From theory to practice to derive an assessment of climatic-impact drivers

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Some definitions from The IPCC Sixth Assessment Report (WG1- *Chapter 1* and *Annex VI*) :

- **RISK**: The potential for adverse consequences for human or ecological systems

IPCC, 2021: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 2391 pp. doi:10.1017/9781009157896.

Some definitions from The IPCC Sixth Assessment Report (WG1- *Chapter 1* and *Annex VI)* :

- **RISK**: The potential for adverse consequences for human or ecological systems

- **Hazard**: The potential occurrence of a natural or human-induced physical event or trend that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems and environmental resources.
- "climate-related hazards" (including extreme weather/climate events)

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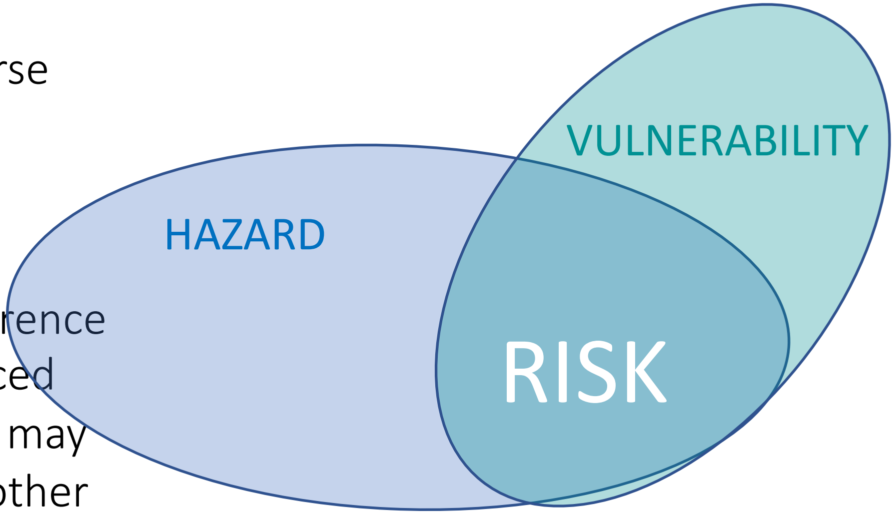

- **Vulnerability**: The propensity or predisposition to be adversely affected.

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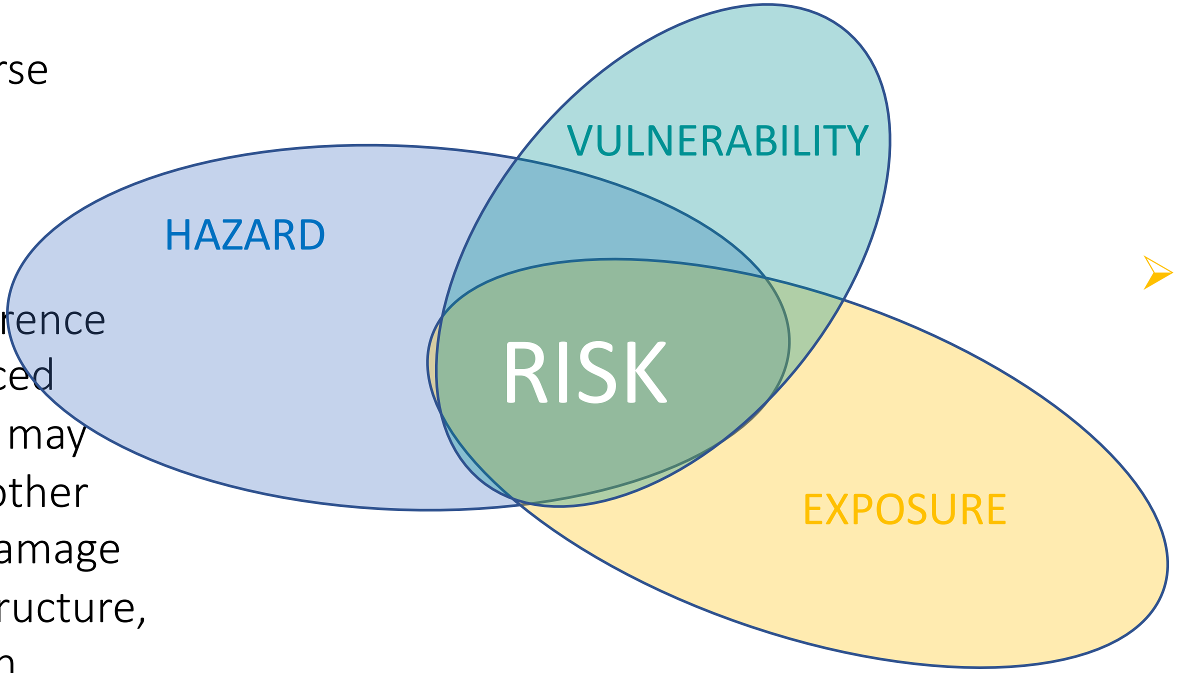

- **Vulnerability**: The propensity or predisposition to be adversely affected.

