Geophysical Research Abstracts, Vol. 6, 04005, 2004
SRef-ID: 1607-7962/gra/EGU04-A-04005

INVESTIGATION OF STABLY STRATIFIED FLOW IN A COASTAL MARINE SURFACE LAYER

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Monin-Obukhov theory, although developed from measurements over land, has been found to be generally applicable over the open sea, when homogenous and stationary flow conditions prevail. In coastal waters, when wind is blowing from land over the sea, the coastline constitutes a pronounced change in roughness and heat transfer. It poses a strong inhomogeneity to the flow, which may limit the applicability of Monin-Obukhov theory.
The wind speed profile in a coastal marine environment is investigated with data from the measurement program Rødsand, where meteorological data are collected with a 50 m high mast in the Danish Baltic Sea, about 11 km from the coast. The turning of the wind direction for wind blowing from land to sea is determined using measurements from surrounding land stations. The vertical wind speed profile over coastal waters shows substantial deviations from Monin-Obukhov prediction for cases with stable and near-neutral stratification. This deviation is systematic for frequently occurring conditions and thus will have an effect on the wind climatology. Measurements also indicate that the turning of the wind direction from land to sea is smaller, or even opposite to, the prediction of the geostrophic drag law.
The theoretical concept offers a qualitative explanation for these findings: When warm air is advected over colder water, a capping inversion might develop. The air below is constantly cooled by the water and gradually develops into a well-mixed layer with near-neutral stratification. Typical examples as well as scatter plots of the data are consistent with this explanation. The deviation of measured and predicted wind speed profiles is shown to be correlated with the height and strength of the inversion layer as theoretically estimated.