Indicator Reference Sheet – March 6, 2022

Projected Precipitation Change

U.S. Environmental Protection Agency

Indicator Names

- *% Projected Change in Annual Precipitation*
- *% Projected Change in Summer Precipitation*
- *% Projected Change in Annual Precipitation, Inverse*
- *% Projected Change in Summer Precipitation, Inverse*

Indicator Category | **Stressor**

Subcategory | *Projected Climate and Hydrologic Change*

Available in RPS Tool files for all lower 48 states

Indicator Description

Background

Precipitation is a fundamental component of the water cycle and occurs when water falls from the atmosphere as rain or snow. As part of climate change research, scientists have developed climate models to estimate future precipitation across the globe.[1] The climate models project future conditions under alternative greenhouse gas emission scenarios, known as *Representative Concentration Pathways (RCPs)*.[2] These projections can be used to assess the magnitude of climate change and potential impacts to people and the environment.[3]

What the Indicators Measure

These indicators measure projected future changes in average precipitation relative to historical conditions in a HUC12 subwatershed.* The indicators reflect projections for a high greenhouse gas emission scenario, known as Representative Concentration Pathway (RCP) 8.5. Under this scenario, an increase in greenhouse gas emissions continues through the year 2100. [2] The indicators depict:

- ***% Projected Change in Annual Precipitation*** – average annual precipitation in the HUC12 that is projected for the years 2050 to 2074, expressed as a percentage change from the historical annual average during 1981 to 2010 (Figure 1).
- ***% Projected Change in Summer Precipitation*** – average summer precipitation in the HUC12 that is projected for the years 2050 to 2074, expressed as a percentage change from the historical summer average during 1981 to 2010. Summer is defined as May 1 to October 31.

Under the RCP 8.5 scenario, precipitation is projected to increase in some HUC12s and decrease in others (Figure 1). To provide flexibility in the application of these indicators, the RPS Tool includes "inverse" versions of precipitation change indicators:

- ***% Projected Change in Annual Precipitation, Inverse*** – calculated by reversing the sign of the *% Projected Change in Annual Precipitation* indicator so that positive values correspond to drier annual conditions (precipitation decrease).
- ***% Projected Change in Summer Precipitation, Inverse*** – calculated by reversing the sign of the *% Projected Change in Summer Precipitation* indicator so that positive values correspond to drier summer conditions (precipitation decrease).

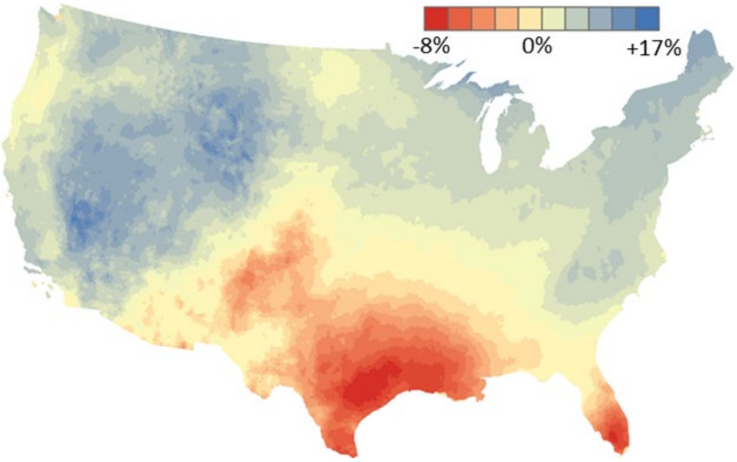

*Figure 1. Map of **% Projected Change in Annual Precipitation** for HUC12s across the contiguous US.*

Relevance to Water Quality Restoration and Protection

Increases in annual and summer precipitation totals can have varied effects on water quality. Increased precipitation may have a diluting effect on pollutants in some watersheds, however, wetter conditions can also contribute to elevated erosion of soil particles and flushing of pollutants from farmland, impervious surfaces, and other developed areas into waterbodies.[3,4] Such increases in sediment and pollutant delivery can degrade water supplies, inhibit recreational uses, and harm aquatic life.[4] Extreme floods can further increase pollutant levels due to inadequate or failing drainage, flood control, or wastewater infrastructure.[3,5]

Areas that are projected to have reduced annual and summer precipitation may be subject to prolonged periods of drought. During drought conditions, low water levels can stress aquatic life and reduce the ability of waterbodies to dilute wastewater discharges.[3,4] Less rain and snowfall can also cause lower water levels in wetlands, riparian zones, and floodplains that are vital habitats for aquatic species and disconnect these areas from nearby waterbodies.[6,7]

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[*] HUC12s are subwatershed delineations in the National Watershed Boundary Dataset. HUC12s are referenced by their 12-digit Hydrologic Unit Code.

Projected Precipitation Change

These indicators can be used to build awareness of how rain and snowfall totals are projected to change in one or more HUC12s and to assess the vulnerability of HUC12s to future degradation due to climate change. An assessment of watershed vulnerability may incorporate additional indicators to characterize the sensitivity of watershed processes and aquatic ecosystems to the expected changes in precipitation. For example, HUC12s with higher amounts of impervious cover may be more susceptible to degraded water quality with increasing precipitation compared to HUC12s with higher vegetative cover. The inclusion of an impervious cover indicator in a vulnerability assessment, therefore, could provide a more complete picture of the likelihood of climate change impacts on watersheds.

