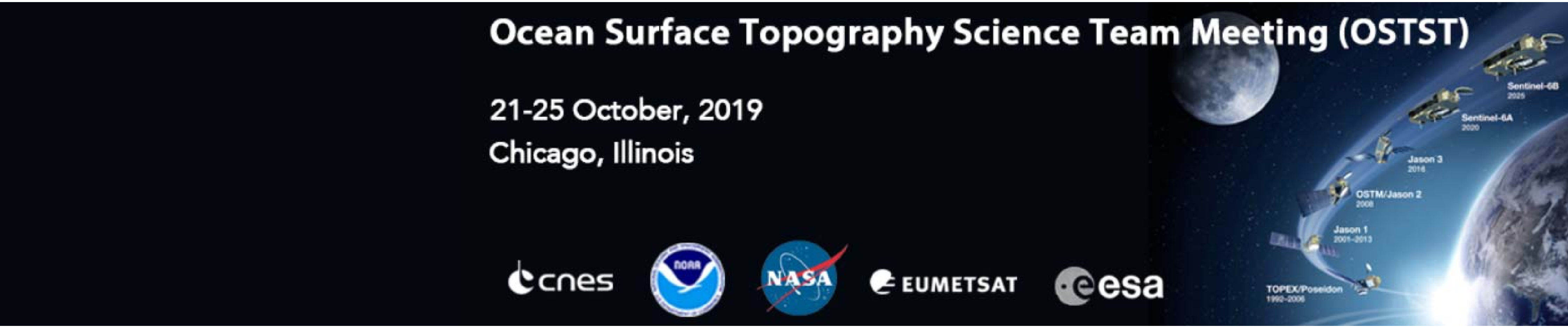

Inspecting Jason-3 and Sentinel-3 WPD over their first 3 years of mission

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Objectives and scope

- **Evaluate the performance of both J3 and S3A MWR-derived WPD over the first 3.5 years of mission**

- **Same for S3B for the first 1.5 years of mission, including the tandem mission with S3A**

This study is a contribution to S3VT project VOCALS3 and to project SCOOP

J3, S3A and S3B data

All data have been extracted from RADS:

- **S3A and S3B –** L2 NTC products, most recent reprocessing
- **J3 –** L2 GDR data

Analysed fields:

- **J3 –** Wet Tropospheric Correction (WTC) from AMR-2
- **S3A and S3B:**
  - WTC from 3 inputs: TB 23.8 GHz, TB 36.5 GHz, Ku σ_0
  - WTC from 5 inputs: TB 23.8 GHz, TB 36.5 GHz, Ku σ_0, SST, T_{atmos} lapse rate with altitude
  - TB 23.8 GHz and TB 36.5 GHz

WTC= - WPD

Methodology

Assessment of J3, S3A and S3B MWR WPD performed by means of:

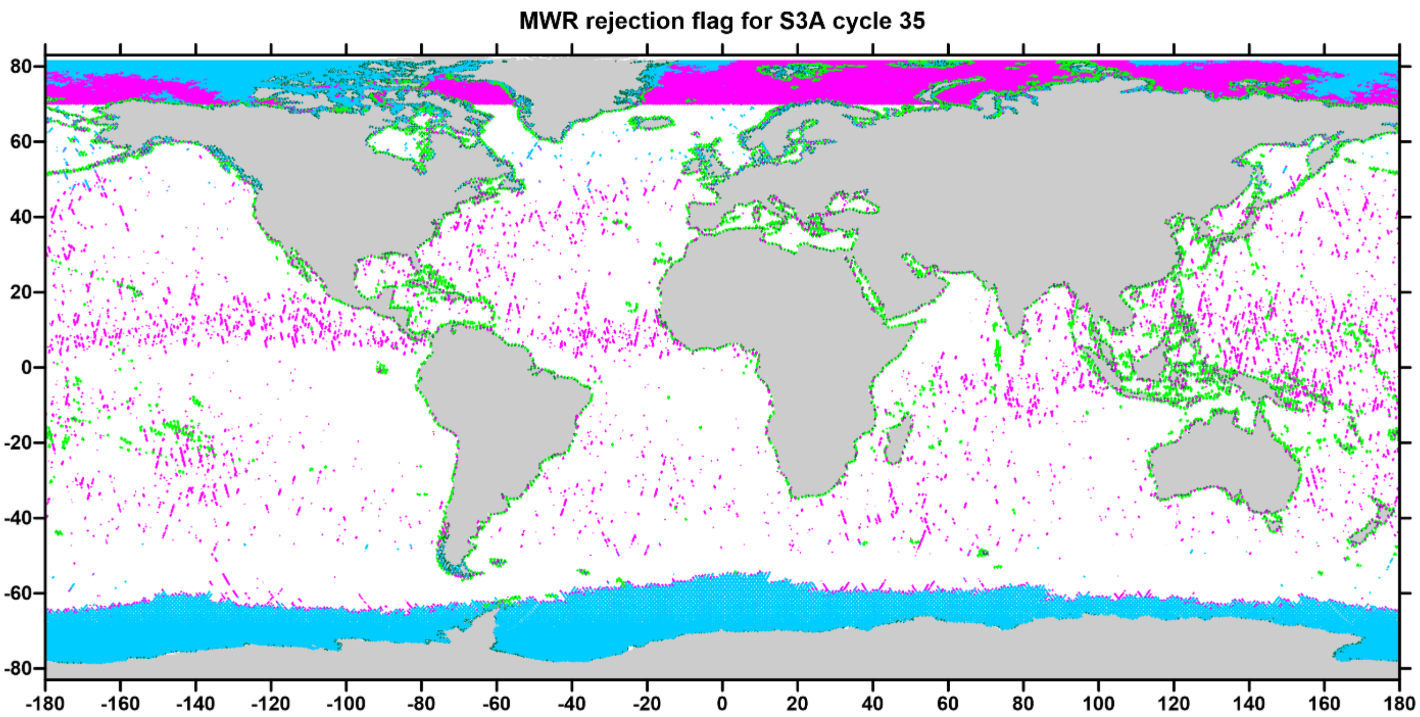
⇨ Comparison of J3, S3A and S3B WPD with other MWR (SSM/IS and GMI) WPD, using matchups with time difference $\Delta T<45$ min and distance $\Delta D<50$ km

⇨ Comparison with GPD+ WPD computed only with third-party data (GPD1);

⇨ Comparison with ERA5 and ECMWF Op. models

⇨ Comparison of S3A and S3B fields during the tandem mission

MWR valid points used in this study



Sensor assessment has been performed only for valid MWR points using the criteria adopted in GPD+

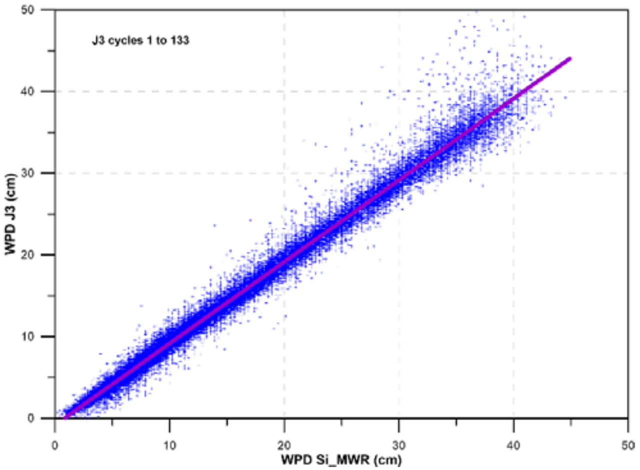
S3A points for cycle 35 with invalid MWR observations: **green** – land contamination; **blue** – ice contamination; **pink** – rain or outliers; **brown** – land points (**28.0% of all points, 10.2% of the points with valid SLA**)

