**Supplementary information**

# Increased risk of heat extremes in the Eastern Mediterranean during weak Indian summer monsoon years

G. Di Capua[1], G. Zittis[2], T. Economou[3], E. Tyrlis[4] and C. Anagnostopoulou[5]

[1]Earth System Analysis, Potsdam Institute for Climate Impact Research, Member of the Leibniz Association, Potsdam, Germany

[2]Climate and Atmosphere Research Center (CARE-C), The Cyprus Institute, Nicosia, Cyprus

[3]Department of Mathematics and Statistics, University of Exeter, Exeter, United Kingdom

[4]Department of Physics, National and Kapodistrian University of Athens, Athens, Greece

[5]Department of Meteorology and Climatology, Aristotle University of Thessaloniki, Thessaloniki, Greece

Corresponding author: Di Capua G. (dicapua@pik-potsdam.de)

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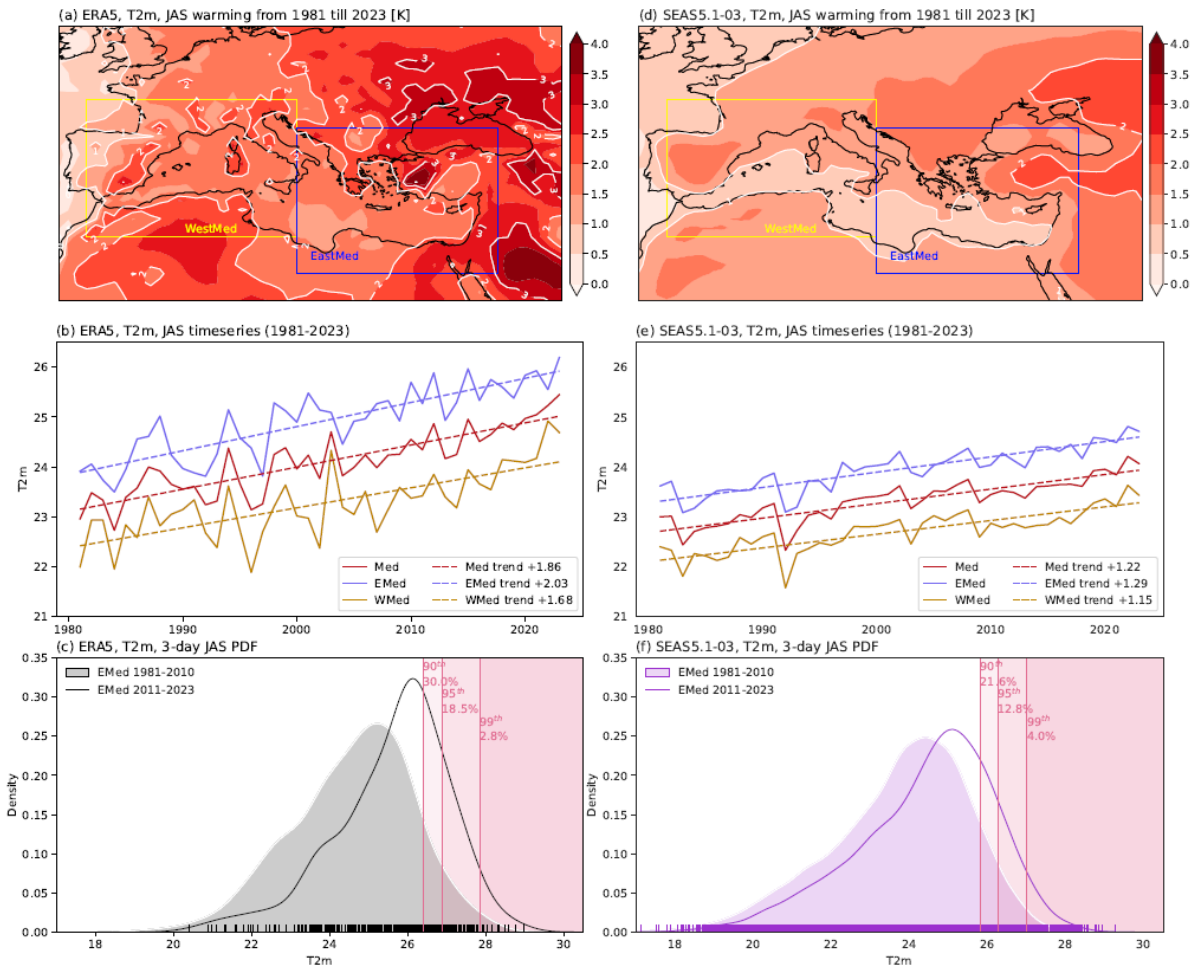


