Impact of Soil Moisture-Atmosphere Interactions on Surface Climate Variability

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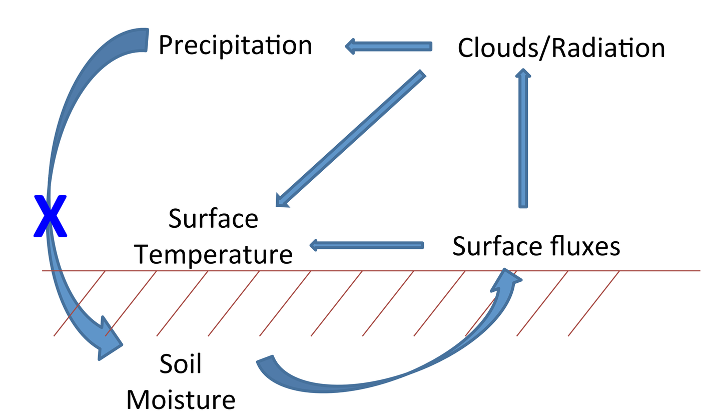
Take home: Soil moisture-atmosphere interactions strongly impact the shape of the temperature PDF over land in summer, and induce a coupling between temperature and precipitation from interannual to multi-decadal timescales.

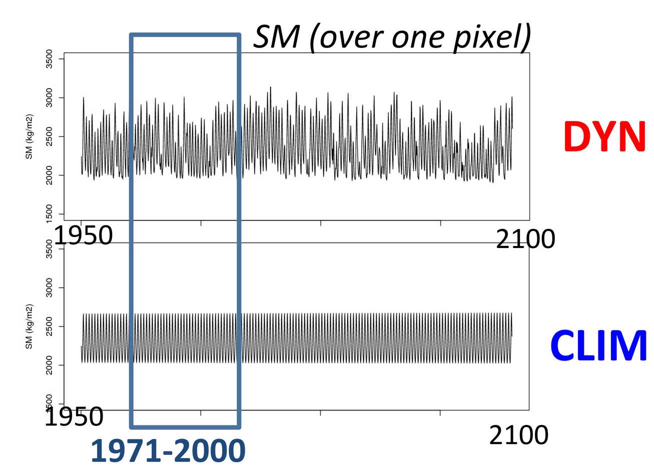
Motivation

- Improved projections of climate change and impacts requires understanding the link between climate PDFs and physical processes, as well as the coupling between different climate variables.
- Prior studies have shown soil moisture (SM)-atmosphere interactions impact surface mean climate and variability.
- Here, we further evaluate the role of SM-atmosphere interactions on the PDF of surface temperatures, as well as on the physical coupling between temperature and precipitation.

Methods

We compare simulations from GFDL's ESM2M model with interactive and prescribed soil moisture, performed for the multi-model experiment GLACE-CMIP5 *(Seneviratne et al. 2013)*.





Impact of soil moisture-atmosphere interactions on surface temperature distribution

