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Comparison of High and Low Resolution Sea Surface Temperatures Satellite Data Assimilation Using Atmosphere-Ocean Model : A Multi-Model Approach

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Abstract. The interaction of the East Indian Ocean is closely related to weather conditions in the Indonesian maritime region. The distribution of latent heat and sensible heat content is one of the most important roles in the indication of precipitation response with the condition of sea surface temperatures rise causing the ocean weather disturbance and tropical cyclone growth. Initiation of sea surface temperature (SST) data with high and low resolution through polar satellites greatly affects the identification of the disturbance process.. This study examine the effect of assimilation of high resolution SST data that is derived from the Advanced Very High Resolution Radiometer (AVHRR) satellites and low resolution SST data that can be obtained from the Advanced Microwave Scanning Radiometer for EOS (AMSR-E) satellite. The wavelength of high and low resolution SST data are 11.50 – 12.50 µm and 7 – 10 µm, respectively. AVHRR and AMSR-E satellites in the Weather Research and Forecasting (WRF) model is use to identify the ocean weather disturbance responses. The WRF model is used as an initial and boundary condition for large-scale circulation model. The comparison of high and low resolution SST satellite data show that the identification of surface weather disturbance evolution occurring more dominant in convection process resulting high clouds and atmospheric boundary condition reinforcing bouyancy response. While at low resolution shows less representative results. The verification is done using Conductivity, Temperature, Depth (CTD) from the buoy of The Research Moored Array for African-Asian-Australian Monsoon Analysis and Predicition (RAMA) observation in the Southern Indian Ocean region, and observation data at several points during Indonesia Program Initiative on Maritime Observartion and Analysis (Ina-PRIMA) 2018 cruise. The analysis of identification for convection response event and precipitation of latent heat process need to use the ensemble approach to improve prediction results.

Keywords: WRF, FVCOM, SST satellite, heat flux

1. Introduction

Indonesia as a maritime country on the equator with two-thirds of the region is the sea has an important role in the process of climate change both locally and globally. Consequently, regional ocean dynamics and SST are important factors in regional climate (Qu et al. 2005). Sea surface temperature is one of the parameters that determine the waters quality, and directly affect the life of marine organisms as well. Temperature changes will affect the metabolism, reproduction, and distribution of fish in the sea (Nibakken, 1988). SST is an essential parameter in weather prediction and atmospheric-ocean model simulation so that the accurate SST information is needed as a comparison material for atmospheric conditions. Ocean - atmospheric interaction in Indonesia is very complex around the coast which is directly adjacent to the ocean. Small physical processes occur throughout the archipelago and play an important role in the nature of regional climate. Changes due to extreme variations are instantaneous, while the latent changes that occur in the global climate are being experienced by the earth. Due to natural and anthropogenic factors the weather and climate change slowly from certain normal stability towards new stability (Asep, 2015). Research on oceanographic phenomena both global and mesoscale requires observations of sea surface temperatures (SST) and ocean color imagery from satellites. Utilization of the use of oceanic and atmospheric numerical models is done to see the prediction conditions by assimilation method so as to provide a visible response to the precipitation parameters that will occur. AVHRR satellite imagery and high resolution AMSR2 satellite imagery can be used as input material for assimilation of atmospheric numerical models and ocean numerical models with S-coordinate depth models. This study aims to examine the comparison of the use of high and low resolution satellite images to the precipitation response in the Eastern Indian Ocean region during the InaPRIMA 2018 cruise.
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2. Data and method

