AOMSUC-12

11 - 18 November 2022

Online, Hosted by Japan Meteorological Agency

12th Asia - Oceania Meteorological Satellite Users' Conference

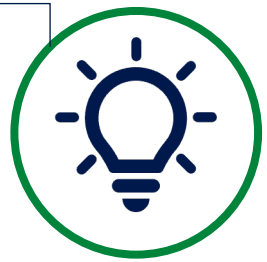
CUMULONIMBUS CLOUD PREDICTION USING *RAPIDLY DEVELOPING CUMULUS AREA* (RDCA) PRODUCTS AT AMBON PATTIMURA AIRPORT

BY: **AYUFITRIYA and RION SUAIB SALMAN**

Indonesian Agency for Meteorology Climatology and Geophysics (BMKG)
State College of Meteorology Climatology and Geophysics (STMKG)

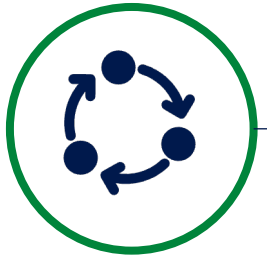
OUTLINE

PRELIMINARY
Background Research, Study Formulation and Scope, Research Objectives, and Benefits



RESEARCH METHODS or PROCEDURES

RESULTS AND ANALYSIS



FUTURE RESEARCH OPPORTUNITIES

REFERENCES

Oleh: Ayufitriya

Background Research

Weather & **Aviation**

- ***Air transportation*** has become the **main mode** of transportation (Dharmawan, 2012; Ricardianto, 2017) in Indonesia, which is an archipelago country.
- **Flight delays,** one of which is the weather, might disrupt the efficient operation of air travel. (Dermadi, 2019; Dissanayaka, et al., 2018) closely related to ***Cumulonimbus (Cb)*** cloud growth (Tuomola, 2021; Metoffice, 2015) such as, heavy rain, lightning, and thunderstorms.
- The increasing intensity of Cb cloud growth is the impact of **Climate Change** (Brosky, 2019; CAPA, 2019)
- **Aviation meteorological information** helps in flight efficiency and safety (Wirjohamidjojo, 2007; Schlultz et al, 2018). To assist the efficient flow of flight traffic and reduce potential impacts, remote sensing instruments such as **weather satellites and radar** must be used as early Cb cloud detection.
- ***Rapidly Developing Cumulus Area (RDCA) products*** has big potential to be optimized, and it can be used to identify Cb clouds using the results of **spatial analysis** of radar data**.** (Harjupa et al, 2022)

STUDY FORMULATION

How accurate is the RDCA product in predicting the occurrence of cumulonimbus clouds in the Ambon Airport area?

PROBLEM SCOPE

1. **The Ambon Pattimura Airport region's jurisdiction**
2. **RDCA** product data
3. Weather radar **as verification**, as well as surface observation data from the Ambon Pattimura Meteorological Station (***Ground Truth***), with geographic coordinates: 3°42' S dan 128°05’ E

