Assessing Climate Change Risks Using a Multi-Model Approach: Equal Weighting Versus Weighting by Performance

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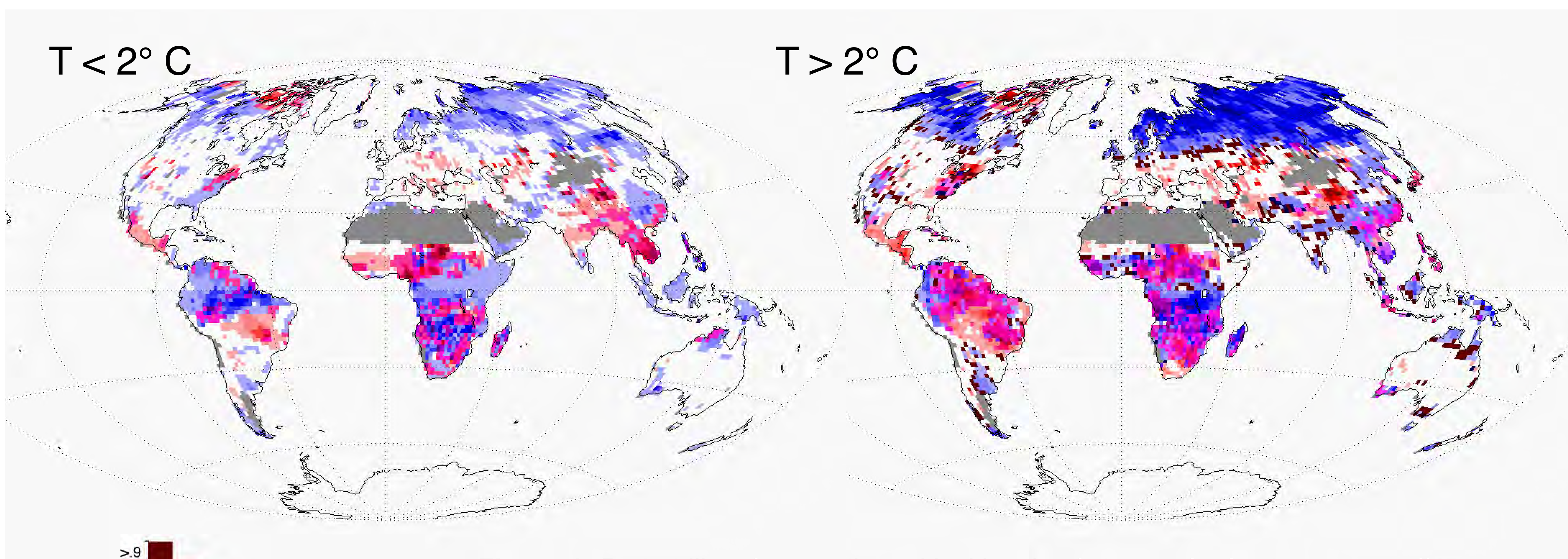
Quantifying and Understanding the Earth System



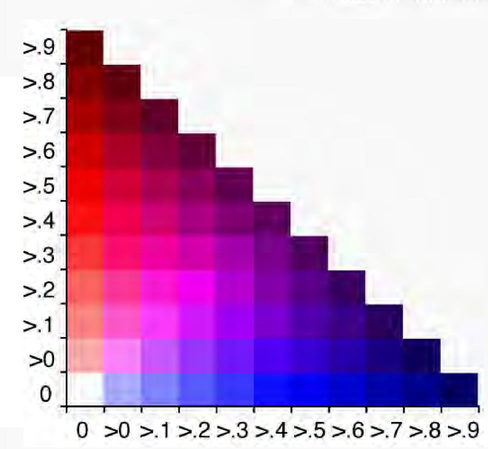


Figure 1: Probability of exceeding critical levels of change for freshwater runoff between 1961–1990 and 2071–2100 for two levels of global warming. Critical change is defined where the change in the mean of 2071–2100 exceeds 1σ of the observed (1961 –1990) interannual variability. Blue for increase, red for decrease; mixed colours show cases where different runs produce changes in opposite directions, i.e., there are runs of both exceeding the critical level by +1σ as well as by -1σ). Gray areas denote grid cells with <10 mm/yr mean runoff for 1961–1990.

