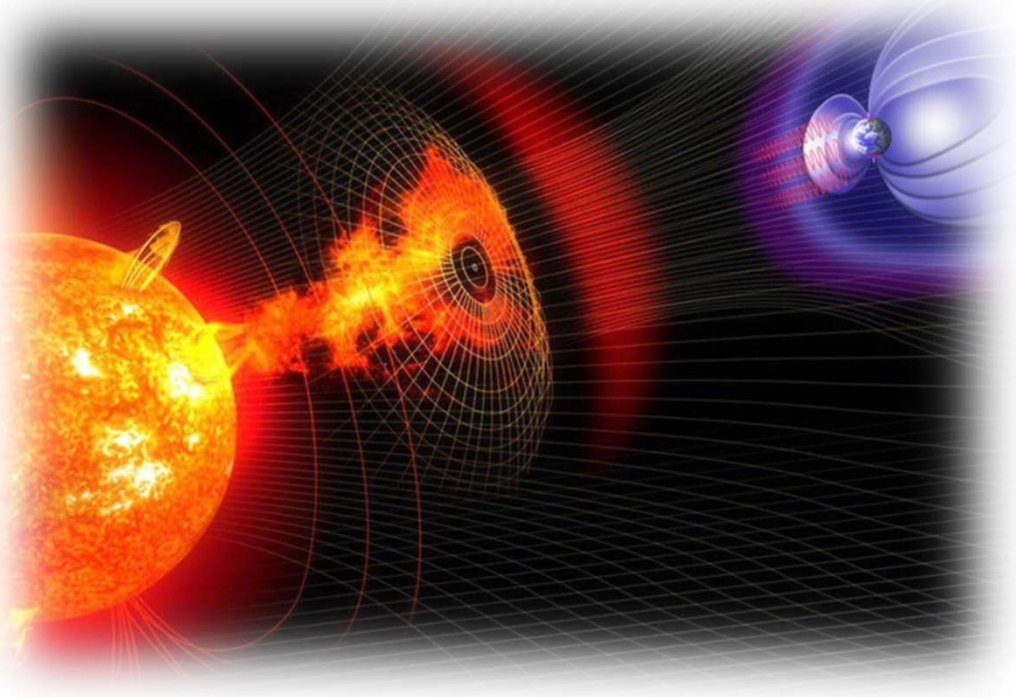
Space Weather Service Network (SWESNET)

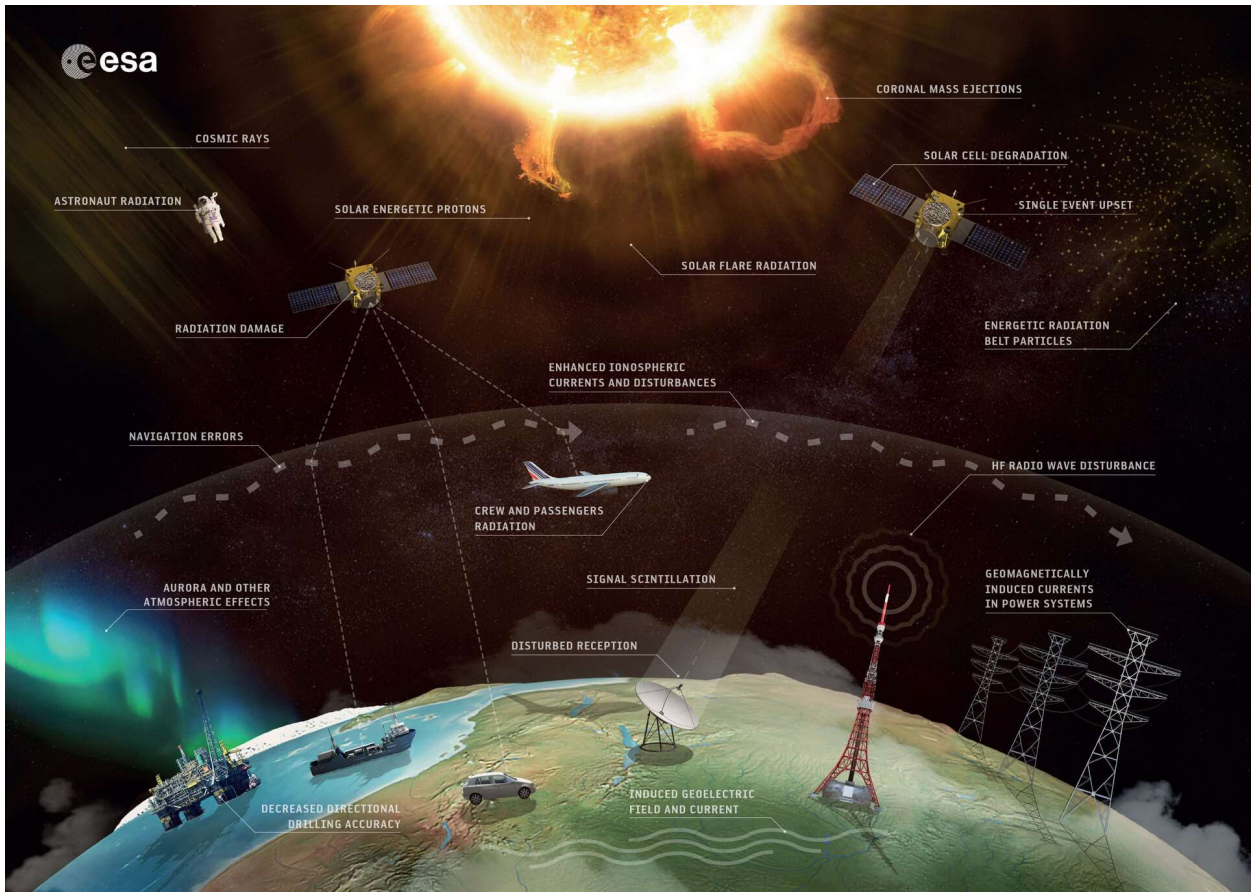
Paolo Romano
on behalf of SWESNET team



Audit CSN3 – Piano Triennale 2021-2024

Introduction

"*Space Weather* is the physical and phenomenological state of natural space environments. The associated discipline aims, through observation, monitoring, analysis and modelling, at **understanding** and **predicting** the state of the Sun, the interplanetary and planetary environments, and the solar and non-solar driven perturbations that affect them, and also at **forecasting** and **nowcasting** the potential impacts on biological and technological systems." - COST Action 724 , 2009



Space Weather Service Network

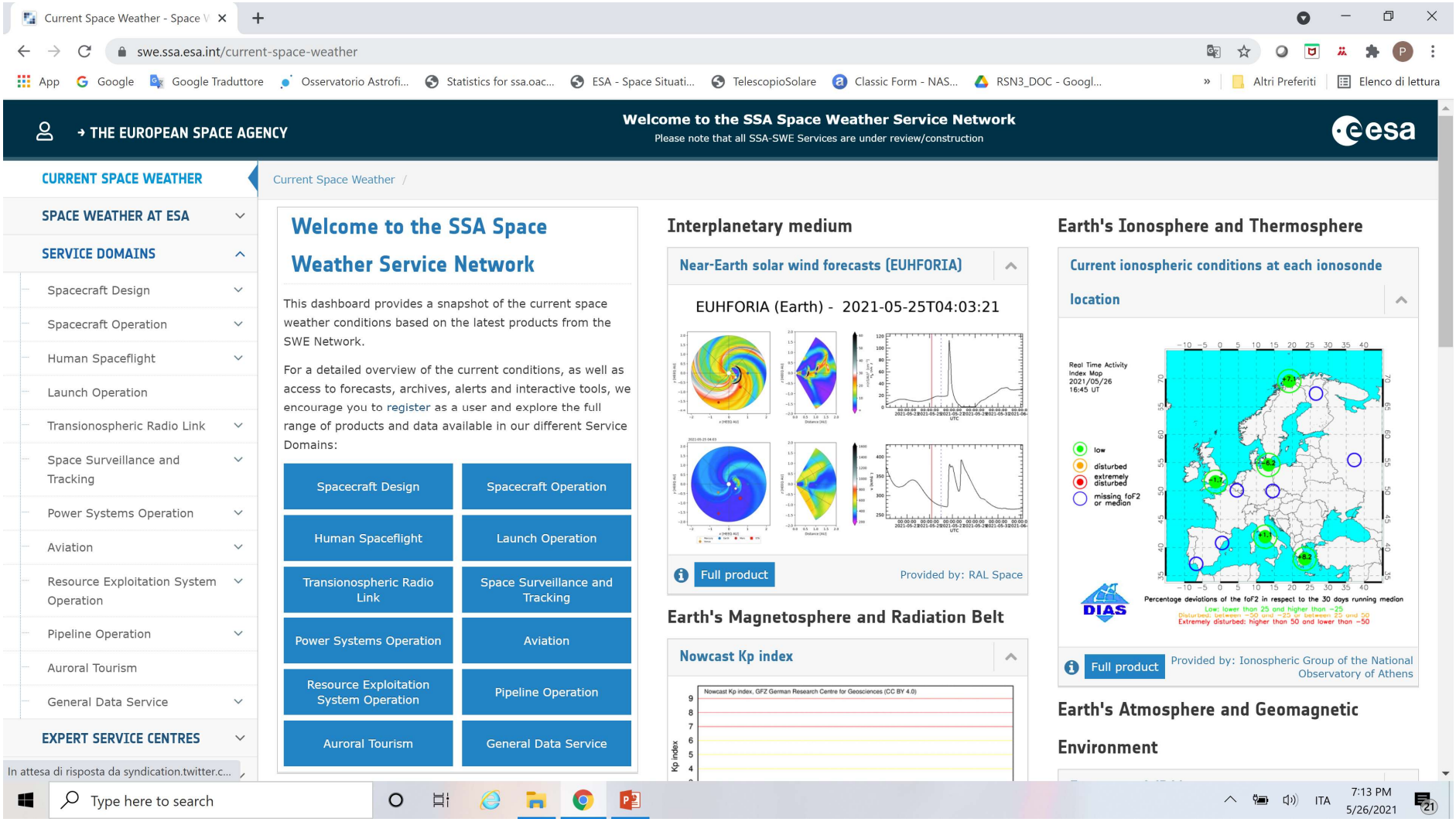
The SWESNET programme actively addresses Space Weather service users in the following domains and SWE developments are targeted towards addressing the needs of these groups for accurate and timely space weather information:

- Spacecraft Designers
- Spacecraft Operators
- Human Spaceflight Mission Operators
- Launch Operators
- Transionospheric Radio Link Service Users and Operators
- Space Surveillance and Tracking Services
- Power System Operators
- Pipeline Operators
- Airlines and Aerospace Sector including Regulatory Authorities
- Resource Exploration: geomagnetic surveying, oil and gas prospecting and exploitation
- Auroral Tourism sector
- General Data Services geared towards downstream service providers, expert users and the **scientific community**

Patrol (medium and high level data) ⟷ **Tools** (nowcast and forecast)

Space Situational Awareness Programme (SSA) (2009-2021)

Data and products are provided through a network of *Expert Service Centres*. Each of these comprises a distributed set of Expert Groups contributing particular data, products and/or expertise. Five ESCs are currently contributing to the network:



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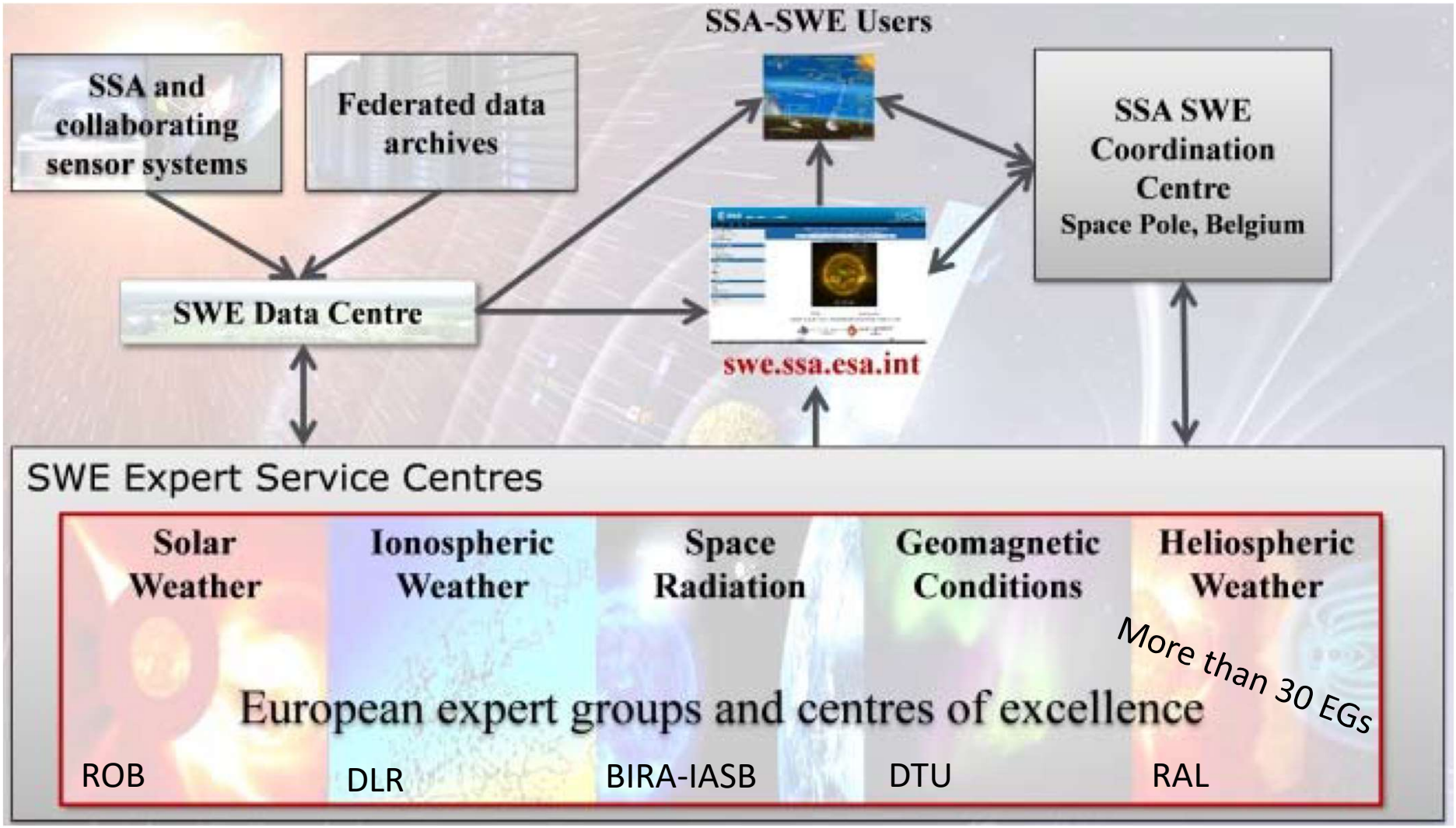


Team

Nome	Struttura	Ruolo / competenza
Giancarlo Bellassai	INAF-OACT	Technician
Alessandro Bemporad	INAF-OATO	WP manager
Pietro Bruno	INAF-OACT	Telescope control software
Salvo Buttaccio	INAF-OACT	Software
Alessandro Costa	INAF-OACT	Software
Pierfrancesco Costa	INAF-OACT	Observer
* Mariachiara Falco (TD)	INAF-OACT	Software management
Silvano Fineschi	INAF-OATO	WP manager
Silvio Giordano	INAF-OATO	Expert
Salvatore Luigi Guglielmino	INAF-OACT	Expert
Salvatore Mancuso	INAF-OATO	Expert
Eugenio Martinetti	INAF-OACT	Telescope control
Gianalfredo Nicolini	INAF-OATO	Expert
Giovanni Occhipinti	INAF-OACT	Mechanics management
Paolo Romano	INAF-OACT	WP manager
Daniele Spadaro	INAF-OACT	Expert
Roberto Susino	INAF-OATO	Expert
Daniele Telloni	INAF-OATO	WP manager
Rita Ventura	INAF-OACT	Expert
Cosimo Volpicelli	INAF-OATO	Expert
Luca Zangrilli	INAF-OATO	Expert
Francesca Zuccarello	Università di Catania	Expert

Fondi

La sorgente di finanziamento è l'ESA.
Sino al 2021 il finanziamento è stato basato sul contratto Contract No. 4000113186/15/D/MRP e successivi emendamenti nell'ambito dell'ESA Space Situational Awareness Programme (SSA).

1° contratto P2-SWE-ESA: No 4000113186/15/D/MRP		
sotto-contratto fra ROB e INAF-OACt: 2015SWE1CAT1		
	dal 1/1/2016 al 30/6/2017	60 k€
1a estensione P3-SWE		
Emendamento No 1 al sotto-contratto 2015SWE1CAT1		
Pre-operational service provision	dal 14/6/2017 al 13/12/2018	
Network promotion activities	dal 1/11/2017 al 30/4/2019	
Tasks 2-3	dal 11/12/2017 al 10/6/2019	37.5 k€
Service extension P3-SWE-II		
Addendum all'emendamento No 1		
Data provision	dal 14/12/2018 al 10/6/2019	8.5 k€
2a estensione P3-SWE		
Emendamento No 2 al sotto-contratto 2015SWE1CAT1		
Service provision		
Tasks 2-3 (http->https, AWSTATS, New WebAgent)	dal 11/06/2019 al 10/12/2019	38.8 k€
3a estensione P3-SWE		
Emendamento No 3 al sotto-contratto 2015SWE1CAT1		
Parte 1		
Service provision		
Tasks 3 (upgrade del sistema di acquisizione)	dal 11/12/2019 al 10/06/2020	54 k€
Parte 2		
Service provision		
Tasks 3 (New WebAgent)	dal 11/06/2020 al 10/12/2020	19 k€

Fondi

Da Maggio 2021 a Giugno 2023 il finanziamento avverrà in base all' ESA Announcement of Opportunity 1-10363/20/D/MRP for the Space Weather Service Network (SWESNET) Development and Pre-Operation Part 1.

