The SWIT-eSWua system: managing, preservation and sharing of the historical and near real-time ionospheric data at the INGV

Emanuele Pica[1], Carlo Marcocci[1], Claudio Cesaroni[1], Enrico Zuccheretti[1], Michael Pezzopane[1], Simone Vecchi[1], Vincenzo ROMANO[1], and Luca SPOGLI[1]

[1]Istituto Nazionale di Geofisica e Vulcanologia (INGV)

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Abstract

The Istituto Nazionale di Geofisica e Vulcanologia (INGV) has a long tradition in collecting scientific data to support upper atmosphere physics research. In addition to the historical equipment no longer operative, an ever-growing number of permanent observatories at high, low, and middle latitudes are part of the INGV network dedicated to the ionospheric and Space Weather monitoring. The management of the data produced by such a dynamic infrastructure required the development of an IT system capable to fulfill several requirements. Among them, the capability to manage and provide access to the continuous flow of information produced by the remote instruments and, at the same time, guarantee the preservation and availability of the historical series, a valuable legacy of this scientific field. To meet these needs, the SWIT-eSWua system was developed and has recently came into operation. The SWIT (Space Weather Information Technology) database management system can store a huge amount of spatially and temporally distributed data, standardizing the observations performed by different instruments and making them available in near real-time. The system is based on open-source software and containers-based virtualization, an architecture that potentially could be deployed in other research facilities to realize a distributed ionospheric monitoring network. The eSWua (electronic Space Weather upper atmosphere) access layer includes several services that allow to share these data with the scientific community. The web-platform (www.eswua.ingv.it) allows to explore, analyse and download all the different kind of historical and real-time data collected by SWIT at multiple levels of elaboration. A dedicated RESTful web-service, a registry for the metadata, the implementation of open data policy and persistent identifiers are just some of the other components which are being integrated into this layer. This work will provide a global view of the SWIT-eSWua architecture and describe the best practices implemented toward the long-term preservation of these data and the realization of a FAIR ecosystem.

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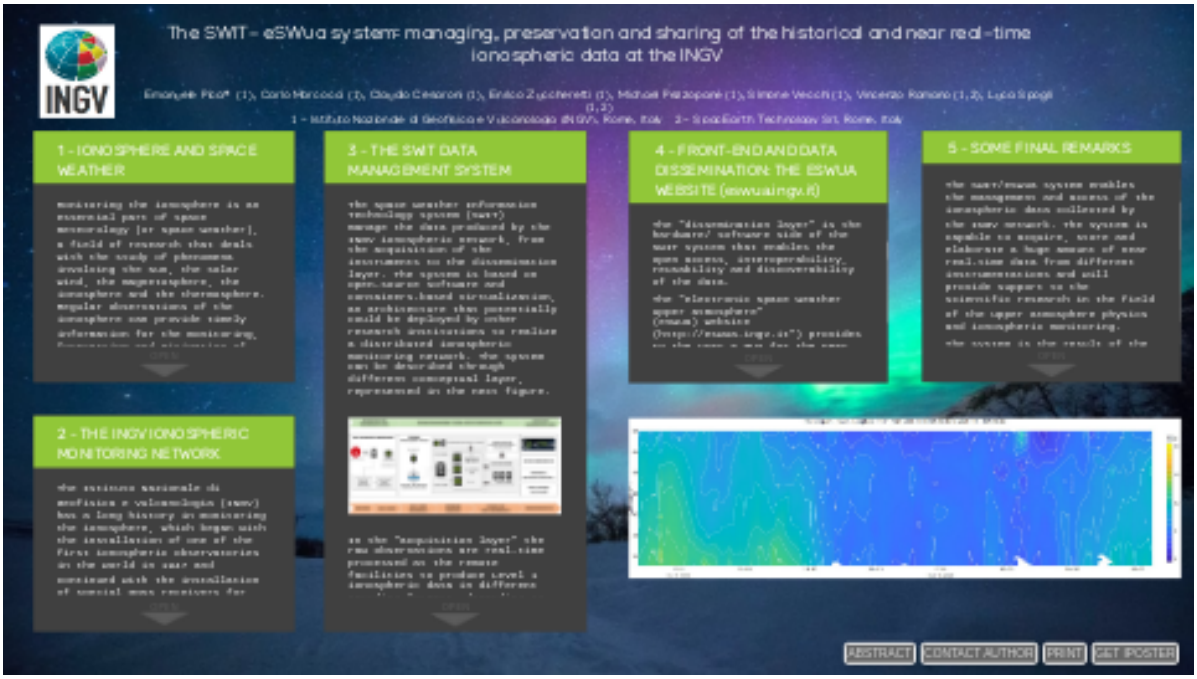

