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Integrating the Sun-Earth System (ISES): The 2008-2009 Whole Heliosphere Intervals

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We simulate the Sun-Earth system throughout the extended solar minimum epoch from 2008 to 2009 using coupled geospace, heliosphere and solar numerical models, systematically validating individual model components with databases of observed geospace composition and solar and heliospheric parameters. We isolate and quantify observed changes of 5% to 25% in global ionosphere electron density and 10% to 40% in thermospheric mass density at 250 km associated with fluctuating solar EUV radiation and geomagnetic activity during this nominally "quiet" period. Corresponding modeled changes of responses to both solar EUV radiation and geomagnetic activity are about a factor of two smaller than is observed. We identify, as well, semiannual and annual oscillations that produce geospace variability comparable to solar and geomagnetic influences, and cause distinct differences among the three individual Whole Heliosphere Intervals. From the first Whole Heliosphere Interval (March-April 2008) to the third Whole Heliosphere Interval (June-July 2009) total electron content decreased 37% and mass density at 250 decreased 42% due to these oscillations, which originate partly in the lower atmosphere. Reliable attribution of the geospace base state during the 2008-2009 solar minimum epoch, and geospace comparisons among the Whole Heliosphere Intervals, requires that the semiannual and annual oscillations be properly distinguished from concurrent solar and heliospheric effects.