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Convective cloud distribution monitoring using Cloud Convective Overlays and Red-Green-Blue Convective Storms methods on Himawari-8 satellite imagery on the Eastern Coast of North Sumatra

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Abstract

The Eastern Coast of North Sumatra which was directly adjacent to the Malacca Strait was an area with a high frequency of **heavy rain** events. This indicates the high intensity of convective activity in the Eastern Coast of North Sumatra, so that the information of **convective cloud** distribution is needed to analysis and forecast the rain events. Convective cloud distribution can be identified using **Cloud Convective Overlays** (CCO) and **Red-Green-Blue Convective Storms** (RGB-CS) methods. The CCO method is an overlay technique of **two types of algorithms** by utilizing differences in the emissivity of two infrared channels or Brightness Temperature Different (BTD), namely Split Windows [SW = BTD (IR1-I2)] and Dual Channel Difference [DCD = BTD (IR1-WV)]. The SW algorithm is used to calculate the amount of water vapor in the atmosphere as an indicator of convective cloud grouping. The DCD algorithm is used to detect the height of clouds reaching the tropopause layer. The RGB-CS method is a **multispectral method** that displays satellite imagery with three specific algorithms to represent red, green, and blue color composites using 6 channels, the 3rd channel (0.64 µm); 5th channel (1.6 µm); 7th channel (3.7 µm); 8th channel (6.2 µm); 10th channel (7.3 µm); 13rd channel (10.4 µm); and 15th channel (12.4 µm). Case studies were carried out on heavy rain events in 15th September 2018. The results of the study show that in the heavy rain events, the CCO and RGB-CS methods can clearly capture **convective cloud patterns**. The RGB-CS method can produce more real color contrast and *'natural look'* images by maintaining the original texture of the cloud so that it is easier to observe and analysis the classification of convective clouds that have the potential to produce the extreme rainfall.

Introduction

The high level of absorption of solar radiation causes high convective activity in the tropics. The high **convective activity** results in high rainfall (Tjasyono, 2004). The high intensity of rainfall on the East Coast of North Sumatra is an important thing to study because it has a significant impact on community activities, e.g. can trigger the flood occurrence. One of the research instrument that can be used to assess the occurrence of heavy rainfall is **satellite imagery**. Satellite image data can be processed and analyzed to find out the convective evolution stage that causes rain in an area (Saragih, et. al., 2017).

Convective distribution analysis can be identified using satellite imagery data **subjectively** and **objectively**. The subjective method is to directly observe rainfall through satellite imagery. Objective method is a method that is carried out by processing satellite data into satellite imagery products by utilizing the characteristics of several satellite-image channels. Subjective interpretation has many shortcomings, one of which is a low and inconsistent level of accuracy.

On 15th September 2018, there was heavy rain in the East Coast region of North Sumatra. Observation data from Kualanamu Meteorological Station (KNO) and Belawan Maritime Meteorological Station (BLW) show that the measured rainfall was **40 mm/day** and 16 mm/day respectively. The rainfall peak occurs at night, ie at 12.00 - 15.00 UTC. The occurrence of rain at night allows a more significant impact due to the unpreparedness of the community, so early warning is needed. This study was conducted to determine the accuracy of the CCO and RGB-CS methods in **identifying convective cloud cover** on the East Coast region of North Sumatra so that it can be used as a reference in making extreme weather early warning.

Data and methods

This study was conducted in the **East Coast region of North Sumatra**, which is at coordinates 0°- 6° N and 96°- 102° E (Figure 1). The data used are measured **rainfall data** from KNO and BLW, as well as **Himawari-8 satellite image** data from the Sub-Section of Satellite Image Management - BMKG.

