

## The utilization of weather and climate information to support marine and fisheries activities

### *Penggunaan informasi cuaca dan iklim untuk mendukung kegiatan kelautan dan perikanan*

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**Abstract.** *Weather and climate condition are certainly changing. In addition to an early warning of the atmospheric hazard, update information about the current and future status of atmospheric condition is necessary to support public activities. The purpose of this paper is to provide freely online weather and climate information that can be easily accessed by the community. The weather and climate products from an official Indonesian agency for Meteorology, Climatology, and Geophysics are used in this paper. The agency serves informative and public accessible weather and climate products. In addition, products from foreign public or private meteorological services are also used since they offer valuable spatial and temporal information including early warning of atmospheric hazards that benefit to assist local community in their daily activities. In marine and fisheries sector, it helps to minimize the risk and losses that may be arisen due to the changing of atmospheric condition, so that, the productivity in this sector is expected to increase in the future*

**Keywords:** *Atmospheric condition; Weather and climate products; Marine and fisheries*

**Abstrak.** Kondisi cuaca dan iklim mengalami perubahan dengan pasti. Selain sebagai peringatan dini tentang bahaya atmosfer, informasi mengenai status terkini dan mendatang mengenai kondisi atmosfer adalah penting guna mendukung aktifitas masyarakat. Tujuan dari makalah ini adalah untuk menyajikan informasi pelayanan cuaca dan iklim secara gratis dan online yang dapat dengan mudah diakses oleh masyarakat. Makalah ini menggunakan produk cuaca dan iklim dari Badan Meteorologi, Klimatologi dan Geofisika Indonesia. Badan ini melayani produk yang informatif dan mudah diakses oleh masyarakat. Selain itu, produk-produk dari layanan meteorologi asing baik milik pemerintah atau swasta juga digunakan dalam makalah ini karena menyediakan informasi spasial dan temporal yang berharga termasuk peringatan dini yang berguna untuk membantu masyarakat lokal dalam melaksanakan kegiatan sehari-hari. Dalam sektor kelautan dan perikanan, informasi ini membantu untuk mengurangi resiko dan kerugian yang mungkin terjadi akibat perubahan kondisi atmosfer, sehingga produktifitas pada sektor ini diharapkan dapat meningkat di masa mendatang.

**Kata kunci:** Kondisi atmosfer; Produk cuaca dan iklim; Kelautan dan perikanan

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### Introduction

The uncertainty of weather and climate condition is less-informed in the community, especially in Aceh. Twisters that hitted in many parts of Aceh coastal areas, such as, Ulee Lheue port (Serambi Indonesia, 2013), west coast of Aceh (Liputan6.com, 2013), etc, lead the local to suffer from severe damages and material losses. Such disasters make the information of weather and climate to become necessary and important. Some atmospheric phenomena, for instances, wind storm along eastern coast of Aceh during southwest monsoon, high ocean waves in the open seas due to severe thunderstorm with occasionally followed by hailstone and lightning strikes in most of the seasons are the impact of extreme weather that are essential to be investigated, analyzed and further informed to the local community. In addition, the rise of Sea Surface Temperatures (SST) and sea level which further lead to inundation, fail to sea, coral bleaching, shiftness and changes in season and types of fish catch, the movement of fishing ground location, the reduction in types and number of fish, poor water quality of fishpond in a certain season, and the reduction of salt production in Aceh are the impact of climatic changes that need to be considered (Pörtner and Peck, 2010; Jury, 2011; Rudi, 2012; IPCC, 2013). Muchlisin *et al.* (2012; 2013) reported that climate condition is one of the most important factors that could inhibit fishermen activity

and highly responsible for the reduction of fish catches in Aceh not only in the present time but also in the forthcoming years.

