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Validation of UWM new global ionosphere model during the most severe geomagnetic storm of the year 2018

Paweł Wielgosz, Anna Krypiak-Gregorczyk, Wojciech Jarmołowski, Beata Milanowska

University of Warmia and Mazury in Olsztyn, Poland

Introduction

- The ionosphere is still considered as the main source of errors in precise positioning, which is affecting surveying and geodetic applications.
- Currently, seven 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 this presentation we verified the accuracy of the new UWMG ionosphere model under various geomagnetic conditions (by comparing to the best available GIMs).
- 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

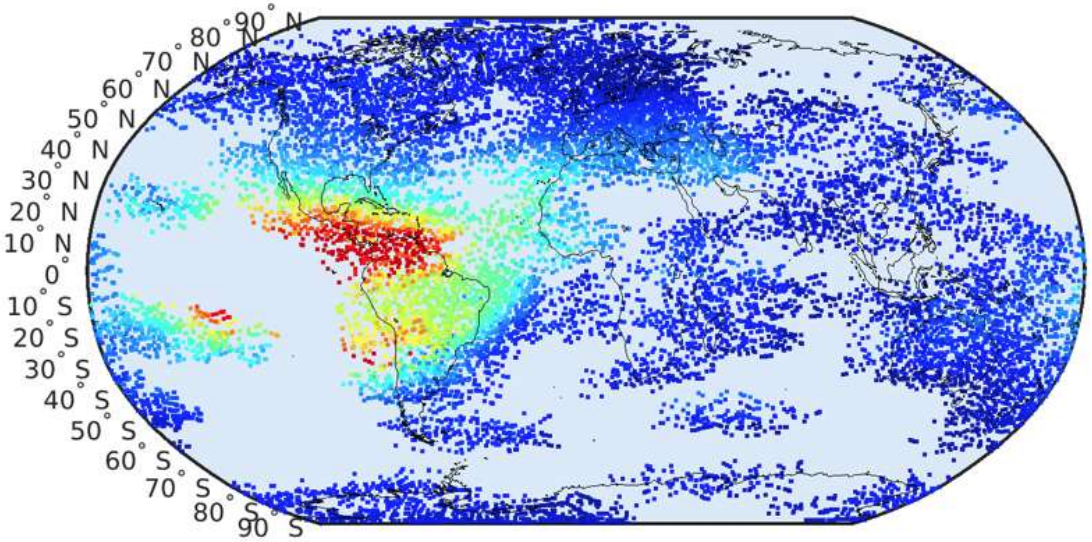
Analyzed Global Ionosphere Maps (GIMs)

GIM ID	Method	Shell model	Time resolution
IGSG	Weighted mean	Combined	2 h
CODG	Spherical harmonics	Modified single-layer	1 h
UQRG*	Tomographic with kriging	Multi-layer	15 min
UWMG-t1*	Spherical harmonics Thin-plate smoothing spline	Modified single-layer	1 h

* not official IGS product

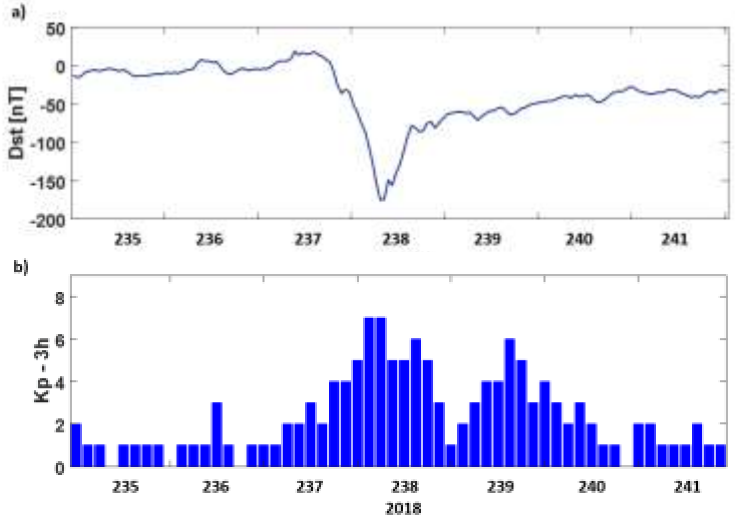
Observational data and tested period

- L1&L2 carrier phase data from ~273 GNSS stations
- dual-frequency carrier phase and pseudorange GPS + GLONASS data
- sampling interval: 30 seconds.
- elevation cut-off: 10º

