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Submesoscale dynamics in the heart of the Baltic Sea: High-resolution model reveals new insights

With the help of highly resolved realistic model simulations physicists at the Leibniz Institute for Baltic Sea Research (IOW) have succeeded in depicting the so-called submesoscale dynamics in the Eastern Gotland Basin – the deepest of the large basins of the central Baltic Sea. Thus, the researchers gained the opportunity to investigate these highly dynamic phenomena, which – although being known for decades through satellite images – are up to now only scarcely studied and poorly understood because of their small size and short-lived nature. The model results confirm that submesoscale processes play an important role in the heart of the Baltic Sea in terms of both, energy balance and ecology.

They are the small cogs in the gears of ocean dynamics: Submesoscale dynamics comprise filaments, fronts, and eddies not more than 1 to 10 km in size. It is known from satellite images that they occur quite frequently. However, they are difficult to study because mostly they are very short-term phenomena. Only within the last two decades computer models gained so much in resolution that nowadays they are valuable tools to investigate such ephemeral small-scale features. Since then, modellers all over the world have put a strong focus on investigating the submesoscale dynamic, especially in the vicinity of large circulation patterns like the Gulf Stream. Studies on their occurrence in the Baltic Sea, until recently, were mainly restricted to the Southern Baltic and the Gulf of Finland.

In a now released publication, Evridiki Chrysagi, postdoc scientist at the IOW, and her Warnemünde colleagues report on new studies concentrating on the Gotland Basin and the effects of storm events. For the central Baltic Sea in general and particularly the Eastern Gotland Basin, where the IOW has conducted long-term observations for many decades, a wealth of observation data on basic parameters exists, with which models can be validated. Thus, this region can perfectly serve as a natural laboratory, ideal to study these features. Under these conditions, the model simulations delivered realistic highly resolved results, which now enable the oceanographers to study the submesoscale structures in detail and to follow their development in space and time, as well as their impact on the upper ocean dynamics.

The authors could prove with their high-resolution model simulation that a strong East-West frontal structure covering the entire Eastern Gotland Basin triggered the submesoscales. Moreover, they showed that this structure persisted during the whole autumn. Satellite images showed that this structure existed in other years, too. So, it is likely that it is a quite common feature in the Eastern Gotland Basin.

Within the frontal structure, the model showed strongly increased vertical velocities of up to 100 meters per day. Evridiki Chrysagi comments: “Like an elevator, this process can transport nutrients to the surface mixed layer and it definitely influences the gas exchange between air and sea. In the end, this might be one of the processes to trigger, for example, cyanobacteria blooms, whereas in the strongly stratified basins of the Baltic Sea, other processes (e.g., strong surface convergence, restratification, reduced turbulent mixing) might be more relevant.”

One of the most important results of the study is that in the vicinity of the submesoscale fronts storm events did not lead to a deepening of the surface mixed layer (SML) as they normally do. Moreover, the shoaling of the SML even intensified afterwards. This is especially important for marine phytoplankton, which can benefit from the associated increase in temperature and light exposition. Inside the fronts, the interaction of near-surface turbulence and restratification leads to highly efficient mixing.

"We proved that our model is capable to resolve these small-scale processes. Now we can investigate them in detail like under a magnifying glass. Our next aim is the interaction of the fronts, filaments, and eddies with the biogeochemistry and thus, with the life cycle in the largest of the Baltic Sea basins," resumes co-author Hans Burchard.

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Publication:

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Scientific experts:

Dr. Evridiki Chrysagi, Department of Physical Oceanography
Leibniz Institute for Baltic Sea Research Warnemünde
phone: +49 381 5197 3489 | evridiki.chrysagi@io-warnemuende.de

Dr. Lars Umlauf, Department of Physical Oceanography
Leibniz Institute for Baltic Sea Research Warnemünde
phone: +49 381 5197 223 | lars.umlauf@io-warnemuende.de

Prof. Dr. Hans Burchard, Dep. Head of Department of Physical Oceanography
Leibniz Institute for Baltic Sea Research Warnemünde
phone: +49 381 5197 140 | hans.burchard@io-warnemuende.de

Contact IOW press and public relations:

Dr. Kristin Beck: +49 381 5197 135| kristin.beck@io-warnemuende.de
Dr. Barbara Hentzsch: +49 381 5197 102 | barbara.hentzsch@io-warnemuende.de