Author comments

Ensemble design for seasonal climate predictions: Studying extreme Arctic sea ice lows with a rare event algorithm

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Figures for replies to reviewer #3

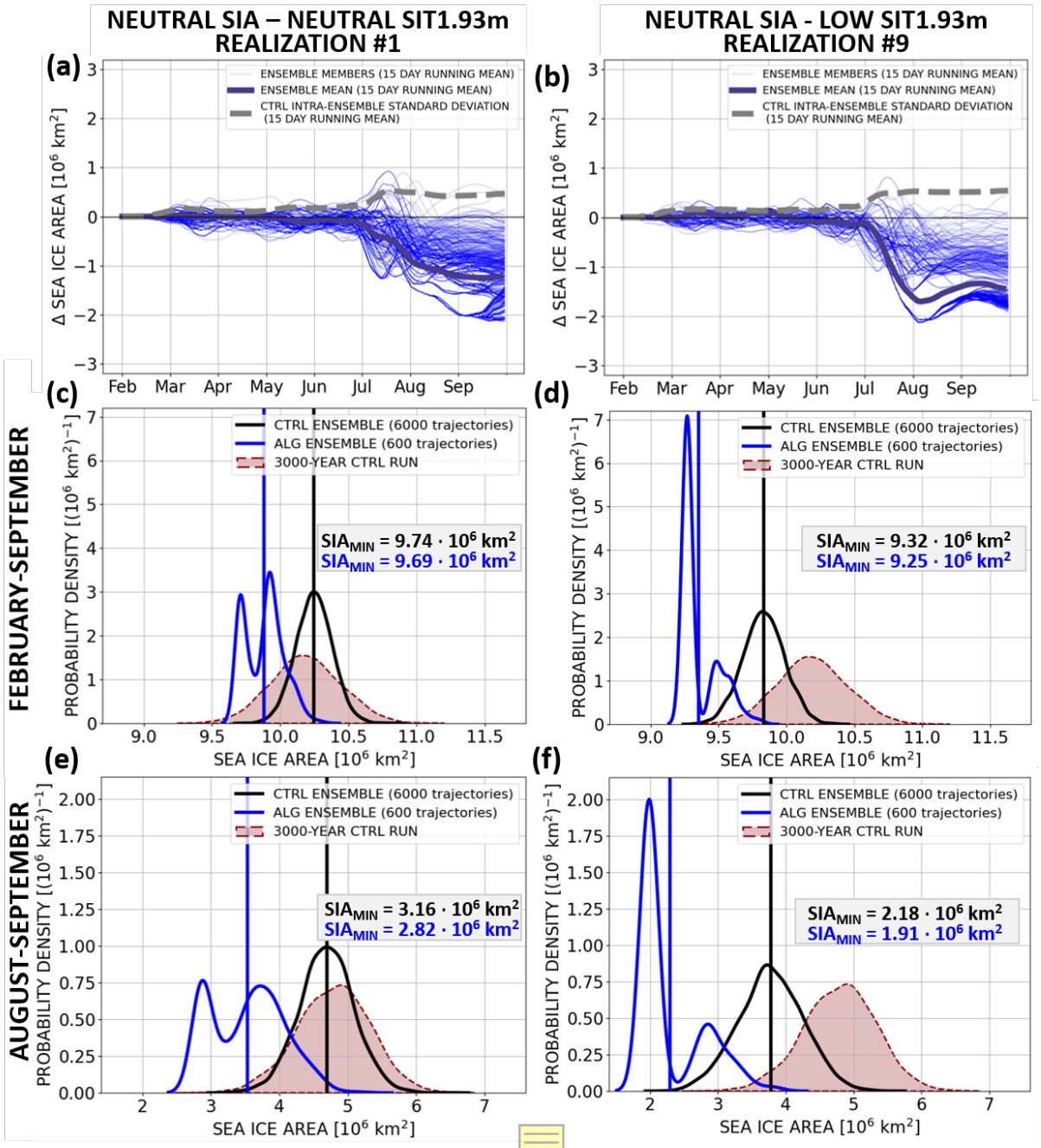

Figure R1: *Ensemble simulations initialized on 01 February (a,c,e) 1930 and (b,d,f) 1037 of the control run. (a-b) Rare event simulations: N=600 trajectories (thin blue lines) and ensemble mean (thick blue line) of daily pan-Arctic sea ice area anomalies relative to the daily climatology of the corresponding control ensemble means. The gray dashed lines show the intra-ensemble standard deviations in the control ensembles. All lines are presented as 15-day running means. (c-f) Probability distribution functions of (c-d) February-September and (e-f) August-September mean pan-Arctic sea ice area for (blue) the rare event simulation, (black) the control ensembles (N=6000 trajectories) and (red) the 3000-year control run. The vertical lines show the mean of the distributions. The black and blue values indicate the smallest February-September and August-September mean sea ice area value in the control and rare event ensemble simulations respectively.*

