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Tryptophan fluorescence in snow as a potential proxy for Antarctic Bottom Water production in the Weddell Sea, Antarctica

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The formation of Antarctic Bottom Water (AABW) within the Weddell Sea Embayment (WSE) plays a major role in the Southern Ocean circulation and its interaction with the global climate system. Increasing importance is attributed to AABW in moderating the Earth's heat and carbon flux. However, historic trends in AABW formation are not well understood across multi-decadal and centennial timescales due to a scarcity of observational data. This study examines the potential for a novel biomarker proxy to reconstruct past trends in AABW production by analysing the fluorescence dissolved organic matter (fDOM) signal in a 16.65m snow/firn core from Patriot Hills, within the Ellsworth Mountains, south of the WSE. The analysis used a novel combination of both fluorescence spectroscopy and liquid chromatography (LC-OCD) to reconstruct contemporary variability in biomarker signals contained within the ice. Stable isotopes provide a seasonally resolved chronology extending from extraction in 2015 to 1974 $\pm$ 1 year. Parallel factor analysis (PARAFAC) paired with fluorescence spectroscopy resolves a clear tryptophan-like signal within the core, peaking during the Weddell Polynya of 1974-1976. Imaging Flow Cytometry (ImageStream$^{®}$) conducted on separate samples from the Patriot Hills site supports the tryptophan signal as being marine in origin, identifying unambiguously the presence of three marine components; pico-plankton, nano-plankton and chitin, confirming our interpretation of a marine source for the fDOM signal. Spatial field analysis with reanalysis products indicates a negative correlation between the tryptophan-like component and sea ice concentration in the Weddell Sea. These results represent the first possible detection of the Weddell Polynya using a proxy, and suggest substantial potential for the use of the tryptophan proxy in reconstructing past trends in AABW formation in the WSE. Future work will focus on investigating this biomarker signal across the Holocene, providing insight into AABW dynamics beyond the observational record.