



Development and Applications of the Earth System Model SYCIM

**Challenges and Response Strategies for Water Resources
in Islands and Coastal Regions Under Changing Climate**

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Outline

- ◆ **A brief description of the high-resolution Synthesis Community Integrated Model (SYCIM)**
- ◆ **Examples of Applications:**
 - **A multi-scale global-regional-coastal-estuarine forecast system**
 - **Ocean-Land-Atmosphere-Sea Ice coupled System**
 - **SYCIM-Macao inundation model**

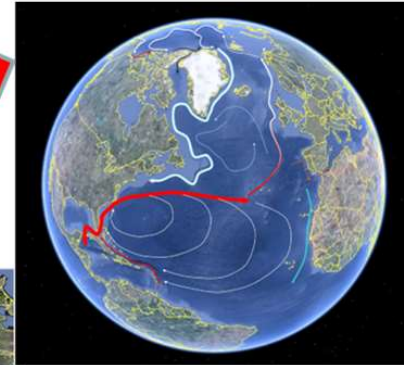
Climate Change



Ecosystem regime shift
Coastal ocean acidification
Water quality
Coastal inundation
Land-river-shelf interaction

Global-to Estuarine Multi-scale Interactions

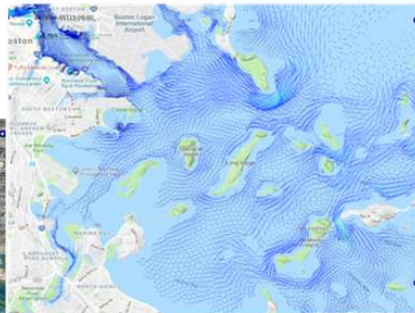
Global-scale



Regional-scale



Coastal-scale



Estuarine-scale



Is it important?
How to approach with modeling?

Challenges We Are Facing to

- Lack of the observation 4-dimensional (x,y,z,t) network that is capable of resolving the multi-scale physical and ecosystem processes;
- Lack of the systematic understanding of impacts of global climate change on the coastal physical and ecosystem processes.

Key Issues

Multi-Scale (global-basin-coastal-estuarine-wetland) Interaction !

Requirements for the Improvement of the Earth System Model

- Improve the horizontal resolution to integrate the global ocean; resolving the multi-scale physical processes.



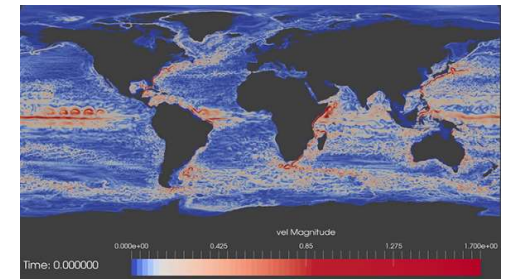
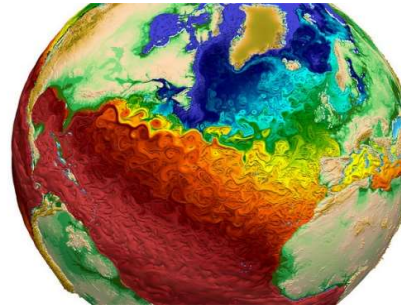
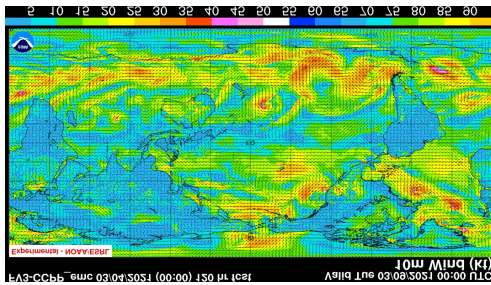
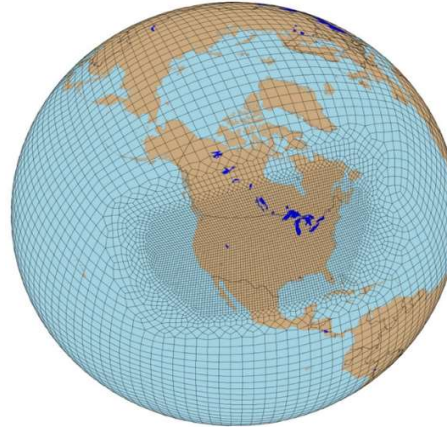
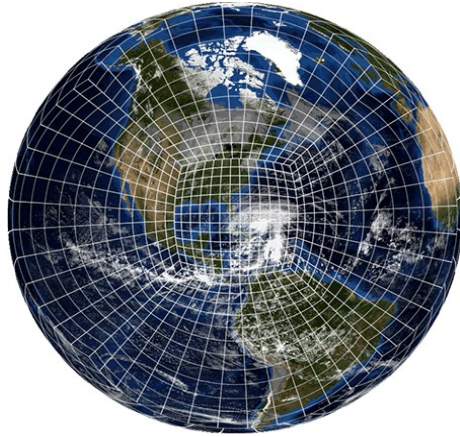
Achievable with high-performance supercomputing

- Resolve the complicate irregular coastal geometry and islands in the ocean



Make the model grid geometrical flexibility: Change the structured (rectangular or curvilinear) grid to the unstructured (e.g. triangle) grid.

Unstructured grid



FV3: Finite-Volume
Cubed-Sphere Dynamical
Core



Model for Prediction
Across Scales (MPAS)
Ocean (MPAS-O)



