TOWARDS COOPERATIVE GLOBAL MAPPING OF THE IONOSPHERE. FUSION FEASIBILITY FOR IGS AND IRI WITH GLOBAL CLIMATE VTEC MAPS

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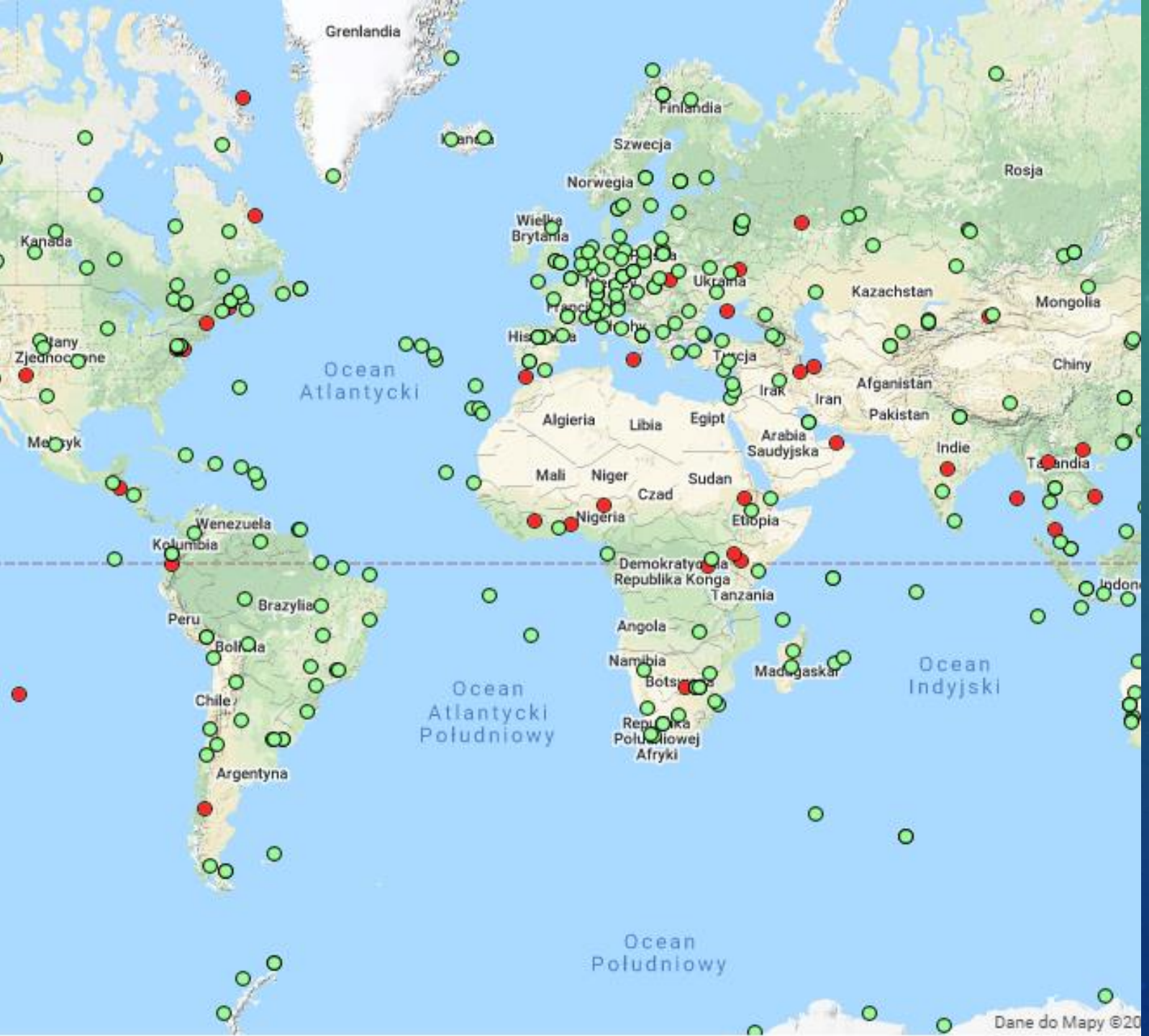


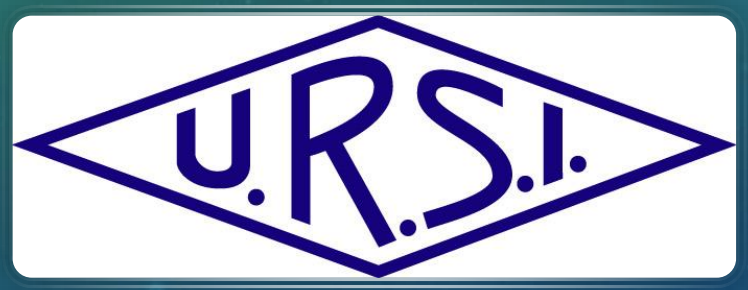
IGS IONO WORKING GROUP

Since 1998, the IGS Iono Working Group has been continuously releasing global VTEC maps in rapid, final, and predicted schedules.

The IGS Ionosphere Combination and Validation Center at University of Warmia and Mazury is responsible for an ensemble analysis of the global VTEC maps synthesized independently by several ISG Associate Analysis Centers by applying the observation uncertainty weights determined by validating the VTEC data against the original slant TEC measurements.

