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Exploring time-dependent reference-level and atmospheric effects on cosmogenic nuclide production-rate scaling

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Investigations of time-dependent effects on in situ cosmogenic nuclide production-rate scaling predictions have focused largely on spatial and temporal variations in the geomagnetic field, and to a lesser extent on solar modulation (e.g., Lifton, 2016. EPSL 433, 257–268). While production-rate scaling models should indeed account for such effects, the magnitudes of these dominantly latitudinal variations are typically limited to less than about a factor of 2 from pole to equator at sea level.

On the other hand, the approximately exponential dependence of the cosmic-ray flux on atmospheric shielding wields a much larger influence on cosmogenic nuclide production rate scaling. As such, it's worth exploring how assumptions about atmospheric structure on which existing scaling models are based may affect those models' predictions. For example, sea-level pressure and temperature conditions typically used in scaling models (e.g., ERA-40 Reanalysis) are not primary measurements, but rather are extrapolated to sea level from measured or modeled pressure and temperature variations at given pressure levels assuming a particular atmospheric lapse-rate structure. Basing altitudinal scaling instead on surface pressure and temperature values, in concert with local re-analysis-derived lapse rates, yields generally comparable results to those using a sea-level basis, but with significant differences in high-altitude areas. Furthermore, while current scaling models assume that modern atmospheric configurations are constant through time, past climate changes undoubtedly affected both sea level and circulation patterns, with potential implications for cosmogenic nuclide production. Scaling effects of time-dependent sea-level (ICE-6G; Peltier et al., 2015. JGR Solid Earth 120, 450-487) and atmospheric models (SynTraCE-21; Liu et al., 2009. Science 325, 310–314) will be explored, and may contribute to improved understanding of long-term production rate variations.