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Surface stress over the ocean in swell-dominated wind-following unstable atmospheric conditions

U Högström, A-S Smedman, E Sahlee, and A Rutgersson
Uppsala University, Department of Earth Sciences, Uppsala, Sweden (ann-sofi.smedman@met.uu.se, +46 18 551124)

Atmospheric and surface wave data from several oceanic experiments carried out on FLIP and ASIS platforms have been analyzed with the purpose to identify swell-related effects on the surface momentum exchange during slightly unstable atmospheric conditions ($L_{MO} < 0$) and wind-following seas. All data have a pronounced negative maximum in *uw* co-spectra centered at the frequency of the dominant swell,n_p, meaning a positive contribution to the stress. This co-spectral maximum is shown to be linearly related to the square of the orbital motion, being equal to $0.85 \cdot H_{sd}^2 n_p^2$, where H_{sd} is the swell significant wave height, the effect being due to strong correlation between the surface component of the orbital motion and the pattern of capillary waves over long swell waves.

A model for prediction of the friction velocity, u_* from U_{10}, H_{sd} and n_p is formulated and tested against an independent data set of 426 half-hour measurements during swell, giving mean deviation 0.01 ms^{-1} and standard deviation 0.02 ms^{-1}for the range 0.13 ms$^{-1} < u_* <$ 0.37 ms^{-1}for 3 $< U_{10} <$ 10 ms^{-1}.

A result of this model is that the drag coefficient C_D , which is traditionally modeled as a function of U_{10} alone (the COARE algorithm), becomes strongly dependent on the magnitude of the 'swell factor', $H_{sd}^2 n_p^2$. It shows that C_D can attain values several times larger than predicted by wind-speed-only models.

For wind speeds below c. 3 ms^{-1} a very different regime is demonstrated to prevail for which accurate prediction of the friction velocity can be made with a simple linear model. Upward directed momentum flux occurs for $H_{sd} <$ 2.0 m, being usually small compared to the downward flux but may dominate in very low wind.