SCOOP
Science Review Meeting

WP7000 – Wet Troposphere Model

• Objectives

- **To develop methods and techniques to produce an enhanced WTC for Sentinel-3 (S3), compared to the S3 baseline correction, over the open and coastal ocean:**
  - based on the combined use of third-party data;
  - evaluated at the S3 orbit space-time sampling.

- **While S3 data are not available, Envisat data will be used for test purposes (e.g., algorithm development)**.

- **In addition, the WTC will be computed for the selected CryoSat-2 (CS-2) regions of interest (ROI)**.

• WP7100 – Data set specification

- **CS-2 data (time and location) for the project ROI.**
- **Envisat and S3-A/B MWR data.**
- **Wet path delays from third-party data sets:**
  - derived at GNSS coastal and island stations,
  - computed from water vapour products from SI-MWR,
  - computed from atmospheric model (ECMWF Operational model).

- **WP7200 – Data set generation**

1) **Data pre-processing, analysis and inter-calibration.**
2) **Algorithm implementation (GPD+ tuning to S3).**
3) **WTC (and associated error) computation:**
   - **WTC provided for:**
     - all selected CS-2 ROI;
     - S3 ground-tracks.

4) Set of recommendations (out of SOW scope) about the correct approaches to compute the DTC to avoid height dependent errors in coastal regions.

- **Recent developments**

  - **Algorithm update: GNSS-derived Path Delay Plus (GPD+) methodology**
  - **GPD+ combines previous GPD and DComb algorithms**

    - Data combination method using space-time objective analysis.

  - **Additional data from**

    - scanning imaging radiometers (SI-MWR) on board various remote sensing satellites, improving the WTC retrieval for the most recent altimetric missions.

  - **All MWR data sets calibrated w.r.t. SSM/I and SSM/IS.**
  - **Improved detection of invalid on-board MWR values:**

    - land and ice contamination; definition of statistical criteria based on MWR and model values in the vicinity of the point; tuning the criteria to each mission, based on a careful inspection of the baseline MWR.