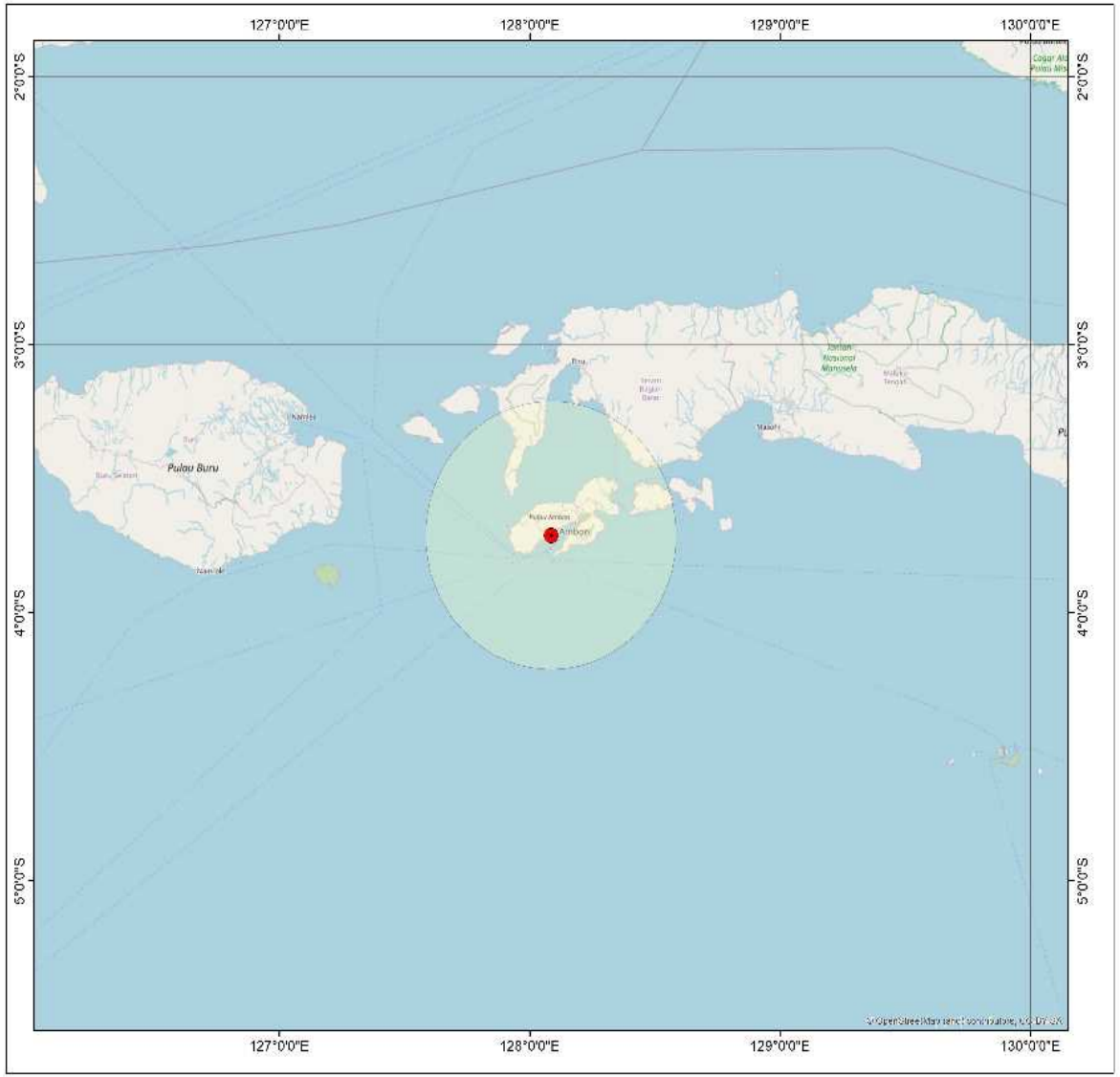
RESEARCH OBJECTIVES

Optimizing the RDCA product so that it can be operationally useful in the future, especially in **aviation meteorology**, one way is to know in advance how much accuracy the RDCA product is when applied in the Ambon Pattimura Airport area, then spatially can present it in the form of a map.

RESEARCH BENEFITS

To get the **accuracy value** of the RDCA application in the Pattimura Airport Ambon area and adjust the results of the research into a **map** so that it is more informative. It can be used as the basis for **nowcasting** considerations, in this case it is a **practical use from an operational perspective** on flights.

Oleh: Ayufitriya



PETA LOKASI PENELITIAN

Insert:

N
W
E
S

Skala:

10 5 0 10 20 30 40
Miles

Legenda:

- Ambon CTR ZONE
- 30 NM from AMN VOR

Nama: Ayufitriya
NPT: 14.21.0004

Sumber data:
- Basemap: OpenStreetMap
- Area: AIP; Indoavis (2022)
- Perangkat lunak: ArcGIS (10.8.1)

RESEARCH PROCEDURES

Research area -> 30 nm / 55,56 km radius from "AMN" VOR, (3º 36' 53,71'' LS dan 128º 11' 09,82'' BT) which is called the ***Ambon Control Zone*** (AMBON CTR) (AIP, 2021; Indoavis, 2021).

Research period -> **July and December 2021**
50 samples of Cb cloud events detected by weather radar

Oleh: Ayufitriya

Verification

dichotomous method

Contingency table schematic

		Observation		
		Yes	No	Total Forecast
Forecast	Yes	a	b	a + b
	No	c	d	c + d
	Total Observation	a + c	b + d	a+b+c+d = n

a → **HITS** represent the RDCA location where in the next 0 – 50 minutes there is a radar image with a value of ≥ 35 dBZ.

b → **FALSE ALARMS**

c → **MISSES**

d → **CORRECT NEGATIVES**

Evaluation of convective initiation nowcasting ability is quantified using categorical prediction scores **(Proportion Correct, Probability of Detection, False Alarm Ratio, Frequency Bias, and Critical Success Index (CSI)).**

Results and Analysis

JULY 2021

		Observation		
		Yes	No	Total Forecast
Forecast	Yes	996	853	1849
	No	1196	8990	10186
	Total Observation	2192	9843	12035

