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Is the Aridity index a good impact model to assess aridity changes? A model validation against hydroclimatological and ecohydrological variables

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Aridity is a complex concept, aiming to indicate and measure the perception of climatological dryness on the earth surface. It is generally defined as the 'degree to which a climate lacks moisture to sustain life in terrestrial ecosystems'. A widely used (offline) impact model to assess projected changes in aridity is the *Aridity index* (defined as the ratio of potential evaporation to precipitation or vice versa). Several studies using climate model output as input to the *Aridity index*, have concluded that aridity will generally increase under conditions of increased CO_2 and associated global warming. However, a growing number of studies, assessing the same climate model output directly, suggests a more nuanced response of aridity to global warming, raising the question if the *Aridity index* provides a good representation of the complex nature of anticipated aridity changes.

Based on the general definition of aridity, we select here several hydroclimatological and ecohydrological variables from the climate model output and systematically compare projected changes (1980-99 vs. 2080-99) in these variables against projected changes in the *Aridity index*. Our results show that the *Aridity index* generally provides a poor proxy for anticipated changes in most hydroclimatological variables. The *Aridity index* further fails to represent projected changes in vegetation. Our results e.g., show that in about $3/4$ of all land area experiencing increases in aridity projected by the *Aridity index*, plant growth is instead simulated to increase. We further identify a substantial mean bias between projected changes in hydroclimatological variables and the *Aridity index*, which is related to the parametrization of potential evaporation. We show that this mean bias can be largely reduced by choosing parameterizations that account for the vegetation response to increased atmospheric CO_2.

Even though we recognize that the aridity index has been used as a proxy for historical geographic patterns of some of the aforementioned quantities, we call here for a more direct approach to assess projected trends of aridity. The central issue is that the offline *Aridity index* model does not directly translate to plant productivity, runoff and many other variables that are related to our common understanding of aridity. Instead, the most direct approach for assessing aridity projections is to use climate model output for these impact-relevant variables.