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A sea-state dependent parameterization of whitecapping and air-sea gas transfer velocities

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A parameterization of whitecapping that depends on sea state in addition to the friction velocity of the wind is justified in terms of the energetics of wind waves. This new parameterization has implications for processes wholly or partly dependent on whitecapping including sea-salt production and air-sea gas transfer.

A parameterization of gas transfer velocities is derived from a previous model modified by the sea-state dependent parameterization of whitecapping. This new model is evaluated. The new model provides a rationale for the divergence of earlier gas transfer coefficient models, giving due consideration to the sea-state conditions prevalent in the underlying data sets.

Contemporary gas transfer is evaluated over the globe at seasonal and regional resolutions (up to monthly and 1 degree) for both the new and traditional parameterisations using both reanalysis products (ECMWF ERA40) and earth observation (scatterometer and altimeter) products. The new model implies mean global transfer velocities, mean global exchange coefficients and a net global carbon dioxide sink broadly in line with previous estimates but with significant differences in detail. The sensitivity of the net carbon dioxide sink to the balance of non-whitecapping and whitecapping components of gas transfer is high. Regional differences in gas transfer between traditional formulations and the new model are substantial. Whitecapping in the North Atlantic is notable for strong inter-annual variability driven primarily by the high sensitivity of wave heights to the North Atlantic Oscillation.