Products:

- Final GIM: resolution - 2 hours x 5 deg. x 2.5 deg (UTxLon.xLat.); latency of 11 days
- Rapid GIM: resolution - 2 hours x 5 deg. x 2.5 deg; latency of less than 24 hours
- Real Time GIM provided independently by several IAACs
- Predicted GIM for 1 and 2 days ahead (pilot product) - resolution - 2 hours x 5 deg. x 2.5 deg; availability 24 and 48 hours in advance

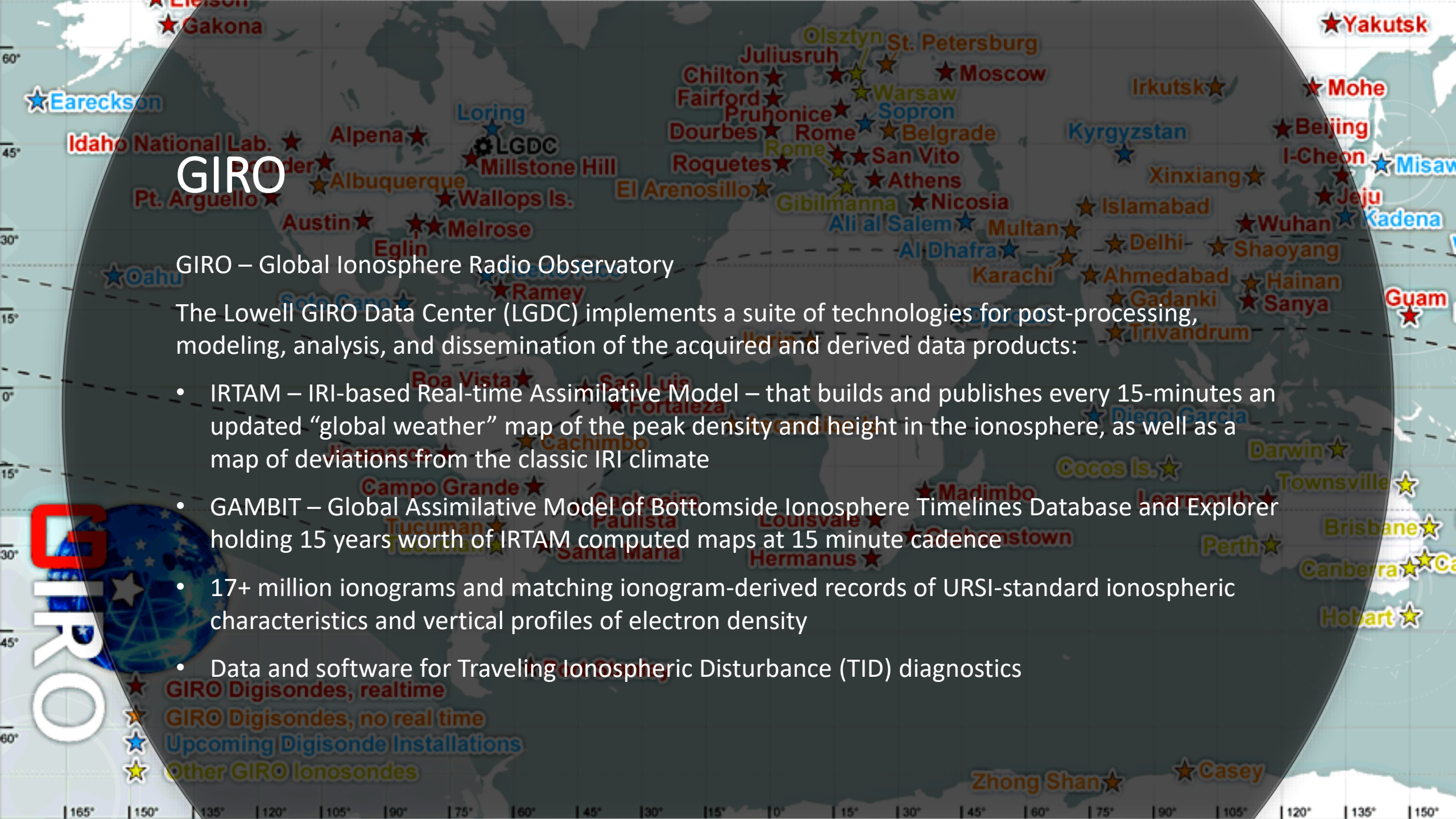


IRI

The International Reference Ionosphere (IRI) is an international project sponsored by the Committee on Space Research (COSPAR) and the International Union of Radio Science (URSI).

For given location, time and date, IRI provides monthly averages of the electron density, electron temperature, ion temperature, and ion composition in the altitude range from 50 km to 2000 km. Additional parameters given by IRI include the Total Electron Content, the occurrence probability for Spread-F and the F1-region, and the equatorial vertical ion drift.

