Sea Level Variability in the Western North Pacific during the 20th Century

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Outline

I. Satellite era: 1993–2010

- spatially high-resolution satellite and tide-gauge data

II. Tide-gauge era: 1906–2010

- spatially low-resolution tide-gauge
- simulation by regional ocean model

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   ▫   spatially high-resolution satellite and tide-gauge data

II.   Tide-gauge era: 1906–2010

   ▫   spatially low-resolution tide-gauge
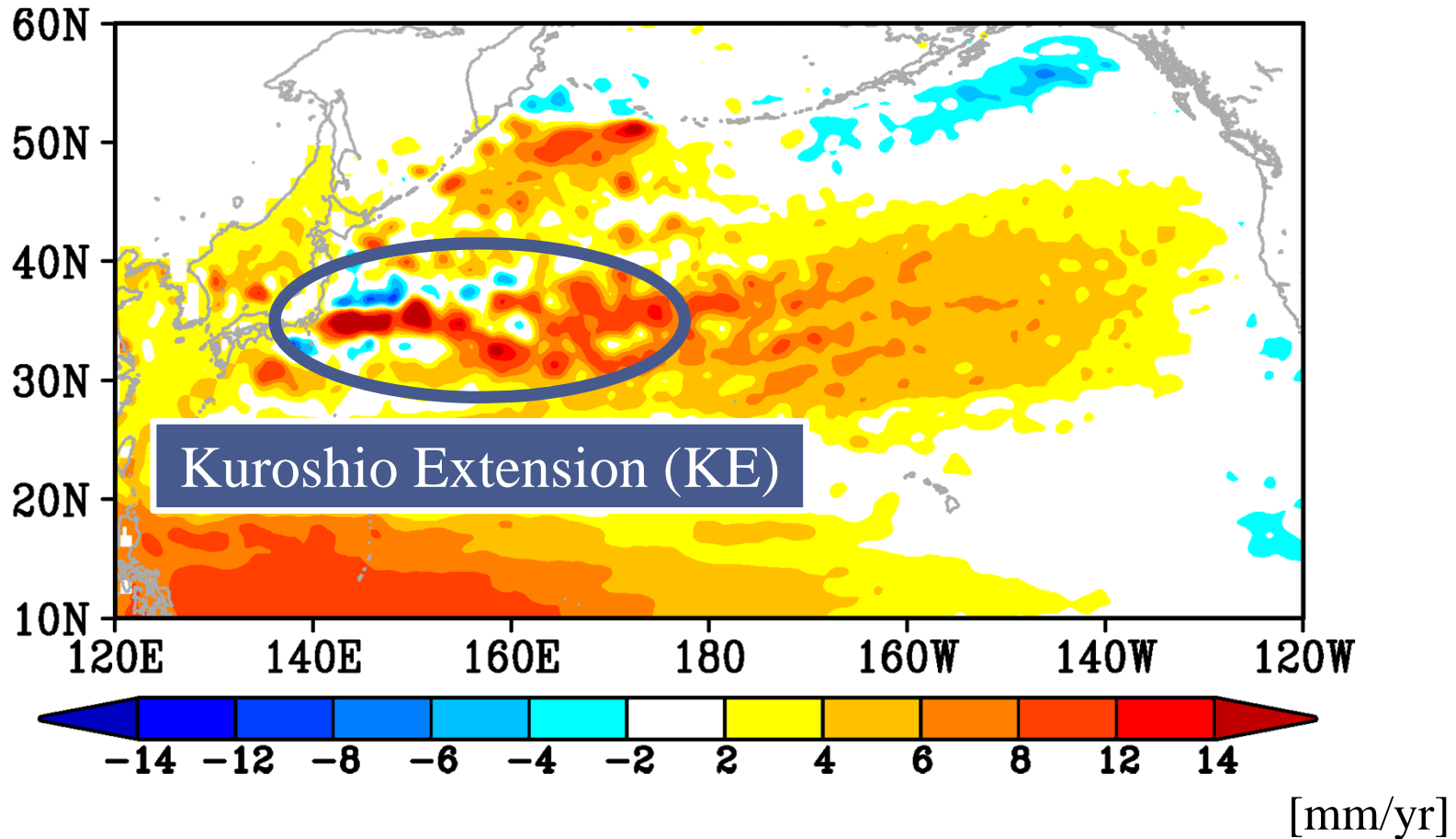
   ▫   simulation by regional ocean model