Calibration of J3 WPD against SSM/IS

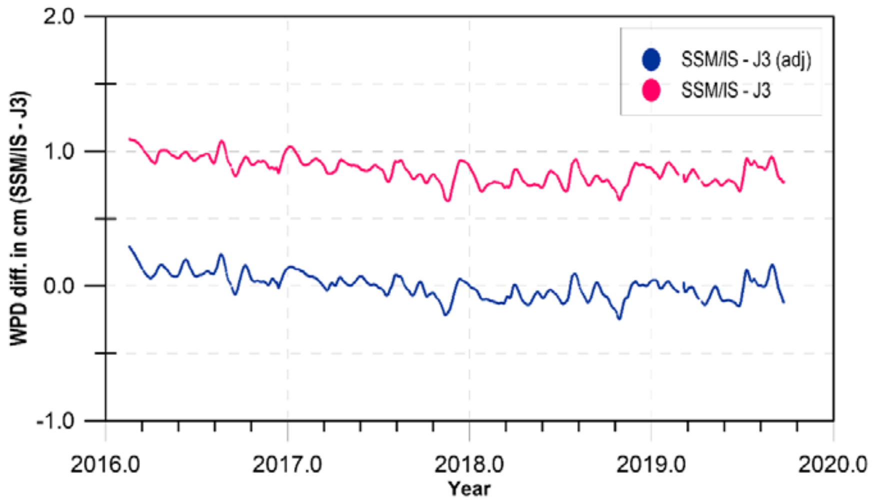
Data: J3 cyc. 1 to 133 (~3.5 years) from RADS; SSM/IS (**F16, F17**, **F18)** from Remote Sensing Systems (RSS)

Calibration mode: 2 or 3 parameters

WPD FXX (cm)= a + b* WPD J3 (cm) + c*(t-2016)



WPD (J3) versus WPD (SSM/I)



Time evolution of smoothed WPD (SSM/IS) – WPD (J3) in cm

2 parameters:
Offset (a) = 0.94 cm
Scale factor (b) = 0.99

3 parameters:
Offset (a) = 1.04 cm
Scale factor (b) = 0.99
Trend (c) = 0.050 cm/yr

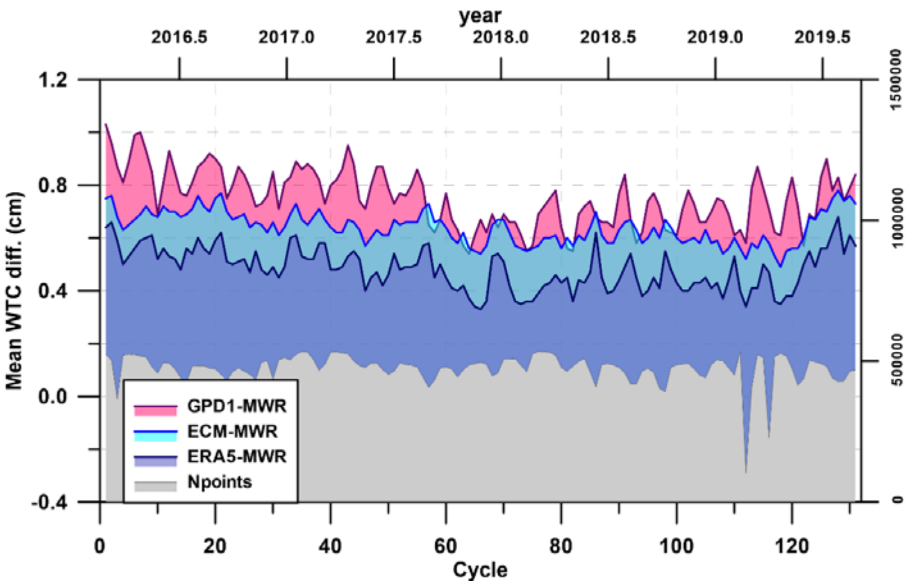
- **J3 measures dryer than SSM/IS by 1 cm**
- **RMS WPD (SSM/IS) – WPD (J3) = 1.2 cm (before adj.)/0.91 cm (after adj.)**

Due to short length of the missions, the 2-parameter calibration mode was adopted for all sensors.

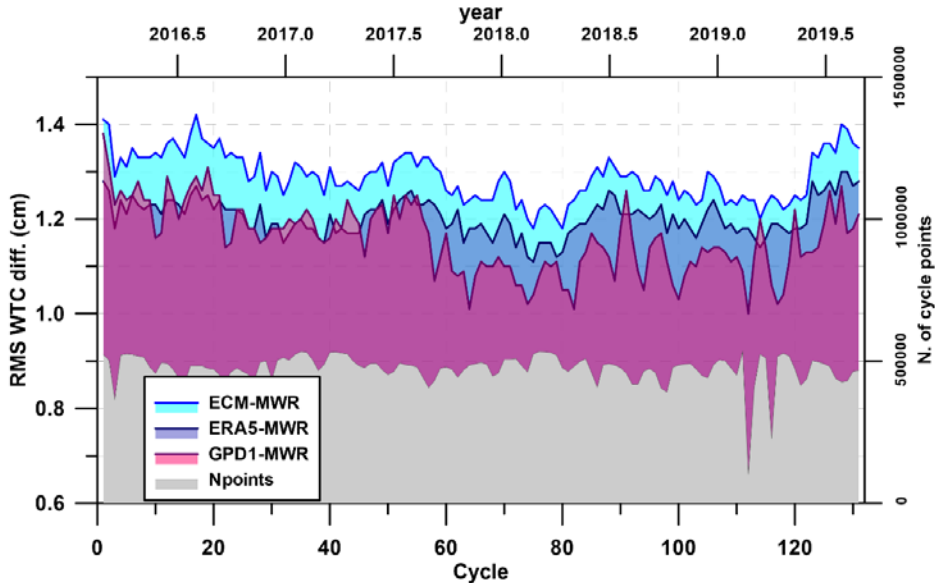
Comparison of J3 WPD with GPD1, ERA5 and ECMWF Op.

Statistics of WPD differences (mean cycle values) between GPD1, ERA5 and ECMWF Op. models and J3 MWR

