# NASA Earth eXchange Global Daily Downscaled Projections version 2 (NEX-GDDP-CMIP6 v2.0)

**Latest update: May 31, 2025**

# 1. Summary

This document provides a brief overview of the latest NASA Earth eXchange (NEX) Global Daily Downscaled Projections (GDDP) dataset, NEX-GDDP-CMIP6 v2. It is intended for users who wish to apply the dataset (https://doi.org/10.7917/OFSG3345; Thrasher, et al., 2022) in studies of climate change impacts, summarizing essential information needed for access and use. References and additional information are provided at the end of this document. (Users can access the v1 Tech Note here.)

# 2. Dataset description

| | |
|---|---|
| Dataset projection: | Geographic |
| Dataset datum: | WGS-84 |
| Location of pixel lat and lon: | The pixel lat and lon fields in the metadata provide the location of the center of each pixel. |
| Coverage: | West Bounding Coordinate: 180° W<br>East Bounding Coordinate: 180° E<br>North Bounding Coordinate: 90° N<br>South Bounding Coordinate: 60° S |
| Spatial resolution: | 0.25 degrees x 0.25 degrees |
| Temporal resolution and extent: | Daily from 1950-01-01 to 2100-12-31<br>Units are in days since a reference date. The reference date varies by model and is based on the reference date used in the corresponding CMIP6 GCM experiment. |

| | |
|---|---|
| CF variable name and units:<br><br>(See metadata in the netCDF headers for more information on each variable.) | hurs<br>Near-Surface Relative Humidity<br>percentage |
| | huss<br>Near-Surface Specific Humidity<br>dimensionless ratio (kg/kg) |
| | pr<br>Precipitation (mean of the daily precipitation rate)<br>kg m-2 s-1 |
| | rlds<br>Surface Downwelling Longwave Radiation<br>W m-2 |
| | rsds<br>Surface Downwelling Shortwave Radiation<br>W m-2 |
| | sfcWind<br>Daily-Mean Near-Surface Wind Speed<br>m s-1 |
| | tas<br>Daily Near-Surface Air Temperature<br>Degrees Kelvin |
| | tasmax<br>Daily Maximum Near-Surface Air Temperature<br>degrees Kelvin |
| | tasmin<br>Daily Minimum Near-Surface Air Temperature<br>degrees Kelvin |

# 3. Data Origin and Methods

## 3.1 Introduction

The NEX-GDDP-CMIP6 dataset is comprised of global downscaled climate scenarios derived from the General Circulation Model (GCM) runs conducted under the Coupled Model Intercomparison Project Phase 6 (CMIP6) [Eyring et al. 2016] and across the four "Tier 1" greenhouse gas emissions scenarios known as Shared Socioeconomic Pathways (SSPs) [O'Neill et al. 2016; Meinshausen et al. 2020]. The CMIP6 GCM runs were developed in support of the Sixth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC AR6). This dataset includes downscaled projections from ScenarioMIP model runs [O'Neill et al. 2016; Tebaldi et al. 2021] for which daily scenarios were produced and distributed through the Earth System Grid Federation. The purpose of this dataset is to provide a set of global, high resolution, bias-corrected climate change projections that can be used to evaluate climate change impacts on processes that are sensitive to finer-scale climate gradients and the effects of local topography on climate conditions.

The demand for downscaling of GCM outputs arises from two primary limitations inherent in current global simulation results. First, most GCMs use relatively coarse resolution grids (e.g., a few degrees or $10^2$ km), which limit their ability to capture the spatial details in climate patterns that are often required or desired in regional or local analyses. Second, even the most advanced GCM may produce projections that are globally accurate but locally biased in their statistical characteristics (i.e., mean, variance, etc.) when compared with observations.

The Bias-Correction Spatial Disaggregation (BCSD) method used to generate the NEX-GDDP-CMIP6 dataset is a statistical downscaling algorithm specifically developed to address these limitations of global GCM outputs [Wood et al. 2002; Wood et al. 2004; Maurer et al. 2008; Thrasher et al. 2012]. The algorithm compares the GCM outputs with corresponding climate observations over a common period and uses information derived from the comparison to adjust future climate projections so that they are progressively more consistent with the historical climate records and, presumably, more realistic for the spatial domain of interest. The algorithm also utilizes the spatial detail provided by observationally-derived datasets to interpolate the GCM outputs to higher-resolution grids.

With the help of the computational resources provided by NEX and the NASA Advanced Supercomputing (NAS) facility, we have applied the BCSD method to produce a global dataset of downscaled CMIP6 climate projections to facilitate the assessment of climate change impacts. The dataset compiles climate projections from thirty-five CMIP6 GCMs (Table 1) and four SSP scenarios (SSP1-2.6, SSP2-4.5, SSP3-7.0, and SSP5-8.5) for the period from 2015 to 2100, as well as the historical experiment for each model for the period 1950-2014. Each of these climate projections is downscaled to a spatial resolution of 0.25 degrees x 0.25 degrees, resulting in a data archive size of more than 18TB (1TB = $10^{12}$ Bytes).

This document provides a basic description of the implementation of the BCSD method as applied in the downscaling of the CMIP6 GCM data. Additional technical details for the algorithm may also be found in Wood et al. [2002, 2004], and Maurer et al. [2008]. The approach used to produce the NEX-GDDP-CMIP6 dataset was previously applied to data from the CMIP5 archive, and the approach used in production of both datasets is described in detail in Thrasher et al. [2012].

# 3.2 Methods

## 3.2.1 Datasets

### 3.2.1.1 Climate Model Output

We compiled output from thirty-five CMIP6 GCM models (Table 1), including the historical experiment and four SSP scenarios (SSP1-2.6, SSP2-4.5, SSP3-7.0, and SSP5-8.5). Each of the climate projections includes daily average variables for the periods from 1950 through 2014 ("retrospective simulation") and from 2015 to 2100 ("prospective simulation"). During the downscaling process, the retrospective simulations serve as the training data and are compared against the observational climate records (see below). The relationships derived from the comparison are then applied to downscale the prospective climate projections. Because all climate projections are downscaled through the same procedures, for simplicity we refer to them as "GCM data" without differentiating any individual models.

### 3.2.1.2 Historical Climate Data

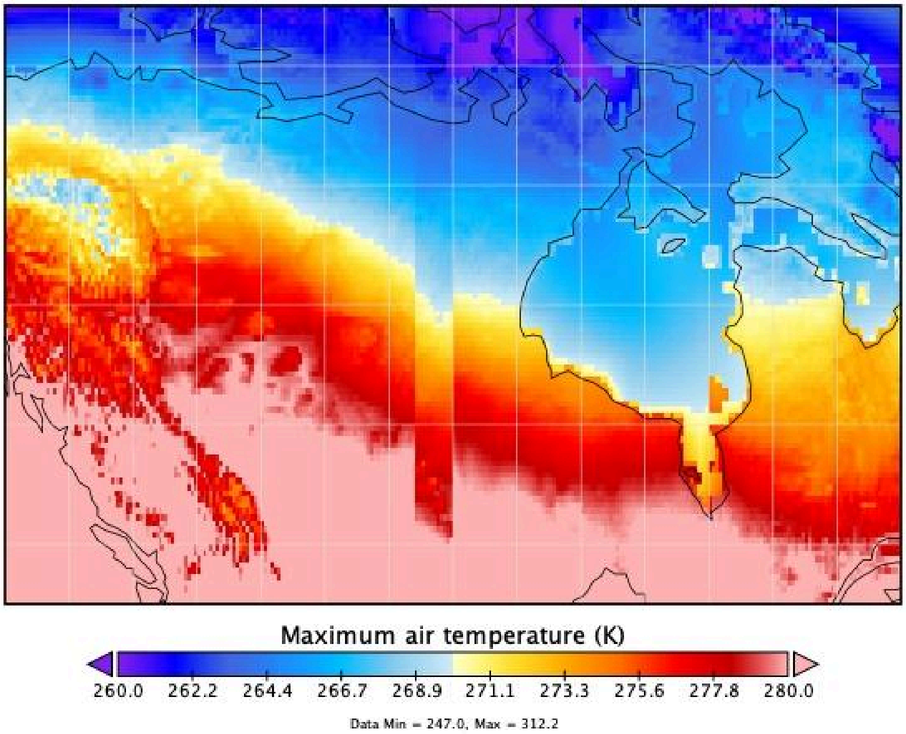
We use a climate dataset from the Global Meteorological Forcing Dataset (GMFD) for Land Surface Modeling, now available from the University of Southampton as the Princeton Global Forcing (PGF) dataset [https://hydrology.soton.ac.uk, Sheffield et al. 2006]. This dataset blends reanalysis data with observations and is currently available at spatial resolutions of 0.25 degrees, 0.5 degrees and 1.0 degree, and temporal resolutions of 3-hourly, daily, and monthly timesteps. For development of the NEX-GDDP-CMIP6 dataset, we used the 0.25-degree historical daily-averaged data for maximum temperature, minimum temperature, precipitation, near-surface humidity, downwell shortwave/longwave radiation, and near-surface wind speed from 1960 to 2014. All processed GMFD files used for GDDPv2 can be found at GMFD_for_GDDPv2.

## 3.2.2 Data Pre-processing

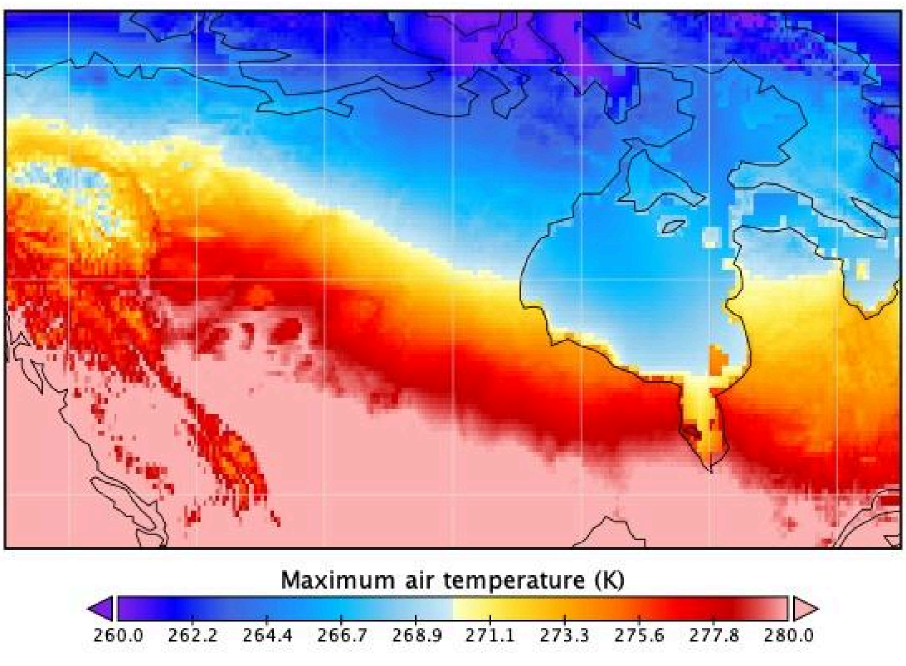
### 3.2.2.1 Temperature artifact adjustment

An artifact exists over central Canada in the GMFD tasmax and tasmin files. This was addressed by removing the grid cells from 50-71°N and 257-260°E and using the NCL poisson_grid_fill procedure to infill with more realistic values. Note that while the adjusted GMFD files were used in the original processing of GDDP, they were inadvertently not used in the v1.1 & v1.2 updates to the SSP126 & SSP370 tasmin (and therefore tas) files.

Original GMFD




Adjusted GMFD



#### 3.2.2.2 Temperature trend preservation

Because the BCSD method does not explicitly adjust the trends (the slopes, in particular) in climate variables produced by GCMs, we extract the monthly large-scale climate trends from the GCM temperature data. This is calculated as a 9-year running average for each individual month (e.g. the trend for all Januaries taken together). These trends are preserved and added back to the adjusted data after the bias-correction step.

### 3.2.2 Bias Correction (BC)

The Bias-Correction step adjusts the bias of the GCM data through comparisons performed against the GMFD historical data. For each climate variable in a given day, the algorithm generates the cumulative distribution function (CDF) for the GMFD data and for the retrospective GCM simulations, respectively, by pooling and sorting the corresponding source values (day of year +/- 15 days) over the period from 1960 through 2014. It then compares the two CDFs at various probability thresholds to establish a quantile map between the GCM data and the historical climate data. Based on this map, GCM values in any CDF quantile (e.g., p=90%) can be translated to corresponding GMFD values in the same CDF quantile. Assuming that the CDF of the GCM simulations is stable across the retrospective and the prospective periods, to “correct” the projected future climate variations the algorithm simply looks up the probability quantile associated with the predicted climate values from the estimated GCM CDF, identifies the corresponding observed climate values at the same probability quantile in the GMFD CDF, and then accepts the latter as the adjusted climate predictions. The climate projections adjusted in this way have the same CDF as the GMFD data; therefore, the possible biases in the statistical structure (the variance, in particular) of the original GCM outputs are removed by this procedure. At the end of the Bias-Correction step, the previously extracted temperature climate trends are added back to the adjusted GCM climate fields

### 3.2.3 Spatial Disaggregation (SD)

The Spatial-Disaggregation step spatially interpolates the Adjusted GCM data to the finer resolution grid of the 0.25-degree GMFD data. Rather than simple linear spatial interpolation, multiple steps are adopted in the SD algorithm to preserve spatial details of the observational data. First, a smoothed daily climatology is generated from the gridded observations over the reference period 1960-2014 using a Fast Fourier Transform retaining three harmonics at both the native and GCM resolutions. Second, for each time step, the algorithm compares the bias-corrected GCM variables with the corresponding GMFD climatology to calculate “scaling factors”. In particular, the scaling factors are calculated as the differences between the bias-corrected GCM and the GMFD data for temperature, and as the quotients (between the two datasets) for the remaining variables to avoid negative values for the latter. Third, the coarse-resolution scaling factors are bilinearly interpolated to the fine-resolution GMFD grid. Finally, the scaling factors are applied, by addition or “shifting” for temperatures and by multiplication for the remaining variables, on the fine-resolution GMFD climatologies to obtain the desired downscaled climate fields. As such, the algorithm essentially merges the observed historical spatial climatology with the relative changes at each time step simulated by the GCMs to produce the final results.

# 4. Description of updates from v1.0

## 4.1 Creation of v1.1

As explained in the v1 Tech Note, in August 2023, the following improvements and fixes were applied to some v1.0 variables:

- The tasmin output for SSP1.2-6 and SSP3.7-0 across all models was found to have incorrect values in a limited number of grid cells, primarily along coasts. These were reprocessed, along with the corresponding tas outputs.
- The original TaiESM1 tasmax and tasmin outputs from the historical experiment were retracted and replaced in the CMIP6 archive. The new outputs were obtained and used to reprocess the tas, tasmax, and tasmin variables.
- Some models were found to have unrealistically high values of hurs in their original CMIP6 output. All hurs downscaled outputs were reprocessed with a more realistic upper bound.
- The pr output has been reprocessed to address an overcorrection in climatologically dry areas. These files were added to the archive as "_v1.1.nc" in February 2024 to accompany the other v1.1 variables added in August 2023.
- The updated files contain version = "1.1" in the global file attributes, and the file names have "_v1.1.nc" to help disambiguate between versions 1.0 and 1.1.

