Investigating Small-Scale Evolution and Energetics of Coronal Hole Boundary

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Key Points

1. **We investigate the evolution of the boundary of an equatorial coronal hole (CH) continuously for 7 days using SDO.**
2. **Differential Emission Measure analysis is used to derive plasma parameters.**
3. **The irregularities of the boundary are estimated using the Correlation Dimension Mapping method.**
4. **Preliminary results suggest that the different parts of the boundary have different properties and evolve differently throughout the observation period.**

1. CH Boundary Region Segmentation

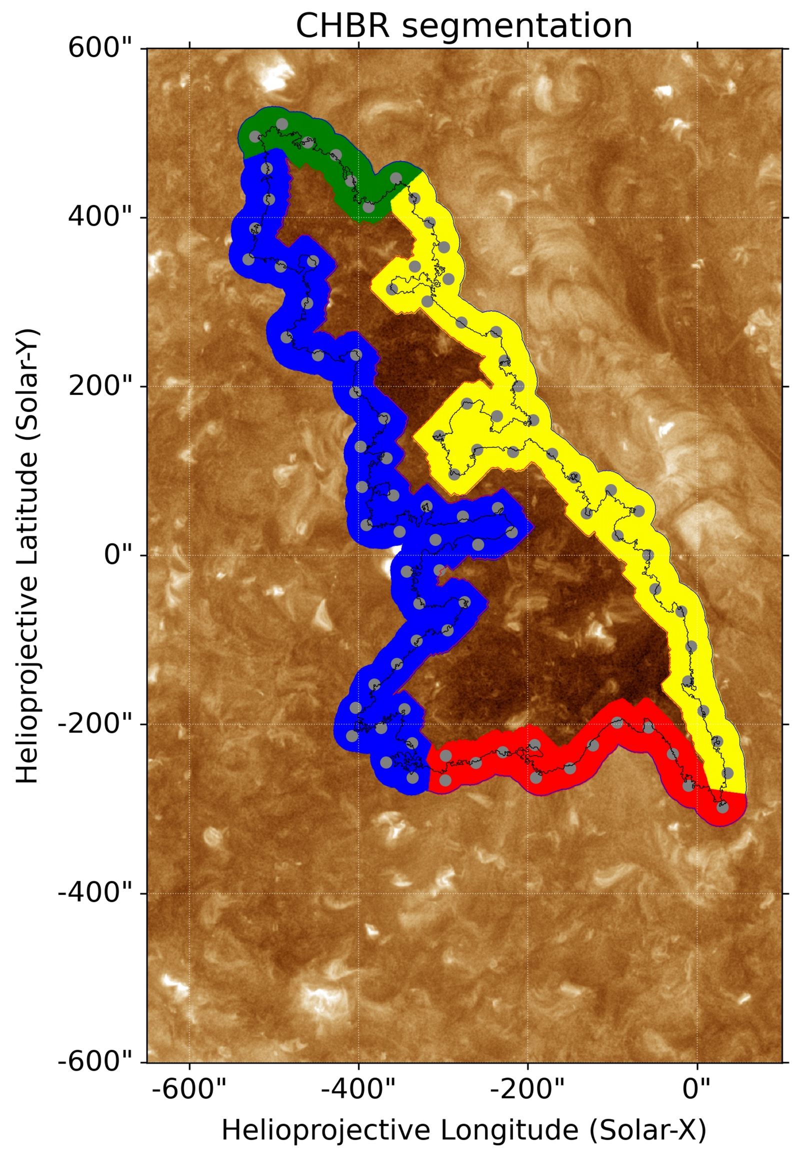

Figure 1: CH boundary region (CHBR) segmentation map, showing four subregions of CHBR: bottom edge (red), trailing edge (blue), top edge (green) and leading edge (yellow). The black contour indicates the CH boundary.

- An equatorial CH surrounded by the quiet Sun region was observed from 2018 October 28 to November 4.
  - CH was located within $\pm 60°$ from the central meridian throughout the period.
- The CH boundary is extracted using the intensity threshold of 46.2% of solar disc median intensity in SDO/AIA 193 Å passband (Heinemann et al., 2019).
- The CH boundary region (CHBR) is defined as the region within 24" (40 pixels) of the boundary on either side
  - CHBR is then segmented into four subregions using a technique based on the k-means clustering method.