The major data sources are the worldwide network of ionosondes, the powerful incoherent scatter radars (Jicamarca, Arecibo, Millstone Hill, Malvern, St. Santin), the ISIS and Alouette topside sounders, and in situ instruments on several satellites and rockets. For further information please refer to: https://iri.gsfc.nasa.gov/



GIRO

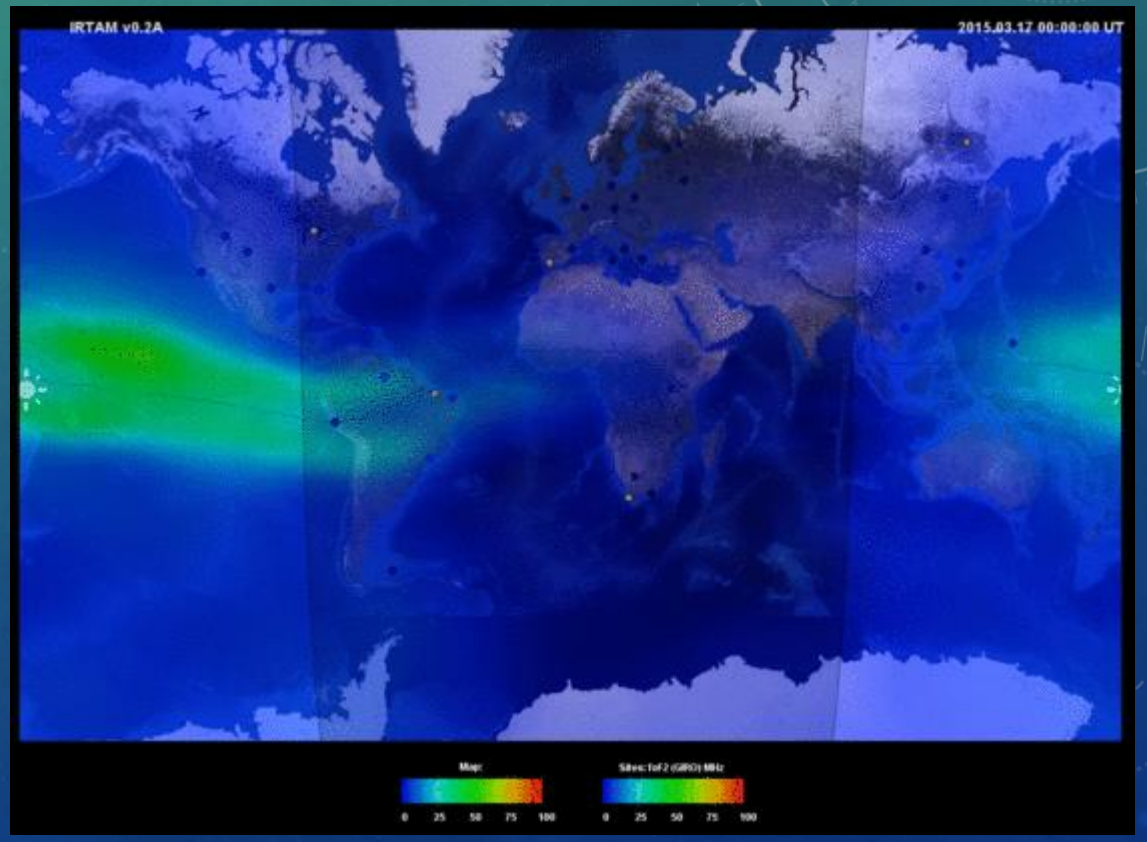
GIRO – Global Ionosphere Radio Observatory

The Lowell GIRO Data Center (LGDC) implements a suite of technologies for post-processing, modeling, analysis, and dissemination of the acquired and derived data products:

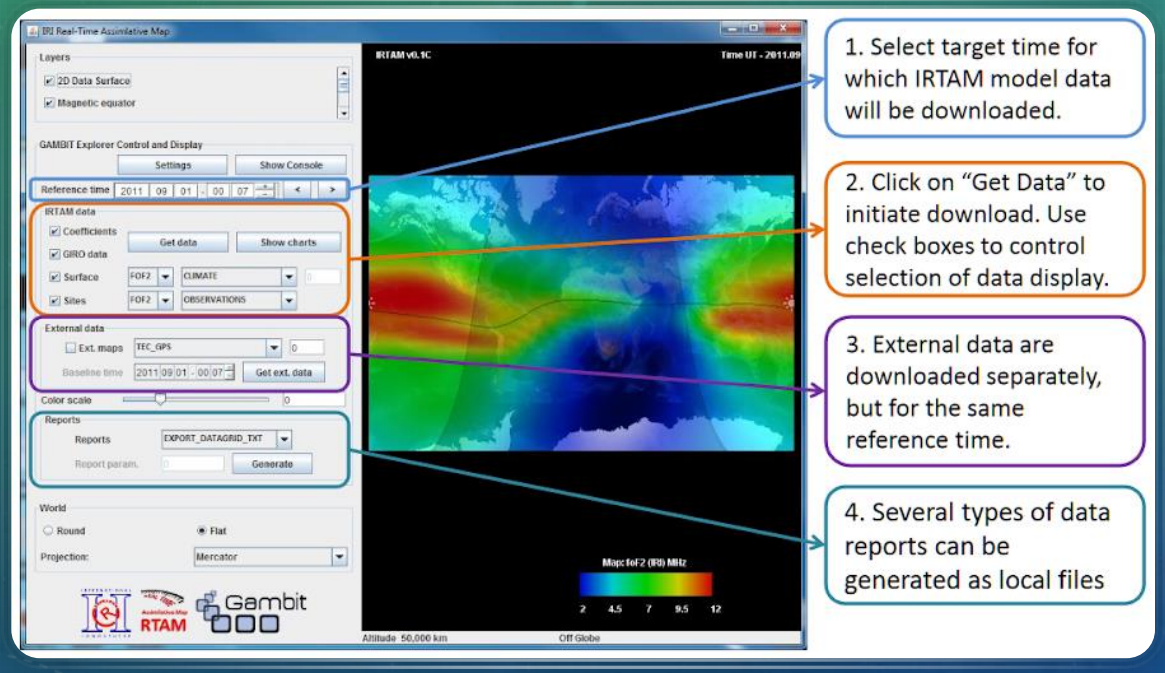
- IRTAM – IRI-based Real-time Assimilative Model – that builds and publishes every 15-minutes an updated “global weather” map of the peak density and height in the ionosphere, as well as a map of deviations from the classic IRI climate
- GAMBIT – Global Assimilative Model of Bottomside Ionosphere Timelines Database and Explorer holding 15 years worth of IRTAM computed maps at 15 minute cadence
- 17+ million ionograms and matching ionogram-derived records of URSI-standard ionospheric characteristics and vertical profiles of electron density
- Data and software for Traveling Ionospheric Disturbance (TID) diagnostics

