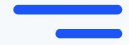




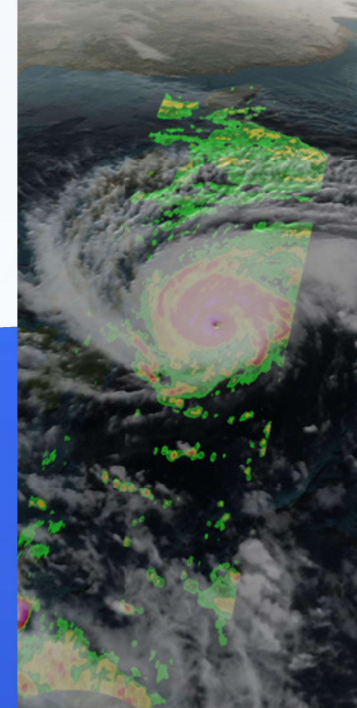
南方海洋科学与工程广东省实验室（珠海）
Southern Marine Science and Engineering Guangdong Laboratory (Zhuhai)



XVIII
World Water Congress
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Beijing, China | September 11-15, 2023



Numerical Simulation of the Coastal Inundation Around Guangdong-Hongkong-Macao Greater Bay Area



Xu Danya
Dao Fuhai
Zhong Kangyou
(Presented by Ji Zhenming)



13 Sep, 2023
Beijing

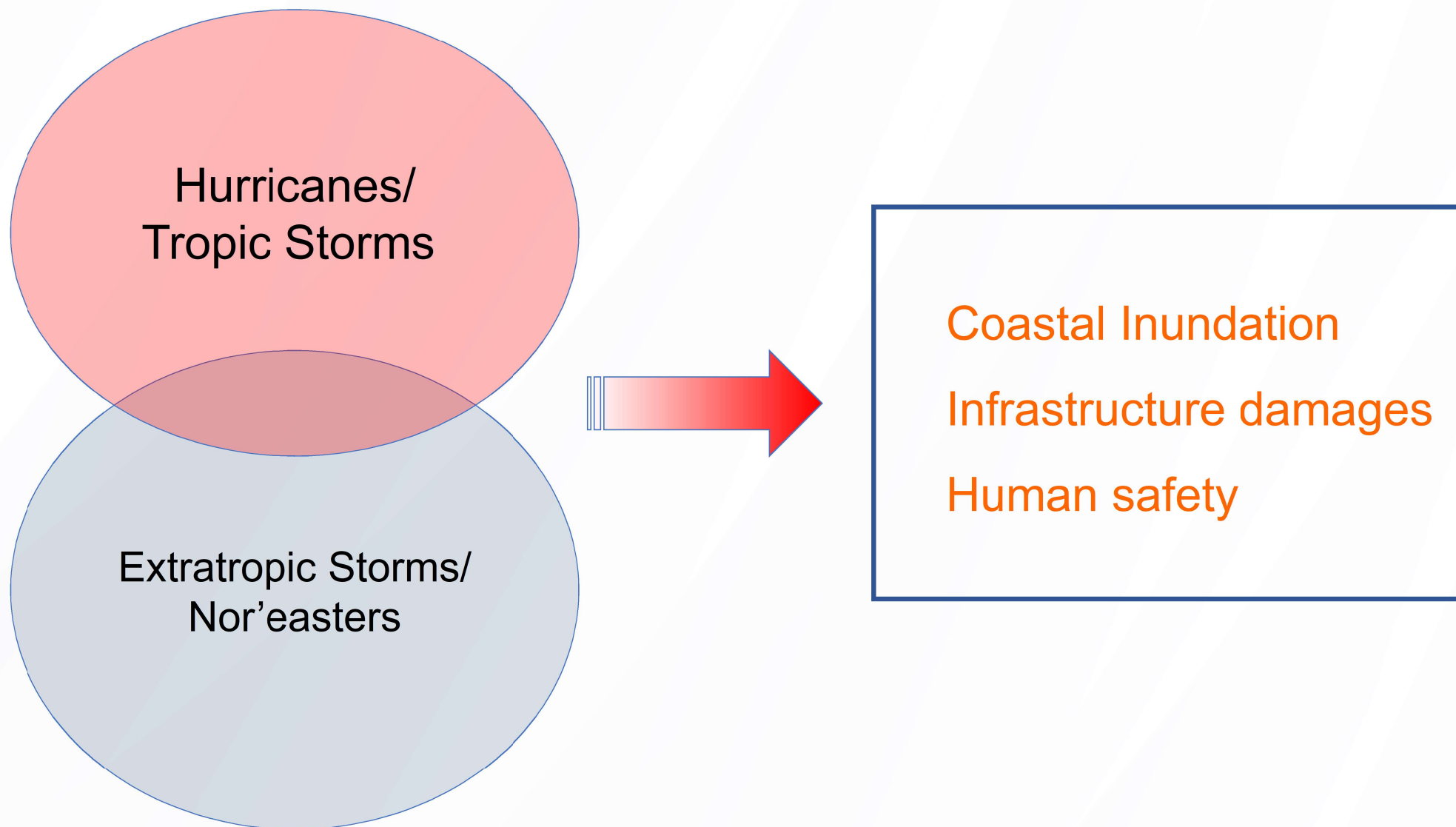




Outline

- ◆ Reviewing the status and challenge of the development of the forecast system for storm surge-induced inundation;
- ◆ Introducing the high-resolution Sun Yat-Sen University Integrated Model (SYCIM);
- ◆ Projection of the Sea Level Rise and Coastal Inundation Around Guangdong-Hongkong-Macao Greater Bay Area Over the Next Century
- ◆ Summary

Storm-induced Hazards and Disasters along the US Eastern Coast





Hampton



Saco



From John Cannon, MWS



Overwash of a Seawall



From Tony Mignone at NOAA

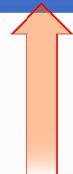
Current US NOAA Storm Forecast Model Systems



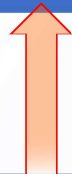
SLOSH (Sea, Lake and Overland Surges from Hurricanes)



A structured grid surge model
(very efficient)



No tides



No waves



No wave runup



Requirements in Improving Physics

01

Nonlinear interaction

Tidal Elevation + Storm Surge

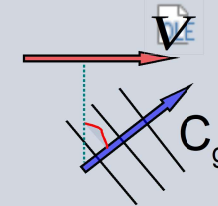
≠

Real Observed Elevation

02

Current-wave interactions

- ➔ Radiation Stress
- ➔ Change the current amplitudes and direction
- ➔ Larger sea level



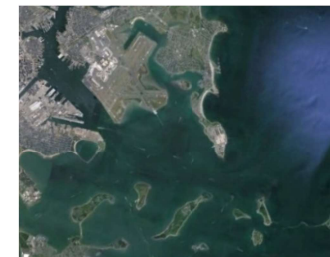
03

Wave run-up produces slashing over or overtopping, even the total water elevation is still lower than the coastal seawall.



04

Coastal irregular geometric fitting requires a unstructured grid modeling approach



