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Southern Ocean heat and momentum uptake are sensitive to the vertical resolution at the ocean surface

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+ COSIMA community

An early case study of implementing the ACCESS-OM2 suite for science

ACCESS Science Day 2019

Earth Systems and Climate Change Hub

National Environmental Science Programme

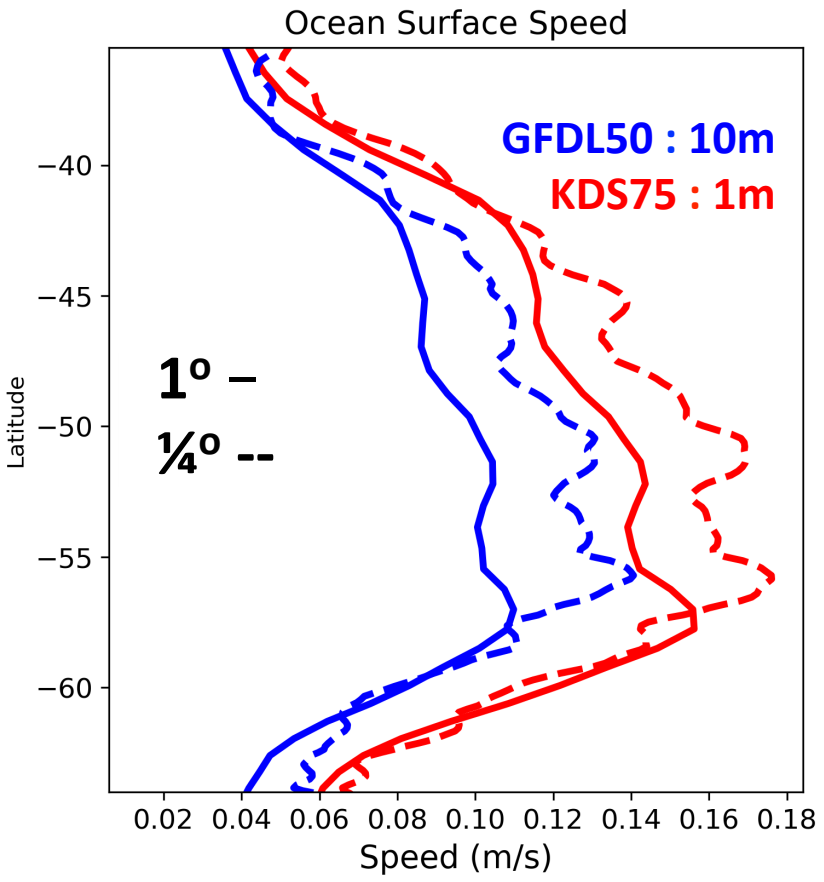
clex

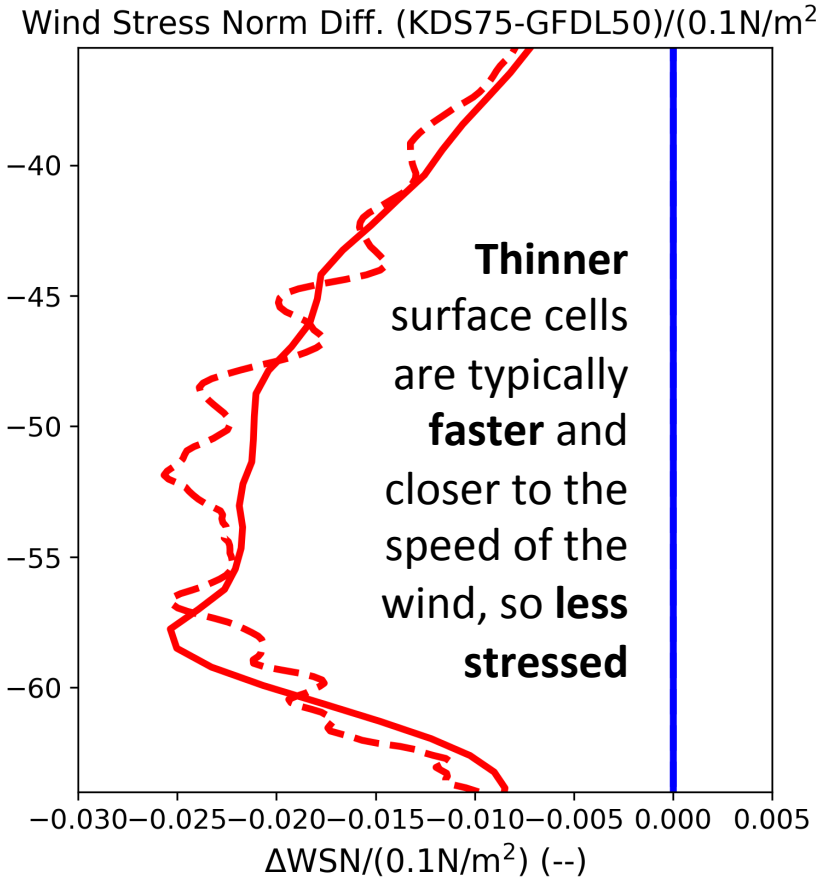
From Pacanowksi (1987), many ocean models treat wind stress as:

$$\tau = \rho_a C_d \left(\mathbf{u_a} - \mathbf{u_o}\right)^2$$

where $\mathbf{u_o}$ is the ocean surface speed, taken as the speed of the uppermost grid cell,

meaning $\mathbf{u_o}$ *and* $\boldsymbol{\tau}$ *are sensitive to the size/thickness of the uppermost grid cell.*





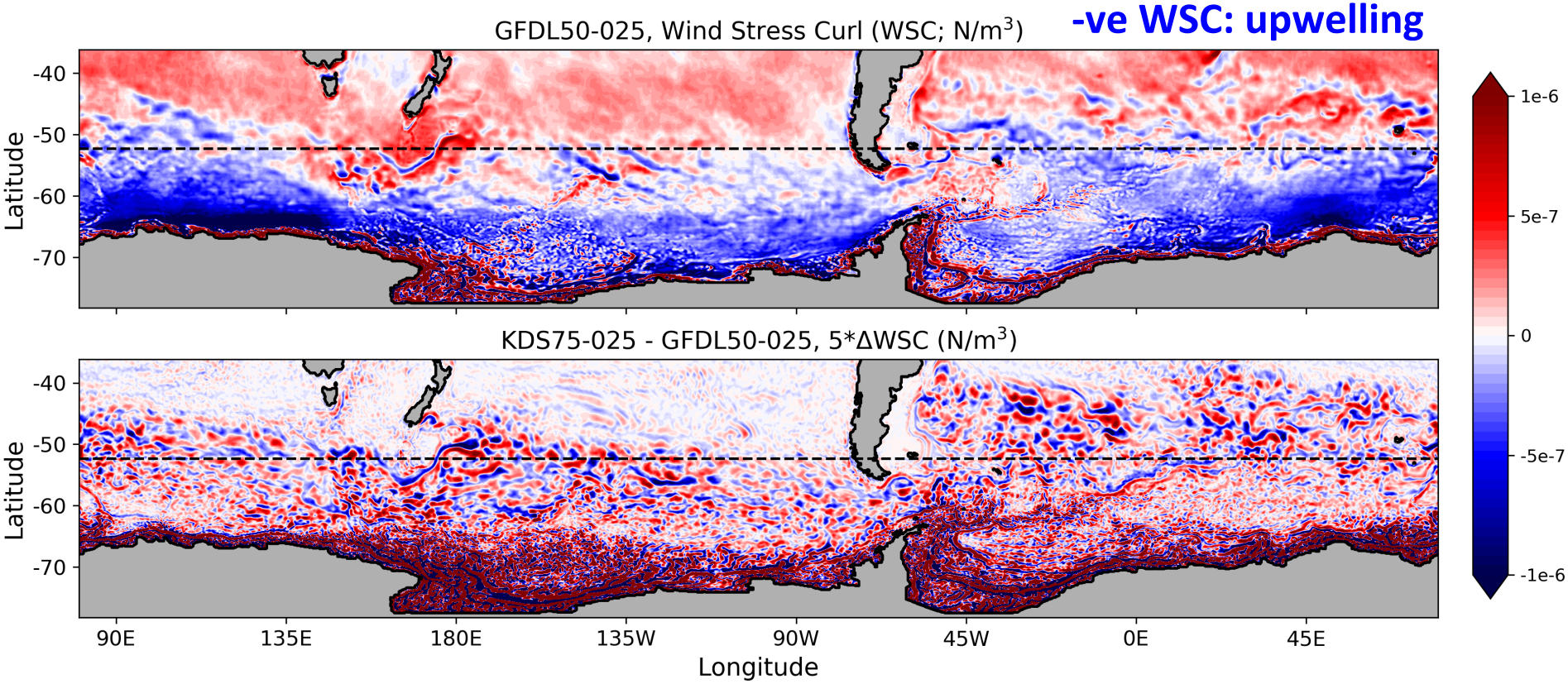
Wind stresses drive vertical velocities (Ekman pumping, w_{Ek}) through the wind stress curl:

$$w_{Ek} = \frac{\nabla \times \tau}{\rho_o f}$$

Ekman pumping is the primary mechanism for tracer (heat) to enter the ocean interior; it too is sensitive to the vertical resolution at the ocean surface.

+ve WSC: downwelling

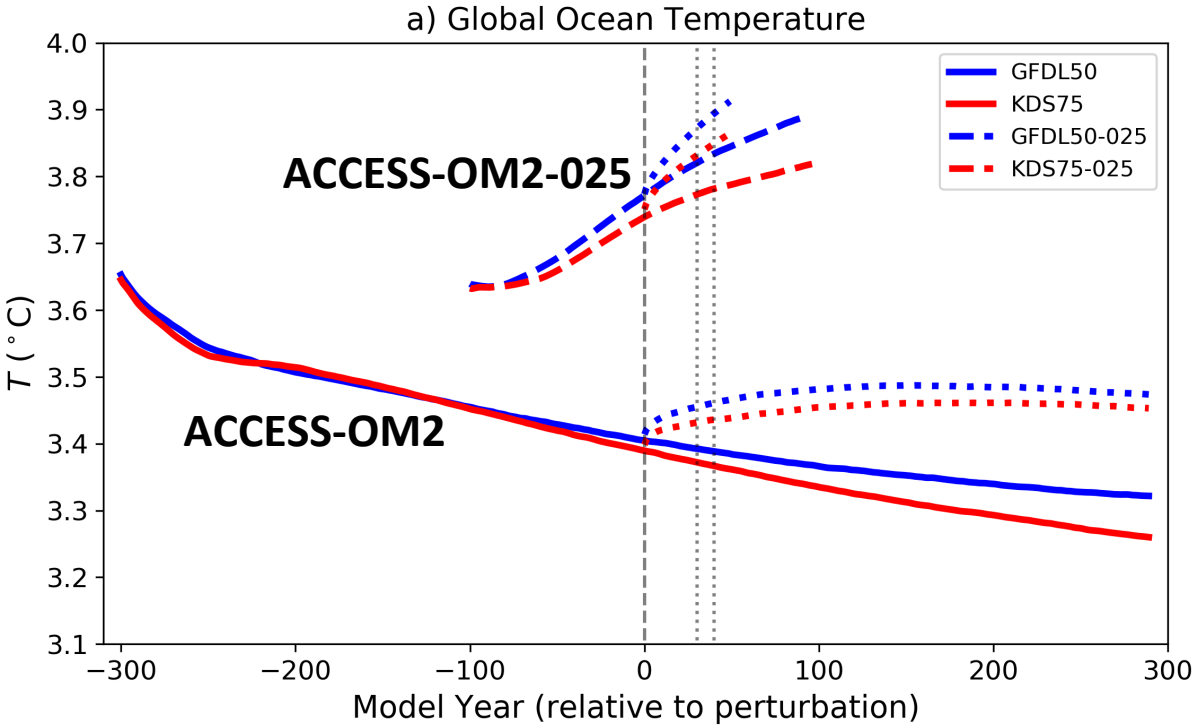
-ve WSC: upwelling

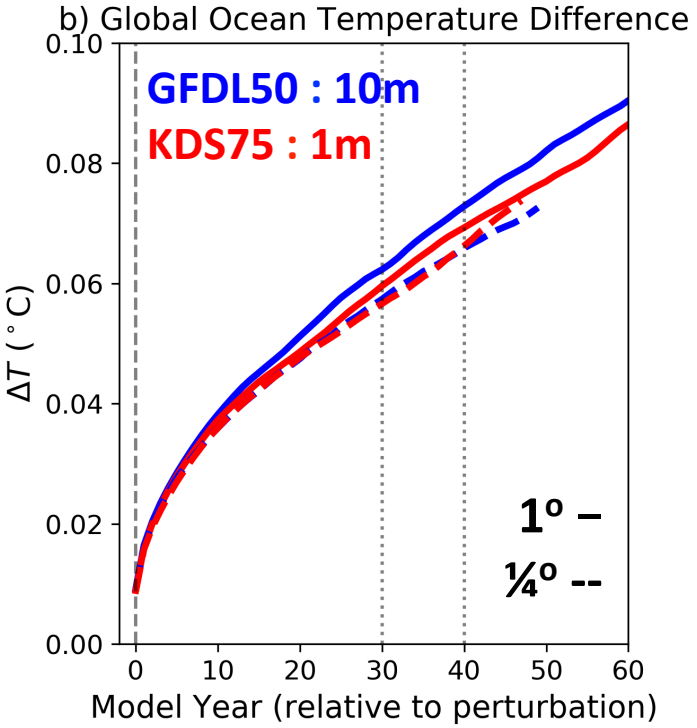


Coarser vertical resolution at the surface => strengthening of wind stress curl.

Given the dependence of wind stress curl on vertical resolution, what are the consequences for Southern Ocean heat uptake?

