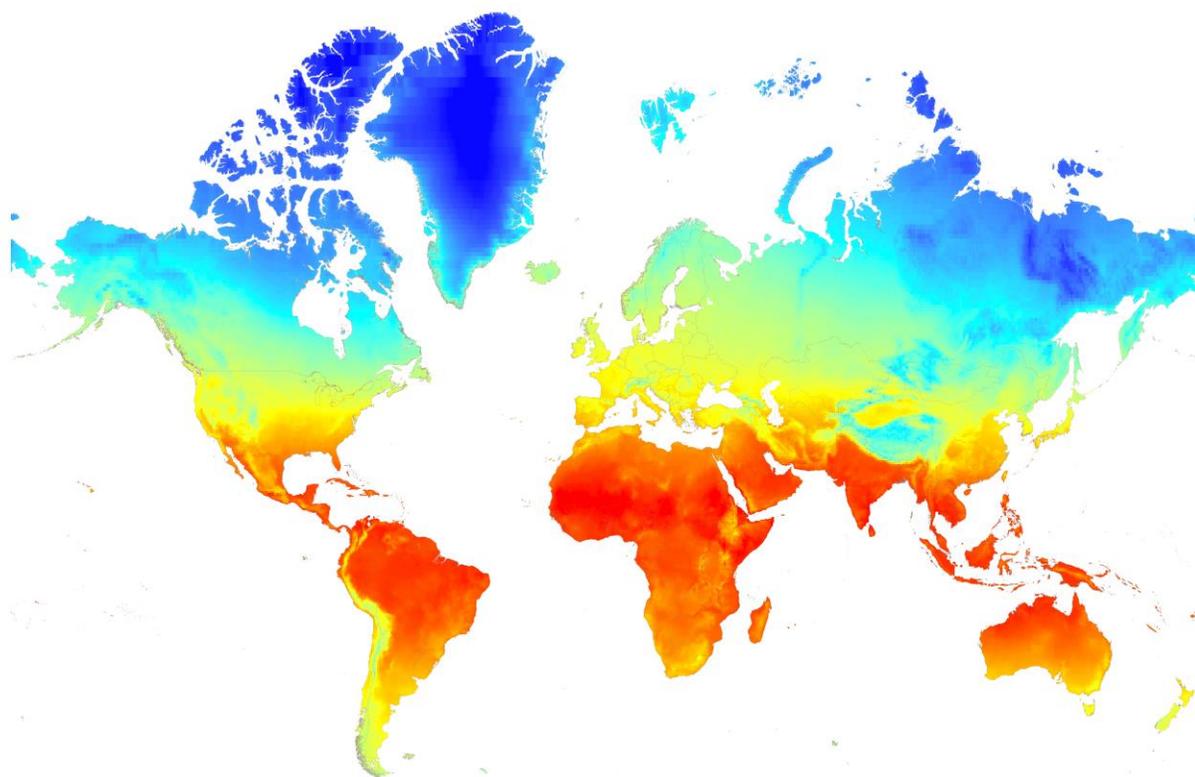


METADATA OF THE CLIMATE CHANGE KNOWLEDGE PORTAL



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CLIMATE DATA

HISTORICAL CLIMATE

DATA SOURCE

CREDITS:

CRU TS v. 4.01, dataset DOI: <http://doi.org/10/gcmcz3>.

General reference: Harris et al., 2014: Updated high-resolution grids of monthly climatic observations – CRU TS3.10: The Climatic Research Unit (CRU) Time Series (TS) Version 3.10 Dataset, *Int. J. Climatology*, 34(3), 623-642, doi: 10.1002/joc3711; updated from previous version of CRU TS3.xx (most recent use in CCKP: TS3.24).

LINK: <https://crudata.uea.ac.uk/cru/data/hrg/>

DESCRIPTION:

Historical CRU Dataset

Historical data originates from observational datasets and allow scientists to understand historical actuals as well as compare projection model outputs against observed data. Historical data is generated from thousands of weather stations worldwide which are collecting temperature and rainfall data.

In order to present the current climate conditions, CCKP uses the globally available observational datasets derived from the Climate Research Unit (CRU) of the University of East Anglia¹. These datasets are widely accepted as reference datasets in climate research. CRU provides gridded historical datasets derived from observational data and provides quality-controlled temperature and rainfall data as well as derivative products including monthly climatologies and long term historical climatologies. Historical trends use CRU data to quantify changes in the annual mean temperature and annual total precipitation, for the period from 1901 to 2016². To test the ability of the models to represent today's climate, simulations are compared to CRU and projection models will undergo bias corrections. For analysis of projected temperature and precipitation, the model's representation of the seasonal cycle is additionally considered. The same thresholds and assumptions to categorize the observed changes have been used as for the projected changes.

Historical data are derived from 3 sources, all quality controlled by leading institutions in the field. To view the historical data, click on the map and under the 'Climate' tab click on the 'Historical' sub-tab. These are organized below under their potential use as follows:

SPATIAL VARIABILITY

Maps show the spatial expression of different climate fields. Temperature changes primarily by latitude and elevation, but proximity to oceans can also influence the temperature. Because of the absence of sunlight in the respective winter period, seasonality is particularly high in polar regions, but it also

¹ <http://www.cru.uea.ac.uk/about-cru>

² <https://crudata.uea.ac.uk/cru/data/hrg/>

increases in the interiors of continents. In the tropics, seasonality is minimized and often more easily recognizable in precipitation. However, the lack of strong seasonal oscillations as well as often a much more muted year-to-year variability causes the tropics to be much more sensitive to changes than higher latitudes where ecosystems are used to large intra and inter-annual variations so that small changes in temperature have often quite small environmental impacts.

While temperatures vary spatially only gradually (or due to topography), the precipitation field is often highly variable. This is caused by the fact that precipitation is not a “continuous” field but represents intermittent processes with rainfall only occurring occasionally (with a few exceptions). Daily cycles as well as seasonal shifts of zones where precipitation occurs more systematically often lead to complex and quite often strongly varying fields over a range of time scales. The only locations where precipitation is more regular is in the inner tropics as well as on the windward side of mountain ranges where orographic lift leads to condensation and precipitation. Therefore, maps of precipitation are often much less smooth than temperature or other fields, even when looking at climatologies that average precipitation over 20 or 30 years. Values from individual grid cells should be used with caution as they might vary depending on the exact selection of the period.

These general differences between temperature- and moisture-related fields also can be observed at the level of climate indicators. But more generally, information from individual grid-cells should always be looked at in context of their broader spatial fields. This is partially due to the spatial variations described above. Spatial variability (or “noise”), particularly when looking at model-based climate projections, arises also in gridded data when small scale processes are averaged over the full grid cell. As models represent the underlying surface slightly differently, they will not reproduce the same details of the climate processes. In particular in the moisture fields, namely precipitation, this will lead to model-to-model differences, further affecting the spatial coherence.

Therefore, maps in the CCKP offer the user the broader context of a climate field to allow for a better interpretation of the robustness of a grid-based measure of the climatology or of a signal of change.

ANNUAL Cycle

The CRU TS version 4.01 gridded historical dataset is derived from observational data and provides quality controlled temperature and rainfall values from thousands of weather stations worldwide, as well as derivative products including monthly climatologies and long term historical climatologies. The dataset is produced by the Climatic Research Unit (CRU) of the University of East Anglia (UEA) CRU- (Gridded Product).

CRU rainfall and temperature data can be mapped to illustrate the baseline climate and seasonality by month for a set of climatological intervals.

