SYMPOSIUM OP'24
ADVANCING OCEAN PREDICTION SCIENCE FOR SOCIETAL BENEFITS

Theme #2.1 Coastal sea level waves and nearshore currents prediction

Response to wind forcing around the Japanese coast represented by operational coastal system in JMA

Nariaki Hirose, Norihisa Usui, Hiroaki Asai, Yuma Kawakami, and Ichiro Ishikawa
Meteorological Research Institute, Japan Meteorological Agency

Introduction

Coastal seas are

- the area with high socioeconomical activities such as fishery and marine transport In Japan,
- sometimes damaged by storm surges and high waves caused by typhoons and extratropical cyclones.

Strong surface wind associated with such cyclones

induces coastal trapped waves,

generates increase of sea level (SL) due to Ekman transport,

decreases sea surface temperature due to coastal upwelling.

- To reveal such coastal responses to surface winds, a coastal assimilation system in JMA with 2-km horizontal is used .

Data assimilation system

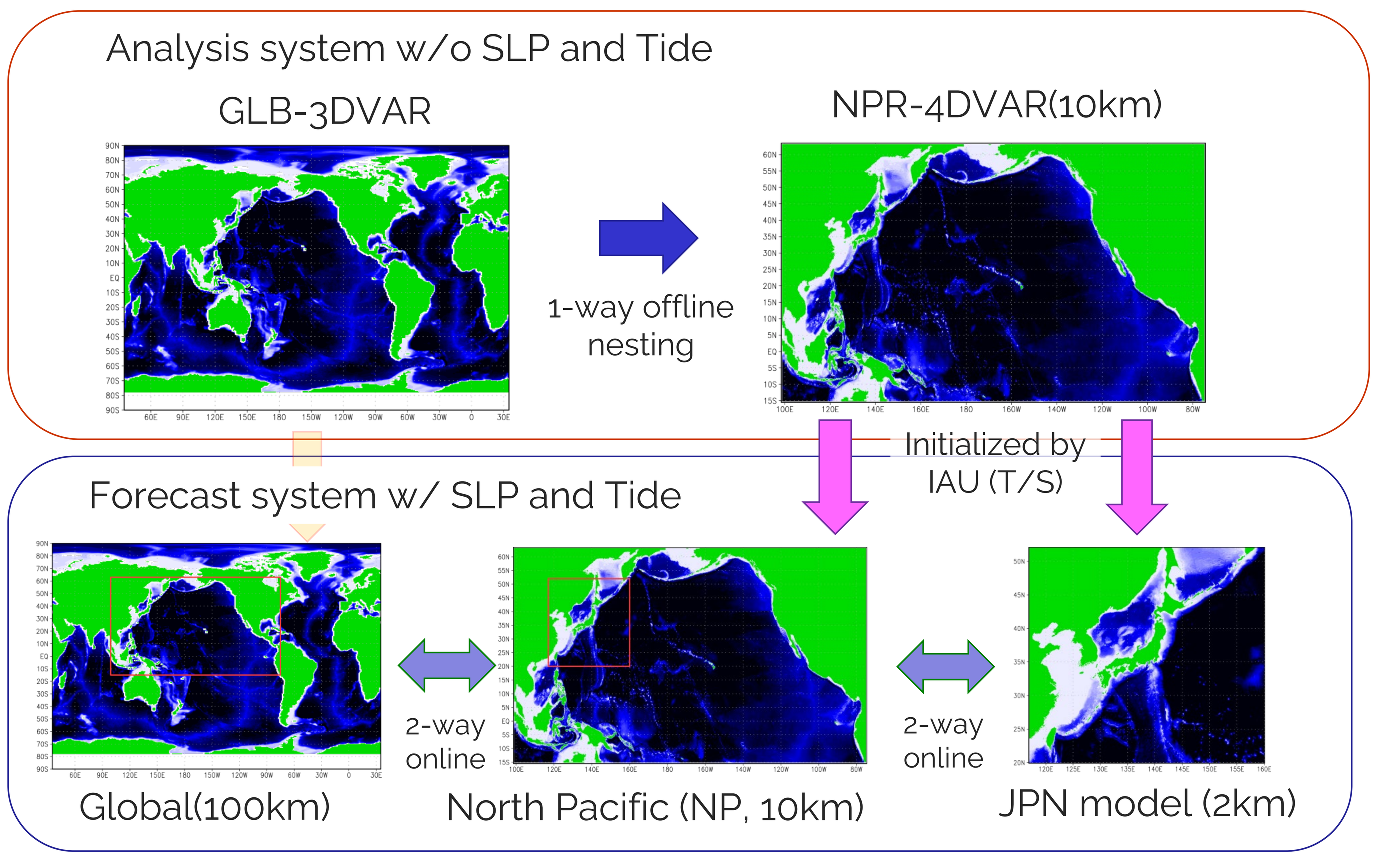


