

Abyssal Current Steering of Upper Ocean Current Pathways in an Ocean Model with High Vertical Resolution

by

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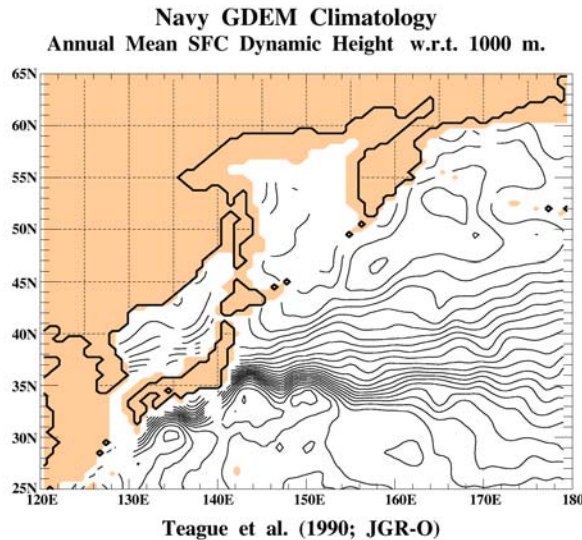
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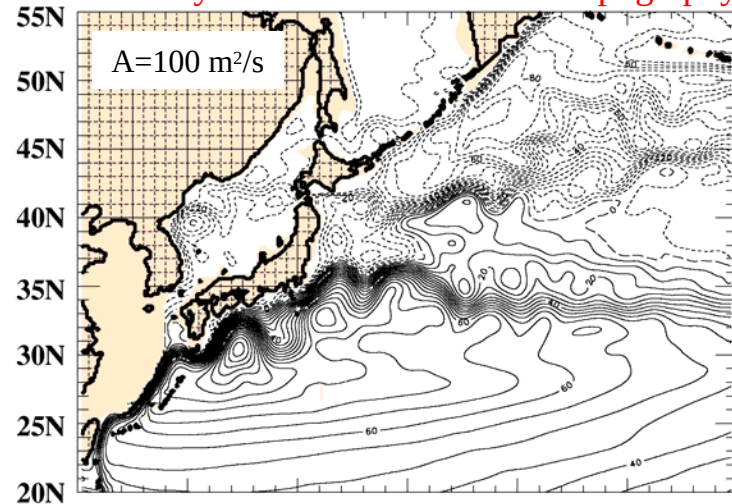
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Kuroshio Pathway East of Japan

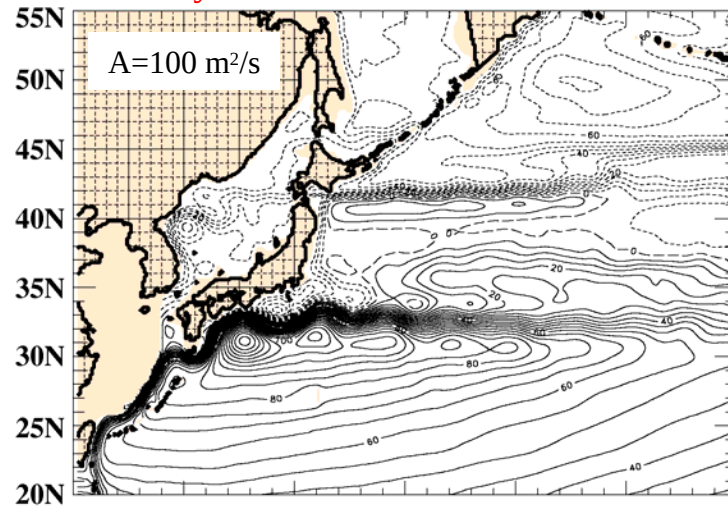
Impact of topography and model resolution



