Supplementary materials of : "Seasonal Forecasts of the Saharan Heat Low characteristics: A multi-model assessment"

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1 Tables

Table S1. Correlation between the HLW(HLE) phases in the models and ERA5: values in brackets/bold indicate the correlation using respectively the corrected anomalies/ temperatures over the 2 boxes (East and West SHL).

	ERA5(W)	ERA5 (E)
SEAS5(W,E)	**0.29**(0.00)	**0.12**(-0.09)
MF7(W,E)	**0.30**(-0.03)	**0.14**(-0.06)

2 Figures

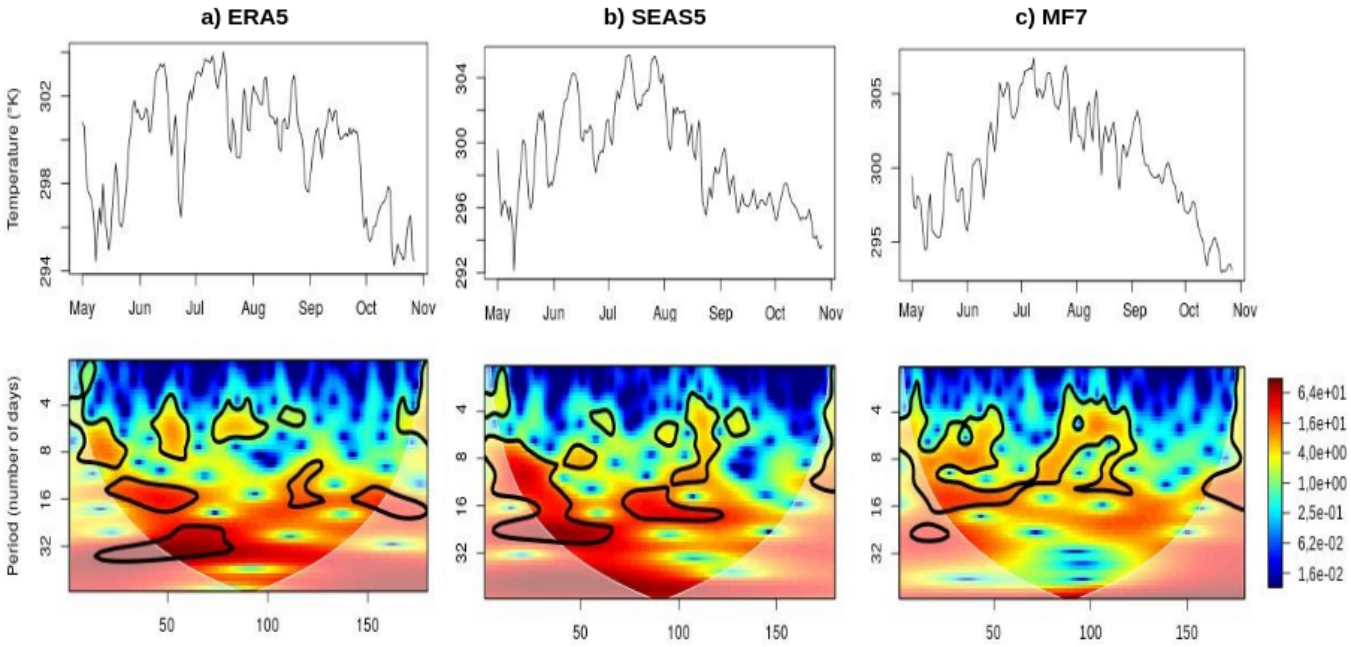

Figure S1. *Wavelet Analysis on the temperature signal over the central SHL box when the models have been launched in May respectively for:* ***a)*** *ERA5,* ***b)*** *SEAS5 and* ***c)*** *MF7 for the year 2016. The above plots represent the temperature time series and the bottom plots the corresponding wavelet decomposition. In the upper plots, the X-axis represents the time (days) and the Y-axis indicates the temperature in degree Kelvin. In wavelet decomposition, the X-axis indicates the time (days) and the Y-axis the frequency or period (days). The color bar represents the intensity of the wavelet, the values are normalized. The computation was realized using the unperturbed member for the ensemble forecast models.*