Mean



RMS

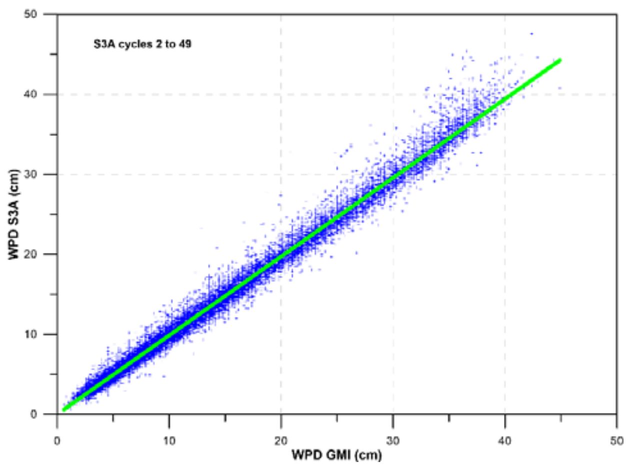


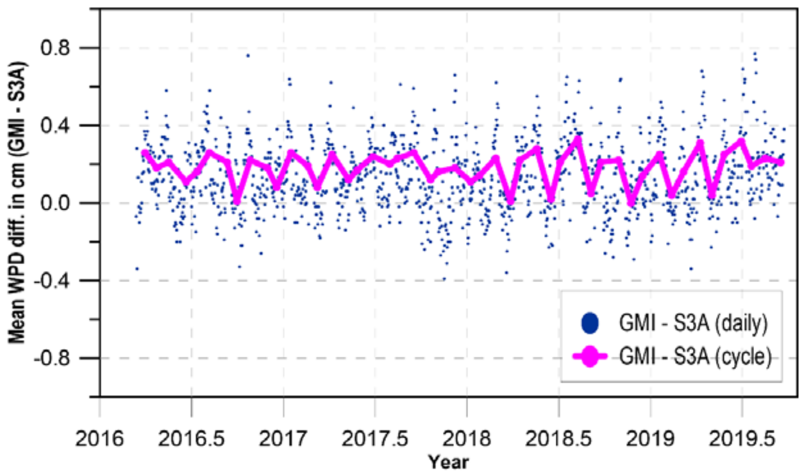
Points used: those with valid MWR values and GPD1 estimations from observations.
⇨ GPD1 does not use J3 MWR, only external WPD observations.

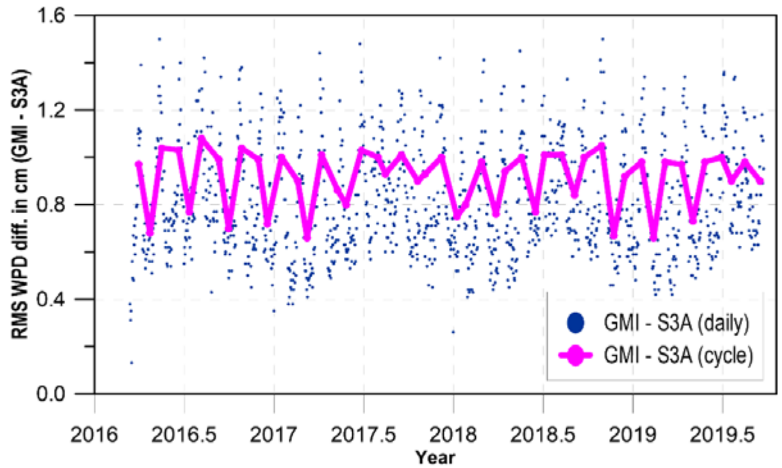
Calibration of S3A WPD against GMI

Data: S3A cycles 02-49 (~3.5 years); GMI from Remote Sensing Systems

GMI and SSM/IS previously inter-calibrated by Remote Sensing Systems







WPD (S3A) versus WPD GMI (cm)

Mean (left) and RMS (right) of WPD (GMI) – WPD (S3A) in cm

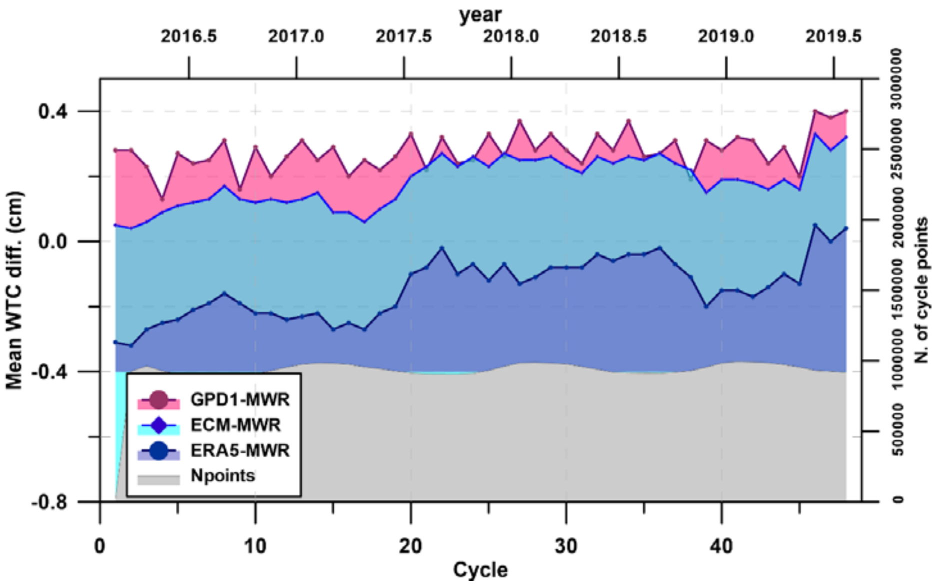
- **S3A measures dryer than GMI by 1 mm**
- **RMS WPD (GMI) – WPD (S3A) = 0.93 cm (before adj.)/0.92 cm (after adj.)**

Offset (a) = 0.12 cm
Scale factor(b) = 1.00

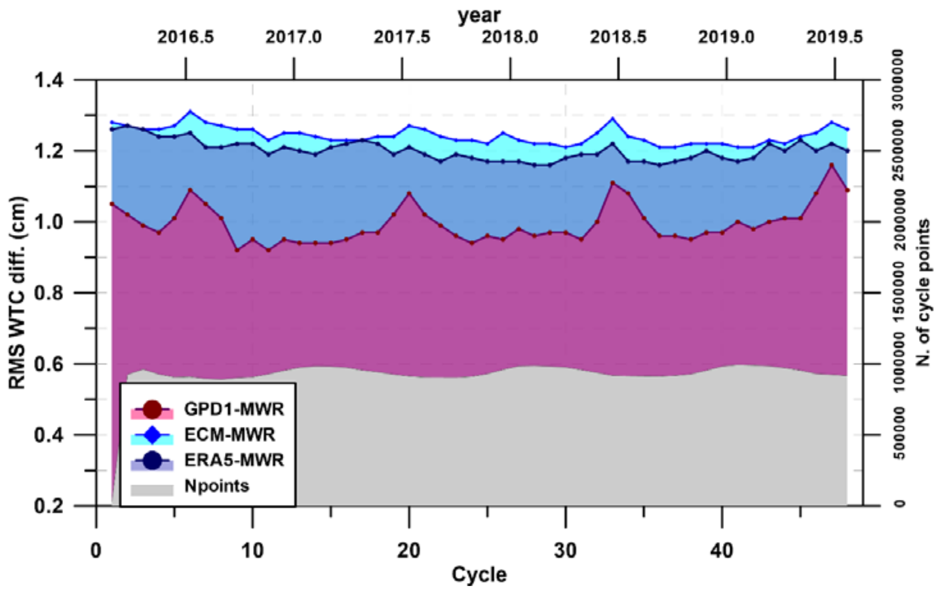
Comparison of S3A WPD with GPD1, ERA5 and ECMWF Op.

Statistics of WPD differences (mean cycle values) between GPD1, ERA5 and ECMWF Op. models and S3A MWR

Mean



RMS

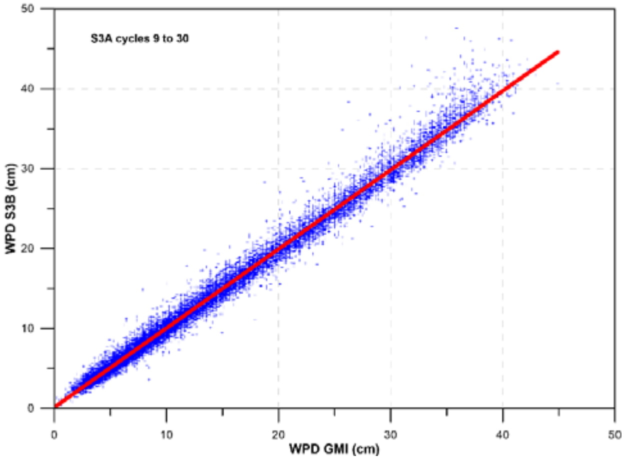


Points used: those with valid MWR values and GPD1 estimations from observations.
⇨ GPD1 does not use S3A MWR, only external WPD observations.

