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Research Paper

Turbulence Motion Model Analysis around Airport Runway

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ABSTRACT: *In this paper, the simulation the models of forecasting based convective cloud growth events are necessary to understand the anomaly symptoms of the atmosphere. This research solve a problem, we propose a method that can analyze convective cloud with Weather Research and Forecasting (WRF) model. The potential of turbulence then needed turbulence index like Richardson Number (Ri). The Richardson Number Index (Ri) takes into account the value of Vertical Wind Shear and the stability of the air. This causes Ri to be considered ideal for describing Clear Air Turbulence (CAT). In this study, the negative Ri results tend to experience mild turbulence due to atmospheric conditions with Ri < 0.25 has a great chance of turbulence.*

KEYWORDS: *Richardson Number, Turbulence, anomaly atmosphere, WRF Model, CAT*

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I. INTRODUCTION

Natural disasters now often occur in Indonesia, especially in terms of atmospheric anomalies. The aircraft accidents are caused by extreme convective cloud growing in other name the Cumulonimbus (Cb) clouds **[1] [2].** The BMKG indicates that this severe level of turbulence in Indonesia is due to a combination of waves in the Bukit Barisan Mountains in Southern Sumatra and Cb clouds around the flight path of the aircraft number EY-474. Three days later, on May 7, 2016, it was the turn of the Hongkong Airways HX-6704 aircraft which experienced turbulence at an altitude of about 41 thousand feet above sea level. This incident resulted in 3 people seriously injured and over 17 passengers suffered minor injuries. Based on documentation from averald.com turbulence occurred in the West Bangka Belitung. Turbulence took place about 45 minutes before landing at Soekarno Hatta Airport for 23 seconds which left 31 people injured and the plane continued its journey until it landed at Soekarno Hatta Airport. Turbulence in the world of aviation is generally common. However, strong turbulence occurs suddenly and can endanger passengers and crew.

In this research with entitled Potential Turbulence in Air Asia QZ 8501 The Aircraft Accident Events by Vahada, analyzed meteorologically related atmospheric conditions at the scene and potential turbulence by using MTSAT satellites. The value of the Ri index obtained is above 100 which indicates the potential for strong shocks at the location around the event. The TI1 index shows the values (2 - 4) $\times 10^{-7}s^{-1}$, this shows the potential for mild turbulence. While the TI2 index is worth (5 – 10) $\times 10^{-7}s^{-1}$ which indicates that the turbulence is moderate to strong **[3].**

In the study of Ellrod and Knapp (1992) the Richardson Number (Ri) index was used to determine the intensity of CAT. However, from the results of his research stated that turbulence can occur when Ri> 0.25 **[4].** As for Jeager (2007), the turbulence index (IT) is better able to detect CAT events than the Richardson Number (Ri). However, in previous studies on CAT analysis using WRF-ARW in Indonesia which is an area with active convective cloud growth showed that the Richardson Number turbulence index is suitable for detection in tropical regions with a Ri value of more than 150 which indicates a fairly strong turbulence **[5].**

In this paper will be conducted research on the calculation of turbulent events by analyzing the Richardson index, some articles as above have not specifically discussed.

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II. EXPERIMENT DETAIL

The method is used in this research are:

2.1. WRF Model Analysis Method:

a. Flight data for from Batik Air with ID number 6890 that uses Boeing 737-800 NG aircraft on October 24, 2017 the website address http://flightradar24.com.

b. Himawari 8's infrared 1 (IR1) and visible (VIS) satellite imagery data and GOES infrared (IR) channel obtained through the Japan Weather Kochi University Homepage as supporting data to see the condition of virginity around the research area. Satellite image data used on October 24, 2017.

c. Final Analysis Data (FNL) as the initial input of the WRF model from the National Center for Atmospheric Research (NCEP-NCAR). FNL data is available per 6 hours and can be downloaded through the website address http://rda.ucar.edu.Data used on October 24, 2017s.