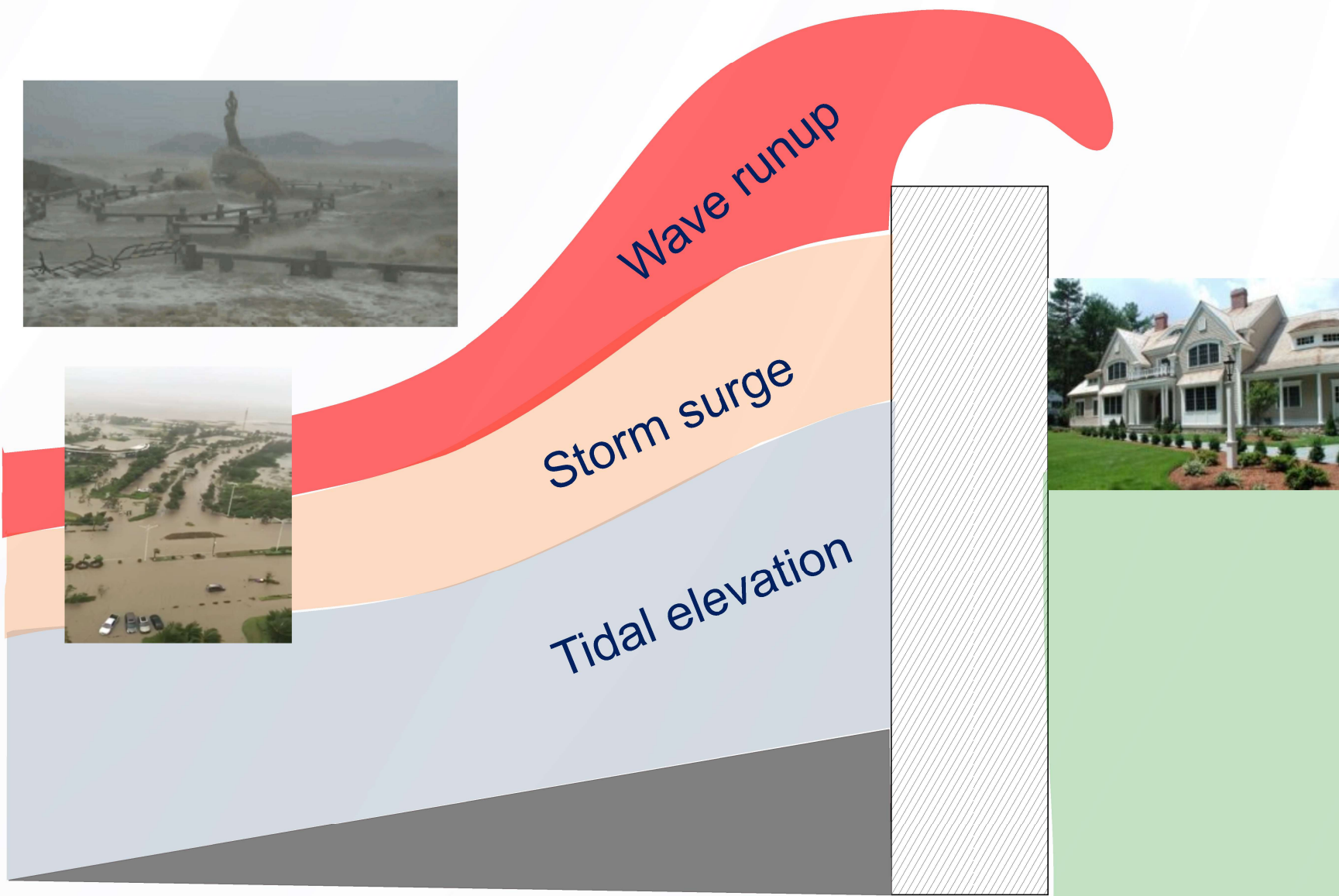


Questions Raised by Climate change-induced Mean Sea Level Rise:

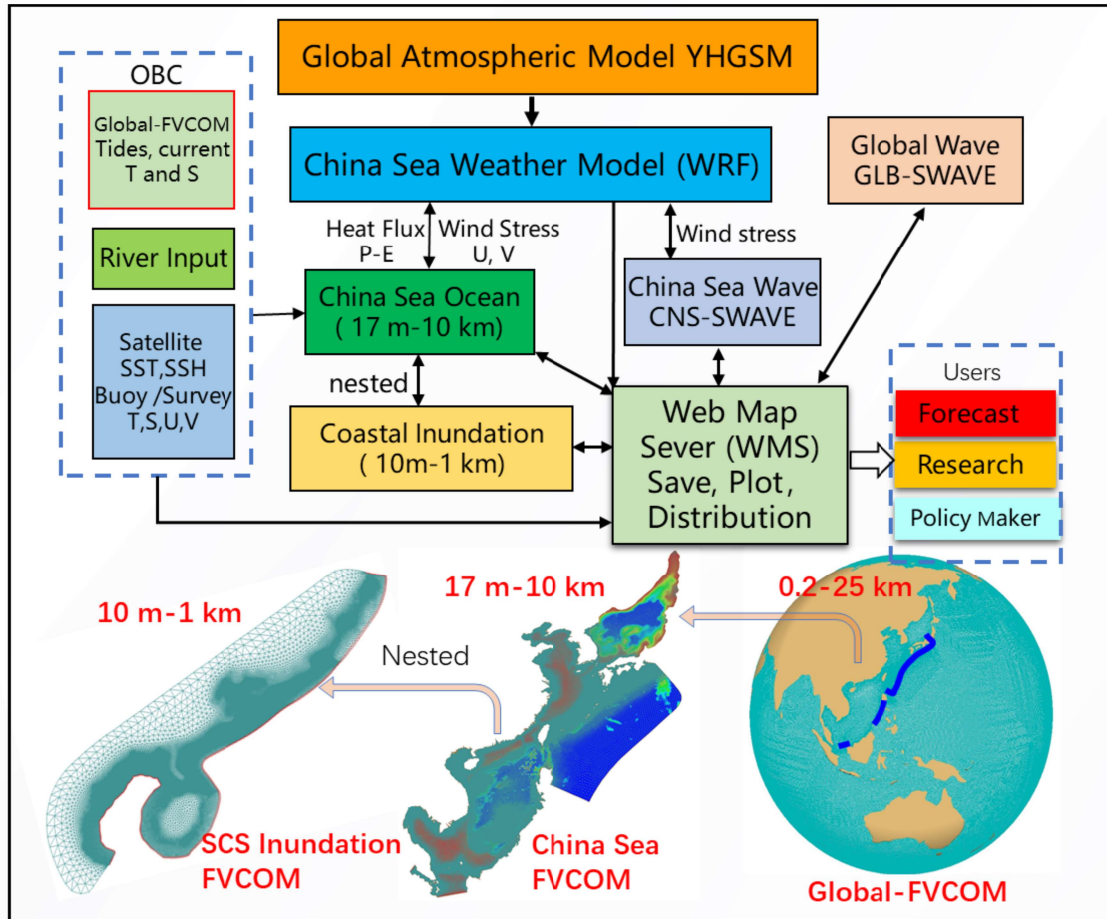
- What level of change would we find for the storm-induced coastal inundation?
- How could we develop an end-to-end forecast system for the storm-induced inundation with accounting of the sea level rise.
- What is the next generation of the storm surge forecast model system?



Coastal Inundation



Sun Yat-Sen University Integrated Model (SYCIM) -ocean forecast system

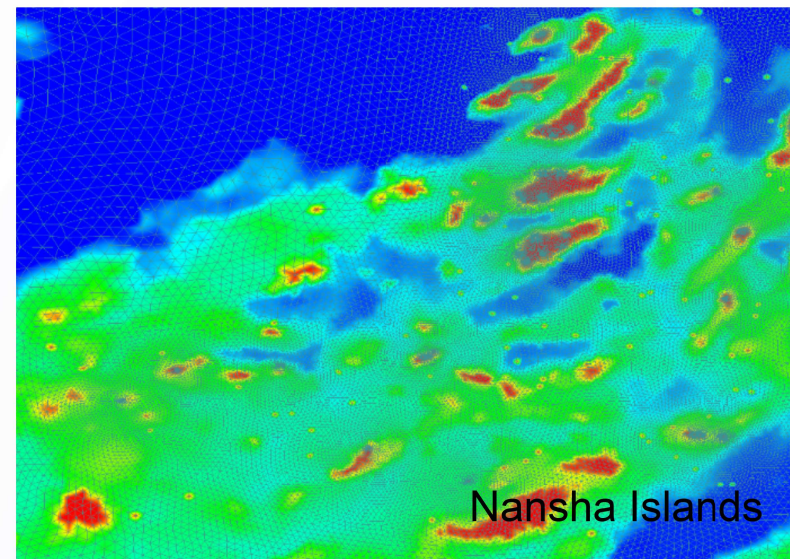
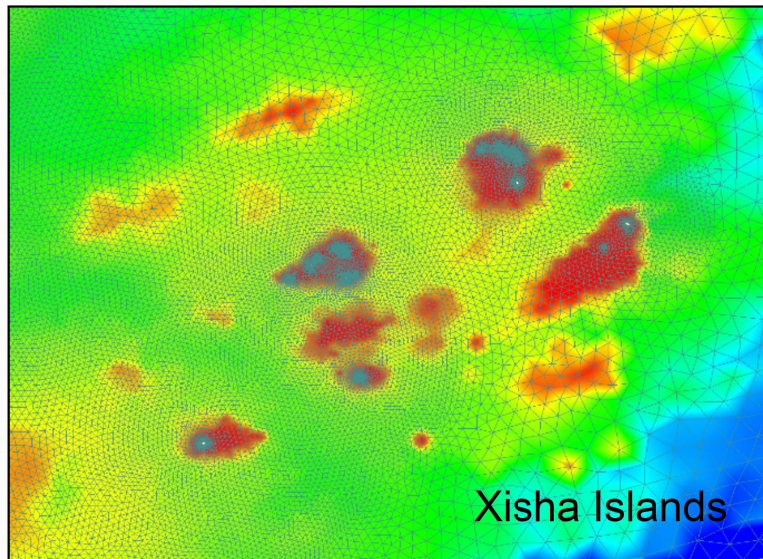
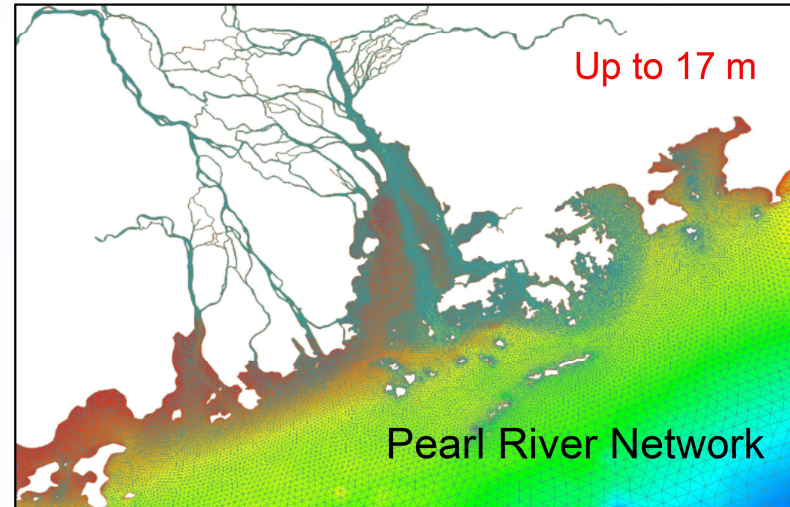
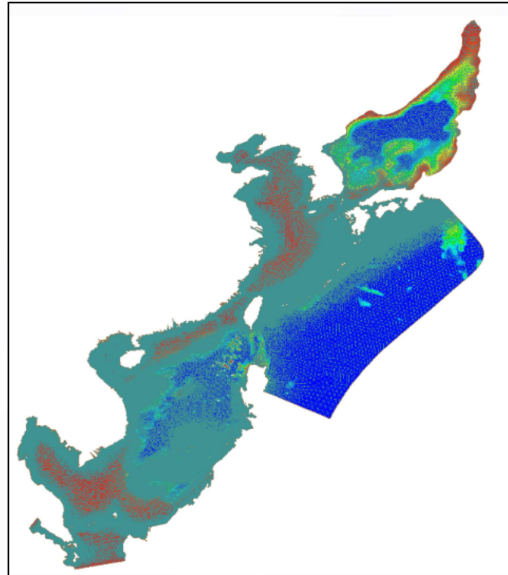