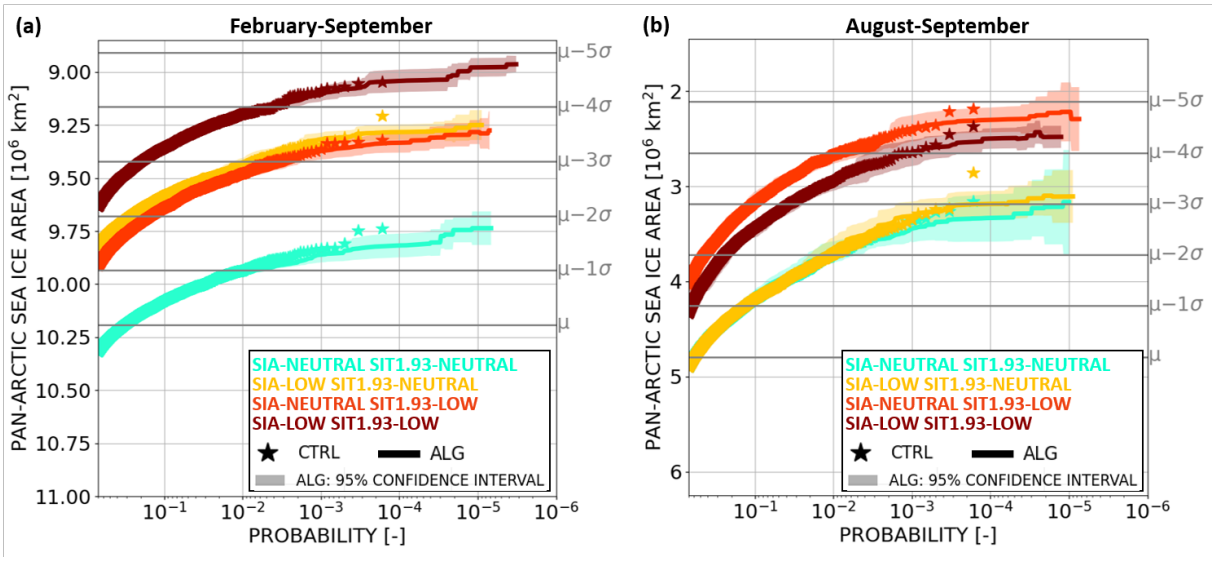

Figure R2: *Probabilities (x-axes) of (a) February-September and (b) August-September mean sea ice area equal or smaller than a given threshold (y-axes) as a function of four different initial conditions for (stars) the N=6000 trajectory control ensembles (i.e. ten realizations are merged into one single ensemble) and (solid lines) the average over four to ten algorithm estimates. The shading are 95% confidence intervals derived from the t-distribution of the four to ten estimates (see Supplementary Information S4 of the revised manuscript). Note that the y-axes are displayed in reverse order. In the legend, "SIA" and "SIT1.93" indicate the state of the January-February mean anomaly of the pan-Arctic sea ice area and the cumulative area with sea ice thickness equal or larger than 1.93 m respectively. The grey labels on the right of each panel show how many standard deviations a sea ice area value is below the mean of the 3000-year control run.*

