Geophysical Research Abstracts
Vol. 18, EGU2016-6517, 2016
EGU General Assembly 2016

Global assessment of river flood protection benefits and corresponding residual risks under climate change

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Global warming increases the water-holding capacity of the atmosphere and this could lead to more intense rainfalls and possibly increasing natural hazards in the form of flooding in some regions. This implies that traditional practice of using historical hydrological records alone is somewhat limited for supporting long-term water infrastructure planning. This has motivated recent global scale studies to evaluate river flood risks (e.g., Hirabayashi et al., 2013, Arnell and Gosling, 2014, Sadoff et al., 2015) and adaptations benefits (e.g., Jongman et al., 2015). To support decision-making in river flood risk reduction, this study takes a further step to examine the benefits and corresponding residual risks for a range of flood protection levels. To do that, we channelled runoff information of a baseline period (forced by observed hydroclimate conditions) and each CMIP5 model (historic and future periods) into a global river routing model called CaMa-Flood (Yamazaki et al., 2011). We incorporated the latest global river width data (Yamazaki et al., 2014) into CaMa-Flood and simulate the river water depth at a spatial resolution of 15 min x 15 min. From the simulated results of baseline period, we use the annual maxima river water depth to fit the Gumbel distribution and prepare the return period-flood risk relationship (involving population and GDP). From the simulated results of CMIP5 model, we also used the annual maxima river water depth to obtain the Gumbel distribution and then estimate the exceedance probability (historic and future periods). We apply the return period-flood risk relationship (above) to the exceedance probability and evaluate the flood protection benefits. We quantify the corresponding residual risks using a mathematical approach that is consistent with the modelling structure of CaMa-Flood. Globally and regionally, we find that the benefits of flood protection level peak somewhere between 20 and 500 years; residual risks diminish substantially when flood protection level exceeds 20 years. These findings might be useful for decision-makers to weight the size of water infrastructure investment and emergency response capacity under climate change.

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