Italian Contribution to Space Weather

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Istituto Nazionale di Geofisica e Vulcanologia (INGV)
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Thanks to:
Mauro Messerotti (INAF), Daniel Biron (ITAF-COMET), Paola De Michelis (INGV), Francesca Zuccarello (Uni CT), Alessandro Bemporad (INAF), Ester Antonucci (INAF), Domenico Di Mauro (INGV). Marco Pietrella (INGV), Anna Milillo (INAF), Francesco Berilli (Uni TOV), Mirko Piersanti (Uni AQ), Federica Marcucci (INAF), Lucilla Alfonsi (INGV), Massimo Materassi (ISC-CNR)

Pamela

Ionosonde and autoscaling

Solar Orbiter

SuperDarn

Themis

Outline

- Italian strategic Initiatives
- Solar physics to Space Weather
- Interplanetary space physics to Space Weather
- Solar-Terrestrial physics to Space Weather
- Upper atmosphere physics to Space Weather

Pamela

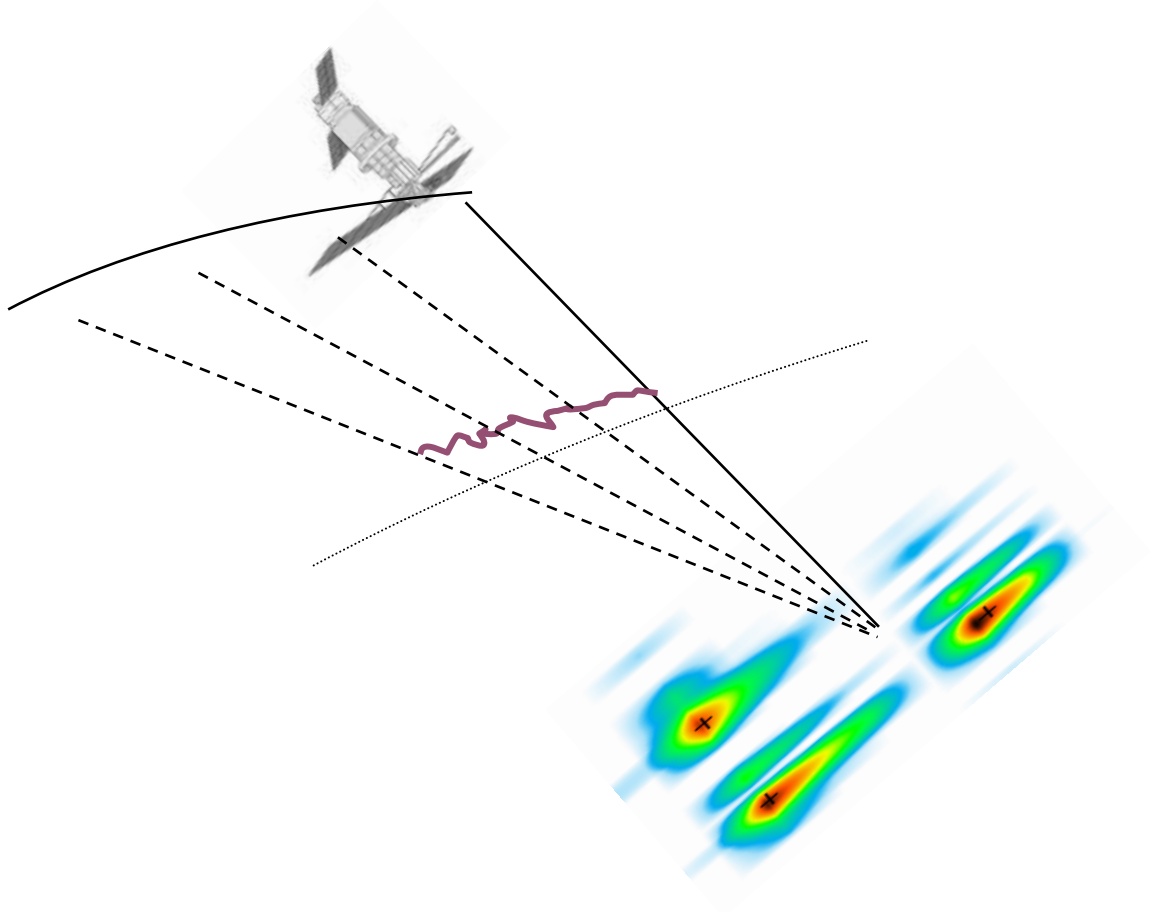
Ionosonde and autoscaling

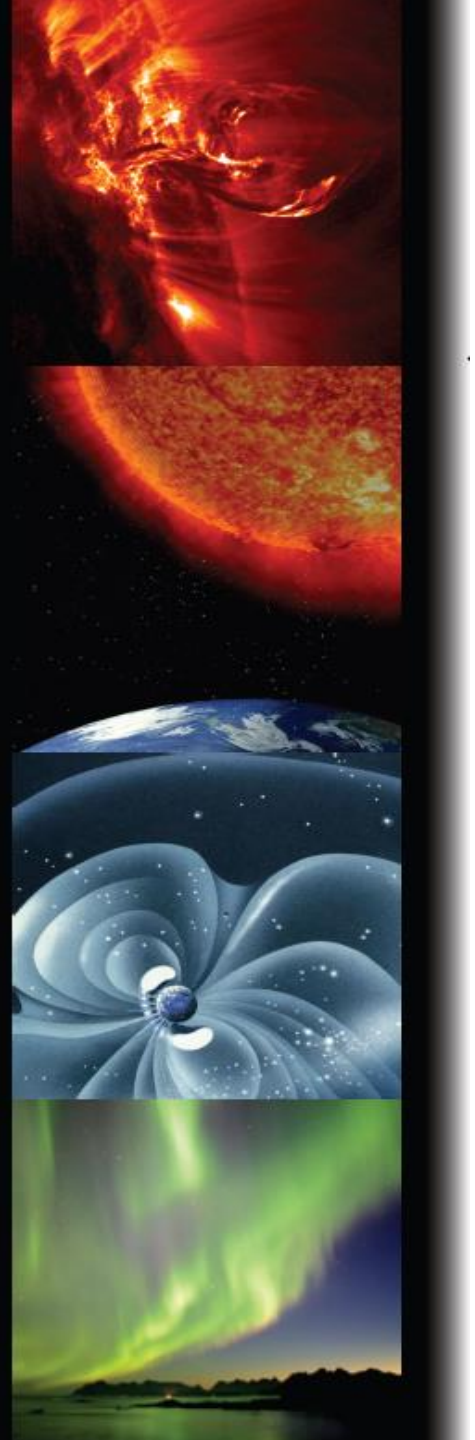
Solar Orbiter

SuperDarn

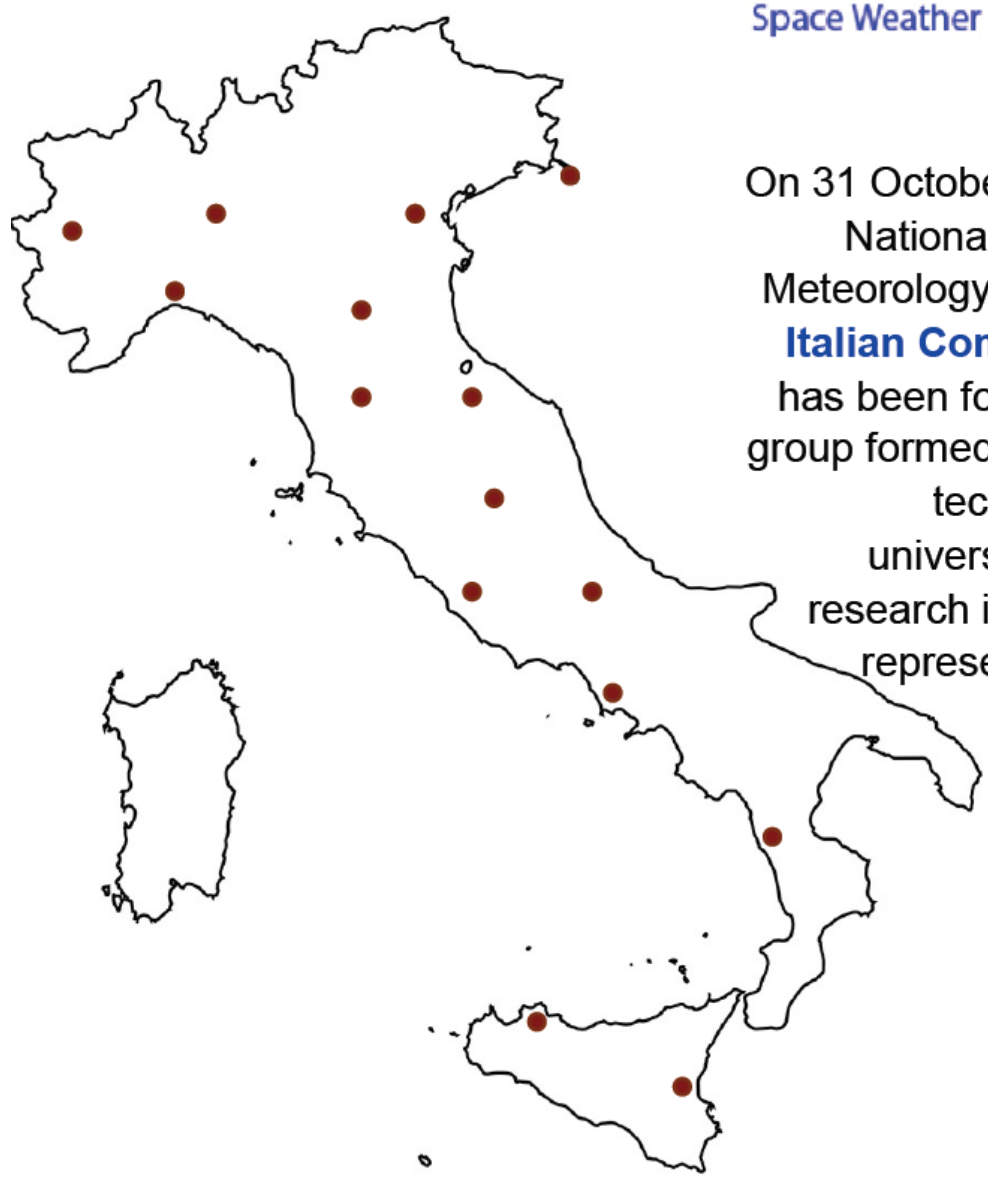
Themis

Italian Space Weather strategic initiatives





SWICo
Space Weather Italian Community



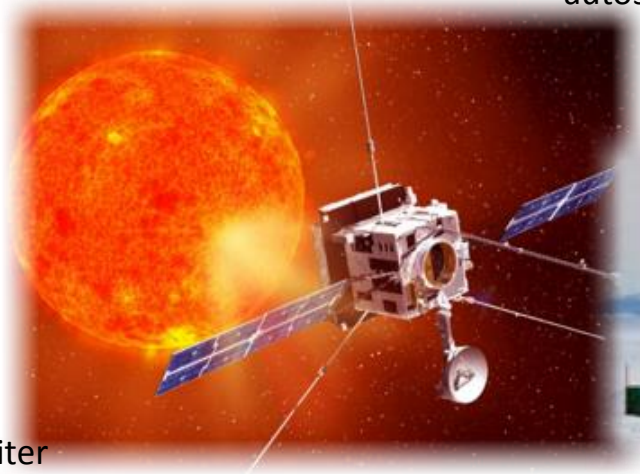
On 31 October 2014 the Italian National Group for Space Meteorology (**Space Weather Italian Community, SWICo**) has been founded as interest group formed by scientists and technologists of both universities and national research institutions and by representatives of Italian industries.