Fig.1 . Schematic view of MOVE-JPN system. Data assimilation is conducted in NPR-4DVAR and GLB-3DVAR. The analysis temperature and salinity (T/S) are added in JPN and NP (Global) model from NPR-4DVAR (GLB-3DVAR) by using IAU scheme.

Response to wind forcing in the coastal assimilation system

- Sensitivity experiments forced by long-term mean wind averaged 30 years. are conducted
- The experiments compared with experiments using realistic wind forcing to reveal the impact of the wind forcing.

Unusual high Sea level in Sep. 1971 (Hirose, et al., 2022)

In early September 1971, coastal flooding occurred along the southern coasts of Japan over the distance of 500 km within a few days, in spite of no severe weather conditions.

Experiment settings

- CNTL in 1971 is performed based on MOVE-JPN system
- Two sensitivity experiments are conducted.
  - WClim: Applying climatological wind forcing
  - FixKR: T/S fields are constrained on 24th Aug. 1971

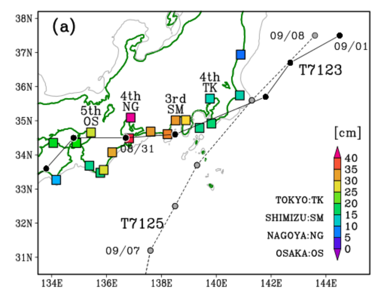


Fig.2 . Observed sea-level anomaly at tide-gauge stations averaged from 1st to 10th Sep. 1971 (squares).

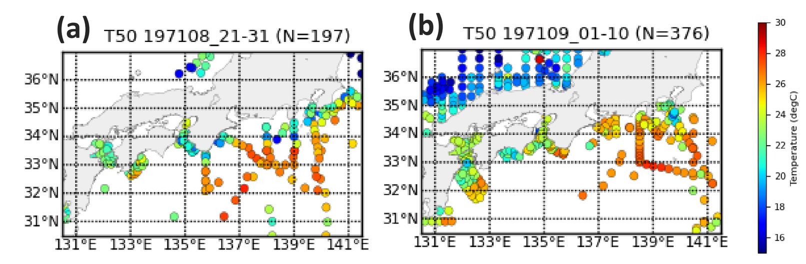


Fig.3 In-situ water temperature at 50 m depth in (a) late August and (b) early September