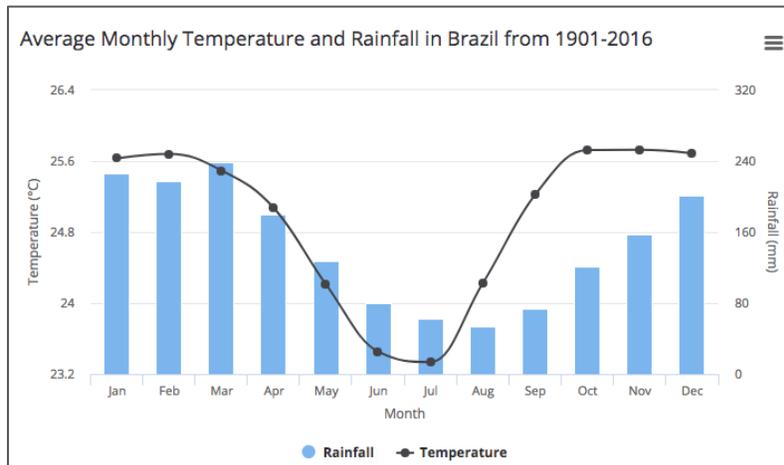


Figure 1: Average monthly Temperature and rainfall for Brazil (1901-2016). (Source: [CCKP](#))

VARIABILITY AT THE STATION LEVEL

Global Historical Climatology Network (GHCN) - provides station level, quality controlled, observational datasets for temperature and rainfall values from thousands of weather stations worldwide (GHCN), as well as derivative products including monthly climatologies and long term historical climatologies. To view the historical data, click on the map and under the 'Climate' tab click on the 'Historical' sub-tab and Select the Historical Variability Analysis Button.

The Historical Variability Analysis Tool allows a user to investigate the historical variability of precipitation and temperature at various time scales (interannual, decadal, and long-term linear trend) over the 20th century near a user-selected location. An example output from this tool is presented below:

a. Jan-Mar Seasonal Average Station Precipitation Values, Decadal Variability, & Linear Trend

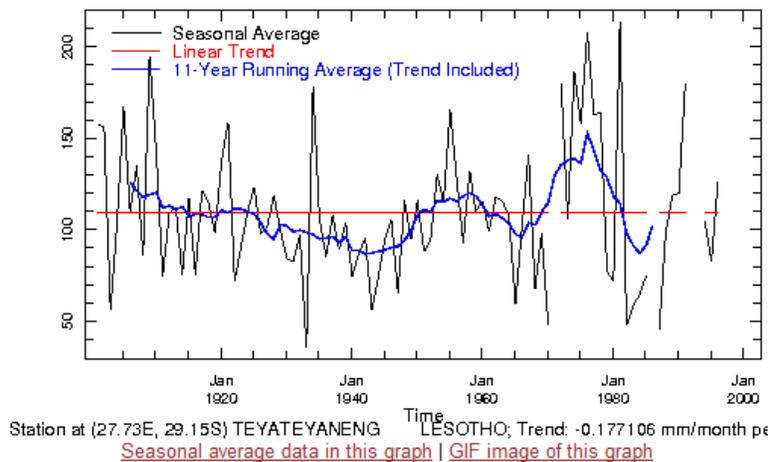


Figure 2: The historical period for these models is 1980-1999. (Source: [IRI Columbia](#))

FUTURE CLIMATE

Data Source

CREDITS:

Original source data: The Coupled Model Intercomparison Project, v. 5 – CMIP5: Taylor, K. E., R. J. Stouffer, and G. A. Meehl, 2012: An Overview of CMIP5 and the Experiment Design. *B Am Meteorol Soc*, **93**, 485-498. 10.1175/bams-d-11-00094.1. CCKP data products: prepared and processed by National Center for Atmospheric Research - Research Applications Laboratory (NCAR-RAL).

LINKS:

CMIP5: <https://cmip.llnl.gov/cmip5/>

NCAR: <http://ncar.ucar.edu>

DESCRIPTION:

CMIP5 Climate Models

The data used in this collection come from the [CMIP5](#) (Coupled Intercomparison Project Phase 5) distribution (Taylor et al. 2012). CMIP is a standard experimental framework for studying the output of coupled atmosphere-ocean general circulation models; CCKP uses the current fifth project phase. CMIP5 is defined by experiment suites divided into three categories: 1) Decadal Hindcasts and Predictions simulations; 2) "long-term" simulations; and 3) "atmosphere-only" (prescribed SST) simulations for especially computationally-demanding models.

CMIP5 is the fifth iteration of a globally coordinated experiment collection using a previously agreed-upon suite of Representative Concentration Pathways – RCPs (Moss et al. 2010), which represent different possible future radiative forcing scenarios through a selected evolution of distinct emissions and land-use change. Previously (up to CMIP3), these scenarios were called emission scenarios as presented in the Special Report on Emission Scenarios – SRES (Nakicenovic and Swart 2000), e.g., SRES scenarios A2, A1FI, A1B, B1. The scenarios considered here are the RCP-2.6, RCP-4.5, RCP-6.0 and RCP-8.5. The numbers attached to the RCPs represent the global mean radiative forcing in watts per square-meter achieved in each of the scenarios by the year 2100. For example, RCP2.6 represents a very strong mitigation scenario, RCPs4.5 and 6.0 represent intermediate stabilization pathways, and RCP8.5 assumes the continuous increase in greenhouse gas emissions.

The CCKP-CMIP5 collection used here consists of up to 35 models (Table 1) that submitted **daily data** across the RCPs and for which the data were readily available over the Earth System Grid. The data used here were obtained through the IPCC Working Group I data snapshot offered by the Swiss Federal Technical University in Zürich (thanks to U. Beyerle). All data was processed using the Climate Risk Management engine (CRMe) infrastructure (Ammann et al. 2016) and formatted using ArcGIS and functions offered through the Open Geospatial Consortium (<http://www.opengeospatial.org/>).

Table 1: List of models used in this compilation

Model	Modeling Center	Institution	Terms of Use
ACCESS1_0	CSIRO-BOM	CSIRO (Commonwealth Scientific and Industrial Research Organisation, Australia), and BOM (Bureau of Meteorology, Australia)	unrestricted
ACCESS1_3			
BCC_CSM1_1 ^{ecv}	BCC	Beijing Climate Center, China Meteorological Administration	unrestricted
BCC_CSM1_1_M ^{ecv}			
BNU_ESM	GCESS	College of Global Change and Earth System Science, Beijing Normal University	unrestricted
CANESM2	CCCma	Canadian Centre for Climate Modelling and Analysis	unrestricted
CCSM4 ^{ecv}	NCAR	National Center for Atmospheric Research	unrestricted
CESM1_BGC	NSF-DOE-NCAR	National Science Foundation, Department of Energy, National Center for Atmospheric Research	unrestricted
CESM1_CAM5 ^{ecv}			
CMCC_CESM	CMCC	Euro-Mediterranean Center on Climate Change	unrestricted
CMCC_CM			
CMCC-CMS			
CNRM-CM5	CNRM-CERFACS	Centre National de Recherches Meteorologiques / Centre Europeen de Recherche et Formation Avancees en Calcul Scientifique	unrestricted
CSIRO_MK3_6_0 ^{ecv}	CSIRO-QCCCE	Commonwealth Scientific and Industrial Research Organization in collaboration with the Queensland Climate Change Centre of Excellence	unrestricted
FIO_ESM ^{ecv}	FIO	The First Institute of Oceanography, SOA, China	unrestricted
GFDL_CM3 ^{ecv}	NOAA GFDL	Geophysical Fluid Dynamics Laboratory	unrestricted
GFDL_ESM2G			
GFDL_ESM2M ^{ecv}			
GISS_E2_H ^{ecv}	NASA GISS	NASA Goddard Institute for Space Studies	unrestricted
GISS_E2_R ^{ecv}			
HADGEM2_CC	MOHC (additional)	Met Office Hadley Centre (additional HadGEM2-ES realizations contributed by Instituto Nacional de Pesquisas Espaciais)	unrestricted
HADGEM2_ES			

