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Quantifying spatial correlation in the turbulent solar wind flow using mutual information and recurrence plots: simultaneous in-situ spacecraft observations from Wind, ACE and Cluster.

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We test mutual information as a method for quantifying spatial correlation within strongly nonlinear systems for which information is sparse, e.g. observations are available at only two or three points in space. Using Vicsek *et al*'s model for multiple interacting particles, we first show that mutual information between only a few particles is sufficient to determine global dynamical changes such as phase transitions. We then apply these ideas to measurements of the solar wind plasma, which is known to be a high Mach number turbulent flow.

We analyse data from the period 1998 to 2001 when the Wind, ACE and Cluster spacecraft were simultaneously in the solar wind, and explore a range of spatial scales sufficient to determine correlation properties (see for example Matthaeus *et al* PRL **95** 2005). Nonlinear correlation is quantified by calculating the mutual information between measurements of **B**, **v**, and ρ from spatially separated spacecraft. We thereby obtain the relative degree of correlation between different solar wind bulk parameters under various conditions. This study necessitates computing the mutual information between timeseries of different quantities with different sampling rates.