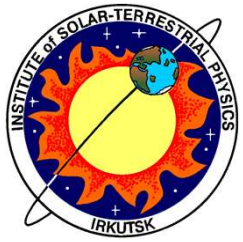


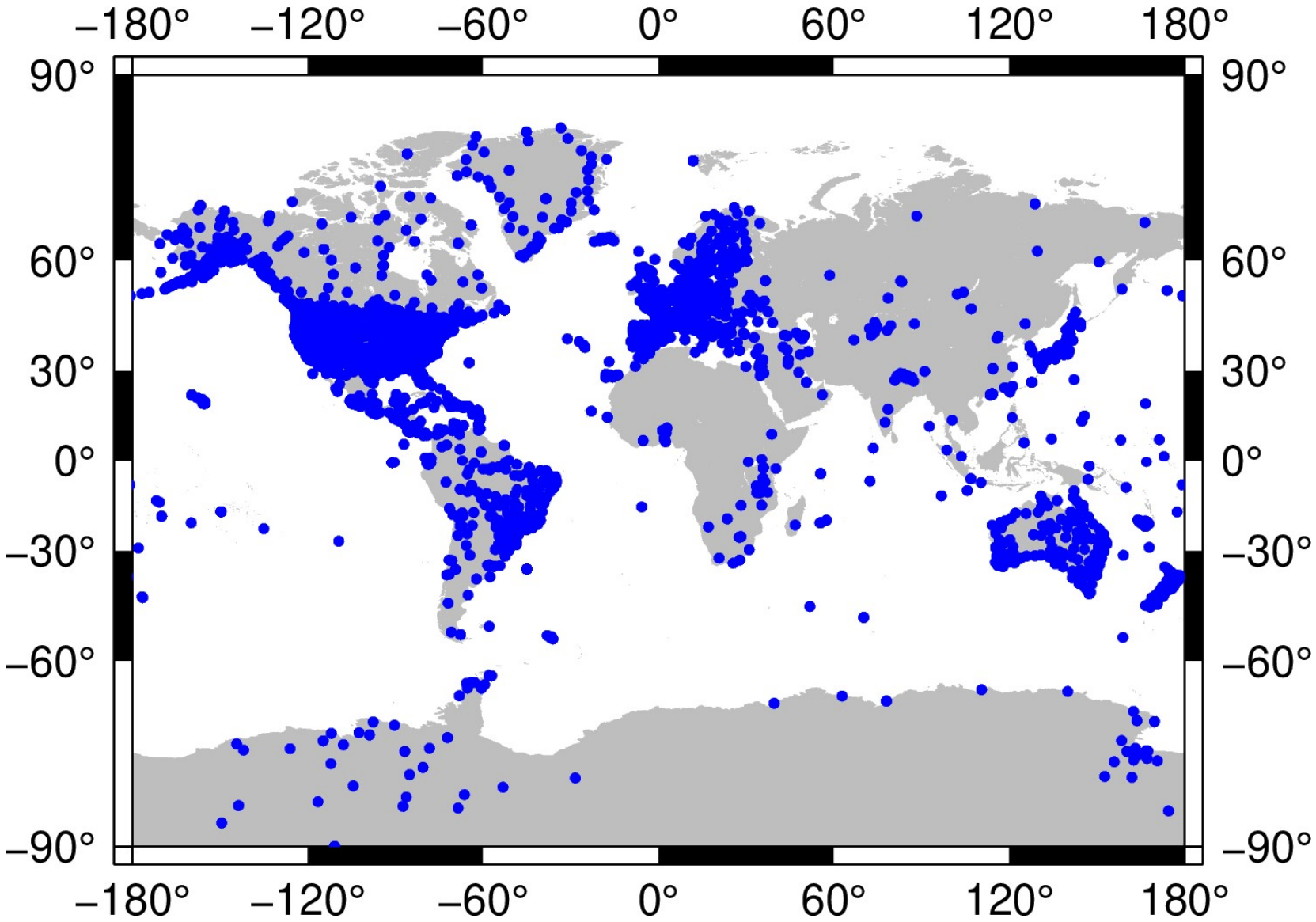
Supported by Российский научный фонд (Project N 17-77-20005)

New insight on the ionosphere through System for Ionosphere Monitoring and Research from GNSS (SIMuRG)

Yury Yasyukevich,

A.V. Kiselev, I.V. Zhivetiev, I.K. Edemskiy, B.M. Maletckii, S.V. Syrovatskiy, A.E. Vasiliev, D.N. Sidorov, S.A. Serebrennikova, A.M. Vesnin

Relevance



There are more than 5000 stations

There are a lot of different networks

IGS (2464)

GSI (1200)

NGS (1041)

UNAVCO (798)

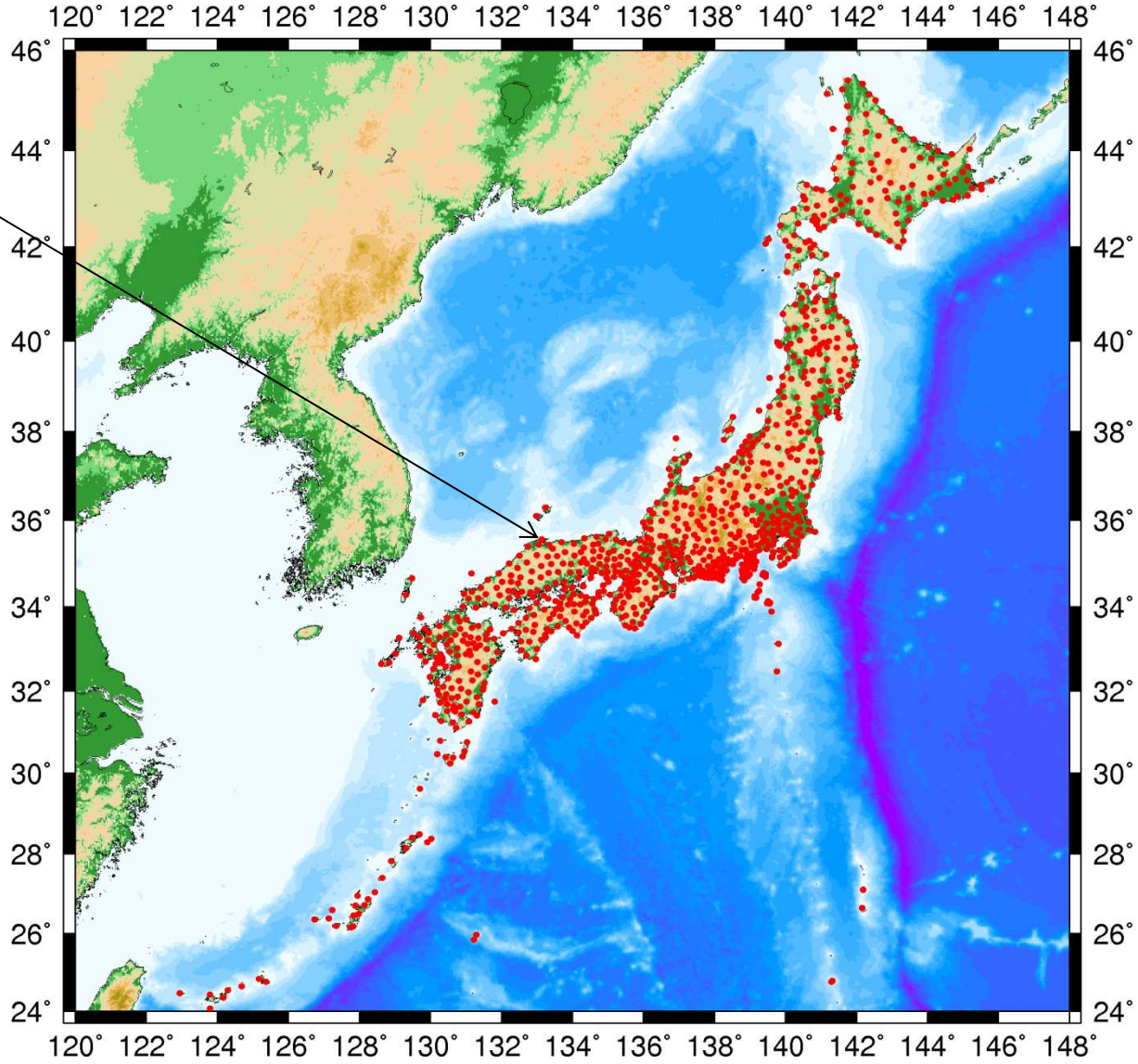
SONEL (794)

