EGSIEM

European Gravity Service for Improved Emergency Management

WP3 Integration of complementary data

HORIZON 2020

Working progress

- T3.1: Reference Frame reprocessing UBERN
  - M03-M10
- T3.2: SLR normal equations UBERN
  - M07-M09
- T3.3: NRT Reference Frame processing UBERN
  - M03-M06
- T3.4: Operational NRT Reference Frame processing UBERN
  - M28-M33
- T3.5: Validation of GRACE gravity products with GNSS UL
  - M19-M36: will presented today by Q. Chen
- T3.6: Validation of GRACE gravity products with Ocean Bottom Pressure GFZ
  - M25-M36: will presented today by L. Poropat
- T3.7: Preparation for Hydroweb data CNES
  - M01-M10
- T3.8 GIA for Hydrology LM
  - M11-M36: will presented today by H. Steffen
- T3.9: Compilation of representative historical flood situations DLR
  - M01-M10

EGSIEM

European Gravity Service for Improved Emergency Management

WP3. Integration of complementary data

Validation with GNSS loading

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EGSIEM Progress Meeting # 4

January 19 – 20, 2017

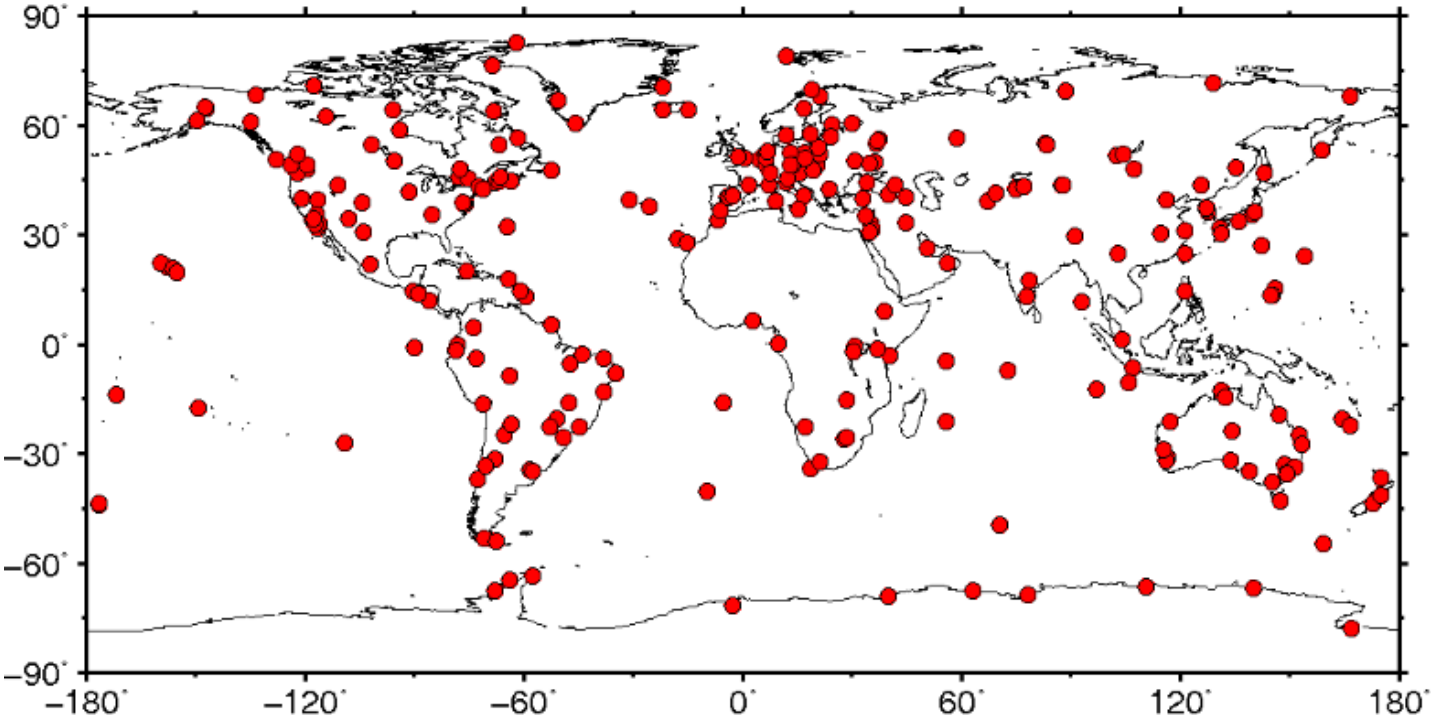
HORIZON 2020

Data

- GNSS data
  - Reference frame data from UBERN (Repro 3)
    - Raw data in SINEX format
  - Latest daily ITRF2014 GNSS residuals (IGN), 1054 stations
    - Rigorously stacking the latest IGS repro2 solutions, averaged into monthly
  - Latest global daily GNSS time series from JPL (1094 stations)
    - Cleaned, detrended and outlier removed, averaged into monthly
- Gravity models
  - EGSIEM combined solution, 2003-2014
  - Official GRACE Release 5 from GFZ (RL05a), CSR and JPL (RL05.1)
  - Addition GRACE products from AIUB (RL2), ITSG (2016) and CNES (GRGS RL03v3)
  - Standard GRACE data processing
    - Replacing C20 term (Cheng et al., SLR) and adding back degree-1 coefficients (Swenson et al., 2008)
    - The Gaussian filtering with a smoothing radius of 500 km
    - Adding back GAC products when comparing to GNSS
    - Converting into displacements using the spherical harmonic approach in the vertical component

Processing Repro3

- Reference frame data (Repro3, GNSS position time series) provided by UBERN in SINEX format from 2003 to 2014
  - 312 stations for further processing (393 stations in total with 81 stations removed due to short time span, very big gaps or very bad data)



Processing Repro3

- Processing procedure
  - Coordinate transformation from XYZ to NEU
  - Offsets detection and removal
  - Removing outliers
  - Average daily data into monthly data