The research location is focused on the buoy point area in the East Indian Ocean precisely in the west of Sumatra Island during the 2018 InaPRIMA cruise. There are 3 buoy points namely Buoy 1 (00000.63'S / 089051.20'E), Buoy 2 (03^{0}58.99 'N / 089^{0}29.46' E), Buoy 3 (12^{0}00.00'S / 110000.00 'E) and 5 in-situ observation points namely Station 1 (00 ° 49 '42.03 "N / 89 ° 27' 08,5937" E), Station 2 (03 ° 59 '45.07 "N / 89 ° 30' 26,13" E), Station 3 (02 ° 00 '16,1566 "N / 96 ° 09' 57,391" E), Station 4 (01 ° 52 '36,82219 "N / 96 ° 35' 56,27963" E), Station 5 (01 ° 46 '56,10915 "N / 96 ° 56' 28,46619" E). The high resolution AVHRR satellite data from the results of GHRSST imagery and low resolution satellite data from AMSR2 satellite imagery are assimilated into the atmospheric model, Weather Research Forecasting (WRF) with the 3DVAR assimilation method. AVHRR data is converted into BUFR data format and AMSR2 update data is converted into grib data to be included in the Weather Research Forecasting (WRF) model by using the parameter Yonsei University

(YSU) for the Planetary Boundary Layer (PBL) scheme, Kain Fritsch (KF) microphysics scheme, Dudhia for the Shortwave Radiation scheme, Rapid Radiative Transfer Model (RRTM) for longwave radiation. SST parameters from assimilation results with and low resolution satellite data are issued with the GrADS open source application. In addition the precipitation response parameters from the total precipitation results are used as a comparison material to determine the response of the ocean and atmosphere interaction. The results of the WRF model are extracted for the SST parameters as input for the Finite Volume Coastal Ocean Model (FVCOM) model for the surface part combined with Hybrid Ocean Model (HYCOM) data input for boundary in the sea (S - Coordinate). Then the FVCOM model results are compared with observation data with 3 points of buoy equipment in the western region of Sumatra and 5 in-Situ observation points during the InaPRIMA cruise. The verification uses the Pearson and RMSE correlation method.

3. Results and Discussion

3.1 Sea Surface Temperature AMSR2 Low Resolution and AVHRR High Resolution

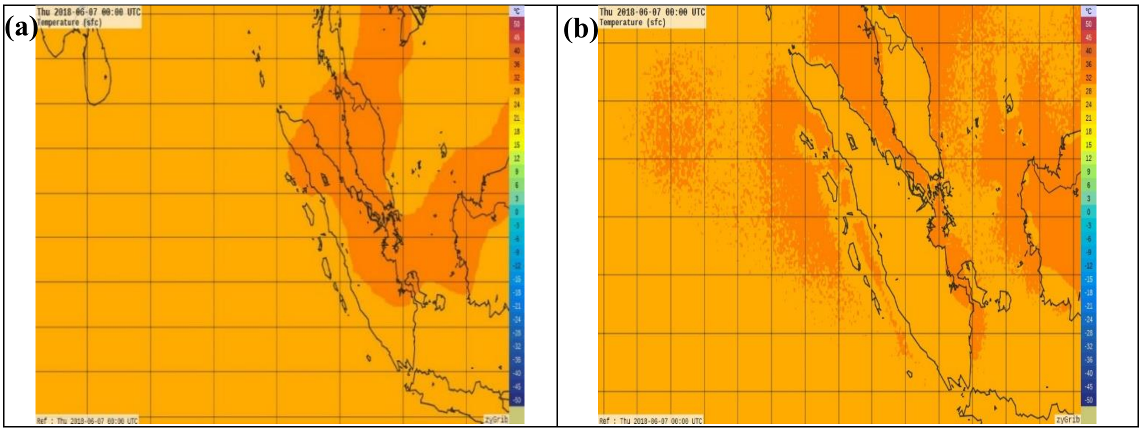
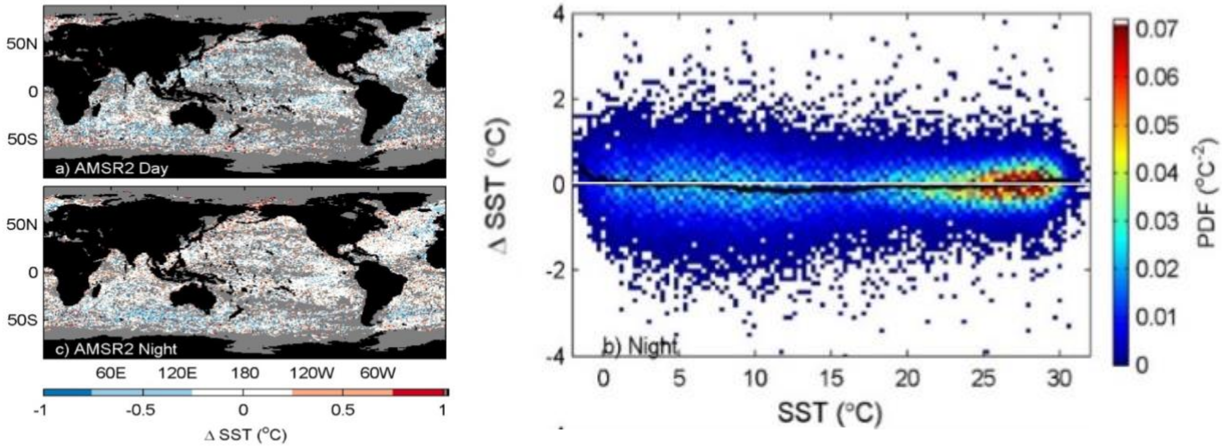