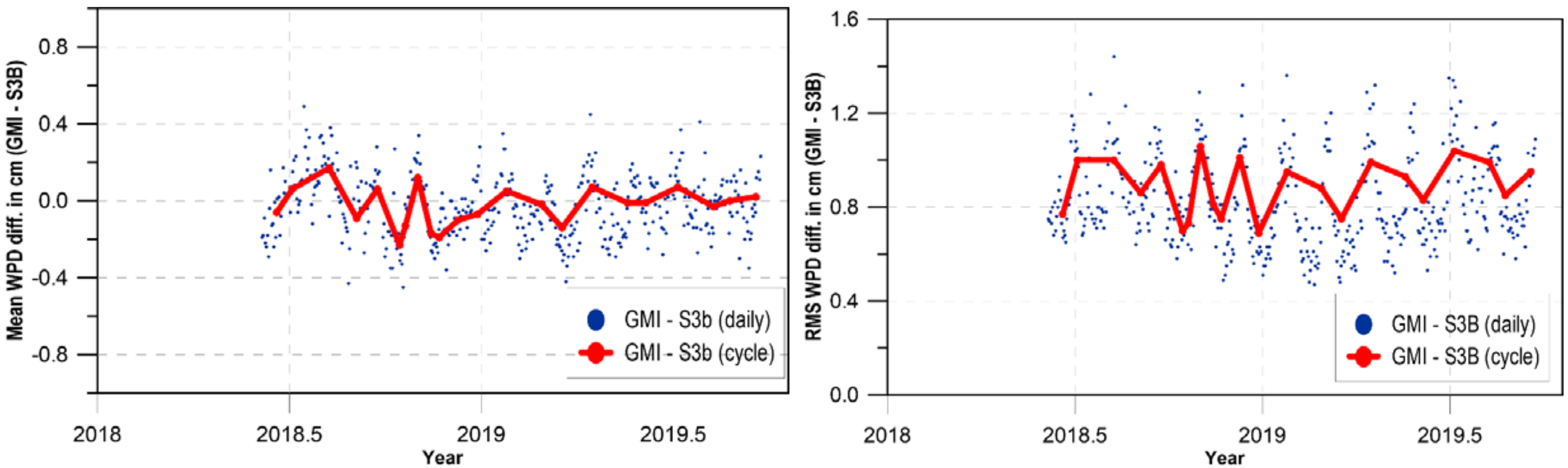
Calibration of S3B WPD against GMI

Data: S3B cycles 09-30 (~1.5 years); GMI from Remote Sensing Systems

⍰ GMI and SSM/IS previously inter-calibrated by Remote Sensing Systems



WPD(S3B) versus WPD(GMI) in cm



Mean (left) and RMS (right) of WPD(GMI) – WPD(S3B) in cm

- **S3B is in line with GMI.**
- **RMS WPD (GMI) – WPD (S3B) = 0.93 cm**

Offset (a) = 0.01 cm
Scale factor(b) = 1.00

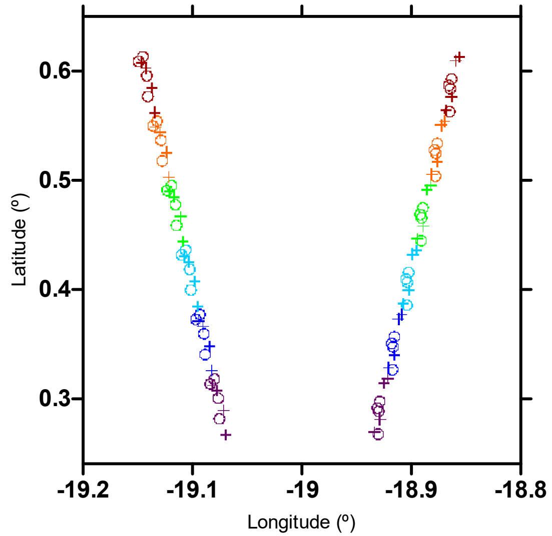
⇨Similar results were obtained for S3A and S3B with crossovers w.r.t. J3.

S3A/S3B Tandem mission analysis

Estimation of matchups

- For each mission, points are organized in 1 sec bins, function of the time difference with respect to equator crossing
- For each cycle, matchups are points in the same pass and bin for the period of S3B cycles 09-14 (S3A cycles 32-37)
- Water points with WTC5 (5 inputs) and WTC3 (3 inputs) within valid limits [-0.5 m, 0 m]; only valid points using the GPD+ criteria were selected.

Each colour represents 1 sec bins for S3A (o) and S3B (+)

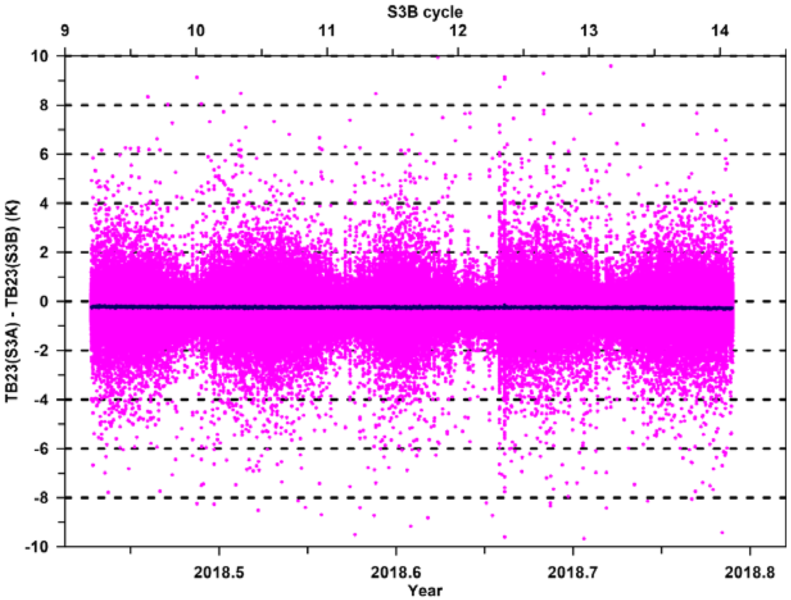


Distance (D) and time difference (Δt) between corresponding S3A and S3B points in the same bin: D=**[0,7] Km**; Δt=**[28,33] sec**.

