



TAJUK PEMBENTANGAN: **The Simulation Performance of Malaysia Ocean Climate with A Regional Atmospheric Ocean Coupled Model**

TEMA: MORFOLOGI PANTAI DAN OSEANOGRAFI

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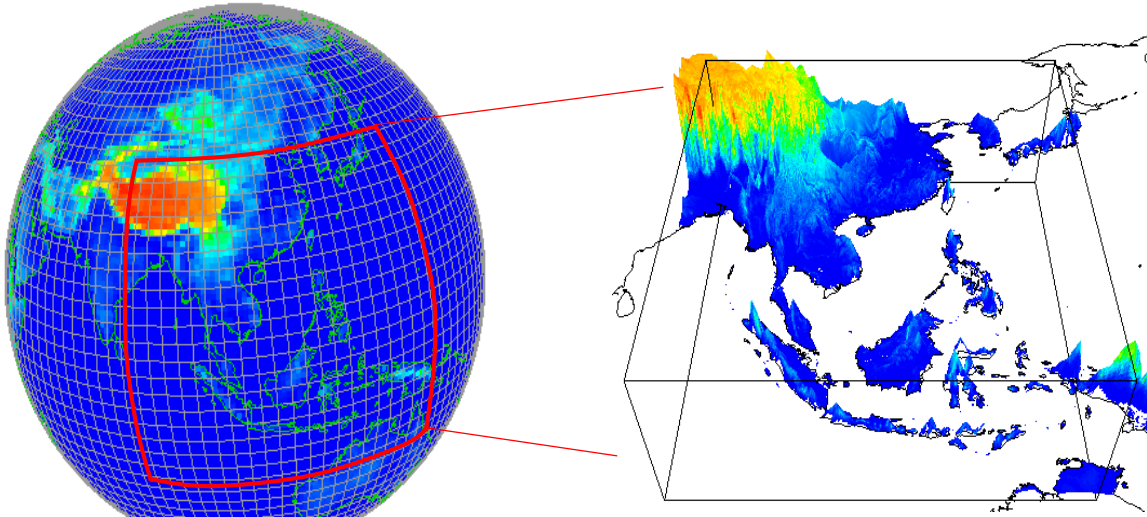
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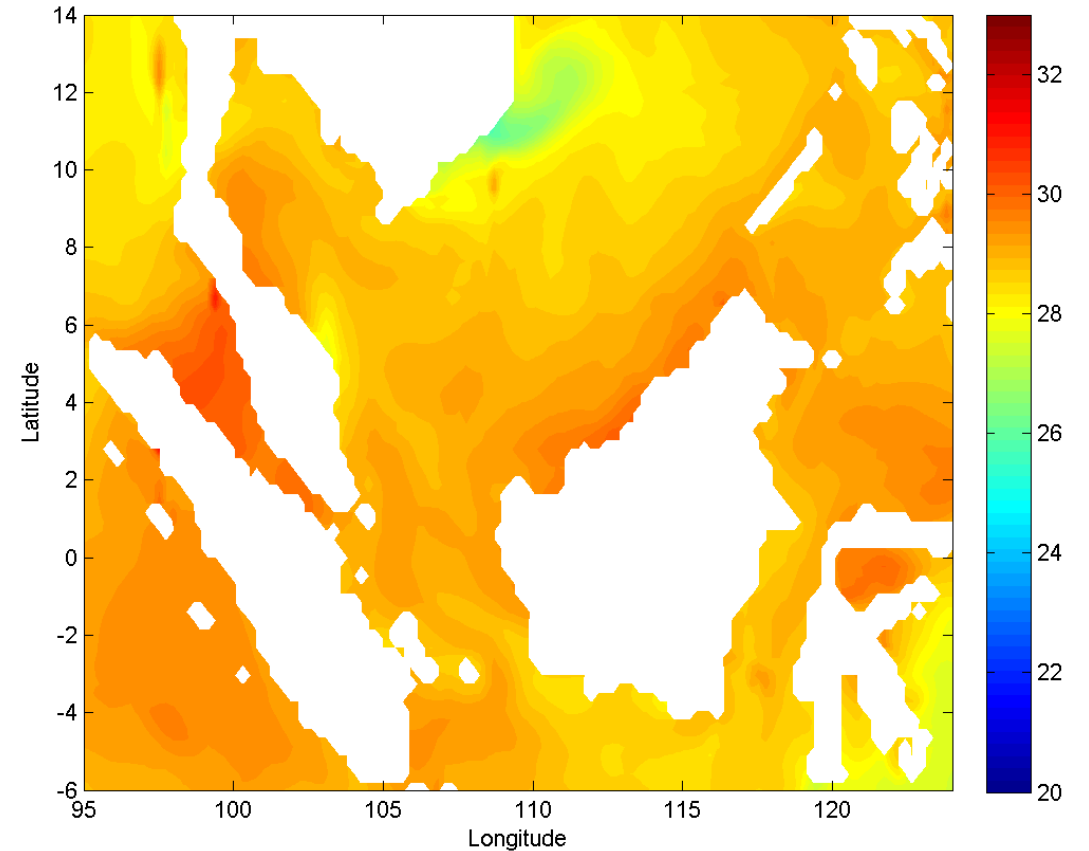
INSTITUSI: NAHRIM