“Tianhe 2” forecast flowchart

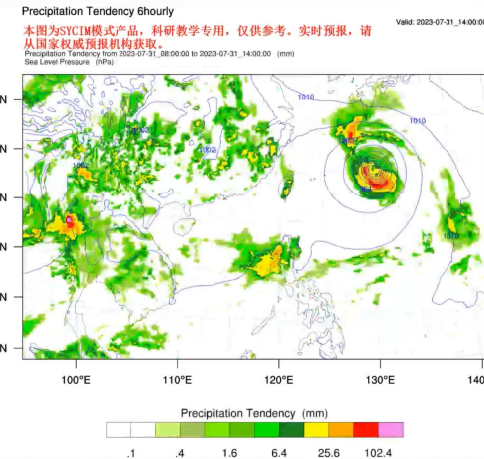
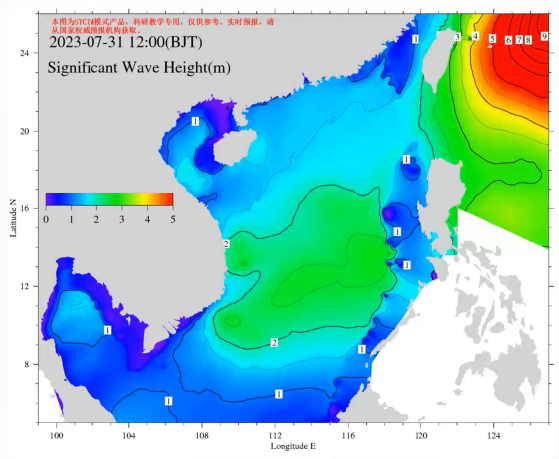
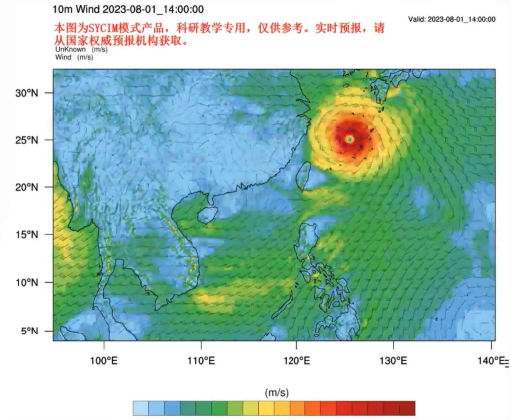
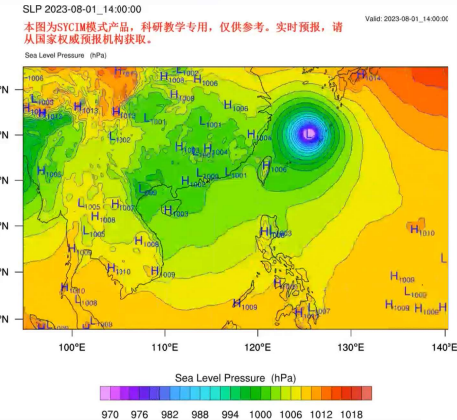
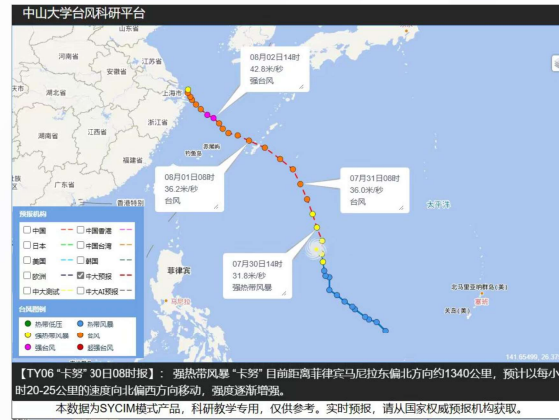
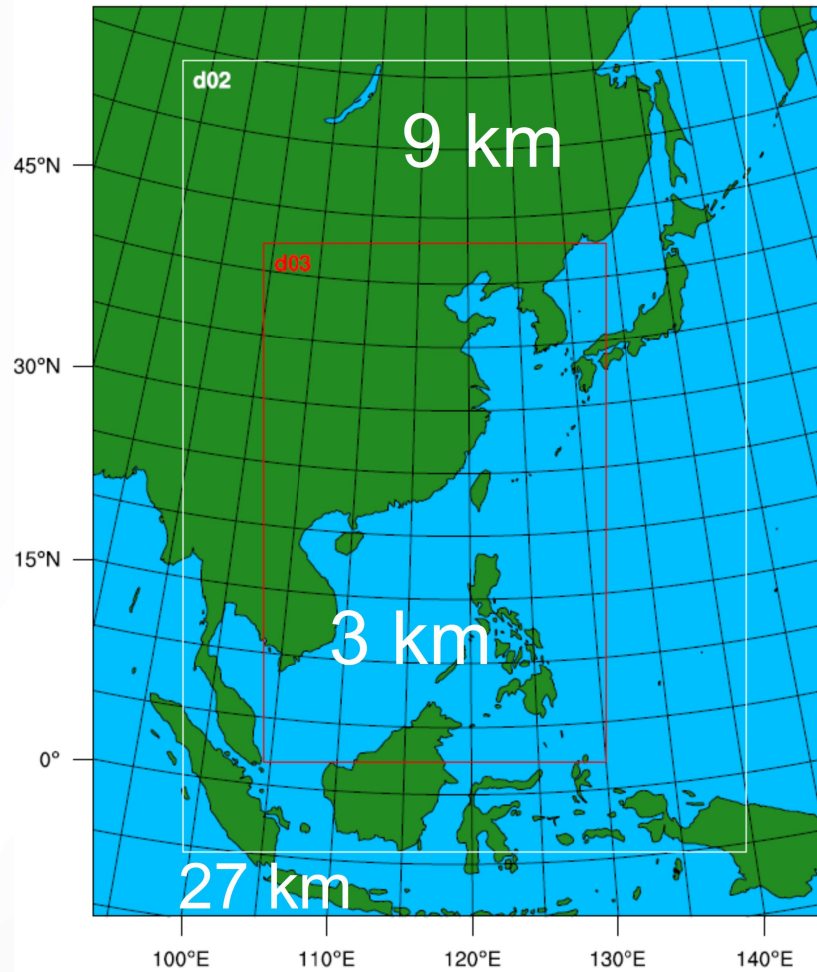