Motivation

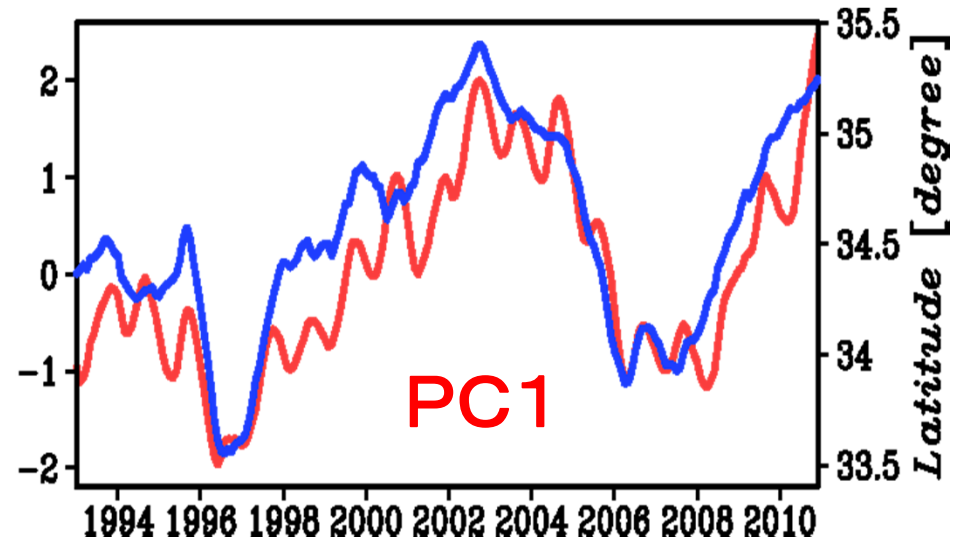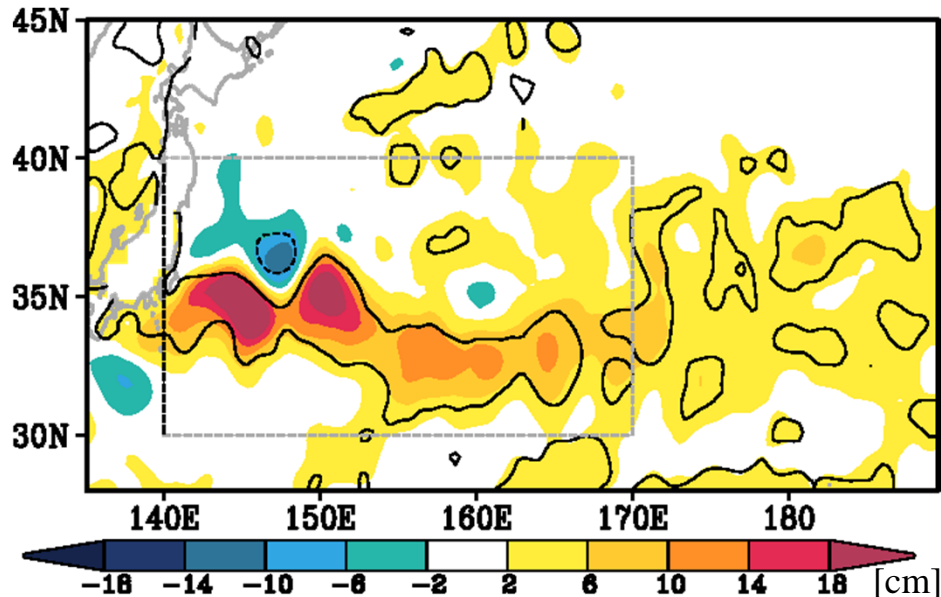Linear trend of satellite sea level (1993–2010)

Motivation

Linear trend of satellite sea level (1993–2010)

Kuroshio Extension (KE)

