

Introduction and approach

Biases in land-atmosphere coupling in climate models can contribute to large errors in climate prediction, but land models are rarely evaluated in the context of this coupling.

We tested land-atmosphere coupling and effects of land surface parameters in a single-column version of the NCAR Community Earth System Model (CESM1.2.2) and offline CLM4.5.

Results

Fig. 1 (right) The correlation between LAI and EF was substantially underpredicted compared to observations, while the correlation between soil moisture and EF was overpredicted by CLM4.5. This coupling was improved by prescribing observed LAI, increasing soil and decreasing vegetation resistances to evapotranspiration (ET), and increasing leaf reflectance.

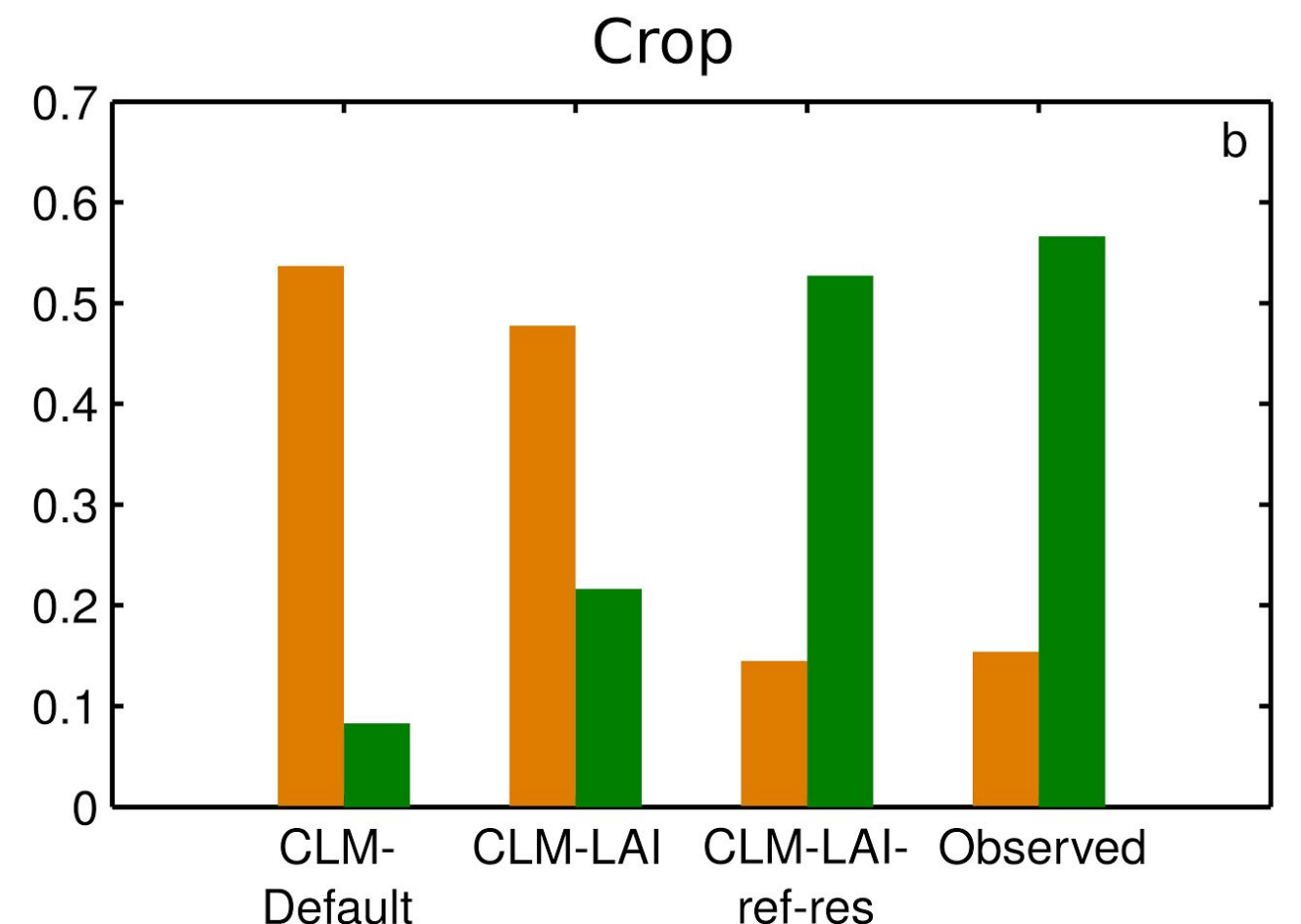
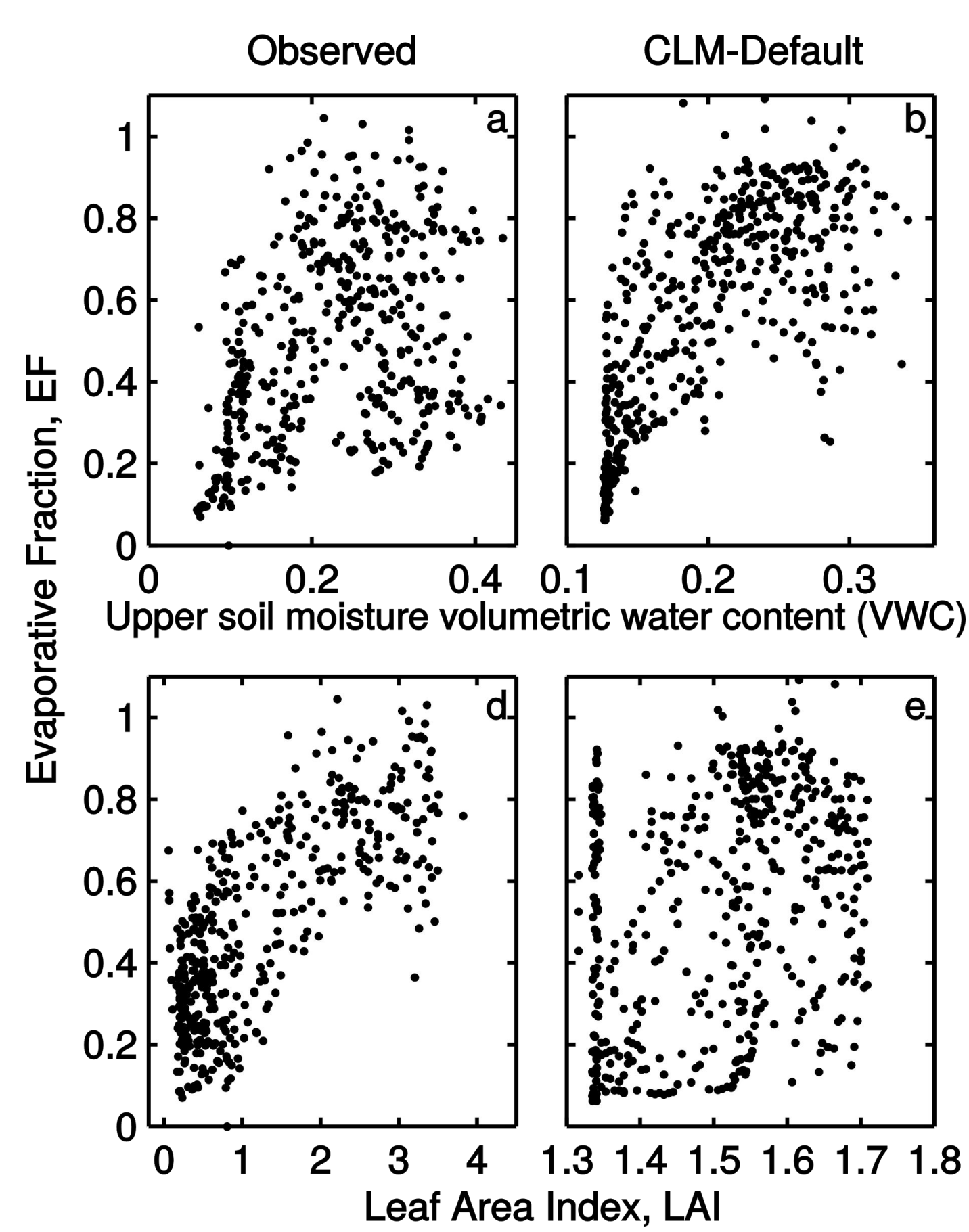
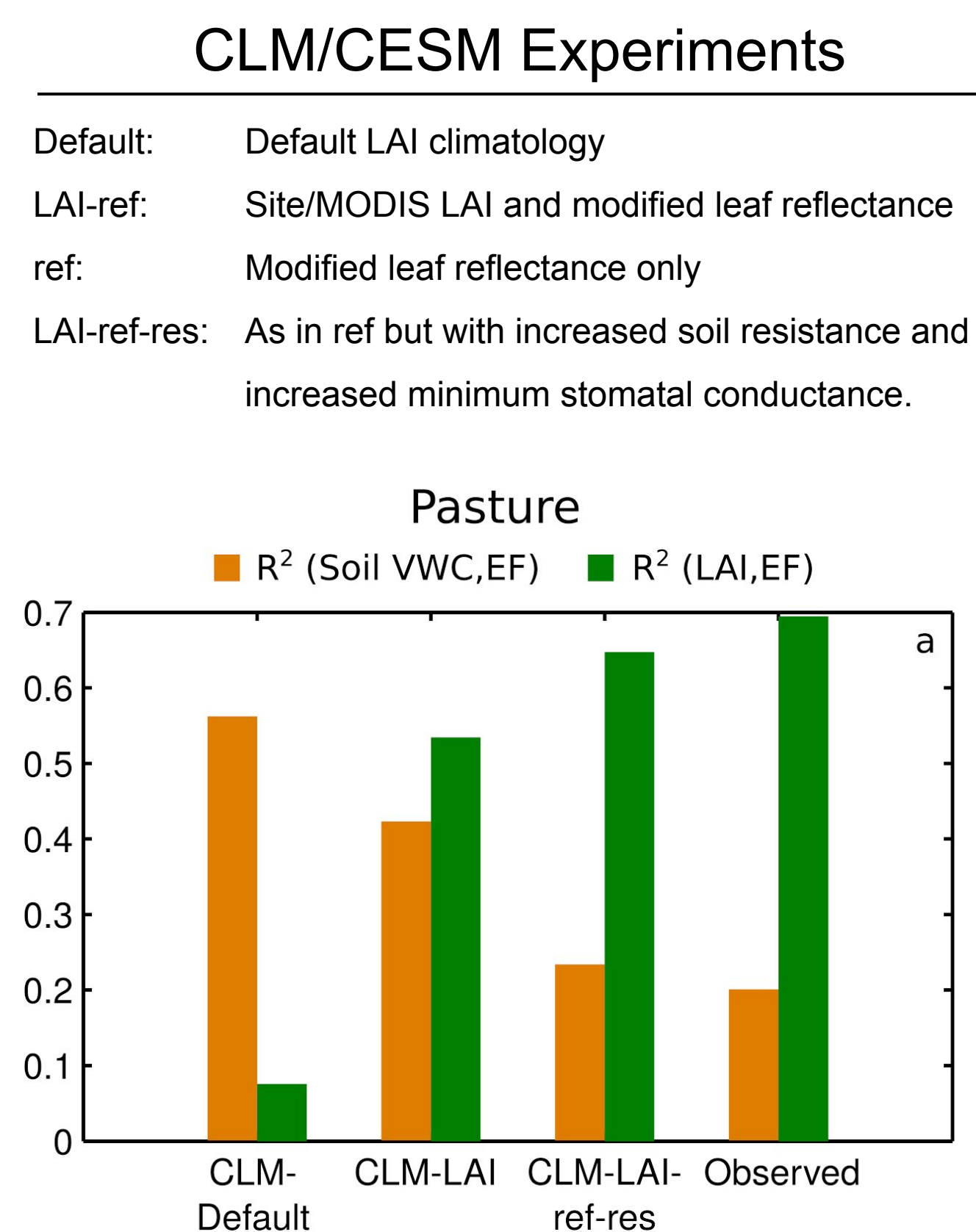