## 4.2 Creation of v1.2

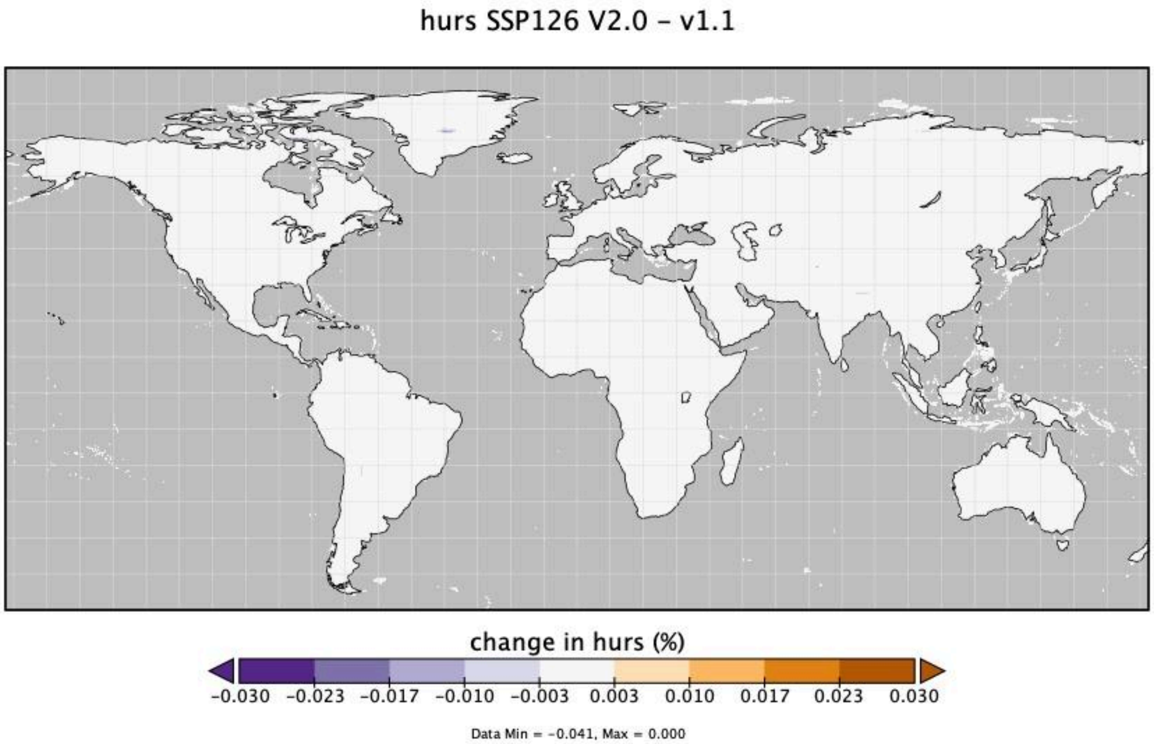
As explained in the v1 Tech Note, the v1.1 fixes to the tasmin output for SSP1.2-6 and SSP3.7-0 were found to have not been applied to enough grid cells. These fields have been reprocessed in full (i.e. all grid cells were touched, though not all values have changed), along with the corresponding tas outputs, both of which are noted as "v1.2" in the filenames.
The updated files contain version = "1.2" or version = "1.1" in the global file attributes, and the file names have "_v1.1.nc" or "_v1.2.nc" to help disambiguate between versions 1.0, 1.1 and 1.2.

## 4.3 Creation of v2.0

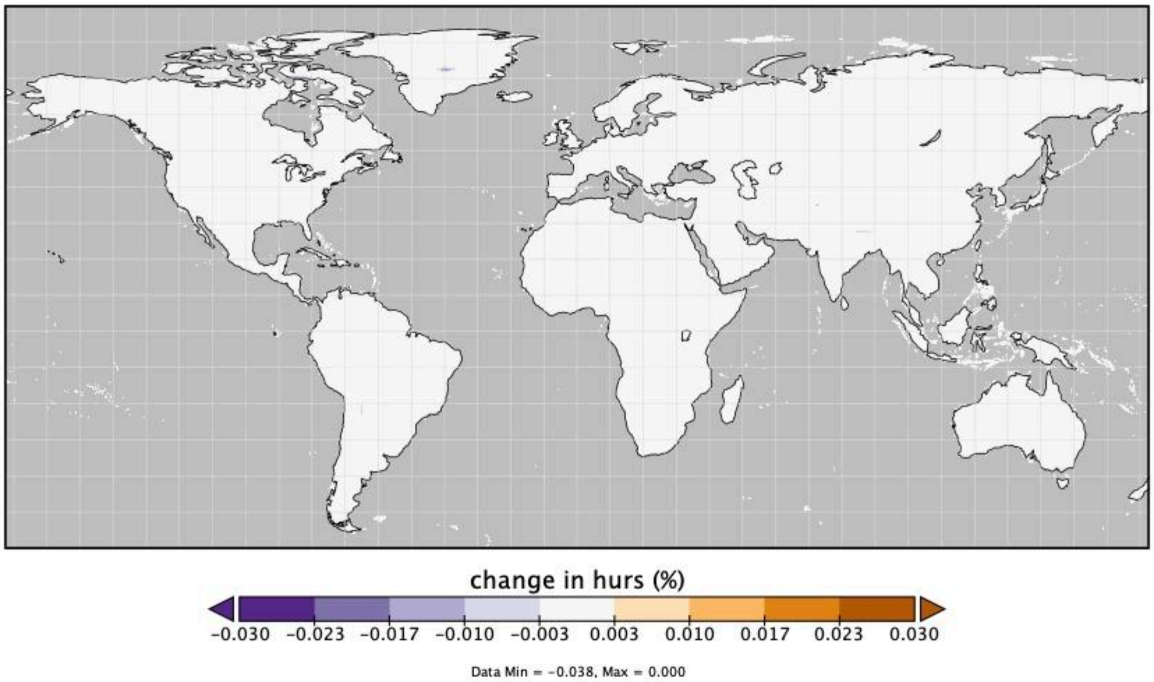
Below is an explanation of the updates applied to the various v1.x GDDP variables to create the v2 output. Please note that the ensemble daily average difference plots below show the location of changes across the ensemble as a whole, so changes reflected in individual models likely occur at a subset of locations and at a different proportional value than shown. The plots are based on the latest v1.x version of each variable and are provided so users can evaluate whether the update is of significance in their region of interest.

## 4.3.1 Relative humidity (hurs)

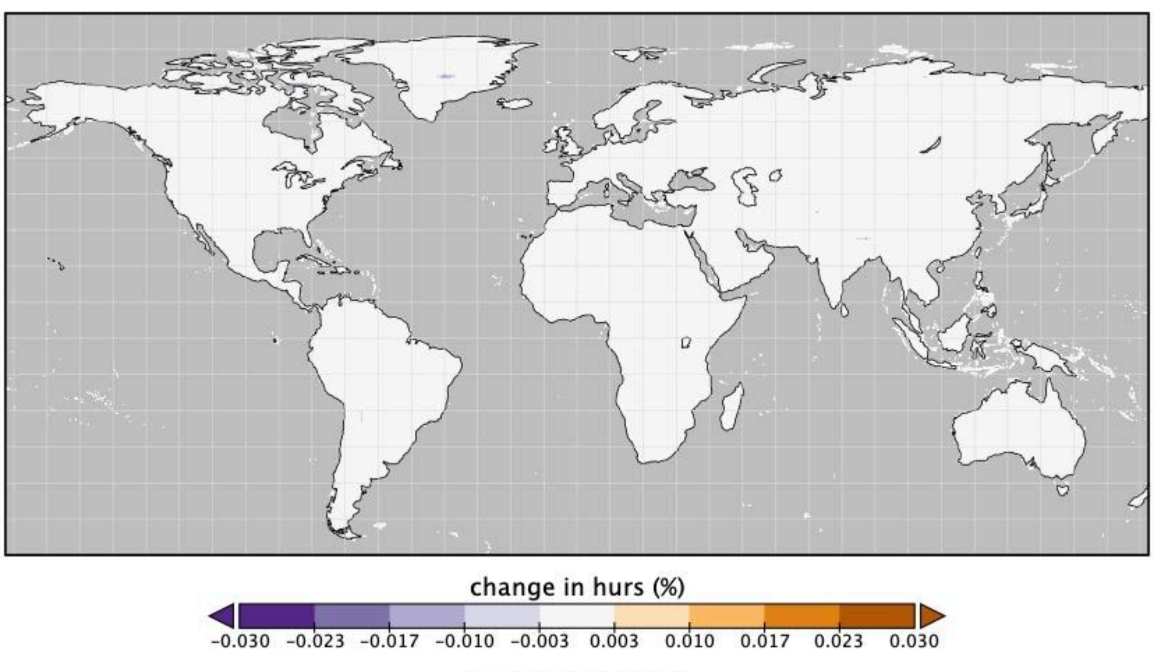
A small percentage of grid cells in v1.1 remained unrealistically high, so an upper bound of 105% was applied.

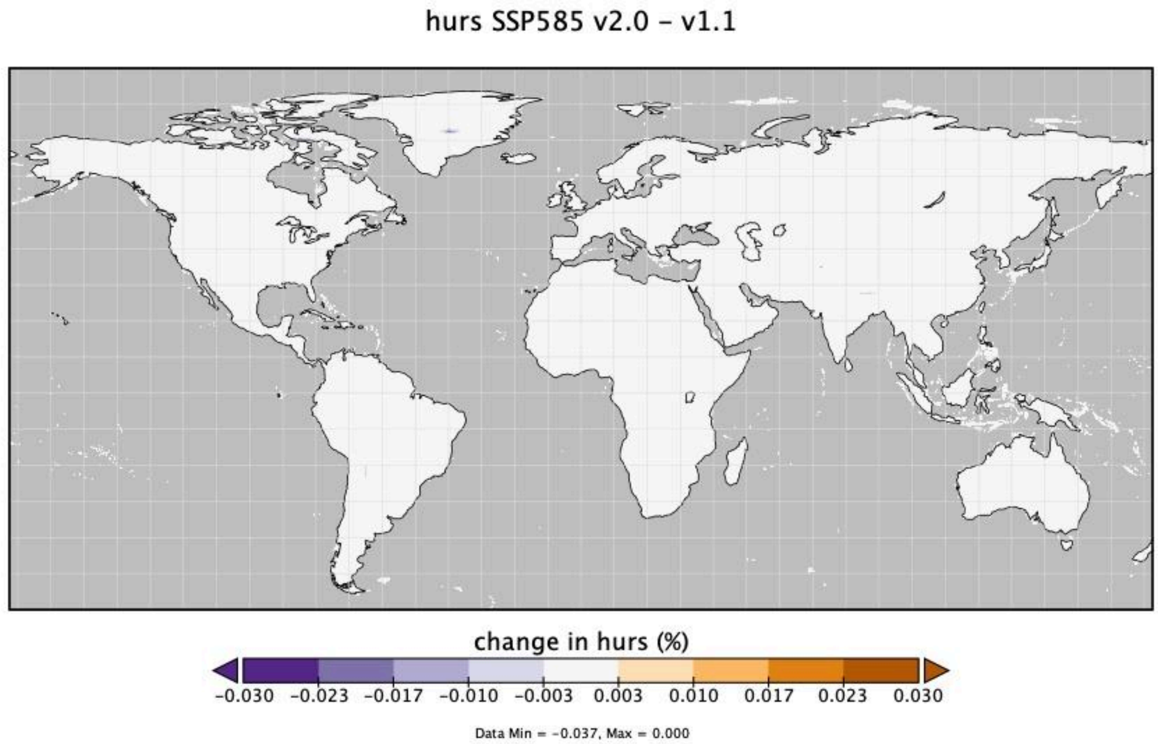


hurs SSP245 V2.0 - v1.1




hurs SSP370 v2.0 - v1.1

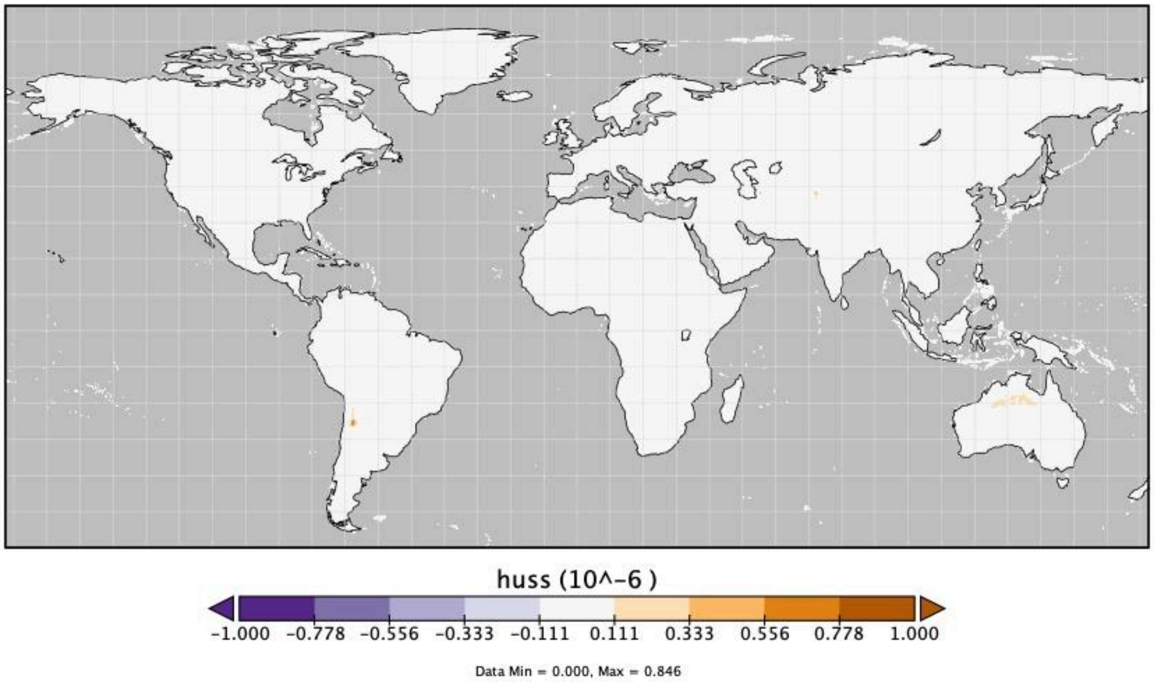




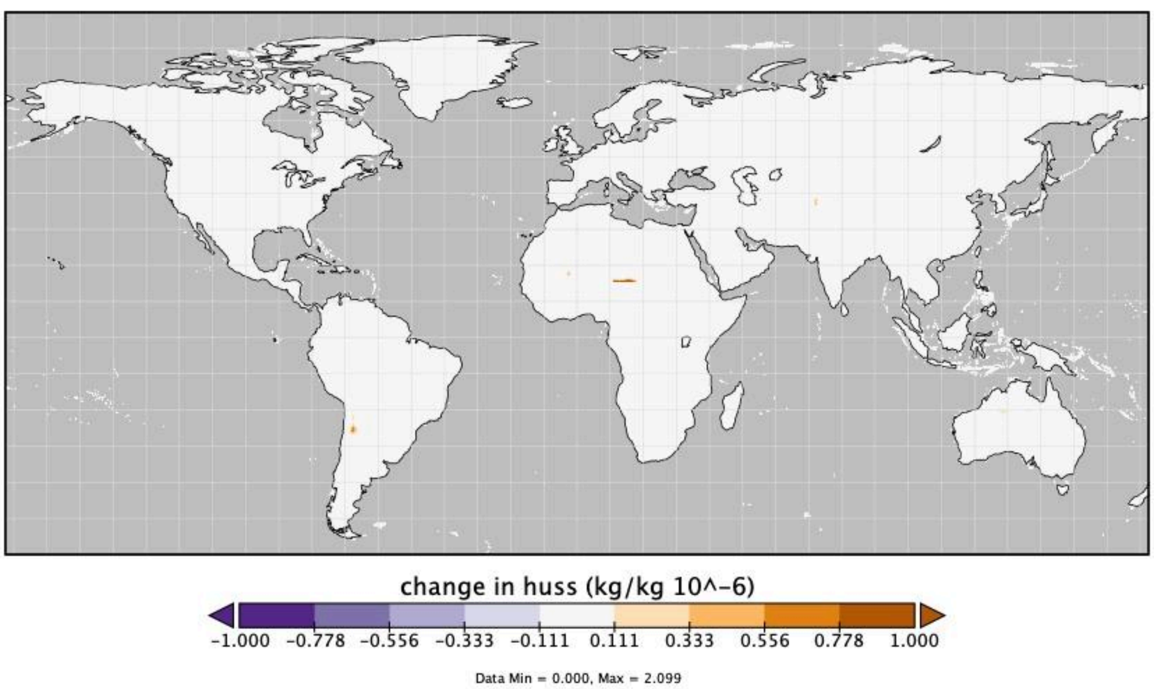

## 4.3.2 Specific humidity (huss)

Some CMIP6 output contained negative values for huss that were then perpetuated through the downscaling process, so a lower bound 0.0 was applied to the v1.0 files.

