

# COMPARISON OF INTERMITTENCY IN ICMES, THEIR SHEATH REGIONS, AND THE SOLAR WIND AT 1 AU



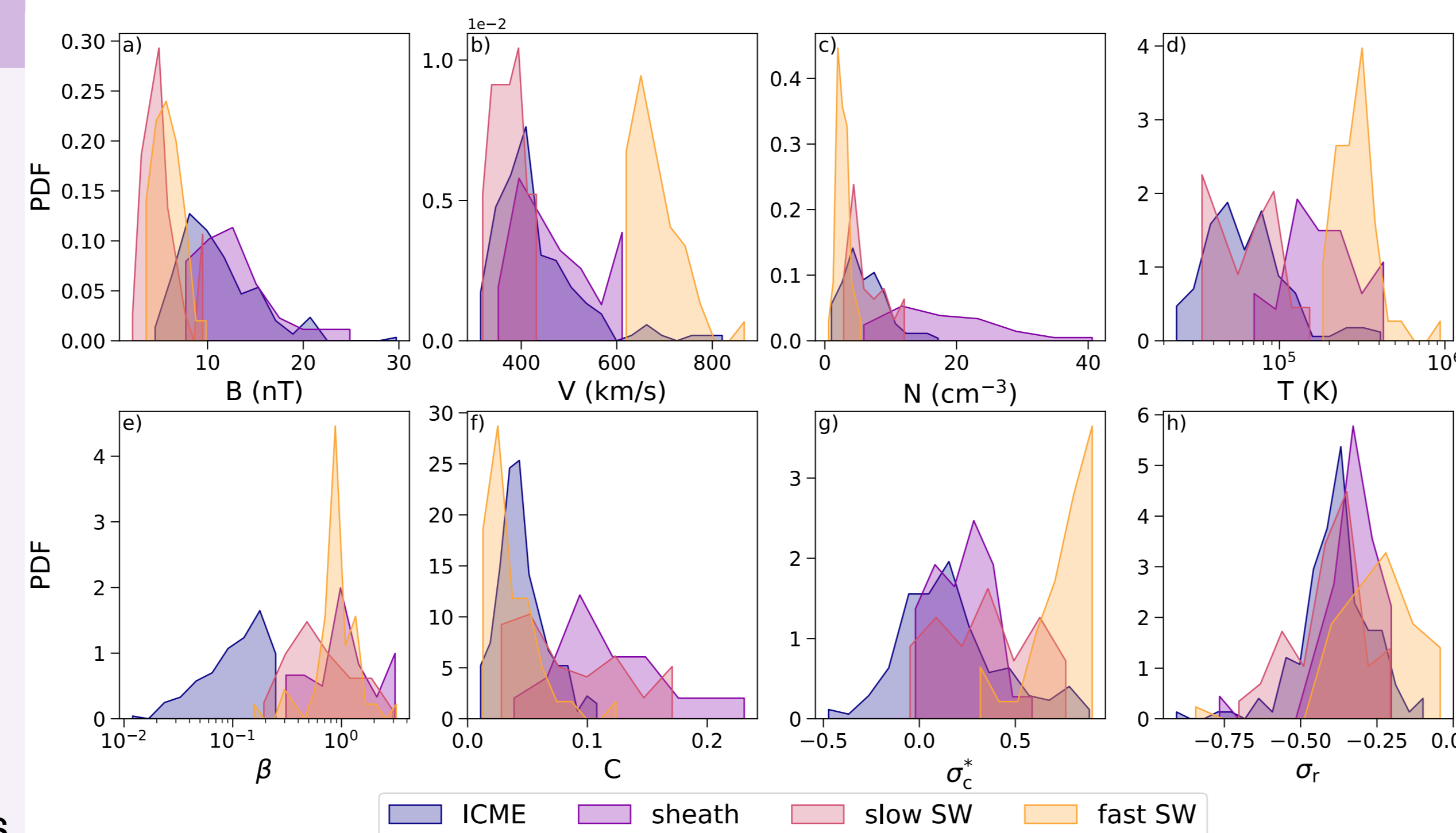
Julia Ruohotie • Simon Good • Emilia Kilpua  
 Department of Physics, University of Helsinki, Finland  
 : julia.ruohotie@helsinki.fi

