Sergej Zilitinkevich Curriculum Vitae

Personal data: Date and place of birth: 13.04.1936, Leningrad, Soviet Union (St. Petersburg, Russia) Citizenship: Russian and Swedish; residence: Helsinki (Finland)

Education and degrees

Graduated from: Faculty of Physics, Leningrad University, USSR (1959); *PhD physics and mathematics:* Leningrad Hydro-meteorological Institute/University (1962); *Dr Sci physics and mathematics:* PP Shirshov Institute of Oceanology Acad. Sci. USSR (1970); *Professor of geophysics:* Presidium of Acad. Sci. USSR (1972); *Professor of meteorology:* Uppsala University, Sweden (1997)

Employment record

Current Research Professor: Finnish Meteorological Institute (FMI); Director of Research: Institute of Atmospheric & Earth System Research, University of Helsinki (*Finland*, since 2004)

As Visiting Scientist/Professor: Universities of Nizhny Novgorod, Moscow, Tyumen; Institute of Geography Russian Acad. Sci. (*Russia*, since 2011)

1998-2003 *Sweden* Professor and Chair of Meteorology, Uppsala University (now Professor Emeritus)

1991-1997 *Germany* Visiting Professor: Max Planck Institute of Meteorology; Hamburg University; Alfred Wegener Institute of Polar and Marine Research; GKSS Research Centre

1990-1990 *Denmark* Visiting Professor: RISØ National Laboratory

1959-1990 *Russia* Main Geophysical Observatory: Head of Lab, Institute of Lake Research: Senior Scientist, Institute of Oceanology Russian Academy of Sciences: Founding Head of the Leningrad Branch, Russian State Hydro-meteorological University: Professor

Major external funding (as project-leader since 2004)

EU Commission: Marie Curie Chair "Planetary boundary layers (PBLs): theory, modelling and role in Earth System" (~500 kEUR), University of Helsinki, FI, 2004-2007

EU Commission: TEMPUS JEP 26005 "Development of competency-based two-level curricula in meteorology" (~500 kEUR), University of Helsinki, FI, 2007-2010

EU Commission: ERC-Ideas Advanced Grant 227915 "Atmospheric PBLs: physics, modelling and role in Earth system" (2.4 million EUR), FMI, FI, 2009-2013, http://pbl-pmes.fmi.fi/

EU Commission: TEMPUS 159352-FI-JPHES "Development of qualification framework in meteorology" (~1 million EUR), University of Helsinki, FI, 2010-2013

EU Commission: ERC PoC Grant 632295 "Integrated monitoring and forecasting system for local weather and microclimate" (150 kEUR), FMI, FI, 2014-2015

EU Commission: Erasmus+ Grant 561975-EPP-1-2015-1-FI-EPPKA2-CBHE-JP Adaptive learning … of local weather/climate (ECOIMPACT ~1 million EUR), University of Helsinki, FI, 2015-2019

Academy of Finland (1st bilateral RU-FI call): Grant 280700 "Atmosphere-hydrosphere interaction in Baltic Basin and Arctic Seas" (373 kEUR), FMI, 2014-2017

Academy of Finland (2nd bilateral RU-FI call / PI FMI team): Grant 314795 "ClimEco" (250 kEUR), FMI, 2018-2020

Russian Mega-Grant 11.G34.31.0048 "Air-sea/land interaction: physics and observation of PBLs" (equivalent to 4.7 million EUR), Nizhny Novgorod Univ., 2011-2015, http://planetlab.unn.ru/

Russian Science Foundation: Grant 15-17-20009 "Physical Nature and Modelling of Atmospheric Boundary Layer" (equivalent to 1.4 million EUR), Nizhny Novgorod Univ., 2015-2018

Supervision and teaching: Supervised 25 PhD and Dr. Sci. dissertations in meteorology, oceanography and space research: created and taught 7 original university courses in the above areas, and also in geophysics and science management in Russia, Germany, Sweden and Finland; created and taught worldwide short courses on geophysical turbulence and boundary layers.

Publications: 9 books, over 200 peer-reviewed papers and 3 literary works. Number of citations over 6000, h-index 41; first or single author in almost all papers making h-index – info from *Google Scholar* http://scholar.google.com/citations?user=y1CJd4MAAAAJ

International conferences, workshops and seminars: During last 10 years took part in organisation of over 30 international events and gave over 80 keynote / invited talks

Membership in editorial boards of scientific journals

International *Geography, Environment, Sustainability* (since 2008), *Advances in Applied Physics* (since 2012); Russian *Ice & Snow* (since 2014), *Proceedings of Moscow University* (Series Geography, since 2014), *Marine Hydrophys. J.* (since 2014); Ukrainian *Ukrainian Hydromet. J.* (since 2014)

Scientific biography

Sergey Zilitinkevich (SZ) graduated from Leningrad University in 1959 as theoretical physicist and made further career in theoretical meteorology, physical oceanography and environmental physics: **1962** (age 26) got PhD; **1964** (age 28) was appointed as head of Lab of Air Pollution at Main Geophysical Observatory, Leningrad; **1966** (age 30) founded Leningrad Branch (focused on turbulence, PBLs and air-sea interaction) of the Moscow Institute of Oceanology Acad. Sci. USSR; **1968** (age 32) got degree of Dr. Sci., initiated inter-institutional coordination in physics and modelling of the atmosphere and ocean through annual all-USSR workshops, was appointed as leader of sub-programme on planetary atmospheres of the USSR National Space Research Programme "Venera" (Venus); **1970** (age 34) was appointed as Chair of the USSR National Commission on Air-Sea Interaction; **1972** (age 36) got degree of Professor of Geophysics from Presidium of Acad. Sci. USSR.