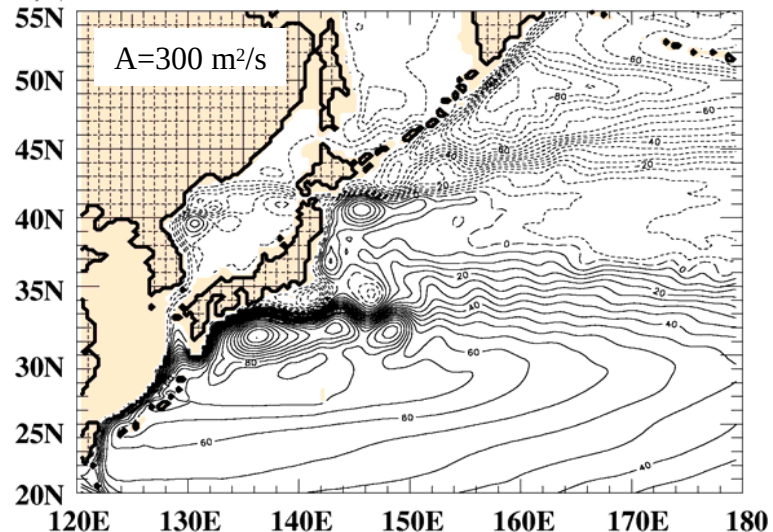
1/8° 6-layer with realistic bottom topography



1/8° 6-layer flat bottom



1/4° 6-layer with realistic bottom topography



Model mean sea surface height forced by Hellerman and Rosenstein (1983, JPO) wind stress climatology
From Hurlburt et al. (1996, JGR-O; 1997, Intl WOCE Newsletter)

Bottom Current Steering of Upper Ocean Current Pathways

In a **two-layer** model, the continuity equation for layer 1 is

$$\frac{\partial h_1}{\partial t} + h_1 \nabla \cdot \vec{v}_1 + \vec{v}_1 \cdot \nabla h_1 = 0 \quad (1)$$

The **advective** term in (1) can be related to the **layer 2 velocity** by

$$\vec{v}_{1g} \cdot \nabla h_1 = \vec{v}_{2g} \cdot \nabla h_1 \quad (2)$$

$$\hat{k} \times f(\vec{v}_{1g} - \vec{v}_{2g}) = -g' \nabla h_1 \quad (3)$$

Since $|\vec{v}_1| \gg |\vec{v}_2|$ (4)

∇h_1 is a good measure of $\vec{v}_1$.

From this, we see that **abyssal currents** affect the **advection** of upper layer thickness gradients and therefore the **pathways of upper layer currents**.

(Hurlburt and Thompson, 1980, JPO; Hurlburt et al., 1996, JGR-O)

Application of the 2-layer Theory for Abyssal Current Advection of Upper Ocean Current Pathways to Models with Higher Vertical Resolution

Applies when all of the following are satisfied:

- a) The flow is nearly geostrophically balanced**
- b) The barotropic and first baroclinic modes are dominant**
- c) The topography does not intrude significantly into the stratified ocean**

The interpretation in terms of surface currents applies when $|\vec{V}_{\text{near sfc}}| \gg |\vec{V}_{\text{abyssal}}|$

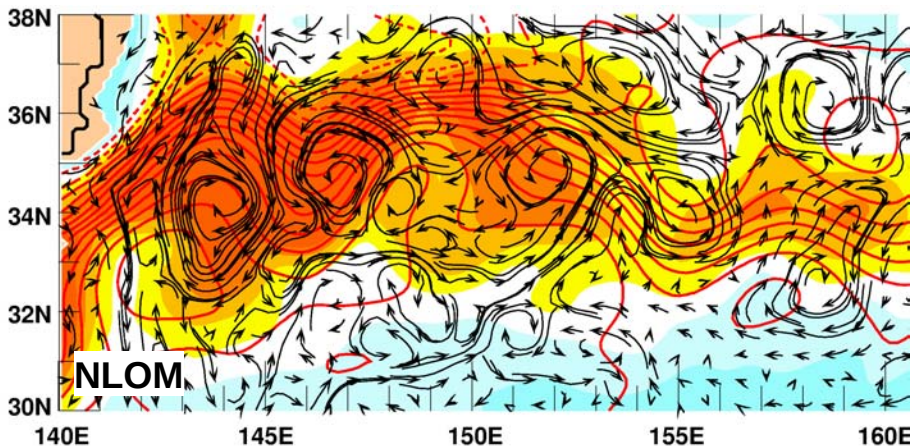
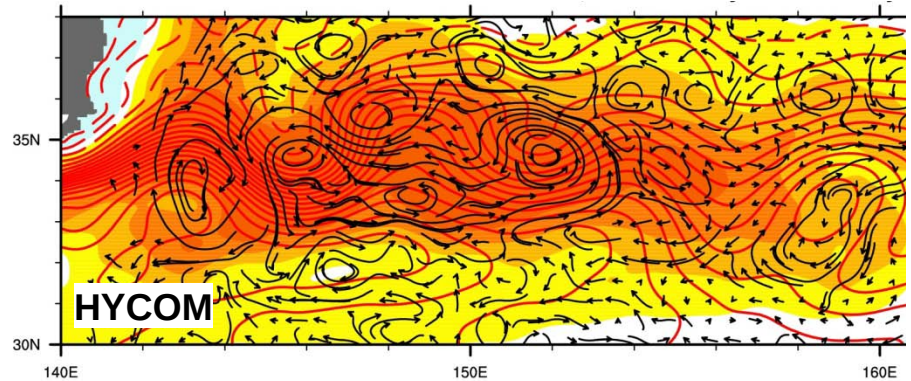
Notes:

