

# Identification of atmospheric boundary layer thickness using doppler radar datas and WRF - ARW model in Merauke

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**Abstract.** In the synoptic scale, one of the important meteorological parameter is the atmospheric boundary layer. Aside from being a supporter of the parameters in weather and climate models, knowing the thickness of the layer of the atmosphere can help identify aerosols and the strength of the vertical mixing of pollutants in it. The vertical wind profile data from C-band Doppler radar Mopah-Merauke which is operated by BMKG through Mopah-Merauke Meteorological Station can be used to identify the peak of Atmospheric Boundary Layer (ABL). ABL peak marked by increasing wind shear over the layer blending. Samples in January 2015 as a representative in the wet and in July 2015 as the representation of a dry month, shows that ABL heights using WRF models show that in July (sunny weather) ABL height values higher than in January (cloudy)

## 1. Introduction

Indonesian territory has a diversity of complex topography in form of mountains and hills on the mainland, while the waters that dominate in form of straits, headlands, bays, and so forth. This topographic diversity affect weather formation in all parts of Indonesia. Weather phenomena often occur in Indonesia as heavy rain and thunderstorms are related to mesoscale weather systems. Mesoscale weather dynamics include the study of motion system that has a horizontal scale in the range of 10 to 1000 km [1]. One of the phenomena associated with meso-scale weather systems is the atmospheric boundary layer (ABL) or commonly abbreviated with ABL. ABL is the bottom part of the atmosphere where the flow field influenced directly by the interaction with the Earth's surface and sensitive to variety of conditions in the Earth's surface for a short time scale [2]. Physical and dynamical processes in ABL related to exchange process of mass, momentum, and heat between the earth's surface with the troposphere. Not only that, the process of cloud formation and hydrological cycle are influenced by ABL.

The structure of the ABL can be complex and variable [2-5], and the height (or depth) of the ABL is commonly used to characterize the vertical extents of mixing within the boundary layer and the level at which exchange with the free troposphere occurs [6-9]. ABL heights is one of important and fundamental parameter to knowing the characteristics of the ABL structure such as turbulence, atmospheric stability and diurnal pattern that related to vertical transport process or convection [10] Although the influence of ABL is not felt immediately by humans, but ABL is very influential in weather formation in a region. ABL heights can vary significantly over time as result of several factors including the dynamics of large-scale, cloud, convective mixing and diurnal variation of solar radiation [11]. In addition, the topography also affects the variation of the height of ABL.



Generally, ABL measured in local scale and short periods of time, because ABL has diurnal variation (daily). ABL heights can not be calculated directly but through specific approaches and simulation. ABL heights can be measured using some weather instruments, such as weather radar and radiosonde. ABL measurement by radar performed by [12] at the Bavarian Alps region showed that ABL structure is strongly influenced by the terrain and topography, in this case the mountains. ABL measurement using radar is also done by [10] which shows that the average height of ABL in January was smaller than in July although the difference is not big enough. Nocturnal Boundary Layer (NBL) peak marked by significant wind shear due to the maximum speed (low-level jet) at ground level, while the peak of Convective Boundary Layer (CBL) marked by increasing wind shear at the top of the mixing layer. Not only that, the simulation model of the WRF-ARW model also be performed to determine ABL profile, as did [13] who analyzed the diurnal variation height of ABL based observations and using simulation models of single-column WRF, then compared with calculations using radiometer and wind profiler. The results of simulation-based ABL heights gives a higher yield of about 500-1000 m of ABL heights based observations. A similar study conducted by [14], which resulted in that measurements using WRF is always lower (underestimated) a few hundred meters. In the country have also been ABL measurements using simulation WRF by [15]. Her research using weather radar and comparing turbulence index and richardson numbers calculated from the results of WRF simulations. The results indicate that wind shear was good to identify ABL heights when the weather is sunny, while the spectral width was good to identify ABL heights when the weather is cloudy. While the Richardson number and turbulence index is unable to identify the ABL heights when the weather is sunny or cloudy. Additionally [16] also studied the Climatology LBA by using ECMWF data. The result shows that LBA heights is low around the beach and Characterized by stratus clouds. LBA can reach 3 km, especially in desert areas, and sometimes in the tropics.

In this study the authors will try to identify the height of ABL in Merauke using weather radar to knowing vertical wind profile and WRF-ARW model simulation. Identification of ABL heights performed on two different weather conditions when sunny and rainy day, to determine the height difference of ABL in different weather conditions.

