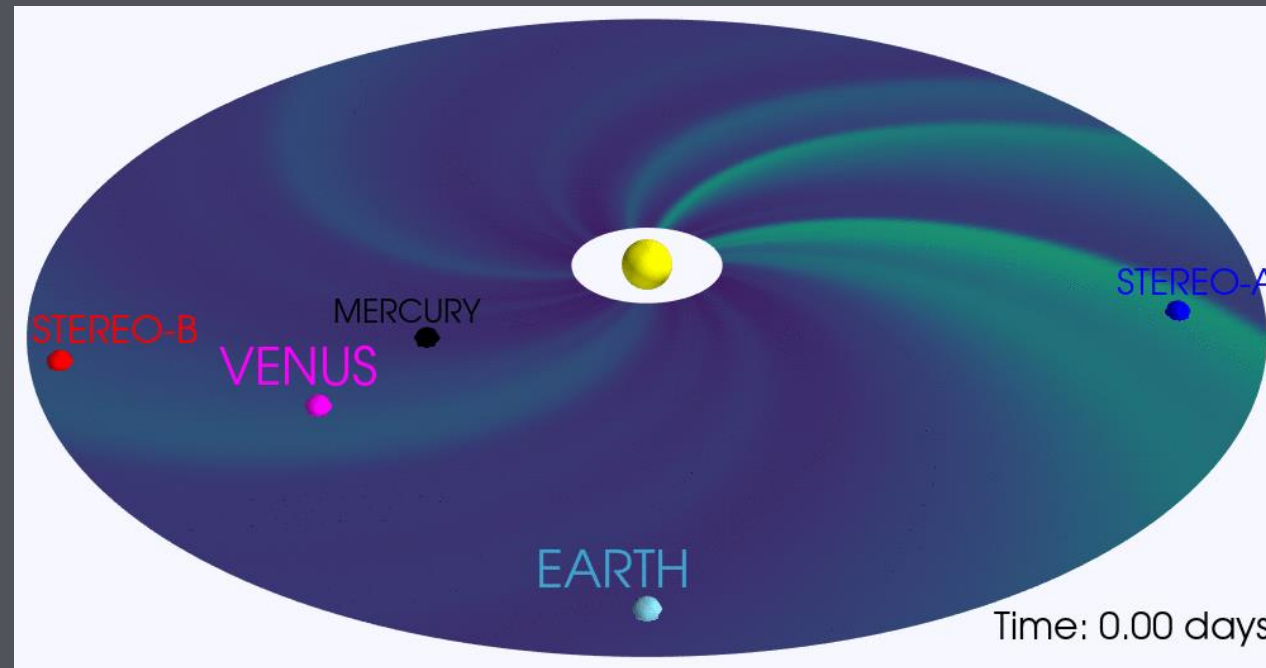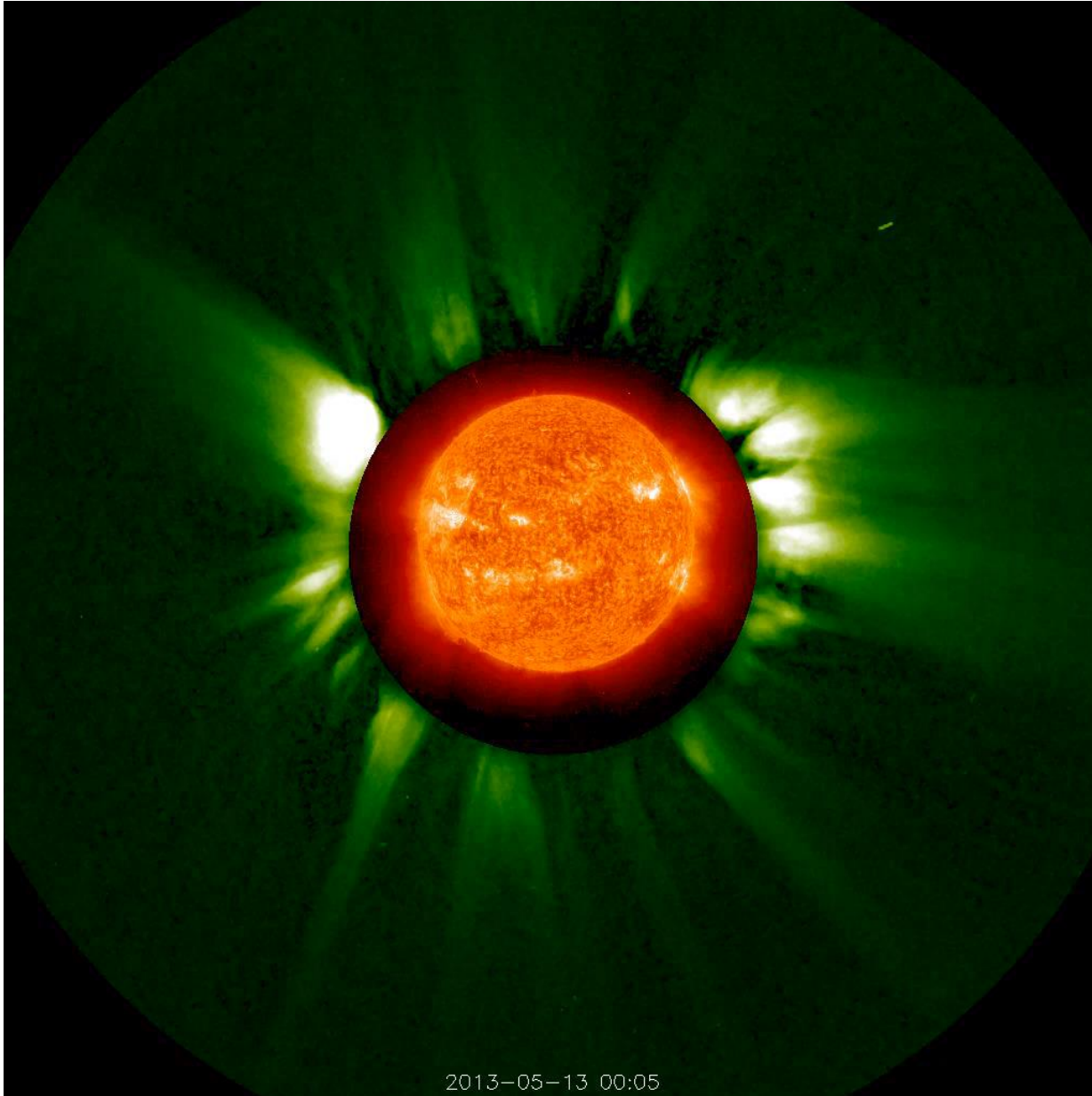University of **Reading**

