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APO observations in Southern Greenland: evaluation of modelled air-sea O_2 and CO_2 fluxes

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Since September 2007, the atmospheric CO_2 mole fraction and O_2/N_2 ratio (a proxy for O_2 concentration) have been monitored continuously at the coastal site of Ivittuut, southern Greenland (61.21°N, 48.17°W). From 2007 to 2013, our measurements show multi-annual trends of +2.0 ppm/year and -20 per meg/year respectively for CO_2 and O_2/N_2, with annual average peak-to-peak seasonal amplitudes of 14+/-1 ppm and 130+/-15 per meg.

We investigate the implications of our data set in terms of APO (Atmospheric Potential Oxygen). This tracer, obtained by a linear combination of CO_2 and O_2/N_2 data, is invariant to CO_2 and O_2 exchanges in the land biota, but sensitive to the oceanic component of the O_2 cycle. It is used as a bridge to evaluate air-sea CO_2 and O_2 fluxes from atmospheric variations of CO_2 and O_2/N_2.

Global ocean biogeochemical models produce estimates of CO_2 and O_2 air-sea fluxes. Atmospheric APO variations can be simulated through transportation of these fluxes in the atmosphere by Eulerian transport models. Thus, model values of atmospheric APO can be extracted at the station location. This study is based on air-sea flux outputs from CMIP5 simulations. After atmospheric transportation, they give access to atmospheric APO climatologies which can be compared, in terms of seasonal cycles and inter-annual variability, to the in situ observations.

A preliminary study is based on the CCSM ocean model air-sea fluxes transported in the atmosphere with the MATCH transport model, over the period 1979-2004. The amplitude of the APO seasonal cycle is correctly captured, but year to year variations on this seasonal cycle appears to be underestimated compared to observations. The LMDZ atmospheric transport model is also used to transport the ocean fluxes from five CMIP5 models, over the period 1979-2005, showing different amplitudes and timings of APO seasonal cycles.

This methodology is a first step to evaluate the origin of observed APO variations at our site and then estimate the variations of atmosphere-ocean fluxes of O_2 and CO_2. Conversely, our new dataset provides an insightful tool to test the validity of CMIP5 models in terms of North Atlantic CO_2 and O_2 cycles.