Validation of DGFI-TUM's new ionosphere model: case studies for year 2018

(EGU22-8931)

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EGU General Assembly 2022

23-27 May 2022, Vienna, Austria

INTRODUCTION

- The ionosphere is still considered as the main source of errors in precise positioning affecting surveying and geodetic applications.
- Currently, 7 IGS Ionosphere Associate Analysis Centers (IAACs) independently produce global ionosphere maps (GIMs) with the use of various methods.
- There are several studies investigating the quality of the IAAC maps, the recent one by Roma-Dollase et al. (2018), and also by Wielgosz et al. (2021)
- In the meantime, DGFI-TUM has developed its own ultra-rapid GIMs (OTHG) available with a 2-3-hour delay.
- Hence, in this presentation we analyze the new OTHG maps with respect to our earlier results presented in Wielgosz et al. (2021) for the full year of 2018.
- The study is based on GIM self-consistency analysis and comparisons to altimetry-derived VTEC.

Roma-Dollase et al. (2018) Consistency of seven different GNSS global ionospheric mapping techniques during one solar cycle. J Geod 92(6):691-706. DOI: 10.1007/s00190-017-1088-9

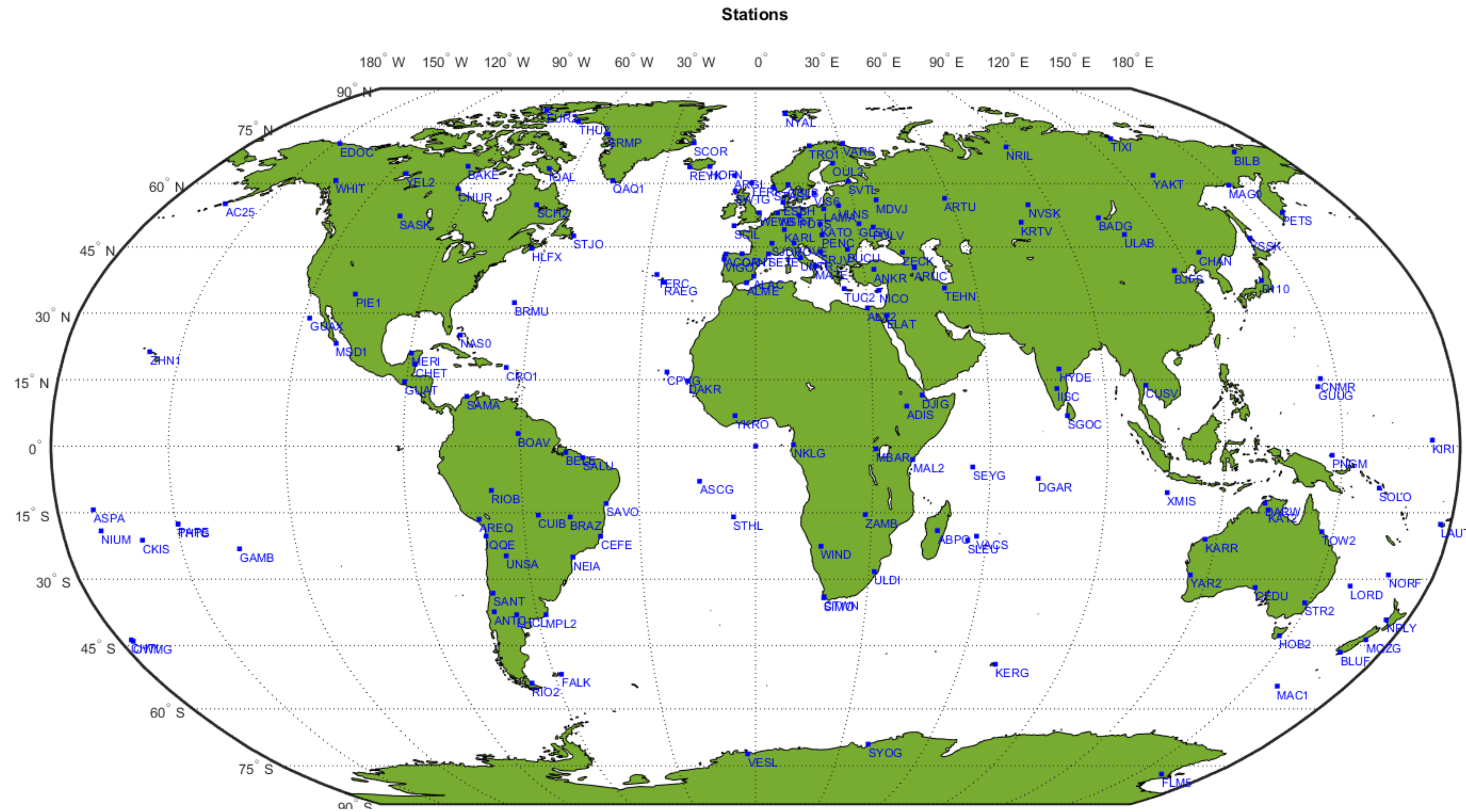
Wielgosz et al. (2021) Validation of GNSS-derived global ionosphere maps for different solar activity levels: case studies for years 2014 and 2018. GPS Solutions 25, 103. DOI: 10.1007/s10291-021-01142-x

IGS IONOSPHERE ASSOCIATED ANALYSIS CENTERS' (IAAC) GLOBAL IONOSPHERE MAPS (GIMs)

GIM ID	Method	Shell model	Time resolution
CASG	Spherical harmonics Plus generalized Trigonometric Series	Single-layer	0.5 h
CODG	Spherical harmonics	Modified single-layer	1 h
EMRG	Spherical harmonics	Single-layer	1 h
ESAG	Spherical harmonics	Single-layer	2 h
IGSG	Weighted mean	Combined	2 h
JPLG	Spherical triangles with splines	Three-shell model	2 h
UPCG	Tomographic with splines	2-layer voxel model	2 h
UQRG*	Tomographic with kriging	Multi-layer	15 min
WHUG	Spherical harmonics and inequality-constrained least squares	Single-layer	2 h
OTHG*	polynomial B-splines of level 5 for latitude and trigonometric B-splines of level 3 for longitude	Single-layer	Ultra-Rapid/10 min