Fig. 2 (left). Scatter diagrams of relationships between soil moisture and EF at the crop site in (a) observations and (b) default CLM; (d-e) as in (a-b) but for LAI and EF.

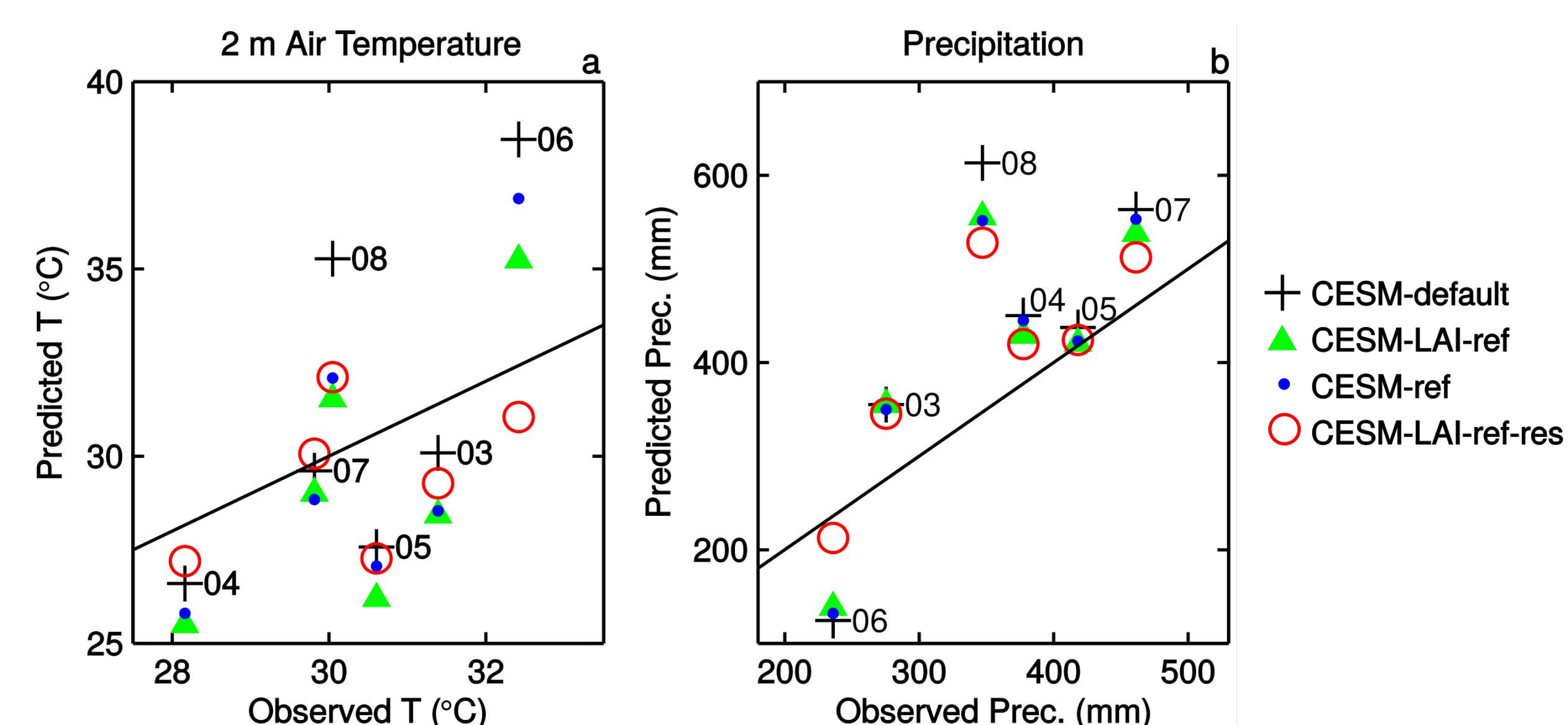


Fig. 3 (above): The modifications to CLM4.5 reduced RMSE in daytime 2 m air temperature from 3.6 to 2°C in summer (JJA), and reduced RMSE in total JJA precipitation from 133 to 84 mm.

The parameters had the largest effect on summer drought in 2006, when a warm bias in daytime 2 m air temperature was reduced from +6°C to -1.3°C, and a corresponding dry bias in total JJA precipitation was reduced from -111 mm to -23 mm.

Fig. 4 (below): Land parameter changes yielded similar climate prediction improvements regardless of the initialization date.

