Ocean Surface Topography Science Team (OSTST

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Inter-calibrated wet path delays for eight altimetric missions

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utline

- GNSS-derived Path Delay (GPD) methodology
  - Objectives and brief description
- Recent improvements: GPD+
  - Additional data sources
  - Inter-calibration of radiometers
- GPD+ WTC result examples
- Closing remarks and future developments

+ methodology

- **Coastal → global**
  - Originally designed to calculate the Wet Tropospheric Correction (WTC) for RADAR Altimetry in the coastal zone, corrected for land contamination in the MWR footprint.
  - Evolved to provide the WTC over open ocean (globally and corrected for ice contamination and spurious measurements e.g. instrument malfunction) and inland water.
- **Data combination using OA**
  - Combines Wet Path Delay (WPD) observations from different sources, using a space-time objective analysis scheme.
  - The spatial/temporal variability of the WPD field and the accuracy of each data set are taken into account

in differences between GPD and GPD+

GPD+ Combines previous GPD and DComb algorithms

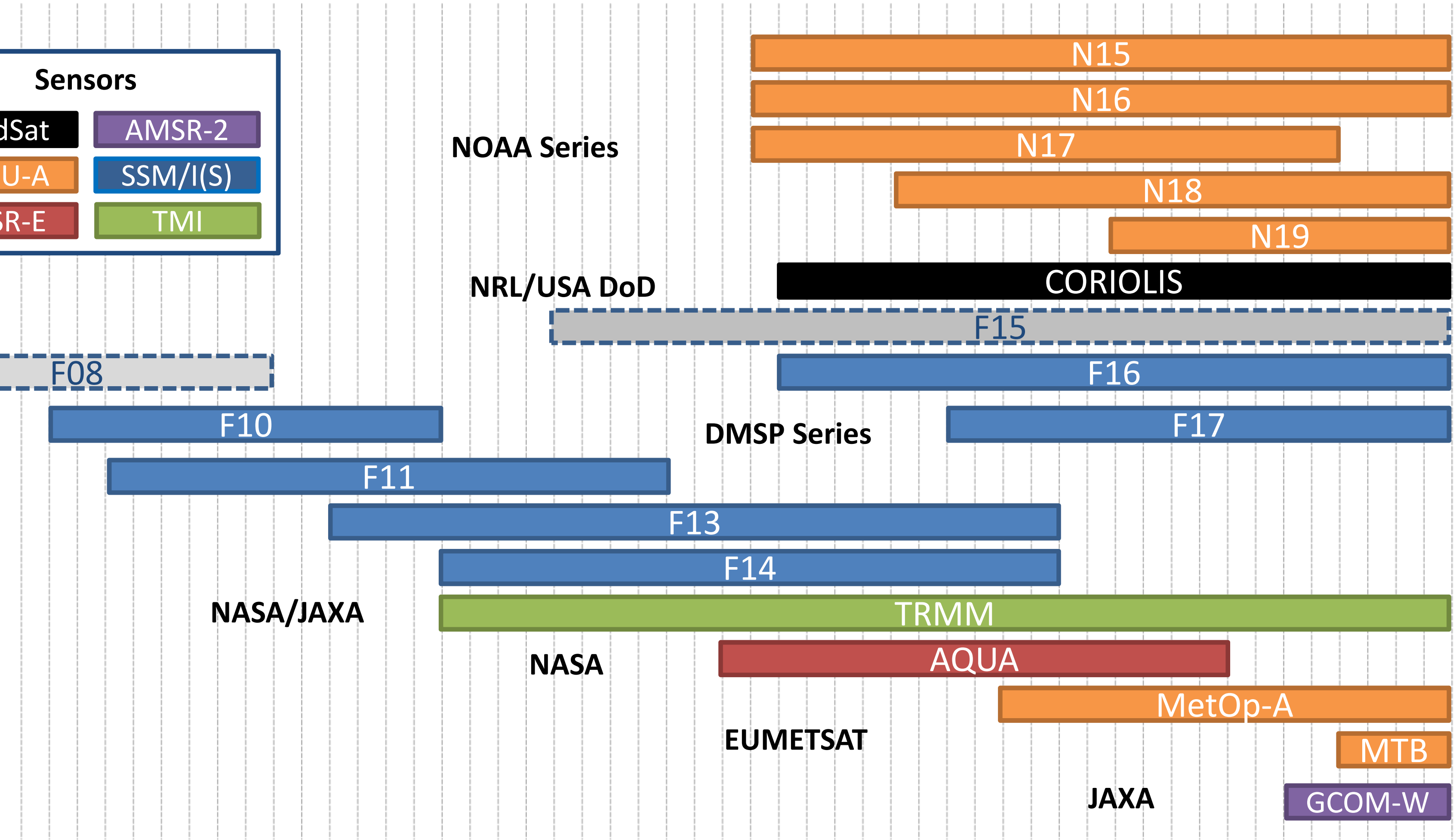
Iore satellites: extended to 8 altimetry missions, including C2 and SA, thus llowing to fill the ENVISAT gap and extend the higher spatial resolution ESA atellite series until present;

Additional data: from scanning imaging radiometers (SI-MWR) on-board arious remote sensing satellites have been used, improving the WTC etrieval, particularly for the most recent missions such as C2 and SA;

nter-calibration: all radiometer data sets have been inter-calibrated, using he set of SSM/I and SSM/IS on-board the DMSP satellite series (FXX) as eference

- improve consistency and long term stability of the correction
- reduce the uncertainty in the long term sea level variation (GOOS requirement: uncertainty < 0.3 mm/yr)

