The cooperative IGS RT-GIMs: a reliable estimation of the global ionospheric electron content distribution in real time

(summarized and updated)

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UPC-IonSAT research group
IGS real-time working group
IGS Ionosphere working group

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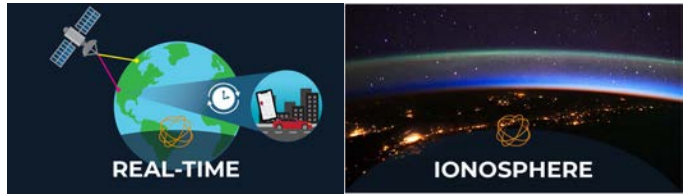

The cooperative IGS RT-GIMs

Earth Syst. Sci. Data, 13, 4567–4582, 2021
https://doi.org/10.5194/essd-13-4567-2021

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The cooperative IGS RT-GIMs: a reliable estimation of the global ionospheric electron content distribution in real time

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Received: 22 April 2021 – Discussion started: 4 May 2021
Revised: 17 July 2021 – Accepted: 19 August 2021 – Published: 23 September 2021

Abstract. The Real-Time Working Group (RTWG) of the International GNSS Service (IGS) is dedicated to providing high-quality data and high-accuracy products for Global Navigation Satellite System (GNSS) positioning, navigation, timing and Earth observations. As one part of real-time products, the IGS combined Real-Time Global Ionosphere Map (RT-GIM) has been generated by the real-time weighting of the RT-GIMs from IGS real-time ionosphere centers including the Chinese Academy of Sciences (CAS), Centre National d'Etudes Spatiales (CNES), Universitat Politècnica de Catalunya (UPC) and Wuhan University (WHU). The performance of global vertical total electron content (VTEC) representation in all of the RT-GIMs has been assessed by VTEC from Jason-3 altimeter for 3 months over oceans and dSTEC-GPS technique with 2 d observations over

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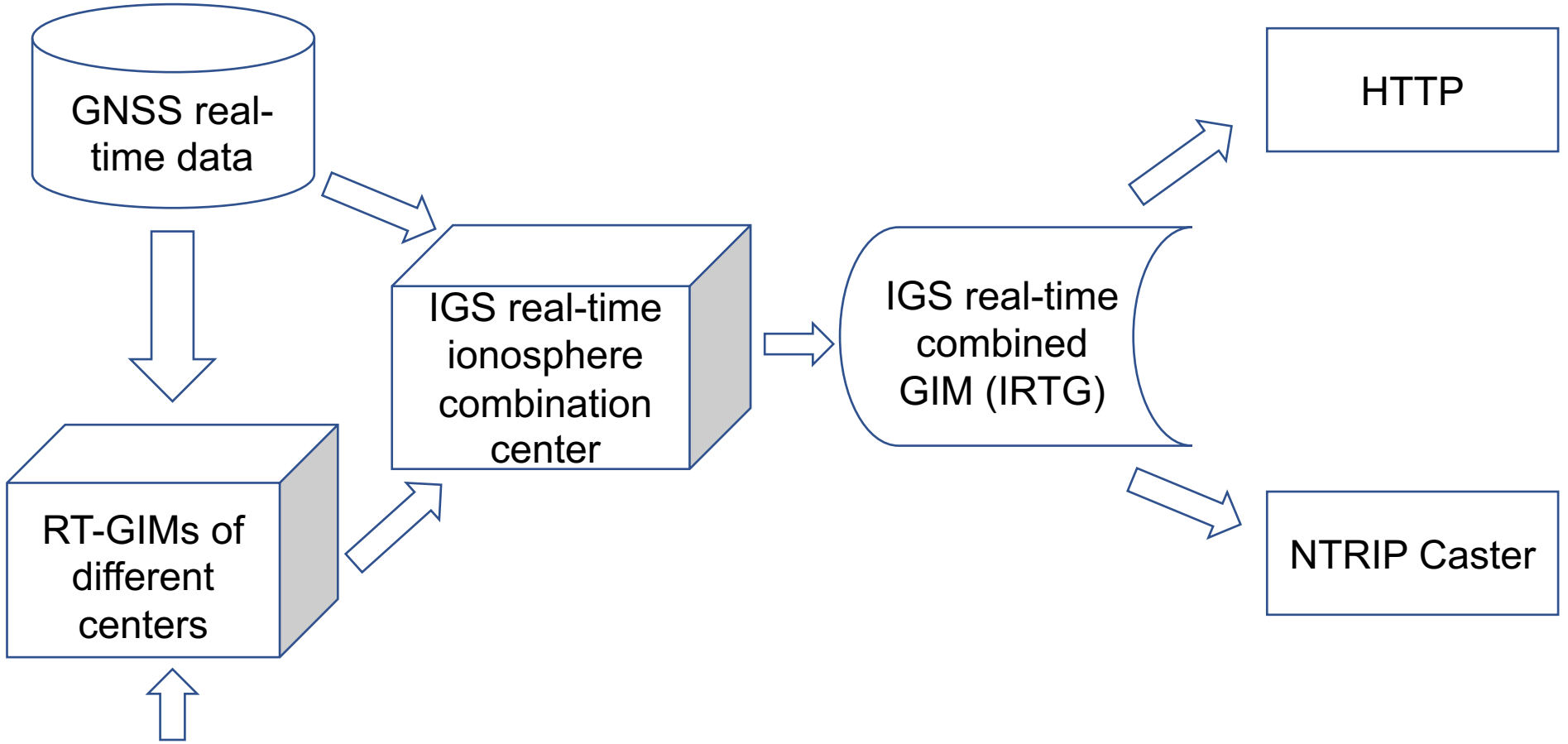
IGS real-time combined GIM

