Effect of SST in the Sea of Japan on the Winter Cyclones

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Introduction: Zhao et al. (2016, JGR) showed that the extratropical cyclone passage results in a localized surface cooling along the subpolar front in the winter Sea of Japan (Fig. 1) because of the cold-air outbreaks associated with the cyclones. It is reasonable that the SST alters atmospheric processes and, thus, a two-way coupling process may occur between SST (hence, the front) and the following cyclones which passing near the Sea of Japan, although the detailed process remains unclear. Using the WRF model Version 3.7.1 (WRFV3), we attempt to uncover such potential effect of the SST altered by the previous cyclones on the following ones during winter in the Sea of Japan.

Methods: We used the cyclone deepening rate as the indicator, and we chose 0.1 Bergeron as the criterion. Any cyclone, with CDR changed over Bergeron and last over 6 hours, would be regarded as “Affected”. There are 26 cyclones simulated in this study.

Results: According to our results, there were nearly one-fourth of cyclones remains unchanged, while others were largely modified. Analyses showed the cold air invasion over the Sea of Japan may be the key to make the cyclones sensitive or insensitive. When the northwesterlies located over the Sea of Japan, the atmosphere above became cold and unstable. A strong low-level baroclinic zone was found at the southern region of Japanese archipelago. With such situation, cyclones generate and pass through a southern path, over the Kuroshio region and Sea of Japan. The colder SST could therefore affect the cyclones aloft easily. When the northwesterlies located over the Okhotsk Sea, the atmosphere over the Sea of Japan was relatively warmer and more stable. Cyclones mainly generated over the continent where the colder SST of the Sea of Japan could hardly affect.
As for the “Affected” cyclones, Yamamoto (2013) suggested a weakening effect of the cold Sea of Japan on the cyclogenesis. However, we found, in this study, half of simulated cyclones was found to be intensified, i.e. CDR was increased over 0.1 Bergeron. Only 6 cyclones were weakened as Yamamoto (2013) suggested. Furthermo, the time series of the central SLP showed the intensified cyclones had an oscillated response. Such oscillation clearly indicated the existence of another effect of the cold Sea of Japan on the extratropical cyclones, and further results and analyses will be showed during the Meeting.

Keywords: Extratropical cyclone, cyclone activity, Air-Sea interaction

Precipitation distributions and cold conveyer belt associated with rapidly developing cyclone over the northwestern Pacific Ocean

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The precipitation distributions associated with the rapidly developing cyclones over the northwest Pacific Ocean are classified by the effect of moisture supply from sea surface on the cold conveyor belt. The difference between the 2 m temperature and the sea surface temperature (ΔT ≡T - SST) of the cyclone northern semicircle is used as a proxy of its effect. The cases of rapidly developing cyclones over the northwest Pacific Ocean are divided into type A: ΔT> -2 (higher temperature/lower SST), type B: -4 <ΔT <-2, and type C: ΔT <-4 (lower temperature/higher SST). Composite analysis is carried out at cyclone center for each type. As any cyclones develop, it transformed into a comma shaped precipitation zone. Type A cyclones are accompanied by the north-south elongated precipitation distribution associated with warm zone in the east side of the cyclone center. Type C cyclones have the precipitation distribution spreading relatively circular around the center of cyclone. There is a greater difference between the 2 m temperature and the sea surface temperature on the northern side of the cyclones, so it is more affected by the surface. Type C cyclones tend to develop over the region of Kuroshio extension and their maximum development rates are small than other types. It is inferred that Type C cyclones are developed mainly by the latent heat flux from the sea surface rather than a large-scale baroclinicity on the atmosphere side.

Impact of SST on heavy precipitation events over Japan during summer

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The previous studies have pointed out the role of sea surface temperature (SST) over the Japan Sea on winter precipitation on the downwind side under the northwesterly East Asian winter monsoon. However, the role of SST over the Japan Sea on precipitation during summer is not well understood. The heavy precipitation event occurred over the northern main island of Japan in early-August, 2013. The unusual precipitation seems to be associated with the significant moisture flux over the Japan Sea where the sea surface temperature was warmer than the normal. Here, the impact of SST warming over the Japan Sea on the heavy precipitation event is examined using a regional atmospheric model. In one experiment, the actual SST is prescribed as a lower boundary condition, while the climatological mean SST is given in another experiment. The simulated precipitation amount associated with the heavy rainfall event in the former experiment is more than that in the latter experiment, associated with the increased moisture flux. In addition, it is found that the heavy rainfall tends to occur near the coast when the SST is higher than the normal. The results suggest a potential impact of SST on severe precipitation events even during summer. The role of SST on other precipitation events are also discussed.