Observational, theorethical studies and modeling

- Solar physics from photosphere to corona and sola irradiance
- Interplanetary medium physics: structures, turbulence and propagation of CMEs and SEPs
- Solar wind-magnetosphere coupling and interactior
- Magnetospheric-Ionospheric dynamics
- Ground based magnetic field variations
- Forecasting and nowcasting modelling
- Planetary Space Weather

Pamela

Ionosonde and autoscaling



Solar Orbiter

SuperDarn

Themis

World Meteorological Organization Congress

Resolution 38 (Cg-17) — “Four-year Plan for WMO Coordination of Space Weather Activities”.

Since 2012 Italy joined the WMO Space Weather initiative

Inter-programme Coordination Team on SW, ITAF – INAF - INGV

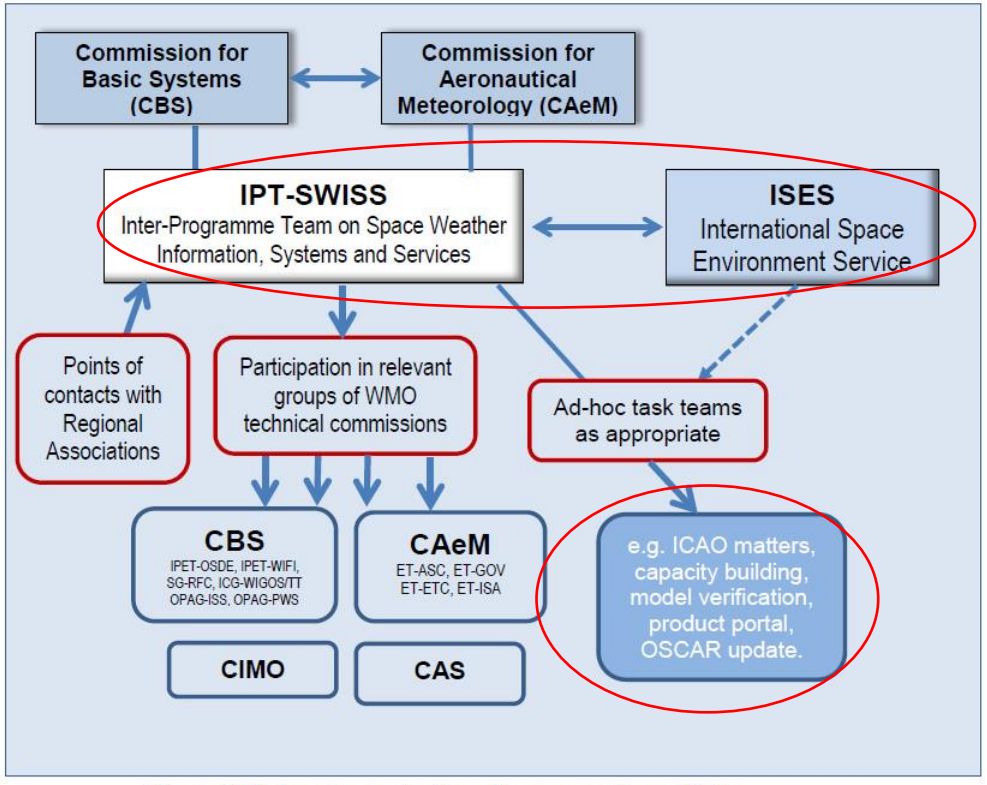
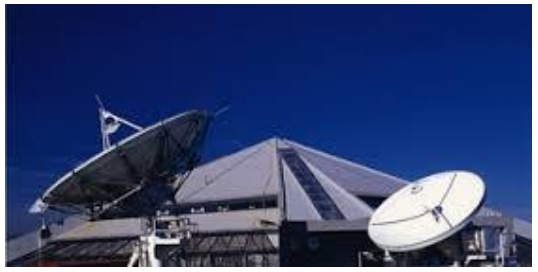


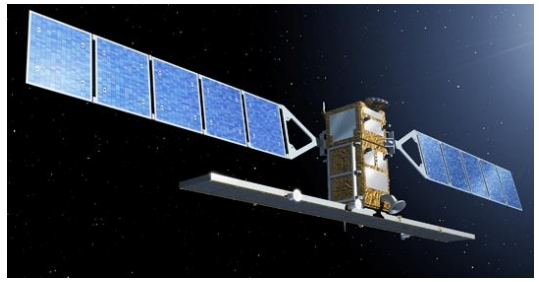
Figure 2: Proposed organization of space weather activities.

World Meteorological Organization
Weather • Climate • Water

Space Weather italian initiative for operations

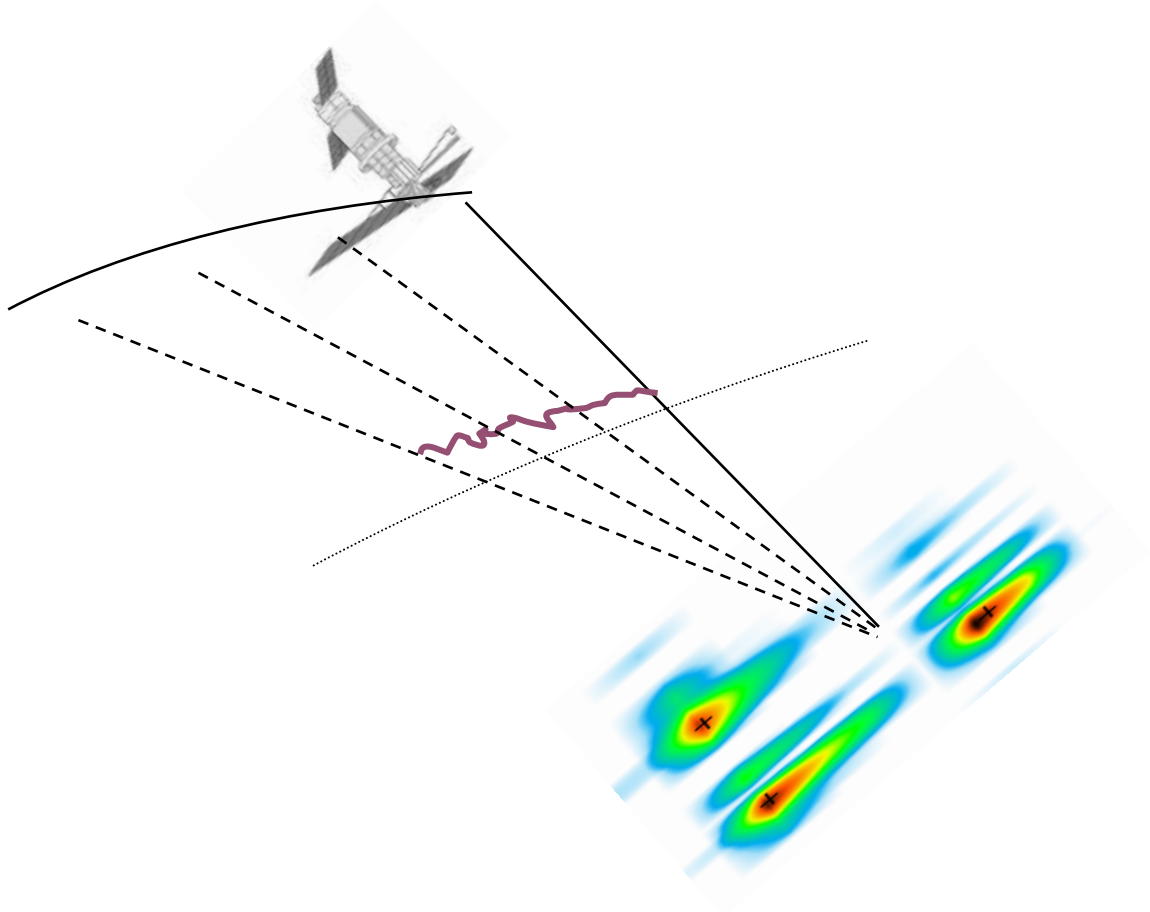
SW nowcasting and safety support





Space Weather knowledge is not only for safety but also for capacity augmentation, as weather.

