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# Nature, theory and modelling of geophysical convective planetary boundary layers

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Geophysical convective planetary boundary layers (CPBLs) are still poorly reproduced in oceanographic, hydrological and meteorological models. Besides the mean flow and usual shear-generated turbulence, CPBLs involve two types of motion disregarded in conventional theories:

- “anarchy turbulence” comprised of the buoyancy-driven plumes, merging to form larger plumes instead of breaking down, as postulated in conventional theory (Zilitinkevich, 1973),
- large-scale organised structures fed by the potential energy of unstable stratification through inverse energy transfer in convective turbulence (and performing non-local transports irrespective of mean gradients of transporting properties).

C-PBLs are strongly mixed and go on growing as long as the boundary layer remains unstable. Penetration of the mixed layer into the weakly turbulent, stably stratified free flow causes turbulent transports through the CPBL outer boundary. The proposed theory, taking into account the above listed features of CPBL, is based on the following recent developments:

- prognostic CPBL-depth equation in combination with diagnostic algorithm for turbulence fluxes at the CPBL inner and outer boundaries (Zilitinkevich, 1991, 2012, 2013; Zilitinkevich et al., 2006, 2012),
- deterministic model of self-organised convective structures combined with statistical turbulence-closure model of turbulence in the CPBL core (Zilitinkevich, 2013).

It is demonstrated that the overall vertical transports are performed mostly by turbulence in the surface layer and entrainment layer (at the CPBL inner and outer boundaries) and mostly by organised structures in the CPBL core (Hellsten and Zilitinkevich, 2013). Principal difference between structural and turbulent mixing plays an important role in a number of practical problems: transport and dispersion of admixtures, microphysics of fogs and clouds, etc. The surface-layer turbulence in atmospheric and marine CPBLs is strongly enhanced by the velocity shears in horizontal branches of organised structures. This mechanism (Zilitinkevich et al., 2006), was overlooked in conventional local theories, such as the Monin-Obukhov similarity theory, and convective heat/mass transfer law: $Nu \sim Ra^{1/3}$, where $Nu$ and $Ra$ are the Nusselt number and Raleigh numbers.

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