AGEOCE Explorer for Climate Change Impact on Water Resources

The AGEOCE Explorer for Climate Change Impact on Water Resources (CCIWR Explorer) is a web application providing information on potential future changes in water resources. It is developed by AGEOCE in collaboration with the Goethe University Frankfurt.

The CCIWR Explorer applies to all land areas of the globe except Antarctica, based on a state-of-the-art multi-model ensemble (MME) of global hydrological models that was generated using the ISIMIP3b protocol (Gosling et al. 2024). It is particularly suited for supporting local climate change adaptation processes by visualizing, for selected grid cells, the range of potential future changes in water resources, taking into account the uncertainty of future greenhouse gas emissions and the uncertainty of climate and hydrological models.

Last update: 2025-07-07

Citation

The CCIWR Explorer results from a joint R&D project between AGEOCE and the Goethe University Frankfurt. When using it, please include the following citation:

Attard, G., Müller, L., Bardonnet, J., Kneier, F., Döll, P. (2025) Explorer for Climate Change Impact on Water Resources, Version 1.0, available from https://ageoce.com/en/apps/climate-change-water, AGEOCE.

What type of information is provided by the CCIWR Explorer?

The web application visualizes potential future changes in water resources under three greenhouse gas emissions scenarios: **low emissions (SSP1-RCP2.6)**, **high emissions (SSP3-RCP7.0)**, and **very high emissions (SSP5-RCP8.5)**. For more information regarding representative concentration pathways, the reader may refer to this article.

For the reference period (1985–2014), the impact of temporally varying water use and artificial reservoirs is considered. However, in simulations for 2015–2100, direct human impacts on water resources and land cover are held constant at 2015 levels. This ensures that changes between the reference and future periods reflect climate change impacts only (see Table 2.3 of ISIMIP3b Protocol).

The application presents changes in three key variables across 0.5° x 0.5° grid cells (~55 km x 55 km at the equator):

1. **Total water resources**: Total runoff (**qtot**).
2. **Groundwater resources**: Diffuse groundwater recharge (**qr**, except **qrd** for the WaterGAP global hydrological model),
3. **Actual evapotranspiration**: Total evapotranspiration (**evap-total**).

For each grid cell, the projected relative changes in these variables, computed by up to 20 multi-model ensemble (MME) members, are visualized. The MME was generated by driving four global hydrological models with bias-adjusted outputs from five global climate models. To avoid large relative changes arising from very small absolute values, an MME member is excluded from the MME if its variable value for the reference period is smaller than 5 mm/year for the yearly analysis and 1 mm/season for the seasonal analysis.

Model output data were downloaded from the ISIMIP repository. For the reference period 1985-2014, the experiments with the specifier “historical_histsoc_default” were selected, for the period 2015-2100 the experiments with the specifiers "ssp12670_2015soc-from-histsoc_default", "ssp370_2015soc-from-histsoc_default" and "ssp585_2015soc-from-histsoc_default" (https://www.isimip.org/outputdata/).

The list of global hydrological models included in the MME reads as follows: **jules-es-vn6p3**, **miroc-integ-land**, **cwatm**, **watergap2-2e**.

Each model was driven by the bias-adjusted output of five different global climate models: **mpi-esm1-2-hr**, **ukesm1-0-ll**, **mri-esm2-0**, **gfdl-esm4**, **ipsl-cm6a-lr**.

This results in a maximum of 20 MME members (in short "models") for each of the three greenhouse gas emissions scenarios SSP 1 (RCP 2.6), SSP 3 (RCP 7.0), and SSP 5 (RCP 8.5).

How is the information provided?

The MME of projected changes is presented in the form of 1) global maps and 2) percentile box plots for a selected grid cell. The latter is displayed when clicking on a specific grid cell on the global maps. To find locations on the maps, you can adjust the transparency of the layers by clicking on "Layers" and moving the slider, and you can type in the location name in the search bar in the header.

🗺️ **Global map showing the median change**: This global map describes the median relative change of a variable of interest, for a given SSP, projection period, and seasonality.

🗺️ **Global map showing the share of models exceeding a threshold**: This global map describes the percentage of MME members (here: "models") for which the relative change of the variable exceeds a certain value defined by the user. For example, select "below" and "-20%" if you wish to see the fraction of MME members that project a decrease of more than 20%. Or select "above" and "10%" to show the fraction of MME members that project an increase of more than 10%.

📈 **Percentile box plots**: Distribution of projected variable changes across the MME in the form of percentile boxes (Müller and Döll, 2024), which display the 10th, 30th, 50th (median), 70th, and 90th percentiles of the changes. For example, if the 10th percentile (P10) equals -25%, then 90% of the MME computes a change that is larger than -25%, and 10% a change that is smaller than -25%, i.e., a decrease of more than 25%. The number of included MME members is indicated in the plot. You can enlarge the graph by clicking on (icon) and then download either the graph in png or svg format, or as csv text file that lists the exact percentage changes that more than 10% (P10), 30% (P30), 50% (median P50), 70% (P70) and 90% of all "models" (ensemble members) exceed.

How is the provided information best utilized for informing local climate change adaptation processes?

Climate change adaptation is challenging due to the large uncertainties about the future. These uncertainties need to be embraced and not neglected when executing (participatory) climate change adaptation processes (Döll and Romero-Lankao 2017).

To support participatory processes for climate change adaptation concerning water resources, e.g. in a city or county, we recommend downloading the percentile box plots for the grid cell that contains the location of interest. Regarding the three provided variables, we suggest selecting at least the variable total water resources and its long-term changes on annual and seasonal time scales.

If groundwater resources are important for human water supply, or if they are a source of streamflow — particularly during the dry season — and thus relevant to the well-being of river biota, we recommend analyzing changes in annual groundwater resources. Changes in seasonal groundwater resources are relevant in the case of small aquifers with low water storage capacity. Changes in actual evapotranspiration can help to understand the impact of climate change on vegetation. As potential evapotranspiration will increase in the future, a decrease in actual evapotranspiration indicates stress for the vegetation.

In a participatory climate change adaptation process, selected percentile box plots should be presented to the stakeholders (Müller and Döll 2024). This helps the stakeholders identify the future changes they wish to adapt to, depending on their risk aversion. For example, in the case of a high risk aversion towards reduced water availability, they may want to adapt to the P10 change of groundwater resources (e.g., -25%), while they may want to adapt to the P30 change (e.g., -15%) in the case of a moderate risk aversion.

The range of potential future changes can also serve as an input to local water resources management models that combine the range of changes with local information on, e.g., water demand (Kneier et al. 2021) or the acceptance of certain adaptation measures (Müller et al. 2024).

Data sources and license

The CCIWR Explorer is made available through a Google Earth Engine App built in the context of an academic research project. The usage of this explorer shall respect Google Earth Engine Terms of Service. In particular, the commercial use of the explorer is prohibited.

The underlying data can be delivered under a commercial license according to your specifications (NetCDF, GeoTIFF, Zarr, etc.), **contact us for a quote**.

Contact

For any questions about the CCIWR Explorer, please contact: contact@ageoce.com

References

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