



Supplement of

An energetic perspective on the impact of the Atlantic Multidecadal Variability on the West African Monsoon

Elsa Mohino et al.

Correspondence to: Elsa Mohino (emohino@ucm.es)

The copyright of individual parts of the supplement might differ from the article licence.

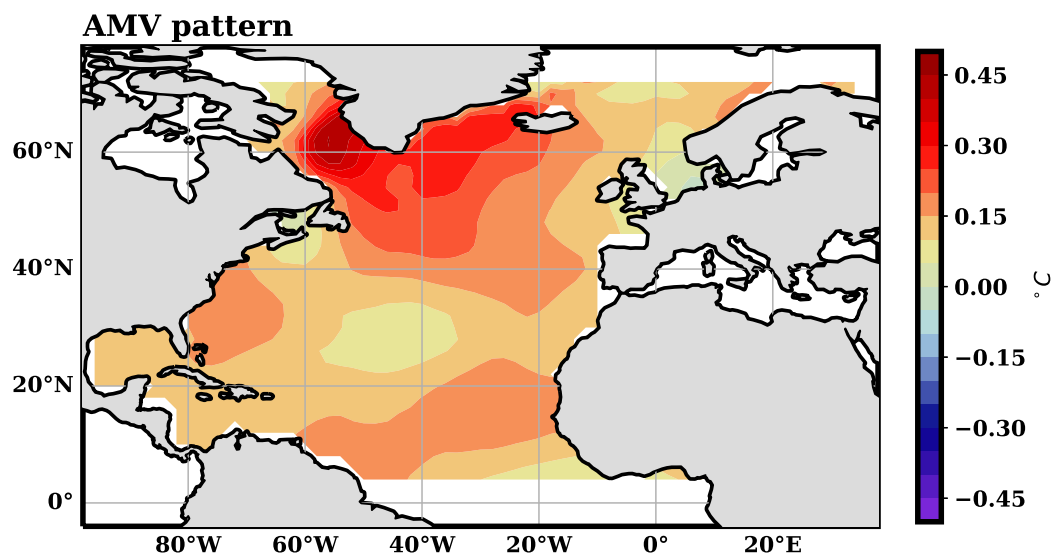


Figure S1. Full AMV⁺ pattern (°C). SSTs are restored to follow the anomalous pattern between 10°N and 65°N. The AMV anomalies to which SSTs are restored are gradually reduced in an additional buffer zone 8° to the north and south of this box.