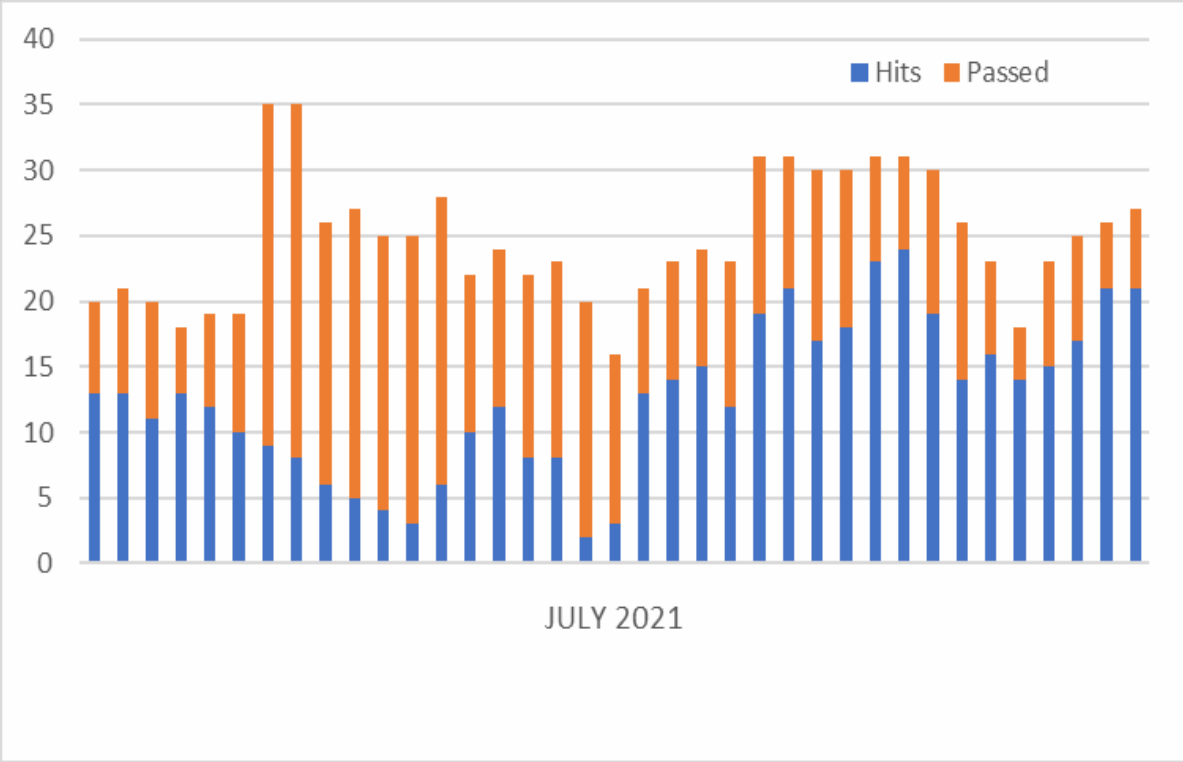
Proportion Correct	PC	0.83
Hit Rate / POD	POD	0.45
False Alarm Ratio	FAR	0.46
Frequency Bias	B	0.84
Threat Score	TS/CSI	0.33

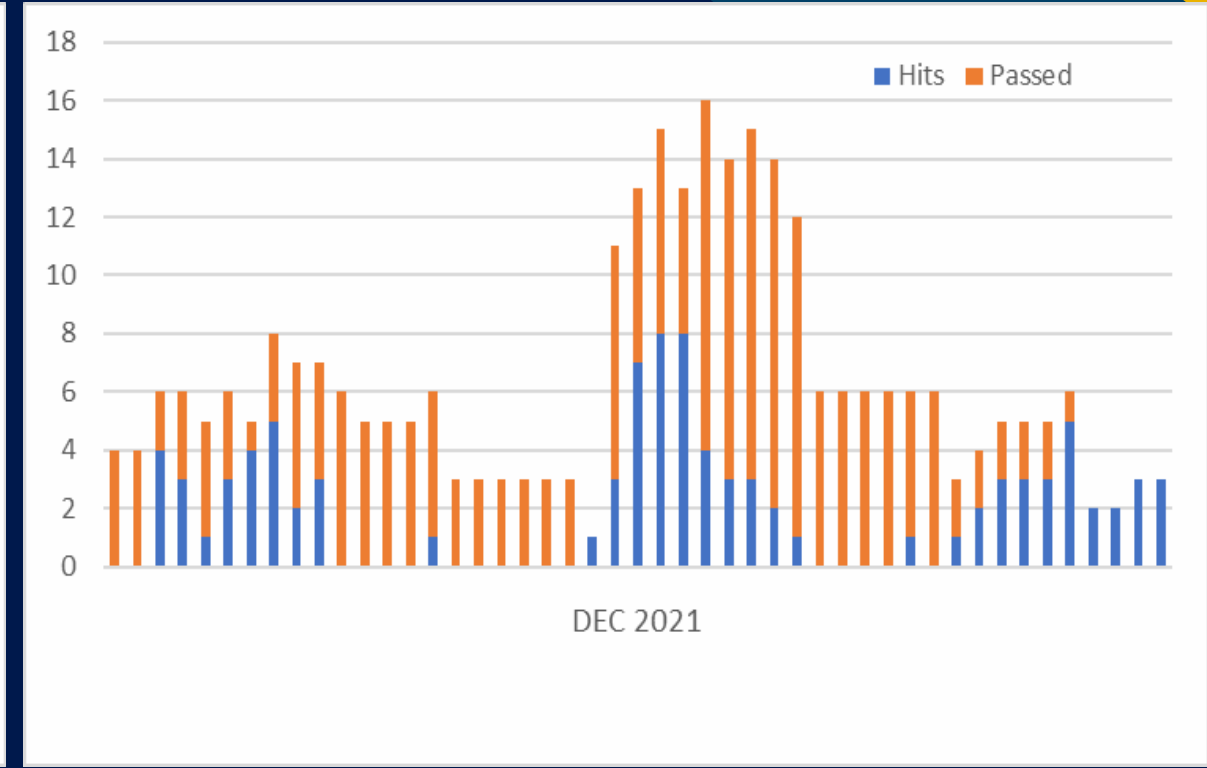
DECEMBER 2021

		Observation		
		Yes	No	Total Forecast
Forecast	Yes	96	329	425
	No	279	11340	11619
	Total Observation	375	11669	12044

