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Characterization of Heat Waves in the Sahel and associated mechanisms

Boutheina Oueslati (1), Benjamin Pohl (1), Vincent Moron (2), and Sandra Rome (3)

(1) CRC, UMR 6282, Biogéosciences, CNRS/Université de Bourgogne – Franche-Comté, Dijon, France, (2) Université Aix-Marseille, UM 34 CNRS, CEREGE, Aix en Provence, France - IRI, Columbia University, Palisades, USA, (3) Université Grenoble Alpes, LTHE UMR 5564, Grenoble, France

Large efforts are made to investigate the heat waves (HW) in developed countries because of their devastating impacts on society, economy and environment. This interest increased after the intense event over Europe during summer 2003. However, HWs are still understudied over developing countries. This is particularly true in West Africa, and especially in the Sahel, where temperatures recurrently reach critical values, such as during the 2010 HW event. Understanding the Sahelian HWs and associated health risks constitute the main objective of ACASIS, a 4-year project funded by the French Agence Nationale de la Recherche.

Our work contributes to this project and aims at characterizing the Sahelian HWs and understanding the mechanisms associated with such extreme events.

There is no universal definition of a HW event, since it is highly dependent on the sector (human health, agriculture, transport...) and region of interest. In our case, a HW is defined when the heat index of the day and of the night exceeds the 90th percentile for at least 3 consecutive days (Rome et al. 2016, in preparation). This index combines temperature and relative humidity in order to determine the human-perceived equivalent temperature (definition adapted from Steadman, 1979).

Intrinsic properties of Sahelian HW are analyzed from the Global Summary of the Day (GSOD) synoptic observations and ERA-interim reanalyses over 1979-2014 during boreal spring seasons (April-May-June), the warmest period of the year in the Central Sahel. ERA-interim captures well the observed interannual variability and seasonal cycle at the regional scale, as well as the 1979-2014 increasing linear trend of springtime HW occurrences in the Sahel. Reanalyses, however, overestimate the duration, spatial extent of HW, and underestimate their intensity. For both GSOD and ERA-interim, we show that, over the last three decades, Sahelian HWs tend to become more frequent, last longer, cover larger areas and reach higher intensities.

The physical mechanisms associated with HWs are examined to assess the respective roles of atmospheric dynamics, radiative and turbulent fluxes, in the establishment of such events, by analyzing the atmospheric moist static energy budget. The results suggest that the greenhouse effect of water vapor is the main driver of HWs in the Sahel, increasing minimum temperatures by the long-wave radiation radiated back to the surface. Maximum temperature anomalies are explained by increased downward shortwave radiation due to a reduction in cloud albedo. Atmospheric circulation plays an important role in sustaining these warm anomalies by advecting dry static energy from the Sahara and both dry and moist static energy from the Atlantic Ocean into the Sahel.