OBJECTIVES

- Introduction of 30-day average empirical (climate) TEC maps into GAMBIT Explorer software in order to build deviation maps for ionosonde-derived global maps of the bottomside ionospheric plasma – fulfilled (presented at EGU General Assembly in Vienna in April 2018) – full data availability since 2010 until now
- Ionospheric weather nowcast based on near real-time data products from IGS and GIRO sensor networks – fulfilled (presented at AT-RASC at Gran Canaria in June 2018)
- System developement for enhanced latency, stability, and reliability – advanced works in progress
- Real-time GIM incorporation into GAMBIT – advanced works in progress
- Full assimilation of empirical VTEC data into IRI – future works



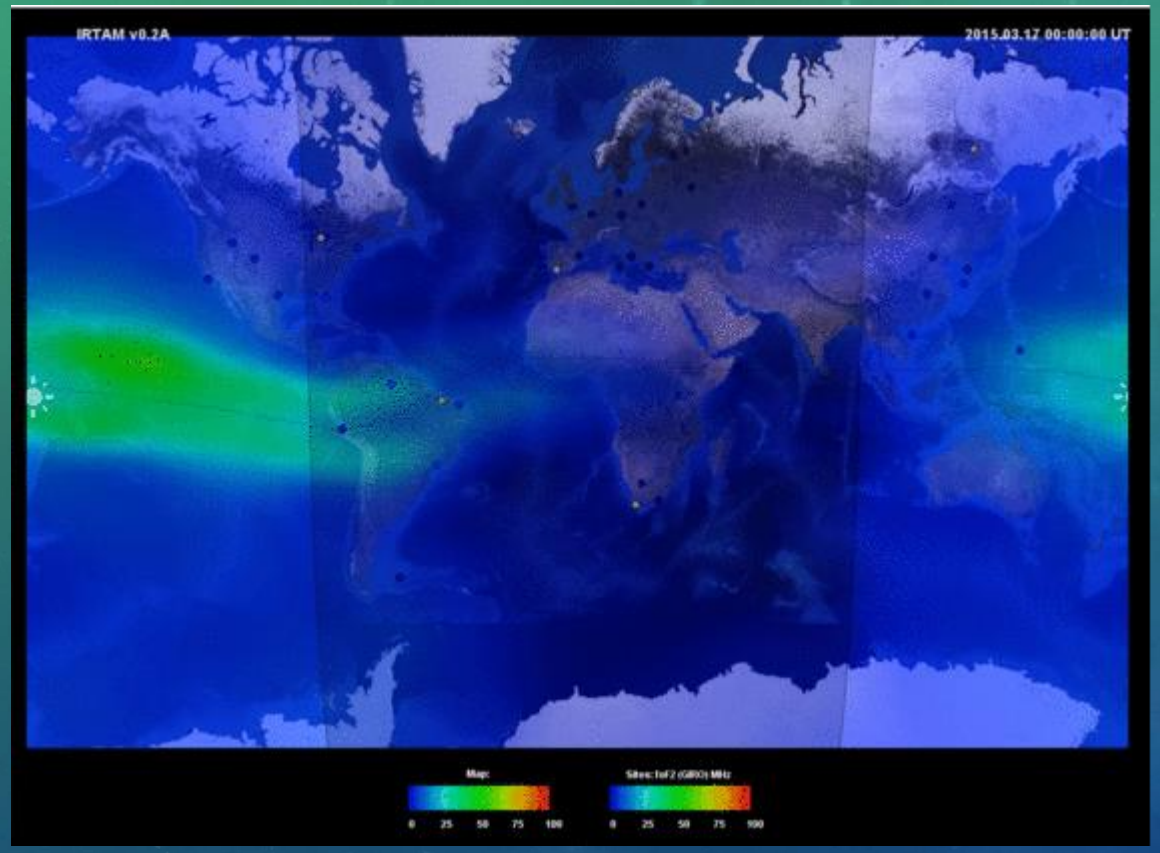
GAMBIT EXPLORER

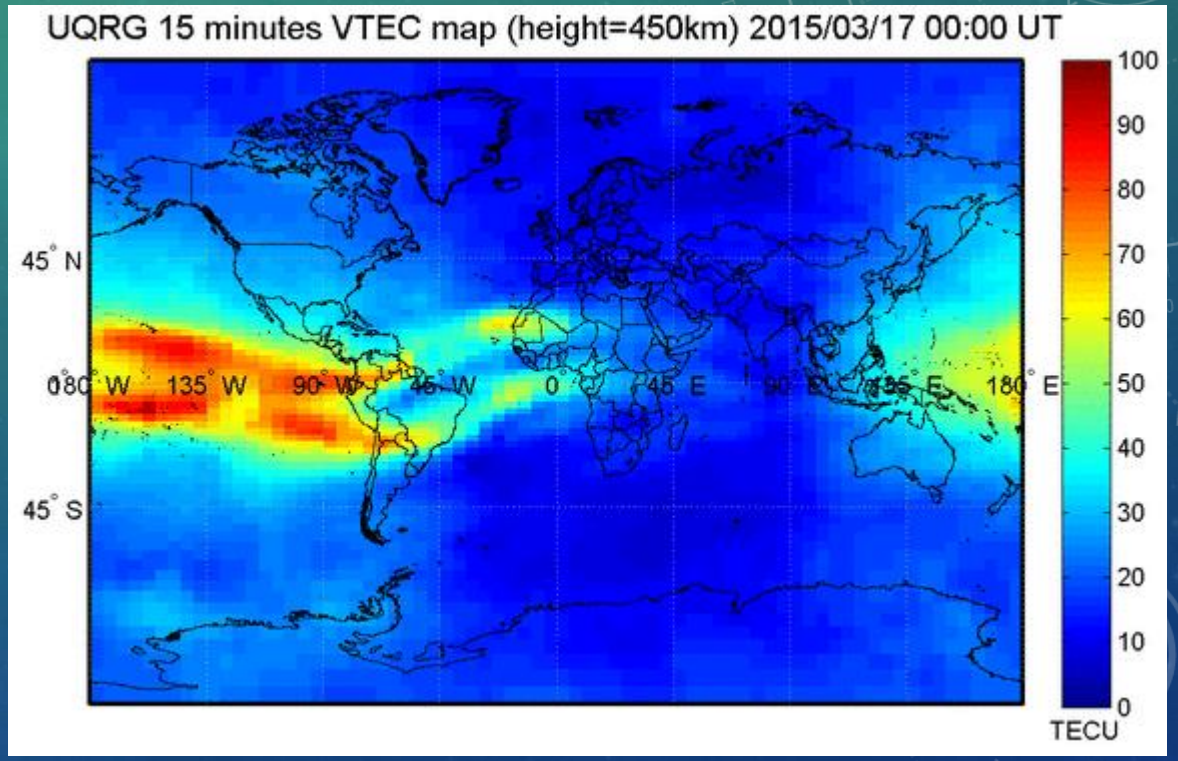