***Figure S1.*** *Same as for Fig. 1 in the main text but for SEAS5.1-03.*

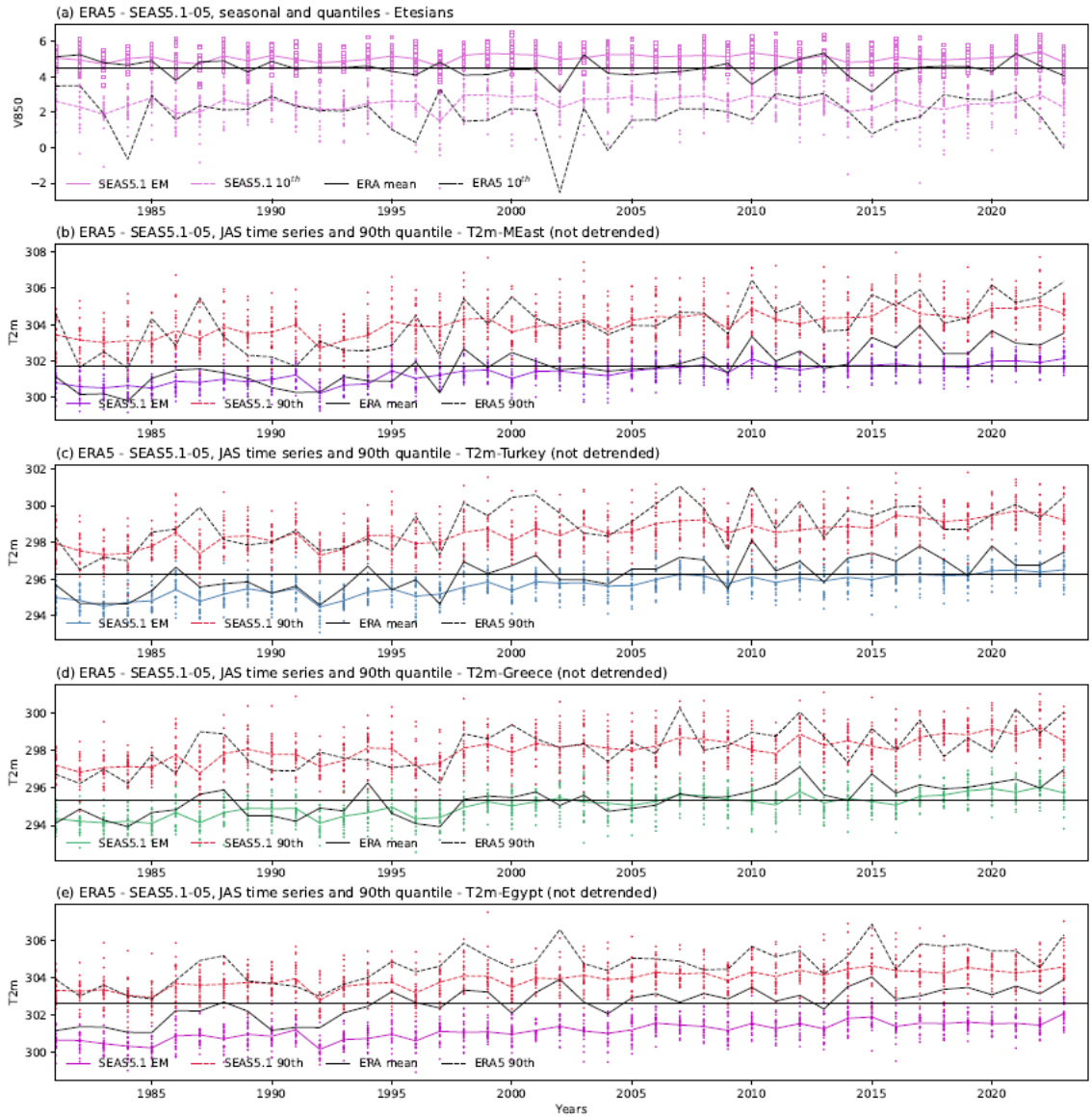


***Figure S2. Trends and model bias for Etesians and T2m regions.*** *Panel (a): non-detrended JAS seasonal averages for the Etesians index for both ERA5 (black solid line) and SEA5.1-05 (pink squared dots). The 10$^{th}$ quantiles for each JAS season are shown as black dashed line for ERA5, while for SEAS5.1-05, both the values are reported for both the ensemble mean and each single ensemble member. Note that for SEAS5.1-05, for each time step 25 values are present, since SEAS5.1 provides an ensemble of forecasts with 25 ensemble members for each year. Panel (b)-(e): same as for Panel (a) but for the Middle East, Turkey, Balkans and Egypt T2m regions respectively.*

