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Parallax correction methods and objective detection of overshooting cloud tops surrounding extreme weather events location in Indonesia

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OUTLINE

I. Introduction

II. Data & Methods

III. Results

IV. Conclusions

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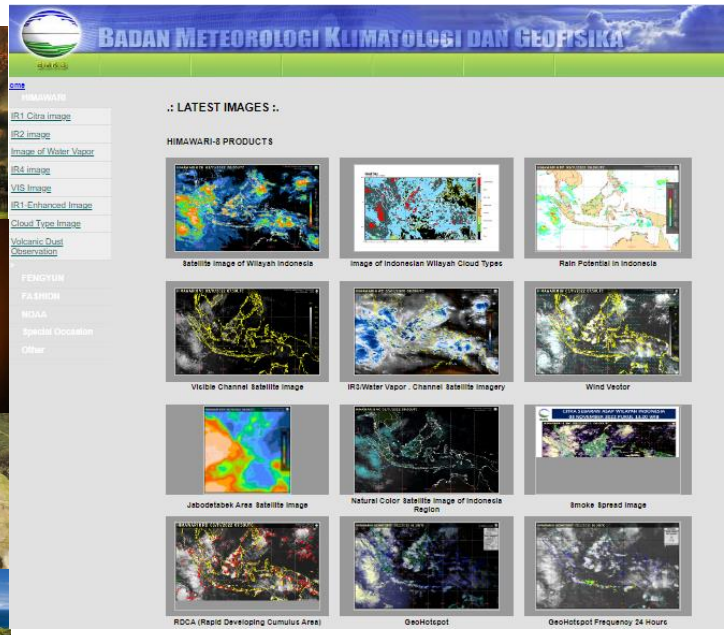
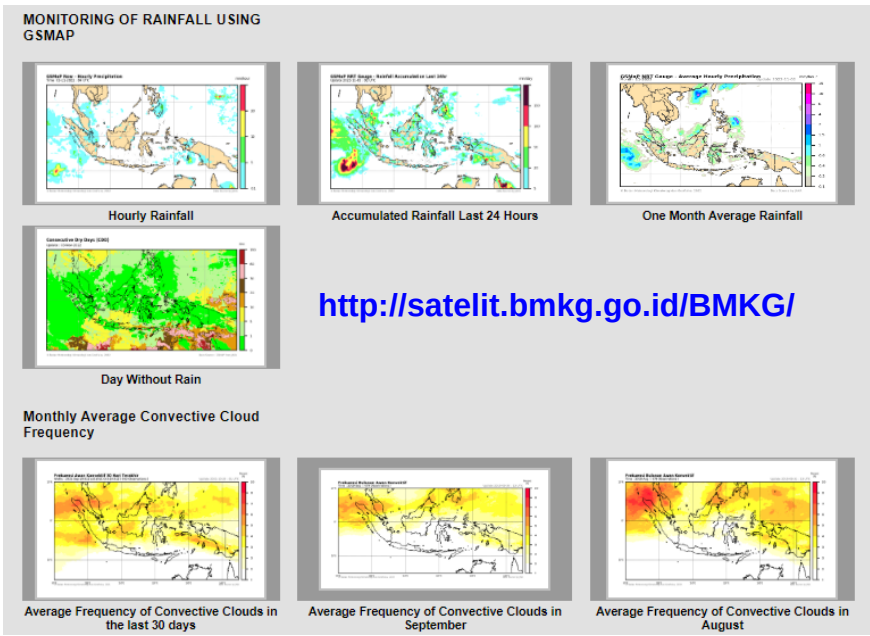
INTRODUCTION

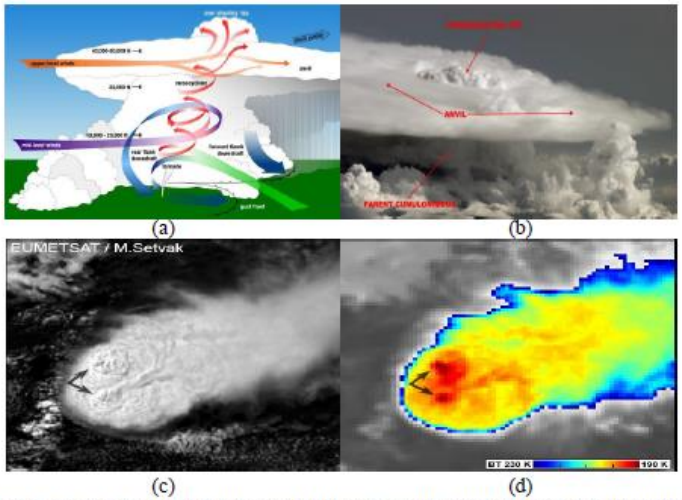
RECENT SATELLITE PRODUCTS IN BMKG





- BMKG has some satellite products as weather forecaster's guidance for weather analysis and forecast
- The need for satellite-derived products to monitor convective clouds that trigger extreme weather in tropical areas such as Indonesia is increasing