GAMBIT Explorer is a Java application based on NASA WorldWind graphics library, released for academic research use at http://giro.uml.edu/GAMBIT, which allows for rapid and interactive visualisation of different ionospheric properties, such as F0F2, NmF2, HmF2, B0 or B1 in various routines (interpolated climate and weather or observations at GIRO sites). But most importantly it integrates different data sources and allows for their combination in a goal of delivering a detailed insight in the ionosphere. Detailed description of the GAMBIT database and Explorer, as well as underlying formalism and algorithms can be found in. Incorporation of the climate global VTEC maps (described further) led us to extend the capabilities of GAMBIT Database in the climate aspect and opened the path for planned inclusion of weather VTEC.

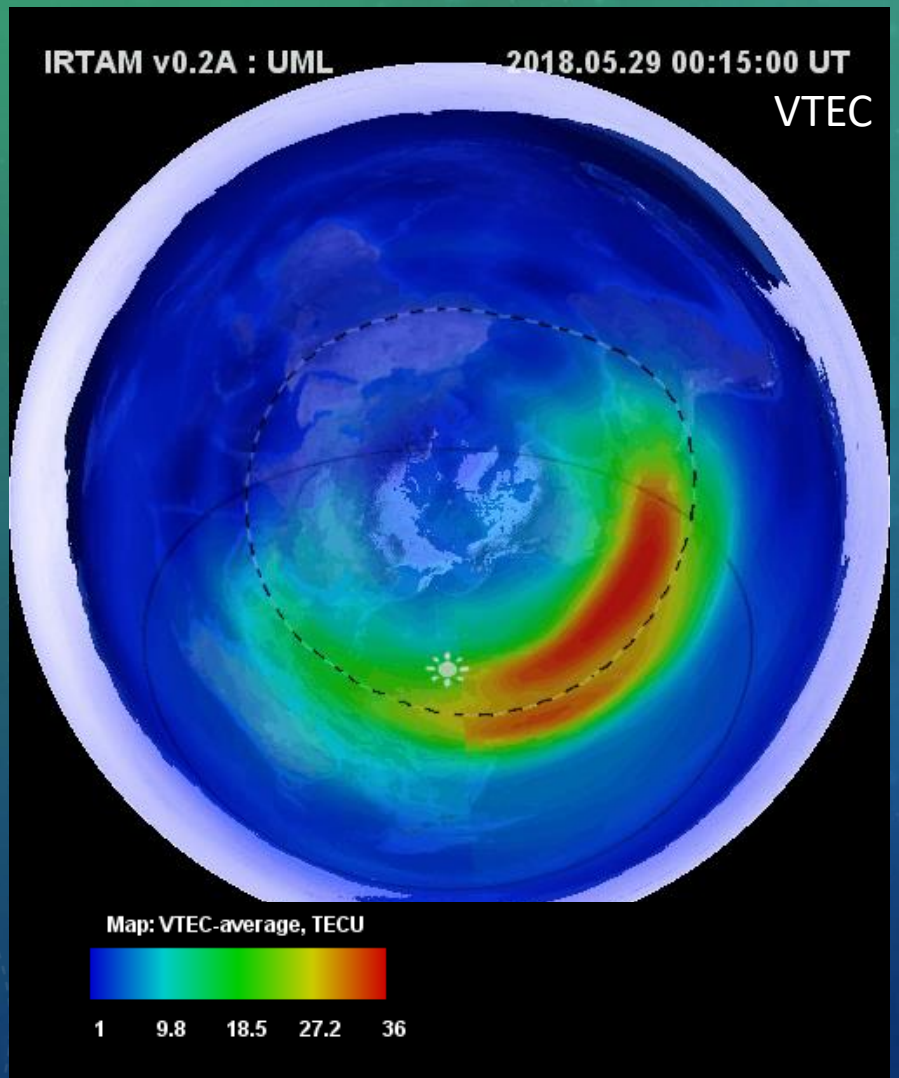
For further details concerning GAMBIT Explorer features please refer to: http://giro.uml.edu/GAMBIT/GAMBIT-X_UserGuide-v01C.pdf

