Validity of substituting flood and drought characteristics obtained from transient simulations to represent an equilibrium climate

*Julien Eric Boulange[1], Naota Hanasaki[1], Yusuke Satoh[1], Tokuta Yokohata[1], Hideo Shiogama[1], Peter Burek[2], Thiery Wim[3], Gerten Dieter[4,5], Hannes Müller Schmied[6,7], Yoshihide Wada[2], Simon Gosling[8], Yadu Pokhrel[9], Niko Wanders[10]

1. National Institute for Environmental Studies, 2. International Institute for Applied Systems Analysis (IIASA), 3. Vrije Universiteit Brussel, 4. Potsdam Institute for Climate Impact Research, 5. Humboldt-Universität zu Berlin, 6. Goethe University Frankfurt, 7. Senckenberg Leibniz Biodiversity and Climate Research Centre (SBiK-F), 8. University of Nottingham, 9. Michigan State University, 10. Utrecht University

The intensification of the hydrological cycle associated with climate change is anticipated to affect future floods and droughts. For moderate increase in global mean temperature (GMT, e.g. increase of 1.5°C and 2.0°C above pre-industrial levels), several studies reported that future floods and droughts are anticipated to transition from moderate to high risk.

However, because most climate scenarios either stabilise greenhouse gas concentrations over the 21st century or limit end-of-century radiative forcing to specific levels, this body of literature largely ignores conditions when the climate system is in equilibrium, stabilised at a given GMT. While some literature has affirmed the need to differentiate between transient and equilibrium climates when conducting climate change impact analyses, other studies have reported non- to marginal differences in climate change impacts between the two climates. It is therefore unclear whether the floods and droughts anticipated at low levels of global warming under a transient climate can systematically be substituted with those occurring in an equilibrated climate at the same temperature.

Here, we present a global evaluation of the characteristics of future floods and droughts for transient and equilibrium climates, respectively. The two 30-year periods representing the transient and quasi-equilibrium climates are selected so that their GMT are identical. Simulations from a pre-industrial climate with constant CO_2 concentration (286 ppm) are additionally used to reveal the effect of natural variability on our statistical analyses (control simulations).

River streamflow simulated globally (0.5°×0.5° spatial resolution) by seven global hydrological models (GHMs) and forced by bias-corrected climate projections from three global circulation model (GCMs) are used to evaluate the characteristics (intensity, duration, volume) of floods and droughts. Altogether, the simulations from 19 combinations of GHMs and GCMs, run using a common protocol under the Inter Sectoral Impact Model Inter comparison Project Phase 2b (ISIMIP2b), are used in this analysis.

Flood (drought) events were identified when daily streamflow was higher (lower) than a given threshold, for as long as the event continue, we recorded its duration (in days), volume (in km^3) and maximum intensity (in m^3/s). When two events were separated by less than 6 days, they were assumed to form a single event and their characteristics were combined.

In the large ensemble, significant differences between the intensity, duration, and volume of floods under transient and quasi-equilibrium climates were obtained, on average (±1 standard deviation), over 1.2 ± 1.7%, 0.9 ±1.2%, and 0.9 ±1.2% of the global land surface area, respectively. Likewise, significant differences in simulated intensity, duration, and volume of droughts under the two climates were obtained over 8.9 ±5.9, 6.4 ±5.7, and 1.3 ±1.2% of the global land surface, respectively. The control simulations revealed that the significant differences in flood characteristics observed between a transient and quasi-equilibrium climates may result from natural variability. In contrast, the global land surface area where significant differences in drought intensity were indicated between the transient and quasi-equilibrium climate exceeded that resulting from natural variability.

The inter-model agreement associated with the significant differences in flood and drought characteristics was computed. Since the inter-model agreement was *low* over the majority (<99.9%) of the global land surface, it can be inferred that, for relatively low level of global warming, the floods derived from a transient climate can be used to infer those occurring under an equilibrated climate. Between the transient and quasi-equilibrium climates, *medium* level of inter-model agreement for significant difference in drought intensity were obtained for 2.6% versus <0.1% of the global land surface area in control simulations. Therefore, for a small percentage of the global land surface, the drought intensity obtained in a transient climate may not substituted for those occurring in an equilibrium climate at the same GMT.

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