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The Kp index and solar wind speed relationship:
Insights for improving space weather forecasts

The Kp geomagnetic index forecasts are currently used to predict the aurora, MeV electron fluxes at geosynchronous, spacecraft anomalies, charging events, and times when accurate geological surveys can be performed. These forecasts rely on the upstream solar wind speed since the speed strongly correlates with the Kp index. However, the distribution of Kp and solar wind speed measurements is quite broad. To understand how common certain combinations of Kp and speed are, we examined the percentage of points in 2-dimensional Kp and speed bins using a color scale. Using these color Kp-solar wind speed distributions for compressions, rarefactions, and Interplanetary Coronal Mass Ejections (ICMEs) separately, we find that much of the variability in the Kp-solar wind speed distribution is attributable to the dynamic interaction between the fast and slow wind. We compare three different criteria for identifying compressions and rarefactions, and find that density criteria provide greater separation between compressions and rarefactions than dynamic pressure or speed-time slope criteria. However, the speed-time slope provides enough separation to be useful given that the solar wind speed has a long autocorrelation time, and can be predicted using solar observations (e.g. expansion factor models). To ensure our work can easily be incorporated into forecast models, we provide the Kp-speed distribution files for all three methods of identifying compressions and rarefactions. At critical times when penetrating radiation is present, the ACE real-time stream solar wind speed values can be accurate even though the density and pressure are not. For these times the amount of compression can be estimated from the speed-time slope and combined with our distributions to improve Kp forecasts. We also describe a method to extend forecast lead times by estimating compression strength with a speed-time profile obtained from solar wind speed predictions based on solar, coronal, and/or heliospheric imaging observations. For additional information see Elliott et al., (2013), *Space Weather, 11,* doi:10.1002/swe.20053.
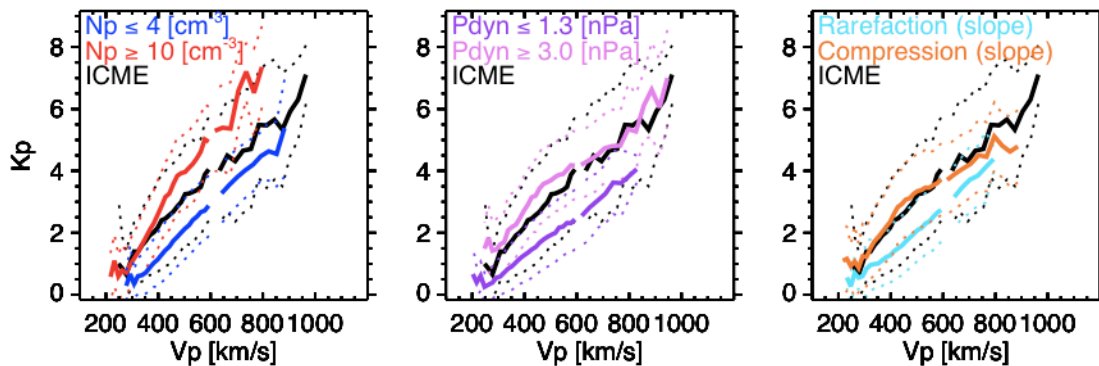

Figure: *The average Kp value for given speed bins (solid) shown for compressions and rarefactions sorted using density (left), dynamic pressure (middle), and speed-time slope (right) criteria. The dashed lines are the average ± one standard deviation for a given bin.*

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