Processing Repro3

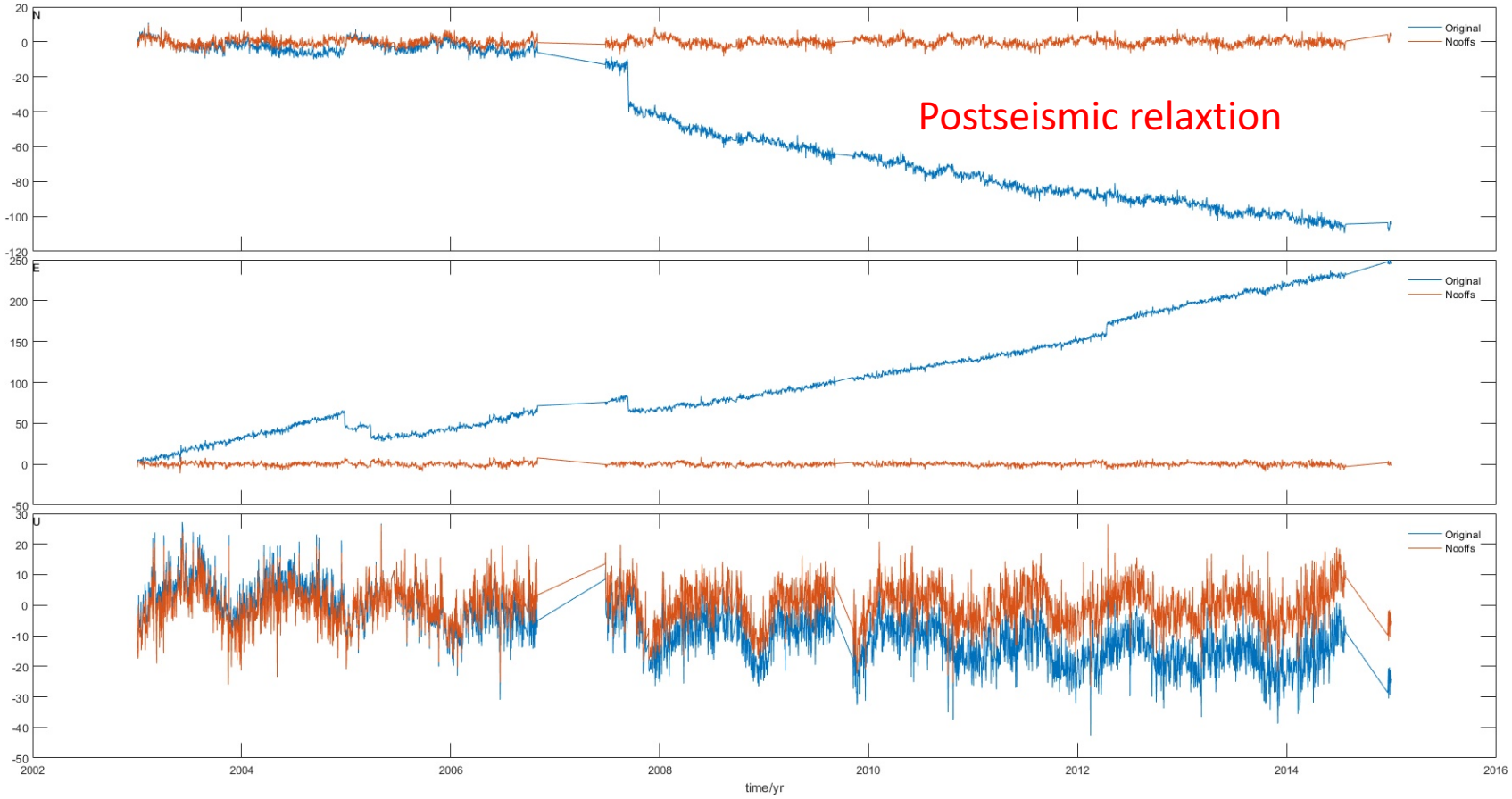
- Offsets detection and removal
  - Including jumps, coseismic offsets and postseismic relaxation
    - 264 out of 312 stations with offsets (84.62%)
    - 33 out of 264 stations with postseismic relaxation
  - No efficient automatic way to detect (Gazeaux et al., 2013)
  - Visual inspection and detection with offset datasets from NGL, JPL and SOPAC
    - An offset dataset for Repro3 and potentially for near-real-time validation using rapid solutions
  - Extended Trajectory Model to remove postseismic relaxation (Bevis and Brown, 2014)

$$\begin{aligned}\mathbf{x} = &\sum_{i=0}^{n_P} \mathbf{p}_i (t - t_R)^i + \sum_{i=1}^{n_J} \mathbf{b}_j H(t - t_j) \\ &+ \sum_{i=1}^{n_F} \mathbf{s}_i \sin(\omega_i t) + \mathbf{c}_i \cos(\omega_i t) \\ &+ \sum_{i=1}^{n_T} \mathbf{e}_i (1 - \exp(-(t - t_i)/T_i)) + \\ &+ \sum_{k=1}^{n_L} \mathbf{a}_k \log(1 + (t - t_k)/T_k))\end{aligned}$$

