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Beaufort shelfbreak eddies related to summertime sea level pressure pattern in the Arctic Ocean

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Mesoscale eddies and shelf-basin exchange of the Pacific water in the western Arctic Ocean are investigated by using a variety of satellite datasets and the eddy-resolving coupled sea ice-ocean model. The Moderate-Resolution Imaging Spectroradiometer (MODIS) sea surface temperature detects a few warm-core eddies along the Beaufort shelf break in September 2003. The eddy-like pattern of sea ice floes are captured by the Global Imager (GLI) and the Land Remote Sensing Satellite (LANDSAT) radiance images in the vicinity of the Barrow Canyon. Modeling results using the National Centers for Environmental Prediction (NCEP) climatological atmospheric forcing suggest that the origin of the Beaufort shelf-break eddies and timing of their generation can be classified into three types. Generation of Type-I eddies is explained by a theory of Kubokawa (1991) who proposed that a low potential vorticity (PV) water outflow from a strait could create a large anti-cyclonic eddy. In this case, the Barrow Canyon plays the role of the strait. There appear to be remarkable differences of origin depth and background hydrographic structure between Type-II and Type-III eddies. Type-II eddies are spawned from the shelf slope at mid-depth during early summer, while Type-III eddies are generated from the PV front in the surface layer over the shelf break during late summer. The baroclinic instability of the eastward shelf-break jet, which is bottom-trapped in July and surface-intensified in September, appears to be a principal factor in generation of these eddies. This shift from Type-II to Type-III eddies is caused by buoyancy input, such as from solar radiation and sea ice melt, in the upstream region.

To verify dependence of the Pacific water transport on the atmospheric circulation field, additional numerical experiments using the NCEP atmospheric forcing dataset in 2003 and 2007 are performed. When the model is driven by the forcing in 2003, the Barrow Canyon outflow and the corresponding eddy generation are notably enhanced. The QuikSCAT sea wind vectors indicate that northwesterly wind is frequently intensified in the Chukchi Sea during the summer in 2003. Hence a westerly wind anomaly arises relative to the climatological wind fields. Therefore, it is suggested that the larger low-PV water outflow and stronger shelf-break current induced by the dominant westerly wind account for more energetic eddy production and consequent eddy-induced transport in the 2003 case. In contrast, the eddy activities significantly subside in 2007 because the intense easterly surface wind accompanying the anomalously high Sea Level Pressure (SLP) over the central Beaufort Sea pushes the Alaskan coastal water, including the Pacific water, northwestward over the Chukchi Sea. The Barrow Canyon outflow then becomes smaller during summer in the 2007 case. The shelf-break current is also quite weak or even sometimes flows westward. These conditions prevent mesoscale eddy generation. Instead, the surface Ekman transport is dominant factor in the shelf-basin exchange.

It is found that the shelf-wide to basin-scale atmospheric dynamics affect the Pacific water pathway including mechanisms controlling the transport, such as the eddy-induced transport or surface Ekman transport, in the southern Beaufort Sea. The interannual to decadal variations of summertime SLP fields in the Arctic Ocean have been discussed. For example, Ogi et al. (2008) suggested that the SLP average during July, August and September in the central Arctic shows high anomalies in 1998, 1999, 2005, 2007, and 2008 and low anomalies in 1992, 1994, 1996, and 2003. Our findings obtained in the present work indicate that the eddy-induced transport in the western Arctic Ocean would be promoted in the low-anomaly year.