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The importance of interactions between intratidal processes for the evolution of stratification in a dynamic salt wedge estuary

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Strongly forced salt wedge estuaries are known to demonstrate significant variability in stratification, currents, and mixing within a tidal cycle. Such estuaries also show strongly spatially varying patterns of stratification and mixing, and the processes causing this spatial and temporal variability are known to interact. As a consequence, the dynamics of these estuaries are distinctly different from well-mixed and partially mixed estuaries, and intratidal processes may play a more central role in the evolution of stratification.

The Rhine-Meuse estuary is an example of a strongly forced salt wedge estuary. It is very dynamic, mesotidal, and stably stratified. In this study, we investigate how individual intratidal estuarine processes contribute to the evolution of stratification in the Rhine-Meuse estuary. Data from recent shipboard measurements are used to assess their relative influence and highlight the potential importance of interactions between these processes.

From measurements in the Rhine-Meuse estuary we find that the availability of salt is determined by tidal advection of the salt wedge. Additionally, exchange flows transfer salt from high-density to low-density regions such as harbour basins and side branches while the salt wedge is advected through the estuary. The combination of the barotropic tidal asymmetry imposed at the river mouth and turbulence damping at the pycnocline results in strong shear and subsequent formation of mid-depth jets at the onset of flood. These mid-depth jets contribute to the transfer of salt by transporting salt from regions of higher momentum to regions of lower momentum. Furthermore, the measurements suggest that several bathymetric transitions locally generate internal wave activity, although the resulting turbulent mixing is not strong enough to erode the persistent salt wedge structure.

These findings underline the importance of interactions between intratidal processes on different spatial scales and their effect on the evolution of stratification in the Rhine-Meuse estuary. As an extension to our findings, measurements in the Rhine region of influence (ROFI) are used to further examine the role of the seaside forcing on the individual physical processes and the resulting intratidal variability of stratification in the estuary.