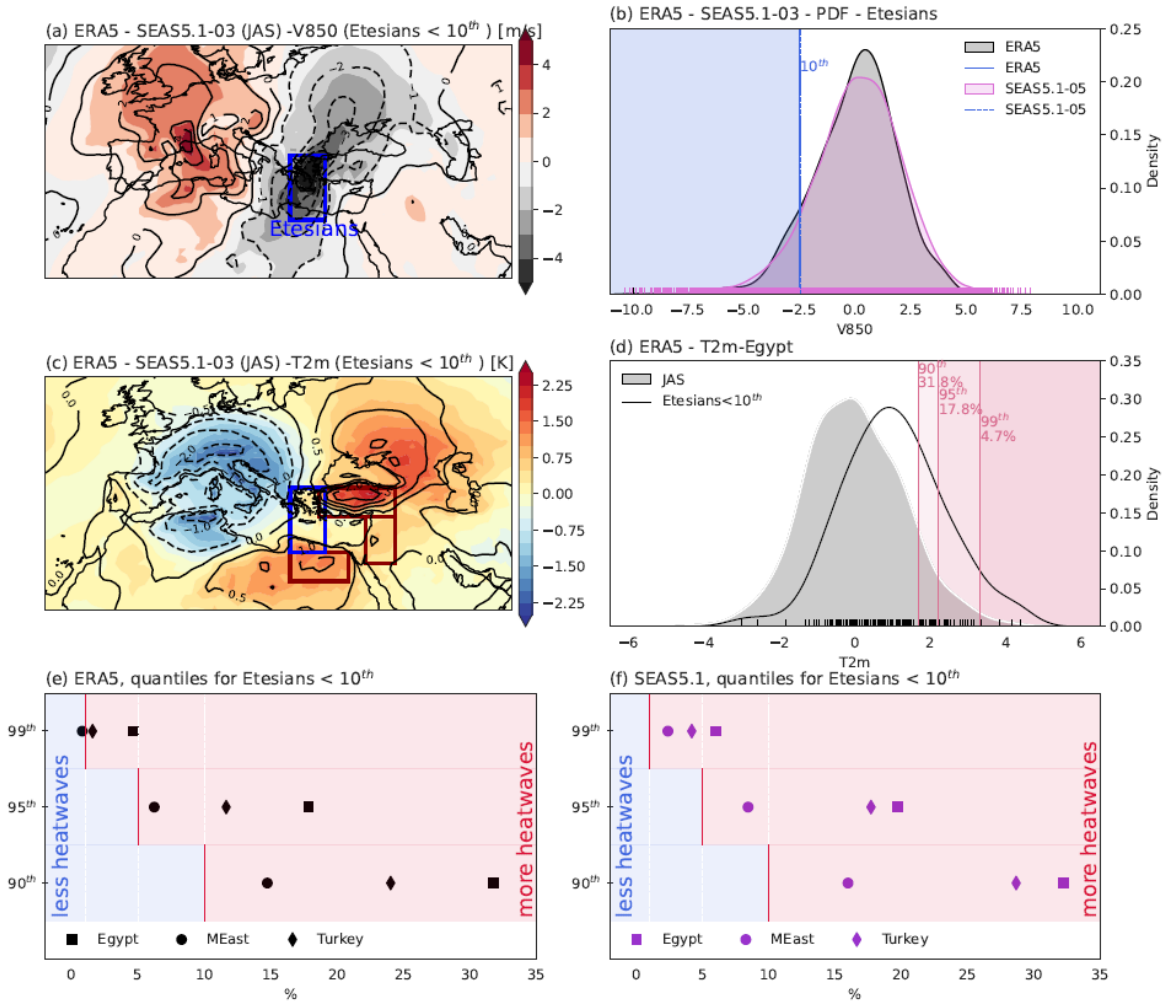


**Figure S3.** *Same as for Fig. 2 in the main text but for SEAS5.1-03.*

The SEAS5.1-05 JAS ensemble mean shows a slight (~0.7 m*s$^{-1}$) overestimation of the mean Etesians index with respect to ERA5, while the SEAS5.1-05 10$^{th}$ quantile range well overlaps with ERA5 (Fig. 1d).