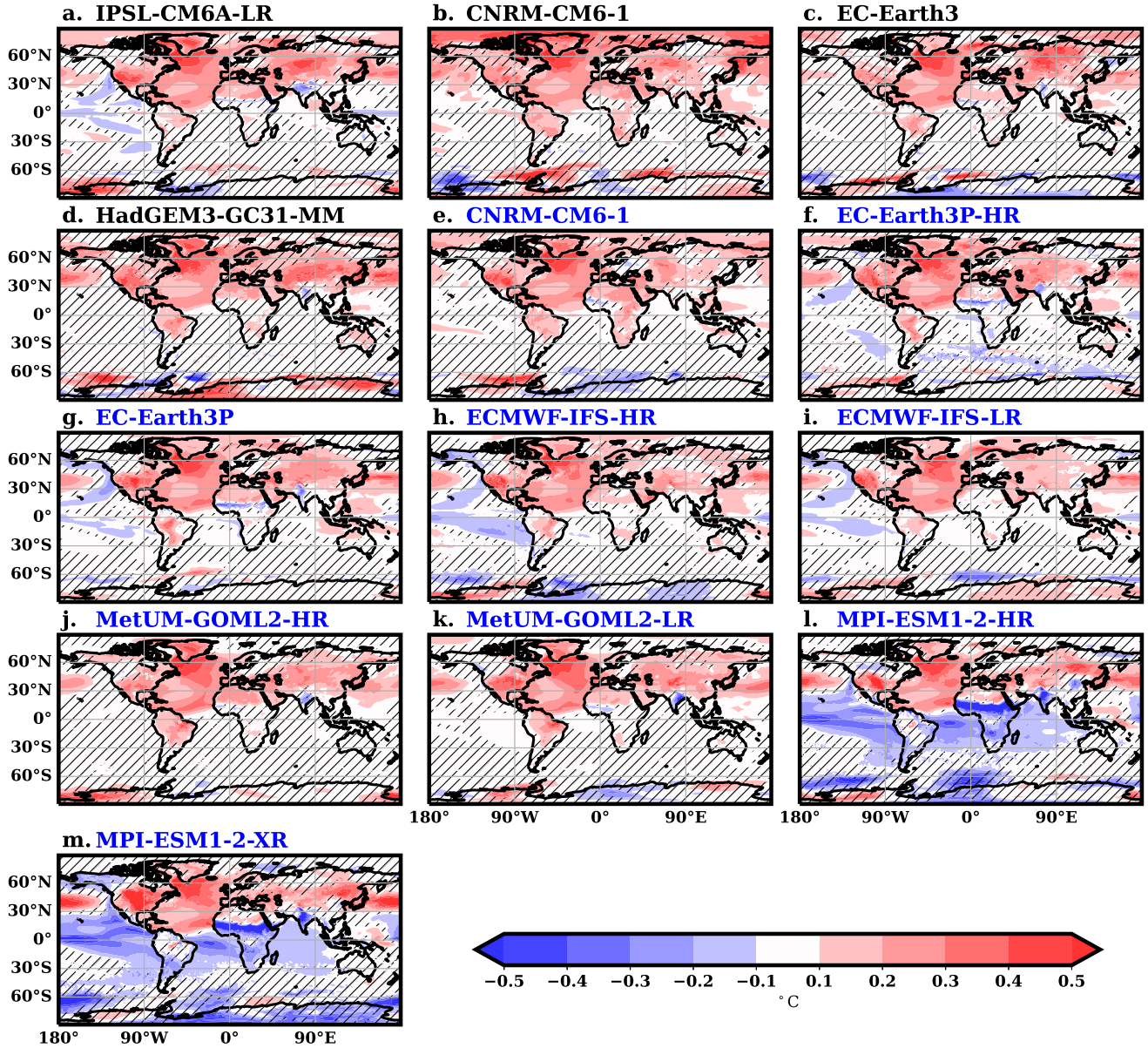


Figure S2. Difference in seasonal mean JAS surface temperature between AMV^+ and AMV^- experiments (shaded; °C). For simulations under the PRIMAVERA protocol (marked blue in the model name labels), only half the anomalous values are shown. Regions where differences are not statistically significant ($p < 0.05$) according to the parametric t-test for differences in the means under independence, assuming a Gaussian distribution for the samples, are hatched.

