Using Wind Profiler Radar to Identify Cumulonimbus at Lombok International Airport's Area

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Abstract: Cumolonimbus became one of the threat for airport activities. The presence of individual cumulonimbus cell were difficult to predict. Cumulonimbus cloud is a convective cloud or cloud system that produces rainfall and lightning. It often produces large hail, severe wind gusts, tornadoes, and heavy rainfall.Wind Profiler Radar utilizes Doppler radar working principle, this tool is used as a tracer variation of the refractive index of air caused by turbulence. This study uses data Wind Profiler installed in Lombok International Airport at January 27th, March 24th, April 3rd, and July 17th in the year of 2016. This research analyze data from wind profiler so the forecaster could recognize the cumulonimbus using WPR and discover the initial sign of cumulonimbus for further information the the flight officers. Wind profiler clearly captured the emergence of cumulonimbus on the parameters Max (dbz) with a range of value (-15) – (20) dBZ. A windshear at low level caught as an initial sign of cumulonimbus emergence. When cumulonimbus exist, horizontal wind speed at the troposphere increased, and there is a convergence activity at low levels and divergence in high levels. The value of cumulonimbus's multipeak coeff display in contrast to when the weather is clear. Multipeak coeff's point at the cumulonimbus case has random pattern and higher wind speed yet multipeak coeff's point at the clear weather close to zero.
Key words: Wind Profiler Radar, Cumulonimbus, Lombok Airport

1. Introduction

Wind Profiler Radar (WPR) on Selaparang Meteorological Station which located at Lombok International Airport intended to assist meteorological officers in the flight services. The data from WPR particularly used for detecting wind shear and gusty.However, there is still many product of WPR that could be very useful for flight operational. So, further research still needed to explore WPR benefit by adjusting the conditions of the field in the Lombok International Airport.
Take off and landing are the most crucial moment on the aircraft operation. The airport weather must be very concerned at the period. If there is any condition that may endanger those activities, the aircraft must consider to divert their planes to another alternate airport or rounded for a while.
Cumolonimbus became one of the threat for airport activities. Cumulonimbus cloud is a convective cloud or cloud system that produces rainfall and lightning. It often produces large hail, severe wind gusts, tornadoes, and heavy rainfall. In the flight operational, the existence of cumulonimbus could be very dangerous. When the aircraft meets the cumulonimbus, there is a possibility of icing, turbulence, electrical disturbance, and other severe weather phenomena. The presence of individual cumulonimbus cell were difficult to predict. Forecaster need to learn what kind of atmospheric condition which triggered cumulonimbus genesis.
Weather radar is common to assist forecasters to detect cumulonimbus. Unfortunately weather radar at the Lombok International Airport (LIA) can not figuring this phenomena because the distance just too close. On the other side we have wind profiler radar as a tool to replace weather radar's function at LIA. So thatthe forecaster able to advise aircraft officers and controllers of the likely timing, height of cells and whether or not they may be embedded. Flight crews can alter their routings to avoid forecast Cb activity or decide to carry extra contingency fuel in case they have to re-route in flight to avoid the storms or burn additional fuel because of the potential use of aircraft de/anti icing systems.
This research aims to know the initial condition of cumulonimbus's presence and how the WPR identify the cumulonimbus. This is important to know how the funnel cloud initial sign shows in wind profiler so the forecaster could make a warning for airport activity.

1.1. Wind Profiler Radar

Wind Profiler Radar measuring vertical profile of the horizontal wind vector in the atmosphere every 10 minutes at high temporal resolution under almost all weather conditions, that is in both the cloudy and the clear atmosphere. WPR accuracy comparable to the accuracy of wind data from the radiosonde. At least three linear independent beam directions and some assumptions concerning the wind field are required to transform the measured 'line-of-sight' radial velocities into the wind vector. WPR data are especially beneficial for short range forecasts at smaller scales. Apparently, the usefulness of WPR data is variable in time and, in specific meteorological situations, also in height[1)]
Single signal WPR use the simple method of Doppler beam swinging (DBS) to determine the wind vector. These wind born variations backscatter part the transmitted energy. In the lower troposphere, the variation of the index of refraction are mainly determined by water vapor[2)].
Currier (2005) analyze some atmosphere condition using WPR such as detecting windshear, boundary layer development and displayed rain rate. He use variation product from WPR and determine the phenomena based on the colour difference[3)].