- **Exposure**: The presence of people; livelihoods; species or ecosystems; environmental functions, services, and resources; infrastructure; or economic, social, or cultural assets in places and settings that could be adversely affected.

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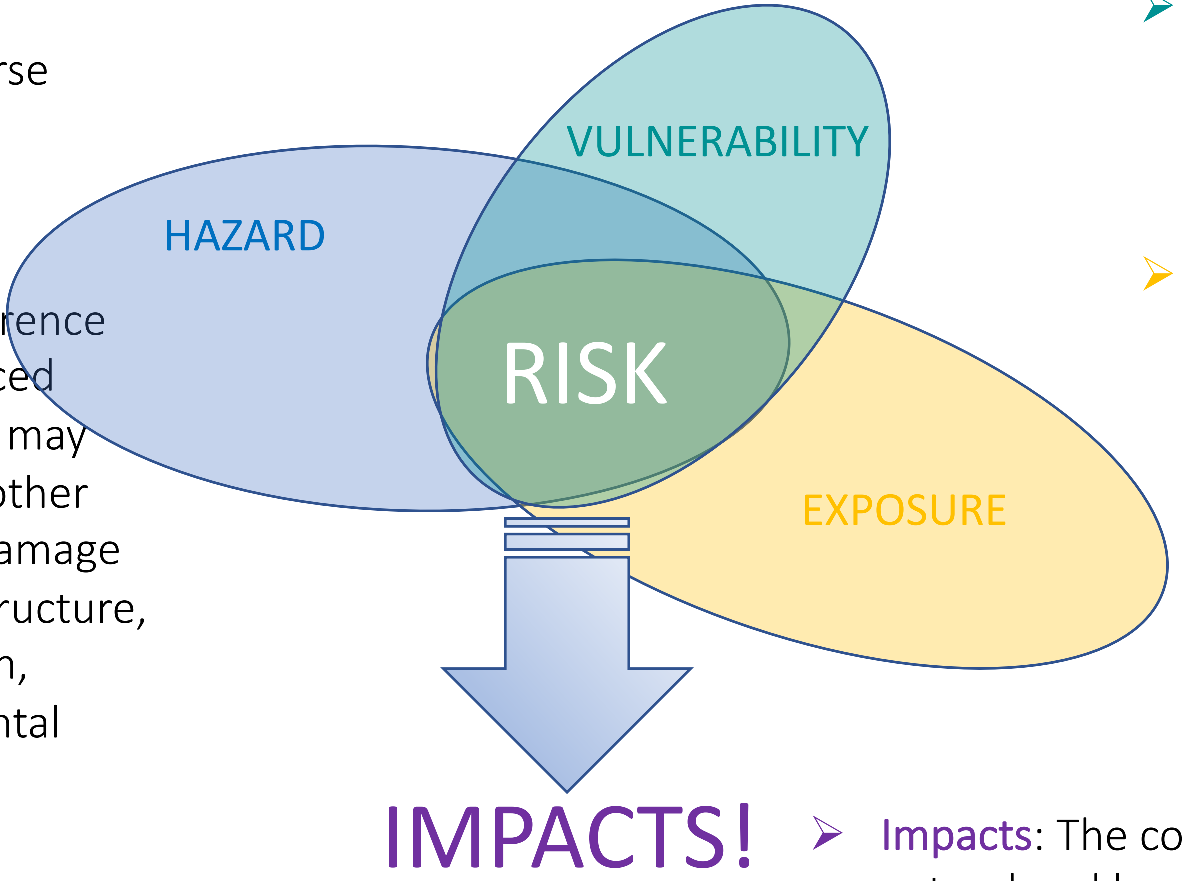

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- **Exposure**: The presence of people; livelihoods; species or ecosystems; environmental functions, services, and resources; infrastructure; or economic, social, or cultural assets in places and settings that could be adversely affected.
- **Impacts**: The consequences of realized risks on natural and human systems. Impacts generally refer to effects on lives, health and well-being, ecosystems and species, economic, social and cultural assets, services and infrastructure. Impacts can be adverse or beneficial.

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Climatic impact-drivers (CIDs): are physical climate system conditions (e.g., means, events, extremes) that affect an element of society or ecosystems. In contrast to the term "hazards", it provides a more value-neutral characterization of climatic changes that may be relevant for understanding potential impacts, without pre-judging.

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'Extremes' are a category of CID, corresponding to unusual events with respect to the range of observed values of the variable.

- **Climatic impact-drivers may not be related only to extremes;**

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'Extremes' are a category of CID, corresponding to unusual events with respect to the range of observed values of the variable.

- **Climatic impact-drivers may not be related only to extremes;**

'Climatic impact-driver indices' are numerically computable indices using one or a combination of climate variables designed to measure the intensity of the climatic impact-driver, or the probability of exceedance of a threshold.

- **Indices are, in principle, computable from observations, reanalyses or model simulations**, although it is important to consider scale in comparing across datasets. For example, an extreme precipitation event has a lower magnitude across a large grid cell than it would at a single station within that grid cell.