T_i and T_k from JPL model

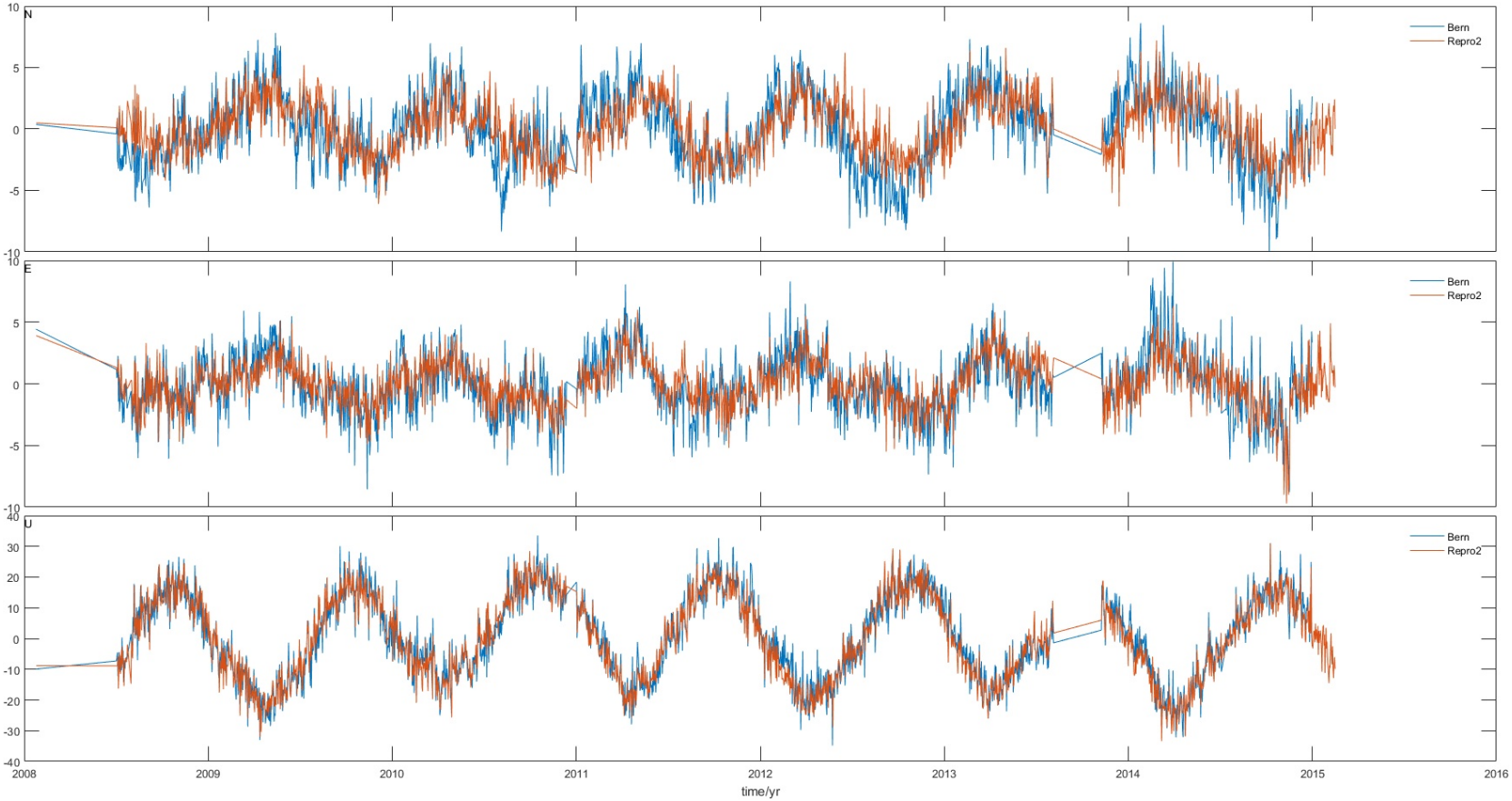
Processing Repro3

- Example of Offsets detection and removal: NTUS



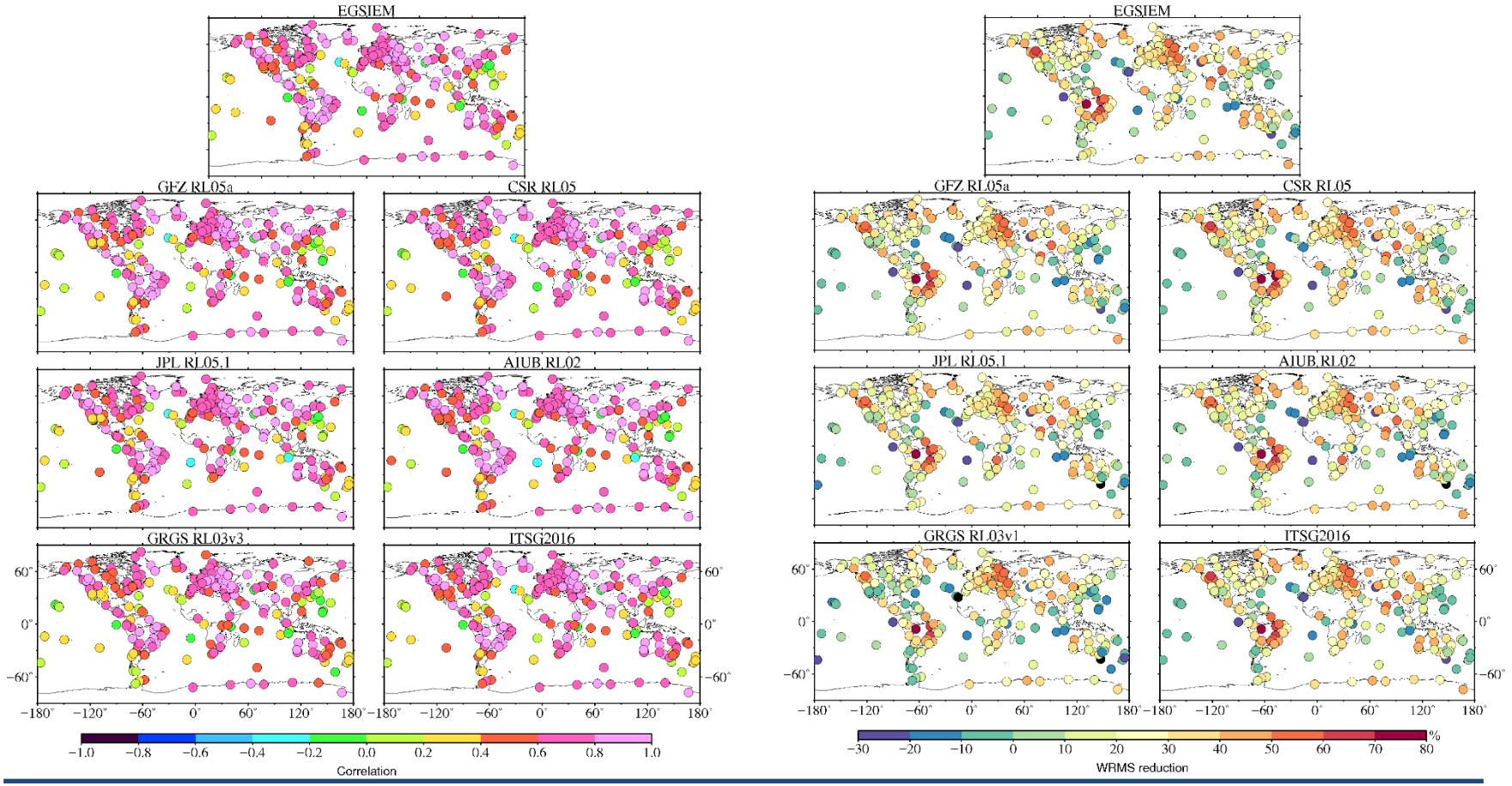
Processing Repro3

- Comparison with respect to the ITRF2014 residuals: POVE



Validation with Repro3

- In a comparison to 312 GNSS stations: correlation (left) and WRMS reduction (right)