ACCESS-OM2 suite: 1° & ¼° with a range of vertical resolutions (2 shown here)





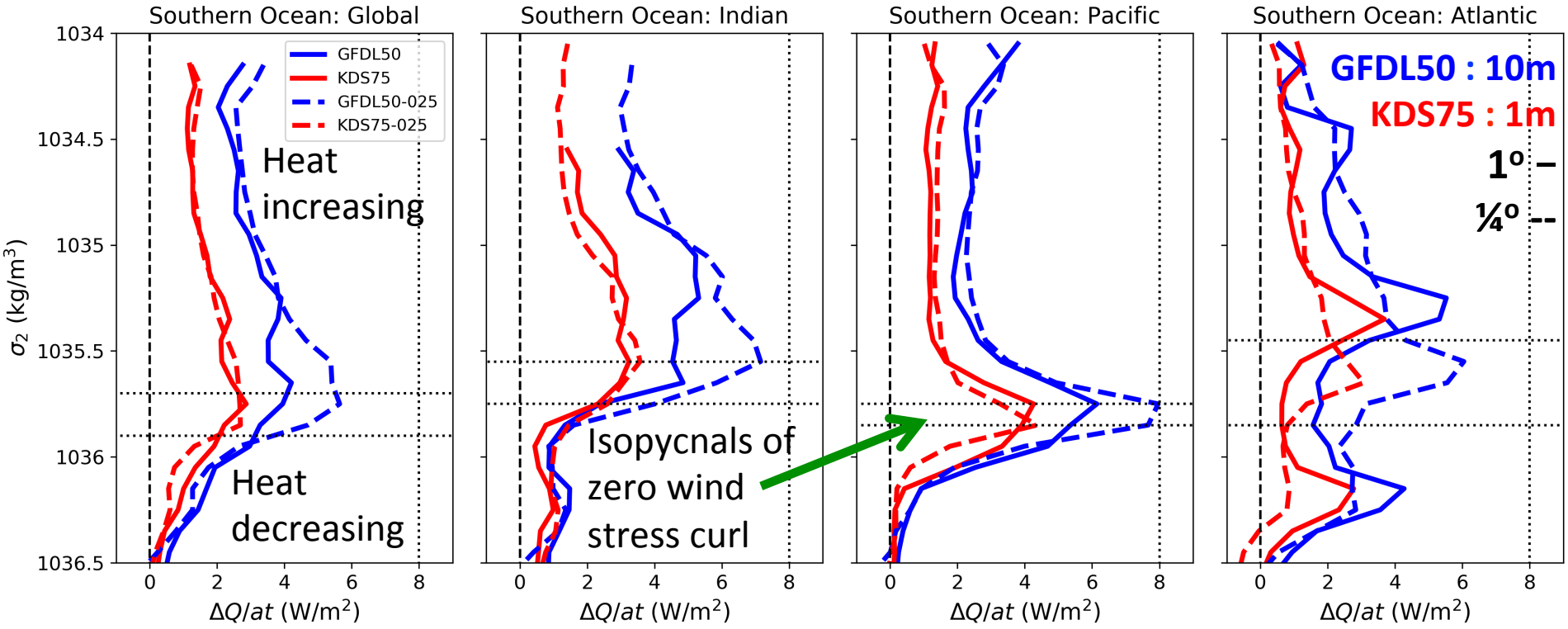
ACCESS-OM2: GFDL50 & KDS75
600 year Controls, 300 year Perturbations

ACCESS-OM2-025: GFDL50 & KDS75
200 year Controls, 50 year Perturbations

Perturbation is a globally uniform thermal anomaly (+1.5°C & +8W/m²) representative of RCP4.5

Southern Ocean heat uptake is sensitive to the vertical resolution at the surface.

