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Data quantile-quantile plots: quantifying the time evolution of space climatology

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The solar wind is inherently variable across a wide range of spatio-temporal scales; embedded in the flow are the signatures of distinct non-linear physical processes from evolving turbulence to the dynamical solar corona. In-situ satellite observations of solar wind magnetic field and velocity are at minute and below time resolution and now extend over several solar cycles. Each solar cycle is unique, and the space climatology challenge is to quantify how solar wind variability changes within, and across, each distinct solar cycle, and how this in turn drives space weather at earth. We will demonstrate a novel statistical method, that of data-data quantile-quantile (DQQ) plots, which quantifies how the underlying statistical distribution of a given observable is changing in time. Importantly this method does not require any assumptions concerning the underlying functional form of the distribution and can identify multi-component behaviour that is changing in time. This can be used to determine when a sub-range of a given observable is undergoing a change in statistical distribution, or where the moments of the distribution only are changing and the functional form of the underlying distribution is not changing in time. The method is quite general; for this application we use data from the WIND satellite to compare the solar wind across the minima and maxima of solar cycles 23 and 24 [1], and how these changes are manifest in parameters that quantify coupling to the earth's magnetosphere.

[1] Tindale, E., and S.C. Chapman (2016), Geophys. Res. Lett., 43(11), doi: 10.1002/2016GL068920.