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*Supplement of*

# Boreal autumn to winter North Atlantic atmosphere–ocean coupling in large ensemble climate simulations

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**Supplement**

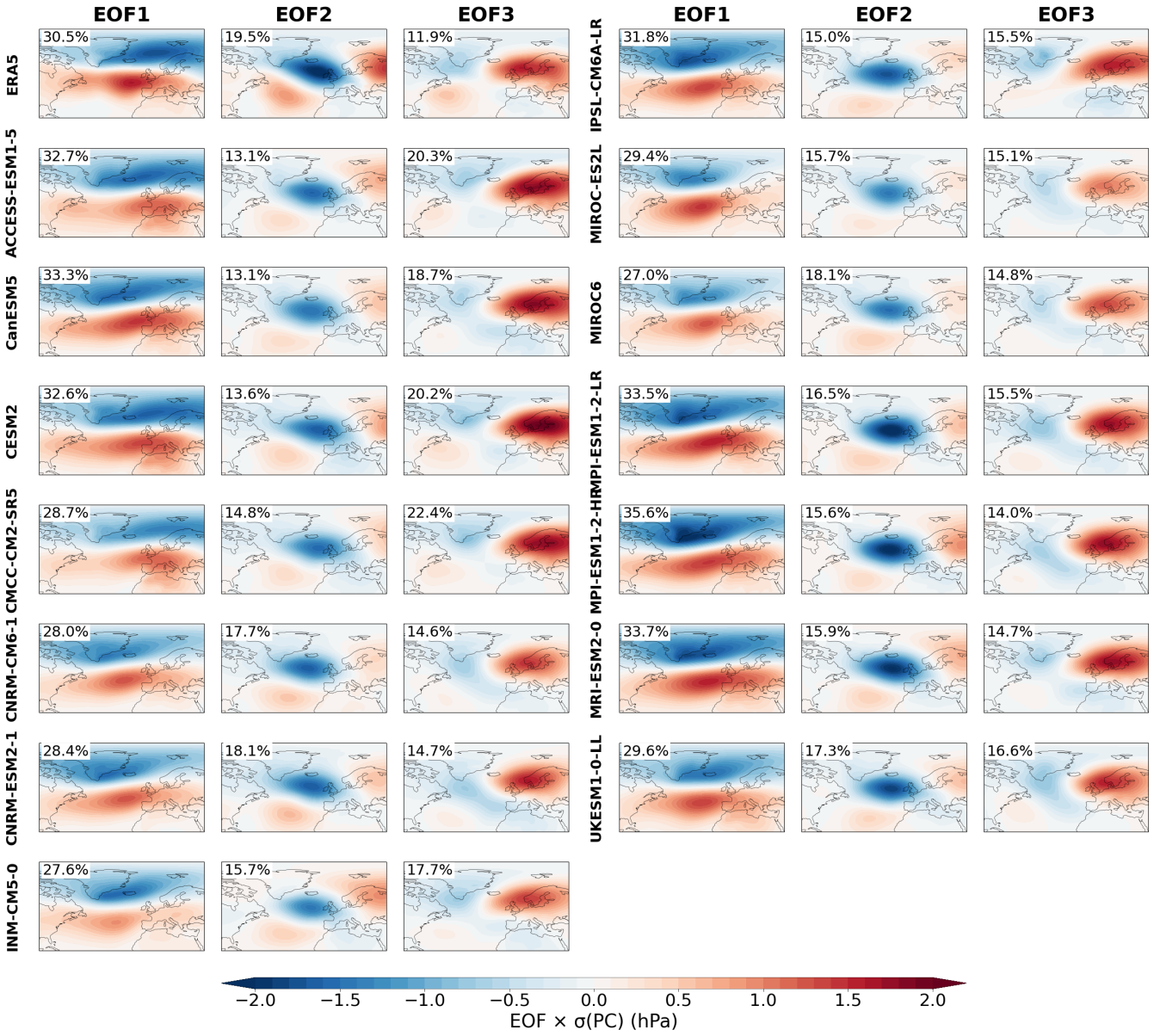



**Figure S1.** EOFs 1-3 of autumn MSLP. Percentage of variance explained by each mode indicated in left corner.

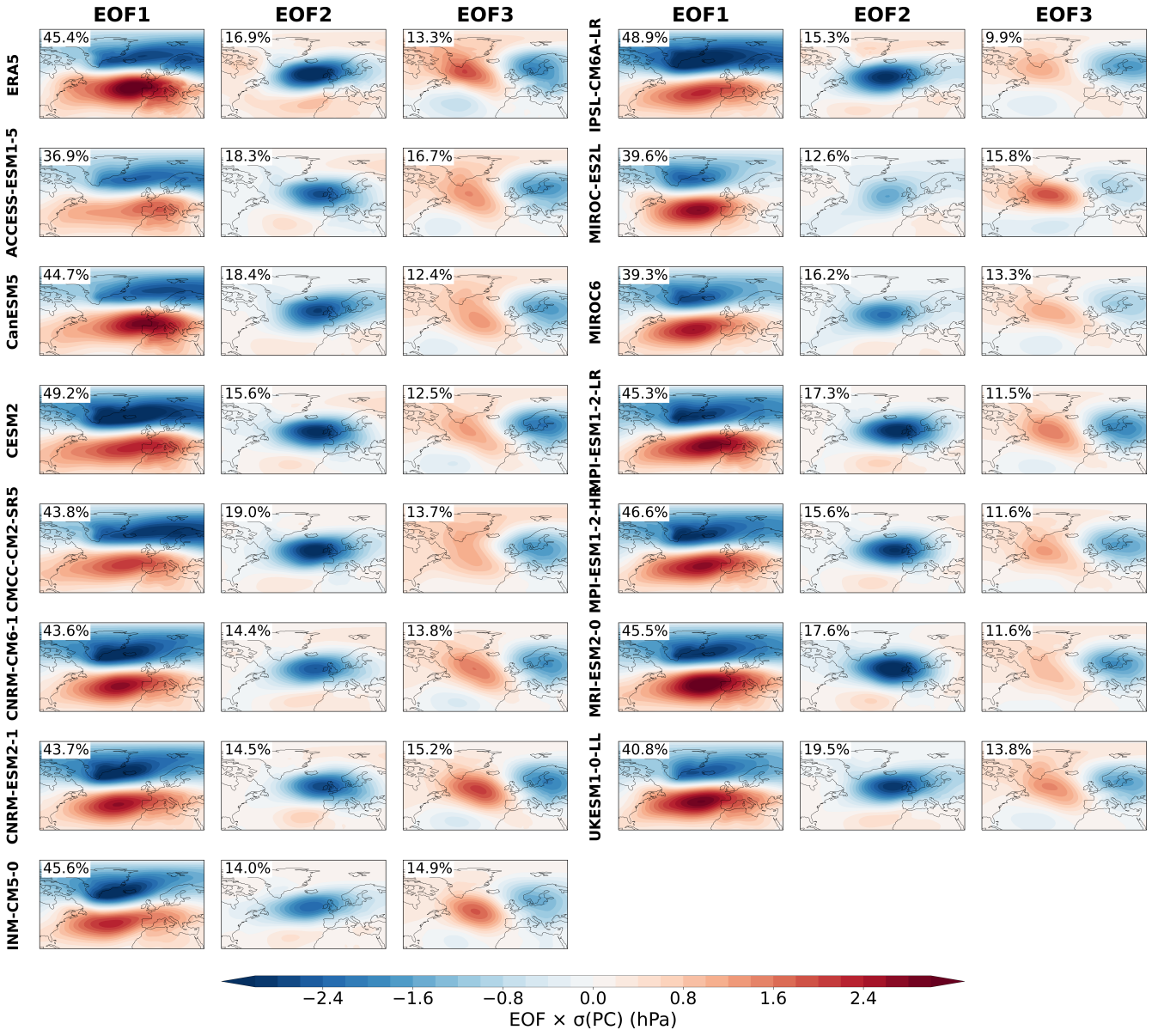



**Figure S2.** EOFs 1-3 of winter MSLP. Percentage of variance explained by each mode indicated in left corner.

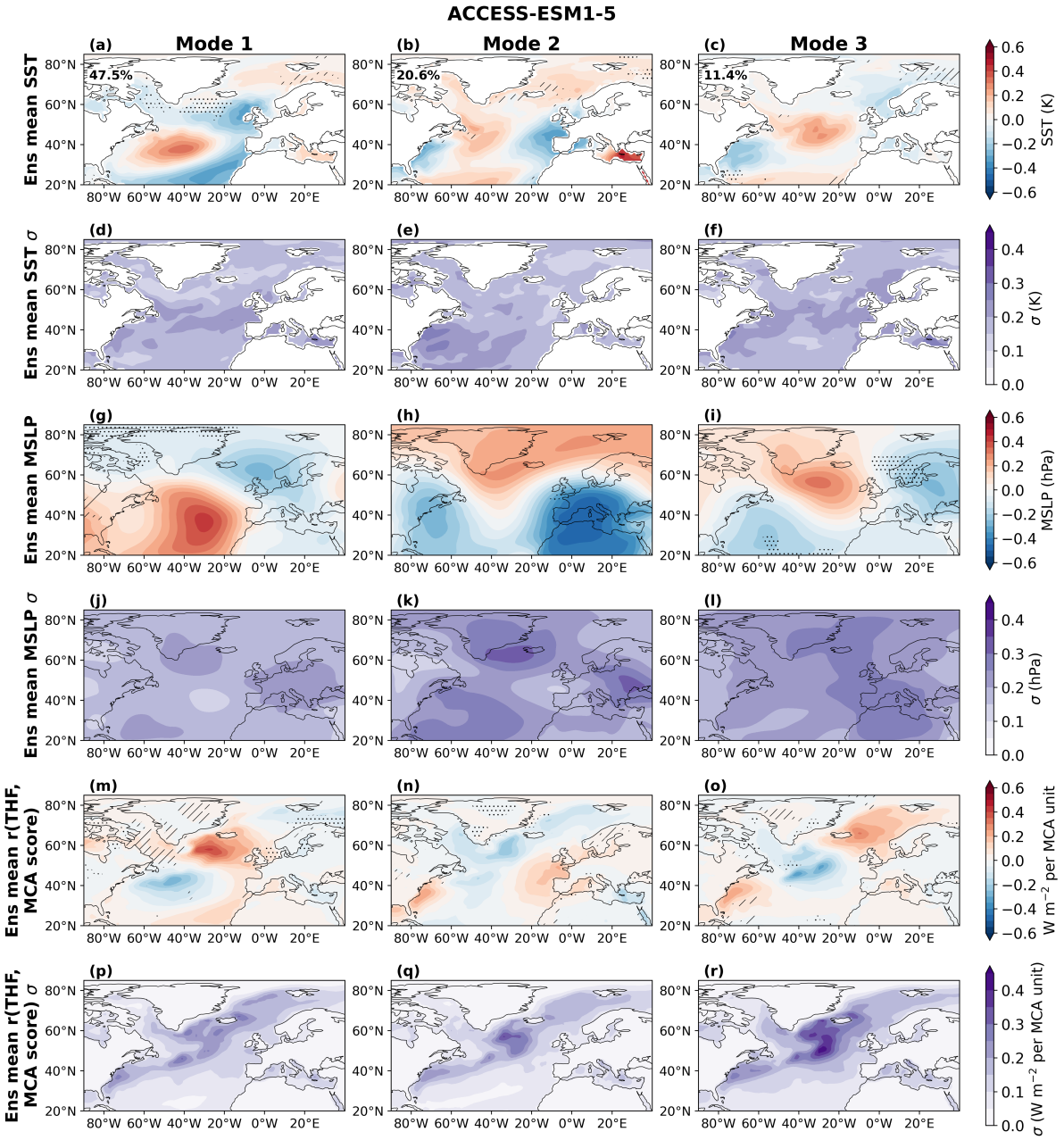



**Figure S3.** Ensemble mean contemporaneous autumn atmosphere-ocean co-variability in ACCESS-ESM1-5. Heterogeneous patterns for MCA modes 1-3 for autumn SST, autumn MSLP, and autumn turbulent heat flux (THF) regressed onto the corresponding MCA time series (r(THF, MCA score)). Panels are arranged left-to-right by mode (columns: Mode 1-3) and top-to-bottom by variable: (a-c) ensemble mean SST, (d-f) ensemble spread in SST, (g-i) ensemble mean MSLP, (j-l) ensemble spread in MSLP, (m-o) ensemble mean r(THF, MCA score), and (p-r) ensemble spread in r(THF, MCA score). Hatching indicates regions where the ERA5 value exceeds the 97.5th percentile of the ensemble spread, and stippling indicates regions where ERA5 falls below the 2.5th percentile of the ensemble spread.