Figure 1. Sea Surface Temperature from Low Resolution AMSR2 0.5 and High Resolution AVHRR 0.083

AMSR2 satellite image data with low resolution of 0.5 degree grid size shows sea surface temperature contour which is more tenuous. This is because the AMSR2 satellite image only covers several regions with a time span of about 4 times in 1 day. Then for AVHRR satellite imagery with high grid resolution of 0.083 degrees has a more contour pattern caused by the resolution captured by the sensor ofAVHRR satellite is better. Both satellite image data with AMSR2 and AVHRR are used in 2-dimensional variations for the assimilation scheme (Thiebaux et al, 2003). Assimilation data provided by NCEP Marine Modeling and Analysis Branch are used as assimilation data for observational data, in-situ observation of the ocean with 36 hours of operation and assimilation of AMSR2 and AVHRR satellite data with grid output of 0.5 degrees and 0.083 degrees. AVHRR satellite image data from MODIS uses channels 11-12 μm` and is commonly used for estimating SST climatological conditions. The satellite imagery product has been compared with buoy data and produces an error of 0.5 degrees Celsius (Minnett et al. 2007) and RMS error of 0.7 degrees Celsius (Haines et al. 2007).



(a) (b)

Figure 2. Bias for Sea Surface Temperature on (a) Night Scanning and (b) Bias Scanning combine PDF

Bias in SST is flat with respect to SST, except for warm bias in coldest SSTs. Uncertainty increases for SST below 15 deg Celcius. The seasonal biases are not evident on these plots because the biases come from the combination of cool SST. PDF control shows the value in AMSR2 satellite image responds faster at night while for positive anomaly more dominant than 2-4 degrees Celsius during the day.

3.3 Comparison and Experiment using WRF-3DVAR Asssimilation Model

The WRF model is used as a tool for calculating SST Low Resolution and High Resolution comparison outputs by using the combination of parameters in WRF version 3.8 with Noah Land, Yonsei University for PBL schemes, WSM-6 for microphysics, Dudhia shortwave radiation and Rapid Radiative Transfer Model (RRTM). The resolution of domain is 3 km with 17 vertical levels. The lowest sigma every 0.01 between 1.00 and 0.90 is good for calculating flux (Hong et al. 2006). Both AMSR2 and AVHRR satellite image data with 0.5 degree spatial resolution and 0.083 degrees used as input for the SST update model in the WRF model.