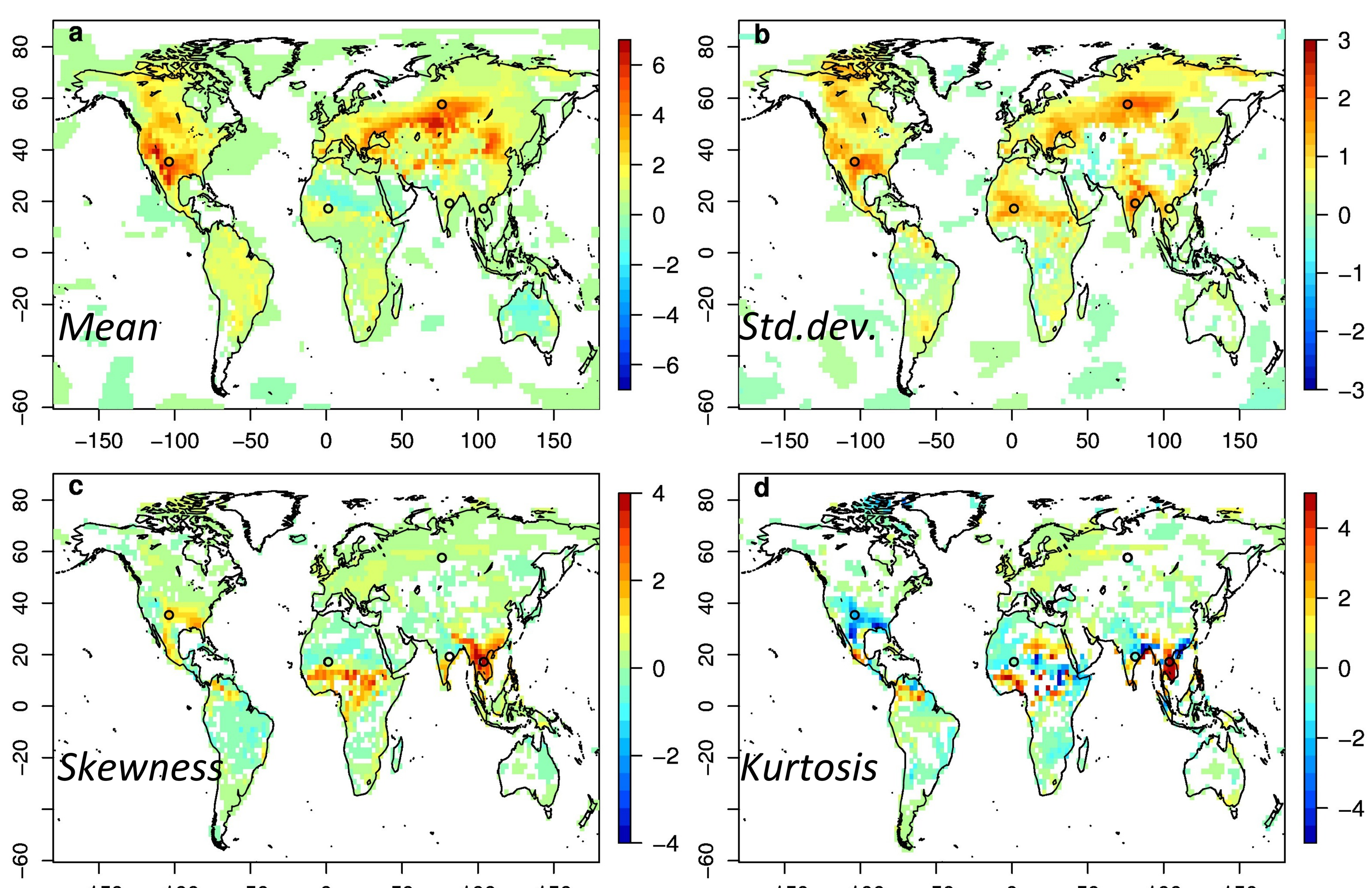


Fig.1: Difference of the four first moments of the distribution of daily JJA 2-m temperature between simulations DYN and CLIM (DYN minus CLIM) over 1971-2000 (Berg et al., in rev.).

- Beyond mean and variance, PDF shape is also impacted by SM-atmosphere interactions *(Fig.1)*.
- Moments are differently affected over different regions *(Fig.1)*.
- High-side of the temperature PDF is mostly affected *(Fig.2)*.
- Regional differences are explained by differences in local hydroclimate, thus differences between climatological and interactive SM, and subsequent impacts on surface fluxes *(Fig.2)*.

