EGSIEM

European Gravity Service for Improved Emergency Management

WP5. NRT and regional Service

Status NRT validation with GNSS during historical events and operational service run

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Validating with GNSS during historical run

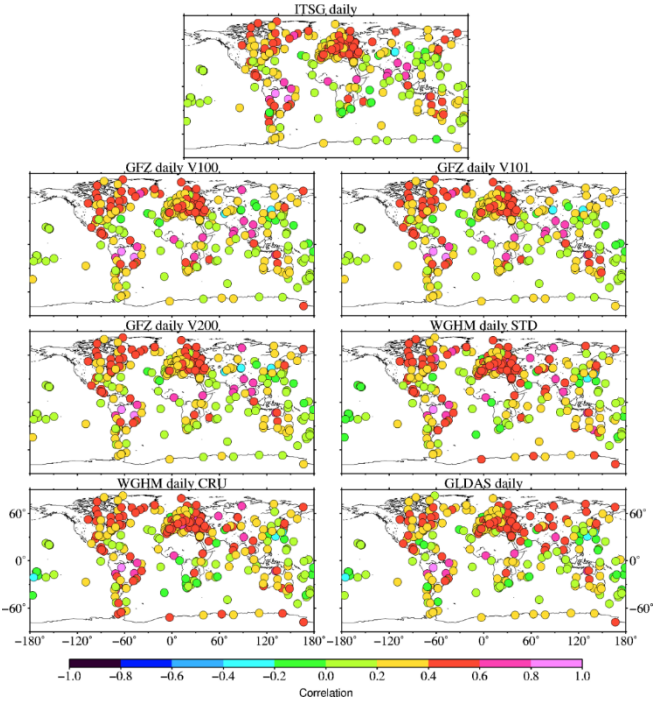
Data

- GNSS data
  - Reprocessed daily UBERN GNSS time series (Repro3)
    - Time period: 2003~2014
    - Cleaned, detrended, outlier and offsets removed
  - Latest daily ITRF2014 GNSS residuals (IGN)
    - Time period: 1994~2015
    - Rigorously stacking the latest IGS repro2 solutions
- Gravity models
  - Daily GRACE products in grids and SHs from GFZ: v201, v211, v221 (fully uploaded on 02.06.2017)
    - Time period: 04.04.2002~31.08.2016 for v201 and v211, 04.04.2002~13.12.2015 for v221
  - Daily GRACE products from ITSG2016
    - Time period: 04.04.2002~31.08.2016

Daily GRACE fields post-processing

	ITSG-Grace2016 Kalman n=40	GFZ daily RBF solutions v201, v211, n=50	GFZ daily RBF solutions v221 n=50
• replace C20 from SLR	-	-	-
• subtract a priori GIA model	-	-	-
• restoring interpolated degree-1	X	X	-
• applying filtering	-	-	-
• adding back GAC product removed during de-aliasing	X	X	X
• fit & remove mean & trend	X	X	X
• displacement in CF	X	X	X

Validation at full GRACE SH spectrum



Both can not tell which degree of GRACE SH coefficients might be problematic!

	WRMS reduction [%]				Positive WRMS reduction [%]
	min	max	mean	median	
GFZ V100	-16.45	63.42	5.79	4.31	84.52
GFZ V101 (without dealiasing)	-16.65	63.97	5.78	4.34	85.79
GFZ V200 (without dealiasing)	-17.33	64.12	5.52	4.00	82.23
ITSG (without dealiasing)	-17.32	64.21	6.10	4.88	84.77
ITSG (with dealiasing)	-12.80	66.45	14.73	14.47	93.40
GLDAS	-12.54	33.42	5.09	3.45	80.92
WGHM STD	-18.61	44.96	5.31	4.10	78.96
WGHM CRU	-14.83	42.80	5.53	4.44	84.48

Degree WRMS reduction

- To better validate at each SH degree, I use

$$Degree\ \mathrm{WRMS}\ reduction = \frac{\mathrm{WRMS}\left[h_i^{\mathrm{GPS}}\right] - \mathrm{WRMS}\left[h_i^{\mathrm{GPS}} - h_i^{\mathrm{GRACE}^{n}}\right]}{\mathrm{WRMS}\left[h_i^{\mathrm{GPS}}\right]}$$

Degree WRMS reduction at the i^{th} GPS station

Compute GRACE-derived displacements using SH at only degree *n*

WRMS reduction is similar (or equivalent) to Relative Explained Variance used by Lea in validation using the OBP data

Accumulative Degree WRMS reduction

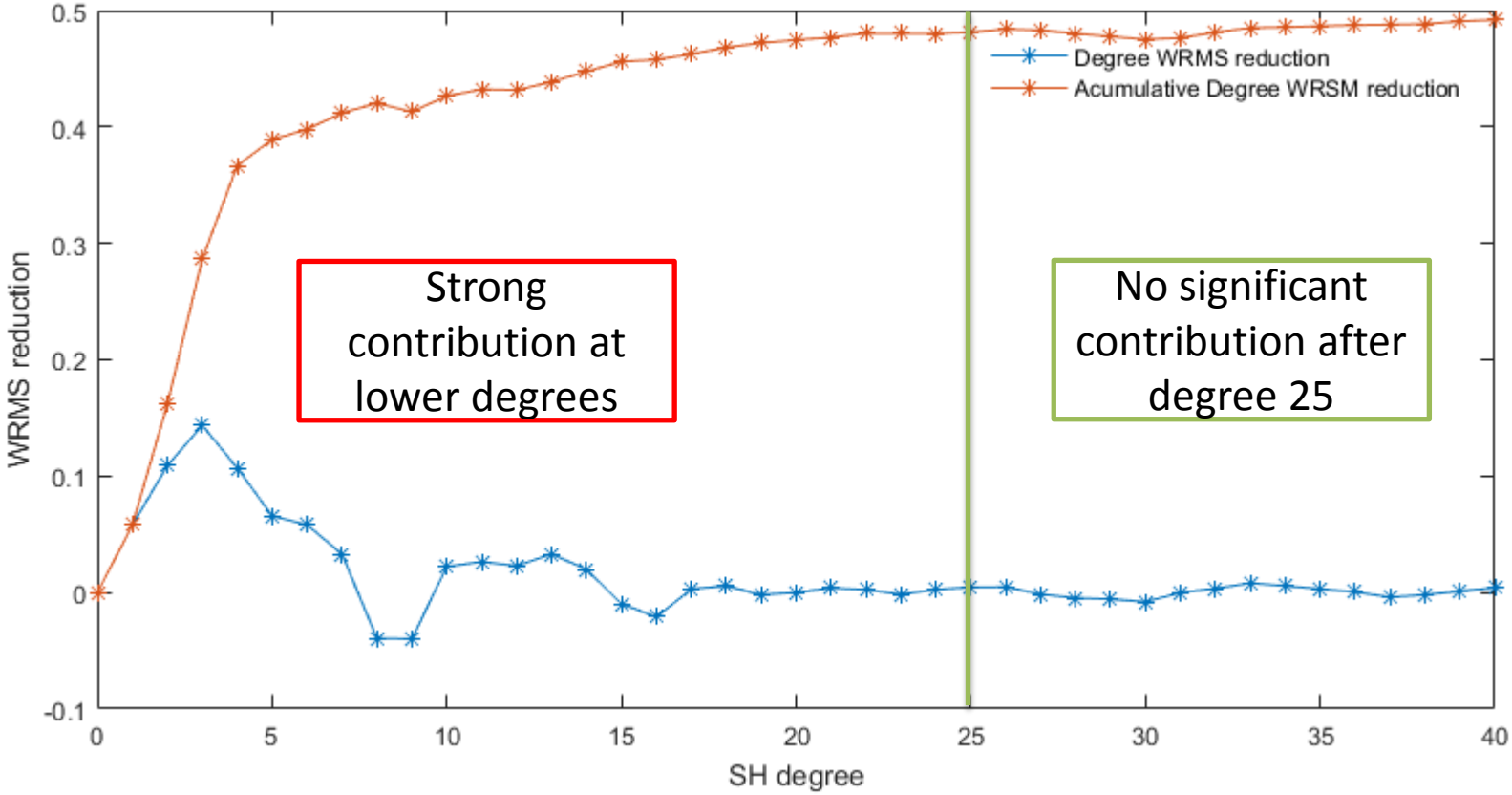
- To better validate at each SH degree, I use

$$\textit{Degree WRMS reduction} = \frac{\mathrm{WRMS}\left[h_i^{\mathrm{GPS}}\right] - \mathrm{WRMS}\left[h_i^{\mathrm{GPS}} - h_i^{\mathrm{GRACE}^{n}}\right]}{\mathrm{WRMS}\left[h_i^{\mathrm{GPS}}\right]}$$

