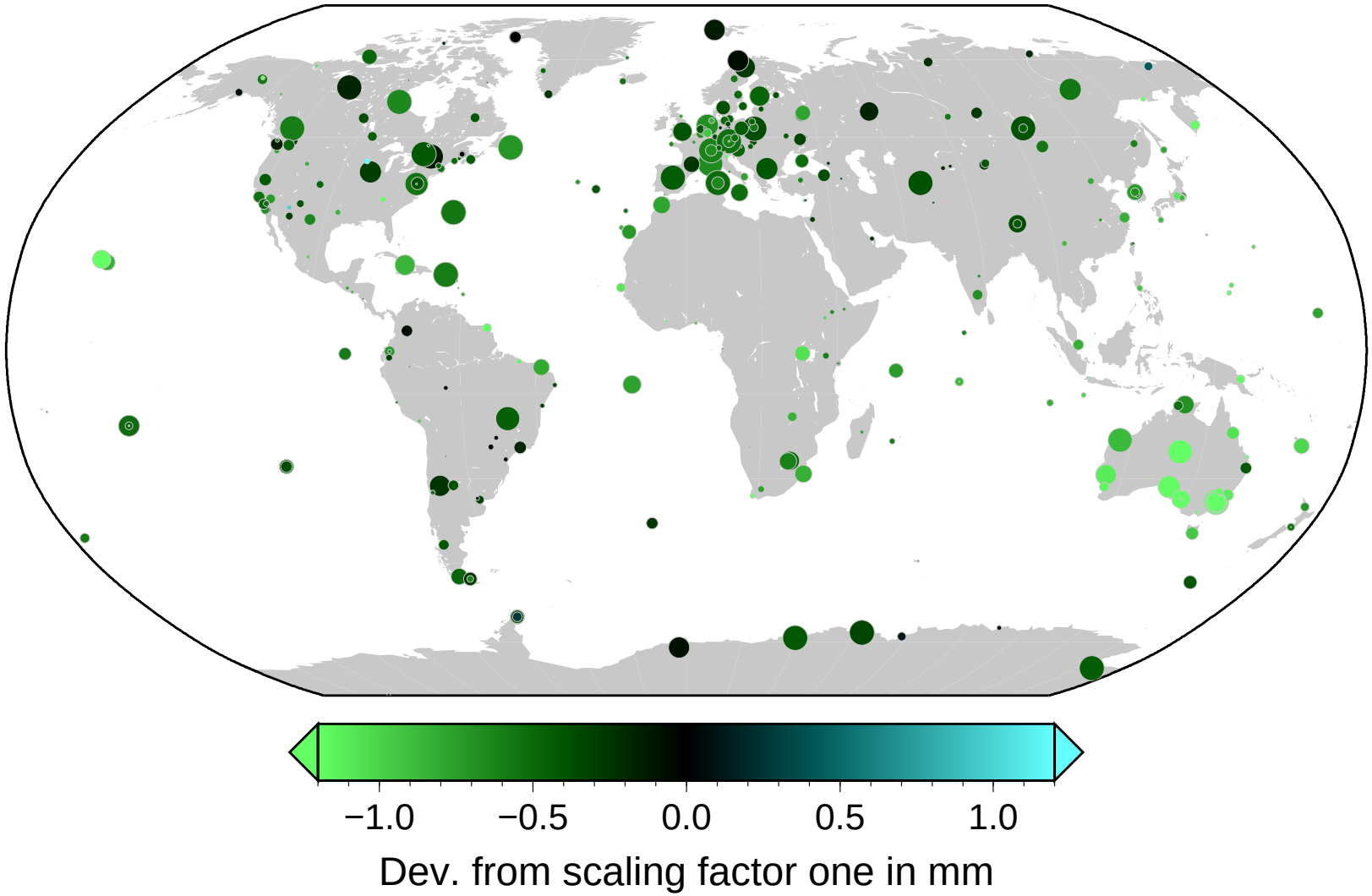
Deviation from one over 15 years, norm. with the RMS