IPCC, 2021: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 2391 pp. doi:10.1017/9781009157896.

A complete set of extreme indices has been identified in the *IPCC Sixth Assessment Report:*

Table AVI.1 | Table listing extreme indices used in Chapter 11.

Extreme	Label	Index Name	Units	Variable
Temperature	TXx	Monthly maximum value of daily maximum temperature	°C	Maximum temperature
	TXn	Monthly minimum value of daily maximum temperature	°C	Maximum temperature
	TNn	Monthly minimum value of daily minimum temperature	°C	Minimum temperature
	TNx	Monthly maximum value of daily minimum temperature	°C	Minimum temperature
	TX90p	Percentage of days when daily maximum temperature is greater than the 90th percentile	%	Maximum temperature
	TX10p	Percentage of days when daily maximum temperature is less than the 10th percentile	%	Maximum temperature
	TN90p	Percentage of days when daily minimum temperature is greater than the 90th percentile	%	Minimum temperature
	TN10p	Percentage of days when daily minimum temperature is less than the 10th percentile	%	Minimum temperature
	ID	Number of icing days: annual count of days when TX (daily maximum temperature) <0°C	Days	Maximum temperature
	FD	Number of frost days: annual count of days when TN (daily minimum temperature) <0°C	Days	Minimum temperature
	WSDI	Warm spell duration index: annual count of days with at least six consecutive days when TX >90th percentile	Days	Maximum temperature
	CSDI	Cold spell duration index: annual count of days with at least six consecutive days when TN <10th percentile	Days	Minimum temperature
	SU	Number of summer days: annual count of days when TX (daily maximum temperature) >25°C	Days	Maximum temperature
	TR	Number of tropical nights: annual count of days when TN (daily minimum temperature) >20°C	Days	Minimum temperature
	DTR	Daily temperature range: monthly mean difference between TX and TN	°C	Maximum and minimum temperature
	GSL	Growing season length: annual (1 Jan to 31 Dec in Northern Hemisphere (NH), 1 July to 30 June in Southern Hemisphere (SH)) count between first span of at least six days with daily mean temperature TG >5°C and first span after July 1 (Jan 1 in SH) of six days with TG <5°C	Days	Mean temperature
	20TXx	One-in-20 year return value of monthly maximum value of daily maximum temperature	°C	Maximum temperature
	20TXn	One-in-20 year return value of monthly minimum value of daily maximum temperature	°C	Maximum temperature
	20TNn	One-in-20 year return value of monthly minimum value of daily minimum temperature	°C	Minimum temperature
	20TNx	One-in-20 year return value of monthly maximum value of daily minimum temperature	°C	Minimum temperature
Precipitation	Rx1day	Maximum one-day precipitation	mm	Precipitation
	Rx5day	Maximum five-day precipitation	mm	Precipitation
	R5mm	Annual count of days when precipitation is greater than or equal to 5 mm	Days	Precipitation
	R10mm	Annual count of days when precipitation is greater than or equal to 10 mm	Days	Precipitation
	R20mm	Annual count of days when precipitation is greater than or equal to 20 mm	Days	Precipitation
	R50mm	Annual count of days when precipitation is greater than or equal to 50 mm	Days	Precipitation
	CDD	Maximum number of consecutive days with less than 1 mm of precipitation per day	Days	Precipitation
	CWD	Maximum number of consecutive days with more than or equal to 1 mm of precipitation per day	Days	Precipitation
	R95p	Annual total precipitation when the daily precipitation exceeds the 95th percentile of the wet-day (>1 mm) precipitation	mm	Precipitation
	R99p	Annual precipitation amount when the daily precipitation exceeds the 99th percentile of the wet-day precipitation	mm	Precipitation
	SDII	Simple precipitation intensity index	mm day^{-1}	Precipitation
	20Rx1day	One-in-20 year return value of maximum one-day precipitation	mm day^{-1}	Precipitation
	20Rx5day	One-in-20 year return value of maximum five-day precipitation	mm day^{-1}	Precipitation
Drought	SPI	Standardized precipitation index	Months	Precipitation
	EDDI	Potential evaporation, evaporative demand drought index	Months	Evaporation
	SMA	Soil moisture anomalies	Months	Soil moisture
	SSMI	Standardized soil moisture index	Months	Soil moisture
	SRI	Standardized runoff index	Months	Streamflow
	SSI	Standardized streamflow index	Months	Streamflow
	PDSI	Palmer drought severity index	Months	Precipitation, evaporation
	SPEI	Standardized precipitation evapotranspiration index	Months	Precipitation, evaporation, temperature

IPCC, 2021: Annex VI: Climatic Impact-driver and Extreme Indices [Gutiérrez J.M., R. Ranasinghe, A.C. Ruane, R. Vautard (eds.)]. In Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 2205–2214, doi:10.1017/9781009157896.020.