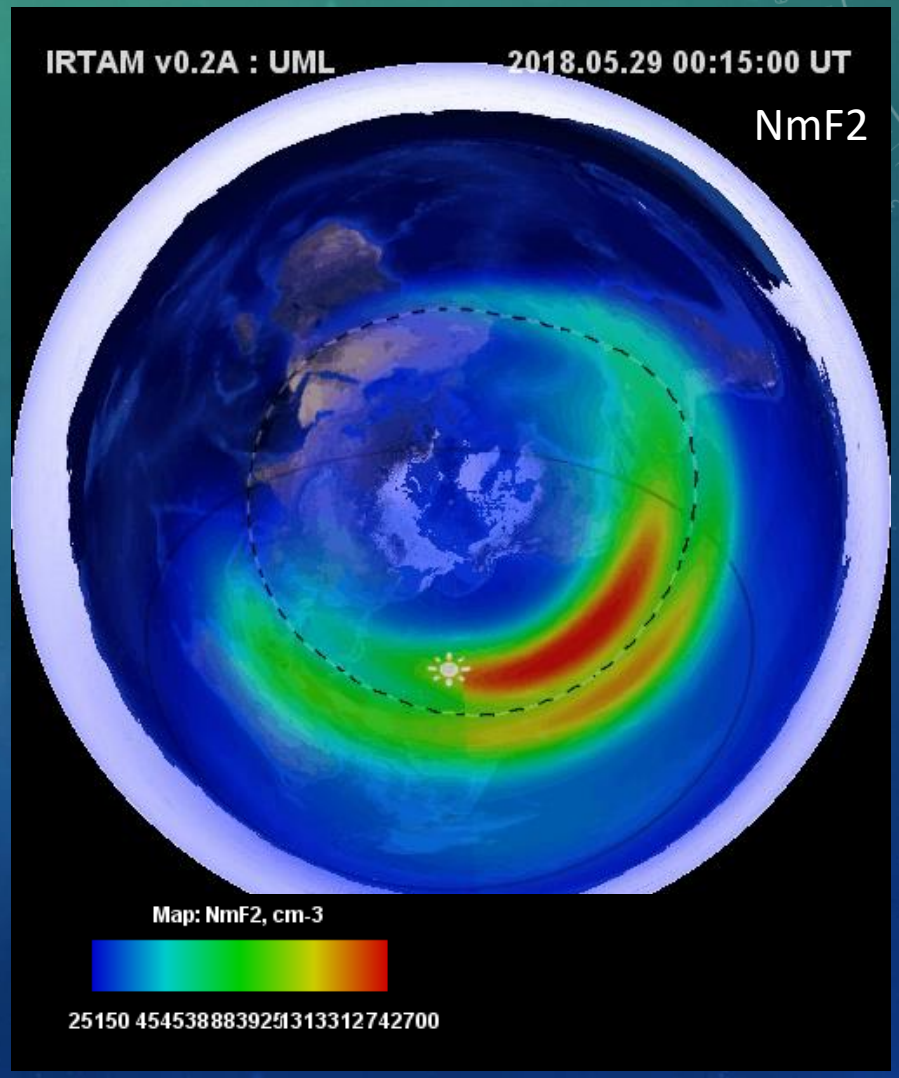
RESULTS


IRTAM v0.2A
2015.03.17 00:00:00 UT


UQRG 15 minutes VTEC map (height=450km) 2015/03/17 00:00 UT
45° N
0
45° S
180° W
135° W
90° W
45° W
0
45° E
90° E
135° E
180° E
100
90
80
70
60
50
40
30
20
10
0
TECU

RESULTS


IRTAM v0.2A : UML
2018.05.29 00:15:00 UT
VTEC
Map: VTEC-average, TECU
1
9.8
18.5
27.2
36


