

## Supplementary Material

### *Attribution of Extreme Events in Arctic Sea-Ice Extent*

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The following supplementary material includes several figures that extend the analysis of Figure 6 to the remaining models and also show results for the March maximum events. Additionally, a table of models used in the CMIP5 ensemble is provided in Table S1.

## References

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TABLE S1. Details of models used to calculate the CMIP5 ensemble. Note that the CSIRO model was not included in the ensemble for most of the results.

| Model           | Modelling Center   | Reference                                   | #  |
|-----------------|--|---|----|
| CanESM2         | Canadian Centre for Climate Modelling and Analysis, Canada   | Arora et al. 2011                           | 5  |
| CNRM-CM5        | Centre National de Recherches Météorologiques / Centre Européen de Recherche et Formation Avancée en Calcul Scientifique, France | Voldoire et al. 2013                        | 1  |
| CSIRO-Mk3.6.0 * | Commonwealth Scientific and Industrial Research Organization / Queensland Climate Change Centre of Excellence, Australia         | Jeffrey et al. 2013; Rotstayn et al. 2012   | 5  |
| GISS-E2-H       | National Aeronautics and Space Administration<br>Goddard Institute for Space Studies, USA  | Schmidt et al. 2014                         | 10 |
| GISS-E2-R       |  |   | 10 |
| HadGEM2-ES      | Met Office Hadley Centre, United Kingdom   | Jones et al. 2011; Collins et al. 2008      | 4  |
| IPSL-CM5A-LR    | Institut Pierre-Simon Laplace, France  | Dufresne et al. 2013                        | 3  |
| IPSL-CM5A-MR    |  |   | 1  |
| NorESM1-M       | Norwegian Climate Centre, Norway   | Bentsen et al. 2013;<br>Iversen et al. 2013 | 1  |

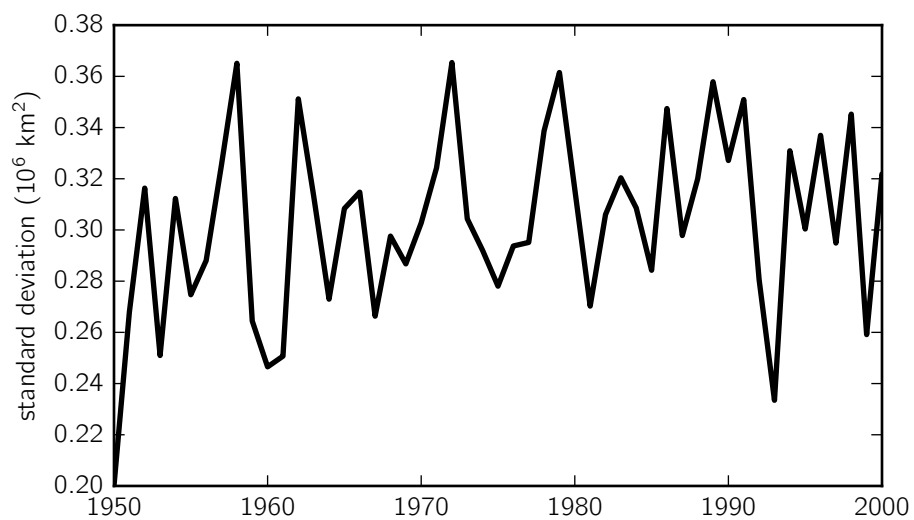


FIG. S1. For mean annual SIE from the CanESM2 NAT simulations, standard deviation across the 10 realizations that branched off of the same run in 1950, averaged across the 5 original realizations.