Stima inviluppo complessivo intera attività (M€):	**50**
Stima inviluppo complessivo per la parte di attività INAF dall'inizio a fine attività (k€):	**630**
Stima fondi acquisiti da INAF fino al 2020 (k€):	**121**

WBS

The Project workflow is divided into 5 main branches:

- WP 10000: Project Management: the B.USOC is supervising the high level execution of the project;
- WP 20000: Operational Activities: the SSCC, led by ROB together with BIRA-IASB , will be responsible for the continuation of the SWE Network operations, with the support of the ESCs and the service and tool provision from the EGs;
- WP 30000: SWE Network Development
- WP 40000: Service Support and User Endorsement
- WP 50000: Product & Tool Development

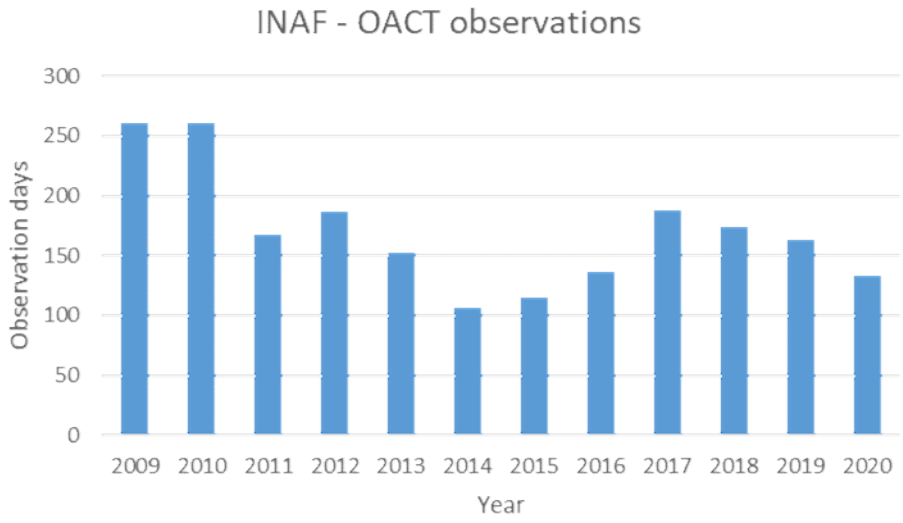
INAF-OACT e I**NAF-OATO** are EGs and in charge of the following 6 WPs:

WP-23361 EG P&T Provision (INAF/OACT),
WP-23362 EG Adaptive maintenance (INAF/OACT),
WP-38360 EG management (INAF/OACT)
WP-38490 EG management (INAF/OATO)
WP-52493 P&T Dev.: Magnetic effectiveness tool (INAF/OATO)
WP-52494 P&T Dev.: CME Propagation tool (INAF/OATO)

WP-23361

INAF – OACT data provision

Solar observations of the photosphere and chromosphere have been carried out at the INAF - Catania Astrophysical Observatory in collaboration with the **University of Catania** since 1876, the year of its foundation.



An equatorial spar which includes:

- a Cook refractor, used to make daily drawings of sunspot groups from visual observations;

- a 0.15 m refractor (f=2230 mm) with an Halpha Lyot filter for chromospheric and photospheric observations;

- a 0.15 m refractor (f=2216 mm)

http://ssa.oact.inaf.it/oact/index.html

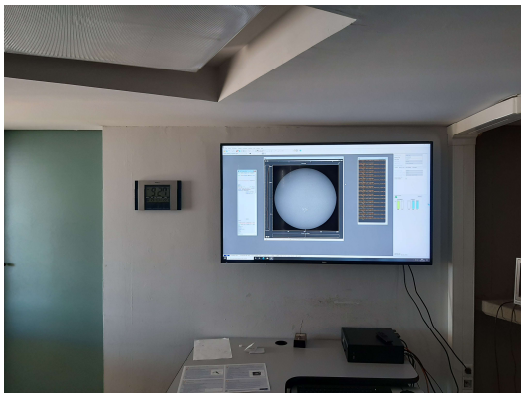
Upgrade of the acquisition system

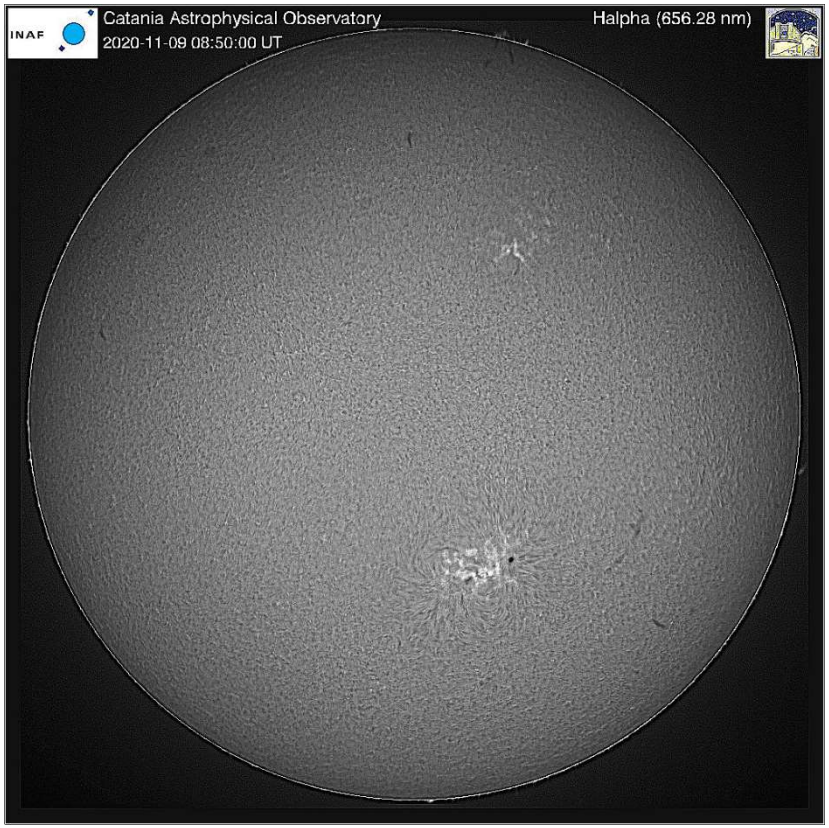
A **CCD** Camera Apogee Alta U9000-HC D09L

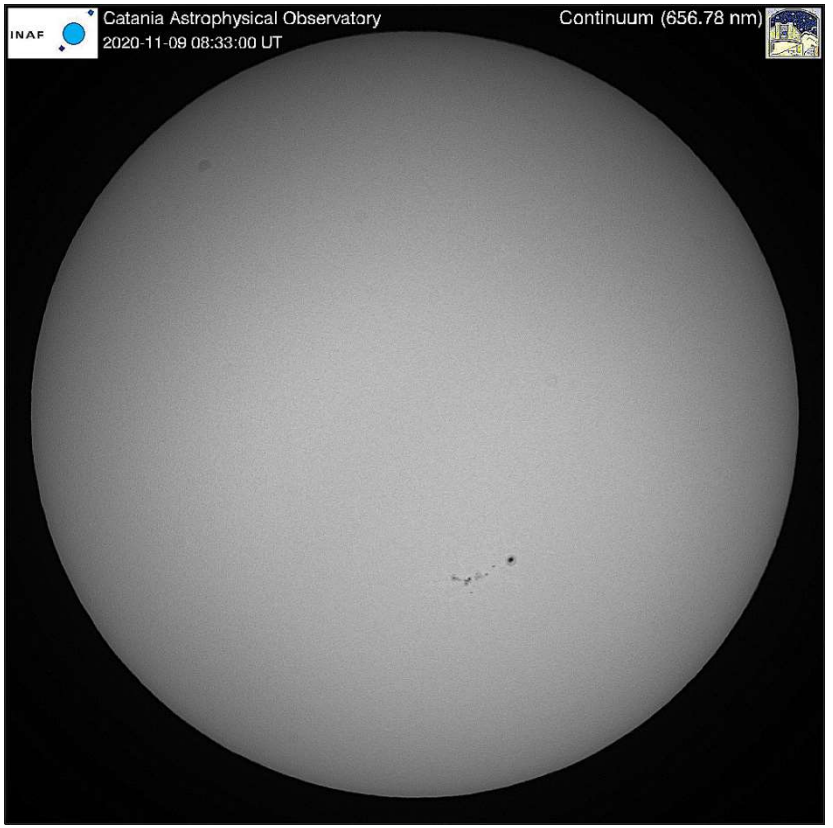
- Mechanical shutter
- Array size: 3096 x 3096 pixel
- Pixel size: 12 mm
- Digital resolution: 16 bit
- Noise: 12 e- RMS
- Dark current < 1.5 e-/pixel/s
- Frame rate: 15 s

A back-illuminated **sCMOS** camera Andoor Marana

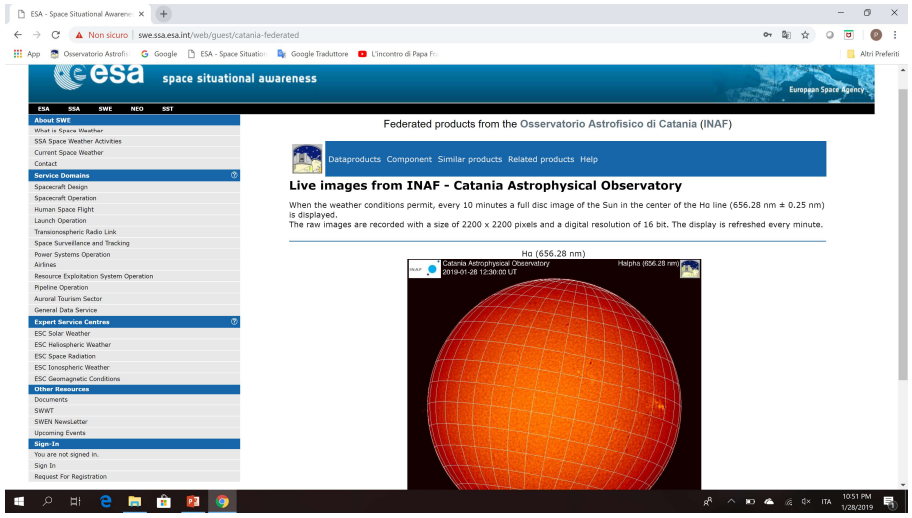
- Rolling shutter
- Array size: 2048 x 2048 pixel
- Pixel size: 11 mm
- Digital resolution: 12/16 bit
- Dark current: 0.4 e-/pixel/s
- QE: 95%
- Frame rate: 24 fps at 16 bit
  48 fps at 12 bit

