Supplementary materials of: "Subseasonal-to-seasonal forecasts of Heat waves in West African cities"

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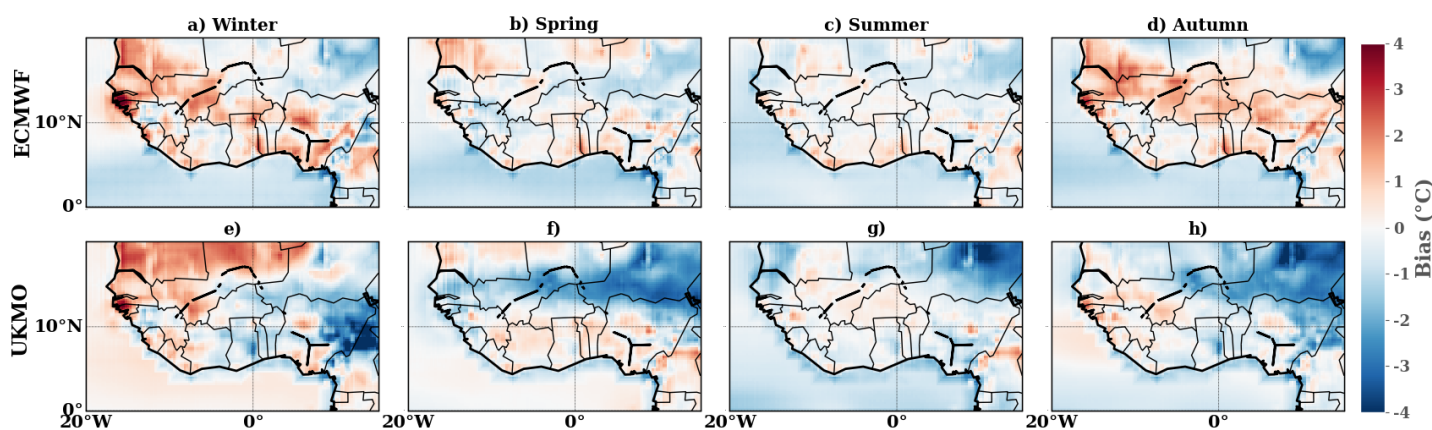
Figure S1. Spatial variability of the climatological bias between the forecast models ensemble mean and MERRA reanalysis over the period 2001-2020 for T2m_min during the seasons : (a,e) winter; (b,f) spring; (c,g) summer and (d,h) autumn. The bias is computed as the difference between the forecast models and ERA5. The color indicates the bias values in degrees Celsius. The X and Y axes represent the longitude and latitude respectively.
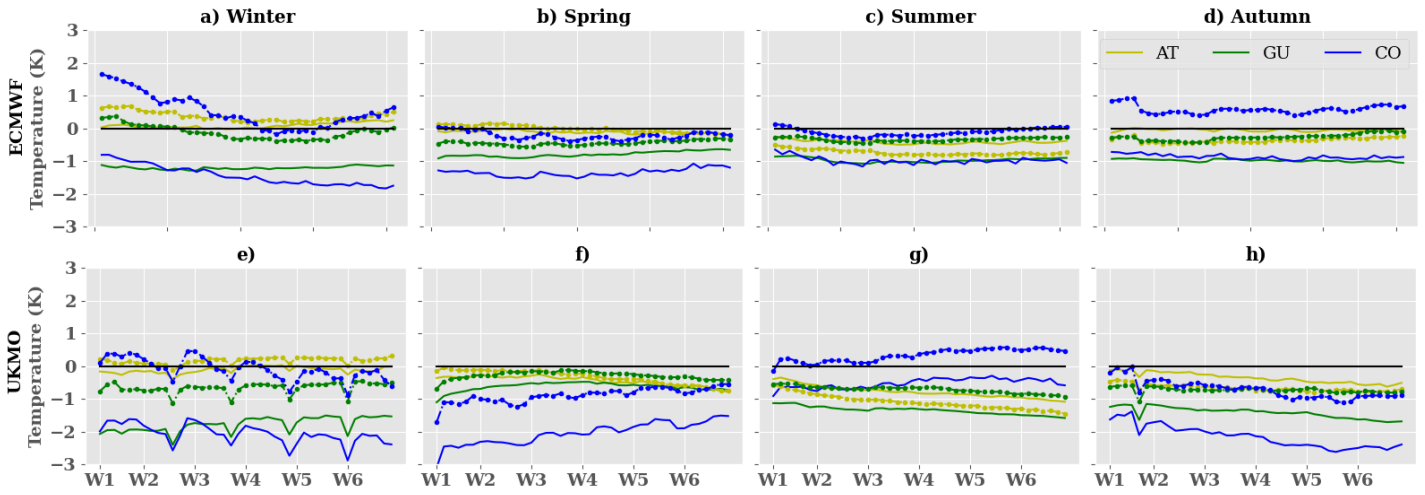
Figure S2. Evolution of the mean climatological biases between the forecast models and reanalyses using T2m_min over the period 2001-2020 during the seasons : (a,e) winter; (b,f) spring; (c,g) summer and (d,h) autumn. The solid black line indicates the zero value (no bias). Yellow, green, blue solid- and dotted- lines represent the bias calculated using ERA5 and MERRA as references over the AT, GU and CO regions respectively. The Y and X axes represent the bias values in degree Kelvin and the time in days respectively.
