SH21C-3317 : Intermittent heating in the inner Heliosphere: PSP observations

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Abstract

The solar wind proton temperature at 1-au has been found to be correlated with small-scale intermittent magnetic structures, i.e., regions with enhanced temperature are associated with coherent structures such as current sheets. Using Parker Solar Probe data from the first encounter, we study this association using measurements of radial proton temperature, employing the Partial Variance of Increments (PVI) technique to identify intermittent magnetic structures.

We observe that the probability density functions of high-PVI events have higher median temperatures than those with lower PVI, The regions in space where PVI peaks were also locations that had enhanced temperatures when compared with similar regions suggesting a heating mechanism in the young solar wind that is associated with intermittency developed by a nonlinear turbulent cascade.n the immediate vicinity.

Introduction

The solar wind at 1-au exhibits localized structures

Several studies have found evidence that plasma turbulence generates these structures dynamically
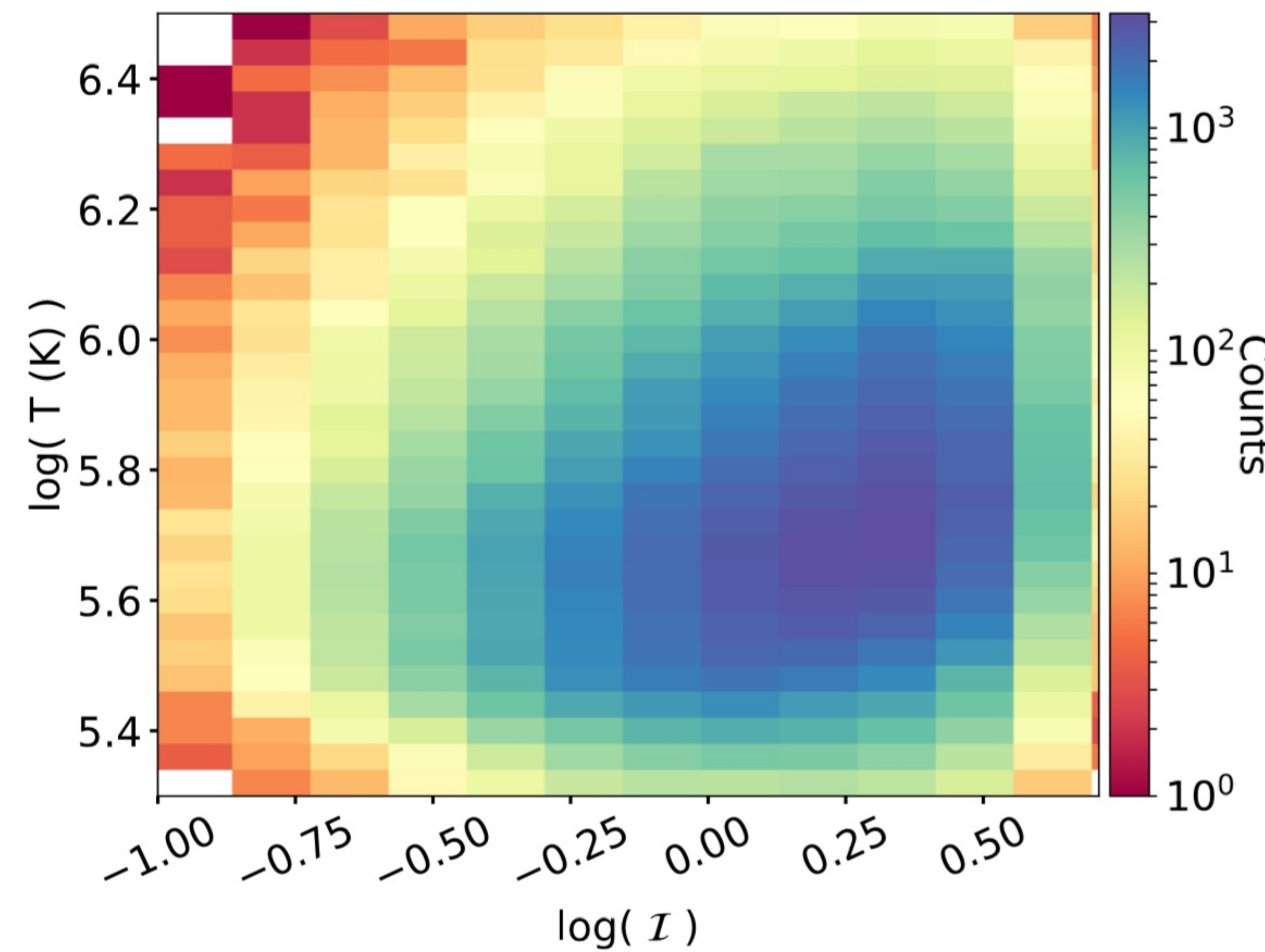
The structures are inhomogeneous and highly intermittent

