Kementerian PPN/ Bappenas

EXECUTIVE SUMMARY

Sea Climate Reconstruction and Projection

Review of National Action Plan for Climate Change Adaptation (RAN-API) 2018

Background

Increased atmospheric and ocean temperatures cause depletion, reduced ice and snow layers, increase sea level as a consequence of increasing greenhouse gases. Observations show that many of the changes that have occurred since the 1950s, have been unprecedented changes for decades to thousands of years. The impacts and consequences of changes in the climate system directly affect sea level rise, especially in coastal areas which are also influenced by various factors that interact with each other, such as tide, subsidence and extreme waves. Adaptation plan is an urgent need due to the increased risk of climate change. Adapting to changes that may occur in the future will require action plans to develop coastal areas as early and as quickly as possible (eg coastal planning and hazard mitigation) based on scientific studies. Therefore, the research publication result on hazards, vulnerabilities and risks of climate change through geodata portals is very important when policy decisions must be based on scientific information and studies.

Rising sea levels due to global warming will bring inevitable consequences. Seasonal ocean current may be affected by changes in sea level rise levels, for example due to higher sea level rise in the Pacific Ocean than in the Indian Ocean. Thus, the rapid sea level rise does not only affect current patterns, but also increase erosion, shoreline changes, and reduction of wetlands in coastal areas. If the increase in sea level rise exceeds the maximum adaptive capacity of coastal ecosystems, wetland ecosystems in coastal areas may experience significant damage. In addition, sea level rise also increases the level of sea water intrusion into the coastal environment.

The increase in greenhouse gases due to anthropogenic processes since the era of industrialization has not only caused a rise in global temperatures, but may also produce dynamic increases on sea level. The increase of sea level is potentially the most serious impacts of global warming and climate change. Furthermore, the projected increase in sea level has moderate to high uncertainty, due to the dynamics of changes in ice sheets and glaciers as well as changes in absorption of heat by sea level that have not been well understood (Vermeer and Rahmstorf, 2009).

Methods and Models

Marine climatology and its changes in the next few decades on sea level currents, the height of sea and its changes by using simulation results. Sea level data consists of sea level, salinity flow and temperature based on the InaROMS model, while wave height and wave direction are based on the results of WAVEWATCH III model.

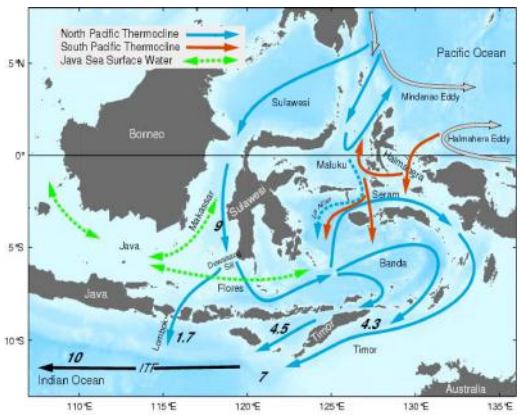
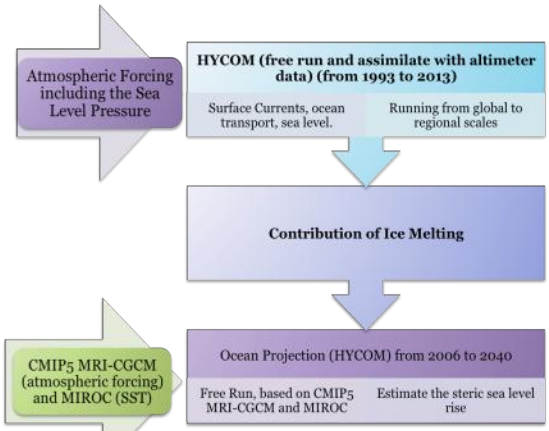
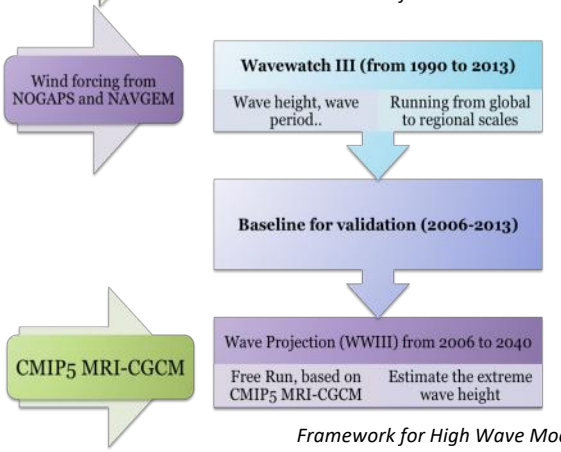