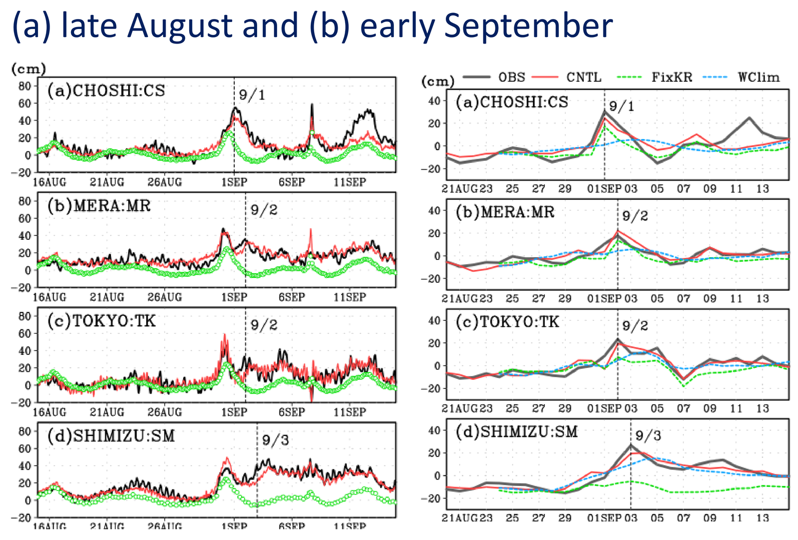


Fig.4 . [Left] Hourly sea-level anomaly in (black) observation and in (red) CNTL. (green circles) Sea-level suction/depression estimated by Inverted Barometer response
[Right] Daily mean sea level of (gray) observation, (red) CNTL , (green) FixKR, and (light blue) WClim.

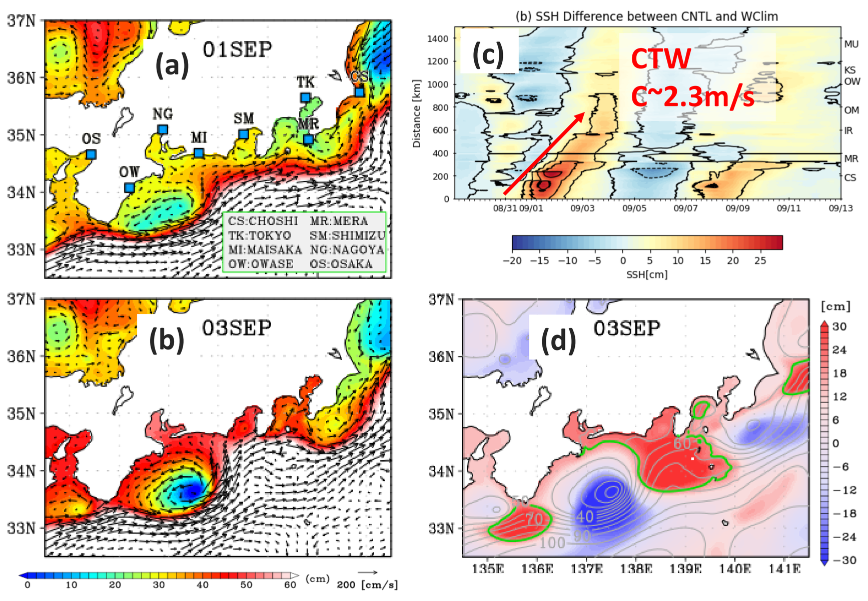


Fig.5 . SSH (shading) with sea surface velocity (vector) of CNTL on (a) 1st and (b) 3rd Sep. 1971. (c) Hovmöller diagram of SSH difference between CNTL and WClim along the southern coast of Japan. Contour interval is 10 cm of SSH difference. (d) SSH of CNTL (contour) and its difference against FixKR (shading) on 3rd Sep. 1971. Green line is contours of SSH difference by 20 cm.

Abruput coastal strong current in Aug. 2022

A strong southward current occurred at the east of the Wakasa Bay and destroyed the fishing set nets. The total damage exceeded several hundred million yen.

Experiments

- CNTL: operational forecast run
- WClim: Applying climatological wind forcing
- Initial: 20220810

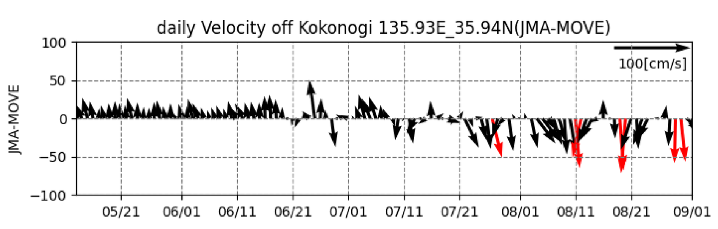


Fig.6 . Surface velocity at Kokonogi (east of the Wakasa Bay) in JPN analysis in summer 2022.

