PyCAT: The SWPC/UKMO Python CME Analysis Tool

George Millward[1,2], Mark Miesch[1,2], Manasi Gopala[1], Charlotte Martinkus[1,2], Anders Englyst[3], Mike Marsh[3], Francois-Xavier Bocquet[3]

[1]NOAA SWPC, [2]CIRES CU, [3]UK Met Office

Abstract

The first operational numerical model to leverage high-performance computing (HPC) resources at NOAA's Space Weather Prediction Center (SWPC) was WSA-Enlil, a three-dimensional, time dependent, MHD model of the Heliosphere. WSA-Enlil, in operations at SWPC since 2011, provides a 5 day forecast of solar wind conditions at Earth.

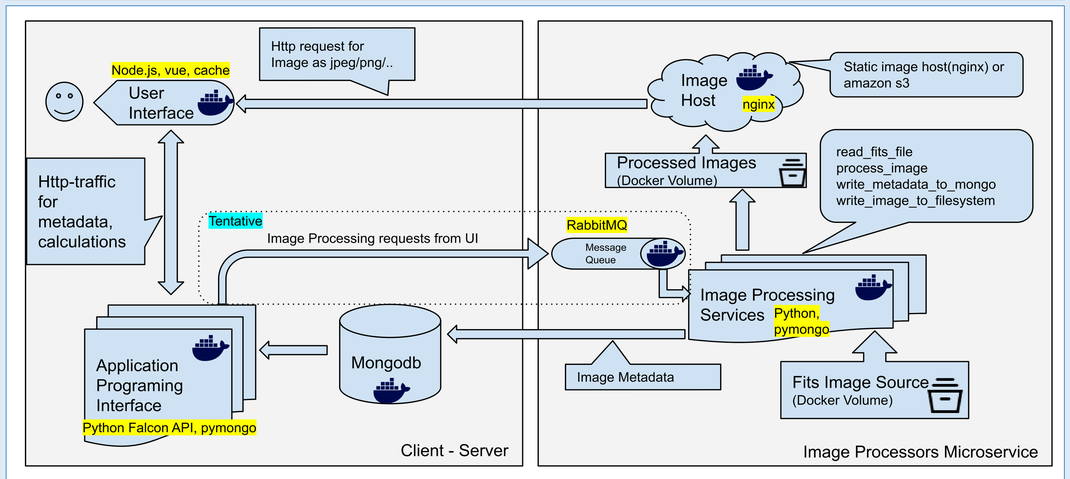
A critical issue for this forecast is the estimation (and subsequent input into the model) of any Coronal Mass Ejections (CMEs) in terms of their size/width, direction of propagation, and speed. After much trial and tribulation, an IDL-based software tool, the CME Analysis Tool (SWPC_CAT) was developed which calculates these parameters by utilizing concurrent coronagraph images from SOHO (LASCO C2/C3) and STEREO (COR-2). The CAT tool has proved very successful as a critical part of the WSA-Enlil system and is a daily aspect of SWPC forecasters' predictions for the incoming solar wind at Earth, particularly with respect to predicting incoming Geomagnetic storms.

Fast-forward to 2023/24 and there is a need to modernize CAT by leveraging state-of-the-art web-based software technologies. The new model, PyCAT, under development as a collaboration between NOAA/SWPC and the UK Met Office, features an interactive browser-based front-end, a Python back-end and an event, and image, database managed by MongoDB. After initial development and deployment, we plan to make PyCAT, not only a full replacement for the existing CAT tool, but also to be available as an open-source application to promote Research to Operations and Operations to Research (R202R).

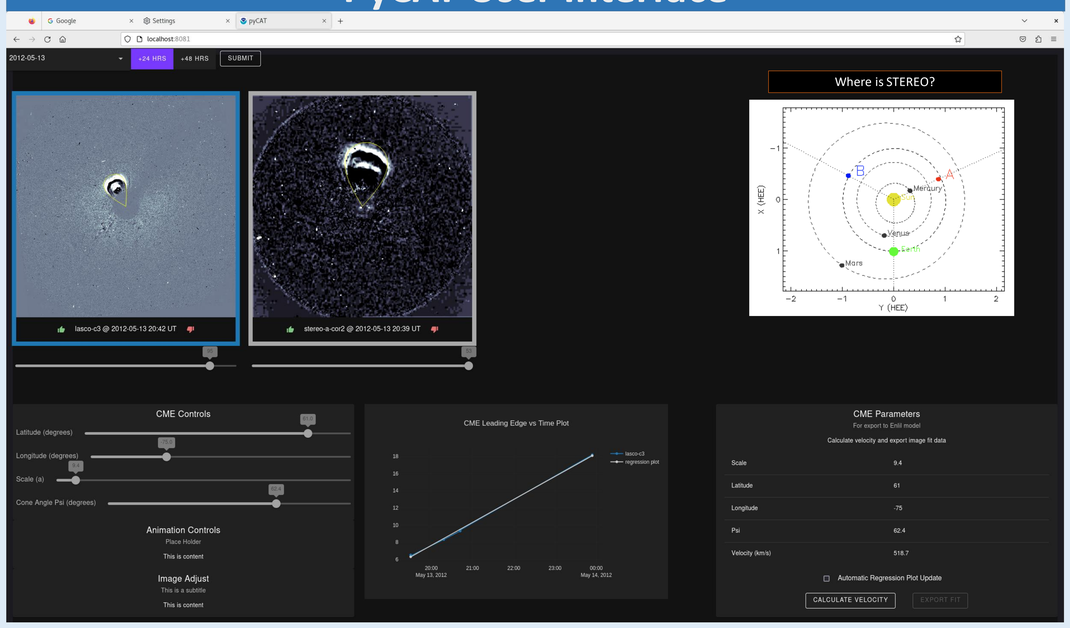
The goal is a modern, containerized, user-friendly, extensible application for modeling CME events that can be progressively improved to leverage future advances in multi-perspective observing platforms and numerical modeling.