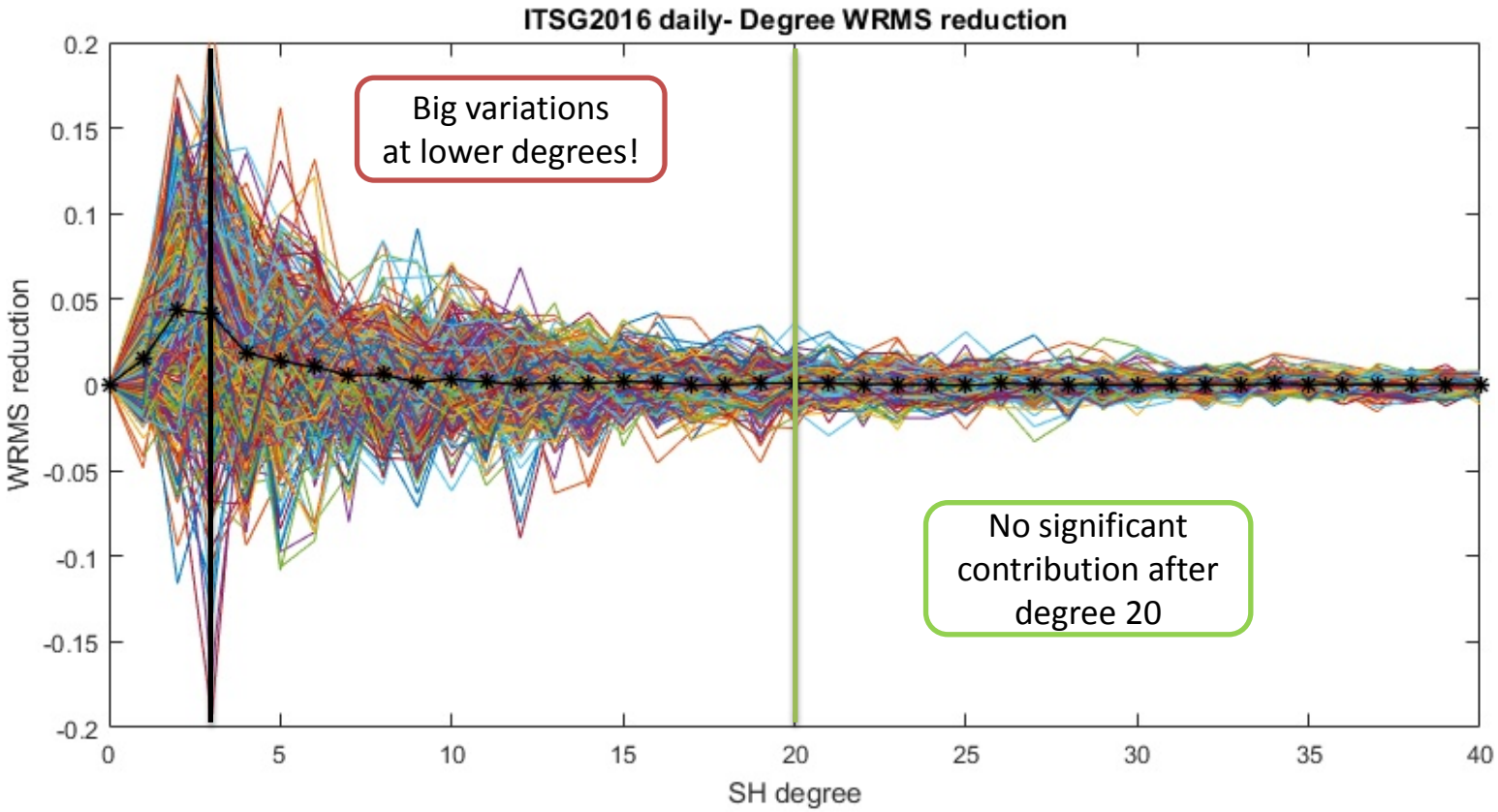
Degree WRMS reduction at the i^{th} GPS station

Compute GRACE-derived displacements using SH up to degree *n*

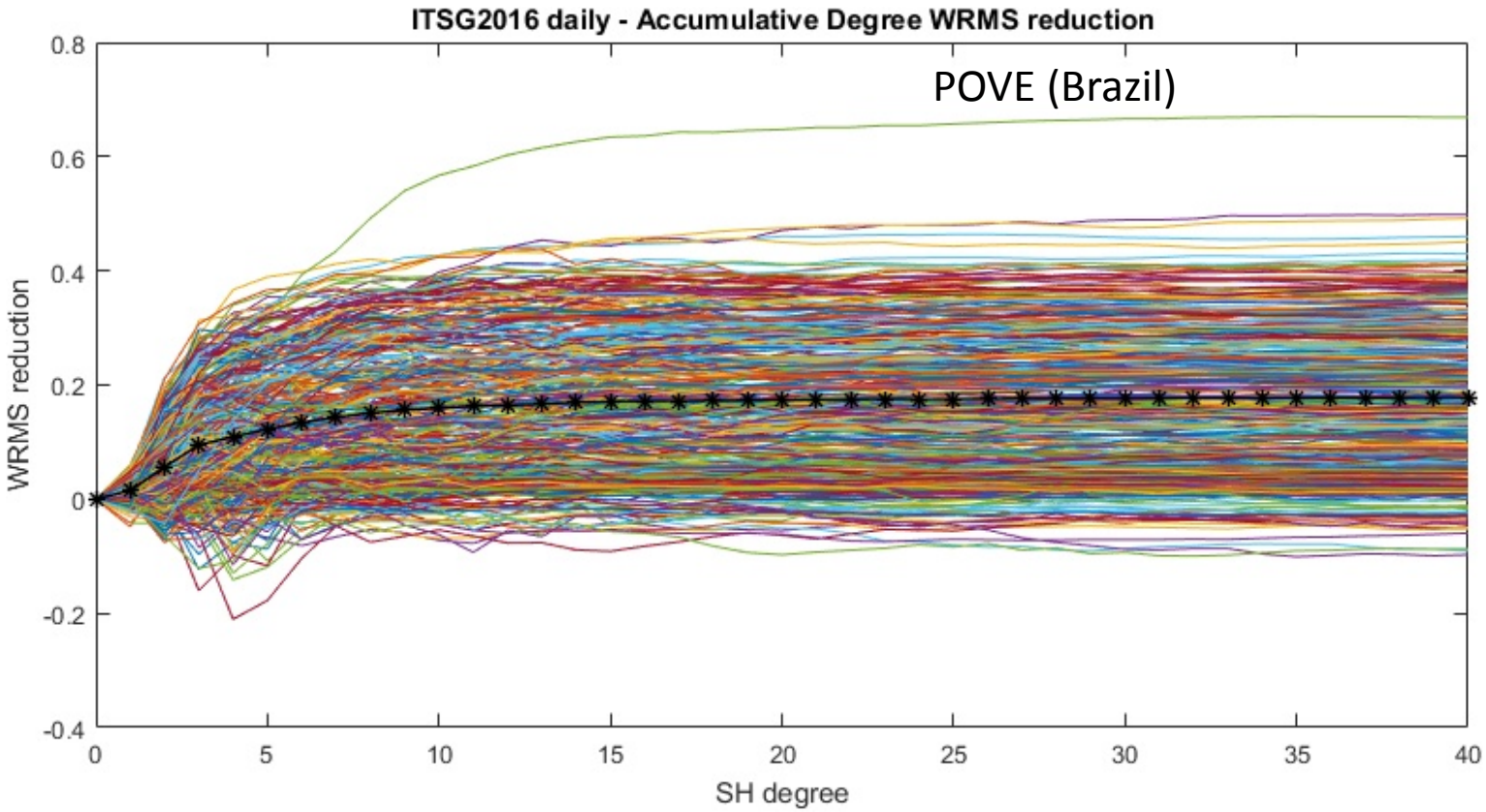
Example: POLV (ITSG2016)