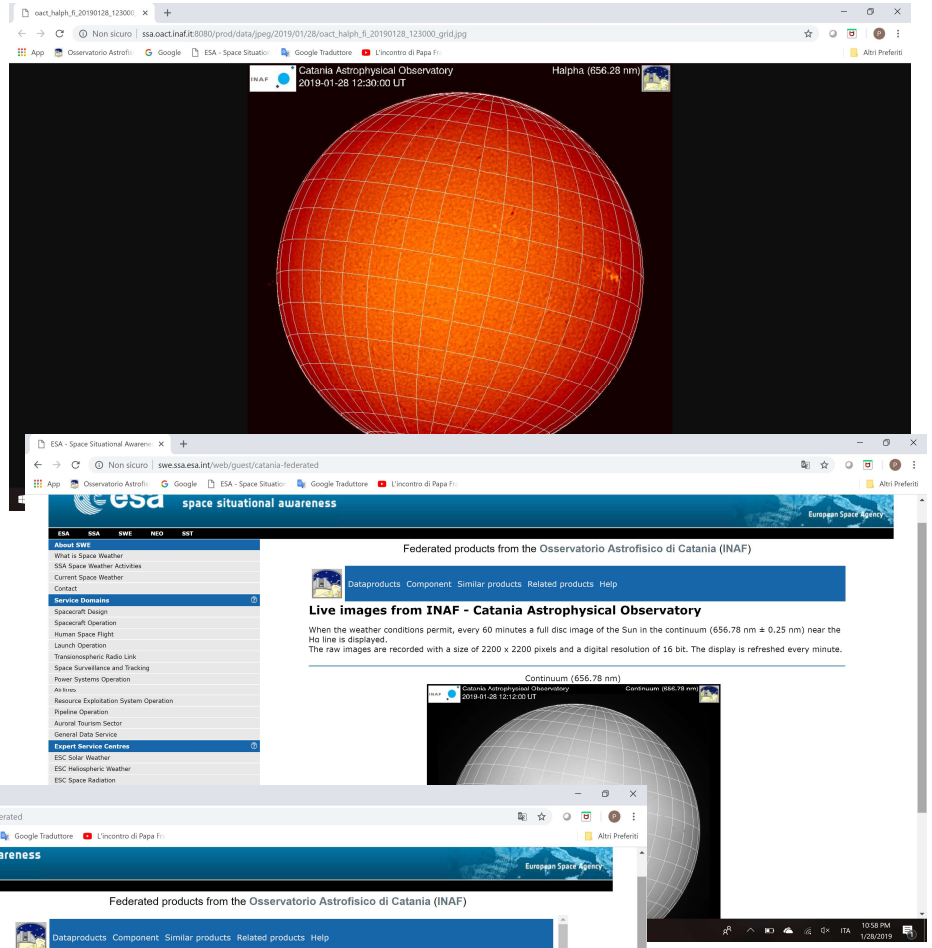






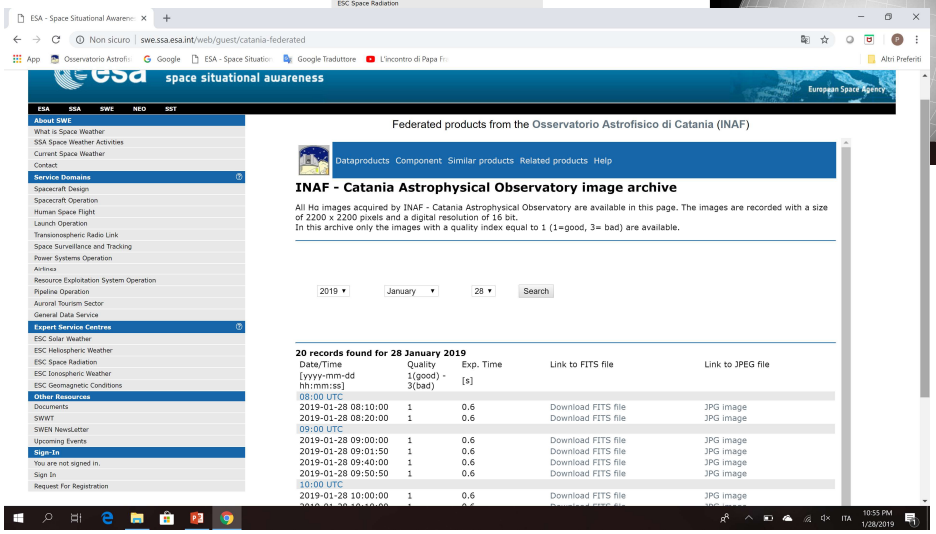
IA2 Italian Center for Astronomical Archives
Centro Italiano Archivi Astronomici





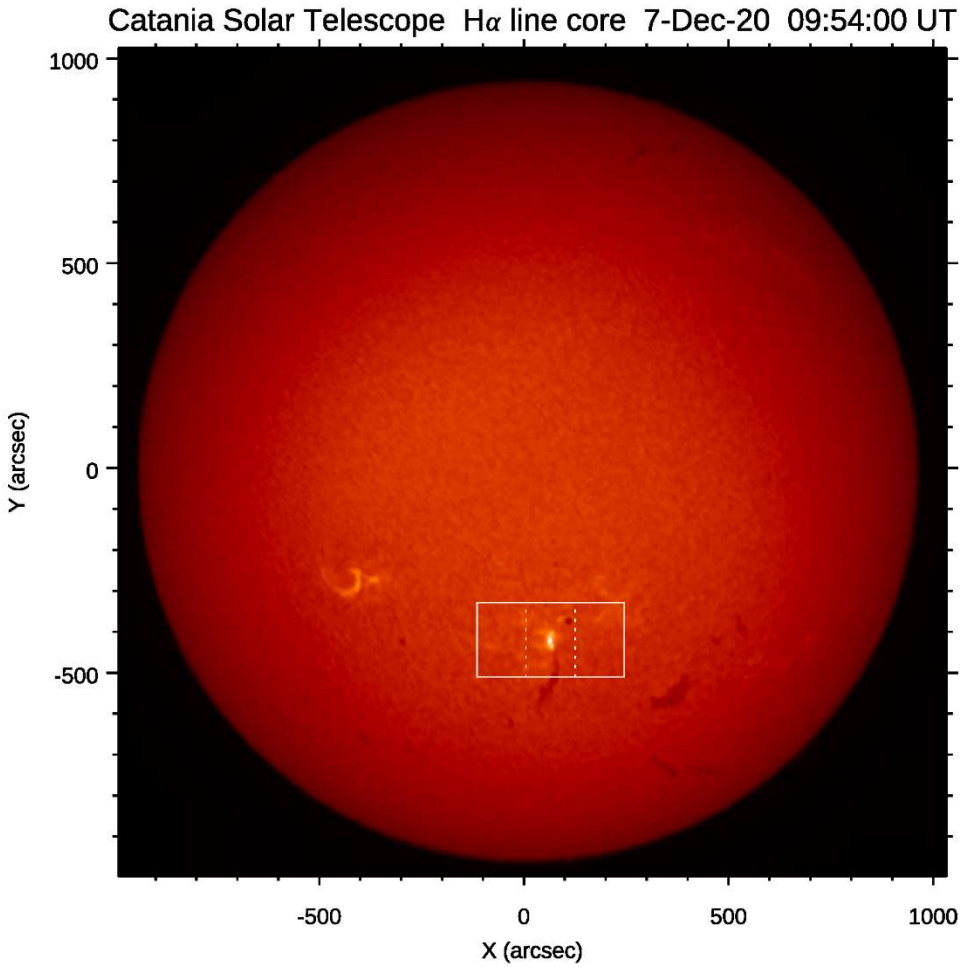
We provide our data to the ESA portal in near real time.

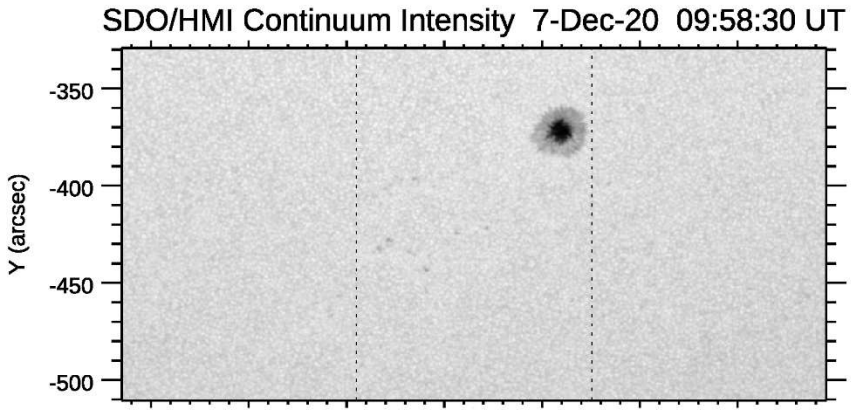
Everyday we transfer our data sets to INAF IA2 Trieste during the night for their storage.