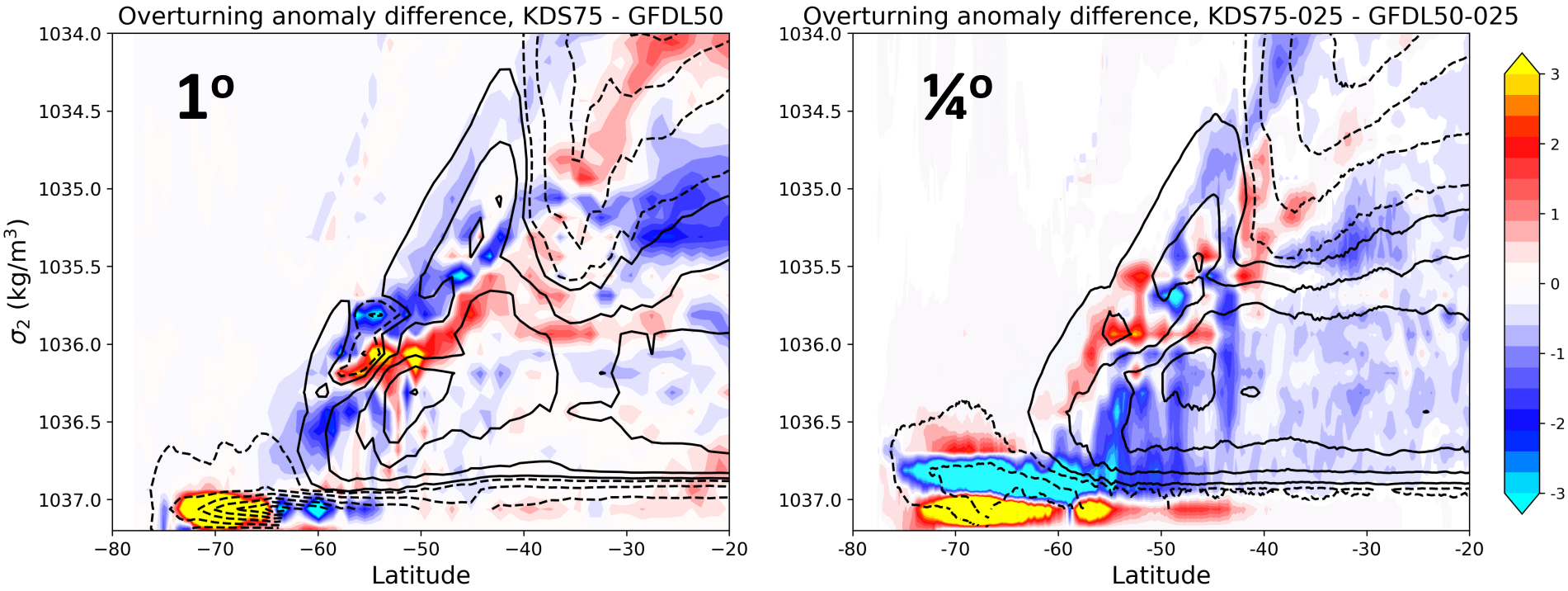
Rates of change of heat on Southern Ocean isopycnals, integrated surface-to-depth.



Distributions of the heat changes are related to the sign of the wind stress curl.

Response of the overturning circulation is sensitive to the vertical resolution at the surface.

Difference between overturning anomalies in density space



Response of the upper overturning cell to the thermal perturbation is stronger in the case of coarser vertical resolution at the surface.

ACCESS-OM2 suite ideal for exploring specific mechanisms and processes across a range of resolutions.

Able to evolve the scientific investigations as resolution is refined.

Vertical resolution at the surface is important for Southern Ocean heat and momentum uptake.