High-resolution studies of the South East Asia regional climate system with a focus on ocean

Marine Herrmann and the LEGOS / USTH team
(LOTUS international joint lab)

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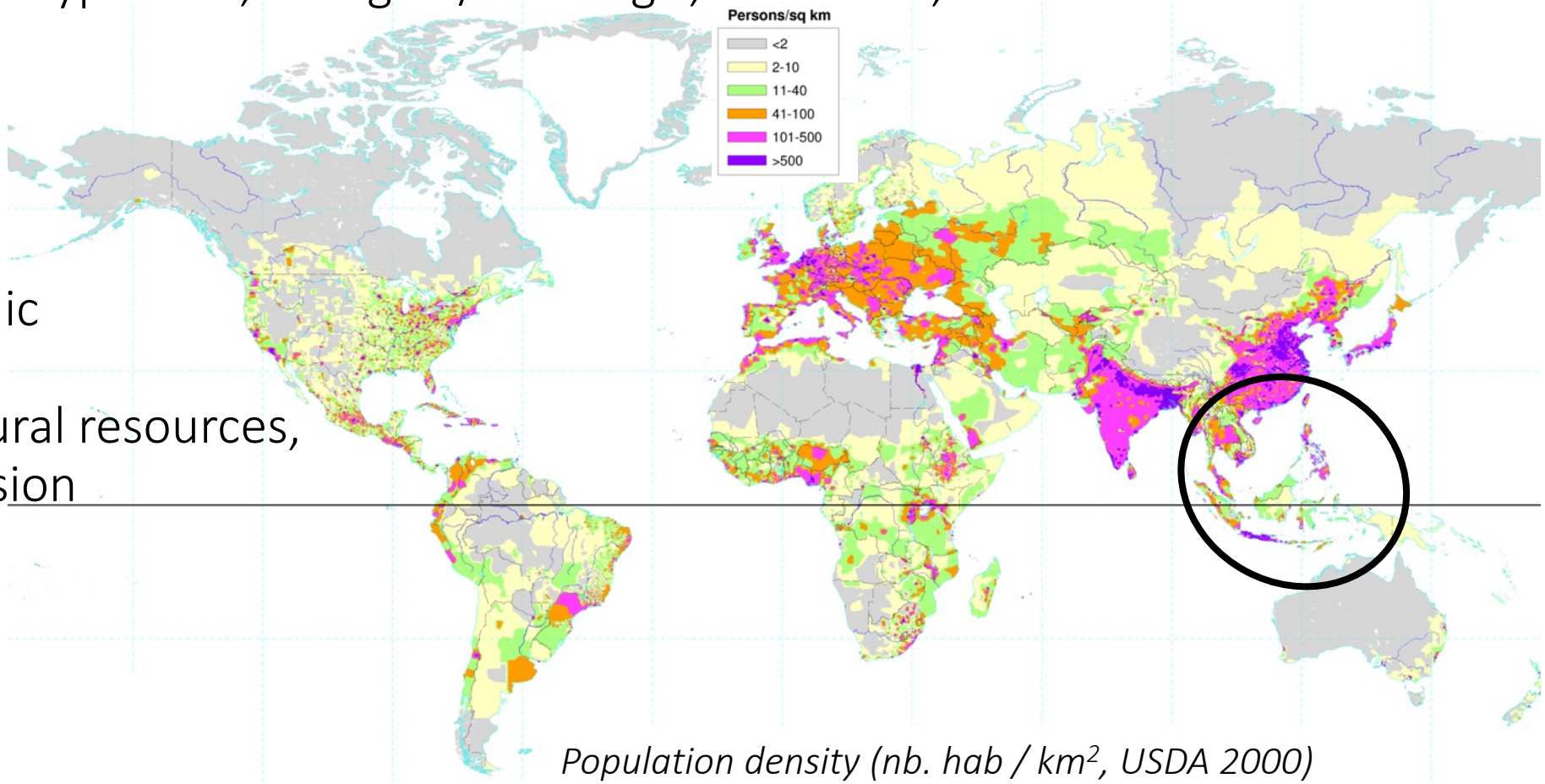
WCRP CORDEX Coordinated Regional Climate Downscaling Experiment
25-29 SEPTEMBER 2023 TRIESTE, ITALY
ICRC-CORDEX 2023
International Conference On Regional Climate

Southeast Asia :
A hot spot of vulnerability to global changes

- 10% of the world population, mainly in low elevated highly populated areas (deltas).

- Natural factors/hazards : typhoons, droughts/floodings , monsoon , ENSO…

- Anthropogenic factors :
  climate change
  + urbanization, economic and industrial growth, overexploitation of natural resources, pollution, coastline erosion
  …



Population density (nb. hab / km², USDA 2000)

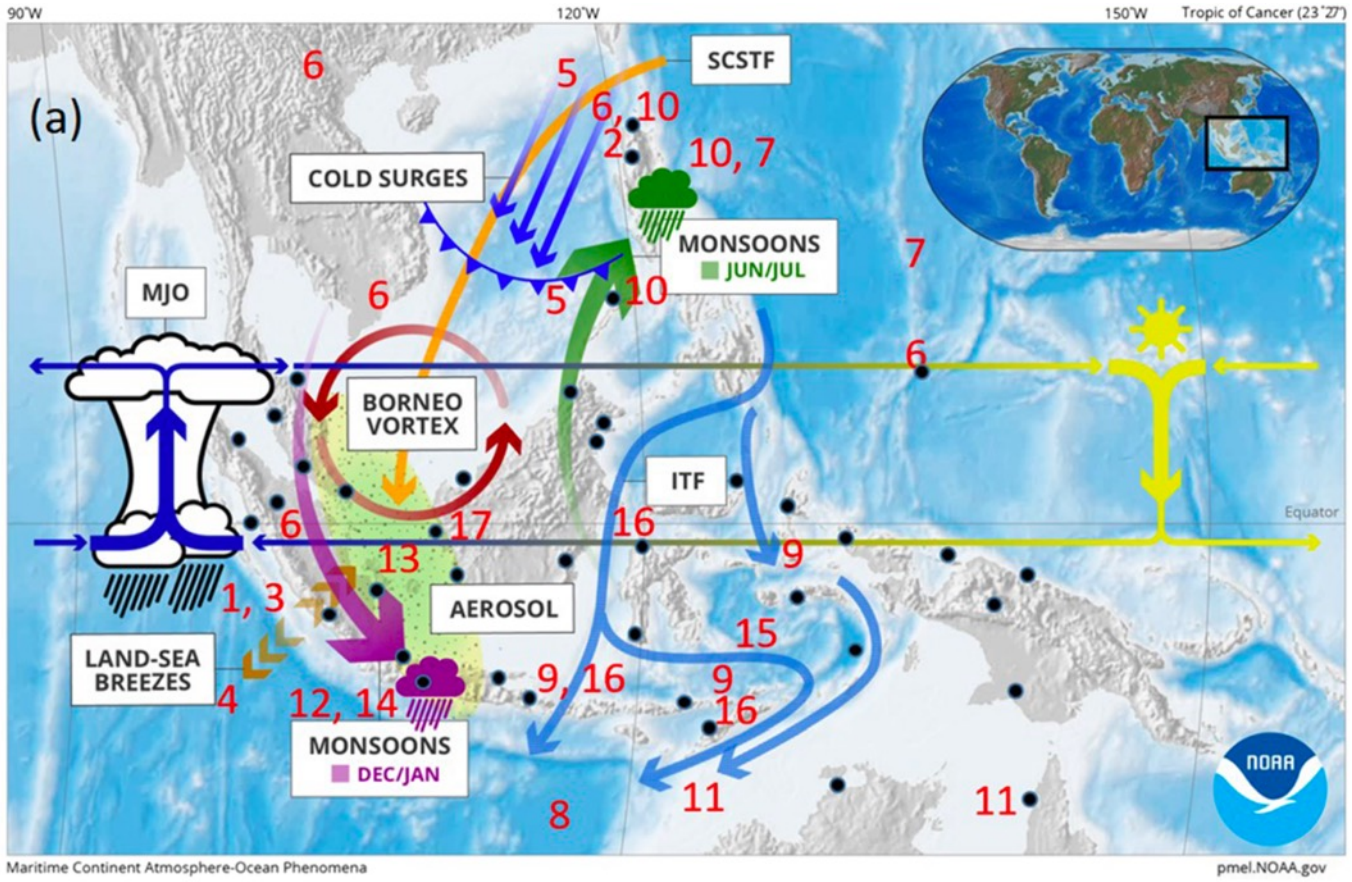
Southeast Asia : a golden case study/challenge for ocean-atmosphere coupled studies for a better understanding of global and regional climate

- Maritime Continent, complex topography, 22 000 islands, straits …

- **Throughflow of the surface branch of the oceanic circulation btw Pacific and Indian oceans** (SCSTF, ITF) :
  net ocean gain of heat and freshwater
- Internal waves
- Huge water + sediment discharge
- Upwellings