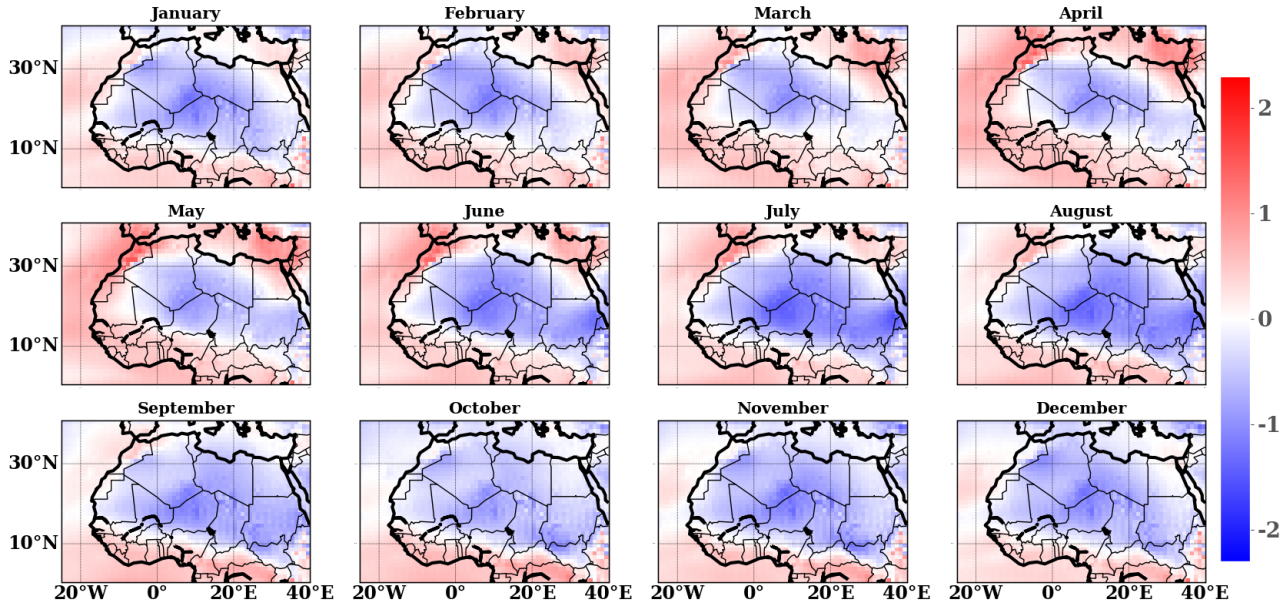

Figure S2. *Climatology of monthly bias temperature over the Sahara region during 1981-2016 between SEAS5 and ERA5. The bias is computed using diurnal cycle temperature (mean between temperature at 00:00 and 12:00 UTC). The computation was made using the ensemble mean member of the models. The color bar indicates the bias value in Kelvin.Y-axis indicates latitudes and X-axis the longitudes of our domain.*