	realizations by INPE)		
HADGEM2_AO	NIMR/KMA	National Institute of Meteorological Research/Korea Meteorological Administration	unrestricted
INMCM4	INM	Institute for Numerical Mathematics	unrestricted
IPSL_CM5A_LR	IPSL	The Institute Pierre Simon Laplace	unrestricted
IPSL_CM5A_MR ^{ecv}			
IPSL_CM5B_LR			
MIROC_ESM ^{ecv}	MIROC	Japan Agency for Marine-Earth Science and Technology, Atmosphere and Ocean Research Institute (The University of Tokyo), and National Institute for Environmental Studies	non-commercial only
MIROC_ESM_CHEM ^{ecv}			
MIROC5 ^{ecv}	MIROC	Atmosphere and Ocean Research Institute (The University of Tokyo), National Institute for Environmental Studies, and Japan Agency for Marine-Earth Science and Technology	non-commercial only
MPI_ESM_LR	MPI-M	Max Planck Institute for Meteorology (MPI-M)	unrestricted
MPI_ESM_MR			
MRI_CGCM3 ^{ecv}	MRI	Meteorological Research Institute	non-commercial only
MRI_ESM1			
NORESM1_M ^{ecv}	NCC	Norwegian Climate Centre	unrestricted

* ECV: Essential (basic) climate variables

For each model (see Table 1), a section of the *historical* simulations was required to form each model's own reference period. While generally the World Meteorological Organization prefers reference periods that span 30 years (e.g., 1971-2000, or 1981-2010), the IPCC-AR5 (Stocker et al. 2013) broadly utilized a **20-year interval of 1986-2005**. This period covers the final 20 years of the *historical* simulations that were driven with observed radiative forcings. A 20-year window also corresponds to the CCKP requested 20-year climatological windows for the future, **namely 2020-2039, 2040-2059, 2060-2079, and 2080-2099**. For each of these future time windows, simulations from all four RCPs were obtained and processed for **4 basic climate variables** and **35 additional climate indicators** (Table 2).

BASIC CLIMATE PROJECTIONS

The basic climate projections for the essential variables of temperature (mean, min and max) and precipitation were produced with the objective of providing the most robust comparison between different RCPs possible. They were processed separately from the climate indicators (see section 3 below).

This most basic climate change projection information was restricted to a fixed collection of models that required that information was available for all of the different RCPs, and therefore a direct comparison between RCPs is most robust. 16 models fulfilled these criteria. They are available individually and in form of a multi-model ensemble for the “essential climate variables” of “monthly temperature”, “monthly maximum temperature”, “monthly minimum temperature” and “monthly precipitation”. They are accessible at the top of the variable list under CMIP5. The models that are part of this distribution are marked in Table 1 with the label “ecv” (essential climate variables).

CLIMATE INDICATORS

Climate indicators capture a specific characteristic of weather and climate that can have more specific impacts on the ground. A selection of 39 indicators was chosen by NCAR for the CCKP. They consist of a subset of the climate statistics indicators from the joint CCI/CLIVAR/JCOMM Expert Team on Climate Change Detection and Indices (ETCCDI) (see: http://etccdi.pacificclimate.org/list_27_indices.shtml) and some others developed during this project specifically to meet sectoral needs or requests (particularly the return intervals and the drought indicators)³. **All data is presented at a 1°x1° global grid spacing, produced through bi-linear interpolation.**

For each indicator, the tables below indicate if they were delivered with annual or monthly breakdowns. Currently, all values are presented as **anomalies** to their respective **baseline period of 1986-2005** for highlighting the information of change in the simplest and most efficient way to users⁴. All temperature base series were bias corrected at the annual mean level of the climatology over the baseline period. Derived indices, such as number of days with temperatures above 35 or 40 degrees Celsius and heat indices are highly sensitive to the absolute temperature and moisture, and thus benefit from such a bias correction. However, because of lack of good observational data and because of much larger challenges in representing this component, rainfall and humidity have not been adjusted to prevent unphysical outcomes.

Table 2: List of climate indicators (39 in total, 4 basic variables and 35 derived indices)

	No.	Variable Name	Unit	Description
Basic Climate	1	Monthly Temperature	°C	Mean or change in monthly temperature.
	2	Monthly Max-Temperature	°C	Mean or change in monthly max-temperature.

³ The precipitation return interval calculations are based on the automatic algorithm of Naveau et al. 2016 (Modeling jointly low, moderate, and heavy rainfall intensities without a threshold selection, *Water Resour. Res.*, 52, 2753 – 2769, doi:10.1002/2015WR018552) that does not require local *a priori* specification of a threshold beyond which precipitation would be considered as distributed following an extreme value distribution. The results presented thus far are the mean expected outcome

⁴ Base climatologies are available for all and can be inspected and compared to observed series, such as the Sheffield et al. (2006: Development of a 50-year high-resolution global dataset of meteorological forcings for land surface modeling. *Journal of Climate*, 19, 3088-3111).

Temperature	3	Monthly Min-Temperature	°C	Mean or change in monthly min-temperature.	
	4	Monthly Precipitation	°C	Mean or change in monthly precipitation.	
	5	Maxima of Daily Max-Temperature	°C	Change in maximum of daily max-temperature per month or year.	
	6	Minima of Daily Min-Temperature	°C	Change in minimum of daily min-temperature per month or year.	
	7	Number of Summer Days (Tmax > 25°C)	Days	Average count of days per month or year where the daily maximum temperature surpassed 25°C.	
	8	Number of Tropical Nights (Tmin > 20°C)	Days	Average count of days per month or year where the daily minimum temperature remained above 20°C.	
	9	Number of Frost Days (Tmin < 0°C)	Days	Average number of days per month or year when the minimum temperature dropped below the freezing point of water at 0°C.	
	10	Number of Ice Days (Tmax < 0°C)	Days	Average number of days per month or year when the daily maximum temperature did not break through the freezing point but remained below 0°C.	
	11	Number of Hot Days (Tmax > 35°C)	Days	Average count of days per month or year when the maximum temperature surpassed 35°C.	
	12	Number of Very Hot Days (Tmax > 40°C)	Days	Average count of days per month or year when the maximum temperature surpassed 40°C.	
	13	Number of Days with Dangerous Heat (Heat Index > 35°C)	Days	Average count of days per month or year when the daily Heat Index surpassed 35°C.	
	Precipitation	14	Number of Days with Rainfall > 20mm	Days	Average count of days per month or year with at least 20mm of daily rainfall.
		15	Number of Days with Rainfall > 50mm	Days	Average count of days per month or year with at least 50mm of daily rainfall.
16		Rainfall Amount from Very Wet Days	Percentage	Monthly or annual sum of rainfall when the daily precipitation rate exceeds the local 95th percentile of daily precipitation intensity.	
17		Largest Single Day Rainfall	mm	Monthly or annual average of the largest daily rainfall amount.	