Scaling factors for the Vienna APL model: north

Estimated scaling factors for the atmospheric loading model

Deviation from one over 15 years, norm. with the RMS



Scaling factors for the Vienna APL model: east

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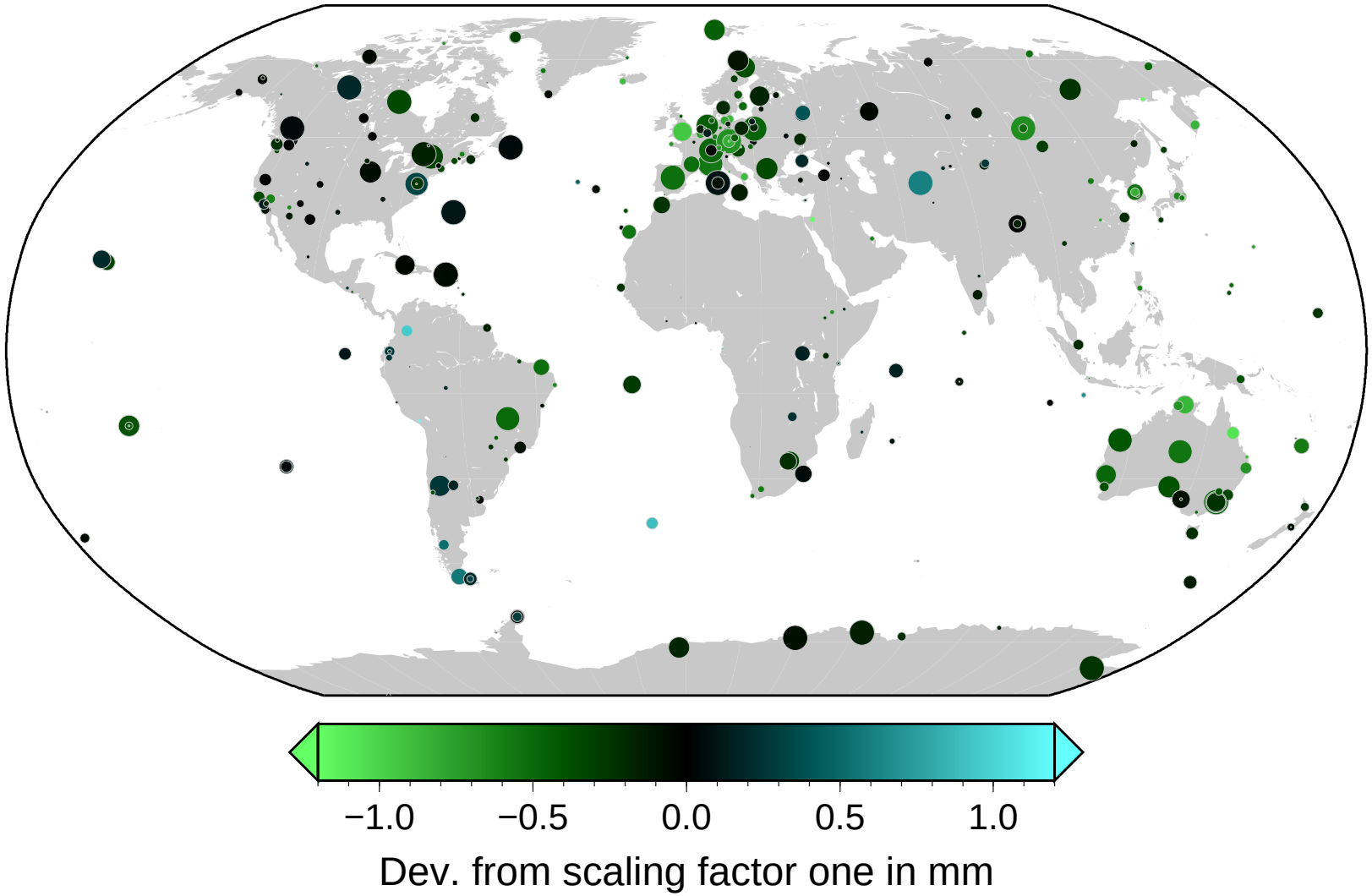
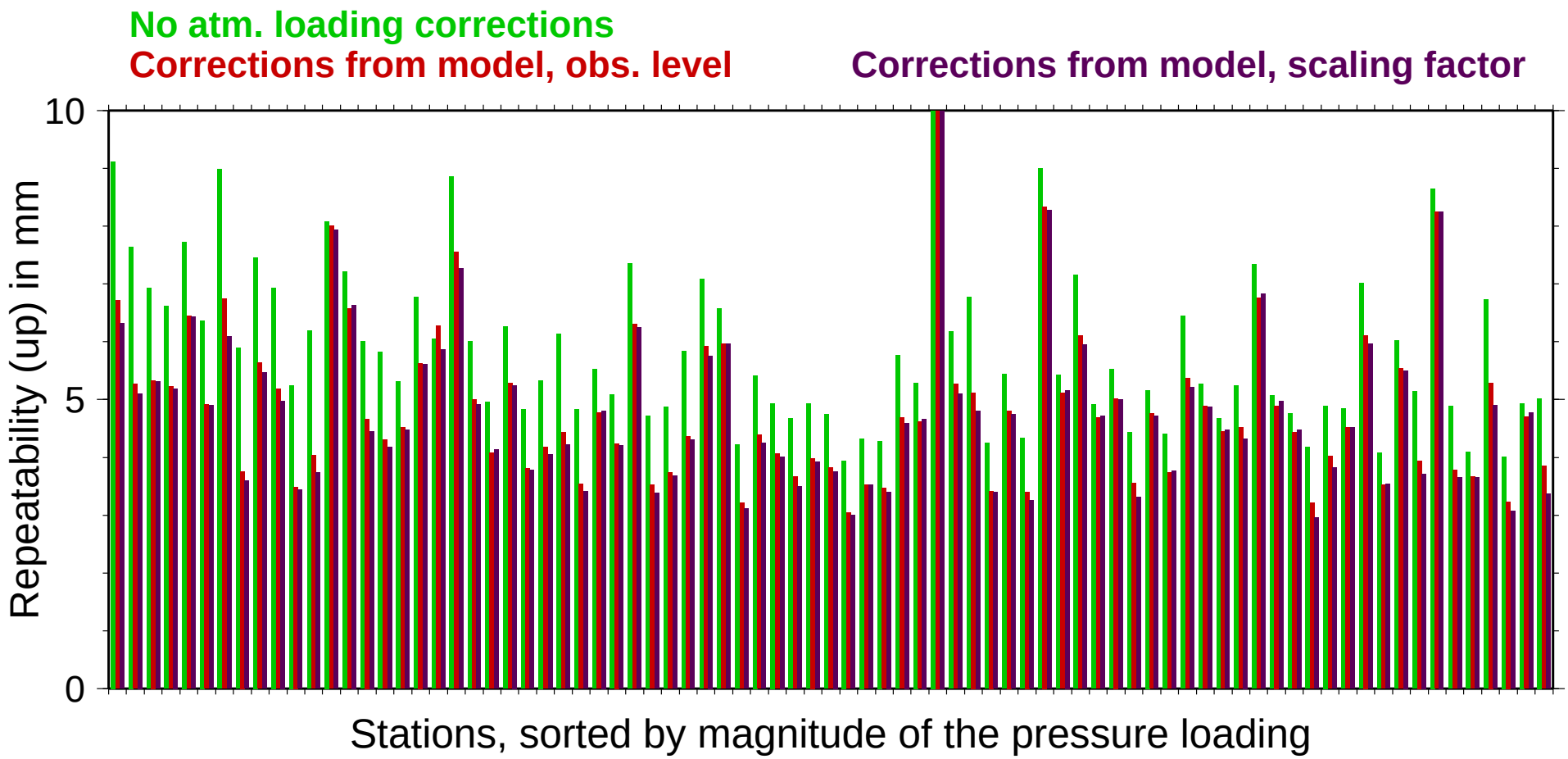