OVERSHOOTING TOP (OT) OF CONVECTIVE CLOUD



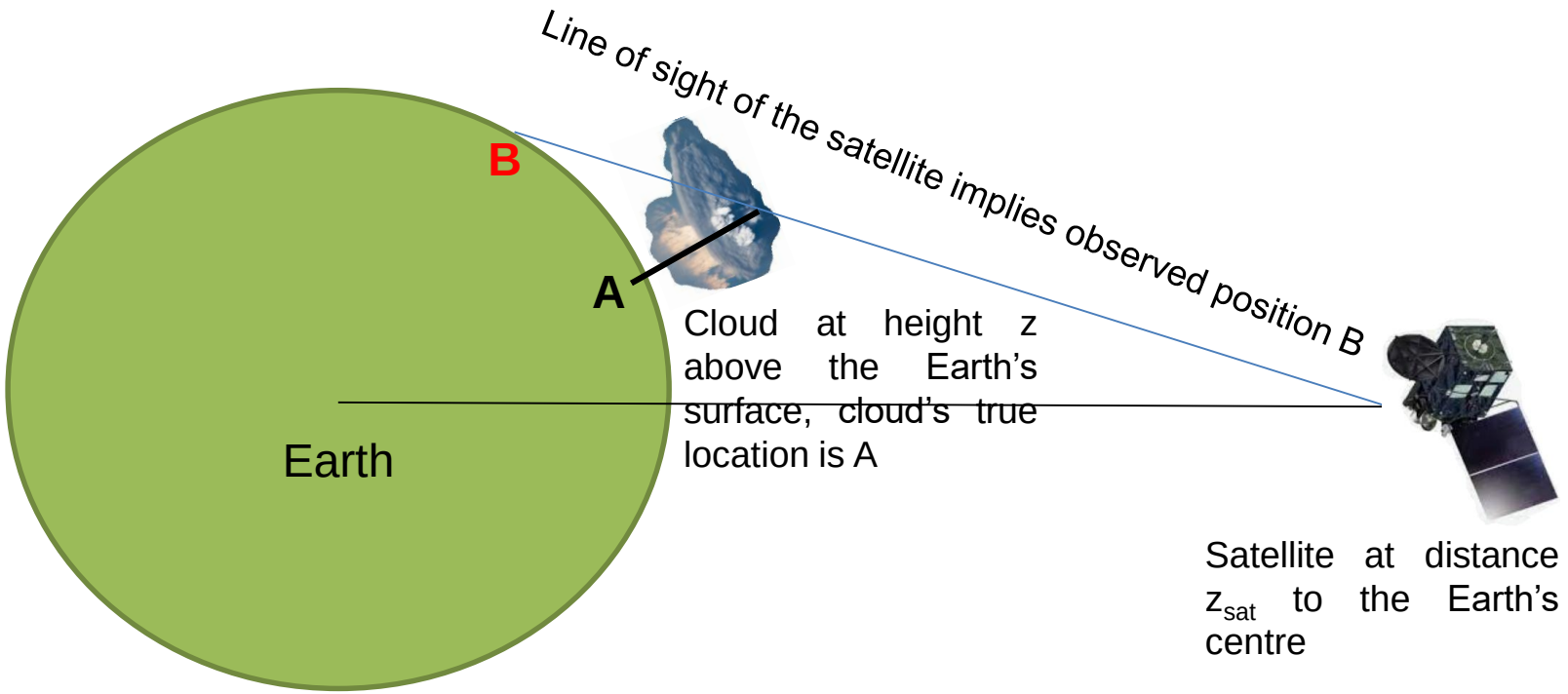
Gambar 1. Gambaran *overshooting top* (OT) berdasarkan: (a) model konseptual struktur awan konvektif beserta OT; (b) potret awan konvektif yang memiliki fitur OT; (c) Fitur OT dalam suatu sistem konvektif dari citra satelit kanal *visible*; (d) Fitur OT dalam suatu sistem konvektif dari nilai *brightness temperature* (BT) citra satelit kanal *infrared*