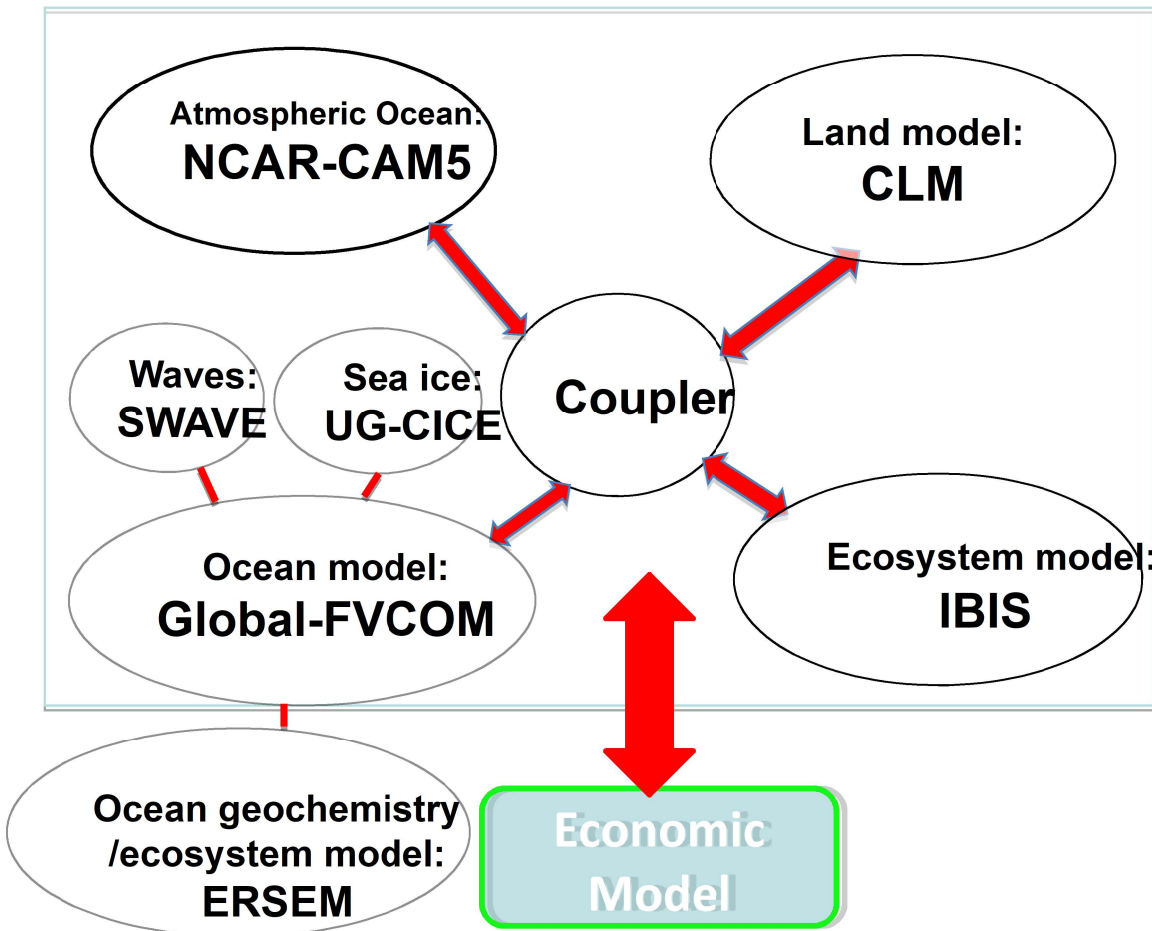
FESOM2



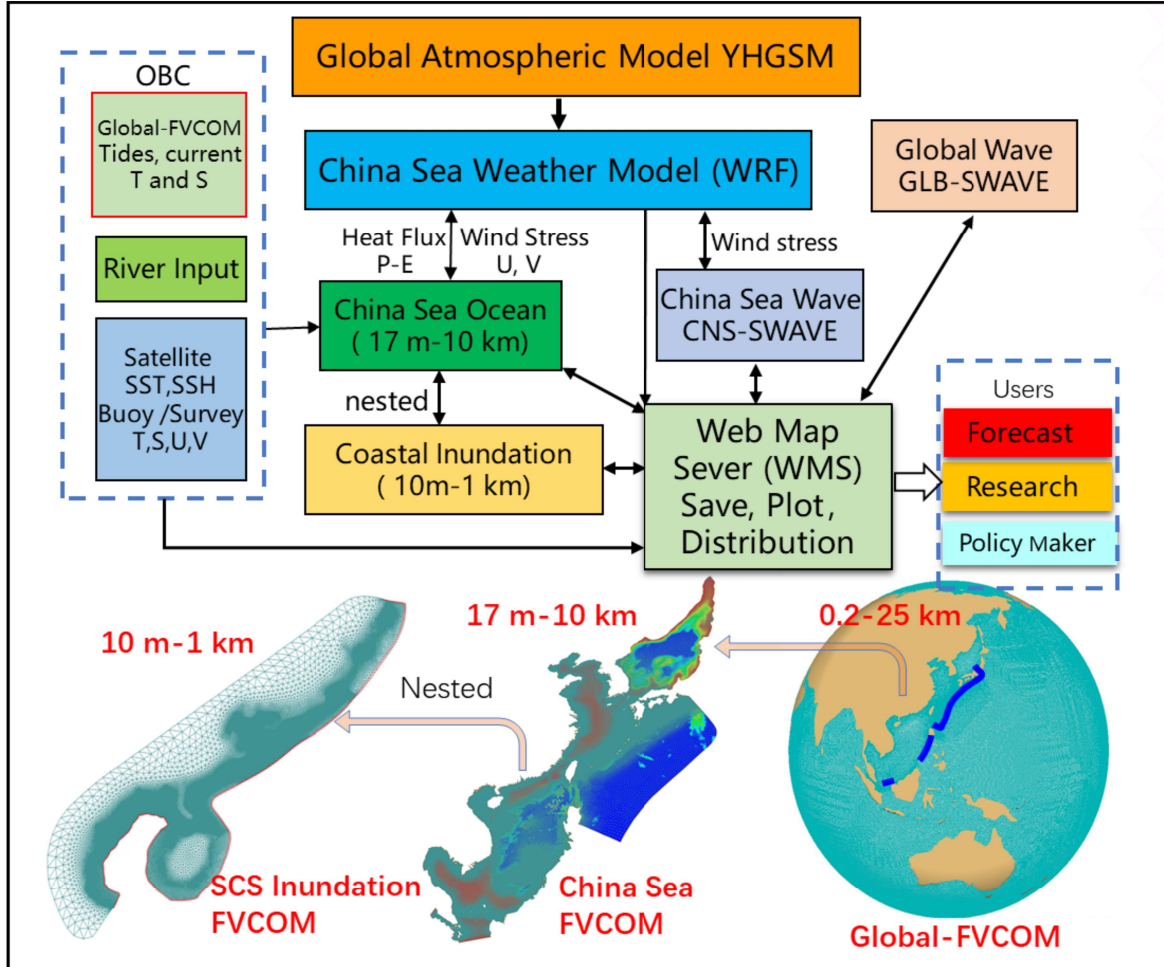
Max-Planck-Institut
für Meteorologie



SYSU Community Integrated Model (SYCIM) (Implementation of Global-FVCOM into NCAR-CESM)