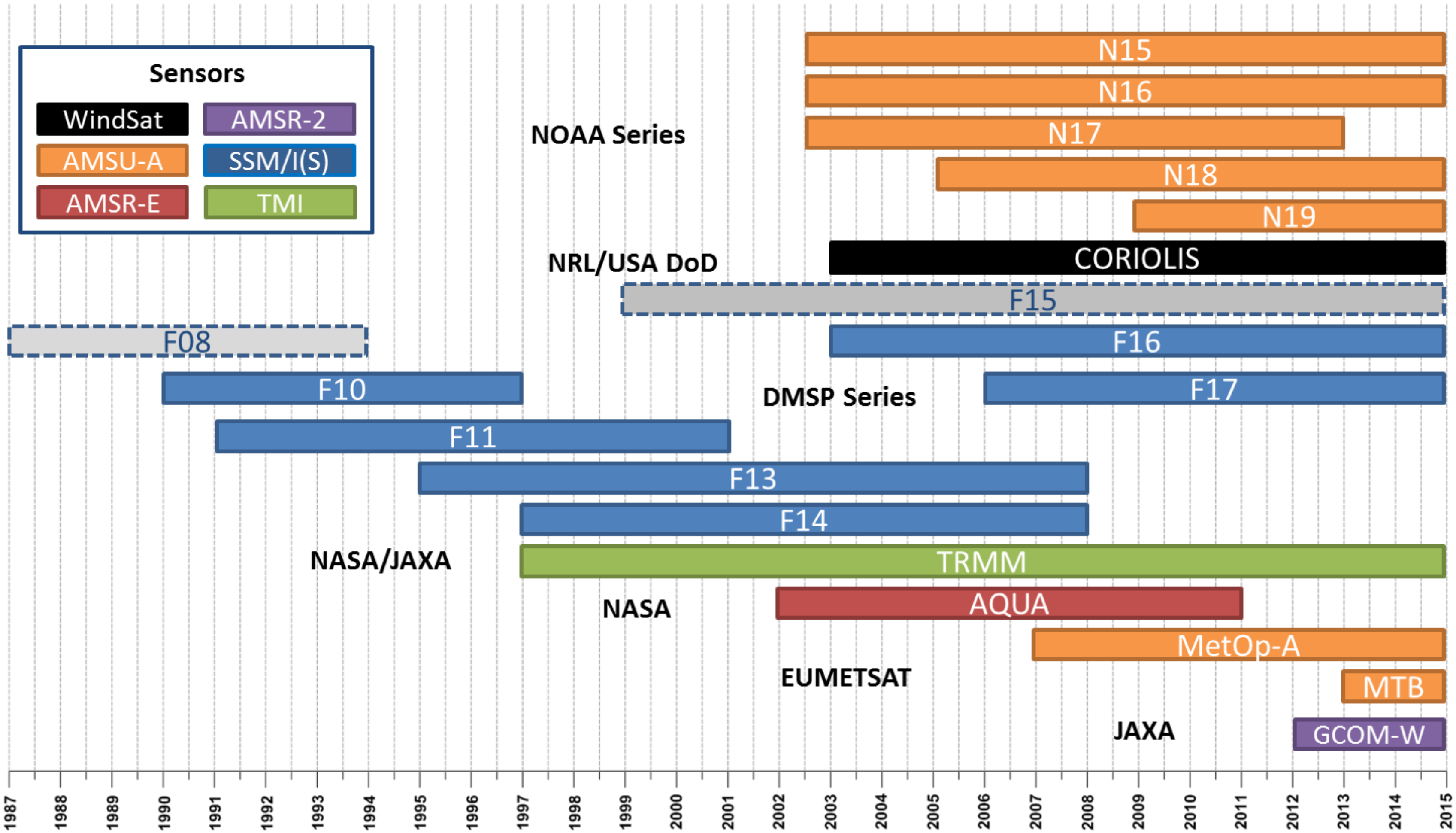
- **MWR calibration**

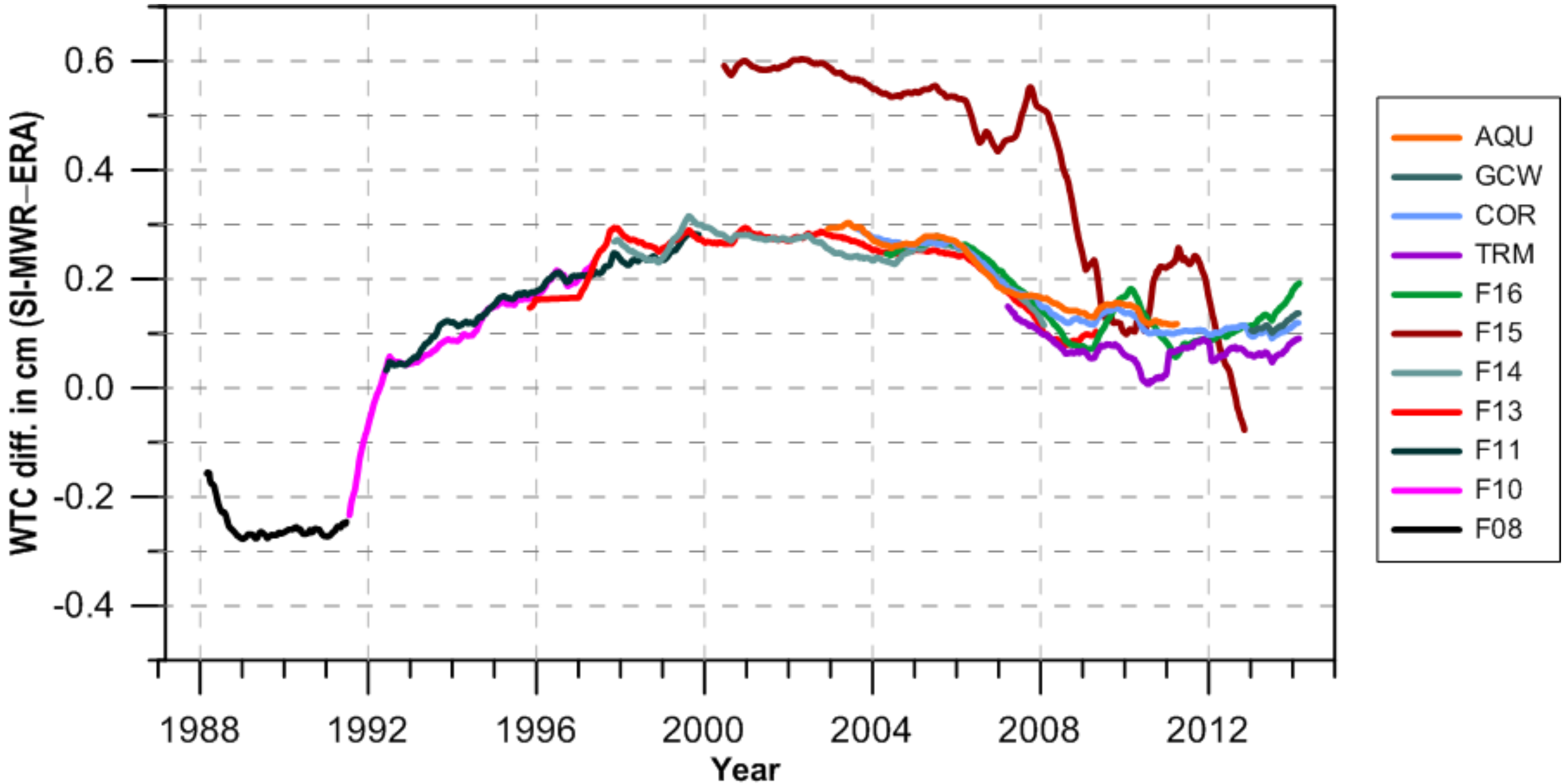
Step 0 – Comparison between each SI-MWR and ERA Interim

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

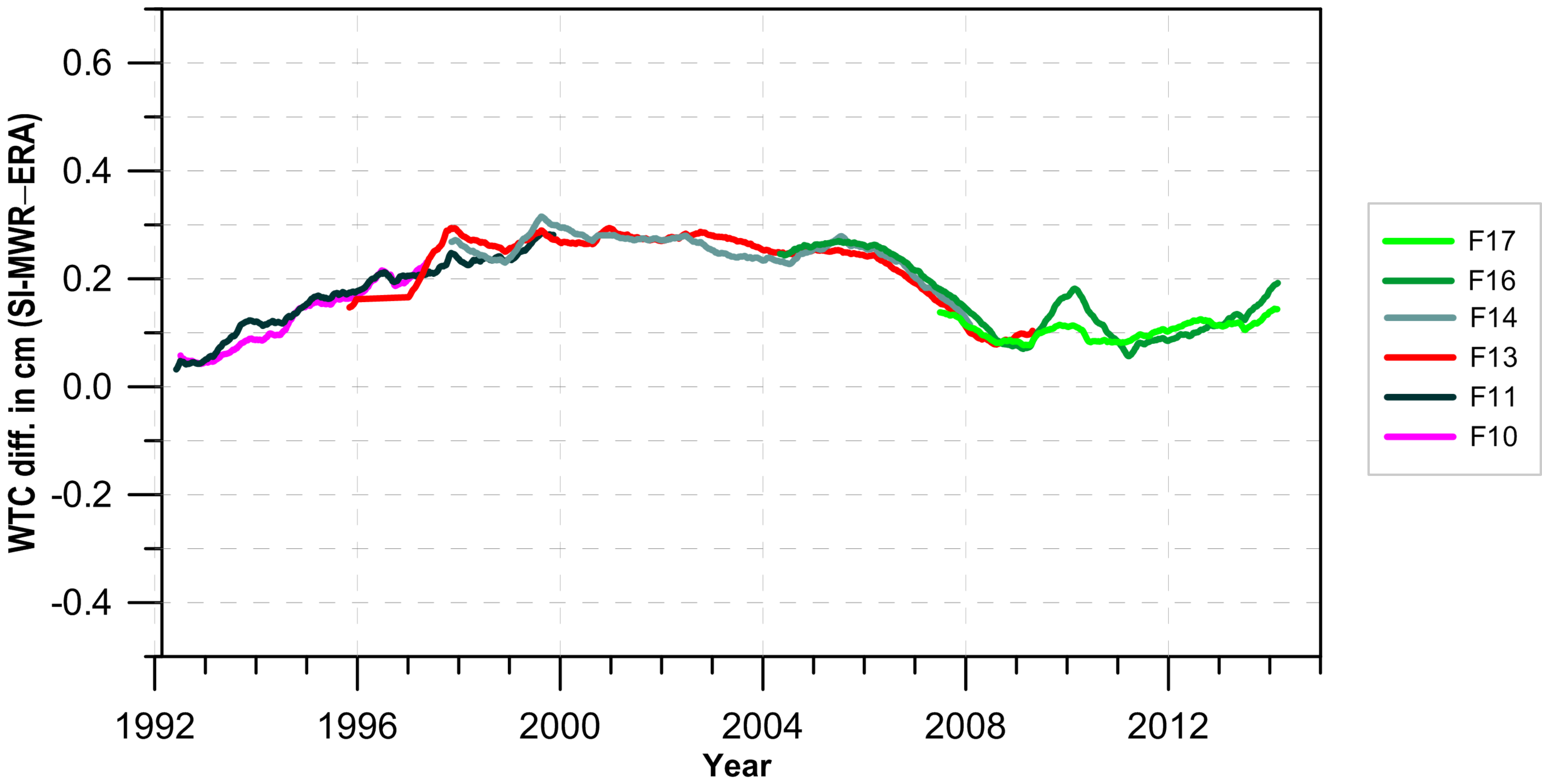
- Identified SI-MWR instability periods:
  - Rejection of F15 data;
  - MTA used only after 2008;
  - N15, N16 and N17 used only after 2005.2.