## BACKGROUND & AIMS

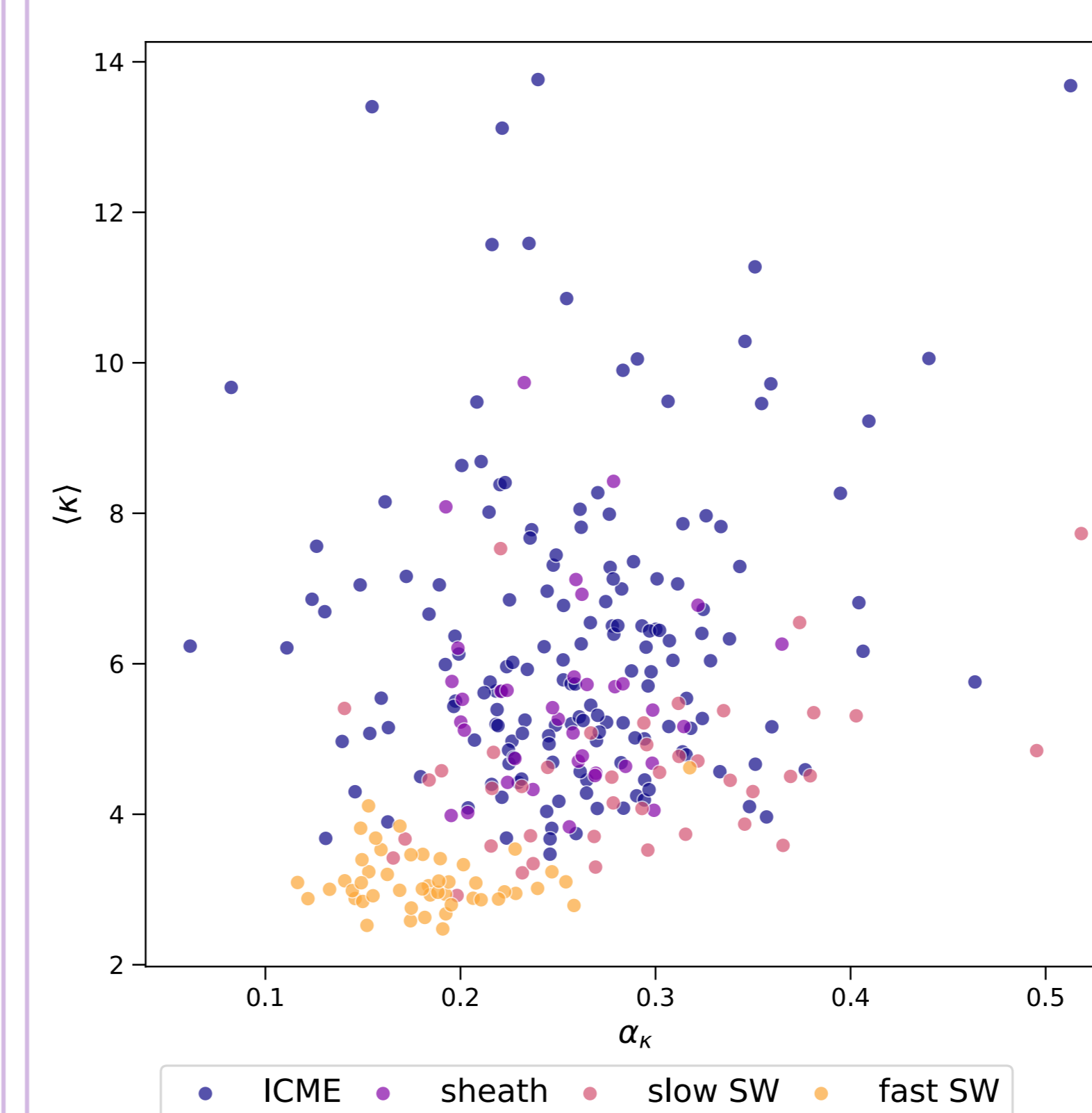
Interplanetary coronal mass ejections (ICMEs), their sheath regions, and the slow and fast solar wind have vastly differing plasma properties and large-scale structures. Nevertheless, at smaller scales MHD turbulence and intermittency are common dynamics for all of them. While intermittency has been studied extensively in the solar wind, the same is not true for ICMEs.