2. Differential Emission Measured analysis

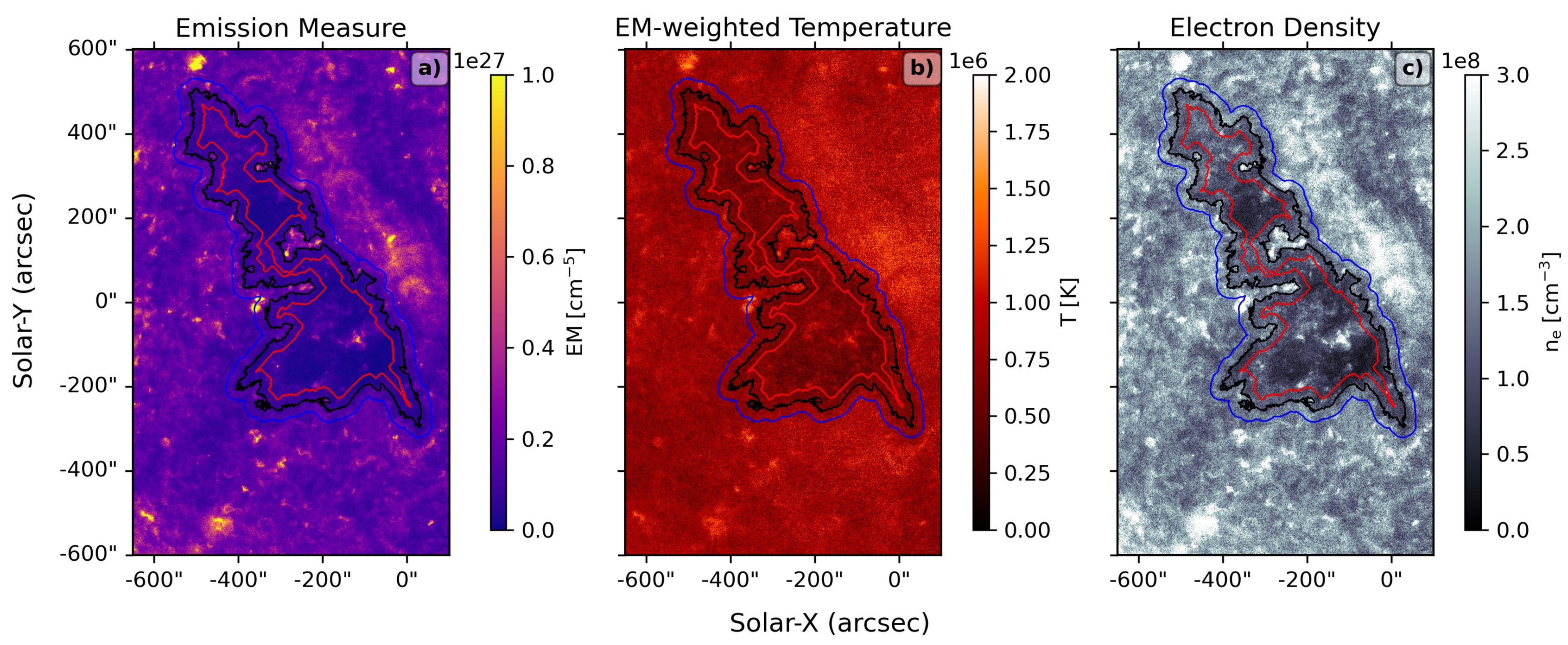

Figure 2: Plasma parameters of CH obtained from Differential Emission Measure analysis, including a) Emission Measure (EM), b) EM-weighted Temperature, and c) Electron density.

