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# Solar change on timescales of days to millennia: evidence and implications (Julius Bartels Medal Lecture)

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High resolution studies using the EISCAT radars gave a new understanding of how the energy and momentum of the solar wind coupled into Earth's magnetosphere. This coupling is central to understanding geomagnetic variations and historic data could then be used to infer the characteristics of the solar wind and the embedded heliospheric magnetic field. In addition, observations by the Ulysses satellite, showing the latitudinal independence of the radial component of this heliospheric field, allowed the total open solar flux that leaves the top of the solar atmosphere to be evaluated back to 1868. This is a revealing complement to the sunspot data record which tells us about large magnetic flux tubes emerging through the solar surface. The open solar flux influences the propagation of galactic cosmic rays through the heliosphere and, as a result, the abundances of the cosmogenic isotopes (produced when cosmic rays hit the atmosphere and stored in terrestrial reservoirs such as tree trunks and ice sheets) could also be physically interpreted in terms of open solar flux variations. There is now considerable agreement between reconstructions of the heliospheric field based on cosmogenic isotopes, on geomagnetic data, and on models based on sunspot observations. As well as influencing cosmic ray fluxes and the solar wind, these changes in solar magnetic fields influence total and ultraviolet solar electromagnetic emissions and the number and fluence of large solar energetic particle events. Using the cosmogenic isotope record it is possible to make analogue forecasts of the range of future solar variations and these show a considerable probability of the Sun returning to "Maunder minimum" conditions within the next 40-100 years. Some of the implications of these long-term changes in solar outputs for space weather hazards and global and regional/seasonal climates will be discussed.