A New Global Bottom Water Climatology for Tracing Abyssal Flow Pathways and Exploring Bottom Water Transformations

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Key Takeaways

- **We produced a new, high-resolution global bottom water climatology by interpolating sparse, high-quality shipboard measurements with a novel machine learning method.**
- **These maps (Θ, S_A, O_2, & nutrients) skillfully illuminate bottom water global flow pathways and regional biogeochemical processes.**

Motivation

- A detailed, global analysis of the mean state of bottom water masses has not been completed since 1983[1] and we have since greatly improved both our sampling coverage of these waters and the quality of our data interpolation methods.
- Detailed bottom water property maps illuminate distributions linked to global circulation pathways.

Data & Methods

- High-quality shipboard datasets are used for bathymetry, Θ, S_A, O_2, & nutrients [2–6]
- Novel **"stacked" random forest regression and objective mapping (RFOM) method** developed.
- RFOM regressions are applied iteratively (order below) so new maps of better sampled properties (e.g., Θ) inform the prediction of more sparsely sampled ones (e.g., nutrients).

RFOM(lat., long., z) → Θ
RFOM(lat., long., z, Θ) → S_A
RFOM(lat., long., z, Θ, S_A) → O_2
RFOM(lat., long., z, Θ, S_A, O_2) → nutrients

Seafloor Areal Coverage of Different Water Masses

- Area of Antarctic-origin waters ≈ 1.87 × area of NADW-dominated waters
  AABW/ $AABW_{source}$/LCDW "pure" NADW/AI-NADW
- Area of "deep" waters ≈ 2.71 × seafloor area of classical bottom waters
  PDW/IDW/LCDW/ "other" AABW/$AABW_{source}$/ "pure" NADW/AI-NADW

