

Heat waves monitoring over West African cities: uncertainties, characterization and recent trends

Cedric G. Ngoungue Langué^{1,2}, Christophe Lavaysse^{2,3}, Mathieu Vrac⁴, and Cyrille Flamant¹

¹Laboratoire Atmosphères, Milieux, Observations Spatiales (LATMOS) - UMR 8190 CNRS/Sorbonne Université/UVSQ, 78280 Guyancourt, France.

²Université Grenoble Alpes, CNRS, IRD, G-INP, IGE, 38000 Grenoble, France

³European Commission, Joint Research Centre (JRC), 21027 Ispra, VA, Italy

⁴Laboratoire des Sciences du Climat et de l'Environnement, CEA Saclay l'Orme des Merisiers, UMR 8212 CEA-CNRS-UVSQ, Université Paris-Saclay & IPSL, 91191 Gif-sur-Yvette, France.

Correspondence: Ngoungue Langué Cedric Gacial (cedric-gacial.ngoungue-langué@latmos.ipsl.fr)

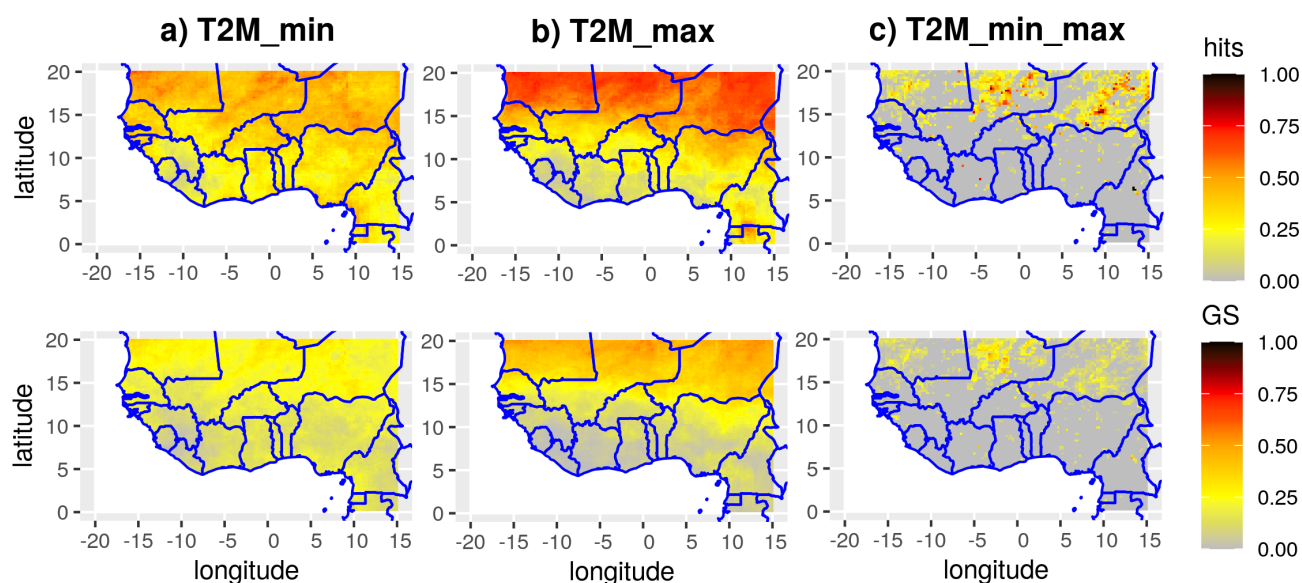


Figure S1. Evaluation of products: The first/second row represents respectively the hit rate/Gilbert score in terms of hot days between ERA5 and MERRA using respectively min/max/min-max values of T2m. X and Y -axis represent respectively the longitude and latitude in degrees. The color bar shows the values of the metrics.

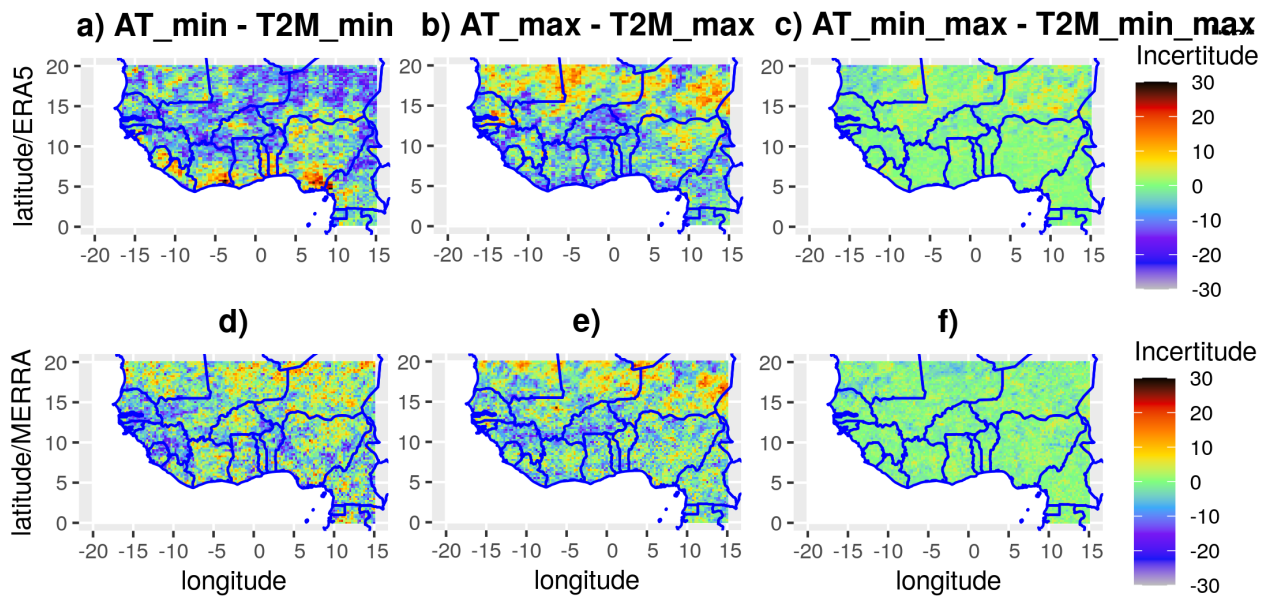


Figure S2. Difference of heat wave occurrence between AT and T2m using respectively min/max/min-max values: a-c) ERA5 and d-f) MERRA. X and Y -axis represent respectively the longitude and latitude in degrees. The color bar shows the difference of occurrences.