2.2. Data needed in this research are:

a. Observation Data:

Data of Himawari 8 and GOES infrared (IR) infrared 1 (IR1) and visible (VIS) channel satellite imagery obtained through Japan's Weather Kochi University Homepage as supporting data to see the conditions of flocks around the study area. The satellite image data used on October 24, 2017.

b. Model Data:

Data Final Analysis (FNL) as the initial input of the WRF model from the National Centre for Atmospheric Research (NCEP-NCAR). FNL data is available every 6 hours and can be downloaded via the website address http://rda.ucar.edu.Data used on October 24, 2017..

c. WRF Preprocessing System (WPS)

WPS performs all preprocessing data needed to numerically integrate WRF (domain definition) which produces terrain, landuse, type soil, and other data in the domain. WPS is governed by the user definition namelist called namelist.wps. WPS consists of three programs:**[7].** Geogrid aims to provide domain simulations (size, location, and resolution), propose geographic data to be used (30 seconds to 2 minutes), choose map designs (lambert comformal, polar stereography, mercator, lat / lon). The input file needed to run geogrid **[8].** The data input for WRF in addition to WRF-ARW running data (Advance research WRF) or the WRF-NMM (Non hydrostatic mesoscale model) also uses observed observations of top surface and air data and uses satellite observation data and makes it possible to use weather radar observation data, called assimilation data**[9].** Ungrib to read GRIB files, do degribs and save data in a simple format called intermediate format.Input and Metgrid aims to interpolate external meteorological data (grib files, in formal FSWs through an ungrib program) to provide horizontal grib points. The interpolated metgrid results are used in the real WRF program. **[10], [11].**

III. EQUATIONS AND ALGORHTM TURBULENCE MOTION

To determine the potential for turbulence, a turbulence index such as the Richardson Number (Ri) is needed. The Richardson Number Index (Ri) takes into account the value of Vertical Wind Shear and stability of air. This causes Ri to be considered ideal for describing Clear Air Turbulence (CAT).

According to Keller (1981), atmospheric conditions with Ri <0.25 have a great chance of turbulence. But, when compared with the results that there is a negative Ri (Ri <0.25) tends to experience mild turbulence **[12].**

Richardson Number Index Formula (Ri)

$$Ri = \frac{g}{\theta_v} \frac{\frac{\delta \theta_v}{\delta z}}{\left|\frac{\delta V}{\delta z}\right|^2} = \frac{N^2}{S^2} \quad (1)$$

Where $N^2 = \frac{g}{\theta_v}\frac{\delta\theta_v}{\delta z}$ is the frequency of Brunt-Väisälä, g is the acceleration of gravity, θ_v is the vertical potential temperature, $\frac{\delta\theta_v}{\delta z}$ is the potential temperature growth with respect to altitude, and $S = \left|\frac{\delta V}{\delta z}\right|$ is vertical wind shear.

3.1. Algorithms and numerical calculations.

The numerical calculates the Richardson number, *Ri*. This number determines whether the wind shear is strong enough to cause turbulence in statically.

The change in geopotential height usually determines the stability of the air. If the change in geopotential height is small, the flow is dynamically unstable and turbulent. This means that the Richardson number is less than the critical Richardson number, where the critical Richardson number is equal to 0.25. In this numerical calculates, you have eight input values:

1. The temperature at the highest geopotential height (T1)
2. The temperature at the lower geopotential height (T2)
3. Wind speed toward East at the highest geopotential height (U1)
4. Wind speed toward East at the lower geopotential height (U2)
5. Wind speed toward North at the highest geopotential height (V1)
6. Wind speed toward North at the lower geopotential height (V2)
7. Geopotential height at the highest geopotential height (z1)
8. Geopotential height at the lower geopotential height (z2)

The Richardson number calculate from formula one above whatever it is:

$$R_i = \frac{g\,(\Delta T_v + T_d \Delta z)\Delta Z}{T_v[(\Delta U)^2 + (\Delta V)^2]} \qquad (2)$$