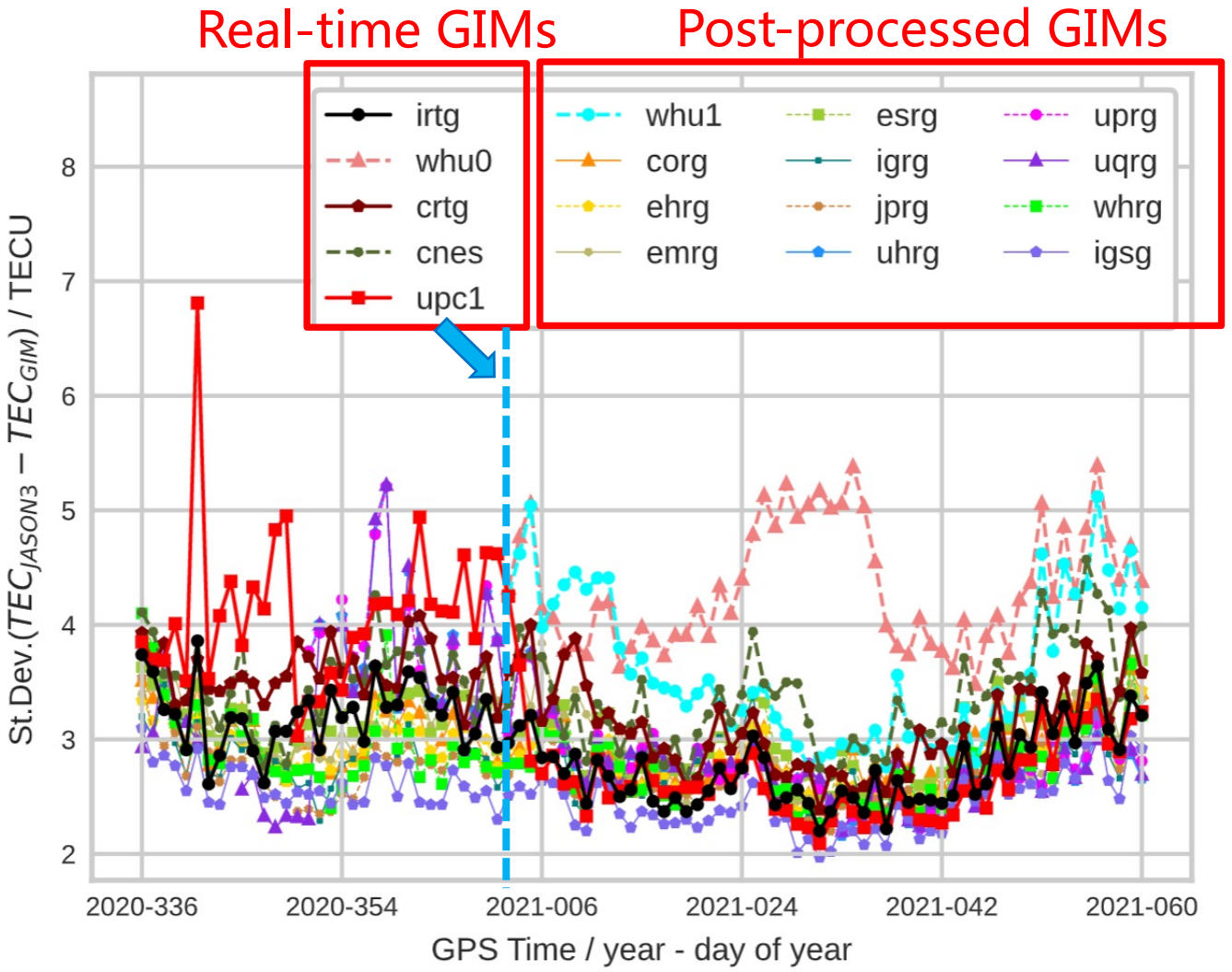


CAS, CNES, UPC, WHU

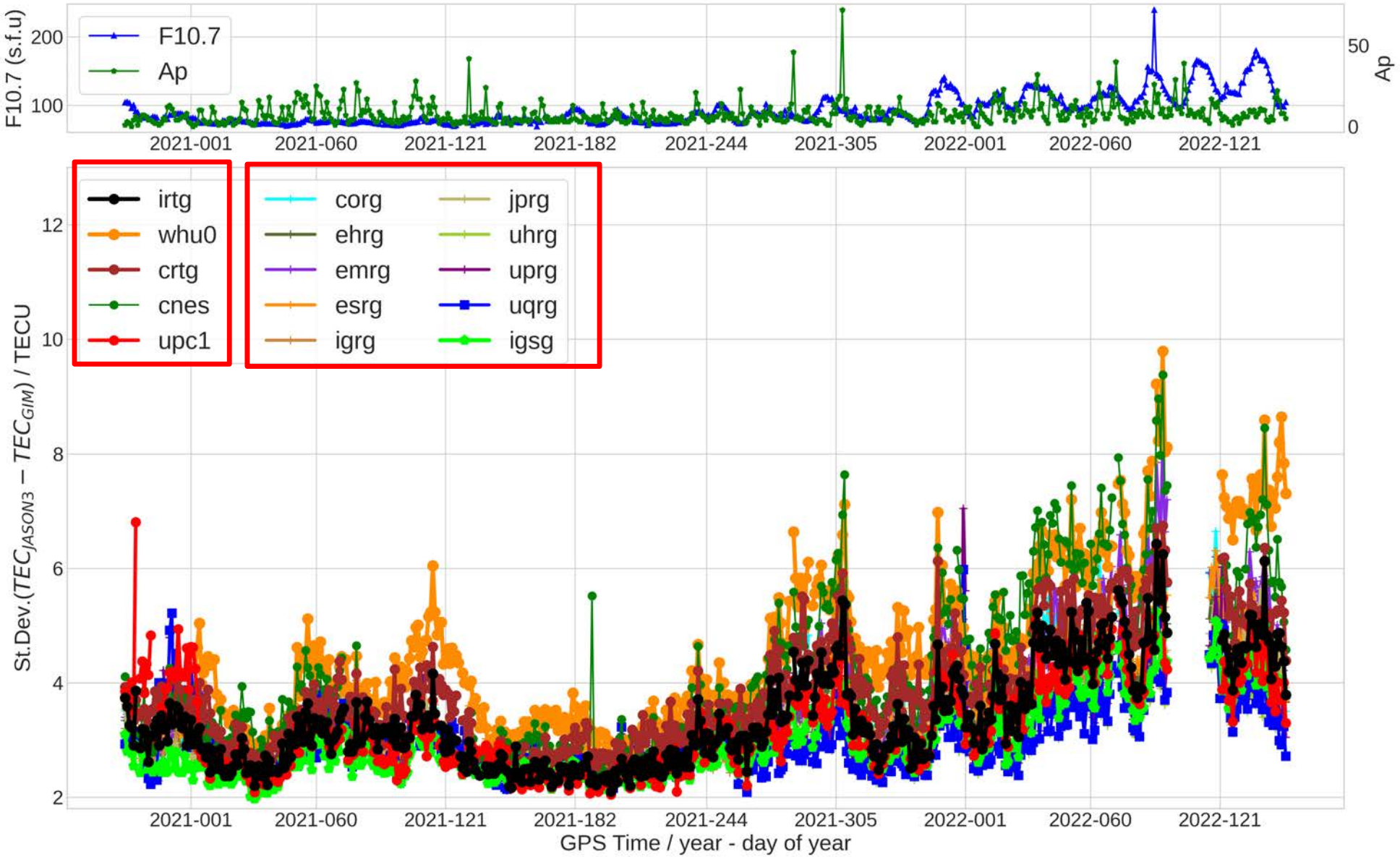
The broadcasting of IGS RT-GIMs

Agency	Temporal resolution	Broadcast frequency	Spherical harmonic degree	Mountpoints in NTRIP caster (in SSR format)	Real-Time IONEX files saved at FTP/HTTP
CAS	5 minutes	1 minute	15	59.110.42.14:2101/SSRA00CAS1 59.110.42.14:2101/SSRA00CAS0 59.110.42.14:2101/SSRC00CAS1 59.110.42.14:2101/SSRC00CAS0 182.92.166.182:2101/IONO00CAS1 182.92.166.182:2101/IONO00CAS0	ftp://ftp.gipp.org.cn/product/ionex/ (update at the end of day)
CNES	2 minutes	1 minute	12	products.igs-ip.net:2101/SSRA00CNE1 products.igs-ip.net:2101/SSRA00CNE0 products.igs-ip.net:2101/SSRC00CNE1 products.igs-ip.net:2101/SSRC00CNE0	No
UPC-IonSAT	15 minutes	15 seconds	15	products.igs-ip.net:2101/IONO00UPC1	http://chapman.upc.es/tomion/real-time/quick/ (update every 15 min)
WHU	5 minutes	1 minute	15	58.49.58.150:2106/IONO00WHU0	ftp://igs.gnsswhu.cn/pub/whu/MGEX/realtime-ionex/ (update every 30 min)
IRTG (IGS)	20 minutes	15 seconds	15	products.igs-ip.net:2101/IONO00IGS1	http://chapman.upc.es/irtg/ (update every 20 min)

Jason3 VTEC assessment around the beginning of 2021



Jason3 VTEC assessment from 2021 to 2022



Statistics of Jason3 VTEC assessment

Overall standard deviation of the GIM-VTEC versus measured Jason-3 VTEC in Jason3 VTEC assessment (TECU)