Open source modelling of space weather

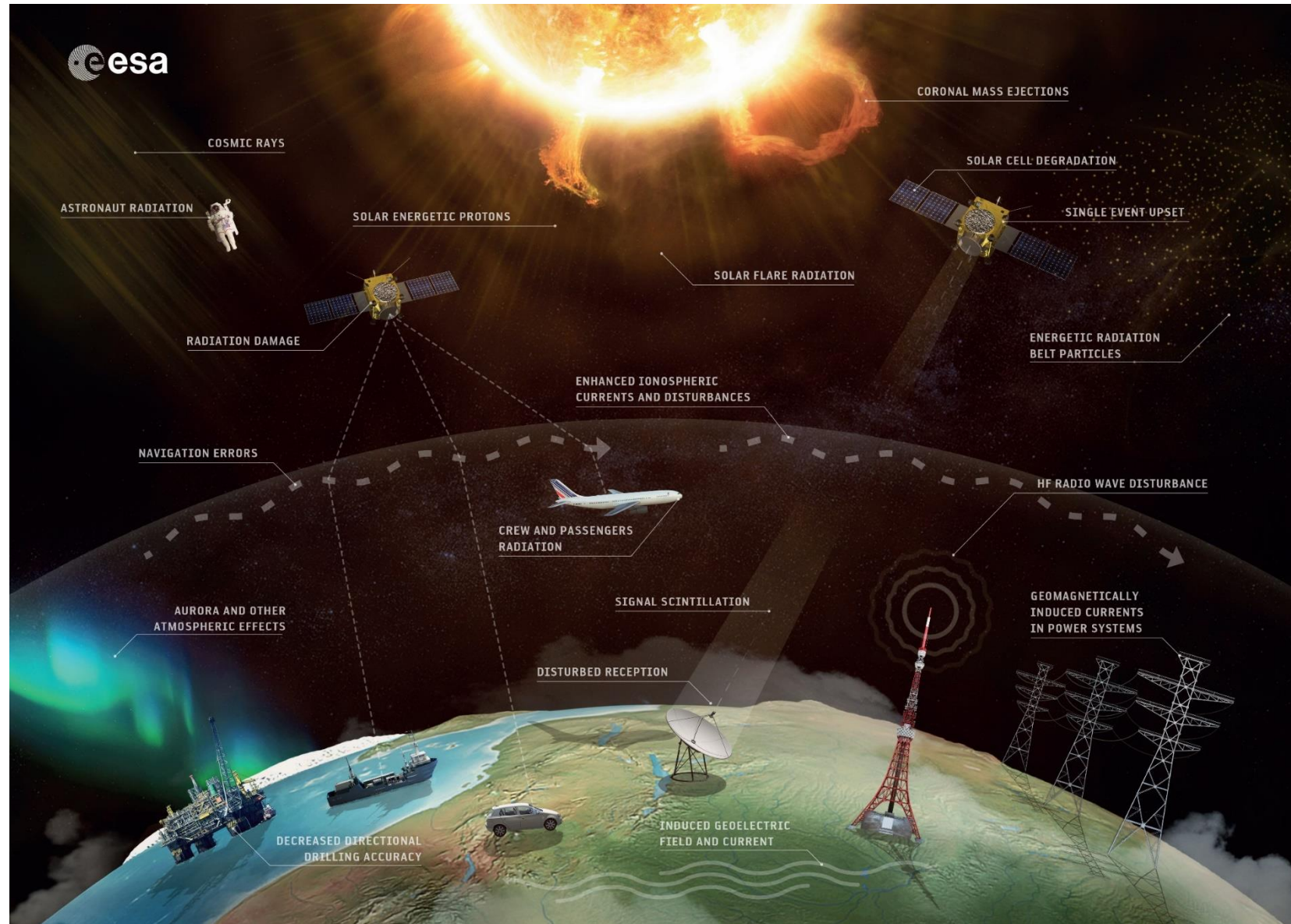Dr Luke Barnard and Professor Mathew Owens