In USSR, he has published a hundred peer reviewed papers and 6 books on PBLs, air-sea interaction, geophysical and astrophysical turbulence, general circulations of Earth's and planetary atmospheres, theory of climate, modelling water ecosystems. In 1990 he has moved to Western Europe:
1990 Denmark: Visiting Professor at Wind Energy Department of RISOE National Laboratory;
1991-1997 Germany: Visiting Professor and leader of projects at Max Planck Institute for Meteorology (MPI), University of Hamburg, Alfred Wegener Institute for Polar and Marine Research (AWI), and Institute for Hydrophysics at GKSS Research Centre;
1998-2003 Sweden: Professor and Chair of Meteorology at Uppsala University;
Since 2004 SZ Finland: Research Professor at FMI; leader of a series of EU grants at University of Helsinki. Since 2012 he acts as Chief Scientist of international program Pan-Eurasian Experiment (PEEX: http://www.atm.helsinki.fi/peex/images/PEEX_SP__May2017.pdf).

Research profile

The main expertise of Sergej Zilitinkevich is in physics of environmental turbulence and planetary boundary layers (PBLs). Over half a century his works pioneered the following basic research responding to major challenges from weather and air-quality prediction and climate modelling:

- turbulence-closure – tool for modelling turbulent transport and dispersion

- drag and heat/mass transfer at the Earth surface – tool for modelling turbulent fluxes linking the atmosphere, lithosphere, hydrosphere, cryosphere and biosphere into climate and Earth systems
- physical nature of PBLs – tool for modelling microclimates, fine features of weather, and extreme weather events

He has deserved credit already in the seventies for invention of the "rotation plus stratification" depth scale, often referred to as "Zilitinkevich scale" (1972); the PBL bulk resistance and heat/mass-transfer laws, linking the surface fluxes with external parameters available in operational models and observations (1967, 1968, 1975); and prognostic equations for the depth of evolving PBLs (1975). Results from these works are employed in weather and climate models, includes in textbooks, and often cited as conventional without references.

SZ (1971, 1973) long ago revealed that conventional paradigm (Kolmogorov-1941), postulating the strictly forwards turbulent energy cascade and strictly down-gradient turbulent transport, is too restrictive. Recently, SZ has given the following explanation to his early finding: In contrast to usual shear-generated eddies that break down to generate smaller eddies, buoyant plumes, comprising convective turbulence, merge to form lager plumes, thus performing inverse cascade and, particularly, providing the energy to self-organised convective motions: cells and rolls typical of convective PBLs (2006, 2013).

In a series of papers starting from 2000 and 2002, SZ has revealed a new type of atmospheric boundary layers: long-lived (LL) PBLs keeping the type of stratification (stable or unstable) over several days or even weeks and, hence, strongly affected by the slow influence from stable stratification inherent to the free troposphere. This makes LL PBLs very shallow and, hence, very sensitive to air-pollution, changes in land-use, or other impacts. SZ has shown wide occurrence and significant role of LL PBLs in polar and marine climates.

Basing of the revised paradigm, SZ and his group have created novel Energy- and Flux-Budget (EFB) turbulence closure theory with the following principal outcomes (2007, 2008, 2009, 2013, 2019):

- Self-control of stably stratified turbulence: The negative heat flux, conventionally considered as a killer of turbulent kinetic energy (TKE), factually converts TKE into turbulent potential energy (TPE). Hence, strengthening of temperature gradient though decreases TKE but increases TPE. The latter (proportional to the mean-squared fluctuation of temperature) generates positive heat flux irrespective of the temperature gradient, thus reduces the negative heat flux and re-establishes TKE.
- Solution to the century-hold paradox of critical Richardson number: Thanks to the above feedback, the high-Reynolds-number geophysical turbulence survives in strongly supercritical stratifications typical of the free atmosphere and ocean, in contrast to the well-known decay of turbulence typical of the low-Reynolds-number flows in lab experiments.
- A hierarchy of the EFB closure models for research and operational modelling, grounded up to extremely stable stratifications: The EFB closure is applicable to both sub-critically stratified boundary layer flows and supercritically stratified free flows. Up to now the supercritical turbulence remained factually unexplained and modelled very uncertainly.