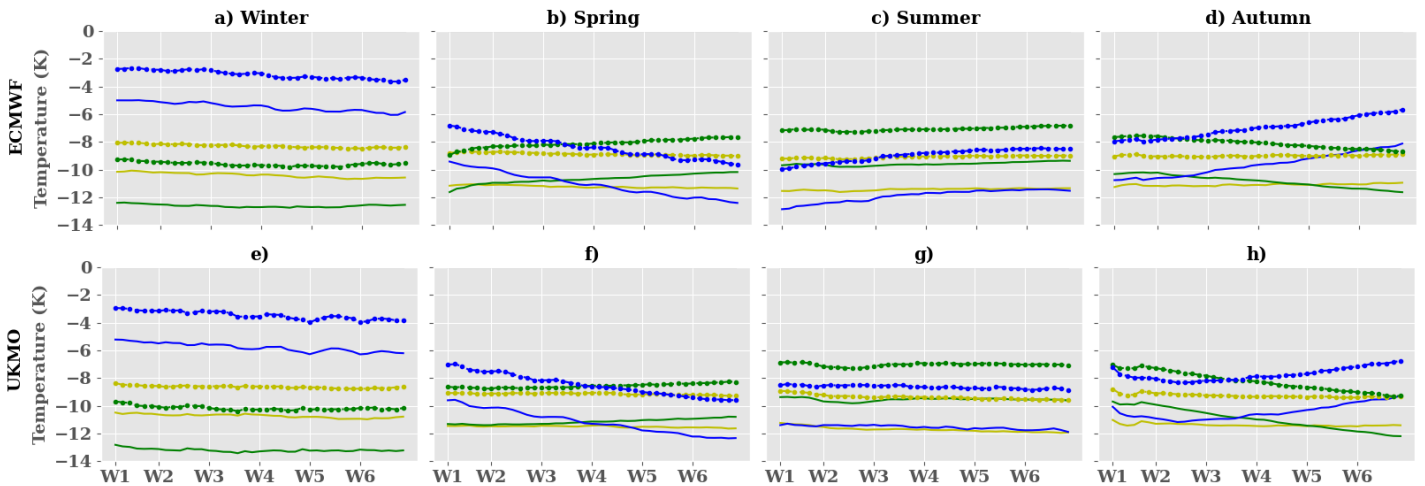
Figure S3. Evolution of the mean climatological biases between the forecast models and reanalyses using Tw over the period 2001-2020 during the seasons : (a,e) winter; (b,f) spring; (c,g) summer and (d,h) autumn. Yellow, green, blue solid- and dotted- lines represent the bias calculated using ERA5 and MERRA as references over the AT, GU and CO regions respectively. The Y and X axes represent the bias values in degree Kelvin and the time in days respectively.
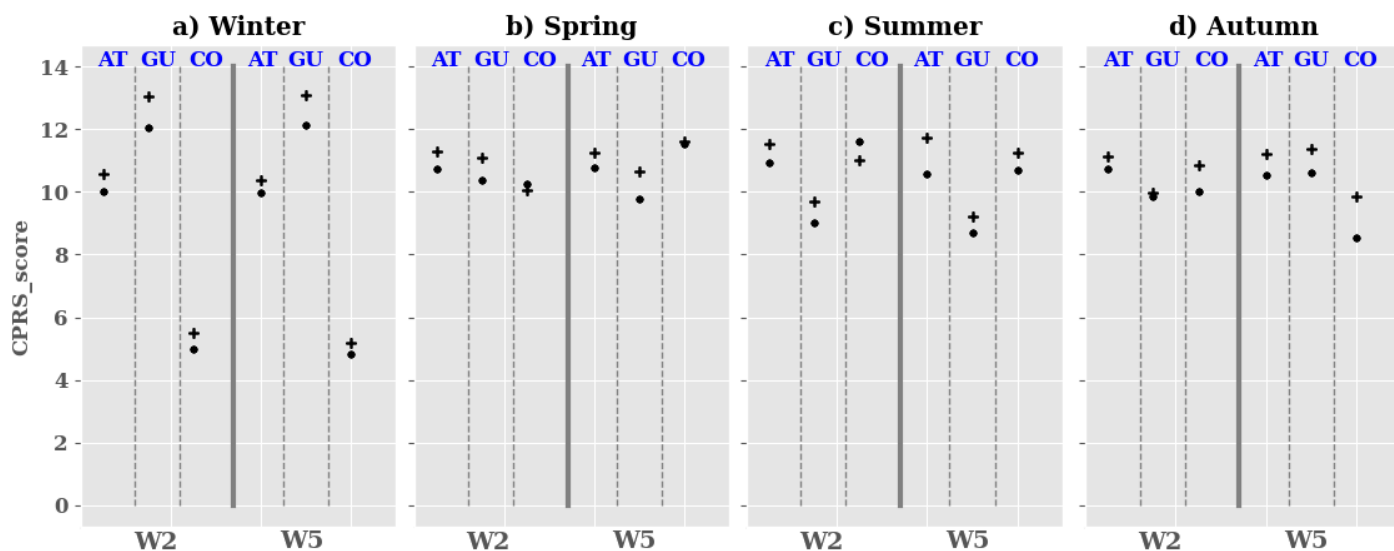
Figure S4. Evolution of the CRPS score between the forecast models and ERA5 reanalysis over the period 2001-2020 during the seasons using Tw : (a) winter, (b) spring, (c) summer and (d) autumn. The dot and cross symbols indicate the CRPS score obtained with ECMWF and UKMO respectively. The Y and X axes show the CRPS values and the lead times (W2: week2 and W5: week5) respectively.
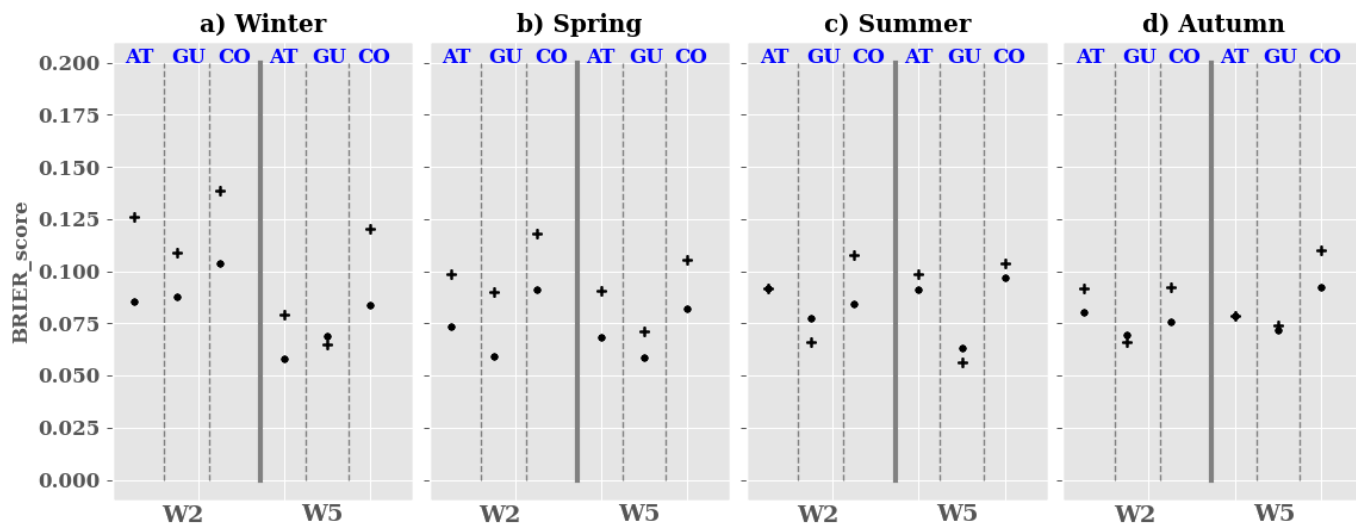
Figure S5. Evolution of the Brier score between the forecast models and ERA5 reanalysis over the period 2001-2020 during the seasons for Tw : (a) winter, (b) spring, (c) summer and (d) autumn. The dot and cross symbols indicate the Brier score obtained with ECMWF and UKMO respectively. The Y and X axes show the CRPS values and the lead times (W2: week2 and W5: week5) respectively.