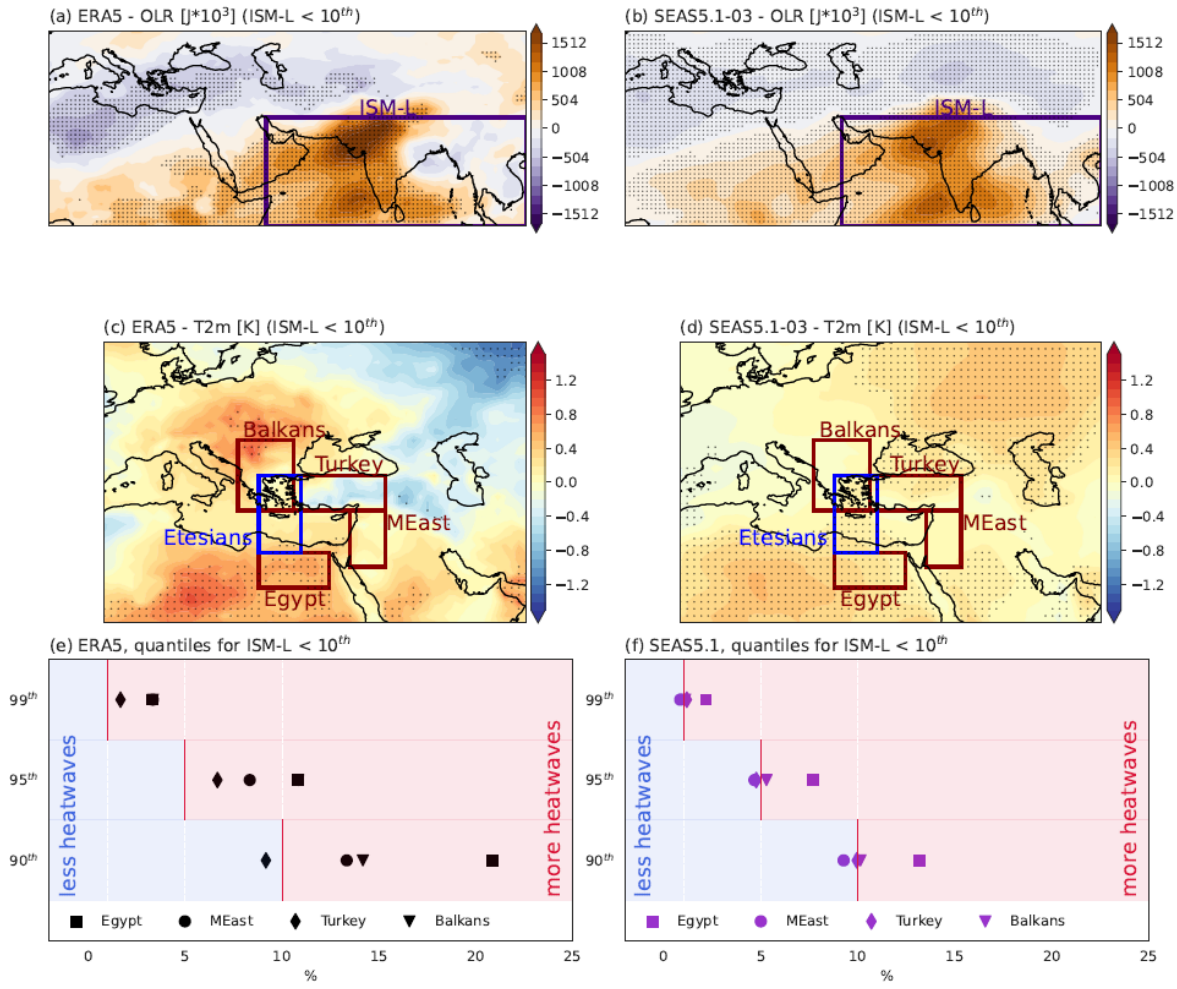


***Figure S4.*** *Same as for Fig. 3 in the main text but for SEAS5.1-03.*

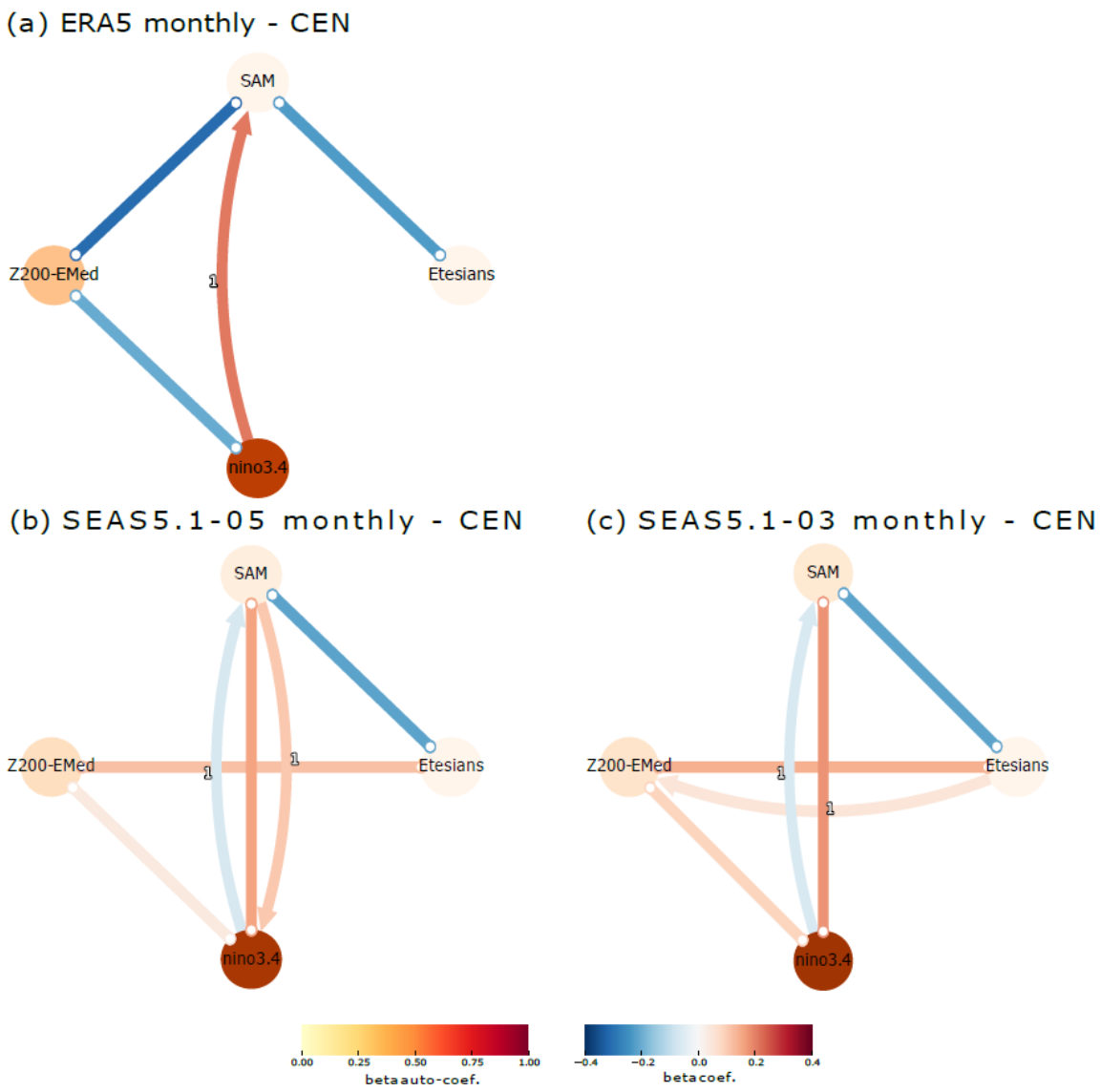


***Figure S5. Monthly causal effect networks (discovery mode).*** *Panel (a): CEN with monthly nino3.4, Etesiand, Z200-EMed and ISM-L indices for ERA5 (1981-2023) obtained by applying PCMCI in discovery mode. Panel (b)-(c): same as for panel (a) but for SEAS5.1-05 and SEAS5.1-03 respectively. Note that for SEAS5.1 each network is calculated on a total of 25 ensembles * 43 years = 1075 total ensemble members. The maximum lag used is -1 (month). Arrows with no edge/direction depict links found at lag 0.*