Processing Method

This indicator is derived from outputs of General Circulation Models (GCM) developed for 5th Climate Model Intercomparison Program (CMIP5) of the Intergovernmental Panel on Climate Change (IPCC).[1] GCM outputs are generated for coarse model grids, with each grid cell covering several thousand square miles. Researchers have applied statistical methods to downscale GCM outputs to produce higher-resolution model results.[8] The downscaled dataset used to calculate these indicators is known as MACAv2-METDATA and provides historical and projected precipitation totals across a 2.5-mile (4 kilometer) model grid over the contiguous US.[9]

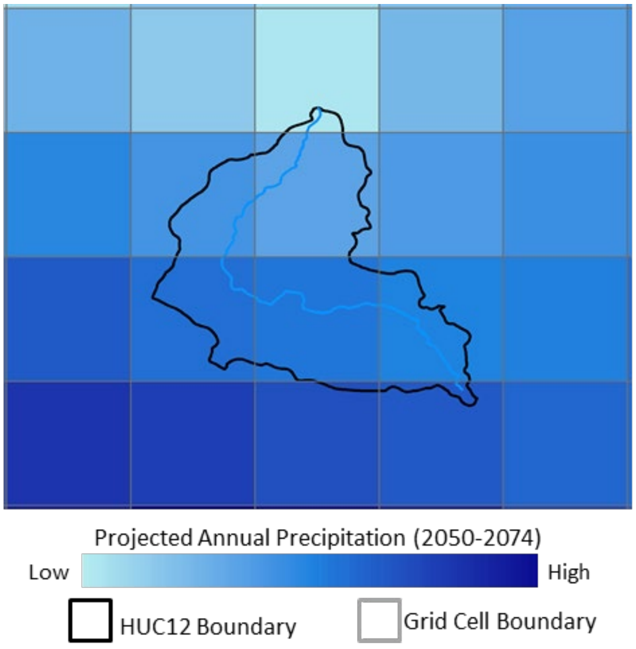

Figure 2. Example overlay map of the projected precipitation grid and HUC12 boundaries.

As part of the National Climate Change Viewer (NCCV) effort, the US Geological Survey (USGS) analyzed the downscaled outputs of GCMs to summarize historical and future precipitation.[9] Rather than relying on a single model to evaluate potential changes in precipitation, the USGS NCCV grids average the results of 20 GCMs.[9]

HUC12 values of precipitation change were generated by overlaying the USGS NCCV grids for the RCP 8.5 scenario with HUC12 boundaries (Figure 2) and calculating a weighted-average of grid cell values within a HUC12. The USGS NCCV grids were acquired from USGS in October 2021.

Limitations

- The GCMs used to estimate historical and future precipitation have been subject to significant review and evaluation as part of the CMIP5 model comparison effort[1]. However, error and uncertainty are inherent in all models.
- This indicator does not *predict* future conditions but rather estimates potential conditions under the greenhouse gas emission patterns and related assumptions of the RCP 8.5 scenario.
- Projections of future precipitation change can vary significantly between different GCMs and greenhouse gas emission scenarios. Readers are encouraged to visit the USGS National Climate Change Viewer to review variation in projected conditions for their area of interest.
- When comparing multiple HUC12s, users should evaluate the magnitude of precipitation changes among the HUC12s of interest. Small differences in precipitation change between HUC12s may fall within the range of uncertainty in model results.

Links to Access Data and Additional Information

HUC12 indicator data can be accessed within the EPA Restoration and Protection Screening (RPS) Tool, in downloadable data files, or as a web service. Visit the EPA RPS website for links to access the RPS Tool, HUC12 indicator database, and web service.

The source dataset for this indicator can be viewed on the USGS National Climate Change Viewer website.

References

[1] Taylow, K., et al. 2012. An Overview of CMIP5 and the Experiment Design. *American Meteorological Society*. 93(4): 485-498.

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[3] Pietrowsky, R., et al. 2012. Water Resources Sector Technical Input Report in Support of the U.S. Global Change Research Program, National Climate Assessment - 2013. 31 pp.

[4] Coffey, R., et al. 2019. A Review of Water Quality Responses to Air Temperature and Precipitation Changes 2: Nutrients, Algal Blooms, Sediment, Pathogens. *JAWRA Journal of the American Water Resources Association*. 55(4): 844-868.

[5] Paul, M., et al. 2019. A Review of Water Quality Responses to Air Temperature and Precipitation Changes 1: Flow, Water Temperature, Saltwater Intrusion. *Journal of the American Water Resources Association*. 55(4): 824-843.

[6] Lynch, A., et al. 2016. Climate change effects on North American inland fish populations and assemblages. *Fisheries*. 41(7): 346-361.

[7] Furniss, M., et al. 2013. Assessing the vulnerability of watersheds to climate change. USDA Forest Service General Technical Report PNW-GTR-884.

[8] Abatzoglou, J., et al. 2012. A comparison of statistical downscaling methods suited for wildfire applications. *International Journal of Climatology*. 32(5): 772-780.

[9] Alder, J., et al. 2021. National Climate Change Viewer Documentation. US Geological Survey.