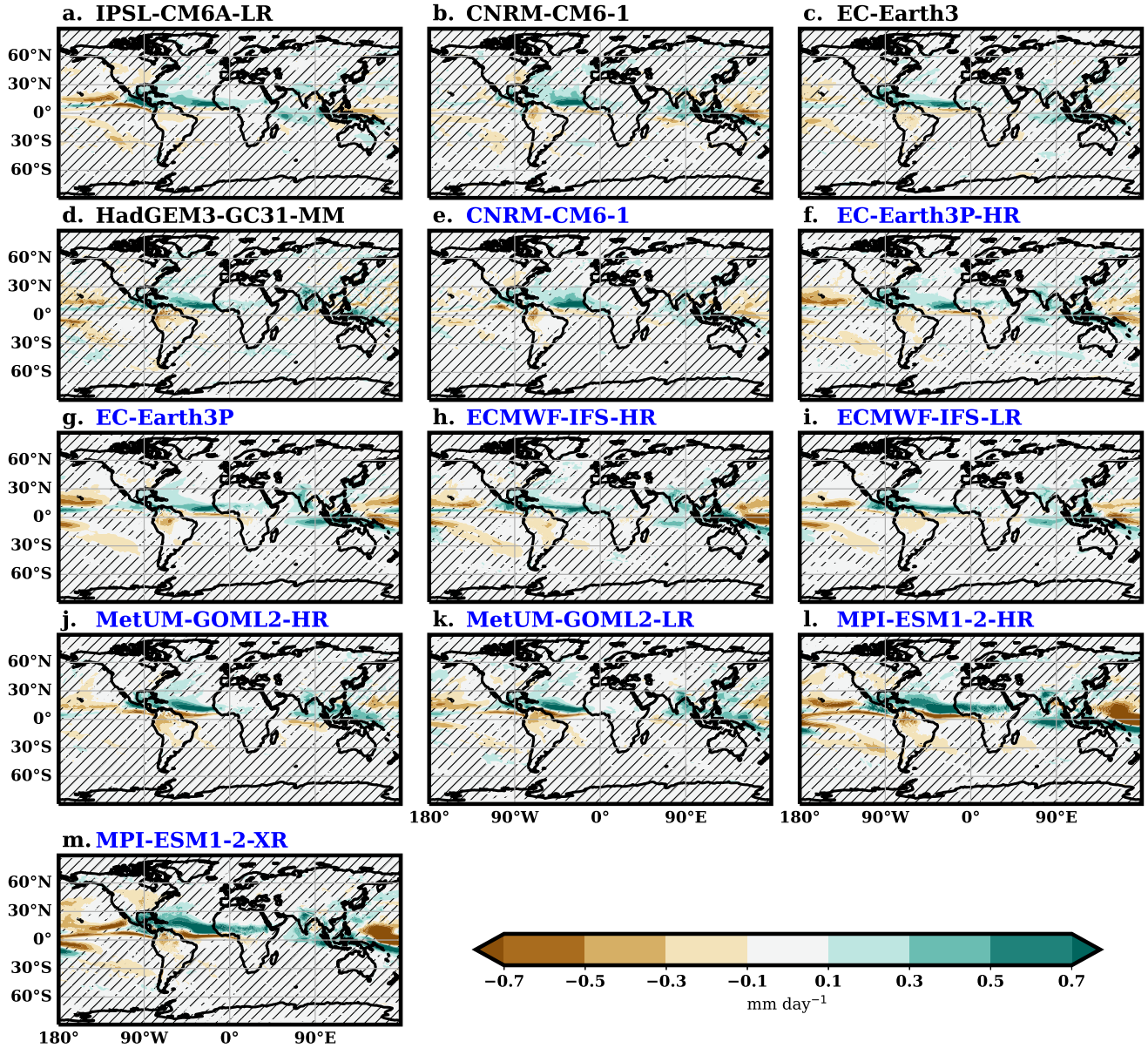


Figure S3. Difference in seasonal mean JAS precipitation between AMV^+ and AMV^- experiments (shaded; $mm\ day^{-1}$). For simulations under the PRIMAVERA protocol (marked blue in the model name labels), only half the anomalous values are shown. Regions where differences are not statistically significant ($p < 0.05$) according to the parametric t-test for differences in the means under independence, assuming a Gaussian distribution for the samples, are hatched.

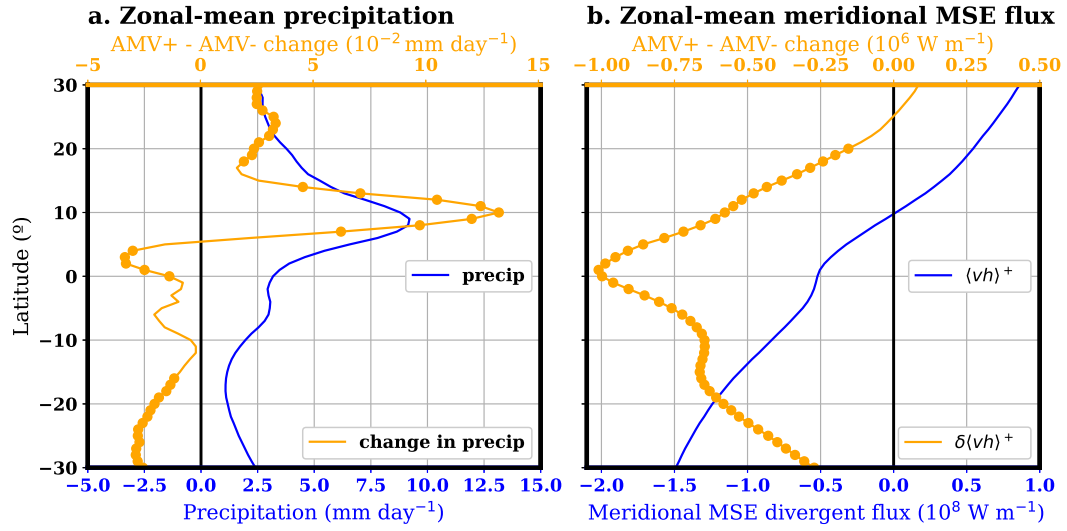


Figure S4. AMV⁺ minus AMV⁻ changes (orange, top axis) and climatological values (blue, bottom axis) of zonal-mean (a) precipitation (mm day^{-1}), and (b) meridional column-integrated moist static energy (MSE) flux ($\langle vh \rangle^+$, W m^{-1}). Dots in the orange lines mark changes for which at least 80% of the models agree on the sign.

