



Université catholique de Louvain
Earth and Life Institute
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Earth and Climate Research

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Inclusion of a katabatic
wind correction in a
coarse-resolution global
coupled climate model

Antoine Barthélemy

The problem

Our solution

Impacts of the katabatic
correction

Experimental design
Sea ice
Ocean

Inclusion of a katabatic wind correction in a coarse-resolution global coupled climate model

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CR9.10: Sea ice physical and biological processes and interactions with climate

Tuesday, 24 April 2012

A trip through the climate system

From the atmosphere ...

- ▶ katabatic winds from the Antarctic ice sheet

... through sea ice ...

- ▶ coastal latent heat polynyas

... to the deep ocean

- ▶ impacts on vertical mixing and deep water formation.

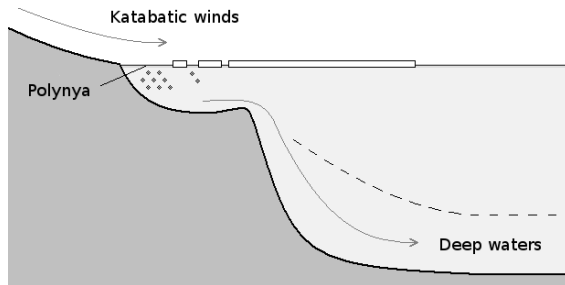


Figure: Processes between katabatic winds and deep waters.

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One picture

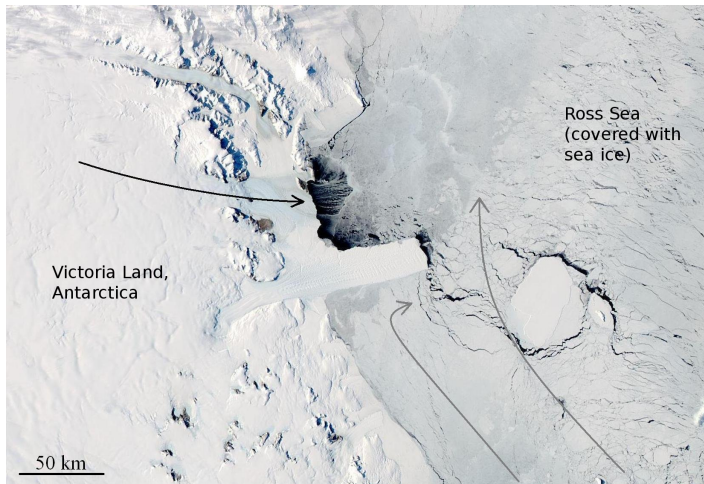


Figure: Coastal latent heat polynya opening by katabatic winds in Terra Nova Bay, Ross Sea (16 October 2007, <http://earthobservatory.nasa.gov>).

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LOVECLIM:

- ▶ 3D Earth system model of intermediate complexity
- ▶ coarse resolution in the atmosphere (5.6° in latitude and longitude, 3 vertical levels)
- ▶ simplistic representation of the atmospheric boundary layer.

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But katabatic winds:

- ▶ strongly influenced by the local topography
- ▶ katabatic layer typically 100 m deep.

So, katabatic winds in LOVECLIM:

- ▶ dramatically too weak
- ▶ biases in the modelled deep ocean properties ?

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A correction of wind stresses:

$$\tau_{\text{corrected}} = \alpha \tau_{\text{model}} + \beta$$

- ▶ based on a comparison with the (realistic) wind fields simulated by the MAR model
- ▶ for both the zonal and meridional components
- ▶ local
- ▶ constant in time
- ▶ applied only along the coast.

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To evaluate the impacts of the katabatic correction:

- ▶ two simulations: CTRL and KATA
- ▶ CTRL: standard configuration of the model
- ▶ KATA: including the correction
- ▶ 2000 year long quasi-equilibrium runs
- ▶ outputs averaged over the last 100 years
- ▶ long term response of the simulated climate.

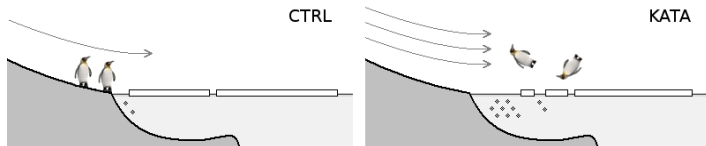


Figure: CTRL and KATA differ only in their coastal wind stresses.