…

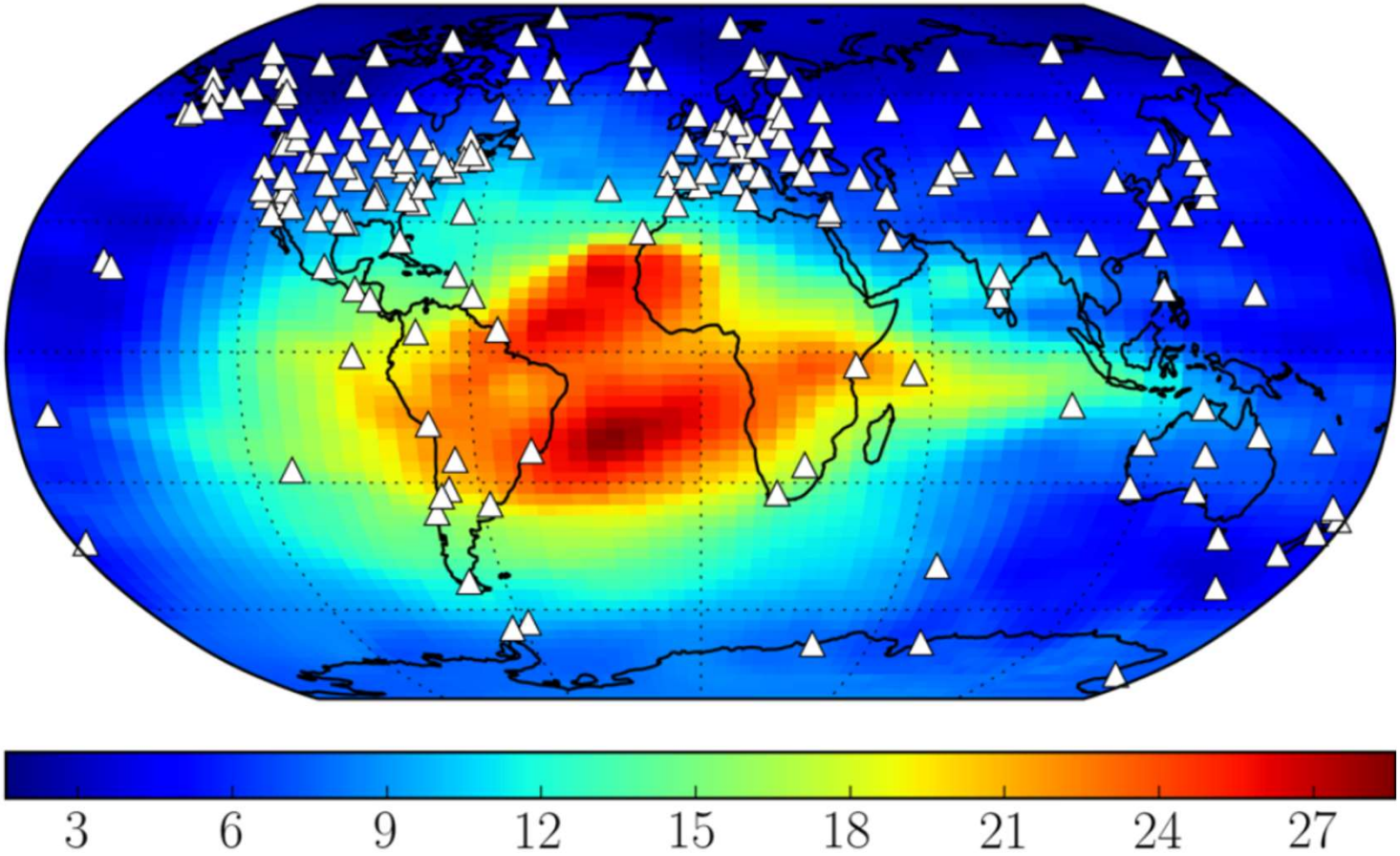
CHAIN (23) –
измерения мерцаний и данные с высоким разрешением

MGEX (5) – multiGNSS and high resolution data

*01.01.2017

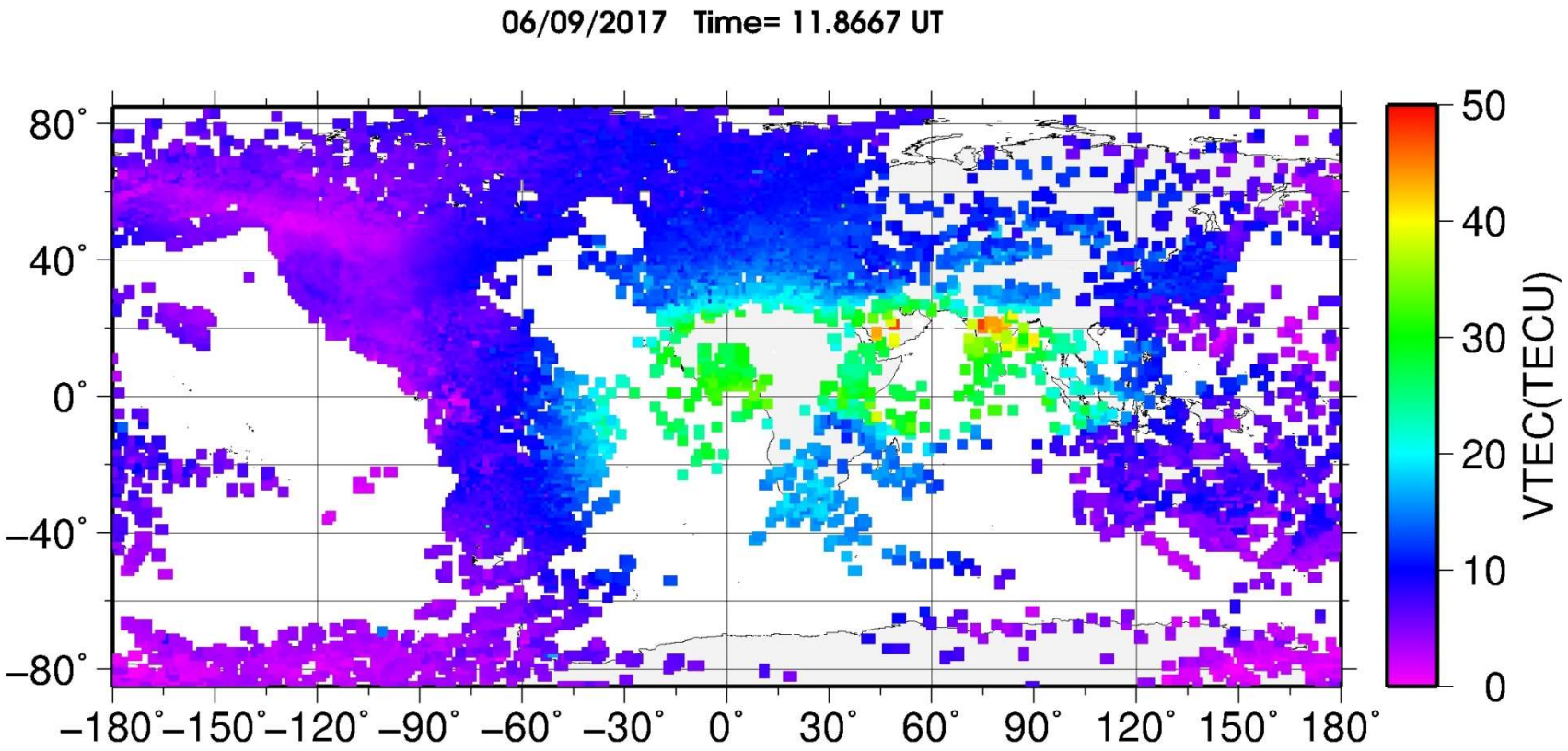


Global ionosphere maps (GIM) of Vertical TEC

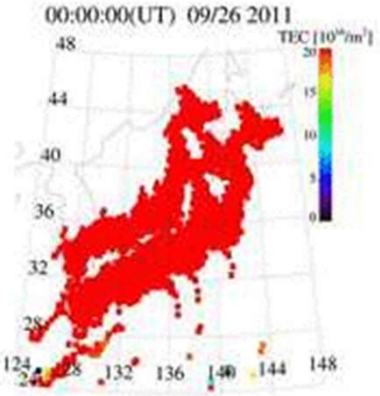


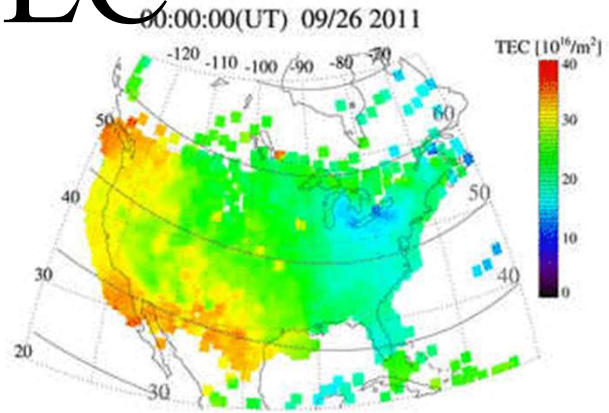
Several laboratories produce GIM (CODE, JPL, UPC, ESA, IGS). Highest time resolution – 15 min (UPC).