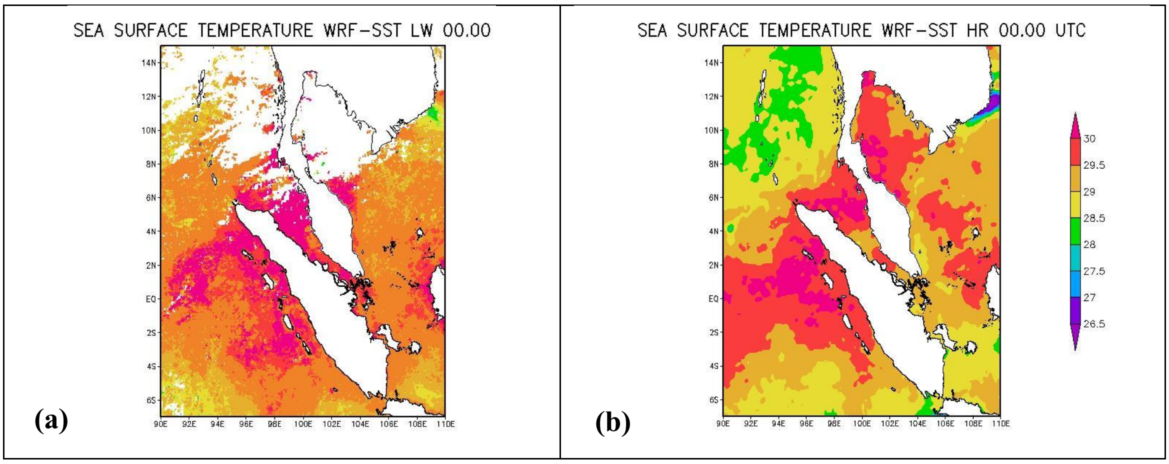
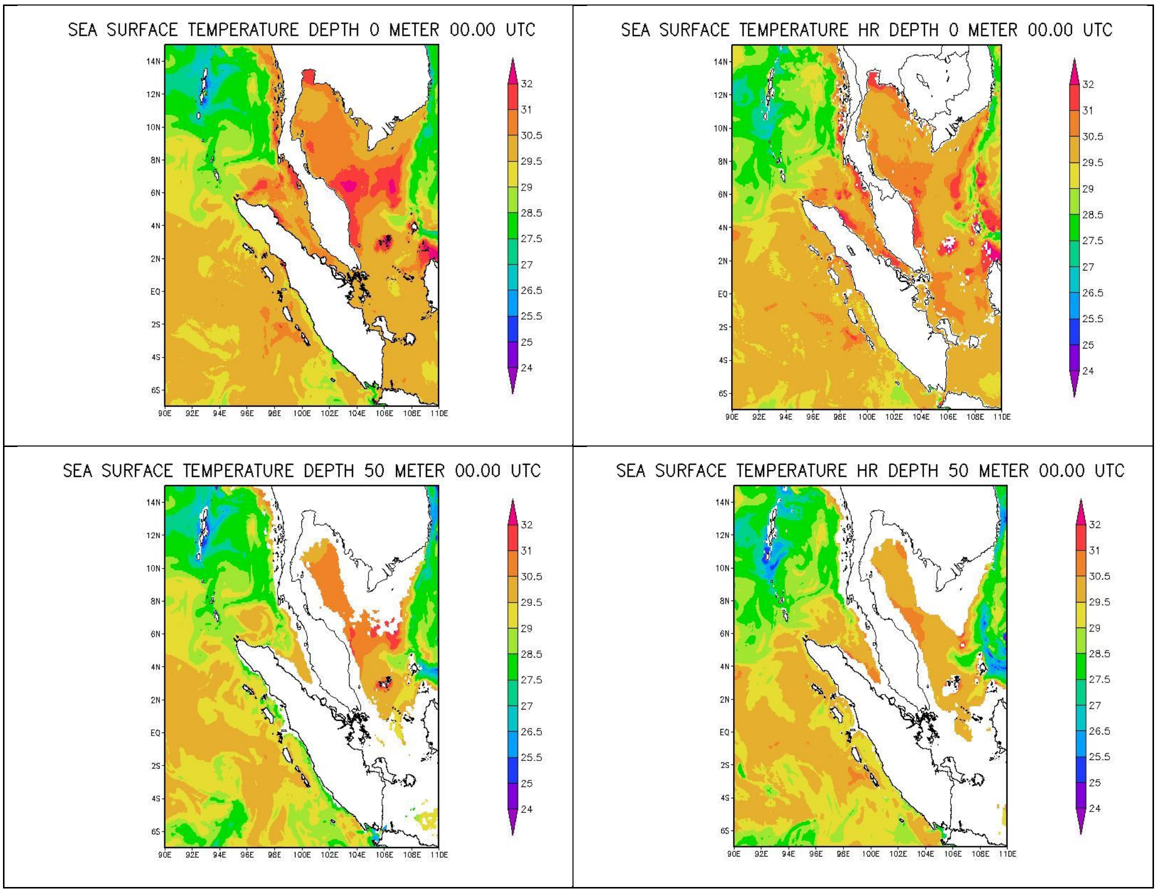