Solar physics to Space Weather



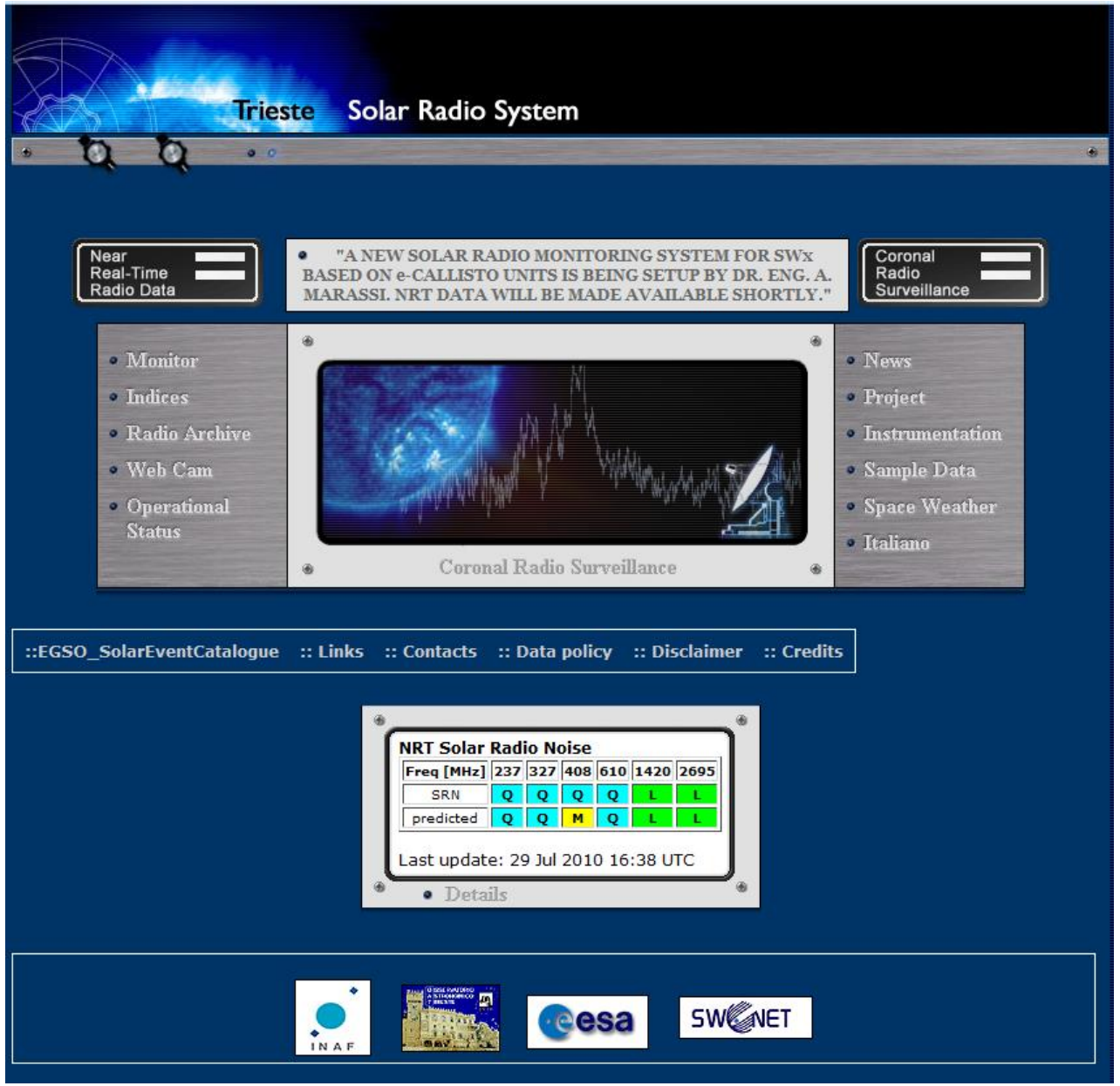
Osservatorio Astronomico di Trieste
Astronomical Observatory of Trieste

Solar Physics activities in Trieste

ESA Space Weather Working Team, Steering Board Member

European Space Weather Week Programme Committee, Chair

NATO Science for Peace (SfP) Project 984894 on “Ionospheric Monitoring”, Co-Director



M. Bilal, V. Alberti, A. Marassi, E. Cianca, **M. Messerotti**, *Performance assessment of GPS receivers during the September 24, 2011 solar radio burst event*, J. of Space Weather and Space Climate, **5**, A32, 16 pp., 2015.

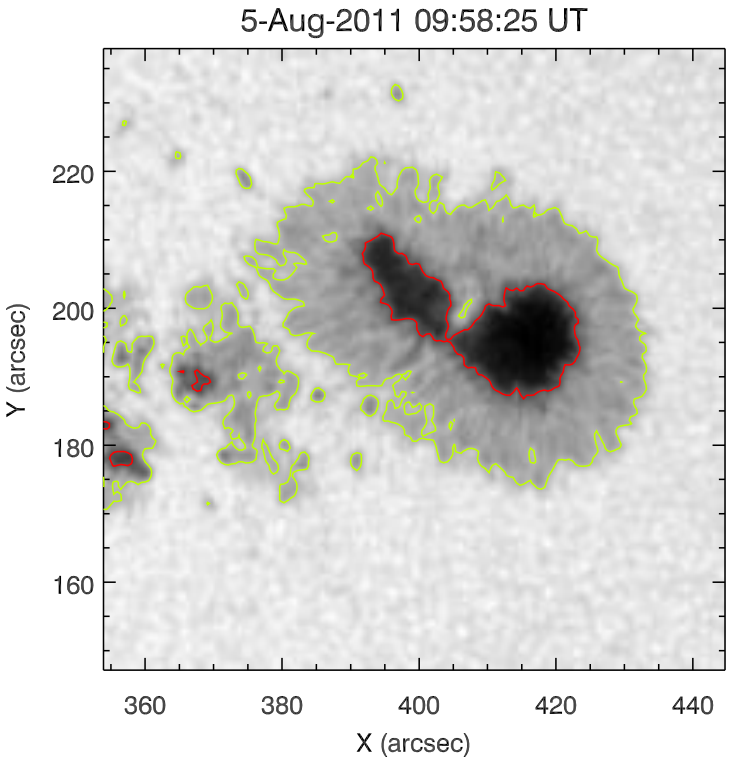
Solar Physics Group in Catania

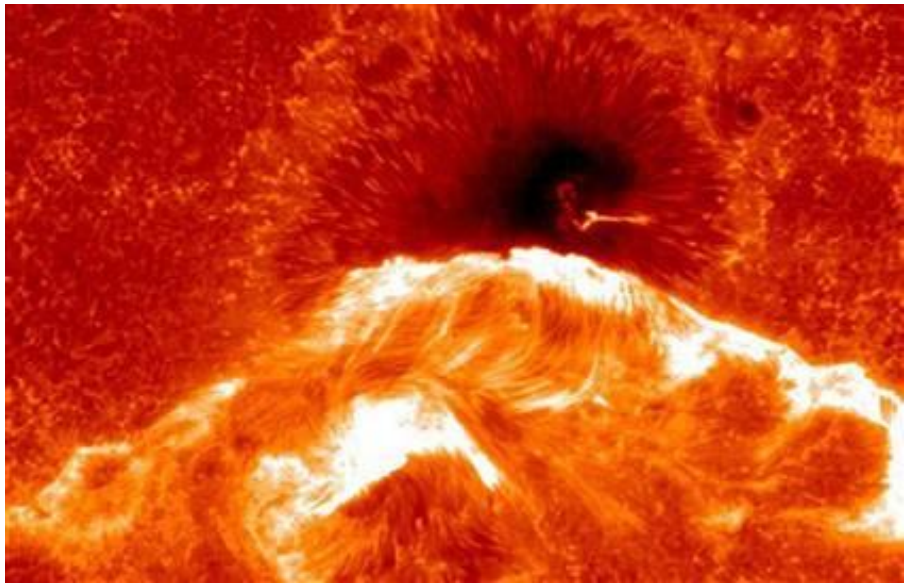
Personnel

V. Capparelli (UniCT), A. Compagnino (UniCT), M. Falco (UniCT), S.L. Guglielmino (UniCT), M. Murabito (UniCT), P. Romano (INAF), F. Zuccarello (UniCT).

Main Research Fields

Participation in the European Solar Telescope Design Phase; Emergence of magnetic flux tubes in the solar atmosphere; Formation and evolution of solar active regions; Flares and Coronal Mass Ejections: drivers and effects on the space environment; Space Weather.