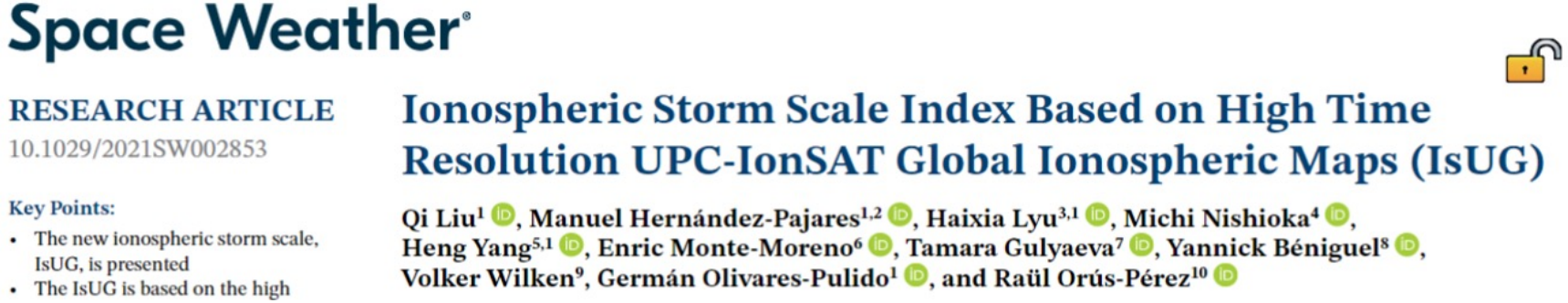
GIM	From 1 December 2020 to 3 January 2021	From 4 January to 1 March 2021	From 4 January 2021 to 1 June 2022	From 4 January 2022 to 1 June 2022
corg	3.1	2.9	3.8	4.9
ehrg	3.0	2.8	3.6	4.5
emrg	3.2	2.9	3.9	5.1
esrg	3.2	3.0	3.8	4.9
igrg	2.9	2.8	3.3	4.0
jprg	2.8	2.7	3.4	4.2
uhrg	3.9	2.8	3.1	3.6
uprg	3.9	2.8	3.3	4.0
uqrg	3.5	2.8	3.1	3.7
igsg	2.6	2.5	3.2	4.0
crtg	3.6	3.2	4.1	5.2
cnes	3.5	3.4	4.7	6.2
upc1	4.3	2.7	3.4	4.2
whu0	4.3	4.4	5.0	6.5
irtg	3.3	2.8	3.5	4.5

Recent activities & Potential new applications

- Recent activities

  CAS has started to provide a second real-time GIM combination: IONO01IGS0 / IONO01IGS1
  The quality monitoring of IGS real-time GIMs are available on IGS RTS website

- Potential space weather applications



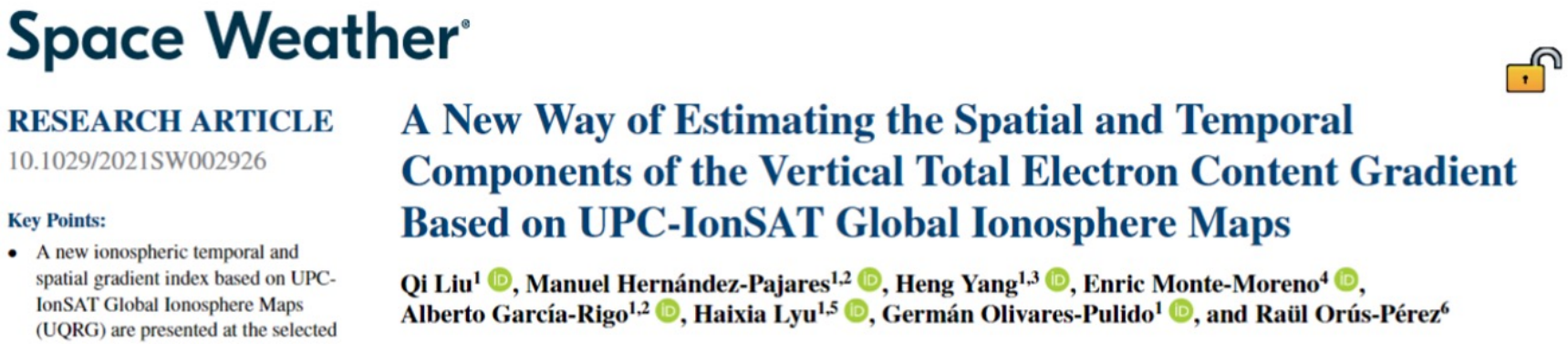
Space Weather

RESEARCH ARTICLE
10.1029/2021SW002853

Key Points:
- The new ionospheric storm scale, IsUG, is presented
- The IsUG is based on the high

Ionospheric Storm Scale Index Based on High Time Resolution UPC-IonSAT Global Ionospheric Maps (IsUG)

Qi Liu[1], Manuel Hernández-Pajares[1,2], Haixia Lyu[3,1], Michi Nishioka[4], Heng Yang[5,1], Enric Monte-Moreno[6], Tamara Gulyaeva[7], Yannick Béniguel[8], Volker Wilken[9], Germán Olivares-Pulido[1], and Raül Orús-Pérez[10]