- Unique pattern on convective cloud tops: overshooting convective top / overshooting top (OT)
- American Meteorological's Glossary of Meteorology – OT = a dome-like “bulge” above the CB anvil that passes through the equilibrium level and tropopause, indicating a strong internal updraft in the convective cloud
- The presence of an overshooting top (OT) in convective clouds is often associated with the presence of extreme weather at that location

Visually detected as:

- Thick / not smooth / 'cauliflower' texture in the visible canal.
- A small group of cold temperature Brightness values at IR 10.4
- significantly cooler than the surrounding cloud temperature.

PARALLAX IN GEOSTATIONARY SATELLITE



- the presence of OT detected by satellite is still in an inappropriate location.
- This is a natural consequence of the parallax error generated by the Himawari 8 Satellite,
- which orbits at 140.7E above the equator with an altitude of 35,793 km

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PURPOSES

- we aim to objectively detect the presence of OT in locations of extreme weather events using Himawari-8 images
- We tested 3 methods for correcting satellite parallax errors with respect to the actual OT position
- The type of study is case study for extreme weather events in Java Island

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DATA & METHOD

DATA

Type	Source	Variable	Attribute
Report of extreme weather event	BMKG	Hail with/without strong winds/puting beliung (local F0 scale tornado)	Time and location

Type	Source	Variable	Level	Resolution
Himawari 8 - *Brightness temperature*	JMA	WV (6.2 µm), O3 (9.6 µm), IR (10.4 µm), IR2 (12.3 µm)	-	Spatial 2 km Temporal 10 minutes
Himawari 8 - Reflectance	JMA	VS (0,64 µm)	-	Spatial 500 m Temporal 10 minutes
Atmospheric Reanalisis ERA5	*Climate Data Store - Copernicus*	Temperature	Surface Tropopause	Spatial 0.1^0 Temporal 1 hour
HCAI	JMA	Cloud top height	-	Spatial 2 km Temporal 10 minutes

METHOD

Method for objectively detecting OT:

Algorithm	Variable
Combination of IRW texture gradient (Bedka,2010) and COMB (Mikuš & Mahović, 2013)	IR (10.4 µm) BTD O3 (9.6 µm) – IR (10.4 µm) BTD WV (6.2 µm) – IR (10.4 µm) BTD IR (10.4 µm) – IR2 (12.3µm) IR (10.4 µm) – tropopause temperature ≤ 12

- Read BT channel IR Window (IRW) 10.7 m and NWP tropopause temperature
- Identify pixels with IRW BT 215 K and NWP tropopause temperature
- Starting with the coldest BT on the list, make sure there are no cold pixels within 15 km of each other. Pixels that meet these criteria are called "OT candidate pixels“
- Sampling the ambient cloud anvil at a radius of 8 km in 16 directions around the OT candidate pixel.
- A radius of 8 km was chosen as a sample area outside the OT, because the OT is generally < 15 km in diameter.
- Pixels that are rated at least 6.5 K cooler than the surrounding anvils are considered "OT center pixels“
- In a search box centered on the OT center pixel, look for a pixel that is at least 50% cooler than the surrounding average.

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METHOD

3 methods for correcting satellite parallax errors:

- to find the height of the cloud top with a cloud-top temperature proxy based on the air lapse rate with a fixed surface temperature value.
- similar to the first method, but the surface temperature value used is the dynamic value of the hourly ERA5 surface temperature according to the closest time to the time of extreme weather events.
- to use the cloud top height of the HCAI cloud top height product from Japan Meteorological Agency.