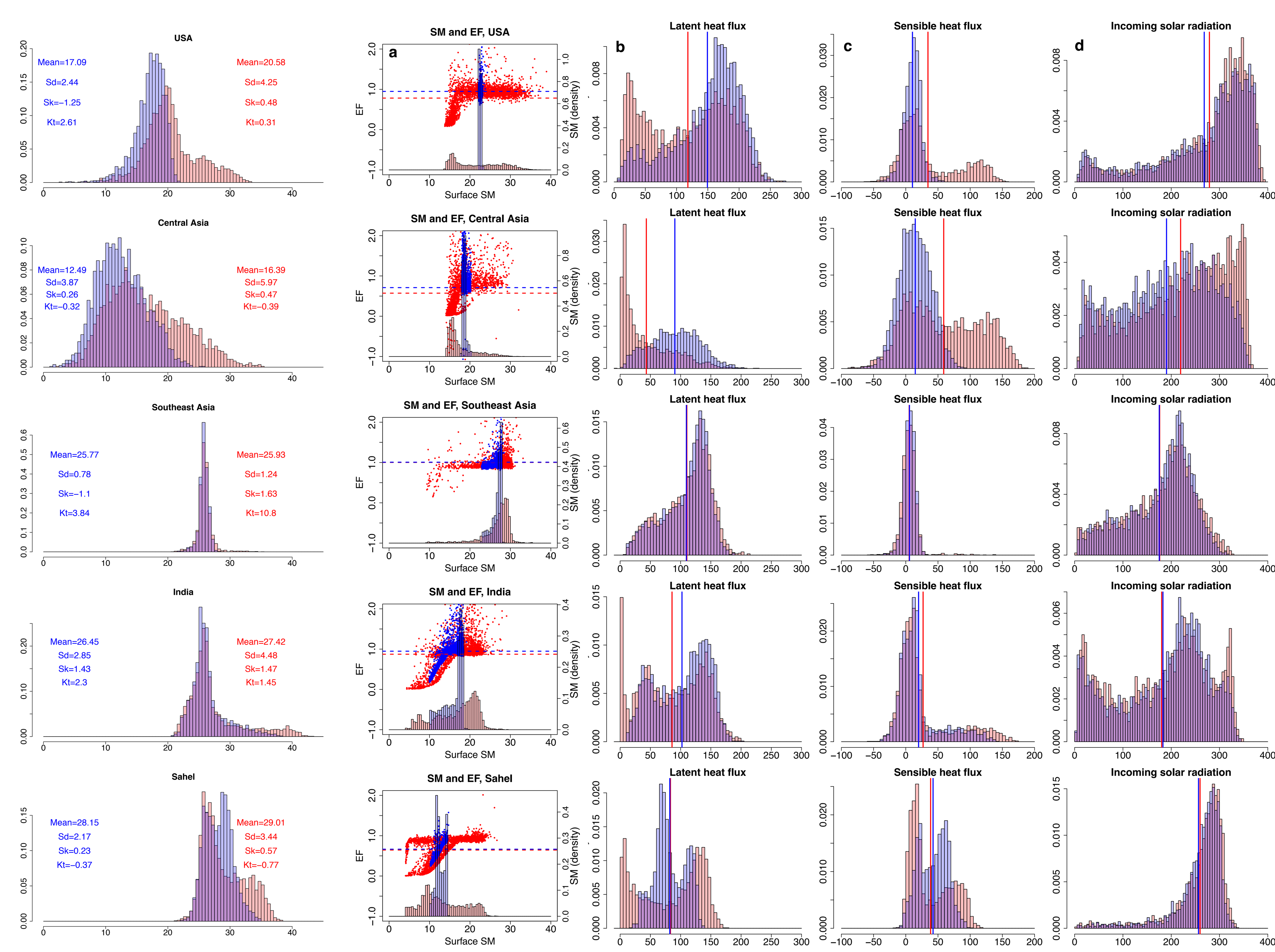


Fig.2: Distribution of daily 2-m temperature, EF and soil moisture, latent and sensible flux, and incoming shortwave radiation, in JJA over 1971-2000 in DYN and CLIM, over five representative points.

