Weather regime characterisation of the atmospheric environment leading to the development of tropical cyclones in the Northern Tropical Atlantic

Marco Gaetani (1), Cyrille Flamant (2), Tanguy Jonville (2), Jean-Pierre Chaboureau (3), Christophe Lavaysse (4), Juan Cuesta (5), Laurent Menut (6), Natalia Castillo (1), Paolo Besana (1) and Paola Formenti (5)

(1) IUSS Pavia, Italy; (2) LATMOS, IPSL, CNRS, Paris, France; (3) Laboratoire d'Aerologie, CNRS, Université de Toulouse, France; (4) IRD, Grenoble, France; (5) LISA, IPSL, CNRS, Creteil, France; (6) LMD, IPSL, CNRS, Palaiseau, France

Background and Objectives

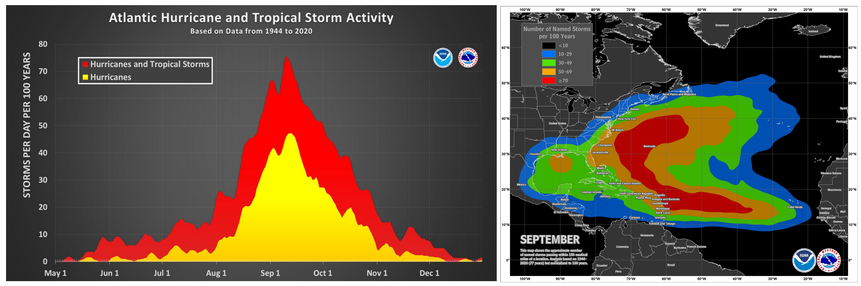

Figure 1: TC climatology (from the US NOAA).

- Tropical cyclones (TCs) development in the Northern Tropical Atlantic occurs off shore Senegal in the Cap Verde region **(Fig. 1)**, peaking in September **(Fig. 1)**.
- TCs develops from depressions travelling westward from West Africa **(Fig. 2)**. However, the mechanisms concurring to the formation of TCs from easterly depressions are still unclear, because the environment where the TC transition occurs is characterised by complex interactions involving atmospheric dynamics and aerosol-cloud-radiation interactions **(Fig. 2)**.
- The purpose of this study is to contribute to enlighten the mechanisms leading an easterly African depression to evolve (or not) into a TC in the Northern Tropical Atlantic, by characterising the atmospheric environment off shore Senegal and south of Cape Verde.

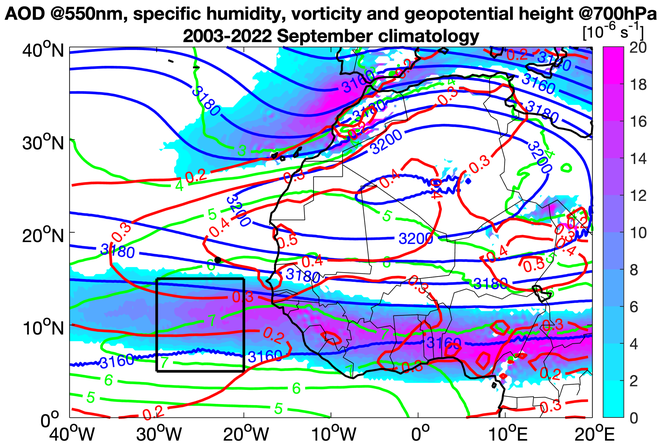

Figure 2: Climatology of the main atmospheric features at the peak of the TC season.

Data and Methods

- Data from ERA5 and CAMS reanalysis products are analysed for the period 2003-2022.
- By using a k-means classification algorithm, a weather regime (WR) classification of the synoptic variability (geopotential height at 700 hPa) is performed during the monsoonal season (JAS), in a region including West Africa and Northern Tropical Atlantic **(Fig. 3)**.
- The WR classification is then used to characterise the relevant atmospheric variables involved in the TC development (aerosol optical depth at 550 nm, vorticity and specific humidity at 700 hPa) **(Fig. 4-6)**.

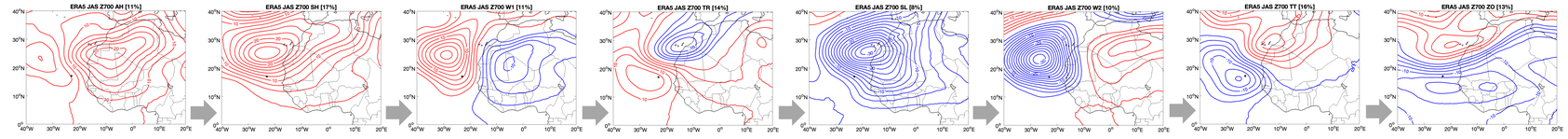

Figure 3: WR classification of the geopotential height anomalies at 700 hPa (July-to-September): AH = African High; SH = Subtropical High; W1 = Wave 1; TR = Tropical Ridge; SL = Subtropical Low; W2 = Wave 2; TT = Tropical Trough; ZO = Zonal.

