

INGV contribution to the PECASUS activities

Space Weather

Claudio Cesaroni on behalf of PECASUS team



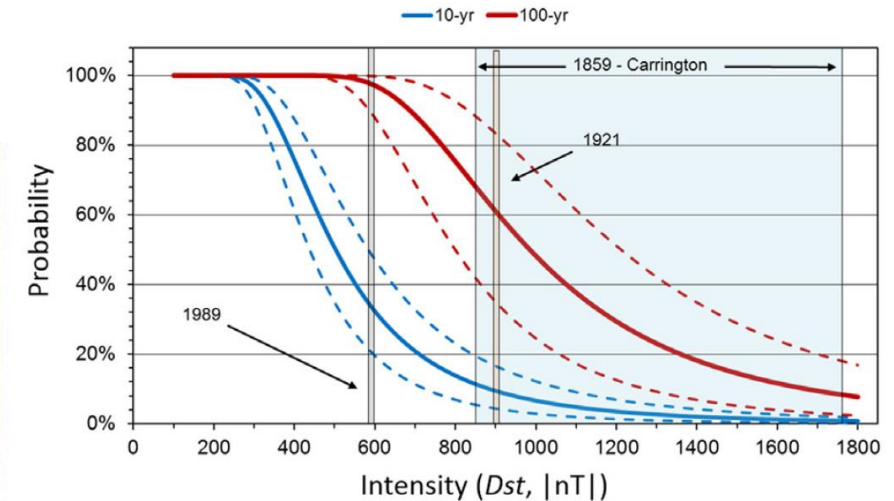
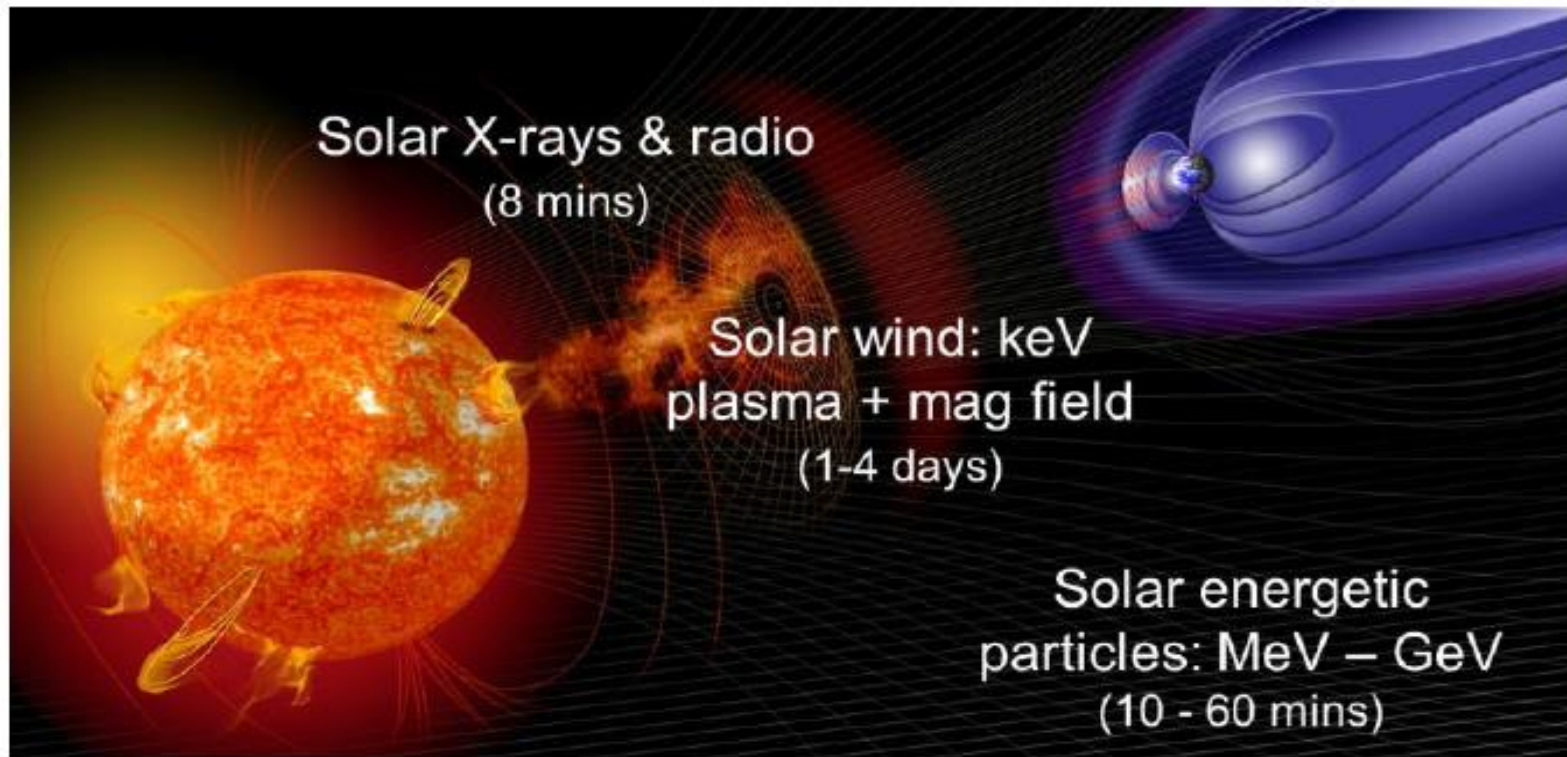
ISTITUTO NAZIONALE DI GEOFISICA E VULCANOLOGIA 