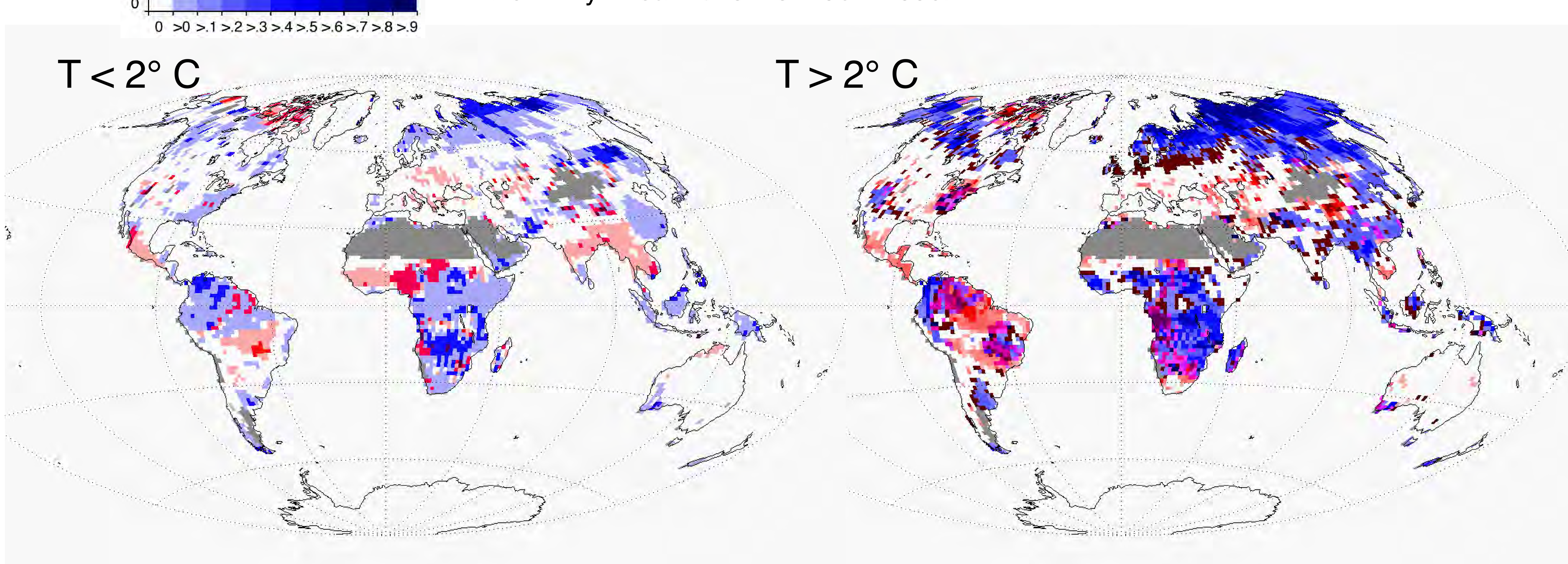


Figure 2: As Figure 1 but only output from climate models which lie within 1-σ envelope of observed NIÑO3 sea surface temperature anomaly for warm events (grey area in Figure 3) is used for forcing LPJ (in this case here HadCM3, CCSM, PCM).

