

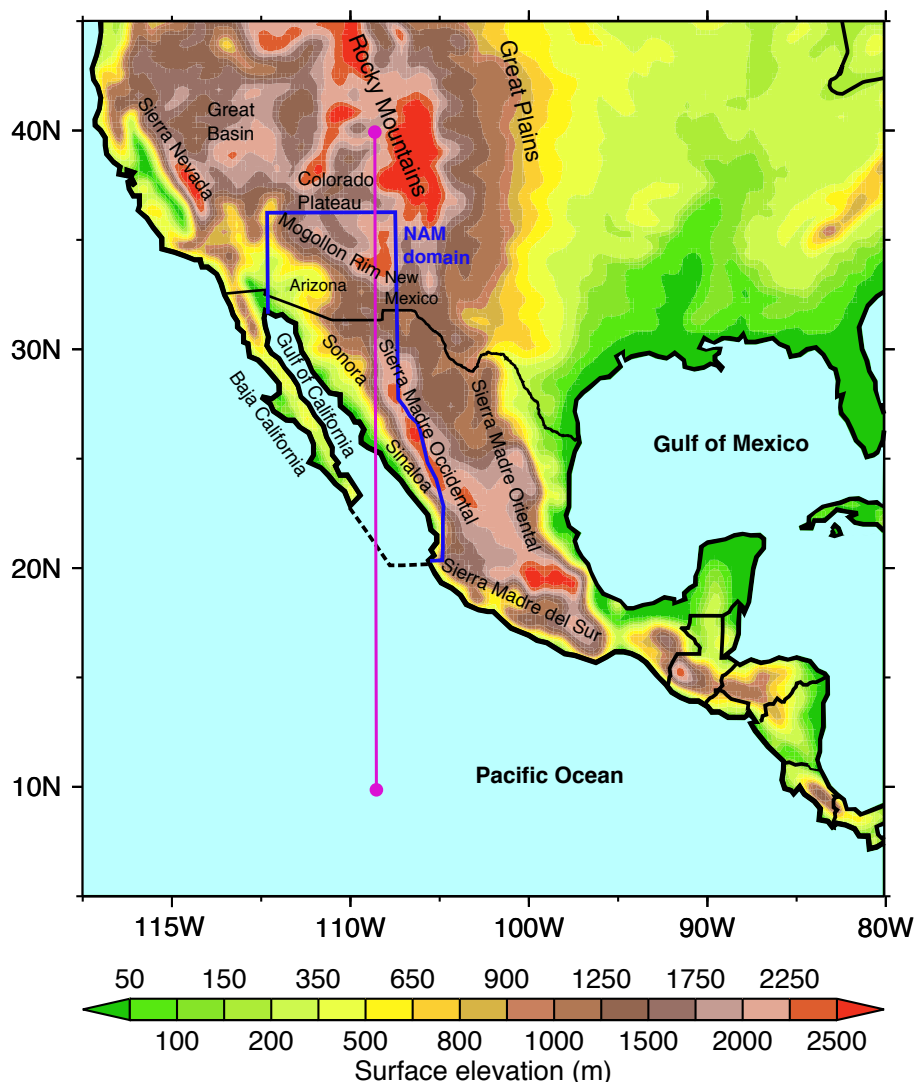
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Weakening of the North American monsoon with global warming