Space Weather



“Conditions on the Sun and in the solar wind, magnetosphere, ionosphere and thermosphere that can influence the performance and reliability of space-borne and ground-based technological systems and can endanger human life or health”

[US National Space Weather Programme]



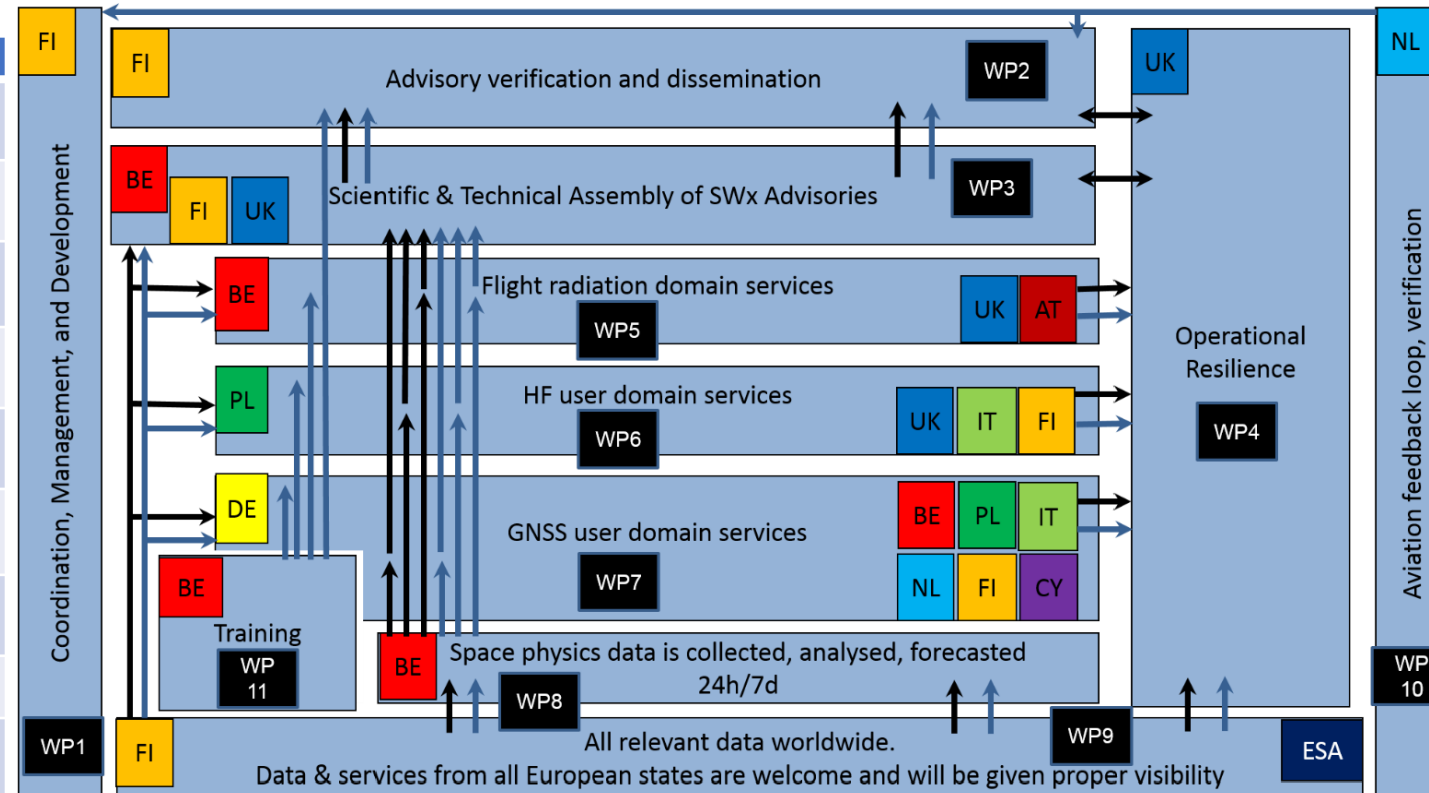
PECASUS in a nutshell

PECASUS SWxC provide information on prevailing and forthcoming SWx in advisories compatible with the standardized ICAO formats. The advisories will be given by a 24/7 service and in the fields of:

1. High Frequency (HF) communications
2. Navigation and surveillance based on Global Navigation Satellite Systems (GNSS), and
3. Radiation exposure at flight altitudes
4. Satellite Communication