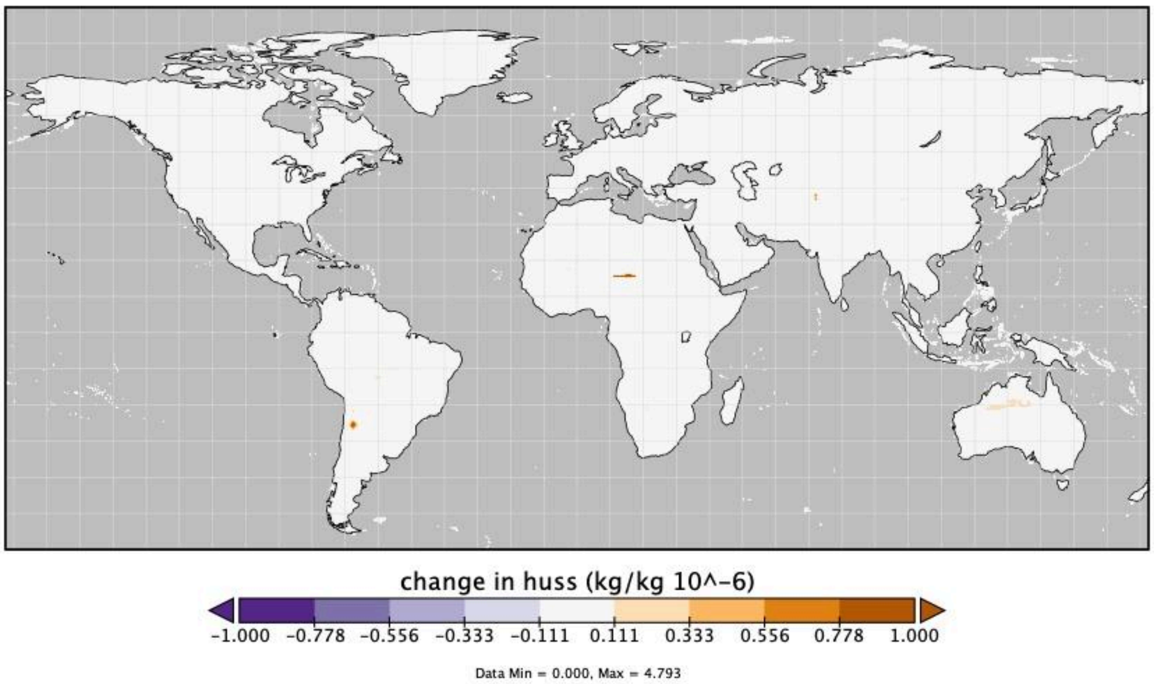
huss SSP126 v2.0 - v1.0



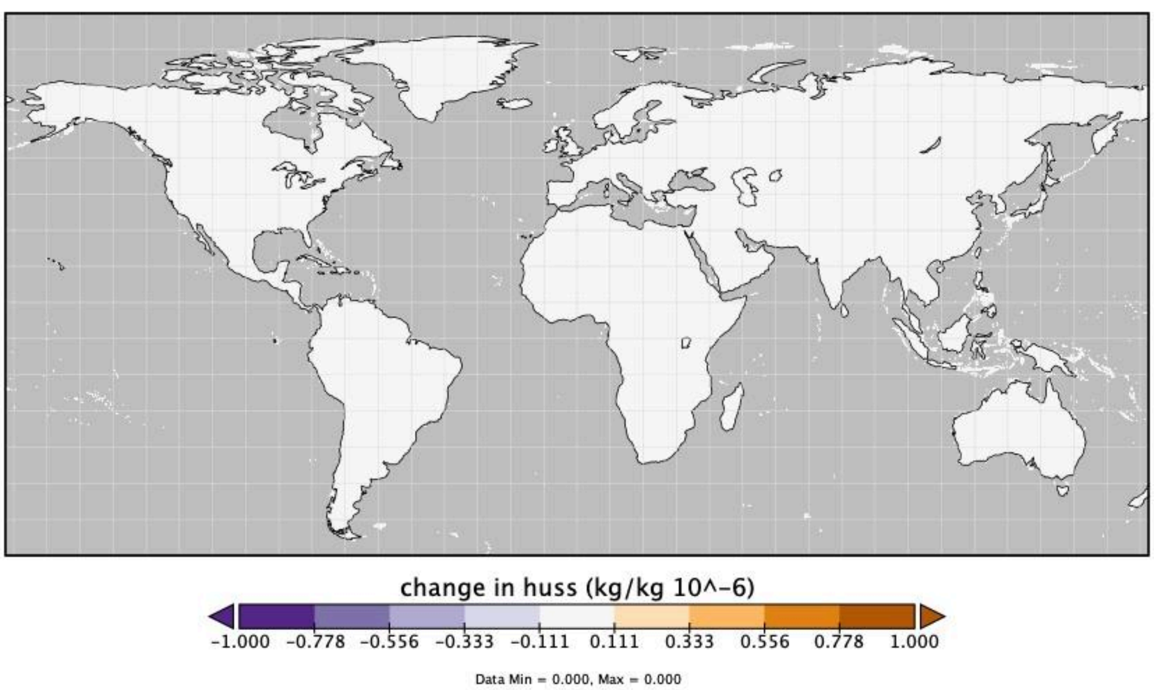

huss SSP245 v2.0 - v1.0



huss SSP370 v2.0 - v1.0

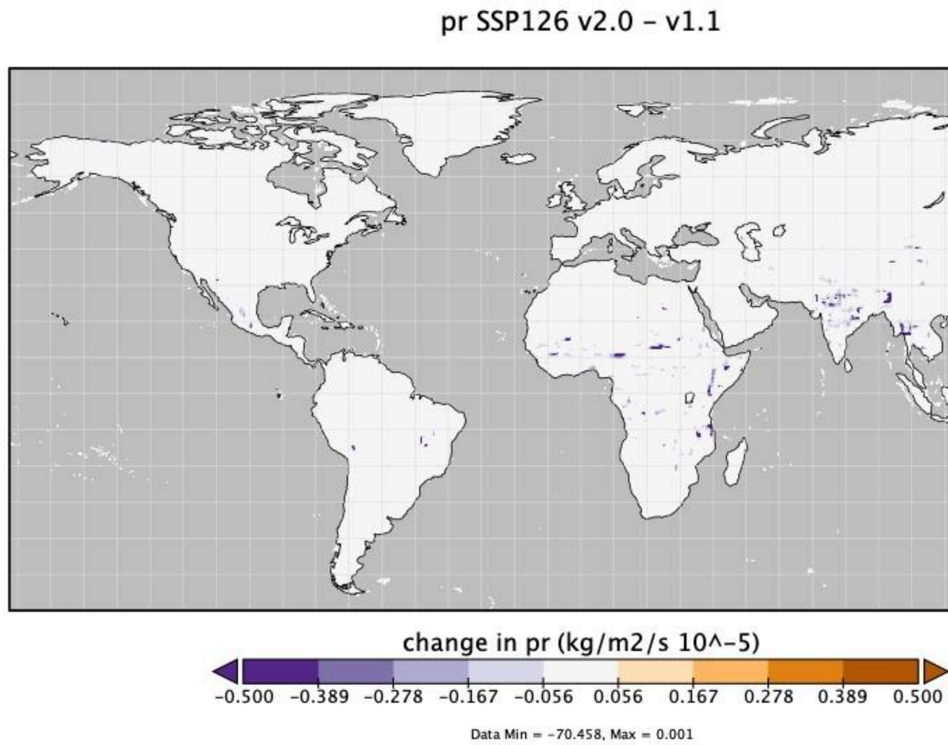


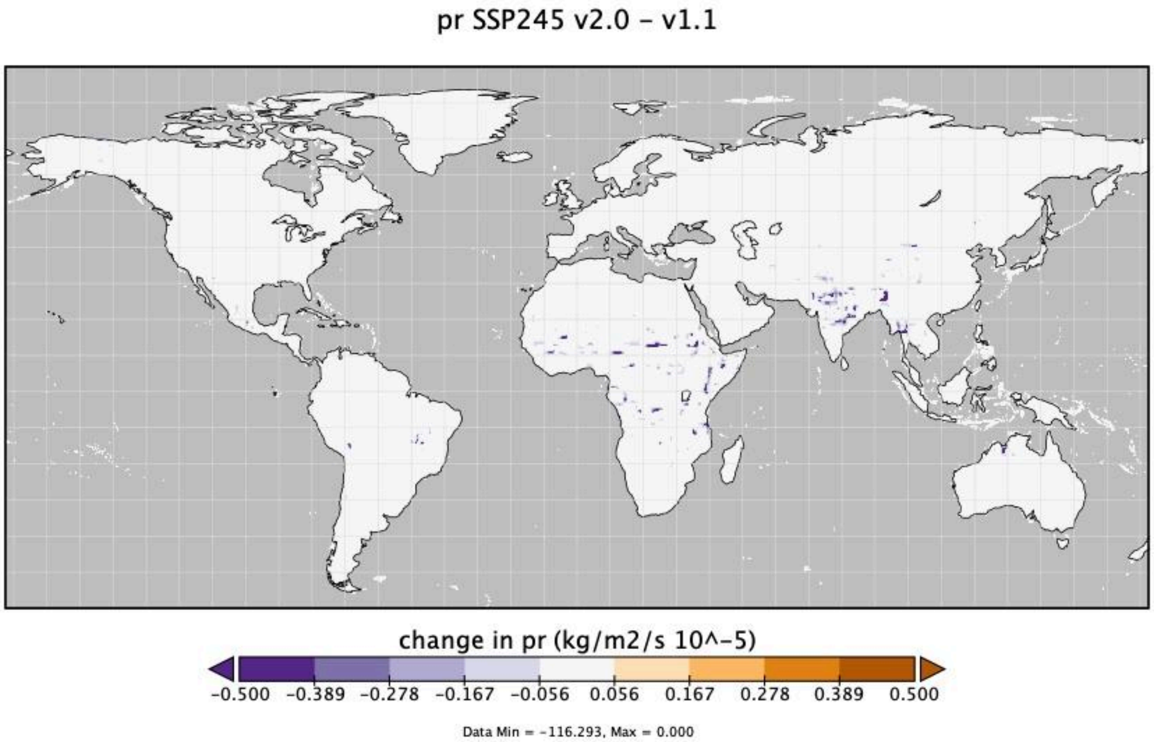

huss SSP585 v2.0 - v1.0

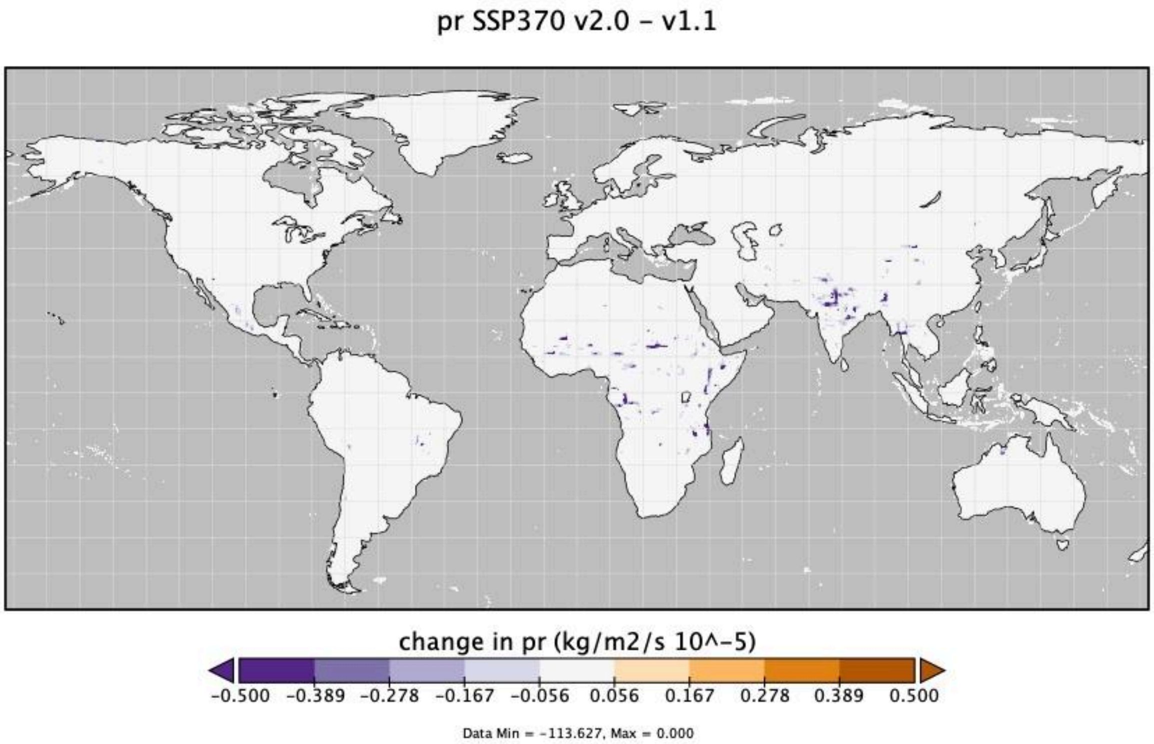


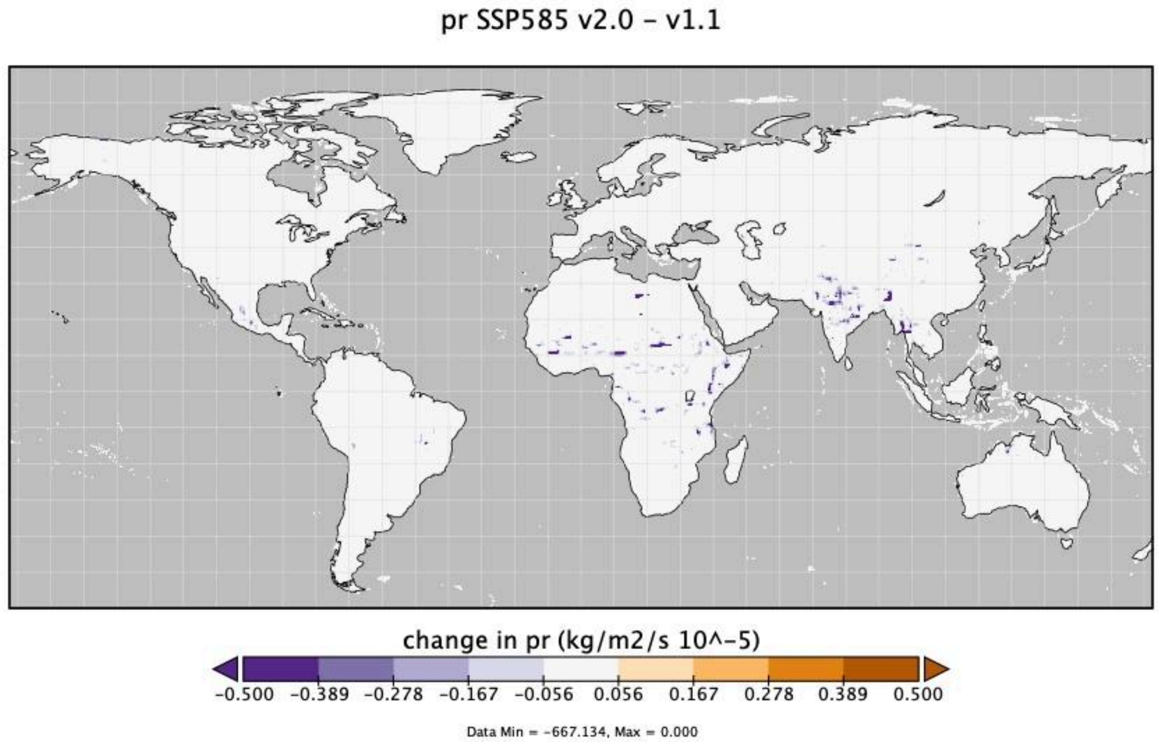
## 4.3.3 Precipitation (pr)

Due to the nature of the BCSD method, cells with extremely small daily climatology values can result in anomalously large downscaled values. These instances were adjusted in the v1.1 files.