Because of geographical position, weather and climate in Aceh have unique characteristics. Geographically, Aceh is situated in the northern part of Sumatera Island between 2.5 N to 6.5 N and 93.5 E to 100.5 E. Aceh is mainly affected by monsoonal circulation and bordered by Indian Ocean in the west. The region is known for the emergence of dipole mode, namely Indian Ocean Dipole (IOD), an internal mode affected by ocean-atmosphere interactions which is similar to El Niño and Southern Oscillation (ENSO) event in the Pacific. In a certain time, the interactions might influence on climate oscillations over the region (Saji *et al.*, 1999; Webster *et al.*, 1999). The dipole mode formation is characterized by SST anomalies in the western tropical Indian Ocean where higher SST was found in the region (Ashok *et al.*, 2001). Thus, it will lead to the increase of precipitation above normal in the east coast of Africa, while in the western part of Indonesia, including Aceh, the precipitation will decline from normal which causes severe drought. The event is known for a positive dipole mode. On the contrary, a negative dipole mode will make SST in the western part of Aceh waters to become warmer and lead the air pressure to decrease. As a result of air mass convergence, deep convection lead the clouds to form higher and further affect to produce towering cumulonimbus clouds with severe thunderstorm and heavy rainfall, especially in most of Aceh waters. The pouring rain occurred during a negative dipole mode might lead to disaster particularly in fisheries sector where fish catches might reduce because of fail to sea and the failure of fishpond activity due to poor water quality. Dipole mode is one of climate deviation which is often referred to extreme climate events. In addition, ENSO events might also affect on climatic conditions in Aceh (Muhammad *et al.*, 2012). Although Aceh is located in the equatorial climatic zone (Boer and Subbiah, 2005), but the appearance of ENSO and dipole mode might simultaneously strengthen the climate irregularities which further lead to climate disaster in Aceh. On the other hand, during transition season mostly on April to November, there exists a long squall line thunderstorm along eastern coast of Aceh, i.e., Sumatera Squall Lines (SSL), resulted from the air convergence, mainly the convergence of land-breeze in the nighttime between land-breeze from east coast of Aceh and west coast of Malaysian Peninsula. The convergence leads to form severe thunderstorm with heavy rainfall, lightning and sometimes twisters that can last for many days along east coast of Aceh. Some researchers have reported the phenomena, e.g., Yi and Koh (2007).

Many people in Aceh are not really aware about the importance of weather and climate information. Most of them think that this information is hardly to find. Especially for marine and fisheries sector, despite of their poor-educated labor, it is important to provide an easy access of weather and climate information. In Indonesia, Agency for Meteorology, Climatology, and Geophysics (BMKG) is a public agency which is assigned to address these issues. BMKG continually assist to provide the current status of weather and climate in the entire Indonesian region, including early warning of some hazards, such as, thunderstorms, twisters, tropical cyclones, ENSO and IOD. Meanwhile, some public and private agencies from foreign country also provide online weather and climate service that can be used as the comparison to find accurate information of weather and climate. Thus, this paper aims to provide an easy access of weather and climate information by accessing freely online webpage from BMKG and other sources. It is expected that with the availability of these information in the community, it helps to minimize the risk and losses that may be arisen due to the changing of atmospheric condition and to support sustainable marine and fisheries activity for years to come.

## Materials and Methods

Climate and weather information are taken from BMKG website which is available at [http://www.bmkg.go.id/BMKG\\_Pusat/Main.bmkg](http://www.bmkg.go.id/BMKG_Pusat/Main.bmkg). The upper part of the main page provides menu for weather and climate public services. The information about weather or climate condition can be accessed at meteorology or climatology menu page. Meteorology page provides informations about weather forecasting, weather outlook, satellite and radar images, wind prediction, tropical cyclones, etc while climatology page provides climate prediction, water budget, atmospheric dynamics, extreme climate, climate change information, SST prediction including the prediction of ENSO and IOD, etc. In addition, the main page also provides a direct access on early warning, wave height, weather forecasting, and season prediction, etc (see Figure 1a).



(a)



(b)

Figure 1. BMKG webpages for (a) main and (b) marine weather webpages.

BMKG collected weather variables, e.g., rainfall, temperatures, humidity, pressure, and wind at the surface and upper layer from all meteorological and climatological stations in Indonesia. Before it is sent to the headquarter, the data is firstly calibrated and analyzed. The satellite images use Multi-functional Transport Satellite (MTSAT) operated by Japan Meteorological Agency (JMA) which can be accessed at <http://satelit.bmkg.go.id/BMKG/>. In addition, BMKG also utilize radar to monitor the current status of weather condition. So far, BMKG has operated 24 C-band weather radars with frequency ranges of about 5 GHz (5.6-5.65 GHz) (Wardoyo, unpublished data). Weather radar is available at <http://radar.bmkg.go.id/bmkg2/>. To monitor the current state of ocean as well as to predict ENSO and IOD and future climate projections, BMKG work closely with other international meteorological agencies from Australia, USA, and Japan in maintaining the instrument, computational infrastructure and performing model run, for information can be accessed at [http://www.bmkg.go.id/Bmkg\\_Pusat/DataDokumen/Update\\_ENSO\\_231213.pdf](http://www.bmkg.go.id/Bmkg_Pusat/DataDokumen/Update_ENSO_231213.pdf). For daily and monthly climate projections, BMKG run Meteorological Research Institute (MRI)-AGCM3.1S based on 20-km spatial resolution of JMA and MRI numerical weather prediction model (Aldrian, unpublished data).