This study analyses intermittency in 166 ICMEs, 36 ICME sheaths, and 41 slow and 48 fast solar wind intervals observed by Wind spacecraft with two main aims:

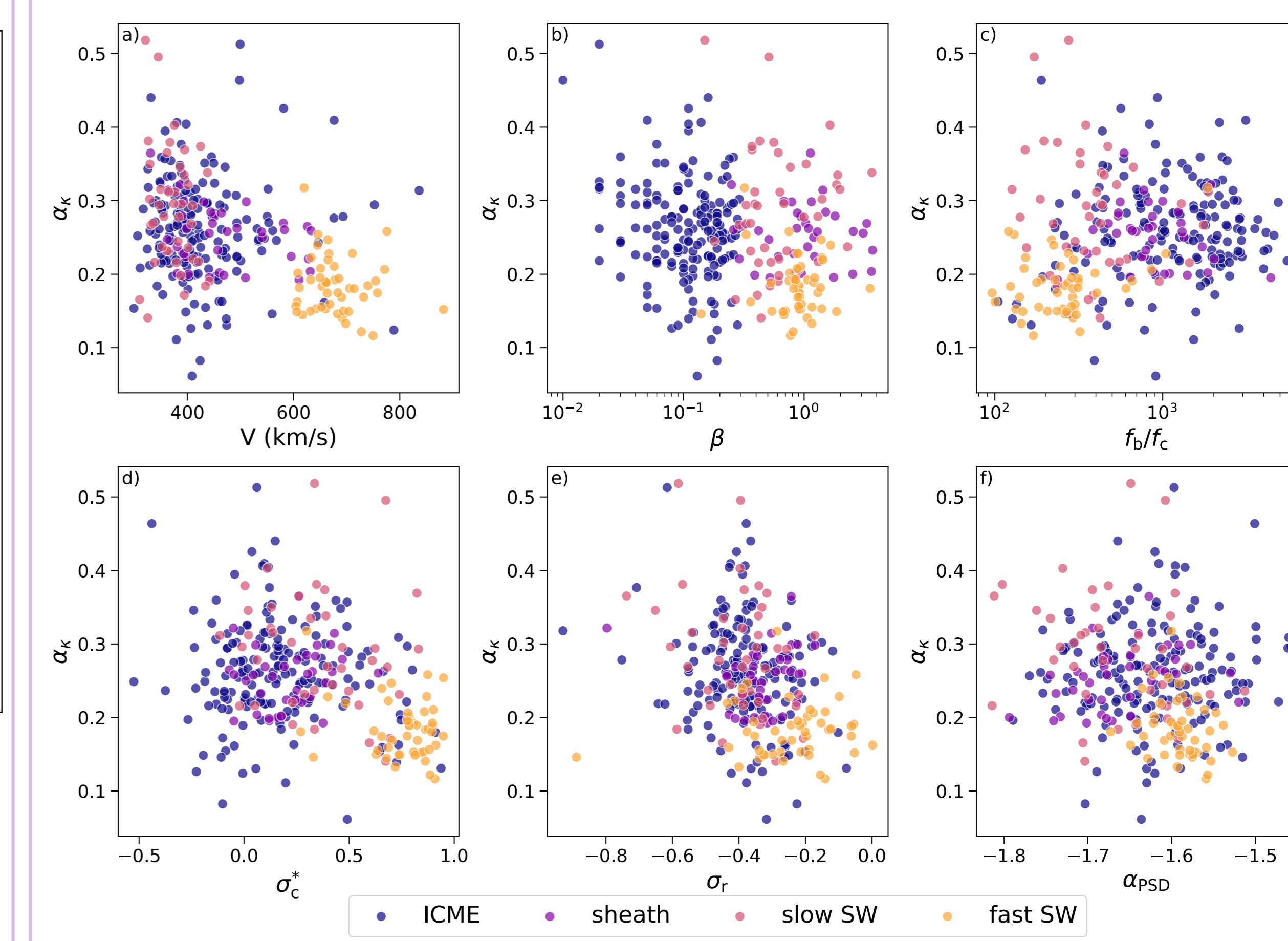
- 1) compare intermittency in these plasma environments
- 2) compare two different measures for intermittency



**FIG 1:** Histograms of different plasma and turbulence parameters in ICMEs, ICME sheaths, and the slow and fast solar wind intervals