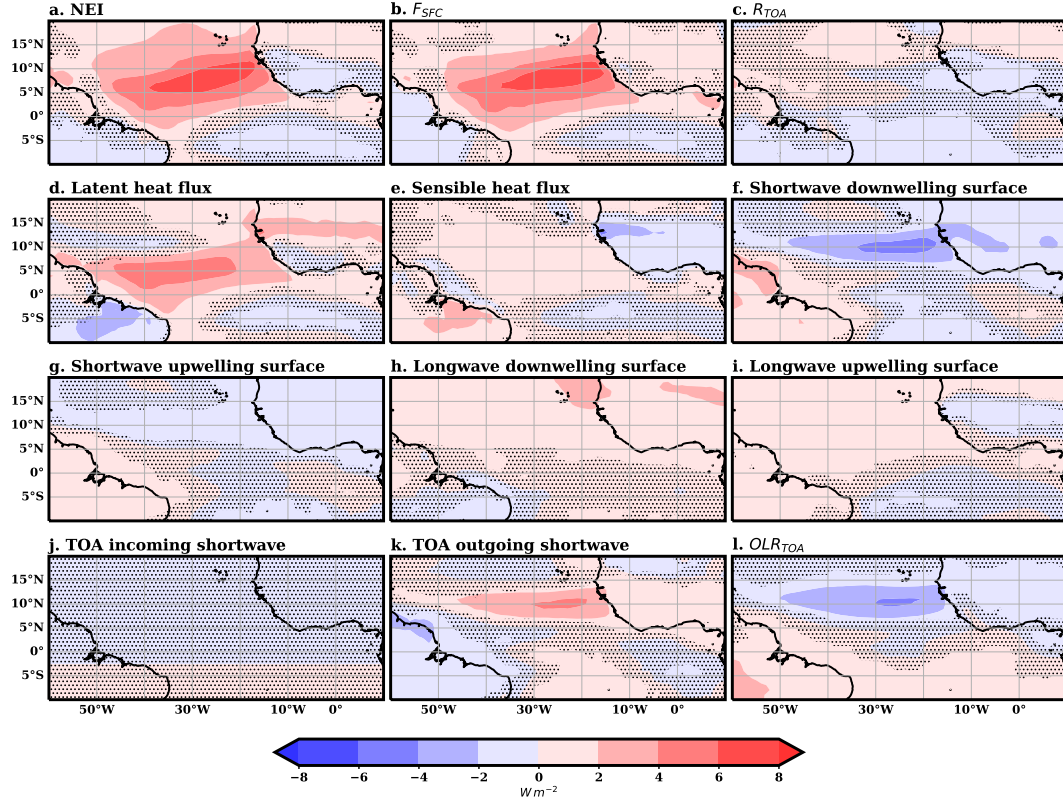


Figure S5. Multimodel average changes in AMV⁺ minus AMV⁻ in JAS for: a) net energy input (NEI) into the atmospheric column; b) energy imbalance at the surface (F_{SFC}); c) energy imbalance at TOA (R_{TOA}); d) latent heat flux; e) sensible heat flux; f) surface downwelling shortwave radiation; g) surface upwelling shortwave radiation; h) surface longwave downwelling radiation; i) surface longwave upwelling radiation; j) TOA incident shortwave radiation; k) TOA outgoing shortwave radiation; l) TOA outgoing longwave radiation. All units are $W m^{-2}$. Positive values in panels f, h, k and l imply energy loss for the atmospheric column. Positive values in all other panels imply energy gain for the atmosphere. Dots mark regions where fewer than 80% of the models agree on the sign of changes.

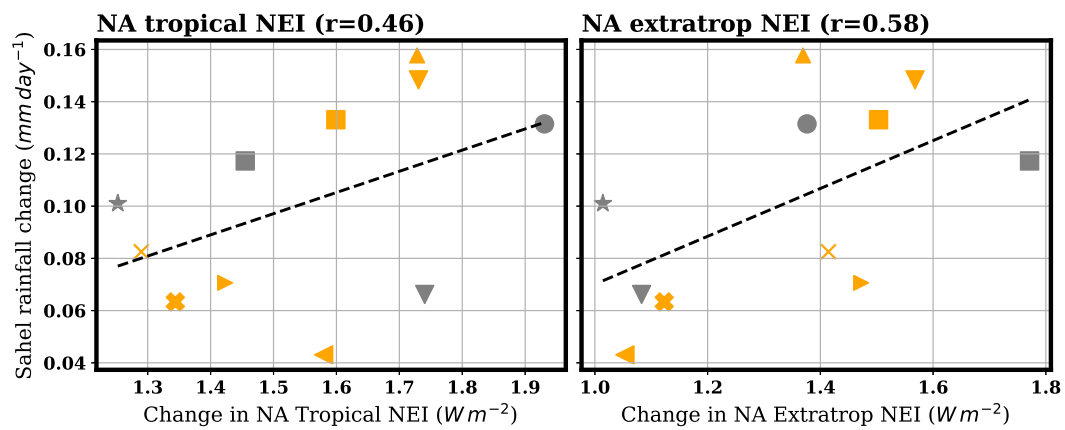


Figure S6. Scatter plots of rainfall change averaged in the Sahel box (mm day⁻¹) and: a) NEI averaged over the tropical North Atlantic (W m⁻², using the orange box in plot 4c in the main article from the equator to 30°N) and b) NEI averaged over the extratropical North Atlantic (W m⁻², using the orange box in plot 4c in the main article only north of 30°N).