Coronal Mass Ejections

2013-05-13 00:05

A movie of the Sun in extreme ultra-violet (inner, orange) and visible light (outer, green)

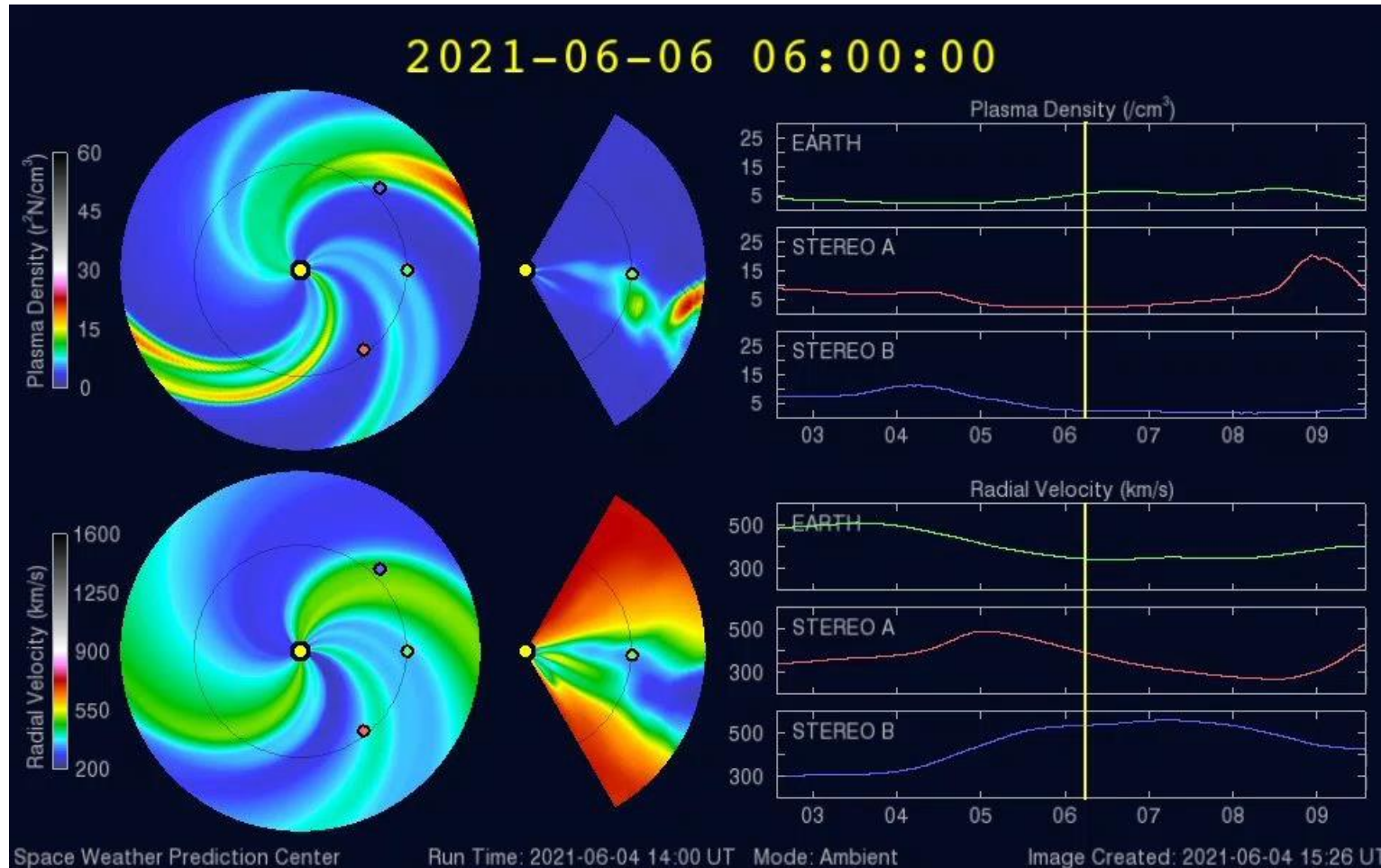This shows the eruption of CMEs low in the Sun's atmosphere.