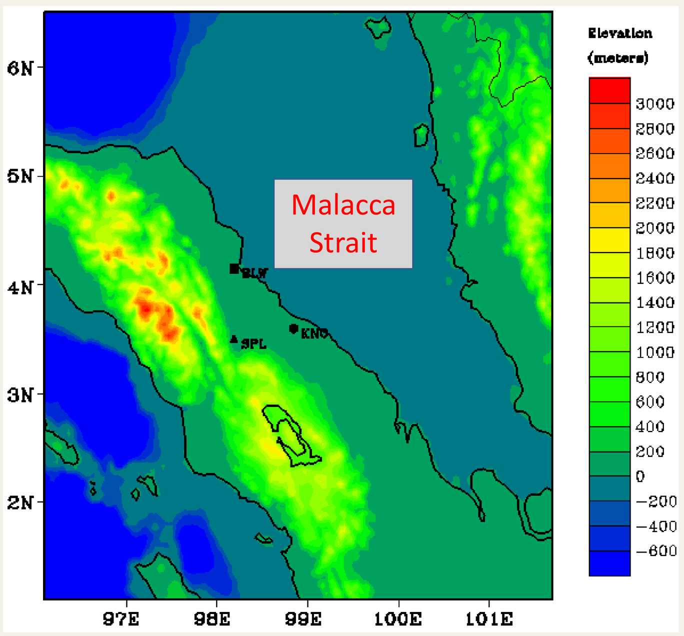

Figure 1. Map of the study area; BLW = Belawan, KNO = Kualanamu, SPL = Sampali

Satellite imagery data used is VS channel data (VIS 0.6 µm), N2 (NIR 1.6 µm), I4 (IR4 3.9 µm), WV (WV 6.2 µm), W3 (WV3 7.3 µm), IR (IR1 10.4 µm), I2 (IR2 12.4 µm). The study time was a case study of heavy rain events on 15th September 2018.

The CCO method uses two algorithms with the use of the IR channel, the I2 channel, and the WV channel. The first algorithm uses the Split Window (SW) method which utilizes two channels that are atmospheric windows (transparent radiation to atmospheric gases) with a spectrum of different wavelengths. This algorithm is used to distinguish between Cumulonimbus clouds (CB) and thin Cirrus (Ci) clouds. Small difference values show high and thick clouds (CB) while large difference values indicate the absence of thin Ci clouds or clouds (Syaifullah et. al., 2016).

$$SW = BTD\ [IR\text{-}I2] < 2$$

The second algorithm is the Dual Channel Difference (DCD) method by utilizing two different channels, namely atmospheric windows and atmospheric bands (radiation absorbed by atmospheric gases). The second algorithm serves to distinguish between CB clouds and low clouds. Small difference values show thick clouds (CB), while large difference values show low and thin clouds (Cumulus/CU) (Syaifullah et. al., 2016).

$$DCD = BTD\ [IR\text{-}WV] < 3$$

Results and discussion

Based on Figure 2 it is known that rain occurs from 09.00 - 12.00 UTC and ends at 06.00 - 09.00 UTC. Rainfall peaks in KNO and BLW occurred at **12.00 - 15.00 UTC**, ie. rainfall value of around **21 mm/3-hour** and 10 mm/3-hour respectively. The similarity of rainfall patterns and the distance between KNO and BLW which are relatively far away indicate that the convective clouds that cause the rain have a relatively broad cover.