**FIG 5:**  $\langle \kappa \rangle$  as a function of  $\alpha_\kappa$  in ICMEs, ICME sheaths, and the slow and fast solar wind intervals



**FIG 6:**  $\alpha_\kappa$  as a function of a) speed  $V$ , b) plasma  $\beta$ , c) width of the inertial range  $f_b/f_c$ , d) rectified cross helicity  $\sigma_c^*$ , e) residual energy  $\sigma_r$ , and f) spectral index  $\alpha_{PSD}$

## INTERMITTENCY

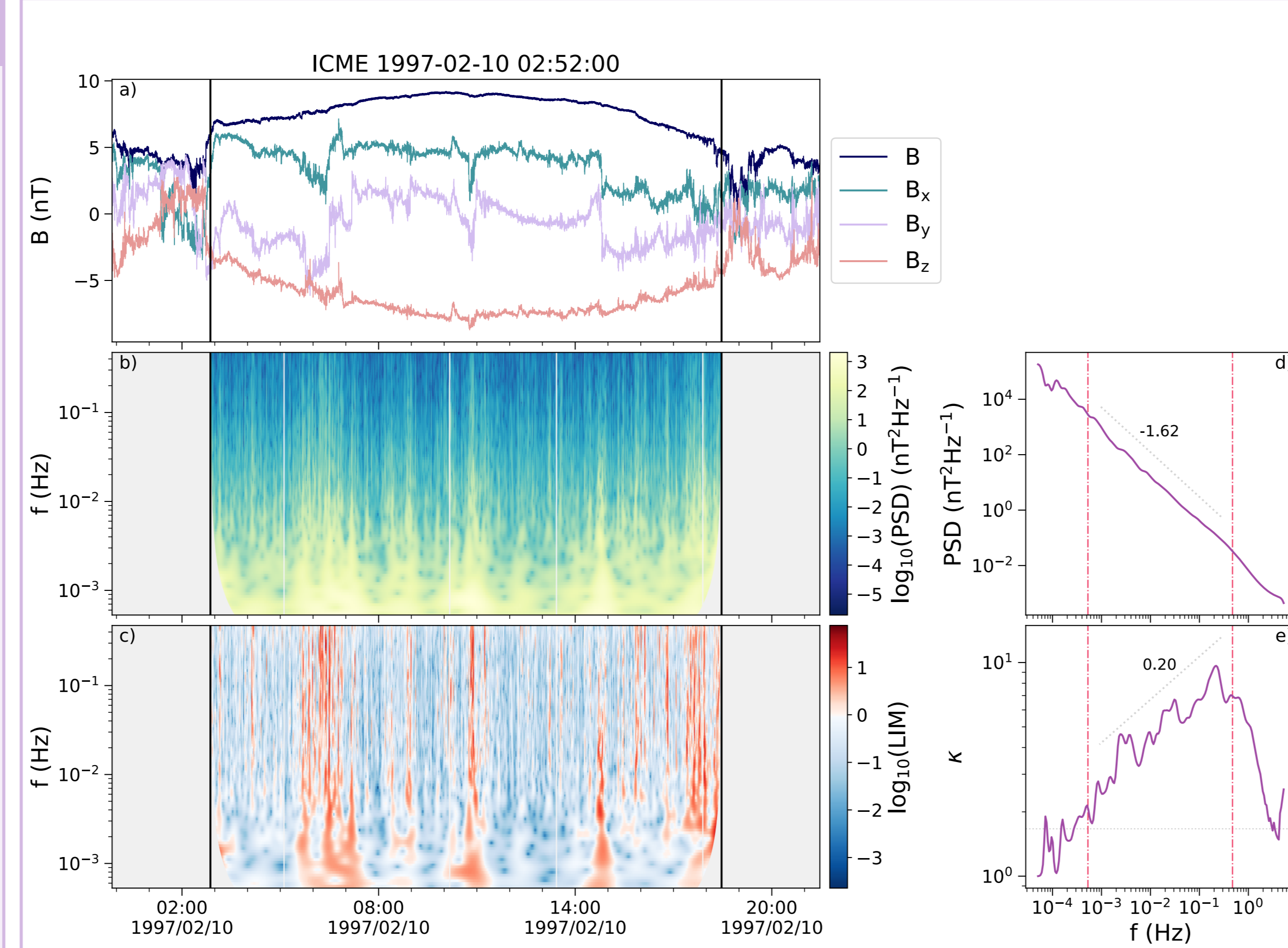
an uneven distribution of energy in the system leading to non-Gaussian statistics at small scales