MWR WPD Observations



er-calibration of the various MWR sensors

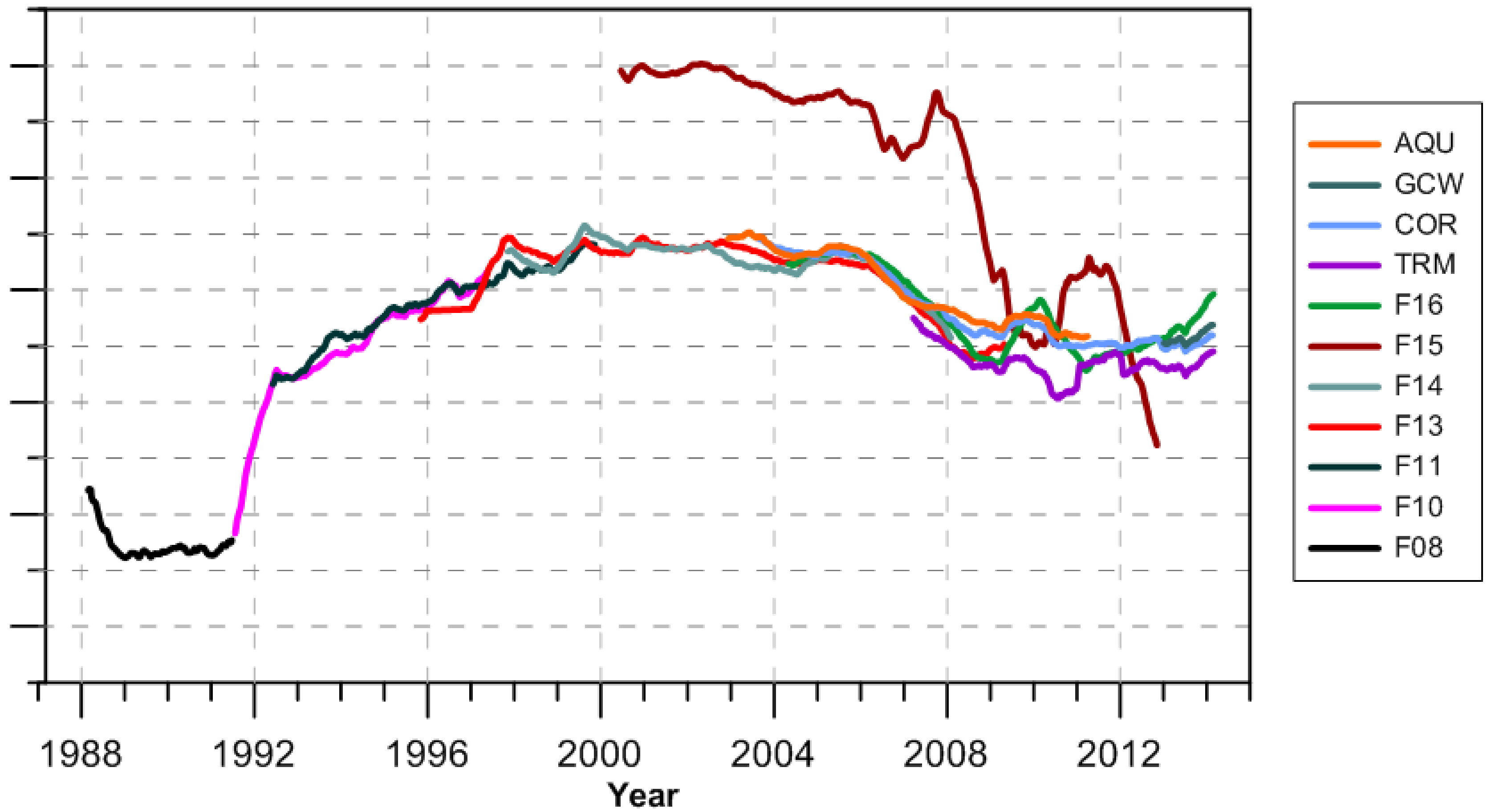
0 – Comparison between each SI-MWR and ERA Interim

Differences between each SI-MWR-derived WTC and ERA-derived WTC, collocated in space and time with each SI-MWR measurement point, were analyzed.

Identified SI-MWR instability periods:

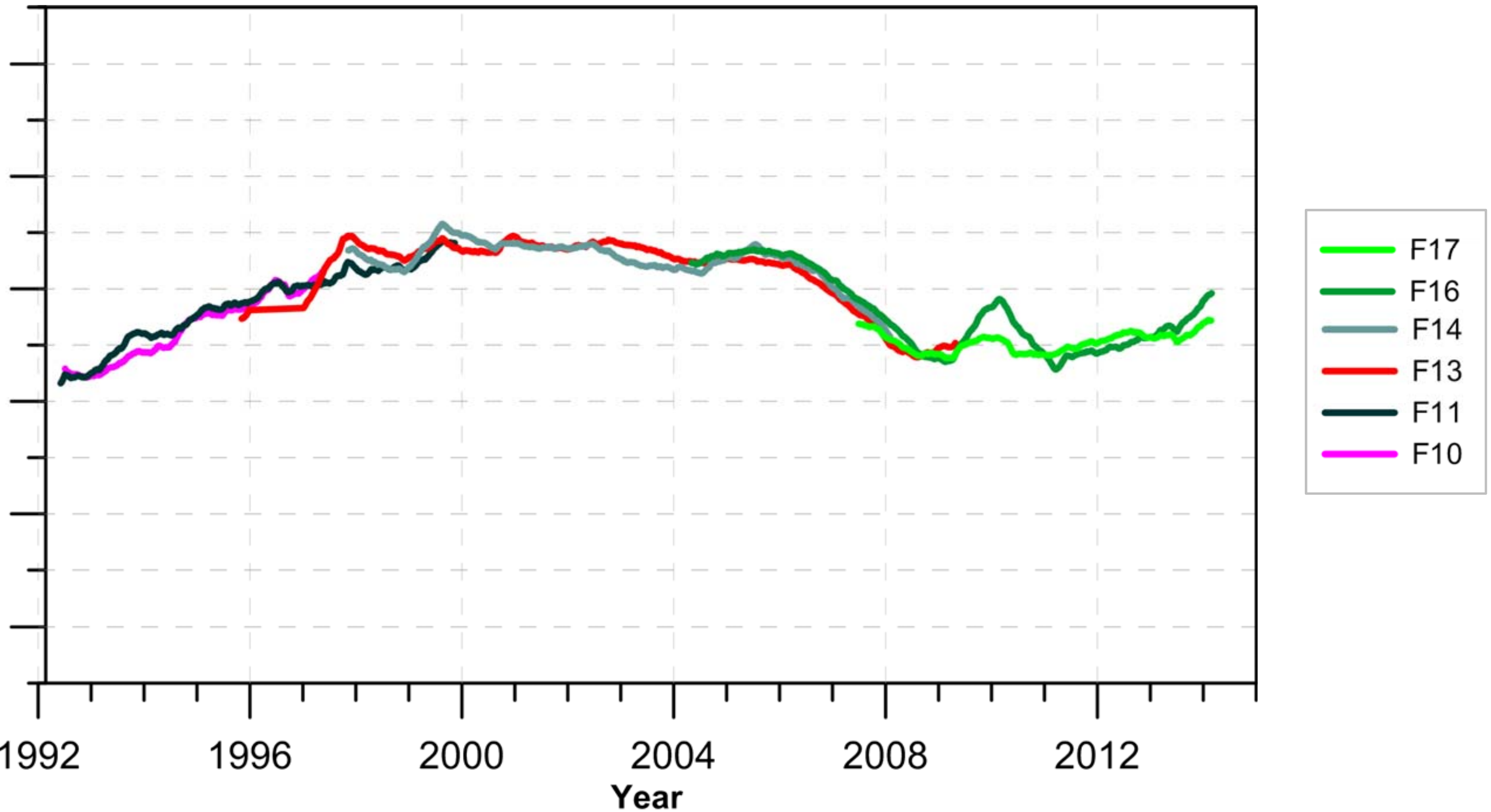
- Rejection of F15 data;
- MTA used only after 2008;
- N15, N16 and N17 used only after 2005.2.