- All radiometer data sets have been calibrated using the set of SSM/I and SSM/IS, on board the DMSP satellite series (FXX), as reference;
- Calibration improves consistency and long term stability.

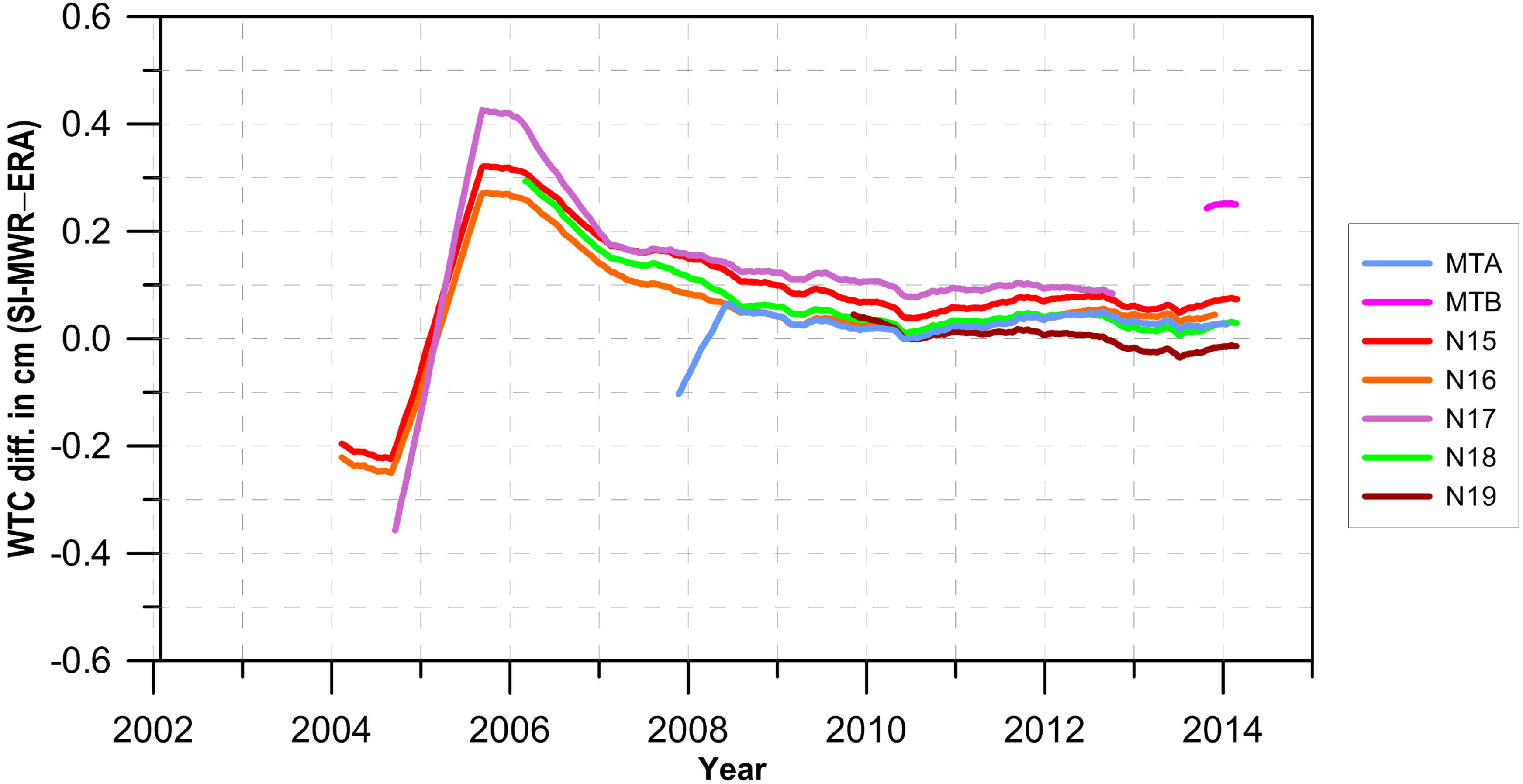




Differences in WTC (cm) from SI-MWR sensors (SSM/I-SSM/IS, TMI, AMSR-E, AMSR-2 and WindSat) and ERA Interim.



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



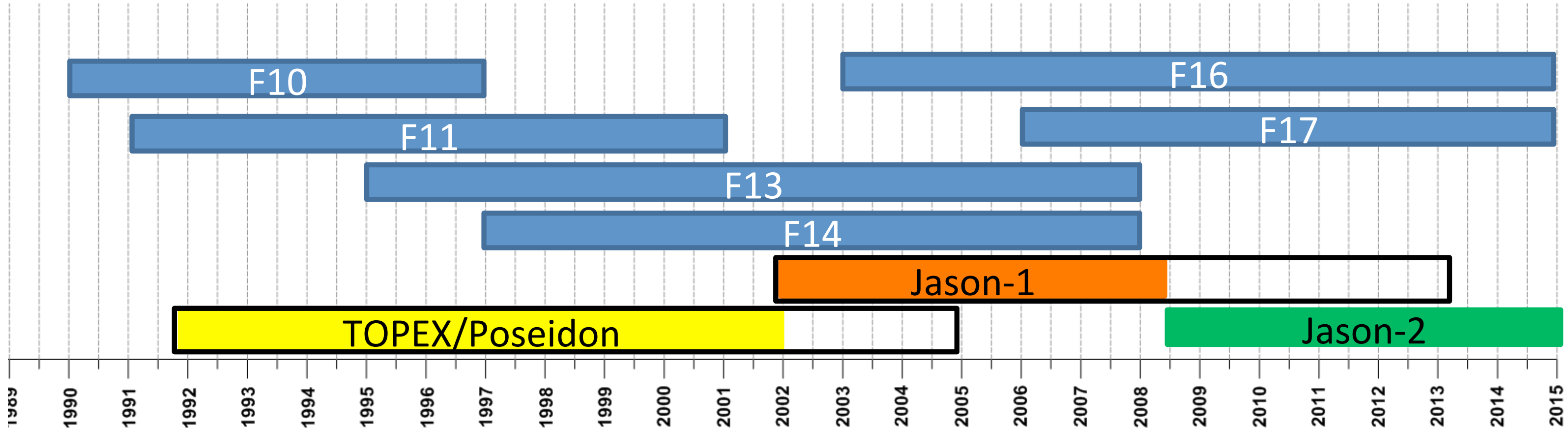
Differences in WTC (cm) from AMSU-A and ERA Interim.