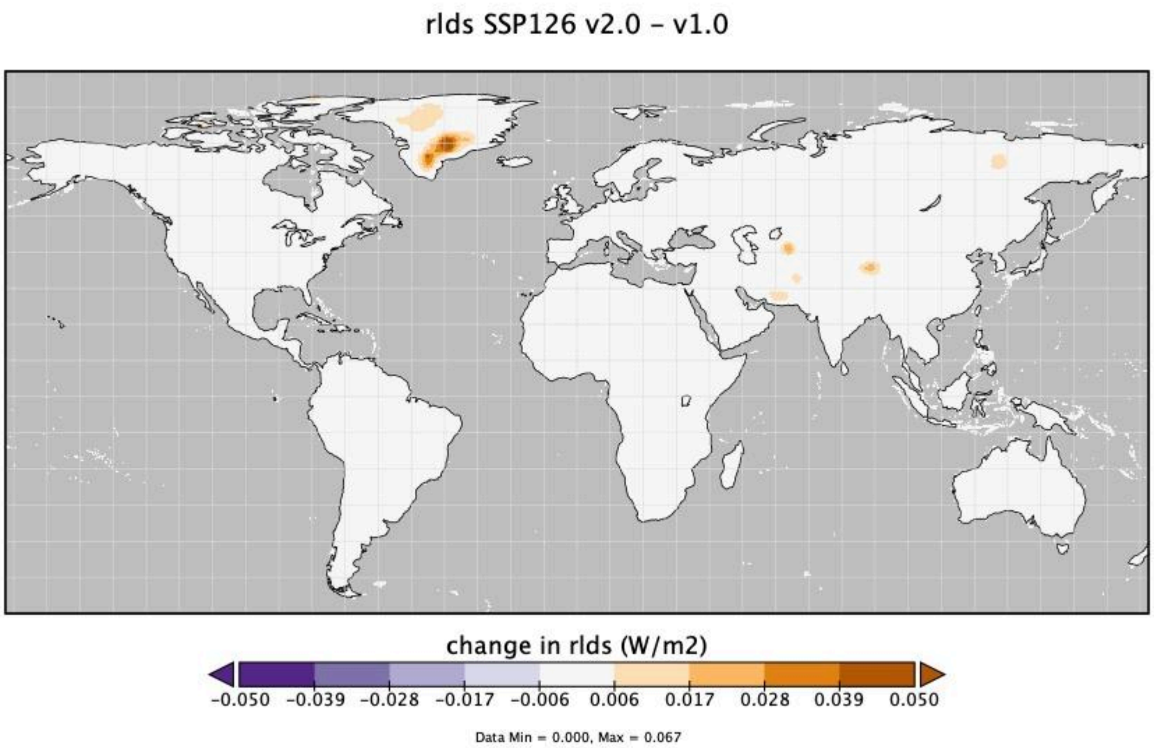

pr SSP245 v2.0 - v1.1
change in pr (kg/m2/s 10^-5)
-0.500 -0.389 -0.278 -0.167 -0.056 0.056 0.167 0.278 0.389 0.500
Data Min = -116.293, Max = 0.000

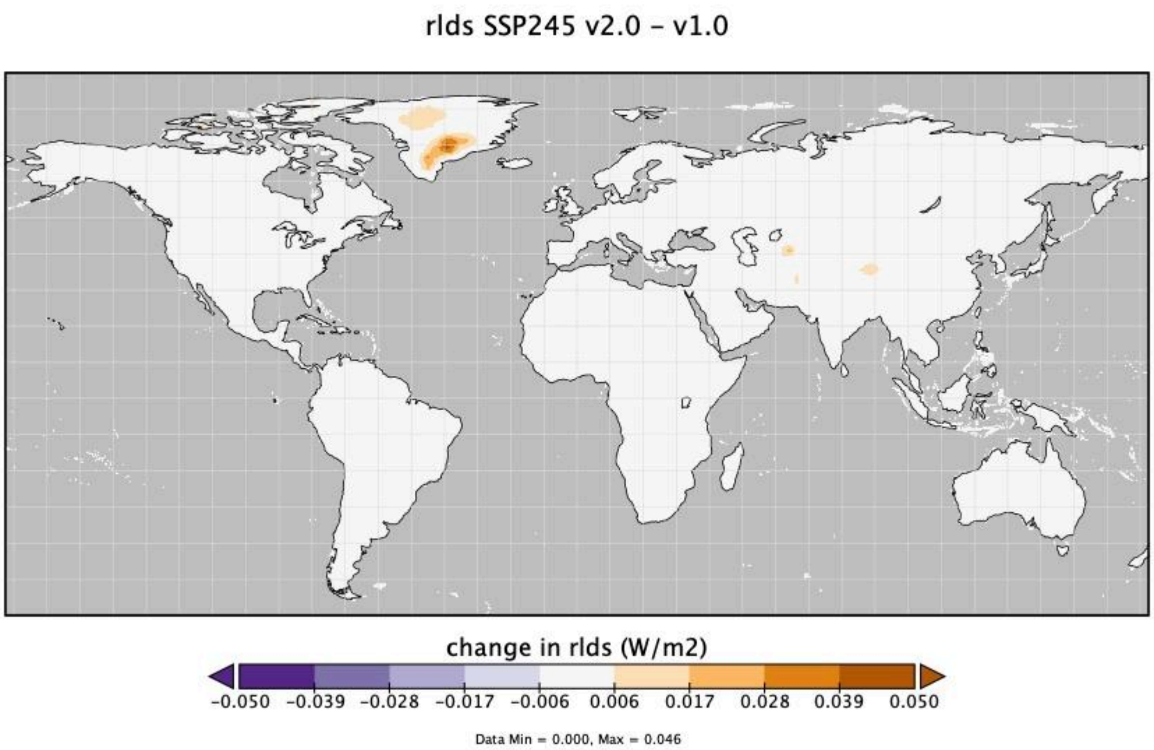

pr SSP370 v2.0 - v1.1
change in pr (kg/m2/s 10^-5)
-0.500 -0.389 -0.278 -0.167 -0.056 0.056 0.167 0.278 0.389 0.500
Data Min = -113.627, Max = 0.000



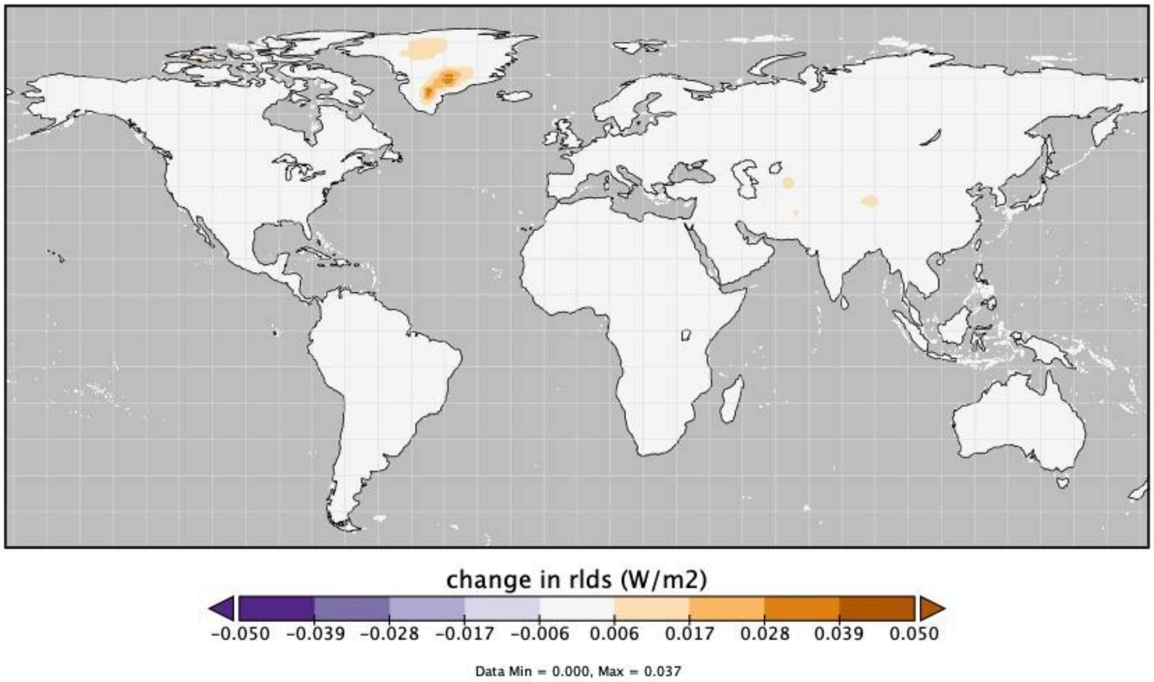

## 4.3.4 Downwelling longwave radiation (rlds)

Some CMIP6 output contained negative values for rlds that were then perpetuated through the downscaling process, so a lower bound 0.0 was applied to the v1.0 files.

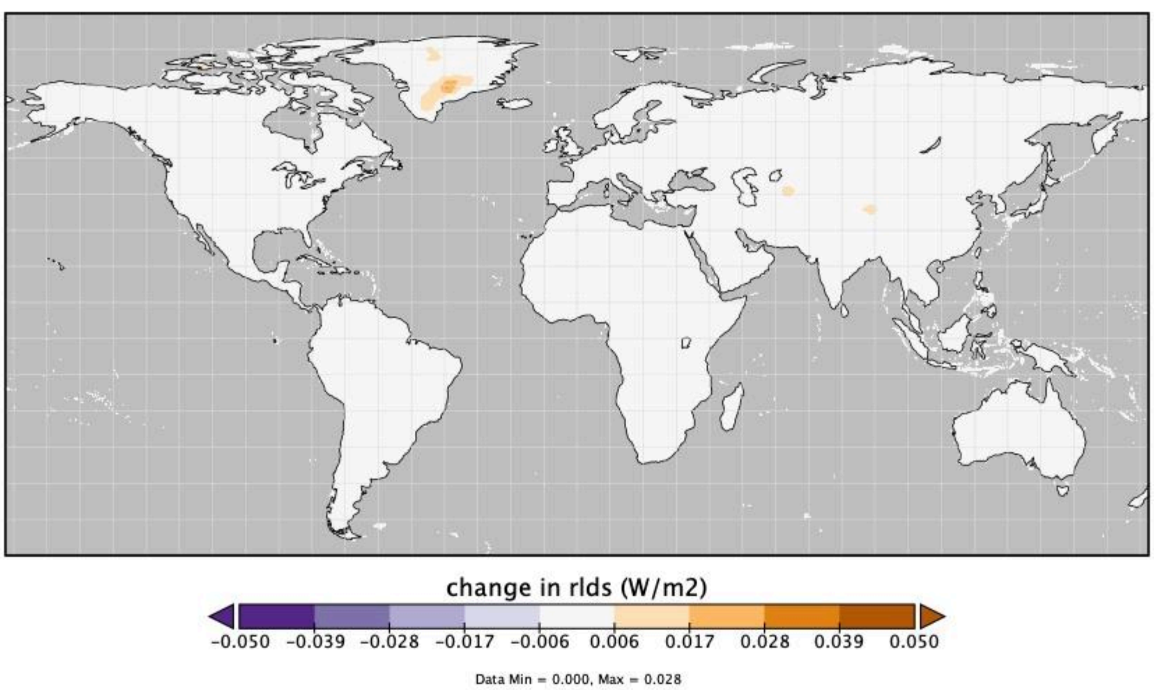

rlds SSP126 v2.0 - v1.0
change in rlds (W/m2)
-0.050 -0.039 -0.028 -0.017 -0.006 0.006 0.017 0.028 0.039 0.050
Data Min = 0.000, Max = 0.067


rlds SSP245 v2.0 - v1.0
change in rlds (W/m2)
-0.050 -0.039 -0.028 -0.017 -0.006 0.006 0.017 0.028 0.039 0.050
Data Min = 0.000, Max = 0.046