r-calibration of the various MWR sensors – step 0



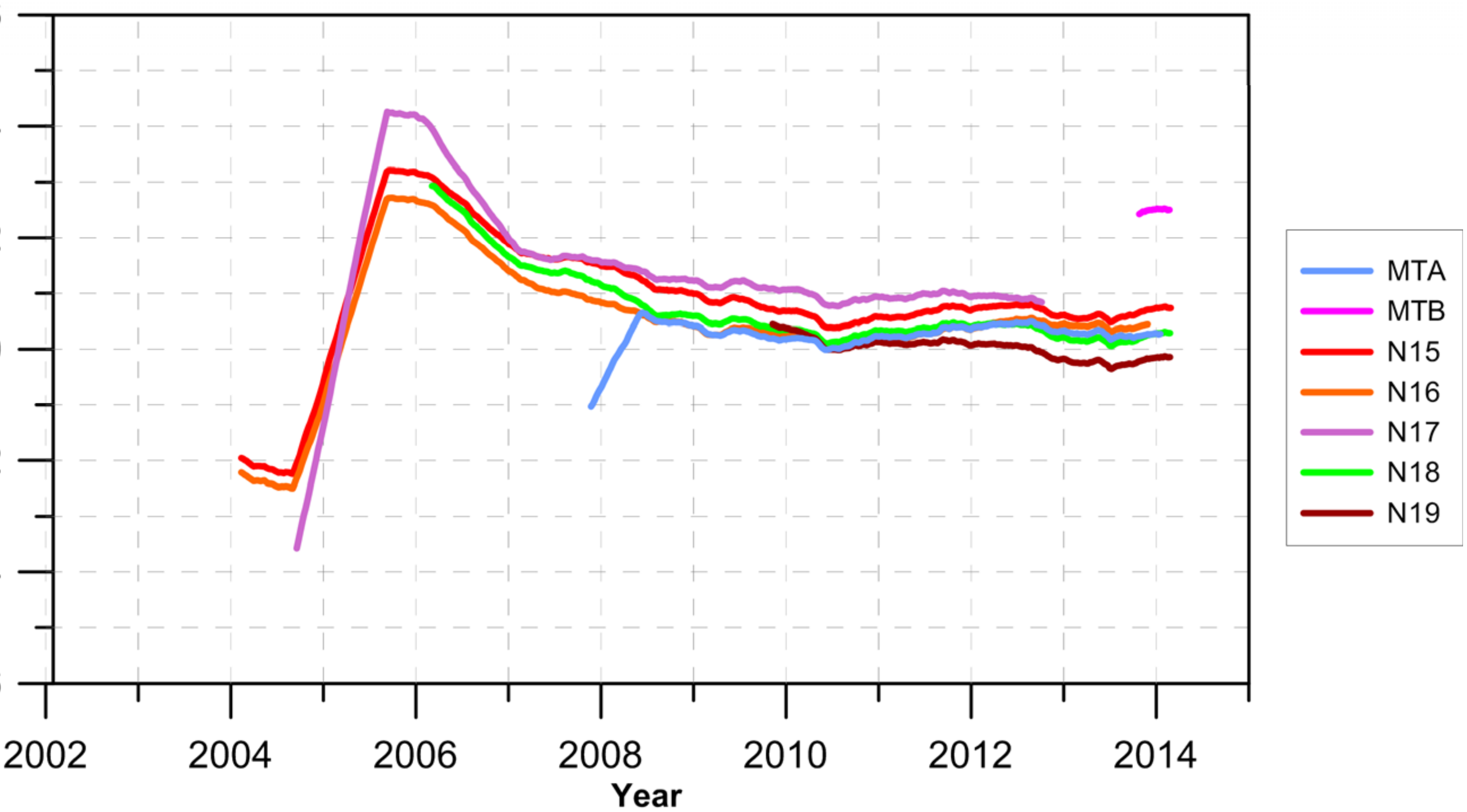
Differences in WTC (cm) from SI-MWR sensors (SSM/I SSM/IS, TMI, AMSR-E

r-calibration of the various MWR sensors – step 0



Differences in WTC (cm) from SSM/I, SSM/IS and from ERA Interim

r-calibration of the various MWR sensors – step 0



Differences in WTC (cm) from AMSU-A and from ERA Interim

er-calibration between all radiometers

e inter-calibration was performed in 3 steps

- Step1 – TP, J1, J2 → FXX
- Step2 – 35-day missions → TP, J1, J2
- Step3 – remaining SI-MWR→ TP, J1, J2

Adjustment model uses Offset (a), scale factor (b) and trend (c)

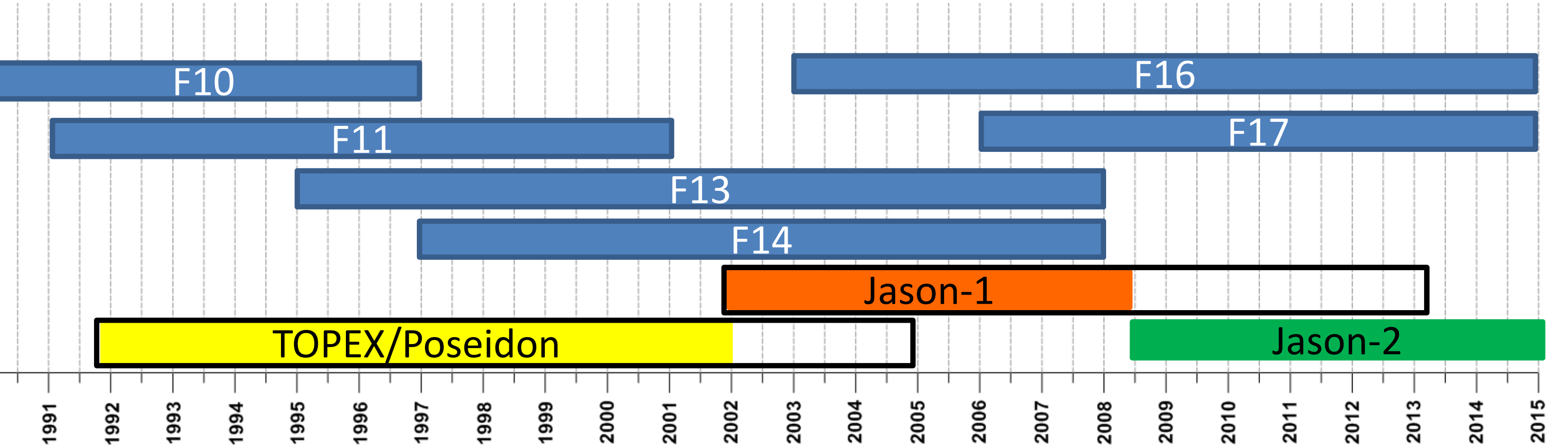
$$Y = a + bX + c(T - T_0), \qquad T_0 = 1992$$

er-calibration between TP, J1, J2 and FXX

ep 1

- Match points between SSM/I and SSM/IS sensors and MWR on-board reference altimetric mission (TP, J1, J2) were calculated:
  - Only points with ΔT < 45 min and ΔD < 50 km were considered.