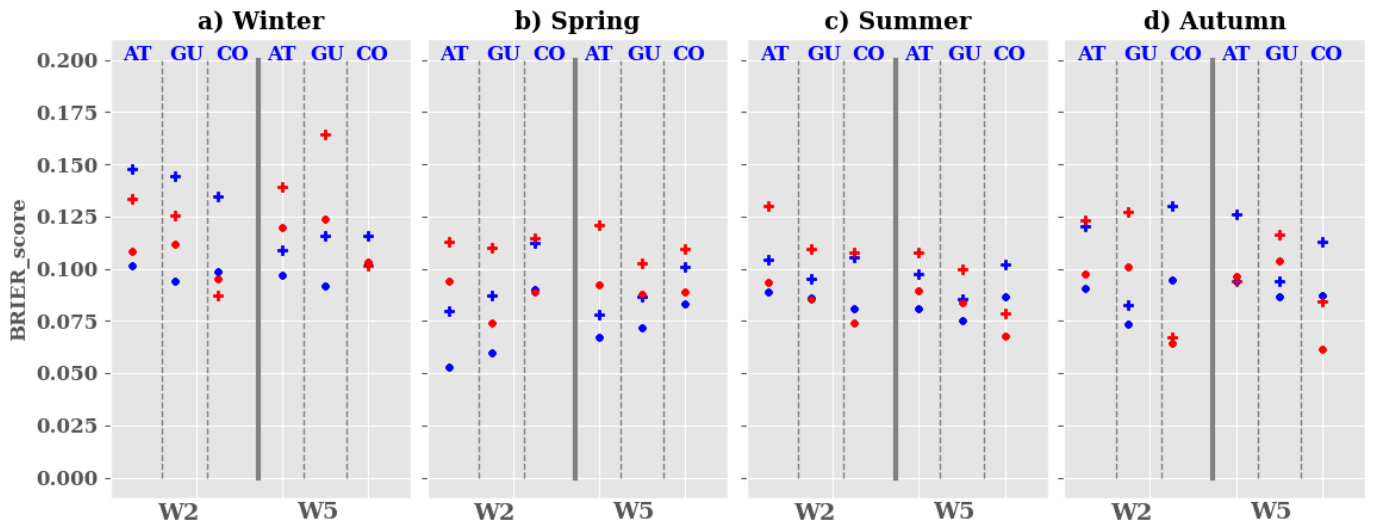
Figure S6. Evolution of the Brier score between the forecast models and MERRA reanalysis over the period 2001-2020 during the seasons : (a) winter, (b) spring, (c) summer and (d) autumn. The blue and red colors represent the Brier score calculated using T2m_min and T2m_max values respectively. The dot and cross symbols indicate the Brier score obtained with ECMWF and UKMO respectively. The Y and X axes show the CRPS values and the lead times (W2: week2 and W5: week5) respectively.
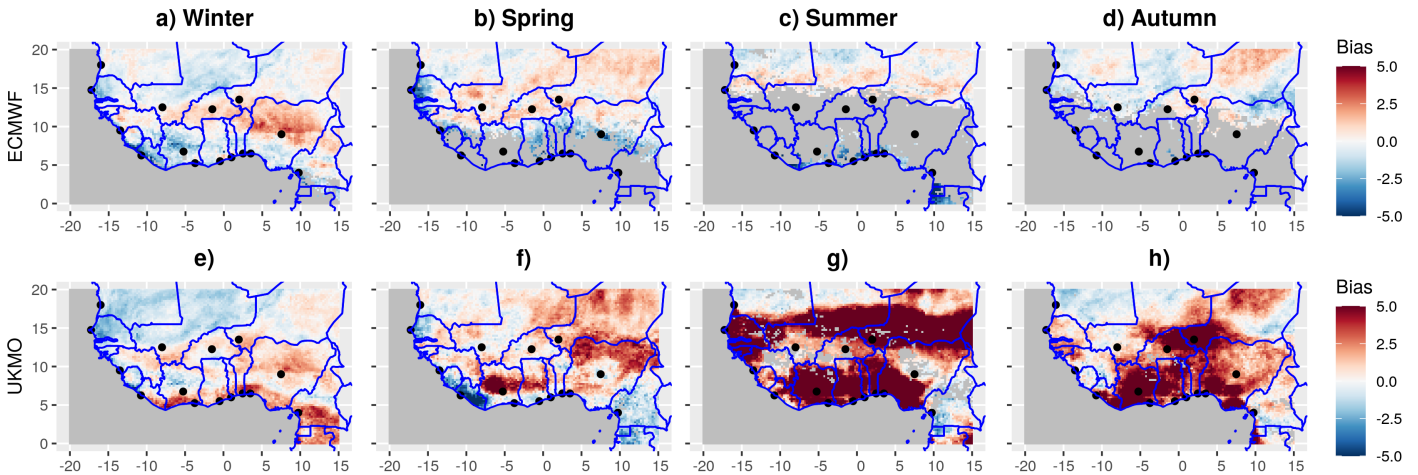
Figure S7. Spatial variability of heat wave duration bias between forecast models and ERA5 over West Africa from 2001 to 2020 using Tw during: (a,e) winter; (b,f) spring; (c,g) summer and (d,h) autumn. The bias is calculated as the difference in heat wave duration between the forecast models and ERA5. This analysis is performed using the unperturbed member of the models. The color bar indicates the bias values without units. The X and Y axes represent longitude and latitude respectively.