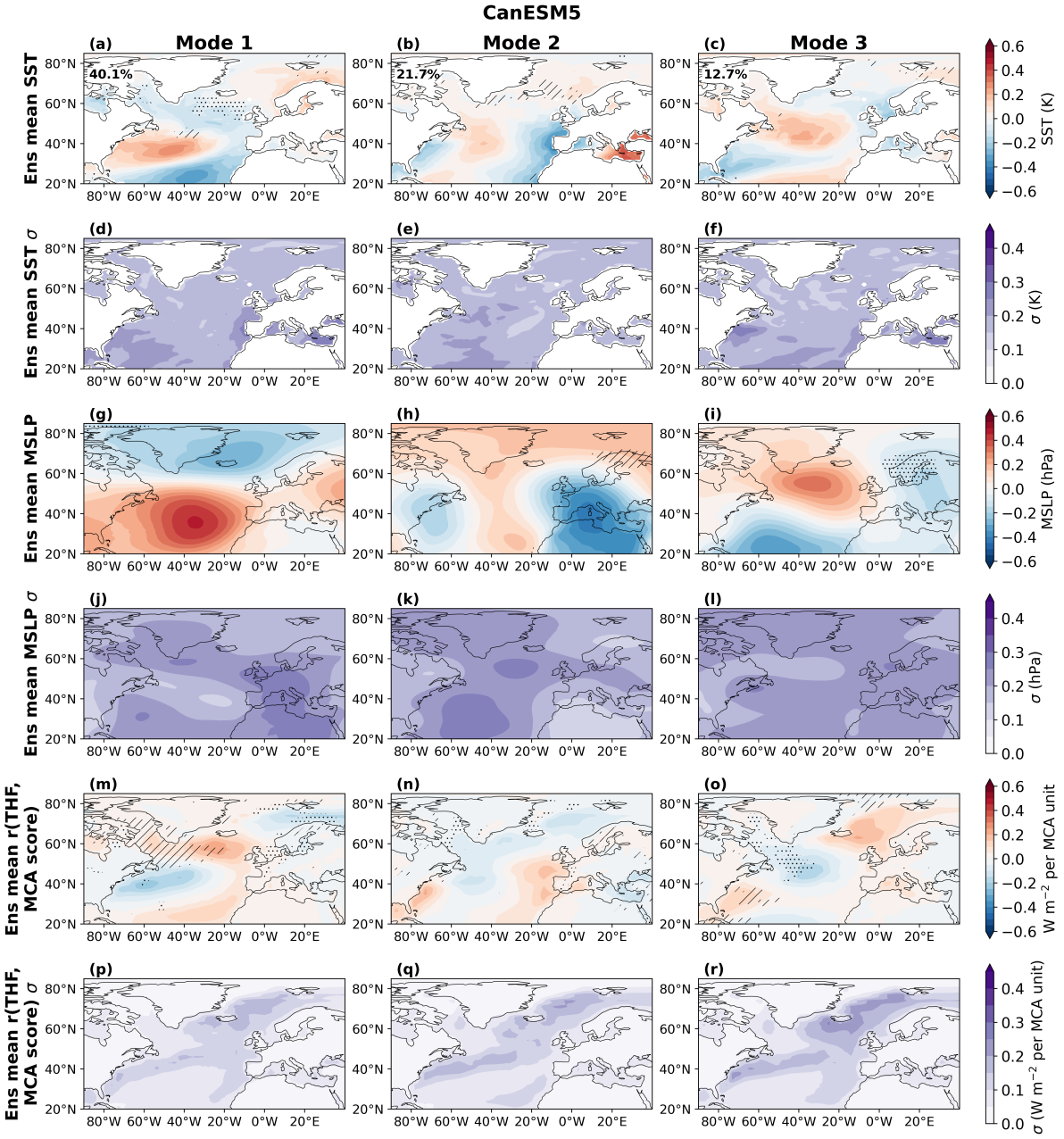



**Figure S4.** As in SI Fig. S3 for CanESM5.

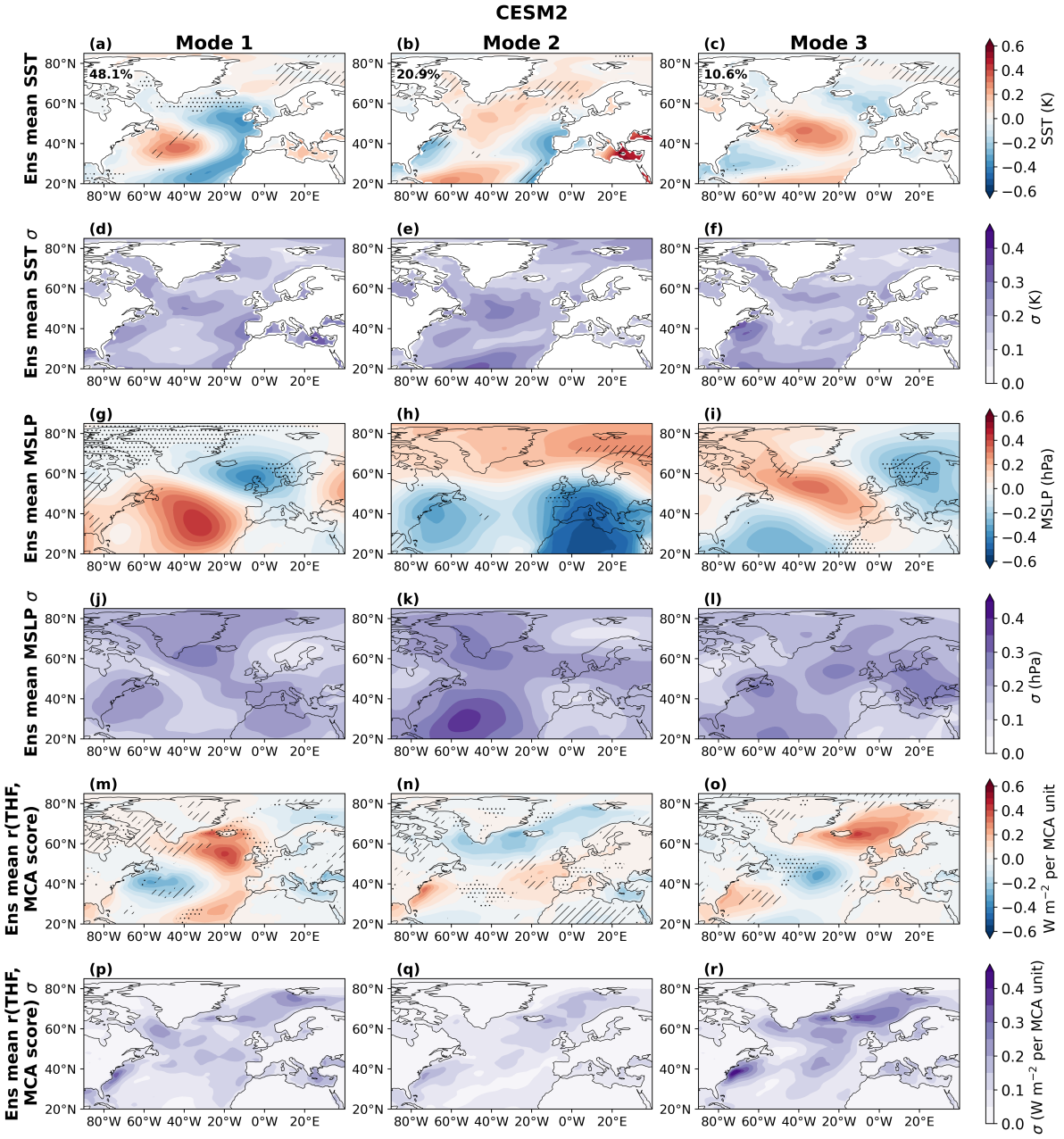



**Figure S5.** As in SI Fig. S3 for CESM2.

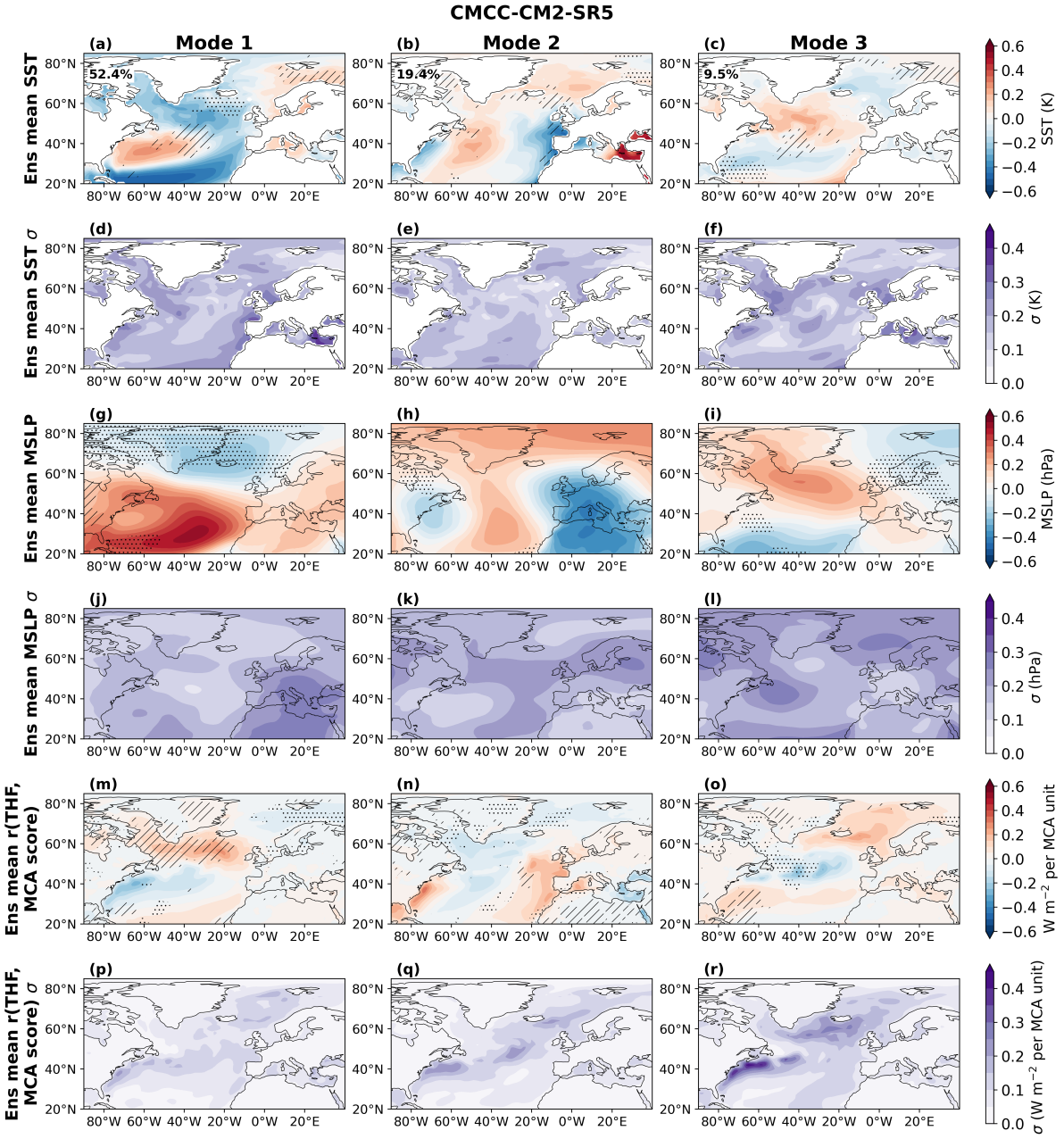



**Figure S6.** As in SI Fig. S3 for CMCC-CM2-SR5.

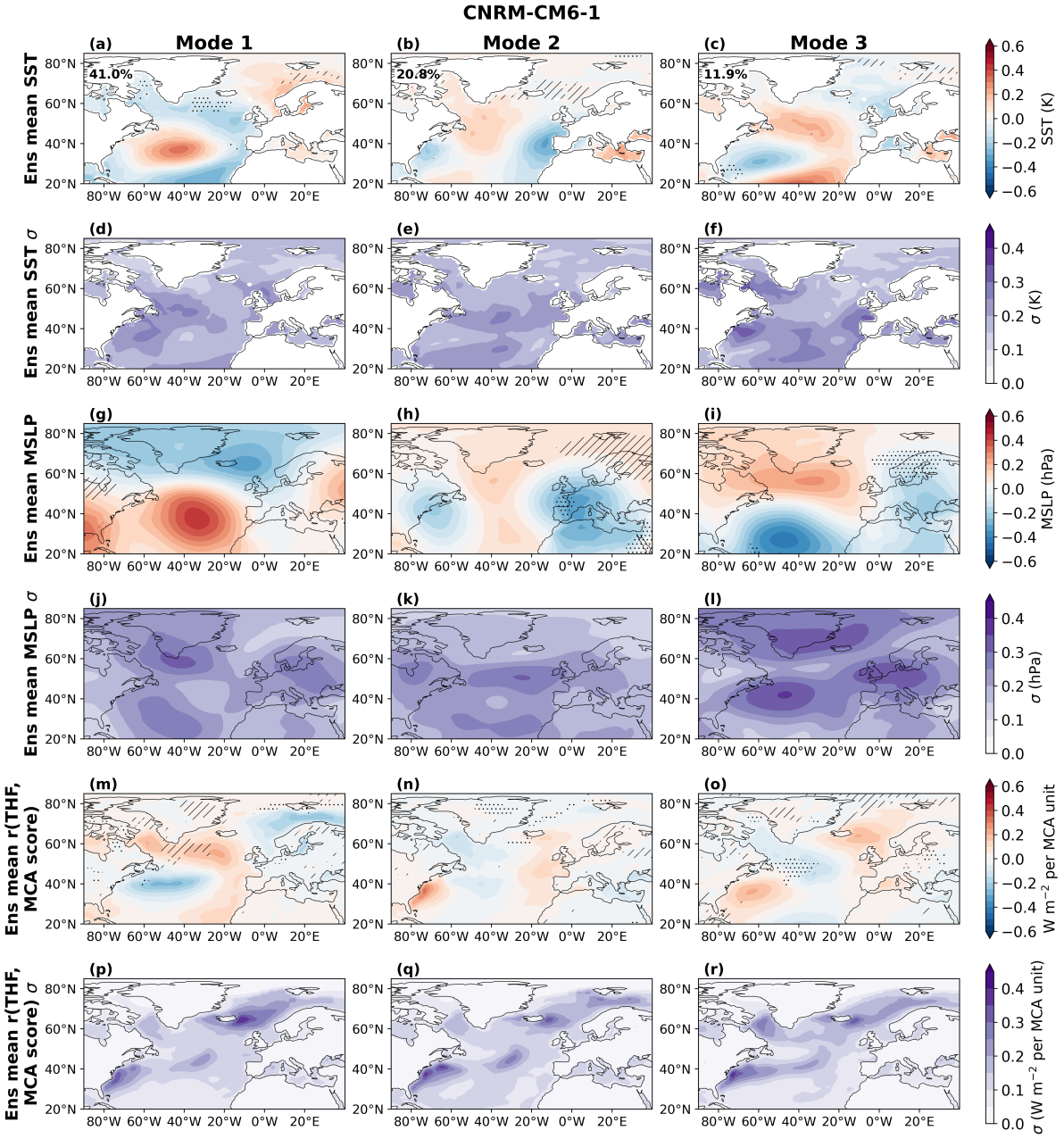



**Figure S7.** As in SI Fig. S3 for CNRM-CM6-1.

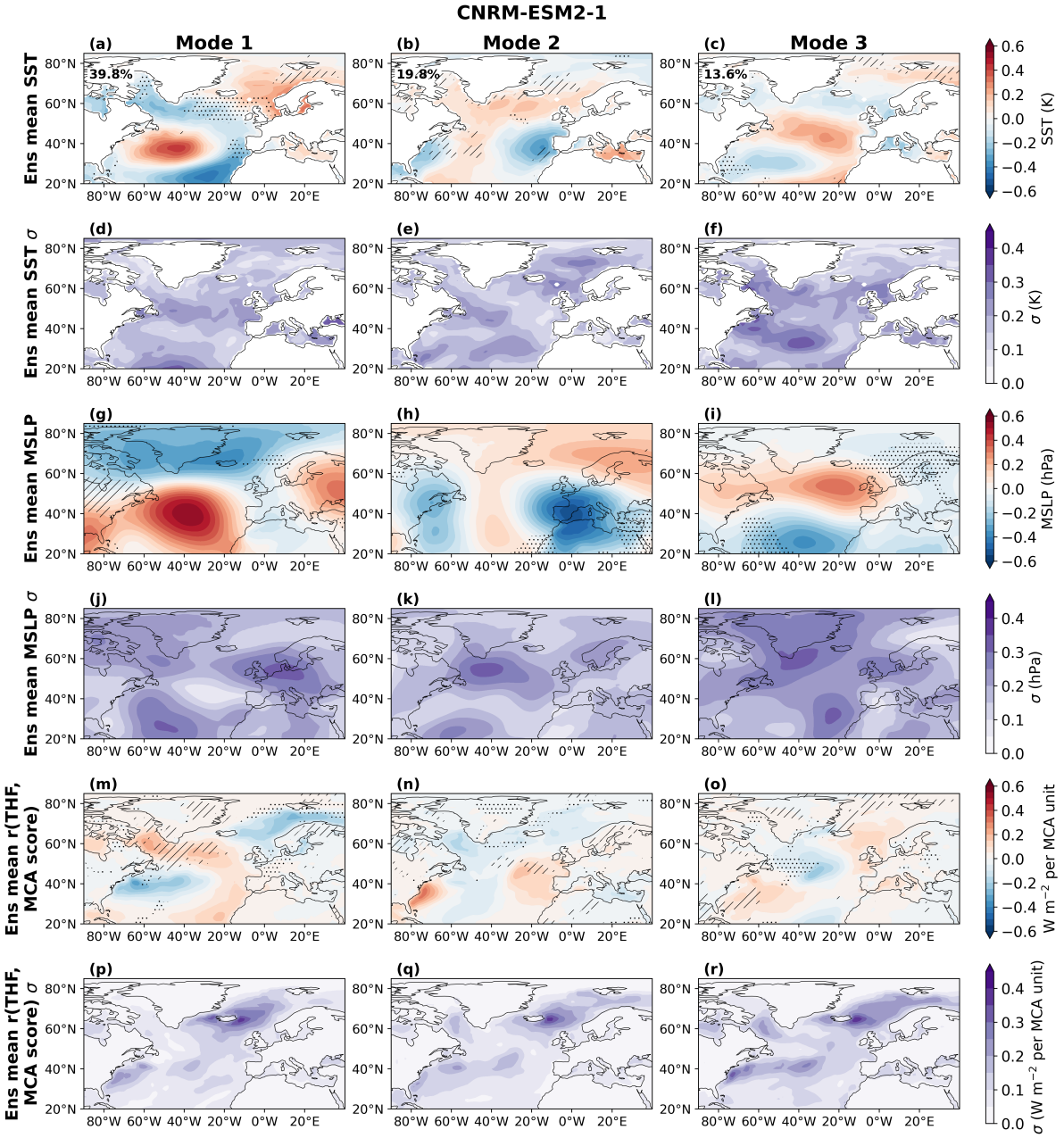



**Figure S8.** As in SI Fig. S3 for CNRM-ESM2-1.

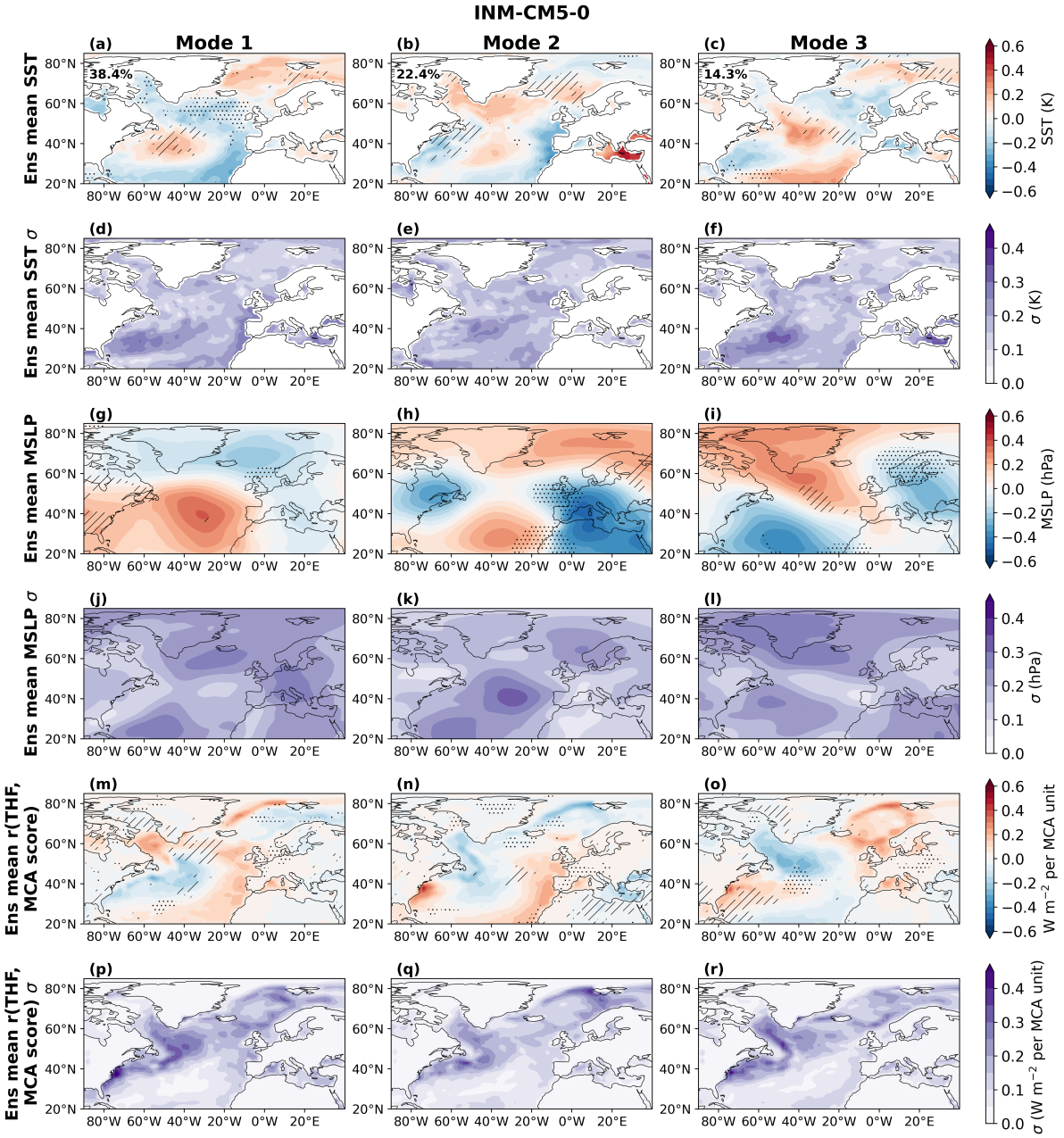



**Figure S9.** As in SI Fig. S3 for INM-CM5-0.

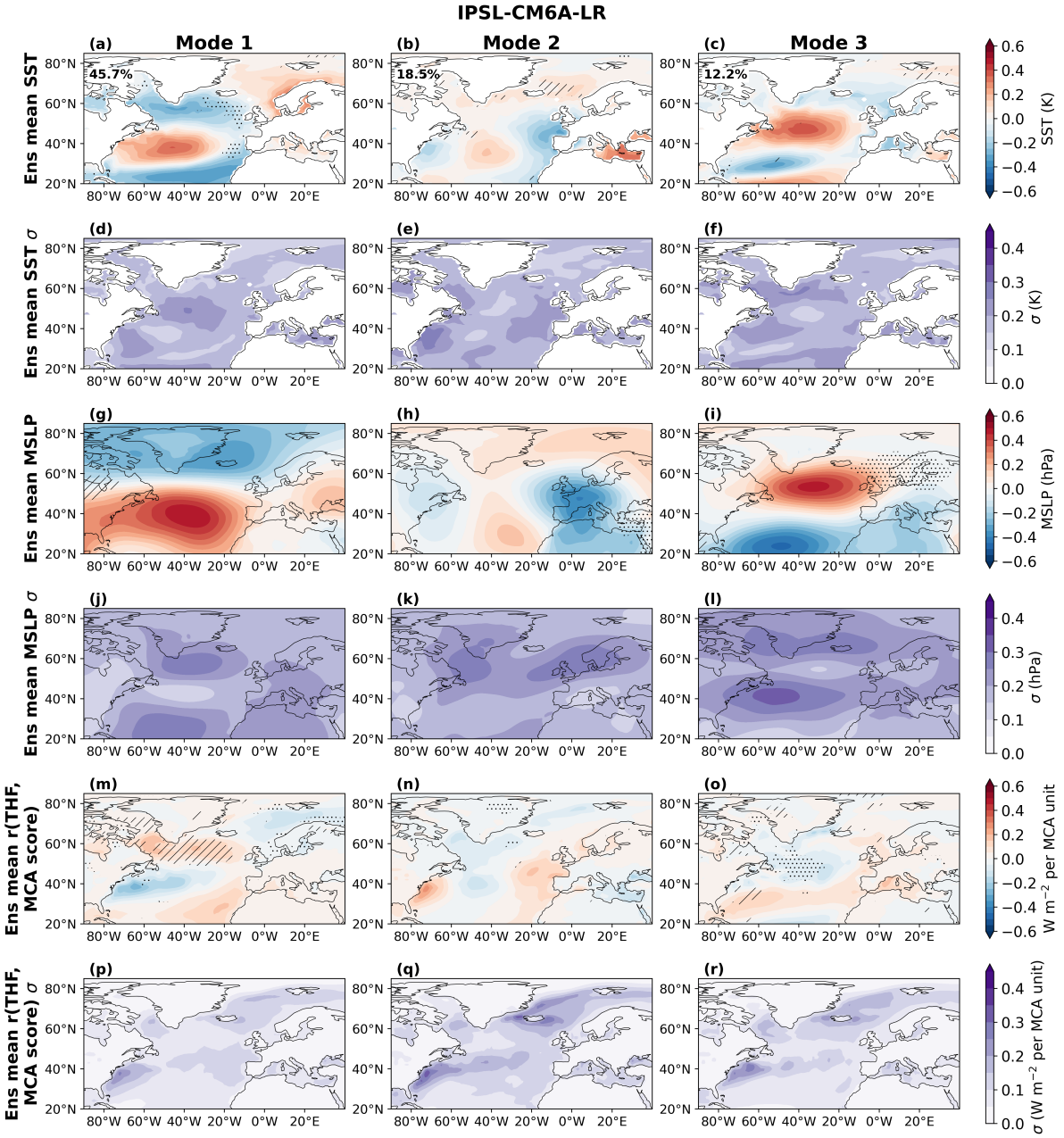