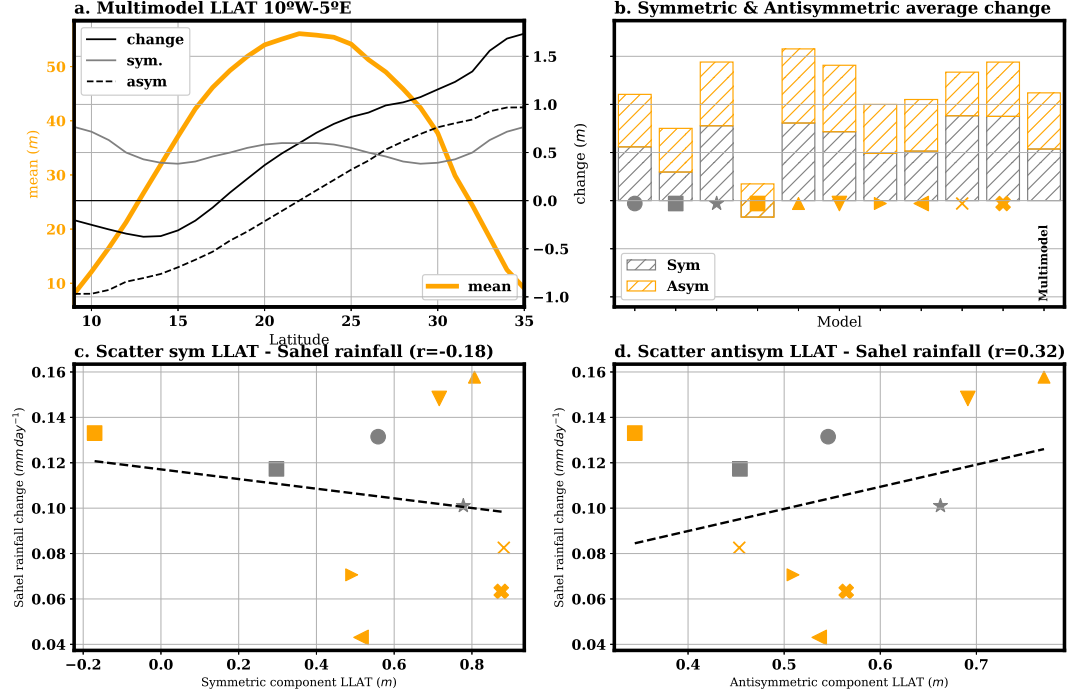


Figure S7. Decomposition of changes in the low-level atmospheric thickness with respect to the tropical mean (LLAT, in m) into symmetric and antisymmetric components. a) Multimodel mean climatology of LLAT in JAS averaged between 10°W and 5°E (orange, left axis) and AMV⁺ minus AMV⁻ change (black continuous line, right axis). The change has been decomposed into symmetric (gray line, right axis) and antisymmetric (dashed line, right axis), taking the maximum climatological value as the central point. b) Symmetric and antisymmetric components of AMV⁺ minus AMV⁻ average LLAT change in the latitudinal window between the maximum value and 35°N in JAS for all models and the multimodel mean. Scatter plots of rainfall change in the Sahel box as a function of the c) symmetric and d) antisymmetric LLAT components. For the models following the PRIMAVERA protocol (marked as orange symbols), only half the anomalies are shown. The legend for the symbols in the scatter plots is the same as in Fig. 2c in the main article. In the scatter plots, the dashed line shows the linear regression fit, and the correlation coefficient is shown in the title. Correlations are marked with one asterisk if they are statistically significant at the $\alpha = 0.05$ level when considering all models as independent samples. Two asterisks are used if correlations are statistically significant when lowering the number of independent samples to 6.

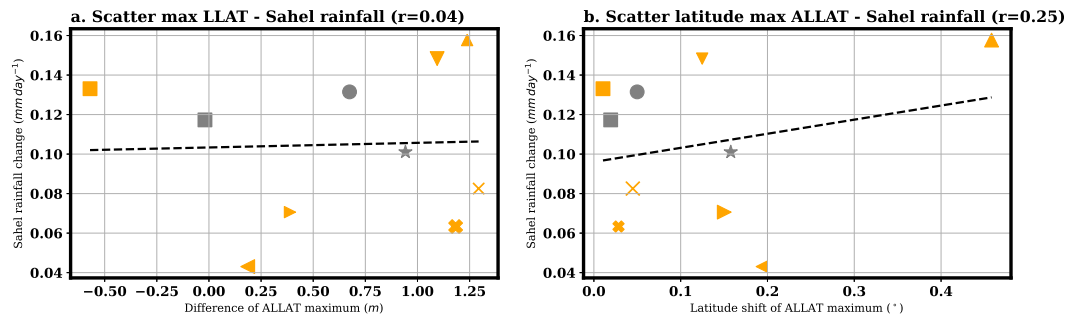


Figure S8. Scatter plots of rainfall change in the Sahel box as a function of the changes in: a) the maximum value of the LLAT (m); and b) the location of the maximum of LLAT (°). For the models following the PRIMAVERA protocol (marked as orange symbols), only half the anomalies are shown. The peak and latitude location of the LLAT have been calculated from a cubic-spline interpolation of the zonal average in the 10°E-10°E. The legend for the symbols in the scatter plots is the same as in Fig. 2c. In the scatter plots, the dashed line shows the linear regression fit, and the correlation coefficient is shown in the title. Correlations are marked with one asterisk if they are statistically significant at the $\alpha = 0.05$ level when considering all models as independent samples. Two asterisks are used if correlations are statistically significant when lowering the number of independent samples to 6.

