EVAPORATION OVER THE BALTIC SEA

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Evaporation is a major term in the energy and water cycle of the Baltic Sea. In the present study the evaporation was estimated from interpolated fields using a bulk parameterization according to $E = -\rho\, C_E\, U_{10}\, \Delta q$,
where ρ is the air density, C_E the bulk transfer coefficient for water vapor, U_{10} the wind speed at a height of 10m, and Δq the difference of specific humidity air-sea.

Wind speeds at a height of 10m were estimated from geostrophic winds by using ageostrophic coefficients, defined as the ratios of 10m to geostrophic wind speed. They were derived by a comparison of analysed geostrophic wind fields with wind observations performed on voluntary observing ships in 1992-1993. The ageostrophic coefficients depend on the distances to the coast with onshore and offshore winds. That accounts for the effect of changing roughness in the coastal zone on the wind speeds at 10m height and results in a decrease of evaporation in coastal waters. An example of the estimated ageostrophic coefficients is given in Figure 1. The calculated wind speeds at 10m height agree well with ship wind observations, which were not used to evaluate the ageostrophic coefficients (Figure 2).

To investigate the influence of the boundary layer parameterization on evaporation several parameterization schemes were applied on the data (Table 1). The resulting mean annual evaporation rates for 1992-1994 range from 458 to 664mm/y depending only on the chosen parameterization scheme.

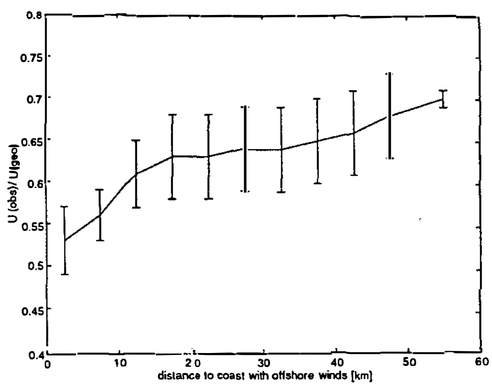

Figure 1: Ratio of the 10m to geostrophic wind speed as a function of the distance to the coast with offshore winds. The bars indicate the variability due to changes in distances to the coast with onshore winds taking the number of available observations into account, too. The distance is set to 55km for all cases having distances to the coast with offshore winds of more than 50km.

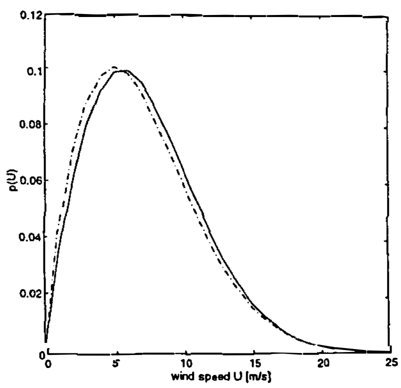

Figure 2: Weibull distribution of observed (full line) and analysed (dashed line) wind speeds at 10m height in 1994.

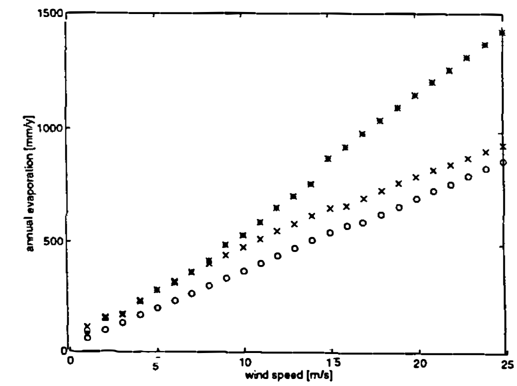

Figure 3: Annual evaporation [mm/y] for parameterization schemes 2(x), 4(o), and 6(*) (see Table 1) as a function of the 10m wind speed [m/s]. $T_{air} = 283K$, $T_{sea} = 285K$, and $\Delta q = -1.084 g/kg$.