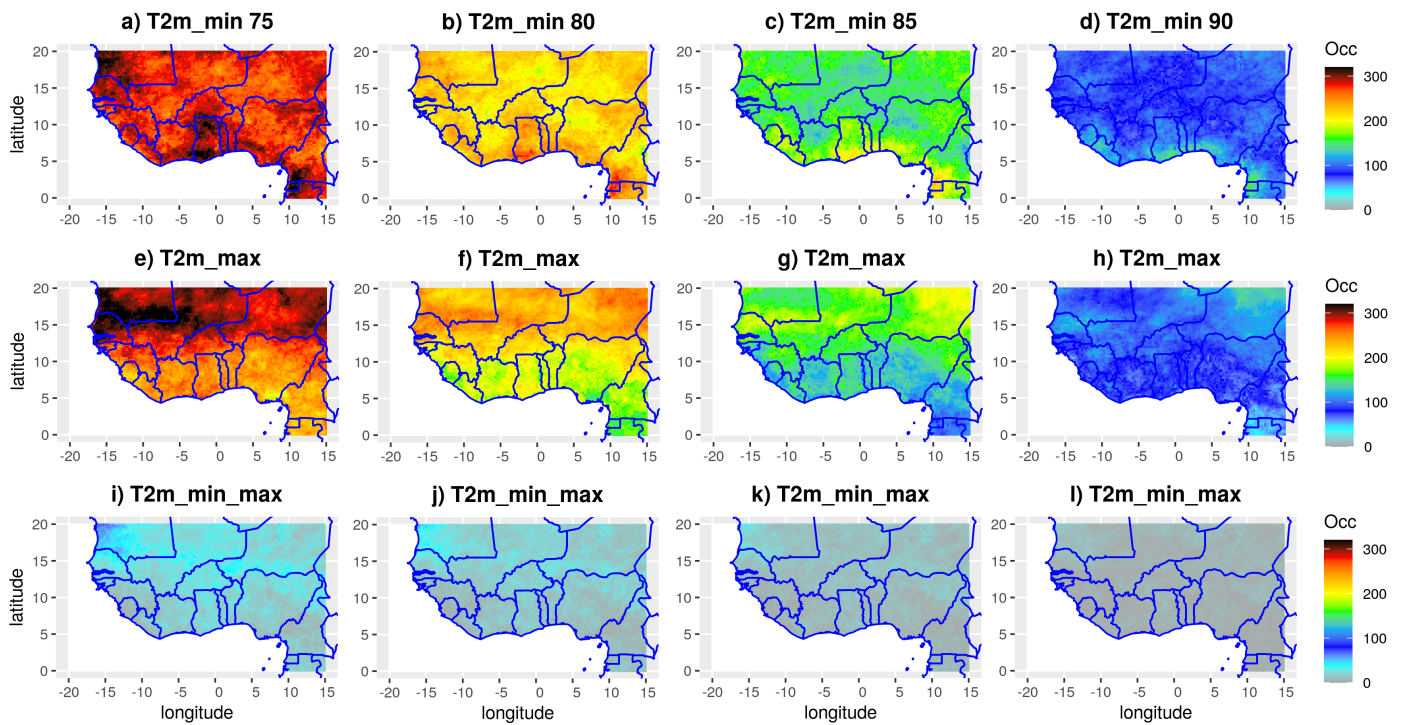


Figure S3. Spatial variability of heat waves occurrence with respect to the threshold values using T2m as indicator respectively for : a,e,i) 75th, b,f,j) 80th, c,g,k) 85th and d,h,l) 90th. X- and Y- axis respectively represent the longitude and latitude in degrees. The color bar shows the values of the occurrence of heat waves.

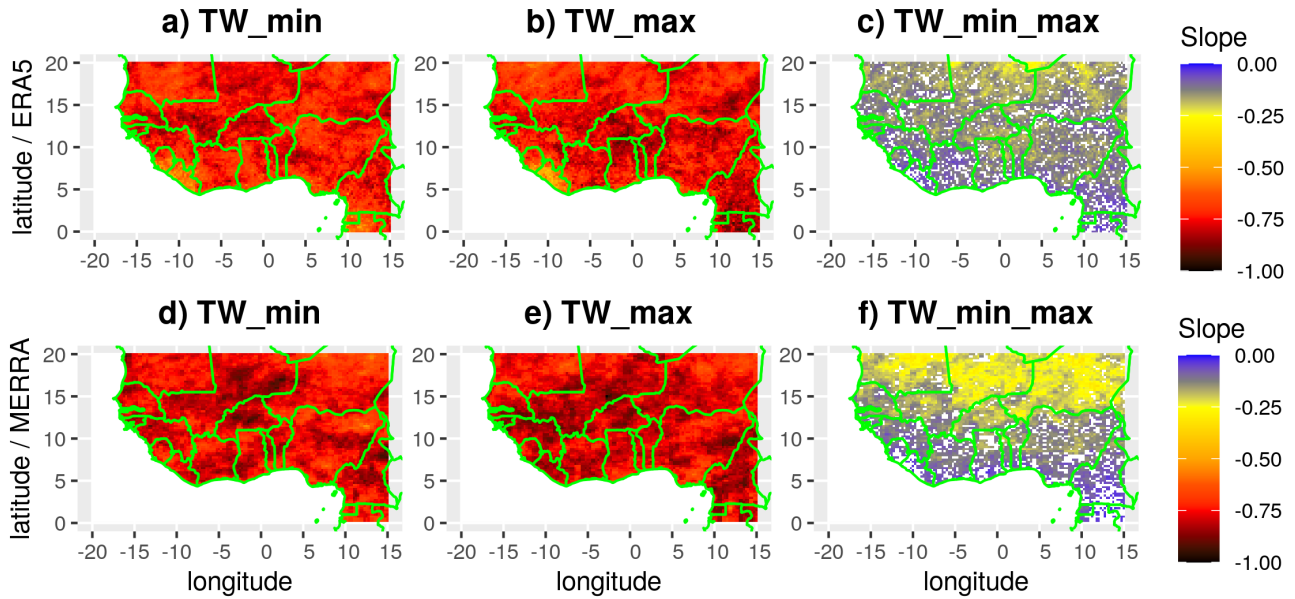


Figure S4. Evolution of the heat wave occurrence with respect to the threshold values using T_w as indicator respectively for : a-c) ERA5 and d-f) MERRA. The slope is computed using the 75th, 80th, 85th and 90th percentiles. X and Y-axis respectively represent the longitude and latitude in degrees. The color bar shows the values of the linear evolution of the heat wave occurrence per percentile. The white blanks indicate non significant changes in the occurrence of heat waves per percentile.