**Figure S10.** As in SI Fig. S3 for IPSL-CM6A-LR.

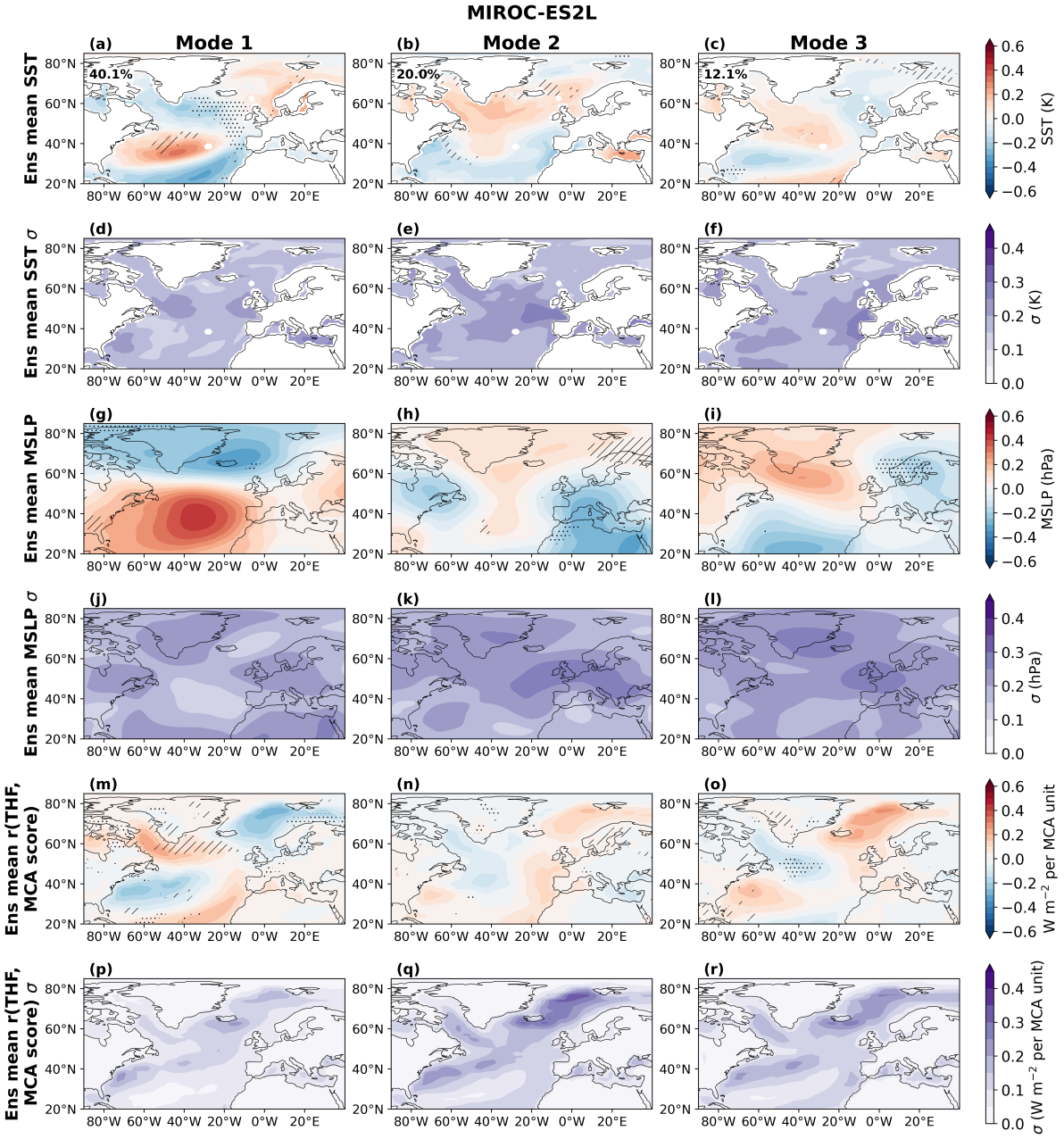



**Figure S11.** As in SI Fig. S3 for MIROC-ES2L.

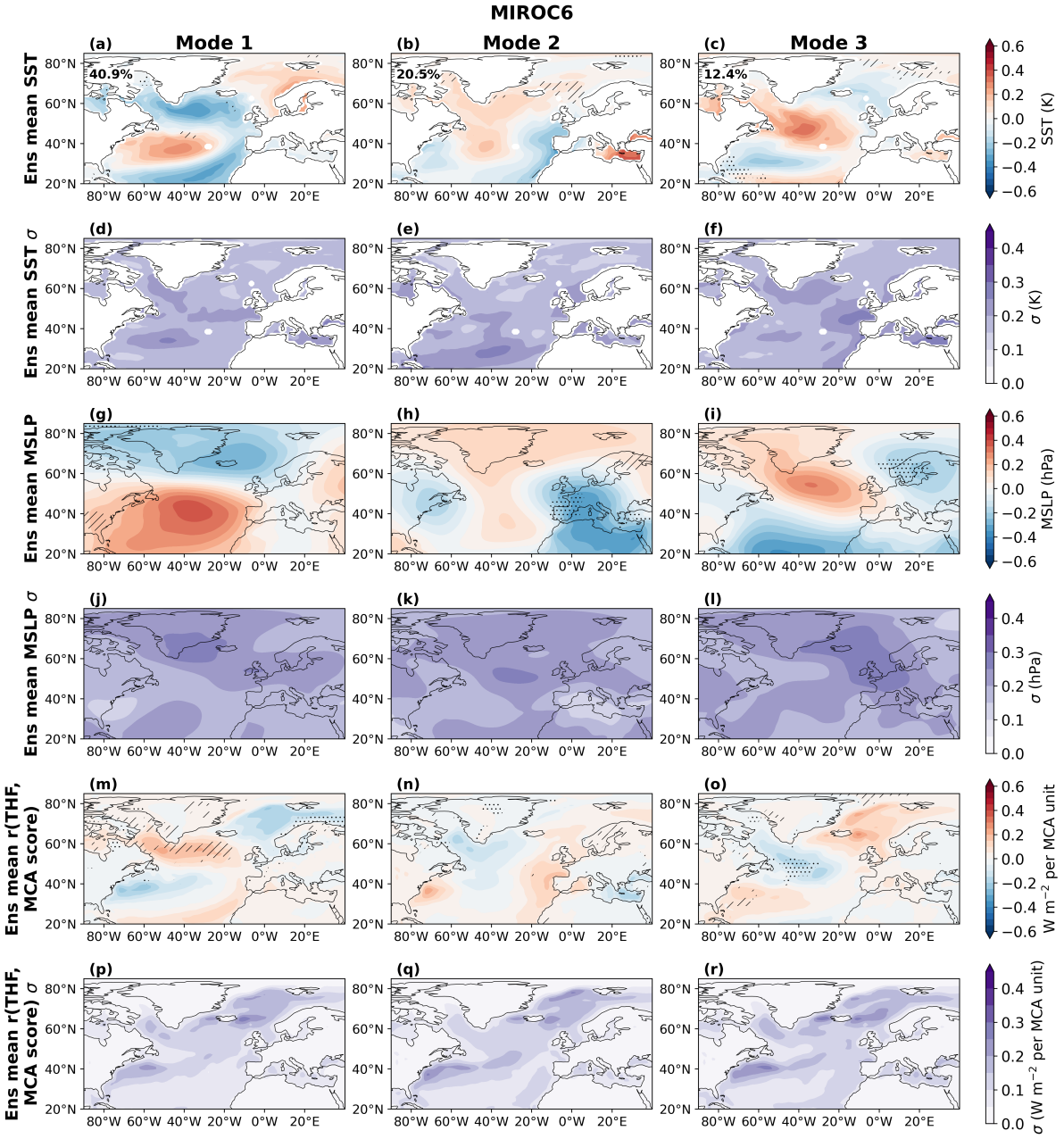



**Figure S12.** As in SI Fig. S3 for MIROC6.

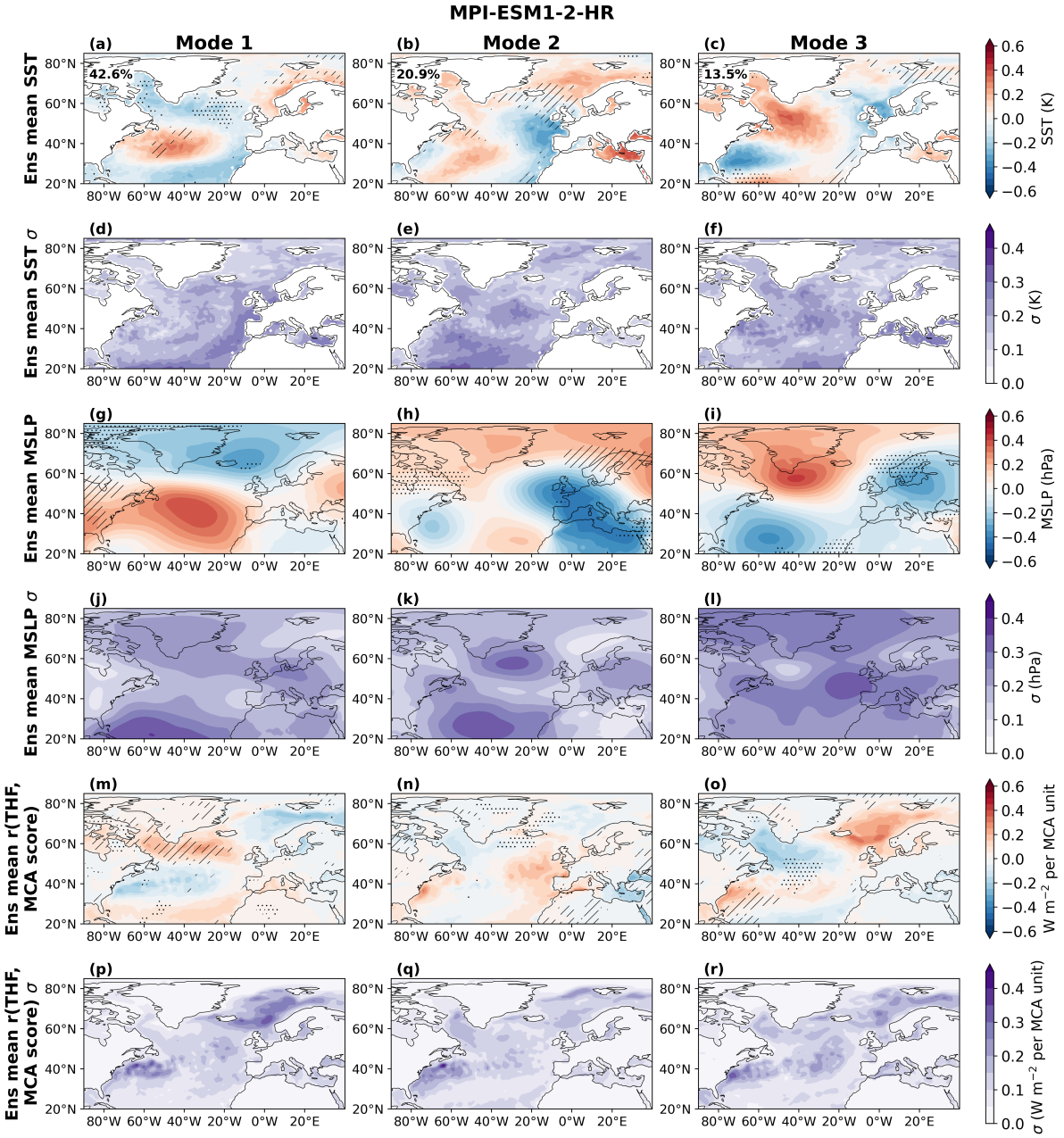



**Figure S13.** As in SI Fig. S3 for MPI-ESM1-2-HR.

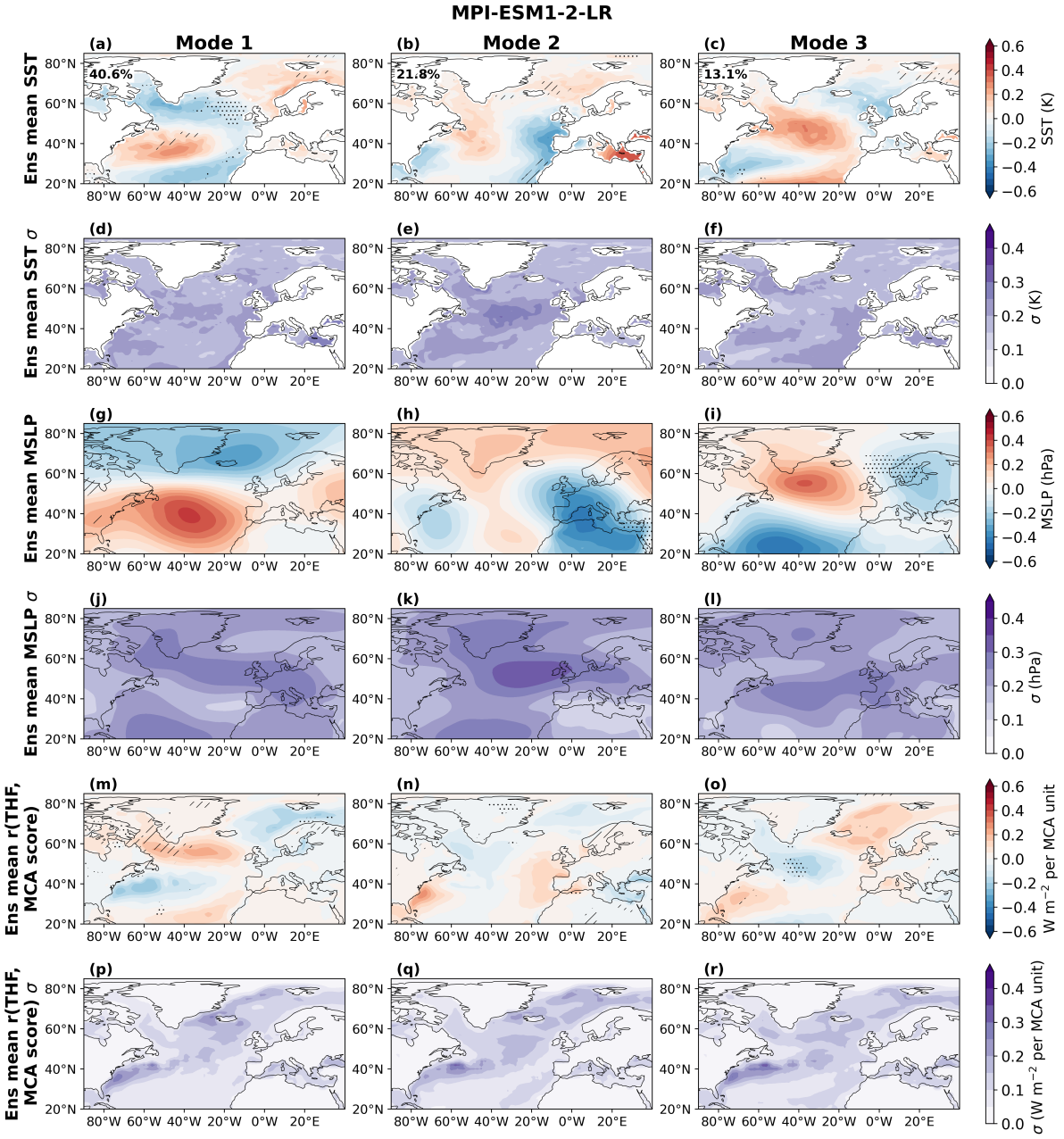



**Figure S14.** As in SI Fig. S3 for MPI-ESM1-2-LR.

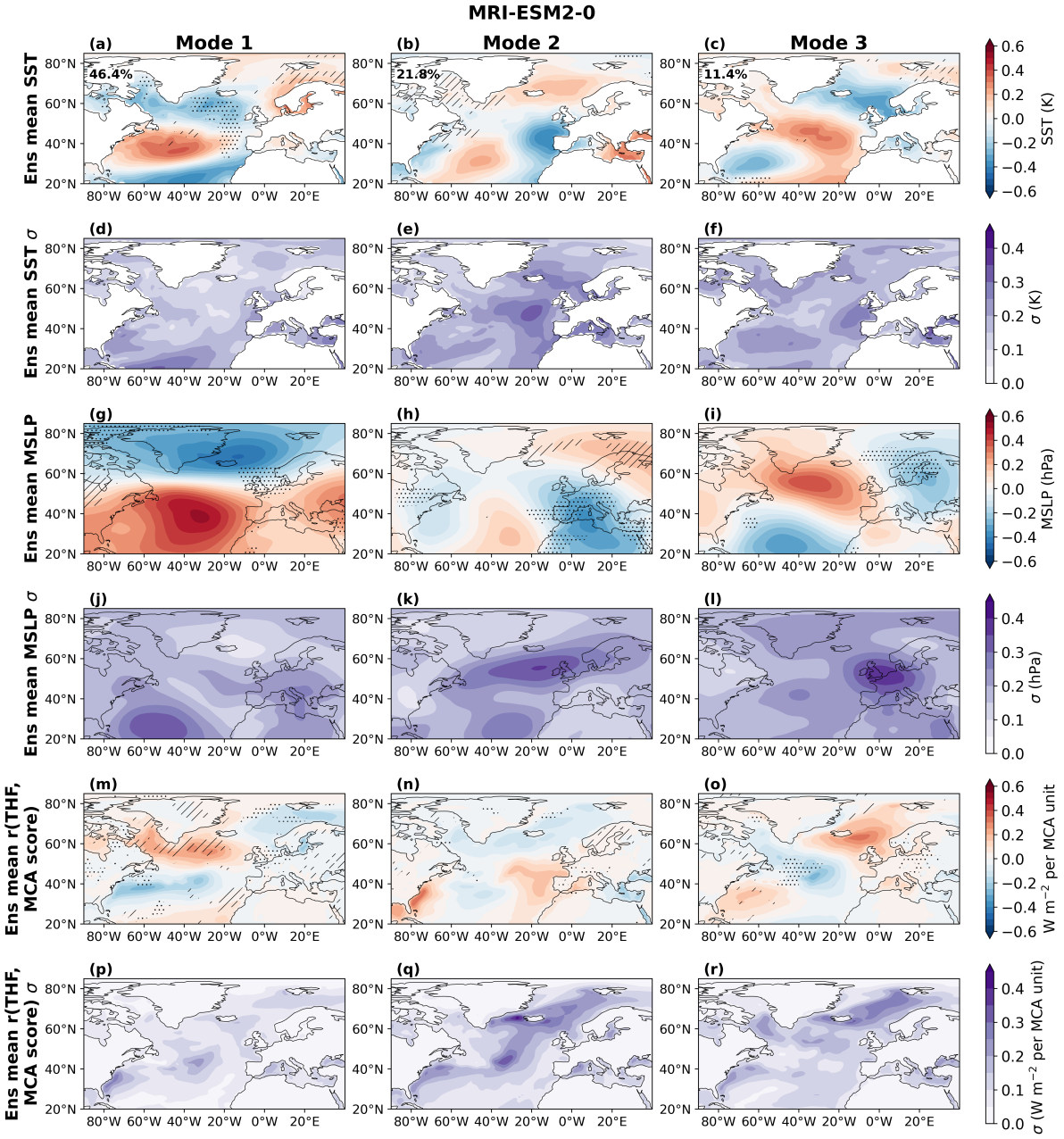



**Figure S15.** As in SI Fig. S3 for MRI-ESM2-0.

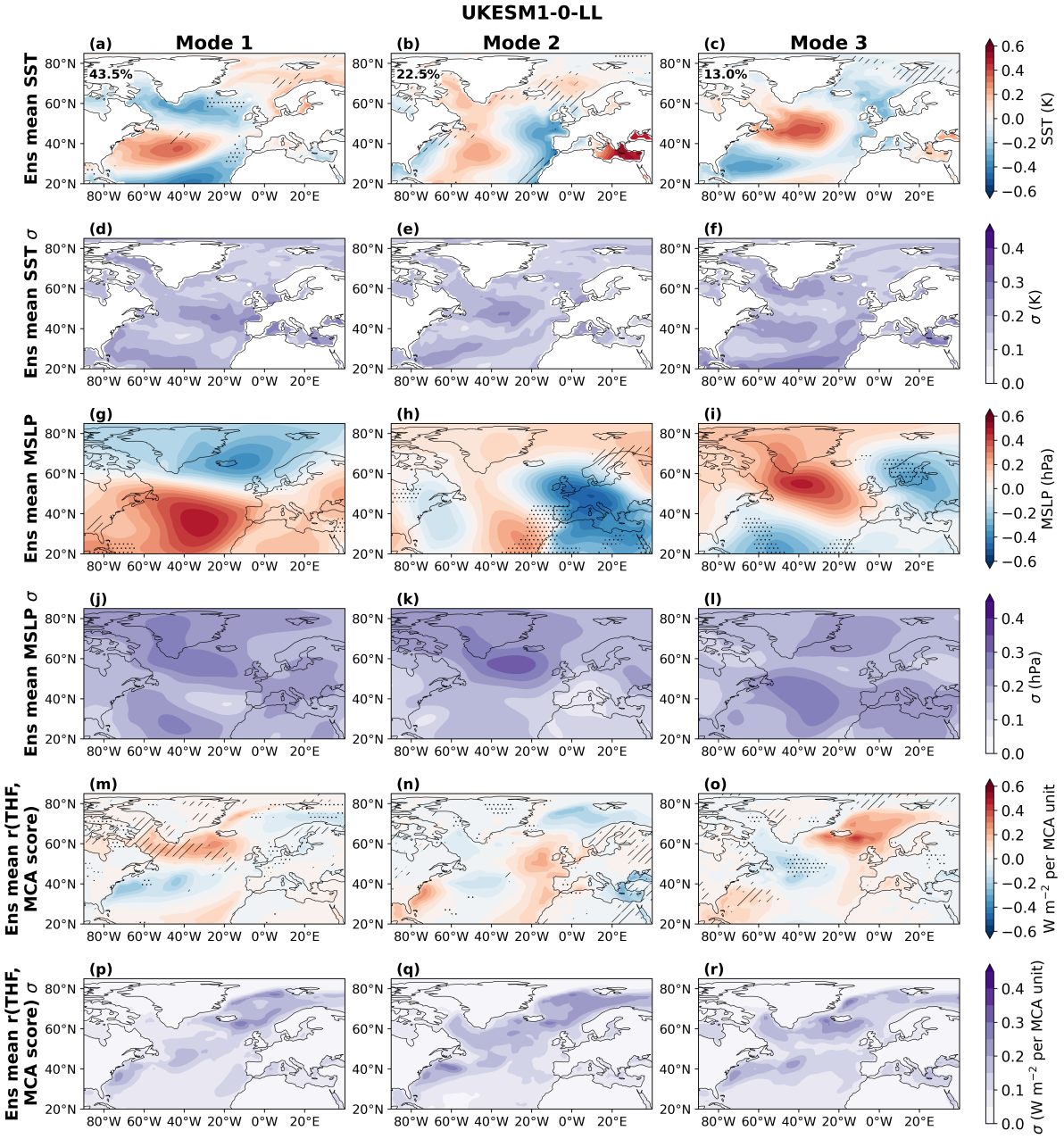



