HELIOSPHERIC SPACE WEATHER CENTRE TOOLS FOR SPACE WEATHER MONITORING

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Monitoring the Heliosphere

Modern societies rely on critical infrastructures for their energy, communication, services and so on. However, those infrastructures are vulnerable to events related to solar activity which are beyond our control, such as Geomagnetic Storms and Coronal Mass Ejections. It is thus fundamental to monitor the Sun, and try to foresee when an event of such could happen, and how intense it will be.

Heliospheric Space Weather Centre

In a context where monitoring the heliosphere became a crucial matter for space agencies, ALTEC, INAF – OATo, and University of Genoa (UniGe) jointly developed the Heliospheric Space Weather Centre (HSWC), a project aimed at providing and supporting services related to the heliosphere. It currently hosts two tools developed by ALTEC and INAF: the Geo Magnetic Effectiveness (H103d) and the CME propagation prediction (H103e). The tools are part of the SWESNET project, within the ESA Space Weather programme.

The HSWC aim is to become a hub of tools for the monitoring and forecasting of the space weather, and a reference for the related scientific community.

Scientific algorithms developed by INAF and UniGe are integrated into ALTEC's infrastructure, which handles data retrieval, scientific product generation, storage, and web interface.

ALTEC infrastructure is currently being upgraded to support AI-based tools and all the related processes, such as model training, retraining, and selection.

Geo-Magnetic Effectiveness Tool

The H103d tool aims at detecting and characterizing Interplanetary CMEs by identifying their flux ropes. Data are retrieved from DSCOVR Faraday Cup (FC) and Magnetometer (MAG), and from Kyoto DST repositories, and have a resolution of 1 minute.

Data from DSCOVR are used to compute the magnetic helicity, a key quantity in the identification of geo-effective events. It analyzes near real-time measurements and generates plots of quantites of interest over a 7-days period.
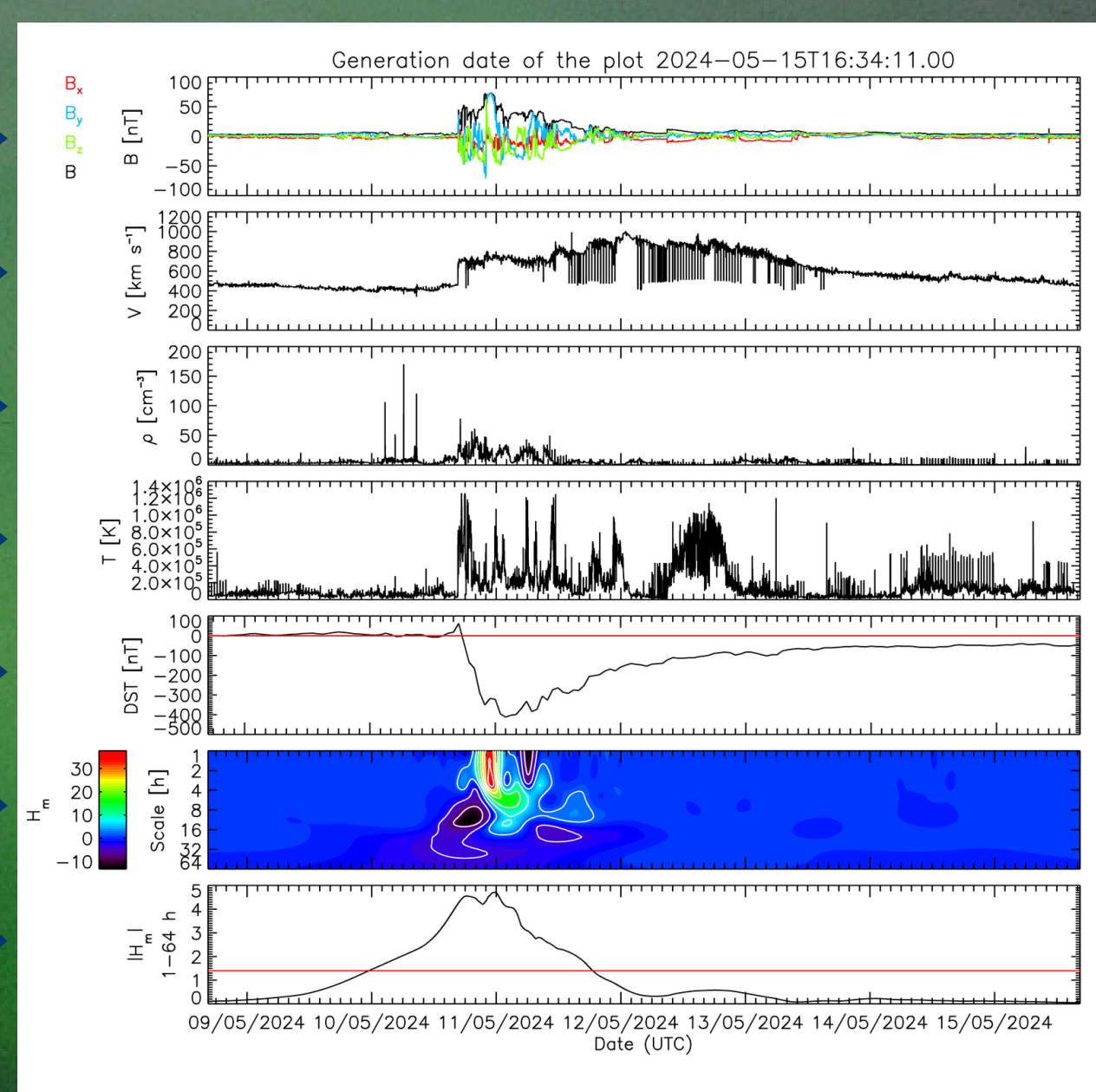