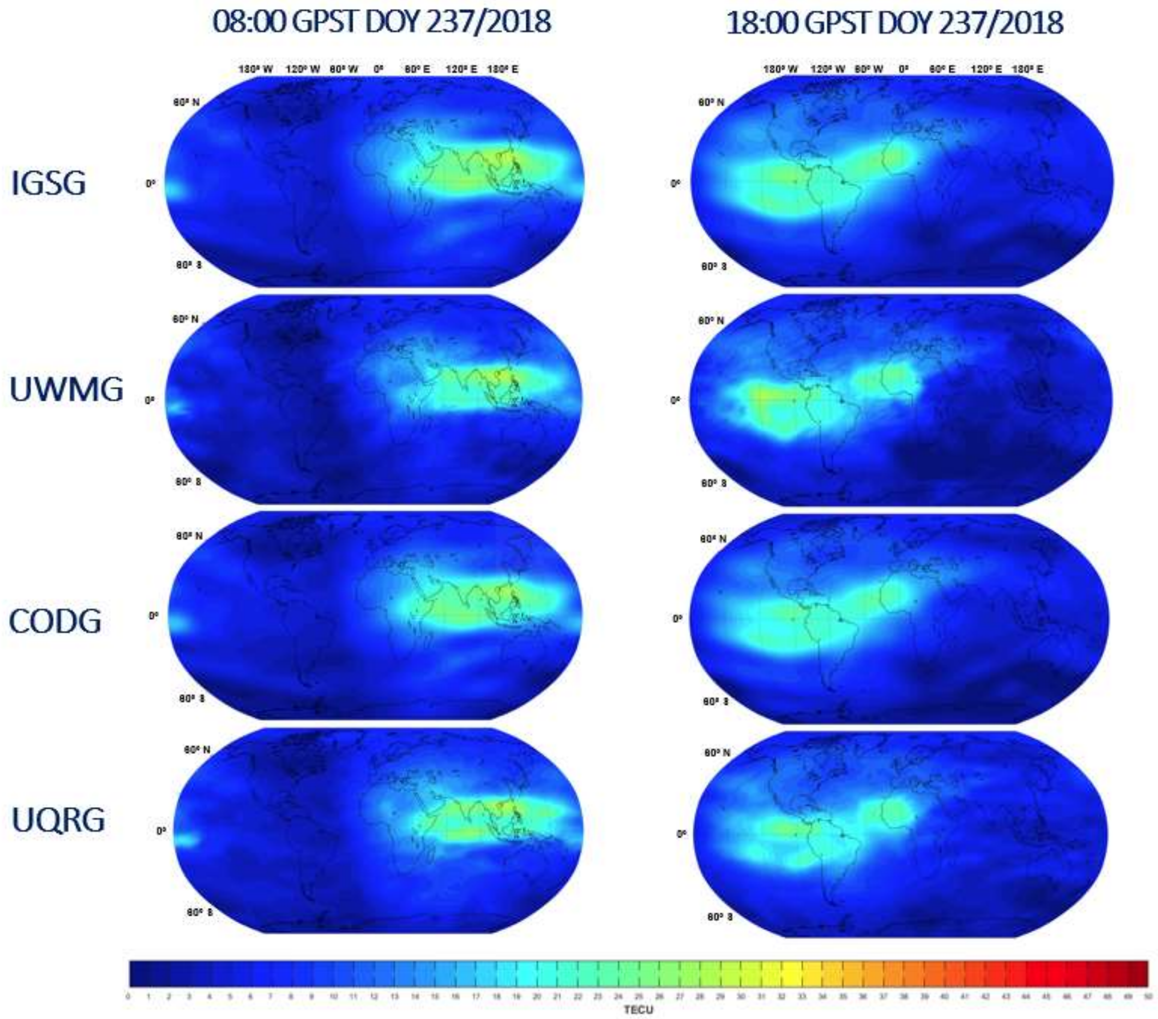


test period:

- 23-29.08.2018 (235-241/2018)



Analyzed Global Ionosphere Maps (GIMs)



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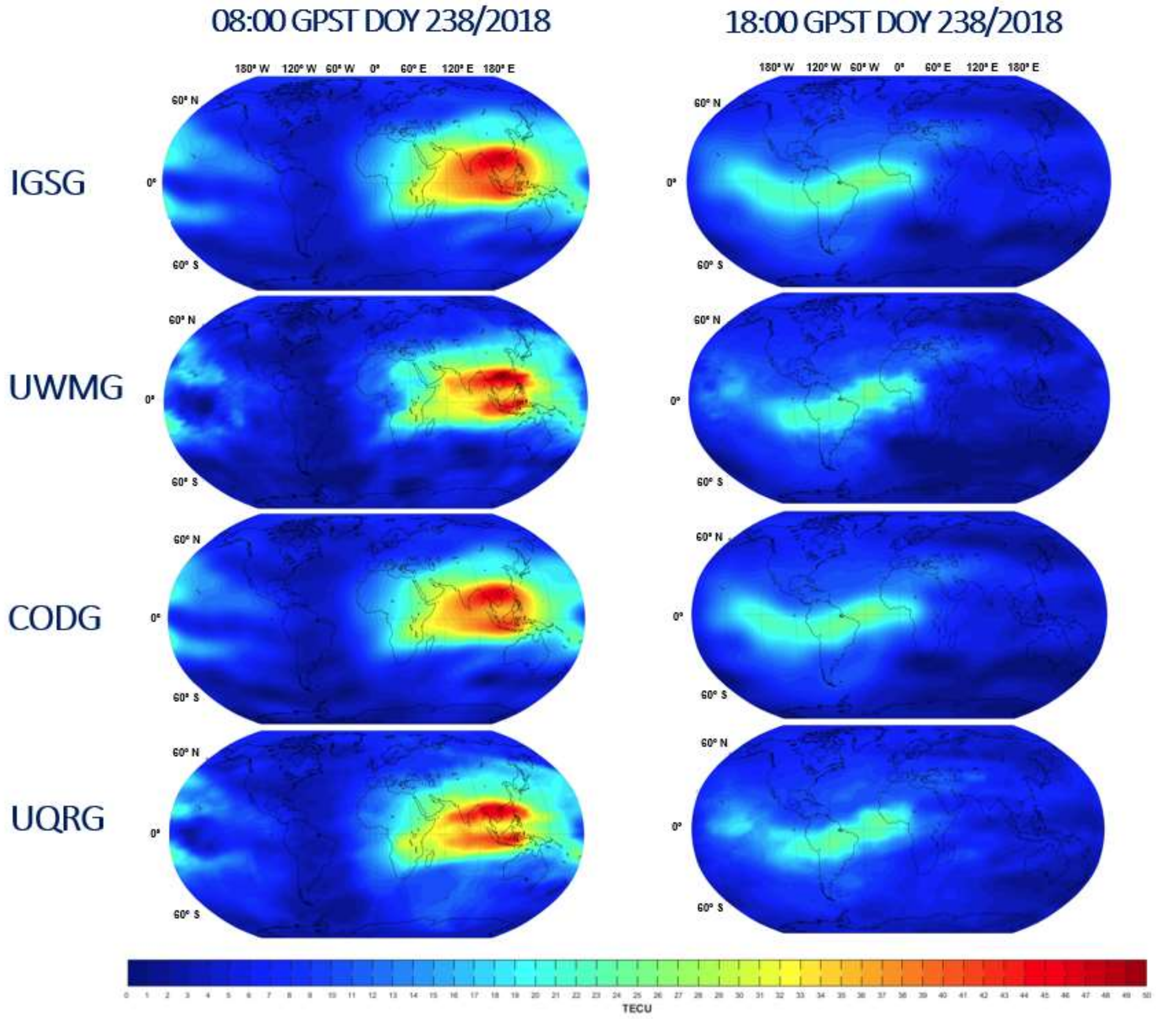