[mm/yr]
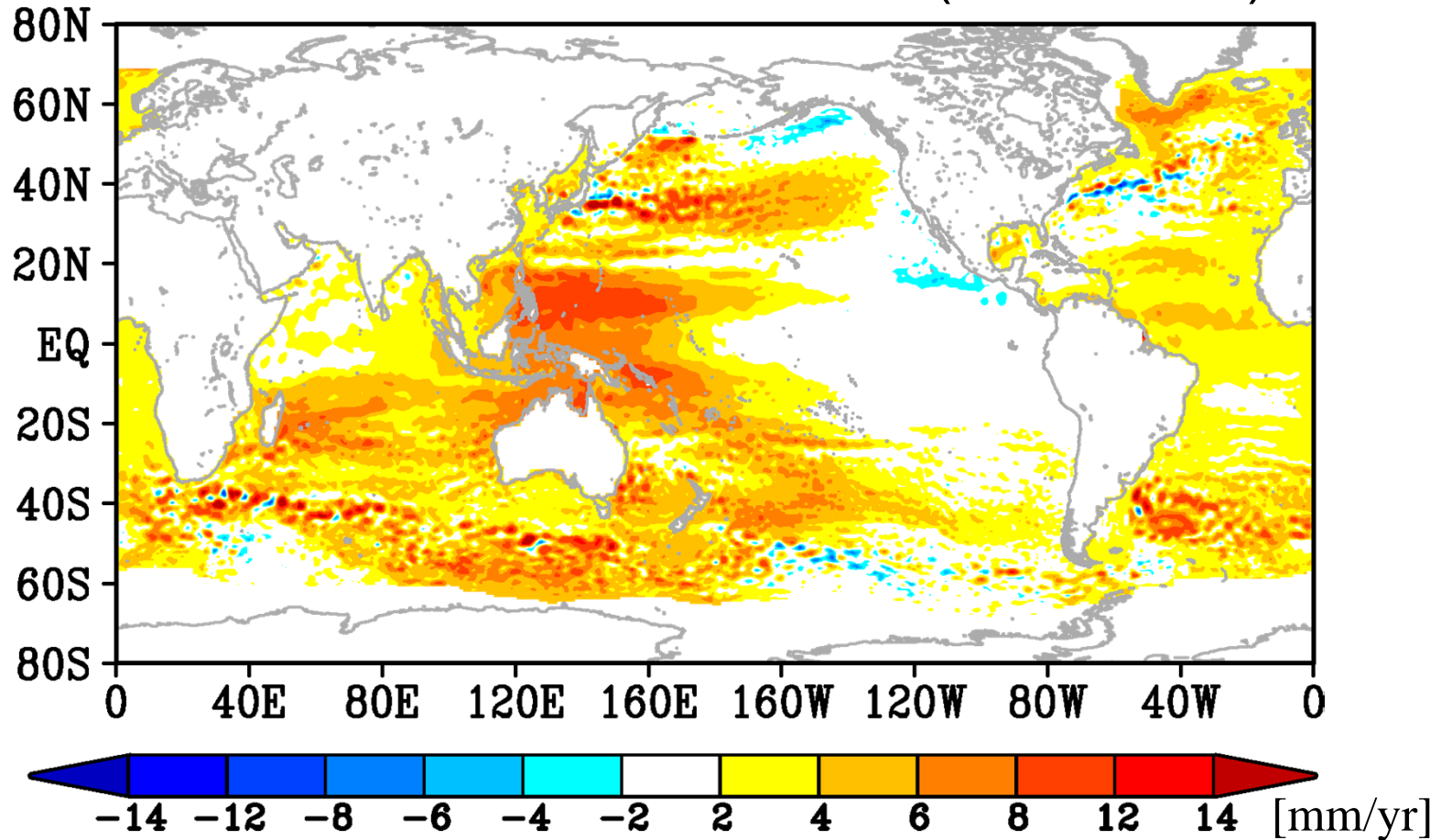
- What happened?
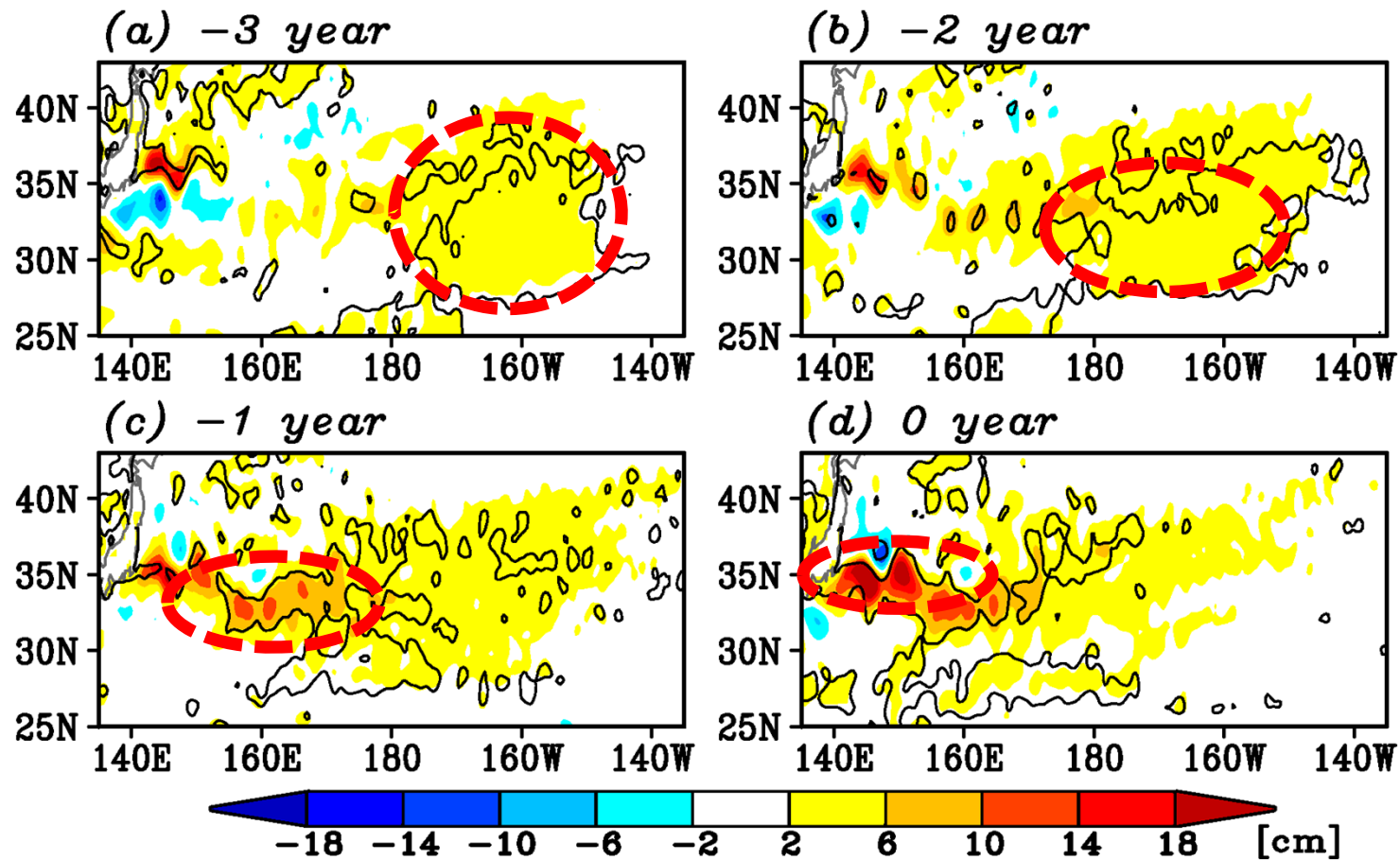
Dominant sea level variability

Satellite 1st EOF mode

- The large sea level rise in the KE is attributed to meridional shifts of the KE jet on decadal timescales
- What is the mechanism for the narrow sea level variability?

