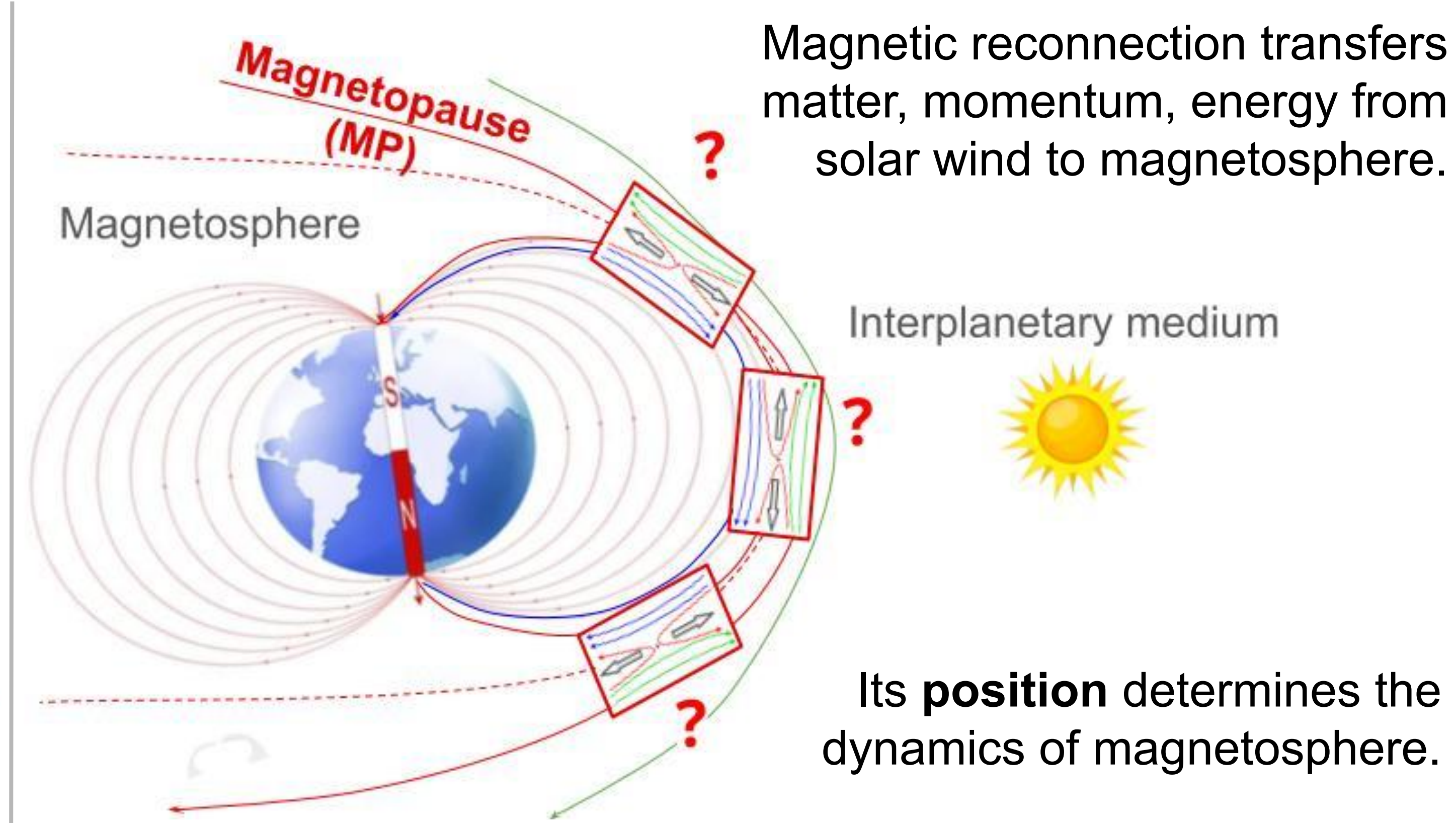