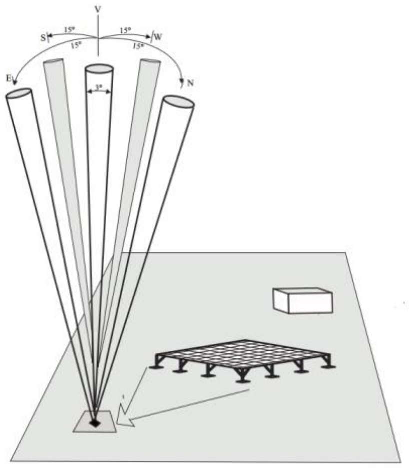

Fig. 1.1.1. Beam pointing configuration of a five-beam DBS Wind Profiler Radar[1)]

1.2. Cumulonimbus

Cumulonimbus clouds are convective clouds brought about when the temperature decreases rather rapidly with increasing height. Differential heating and converging air currents in this circumstance can therefore send plumes of warmer air skyward with relative ease. Cumulonimbus clouds span a wide range of depths, from miniature versions only about 2km deep in polar air masses over the oceans, to as much as 20 km in the most severe thunderstorms in equatorial regions[4)].
In particular, deep cumulonimbus convection characterizes the Tropics, as the principal rain-bringing cloud form, and as an agent of thermal and chemical transport. The tropopause is typically high and some cumulonimbus systems can extend beyond 15 km in height. These cumulonimbus clouds are observed to have complex morphology, organizing into mesoscale convective systems (MCSs), and being controlled by an interaction between their own internal dynamics and the environmental state such as CAPE and wind shear[5)].
Cumulonimbus is a heavy and dense cloud, with a considerable vertical extent,in the form of a mountain or huge towers. At least part of its upper portion isusually smooth, or fibrous or striated, and nearly always flattened; this part oftenspreads out in the shape of an anvil or vast plume[6)]. Individual cumulonimbus (thunderstorms), which precipitate heavily, exhibit lightning and thunder, produce strong outflow winds and tornadoes, have widths of the order of tens of kilometers, and extend vertically to the tropopause, where their tops spread out and form the characteristic anvil, or thunderhead[7)].

Cumulonimbus convection can produce rapid turbulent transports of heat and momentum through the entire depth of the troposphere. By continuity of mass the upward motion in cumulonimbus convection requires convergence at low levels and divergence in the upper troposphere. Frictionally induced boundary layer convergence moistens the environment and destabilizes it through layerascent. This enables small-scale plumes to reach their levels of free convection easily and toproduce cumulonimbus clouds[8)].