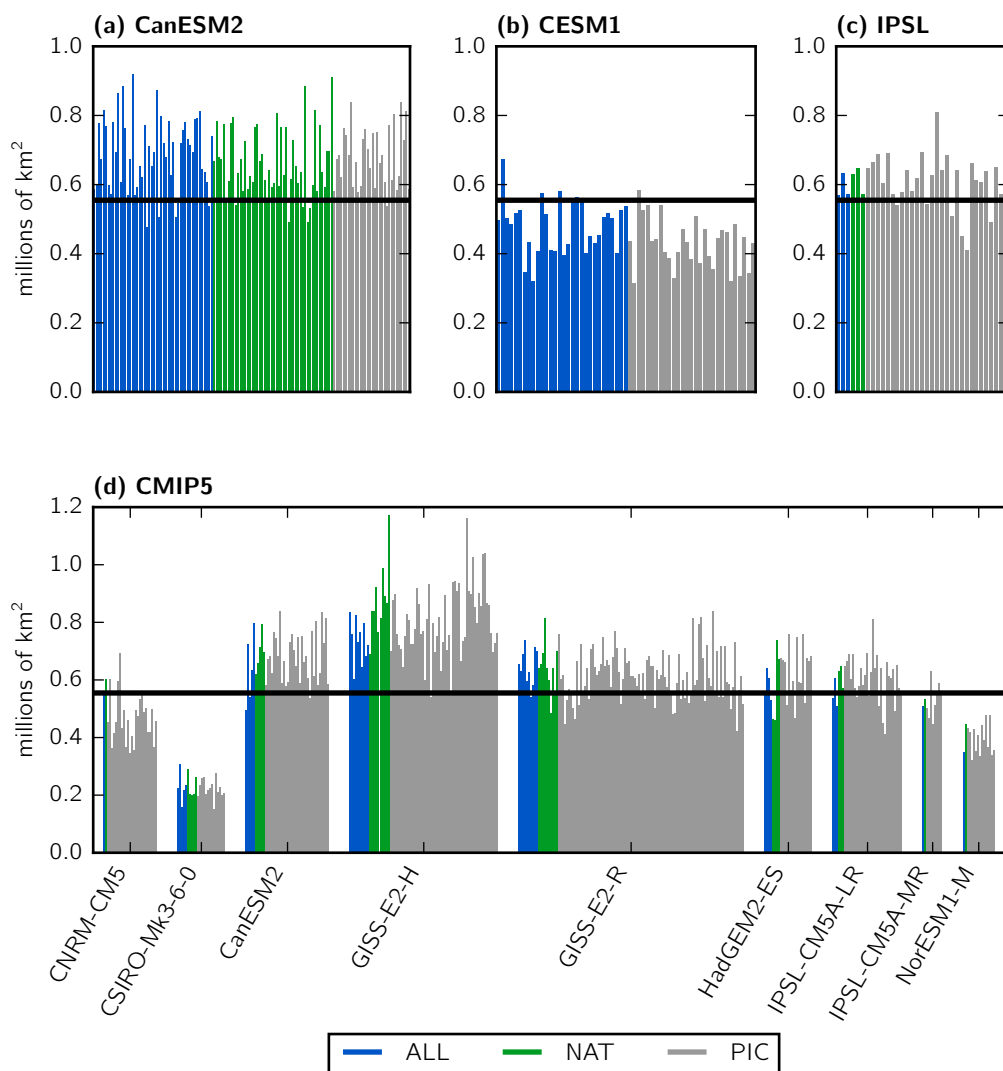


FIG. S2. Standard deviation of September SIE for 1979-2012 for each realization in the ensemble for ALL (blue) and NAT (green) forcing and the PIC segments of the same length (grey). Horizontal black bar indicates the standard deviation of the observations. The ALL responses and the observations have had a linear trend removed before the standard deviation calculation.

