SIMULATION SEA SURFACE TEMPERATURE OVER GULF OF THAILAND BY USING ROMS MODEL

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ABSTRACT: The Gulf of Thailand and neighbor area was studied using the Regional Oceanic Model System (ROMS). The horizontal resolution and vertical levels were 10 km × 10 km and 40 layers respectively. The domain situated between longitudes 95o E to 109o E and latitudes 0o N to 17o N. The initial and boundary conditions was used in this study that includes potential temperature, salinity, u-component of current, v-component of current and sea surface height relative to geoid from NCEP-CFSV2 data. The simulation dates were the end of month of May, June and July. Discussion from the literature review is found that the Sea Surface Temperature (SST) is a very important factor in the ocean and coupled atmosphere-ocean interaction. In this study used Generic Length Scale (GLS) vertical mixing method to simulate SST. The results from the model simulation are compared with spatial pattern with grids global observation data from the Optimum Interpolation Sea Surface Temperature (OISST) observation data. Overall the ROMS model can capture trend of SST pattern similarly OISST observation especially June 30 and July 31, 2018. In future work will simulate monthly mean SST from ROMS model and will compare with OISST monthly observation data in spatial pattern and statistical.

Keywords: The Gulf of Thailand, ROMS, GLS, and OISST

1. INTRODUCTION

The Gulf of Thailand is located in Southeast Asia immediately to the west of the South China Sea. The Gulf is a semi-enclosed sea that measures approximately 400 km by 800 km, covering an area of about 320,000 square kilometers. The Gulf of Thailand is the main factor agriculture, fishing, industrial, oil and etc. in Thailand. The location is between Latitude at 6oN to 14oN and Longitudes at 99oE to 105oE. It is surrounded by the Kingdom of Cambodia, Malaysia, the Kingdom of Thailand and the Socialist Republic of Vietnam. Over the Sunda Shelf, which is a submerged connection between Southeast Asia, Malaysia, Sumatra, Java and Borneo [1].

Since a study about SST over the Gulf of Thailand didn't receive a lot of attention studies emphasizing on oceanic model.

From [2] were used the coupled model to simulate rainfall over Thailand. The SST parameter was main to exchange between atmospheric and Oceanic in coupled model for simulating rainfall. But in this study was used ROMS ideal case simulation to simulate SST in oceanic model. So the rainfall simulation can be less accuracy SST than ROMS real time simulation. So, this study was simulated the ROMS real time over the Gulf of Thailand for checking performance of SST from ROMS model.

Because a good simulation and forecasting SST are main factor for improving the rainfall from coupled model over Thailand. Then a good rainfall simulation that can manage and decrease the risk from natural disasters.

In this study, to use the ROMS model simulating SST pattern over The Gulf of Thailand and neighbor area. The vertical mixing scheme was used in this research that was Generic Length Scale (GLS). The dates of simulation was on May 31, June 30, and July 31, 2018. The results were basic spatial pattern comparing with gridded data from NOAA OISST observation data.

2. METHODOLOGY

2.1 MODEL DESCRIPTION

2.1.1 The Regional Oceanic Model System (ROMS)

The Regional Oceanic Model System (ROMS) is a member of a general class of three-dimensional, free-surface, terrain-following numerical models that solve the Reynolds-averaged Navier-Stokes equations using the hydrostatic and Boussinesq assumptions. The governing equations in Cartesian coordinates can be written:

The momentum balance in the $x-$ and $y-$ directions are:

$$\frac{\partial u}{\partial t} + \vec{v} \cdot \nabla u - fv = -\frac{\partial \phi}{\partial x} - \frac{\partial}{\partial z}\left(\overline{u'w'} - v\frac{\partial u}{\partial z}\right) + F_u + D_u$$

(1)

$$\frac{\partial v}{\partial t} + \vec{v} \cdot \nabla v - fu = -\frac{\partial \phi}{\partial y} - \frac{\partial}{\partial z}\left(\overline{v'w'} - v\frac{\partial v}{\partial z}\right) + F_v + D_v$$

(2)

$$\frac{\partial \phi}{\partial z} = \frac{-\rho g}{\rho_0}$$ (3)

with the continuity equation:

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial w}{\partial z} = 0$$

(4)

and temperature and salinity given by:

$$\frac{\partial T}{\partial t} + \vec{v} \cdot \nabla T = -\frac{\partial}{\partial z}\left(\overline{T'w'} - v_\theta \frac{\partial T}{\partial z}\right) + F_T + D_T$$

(5)

$$\frac{\partial S}{\partial t} + \vec{v} \cdot \nabla S = -\frac{\partial}{\partial z}\left(\overline{S'w'} - v_\theta \frac{\partial S}{\partial z}\right) + F_S + D_S$$

(6)

An equation of state is also required

$$\rho = \rho(T, S, P)$$ (7)

The variables are shown in Table 1. An over bar represents a time average and a prime represents a fluctuation about the mean. These equations are closed by parameterizing the Reynolds stresses and turbulent tracer fluxes as:

$$\overline{u'w'} = -K_M \frac{\partial u}{\partial z}; \qquad \overline{v'w'} = -K_M \frac{\partial v}{\partial z};$$

$$\overline{T'w'} = -K_T \frac{\partial T}{\partial z}; \quad \overline{S'w'} = -K_S \frac{\partial S}{\partial z};$$

(8)

Equation (1) and (2) express the momentum balance in the $x-$ and $y-$ directions, respectively. In the Boussinesq approximation, density variations are neglected in the momentum equations except for their contribution to the buoyancy force in the vertical momentum equation (3). Under the hydrostatic approximation, it is further assumed that the vertical pressure gradient balances the buoyancy force. Equation (4) expresses the continuity equation for an incompressible fluid. The time evolution of temperature and salinity are governed by the advective-diffusive equation (5 and 6). For the moment, the effects of forcing and horizontal dissipation will be represented by the schematic terms F and D, respectively.

2.2 Vertical Mixing Parameterizations

2.2.1 Generic Length Scale

A generic two-equation turbulence closure scheme [3] which can be tuned to be have similarly

several of the traditional schemes, including that Generic Length Scale (GLS) vertical mixing scheme and was introduced to ROMS in [4]. The first of Warner et al. (2005)'s [4] equations is define $k = 0.5q^2$. Their dissipation is given by

$$\varepsilon = \left(c_\mu^0\right)^{3+p/n} k^{3/2+m/n} \psi^{-1/n}$$

where ψ is a generic parameter that is used to establish the turbulence length scale. The equation for ψ is:

$$\frac{D\psi}{Dt} = \frac{\partial}{\partial z}\left(K_\psi \frac{\partial \psi}{\partial z}\right) + \frac{\psi}{k}\left(c_1 P_s + c_3 P_b - c_2 \varepsilon F_{wall}\right)$$

Coefficients c_1 and c_2 are chosen to be consistent with observations of decaying homogeneous, isotropic turbulence. The parameter c_3 has differing values for stable $\left(c_3^+\right)$ and unstable $\left(c_3^-\right)$ stratification. Also

$$\psi = \left(c_\mu^0\right)^p k^m l^m, \ l = \left(c_\mu^0\right)^3 k^{3/2} \varepsilon - 1$$

Table 1. The variables used in the description of the ocean model

Variable	Description
D_u, D_v, D_T, D_S	Diffusive terms
F_u, F_v, F_T, F_S	Forcing terms
$f(x, y)$	Coriolis parameter
g	Acceleration of gravity
$h(x, y)$	Bottom depth
v, v_θ	Molecular viscosity and diffusivity
K_m, K_T, K_S	Vertical eddy viscosity and diffusivity
P	Total pressure $P \approx -\rho_0 g z$
$\phi(x, y, z, t)$	Dynamic pressure $\phi = \left(P / \rho_0\right)$
$\rho_0 + \rho(x, y, z, t)$	Total in situ density
$S(x, y, z, t)$	Salinity
t	Time
$T(x, y, z, t)$	Potential temperature
u, v, w	The (x, y, z) components of vector velocity $\vec{v}$
x, y	Horizontal coordinates
z	Vertical coordinate
$\zeta(x, y, t)$	The surface elevation

2.3 Initial condition, boundary condition and data observations

The initial condition and boundary condition

were used the National Centers for Environmental Prediction Climate Forecast System Version 2 (NCEP-CFSV2). The data is 6 hourly atmospheric, oceanic and land surface reanalysis products and forecast. In this study, five parameters was included potential temperature, salinity, U-component of current, V-component of current and sea surface height relative to geoid to use initial and boundary condition in ROMS model [5].