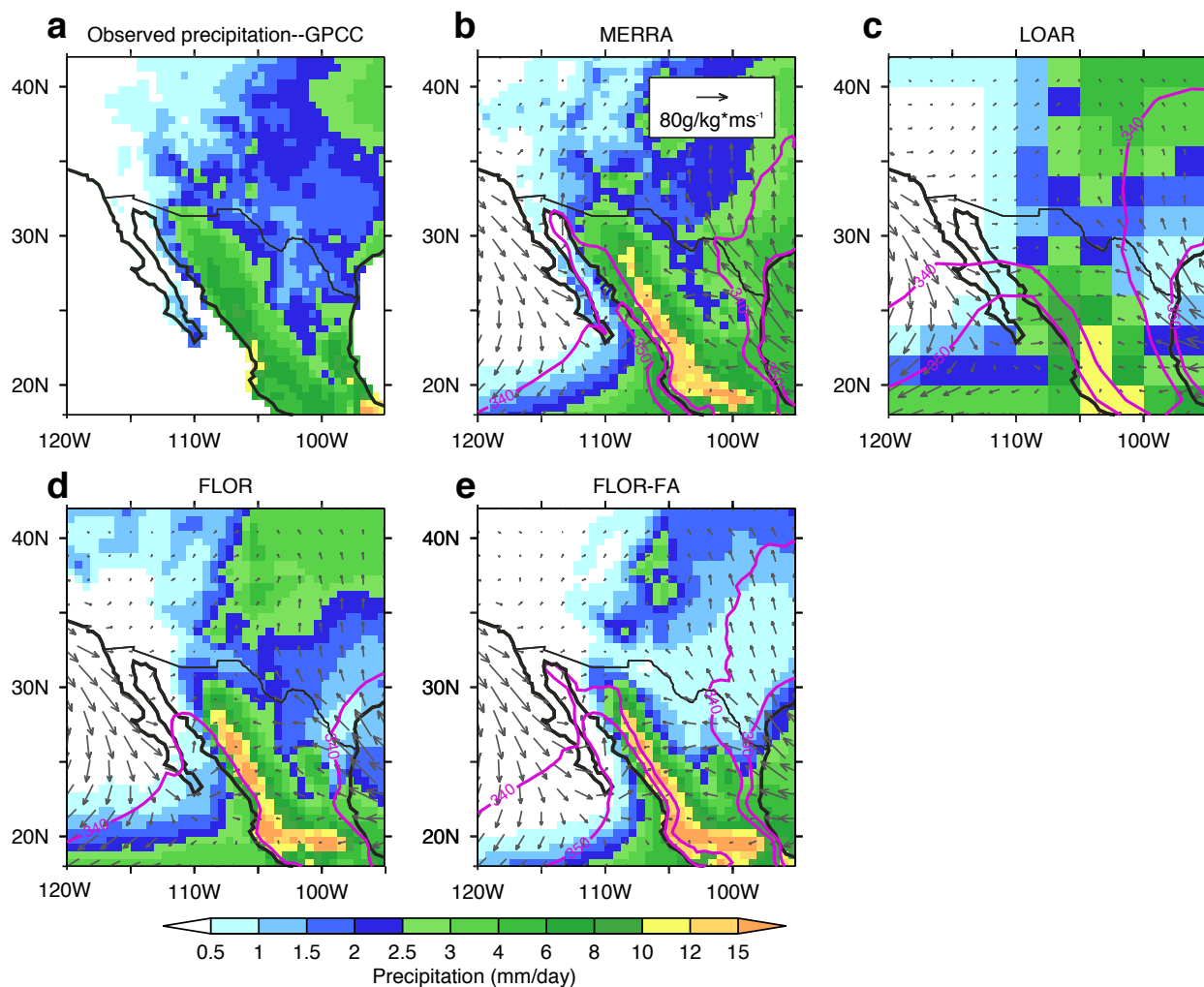
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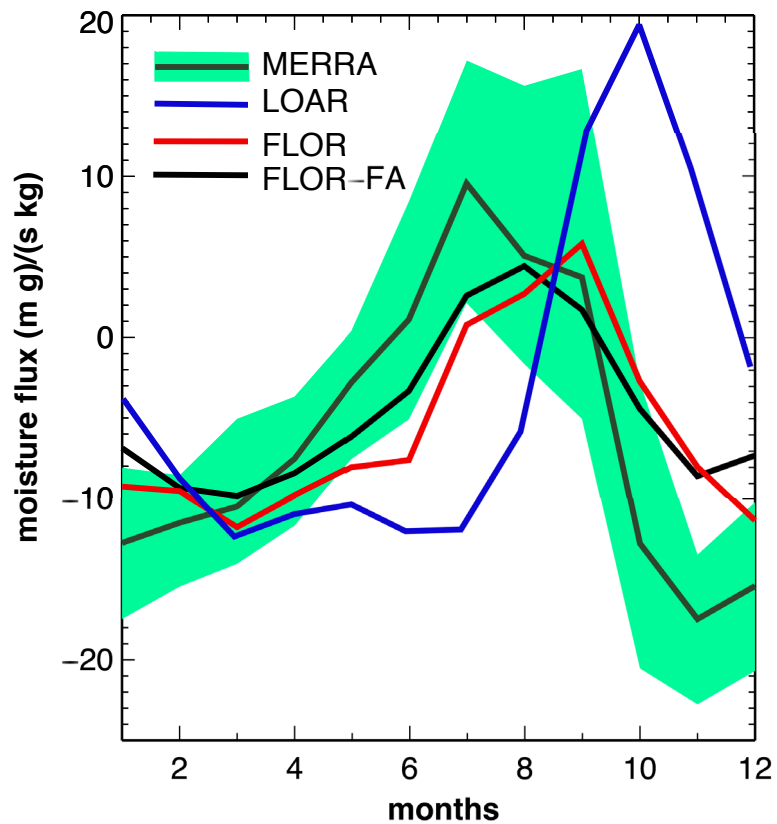
1 Figures for supplementary material