rlds SSP370 v2.0 - v1.0

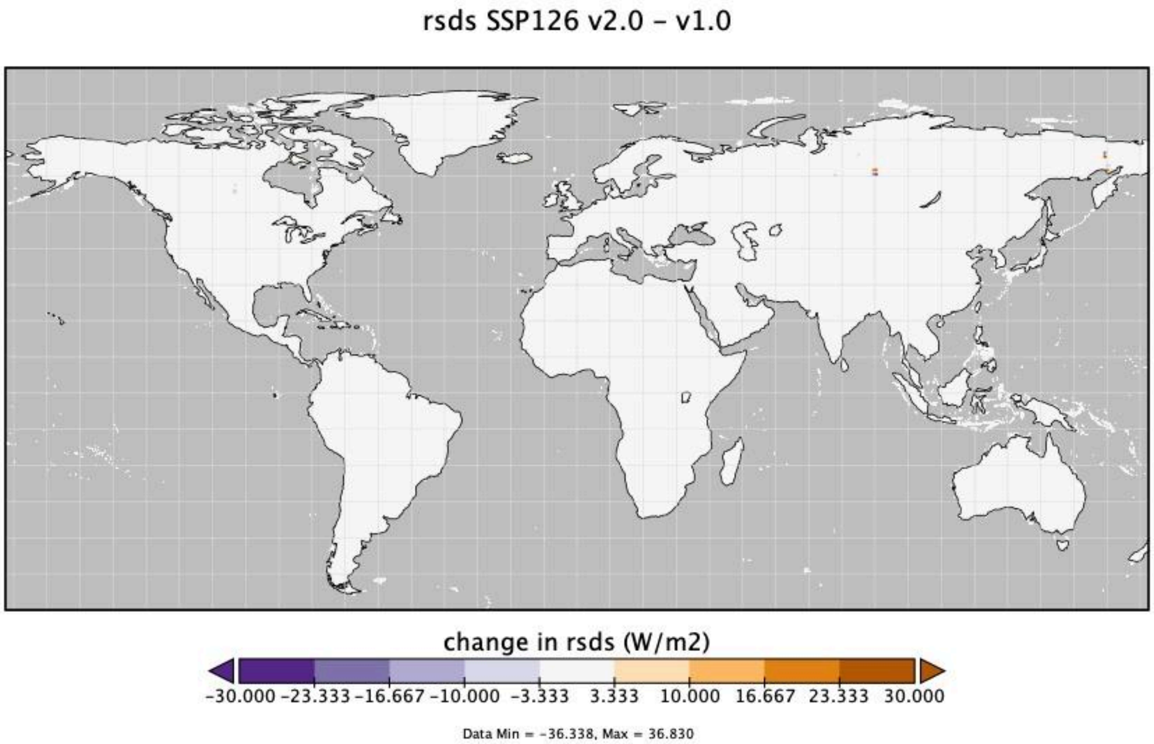


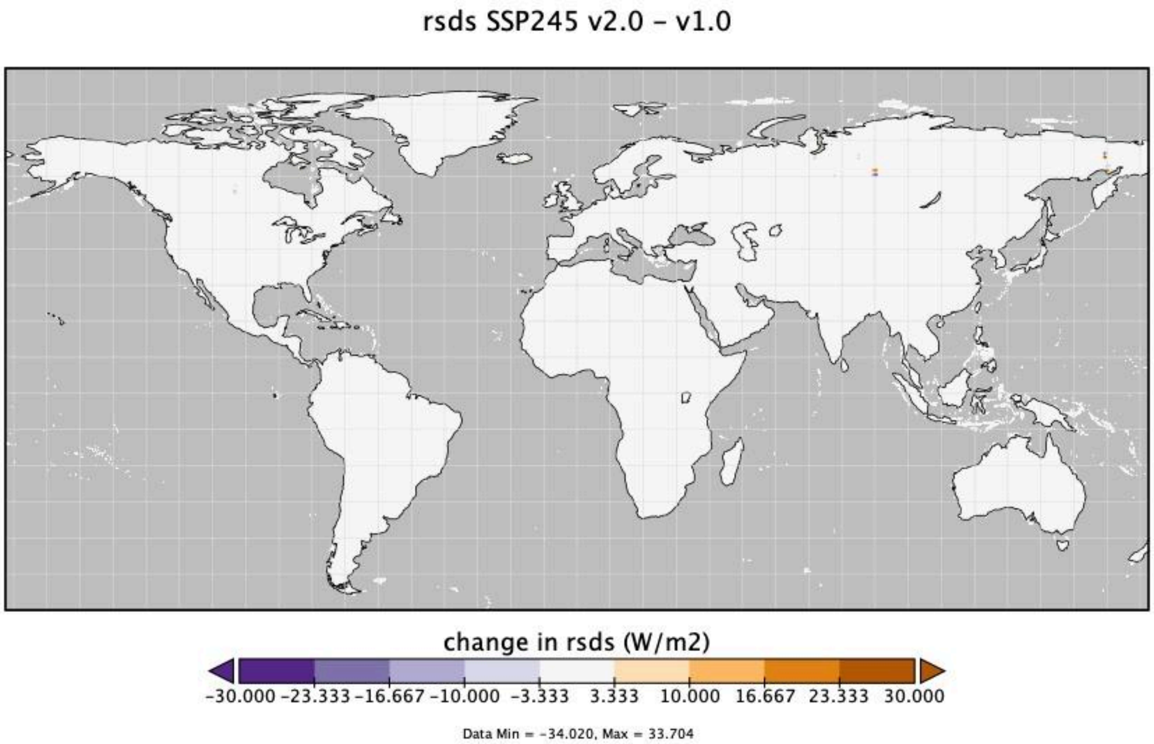

rlds SSP585 v2.0 - v1.0

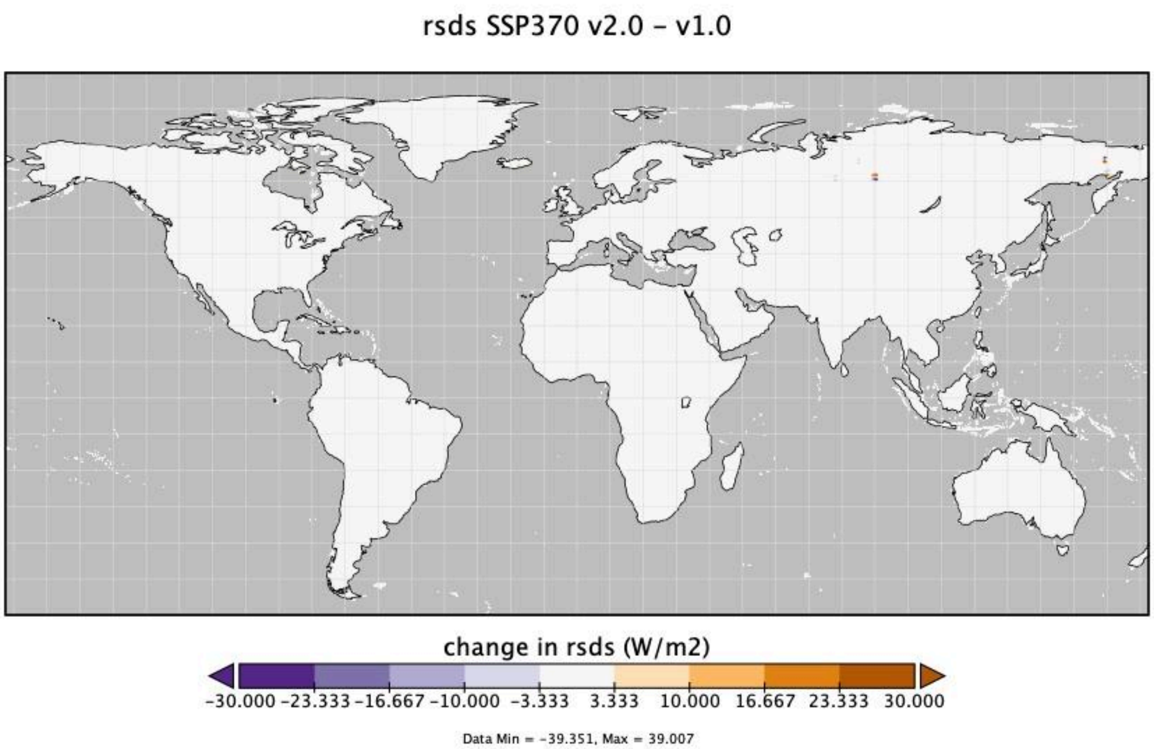


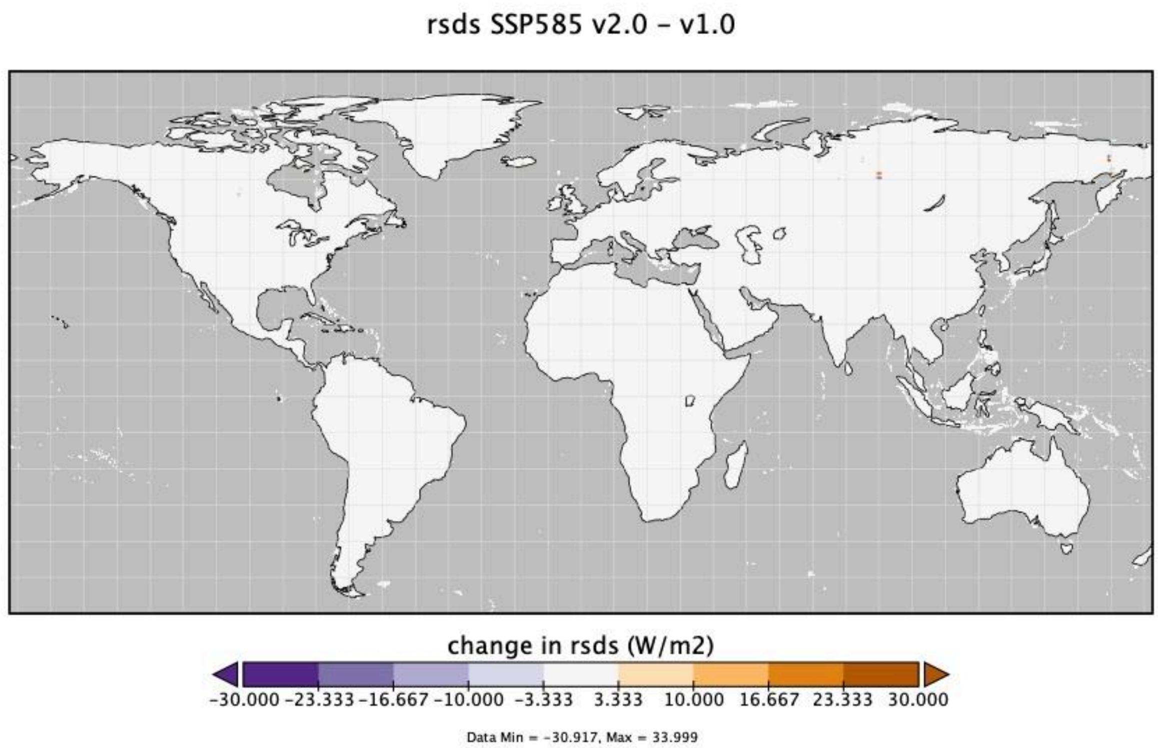
## 4.3.5 Downwelling shortwave radiation (rsds)

Due to the nature of the BCSD method, cells with extremely small daily climatology values can result in anomalously large downscaled values. These instances were adjusted in the v1.0 files.




rsds SSP245 v2.0 - v1.0
change in rsds (W/m2)
-30.000 -23.333 -16.667 -10.000 -3.333 3.333 10.000 16.667 23.333 30.000
Data Min = -34.020, Max = 33.704

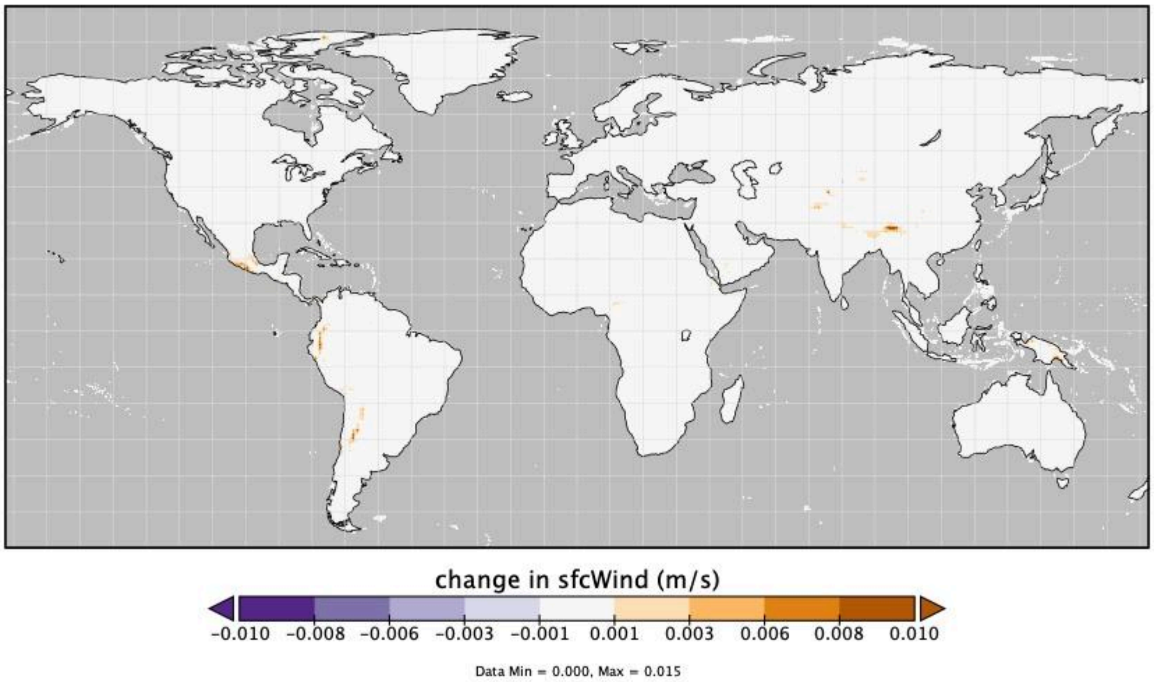

rsds SSP370 v2.0 - v1.0
change in rsds (W/m2)
-30.000 -23.333 -16.667 -10.000 -3.333 3.333 10.000 16.667 23.333 30.000
Data Min = -39.351, Max = 39.007



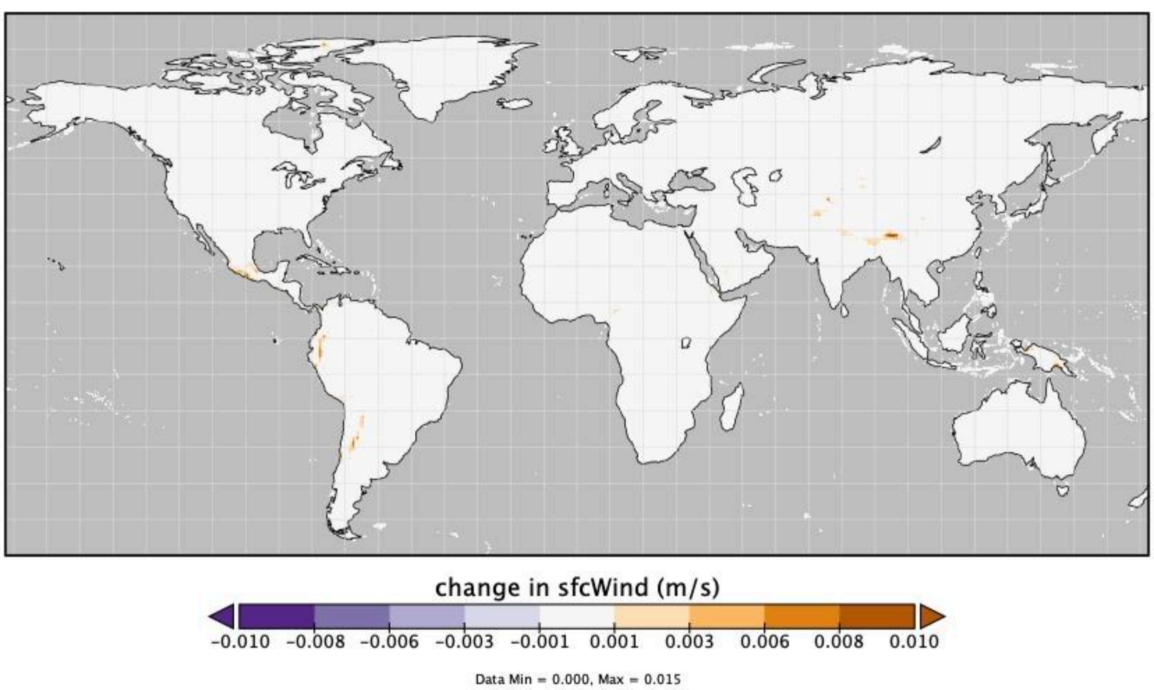

## 4.3.6 Wind speed (sfcWind)

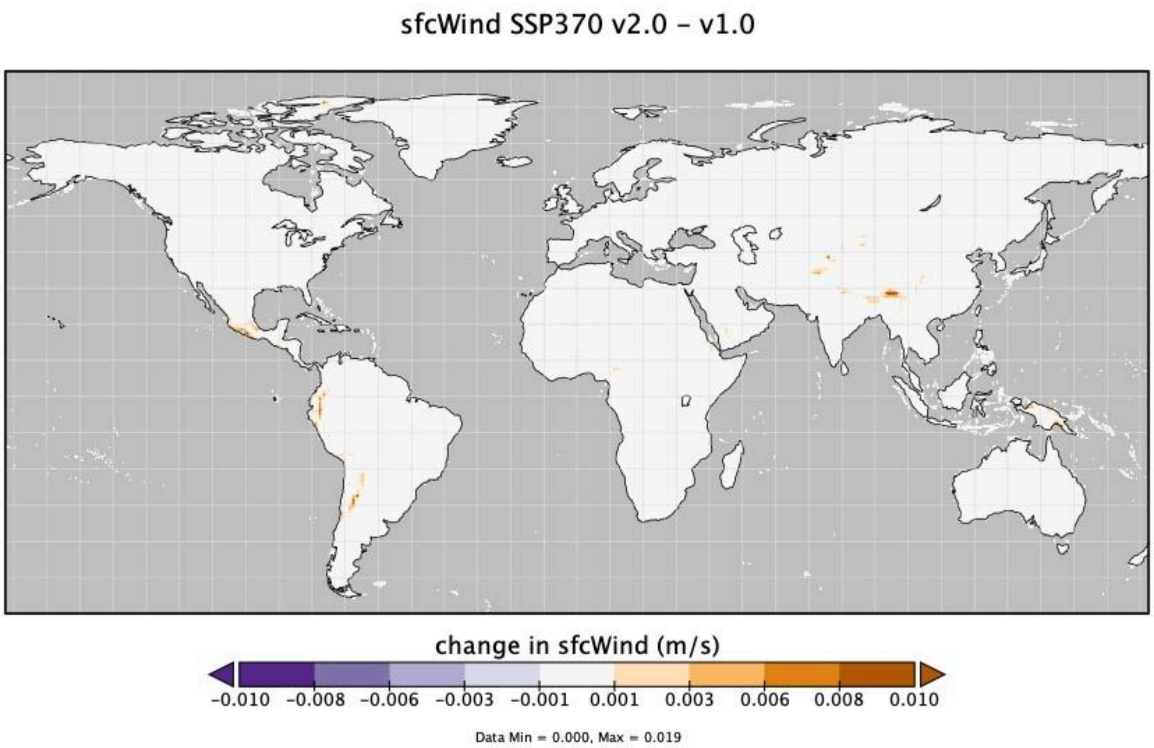
Some CMIP6 output contained negative values for sfcWind that were then perpetuated through the downscaling process, so a lower bound 0.0 was applied to the v1.0 files.