Download data, GFS、SST、SSH、river input, prepare forcing files, run the model, plot, save data, quasi operational run ~15 thousands core hours/day

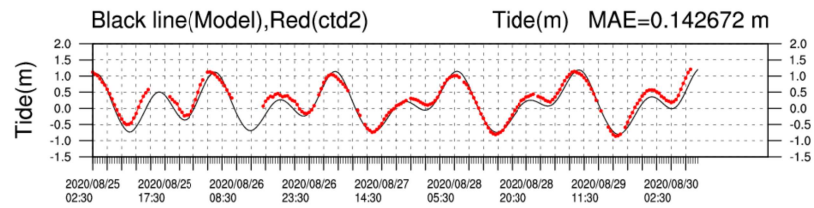
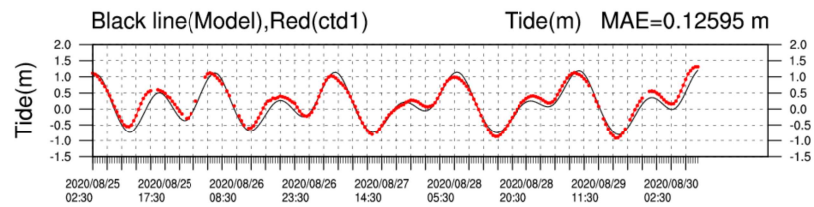
China Sea Ocean Model Grid



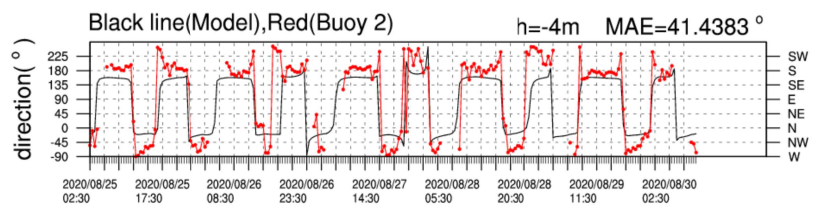
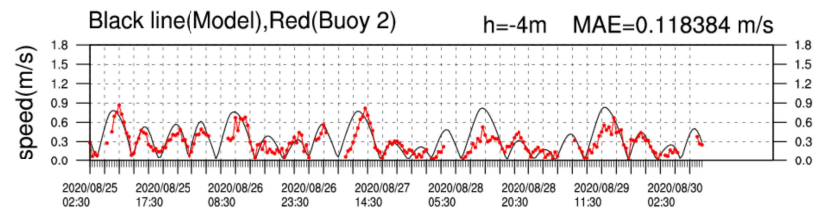
WPS Domain Configuration



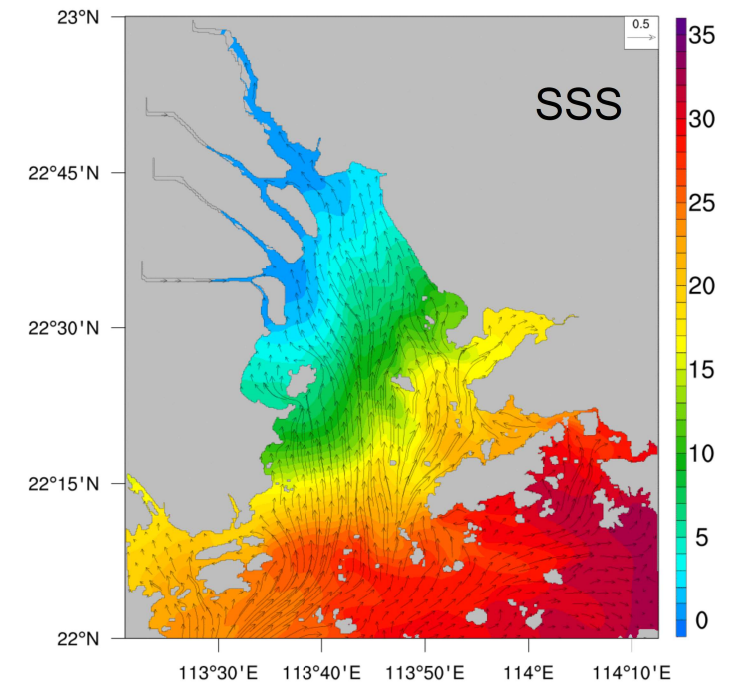
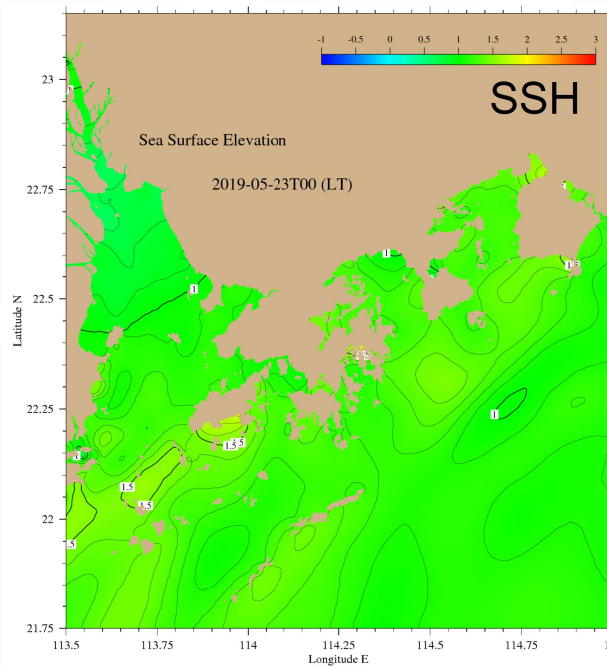
Typhoon Khanun



Simulated water level vs. observations



Simulated currents vs. observations





Typhoon Hato (天鴿) (August 23, 2017)



