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On the Possible Solar Cosmic Ray Signal in Cosmogenic Isotope Data

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Cosmogenic nuclides are produced by galactic cosmic rays in the Earth's atmosphere, and the record of cosmogenic isotopes in natural archives serves as a proxy for galactic cosmic ray flux. During strong solar energetic particle events, the flux of energetic particles bombarding the Earth can increase by orders of magnitude. The question whether such strong sporadic events may leave their imprints in cosmogenic isotope records was studied earlier but the conclusions were contradictory. We have performed a detailed numerical study of a possible signal from a strong solar particle event in annual ^{14}C (tree rings) and ^{10}Be (polar ice) data. We have computed the expected production of the isotopes for such strong solar particle events, as 23/02/1956, 29/09/1989. It is shown that the contribution of solar cosmic rays into the globally mixed ^{14}C is negligible on average, and a giant solar flare would produce a few % increase in the annual ^{14}C production rate, which is further greatly attenuated by the global carbon cycle. The effect is stronger for polar ^{10}Be, being about few % on average, and a giant flare can cause an increase of the annual polar ^{10}Be production of about 20 %. Because of the simple and quick transport/precipitation mechanism, such an increase in ^{10}Be can be visible in the ice record. Our conclusion is that strong solar energetic particle events may be visible in the polar ^{10}Be data, that may produce a 5.5-year quasi-periodicity for some solar cycles. However, solar flares/CME are often accompanied with galactic cosmic ray suppressions (Forbush decreases) which would further decrease the estimated effect. We have analyzed the available data on solar cosmic ray flux in the past as well as the statistics of Forbush decreases occurrence, and show that during the modern history of the Sun the cosmogenic isotope production is dominated by galactic cosmic ray modulation, and solar cosmic rays can produce, occasionally, only some additional signals.