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Outline



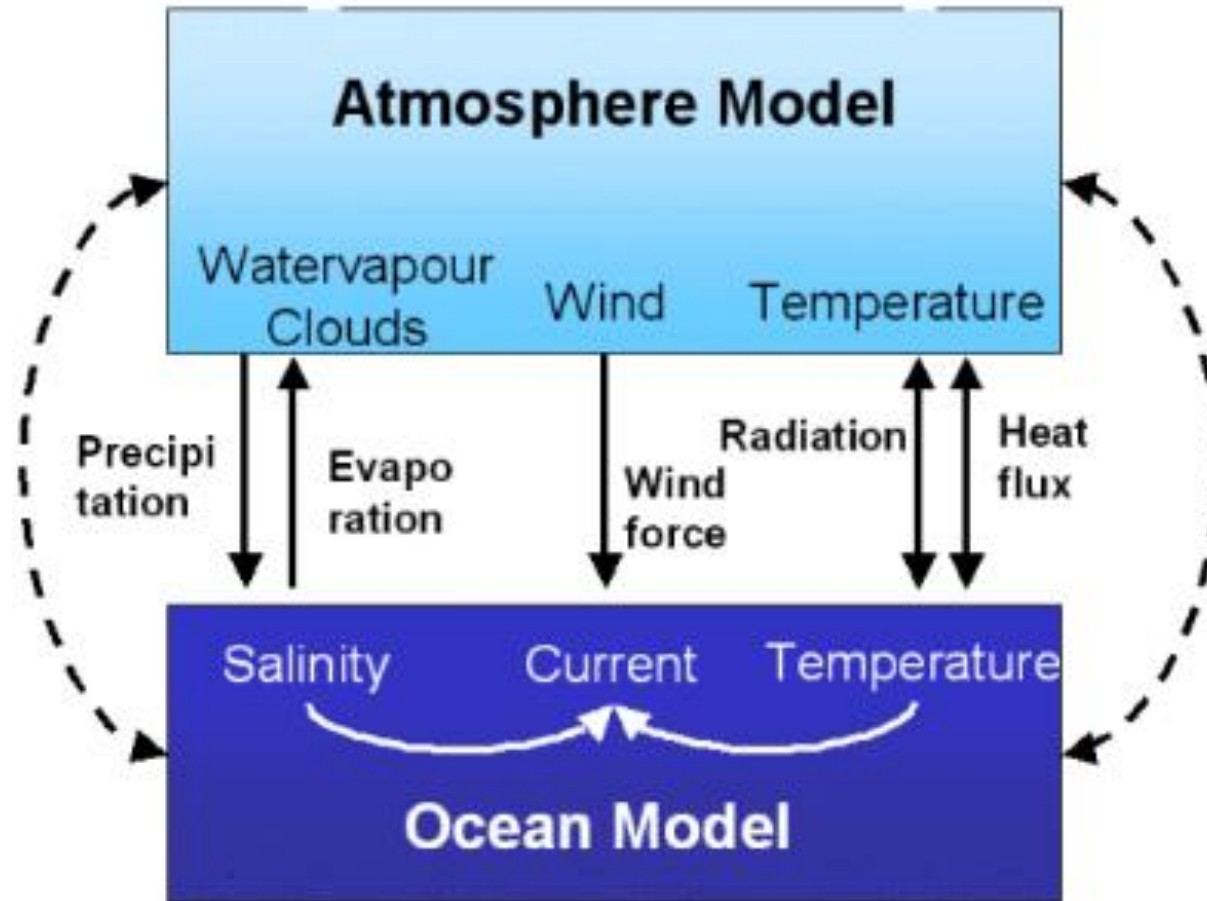
- Introduction
- The GRIMs and ROP Simulation
- The simulation setup
- Simulation Results (SST and GRIMs performance)
- Problems and some suggestion



Modeling the Climate

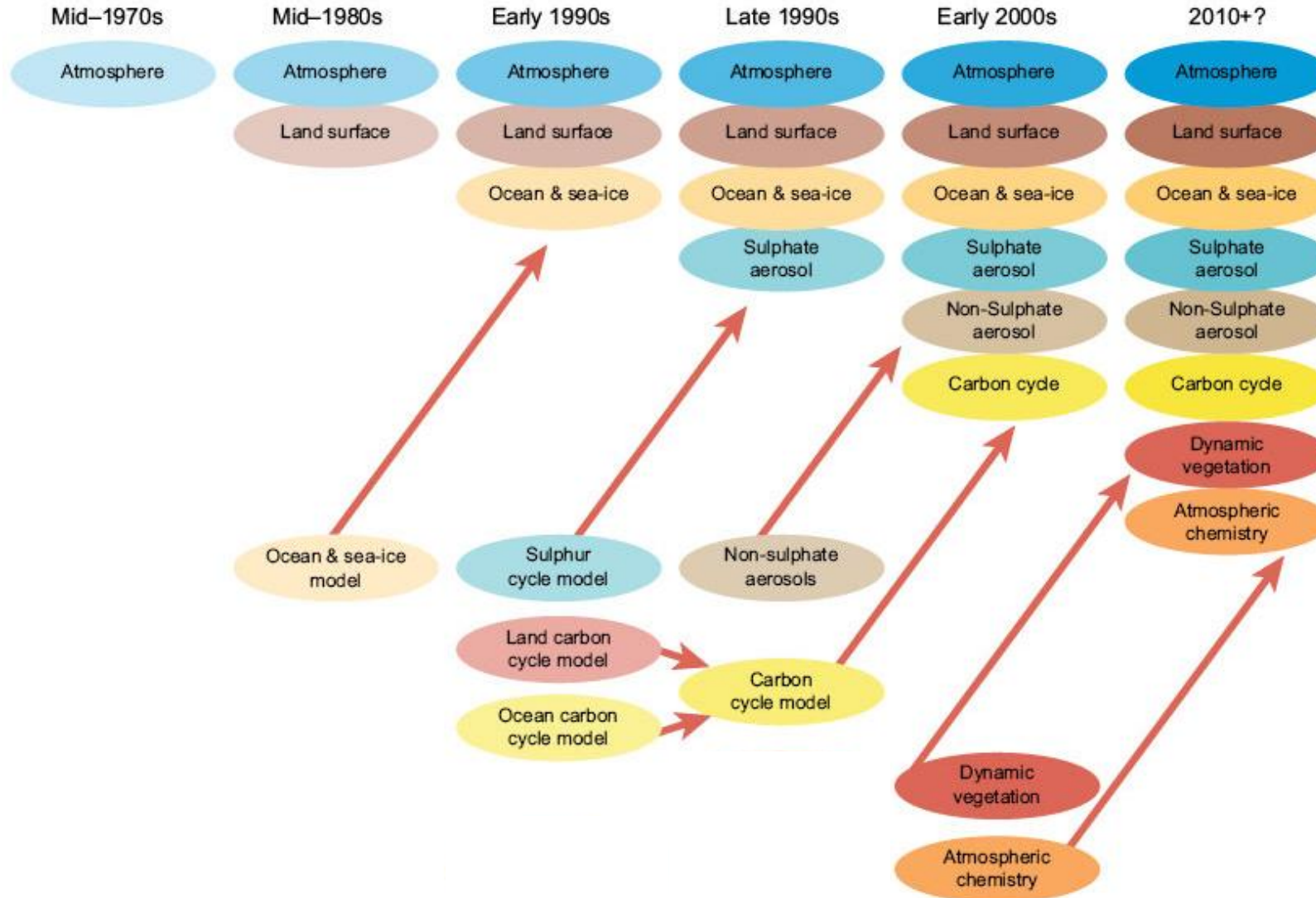
- Mathematical representation of the climate system.
- Climate models initiate what **POTENTIAL CHANGES** not **PREDICT HAPPEN** in the future
- Simple (energy balance) > most sophisticated (coupled GCMs/RegionalCMs) (**DOWNSCALING**)
- Can be computationally **VERY** expensive.

What information is exchange between the ocean and the atmosphere?



