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Climate Change Projections for Switzerland: A Bayesian multi-model Combination using ENSEMBLES Regional Climate Models

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Given that future climate projections are necessarily based on a finite number of climate models, it remains one of the key challenges to quantify the uncertainty range of the projections obtained. Ideally, the model projections should sample the whole cascade of uncertainties, ranging from emission uncertainty over uncertainties about physical process understanding and model formulations down to internal variability. However, this goal can at present hardly be achieved due to a range of conceptual and computational limitations (e.g. the quantification of the "unknown unknowns" of the climate system). Any uncertainty estimate obtained is therefore necessarily conditioned on an array of unprovable assumptions (e.g. assumptions concerning the future behaviour of systematic model biases). To treat this kind of conditional uncertainty, a Bayesian framework is particularly appealing, since it allows decomposing the complex interrelationships between observations, model projections and unavoidable (subjective) prior assumptions in a systematic and transparent way.

Here, we discuss the recently developed Bayesian multi-model combination algorithm of Buser et al. (2009) with regard to its applicability for regional climate scenarios of temperature and precipitation at the example of Switzerland. The Bayesian algorithm not only considers changes of the mean signal and of the interannual variability, but also explicitly treats systematic model biases, and allows for bias changes between the control and scenario periods. We have extended the algorithm such that also internal decadal variability is considered. Due to an unavoidable identifyability problem between the mean climate change signal and model projection uncertainty, an informative prior needs to be set.

In this presentation, we discuss a pragmatic approach to specify this prior, as well as other key assumptions, using ENSEMBLES regional climate model (RCM) projections driven by general circulation models (GCMs) over 1950 to 2050 and beyond. Projection uncertainty is thereby estimated separately both for the RCMs and the driving GCMs for different lead times. It turns out that total projection uncertainty is generally dominated by the uncertainties stemming from the driving GCMs. The exception is summer precipitation where RCM uncertainty is of comparable magnitude. The relative contribution of internal decadal variability is substantial at short lead-times of a few decades, particularly for precipitation, but decreases towards the end of the century. Feeding all these prior estimates into the Bayesian algorithm, and explicitly considering internal variability, probabilistic projections are obtained for Switzerland. Under the A1B emission scenario, the projections indicate a significant increase of seasonal mean temperature of 3.3-4.7°C by 2085, depending on region and season, and a decrease of summer mean precipitation of 20-27%.