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Decadal predictions of the North Atlantic CO_2 uptake

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Oceanic uptake of anthropogenic CO_2 is critical for predicting and projecting climate and ocean acidification. The North Atlantic Ocean plays a crucial role in modulating global carbon cycle as a major CO_2 sink region, and the subpolar gyre (SPG) region contributes the most to the variation of the North Atlantic CO_2 uptake. Previous studies revealed abrupt warming/cooling events in the SPG region, with sea surface temperature (SST) increasing/decreasing by 1°C in only a few years. The abrupt SPG warming/cooling events can be predicted several years in advance by initialization of the earth system models. The CO_2 uptake in the North Atlantic is largely driven by ocean mixing variations and SST anomalies. In this study, we investigate the response of the North Atlantic CO_2 uptake to observed SST variations and explore the decadal predictability of the North Atlantic CO_2 uptake during the period of 1961-2013 with the Max Planck Institute Earth System Model (MPI-ESM). Our results suggest significant inter-annual and decadal variability of the North Atlantic CO_2 uptake which is closely related to the evolution of North Atlantic Oscillation (NAO) and corresponding oceanic mixing strength, and this coherence is confined to the western SPG region. We show that the potential predictability of CO_2 uptake in the western SPG region is up to 4 years, which is similar to the prediction skill of SPG SST. Direct comparison of initialized simulations with observations implies prediction skill of the North Atlantic CO_2 uptake. The predictability of both CO_2 uptake and SST in the North Atlantic is assured by initialization of the Atlantic meridional overturning circulation (AMOC).