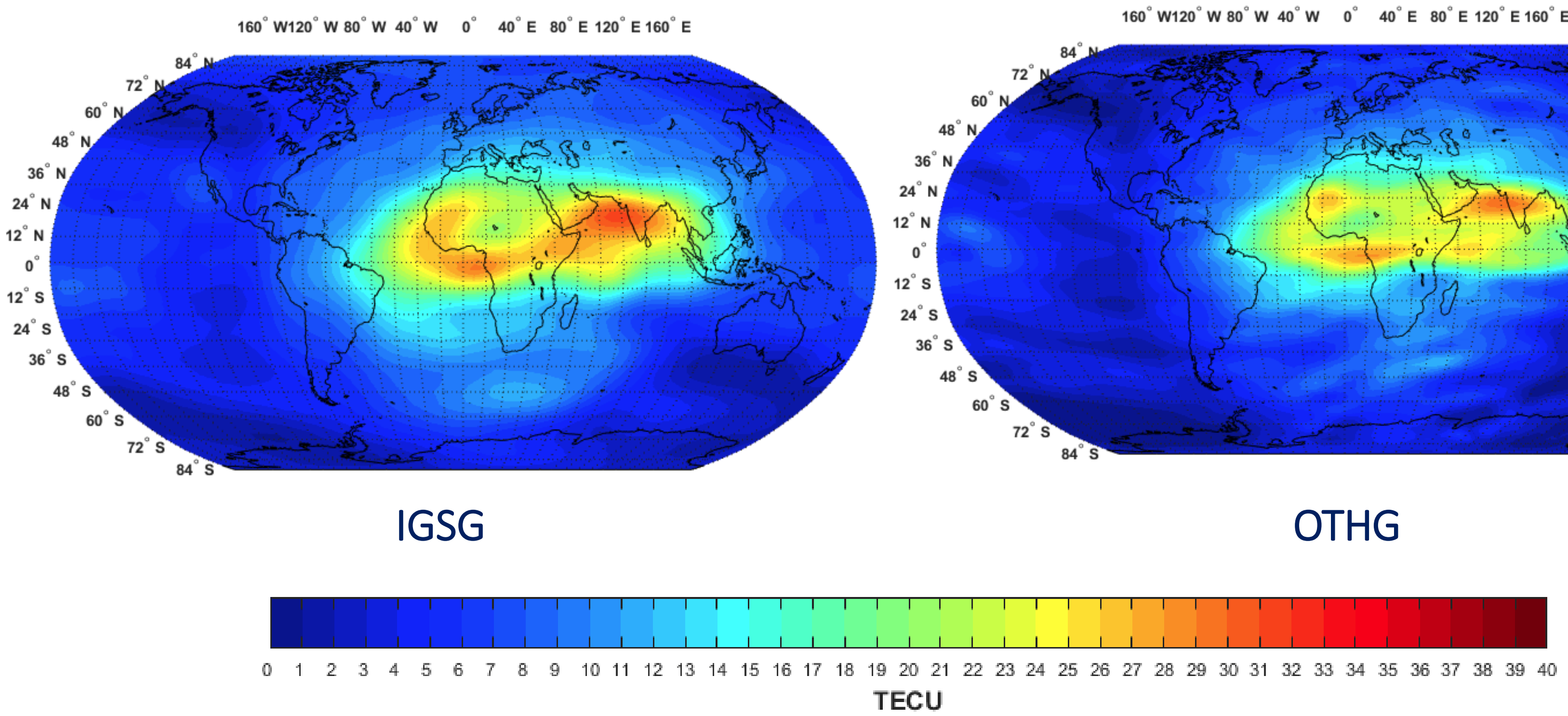
* not official IGS product

DISTRIBUTION OF GNSS STATIONS USED IN OTHG



- For the following comparisons only hourly IGS network data have been used for the generation of the OTHG maps.
- A default version of DGFI-TUM's VTEC software uses additionally 30 stations from UNAVCO placed in critical regions, e.g. Alaska and the west coast of the US.

IGS vs.OTHG GIMs (DOY 241/2018, 12:00 GPST)

