Geophysical Research Abstracts
Vol. 19, EGU2017-7968, 2017
EGU General Assembly 2017

Identifying and Representing Global Climates for Hydrology: Bimodal seasonal behaviour is rare

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How can we improve hydrologically relevant descriptions of climate?

Climate variables precipitation (P), temperature (T), rainfall days (N) and potential evapotranspiration (E) are driving forces behind differences in global hydrology. It is possible to adequately summarize global climate variables with a simple sine curve for many locations, which makes it easier to compare climates between locations. Instead of monthly average P, T, N or E, three parameters in the sine curve approximate these monthly averages, with low loss of accuracy for most locations. This approach works best for locations where the seasonal pattern has one clear peak (unimodal, e.g. distinct wet and dry season in a monsoon climate) and adequately when the seasonal pattern is more or less constant (e.g. low annual variation such as temperatures in the tropics). In earlier research the sinusoidal functions used 12 months as the length of the seasonal cycle, giving one peak per calendar year. This approach is expected to be inadequate in parts of the tropics, where climates can follow bimodal, dual-peak, patterns. Expressing bimodal monthly climates with sine curves has so far not been systematically investigated. The ability to succinctly describe these bimodal climates and knowledge of where these climates occur can be helpful in better understanding global climate-hydrology interactions.

We use the public CRU TS v3.23 data set (available at 0.5° latitude/longitude resolution) to derive sinusoidal functions that describe a typical year of monthly average P, T, N and E for all 0.5°x0.5° land cells. We derive these functions with a seasonal cycle length of both 12 (representative of unimodal climates) and 6 months (simulates bimodal climates). Two 6-month duration sine curves are used back-to-back to describe the full January to December year, assuming equal amplitudes for both peaks. The results show that the shorter length of the seasonal cycle improves the accuracy of our sinusoidal functions for approximately 7.0 % (P), 8.2 % (T), 7.2 % (N) and 6.2 % (E) of land cells in the tropics, and for approximately 8.1 % (P) and 9.8 % (N) of land cells outside the tropics. The locations of our improvements agree with locations where bimodal climates are present according to the relevant literature. Our method is unable to correctly identify all regions with bimodal climates, showing no improvement for approximately 3 % of tropical land cells, where bimodal climates are present. This is primarily due to asymmetry in the height and shape of both annual peaks in these climates, which our simple sine curves are unable to fully describe.