The GRR product: A regionally adjusted rainfall retrieval for the Galápagos archipelago

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Introduction: *The unique geographical location of the Galápagos Archipelago creates distinctive climatic conditions that support its exceptional endemic biodiversity. However, the archipelago's water cycle remains poorly understood due to the limited availability of long-term, spatially distributed meteorological observations. In particular, the spatial and temporal variability of convective, stratiform, and occult precipitation remains largely unknown. To address this gap, the Galápagos Rainfall Retrieval (GRR) was developed to provide near realtime rainfall estimates and improve our understanding of precipitation variability across the archipelago.*

Methods

Galápagos Rainfall Retrieval (GRR) product:

- Locally adjusted satellite-based rainfall retrieval
- High spatio-temporal resolution (2 km, 10 min) rainfall product in near real-time
- Hybrid physical–machine learning method

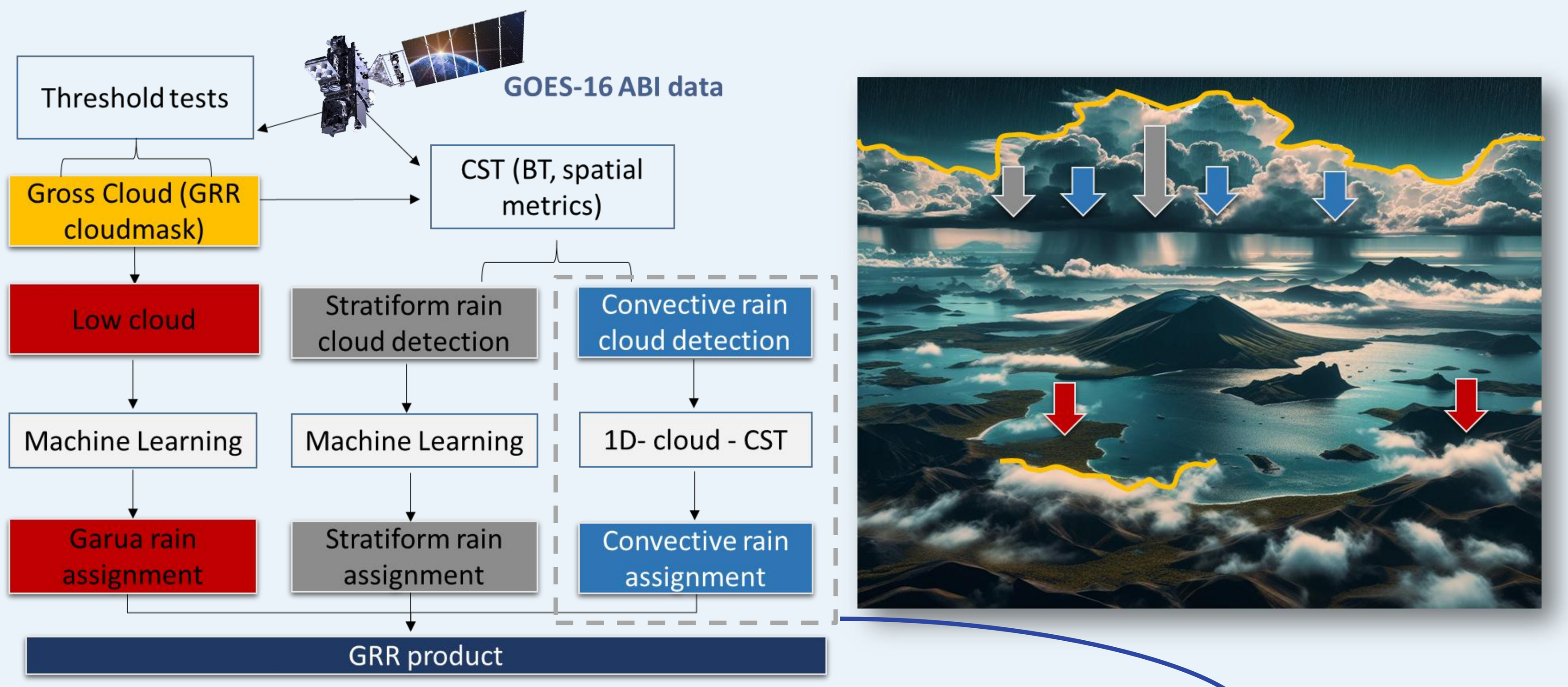

Fig 1. General framework of GRR retrieval

GRR-convective rainfall:

- Physical method: Adjusted convective stratiform technique (CST) and 1d cloud model (Bendix, 1997)

