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A model-based evaluation of sedimentary reconstructions of 10Be production rates

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Atmospheric production of 10Be is small when solar activity and, therefore, solar magnetic field and total solar irradiance are strong. Variations in solar activity affect climate and the production of other climate-relevant isotopes, such as 14C. Solar activity is thus an important variable to constrain. Since 10Be production is clearly related to solar activity and the cycle of beryllium is simpler than that of carbon, 10Be records in ice cores have been used to reconstruct total solar irradiance variability. Unfortunately, 10Be records in ice cores are not only affected by variations in atmospheric production, but are also modulated by changes in wind patterns since spatiotemporal atmospheric 10Be gradients are quite large. In that context, sedimentary 10Be records from the abyssal ocean could be of great interest: since the residence time of 10Be in the ocean is thought to be comparable to the overturning time-scale of the ocean, spatial 10Be gradients may be relatively weaker than those in the atmosphere. Under these conditions, regional oceanic variability should only weakly affect the distribution of 10Be in the ocean and local sedimentary 10Be records are expected to represent the global average 10Be production better than 10Be measured in ice cores.

We here show results from a global ocean model of 10Be that we use to investigate the spatial variability of simulated sedimentary 10Be records and test the sensitivity of the 10Be sedimentary flux to uncertainties in the circulation field and in the particle chemistry of beryllium. Our ocean model is based on the Transport Matrix method. The surface 10Be input fluxes are taken from atmospheric model simulations. Our model experiments, constrained by available dissolved 10Be data, show that there exist regions in the ocean where the sedimentary 10Be flux is relatively insensitive to changes in input patterns and magnitudes, assumed particle chemistry and flux patterns, and ocean circulation. We submit that sediments records from specific regions, typically located near the centers of oligotrophic gyres, could in principle be used to produce an accurate reconstruction of atmospheric 10Be production and thus total solar irradiance. Away from these specific regions, however, our model results indicate that sedimentary records could produce reconstructions that could be even more inaccurate than those from ice cores. While our detailed results depend on assumptions about the flux of marine particles and their scavenging behavior, our qualitative conclusions hold over a wide range of parameters. Our ability to better constrain the model is limited by the scarcity of available dissolved 10Be observations. Additional measurements and experiments targeted to constrain the adsorption behavior of Be in seawater would help constrain the model further and yield an improved understanding of the marine Be cycle.