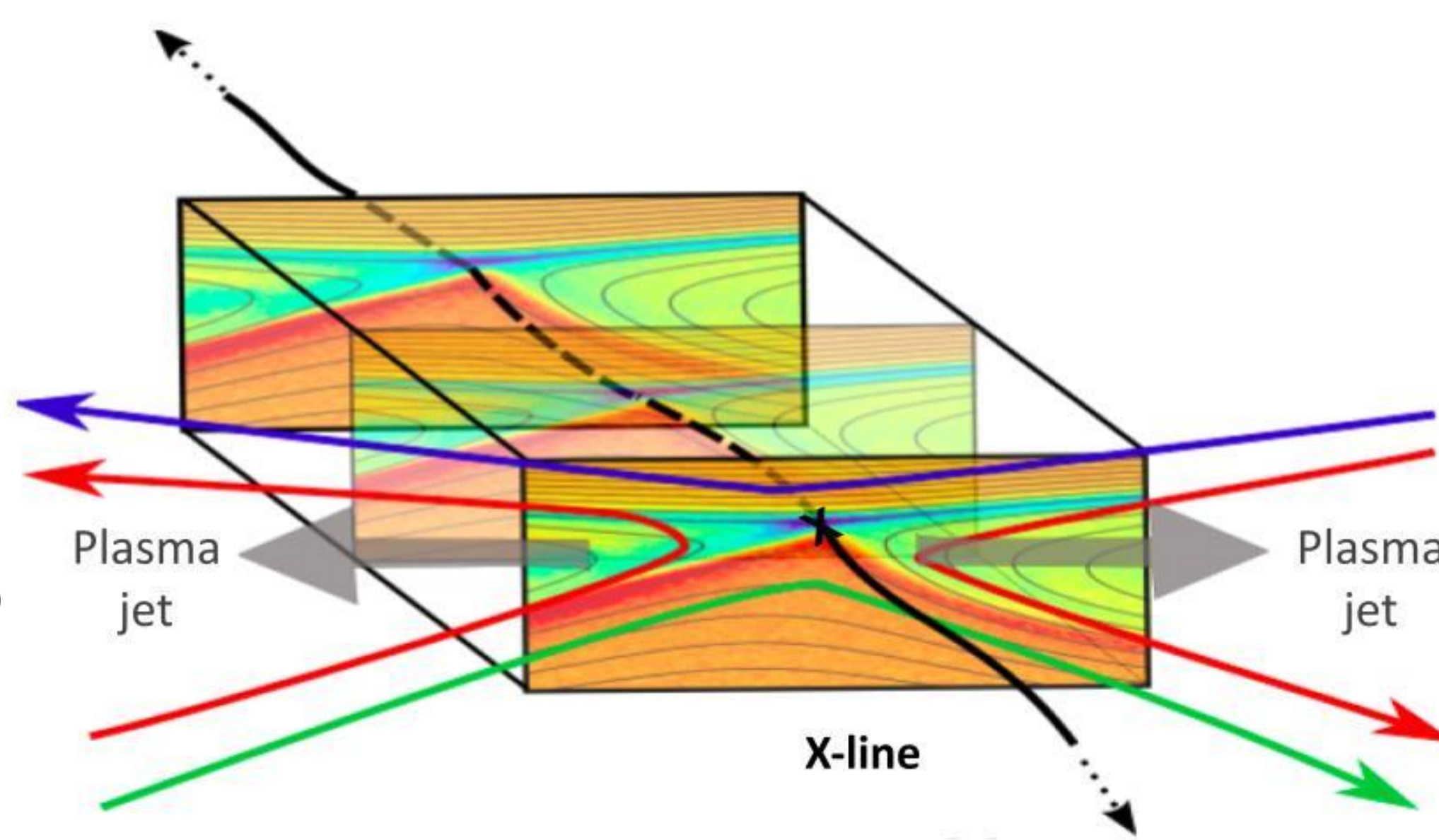