Sasaki et al. (2013, JPO)
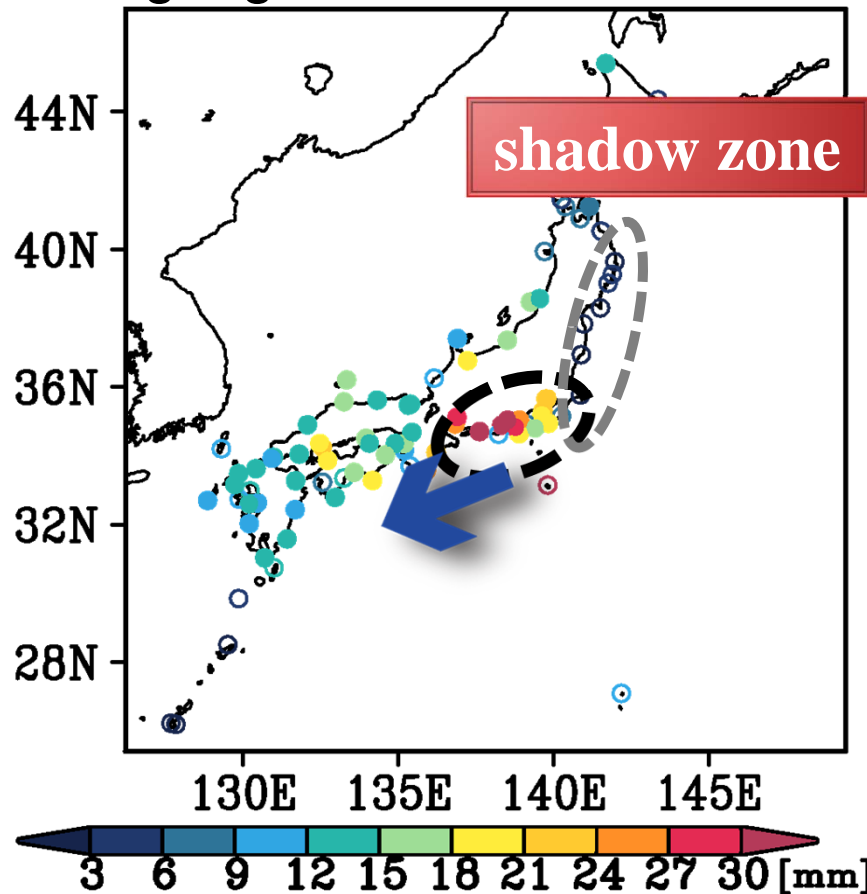
Propagating signal

- Jet-trapped Rossby waves (Sasaki and Schneider, 2011) propagate westward and induce shifts of the jet
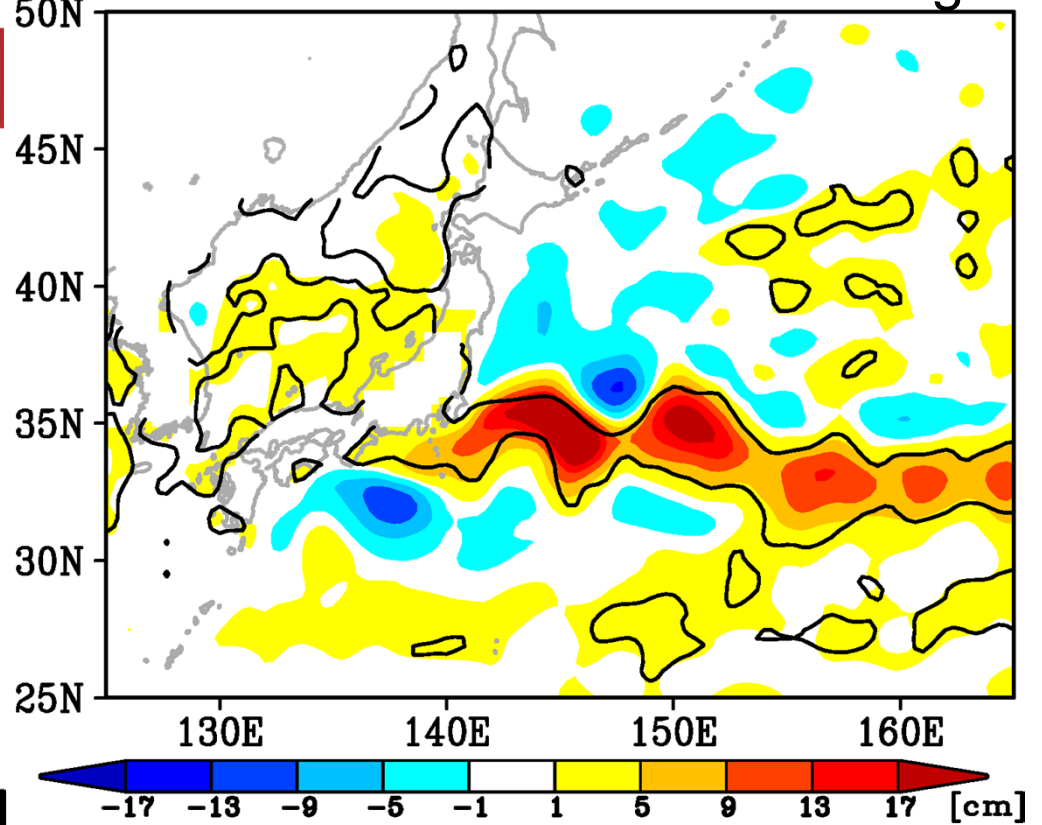
Sasaki et al. (2013, JPO)

Response of coastal sea level

Tide-gauge derived sea level change

- The jet-trapped nature of the incoming signals cause large spatial contrast of coastal sea level change

Sasaki et al. (2014, JGR)

