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On the use of various k-U relationships and satellite wind speeds for studying air-sea CO_2 gas exchange coefficients

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Several attempts have been made to relate air-sea gas transfer velocities, k, to wind speed, U. Relating k to U is not completely satisfactory because k is known to be driven by sea surface roughness which is not only dependent on wind speed and alternative approaches attempt to relate k to sea surface slopes (Frew et al., 2004) that is accessible using dual-frequency altimeters. However, scatterometer instruments provide a much better spatial coverage than altimeters.

At present, three k-U relationships are commonly used to derive CO_2 air-sea fluxes from wind speed and air-sea CO_2 partial pressure gradient:

-The Liss and Merlivat (1986) relationship deduced from process studies in wind tunnel and calibrated with lake measurements.

-TheWanninkhof (1992) relationship deduced by assuming (1) k is proportionnal to U^2, (2) the global distribution of U is a Rayleigh distribution and (3) the global k average is constrained by the Broecker et al. (1985) ocean ^{14}C inventory ($K_{broecker}$).

-The Nightingale et al. (2000) relationship deduced from in situ tracer measurements (SF_6,^3He) performed at sea and assuming a second order polynomial k-U relationship.

Three sets of CO_2 exchange coefficients corresponding to the above k-U relationships have been computed since 1991 using ERS and QSCAT wind speeds. In order to correctly take into account the non-linearity of the k-U relationships in the K averages,

K has been computed for each 25km scatterometer wind speeds and these values have been interpolated using a kriging method to produce weekly and monthly K maps at global scale.

As expected from older studies, global mean K values deduced from these 3 k-U relationships are quite stable temporally (no seasonal cycle) but the K deduced from various relationships disagree by up to a factor 1.8 and this factor varies regionally (Boutin et al., 2002).

The mean global K value derived from QSCAT wind speeds and the Wanninkhof (1992) relationship, Kw, is 20% higher than the one derived with the Nightingale relationship, Kn; Kw is 4% higher than $K_{broecker}$ as QSCAT winds do not exactly follow a Rayleigh distribution and are on average higher than the mean value assumed by Wanninkhof (1992) to calibrate his relationship. Kn are 15% lower than $K_{broecker}$, in better agreement with Peacock (2004) and Naegler et al. (2005) new revisited inventory. The consequences of these results for the choice of a k-U relationship will be analysed relatively to the absolute accuracy and the variability of the satellite wind speeds and to the shape of k-U relationship (polynomial versus quadratic).