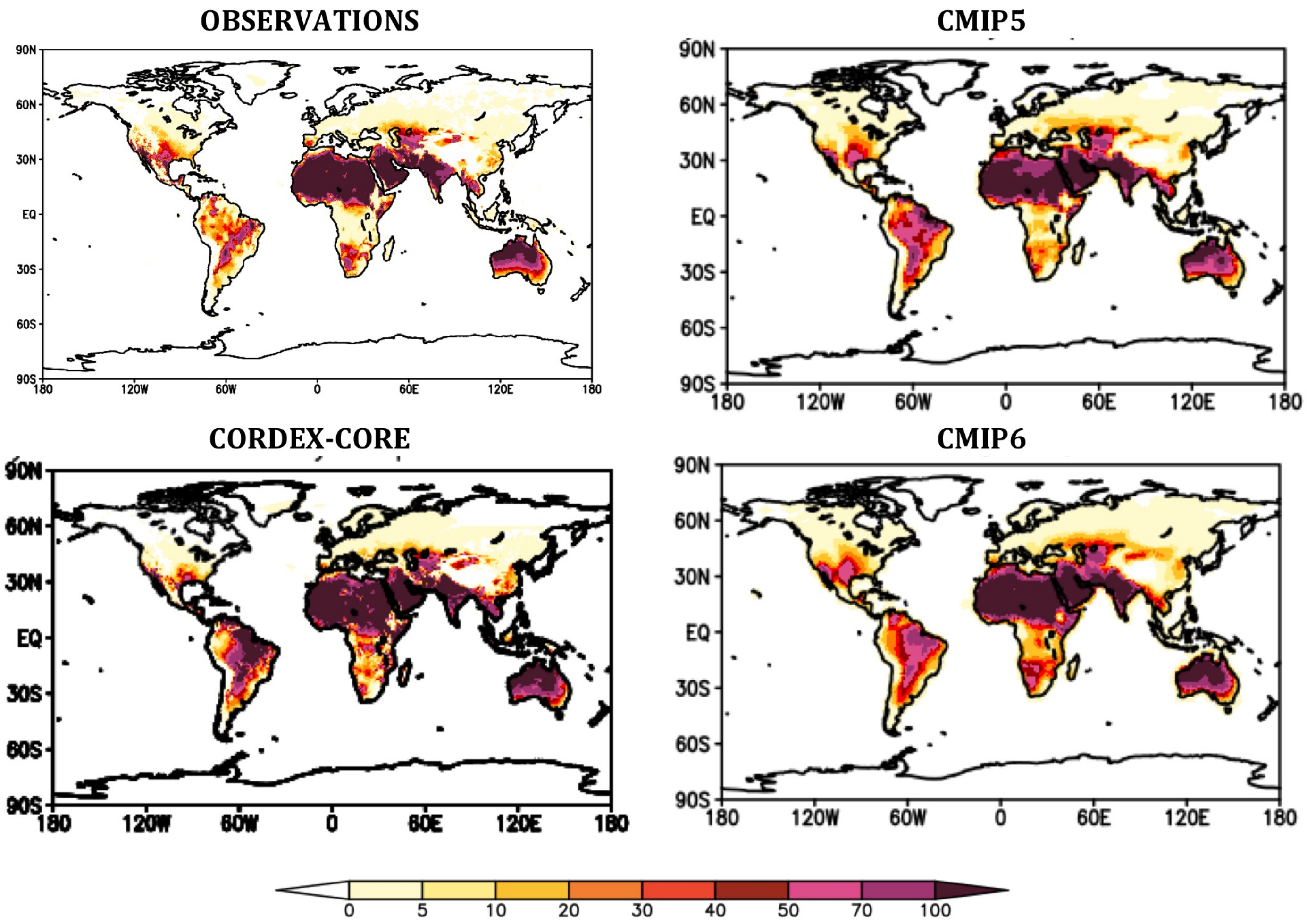
CID categories are identified on the basis of relevance for risks and impacts and available literature. They are classified into seven types: heat and cold, wet and dry, wind, snow and ice, coastal, open ocean, and other

Table AVI.2 | Regional CID indices table and relevant references.