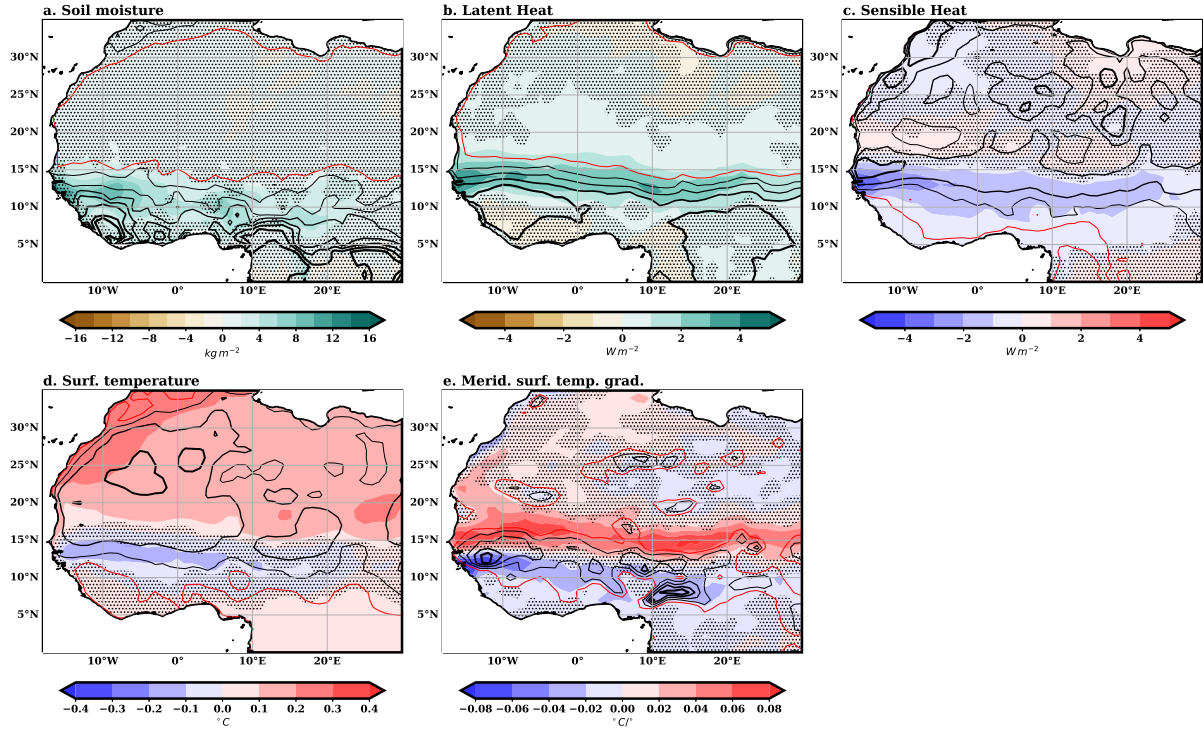


Figure S9. Multimodel average changes (shaded) in AMV⁺ minus AMV⁻ in JAS and climatological values (contours starting from the red one and increasing in thickness with magnitude) of: a) soil moisture (kg m^{-2} , contours drawn every 100 kg m^{-2} starting from 100 kg m^{-2}); b) latent heat flux (W m^{-2} , contours drawn every 20 W m^{-2} starting from 20 W m^{-2}); c) sensible heat (W m^{-2} , contours drawn every 15 W m^{-2} starting from 30 W m^{-2}); d) surface temperature ($^{\circ}\text{C}$, contours drawn every 3°C starting from 25°C); e) meridional component of the surface temperature gradient ($^{\circ}\text{C}$ per degree of latitude, contours drawn every 0.5°C per degree of latitude).

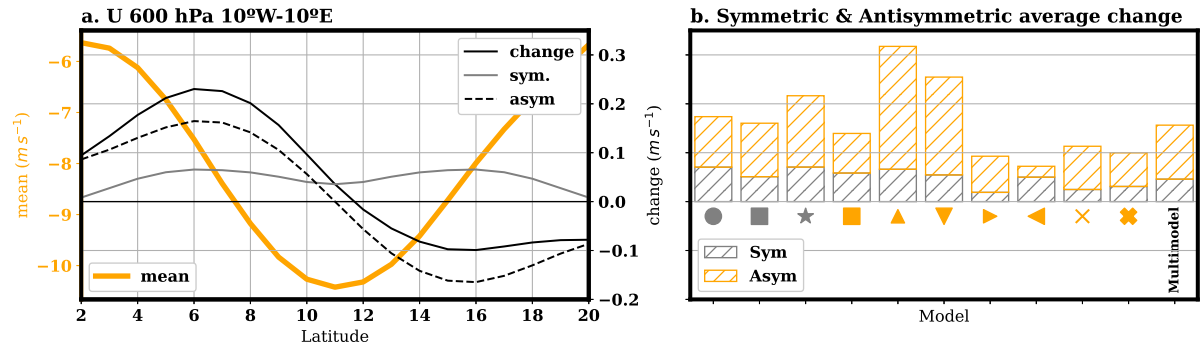


Figure S10. Decomposition of changes in the core of the AEJ (in m s^{-1} into symmetric and antisymmetric components. a) Multimodel mean climatology of the zonal wind at 600hPa in JAS averaged between 10°W and 10°E (orange, left axis) and AMV^+ minus AMV^- change (black continuous line, right axis). The change has been decomposed into symmetric (gray line, right axis) and antisymmetric (dashed line, right axis), taking the maximum climatological value as the central point. b) Symmetric and antisymmetric components of AMV^+ minus AMV^- average AEJ change in the latitudinal window between the maximum value and 20°N in JAS for all models and the multimodel mean. The legend for the symbols in the scatter plots are the same as in Fig.2c in the main text.

