The Utilization of SATAID For Extreme Weather Analysis (Case Study: January 27th, 2016)

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Abstract : In order to support the safety of sailing operation, BMKG issued regulations no.009 of KBMKG y/of 2010 about the sea's early warning of extreme weather, including gusty, extreme waves and heavy rains. All of these phenomenon caused by the activity of a Cumulonimbus (Cb) cloud. There has been detected Mesoscale Convective System (MCS) categorized as squall line type at the north of Lombok on January 27th, 2016 at 6:00 UTC to 19:00 UTC. This research using SATAID which conducted to determine the characteristics of the system in order to perform the better early warning weather. The results of this research is this system has a length of 102 km at 11:27 UTC. Based on the SATAID application, lability of the air in the system can be known. Assessment of air instability done at 13:47 UTC when the air is very unstable, with SSI value of (-0.4)° C. This indicated that the oportunities of thunderstorm was quick. LI value (-3.2)°C qualify as very unstable, severe thunderstorm might occur, KI value of 34.7° C indicates possible TS to grow by 60 - 80 %, a very strong Thunderstorms may occur with SWEAT value of 276. CAPE value in the period of growth 434 k/j and increases dramatically at 13:47 UTC become 855 kg/j. Vertical wind profile indicates wind shear between 400 mb to 300 mb during the mature stage. The wind in the surface layer reaches 33 km/h and categorized as strong winds and could be endangering shipping operational. The graph shows the temperature of the cloud tops of the system during his life time has a temperature $< (-60)^0$ C. The system is formed as the impact of the bigger squall line system on the north coast of Java, Bali and Nusa Tenggara.
Key words: Squall Line, SATAID, Cumulonimbus and Atmosphere Lability

1. Introduction

As the unique country located near the equatorial region called as the Indonesan Maritime Continent (IMC), the sea area of Indonesia larger than the land. Management of marine areas are very important for this nation, and it still needs further development in exploring the role of ocean so we can maximalize the benefit of it. Indonesia has a huge marine resources both in terms of quantity and diversity of the results, and has recently become a major focus of the attention of the State. BMKG is also playing an important rule on it. BMKG contributes for weather information, waves, and tides. According to KBMKG regulation no.009/2010 on the sea early warning of extreme weather, BMKG will issue a warning when in condition of tropical cyclones, gusty, waterspouts, extreme ocean waves, tidal waves, torrential rains, and extreme horizontal visibility[1)].
Strong winds, high waves and heavy rain mostly caused by Cumulonimbus (Cb). Hence the emergence of cumulonimbus should be concerned for the early warning manufacture. On January 27th, 2016 the satellite captured cumulonimbus system that extends from the Java Sea to the top of the island NTB. The Mesoscale Convective System (MCS) categorized as squall line type which grow and affect surrounding environtment.
Weather satellites monitoring the weather and has a high spatial resolution range compared to other tools. This tool able to cover almost the entire surface of the earth including oceans. Sufficiently high temporal resolution of satellite Multi-Functional Transport Satellite (MTSAT) issued a new image every 10 minutes.
This study was conducted to determine the state of the atmospheric condition when the system activated. By analyzing atmospheric conditions, we can expect better weather early warning made by forecaster BMKG and minimize the impact of disasters that may arise.

1.1. *Sattelite Animation and Interactive Diagnosis* (SATAID)

SATAIDS is a software which runs on the Windows operating system, used to process satellite images from MTSAT. SATAID is an application which display the binary data from the satellite into the picture. This application was developed as JMA as a contribution to the World Meteorology Organization (WMO). Currently SATAID has been used as an operational tool in the JMA for daily weather analysis, including tropical cyclone monitoring. The image which will be processed by

SATAID derived from the Multi-Functional Transport Satellite (MT-SAT) which is a multi-functional geostationary satellites for meteorology and aeronautics missions[2].
Some advantages of SATAID such as: (a). Procceed data faster, (b). Able to overlay satellite images with other images, such as: NWP, Synop, METAR, RADAR, recording wind profile, and etc, and (c). Featuring animated image so the physical changes could be known in the cloud over time[3].
NWP data which generated by SATAID include air instability in terms of some indexes such as Showalter Stability Index (SSI), K index, L index, Severe Weather Threat Index (SWEAT), Convective Available Potential Energy (CAPE) and Total Total (TT) Index[4].