The evolution of climate model

The Development of Climate Models: Past, Present and Future

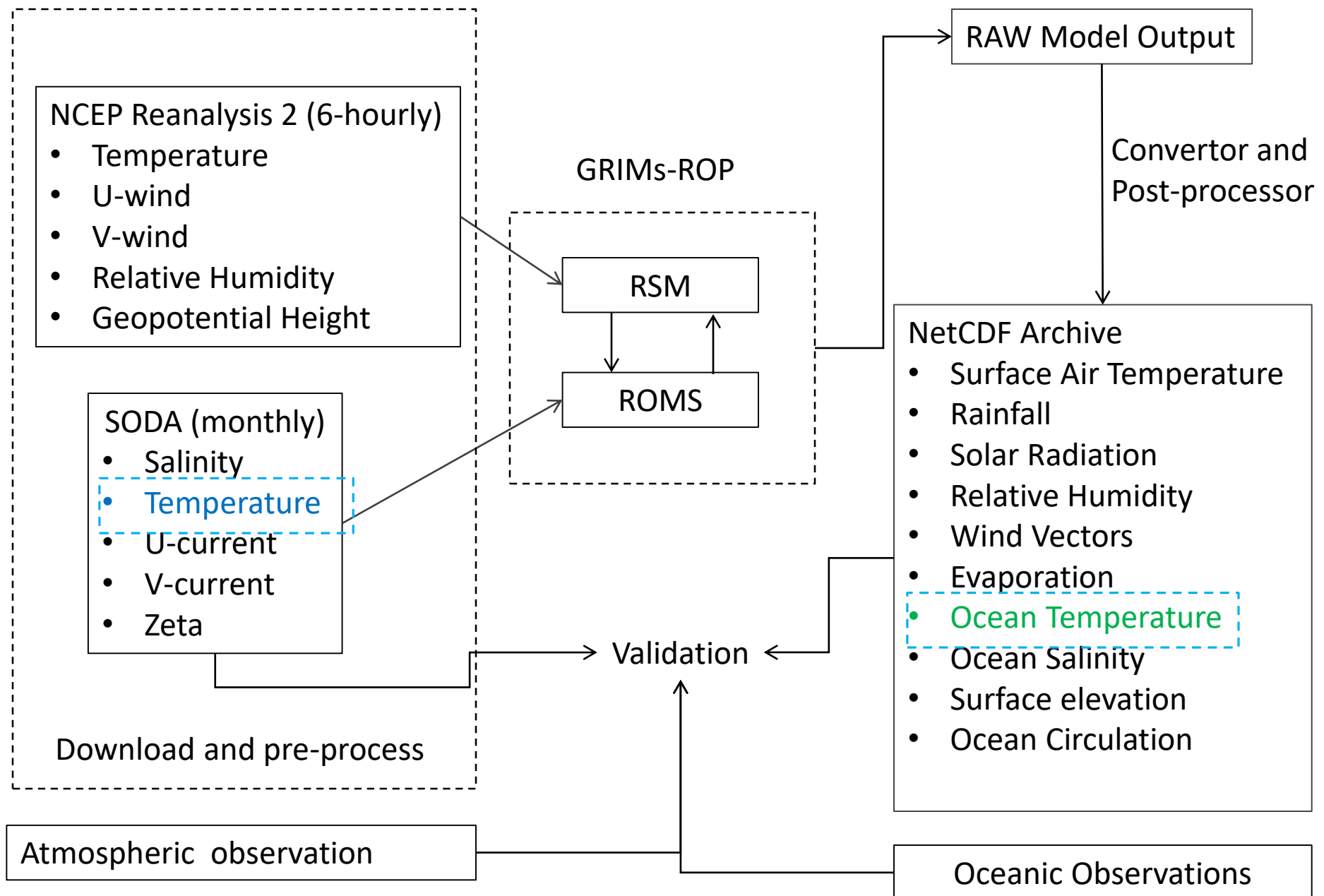


GRIMs

- *The Global/Regional Integrated Model System.
- It is the Coupled regional ocean/atmosphere model program (ROP)
- It is a multi-scale atmospheric/oceanic modeling system suitable for:
 - numerical weather prediction
 - seasonal forecast
 - climate projections

*The GRIMs-CCM (Chemistry Climate Model) simulates gas and aerosol concentrations to calculate time series radiative transfer

Ref: Lee, Seungun, et al. "A New Chemistry-Climate Model GRIMs-CCM: Model Evaluation of Interactive Chemistry-Meteorology Simulations." *Asia-Pacific Journal of Atmospheric Sciences* (2022): 1-20.



GRIMs

- The regional ocean-atmosphere model components of GRIMS
- ***Atmosphere** – NCEP's Regional Spectral Model (RSM) with spectral nudging turned on.
- **Ocean** – Regional Ocean Modeling System (ROMS).
- The source code is a mixture F90 and F77 and run in Message Passing Interface (MPI) configuration (platform was used).