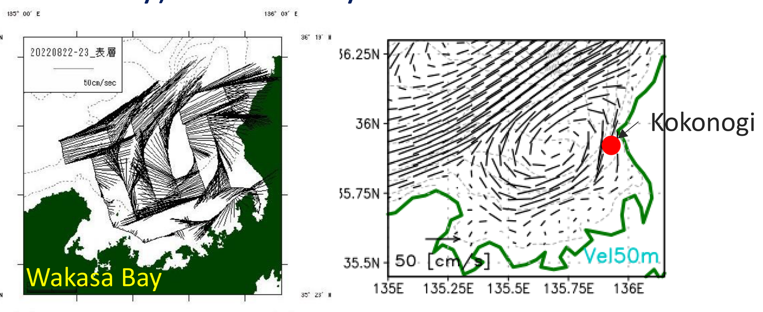


Fig.7 . Velocity at 50 m depth (left) observed by ship-mounted ADCP and (right) JPN analysis on 23 Aug. 2022

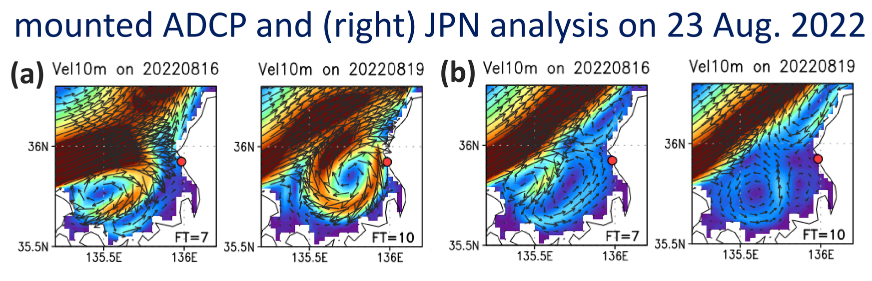


Fig.8 . Surface velocity around the Wakasa Bay in (a) CNTL and (b) WClim on 16th and 19th Aug. 2022.

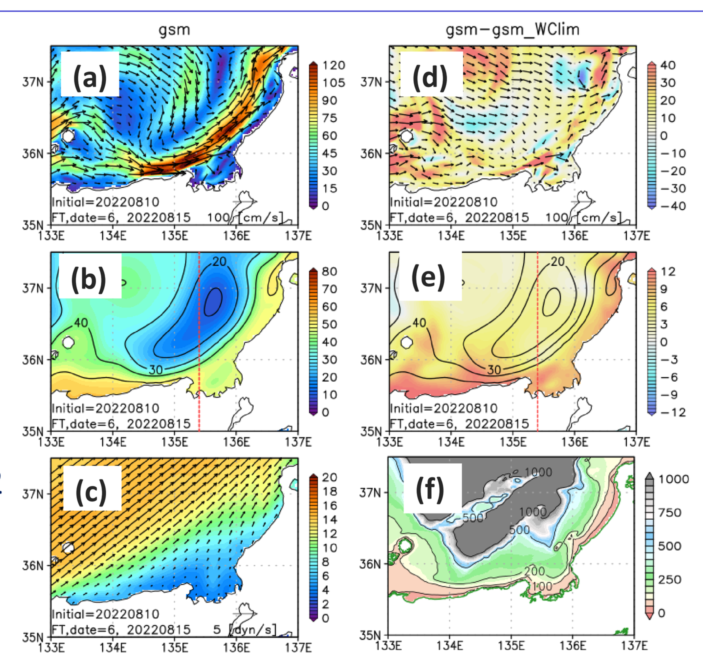


Fig.9 . (a) Surface velocity (b) SSH, and (c) surface wind speed in CNTL on 15th Aug. 2022. (d-e) Difference between CNTL and WClim, respectively. (f) Bottom topography.