ENTER AUTHOR NAMES

Emanuele Pica* (1), Carlo Marcocci (1), Claudio Cesaroni (1), Enrico Zuccheretti (1), Michael Pezzopane (1), Simone Vecchi (1), Vincenzo Romano (1,2), Luca Spogli (1,2)

1 - Istituto Nazionale di Geofisica e Vulcanologia (INGV), Rome, Italy 2- SpacEarth Technology Srl, Rome, Italy

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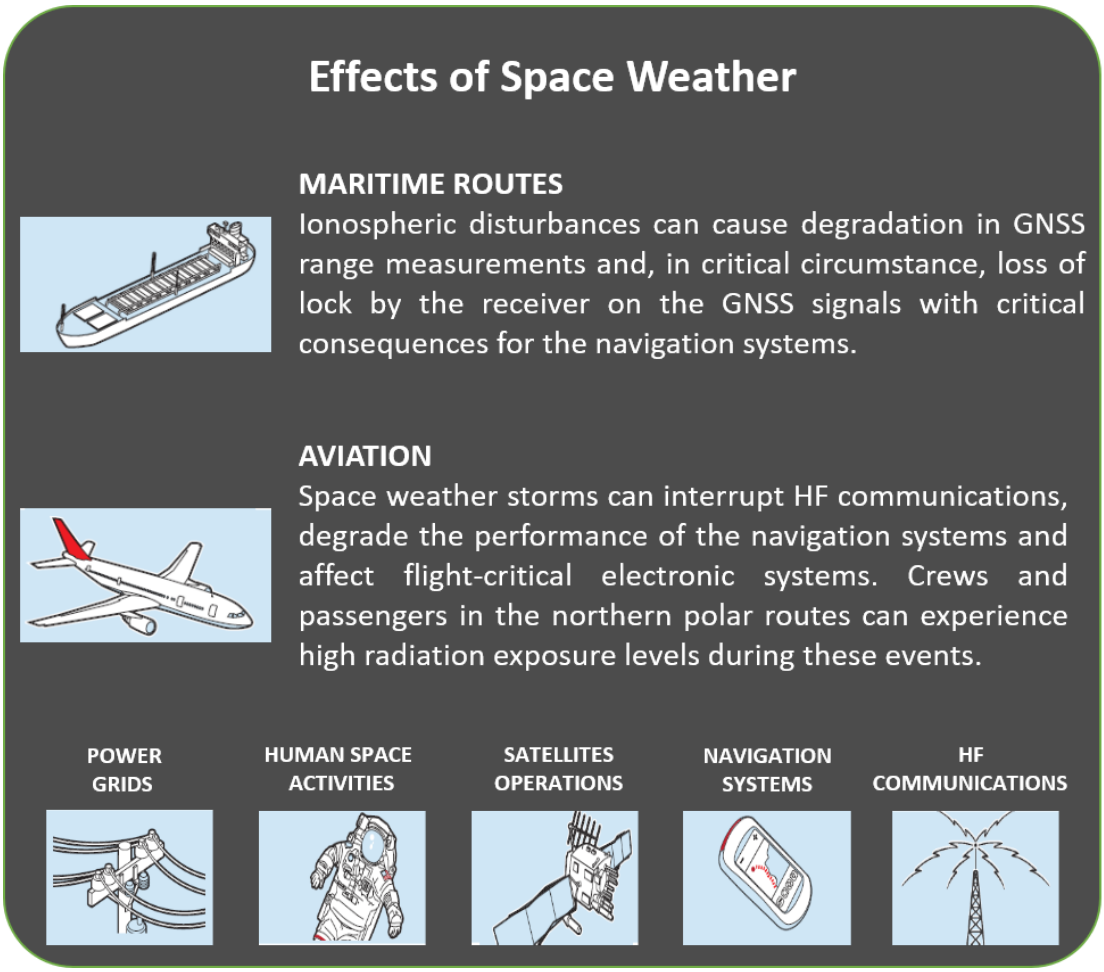
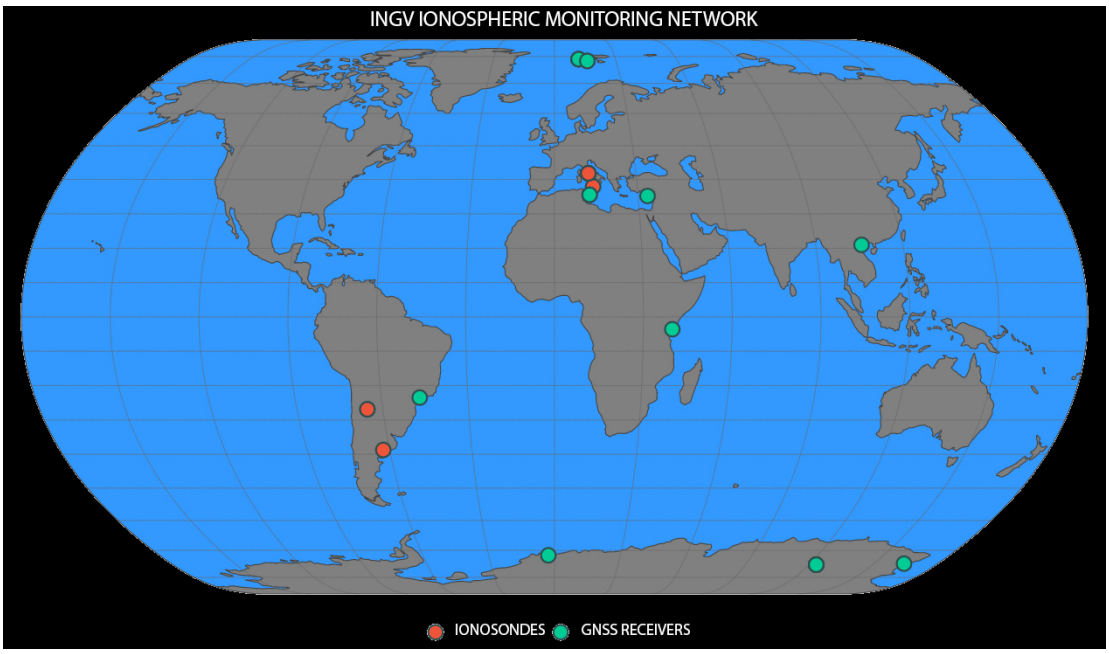
1 - IONOSPHERE AND SPACE WEATHER