BMKG also operate shipping Automatic Weather Station (AWS) to observe the status of marine weather. The results of the data analysis are presented in shipping weather bulletin and marine weather webpage, available at <http://maritim.bmkg.go.id/index.php/main/home> (see Fig. 1b). For tropical cyclones, BMKG collaborated with Joint Typhoon Warning Center (JTWC) and JMA to inform cyclones occurrences around Indonesian Waters which can be explored at <http://meteo.bmkg.go.id/siklon>.

## Results and Discussion

Figure 2a and Figure 2b showed weather radar images from BMKG. It showed large-scale cumulonimbus clouds on January 20<sup>th</sup>, 2013 in the north of Aceh Waters which indicate a squall line thunderstorm with heavy rainfall. Figure 2a showed radar reflectivity which is the potential rainfall intensity detected by a weather radar. Measurement of rainfall intensity (or precipitation) is based on the reflection of emitted radar energy by water droplets in clouds, the units of reflectivity are in dBZ (decibels). The more the reflected energy received by radar, the higher dBZ, which is also indicate stronger rainfall intensity. The maximum range of BMKG radar reflectivity is about 240 km from the site. The range of dBZ scales are from 5 to 75 which are represented by multiple colors as shown in the legend. Rainfall intensity (mm/hours) based on the color scale is given in table 1. Figure 2b showed the velocity of wind inside the clouds. It is also shown that maximum wind speeds are found in high precipitation areas.

Table 1. The conversion of reflectivity of BMKG weather radar

Rainfall intensity	dBZ	mm/hours
Light rain	30 to 38	1 to 5
Medium rain	38 to 48	5 to 10
Heavy rain	48 to 58	10 to 20
Very heavy rain	> 58	> 20