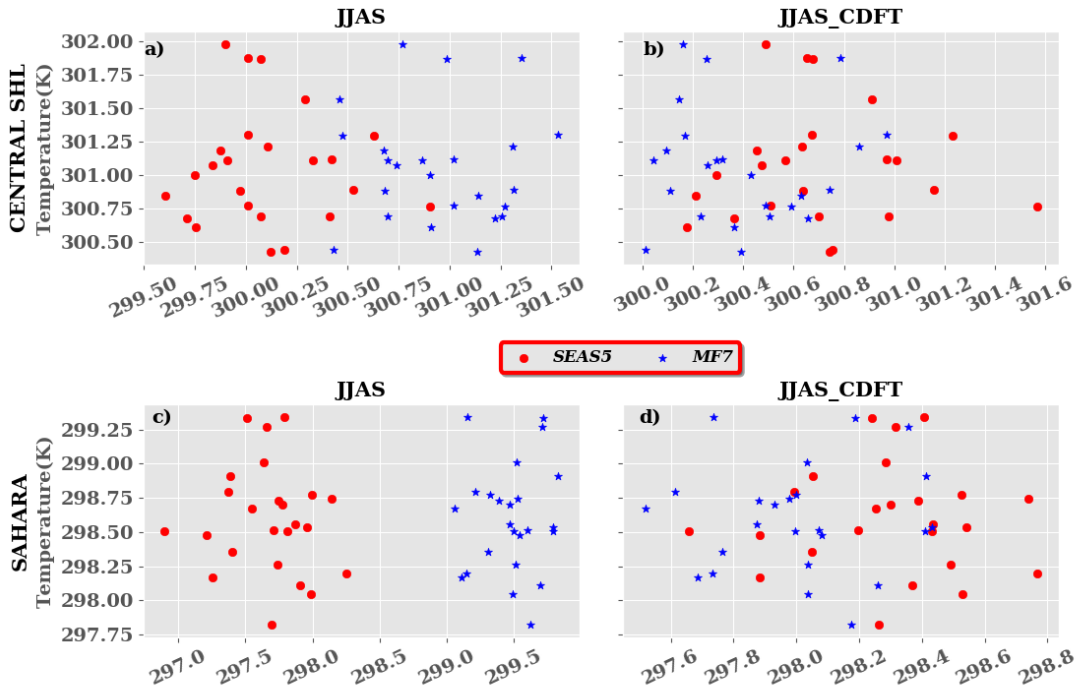

Figure S3. *Analysis of the correlation between reanalysis ERA5 and seasonal forecast models during the JJAS period from 1993-2016 with an initialization of the models on the* 1^{st} *of June over:* ***a), b)*** *central SHL box and* ***c), d)*** *Sahara. Red points and blue stars represent the corresponding forecast for a giving temperature in ERA5 respectively for SEAS5 and MF7. JJAS and* $JJAS\_CDFT$ *refer to the [June,July,August,September] period for SEAS5, MF7 raw and corrected forecasts respectively. The computation was made just using the unperturbed member of the ensemble forecast models.*

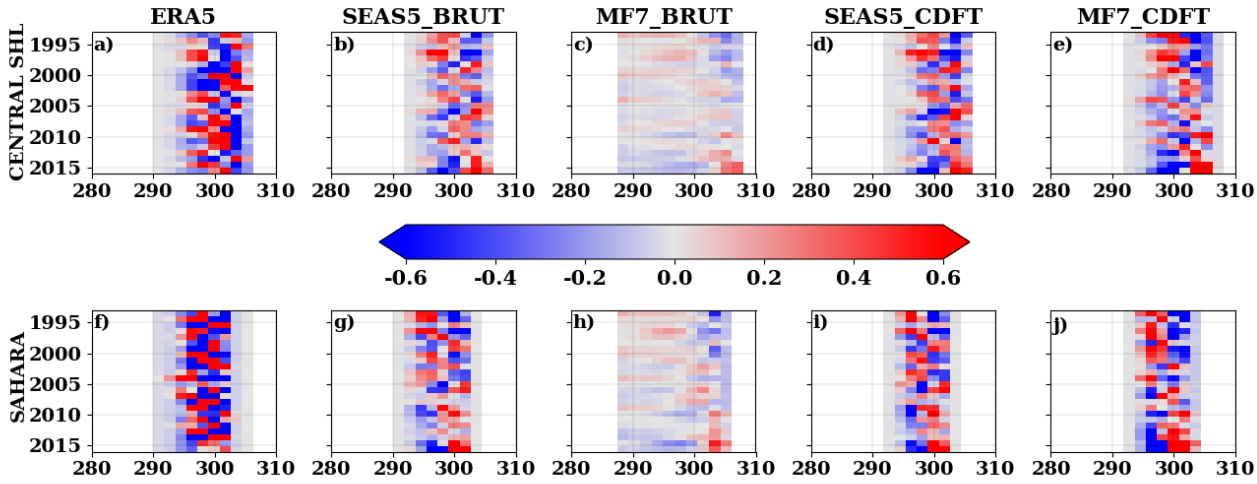

Figure S4. *Anomaly of temperature occurrence over JJAS period during 1993-2016 over:* ***a) - e)*** *central SHL box and* ***f) - j)*** *Sahara respectively. "$ERA5$", "$SEAS5\_BRUT$", "$MF7\_BRUT$" here correspond to the anomaly of the SHL using reanalysis data, SEAS5 and MF7 raw climate forecasts respectively. "$SEAS5\_CDFT$", "$MF7\_CDFT$" refer to the anomaly of the SHL using SEAS5 and MF7 corrected forecasts respectively. The computation was made using the ensemble member of the forecast models. The X-axis represents the temperature in degree Kelvin and Y-axis the time in year. The color bar indicates the anomaly of occurrence values (no unit).*

