The Capability of Single Polarization C-Band Radar to detect Volcanic Ash (some cases of Volcanic Eruption in Indonesia)

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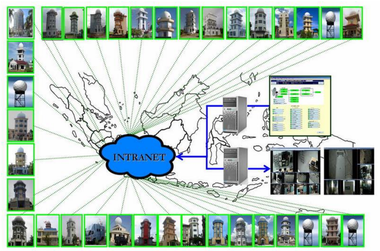
Abstract

Volcanic activity is not only harmful to the safety of life, property and infrastructure located on the mainland, because the eruption activity is always accompanied by a blast of hot clouds containing volcanic ash is very dangerous for flight may cause engine damage. This study aimed to detect volcanic ash using Single Polarization C-band weather radar is done in the case of the eruption of Lokon Mountain on December 6th , 2012, Kelud Mountain at February13th 2014 and some eruption from Sinabung Mountain In Indonesia. Products used in this study is the MAX product and Cross Section tools to analyze characteristics and patterns of volcanic ash Echo-looking compared to the precipitation echo a common sight. of these two products will be known characteristics of the eruption, the height of eruption, intensity and movement so that it can be used as the basis for estimating the direction of movement of the volcanic ash which is very useful for service to the aviation.

Keywords: *weather radar, Volcanic Ash, reflectivity, Aviation, cross section*

Introduction



- Indonesia is the country with the distribution of active volcanoes in the world, causing these regions have the potential threat posed by volcanic activity that is very dangerous for the survival of mankind in various sectors of economy, transport and safety of human lives.
- The distribution of volcanoes with high seismic activity in Indonesia led to a very high potential threat to the continuity of airport operations and flight activities for domestic and international flights passing through Indonesian airspace. This makes the importance of accurate information related to the spread of volcanic ash that could endanger the rapid flight. Hysplit models to provide information about the distribution of volcanic ash is very important in providing certainty for aviation safety. The accuracy of this model is strongly influenced input data that altitude volcanic eruptions are sometimes difficult to obtain certainty.
- Meteorology Climatology and Geophysics Agency Indonesia operates 36 C-band weather radar single polarization which spread all over Indonesia from multiple vendors. At least literature on observations of volcanic ash using a single radar weather radar polar causing potential single polarization C-band are ignored, and are not fully utilized in the detection of volcanic ash from the eruption and the volcano. This study wants to prove the ability of single polarization weather radar to detect volcanic ash using a standard radar image products from all manufacturers using a modified algorithm parameters CMAX radar products.

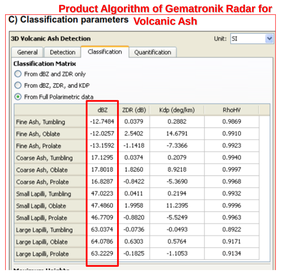
Main Characteristics of Material Explosion

TEPRHA	Particle type	Particle size	Distance from the volcano vent	Residence time in the atmosphere
Ash	*Fine ash (FA)*	Less than 64 μm	Hundred to thousand kilometers	Day to month
	Coarse ash (CA)	From 64 μm to 532μm	Ten to hundred kilometers	Day
Lapilli	*Small lapilli (SL)*	From 0.532 mm to 2.56 mm	Few to ten kilometers	Few minutes
	Large lapilli (LL)	From 2.56 mm to 32 mm	Hundred meters to few kilometers	Seconds to minutes
Blocks	*Blocks and bombs (BB)*	Greater than 32 mm	Ten to hundred meters	Tens of seconds

R. S. J. Sparks, M. I. Bursik, S. N. Carey, J. S. Gilbert, L. S. Glaze, H. Siggurdsson, and A. W. Woods, *Volcanic Plumes*. New York: Wiley, 1997, p. 574.

Based on the table, we have to watchful to the ASH which divided into Fine Ash and Coarse Ash. Both have very small size particles and can't be seen by volcano observer within > 5 km from volcanic observation.

Product Algorithm of Gematronik Radar for Volcanic Ash

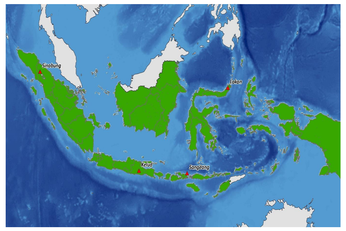


1. The VAD3D (Rainbow/selex) product algorithm is a product of Dual Polarization Radar, which is one of parameter taken from Z (dBZ) data [Rainbow 5 Product & Algorithm, Volcanic Ash Detection 3 Dimensional).[Rainbow 5 Product & Algorithm, Volcanic Ash Detection 3 Dimensional)
2. BMKG's Single Polarization Radar has a capability to generate Z (dBz) data radar, and can detect 6 (six) main characteritics/types of volcanic ash.
3. The volcanic ash characteristics of single polarization weather radar has a reflectivity value between -20 dBz to + 20 dBz [Wardoyo Eko, *Volcanic Ash Detection Using C-Band Doppler Radar Case Study Lokon Eruption December 6 2012*. 1st Asian Conference on radar Meteorology, Jeju- South Korea 2013]

Purposes

1. Give prove the ability of single polarization weather radar to detect volcanic ash using a standard radar image products from all manufacturers using a modified algorithm parameters CMAX radar products.
2. Giving the guidance for the region forecaster to identify and predict the directions distribution of volcanic ash, shortly after eruption in the coverage radar observation.
3. To optimize the utilization of radar according to the needs and phenomenon that occurs around the radar site.
4. Giving the information as quick as user needed.
5. Giving the information about height eruption and ash volcanic explosion more accurately and surely.