If g = 9.8 m/second
T_d (dry adiabatic laps rate)= 9,8 K/km

```
{Description}
{Determines whether the wind shear is strong enough to cause}
{turbulence in statically stable air used Ri}
{Dictionary}
T1: float {Temperature at the highest geopotential height}
T2: float {Temperature at the lower geopotential height}
U1: float{Wind speed toward East at the most top geopotential height}
U2: float {Wind speed toward East at the lower geopotential height}
V1: float{Wind speed toward North at the highest geopotential height}
V2: float {Wind speed toward North at the lower geopotential height}
z1: float {Geopotential height at the highest geopotential height}
z2: float {Geopotential height at the lower geopotential height}
  Ri: float {Richardson number}
 Stability: string {air stability}
{Algorithm}
input(T1,T2,U1,U2,V1,V2,z1,z2,g)
{Ri calculate}
  Ri=(9,8*((T1-T2)+9,8*(z1-z2))*((z1-z2)*1000))/
((T2+273.15)*(Pow((U1-U2),2)+(Pow((V1-V2),2))))

if (Ri< 0.25) then{turbulent check}
    Stability='Turbulent'
else {Ri>=0.25}
    Stability='Not Turbulent.'
output(Ri,Stability)
```

IV. SIMULATION OF TURBULENCE MOTION

The model is run in 3 domains. Domain 3 (DO3) is used for research areas with a resolution of 4 km. The model is run using the MRF boundary layer scheme, the Kessler microphysics scheme, and the Devenyi Grell cumulus scheme. The MRF scheme is able to show a good correlation in the simulation of gravitational waves (potential temperature and wind speed). The Kessler scheme is able to simulate the process the formation of clouds and rain and the mechanism of mountain waves on the meso scale. The Grell Devenyi scheme is able to describe the movement of clouds and indications of rain related to air stability **[13].**