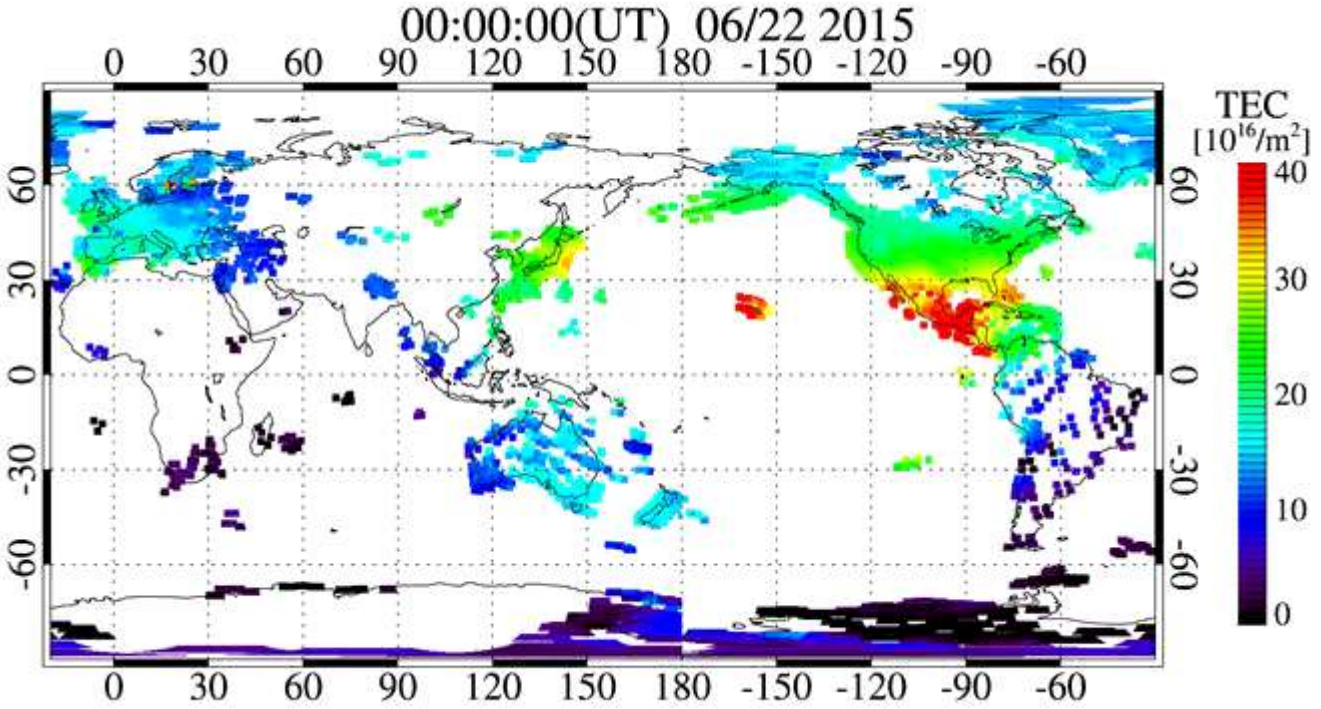
Madrigal Database at Haystack Observatory: Vertical TEC



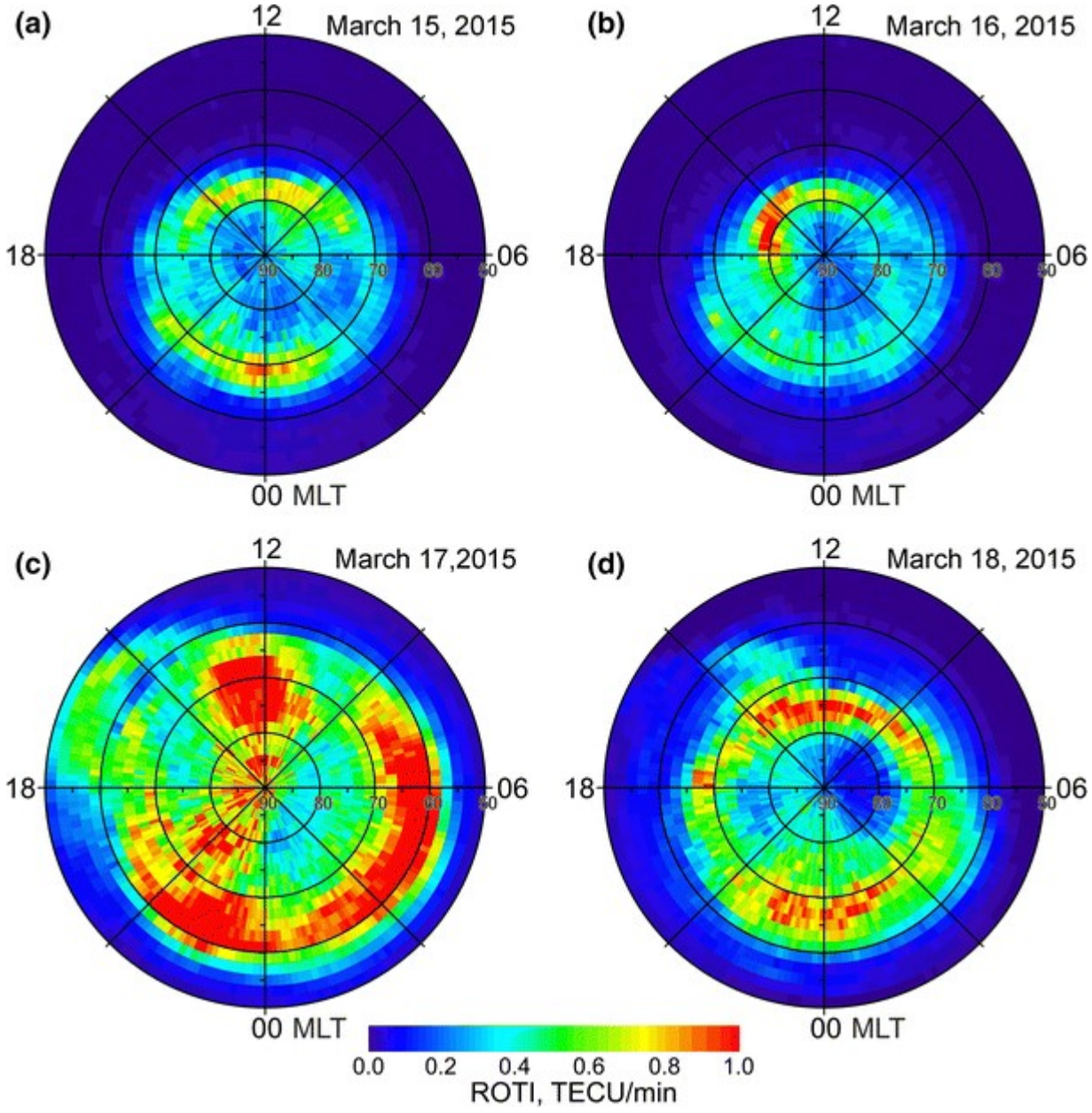
DRAWING-TEC


00:00:00(UT) 09/26 2011
TEC [10^16/m^2]


00:00:00(UT) 09/26 2011
TEC [10^16/m^2]


00:00:00(UT) 06/22 2015
TEC
[10^16/m^2]

IGS: ROTI maps – new product



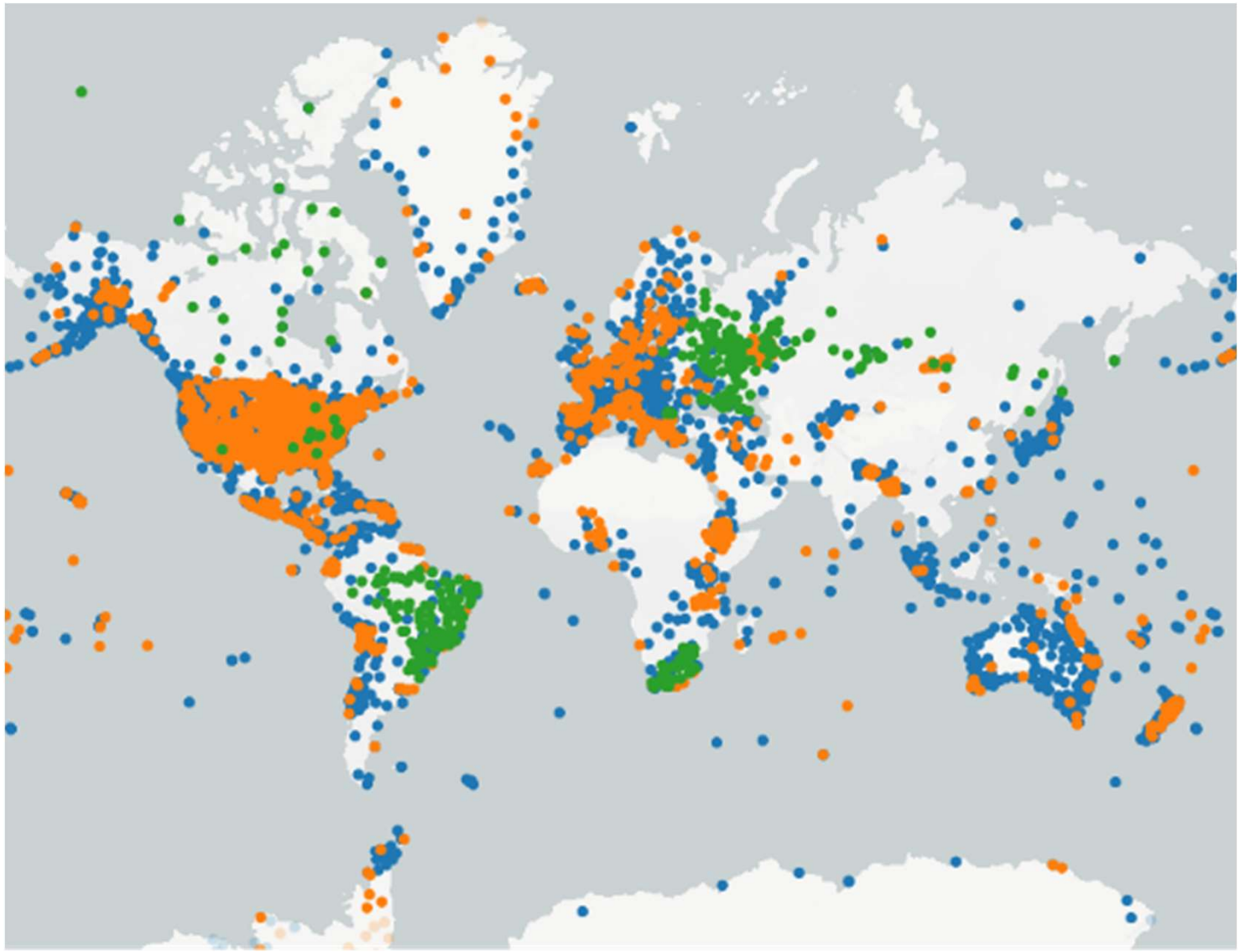
Our tasks

1) “Ionosphere” maps of high time-space resolution.
2) Treat data from a lot of sources.
3) Treat data from all GNSS: GPS, GLONASS, Galileo, Beidou (+SBAS).