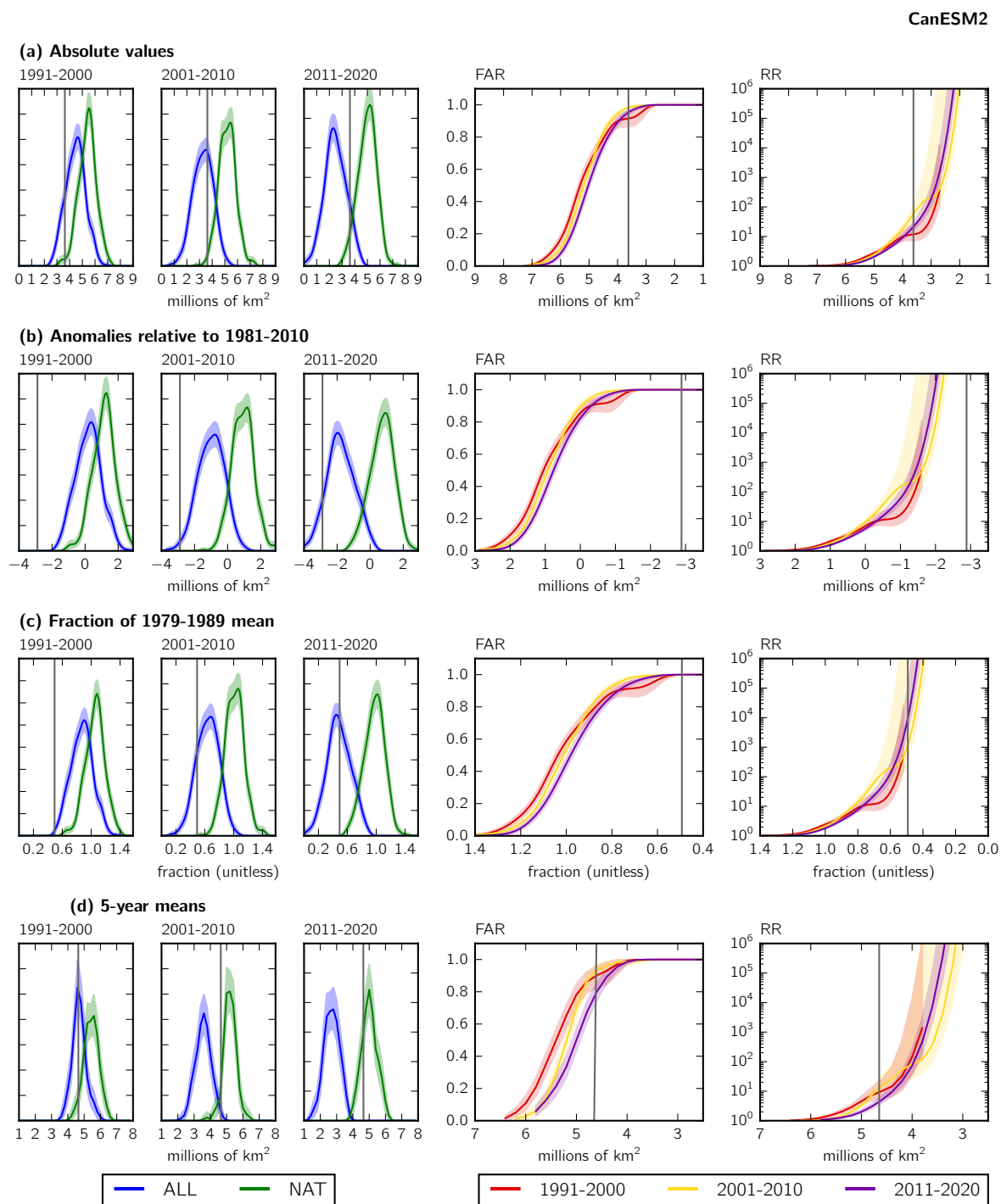


FIG. S3. As in Figure 6 for the un-adjusted CanESM2.

CESM1

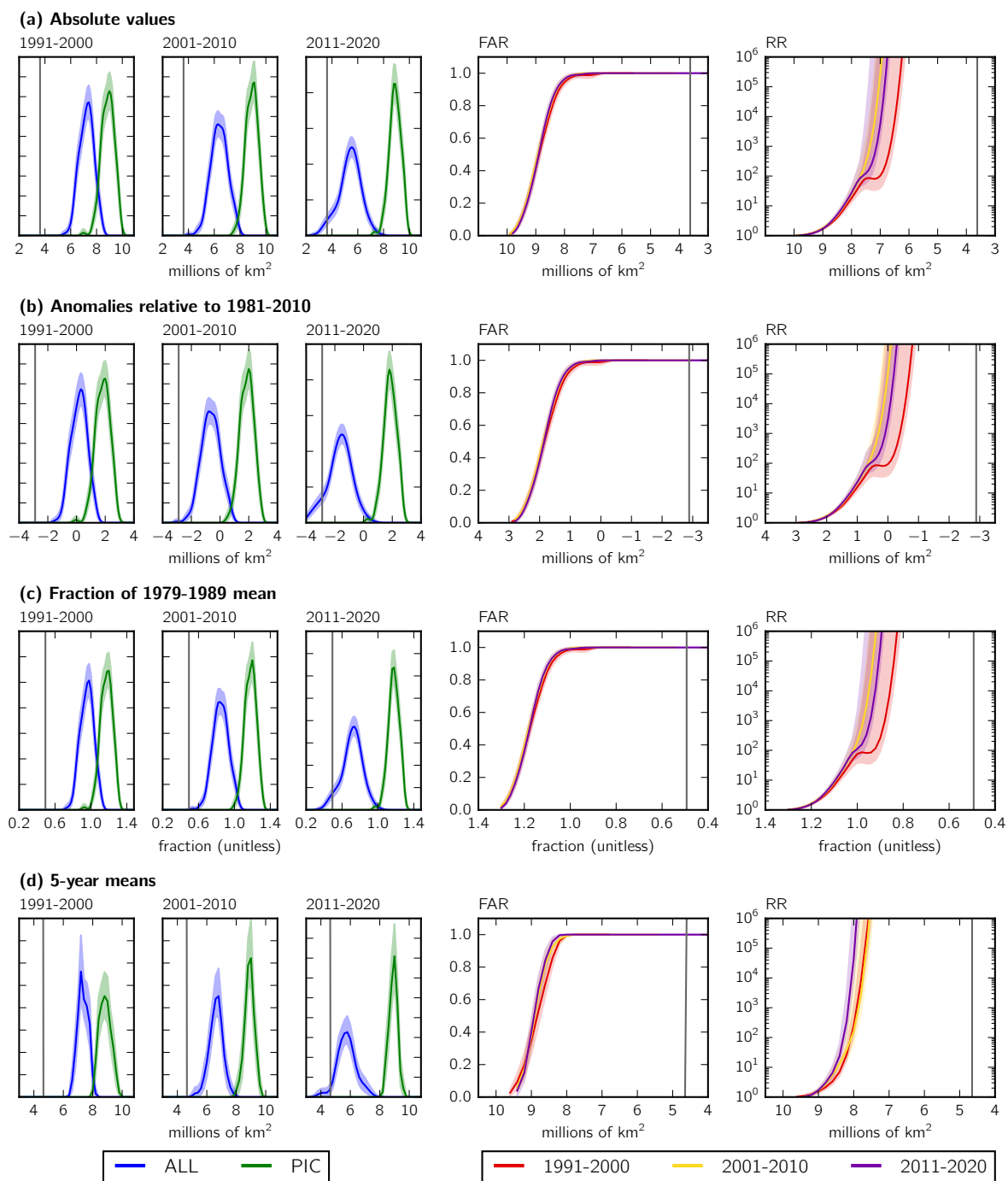


FIG. S4. As in Figure 6 for CESM1.