Monitoring the ionosphere is an essential part of space meteorology (or Space Weather), a field of research that deals with the study of phenomena involving the Sun, the solar wind, the magnetosphere, the ionosphere and the thermosphere. Regular observations of the ionosphere can provide timely information for the monitoring, forecasting and mitigation of the effects on several modern technologies (such as telecommunication systems, power networks and in general systems relying on satellite navigation) during Space Weather events.



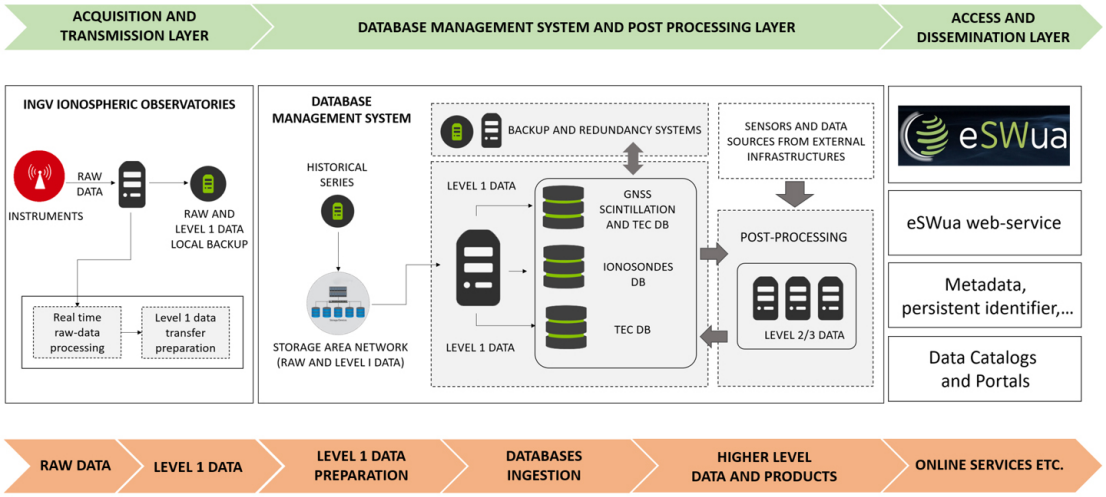
2 - THE INGV IONOSPHERIC MONITORING NETWORK

