Magnitude of extreme indices for transient and stabilized climates

*Julien Eric Boulange[1], Naota Hanasaki[1]

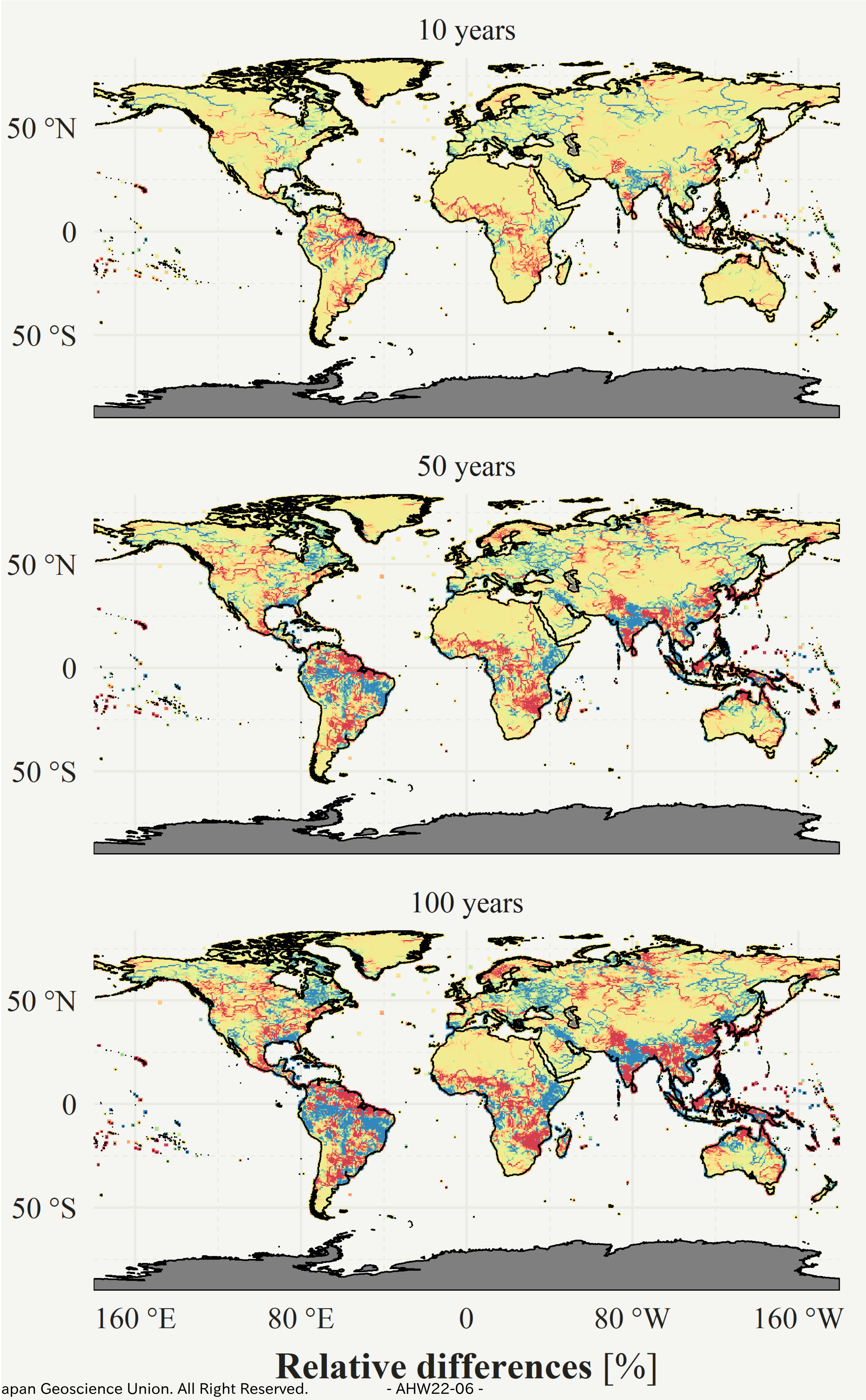
1. National Institute for Environmental Studies

Significant attention has been dedicated to evaluating the potential benefits of limiting global warming at various global temperature goals (Gosling et al., 2017) as alterations in the frequency and duration of both wet and dry events have direct repercussions on water supplies and water quality (Naz et al., 2018). Most of these studies considered time-slice periods (typically 30 years long) centered around the year when the global mean temperature of a given global circulation model (GCM) reaches a global temperature goal (e.g. +1.5 °C above pre-industrial levels). Then by extracted relevant variables for the given time-slice period, it possible to investigate the potential differences in the given variables for different warmer worlds. However, until recently, the GCMs available only spanned until the end of this century and, as a result, the above-mentioned studies faced two shortcomings: (1) the time-slice periods frequently overlapped when comparing specific global temperature goals (e.g. 1.5 and 2.0 °C), and (2) the climate is typically not yet stabilized (i.e in a transient climate) until the end of the century. In this research, we address the second shortcoming and investigate whereas the magnitude and frequency of extreme hydrological indices computed for the transient and stabilized climates are significantly different, thereby potentially compromising former reports relying solely on transient climate time-slices.

The phase 2b of the ISIMIP project (Warszawski et al., 2014) provides bias corrected GCMs that span until 2299, offering access to a stabilized climate era. The whole datasets were used in conjunction with a global hydrological model, the H08 model, which operates daily at a 0.5° x 0.5° spatial resolution with water and energy balance closure. Separate analyses were conducted for each of the four ensemble members and for two 30-years periods, representative of transient and stabilized climates. The extreme indices include (1) monthly maximum consecutive 5-day precipitation (*Rx5day*), (2) annual count when precipitation is higher than 10 mm (*R10*), (3) annual 7-day minimum discharge (proxy for droughts, *7min*), and (4) annual 7-day maximum discharge (proxy for the likelihood of flooding, *7max*) were computed for all land grid cells and, using the generalized extreme value (GEV) distribution with the L-moments method, extreme indices expected with 0.1, 0.02, and 0.01 probability of occurrence (10, 50, and 100-years) were computed.

The differences in extreme indices calculated for the 30-years transient and stabilized climates were significantly different from zero for a relatively small land surface of the globe: 1.9%, 0.62%, 0%, and 0.004% of the global land surface area for *7min*, *7max*, *Rx5day*, and *R10* indices, respectively (two tails t test, $p < 0.05$). The differences between indices expected with 0.1, 0.02, and 0.01 probability of occurrence predicted for the transient and stabilized climates relative to an historical period (1975-2005) were calculated and the results for *7max* are presented in Fig. 1. The patterns observed in Fig. 1 were generally similar to those of other extreme indices. In Europe, Eastern U.S., Northern China, and Northern India, extreme indices were higher for the stabilized climate and lower for the transient climate. In contrast, in Western U.S., Central America, Central Africa, South Asia, and South India, the extreme indices were higher during the transient climate. Regional difference in temperature and precipitation sensitivities per 1 °C warming for the transient and stabilized climates due to different emissions of aerosols and by changes in the land-ocean warming contrasts may be responsible for such patterns.

Keywords: Global hydrology, Climate change, Transient and stabilized climate


10 years
50 years
100 years
50 °N
0
50 °S
160 °E
80 °E
0
80 °W
160 °W
Relative differences [%]