Storm surge in HK waters: hydrodynamics and modeling

Jianping Gan

1. Storm surge
2. Local examples
3. Challenge of storm surge prediction in PRE and GBA
4. Response to Climate Change

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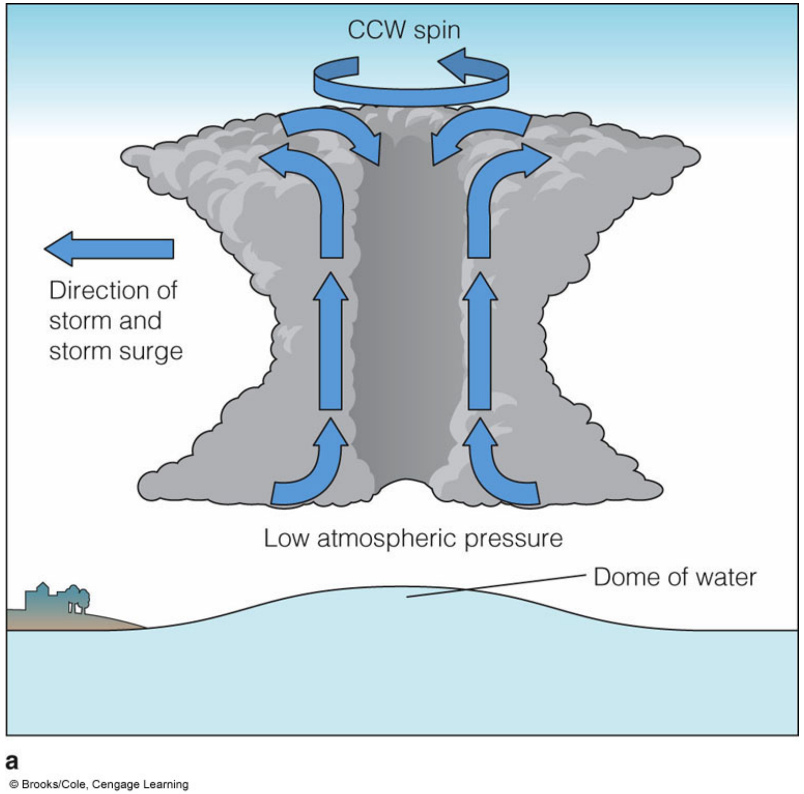
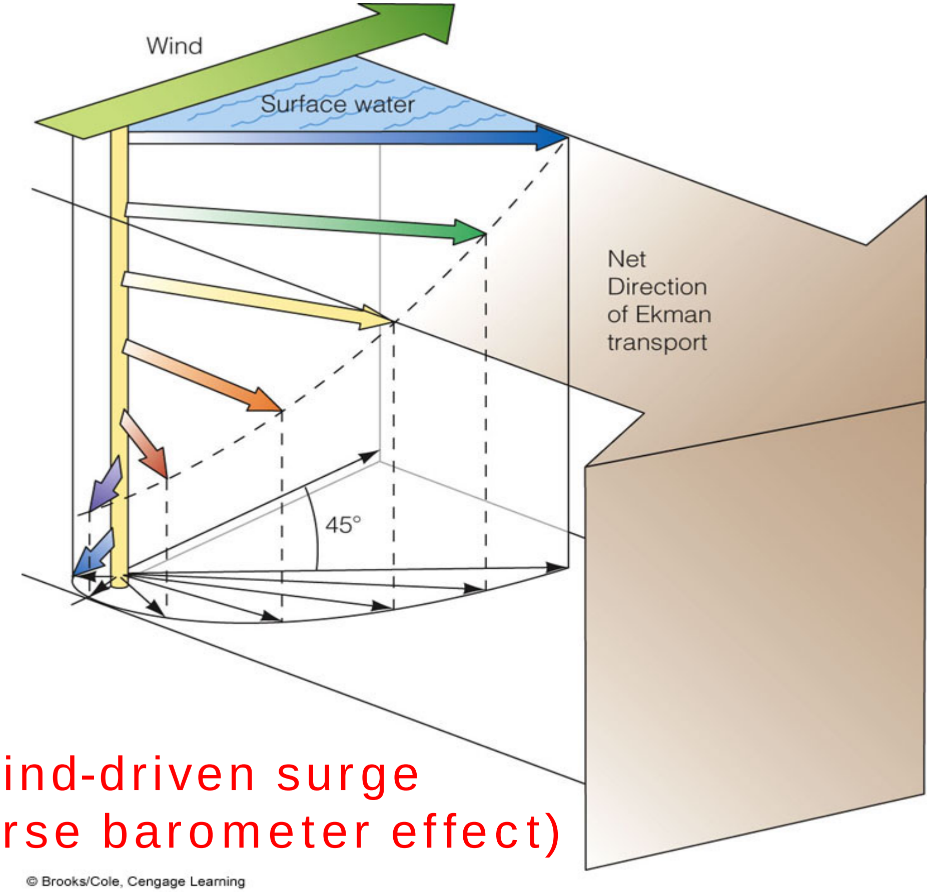
1. Storm surge





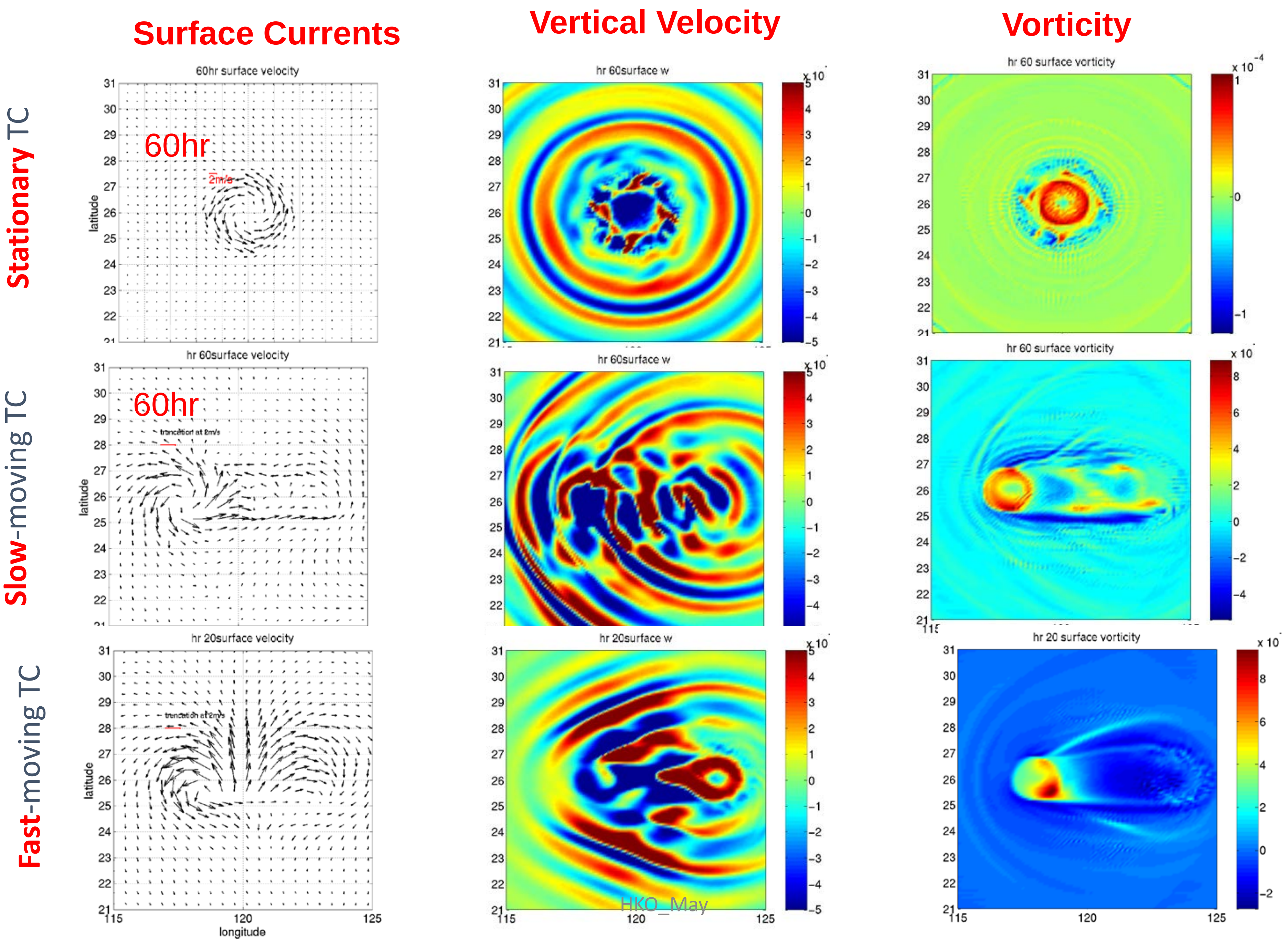
Wind-driven surge
(>>inverse barometer effect)

