Effect of ACE Spacecraft Repointing on SWEPAM Calculated Moments

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Valid SWEPAM moments, in particular the proton density and to lesser extent the temperature, became increasingly sparse starting in 2010 as the primary channel electron multiplier (CEM) detectors have aged. This aging is a natural and expected feature of such detectors. Now, 13 years past the original planned mission lifetime, these Ulysses spare detectors do not all provide adequate gain to make good measurements. In response, the ACE science team has developed and implemented, starting Oct 23 2012, an innovative mission operations concept that more frequently repoints the ACE spacecraft's spin axis further away from the Sun. This allows other CEMs, that have received significantly less total fluence and thus still have higher gains, to measure the solar wind. This operational improvement has significantly increased the frequency of good quality SWEPAM observations, back to levels not seen in several years.

Figure 1 shows the change in spacecraft pointing as a function of time for the years 2005 through mid-2014. The black line shows monthly averaged values of the angle between the spacecraft spin axis and the GSE-x axis. The red line shows monthly averaged values of the angle between the spacecraft spin axis and the solar wind velocity vector. The latter is what determines which CEM detector will be impacted by the solar wind, while the former is what can be controlled through spacecraft pointing. In this figure, values aligned with the spin axis appear at an angle of 180 degrees, values 10 degrees from the spin axis are at 170 degrees, and so on. The change in pointing is clearly seen in late 2012.

Figure 2 shows an example of the effect of pointing on the calculated moments. In this figure, from 14 May 2012, the bottom panel shows the SWEPAM CEM detector (numbered 0-11) with maximum counts, and the top 4 panels show the proton density, proton speed, alpha to proton density ratio, and proton temperature calculated from the SWEPAM measurements. In the top panels, Wind/SWE moments are shown in blue for comparison, and white, red, and green points all show SWEPAM moments. At the beginning of the day, the solar wind is primarily impacting the CEMs closest to the spacecraft spin axis (#4-5); it is clear that the density is significantly underestimated at these times. At ~1330 UT, the relative solar wind / spacecraft orientation changes, leading to the solar wind impacting primarily CEMs #7-8. The improvement in the calculated moments from measurements by these higher numbered CEMs is obvious. After ~1330 UT, the proton density and alpha/proton density ratio show reasonable values, in good agreement with Wind/SWE. The proton temperature is less affected, but values are more consistent after 1330 UT. We note that the proton speed calculation is relatively unaffected by the differing CEM gains, with reasonable speeds obtained throughout the day.

Figure 3 shows data from a 30-day period in May-June 2014, following the change in spacecraft pointing. Again, Wind/SWE moments for comparison are shown in blue, with SWEPAM moments shown in white, red, and green. Because of repointing, the solar wind impacts higher-numbered CEM detectors and valid densities and temperatures are calculated throughout nearly the entire period. We note that the SWEPAM energy response which leads to reduced sensitivity at low energies (and thus at times of low solar wind speeds) is not affected by repointing. This reduced sensitivity still leads to underestimated densities at times when the solar wind speed is lowest (May 29 – Jun 3, Jun 24-25, and Jun 27-28).

Valid Level 2 solar wind speeds are obtained >97% of the time over the full ACE mission. Figure 4 shows the monthly averaged fraction of time with valid Level 2 densities through mid-2014. Also shown on the plot is the fraction of time when the solar wind speed is greater than 350 km/s. Following the spacecraft repointing in Oct 2012, the fraction of time with valid density again approximately tracks the time with relatively high solar wind speed.

We thus see that despite the continued weak solar maximum and continued prevalence of low speed solar wind, spacecraft repointing has led to a dramatic improvement in the calculation of solar wind moments as the solar wind impacts different CEM detectors. The SWEPAM team continues to monitor detector gains, and based on current trends we anticipate continued successful operation for the foreseeable future.

