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An error model for GCM precipitation and temperature simulations

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Water resources assessments for future climates require meaningful simulations of likely precipitation and evaporation for simulation of flow and derived quantities of interest. The current approach for making such assessments involve using simulations from one or a handful of General Circulation Models (GCMs), for usually one assumed future greenhouse gas emission scenario, deriving associated flows and the planning or design attributes required, and using these as the basis of any planning or design that is needed. An assumption that is implicit in this approach is that the single or multiple simulations being considered are representative of what is likely to occur in the future. Is this a reasonable assumption to make and use in designing future water resources infrastructure? Is the uncertainty in the simulations captured through this process a real reflection of the likely uncertainty, even though a handful of GCMs are considered? Can one, instead, develop a measure of this uncertainty for a given GCM simulation for all variables in space and time, and use this information as the basis of water resources planning (similar to using "input uncertainty" in rainfall-runoff modelling)? These are some of the questions we address in course of this presentation.

We present here a new basis for assigning a measure of uncertainty to GCM simulations of precipitation and temperature. Unlike other alternatives which assess overall GCM uncertainty, our approach leads to a unique measure of uncertainty in the variable of interest for each simulated value in space and time. We refer to this as an error model of GCM precipitation and temperature simulations, to allow a complete assessment of the merits or demerits associated with future infrastructure options being considered, or mitigation plans being devised. The presented error model quantifies the error variance of GCM monthly precipitation and temperature, and reports it as the Square Root Error Variance (SREV), equivalent to the error standard deviation of the simulated value. The SREV is derived taking into account the model structural, the emission scenario, and the initial condition uncertainty of the simulated value, the full error model being formulated using six GCMs (from the Coupled Model Inter-comparison Project phase 3 (CMIP3) multi-model dataset); three emission scenarios (B1, A1B and A2) and three ensemble runs, with a total of 54 time series representing the period 2001 to 2099.

The results reveal that model uncertainty is the main source of error followed by scenario uncertainty. For precipitation, total uncertainty is larger in the tropical region close to the equator and reduces towards the north and south poles. The opposite is true for temperature where uncertainty is larger in the north and south poles than tropical region. Time series of global and regional mean SREV results suggest that scenario uncertainty slightly increases in the future because of divergences of the three scenarios. This increase is more pronounced for temperature than precipitation. The quantified SREV together with GCMs predictions can be used to minimise bias in parameter estimation of impact models using frameworks that are already available for this purpose.