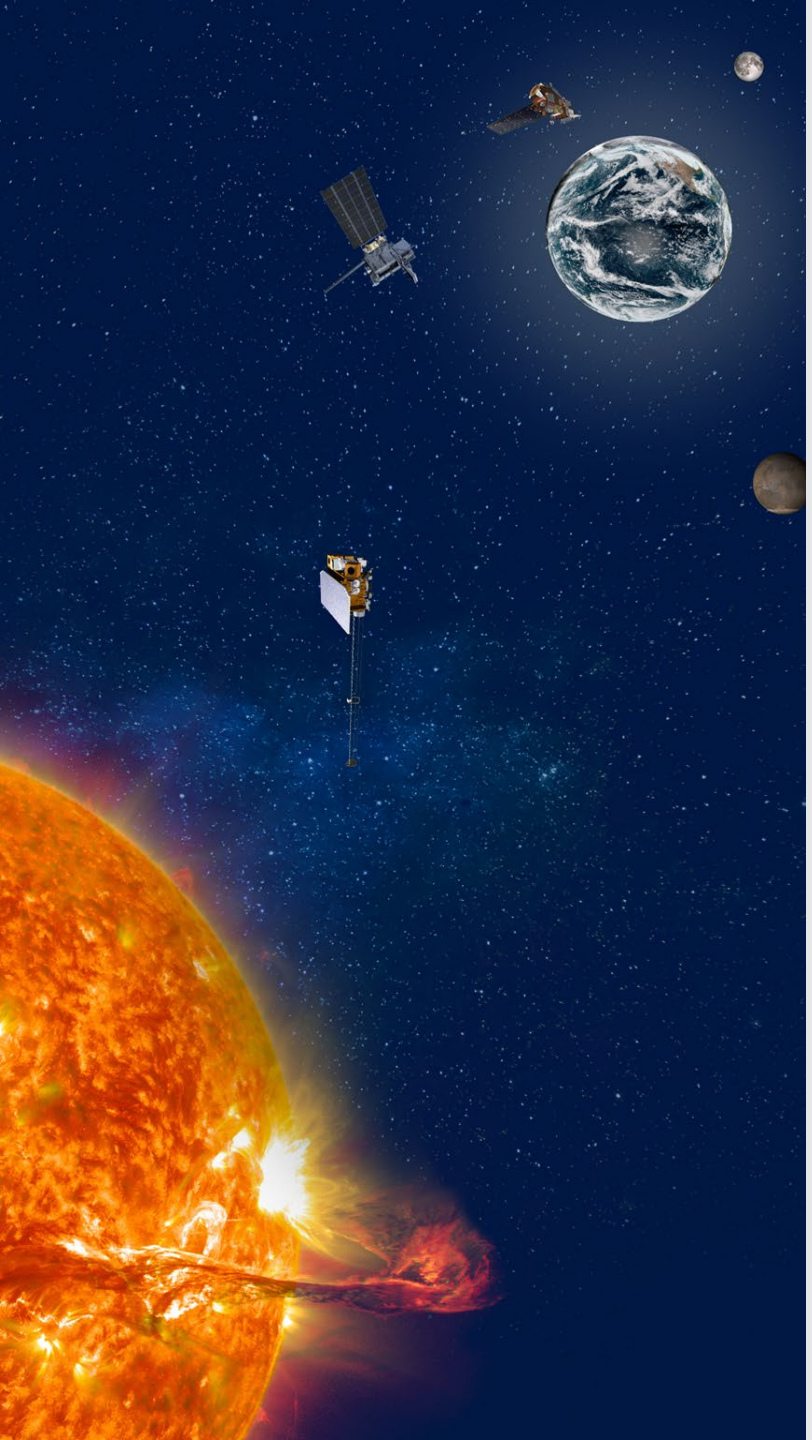

Space Weather Next Lagrange 5 (L5) Project

Ame Fox, Deputy Project Manager, SWO, NASA
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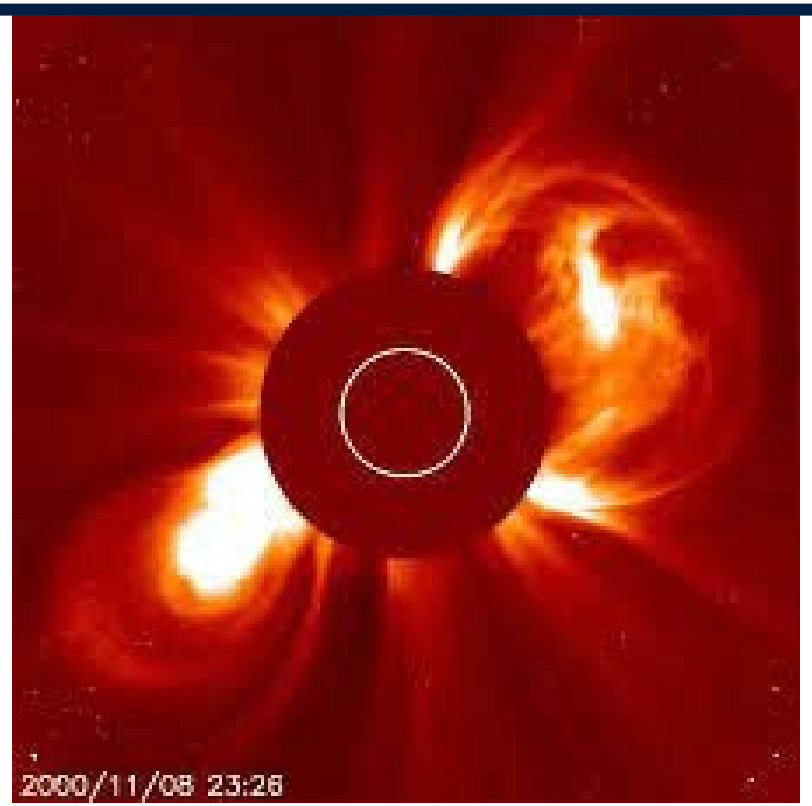
Coronal Mass Ejections (CMEs)

