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Seasonal carbon dynamics in the Southern Ocean based on a neural network mapping of ship measurements

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We present a monthly climatology of dissolved inorganic carbon (DIC) in the upper 2000 m of the Southern Ocean north of 65°S, based on a 2-step neural network method that establishes and applies statistical relationships between global fields of physical and biogeochemical properties and direct DIC measurements from the GLODAPv2.2019 database from 2004 trough 2017. We test our method using synthetic data from a global hindcast simulation of the HAMOCC ocean biogeochemistry model, and independent observational datasets. At the month and location of biogeochemical floats from the SOCCOM array, our estimate is on average ~10 µmol kg^{-1} lower than the calculated DIC based on the float measurements. This difference can be partially explained by the difference in time period (SOCCOM floats used: 2014 through 2017; our estimate: 2004 through 2017). We find that the surface seasonal cycle of DIC has a mean amplitude of ~20 µmol kg^{-1} in the Southern Ocean, and the months of the highest surface DIC concentrations tend to be in austral spring when vertical mixing dominates the seasonal maximum. We also find that the nodal depth of DIC, the depth where the phase of the seasonal cycle of DIC shifts due to photosynthesis near the surface and remineralisation below, partially extends to several hundred meters. Using the nodal depth allows us for the first time to estimate the basin-wide seasonal net community production (NCP) based on direct DIC measurements. We find a mean NCP of ~2 mol C m^{-2}, which is considerably lower than in the temperate northern hemisphere.

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