Methods

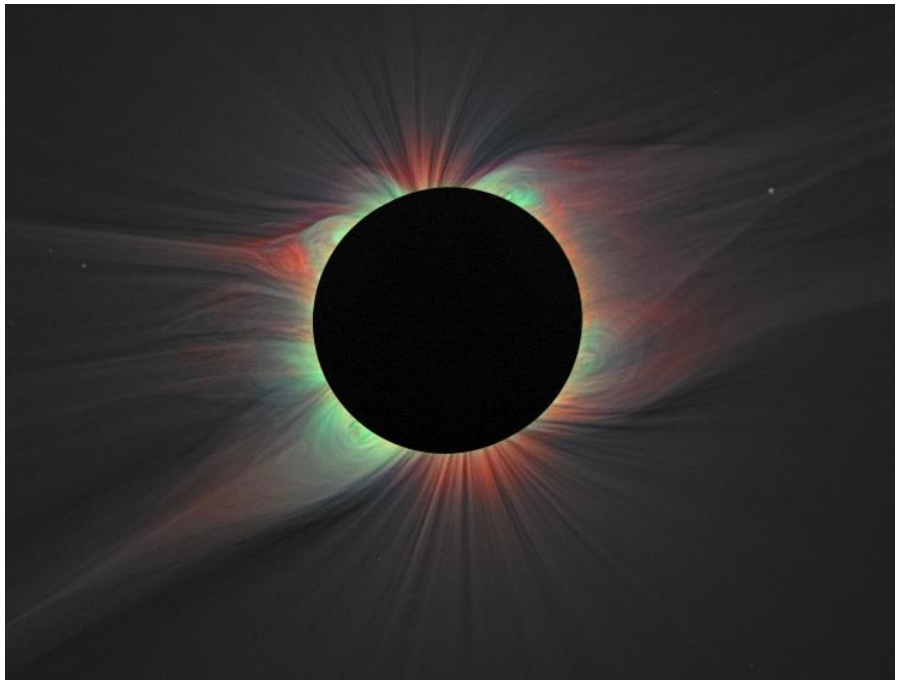
- Coordinated observing Campaigns between ground-based and space-based satellites
- Analysis of spectroscopic and spectro-polarimetric data acquired from space and ground.
- Design and development of new instrumentation for future ground based observations.

Solar Physics Group in Catania

Project Name	Short description	Role	Timeline
SOLARNET	The project brings together and integrates the major European research infrastructures in the field of high-resolution solar physics, in order to promote their coordinated use and development (FP7)	Responsible for WP30: Networking Activities (Leader: F. Zuccarello)	2013 April 1 – 2017 March 31
F-CHROMA	To acquire, analyse and interpret ground- and space-based observational data of solar flares, test these against model predictions, and create an archive of solar flare observations and models (FP7)	Responsible for WP5: Joint analysis of space-based and ground-based observations (Lead: F. Zuccarello)	2014 January 1 – 2016 December 31
Metis	WL and UV Coronagraph for ESA-Solar Orbiter spacecraft → first close-up (0.3 AU) observations of coronal plasmas	Participant to Science Team	Launch: October 2018, nominal mission 7.5 years

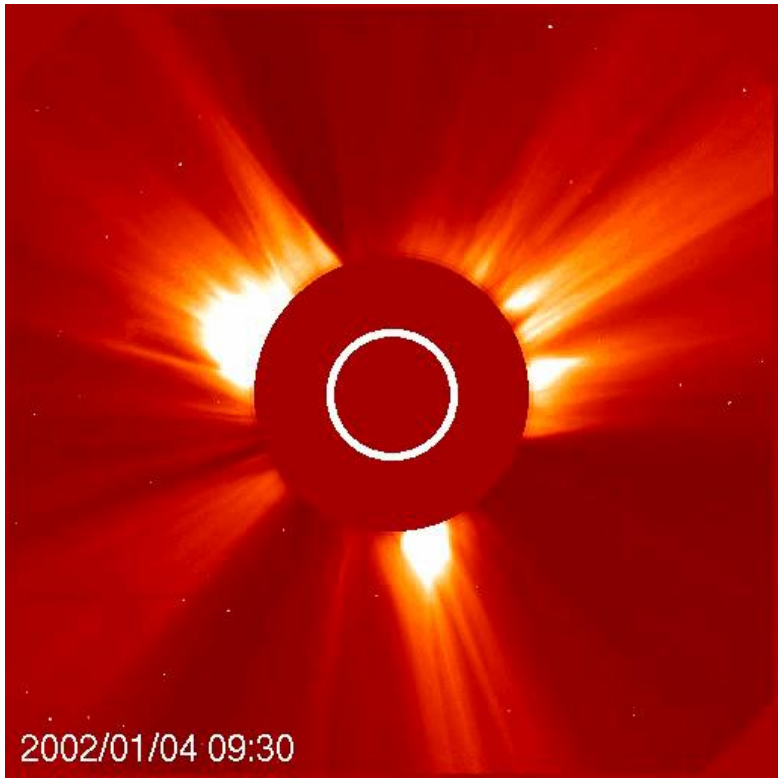
Valori, G., Romano, P., Malanushenko, A., Ermolli, I., Giorgi, F., Steed, K., van Driel-Gesztelyi, L., Zuccarello, F., Malherbe, J.-M., 2015, Time Evolution of Force-Free Parameter and Free Magnetic Energy in Active Region NOAA 10365, Sol. Phys. 290, 191

Solar Physics Group in Turin



Main Research Fields

- Physics of the solar corona, understanding the origin and evolution of the main drivers of Geomagnetic Storms on Earth: Solar Wind and Coronal Mass Ejections (CMEs).



Methods

- Coordination of observational campaigns from space and ground (total solar eclipses)
- Development of diagnostic techniques for the analysis of coronagraphic and spectroscopic data acquired from space and ground.
- Development of new instrumentation for future space missions and ground based observations.

Solar Physics Group in Turin

On-going experimental projects

Project Name	Short description	Role	Timeline
Metis 	WL and UV Coronagraph for ESA-Solar Orbiter spacecraft → first close-up (0.3 AU) observations of coronal plasmas	Leader of the international science consortium (PI: E. Antonucci)	Launch: October 2018, nominal mission 7.5 years
ASPIICS 	WL coronagraph for ESA-PROBA3 satellite → first eclipse-like, long-term observations of the inner corona	Italian leader for Formation Flying metrology (Lead Co-I: S. Fineschi)	Launch: 2019, nominal mission 2 years
SCORE 	Helium Sounding rocket coronagraph → first determination of coronal Helium abundance	Leader of the italian instrument consortium (PI: S. Fineschi)	First launch: September 2009, Second launch: June 2016
ESCAPE 	Coronagraph in Antarctica (Concordia base) → first long-term coronal magnetic fields monitoring	Leader of the italian instrument consortium (Co-PI: S. Fineschi)	Deployment: 2017, nominal duration 3 years

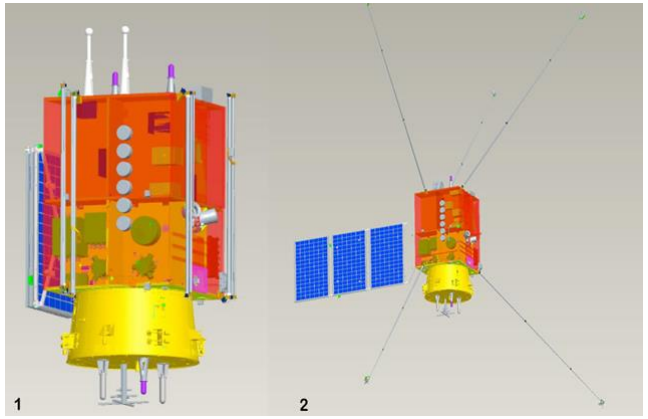
University of Rome Tor Vergata

https://www.fisica.uniroma2.it/solare

F. Berrilli, M. Casolino, D. Del Moro, L. Giovannelli, R. Forte, M. Lovric, M. Martucci, M. Mergè, L. Narici, V. Penza, G. Pucacco, F. Pucci, A. Rizzo, S. Scardigli, R. Sparvoli

Main Projects: FP7-EST, FP7-SOLARNET, H2020-GREST, EU-REACT-SPARC, EU-Ionosphere Prediction Service, PAMELA, ALTEA, CSES

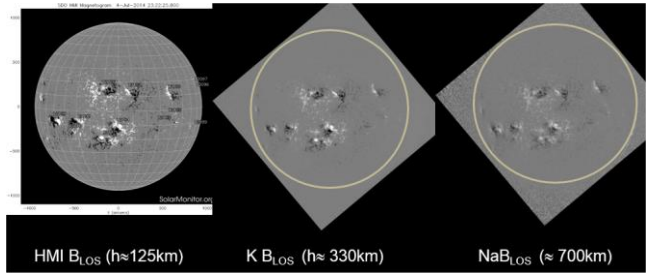
Activity: Solar Dynamics and Activity, Sun-Earth interaction, Space Weather, Improve tools for solar synoptic observations and particle detection.