IPSL

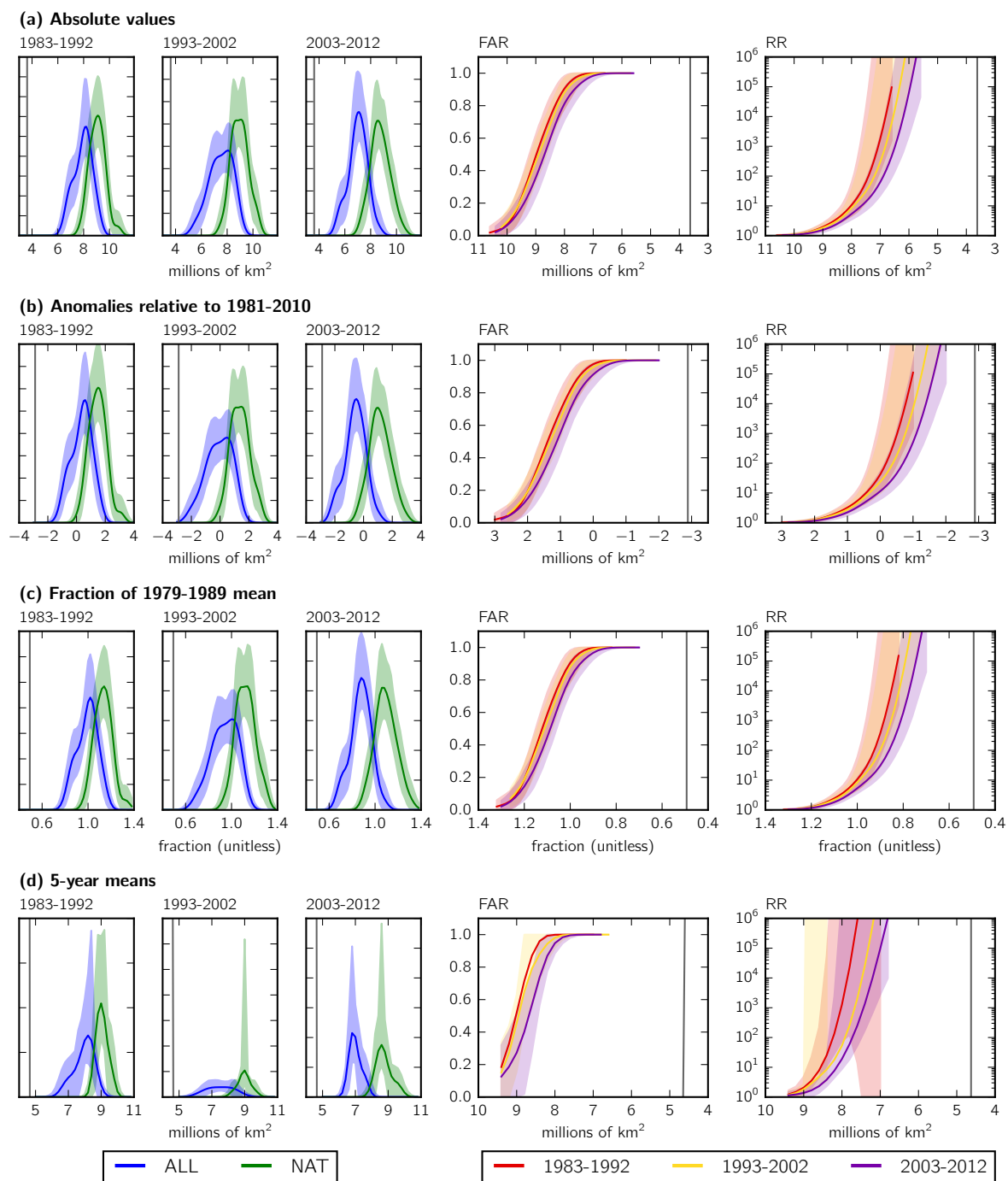


FIG. S5. As in Figure 6 for IPSL.