## 2. Introduction

### 2.1 Research Location and Time

The research location is in Merauke with location point is Meteorological Station Mopah Merauke with coordinate  $08^{\circ}31'03''$  "LS and  $140^{\circ}25'01''$  BT and height 3 m above sea level. Merauke region dominated by lowlands and the hilly area near the coast. Research time was on January 13, 2015 during cloudy and rainy weather conditions, and on July 8, 2015 during cloudy weather conditions.



**Figure 1.** South Papua Island (Merauke is shown with blue circle)

### 1.2. Data

The data used in this study include:

1. C-Band Doppler radar Data with the format \*.RAW from Mopah merauke meteorological station, which then processed using Rainbow TM application for radar gematronic
2. FNL data as input for model WRF-ARW with 10x10 spatial resolution and temporal resolution of 6 hours.

### 1.3. Step Work

1. Data collection
2. Processing of radar data using Rainbow app. Products shown are Volume Velocity Processing (VVP) that depicting vertically meteorological parameters, such as divergence, direction and wind speed of 3-dimensional (u, v, w). From these products can be seen as a marker peak wind shear atmospheric boundary layer.
3. Running WRF-ARW models with three domain downscaling with the center point of the meteorological station Mopah Merauke (domain 3). Schemes used in the process of running WRF-ARW is the default scheme with the following details:

**Table 1.** WRF default parameterization scheme

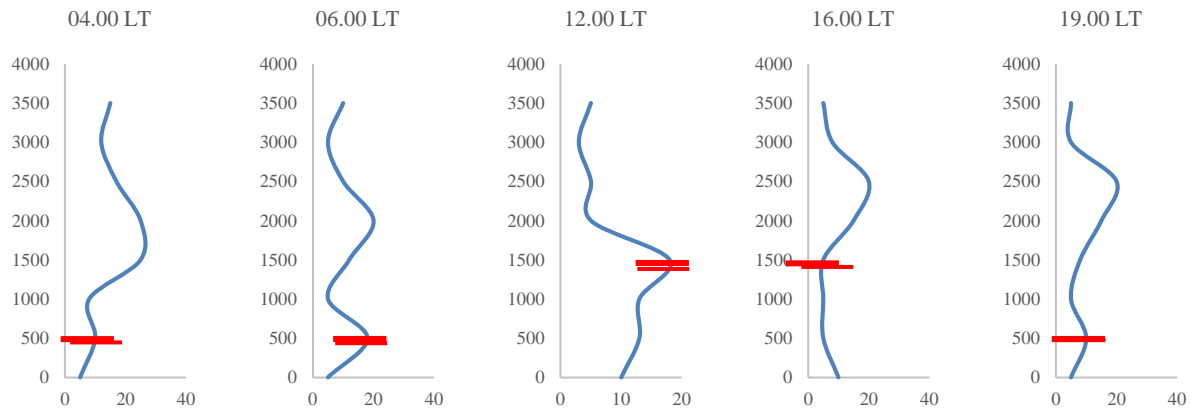
Parameterization Scheme	Number	Selection Scheme
Cumulus	1	Kain-Fritsch
Microphysics	3	WSM-3
Shortwave Radiation	1	Dudhia
Longwave radiation	1	RRTM
Planetary Boundary Layer	1	YSU

4. Then running model is done to get .ctl and .dat file. Then we do visualization outcome parameter models which are a boundary layer (pblh).
5. After that, the analysis and discussion based on the results of data processing, and the conclusions drawn.

## 3. Results

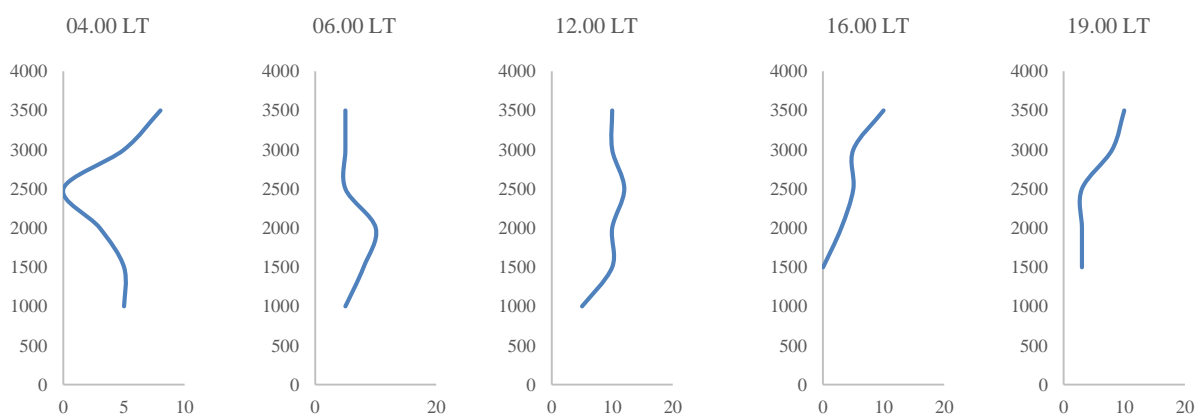
### 3.1. Identification ABL Heights Using Doppler Radar Data

