Project on "CME propagation and solar wind interaction – forecasting CME impacts“

Learn about the *drag force* acting between CME and solar wind. Understand the physical process depending on CME size, speed, solar wind density etc. Learn how to forecast transit times of CMEs, impact possibilities, CME arrival speed – all relevant for predicting geomagnetic effects on Earth or other targets (e.g., Mars for robotic missions). Derive from remote sensing image data the (3D) geometry of CMEs close to the Sun and their speeds and use the DBEM (drag-based ensemble model). Think about projection effects (projected speed in the plane of sky versus de-projected speed based on visual fitting methods using idealized CME shapes = 3D geometry). Get the solar wind speed from either models (STEREO+CH or ESWF available as ESA service) or use in-situ measurements.

CME event catalogue (projected speeds, width, movies):
https://cdaw.gsfc.nasa.gov/CME_list/index.html
Use the event from 2017-09-06 (12:24UT first C2 observation)

1) Check the movies (Java Movie) and make yourself familiar with the event. Have a look at the different perspectives using STEREO image data. Can you see some differences?
2) Answer the questions: Will the event hit Earth? If yes, when, and how fast will it be upon arrival?
3) What are the uncertainties? Can you derive unique solutions?
4) How would you define error bars?
5) Analyze and describe your results with numerical values and plots!

JHelioviewer – relate the CME of interest to the source region on the Sun (coordinates):
Watch out for solar activity features (like flares, waves, dimmings) and produce e.g., difference images to track and analyze your CME.
Webpage: https://helioviewer.org
Easier when downloading the latest version of the App: https://www.jhelioviewer.org
Alternative: https://solarmonitor.org, http://suntoday.lmsal.com

Analysis for deriving the CME de-projected speed and geometry:
Geometry derivation from NASA STEREO-Cat https://ccmc.gsfc.nasa.gov/analysis/stereo/
Sophisticated users (Python skills necessary) – apply GCS to derive the 3D geometry and 3D speed: https://github.com/johan12345/gcs_python

Solar wind magnetic and plasma parameters measured at Earth (L1):
https://www.swpc.noaa.gov/products/real-time-solar-wind
Derive the pre-CME speed from the in-situ data as input for the solar wind speed for your propagation model (average over ca. 12-24 hours ahead of CME shock arrival).
For the time use “all” and then zoom in to individual dates. Get familiar with typical CME structures and learn how to distinguish from e.g., solar wind high speed stream structures.

CME propagation in IP space - ESA - SSA tools:
DBEM (learn also about ensemble modelling - a way forward to deal with uncertainties in the observational data analysis) – use the derived parameters of CME speed, size, latitude/longitude of source region, solar wind pre-speed at 1AU + uncertainties to calculate impact probability, transit time and arrival speed.
https://swe.ssa.esa.int/graz-dbem-federated (you need to register first!)
http://phyk039240.uni-graz.at:8080/DBEMv3/dbem.php