The Istituto Nazionale di Geofisica e Vulcanologia (INGV) has a long history in monitoring the ionosphere, which began with the installation of one of the first ionospheric observatories in the world in 1947 and continued with the installation of special GNSS receivers for ionospheric monitoring at high, medium and low latitudes starting from early 2000s. To date, nearly twenty scientific instruments (ionosondes and GNSS receivers for TEC and scintillations monitoring) operate permanently in the network, producing a large amount of data in near real-time every day.



3 - THE SWIT DATA MANAGEMENT SYSTEM

The Space Weather Information Technology system (SWIT) manage the data produced by the INGV ionospheric network, from the acquisition of the instruments to the dissemination layer. The system is based on open-source software and containers-based virtualization, an architecture that potentially could be deployed by other research institutions to realize a distributed ionospheric monitoring network. The system can be described through different conceptual layer, represented in the next figure.



In the "acquisition layer" the raw observations are real-time processed at the remote facilities to produce Level 1 ionospheric data in different encoding formats, depending on the particular acquisition instrument. A copy of the raw-data is locally stored while the Level-1 data (and the raw data when possible) are transmitted in near real-time to the INGV central repository in Rome.

In the "database management system (DBMS) layer", the Level-1 data coming from the remote stations are collected at the INGV storage area network where automatic procedures harvest and elaborate the files. The DBMS is capable to autonomously recognize the provenance of the Level 1 data, triggering the proper procedures to validate and insert the information into different relational databases. The system allows to standardize spatially and temporally distributed data coming in near real-time from different sources as well as to organize the historical observations of the instruments no more operative.

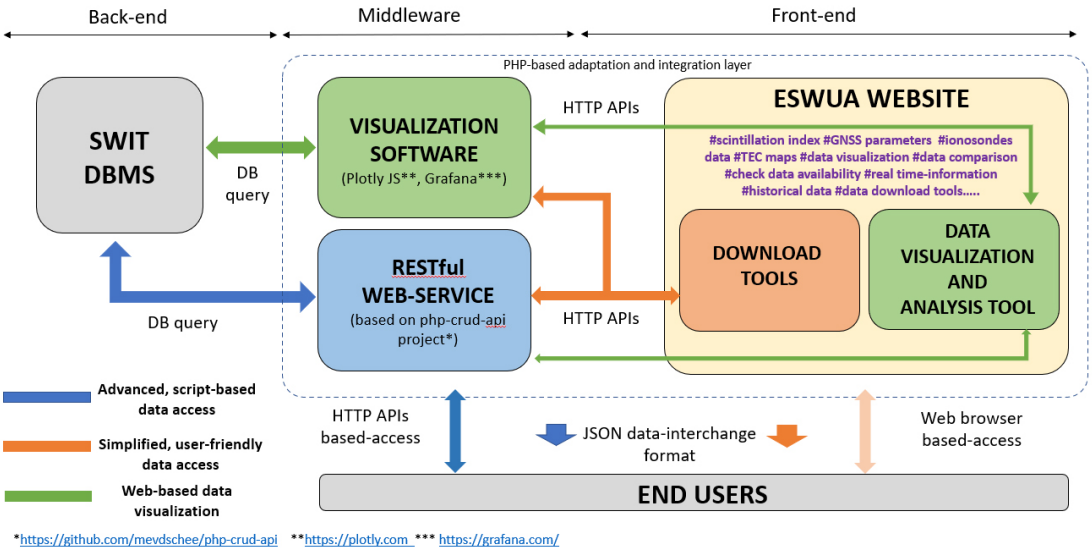
In the “post-processing layer”, the data collected by the DBMS are exploited to build and validate scientific models and are further processed to produce higher-level data and ionospheric space weather targeted products. This system also integrates data sources from external infrastructure such as the Italian RING network (http://ring.gm.ingv.it), the EUREF permanent GNSS network (http://www.epncb.oma.be) and the IGS network (http://www.igs.org).

