Non-dimensional wind-induced surface current in the cool skin by introducing the Richardson number $R_b$ as a determining parameter for the temperature difference across the cool skin of the ocean and the air-sea gas transfer velocity.

The more readily available cool skin data were then used for an adjustment of the gas transfer parameterization. Extensions of the renewal model included the effects of whitecap coverage on wind and wind-wave properties. The empirical coefficients that enter the renewal model have been specified more accurately using laboratory data on the aqueous molecular sublayers. The coefficient linking the cool skin and gas transfer parameterizations has been determined from the Garbe et al. (2001) probability distribution function for renewal events. At light winds, the renewal model with refined coefficients predicts larger temperature differences across the cool skin and smaller gas transfer velocities compared to the original model of Soloviev and Schluessel (1994). Finally, the renewal model is compared with the cool skin data collected by Hartmut Grasul during COARE and gas transfer data collected during the GasEx-98 and GasEx-01 field campaigns (Wanninkhof and McGillis, 1999; Hare et al., 2004).

**Table:** Parameter $a$ from the laboratory results of Garbe et al. (2002) and its comparison of coefficient $A$.

**References:**


**Figure 1:** Non-dimensional wind-induced surface current in the laboratory tank for different wind friction velocities (Zhang and Harrison, 2004) in comparison with the renewal model for two surface cooling rates: (a) 20 W m$^{-2}$ and (b) 200 W m$^{-2}$.

**Figure 2:** Comparison of the gas transfer velocity obtained in the open ocean with the renewal model calculated for two surface cooling rates and for young and old seas.

**Figure 3:** Renewal model in comparison with the gas transfer results over the ocean using the dual tracer and radon techniques as well as direct measurements. The continuous lines are the theoretical relationships for the gas transfer in the corresponding measurement techniques (Taylor diagram). The theoretical dependence for CO$_2$ is also shown. The dual tracer data are from Wanninkhof et al. (1997), Asher and Wanninkhof (1999), and Thiemig et al. (2000). The radon data are from Peng et al. (1974), Peng et al. (1976), and Comber (1998). The results of data from Wanninkhof and McGillis (1999), and the GasEx-01 data are from Hare et al. (2004).