Kuroshio Extension and Gulf Stream’s influences on the variability of near-surface baroclinicity and the associated atmospheric fields

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Evidence is mounting that mid-latitude western boundary currents (WBCs) can influence large-scale atmospheric circulation variability on interannual-to-decadal time scales. It is, however, still unclear how significantly such extra-tropical oceanic influences stand out of the intense variability intrinsic to the mid-latitude atmosphere. Here we examine the influences of extra-tropical oceanic frontal zone and its variability in the Gulf Stream (GS) and Kuroshio Extension (KE) regions on winter-season atmospheric variability in 20-member ensemble historical AGCM simulations with a horizontal resolution about 100km prescribed with satellite-observed, high-resolution sea surface temperature (SST) and sea-ice variability for the period 1982-2013. We focus on the near-surface baroclinicity ***B*** at 925 hPa as the quantity that is crucial for baroclinic eddy growth in the troposphere and is likely to be highly constrained by underlying oceanic frontal zones via air-sea heat exchange. We characterize the ***B*** variability separately in the GS and KE regions by applying EOF analysis to DJF-mean ***B*** across all the ensemble members and to that based on JRA55 reanalysis and then examine atmospheric and sea surface fields associated with their leading modes.

The simulations capture well the spatial structure of the observed ***B*** variability in both the WBC regions. Their leading modes (EOF1), explaining 42% (35%) of the total variance, represents intensifications of ***B*** over the GS (KE). While the EOF1 in the GS region is associated with enhanced storm track activity and westerly jet aloft, and geopotential height anomalies that resemble the negative phase of North Atlantic Oscillation (NAO), the EOF1 in the KE region is associated with a meridional dipole in height anomalies that resembles Western Pacific pattern. Further analysis of surface heat flux and SST anomalies contrasts the role of the two WBCs in the variability of ***B*** and the associated atmospheric features. Specifically, the enhanced ***B*** in the GS region is associated with enhanced heat release from the ocean, but with no SST anomalies, when cold air outbreaks spread across the sharp SST front over the GS. Over the KE, on the other hand, ocean-induced warm SST anomalies enhance heat release from the ocean, strengthening the overlying ***B***. Consistently, the evolution of observed PC1 time series is captured by the ensemble mean of the simulated PC1 in the KE region (r=0.46) but not in GS region (r=0.05). The former indicates the KE-induced SST anomalies adds a predictable component to ***B*** and the associated atmospheric variability in the North Pacific, while the latter reflects the variability mainly initiated by intrinsic NAO.

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