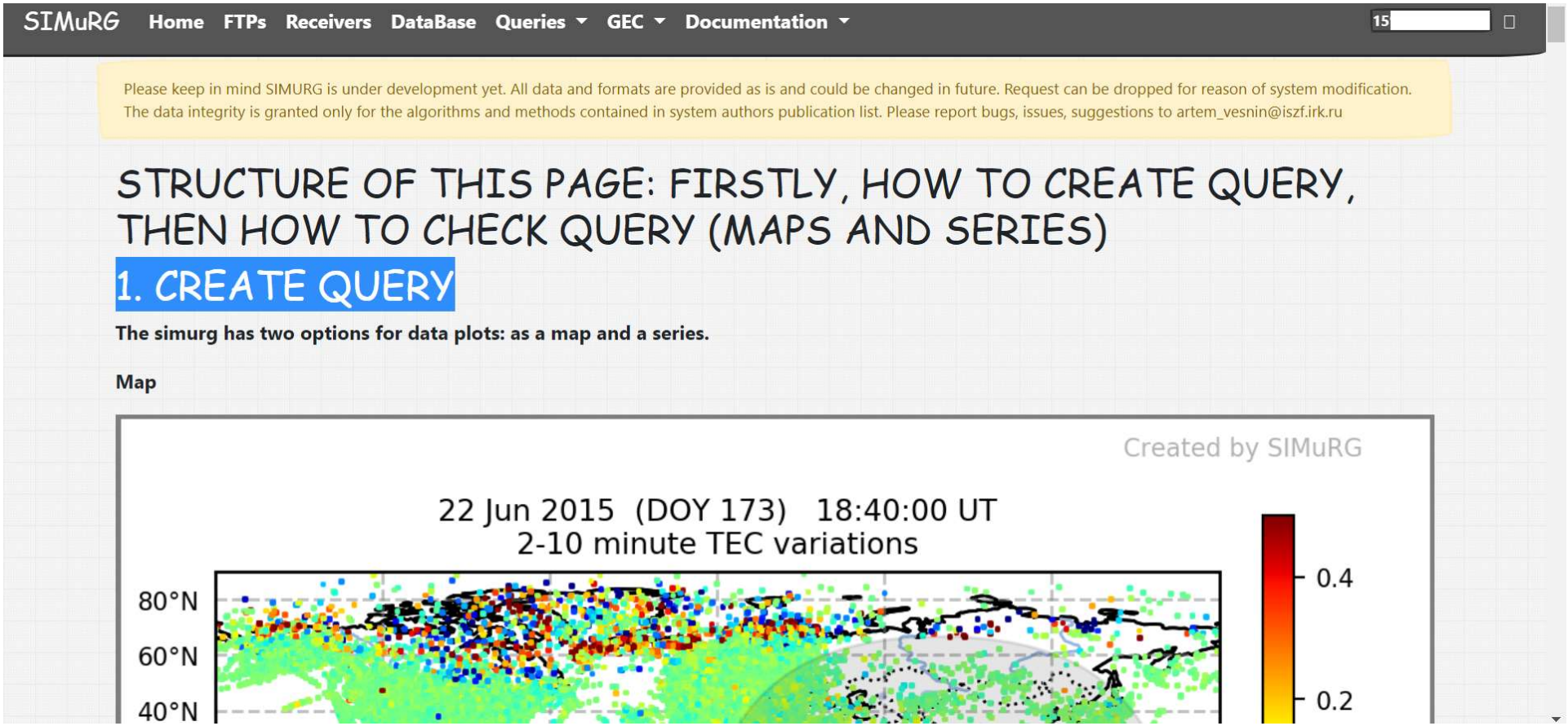
SIMuRG:
System for the Ionosphere Monitoring and Researching from GNSS

https://simurg.iszf.irk.ru/

Stations



https://simurg.iszf.irk.ru/



Flow to treat the GNSS Rinex data

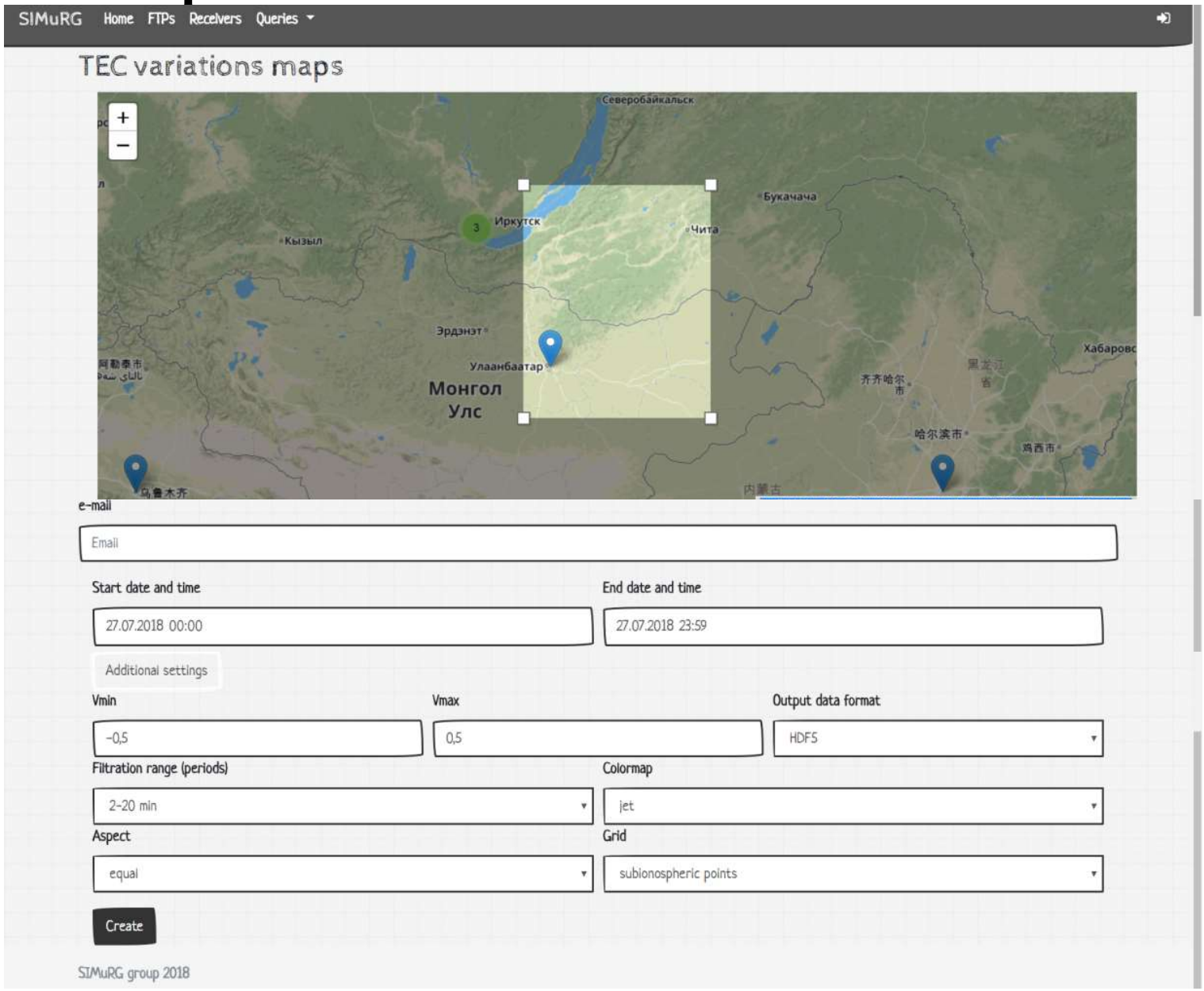
- Download data (navigation and observations).
- TEC calculation from phase and pseudorange.
- Elevations and azimuths calculation.
- Variation filtering.
- Database.
- Maps of TEC variations.
- * Preliminary analysis.