Image of surface current and the depth of thermocline layer in Indonesian waters (Gordon, 2006)

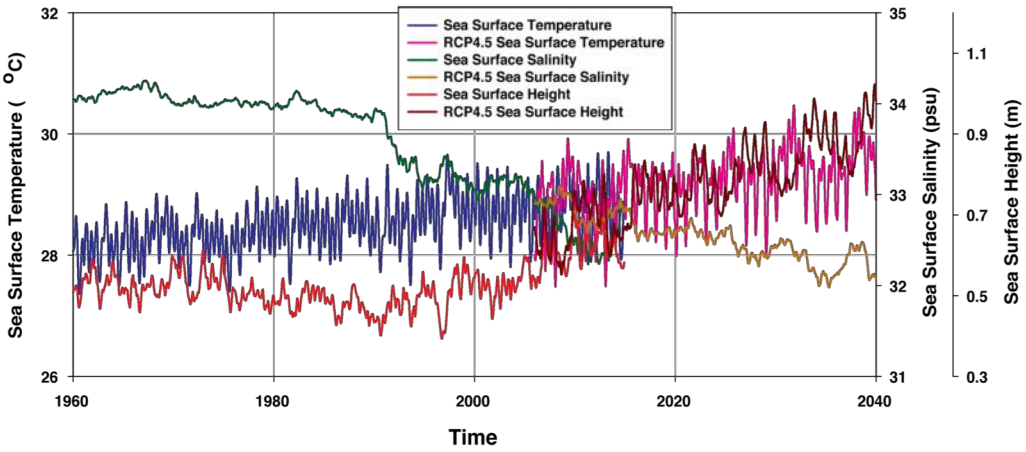


Framework for Sea Advancement Models



Framework for High Wave Model

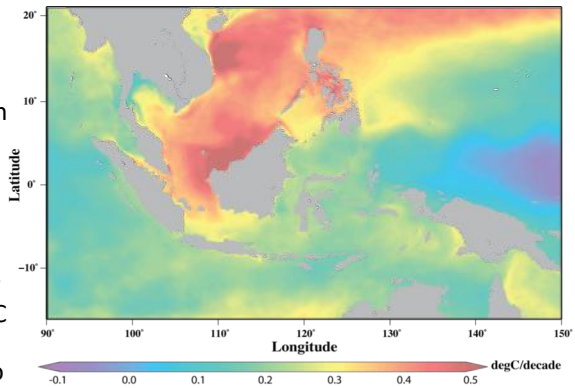
Sea Climate Projection



Simulation results from 1961 to 2015 and extension of RCP4.5 from 2006 to 2040 from regional sea level averages, sea surface temperatures and salinity from 90°E to 150°E and from 15°S to 15°N are presented in Figure above. The trend of RCP4.5 simulation results is relative to the trend from 1990 to 2015. Based on these simulations and projections, sea level in 2040 will experience a 50cm increase since 2000. Sea surface temperatures will rise by 1°C and 2°C compared to sea surface temperature in 2000 and 1961. Meanwhile, surface salinity continued to decline from 33.2psu in 2000 to 32.1psu in 2040. Furthermore, due to the increase in sea surface temperature and a decrease in salinity, it can be ascertained that the acidification process will continue with the same process speed as the events of the past few decades. Sea response to inter-annual climate variability is also evident through sea level characteristics and sea surface temperature characteristics. This model tends to be said as successful in ENSO simulations. However, this ENSO event is projected to occur every 7 years on a regular basis. Therefore, strong El Nino and La Niña are likely to occur every 6-7 years.