CID Category	Climatic Impact-driver (from Table 12.1) and Potential Affected Sectors	Index	Required ECVs	Way to Calculate	Bias Adjustment	References
Heat	Change in cooling demand for energy demand and building consumption	Cooling degree days above 22°C	Tas, tasmin, tasmax	From projections	Yes	Spinoni et al. (2015, 2018)
	Heat, with thresholds important for agriculture	Number of days with Tmax >35°C or 40°C (TX35, TX40)	Tasmax	From projections	Yes	Hatfield and Prueger (2015); Hatfield et al., (2015); Grotjahn (2021)
	Heat stress index combining humidity used in occupational and industrial health	NOAA heat index (HI): number of days above 41°C threshold	Tasmax, huss, ps	From projections	Yes	Burkart et al. (2011); Lin et al. (2012); Kent et al. (2014)
Cold	Heating degree day for energy consumption	Heating degree days below 15.5°C	Tas, tasmin, tasmax	From projections	Yes	Spinoni et al. (2015, 2018)
	Frost	Number of frost days below 0°C (FD)	Tasmin	From projections	Yes	Barlow et al. (2015); Rawlins et al. (2016)
Wet	River flooding	Flood index (FI)	srroff/mrro	From projections and simplified routing model	No	Forzieri et al. (2016); Alfieri et al. (2017)
Drought	Aridity	Soil moisture (SM)	mrso	From projections	No	Cook et al. (2020)
	Droughts	Standardized Precipitation Index accumulated over 6 months (SPI-6)	Pr	From projections	No	Naumann et al. (2018)
Wind & storm	Mean wind speed	Annual mean wind speed	sfcWind	From projections	No	Karnauskas et al. (2018); Li et al. (2018)
Snow/ice	Snow season length	Number of days with snow water equivalent >100 mm (SWE100) over the snow season (Nov–Mar for NH)	Snw	From projections	No	Damm et al. (2017); Wobus et al. (2017)
Coastal	Extreme sea level (ETWL) inducing storm surges	1-in-100-year return period level (ETWL)		Data from authors	No	Vousdoukas et al. (2018)
	Coastal erosion	Shoreline retreat by mid- and end of century		Data from authors	No	Vousdoukas et al. (2020)

CID category: HEAT

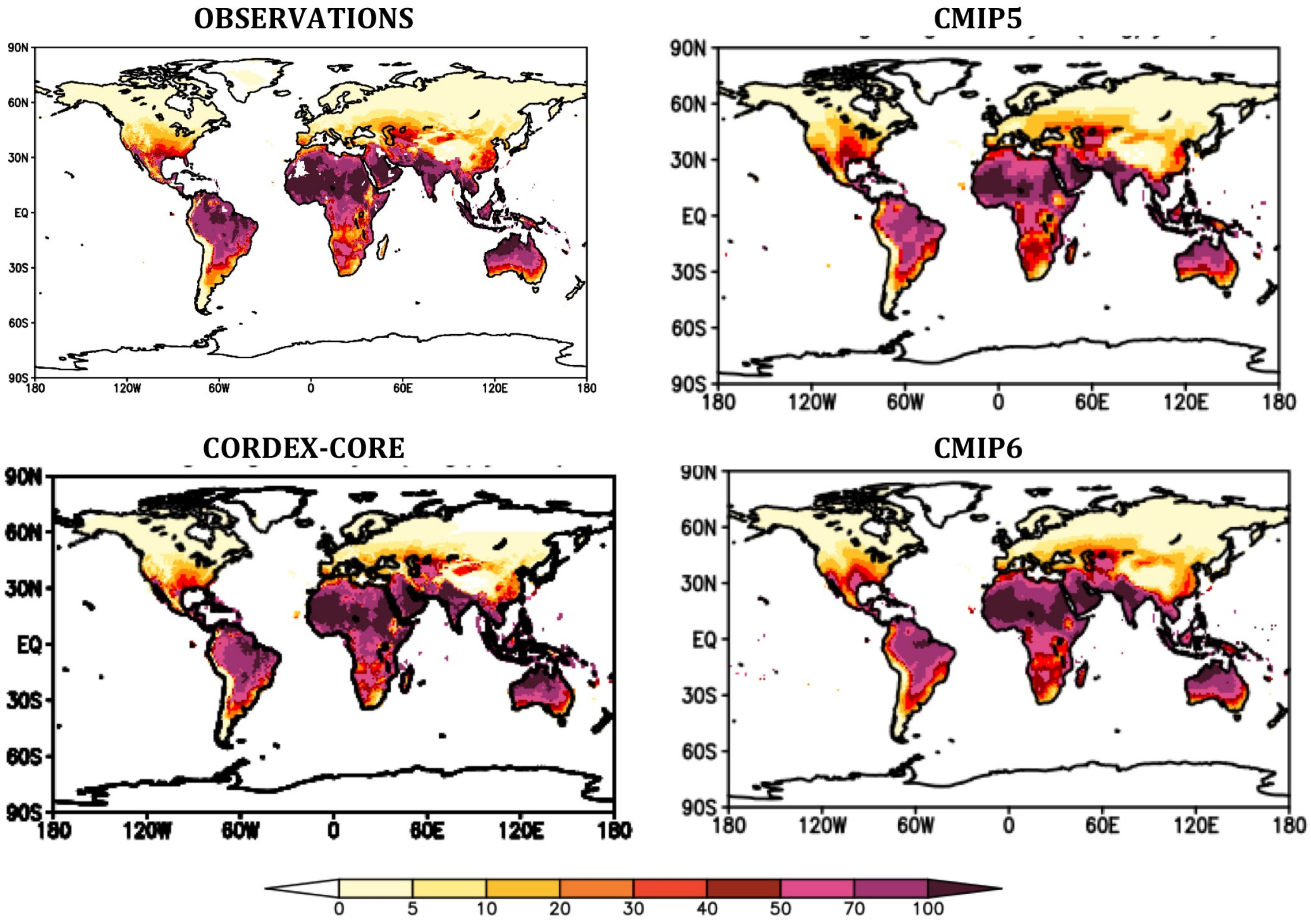
TX35:
Number of days with TMAX > 35 degrees



Coppola. *et al.* Climate hazard indices projections based on CORDEX-CORE, CMIP5 and CMIP6 ensemble. *Clim Dyn* (2021). https://doi.org/10.1007/s00382-021-05640-z

CID category: HEAT

CDD: Cooling degree days, a measure of the energy consumption for cooling in hot environments. It is based on the daily mean, maximum and minimum temperature and it is computed as in Spinoni et al. (2015), except that here the sum is cumulated over the whole year (instead of 6 months) so that it applies to both Hemispheres.