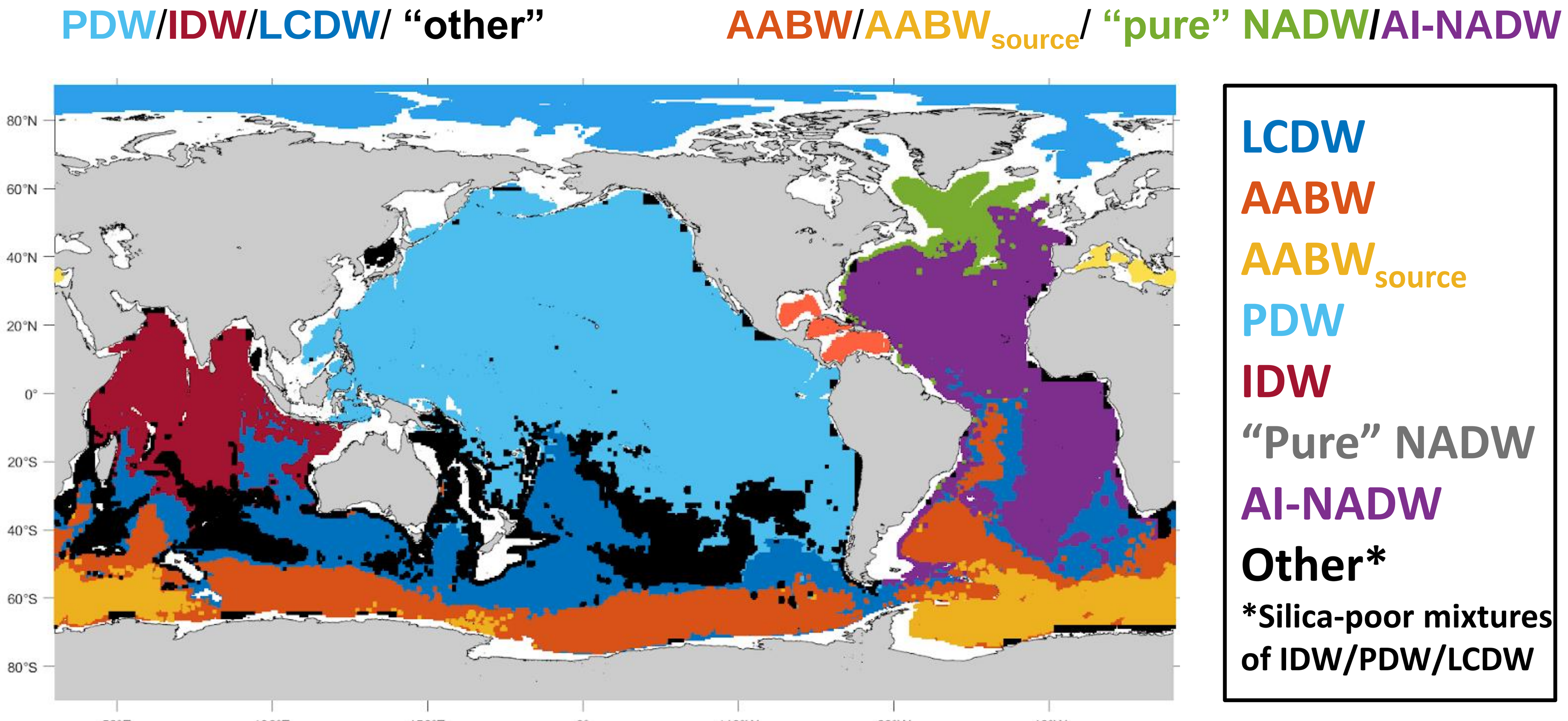

Fig.2: Assignments of each 0.5º latitude × 0.5º longitude box to one of the along-bottom water masses defined using neutral density and/or silica ranges.