	18	Largest 5-day Cumulative Rainfall	mm	Monthly or annual average of the largest 5-day consecutive rainfall amount.
	19	Expected Daily Rainfall Maximum in 10 Years (10-yr Return Level)	mm	Statistical 10-yr return level of the largest daily rainfall event.
	20	Expected 5-day Cumulative Rainfall Maximum in 10 Years (10-yr Return Level)	mm	Statistical 10-yr return level of the largest 5-day consecutive rainfall sum.
	21	Expected Daily Rainfall Maximum in 25 Years (25-yr Return Level)	mm	Statistical 25-yr return level of the largest daily rainfall event.
	22	Expected 5-day Cumulative Rainfall Maximum in 25 Years (25-yr Return Level)	mm	Statistical 25-yr return level of the largest 5-day consecutive rainfall sum.
	23	Expected Largest Monthly Rainfall Amount in 10 Years (10-yr Return Level)	mm	Statistical 10-yr return level of the largest monthly rainfall sum.
	24	Expected Largest Monthly Rainfall Amount in 25 Years (25-yr Return Level)	mm	Statistical 25-yr return level of the largest monthly rainfall sum.
Agriculture	25	Growing Season Length	Days	Number of days between the first and last period of 6 or more consecutive days with a daily mean temperature above 5°C
	26	Maximum Length of Consecutive Dry Spell	Days	Number of days in the longest period without significant rainfall of at least 1mm.
	27	Maximum Length of Consecutive Wet Spell	Days	Number of days in the longest period with continuous significant rainfall of 1mm or more.
	28	Rainfall Seasonality	Standard Deviation	Standard deviation of monthly rainfall against the mean monthly rainfall across the year.
Drought	29	Mean Drought Index	SPEI	Changes in the mean of 12-month cumulative water balance, taking into account evapotranspiration.
	30	Annual Severe Drought Likelihood	Probability	Annual probability of experiencing at least severe drought conditions (Standardized Precipitation Evapotranspiration Index <-2).
	31	Range between Wettest and Driest Month	mm	The rainfall range between the driest and the wettest month over the period.

	32	Range between Wettest and Driest Year	mm	The rainfall range between the driest and the wettest year over the period.
Energy	33	Heating Degree Days	°C	Number of degrees that a day's average temperature is below 18.3°C.
	34	Cooling Degree Days	°C	Number of degrees that a day's average temperature is above 18.3°C.
	35	Number of Days without Noticeable Wind	Days	Number of days where the mean wind speed is below 1m/s.
Health	36	Warm Spell Duration Index	Days	Number of days that are part of a sequence of 6 or more days in which the daily maximum temperature exceeds the 90th percentile of the reference period.
	37	Cold Spell Duration Index	Days	Number of days that are part of a sequence of 6 or more days in which the daily minimum temperature exceeds the 10th percentile of the reference period.
	38	Daily Probability of Heat Wave	Probability	This index gives the daily probability of observing such a heat wave, which is a 3 or more-day sequence where the daily temperature is above the long-term 95th percentile of daily mean temperature.
	39	Daily Probability of Cold Wave	Probability	This index gives the daily probability of observing such a cold wave, which is a 3 or more-day sequence where the daily temperature is below the long-term 5th percentile of daily mean temperature.

INTERACTIVE CLIMATE INDICATOR DASHBOARD

The climate models used in this latest update of CCKP and the specific dashboard/ portlets are also drawn from the CMIP5 distribution. Different selection criteria were used for the basic climate variables (temperature and precipitation) than for the indicators (derivatives of the temperature and moisture fields as well as other climate variables).

The core concern for the basic climate variables was direct comparison with the observed record (CCKP uses CRU-TS). For this, all projections had to be based on the exact same model collection for each RCP to ensure a balanced view of the different changes. Based on the resources available, the calculations were done from the monthly output for 16 models (see Table 1).

Climate indicators, however, require daily output and from variables beyond the basic temperature and precipitation fields. The collection of that data suffered from the fact that many of the variables needed for computation were not available from all models, even in some of the RCPs with most overall output.

The number of models fulfilling the strict criteria applied to the basic climate variables would have been too small. Therefore, the condition of having the same model collection forming the multi-model ensemble was not practical. A larger number of models (32 models, see Table) was consulted and climate indicators were computed where possible. Therefore, the multi-model ensembles are composites of varying number of models.

DATA PROCESSING STEPS & EVALUATION PROTOCOL

Basic Climate Fields:

The original CMIP5 model simulations were processed individually to establish a common dataset for which both absolute climatologies for the present and future 20-year intervals (2020-2039, 2040-2059, 2060-2079, and 2080-2099), as well as their relative changes in comparison to their common reference period of 1986-2005, could be computed. While the base-data was obtained as monthly time series, the products were to represent 20-year climatologies. Because of internal climate variability, the 20-year intervals at the grid level (or at aggregation levels of relatively small domains) become more useful when looking at the progressive changes throughout the 21st century with its continuously shifting climate. Each 20-year time windows can therefore be compared to the standard “present day” reference period of 1986-2005. The resulting anomalies also correspond well to results presented in the IPCC (Stocker et al. 2013). All models used in the calculations had to offer exactly the same suite of RCP experiments and represented time periods (see a description above).

Derived Indicators

Sector-oriented climate indicators often build on daily rather than monthly data. A collection of daily model output was processed for input into calculation of the 35 additional climate indicators. Depending on the indicator, monthly and/or annual were generated for the RCPs and time intervals as for the basic climate fields. Some GCM groups did not store or report humidity, pressure or wind fields on a daily basis, and thus not all indicators could be computed for all models. Therefore, in contrast to the basic climate fields, there are different numbers of models that contributed to the various ensembles at the level of the climate indicators. *This can introduce some inconsistencies when comparing different scenarios, though the direction and even the relative magnitude of the changes should still be useful.*

The following steps describe how each of the models (listed in Table 1) were processed:

- a. **Re-gridding: Initially, because all original model output is offered on their own native grids, the multi-model collection needed to be re-gridded to a common resolution.** Data presented previously through the CCKP has been using a half-degree (0.5°x0.5°) grid. That grid spacing represents a significantly higher resolution than most of the global models in CMIP3 as well as CMIP5. In consultation with the World Bank CCKP team, and in order not to imply a false promise of high-resolution content in the GCM (CMIP5) data, **a new common 1°x1° global grid spacing was produced through bi-linear interpolation.** This resolution is slightly coarser than the CMIP3 data presented on the CCKP, yet it contains at least the same information detail as before, particularly since the underlying models sometimes improved their resolutions since CMIP3. All analyses and data products within the CCKP CMIP5 distribution exclusively utilize these re-gridded data.

