The diurnal cycle of rainfall and cloud properties from Himawari-8 during the austral summer (2016-2020).

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Abstract

In this work, the characteristics of the diurnal cycle around Sumatra are examined with unprecedented detail using high-resolution satellite-derived cloud properties from the Himawari-8 Advanced Himawari Imager (AHI) data. Offshore propagation is resolved into multiple local propagation directions of cloud cells, and the interaction between propagations is shown to result in forced convection over the Strait of Malacca, Java Sea, and the Indian Ocean. The diurnal cycle of rainfall and deep convection over Sumatra show complex interactions between the land-sea-breeze system, the seasonal background wind, the local topography, and the influence of surrounding islands. We used high-resolution satellite-derived products from Himawari-8 AHI, the Geostationary Cloud Algorithm Testbed Geocat, and Integrated Multi-satellitE Retrievals for Global Precipitation Measurement (IMERG) to investigate the cloud properties of deep convection and the signatures of the diurnal cycle of rainfall and cloudiness over Sumatra. Previous studies have shown evidence of the variability of diurnally forced convection in the Maritime Continent, including the diurnal signal over land in the late afternoon and the offshore propagation of Sumatra at night (Yang and Slingo 2001). The role of gravity waves has explained the night-time propagation (e.g., Mapes 2003; Love et al. 2011; Vincent and Lane 2016; Sakaeda et al. 2020). This propagation can be modified by the influence of small islands and the interconnection of diurnal cycles between Sumatra, Malay Peninsula, Java, and Borneo (Ruppert and Zhang 2019; Ruppert and Chen 2020). In this work, we present evidence of the cloudiness and rainfall patterns propagating offshore/onshore Sumatra during five austral summers from 2016 to 2020, employing cloud properties from Himawari-8 and IMERG collections. By combining detailed satellite-based cloud properties and rainfall estimates, we highlight the strong dependency of the diurnal cycle on local modulators.

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INTRODUCTION

- The Maritime Continent is characterized by intense, deep atmospheric convection dominated by the diurnal cycle of rainfall. Sumatra presents a unique condition in the tropics. The geographical location on the western region of the Maritime Continent and the position of the Equator define the weather conditions associated with diurnally forced convection.
- Launched in 2014, Himawari-8 has been a revolutionary advance in geostationary satellite capability (Fig. 1). The high spatial (0.5-2 km) and temporal (10 minutes) resolution allow individual cloud targets to be observed in a near-continuous manner, enabling the study of the full lifecycle of the clouds, including their diurnal cycle.

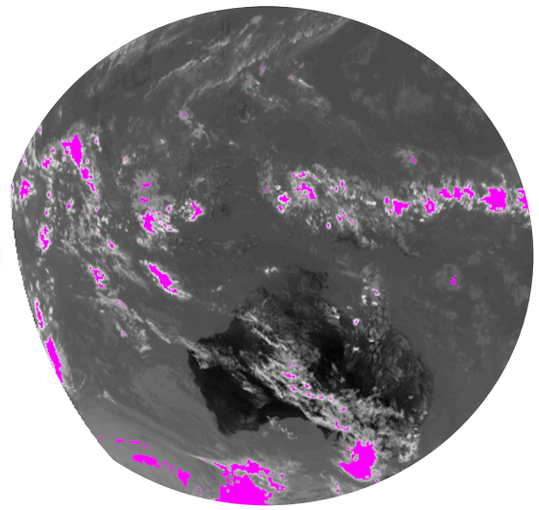

Figure. 1: Brightness temperature of 10.4 μm spectral band in shaded (Grey scale). Potential areas of rainfall associated with deep convective clouds in magenta.

MOTIVATION

The derived cloud properties from Himawari-8 AHI of five extended austral summers (November-March, 2015-2020), and satellite-based rainfall over Sumatra from the Integrated Multi-satellitE Retrievals for Global Precipitation Measurement (IMERG) have been analyzed to understand the characteristics and signatures of cloudiness at the diurnal scale over Sumatra.