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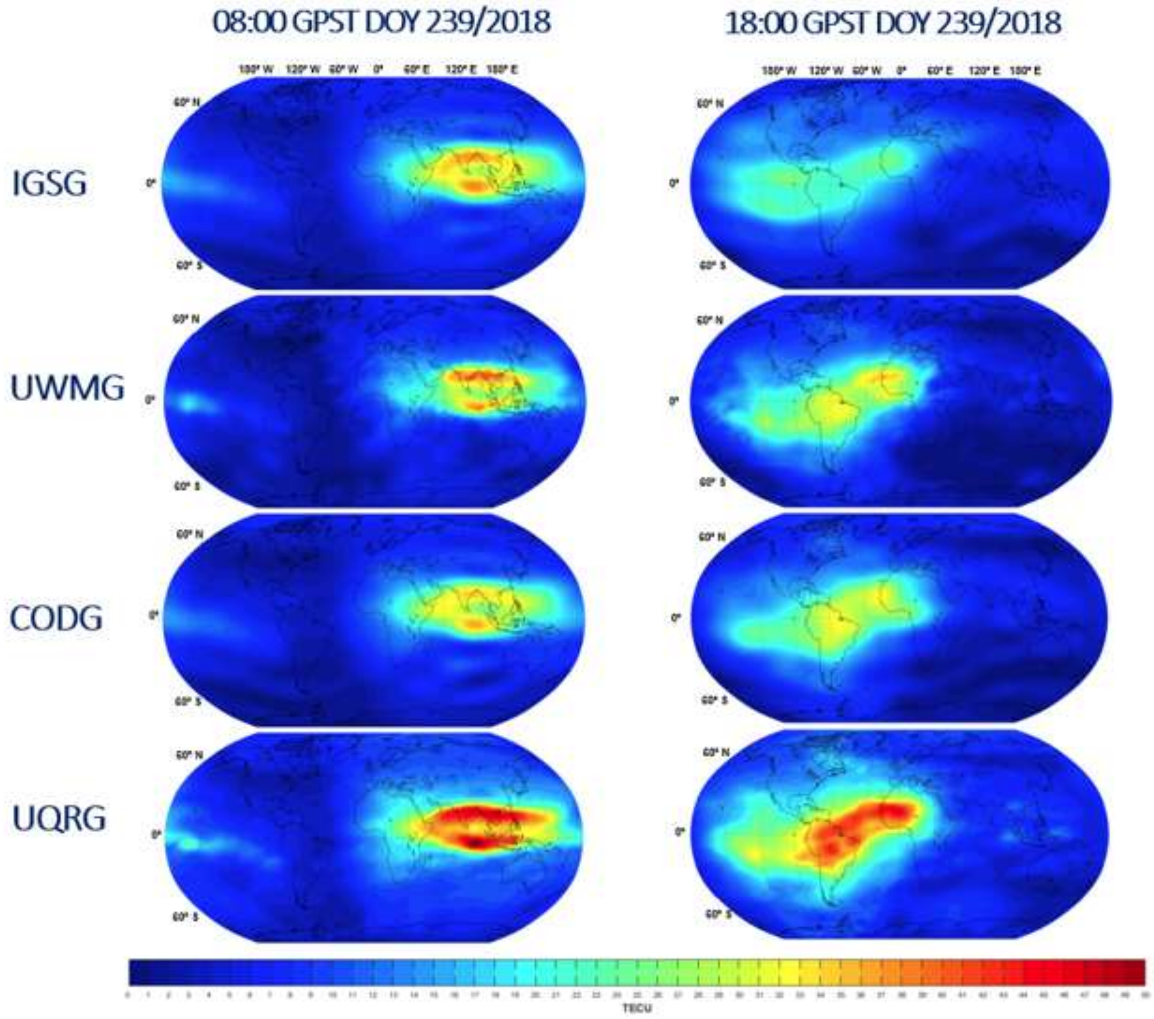
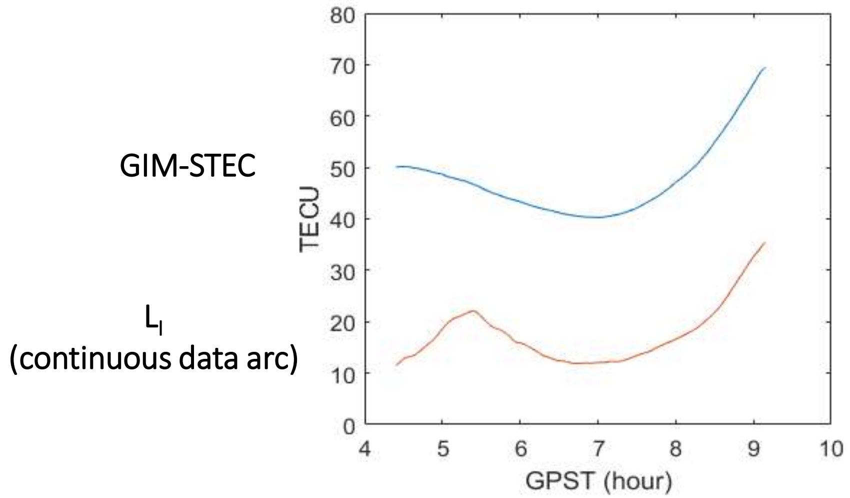
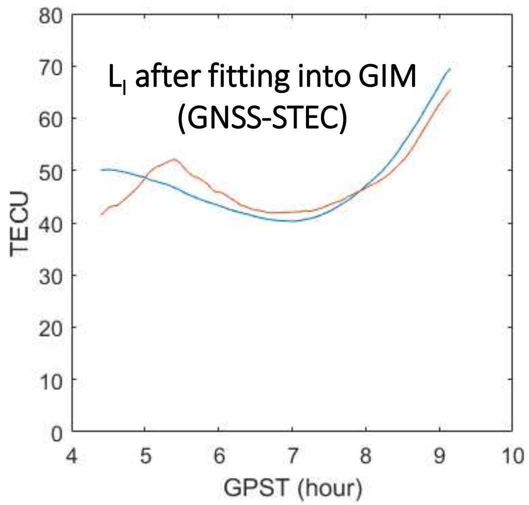


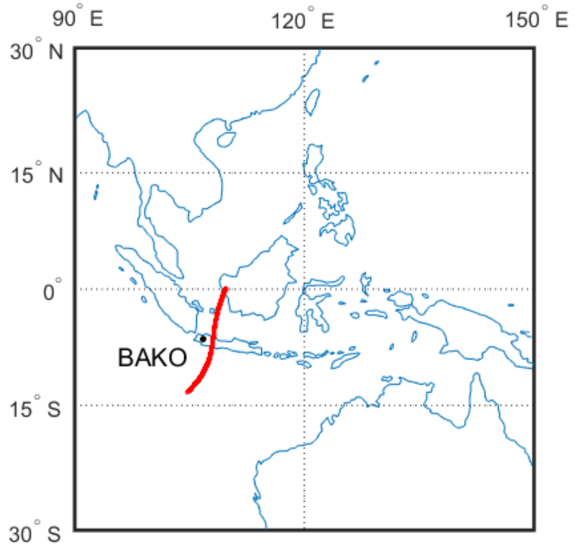
Self-consistency analysis

Our approach is based on:

1. Calculation of geometry free L_I of carrier phase observations for a continuous arc (elevation cut-off 20 degrees).
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).
4. Residual analysis (see in. Krypiak-Gregorczyk et al. 2017, Remote Sens 9 (12):1221. DOI: 10.3390/rs9121221

