Project: **1102**
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Within this project, we are running the highest resolved ocean ICON ocean configurations which are currently available. Therewith, we reach resolutions which allow to simulate submesoscale instability, baroclinic tides, low to intermediate mode internal waves and the interactions between these processes. Our results originate from simulations with a SubMesoscale Telescope (SMT). Currently, we are analysing two configurations of this type: (1) with a focus are that has the highest horizontal resolution of 530m in the North Atlantic, referred to as SMT-NATL and one with the focus area in the South Atlantic referred to as SMT-WAVE (the WAVE stands for tidally generated waves that we obtain by activating the ICON-O's tidal module).

Dissipation of submesoscale dynamics in the upper and deep ocean

During the last year, we constantly expanded the post-processing toolbox pyicon (https://gitlab.dkrz.de/m300602/pyicon), that allows for sophisticated diagnostics of ICON data on the native grid. In particular, we recoded important mathematical operators like gradient, divergence and curl which are required to estimate the horizontal energy dissipation of the resolved flow. This diagnostic was used to study the relationship between ageostrophic dynamics and a downscale energy transfer in SMT-NATL. Indeed, we find that a substantial amount of kinetic energy ends up at the grid scale where it then dissipated by the biharmonic friction. Strong dissipation is found where the Rossby number is enhanced e.g. in the upper ocean mixed layer (see Fig. 1) what confirms previous theories that ageostrophic dynamics can be responsible for downscale energy transfer (e.g. Brüggemann and Eden, 2015). Therewith, we confirm an important mechanism regarding the ocean energy dissipation.

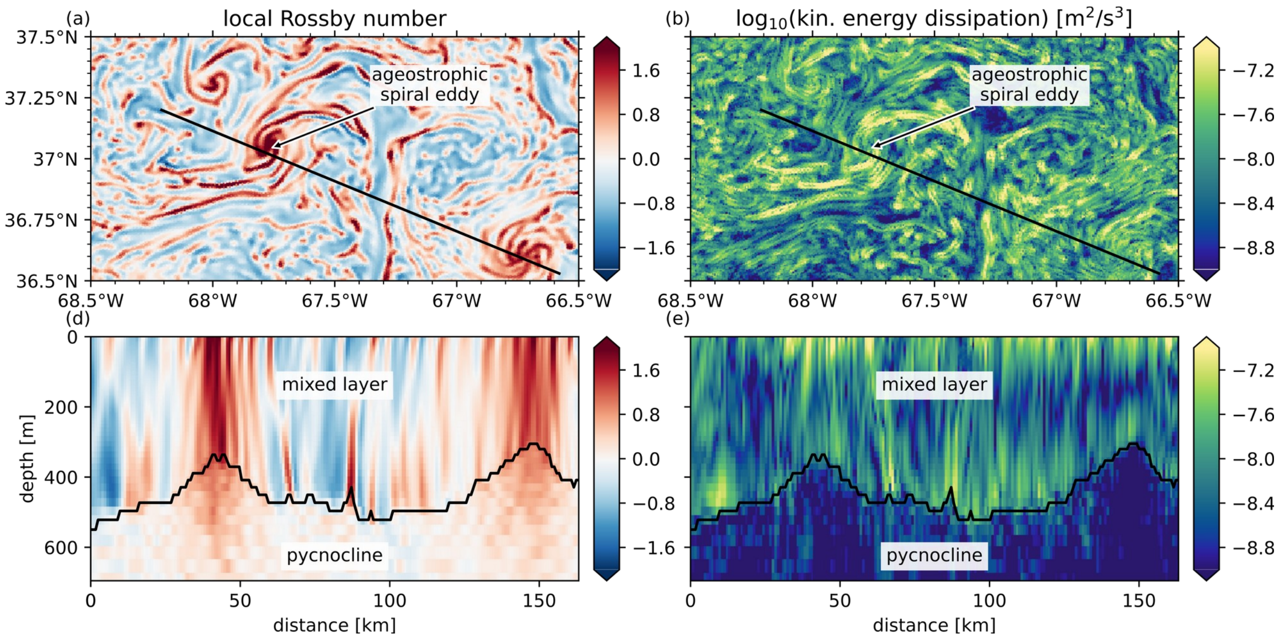
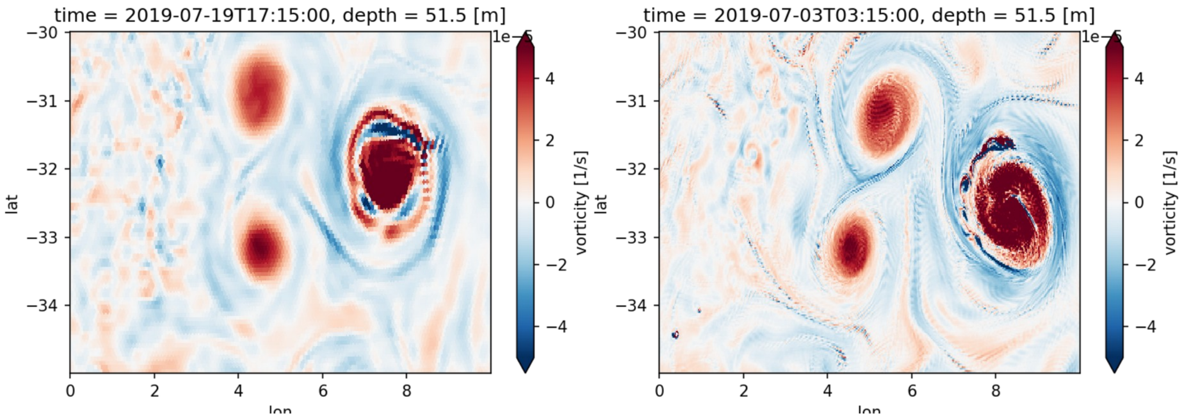