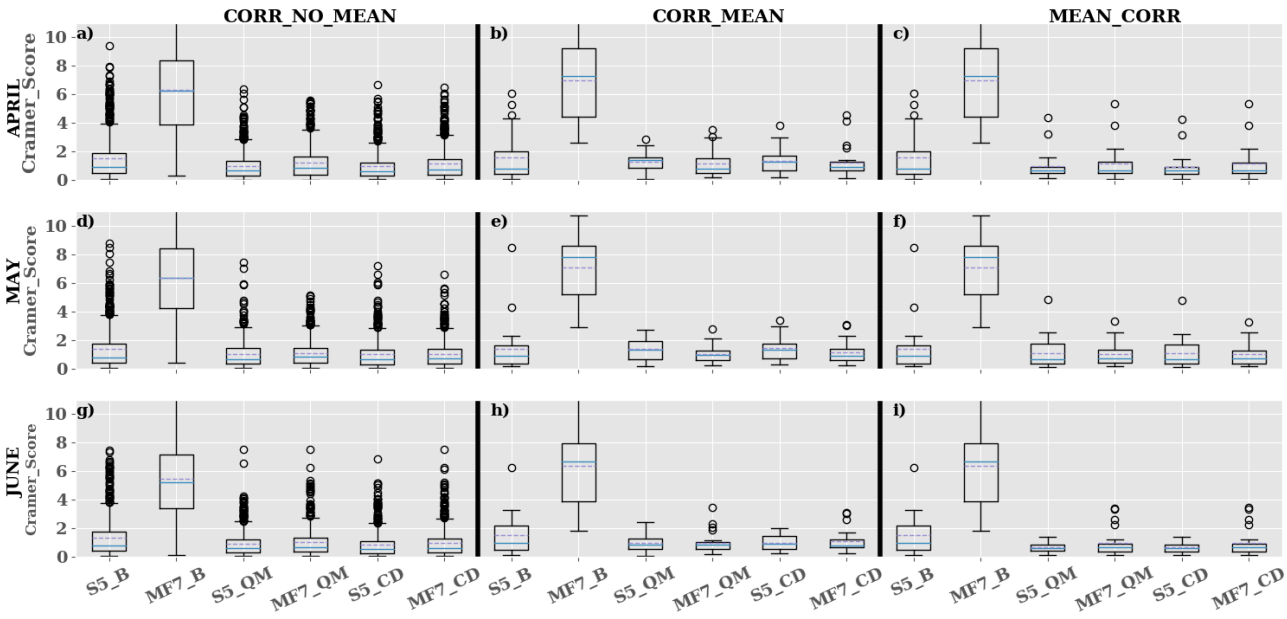

Figure S5. *Bias Correction evaluation using Cramer Von Mises score over JJAS period during 1993-2016 over the Sahara at different initialization months:* ***a) - c)*** *April,* ***d) - f)*** *May and* ***g) - i)*** *June respectively.* ***"CORR_NO_MEAN"***, ***"CORR_MEAN"*** *and* ***"MEAN_CORR"*** *methods are well described in* ***section 3.4***. *"$S5\_B$","$S5\_CD$","$S5\_QM$" represent the Cramer score computed using respectively SEAS5 raw forecasts, SEAS5 corrected with CDF-t and QMAP methods. Idem for "$MF7\_B$","$MF7\_CD$","$MF7\_QM$" with the MF7 model. Y-axis indicates the Cramer score and X-axis the different products used for the computation of Cramer score.*