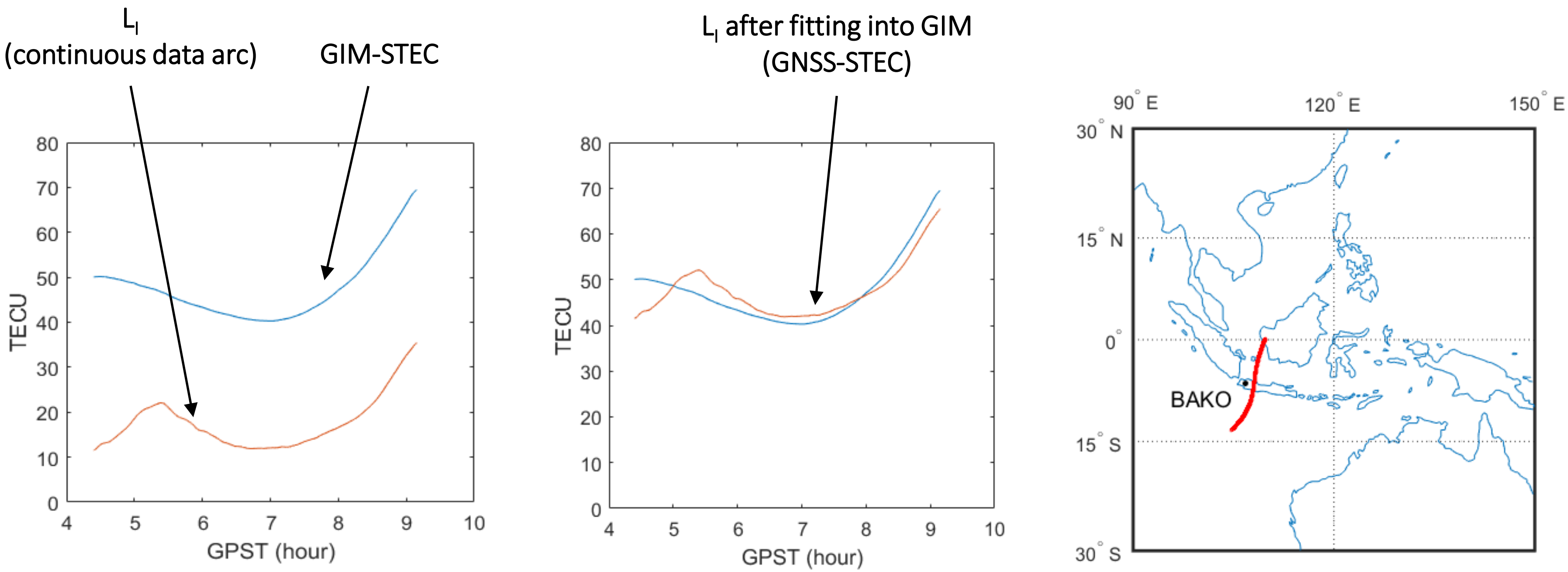


SELF-CONSISTENCY ANALYSIS

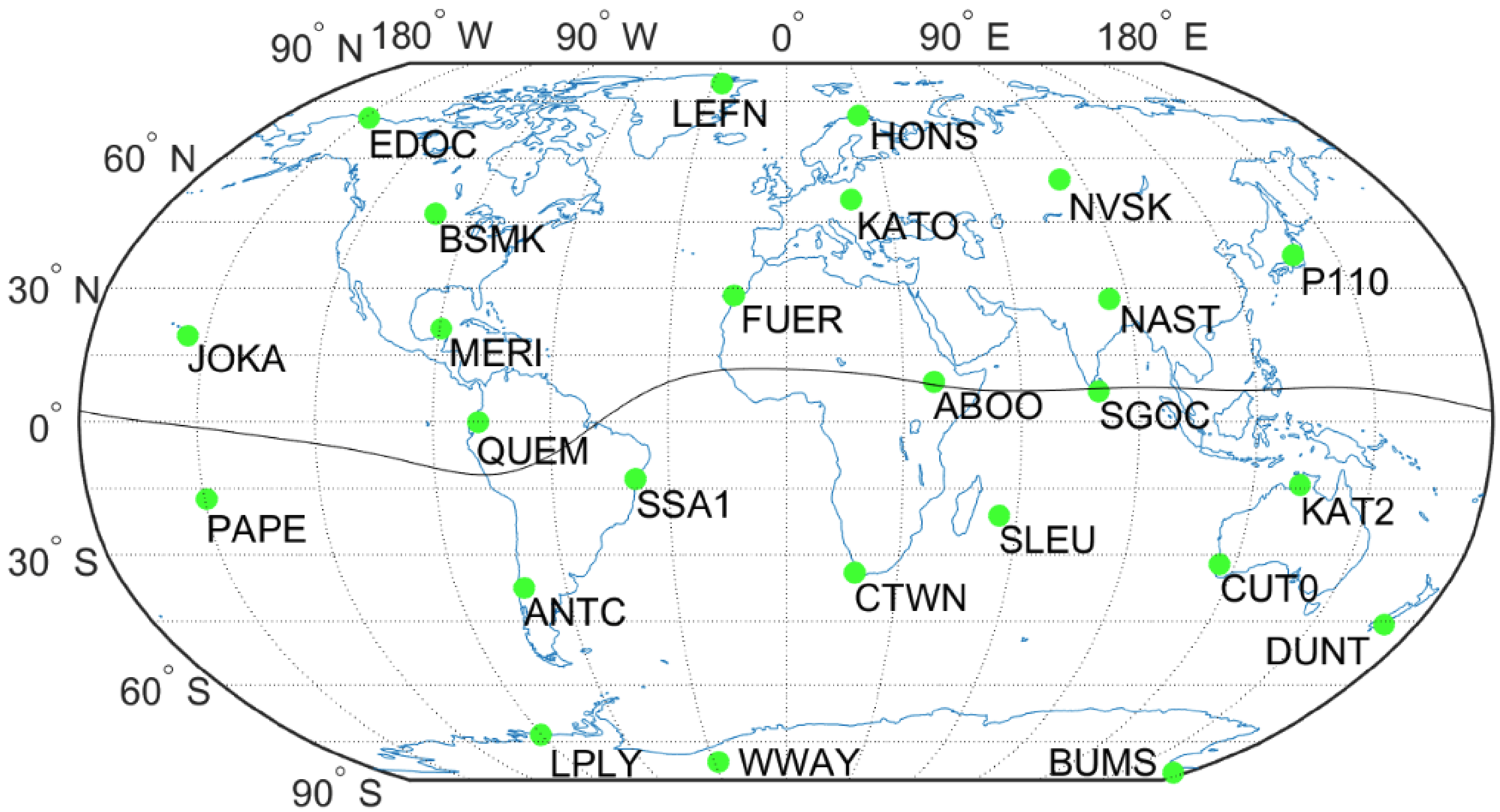
- **Self Consistency Analysis**

  Our approach is based on:

  1. Calculation of geometry free L_I of carrier phase observations for a continuous arc (elevation cut-off 20 deg.).
  2. Calculation of STEC for the same satellite arc, but from given GIMs (GIM-STEC).
  3. Fitting L_I into GIM-STEC (removing L_I bias, resulting in GNSS-STEC).
  4. Residual analysis (RMS)
     (e.g., Krypiak-Gregorczyk et al. 2017, Remote Sens 9(12):1221. DOI: 10.3390/rs9121221