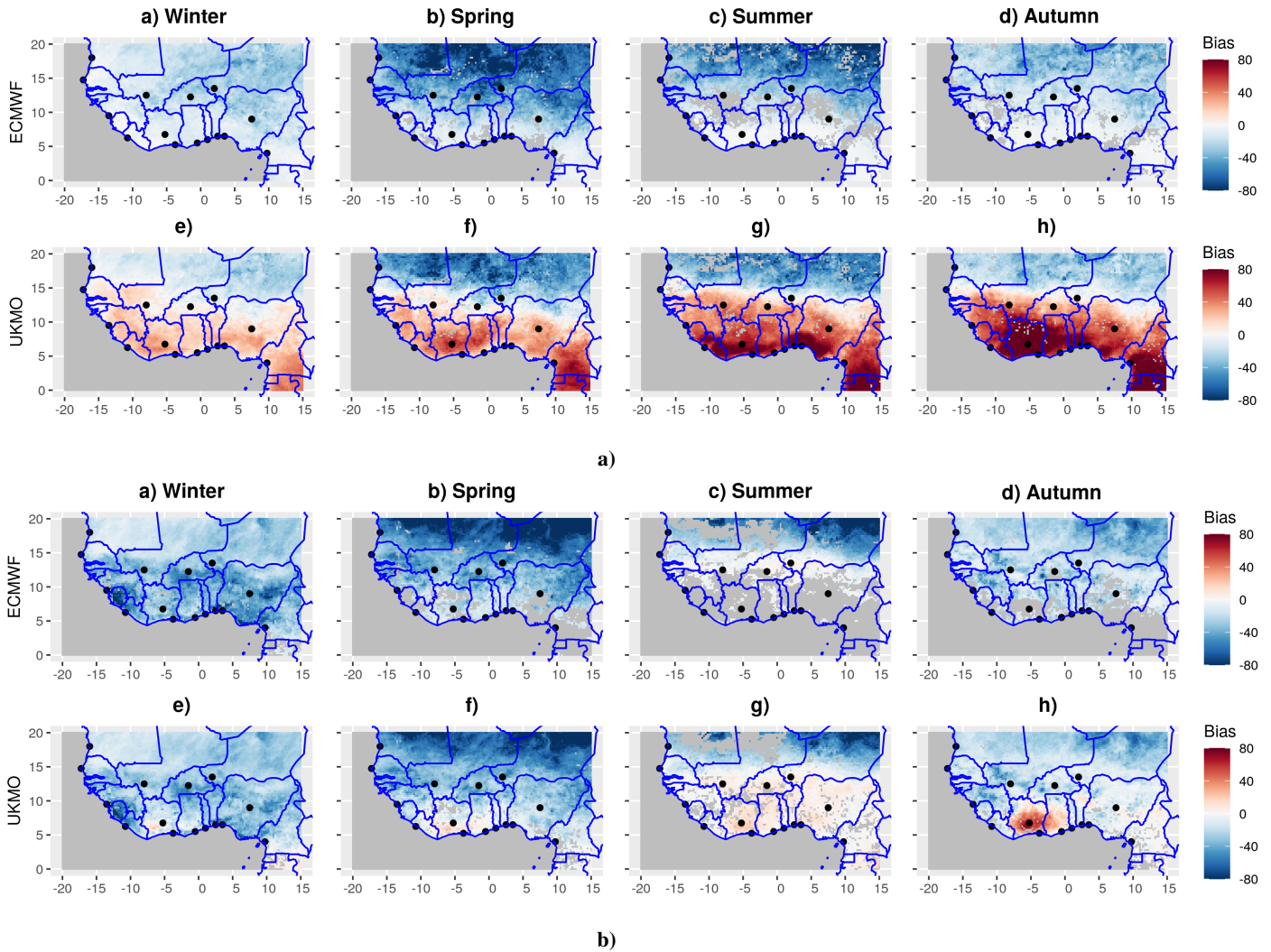
Figure S8. Spatial variability of heat wave intensity bias between the forecast models and ERA5 over West Africa from 2001 to 2020 for: **(a)** T2m_min values and **(b)** T2m_max values, during: (a,e) winter; (b,f) spring; (c,g) summer and (d,h) autumn. The bias is calculated as the difference in heat wave intensity between the models and ERA5. This analysis is performed using the unperturbed member of the models over years where heat waves were detected. The color bar indicates the bias values without units. The X and Y axes represent longitude and latitude respectively.
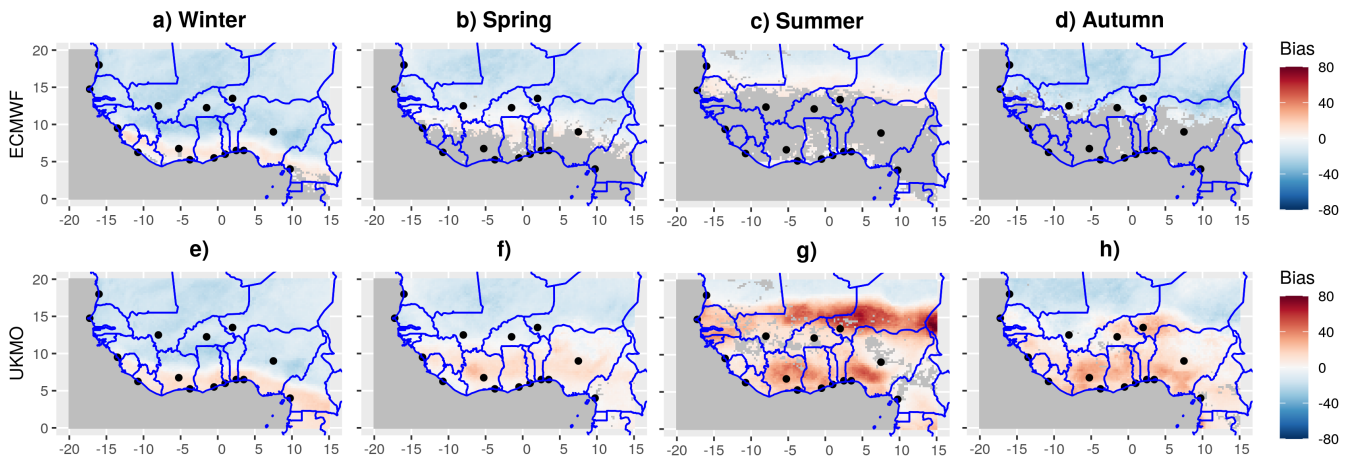
Figure S9. Spatial variability of heat wave intensity bias between the forecast models and ERA5 over West Africa from 2001 to 2020 for Tw during: (a,e) winter; (b,f) spring; (c,g) summer and (d,h) autumn. The bias is calculated as the difference in heat wave intensity between the models and ERA5. This analysis is performed using the unperturbed member of the models over years where heat waves were detected. The color bar indicates the bias values without units. The X and Y axes represent longitude and latitude respectively.