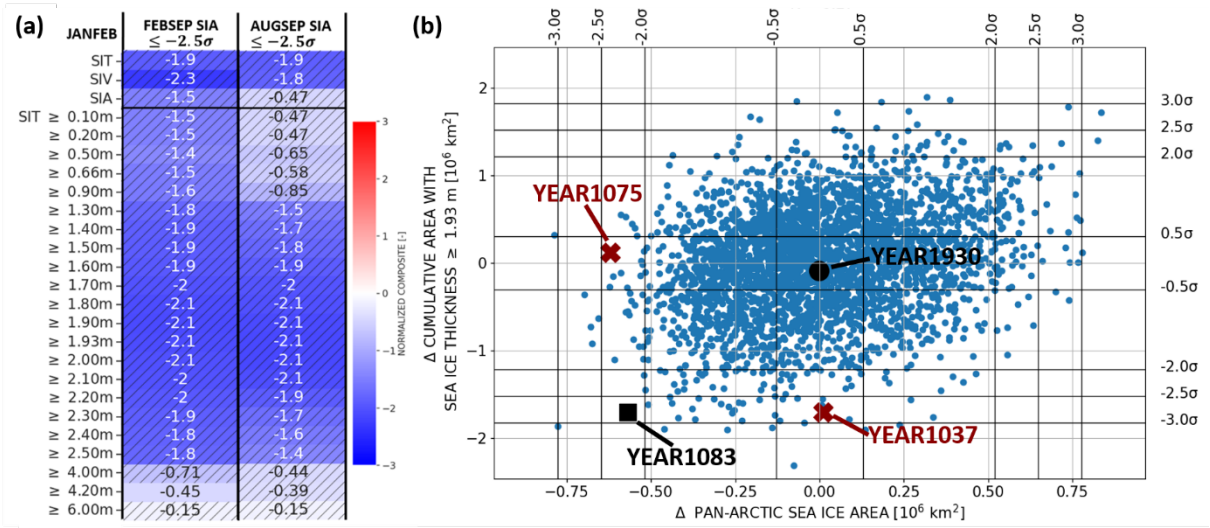

Figure R3: PlaSim-LSG 3000-year control run (Sauer et al. [2024])): (a) Normalized mean anomalies of January-February mean quantities conditional on extreme negative (left) February-September (FEBSEP) and (right) August-September (AUGSEP) mean pan-Arctic sea ice area anomalies equal or smaller than -2.5 standard deviations. "SIV", "SIA" and "SIT" are the pan-Arctic sea ice volume, sea ice area and mean sea ice thickness. "SIT ≤ threshold" are anomalies in the cumulative area with sea ice thickness equal or larger than a critical threshold. Hatching denotes statistical significance at the 5% level assessed from a two-sided t-test applied to five composite estimates after subdividing the 3000-year control run into five 600-member ensembles (see Supplementary Information S4 of the revised manuscript). (b) Scatter plot of January-February mean anomalies of SIT1.93 vs. pan-Arctic sea ice area including the years from the selected initial conditions.

References

Plotkin, D. A., Webber, R. J., O'Neill, M. E., Waere, J., and Abbot, D. S.: Maximizing simulated tropical cyclone intensity with action minimization, Journal of Advances in Modeling Earth Systems, 11, 863–891, https://doi.org/10.1029/2018ms001419, 2019.

Sauer, J., Demaeyer, J., Zappa, G., Massonnet, F., and Ragone, F.: Extremes of summer Arctic sea ice reduction investigated with a rare event algorithm, Climate Dynamics, pp. 1–19, https://doi.org/10.1007/s00382-024-07160-y, 2024.