Kurtosis  $\kappa$  measures the tailedness of the distribution of fluctuations

- two ways to measure intermittency: kurtosis scaling exponent  $\alpha_\kappa$  or the mean value of kurtosis  $\langle \kappa \rangle$

From wavelet analysis:

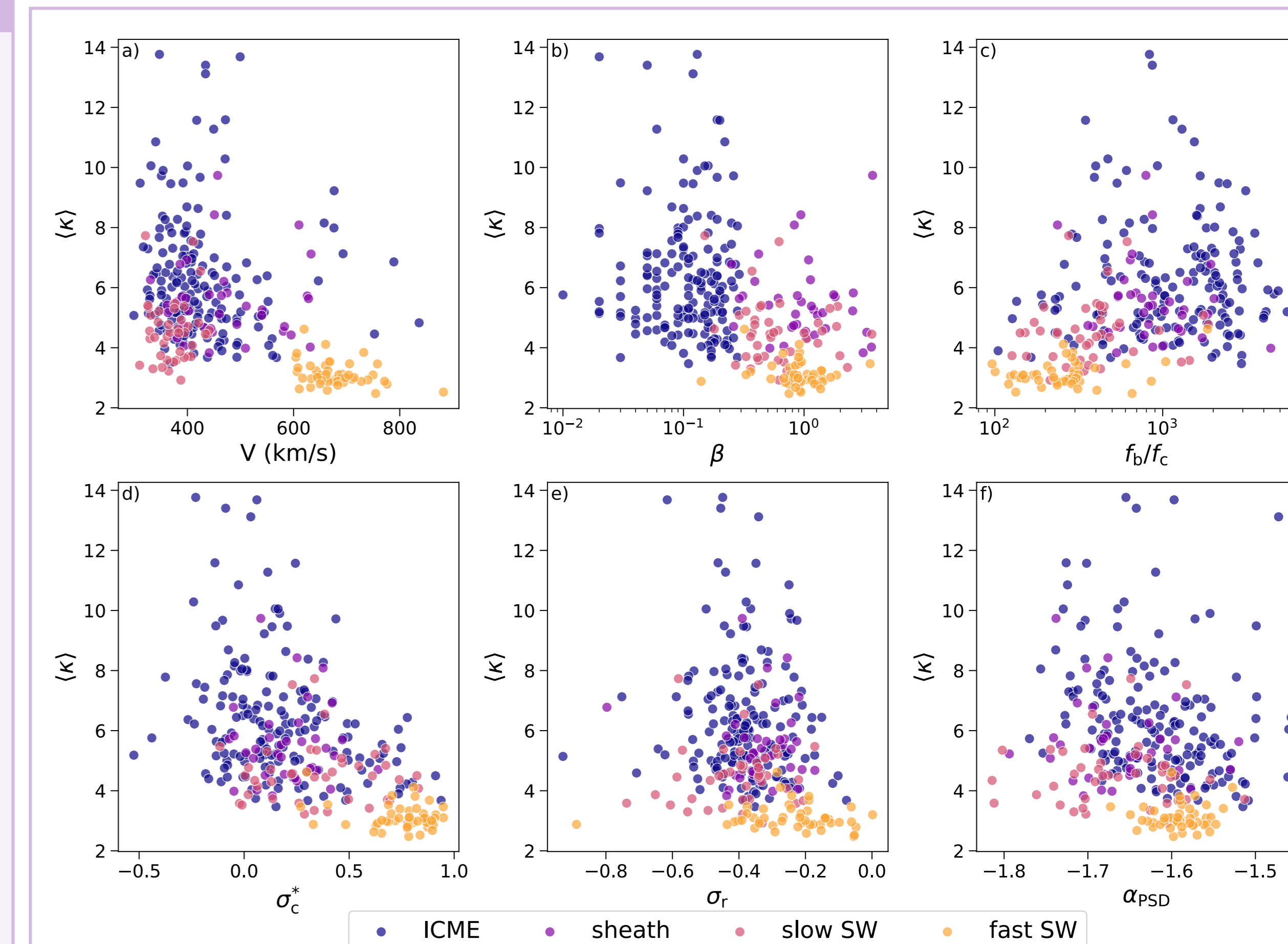
- power spectral density (PSD):
  - $PSD(\tau, t) = 2\delta t |\mathcal{W}(\tau, t)|^2$
- local intermittency measure (LIM):
  - $LIM(\tau, t) = \frac{|\mathcal{W}(\tau, t)|^2}{\langle |\mathcal{W}(\tau, t)|^2 \rangle_t}$
- kurtosis  $\kappa$ :
  - $\kappa(\tau) = \langle LIM^2(\tau, t) \rangle_t$