24/7 operations today 7-Nov, 2019

Company/Organization	Country
Finnish Meteorological Institute (FMI)	Finland
Solar-Terrestrial Centre of Excellence (STCE)	Belgium
Met Office (UKMO)	United Kingdom
Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR)	Germany
Royal Netherlands Meteorological Institute (KNMI)	Netherlands
Centrum Badan Kosmicznych Polskiej Akademii Nauk (SRC)	Poland
Istituto Nazionale di Geofisica e Vulcanologia (INGV)	Italy
Seibersdorf Labor GmbH (SL)	Austria
The Cyprus Department of Meteorology (DoM)	Cyprus



ICAO



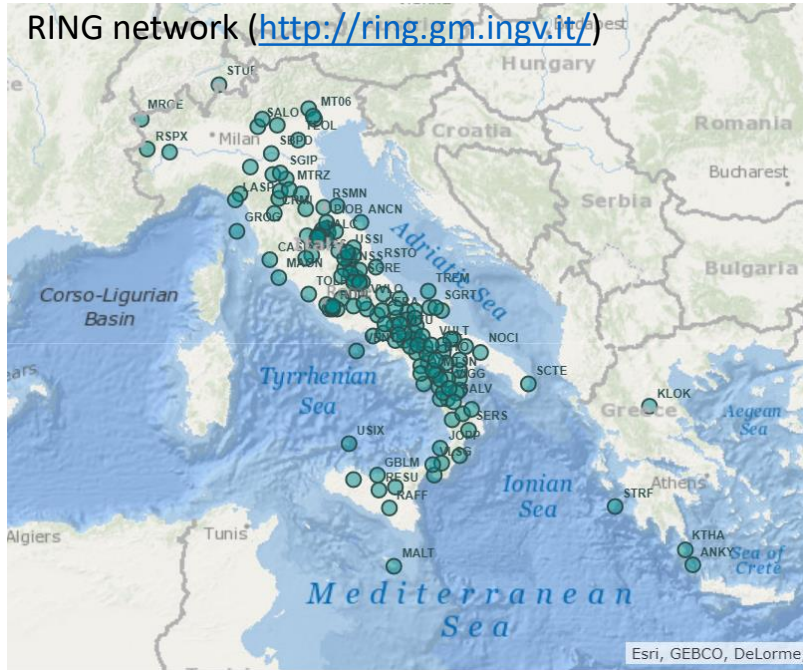
Observational infrastructure (INGV ionospheric/geomagnetic facilities)

INGV IONOSPHERIC MONITORING NETWORK

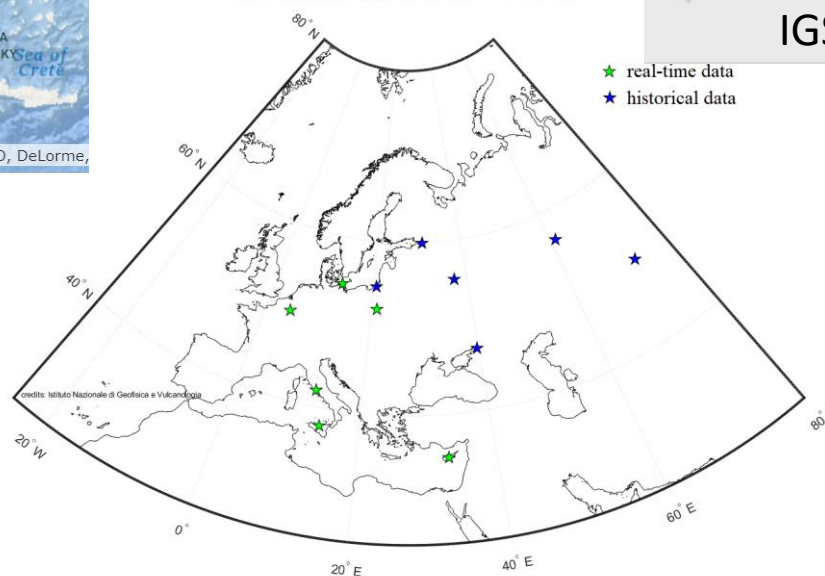


Observational infrastructure (external facilities)

RING network (<http://ring.gm.ingv.it/>)