SELF-CONSISTENCY ANALYSIS



GNSS TEST DATA - 25 GLOBALLY DISTRIBUTED STATIONS

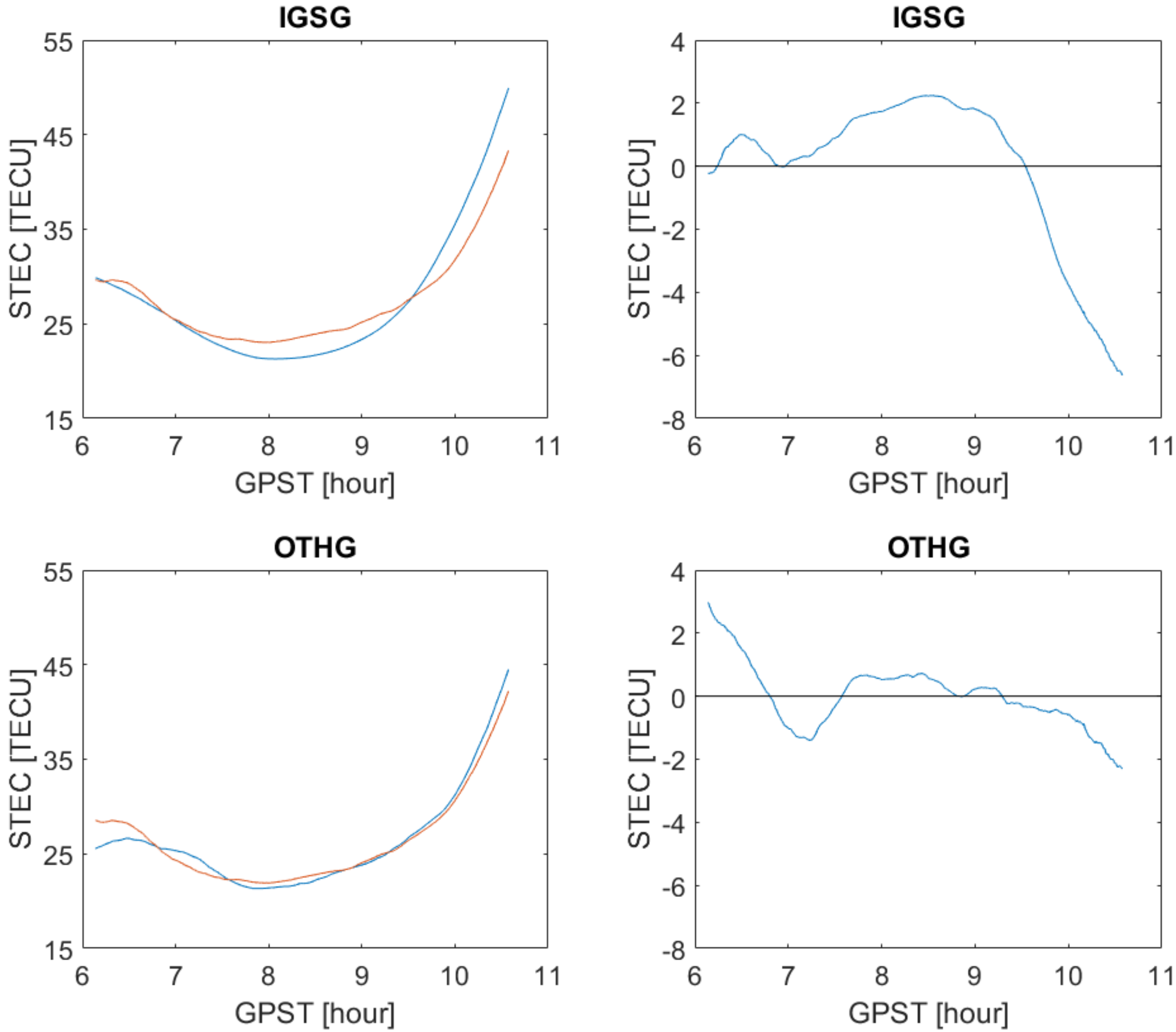
SELF-CONSISTENCY ANALYSIS

Station: ABOO

Year: 2018

DOY: 11

PRN: 01



A. GNSS STEC & GIM STEC

B. Residuals

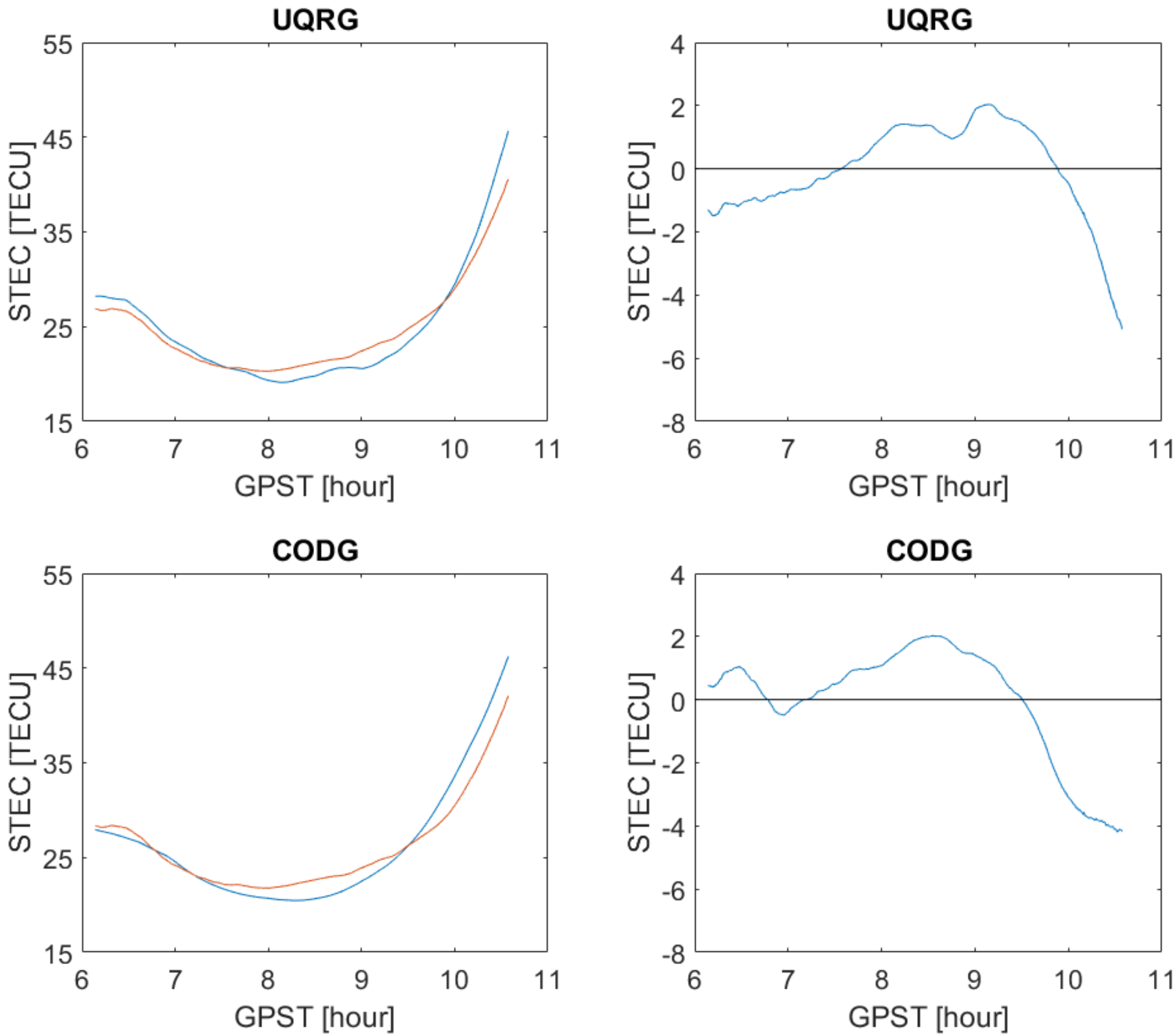
SELF-CONSISTENCY ANALYSIS

Station: ABOO

Year: 2018

DOY: 11

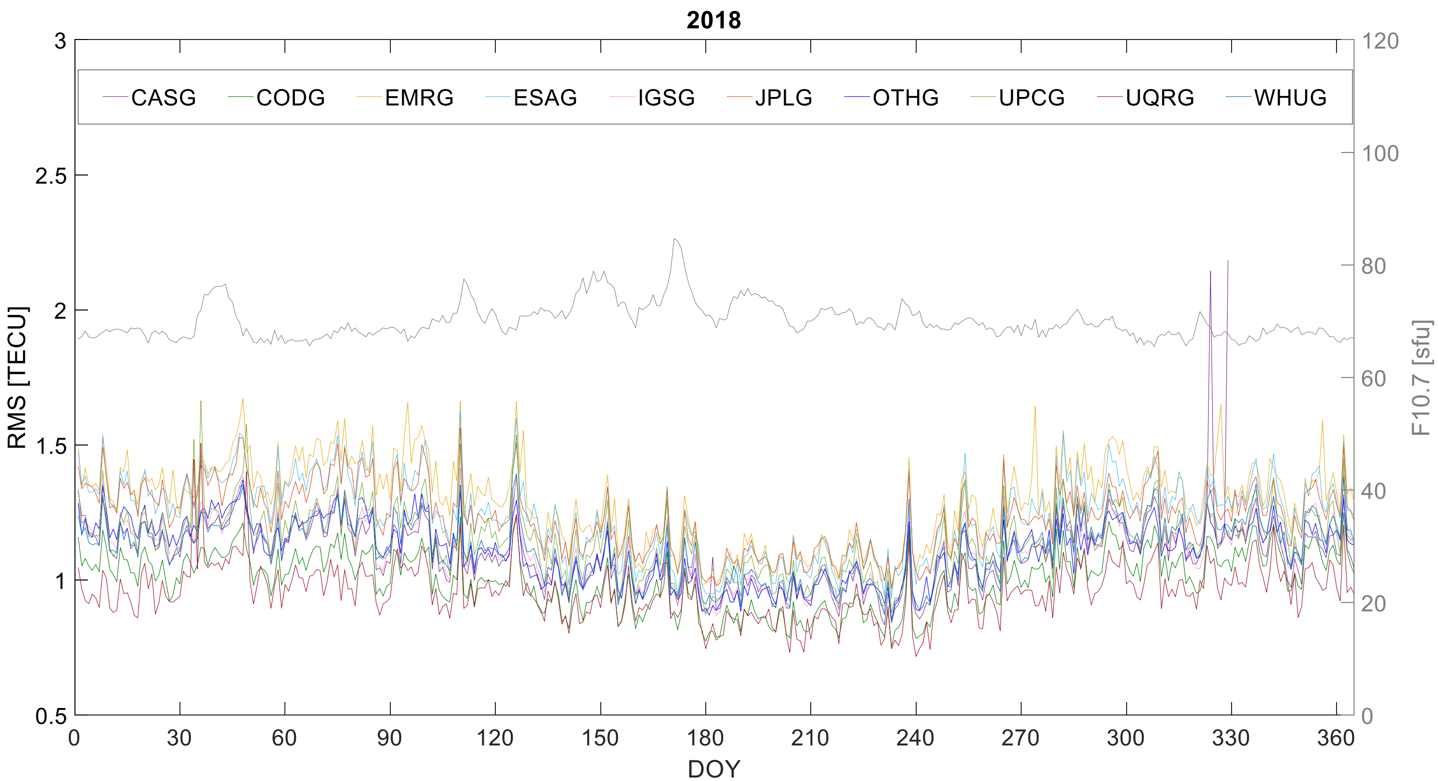