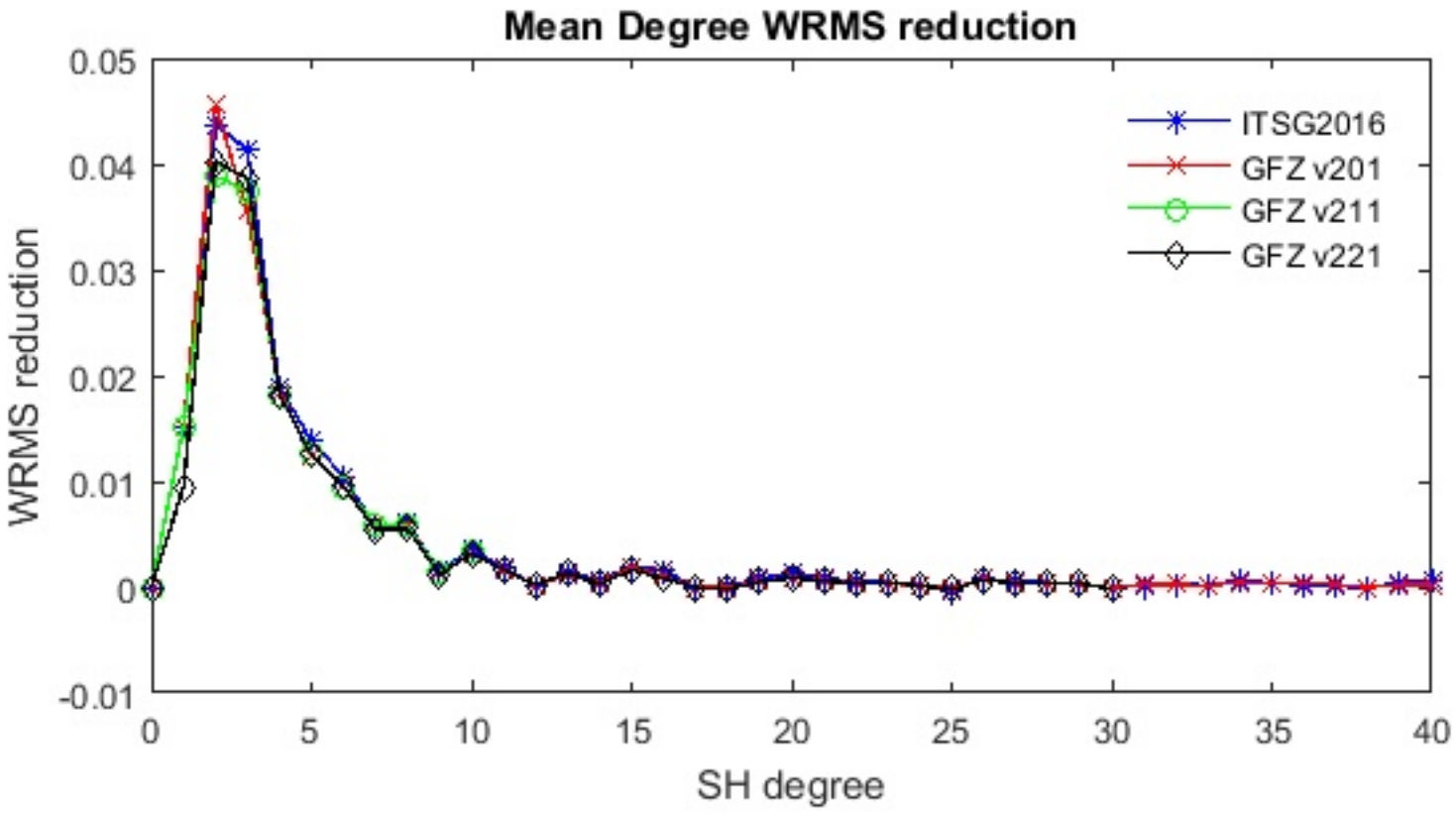
Example: all selected 394 stations



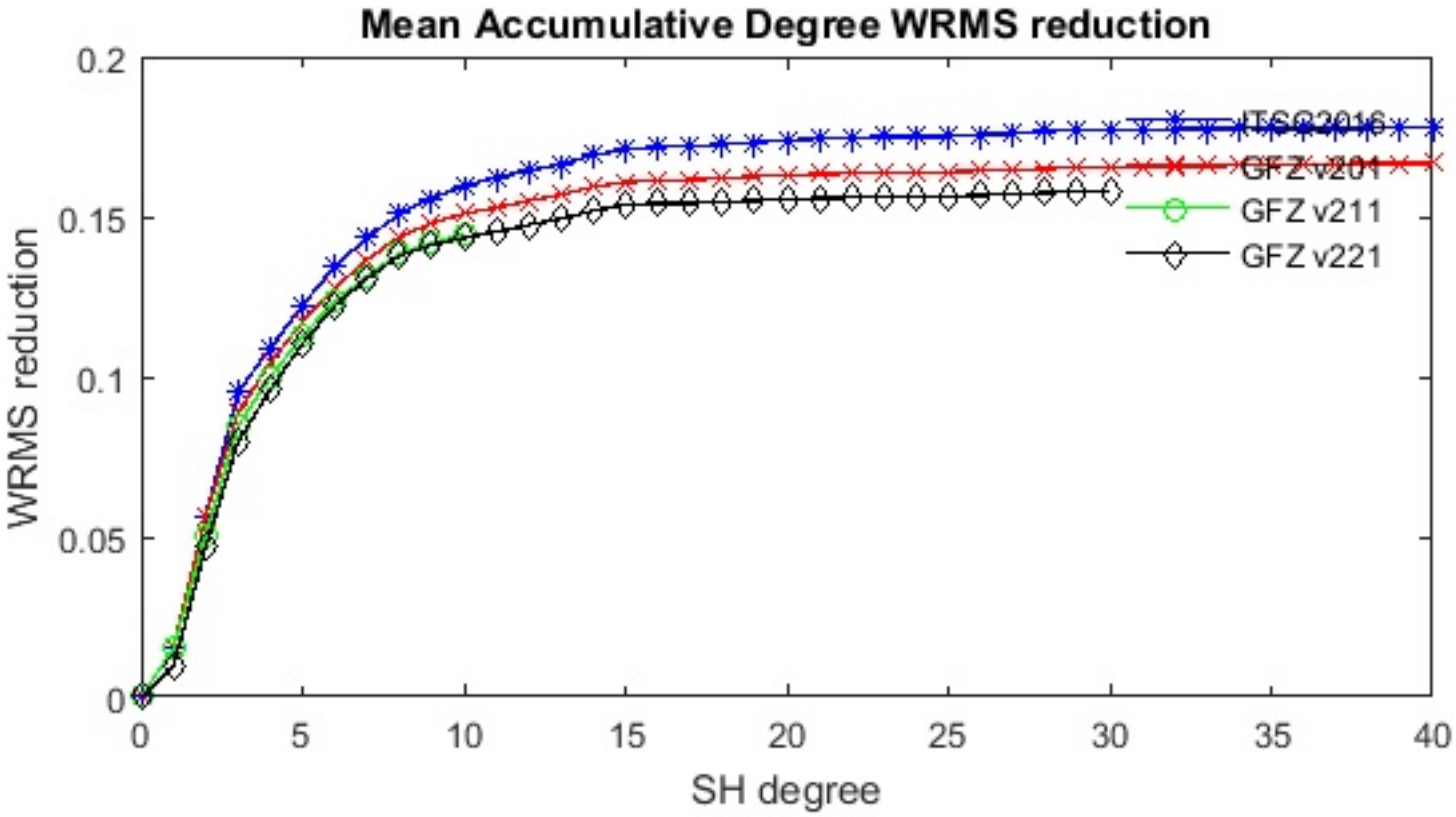
Example: all selected 394 stations



Comparison over all daily solutions



Comparison over all daily solutions



Comparison with respect to models

	WRMS reduction [%]				Positive WRMS reduction [%]
	min	max	mean	median	
ITSG2016	-9.74	66.87	17.79	17.53	94.42
GFZ V201	-10.85	64.83	16.71	17.12	93.15
GFZ V211	-10.80	61.48	16.02	15.97	91.37
GFZ V221	-10.35	64.72	15.95	15.35	92.39
models	-	-	-	11.53	90.74

All daily GRACE solutions are better models!

models: a combination of NCEP, ECCO and GLDAS, see Weiwei Li et al., (EGU 2016)

Validating with GNSS during operational run

Data

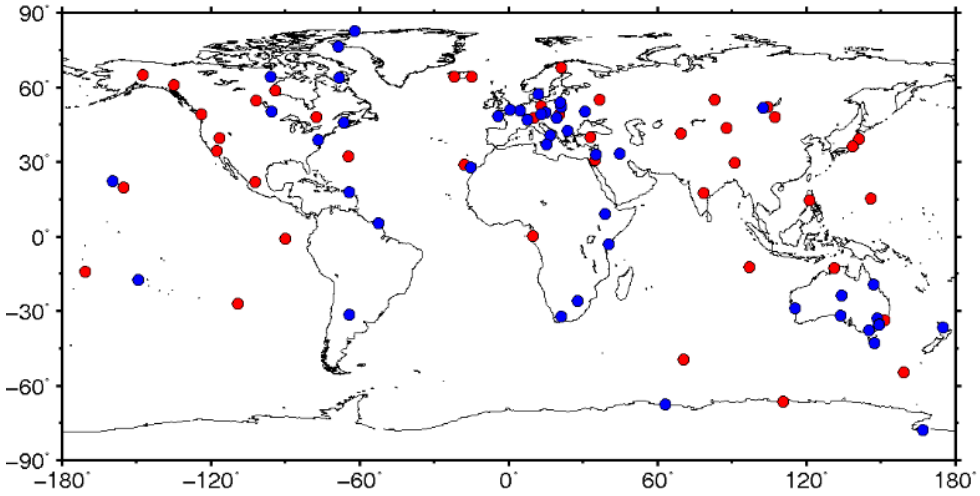
- GNSS data