Station repeatability: vertical

Repeatability of the weekly solutions

Vienna APL modell considered



Stations with an APL effect $\geq$3 mm RMS and at least 5 years of data are included.

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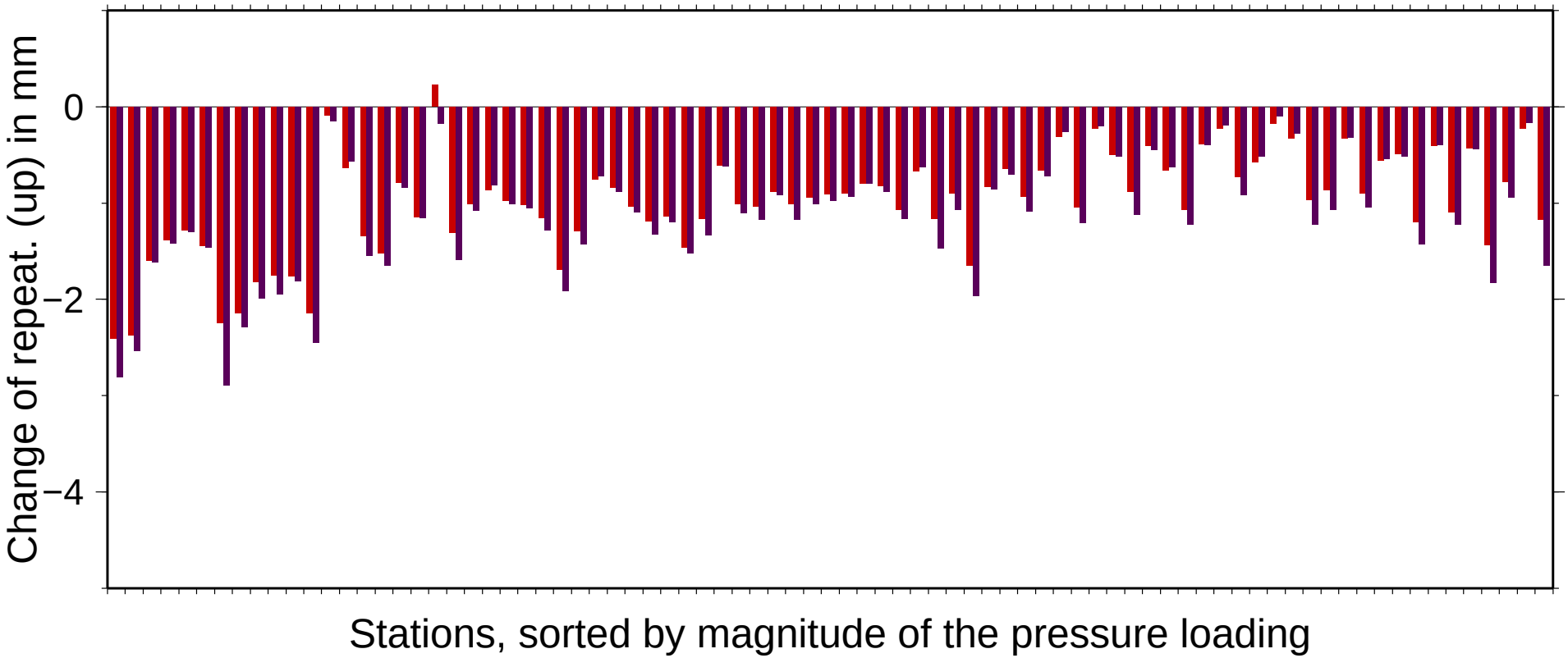
Corrections from model, obs. level **Corrections from model, scaling factor**