Coastal upwelling in Jun. 2022

At the seaside of Boso Peninsula, air temperature in summer is moderate compared with inner side of the Kanto region.
11-day Forecast experiments from the Initial condition: on 20220618

- CNTL: realistic wind forcing (JRA55-do)
- WClim: Applying climatological wind forcing

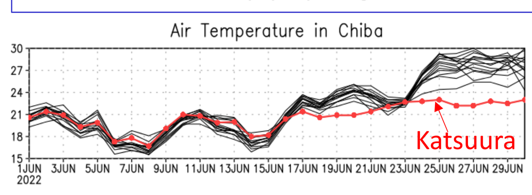
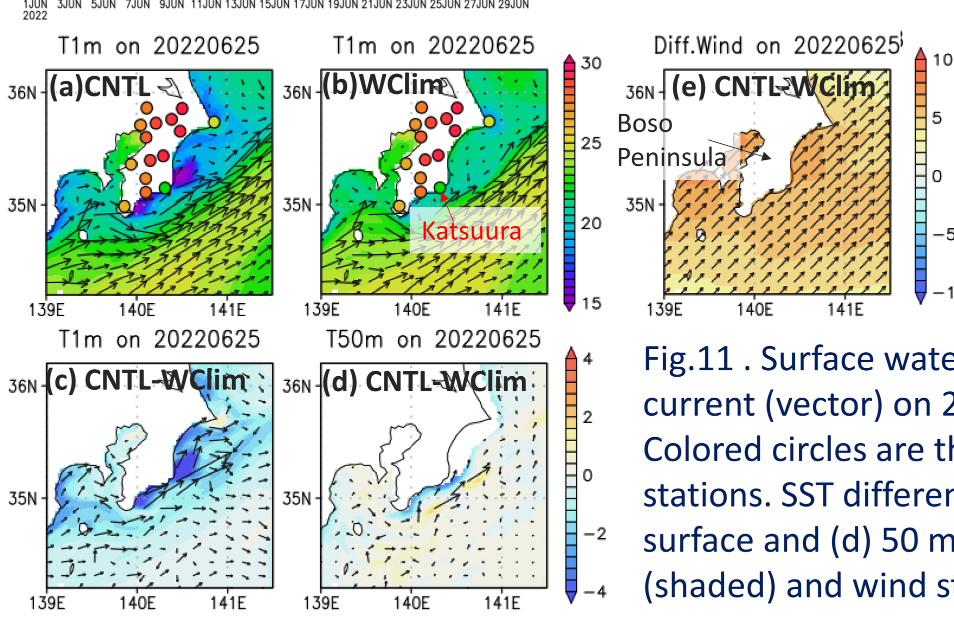


Fig.10 . Daily surface air temperature observed at weather stations around the Boso Peninsula in Jun. 2022 . Red line: Katsuura station which is located at seaside of the Boso Peninsula.



- Air temperature at Katsuura is cooler than the other stations.
- Northeastward was strong.
- SST at the Boso Peninsula in CNTL is also lower than WClim.

Fig.11 . Surface water temperature (SST) and surface current (vector) on 25th Jun. 2022 in (a) CNTL and (b) WClim. Colored circles are the air temperature at the weather stations. SST difference between CNTL and WClim at (c) surface and (d) 50 m depth. (e) Difference of wind speed (shaded) and wind stress (vector) between CNTL and WClim.

Conclusions

- Reponse to wind forcing is investigated by using the operational coastal assimilation sytem in JMA.
- Coastal trapped wave partially contributed to unusual high sea level in early Sep. 1971, with approaching the surface warm water associated with the Kuroshio.
- Strong coastal current in the east of the Wakasa Bays was caused by the eddy propageting eastward, guided along the large SSH gradient setup by Ekman transport
- Coastal upwelliing outside of the Boso Peninsual occurred when northeastward strong wind.