The climatological freshwater input to the Sea of Okhotsk and the potential role of terrestrial water from the Kamchatka Peninsula

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The Sea of Okhotsk, which is covered by sea ice in winter, is recognized as having a dramatic relationship with terrestrial water. An example is the Amur River. Abundant freshwater and terrestrial materials from the Amur River could contribute to sea ice variability and phytoplankton growth within and around the Sea of Okhotsk. Dense Shelf Water (DSW), which is activated by salt rejection with high sea ice productivity in the northwestern continental shelf, plays as an important transporter of many materials to the North Pacific Ocean via the intermediate layer. On the other hand, the variability of the DSW salinity significantly correlates the precipitation over the Kamchatka Peninsula and the northern coast of the Sea of Okhotsk with anti-phase (Uehara et al. 2014, Progress in Oceanography). This negative correlation suggests that freshwater input except the Amur River might have a hidden contribution to the hydrological cycle and the environment in the Sea of Okhotsk. However, the amount of freshwater discharge from the Kamchatka Peninsula and other coastal lands is unclear because there are numerous small river basins with complex mountains and the lack of the direct observation. Such uncertainty also leads to unclarity of total freshwater input in the Sea of Okhotsk. Although the previous study (Aota and Ishikawa 1991) roughly demonstrated the total freshwater input into the Sea of Okhotsk by manually reading charts of precipitation and evaporation, a more reliable approach is needed.
In this study, we evaluated riverine discharge from the Kamchatka Peninsula by using the atmospheric model (WRF) with high horizontal resolution (5km). The riverine discharge was derived by the precipitation and evaporation of model output and compared with 11 observed riverine discharge provided by Russian Hydromet. WRF succeeded in replicating the annual amount of observed discharge. Additionally, the climatic freshwater input into the Sea of Okhotsk was evaluated by using several atmospheric reanalyses together with WRF during 1982 to 2016. As a result, the total freshwater reached about 1284 km^3 /yr which consists of 49 % from the precipitation over the Sea of Okhotsk, 28 % from the Amur River, and 21 % from the northern coast of Sea of Okhotsk and the west side of the Kamchatka Peninsula. The last region occupies about 14 % to the total catchment area although the Amur River has 46 %. This implies that heavy precipitation (snowfall) occurred in a narrow region and discharged to the Sea of Okhotsk as terrestrial water. We also tested that the variability of annual freshwater discharge from the Kamchatka Peninsula relates to sea ice and sea surface temperature (SST). The significant lag relation preceding the discharge from the Kamchatka Peninsula was found as negatively to the sea ice and positively to annual SST around Peninsula from 1982 to 2004, which looks similar to the evidence found for the Amur River (Ogi et al.2001).

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