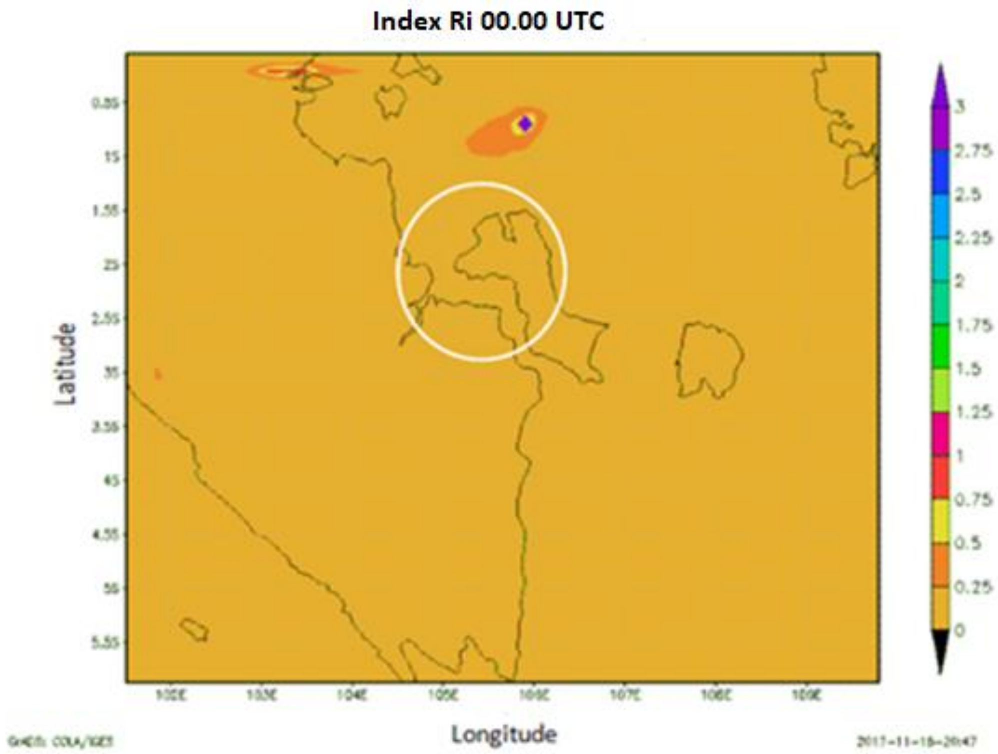

Figure 1.1 Richardson Index Layer 250 to 200 MB at 00.00 UTC

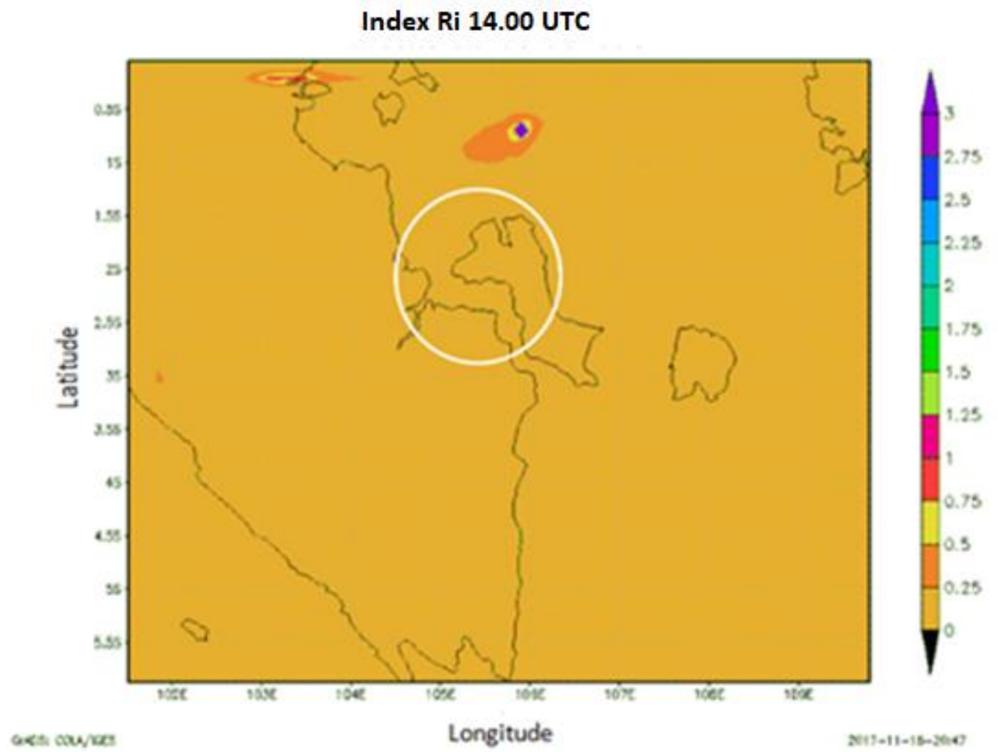

Figure 1.2 Richardson Index Layer 250 to 200 MB at 07.00 UTC

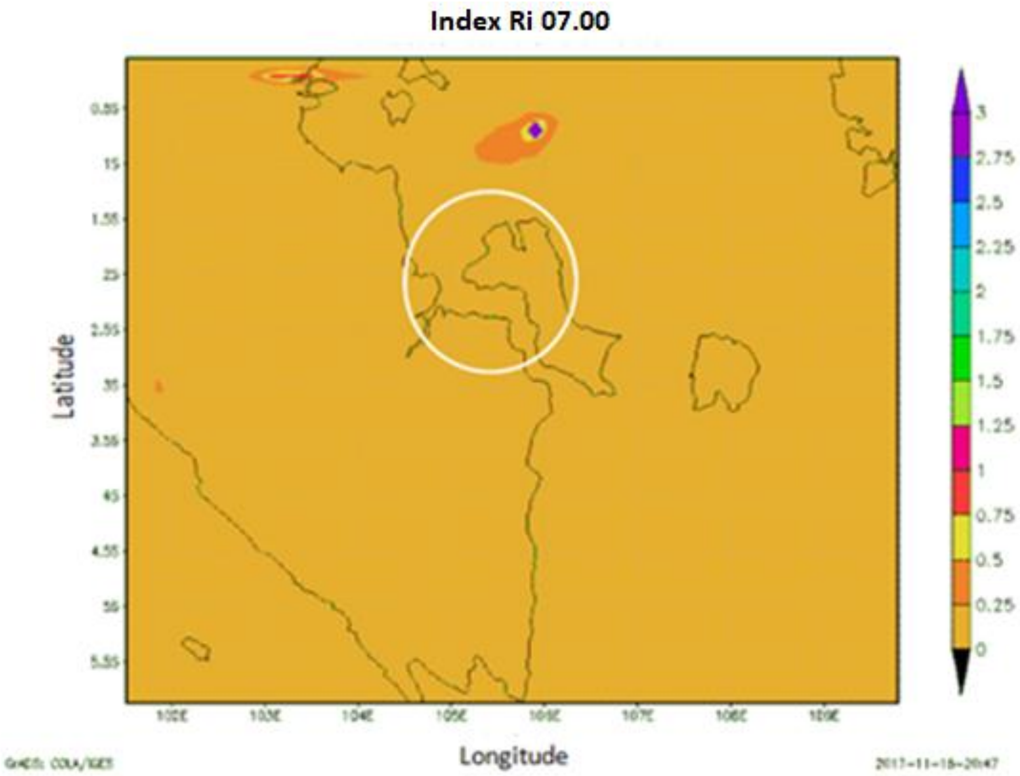

Figure 1.3 Richardson Index Layer 250 to 200 MB at 14.00 UTC

As in the figure can be explained (Figure 1.1, Figure 1.2, and Figure 1.3) with a white circle indicating the value of the Ri index in layers 250 to 200 mb at 00.00 UTC, 07.00 UTC, and 14.00 UTC. Where the value of Ri shows 0 in all three times that is to indicated a high turbulence. In accordance with Keller's research (1981), Ri <0.25 indicates high turbulence.

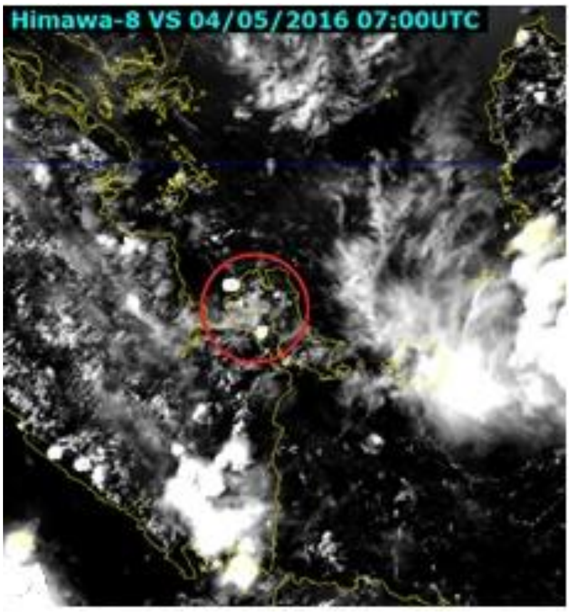

Figure 1.4 Satellite Imagery around event Location 07.00 UTC VIS Satellite Imagery

Figure 1.4 shows VIS satellite channel imagery around the scene at 07.00 UTC in the area marked with a red circle showing the VIS channel satellite image showing 96% albedo value. Based on the results of the analysis, albedo conditions indicated a thick cloud and can be said to have a cloud of convective clouds.

V. CONCLUSION

The results of the identification of the calculation of the Richardson index value (Ri index) shows a value of 0 which is high turbulence. In accordance with Keller's research (1981), Ri <0.25 shows high turbulence. This is supported by the results and VIS channel satellite imagery around the scene shows the presence of cloud cover of a type of convective cloud. But to be able to analyze more deeply about the occurrence of turbulence other than the Ri index, other analysis calculations are still needed.

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