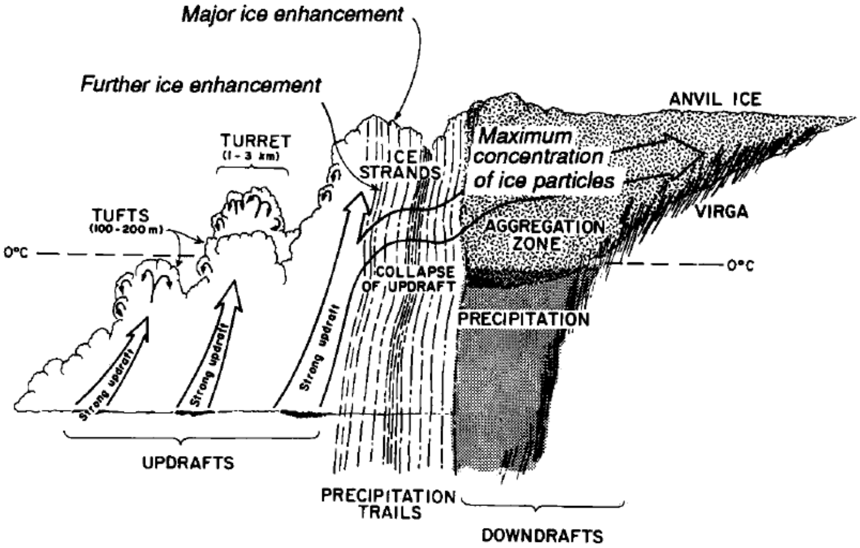

Fig. 1.2.1. Empirical model of a small cumulonimbus cloud[7)].

2. Material and Method

This research will analyze WPR's data based on Special Report (SPECI) in Selaparang Meteorological Stasiunat. The WPR at Selaparang has five linear independent beam directions to measure the wind. We choose the date where the special report (SPECI) of significant weather phenomena contain wind gust or gusty information with the wind speed > 25 knots at January 27th, March 24th, April 3rd, and July 12th in year 2016. Wind gust on SPECI defined as the wind which have increased by 10 knot or more, the mean wind speed before and/or after the change being 15 knot or more[9)].

Table 2.1. SPECI data in Selaparang Meteorological Station

Date	SPECI
January 27th at 09.10 UTC	SPECI WADL 270910Z 30016G34KT 1000 R13/2000D -TSRA FEW015CB SCT016 27/24 Q1009 TEMPO TL1000 1000 TSRA FEW015CB BKN016 RMK CB TO W=
March 24th at 07.11 UTC	WADL 240711Z 03019G29KT 350V060 0500 R13/2000D TSRA FEW015CB BKN016 24/23 Q1012 TEMPO TL0900 1000 TSRA FEW015CB BKN016 RMK CB TO N=
April 3rd at 08.32 UTC	SPECI WADL 030832Z 15012G23KT 060V220 1000 R13/1500D TSRA FEW015CB SCT016 26/23 Q1011 TEMPO TL0900 1000 -TSRA FEW015CB SCT016 RMK CB TO NE=
July 12th at 06.44 UTC	SPECI WADL 120644Z 20008G23KT 170V240 0400 RA FEW015CB BKN016 27/24 Q1009 TEMPO TL0700 3000 -RA RMK CB TO ALL RWY=

Selaparang Meteorological Station located at 08°45’ S and 116°17' W.

Fig. 2.1. Lombok Island

WPR products that will be used are :

a. colour info of ***Max dBZ*** (maximum decibel of Z) and ***ff*** (speed and wind direction) at the choosen time

b. b. multipeakcoeff from spectra/countour display of radial velocity at the choosen time

We adjust the range value for colour info max dbZ to find the best value which clearly showed the cumulonimbus. We will compare the value and image of Max dbZ and the multi peak coeff when the cumulonimbus exist with the clear condition.

3. Result and Discussion

WPR at Lombok International Airport successfully capture the Cumulunimbus genesis through colour info Max dBZ with value ranged between (-15) until (+20). For the colour info *ff* we use value ranged between 0 until (+15). The multi peak coeff from spectra/countour display value increased when the cumulonimbus occupied the sky comparing to the clear sky. The radial velocity measured by WPR has a top speed up to 6.01 m/s in the inbound and 5.92 in the outbond

3.1. Colour Info of Max dBZ.

From the Fig. 3.1.1. which show the colour info of Max dBZ, we can see the colour differences between cumulonimbus existance and the clear atmosphere. From all sampling data, gusty occurs at the beginning of the colour change. Which indicate gusty is an initial sign of cumulonimbus presence. After the gusty detected, the Max dBZ value increase significantly and the WPR able to gain data up to higher altitude which mean the cumulonimbus has a top up to 8000 metre or more. However not every cumulonimbus presence signed by gusty appearance.