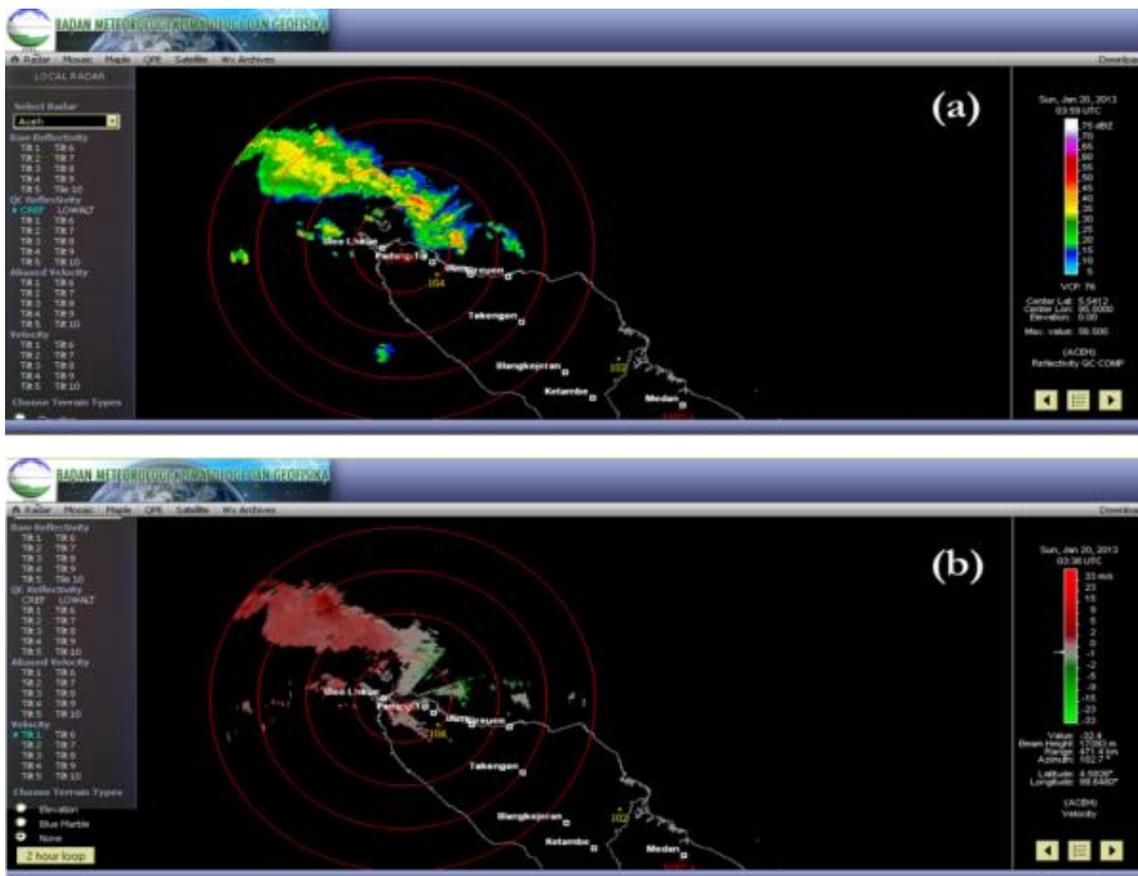


Figure 2. Weather radar retrieved from BMKG on January 20<sup>th</sup>, 2013, (a) reflectivity and (b) velocity.

Meanwhile, Figure 3 showed satellite images retrieved from BMKG on October 21<sup>th</sup>, 2013 on the occasion of SSL event along the Malacca Strait. The thunderstorm occurred early in the morning as a result of air mass convergence due to land-breeze flow between Sumatera and Malaysia in the nighttime. Figure 3a showed clouds image with temperature at the top are less than 0 °C. The colder the temperature at the top (indicated by an increasing white color), the heavier rainfall potential. Figure 3b showed an infrared image, the image describe temperatures of clouds where warmer temperatures are found in low clouds and often situated near the surface while colder temperatures are found in higher clouds where top of the clouds can reach the stratosphere. This infrared image is useful for detecting clouds either in the day or nighttime. Figure 3c showed the water vapor image, the image was taken at the wavelength bands which are sensitive to moisture content in the atmosphere. The bright white color describes the presence of water vapor (moist air), blue areas indicate high humidity and/or ice crystals in the clouds while brown color indicates low air humidity with less moisture. Water vapor is important to determine the areas with high moisture and to detect the circulation or air mass flow in the atmosphere. Figure 3d showed the rainfall potential retrieved from satellite image. The image is consistent with figure 3a, b, and c where heavy rainfall is produced by higher cumulonimbus clouds. By monitoring the information provided by BMKG, fishermen can easily avoid hazardous areas affected by thunderstorm. Weather radar can also be utilized to detect the possible occurrences of strong winds such as: gust, derecho, downburst, microburst, gale, or even twisters since these phenomena are often generated by atmospheric instability inside severe thunderstorm (Ilhamsyah, 2012).

Figure 4 showed the forecasting of marine weather issued by BMKG. So far, weather and climate services have been well-informed by BMKG. For those, particularly fishermen, who area poor-informed can contact nearby BMKG station for a close guidance in accessing weather and climate products released by BMKG. In addition, atmospheric information over Indonesian region can be obtained from some credible foreign public or private meteorological agencies, such as, Australian Bureau of Meteorology (BoM) which can be retrieved from <http://www.bom.gov.au/>. The agency actively provides states of SST, ENSO and IOD, tropical cyclones, weather forecasting, etc. These informations are useful for fishermen who live along southern coast of Indonesian Archipelago. In addition, the quick information of the changing states of SST that lead to the emergence of ENSO and IOD issued by the agency can also be used as an early warning to the climate impact on Indonesian region. BMKG also work closely with BoM and other agencies to improve the weather and climate networking system over Southeast Asia region (see Fig. 5a and b).