SIMuRG products

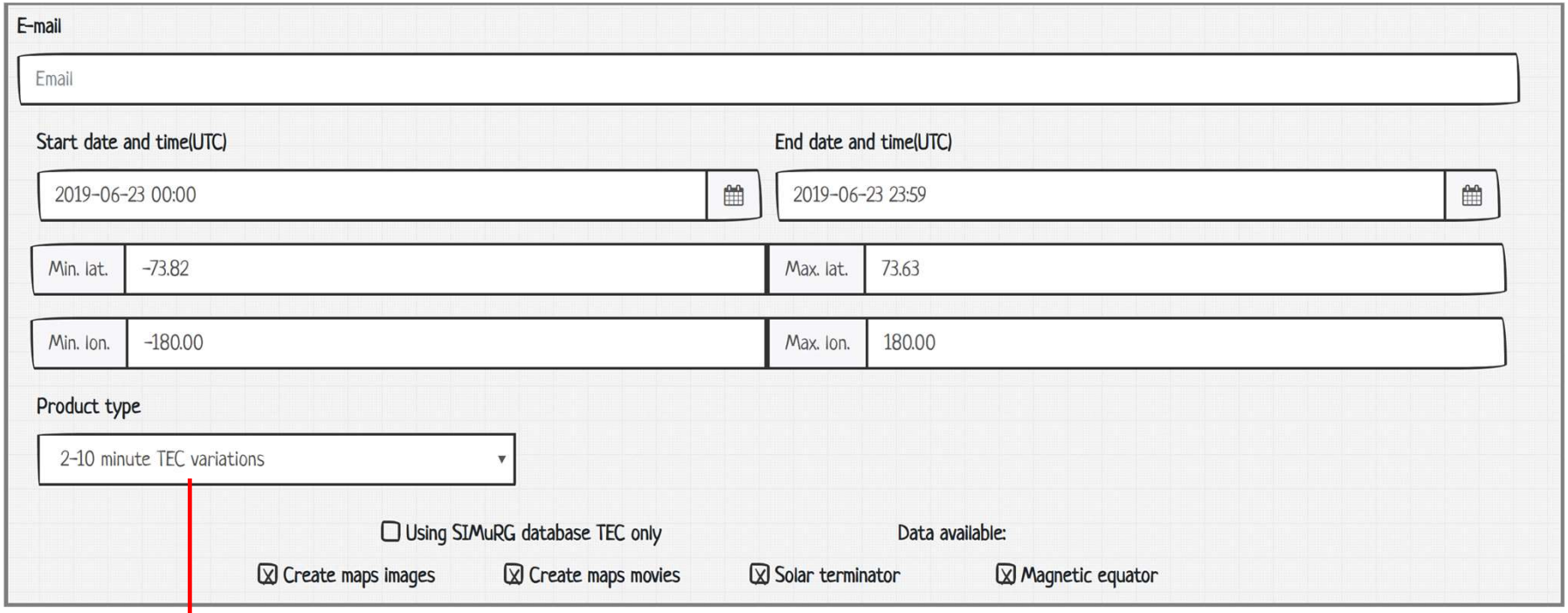
1) Global and regional maps
2) Data from a single station
3) Secondary data treatment

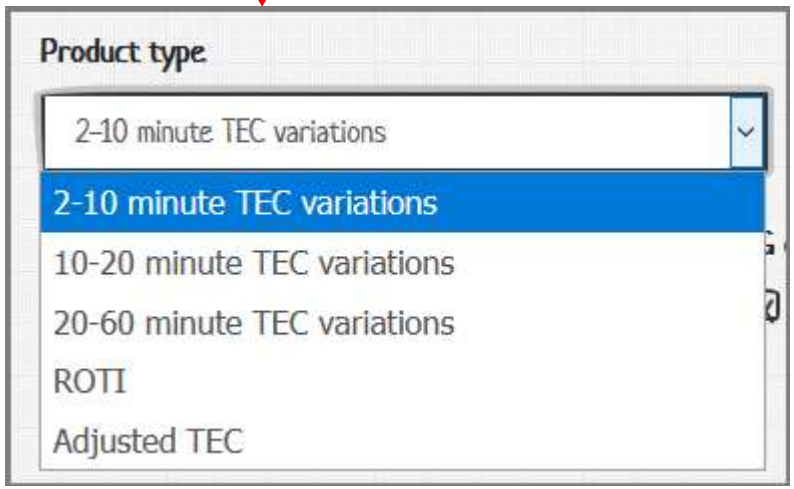
1) TEC variations of 2-10 min, 10-20 min, 20-60 min
2) ROTI
3) TEC adjusted

Graphical interface vs API



SIMuRG


E-mail
Email
Start date and time(UTC)
End date and time(UTC)
2019-06-23 00:00
2019-06-23 23:59
Min. lat.
-73.82
Max. lat.
73.63
Min. lon.
-180.00
Max. lon.
180.00
Product type
2-10 minute TEC variations
Using SIMuRG database TEC only
Data available:
Create maps images
Create maps movies
Solar terminator
Magnetic equator


Product type
2-10 minute TEC variations
2-10 minute TEC variations
10-20 minute TEC variations
20-60 minute TEC variations
ROTI
Adjusted TEC

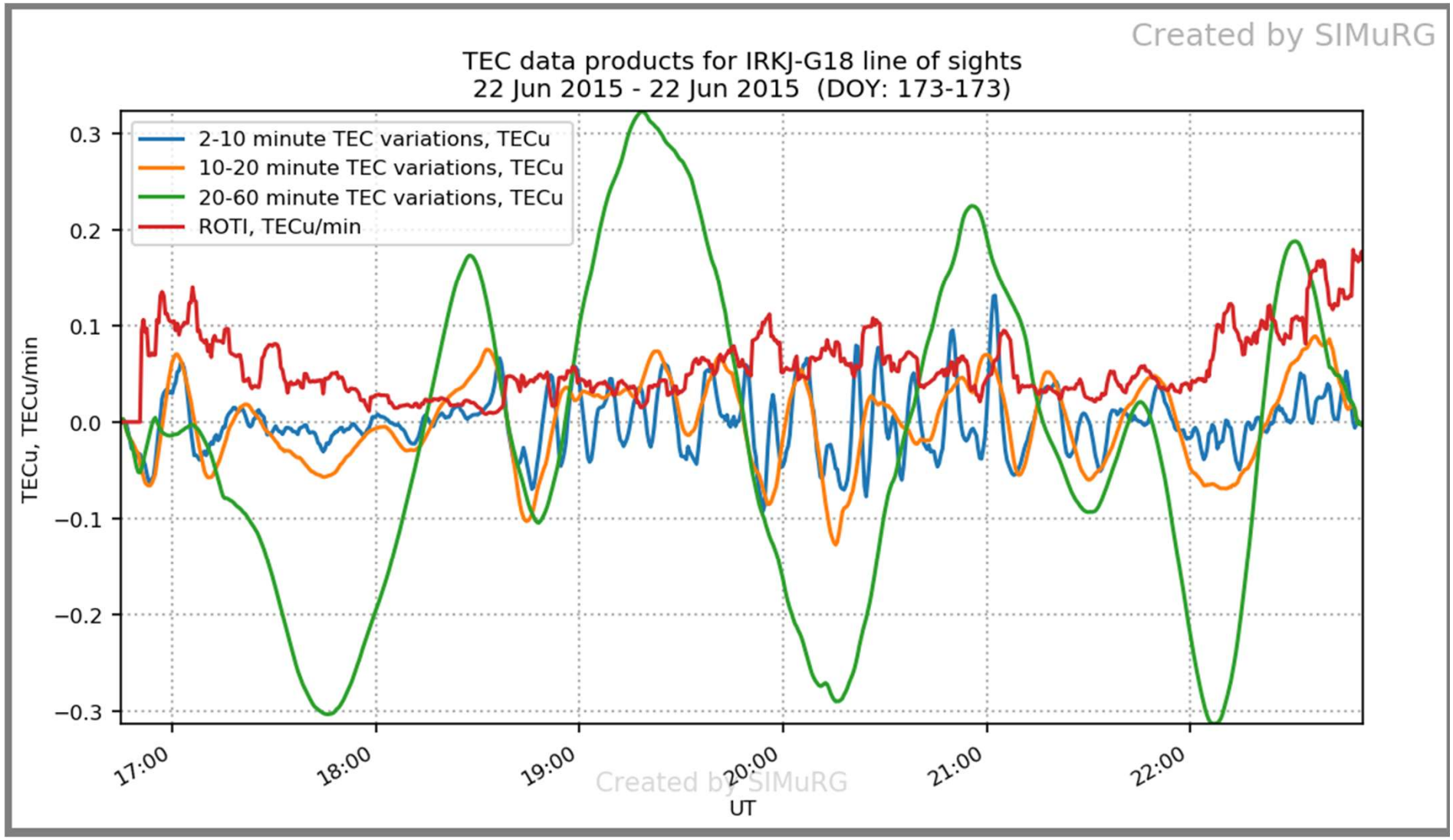
Graphical interface vs API

API for SIMuRG use JSON-format both for queries/requests and its replies. API for SIMuRG is under development. Please, check method names by request:

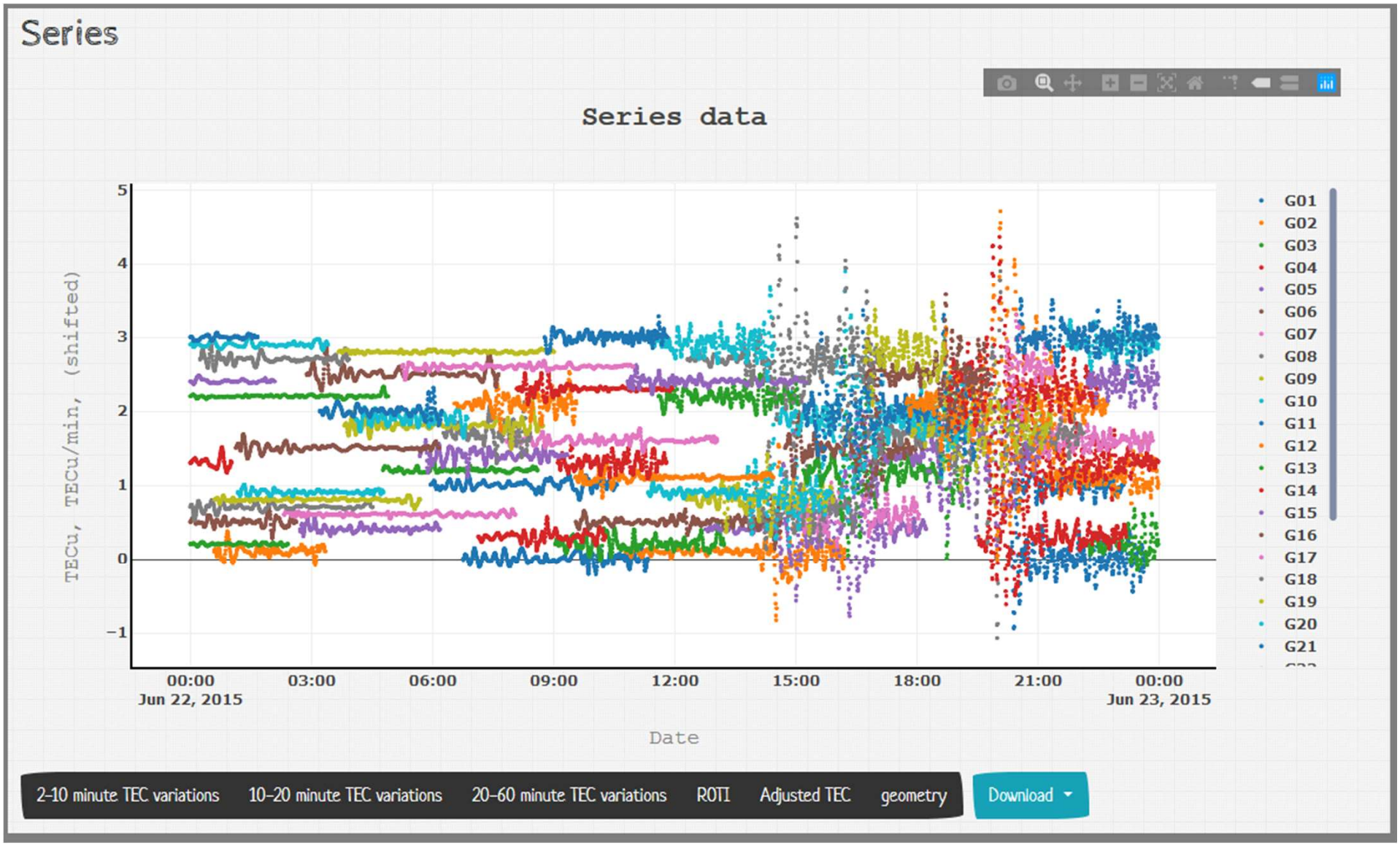
▼ Подробнее

```
import json
import requests
rq = requests.post("https://simurg.iszf.irk.ru/api",
                   json={"method": "get_list_of_methods", # This method
                         # provides you list of our methods
                         "args": {} # It doesn't need any arguments
                        }
                  )
methods = rq.json()
print(methods)
```