We evaluated these 3 methods with a case study of extreme weather in Java Island

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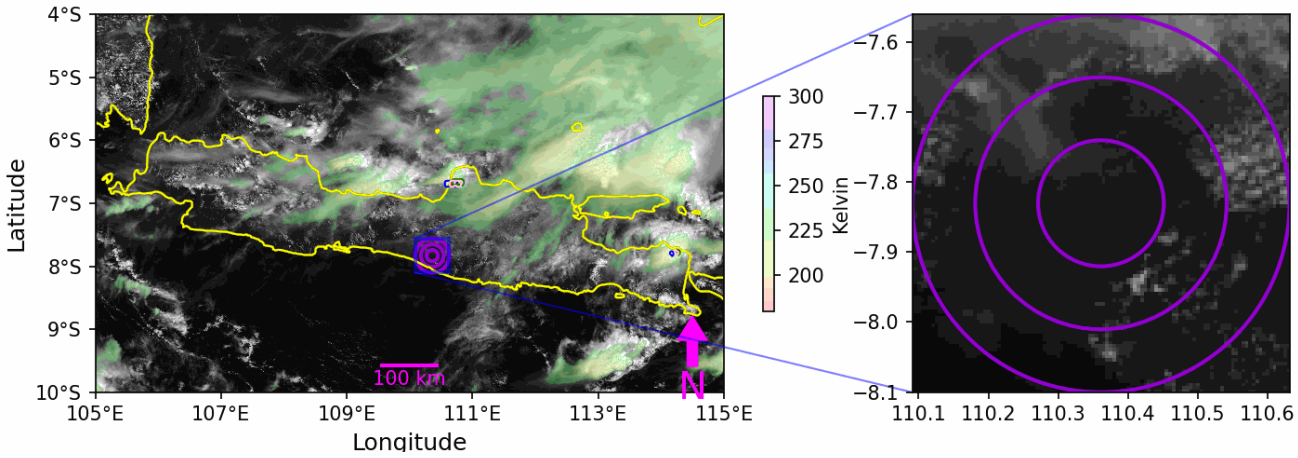
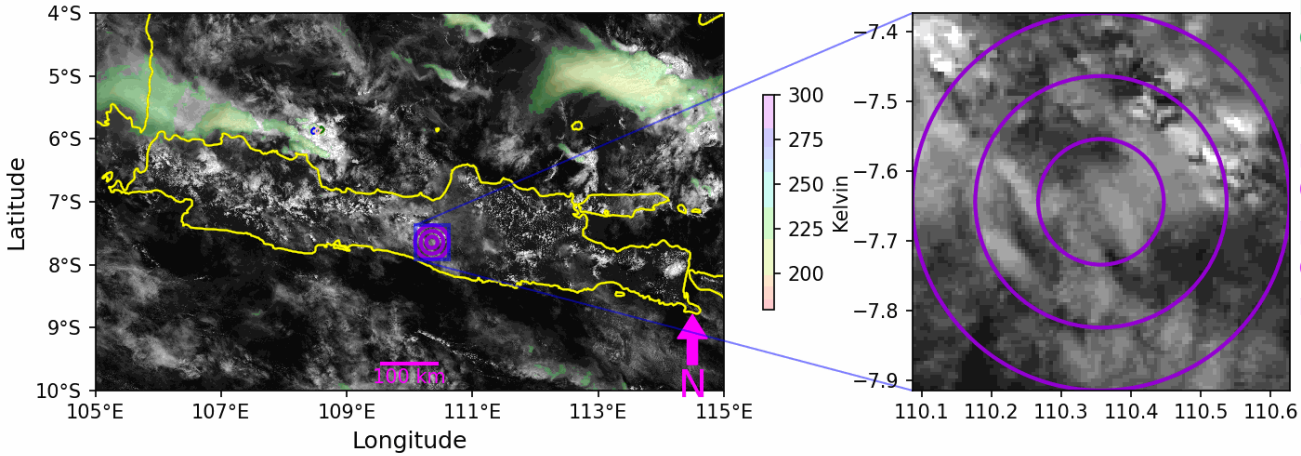
RESULTS

OT Detection in Extreme Weather Location With 3 Methods of Parallax Correction

Himawari-8 Sandwich (IR & Visible Composite Image) Product 2021-03-10 03:53 UTC Case no. 8



Himawari-8 Sandwich (IR & Visible Composite Image) Product 2021-03-02 03:53 UTC Case no. 6



blue polygons = OT without parallax correction;