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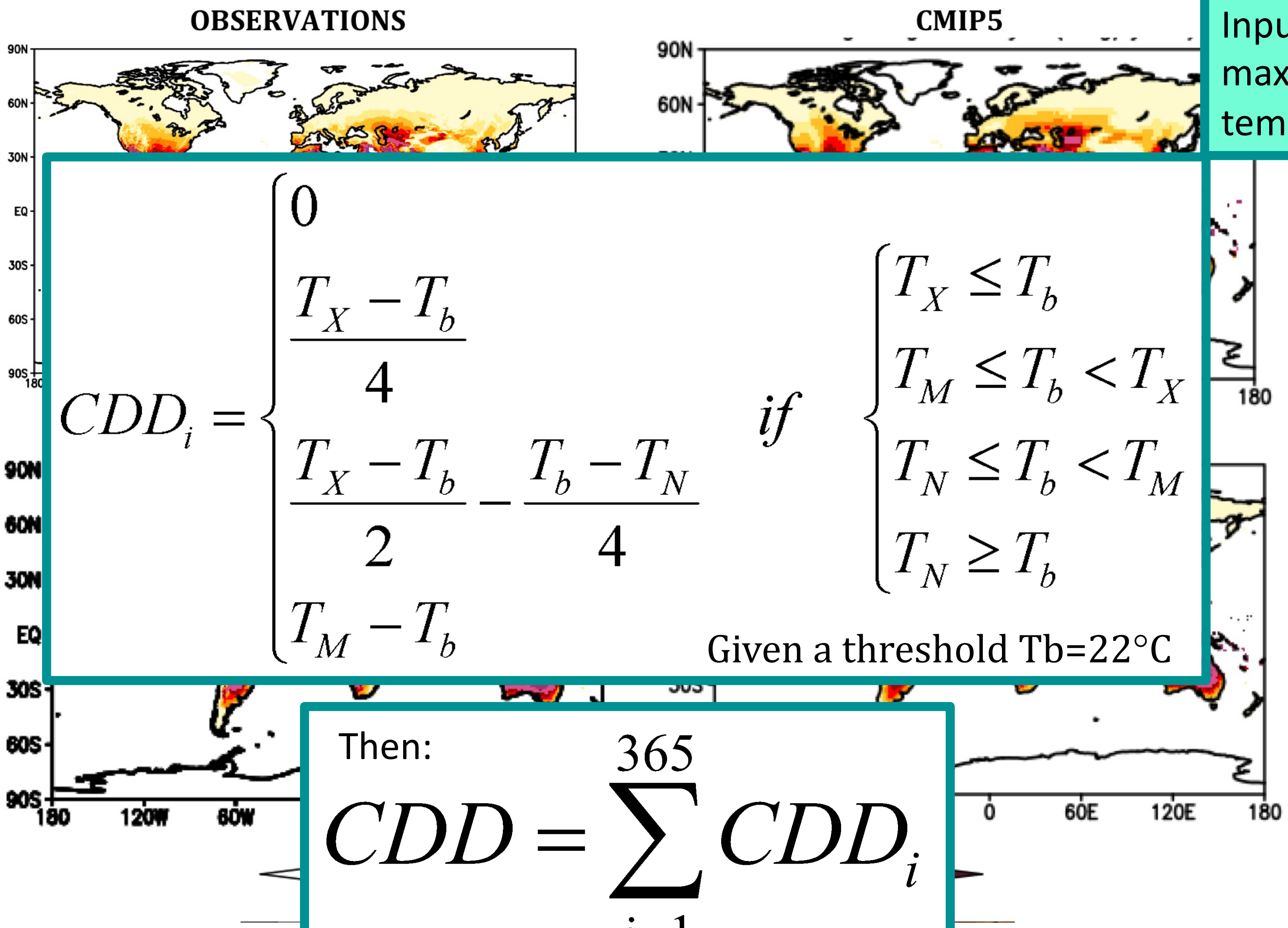
Input: daily min. max and mean temperature!



$$CDD_i = \begin{cases} 0 & \\ \dfrac{T_X - T_b}{4} & \\ \dfrac{T_X - T_b}{2} - \dfrac{T_b - T_N}{4} & \\ T_M - T_b & \end{cases} \quad if \quad \begin{cases} T_X \leq T_b \\ T_M \leq T_b < T_X \\ T_N \leq T_b < T_M \\ T_N \geq T_b \end{cases}$$

