Characterization of the Atmospheric Conditions and Cloudiness Leading to Extreme Rainfall Events over the Northern South America Andean Region

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Introduction

Antioquia is a department of Colombia, located in the northwestern corner of South America.

Its complex topography, associated with the branches of the Andes Cordillera, and the interplay among different atmospheric mechanisms result in a high precipitation and cloud cover variability over this region.

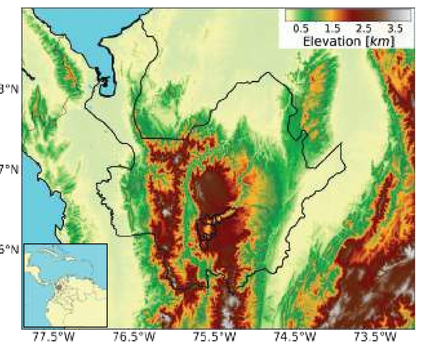


Figure 1: *Geographical context and topography.*

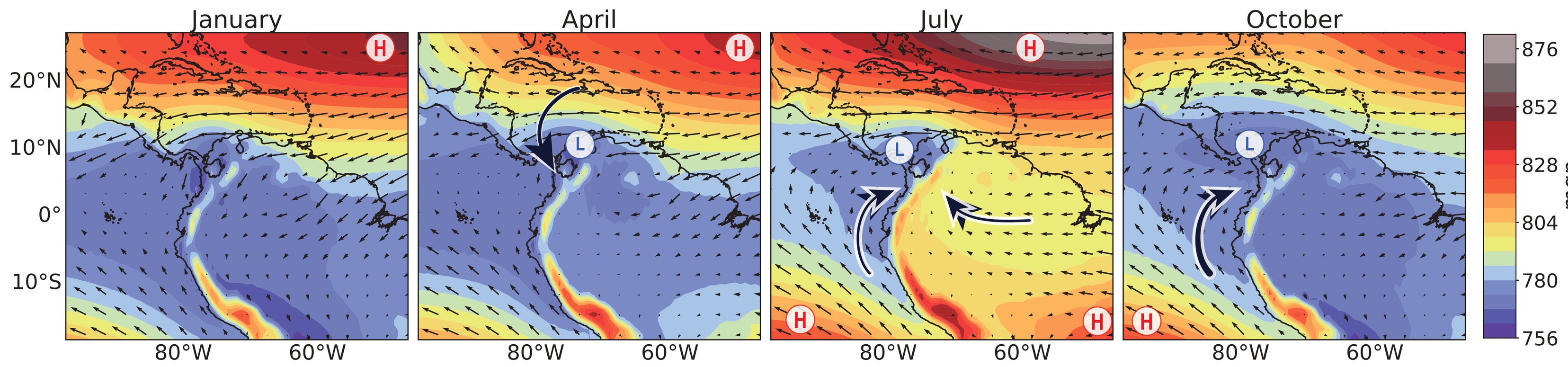


Figure 2: *Monthly mean 925-hPa geopotential height (m) and winds (m/s). ERA-Interim 1979-2018.*

Historically, extreme rainfall events have resulted in flooding, landslides, and other phenomena affecting vulnerable communities. This study aims to provide a characterization of the atmospheric conditions and cloudiness, leading to extreme rainfall events over Antioquia.

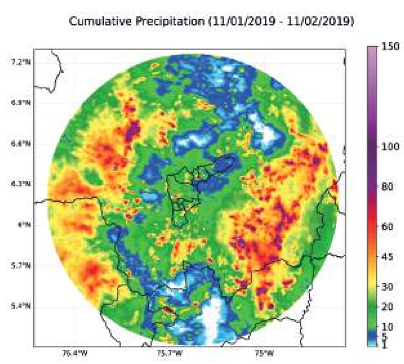


Figure 3: *Cumulative precipitation (18-11-01 07:00 – 18-11-02 07:00). Radar data.*

