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Impact of glacial isostatic adjustment on ice sheet reconstructions

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Past changes in the extent of large ice masses are reconstructed using the geochronological approach of cosmogenic-nuclide surface-exposure dating. Calculating surface-exposure ages is critically dependent on a knowledge of the altitude of the sample site. Changes in altitude have occurred through time as a result of glacial isostatic adjustment (GIA), potentially altering local nuclide production rates and, therefore, surface-exposure ages. Here we assess the impact of GIA on surface-exposure dating by calculating global time-dependent production rates since the Last Glacial Maximum using surface elevations that were corrected and uncorrected for GIA. We find that the magnitude of the GIA effect is spatially and temporally variable. Nuclide production could be reduced by up to 50% in the interior of large ice masses (in North America, Scandinavia and West Antarctica) at times of maximum glacial isostatic depression. Although smaller, the effect is still significant at ice sheet margins, where nuclide production is reduced by >5% and potentially >10%, making exposure ages older in those areas. Away from the ice sheet margins, land surfaces may have been isostatically elevated during the Last Glacial Maximum, which can increase nuclide production by >5% and, therefore, make exposure ages younger. Areas that were more recently exposed or that are distal to large ice masses will generally be less affected. Applying a GIA correction to surface-exposure data may help resolve mismatches between some chronologies, but not necessarily in all regions, implying that additional factors may need to be considered. Past atmospheric changes could amplify or reduce the impact of GIA on nuclide production, and the combined effects should be fully accounted for in the future. These time-dependent influences on surface-exposure dating have potentially large implications for interpreting chronologies and for using the data to constrain ice sheet models.