- 1) The theory does not apply at low latitudes because of a) and b)**
- 2) Abyssal current advection of upper ocean current pathways is strengthened when the currents intersect at large angles, but often the end result of this advection is near barotropy**

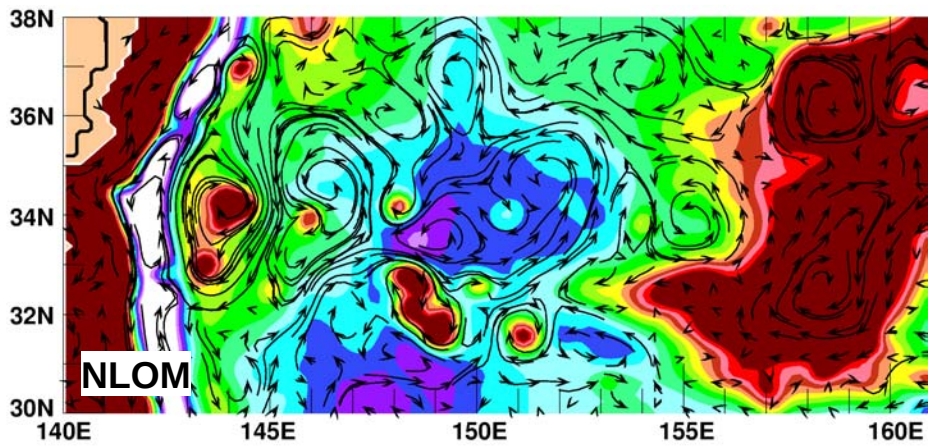
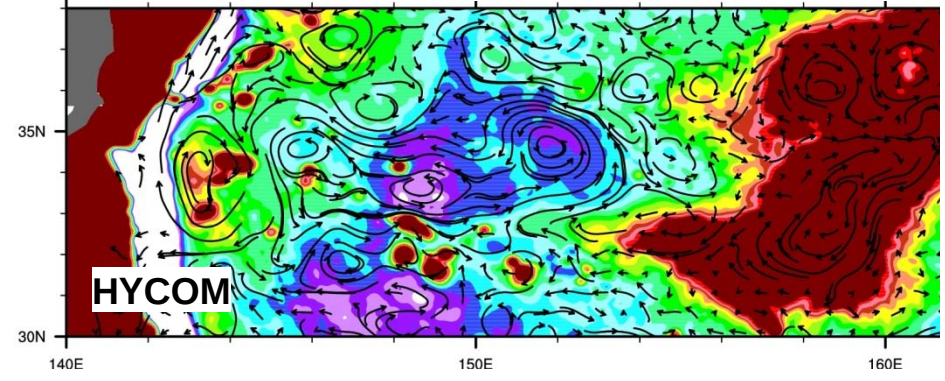
Upper Ocean – Topographic Coupling in the Kuroshio Extension

