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Nineteen years of surface ocean nitrous oxide along the Atlantic Meridional Transect

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Nitrous oxide (N_2O) is the third most important anthropogenic greenhouse gas and the most important stratospheric ozone depleting substance in terms of current emissions. Approximately 25 % of global N_2O emissions originate from the oceans, coasts and estuaries, produced during microbial nitrification and denitrification. However, the uncertainty around the relative contribution from the ocean is large and our current best estimates range from 11 to 69 % of total emissions.

Only very few open ocean regions have been occupied by sufficiently frequent repeat transects to provide robust constraints on seasonal and internannual variations in N_2O emissions, which would help reduce budget uncertainties, offer potential mechanistic insights into the biogeochemical and physical processes responsible for oceanic N_2O cycling and study the effects of climate change.

Here, we present eight boreal autumn and austral spring ocean surface water datasets for N_2O spanning a 19-year period from 1996 to 2014, acquired during Atlantic Meridional Transect (AMT) research cruises AMT3 to AMT24. These are used to consider whether a change in the surface ocean N_2O budget has occurred during this period. The datasets combine high-resolution (equilibrator-based) and discrete (CTD rosette) measurements, analysed by different instruments including gas-chromatographic separation and electron capture detection (GC-ECD) and as well as integrated cavity output laser spectrometry (ICOS).

Perhaps surprisingly, all eight datasets displayed regions of N_2O undersaturations in contrasting hemispheres and seasons in the Atlantic Ocean. This was more pronounced in the recent datasets (AMT20, 22, 23 and 24), where most of the Atlantic Ocean acted as a small N_2O sink. Seasonal variations between the two hemispheres were found, with autumn cooling producing surface waters more undersaturated for N_2O in the northern than the southern hemisphere. The surface concentration of N_2O between 10 to 30° S appeared to be influenced by increases in the atmospheric concentration of N_2O, with the surface waters remaining at around saturation (98 to 102 %). Recommendations for future oceanic N_2O observation programmes include interlaboratory calibration against reference standards and maintaining repeat transects for longer durations and along the same geographic coordinates.