Proportion Correct	PC	0.95
Hit Rate / POD	POD	0.26
False Alarm Ratio	FAR	0.77
Frequency Bias	B	1.13
Threat Score	TS/CSI	0.14

Results and Analysis

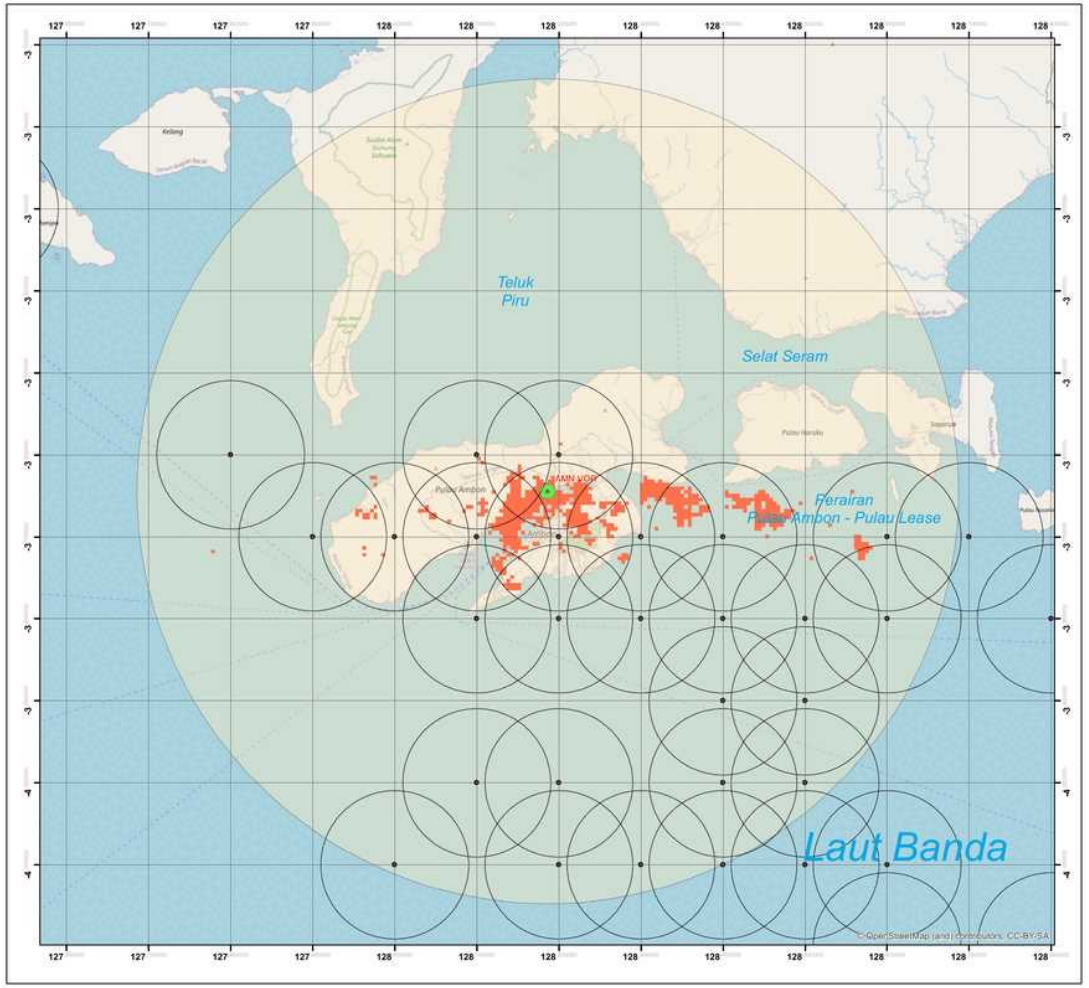




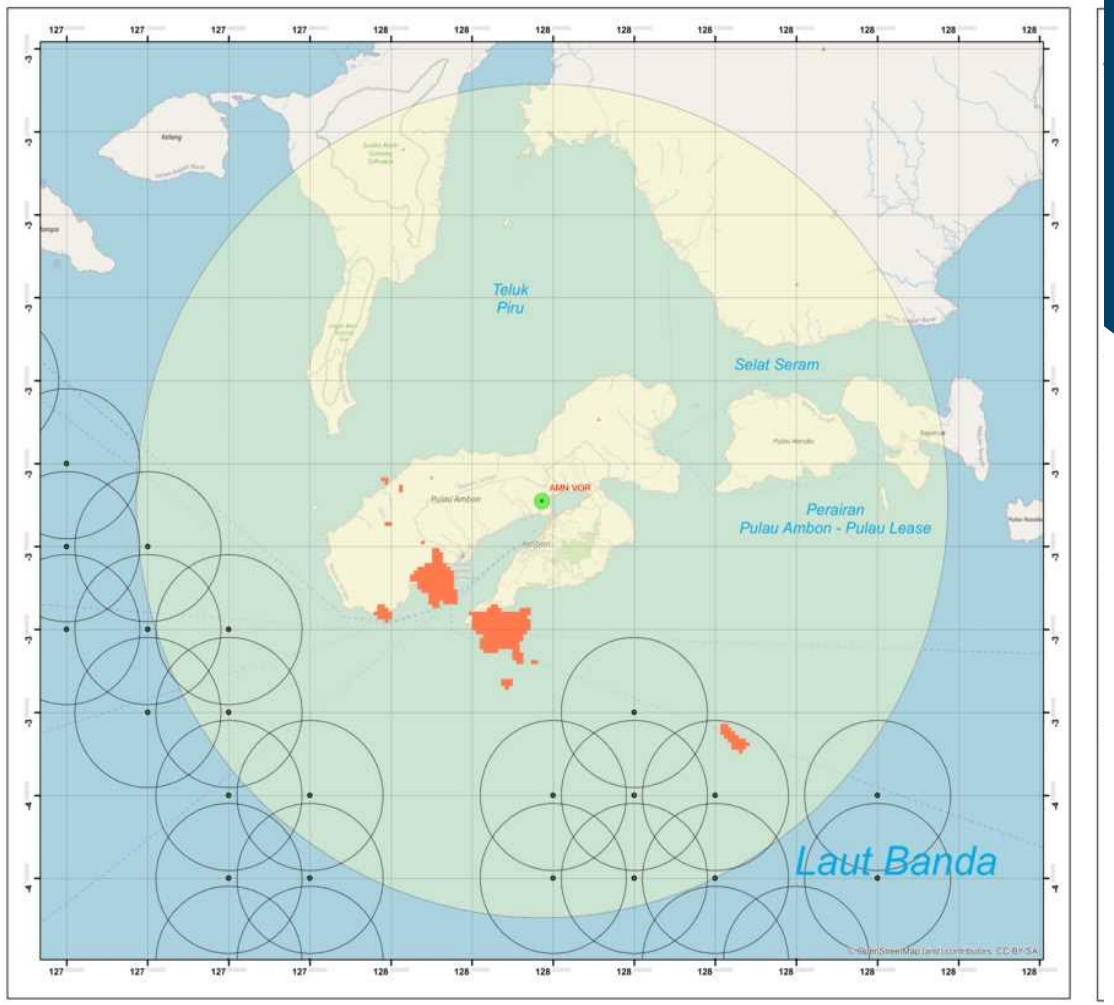
Number of **hits** and **passed** during July and December 2021

Predictive value is obtained by divided number of hits by sum of number of hits and passed (Sobajima, 2012).
Predictive value **was 0.51 in July and 0.31 in December.**

Animated Example Data



9 July 2021 (20.00-20.50 UTC)



25 December 2021 (10.00-10.50 UTC)

FUTURE RESEARCH OPPORTUNITIES

- Optimizing the verification methods using **coding and programming languages**
- Research in other months according to the **season**, with a longer time period
- Considering observational error and parallax correction, by remapping/expanding the grid

Acknowledgements

The researchers would also like to express our deep and sincere gratitude for JMA, Vaisala, BMKG HQ for the data and resources. To our research advisers, Dr. Giarno, Dr. Yahya Darmawan, and Imma Redha, M.Si, for providing us invaluable supervision and support during the course of our research study.

References