Space Weather

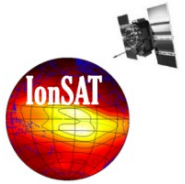
RESEARCH ARTICLE
10.1029/2021SW002926

Key Points:
- A new ionospheric temporal and spatial gradient index based on UPC-IonSAT Global Ionosphere Maps (UQRG) are presented at the selected

A New Way of Estimating the Spatial and Temporal Components of the Vertical Total Electron Content Gradient Based on UPC-IonSAT Global Ionosphere Maps

Qi Liu[1], Manuel Hernández-Pajares[1,2], Heng Yang[1,3], Enric Monte-Moreno[4], Alberto García-Rigo[1,2], Haixia Lyu[1,5], Germán Olivares-Pulido[1], and Raül Orús-Pérez[6]

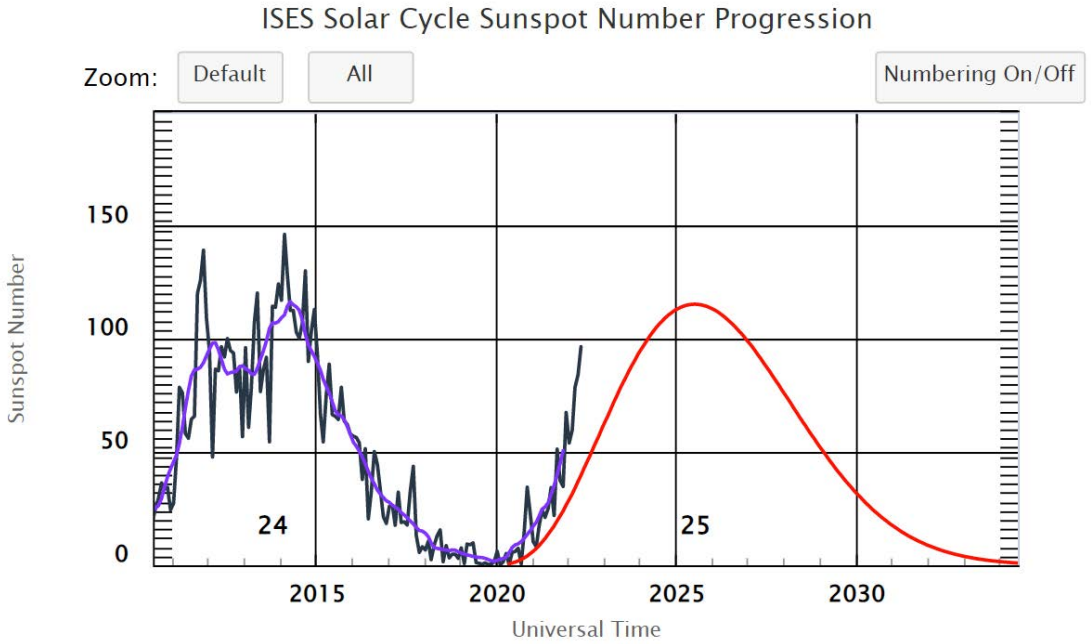
Details have been presented at Iono. WG session 27 June 2022