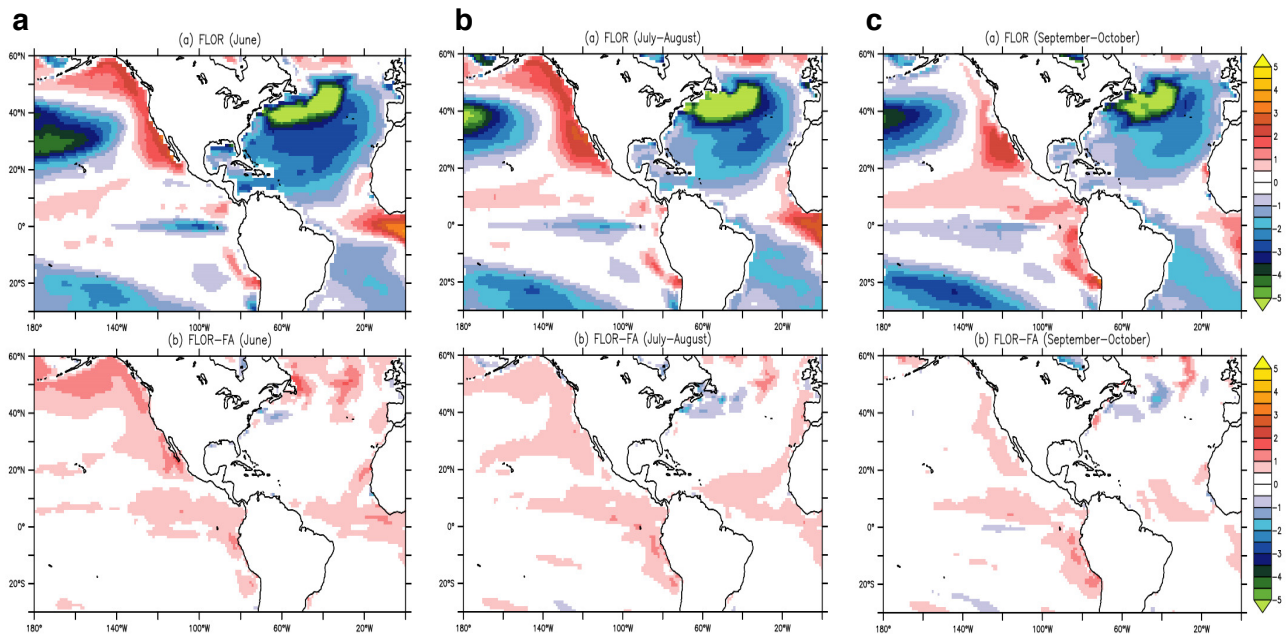
Supplementary Fig. 1: **The North American monsoon region.** Main geographical and topographical features of the North American monsoon region (blue contour, based on the definition of the North American Monsoon Experiment (NAME) Science and Implementation Plan and in [1]). The blue contour delimits the area over which precipitation is averaged and the pink line the transect for vertical cross-sections shown in Fig. 3.