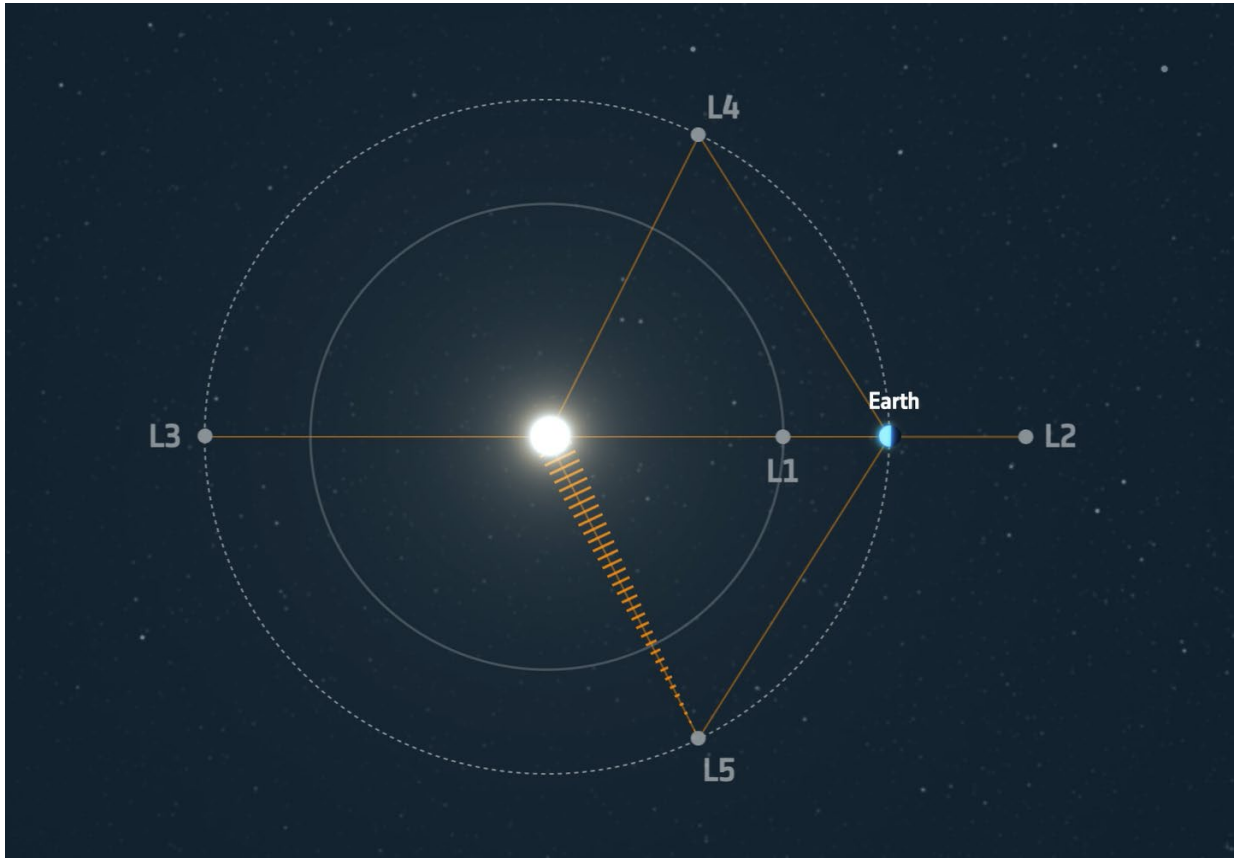
- CMEs are optically thin large-scale solar phenomenon that are traditionally observed by white-light coronagraphs as enhanced intensity structures. The intensity increase is due to photospheric light that is Thomson scattered off the electrons forming the CME body and integrated over the line-of-sight (Hundhausen 1993).

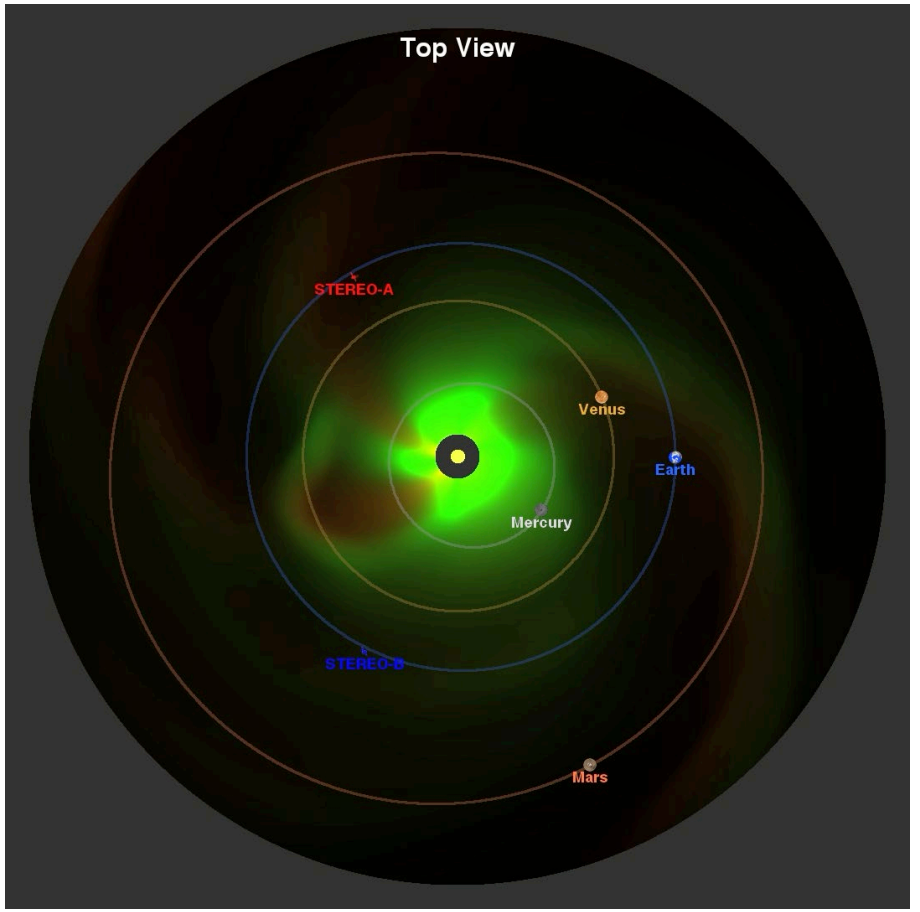
- Due to strong projection effects, CMEs morphology greatly depends on the viewpoint. This makes CMEs a rather tricky object to measure (Burkepile et al. 2004; Cremades and Bothmer 2004).