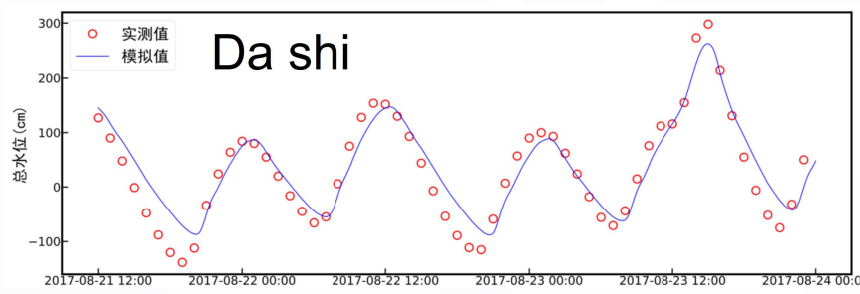
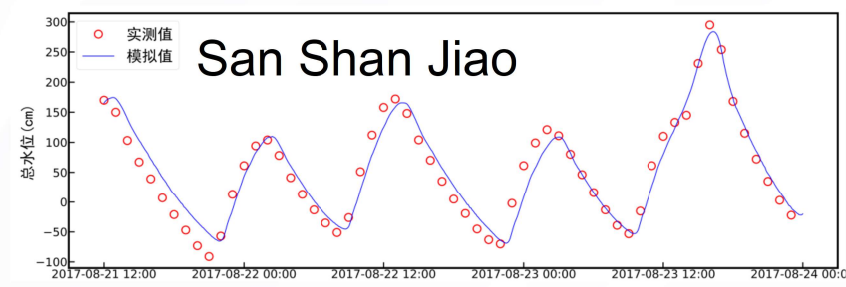
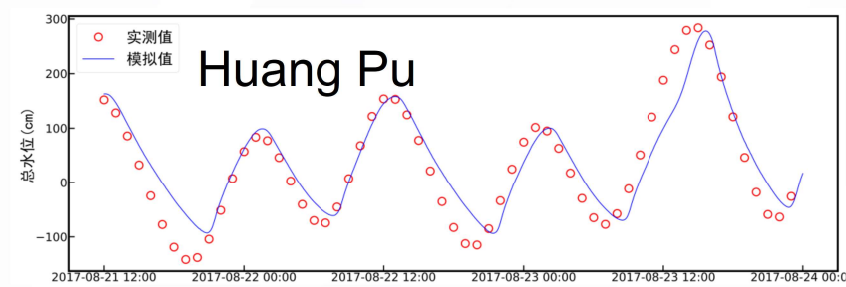
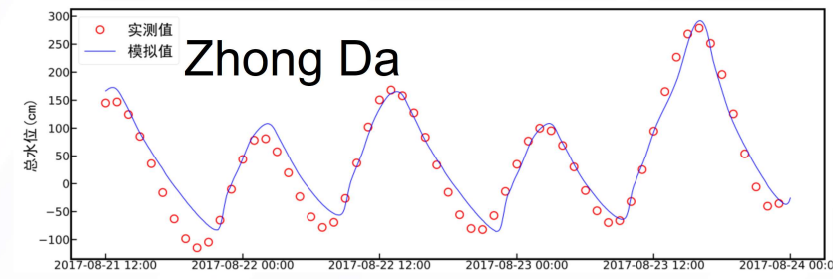
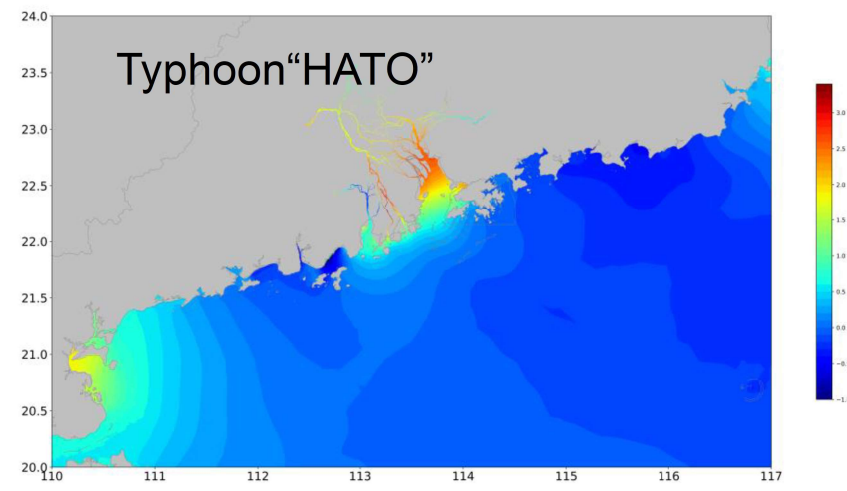
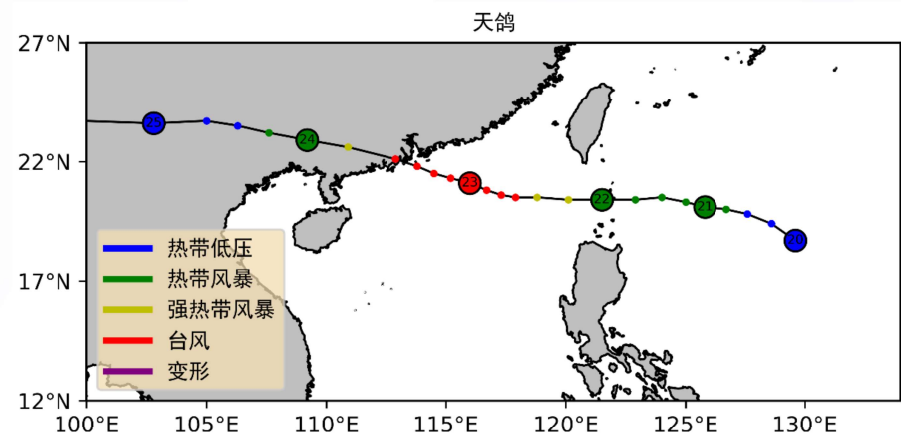
Wave runup Splashing or overtopping

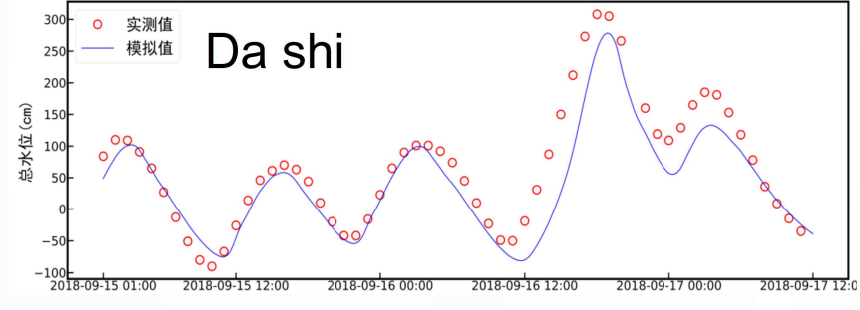
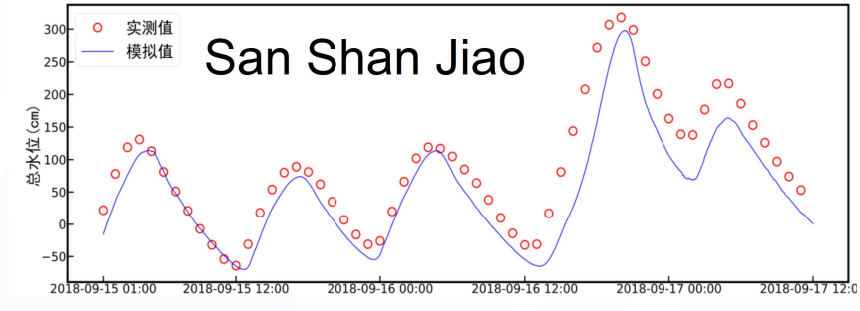
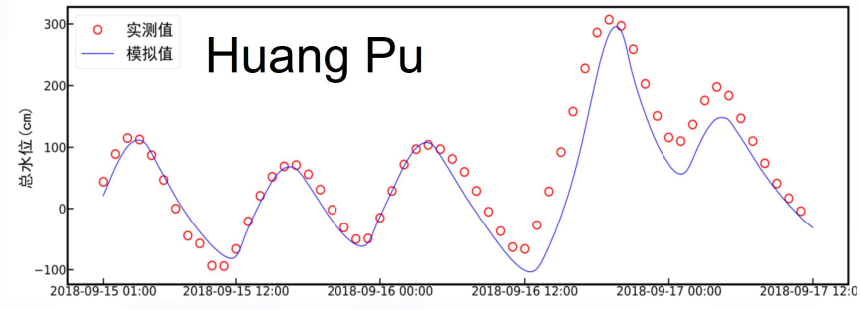
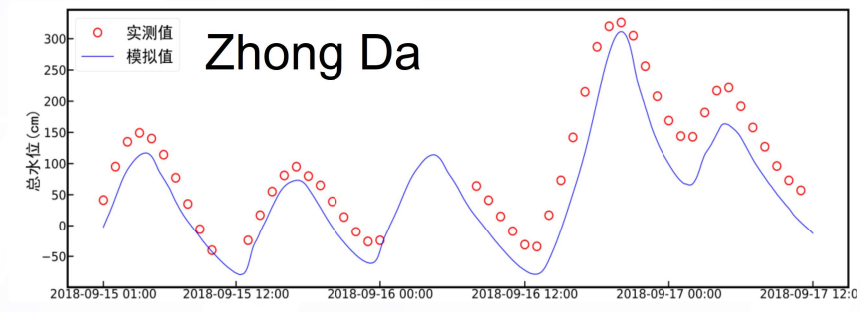
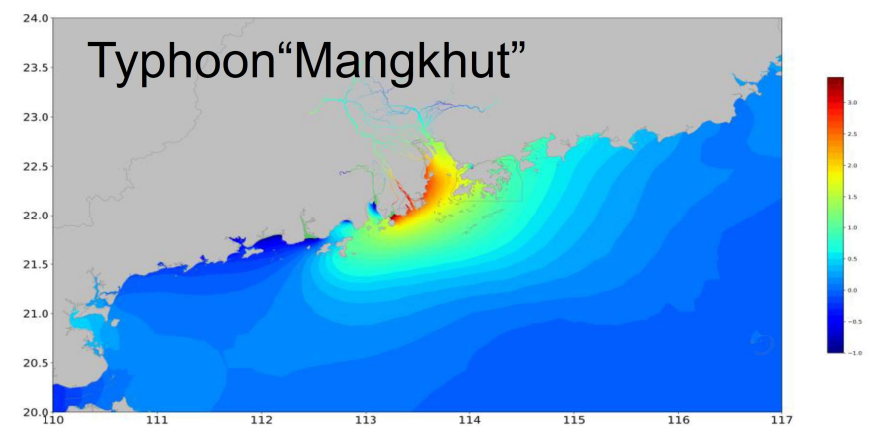
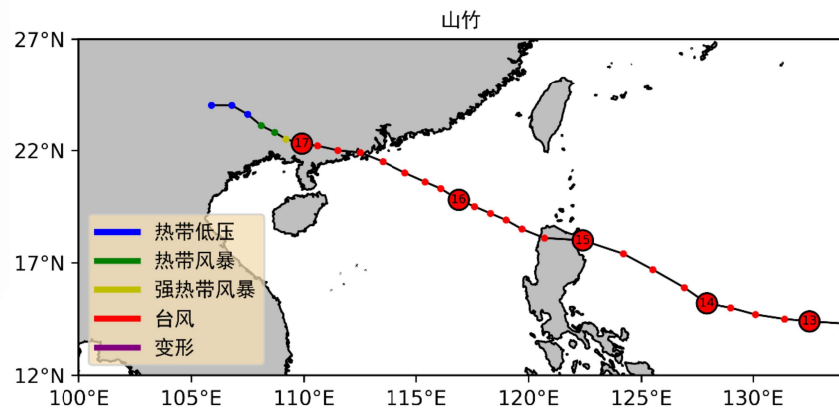