METHODS

- Identification of satellite-derived potential areas of rainfall (RPA) from Himawari-8 GeoCat 1.0.3 Australian Domain Level 1 v1.0 (Lopez-Bravo, Vincent and Huang, 2021) based on thresholding in Fig. 1 (6.2, 10.4, and 12.4 μm (JMA 2015). Period: November-March, 2015-2020).
- Verification of RPA detection was performed by using satellite-derived rainfall from IMERG.
- Count of pixels that satisfy the condition of RPA (Himawari-8) and rainfall detection (IMERG).

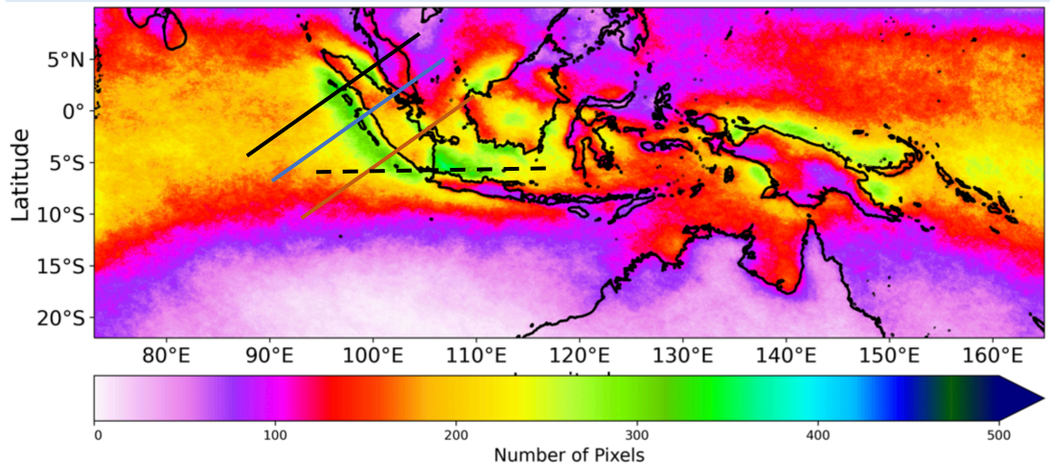

Figure 2: Diurnal cycle of cloud top associated with RPA. 00 UTC is shown to illustrate the diurnal cycle. Period: NDJFM, 2015-2020. Lines indicate the section in Fig. 3.