1.2. Air Instability Index

Unstable air can cause the formation of convective clouds, causing bad weather. The Lability of air can be demonstrated by looking at some lability index is an algorithm that is designed to evaluate the stability properties of atmospheric vertical sounding[5].
Showalter Stability Index (SSI) is an easy way to calculate the stability of the local atmosphere. Positive value indicates parcel cooler than the environment, so the atmosphere is stable, and vice versa. K Index (KI) is one of the air stability index is calculated using the ambient temperature at layers 850 and 500 mb and dew point temperature on layers 850 and 700 mb. The higher the temperature difference between the layers 850 and 500 mb will create greater value for KI. KI value is used to determine the convection process in units (^{0}C). Total Total Index (TTI) introduced by Miller in 1972 to identify potential areas for the development of thunder storms[6].
SWEAT is used to estimate the potential for bad weather that was obtained from air mass. If there is an index value SWEAT high early in the day, there can be a high index value SWEAT in the afternoon or evening before. Convective Available Potential Energy (CAPE) is the amount of potential energy that can carry air parcels moving up. Also known as the buoyancy of energy, an area in closed thermodynamic diagram by environmental temperature profile and wet adiabat to a level that connects LFC EL with units of Joules/kilogram[7].

1.3. Squall Line

A Mesoscale Convective System (MCS) is an organized group of thunderstorms that produces a contiguous precipitation area measuring 100 km or more in at least one direction. This system grows upscale from convective towers to a convective-stratiform coupled vertical circulation, ultimately meeting its demise as only a stratiform rain region. Tropical convection is most often organized into mesoscale systems, with length scales of 100-1000 km and duration of several hours[8].
A squall line is an Mesoscale Convective System that is linearly-oriented (along a line). Squall lines usually start as cumulonimbus along a low-level convergence boundary then merge and organize upscale to form a single cloud system with large contiguous areas of rain[9]. Squall also is defined as a sudden violent gust of wind or a localized storm, especially one bringing rain, snow, or sleet. Bluestain defines squall line is a area with gusty which orientated lineary[10].
Houze (1977) called tropical squall used for the first time by Hamilton dan Archbold (1945). They deduced that a typical tropical squall line consists of a row of cumulonimbus cloud forming at the edge of a broad downdraft region. They noted that the downdraft region is located under the precipitating trailing anvil cloud which emnates from the cumulonimbus towes and that “a sudden squall from between southeast and northeast” accompanied by a frontal-like temperature drop ypically precedes the downpour of rain from the row of cumulonimbus cloud by just 2 or 3 minute. This squall front is the last warning to take cover and marks the edge of cold downdraft air, which spreads under the warm air ahead of the system and generates the uplift for the line of cumulonimbus clouds[11].
Squall line often formed at the area which has high value of CAPE. Squall line also developt in area convergence activity at the low level and divergence at higher level[12].

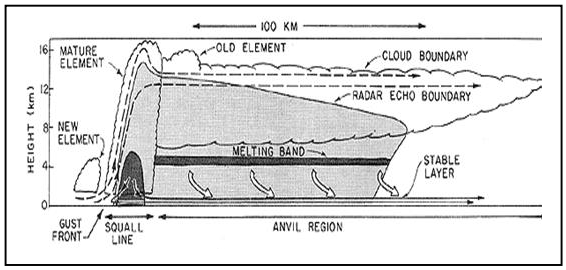

Fig. 1.3.1. Schematic cross section through squall line system[11)]

2. Material and Metodh

This study was conducted in the north of the Bali and Lombok Island. These area become major shipping lanes beetween Bali and Lombok Island and Sulawesi.

