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Analytical derivation and empirical validation of the resistance laws for different types of planetary boundary layer

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The resistance laws for the planetary boundary layer (PBL) express the surface flux of momentum through the PBL governing parameters. Traditionally the dimensionless coefficients A and B in these laws were considered as functions of internal stability parameters: $\mu = u_*/|f|\,L$ in the steady-state PBL, or h/L in the non-steady PBL, where u_* is the friction velocity, f is the Coriolis parameter, L is the Obukhov length and h is the PBL height. Numerous studies revealed a wide spread of data on empirical plots of A and B versus μ or h/L. Zilitinkevich and Esau (2005) demonstrated that this approach is applicable only to the barotropic nocturnal PBL. Accounting for the free-flow stability, they proposed alternative formulations for newly discovered PBL regimes.

In the present study we derive the general formulation of the resistance law using a simple analytical model implying the two-layer PBL structure, namely the logarithmic layer and the z-less stratification layer, and determine the matching height z_* through the inverse square interpolation (following Zilitinkevich et al., 2007). The model is validated through LES data available for various PBL types. The proposed generalised resistance law can be used in a number of practical applications, in particular, for retrieving the geostrophic wind (and hence the atmospheric pressure) from satellite observations of the sea surface.

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Zilitinkevich S., Esau I., Baklanov A. (2007). Further comments on the equilibrium height of neutral and stable planetary boundary layers. *Q. J. R. Meteorol. Soc.* **133**: 265–271.