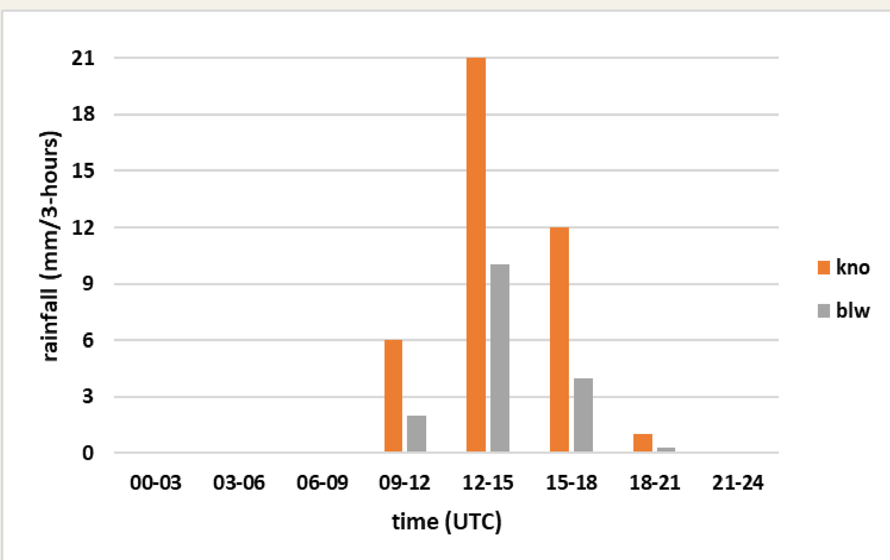

Figure 2. Graphs of measured rainfall at KNO and BLW weather station on 15th September 2018

The time series graph of the cloud peak temperature in Figure 3 represents the stages of convective cloud development around the KNO. Based on the cloud peak temperature analysis, **three stages of convective cloud evolution** can be identified, namely the growth stage (10.00 - 13.00 UTC), the mature stage (13.00 - 19.00 UTC), and the dissipation stage (19.00 - 20.00 UTC).

Based on the value of the lowest cloud peak temperature, this convective cloud is **included as a CB** with the top cloud temperature value less than -70°C. Analyse from the duration of its development, this convective cloud has a life-time that is relatively longer than its normal time, which is normally about 3-4 hours. When compared to the measured rainfall graph, the time-series graph of the top cloud temperature is related to graph of rainfall.

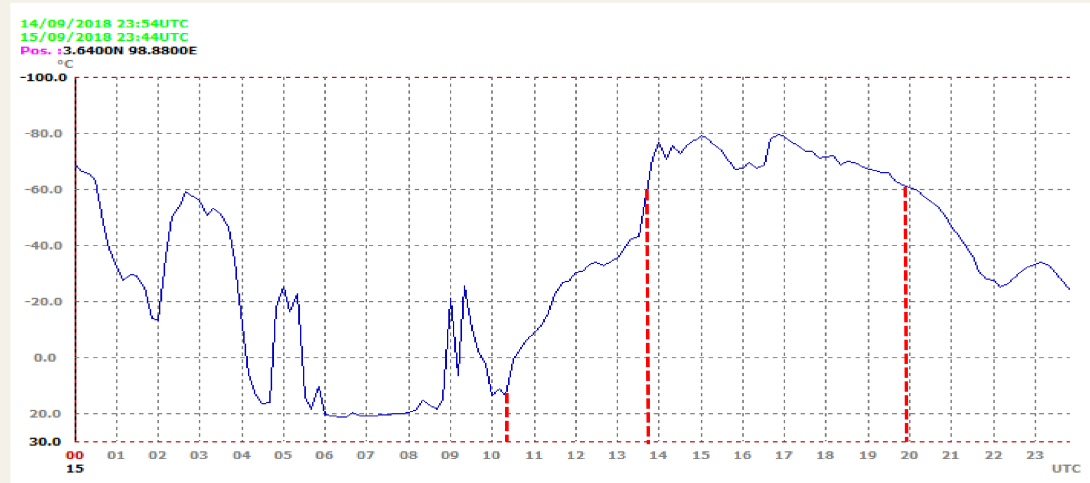

Figure 3. Graphs of top cloud temperature from the IR channel of Himawari-8 on 15th September 2018