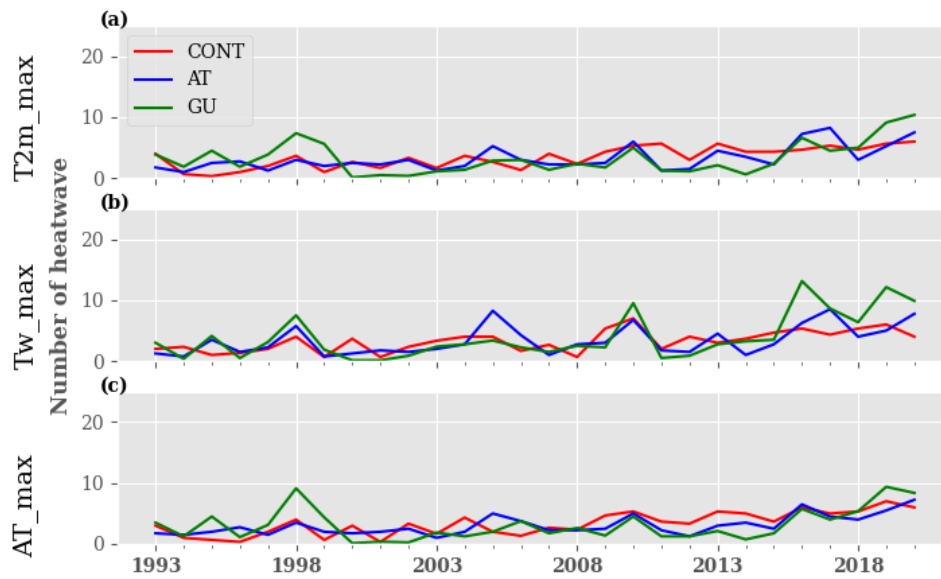


Figure S5. Interannual variability of heat wave occurrence using maximum values of the indicators: a) T2m, b) TW and c) AT. The Y-axis represents the frequency of heat waves and the X-axis represents the time in year. Red/blue/green lines represent the evolution of heat wave occurrence over CONT/AT/GU regions (see region of interest section for more details).

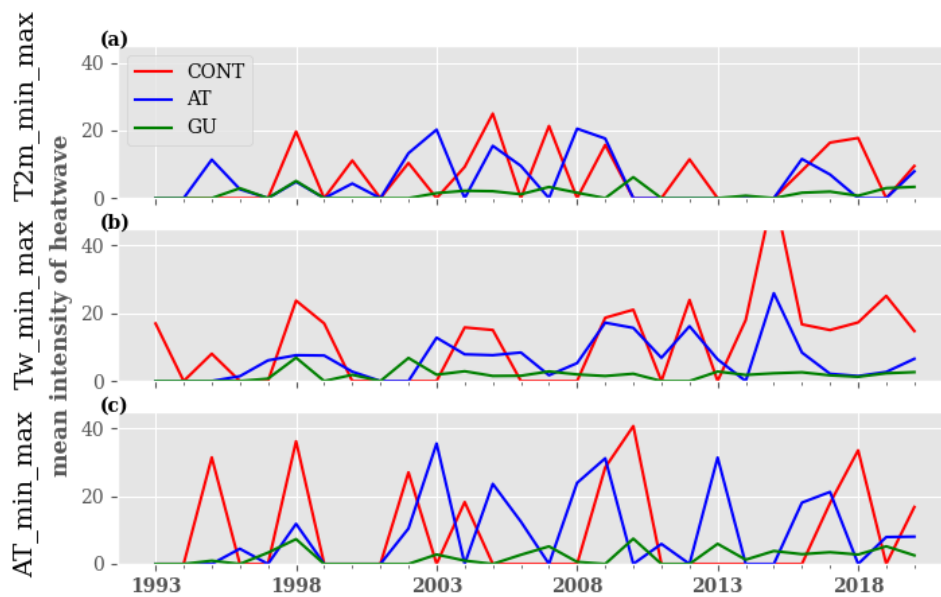


Figure S6. Interannual variability of heat wave intensity using minimum and maximum values of the indicators: a) T2m, b) TW and c) AT. The Y-axis represents the frequency of heat waves and the X-axis represents the time in year. Red/blue/green lines represent the evolution of heat wave intensity over CONT/AT/GU regions (see region of interest section for more details).