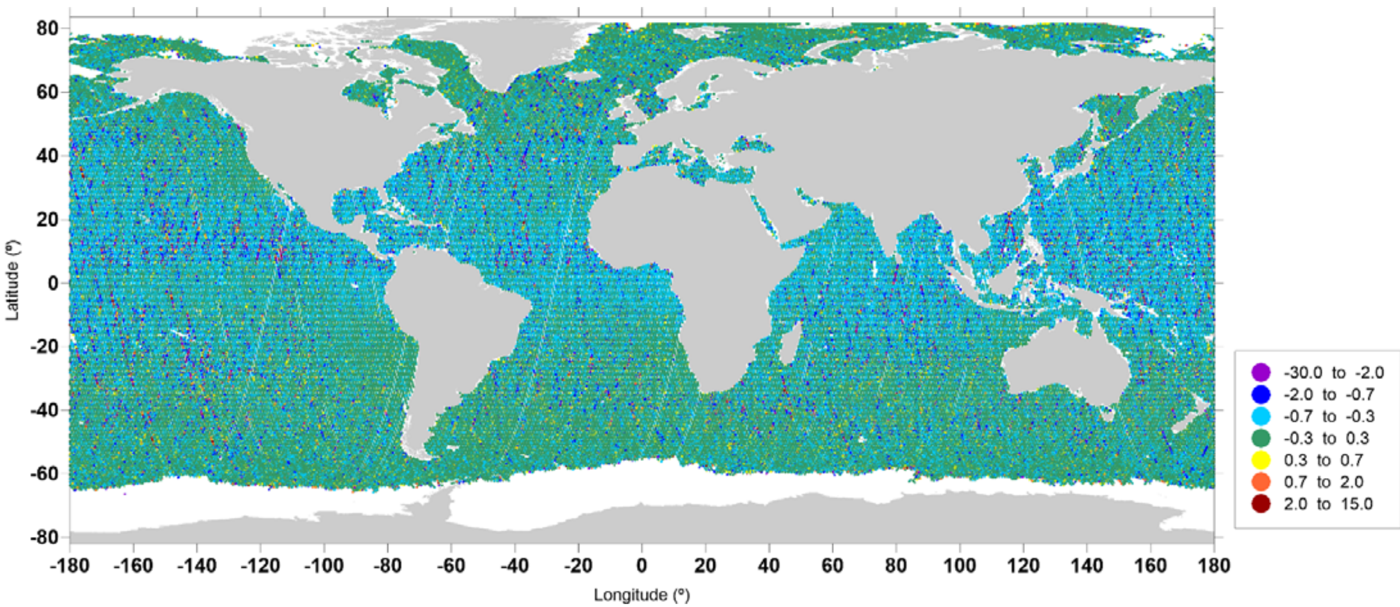
Tandem mission: TB23 (S3A) – TB23 (S3B)

Global statistics for the tandem mission:

mean=-0.24 K
sigma=0.41 K



Time evolution of TB23 (S3A) – TB23 (S3B) in Kelvin for the tandem mission (S3B cycles 09-14)

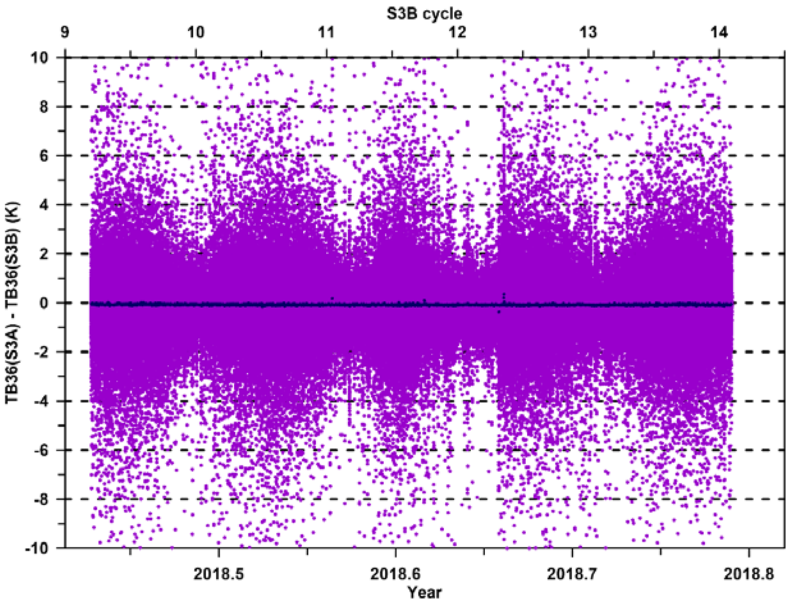


TB23 (S3A) – TB23 (S3B) in Kelvin for S3B cycle 12 (S3A cycle 35)

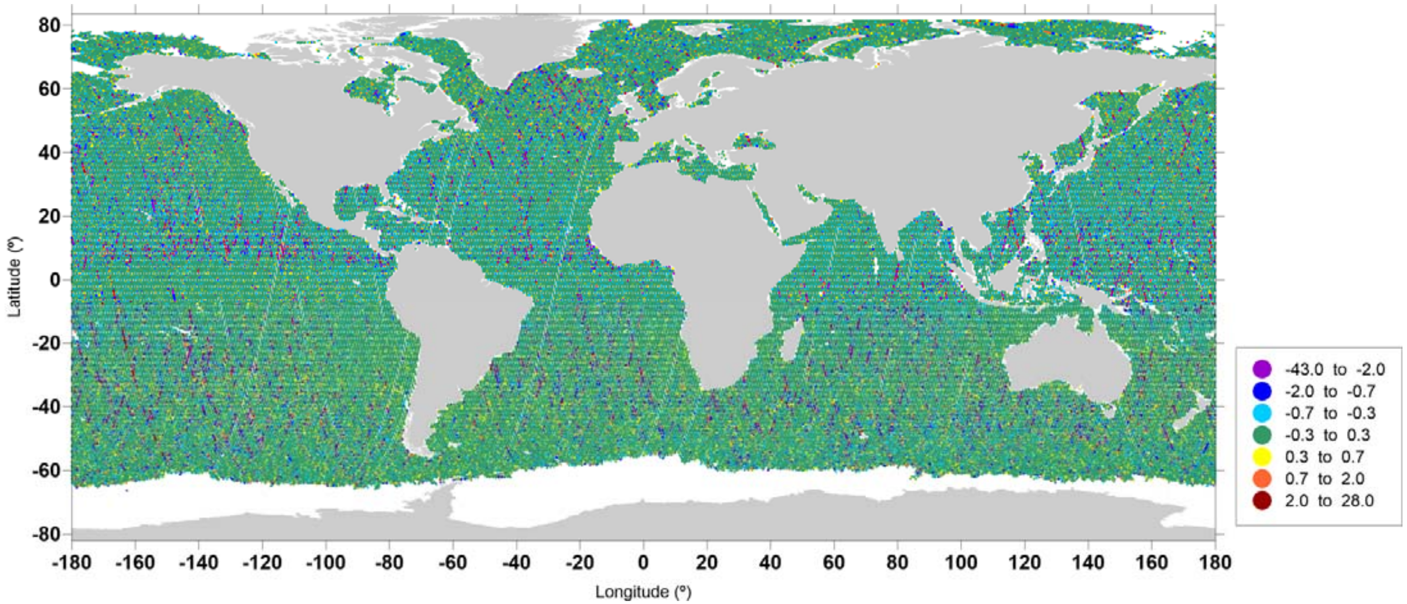
Tandem mission: TB36 (S3A) – TB36 (S3B)

Global statistics for the tandem mission:

mean=-0.07 K
sigma=0.76 K



Time evolution of TB36 (S3A) – TB36 (S3B) in Kelvin for the tandem mission (S3B cycles 09-14)