Sea Surface Temperature (SST) Projection

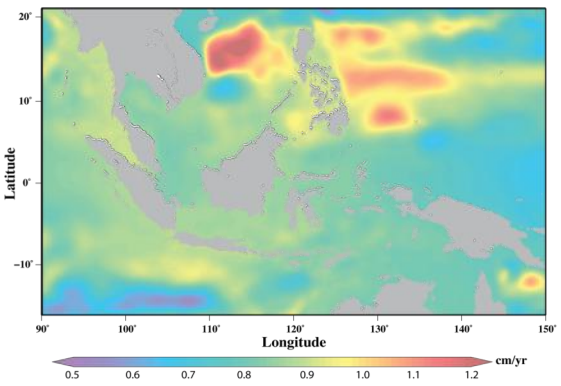
The spatial distribution of the rate of increase in SST from the ROMS model from 2006 to 2040 is presented in the Figure on the side (RCP 4.5 scenario). The model results show that SST changes rapidly with the average regional SST rising by more than 0.25°C / decade. The projection results are relatively compatible with the results of observations using satellite and reconstructed data. The highest rate of increase in SST is likely to occur in South China Sea and Karimata Strait which reach 0.5°C / decade. The increase in SST in Java Sea, Banda Sea, Sulawesi Sea and the surrounding sea ranges from 0.2 to 0.3°C / decade. Meanwhile, the increase of SST in the Pacific, the northern part of Papua may be the lowest compared to the increase in other regions.



Projection of sea level temperature rise based on RCP4.5 scenario

Sea level projection

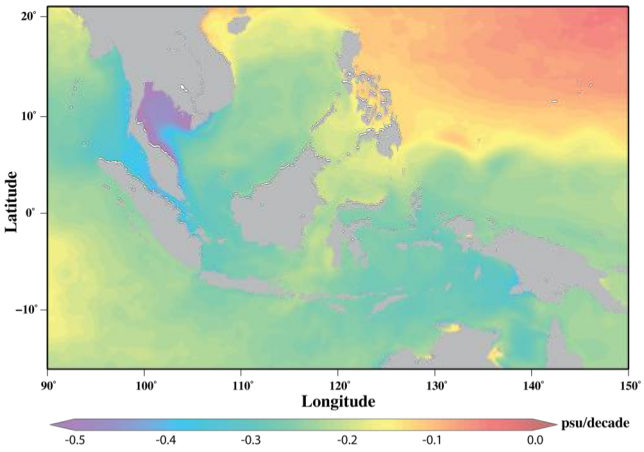
The spatial distribution of sea level rise in Indonesian waters from 2006 to 2040 is presented in the Figure below (RCP scenario 4.5). The projection results show that the level of sea level rise is relatively homogeneous. In general, sea level rise varies from 0.6cm / year to more than 1.2cm / year. The highest sea level rise is projected to occur in South China Sea at 1.2cm / year, where in other regions the value varies from 0.7cm / year to 1.0cm / year. The increase in sea level caused by melting ice and increasing volume of sea water due to rising temperatures, which can be called absolute sea level rise is not proportional to changes in land elevation due to land subsidence.



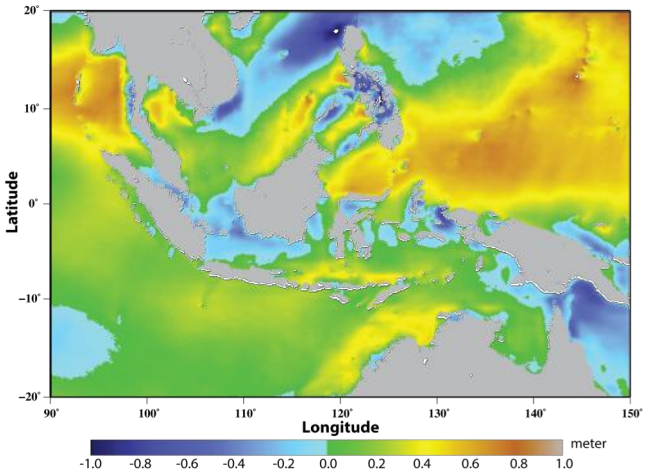
Projection of sea level Based on RCP4.5 Scenario