Whilst continuing to work with existing coronagraph images from SOHO and STEREO-A, PyCAT will also support the new generation of operational coronagraphs, notably CCOR-1 on the upcoming GOES-U satellite, CCOR-2 on SWFO-L1, coronagraphs on the PUNCH mission and CCOR-3, to be flown to the L5 point on the VIGIL satellite.

PyCAT Architechture

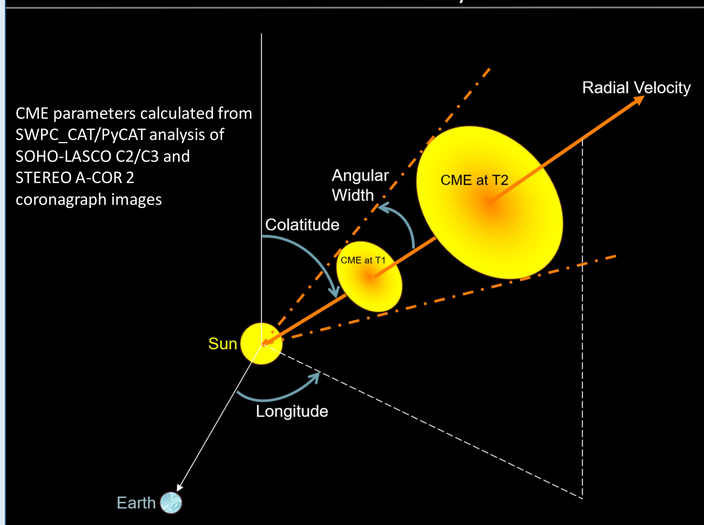


PyCAT User Interface

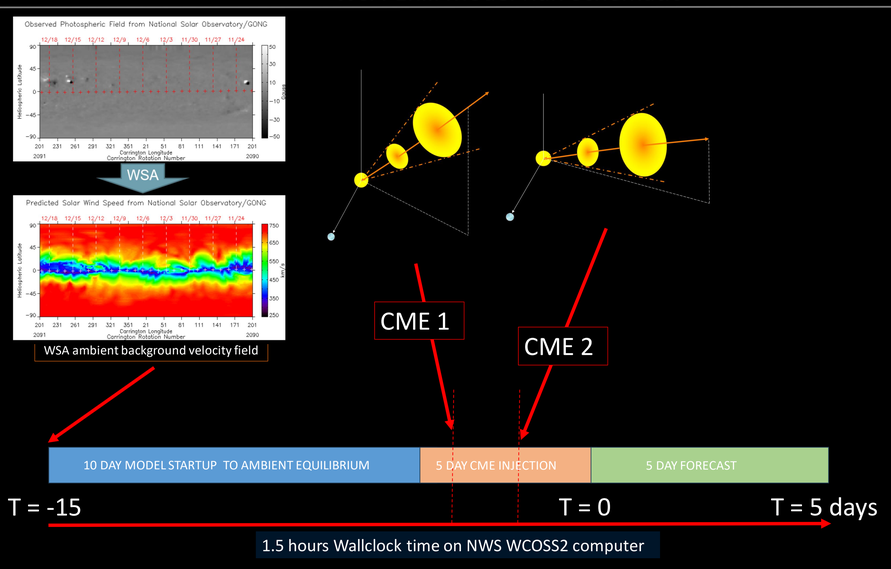


CME Analysis and Heliospheric modeling with WSA-Enlil

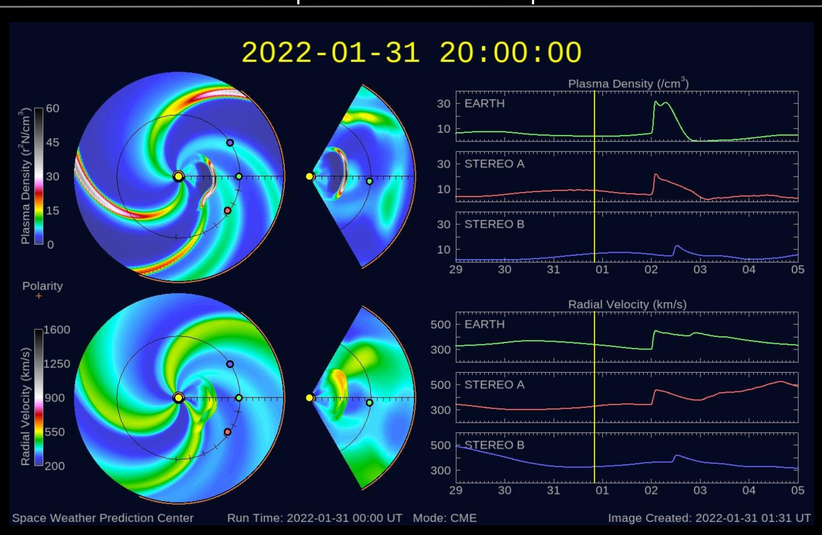
CME Cone Geometry



WSA-Enlil Model Run Schematic



WSA-Enlil Operational Model Output



Contact

George Millward, Mark Miesch
NOAA Space Weather Prediction Center (SWPC)
Email: george.millward@noaa.gov, mark.miesch@noaa.gov