Sea ice and biological production variability reconstructed in the Adélie Basin, East Antarctica, during the late Holocene

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Antarctic sea ice impacts on the ocean-atmosphere heat and gas fluxes, the formation of deep and intermediate waters, the nutrient distribution and primary productivity, the so-called 'biological carbon pump', one of the most active in the global ocean. In this study, we explore the link between sea ice dynamic and biological production during the late Holocene (the last 2,000 yrs) in the Adélie Basin, East Antarctica, from the well-dated sediments of the Ocean Drilling Program (ODP) Site U1357. This archive, composed from ~32 meters of seasonal to annual laminated diatomaceous sequences, allows reconstructions at an unprecedented time resolution (5-10 yrs). Our study combines records of diatom census counts and diatom-specific biomarkers (a ratio (D/T) of di- and tri-unsaturated Highly Branched Isoprenoid lipids (HBI)) as indicators of sea ice and biological production changes.

The diatom and HBI records reveal five distinct phases. From 0 to 350 yrs AD, decreasing occurrences of sea ice-related diatom species (e.g. *Fragilariopsis curta* + *F. cylindrus*) together with low D/T values and increasing open ocean diatom species (large centrics, *Chaetoceros* Resting Spores (CRS)) document a progressive decline of sea ice presence during the year (> 9 months per year) with spring melting occurring earlier in the year and autumn sea ice formation appearing later. In contrast, between 350 and 750 yrs AD, high production of open ocean diatom species and low low D/T values and sea ice related species indicate a short duration of sea ice cover (< ~8 months per year). From 750 to 1400 yrs AD, a prolonged seasonal sea ice (> ~10 months per year) is illustrated by a pronounced increase of sea ice-associated diatom species and high D/T values. Between ~1400 and 1850 yrs AD, seasonal sea ice strongly declines (<~7 months per year) as a result of early spring melting (increasing CRS production) and late autumn waxing (high occurrences of *Thalassiosira antarctica*). Longer growing seasons promoted a substantial development of phytoplankton communities (especially large centric diatoms) that conducted to lower D/T values.

Based on these results, we find that sea ice dynamic and associated diatom production in the Adélie Basin revealed an opposite climatic trend than that identified in the Northern Hemisphere for the last 2000 years. The 'Little Ice Age' (1400-1850 yrs AD) or the 'Dark Ages' (400-750 yrs AD) corresponded to warmer climate conditions in the Adélie Basin, while the 'Roman Warm Period' (0-350 yrs AD) or the 'Medieval Warm Period' (900-1200 yrs AD) were associated to colder conditions. We therefore emphasize that Northern and Southern Hemisphere climate evolved in anti-phase seesaw pattern during the late Holocene.