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



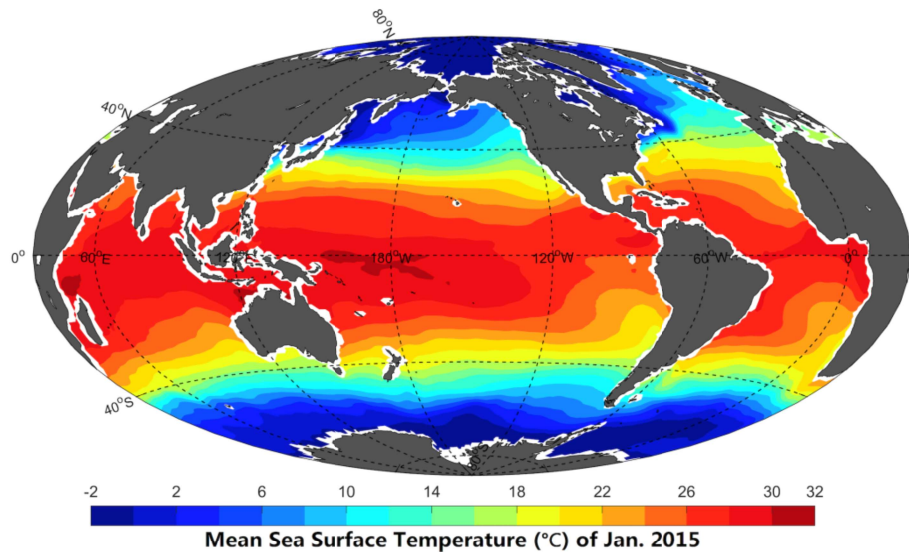
“Tianhe 2” forecast flowchart



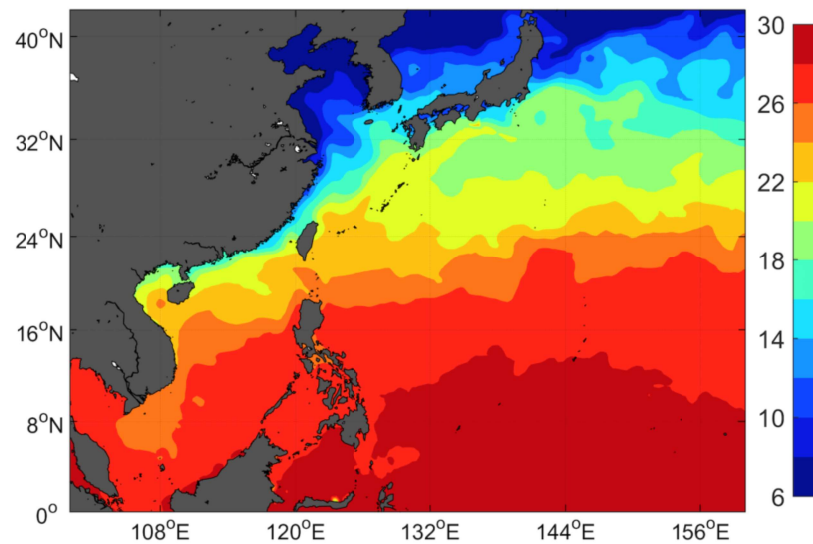
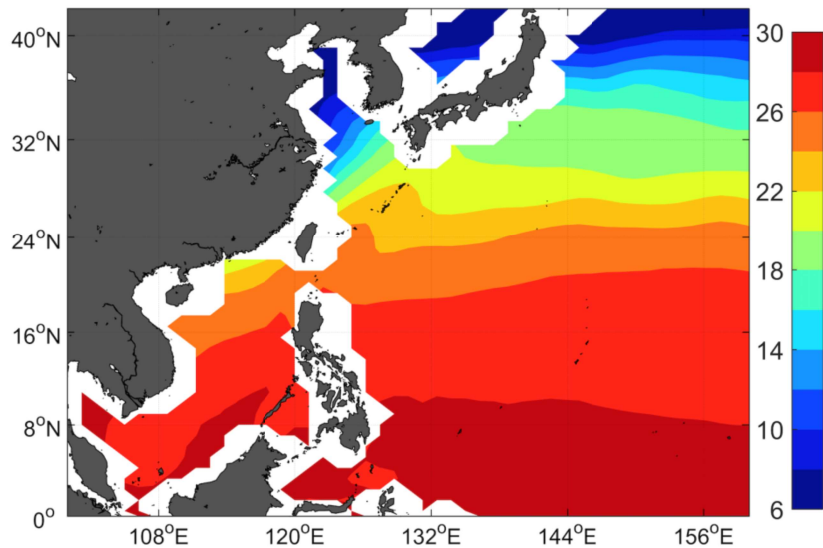
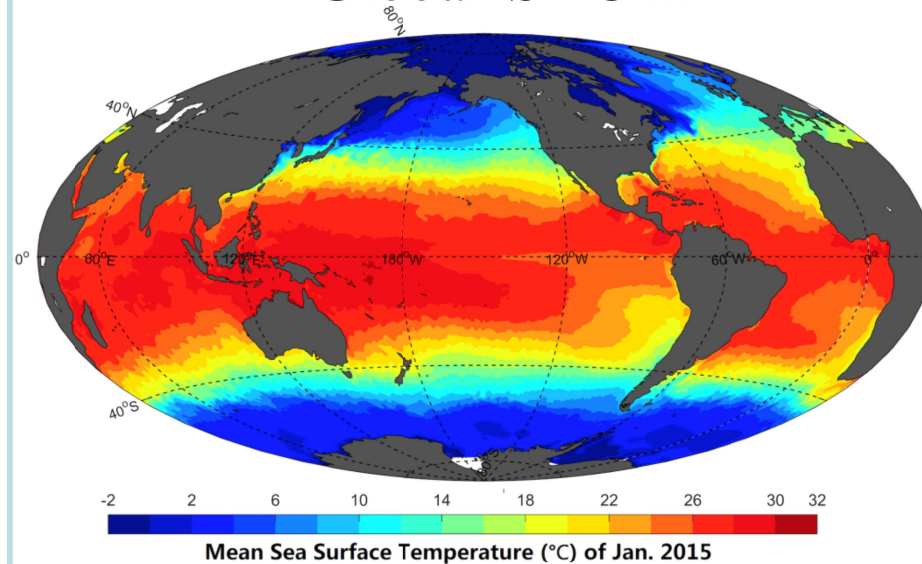
Download data,
GFS、SST、SSH、river
input, prepare forcing files, run
the model, plot, save data,
quasi operational run
~15 thousands core hours/day