The observation data was used the OISST version 2 AVHRR SST. This data is cover global observation data and developed by National Oceanic and Atmospheric Administration (NOAA) from United State of America. This data is an analysis constructed by combining observations from different platforms (satellites, ships, buoys) on a regular global grid [6].

2.4 Domain description and Experiments design

The domain experiment is cover on the Gulf Thailand and neighbor area. The domain situated between longitudes 95° E to 109° E and latitudes 0° N to 17° N (Fig 1). The horizontal and vertical level in this study that were 10 km ×10 km and 40 layers respectively.
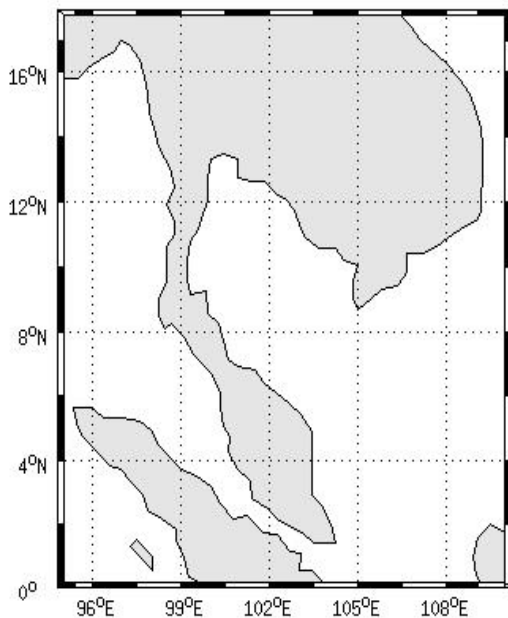

Fig. 1 The domain was used in this study.

In this study, the experiments design was included three cases simulation. The first of simulation was on May 31, 2018. The second of simulation was on June 30, 2018. The last simulation was on July 31, 2018. Table 2 was shown about summary of methodology part in this study.

Table 2. Summary method used in this study.

Parameters	Detail
Model	The Regional Oceanic Model System (ROMS)
Vertical Mixing Parameterizations	Generic Length Scale (GLS)
Initial and Boundary Condition	The National Centers for Environmental Prediction Climate Forecast System Version 2 (NCEP-CFSV2)
Observation Data	OISST version 2
Parameter from Initial and Boundary Condition	- Potential temperature - Salinity - U-component of Current - V-component of Current - Sea Surface Height relative to geoid
Domain	Longitudes 95° E to 109° E and Latitudes 0° N to 17° N
Horizontal Grids	10 km×10 km
Vertical Levels	40 layers
Date of Simulation	- May 31, 2018 - June 30, 2018 - July 31, 2018

3. RESULTS AND DISCUSSION

Fig 2 shows the Sea Surface Temperature from the NOAA OISST version 2 and ROMS on May 31, 2018.

The OISST observation data show the SST pattern (in the rage of 28.2 °C to 28.4 °C) almost over Andaman Ocean. But the SST pattern with high temperature (more than 29.4 °C) almost over nearly Malay Peninsula, eastern Indonesia Peninsula, Gulf of Thailand nearly Cambodia, Prachuap Khiri Khan province and lower southern Thailand, as shown in Fig 2(a).

The ROMS model show the SST pattern (in the rage of 28.2 °C to 28.4 °C) almost over Andaman Ocean similarly OISST observation data. But the SST pattern with high temperature (more than 29.4 °C) almost over nearly Malay Peninsula, western and eastern Indonesia Peninsula, Gulf of Thailand nearly Cambodia, eastern and lower southern Thailand, as shown in Fig 2(b).

Fig 3 shows the Sea Surface Temperature from the NOAA OISST version 2 and ROMS on June 30, 2018.