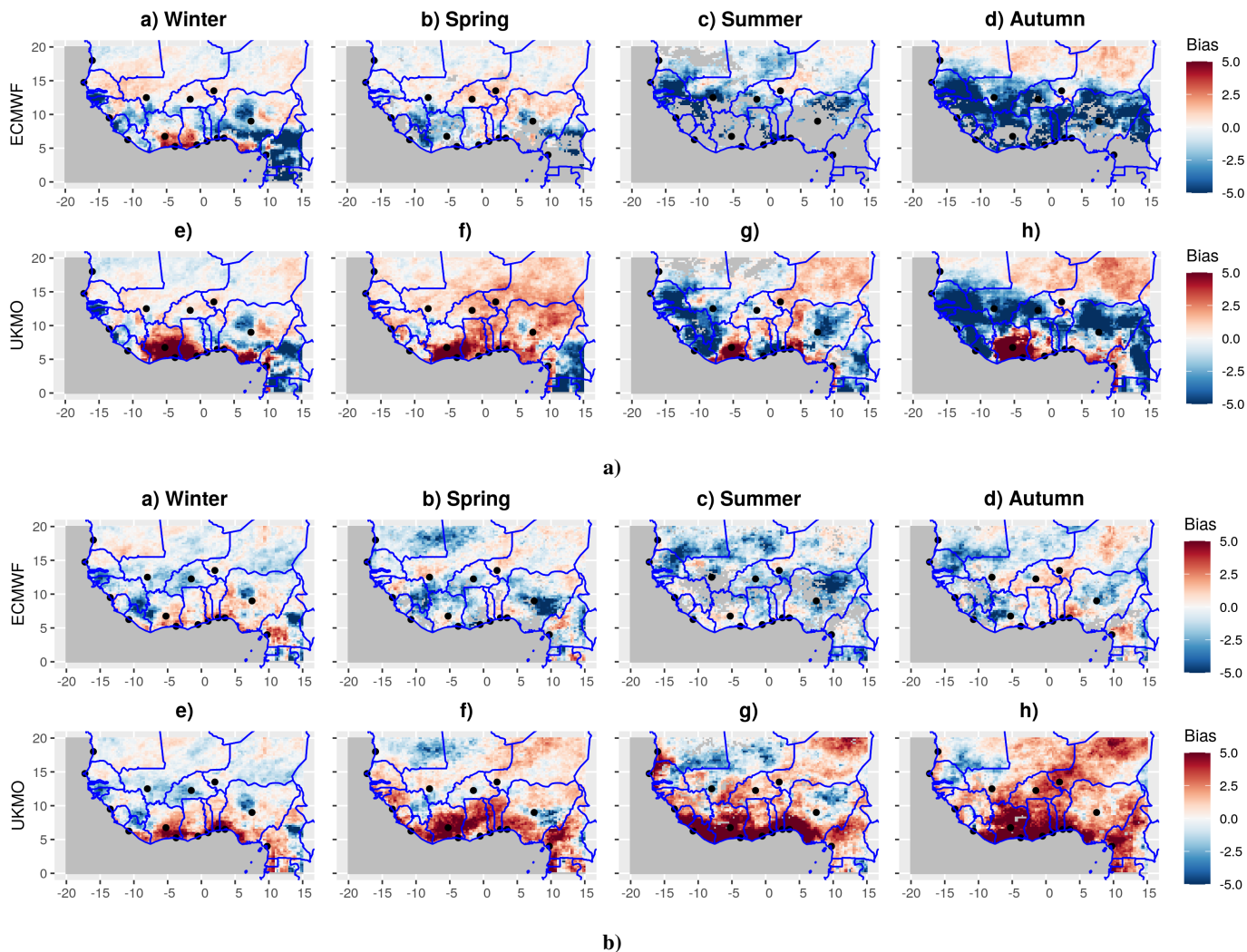
Figure S10. Spatial variability of heat wave duration bias between the forecast models and MERRA over West Africa from 2001 to 2020 for:
(a) T2m_min values and **(b)** T2m_max values, during: (a,e) winter; (b,f) spring; (c,g) summer and (d,h) autumn. The bias is calculated as
the difference in heat wave duration between the models and ERA5. This analysis is performed using the unperturbed member of the models
over years where heat waves were detected. The color bar indicates the bias values without units. The X and Y axes represent longitude and
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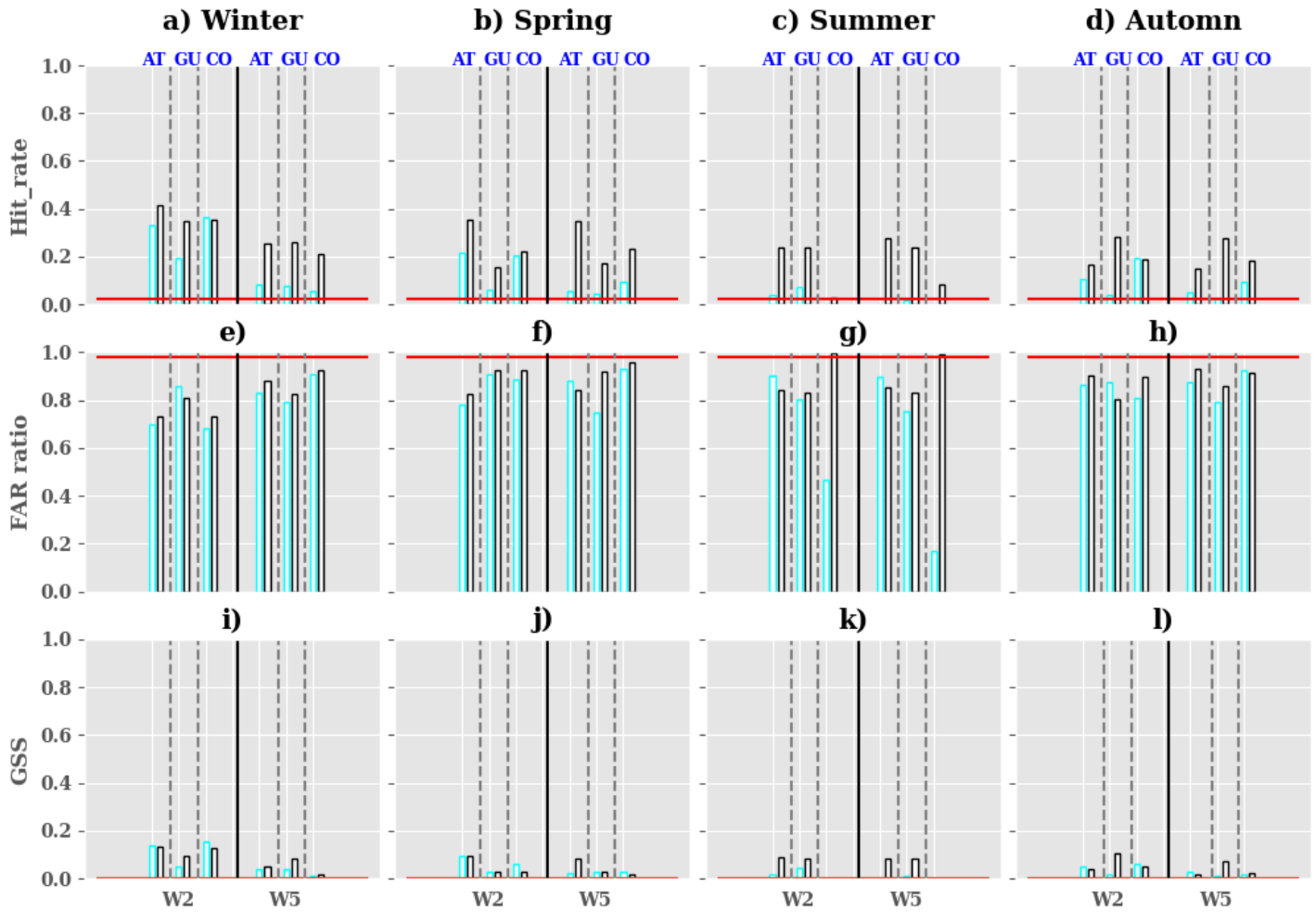
Figure S11. Evaluation of heat waves detection in the forecast models with respect to ERA5 at daily time scale over the period 2001-2020 using Tw for : (a-d) hit-rate, (e-h) FAR ratio and (i-l) GSS. The metrics were computed using the optimized forecasts (see section Methods for the optimisation of the ensemble forecasts). The metrics were calculated during the seasons : (a,e,i) winter; (b,f,j) spring; (c,g,k) summer and (d,h,l) autumn. The cyan and black borders of bar plots indicate the metrics obtained when using ECMWF and UKMO respectively. The Y and X axes show the metrics values and the lead times (W2: week2 and W5: week5) respectively. The horizontal red line represents the baseline climatology.