*The Geophysical Fluid Dynamics Laboratory (GFDL) Modular Ocean Model version 3

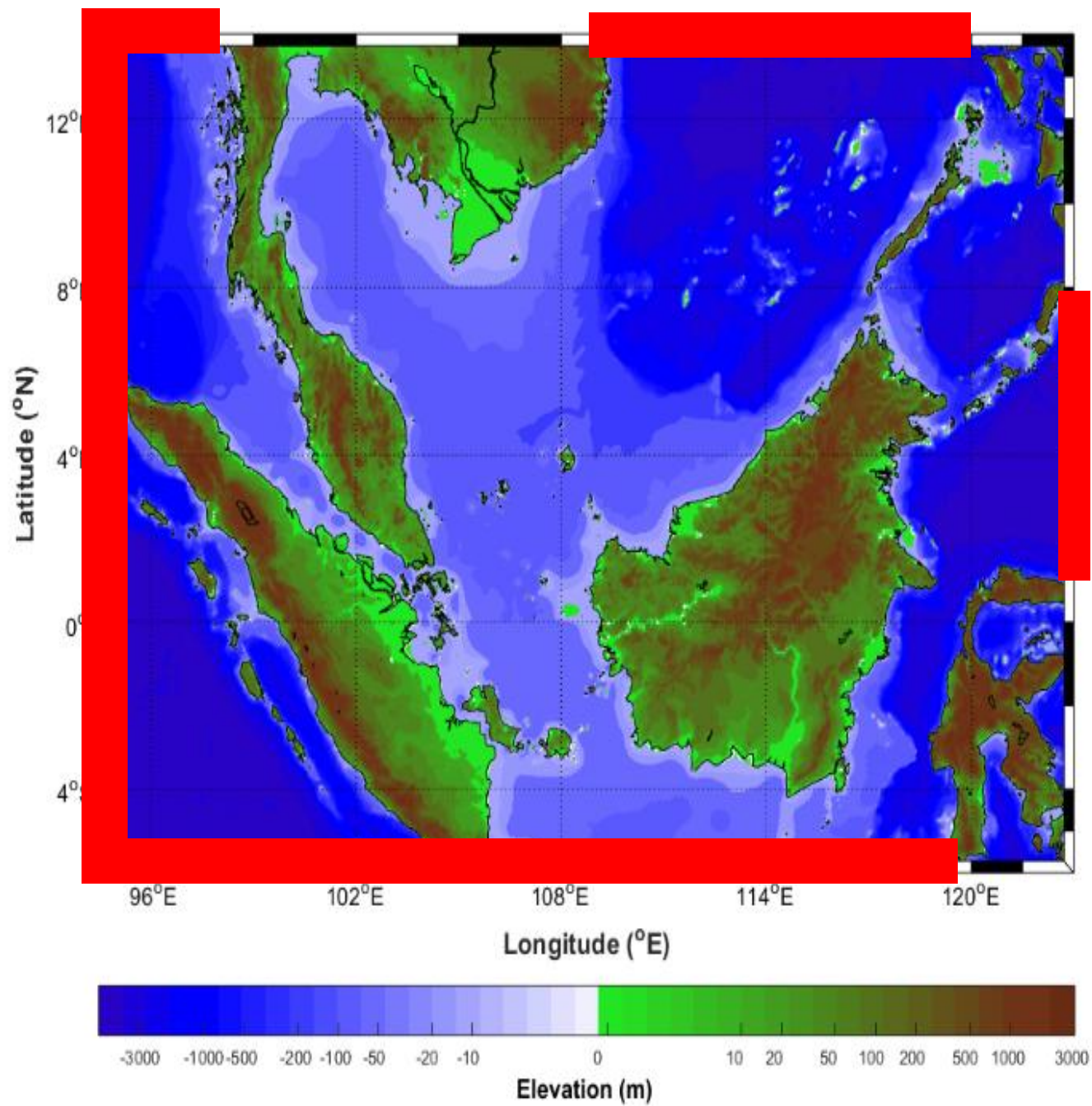
GRIMs Output

- Atmosphere model output variables:
 - Rainfall, temperature, surface radiation (longwave, shortwave), surface air temperature, surface heat fluxes, evaporation, runoff, soil moisture, total cloud cover, 3D humidity, 3D temperature, 3D winds (U, V, W) etc.
- Ocean model output variables:
 - 3D surface salinity, 3D surface temperature, 3D surface current (u, v and w), sea surface elevation, mixing depth

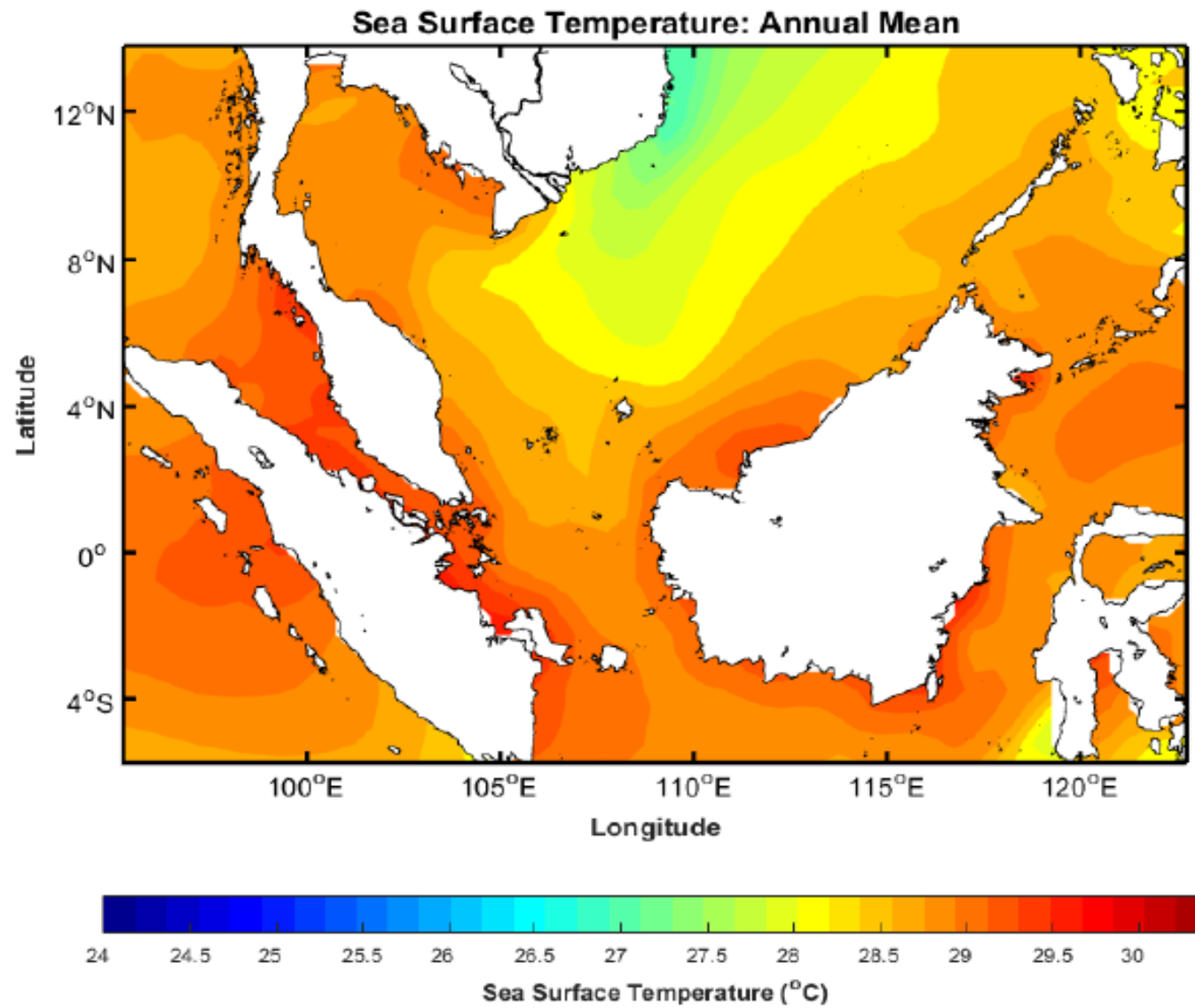
GRIMs Simulation Setup

- Domain – covering Malaysia and South China Sea
- Grid resolutions: (20 km)
- ROMs (ocean) vertical layers: 28
- RSM (atmosphere) vertical layers: 30
- Coupling time steps: 24 hours
- Output results: 6 hour (RSM), 24 hours (ROMS)
- Simulation period: 1986 – 2006, 22 years
- 2 years for warm-up periods (1984-1985)