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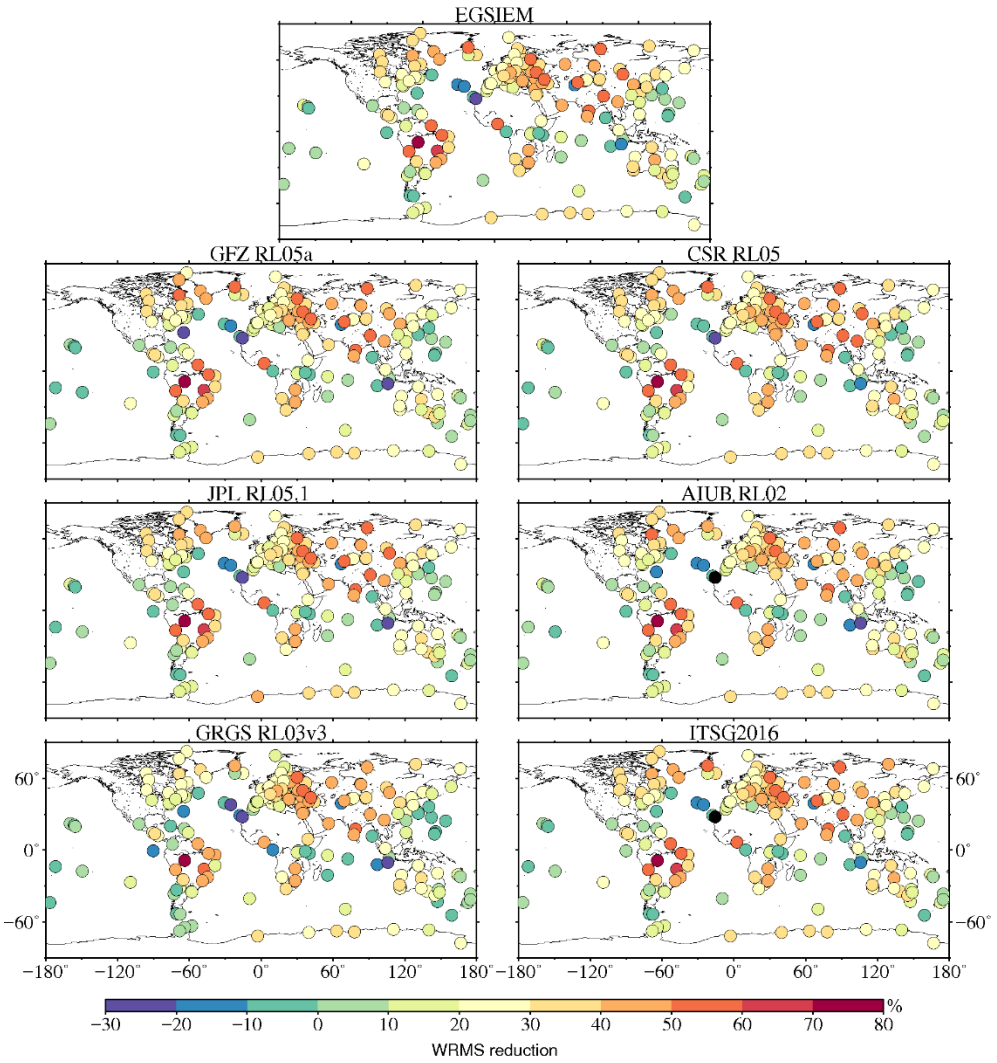
Validation with Repro3

	Correlation			Stations with correlation> 0.6 [%]	WRMS reduction [%]			Positive WRMS reduction [%]
	min	max	mean		min	max	mean	
GFZ RL05a	-0.24	0.98	0.60	62.18	-26.82	76.48	22.23	86.86
CSR RL05	-0.28	0.99	0.62	66.67	-28.07	78.87	24.22	88.14
JPL RL05.1	-0.37	0.98	0.60	63.78	-31.19	77.05	22.52	87.18
AIUB RL02	-0.30	0.99	0.60	63.78	-34.87	78.56	22.80	87.50
GRGS RL03v3	-0.25	0.98	0.57	56.41	-33.49	78.48	20.26	81.41
ITSG2016	-0.29	0.98	0.61	66.03	-27.44	78.38	23.91	87.18
EGSIEM	-0.30	0.99	0.62	66.99	-28.76	78.57	24.05	89.42

- All seven GRACE products display good agreements with the Repro3 solutions
- EGSIEM, CSR RL05 and ITSG2016 provide close performances and slightly better than others

GRACE .VS. GNSS (ITRF2014)

- In comparison to 236 common GNSS stations from ITRF2014, Repro3 and JPL solutions: WRMS reduction



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GRACE .VS. GNSS (Repro3)

