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The effect of Forced Convection on the turbulent fluxes in the marine surface layer

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The behaviour of the bulk exchange coefficients, CE and CH, has been analyzed in the marine surface layer. It is found that these coefficients are functions of both wind speed and air-sea temperature difference and a new parameterization for CE and CH based on the two variables are presented. This is in contrast to the traditionally assumed stability dependence. Assuming constant value for CH as done in many models, underestimates the mean sensible heat flux by about 25%; for $U>10ms^{-1}$ the underestimation is 40%. Much of this bias is removed with the new expressions. The bias for CE assuming constant value isn't that pronounced, but the new parameterization does a good job reducing the scatter in comparison to measured values. Both CE and CH increase as the air-sea temperature difference decreases and the wind speed increase, i.e. as the boundary-layer approaches neutral stratification.

Spectral analysis was performed on the whole data set. The data was systematically divided into different groups depending on wind speed and temperature difference. Study of the median spectra in each group revealed an interesting feature: In groups representing small temperature differences and high wind speed, a second peak was found in the high frequency part of the spectra. When studying the response of the normalized cospectra of decreasing air-sea temperature difference and increasing wind speed, it was found that the high frequency peak was gradually strengthening at the expense of the low frequency peak. For the group representing the smallest temperature difference and the highest wind speed, the low frequency peak was almost non-existing.

It is suggested, based on earlier predictions for the high Reynolds number boundary by Hunt and Carlotti (2001), that the atmospheric surface layer can subsequently be divided into an Eddy Surface Layer (ESL). The height of the ESL is about 1% of

the total boundary layer height and it is dominated by vertically small, but strongly elongated eddies originating from detached eddies created in the layer above. The detached eddies are distorted by the strong local shear close to the ground as they enter the ESL. The ESL could be interpreted as being strongly influenced by forced convection (Monin and Yaglom, 1971). During forced convection, the temperature differences are sufficiently small, that they seize to have any effect on the flow itself, i.e. it is a true passive scalar. In a forced convective regime, eddies originating by temperature difference should be strongly suppressed, vertical transport of scalars is instead dominated by mechanically produced small scale eddies.