AIP, 2021, *Aerodrome Chart of WAPP Ambon/Pattimura AIRAC AMDT 07 Oct 21*, Aeronautical Information Publication Vol. II, Directorate General of Civil Aviation, Indonesia.

Ali, A., Adrianto, R., dan Saepudin, M., 2019, Preliminary Study of Horizontal and Vertical Wind Profile Of Quasi-Linear Convective Utilizing Weather Radar Over Western Java Region, Indonesia. *International Journal of Remote Sensing and Earth Sciences*, Vol.15, No.2, pp 177-186.

Ali, A., 2020, *Ekstrak Data Radar VAISALA (Single Pol)*, diunduh dari laman http://wxradarexplore.com/2020/06/22/ekstrak-data-radar-vaisala-single-pol/.

Ali, A., Supriatna, Sa'adah, U., 2021, Radar-Based Stochastic Precipitation Nowcasting Using The Short-Term Ensemble Prediction System (STEPS) (Case Study: Pangkalan Bun Weather Radar), *International Journal of Remote Sensing and Earth Sciences*, Vol.18, No.1, pp 91-102.

Antonescu, B., Burcea, S., dan Tanase, A., 2012, Forecasting The Onset Of Cloud-To-Ground Lightning Using Radar And Upper-Air Data In Romania, *International Journal of Climatology*, Vol.33, No.6, pp 1579-1584.

Banuara, S., Purba, J.T., 2017, Analysis Of The Aviation Industry In Indonesia Period 2003-2015 Based On Domestic Passenger Growth And The Strategic Implication For Airlines And Government, *Jurnal Manajemen dan Pemasaran Jasa,* Universitas Pelita Harapan.