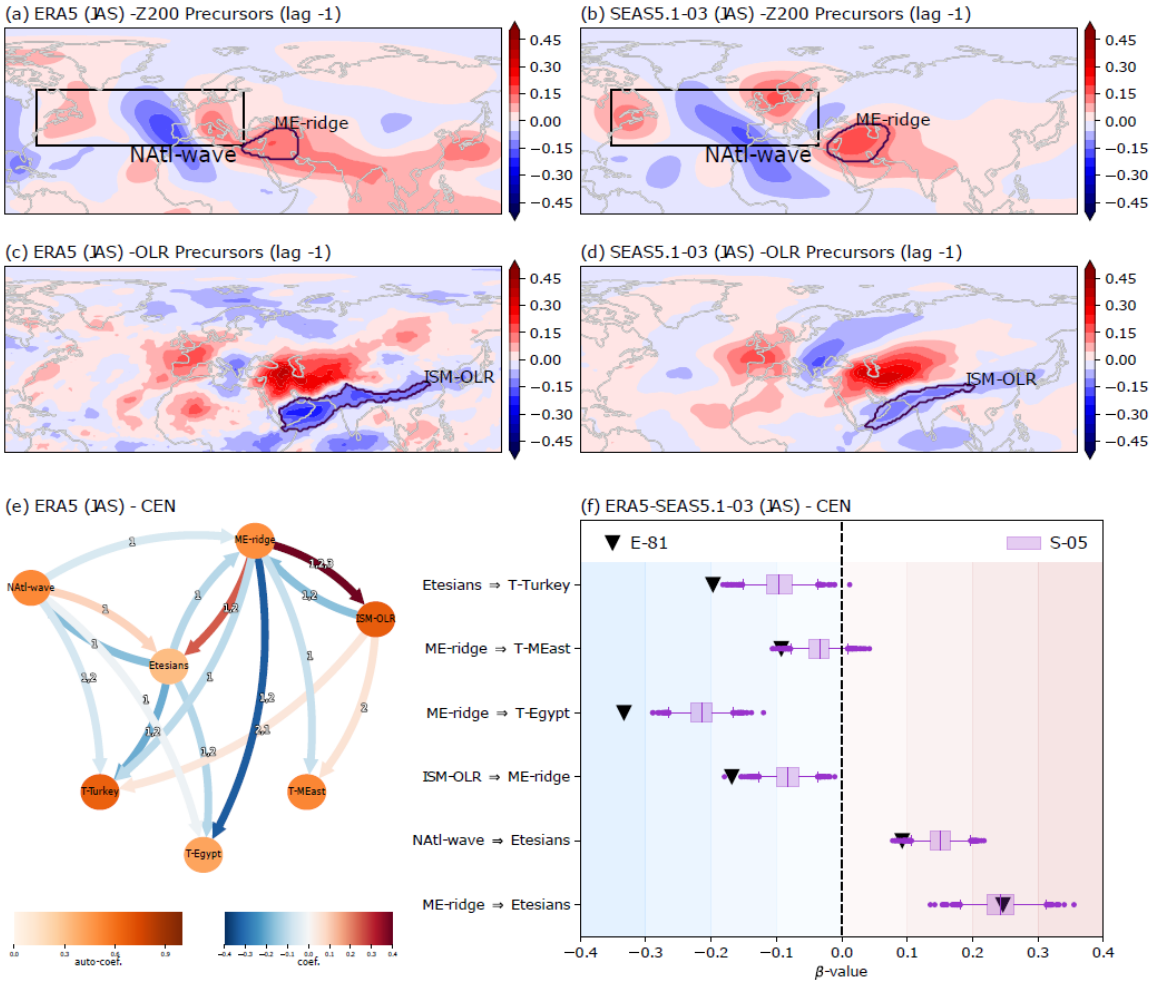


***Figure S6.*** *Same as for Fig. 4 in the main text but for SEAS5.1-03.*

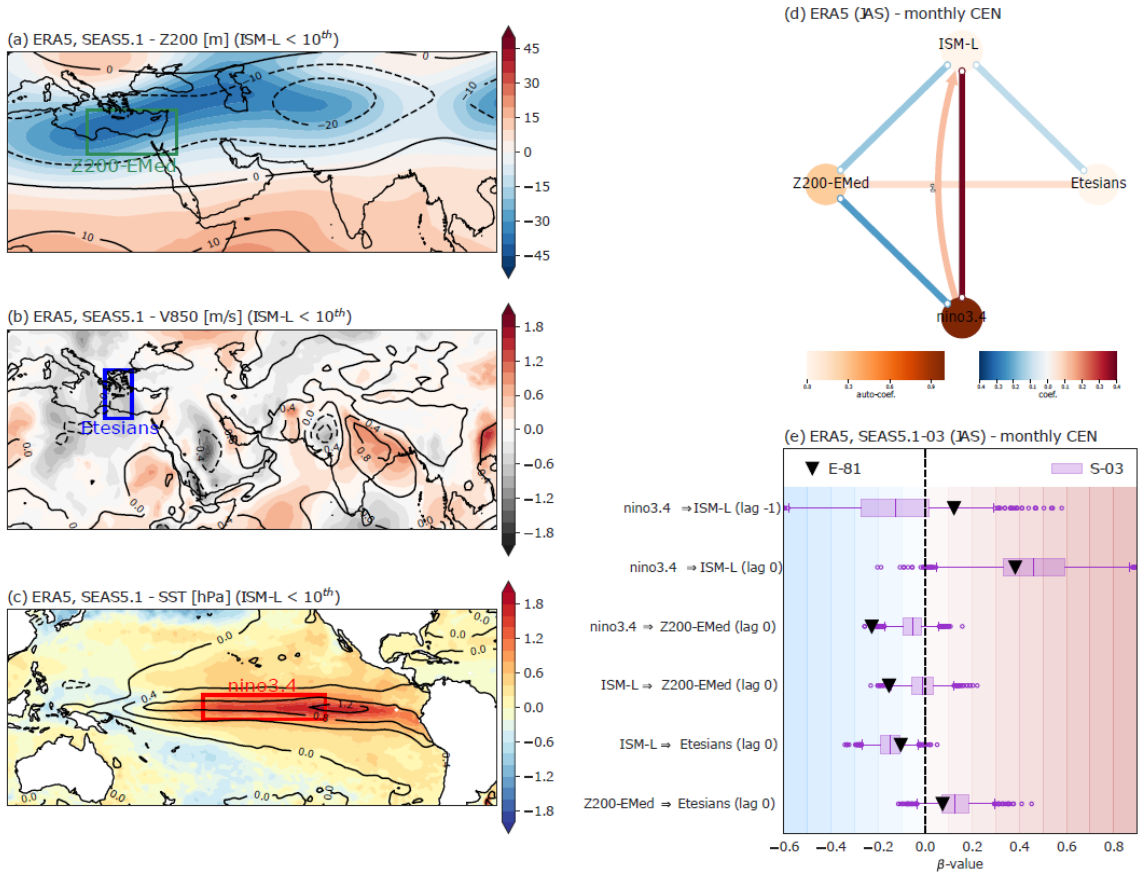


***Figure S7.*** *Same as for Fig. 5 in the main text but for SEAS5.1-03.