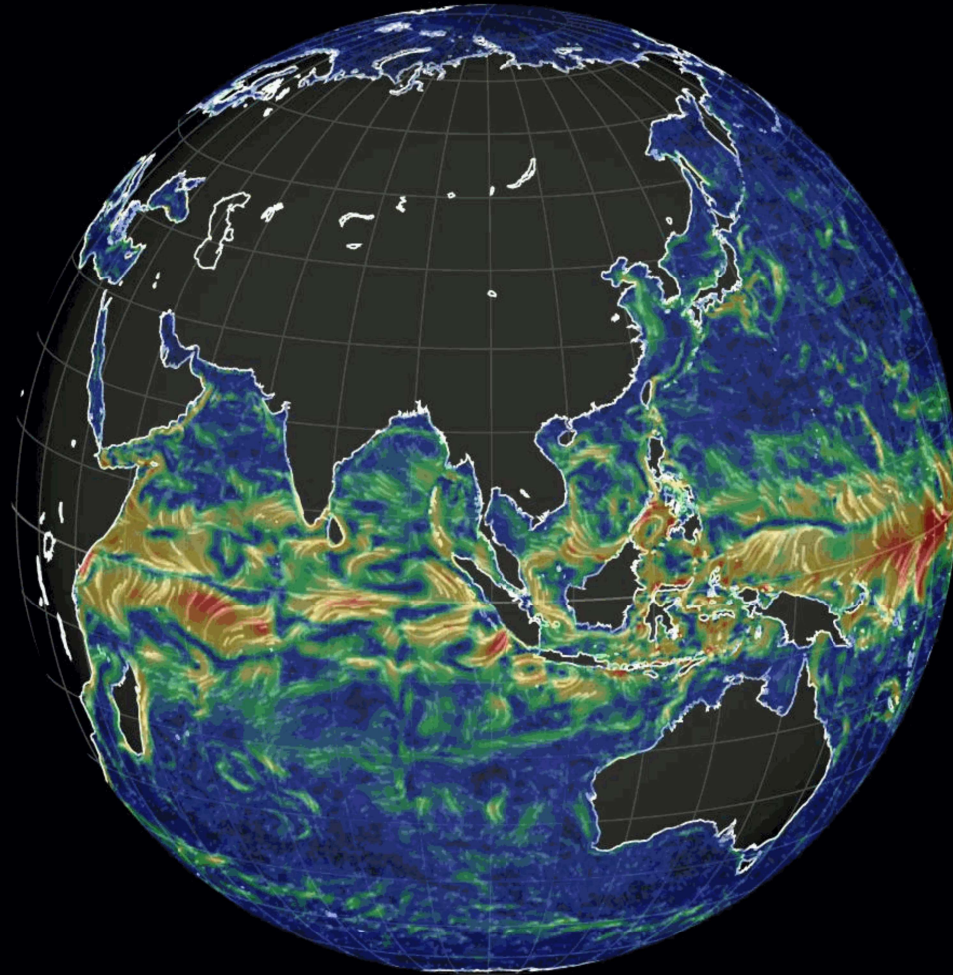
NCAR-CESM



Global-SYCIM



Global surface currents



earth

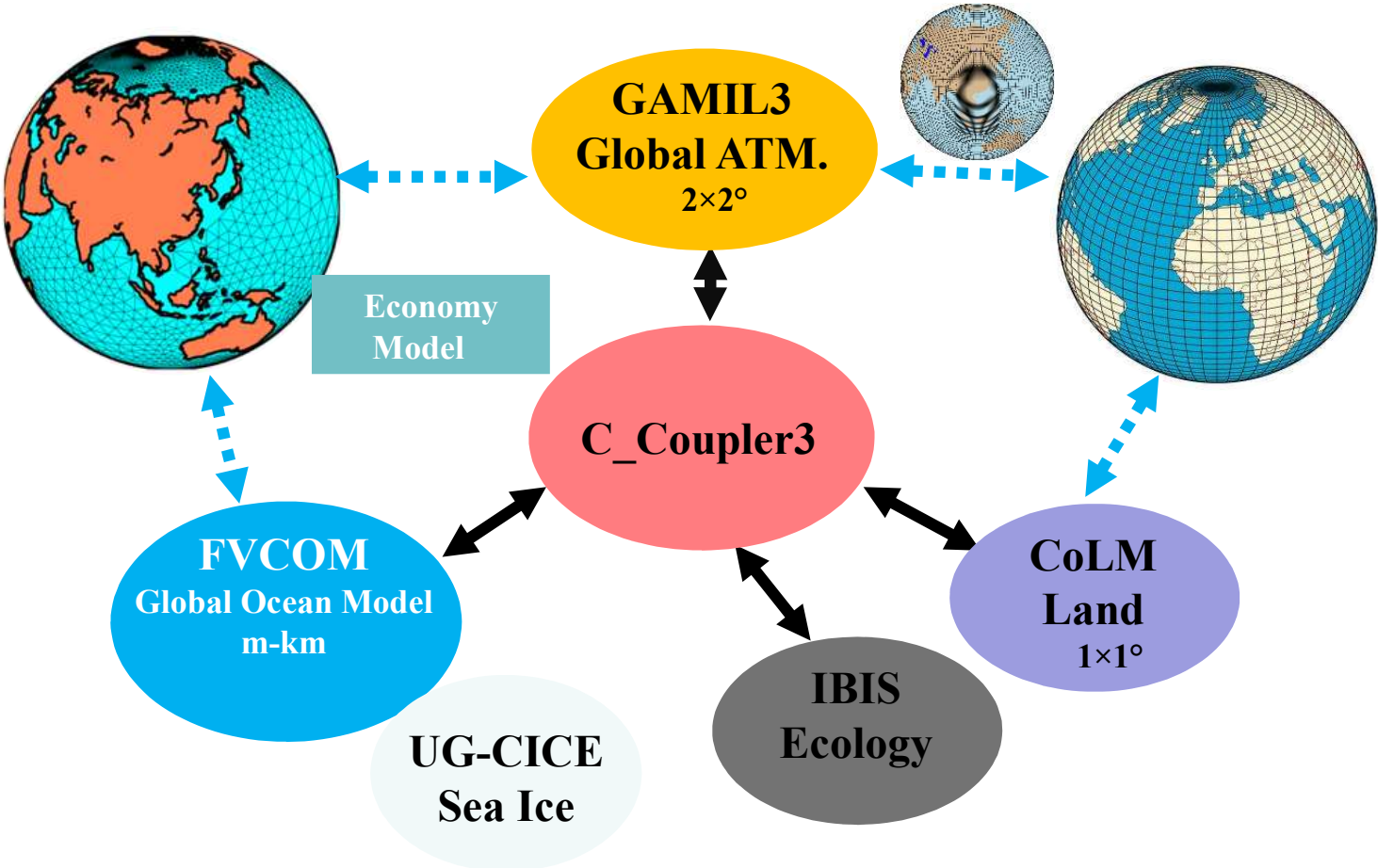


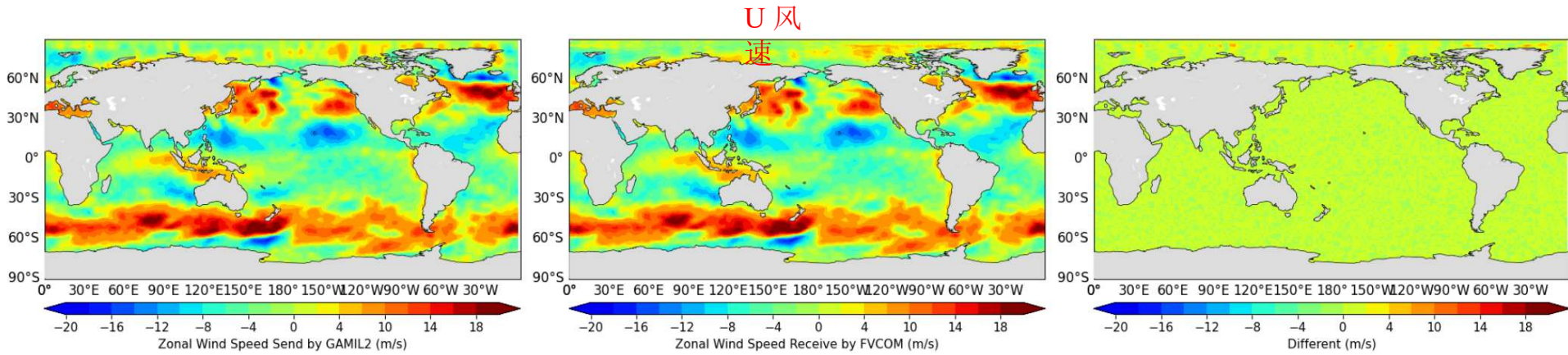
中山大學 大气科学学院
SUN YAT-SEN UNIVERSITY School of Atmospheric Sciences



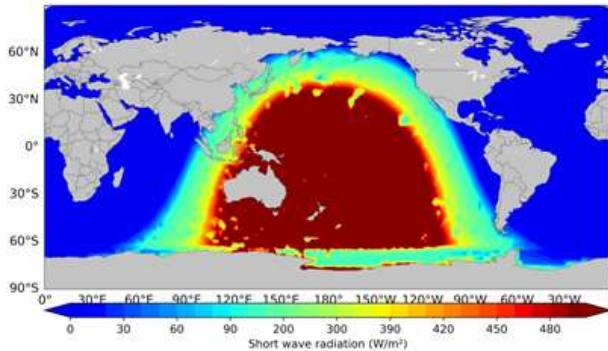
国家超级计算广州中心

Ocean-Land-Atmosphere-Sea Ice coupled System

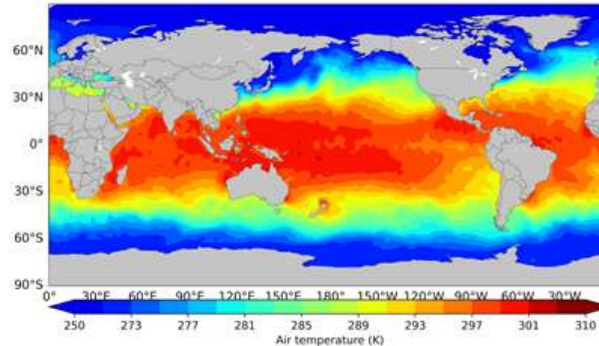




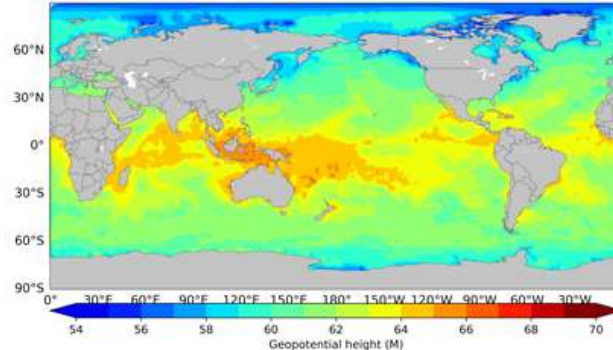
向下短波辐射



大气底温度



大气底位势高度



GAMIL3 and SYCIM Exchange

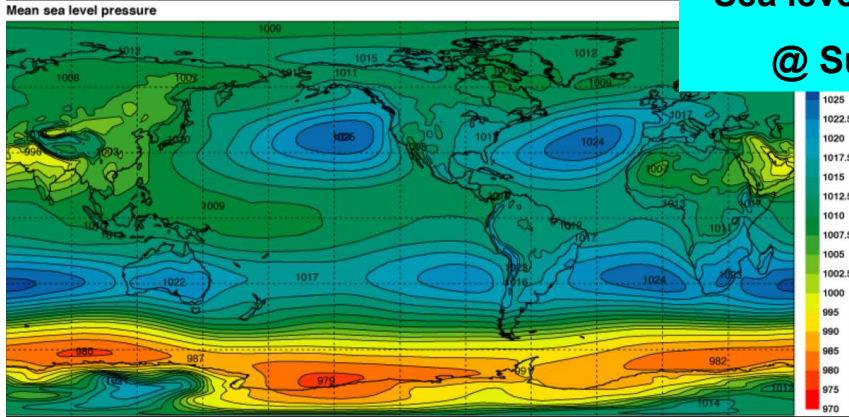
Model Results



Obs.

Sea level pressure

@ Summer



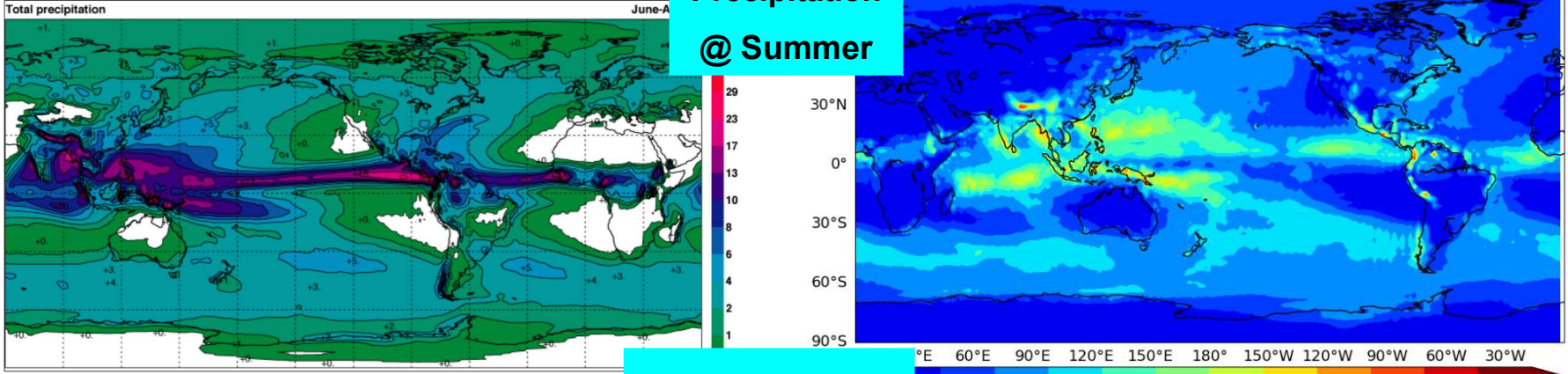
Model Results



Obs.