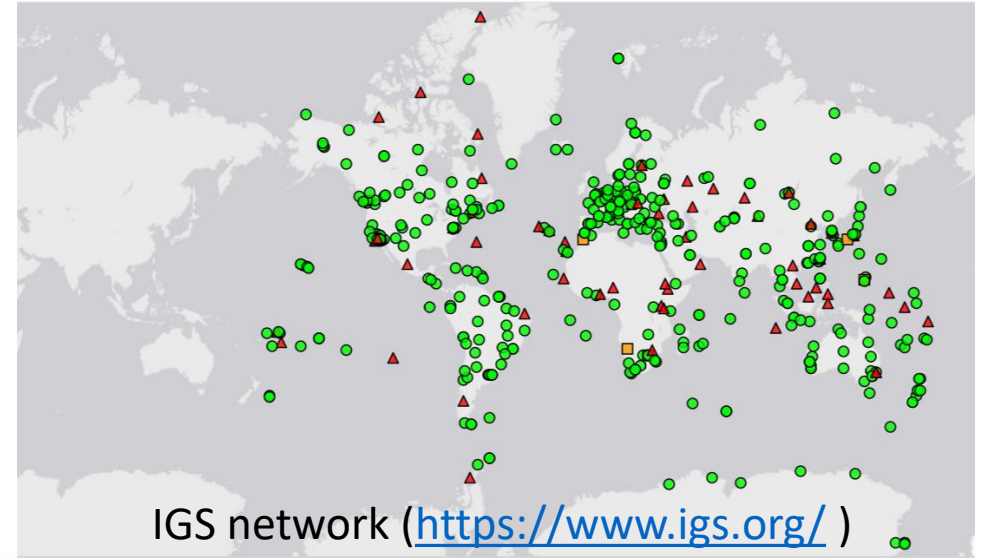


Ionosonde data for PECASUS



European ionosonde network

IGS network (<https://www.igs.org/>)



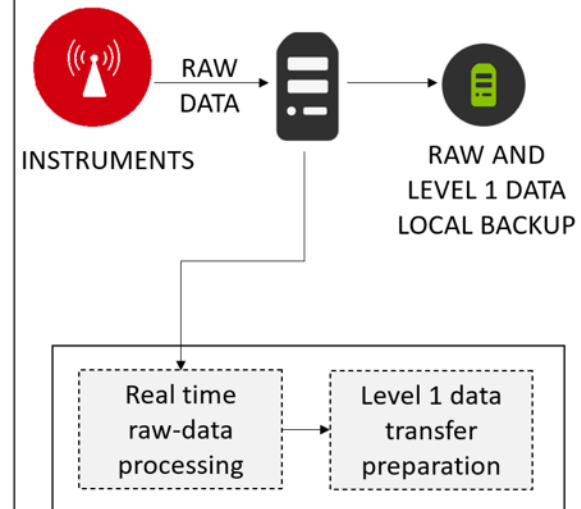
Infrastructure for Data Processing and Management

ACQUISITION AND
TRANSMISSION LAYER

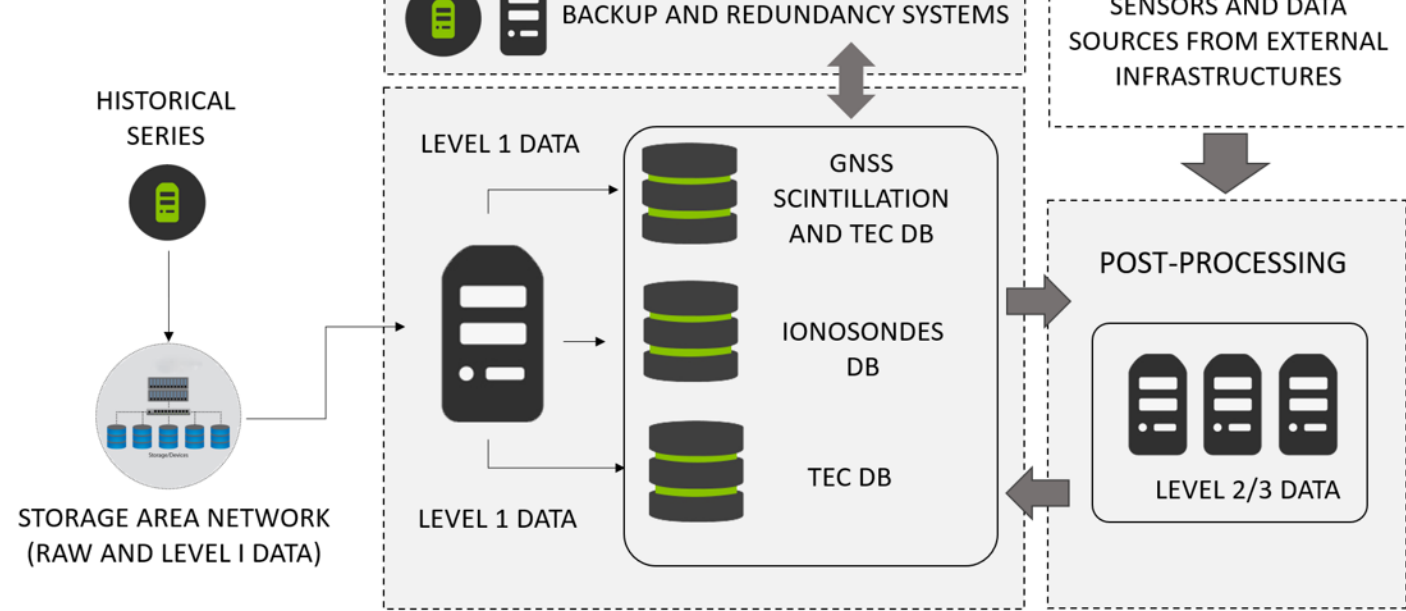
DATABASE MANAGEMENT SYSTEM AND POST PROCESSING LAYER

