Eddy Dynamics in the Southern Ocean: How does the interaction of the Antarctic Circumpolar Current with sea-bed topography influence the surface mixed layer and hence the carbon-climate feedback processes

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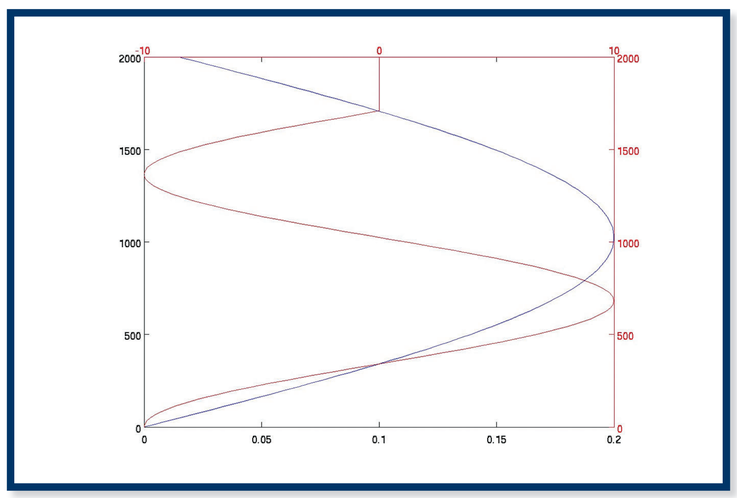
INTRODUCTION

The Southern Ocean (SO) is an important sink for heat and CO_2 and is one of the world's most productive regions[1]. The unique absence of blocking continents allows the Antarctic Circumpolar Current (ACC) to connect all ocean basins (Atlantic, Pacific and Indian). While the dynamics of the SO are dominated by this large meandering current, smaller scale processes are also important. For example, when flow encounters topography the generation of mesoscale features (such as eddies) can result. These mesoscale features influence water mass formation, meridional heat transport and carbon dioxide uptake[2]. This project investigates the how.

METHODS

The Regional Ocean Model Systems (ROMS) was used to simulate the idealised configuration of the ACC.



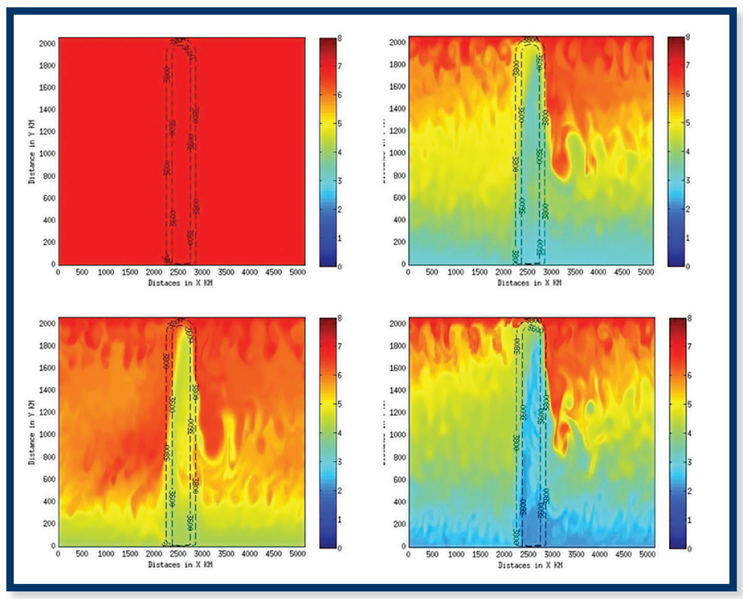
Left: Temporally-constant westerly wind and surface heat flux used to force the model.

Three experiments were performed to test the different topographic features on the ACC:

- A ridge;
- A plateau; and
- A canal full of seamounts.

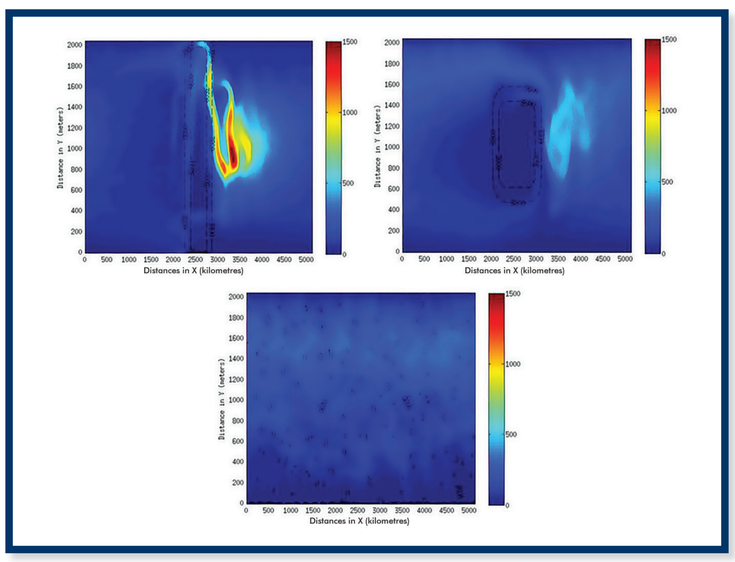
Model: 5 000 km horizontal direction, 2 000 km in meridional direction at 16 km resolution.

Evolution of Sea Surface Temperature (SST) in experiment 1 (experiment with a ridge)



From left: Model initialised with constant T of 8 °C over the whole domain, January year 5 (horizontal temperature gradients starts developing), January year 10 (upstream-downstream, differences start developing), January year 20 (upstream-downstream getting even worse), Bottom: January year 30 (model starts stabilising).

Comparison of EKE (kinetic energy resulting from perturbations) in all different experiments.
Stronger EKE means more eddies



From left: EKE from the 1st experiment (ACC flow over a ridge), 2nd experiment (ACC flow in a channel full of seamounts)

In all experiments, high EKE is observed downstream of the topographic features, which indicates the presence of mesoscale features such as eddies and movement of fronts which affects the mixed layer.

OUTLOOK

- Diagnose the EKE upstream-downstream
- Diagnose the Potential Vorticity (PV) of the ACC

REFERENCES

[1] Rintoul R. S. The Southern Ocean in the Earth System, 2011.
[2] Thompson et al., Rapid Southern Ocean front transitions in an eddy-resolving ocean GCM.

Eddy dynamics may hold the key to the climate sensitivity of the Southern Ocean carbon cycle.

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