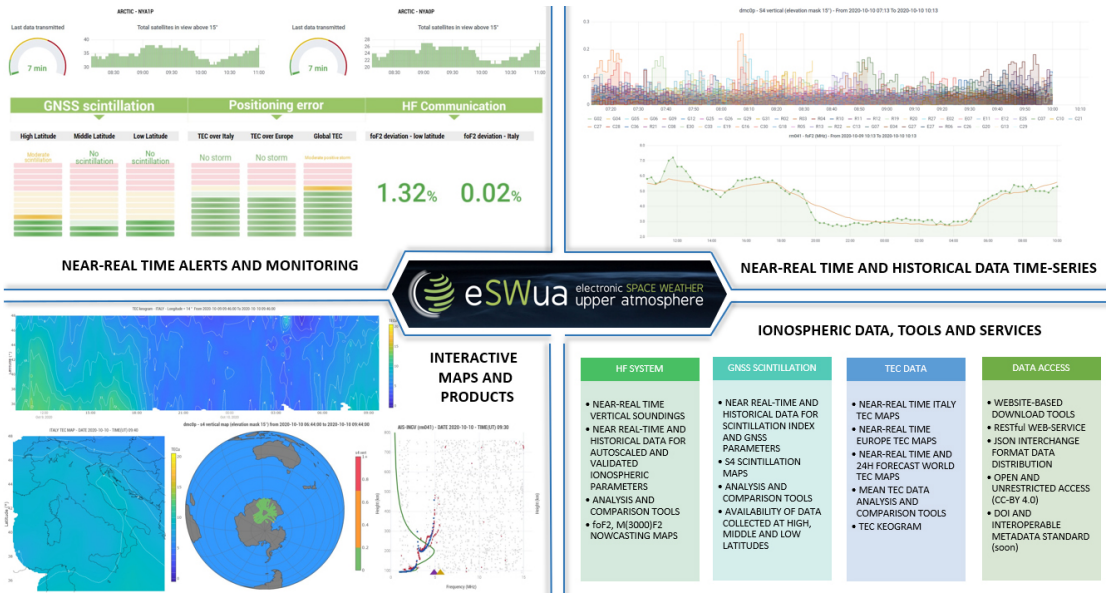
Finally, there is the "dissemination layer" that is described in the next section.

4 - FRONT-END AND DATA DISSEMINATION: THE ESWUA WEBSITE (ESWUA.INGV.IT)

The "dissemination layer" is the hardware/ software side of the SWIT system that enables the open access, interoperability, reusability and discoverability of the data.

The "electronic Space Weather upper atmosphere" (eSWua) website (http://eswua.ingv.it") provides to the user a GUI for the near real-time and historical data visualization. This platform allows to query the databases in multiple ways, providing data and products at different levels of elaboration. A RESTful web-service and web-based tools provide free access to the data: the information can be filtered by several criteria and downloaded in the JSON interchange format. A simplified representation of this layer and a list of the products and services provided are presented in the following images.

