CMI Best Paper Award for Doctoral Students



Allison Hogikyan, Laure Resplandy, Maofeng Liu, Gabriel Vecchi

"Hydrological Cycle Amplification Reshapes Warming-driven Oxygen Loss in the Atlantic Ocean"

Most marine animals breathe oxygen just like land animals, relying on dissolved oxygen in the ocean. Oxygen dissolves in seawater at the surface and is transported below by the ocean circulation and turbulent mixing. Global warming causes the oxygen content of the ocean to decrease, with the double whammy of (i) a decrease in solubility of oxygen (warmer waters hold less gas) and (ii) a decrease in circulation strength, or 'ocean ventilation'. Observations show that most of the ocean is indeed losing oxygen, but that some regions of the ocean are not losing oxygen, and may even be slightly gaining oxygen. Most notably, the upper kilometer of the subtropical Atlantic Ocean experiences a robust gain of oxygen, introducing a surprising pattern of oxygen gain/oxygen loss across the Atlantic Ocean (Figure 1). This pattern has been reported in prior work but not yet explained. Our study is the first to propose a mechanism linking greenhouse gas forcing to this pattern of oxygen gain/oxygen loss, using a series of climate model simulations that reproduce the observed pattern.

We find that the amplification of the hydrological cycle, a response to climate change that results in a 'salty-get-saltier, fresh-get-fresher' sea surface salinity pattern, explains the spatial pattern in oxygen changes. Warming makes water lighter. As oxygenated surface waters warm, the rate at which they are transported downwards into the ocean slows, leading to oxygen loss. In contrast, salt makes water heavier, accelerating the transport of these oxygenated waters into the ocean, leading to a gain of oxygen. We show that the hydrological cycle amplification induces a salinification and oxygenation opposing warming-driven oxygen loss in the subtropics, and a freshening that accelerates warming-driven oxygen loss at higher latitude (Figure 1). We show for the first time that climate change introduces patterns of oxygenation through surface salinity changes, key to understanding observed and future regional changes.

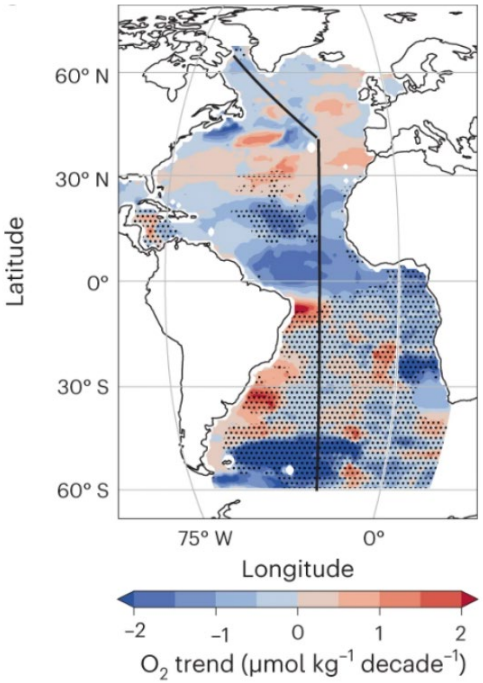


Figure: Observed change in oxygen concentration from observations (1950–2016), averaged over the upper 1,000 m in the Atlantic Ocean. Stippling indicates where at least one depth level (out of 47) has fewer than 20 years of data from which to estimate the trend. Hogikyan and co-authors attribute the so far unexplained oxygen gain in subtropical regions (in red) to increased ventilation by 'salty-get-saltier' waters.

PRINCETON UNIVERSITY

High Meadows Environmental Institute

Carbon Mitigation Initiative