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The influence of spatially and temporally high-resolution wind forcing on the power input to near-inertial waves in the ocean

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The estimated power required to sustain global general circulation in the ocean is about 2 TW. This power is supplied with wind stress and tides. Energy spectrum shows pronounced maxima at near-inertial frequency. Near-inertial waves excited by high-frequency winds represent an important source for deep ocean mixing since they can propagate into the deep ocean and dissipate far away from the generation sites.

The energy input by winds to near-inertial waves has been studied mostly using slab ocean models and wind stress forcing with coarse temporal resolution (e.g. 6-hourly). Slab ocean models lack the ability to reproduce fundamental aspects of kinetic energy balance and systematically overestimate the wind work. Also, slab ocean models do not account the energy used for the mixed layer deepening or the energy radiating downward into the deep ocean. Coarse temporal resolution of the wind forcing strongly underestimates the near-inertial energy. To overcome this difficulty we use an eddy permitting ocean model with high-frequency wind forcing.

We establish the following model setup: We use the Max Planck Institute Ocean Model (MPIOM) on a tripolar grid with 45 km horizontal resolution and 40 vertical levels. We run the model with wind forcings that vary in horizontal and temporal resolution. We use high-resolution (1-hourly with 35 km horizontal resolution) and low-resolution winds (6-hourly with 250 km horizontal resolution). We address the following questions: Is the kinetic energy of near-inertial waves enhanced when high-resolution wind forcings are used? If so, is this due to higher level of overall wind variability or higher spatial or temporal resolution of wind forcing? How large is the power of near-inertial waves generated by winds?

Our results show that near-inertial waves are enhanced and the near-inertial kinetic energy is two times higher (in the storm track regions 3.5 times higher) when high-resolution winds are used. Filtering high-resolution winds in space and time, the near-inertial kinetic energy reduces. The reduction is faster when a temporal filter is used suggesting that the high-frequency wind forcing is more efficient in generating near-inertial wave energy than the small-scale wind forcing. Using low-resolution wind forcing the wind generated power to near-inertial waves is 0.55 TW. When we use high-resolution wind forcing the result is 1.6 TW meaning that the result increases by 300%.