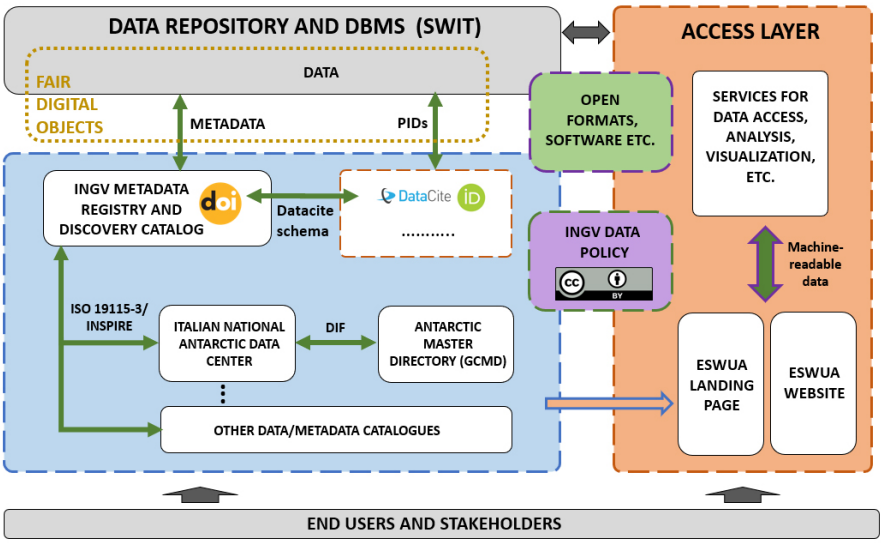




5 - SOME FINAL REMARKS

The SWIT/eSWua system enables the management and access of the ionospheric data collected by the INGV network. The system is capable to acquire, store and elaborate a huge amount of near real-time data from different instrumentations and will provide support to the scientific research in the field of the upper atmosphere physics and ionospheric monitoring.

The system is the result of the work of many people (form researchers to IT specialists). A development approach based on the open science principles and toward the realization of a FAIR ecosystem was adopted; for this ultimate goal, a cooperation between researchers and data managers at international level is needed.



A conceptual view of the SWIT-eSWua ecosystem and an abstraction of its FAIR components