Detection of magnetopause boundary layers with machine learning: implications for the magnetic reconnection X-line

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1 - Magnetic reconnection at the magnetopause

- **Magnetic reconnection** : process that converts magnetic energy into thermal and kinetic energy
- Signature : accelerated jets in the **boundary layer (BL)** between magnetosphere and magnetosheath



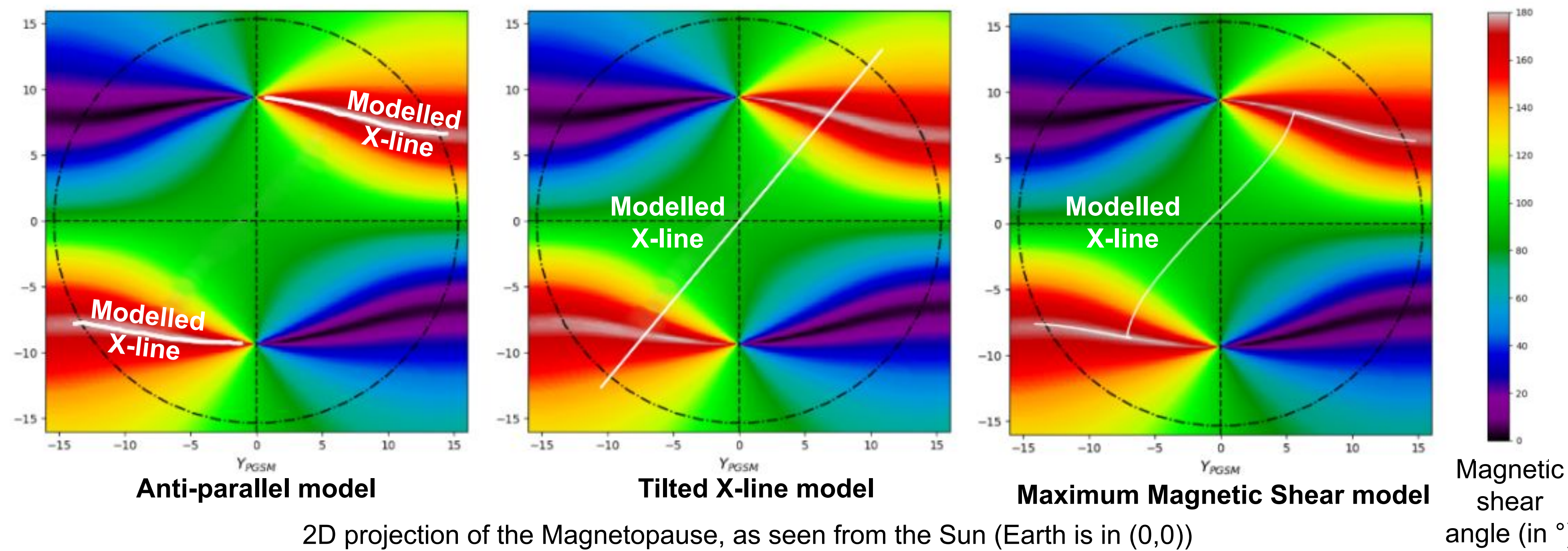
Magnetic reconnection transfers matter, momentum, energy from solar wind to magnetosphere.