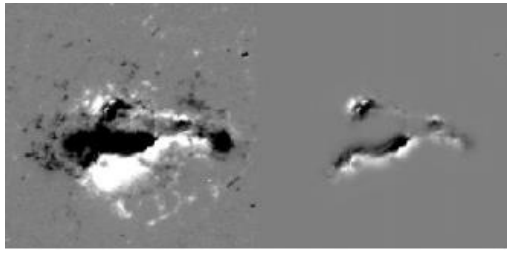


Italian Collaboration to CSES China Seismo-Electromagnetic Satellite

PAMELA satellite in orbit since 2006

Magneto Optical filters at Two Heights (**MOTH**) instrument
University of Hawaii, USA
Jet Propulsion Laboratory, Japan
Eddy Company, USA



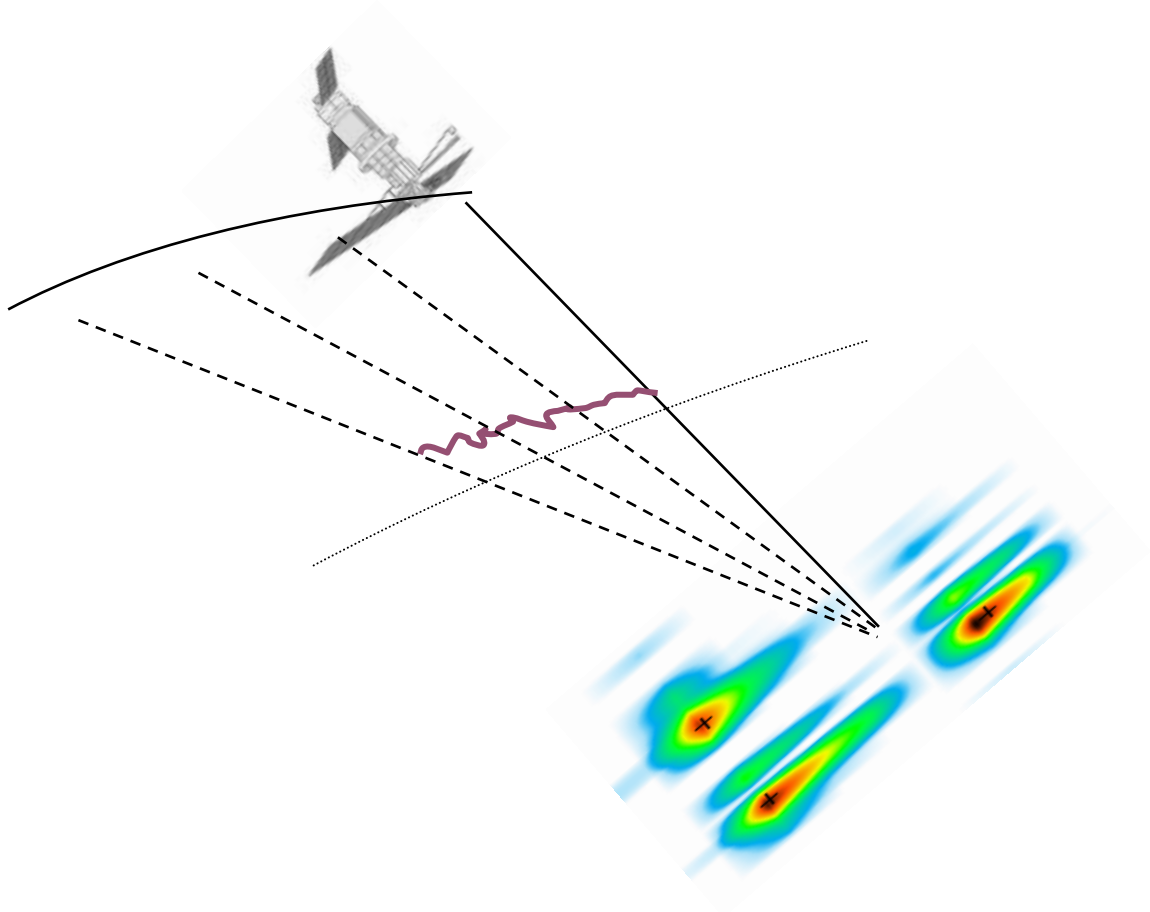


Automated Solar Flare Forecasting with multiline MOTH synoptic magnetograms

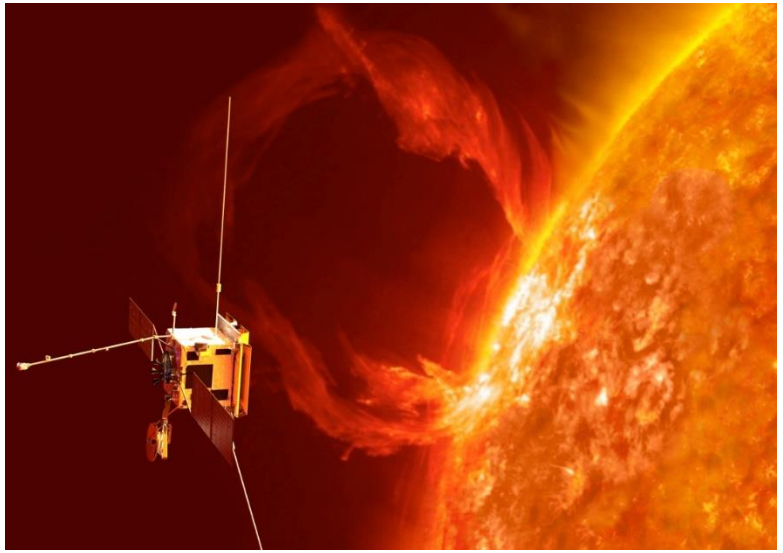
PAMELA collaborations

Cosmic Rays Laboratory, Moscow Engineering and Physics Institute, Moscow, Russia
Laboratory of Solar and Cosmic Ray Physics, P.N. Lebedev Physical Institute Academy of Sciences, Moscow, Russia
Ioffe Physical Technical Institute, St. Petersburg, Russia
Physics Department of Siegen University, Germany
Royal Institute of Technology, Stockholm, Sweden

Interplanetary space physics to Space Weather

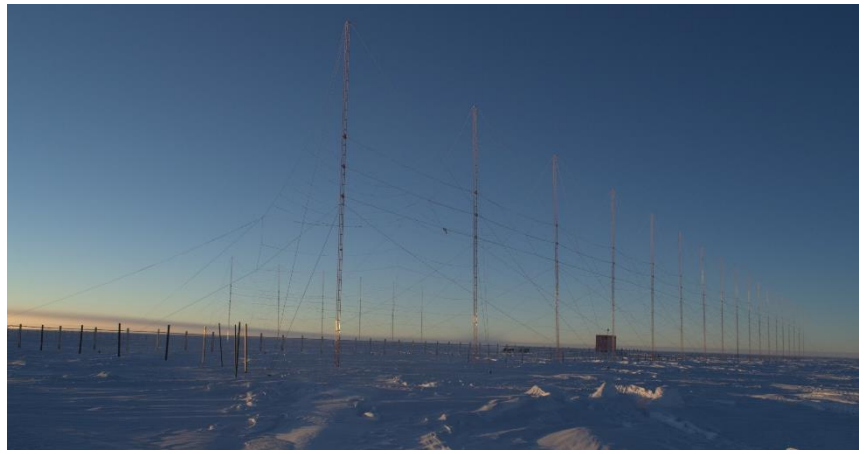


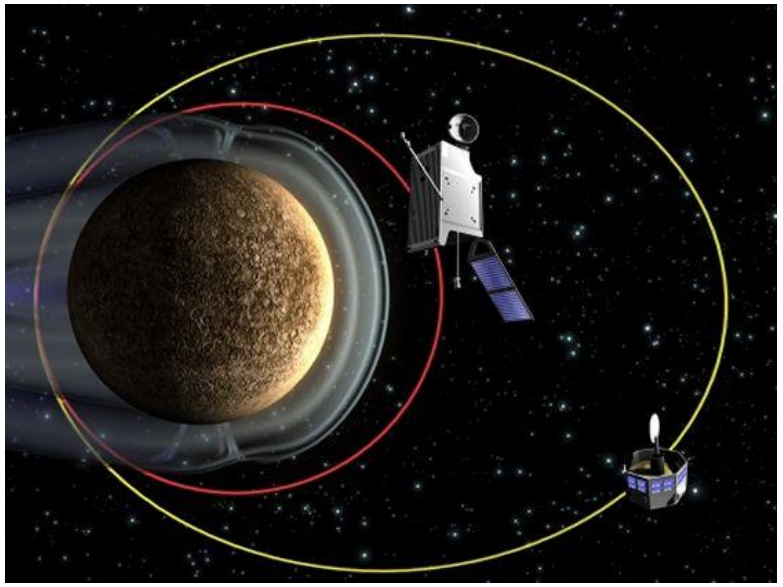
Interplanetary Space Physics Group @ INAF/IAPS



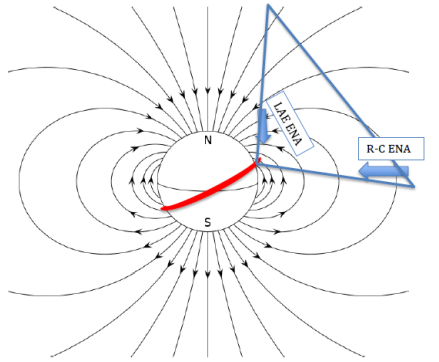
Solar Orbiter - A high-resolution mission to the Sun and inner heliosphere. The ISP group participates to the SWA, a plasma feature instrument suite, with the responsibility of the development of the on board DPU.

Super Dual Auroral Radar Network international network of HF ionospheric radars dedicated to the study of the magnetosphere-ionosphere system - The ISP group is responsible for the Dome C East radar located at the research station Dome Concordia in Antarctica.