  - JPL and SOPAC daily data
    - Cleaned, detrended, outlier and offsets removed
  - Rapid solutions from UBERN since 11.11.2016
- Gravity models
  - NRT daily GRACE products from GFZ since 16.03.2017
    - The same post-processing as v221
  - NRT daily GRACE products from TUG since 02.02.2016 (big gap from 28.11.2016 to 13.01.2017)
    - The same post-processing as daily ITSG2016

Common periods of GNSS,
NRT GFZ and NRT TUG
(16.03.2017 - 26.05.2017)

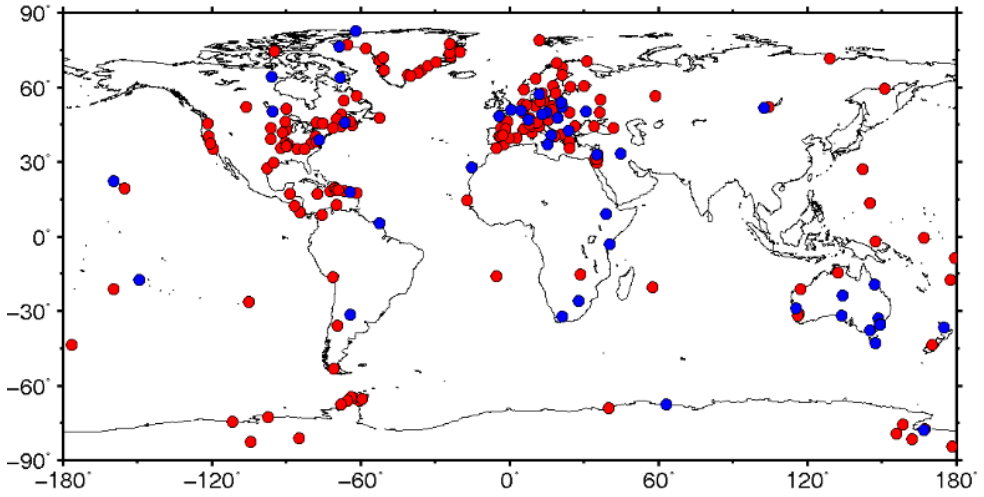
Daily GNSS time series post-processing

	JPL and SOPAC	Bern Rapid
• raw XYZ to NEU	-	X
• removing stations with data less than 30 common days	X	X
• removing stations affected by earthquake	X	X
• removing offsets	-	X
• removing outliers	X	X
• fit & remove mean & trend	-	X