- WTC from each reference altimetric mission was adjusted to WTC from SSM/I and SMM/IS set of sensors

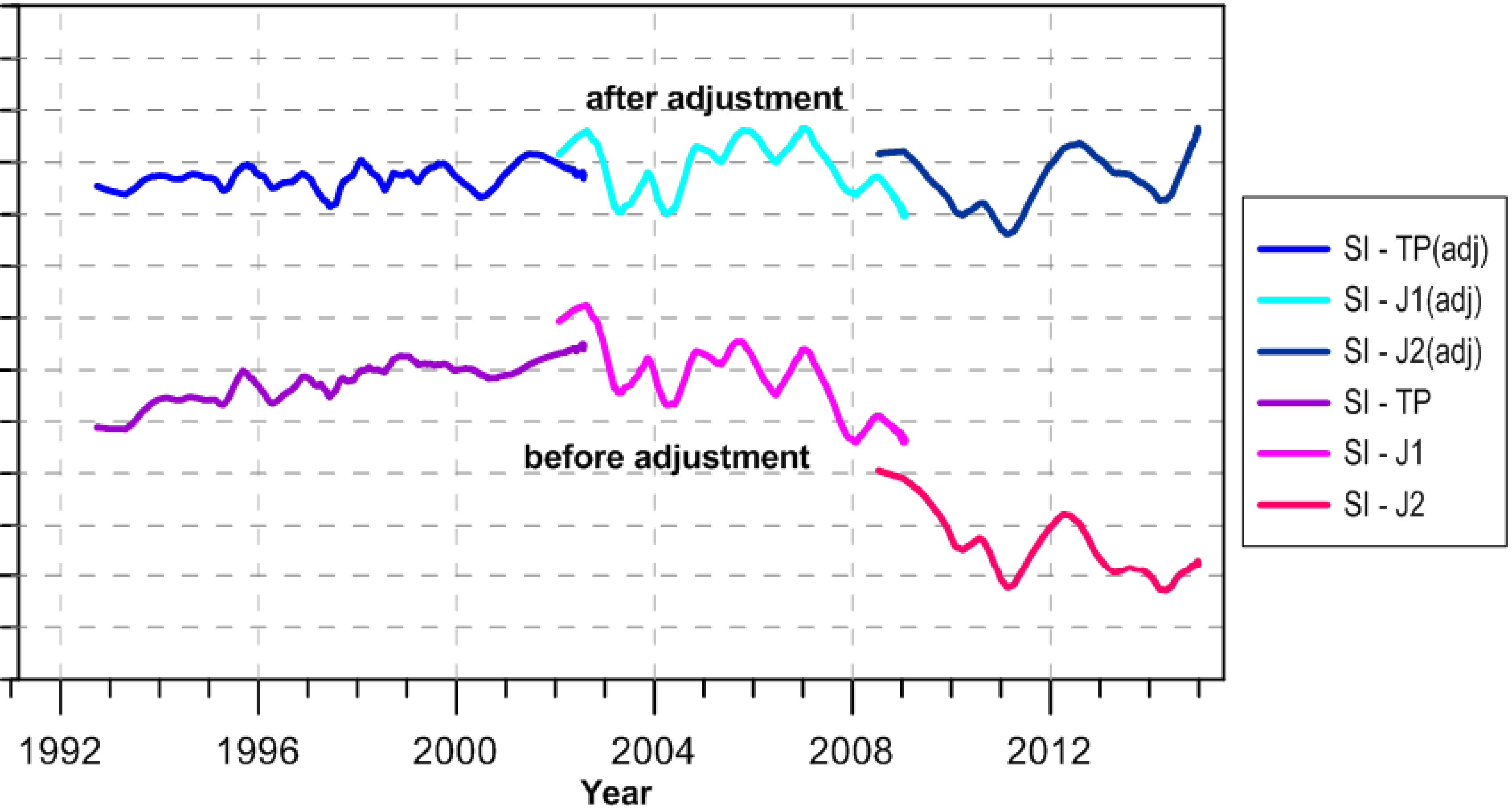


er-calibration between TP, J1, J2 and FXX

tep 1

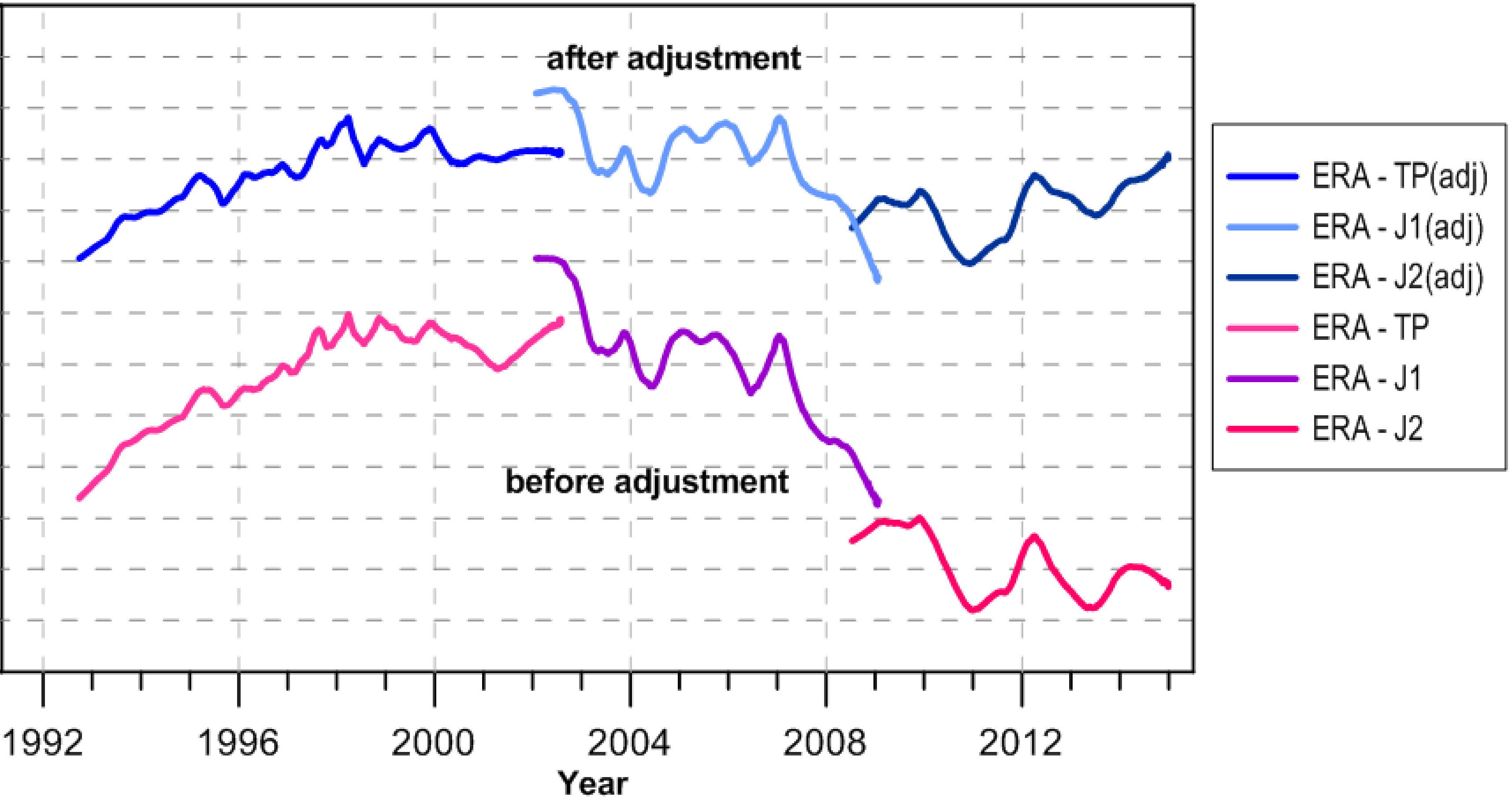
Mission	Offset (mm)	Scale factor	Trend (mm/y)
TP	-8.1882	0.97720	0.1542
J1	-4.3642	0.98428	-0.1399
J2	-5.6329	0.97704	-0.2288