A storm surge.

The low pressure and high winds generated within a hurricane can produce a storm surge up to 9 meters (30 feet) high.

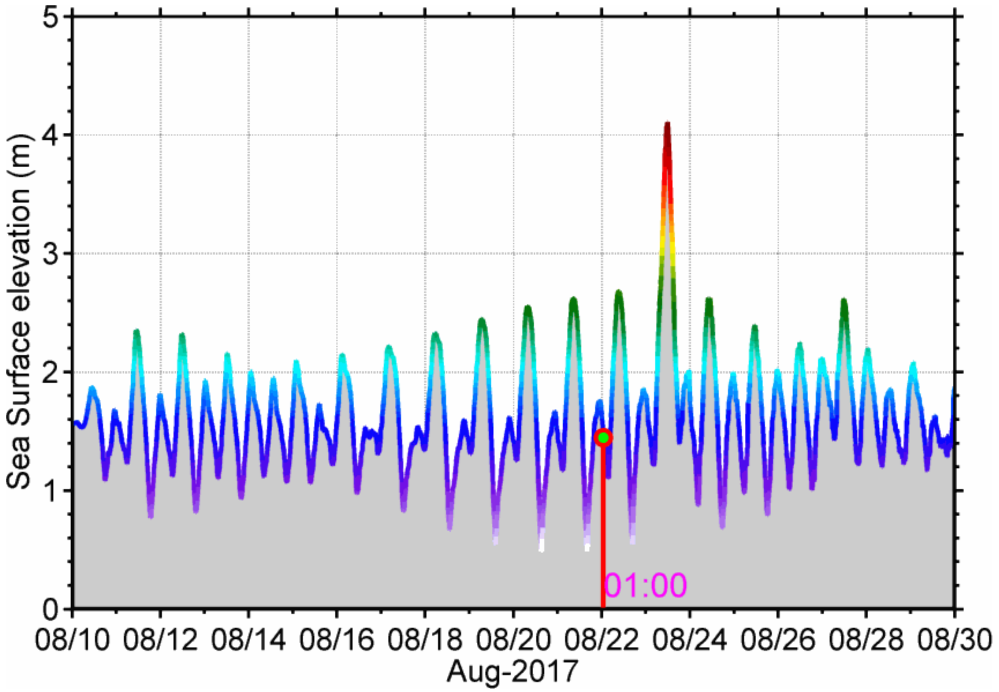
Factors controlling surge:

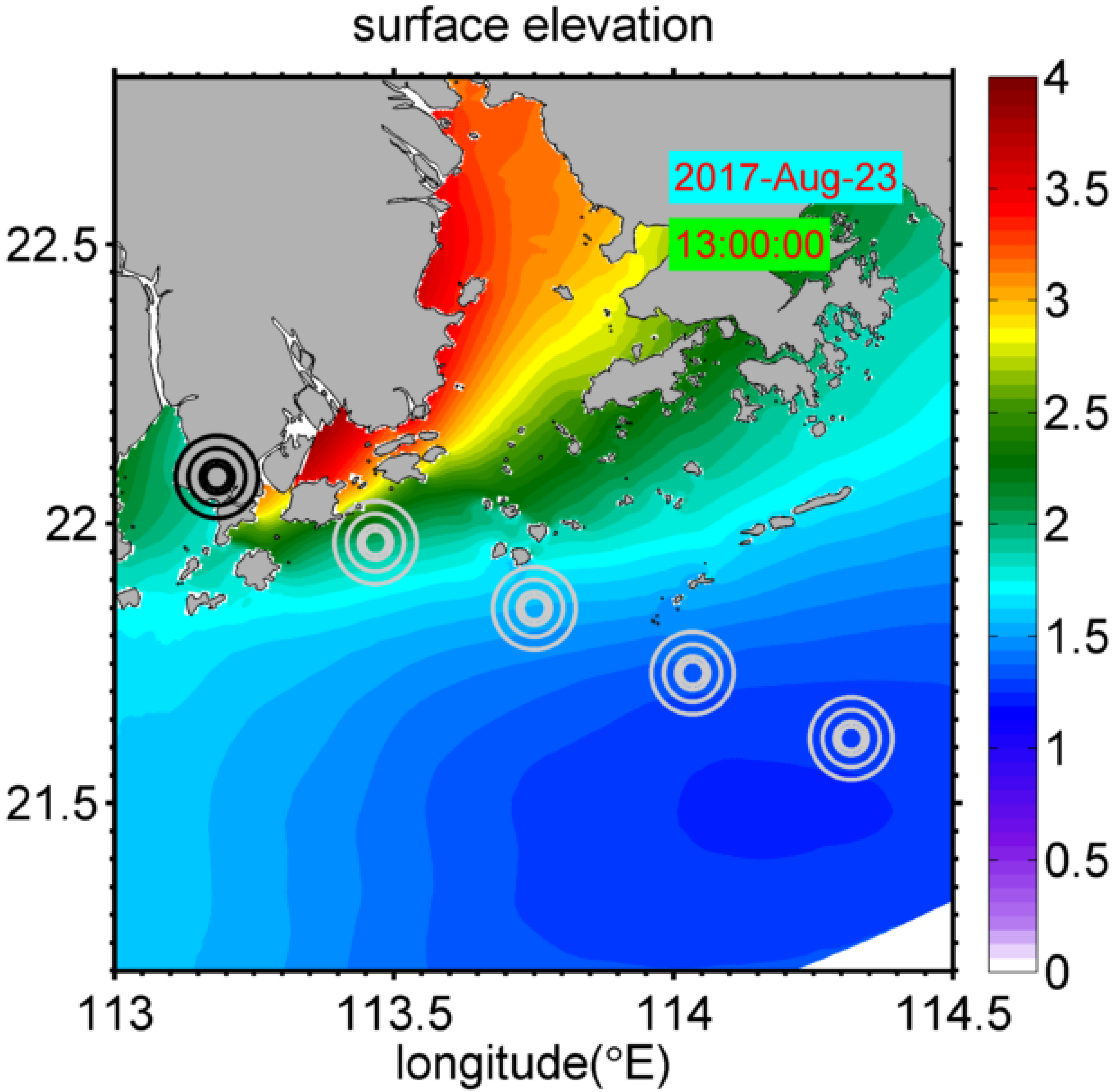
- 1: storm intensity
- 2: TC translation speed,
- 3: Size and central P of TC
- 4: Angle and track of TC
- 5: shape and characteristics (water depth) of coastal features such as bay and estuary.