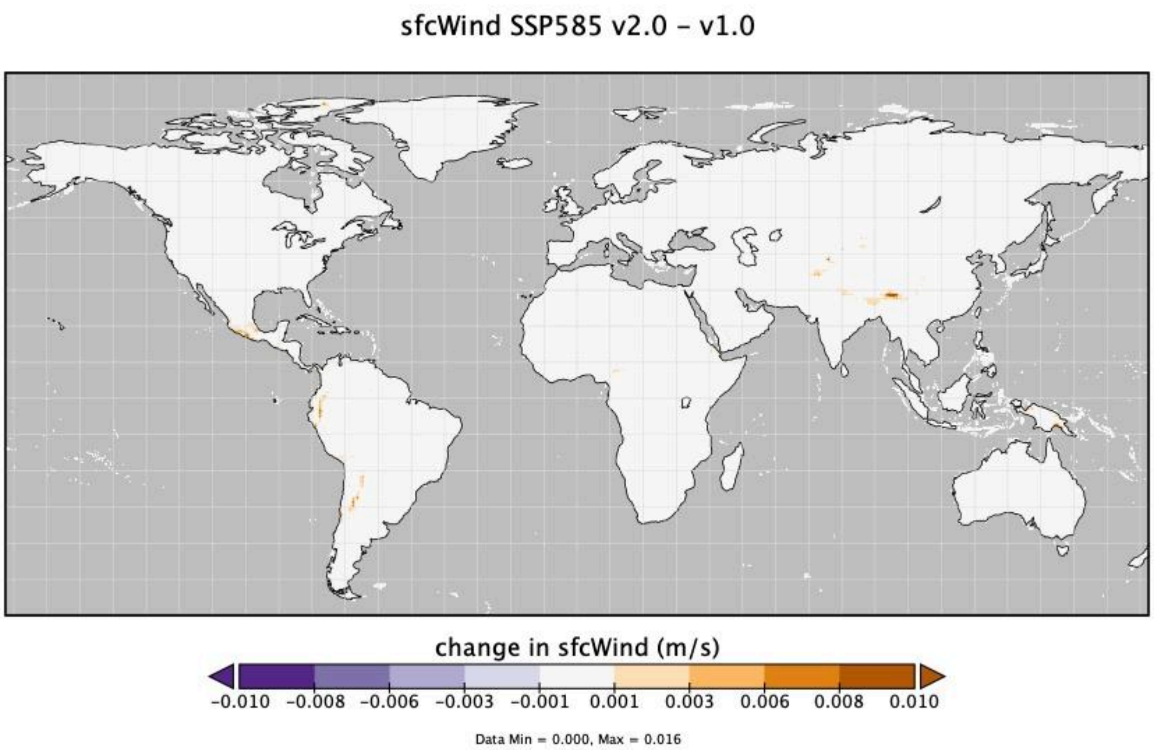
sfcWind SSP126 v2.0 – v1.0




sfcWind SSP245 v2.0 – v1.0

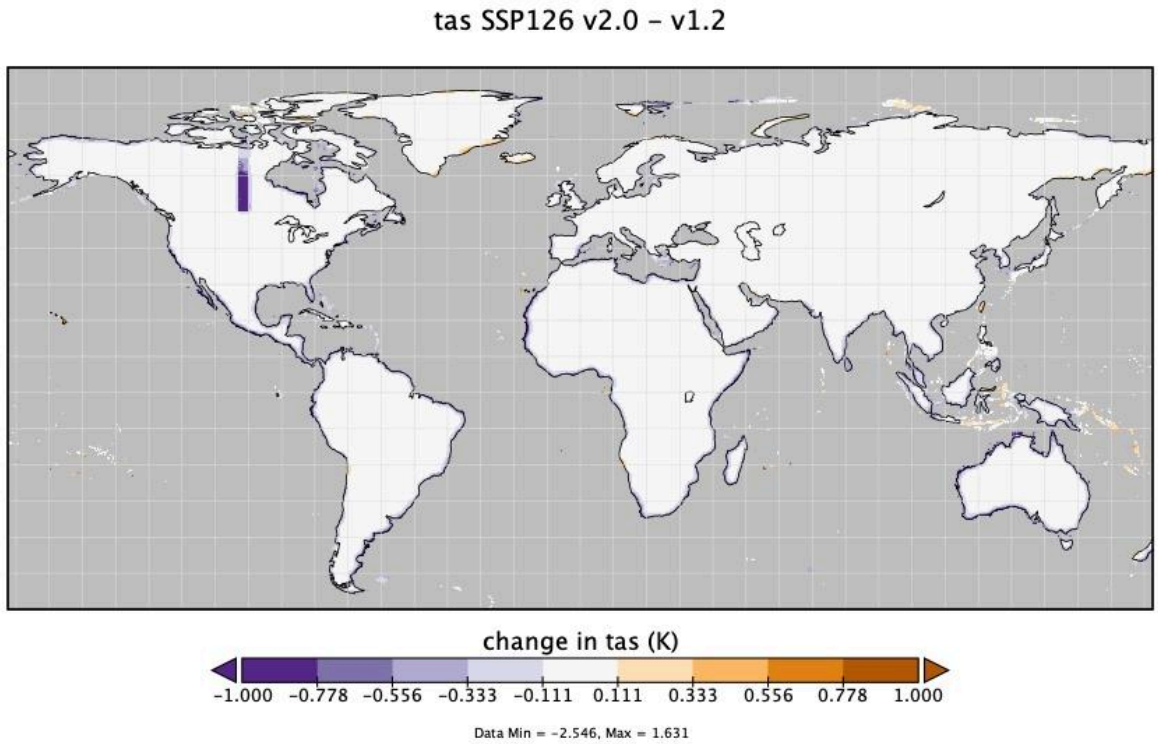



sfcWind SSP370 v2.0 – v1.0
change in sfcWind (m/s)
−0.010 −0.008 −0.006 −0.003 −0.001 0.001 0.003 0.006 0.008 0.010
Data Min = 0.000, Max = 0.019

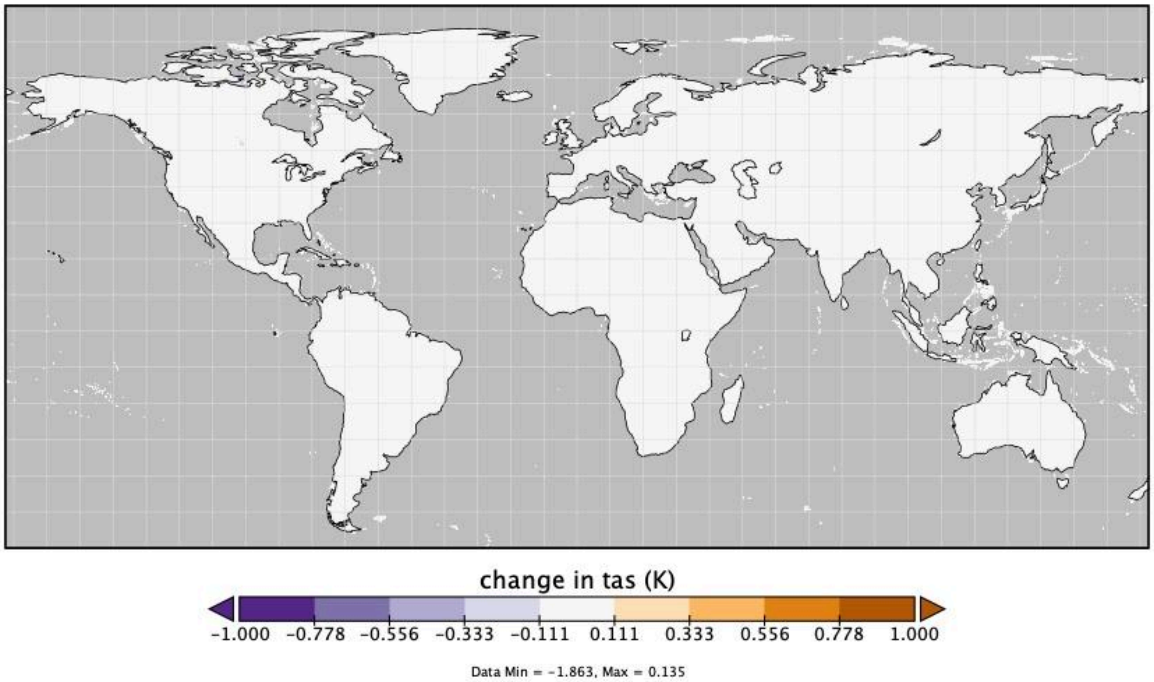

sfcWind SSP585 v2.0 – v1.0
change in sfcWind (m/s)
−0.010 −0.008 −0.006 −0.003 −0.001 0.001 0.003 0.006 0.008 0.010
Data Min = 0.000, Max = 0.016

## 4.3.7 Average temperature (tas)

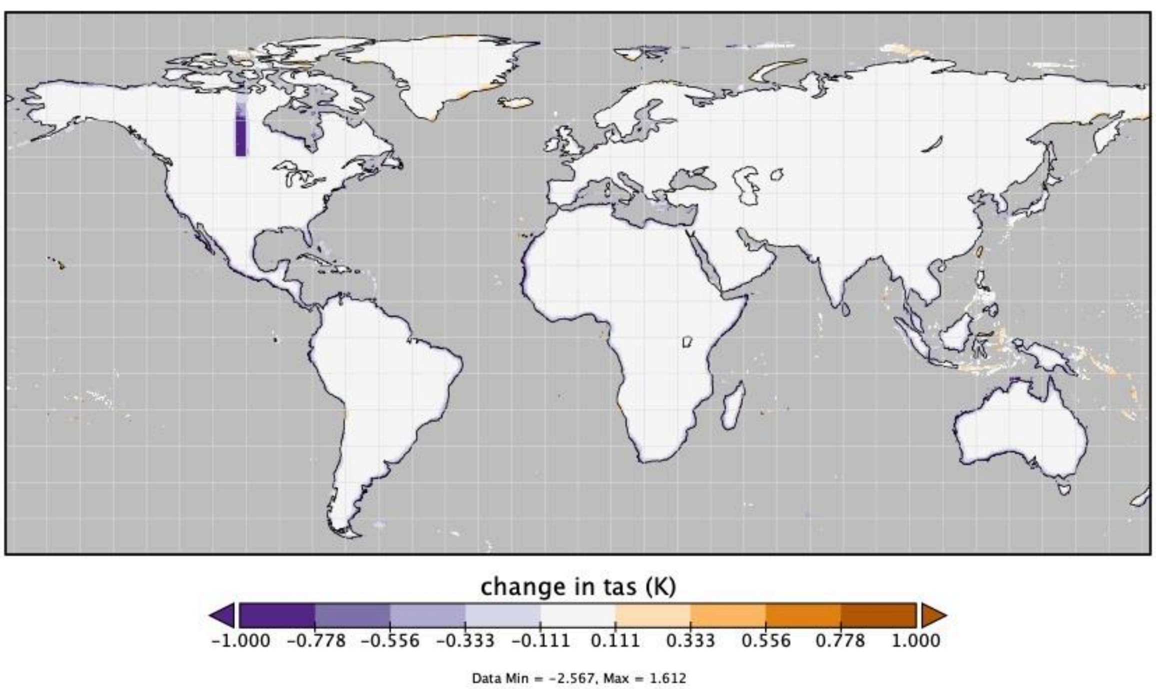
Due to the reprocessing of tasmax & tasmin (see below), new tas files were calculated.