**Figure S16.** As in SI Fig. S3 for UKESM1-0-LL.

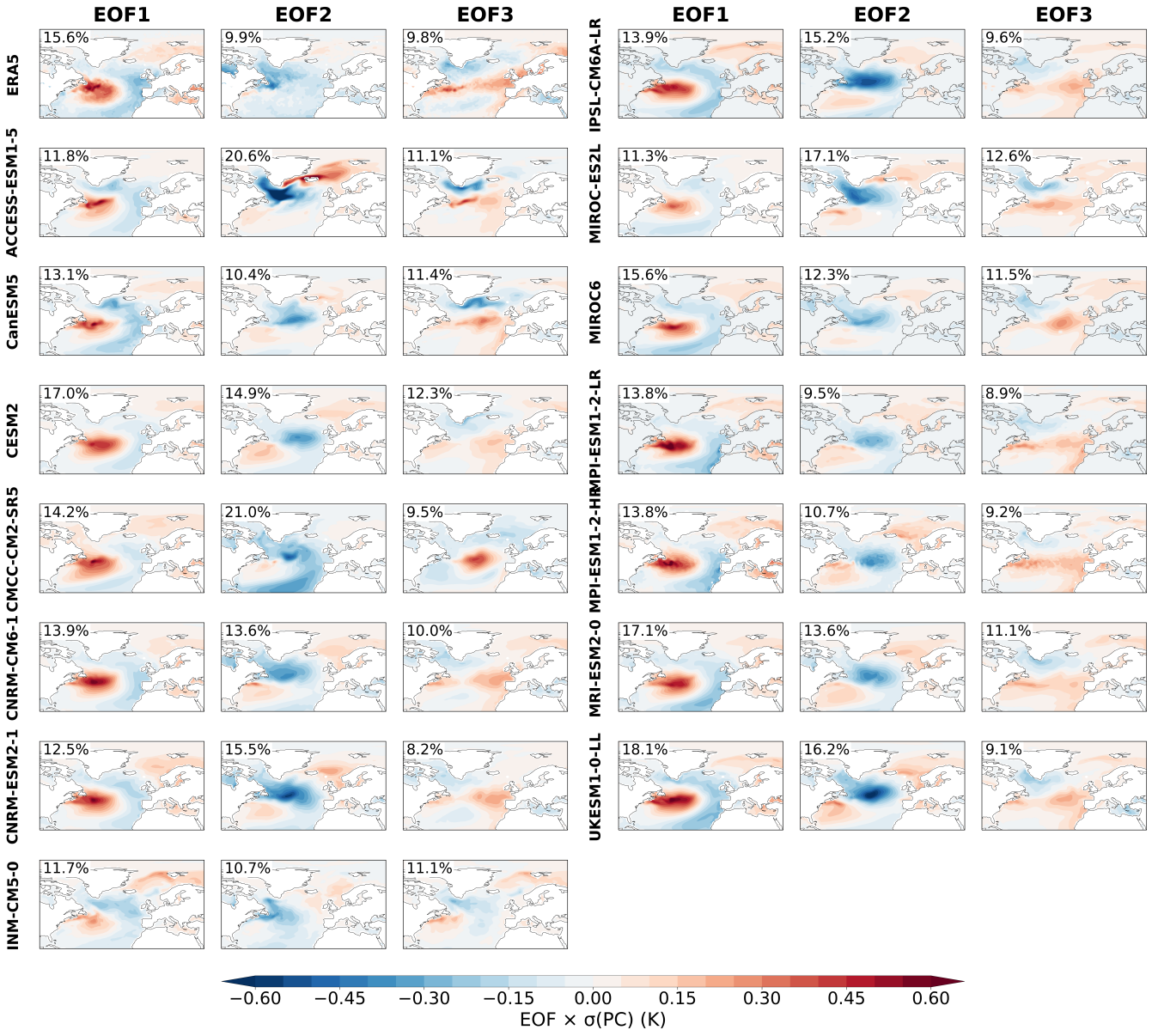



**Figure S17.** EOFs 1-3 of autumn SST. Percentage of variance explained by each mode indicated in left corner.

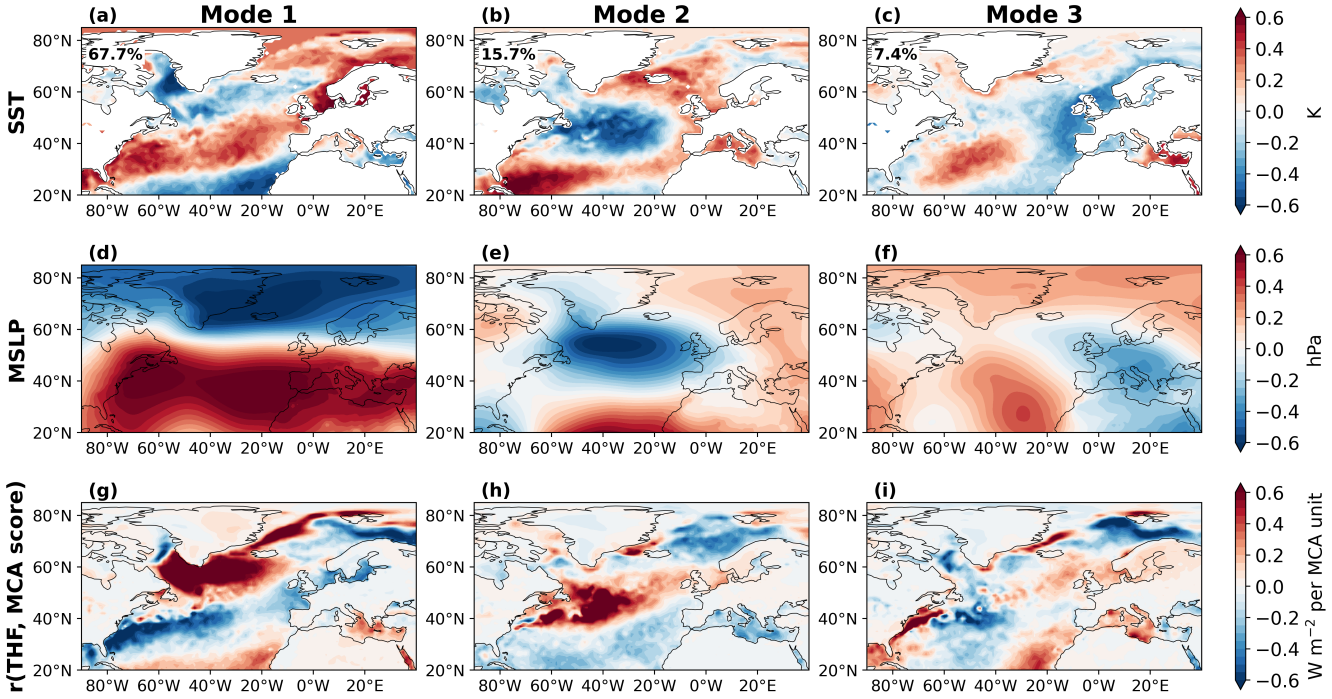



**Figure S18.** Contemporaneous winter atmosphere-ocean co-variability in ERA5. Heterogeneous patterns for MCA modes 1-3 are shown for winter SST (a-c), winter MSLP (d-f), and winter THF regressed onto the corresponding MCA timeseries (rTHF; MCA score) (g-i). Percentage of squared covariance explained by each mode is shown in the legend in panels a-c