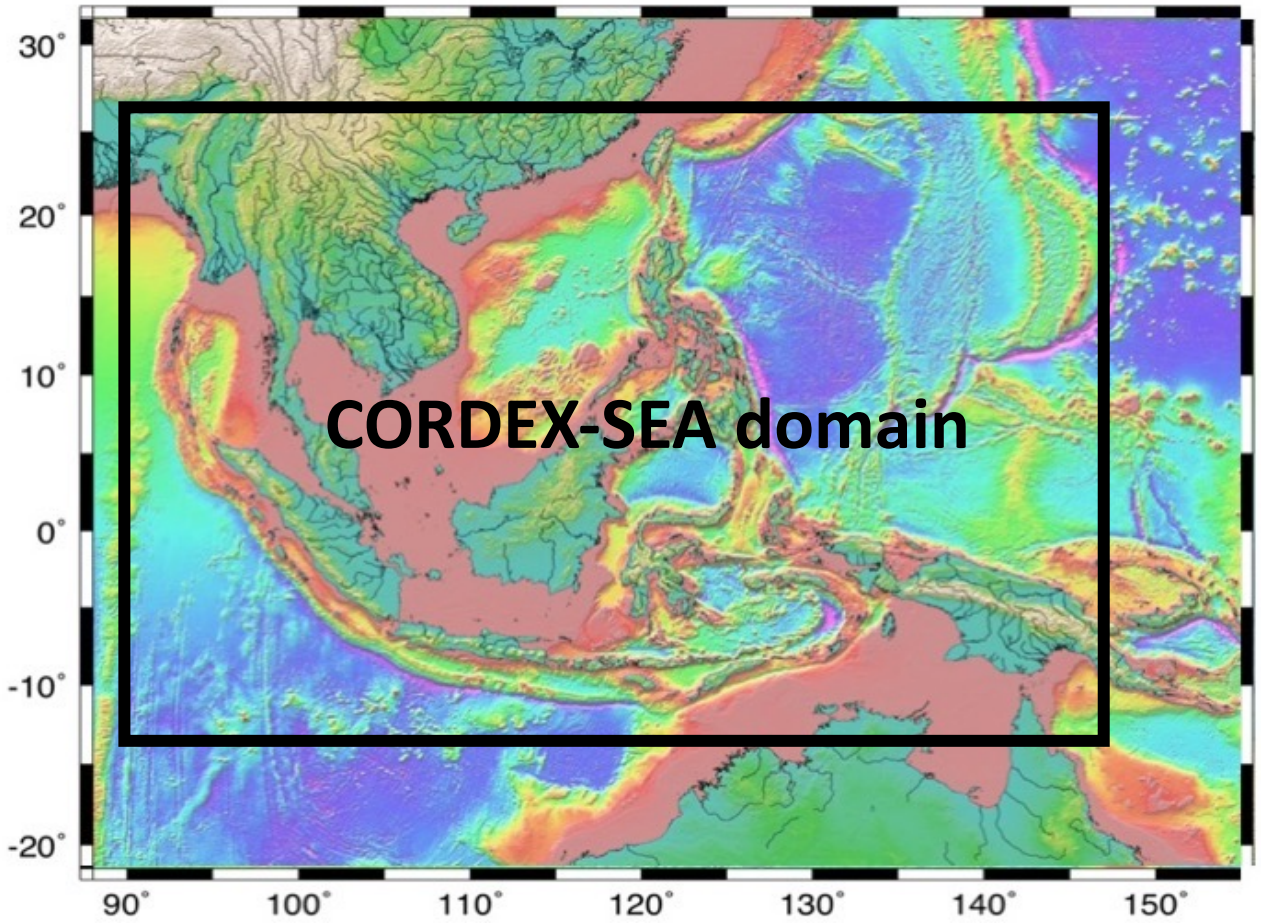
- Strong atmospheric convection
- Monsoon, typhoons, ENSO
- MJO barrier
- Aerosols

Yoneyama & Zhang (GRL, 2020)



The CORDEX-SEA modeling Group

- Regional downscaling simulations performed by several groups : Vietnam, Malaysia, Sweden, Philippines, Thailand
- Atmospheric models:
  RegCM and RCA
  Tangang et al. (2020)
- Focus on atmosphere and continent (precipitations, surface temperature, TC)
- Very few studies over the sea (e.g. sea surface wind, *Herrmann et al. 2020,2021*)



Development of a high-resolution regional coupled ocean-atmosphere model over the SEA region

Development of a high–resolution coupled model over the SEA domain.

RegCM atmospheric model (ICTP, USTH)

CORDEX-SEA config, 25 km

Phan-Van et al. 2018, Herrmann et al. 2020

OASIS3-MCT coupler (CERFACS)

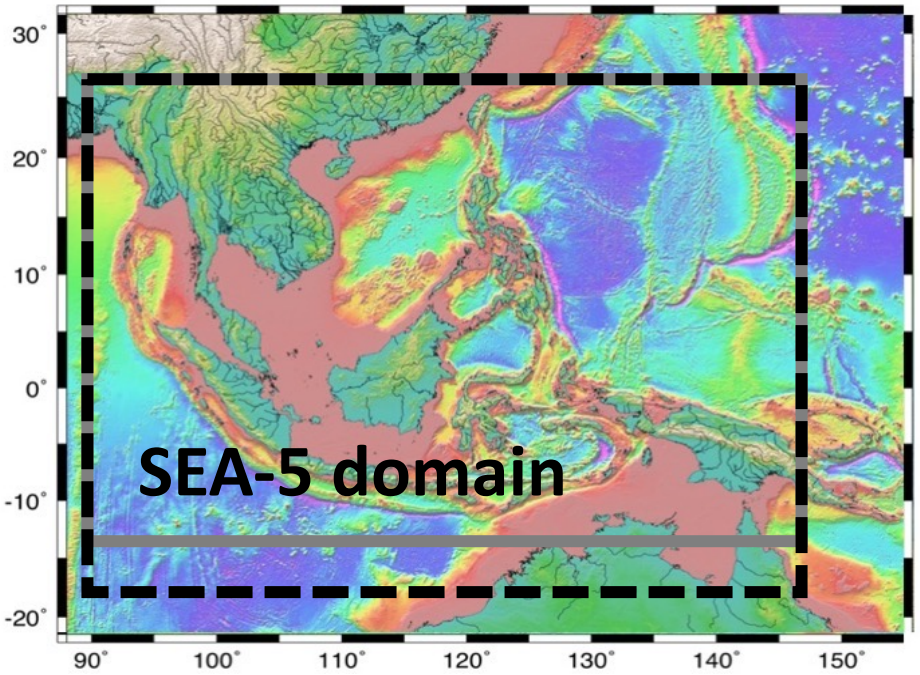
SYMPHONIE ocean model (SIROCCO group, LEGOS)

5 km, 60 vqs levels

Explicit tide representation

Online closed V,T,S budget

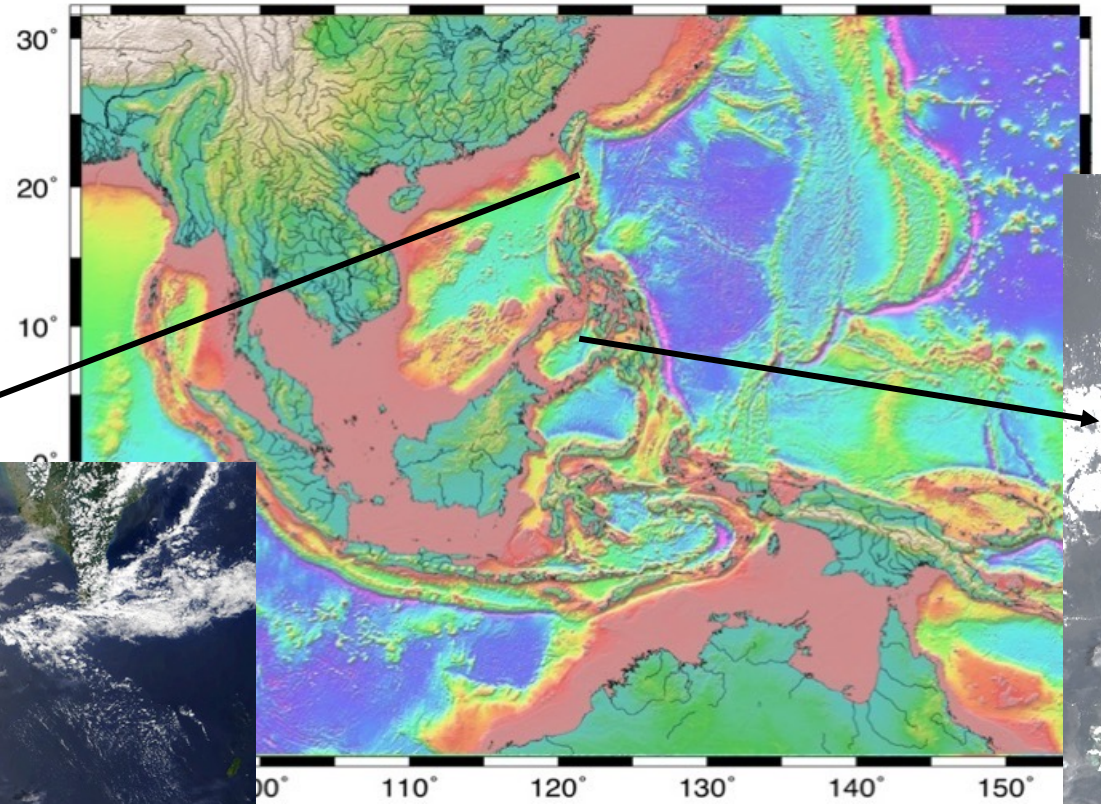
Marsaleix et al. 2009, Trinh et al. 2023