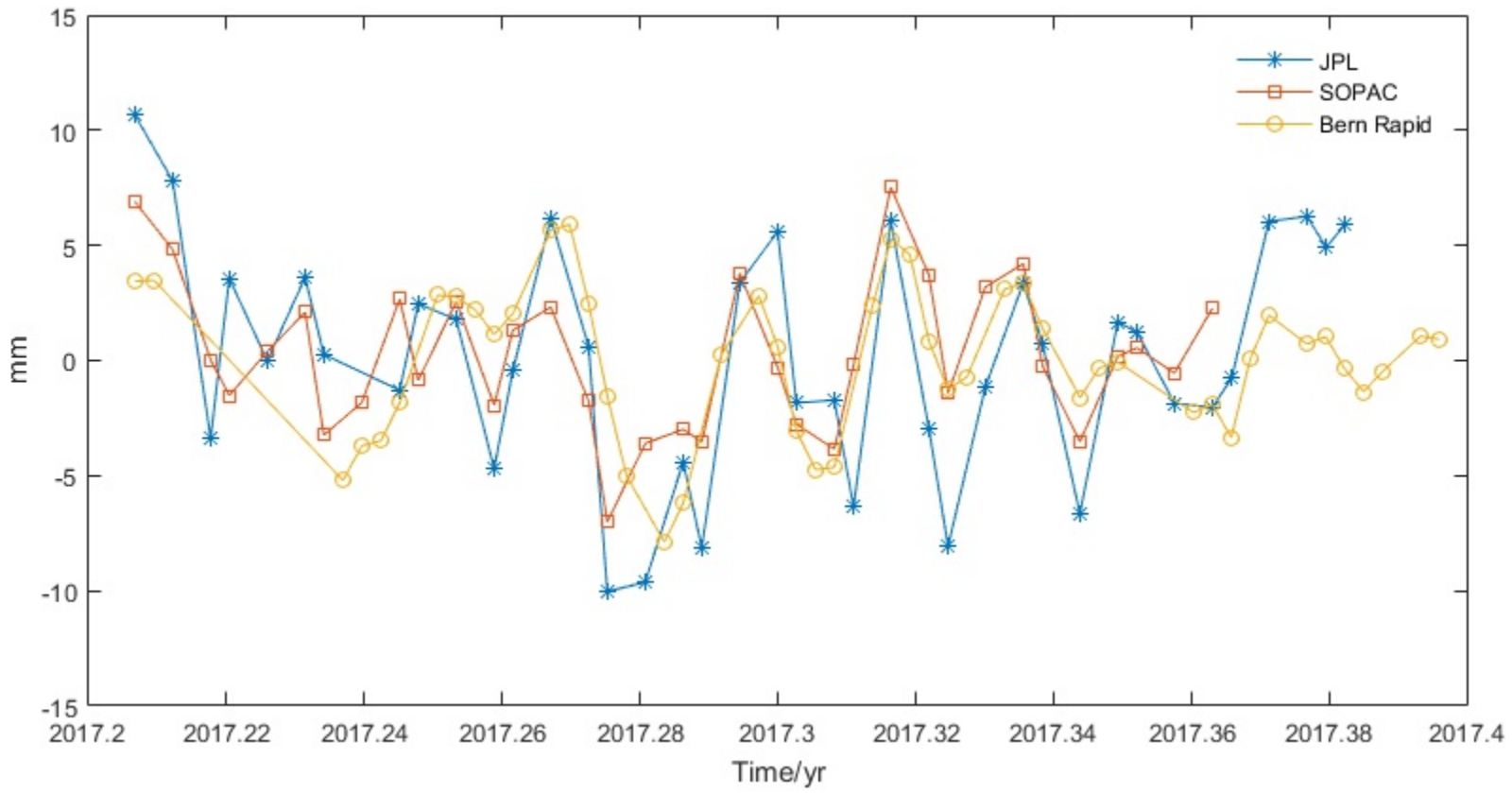
Daily GNSS time series: stations



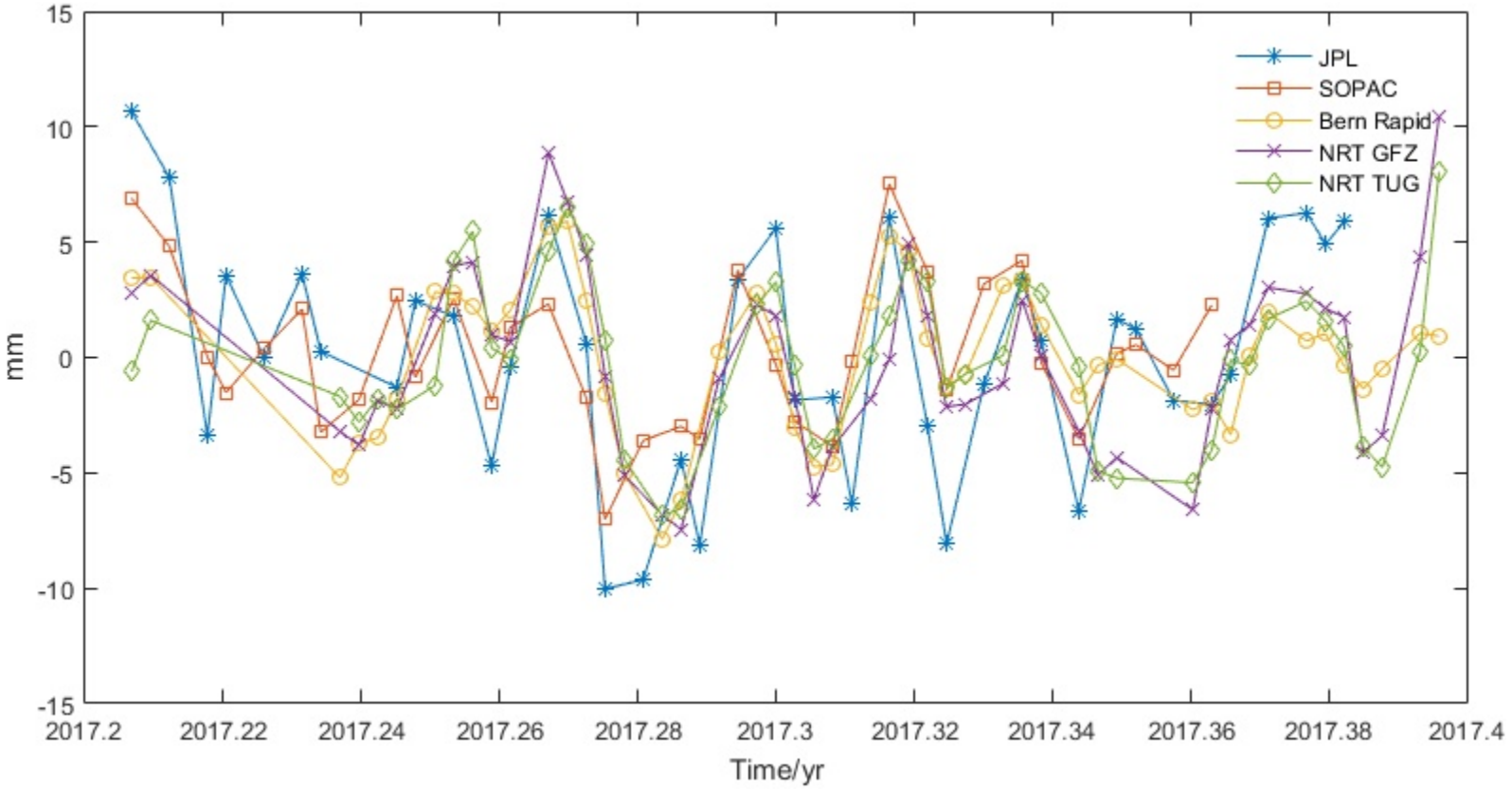
- 95 Rapid GNSS stations (Top left)
- 228 JPL and SOPAC stations (Bottom right)
- 49 in common with JPL and SOPAC



