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Deep-convection events foster carbonate ion reduction in deep coral reefs

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Since millennial times, water mass circulation and deep-convection events have been transforming warm upper waters at high latitudes into cold and well-oxygenated deep waters. These processes have filled the deep North Atlantic Ocean with waters moderately saturated in calcium carbonate, thus promoting the growth of stony corals, which are hotspots of biodiversity. During the Anthropocene, the meridional circulation has been conveying cumulative amounts of more acidified waters with lower calcium carbonate saturation levels due to the incorporation of anthropogenic carbon dioxide, with very harsh conditions for deep cold-water corals projected by 2100. We evaluate the diminution of calcium carbonate saturation levels (aragonite form) due to the increase in anthropogenic carbon dioxide during the last two decades (2002-2016). We observe a strong decrease in the aragonite saturation levels concomitant with the reduction in the volume transport of aragonite-saturated waters. We estimate a 30-35% reduction in the transport of ion carbonate excess over the saturation levels with respect to the natural carbon cycle for the period 2002-2016. This reduction is associated with an increase in the downward transport of hydrogen ions. We also observe a heaving of the aragonite saturation horizons during the last 25 years, which is estimated at 6 m year^{-1} for the deep waters and 12-14 m year^{-1} for the intermediated waters. The harsh winters of 2015 and 2016 have fostered the fast addition of more acidified water into the lower layers of the North Atlantic through deep-convection events. In the future scenario of 2^{o}C warming, the anthropogenic carbon dioxide in the water column would be double than today and the associated transport of hydrogen ions towards the bottom water would reduce the aragonite saturation levels to 60-80% with respect to preindustrial levels. This reduction in the aragonite saturation levels would suppose a strong diminution of the North Atlantic habitats where stony corals will be able to inhabit.