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Sea ice thickness

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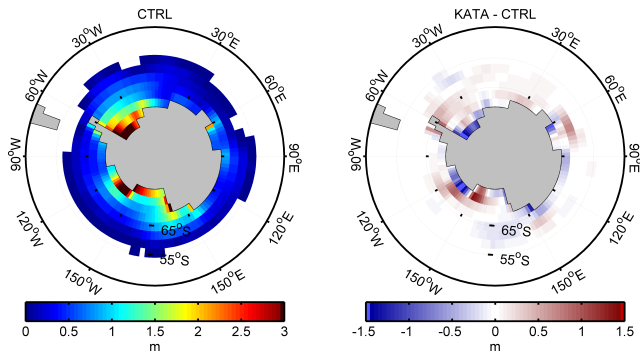


Figure: Modelled sea ice thickness in September.

- Strong ice thinning along the continent.

Winter mean coastal changes

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Simulation	CTRL	KATA	Difference
Concentration (%)	88	83	- 5
Thickness (m)	1.04	0.80	- 0.24
Production rate (m month ⁻¹)	0.18	0.27	+ 0.09

Table: Sea ice properties and production, averaged over a period from April to September and over the coastal ocean grid cells.

- Substantial increase in coastal sea ice production, therefore also in brine release.

Salinity changes

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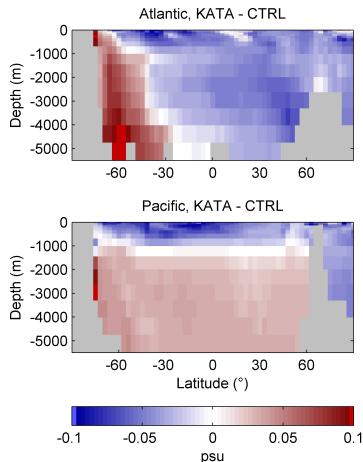
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- ▶ Saltier, denser waters on the shelf
- ▶ AABW production enhanced by 2.8 Sv
- ▶ Increase in the AABW salinity.

Figure: Salinity difference, on an annual and zonal average, between KATA and CTRL.

Temperature changes

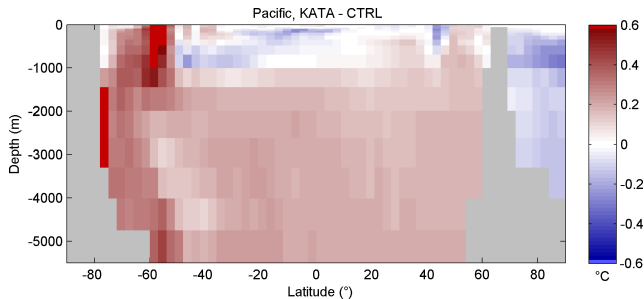


Figure: Temperature difference, on an annual and zonal average, between KATA and CTRL.

- ▶ Warming of the deep ocean
- ▶ Warmer AABW due to mixing with warmer water masses during its formation and to reduced open ocean convection in the Southern Ocean.

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Better agreement with observations

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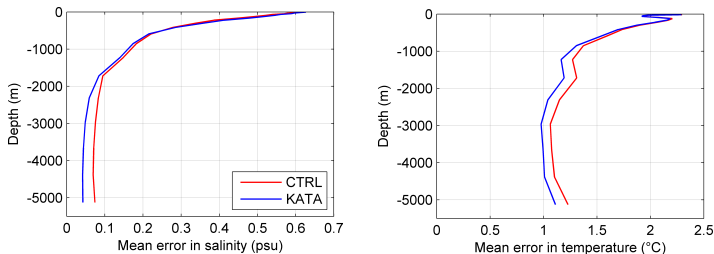


Figure: Global mean absolute error in salinity and in temperature, as a function of depth (errors with respect to observations from the World Ocean Atlas, Conkright et al., 2002).

Decrease of the mean error:

- ▶ 11 % for salinity (~ 37 % below 2000 m)
- ▶ 7 % for temperature (~ 9 % below 1000 m).

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The katabatic wind correction induces:

- ▶ an increase in coastal sea ice production
- ▶ a saltier and warmer AABW
- ▶ an improvement in ocean model results.

In a broader perspective:

- ▶ atmosphere-sea ice-ocean interactions important for the modelled deep ocean properties
- ▶ simple and efficient correction for the effects of katabatic winds
- ▶ applications for a wide range of climate models.

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Want more ?

Barthélemy, A., Goose, H., Mathiot, P., Fichefet, T., 2012. Inclusion of a katabatic wind correction in a coarse-resolution global coupled climate model. Ocean Modelling 48, 45-54, doi:10.1016/j.ocemod.2012.03.002.

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