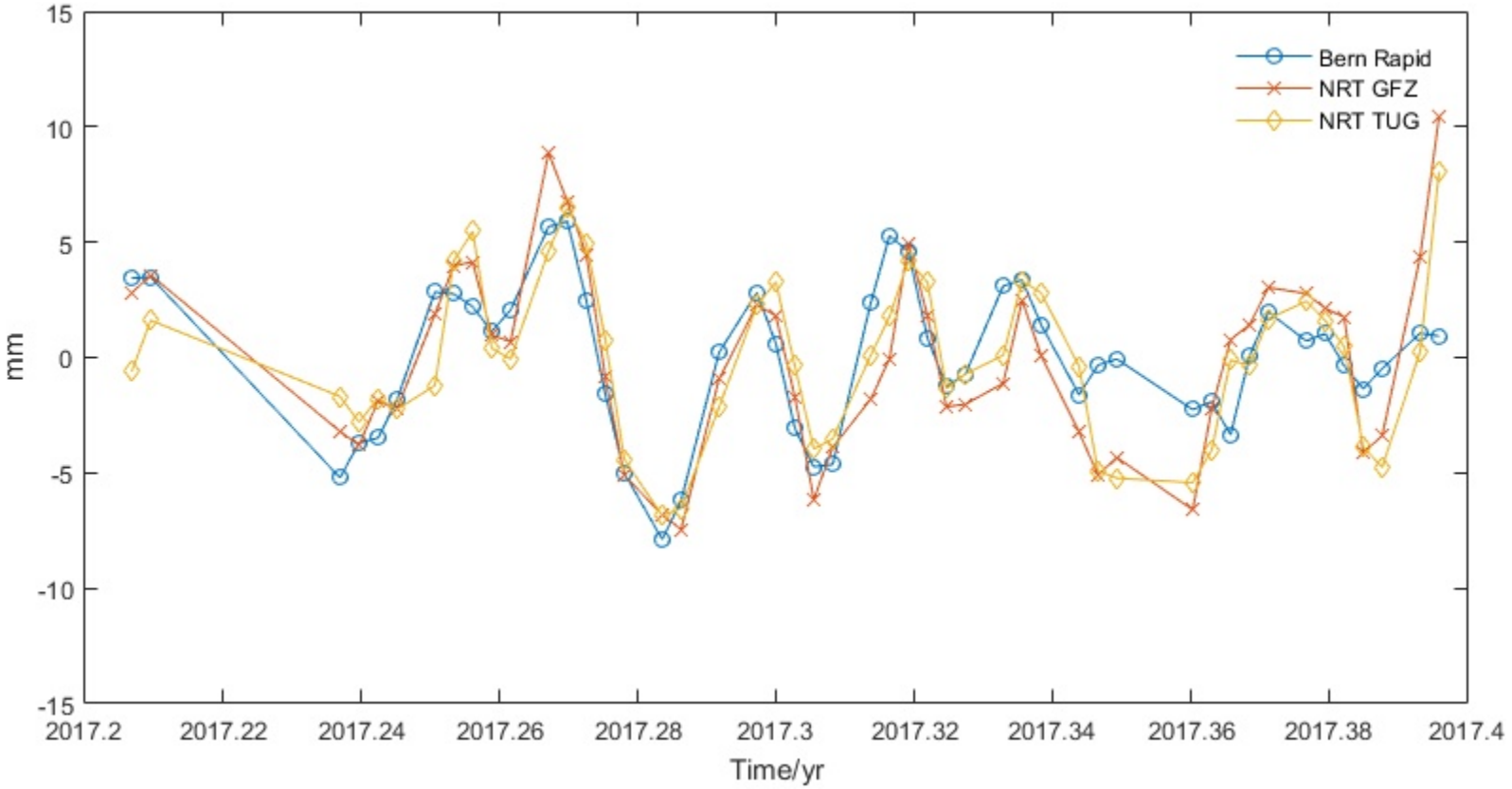
Daily vertical GNSS time series: BAKE



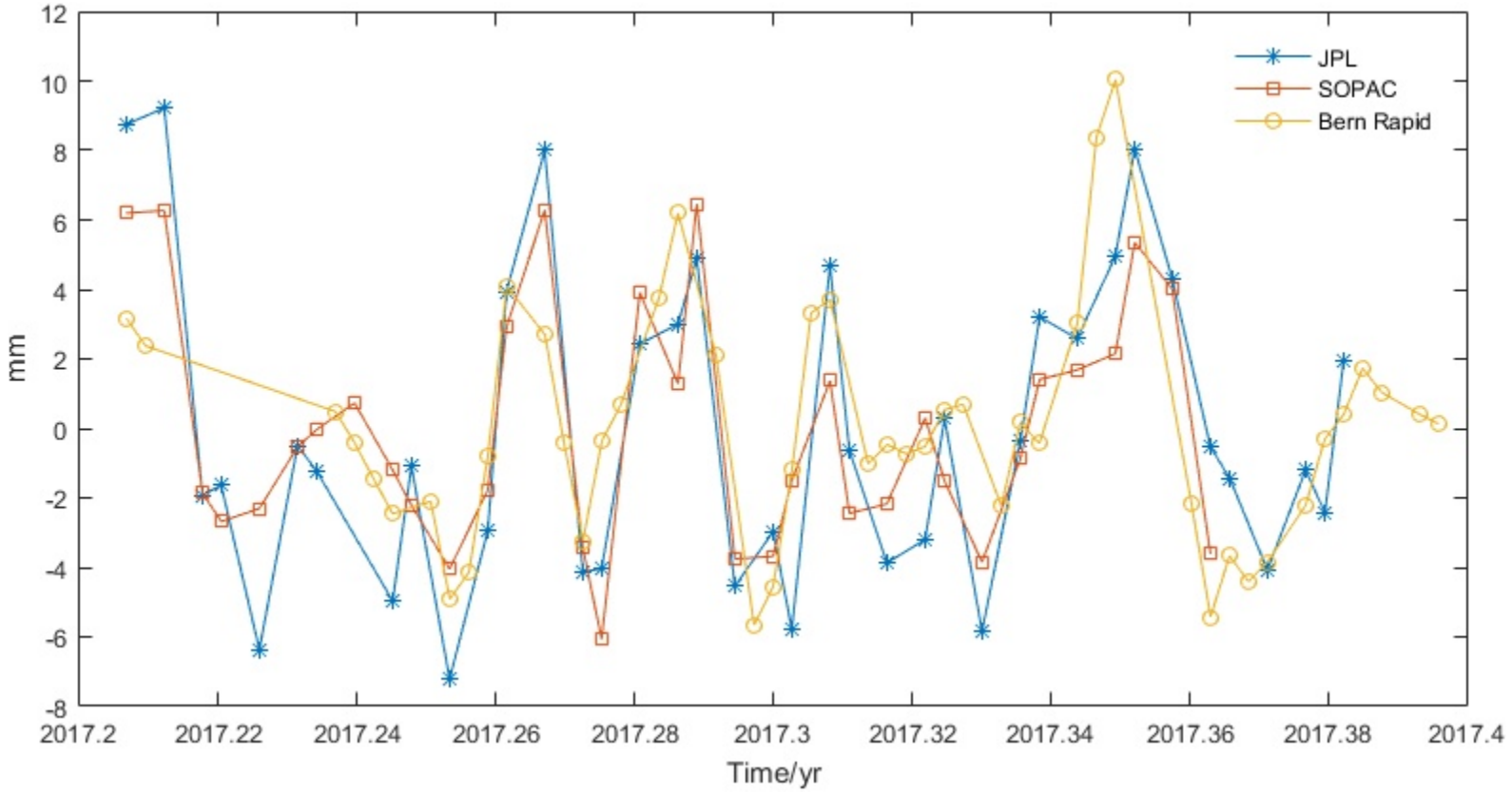
Daily vertical GNSS time series: BAKE with NRT