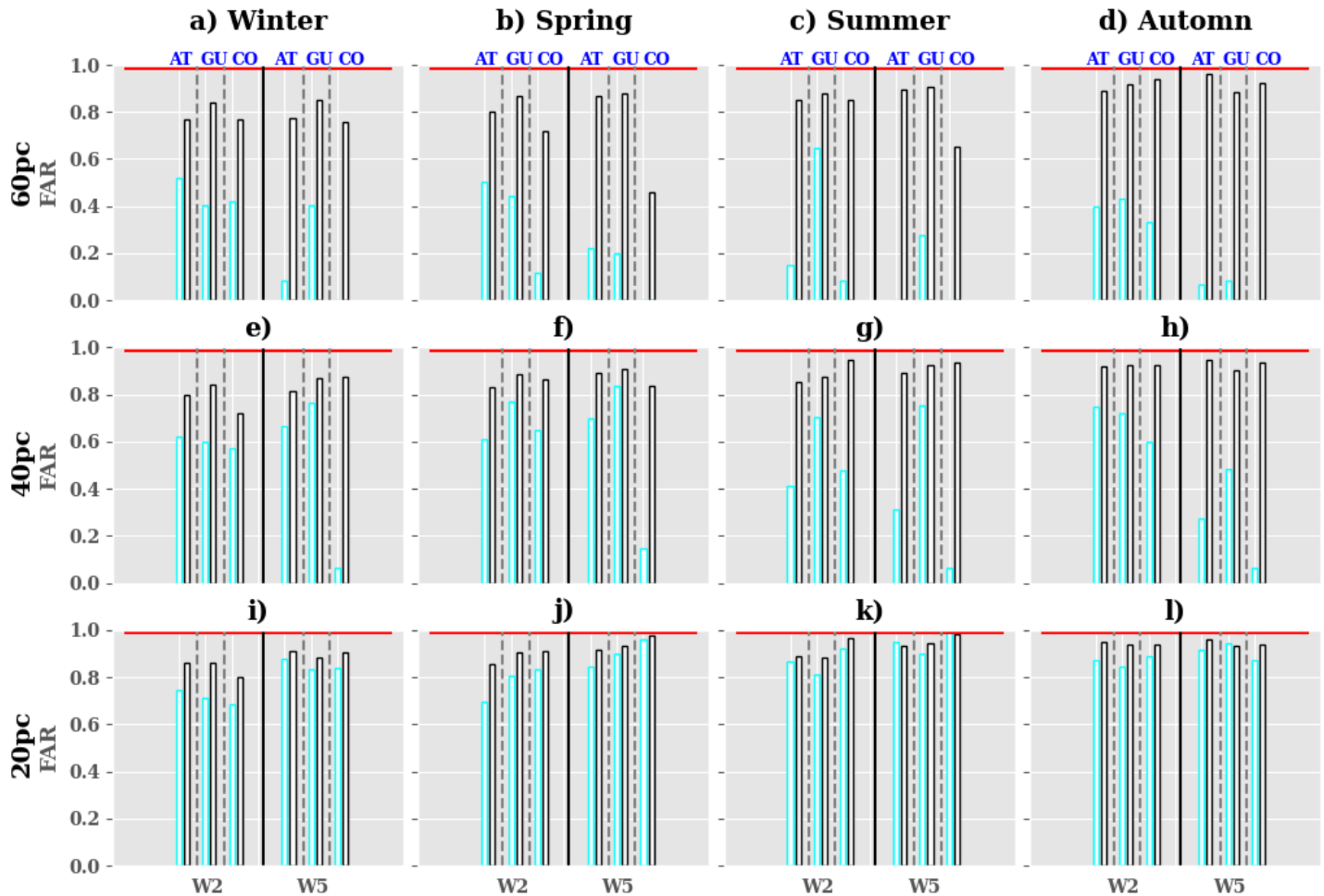
Figure S12. Sensitivity of the FAR ratio to the thresholds used to optimize forecasts over the period 2001-2020 using T2m_min values at daily time scale for : (a-d) a 60 percentile threshold, (e-h) a 40 percentile threshold and (i-l) a 20 percentile threshold (see Section Methods on optimization forecasts for more details). The FAR ratio is calculated during the seasons : (a,e,i) winter; (b,f,j) spring; (c,g,k) summer and (d,h,l) autumn. The cyan and black borders of bar plots indicate the FAR ratio obtained when using ECMWF and UKMO respectively. The Y and X axes show the FAR ratio values and the lead times (W2: week2 and W5: week5) respectively. The horizontal red line represents the baseline climatology.