Surface Currents
Vertical Velocity
Vorticity
Stationary TC
Slow-moving TC
Fast-moving TC
60hr surface velocity
60hr
2m/s
hr 60surface w
hr 60 surface vorticity
hr 60surface velocity
60hr
truncation at 2m/s
hr 60surface w
hr 60 surface vorticity
hr 20surface velocity
truncation at 2m/s
hr 20surface w
hr 20 surface vorticity
latitude
longitude
HKO_May

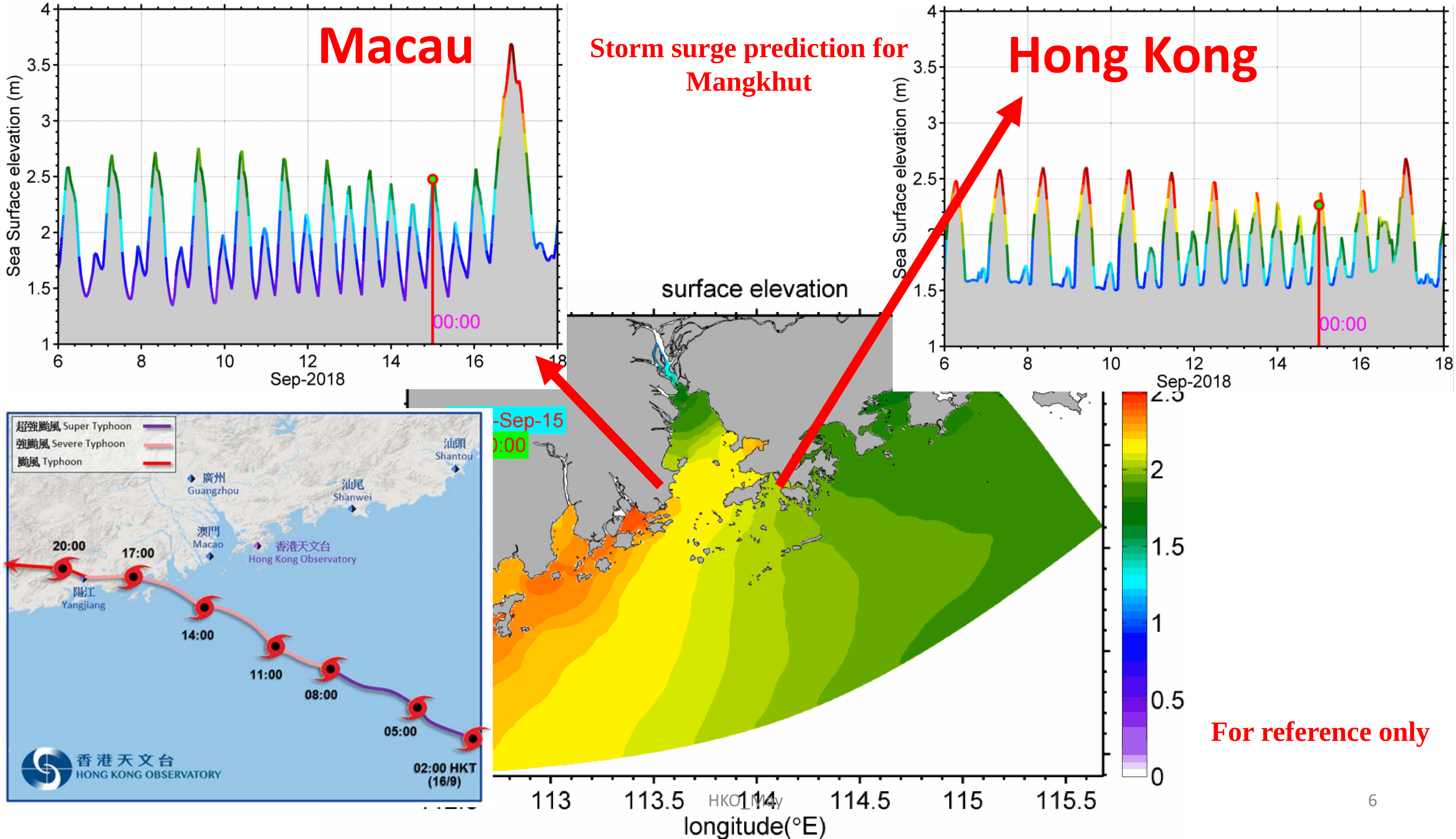
2. Local examples

Typhoon Hato





Storm surge prediction for Mangkhut



For reference only

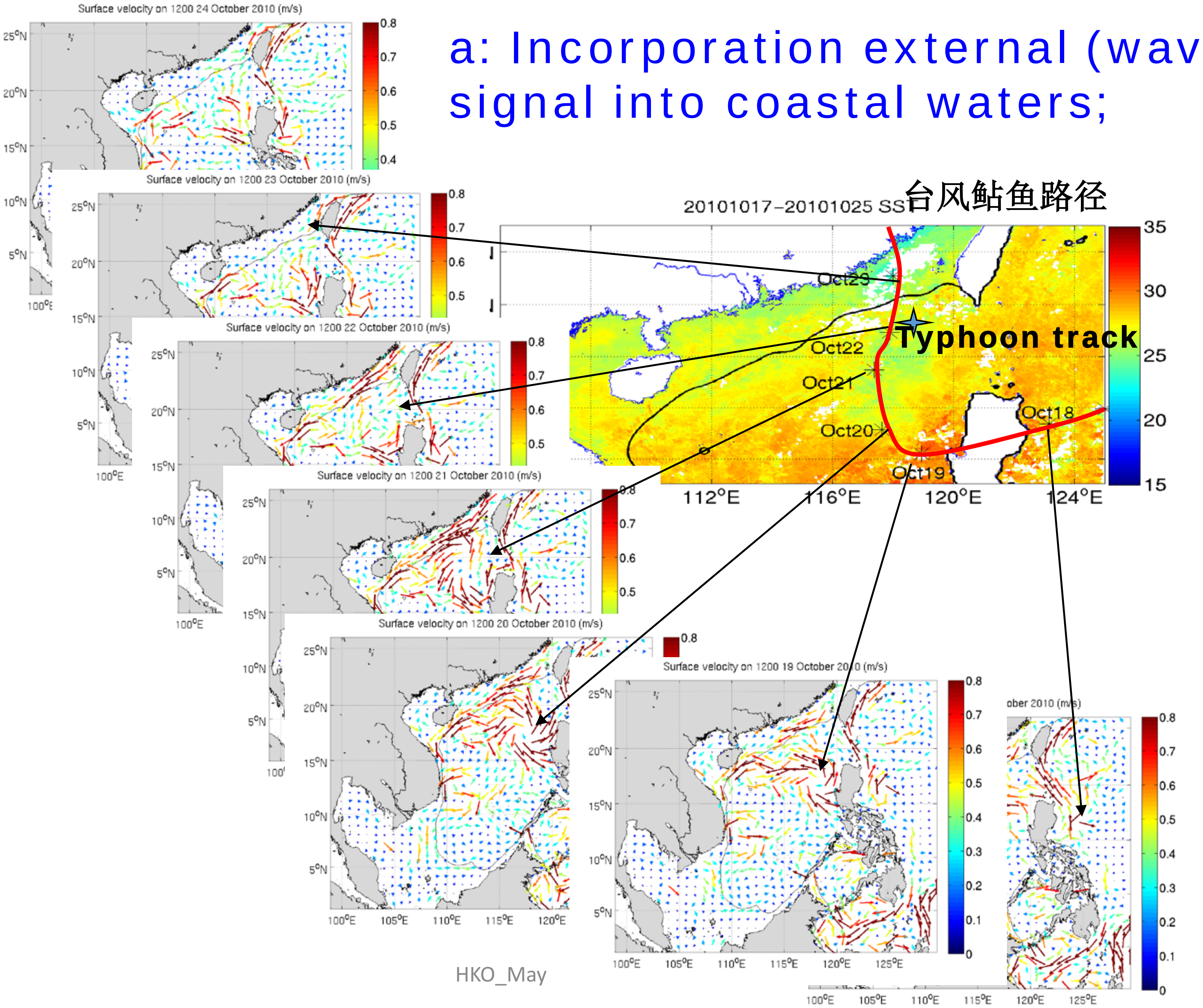
3. Challenge of storm surge prediction in PRE and GBA