The eruption of two CMEs on Nov. 8, 2000 recorded from NASA's LASCO coronagraph

Lagrange 5 (L5) Project: ESA Vigil Mission

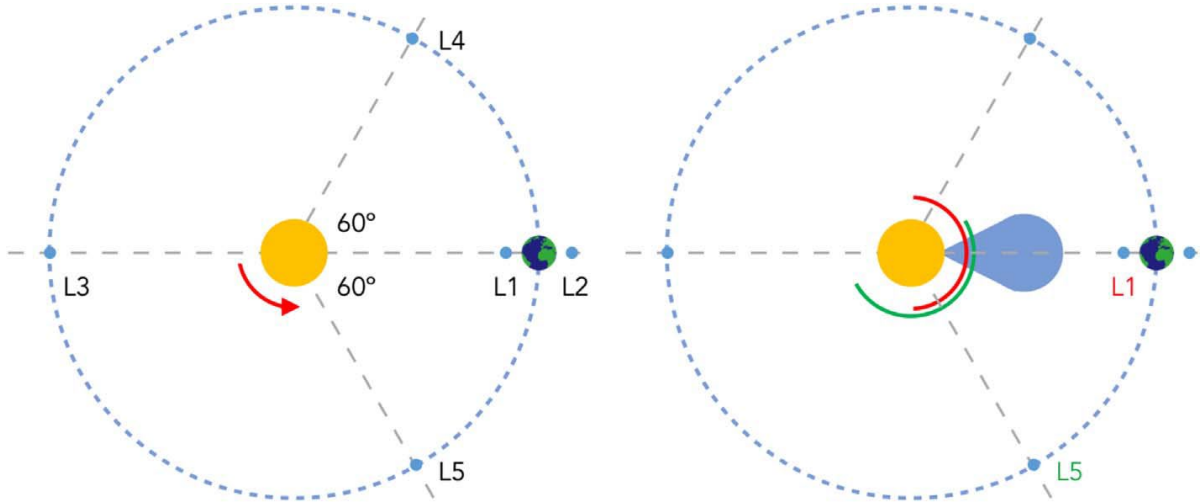




Model of July 2012 CME – Carrington level event, missed Earth

Why L5 ?

- Most space weather monitoring satellites are placed along the Sun–Earth line, principally in Earth orbit and at the Lagrange point 1 (L1), which is upstream in the solar wind with respect to the Earth, providing us with information about space weather coming towards the Earth.
- A satellite located at the Lagrange point 5 (L5) will be trailing the Earth by 60°. The L5 vantage point extends the view of the Sun by an additional of 60°. The view covers a part of the Sun that is not yet visible from Earth and can therefore provide earlier warning of solar activity regarding the emergence, complexity, and eruptive potential of active regions and irradiance variations.

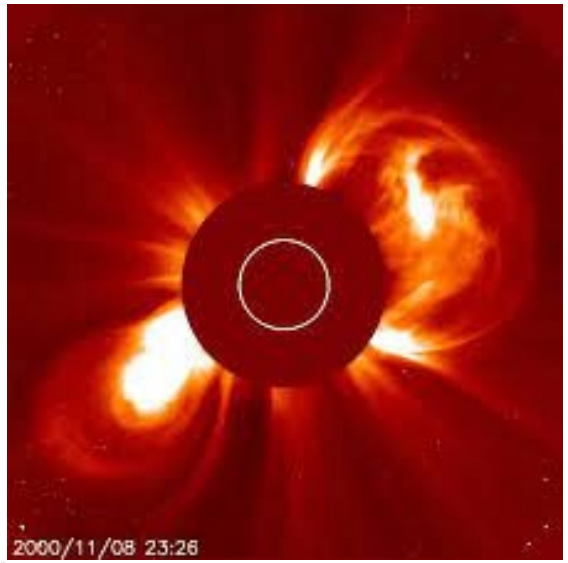


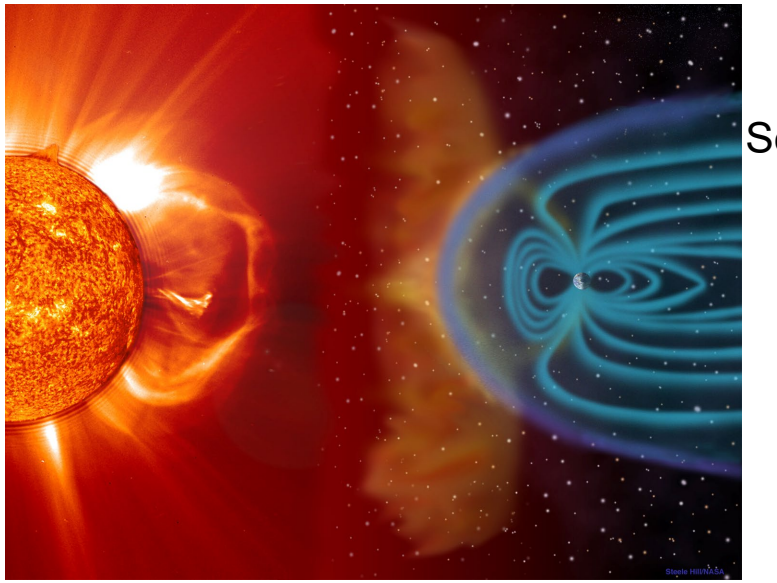
M. West et al., 2020

Objectives of CME Forecasting

Objectives of space weather forecasting of coronal mass ejections (CMEs)