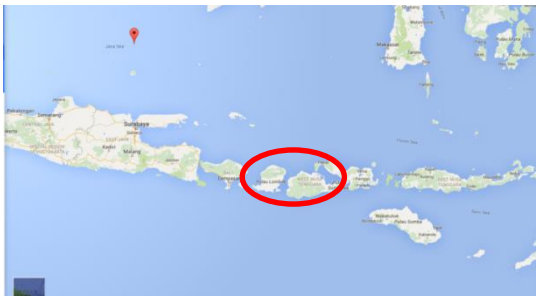

Fig. 2.1. Event Location

In this research, we use of computer hardware and software such as HP computer and SATAID application made by Meteorological Satellite Center JMA and GMSLPW. We use the new MTSAT Satellite in IR channel, called "Himawari Sattellite" image data every 10 minutes on January 27th, 2016 between 06:30 and 18:30 UTC downloaded from ftp://satelit.bmkg.go.id.

3. Result and Discussion

Based on analysis of satellite imagery on January 27th, 2016 the Cumulonimbus (Cb) clouds appeared on north of Bali and Lombok almost throughout the day. With the rapid growing cycle and extinction, these systems lead to bad weather at sea. Mesoscale Convective System in meticulous at 07:00 to 18:30 UTC in the waters north of the island of Java to Lombok indicates of squall line formed after the previous system destroyed.

This system reached the peak phase approximately at 11:27 with a length of 102 km of this system extends towards the west east. Squall line began to enter a period of decay at 19:00 UTC.