Surface Salinity Projection

The projection of changes in sea surface salinity (SSS) is relatively in accordance with the simulation results from 1991 to 2015. Although the projection of SSS changes is not as high as the simulation results from 1991 to 2015, the difference in projection and simulation results may be due to lower rainfall projections than historical data in northern Australia, south of the Java Sea, west and east of Sumatra, Tomini Bay, and the Malacca Strait. Surface salinity tends to decrease at a rate of -0.3 ± 0.2psu / decade. The highest decrease in salinity occurred in the Gulf of Thailand, where in other locations showed a SSS decrease from moderate to high and lower compared to historical simulation data, as illustrated in the Figure on the side.



Projection of Salinats Surface Based on RCP4.5 Scenario

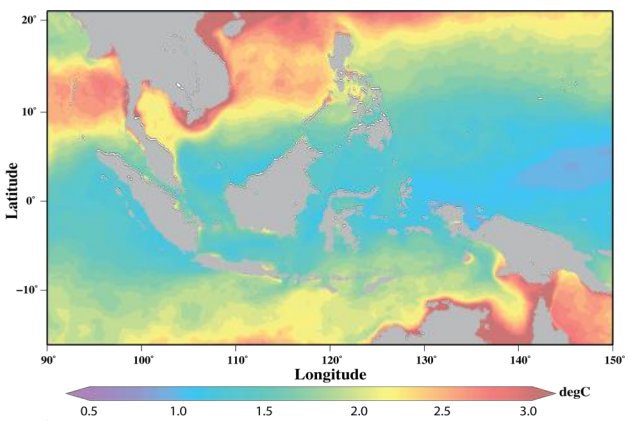


Projection of 99 percentile wave height until 2040

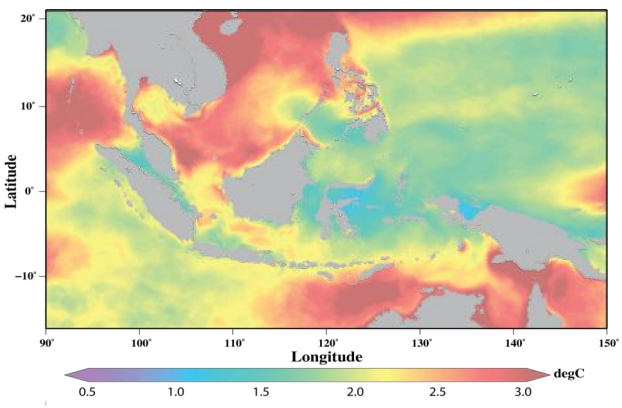
Projections of Significant Wave Height

Projected changes in significant wave height from 2006 to 2040 based on 99 percentile of data presented in Figure on the side. In the La Niña phase, generally, the trade winds from the Pacific Ocean strengthen, which increases the wave height. It is clear that the effects of climate variability such as La Niña can be distinguished by increasing wave heights in 50 to 99 percentiles of data. However, the wave height also strengthens in Indian Ocean, southern Java and western Sumatra. This might also indicate that Indian Ocean Dipole (IOD) plays a more significant role compared to the last few decades. Wave height on the east coast of Sumatra and most of the Java Sea is getting lower. However, wave heights in Banda Sea, Sulawesi Sea, South Java, western Sumatra and the southern part of the South China Sea is getting stronger.

Projections of Extreme Sea Surface Temperature events



Extreme sea surface temperature 1991-2015



Extreme sea surface temperature projection 2006-2040 RCP4.5

The picture above shows changes in sea surface temperature (SST) during extreme events. SST changes vary from 1°C to more than 3°C. The highest changes are expected to occur in the South China Sea, north of Kalimantan and south of Nusa Tenggara which reaches more than 3°C. Meanwhile, extreme increases in SST in the Java Sea, south of Java and west of Sumatra, Banda and Sulawesi Sea varied from 2°C to 2.5°C. The lowest changes occurred in Tomini Bay and Makassar Strait. Assuming that coral reefs are able to adapt but are vulnerable to sudden changes in sea surface temperature (La Niña) more than 1.5°C, it is estimated that all coral reefs and ecosystems in Indonesian waters will experience bleaching.