CME Propagation Prediction tool

The H103e tool forecasts the arrival of Earthward CME using data from SOHO LASCO C2/C3, STEREO-A PLASTIC and DSCOVR FC; its algorithms are designed to detect halo CMEs, identify CME features, model solar wind, and model CME propagation.

Every 30 minutes, the solar wind model compiles maps of proton density and speed, which are then published on the tool page. Dedicated modules use LASCO images to identify, track, and calculate physical parameters and arrival time of earthward CMEs. When a CME is identified, a movie depicting its propagation front is created.

The cumulated events are used to improve the tool performaces; reprocessing on past events is ongoing to increase the statistics.
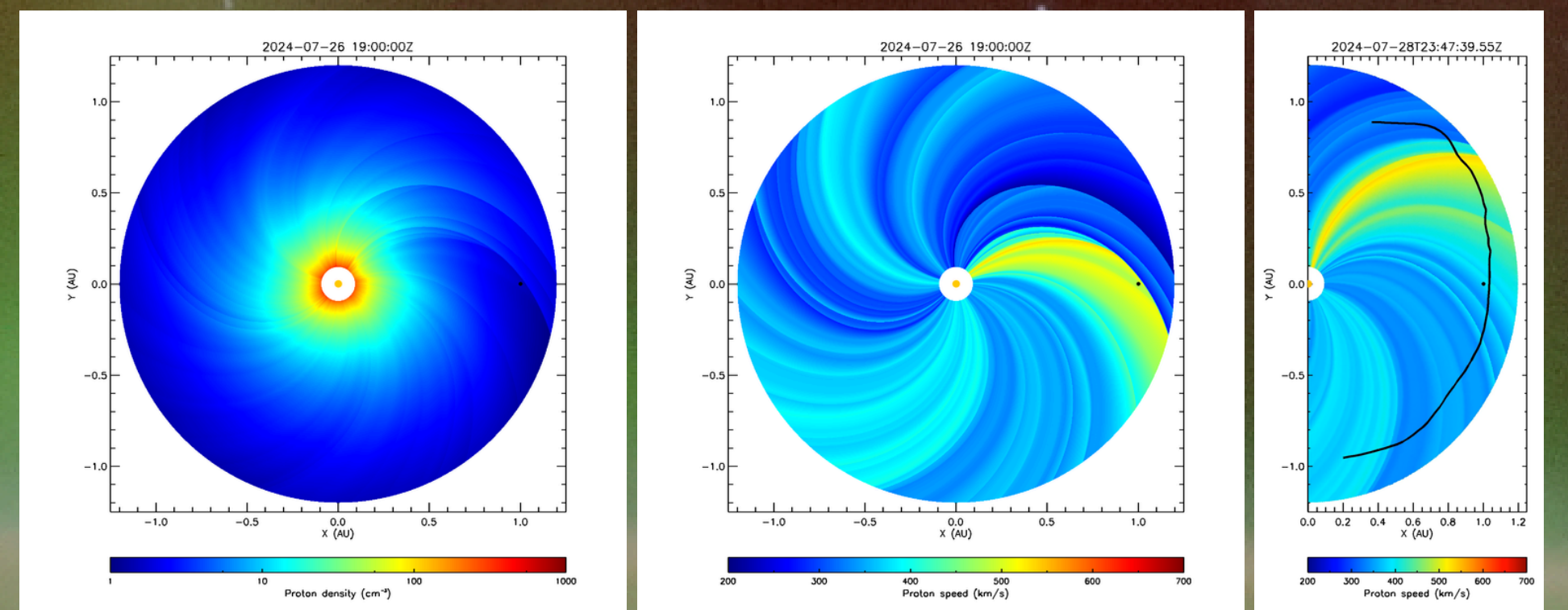
AI-based tools in HSWC

AI features are in development for both the H103d and H103e tools. In the former, AI will expand the prediction capability (currently limited to few hours); in the latter, AI arrival time forecast will be used as support for the physics driven forecast (e.g. more accurate drag coefficient in Drag Based Model).

A third AI based tool aims at predicting the development of class C or higher flares by observing the evolution of specific active regions. The prediction can be based on sequences of images from SDO-HMI or active regions features.

All of the AI tools are currently in the integration phase in ALTEC infrastructure.

Guastavino et al., Implementation paradigm for supervised flare forecasting studies: a deep learning application with video data, (2022) A&A, vol. 662, iss. A105

Guastavino S., et al., Forecasting Geoffective Events from Solar Wind Data and Evaluating the Most Predictive Features through Machine Learning Approaches, ApJ 971(1), 94 (2024)

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