a: Incorporation external (wave) signal into coastal waters (large-scale model);

b: Physically sensible numerical model that resolves well the local hydrodynamics;

c: Real-time monitoring and effective (short-time scale) data-assimilation;

a: Incorporation external (wave) signal into coastal waters;

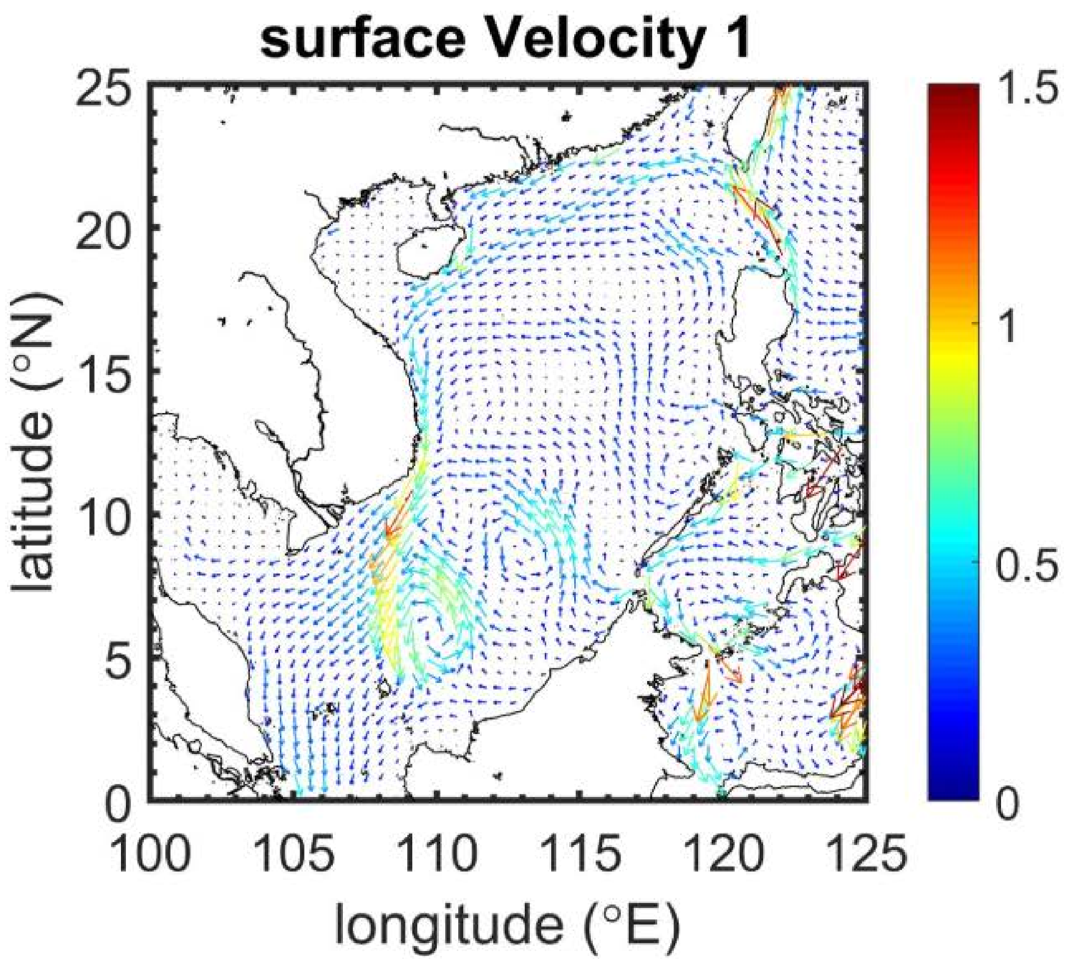


Categories

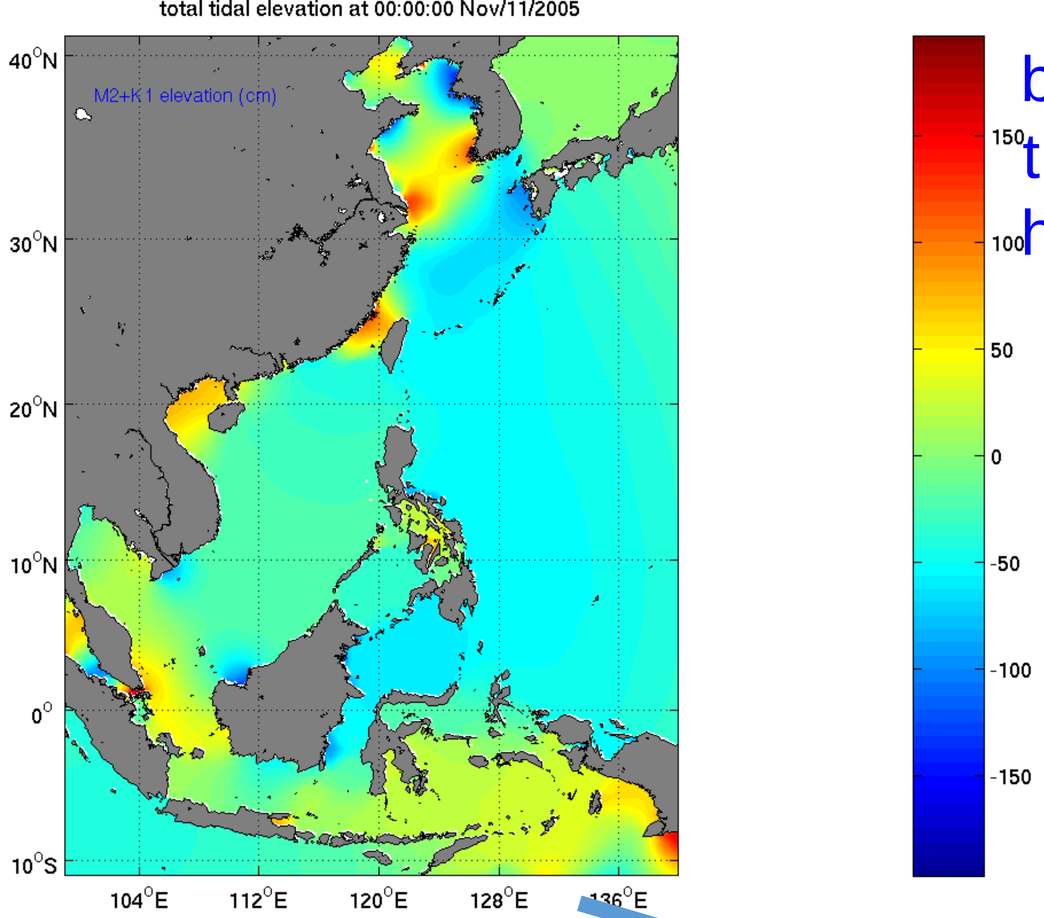
- Pearl River Estuary
- South China Sea

SCS Realtime Forecast (Demo)