The OISST observation and ROMS model show similar the SST pattern (in the rage of 28.2 °C to 28.4 °C) almost over Andaman Ocean. In case temperature more than 29.4 °C OISST observation and ROMS model can capture SST pattern over Malay Peninsula and Indonesia Peninsula. Over eastern Malay Peninsula ROMS model and capture temperature over 28.8 °C similarly OISST observation.
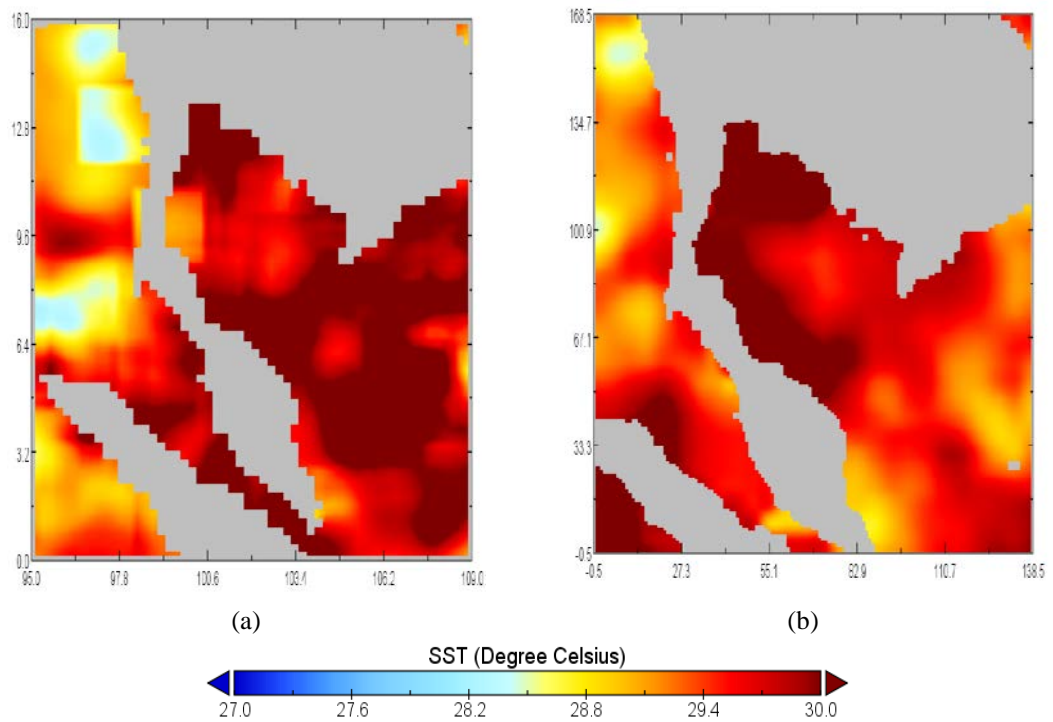
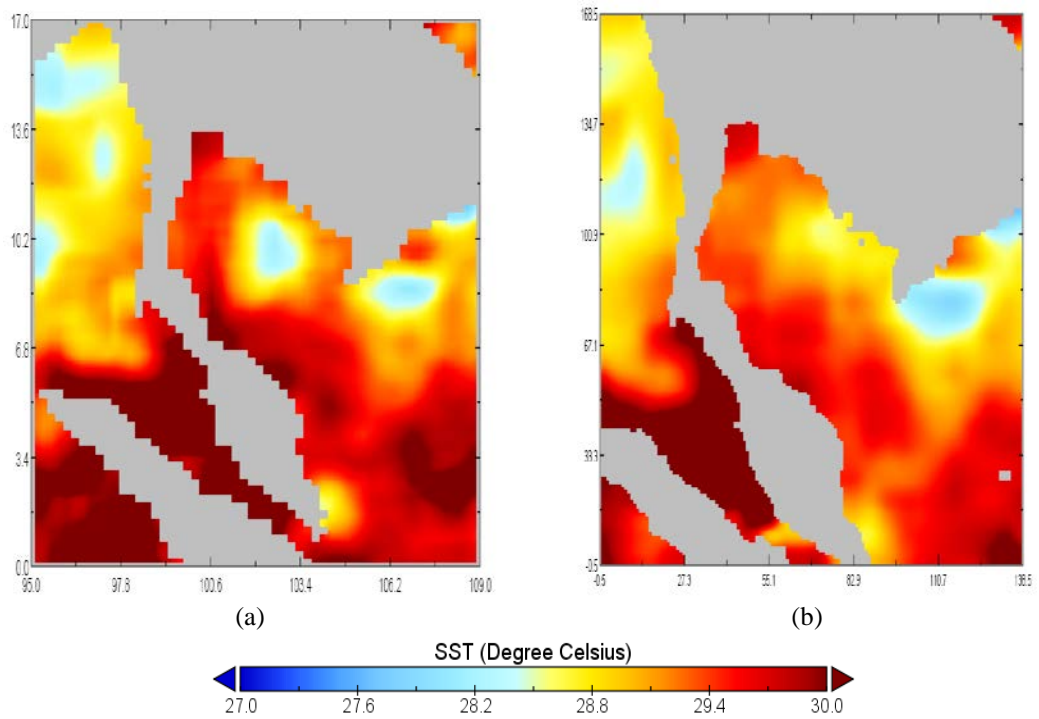Fig. 2 Spatial SST (Degree Celsius) pattern on May 31, 2017: a) OISST observation and b) ROMS model.