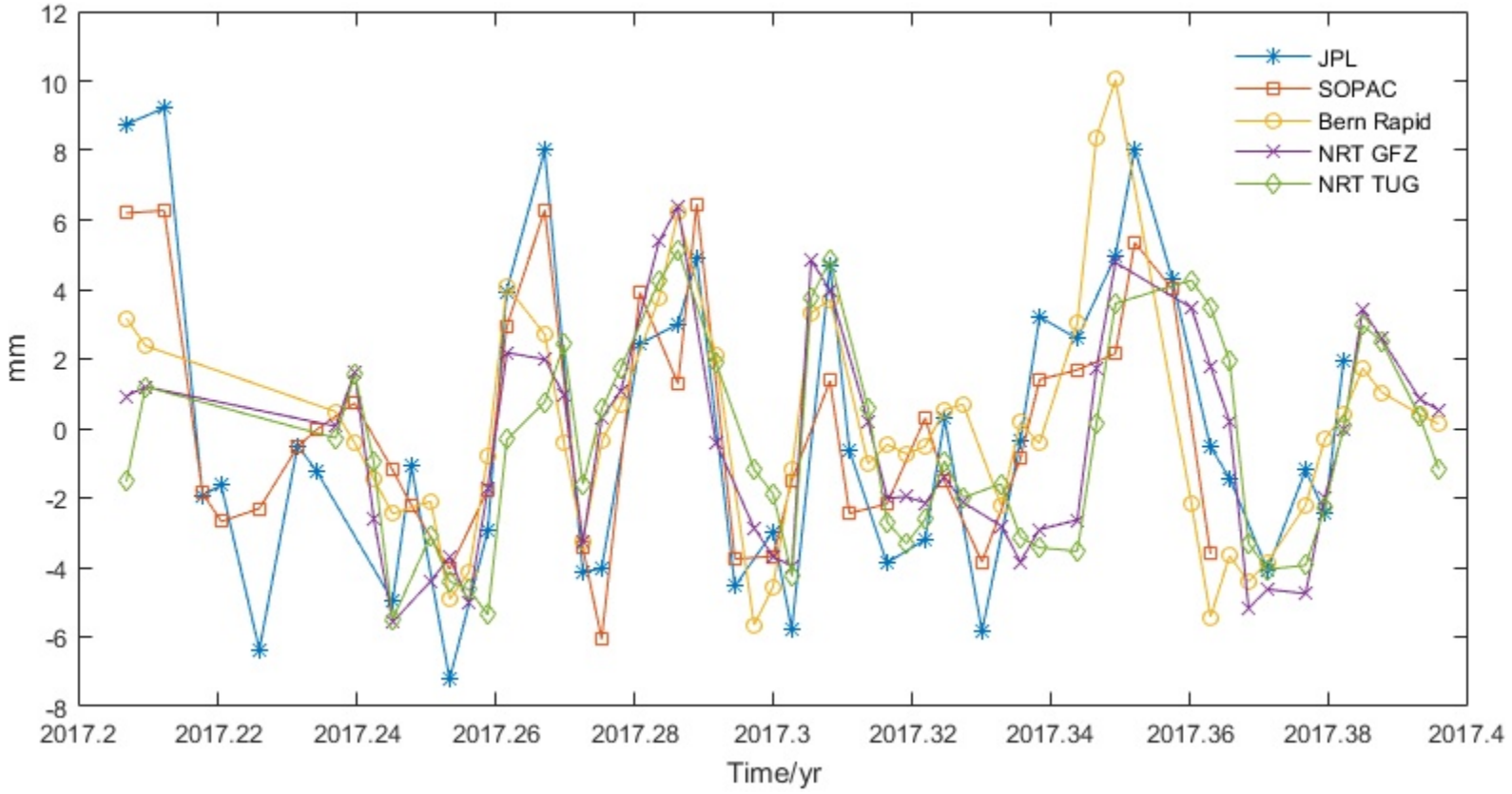
Daily vertical Rapid GNSS time series: BAKE with NRT