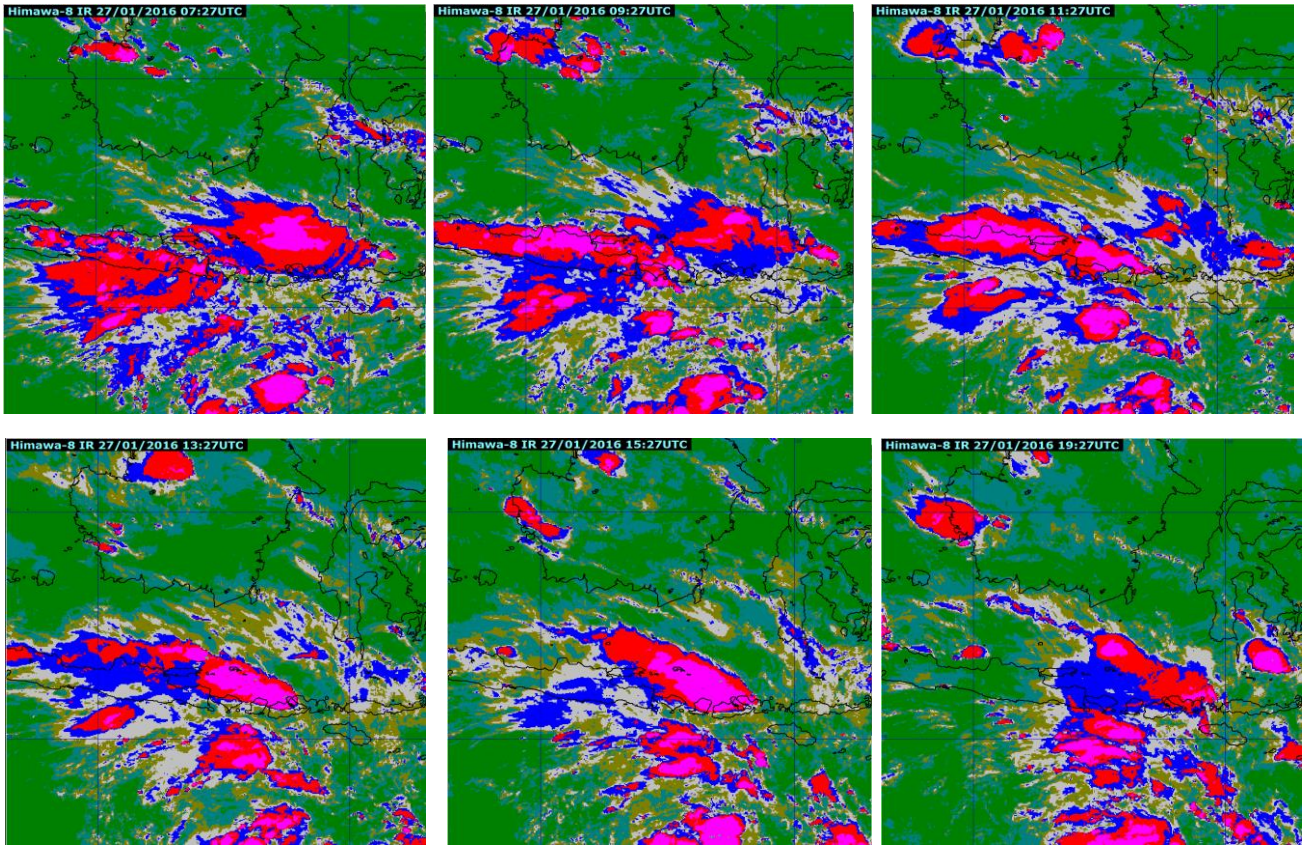

Fig. 3.1. MT-SAT image IR's channel

3.1. Analyze of Atmospheric Condition

The lability of atmosphere data is obtained by using brightness feature on SATAID. The sample taken based on life cycle period Cumulonimbus cloud over the area during Netral, Mature and Decay period.

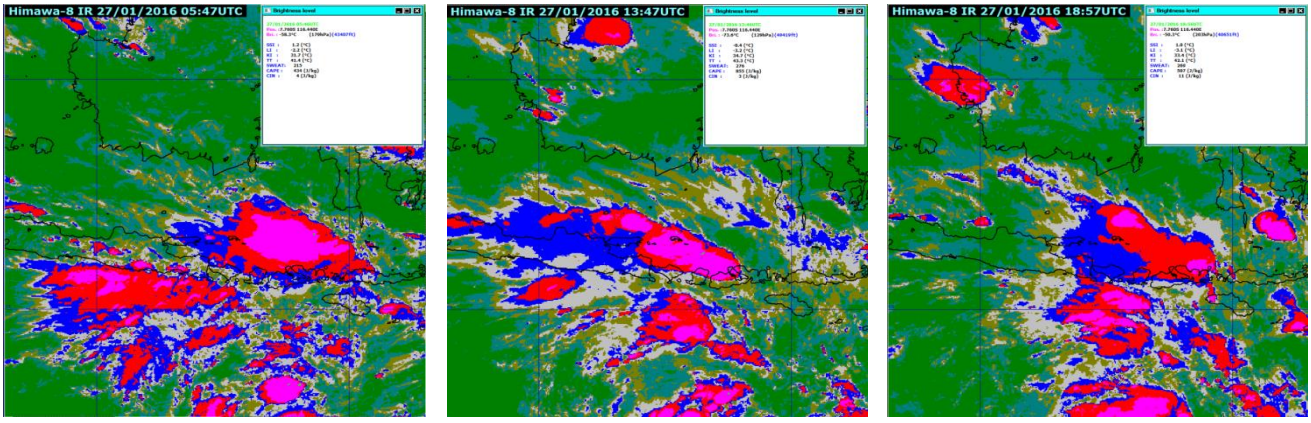

Fig. 3.1.1. Air instability index

Based on the results of software SATAID, then obtained lability index value of air. There are six index that will be discussed , which are SSI, LI, KI, TT, SWEAT and CAPE. Those are an indicator of unstable air. The detail is in the table below.

