**Supporting Information for:**

**Sea ice-ocean coupling during Heinrich Stadials in the Atlantic-Arctic gateway**

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**Correlation with published sea-ice records**

Core HH15-1252PC was tuned to the GICC05modelext timescale b2k (1). To allow comparison between our sea-ice biomarker record and other records in the Nordic Seas, we correlated core HH15-1252PC to other cores (Table S1) using the planktic foraminiferal δ18O maxima and minima (Fig. S4B and Fig. S5B), when their chronology was originally based on radiocarbon dating. With cores that were tuned to NGRIP, we used their originally published age-depth model (Table S1).

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Description automatically generatedFig. S1. Temporal variability of benthic foraminiferal species distribution and sea ice data from core HH15-1252PC. (A)** NGRIP ice-core δ18O on the GICC05modelext b2k timescale (2–4), which was used to build the age-depth model for core HH15-1252PC (1). **(B)** IP25 normalized against total organic carbon (dark curve) and sediment weight (light curve). **(C)** Ice rafted debris grain-size ratio (150–500 μm/ >500 μm) calculated following Jessen et al. (5); values >1 indicate iceberg rafted debris and <1 indicate sea-ice rafted debris. **(D)** HBI III normalized against total organic carbon (dark curve) and sediment weight (light curve). **(E)** Relative abundance of benthic foraminifera *Stainforthia* spp. and *Nonionella* spp. (1). **(F)** Relative spring sea-ice concentration (SpSIC). Shaded areas show results from the classification tree, categorizing sea ice into extensive (>50%; green), intermediate (10–50%; orange) and marginal (<10%; red). **(G)** Relative abundance of benthic foraminifera *Cassidulina neoteretis* (1)*.* **(H)** Reconstructed bottom water temperature (BWT) and its uncertainty interval (red shading) (1). Dark gray shadings mark Heinrich Stadial (HS), with darker grade shades indicating the late stage of HSs when BWT and SpSIC drop. Light gray shadings indicate Greenland Stadial (GS) (1).

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A screenshot of a computer screen

Description automatically generated with low confidenceFig. S3. Stacks of all Heinrich Stadial (HS) in core HH15-1252PC showing normalized bottom water temperature (BWT) and sea-ice variability in time. Stacks including HS 6 to 1 (A, B, C) and stacks including HS 6, HS 5, HS 2, HS 1 (D, E, F). Stacking was done setting time 0 at the mid-point of an abrupt BWT drop during HS (see Material and Methods).

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**Fig. S4. Compilation of PIP25 data from the south-east Nordic Seas and spring sea-ice concentration (SpSIC) in the northern Nordic Seas.**(**A**) NGRIP ice-core δ18O on the GICC05modelext b2k timescale (2–4). (**B**) Planktic foraminiferal δ18O (δ18ONps) of the different cores. (**C**) SpSIC of core HH15-1252PC. (**D–G**) PIP25recorded in cores from literature and used in discussion (see Table S1). (**J**) Reconstructed bottom water temperature (BWT) and its uncertainty interval (red shading) (1). Dark gray shadings mark Heinrich Stadial (HS), with darker grade shades indicating the late stage of HSs when BWT and SpSIC drop. Light gray shadings indicate Greenland Stadial (GS) (1). All data is presented on the GICC05modelext b2k timescale (2) (see Supporting Text S1).

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Description automatically generatedFig. S5. Compilation of IP25 data from the south-east Nordic Seas to the Yermak Plateau.** (**A**) NGRIP ice-core δ18O on the GICC05modelext b2k timescale (2–4). (**B**) Planktic foraminiferal δ18O (δ18ONps) of the different cores (**C–I**) IP25 recorded in cores from the literature and used in the discussion (see Table S1). (**J**) Reconstructed bottom water temperature (BWT) and its uncertainty interval (red shading) (1). Dark gray shadings mark Heinrich Stadial (HS), with darker grade shades indicating the late stage of HSs when BWT and SpSIC drop. Light gray shadings indicate Greenland Stadial (GS) (1). All data is presented on the GICC05modelext b2k timescale (2) (see Supporting Text S1).

Table S1. References for sea-ice biomarkers and planktic foraminiferal δ18O data from the south-east Nordic Seas to the Yermak Plateau used in the discussion. Planktic foraminiferal δ18O was used to correlate the records if needed (see Supporting text 1).