Year : 2017 ▾ Month : 01 ▾ Variable : Velocity ▾ Depth : Surface ▾ Submit



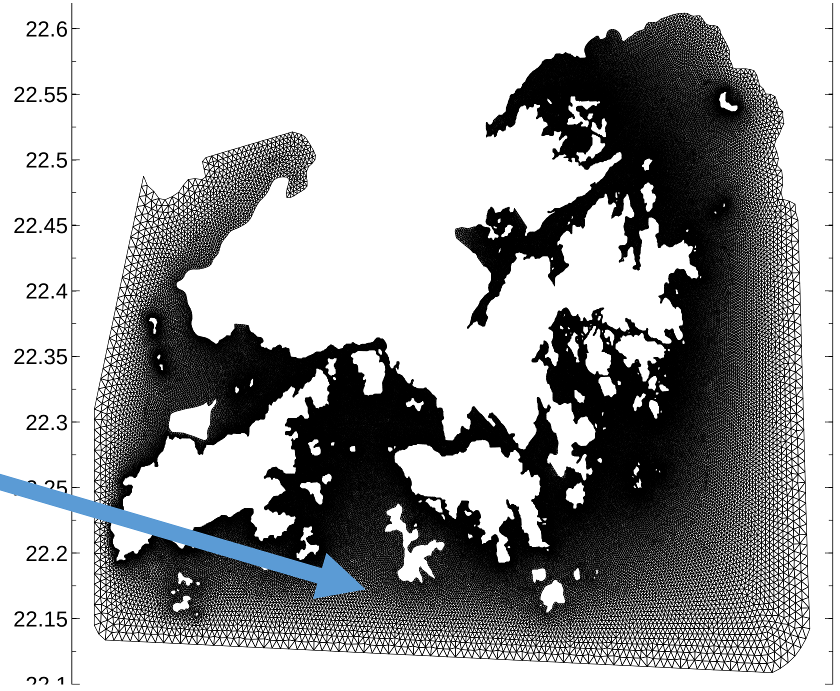
Forward Backward Stop Go one step Back one step Initial End



b: Physically sensible numerical model that resolves well the local hydrodynamics;

(From Zu and Gan, 2008)

