Observations of ice draft (top), current speed (bottom, color), and mean surface velocity maximum [6, 13].

Baroclinic eddies play an important role in regulating the large scale circulation, momentum transfer, the transport and mixing of water masses and heat, and biology. The development of baroclinic eddies depends on a combination of the destabilizing effect of the velocity shear and the stabilizing effect of stratification.

The time scales characterizing baroclinic instability are local and based on linear assumptions. In order to gain further insights about the spatial and temporal evolution of the eddy field as a function of the ice cover we resort to a Pan-Arctic eddy resolving, 4 km resolution, multi-decadal run based on NSM4 GCM.

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Two snapshots of the vorticity field for September 2031 are shown above. As predicted by the theory, mixed layer eddies (left) rapidly disappear in the presence of ice, with relative vorticity dropping by more than five orders of magnitude across the marginal ice zone. In contrast, halocline eddies (right) are unaffected by the presence of ice.

Our analysis suggests that increasingly ice free summers will result in important changes in the state of the Arctic. The time scales characterizing baroclinic instability are local, but of the order of the seasonal cycle, suggesting that eddies are actually growing exponentially over most of the summer. Even a moderate extension of the ice free season will result in a large increase in the eddy activity in the mixed layer, with consequences on mixing of heat at the ocean surface, and on the re-growth of the ice cover following the winter.

References