PRN: 01



A. GNSS STEC & GIM STEC

B. Residuals

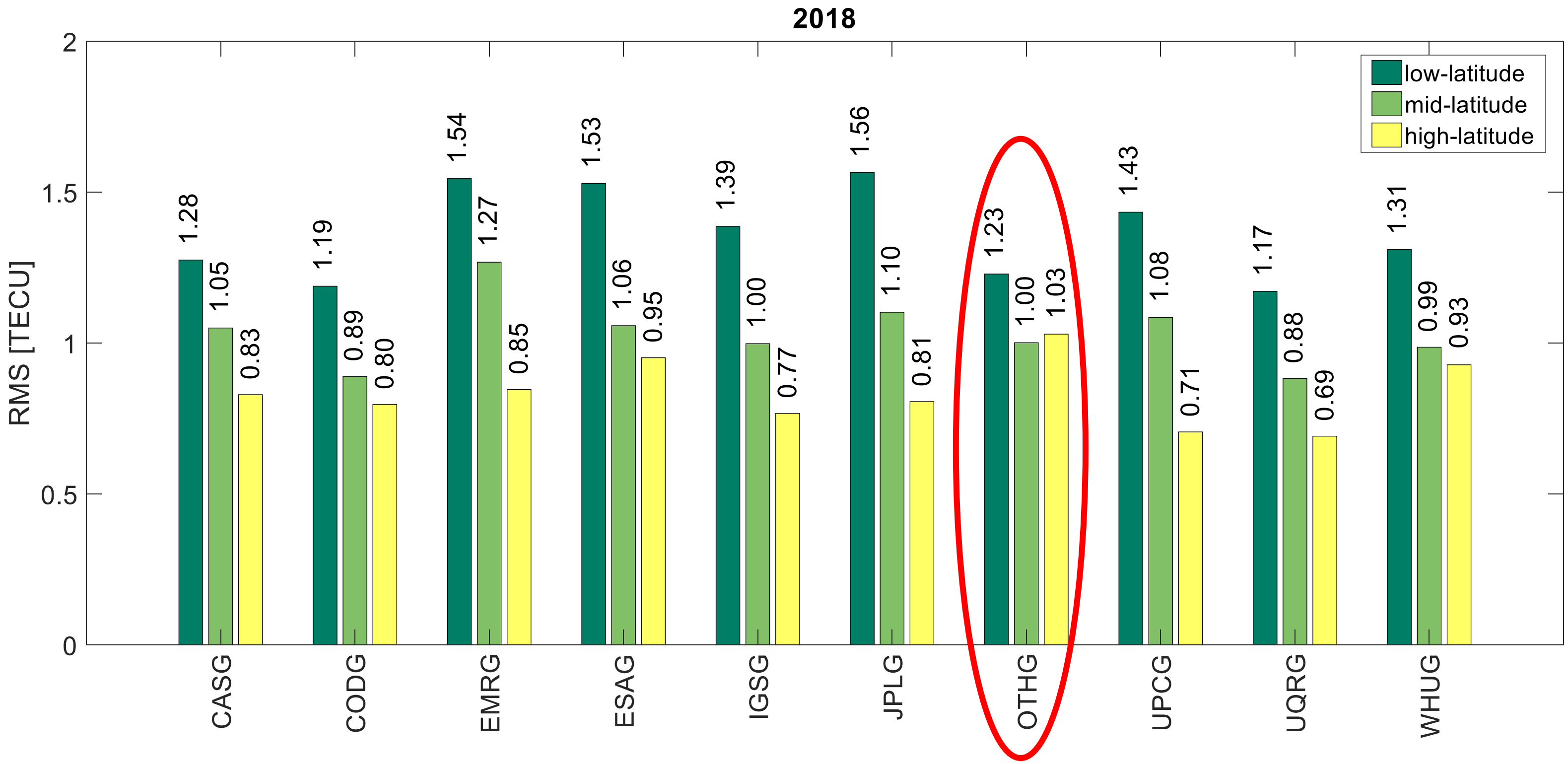
SELF-CONSISTENCY ANALYSIS



Daily RMS distribution for all analysed GIMs in 2018 [TECU]

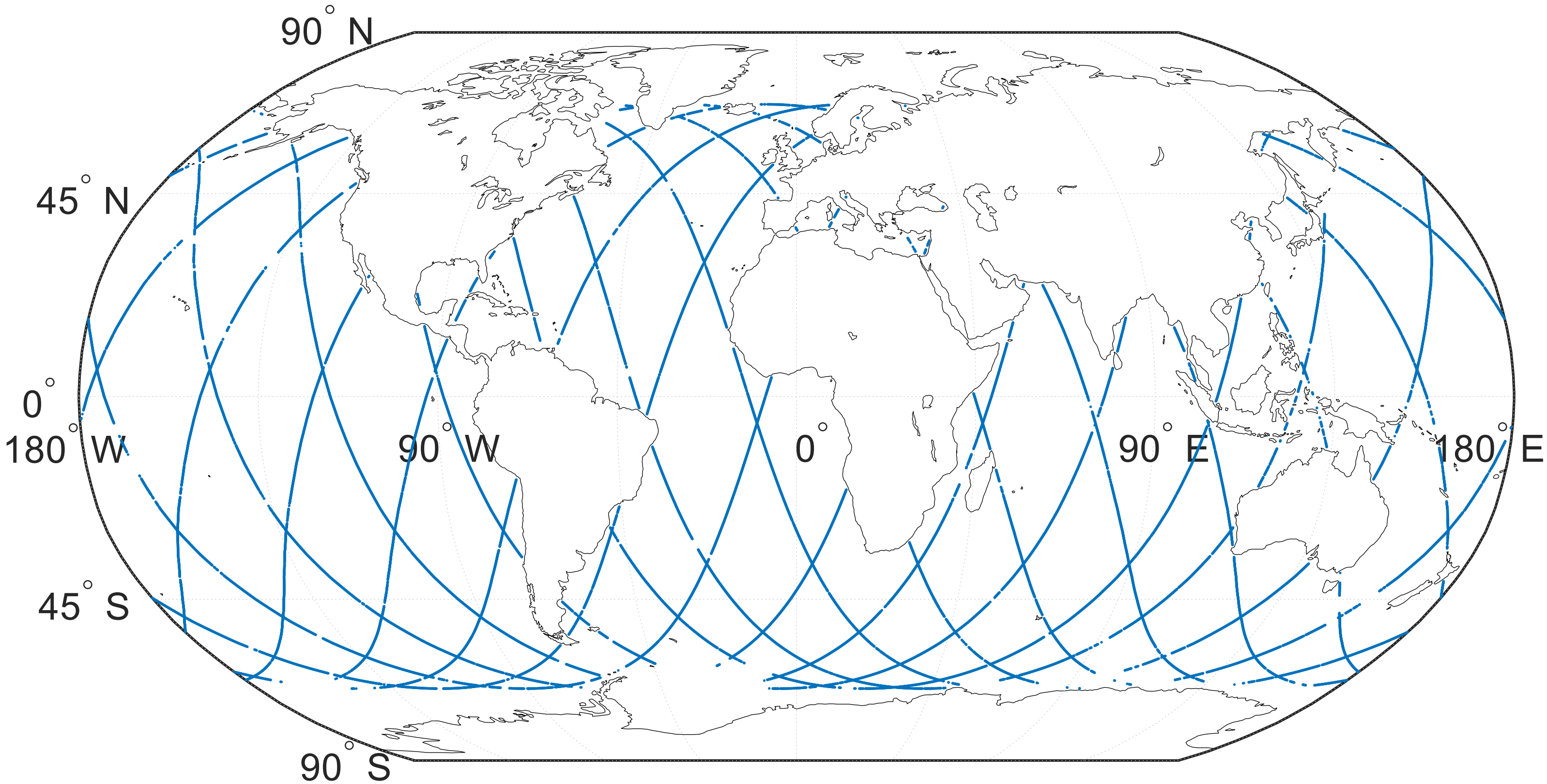
GIMs	Average RMS
UQRG*	0,96
CODG	1,00
CASG	1,10
OTHG*	**1,11**
IGSG	1,12
WHUG	1,12
UPCG	1,15
JPLG	1,24
ESAG	1,25
EMRG	1,29