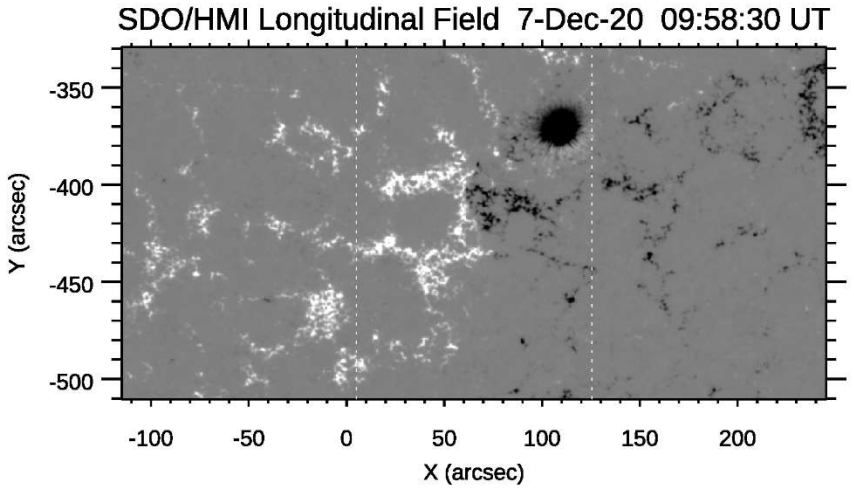


OATS: Cristina Knapic
Massimo Sponza
Cristiano Urban

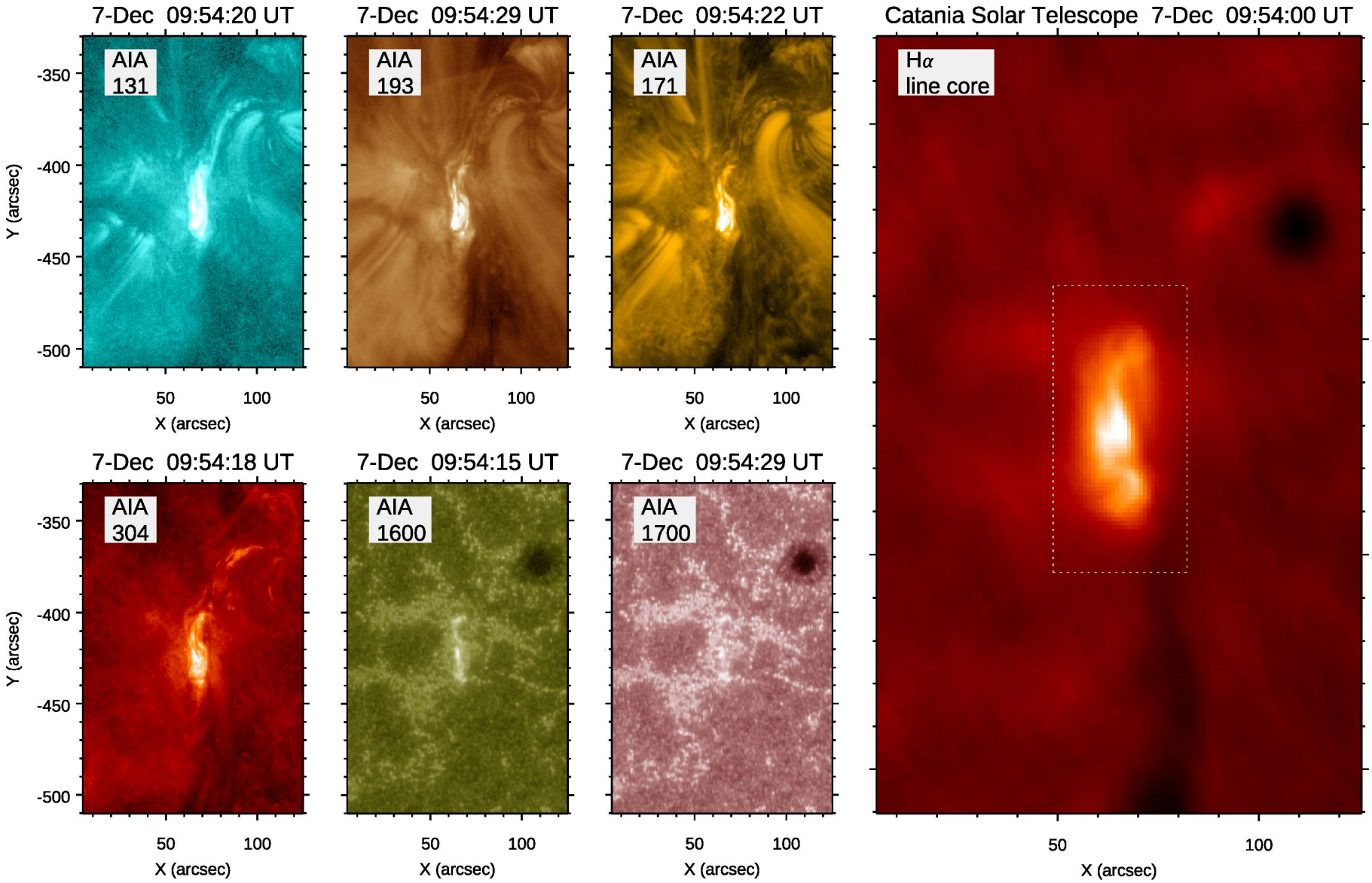
Showcase: a B5 flare observed by the Catania Solar Telescope







Synoptic view of the B5.4 flare event at the peak



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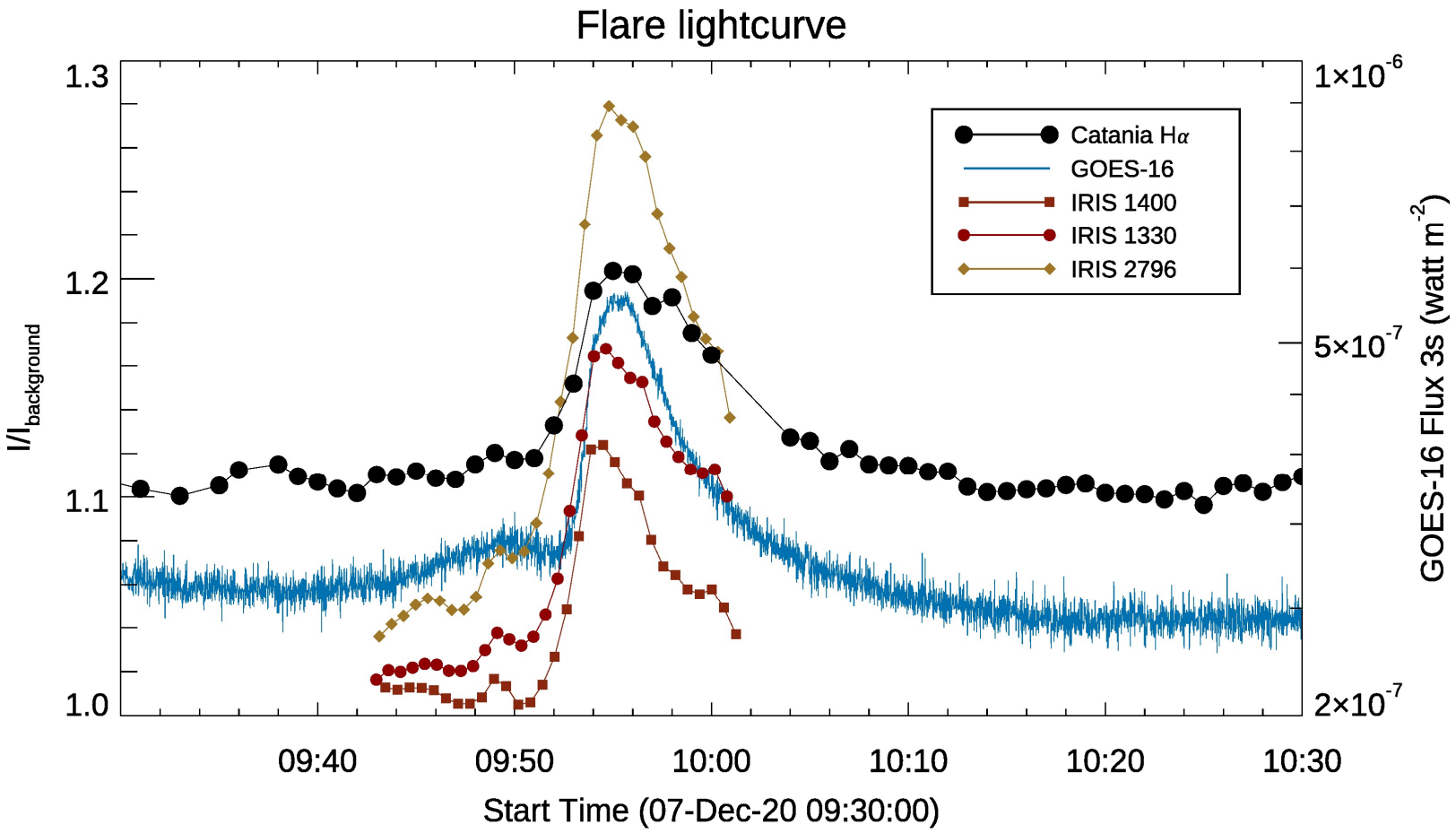
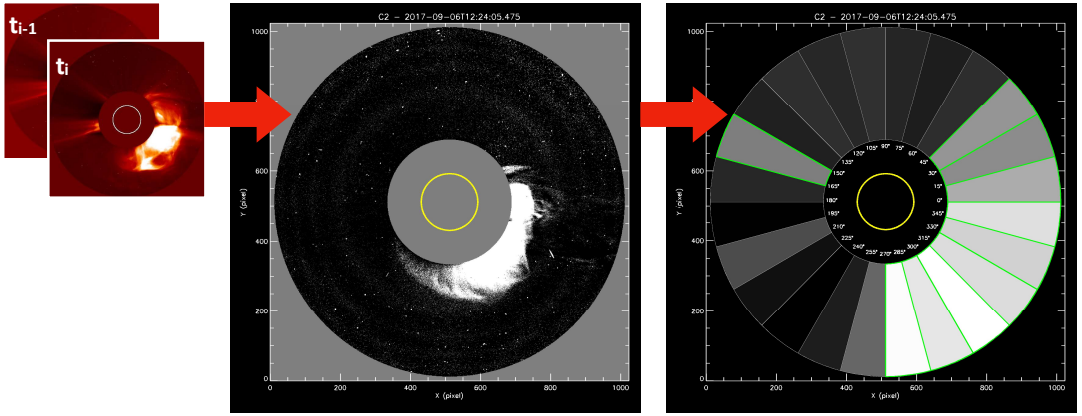