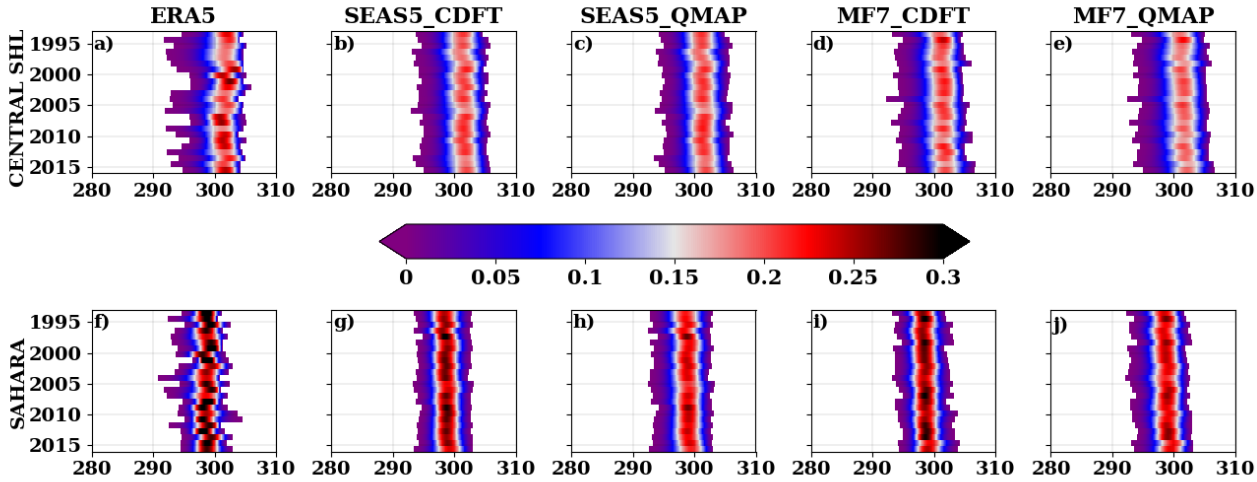

Figure S6. *Distribution of yearly temperature over JJAS period during 1993-2016 respectively over:* ***a) - e)*** *central SHL and* ***f) - j)*** *Sahara. "ERA5", "SEAS5_CDFT", "MF7_CDFT" here correspond to the intensity of the SHL using respectively reanalysis data, SEAS5 and MF7 corrected forecasts with CDF-t method. "SEAS5_QMAP", "MF7_QMAP" refer to the intensity of the SHL using respectively SEAS5 and MF7 corrected forecasts with QMAP method. The computation was made using the ensemble member of the forecast models. Y-axis indicates time in year and X-axis respectively time in year and temperature in degree Kelvin. The color bar in each case indicates the probability of occurrence.*

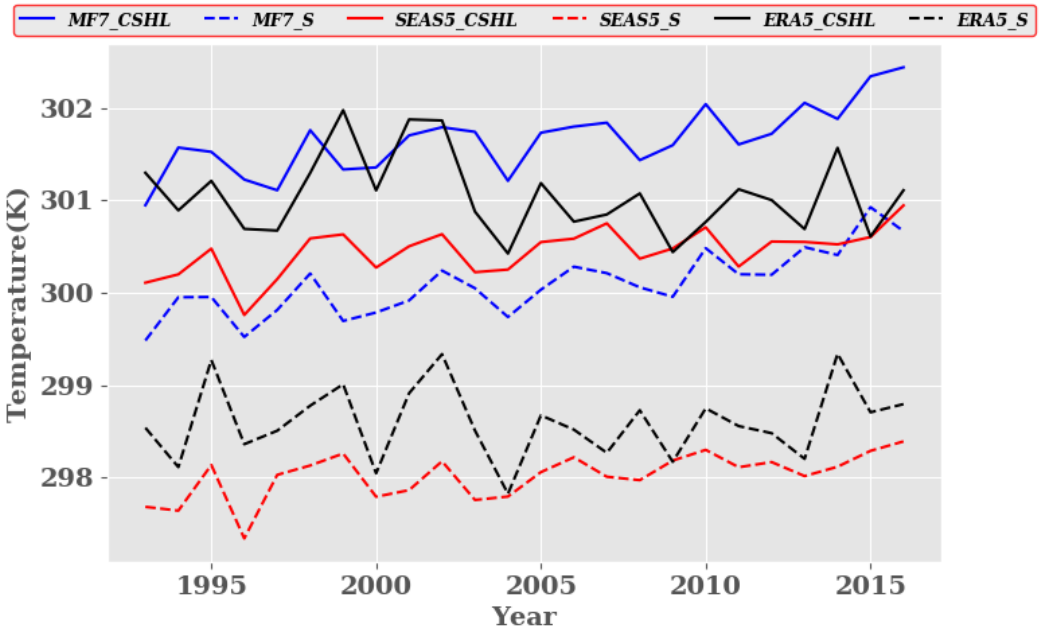

Figure S7. *Evolution of the yearly mean temperature during the JJAS period for June lead time 0 (models initialization on June for the JJAS period). "*$MF7\_CSHL$*","*$SEAS5\_CSHL$*","*$ERA5\_CSHL$*" and "*$MF7\_S$*","*$SEAS5\_S$*","*$ERA5\_S$*" represent respectively the seasonal forecasts for MF7 and SEAS5, and the reanalyses ERA5 over central SHL box and the Sahara region. The computation was made using the raw forecasts and the ensemble members for MF7 and SEAS5. The X-axis represents the time in year and the Y-axis indicates the temperature in degree Kelvin.*

