Future climate projections in the French West Indies: Regional climate, tropical cyclones and storm waves

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Abstract

Although small island nations and territories such as the West Indies have long been identified as among the most vulnerable to climate change and climate extremes, few studies have focused on future projections at spatial scales relevant for island communities in the eastern Caribbean. While consistent future warming and drying trends have been recently documented, together with an increase in extreme drought and rainfall events and in the frequency of major hurricanes, most climate models do not have resolutions high enough for meaningful projections at the island scale and for adequate representation of tropical cyclones (TCs) and of the associated storm waves.

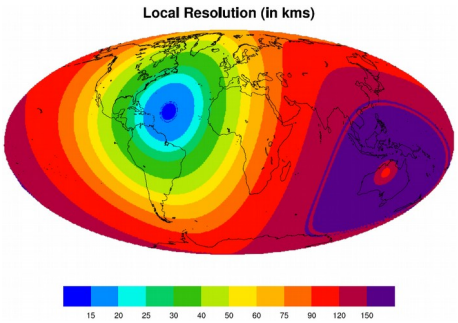

Fig. 1 Grid spacing (km) for the ARPEGE-Climat atmospheric GCM. Adapted from Chauvin et al. 2020.

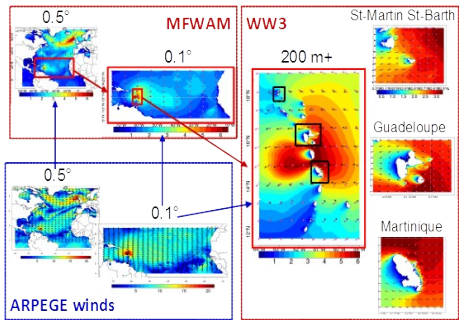

Fig. 2 The MFWAM and WaveWatch3 nested wave models driven by ARPEGE-Climat.

The interdisciplinary collaborative C3AF project (*Climate Change and Consequences over the French Antilles*, http://c3af.univ-montp3.fr) aims at studying trends and hazards associated with climate change in the French West Indies (Guadeloupe, Martinique, Saint-Barthélemy, Saint-Martin), as well as their environmental and socio-economic impacts. At Météo-France, a group of researchers study future changes in Atlantic TC activity, in the associated swells that hit Antillean coasts, in regional and local climate. 5-member global atmospheric model simulations on a stretched grid with mesoscale-permitting resolution in the tropical North Atlantic (Fig. 1) and SST forcing from the CNRM-CM5 global climate model under the RCP8.5 scenario for 2031-2080 allow tracking tropical storms and hurricanes in order to detect changes in their frequency, intensity and geographical distribution. These simulations are also used both to drive wave models of increasing resolutions towards the eastern Caribbean (from 50 km to 200 m, Fig. 2) in order to estimate changes in TC wave climate, and to infer temperature and rainfall projections at

the island scale after quantile-quantile corrections with long station data (Fig. 3) and further high-resolution mapping using an advanced kriging technique.

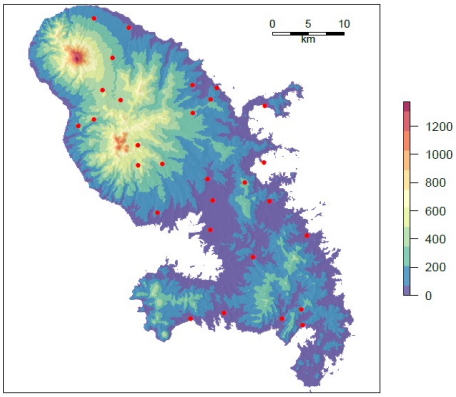

Fig. 3 Locations of the 29 stations used for correction of ARPEGE-Climat rainfall data for Martinique, overlaid on SRTM topography.