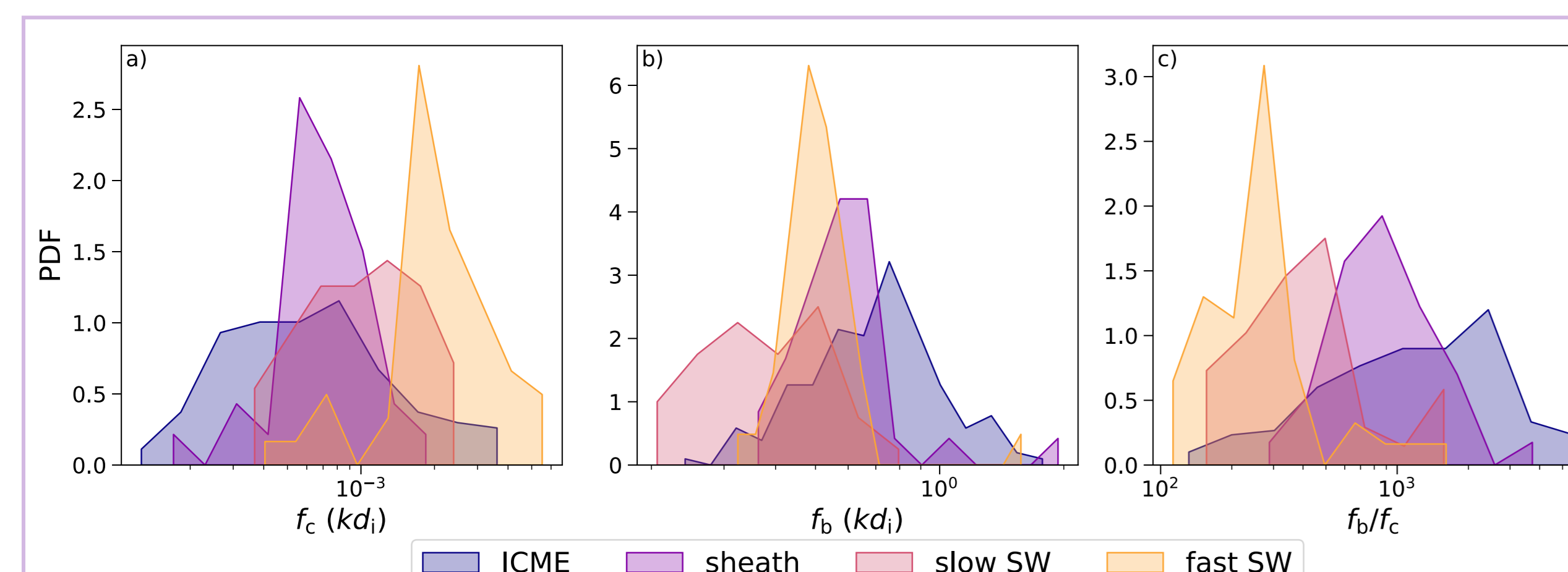
**FIG 2:** The panels show a) magnetic field observations, b) PSD, and c) LIM during an ICME interval. Time-averaged PSD and  $\kappa$  in panels d and e, respectively.