Credit: STEREO / NASA

# Space Weather at Earth

Space Weather Forecasting

A recent forecast from the Space Weather Prediction Center in the US

Uses an numerical model with many physical processes and parameters.
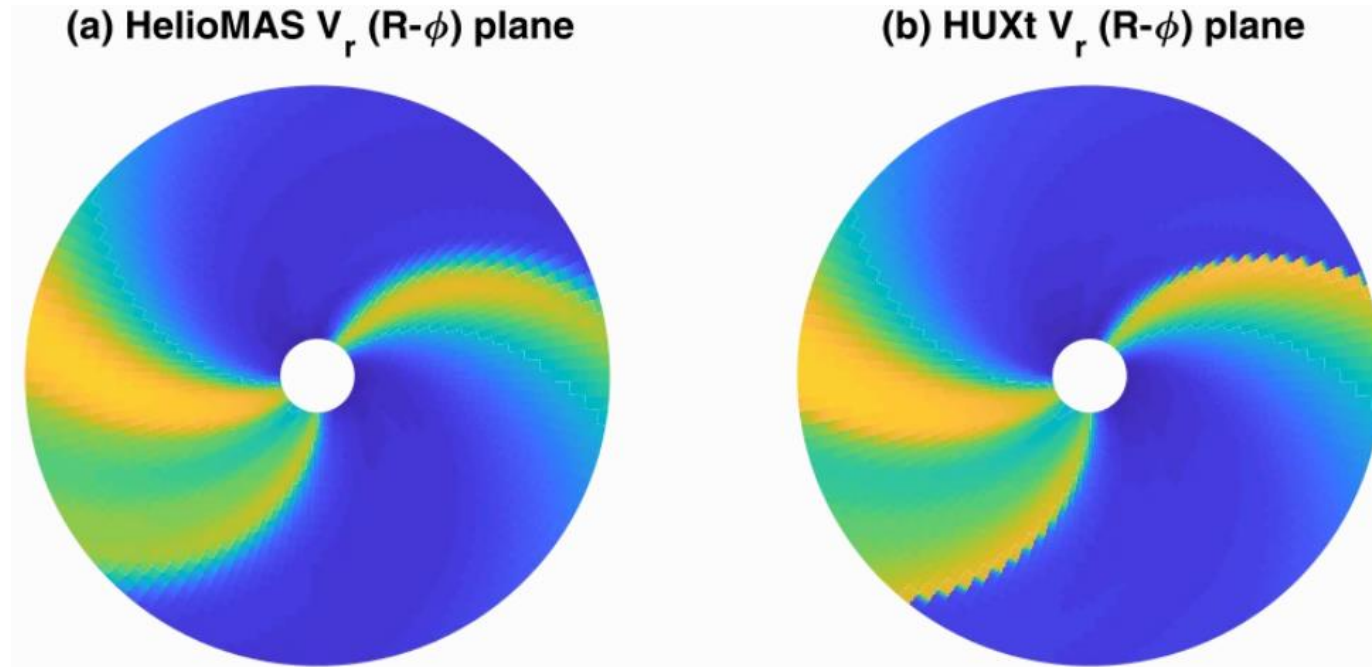
Ensemble modelling

- Ensemble modelling helps us understand and quantify the uncertainty in a space weather forecast due to our limited knowledge of the conditions near the Sun.