1/12°, 20-Layer Pacific HYCOM vs. 1/8° 6-Layer NLOM

Mean SSH, RMS SSH, and mean abyssal currents

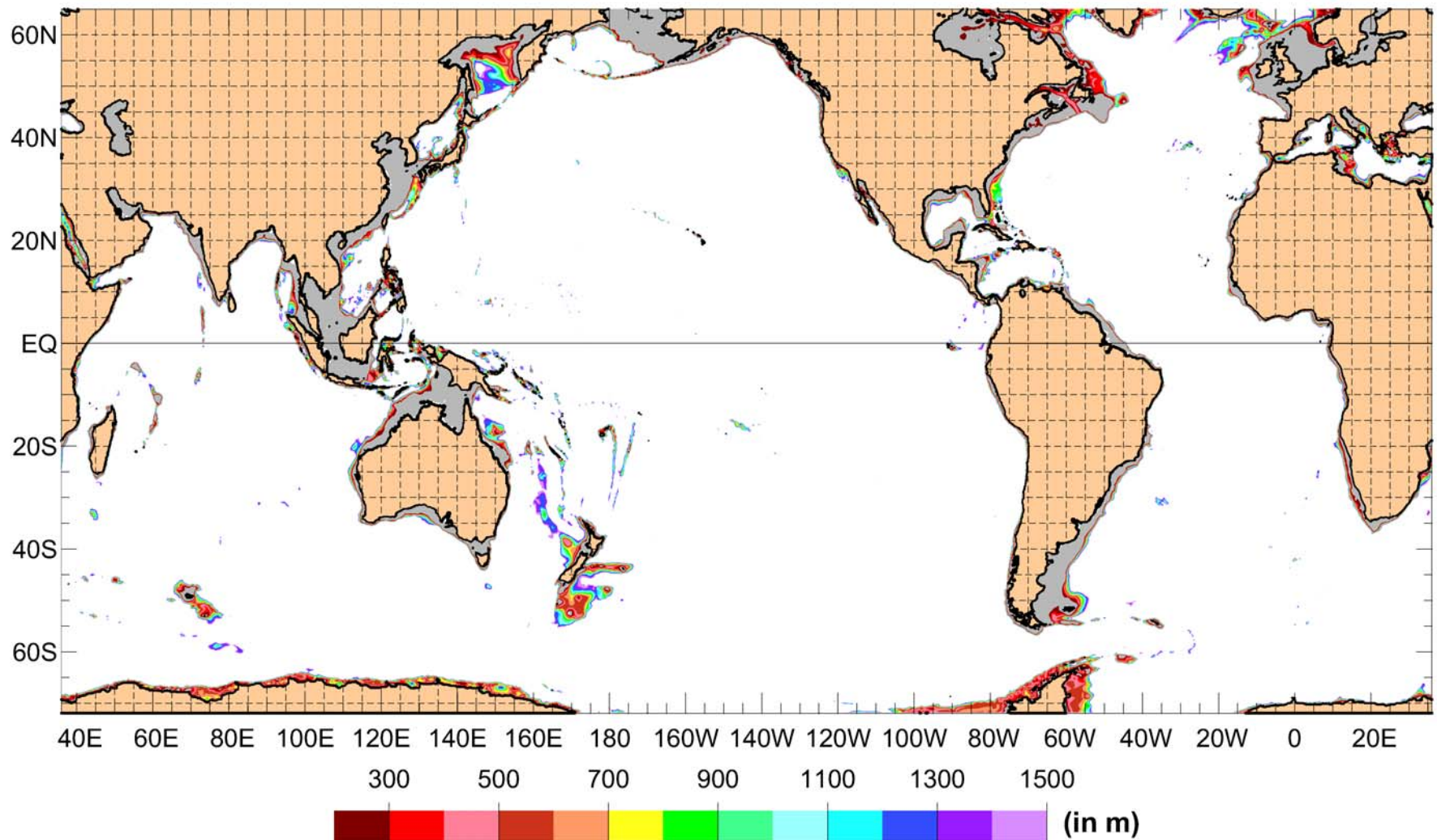