Figure 1: Rossby number (derived as relative vorticity divided by planetary vorticity) of the submescale eddy field characterized by spiral eddies. (a) shows the planar view at 50m depth and (d) shows a section along the black line in (a). (b) and (e) show the dissipation by biharmonic horizontal friction. The black line in (d) and (e) indicates the mixed layer base.

Submesoscale Karman vortex street

With our SMT-WAVE simulation, we study among other things, how mesoscale eddies interact with topographic obstacles and if instabilities or topographic waves are triggered. Here, we observe that a mesoscale eddies that hits a topographic obstacle can lead to substantial submesoscale Karman vortices downstream of the eddy rim. We refer to these eddies as submesoscale Karman vortices due its frequently observed mesoscale analogue. A comparison with a coarser resolved simulation (R2B9 with 5km horizontal resolution instead of less than 700m of the SMT-WAVE simulation) shows that only in SMT-WAVE intense submesoscale Karman vortices are forming. Investigations about relevant energy transfers of these Karman vortices is ongoing. In particular, we want to study how much dissipation is triggered by this Karman vortices generation.



Implications of tidal forcing for ocean energetics

During 2024, we substantially expanded the ICON SMT-WAVE simulation with tidal forcing for the period of nearly one year. This expansion was necessary since we realized that the Agulhas rings that form in the South Atlantic substantially influence the energy frequency spectra. We noticed that whenever an Agulhas ring was entering the study area, energy levels on all frequencies substantially increased. One year of data showed enough eddy crossings to obtain a reliable estimate of a mean energy spectrum. When comparing with energy spectra observed from mooring data, we noticed that the modelled energy frequency spectrum derived from the entire year was in much better agreement with the observations when comparing with previous estimates from shorter time periods (note that mooring data of two years from the TRR SONETT cruise was available to us). Currently, we are investigating the origin of the enhanced spectra. There are some indications that waves are trapped within the eddies before they dissipate. Those eddies could thus act as an internal wave grave yard and catalyse important energy conversions.

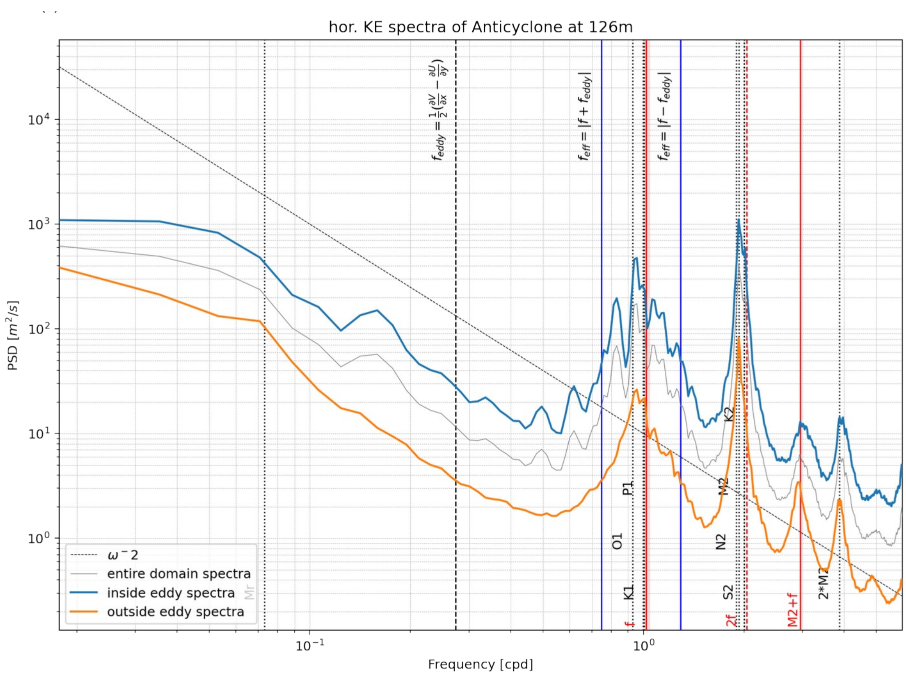


Figure 3: Energy spectra where the domain is filtered into points within an Agulhas ring (blue curve) and points without the eddy (orange curve), the spectrum derived from all points is denoted by the gray line.