Storm surge level



Seawall







Greater Bay Areas: Big 4



New York Bay
Area



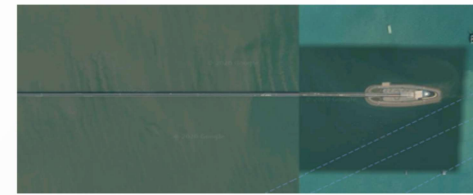
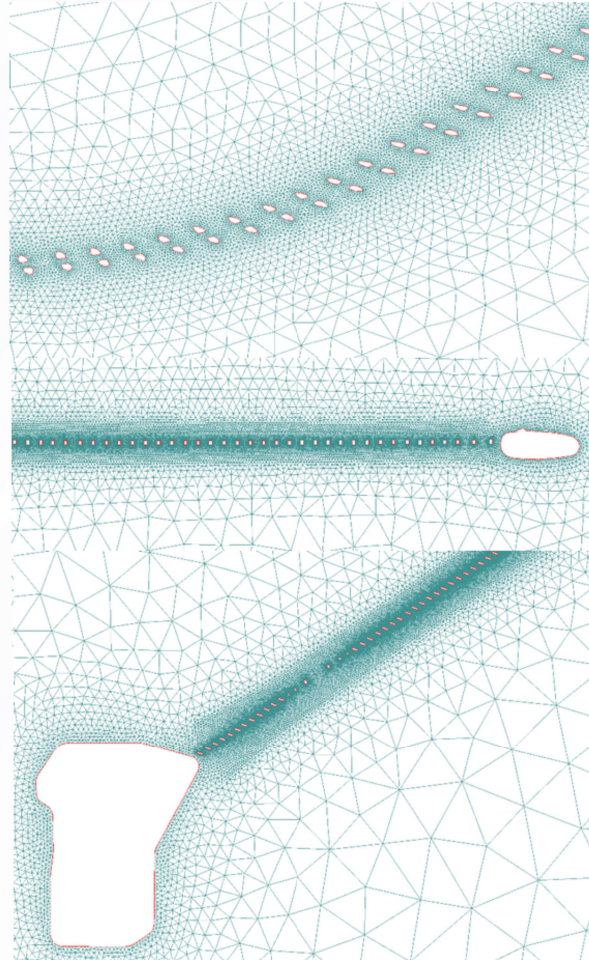
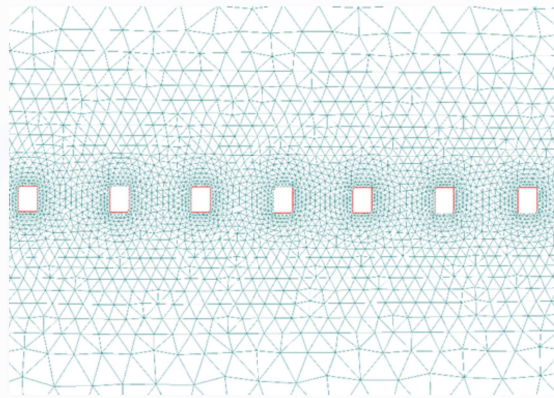
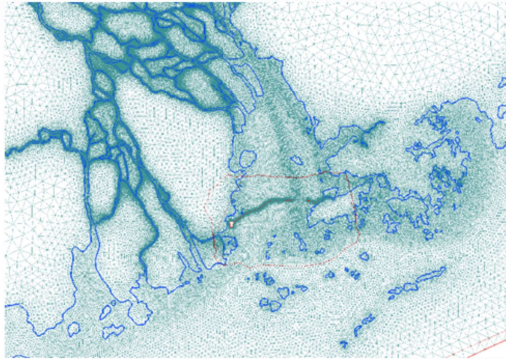
Guangdong-Hong
Kong-Macao
Greater Bay Area



San Francisco
Bay Area



Tokyo Bay
Area



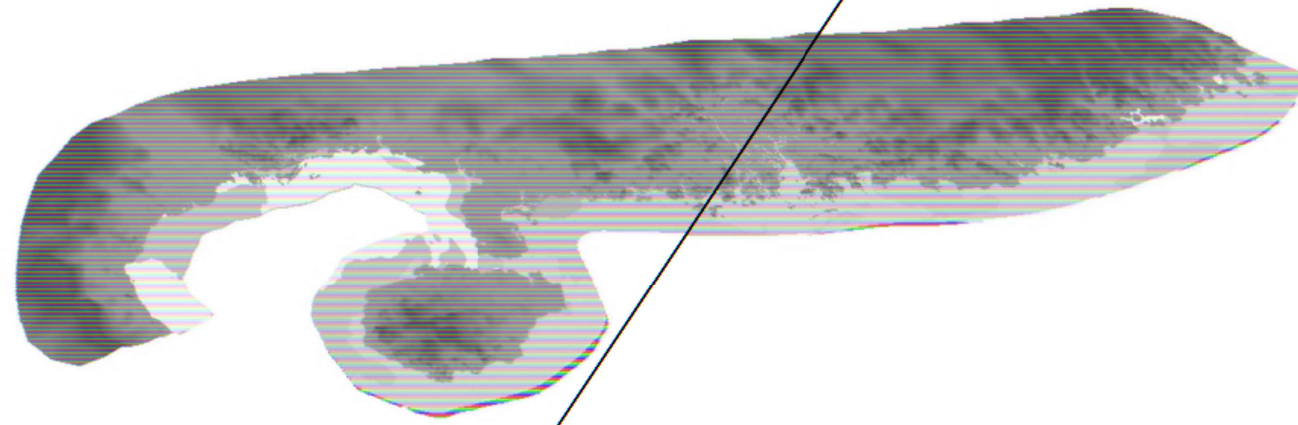
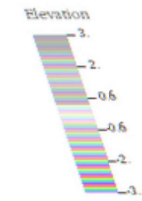
Coastal inundation model grid, resolution~2m

China Sea Coastal Inundation Forecast System



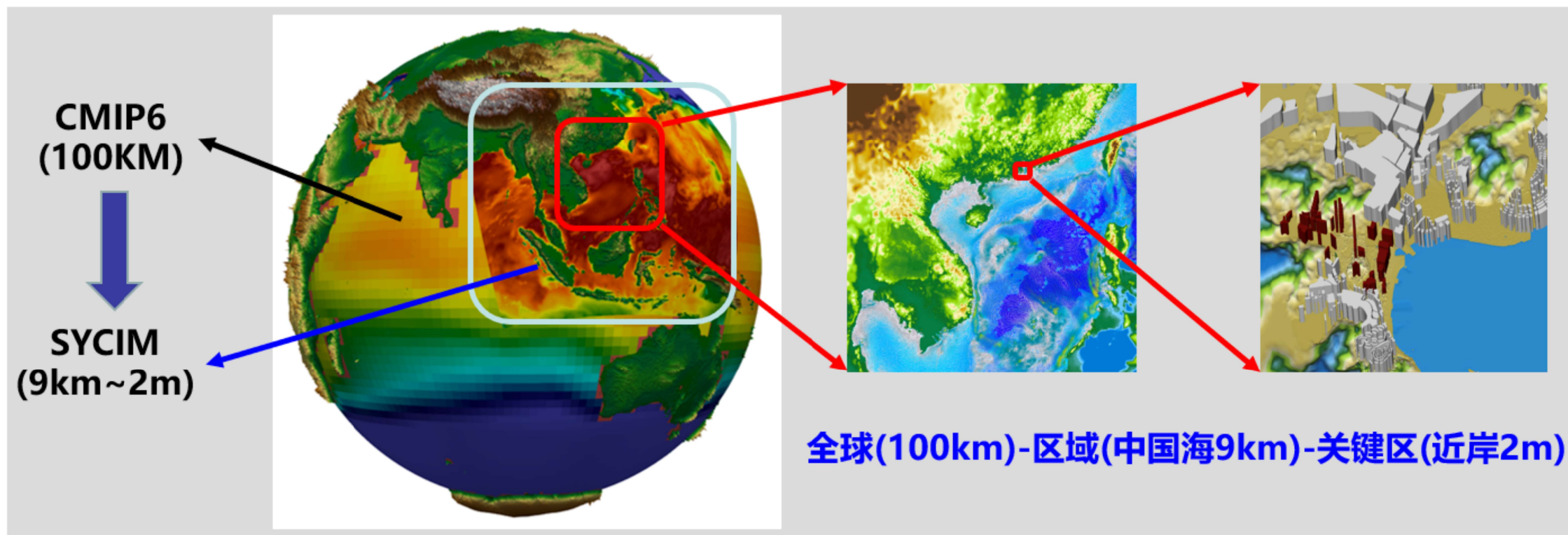
South China Sea

August 2-8, 2021



Sun Yat-Sen University Integrated Model (SYCIM)