Given a threshold Tb=22°C

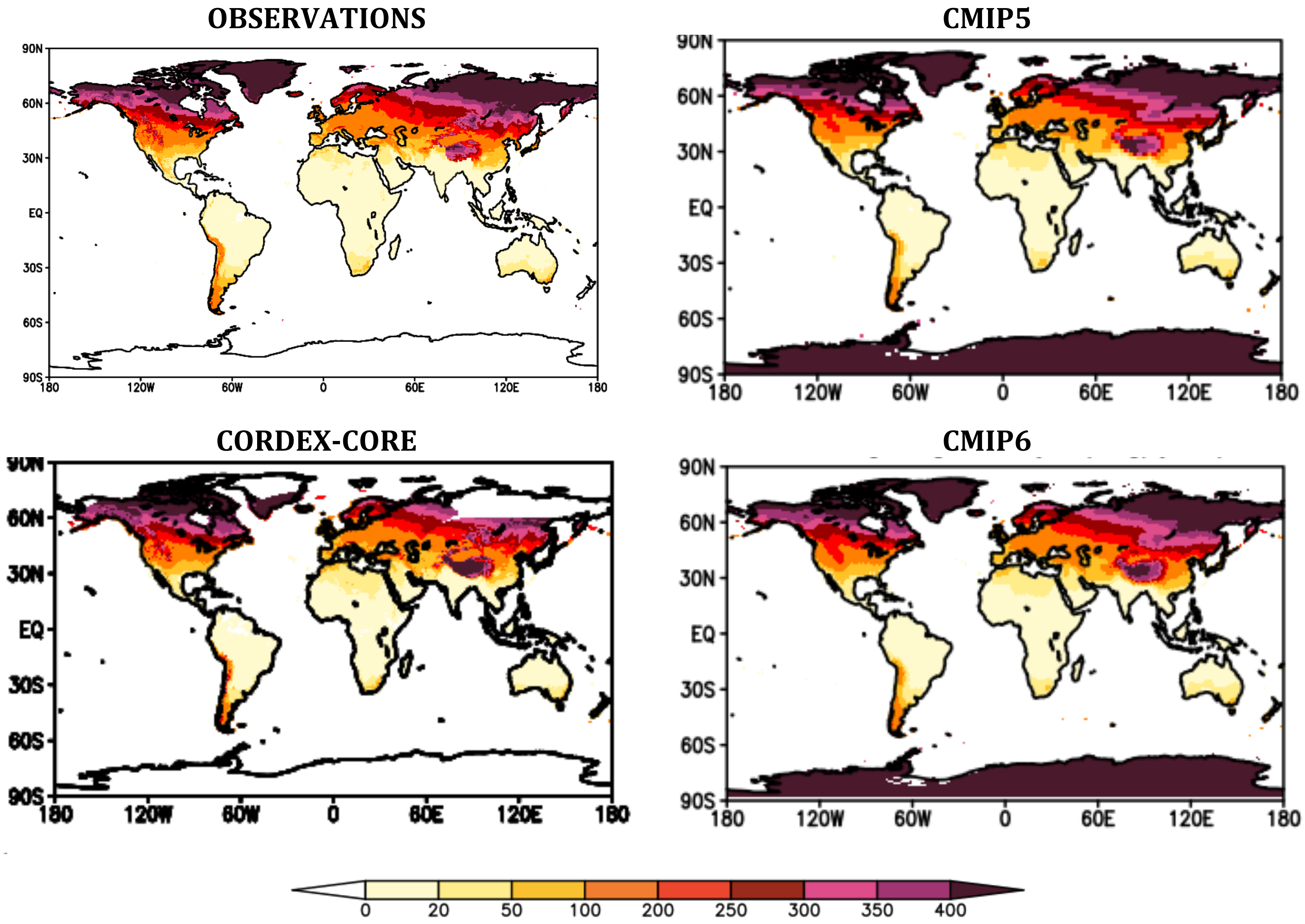
Then:

$$CDD = \sum_{i=1}^{365} CDD_i$$

Coppola. *et al.* Climate hazard indices projections based on CORDEX-CORE, CMIP5 and CMIP6 ensemble. *Clim Dyn* (2021). https://doi.org/10.1007/s00382-021-05640-z

CID category: COLD

HDD: Heating Degree Days: similarly to the CDD, it is the energy demand for heating and it is computed as in Spinoni et al. (2015), but for the whole year.



