The Role of North Pacific Teleconnection in the Beaufort Sea Level Change from Cryo-TEMPO Project

Yang Liu[1], Jianqi Sun[1], Roshin Raj[2]
1: Institute of Atmospheric Physics Chinese Academy of Sciences, People's Republic of China
2: Nansen Environmental and Remote Sensing Center, Norway

Abstract

In this paper, continuously altimetric satellite sea surface height measurements from Cryo-TEMPO between 2011 and 2020 are used to illustrate that the NPO plays a significant role in connecting the Beaufort Sea level to the Pacific Ocean. It is found that summertime NPO has a significant negative connection with sea surface heights in the Beaufort Sea. A negative NPO phase tends to be associated to an intensified Beaufort High paired with anomalous anticyclonic circulations over the Arctic, contributing to positive SSH anomalies locally because of increasing more freshwater entering the Beaufort Sea from the Chukchi Sea through Bering Strait. CESM2-LE is used to examine the connection between North Pacific teleconnection and the Beaufort Sea level change for longer time spans. It is suggested that the remarkable relationship between SSH in the Beaufort Sea and NPO is reproduced during 2011–2020, 2000–2020 and 1990–2020. In addition, the pre-winter SST may be a predictor for SSH in the Beaufort Sea. These findings highlight that the impacts of the teleconnection and SST anomalies in North Pacific on the Arctic sea level are of great importance and need to be taken into consideration when evaluating future climate predictions and projections.

Introduction

Sea level change is a vital sign of the changing climate, and sea level rise can have serious consequences for coastal societies and low-lying areas (e.g., Hauer et al., 2016; Kulp and Strauss, 2017; Song et al., 2017). While global mean sea level changes are an important indicator of global warming, sea level changes are not uniform at the globe scale and varies regionally (e.g., Cazenave and Llovel, 2010; Stammer et al., 2013). Sea level changes in Beaufort Sea are closely related to the climate variability in the Arctic. Recent studies showed that climate change in the Pacific can influence Arctic warming and sea ice (Svendsen et al., 2018; Yang et al., 2020). However, the role of Pacific Ocean in affecting sea level change in the Arctic Ocean is not clear. Here we use the state-of-the-art altimeter data and atmospheric reanalysis data to investigate the link between North Pacific atmospheric mode and the sea level change in the Arctic Ocean freshwater region, i.e., Beaufort Sea.

Data and Method

- Monthly sea surface heights are obtained from European Space Agency (ESA)' s CryoSat ThEMatic PrOducts (Cryo-TEMPO) project.
- Monthly mean atmospheric variables (such as SLP, zonal and meridional winds, geopotential height) are obtained from the fifth generation European Center for Medium-Range Weather Forecasting (ECMWF) atmospheric reanalysis (ERA5).
- Global monthly SST data are from NOAA Extended Reconstructed SST V5.
- Data from the large ensemble simulation by the Community Earth System Model version 2 (CESM2-LE).

Results

The time evolution of Beaufort Sea SSH (BSSSH) index during the period 2011–2020 summer is shown in Figure 1a. The index represents well variations of SSH in the Beaufort Sea (Figure 1b).