Fig. 3 Spatial SST (Degree Celsius) pattern on June 30, 2017: a) OISST observation and b) ROMS model.

Fig 4 shows the Sea Surface Temperature from the NOAA OISST version 2 and ROMS on July 31, 2018. The OISST observation and ROMS model show similar the SST pattern (in the rage of 28.2

ᵒC) almost over Andaman Ocean. In case temperature more than 29.4 oC OISST observation and ROMS model can capture SST pattern over Malay Peninsula and Indonesia Peninsula
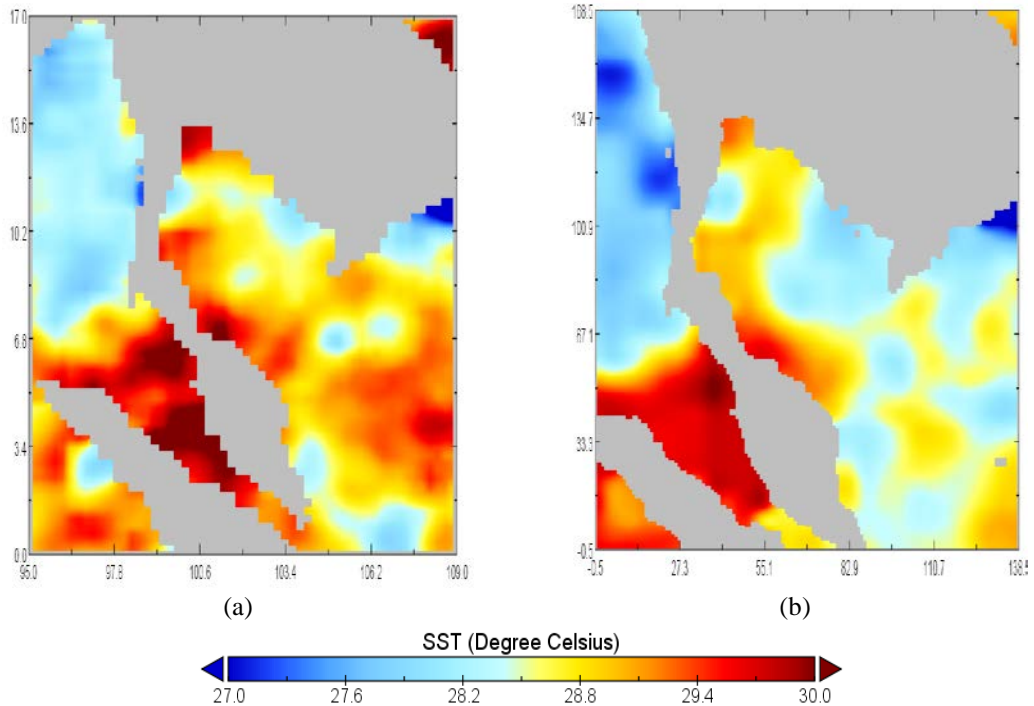

Fig. 4 Spatial SST (Degree Celsius) pattern on July 31, 2017: a) OISST observation and b) ROMS model.

4. CONCLUSIONS

In this study, to use the ROMS mode simulation performance SST on 3 cases that included May 31, June 30 and July 31, 2018 over the Gulf of Thailand and neighbor area. Overall the ROMS model can capture trend of SST pattern similarly OISST observation especially June 30 and July 31, 2018. In Future work will simulate monthly mean SST from ROMS model and will compare with OISST monthly observation data in spatial pattern and statistical.

5. ACKNOWLEDGEMENTS

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