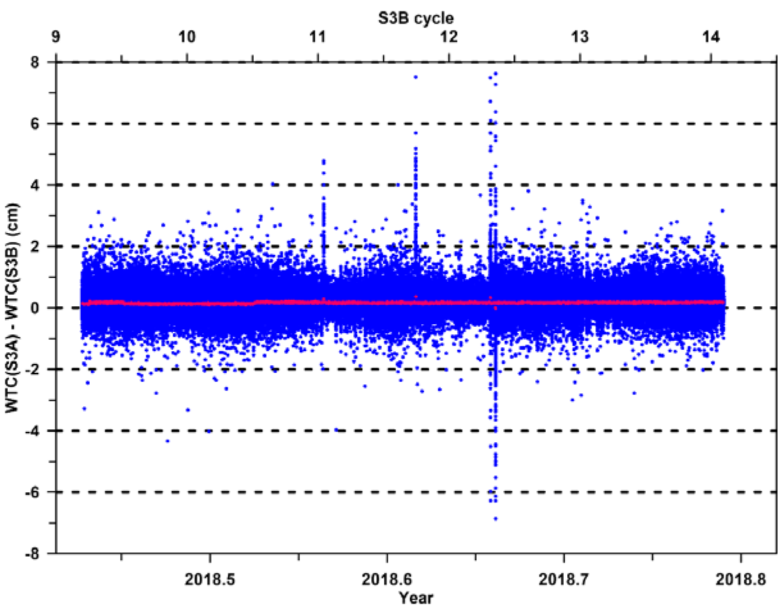


TB36 (S3A) – TB36 (S3B) in Kelvin for S3B cycle 12 (S3A cycle 35)

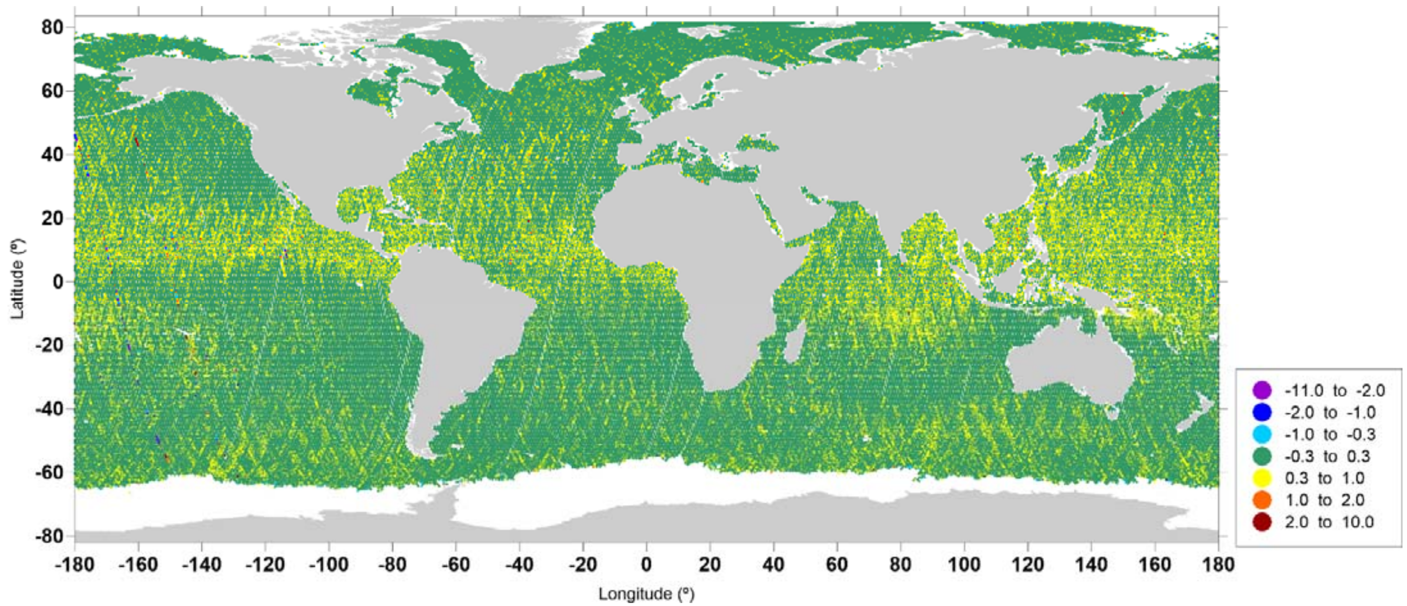
Tandem mission: WTC (S3A) – WTC (S3B) - 3 inputs

Global statistics for the tandem mission:

mean=0.16 cm
sigma=0.19 cm



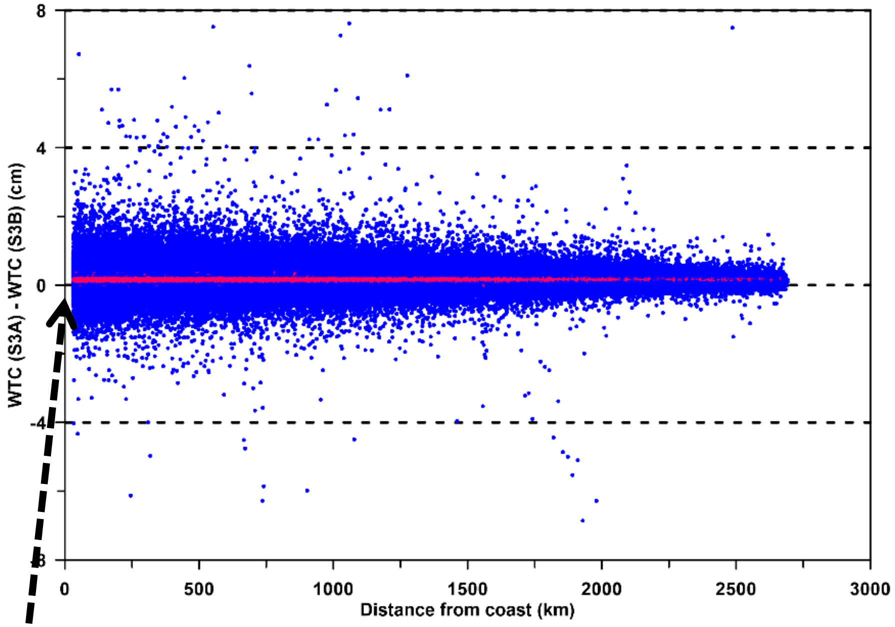
Time evolution of WTC (S3A) – WTC (S3B) in cm for the tandem mission (S3B cycles 09-14)



WTC (S3A) – WTC (S3B) in cm for S3B cycle 12 (S3A cycle 35)

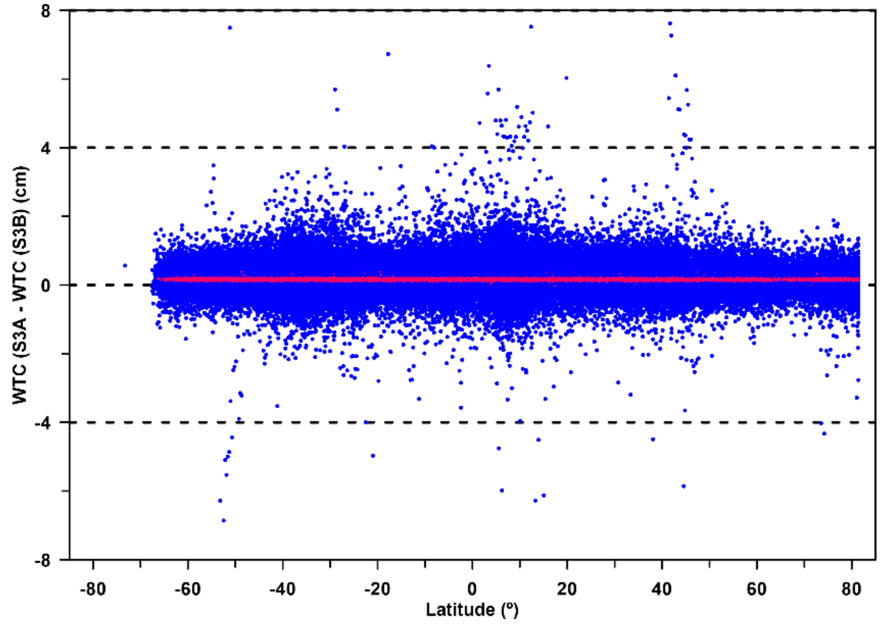
Tandem mission: WTC (S3A) – WTC (S3B) - 3 inputs