Method

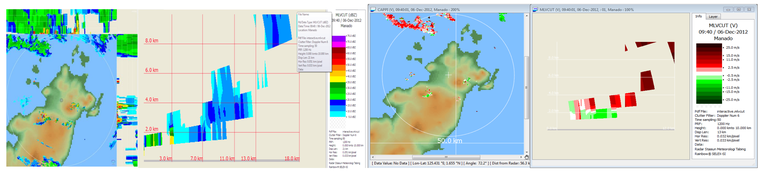


Using the MAX/CMAX Product Analysis

The MAX/CMAX product can provide maximum value which is obtained in every column scan. This product is expected to show the volcanic ash reflectivity values which is generally very small particles < 20 dBz [3.EW 2012].

1. Using the information about characteristic of volcano (esp. high mountain peak) as the "***Lower Limit***" and the information of height explosion as the "***Upper Limit***" input values when generate the MAX/CMAX product..
2. Creating products 1 hour before explosion to ascertain whether there is precipitation in the surrounding volcano, and creating products after explosion to see the movement (distribution) of volcanic ash.
3. Using VAD product to see vertical profile (wind per layer) as the reference to observe the pattern of layer distribution and compare to wind surface data.
4. Adding RHI scanning specifically to observe vertical condition above the active volcano. -

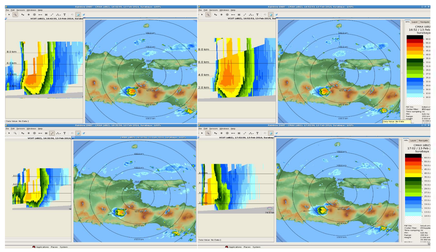
Lokon Mt. (6th Dec 2012)



This eruption is the first weather radar anaysis in Indoneisa for Vulcanic ash detecion. For do analyze and recognize the ash volcano echo, do Cross section to make sure Ash Volcano Signature. Cross Section from the Ash Volcano suspect, from the data its have different signature if we compare with precipitation echo. Its low intensity without developed phase like precipitation cloud.

For look trajectory we can use the velocity data to know the direction of ash volcano movement

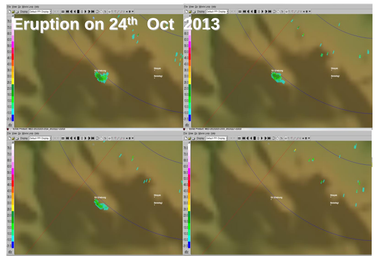
Kelud Mt.



Weather radar Juanda detected activity of Kelud eruption time by time. Its good observation from rainy to clear condition for while than at 15.52 UTC on 13 February 2013 the Eruption of kelud has started.

More than three hours the big eruption from Kelud mountain has recorded by Juanda Weather Radar, time by time use the VCP 21 Scanning with 10 minutes interval. Almost whole of java island affected by ash for a week with different thickness.

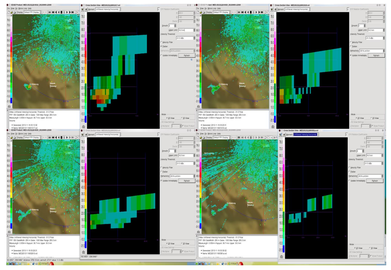
Sinabung Mt.



Radar analysis :

- Based on CMAX product Medan Radar, there were echo volcanic ash activity from CMAX products 22.55 UTC until 23.34 UTC.
- From cross section analysis on Echo Volcanic Ash, it can be seen that maximum peak explosion 4 km MSL.
- The volcanic ash distribution was generally to the East.

Radar Analysis case 14 Nov 2013



Radar Analysis

- Based on CMAX product Medan Radar, there were echo volcanic ash CMAX products from 23.58 UTC until 00.55 UTC.
- From the radar images (at that time) could detected explosion pattern of volcano, which there was a maximum reflectivity value on the sub/under layer that nearby the peak of Mt. Sinabung. The maximum value was the echo from lava material and the other solid material of eruption.
- From cross section analysis on Echo Volcanic Ash, it can be seen that maximum peak explosion 12 km MSL.
- The volcanic ash distribution was generally to the West and the particle ash was detected to the North.

General Analysis

- Based on CMAX product analysis, have a good capability to detect the whole eruption occurred with various intensities, by the light to the large eruption.
- From the radar images could detected cloud explosion pattern of volcano, which there was a maximum reflectivity value on the sub/under layer that nearby the peak of Mt. Sinabung. The maximum value was the echo from lava material and the other solid material of eruption.
- Significantly, there was the difference between radar observation and BVMBG on the low intensity radar data < 20 dBz, in every explosion occurred.

Conclusions

- The Single Polarization C-Band Radar can be used to detect volcanic ash using MAX/CMAX product, by giving specific input to the algorithm product.
- The C-Band Radar is good enough to detect the height explosion by noticing to reflectivity value < 20 dBz at the volcano area.
- From some cases of volcano explosion, there was the difference between radar observation and BVMBG to detect the maximum height explosion.
- In some cases, radar detected Noise/Ground clutter pattern for height explosion < 1 km.
- The velocity product and wind per layer (vertical profile) or VVP product can be used as reference of directions distribution.
- Sustainable observations and certain concern from forecaster on duty are required shortly after eruption occurred.
- Another method which can be used to observe the volcano with increased status, by using RHI scan.

Recomendation

- Modification scan mode based on Clear Air Observation (VCP31) or increasing vertical scan are required on the observation of height explosion or volcano eruption activities.
- Sustainable researches are required to determine parameter scanning strategy (i.e anntena speed, filtering, sampling, etc.), adjusted to the condition of each site.
- The observation result of height explosion and eruption from radar can be used as Hysplit Model input, then will be obtained trajectory output more accurate.

References

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