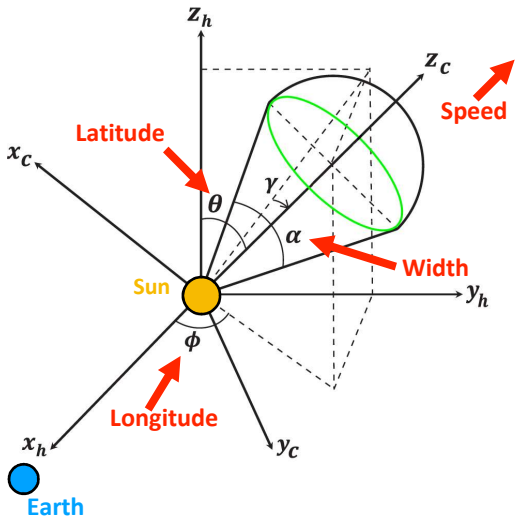
INAF – OATO CME propagation tool

The detection algorithm provides the **first indication on the occurrence** of a CME

Detection of the CME in LASCO C2/C3 images is performed automatically by:

- averaging the total brightness on angular sectors
- calculating the relative variation of the intensity between two consecutive images
- applying a threshold criterion to identify the sectors containing the CME





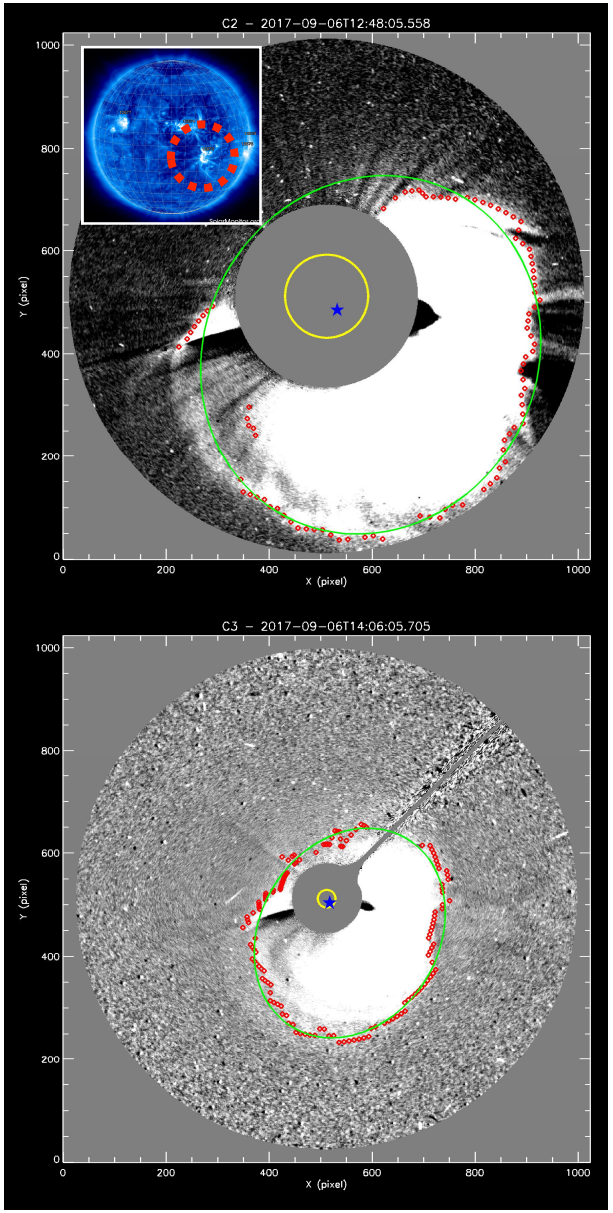
The cone model (Zhao et al. 2002; Xie et al. 2004) is used to derive the **geometric parameters of the CME**

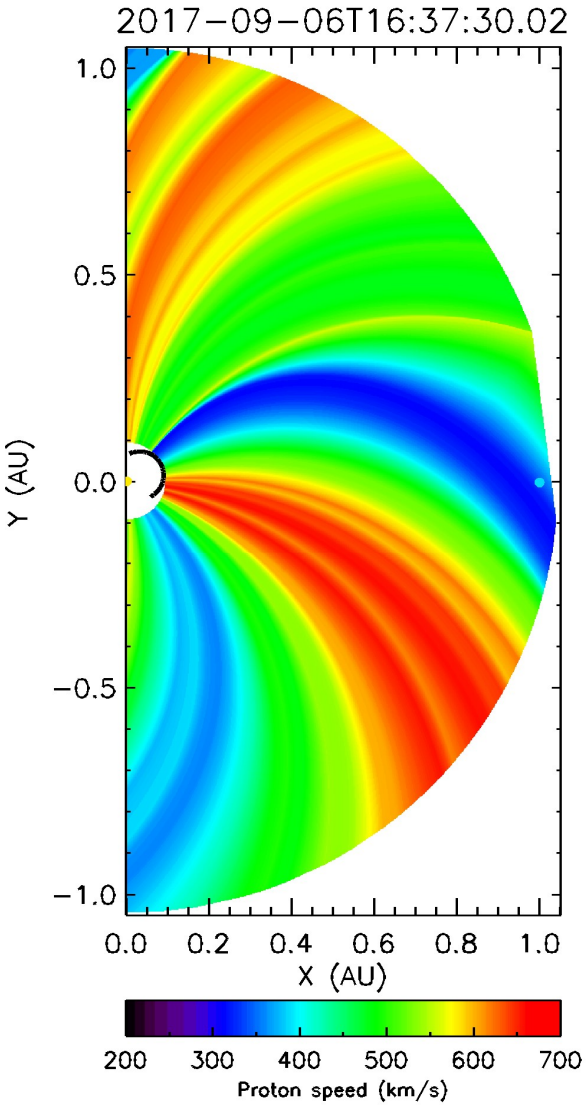
The elliptical fit to the projection of the CME front allows the determination of:

- the propagation direction (latitude and longitude)
- the true radial component of the CME speed

WP-52494

CME propagation and forecast





The propagation of the ICME is derived with the **2D drag-based** model (Vršnak et al. 2013) using a 2D model of the heliospheric solar wind (density and velocity) derived from measured L1 in-situ data acquired by STEREO/PLASTIC and DSCOVR.

Test case:

CME projected speed: 978 km/s (Cactus)

CME real speed: 715 km/s (linear)

Direction: 25°S 20°W

Width: 110°

WP manager: Alessandro Bemporad

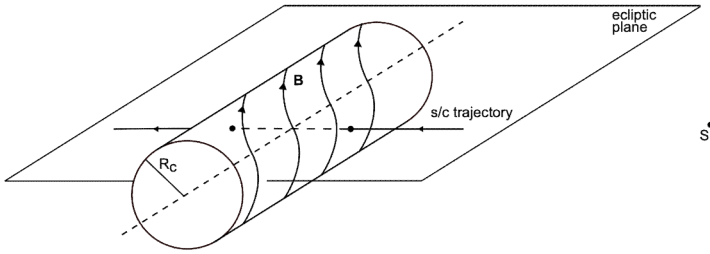
WP-52493

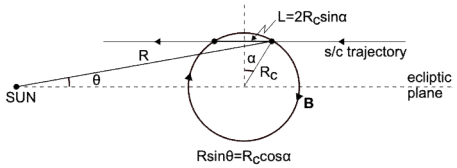
INAF – OATO magnetic effectiveness tool

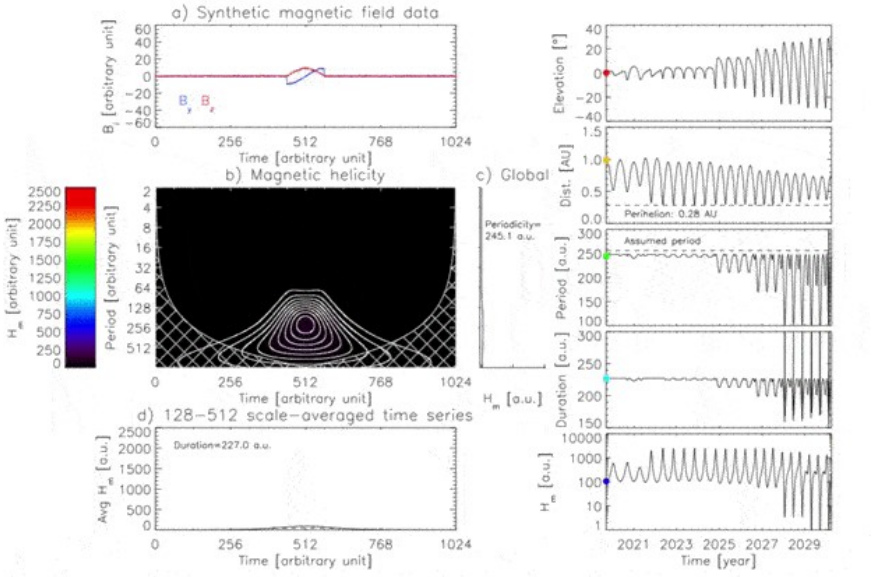
- CMEs are highly twisted magnetic field structures
- Magnetic helicity H_m measures the twist of **B**
- CMEs can be detected as regions with high H_m

$$H_m = \int \mathbf{A} \cdot \mathbf{B} d^3\mathbf{r}$$

$$H_m(t,s) = \frac{\varepsilon_{ijk} V_{0,i} \Im[\mathcal{W}_j^*(t,s)\mathcal{W}_k(t,s)]}{\pi} s$$