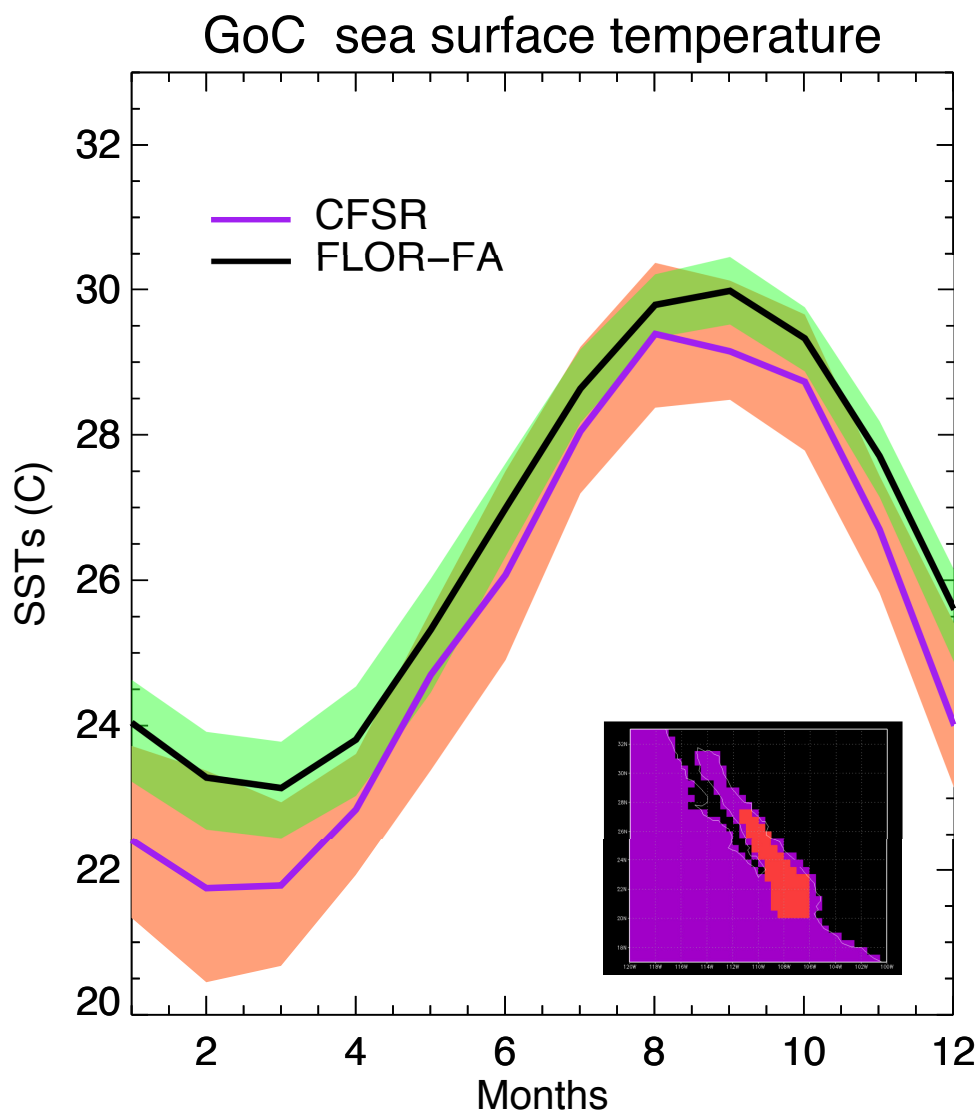
Supplementary Fig. 2: **Regional focus of the NAM climatology.** July-August precipitation and 10m moisture flux in the North American monsoon region in **a**, GPCCC, **b**, MERRA, **c**, LOAR, **d**, FLOR and **e**, FLOR-FA. Magenta contours in **b-e** indicate isolines of 10m-moist static energy (340 and 350 kJ/kg).