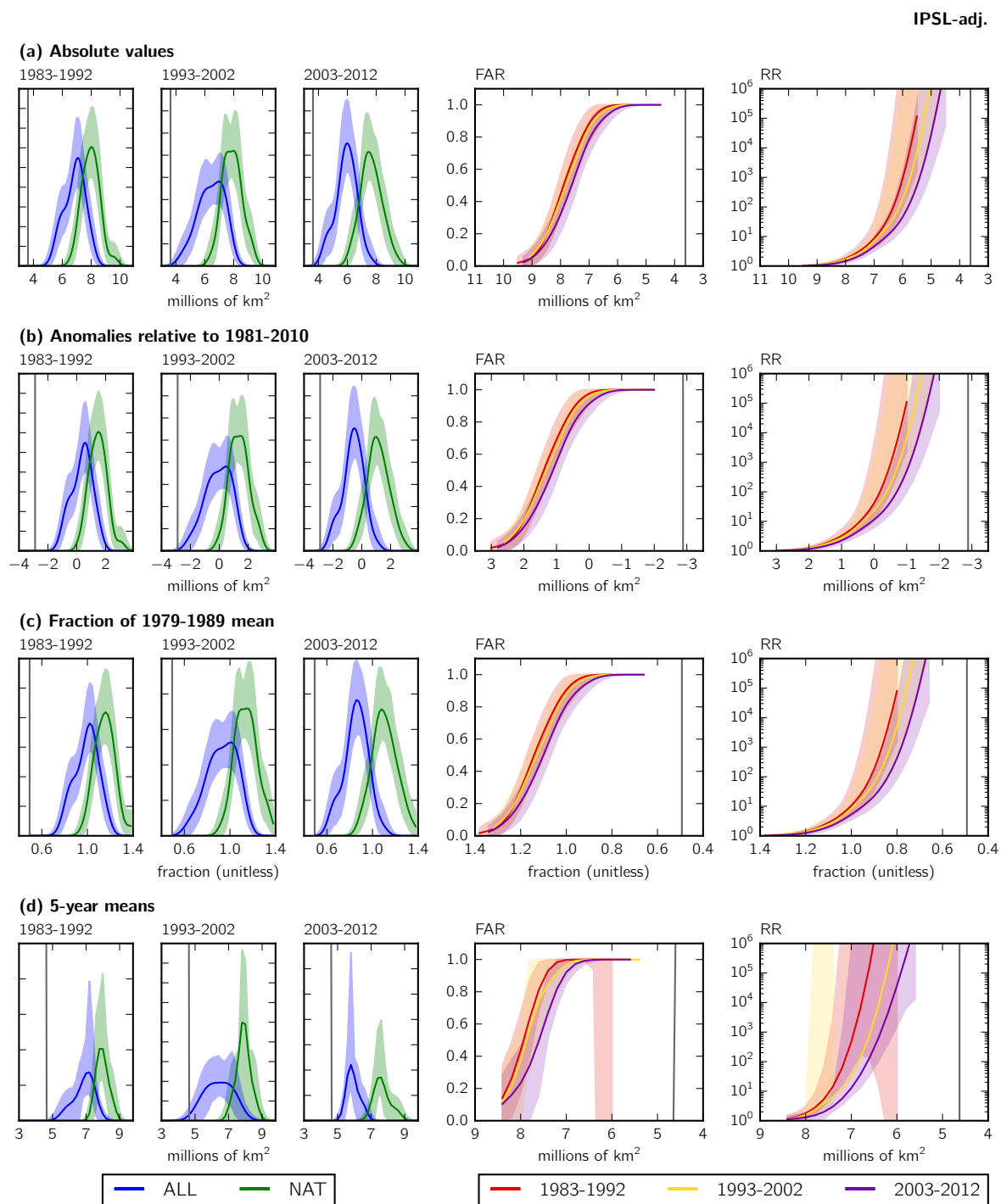


FIG. S6. As in Figure S5 for adjusted IPSL.