In order to get a better understanding in the community, those information need to be well-interpreted as shown in figure 5a and b where they forecasted that 2014 is a normal year without experiences of any climate anomalies. Thus, we can expect high marine and fisheries production in 2014. Meanwhile during ENSO and IOD year, a quick warning should be delivered to fishermen, they are asked to modify their fishing tools and to prepare a well-equipped vehicle to adapt with the future changing of climate condition. With a good adaption and mitigation, we can possibly maintain high production in this sector. National Oceanic and Atmospheric Administration (NOAA) through Earth System Research Laboratory (ESRL) which is available at <http://www.esrl.noaa.gov/psd/> also provided ocean and meteorological reanalysis data. However, the products are still in raw gridded data which still need to be depicted by using certain software even though plotting tools are also given. Mostly, NOAA products are often used as primary or secondary data to support the research in the field of ocean, weather and climate. National Aeronautics and Space Administration (NASA) provide state of the ocean, namely SOTO at <http://podaac-tools.jpl.nasa.gov/soto/>. SOTO benefit as a tool to detect the appearance of ENSO or IOD signal. NASA also launched Tropical Rainfall Measuring Mission (TRMM) to monitor rainfall over tropical region. The information can be found at <http://trmm.gsfc.nasa.gov/>. Tropical atmosphere group from Nanyang Technological University run a numerical weather prediction model and the outputs are presented at <http://web.spms.ntu.edu.sg/~sunshine/WeatherWeb/html/weather.php>. The products also describe the current atmospheric state over the Malacca Strait which is also useful to capture thunderstorm occurrences particularly during SSL period. World's Weather Authority established by worldwide meteorologist with its product Accuweather (<http://www.accuweather.com/en/id/indonesia-weather>) provide worldwide weather forecasting with attractive weather map. Special features are also given in Accuweather where we can easily find weather forecasting and outlook not only in a given

location but also in the surrounding areas. In addition, it also provides the historical climate data derived from model performance.

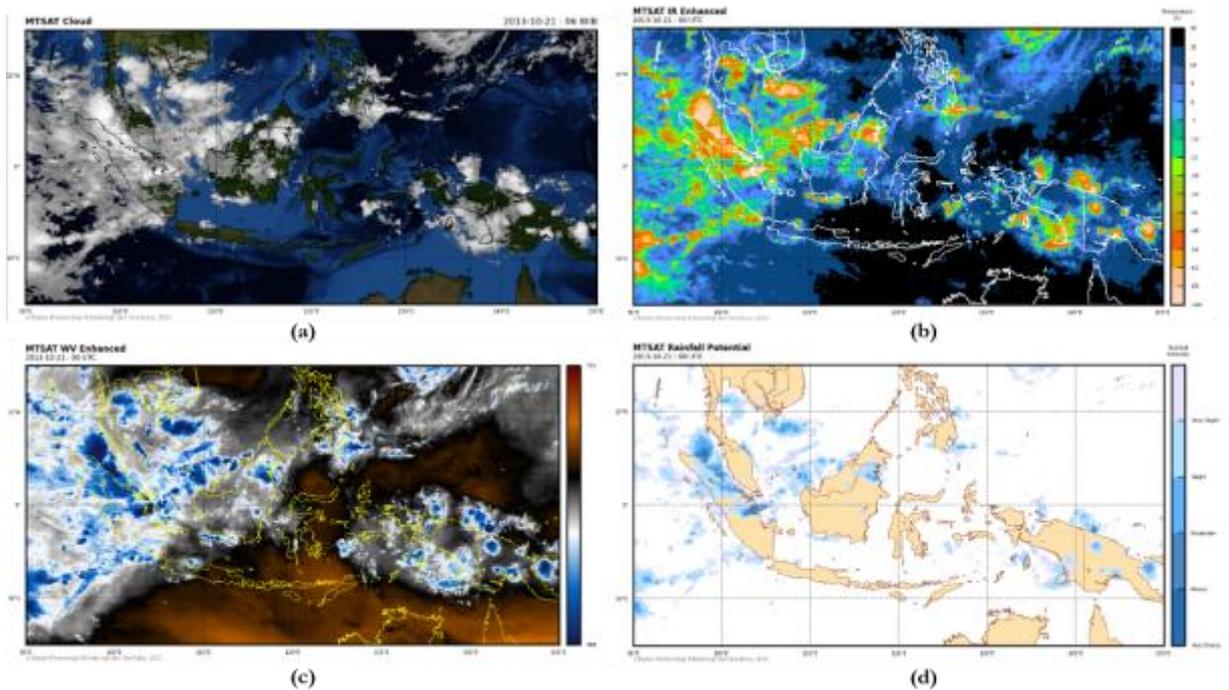


Figure 3. Satellite images retrieved from BMKG on October 21<sup>th</sup>, 2013 on the period of SSL over the Malacca Strait, (a) clouds, (b) infrared, (c) water vapor, and (d) rainfall potential images.