Simul.

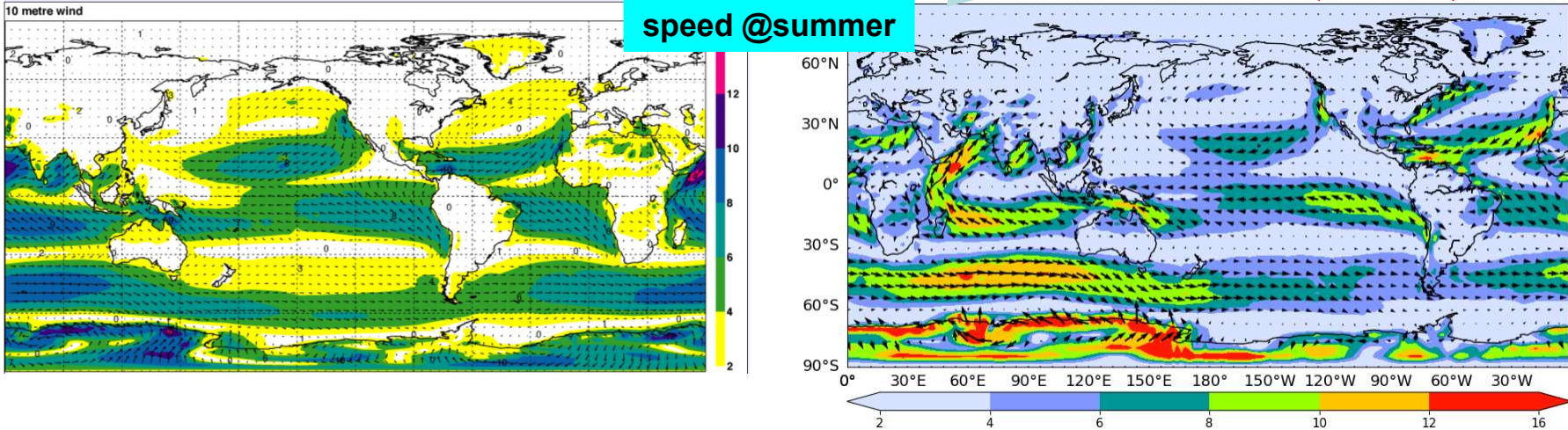
Precipitation
@ Summer



10m

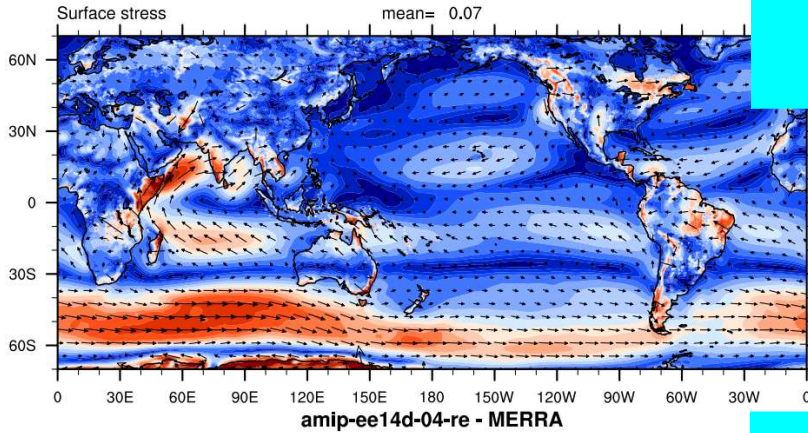
Low-level wind
speed @summer

Model lowest level ($\approx 50m$)



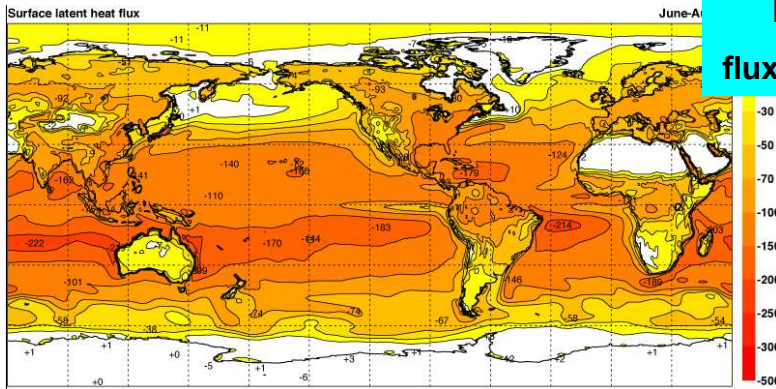
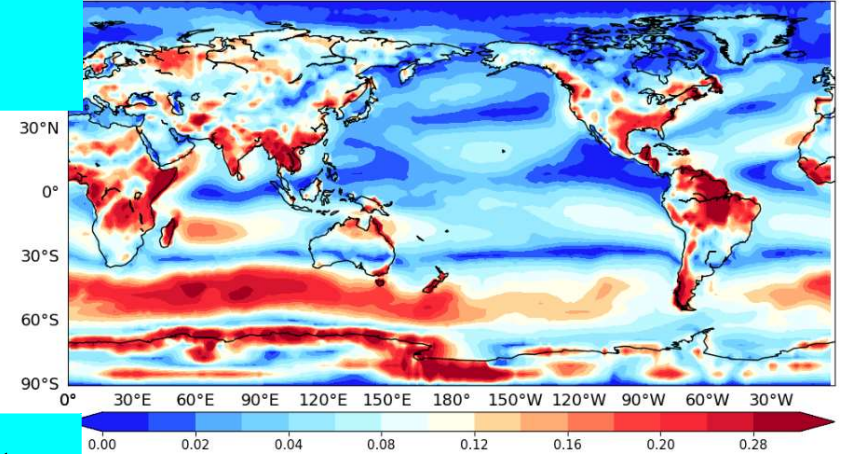
Model Results

Obs.

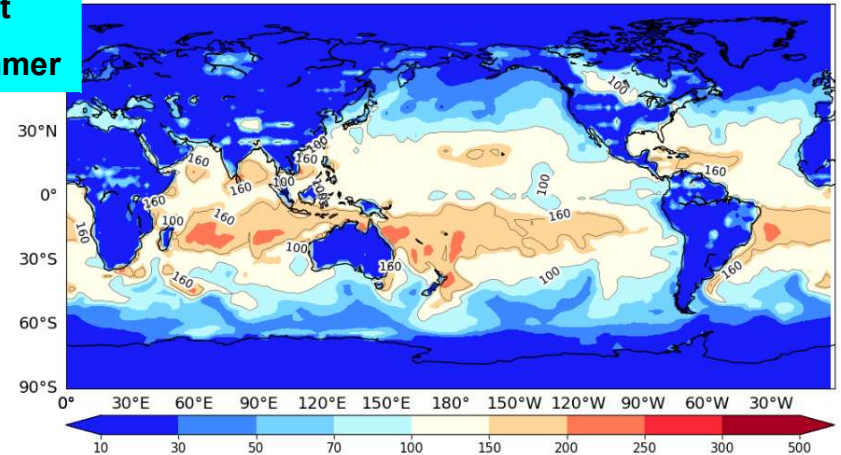


Surface wind
stress @
Summer

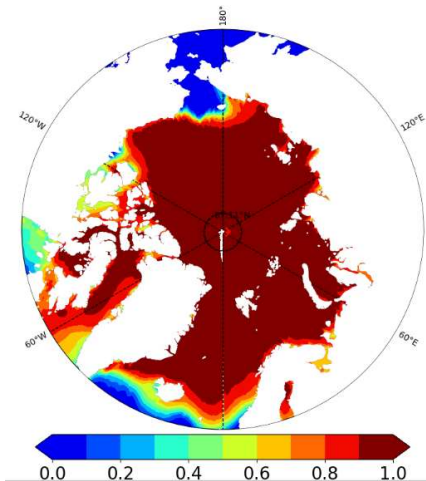
Simul.