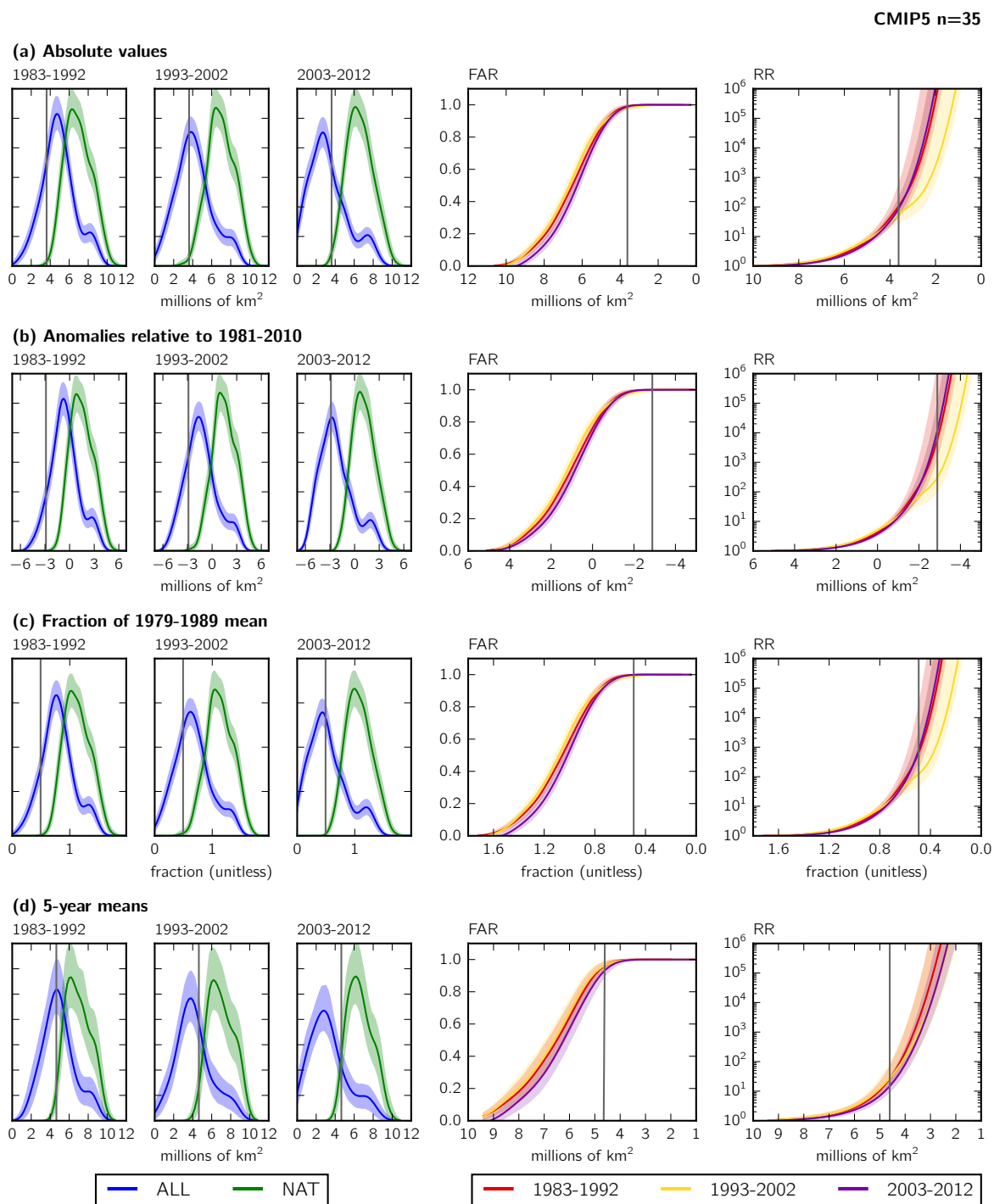


FIG. S7. As in Figure 6 for CMIP5.

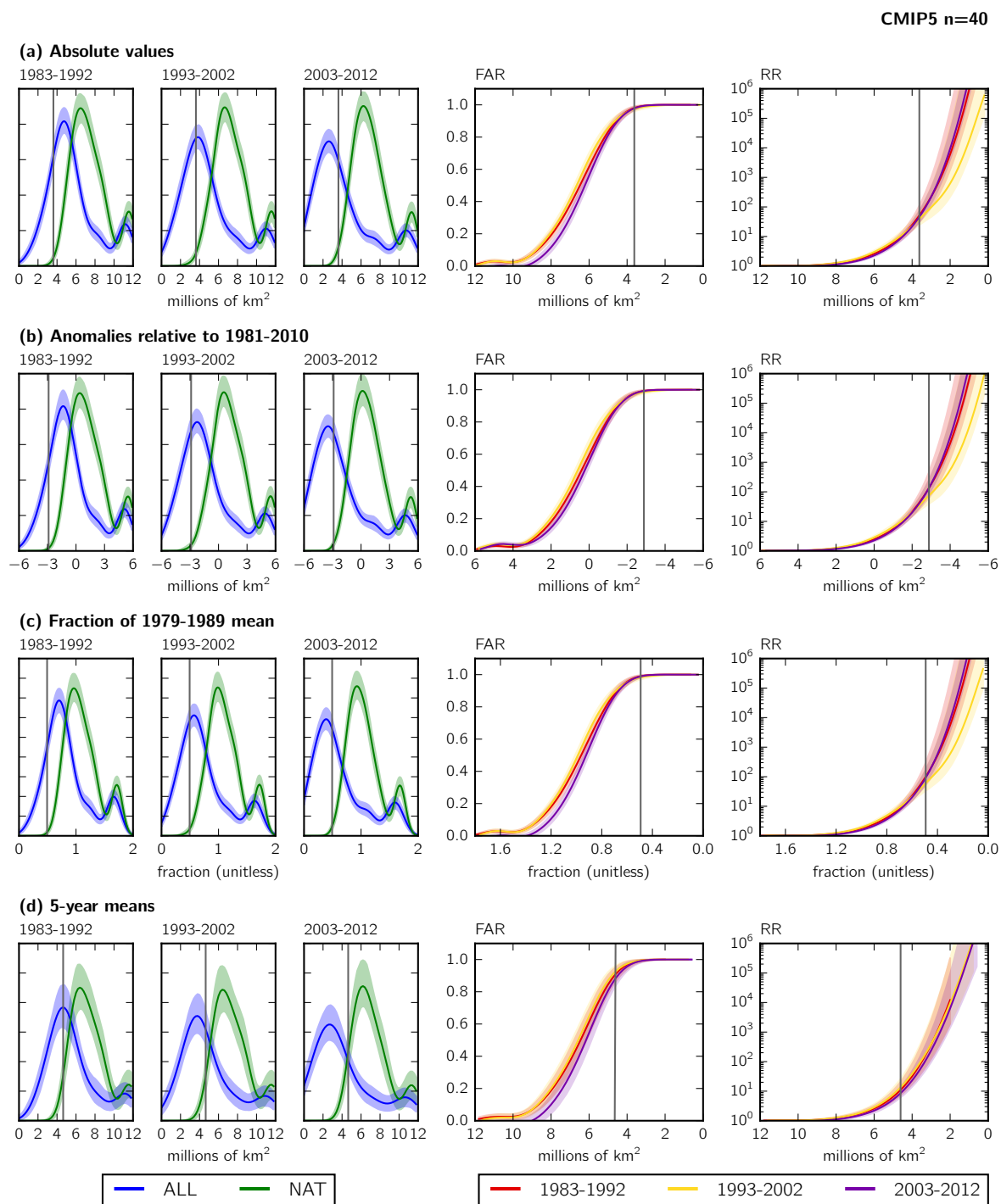


FIG. S8. As in Figure S7 for the CMIP5 ensemble including CSIRO.