– **The calibration was performed in 3 steps:**

- Step 1 – TP, J1, J2 → FXX
- Step 2 – 35-day missions → TP, J1, J2
- Step 3 – remaining SI-MWR→ TP, J1, J2

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

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



Satellite altimetry reference missions calibrated against the contemporary DMSP missions (all data from FXX satellites in the common T/P, J1 or J2 periods were used).

Step 1 – Calibration between TP, J1, J2 and SSM/I & SSM/IS

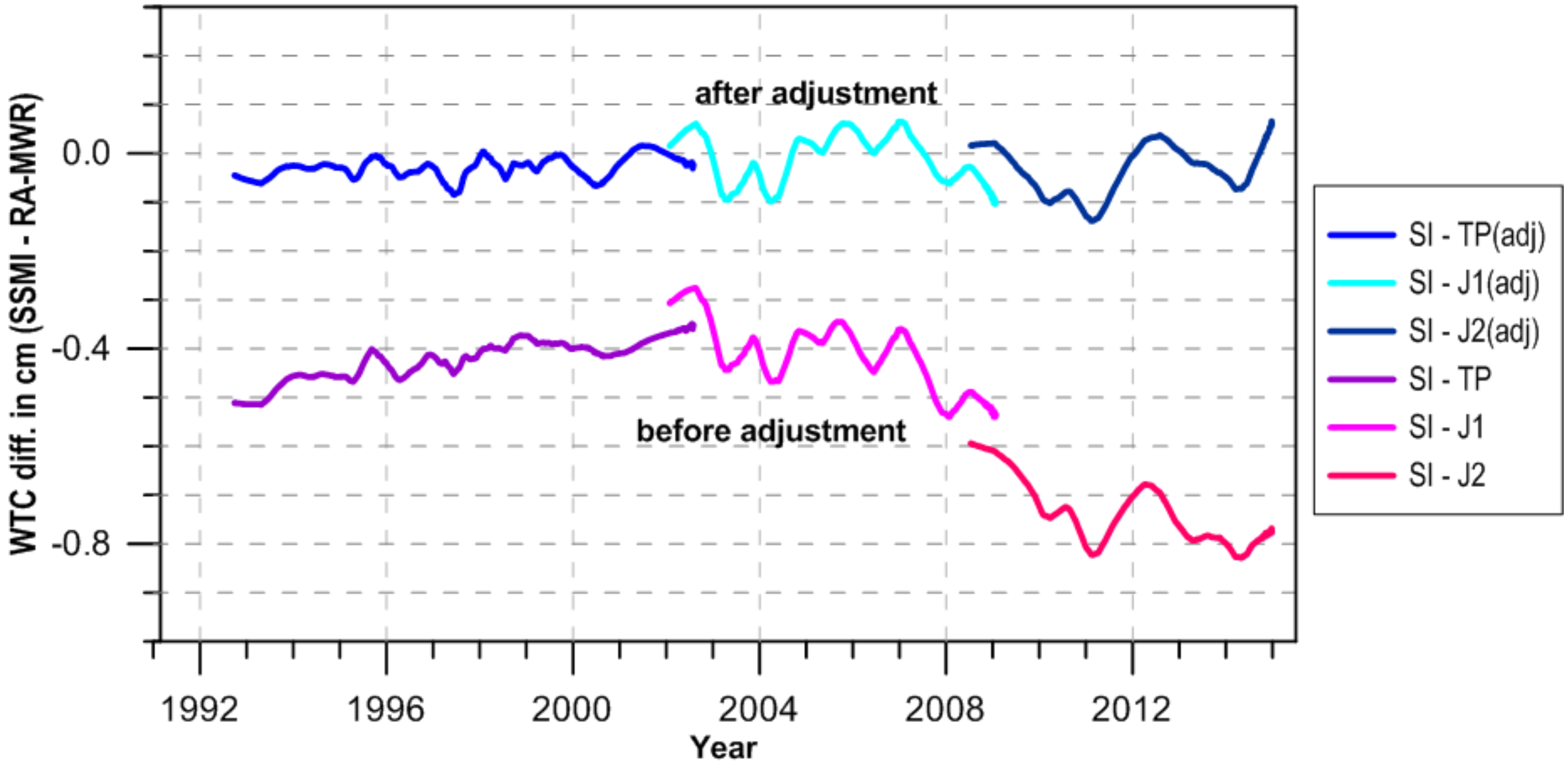
- Matching points between SSM/I and SSM/IS sensors and MWR on board reference altimetric mission (TP, J1, J2) were identified:

  – Only points with $\Delta T < 45$ min and $\Delta D < 50$ km were considered.