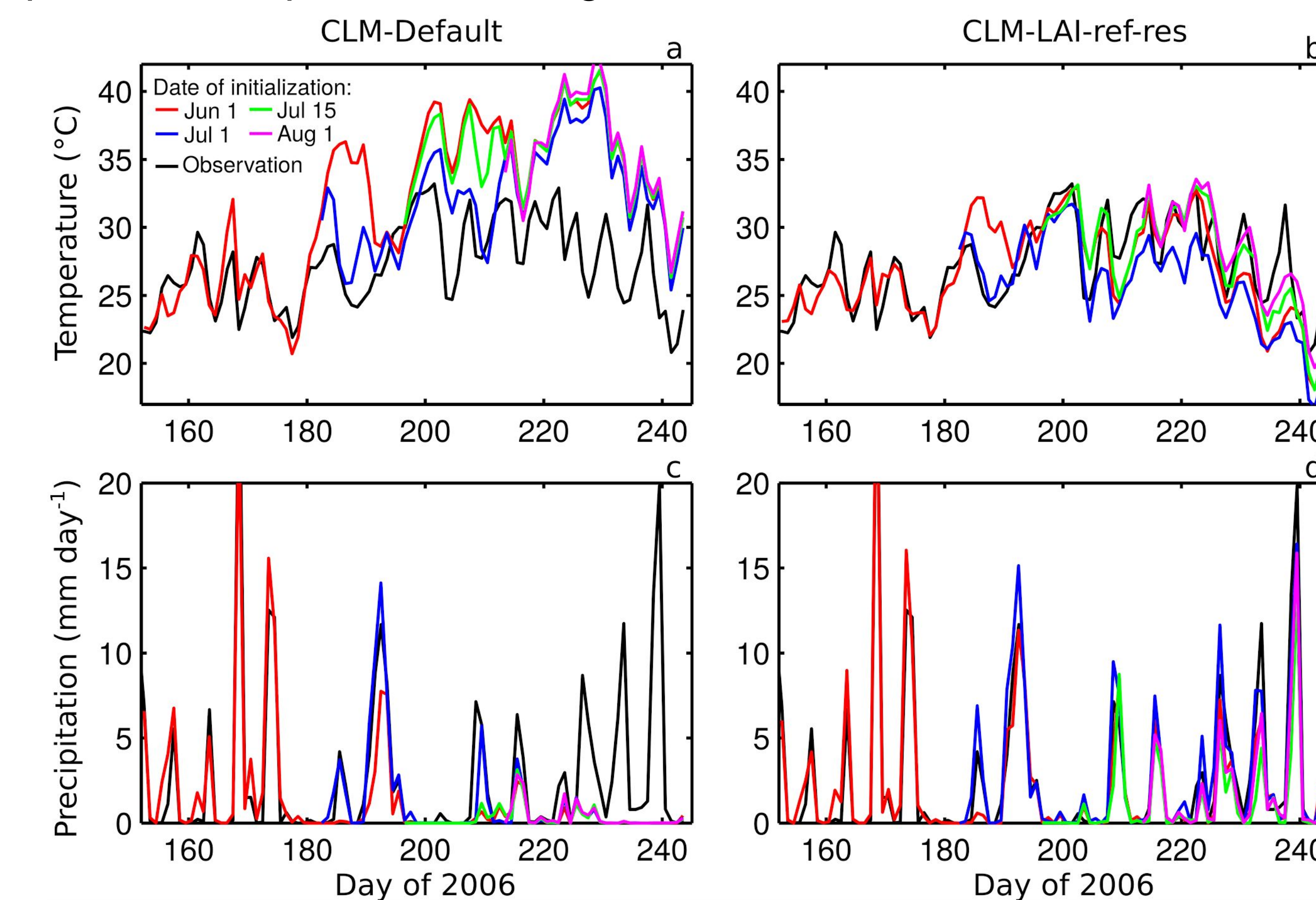
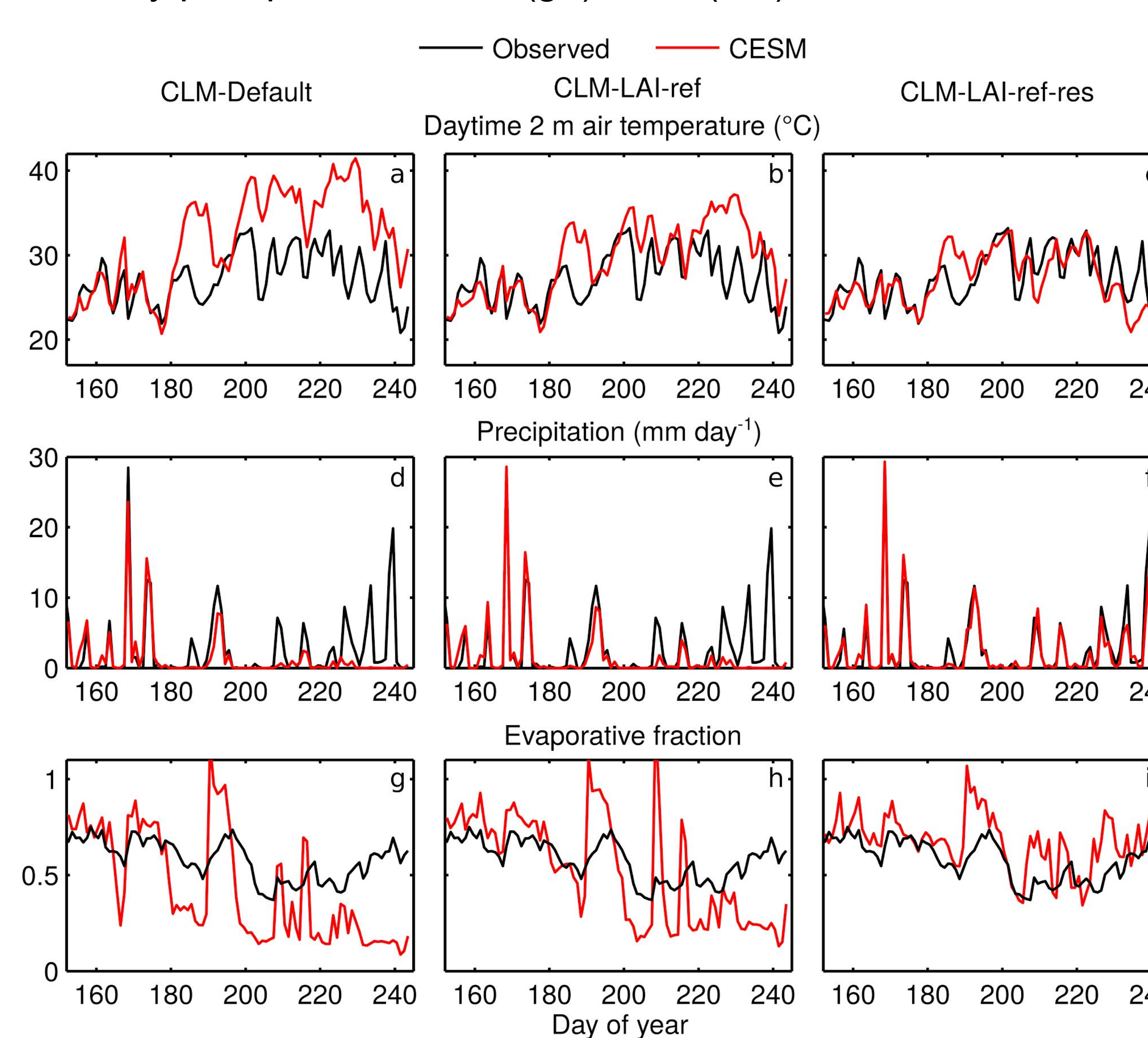