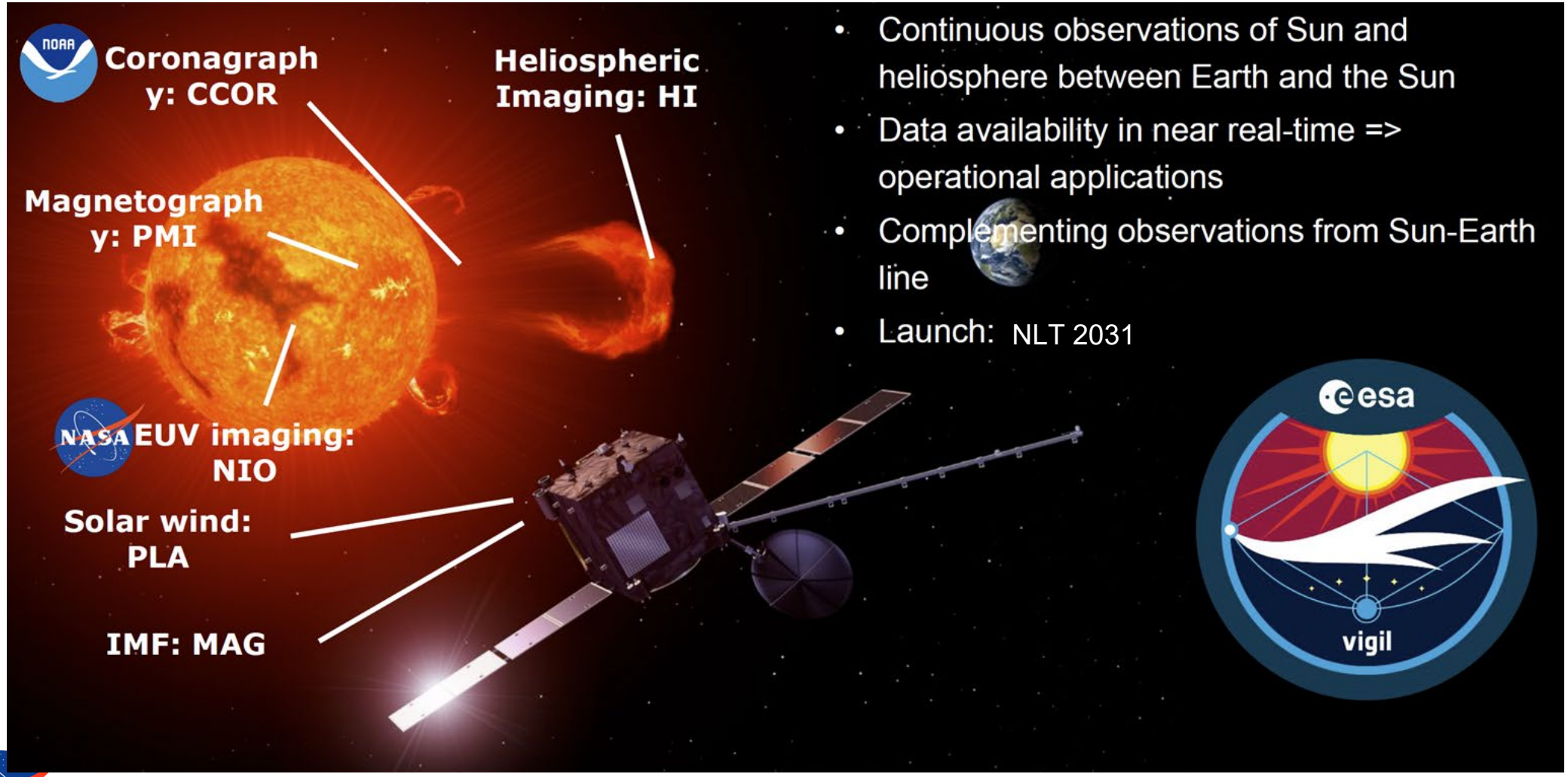
- Determining whether the coronal mass ejections (CMEs) are Earth-bound
- Determining the CME internal magnetic field configuration, the time of arrival (ToA), and the velocity on arrival (VoA).
  - Magnetic field configuration is currently not achievable by remote sensing measurements
  - ToA and VoA currently are derived from coronagraphic and heliospheric observations of propagating plasma transients from Sun-Earth Line (SEL)