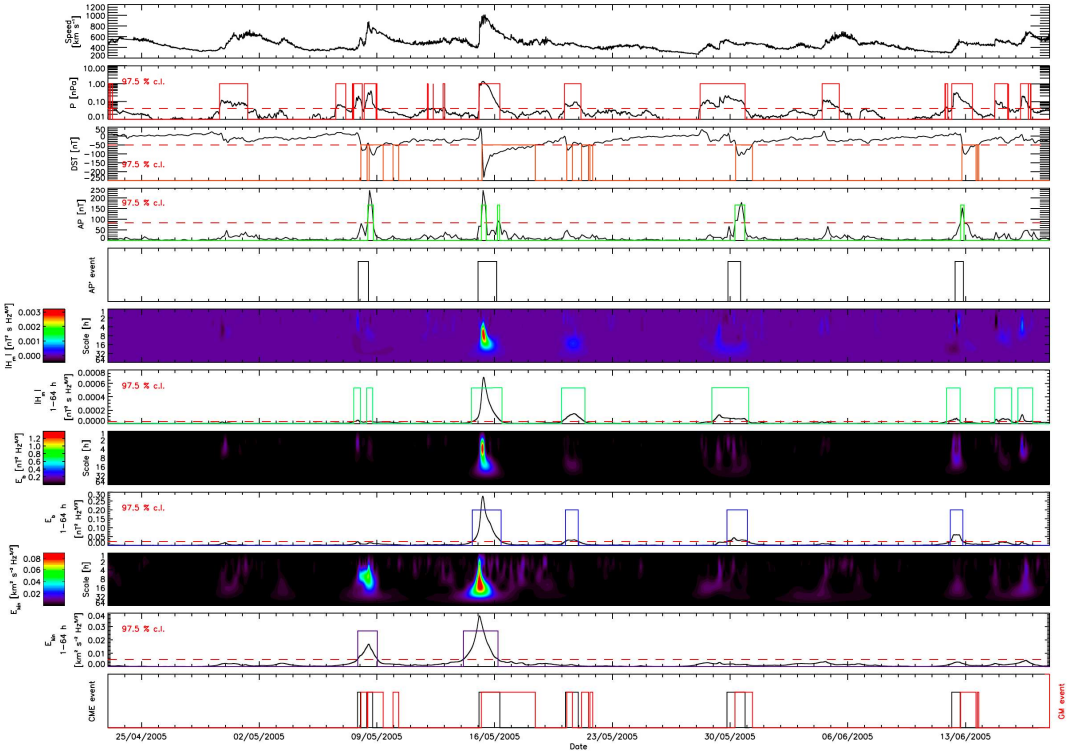




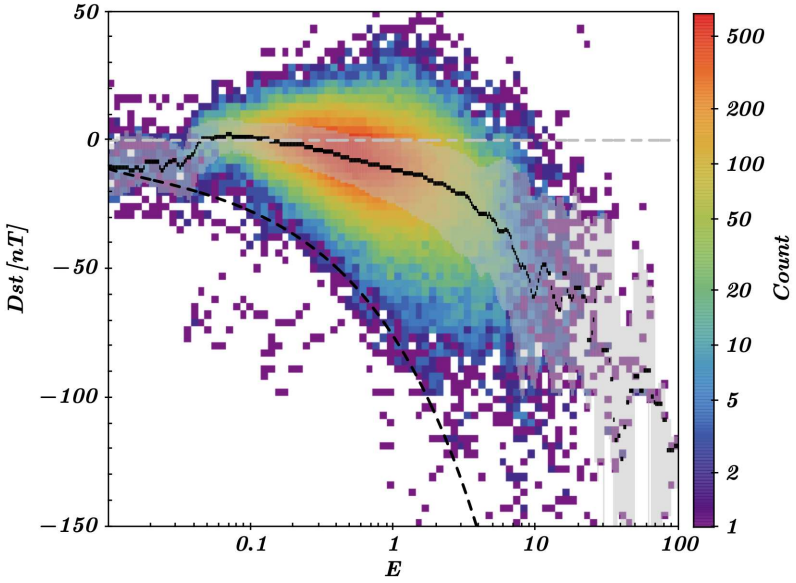
- A very promising and powerful approach to address the CME flux rope investigation and characterization is based on wavelet spectrograms of H_m
- Results on the study of the detection capability of flux ropes during the Solar Orbiter mission:
  - the accuracy in inferring CME flux rope properties (e.g. duration and timescale) depends on the proper evaluation of the CME propagation direction: complementarities with CME propagation and forecast tool.
  - flux-rope intrinsic properties (duration and timescale) can be properly recovered provided the CME direction is known

WP-52493

CME in-situ detection at L1 and geoeffectiveness



- Test case: two-month period from April 23 to June 18, 2005
- CMEs are clearly identified by enhancements of total pressure, magnetic helicity and magnetic/kinetic energies
- About 4 hour advance warning



- The geomagnetic activity is regulated by the solar wind energy fluctuations
- The Earth's magnetosphere has a maximum response to the energetic content of the solar wind

$$\mathrm{Dst} = -10 + \frac{a}{(E - E_0)^b} \qquad a = -66.58\mathrm{nT} \quad b = -0.55 \quad E_0 = 9.55 \times 10^{-3}$$

WP manager: Daniele Telloni

Opportunità / Criticità

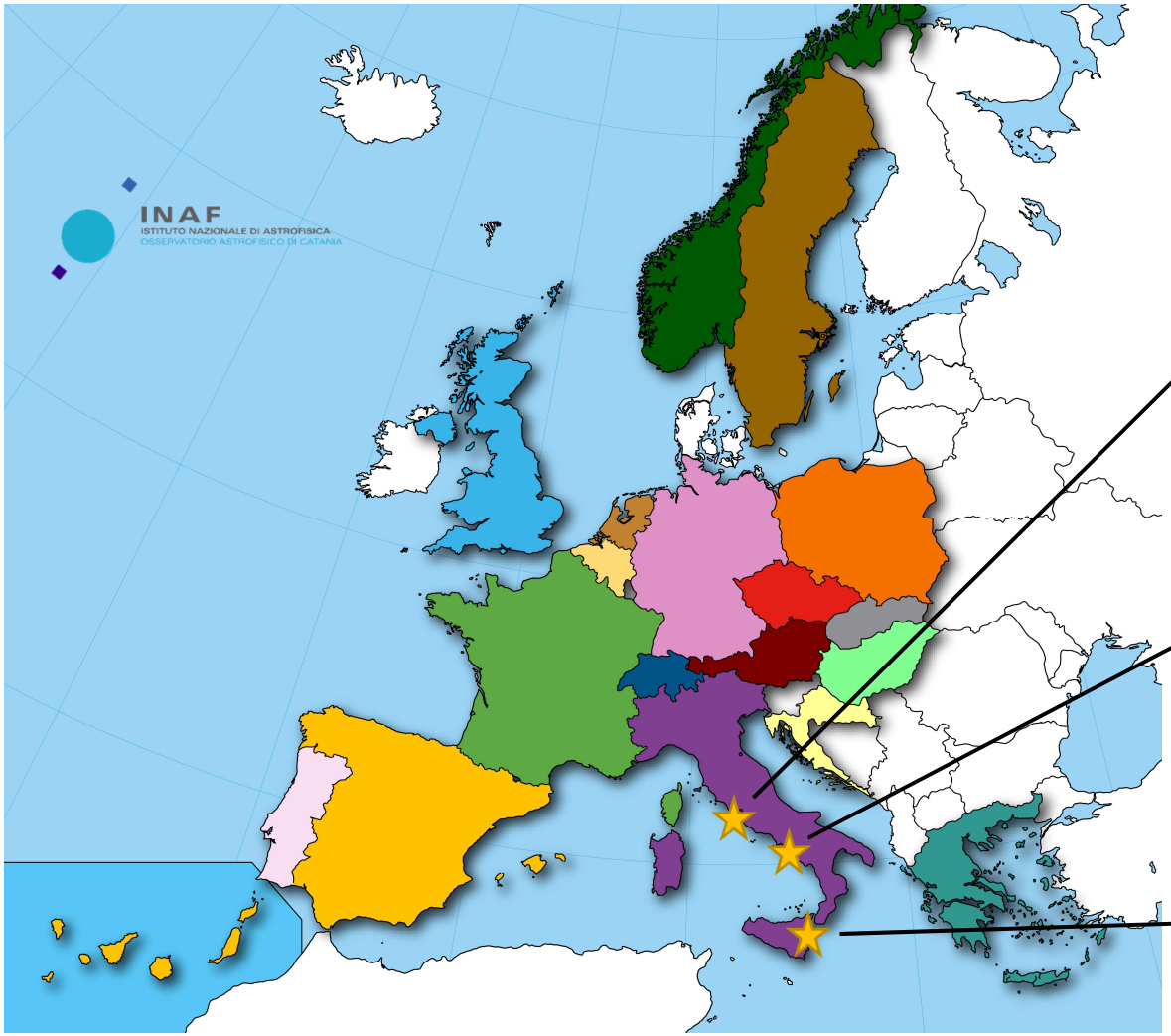
1- L'attività osservativa del Telescopio Solare dell'INAF-OACT richiederebbe almeno un **secondo osservatore** per poter garantire una maggiore copertura temporale nell'arco dell'anno.
A fronte di più di 300 giorni per anno potenzialmente favorevoli per le osservazioni con buone condizioni meteo, la carenza di personale dedicato alle osservazioni fa sì che si osservi in media solo 150 giorni per anno

2- Difficoltà a reperire nuove figure professionali con competenze informatiche per la completa robotizzazione del telescopio e il mantenimento dei software dedicati alla riduzione e pubblicazione dei dati.

3- Definizione di linee di indirizzo condivise per massimizzare il ritorno di investimenti della comunità italiana nel settore (vedi scheda Mauro Messerotti INAFSWSN, roadmap ASI, contrinuto ad ESA-SSA, nuova call ASPIS, etc etc.)

