ACE News #146 – December 19, 2011

Dropping Coronal Temperatures in the Protracted Cycle 23-24 Solar Minimum

In ACE News #142 we discussed how the decreasing flux of interplanetary magnetic field lines during the protracted solar minimum could be accounted for by ongoing magnetic reconnection below the Alfven critical point. We suggested that reconnection was ongoing on the quiet Sun at a steady rate over the years when there was remarkably little transient activity evident.

If we take this conclusion to the next step, we can examine the conditions for solar wind acceleration under decreasing interplanetary fields. Since the reconnection below the Alfven critical point reduces not only the interplanetary field, but also the magnetic field pressure in the Sun's lower atmosphere, this leads to a decrease in the height of the Alfven critical point. In short, the solar atmosphere contracts under reduced pressure and this changes the circumstances and boundary conditions for solar wind acceleration.

ACE has been instrumental in establishing the fact that the ionic composition of the solar wind varies with wind speed (see ACE News 26 and 141) and for transients (see ACE News 16, 24, 29, 45, 50, 52, 63, 84 and 124). This indicates that there is a direct correlation between the wind speed and electron temperatures at the source of the acceleration. The recent extended solar minimum provided a unique contradiction to this relation.

Figure 1 (right) shows the average ionic composition for Oxygen and Carbon solar wind ions as a function of time in four bins of wind speed (these four speed bins are shown in different colors) throughout the lifetime of the ACE mission. A fixed correlation between wind speed and ionic composition would provide flat curves (a given speed is associated with a given ionic composition) on these plots. Instead, the ionic composition for a given speed bin changes with time. In fact, the coronal temperature in all speed bins has been steadily dropping in the recent protracted solar minimum. In short, the corona has been cooling as the solar wind flux and magnetic flux have been dropping.

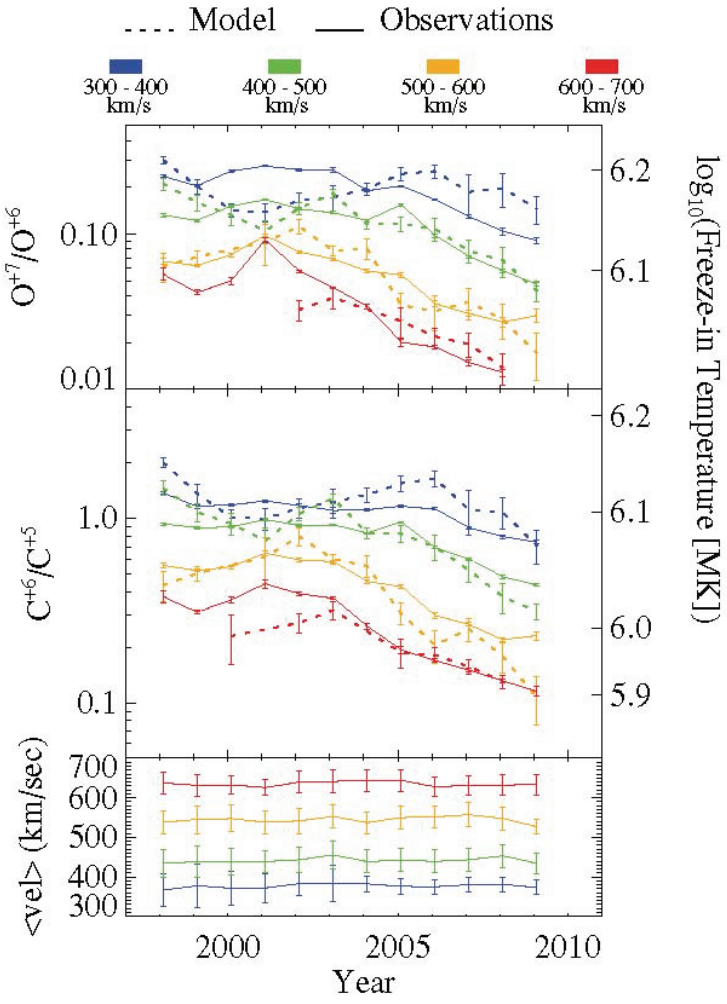

Figure 1: Ionic composition of solar wind broken down according to wind speed as a function of time. Note steady decrease in charge state for fixed wind speeds over the years 2005-09.

In our recent publication, Schwadron et al. (ApJ, 739, 9, 2011) show that the solar wind scaling Law of Schwadron and McComas can account for the observed changes in the solar atmosphere. The observed ongoing magnetic reconnection that leads to a decreased height of the solar atmosphere alters the acceleration conditions so that cooler electrons can be associated with faster wind speeds. Therefore, the observed change in charge state abundances can be traced back to the ongoing magnetic reconnection in the lower solar atmosphere.

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