Using ROMS To Reconstruct Storm Surge Striking Southwest Coast Of Taiwan (Yunlin) During Typhoon Khanun (2023)

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Introduction

A storm surge is the rise in water level caused by a tropical cyclone, often leading to seawater intrusion in coastal regions. In 2023, Typhoon Kahnun caused a storm surge in Yulin on August 4th, even though it did not make landfall in Taiwan. The typhoon's track was far from Taiwan. Typically, storm surges occur in region close to the typhoon's center; however, in this case, the affected region was at an unusual distance from the typhoon. Through the ocean numerical model, ROMS (Regional Ocean Model System), storm surge can be reconstructed. By analyzing the temporal variation of the spatial contribution of sea surface height (SSH) and currents, a better understanding of the formation of storm surges can be achieved.

Model Configuration and Typhoon Track

Item	Configuration	Item	Configuration
Domain center	121° N, 23.5° E	Vertical layer	15
Resolution	1/50°	Initial and boundary condition	HYCOM
Grid point	218 × 199	bathymetric data	GEBCO
Time range	2023/08/02 | 2023/08/07	Tide forcing	TPXO9-atlas
Time step	100s	Atmospheric forcing	Merra-2

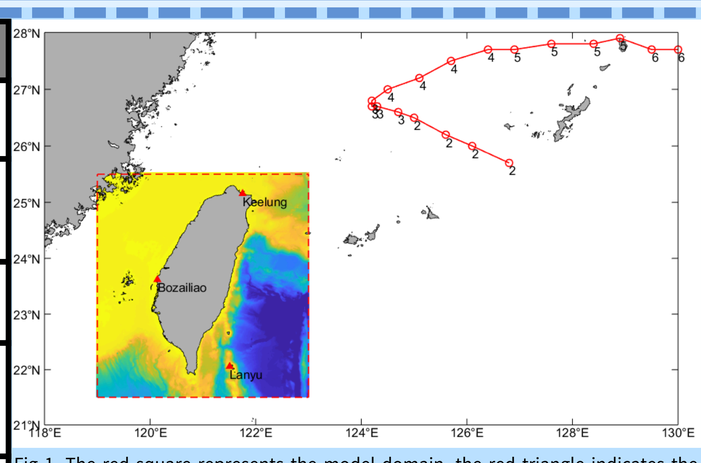

Fig 1. The red square represents the model domain, the red triangle indicates the locations of the tide stations used for validation, and the red dotted line shows the track of Typhoon Kahnun (data from the China Meteorological Administration)

Validation

To validate the simulation, observations from three tide stations are used: Keelung, Bozailiao, and Lanyu. The observational data were obtained from the Central Weather Administration. The simulation of overall water level trends are consistent; however, the Bozailiao and Lanyu stations exhibit a slight positive bias, indicating that ROMS tends to overestimate.

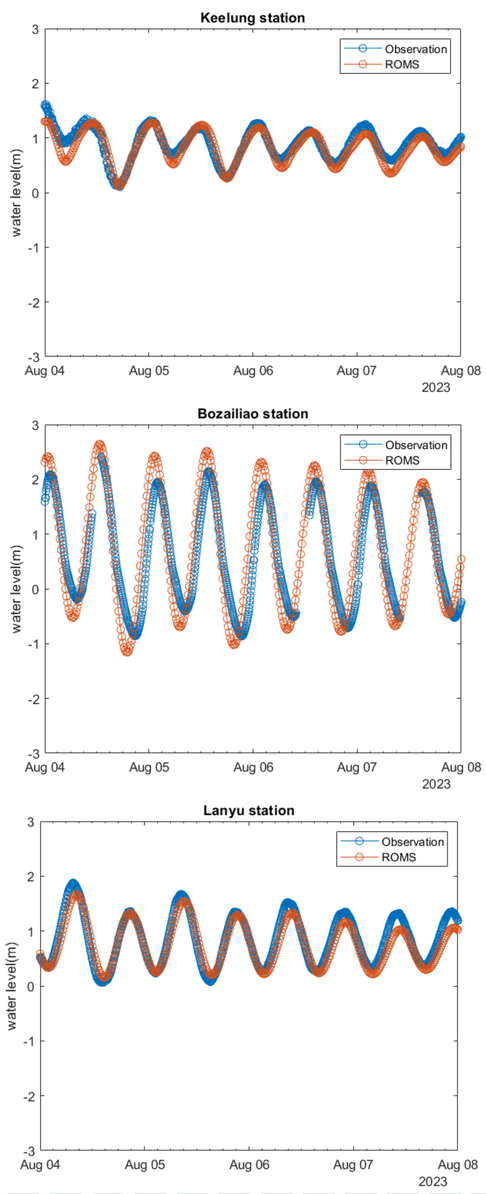

Fig 2. The time-varition of SSH at three tide stations between simulation and observation