Data and methodology

Regionalization of Antioquia based on a K-means clustering analysis

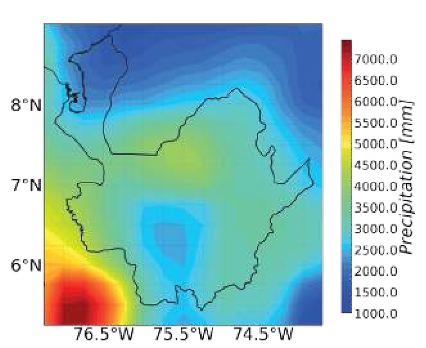


Figure 4: *Mean annual precipitation. (TRMM 3b42 v7).*

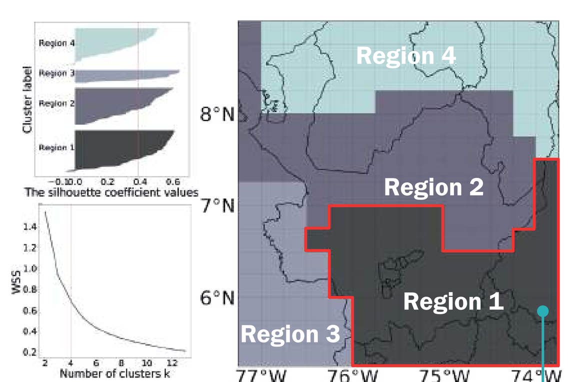


Figure 5: *Regions based on the K-Means clustering analysis.*

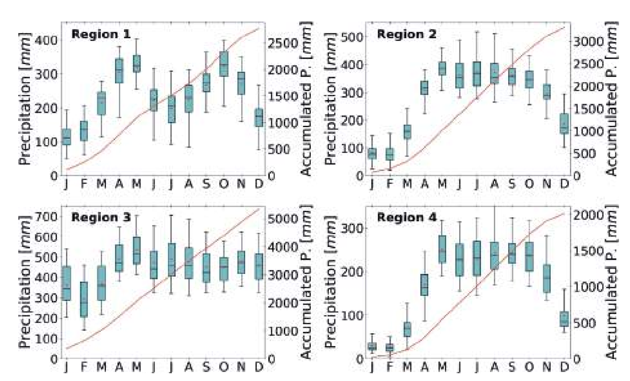


Figure 6: *Annual cycle precipitation for each region. (TRMM 3b42 v7).*

Event Identification

- Regional monthly threshold based on the regional daily average precipitation percentiles 25, 75, 90 and, 99.
- At least two pixels exceeded the threshold.

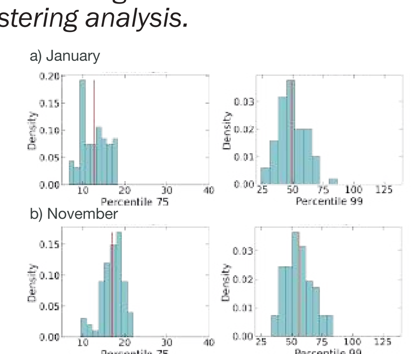


Figure 7: *Daily precipitation percentile 75 and 99 for (a) January and (b) November over region 1.*

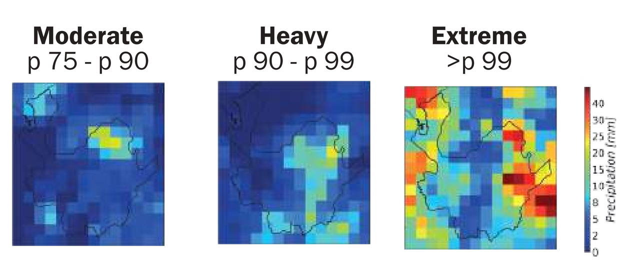
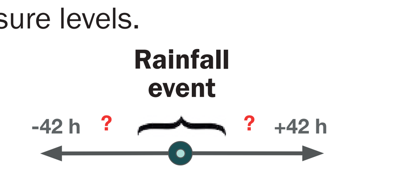


