Decadal sea level variability along the coast of Japan in response to ocean circulation changes

Yoshi N. Sasaki[1] (sasakiyo@mail.sci.hokudai.ac.jp), S. Minobe[1], and Y. Miura[2]
1. Hokkaido University, Japan, 2. Geospatial Information Authority of Japan

Published in 2014
in JGR-Oceans,
doi:10.1002/2013JC009327

1. Motivation

The sea level is rising, but its rate is not globally uniform. Although the sea level rise is prominent in the western North Pacific (**Fig. 1**), but the corresponding sea level change along the coast of Japan is not fully understood. Hence, the purpose of this study is to clarify coastal sea level variability along Japan in response to ocean circulation changes (**Fig. 2**).

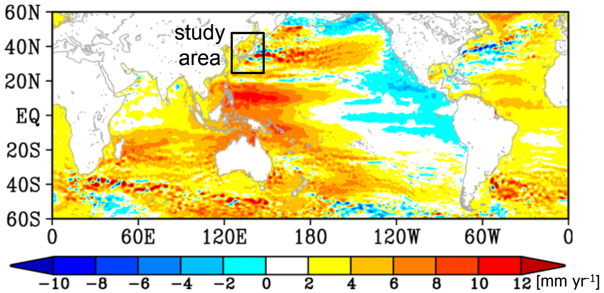

Fig. 1 Linear trend of sea level anomalies (SLAs) of the satellite altimeter from 1993 to 2010.

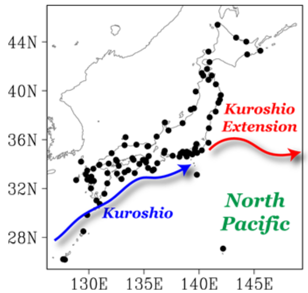

Fig. 2 Locations of 95 tide-gauge stations obtained from PSMSL.

2. Data and method

To understand a relation between sea level variability along Japan and in the western North Pacific, a singular value decomposition (SVD) analysis is performed between tide-gauge sea level along Japan from PSMSL and altimeter sea level in the western North Pacific provided by AVISO from 1993 to 2010.

To focus regional sea level fluctuations, the global mean linear sea level trend of +3.0 mm yr^{1} is removed from all sea level data. In addition, we subtract monthly mean climatology from each sea level time series, and all sea level time series are smoothed with a 9-month running mean filter.

3. Coastal sea level variability

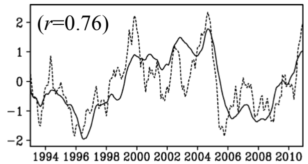

Fig. 3 Time series of the first SVD mode between SLAs of satellite (solid line; **TA1**) and the tide-gauge data (dashed line).

- ✓ The time series of the first SVD mode are well correlated and exhibit prominent decadal variability (**Fig. 3**).
- ✓ The regression coefficients of coastal sea level (**Fig. 4**) exhibit:
  - i. SLAs along the southeastern coast of Japan are quite large
  - ii. SLAs are also large in the western coast of Japan
  - iii. SLAs along the eastern coast of Japan north of 36°N are quite weak and statistically insignificant
- ✓ The spatial contrast of SLAs is quite clear over the Boso Peninsula (**lower in Fig. 4**).

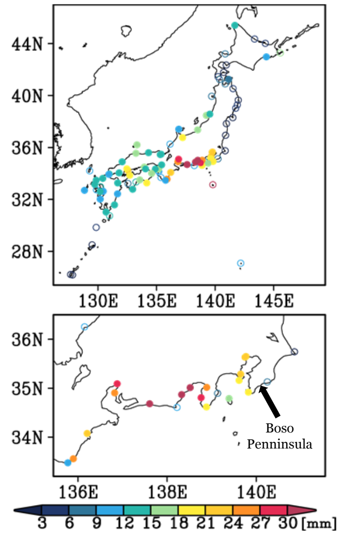

Fig. 4 Regression coefficients of coastal SLAs onto TA1. The closed and open circles denote that the corresponding correlation is statistically significant or insignificant.

4. Changes in ocean circulation

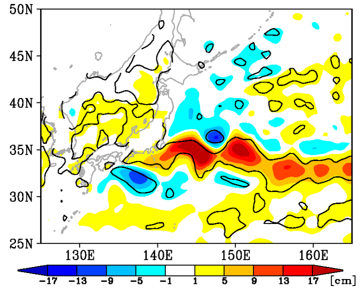

Fig. 5 Regression coefficients of SLAs onto TA1. The contour indicates the regions where the correlations are statistically significant.

- ✓ Large SLAs were located along the Kuroshio Extension jet (**Fig. 5**), suggesting the meridional shift of the jet.
- ✓ Positive SLAs emerged in the eastern North Pacific 3-yr before the jet shift (**Fig. 6b**).
- ✓ This signal propagated westward along the jet as the jet-trapped Rossby wave (Sasaki et al. 2013, JPO).

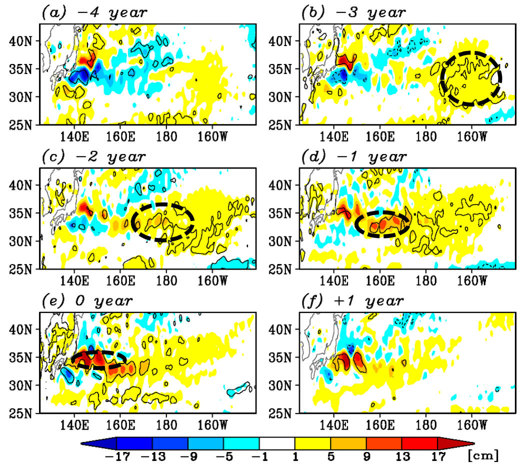

Fig. 6 Lag regressions of SLAs onto TA1 for the number of lag years: (a) −4, (b) −3, (c) −2, (d) −1, (e) 0, and (f) +1. The contour indicates the correlations that are statistically significant.

5. Conclusions

- ✓ Coastal sea level changes along Japan are understood as the sum of the global mean sea level rise and decadal variability induced by jet-trapped Rossby waves.
- ✓ The decadal sea level variability is quite large along the southeastern coast of Japan, but is small north of the Kuroshio Extension jet ("active zone" and "shadow zone" in **Fig. 7**).
- ✓ **The correct representation of western boundary currents is needed for reliable prediction of coastal sea level changes.**

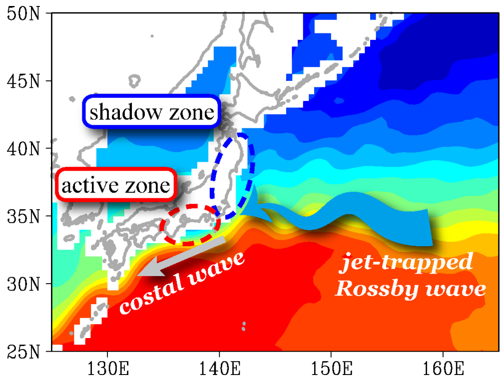

Fig. 7 Schematic diagram illustrating sea level changes along Japan. The blue arrow denotes incoming jet-trapped Rossby waves, and the gray arrow denotes coastal waves in response to the incoming wave.