Tabel 3.1.1. Air instability index

No	Periode	Indeks	Value	Explaination
1	BEFORE SYSTEM FORMED/ NEUTRAL (05.47 UTC)	SSI	1.2 ^{0}C	shower.
		LI	-2.2 ^{0}C	Very unstable,great thundestrom possible
		KI	31.7 ^{0}C	The probability of *thunderstorm*about 60 – 80 %.
		TT	41.4 ^{0}C	Convective
		SWEAT	215	The Cumulus Clous growth
		CAPE	434 k/j	The stability of weak convective
2	MATURE (13.47 UTC)	SSI	-0.4 ^{0}C	Probability of thunderstorm grows rapidly.
		LI	-3.2 ^{0}C	Very unstable,great thundestrom possible
		KI	34.7 ^{0}C	The probability of *thunderstorm*about 60 – 80 %.
		TT	43.3 ^{0}C	Convective
		SWEAT	276	Thunderstorm
		CAPE	855 k/j	The stability of weak convective
3	DECAY (18.57)	SSI	1.0 ^{0}C	shower
		LI	-3.1 ^{0}C	Very unstable, great thundestrom possible
		KI	33.4 ^{0}C	The probability of *thunderstorm*about 60 – 80 %.
		TT	42.1 ^{0}C	Convective
		SWEAT	269	Thunderstorm
		CAPE	507	The stability of weak comvective

SSI in mature period had a significant difference compared to the period neutral and decay. In the mature period, SSI supports thunderstorm chances to grow rapidly. SWEAT Index height when mature and

decay also showed that air lability favor the occurrence of thunder storms. LI and KI value throughout the analysis period may indicate severe thunderstorm that occurs with probability 60-80 %. While the value of TT only range (41.4 - 43.3) goes with convective events. CAPE value indicates only a weak convective stability.
From the six indexes are displayed in the current system has been mature, only CAPE values that does not support the criteria of cumulonimbus, while another index shows instability that led to the growth of air to form cumulonimbus clouds.

3.2 Vertical Wind Profile

NWP SATAID application can be read on the vertical wind profile. The reading of the vertical wind profile will be made based on the time series to see the dynamics of the atmosphere at the time of the cumulunimbus cloud formation.

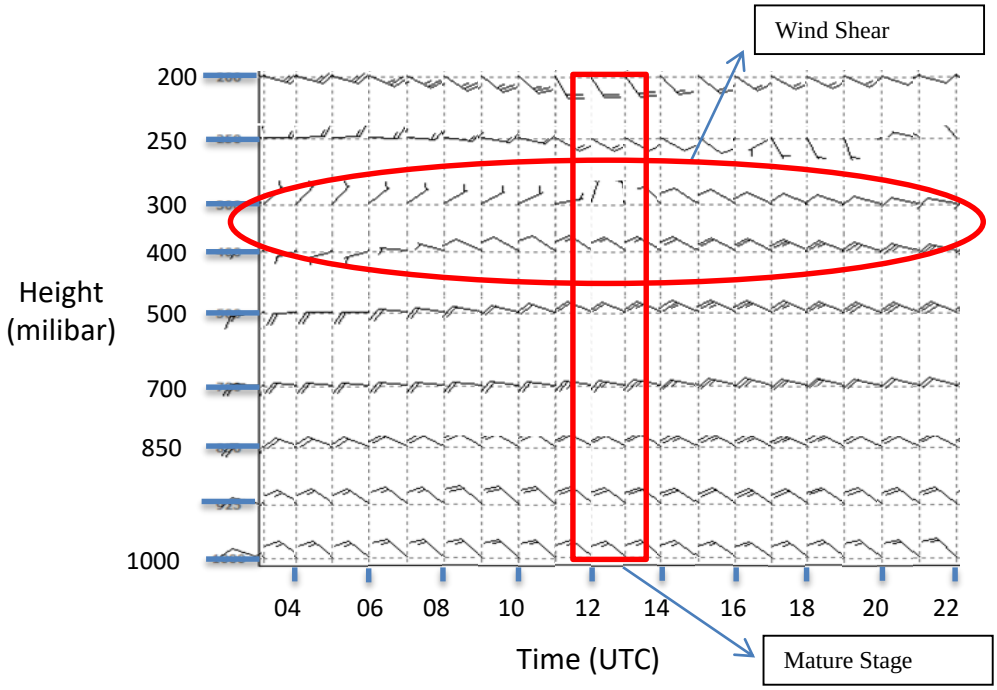

Fig. 3.2.1. Time series of vertical wind profile

From the picture above shows no significant change in either direction and the wind speed at each critical layer at January 27th, 2016. However, there is wind shear between the layers 400 to 300 mb layer where the wind speed and direction changes. Wind at the low level come from the west and contrary with wind direction at the higher level. We can assume convergence activity happen at the low level and pushing up the air mass when the divergence activity at the high level causing anvil spread. The cumulonimbus occupied the sky between 04:00 to 14:00 UTC. The wind in the surface reaches 33 km / s which categorized of strong winds in the world of shipping. The wind can affect the increase of wave height which could be threaten shipping activity.