Mean abyssal currents and bottom topography



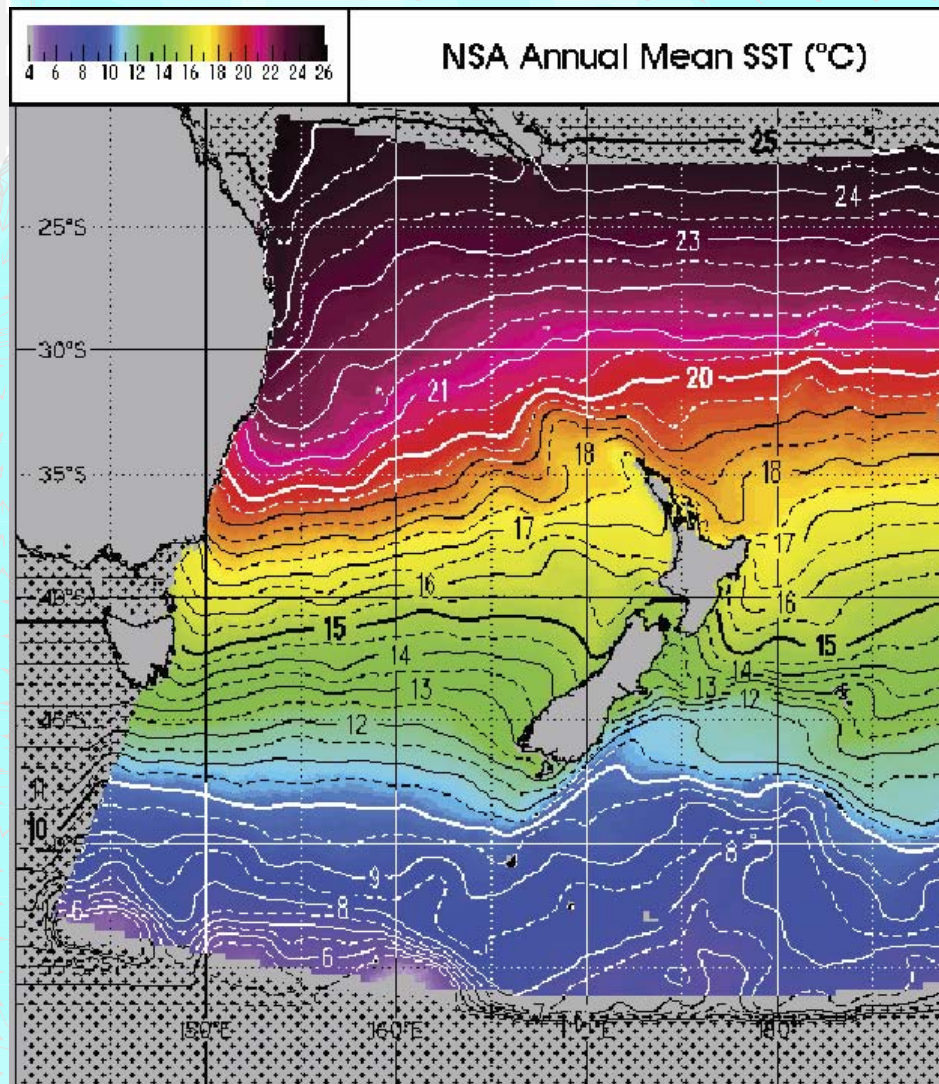
Adapted from Hurlburt et al. (2006; DAO submitted) and Hurlburt et al. (1996; JGR-O)