Figure 8: *Examples of daily precipitation events for each category.*

Atmospheric Precursors Pattern Identification

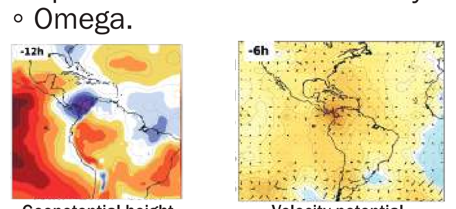
Characterization based on a lagged composite analysis of anomalies of different variables at several pressure levels.



Anomalies relatives to the monthly diurnal cycle.

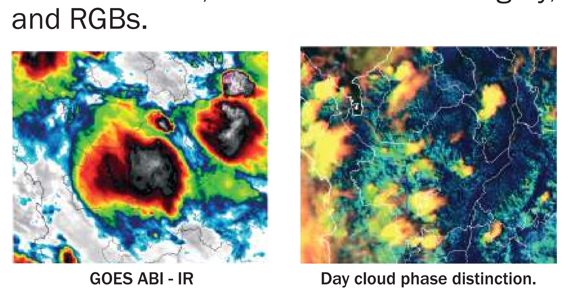
Reanalysis ERA-INTERIM:

- Geopotential height.
- Wind (zonal and meridional).
- Velocity potential.
- Specific and Relative humidity.
- Omega.



Cases of study

We use ERA-INTERIM, ERA-5, C-band weather radar, GOES-East ABI Imagery, and RGBs.