er-calibration between TP, J1, J2 and FXX



Differences in WTC (cm) from SSM/I, SSM/IS and from MWR on board satellite

parison between TP, J1, J2 and ERA, before and after adjustment



Differences in WTC (cm) from ERA Interim and from MWR on board satellite

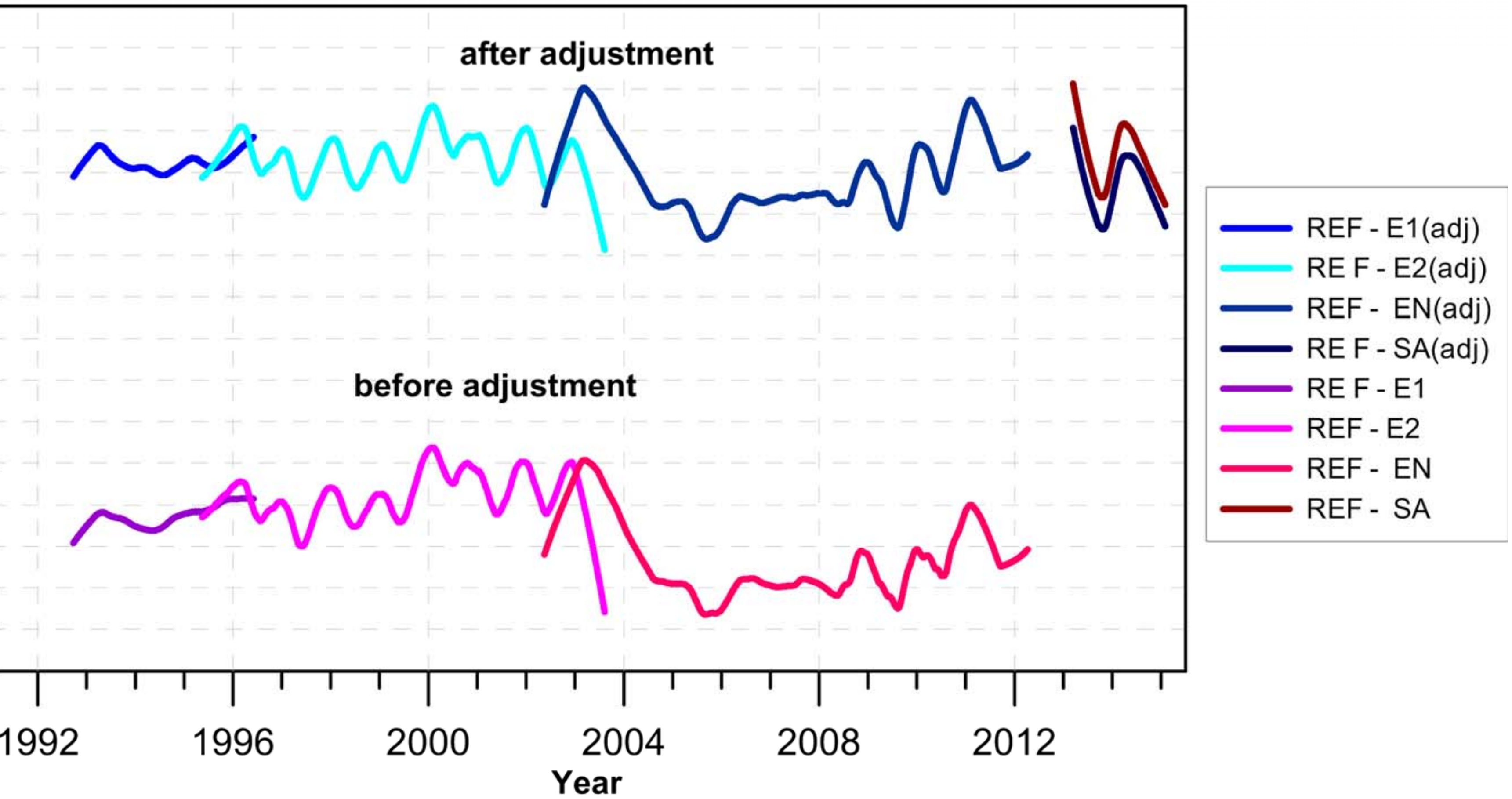
r-calibration between 35-day and TP, J1, J2

tep 2 – 35-day missions

- Crossovers between each sun-synchronous 35-day altimetric mission (E1, E2, EN, SA) and the altimetry reference missions (TP, J1, J2) were calculated (matching points).
  - Only points with a $\Delta T < 180$ min were considered.
- WTC from 35-day missions were calibrated against the WTC from reference missions using a crossover adjustment.