Outline
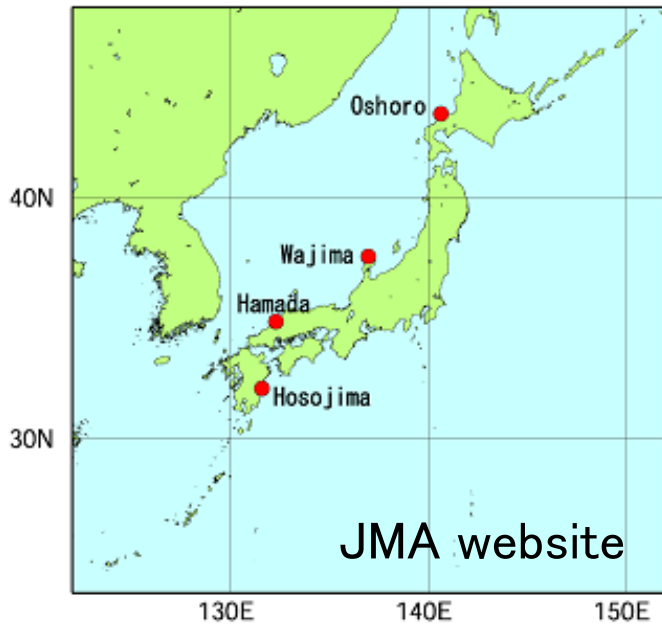
I. Satellite era: 1993–2010
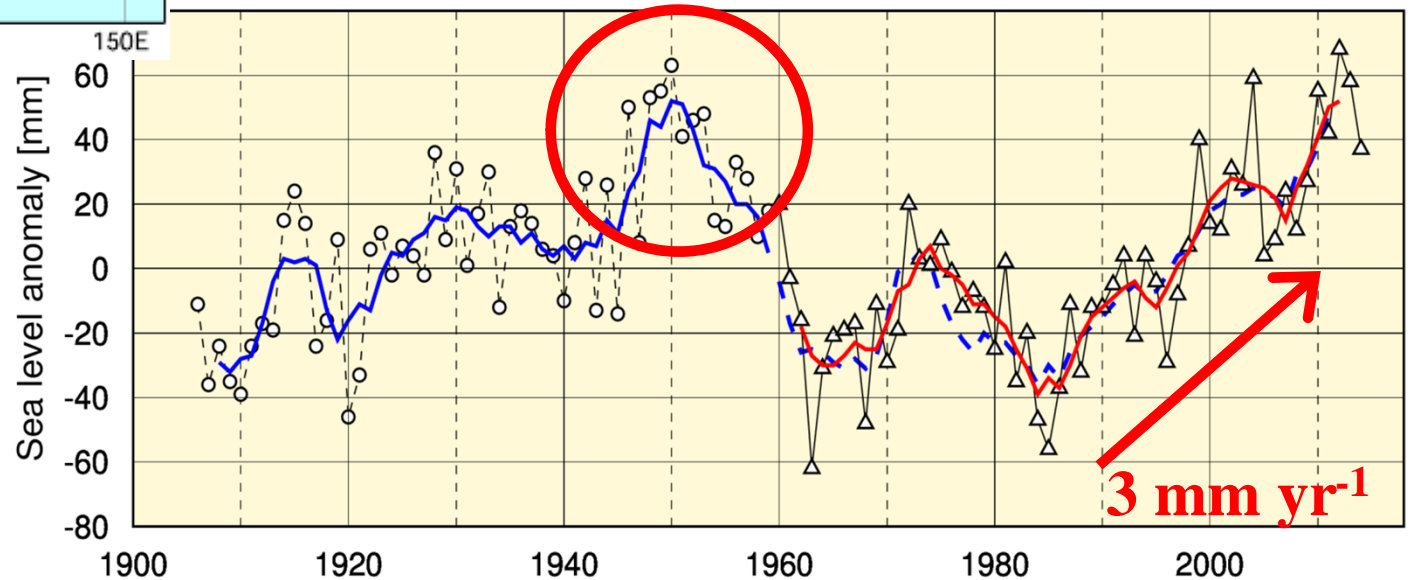- spatially high-resolution satellite and tide-gauge data

II. Tide-gauge era: 1906–2010
- spatially low-resolution tide-gauge
- simulation by regional ocean model

Long-term sea level around Japan

JMA website

What is the mechanism of the high sea level around 1950?

3 mm yr^{-1}

www.data.jma.go.jp/gmd/kaiyou/english/sl_trend/sea_level_around_japan.html

Numerical model

- ROMS (Regional Ocean Modeling System)
  - Horizontal Resolution: 1° ×1°, Vertical: 32 sigma layer
  - Domain: from 30°S to 61°N, from 100°E to 80°W
  - Period: from 1871 to 2010 (analyze after 1906)
  - Domain averaged steric sea level change are estimated from simulated T/S fields (Mellor and Ezer, 1995)

- Forcings
  - NOAA Twentieth Century Reanalysis
    - daily wind stress, and surface heat flux calculated from daily variables using a bulk formula
  - SODA v2.2.4 Reanalysis
    - lateral temperature and salinity and surface salinity are restored to the monthly values