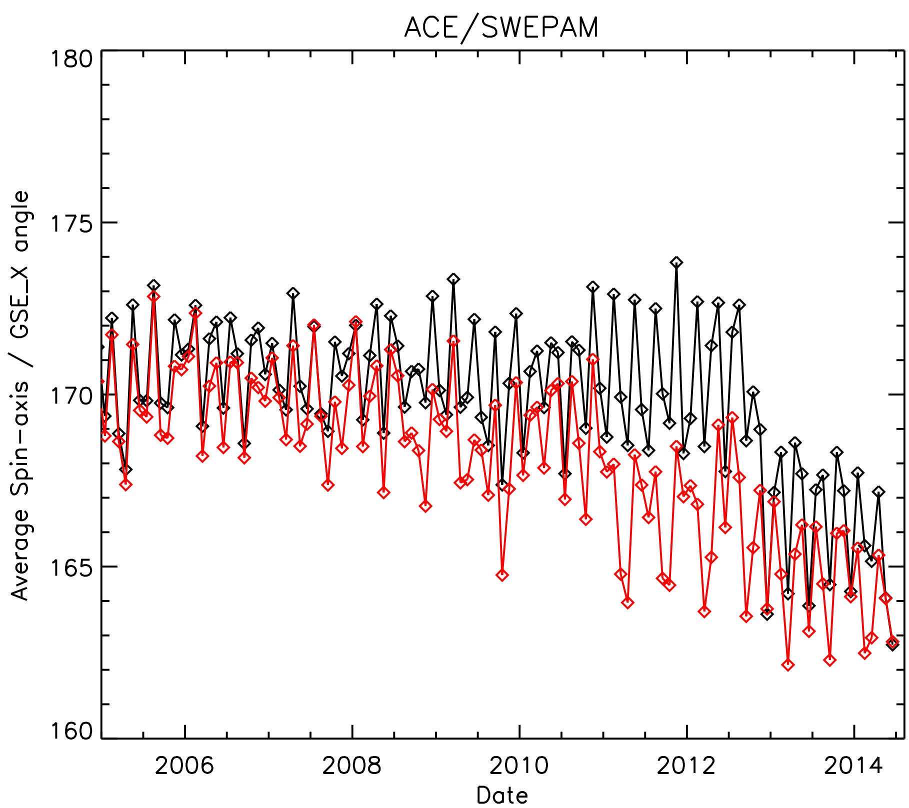

Figure 1. ACE spacecraft spin-axis pointing relative to the GSE X-axis (black) and the solar wind velocity vector (red).