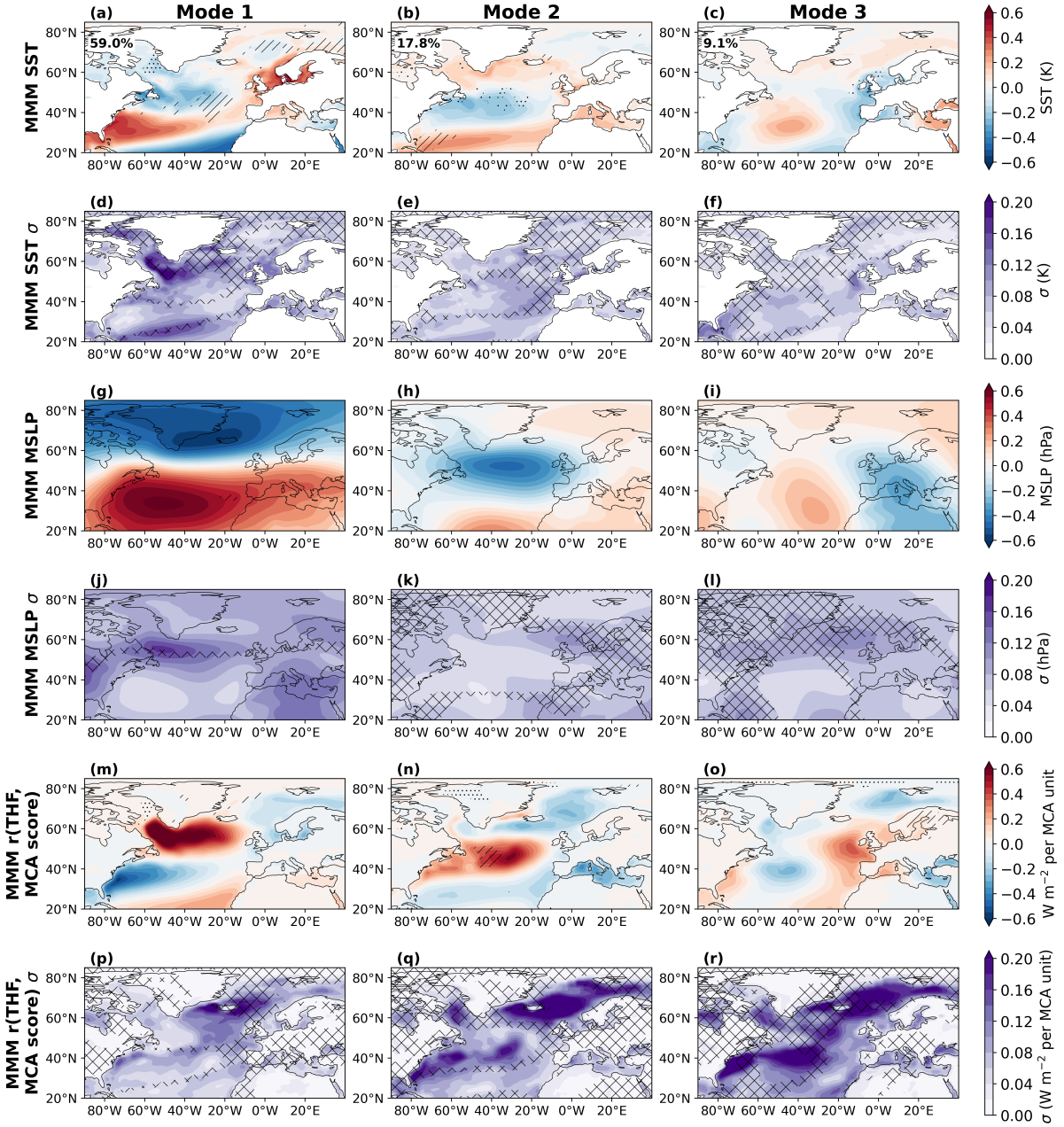



**Figure S19.** Multi-model mean contemporaneous winter atmosphere-ocean variability. Heterogeneous patterns for MCA modes 1-3 for winter SST, winter MSLP, and winter turbulent heat flux (THF) regressed onto the corresponding MCA time series (rTHF; MCA score). Panels are arranged left-to-right by mode (columns: Mode 1-3) and top-to-bottom by variable: (a-c) MMM SST, (d-f) inter-model spread in SST ($\sigma$), (g-i) MMM MSLP, (j-l) inter-model spread in MSLP ($\sigma$), (m-o) MMM r(THF, MCA score), and (p-r) inter-model spread in r(THF, MCA score) ($\sigma$). Hatching indicates regions where the ERA5 value exceeds the 97.5th percentile of the ensemble spreads, and stippling indicates regions where ERA5 falls below the 2.5th percentile of the ensemble spreads. Cross-hatching in panels (d-f), (j-l) and (p-r) indicate where the inter-model spread is greater than the multi-model mean. The mean percentage of squared covariance explained by each mode is shown in the legend in panels a-c

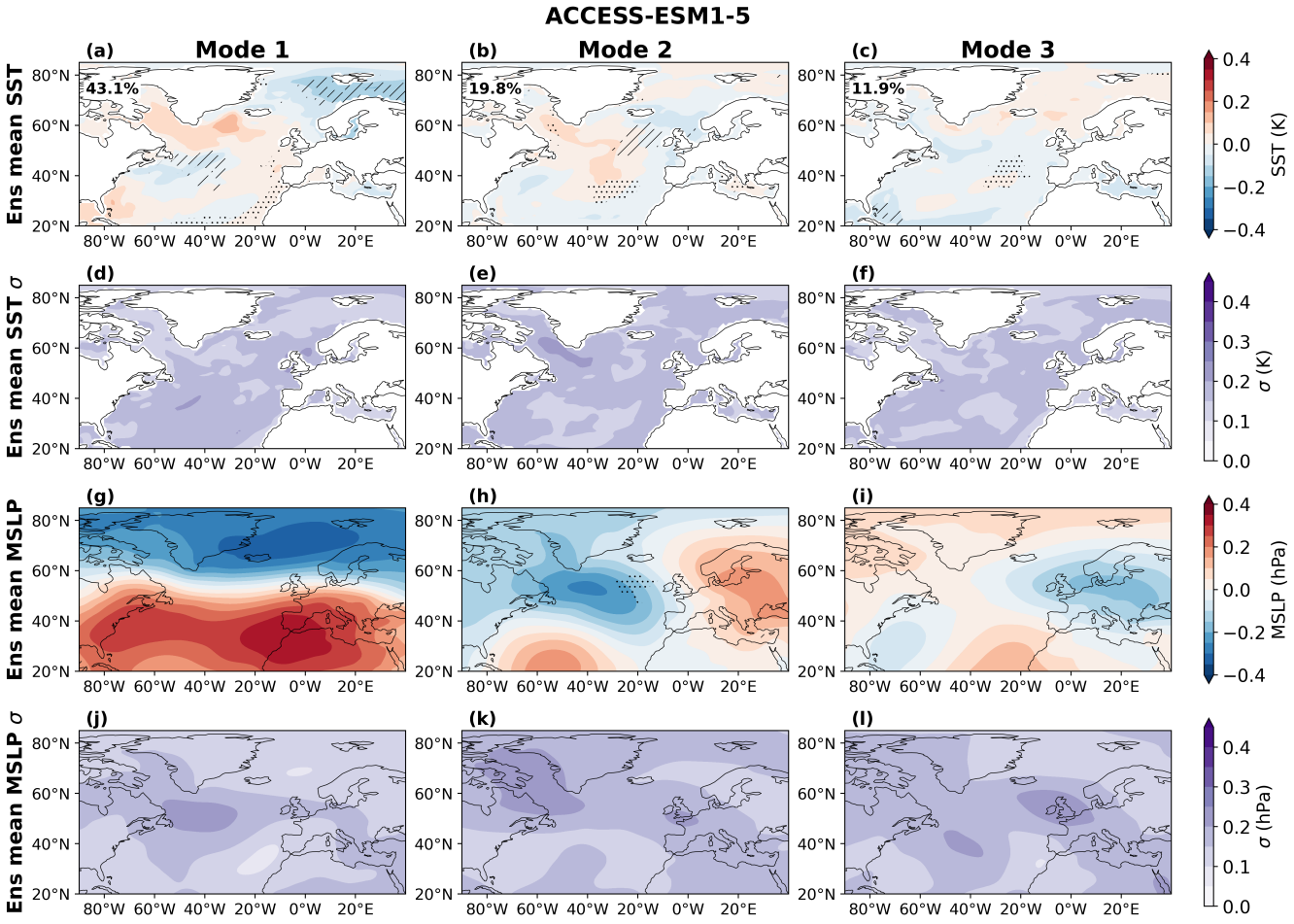



**Figure S20.** Ensemble mean lagged autumn-winter atmosphere-ocean co-variability. Heterogeneous patterns for MCA modes 1-3 are shown for autumn SST and winter MSLP. (a-c) ensemble mean SST, (d-f) ensemble spread in SST ($\sigma$), (g-i) ensemble mean MSLP, (j-l) ensemble spread in MSLP ($\sigma$). Hatching indicates regions where the ERA5 value exceeds the 97.5th percentile of the ensemble spread, and stippling indicates regions where ERA5 falls below the 2.5th percentile of the ensemble spread. The percentage of squared covariance explained by each mode is shown in the legend in panels a-c