Some recent studies, both observational and numerical, have shown that these structures are correlated with the regions of enhanced temperature in the plasma
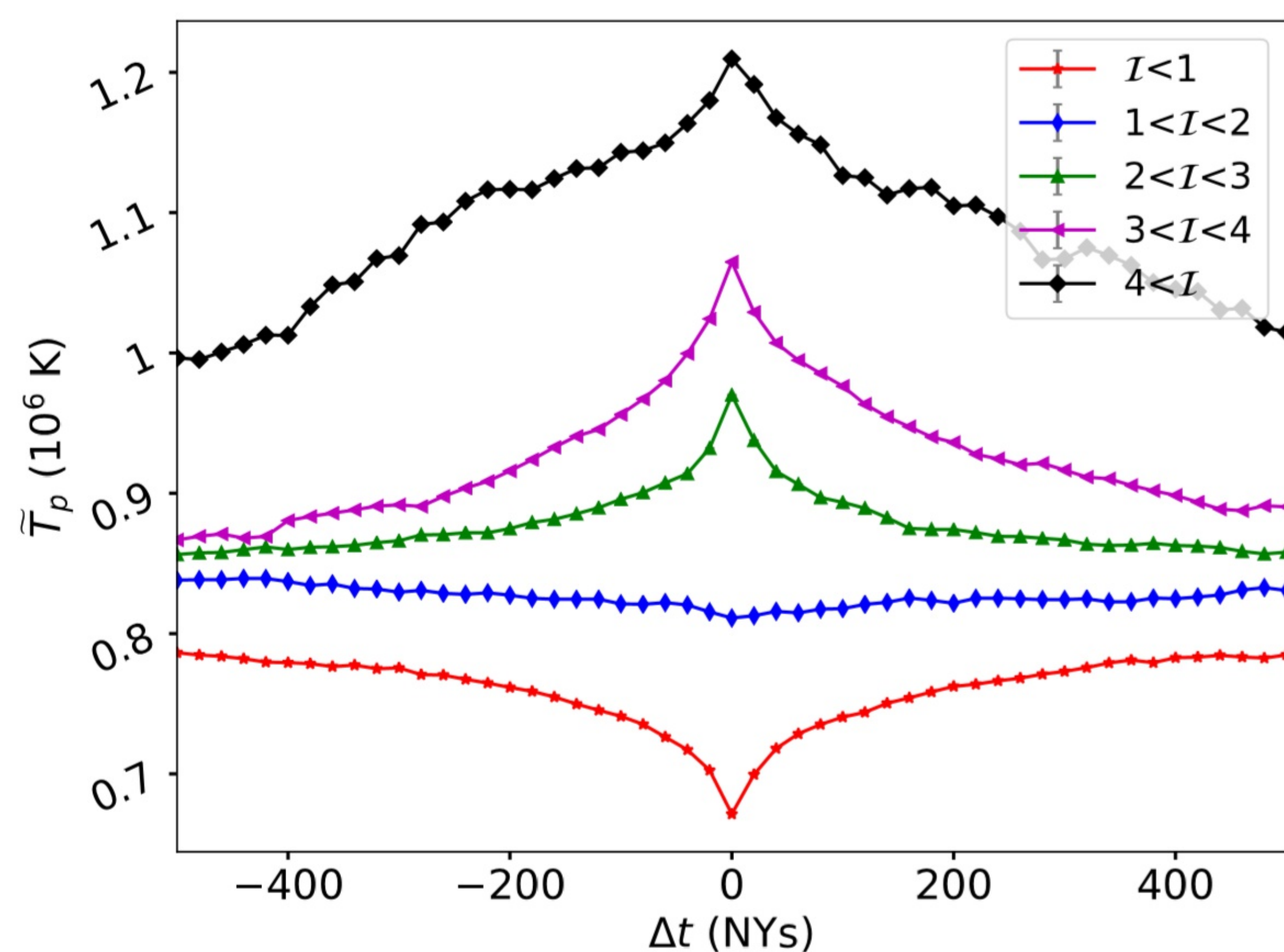
Partial Variance of Increment (PVI) is an unbiased tool to measure these structure/discontinuities.

$$\mathcal{I}(t, \Delta t) = \frac{|\Delta \mathbf{B}(t, \Delta t)|}{\sqrt{\langle |\Delta \mathbf{B}(t, \Delta t)|^2 \rangle}}$$

Results from PSP observation

- Joint histogram between proton radial temperature and PVI in a log-log scale for the second half of first PSP encounter with the Sun

- Majority of data are concentrated in low PVI values

- Increasing PVI color contours have an upward trend

- The positive correlation between temperature and PVI suggest some kind of heating in the regions with high PVI

- Probability distribution of conditionally sampled proton radial temperature

- Data is divided in 6 PVI bins such that each bin contains equal number of data points