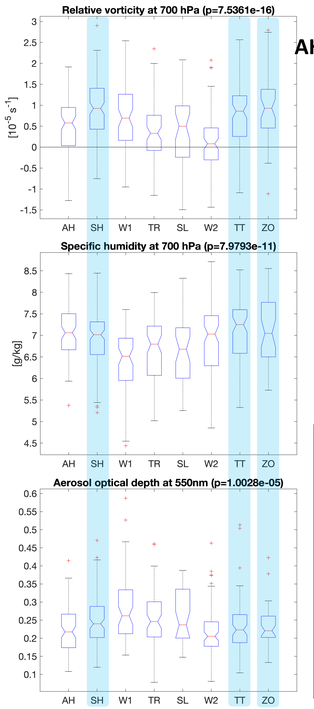

Figure 4: WR characterisation of the atmospheric environment in the Cape Verde region in September. The WRs favourable to cyclogenesis (high positive vorticity and specific humidity, low dust content) are highlighted.

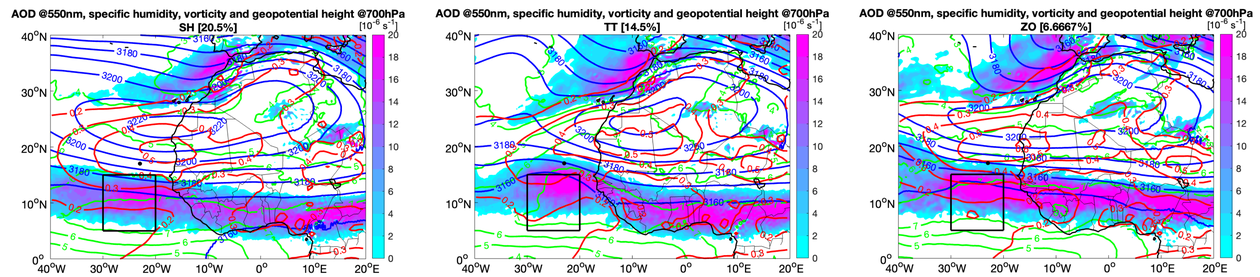

Figure 5: Synoptic conditions associated with WRs favourable to cyclogenesis.

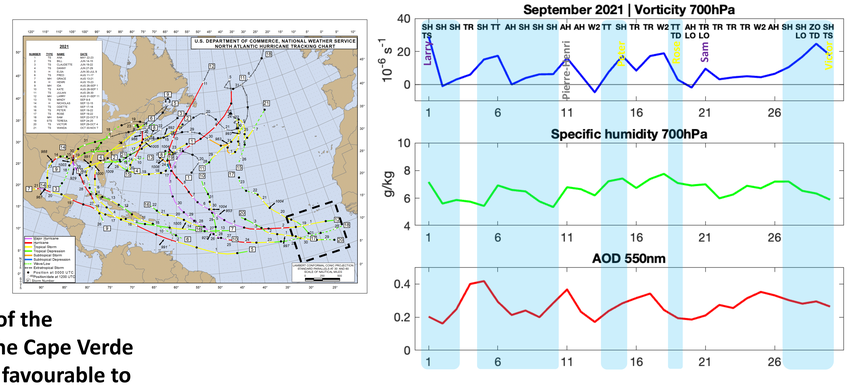

Figure 6: September 2021: (left) hurricane tracking chart (from the US NWS); (right) WR characterisation of the atmospheric environment in the Cape Verde region in September 2021 [CADDIWA campaign].

Preliminary results

- WR classification is effective in characterising the atmospheric environment favourable to the development of TCs in the Cape Verde region.
- Atmospheric circulation anomalies characterised by high/low pressure in the subtropical/tropical Atlantic are associated with: 1) zonal pattern for the West African disturbances; 2) northward penetration of the monsoonal flow; 3) zonal dust transport.
- Testing the WR characterisation during the CADDIWA campaign shows promising results.
- However, more variables must be analysed to refine the WR characterisation and improve its robustness.

IUSS Scuola Universitaria Superiore Pavia

Contact: marco.gaetani@iusspavia.it

CADDIWA