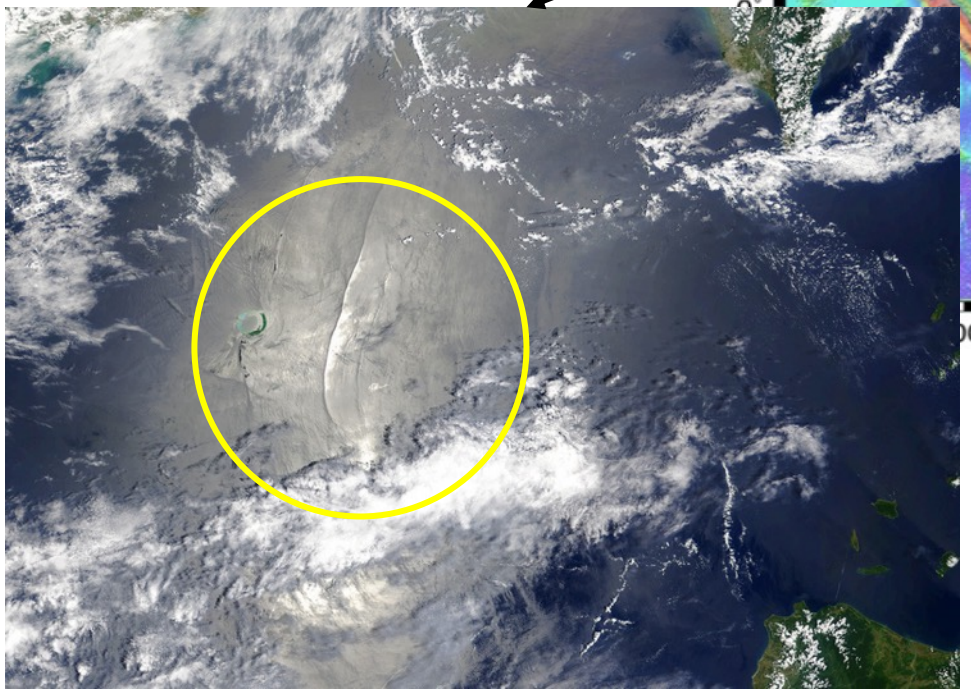
Topographie of SEA-5

Presentation of coupling algorithm and calibration of atmospheric component of the coupled model : *talk by Quentin Desmet, Tuesday*

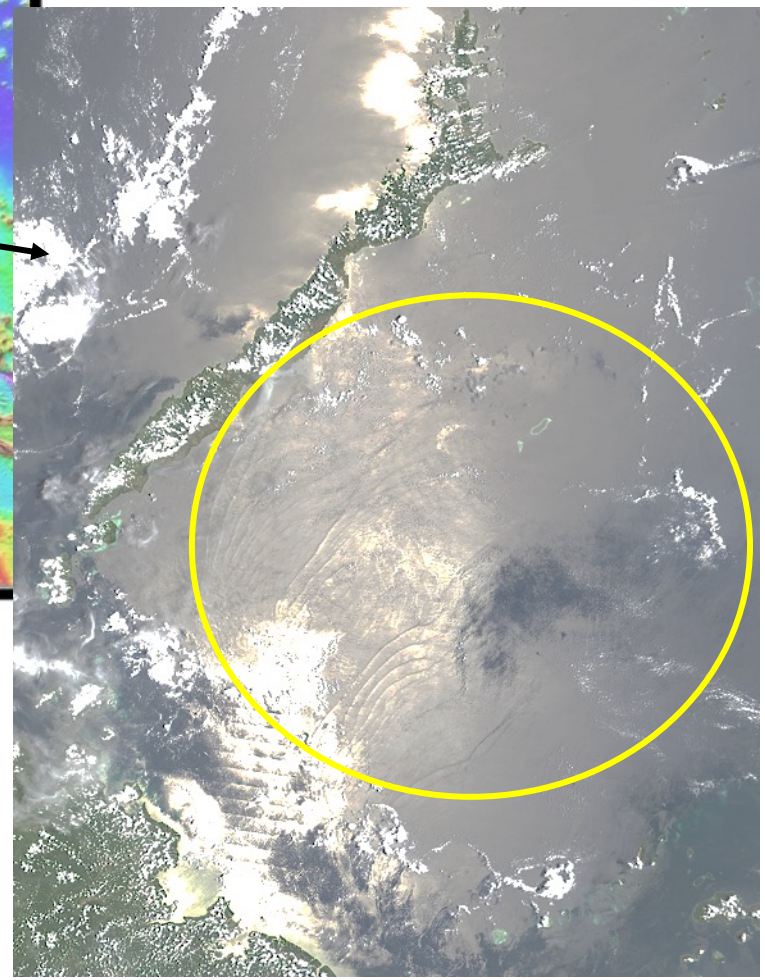
Tidal representation : importance of high resolution of topography and land-sea mask



Luzon Strait

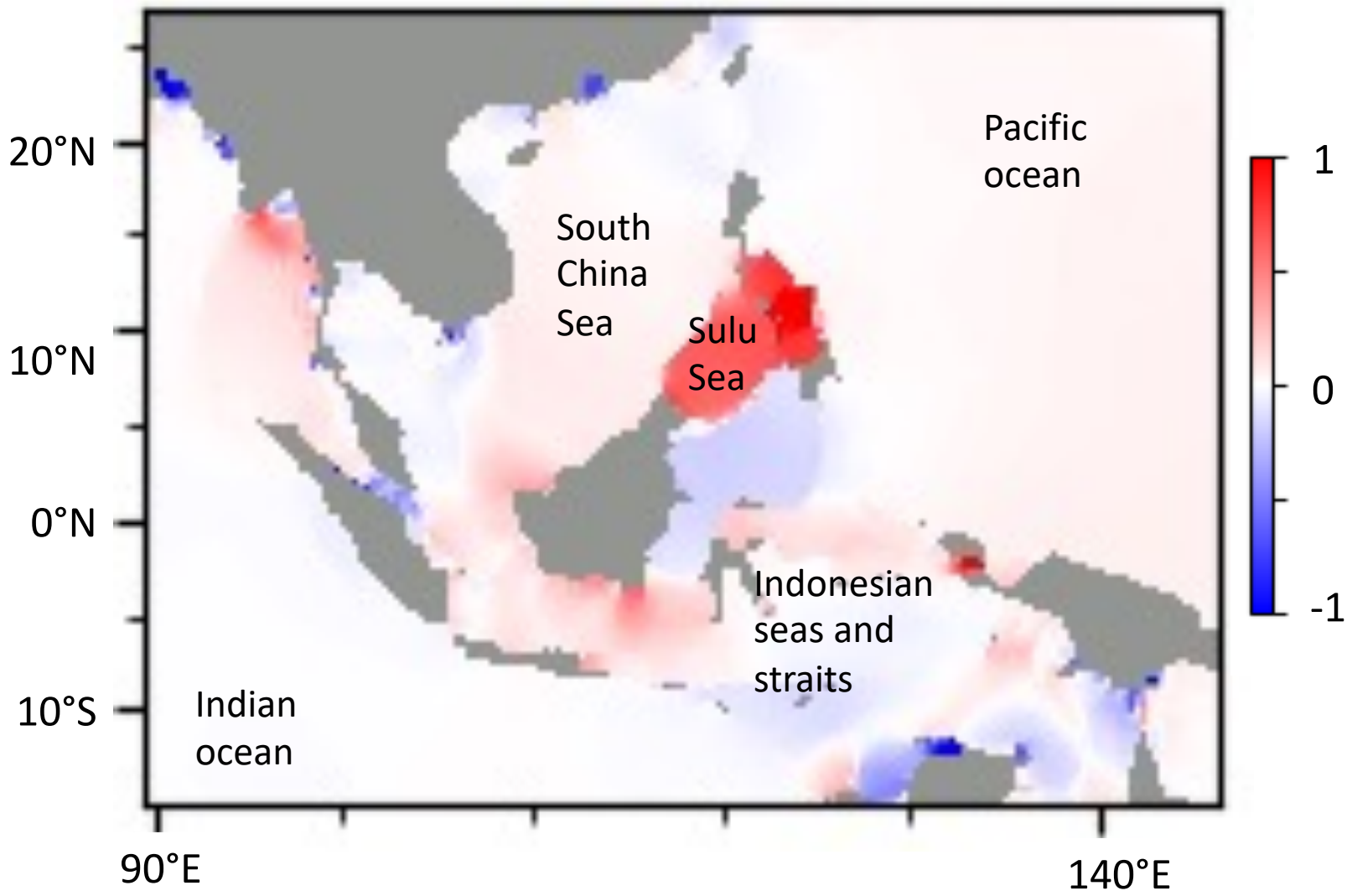


Sulu Sea



Tidal representation : importance of high resolution of topography and land-sea mask