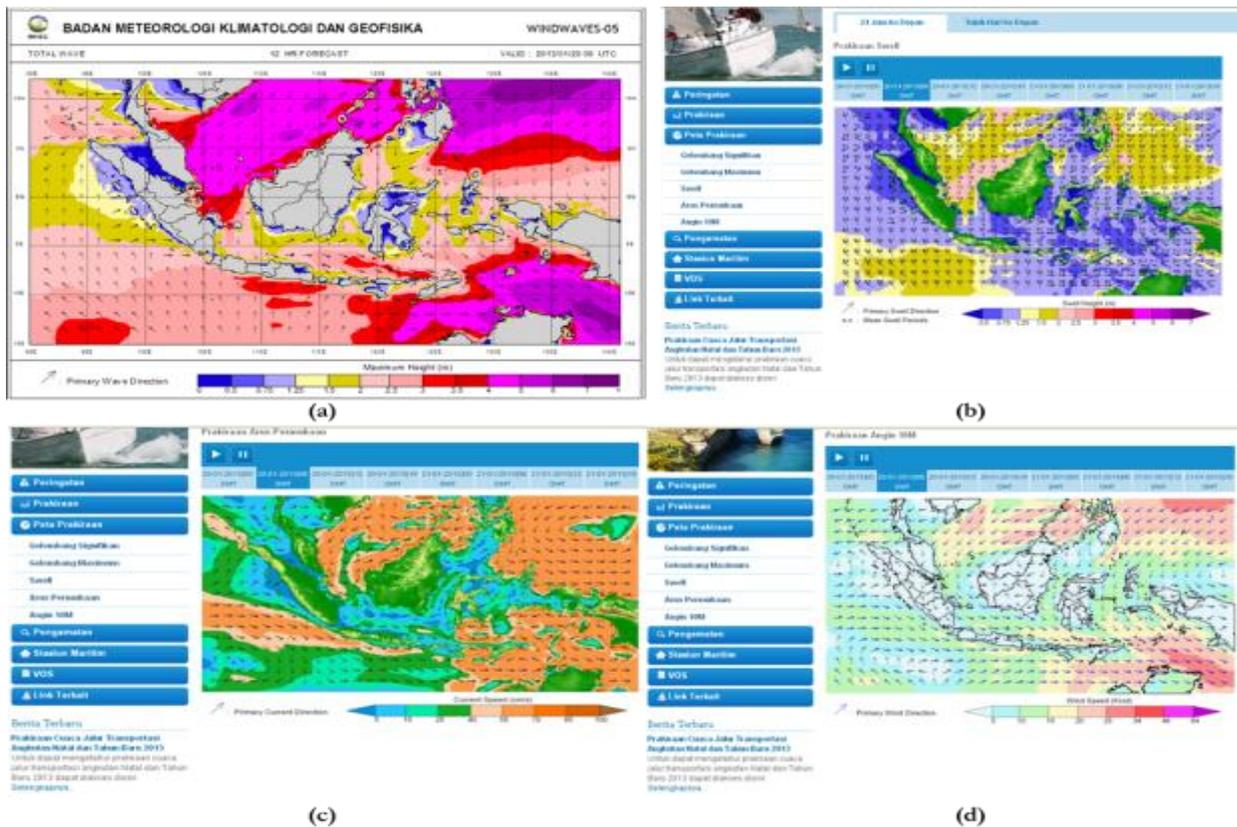


Figure 4. Marine weather prediction by BMKG on January 20<sup>th</sup>, 2013, (a) height of ocean waves in m, (b) height of swell in m, (c) surface current in cm/s, and (d) wind speed in knot.