IRTAM v0.2A : UML
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NmF2
Map: NmF2, cm-3
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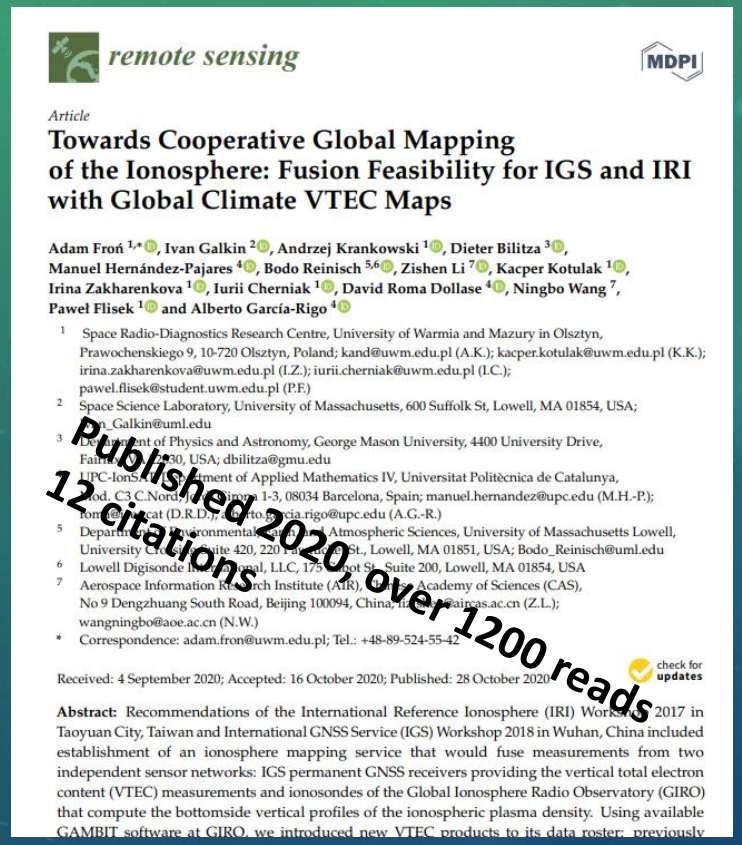
PUBLICATIONS



remote sensing

MDPI

Article

Towards Cooperative Global Mapping of the Ionosphere: Fusion Feasibility for IGS and IRI with Global Climate VTEC Maps

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Received: 4 September 2020; Accepted: 16 October 2020; Published: 28 October 2020

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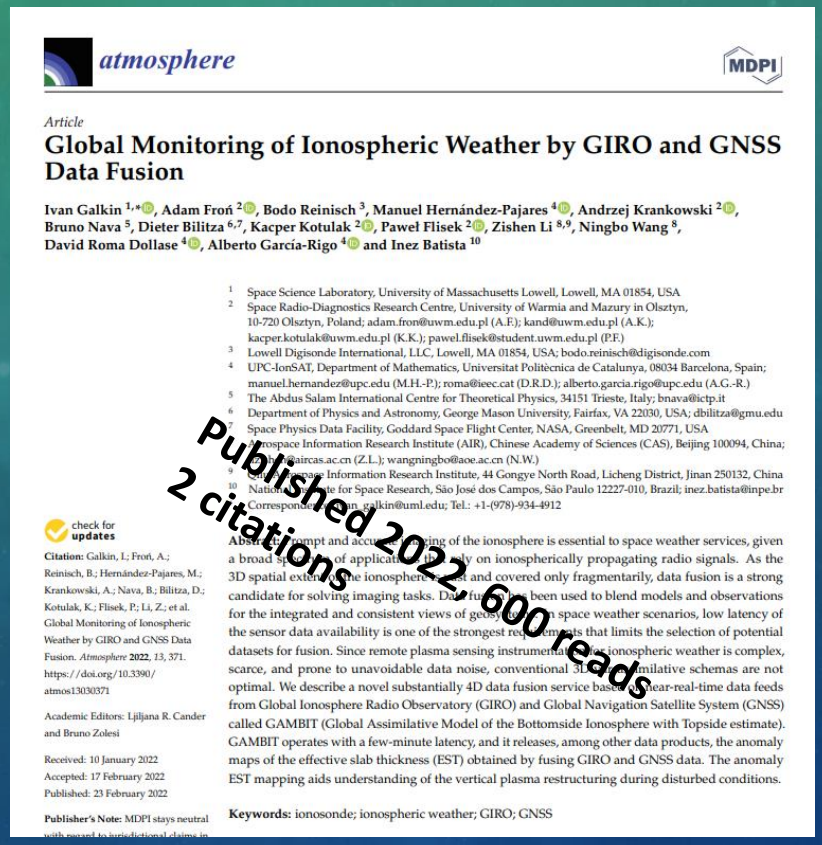
Abstract: Recommendations of the International Reference Ionosphere (IRI) Workshop 2017 in Taoyuan City, Taiwan and International GNSS Service (IGS) Workshop 2018 in Wuhan, China included establishment of an ionosphere mapping service that would fuse measurements from two independent sensor networks: IGS permanent GNSS receivers providing the vertical total electron content (VTEC) measurements and ionosondes of the Global Ionosphere Radio Observatory (GIRO) that compute the bottomside vertical profiles of the ionospheric plasma density. Using available GAMBIT software at GIRO, we introduced new VTEC products to its data roster: previously

Published 2020, over 1200 reads

12 citations



atmosphere

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Article

Global Monitoring of Ionospheric Weather by GIRO and GNSS Data Fusion

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Citation: Galkin, I.; Froń, A.; Reinisch, B.; Hernández-Pajares, M.; Krankowski, A.; Nava, B.; Bilitza, D.; Kotulak, K.; Flisek, P.; Li, Z.; et al. Global Monitoring of Ionospheric Weather by GIRO and GNSS Data Fusion. *Atmosphere* **2022**, *13*, 371. https://doi.org/10.3390/atmos13030371