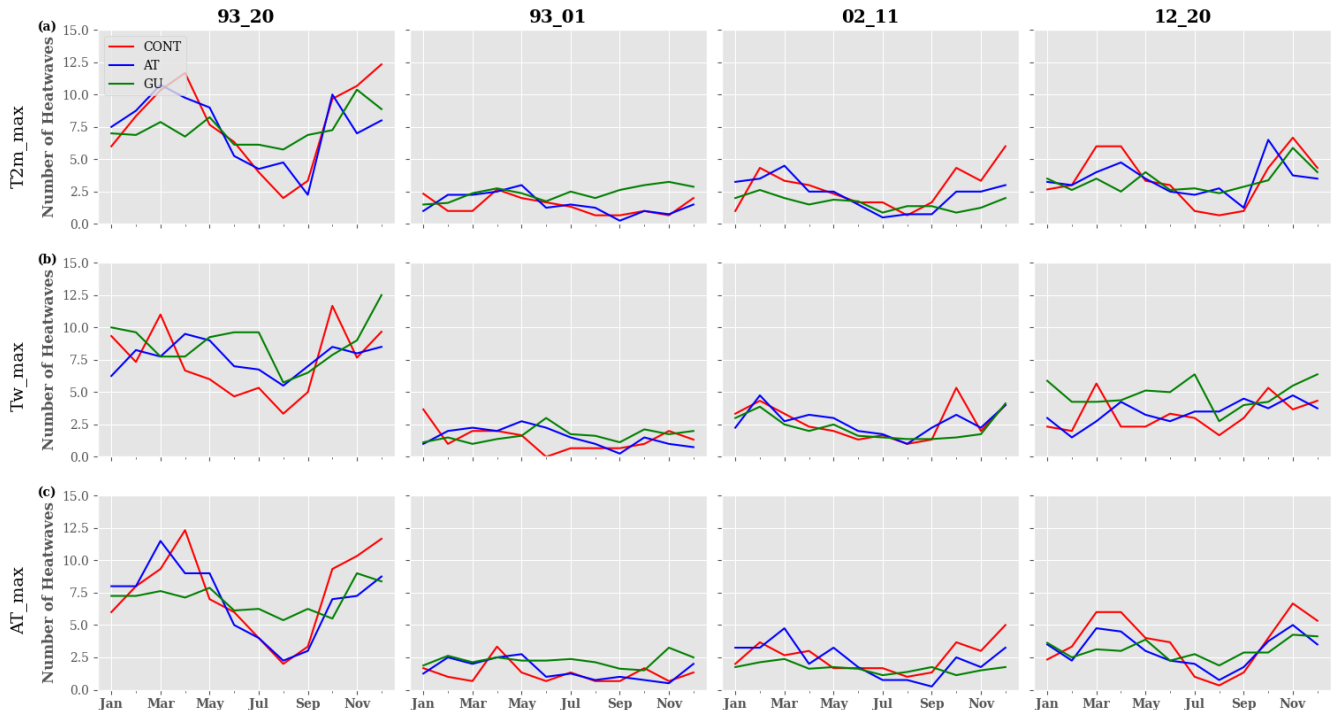


Figure S7. Seasonal variability of heat wave occurrence using maximum values of indicators: a) $T2m$, b) TW and c) AT . The first column shows the evolution of heat wave frequency over the whole period 1993-2020. The 2nd (d, e, f), 3rd (g, h, i) and 4th (j, k, l) columns represent respectively the heat wave duration over the sub-periods 1993-2001, 2002-2011 and 2012-2020. The X and Y-axis represent respectively the frequency of the heat wave and the time in month. Red/blue/green lines represent the evolution of heat wave intensity over CONT/AT/GU regions (see region of interest section for more details).

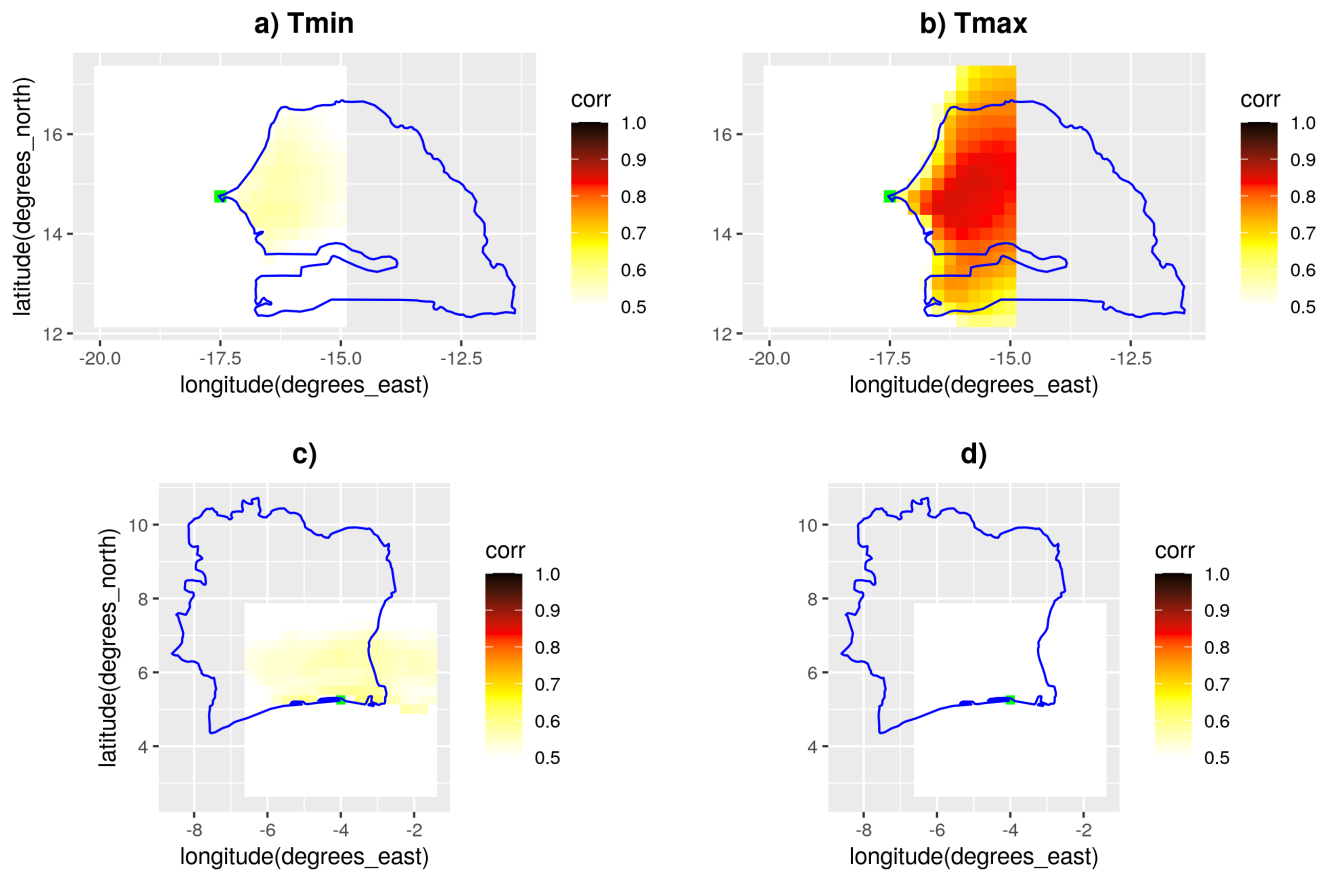


Figure S8. Spatial variability of the anomaly of correlation coefficient between the station observations and ERA5 reanalysis over Dakar : a) Tmin and b) Tmax and Abidjan : c) Tmin and d) Tmax. X- and Y- axis respectively represent the longitude and latitude in degree. The color bar shows the values of the correlation. The stations used for this analysis are located at Yoff in Senegal and Felix Houphouet Boigny airport in Ivory coast.