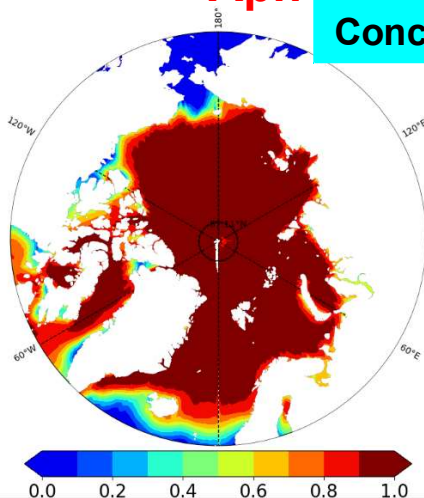
Latent heat
fluxes @ Summer



Jan.

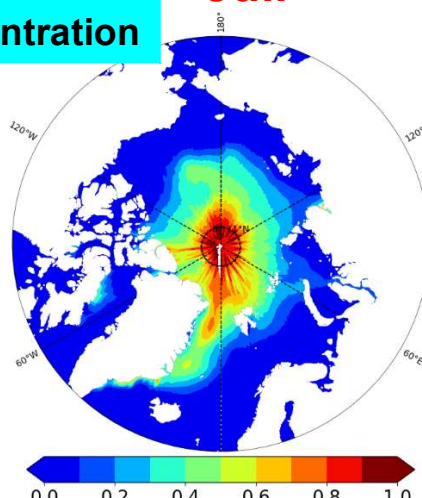


Apr.

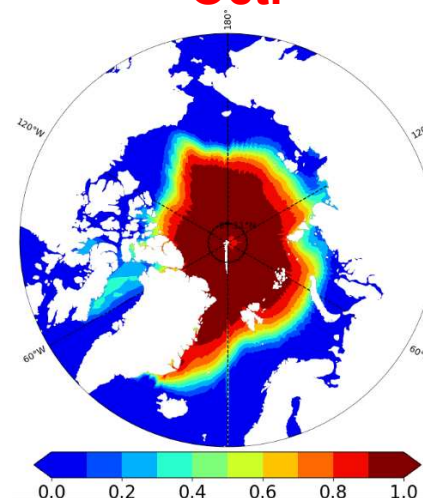


Arctic Sea Ice
Concentration

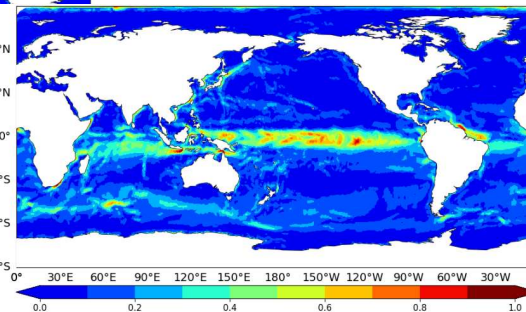
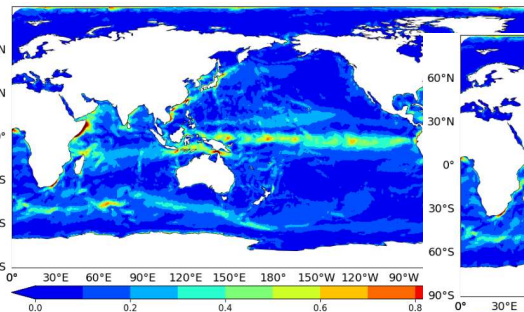
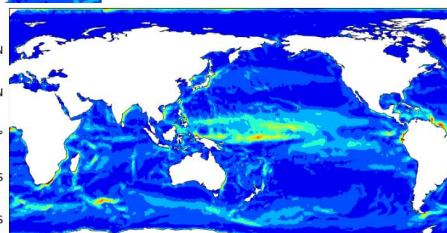
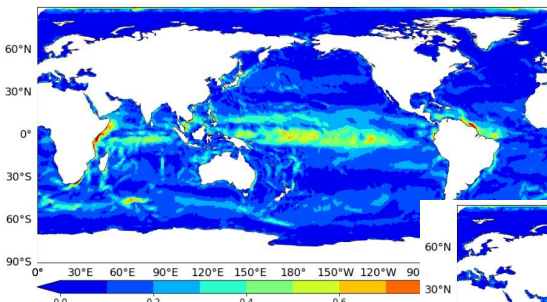
Jul.

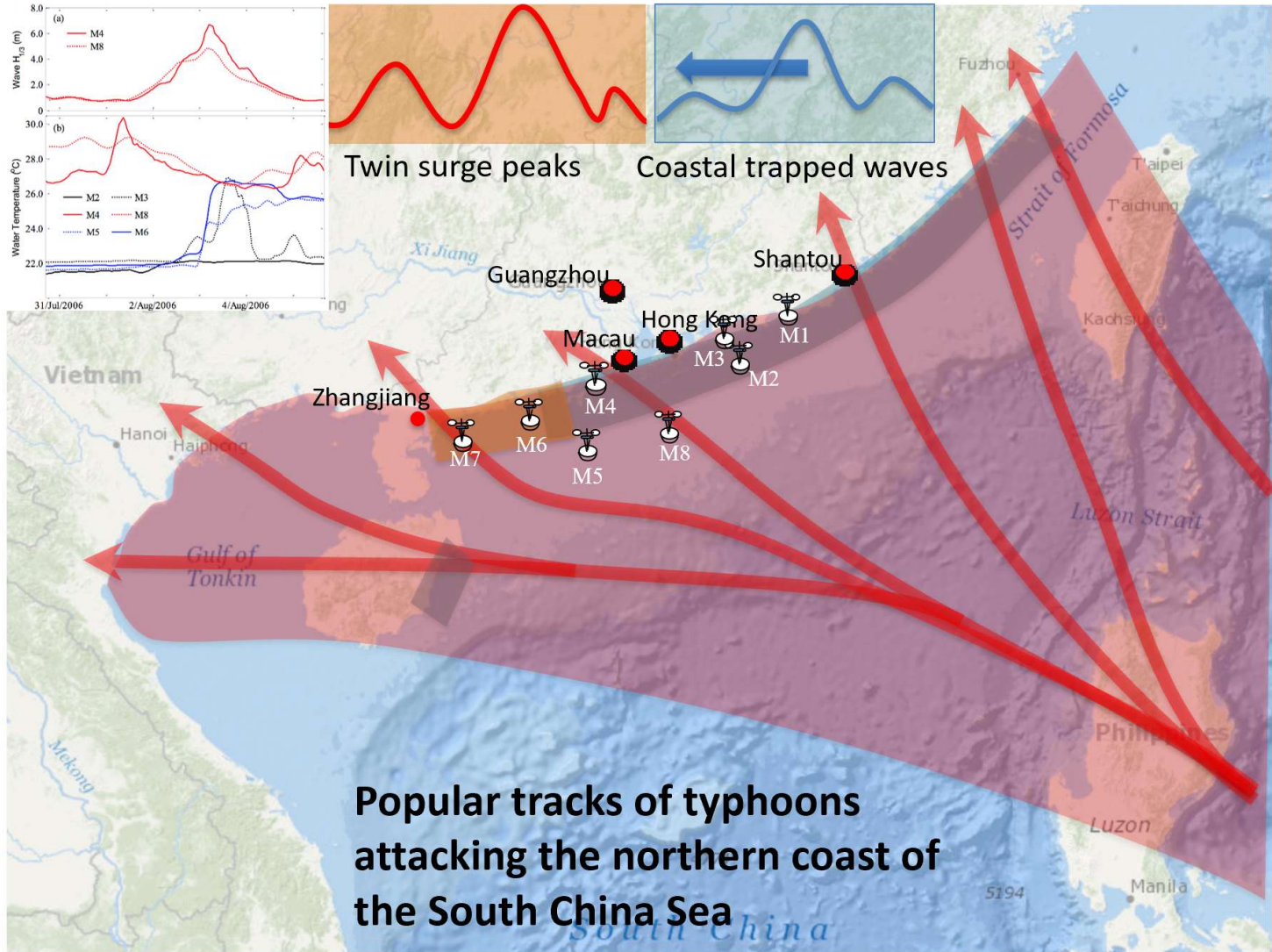


Oct.