Global ocean depths between 200 m and 1500 m



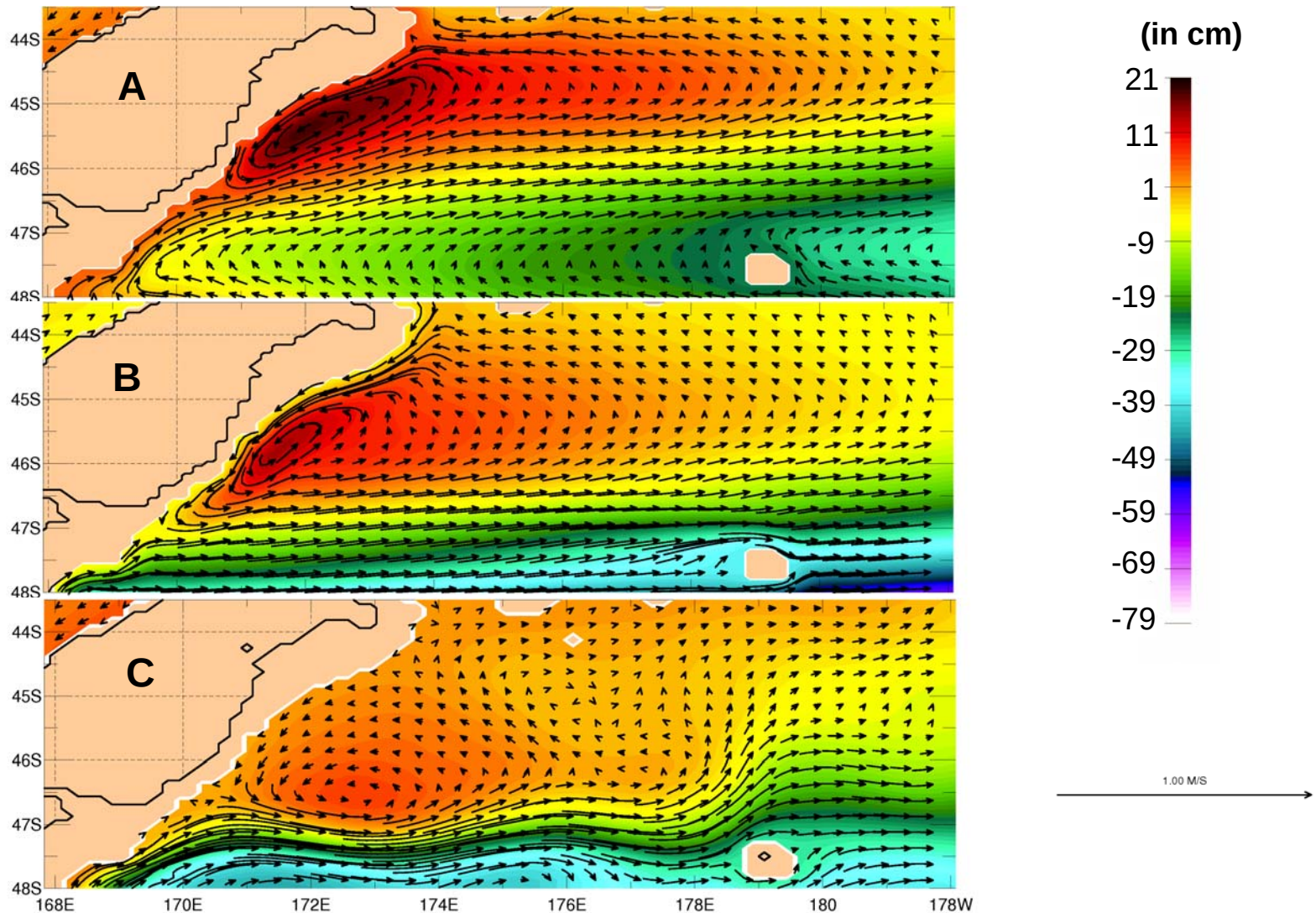
Only 6.5% of the seafloor lies in the depth range 200-1500 m

Mean Sea Surface Temperature Around New Zealand



- Uddstrom and Oien,
JGR (1999)