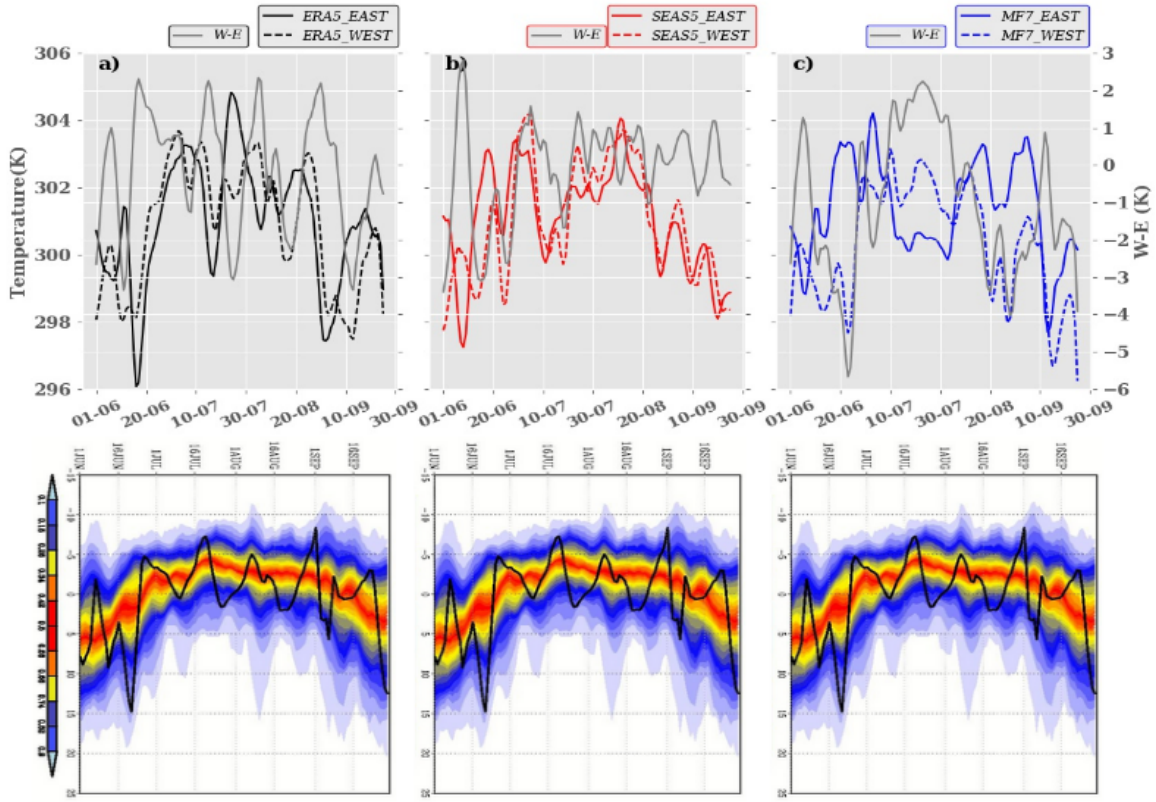

Figure S8. *Detection method of the East and West SHL components using the dipole approach for the year 2005 at June lead time 0 respectively for:* ***a)*** *ERA5 ,* ***b)*** *SEAS5,* ***c)*** *MF7. "*$ERA5\_EAST$*","*$SEAS5\_EAST$*","*$MF7\_EAST$*" represent the HLE computed respectively from ERA5, SEAS5 and MF7. "*$ERA5\_WEST$*","*$SEAS5\_WEST$*","*$MF7\_WEST$*" represent the HLW computed respectively from ERA5, SEAS5 and MF7. The gray line represents the dipole for each product ("*$W-E$*"). The bottom panel represents the evolution of the seasonal SHL location with respect to the barycenter (black line). The first and second Y-axis indicate respectively the temperature and the dipole values in degree Kelvin. X-axis indicates the time (days). The computation was made using the unperturbed member of the ensemble models.*

