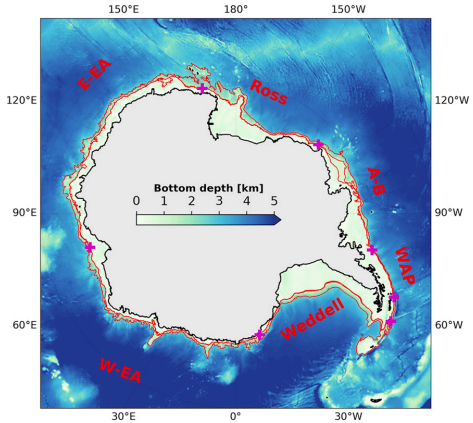
The Large-Scale Vorticity Balance of the Antarctic Continental Margin in a Fine-Resolution Global Simulation

Objective

Investigate cross-slope water transport mechanisms around Antarctica.



Approach

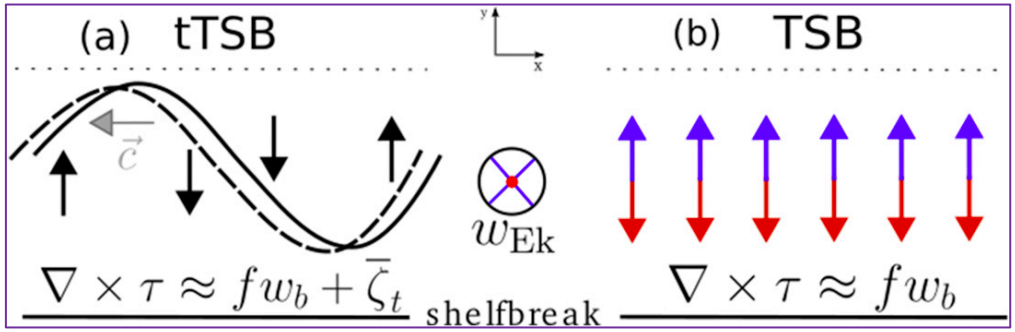
- Diagnose a full vorticity budget from a forced global 0.1° POP/CICE simulation around Antarctica.
- Compare regional differences in the vorticity balances.

$$\underbrace{\partial_t \overline{\zeta} = \overbrace{\overbrace{-\beta\overline{v} + \nabla\times\tau_s}^{\text{SB}} - fw_b}^{\text{TSB}} - \nabla\times\tau_b - \overline{\nabla\times(\mathbf{u}\cdot\nabla\mathbf{u})} + \overline{A_H\nabla^4\zeta}}_{\text{tTSB}}$$

where f and β are planetary vorticity and its gradient, v is meridional velocity, w_b and τ_b are, respectively, vertical velocity & horizontal kinematic stress at the bottom, τ_s is the total surface kinematic stress (due to relative sea ice motion and wind), **u** is the horizontal velocity vector, ζ is the vertical component of relative vorticity & A_H is the lateral viscosity coefficient. Overbars: vertical integrals. SB, TSB, and tTSB are the Sverdrup balance, topographic Sverdrup balance, and transient topographic Sverdrup balance, respectively.

Impact

This study performs a detailed examination of the depth-integrated vorticity balance in a global coupled ocean-sea ice simulation around the Antarctic Continental Margin (ACM) that is eddy-permitting in the study region. A potential mechanism for cross-slope transport (both onshore and offshore) based on the vorticity input of the surface stress curl (wind and sea-ice) is identified. The mechanism is more important in certain segments of the ACM than in others. These findings may have relevance for the representation of cross-slope transport in the ACM in next-generation Earth System Models, such as the Energy Exascale Earth System Model (E3SM).



Schematic: Physical interpretation of cross-slope transport in (a) the tTSB and (b) the steady TSB over a zonally oriented continental margin. βV is smaller than the other terms so is omitted; $\tau \equiv \tau_s - \tau_b$ is the net kinematic stress vector. In (a), the gray arrow indicates the direction of propagation of the topographically trapped waves associated with the tTSB, and the black arrows indicate the associated instantaneous meridional, cross-slope flow. The black curves show the displacement of a waveform (from solid to dashed). In (b), the red arrows indicate onshore transport associated with upward Ekman pumping ($w_{EK} > 0$, directed out of the page), while the blue arrows indicate offshore transport associated with downward Ekman pumping ($w_{EK} < 0$, directed into the page).

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