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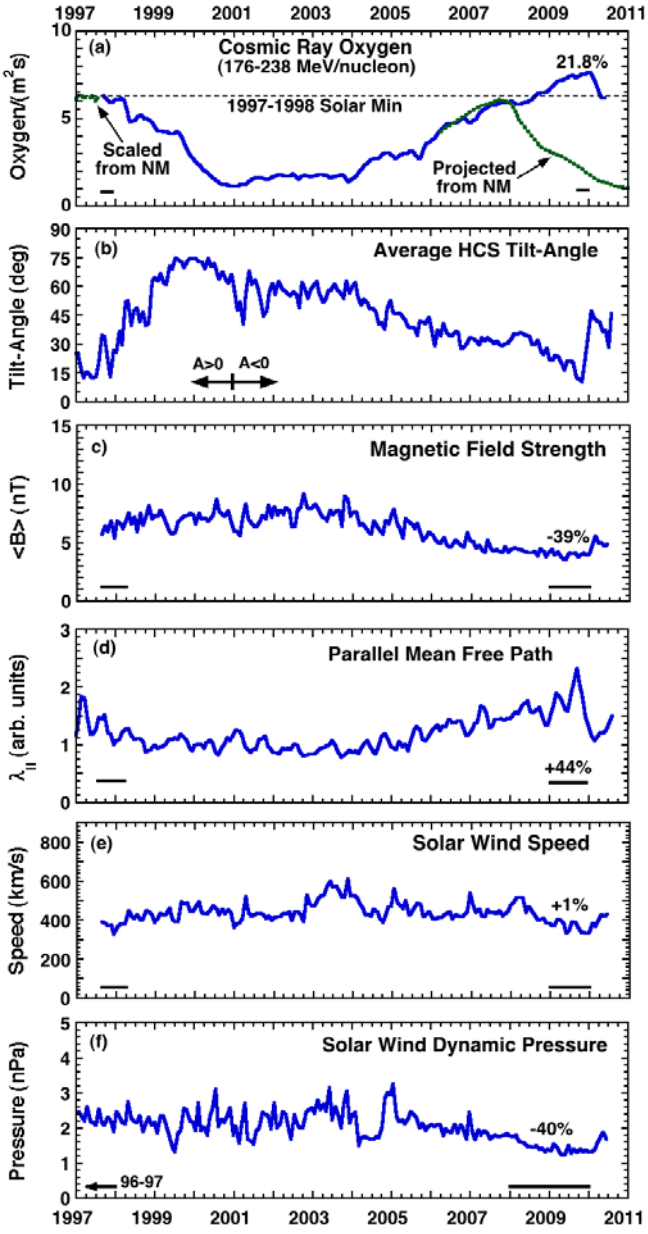
Update on Record-Setting Galactic Cosmic Ray Intensities in 2009-2010

ACE News #122 (4/30/2009) reported that the intensity of galactic cosmic ray (GCR) Fe at ~350 MeV/nuc, was ~12% greater in early 2009 than in 1997-1998 and also greater than ever before in the space age. The measurements were made with the Cosmic Ray Isotope Spectrometer (CRIS) on ACE. As 2009 progressed the GCR intensity continued to increase until approximately New Years Eve, when the intensities of major species from C to Fe were each 20% to 26% greater than in 1997-1998 (e.g., oxygen in Panel (a) at the right). Early in 2010 the intensity decreased to 1997-1998 levels.



The elevated 2009 intensities measured by ACE [and by neutron monitors (NM)] were undoubtedly due to several unusual aspects of the cycle 23/24 solar minimum. During A<0 solar minima (when Sun's north polar field points inward) GCR ions reach 1 AU mainly by drifting in along the Heliospheric Current Sheet (HCS), and their path-length depends inversely on the tilt-angle of the HCS. The HCS tilt-angle [Panel (b)] played a key role in modulating the GCR intensity at 1 AU in 2007-2009 and the maximum intensities followed soon after the minimum tilt-angle within 2-3 months. However, the minimum tilt was less in 1987 (the last A<0 minimum) than in 2009.

More important factors were the record-low interplanetary magnetic field (IMF) strength [Panel (c)] which was 39% lower than in 1997-98 (resulting in correspondingly greater drift velocities), and an extended period of reduced IMF turbulence. The estimated GCR scattering mean-free-path along the IMF [$\lambda_{||}$ -- which scales as $B^{5/3}/(\delta B^2)$; see Panel (d) and Zank et al. JGR 103, 2085, 1998] indicate that $\lambda_{||}$ was ~44% greater in 2009 than in 1997-1998. The reduced scattering and increased drift velocities enabled greater GCR access to the inner heliosphere in 2009.

The solar wind speed in 2009 was similar to that in 1997-1998 [Panel (e)], but the solar-wind dynamic pressure [Panel (f)] was ~40% lower due to a reduced solar-wind density. Although reduced dynamic pressure means that the size of the heliosphere is now shrinking, this probably has a minor effect on cosmic ray intensities at 1 AU because the intensity in the outer heliosphere depends only weakly on radius.

In 2010 the intensities suddenly decreased to 1997 levels following increases in solar activity, the HCS tilt-angle, and the IMF strength, and a decrease in $\lambda_{||}$. Since mid-2010 GCR intensities have been at 1997-1998 solar-minimum levels. Although the 2009 intensities were at a 50-year high level, measurements of ^{10}Be deposited in polar ice cores over the last ~500 years (McCracken et al. Adv. Sp. Res. 34. 397, 2004) indicate that the space era has occurred during a period of very-low GCR intensity. Between the years ~1400 and ~1900 ^{10}Be production was typically ~40% to ~80% greater than in the early 1970s. It is possible that the near-Earth radiation environment is returning to more "normal" conditions. For more information, see the paper by Mewaldt et al. (2010) soon to appear in ApJ Letters.

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