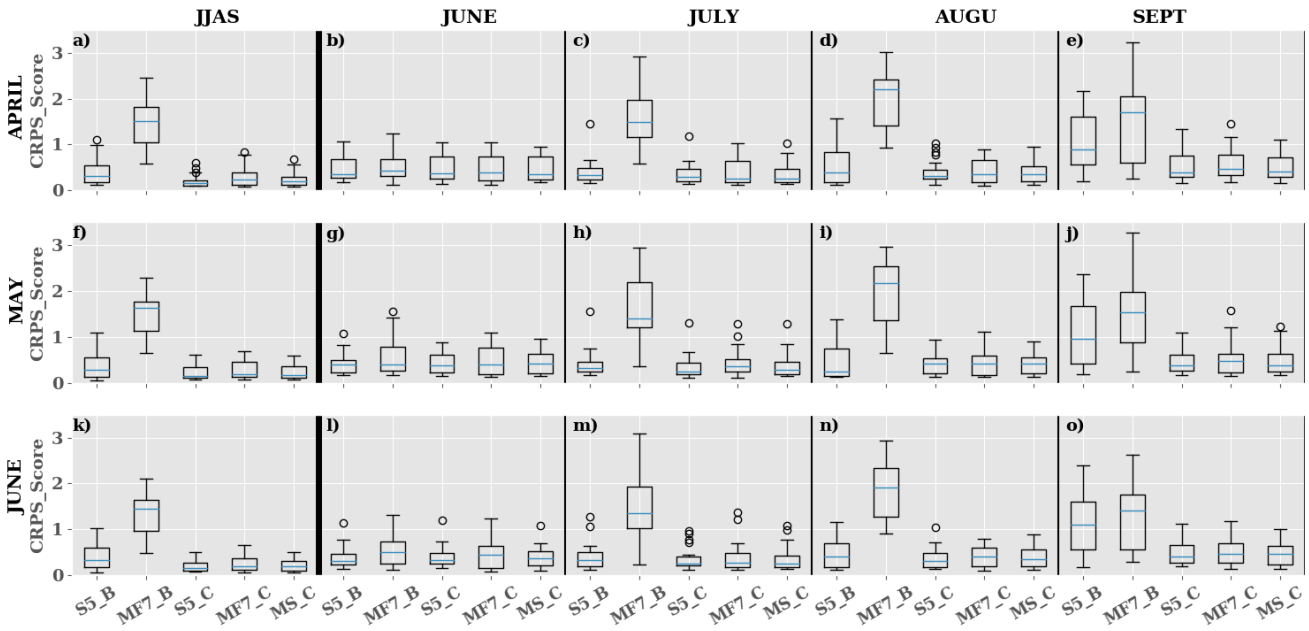

Figure S9. *Evaluation of seasonal forecast models (SEAS5, MF7) over JJAS period and separately on June, July, August, September during 1993-2016 using CRPS score over the Sahara at different lead times:* ***a) - e)*** *April,* ***f) - j)*** *May and* ***k) - o)*** *June respectively.* $"S5\_B","SS5\_C"$ *represent respectively the CRPS score evaluated using raw SEAS5 forecasts and SEAS5 corrected forecasts with CDF-t method. Idem for* $"MF7\_B","MF7\_C"$ *with the MF7 model.* $"MS\_C"$ *represents the CRPS score evaluated on the multi-model formed by SEAS5 and MF7 corrected forecasts with the CDF-t method. The computation was made using the ensemble member both for corrected and raw forecasts.*