Atmospheric Precursors Pattern

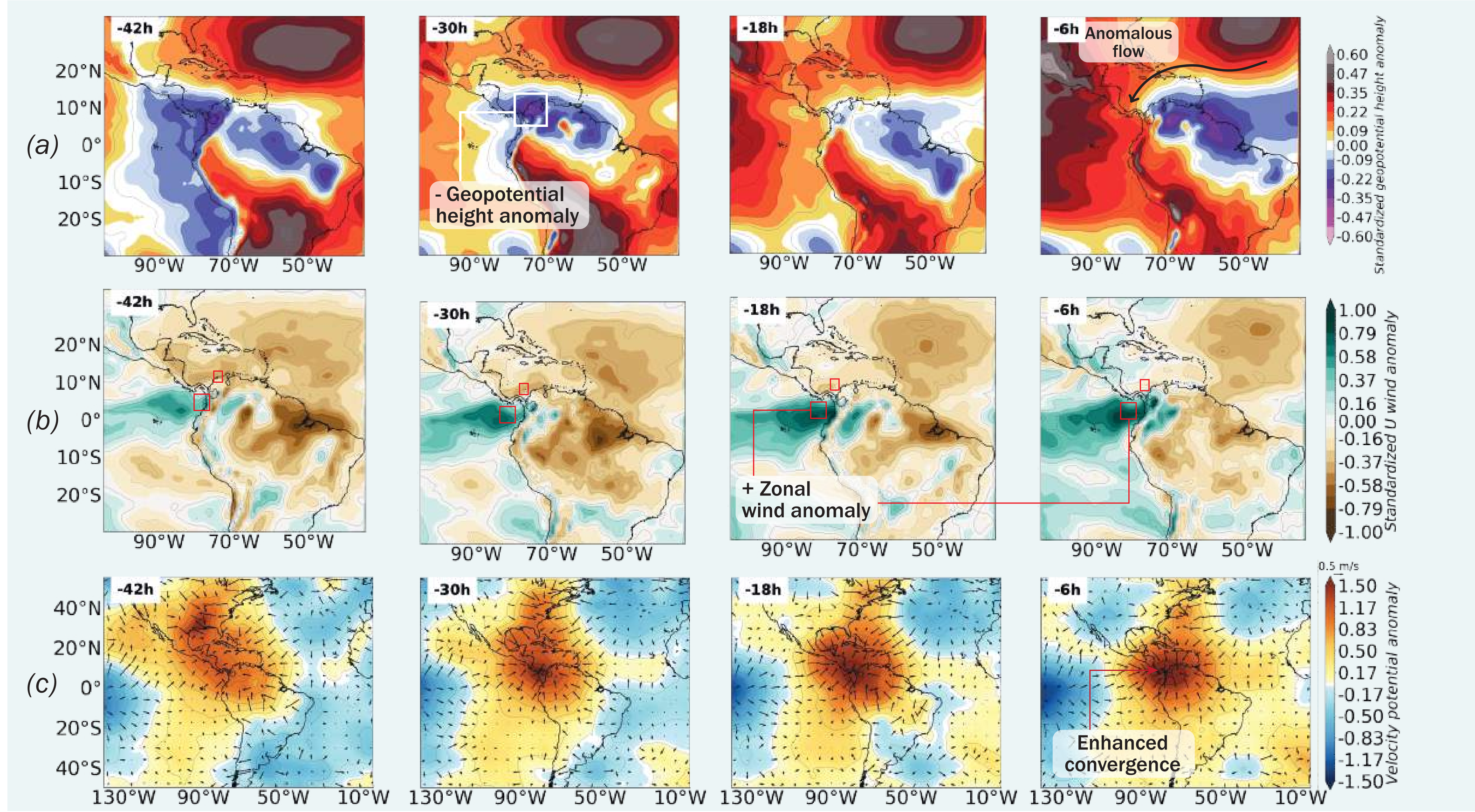


Figure 9: *Composite standardized anomaly for (a) geopotential height and (b) zonal wind, at 925 hPa; composite anomaly for (c) velocity potential at 925 hPa scaled by $1 * 10^6$ m s^{-1} during January extreme rainfall events. (ERA-Interim).*