Bessho, K., Date, K., Hayashi, M., Ikeda A., Imai, T., Inoue, H., Kumagai, Y., Miyakawa, T., Murata, H., Ohno, T., Okuyama, A., Oyama, R., Sasaki, Y., Shimazu, Y., Shimoji, K., Sumida, Y., Suzuki, M., Taniguchi, H., Tsuchiyama, H., Uesawa, D., Yokota, H., Yoshida, R., 2016, An Introduction to Himawari-8/9 – Japan's New-Generation Geostationary Meteorological Satellites, Journal of the Meteorological Society of Japan, Vol. 94 No.2, Meteorological Society of Japan.

Byers, H.R., dan Braham, R.R., 1948, Thunderstorm Structure and Circulation, Journal of Atmospheric Sciences, Vol. 5, no.3, pp 71-86, American Meteorological Society.

CAPA, 2019, Climate Change: Its Impact On Aviation, diunduh dari laman https://centreforaviation.com/analysis/reports/climate-change-its-impact-on-aviation-the-time-to-plan-is-now-454475.

Capozzi, V., Montopoli, M., Mazzarella, V., Marra, A.C., Roberto, N., Panegrossi, G., Dietrich, S., Budillon, G., 2018, Multi-Variable Classification Approach for the Detection of Lightning Activity Using a Low-Cost and Portable X Band Radar, Journal of Remote Sensing, Vol.10, pp 1-26.

Oleh: Ayufitriya

References

Clements, N.C., 2007, The Warning Time For Cloud-To-Ground Lightning In Isolated, Ordinary Thunderstorms Over Houston, Texas, Thesis, Atmospheric Sciences, Texas University.

Cristani, M., Domenichini, F., Olivieri, F., Tomazzoli, C., Zorzi, M., 2018, It Could Rain: Weather Forecasting As A Reasoning Process, Proceeding of Computer Science, Vol.126, pp 850-859, Elsevier Masson SAS.

Dance, S., Ebert, E., dan Scurrah, D., 2010, Thunderstorm Strike Probability Nowcasting, Journal of Atmospheric and Oceanic Technology, Vol. 27, pp 79-93.

Davey, M.J., dan Fuelberg, H.E., 2017, Using Radar-Derived Parameters To Forecast Lightning Cessation For Nonisolated Storms, Journal of Geophysical Research: Atmospheres, Vol. 122, Issue 6, pp 3435-3456.

Delobbe, L., dan Holleman, I., 2006, Uncertainties In Radar Echo Top Heights Used For Hail Detection, Journal Meteorological Applications, Vol 13, No.4, pp 361-374, Royal Meteorological Society.

Donavon, R.A., dan Jungbluth, K.A., 2007, Evaluation of a Technique for Radar Identification of Large Hail across the Upper Midwest and Central Plains of the United States, Journal Weather and Forecasting, Vol.22, pp 244–253.

Ebert, B., 2009, Methods for Verifying Spatial Forecasts, International Verification Methods Workshop, Helsinki.

Fatchiyah, I., 2017, Analisis Dampak Delay Yang Terjadi Pada Runway, Apron Dan Ruang Udara Terhadap Operasional Pesawat (Studi Kasus: Bandara Internasional Juanda), Tesis, Institut Teknologi Sepuluh November.

Gamache, J.F., dan Houze R.A., Mesoscale Air Motions Associated with a Tropical Squall Line, Monthly Weather Review, Vol. 110 No.2, pp 118–135, American Meteorological Society.

Gonz´alez-Arribas, D., Soler, M., Sanjurjo-Rivo, M., Kamgarpour, M., Simarro, J., 2019, Robust Aircraft Trajectory Planning Under Uncertain Convective Environments With Optimal Control and Rapidly Developing Thunderstorms, Journal of Aerospace Science and Technology, Vol. 89, pp 445-459, Elsevier Masson SAS.

Griffith, C.G., Woodley, W.L., Grube, P.G., Martin, D.W., Stout, J., Sikdar D.N., 1978, Rain Estimation From Geosynchronous Satellite Imagery-Visible and Infrared Studies, Monthly Weather Review,Vol. 106, pp 1153-1171, American Meteorological Society.

Oleh: Ayufitriya

References

Harjupa, W., Nakakita, E., Sumida, Y., Masuda, A., 2018, Trial Utilization of Rapid Scan Observation of Himawari-8 for Obtaining Information on Cumulus Life Stage, Journal of Hydraulic Engineering, Vol. 74, no. 5 pp 283-288, Japan Society of Civil Engineers.

Harjupa, W., Nakakita, E., Sumida, Y., Masuda, A., 2019, The Utilization of Rapid Scan Observation Data Through Rapid Development Cumulus Area Index to Estimate Updraft, DPRI Annuals Meeting, no. 62 B pp 554-559, Japan Disaster Prevention Research Institute.

Harjupa, W., Nakakita, E., Sumida, Y., Masuda, A., 2019, RDCA Index Based Updraft Area and Its Verification Using Polarimetric Doppler Radar, Journal of Hydraulic Engineering, Vol. 75, no. 2 pp 127-132, Japan Society of Civil Engineers.