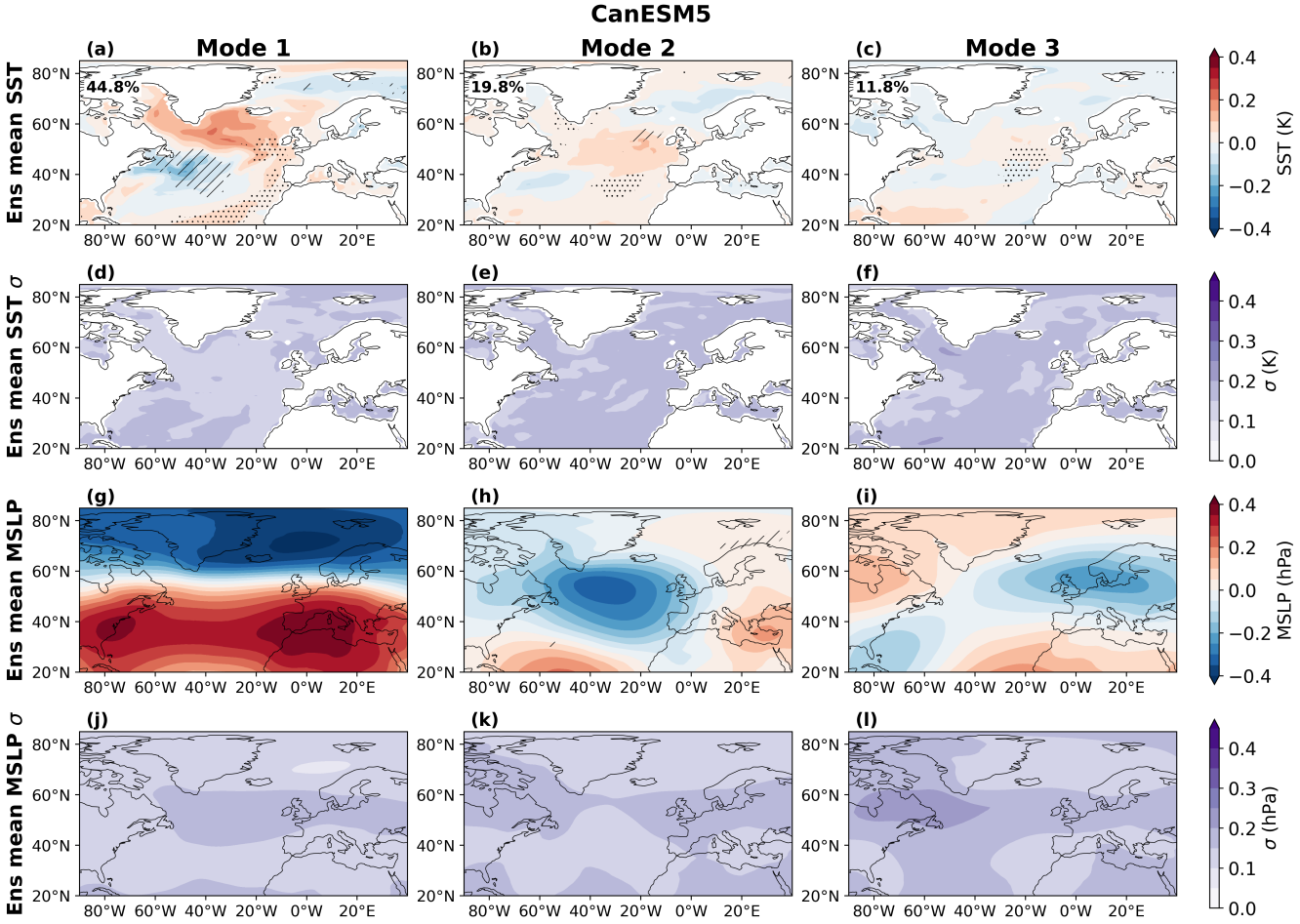



**Figure S21.** As in SI Fig. S20 for CanESM5.

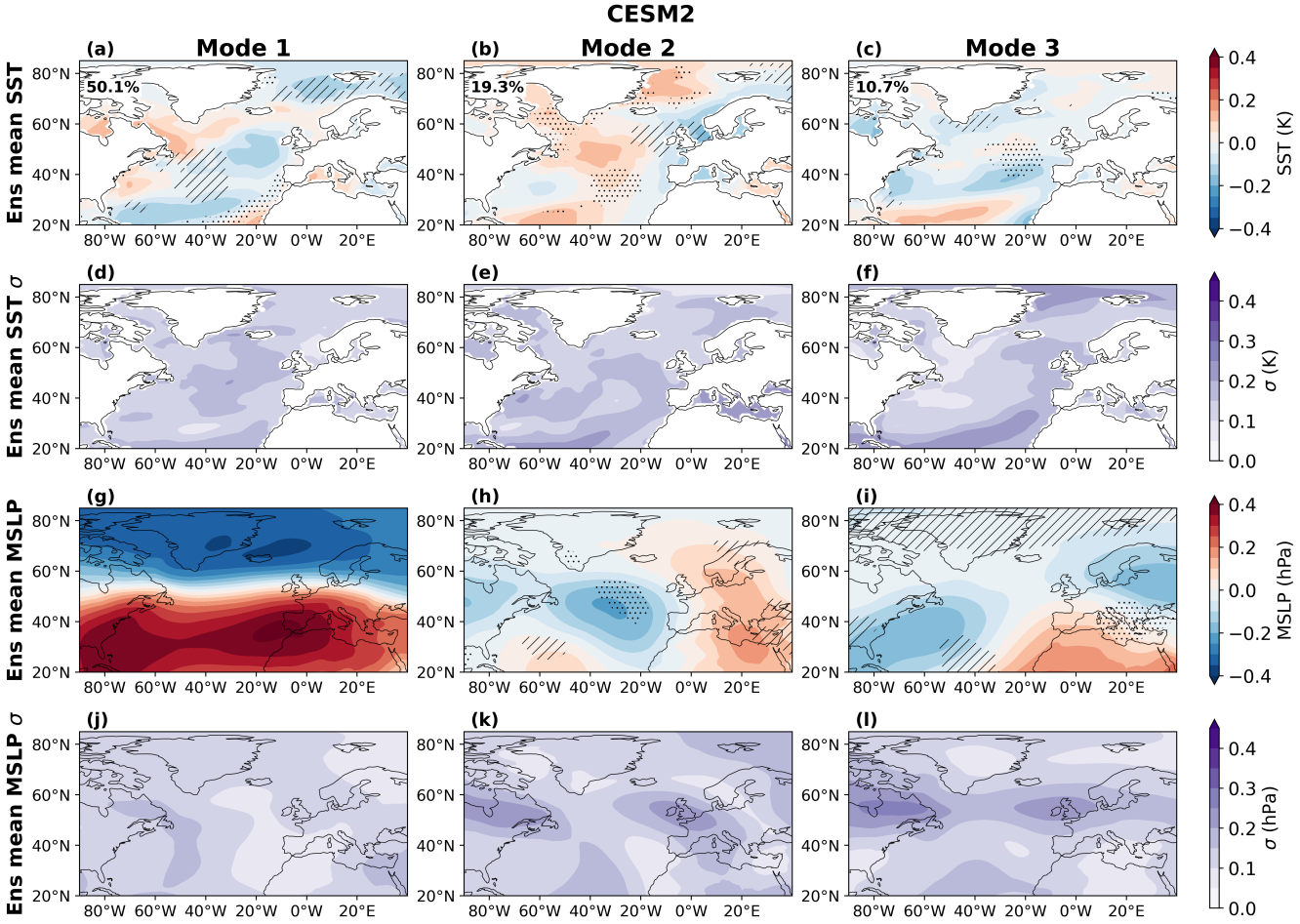



**Figure S22.** As in SI Fig.S20 for CESM2.

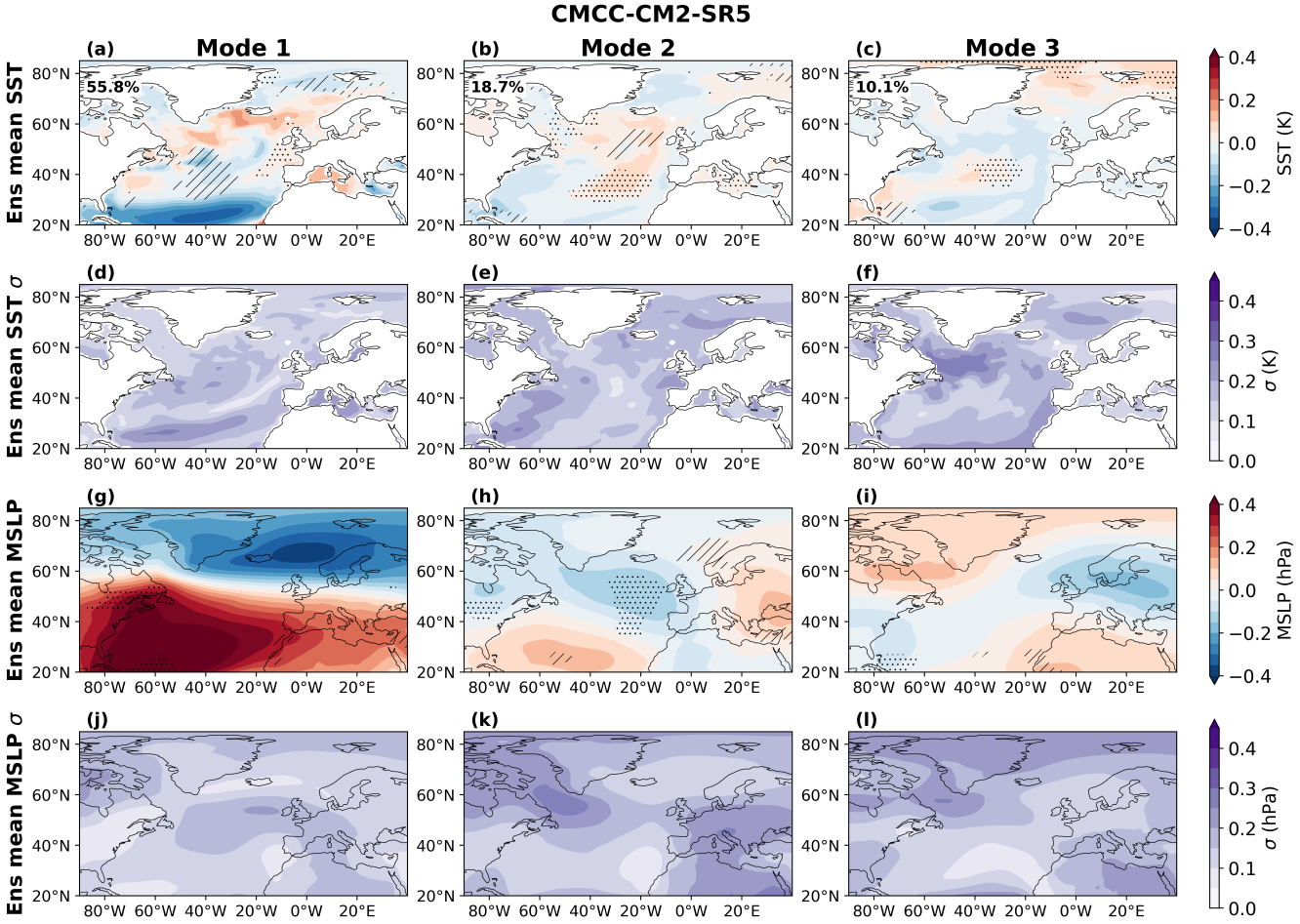



**Figure S23.** As in SI Fig.S20 for CMCC-CM2-SR5.

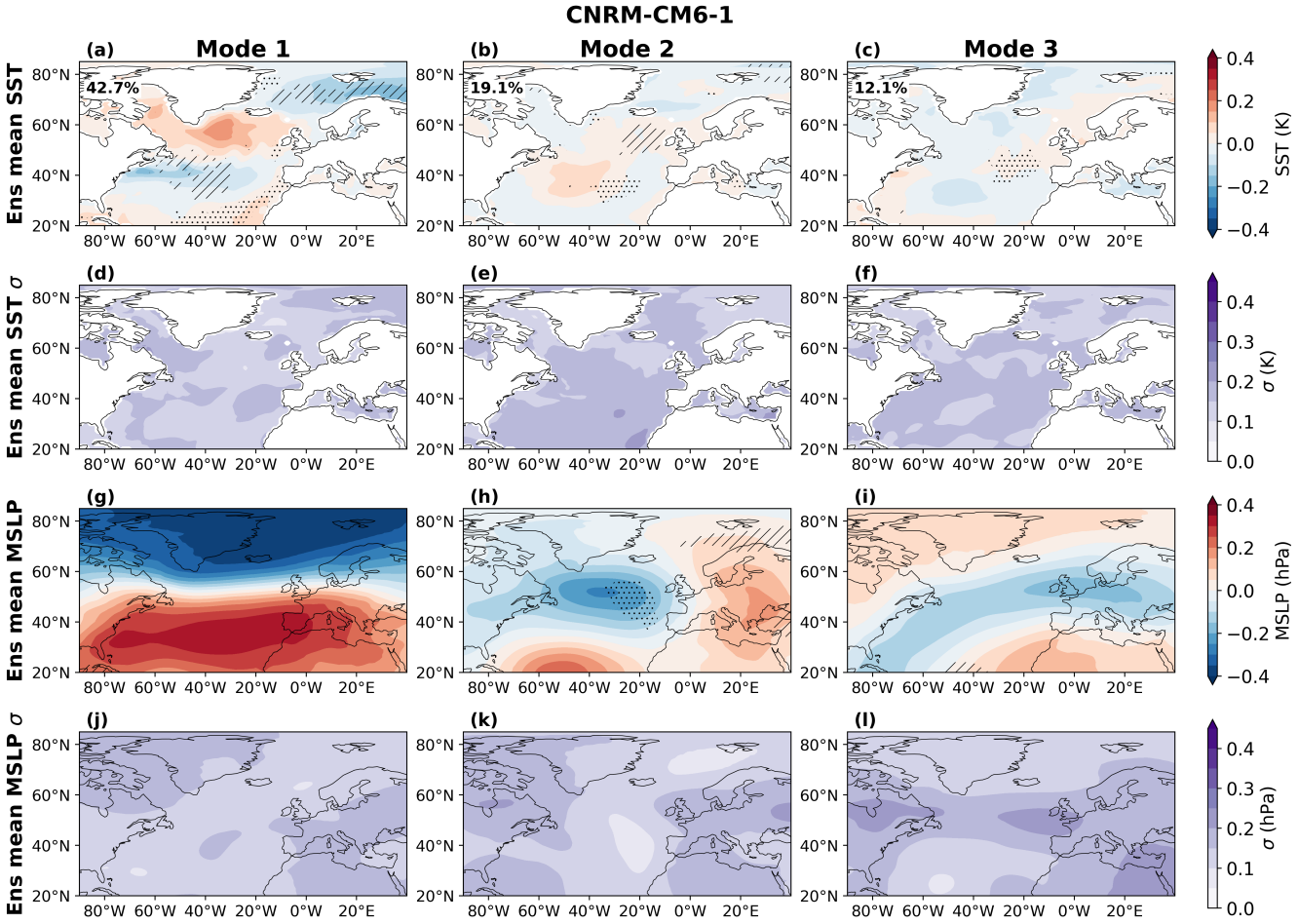



**Figure S24.** As in SI Fig.S20 for CNRM-CM6-1.

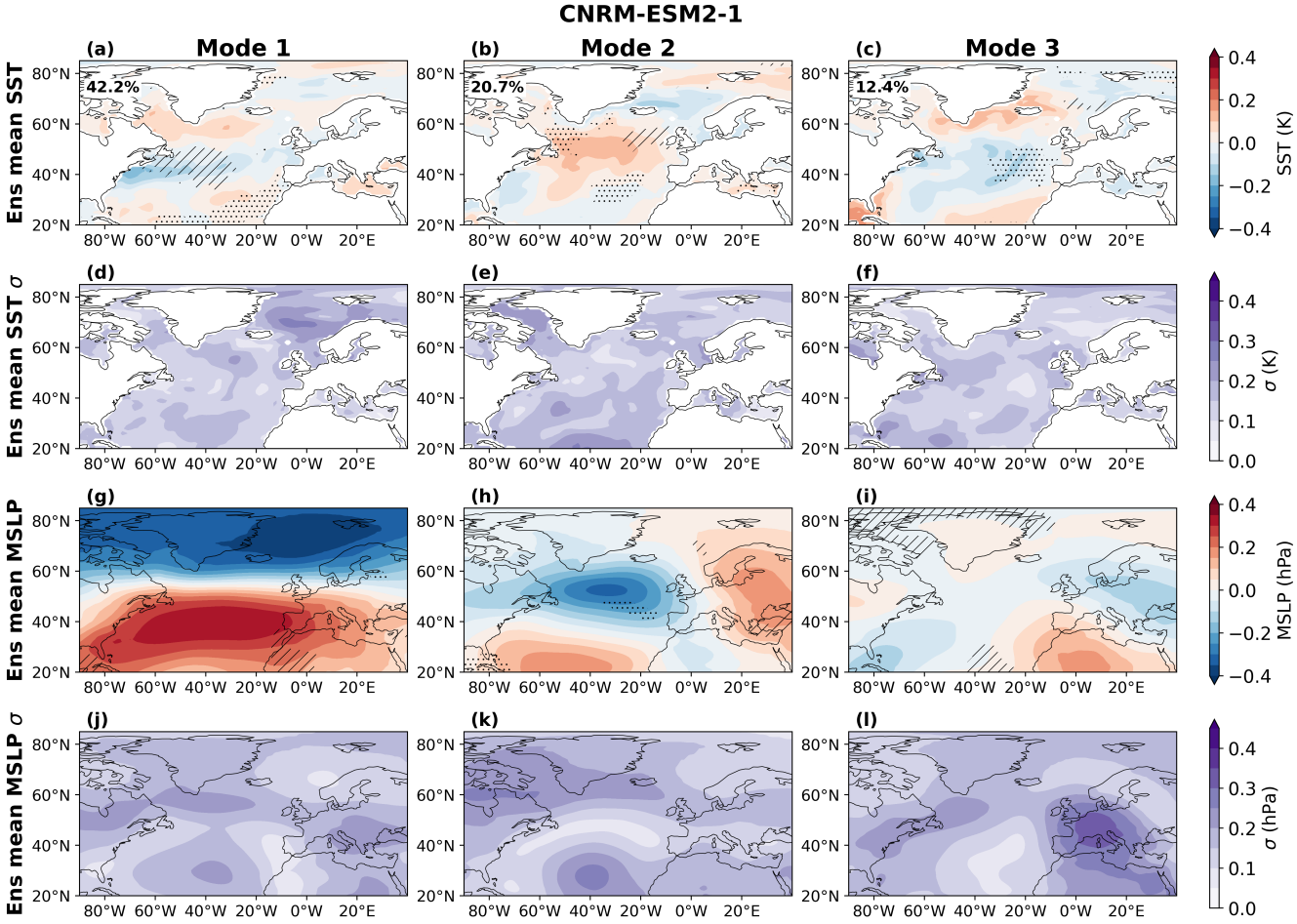



**Figure S25.** As in SI Fig.S20 for CNRM-ESM2-1.

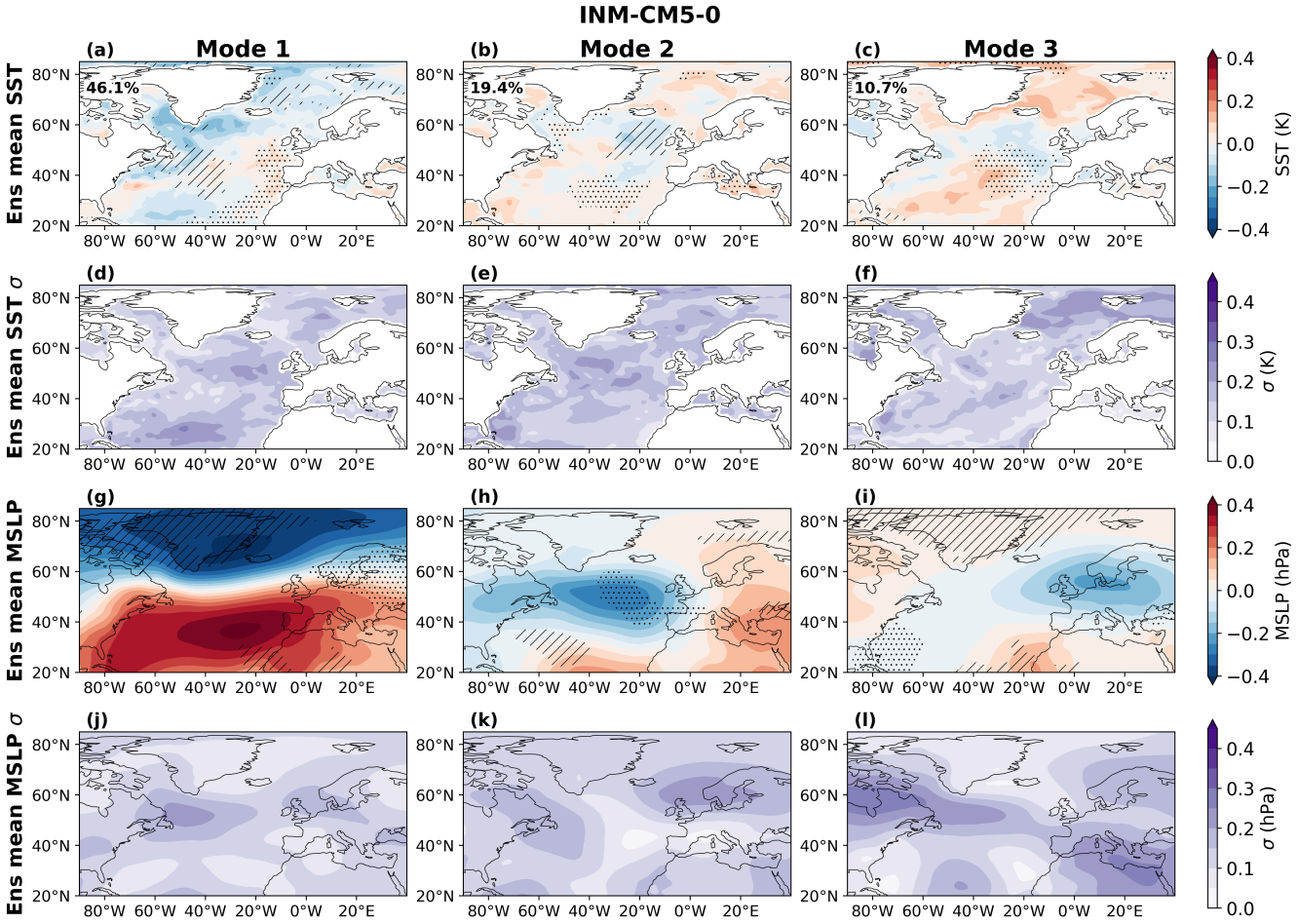



**Figure S26.** As in SI Fig.S20 for INM-CM5-0.

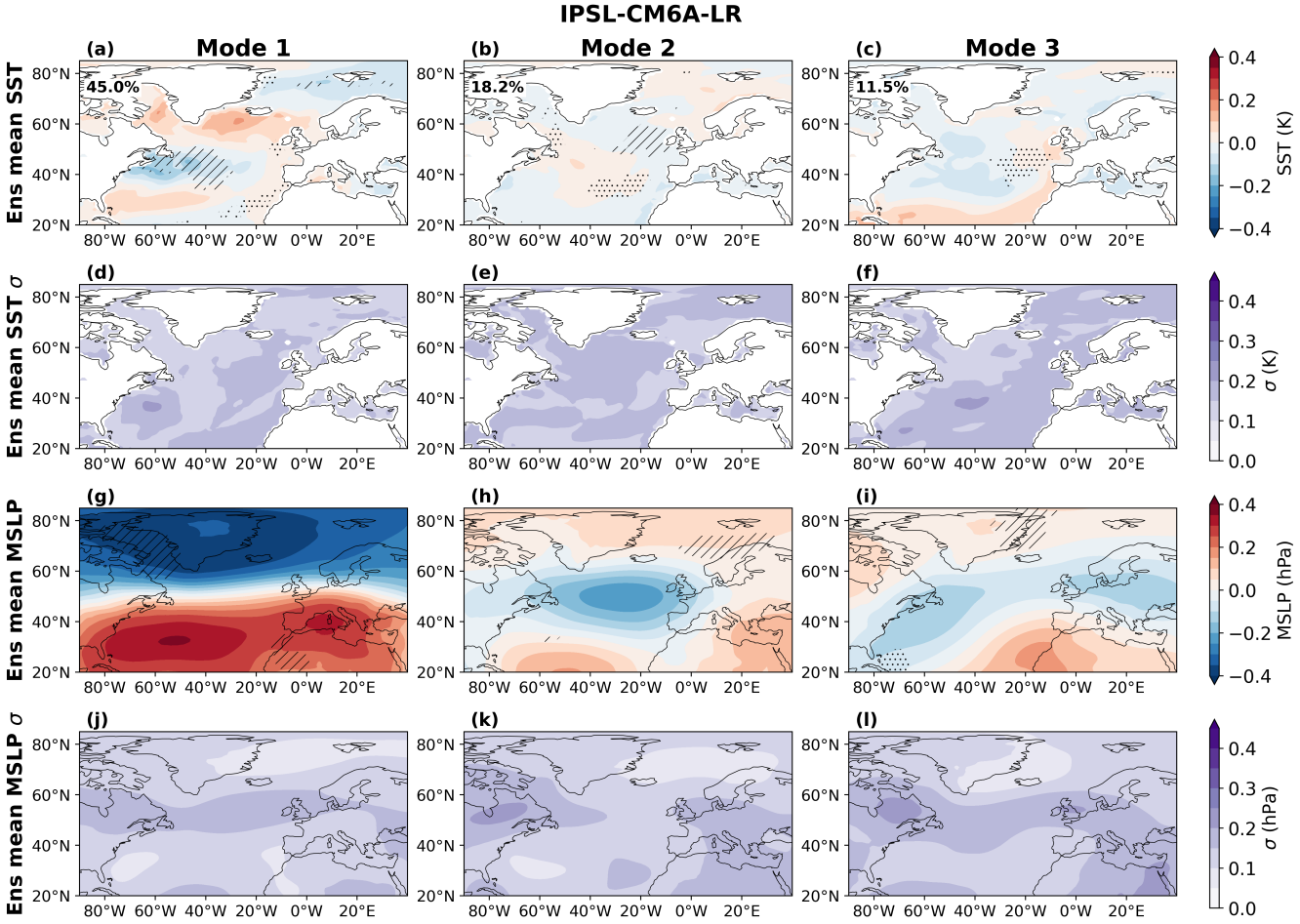



**Figure S27.** As in SI Fig.S20 for IPSL-CM6A-LR.

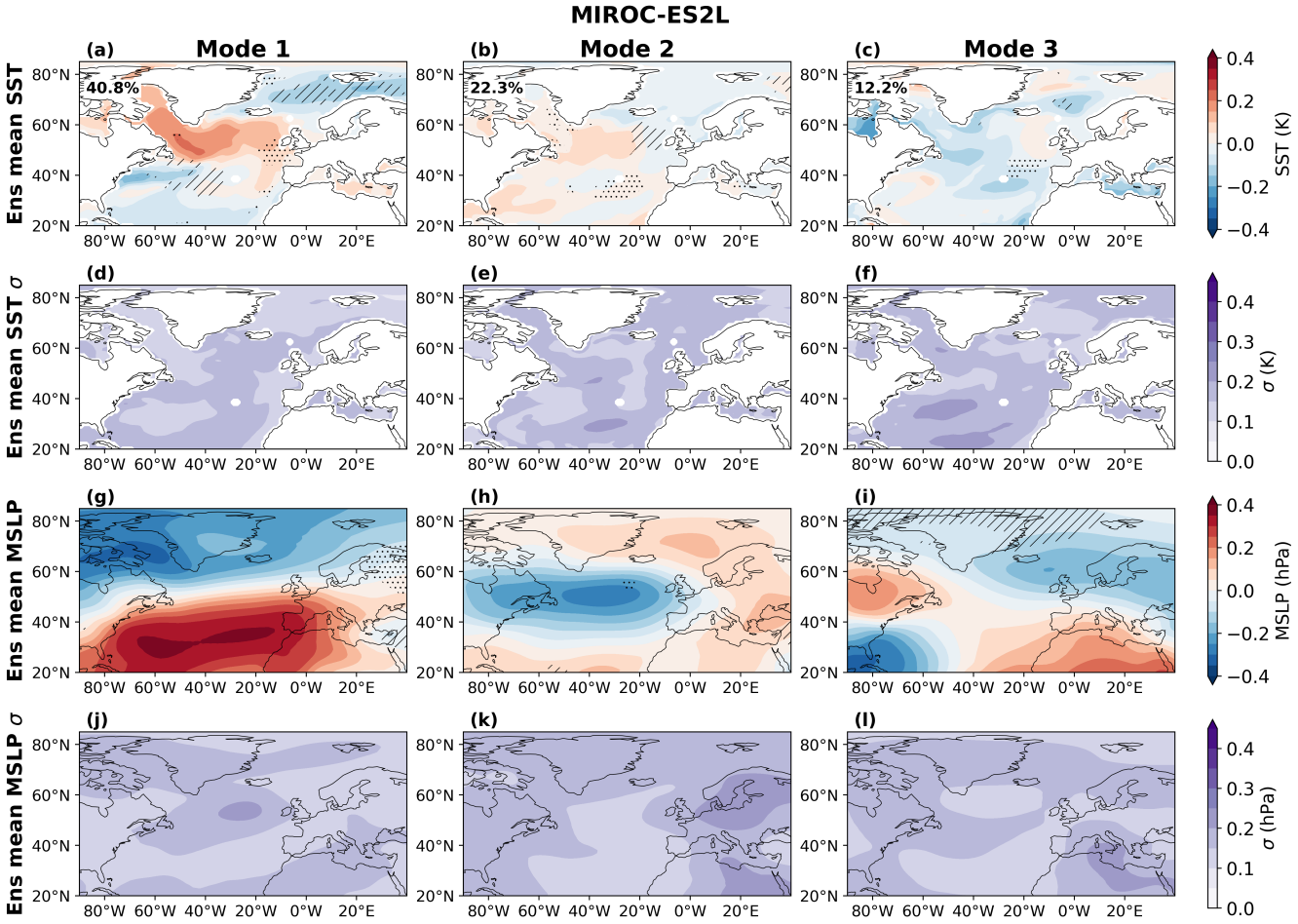



**Figure S28.** As in SI Fig.S20 for MIROC-ES2L.

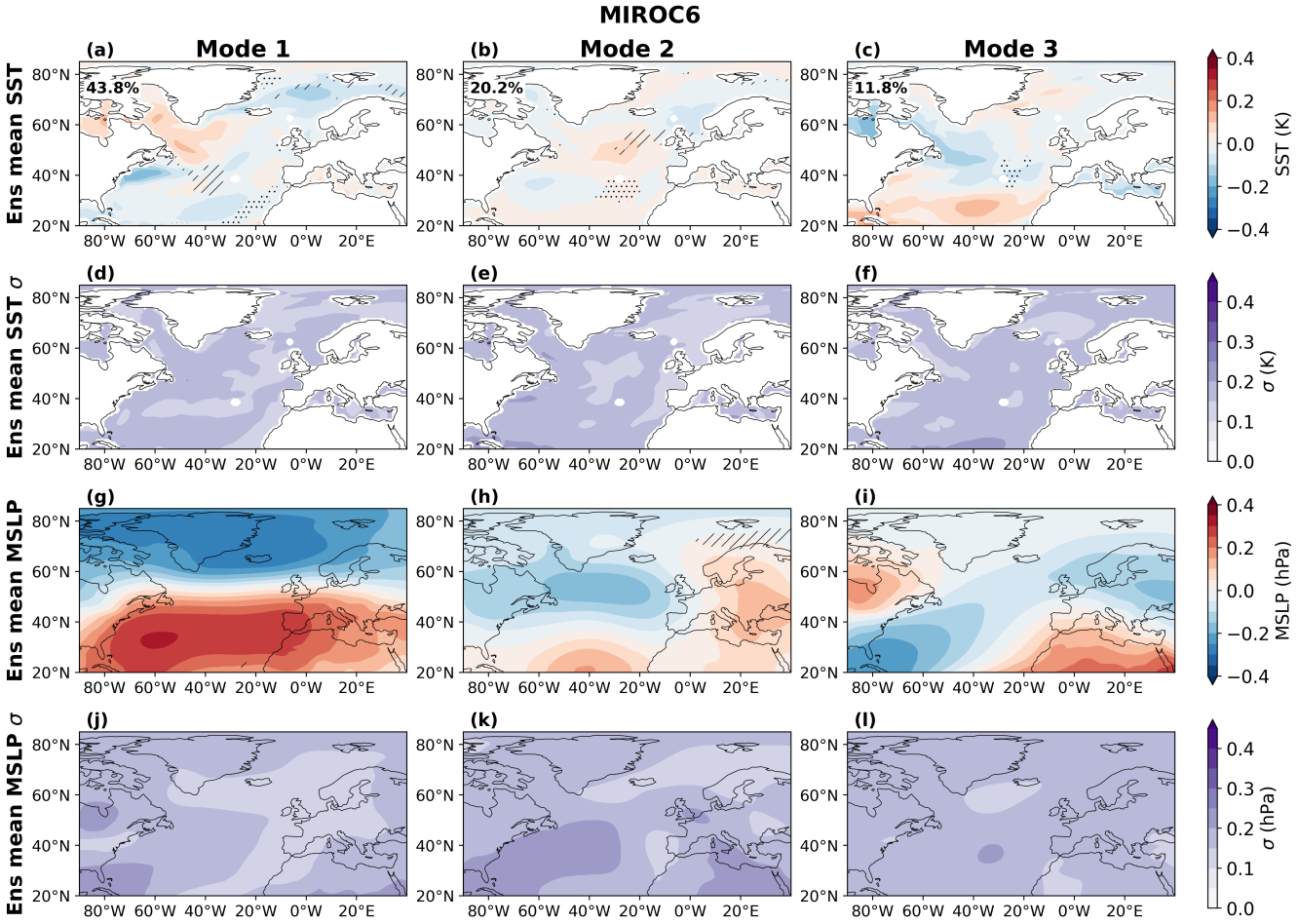



