Evaluation of downscaled near-surface wind over maritime continent based on stations measurement

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Abstract. In the maritime continent where most of the region is an ocean, wind field is the main driving force to generate ocean wave. The use of inaccurate wind fields to drive ocean model may result in significant biases. Many global reanalysis wind data are available, but the performance is subject to each region. Moreover, the resolution of global data is less representative for the maritime continent region. This paper presents the dynamically downscaled near-surface wind of NCEP/DOE re-analysis II (R2) over the maritime continent by regional climate model (RegCM4.6). We evaluate 10m wind modeled by R2 and its downscaled based on stations measurement available from Agency for Meteorology, Climatology and Geophysics (BMKG). Moreover, the results of downscaled wind are also compared with re-analysis wind from ECWMF ERA-Interim. We compare daily 10m zonal and meridional wind speed from 10 stations near the coast during 1 January 2013 until 31 December 2016. Then, we investigate the added value of the dynamical downscaling to the near-surface wind fields over the maritime continent.

1. Introduction

Ocean waves are the result of the interactions between wind and the ocean surface, in which the main energy resources to generate is so-called the wind force [1]. Moreover, the most frequently used parameters of global reanalysis products is near-surface wind (10m) [2]. The inaccuracy of wind field, which is the input of ocean wave model, may drive wrongly generated ocean wave. The use of wind data measurement is unlikely since the number of stations is limited. A number of global data provide wind field data over the globe, but the quality of the data should be evaluated. Moreover, the resolution of the global data is still relatively coarse. Study of [3] confirmed that the different resolution of the wind data gives quite differences in the generated ocean wave. Therefore, the coarse resolution of global data should be reduced to be implemented in a local region. One approach increasing the resolution of the wind data is a dynamical downscaling of the global climate data, for example the study [4] that downscale the wind over the United States.

Among the global climate data, some of the inter-comparison of climate data has been studied. Stopa and Cheung in [5] compared the wind and wave data from ECMWF Reanalysis Interim and the NCEP Climate Forecast System Reanalysis over the globe and resulted that both reanalysis data perform the spatial homogeneity with consistent levels of errors in the Northern and Southern Hemispheres. Mooney et al. in [6] compared the surface air temperature modeled by ERA-40, ERA-Interim, and NCEP/NCAR reanalysis (NNRP-1) with the observations over Ireland and the three
Reanalysis data showed good agreement with the observation and with each other. Chaudhuri et al. in [7] evaluated atmospheric fields over the Arctic from the ERA-Interim, Common Ocean-Ice Reference Experiment version 2 (CORE2), Japanese 25-yr Reanalysis Project (JRA-25), NNRP-1, NCEP Climate Forecast System Reanalysis (CFSR), and Modern-Era Retrospective Analysis for Research and Applications (MERRA) against satellite-derived and in situ observations. In their study, comparison to reference observations showed that for variables such as air temperature and humidity, all reanalysis products have similar solutions, but winds, precipitation, and radiation showed large spreads.

In this paper, we evaluate the near-surface wind of the downscaled global climate data over the Maritime Continent. We compare the downscaled wind from the global data of NCEP-DOE AMIP-II Reanalysis (R2) with the wind measurement from the meteorological stations. In order to evaluate the uncertainty of the wind field among the global reanalysis data, we also compare the global wind data from R2 and ERA-Interim over Maritime Continent. The comparison of the product of ECMWF (ERA-40) and NCEP against the observation had been done by [8]. They compared the dataset with Antarctic station observations and showed that the wind velocity fields in both datasets do not agree well with the atmospheric observations.

2. Dataset and method
2.1. Global reanalysis data
Reanalysis data is globally gridded dataset recording the changing of weather and climate over time. It incorporates observations and numerical prediction model and covers the entire globe. This paper investigates the near-surface wind, the zonal wind ($u_{10}$) and meridional wind ($v_{10}$) from two reanalysis data, NCEP-DOE AMIP-II Reanalysis (R2) and ERA-Interim. The R2 is an updated 6-hourly with a 2.5 x 2.5 latitude-longitude horizontal resolution global reanalysis series from 1979-present, which fixes the known processing errors in the NCEP-NCAR reanalysis (R-I) and uses an improved forecast model and data assimilation system [9]. The resolution of the data is T62 Gaussian grids, i.e 192 longitudes equally spaced and 94 latitudes unequally spaced grid points with 28 vertical sigma levels. The data assimilation system uses a 3D-variational analysis scheme and is described in more detail in [10].

The ERA-Interim is a global atmospheric reanalysis from 1979 and continuously updated in real time, produced by European Centre for Medium-Range Weather Forecasts (ECMWF) in collaboration with many institutions. The data assimilation system uses 4D-variational analysis (4D-Var) on a spectral grid with triangular truncation of 255 waves (corresponds to approximately 80 km) and a hybrid vertical coordinate system with 60 vertical levels. The ERA-Interim data used in this study is 6-hourly data on a fixed grid of 1.5° horizontal resolution.