Keywords: Sea Surface Temperature, Precipitation, Japan Sea

Persistence of the sea surface temperature anomalies near the North Pacific oceanic front in early summer and the associated atmospheric and oceanic circulations

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This work examines the persistence of sea surface temperature (SST) anomalies in the early summer (June and July) along the North Pacific oceanic front and the associated atmospheric and oceanic circulations. Dividing the region of this oceanic front into two, i.e., the western(160˚E-170˚W, 35˚-45˚N) and the eastern(170˚-140˚W, 35˚-45˚N) parts, the discussion is enhanced through the comparison of anomalous circulations in these two regions. In the west, the early summer SST anomalies exhibit strong persistence from spring to fall. In the east, the persistence is rapidly weaken in fall.

The western SST anomalies have feedback with the lower stratus during summer, which enhances the persistence from spring to fall. On the other hand, the eastern SST anomalies decrease the amplitude by fall due to damping by surface heat flux. In addition, the sea water temperature (SWT) anomalies show significant differences in the depth profiles between the two regions. In the west, the SWT anomalies keep the strong persistence from the surface to at least 300m depth below the seasonal thermocline, while the persistence is weaken near the surface shallower than 25m by fall in the east, although the persistence is strong until winter in the deeper depth in the east. The eastern SWT anomalies in this deep depth reemerge near the surface with strong vertical convective mixing from fall to winter.

Keywords: the North Pacific oceanic front, persistence of summer SST anomalies

Influences of sea surface temperature on a heavy rainfall event over Shimane in late August 2013

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Shimane in western Japan suffered from heavy rainfall in late August 2013. This heavy precipitation is associated with a seasonal rain front and warm humid airflow over the Tsushima warm current. Although sea surface temperature (SST) distribution is considered to be important for the heavy precipitation, SST analysis data sets with high spatial resolution currently available have certain uncertainties because of differences in observations used and analysis procedures for the datasets. To investigate influences of SST on the heavy precipitation event and its sensitivity to SST datasets, we have conducted hindcast experiments with the weather research and forecasting (WRF) model with 3-km horizontal resolution with five different SST data as its lower-boundary condition. The experiments can reproduce heavy precipitation, though somewhat underestimated. The experiments have confirmed that the experiments with warmer SST data along the Tsushima current tend to reproduce the stronger precipitation. Since differences in evaporation and near-surface equivalent potential temperature are sensitive to the SST distribution, moisture supply, low-level stability and resulted precipitation can be modified by uncertainties in SST estimations. Therefore, the present study implies that quantitatively more accurate forecasts of heavy precipitations require more reliable SST distribution.

Keywords: sea surface temperature, heavy rainfall, air-sea interaction, Tsushima current

The role of midlatitude oceanic front in the formation of the climatological-mean atmospheric circulation

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We have performed a set of 15-member ensemble experiments using an atmospheric general circulation model (AGCM) to evaluate the role of midlatitude oceanic fronts in forming the climatological-mean atmospheric circulation. The first set of experiments (CNTL) is forced with satellite-observed sea surface temperature (SST) while the second set (SMTH) is with smoothed SST in which steep meridional gradient of SST associated with confluence of warm subtropical and cool subarctic current is largely reduced. Difference between the two experiments (CNTL-SMTH) highlights the role of frontal SST gradient. Namely, resolving the SST front in the mid-latitude North Pacific leads to enhancement of northward eddy heat flux by transient eddies around the latitudes of the SST front. It also leads to weakening of westerlies just to south of the climatological subtropical jet, while enhancement of the westerlies to the north of it in the mid to upper troposphere. Tropospheric geopotential height response to the frontal SST gradient is characterized by a meridional dipole of negative and positive anomalies over the Sea of Okhotsk and over the midlatitude western North Pacific, respectively, which resembles the Western Pacific (WP) pattern. In association with the WP-like pattern, the polar stratospheric temperature is elevated. Resolving SST front over the North Atlantic shows similar atmospheric responses to that over the North Pacific.

Keywords: oceanic front, midlatitude air-sea interaction

Effects of the Pacific high and the Tibetan high on occurrence of drought and cool summer in northern Japan

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Meteorological disasters, including drought, cool summer, and heavy rain, have a serious effect on the crop yields in Japan. In this study, the connections between occurrence of agro-meteorological disasters in northern Japan and pressure and temperature fields in the tropospheric and lower stratospheric circulation over East Asia are examined. Based on the monthly air temperature for northern Japan, hot summer years and cool summer years in northern Japan are extracted from the 35-year (1980-2014) sample. To investigate the connection between the hot/cool summer in northern Japan and atmospheric circulation over East Asia in summer, composite differences (hot summer years minus cool summer years) of several variables such as geopotential height, temperature, and vertical p-velocity are calculated. In addition, the statistical significance of these composite differences is evaluated using Welch’ s t test. The analysis showed high pressure anomalies over northern Japan in the troposphere and lower stratosphere. This indicates that both the North Pacific high and the Tibetan high tend to extend to northern Japan during the hot summer years. On the other hand, cool summer in northern Japan seems to be associated with the weakening of these highs. Additionally, we show the meridional circulation and rainfall distribution in hot/cool summer years.

Keywords: drought, cool summer, Tibetan high, North Pacific high