- This requires running the model many times.
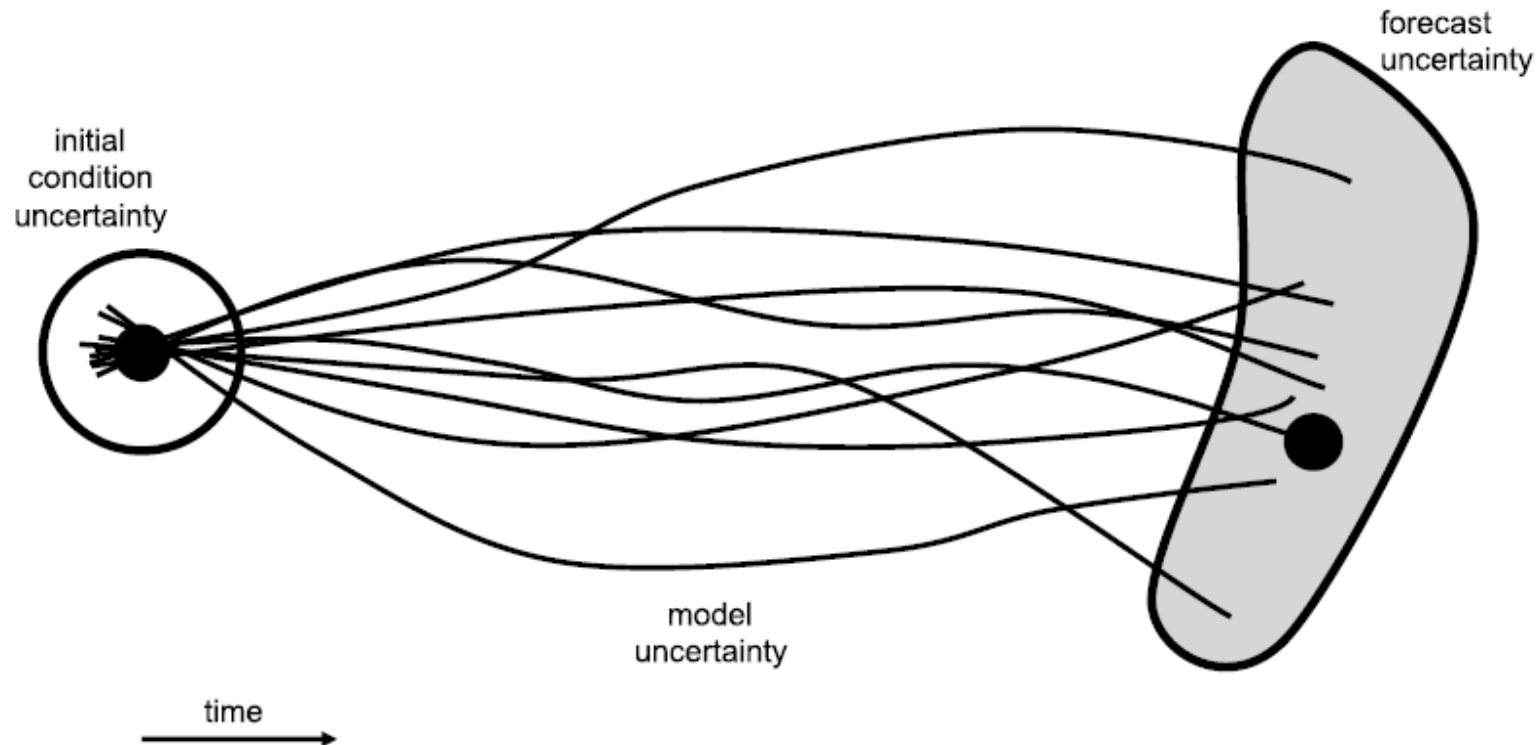
Credit: Murray, 2018, doi:10.1029/2018SW001861

HUXt

- An open source model of the solar wind.
- Written in Python.
- Uses some approximations to reduce the model complexity.
- This makes the model much faster to run, with only a small reduction in accuracy.
- This also makes the model accessible to anyone with modest computing resources

(a) HelioMAS V_r (R-ϕ) plane

(b) HUXt V_r (R-ϕ) plane

Owens et al., 2020, https://doi.org/10.1007/s11207-020-01605-3

Open Source in Space Weather

- There is growing environment of open source software in Space Weather research.

- This is mostly based in the Python language.

- These provide tools that we increasingly depend upon to analyse observations and develop space weather models.