Interplanetary medium

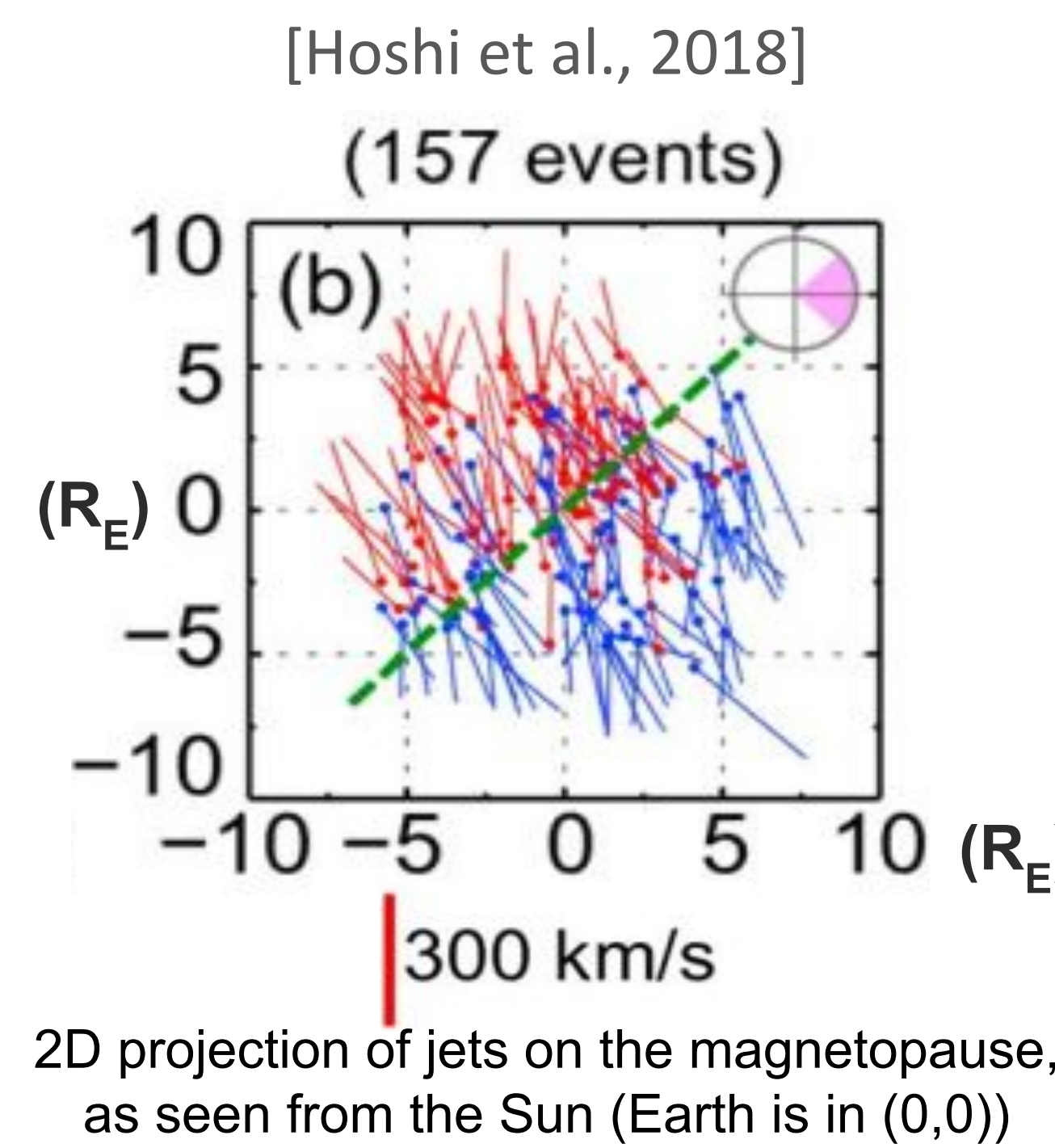
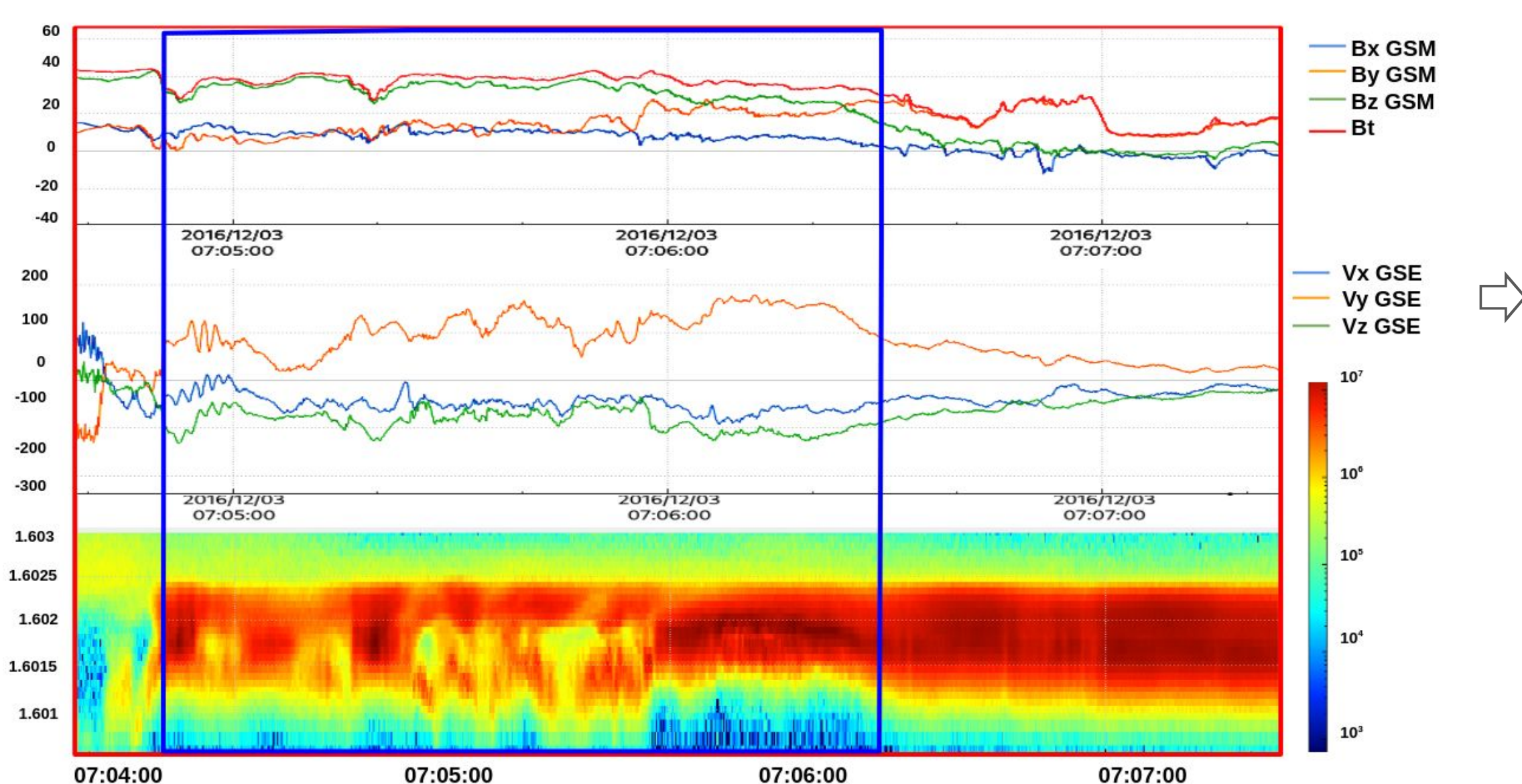