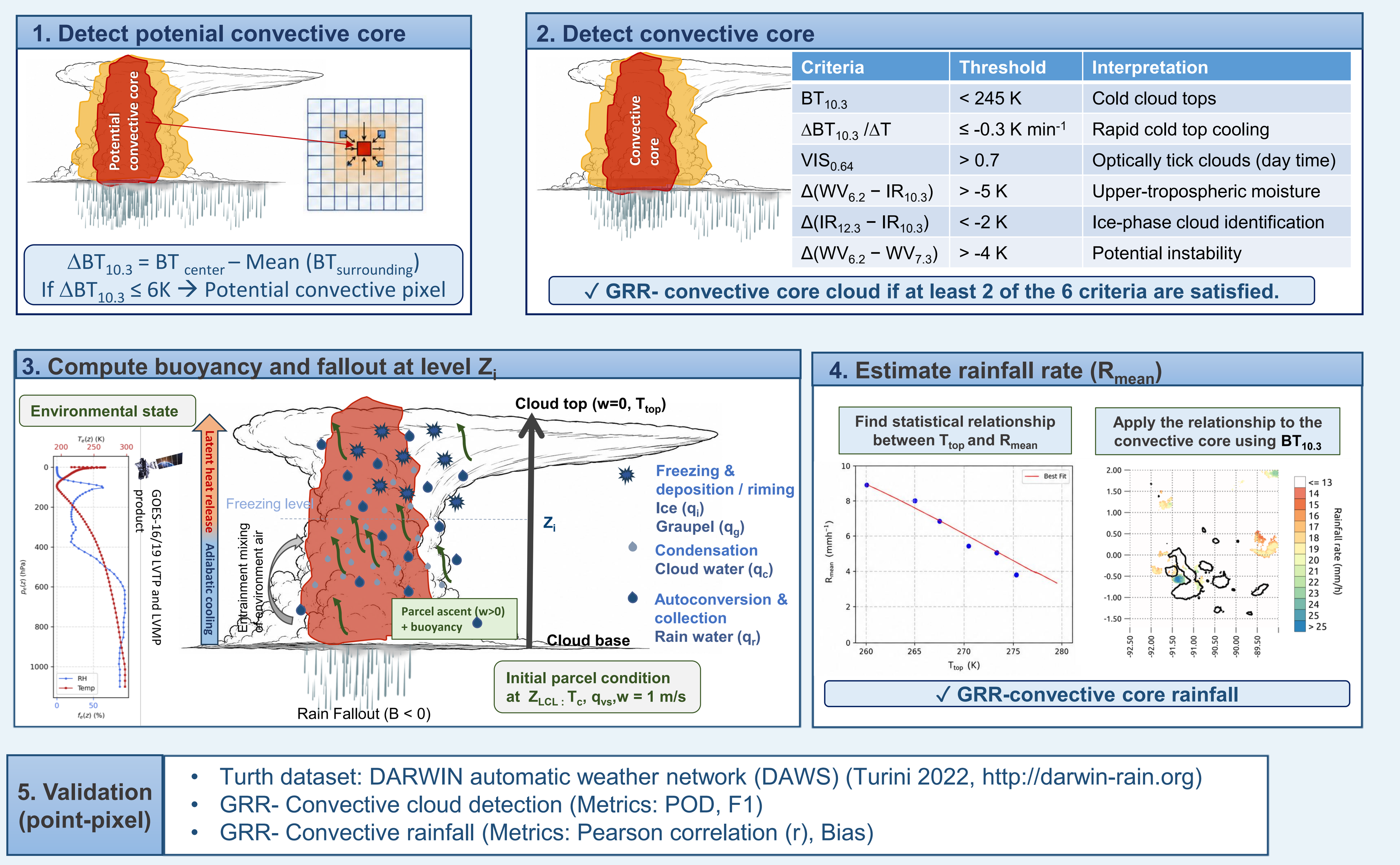

Fig 2. General framework of GRR-convective retrieval

Result – GRR-convective retrieval

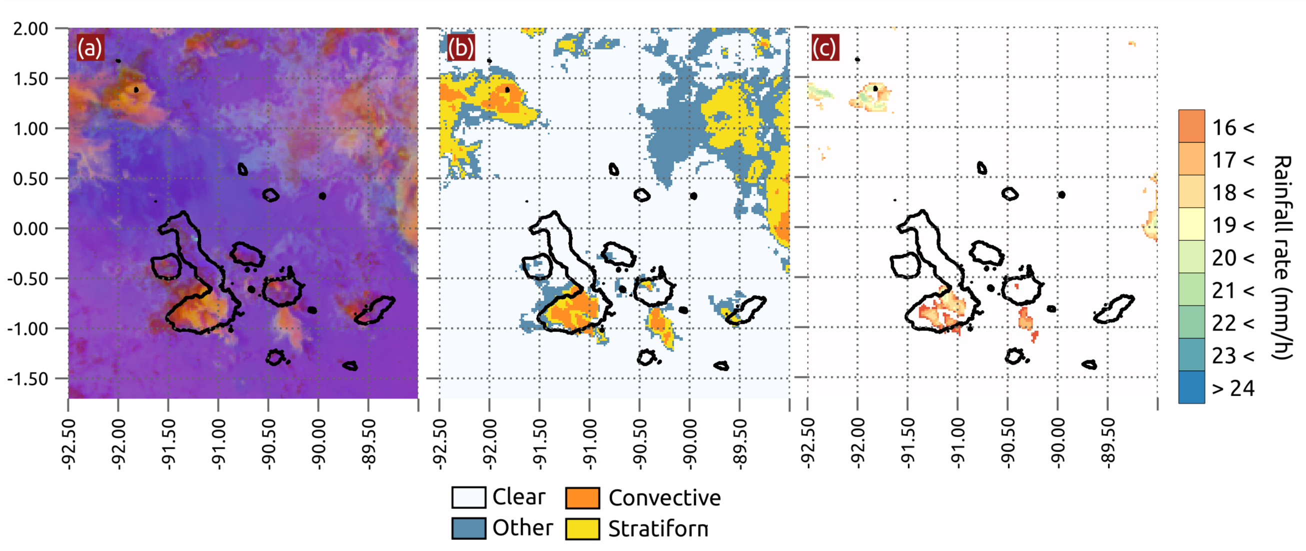

Fig 3. Example scene of a) Micorphysic composite, b) GRR-cloud type, b) GRR-Convective core rainfall for 2022/03/20 at 20:20 UTC

Table 1. Performance of GRR-Convective rainfall against Darwin automatic station network (Turini 2022, http://darwin-rain.org)

Metric	1 hour	3 hour	Daily	Monthly
POD	0.75	0.8	0.9	1
F1	0.28	0.32	0.52	0.75
Pearson correlation	0.15	0.4	0.50	0.91
Bias (mm)	0.9	1.82	1.62	2.86

- High convective rainfall detection capability was maintained across all temporal scales (POD = 0.75–1.00).
- Overall convective detection skill was limited at the hourly scale but improved substantially with temporal aggregation (F1 = 0.75 at monthly).
- Convective Rainfall estimates showed good agreement with the reference dataset at 3 hourly resolution (r = 0.4) and strong agreement at monthly resolution (r = 0.91).