- b. Climatologies: For each model, and for each of the four selected essential climate variables, 20-year climatologies were formed. The ‘baseline’ interval (1986-2005) was derived from the *historical* simulations (“*hist*”), while the future climatologies (2020-2039, 2040-2059, 2060-2079, 2080-2099) were computed for all four RCPs (“*rcp26*”, “*rcp45*”, “*rcp60*”, “*rcp85*”). These climatologies consist of 12 monthly average values and one annual mean value established over the respective time windows (sums for precipitation). To form the climatologies, all values were computed directly from the absolute temperature and precipitation data taken from the model simulations. Note, each model might exhibit slightly different absolute temperatures and precipitation. These offsets compared to observational data are generally small, yet in some regions they can be significant. In fact, because of these offsets in the depiction of climate in absolute values, the climatologies don’t lend themselves easily for model-to-model intercomparisons of change. Better suited are comparisons of relative changes.
- c. Bias correction: Because derived indicators can be very sensitive to errors in the data, particularly when looking at absolute thresholds (e.g., number of days with daily maximum temperatures above 40 °C), a simple bias correction step was performed on the model’s temperature data using the CRU-TS3.24 data (Harris and Jones, 2014), as the observational baseline. Each model’s mean temperature was adjusted by the bias in their annual mean. For precipitation, this correction was not performed because of large uncertainties across the different gridded observational dataset that are available. For the temperature part, this bias correction is removing the first order discrepancies between models and observations during the historical period (1986-2005). Such differences result from different choices and tuning across the models. Generally, the relative changes are regarded as more robust than the absolute temperatures which might be biased due to slight differences in geopotential height, land surface conditions (albedo), or other factors. After bias correction, the divergence between different model responses is cleanly seen for the future periods. However, there are also some drawbacks. A few indicators, and particularly in most extreme climates, such as the polar regions, can at times exhibit unrealistic responses. For example, *because of the commonly large systematic errors in reproducing the extremely cold Antarctic interiors, the annual mean bias correction can sometimes lead to unrealistic values. In temperate and tropical regions, these errors are much smaller or nearly absent.*
- d. Anomalies: For each model, each variable, and for each of the four future time windows, anomalies for each month as well as the annual value were computed and assessed relative to their corresponding *historical* reference period (1986-2005). In contrast to the climatologies, these values are well suited for model-to-model intercomparisons as they always refer to the change simulated by each model. Prior bias correction only is important for a few indicators that represent departures or counts above absolute thresholds (for example the number for days with minimum nighttime temperatures above 20 °C).
- e. Ensemble information: Ensemble values were calculated from the anomalies from each of the models in the collection, and for every 20-year climatological period in the future. These ensembles describe how the collection of up to **35** CMIP5 models on average project the climatological changes. Different ways of exploring the ensemble distribution are possible. Here, the choice was done to use the median across the individual model values as the main representation. Next to that central value of the ensemble, also ensemble high (90th-percentile) and low (10th-percentile) values for all the climatological anomalies were generated to help users recognize the range of likely outcomes driven by the different sources of uncertainty. But values are available for each model separately, and thus the user could explore the distribution in more

detail. Because each model has slightly different climate sensitivity and simulated different internal climate variability, the projections increasingly diverge into the future. Therefore, the ensemble spread generally increases with time. Note, each individual model's anomalies can be compared with the provided ensemble description that encompasses the range between high (90th percentile) and low (10th percentile) levels of the underlying distribution.

(Note: the number of available CMIP5 models may vary for different climate indicators. For instance, the ensemble of tropical nights is calculated using 32 out of 35 models from the collection.)

- f. Climatological ensemble based on observational basis: A second ensemble product is provided as a condensed climatological description in absolute values of the projected changes across the multi-model collection. This ensemble is the combination of the absolute values from a common observational baseline dataset and the superposed multi-model ensemble anomalies (note, only the ensemble quantities are used, not each model's climatologies). The result is a description in absolute units of projected future climate as represented by the 90th-percentile, the median (the 50th-percentile), and the 10th-percentile series. For the essential climate variables these ensemble values were derived from the 16 contributing models that reported all RCPs, and in case of the sectoral indicators the values were established from across up to 35 models. In each case, the baseline was taken from the University of East Anglia, Climatic Research Unit (CRU) Time Series (TS) globally gridded dataset that was re-gridded to the same $1^{\circ} \times 1^{\circ}$ grid as the CMIP5 data using bi-linear interpolation.

The intent of this ensemble is to provide users a condensed perspective in absolute values of projected future climate with its most faithful representation of uncertainty. Because individual models might potentially exhibit substantial biases, this composite approach of an ensemble characterization is significantly more useful for projecting the future climate than a direct ensemble visualization generated on the raw climatologies of each of the individual climate model. *Because of the biases, it is not recommended to plot the individual raw, absolute model climatologies together with the condensed ensemble ranges. Equally, just plotting the individual climatologies and forming an "on-the-fly" ensemble is not meaningful because the majority of differences (spread) is based simply on biases in each of the individual climate models and not a faithful representation of the true physical uncertainty.*

- g. Quality Control: Because of the large data volumes, not every field individually could be inspected visually. Rather, NCAR implemented an automated final quality control algorithm on the publication-ready data to identify odd outliers in both absolute and anomaly fields. Suspicious values and potentially suspicious model simulations were flagged and ultimately 4 models were excluded from the results. Once implemented into the CCKP, thorough visual inspection was performed to identify any remaining issues.

The data tables were provided for the following spatial aggregation categories: Basins, countries and regions. Figure 3 provides a global overview of this spatial sub-setting.

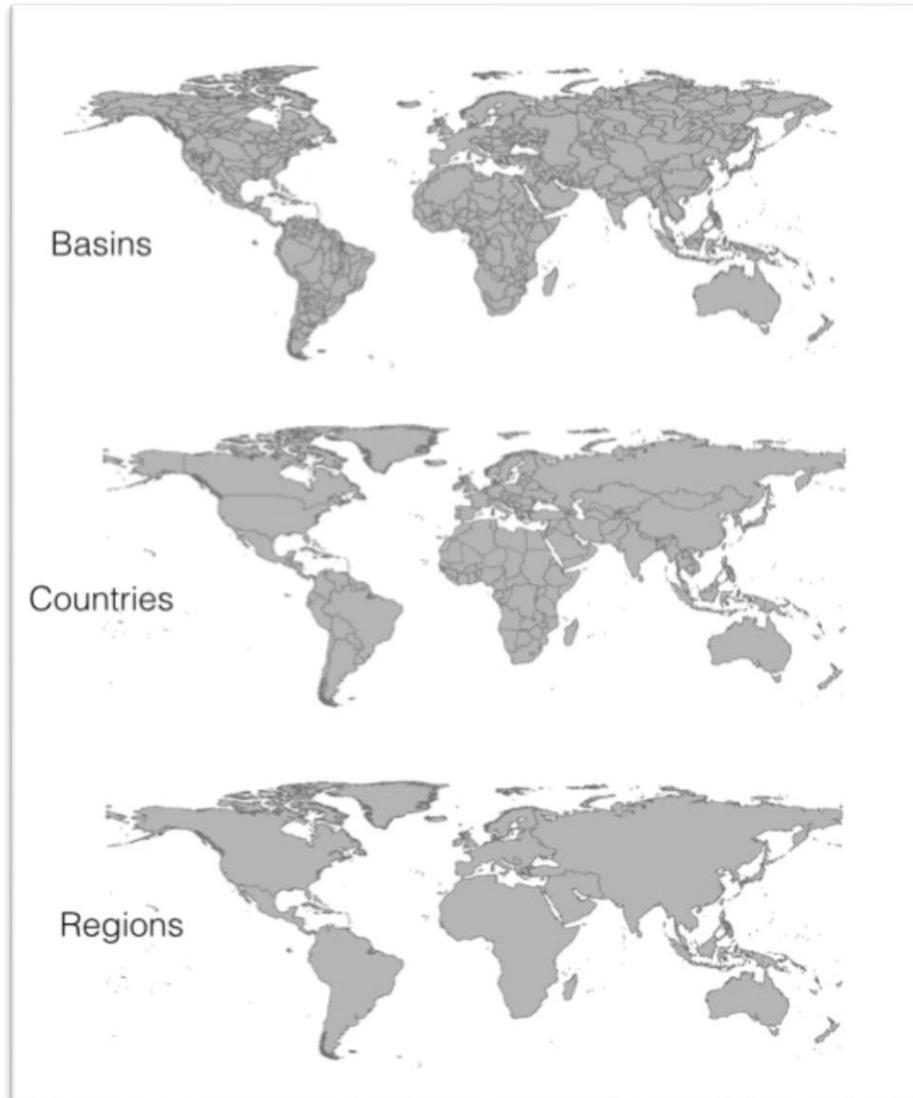


Figure 3: Map representation of the three regional aggregations

CLIMATE BY SECTOR

SECTORAL CLIMATE INDICATORS

- Same as "[Future Climate-Climate Indicators](#)".