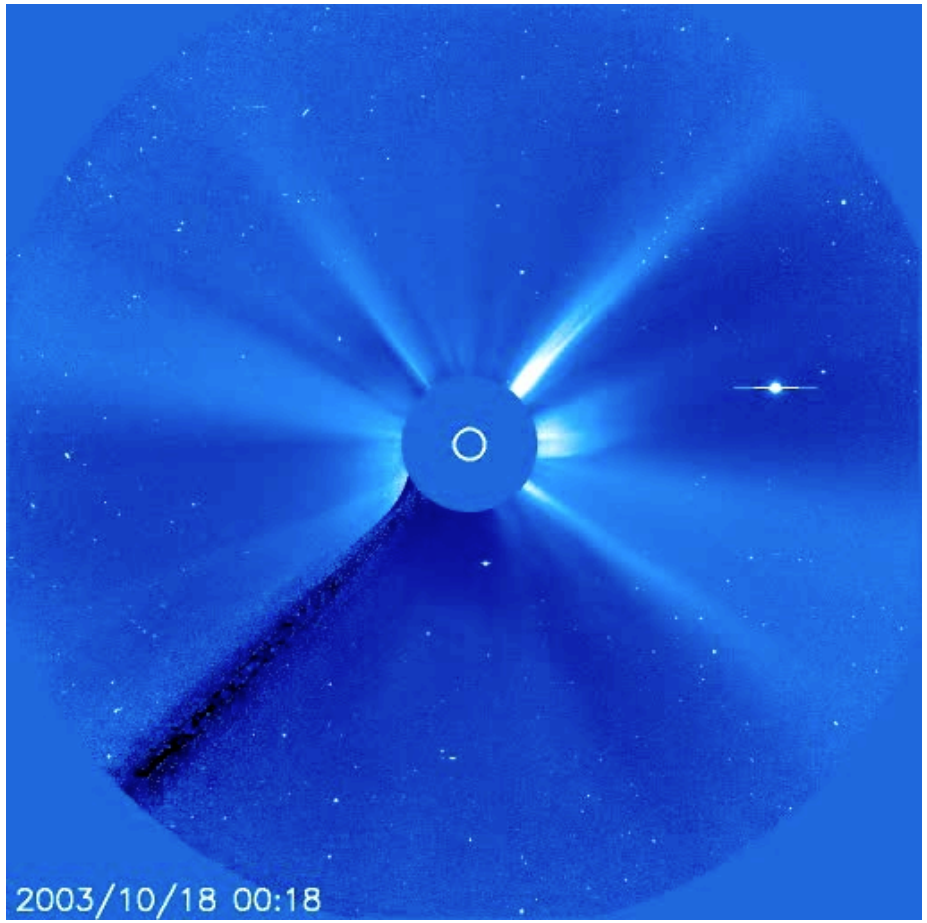


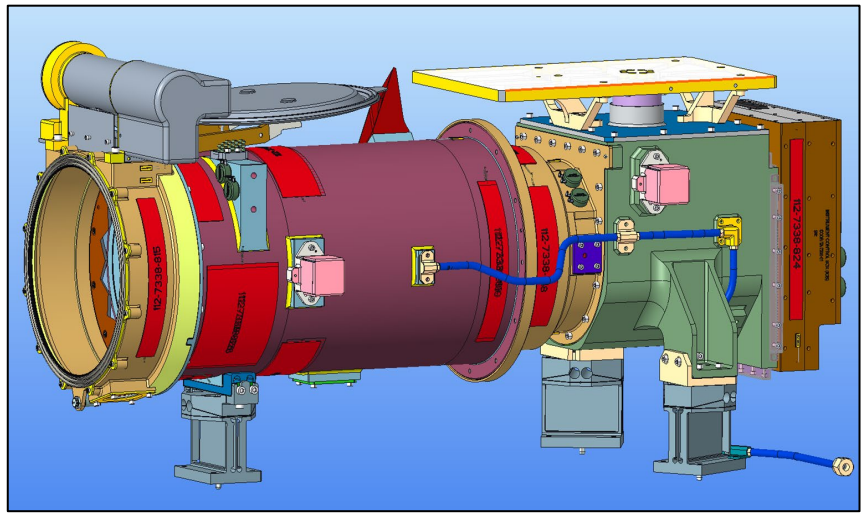
The off the Sun-Earth Line (off-SEL) from the Solar Terrestrial Relations Observatory (STEREO) mission demonstrated improvement of ToA from >12 h to +-6h from pre-STEREO (Millward et al., 2013; Colaninno et al., 2013). VoA accuracy is still relatively low.

Vigil Mission (L5) Observations



SWO L5 Project – Compact Coronagraph CCOR-3





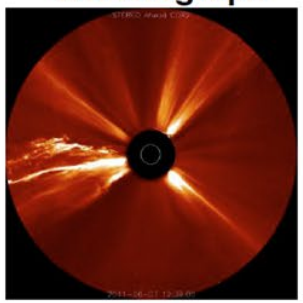
- Coronal White Light Imager (Off-SEL)
- Key instrument for monitoring SW conditions, detecting Coronal Mass Ejections (CMEs), and furthering forecasting capabilities
- 3rd iteration of the NOAA CCOR instrument series that leverages previous design heritage
  - CCOR-1 in GOES-U
  - CCOR-2 in SWFO-L1
- CCOR-3 is currently in development at NRL

Vigil Payloads

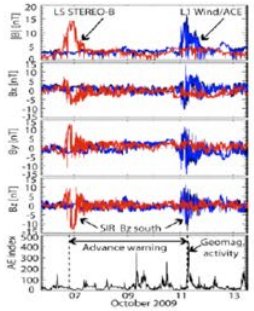
Carrington: UK/US Operational Space Weather Mission