Honours and awards

Vilhelm Bjerknes Medal-2000 of European Geophysical Society
Alfred Wegener Medal-2015 of European Geoscience Union
Member of Academia Europaea (Earth and Cosmic Sciences, since 2002)
Member of Finnish Academy of Science and Letters (Geosciences, since 2009)
Member of *Societas Scientiarum Fennica* (Mathematical & Physical Sciences, since 2012)
Member of International Eurasian Academy of Sciences (Geosciences, since 2012)
Fellow of Royal Meteorological Society (UK, since 2004)

Honorary member of European Geoscience Union (since 2015)
Professor Emeritus, Uppsala University (Sweden, since 2003)
Doctor *honoris causa*, University of Pretoria (South Africa, since 2015)
Doctor *honoris causa*, University of Nizhny Novgorod (Russia, since 2015)
Doctor *honoris causa*, Odessa State Ecological University (Ukraine, since 2016)

Personal web-pages

FMI: https://en.ilmatieteenlaitos.fi/cv-sergej-zilitinkevich
University of Heksinki: https://tuhat.helsinki.fi/portal/en/persons/sergej-zilitinkevich(3c77bd8a-4640-4640-a964-3d8ecd17bba4).html
Academia Europaea: https://www.ae-info.org/ae/Member/Zilitinkevich_Sergej

Selected publications

Zilitinkevich, S.S., Laikhtman, D.L., Monin, A.S., 1967: Dynamics of the boundary layer in the atmosphere. Izvestija, AN SSSR, FAO, **3**, No. 3, 297-333.

Zilitinkevich, S.S., and Chalikov, D.V., 1968: On the resistance and heat/moisture transfer laws in the interaction between the atmosphere and the underlying surface. *Izvestija AN SSSR, FAO*, **4**, No. 7, 765-772.

Zilitinkevich, S.S., 1972: On the determination of the height of the Ekman boundary layer. *Boundary-Layer Meteorol*., **3**, 141-145.

Zilitinkevich, S.S., 1973: Shear convection. *Boundary-Layer Meteorol*., **3**, 416-423

Zilitinkevich, S.S., 1975: Resistance laws and prediction equations for the depth of the planetary boundary layer. *J. Atmos. Sci*., **32**, 741-752.

Zilitinkevich, S.S., 1975: Comments on "A model of the dynamics of the inversion above a convective boundary layer". *J. Atmos. Sci*., **32**, 991-992.

Zilitinkevich, S., and Calanca, P., 2000: An extended similarity-theory for the stably stratified atmospheric surface layer. *Quart. J. Roy. Meteorol. Soc*., **126**, 1913-1923.

Zilitinkevich S.S., and Esau, I.N., 2002: On integral measures of the neutral, barotropic planetary boundary layers. *Boundary-Layer Meteorol*. **104**, 371-379.

Zilitinkevich, S.S., Hunt, J.C.R., Grachev, A.A., Esau, I.N., Lalas, D.P., Akylas, E., Tombrou, M., Fairall, C.W., Fernando, H.J.S., Baklanov, and A., Joffre, S.M., 2006: The influence of large convective eddies on the surface layer turbulence. *Quart. J. Roy. Met. Soc*. **132**, 1423-1456.

Zilitinkevich, S.S., Elperin, T., Kleeorin, N., and Rogachevskii, I., 2007: Energy- and flux-budget (EFB) turbulence closure model for the stably stratified flows. Part I: Steady-state, homogeneous regimes. *Boundary-Layer Meteorol*. **125**, 167-192.

Zilitinkevich, S.S., Elperin, T., Kleeorin, N., Rogachevskii, I., Esau, I., Mauritsen, T., and Miles, M. W., 2008: Turbulence energetics in stably stratified geophysical flows: strong and weak mixing regimes. *Quart. J. Roy. Met. Soc*. **134**, 793-799.

Zilitinkevich, S.S., Elperin, T., Kleeorin, N., L'vov, V., and Rogachevskii, I., 2009: Energy- and flux-budget (EFB) turbulence closure model for stably stratified flows. Part II: The role of internal gravity waves. *Boundary-Layer Meteorol*. **133**, 139-164.

Zilitinkevich, S.S., 2010: Self-organisation and non-local nature of geophysical turbulence and planetary boundary layers. *Geophysical J*., No. 6, 168-174.

Zilitinkevich, S.S., Elperin, T., Kleeorin, N., Rogachevskii, I., Esau, I.N., 2013: A hierarchy of energy- and flux-budget (EFB) turbulence closure models for stably stratified geophysical flows. *Boundary-Layer Meteorol*. **146**, 341-373.

Zilitinkevich S., Kulmala M., Esau I., Baklanov A., 2015: Megacities – refining models to personal environment. *WMO Bulletin* **64** (1), 20-22.

Zilitinkevich S., Druzhinin O., Glazunov A., Kadantsev E., Mortikov E., Repina I., Troitskaya Yu., 2019: Dissipation rate of turbulent kinetic energy in stably stratified sheared flows, *Atmos. Chemistry and Physics*

28.01.2019