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Young and mature convective boundary layers in the atmosphere

Sergej Zilitinkevich (1,2,3)

(1) Finnish Meteorological Institute, Helsinki, Finland (sergej.zilitinkevich@fmi.fi), (2) Division of Atmospheric Sciences, University of Helsinki, Finland, (3) Department of Radiophysics, University of Nizhny Novgorod, Russia

In theoretical analyses, atmospheric convective boundary layers (CBLs) are treated as ever-growing flow patterns. However, the height of a sunny-day CBL over land usually stops growing and levels off much before the sunset. Similarly, CBLs developing in the atmosphere over the warmer sea or lake level off at a certain distance from the shore, after which the CBL height remains practically constant. The same is true for CBLs over megacities: except for sharp growth over the windward side, the height of such urban CBL is usually more or less homogeneous in the horizontal. In this paper, the commonly recognised prognostic CBL-height equation is generalised accounting for the following two stabilising mechanisms: (i) the fluid-dynamic effect of the synoptic scale subsidence counteracting the CBL growth in anticyclones; and (ii) the thermodynamic effect of CBL's negative radiation heat budget, which strengthens along with the increasing CBL height and eventually compensates for the CBL buoyancy supply, thus, preventing its further growth. To highlight principal importance of the thermodynamic mechanism, the following names are proposed: "young" – for developing CBLs (either growing or levelled off only because of the large-scale subsidence), and "mature" – for CBLs approached the steady-state balance between the buoyancy supply and buoyancy loss.