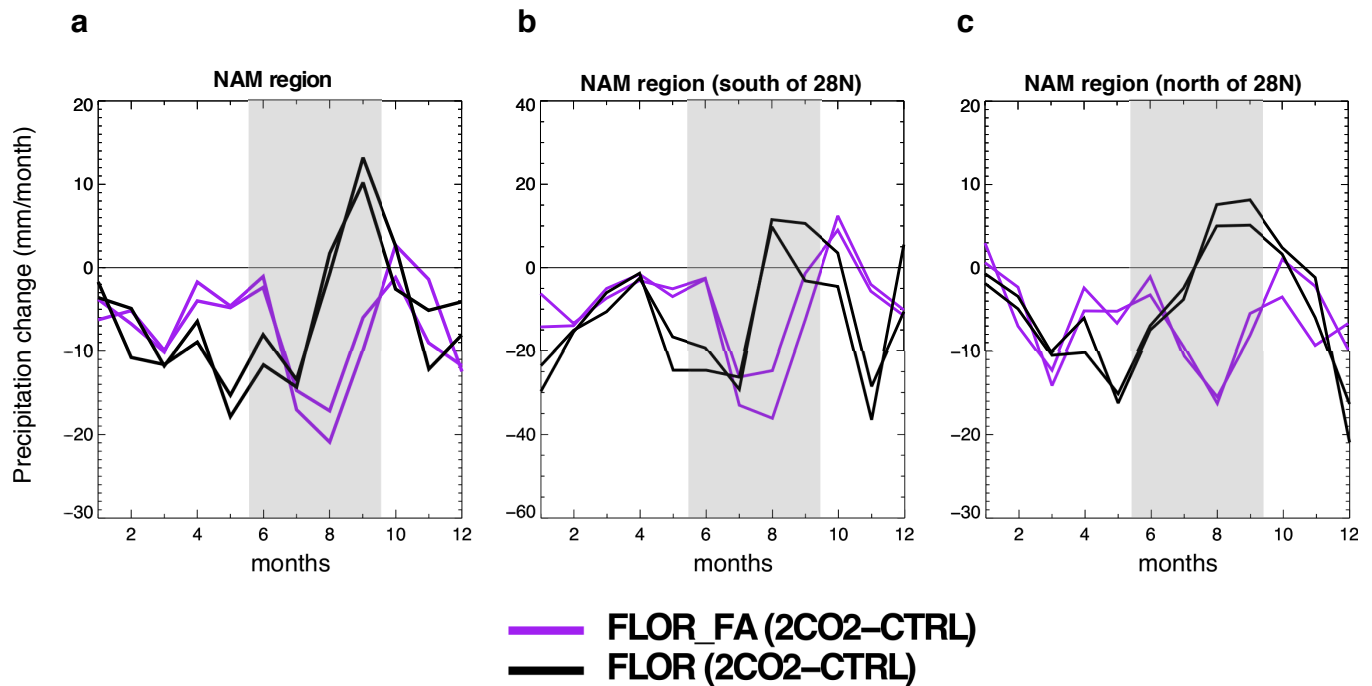
Supplementary Fig. 3: **Seasonal cycle of the low-level Gulf of California moisture flux.** Monthly area-averaged “alongshore” 925 hPa moisture flux in MERRA, LOAR, FLOR and FLOR-FA. Area-averaging is performed over the area encompassing the Gulf of California (shown in Supplementary Fig. 1). Lines denote the medians (over a 100-year period for models and 1979-2010 for MERRA) and green shading denotes the 25th-75th percentile in the MERRA reanalyses (a measure of the spread due to interannual variability).