Sasaki et al. (2017, JC)
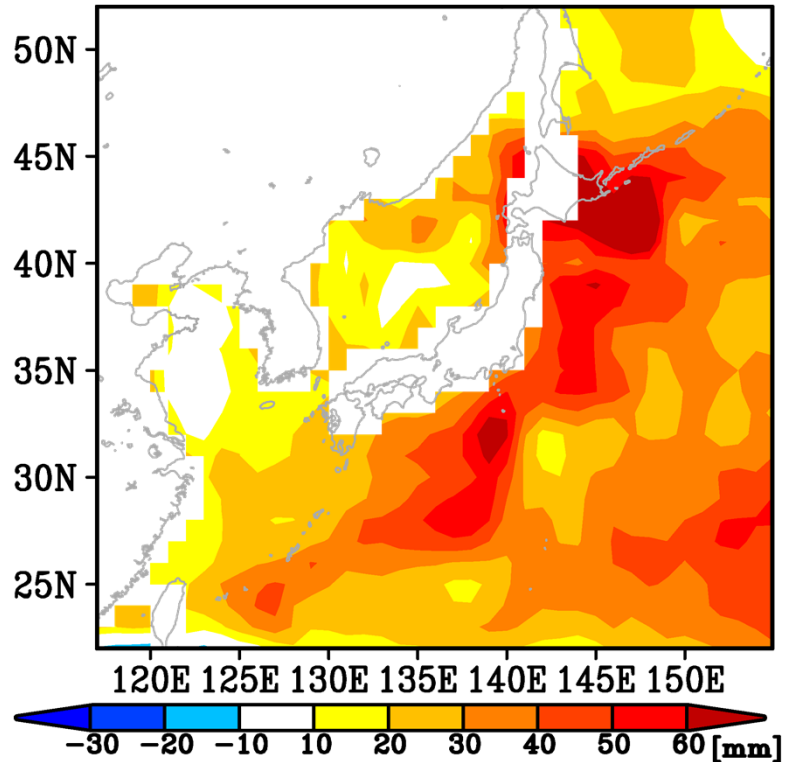
Control run

Coastal sea level along Japan
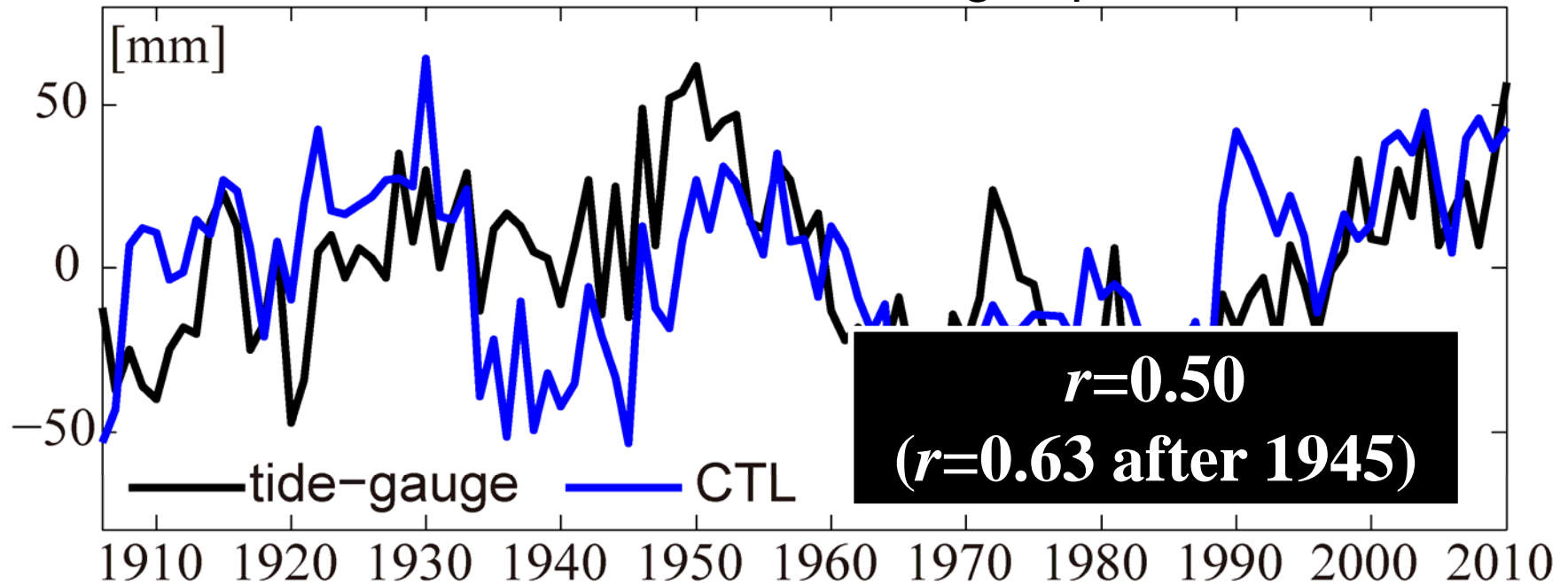
- The model reproduces the interdecadal sea level variability along the Japanese coast during the 20th century
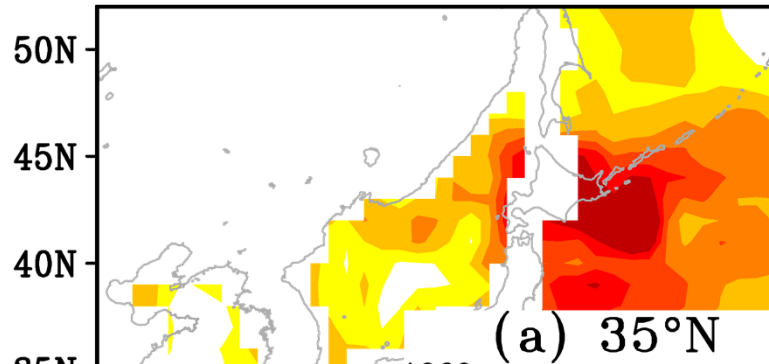
Sasaki et al. (2017, JC)