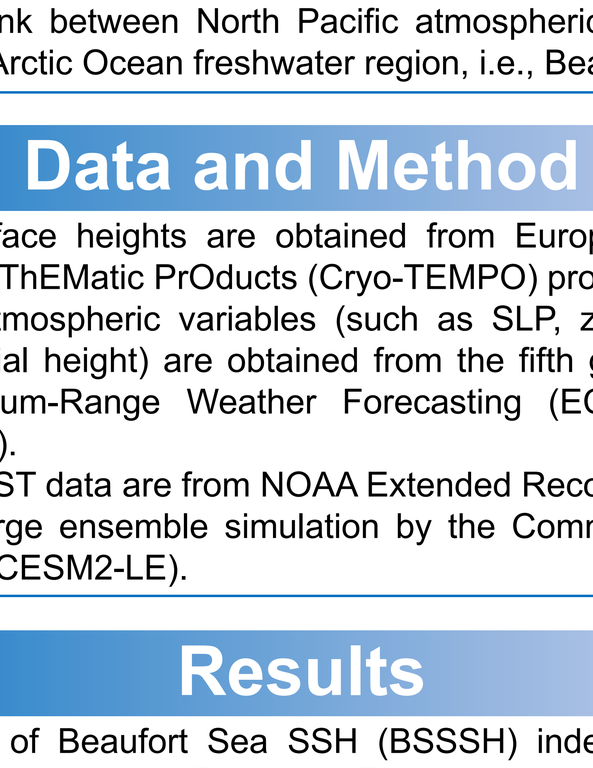

Figure 1 Temporal and spatial variations in SSH in the Beaufort Sea during 2011–2021 summer.

The SLP field shows a meridional dipole pattern, with positive anomalies distributing over the Arctic Ocean and negative anomalies over the subtropical North Pacific when the BSSSH index is positive. The meridional dipole pattern in SLP field over subtropical North Pacific resembles a typical of North Pacific Oscillation (NPO) pattern, whose positive phase is featured by lower-than-average SLP over the Arctic paired with higher-than-average SLP over the mid-latitude North Pacific.

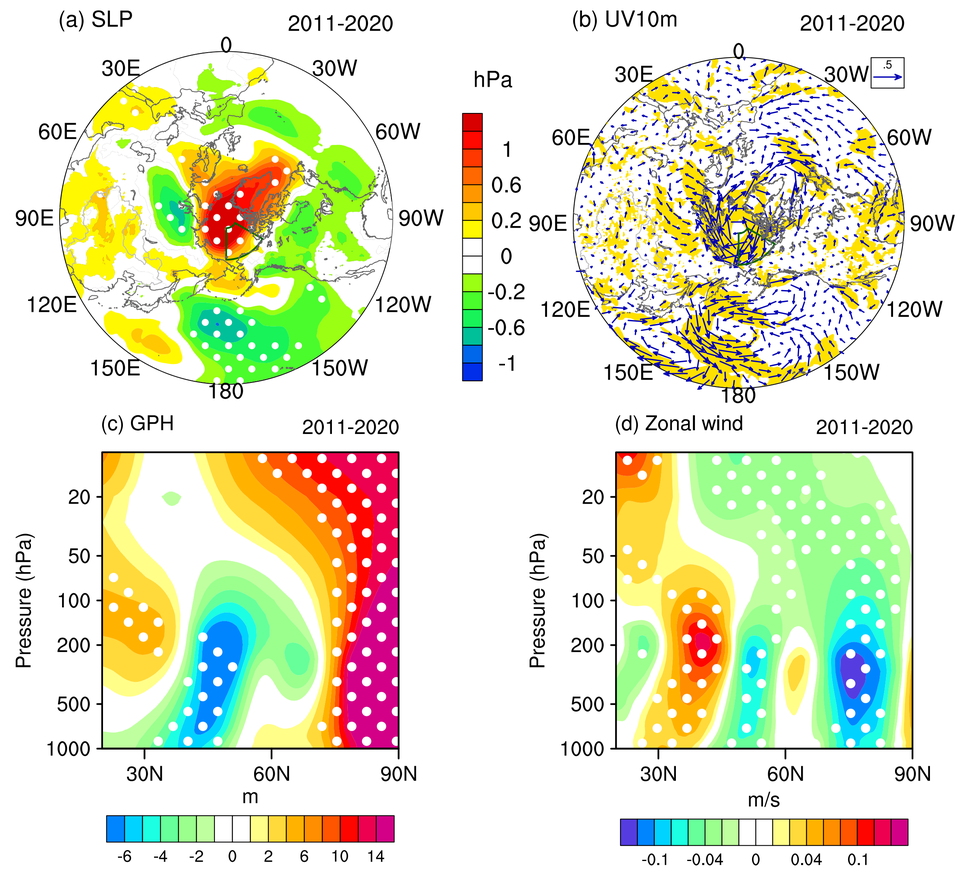

Figure 2 The regressions of SLP, GPH, wind anomalies onto the summer BSSSH index during 2011–2020.