Significant shifts in TC activity towards the Cape Verde region and mid-latitudes to some extent (*i.e.* away from the Caribbean) were found with a peak in September (Fig. 4), as well as a shortening of the hurricane season, intensified TC rainfall, and a larger proportion of major hurricanes. Whereas basin-wide seasonal mean significant wave heights were found to decrease, both TC-induced mean and extreme wave heights were found to increase within a large region extending from the african coasts to the american continent, with variable impacts along eastern Caribbean shores (Fig. 4). Strong year-round warming and significant wet-season drying (Fig. 5) were also found for the French West Indies, together with more frequent heat waves and droughts yet less frequent extreme rainfall events, with potentially adverse impacts on key sectors of the islands' economy such as water and agriculture.

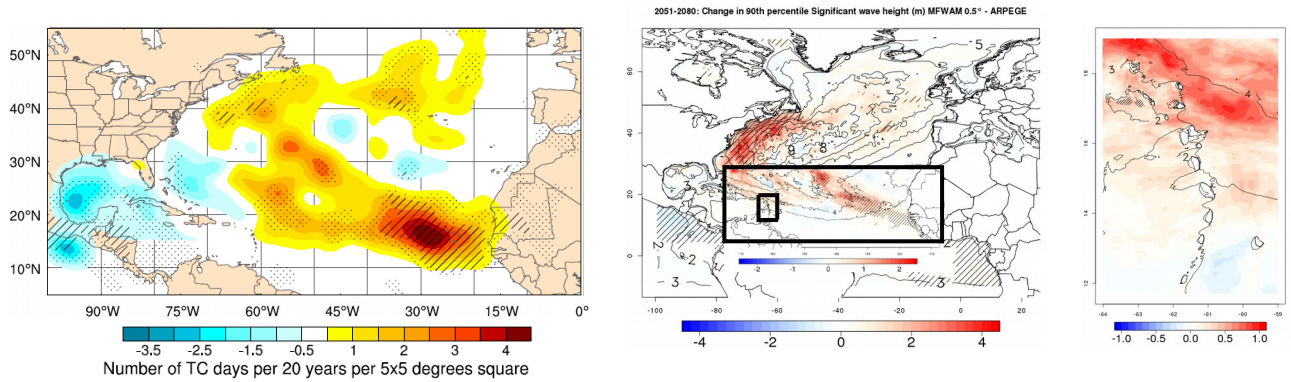

Fig. 4 (left) Future changes in Atlantic TC numbers in September (Chauvin et al. 2020) and (middle/right) in extreme TC-related wave heights from mid-August to mid-September (Belmadani et al. 2020).

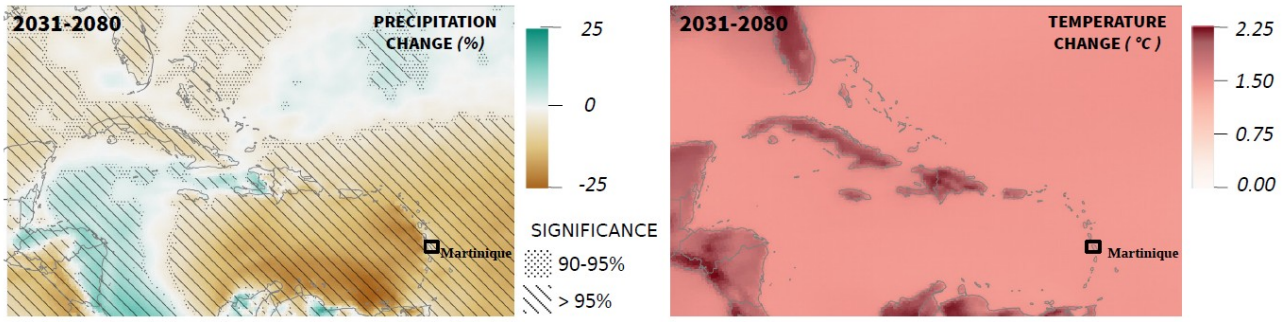

Fig. 5 (left) Future changes in Caribbean annual rainfall (%) and (right) annual mean surface temperature.

References

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