Robust adaptation decisions amid climate change uncertainties

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Abstract

Projections of future climate change are plagued with uncertainties, which cause difficulties for planners taking decisions on adaptation measures. This thesis presents an interdisciplinary framework that allows the identification of adaptation strategies that are robust (i.e. insensitive) to climate change uncertainties. A range of tools and methods are used to explicitly quantify uncertainties in climate change projections. These include scenario analysis, Monte Carlo simulations and the pattern-scaling technique applied to simple and complex climate models.

The framework is applied to a case study of water resources management in the East of England, more specifically to the Anglian Water Services' 25 year Water Resource Plan (WRP). The institutional setting where adaptation decisions occur is explained. Adaptation options are elicited from decision-makers and linked to changes in the climate. Three sets of analyses are performed on the framework: (1) sensitivity analysis determines which are the most influential variables of the framework from an adaptation perspective; (2) uncertainty analysis assesses whether currently planned adaptation strategies are robust against climate change uncertainties, assuming risks can be quantified; and (3) robustness analysis assesses adaptation strategies against climate change and other uncertainties, assuming the uncertainties cannot be quantified using probabilities.

Water resources are found to be sensitive to uncertainties in regional climate response from General Circulation Models and dynamical downscaling, in climate sensitivity and in climate impacts. Aerosol forcing and greenhouse gas emissions uncertainties are also important, whereas uncertainties from sampling strategies, ocean mixing and the carbon cycle are not. The uncertainty analysis estimates the conditional probability of additional water required for two Water Resource Zones (WRZs) in the Anglian region. This is performed for the 2030s under the SRES A2 scenario and using the most skilled models. At the 95% confidence level the bounds of additional water required ranged from -6.67 to 26.34 Megalitres/day (Ml/d) for the East Suffolk & Essex (ES&E) WRZ and from -24.30 to 111.81 Ml/d for the Ruthamford WRZ. This represents an

uncertainty range of 33.01 Ml/d (33% of demand) for the ES&E WRZ and 136.11 Ml/d (39% of demand) for the Ruthamford WRZ.

Despite these large uncertainties, Anglian Water's WRP remains robust to the climate change uncertainties sampled because of the adaptation options being considered (e.g. new reservoirs) and because the climate model used for planning (HadCM3) predicts drier conditions than other models. According to the robustness analysis, the WRP is vulnerable to some combinations of uncertain factors (e.g., if very high climate sensitivity is combined with low aerosol forcing and large decreases of precipitation per degree of global warming). This suggests that the current WRP needs some adjustment for it to be robust to uncertainties. This research raises the question of how much certainty is required in climate change projections to justify investment in adaptation measures.