Boundary Layer Model	C_D of	C_H and C_E of	evaporation [mm/y]
(1) Liu and Blanc(1984)	Kondo(1975)	roughn. Reynolds no.	617
(2) Liu and Blanc(1984)	Smith et al.(1992)	roughn. Reynolds no.	567
(3) Large+Pond(1981,82)	Large+Pond(1981)	Large+Pond(1982)	501
(4) Smith(1988)	Smith(1980)	DeCosmo et al.(1996)	458
(5) Smith(1988)	Smith et al.(1992)	DeCosmo et al.(1996)	461
(6) no	no	Bunker(1976)	664

Table 1: Mean annual evaporation for 1992 to 1994 estimated from the IfM Kiel analysis using different boundary layer parameterizations as given in the Table.

More in detail Figure 3 shows the differences in evaporation for three of the parameterization schemes (1, 4, and 6, see Table 1). Differences are of the order of 25 % and more even for small air-sea humidity differences. Generally deviations between the schemes are smaller for stable than unstable stratification.

From Figure 3 it is obviously that the boundary layer parameterization used by Bunker et al.(1997) (scheme 6, Table 1) produces for unstable conditions an extreme overestimation of evaporation for wind speeds exceeding about 10m/s at air-sea temperature differences of -2K. Because Figure 2 depicts that wind speeds over the Baltic Sea are often higher, an overestimation in evaporation is to be expected using this parameterization. That agrees well with results of a study of Isemer and Hasse (1987). Using the model of Liu and Blanc (1984) in its original formulation (scheme 1, see Table 1) instead of Bunker's coefficients gave only slightly smaller rates of evaporation. Furthermore it is the only one of all schemes investigated in the present study, where the resulting evaporation depends strongly on the chosen drag coefficient (Table 1), although different drag coefficients lead to minor changes of stability only. Thus, it can be assumed that annual evaporation rates estimated by using boundary layer parameterization schemes of Smith(1988) or Large and Pond (1981/1982) are more reliable.

References:

Bunker,A.F., 1976: Computations of Surface Energy Flux and Annual Air-Sea Interaction Cycles of the North Atlantic Ocean, Mon. Weath. Rev. 104, 1122-1140

DeCosmo,J.,K.B.Katsaros,S.D.Smith,R.J.Anderson,W.A.Oost,K.Bumke and H.Chadwick, 1996: Air-Sea Exchange of Water Vapor and Sensible Heat: The Humidity Exchange Over Sea (HEXOS) Results, J. of Geoph. Res., Vol. 101, No. C5, 12001-12016

Isemer,H.J. and L.Hasse, 1987: The Bunker Climate Atlas of the North Atlantic Ocean: 2. Air Sea Interactions, Springer, 256p

Kondo, 1975: Air-Sea Bulk Transfer Coefficients in Diabatic Conditions, Bound. Layer Met. 9, 91-112

Large,W.G. and S.Pond, 1981: Open Ocean Flux Measurements in Moderate to Strong Winds, J. of Phys. Oceanography 11, 324-336

Large,W.G. and S.Pond, 1982: Sensible and Latent Heat Flux Measurements over the Ocean, J. of Phys. Oceanography 12, 464-482

Liu,W.T. and T.V.Blanc, 1984: The Liu, Katsaros and Businger (1979) Bulk Atmospheric Flux Computational Iteration Program in FORTRAN and BASIC, NRL Mem. Rep. 5291, NRL, Washington D.C., 16p

Smith,S.D., 1980: Wind Stress and Heat Flux Over the Ocean in Gale Force Winds, J. Phys. Oceanogr., Vol. 10, 709-726

Smith,S.D., 1988: Coefficients for Sea Surface Wind Stress, Heat Flux and Wind Profiles as a Function of Wind Speed and Temperature, J. of Geoph. Res., Vol. 93 C12, 15467-15472

Smith,S.D.,R.J.Anderson,W.A.Oost,C.Kraan,N.Maat,J.DeCosmo,K.B. Katsaros,K.L.Davidson,K.Bumke, L.Hasse and H.Chadwick, 1992: Sea Surface Wind Stress and Drag Coefficients: The HEXOS Results, Bound. Lay. Met. 60, 109-142