Extratropical Cyclone Structures around Japan -Comparison between Extratropical Cyclones Developing around Japan and those in Northwestern Atlantic Ocean-

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Extratropical cyclones (ECs), which have horizontal scale of several thousands and time scale of a week, develop mainly in mid-latitude. They affect daily weather and sometimes cause extreme rainfall and severe winds, which result in meteorological disasters. ECs also affect climate variability: They interact with low-frequency variability such as North Atlantic oscillation. It is also pointed out that diabatic effects associated with ECs contribute to the initiation of atmospheric blocking.

Generally, there are two major conceptual model of ECs. The first model is Norwegian model, which was proposed in the beginning of 20 century. In this model, cold fronts catch up with warm fronts, and then occluded fronts form in the mature stage of ECs. The second model is Shapiro-Keyser model, which was proposed in 1990’s. In this model, an occluded front does not form, and bentback fronts extending rearward from the EC center develop. These two conceptual models are proposed mainly with the results of studies in the Northwestern Atlantic Ocean and Europe. Although the Northwestern Pacific is one of the major storm tracks, difference in EC structures between Northwestern Atlantic and Northwestern Pacific Oceans have not been well understood. In addition, a considerable number of ECs also passes over the Sea of Japan and Okhotsk Sea. Thus, the objective of our study is to clarify the differences in structures between ECs that develop around Japan and those develop in Atlantic Ocean

Firstly, ECs are automatically detected with the tracking method developed by Hodges (1994, 1995, 1999). Secondly, ECs that develop in Okhotsk Sea or the Sea of Japan (OJC), Northwestern Pacific (POC) and Northwestern Atlantic (AOC) were selected based on the locations where the ECs underwent the maximum deepening rate (in Bergeron; Sanders and Gyakum 1980). In the present study, only ECs with Bergeron larger than 0.5 are used to examine the structures of fully-developing ECs. In the composite analysis, physical variables are superposed with respect to the cyclone center. Furthermore, to examine differences in frontal characteristics between POCs and AOCs, atmospheric fronts are objectively detected with a method using thermal front parameter (e.g., Schemm et al. 2015).

The composite analysis shows clear differences in structures between OJCs, POCs and AOCs: OJCs have relatively strong cold fronts compared to warm fronts at KT, especially in Spring. On the other hand, both warm and cold fronts develop well for POCs and AOCs. Differences in frontal characteristics between POCs and AOCs are most notable in warm fronts. Warm fronts for AOCs tend to extend eastward or east-northeastward from the EC center, while those for POCs southeastward. It is also noted that bentback fronts for AOCs are stronger than those for POCs.

An analysis using a frontogenesis function shows that this difference in warm front is mainly due to the effect of shear deformation: the shear deformation in the southeast quadrant of POCs is larger than that of AOCs, resulting in development of the warm fronts in the southeast quadrant of the EC center for POCs, which are most notable in warm fronts.

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