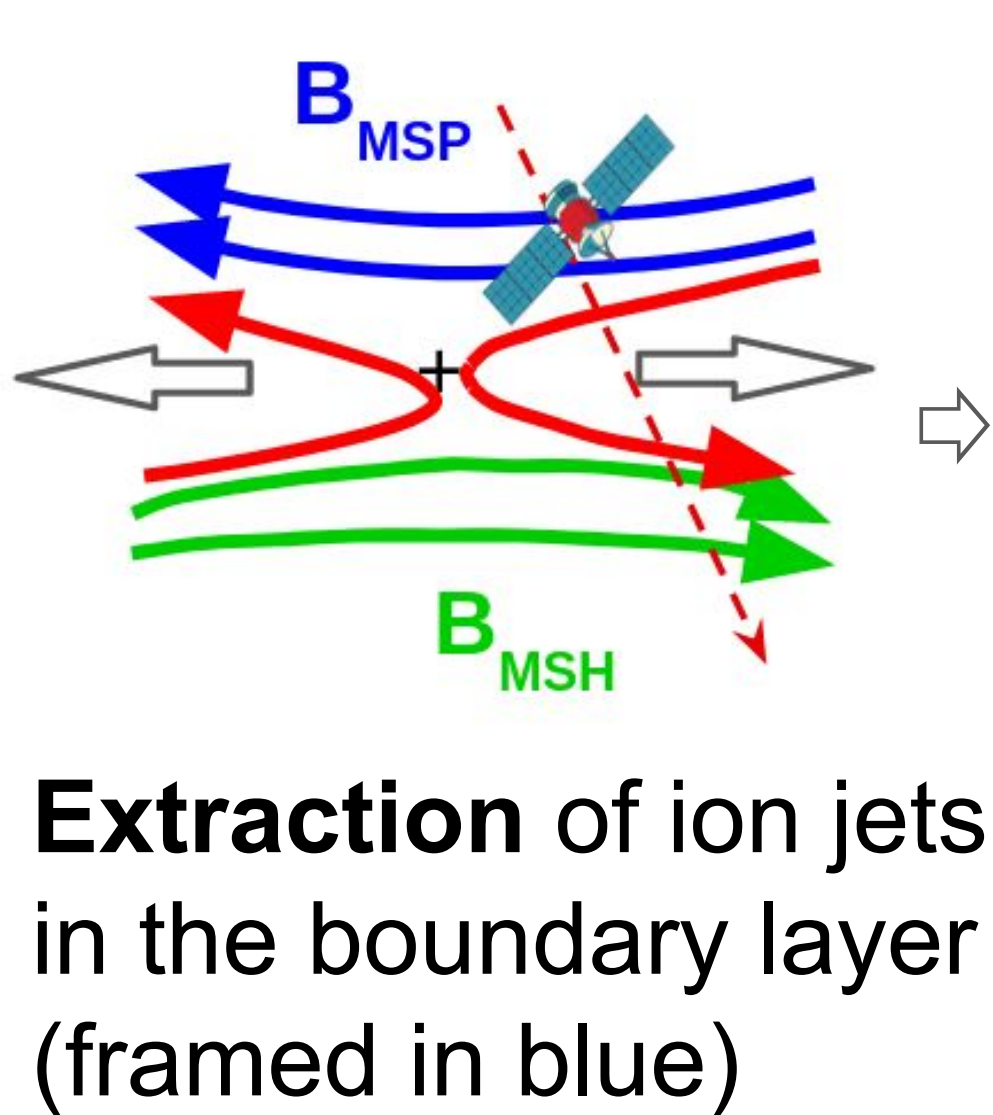
Its **position** determines the dynamics of magnetosphere.