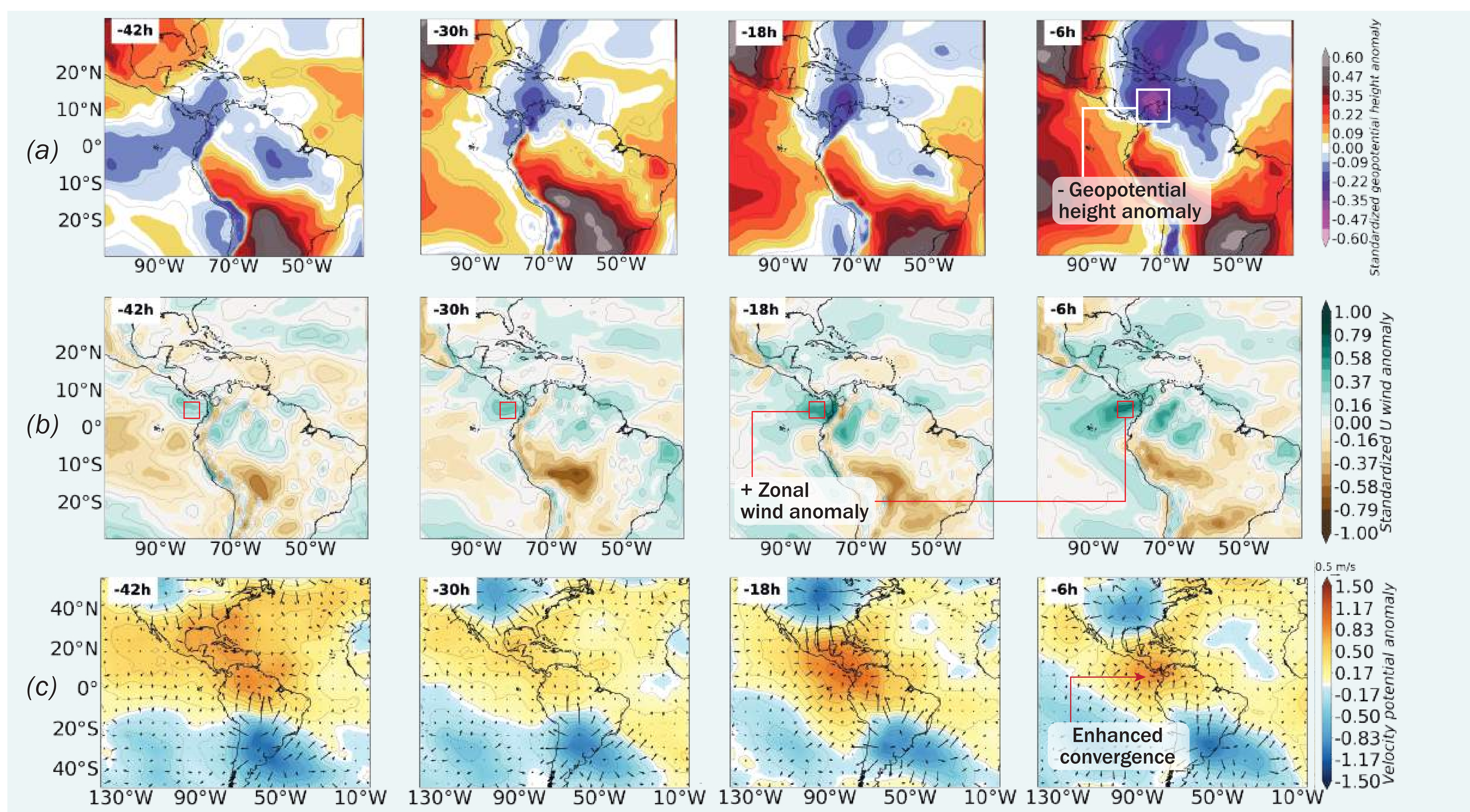


Figure 10: *Same as in Figure 9, but for November extreme rainfall events.*

Zonal wind anomalies at 925 hPa

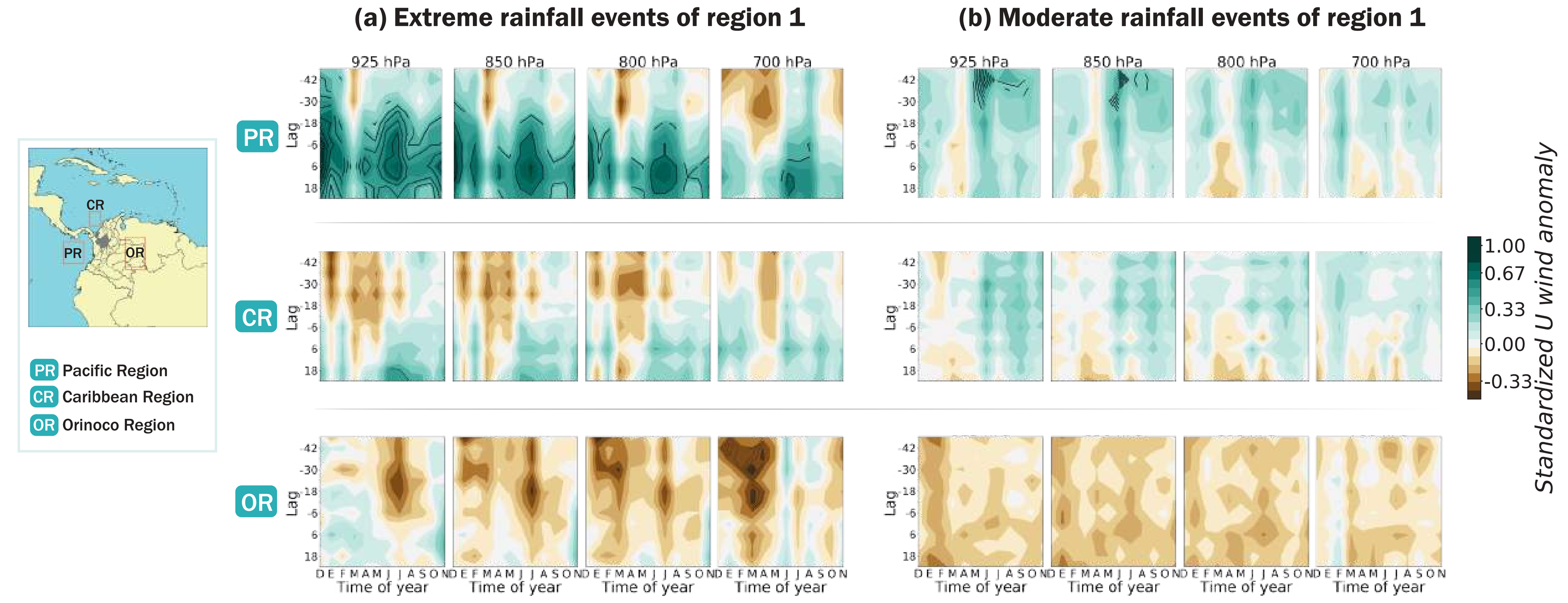


Figure 11: *Zonal wind standardized anomalies at 925, 850, 800 and, 700 hPa for events of each month. (a) Extreme rainfall events and (b) Moderate rainfall events.*

Cases of study