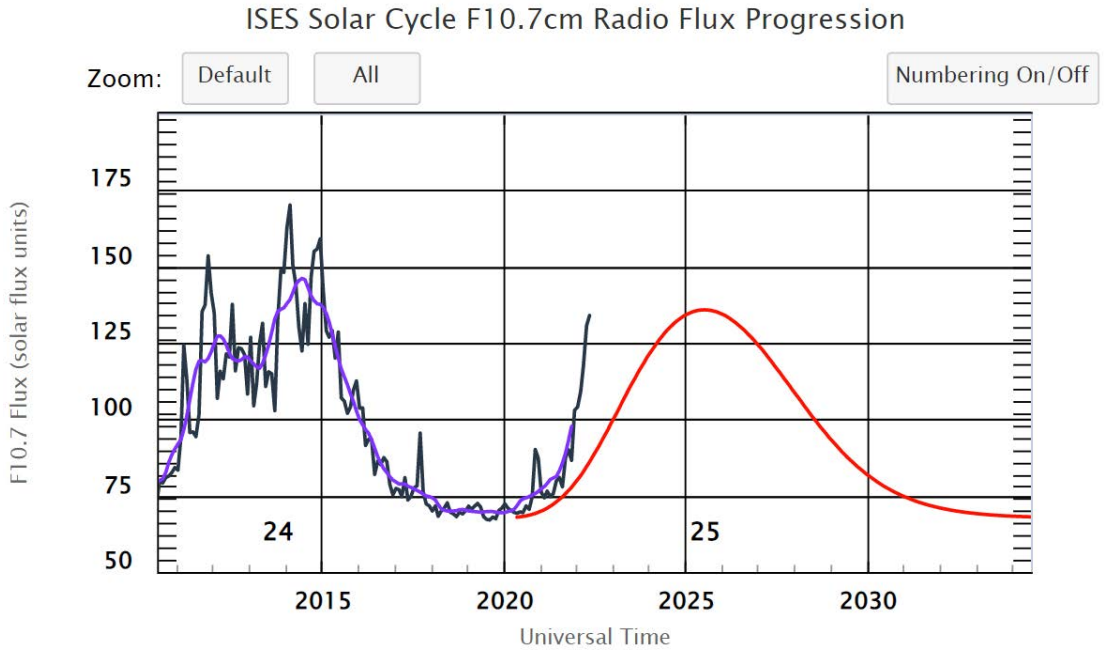


Thanks for you attention!

Back-up Slides

The current phase of solar cycle





