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A Package of New Universal Non-Iterative Parametrizations for Stable Surface Layer Transfer Coefficients of Momentum, Heat and Moisture in Numerical Earth System Models

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Results of weather forecast, present-day climate simulations and future climate projections depend among other factors on the interaction between the atmosphere and the underlying sea-ice, the land and the ocean. In numerical weather prediction and climate models some of these interactions are accounted for by transport coefficients describing turbulent exchange of momentum, heat and moisture. Currently used transfer coefficients have, however, large uncertainties in flow regimes being typical for cold nights and seasons, but especially in the polar regions. Furthermore, their determination is numerically complex. It is obvious that progress could be achieved when the transfer coefficients would be given by simple mathematical formulae in frames of an economic computational scheme. Such a new universal, so-called non-iterative parametrization scheme is derived for a package of transfer coefficients.

The derivation is based on the Monin-Obukhov similarity theory, which is over the years well accepted in the scientific community. The newly derived non-iterative scheme provides a basis for a cheap systematic study of the impact of near-surface turbulence and of the related transports of momentum, heat and moisture in NWP and climate models.

We show that often used transfer coefficients like those of Louis et al. (1982) or of Cheng and Brutsaert (2005) can be applied at large stability only with some caution, keeping in mind that at large stability they significantly overestimate the transfer coefficient compared with most comprehensive measurements. The latter are best reproduced by Gryanik et al. (2020) functions, which are part of the package. We show that the new scheme is flexible, thus, new stability functions can be added to the package, if required.

Gryanik, V.M., Lüpkes, C., Grachev, A., Sidorenko, D. (2020) New Modified and Extended Stability Functions for the Stable Boundary Layer based on SHEBA and Parametrizations of Bulk Transfer Coefficients for Climate Models, J. Atmos. Sci., 77, 2687-2716