*

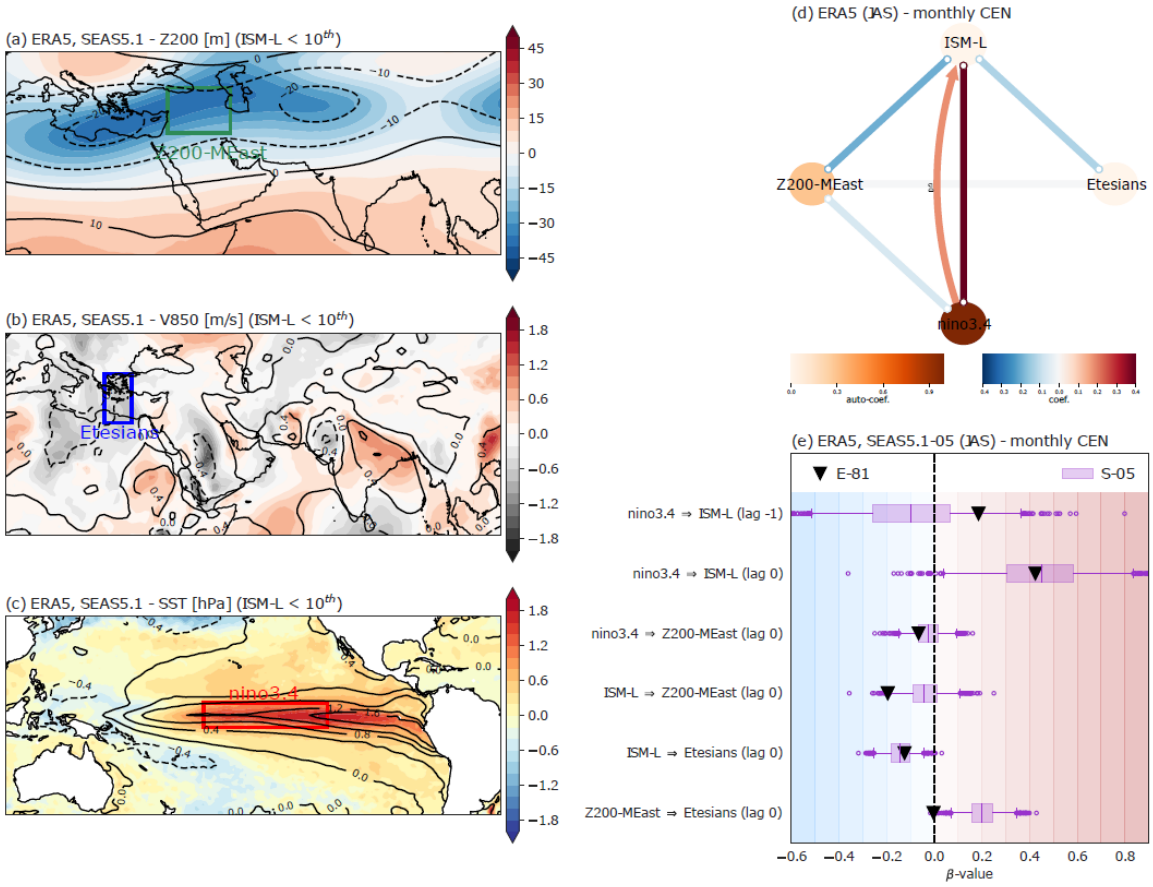


***Figure S8.*** *Same as for Fig. 5 in the main text but build with Z200-MEast instead of Z200-EMed. The Z200-MEast region is depicted in panel (a) in the green box.*