Sea level rise around 1950
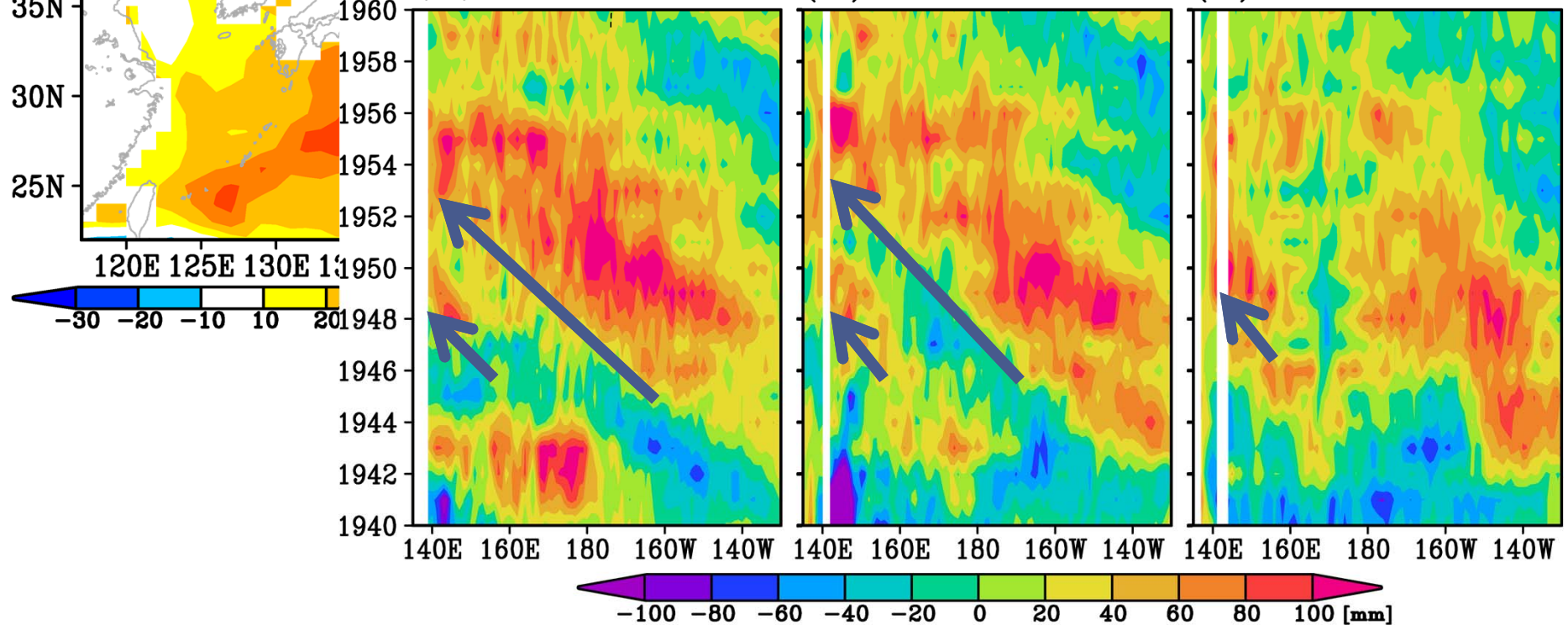

- Positive SLAs in the western North Pacific

$\Rightarrow$ signals coming from east

Sasaki et al. (2017, JC)
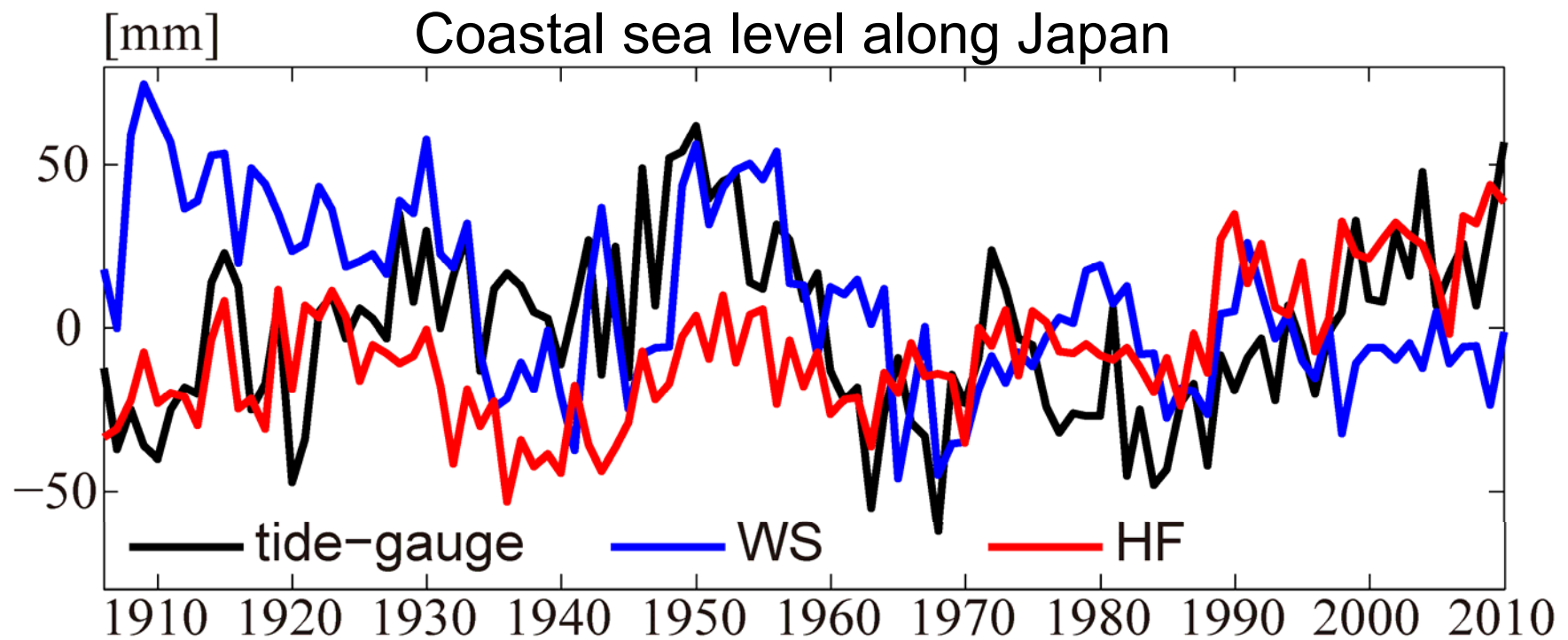
Sea level rise around 1950