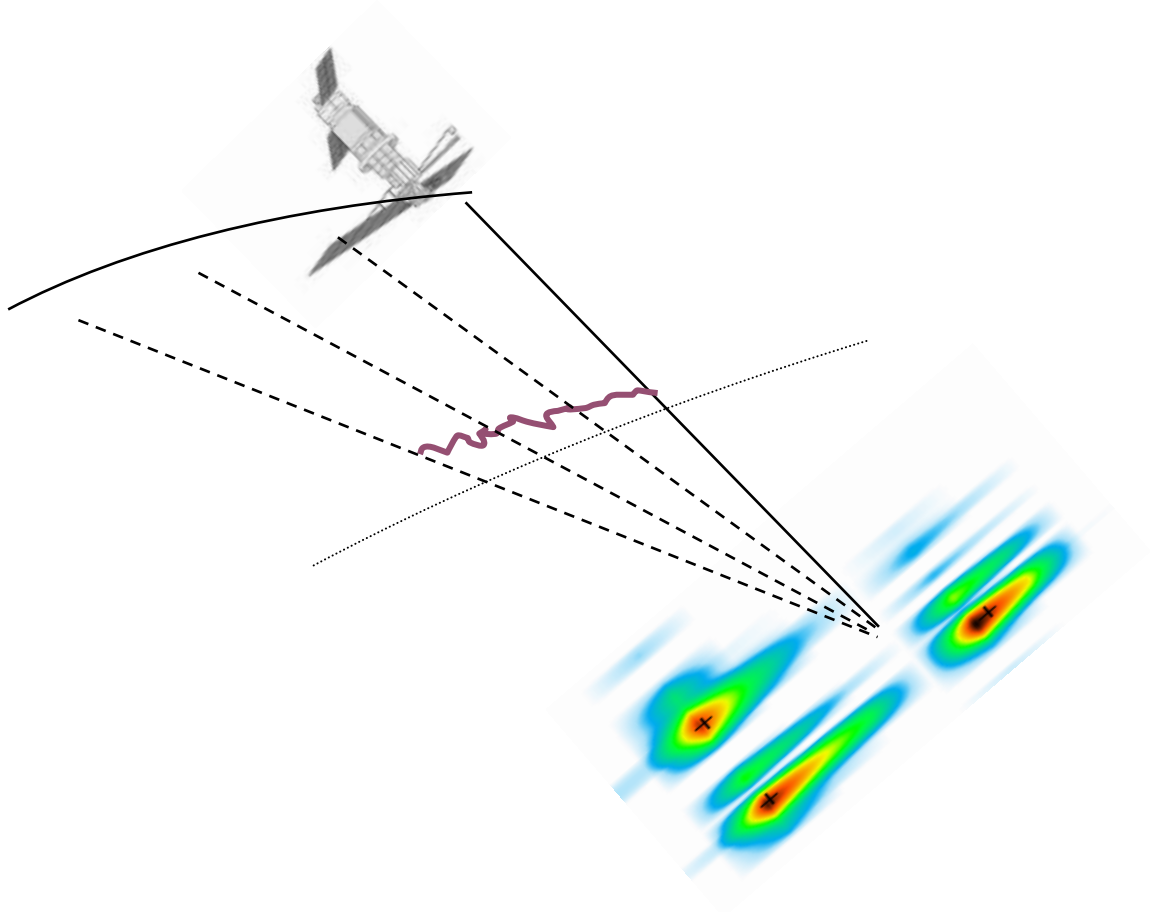


BepiColombo an ESA mission to Mercury – The ISP group is involved in the MEA (Mercury Electron Analyzer) and SIXS (Solar Intensity X-ray and particle Spectrometer) experiments onboard Mercury Magnetospheric Orbiter and Mercury Planetary Orbiter, respectively.



PROPOSAL: Development of an ENA sensor, namely **ENAMISS**, to be uploaded on the International Space Station for continuous magnetosphere observation

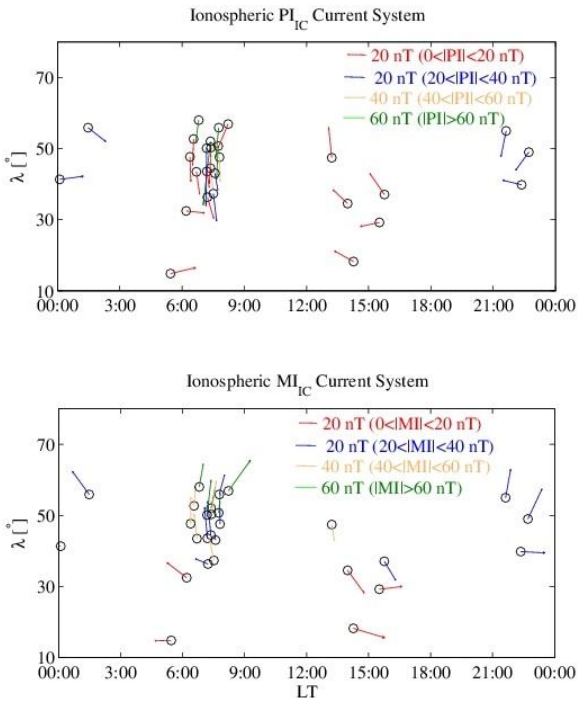
Solar-Terrestrial physics to Space Weather



SolarTerrestrial and Space Physics GROUP
Dipartimento di Scienze Fisiche e Chimiche
Università degli Studi dell'Aquila

University of L'Aquila

Analysis of the ground-based and magnetospheric response to active Solar Wind (SW) conditions



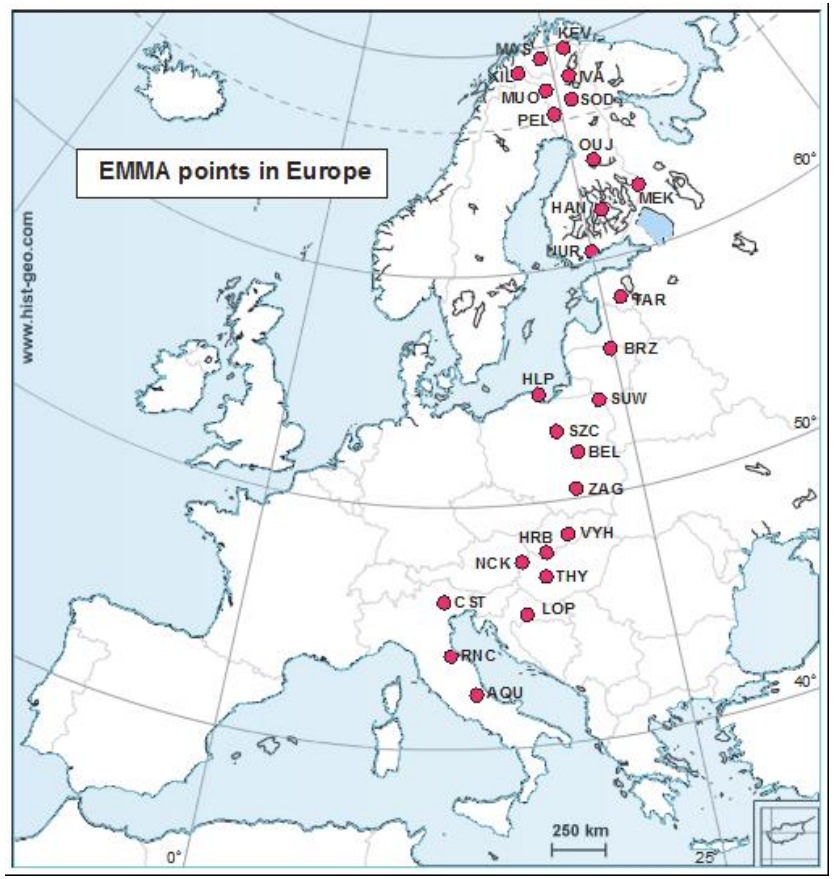
Example of the reconstruction of the ionospheric current flow pattern during November 11, 2000 SI event.

Scientific collaborations

- *Geological and Geophysical Institute of Hungary, Hungary*
- *Electrical Engineering Department, New Mexico Tech, USA*
- *Institute of Geophysics-PAS, Poland*
- *Finnish Meteorological Institute, Finland*
- *Space Research Institute (IWF), Graz, Austria*
- *School of Mathematical and Physical Sciences, University of Newcastle, Callaghan, New South Wales, Australia.*
- *Physics Department, University of Calabria, Rende (CS), Italy.*
- *National Institute for Geophysics and Volcanology INGV, Rome, Italy.*
- *National Research Council, Institute for Complex Systems ISC-CNR, Florence, Italy.*

EMMA (European Meridional Magnetometer Array)

25 stations, 1.6 < L < 6.1

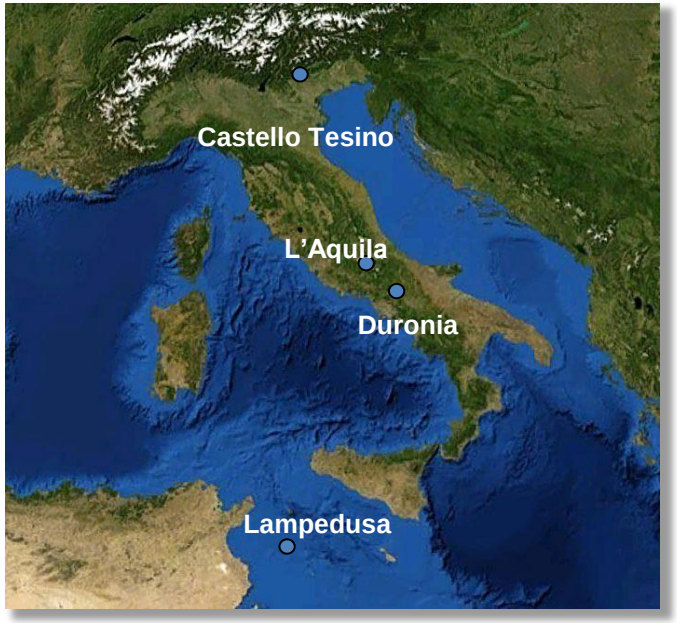


Villante, U., S. Di Matteo, and M. Piersanti (2015), On the transmission of waves at discrete frequencies from the solar wind to the magnetosphere and ground: A case study, J. Geophys. Res. Space Physics,120, doi:10.1002/2015JA021628.