Making HUXt Open Source

- HUXt is hosted on both GitHub and zenodo under the MIT license.

- Working this way made it simple for researchers outside our group to review the code and suggest improvements.


8
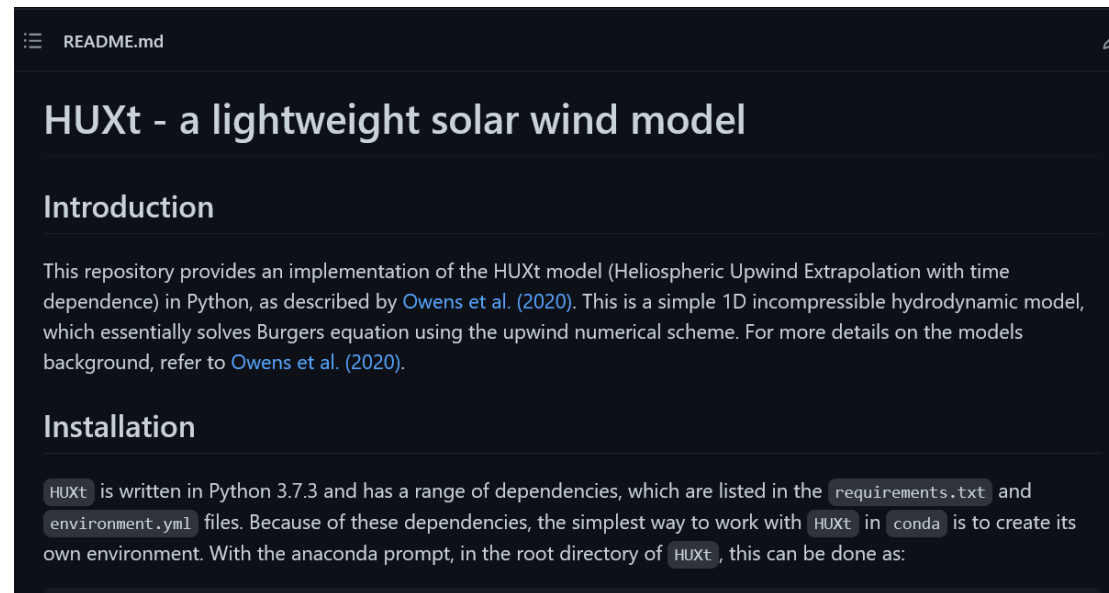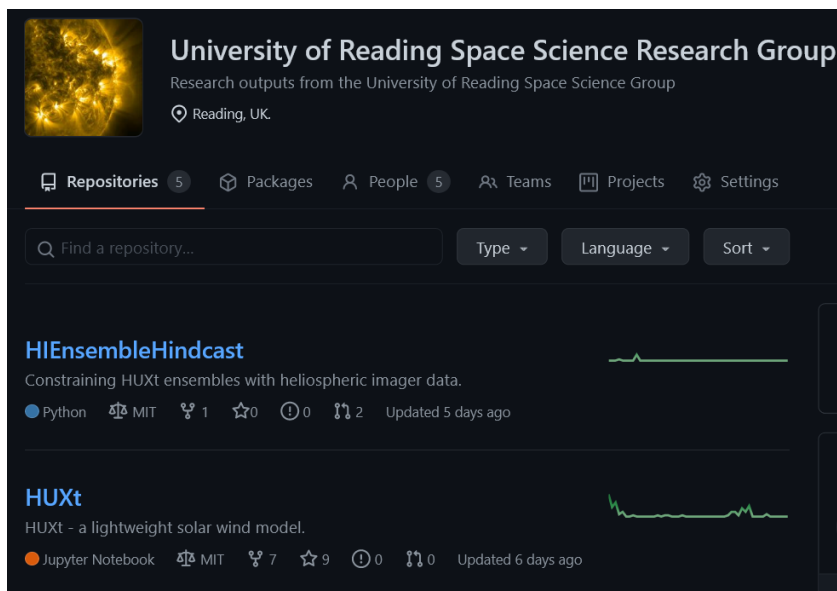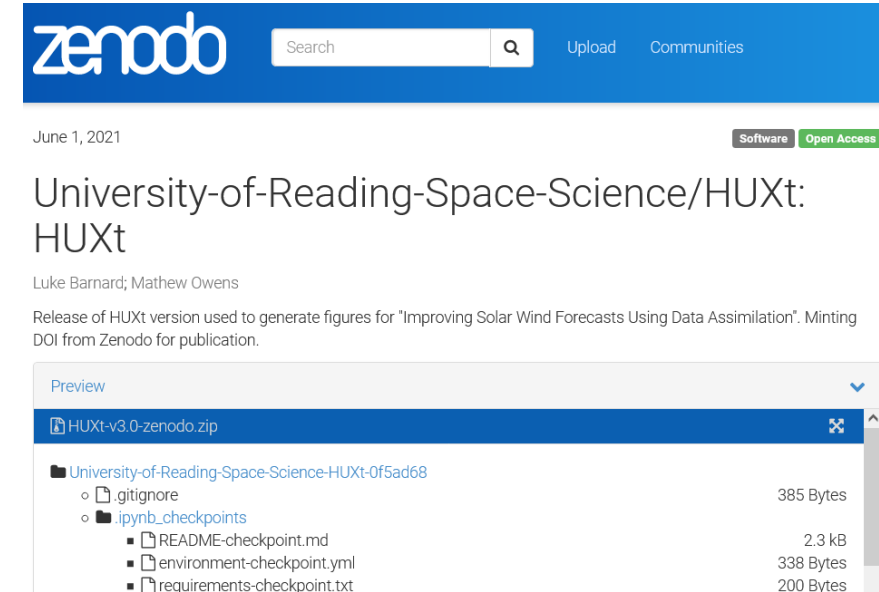
HUXt impacts - Research