ACCESS AND
DISSEMINATION LAYER

INGV IONOSPHERIC OBSERVATORIES



DATABASE MANAGEMENT SYSTEM



FMI
repository

STCE
repository

RAW DATA

LEVEL 1 DATA

LEVEL 1 DATA
PREPARATION

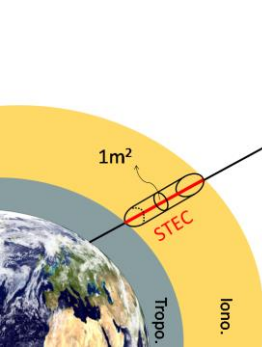
DATABASES
INGESTION

HIGHER LEVEL
DATA AND PRODUCTS

ONLINE SERVICES ETC.

Products Available

Total Electron Content

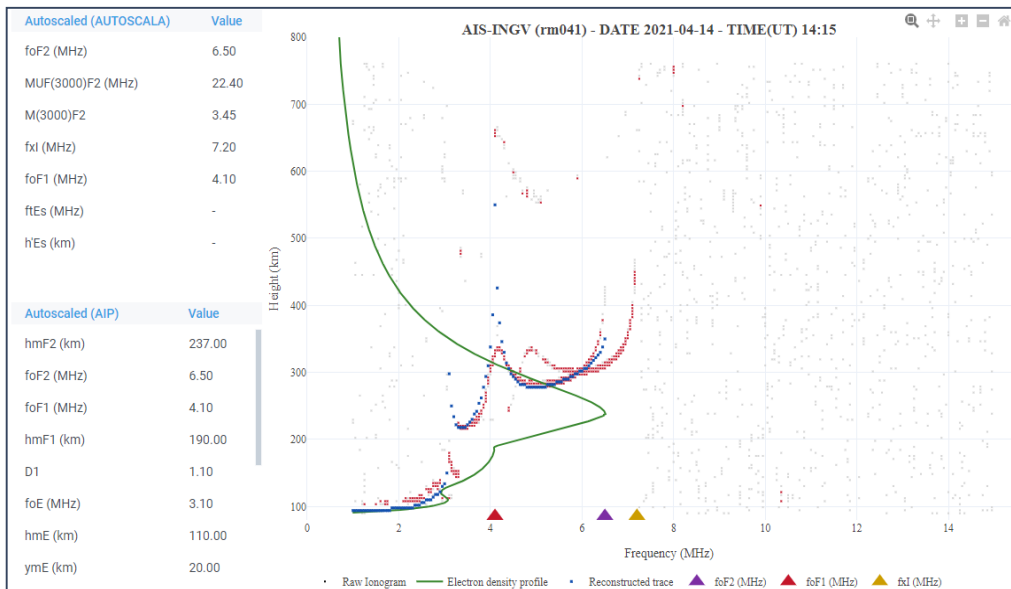


$$STEC = \int Ne \, ds_0$$

$$STEC = \frac{1}{40.3} \left(\frac{L1^2 L2^2}{L2^2 - L1^2} \right) (P_2 - P_1) - \epsilon$$

$$TECU = 10^{16} \text{ electrons per m}^2$$

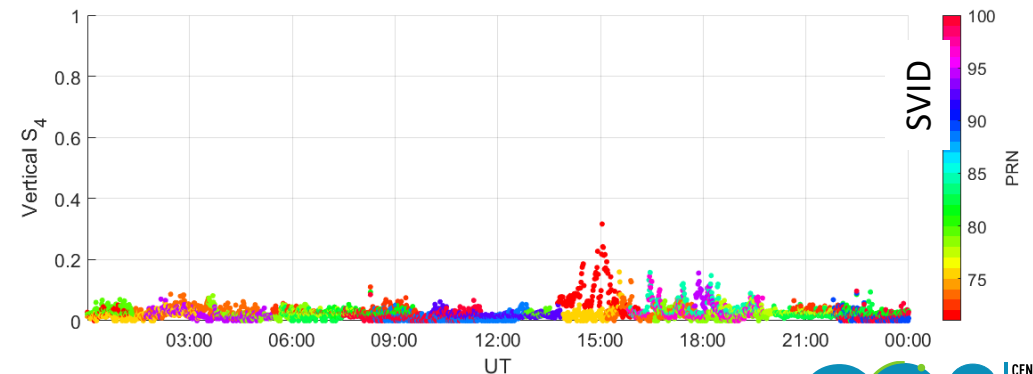
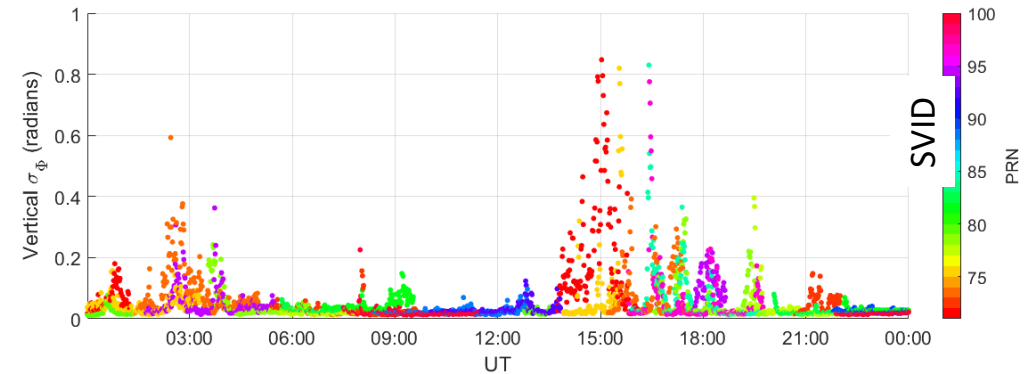
Electron density profiles