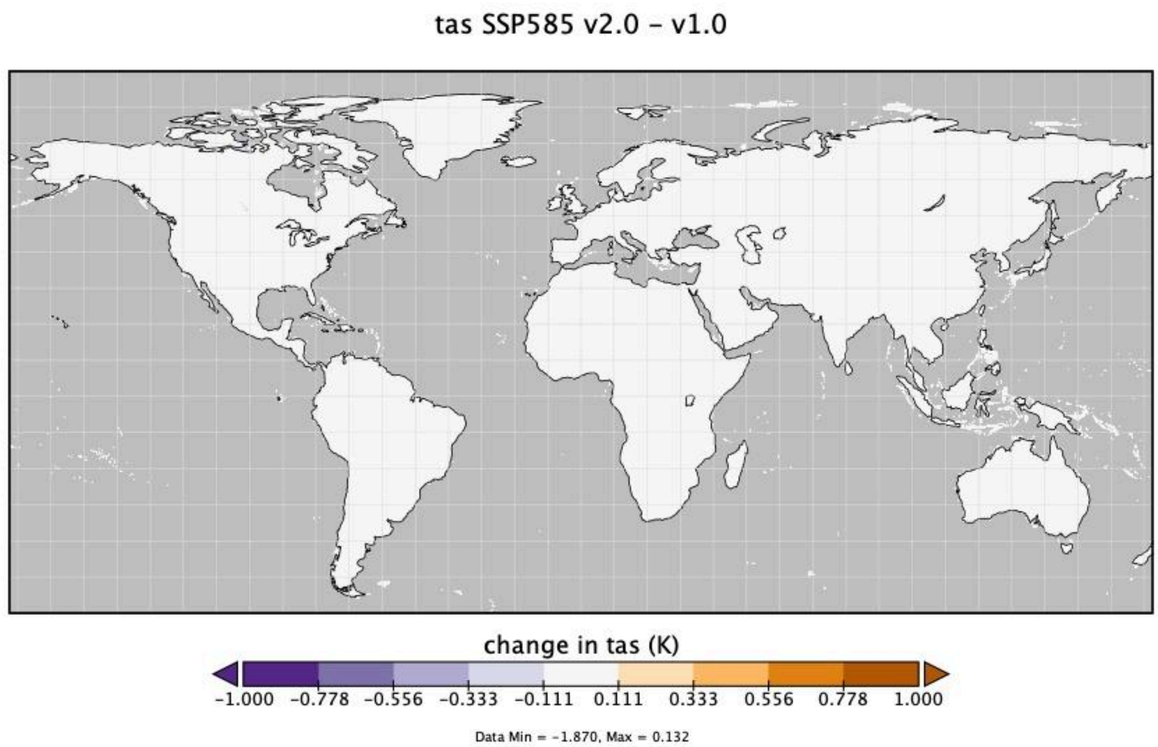


tas SSP245 v2.0 - v1.0




tas SSP370 v2.0 - v1.2

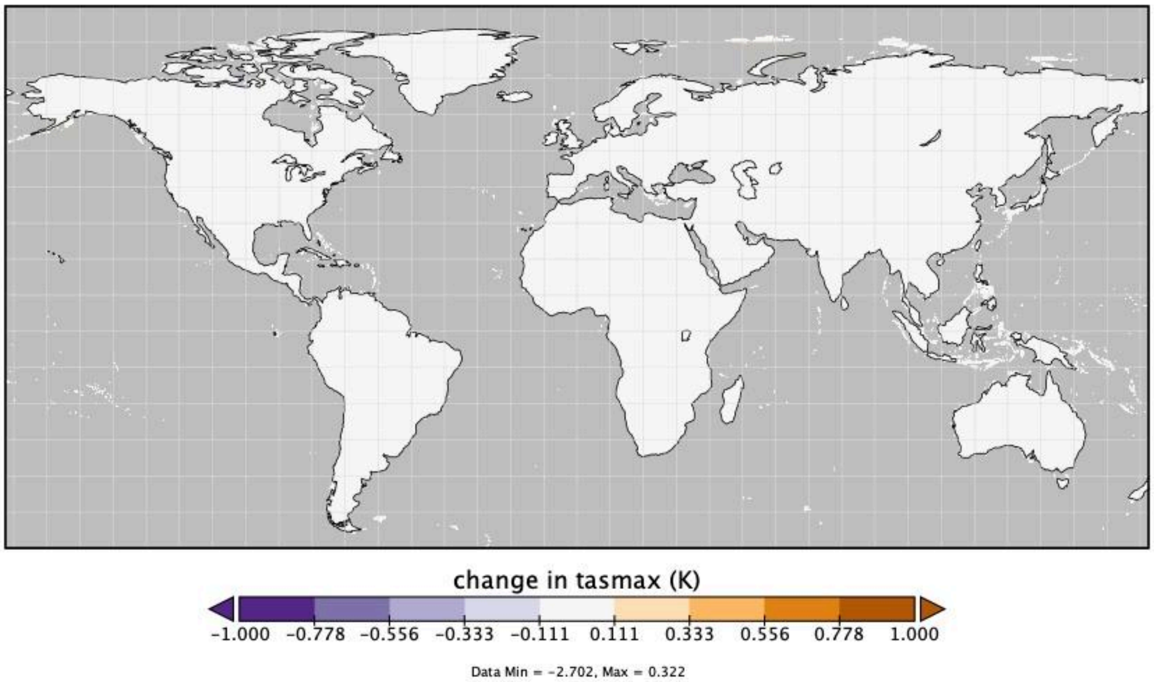




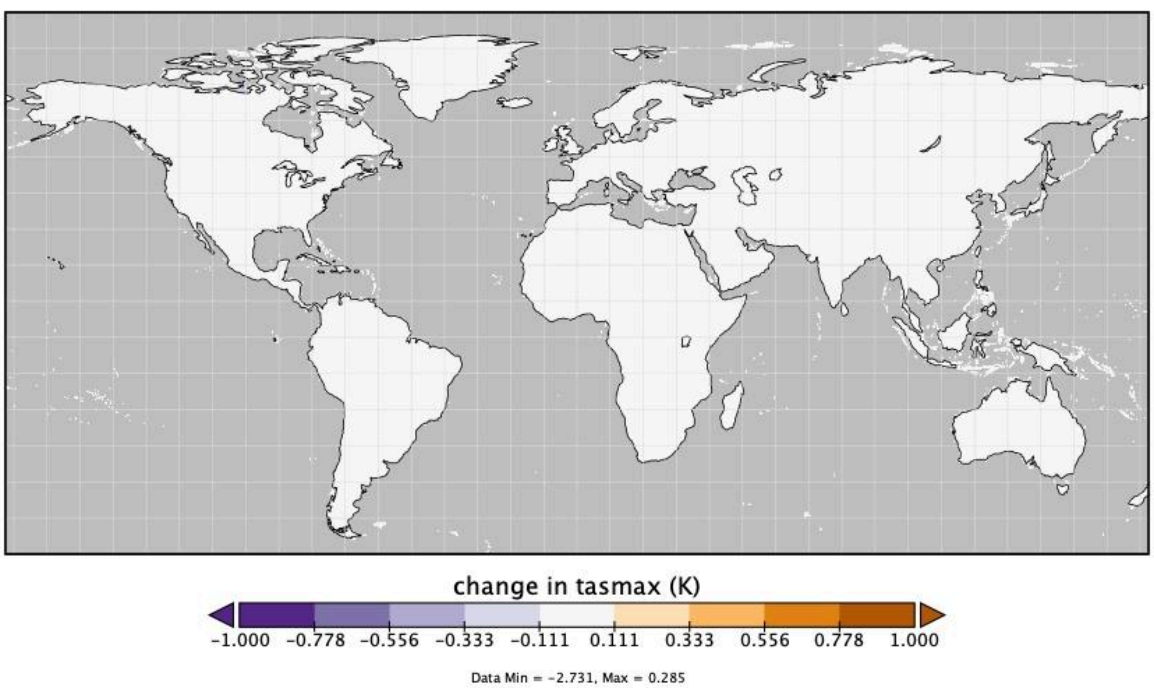

## 4.3.8 Maximum temperature (tasmax)

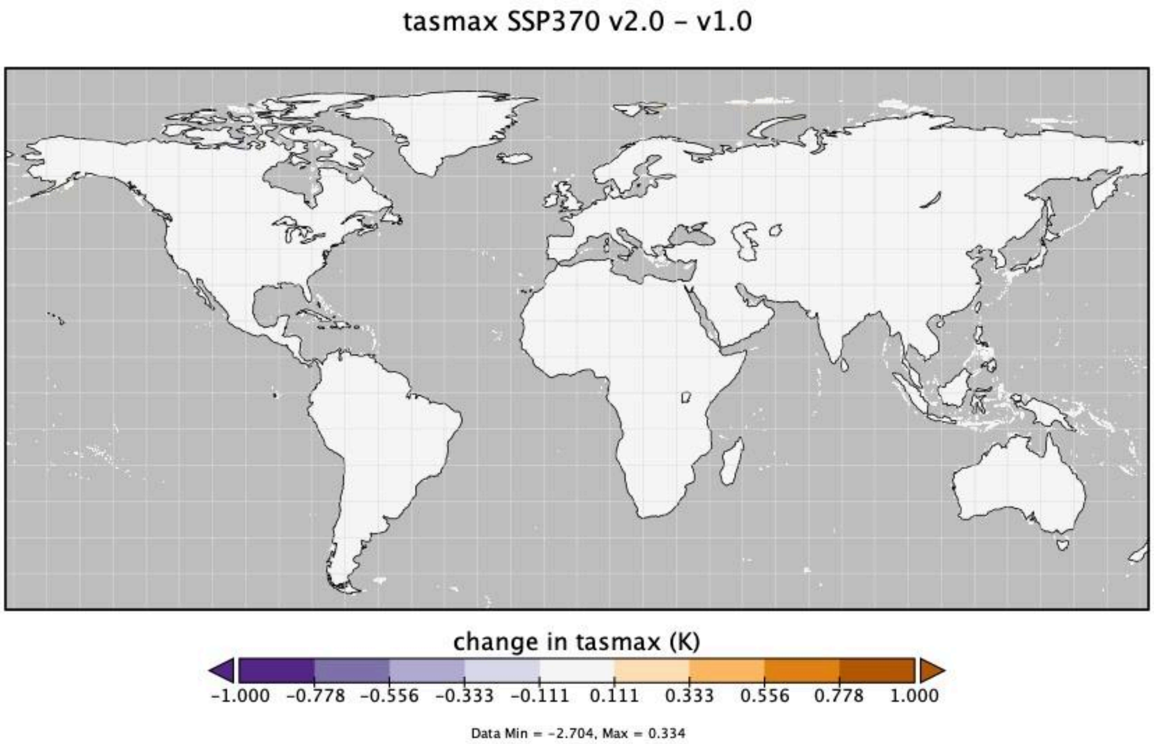
The tasmax variable was re-processed in its entirety with the adjusted GMFD tasmax (see section 3.2.2.1). Also, values have been swapped in grid cells where tx<tn. (See Thrasher, et al., 2012, for a discussion of this phenomenon.)

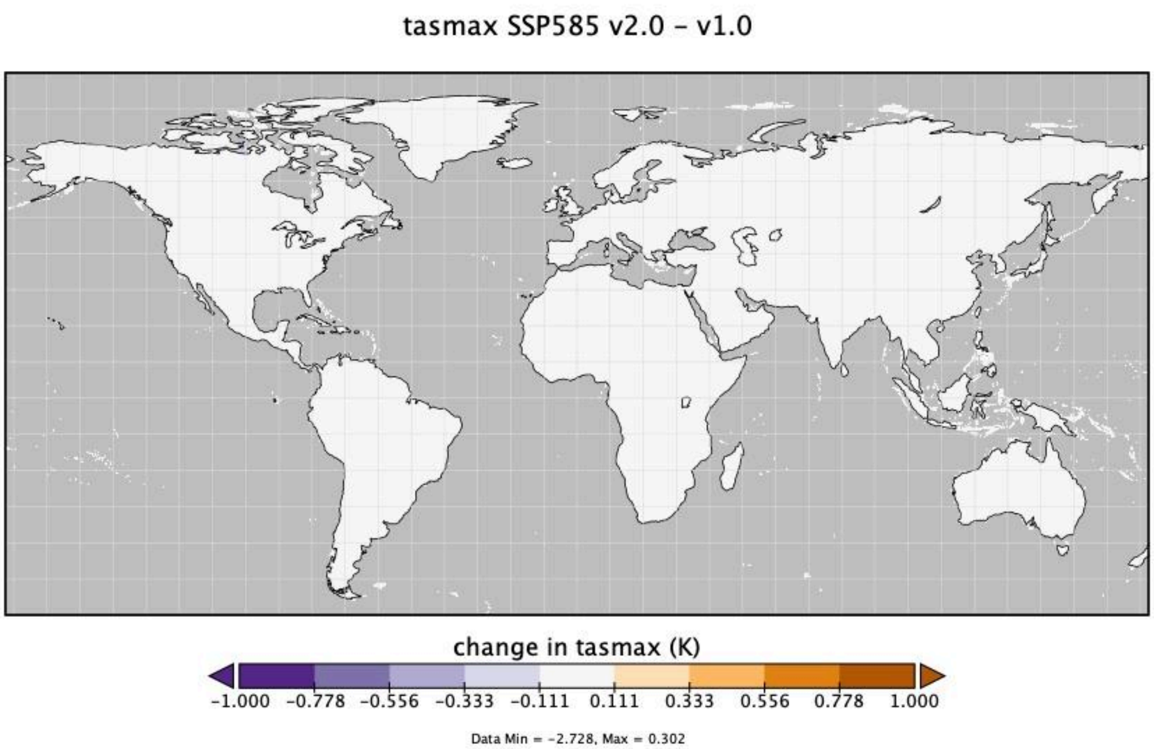
tasmax SSP126 v2.0 - v1.0




tasmax SSP245 v2.0 - v1.0

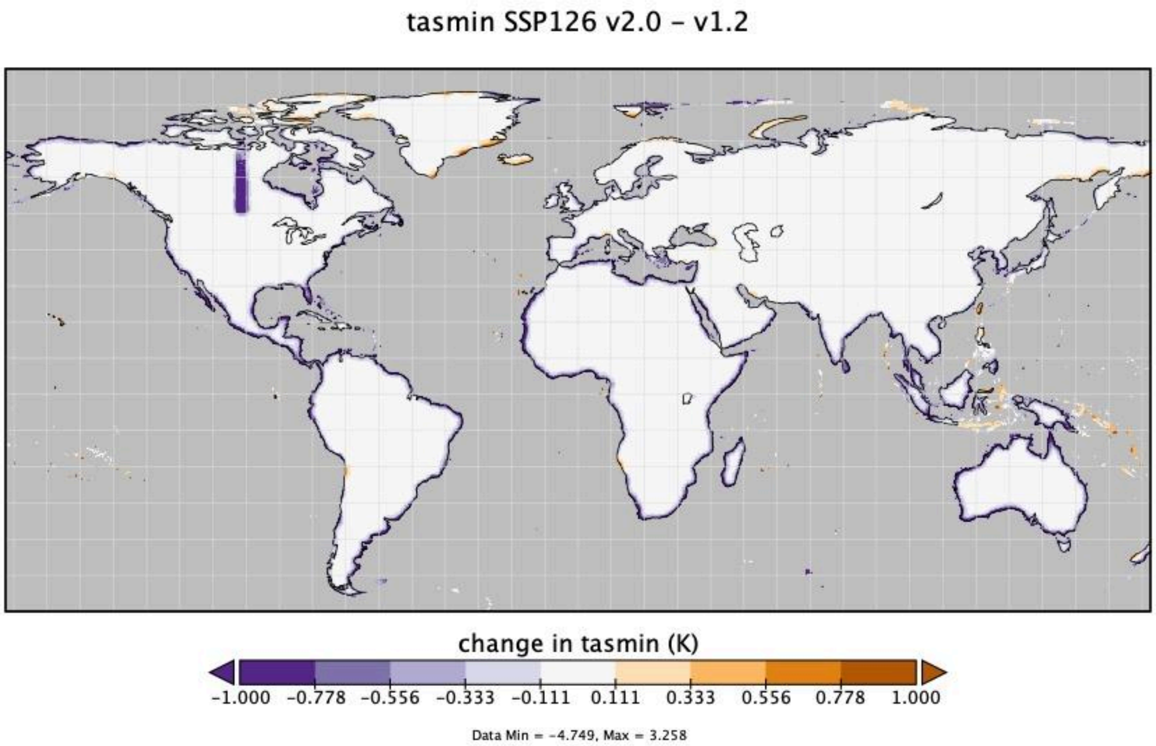


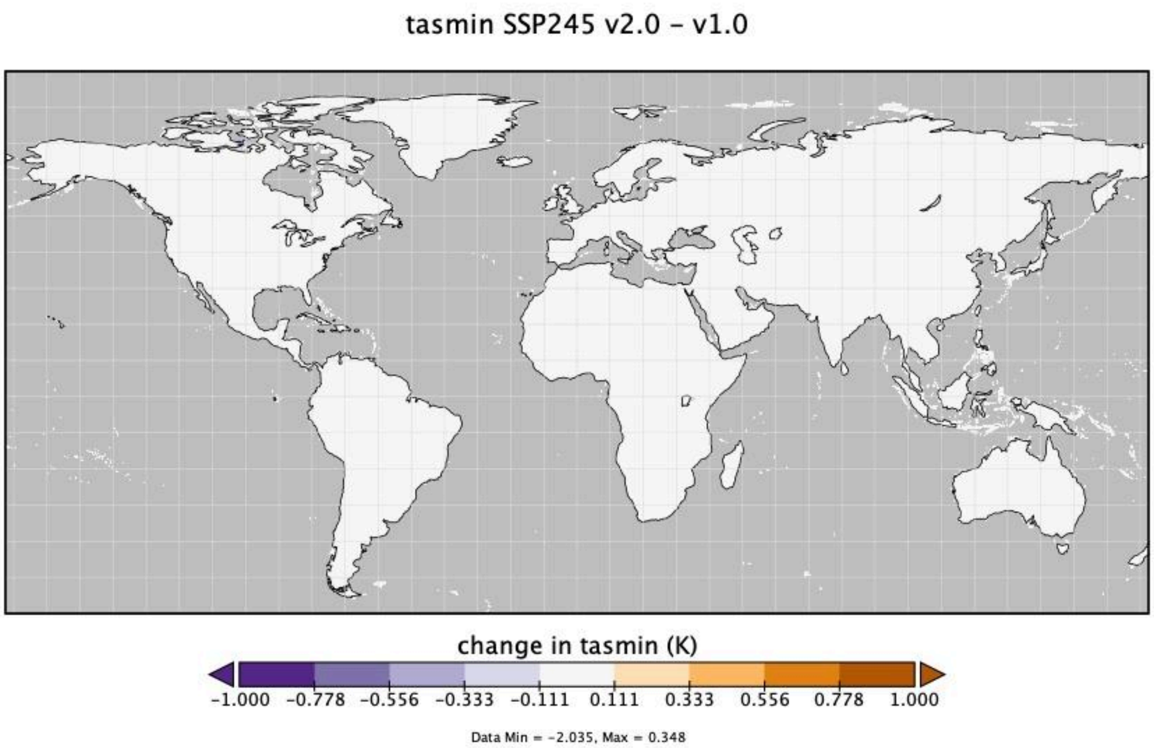

tasmax SSP370 v2.0 - v1.0
change in tasmax (K)
-1.000 -0.778 -0.556 -0.333 -0.111 0.111 0.333 0.556 0.778 1.000
Data Min = -2.704, Max = 0.334