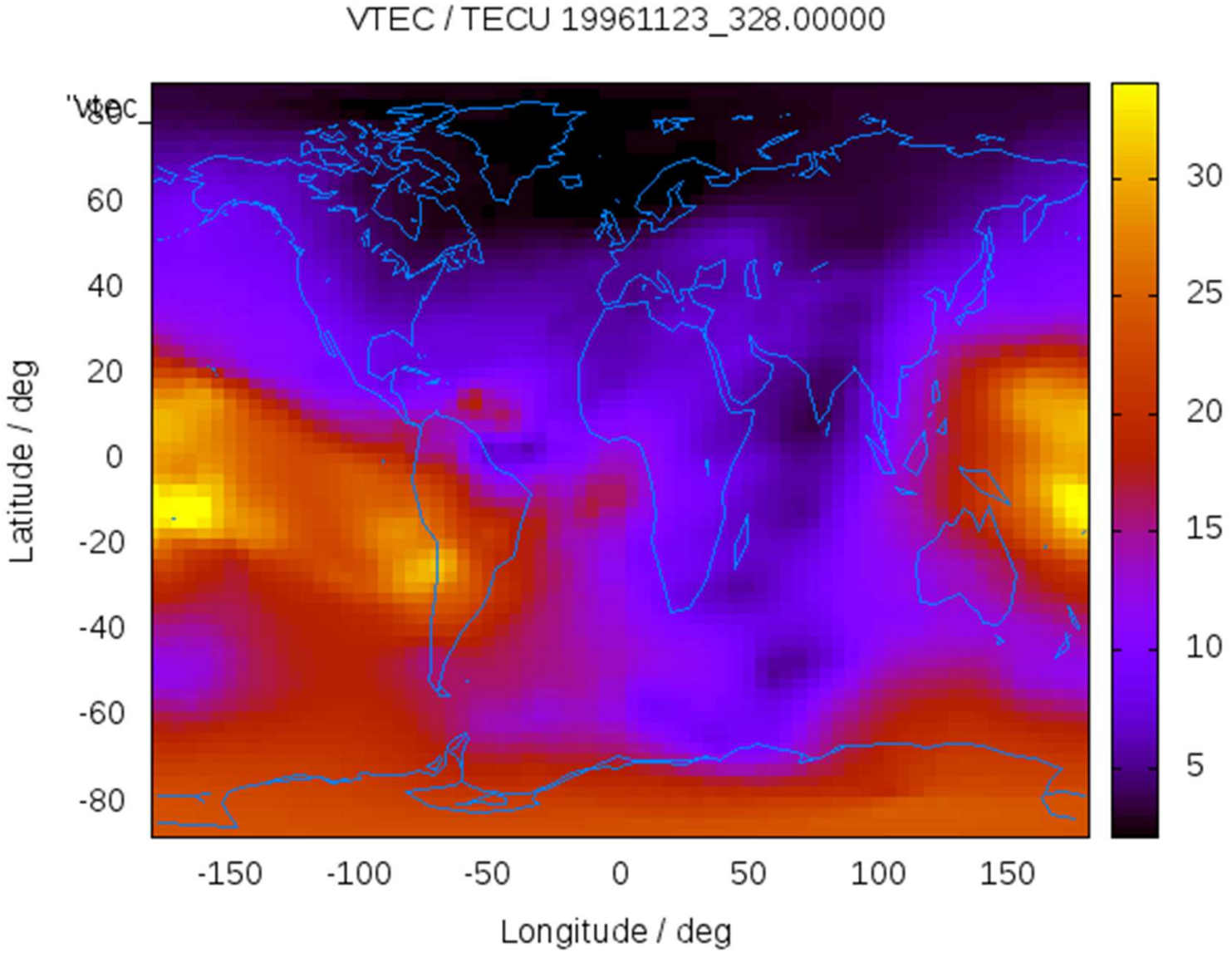
SIMuRG: data series



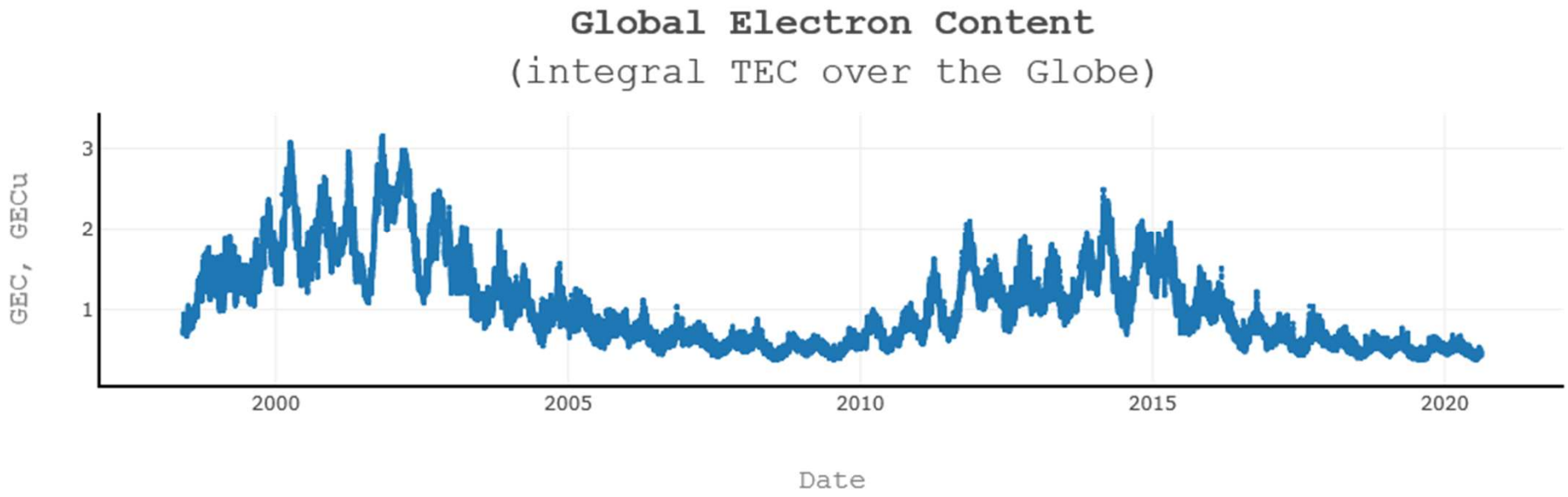
SIMuRG: data series



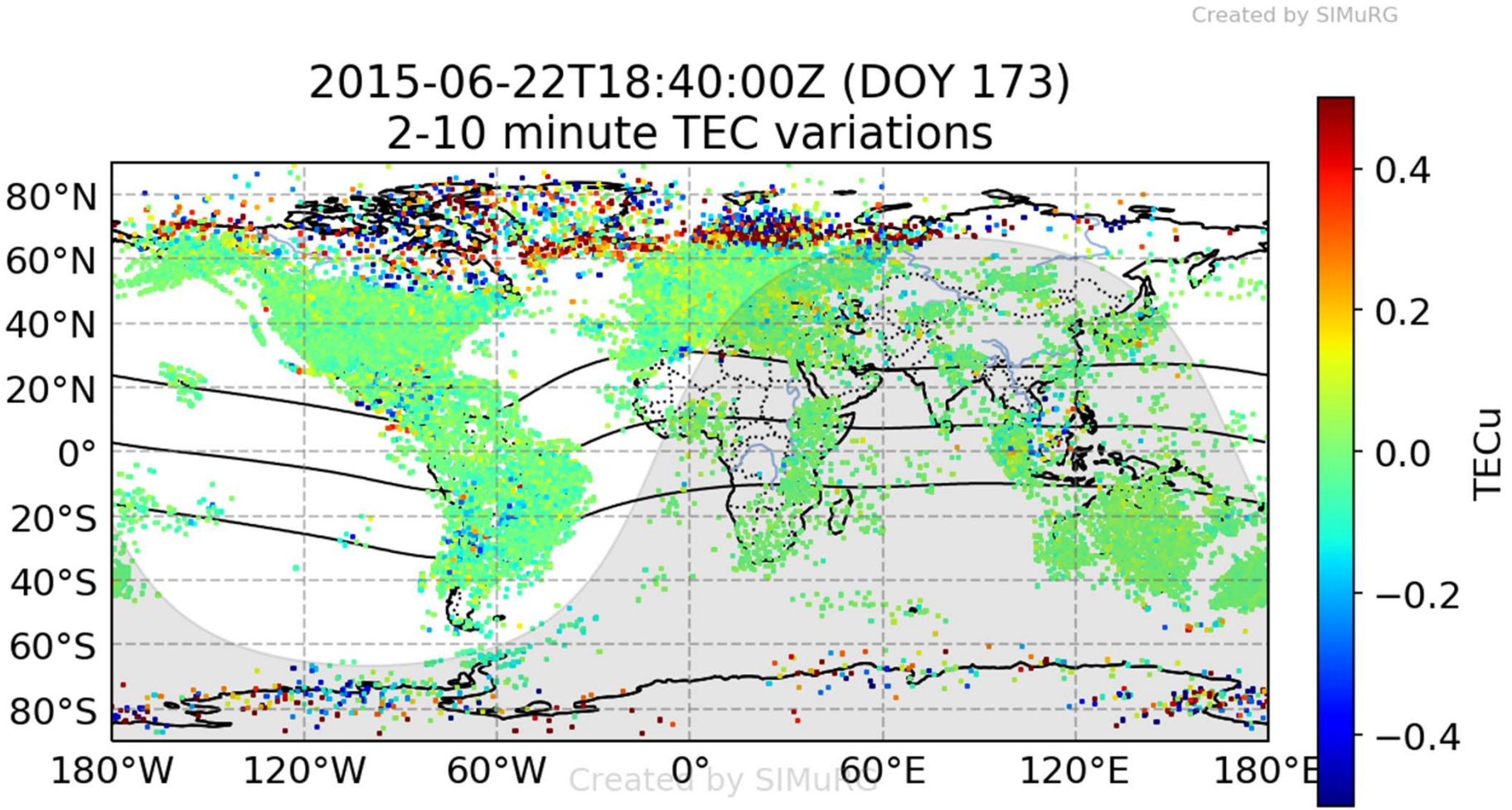
SIMuRG: global electron content



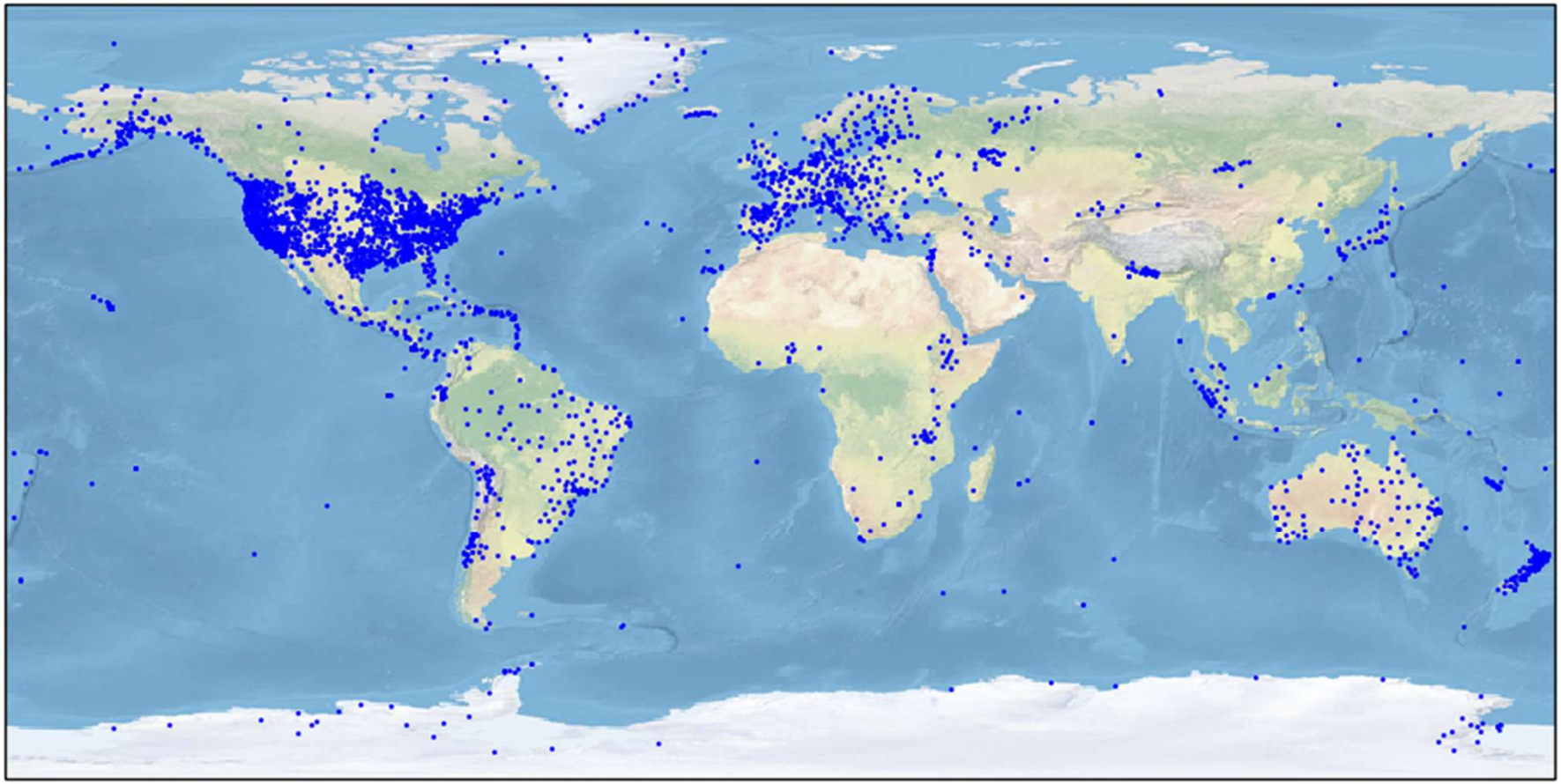
SIMuRG: глобальное электронное содержание