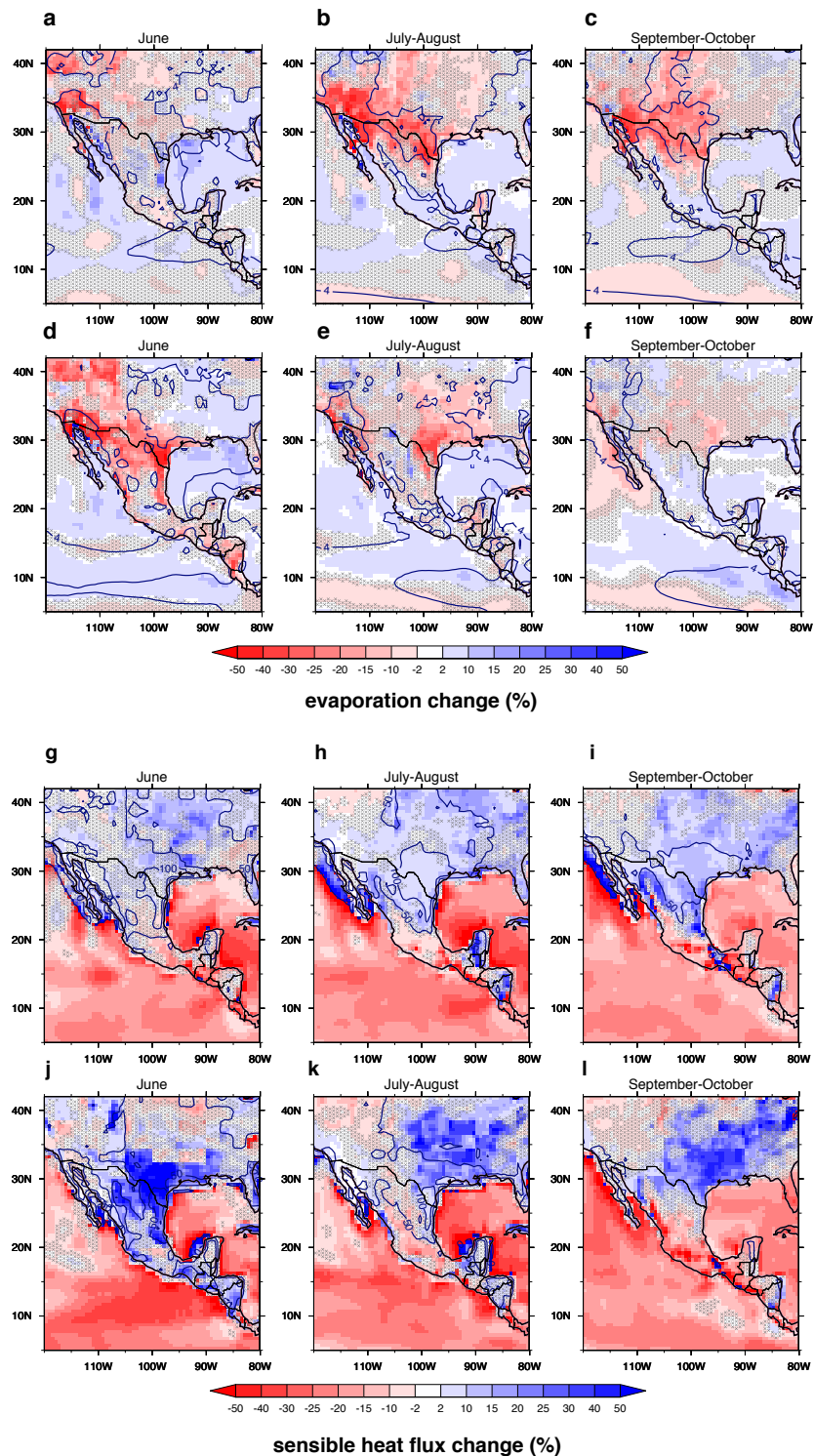
Supplementary Fig. 4: **Impact of flux adjustment on SSTs.** Difference between the climatological SSTs in FLOR (upper panels) and FLOR-FA (lower panels) relative to 1981-2010 HadISST.v1 SSTs [2] for **a** June, **b** July-August and **c** September-October.



Supplementary Fig. 5: **Modeled and observed GoC SST.** Annual cycle of GoC SST from observations (CFSR, purple line; 1979-2012) and FLOR-FA control run (black line). Shadings around the two lines quantify the respective interannual spread (10th-90th percentile) for each curve. The averaging region is shown in red in the inset map.



Supplementary Fig. 6: **Impact of increased CO₂ concentration and SST biases on the North American monsoon precipitation.** Monthly precipitation anomalies (mm/month) for **a** the NAM region, **b** the NAM region south of and **c** north of 28°N. Gray shading highlights the monsoon season.



Supplementary Fig. 7: **Impact of CO₂ forcing on evaporation and sensible heat fluxes.** **a-c**, Percent evaporation change (%; color shading) in FLOR-FA and **d-f**, FLOR due to CO₂ doubling (green contours denote climatologies in the respective control runs). **g-i**, and **j-l**, as in **a-f**, but for sensible heat flux. Stippling indicates regions where differences are not statistically significant at the 5% level on the basis of a t-test.

References

- [1] Castro C. L., H.-I. Chang, F. Dominguez, C. Carrillo, J.-K. Schemm, and H.-M. H. Juang. Can a regional climate model improve the ability to forecast the North American monsoon? *J. Climate*, 25:8212–8237, 2012.
- [2] Rayner N., D. E. Parker, E. Horton, C. Folland, L. Alexander, D. Rowell, E. Kent, and A. Kaplan. Global analyses of sea surface temperature, sea ice, and night marine air temperature since the late nineteenth century. *J. Geophys. Res.*, 108:4407, 2003.