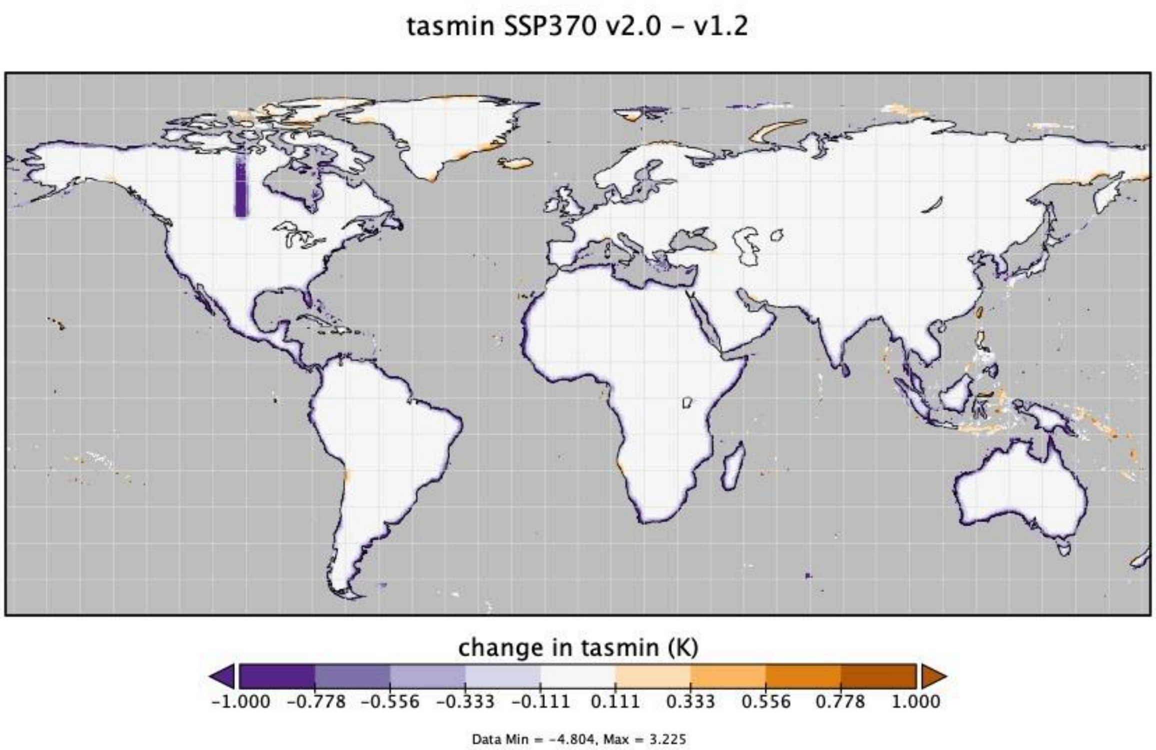

tasmax SSP585 v2.0 - v1.0
change in tasmax (K)
-1.000 -0.778 -0.556 -0.333 -0.111 0.111 0.333 0.556 0.778 1.000
Data Min = -2.728, Max = 0.302

## 4.3.9 Minimum temperature (tasmin)

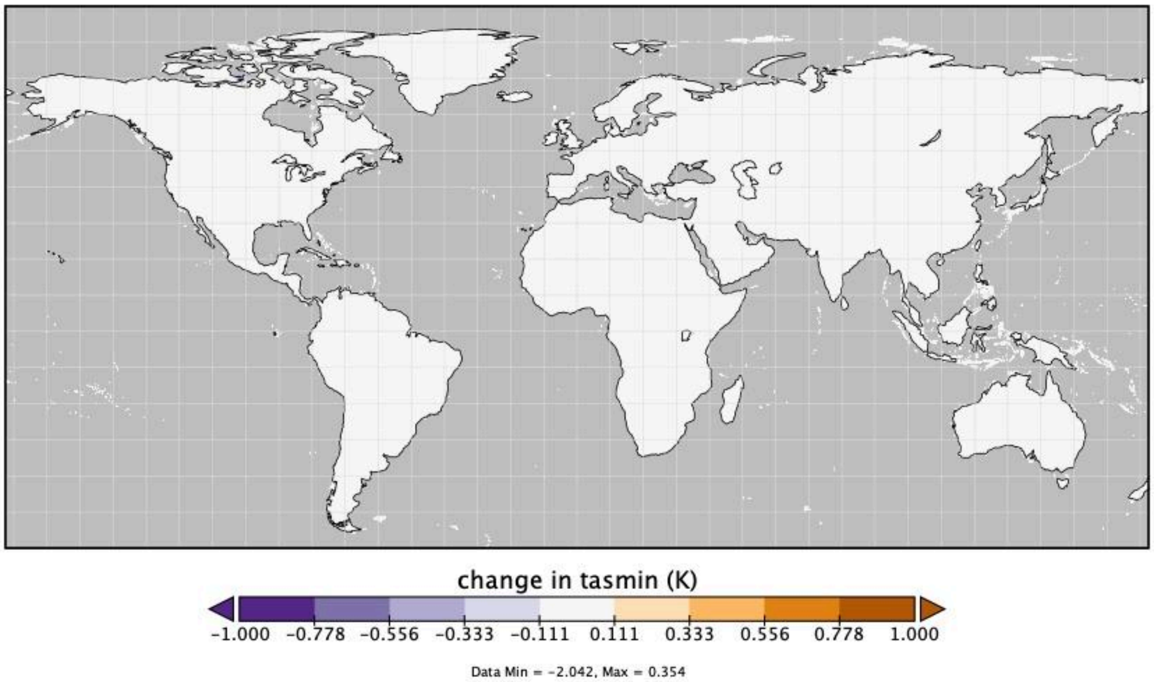
The tasmin variable was re-processed in its entirety with the adjusted GMFD tasmin (see section 3.2.2.1). Also, values have been swapped in grid cells where tx<tn. (See Thrasher, et al., 2012, for a discussion of this phenomenon.)




tasmin SSP245 v2.0 - v1.0
change in tasmin (K)
-1.000 -0.778 -0.556 -0.333 -0.111 0.111 0.333 0.556 0.778 1.000
Data Min = -2.035, Max = 0.348


tasmin SSP370 v2.0 - v1.2
change in tasmin (K)
-1.000 -0.778 -0.556 -0.333 -0.111 0.111 0.333 0.556 0.778 1.000
Data Min = -4.804, Max = 3.225

tasmin SSP585 v2.0 – v1.0




# 5. Considerations and Recommended Use

## 5.1 Recommended Use

This dataset has been generated and is being distributed to assist the science community in conducting studies of climate change impacts at local to regional scales, and to enhance public understanding of possible future climate patterns and climate impacts at the scale of individual cities, communities, and watersheds. This dataset is intended for use in scientific research only, and use of this dataset for other purposes, such as commercial applications, and engineering or design studies is not recommended without consultation with a qualified expert.

## 5.2 Assumptions and Limitations

The BCSD approach used in generating this downscaled dataset inherently assumes that the relative spatial patterns observed from 1960 through 2014 will remain constant under future climate change. Other than the higher spatial resolution and bias correction, this dataset does not add information beyond what is contained in the original CMIP6 scenarios, and preserves the frequency of periods of anomalously high and low values (i.e., extreme events) within each individual scenario. Due to the lack of validation of the GMFD over oceans, GDDP values over smaller island areas might not be realistic.

## 5.3 Trend Adjustment to Individual Models

As described in Section 3.2, the BCSD algorithm does not adjust the slope of the trends in the GCM projections. In the case of temperature, for instance, if the GCM predicts a mean temperature increase of 2°C between 2015 and 2100, the same temperature change (i.e., a trend of 2°C over 86 years) will be observed in the downscaled temperature field. However, the BCSD algorithm does adjust the offset of the climate trends by shifting the retrospectively simulated climate variables (1960 through 2014) to match the GMFD data. In the previous example, if the simulated mean temperature from the GCM over the period 1996-2005 is 14°C, while the observed mean temperature is 15°C, the BCSD algorithm will correct the “bias” by shifting the GCM retrospective and prospective projections upward by 1°C. The adjusted mean temperature projected for the end of the 21st century will then be raised from 16°C to 17°C, though its relative change over the period 2015-2100 is preserved as 2°C. Though such adjustments of future climate projections are qualitatively justifiable, quantitatively the linear shifting itself may not be realistic because the climate system is nonlinear in nature. Users of this dataset should be aware of this limitation of the downscaled data, particularly when using downscaled scenarios from individual GCMs.

# 6. Credits and Acknowledgements

Please use the references below as the primary citations for the dataset described herein:

Thrasher, B., Wang, W., Michaelis, A. et al. (2022). NASA Global Daily Downscaled Projections, CMIP6. Sci Data 9, 262. https://doi.org/10.1038/s41597-022-01393-4

Thrasher, B., Wang, W., Michaelis, A. Nemani, R. (2021). NEX-GDDP-CMIP6. NASA Center for Climate Simulation. https://doi.org/10.7917/OFSG3345

Please use the reference below as the primary citation for the methods used to produce this dataset:

> Thrasher, B., Maurer, E. P., McKellar, C., & Duffy, P. B. (2012). Technical Note: Bias correcting climate model simulated daily temperature extremes with quantile mapping. Hydrology and Earth System Sciences, 16(9), 3309-3314. doi:10.5194/hess-16-3309-2012

Please add the following acknowledgement to any publications that result from use of this dataset:

> Climate scenarios used were from the NEX-GDDP-CMIP6 dataset, prepared by the Climate Analytics Group and NASA Ames Research Center using the NASA Earth eXchange (NEX) and distributed by the NASA Center for Climate Simulation (NCCS).

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# 7. Terms of Use

All CMIP6 GCM model inputs, as noted in Table 1, and any derivatives work, such as this dataset, are governed by the original Terms of use (https://pcmdi.llnl.gov/CMIP6/TermsOfUse/TermsOfUse6-1.html) and may have some restrictions on usage. See the individual netcdf files for the data licensing, the global attribute “cmip6_license” notes the specific license the data may fall under.

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# 9. Points of contact

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# 10. Dataset and Document Revision History

Rev 1 – March 2025 – Document created.

# Appendices

## Appendix I – CMIP6 models included in downscaled archive

| Model | Variant | hurs | huss | pr | rlds | rsds | sfcWind | tas | tasmax | tasmin |
|---|---|---|---|---|---|---|---|---|---|---|
| ACCESS-CM2 | r1i1p1f1 | | | | | | | | | |
| ACCESS-ESM1-5 | r1i1p1f1 | | | | | | | | | |
| BCC-CSM2-MR | r1i1p1f1 | | | | | | | | | |
| CanESM5 | r1i1p1f1 | | | | | | | | | |
| CESM2 | r4i1p1f1 | | | | | | | | | |
| CESM2-WACCM | r3i1p1f1 | | | | | | | | | |
| CMCC-CM2-SR5 | r1i1p1f1 | | | | | | | 1 | 1 | 1 |
| CMCC-ESM2 | r1i1p1f1 | | | | | | | | | |
| CNRM-CM6-1 | r1i1p1f2 | | | | | | | | | |
| CNRM-ESM2-1 | r1i1p1f2 | | | | | | | | | |
| EC-Earth3 | r1i1p1f1 | | | | | | | | | |
| EC-Earth3-Veg-LR | r1i1p1f1 | | | | | | | | | |
| FGOALS-g3 | r3i1p1f1 | | | | | | | | | |
| GFDL-CM4 (gr1) | r1i1p1f1 | | | | | | | | | |
| GFDL-CM4 (gr2) | r1i1p1f1 | | | | | | | | | |
| GFDL-ESM4 | r1i1p1f1 | | | | | | | | | |
| GISS-E2-1-G | r1i1p1f2 | | | | | | | | | |
| HadGEM3-GC31-LL | r1i1p1f3 | | | | | | | | | |
| HadGEM3-GC31-MM | r1i1p1f3 | | | | | | | | | |
| IITM-ESM [2] | r1i1p1f1 | | | | | | | | | |
| INM-CM4-8 | r1i1p1f1 | | | | | | | | | |
| INM-CM5-0 | r1i1p1f1 | | | | | | | | | |
| IPSL-CM6A-LR | r1i1p1f1 | | | | | | | | | |
| KACE-1-0-G | r1i1p1f1 | | | | | | | | | |
| KIOST-ESM | r1i1p1f1 | 3 | | | | | | | | |
| MIROC-ES2L | r1i1p1f2 | | | | | | | | | |
| MIROC6 | r1i1p1f1 | | | | | | | | | |
| MPI-ESM1-2-HR | r1i1p1f1 | | | | | | | | | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| MPI-ESM1-2-LR | r1i1p1f1 | | | | | | | | | |
| MRI-ESM2-0 | r1i1p1f1 | | | | | | | | | |
| NESM3 | r1i1p1f1 | | | | | | | | | |
| NorESM2-LM | r1i1p1f1 | | | | | | | | | |
| NorESM2-MM | r1i1p1f1 | | | | | | | | | |
| TaiESM1 | r1i1p1f1 | | | | | | | | | |
| UKESM1-0-LL | r1i1p1f2 | | | | | | | | | |

Key: Green = historical & all SSPs available; yellow = historical & some SSPs available; red = no data available

[1] Original GCM tasmax & tasmin output retracted by CMCC. (https://errata.es-doc.org/static/view.html?uid=33496f30-9e86-c0ff-874c-61f78df0509a)

[2] Original GCM output missing year 2100 and SSP3.7-0 missing year 2099 for all variables.

[3] Original GCM output for hurs SSP2.4-5 missing year 2058, hurs SSP1.2-6 missing year 2023.

Note, all CMIP6 source_id and institutional_id's as listed in the CMIP6 controlled vocabulary are noted in each individual netcdf files as a global attribute cmip6_source_id and cmip6_institution_id. The controlled vocabulary is defined here:
https://github.com/WCRP-CMIP/CMIP6_CVs/blob/master/CMIP6_source_id.json
and here:
https://github.com/WCRP-CMIP/CMIP6_CVs/blob/master/CMIP6_institution_id.json.

## Appendix II – Working with the NetCDF files

The data provided is in NetCDF (https://www.unidata.ucar.edu/software/netcdf/) file format. All files are written with the CF-1.7 metadata conventions (https://cfconventions.org/), as noted by the “Conventions” global attribute within the files.

There are many software options available for reading and writing NetCDF files. The most basic option is to use the ncdump command line utility, which the standard netCDF-c software package (https://github.com/Unidata/netcdf-c) provides. Note, many Linux distributions provide pre-built packages that can be installed, e.g. Ubuntu. There are also pre-built Windows and MacOS packages available.

An example of viewing a file's structure, or header, in a terminal one can execute the following command line:

```
$ ncdump -h hurs_day_ACCESS-CM2_historical_r1i1p1f1_gn_1971.nc
netcdf hurs_day_ACCESS-CM2_historical_r1i1p1f1_gn_1971 {
dimensions:
        time = UNLIMITED ; // (365 currently)
        lat = 600 ;
        lon = 1440 ;
variables:
        double time(time) ;
                time:axis = "T" ;
.
.
.
}
```

Python (https://www.python.org/) is a popular scripting language that can be used to view and analyze the data. You will need to install the Python package netCDF4 (https://unidata.github.io/netcdf4-python/) via pip, conda or build the package from source. With the netCDF4 package installed on your system, in the Python interpreter:

```
$ python
Python 3.7.3 (default, Mar 27 2019, 22:11:17)
[GCC 7.3.0] :: Anaconda, Inc. on linux
Type "help", "copyright", "credits" or "license" for more information.
>>> import netCDF4
>>> data = netCDF4.Dataset('tasmax_day_ACCESS-CM2_historical_r1i1p1f1_gn_2014.nc')
>>> # print out the file structure
>>> print(data)
```

```
.
.
.
>>> # print out the variables
>>> print(data.variables)
>>> # get a variable
>>> var_tasmax = data.variables['tasmax']
>>> # print the variable structure and attributes
>>> print(var_tasmax)
.
.
.
>>> # print the variable units and fill value
>>> print(var_tasmax.units)
K
>>> print(var_tasmax._FillValue)
1e+20
>>> # actually load the data into an numpy array
>>> dat = var_tasmax[:]
dat = var_tasmax[:]
>>> # compute the max and min
>>> dat.max()
329.3559
>>> dat.min()
211.7591
>>> # subset or slice the data
>>> sub_dat = dat[10:50,20:30]
>>> # close for clean up.
>>> data.close()
```