Rainfall event: November 1 at 12 utc to November 2 at 12 utc

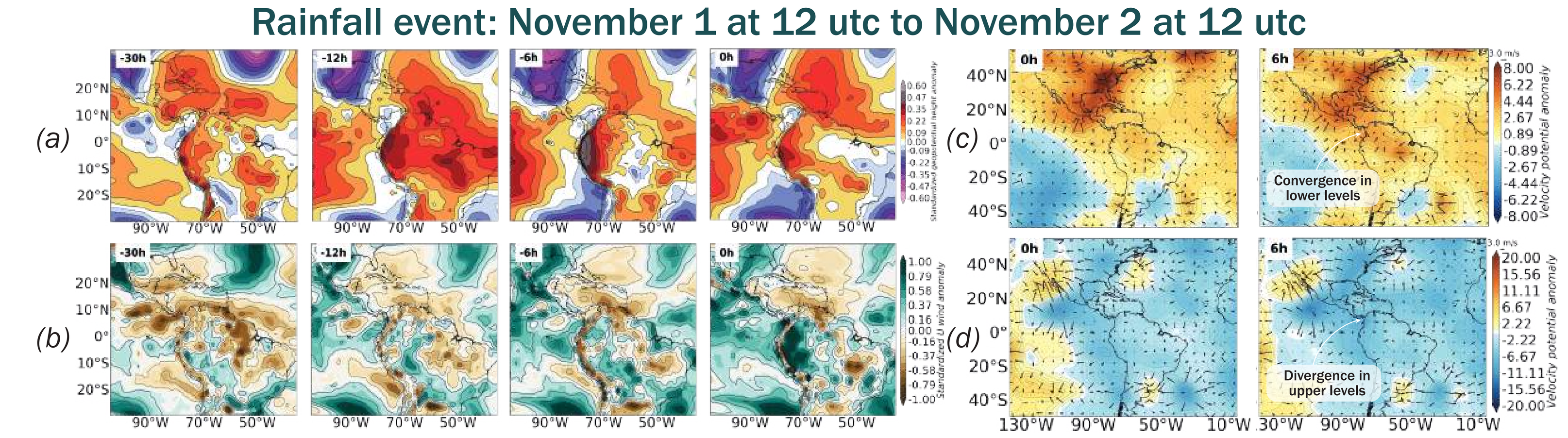


Figure 12: *Composite standardized anomaly for (a) geopotential height and (b) zonal wind at 925 hPa; composite anomaly for (c) velocity potential at 925 hPa and (d) 200 hPa scaled by $1 * 10^6$ m s^{-1} during extreme rainfall event 2018/11/01 to 2018/11/02.*

