Indicator Reference Sheet – March 6, 2022

Projected Air Temperature Change

U.S. Environmental Protection Agency

Indicator Names

- *Projected Change in Annual Temperature*
- *Projected Change in Summer Temperature*

Indicator Category | **Stressor**

Subcategory | *Projected Climate and Hydrologic Change*

Available in RPS Tool files for all lower 48 states

Indicator Description

Background

Air temperature is an important climate variable in the water balance and other ecosystem processes. As part of climate change research, scientists have developed climate models to project future air temperatures 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 air temperature 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. The indicators depict:

- ***Projected Change in Annual Temperature*** - the difference in average annual daily high temperature in the HUC12 that is projected for the years 2050 to 2074 compared to the historical period of 1981 to 2010, reported in degrees Celsius (Figure 1).
- ***Projected Change in Summer Temperature*** – the difference in the average summer daily high temperature in the HUC12 that is projected for the years 2050 to 2074 compared to the historical period of 1981 to 2010, reported in degrees Celsius. Summer is defined as May through October 31.

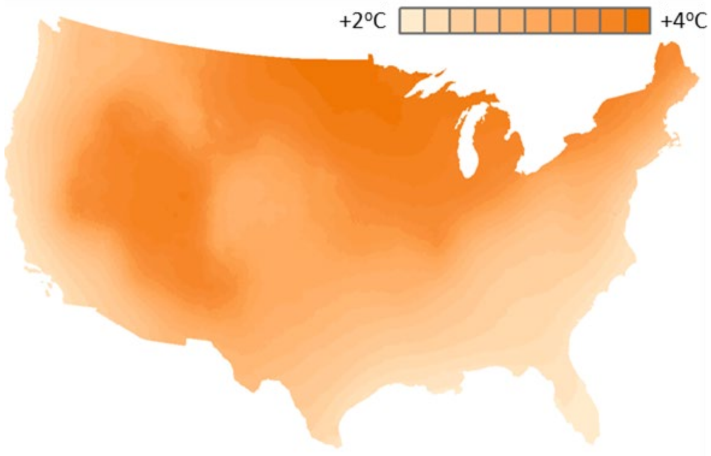

*Figure 1. Map of **Projected Change in Annual Temperature** for HUC12s across the contiguous US.*

Relevance to Water Quality Restoration and Protection

Warmer air can elevate water temperatures in rivers, lakes, and other waterbodies through air-to-water heat transfer and when runoff encounters warmed surfaces.[3,4] Increased air temperatures can affect water quality, water quantity, and aquatic ecosystem health in a variety of ways.[3] For example, warmer waters are more prone to harmful algal blooms[5] and are able to hold less dissolved oxygen, which can impact the survival, growth, and reproduction of other aquatic organisms.[4] Elevated water temperatures can also increase the toxicity of ammonia or other pollutants through increased solubility and enhanced survival rates of waterborne pathogens.[4]

Air temperature changes also affect the hydrologic cycle. Increased air temperatures may increase the relative distribution of rain versus snowfall in a watershed, increase water loss into the atmosphere through evapotranspiration, and accelerate snowmelt.[3,4] Changes in precipitation patterns can magnify these hydrologic effects and alter the amount of water available for drinking water use, recreation, and aquatic life.[3,4]

These indicators can be used to build awareness of projected temperature changes 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 that characterize the sensitivity of watershed processes and aquatic ecosystems to the expected temperature changes. For example, HUC12s with high amounts of forest cover in the riparian zone may be less susceptible to elevated water temperatures due to canopy shading compared to HUC12s with extensive development in the riparian zone. The inclusion of a riparian zone forest cover indicator in a vulnerability assessment, therefore, could provide a more complete picture of the likelihood of climate change impacts on watersheds.

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

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Processing Method

This indicator is derived from outputs of General Circulation Models (GCMs) developed for the 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.[6] The downscaled dataset used to calculate these indicators is known as MACAv2-METDATA and provides historical and projected air temperature across a 2.5-mile (4 kilometer) model grid over the contiguous US.[7]

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 air temperature for the RCP 8.5 scenario.[7] The USGS NCCV grids average the results of 20 GCMs to quantify projected changes in temperature.[7]

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

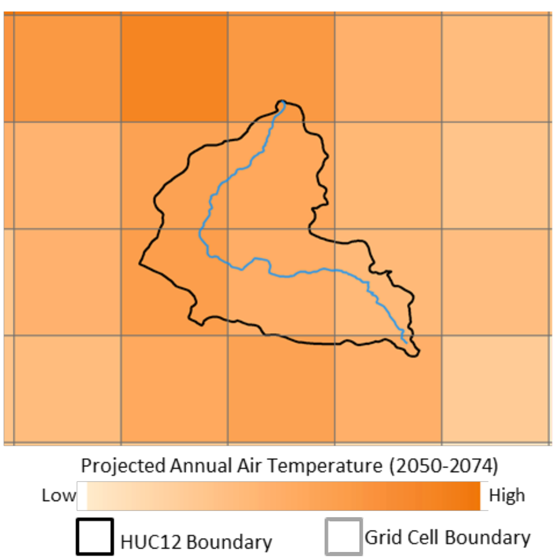

Figure 2. Example overlay of the projected air temperature change grid and HUC12 boundaries.

Limitations

- The GCMs used to estimate historical and future temperature 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 air temperature 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 temperature changes among the HUC12s of interest. Small differences in projected temperature change between two or more 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.

[2]Van Vuuren, D., et al. 2011. The representative concentration pathways: an overview. *Climatic Change*. 109: 5.

[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.

[4]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.

[5]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.

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

[7]Alder, JR and SW Hostetler. 2021. National Climate Change Viewer Documentation. US Geological Survey.