Identification of ABL heights by using Doppler radar is done by looking the vertical wind profile and the identification result shows that the peak height of ABL elevation change in a day. During the day, ABL heights characterized by maximum peak wind speeds due to reduced turbulence intensity above the LBA. At night, ABL heights characterized by maximum wind speeds on the bottom layer or so-called nocturnal jet which is a kind of low-level jet. Here is the result of the identification of ABL heights by using weather radar data (marked with a red line).



**Figure 2.** The vertical wind profile using weather radar data on January 13, 2015. ABL heights indicated by red line

Figure 2 shows vertical wind profiler by radar weather on January 13, 2015 during cloudy and rainy weather conditions. ABL heights varies with time. In the early morning at 04.00 LT (Local time = GMT + 9 h) and 06.00 LT, ABL heights are low in the range of 500 m. During the day at 12.00 LT, ABL maximum heights within the value range of 1200 m to 1500 m and it last until afternoon at 16.00 LT. At night, ABL heights decreased again at 500 m. The height of the ABL during the daytime is higher than the height of ABL at night, and the difference ABL heights in the mornings and afternoons tend to be insignificant. ABL layer formation is as a result of the interaction of the atmosphere with the surface of the earth to produce ABL thickness values varying depending on heating / cooling factors of the earth's surface, and also the surface roughness characteristics of the surface topography. ABL greater heights at noon because of high rates of warming at the daytime.

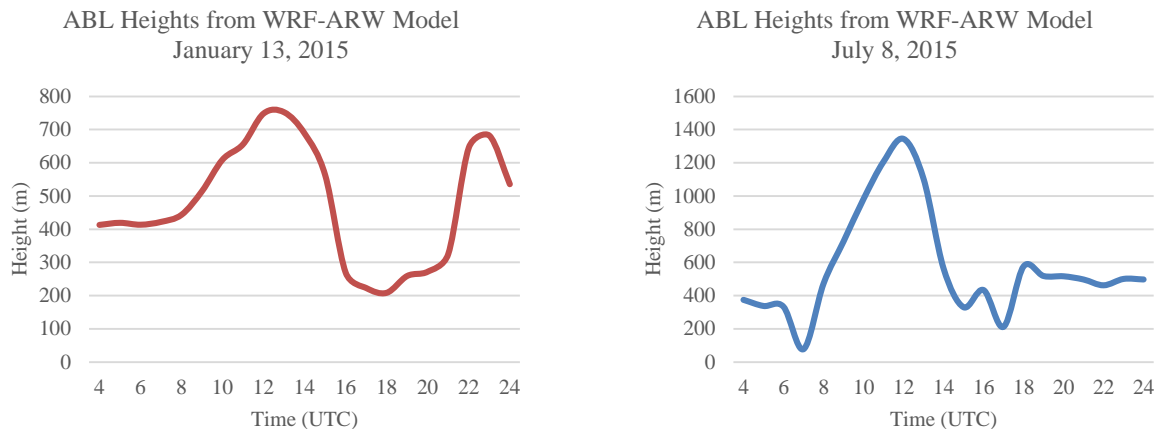


**Figure 3.** The vertical wind profile using weather radar data on July 8, 2015. ABL heights indicated by red line

Figure 3 shows the vertical wind profiler by radar weather on July 8, 2015 when the weather was sunny and cloudy conditions. But ABL heights on July 8, can not be identified because of the weather radar wind profiler irregular.

### 3.2. Identification ABL Heights Using WRF-ARW Model Simulation

In addition to using radar, ABL heights can also be identified by the WRF-ARW model simulation. The parameters used for identification ABL heights is pblh. Furthermore, this parameter will displayed in graphical form. Here's a graph of ABL heights every hour using a model WRF-ARW.