VULNERABILITY

NATURAL HAZARDS DATA

(CCKP → IMPACTS → NATURAL HAZARDS)

UNISDR GLOBAL ASSESSMENT REPORT (2015) RISK PLATFORM

DATASETS: Tropical cyclone, Storm surge, Earthquake, Volcanic eruption, Tsunami, Flood

CREDITS: the global assessment report 2015 is based on a joint effort by leading scientific institutions, governments, un agencies and development banks, the private sector and non-governmental organizations. The CAPRA software used for visualization was developed by UNISDR in collaboration with the world bank, CIMNE, ERN and INGENIAR, with the generous financial support of the European Commission.

LINK: <http://risk.preventionweb.net/capreviewer/main.jsp?countrycode=g15>

DESCRIPTION:

In the UNISDR-led assessment, probabilistic hazard models have been developed for earthquake, tropical cyclone wind and storm surge, tsunami and river flooding worldwide, for volcanic ash in the Asia-pacific region and for drought in parts of Africa. The probabilistic hazard models were later used to inform the global risk model for each hazard type. The datasets and methods used to calculate probabilistic hazard is different for each hazard type. The return periods selected to be represented in the CCKP is different for each hazard. Global cyclone hazard data measured as wind speed that is expected to be exceeded at least once in a 100-year mean return period. Global storm surge hazard data measured as inundation height that is expected to be exceeded at least once in a 10-year mean return period. Global earthquake hazard data measured as ground motion intensity (PGA) that is expected to be exceeded at least once in a 475-year mean return period. Global tsunami hazard data which is expected to occur at least once in 500-year mean return period. Global flood hazard data measured as inundation height that is expected to be exceeded at least once in 100-year mean return period.

More information and metadata/credits specific to each hazard type can be found [here](#).

GLOBAL RISK DATA PLATFORM

DATASETS: Wildfire, Drought, Earthquake-induced Landslides, Rainfall-induced Landslides

CREDITS: GIS processing UNEP/UNISDR

LINK: <http://preview.grid.unep.ch/index.php?preview=data&lang=eng>

DESCRIPTION: The Global Risk Data Platform is a multiple agencies effort to share spatial data information on global risk from natural hazards. Users can visualize, download or extract data on past hazardous events, human & economical hazard exposure and risk from natural hazards. It covers

tropical cyclones and related storm surges, drought, earthquakes, biomass fires, floods, landslides, tsunamis and volcanic eruptions. The collection of data is made via a wide range of partners (see About for data sources). This was developed as a support to the Global Assessment Report on Disaster Risk Reduction (GAR) and replace the previous PREVIEW platform already available since 2000. Many improvements were made on the data and on the application. More information and metadata/credits specific to each hazard type can be found [here](#).

PACIFIC ISLANDS HAZARDS

DATASETS: Earthquake, Tropical Cyclone (for a selection of Pacific Islands)

CREDITS: PCRAFI - PCRAFI is a joint initiative of SOPAC/SPC, World Bank, and the Asian Development Bank with the financial support of the Government of Japan and the Global Facility for Disaster Reduction and Recovery (GFDRR), and technical support from AIR Worldwide, NZ GNS Science, Geoscience Australia, Pacific Disaster Center (PDC), OpenGeo and GFDRR Labs

LINK: <http://pcrafi.sopac.org/>

DESCRIPTION: The Pacific Catastrophe Risk Assessment and Financing Initiative (PCRAFI) aims to provide the Pacific Island Countries (PICs) with disaster risk modeling and assessment tools. PCRAFI produced detailed probabilistic hazard models for all 15 countries, such as Tropical Cyclones with Winds, Storm Surge, Rain Earthquake with Ground-shaking, and Tsunami. The information displayed on the CCKP are earthquake hazard data measured as ground motion intensity (PGA) that is expected to be exceeded at least once in 100 year mean return period, and tropical cyclone hazard data measured as wind intensity that is expected to be exceeded at least once in 100 year mean return period. More information and metadata/credits specific to each hazard type can be found [here](#).

EM-DAT

DATASETS: Top disasters (number killed), Number of affected, Average annual disaster occurrence by type.

CREDITS: EM-DAT: The OFDA/CRED International Disaster Database – www.emdat.be – Université Catholique de Louvain – Brussels – Belgium.

LINK: <http://www.emdat.be/>

DESCRIPTION:

EM-DAT contains essential core data on the occurrence and effects of over 18,000 mass disasters in the world from 1900 to present. The database is compiled from various sources, including UN agencies, non-governmental organisations, insurance companies, research institutes and press agencies.

IMPACTS

AGRICULTURAL DATA

(CCKP → IMPACTS → AGRICULTURE)

LOW/HIGH INPUT, IRRIGATED/RAINFED CROPS

CREDITS: Fischer, G., F. Nachtergaele, S. Prieler, H.T. van Velthuisen, L. Verelst, D. Wiberg, 2007. Global Agro-ecological Zones Assessment for Agriculture (GAEZ 2007). IIASA, Laxenburg, Austria and FAO, Rome, Italy.

LINK: (link to document already in Portal)

DESCRIPTION: The datasets provided under this contract were calculated with the latest version of AEZ programs (termed GAEZ 2007) being published by IIASA and FAO. The files prepared for download on 19 May 2008 represent additions and a partial update of files provided to the World Bank's Climate Change Team in October 2007.

GLOBAL IRRIGATED AREAS MAP

CREDITS: IWMI, [View Full Credits](#)

LINK: <http://www.iwmigiam.org/info/main/index.asp>

DESCRIPTION:

This is the version 2.0 release (update; as of May 10, 2007) of the International Water Management Institute's (IWMI's) Global irrigated area map (GIAM) and associated products and data. The GIAM products are produced using time-series data of: (a) AVHRR 10-km monthly from 1997-1999, (b) SPOT 1-km monthly for 1999, (c) GTOPO30 1-km elevation, (d) CRU 50-km grid monthly precipitation from 1961-2000, (e) AVHRR derived 1-km forest cover, and (f) AVHRR 10-km skin temperature. In addition JERS SAR data was used for the African and South American rainforests.