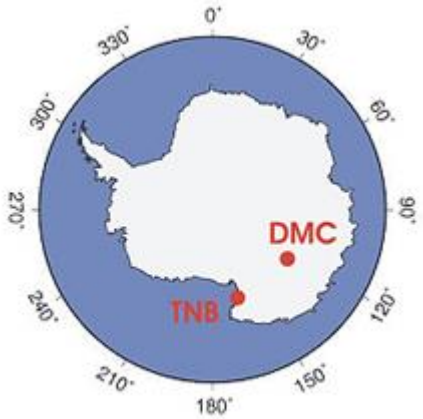
Lichtenberger, J., M. A. Clilverd, B. Heilig, M. Vellante, J. Manninen, C. J. Rodger, A. B. Collier, A. M. Jørgensen, J. Reda, R. H. Holzworth, R. Friedel, and M. Simon-Wedlund (2013), The plasmasphere during a space weather event: first results from the PLASMON project, *J. Space Weather Space Clim.*, *3*, A23, doi: http://dx.doi.org/10.1051/swsc/2013045.

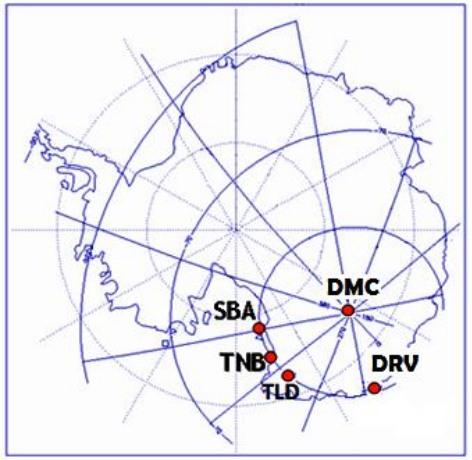
Geomagnetic Observatories

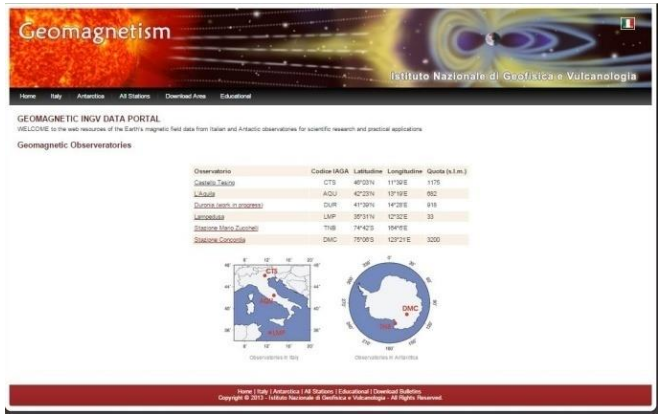
Italy

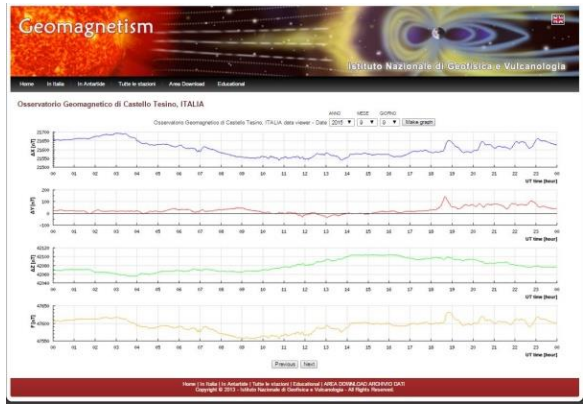


Antarctica



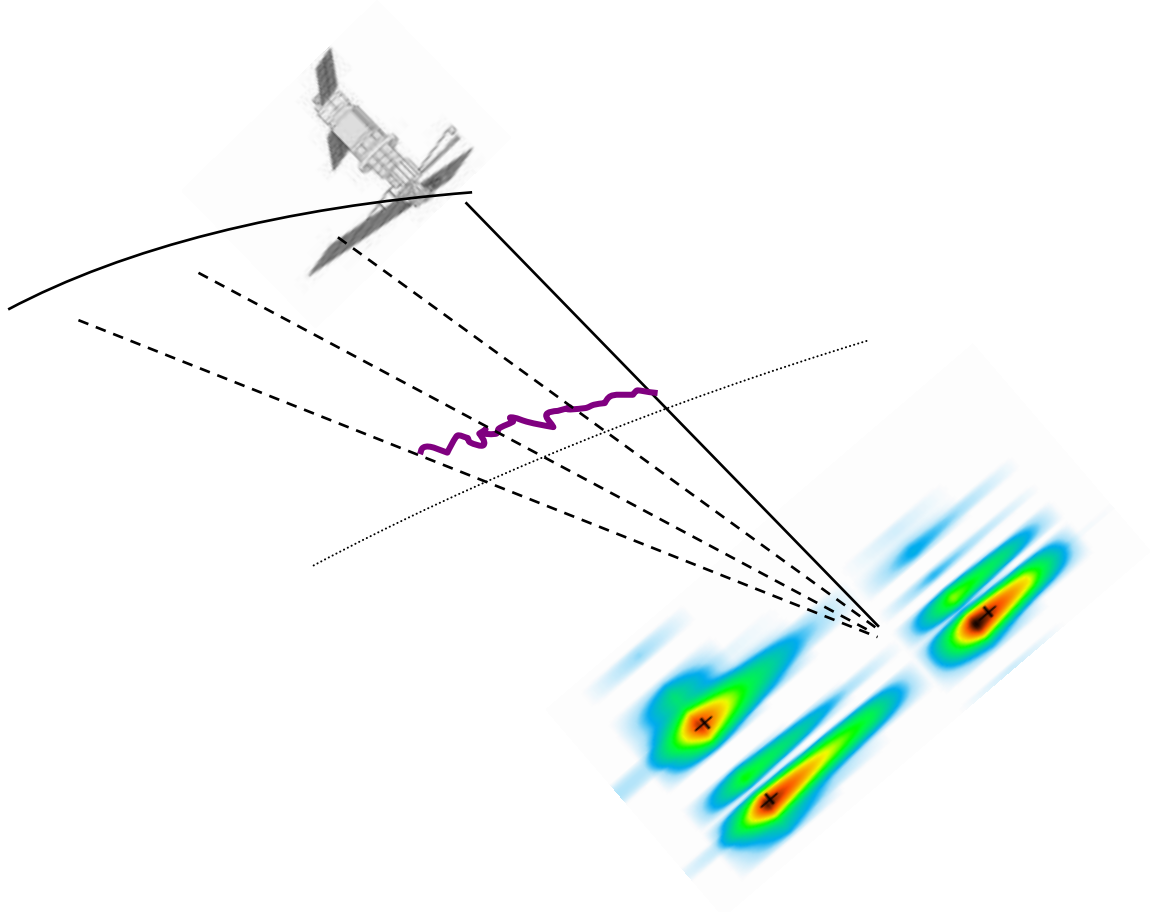




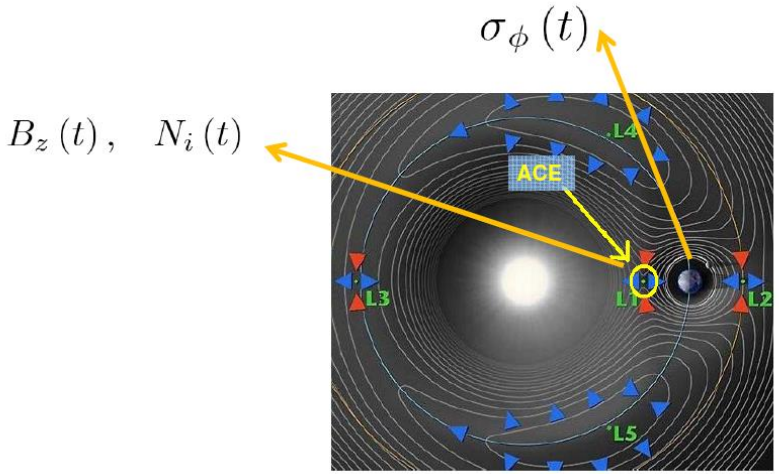


Observatory data are available at the following URL address:
http://geomag.rm.ingv.it

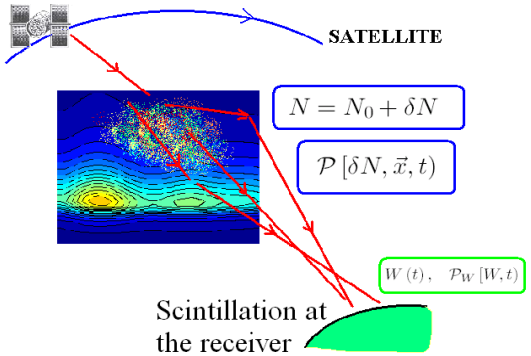
Upper atmosphere physics to Space Weather



National Research Council (Institute for Complex Systems) Recent Activities:



Predictive Space Weather via information theory tools for data analysis



Ionospheric irregularity sensing through multi-scale analysis of radio scintillation on GNSS signals

- **Space Research Centre of the Polish Academy of Science, Warsaw, Poland (ionospheric irregularities and radio scintillation)**
- **Centre for Theoretical Physics of the University of Marseille, France (dissipative Magneto-Hydro-Dynamics)**
- **University of Bath, UK (information theory analysis tools applied to Space Weather)**

Wernik, A. W., L. Alfonsi, and M. Materassi (2007), Scintillation modeling using in situ data, Radio Sci., 42, RS1002, doi:10.1029/2006RS003512.