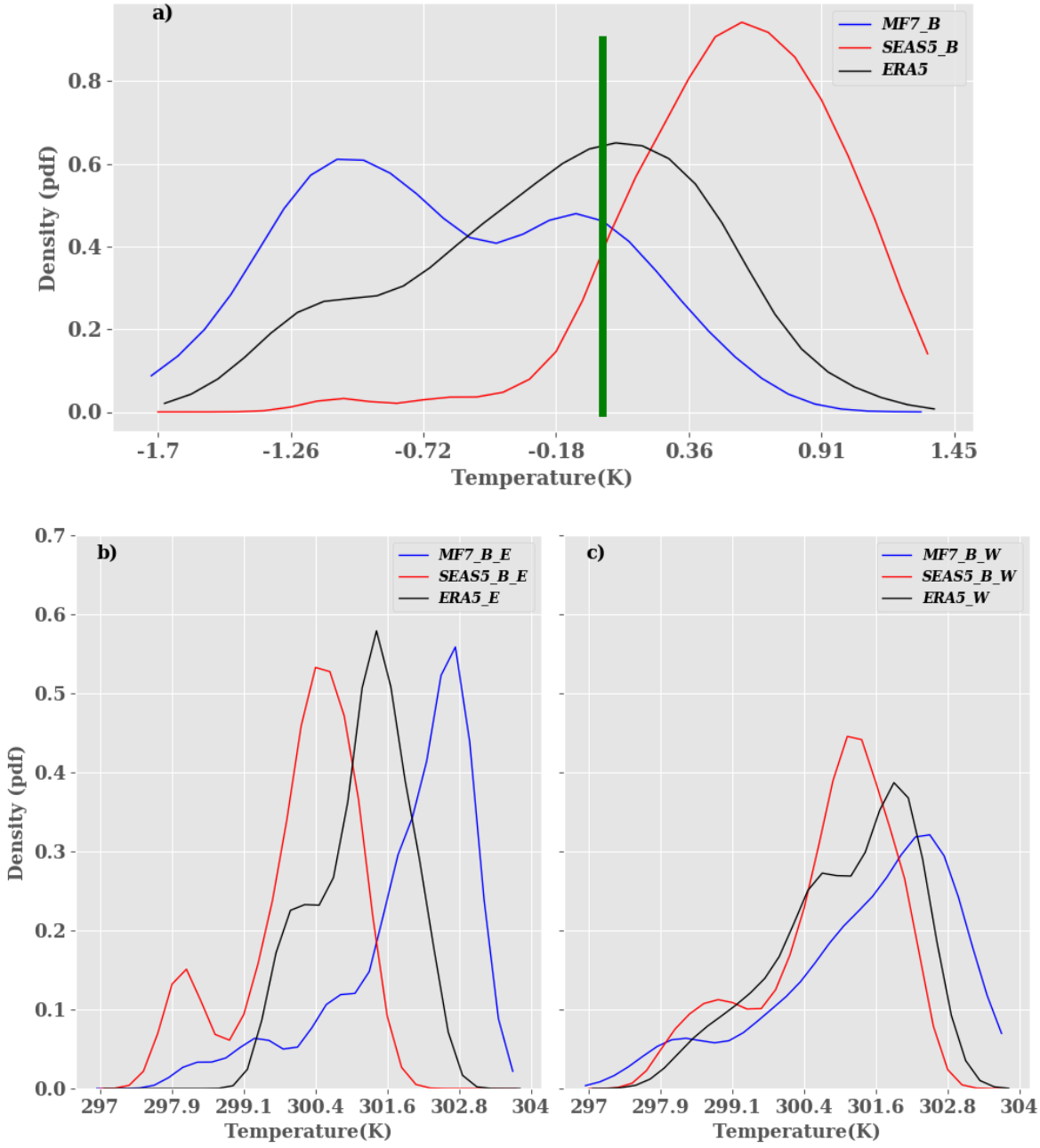

Figure S10. *Distribution of the climatology over the period* $20^{th}\,June - 17^{th}\,September$ *from 1993 to 2016 at June lead time 0 for:* ***a)****the dipole which represents the difference between heat low West and heat low East,* ***b)*** *Heat low East and* ***c)*** *Heat low West.* $MF7\_B$ *and* $SEAS5\_B$ *refer respectively to the MF7/SEAS5 raw forecasts.* "$ERA5\_E$", "$MF7\_B\_E$" *and* "$SEAS5\_B\_E$" *refer respectively to the HLE in the reanalyses, MF7/SEAS5 raw forecasts.* "$ERA5\_W$", "$MF7\_B\_W$" *and* "$SEAS5\_B\_W$" *refer respectively to the HLW in the reanalyses, MF7/SEAS5 raw forecasts.Y-axis indicates the probability of occurrence and X-axis the temperature in degree Kelvin. The vertical green bar represents the boundary between the HLE and HLW phases. The analysis was carried out using the unperturbed member.*