2.2. Regional model data
The regional data is obtained from the dynamical downscaling of the global reanalysis data over the maritime continent (95°E-155°E and 11°S-8°N). This paper uses the downscaled of R2 with 0.25-degree resolution by regional climate model RegCM4.6 as proposed by [11-12]. The model is run for climatologically simulation in the period of 1980-2016, but this study only extracts 6-hourly variables $u_{10}$ and $v_{10}$ from the model output in the period of 1 January 2013 until 31 December 2016.

2.3. Measurement data
Measurement data from 10 meteorological stations of Agency for Meteorology, Climatology and Geophysics (BMKG) are used for the evaluation. The measurement stations in this study are chosen near the coast from various part of the maritime continent. The locations of the stations are presented in Figure 1. The measurement data are provided in a daily average and in term of the magnitude and the direction of the near-surface wind. The accuracy of the direction is quite weak since the measurement data uses the eight principal wind directions. It may result in a deviation of the wind speed up to approximately ±0.38 of the exact wind speed.
Figure 1. Map showing the location of the measurement stations used in this study.

2.4 Comparison methods
The grid size among the reanalysis datasets is different. To compare the dataset of R2 and ERA-Interim we synchronize the grid by bilinear interpolation. We compare the spatial distribution of the zonal and meridional wind in DJF and JJA season from R2 and ERA-Interim.

Further, the geographic coordinates of the measurement stations are neither equal to the grid point of the global nor regional dataset. The location of a station can be in the grid box or in the edge of the dataset. Study of [6] investigated four different approaches to compare reanalysis and observed data and resulted that there is no superior among the methods. To evaluate all the dataset we compute the correlation and the mean absolute deviation between each data with the measurement.

3. Comparison of reanalysis data

Figure 2. Zonal wind (u10) of R2 (top) and ERA-Interim (bottom) in DJF and JJA season.
Figure 2 shows that the spatial variability of the zonal wind of both R2 and ERA-Interim that have similar pattern over MC in either DJF or JJA season. However, their magnitudes of the zonal wind are slightly different. In DJF season, the R2 zonal wind are much stronger than ERA-Interim in most of the region while in JJA season, the differences are less significant. This is confirmed in Figure 4 that the trend line slope of ERA-Interim data versus R2 is mostly less than unity.

Figure 3 shows that the meridional wind of R2 is also stronger than ERA-Interim in both DJF and JJA season. The differences in the matter of the pattern and the magnitude are more significant than the zonal wind. The stronger magnitude of the meridional wind of R2 against ERA-Interim is also confirmed in Figure 4.

**Figure 3.** Meridional wind (v10) of R2 (top) and ERA-Interim (bottom) in DJF and JJA season.

**Figure 4.** Plot of the slope of the least squares linear fit of the ERA-Interim to the R2 daily wind data for the time period 2013-2016.
Figure 4 shows that both zonal and meridional wind of the R2 and ERA-Interim give similar behavior at each station. Both zonal and meridional wind of the R2 are stronger than ERA-Interim, except at two stations in Borneo island (Sepinggan and Iskandar) where ERA-Interim data shows much larger than R2.

4. Comparison dataset with measurement

![Correlation and Mean Absolute Deviation](image)

**Figure 5.** Correlation and mean absolute deviation to the wind measurement at 10 stations.

We analyze the performance of the annual cycle of the zonal and meridional wind from the datasets against the measurement at 10 stations. The correlation and the deviation are shown in Figure 5. Based on the correlation, the meridional wind of R2, ERA-Interim, and RegCM at most of the stations give strong correlation (> 0.5) with the measurements, while the zonal wind give poor correlation. This is also shown by the mean absolute deviation that the meridional wind of R2, ERA-Interim, and the regional data deviates relatively small from the measurements.

Meanwhile the annual cycle at three stations is shown in Figure 6. These stations are selected to show that the dynamical downscaling can improve the global data at one station, but it can also give worse performance at another station. For example, at Sepinggan station the model gives more deviation from the measurement in the zonal and meridional wind. At Seigun, the model improves only the R2 meridional wind. At Namlea, the RegCM improves both zonal and meridional of R2 data. In general, the zonal wind of the global reanalysis data or the downscaled data is still give large deviation, while the meridional wind perform the measurement well.
5. Summary

A comparison of the near-surface wind between the R2 and ERA-Interim reanalysis data in Maritime Continent over the period 2013-2016 has been presented. The result shows that over most of MC the R2 gives stronger wind than ERA-Interim in both DJF and JJA season. Moreover, the ability of ERA-
Interim, R2, and the downscaled of R2 to reproduce the near-surface wind at 10 measurement stations has been investigated. There is no optimum among the three dataset. All three dataset show similar annual cycle, but at some stations it does not fit the measurement. Based on the correlation analysis, all three dataset model the meridional wind well, but not the zonal wind. Therefore, this result should be considered in the studies using the reanalysis data. Further, the performance of RegCM to downscale the global data is still need to be investigated further since the model may perform well at one region, but does not perform well at another region.

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