Academic Editors: Ljiljana R. Cander and Bruno Zolesi

Received: 10 January 2022
Accepted: 17 February 2022
Published: 23 February 2022

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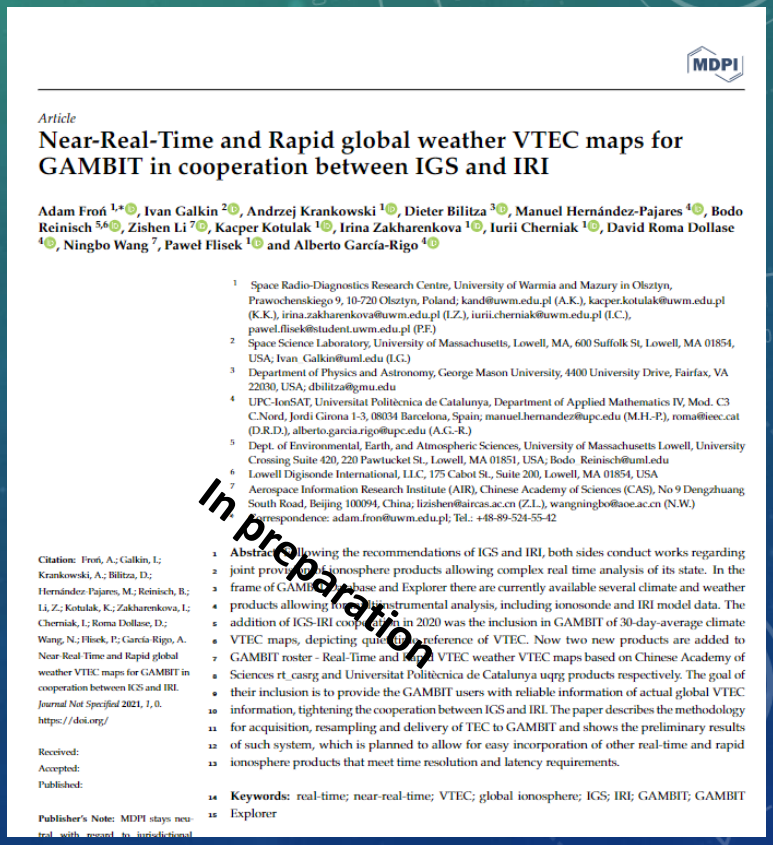
Abstract: Prompt and accurate mapping of the ionosphere is essential to space weather services, given a broad spectrum of applications relying on ionospherically propagating radio signals. As the 3D spatial extent of the ionosphere is vast and covered only fragmentarily, data fusion is a strong candidate for solving imaging tasks. Data fusion has been used to blend models and observations for the integrated and consistent views of geospace in space weather scenarios, low latency of the sensor data availability is one of the strongest requirements that limits the selection of potential datasets for fusion. Since remote plasma sensing instrumentation for ionospheric weather is complex, scarce, and prone to unavoidable data noise, conventional 3D-Var assimilative schemas are not optimal. We describe a novel substantially 4D data fusion service based on near-real-time data feeds from Global Ionosphere Radio Observatory (GIRO) and Global Navigation Satellite System (GNSS) called GAMBIT (Global Assimilative Model of the Bottomside Ionosphere with Topside estimate). GAMBIT operates with a few-minute latency, and it releases, among other data products, the anomaly maps of the effective slab thickness (EST) obtained by fusing GIRO and GNSS data. The anomaly EST mapping aids understanding of the vertical plasma restructuring during disturbed conditions.

Keywords: ionosonde; ionospheric weather; GIRO; GNSS

Published 2022, 600 reads

2 citations



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Article

Near-Real-Time and Rapid global weather VTEC maps for GAMBIT in cooperation between IGS and IRI

Adam Froń [1,*], Ivan Galkin [2], Andrzej Krankowski [1], Dieter Bilitza [3], Manuel Hernández-Pajares [4], Bodo Reinisch [5,6], Zishen Li [7], Kacper Kotulak [1], Irina Zakharenkova [1], Iurii Cherniak [1], David Roma Dollase [4], Ningbo Wang [7], Paweł Flisek [1] and Alberto García-Rigo [4]

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Citation: Froń, A.; Galkin, I.; Krankowski, A.; Bilitza, D.; Hernández-Pajares, M.; Reinisch, B.; Li, Z.; Kotulak, K.; Zakharenkova, I.; Cherniak, I.; Roma Dollase, D.; Wang, N.; Flisek, P.; García-Rigo, A. Near-Real-Time and Rapid global weather VTEC maps for GAMBIT in cooperation between IGS and IRI. *Journal Not Specified* **2021**, *1*, 0. https://doi.org/

Received:
Accepted:
Published:

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Abstract: Following the recommendations of IGS and IRI, both sides conduct works regarding joint provision of ionosphere products allowing complex real time analysis of its state. In the frame of GAMBIT database and Explorer there are currently available several climate and weather products allowing for ionospheric instrumental analysis, including ionosonde and IRI model data. The addition of IGS-IRI cooperation in 2020 was the inclusion in GAMBIT of 30-day-average climate VTEC maps, depicting quiet reference of VTEC. Now two new products are added to GAMBIT roster - Real-Time and Rapid VTEC weather VTEC maps based on Chinese Academy of Sciences rt_casrg and Universitat Politècnica de Catalunya uqrg products respectively. The goal of their inclusion is to provide the GAMBIT users with reliable information of actual global VTEC information, tightening the cooperation between IGS and IRI. The paper describes the methodology for acquisition, resampling and delivery of TEC to GAMBIT and shows the preliminary results of such system, which is planned to allow for easy incorporation of other real-time and rapid ionosphere products that meet time resolution and latency requirements.

Keywords: real-time; near-real-time; VTEC; global ionosphere; IGS; IRI; GAMBIT; GAMBIT Explorer

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