Fig. 5 (below). Daytime 2 m air temperature for JJA of 2006, for the three CESM experiments with (a) default CLM, (b) modified LAI and leaf reflectance, and (c) modified LAI, reflectance, stomatal conductance, and soil resistance. (d-f) As in (a-c), but for daily precipitation totals. (g-i) As in (a-c), but for EF.



The primary control on EF shifted from soil to vegetation between the default and modified CESM, and this change reduced the problem of excessively warm daytime temperatures in dry periods having depleted near-surface soil moisture. **These results indicate that the role of vegetation in droughts and heat waves may be underpredicted, and improvements in land models can improve prediction of climate extremes.**

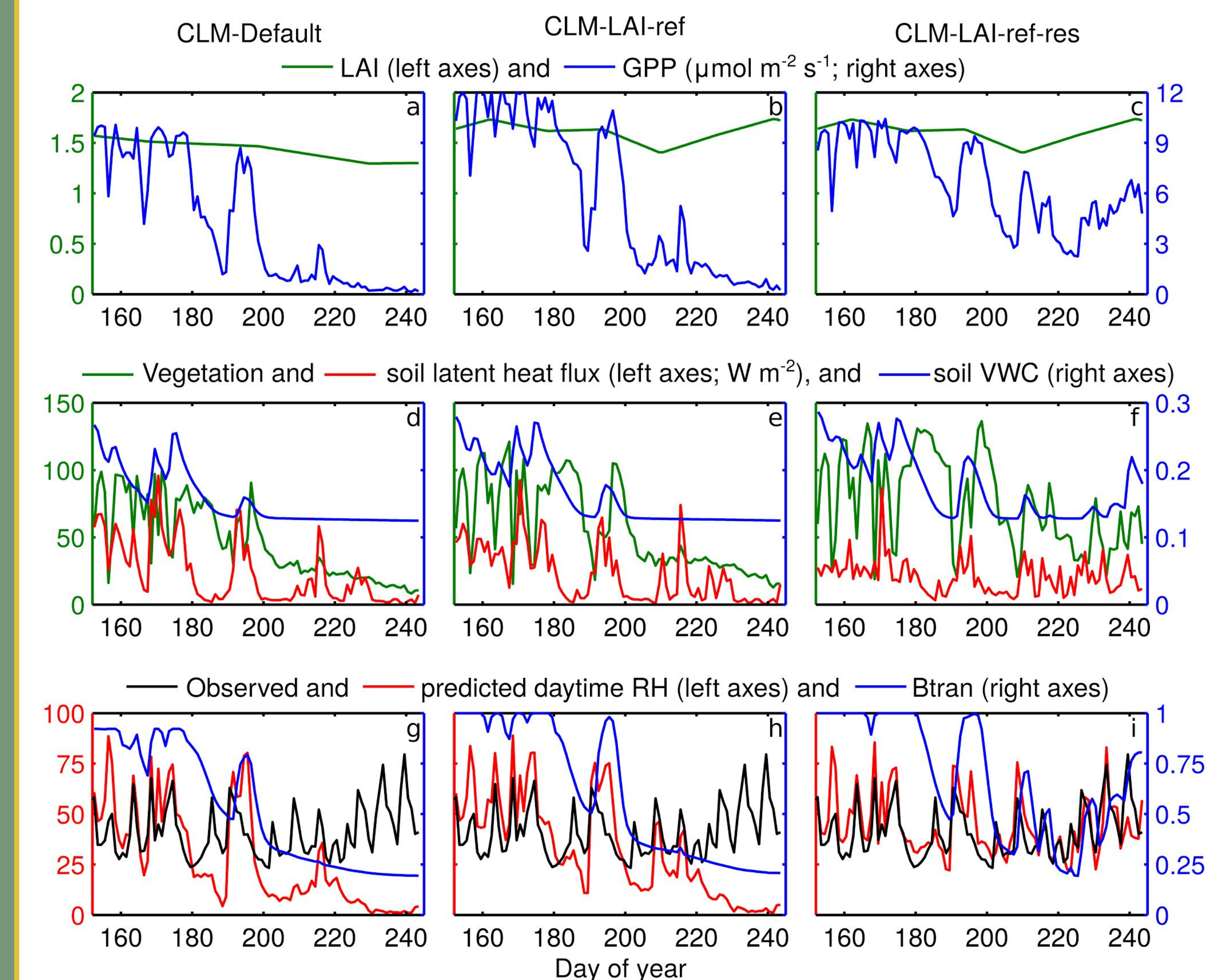
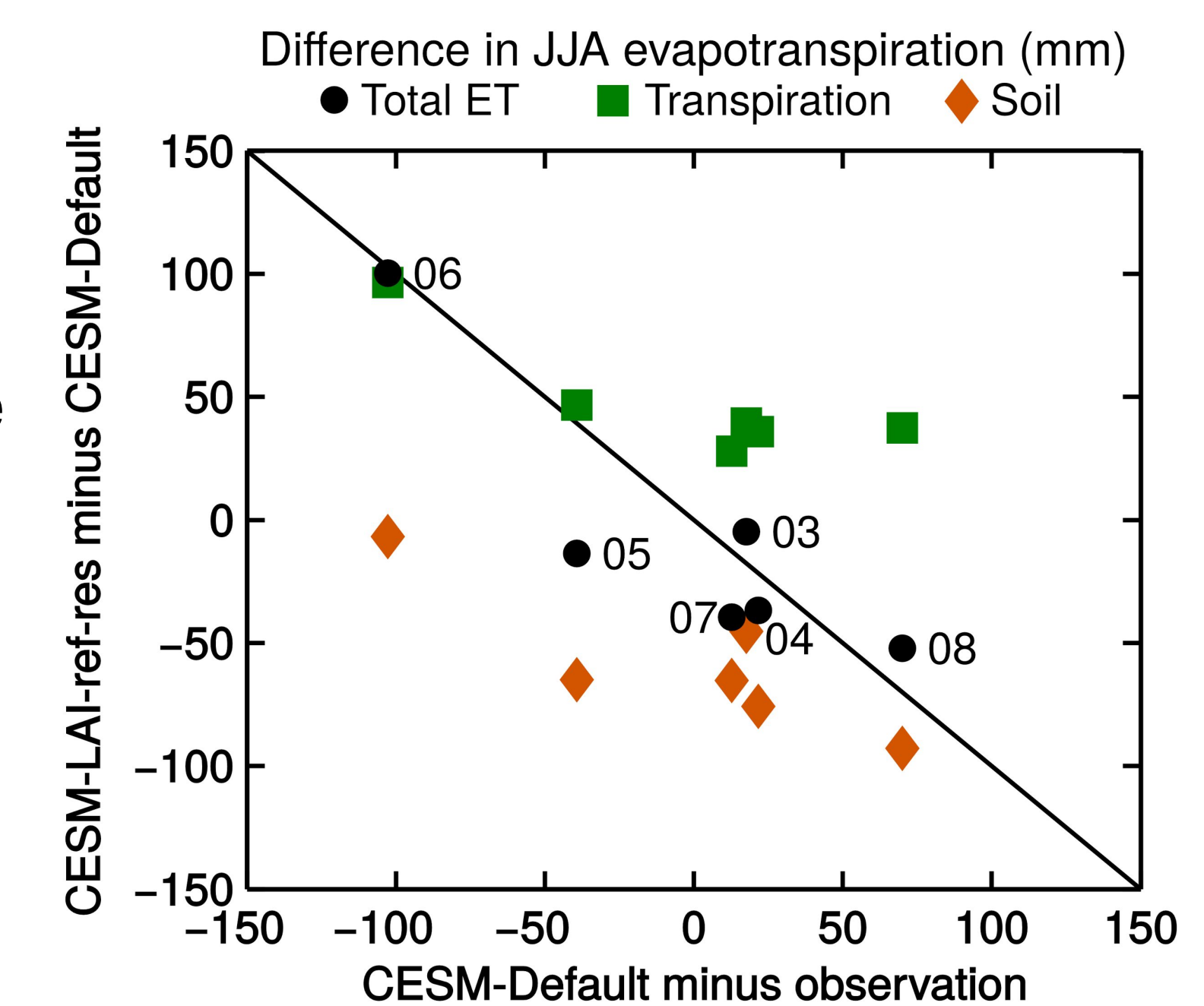