Figure 3. Sea Surface Temperature estimation using WRF-SST as SST forcing using SST update (a) Low Resolution AMSR2 (b) High Resolution AVHRR/GHRSST

High Resolution satellite image pattern from Advanced Very High Resolution Radiometer (AVHRR) channel 11.50 - 12.50 as the input for SST update data in the Weather Research and Forecasting (WRF) model. The dominant contour is in the range of 29.5-30 degrees Celsius in the west of Sumatra. The output of the WRF model with Low Resolution satellite imagery only responds to SST with a range of 28.5 - 29.0 in Celsius in the region. This shows that High Resolution SST responds faster in atmospheric numerical models than Low Resolution SST.

3.4 Comparison of WRF SST + FVCOM + HYCOM Model for Subsurface Temperature Depth

The use of a depth-based ocean model with S Coordinate contours is carried out as an identification material for sigma theta content and temperature contours that respond above sea level. In this case, using the FVCOM model with S Coordinates and HYCOM as boundary models with Hybrid Coordinate levels as identification of the oceanic subsurface. With the input of WRF-SST surface data running in the previous Low Resolution and High Resolution data input.



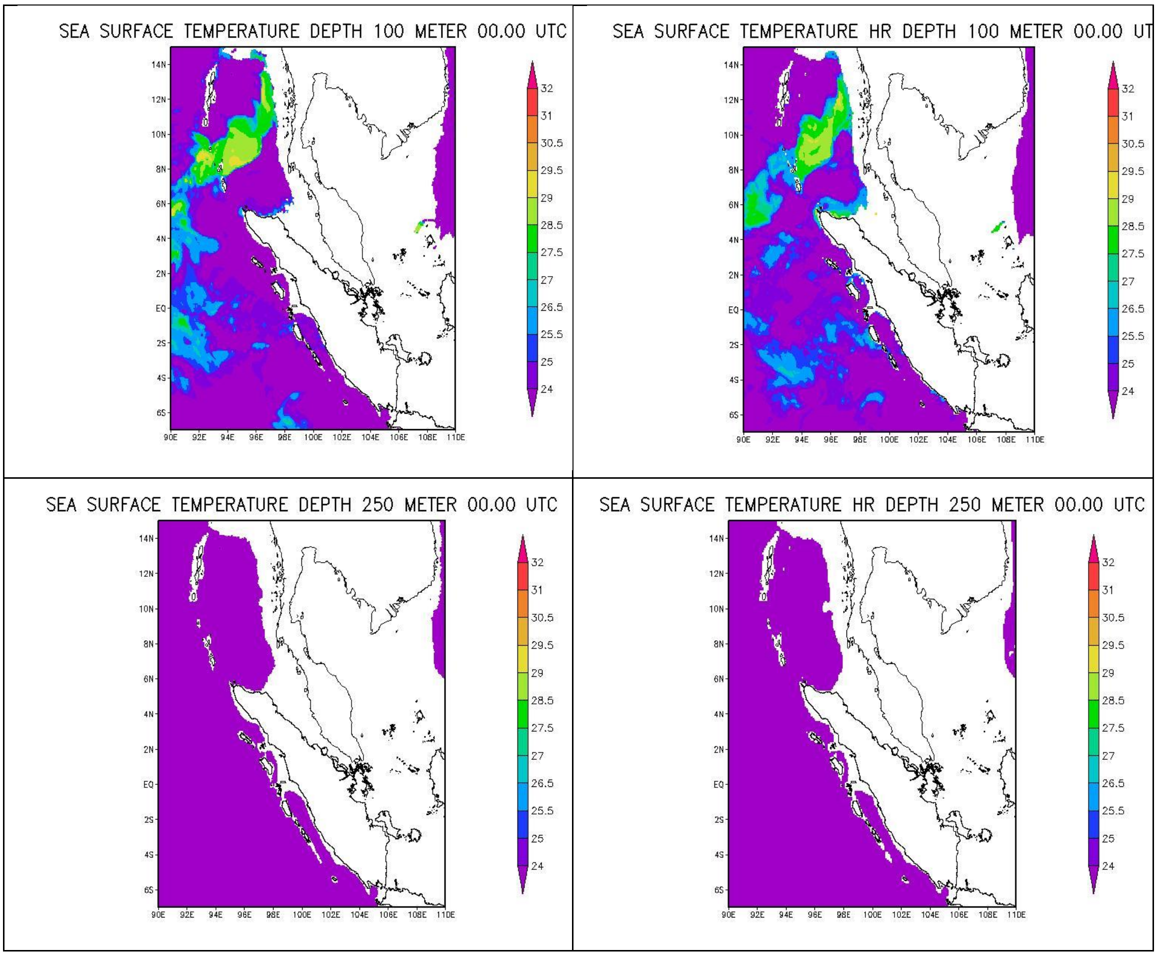


Figure 4. Sea Surface Temperature estimation using WRF-SST as SST forcing into FVCOM+HYCOM Model (S-coordinate) (left side) Low Resolution AMSR2 (right side) High Resolution AVHRR from WRF SST as forcing and using parameterization

WRF SST model output with Low Resolution satellite imagery in the Finite Volume Coastal Ocean Model (FVCOM) models shows the S coordinate system patterns displayed on 0 meters less responding and approaching the pattern results from actual satellite image observations. And the results of the High Resolution model from AVHRR satellite imagery are almost closer to the pattern of WRF SST results and observations of actual satellite imagery observations. Both patterns of the WRF-SST + FVCOM + HYCOM model output are caused by differences in the results issued by WRF-SST as SST forcing in the surface FVCOM model. The results of AVHRR have better grid precision and Low Resolution is less representative on the grid size in the WRF nesting domain for 3 km. It can be seen from the contour of a temperature of 100 meters in the northern region of Indonesia still looks warm with a range of 28.5 - 29.5 degrees Celsius and the area is considered as a Low Pressure area during the InaPRIMA 2018 expedition. Warm SST patterns and precipitation were formed around the area.