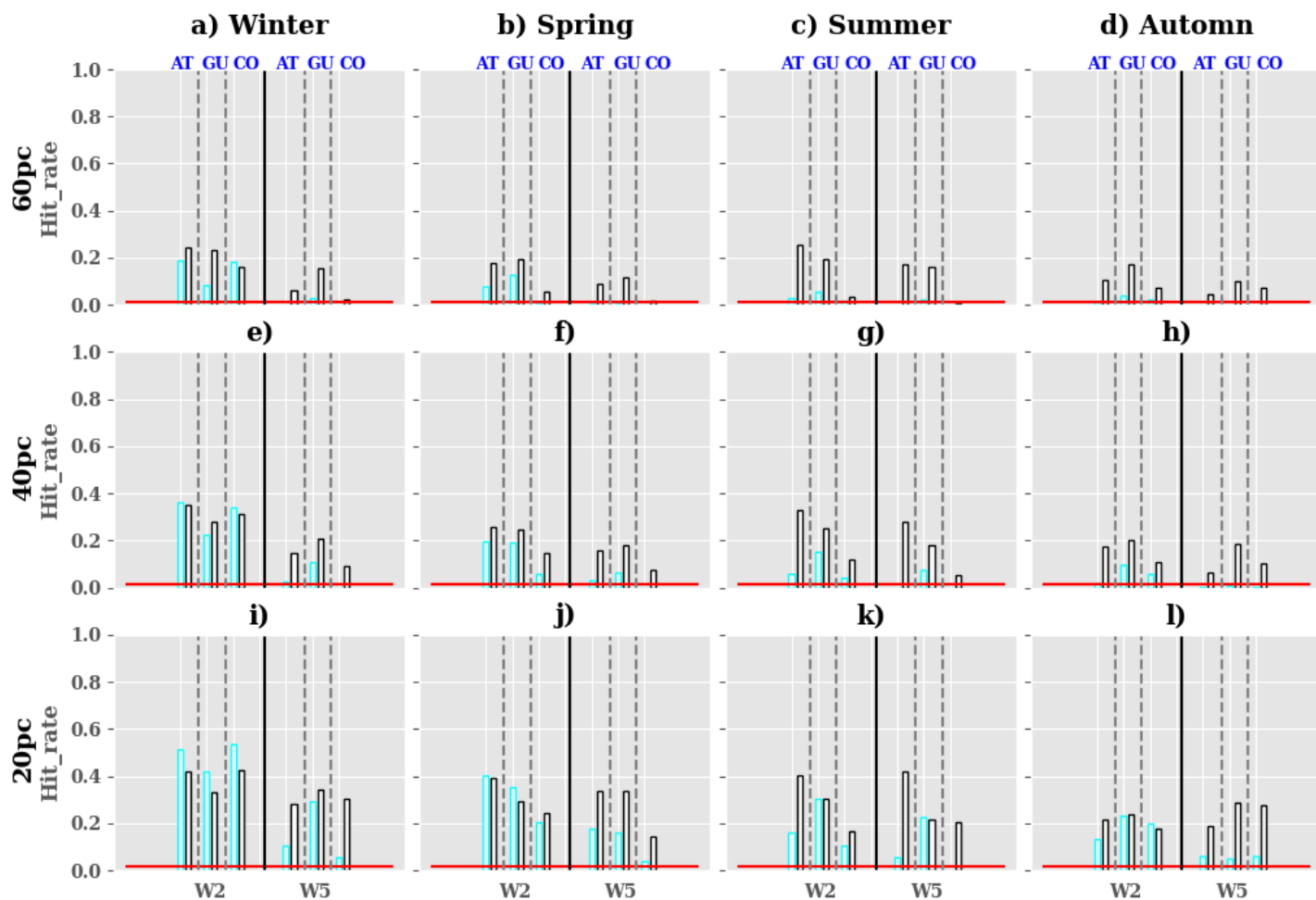
Figure S13. Sensitivity of the hit-rate to the thresholds used to optimize forecasts over the period 2001-2020 using T2m_min values at daily time scale for : (a-d) a 60 percentile threshold, (e-h) a 40 percentile threshold and (i-l) a 20 percentile threshold (see Section Methods on optimization forecasts for more details). The hit-rate is calculated during the seasons : (a,e,i) winter; (b,f,j) spring; (c,g,k) summer and (d,h,l) autumn. The cyan and black borders of bar plots indicate the hit-rate obtained when using ECMWF and UKMO respectively. The Y and X axes show the hit-rate values and the lead times (W2: week2 and W5: week5) respectively. The horizontal red line represents the baseline climatology.
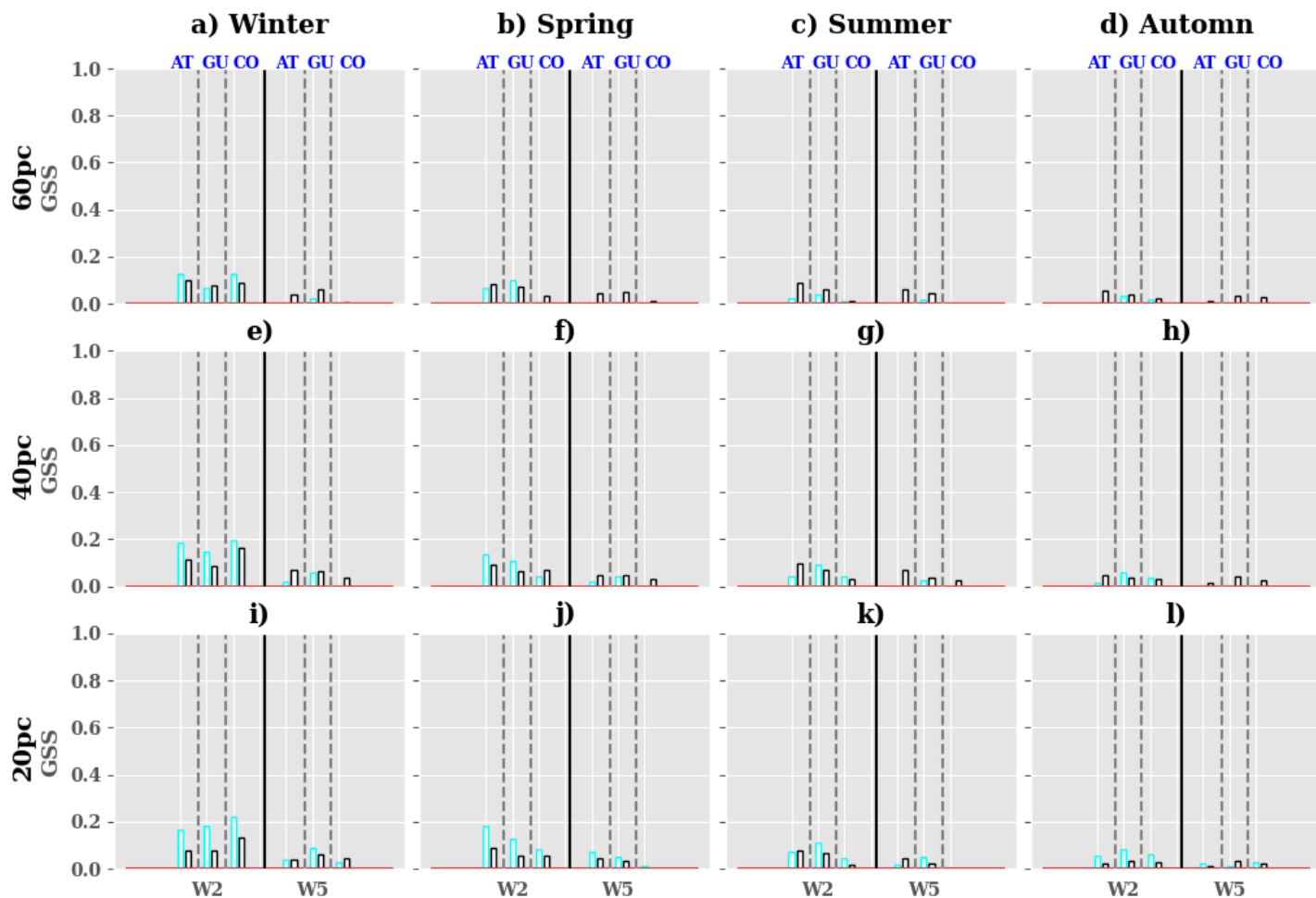
Figure S14. Sensitivity of the GSS to the thresholds used to optimize forecasts over the period 2001-2020 using T2m_min values at daily time scale for : (a-d) a 60 percentile threshold, (e-h) a 40 percentile threshold and (i-l) a 20 percentile threshold (see Section Methods on optimization forecasts for more details). The GSS is