2 - Historical X-line models

- **Anti-parallel** reconnection : reconnection happens only in anti-parallel regions
- **Tilted X-line** : the X-line goes through the subsolar point and its orientation depends on the interplanetary magnetic field direction
- **Maximum Magnetic Shear** : reconnection happens in anti-parallel regions, and in-between, maximizing magnetic shear



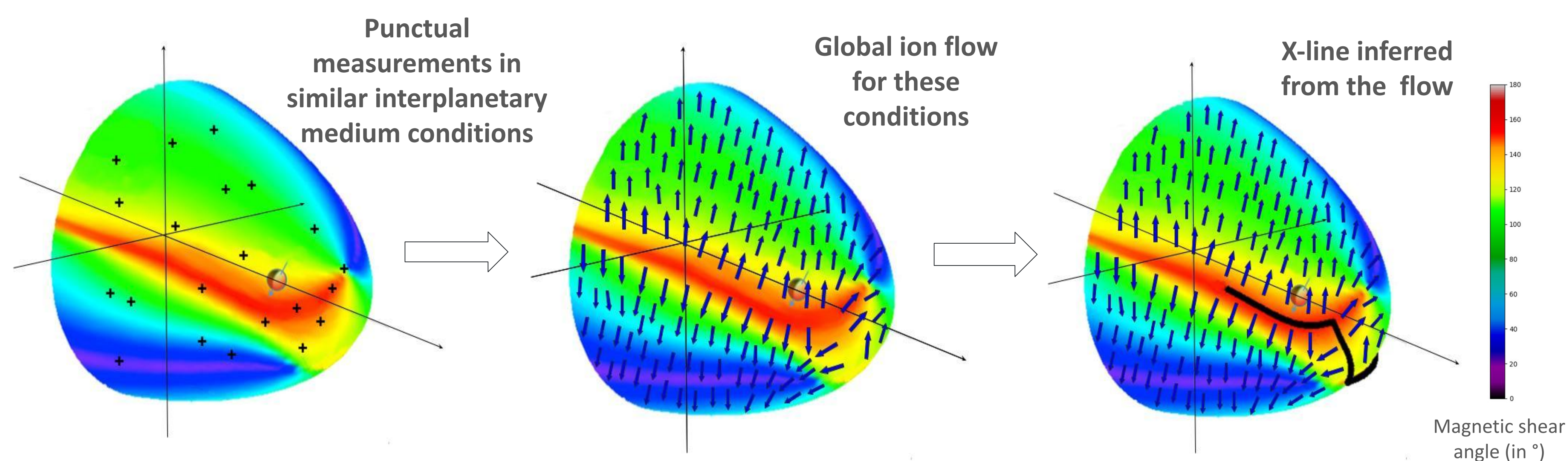
3 - Constraining the X-line with in-situ satellite data



