Geophysical Research Abstracts
Vol. 20, EGU2018-635, 2018
EGU General Assembly 2018

Future evolution and uncertainty of river flow signatures in a deglaciating river basin

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Downstream river flows from glaciated river basins are extremely sensitive to climate change due to strong atmosphere-hydrosphere-cryosphere coupling. As the climate warms, the loss of snow and ice and their unique water storage properties will bring about complex changes to river flow regimes by affecting the timing, magnitude, frequency and variability of flows. Glacio-hydrological models (GHMs) driven with future climate scenarios underpin our current understanding of river flow regime change in glaciated river basins. These projections are inherently uncertain due to imperfections in the numerical climate models and GHMs used to produce them. While most studies account for climate uncertainty, almost none taken account of GHM uncertainty. Furthermore, most studies to date have focussed on mean annual and monthly flows as the sole indicators of river flow regime change and none have accounted for the full range of regime changes which could have profound impacts on downstream human populations and fragile ecosystems. This study addresses both of these shortcomings by combining a multi-model ensemble of climate projections with a multi-model ensemble of GHM structures and parameterisations. The model ensemble chain is applied to the rapidly deglaciating Virkisá river basin in southern Iceland and used to project changes and uncertainties in 22 different 'signatures' of river flow regime which characterise the timing, magnitude, frequency and variability of flows. The results demonstrate that the predicted magnitude of change and the associated uncertainty varies across the signatures of river flow regime. Furthermore, by decomposing the total prediction uncertainty into a number of different sources stemming from the model ensemble chain, the results also show the significance of these sources and how these change across the river flow signatures.