Quantifying the added value of underway pCO_2 data from sailboats

JACQUELINE BEHNCKE[1], PETER LANDSCHÜTZER[1,2]

[1] *Max Planck Institute for Meteorology, Germany*

[2] *Flanders Marine Institute, Belgium*

The ocean regulates the climate by annually absorbing roughly 25 % of anthropogenic CO_2 emissions from the atmosphere. In order to quantify the capacity of the ocean carbon sink from observations, measurements of the sea surface partial pressure of CO_2 (pCO_2) are essential. Building on the existing observational networks, we can utilize neural networks and other machine learning tools to interpolate data gaps in time and space creating homogeneous pCO_2 maps to estimate the exchange of CO_2 through the air-sea interface. However, uncertainties in these neural network interpolations are still substantial, particularly in less frequently monitored ocean regions such as the polar ocean. Since 2018 the sea surface pCO_2 has been regularly collected on sailboats in undersampled ocean regions, however, their added value to polar ocean CO_2 exchange estimates are yet to be determined. Here, we quantified the added value and rate of improvement of underway pCO_2 data from sailboats by creating a twin of all available pCO_2 measurements excluding sailboat data. We adopted a 2-step interpolation technique based on a self-organizing map and a feed-forward neural network on all pCO_2 observations as well as the twin dataset and calculated the sea surface pCO_2 and subsequently the air-sea CO_2 exchange. Using a signal-to-noise detection method enables us to quantify the added value of sailboat racing events to current air-sea CO_2 flux estimates. Our results show that neural network interpolations significantly differ in the air-sea CO_2 flux density on regional scales by up to 1.26 mol m^{-2} yr^{-1}. 99 % of the significant differences fall below 0.40 mol m^{-2} yr^{-1}. While differences are within the noise in many regions, significant differences can be detected in the less frequently monitored Southern Ocean, where pCO_2 data from single cruises were added, as well as in the temperate and subpolar North Atlantic, where the majority of sailing events took place. The impact was greatest along the Subantarctic Front but lower in the North Atlantic, where the data density is already high. We conclude that sailboat races provide a complementary observing platform to research vessels and robotic floats. Considering the recurrence of sailboat races, they have in combination with machine learning tools, the potential to improve reconstructive air-sea CO_2 flux estimates on larger scales in the future.