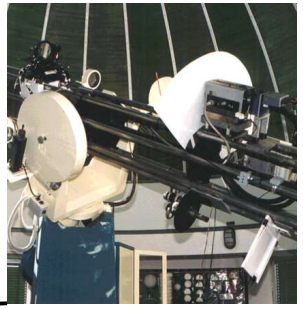
4- Necessità di competenze trasversali o di nuovi accordi fra enti di ricerca (INGV, CNR…)

INAF telescopes for solar synoptic observations



Rome-PSPT
PI: Ilaria Ermolli

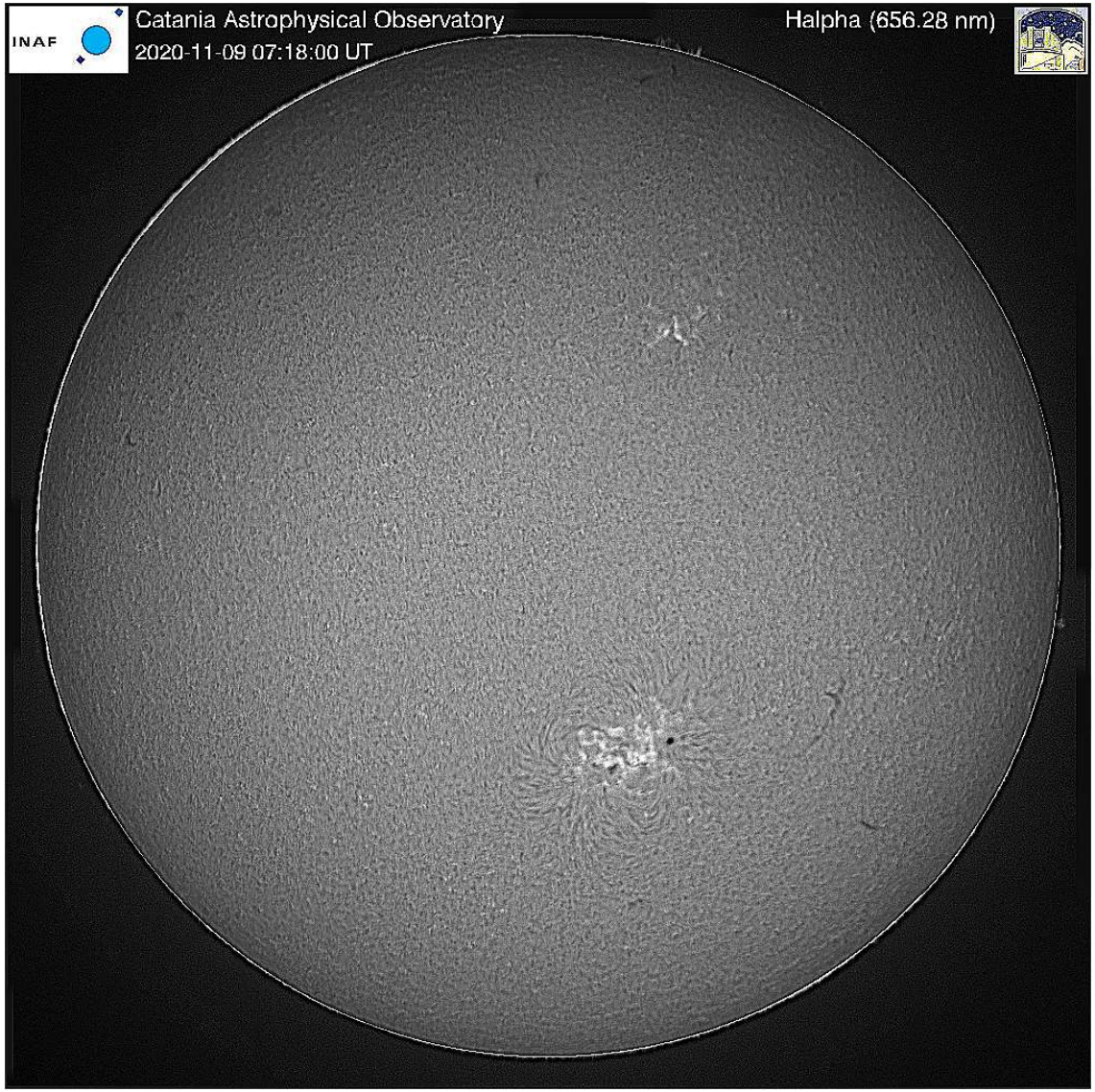
Naples-VAMOS
PI: Maurizio Oliviero



Catania Solar Telescope
PI: Paolo Romano

Opportunità / Criticità

Application of the lucky imaging technique



Horizon 2020
Call: H2020-INFRAIA-2018-2020
(Integrating and opening research infrastructures of European interest)
Topic: INFRAIA-01-2018-2019
Type of action: RIA

Proposal number: SEP-210489629
Proposal acronym: SOLARNET
Deadline Id: H2020-INFRAIA-2018-1

INAF PI: Ilaria Ermolli (OAR)

WP8 SPRING
High-Resolution Solar Physics Network

SOLARNET

Opportunità / Criticità

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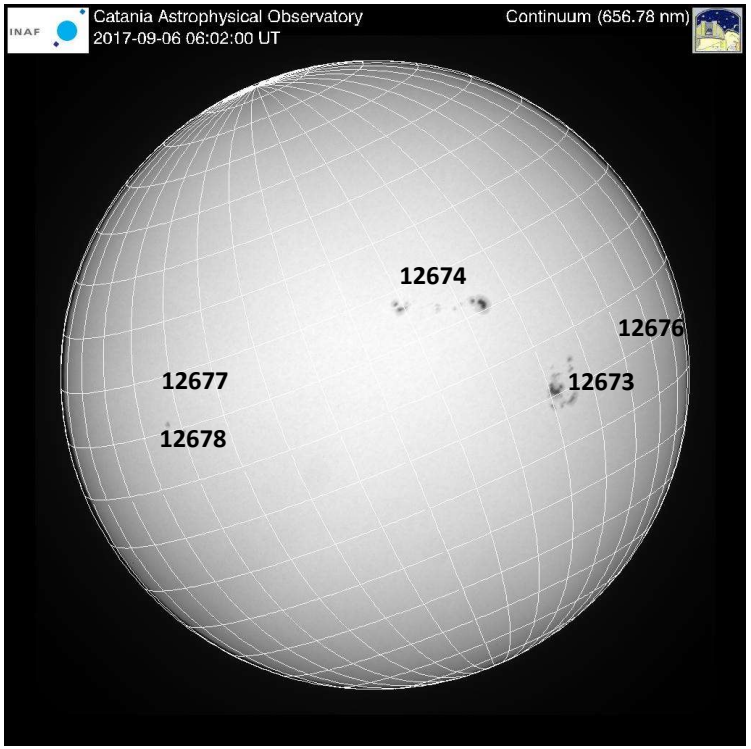
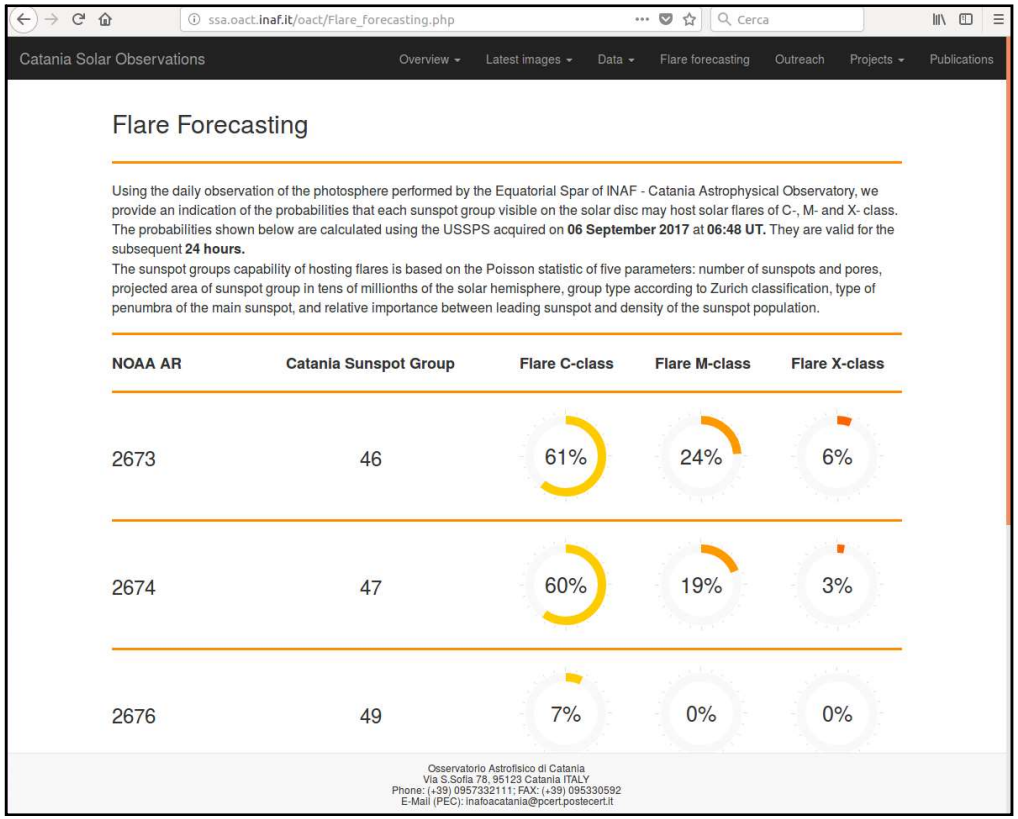
4- Necessità di competenze trasversali o di nuovi accordi fra enti di ricerca (INGV, CNR…)

Opportunità / Criticità

Solar flare forecasting service

When weather conditions permit, we provide daily an indication of the probabilities that each sunspot group visible on the solar disc may host solar flares of C1.0+, M1.0+ and X1.0+ class at: http://ssa.oact.inaf.it/oact/Flare_forecasting.php





For more details see Falco, M., Costa, P., Romano, P., JSWSC, 9, 22, 2019