- Since HUXt was published in February 2020:

  - Was central to three of our groups recent research papers.

  - Is being used and developed by 3 PhD students in our group for their research

  - Has led to new international collaborations with teams in the US, Austria, and China. This has produced 1 new submitted publication, with 2 more being written.

HUXt impacts - Research

- We used HUXt to demonstrate a proof-of-concept method for using ensemble modelling with spacecraft observations to improve CME arrival times by up to 20%.

- Published in AGU Advances which had an open peer review process.

Ensemble CME Modeling Constrained by Heliospheric Imager Observations

Overview of attention for article published in AGU Advances, September 2020

872
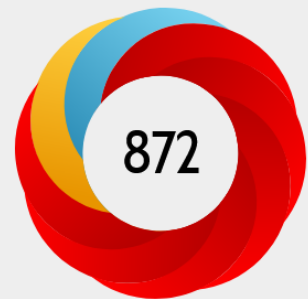
About this Attention Score

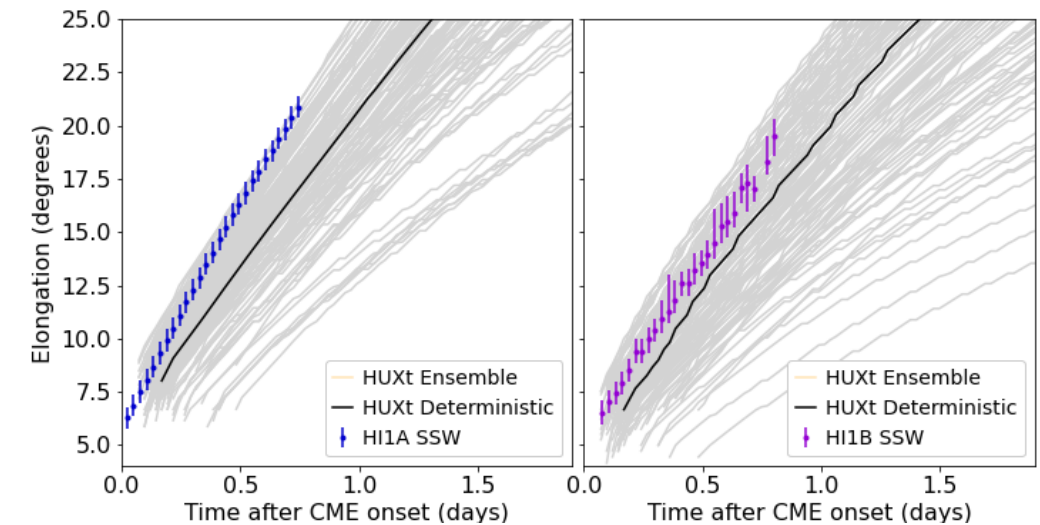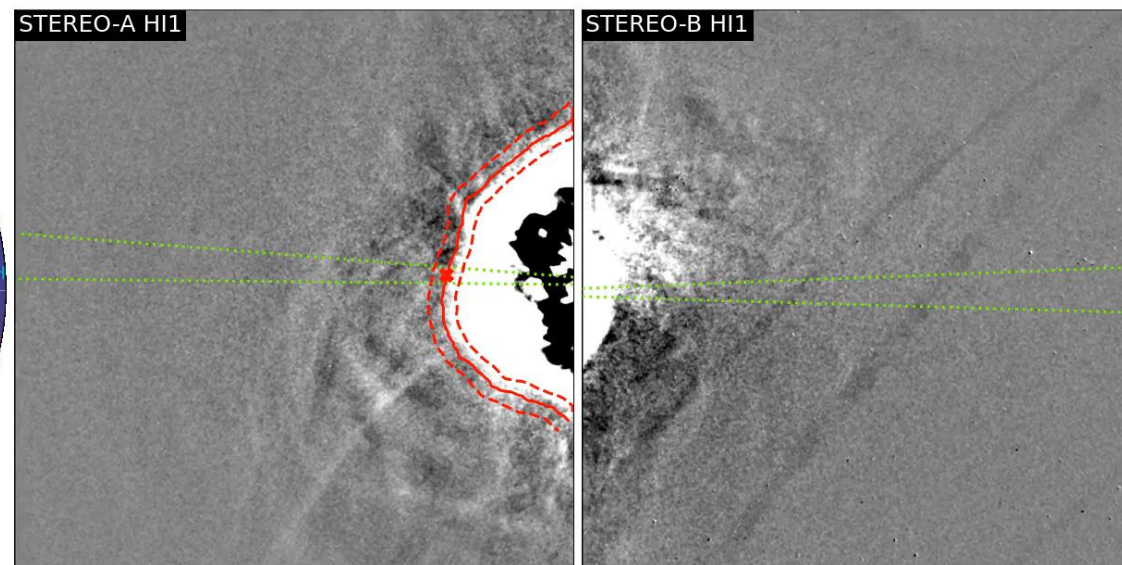In the top 5% of all research outputs scored by Altmetric
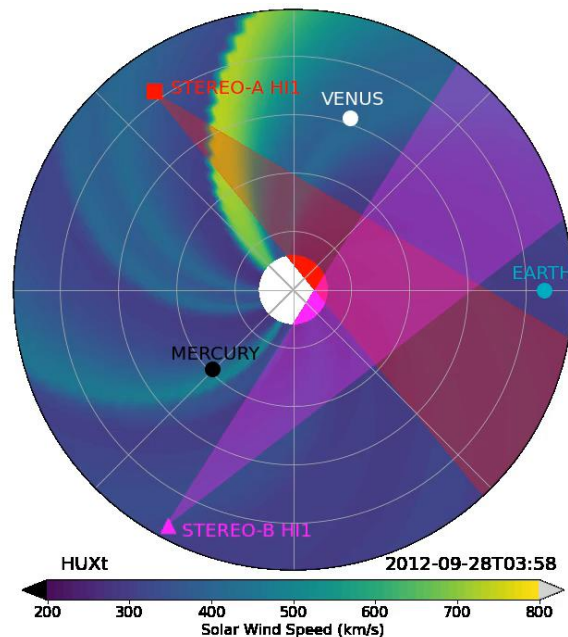
MORE...

Mentioned by
108 news outlets
2 blogs
20 tweeters