Bias of M2 amplitude (m)



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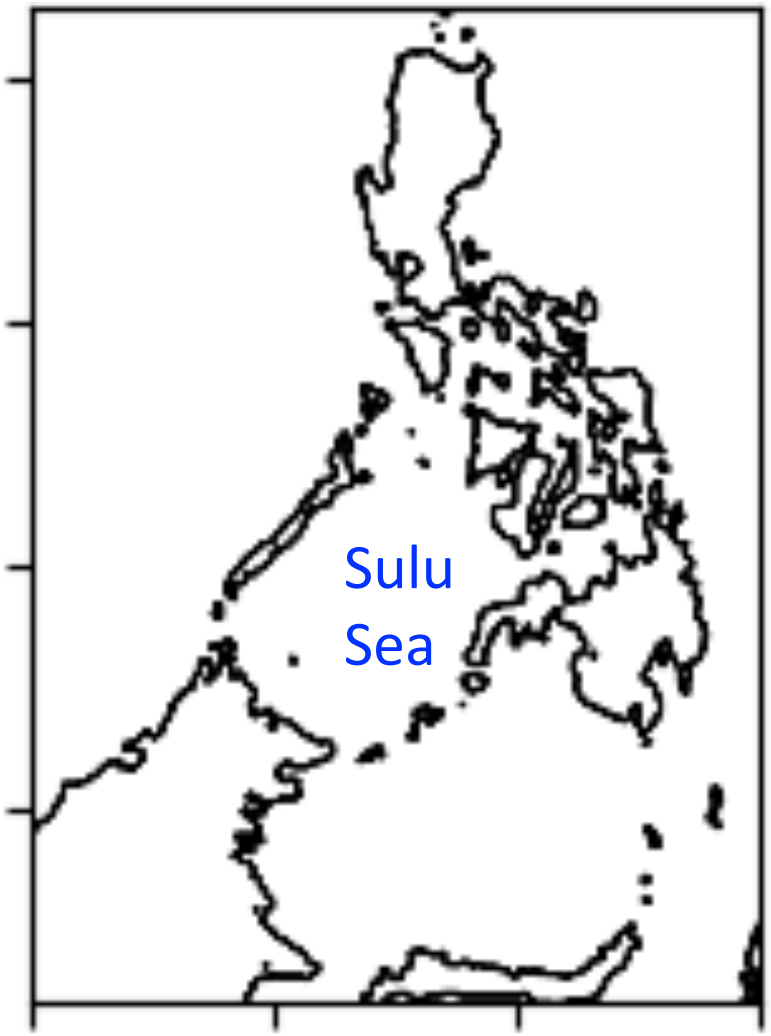

Air-sea mask from GEBCO

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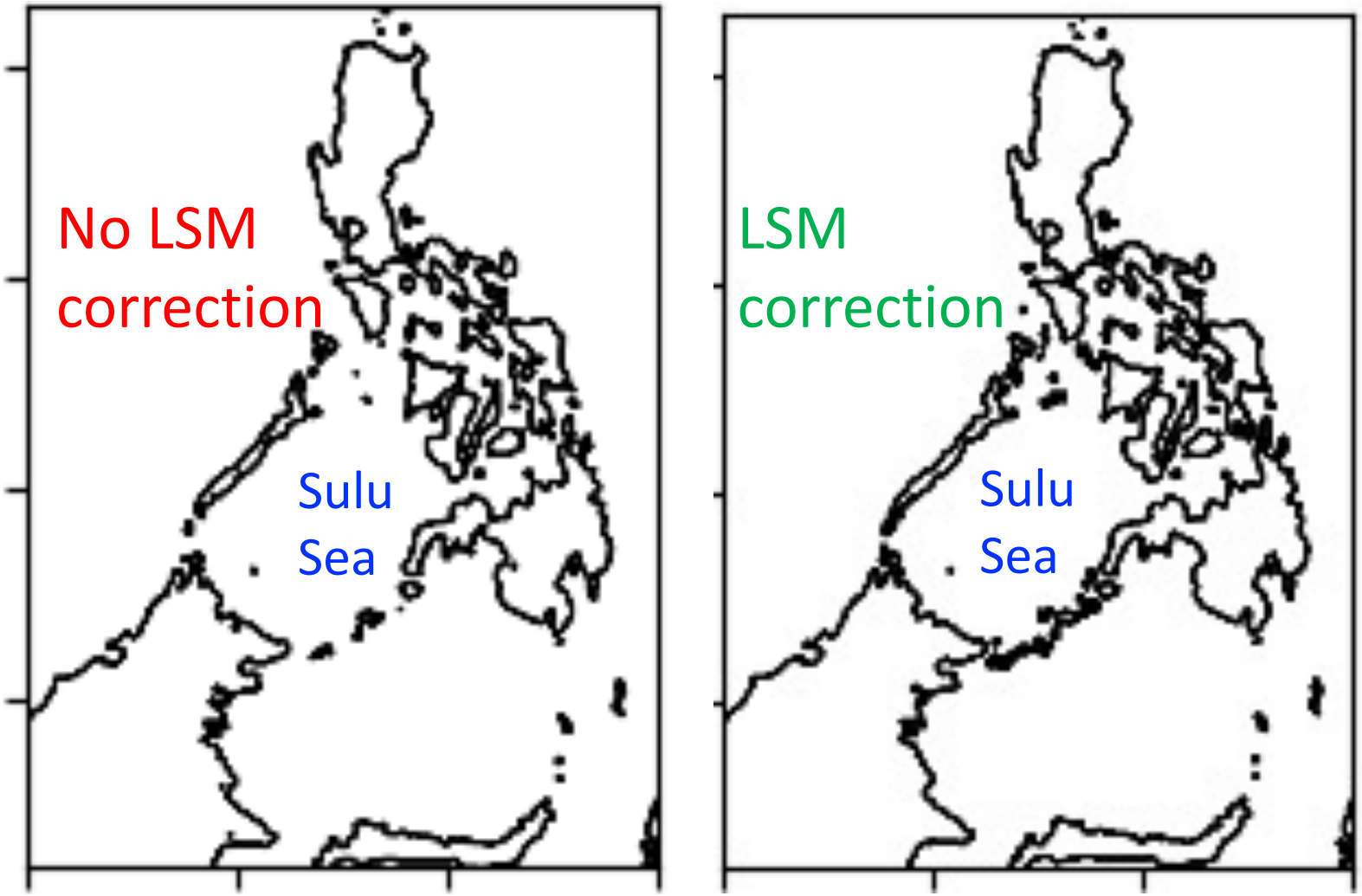

Air-sea mask from GEBCO
without (left) and with (right) topography correction

Tidal representation : importance of high resolution of topography and land-sea mask