SIMuRG: 2-10 min TEC variations maps

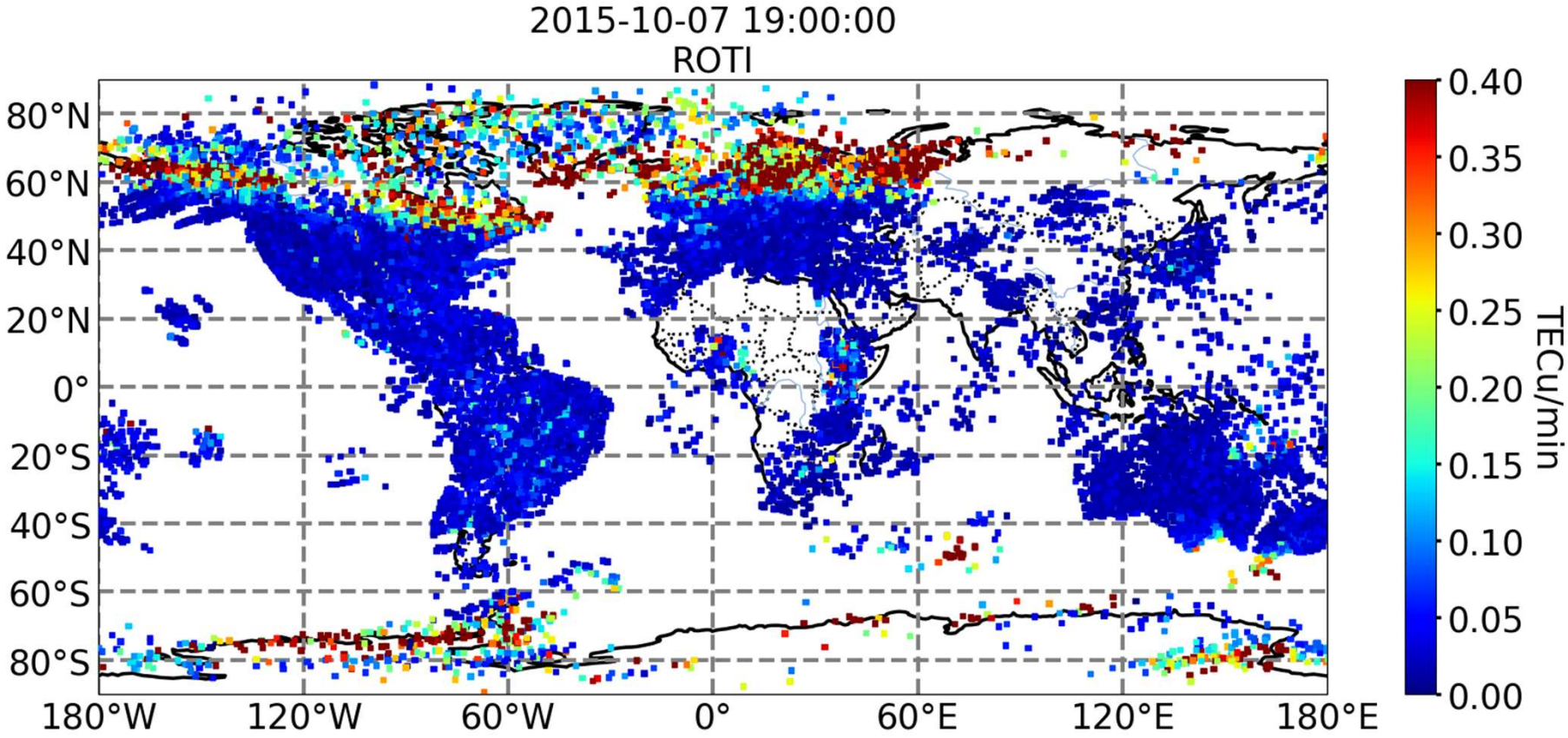


SIMuRG

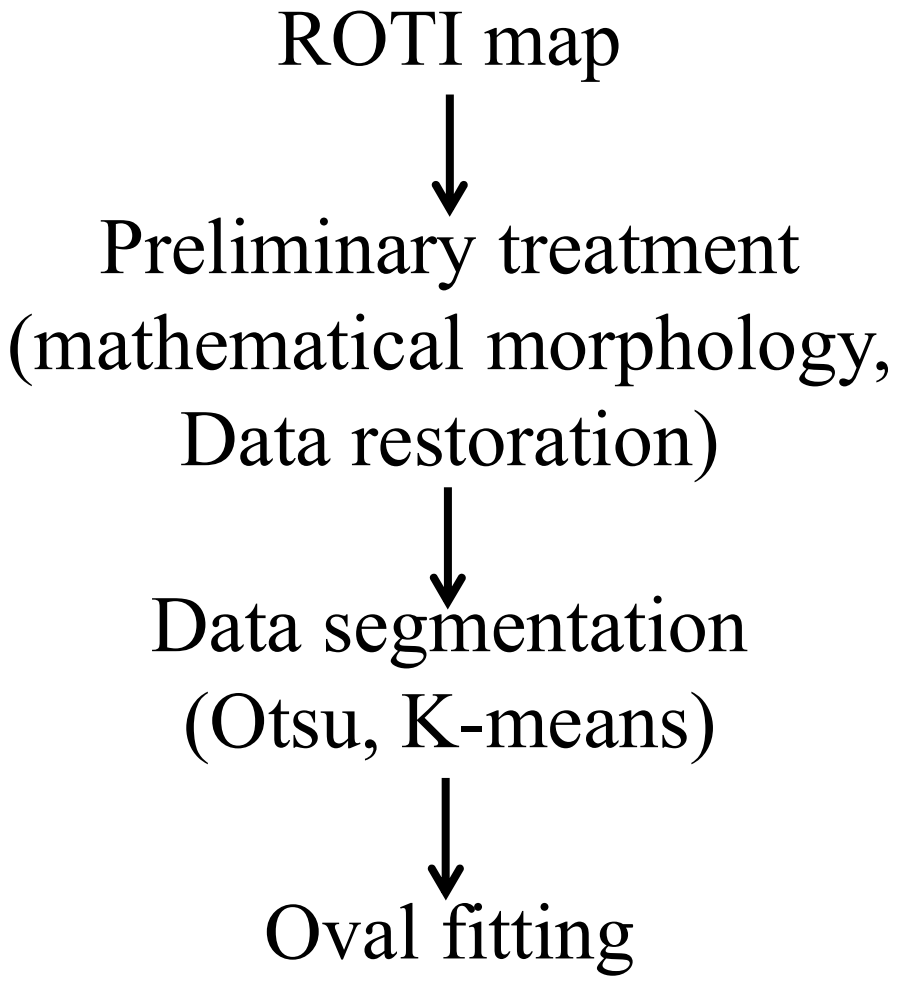


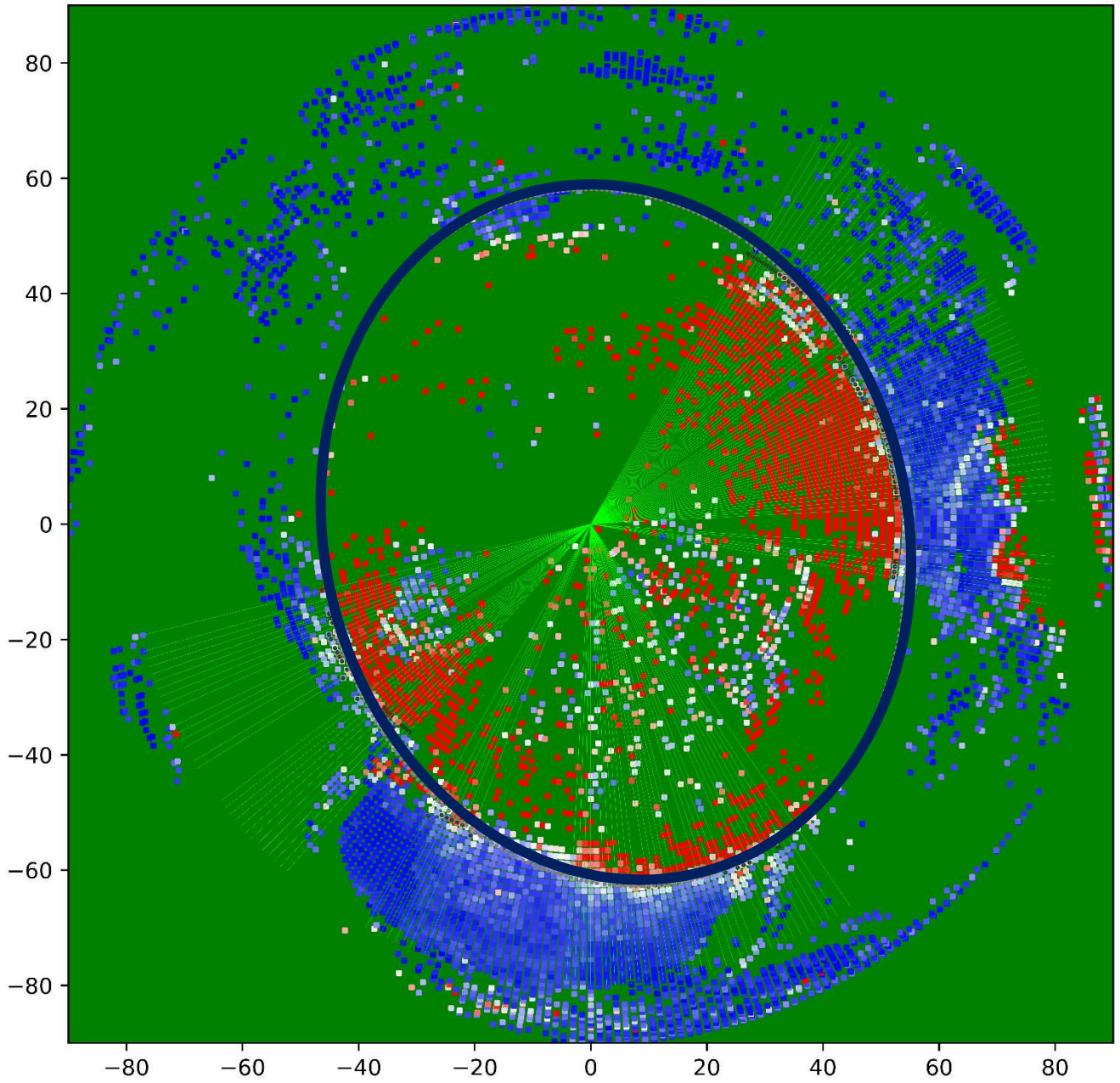
For provided GNSS data we acknowledge: Austrian data center (BEV), Northern California Earthquake Data Center, Pacific Northwest Geodetic Array (PANGA), INGV - Rete Integrata Nazionale GPS, Institute of Geodynamics, National Observatory of Athens, Dutch Permanent GNSS Array (DPGA), Scripps Orbit and Permanent Array Center, UCSD\cite(Dow2009), Earth Observatory of Singapore, Royal Observatory of Belgium\cite(Bruyninx2012), REseau NAtional GPS permanent (RENAG), Institute of solar-terrestrial physics SB RAS \cite(Yasyukevich2018).

SIMuRG: ROTI maps



Computer vision




80
60
40
20
0
−20
−40
−60
−80
−80
−60
−40
−20
0
20
40
60
80

Instead conclusion

It is free-to-use system - https://simurg.iszf.irk.ru/

We will be glad if

1) Someone would like to use SIMuRG and need assistance.
2) You find any errors.
3) You have some suggestions how to improve or where to apply.
4) You are ready to exchange your data or would like to incorporate your data in the system.

Just mail me!

yu.yasyukevich@gnss-lab.org

Thank you for attantion!

simurg.iszf.irk.ru

yu.yasyukevich@gnss-lab.org

Yasyukevich, Y.V., Kiselev, A.V., Zhivetiev, I.V. *et al.* SIMuRG: System for Ionosphere Monitoring and Research from GNSS. *GPS Solut* 24, 69 (2020). https://doi.org/10.1007/s10291-020-00983-2

Ю.В. Ясюкевич, А.С. Ясюкевич. Взгляд на ионосферу земли через GPS и ГЛОНАСС // Земля и Вселенная. 2020. DOI: 10.7868/S0044394820040064