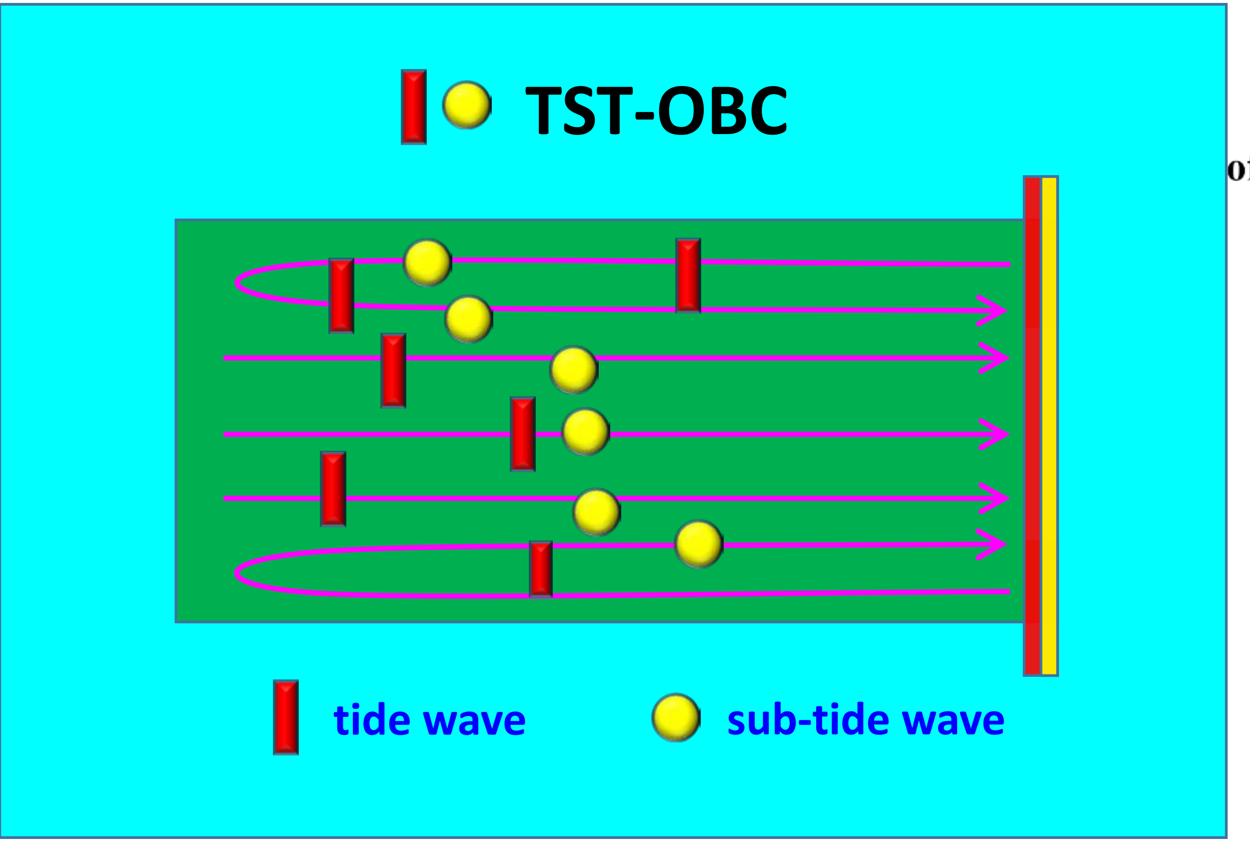
Downscaling

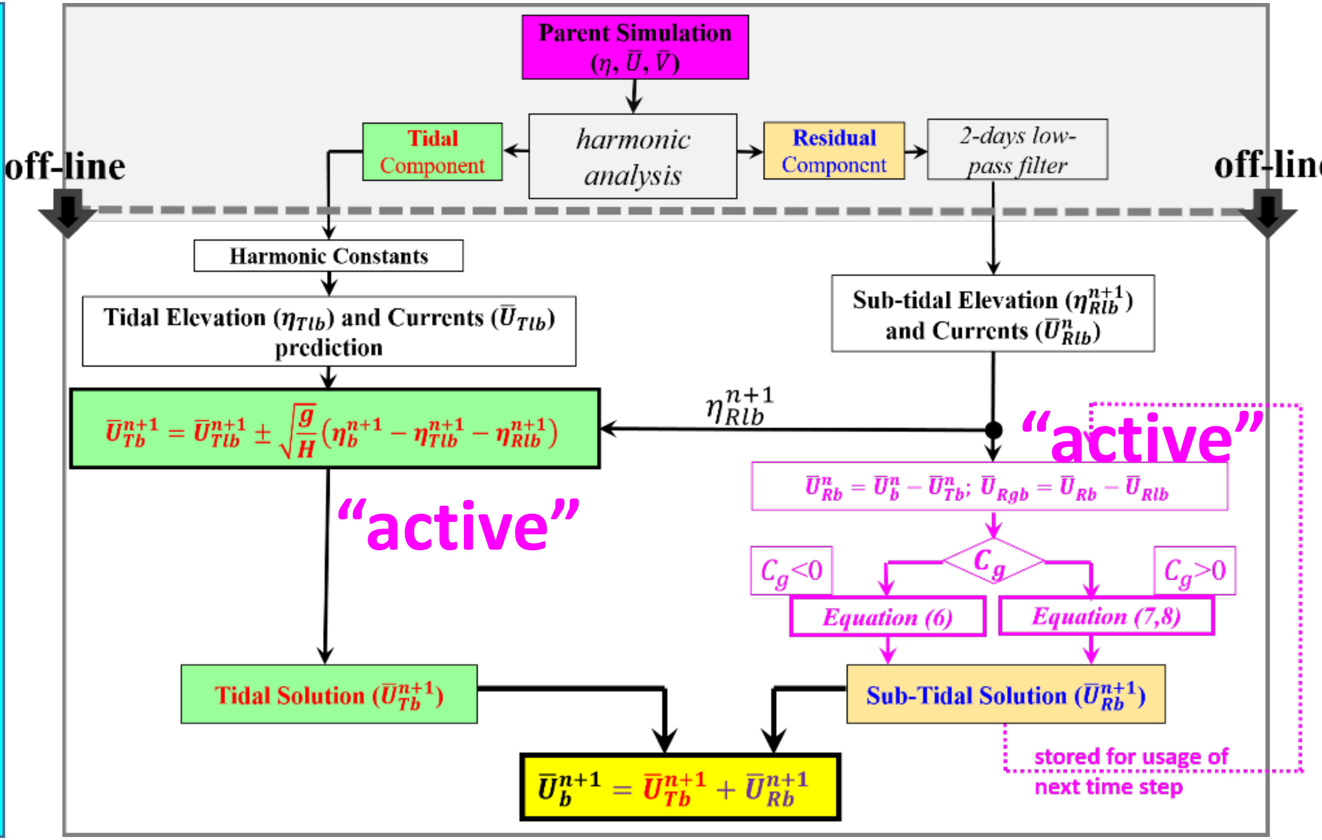


To link processes driven by wind, tides, river discharge and remote TC and non-TC forced signals

TST-OBC

Tidal and subtidal Open Boundary Condition (Liu and Gan, 2016, JGR)



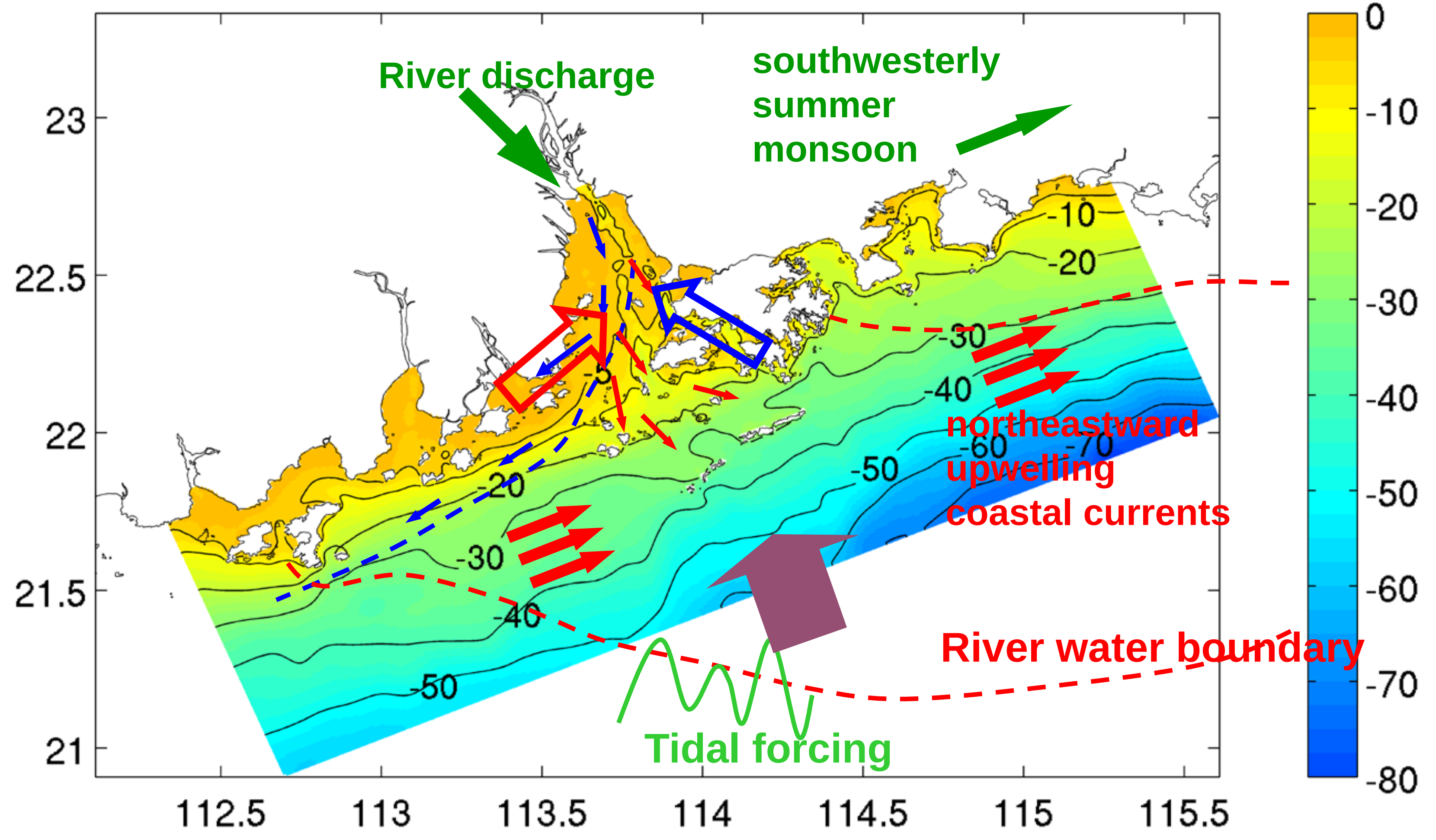


"active"

$$\bar{U}_b^{n+1} = \bar{U}_{Rb}^{n+1} + \bar{U}_{Tlb}^{n+1} \pm \sqrt{\frac{g}{H}}\left(\eta_b^{n+1} - \eta_{Tlb}^{n+1} - \eta_{Rlb}^{n+1}\right)$$