**Figure 4.** The vertical wind profile using weather radar data on July 8, 2015. ABL heights indicated by red line

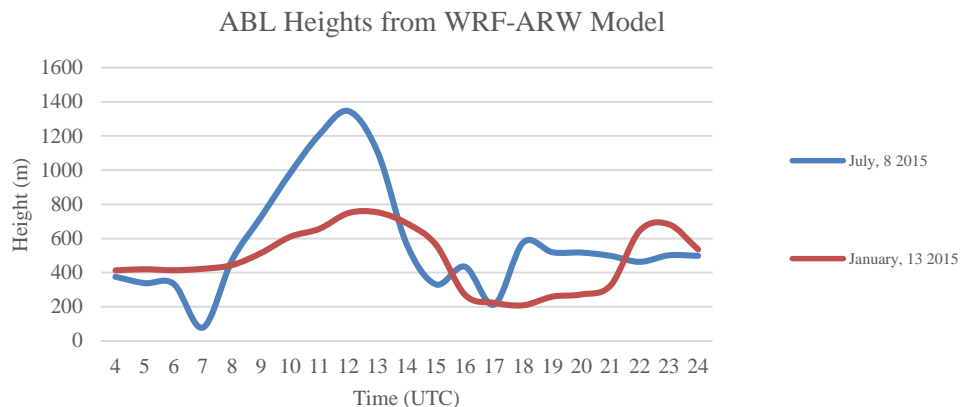
Based on WRF-ARW model results on January 13, 2015 when the weather is cloudy and rainy, ABL heights ranging between 208 m to 752 m. In the morning from 04.00 LT to 08.00 LT, ABL heights ranges between 410 to 440 m. ABL heights increase during the day and reach maximum value at 13:00 LT with height about 752 m. In the afternoon until evening ABL heights decreasing and minimum value of ABL heights at 18.00 LT with heights about 208 m.

Based on WRF-ARW model results on July 8, 2015 when the weather was sunny and cloudy, BL heights ranging between 77 m to 1344 m. in the morning from 04.00 LT to 06.00 LT, ABL heights ranges between 332 m to 374 m. differ on January 13, 2015, the minimum height of ABL on July 8, 2015 occurred in the morning at 07.00 LT with height of 77 m. ABL heights begin increase during the day and reach maximum value at 12:00 LT with height about 1344 m. in the afternoon until the evening ABL heights decreases.

ABL heights using WRF models show that in July (sunny weather) ABL height values higher than in January (cloudy). From the data of the average humidity in January and July in Merauke show that the average air humidity in January (wet season) is higher than in July (dry season). In addition, the average temperature in January was lower than in July. This has led to an altitude of ABL in July (sunny weather) is higher than the height of ABL in January (cloudy). Humidity higher in January makes the surface warming during the day is not as intense as in July.

### 3.3. ABL heights in different weather condition

ABL heights varies with time. Variation of ABL heights caused by daily cycle of solar radiation. ABL heights tends to be low during morning and evening where air condition is stable and radiative cooling of the Earth's surface. The stability ABL withstand turbulence so ABL heights become lower. Unlike the situation during sunshines, when maximum solar radiation occur that generally is going convection activity. Convection causes the radiative warming occurs in the earth's surface so that ABL heights increases.



**Figure 5.** ABL heights in different weather condition (July 8, 2015 is sunny weather and January 13, 2015 is rainy weather)

In addition, weather conditions factors may also affect the ABL height variation. Figure 5 shows the difference in ABL heights in different weather conditions. When cloudy and rainy weather conditions, ABL is higher than when the cloudy and rainy weather conditions. This is due to cloud cover and rain blocking incoming solar radiation so that played a role in decreasing surface temperature. As a consequence of energy that supports the growth of ABL reduced and become lower heights. Unlike when the weather is sunny, the earth's surface receives solar radiation is intense enough so that the earth's surface heat increases as the energy of formation of ABL. This causes ABL heights when sunny conditions are higher.

#### 4. Conclusion

The conclusion of this study are:

1. Identification of ABL heights by using Doppler radar is done by looking the vertical wind profile and the identification result shows that the peak height of ABL elevation change in a day.
2. ABL heights using WRF models show that in July (sunny weather) ABL height values higher than in January (cloudy). This situation is caused by differences in humidity and temperature in the second month, in January of air humidity is higher and temperatures lower than in July makes the surface warming during the day is not as intense as in July.
3. The determination of the height of the ABL method of wind profiles can be done, but there are some conditions in which the height of ABL difficult identified include irregular weather radar wind profiler.

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