3.1. Verification using In-Situ and Surface data

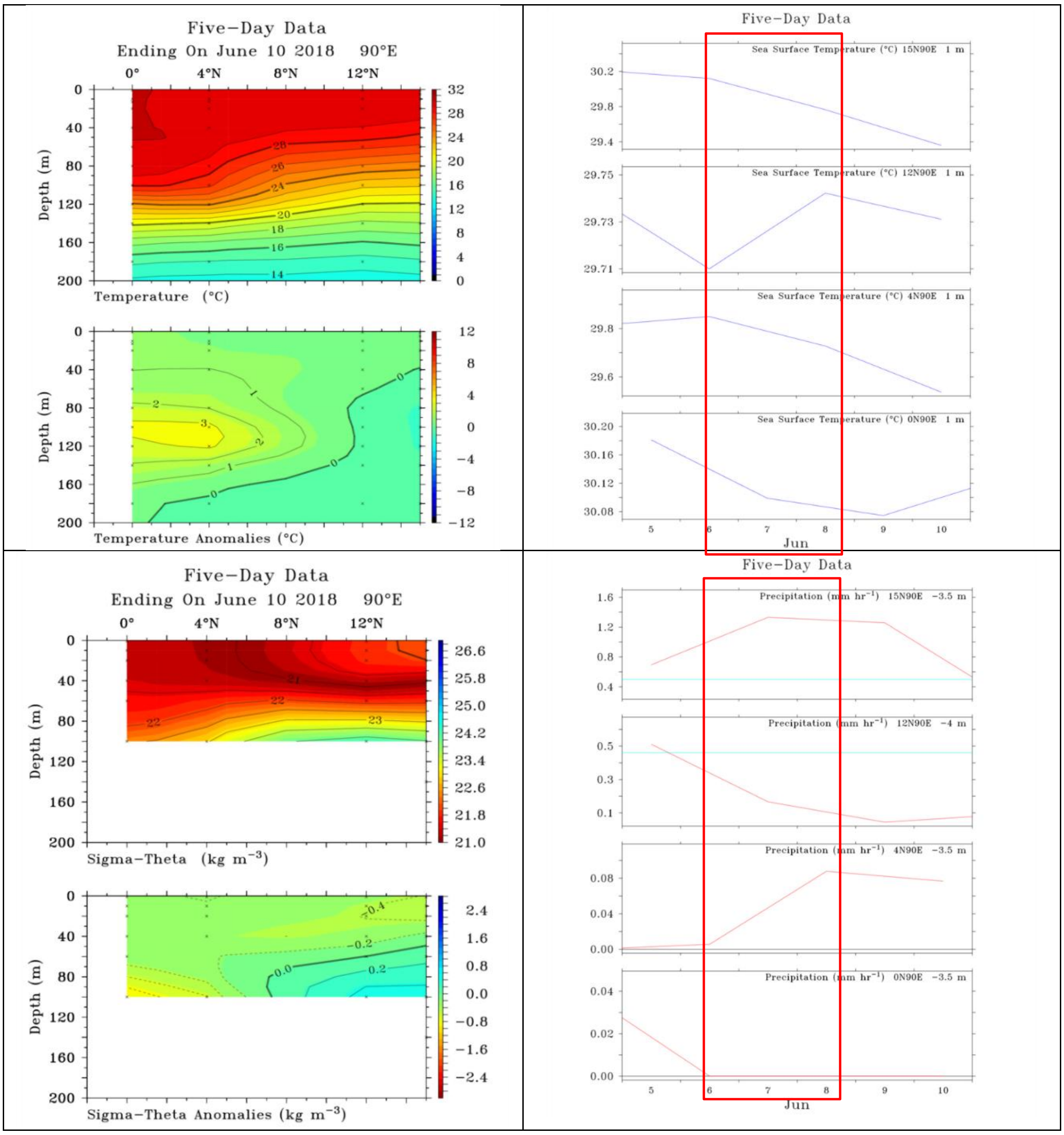


Figure 5. Insitu observation for subsurface on 0N90E, 4N90E, 12N90E, 15N90E

Figure 5 shows the pattern of depth temperature of the CTD buoy data has a range of values on the surface between 28 - 32 degrees Celsius. This pattern is almost the same as the FVCOM-HYCOM model output. Where the range of values at the three points ranges from 29.5 - 30.5 degrees Celsius. The temperature anomaly on the buoy data is positive 1 - 3 at a depth of 0 - 80 meters and the temperature is warmer than the normal average for 5 days. The precipitation pattern measured at the buoy sensor shows an increase on June 7 towards June 8 at 15N90E coordinates and the average precipitation is 0.5 mm.