Spatial Contribution Of Wind-Currnet-SSH

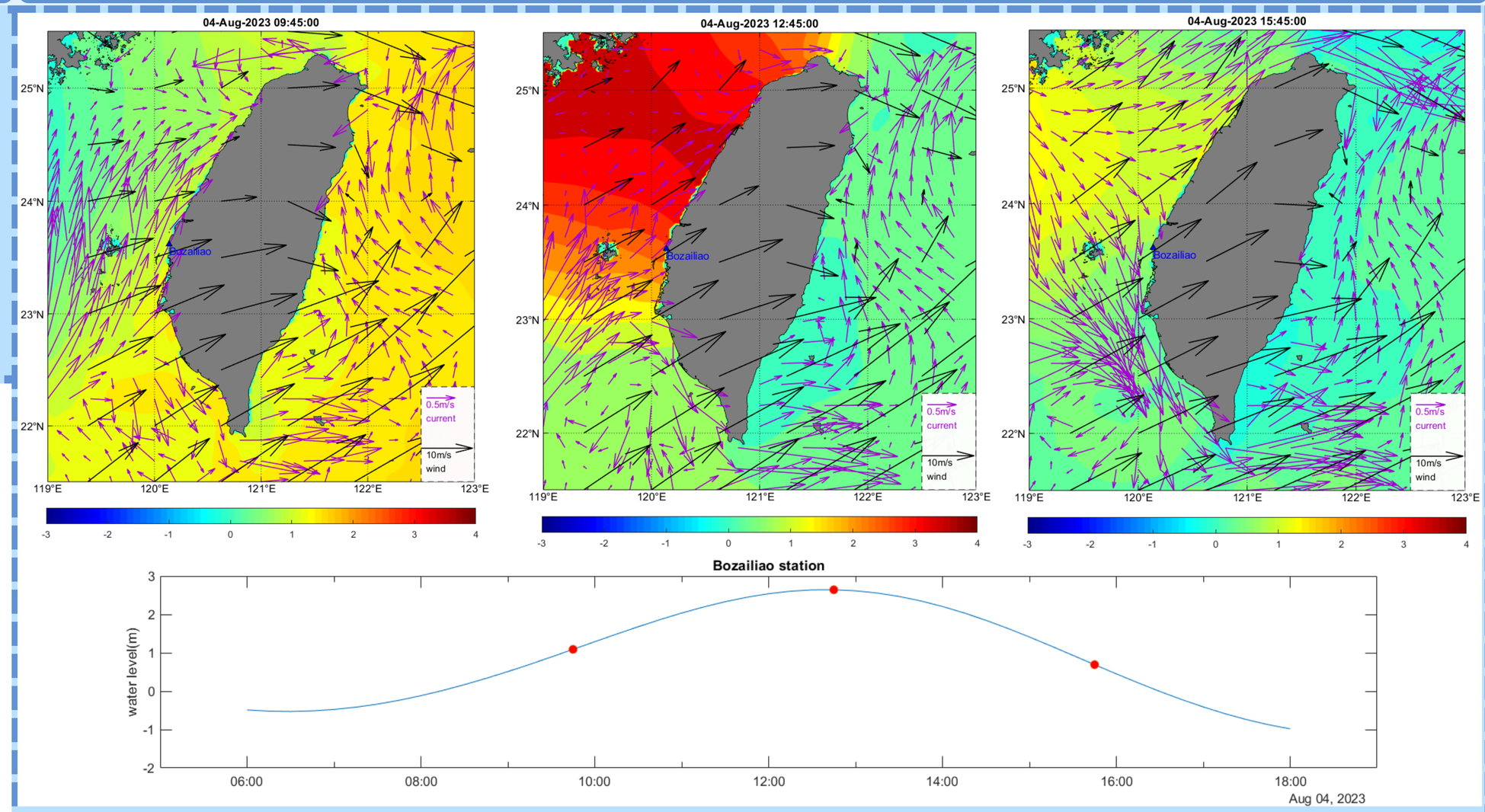

Fig 3. The three figures at the top illustrate the spatial contributions in the model domain on August 4th at 09:45, 12:45, and 15:45. The black arrows represent the wind data from MERRA-2, while the purple arrows indicate the currents from the ROMS simulation. The blue triangle marks the location of the Bozailiao tide station. The figure at the bottom shows the temporal variation of SSH at the Bozailiao station on August 4th. The red spots correspond to the spatial contributions shown above at 09:45, 12:45, and 15:45, from left to right.

SSH：

The peak sea surface height (SSH) at Bozailio station reached 2.64 m on August 4th at 12:45, while the most significant peak SSH was 3.74 m observed off the coast of Taichung.

Wind：

On August 4th, the wind field over Taiwan was primarily from the northwest. In the Taiwan Strait, the wind gradually shifted from a westerly to a northwesterly direction between 9:45 and 15:45.

Current：

Before 12:45, influenced by the flood tide, the ocean current flowed into the Taiwan Strait. In the region of the Taiwan Strait south of 23 degrees north latitude, strong westerly winds caused the current to move slowly. After 12:45, as the tide began to recede, the ocean current started flowing out of the Taiwan Strait. However, off the coast of Yunlin, strong southwest winds forced the current to move more easterly toward the coast.

Conculsion and Discussion

- The maximum SSH on August 4th occurred at 12:45. According to the spatial contribution of SSH, the most significant peak occurred at off the coast of Taichung, reaching 3.74 m .
- The storm surge hit the coast of Yunlin for two reasons: the first was the rising SSH during the flood, increasing the likelihood of seawater intrusion. The second was the strong southwest wind, which pushed the current toward the coast during the ebb tide, hindering the discharge of the intruding seawater.

Future work

- Incorporating the pressure effect enhances the accuracy of the sea level in reflecting real conditions.
- employing the wet-dry method can further validate the occurrence of seawater intrusion.

Reference

1. Qin, Gangri, et al. "Storm Surge Inundation Modulated by Typhoon Intensities and Tracks: Simulations Using the Regional Ocean Modeling System (ROMS)." Journal of Marine Science and Engineering 11.6 (2023): 1112.
2. 林慧貞，黃浩珉。《無風無雨卻水淹魚塭——颱風暴潮如沉默殺手，西南沿海如何補破網？》。報導者，2023年8月29日，https://www.twreporter.org/a/storm-surge-during-typhoon-caused-damage-on-southwest-coast