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Estimation of the atmosphere-ocean fluxes of greenhouse gases and aerosols at the finer resolution of the coastal ocean.

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The balances and fluxes of greenhouse gases and aerosols between atmosphere and ocean are fundamental for Earth's heat budget. Hence, the scientific community needs to know and simulate them with accuracy in order to monitor climate change from Earth-Observation satellites and to produce reliable estimates of climate change using Earth-System Models (ESM).

So far, ESM have represented earth's surface with coarser resolutions so that each cell of the marine domain is dominated by the open ocean. In such case it is enough to use simple algorithms considering the wind speed 10m above sea-surface (u10) as sole driver of the gas transfer velocity. The formulation by Wanninkhof (1992) is broadly accepted as the best. However, the ESM community is becoming increasingly aware of the need to model with finer resolutions. Then, it is no longer enough to only consider u10 when modelling gas transfer velocities across the coastal oceans' surfaces. More comprehensive formulations are required that adjust better to local conditions by also accounting for the effects of sea-surface agitation, wave breaking, atmospheric stability of the Surface Boundary Layer, current drag with the bottom, surfactants and rain.

Accurate algorithms are also fundamental to monitor atmosphere and ocean greenhouse gas concentrations using satellite data and reverse modelling. Past satellite missions ERS, Envisat, Jason-2, Aqua, Terra and Metop, have already been remotely sensing the ocean's surface at much finer resolutions than ESM using instruments like MERIS, MODIS, AMR, AATSR, MIPAS, Poseidon-3, SCIAMACHY, SeaWiFS, and IASI. The planned new satellite missions Sentinel-3, OCO-2 and GOSAT will further increase the resolutions.

We developed a framework to congregate competing formulations for the estimation of the solubility and transfer velocity of virtually any gas on the biosphere taking into consideration the atmosphere and ocean fundamental variables and their derived geophysical processes mentioned above. First, we tested with measured data from the Baltic. Then, we adapted it to a coupler for atmosphere (WRF) and ocean (WW3-NEMO) model components and tested with simulated data relative to the Mediterranean and coastal North Atlantic. Computational speed was greatly improved by calculus vectorization and parallelization.

The classical solubility formulation was compared to a recent alternative relying in a different chemistry background. Differences between solubility formulations resulted in a bias of 3.86×106 ton of CO_2, 880.7 ton of CH4 and 401 ton of N2O dissolved in the first meter below the sea-surface of the modelled region, corresponding to 5.9% of the N2O yearly discharged by European estuaries. These differences concentrated in sensitive areas for Earth-System dynamics: the cooler polar waters and warmer less-saline coastal waters. The classical transfer velocity formulation using solely u10 was compared to alternatives using the friction velocity, atmospheric stability, sea-surface agitation and wave breaking. Differences between estimated transfer velocities concentrated at the coastal ocean and resulted in 55.82% of the gas volume transferred over the sea-surface of the modelled region during the 66h simulated period.