## THE MOST INTERMITTENT EVENTS AMONG THE ICMEs

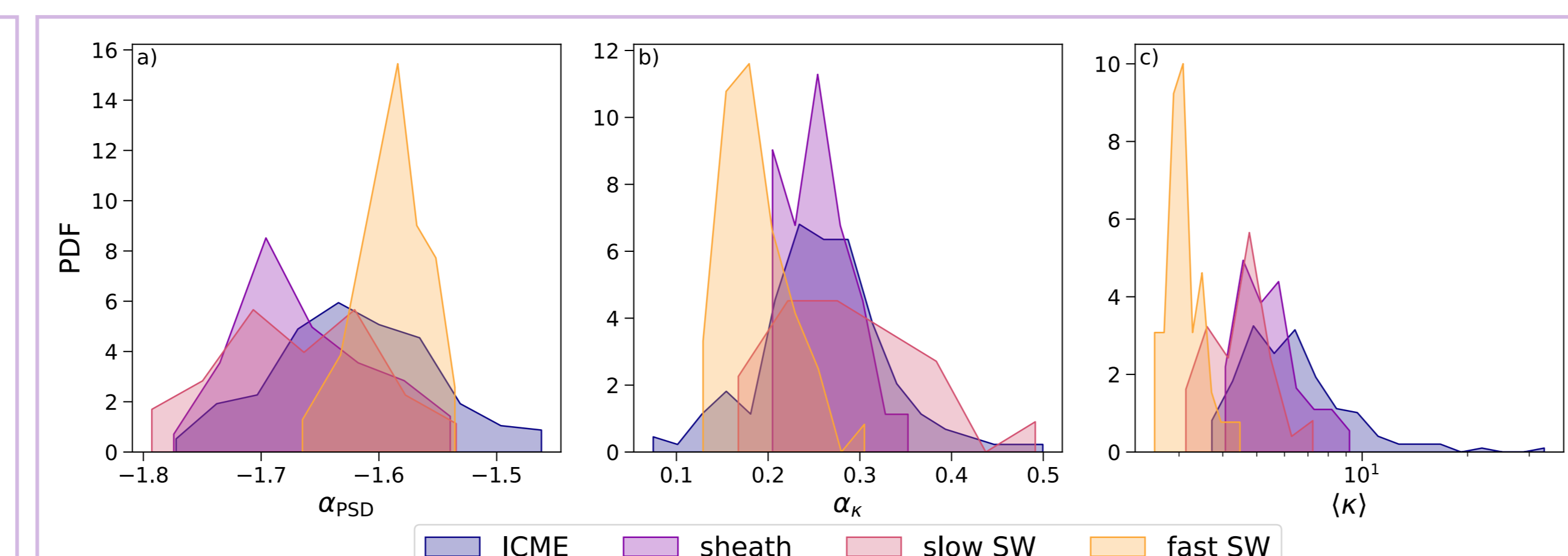
- $f_b/f_c$  grows when moving from the fast solar wind to the slow solar wind and ICME sheaths
- ICMEs have the largest  $f_b/f_c$  but also most spread in the values
- $\alpha_{PSD}$  show the steepest PSD slopes for ICME sheaths and the slow solar wind
- both  $\alpha_\kappa$  and  $\langle \kappa \rangle$  show **the fast solar wind as the least intermittent** plasma environment
- **the most intermittent events among ICMEs based on both  $\alpha_\kappa$  and  $\langle \kappa \rangle$**
- ICME sheaths and the slow solar wind show different amount of intermittency depending on the measure used



**FIG 7:**  $\langle \kappa \rangle$  as a function of a) speed  $V$ , b) plasma  $\beta$ , c) width of the inertial range  $f_b/f_c$ , d) rectified cross helicity  $\sigma_c^*$ , e) residual energy  $\sigma_r$ , and f) spectral index  $\alpha_{PSD}$



**FIG 3:** Histograms of a) correlation lengths  $f_c$ , b) break scales  $f_b$ , and c) widths of the inertial range  $f_b/f_c$



**FIG 4:** Histograms of a) spectral indices  $\alpha_{PSD}$ , b)  $\alpha_\kappa$ , and c)  $\langle \kappa \rangle$  in the inertial range

- ICMEs include also a few events with the smallest  $\alpha_\kappa$

## DIFFERENT CORRELATIONS SEEN WITH DIFFERENT INTERMITTENCY MEASURES

- both measures show correlation with  $V$  and  $\sigma_c^*$ 
  - slower the event, more time there is for turbulence to evolve before reaching 1 au
- $\langle \kappa \rangle$  also shows correlation with plasma  $\beta$ ,  $\sigma_r$ , and  $f_b/f_c$
- neither of the measures correlates with  $\alpha_\kappa$
- **weak correlation between  $\alpha_\kappa$  and  $\langle \kappa \rangle$** 
  - $\langle \kappa \rangle$  seems more sensitive to individual localized extreme fluctuations