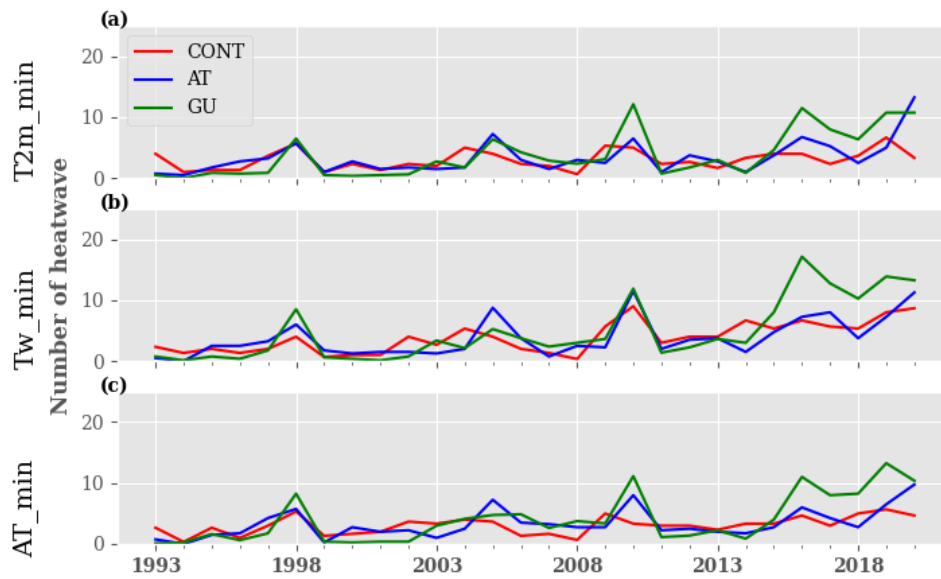


Figure S9. Interannual variability of heat wave occurrence using minimum values of the indicators: a) T2m, b) TW and c) AT. The Y-axis represents the frequency of heat waves and the X-axis represents the time in year. Red/blue/green lines represent the evolution of heat wave occurrence over CONT/AT/GU regions (see region of interest section for more details).

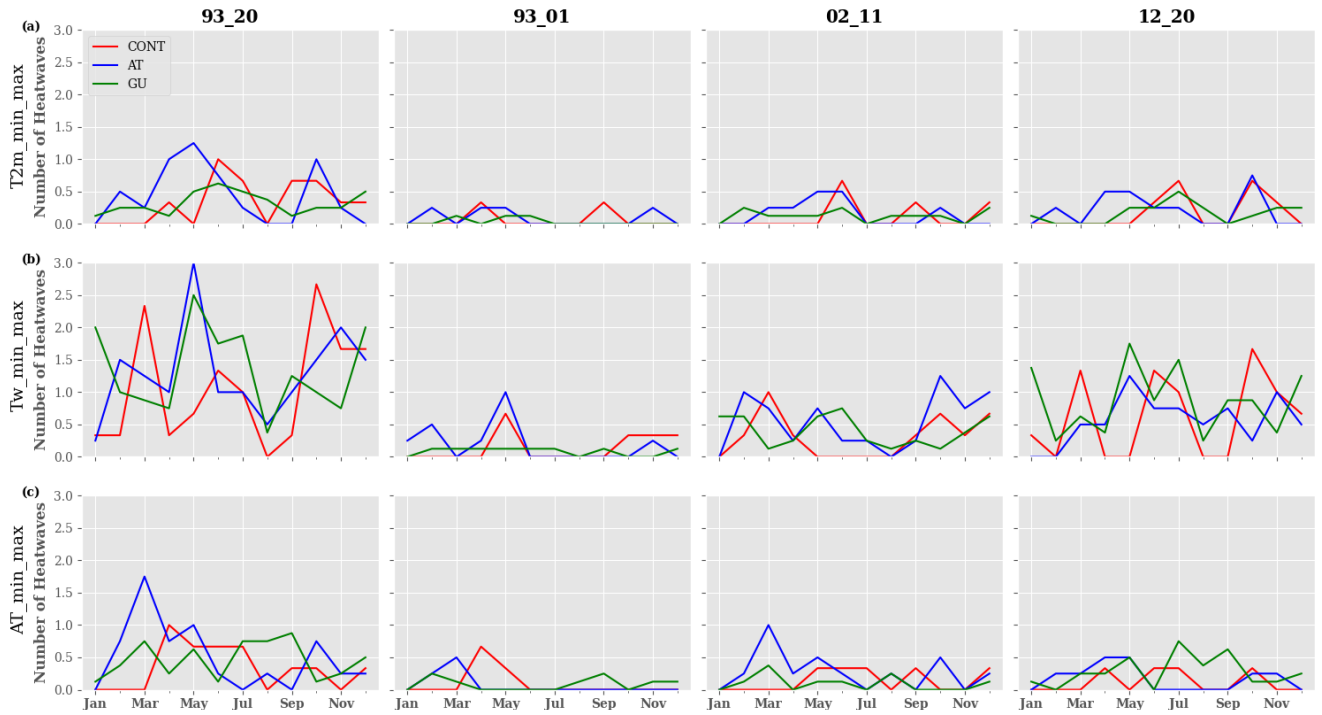


Figure S10. Seasonal variability of heat wave frequency using min and max values of indicators: a) T2m, b) TW and c) AT. The first column shows the evolution of heat wave frequency over the whole period 1993-2020. The 2nd (d, e, f), 3rd (g, h, i) and 4th (j, k, l) columns represent respectively the heat wave duration over the sub-periods 1993-2001, 2002-2011 and 2012-2020. The X- and Y- axis represent respectively the frequency of the heat wave and the time in month. Red/blue/green lines represent the evolution of heat wave intensity over CONT/AT/GU regions (see region of interest section for more details).