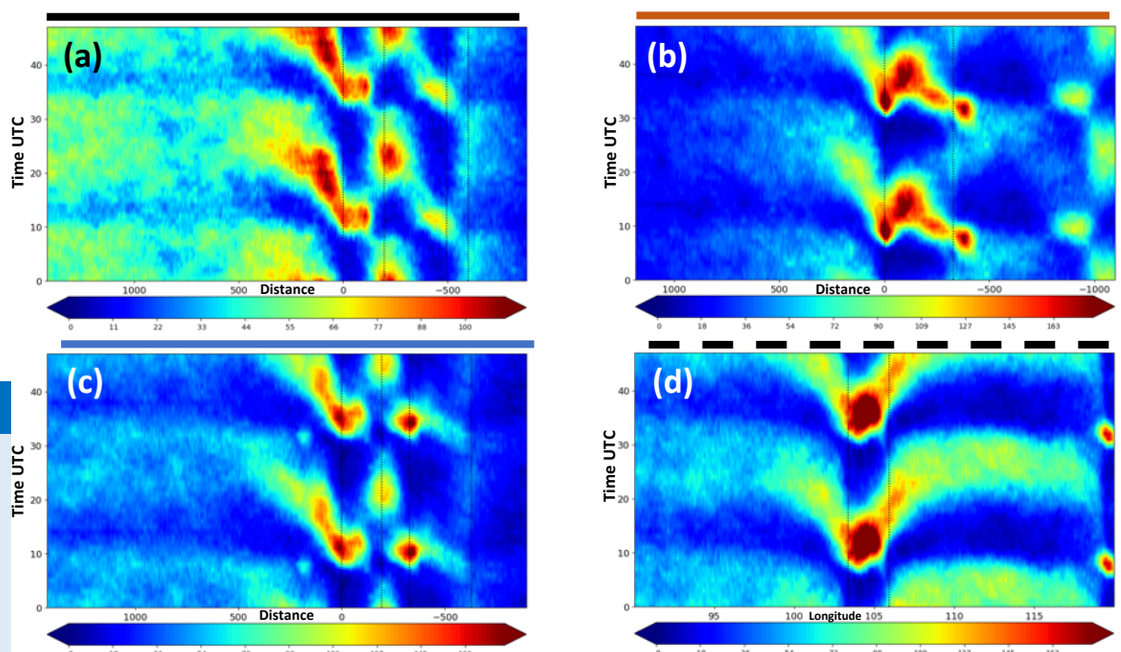

Figure 3: Number of pixels of RPA and rainfall events. (a) The northern region of Sumatra. (b) Central region. (c) Central-South, and (d) Java sea. Lines located above each subplot indicate the line colours in Fig. 2.

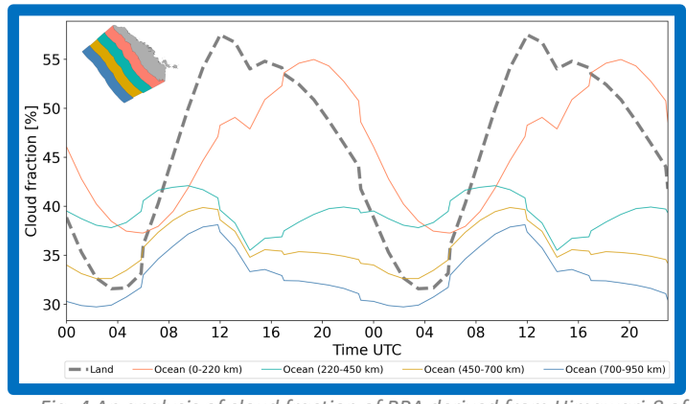

Fig. 4 An analysis of cloud fraction of RPA derived from Himawari-8 of NDJFM between 2015 and 2020 shows the diurnal cycle over Sumatra and the Indian Ocean over land (dotted grey line) and ocean (solid color lines).

RESULTS

The features of the diurnal cycle derived by satellite-derived from Himawari-8 show the diversity of diurnal responses across the Maritime Continent (Fig. 2).

The probability of detection between the detected cloud tops RPA and the estimated rainfall was approximately 81%.

The results show apparent differences in cloud population between islands, coastal and offshore areas.

Sumatra:
The West Coast exhibits a significant influence from the Indian Ocean (Fig. 4). That may affect the tropical land- and sea-breeze system (inertia–gravity wave and density currents mechanisms).
The East Coast can be described by the influence of the Malay Peninsula (Fig. 3a,b), Borneo (Fig. 3c), Java(Fig. 3d), and the influence of regional modulators of the diurnal variability, which results in an inhomogeneous structure of the cloud population linked with coastal activity in Sumatra.

FUTURE WORK

- ❖ A statistical analysis of cloud properties during the austral summer between 2016 and 2020 will be performed.
- ❖ Identification of background wind flow regimes. .
- ❖ Changes in the diurnal cycle amplitude and phase will be analysed when large-scale forcing drives the weather conditions such as active or inactive phases of MJO and equatorial wave modes.

Acknowledgements

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REFERENCES: Japanese Meteorological Agency (JMA), 2015: Users' Guide to Imagery with Heavy Rainfall Potential Areas.
Lopez-Bravo, C., C. L. Vincent, and Y. Huang, 2021a: Himawari-8 GeoCat 1.0.3 Australian Domain Level 1 v1.0. NCI National Research Data Collection. doi:10.25914/60096221a8f7a