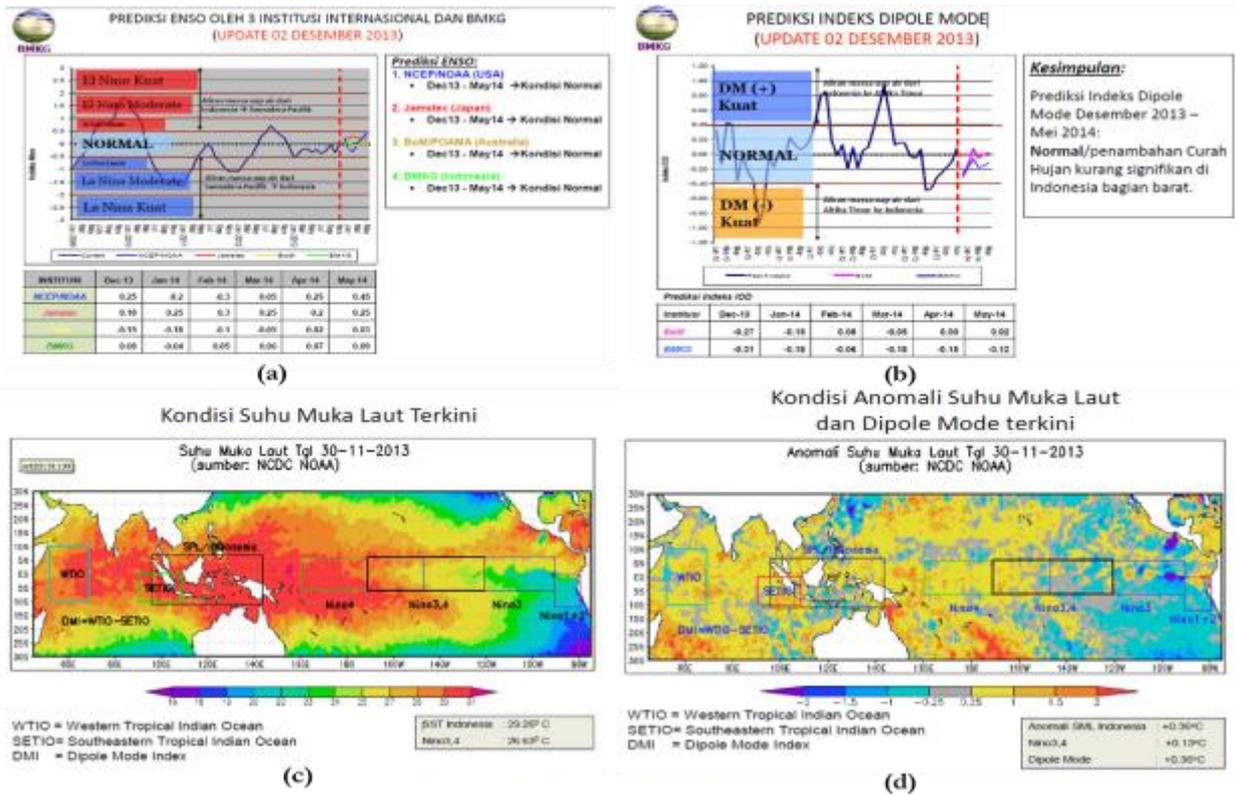


Figure 5. The prediction of ENSO and Indian dipole and state of the ocean by BMKG, (a) prediction of ENSO and (b) IOD, (c) state of SST and (d) SST anomaly.