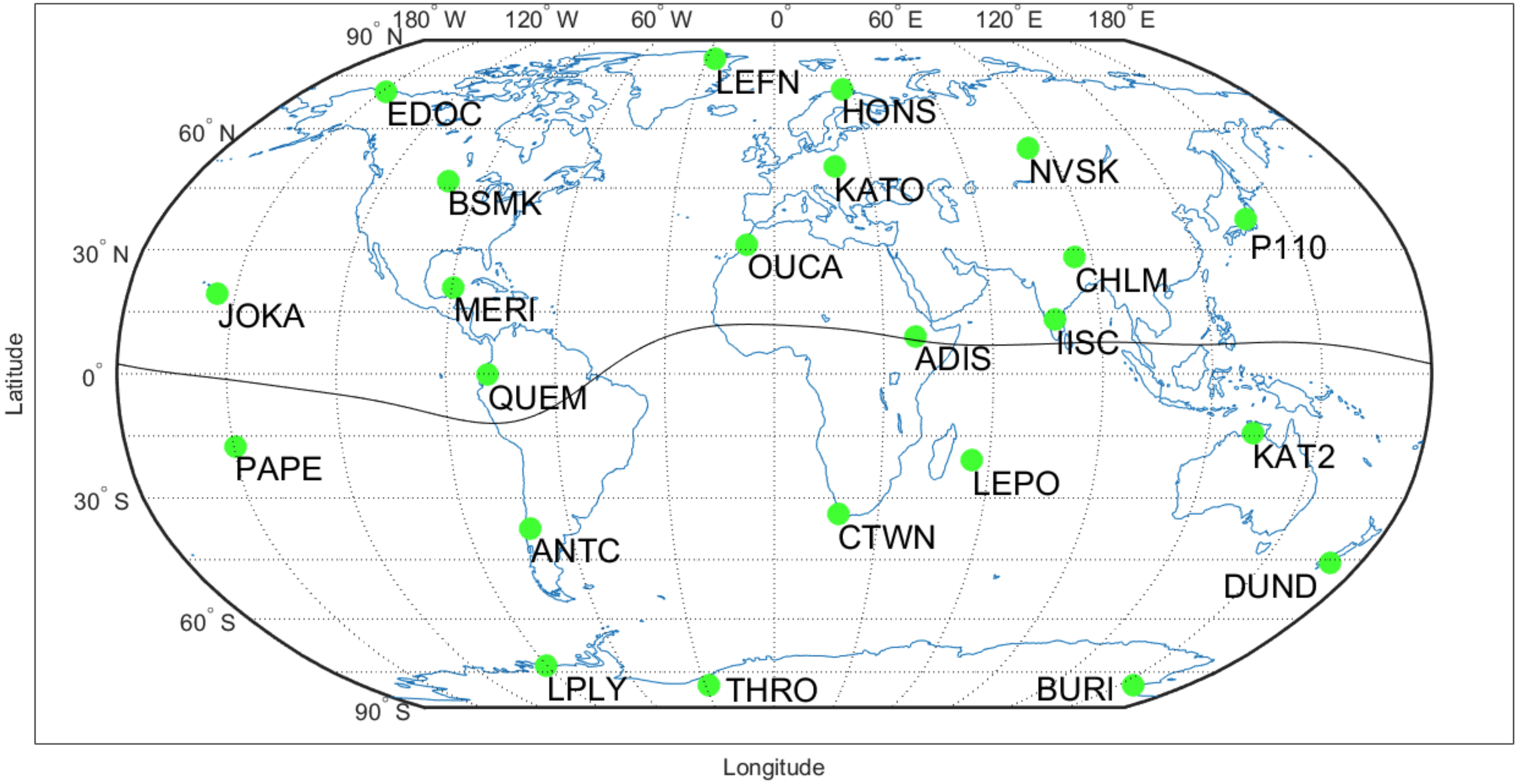






Self-consistency analysis

GNSS Test data from 23 globally distributed stations



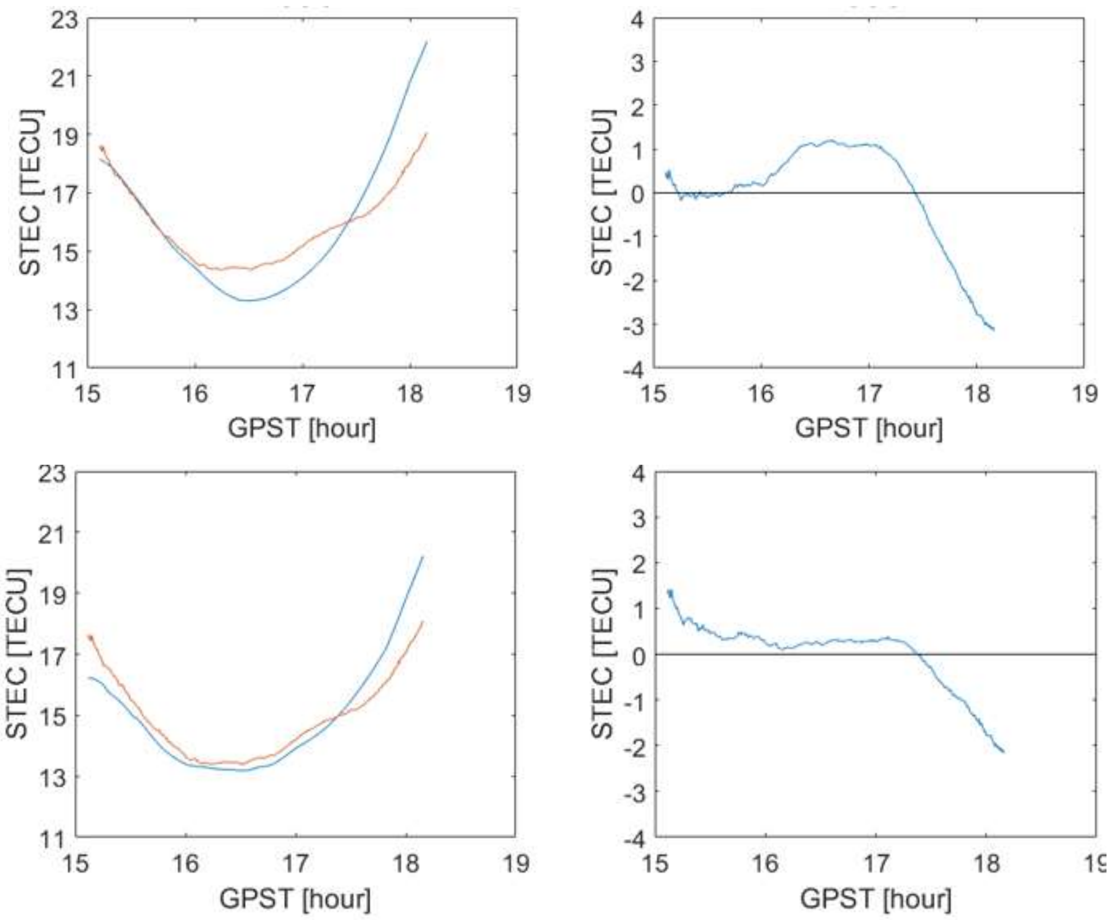
Self-consistency analysis

Station: KATO
Year: 2018
DOY: 238
PRN: 19