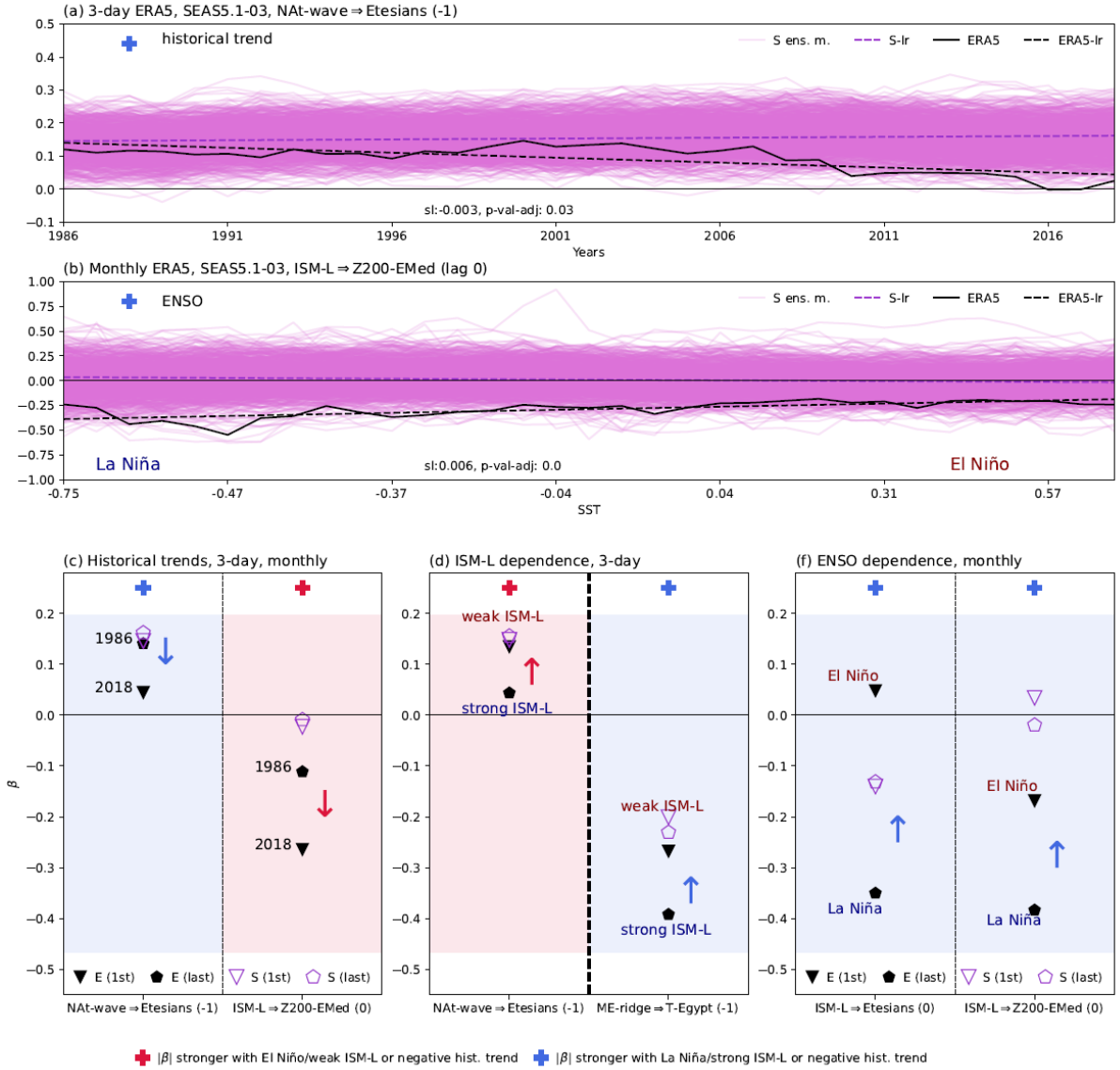


***Figure S9.*** *Same as for Fig. 6 in the main text but for SEAS5.1-03.*

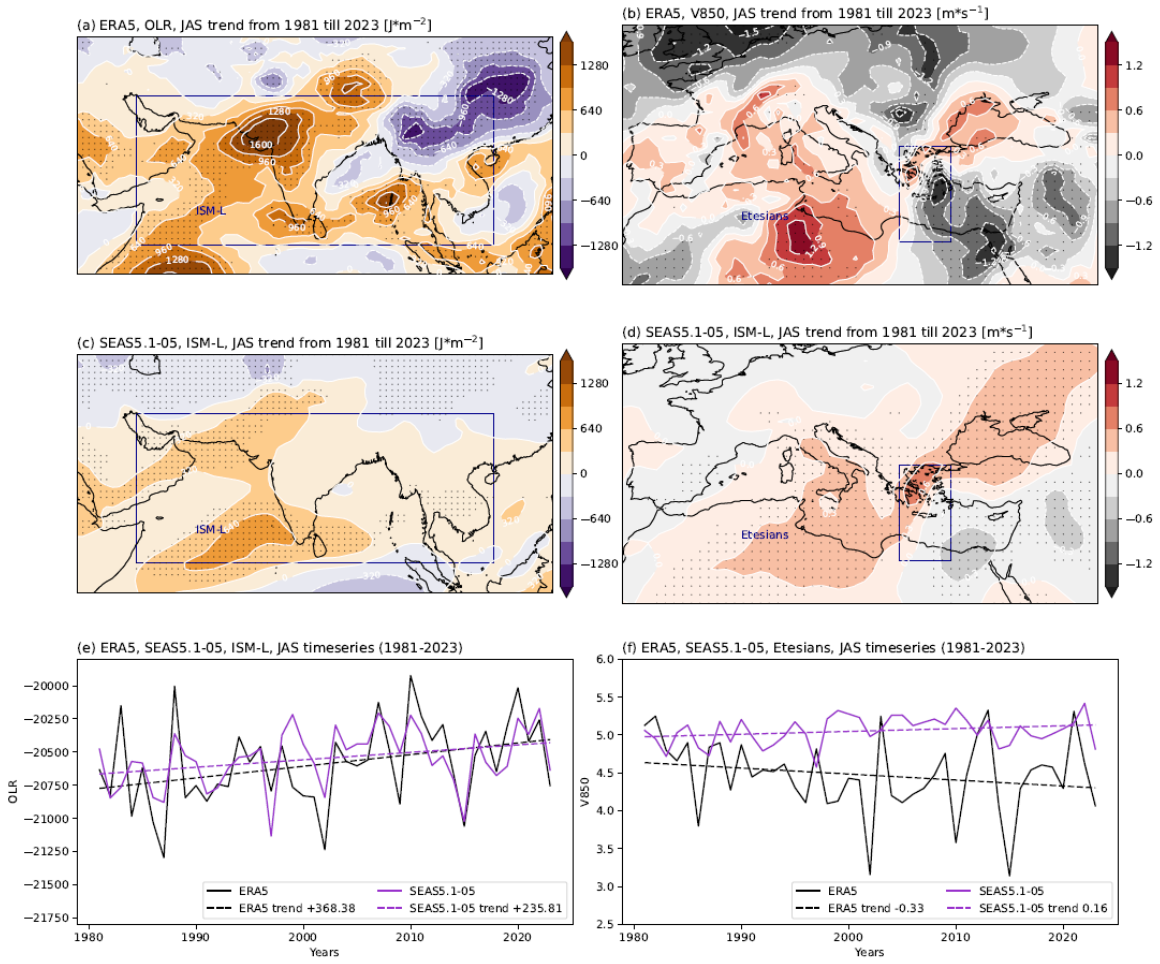


***Figure S10. Historical trends in ERA5 and SEAS5.1.*** *Panel (a) shows the JAS cumulative trend in the OLR field over the ISM region obtained by calculating a linear trend over each gridpoint for the 1981-2023 ERA5 dataset. Panel (b) same as for panel (a) but for the V850 fields, note that red shading denotes stronger northerlies and grey shading denotes stronger southerlies. Panels (c) and (d) same as for Panels (a) and (b) but for the SEAS5.1-05 dataset. Panel (e) shows the JAS 1981-2023 time series for the ISM-L index (ERA5 solid black and SEAS5.1-05 solid purple) together with the respective linear trends (ERA5 dashed black and SEAS5.1-05 dashed purple). Panel (f) same as for panel (e) but for the Etesians index. Note that for SEAS5.1, trends are calculated using the ensemble mean of each year in the 1981-2023 period.*