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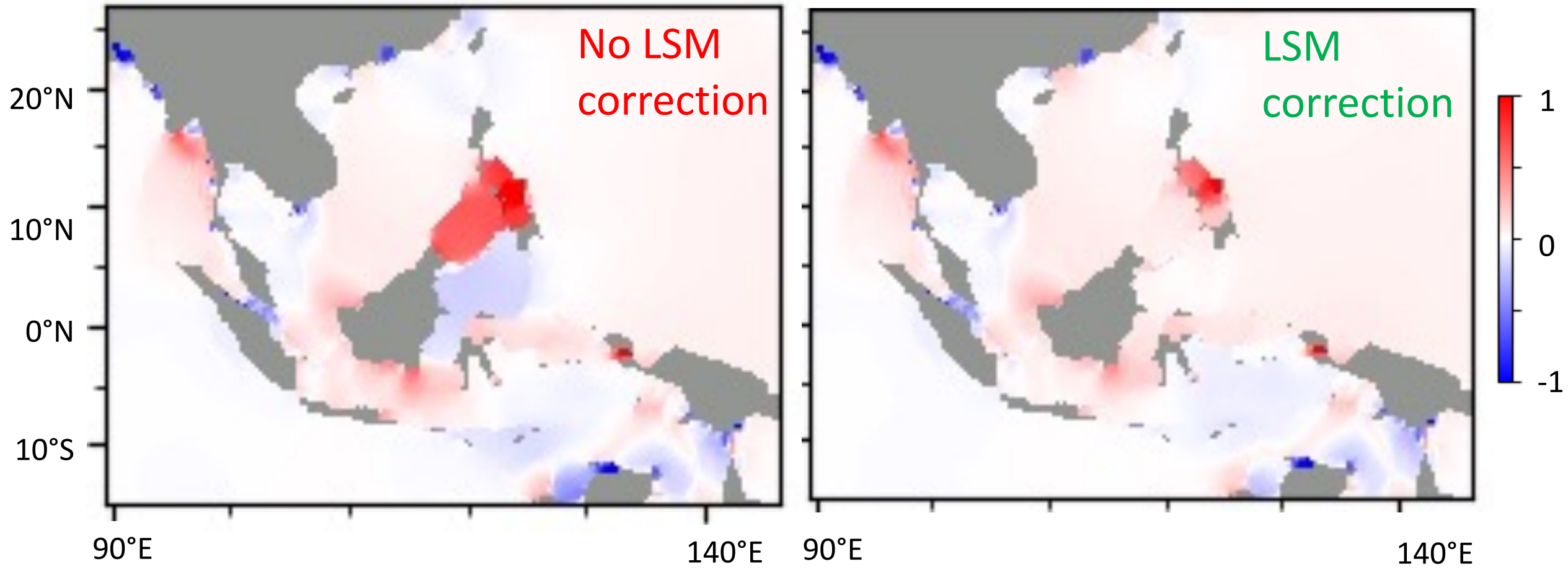
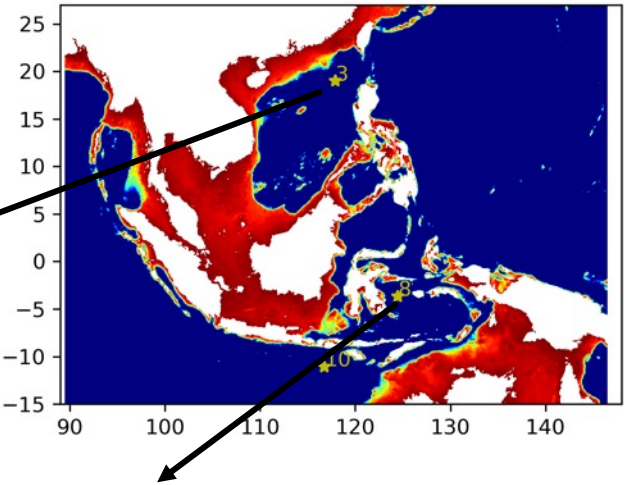
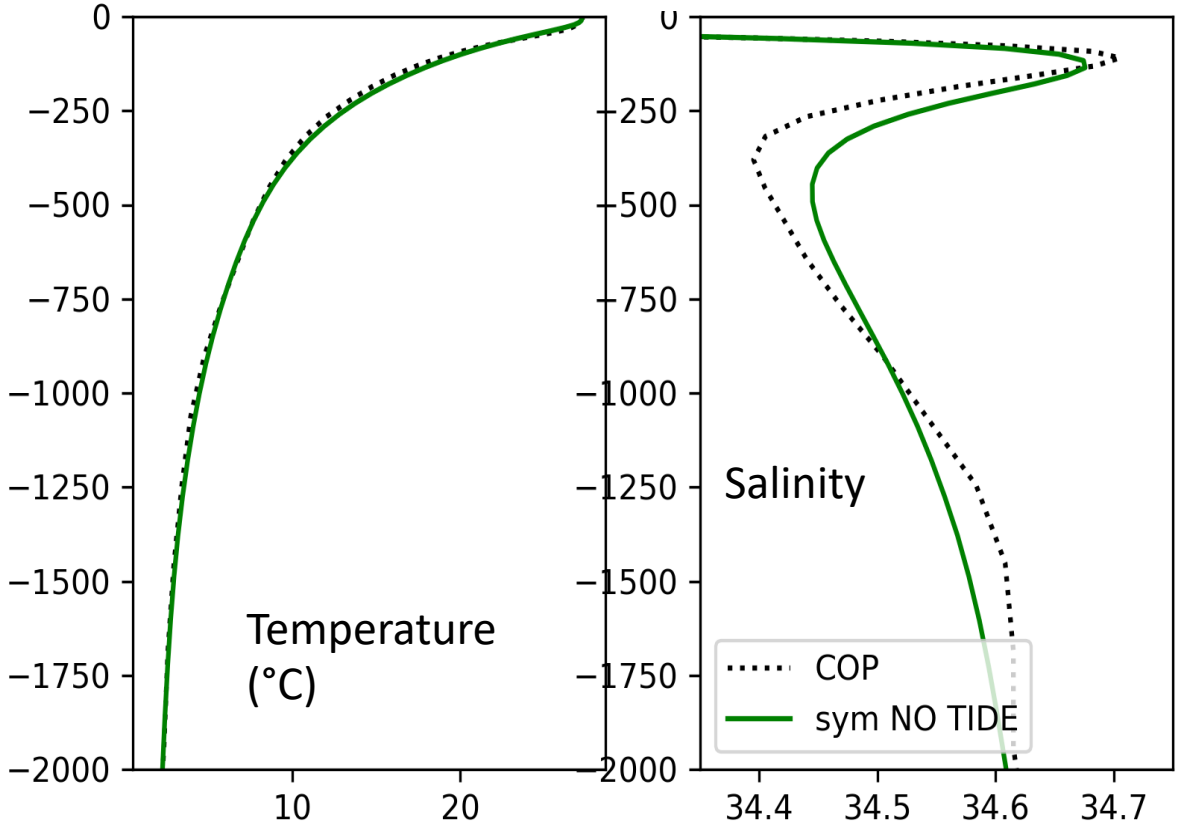


Including tidal explicit representation without destroying stratification

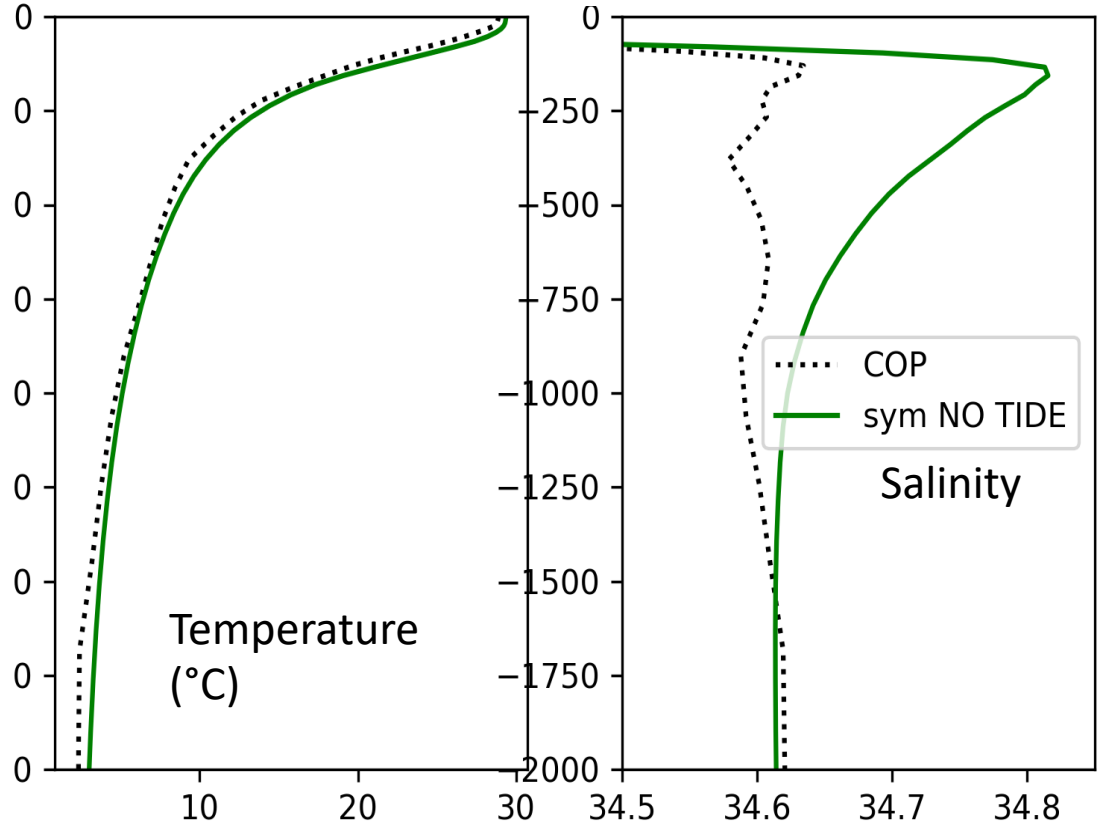
Work on the diffusive part of vertical advection scheme to avoid excessive erosion of profiles



South China Sea (SCSTF entrance)



Banda Sea (exit, strong tidal mixing)



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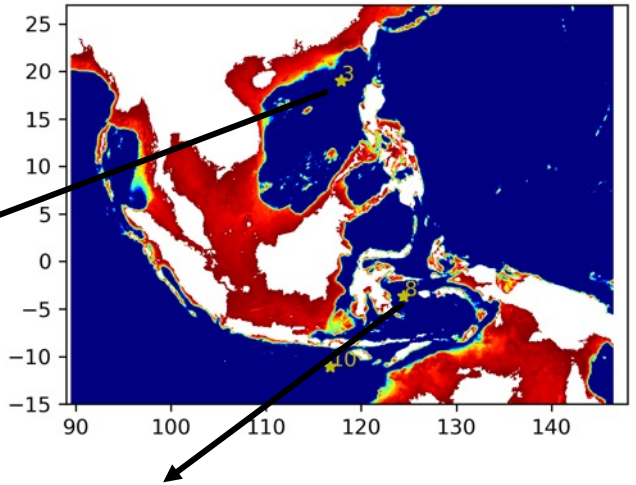