- Positive SLAs in the western North Pacific

$\Rightarrow$ signals coming from east

Sensitivity runs

1. HF run (heat and freshwater flux run)
   - Wind stress climatology is used

2. WS run (wind stress run)
   - Atmospheric variables to calculate surface heat flux are changed to daily climatologies
   - Surface salinity and lateral temperature and salinity fields for restoring are monthly climatologies

Sasaki et al. (2017, JC)
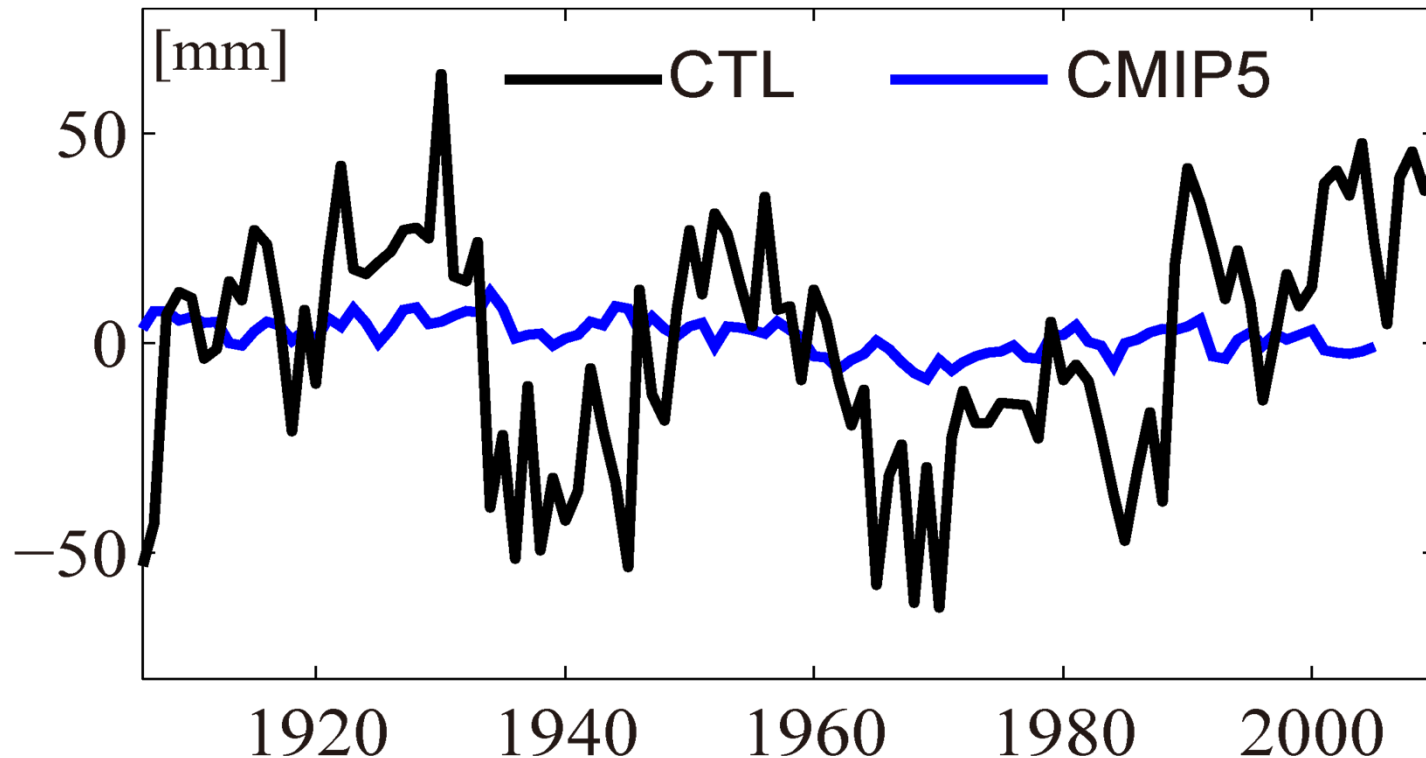
Sensitivity runs

[mm]   Coastal sea level along Japan

- Wind stress forcing is dominant for the high sea level around 1950
  - Weakening of the Aleutian Low around 1950

Sasaki et al. (2017, JC)

Natural or forced variability?

Sea level averaged around Japan

- The multi-model ensemble mean sea level variability around Japan does not show the high sea level around 1950
- The high sea level was caused by natural variability

Sasaki et al. (2017, JC)

Summary

I. The large sea level rise in the western North Pacific is attributed to the jet-trapped Rossby wave in KE region

   ▫ also highlights importance of variability of the western boundary current on coastal sea level change

II. highlights importance of natural wind variability for coastal sea level change even on interdecadal timescales

Sasaki et al. (2011, JPO; 2013, JPO; 2014, JGR; 2017, JC)