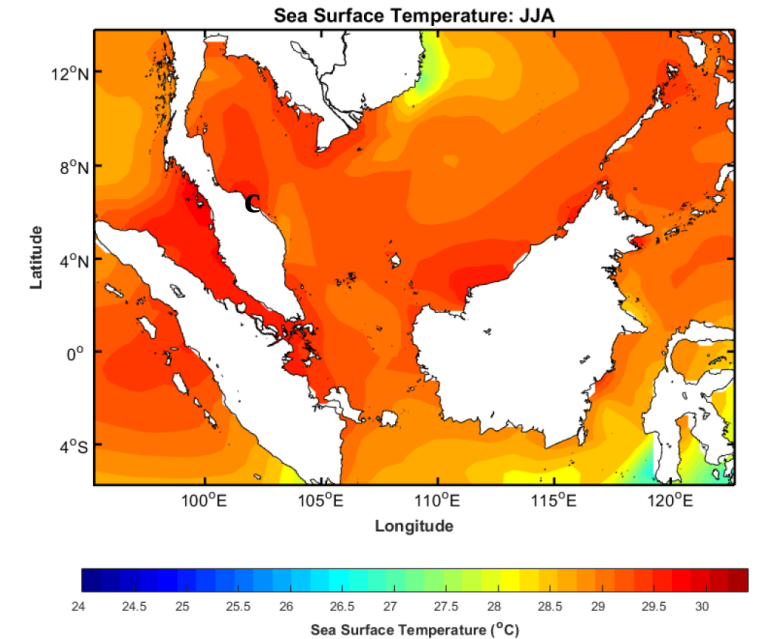
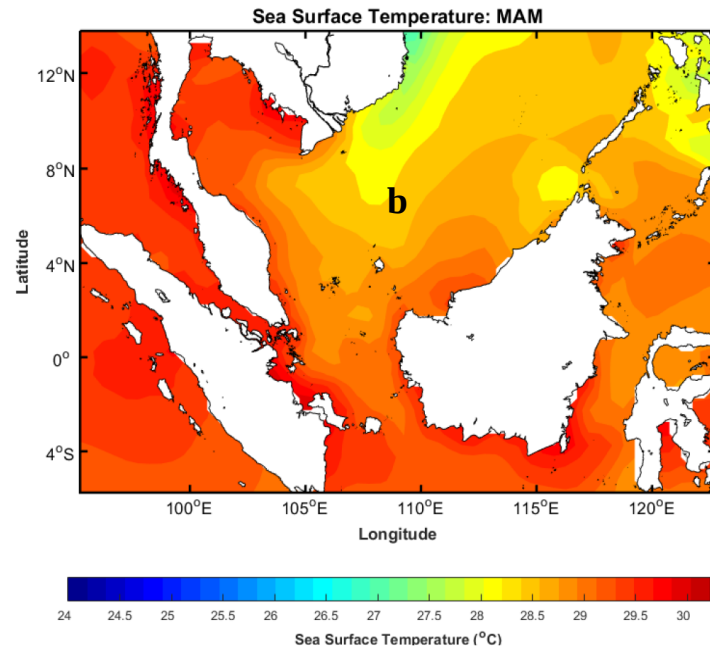
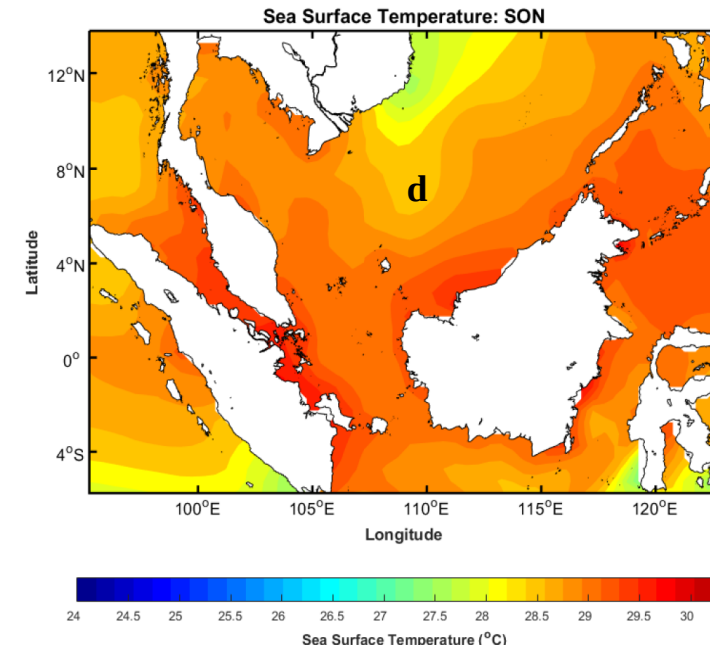
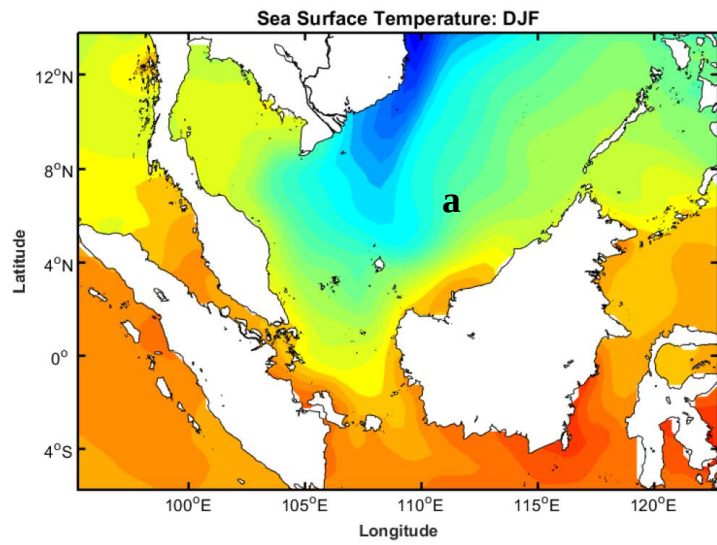
GRIMs Boundary Condition



Validation - Comparison between the
GRIMs-ROP simulations and the
observation (SODA)