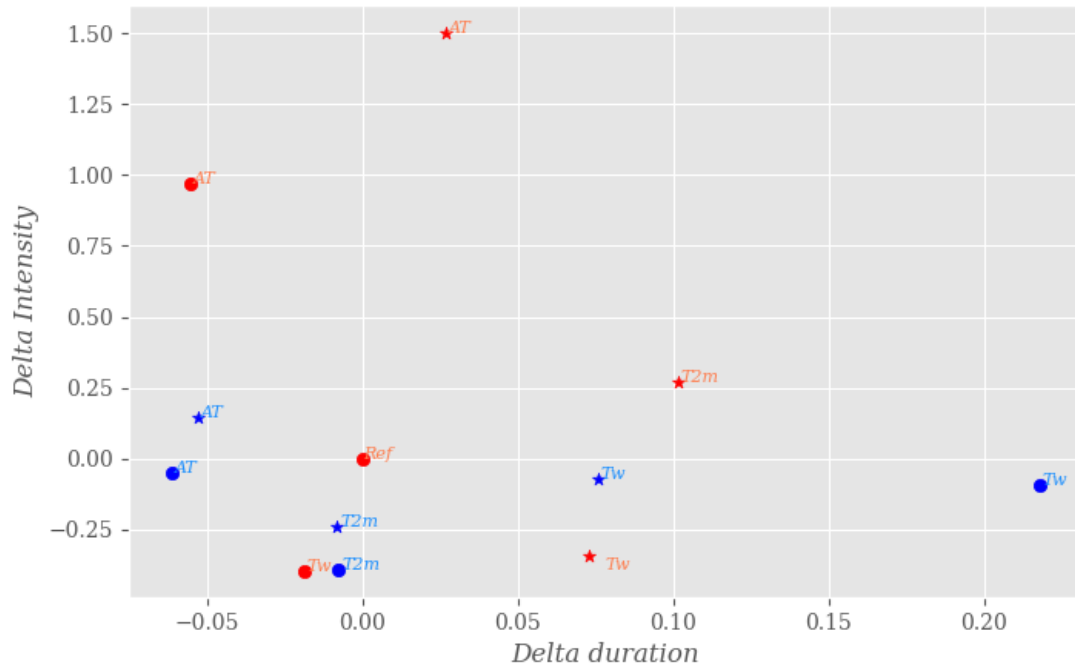


Figure S11. Sensitivity of heat wave characteristics to the datasets, indicators and methodology used in the AT region. The circles and stars in the figure represent respectively ERA5 and MERRA reanalyses. The blue/red color represents min/max values of the indicators. "Ref" is the reference variable used for the analysis, here "T2m_{max}" from ERA5. The Y- and X-axis show the standardized variation of intensity and duration respectively from the reference (no unit). The variation of duration and intensity have been computed using max daily T2m in ERA5 as reference.

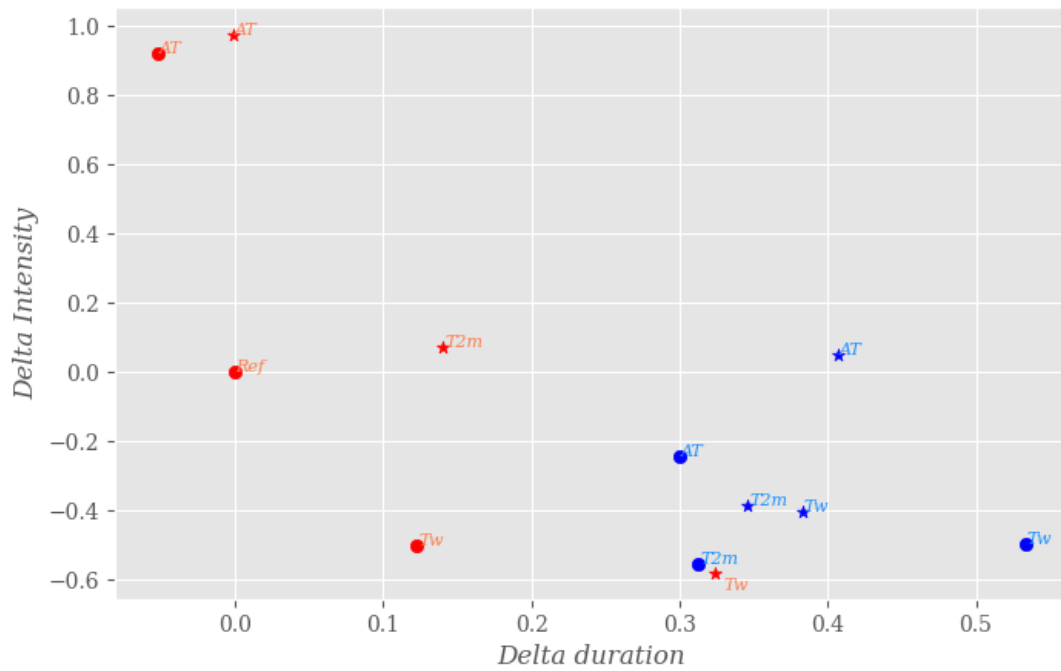


Figure S12. Sensitivity of heat wave characteristics to the datasets, indicators and methodology used in the GU region. The circles and stars in the figure represent respectively ERA5 and MERRA reanalyses. The blue/red color represents min/max values of the indicators. "Ref" is the reference variable used for the analysis, here "T2m_{max}" from ERA5. The Y- and X-axis show the standardized variation of intensity and duration respectively from the reference (no unit). The variation of duration and intensity have been computed using max daily T2m in ERA5 as reference.