Mission	Offset (mm)	Scale factor	Trend (mm/y)
E1	-12.1711	0.96279	0. 1724
E2	-12.7178	0.95680	0. 0970
EN	-12.2356	0.95462	-0. 0809
SA	8.7741	1.03088	-0. 2130

r-calibration between 35-day and TP, J1, J2



Differences in WTC (cm) derived from satellite altimetry reference missions and

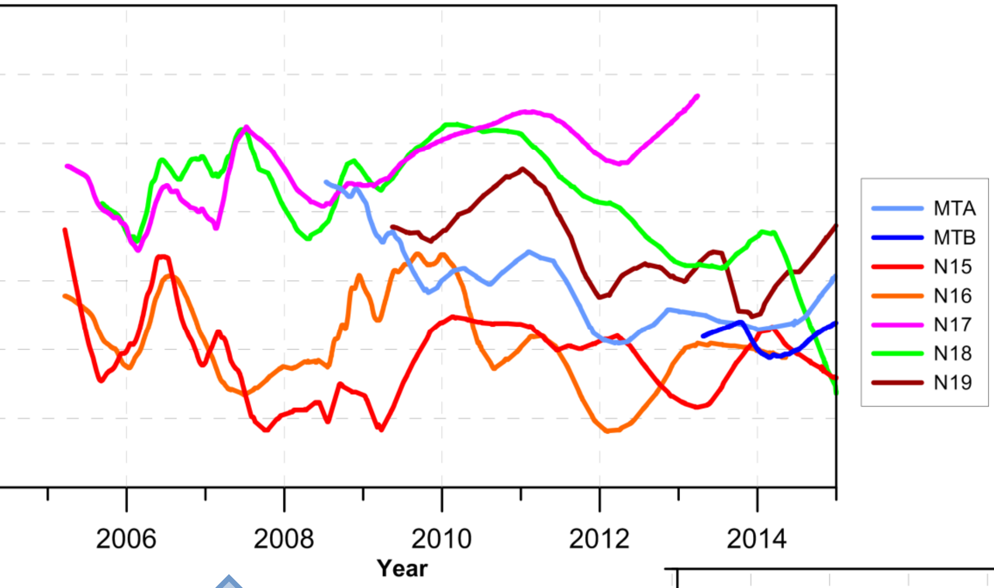
-calibration between other SI-MWR and TP, J1, J2

p 3 – remaining SI-MWR

WTC from all remaining SI-MWR (except the FXX series) sensors were adjusted to the WTC from altimetric reference missions.

Mission	Offset (mm)	Scale factor	Trend (mm/y)
COR	-0.4262	0.98909	-0.0581
N15	-4.7925	1.01624	-0.0760
N16	-5.2776	1.01222	-0.0737
N17	-11.6989	0.98413	0.2560
N18	-2.5803	1.00950	-0.1422
N19	-2.8430	1.00711	-0.1673
AQU	-0.5598	0.99023	0.0134
TRM	0.1653	0.99514	-0.0327
MTA	-2.5543	0.99882	-0.2594
MTB	5.4636	0.99673	0.1872

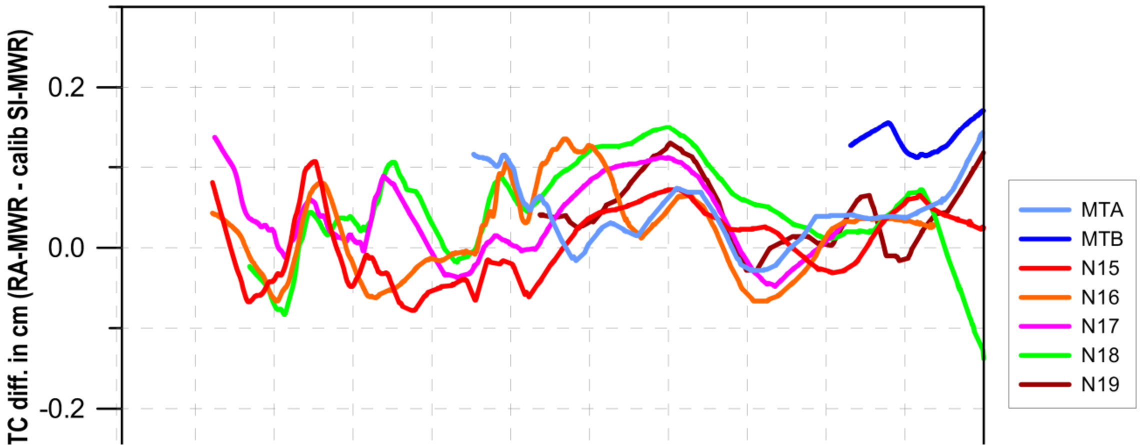
r-calibration between other SI-MWR and TP, J1, J2



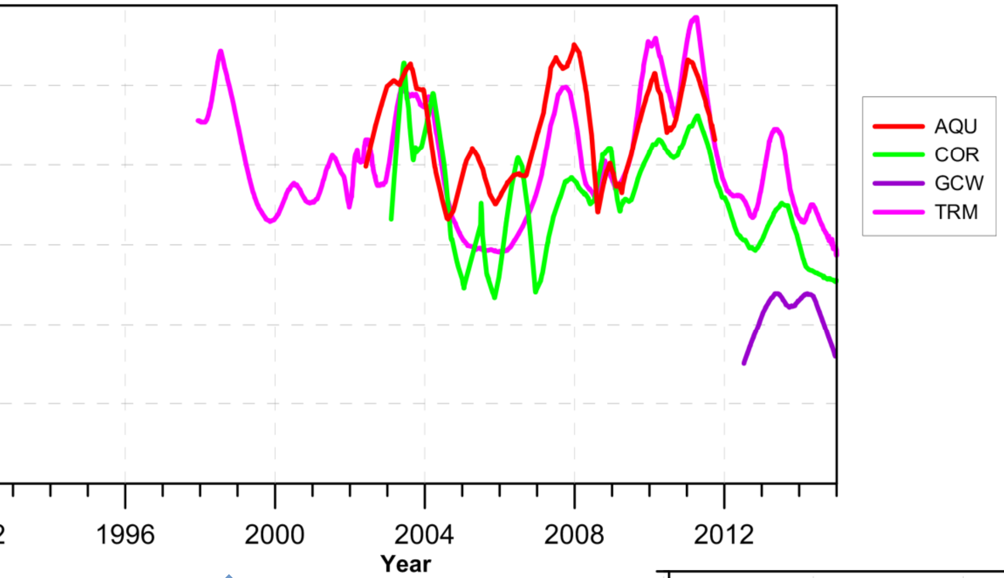
Differences in WTC (cm) derived from MWR on board altimetric reference missions and from AMSU-A.