SELF-CONSISTENCY ANALYSIS



Average RMS in low-, mid- and high-latitude regions for selected GIMs - 2018

VALIDATION BY ALTIMETRY



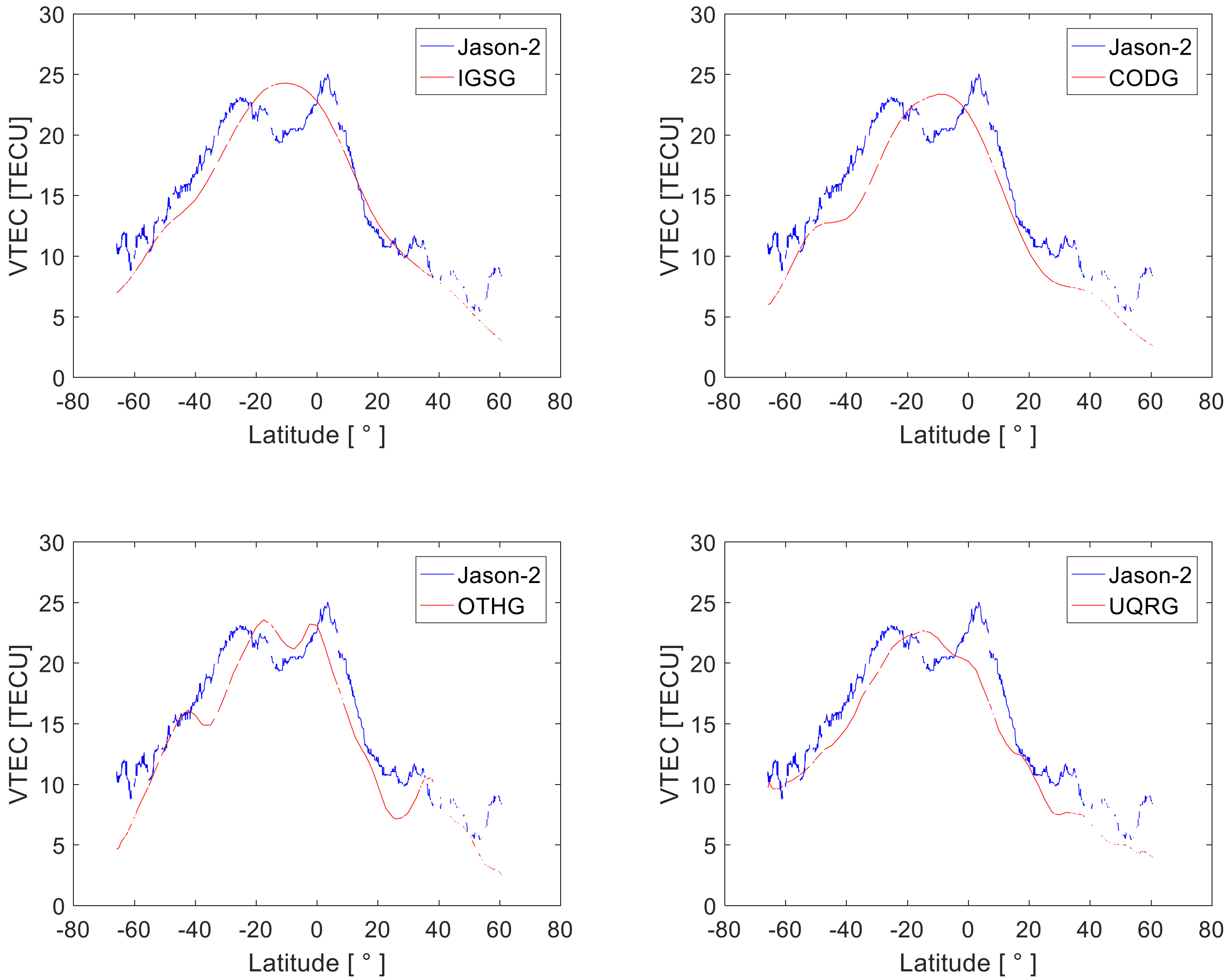
Daily ground track of Jason-2

VALIDATION BY ALTIMETRY

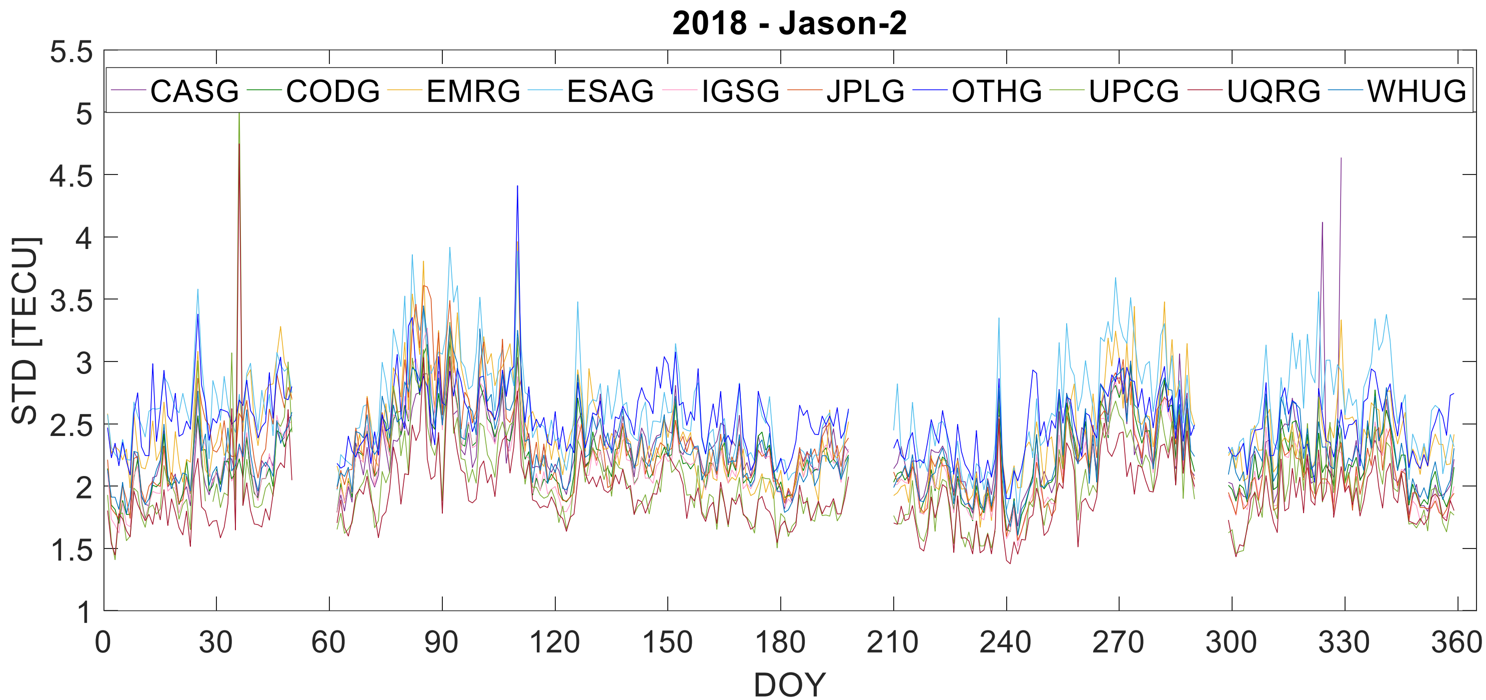
Jason-2

Year: 2018

DOY: 1



VALIDATION BY ALTIMETRY

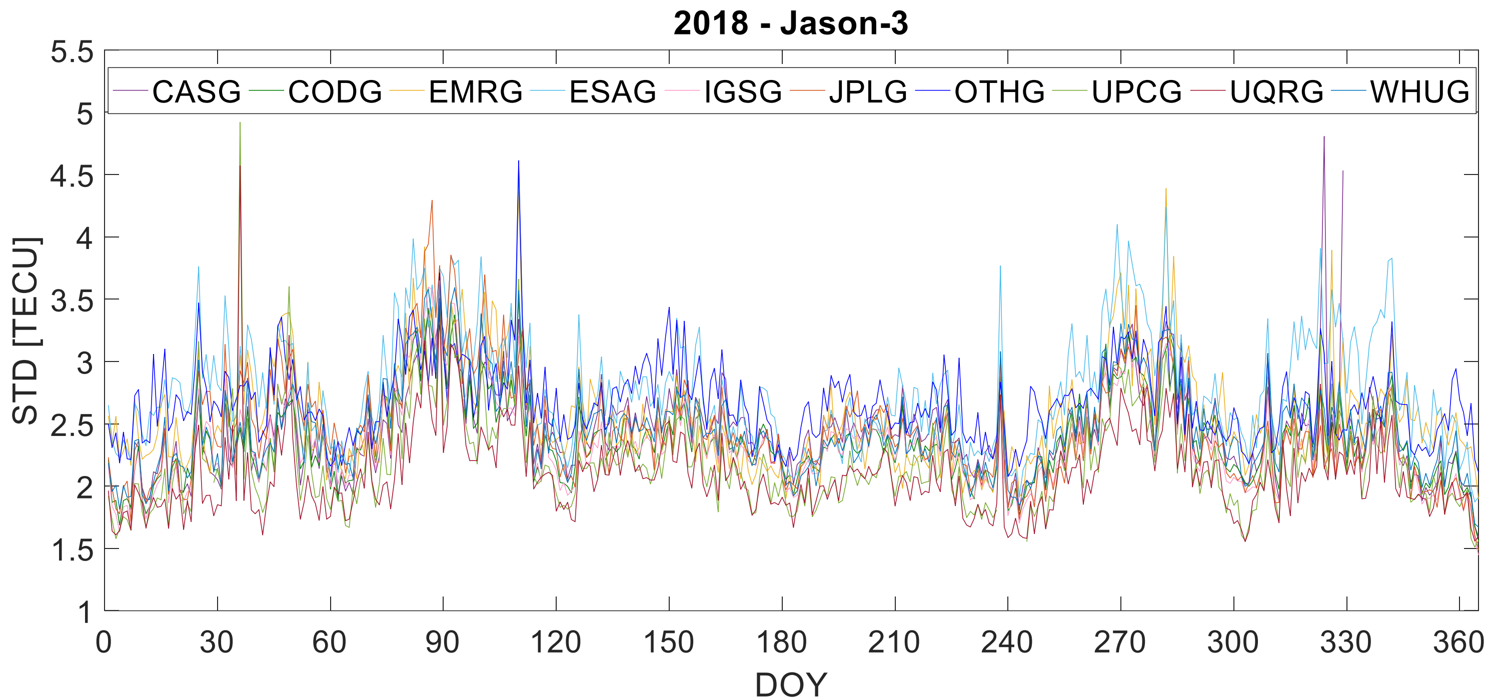