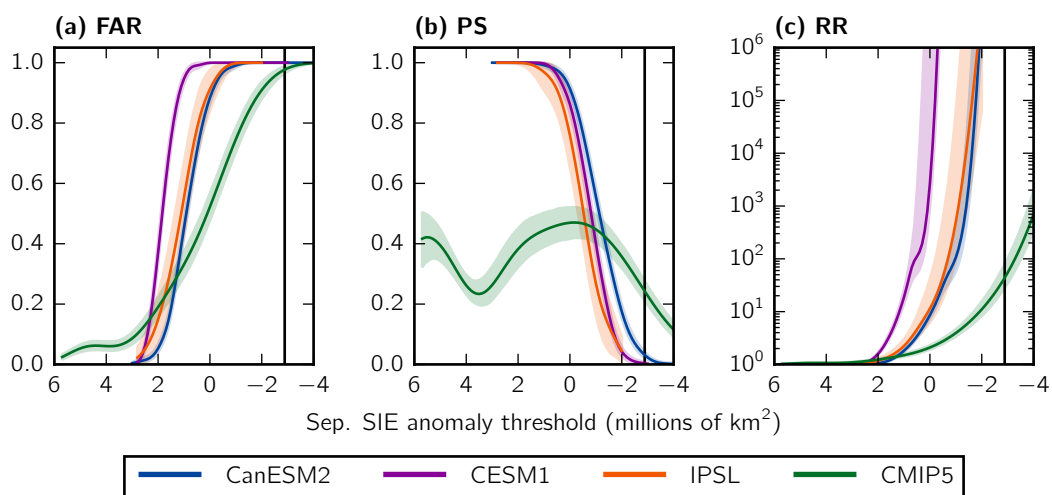


FIG. S9. As in Figure 7 but using a CMIP5 ensemble that includes the CSIRO model. Note the wider range of SIE anomaly values to show an additional feature in the CMIP5 curves.

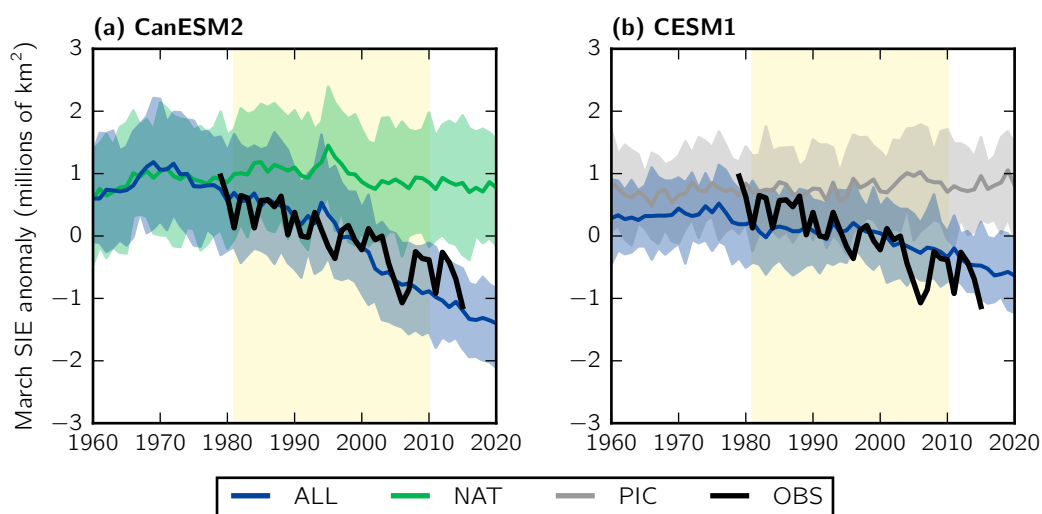


FIG. S10. Time series of the model responses to ALL (blue) and NAT (green) forcing during March, expressed as anomalies relative to 1981-2010 for the CanESM2 (a) and CESM1 (b) large ensembles. Shading represents the 5th to 95th percentile range across the ensemble. Observed values are shown in black.