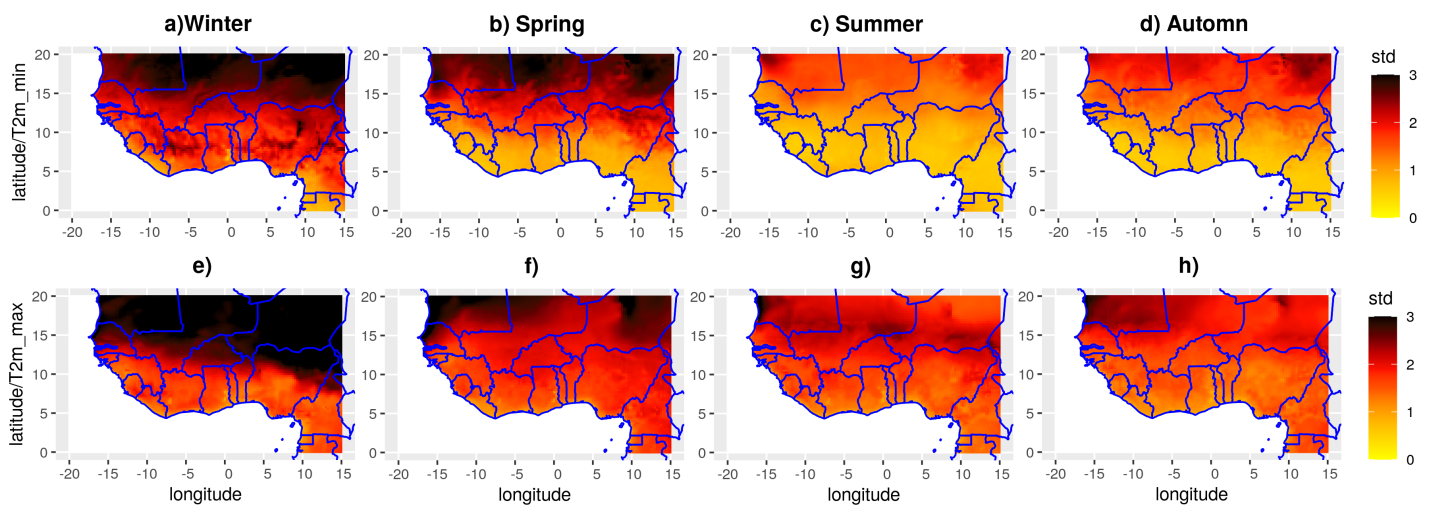


Figure S13. Spatial variability of the interannual daily standard deviation over West Africa regions over the period 1993-2020 using T2m variables. The first row shows the results obtained with the min values of T2m and the second row, the results with the max values of T2m. X- and Y- axis show respectively the longitude and latitude in degrees. The color bar represents the values of the std.

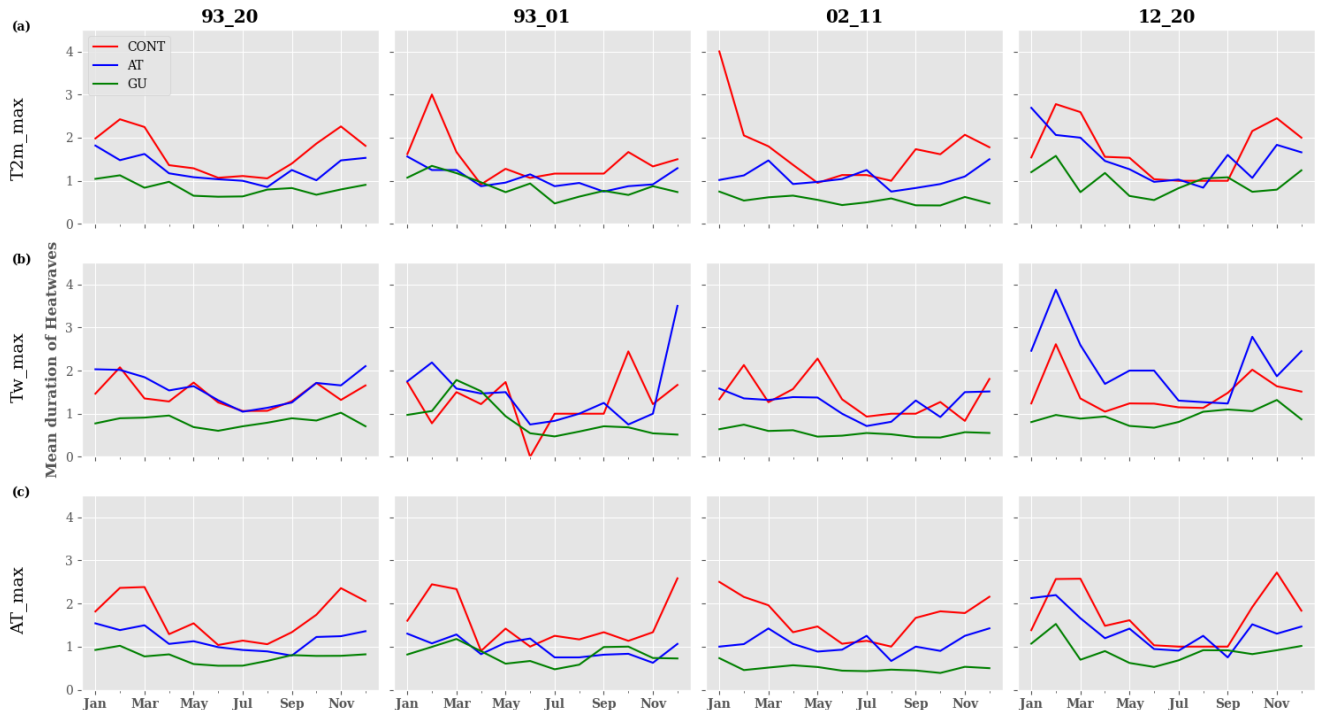


Figure S14. Seasonal variability of heat wave mean duration using maximum values of indicators: a) $T2m$, b) TW and c) AT . The first column shows the evolution of heat wave duration over the whole period 1993-2020. The 2nd (d, e, f), 3rd (g, h, i) and 4th (j, k, l) columns represent respectively the heat wave duration over the sub-periods 1993-2001, 2002-2011 and 2012-2020. The X- and Y- axis represent respectively the duration of the heat wave and the time in month. Red/blue/green lines represent the evolution of heat wave duration over $CONT/AT/GU$ regions (see region of interest section for more details).