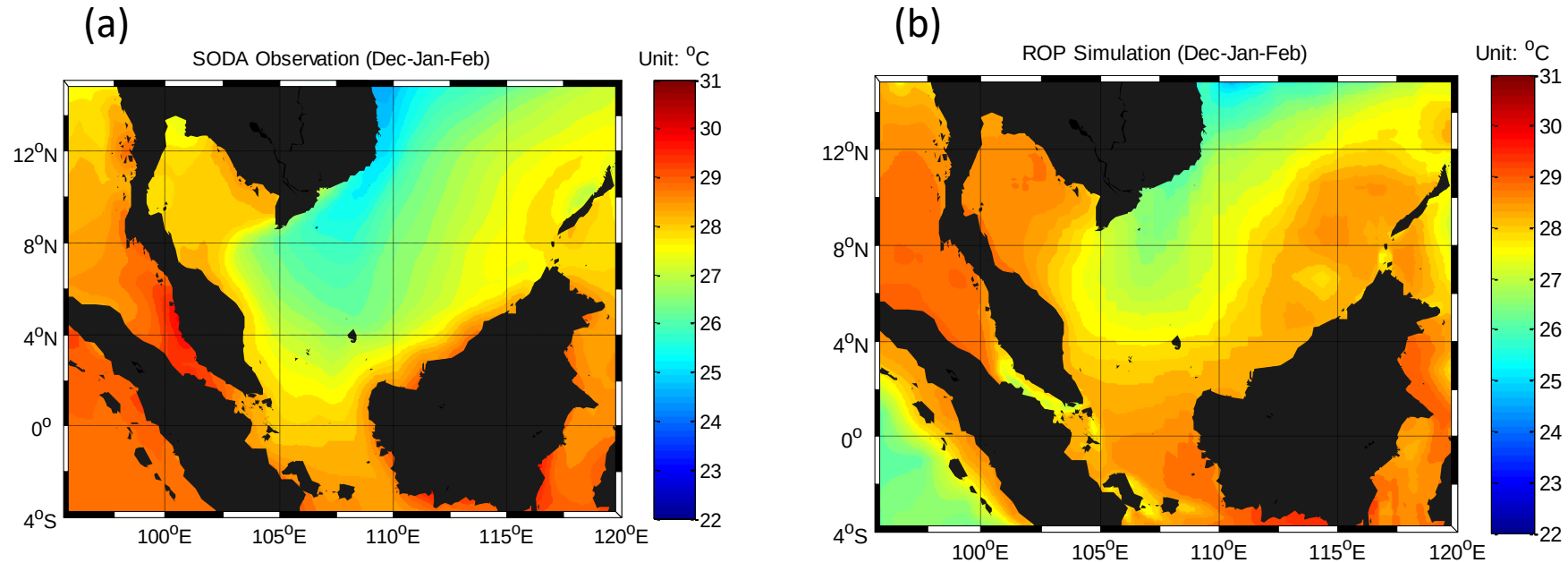


Climatology mean of annual SST in SCS. Units in degree Celsius



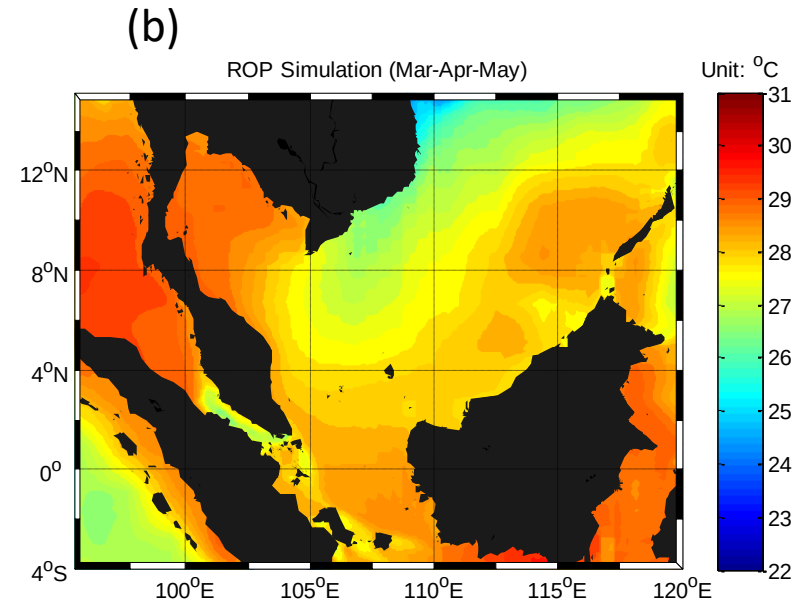
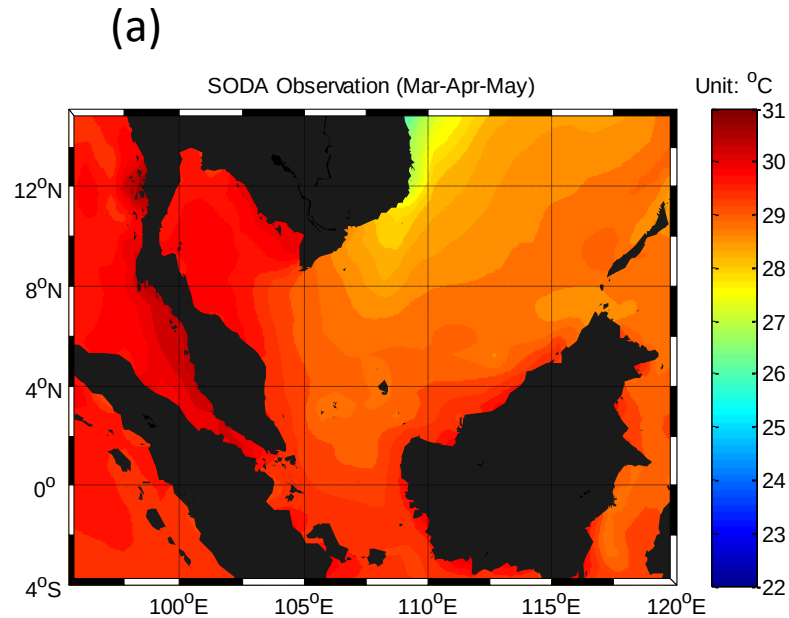
Climatology mean of SST in SCS during SON season. Units in degree Celsius