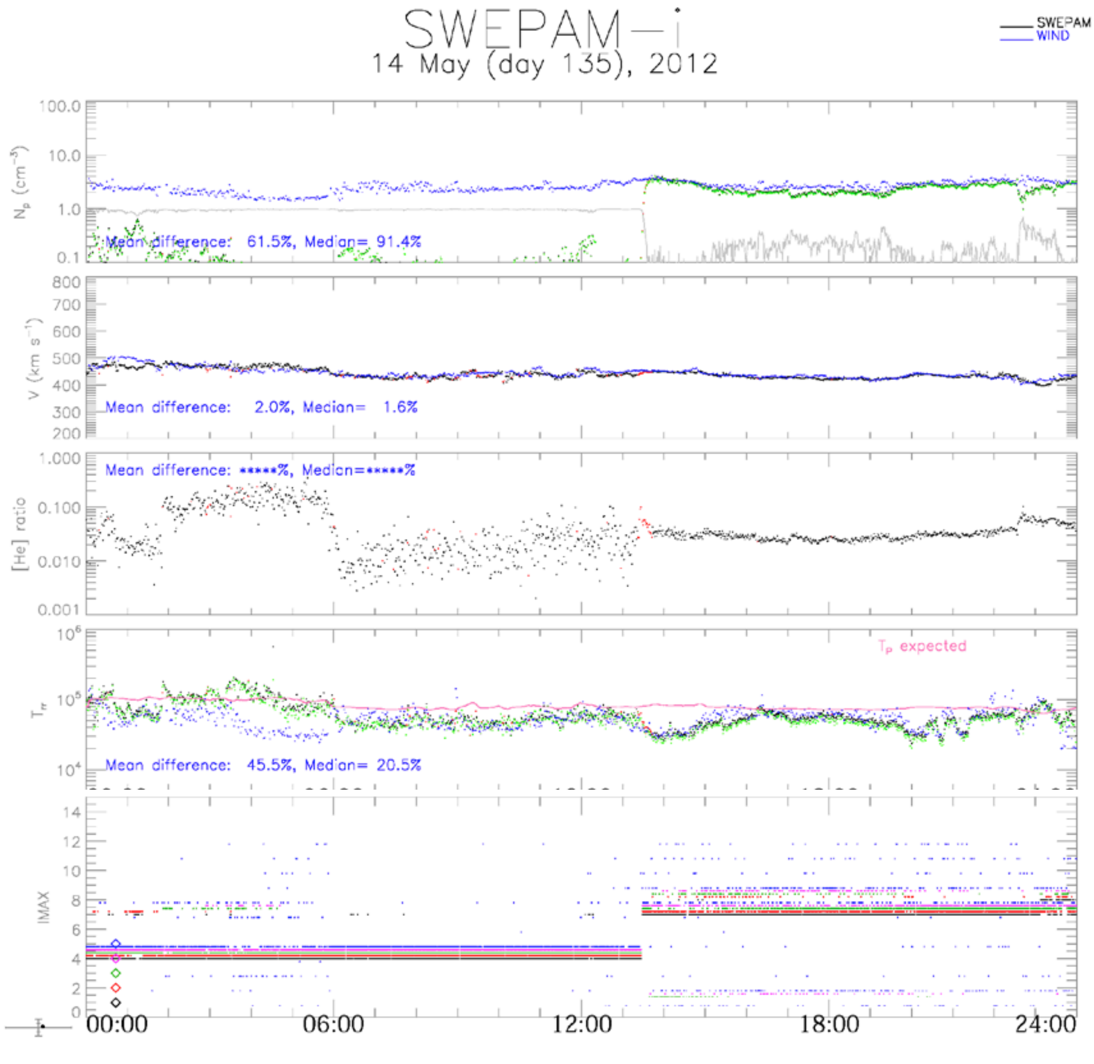

Figure 2. From top to bottom, SWEPAM proton density (cm^{-3}), proton speed (km/s), alpha to proton density ratio, proton temperature (K), and CEM detector (#0-11) with peak counts as a function of time for 14 May 2012. In the top 4 panels, white, red, and green data points all represent SWEPAM data. For comparison, Wind/SWE moments are shown in blue.

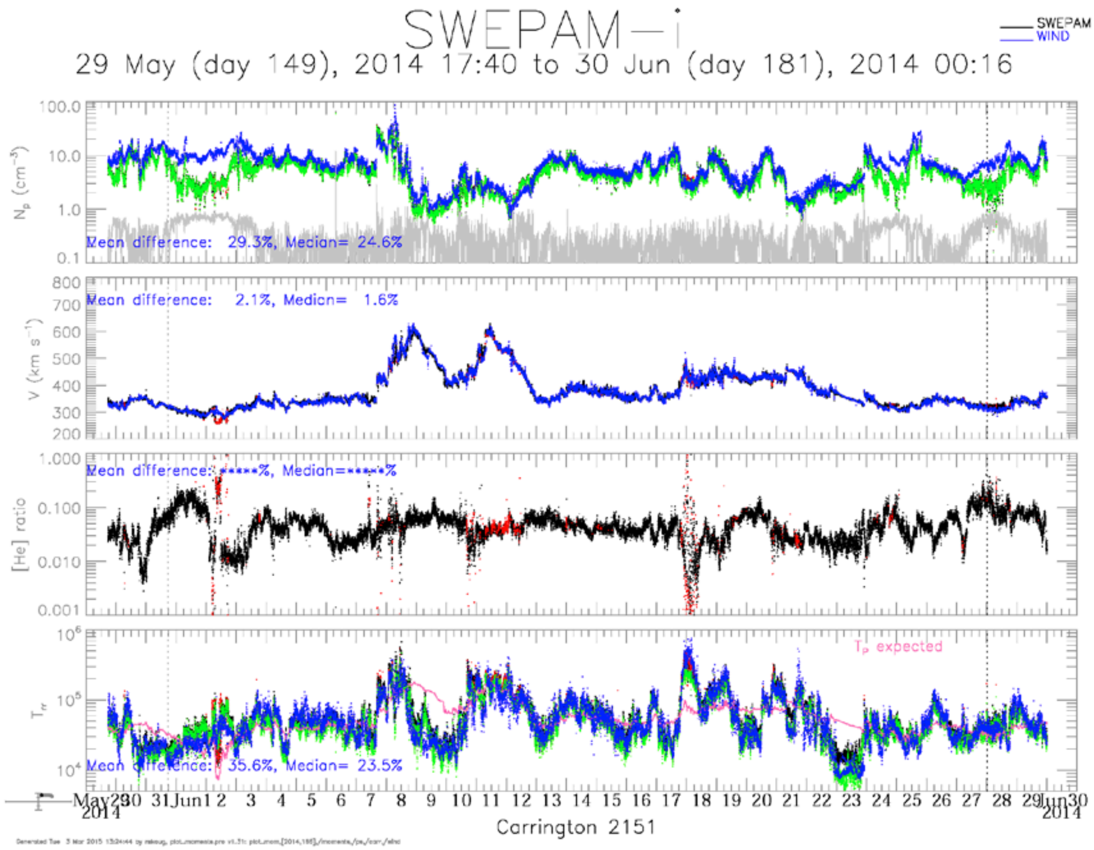

Figure 3. From top to bottom, SWEPAM proton density (cm^{-3}), proton speed (km/s), alpha to proton density ratio, and proton temperature (K) for a 30-day interval in May/June 2014. White, red, and green data points all represent SWEPAM data. For comparison, Wind/SWE moments are shown in blue.