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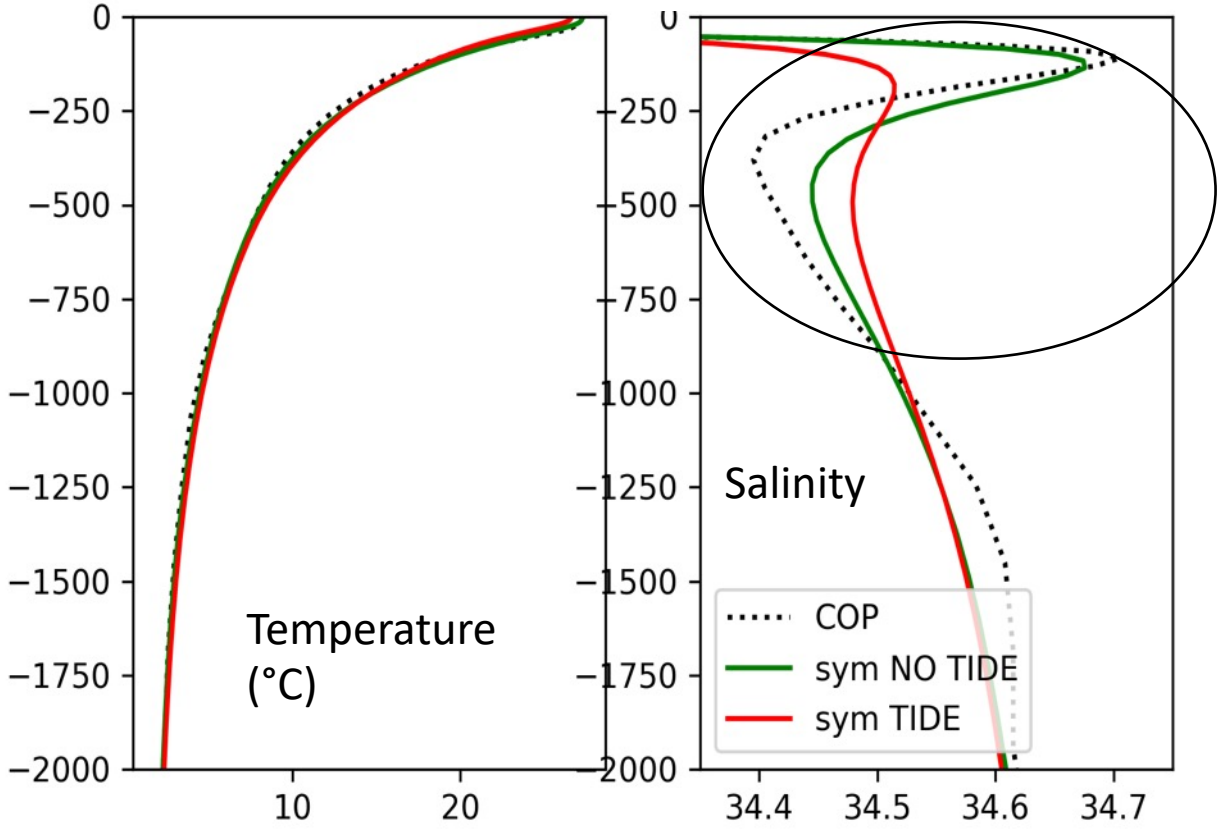

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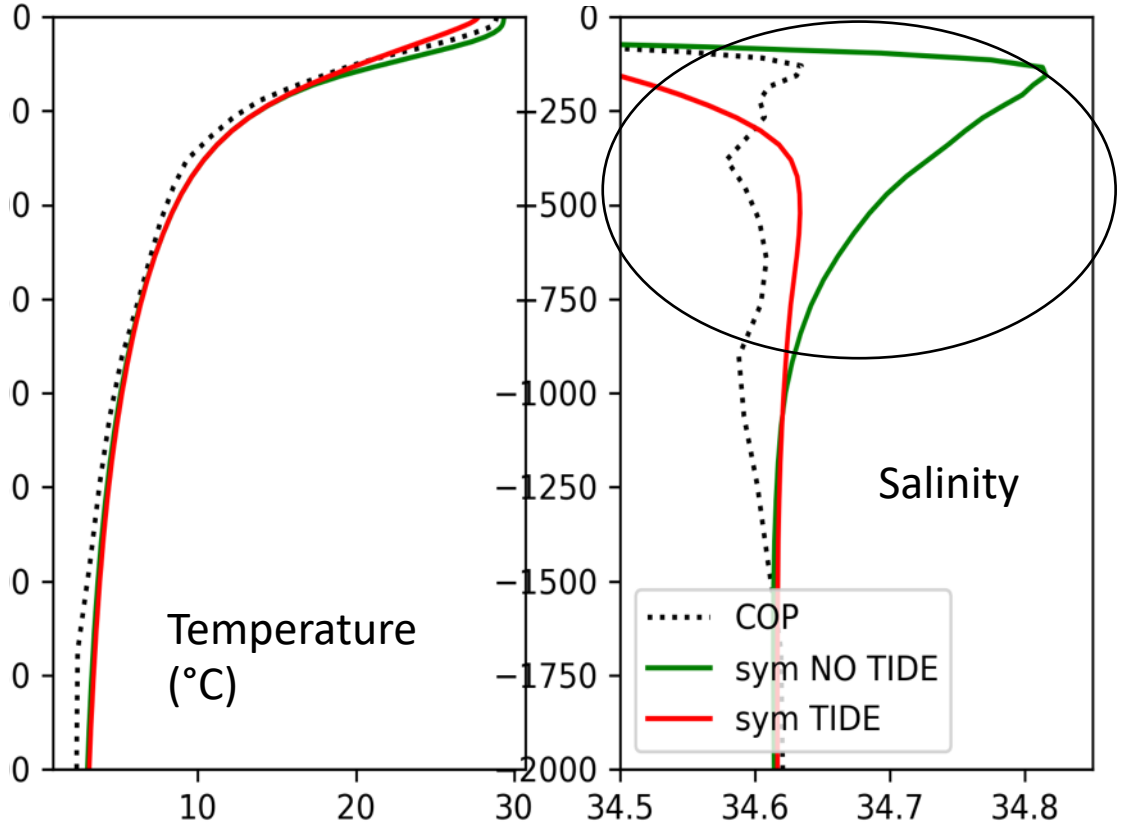
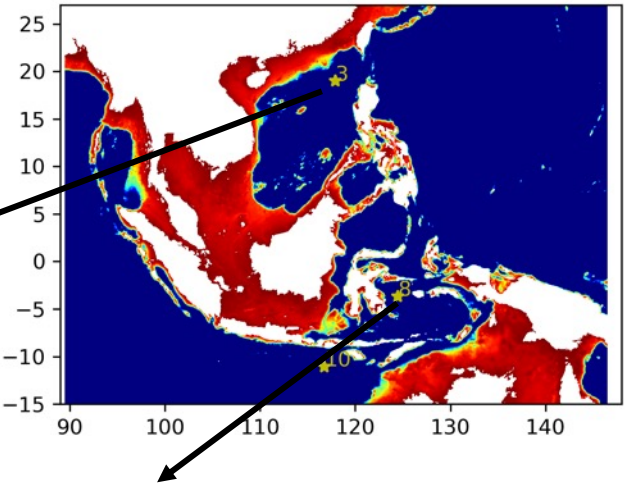


Including tidal explicit representation without destroying stratification

Work on the diffusive part of vertical advection scheme to avoid excessive erosion of profiles