Bottom Water Property Maps & Spreading Pathways

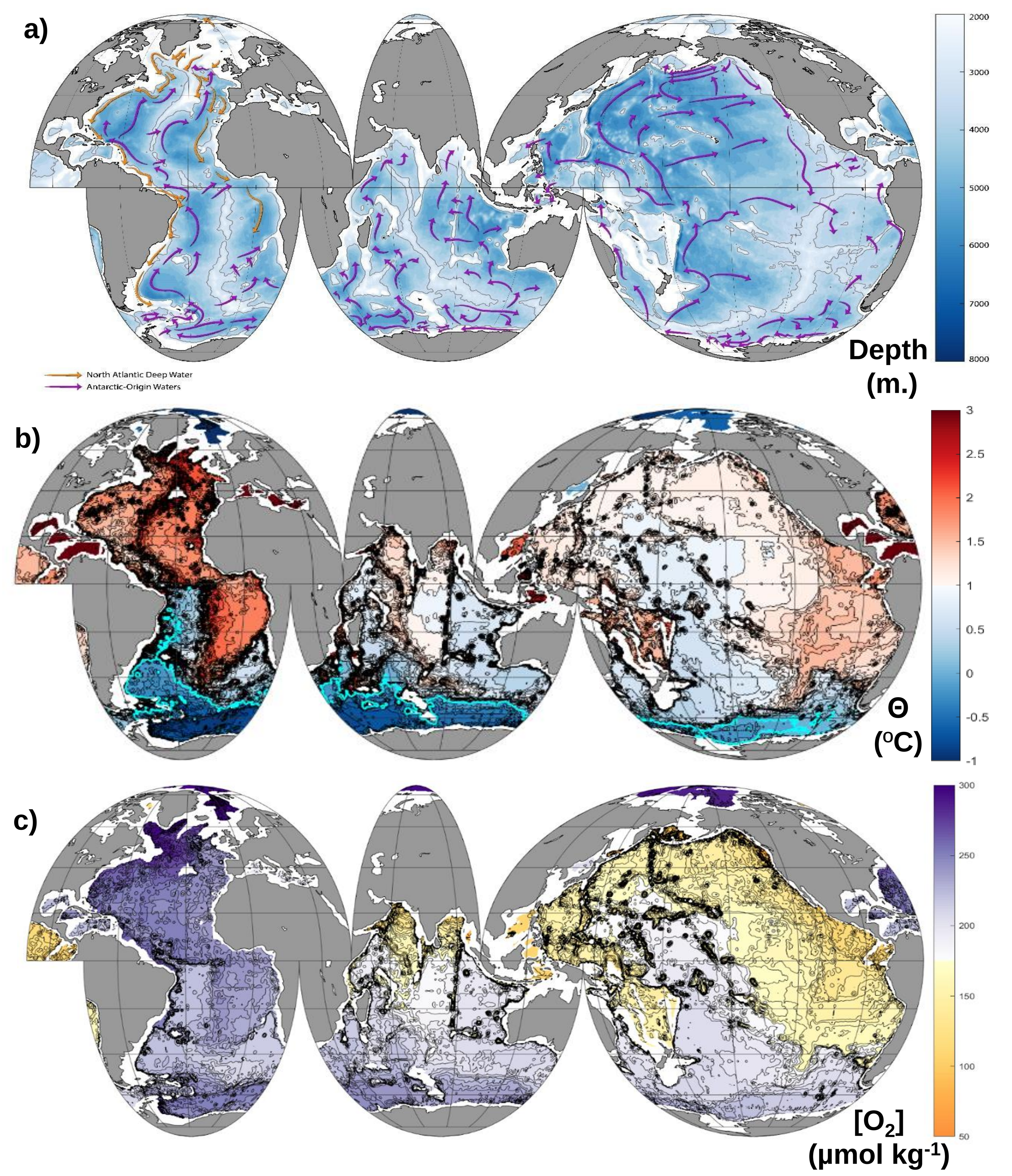

Fig.1: a) ETOPO-2 bathymetry smoothed and subsampled to 0.5º resolution (Contour interval (CI) = 250 meters) with the 3500-meter isobath highlighted (light grey) and arrows representing the along-bottom flow paths of North Atlantic Deep Water (orange) and Antarctic-origin waters (purple). RFOM-generated maps at 0.5º resolution of **b)** conservative temperature (CI = 0.1ºC) with the Θ = 0ºC contour highlighted (cyan) and **c)** dissolved oxygen (CI = 5 μmol kg^{-1}).

Regional Biogeochemical Features of Interest

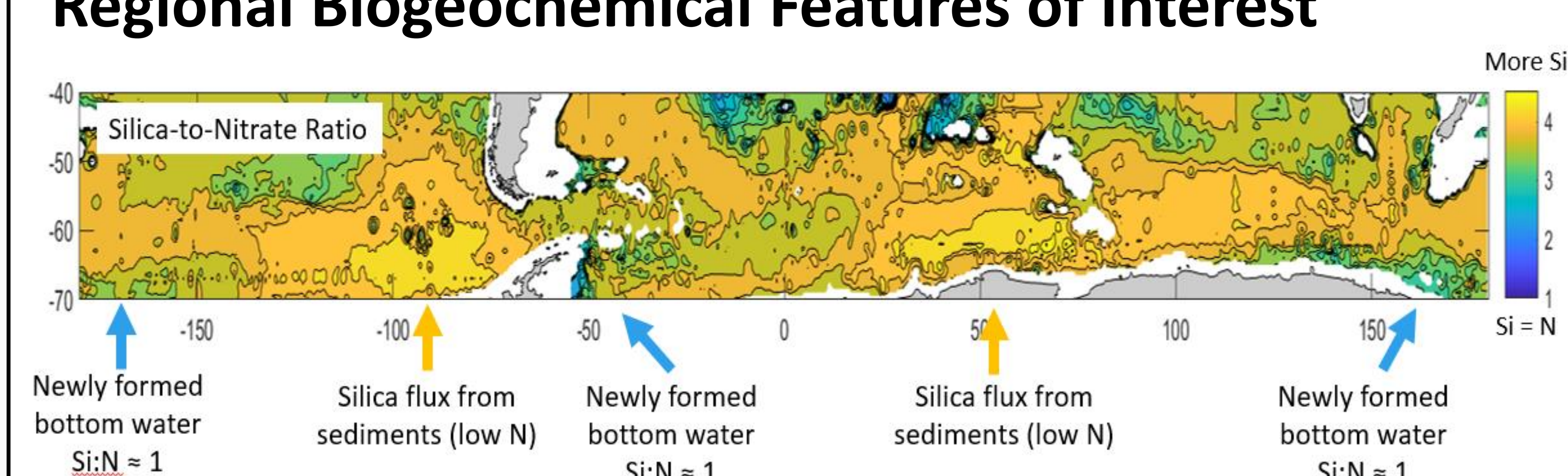

Fig.3: RFOM-generated silica to nitrate ratio maps at 0.5º resolution.

- Silica-to-nitrate (Si:N) ratios in the Southern Ocean act as a tracer of the many, sub-basin scale cyclonic gyres where newly-formed bottom waters (low Si:N) preferentially gain more silica than nitrate over time.
- More localized biogeochemical features of interest are also visible, such as the small region of especially high Si:N ratios in the SE corner of the Enderby Basin, which is may be due to the downslope transport of diatom skeletons.

References

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