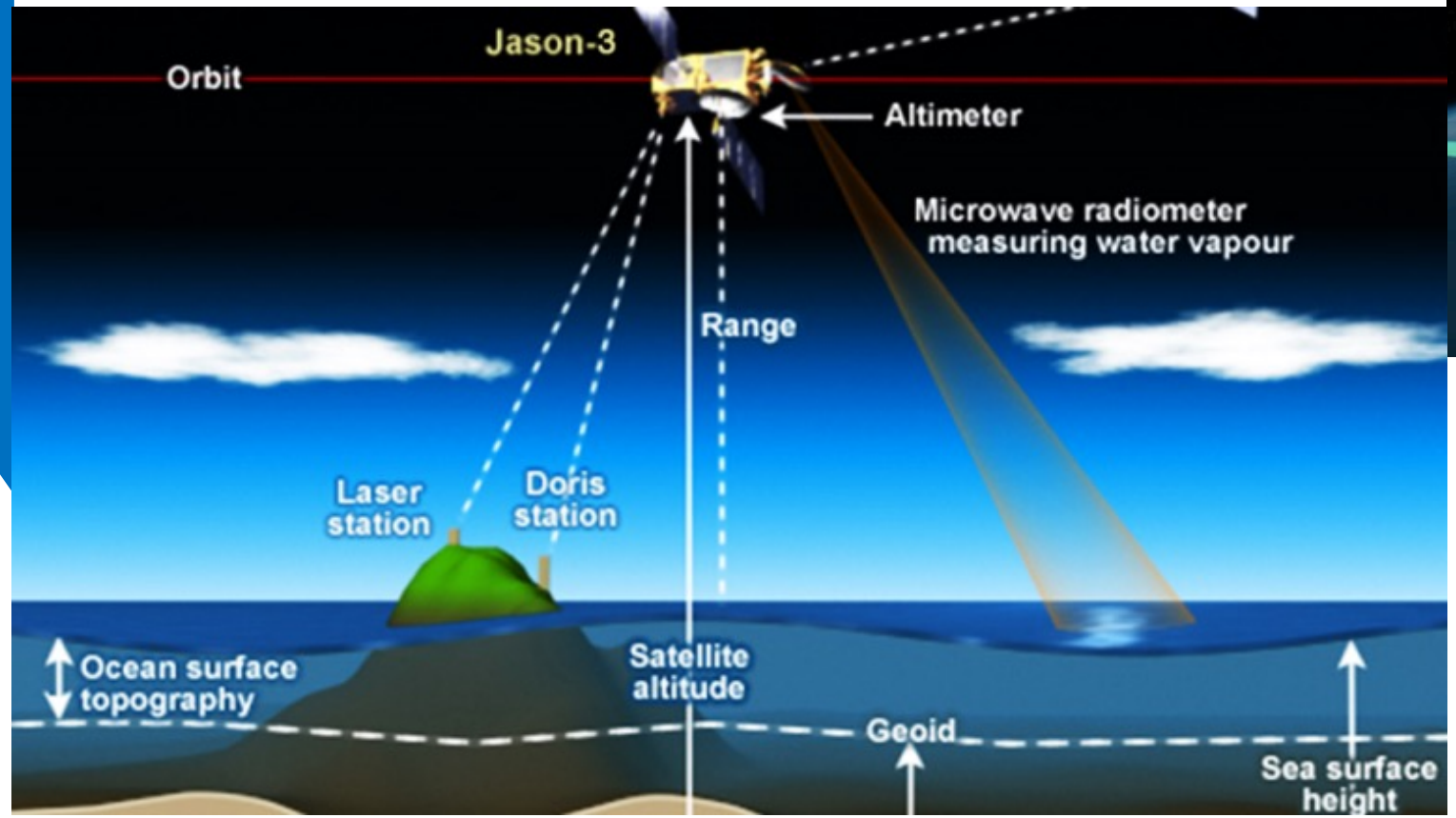
Monthly Values Smoothed Monthly Values Predicted Values