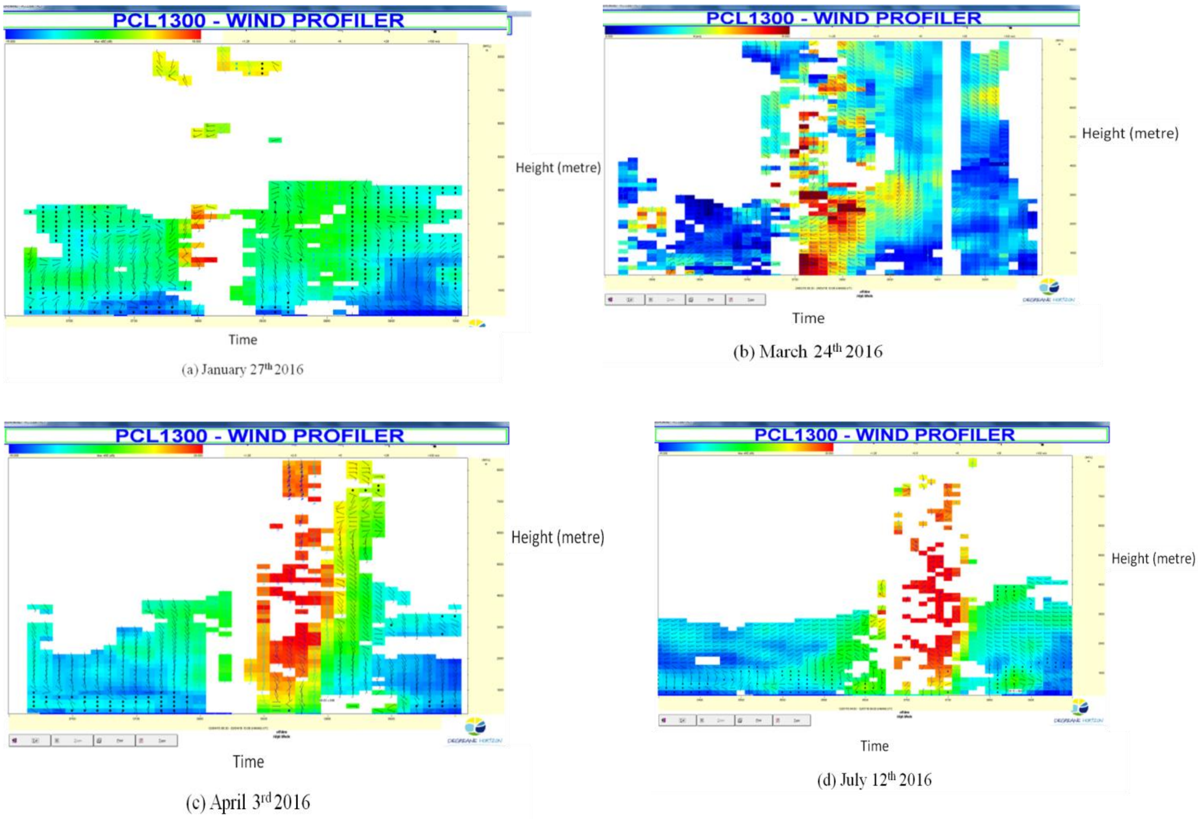

Fig. 3.1.1. Colour info of ***Max dBZ***

3.2. Colour Info of *ff*

WPR calculate horizontal wind speed and direction vertically and convert it into an image. From the image beside we can gain information from the colour. We can see the barbs which has speed value and also showed us the wind direction. The value range for wind speed that used by Selaparang's WPR is between (0) – (15) m/s.