**Figure S29.** As in SI Fig.S20 for MIROC6.

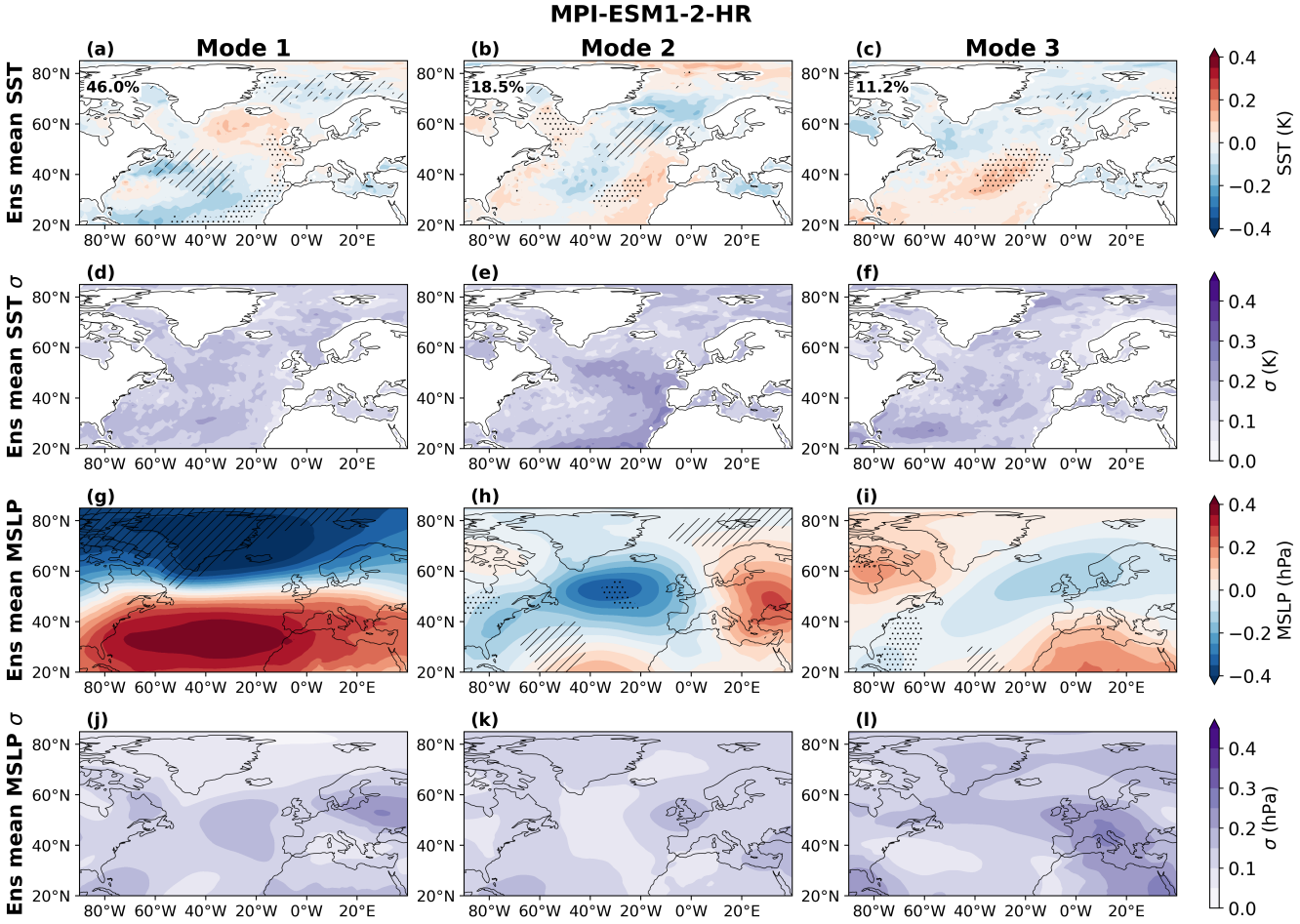



**Figure S30.** As in SI Fig.S20 for MPI-ESM1-2-HR.

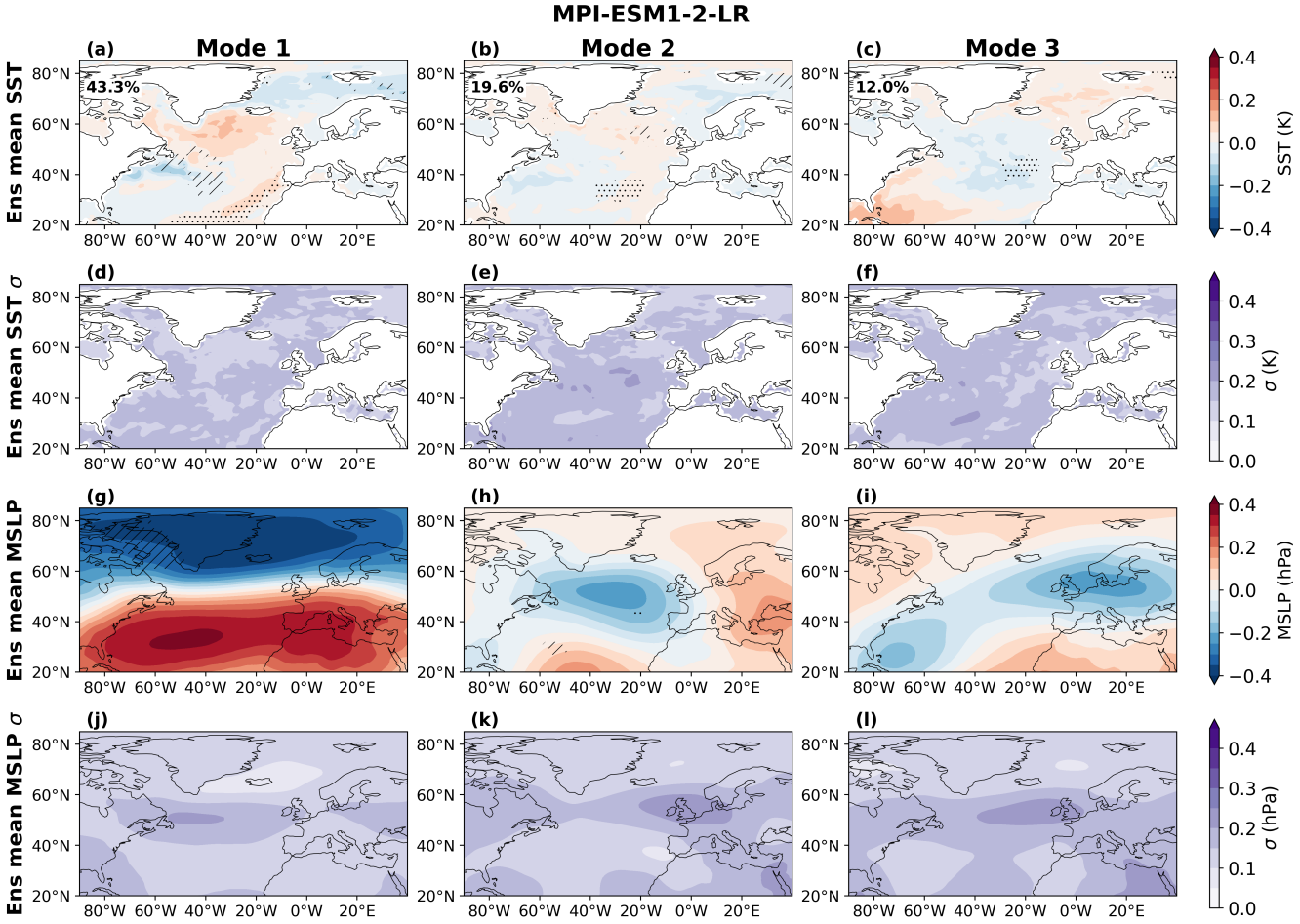



**Figure S31.** As in SI Fig.S20 for MPI-ESM1-2-LR.

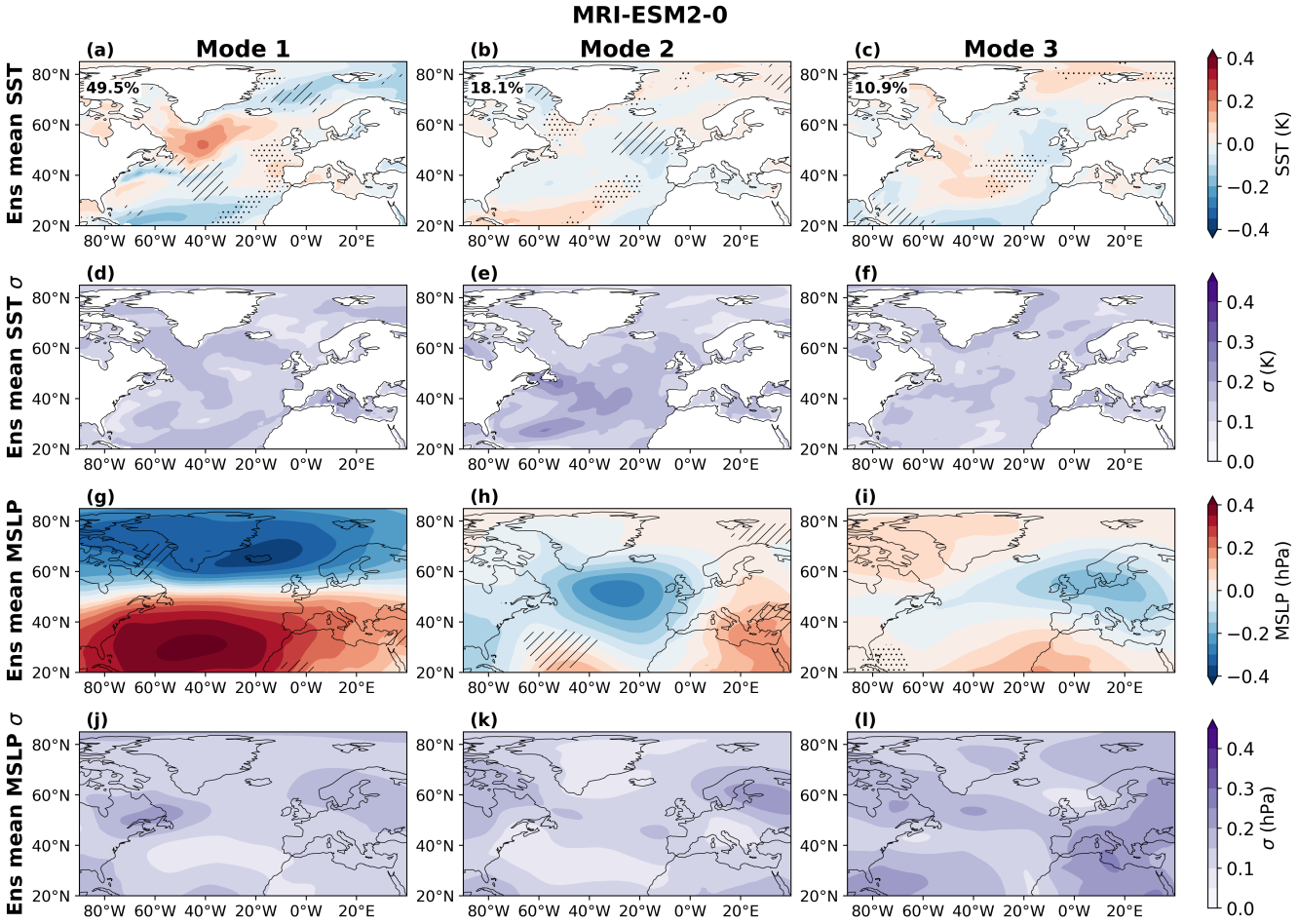



**Figure S32.** As in SI Fig.S20 for MRI-ESM2-0.

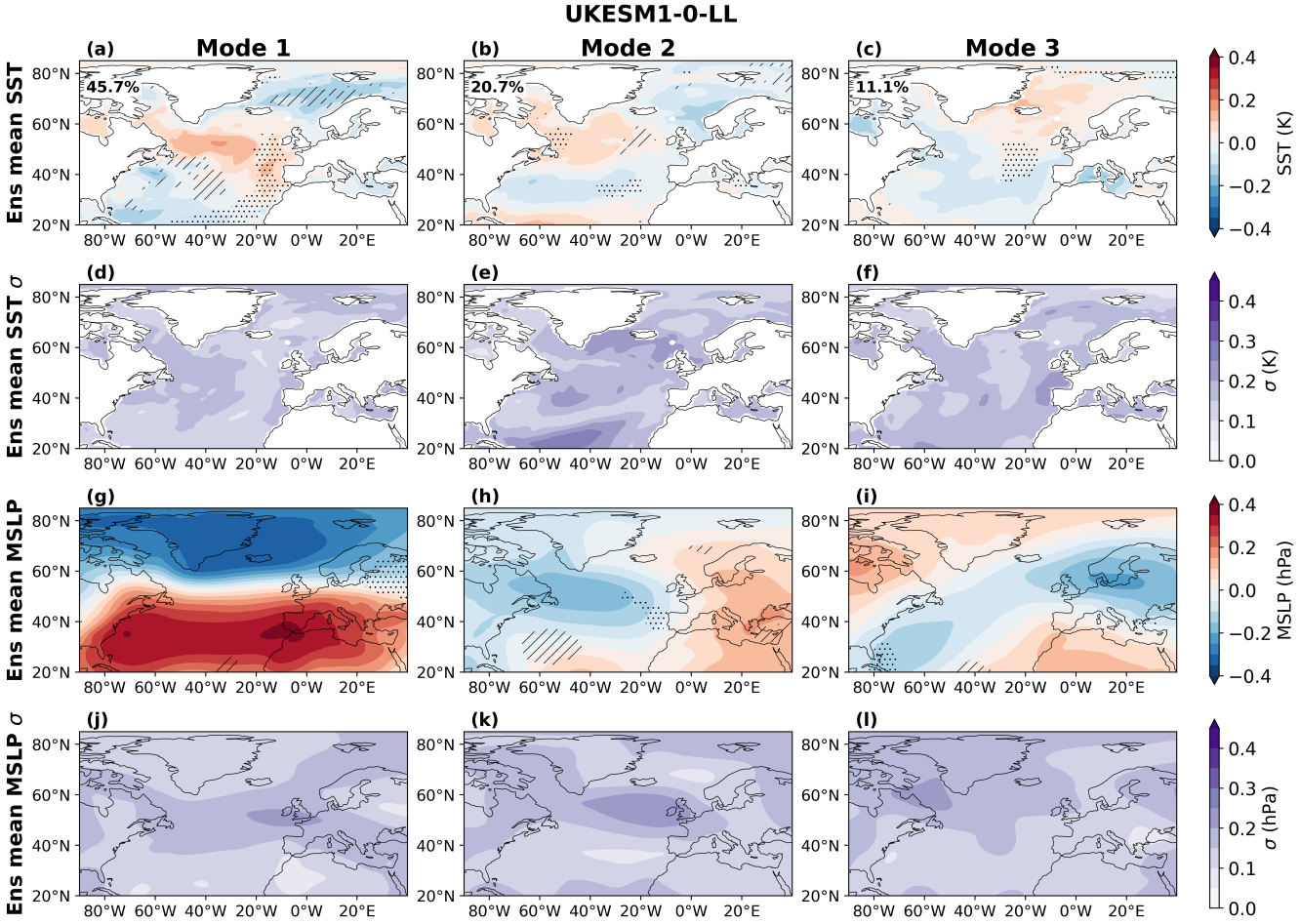



**Figure S33.** As in SI Fig.S20 for UKESM1-0-LL.

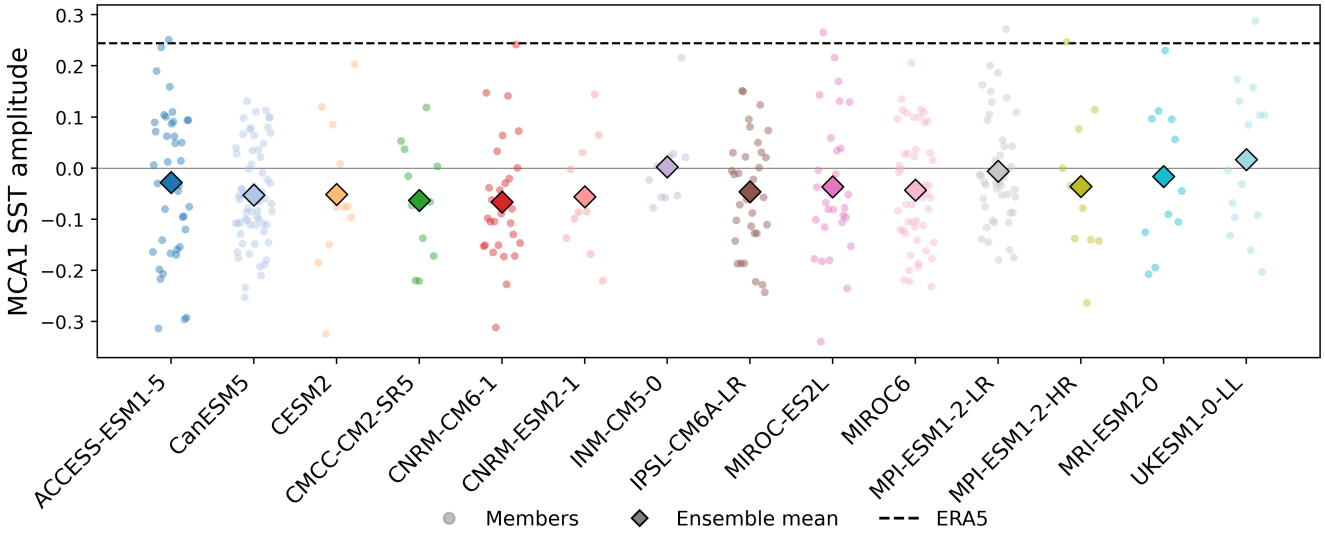



**Figure S34.** Lagged autumn SST–winter MSLP MCA mode 1 SST pattern averaged over the central North Atlantic (35–45°N, 45–25°W). Circles show individual ensemble members, diamonds show ensemble means and the dashed line shows ERA5.

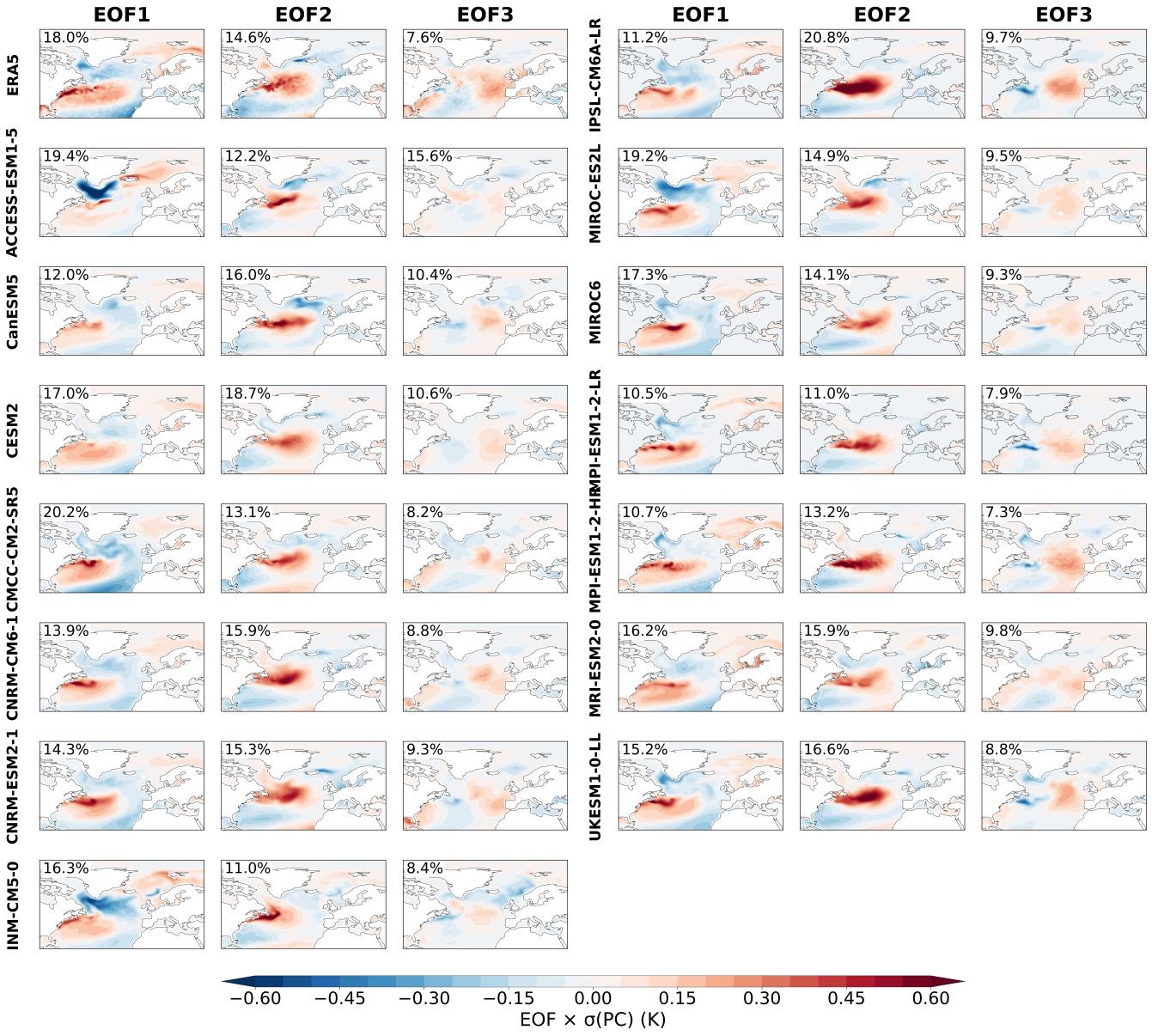