3.3. Top Cloud Temperature

Temperature of top cloud in SATAID software is based on the brightness of the color produced by the MT - SAT IR channels. The brighter the color indicates the temperature gets colder. And assumed as a Cumulunimbus cloud.

Fig. 3.3.1. Top Cloud Temperatur

The graph above shows the squall line peak temperature decreased starting at 9:00 UTC. At 10:00 UTC the temperature of the cloud tops decreased drastically to - 60^0 C and last until 16:00 UTC.
Generally it can be seen from satellite imagery and chart peak temperature cloud that Cumulunimbus occupied the sky of the north of Bali and Lombok almost along day, and become dense between 11:00 to 16:00 UTC, the system is stable in the area with a temperature of ± (- 80)^{0}C and gradually began 16:00 UTC indicating cumulonimbus clouds began to disappear.

3.4 The TRMM Image as Support Data

Tropical Rainfall Measuring Mission or TRMM is used as the real rainfall data in this research. This kind of data can proof or emphasize the SATAID data. TRMM provides rainfall information with the measurement of the rainfall itself (in milimeter).

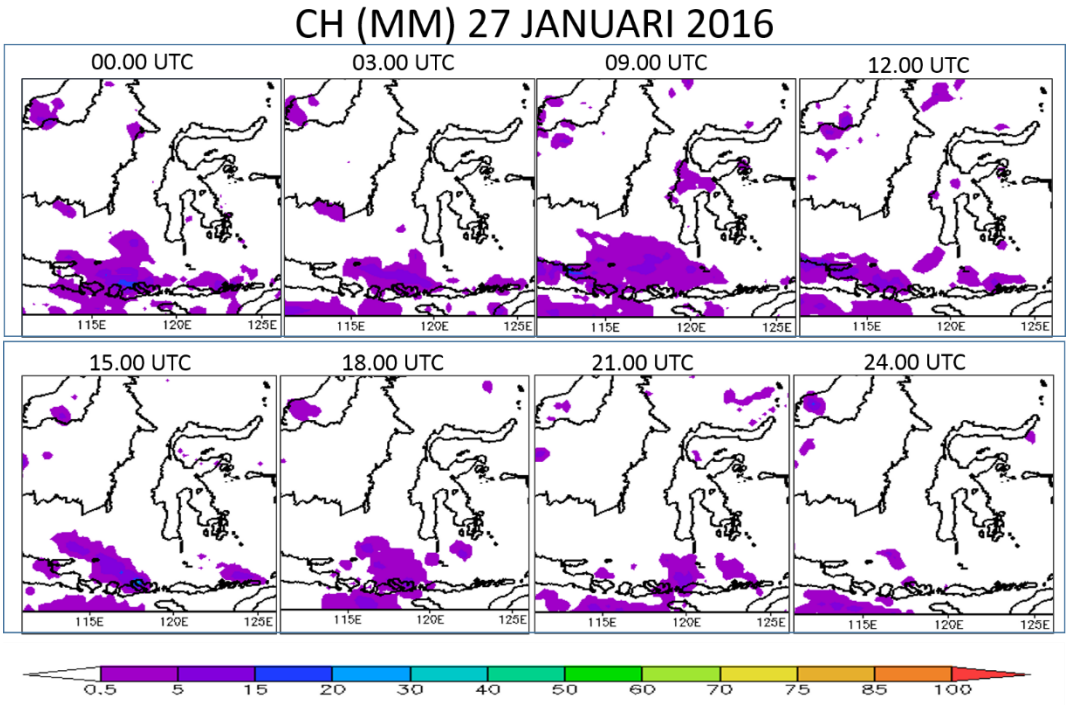

Fig. 3.4.1. TRMM image on January 27th , 2016[13)]

Based on TRMM data on January 27th, 2016 from 00.00 - 24.00 UTC there was a rainfall about 5-20 mm. TRMM data showed us the impact of this system, eventough the validation still needed, but it become clear that this system causing bad weather at the location.

