Geophysical Research Abstracts
Vol. 20, EGU2018-6975, 2018
EGU General Assembly 2018

A hydroclimatically (hyper-)stressed future for planet Earth? A central challenge for developing countries.

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Climate change can have profound effects on the Earth's hydrologic cycle and a number of studies identified consistent responses of impact-relevant surface hydroclimatic extremes and regimes to global warming. After a brief review of these responses, I will introduce a new index of potential Cumulative Hydroclimatic Stress (CHS) based on extreme precipitation intensity and extreme negative monthly precipitation anomalies, i.e. an index representative of the risk of flood and meteorological drought. The change in this index is expressed in terms of an intuitive metric (the "Equivalent Reference Stress Year" or ERSY), and the index itself can easily incorporate socio-economic information, leading to an integrated CHS, or ICHS. Here, population information is introduced in the ICHS definition as an illustrative metric of exposure. The CHS and ICHS are calculated for an ensemble of global climate model (GCM) projections from CMIP5 under the RCP8.5 and RCP2.6 greenhouse gas concentration scenarios, along with corresponding population scenarios. Under the high end RCP8.5 scenario, by 2100, wet and dry extremes add ∼155 ERSY over global land areas (∼125 for wet and ∼30 for dry extremes), with wet hot-spots (>250 added ERSY) over regions of Asia, Eastern Africa and the Americas, and dry hot-spots (>100 added ERSY) across Central and South America, Europe, West Africa and coastal Australia. When accounting also for population exposure, a large maximum total (dry+wet) potential stress level exceeding 400 added ERSY by 2100 is found over Africa, North America, and Australia. These results thus indicate that the increase in wet and dry extremes under the RCP8.5 scenario can pose a severe threat to the sustainable development of societies, especially when added to other environmental (e.g. sea level rise) and socio-economic (e.g. poverty) stresses. The changes in CHS and ICHS are dramatically reduced in the RCP2.6 scenario (close to the 2°C global warming stabilization target), which calls for urgent action to achieve the goals of the Paris agreement.

Although providing useful information, coarse resolution GCMs have limitations in representing extreme hydroclimatic events. Regional climate models (RCMs) have been developed to regionally enhance the GCM information, and they can yield fine scale climate change information often different from that derived from GCMs due to their ability to capture regional processes and forcings (e.g. topography and land use). In fact, it is now becoming possible to run RCMs at convection-permitting resolutions of a few km, which will substantially enhance our ability to study hydroclimatic extremes. The Coordinated Regional climate Downscaling Experiment (CORDEX) was recently implemented to provide an internationally coordinated framework aimed at producing large ensembles of downscaled high resolution climate projections over regions worldwide. I will describe two new initiatives within the CORDEX framework, the CORDEX-CORE (Coordinated Output for Regional Evaluations) and the CORDEX FPSs (Flagship Pilot Studies), which constitute fundamental advances in RCM research and application. The involvement of the scientific community from developing countries, in terms of production, analysis and use of RCM results, will be a critical element for the success of these initiatives.