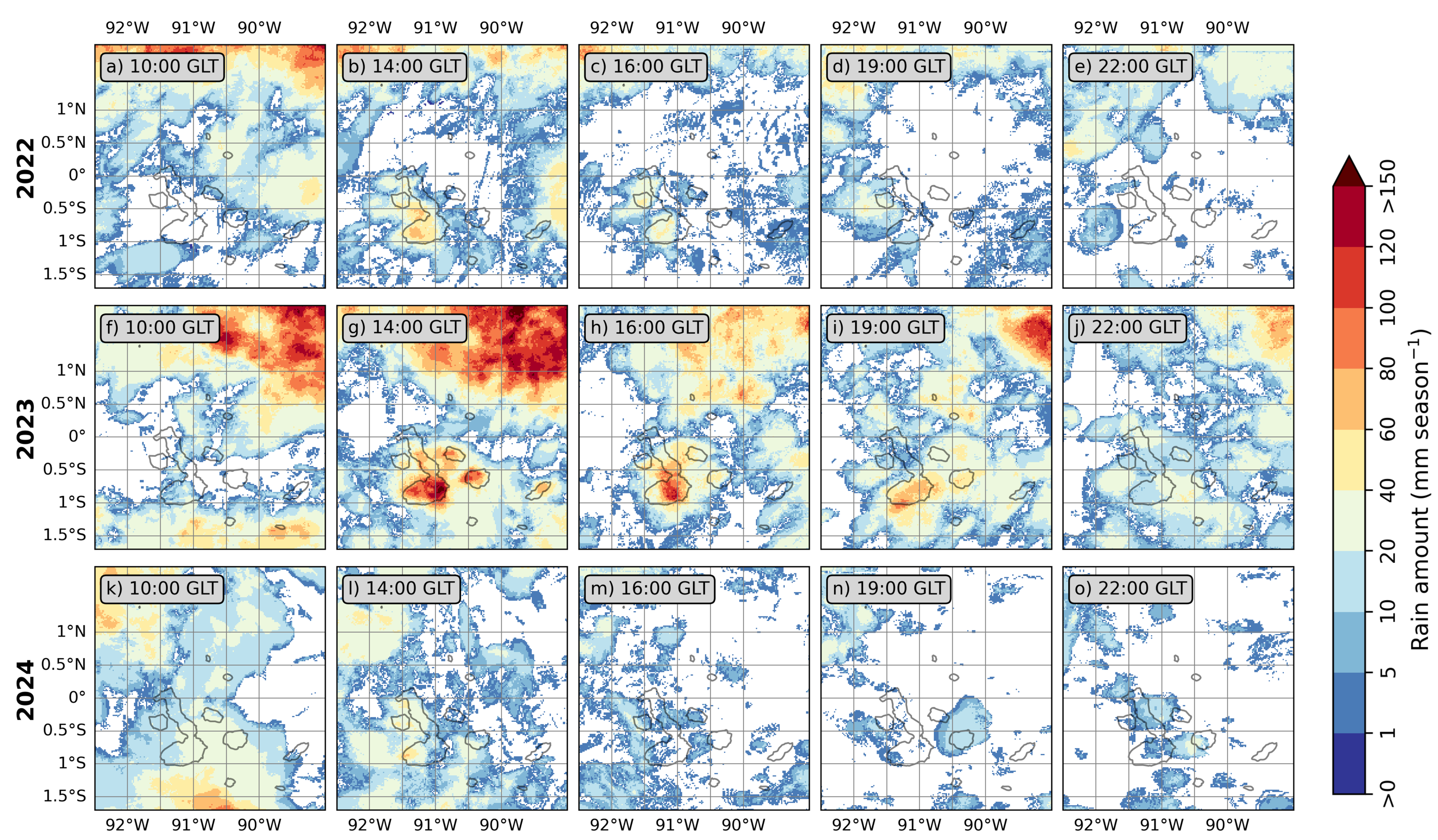

Fig 4. Diurnal distribution of convective rain amount observed by GRR during the hot season for 2022–2024.

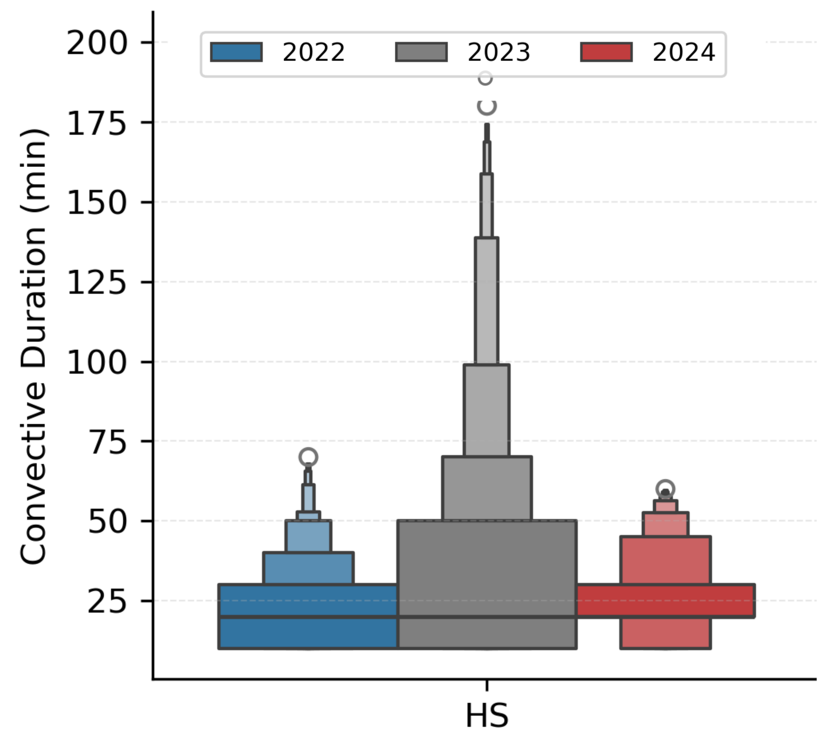

Fig 5. Convective duration observed by GRR-Convective core rainfall

- Midday convective rainfall is most pronounced during the hot season (HS) (Fig 4. b,g,l).
- The 2023 El Niño event was associated with increased rainfall amounts (Fig 4. g).
- Convective rainfall last longer during the 2023 El Niño event (Fig. 4g–j) and Fig 5.

Conclusion

- **GRR retrieval algorithm** uses multispectral observations from **GOES-16/19** to classify cloud types and estimate rainfall through a hybrid retrieval model.
- Successful capturing of main characteristics of convective rainfall by GRR-convective rainfall retrieval successfully.
- Improvement of retrieval performance with increasing temporal aggregation, from **hourly** to **monthly** scales.
- **Strong midday convection** during the hot season and **enhanced daytime convective rainfall** during the **2023 El Niño** event.

References:

- Bendix, J., 1997. Adjustment of the Convective-Stratiform Technique (CST) to estimate 1991/93 El Niño rainfall distribution in Ecuador and Peru by means of Meteosat-3 IR data. *International Journal of Remote Sensing*, 18(6), pp.1387–1394. https://doi.org/10.1080/014311697218502

Acknowledgements :

The project is kindly funded by the Research Foundation of Germany (DFG) under the grant number BE 1780/60-1.

Deutsche Forschungsgemeinschaft