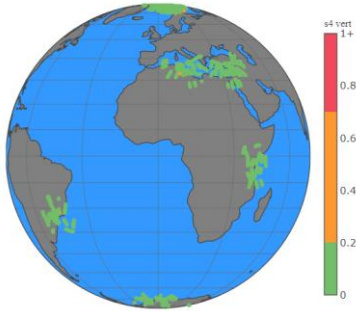
Scintillation Indices

$$\sigma_{\phi}^2 = \langle \phi_{detr}^2 \rangle - \langle \phi_{detr} \rangle^2$$

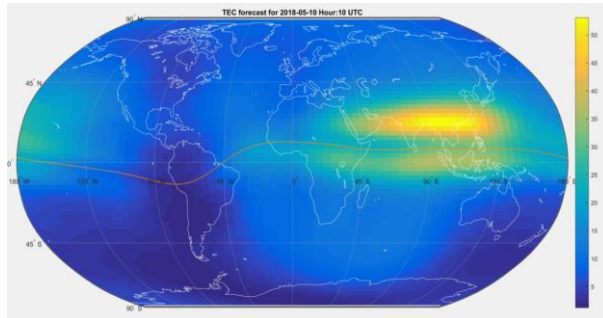
$$S_4 = \sqrt{\frac{\langle I^2 \rangle - \langle I \rangle^2}{\langle I \rangle^2}}$$



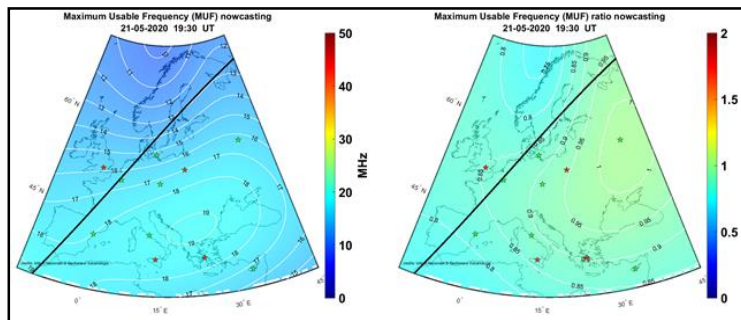
Products Available



Scintillation Nowcasting



TEC LT Forecasting



MUF (3000) Nowcasting

	EG	Spatial coverage	Spatial resolution (latxlong)	Update rate	Prediction time	Latency
INGV_ROTI_LTF_GL_3hrs	GNSS	Global	2.5°x5°	3 hrs	24 H	1 min
INGV_ROTI_NC_GL_15min	GNSS	Global	2.5°x5°	15 min	N/A	10 min
INGV_Scint_NC_EU_15min	GNSS	European	@IPP	15 min	N/A	2 min
INGV_TEC_LTF_GL_2hrs	GNSS	Global	2.5°x5°	2 hrs	24 H	15 min
INGV_MUF_forecasting_RATIO	HF	European	2.5°x5°	1 hr	24h	15 min
INGV_MUF_nowcasting_RATIO_15min	HF	European	0.5°x0.5°	15 min	N/A	2 min
INGV_MUF_nowcasting;	HF	European	0.5°x0.5°	15 min	N/A	2 min
INGV_MUF_forecasting;	HF	European	2.5°x5°	1 hr	24h	15 min
INGV_MUF_forecasting_Global;	HF	Global	2.5°x5°	1 hr	24h	15 min
INGV_MUF_forecasting_ratio_Global	HF	Global	2.5°x5°	1 hr	24h	15 min
INGV_TEC_NC_EU_5min	GNSS	European	0.5°x0.5°	5 min	N/A	2 min
INGV_TEC_NC_MED_10min	GNSS	Mediterranean	0.1°x0.1°	10 min	N/A	2 min
INGV_TEC_STF_EU_15min	GNSS	European	0.5°x0.5°	15 min	30 min	2 min
INGV_TEC_STF_MED_10min	GNSS	Mediterranean	0.1°x0.1°	10 min	30 min	2 min
INGV_TEC_NC_GL_15min	GNSS	Global	2.5°x5°	15 min	N/A	7 min