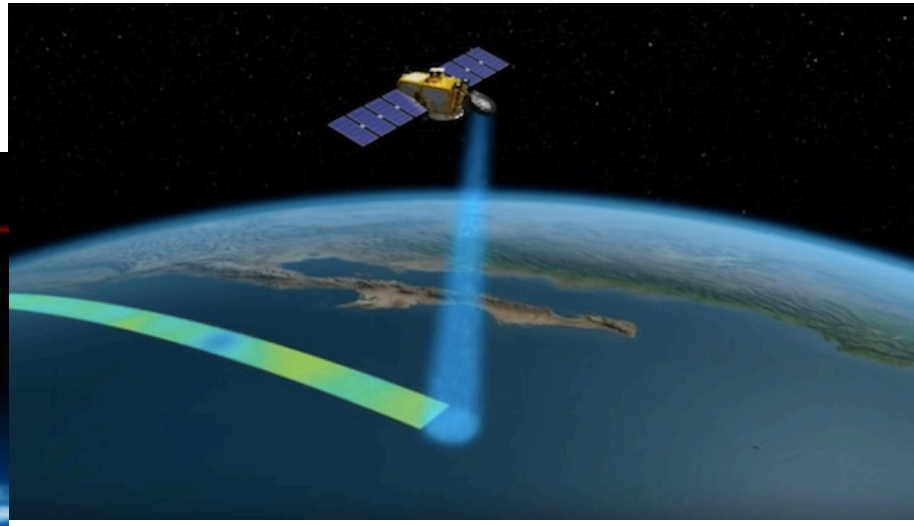
Figure from Space Weather Prediction Center
https://www.swpc.noaa.gov/products/solar-cycle-progression

Broadcasting and receiving SH expansions in SSR format

$$
\begin{cases}
M_z = \left[1 - \sin^2 z/(1 + H_{\text{ion}}/R_{\text{E}})^2\right]^{-\frac{1}{2}} \\
\text{VTEC}_t = \text{STEC}_t / M_z \\
\text{VTEC}_t = \sum_{n=0}^{N_{\text{SH}}} \sum_{m=0}^{\min(n, M_{\text{SH}})} P_{n,m}(\sin \varphi_{\text{I}}) \\
\qquad \cdot (C_{n,m} \cos(m\lambda_{\text{S},t}) + S_{n,m} \sin(m\lambda_{\text{S},t})) \\
\lambda_{\text{S},t} = (\lambda_{\text{I}} + (t - t_0) \times \pi / 43\,200) \text{ modulo } 2\pi
\end{cases}
$$

GIM assessment methods





Jason VTEC