A. GNSS STEC & GIM STEC   B. RESIDUALS

IGSG

UWMG-t1



Self-consistency analysis

Station: KATO

Year: 2018

DOY: 238

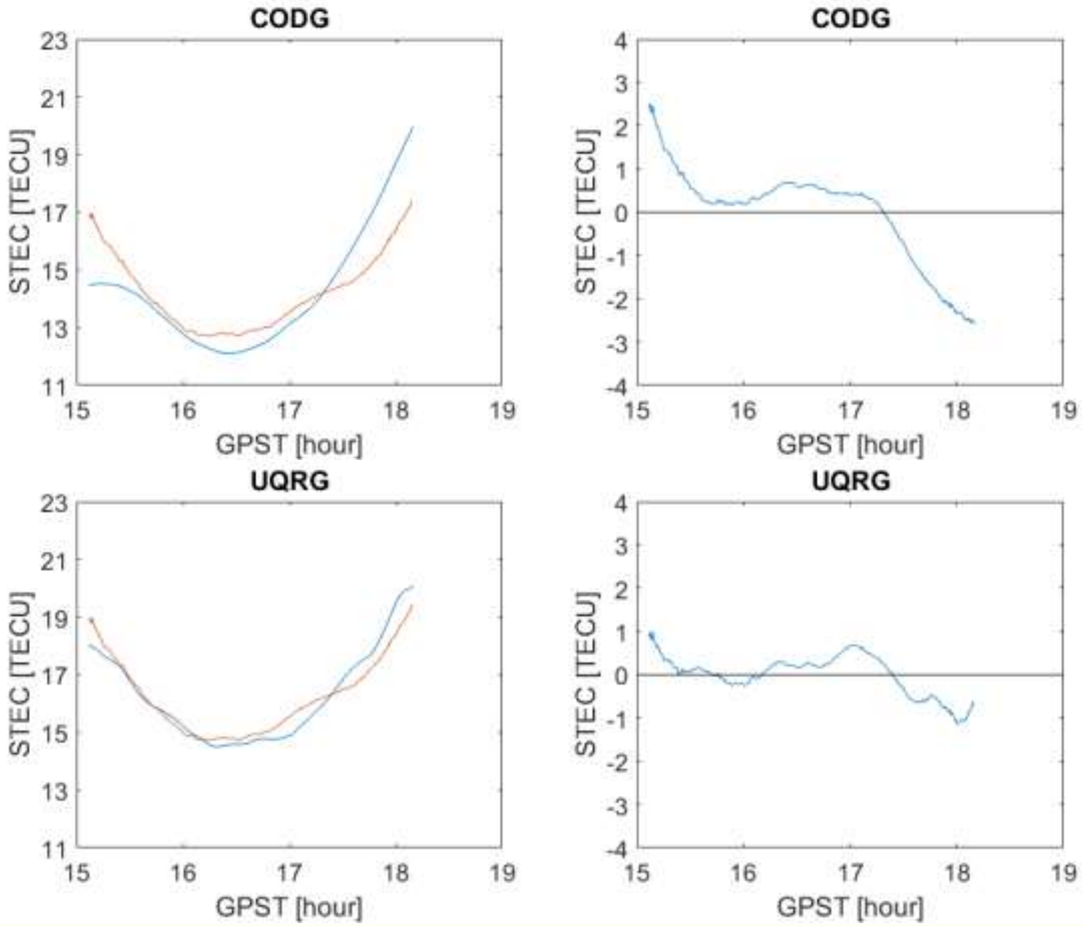
PRN: 19

CODG

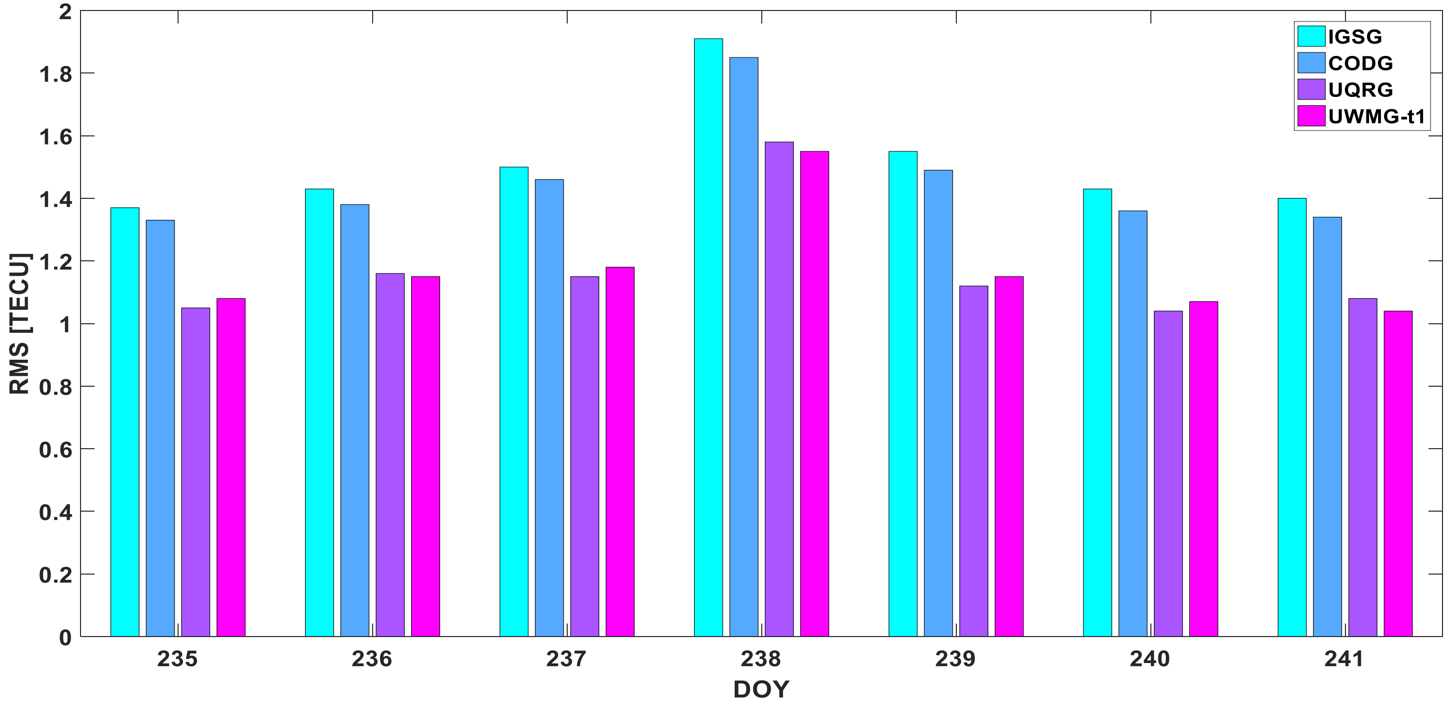
UQRG

A. GNSS STEC & GIM STEC

B. RESIDUALS