Current Distribution Of Products

07/06/2021
12:56 UTC

STATUS
PBC

MAIN

GNSS

RADIATION

RF COM

ARCHIVE

Advisory

Daily Brief

Data

Portfolio

CAD Docs

Workflow

Backup

RWC

Contact

Year Guide

GNSS: Phase Scintillation (more data, analysed data)

MSD-DLR Bahir Dar/Ethiopia *	MSFO-DLR Fortaleza/Brazil	MSK-DLR Kiruna/Sweden	MSST-DLR Stanford/USA	MSTE-DLR Tenerife/Spain *	MSTO-DLR Toulouse/France	MSTR-DLR Norway/Tromsø	MSRF-DLR Ramfjordbotn/Norway
-----	2021-06-07 12:50	2021-06-07 12:50	2021-06-07 12:50	-----	2021-06-07 12:50	2021-06-07 12:50	2021-06-07 12:50
FAILURE	QUIET = 0.08	QUIET = 0.10	QUIET = 0.10	FAILURE	QUIET = 0.10	QUIET = 0.10	QUIET = 0.10
Last 3-hour:		Last 3-hour:	Last 3-hour:	Last 3-hour:	Last 3-hour:	Last 3-hour:	Last 3-hour:
FAILURE	QUIET = 0.10	QUIET = 0.15	QUIET = 0.21	FAILURE	QUIET = 0.33	QUIET = 0.17	QUIET = 0.42

NYA1P-INGV Ny1 Alesund/Norway	NICOP-INGV Nicosia/Cyprus	HANOI-INGV Hanoi/Vietnam	LYBSP-INGV Longyearbyen/Norway	LAMP-INGV Lampedusa/Italy	KILIN-INGV Kilifi/Kenya	EMCOP-INGV Concordia station/Antarctica	SANAE-INGV SANAE IV station/Antarctica	SAOP-INGV Sao Paulo/Brazil	MZSP-INGV M. Zucchelli/Antarctica
2021-06-07 12:45	2021-06-07 12:45	2021-06-07 12:45	2021-06-07 12:45	2021-06-07 12:45	2021-06-07 12:45	-----	-----	2021-06-07 12:45	-----
QUIET = 0.12	QUIET = 0.05	QUIET = 0.06	QUIET = 0.19	QUIET = 0.04	QUIET = 0.10	FAILURE	FAILURE	QUIET = 0.03	FAILURE
Last 3-hour:	Last 3-hour:	Last 3-hour:	Last 3-hour:	Last 3-hour:	Last 3-hour:	Last 3-hour:	Last 3-hour:	Last 3-hour:	Last 3-hour:
QUIET = 0.51	QUIET = 0.13	QUIET = 0.19	QUIET = 0.35	QUIET = 0.12	QUIET = 0.16	QUIET = 0.09	QUIET = 0.10	QUIET = 0.16	QUIET = 0.26

GNSS: Amplitude Scintillation (more data, analysed data)

MSD-DLR Bahir Dar/Ethiopia *	MSFO-DLR Fortaleza/Brazil	MSK-DLR Kiruna/Sweden	MSST-DLR Stanford/USA	MSTE-DLR Tenerife/Spain *	MSTO-DLR Toulouse/France	MSTR-DLR Norway/Tromsø	MSRF-DLR Ramfjordbotn/Norway
-----	2021-06-07 12:50	2021-06-07 12:50	2021-06-07 12:50	-----	2021-06-07 12:50	2021-06-07 12:50	2021-06-07 12:50
FAILURE	QUIET = 0.21	QUIET = 0.28	QUIET = 0.05	FAILURE	QUIET = 0.30	QUIET = 0.20	QUIET = 0.25
Last 3-hour:	Last 3-hour:	Last 3-hour:	Last 3-hour:	Last 3-hour:	Last 3-hour:	Last 3-hour:	Last 3-hour:
FAILURE	QUIET = 0.30	QUIET = 0.39	QUIET = 0.33	FAILURE	QUIET = 1.07	QUIET = 0.39	QUIET = 1.19