Impact of soil moisture-atmosphere interactions on temperature-precipitation coupling

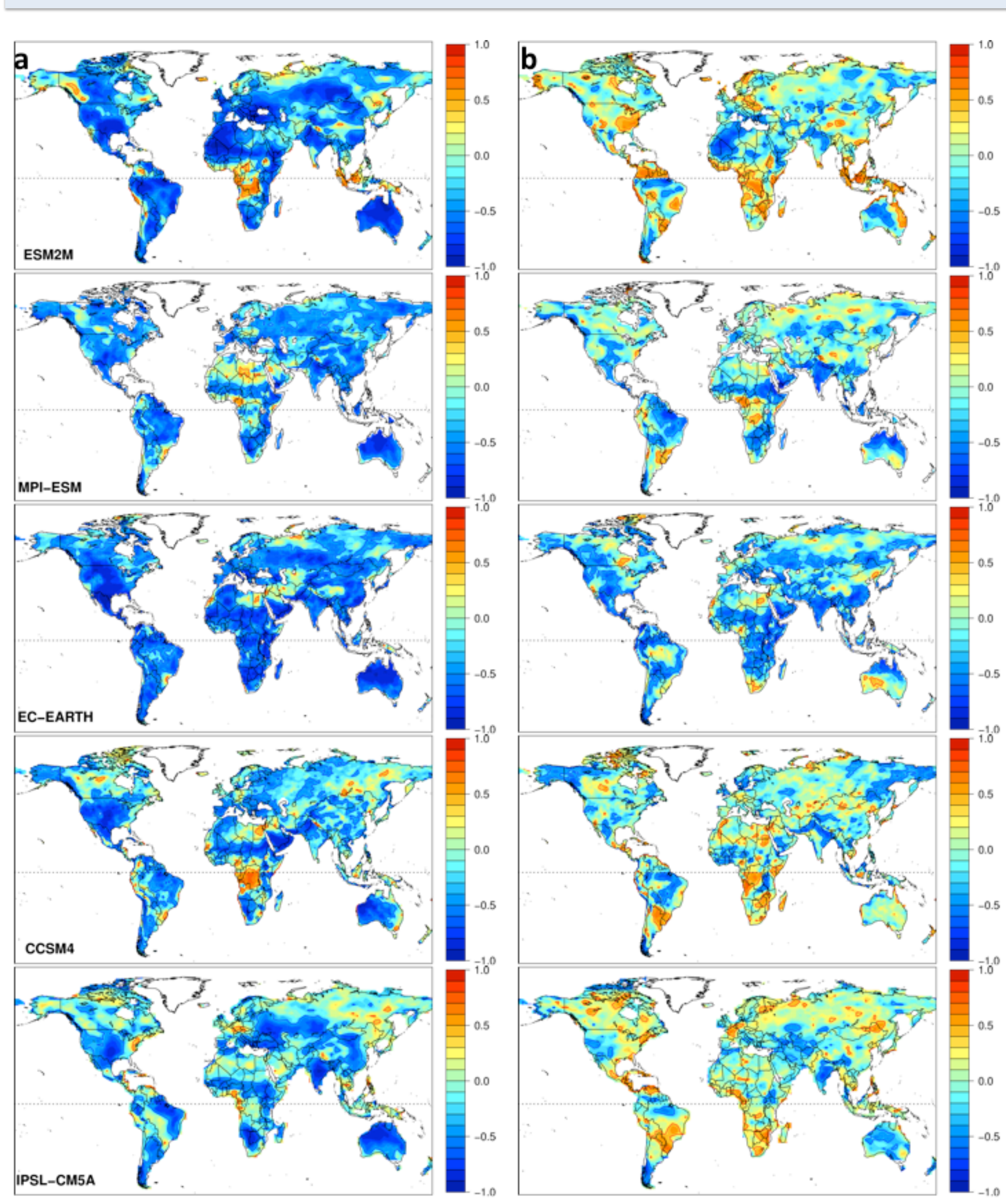


*Fig.3: Interannual correlation between summertime-mean T and P over 1971-2000 over land, in DYN (**a**) and CLIM (**b**), for the different GLACE-CMIP5 models (Berg et al., subm.).*