Harjupa, W., Abdillah, M.R., Azura, A., Putranto, M.F., Marzuki, M., Nauval, F., Risyanto, Saufina, E., Jumianti, N., Fathrio, I., 2022, On the utilization of RDCA method for detecting and predicting the occurrence of heavy rainfall in Indonesia, Journal of Remote Sensing Applications: Society and Environment, pp 1-14, Elsevier Masson SAS.

Haryani, N.S., 2017, Potensi Pemanfaatan Data Satelit Himawari, Jurnal Berita Dirgantara, Vol.18, no. 2 pp 93-98, Lembaga Penerbangan dan Antariksa Nasional.

Hidayah, Q.A., Bimaprawira, A.K., Yulitamora, N.R., Nugraheni, I.R., Deranadyan, G., 2019, Identifikasi Karakteristik Awan Penyebab Hujan Lebat Pada Musim Kemarau Dan Musim Hujan Di Jambi (Studi Kasus : Juni dan November 2017), Prosiding, Seminar Nasional Geotik, pp.185-195.

Hondl, K.D., dan Eilts, M.D., 1994, Doppler Radar Signatures of Developing Thunderstorms and Their Potential to Indicate the Onset of Cloud-to-Ground Lightning, Monthly Weather Review, Vol.122, pp 1818–1836, American Meteorological Society.

Indoavis, 2021, Airspace Ambon Aerodrome Traffic Zone, Jakarta, diunduh dari laman http://indoavis.co.id/main/search.php?sid=&rSearch=AIRSPC&obj=an&tKeyword=AMBON%20ATZ

Jatmiko, D.T.W., Efendi, U., Kristianto, A., Zakir, A., 2018, Prosiding, Pemanfaatan Data Radar Cuaca C-Band dan Satelit Himawari- Untuk Identifikasi Hujan Lebat (Studi Kasus Tanggal 20 Februari 2017 di Lanud Halim Perdana Kusuma), Seminar Nasional Penginderaan Jauh ke-5 Tahun 2018.

JMA, 2015, Himawari-8/9 Standard Data User's Guide, Japan Meteorological Agency, Jepang.

Oleh: Ayufitriya

References

JMA, 2018, Summary Report Technical Meeting on Himawari-8/9 Rapidly Developing Cumulus Area (RDCA) product, Japan Meteorological Agency, Jepang.

Jolliffe, I. T., dan Stephenson, D. B., 2012, Forecast Verification : A Practitioner's Guide in Atmospheric Science Second Edition, United Kingdom, John Willey & Sons.

Karttunen, H., Koistinen, J., Saltikoff, dan Manner, E., Olli, 2001, Ilmakehä ja sää (3 edition.), Suomalaisen säätiedon perusteos, Ursa, Finlandia.

Kulesa, G., 2003, Weather And Aviation: How Does Weather Affect The Safety And Operations Of Airports And Aviation, And How Does FAA Work To Manage Weather-Related Effects?, Prosiding, Conference on the Potential Impacts of Climate Change on Transportation, Washington DC.

Mecikalski, J.R., Bedka, K.M., 2006, Forecasting Convective Initiation By Monitoring The Evolution Of Moving Cumulus In Daytime GOES imagery, Monthly Weather Review, Vol. 134, pp 49–78, American Meteorological Society.

Okabe, I., Imai, T., dan Izumikawa, Y., 2011, Detection of Rapidly Developing Culumus Areas through MTSAT Rapid Scan Operation Observation, Meteorological Satellite Center Technical Note, no.55 pp 69-90, Japan Meteorological Agency.

Oo, K. T., dan Oo, K. L., 2022, Analysis of the Most Common Aviation Weather Hazard and Its Key Machanisms over the Yagon Flight Information Region, Journal Advances in Meteorology, Vol. 2022, pp 1-15, Hindawi.

Pandjaitan, B.S., Rachmawati, A., Hidayat, R., Wirahma, S., Vahada, A.D., 2019, Pemanfaatan Skema Daytime Microphysics RGB Himawari 8 untuk Mendeteksi Awan Cumulus Potensial dalam Kegiatan Teknologi Modifikasi Cuaca, Jurnal Sains dan Teknologi Modifikasi Cuaca, Vol. 20, pp 91-103, Badan Pengkajian dan Penerapan Teknologi.

Peraturan Kepala Badan Meteorologi Klimatologi dan Geofisika No.9, 2014, Uraian Tugas Stasiun Meteorologi, pp. 7.

Peraturan Kepala Badan Meteteorlogi dan Geofisika Nomor: SK.38/KT.104/KB/BMG-2006, 2006, tentang Tata Cara Tetap Pelaksanaan Pengamatan, Penyandian, Pelaporan dan Pengarsipan Data Meteorologi Permukaan.

Perdana, I.F.P., dan Septiadi D., 2021, An Assessment of Convective Initiation Nowcasting Algorithm within 0-60 Minutes using Himawari-8 Satellite. Proceeding of the Second International Conference on Tropical Meteorology and Atmospheric Sciences, IOP Conference Series: Earth and Environmental Science, Vol. 893, Jakarta.

Oleh: Ayufitriya

References

Putri, A.R., Hearttiana, V., Kristianto, A., Suyatim, 2018, Evolusi Awan Cumulonimbus Saat Hujan Lebat Berbasis Citra Satelit Cuaca dan Stabilitas Atmosfer (Studi Kasus Longsor Banjarnegara), Seminar Nasional Penginderaan Jauh ke-5, pp 729-737, Lembaga Penerbangan dan Antariksa Nasional.