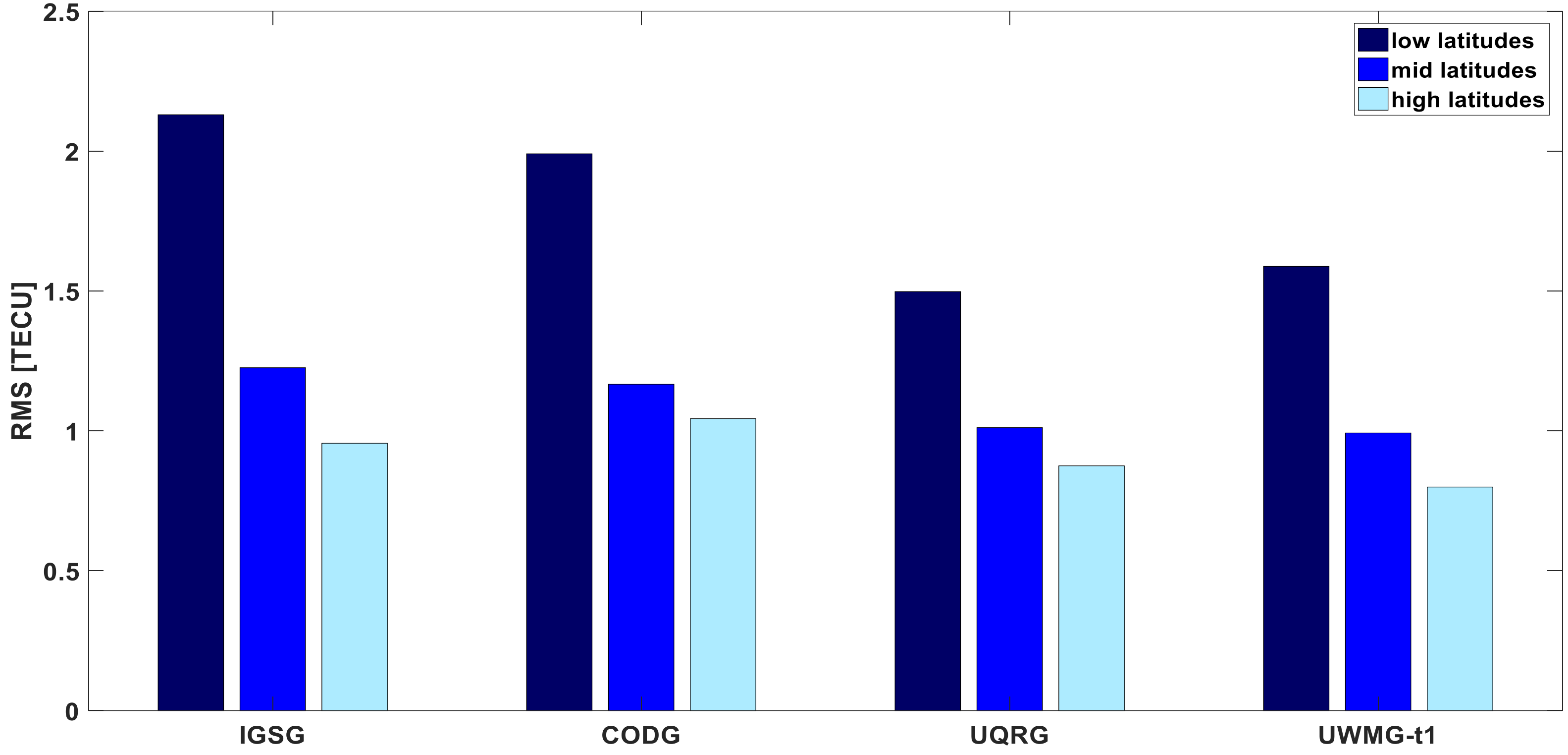
Self-consistency analysis



Daily RMS distribution for all analysed GIMs [TECU]

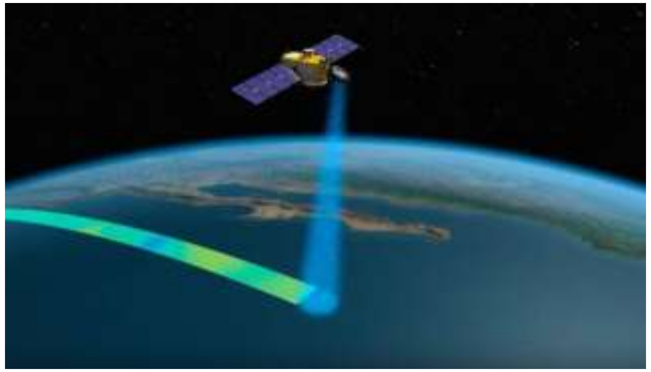
GIMs	Average RMS
UQRG*	**1,17**
UWMG-t1*	**1,18**
CODG	**1,46**
IGSG	**1,51**