The NPO-related atmospheric circulations are shown in Figure 3. Corresponding to positive NPO index, the SLP anomaly shows an intensified of Aleutian Low and Beaufort High. Stronger-than-normal Beaufort High, on the one hand, contributes to increasing more freshwater into the local region (Proshutinsky et al., 2002). On the other hand, it can increase freshwater via melting sea ice through increased shortwave radiation. This leads to positive SSH anomalies over the Beaufort Sea (Figure 3c).

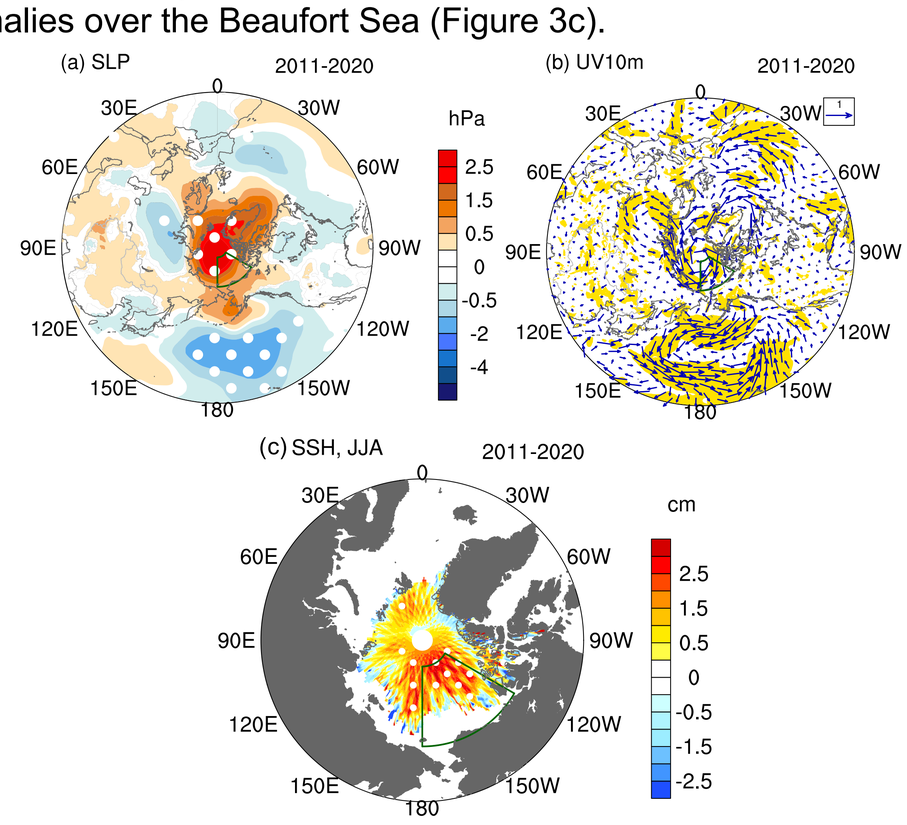

Figure 3 NPO-related atmospheric circulations.

Conclusion

Results imply that the higher sea surface in the Beaufort Sea associates with a negative NPO during 2011–2020. When NPO is in its negative phase, there is an intensified Beaufort High along with anomalous anticyclonic circulations over the Arctic, and Aleutian Low with anomalous cyclonic circulations over the mid-latitude North Pacific. Stronger-than-normal SLP over the Beaufort Sea leads to positive SSH anomalies locally because of increasing more freshwater entering the Beaufort Sea from the Chukchi Sea through Bering Strait (Nikolopoulos et al., 2009; Aksenov et al., 2016). We also propose that the teleconnection and SST anomalies in North Pacific play a major role in changing SSH in the Beaufort Sea.

References

- Cazenave, A., Llovel, W. 2010. Contemporary sea level rise. Annual review of marine science, 2, 145-73.
- Hauer, M.E., J.M. Evans and D.R. Mishra, 2016. Millions projected to be at risk from sea–level rise in the continental United States. Nat. Clim. Change, 6(7), 691.
- Song J, et al., 2017. An examination of land use impacts of flooding induced by sea level rise. Nat. Hazards Earth Syst. Sci., 17(3), 315.
- Etc.