Before calibration

After calibration



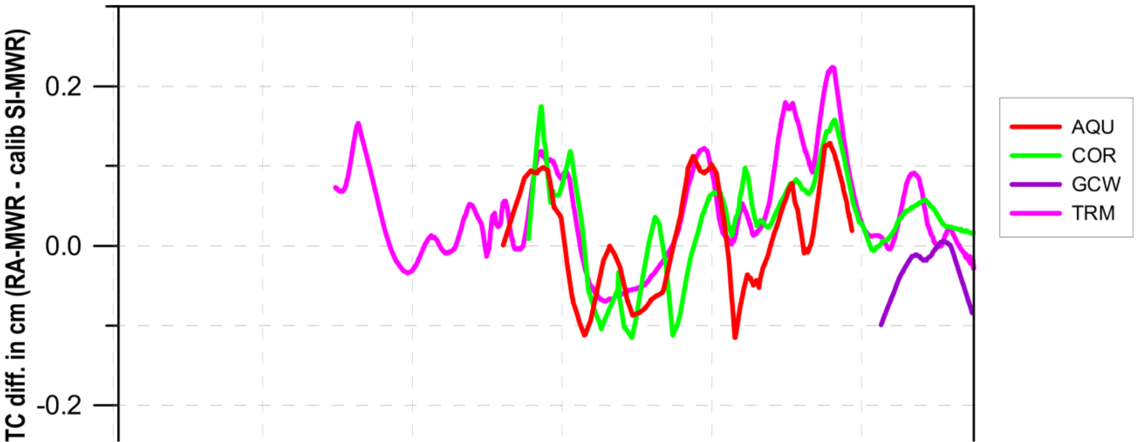
-calibration between other SI-MWR and TP, J1, J2



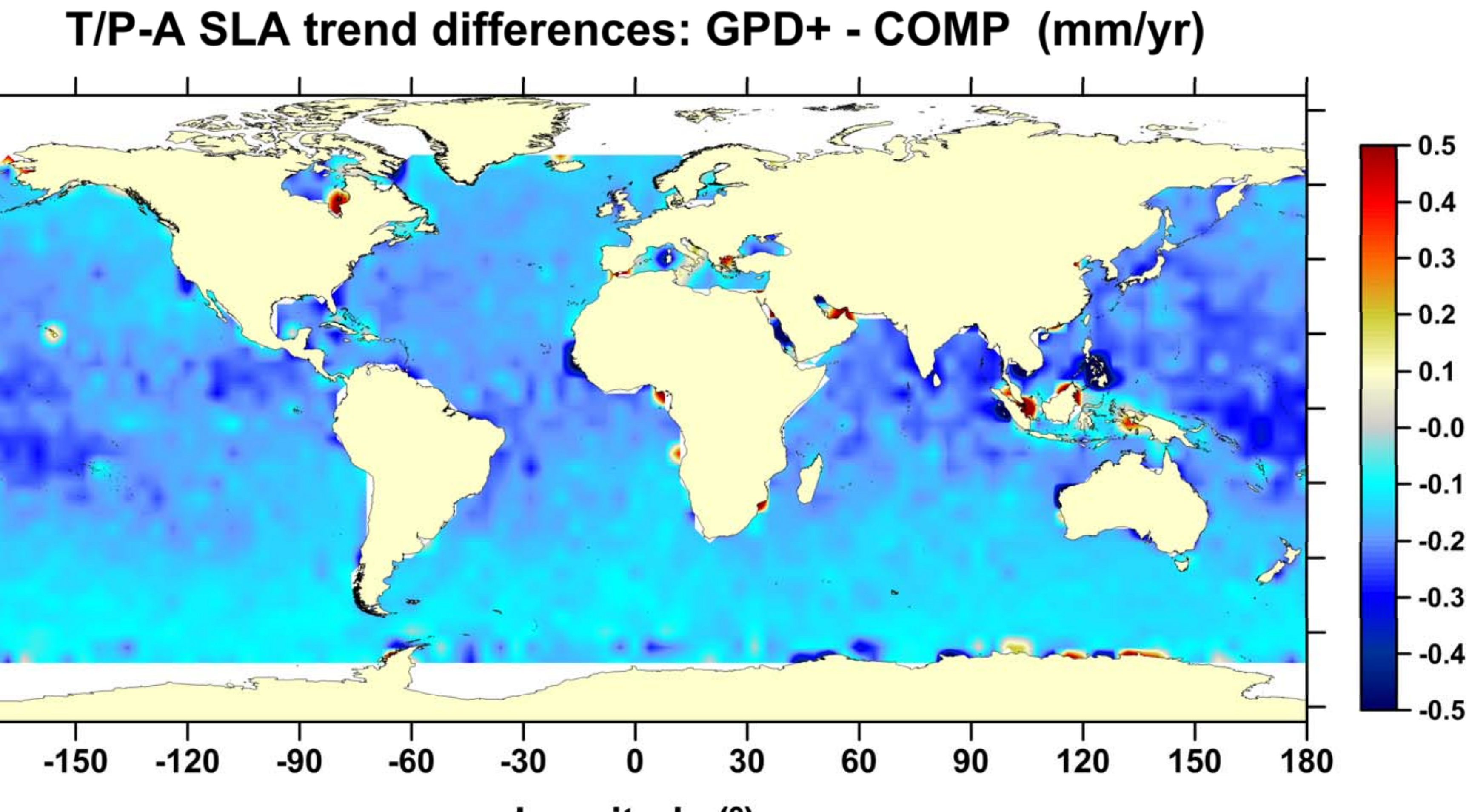
Differences in WTC (cm) derived from MWR on board altimetric reference missions and from AMSR-E (AQU), AMSR-2 (GCW), TMI (TRM) and WindSat (COR).

