Geophysical Research Abstracts
Vol. 21, EGU2019-2626, 2019
EGU General Assembly 2019

The Baltic Sea – a challenging numerical laboratory for ocean mixing studies

Hans Burchard
Leibniz Institute for Baltic Sea Research, Physical Oceanography, Rostock, Germany (hans.burchard@io-warnemuende.de)

The Baltic Sea is a great natural and numerical laboratory for studying density-driven circulation and ocean mixing. This circulation is characterised by highly episodic near-bed salty water inflows from the ocean, freshwater run-off from rivers, and the mixing product of both, near-surface brackish water outflow. Energetically, the circulation is closed by mixing, causing vertical turbulent buoyancy fluxes lifting up the salty water from the bottom to the surface.

The Baltic Sea exchange flow had been first quantified by Martin Knudsen in 1900. Since then, his relations became a major tool for studying all types of estuaries around the world. However, the inherent basin-wide mixing connected to such exchange flows has been linked to the Knudsen relations only very recently by Parker MacCready, Rocky Geyer and Hans Burchard. According to a rule of thumb derived by these authors, and based on data from Martin Knudsen as well as based on long-term model simulations by Hans Burchard, Ulf Gräwe and co-workers, the long-term-mean mixing in the Baltic Sea should be 220.000 m3/s (g/kg)2. It is still an open research question, how this mixing is distributed in time and space. The only way to properly quantify mixing and its attribution to certain hydrodynamic processes is via long-term high-resolution numerical modelling. This is a challenging task, physically as well as numerically.

Physically, a basic mixing process has been parameterised by Hans Burchard, Helmut Baumert and Lars Umlauf: mixing in stratified shear flow, calibrated by a mixing efficiency of 0.25. Including this and other parameterisations, Hans Burchard, Karsten Bolding, Lars Umlauf and co-workers developed GOTM (General Turbulence Closure Model) a turbulence closure library which today is integrated into many ocean models. Parameterisations of other processes such as boundary mixing, internal wave breaking, Langmuir Circulation and Double Diffusion are still in a stage of infancy.

Numerical problems arise due to the fact that ocean models are not energy-consistent. Among many others, proper tracer advection schemes are inherently causing numerical mixing, which amounts to a considerable part of the computed total mixing and needs to be taken into account. Hans Burchard, Knut Klingbeil and co-workers developed methods for exactly quantifying this mixing contribution. The numerical model which is used to calculate the space and time distribution of Baltic Sea mixing is GETM (General Estuarine Transport Model), developed by Hans Burchard, Karsten Bolding, Knut Klingbeil and many co-workers. It contains a detailed mixing analysis as well as vertically adaptive coordinates, which have been developed by Hans Burchard, Jean-Marie Beckers, Richard Hofmeister and co-workers. These flexible coordinates reduce numerical mixing, and without them, accurate Baltic Sea mixing calculations would not be possible.

With this, theoretical and numerical methods for quantifying mixing in the Baltic Sea are at hand. It is however a long-term challenge to improve these methods to be able to gain a deep understanding of the Baltic Sea mixing. This will considerably help understanding other estuarine systems, as already demonstrated for the Knudsen relations since 1900.