Numerical Downscaling

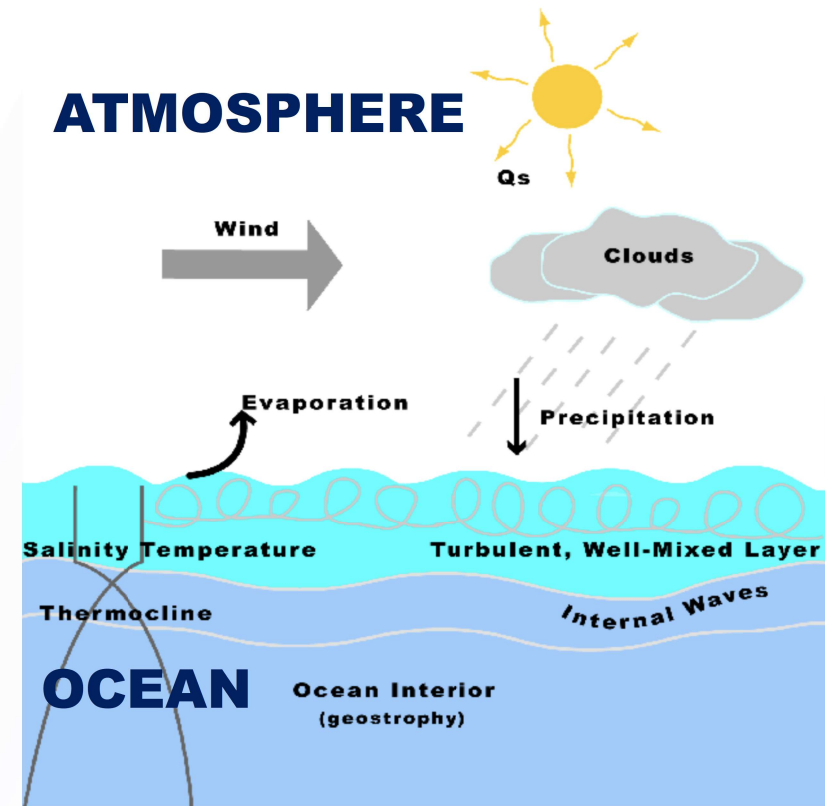
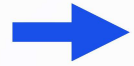
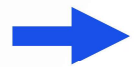




Sun Yat-Sen University Integrated Model (SYCIM)

Numerical Downscaling

CMIP6 Name	CF Name	CF Units
ta	Air Temperature	K
tas	Near-Surface Air Temperature	K
ua	Eastward Wind	m s-1
uas	Eastward Near-Surface Wind	m s-1
va	Northward Wind	m s-1
vas	Northward Near-Surface Wind	m s-1
hus	Specific Humidity	1
huss	Near-Surface Specific Humidity	1
zg	Geopotential Height	m
ps	Surface Air Pressure	Pa
psl	Sea Level Pressure	Pa
tsl	Temperature of Soil	K
mrsos	Moisture in Upper Portion of Soil Column	kg m-2
mrsol	Total Water Content of Soil Layer	kg m-2
ts	Surface Temperature	K
snw	Surface Snow Amount	kg m-2
CMIP6 Name	CF Name	CF Units
zos	Sea-surface-height	m
uo	Eastward-sea_water_velocity	m s-1
vo	Northward-sea_water_velocity	m s-1
wo	Upward-sea_water_velocity	m s-1
so	Sea_water_salinity	1e-3
thetao	Sea Water Potential Temperature	degC

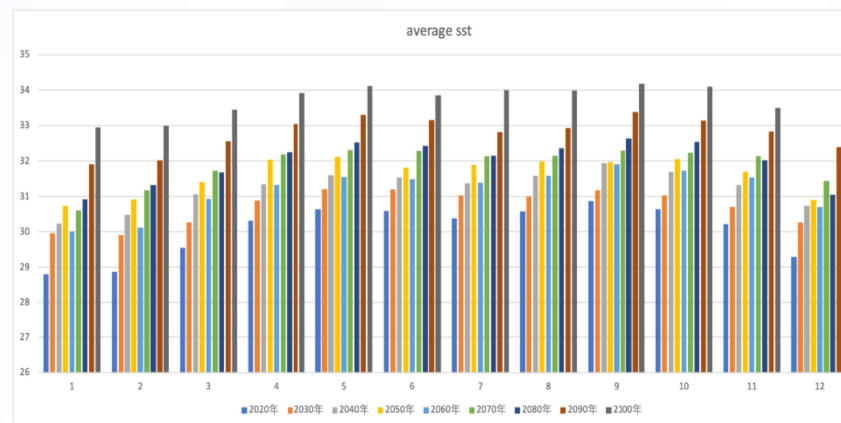
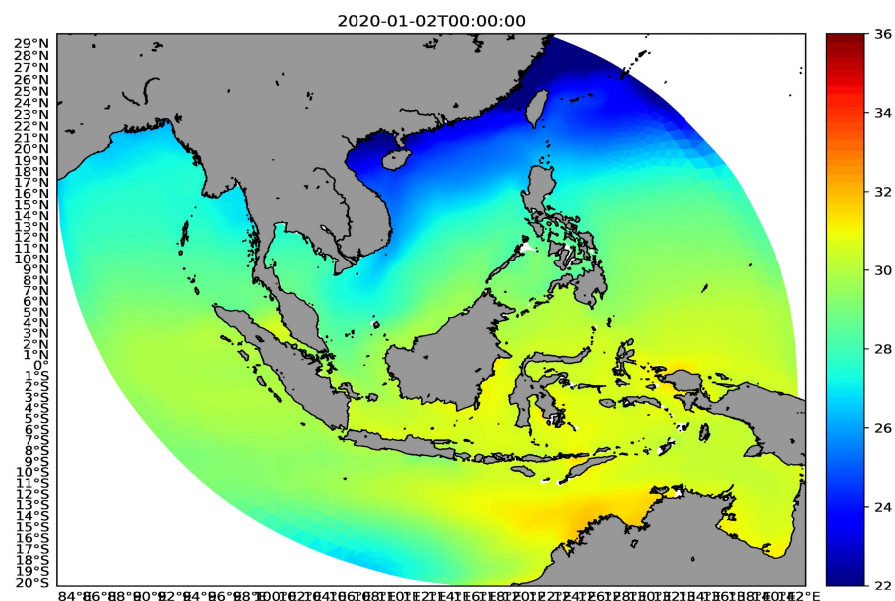


