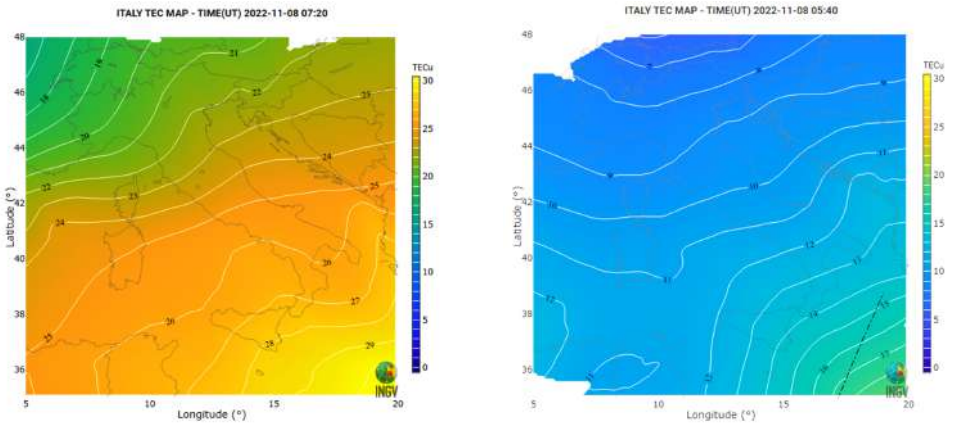
INGV SPACE WEATHER PRODUCTS FOR AVIATION AND HF RADIOCOMMUNICATION

The INGV participates in two important projects PECASUS -Consortium for Aviation Space Weather User Services and SWESNET-Space Weather European Network which aim to improve the monitoring capabilities of the ionosphere over the European area to mitigate the effects of Space Weather on flight operations and HF communications.

THE SPACE WEATHER AND THE IONOSPHERE

The ionosphere over the European area is routinely monitored to provide information on ionospheric conditions that may have an impact on GNSS-based systems and services and on HF communications. The ionosphere is disturbed during geospheric storms, which occur especially - but not only - when solar activity is high. Nowcasting and forecasting products of the ionospheric conditions are provided leveraging on ionosonde data and TEC (Total Electron Content) data. The TEC expresses the electronic content along the radio link connecting each pair receiver-GNSS satellite. The ionosonde data provides the maximum frequency that can be used to establish a HF link over the standard distance of 3000 km.

Both the ICAO (International Civil Aviation Organization) and the ESA (European Space Agency) support the development of these products respectively through the PECASUS (Partnership for Excellence in Civil Aviation Space weather User Services) and SWESNET (Space Weather Service Network Development and pre-Operation) projects, respectively.

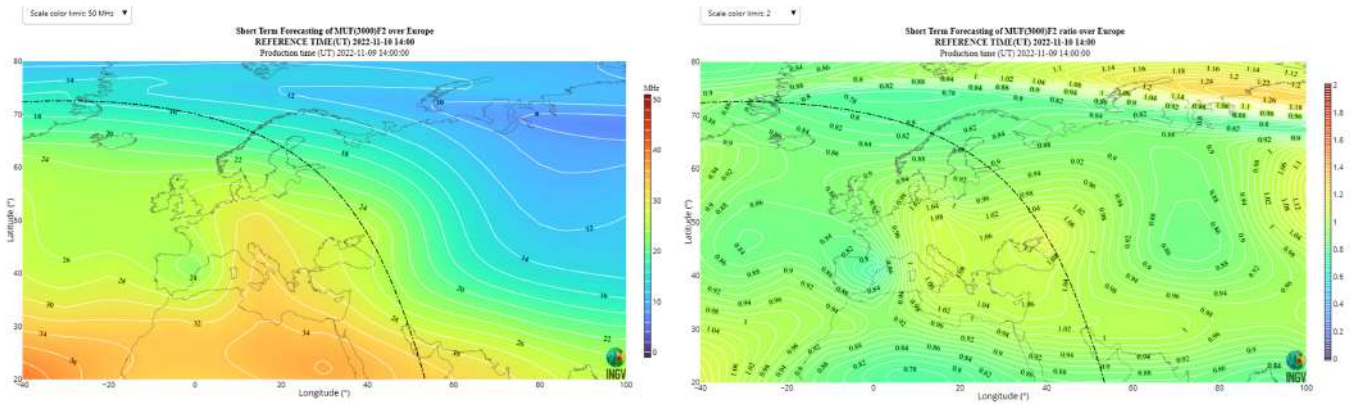


FORECASTING OF TEC OVER ITALY

Based on nowcasting TEC maps over Italy provided by INGV, forecasting vTEC maps over Italy are estimated 30 minutes in advance. New maps are provided every 10 minutes.