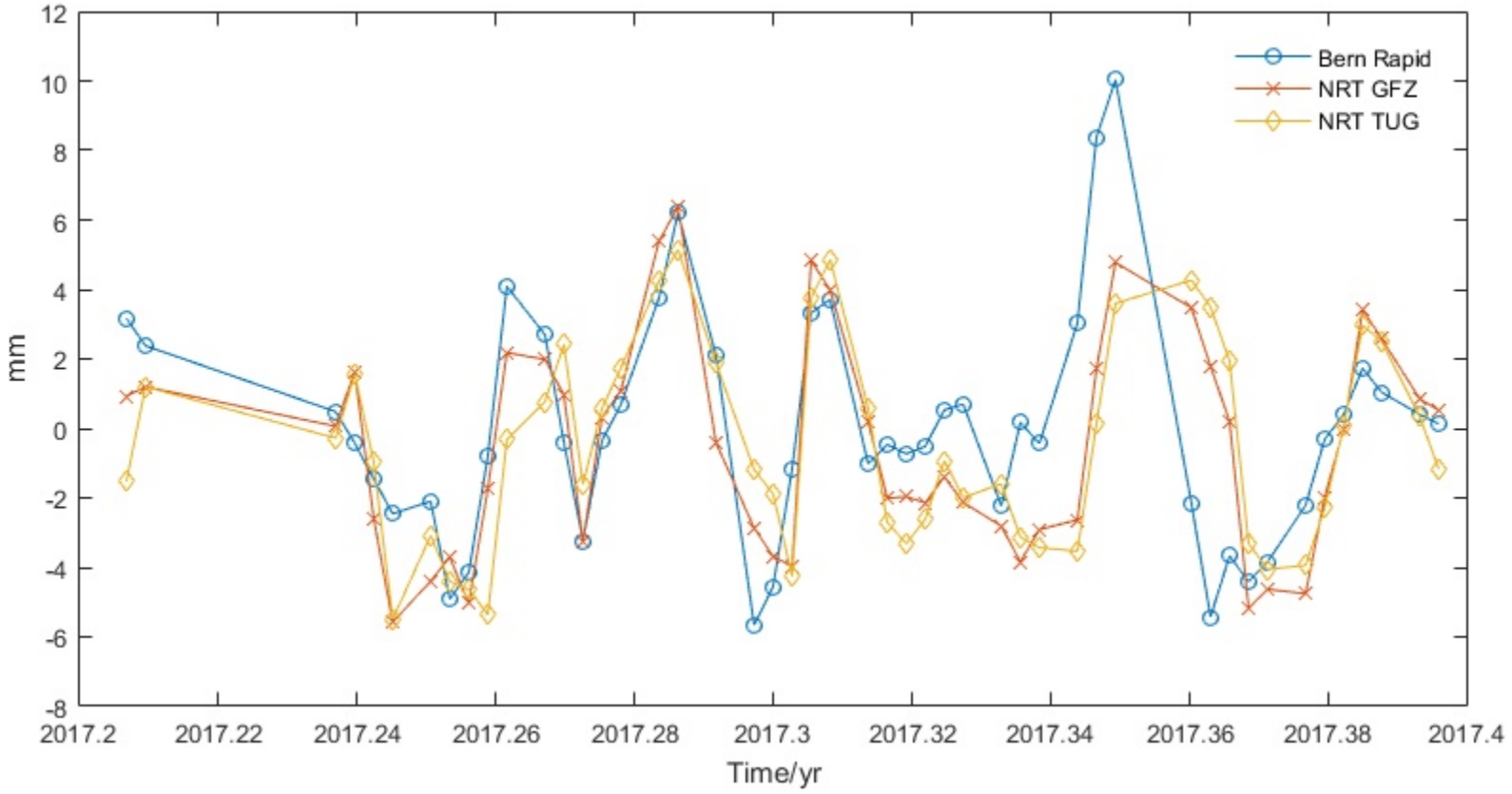
Daily vertical GNSS time series: GLSV



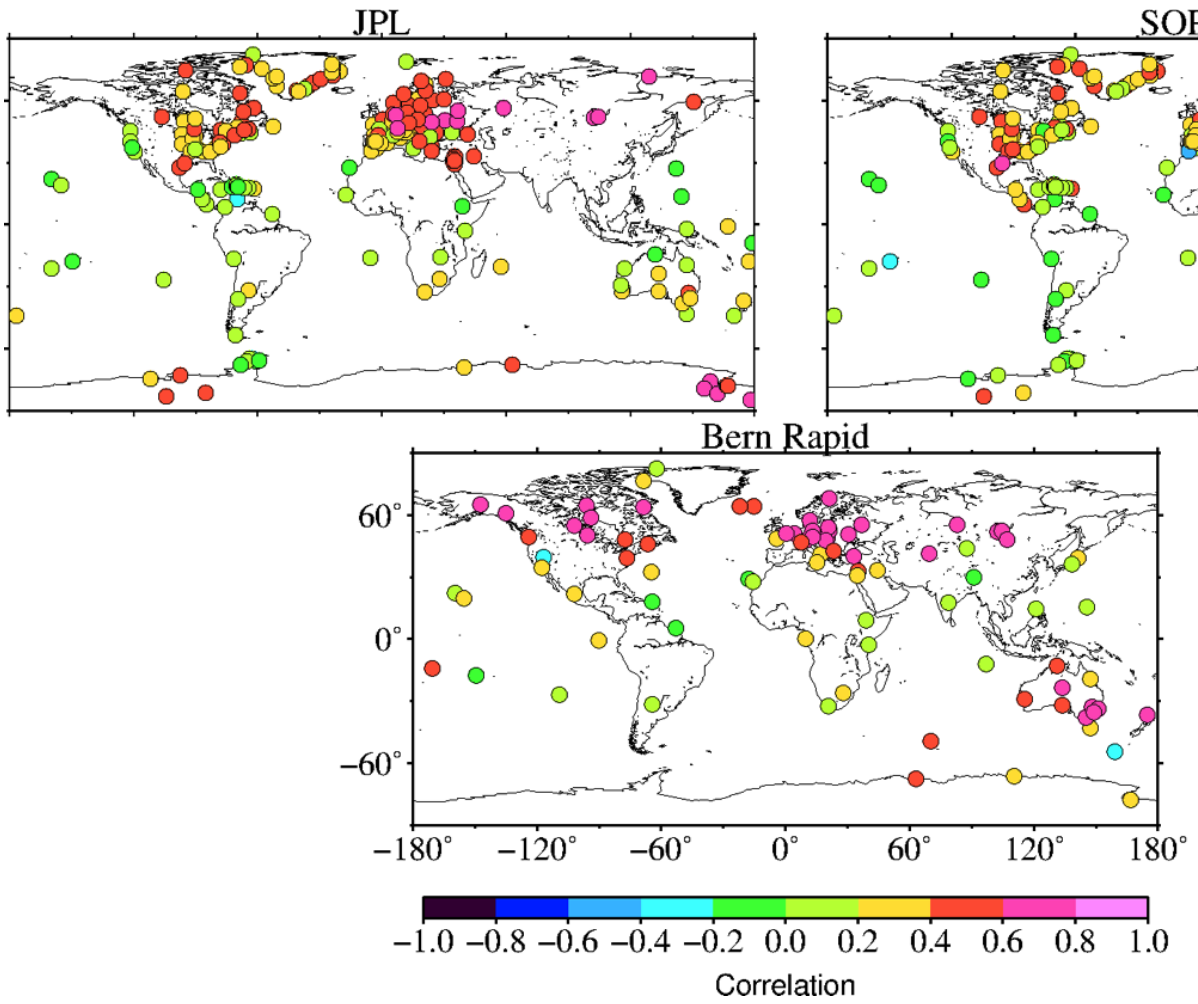
Daily vertical GNSS time series: GLSV with NRT



Daily vertical Rapid GNSS time series: GLSV with NRT

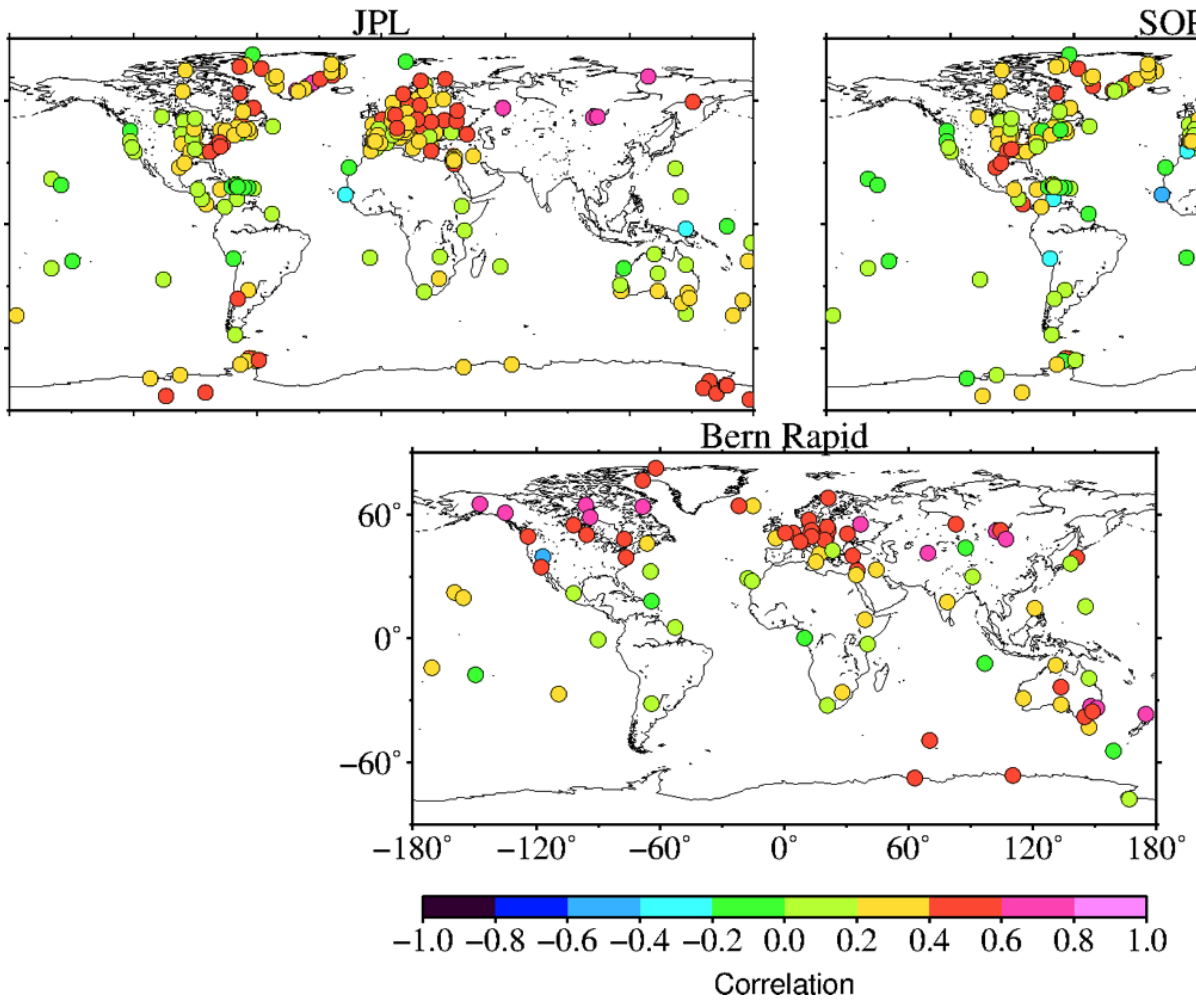


Correlation: daily GNSS and GFZ NRT



mean
JPL: 0.31
SOPAC: 0.24
Bern Rapid: 0.41

Correlation: daily GNSS and TUG NRT



mean
JPL: 0.28
SOPAC: 0.19
Bern Rapid: 0.36

Summaries

- Validation over historic events
  - Degree WRMS reduction is helpful in validation with GNSS
  - Both ITSG2016 and GFZ daily fields are better than models
  - GFZ v201 seems to be slightly better than v211 and v221

- Validation during operational run
  - Time series is too short to make strong conclusions
  - Based on current time series, both GFZ and TUG NRT fields agree well with the rapid solutions from Bern
  - The rapid solutions seem to have better agreements than the JPL and SOPAC solutions