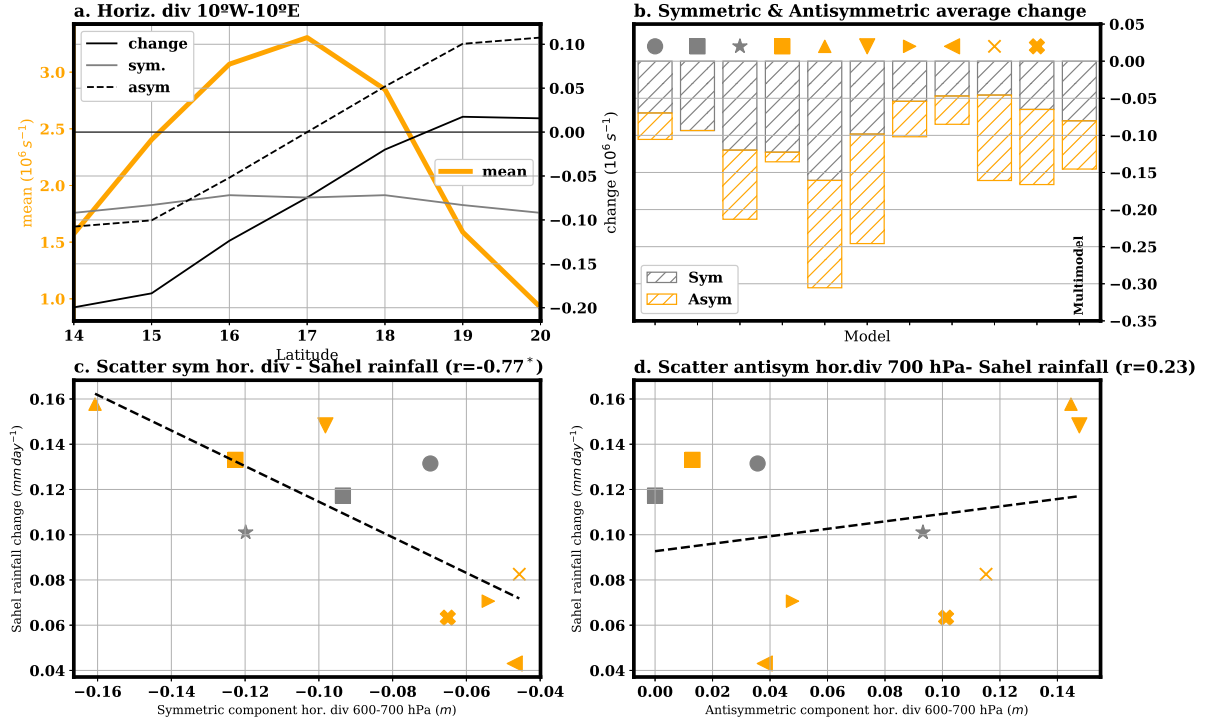


Figure S11. Decomposition of changes in the mid-level divergence associated with the shallow meridional circulation (units are 10^{-6} s^{-1}) into symmetric and antisymmetric components. a) Multimodel mean climatology of horizontal wind divergence averaged between 10°W-10°E and the levels of 600 hPa and 700 hPa in JAS (orange, left axis) and AMV⁺ minus AMV⁻ change (black continuous line, right axis). The change has been decomposed into symmetric (gray line, right axis) and antisymmetric (dashed line, right axis), taking the maximum climatological value as the central point. b) Symmetric and antisymmetric components of AMV⁺ minus AMV⁻ averaged change in the latitudinal window between the maximum value and 20°N in JAS for all models and the multimodel mean. For easy comparison between the symmetric and antisymmetric components, the sign of the antisymmetric component has been reversed in plot b. Scatter plots of rainfall change in the Sahel box as a function of the c) symmetric and d) antisymmetric components. For the models following the PRIMAVERA protocol (marked as orange symbols), only half the anomalies are shown. The legend for the symbols in the scatter plots is the same as in Fig. 2c in the main text. In the scatter plots, the dashed line shows the linear regression fit, and the correlation coefficient is shown in the title. Correlations are marked with one asterisk if they are statistically significant at the $\alpha=0.05$ level when considering all models as independent samples. Two asterisks are used if correlations are statistically significant when lowering the number of independent samples to 6.