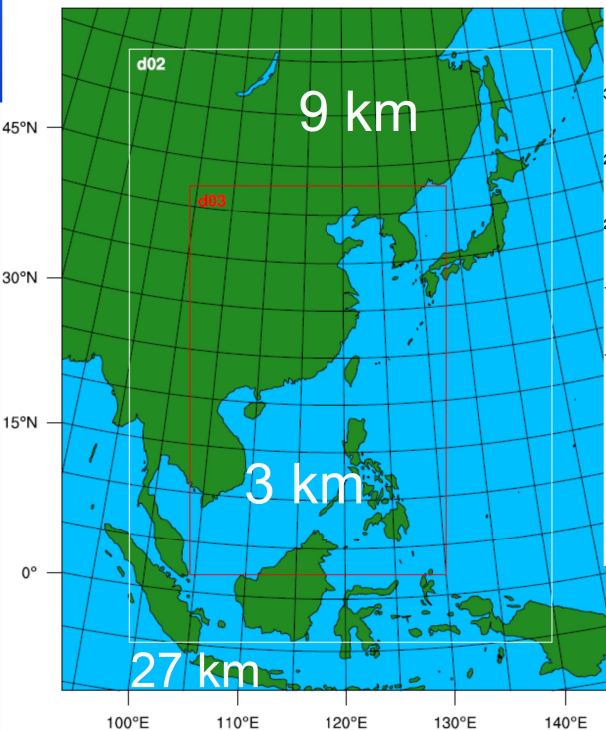


Global Surface Currents





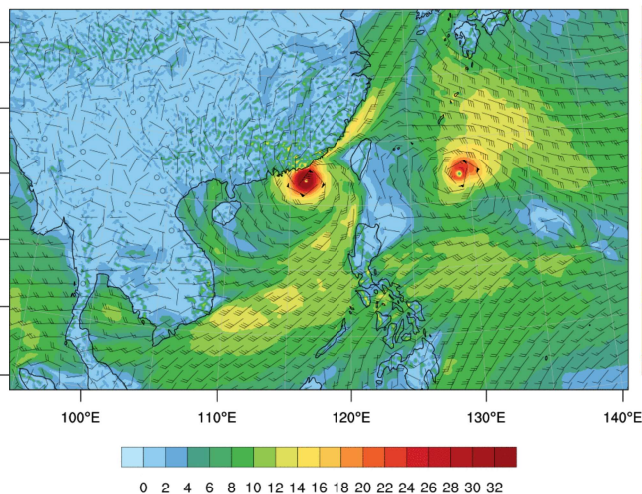
WPS Domain Configuration



10m Wind 2023-09-01_08:00:00

本图为SYCIM模式产品，科研教学专用，仅供参考。实时预报，请从国家权威预报机构获取。

Unknown Wind (m/s)



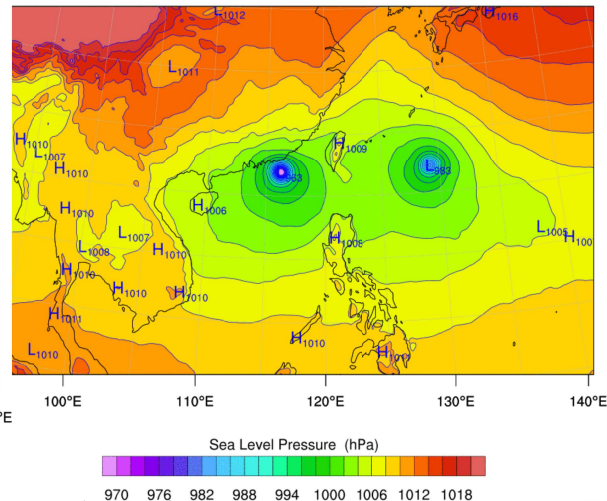
Valid: 2023-09-01_08:00:00

P 2023-09-01_08:00:00

本图为SYCIM模式产品，科研教学专用，仅供参考。实时预报，请从国家权威预报机构获取。

Valid: 2023-09-01_08:00:00

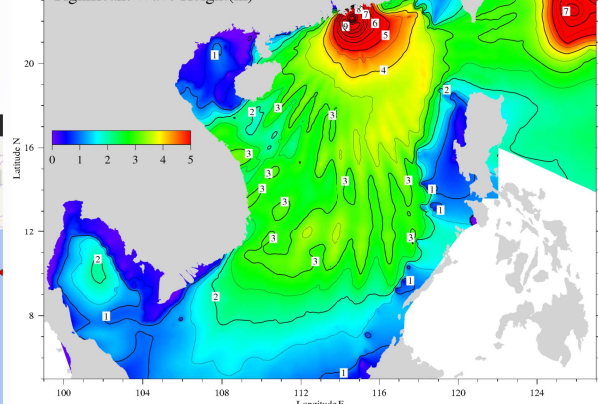
1 Level Pressure (hPa)



本图为SYCIM模式产品，科研教学专用，仅供参考。实时预报，请从国家权威预报机构获取。

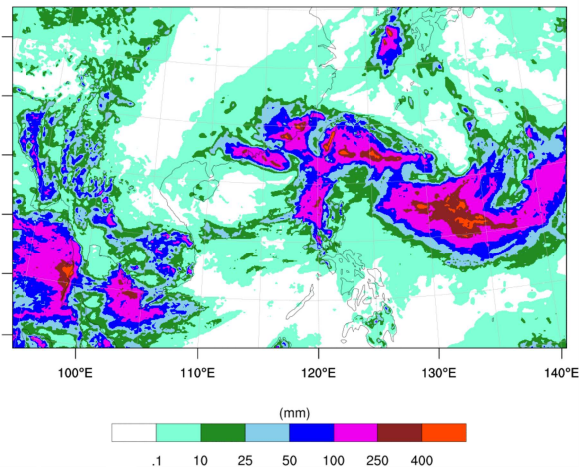
2023-09-01 09:00(BJT)

Significant Wave Height(m)



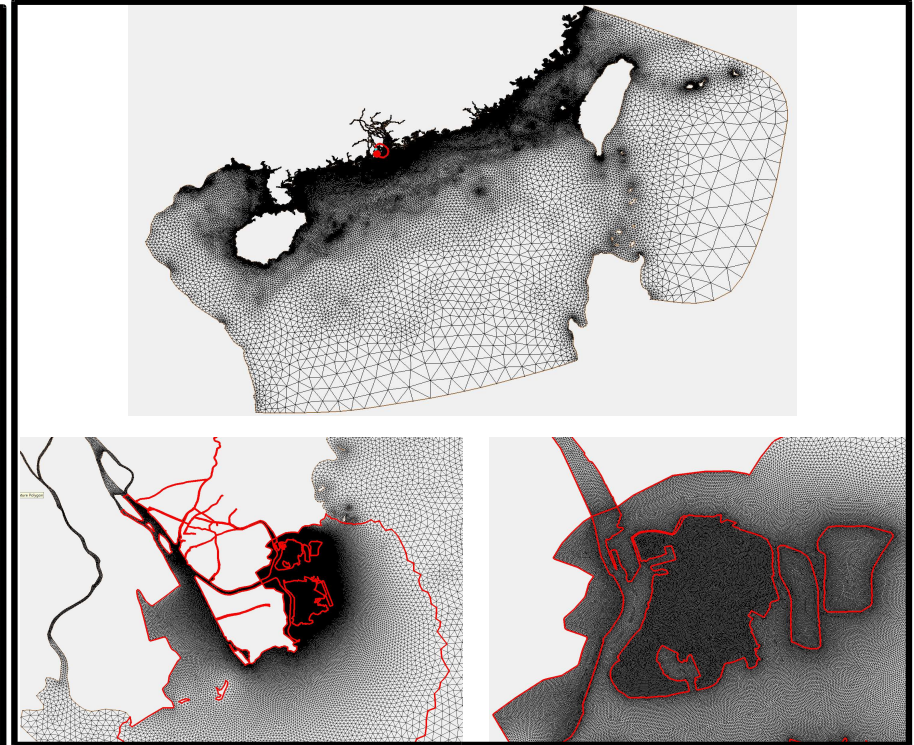
本图为SYCIM模式产品，科研教学专用，仅供参考。实时预报，请从国家权威预报机构获取。

from 2023-09-01_02:00:00 to 2023-09-06_08:00:00 (mm)