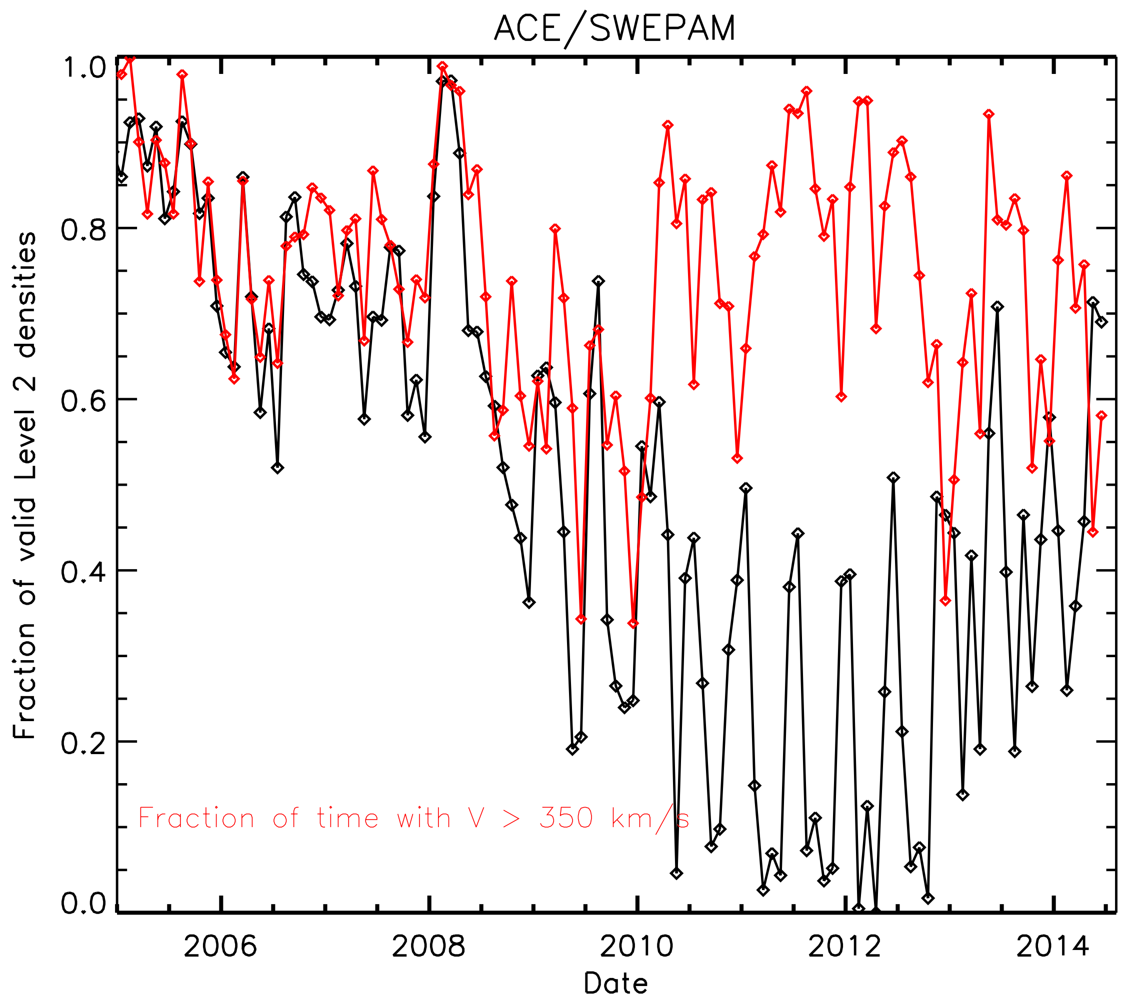

Figure 4. For years 2005 through mid-2014, the monthly averaged fraction of time with valid Level 2 SWEPAM proton density (black), and the monthly averaged fraction of time when the solar wind speed exceeds 350 km/s (red).