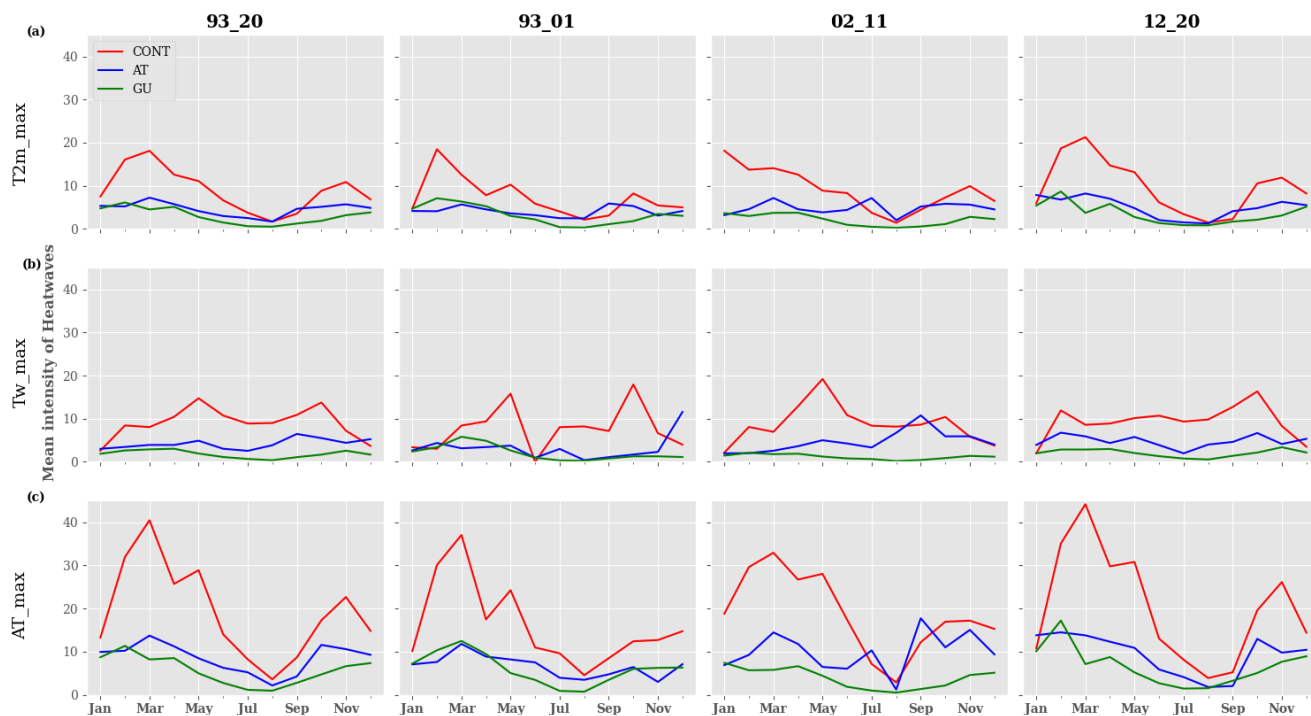


Figure S15. Seasonal variability of heat wave intensity using maximum values of indicators: a) $T2m$, b) TW and c) AT . The first column shows the evolution of heat wave duration over the whole period 1993-2020. The 2nd (d, e, f), 3rd (g, h, i) and 4th (j, k, l) columns represent respectively the heat wave duration over the sub-periods 1993-2001, 2002-2011 and 2012-2020. The X- and Y- axis represent respectively the intensity of the heat wave and the time in month. Red/blue/green lines represent the evolution of heat wave intensity over CONT/AT/GU regions (see region of interest section for more details).

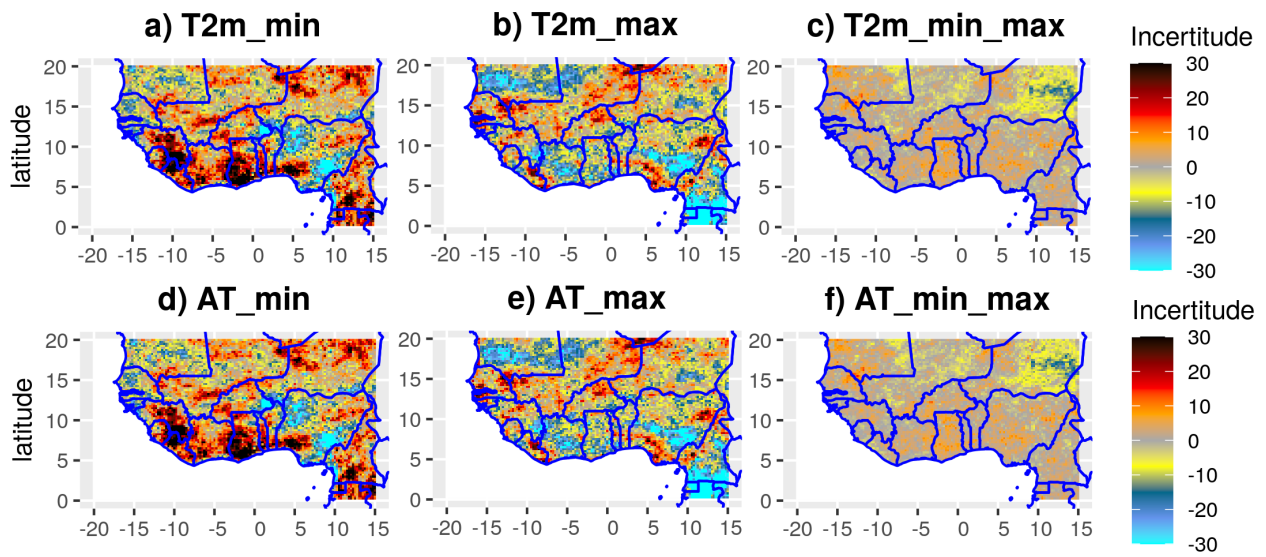


Figure S16. Evaluation of the incertitude of heat wave occurrence in the reanalyses ERA5 and MERRA. The incertitude is computed as the difference between the heat wave occurrence in ERA5 and MERRA. The X- and Y-axis represent respectively the longitude and latitude in degree.