Daily STD distribution based on a comparison with the Jason-2 data for all analysed GIMs in 2018

GIMs	Average STD
UQRG*	1,92
UPCG	2,04
IGSG	2,17
CODG	2,22
JPLG	2,26
CASG	2,26
WHUG	2,30
EMRG	2,42
OTHG*	**2,53**
ESAG	2,64

STD = STD of differences between GIM_VTEC and ALT_VTEC

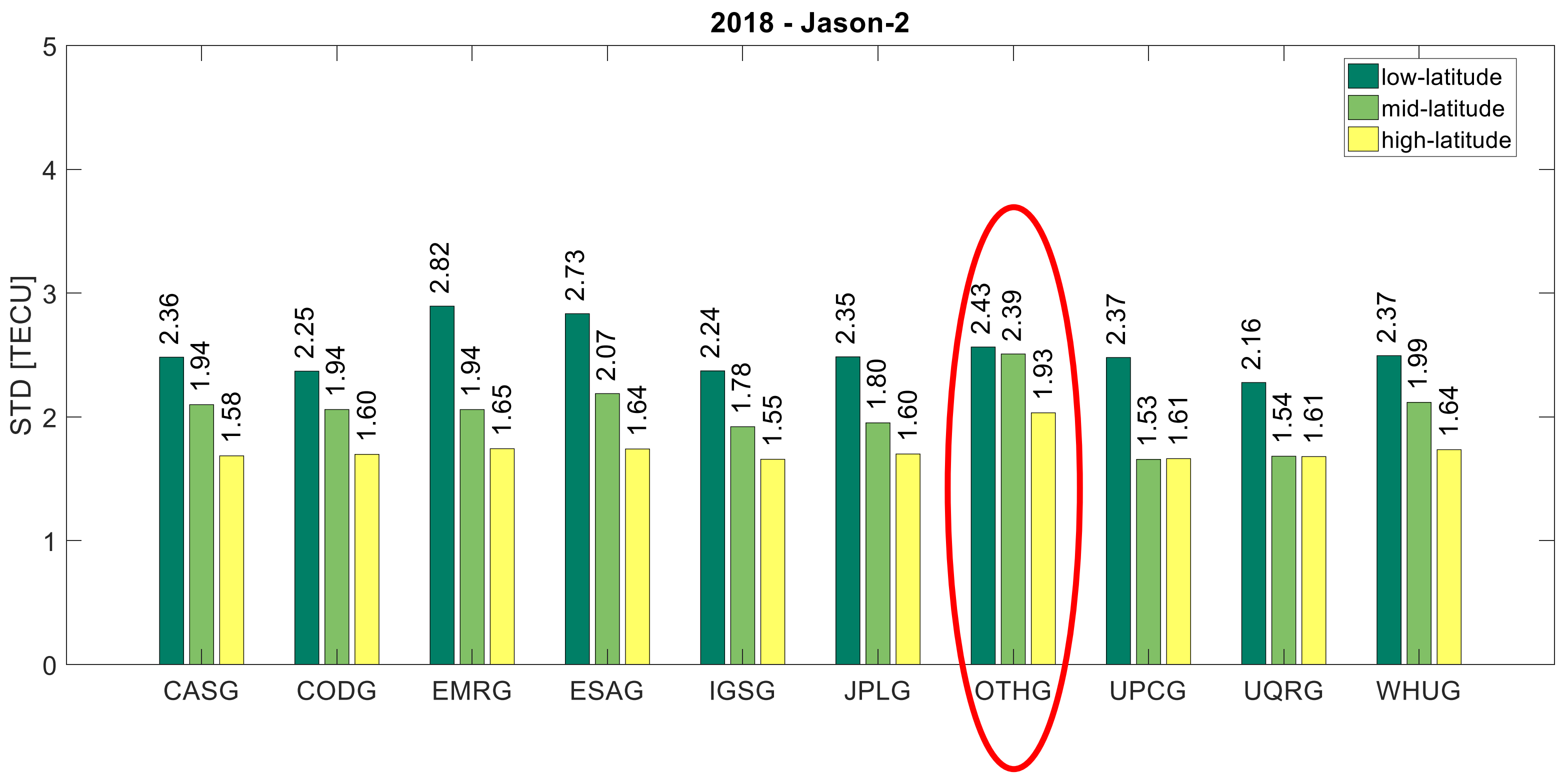
VALIDATION BY ALTIMETRY



Daily STD distribution based on a comparison with the Jason-3 data for all analysed GIMs in 2018