- Vertical lines show the median temperature for the respective PVI bin

- PVI bin with higher value has higher median temperature implying some kind of heating in those regions
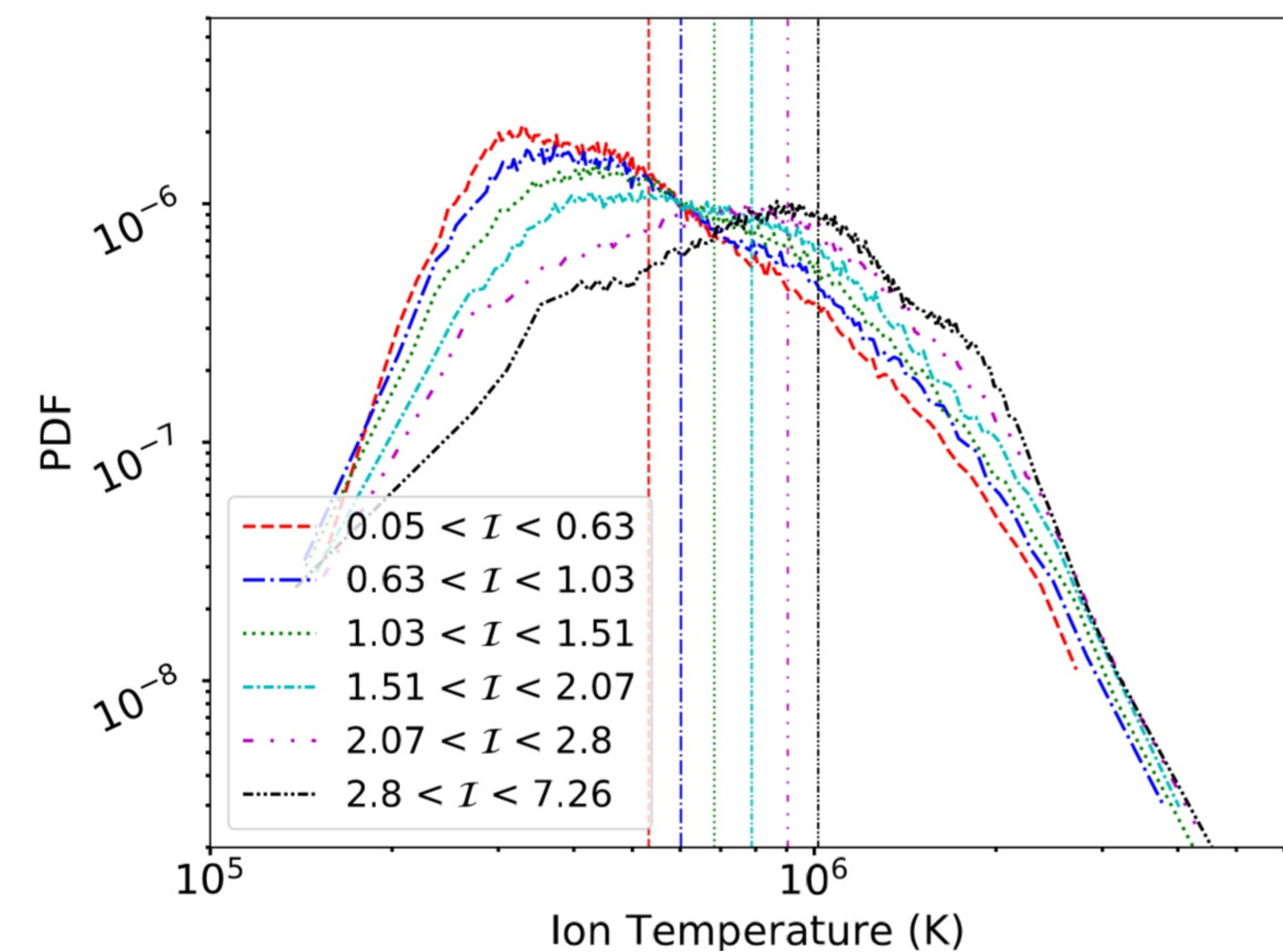
- Conditional average temperature for different PVI thresholds at the point of a PVI event and surrounding region upto one correlation length

$$\widetilde{T}_p(\Delta t, \theta_1, \theta_2) = \langle T_p(t_\mathcal{I} + \Delta t) | \theta_1 \leq \mathcal{I}(t_\mathcal{I}) < \theta_2 \rangle$$

- Average temperature peaks at the instant of PVI event and continues to have elevated temperature in its vicinity within the correlation time scale

- Some of this effect may be due to clustering of PVI events

- Regions with very low PVI (< 1) are colder than the surrounding region

Conclusion and Discussion

- The PDF of data with higher PVI has higher mean temperature compared to those with lower PVI

- For conditionally averaged temperature, the point of PVI event and its vicinity shows enhanced temperature compared to lower PVI events upto one correlation length

- The plateau region of each thresholds are distinct, and for higher threshold they maintain a high value suggesting clustering of PVI events around a large discontinuity

- Since these coherent structures are generated by plasma turbulence, these observations suggest that non-linear turbulence cascade play a crucial role in heating the nascent solar wind

Future Work

- Revisit this work to explore both scalar and anisotropic heating

- Further explore the assymetry in the conditionally averaged temperature profile before and after a PVI event

- Study the distribution of PVI waiting time and its correlation with the presence of linear instability hrowth rates

References and Acknowledgements

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