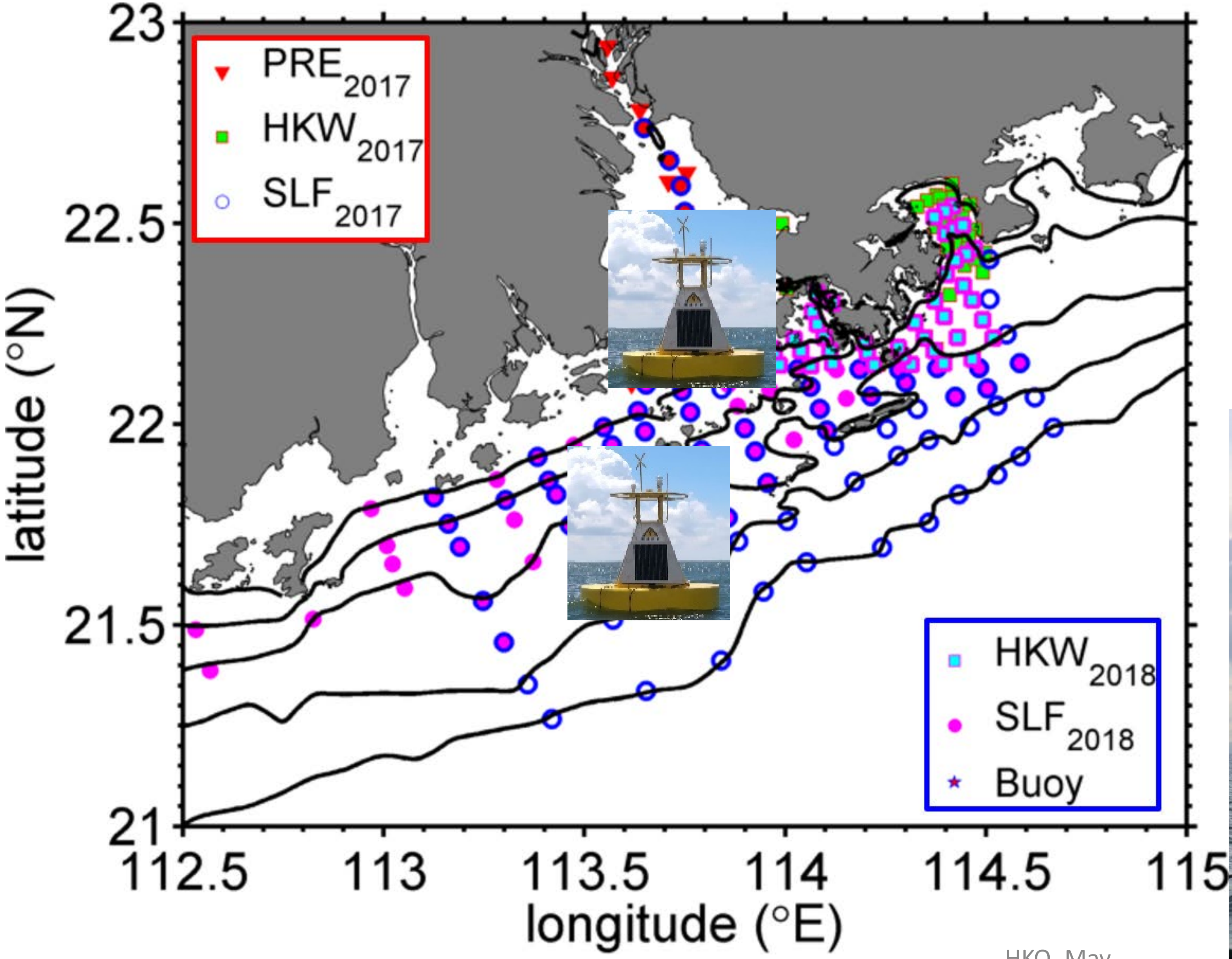
(From Liu and Gan, JGR, 2017).

Summary of hydrodynamics in HK and adjacent waters



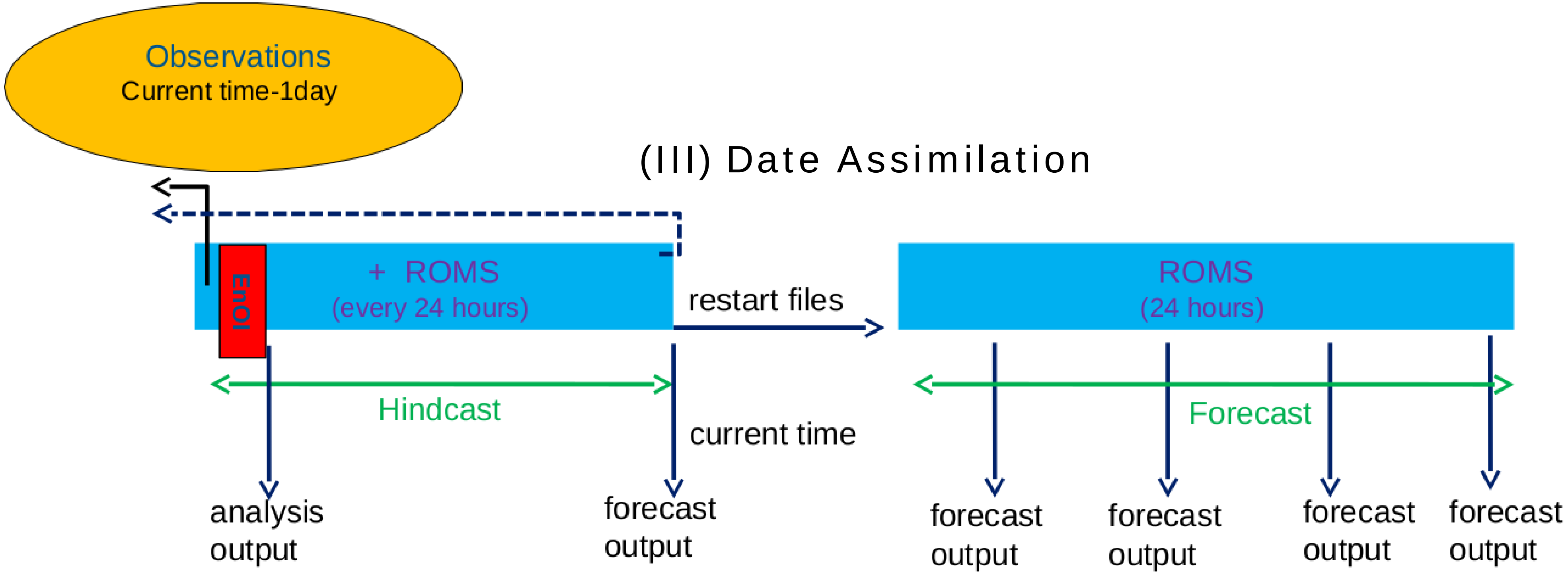
Sketch of the river plume and coastal currents in the PRE and adjacent shelf in winter (blue dashed lines and arrows) and summer (red dashed lines and arrows), drawn from the results of Gan et al. (2009), Zu and Gan (2013) and others.

c: Real-time monitoring and effective (short-time scale) data-assimilation;