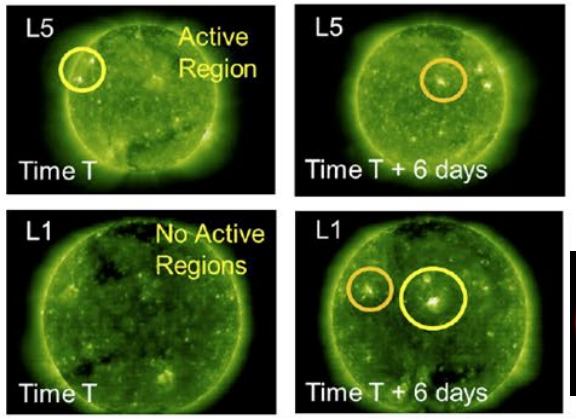
Payloads

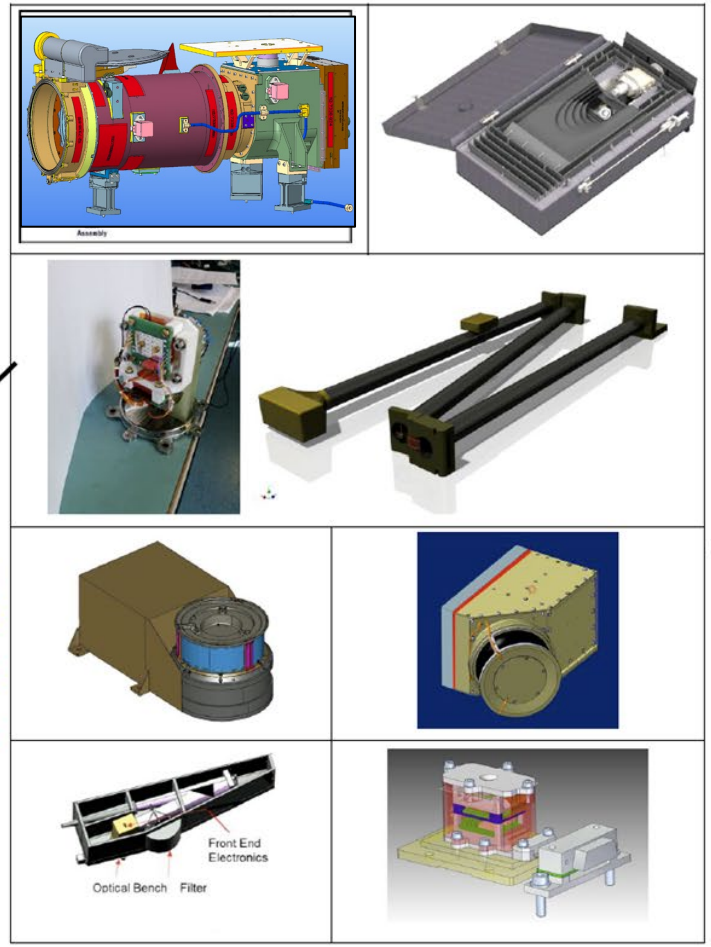
Coronagraph



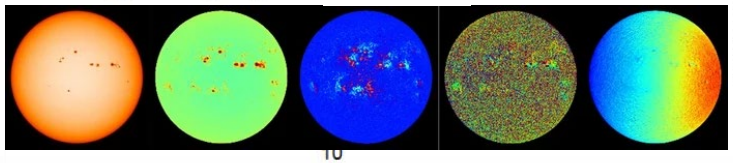
Magnetometer



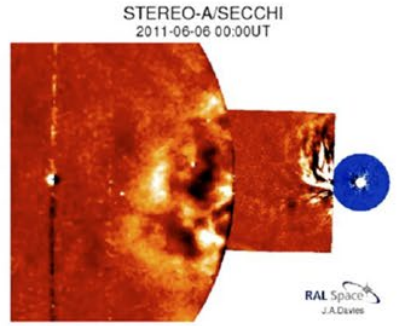




Magnetograph & JEDI

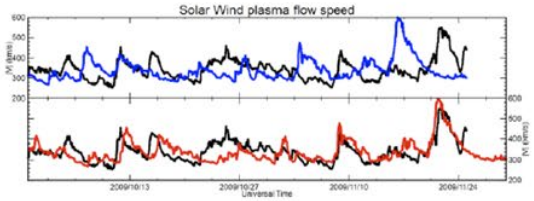


Heliospheric Imager

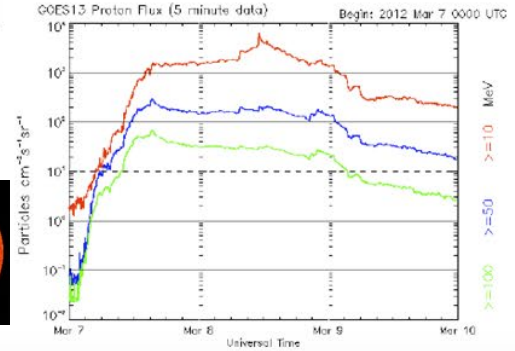


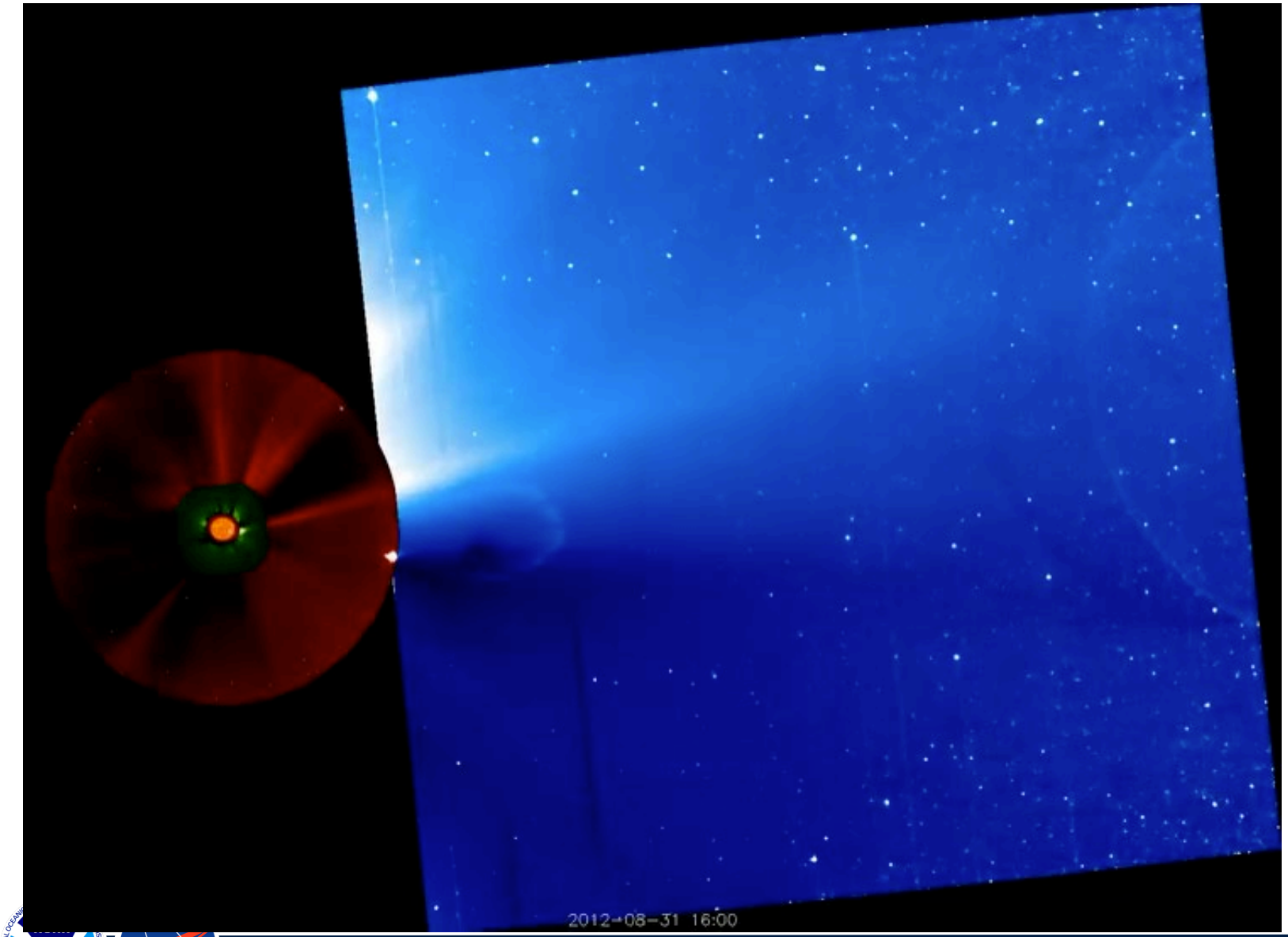
Airbus DS Boom

Plasma instrument



Radiation Monitor



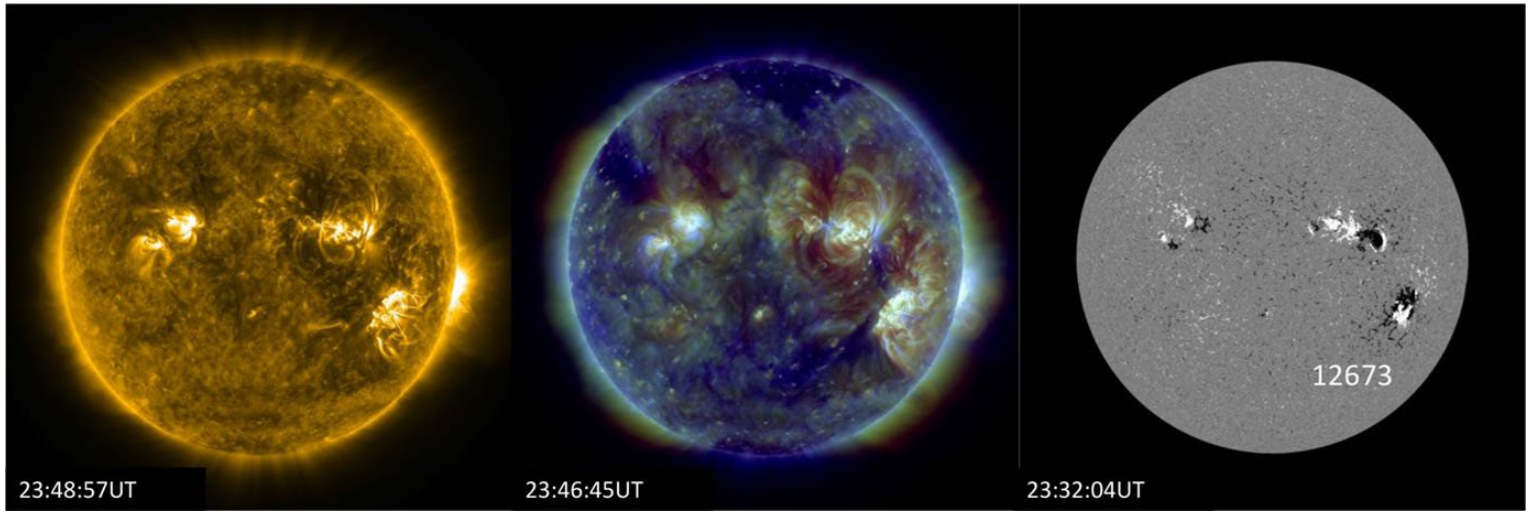


Vigil position from L5 enables tracking CMEs from Sun to Earth, providing more accurate timing information than L1 observations alone

Example from STEREO, near L5. Movie combines EUV Imager, COR-2 coronagraph, and Heliospheric Imager – Earth would be off to the right

Improvement of CME Propagation Models with Magnetogram

