EGU2020-21330
https://doi.org/10.5194/egusphere-egu2020-21330
EGU General Assembly 2020

Eddy-Mean flow oscillations in the Southern Ocean

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Geostrophic eddies have a leading order effect on the dynamics of the Southern Ocean (SO), and numerous studies have shown that they are also key to the response of both the zonal transport and the meridional overturning circulation to wind stress changes. The role played by eddies in setting the intrinsic variability of the SO, however, is less well-understood. Here, inspired by recent work on the atmospheric jet, we investigate whether the eddy-mean flow interaction in the Antarctic Circumpolar Current can be described by a prey-predator nonlinear model.

To this end, we analyse data from a high-resolution eddy-resolving configuration of the MIT general circulation model: an idealised "channel" model with mechanical and thermodynamical forcing at the surface, and plausible zonal and meridional circulations.

Here, we show that a mechanism of eddy-mean flow interaction driving the intrinsic variability of the SO-like model is well described by a stochastic non-linear oscillator with damping. This model is a generalisation of the Ambaum-Novak oscillator, which has been successfully employed to describe the atmospheric storm track variability.

We find that, on length scales similar to that of individual zonal jets, the eddy-mean flow interaction is characterised by a high-frequency oscillatory mode, and that the characteristic time scale of the oscillation is comparable with classical estimates of the baroclinic life-cycle. A Gaussian smoothing of the phase space diagram also reveals the damped oscillatory character of the oscillation: this is in contrast with the atmospheric case, where damping is negligible and orbits are confined to energy surfaces.

This result may help inform the interpretation of the SO intrinsic and forced variability (such as, for example, the response to wind stress changes), and pave the way to further studies featuring more realistic model configurations.