Function of distance from coast



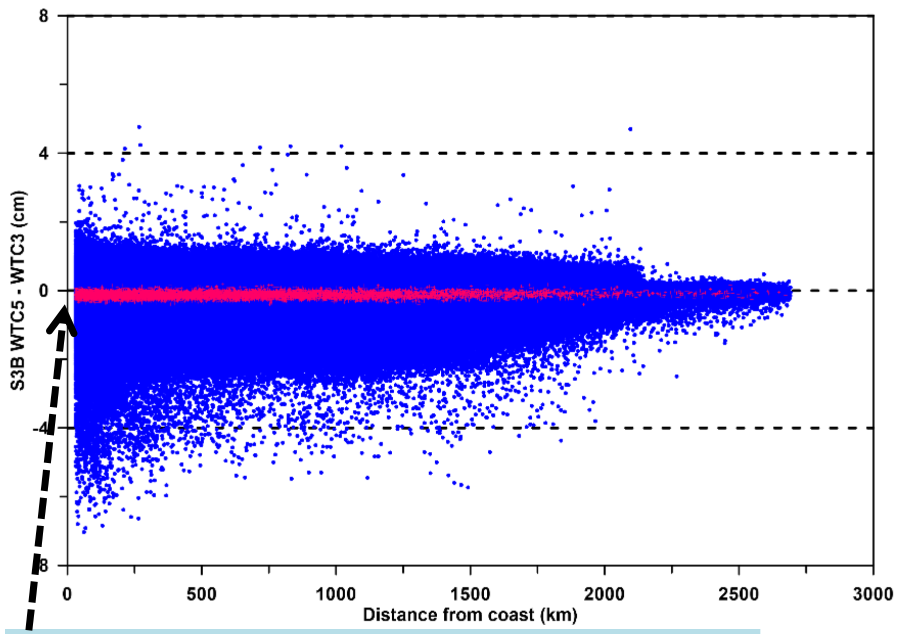
Distances 0-25 km have not been used

Function of latitude



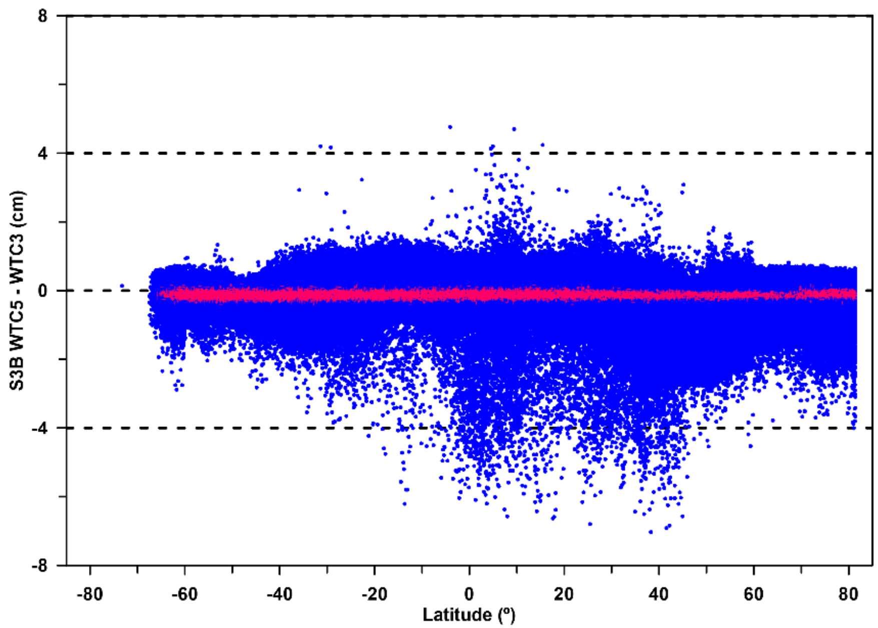
Tandem mission: WTC 5 inputs – WTC 3 inputs (S3B)

Function of distance from coast



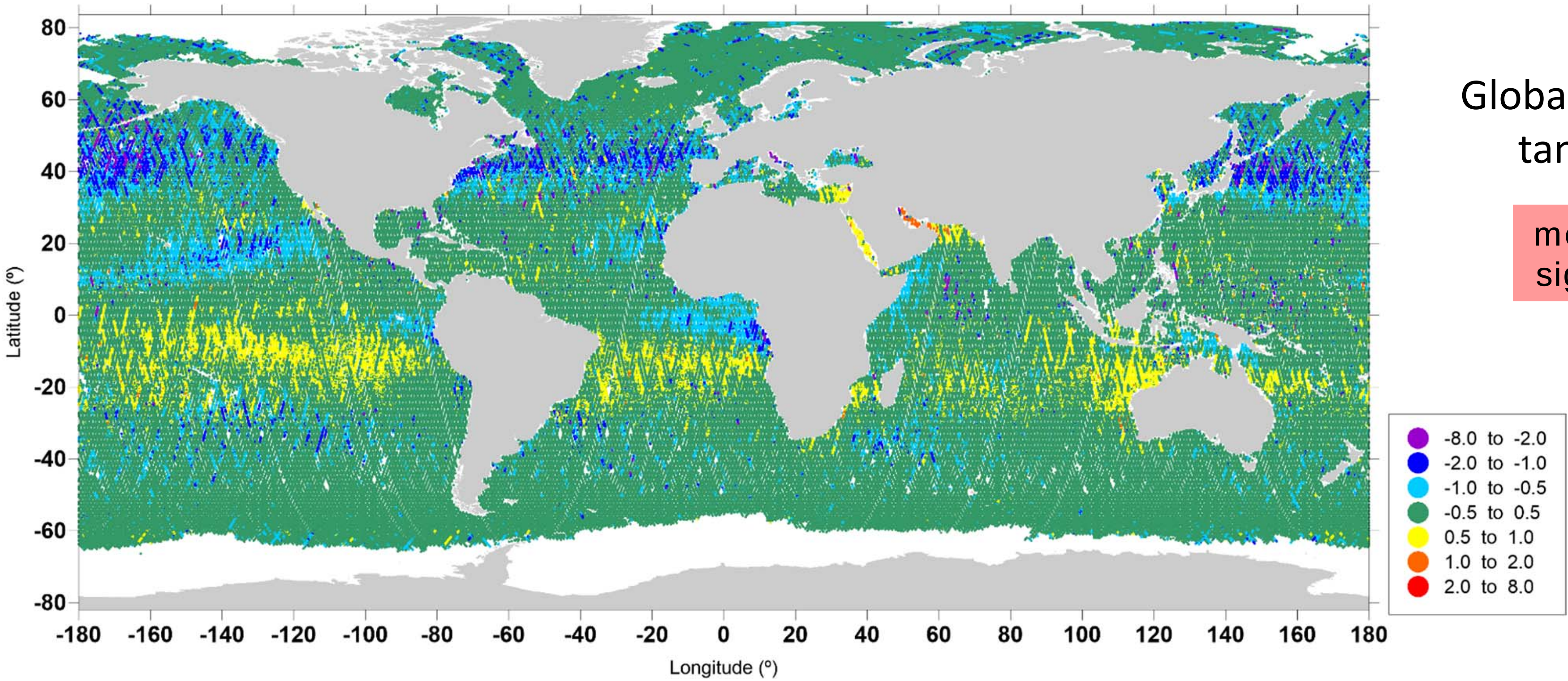
Distances 0-25 km have not been used

Function of latitude



WTC 5 inputs – WTC 3 inputs (S3B)