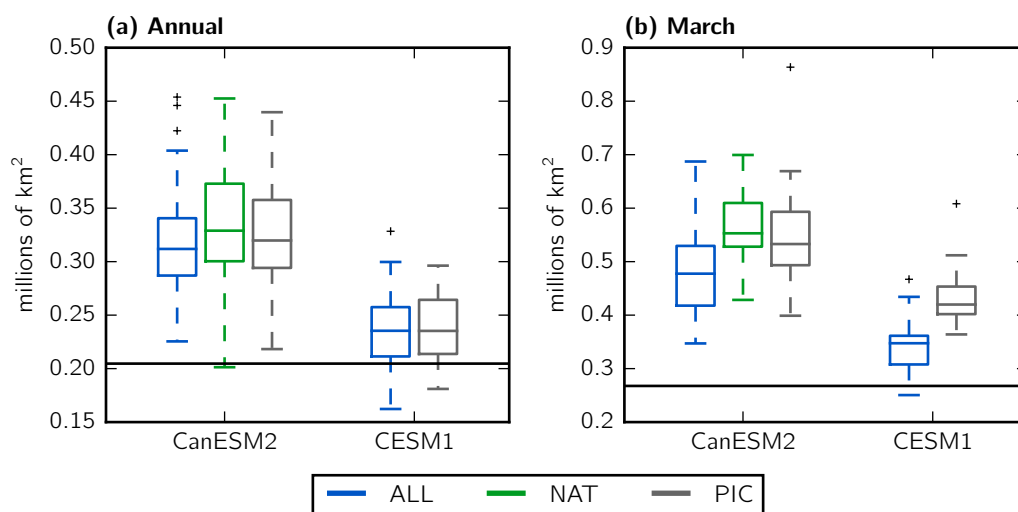


FIG. S11. Box plots representing the spread of standard deviation values across the ensemble for each forcing. Standard deviation is calculated for 1979-2015 for each time series. The horizontal bar represents the observed value. A linear trend was removed from the observations and from the ALL forcing responses before the standard deviation was calculated.

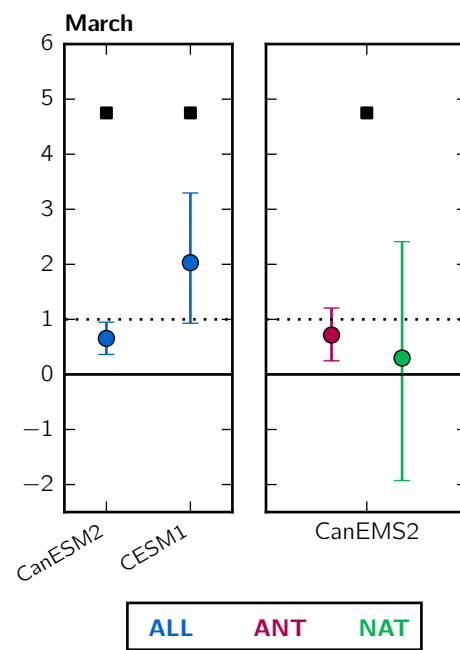


FIG. S12. As in Figure 5 c,d for March.

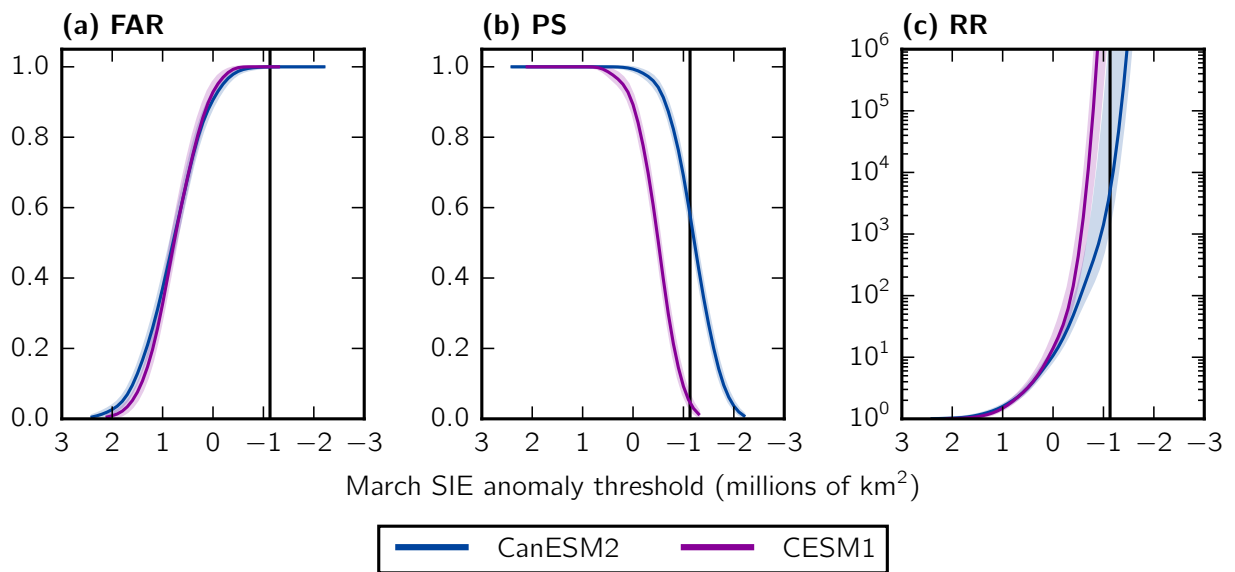


FIG. S13. FAR (a), PS (b), and RR (c) values of experiencing a March SIE value more extreme than the given threshold, using data from 2011-2020. These statistics are calculated only for values within the realized range of the ensemble for this period. Vertical bars represent the 2015 event.