4. Conclusion

MTSAT Satellite imagery is able to monitor the weather conditions very well both on land and at sea with very high spatial resolution every 10 minutes. By using SATAID application, it can be seen atmospheric conditions at the time of bad weather potential that could endanger shipping. Based on analysis of satellite imagery using SATAID, the waters north of Bali and Lombok covered with clouds since the morning and the cloud continues to grow at 7:00 a.m. to 18:30 UTC, and observed as a squall line. The system was composed from a larger system at the Java Sea. This summary atmospheric conditions are analyzed using SATAID:

a. Atmospheric conditions categorized as volatile, with indexes SI, KI, LI, TT, SWEAT supported the formation of convective clouds and causing bad weather.

b. There is a wind shear with the direction changed in 1500 between the 400 mb to 300 mblayer, which occurs until the cumulonimbus decay. The wind shear contribute to support the development of this clouds.

c. Analysis of the temperature of the cloud tops showing at 11:00 to 18:00 UTC, squall line has a cloud Cumulunimbus cloud with ± temperature $(- 80)^0$ C.

Acknowledgements

We appresiates Mr. Alpon Manurung for the generosity give us the Satelit and Numerical Weather Prediction at the event. We also indebt to ISAST committee who giving us this opportunity.

Reference

1) BMKG.: *Prosedur Standar Operasional Pelaksanaan Peringatan Dini, Pelaporan, Dan Diseminasi Informasi Cuaca Ekstrim, Peraturan KBMKG No : Kep 009*, Badan Meteorologi Klimatologi dan Geofisika, 2010.
2) Harsa, H., Linarka, U. A., Kurniawan, R., danNoviati. S,: *Pemanfaatan Sataid Untuk Analisa Banjir Dan Angin Puting Beliung: Studi Kasus Jakarta Dan Yogyakarta. (2011)*, Jurnal Meteorologi Dan Geofisika. Vol. 12. No. 2. Pp. 195- 205
3) Panjaitan, A.: *Pemanfaatan Citra Satelit untuk Informasi Meteorologi Penerbangan.* Jakarta: Materi Diklat Penerbangan, 2012.
4) BMKG.: Manual Sataid. BMKG, Jakarta, 2007.
5) Prawirowardoyo, S.: *Meteorologi*, Institut Teknologi Bandung, Bandung, 1996.
6) Air Weather Service.: *The Use of the Skew T Log P Diagram in Analysis and Forecasting*, Scott Air Force Base, Illinois, 1990.
7) National Weather Service Training Centre.:*The Skew-T Log P Diagram and Sounding Analysis Remote Training Module*, 2000.
8) http://www.meted.ucar.edu/radar/tropical_cases/print_2.htm#page_3.1.0 , downloaded at June 15th 2016.
9) http://www.meted.ucar.edu/tropical/synoptic/trop_MCS/navmenu.php?tab=&page=1.1.0 , downloaded at June 15th 2016.
10) Blustein, B.H., dan Jain, M.H.: *Formation of Mesoscale Lines of Precipitation : Severe Squall lines in Oklahoma during the Spring*, Weather Alert Radar Network, Wellston, 1985.
11) Houze, A.R.: Structure and Dynamic of a Tropical Squall Line System, Monthly Weather Review, Vol 105, 1997.
12) Dewita, A.: *Identifikasi Squall Line Menggunakan Radar Gematronik (Studi Kasus Radar Selaparang, 21 Februari 2015)*, Bachelor's Thesis, 2015.
13) http://pmm.nasa.gov/data-access/download/trmm.