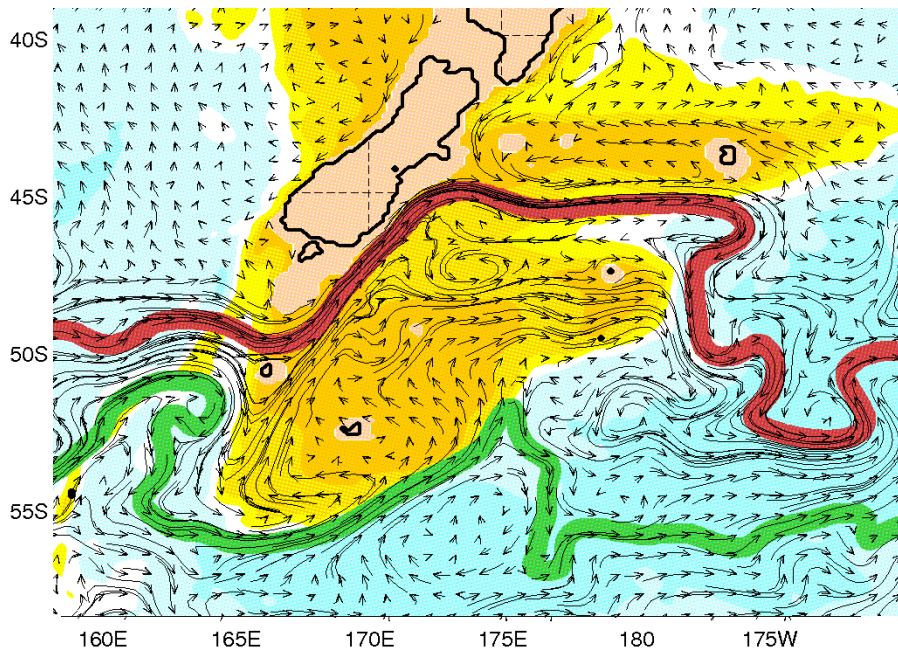
Mean Currents and Sea Surface Height Simulated by (A,B) $1/16^\circ$ Linear Barotropic Model and (c) the Surface Layer from $1/8^\circ$, 6-Layer Flat Bottom NLOM



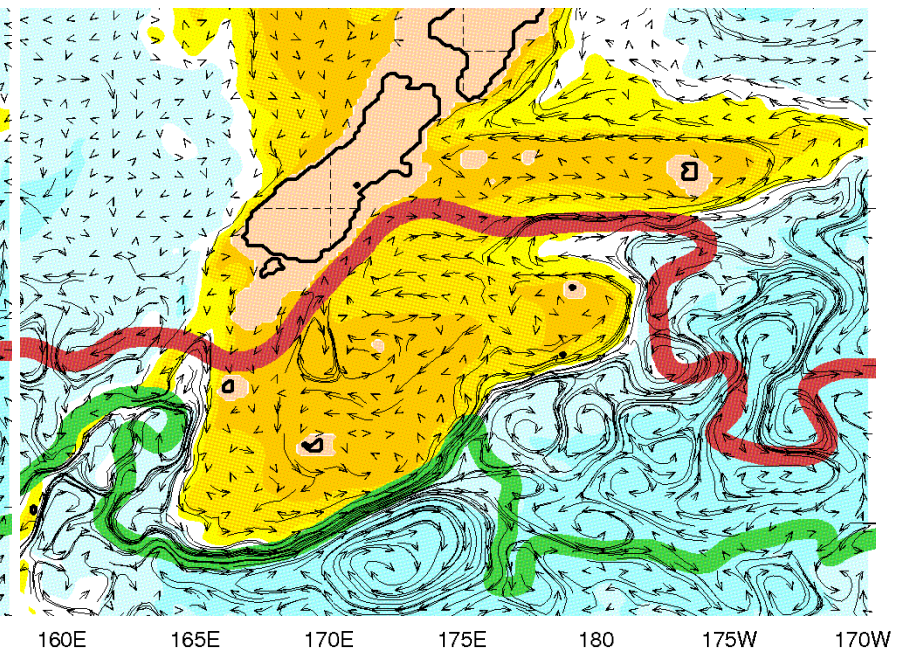
(A) QuikSCAT-corrected ECMWF ERA-40 climatological wind forcing
(B,C) Smoothed Hellerman and Rosenstein (1983) wind stress forcing

1/8°, 6-Layer NLOM Simulation of Mean Surface and Abyssal Currents East of South Island, New Zealand