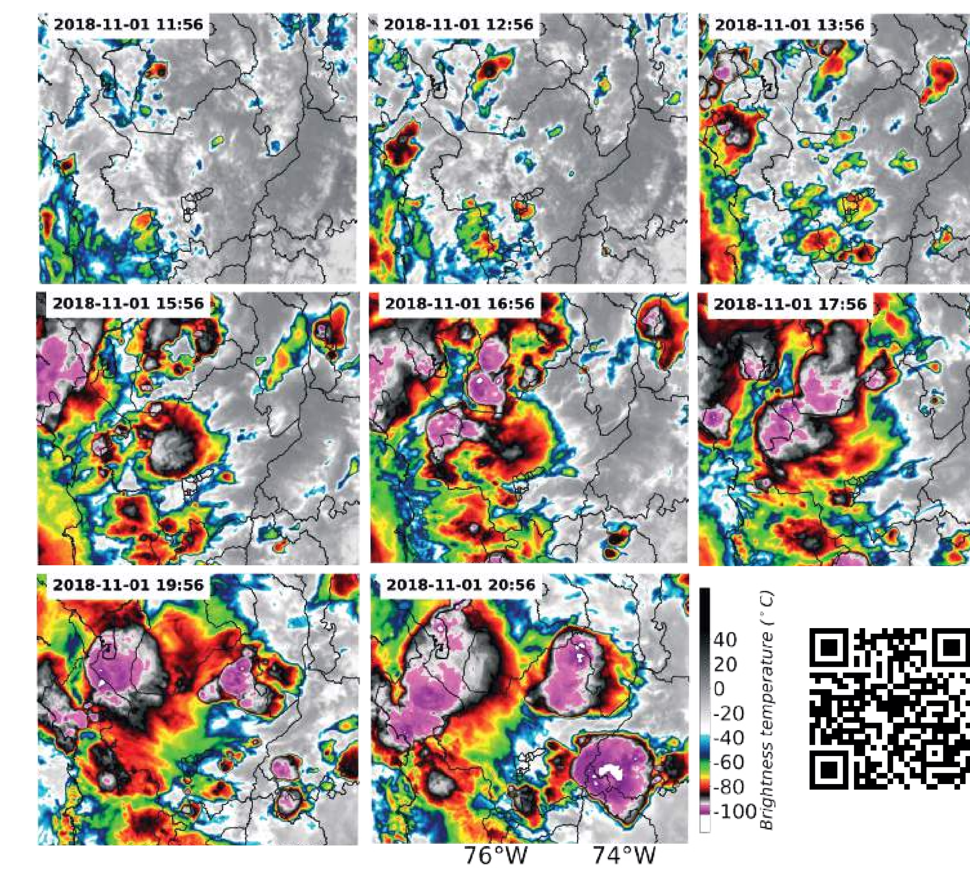
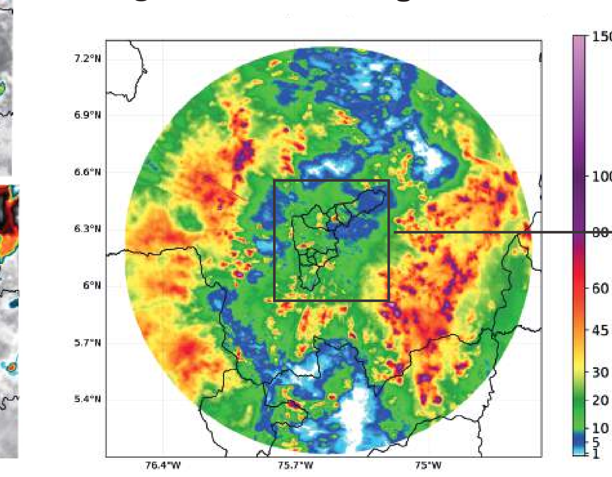


Figure 13: *GOES-ABI IR imagery evolution during the rainfall event 20818/11/01 to 2018/11/02.*