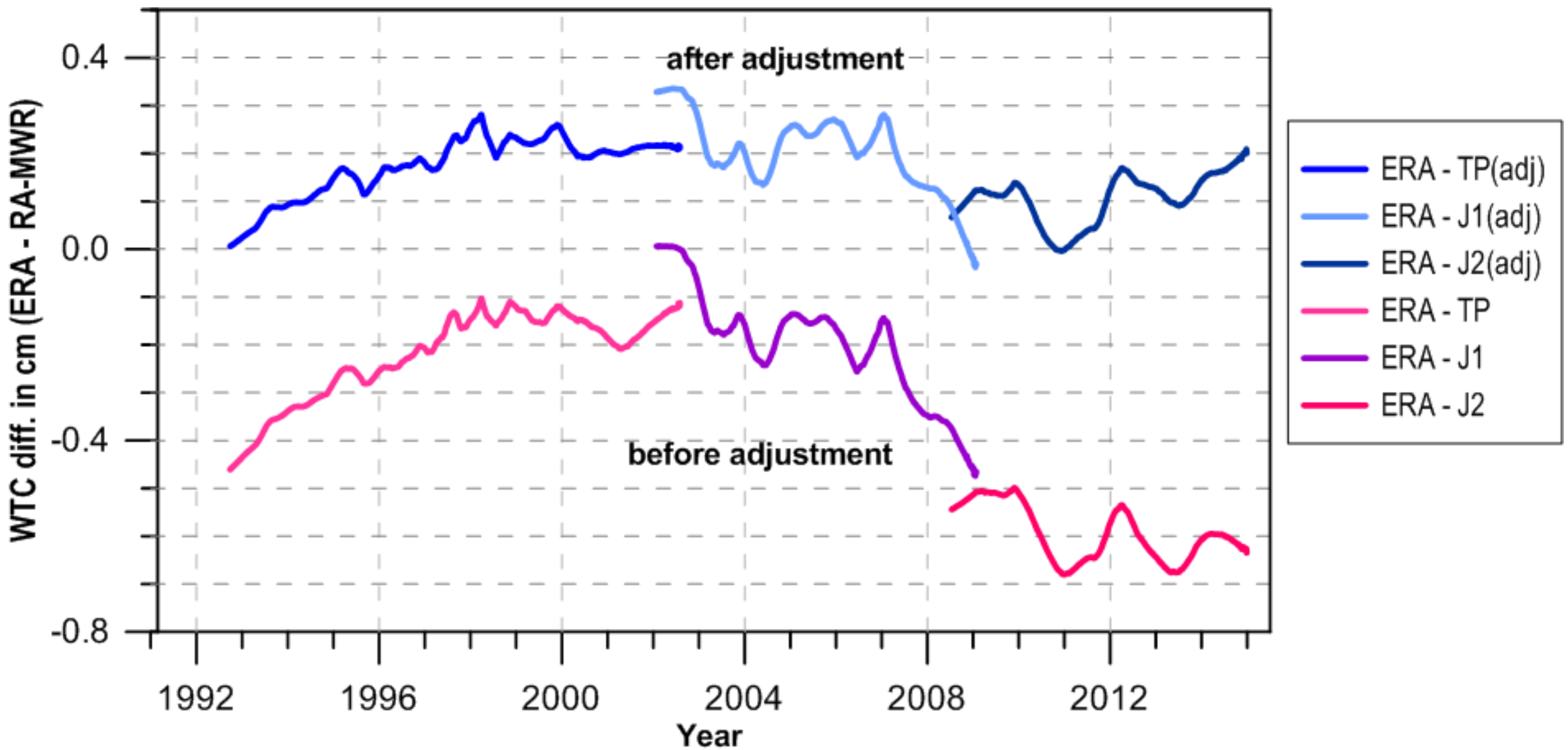
- WTC from each reference altimetric mission was adjusted to WTC from SSM/I and SMM/IS set of sensors.

Calibration parameters

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



Differences in WTC (cm) from SSM/I, SSM/IS and T/P, J1 and J2 radiometers, before and after calibration.



Differences in WTC (cm) from ERA Interim and T/P, J1 and J2 MWR, before and after calibration.

Step 2 – Calibration between 35-day missions and TP, J1, J2

- Crossovers (matching points) between each sun-synchronous 35-day altimetric mission (E1, E2, EN, SA) and the altimetry reference missions (TP, J1, J2) were identified.
  - 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.

Calibration parameters

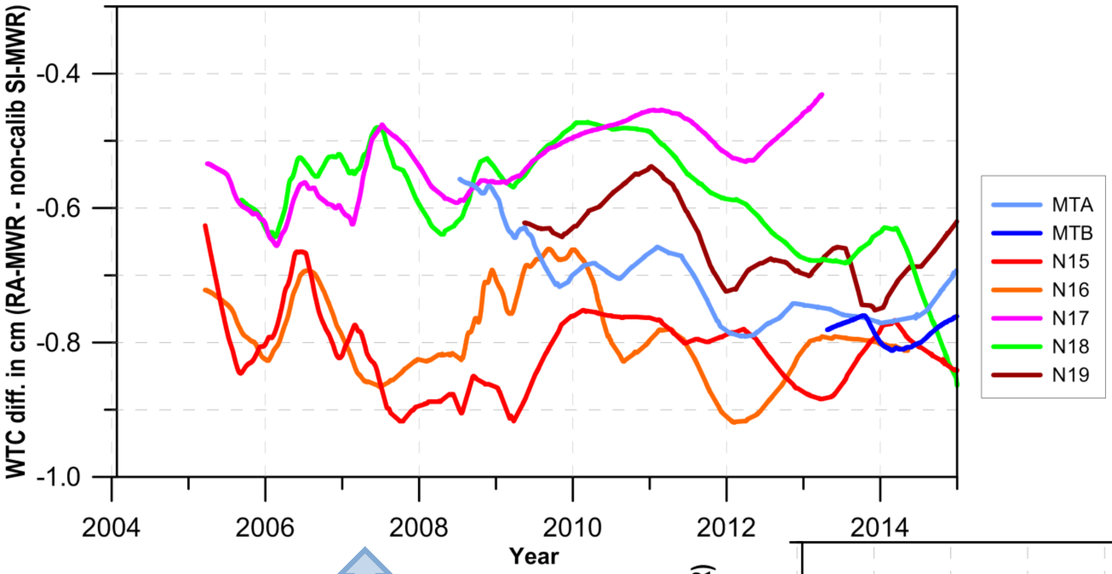
Mission	Offset (mm)	Scale factor	Trend (mm/y)
E1	-12.1711	0.96279	0. 1724
E2	-12.7178	0.95680	0. 0970
EN	-12.2356	0.95462	-0. 0809
SA	6.1130	1.00681	-