Reference: **No atm. loading corrections**



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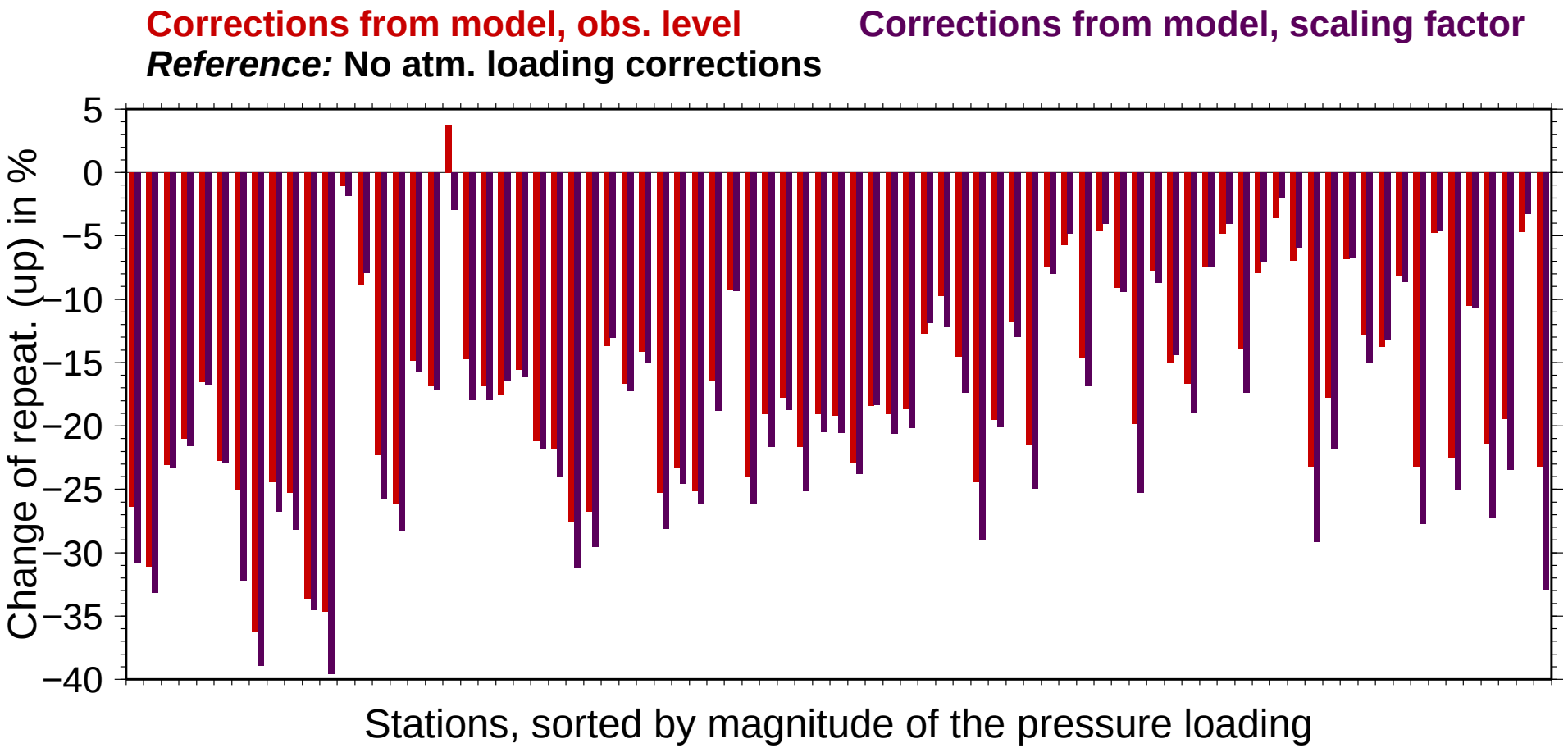

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Cumulative solution: coordinates and velocities

Three consistent cumulative solutions over 15 years are available:

1. without applying APL corrections
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RMS differences for all stations with at least 5 years:

	coordinates (mm)			velocities (mm/year)		
	north	east	up	north	east	up
	0.25	0.11	0.42	0.05	0.03	0.10
	0.25	0.13	0.38	0.04	0.03	0.08
	0.13	0.11	0.57	0.02	0.03	0.15

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$3-2$	0.25	0.13	0.38	0.04	0.03	0.08
$3-1$	0.13	0.11	0.57	0.02	0.03	0.15

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- The number of potential candidates of APL models for an IGS–like processing is limited.

- Station coordinates and velocities from a long–term cumulative solution are not affected by correcting or not correcting for the APL–effect.

THANK YOU
for your attention

Publications of the GNSS–research group: `http://www.bernese.unibe.ch/publist`