- Statistical studies of reconnection position: Hoshi et al. (2018), Trenchi et al. (2008)
- Red jets towards the North and blue jets towards the South bound the X-line
- modelled tilted X-line in green
- Not enough jets to have meaningful conclusions (because complex and long to extract)

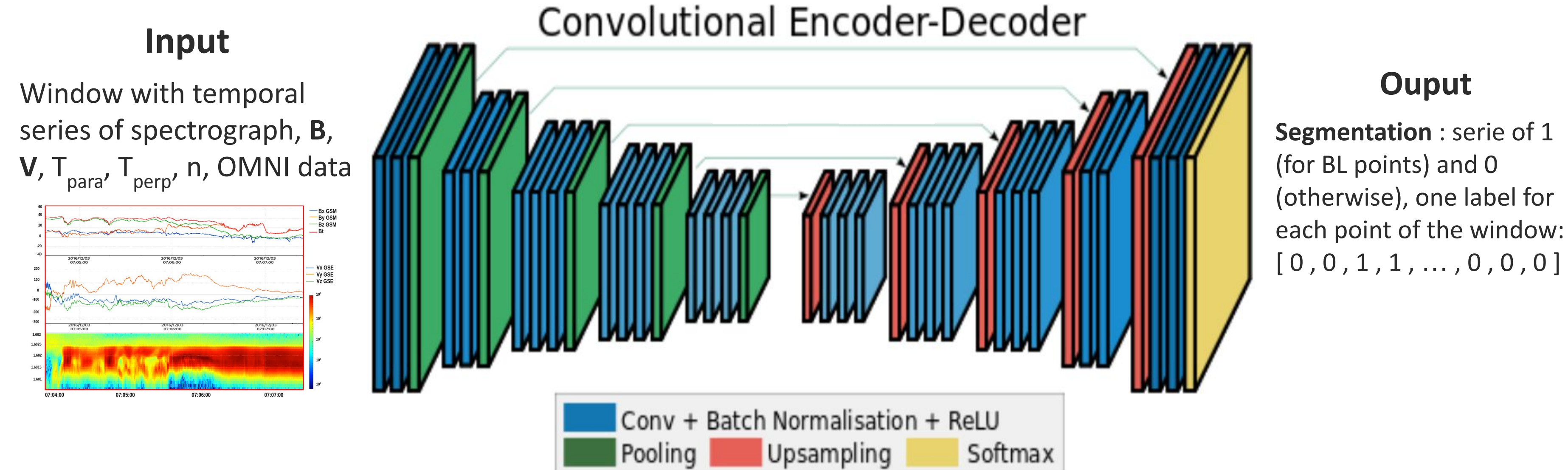
4 - Goal : Reconstruction of the ion flow in the BL

- Generalization of Hoshi et al. (2018)
- Reconnection jets = acceleration of ion flow in the BL
- The ions in the BL flow out from the X-line ⇒ constrains the X-line position
- Many BL points needed to build precise maps for different solar wind conditions



5 - How? Detection of the BL with a neural network

- Architecture: adapted from **UTime** (Encoder-decoder with skip connections), coded in **PyTorch**
- Windows of four hours are taken within 3 Earth radii from the magnetopause given by Shue's model (Shue et al., 1998)
- BL is labelled in these windows with the **SciQLop** tool



6 - Challenges

- Very little BL compared to the rest ⇒ Imbalanced dataset
- Ambiguous data, difficult to label consistently ⇒ little and variable dataset
- Large windows needed to englobe the context ⇒ few windows

7 - References

Trattner et al. (2021), Hoshi et al. (2018), Trenchi et al. (2008), Shue et al. (1998), Perslev et al. (2019), Michotte de Welle (PNST 2024), Jeandet et al. (2023)