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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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 between the 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)
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)

The CORDEX-SEA modeling Group

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

**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

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
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Bias of M2 amplitude (m)
Tidal representation: importance of high resolution of topography and land-sea mask

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

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

No LSM correction

LSM correction

Sulu Sea

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

Bias of M2 amplitude (m)

No LSM correction

LSM correction
Including tidal explicit representation without destroying stratification

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

Temperature (°C)  Salinity  Temperature (°C)  Salinity

Legend:
- COP
- sym NO TIDE
- sym TIDE
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

South China Sea (SCSTF entrance)

Banda Sea (exit, strong tidal mixing)
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.: $5.1 \times 10^3$ m$^3$/s
(Climato $9.8 \times 10^4$ m$^3$/s)

RED.: $2.9 \times 10^3$ m$^3$/s
(Climato $3.5 \times 10^3$ m$^3$/s)

MÉKONG : $1.56 \times 10^4$ m$^3$/s
(Climato $1.4 \times 10^4$ m$^3$/s)

Total discharge over the area:
$1.9 \times 10^5$ m$^3$/s
Retrieving river discharge in a region with huge discharge but few data

*Average discharge, 2009-2018*
Retrieving river discharge in a region with huge discharge but few data
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)