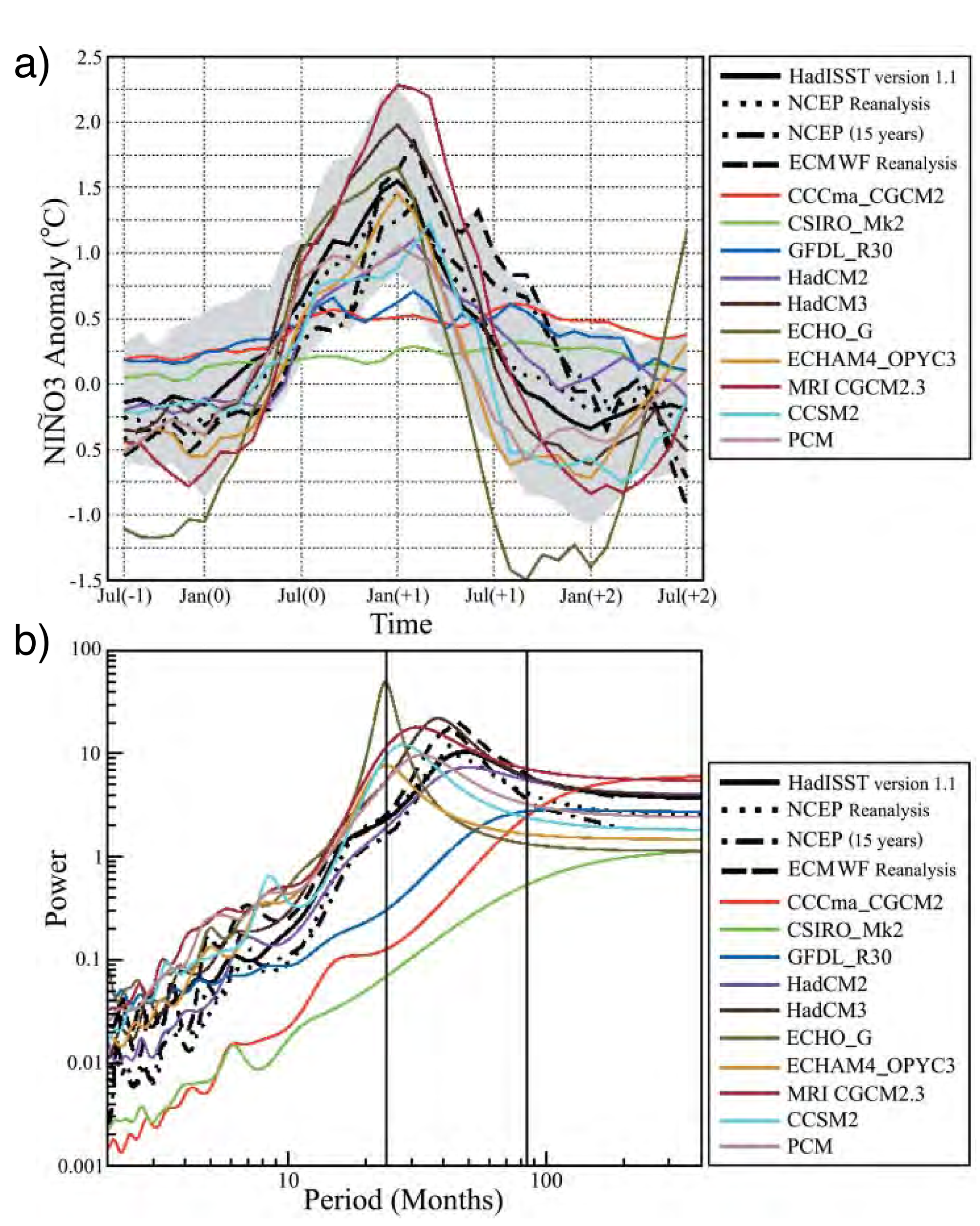


Figure 3: Aspects of climate model simulations of the ENSO compared with observation-based estimates. a) The evolution of the surface air temperature anomaly in the NIÑO3 region (5°S–5°N and 150°W–90°W). The shaded area represents the 1-σ envelope of the observed NIÑO3 sea surface temperature anomaly for warm events in the HadISST 1.1 data set. b) The maximum entropy power spectra calculated from the climate model monthly mean surface air temperature anomalies compared to HadISST1.1 sea surface temperature anomalies for the NIÑO3 region. From Phillips et al., 2006.

Background

Multi-model approaches to quantify climate induced risks for future changes in extreme events of key ecosystem processes such as freshwater runoff exhibit substantial uncertainties as has been demonstrated by Scholze et al., 2006. Often, the different models do not even agree on the sign of the change in the extremes for certain regions. The reasons for this being the different response of the various climate models to the applied greenhouse gas forcing. Scholze et al., 2006, have used output from 16 different climate models and they did not assign weights to the models for their risk analysis.

Approach

We use output from six climate models (CCCma, CSIRO, HadCM3, MRI, CCSM, PCM) to force the dynamic global vegetation model LPJ with multiple scenarios and map the proportions of model runs showing exceedance of natural variability in freshwater runoff (if the mean at the end of this century lies outside of 1-σ bound for 1961–1990). Our analysis does not assign probabilities to scenarios. Instead, we consider the distribution of outcomes within two sets of model runs grouped according to the amount of global warming they simulate: <2° C and >2° C. We are contrasting two different methods for calculating the risks: first, equal weighting, and second, weighting the models according to their ability to reproduce current climate phenomena such as ENSO (see Figure 3 taken from Phillips et al., 2006). As a first step we give the models lying outside the grey shaded are a weight of zero.

Results

Fig. 1 shows risks for a change in runoff as a composition of results from six climate models equally weighted. In Fig. 2 the models have been weighted using a δ-function such that the composition is only made out of three models. The appearance of mixed colours is much less in Fig. 2 suggesting that the three models agree much better in the direction of change. We applied the most rigorous weighting and only based it on one aspect of the climate system, however, there is a clear need for a standard metric (based on a whole range of climate indices, ideally also including paleo climate regimes) to assess and accordingly weight climate models for use in multi-model ensembles.

References

Scholze, M., W. Knorr, N. Arnell and I.C. Prentice, 2006. A climate-change risk analysis for world ecosystems: *PNAS* 103, 13116–13120.

Phillips, T. J., K. Achutarao, D. Bader, C. Covey et al., 2006.Coupled Climate Model Appraisal: A Benchmark for Future Studies: *EOS* 87, No. 19.

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