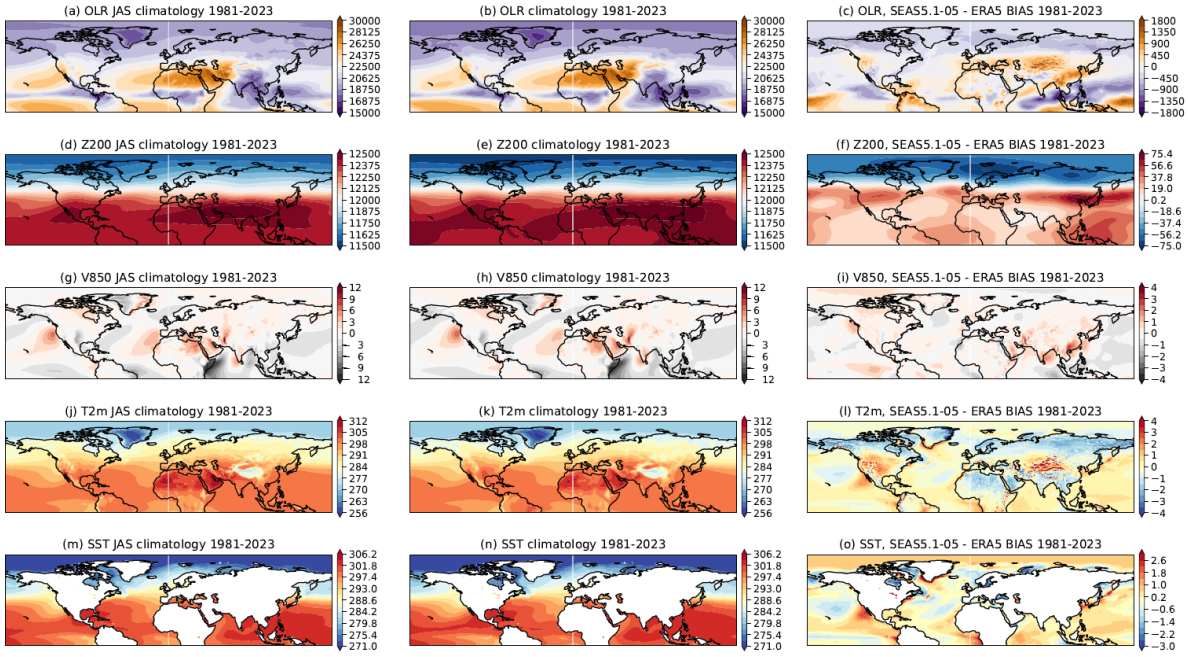


***Figure S11. JAS climatology for ERA5 and SEAS5.1-05.*** *Panel (a) shows the JAS 1981-2023 climatology for the OLR field in the northern hemisphere. Panels (d), (g), (j) and (m) same as for panel (a) but for Z200, V850, T2m and SST fields respectively. Panels (b), (e), (h), (k), and (n) same as for panels (a), (d), (g), (j) and (m) but for SEAS5.1-05. Panel (c) shows the difference between the SEAS5.1 and the ERA5 climatologies (model bias) for the OLR field. Panels (f), (i), (l) and (o) same as for panel (c) but for Z200, V850, T2m and SST fields respectively. Note that the V850 field is multiplied by -1, thus red shading indicates northerly winds. and bias for T2m, SST, Z200, V850, OLR*

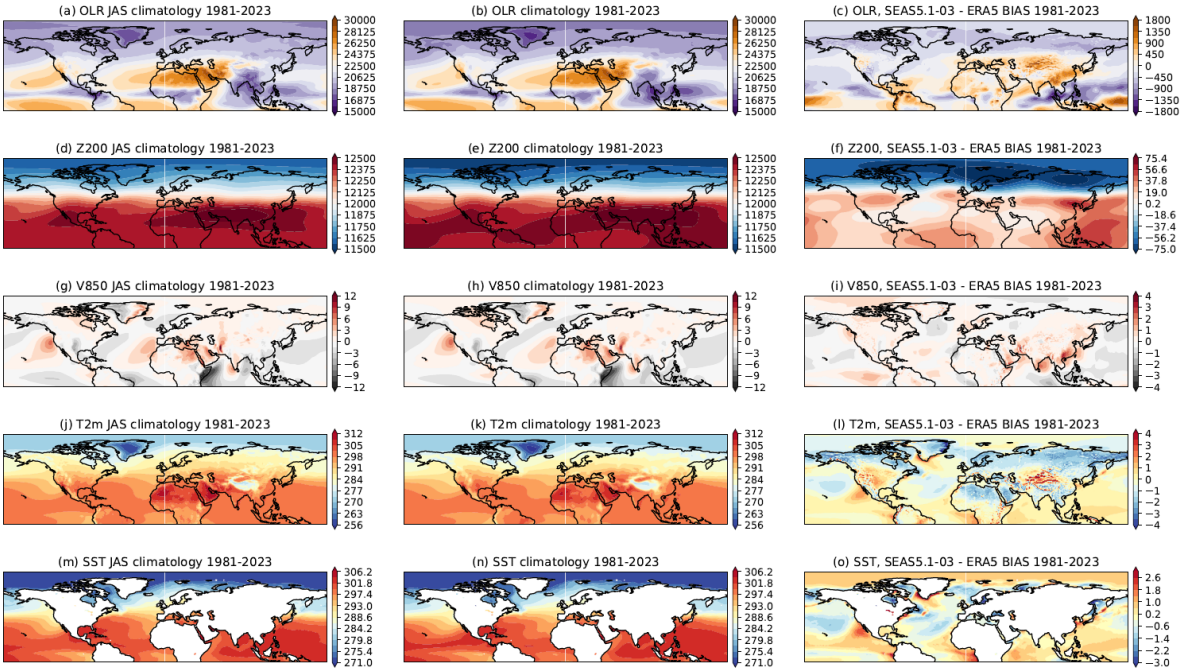


***Figure S12. JAS climatology for ERA5 and SEAS5.1-05.*** *Same as for Fig. S10 but for SEAS5.1-03.*