Step 3 – Calibration between other SI-MWR and TP, J1, J2

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

Calibration parameters

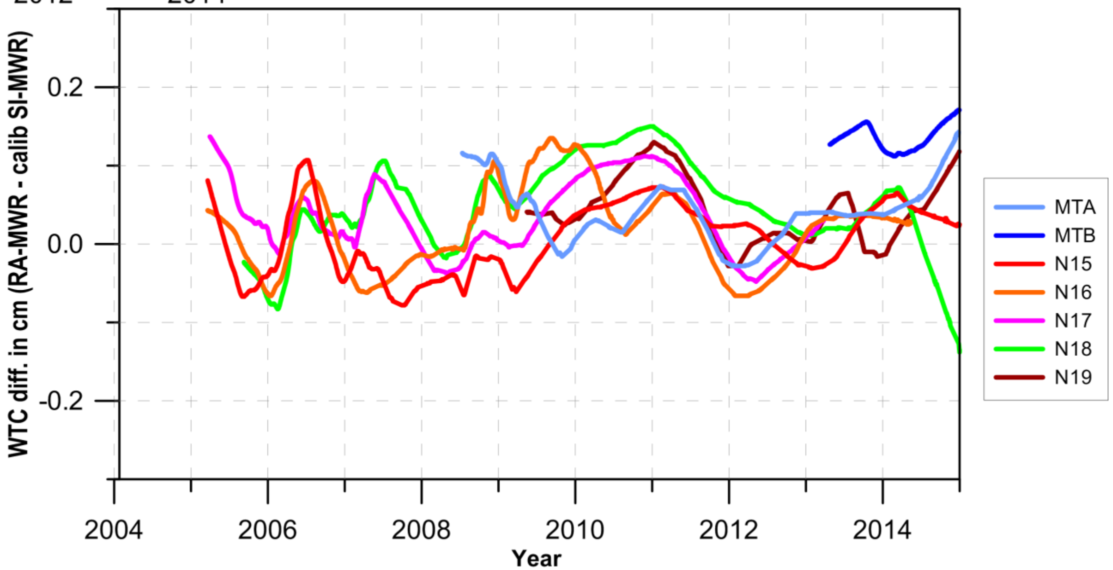
Mission	Offset (mm)	Scale factor	Trend (mm/y)
COR	-0.4262	0.98909	-0.0581
N15	-4.7925	1.01624	-0.0760
N16	-5.2776	1.01222	-0.0737
N17	-11.6989	0.98413	0.2560
N18	-2.5803	1.00950	-0.1422
N19	-2.8430	1.00711	-0.1673
AQU	-0.5598	0.99023	0.0134
TRM	0.1653	0.99514	-0.0327
MTA	-2.5543	0.99882	-0.2594
MTB	-5.4636	0.99673	-0.1872
GCW	-0.6326	0.98857	-0.0414

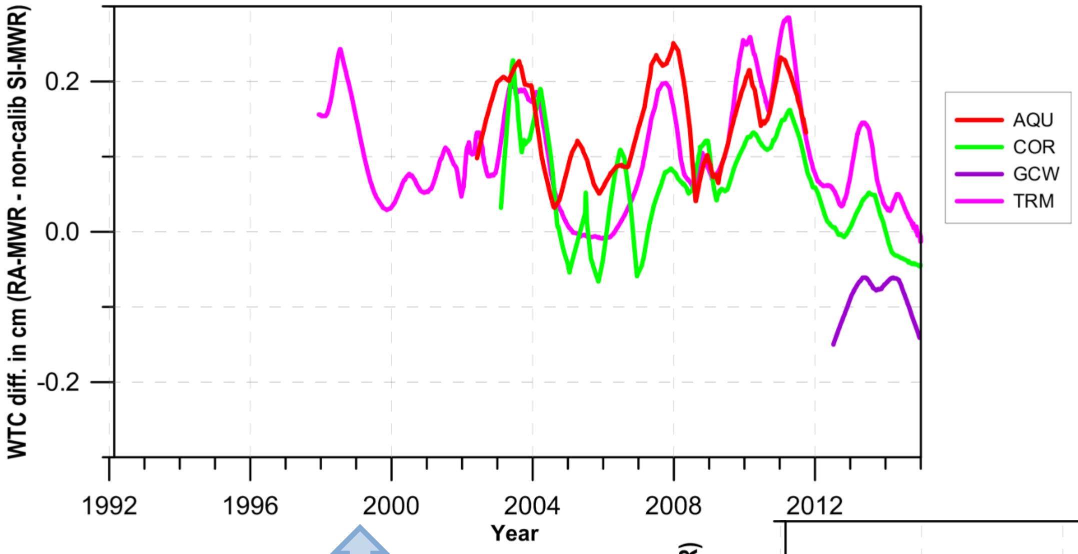


Differences in WTC (cm) derived from MWR on board altimetric reference missions and from AMSU-A.

Before calibration

After calibration

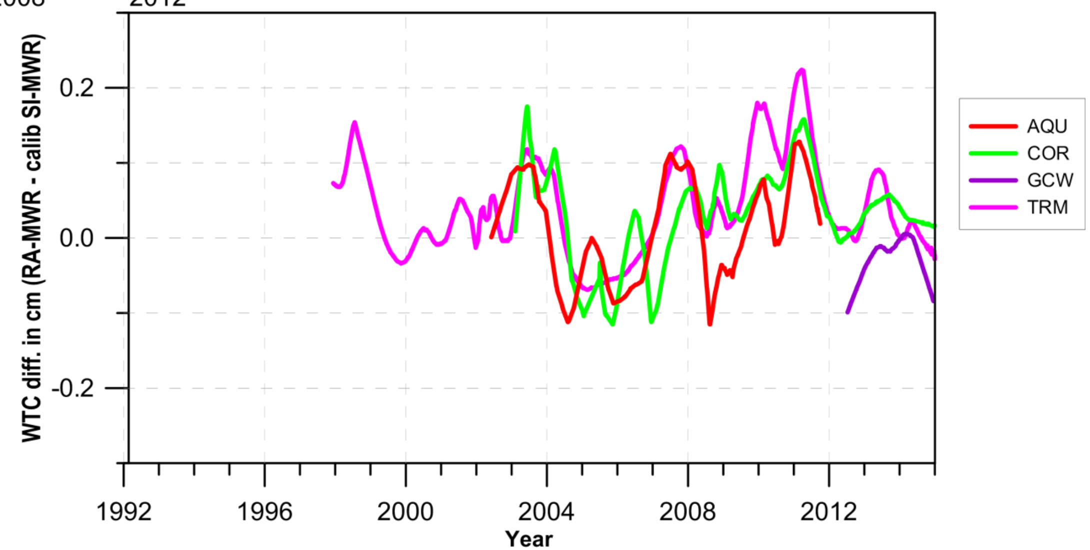




Differences in WTC (cm) derived from MWR on board altimetric reference missions and from AMSR-E (AQU), AMSR-2 (GCW), TMI (TRM) and WindSat (COR).