There are many unique features in the IWMI's GIAM product line. First, this is the very first satellite sensor based global irrigated area map. Second, the resolution of the map (10-km) is the best that is presently available for irrigated areas at global level. Third, the area calculations are done for each season. So the area irrigated @ the end of the last millennium for the entire world was: (a) 257 Mha during June-September, (b) 174 Mha during October-February, and (c) 41 Mha during March-May. Further, there is a flexibility to calculate areas every month. Fourth, this is NOT just a map. There are suite of products that consists of maps, images, class characteristics, area calculations, snap-shots and photos, animations, and accuracies. There are numerous advantages of such a product line. For example, disaggregated class images can be downloaded and a more refined map can be created with local expertise for one's area of interest. The irrigated areas are used to create a 20-year animations using AVHRR monthly time-series, so that one can spatially re-create the history of an irrigated area class. The class characteristics facilitate deriving crop calendar, sowing-peak-harvest dates of each class, and determine whether a class is single, double, or continuous crop. Fifth, the study develops and/or adopts a suite of innovative methods and

techniques to map irrigated areas of the World at Global to local levels and at all resolutions or scale. The methods include spectral matching techniques (SMTs), image segmentation, decision tree algorithms and spatial modeling, data fusion, space-time spiral curves, brightness-greenness-wetness 2-dimensional feature space plots, NDVI time series plots, NDVI thresholds, principal component analysis, and unsupervised clustering algorithms. The wide array of ground truth data was also used. This included ground truth data of the Indus-Ganges river basins, Krishna river basin, IWMI's ground truth data of the World that included data for Middle East and Africa, the degree confluence project data of the world, and the 150-m Landsat geocover mosaic of the world.

GLOBAL MAP OF RAINFED CROPLAND AREAS

CREDITS: IWMI, [View Full Credits](#)

LINK: <http://www.iwmigiam.org/info/main/index.asp>

DESCRIPTION:

The IWMI's Global Map of Rainfed Cropland Areas (GMRCA) is a by-product derived when working on IWMI's Global Map of Irrigated Areas (GMIA). The datasets approaches, and methods used to produce GMRCA are, to a great extent, similar to producing GIAM. Thereby, we refer the reader to detailed documentation on GIAM made available in this web site.

The Global Rainfed Croplands were estimated at 1.132 billion hectares at the end of the last millennium, from the GMRCA products (Biradar et al., 2007). This is 2.78 times the TAAI or net irrigated areas (407 Mha) of the World. The GMRCA area provided here is for the June-October period only. Like, GMIA it is possible to estimate seasonal Global Rainfed Cropland areas using the products and methods developed in this study. However, double crop rainfed is considered negligible. The total cropland is estimated as 1.539 billion hectares of which 1.13 billion rainfed and 0.407 irrigated.

The importance of rainfed croplands cannot be over-emphasized. Rainfed croplands meet about 60 percent of the food and nutritional needs of the World's population, are backbone of the marginal or subsistence farmers, and are increasingly seen as better alternative to irrigated agriculture as a result of its environmental friendliness and sustainability over long time periods. Rainfed agriculture has an history of roughly 10,000 years compared to about 6000 year history of irrigated agriculture (see World resources 1992-1999, and Mackenzie and Mackenzie, 1995). Literature shows that the World's croplands increased from about 265 million hectares in year 1700 to about 1.4 billion hectares in 1990, of which rainfed cropland alone is about 1.2 billion hectares (Cramer and Soloman, 1993, Richards, 1990, Grubler, 1994, World Resources 1992-1999). Our estimate of rainfed croplands of the World, at the end of the millennium, is 1.13 billion hectares.

Most global digital maps (e.g., Loveland et al. 1999, Olson and Watts, 1982, Matthews, 1983) over estimate agricultural areas as a result of the pixel based area calculations (see Xiao, 1997, Cramer and Soloman, 1993). A pixel when classified as agriculture is automatically taken to have 100 % croplands in digital global maps. In reality only a certain percentage of a pixel is in cropland and that percentage can vary substantially. As a result the total agricultural lands estimated in various digital maps were 2.7 billion hectares by Olson and watts (1982) using a 50-km grid, 3.2 billion hectares by Matthews (1983) using 100-km grid, and 2.8 billion hectares by IGBP and USGS using 1-km grid (see Loveland et al. 1999). The FAO estimates based on Country statistics are closer to reality. The FAO statistics show cultivated areas at

about 1.5 billion hectares (FAO, 2002). Grubler (1994) estimated that an increase of 1 billion arable lands would be needed for additional 5 billion world population in the 21st century.

The theoretical potential for cropland areas in the present climatic conditions and based on soil, climate, and topography are estimated at 3.29 billion hectares (Xiao et al. 1997) to 4.15 billion hectares (Cramer and Soloman, 1993). However, it must be noted that the productivity of a large proportion of these lands is limited due to poor soil fertility, soil depth, access to water, and disease (e.g., Tse-tse flies and the black fleas). Any increase will have to come from land conversions from forests and rangelands which will be environmentally costly (Richards, 1990) or from protected areas which is unacceptable.

In reality, cropland areas are shrinking in recent times as a result of soil degradation, urbanization, and desertification and global warming. Between the early 1960s and the late 1990s, world cropland grew by only 11 percent, while world population almost doubled. As a result, cropland per person fell by 40 percent, from 0.43 ha to only 0.26 ha and reduced from 0.23 to 0.11 hectares (FAO, 2002). In future, 80 percent of increased crop production in developing countries will have to come from intensification: higher yields, increased multiple cropping and shorter fallow periods.

Thereby, tracking changes in spatial distribution and changing patterns of rainfed croplands is essential for understanding and planning food and nutritional demands of expanding populations of the World.

In this context, the IWMI's GMRCA product-line provides a benchmark measure of Rainfed Cropland Areas of the World at the end of the last millennium. The sub-pixel area (SPAs) of GMRCA provides realistic estimates of the actual area cultivated unlike the full pixel areas (FPAs) of almost all other studies. The GMRCA product-lines have maps, images, area characteristics and calculations, snap-shots, and animations. In addition the satellite sensor data mega-files and the ground-truth data used to produce the GMRCA are made available.

There are two product-lines within GMRCA. These are: (1) aggregated 9-class GMRCA map of the World; and (2) dis-aggregated 67-class GMRCA map of the World. The aggregated classes provide broad categories of rainfed cropland classes. Often, most users would just need such broad classes. The disaggregated classes provide a detailed picture and are often invaluable at regional, National, and local levels. For certain users, even at global level so that they can derive specific classes of interest to them. The class labeling in disaggregated classes are only indicative and can be improved.

GLOBAL MAP OF IRRIGATION AREAS

CREDITS:

Stefan Siebert, Petra Döll, Sebastian Feick, Jippe Hoogeveen and Karen Frenken (2007) *Global Map of Irrigation Areas version 4.0.1*. Johann Wolfgang Goethe University, Frankfurt am Main, Germany / Food and Agriculture Organization of the United Nations, Rome, Italy

LINK: <http://www.fao.org/nr/water/aquastat/irrigationmap/index10.stm>

DESCRIPTION:

The latest version of the “Global Map of Irrigation Areas” is version 4.0.1. The map shows the amount of area equipped for irrigation around the turn of the 20th century in percentage of the total area on a raster with a resolution of 5 minutes. The area actually irrigated was smaller, but is unknown for most countries. A special note has to be made for Australia and India where the map shows the total area actually irrigated. This is due to the fact that statistics collected in Australia and India refer to actually irrigated area as opposed to statistics with area equipped for irrigation which are collected in most other countries. An explanation of the different terminology to indicate areas under irrigation is given in this [glossary](#).