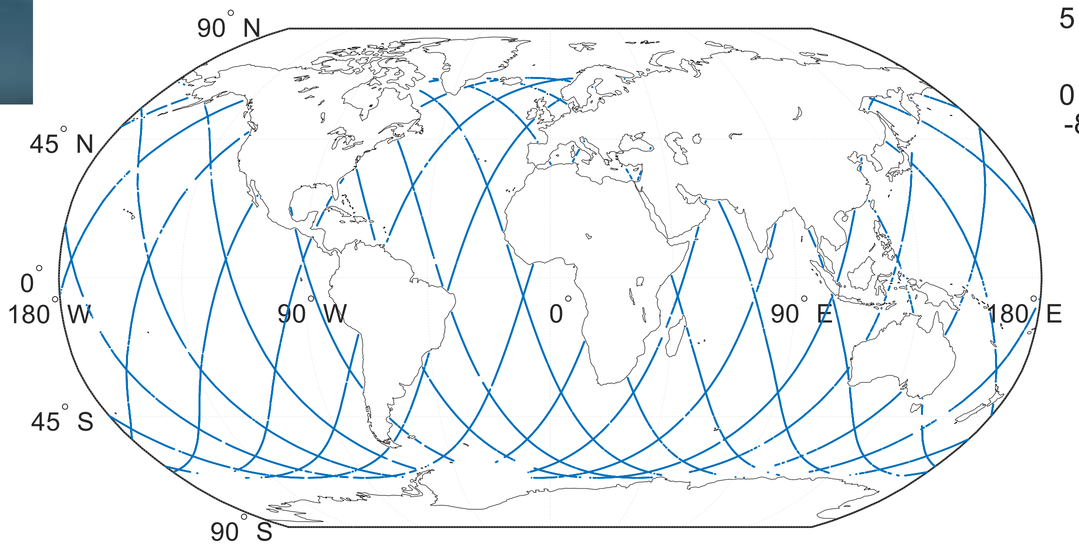
Self-consistency analysis

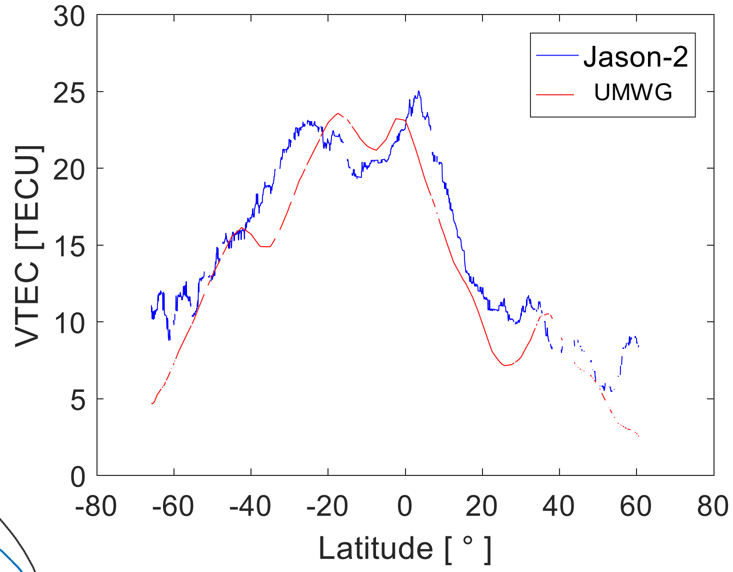


Average RMS in low-, mid- and high-latitude regions for selected GIMs (235-241 DOY/2018)