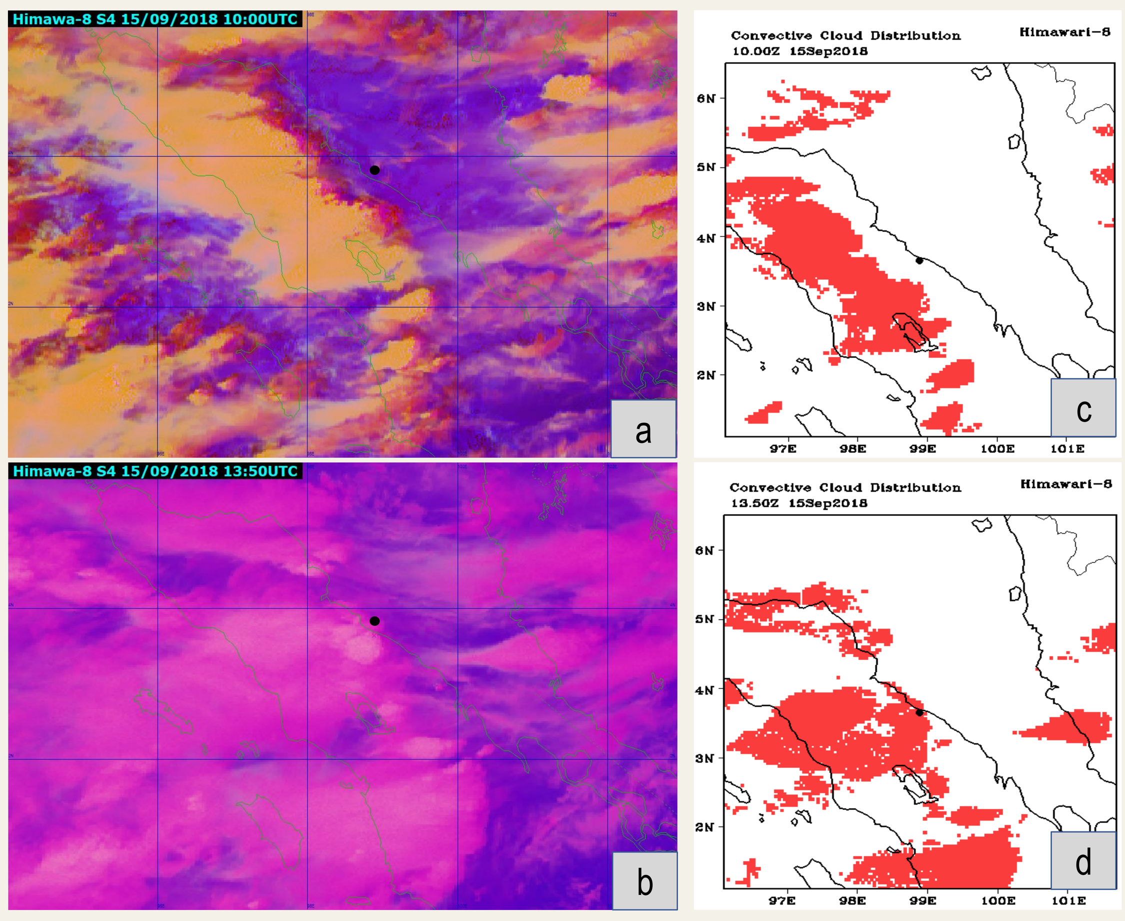

Figure 4. Convective distribution by RGB-CS (a,b) and CCO (c,d) methods on the growth (a,c) and mature (b,d) stage of convective cloud evolution on 15th September 2018; the 'black dot' is the location of the KNO

In general, the convective distribution of the CCO and RGB-CS methods shows the **relatively-same pattern**. However, the CCO method only shows the convective cloud cover while the RGB-CS can show convection area and convective cloud concentration distribution. The RGB-CS method can be used as a convective **cloud type classification** analysis indicator based on its color-difference. At Figure 4.a, it can be seen that there is a **yellowish color** that shows the areas with strong convection and updraft processes. The yellowish color is a combination of red and green colors. The 'Red' indicates a thick cloud, while the 'Green' indicates the presence of small ice particles in the cloud.

Conclutions

Based on convective distribution monitoring using RGB-CS and CCO methods shows that extreme rain on the East Coast of North Sumatra on 15th September caused by the **convective cloud** (CB) clusters that grow and develop very intense. The linear pattern of the top cloud temperature and the rainfall graphs can be used as a reference in the making of early warnings of heavy rain. Both RGB-CS and CCO methods show relatively similar **convective distribution patterns**, but in the RGB-CS method the convective area looks **more real** and can be classified and used to forecast the growth and movement of clouds based on the visible color-differences.

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