Measuring the Magnetopause Position with SMILE-SXI

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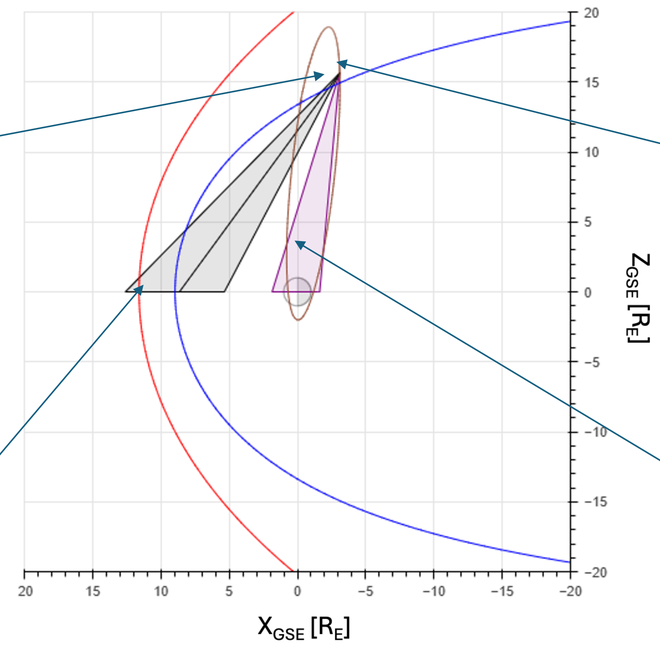
Key Points:

- The ESA-CAS SMILE mission will be launched in 2026 with a lifetime of 3-7 years. It has four instruments to investigate solar wind – magnetosphere – ionosphere coupling.
- Its soft X-ray imager (SXI) will observe solar wind charge exchange (SWCX) emission from the magnetosheath and estimate the magnetopause position.
- We have developed techniques to extract the magnetopause position from simulated SMILE-SXI images.

SMILE will operate from an elliptical orbit above the Earth's north pole.

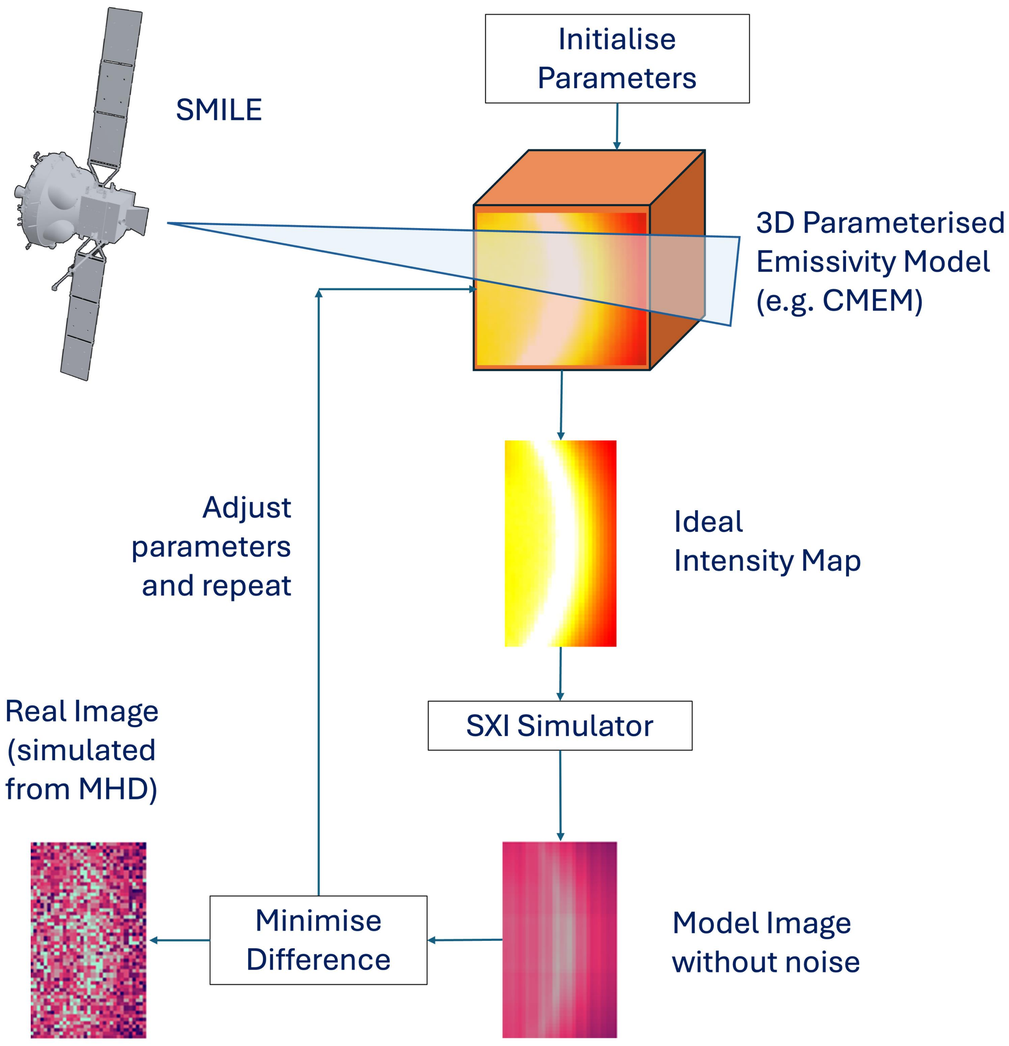
The SXI will detect SWCX emission from near the magnetopause. Images can be constructed with exposure times of 5-20 minutes.