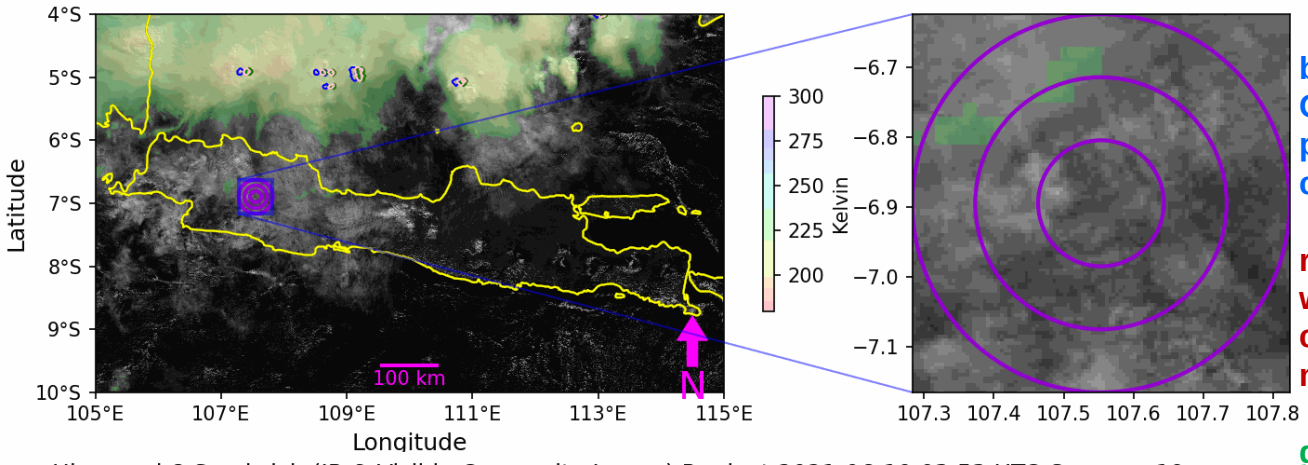
red polygon = O T with the parallax correction method 1;

green polygon =OT with the parallax correction method 2;

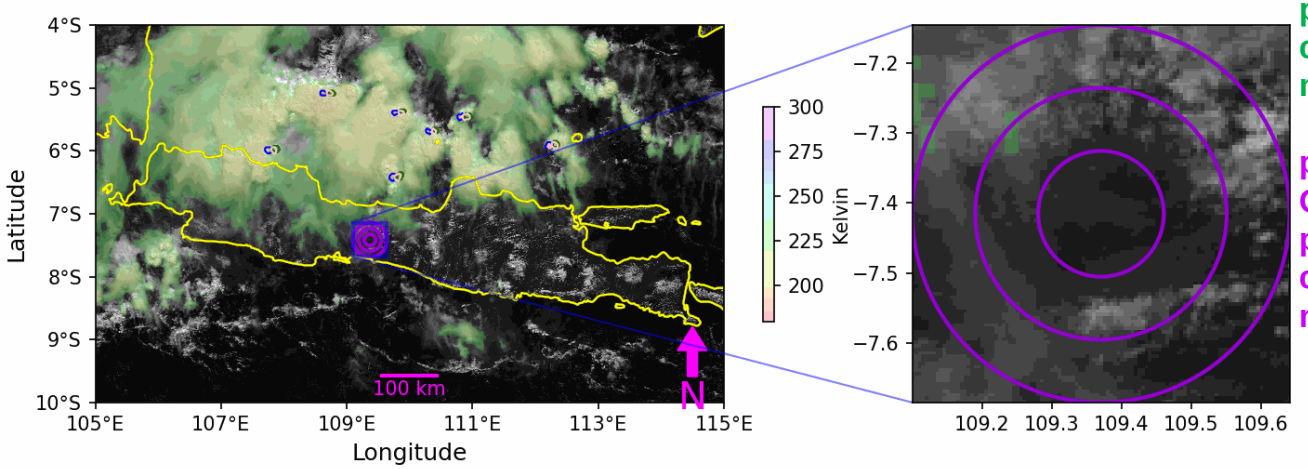
pink polygon = OT with the parallax correction method 3

OT Detection in Extreme Weather Location With 3 Methods of Parallax Correction

Himawari-8 Sandwich (IR & Visible Composite Image) Product 2021-07-01 03:53 UTC Case no. 21



Himawari-8 Sandwich (IR & Visible Composite Image) Product 2021-06-19 03:53 UTC Case no. 19



blue polygons = OT without parallax correction;

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CONCLUSIONS

- The result shows that the image's product with this OT feature without parallax correction is able to detect the presence of OT around extreme weather locations with a distance difference of about 13 km.
- All of these parallax correction methods are able to correct the OT position so that the distance between the OT location and extreme weather locations becomes only less than 3 km.
- The first and second method show almost similar location of the presence of OT which is closer to the location of extreme weather events with a distance only less than 1 km from extreme weather location.
- However, the first method provides simplicity in computing with result that is almost similar to the second method.

Future Work:

- Further development and validation of this product at BMKG are expected to help weather forecasters in tropical Indonesia monitor the development of convective clouds that induce extreme weather.

Thank You

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