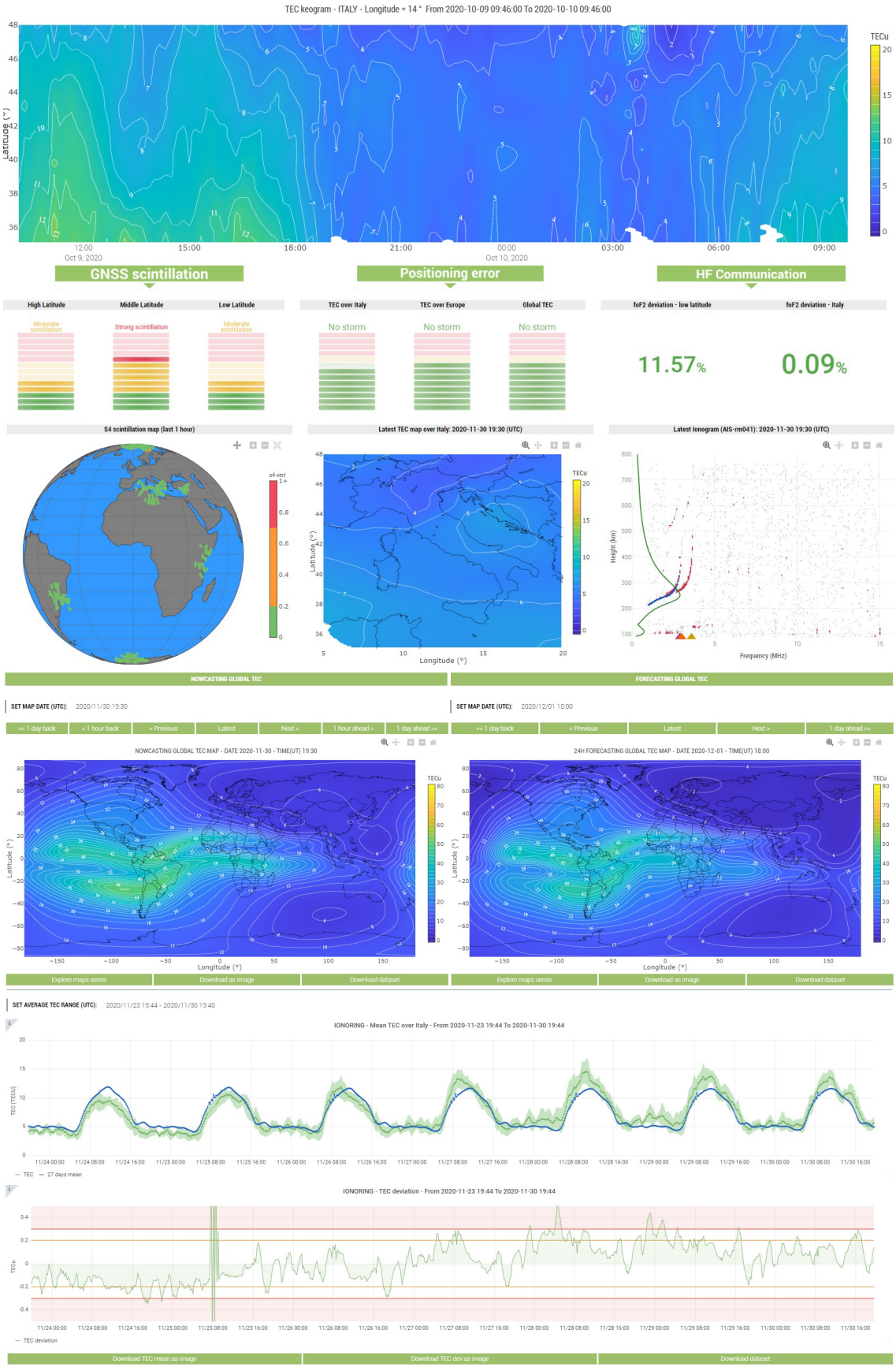
Color legend

Findable

Accessible

Interoperable

Reusable


TEC keogram - ITALY - Longitude = 14 ° From 2020-10-09 09:46:00 To 2020-10-10 09:46:00
Latitude (°)
TECu
Oct 9, 2020
Oct 10, 2020
GNSS scintillation
Positioning error
HF Communication
High Latitude
Middle Latitude
Low Latitude
Moderate scintillation
Strong scintillation
Moderate scintillation
TEC over Italy
TEC over Europe
Global TEC
No storm
No storm
No storm
foF2 deviation - low latitude
foF2 deviation - Italy
11.57%
0.09%
S4 scintillation map (last 1 hour)
s4 vert
Latest TEC map over Italy: 2020-11-30 19:30 (UTC)
Latitude (°)
Longitude (°)
Latest Ionogram (AIS-rm041): 2020-11-30 19:30 (UTC)
Height (km)
Frequency (MHz)
NOWCASTING GLOBAL TEC
FORECASTING GLOBAL TEC
SET MAP DATE (UTC): 2020/11/30 19:30
<< 1 day back
< 1 hour back
< Previous
Latest
Next >
1 hour ahead >
1 day ahead >>
NOWCASTING GLOBAL TEC MAP - DATE 2020-11-30 - TIME(UT) 19:30
Explore maps series
Download as image
Download dataset
SET MAP DATE (UTC): 2020/12/01 18:00
24H FORECASTING GLOBAL TEC MAP - DATE 2020-12-01 - TIME(UT) 18:00
SET AVERAGE TEC RANGE (UTC): 2020/11/23 19:44 - 2020/11/30 19:40
IONORING - Mean TEC over Italy - From 2020-11-23 19:44 To 2020-11-30 19:44
TEC (TECU)
TEC
27 days mean
IONORING - TEC deviation - From 2020-11-23 19:44 To 2020-11-30 19:44
TECu
TEC deviation
Download TEC mean as image
Download TEC dev as image
Download dataset

STATION NAME
STATION CODE
AREA
STATION LATITUDE
STATION LONGITUDE
STATION INSTRUMENT
Rome
rm041
MEDITERRANEAN
41.80
12.50
AIS
Station Location
Latest Ionogram
13 min
Reference time
19:48:43
UTC
rm041 24h parameters - From 2020-11-29 19:30 To 2020-11-30 19:30
foF2
MUF(3000)F2
M(3000)F2
fxI
foF1
fhEs
hEs
<<< One day back
<< One hour back
Latest
One hour ahead >>
One day ahead >>>
AIS-INGV (rm041) - DATE 2020-11-30 - TIME(UT) 19:30
AIS-INGV (rm041) - DATE 2020-11-30 - TIME(UT) 19:15
AIS-INGV (rm041) - DATE 2020-11-30 - TIME(UT) 19:00
AIS-INGV (rm041) - DATE 2020-11-30 - TIME(UT) 18:45
Height (km)
Frequency (MHz)
View full ionogram and parameters
nic0p - S4 vertical (elevation mask 15°) - From 2020-11-30 16:46 To 2020-11-30 19:46
nic0p - SigmaPhi vertical (elevation mask 15°) - From 2020-11-30 16:46 To 2020-11-30 19:46
nic0p - vTec (elevation mask 15°) - From 2020-11-30 16:46 To 2020-11-30 19:46
nic0p - s4 vertical map (elevation mask 15°) from 2020-11-30 16:46:00 to 2020-11-30 19:46:00
Explore data
Download as image
Download dataset

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