Evaluating downscaled CMIP5 and CMIP6 for rainfall erosivity projections

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Abstract: Soil erosion has negative effects on agriculture, water resources and ecosystems. It is prone to both direct and indirect impacts of climate change, where the former is a consequence of changes to rainfall attributes that affect the ability of rainstorms to detach soil particles and transport them at a site. The long-term cumulative erosive power of rainfall is commonly quantified with the R-factor (also known as rainfall erosivity) and applied in the Revised Universal Soil Loss Equation (RUSLE), the most widely used soil erosion model for regional scale assessments.

Understanding and projecting climate change impacts on rainfall erosivity is critical, but current research suffers from three main limitations: (1) Most studies use methods for deriving R-factor that cannot capture changes in rainfall intensity and timing, which are arguably the most important attributes for soil erosion applications. This is because they either use simplified R-factor models or basic bias correction approaches (delta change). (2) Projections generally do not account for climate model uncertainty, typically only using single model realisations. (3) Nearly all findings are based on the fifth phase of the Coupled Model Intercomparison Project (CMIP5). However, CMIP5 is gradually being superseded by the more recent Coupled Model Intercomparison Project Phase 6 (CMIP6), raising questions on the validity and robustness of current knowledge.

In this study, we perform the first intercomparison of rainfall erosivity estimates and their uncertainty, using ensembles of dynamically downscaled CMIP5 and CMIP6 rainfall. Downscaled daily rainfall at a 10 km resolution is obtained from the Queensland Future Climate science program (Syktus et al. 2020) for two climate scenarios over a 120-year period (1980 to 2099). The intercomparison focuses on three main aspects: the impact of CMIP version on rainfall erosivity and ensemble uncertainty, how sensitive projections are to emissions scenarios, and what aspects of changes in rainfall explain the differences in erosivity results between CMIP5 and CMIP6. Two 30-year time periods are considered, namely baseline (1981–2010) and end-century (2070–2099). The state of Queensland is used as a case study.

We found that changes in end-century erosivity were similar between CMIP versions, with erosivity projected to slightly increase across most of the state other than along the equatorial and tropical coast. However, the changes in erosivity are predicted to be smaller by CMIP6 in comparison to CMIP5. Furthermore, ensemble spread was substantially narrower for CMIP6 and independent of emission scenario, unlike CMIP5. Shifts towards a more summer-dominant rainfall regime were responsible for erosivity increases in southern Queensland, while decreased erosivity across the north of the state was due to changes in wet-day rainfall intensity. This study highlights the value of daily RCM projections, when used with suitable erosivity models, in better understanding variability in impacts and mechanisms across different regions.

REFERENCES

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