The map is generated as a grid and distributed with the following characteristics:

Projection:	Geographic
Number of columns:	4320
Number of rows:	2160
North Bounding Coordinate:	90 degrees
East Bounding Coordinate:	180 degrees
South Bounding Coordinate:	-90 degrees
West Bounding Coordinate:	-180 degrees
Cell Size:	5 minutes, 0.083333 decimal degrees
NODATA values:	Cells without irrigation are characterized by NODATA (-9), it does not mean that there was no data for these cells

For the GIS-users the map is distributed in two different formats: as zipped ASCII-grid that can be easily imported in most GIS-software that support rasters or grids; and, to accommodate people who use GIS-software that doesn't support rasters or grids, as a zipped ESRI shape file. It should be noted, however, that the values in the ASCII-grid have a precision of 6 decimals while the values in the shape-file have a precision of 2 decimals. For model calculations, it is therefore recommended to use the grid-version. As a service to those people who would need to know the absolute area equipped for irrigation, another ASCII-grid is available in which the area equipped for irrigation is expressed in hectares per cell. Non-GIS-users can download the map as PDF-file in two different resolutions.

HARVESTED AREA AND YIELDS (M3- CROPS DATA)

CREDITS:

Monfreda et al. (2008), "Farming the planet: 2. Geographic distribution of crop areas, yields, physiological types, and net primary production in the year 2000", *Global Biogeochemical Cycles*, Vol.22, GB1022, doi:10.1029/2007GB002947

LINK: <http://www.geog.mcgill.ca/landuse/pub/data/agland2000/>

DESCRIPTION:

Described in the publication, Monfreda et al. (2008), "Farming the planet: 2. Geographic distribution of crop areas, yields, physiological types, and net primary production in the year 2000", *Global Biogeochemical Cycles*, Vol.22, GB1022, doi:10.1029/2007GB002947. The data is provided in NetCDF and ArcGIS ASCII format at 5 minute resolution in latitude by longitude. The NetCDF files have 4 levels (ArcGIS files only have the 1st two levels; contact authors if you want the other two levels), as follows:

Level 1 = Harvested Area (unit = proportion of grid cell area). Note that values can be greater than 1.0 because of multiple cropping. Level 2 = Yield (unit = tons per ha). Levels 3 and 4 = Administrative levels from which the source data in levels 1 and 2 come from respectively. In levels 3 and 4, a value of 1 = county; .75 = state; .5 = interpolated from within 2 degrees lat/long; .25 = country; 0 = missing.

WATER DATA

(CCKP → IMPACTS → WATER)

WATER INDICATOR

DATASETS: Flood Indicator, Drought Indicator, Mean Annual Runoff, Annual Base Flow, Storage, Mean Annual Irrigation Deficit

CREDITS: Strzepek, K., McCluskey, A., Boehlert, B., Jacobsen, M., & Fant IV, C. (2011). *Climate Variability and Change: A Basin Scale Indicator Approach to Understanding the Risk to Water Resources Development and Management*. The World Bank.

LINK:

http://www.un.org/waterforlifedecade/pdf/2011_world_bank_climate_variability_change_eng.pdf

DESCRIPTION:

This study evaluates the effects of climate change on six hydrological indicators across 8,413 basins in World Bank client countries. These indicators—mean annual runoff (MAR), basin yield, annual high flow, annual low flow, groundwater (baseflow), and reference crop water deficit—were chosen based on their relevance to the wide range of water resource development projects planned for the future. To generate a robust, high-resolution understanding of possible risk, this analysis examines relative changes in all variables from the historical baseline (1961 to 1999) to the 2030s and 2050s for the full range of 56 General Circulation Model (GCM) Special Report on Emissions Scenario (SRES) combinations evaluated in the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (AR4).

AQUASTAT

CREDITS: FAO

LINK: <http://www.fao.org/nr/water/aquastat/main/index.stm>

DESCRIPTION:

AQUASTAT is FAO's global information system on water and agriculture, developed by the Land and Water Division. The main mandate of the programme is to collect, analyze and disseminate information on water resources, water uses, and agricultural water management with an emphasis on countries in Africa, Asia, Latin America and the Caribbean. This allows interested users to find comprehensive and regularly updated information at global, regional, and national levels.

In AQUASTAT, three types of water withdrawal are distinguished: agricultural, municipal (including domestic), and self-abstracted industrial water withdrawal. A fourth type of anthropogenic water use is the water that evaporates from artificial lakes or reservoirs associated with dams. Information on evaporation from artificial lakes will be available in the AQUASTAT database in the near future.

At global level, the withdrawal ratios are 70 percent agricultural, 11 percent municipal and 19 percent industrial. These numbers, however, are biased strongly by the few countries which have very high water withdrawals. Averaging the ratios of each individual country, we find that "for any given country" these ratios are 59, 23 and 18 percent respectively.

For Africa, Asia, Latin America and the Caribbean, AQUASTAT obtains water withdrawal values from ministries or other governmental agencies at a country level, although some data gaps are filled from UN Data. For Europe and for Northern America, Japan, Australia and New Zealand, Eurostat and OECD are valuable sources of information, and also used to fill data gaps.

SEA LEVEL RISE DATA

(CCKP → IMPACTS → SEA LEVEL RISE)

CREDITS: ESA, CNES, CGI

DOI: 10.5270/esa-sea_level_cci-MSLA-1993_2015-v_2.0-201612

LINK: <http://www.esa-sealevel-cci.org>

DESCRIPTION:

This dataset contains monthly global sea surface height products from satellite observations. These data were produced at CNES as part of the European Space Agency's (ESA) Sea Level Climate Change Initiative (CCI) project. It contains a multi-satellite merged time series of monthly gridded Sea Level Anomalies (SLA) which has been produced from satellite altimeter measurement. This dataset is available at spatial resolution of 1/4 degrees lat/lon in Cartesian grids projection. The products are stored using the NetCDF (Network Common Data Form) format and CF (Climate and Forecast) metadata conventions. The way CF conventions are applied to ECV products with specific CCI additional vocabularies is defined in the frame of CCI Data Standards Working Group (DSWG).

Data Processing for the Climate Change Knowledge Portal includes:

1. Land Masking

Due to the resolution of the raw Sea Level Anomaly data, parts of the dataset overlap with land. To remove the data over land, the following process was applied:

- a. The resolution of each image was up-sampled to have a resolution of 1km x 1km;
- b. Each image was clipped using a land-mask based on the Open Street Map Data Land polygons dataset¹ such that the sea level anomaly data would be at most 1km from land; and
- c. Each image was compressed and projected to EPSG:3857 (web mercator) to overlay on Google Maps in the Climate Change Knowledge Portal.

2. Creating Country-level Data

In discussion with the World Bank, it was determined that Sea-Level Anomaly data assigned to a country and made available in a Data API should be displayed in graph or tabular form in the Climate Change Knowledge Portal only at a country's coast line.

It is important to note that the global sea level product was developed for open ocean applications and not coastal adaptation. Its interpretation and use in the coastal zone should therefore be taken with caution. It is recommended to combine the product with local in situ and regional model data to better estimate coastal sea level rise for adaptation purposes.

To extract sea level anomaly information at the coast line, a custom open source processing tool that combines R with Hadoop Map/Reduce streaming has been created. This tool can be published as an OGC Web Processing Service. The R code for this processing system has been made available in an Open Source (Apache 2) license in a public GitHub repository (<https://github.com/Terradue/eowb-cckp>).

To process data for each country, the following processing chain is followed:

- a. Retrieve Web Coverage Service (WCS) online resource stored in the OpenSearch catalogue for the Sea Level Anomaly datasets;
- b. Extract the country extent minimum bounding box;
- c. For each date in the Time of Interest interval, extract the Coverages and create a Coverage stack;
- d. Clip the Coverage stack with the coastal line; and
- e. Post the values to the Data API access point.