Figure 14: *Same as Figure 3*



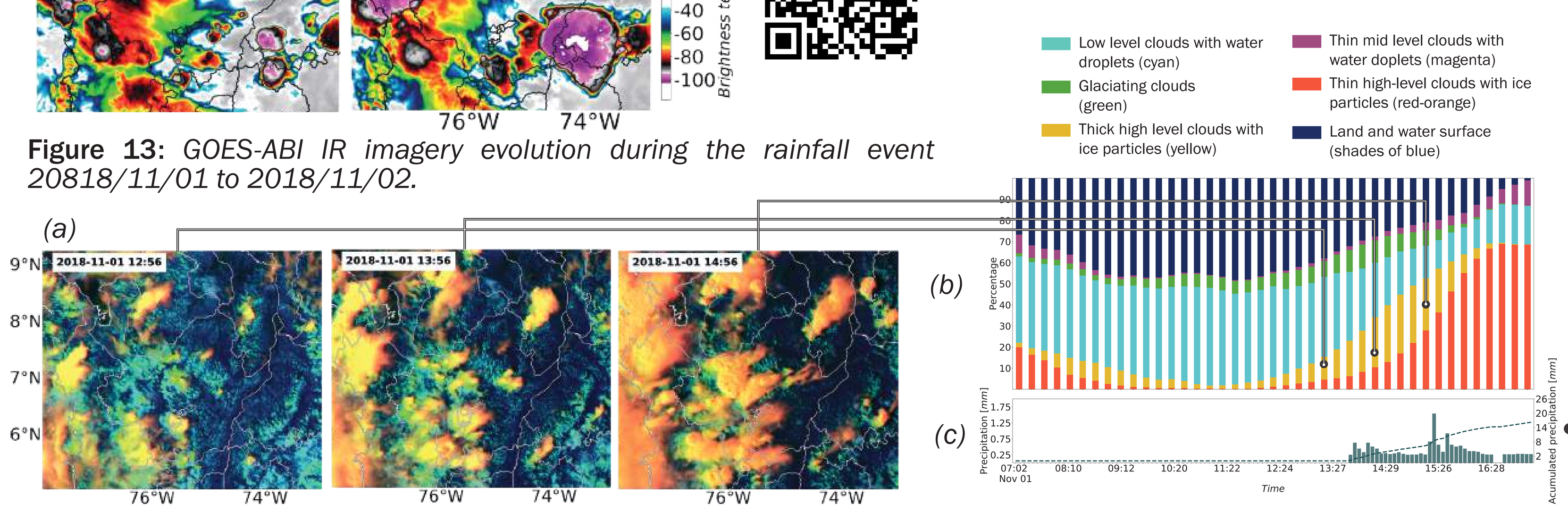


Figure 15: *Cloud phase distinction (CIRA, CIMMS) analysis for rainfall event 20818/11/01 to 2018/11/02. (a) Spatial distribution of cloud phases and, (b) time series evolution of cloud top phases, (c) time series of the spatial mean over the marked area in figure 14.*

Conclusions

- The results and their physical coherence suggest that standardized anomalies can potentially be useful for forecasting extreme events in the region in the short term (1-2 days).
- January extreme rainfall events appear to be linked to positive anomalies of geopotential height over the western Atlantic Ocean and the Eastern Pacific Ocean and negative anomalies over northwest South America. The enhancement of easterly winds and the development of positive zonal wind anomalies over the eastern Pacific lead to strong convergence over the northwestern corner of South America and Central America.
- Zonal wind standardized anomalies over the eastern Pacific at 925, 850, and, 800 hPa appear to be associated with the occurrence of the extreme rainfall events over Antioquia during most months, except March, April, and May. For these months, negative standardized anomalies over the Orinoquia (eastern Colombia) at 800 and 700 hPa appear to be related to the occurrence of rainfall.
- Trends in cloud top phases are an excellent tool for forecasting and monitoring the characteristics of the evolution of rainfall events.

Acknowledgements

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