Ionospheric Observatories

Gibilmanna (Italy)

Rhombic Antennas
(TX and RX)

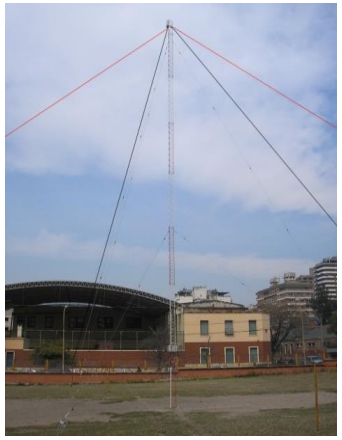
AIS - INGV

Rome (Italy)

AIS - INGV

Antennas (TX and RX)

S. Miguel de Tucumán (Argentina)

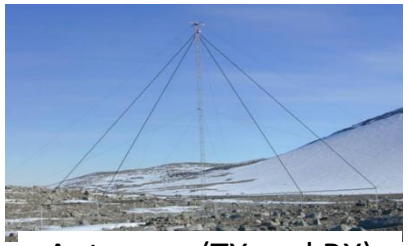


Delta Antennas
(TX and RX)

AIS - INGV

Mario Zucchelli Station (Antarctica)

AIS - INGV



Antennas (TX and RX)

Space Weather forecast

Achievement of forecasting and nowcasting three dimensional (3-D) electron density mapping of the ionosphere.

INGV GNSS receivers network

- First receiver installed at Ny-Alesund (Svalbard) on 2003
- Polar ionosphere
  - Svalbard islands (3)
  - Antarctica (4)
- Mid latitude ionosphere
  - Chania (Crete)
  - Huelva (Spain) – stopped
  - Huelva station moved to Lampedusa
- Equatorial Ionosphere
  - Tucuman (Argentina)

Data are accessible at the *electronic Space Weather upper atmosphere* website

eSWua

www.eSWua.ingv.it

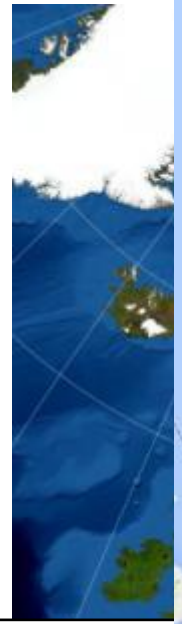
INGV network partners

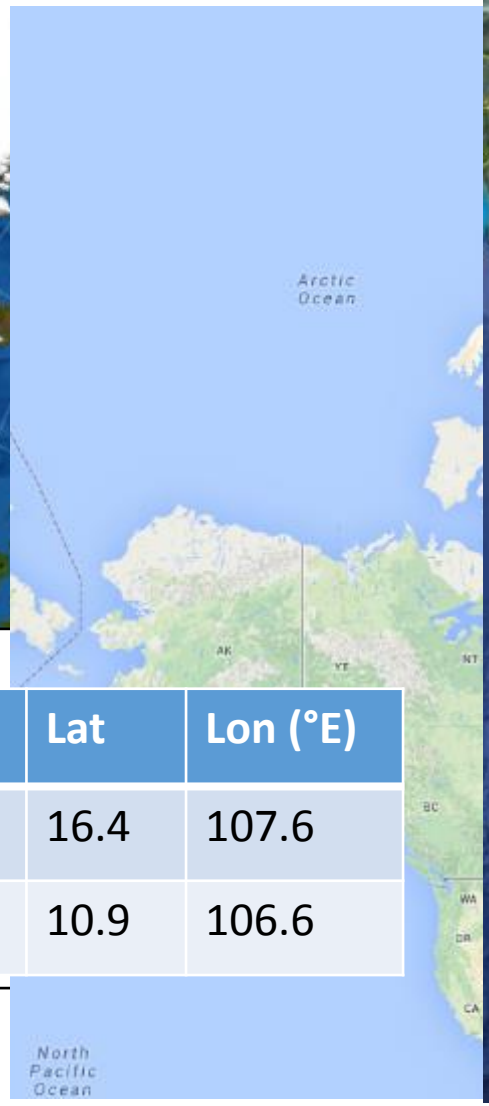
CIGALA/CALIBRA Network

Institute of Electronics and Telecommun[illegible]es

Vietnam Academy of Science and Tech[illegible]

- CHAIN (Canadian High Arctic Ionospheric Network)





CBK-PAN

Location	Lat	Lon (°E)
Hue	16.4	107.6
Hoc Mon	10.9	106.6

Most relevant past and on-going projects

CALIBRA: Countering GNSS high Accuracy applications LImitation due to ionospheric disturbance in BRAzil, FP7–GALILEO–2011–GSA–1

TRANSMIT: Training Research and Applications Network to Support the Mitigation of Ionospheric Threats, FP7-ITN Marie Curie

ESPAS: Near-Earth space data infrastructure for e-science, FP7-Research Infrastructure

MISW: Mitigation of space weather threats to GNSS services, FP7-Space

ERICA: EquatoRial Ionospheric Characterization in Asia, ESA-ALCANTARA

MIMOSA2: Monitoring Ionosphere Over South America, ESA-ALCANTARA

DemoGRAPE: Demonstrator of GNSS Research and Application for Polar Environment, PNRA

GRAPE: GNSS Research and Application for Polar Environment, SCAR

GINESTRA – MIMOSA - MEDSTEC

COMPETENCE SURVEYS WITHIN THE ESA ALCANTARA INITIATIVES

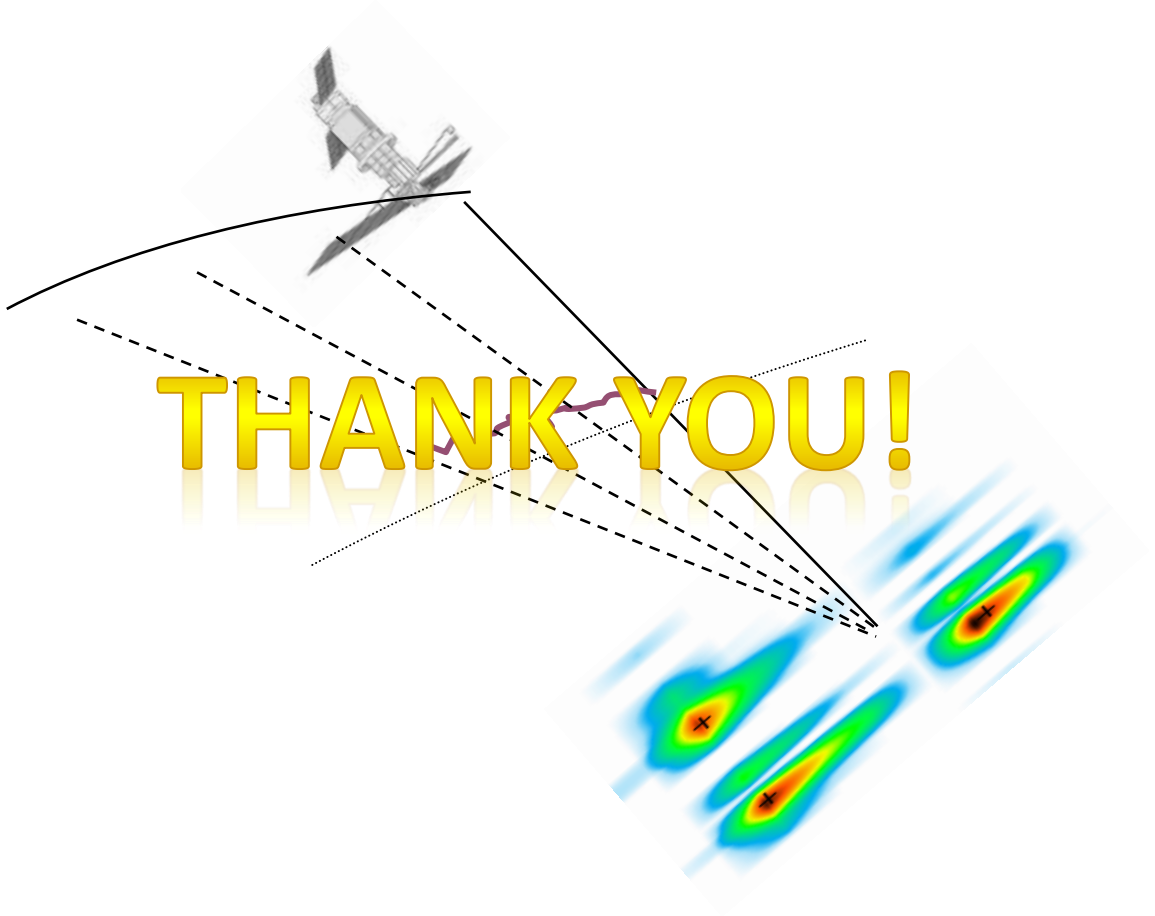
MImOSA2

Monitoring **I**onosphere **O**ver **S**outh **A**merica to support high precision applications

ERICA

Equato**R**ial **I**onosphere **C**haracterization in **A**sia

WHO WITH



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