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Redating the Global Abrupt Sea-Level Rise during Meltwater Pulse-1A and Implications for Global Ice Mass Loss

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Model-based projections of ice-sheet thresholds and global sea-level rise are severely constrained by instrumental observations being only decadal to century-long. As we improve our understanding of these processes, projections just a few years old are now considered conservative, raising concerns about our ability to successfully plan for abrupt future change. Past periods of abrupt and extreme warming offer 'process analogues' that can provide new insights into the future rate of response of polar ice sheets to warming of the Earth system. The Last Termination (20,000-10,000 years ago or 20-10 ka BP) in the North Atlantic region was characterised by a series of abrupt climatic changes including rapid warming at 14.7 ka BP (the start of the "Bølling", or GI-1 in the Greenland ice-core isotope stratigraphy) which was accompanied by an Antarctic Cold Reversal (ACR) in the south. Potentially important, during the onset of GI-1, warming persisted in the south for some 256±133 calendar years before the ACR, providing a period of time during which both polar regions experienced increasing temperatures. Sometime around the onset of GI-1 and the ACR, Meltwater Pulse 1A (MWP-1A) formed an abrupt sea level rise of ~15 metres, and was coincident with a period of enhanced iceberg flux in the Southern Ocean. It seems likely the majority of the sea level rise came from the Northern Hemisphere – up to 5-6 metres from the Laurentide Ice Sheet – though the timing remains uncertain. The contribution of Antarctic Ice Sheets (AIS) to global mean sea level (GMSL) rise during MWP-1A range from 'high-end' scenarios (>10 m contributing over half of the total GMSL rise), to 'low-end' (scenarios with little to no contribution). Here we report the results of a multidisciplinary study, with refined age and Antarctic ice-sheet modelling of the MWP-1A sea-level rise. With the recently released international radiocarbon calibration curve (IntCal20), our Bayesian age modelling of terrestrial ages from flooded mangrove swamps suggests global sea level rose across a mean age range of 14.58 ka BP to 14.42 ka BP, with a mean rate of sea-level rise of 0.94 metres

per decade (14.97 metres over 160 years). Because the calibrated age range at 95% confidence overlaps in this age model, it is possible the 15 metre rise during MWP1A could have taken place essentially instantaneously. Even the most conservative age modelling we have undertaken indicates an extraordinary rapid rate of sea-level rise; two orders of magnitude larger than the mean rate of global sea level rise since 1993 (0.03±0.003 metres per decade). Our ice-sheet modelling suggests a substantial and rapid loss of Antarctic ice mass (mostly from the Weddell Sea Embayment and the Antarctic Peninsula), synchronous with warming and ice loss in the North Atlantic. The drivers and mechanisms of the observed near-synchronous interhemispheric changes will be discussed, with implications for the future.