Currier (2005) simply identify windshear at WPR by the colour change from colour info *ff* [3)]. As showed on the Fig. 4, before the cumulonimbus appears, we also can see there is a windshear at the low level (1000 – 3000 mean groun level), the wind speed and/or direction changed quite significant with the next altittude level. And the cloud start to dissipating when the wind direction become homogen again. Forecaster can use this initial sign as a basic when they made weather forecast for flight crews and controllers.

The wind speed and the colour change dramatically because of the presence of cumulonimbus. It has higher speed value than before.At March 24^{th}, April 3^{rd}, and July 17^{th} the wind barbs on the low level changed significantly with the difference up to $>120^{o}$ with the wind direction on the higher level when the cumulonimbus exist. We can assume there is a convergence activity at low levels and divergence in high levels.

But this theory does not in accordance with the data from January 27^{th}. The wind direction dominant from the west, which indicate strong Asian monsoon probably became the trigger at this time. That mean at the Asian monsoon period, the genesis of cumulonimbus more difficult to predict using WPR.

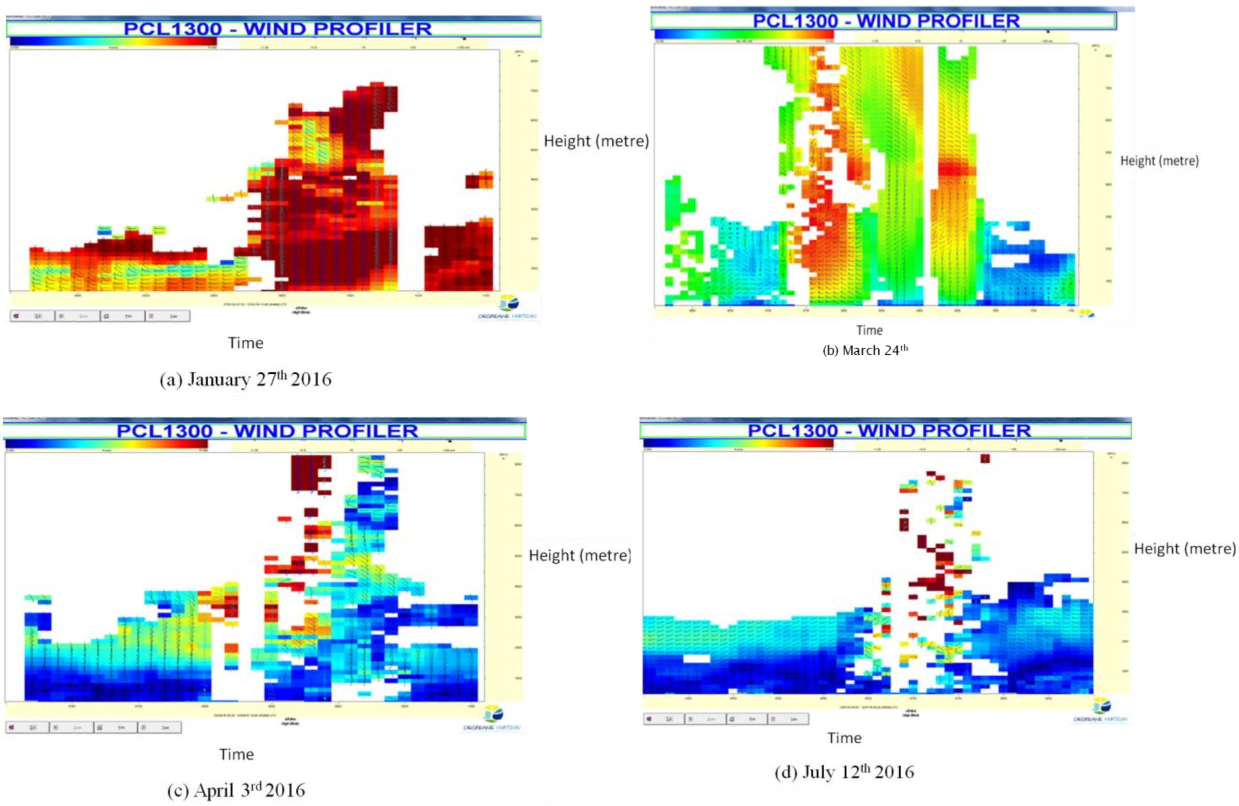

Fig. 3.2.1. Colour Info of ***ff***

3.3. MultipeakCoeff From Spectra Display Of Radial Velocity