On-going work of Adrien Garinet PhD



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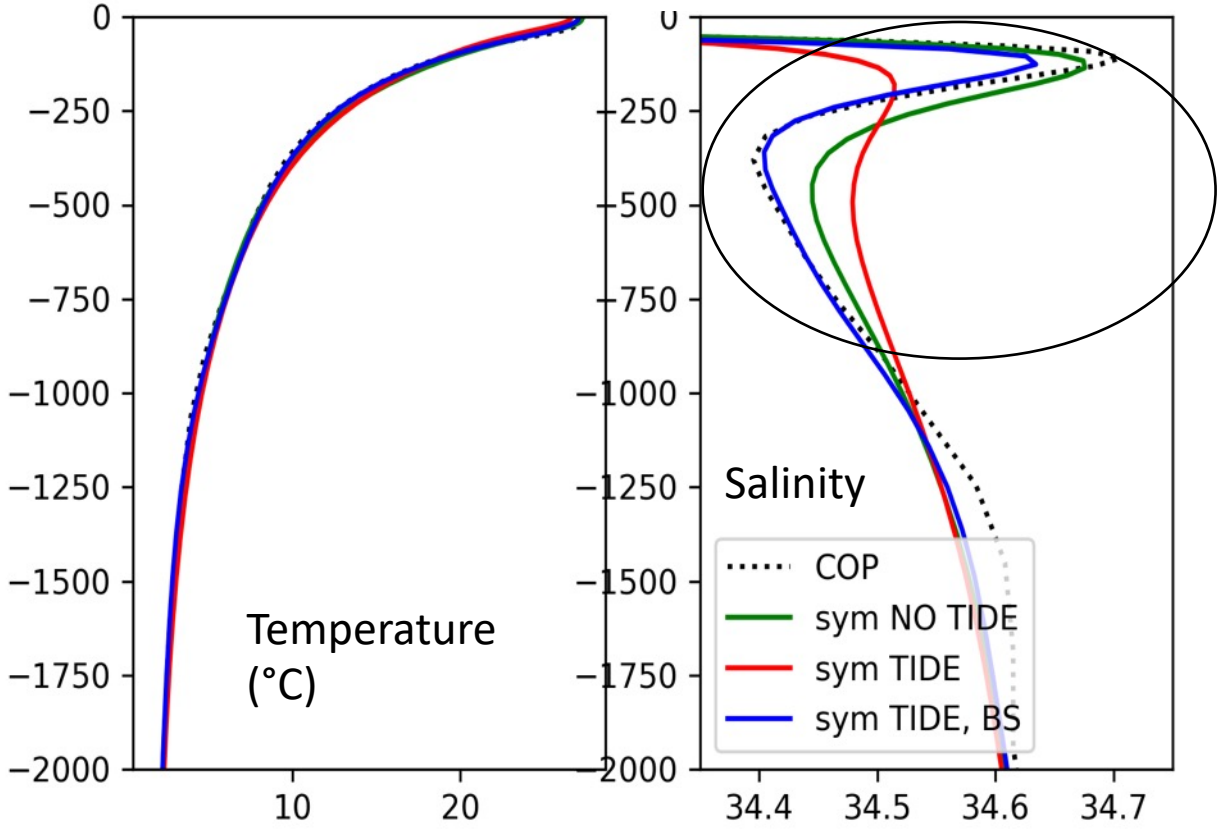

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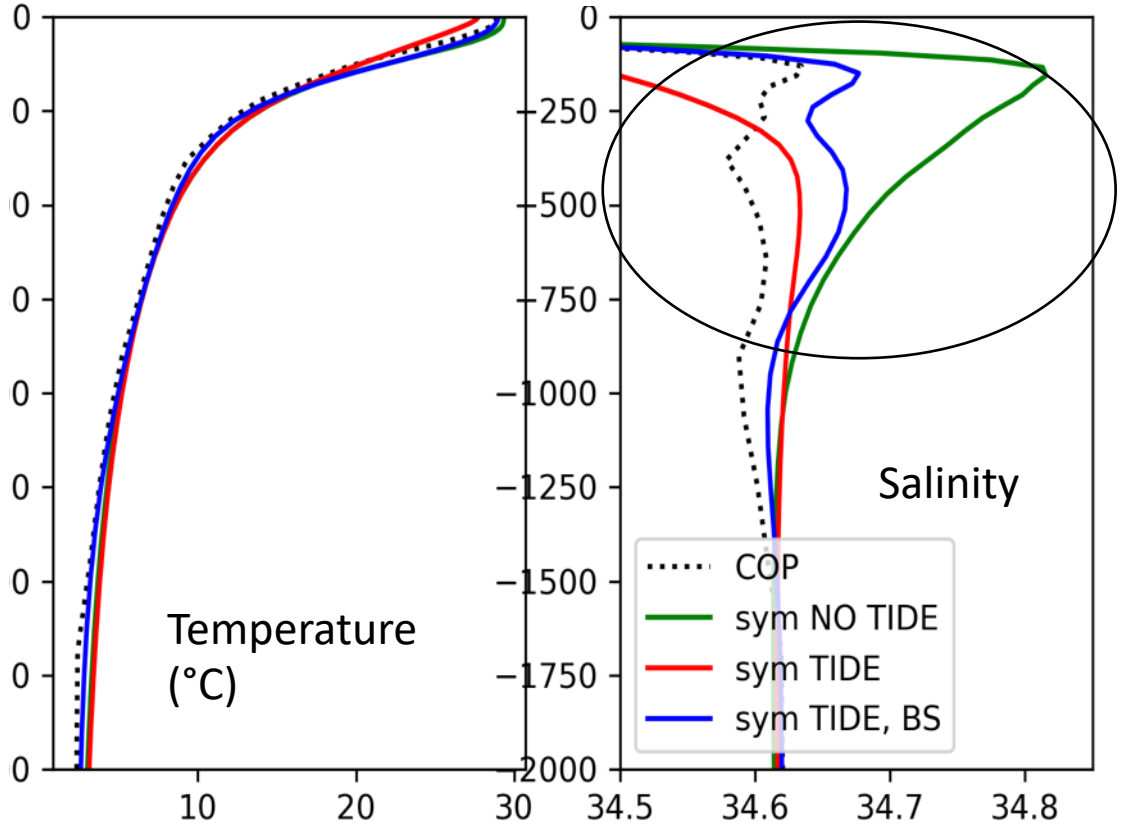


Retrieving river discharge in a region with huge discharge but few data

GLOFAS (Copernicus)
Hydrological model, 1/10° reanalysis
Daily, since 1979

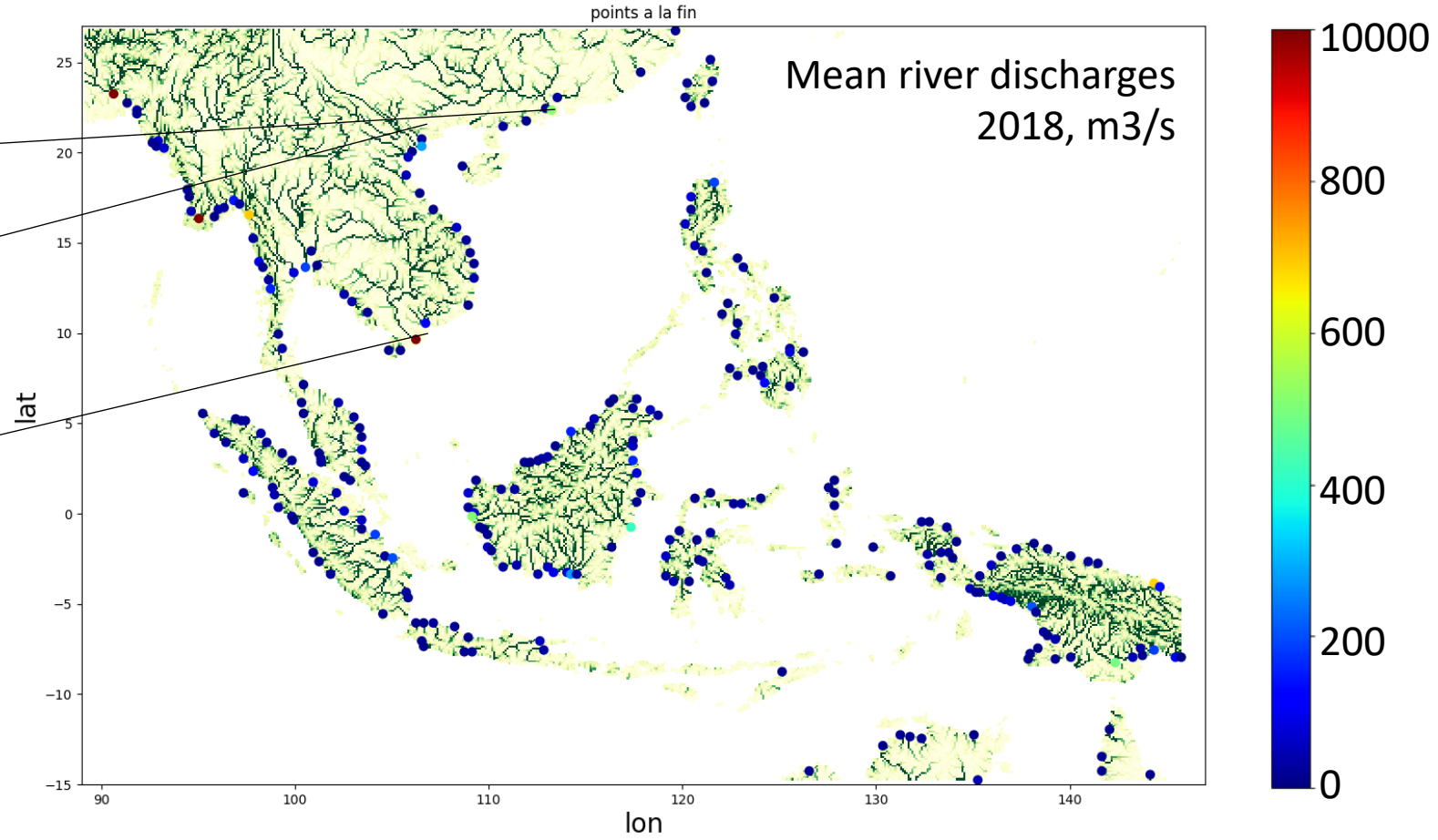
→ > 300 daily interannually varying river discharges
vs. 99 monthly climato in *Dai and Trenberth (2002)*

