Response of atmosphere-ocean system to latitudinal shifts of the North Pacific subarctic frontal zone: A basin-scale two-way feedback

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Basin-scale ocean-atmosphere interaction associated with a western boundary current (WBC) in the extratropical North Pacific is investigated by performing idealized coupled GCM experiments. The subarctic frontal zone (SAFZ)–a North Pacific WBC that is characterized by sharp gradients of sea surface temperature (SST)– swings in latitude responding to basin-scale wind change and thus generates pronounced SST variability there on interannual-to-decadal time-scale. Recent observational diagnostic studies suggest that the latitudinal shifts of the North Pacific SAFZ can have significant impacts on basin-scale atmospheric circulation through modulations of near-surface baroclinicity and storm track. Robustness of the large-scale atmospheric response remains to be confirmed by modeling studies and it is an open question whether the WBC-induced atmospheric circulation change may in turn exert any dynamical forcing on the ocean, possibly leading to two-way ocean-atmosphere feedback in the extratropical North Pacific and thereby contributing to Pacific decadal variability (PDV). To address such climatic implications of the North Pacific SAFZ, we use an ocean-front resolving coupled GCM and conduct ensemble sensitivity experiments in which northward shifts of simulated WBCs are deliberately induced by imposing idealized wind stress anomaly in the central North Pacific that represents weakend Aleutian low, during the coupled integration. These partially constrained integrations are followed by further free integrations with the wind stress anomaly turned off, during which simulated ocean-atmosphere response is examined. Composite analysis across ensemble members reveals the existence of two regimes in the atmospheric circulation response and its feedback on the ocean. Namely, ensemble composite with warm (cold) SAFZ tends to be accompanied by weakened (enhanced) Aleutian Low acting as positive (negative) feedback (Fig. 1 top). The positive (negative) feedback promotes persistency (phase transition) of latitudinal position and SST anomalies in SAFZ (Fig. 1 bottom), a dynamical feedback that can be a key process for PDV and its predictability.

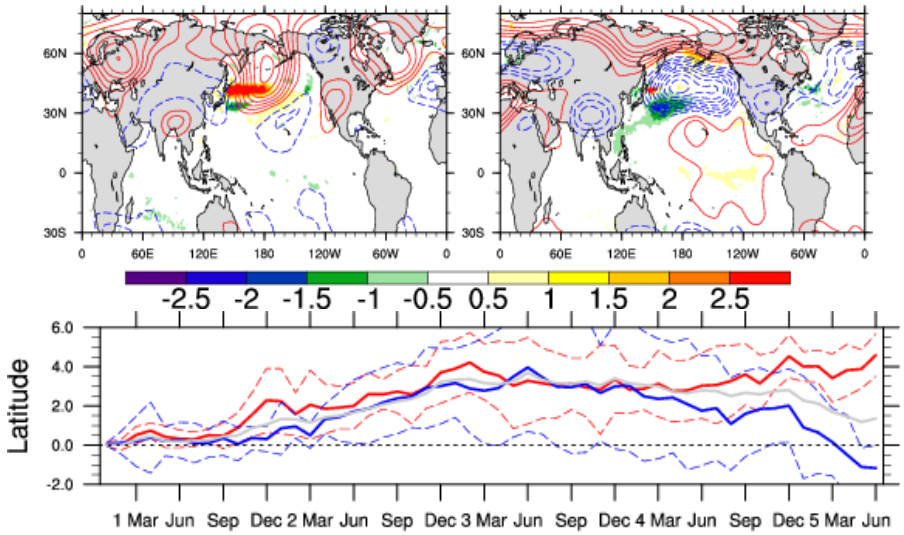

Figure 1: (Top) Ensemble composite of responses (sensitivity run minus control run) in geopotential height at 250 hPa level (contoured every 10m) and SST (shaded every 0.5°C). Positive (left) and negative (right) ensemble composite means are constructed for members whose SSTs averaged over SAFZ exceed one std dev and fall short of minus one std dev, respectively. (Bottom) Temporal evolutions of ensemble mean differences of SAFZ latitude. Red, blue, and gray curves display for positive, negative feedback, and total ensembles.