Roberts, R. D., dan Rutledge, S., 2003, Nowcasting storm initiation and growth using GOES-8 and WSR-88D data, Journal Weather and Forecasting, Vol.18 No.4, pp 562–584.

Rodriguez-Sanz, A., Cano, J., Fernandez, B.R., 2021, Impact of Weather Conditions on Airport Arrival Delay and Throughput, Proceeding of the EASN 2020 : 10th EASN International Conference on Innovation in Aviation & Space to the Satisfaction of the European Citizens, IOP Conference Series: Materials Science and Engineering, Vol. 1024 No.1, pp 1-8, Italia.

Rogers, R.R., dan Yau, M.K., 1976, A Short Course in Cloud Physics, Oxford: Elsevier's Science and Technology.

Sanggyun, L., Hyangsun, H., Jungho, I., Eunna, J., Myong-In, L., 2016, Detection Of Deterministic And Probabilistic Convective Initiation Using Himawari-8 Advanced Himawari Imager Data, Journal of Atmospheric Measurement Techniques, Vol. 308, pp 1-38, European Geosciences Union.

Schultz, M., Lorenz, S., Schmitz, R., Delgado, L., 2018, Weather Impact on Airport Performance, Journal Aerospace, Vol.5 Issue.4, pp. 1-19, Multidisciplinary Digital Publishing Institute.

SELEX, 2013, Software Manual Rainbow 5 Product & Algorithms, SELEX SIGmbH, Germany.

Siyoto, S., dan Sodik, M. A., 2015, Dasar Metodologi Penelitian, Literasi Media Publishing, Yogyakarta.

Sobajima, A, 2012, Rapidly Developing Cumulus Areas Derivation Algorithm Theoretical Basis Document, Meteorological Satellite Center, Japan Meteorological Agency, Japan.

Sugiyono, 2009, Metode Penelitian Pendidikan, Alfabeta, Bandung.

Sumida, Y., Suzue, H., Imai, T., Sobajima, A., 2016, Convective Cloud Information Derived from Himawari-8 Data, Meteorological Satellite Center Technical Note, no. 62 pp 20-37, Japan Meteorological Agency.

Sumida, Y., dan Suzue, H., 2017, Convective Cloud Detection Product Derived from Himawari-8/9 Rapid Scan Observation, Proceeding of European Conference on Severe Storms, Pula Croatia.

Oleh: Ayufitriya

References

Suzue, H, 2016, Detection Of Rapidly Developing Cumulus Areas From Himawari-8 Data, Meteorological Satellite Center, Japan Meteorological Agency, Jepang.

Tan, S.Y., 2014, Meteorological Satellite Systems, International Space University, Springer.

Tuomola, L., 2021, Cumulonimbus cloud detection with weather radar at Helsinki-Vantaa Airport, Thesis, Master's Programme in Atmospheric Sciences Meteorology, Faculty of Science, University of Helsinki.

Valk, P.D., Westrhenen, R.V., 2011, The Implementation Of Automated Cb-Tcu Detection, Royal Netherlands Meteorological Institute, Ministry of Infrastructure and the Environment.

Voormansik, T., Rossi, P.J., Moisseev, D., Tanilsoo, T., Post, P., 2017, Thunderstorm Hail And Lightning Detection Parameters Based On Dual-Polarization Doppler Weather Radar Data, Journal Meteorological Applications, Vol 24, pp 521-523, Royal Meteorological Society.

Wahyudi P.P, dan Rani N.A., 2016, Analisis Kondisi Atmosfer Pada Kejadian Hujan Lebat Di Ambon Tanggal 29 Juli 2016, Prosiding Seminar Nasional Fisika dan Aplikasinya, Universitas Padjajaran.

Walker, J.R., Mackenzie, W.M.Jr., Mecikalski, J.R., Jewett, C.P., 2012, An Enhanced Geostationary Satellite-Based Convective Initiation Algorithm For 0-2-H Nowcasting With Object Tracking, Journal of Applied Meteorology and Climatology, Vol.51 No.11, pp 1931–1949, American Meteorological Society.

Wang, F., Bi J., Xie, D., Zhao, X., 2022, Flight delay forecasting and analysis of direct and indirect factors, Journal of Intelligent Transport System, pp 890–907, The Institution of Engineering and Technology, John Willey & Sons.

Wirjohamidjojo, S. dan Budiharjo, S., 2007, Praktek Meteorologi Penerbangan, Badan Meteorologi dan Geofisika, Jakarta.

WMO, 1956, International Cloud Atlas, Vol. 1, World Meteorological Organization.

WMO, 1975, Manual on The Observation of Clouds and Other Meteors No. 407, International Cloud Atlas, World Meteorological Organization.

Zhang, G., 2016, Weather Radar Polarimetry, Crc Press.

Oleh: Ayufitriya

Thank you!

Ayufitriya – Pattimura Meteorological Station

+6281240254523

rindyu@gmail.com I ayufitriya@bmkg.go.id