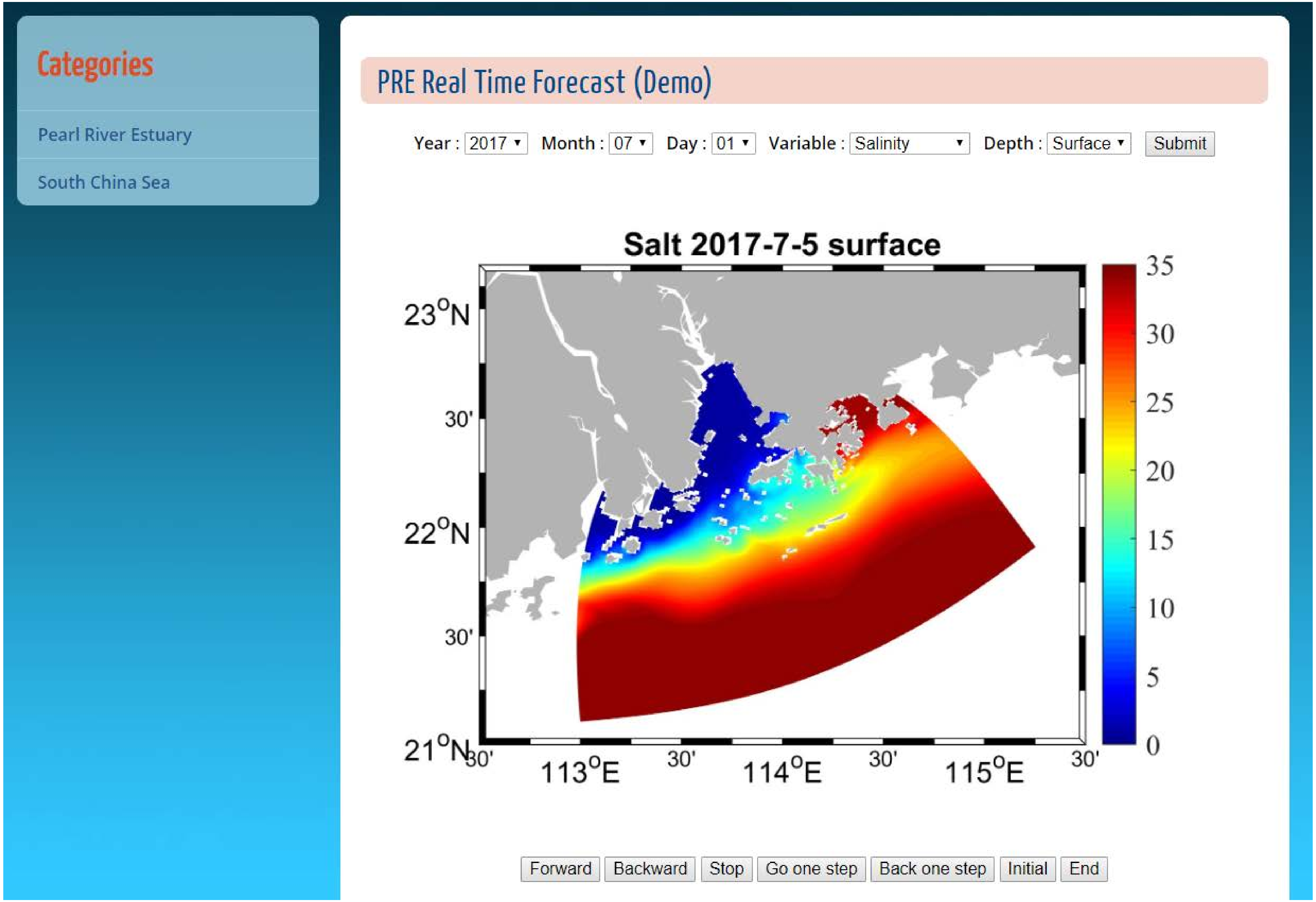


Data assimilation

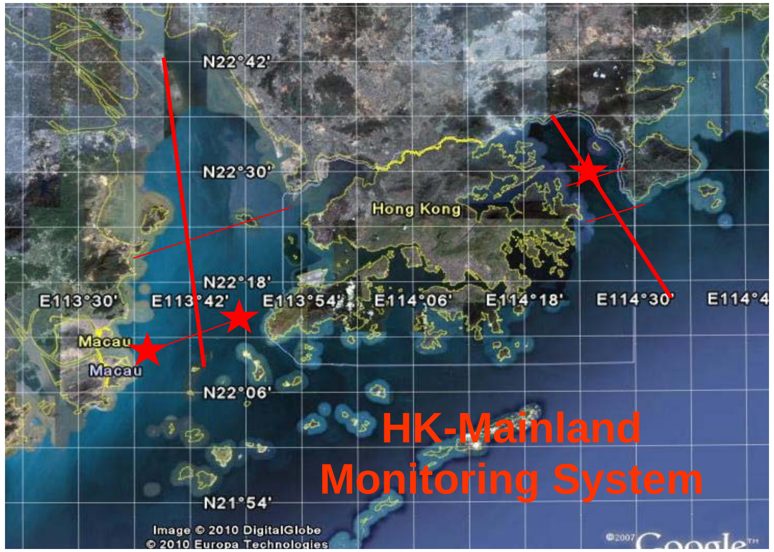
Hindcast with DA + forecast without DA

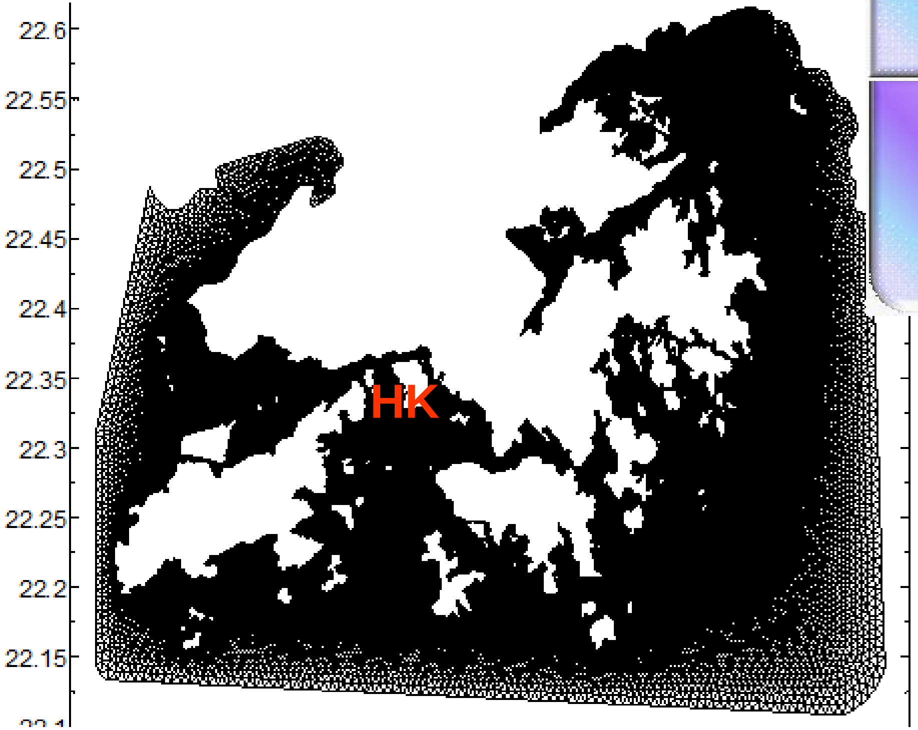


- Observation data:are assimilated when they are available in the hindcast period
- Restart files from the DA run are used for the forecast run


Categories
Pearl River Estuary
South China Sea
PRE Real Time Forecast (Demo)
Year : 2017
Month : 07
Day : 01
Variable : Salinity
Depth : Surface
Submit
Salt 2017-7-5 surface
23°N
30'
22°N
30'
21°N
30'
113°E
30'
114°E
30'
115°E
30'
35
30
25
20
15
10
5
0
Forward
Backward
Stop
Go one step
Back one step
Initial
End

5. Storm surge forecast and management system





Science

Monitoring

Numerical Modeling

Forecast and Management

Keys to the storm surge forecasting system:

- Science-based (hydrodynamics, storm surge/waves physics)
- Physics-based numerical model (both physics and observation validation)
- Monitoring system and data assimilation

Research+Development=Storm Surge Forecasting System

There is NO forecasting system that fits all coastal oceans!

4. Response to climate change