SHORT TERM FORECASTING OF MUF(3000)F2 OVER EUROPE

Figures below report the results obtained from EUROMAP, a model to forecast Maximum Usable Frequency (MUF) at a distance=3000 km over Europe.



graphic design Laboratorio Grafica e Immagini | INGV

INGV Space Weather Products for Aviation and Radiocommunication HF

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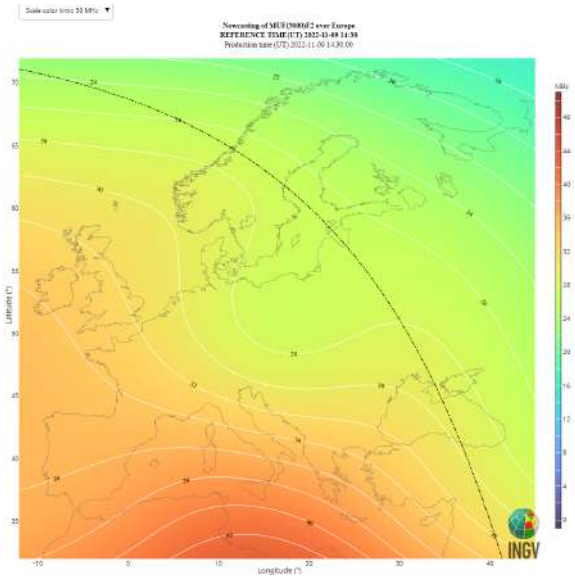
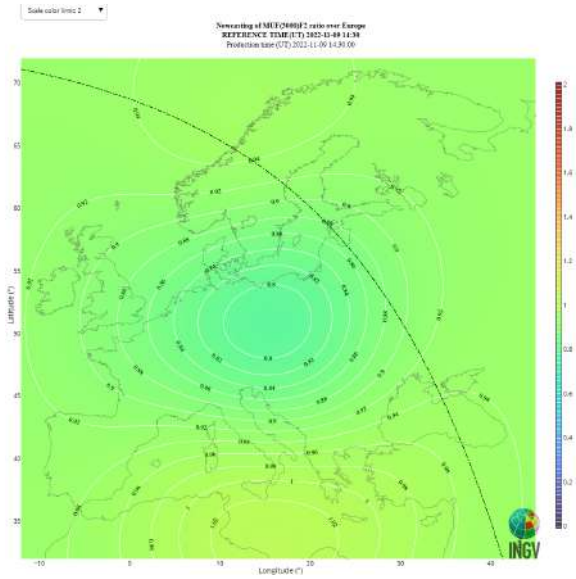
The terrestrial ionosphere is becoming more important to our society with its reliance on modern technology, since the accuracy of positioning and navigation, and quality of telecommunication are influenced by **ionospheric weather**. The ionosphere is a **highly variable environment** that exhibits variation with altitude, latitude, longitude, time of the day, season, solar, and geomagnetic activity. This variability is consequence of the **coupling**, between the ionosphere and thermosphere and the effects of the solar, interplanetary, magnetosphere, mesosphere, stratosphere, troposphere, and even lithosphere processes. The variations of ionosphere are substantially variations of the **electron density distribution**. These variations can adversely affect numerous human activities and systems disrupting communication systems and degrading the performance of radionavigation and systems.
Of course, to define the variations of the ionosphere, it is necessary to define a **background**, which may be considered as a "normal" or "quiet" ionosphere.
For this reason reference is usually made to the "**ionospheric climate**", which is defined as the overall feature of the ionosphere averaged over a **long period** of several years or decades. It provides information about the normal, longer-term, and more permanent conditions of the ionosphere. In contrast, the **ionospheric weather** is the **short-term** variations occurring in minutes to weeks.





Nowcasting of MUF(3000)F2 and MUF(3000)F2 ratio over Europe

The **near real-time maps** of MUF(3000) are estimated every 15 minutes from real-time ionosonde data recorded at several stations over Europe. Such measurements are integrated into the International Reference Ionosphere (IRI) background model, which is upgraded starting from the relative deviations at the stations. Kriging techniques are then applied for spatial interpolation.
The MUF(3000)F2 ratio is the ratio between the nowcasted MUF(3000) derived from real-time ionosonde data and the background.
The background is the MUF monthly median derived from the International Reference Ionosphere Model (IRI).

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Unlike the meteorological weather forecast, which now boasts a tradition of several years, the ionospheric weather monitoring and forecast is just taking its firs steps. Despite this, notable results have already been achieved. Besides, direct observations of the thermosphere are technically very complicated and expensive. A new approach to monitor the thermosphere based on routine ionospheric observations has been recently proposed. This may open a way to monitor the state of the thermosphere using the world-wide network of ionospheric observatories.