Before calibration

After calibration

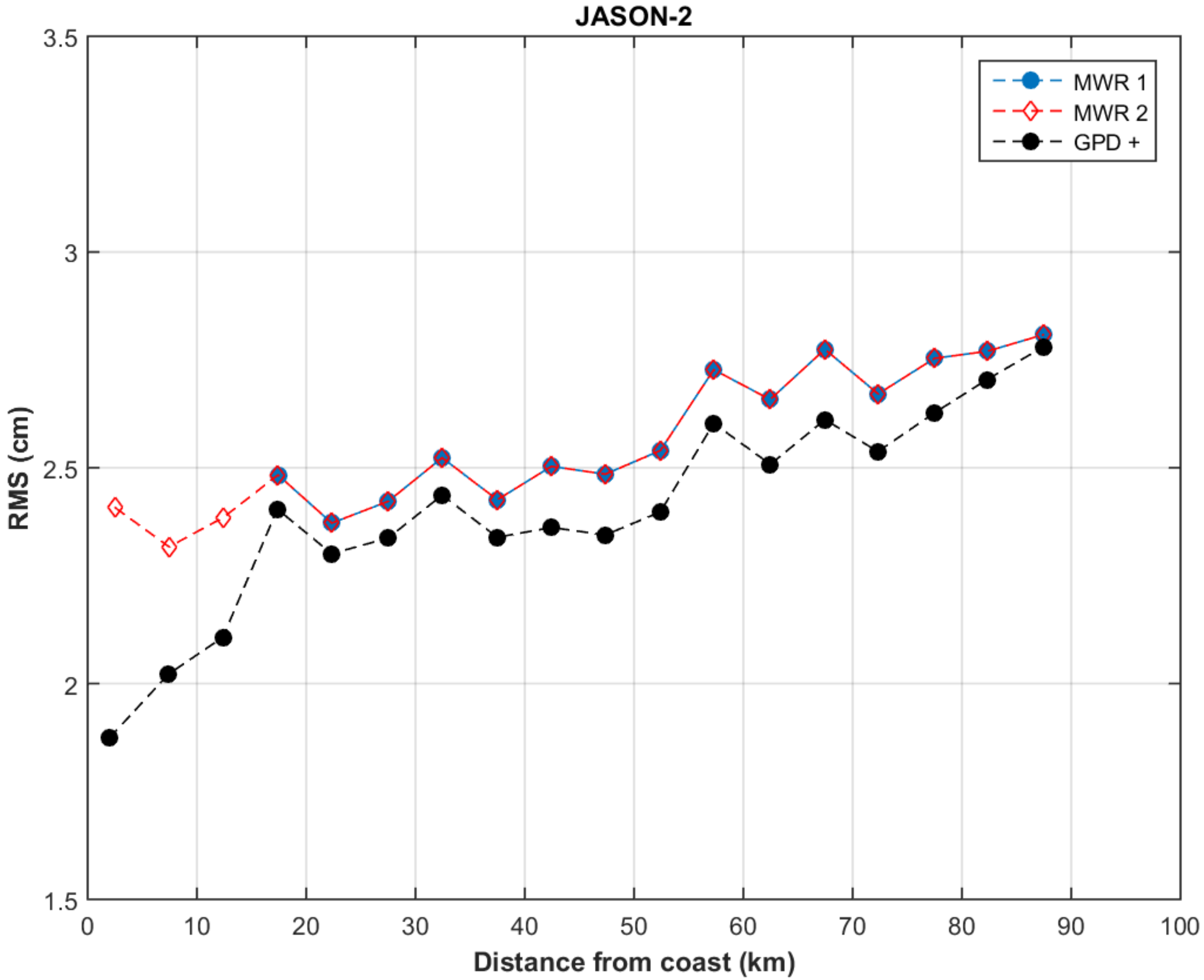


• GPD+ performance in coastal regions

- The next slides show, for various missions, the RMS difference between various WTC and the WTC derived at the nearby coastal GNSS stations.
- A set of over 700 stations has been used.
- Only points up to 100 km from the station are considered.
- Differences are binned function of distance from coast.
- For each bin, the RMS is presented.
    - **Black dots**: GPD+ WTC
    - **Blue dots**: Baseline MWR valid according to all criteria
    - **Red dots**: Baseline MWR valid according to all criteria except the maximum distance from coast (D_{max})