Conclusion

Sea surface temperatures (SST) and sea levels gradually increase with an average increase of 0.15°C / decade and 3mm / year, from 1961 to 2015. However, even though sea surface temperatures have increased, sea levels have shown a negative trend, from 1980 to 1994. Climate variability such as El Niño plays a significant role in the characteristics of sea level. The high frequency of El Niño during 1980 to 1994 decrease sea level in Indonesian waters. Therefore, the lowest sea level occurred in 1993 and during El Niño in 1997/1998, since 1961. Since 1990 sea level height characteristics have followed changes in surface temperature. In general, SST are projected to rise 0.25°C / decade. The highest rate of increase is likely to occur in the South China Sea and the Karimata Strait which reaches 0.5°C / decade. The level of increase in SST in the Java Sea, Banda Sea, Sulawesi Sea and the surrounding sea ranges from 0.2 to 0.3°C / decade. If the 0.2°C / decade or more increase continues, it will increase the risk of coral bleaching in all coral reef locations. Meanwhile results from the projection of SST and its anomalies indicate that there is an increase in extreme SST compared to historical data. This resulted in the acceleration of the process of bleaching and damage to coral reefs. Existing coral reefs will experience greater pressure due to sudden changes in sea surface temperature, and at the end of the day all coral reefs and their ecosystems will experience greater damage than the events of the past few decades.

On the other hand, sea surface salinity (SSS) tends to decrease at a rate of -0.35 $\pm$ 0.2psu / decade. The highest reduction in SSS occurred in northern Australia, the southern Java Sea, west and east Sumatra, Tomini Bay, the Malacca Strait and the Gulf of Thailand. However, the projection result of SSS negative change with rcp4.5 shows lower results than simulation data. This is due to lower rainfall projections than historical data in northern Australia, the southern part of the Java Sea, west and east of Sumatra, Tomini Bay and the Malacca Strait. Increased acidification of seawater, temperature and changes in sea water salinity are expected to occur during this century. It is estimated that the pH in Indonesian waters will decrease with increasing SPL and a decrease in SSS. As it is known that coral reefs are not only affected by rising temperatures, but also influenced by changes in pH. Thus, coral reefs will also experience pressure due to changes in SST and SSS or a combination of both.

Following the increase in SST, sea level increases also vary from 0.6cm / year to 1.2cm / year. The highest sea level increase is projected to occur in the South China Sea, while in other regions it varies from 0.7cm / year to 1.0cm / year. Therefore, sea levels in Indonesian waters will likely increase by more than 30cm for a span of 40 years. The increase in sea level caused by ice melting and increasing the volume of sea water due to rising temperatures, which can be called absolute sea level rise is not proportional to changes in land elevation due to land subsidence. The combination of land subsidence and absolute sea level rise is usually referred to as relative sea level rise. Relative sea level rise that occurs in the Java coast, can reach more than 10cm / year. The high relative sea level rise causes an increased risk of flooding and tidal flooding. Although there is still no physical relationship between the change in absolute sea level rise, changes in sea water intrusion and relative sea level rise, adaptation to the relative sea level rise must be done. Regulation of groundwater use, which is one of the biggest causes of subsidence, becomes a necessity.

The model projection results also show that extreme wave heights may increase by 1.0m, but in real conditions, there will be a possibility of rising more than 1.5m, because of local and regional wind speed changes due to climate variability that happens more often than projection models , and sea level rise due to global warming. The incidence of extreme wave heights in the future will not only affect the fisheries sector, the safety of sea transportation, prevent the flow of goods and other commodities using sea transportation facilities, but also increase the risk of flooding in low altitude coastal zones between 0m to 3m.