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Ocean carbon inventory under warmer climate conditions – the case of the Last Interglacial

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During the Last Interglacial period (LIG), the transition from 125 to 115 ka provides a case study for assessing the response of the carbon system to high-latitude warming. Elucidating the mechanisms responsible for interglacial changes in the ocean carbon inventory provides constraints on natural carbon sources and sinks and their climate sensitivity, which are essential for assessing potential future changes. However, the mechanisms leading to modifications of the ocean's carbon budget during this period remain poorly documented and not well understood. Using a state-of-the-art Earth system model, we analyze the changes in oceanic carbon dynamics by comparing two quasi-equilibrium states: the early, warm Eemian (125 ka) and the cooler, late Eemian (115 ka). We find considerably reduced ocean dissolved inorganic carbon (DIC; −314.1 PgC) storage in the warm climate state at 125 ka as compared to 115 ka, mainly attributed to changes in the biological pump and ocean DIC disequilibrium components. The biological pump is mainly driven by changes in interior ocean ventilation timescales, but the processes controlling the changes in ocean DIC disequilibrium remain difficult to assess and seem more regionally affected. While the Atlantic bottom-water disequilibrium is affected by the reorganization of sea-ice-induced southern-sourced water (SSW) and northern-sourced water (NSW), the upper-layer changes remain challenging to discern. Due to its large size, the Pacific accounts for the largest DIC loss, approximately 57% of the global decrease. This is largely associated with better ventilation of the interior Pacific water mass. However, the largest simulated DIC differences per unit volume are found in the SSWs of the Atlantic. Our study shows that the deep-water geometry and ventilation in the South Atlantic are altered between the two climate states where warmer climatic conditions cause SSWs to retreat southward and NSWs to extent further south. This process is mainly responsible for the simulated DIC reduction by restricting the extent of DIC-rich SSW, thereby reducing the storage of biological remineralized carbon at depth.