- Obtain differential emission measure (DEM) of CH using seven EUV passbands of SDO/AIA
  - Using the inversion algorithm by Hannah and Kontar (2012)
  - Temperature range: log(T) = 5.5 - 6.5
- Calculate plasma emission measure (EM), EM-weighted temperature ($\bar{T}$), and electron density (n_e)

$$\mathrm{EM} = \int_T \mathrm{DEM(T)dT}, \quad \bar{T} = \frac{\int_T \mathrm{DEM(T)\,TdT}}{\mathrm{EM}}, \quad n_e = \sqrt{\frac{\mathrm{EM}}{h}}$$

- h = scale height ≈ 42 Mm (Saqri et al. 2020)

3. Correlation Dimension Mapping

- Developed by Mason and Uritsky (2022)
- Quantify the local irregularities of the boundary lines using the correlation dimension parameter (D)
  - D = 1 → straight line
  - Higher D → more irregular
- D is computed based on the radius range of 5 – 20 Mm
  - Similar scale to plumelets

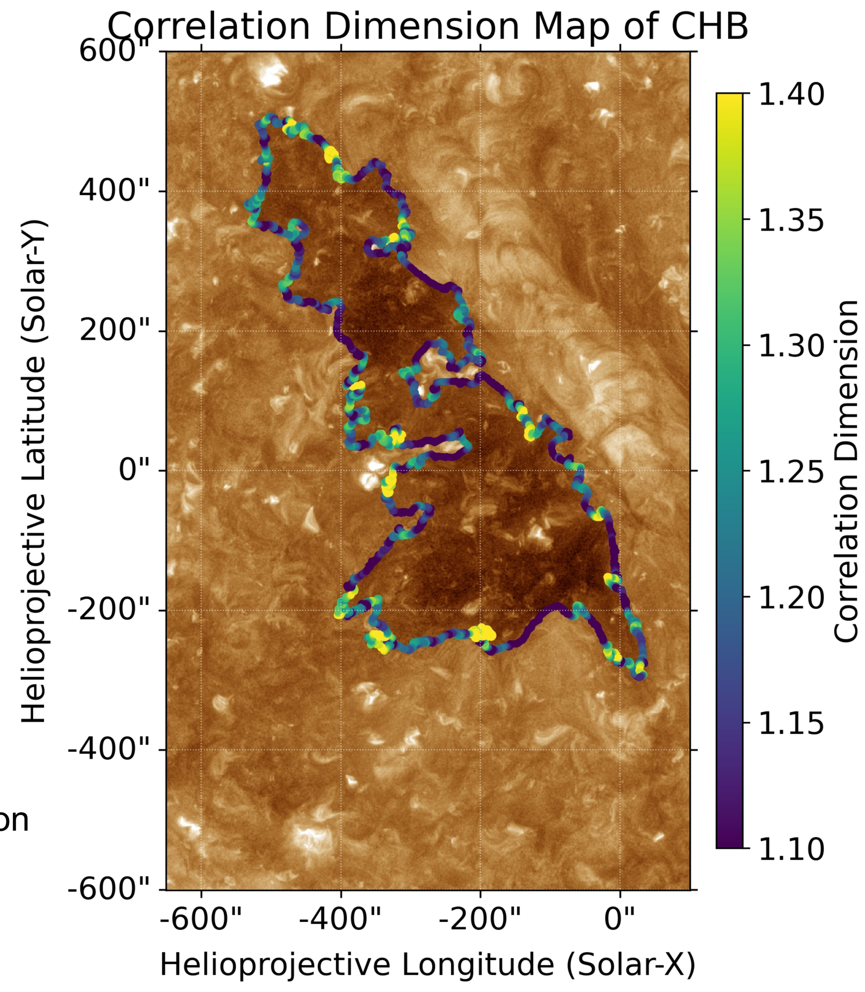

Figure 3: Correlation dimension map overlaid on the boundary of CH. More irregular sections of the boundary (higher D) are denoted in yellow while the straighter sections (lower D) are denoted in blue.