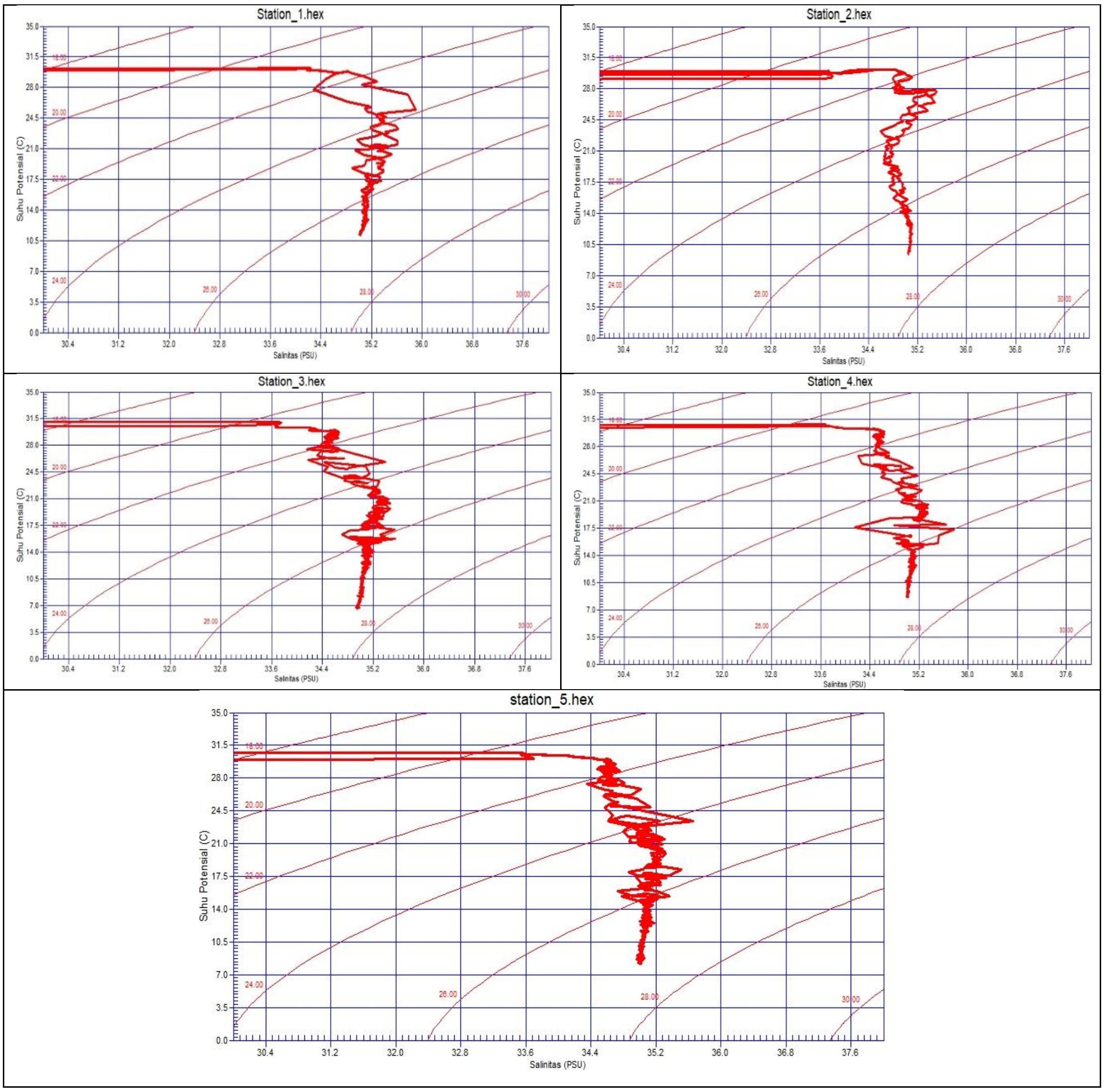


Figure 6. Insitu observation using CTD during InaPRIMA 2018 cruise

4. Conclusion

Based on the results of the model from Weather Research Forecasting (WRF) with Low Resolution input shows that the output model does not respond to the precipitation in the Bay of Bengal. This is because the grid system used in the Low Resolution SST is greater than in the nesting system in the WRF model. There are several scanned sectors that are not covered, causing the interpolation area of the model to be a blank area. Whereas the output of High Resolution SST is quite good for the precipitation response as well as the SST parameters. The similarity of contours is seen in the High Resolution AVHRR satellite image with the results of the WRF model. Bias on AMSR2 satellite imagery for SST is more likely to have no effect on the response of the WRF-SST model output but rather respond to indications of precipitation. In addition, the subsurface output on the FVCOM + HYCOM model with the initial SST forcing input surface from WRF-SST shows that the pattern at Low Resolution does not respond to the conditions of observation and output of the High Resolution satellite image at the ocean depth model responds to the actual SST buoy observation conditions.

5. Reference

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