NYA1P-INGV Ny1 Alesund/Norway	NICOP-INGV Nicosia/Cyprus	HANOI-INGV Hanoi/Vietnam	LYBSP-INGV Longyearbyen/Norway	LAMP-INGV Lampedusa/Italy	KILIN-INGV Kilifi/Kenya	EMCOP-INGV Concordia station/Antarctica	SANAE-INGV SANAE IV station/Antarctica	SAOP-INGV Sao Paulo/Brazil	MZSP-INGV M. Zucchelli/Antarctica
2021-06-07 12:45	2021-06-07 12:45	2021-06-07 12:45	2021-06-07 12:45	2021-06-07 12:45	2021-06-07 12:45	-----	-----	2021-06-07 12:45	-----
QUIET = 0.06	QUIET = 0.05	QUIET = 0.05	QUIET = 0.19	QUIET = 0.05	QUIET = 0.08	FAILURE	FAILURE	QUIET = 0.07	FAILURE
Last 3-hour:	Last 3-hour:	Last 3-hour:	Last 3-hour:	Last 3-hour:	Last 3-hour:	Last 3-hour:	Last 3-hour:	Last 3-hour:	Last 3-hour:
QUIET = 0.10	QUIET = 0.11	QUIET = 1.06	QUIET = 0.27	QUIET = 0.14	QUIET = 0.23	QUIET = 0.15	QUIET = 0.09	QUIET = 0.14	QUIET = 0.17

GNSS: Vertical TEC MAP Nowcast (more)

Vertical TEC Nowcast (INGV)	Vertical TEC Nowcast (DLR)	Vertical TEC Forecast (DLR)
Current value:	Current value:	Current value:
2021-06-07 12:30	2021-06-07 12:50	2021-06-07 12:50
QUIET 41.14	QUIET 52.40	QUIET 59.21
Last 3-hour value:	Last 3-hour value:	Last 3-hour value:
QUIET 41.14	QUIET 52.65	QUIET 74.18

INGV VERTICAL TEC NOWCAST 2021-06-07 12:56 UTC

DLR VERTICAL TEC NOWCAST 2021-06-07 12:56 UTC

DLR VERTICAL TEC FORECAST 2021-06-07 12:56 UTC

Data and products are pushed to the STCE and FMI (backup) repository in order to feed the dashboard driving the decision of the SW operator in sending the advisory

COS

CENTRO OSSERVAZIONI
SPAZIALI
DELLA TERRA

ISTITUTO NAZIONALE DI GEOFISICA E VULCANOLOGIA

Programs/Projects Of Reference

Ente/Organismo finanziatore	Nome Progetto	Fondi per Annualità 2021 in €	Fondi per Annualità 2022 in €	Fondi per Annualità 2023 in €	Eventuali note aggiuntive
INGV	Decreto 1110	500 keuro	150 keuro	150 keuro	I fondi relativi alle attività sono stimati come il 100% dei fondi totali del progetto
PNRA	PNRA 14/110 PNRA 14/133	20 keuro	20 keuro	20 keuro	I fondi relativi alle attività sono stimati come il 30% dei fondi totali del progetto
EC	PITHIA	50 keuro	50 keuro	50 keuro	Fondi per personale TD
ASI	NORISK	50 keuro	50 keuro	50 keuro	In negoziazione. -I fondi relativi alle attività sono stimati come il 50% dei fondi (stimati) totali del progetto. Parte dei fondi sono destinati all'alta formazione



Team and Affiliations

Surname	Name	INGV section	P/M 2021	P/M 2022	P/M 2023
TI	Romano	Vincenzo	Roma2	2	2
TI	Cesaroni	Claudio	Roma2	3	3
TI	Spogli	Luca	Roma2	3	3
TI	Perrone	Loredana	Roma2	2	2
TI	Di Mauro	Domenico	Roma2	1	1
TI	Tozzi	Roberta	Roma2	0,5	0,5
TI	Cafarella	Lili	Roma2	0,5	0,5
TI	Alfonsi	Lucilla	Roma2	0,5	0,5
TI	De Franceschi	Giorgiana	Roma2	0.5	0.5
TI	Pezzopane	Michael	Roma2	0.5	0.5
Assegno	Pignalberi	Alessio	Roma2		
TI	Sciacca	Umberto	Roma2	0.5	0.5

Surname	Name	INGV section	P/M 2021	P/M 2022	P/M 2023
TI	Scotto	Carlo	Roma2	1	1
Assegno	Sabbagh	Dario	Roma2		
TI	Pietrella	Marco	Roma2	0.5	0.5
TD	Bagiacchi	Paolo	Roma2	2	2
TI	Dominici	Guido	Roma2	2	2
TI	Lepidi	Stefania	Roma2	1	1
TI	Regi	Mauro	Roma2	0.5	0.5
TI	Marcocci	Carlo	Roma2	2	2
TI	La Longa	Federica	Roma1		
TI	Crescimbene	Massimo	AC		
Assegno	Pica	Emanuele	Roma2		
TI	Ficeli	Pietro	AC	2	2
TI	Sensale	Gianpaolo	AC	2	2



ISTITUTO NAZIONALE DI GEOFISICA E VULCANOLOGIA

**Istituto Nazionale di Geofisica
e Vulcanologia
AOO INGV
Protocollo Generale - U
N. 0002779
del 25/02/2019**



Decreto n. 5

Oggetto: Costituzione Gruppo di Lavoro dell'Istituto Nazionale di Geofisica e Vulcanologia, denominato "PECASUS", per gestire le attività di *space weather* nell'ambito del Consorzio europeo PECASUS.

IL PRESIDENTE