Radial velocity is motion toward or away from Doppler RADAR[10)]. WPR provide multipeak coeff from spectra display of radial velocity. As shown by Fig. 3.3.1., The value of cumulonimbus's multipeak coeff display in contrast to when the weather is clear. Multipeak coeff's point at the cumulonimbus case has random pattern and higher wind speed yet multipeak coeff's point at the clear weather close to zero.

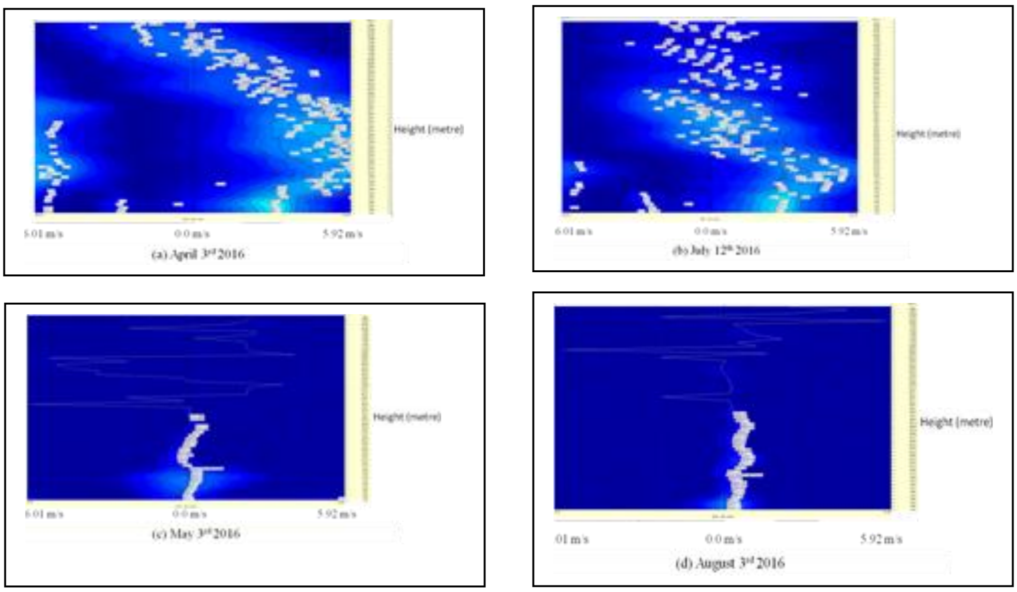

Fig. 3.3.1. Multi peak coeff from spectra display of radial velocity

4. Conclusion

Wind profiler radar clearly captured the emergence of cumulonimbus on the parameters Max (dbz) with a range of value (-15) – (20) dBZ and range value 0 – (+15) m/s for colour info *ff.*. From colour info ***ff,*** when cumulonimbus exist, horizontal wind speed at the troposphere increased, and convergence activity at low levels and divergence in high levels happened.
Windshear at low level has been caught as an initial sign of cumulonimbus emergence. We could preach to the forecasters to consider the windshear when they made a aerodrome forecast. However, this windshear does not happen at the Asia Monsoon period which often associated with wet season in Lombok island. So the forecaster need further research to maximaze the utilization of WPR for identify cumulonimbus at wet season.
The value of cumulonimbus's multipeak coeff display in contrast to when the weather is clear. Multipeak coeff's point at the cumulonimbus case has higher wind speed when multipeak coeff's point at the clear weather close to zero.

5. Acknowledgements

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