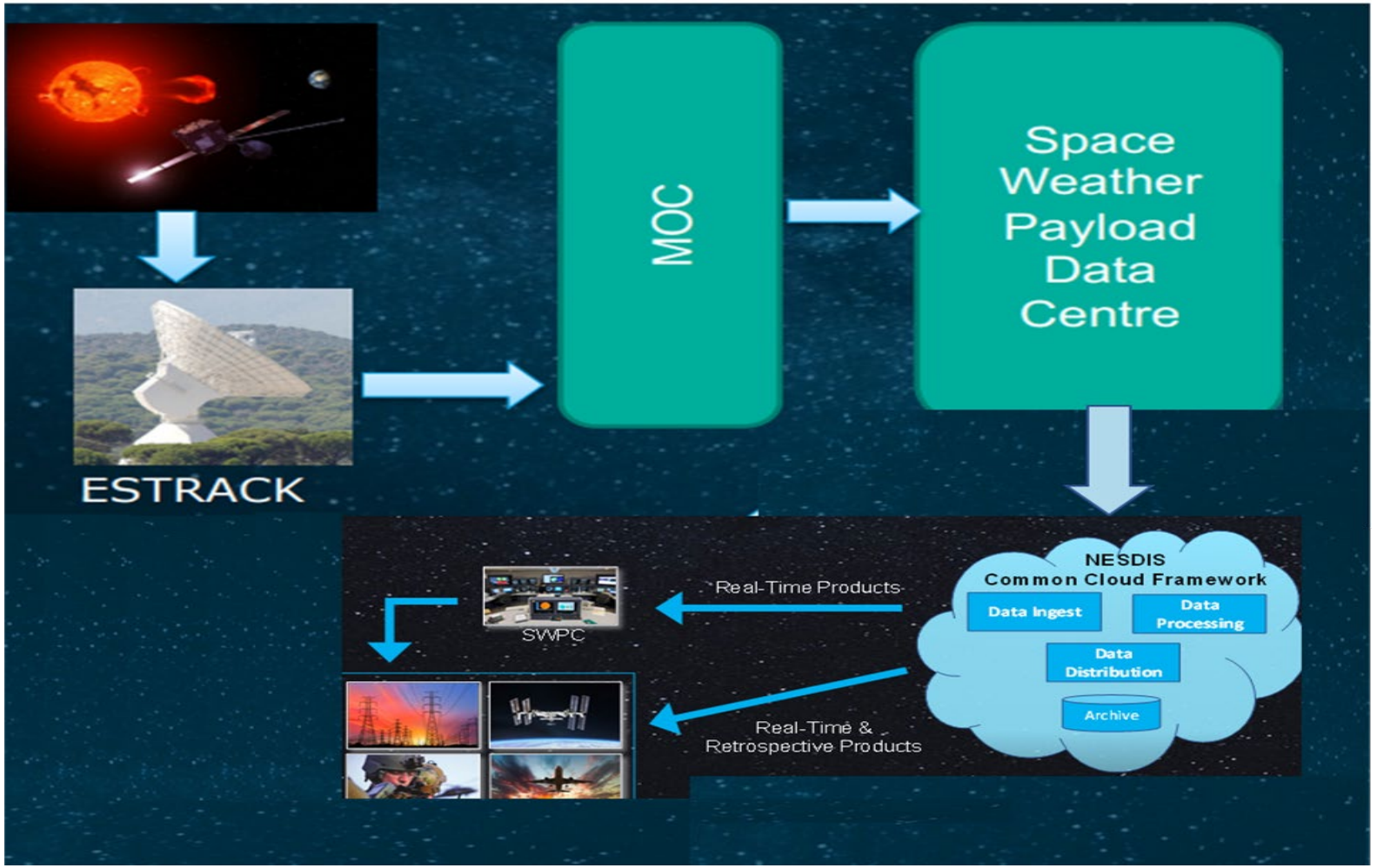
- Currently, the boundary conditions for heliophysics and space weather modeling use full disk photospheric magnetograms built over the 27 day solar rotation. **The data beyond the east limb are the oldest and thus least reliable inputs leading to large discrepancies in the modeling outputs (e.g., missing fast streams) during periods of solar activity. The addition of the L5 magnetogram information to the Earth-based maps will provide instantaneous coverage of photosphere leading to huge quality improvements of the background solar wind models, which are essential for operational CME propagation models**. As an added bonus, the modeling results could be validated against the solar wind measurements at L5.