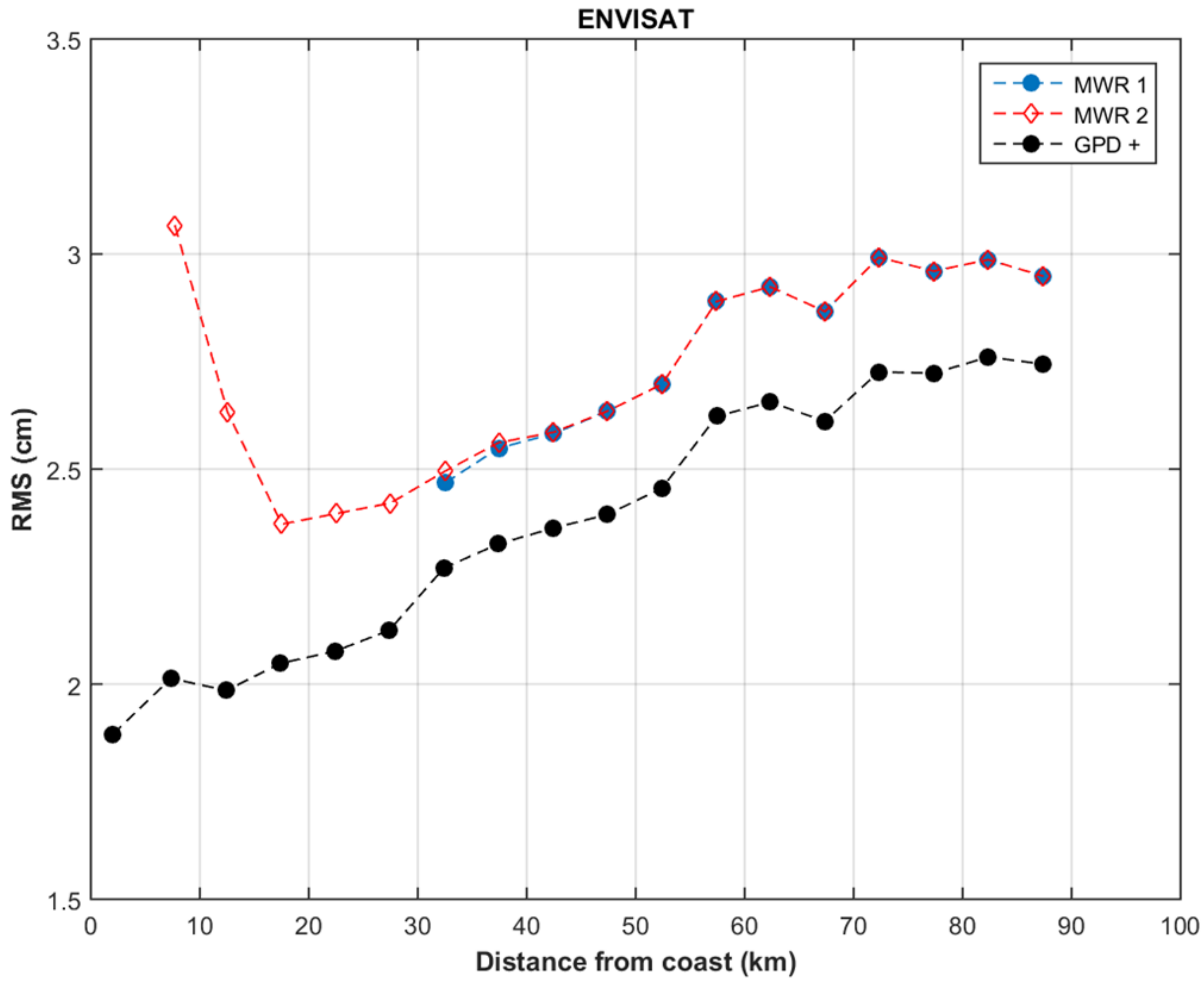
Jason-2

D_{max}=15 km



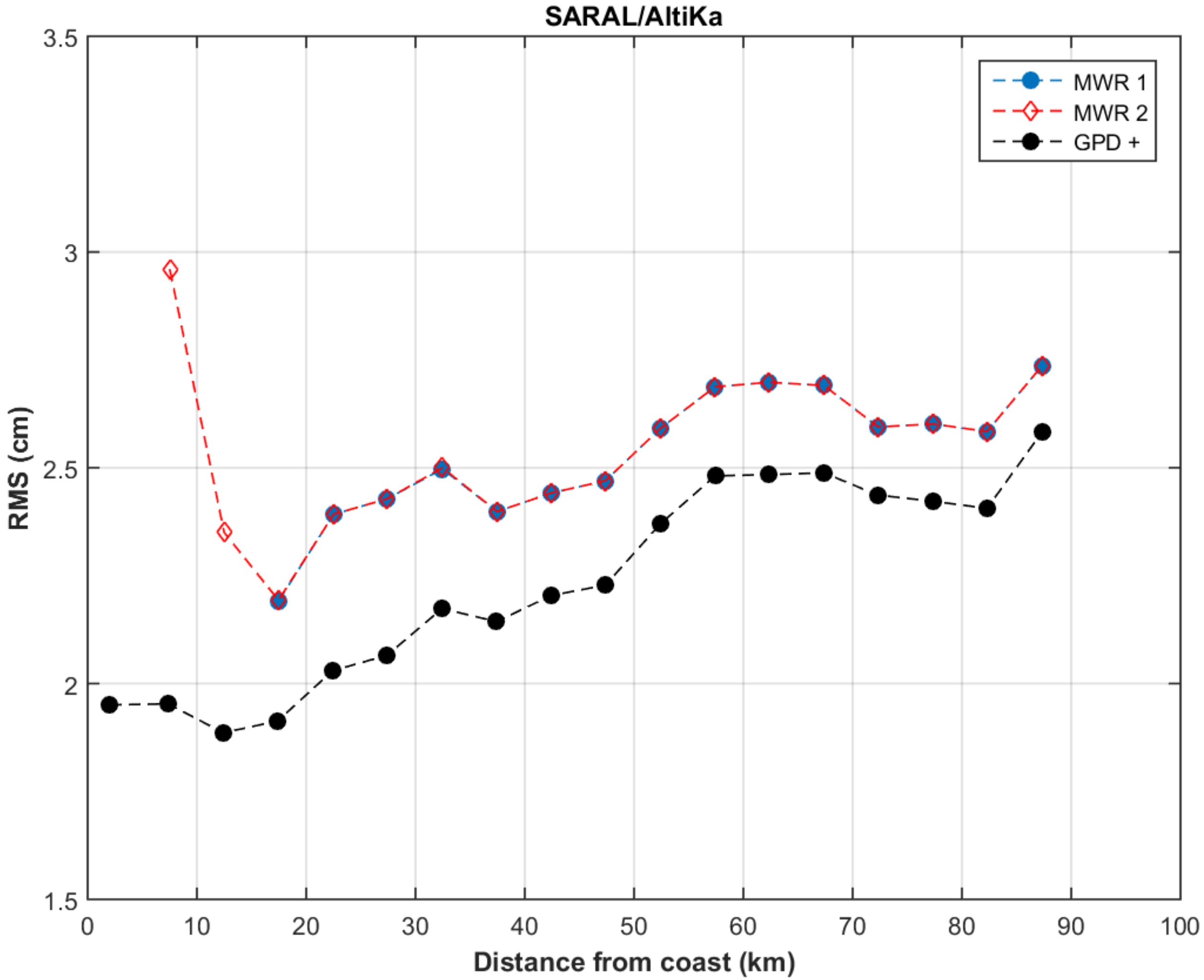
Envisat

D_{max}=30 km



SARAL

D_{max}=15 km



- **Summary**

  − GPD+ implemented for 8 mission in the scope of the SL-cci project.

  − For most missions, the new WTC reduce sea level anomaly variance w.r.t. previous non-calibrated versions.

  − Coastal improvements are also illustrated through the reduction of the RMS differences between GNSS-derived wet path delays at coastal stations and the WTC at the nearby altimeter points, function of the distance from coast.

- **GPD+ will be tuned for S3 in the scope of the project.**

- **WP7300 – Data set validation**
  - **The WTC will be evaluated through an independent validation, within WP5000 and WP6000.**
  - **WTC will be validated in this task by means of a set of statistical analyses of sea level anomaly (SLA) variance (along-track, at crossovers, function of distance from coast and function of latitude).**

• Outline of deliverables

- **Product Validation Plan D2.4 (Feb. 9, 2016)**
- **Product Validation Report D2.5 (Oct. 9, 2016, Updated Jul. 9, 2017)**
- **WTC Output Products D2.9 (Jul. 9, 2017)**