**Figure S35.** EOFs 1-3 of winter SST. Percentage of variance explained by each mode indicated in left corner.

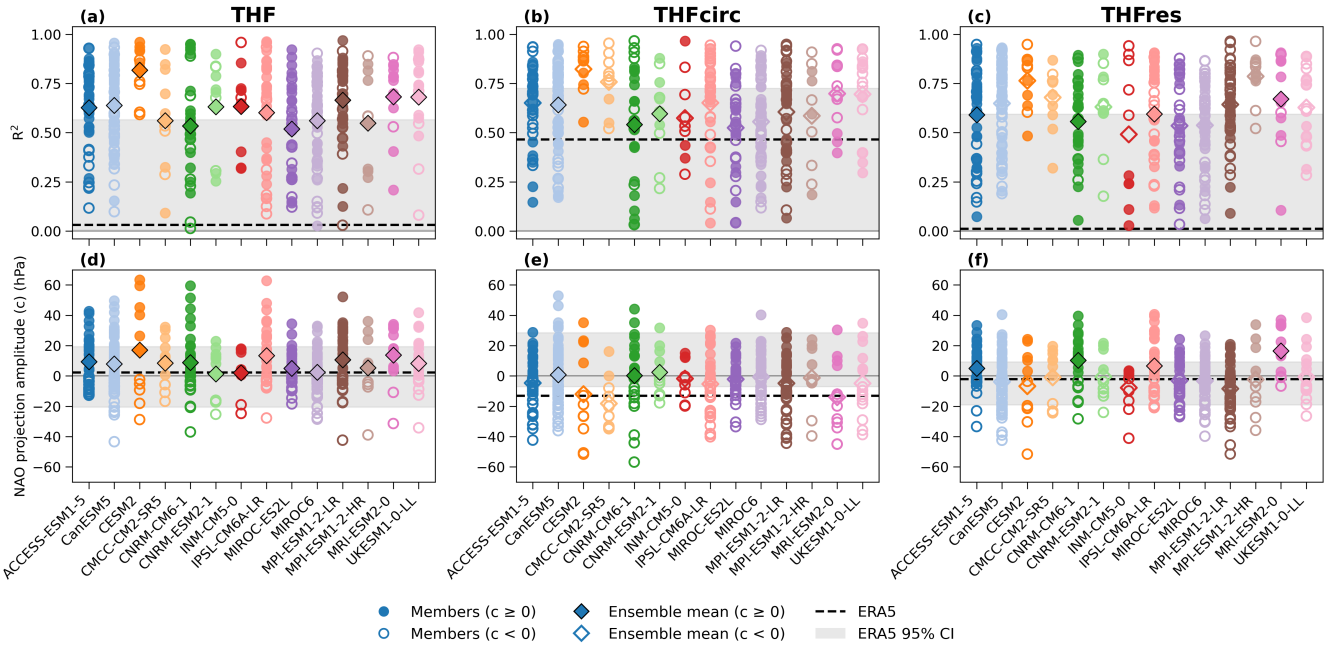



**Figure S36.** Projection of the regression pattern of winter North Atlantic MSLP onto PC2 of the autumn THF components onto the winter NAO (EOF1) in ERA5 and models. Fraction of the variance explained by the NAO (a-c) and strength of the NAO signal (d-f). Circles are model members, diamonds are ensemble means, dashed black lines represent ERA5 1940-2014 and grey shading represents the sampling uncertainty for 1940-2014, blue solid lines represent ERA5 1940-2022 and blue dotted lines represent the sampling uncertainty for 1940-2022. Positive $c$ values indicate a positive NAO and negative indicate a negative NAO.