4. Preliminary Results

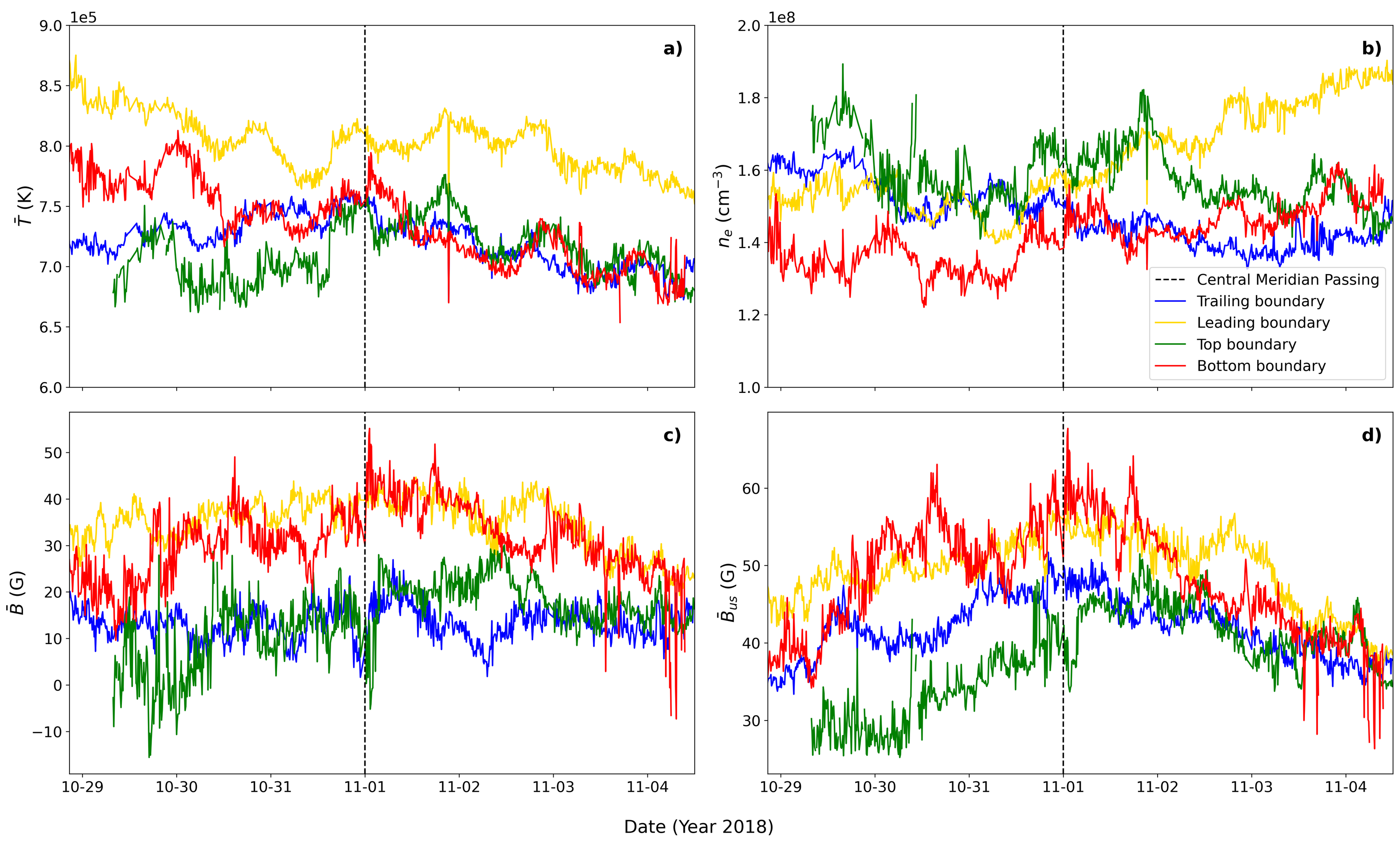

Figure 4: The evolution of averaged plasma and magnetic field parameters inside each subregion of CHBR across 7-day observation, including a) EM-weighted temperature, b) Electron density, c) Unbalanced magnetic flux density, and d) Unsigned magnetic flux density. The time cadence is 10 minutes.

Plasma Properties

- The leading edge generally has a higher temperature than other sections.
- Electron density (and EM) at the leading edge significantly increase after central meridian passing.
- Temperature and density evolve differently in CHBR.

Magnetic Field Properties

- We select only magnetogram pixels with |B| > 20 G.
- The leading and bottom edges have higher unbalanced and unsigned flux densities than the two other sections.
- Every value peak around the central meridian: may be subjected to the projection effect.

5. Future Works

- **Study the evolution at specific parts of the CH boundary**
  - Using the highest temporal resolution (12-second)
  - Investigate whether the irregularities of the CH boundary are correlated with changes in plasma and magnetic properties
  - Determine the thermal energy released from small-scale jet/brightenings in the CH boundary region
- **Analyse the magnetic configuration around the CH using magnetic field extrapolation**
- **Link and compare results with the in-situ observation of solar wind originating from this CH by PSP and WIND**

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