Before calibration

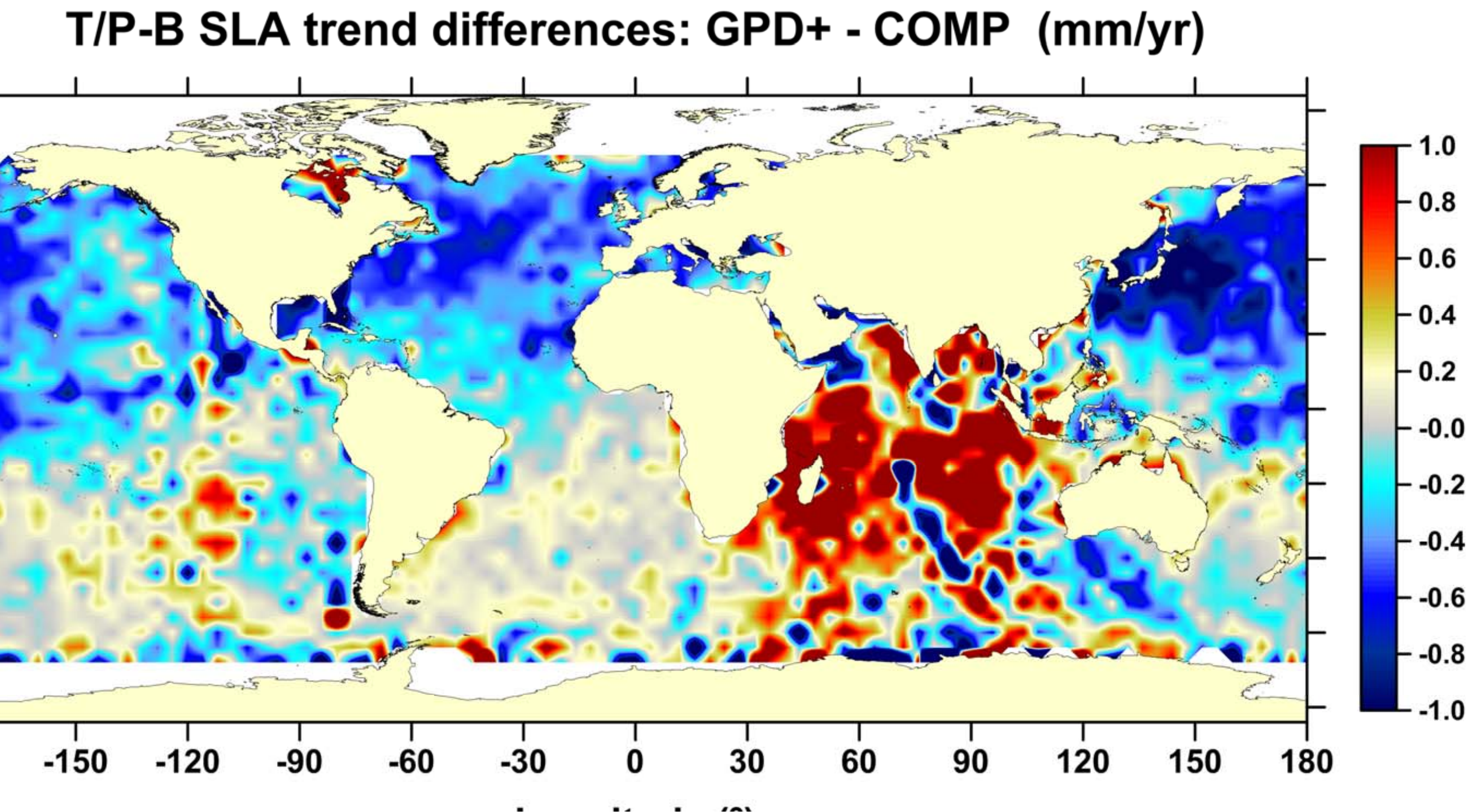
After calibration



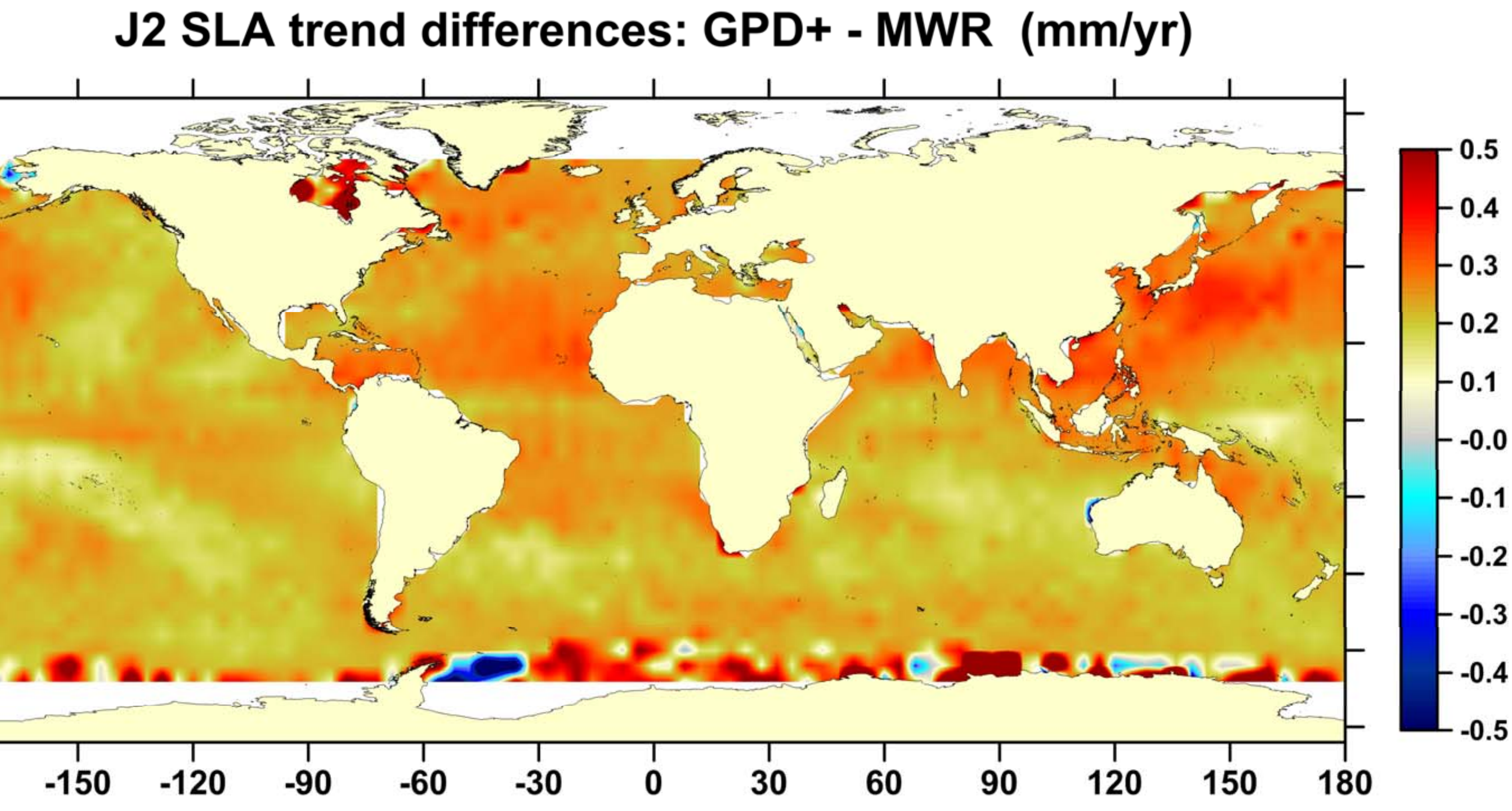
esults – TP phase A



esults – TP phase B



esults – Jason-2



cluding remarks and future developments

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oncluding Remarks

- For most missions, the new GPD+ products are shown to reduce sea level anomaly variance with respect to previous non-calibrated versions and to other WTC data sets such as the AVISO Composite or the model-based WTC.
- Strongest impacts on sea level trends.
- GDP+ WTC currently under independent validation in the scope of SL_cci project.
- Validation by various groups using other methods and in situ data are welcome.

going and future developments

- Sentinel-3 over ocean in the scope of SCOOP project.
- Sentinel-3 over inland water in the scope of SHAPE projects.
- CryoSat-2 – Operational production of GOP.