SDO/AIA multi-wavelength imagery from September 6, 2017 (left: 171 A ° , middle: composite from 211-193-171 A °) and SDO/HMI line-of-sight magnetic field (right panel). The prominent active region NOAA 12673 caused the strongest eruptions during solar cycle 24 including SEPs. From http://suntoday.lmsal.com

L5 Project Ground Segment

ESA will provide the downlink and transfer of data to NESDIS Common Cloud Framework for data processing and distribution.



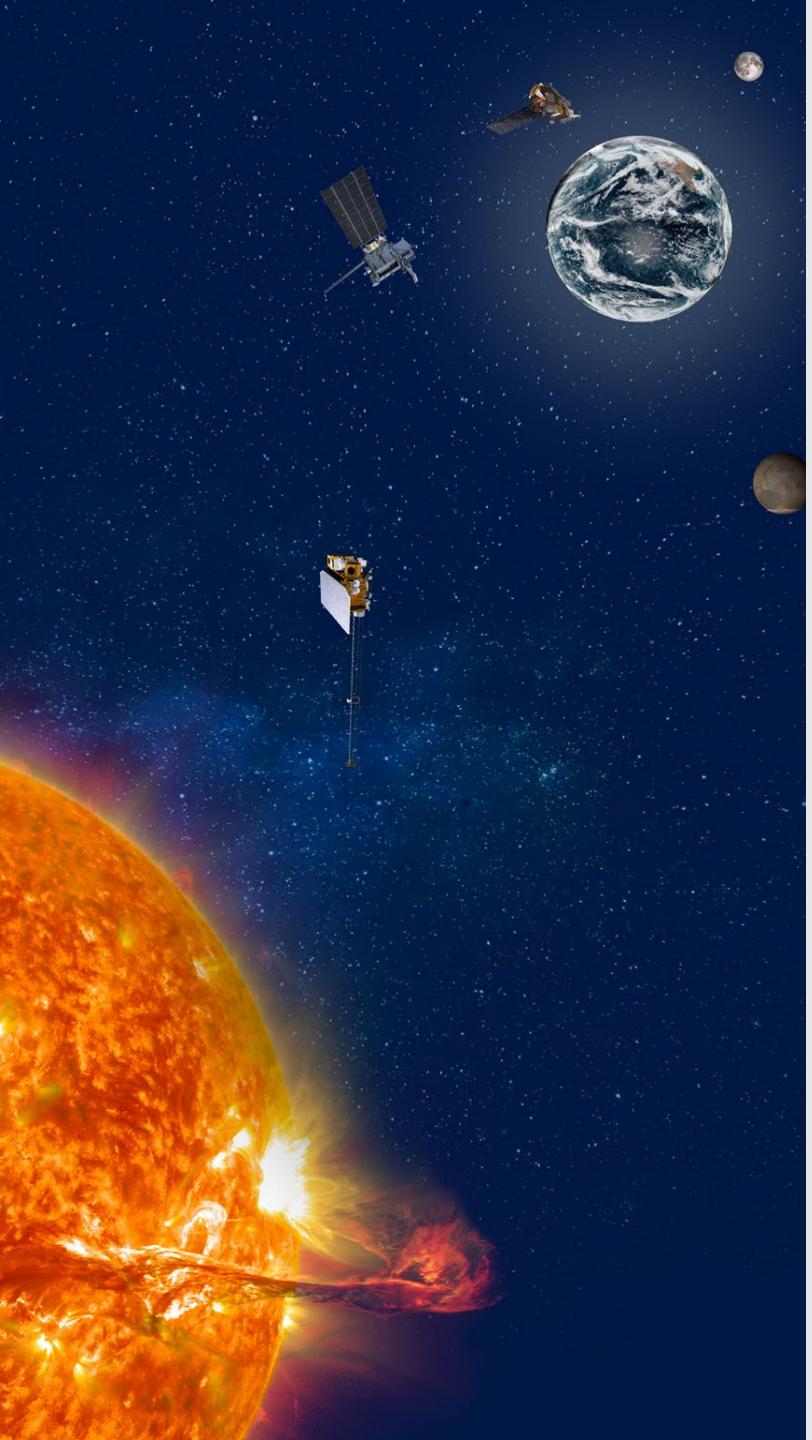
Summary

- The L5 project will provide key hardware (a solar coronagraph) to the ESA Vigil mission, scheduled to Launch in 2031, with a ~3.5 year cruise to L5 and a ~7.5 year mission.
- The L5 Project will provide key data (coronagraph + other Vigil instrument data as appropriate) to SWPC for space weather forecasting as well as archival data.

BACKUP

L5 Project Data Products

Vigil Instrument	Data Level	Data Product
CCOR-3	1b	CCOR-3 Calibrated Radiances [1]
	2	Coronal White Light Imagery (Off-SEL) [2]
	2	Coronal White Light Imagery (Off-SEL) [3]
HI	2	Heliospheric Imagery (Off-SEL) [4]
PMI	2	Photospheric Magnetic Imagery (Off-SEL) [4]
PLA	2	Solar Wind Density (Off-SEL) [4]
	2	Solar Wind Velocity (Off-SEL) [4]
	2	Solar Wind Temperature (Off-SEL) [4]
MAG	2	Interplanetary Magnetic Field (Off-SEL) [4]
JEDI	2	Solar EUV Imagery (TBD) [5]



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