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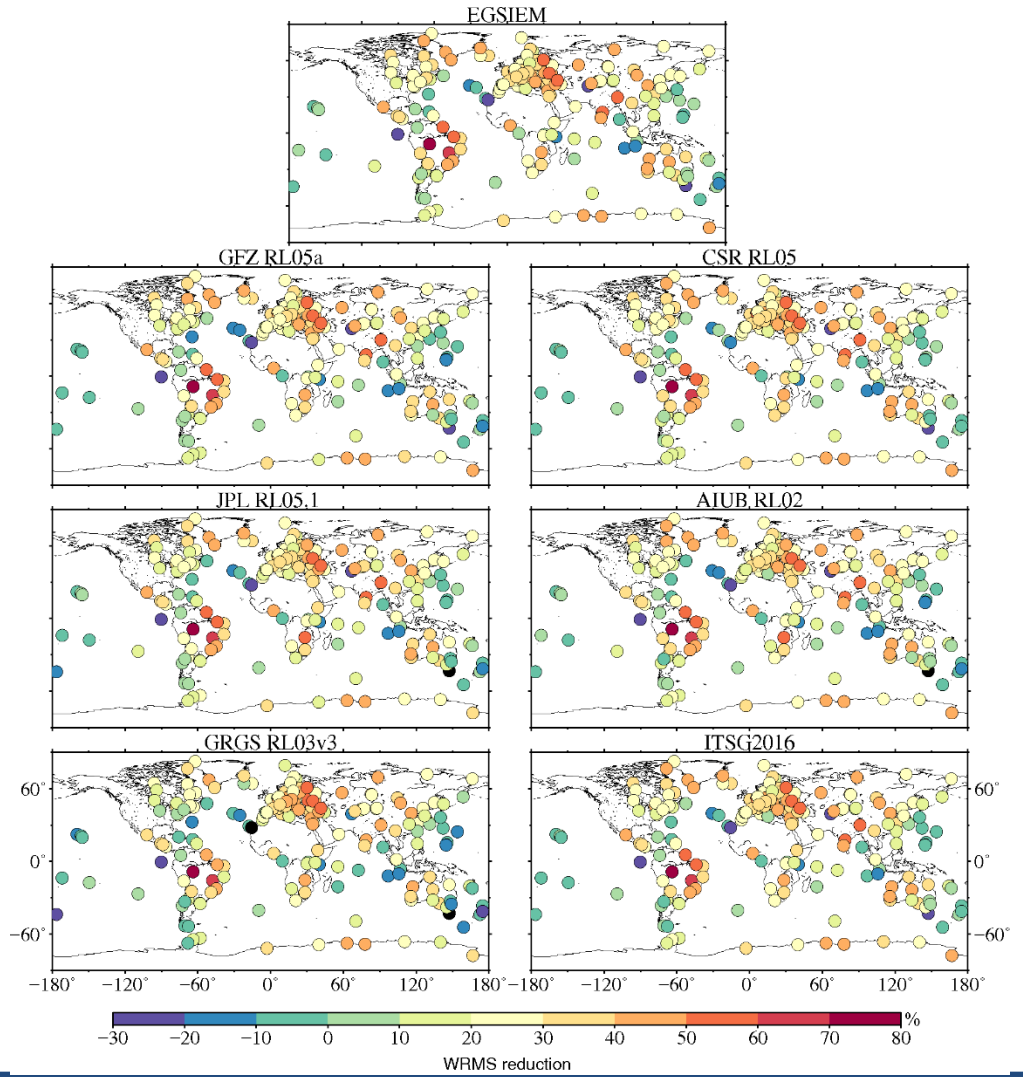