December-January-February



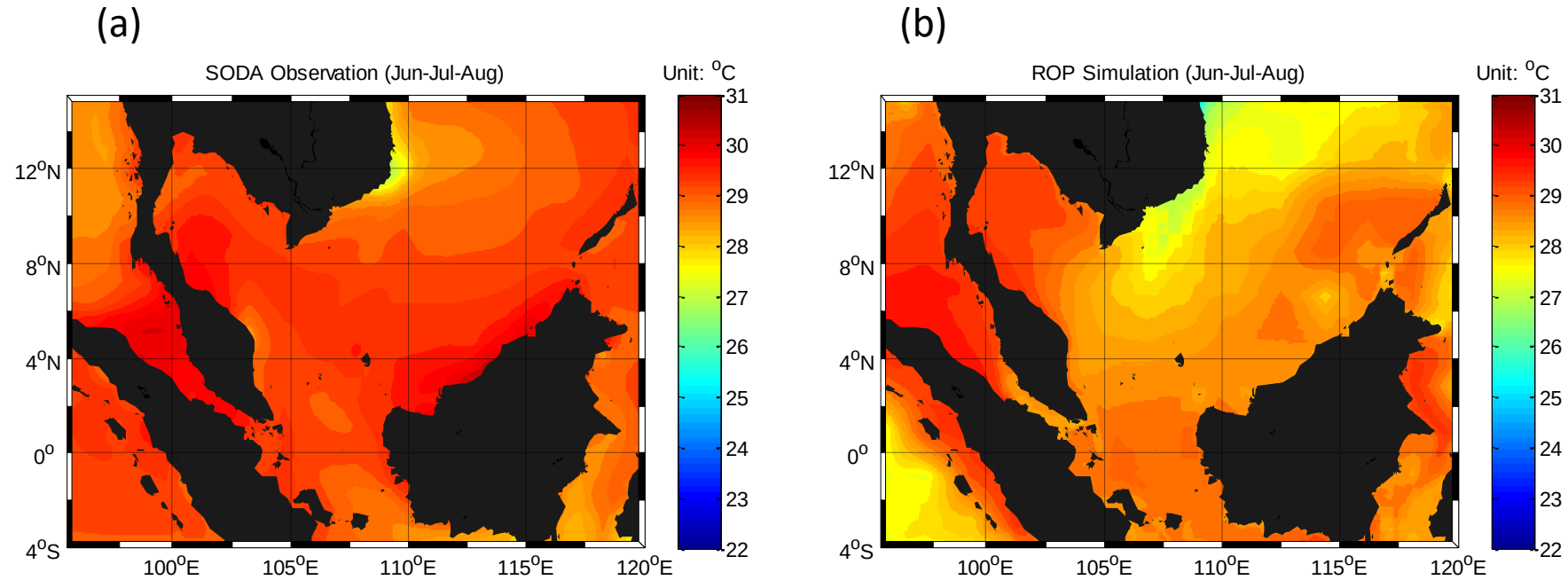
- Generally ROP capture the SST pattern.
- The South China Sea cold tongue doesn't extend far south compare to the observation.
- Warmer SST over the northern coast of Borneo.

March-April-May



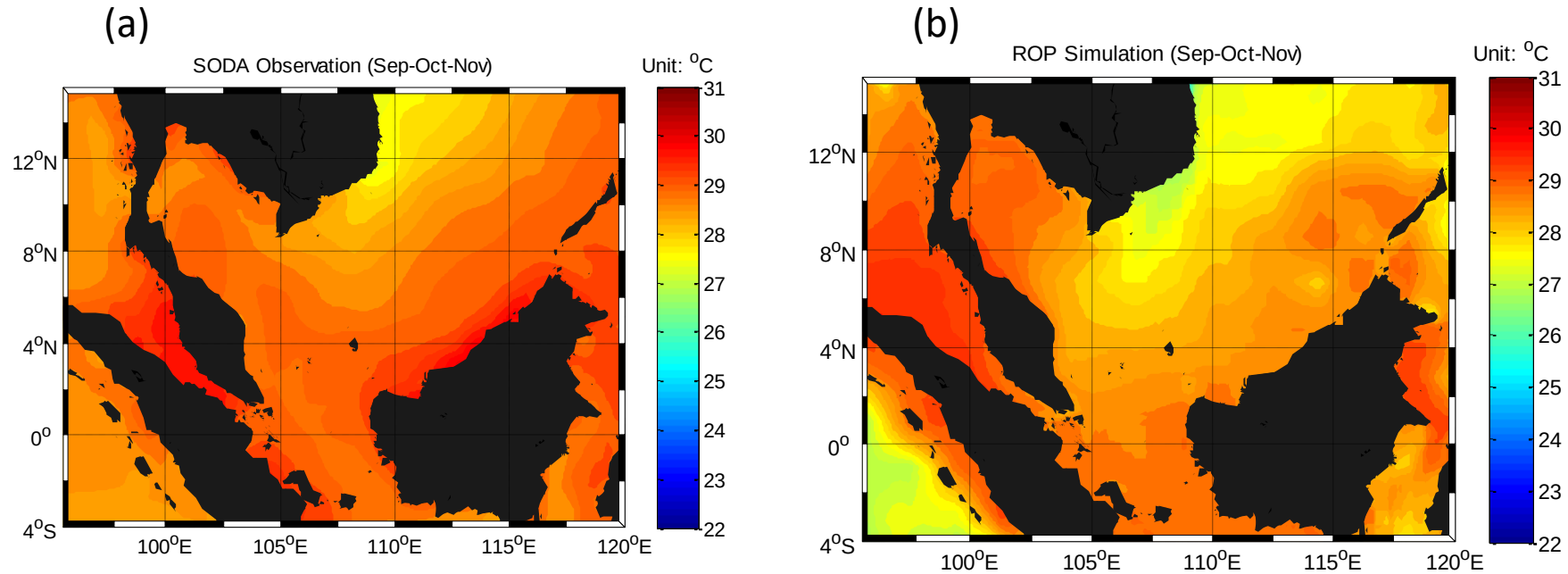
- In SODA, the SST warm up fast in spring.
- However, in the simulation the SST pattern during the winter months persisted.
- Resulting in a much colder SST.

