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Rapid propagation of deglacial precipitation changes to turbidite systems on the Chile continental slope

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Understanding how Earth surface processes respond to past climatic perturbations is crucial for making informed predictions about future impacts of climate change on sediment fluxes. Beyond the instrumental record, sedimentary records provide the necessary archives for inferring these processes. Yet, their interpretation is compromised by our incomplete understanding of the sediment routing system whose response to high-frequency, millennial-scale cycles is strongly debated. Key questions include if, how, and how fast climatic signals propagate through a sediment routing system. Furthermore, it is still unclear how perturbations are manifested in the ultimate sinks of such complex sedimentary systems.

In this study, we analyzed eight sediment cores recovered from marine turbidite depositional sites along the Chile continental margin. The sites span a pronounced arid-to-humid gradient with distinct geomorphic characteristics (e.g., onshore gradient, shelf width), which allowed us to study event-related depositional processes during the Last Glacial Maximum to present in different geomorphic and climatic settings. The turbidite record was quantified in terms of turbidite thickness and frequency between 25 ka cal BP to present.

Our results indicate that the three study areas show a steep decline of turbidite deposition during deglaciation: between 19-16.5 ka cal BP in the arid and semiarid study area and around 16-15.5 ka cal BP in the humid study site. Sea-level rise significantly lags the decline in turbidite deposition by 3-6.5 kyrs. However, comparison to paleoclimate proxies obtained in the same region shows that this spatio-temporal sedimentary pattern follows the postglacial southward migration of the Southern Hemisphere Westerly Winds and related pronounced precipitation decline. The turbidite record shows little to no lag times when compared to precipitation proxies, such as sea surface temperatures, pollen records, clay mineralogy and grain size of hemipelagic sediment. Lower magnitude precipitation changes due to changes of the position and strength of the Southern Hemisphere Westerly Winds during the Holocene, however, are not resolved in the turbidite records.

The terrestrial sediment routing system has often been described as a “jerky conveyor belt” that generates significant lag times between erosion and sedimentation, and shreds climatic signals. However, our results suggest that major changes during the transition from glacial to interglacial climates propagate rapidly through the tested sediment routing systems and are manifested in the sedimentary record on the continental slope. Hence, we conclude that turbiditic strata can act as reliable recorders of climate change, indicating related changes in sediment supply, and fluvial transport capacity across a wide range of climatic zones and geomorphic conditions.