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Exploring the dynamics of Tropical Cyclones in the Eastern Tropical Atlantic: a Weather Types perspective

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Studying Major Tropical Cyclones (MaTCs) is vital due to their significant impact on natural resource management, infrastructure resilience, and disaster preparedness, especially in vulnerable regions.

However there exists a gap in our understanding of the MaTC development and occurrence processes, particularly in the Eastern Tropical Atlantic (ETA) and on the Atlantic coast of West Africa where the interaction with African Easterly Waves (AEWs) appears to be a crucial aspect. In fact, although some AEWs evolve into MaTCs, a clear causal relationship between the two phenomena has not been established yet. In particular, the reason why only some AEWs evolve into MaTCs and other MaTCs evolve without an AEW's contribution has not been elucidated yet.

The primary focus of this study is the characterization of the MaTCs in terms of “Weather Types” (WTs), which represent distinct atmospheric states showing persistence over days.

The aim of this research is to answer the following scientific questions:

1)Without explicitly describing the dynamic system or solving it analytically, how can WTs be utilized to characterize the patterns of atmospheric circulation in the ETA?

2)Which specific WTs exert a more significant influence on the frequency or occurrence of MaTCs in the region, assuming such a dependency exists?

3)How do MaTCs and AEWs interact with respect to the atmospheric circulation expressed through WTs?

To answer these questions we employed Self-Organizing Maps and Hierarchical Agglomerative Clustering to analyze atmospheric variables extracted from the ECMWF Reanalysis v5 (ERA5) and ECMWF Atmospheric Composition Reanalysis 4 (EAC4) reanalyses. Moreover, detailed information on the location, maximum winds, central pressure, and size of cyclones is extracted from the National Hurricane Centre database (HURDAT), while AEWs are identified and tracked by an algorithm developed at the Karlsruhe Institute of Technology (AEWDAT).

This approach enables the identification of eight distinct WTs characterizing the atmospheric circulation in a region including ETA and the Atlantic coast of West Africa, making it possible to observe how the occurrence of a specific WT is suppressive or favorable for the occurrence of a MaTC.

The analysis shows specific atmospheric conditions under which AEWs and MaTCs co-occur: in this sense we have identified WTs that are associated with the occurrence of a MaTC together with an AEW or with a MaTC alone.

These results improve our knowledge on the relationship between AEWs and MaTCs as they provide the atmospheric circulation context in which they interact.

The insights gained from this study may contribute to the field by offering a refined methodological framework, employing a WT-centric approach, and providing a comprehensive analysis of MaTC dynamics in the context of atmospheric circulation.