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Core** | **Area** | **Time period (ky BP)** | **Type of data** | **Lat/Long** | **Reference** | **Dataset** | |
| **Biomarker** | **Planktic isotopes** |
| MD99-2284 | S Norwegian Sea (S Nordic Seas) | 32-41 | Brassicasterol, IP25 | 62.374667N  0.980167W | Sadatzki et al., 2019 (6) | Sadatzki et al. 2020 – suppl. Material (7) | Dokken et al., 2013 (8) |
| JM11-FI-19PC | S Norwegian Sea (S Nordic Seas) | 0-90 | Brassicasterol, Dinosterol, PBIP25, PDIP25, IP25 | 62.832830N  3.867170W | Hoff et al., 2016 (9)  Ezat et al., 2014 (10) | <https://doi.pangaea.de/10.1594/PANGAEA.859992> | <https://doi.pangaea.de/10.1594/PANGAEA.859992> |
| MD95-2010 | Central Norwegian Sea (S Nordic Seas) | 32-41 | Brassicasterol, HBI III, IP25 | 66.68N  4.57E | Sadatzki et al., 2020 (7) | Sadatzki et al. 2020 – suppl. Material (7) | <https://doi.org/10.1594/PANGAEA.61471> |
| GS14-190-01PC | SW Barents Sea (slope) | 16-27 | IP25 | 71.4755N  16.1650E | Knies et al., 2018 (11) | Knies et al., 2018 – suppl. material (11) | Knies et al., 2018 – suppl. material (11) |
| MSM5/5-712-2 | W Svalbard margin | 11-30 | Brassicasterol, PBIP25, PDIP25, IP25 | 78.915662N  6.767167E | Müller and Stein, 2014 (12) | <https://doi.pangaea.de/10.1594/PANGAEA.833668> | Zamelczyk et al., 2014 (13) |
| HH15-1252PC | W Svalbard margin | 13-64 | HBI III, IP25, SpSIC, HBI T25 | 79.041517N  6.887283E | This study | This study | <https://doi.org/10.1594/PANGAEA.925428> |
| PS93/006-1 | NW Barents Sea | 0-190 | IP25 | 79.203670N  4.668830E | Kremer et al., 2018 (14) | <https://doi.pangaea.de/10.1594/PANGAEA.884797> | Not correlated |
| PS92/039-2 | Yermak Plateau/Sofia Basin | 0-160 | Brassicasterol, HBI III, IP25 | 81.949830N  13.828330E | Kremer et al., 2018 (14) | <https://doi.pangaea.de/10.1594/PANGAEA.884792> | Not correlated |
| PS2837-5 | Yermak Plateau/Fram Strait | 0-30 | Brassicasterol, HBI III, IP25 | 81.233333N  2.381667E | Müller et al., 2009 (15) | <https://doi.org/10.1594/PANGAEA.728973> | <https://doi.org/10.1594/PANGAEA.107125> |

Table S2. Relative succession of events during stadials and at their transition with interstadials in the eastern Nordic Seas.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  |  | **Relative timing of events** | | | | **References** |
|  |  | **Early stadial** | **Mid/Late stadial** | **Late/End stadial** | **Early interstadial** |
| **NE Nordic Seas** | BWT | **↗** | **↘** | **-** | **-** | (1, 12, 16–19) |
| SST | **↘** |  | (**↗**?) | **↗** |
| Sea-ice cover | **↗** | **↘** | **-** |  |
| Ice-sheet retreat/Freshwater input |  |  | **↗ \*** | **↗ \*** |
| Atmospheric temperature | **- - -** | **- - -** | **- - -** | **+** |
| **Central Nordic Seas (E Norwegian Sea, Vøring Plateau)** | BWT | **?** | | | | (7, 17, 20–23) |
| SST | **↘** |  |  | **↗** |
| Sea-ice cover | **↗ \*\*** |  | **↘ \*\*** | **-** |
| Ice-sheet retreat/Freshwater input |  | **↗ \*** | **↗ \*** |  |
| Atmospheric temperature | **- -** | **- -** | **- -** | **+ +** |
| **SE Nordic Seas** | BWT | **↗** |  | **↘** | **-** | (6, 9, 10, 24–27) |
| SST | **↘** |  |  | **↗** |
| Sea-ice cover | **↗** | **↘** | **-** |  |
| Ice-sheet retreat/Freshwater input | **↗ \*** | **↗ \*** |  |  |
| Atmospheric temperature | **-** | **-** | **-** | **+ + +** |

↗ = increase; ↘ = decrease; - = low/lower (relatively to other regions in table); + = high/higher (relatively to other regions in table); \* Short-term records (32 to 40 ka); \*\*Known for the late deglaciation-HS1 (Lekens et al., 2006 includes HS 4, HS 3 and HS 2); Atmospheric temperature based on modern latitudinal differences. BWT=Bottom Water Temperature; SST=Sea (sub)Surface Temperature (planktic foraminifera-based)

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