WTC (5 inputs) – WTC (3 inputs) for S3B cycle 12 (cm)

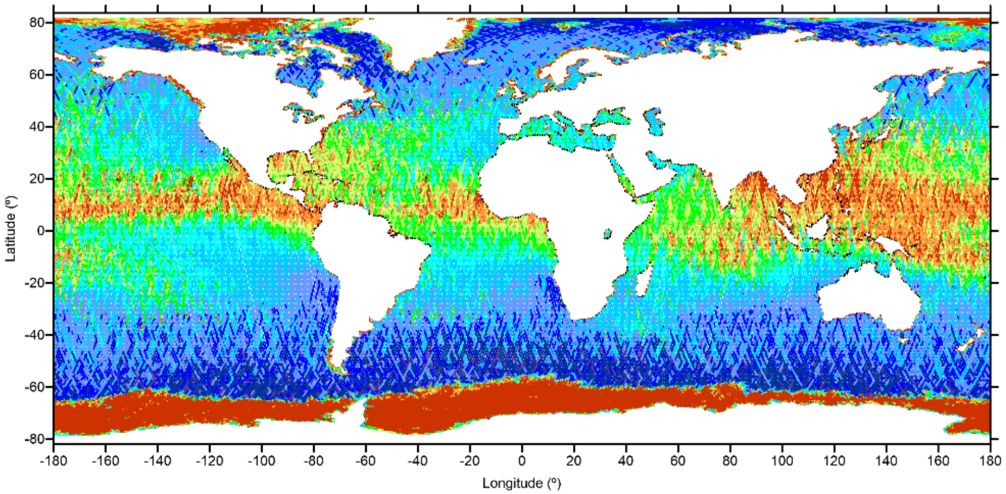


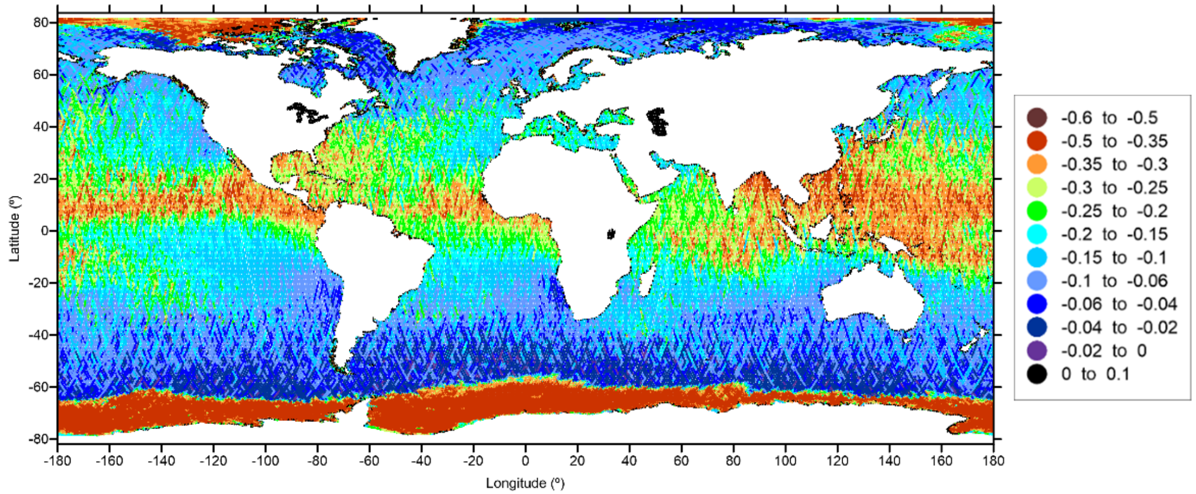
Global statistics for the tandem mission:

mean=-0.12 cm
sigma=0.50 cm

⇨ **Differences have a clear seasonal pattern.**

WTC 5 inputs – WTC 3 inputs (S3B)





MWR WTC for S3B cycle 12 (m). All marine data available in RADS were considered.
The 5-input WTC is not available over lakes and the Caspian Sea.

Conclusions

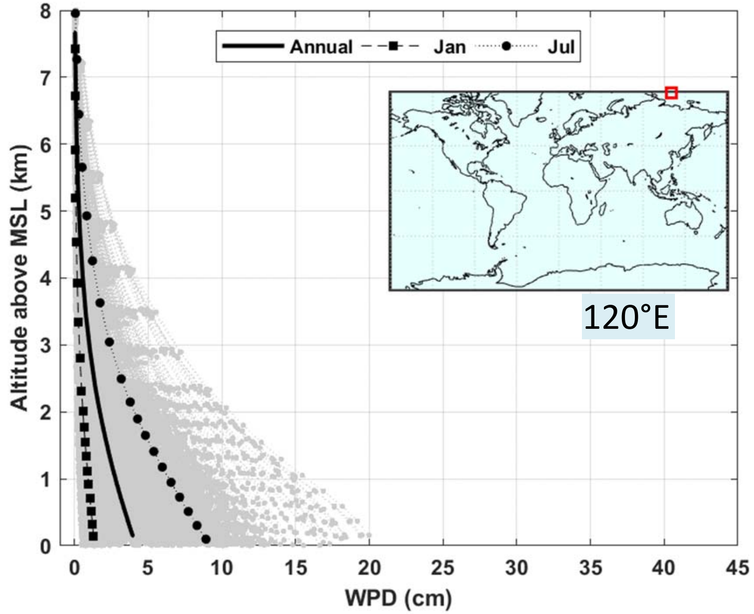
- WPD of J3 (3.5 years):
  - Good agreement with SSM/IS: scale factor=1.0, offset=1 cm, RMS =1.2/0.9 cm before/after calibration;
  - Comparison with GPD1 and models confirms offset;
  - Stable temporal evolution of the J3 WPD: it is not possible to infer any drift yet.
- WPD of S3A (3.5 years):
  - Good agreement with GMI: scale factor=1.0, offset=0.1 cm, RMS = 0.9 cm;
  - Stable temporal evolution of the S3A WPD;
  - 5-input WTC does not seem to be a clear improvement w.r.t. to the 3-input WTC.
- S3B is aligned with GMI. Good agreement between S3A and S3B MWR during the tandem phase:
  $\Delta TB23 = -0.2 \pm 0.4$ K; $\Delta TB36 = -0.1 \pm 0.8$ K; $\Delta WTC = 0.2 \pm 0.2$ cm
- Comparison with GPD1, ERA5 and ECMWF Op. provides additional independent validation.

Ongoing work: GPD+ new features

- **First guess: ERA5 (0.25°x0.25°, 3-h)**
  - Improved temporal resolution

- **New vertical modelling of the WTC** (prior to data combination, first guess and all observations are reduced to the height of the estimation point using new expressions):
  - Improved WTC vertical modelling dependent on geographic location and period of the year (Vieira et al., 2019).

- **Implementation extended to all surface types** – emphasis on **inland waters.**



WPD (cm) vertical profiles computed using temperature and specific humidity on pressure levels from ERA5

Thank you!

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