CMIP6



SYCIM

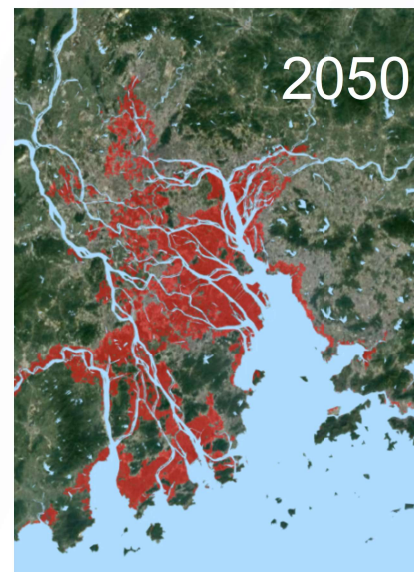
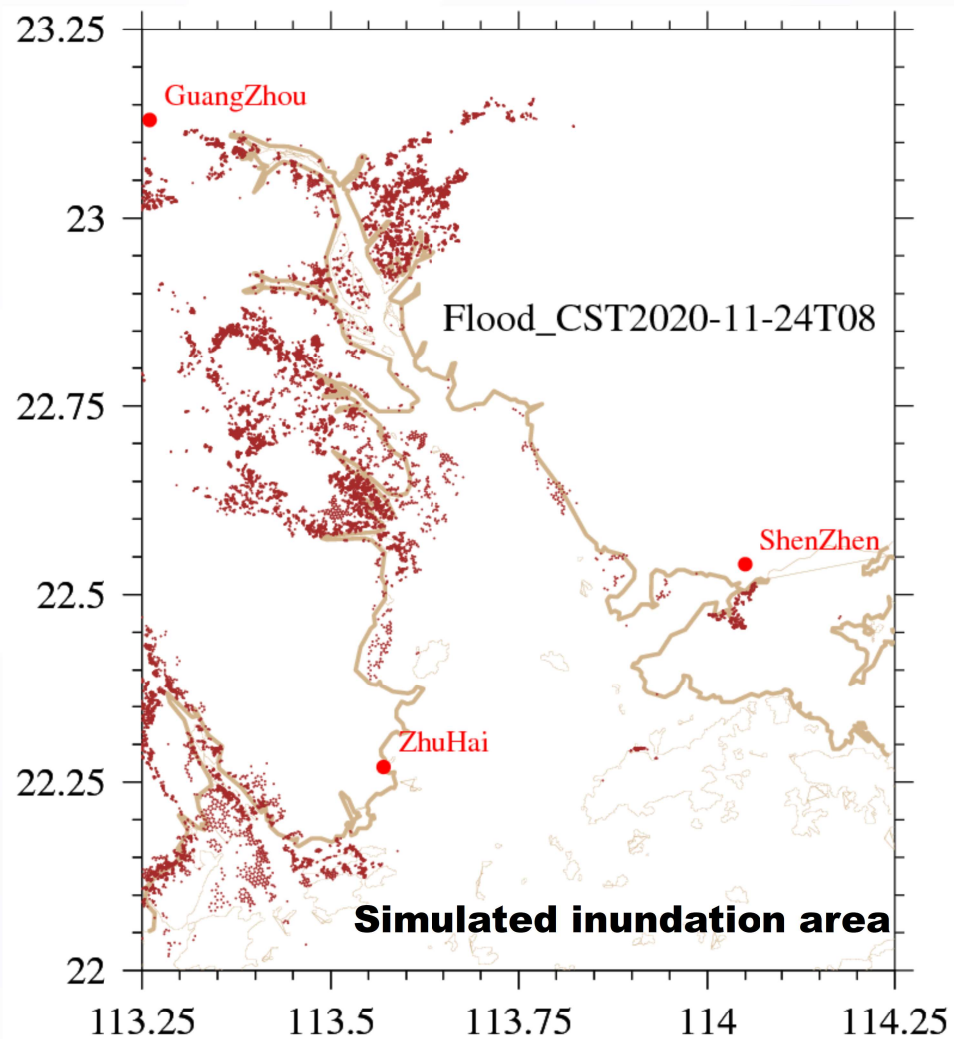
Hot SCS



- In SSP585 scenario , The SCS SST will rise up to 3.6°C by the end of 2100

SSP585: With an additional radiative forcing of 8.5 W/m² by the year 2100, this scenario represents the upper boundary of the range of scenarios described in the literature.
CMIP6 (IPCC AR6)

Projection of the Coastal Inundation



SLR only

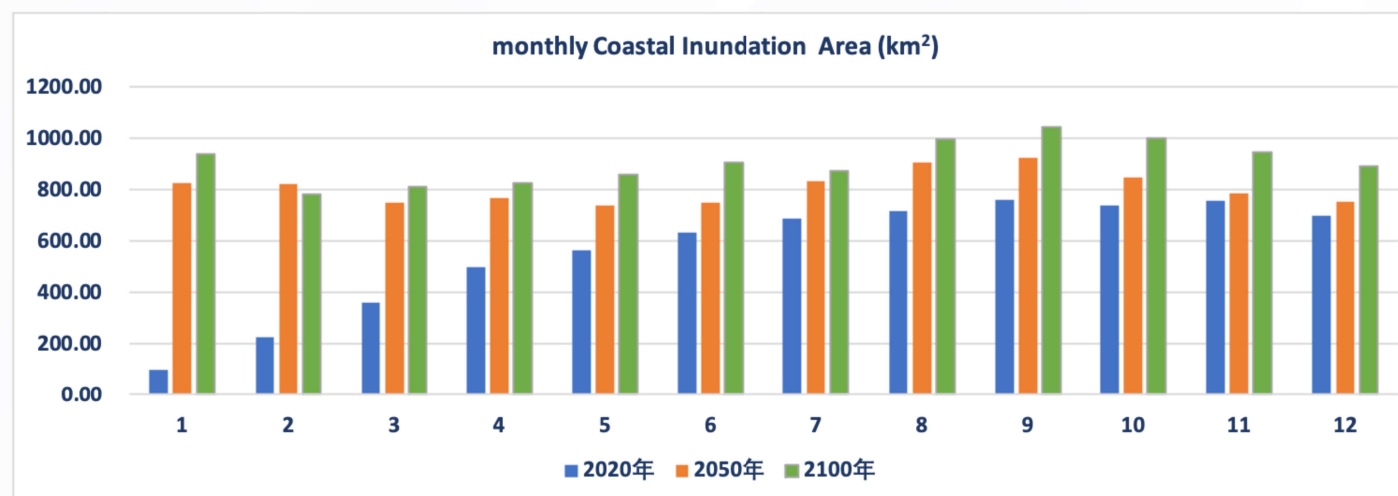
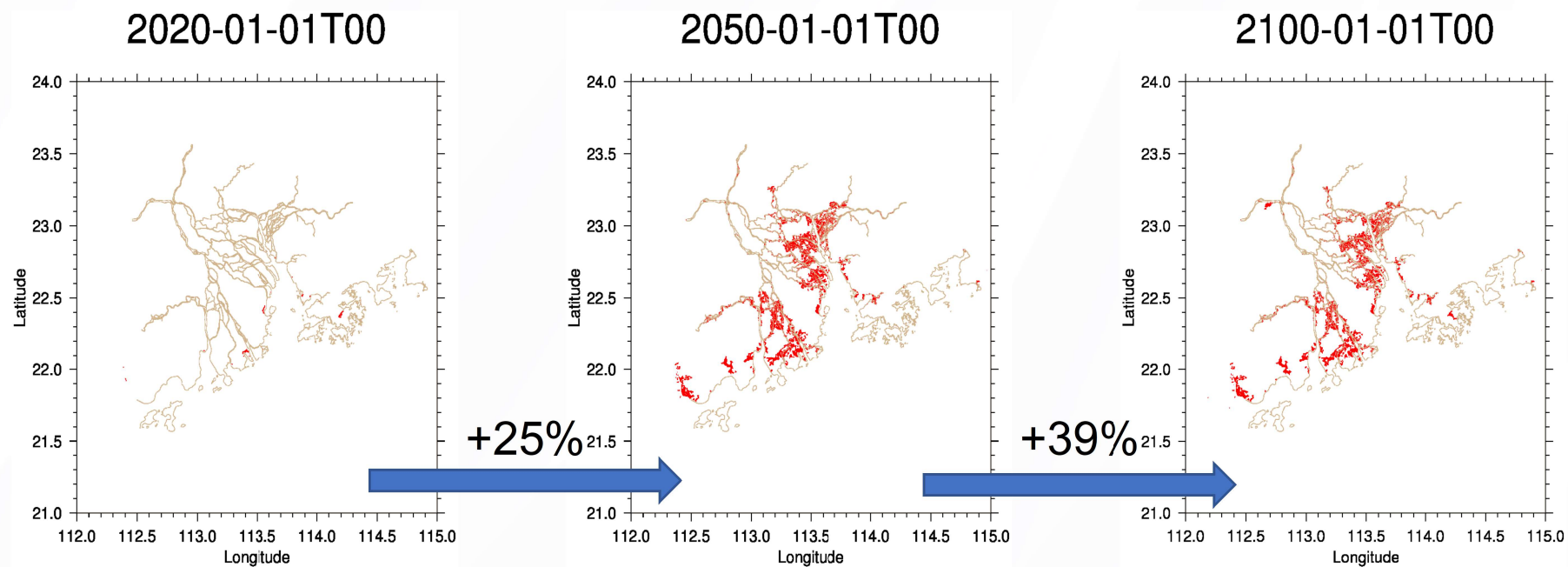


SLR + Storm inundation

(Kulp & Strauss, Nat. Commu. , 2019)

To 2050, The most coastal region of the Guangdong-Hong Kong-Macao Greater Bay Area are in the risk of flooding

Projection of the Coastal Inundation





Summary

- The coastal inundation is the major task of the “end to end” storm forecasting. The ultra-high resolution numerical model must be used in the storm surge forecast system

- The SYSU research team has established a new global-regional-land nested model system (SYCIM) that is ready for an application to develop a storm forecasting and hazard assessment system along the China’s coast

- The most coastal region of the Guangdong-Hong Kong-Macao Greater Bay Area are in the risk of flooding under the changing Climate

谢谢!

Thanks !

xudanya@sml-
zhuhai.cn



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