June-July-August

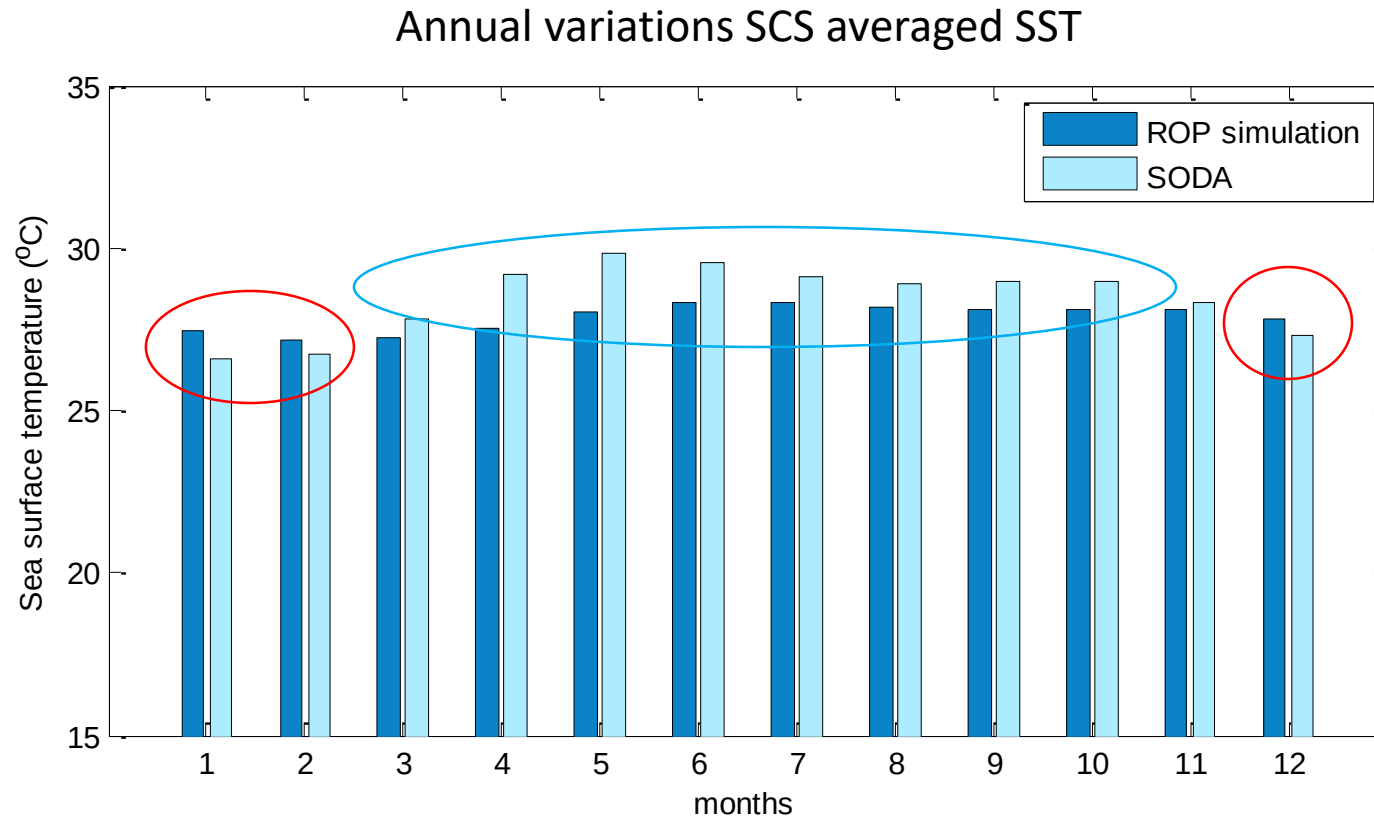


- The summer time SST over SCS is characterized by the upwelling system off Vietnam coast.
- In the simulation, the upwelling region extended further eastward.
- Colder SST.

September-October-November



- Generally consistent SST pattern.

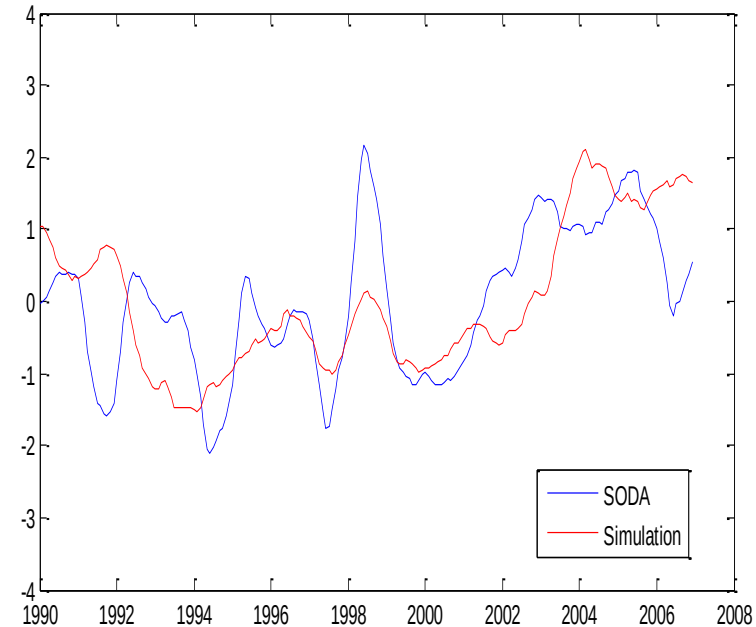
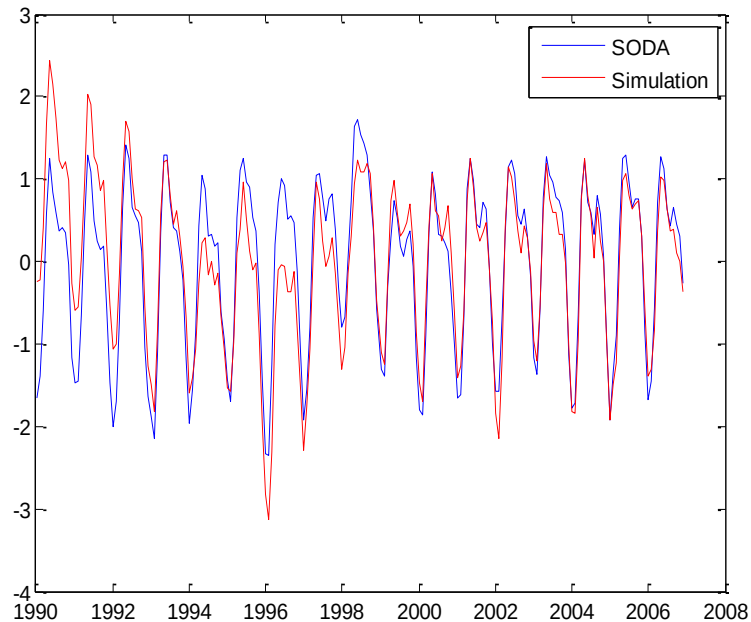


- Lower seasonal variability in the simulation.
- Potential weakness in air-coupling process in the model?
- Larger discrepancy in spring
- RMSE $\sim 1^{\circ}\text{C}$

Table of spatial correlation

Month	Spatial-Correlation
January	0.65
February	0.63
March	0.70
April	0.82
May	0.58
June	0.36
July	0.43
August	0.42
September	0.46
October	0.62
November	0.75
December	0.75

The pattern correlation using Canonical Correlation Analysis (CCA)



- 1st CCA mode correlation of the SST (without removing annual cycle) is 0.88.
- 1st CCA mode correlation of the SST anomaly is ~ 0.60 .
- The simulation weakly reproduce the interannual variability but well reproduce the long term changes over the SCS.
- **Potential issue** with the air-sea interaction in the coupling process

Concluding Remarks

- The GRIMs-ROP simulated the ocean reasonably.
- Miss-representation of the air-sea processes which lead to over cooling of the SST.
- The coupling problems due to the physics in the atmospheric component model (RSM).
- The complete ROP code has never been fully tested with GCC compilers by the developer.
- The GCC compiled code and the IFORT suggests a very different simulation result (not synchronized)

Suggestion/Solution

- Hardware upgrade to cope with the expensive computational demand.
- Intel Compilers suite.
- Run only the ocean model (ROMS) instead. Better control over the forcings input. The ROP is essentially a test-bed for model physics development.
- ROMS is a well documented ocean model with good community support.