Model estimates of air-sea gas exchange under non-stationary high wind conditions

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High winds create explicit non-stationarity in near-surface air and water layers. The numerical non-stationary upper ocean model [D’Alessio et al., 1998] is modified by air gas constituents transfer equations included. The modified model is used to simulate transfer processes in cases, when wind velocity increases for several hours from the mean climatic one to a given higher value being in the range circa 10-25 m/s. Source functions, describing gas exchange between bubble population and water environment at high winds, are calculated and included in the gas transfer equations [Bortkovski, 2002; Bortkovski, 2003]. The gas transfer by bubbles, generated by breaking wind waves, is considered along with the diffusive transfer through the air-sea interface. The sum of them is treated as the total gas flux.

The instant fluxes of air gas components under high wind conditions are calculated for given wind speed values using the modified model. Influence of the seawater carbonate system on the carbon dioxide transfer at non-stationary conditions is evaluated. Changes of dissolved gases sub-surface concentrations caused by wind speed increase are taken into account. It is found that these wind dependent changes visibly influence on air-sea gas exchange.

Total gas flux dependencies on wind speed for several key ocean locations are obtained. These dependencies are not universal, because the significant part of total gas transfers is conditioned by the upper ocean layer structure, which varies from place to place. Mean gas fluxes are estimated using wind speed probability distributions in the locations discussed. The high wind contribution in mean air-sea gas exchange is estimated. It is found that the contribution is significant for mean CO₂ exchange, and determines the oxygen exchange almost completely.

The obtained estimates of mean fluxes are compared with fluxes calculated by well-known routine procedures. The significant differences are found and explained. The necessity in mean gas exchange calculations to take into account the revealed dependence on wind speed of air-water gas concentration difference is shown.

REFERENCES