PEARL.: 5.1 x 10^3 m^3/s
(Climato 9.8 x 10^4 m^3/s)

RED.: 2.9 x 10^3 m^3/s
(Climato 3.5 x 10^3 m^3/s)

MÉKONG : 1.56 x 10^4 m^3/s
(Climato 1.4 x 10^4 m^3/s)

Total discharge over the area:
1.9 x 10^5 m^3/s



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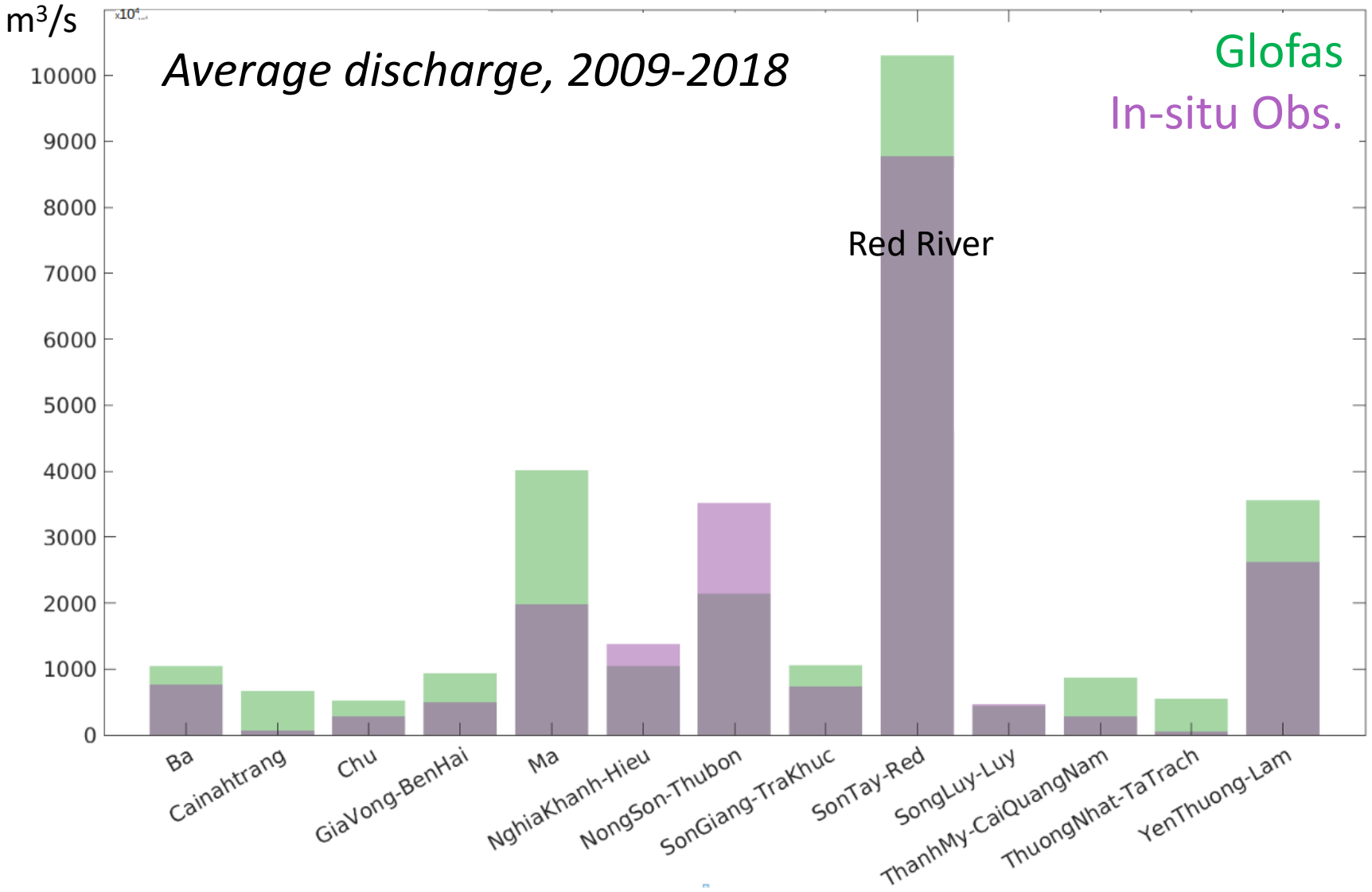

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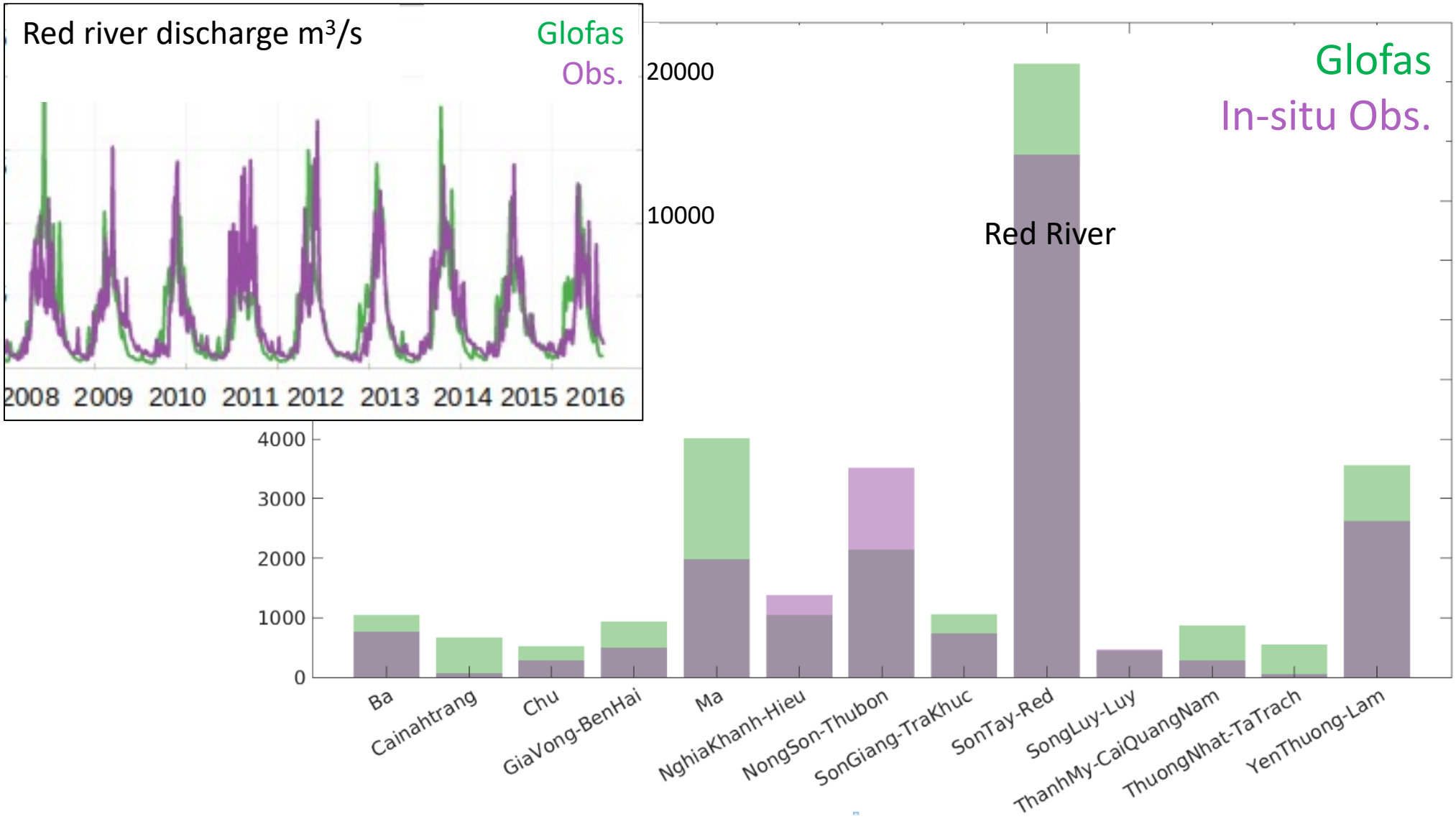

Development of an ocean model at high resolution, including tides and coupled with an atmospheric model

Can now be used :

- Studies of SEA climate at different temporal and spatial scales, from typhoon to climate change, role of air-sea interactions

PhDs Nguyen Thanh Hue, Quentin Desmet, Adrien Garinet

- Investigation of South China Sea Throughflow and Indonesian Seas Throughflow, seasonal to interannual variability. *Trinh et al., GMD, under rev.*
- Role of small scale processes, upwellings, tides, air-sea interactions on water masses mixing and transport. *To-Duy et al. 2022 OS, Herrmann et al. 2022 OS*
- Good case study to investigate the ability of parameterisations to represent atmospheric convection, clouds, islands effects, air-sea fluxes (*SEASTERS project*)