Fig. 6: The modified CLM increased vegetation latent heat flux, which led to higher relative humidity and a feedback on soil moisture that led to higher soil latent heat flux.

Fig. 7 (right): The modified CESM1.2.2/CLM4.5 increased transpiration more than it decreased soil evaporation when ET was underpredicted (e.g. 2006), and conversely when ET was overpredicted.



Conclusions

Summer climate prediction is significantly influenced by the representation of land surface forcing in a single-column version of CESM1.2.2. Seasonal climate extremes were affected by the partitioning of ET into soil evaporation and transpiration, and by how this partitioning changes in wet and dry summers. Increasing the soil resistance to evaporation and increasing the minimum stomatal conductance greatly improved modeled land-atmosphere coupling, and had a positive impact on summer precipitation and surface temperature prediction.

References and acknowledgments

Williams, I. N., and M. S. Torn (2015), Vegetation controls on surface heat flux partitioning, and land-atmosphere coupling, *Geophys. Res. Lett.*, **42**(21), 9416–9424.

Williams, I.N., Y. Lu, L.M. Kueppers, W.J. Riley, S.C. Biraud, J.E. Bagley, M.S. Torn (under review for *JGR Atmospheres*), Land-atmosphere coupling and climate prediction over the U.S. Southern Great Plains.

Data for the SGP sites were obtained from arm.gov, from the following data streams: sgp30co2flx4mmetC1.b1, sgp30baebbrE13.c1, sgp30swatsE13.b1, sgp30pmfrsC1.b1, sgp30pmfrsE13.b1, and sgp30varanarucC1.c1. This material is based upon work supported by the U.S. Department of Energy, Office of Science, Office of Biological and Environmental Research, Atmospheric System Research and Atmospheric Radiation Management Programs, under contract number DE-AC02-05CH11231.