calculated during the seasons : (a,e,i) winter; (b,f,j) spring; (c,g,k) summer and (d,h,l) autumn. The cyan and black borders of bar plots indicate the GSS obtained when using ECMWF and UKMO respectively. The Y and X axes show the GSS values and the lead times (W2: week2 and W5: week5) respectively. The horizontal red line represents the baseline climatology.
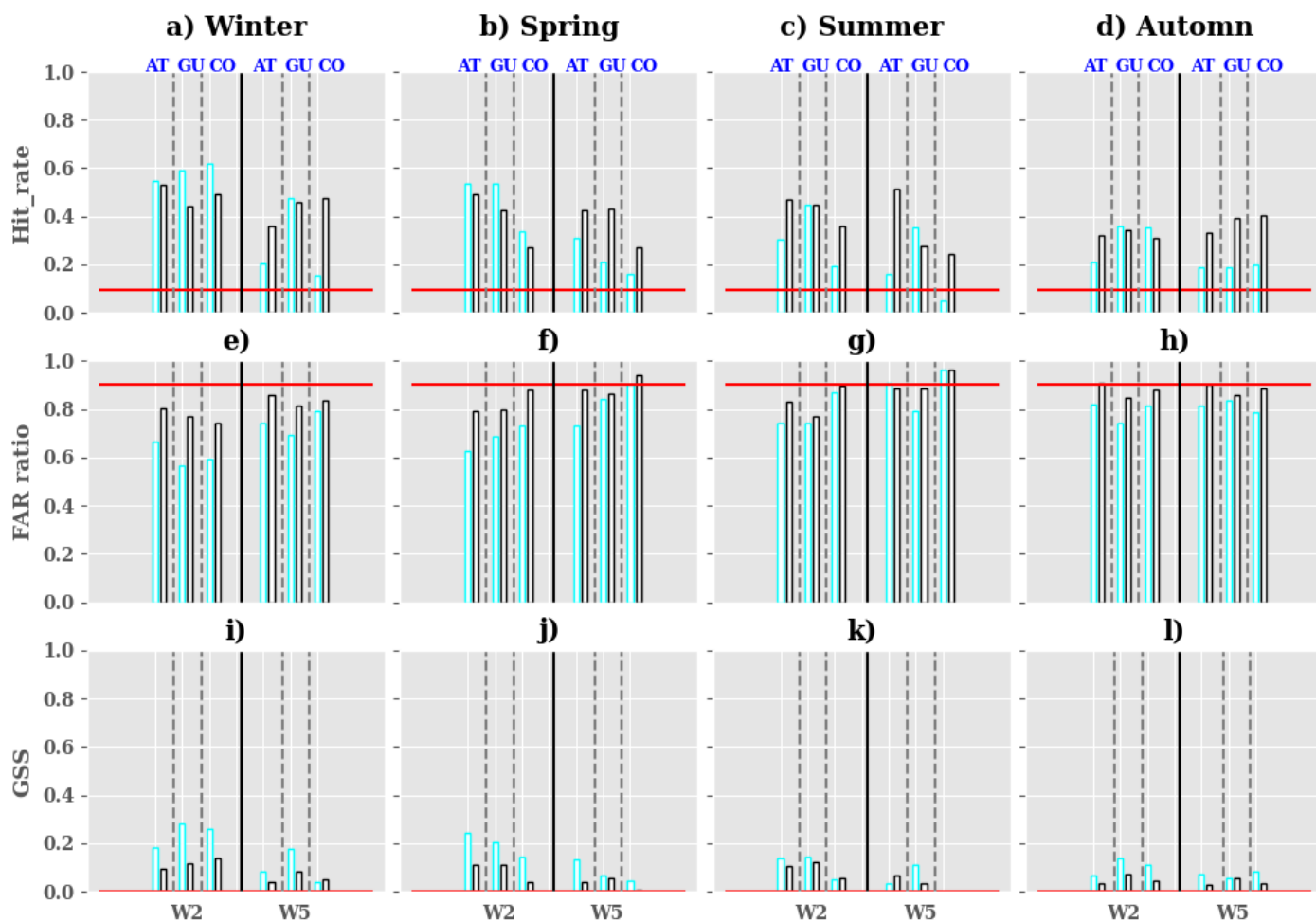
Figure S15. Evaluation of heat waves detection metrics in the models with respect to ERA5 at weekly time scale over the period 2001-2020 using T2m_min values for : (a-d) hit-rate, (e-h) FAR ratio and (i-l) GSS. The metrics were computed using the optimized forecasts (see section Methods for the optimisation of the ensemble forecasts). The metrics were calculated during the seasons : (a,e,i) winter; (b,f,j) spring; (c,g,k) summer and (d,h,l) autumn. The cyan and black borders of bar plots indicate the metrics obtained when using ECMWF and UKMO respectively. The Y and X axes show the metrics values and the lead times (W2: week2 and W5: week5) respectively. The horizontal red line represents the baseline climatology.