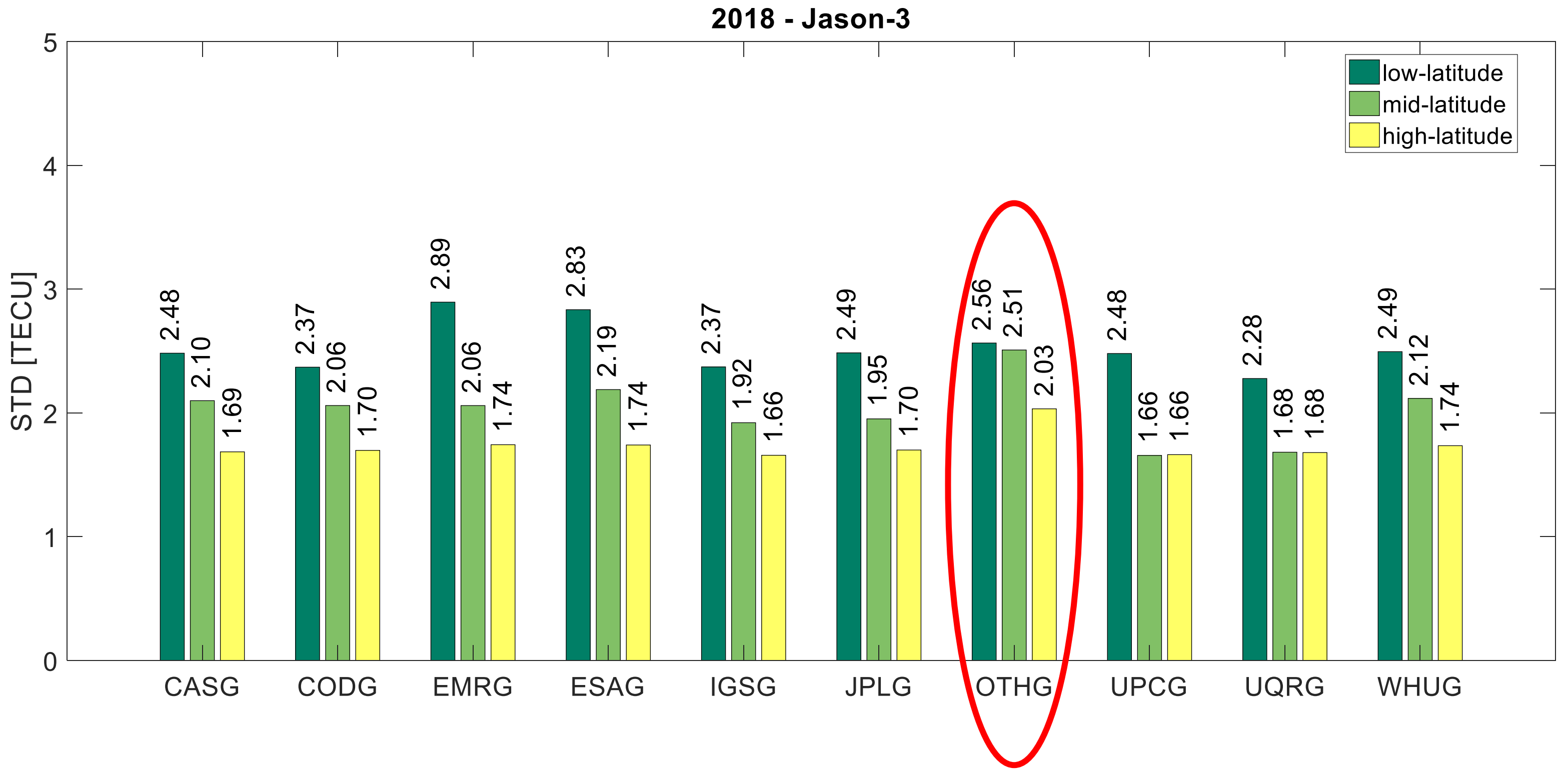
GIMs	Average STD
UQRG*	2,09
UPCG	2,20
IGSG	2,34
CODG	2,37
CASG	2,44
JPLG	2,45
WHUG	2,46
EMRG	2,57
OTHG*	**2,68**
ESAG	2,78

VALIDATION BY ALTIMETRY



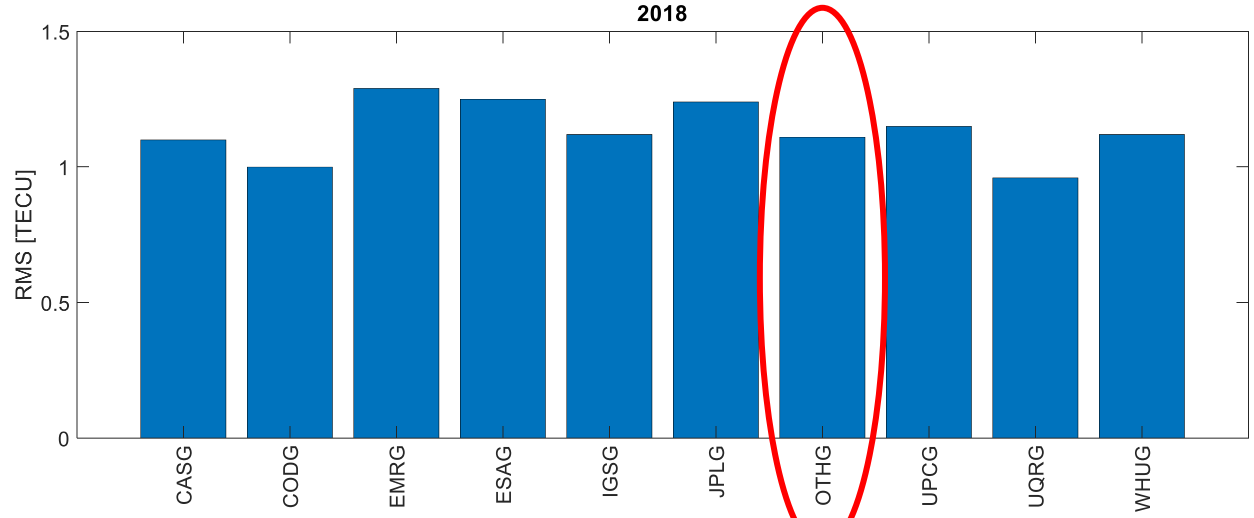
Average STD values for low-, mid-, and high-latitude regions for all analyzed GIMs based on comparisons with the Jason-2 satellite data for 2018

VALIDATION BY ALTIMETRY

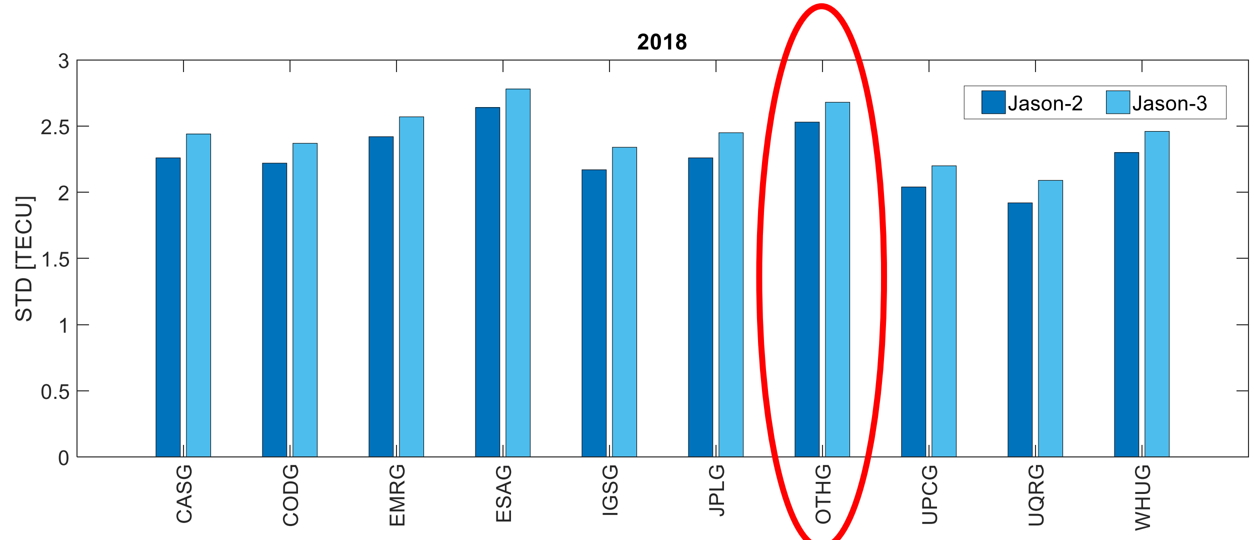


Average STD values for low-, mid-, and high-latitude regions for all analyzed GIMs based on comparisons with the Jason-3 satellite data for 2018

SUMMARY OF THE RESULTS



Overall RMS from self-consistency tests in 2018



Overall STD from comparisons to altimetry data in 2018

CONCLUSIONS

- The self-consistency RMS for all IAAC GIMs varies from 0.96 TECU to 1.29 TECU, with an RMS value for OTHG of 1.11 TECU.
- STDs from altimetry comparisons vary from 1.92 (UQRG, Jason-2) to 2.78 TECU (ESAG, Jason-3), with the values 2.53 and 2.68 TECU for OTHG.
- OTHG presents good accuracy in the low and mid-latitude regions, especially in regions with sufficient data availability, due to the localizing modeling approach based on B-splines.
- The quality of OTHG is degrading towards very high latitude and oceanic regions with less data availability.
- Note, OTHG is an ultra-rapid product, which could be provided publicly with a delay of 2 to 3 hours every 10 minutes.

Thank you for your attention!

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