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# Scientific legacy of Sergej Zilitinkevich for boundary layer research and modelling

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Last year the scientific community lost a great scientist; leader in environmental turbulence and planetary boundary layer research; recipient of the 2019 International Meteorological Organization (IMO) Prize and many other science awards; leader of numerous international research projects; outstanding mentor, and dear friend, Professor Sergej Zilitinkevich.

Among his numerous outstanding scientific achievements in the boundary layer theory, several theoretical results broadly used in the numerical weather prediction, climate, and air pollution modelling communities, in particular, should be mentioned:

- The Zilitinkevich formula for the depth of stably stratified PBLs is often called that depth scale by Sergej's name, which indicates that his result is a truly classical one.
- The Zilitinkevich correction to the rate equation for the depth of a convectively mixed layer, and the resistance and the heat and mass transfer laws for geophysical turbulent flows are also widely known and used.
- The Zilitinkevich scale - a length scale of a rotational stratification turbulent mixing in stably stratified PBLs.
- Conceptual models of new types of atmospheric PBLs, i.e.,: *conventionally neutral* PBLs settled on the background of the strongly stable stratification typical of the free atmosphere are several times thinner than truly neutral PBLs settled in neutral stratification; and *long-lived stable* PBLs typical in winter time at high latitudes and affected by the stably stratified free atmosphere.
- Discovered and described by Zilitinkevich: the "weak turbulence regime," typical of the free atmosphere, which determines the turbulent transport of energy and momentum and the diffusion of passive scalars.
- Non-local turbulent transport for BLM and the pollution dispersion aspects of the coherent structure of convective flows.

These results have paved the way towards improved theories and parametrizations of boundary layers in many NWP, climate, and ACT models worldwide.
Over the last few decades, Sergej Zilitinkevich was deeply concerned with general questions of the physical nature of geophysical (and astrophysical) turbulence. The classical view, pioneered by

Kolmogorov, assumes a cascade process from large eddies towards small eddies and eventually to heat. This “chaos out of order” paradigm put forward for shear-generated non-stratified turbulence is shifted towards an “order out of chaos” paradigm more appropriate for real-world turbulence complicated by body forces, where small-scale motions can organize themselves and give rise to quasi-organized coherent structures at larger scales. Sergej made a remarkable contribution to this paradigm shift. He passionately addressed several fundamental issues, such as the: origin and transport properties of coherent motions, effect of buoyancy on turbulent transport, and maintenance of turbulence at strongly stable stratification. This promising and long-awaited scientific revolution in this area of research will allow for a better understanding of the nature of global pollution and climate change.

In this presentation we analyze the scientific legacy of Sergej Zilitinkevich for further developments in boundary layer research and modelling.