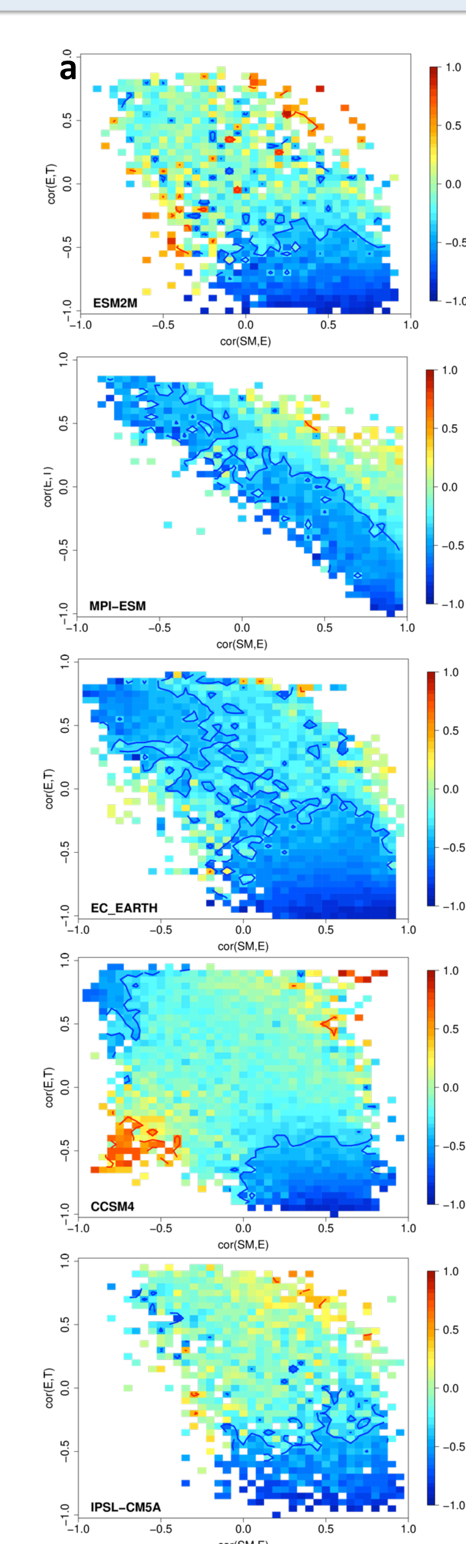


Fig.4: T-P correlation in DYN, binned as a function of SM-E and E-T correlations

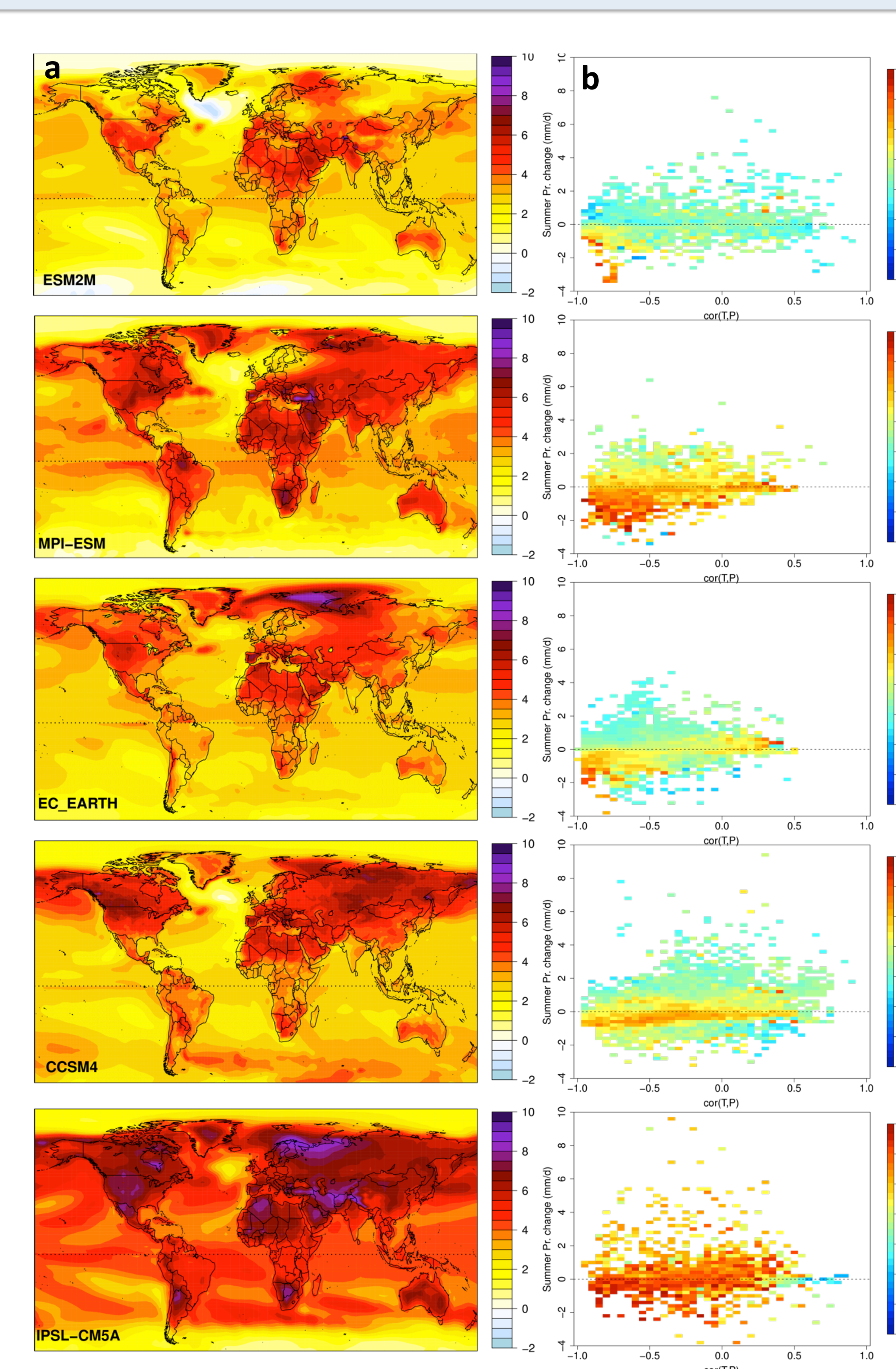


*Fig.5:(**a**) Mean summer T change between 1971-2000 and 2071-2100, in DYN; (**b**) (**a**) as a function of present-time T-P correlations and mean summertime P change, over land.*

- Negative interannual correlations between summertime T and P over land arise largely as a result of soil moisture -atmosphere interactions *(Fig.3)*.
- Yet in some models, atmospheric processes contribute as well *(Fig.3 and 4)*.
- Through soil moisture – atmosphere interactions, projected precipitation changes modulate regional warming *(Fig.5)*.

References

Seneviratne et al., 2013: Impact of soil moisture-climate feedbacks on CMIP5 projections: First results from the GLACE-CMIP5 experiment. *Geophys. Res. Lett.*, **40**, 5212-5217

Berg et al. , in rev. for J.Climate.: Impact of soil moisture-atmosphere interactions on surface temperature distribution

Berg et al. , subm. to J.Climate : Interannual coupling between summertime surface temperature and precipitation: processes and implications for climate change