Validation by altimetry

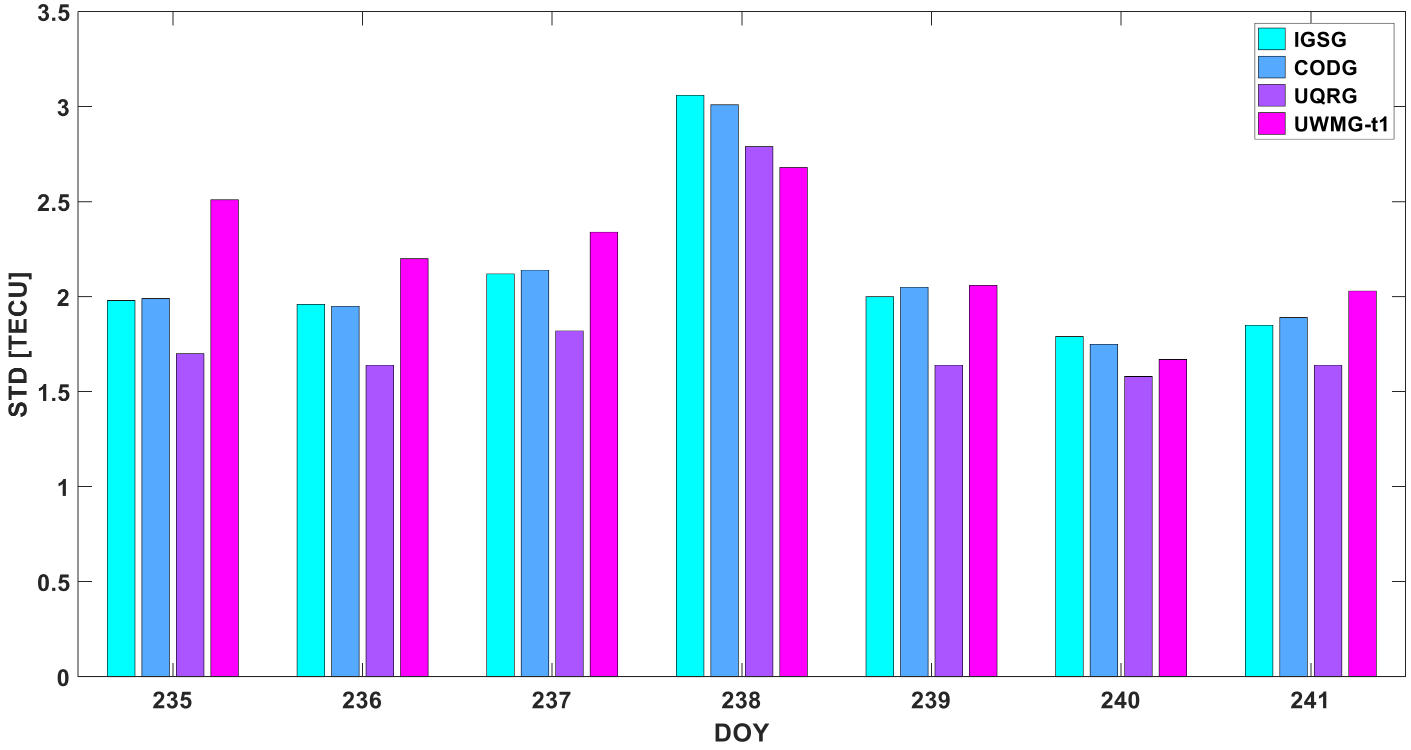






Validation by altimetry

Jason-3



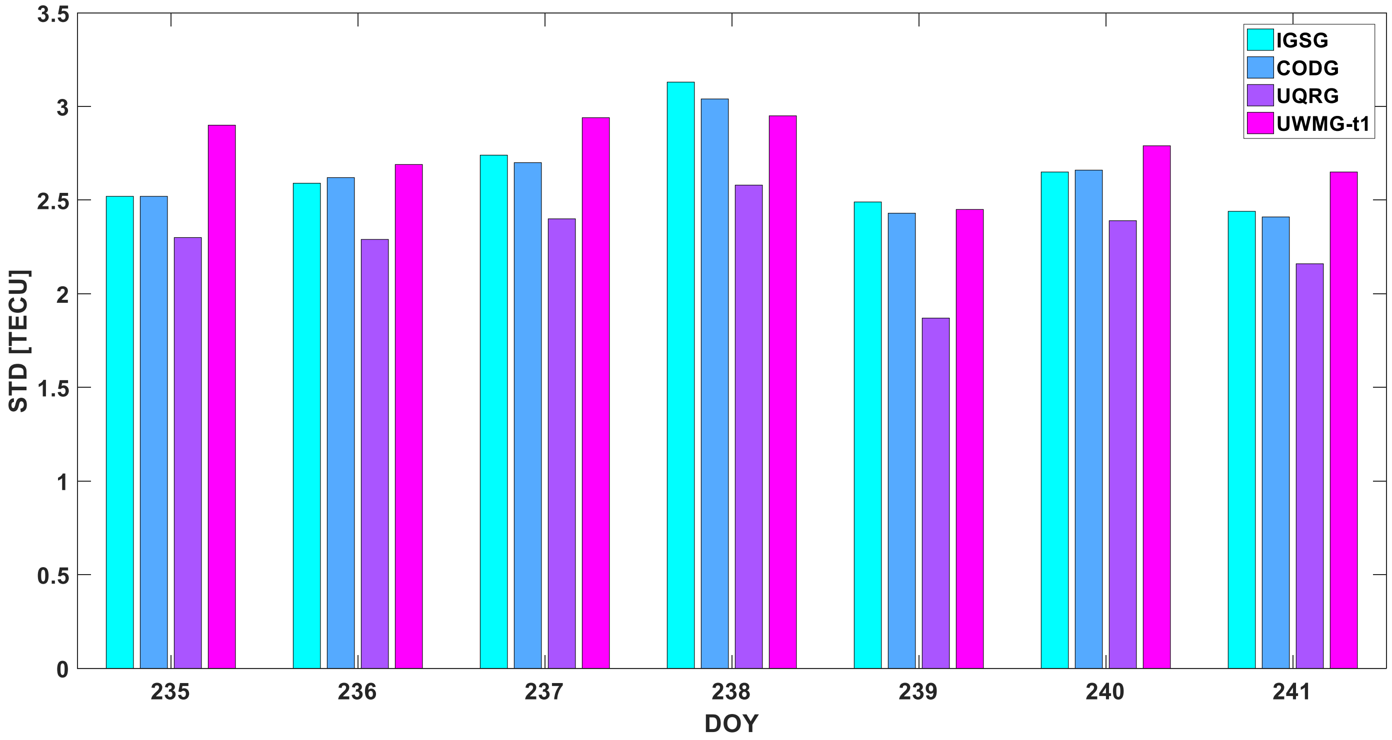
GIMs	Average STD
UQRG*	**1,83**
IGSG	**2,11**
CODG	**2,11**
UWMG-t1*	**2,21**

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

STD = STD różnicy pomiędzy GIM_VTEC and ALT_VTEC

Validation by altimetry

Sentinel-3A

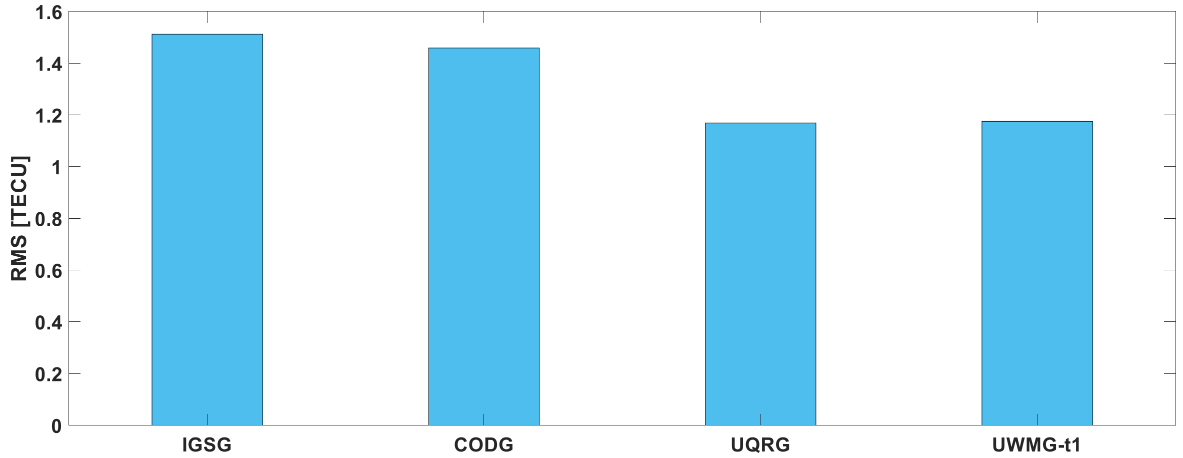


GIMs	Average STD
UQRG*	**2,29**
CODG	**2,63**
IGSG	**2,65**
UWMG-t1*	**2,77**

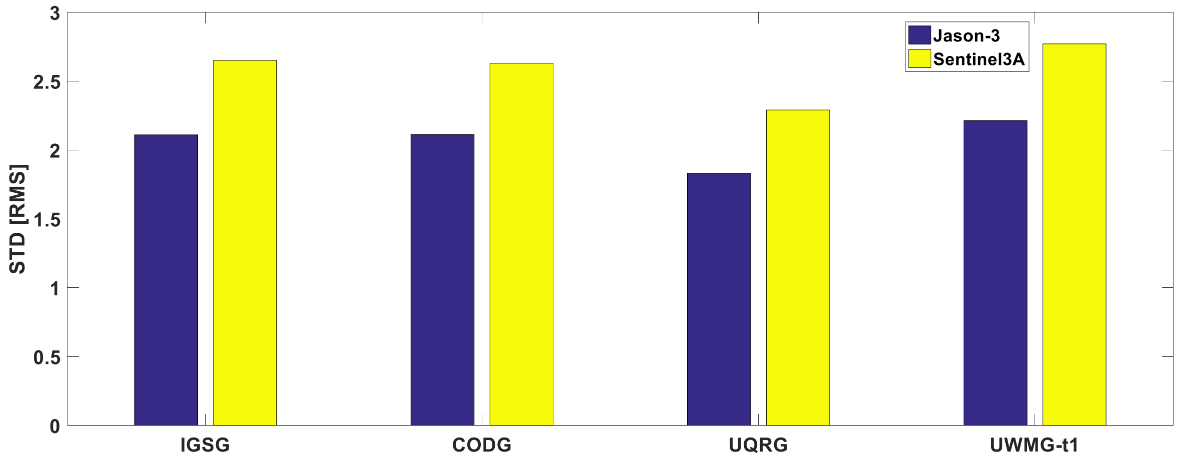
Daily STD distribution based on the comparison with Sentinel-3A data for all analysed GIMs

Summary of the results

Overall RMS from self-consistency tests



Overall STD from comparisons to altimetry from Jason-3 and Sentinel3A



Conclusions

- The self-consistency RMS for all tested GIMs varies from 1.17 TECU to 1.51 TECU, with an RMS value for UWM of 1.18 TECU.
- STDs from altimetry comparisons vary from 1.83 TECU (UQRG, Jason-3) to 2.77 TECU (UWMG-t1, Sentinel-3A).
- **UWMG-t1 has the best accuracy in the high and mid latitude regions, while in low latitude regions the accuracy of the UWMG-t1 is slightly lower than UQRG.**
- **The accuracy of the UWMG-t1 model is the lowest for ocean regions with less data availability - which indicates the need to complete the measurement data set.**
- UWMG model can be provided publicly with a delay of 12 hours, a time resolution every 10 minutes and a spatial resolution of 1x1 degree.

Thank you for your attention!

pawel.wielgosz@uwm.edu.pl

NCN UMO-2017/27/B/ST10/02219