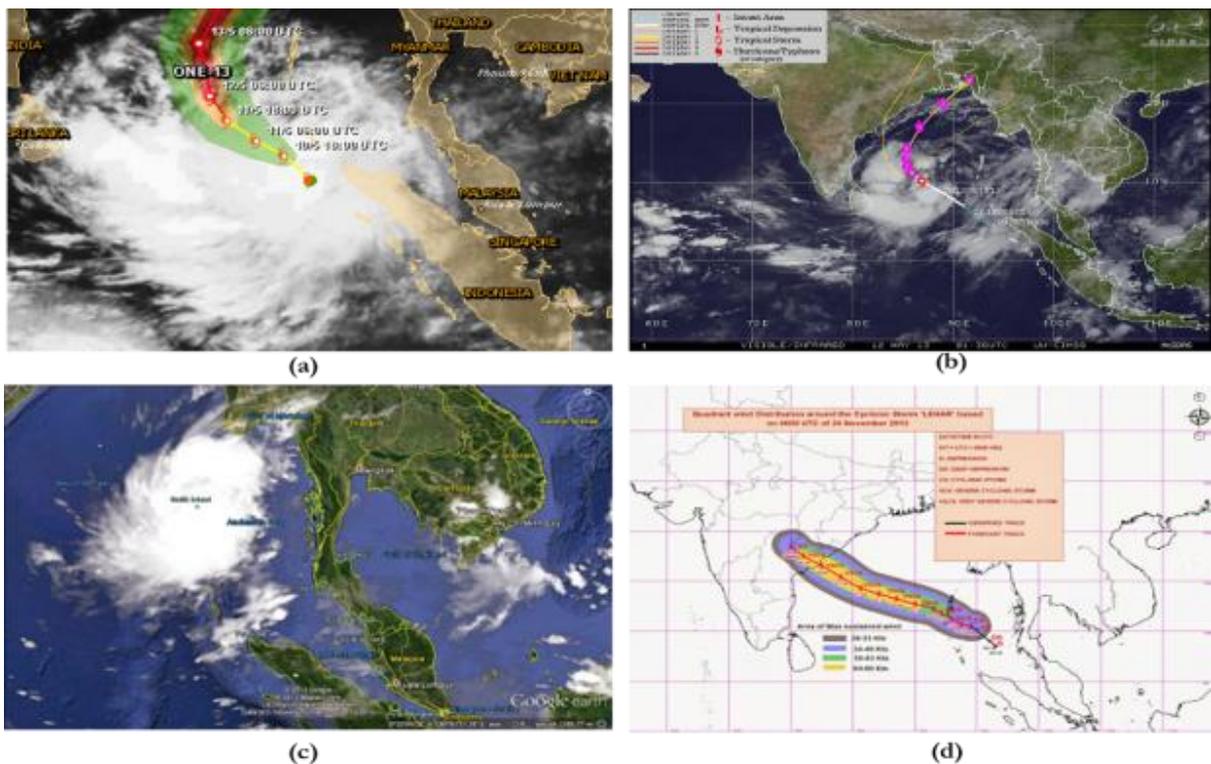


Figure 6. Tropical cyclones in the north of Aceh Waters and the prediction of tracks and stages by India Meteorological Department, (a) and (b) Cyclone Mahasen on May 10<sup>th</sup>-17<sup>th</sup>, 2013, (c) and (d) Cyclone Lehar on November 19<sup>th</sup>-28<sup>th</sup>, 2013.

Cooperative institute for meteorological satellite studies from University of Wisconsin-Madison (<http://tropic.ssec.wisc.edu/>) provide current occurrences of tropical cyclones over tropical region basin based on satellite imagery. This agency also provides the wind analysis over Indian Ocean region including Aceh. Aceh is not directly hit by tropical cyclones, however, the region is known for early emergence of tropical cyclones due to the rise of SST. Thus, monitoring SST over the region becomes crucial to anticipate the development of cyclones since early genesis is often related to SST exceeding 26°C (Asrianti *et al.*, 2013; Ilhamsyah *et al.*, unpublished data). Aceh is only affected by cyclone's tails by the time it grows into a mature cyclone. Under this circumstance, Aceh region will suffer from intense rainfall, strong wind speed, and high ocean waves which surely bring negative impact to the fisheries activity around Aceh Waters. For an early warning of this event, a real-time information can be retrieved from India Meteorological Department through <http://www.imd.gov.in/section/nhac/dynamic/cyclone.htm> as shown in figure 6. Other private companies, Weather Underground and Meteoblue for instance, also provide many attractive features which involve observation, radar, satellite images, and model. Those products can be explored at <http://www.wunderground.com/> and <http://www.meteoblue.com/>. On the other hand, to monitor a real-time climate impact on coral reef, we can access <http://coralreefwatch.noaa.gov/satellite/index.php>. Those information are useful to assist workers in marine and fishery sector, including fishermen and other seaside workers such as: salt and fishpond farmers, etc. It is expected that the productivity in this sector can grow and thus, the sustainable livelihood can be achieved in the upcoming years. Story of successful community service in applying weather and climate information can be found in Sari (2007).

## Conclusions

By interpreting weather radar reflectivity, BMKG radar image clearly depicted massive cumulonimbus clouds with heavy rainfall on late January 2013 along northern Aceh Waters. Satellite images proved the presence of Sumatera squall lines over the Malacca Strait on late October 2013 during transition period. The indication of potential hazardous areas is valuable information for fishermen prior to conducting their activities at sea. Meanwhile, some information of marine weather and the prediction of ENSO and IOD as well as current state of the ocean are also well-informed by BMKG. In addition, a good quality of weather and climate services can also be retrieved from foreign companies by opening their webpages. With the abundance of weather and climate sources, hopefully, it will not become an obstacle for workers in marine and fisheries sector to enhance their productivity in the future.

## Acknowledgement

Figures used in this paper are taken from BMKG and India Meteorological Department websites. We express our thanks to BMKG and India Meteorological Department.

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