Mean currents over bottom topography



Mean abyssal currents over bottom topography

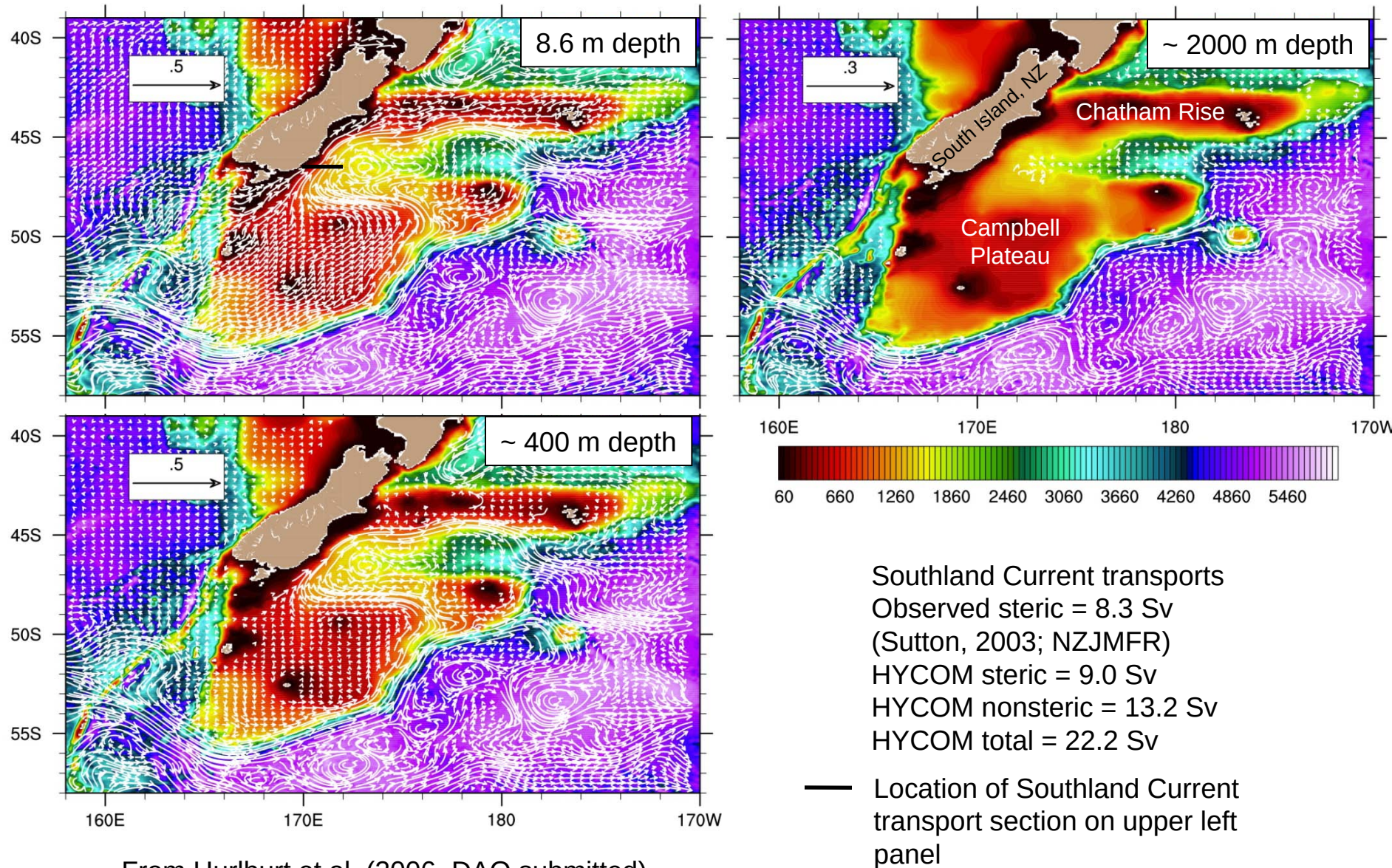


— Mean subtropical front (STF)
— Mean subantarctic front (SAF)

Smoothed Hellerman and Rosenstein (1983)
(HRSM) wind forcing

From Tilburg et al. (2002; JPO)

Mean currents simulated by 1/12°, 32-layer global HYCOM in the New Zealand region overlaid on seafloor depth



Mean sea surface height in the New Zealand region