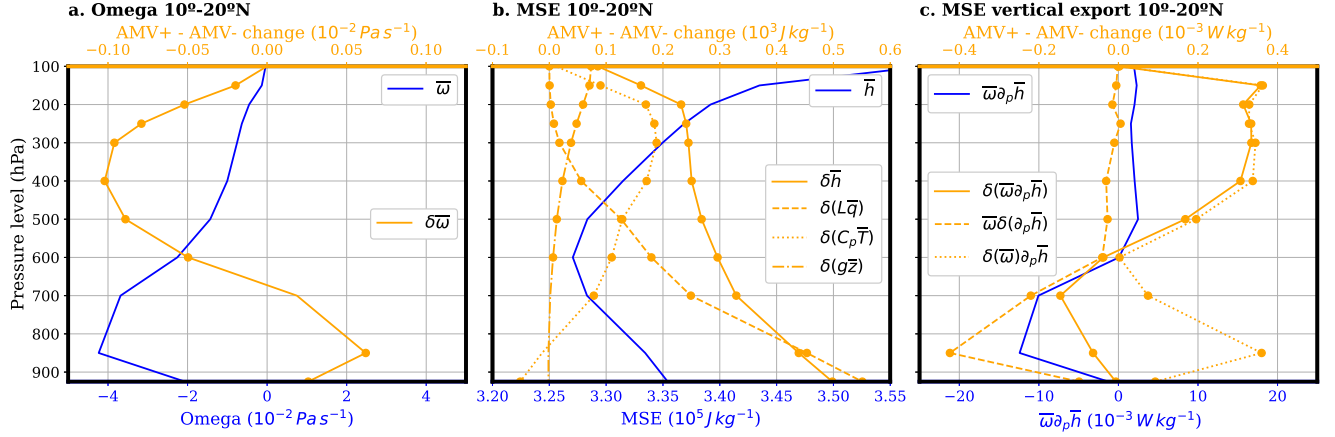


Figure S12. Profiles of AMV^+ minus AMV^- differences (orange, top axis) and climatological values (blue, bottom axis) in the Sahel box defined as 10°W - 10°E , 10°N - 20°N (see purple box in figure 2b of the main article) of: a) omega (ω , Pa s^{-1}); b) moist static energy (MSE, J kg^{-1}) and c) vertical export of moist static energy ($\overline{\omega}\partial_p\overline{h}$, W kg^{-1}). Changes in moist static energy in panel b are further partitioned into the potential energy (gz , dashed dot line), dry enthalpy (c_pT , dotted line) and latent energy (Lq , dashed line). The vertical export of moist static energy in panel c is decomposed into its thermodynamic ($\overline{\omega}\delta(\partial_p\overline{h})$, dashed line) and dynamic ($\delta(\overline{\omega})\partial_p\overline{h}$, dotted line) components. Models EC-Earth3P-HR and EC-Earth3P in the PRIMAVERA protocol were not used to calculate the multi-model mean omega, as we could not find this variable for these models. In addition, model EC-Earth3 in the DCP-C protocol was also excluded from the vertical profile analysis because too few vertical levels were available in its outputs. Dots in the orange lines mark changes for which at least 80% of the models agree on the sign.

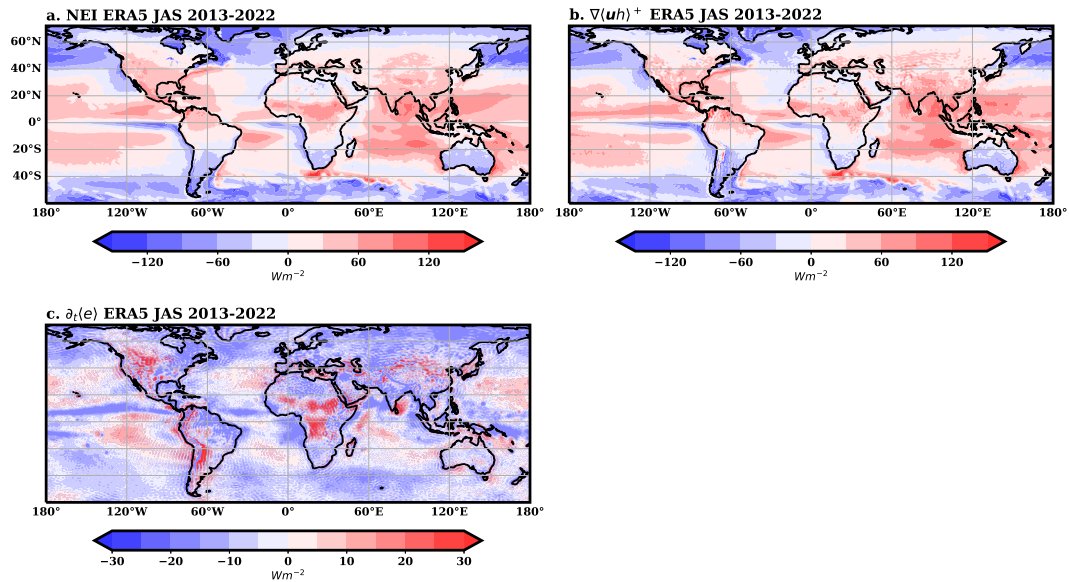


Figure S13. a) Net energy input (NEI) calculated from ERA5 (Hersbach et al., 2020) energy imbalances at TOA and the surface averaged for the July to September season for the 10-year period of 2013-2022 (shaded, $W m^{-2}$); b) Mass-consistent divergence of the vertical integral of total energy flux (Mayer et al. 2021) averaged for the same season and period; c) time tendency of the mass-weighted vertical integral of moist enthalpy calculated as the residual between NEI and the mass-consistent divergence of the vertical integral of total energy flux averaged over the same season and period. Note the different colorscale.