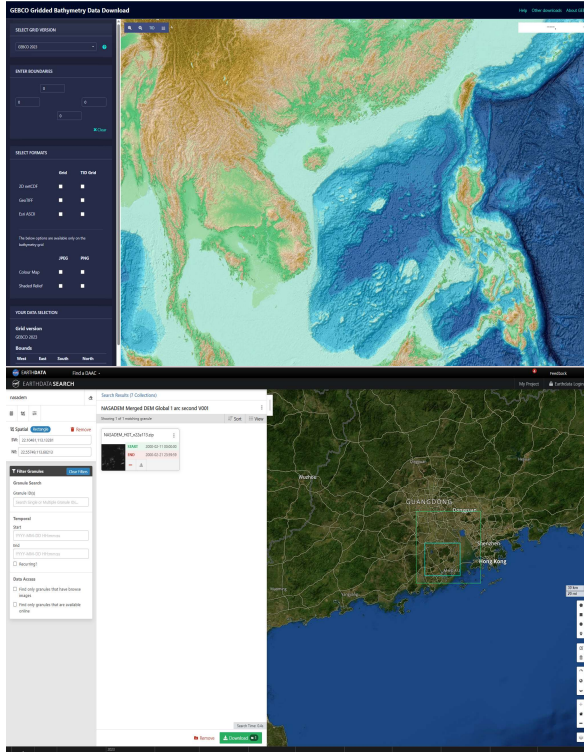
2309 Typhoon Saola

SYCIM-Macao inundation model



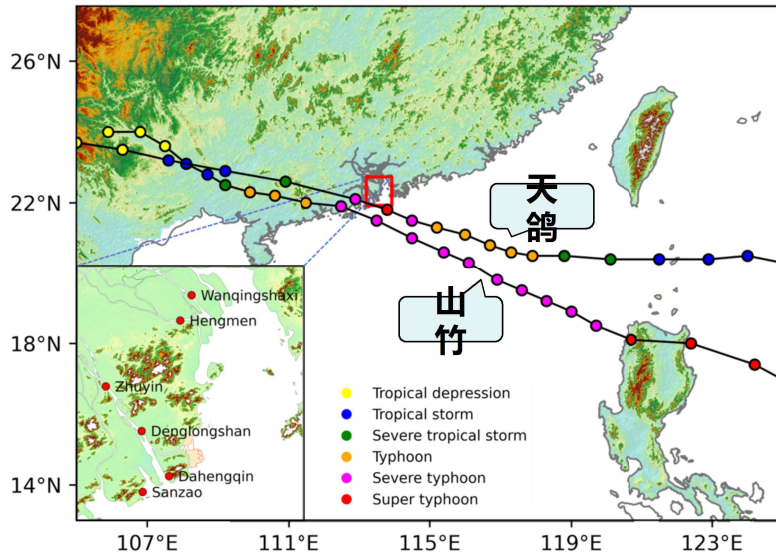
Macao inundation model grid

SYCIM-Macao inundation model

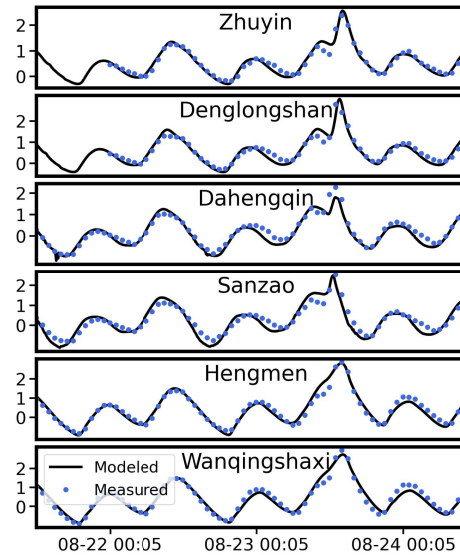


- The elevation data are from the Macao Cartographic and Cadastral Bureau, the nearshore bathymetric data are from the nautical charts of the Department of Naval Navigation and Conservation, and other data are from open data (NASADEM、GEBCO)
- High precision land surface elevation data and nearshore water depth data ensure the accuracy of simulation results

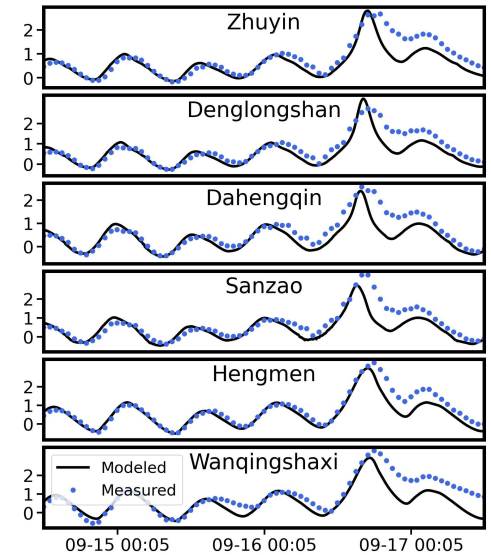
SYCIM-Macao inundation model



Hato(2017)



Mangkhut(2018)

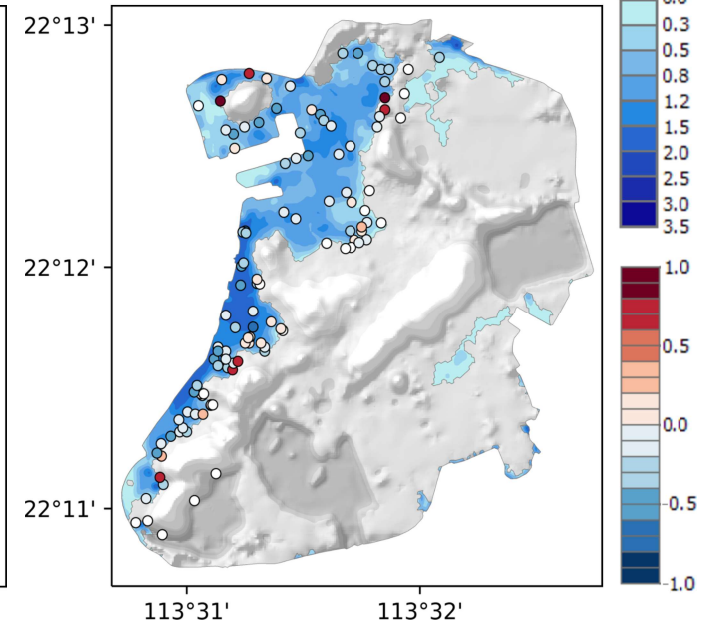
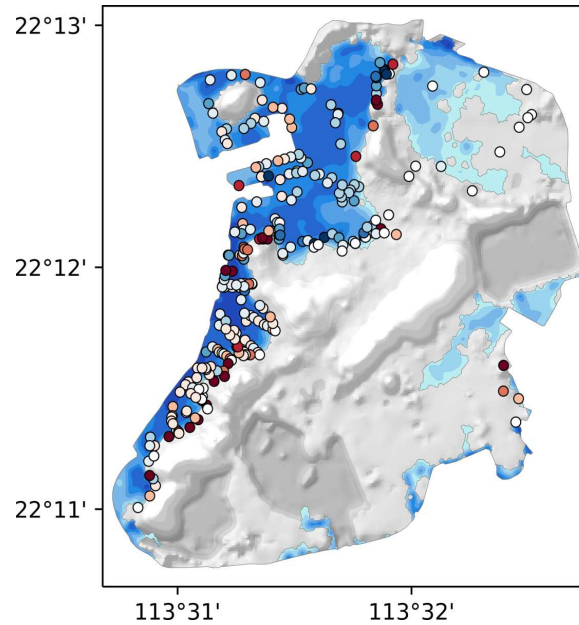


➤ The maximum water level error is mostly within 0.3m

SYCIM-Macao inundation model

Hato

Mangkhut



Satellite image

Water level difference between model and observation

➤ After AI correction, the average error is less than 0.1m compared with the observation

Summary

- High Resolution unstructured Numerical Model is a powerful tool in climate study and coastal environment forecast.
- The SYSU research team has established a new global-regional-land nested model system (SYCIM)
- SYCIM is continuously upgraded with attentions to improving physics, computational efficiency, multi-scale interactions and interdisciplinary applications.

Acknowledgments:

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Mr. Fuhai Dao, Jie Yang, Qinyang Li, SYSU

Mr. Song Wang, SML-Zhuhai

Thanks !