Citations
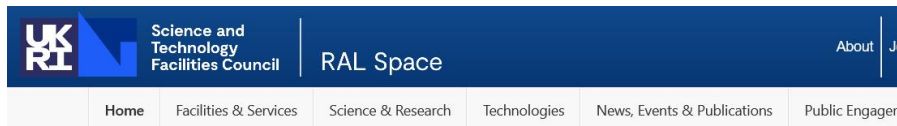1 Dimensions

Readers on
6 Mendeley

HUXt impacts - Teaching

- HUXt is being used by Peking University in the Masters course on Heliophysics.

- We received feedback that the accessibility of the model makes it a good tool for teaching about both the dynamics of the solar wind, and how to model it.

HUXt impacts - Future

University of Reading

- Through the £20M UKRI-STFC SWIMMR Programme, we are now funded to develop HUXt to be an operational model for the UK Met Office.

- The Met Office Space Weather Operations Center are enthusiastic about the benefits that large ensembles from HUXt could offer their forecasters.

SWIMMR (Space Weather Instrumentation, Measurement, Modelling and Risk)

Space Weather Instrumentation, Measurement, Modelling and Risk (SWIMMR)

- Programme overview

SWIMMR (Space Weather Instrumentation, Measurement, Modelling and Risk) is a £20 million, four-year programme that will improve the UK's capabilities for space weather monitoring and prediction. There will be an emphasis on