Introduction
Regional projection of sea level changes can deviate significantly from the global mean projection. Sea level integrates variations through the water column, therefore water density and ocean circulation changes at different depths provide more information about sea level changes. Dynamic height (DH) with reference to a deep no-motion layer derived from ocean temperature and salinity can build up connection between sea level and subsurface oceanic topography and circulation.

Projection based on CMIP3&5 climate models
DH with reference to 2000 db is used here as a proxy to diagnose dynamic topography and ocean circulation (Figs. 1&2). In the current climate, the subtropical gyre circulation in the mid-latitudes in both hemispheres is defined by the relatively high values, contracting poleward and weakening with increasing depth (Qu 2002; Figs. 1a&2). For the future climate under the SRES A1B Scenario,

- Poleward expansion of the subtropical gyre circulation is projected in the upper ocean for both hemispheres (Saenko et al. 2005; Figs. 1a2a).
- The subtropical gyre circulation is projected to spin down by about 20% in the subsurface North Pacific (NPac from the main thermocline around 400 m to at least 2,000 m, while the South Pacific (SPac) subtropical gyre is projected to strengthen by about 25% and expand poleward in the subsurface to at least 2,000 m (Figs. 1&2).
- This asymmetric distribution of subtropical gyre changes (barotrophic in the SPac vs baroclinic in the NPac) is closely related to the temperature field changes (Figs. 1a,b3). Similar asymmetric distribution can also be found in the new CMIP5 models (not shown).

Underlying mechanism
- Surface wind stress changes play significant roles in the regional distributions of DH and sea level, and in the asymmetry of the vertical distribution of DH in the subtropical gyres in the Pacific (450). However, both surface heat flux and freshwater fluxes also have non-negligible impacts. For example, stronger surface warming (with the help of fresher salinity change) in the upper ocean in the NPac subtropical gyre region makes the ocean more stratified, reinforcing the difficulty of the upper ocean warming penetrating to depth and accentuating the upper ocean warming (Fig. 3).
- The large-scale meridional atmospheric circulation (i.e., the Hadley Cell) is projected to expand poleward (e.g., Seidel et al. 2008, Fig. 4a). According to Sverdrup Balance (Sverdrup 1947), such poleward expansion in the atmosphere can also induce a poleward expansion of the subtropical ocean gyres (Fig. 4c). The NPac subtropical gyre interior is projected to spin down slightly between 15°N and 35°N (Fig. 4c), as a result of relatively weak cyclonic wind stress curl changes (Fig. 4b). Such weak spin-down is also evident in the depth-integrated steric height (DISH) changes (Fig. 4d). Anticyclonic wind stress curl change in the Kuroshio Extension region causes the Kuroshio recirculation gyre to spin up, however the spin-up only appears in the upper several hundred meters (Figs. 1&2). In contrast, the broad-scale anticyclonic wind stress curl associated with strengthening of southeasterly trade winds and mid-latitude westerly, drive the SPac subtropical gyre to expand and intensify poleward with peak stream function change of ~11 Sv east of New Zealand (Fig. 4c), consistent with DISH changes (Fig. 4d).
- The wind stress curl changes often result in westward intensification in the stream function and DISH change fields (Fig. 5). Along 45°S, coherent and strong anticyclonic wind stress curl changes across the whole basin lead to penetration of positive DH changes increasing westward from the eastern boundary. Heat content change also increases westward at this latitude (Cai et al. 2010). In contrast, along 35°N, the section east (west) of 160°W is projected to have anticyclonic (anticyclonic) wind stress curl changes, and the curl changes are also weaker. Therefore, the westward intensification of DH increases much shallower and is confined to the western half basin at the poleward edge of the NPac subtropical gyre (Fig. 5).

References
Sverdrup, H. U., 1947: Wind stress curl changes, and the curl changes are also weaker.

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Projection of subtropical gyre circulation and associated sea level changes in the Pacific based on CMIP3 and CMIP5 climate models
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Figure 1. Vertical distributions of specific volume anomaly change and dynamic height change under the SRES A1B Scenario during 2000-2080 relative to 1980-1999, and its thermosteric and haline components averaged over the western part of poleward flank of the North Pacific (South Pacific) subtropical gyre as shown on top (bottom) panels.