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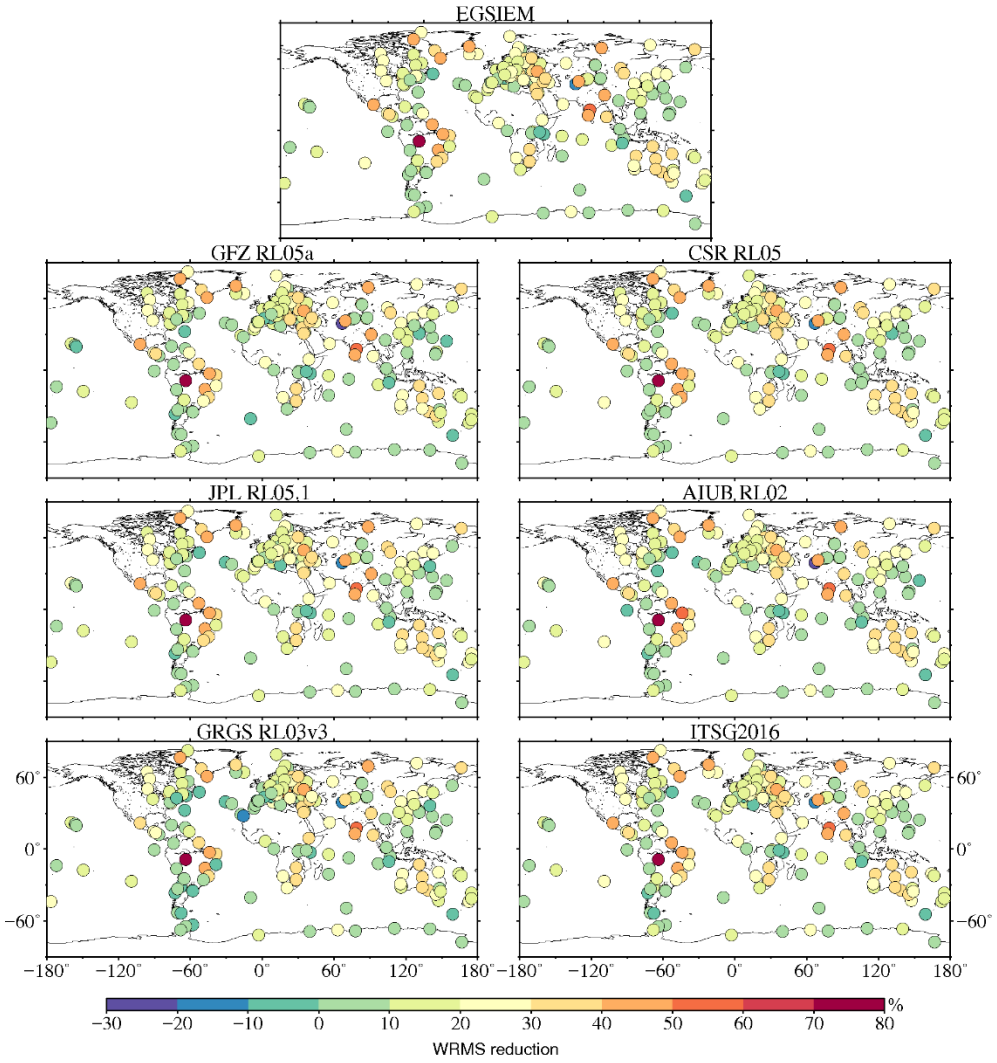
GRACE .VS. GNSS (JPL)

- In comparison to 236 common GNSS stations from ITRF2014, Repro3 and JPL solutions: WRMS reduction



GRACE .VS. GNSS

	Repro3		JPL		ITRF2014	
	mean [%]	positive [%]	mean [%]	positive [%]	mean [%]	positive [%]
GFZ RL05a	21.68	85.59	17.33	91.95	23.71	87.71
CSR RL05	23.58	87.29	18.75	94.92	25.50	89.41
JPL RL05.1	21.78	85.59	18.13	93.64	24.04	89.41
AIUB RL02	22.00	85.59	18.09	92.80	24.01	88.98
GRGS RL03v3	20.36	80.51	16.33	89.83	21.83	85.17
ITSG2016	23.12	85.59	18.61	93.64	25.08	89.83
EGSIEM	23.36	88.56	19.07	94.92	25.50	89.41

- In comparison to 236 common GNSS stations from Repro3, JPL and ITRF2014 solutions
- Repro3 performs between ITRF2014 and JPL solutions
- Again, EGSIEM, CSR RL05 and ITSG2016 provide close performance and better than others

Conclusions

- Generally, all seven GRACE products are in good agreements with the three GNSS Solutions. More than 80% stations (out of 236 stations) have positive WRMS reduction.

- Comparing to the three GNSS solutions, close performances are observed among EGSIEM, CSR RL05 and ITSG2016. They show slightly better statistics than other gravity models.

- Our Repro3 solution provides very close performances to the latest ITRF2014 residuals.

Thanks for your attention!