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Evaluating the precipitation regime of the Great Lakes Region in CMIP6 models

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The Laurentian Great Lakes region has a distinct precipitation seasonality, with highest magnitudes in the summer months of June to September and drier conditions in the winter months (December to March). The region also exhibits a 'mid-summer drying' behaviour, where the precipitation magnitude drops from July to August by approximately 7% and recovers in September before declining again in the autumn season. The distinct precipitation seasonal cycle modulates the land hydrological budget and has significance for regional water resources. This study aims to understand the precipitation seasonality in 20 CMIP6 models for historical (1980 – 2014) and mid-century (2030 – 2060) SSP2-4.5 scenario. Seasonal wet/dry biases in historical data are computed using CRU TS4.03 precipitation data as baseline.

CMIP6 models show a myriad of different patterns, none of which conform to the observed precipitation seasonality. Some models show a singular skewed peak with the maxima in either June or July flowed by slow tapering off until December (e.g., MRI-ESM2.0, CanESM, GFDL-CM4). Various models show a spring and winter-time wet bias (NUIST-NESM3, ACCESS-ESM1-5) and/or underestimation of the summer-season magnitudes (FGOALS-f3-L, NCAR-CESM2, NorESM2-MM). In general, the precipitation seasonality exhibited by the CMIP6 models is not characteristic of the region. We also find that while some models are wet or dry throughout the year, others show only seasonal biases indicating that their convective parameterization and/or microphysics schemes fail to adequality capture precipitation patterns in these seasons. While most CMIP6 models and reanalysis datasets show a gaussian convective precipitation cycle with the annual maxima in July, some models (e.g., BCC-CSM2-MR, NCAR-CESM2) show strong biases in it, indicating issues with their convective schemes.

These biases and anomalous precipitation cycle can be propagated or even amplified in the future climate model simulations, significantly altering the projections. Therefore, identifying the models that best represent the regional precipitation spatiotemporal characteristics can assist in better assessment of the future changes in the region's hydroclimate.