SMILE's orbit gives up to 40 hours of continuous monitoring time.

The Ultraviolet Imager will monitor the northern auroral oval simultaneously.

How will we Measure the Magnetopause Position?



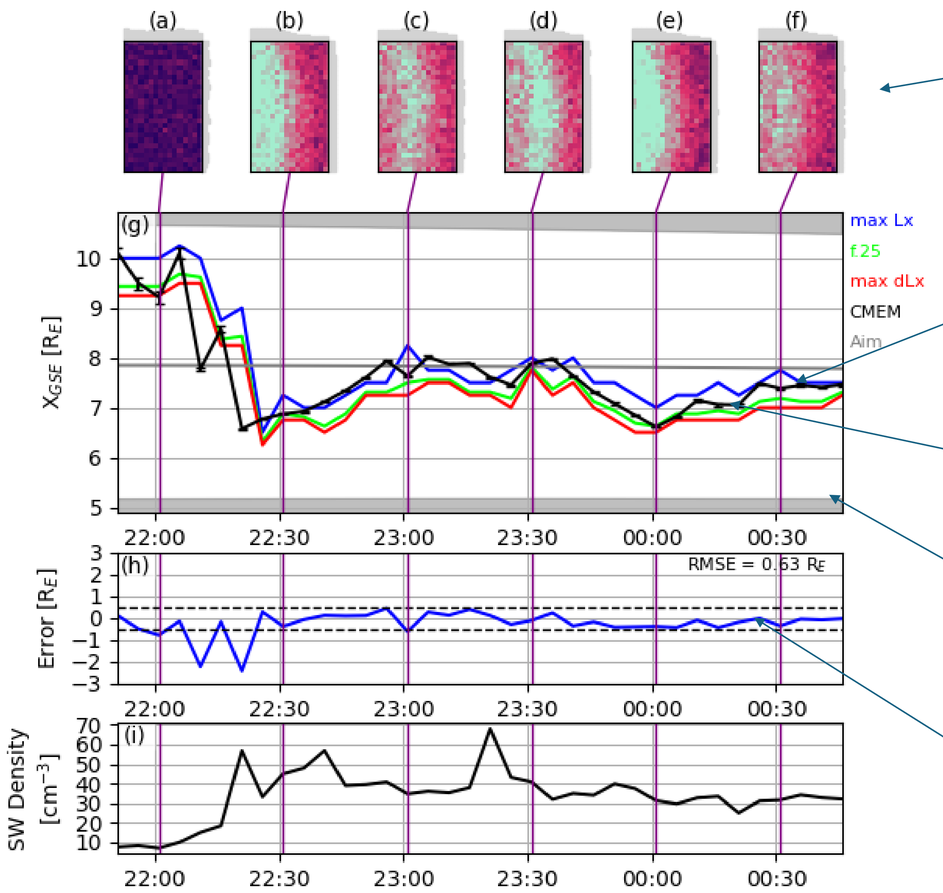
1. A 3D geometric model of the SWCX emissivity is initialised. We use the Cusp and Magnetosheath Emissivity Model (CMEM). The magnetopause position is encoded within the model.

2. An image is simulated through CMEM from the perspective of the spacecraft. This is passed into the SXI simulator to produce a realistic counts map.

3. A fitting algorithm, such as the Nelder Mead, Levenberg-Marquardt or L-BFGS-B algorithm, is used to optimise the parameters of the model until it matches the image.

How well does it work?

- We are simulating different scenarios using MHD models and the SXI simulator.
- We investigated a set of static scenarios and showed the accuracy of the technique improves with increasing solar wind density.
- We are now testing the method on scenarios with realistic time-varying solar wind conditions.
- This example shows three hours with a strong southward turning of the IMF and a strong increase in solar wind density.
- The absolute error was less than 0.5 RE for the majority of the observing time.



Example SXI images.

3 magnetopause definitions (colours), as the magnetopause has a width. Blue is best for the version of CMEM used here.

The CMEM method's estimation of the subsolar magnetopause position (black).

Field of view of SXI.

Error for this method.

References:

Wharton et al. (2025a), JGR,
Sembay et al. (2024), EPP,
Samsonov et al. (2024), EPP
Wharton et al. (2025b), JGR
Wharton et al. (In Prep)

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