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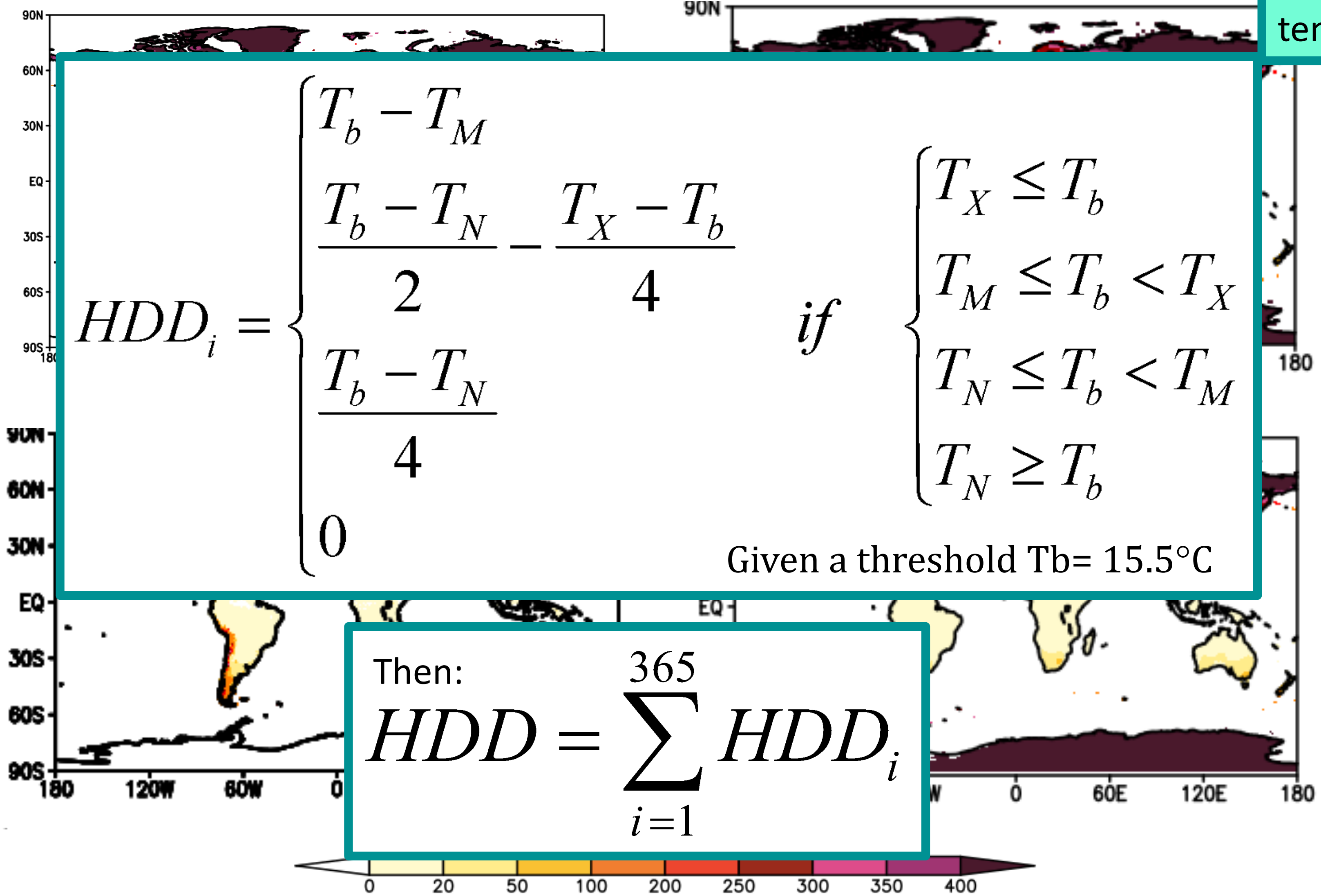
Input: daily min. max and mean temperature!



$$HDD_i = \begin{cases} T_b - T_M \\ \dfrac{T_b - T_N}{2} - \dfrac{T_X - T_b}{4} \\ \dfrac{T_b - T_N}{4} \\ 0 \end{cases} \quad if \quad \begin{cases} T_X \leq T_b \\ T_M \leq T_b < T_X \\ T_N \leq T_b < T_M \\ T_N \geq T_b \end{cases}$$

Given a threshold Tb= 15.5°C

Then: $$HDD = \sum_{i=1}^{365} HDD_i$$

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CID category: DROUGHT

Standard Precipitation Index: designed to quantify the precipitation deficit for multiple timescales, thus reflecting the impact of drought on the availability of the different water resources.

CID category: DROUGHT

SPI Calculation:

(1) A monthly precipitation time series is selected (at least 30 years).

(2)A set of averaging periods are selected to determine a set of time scales of period n months where

n is 3, 6, 12, 24 months. These sets are generated computing the running mean for each window.

(3) Each of the dataset are fitted to the Gamma distribution. The fitting can be achieved through the maximum likelihood estimation of the gamma distribution parameters.

(3) The values from this probability distribution are then transformed into a normal distribution, so that the mean SPI for the location and desired period is zero and the standard deviation is 1 (Edwards and McKee, 1997).

CID category: DROUGHT

SPI	Cumulative Probability	Interpretation
-3.0	0.0014	extremely dry
-2.5	0.0062	extremely dry
-2.0	0.0228	extremely dry (SPI < -2.0)
-1.5	0.0668	severely dry (-2.0 < SPI < -1.5)
-1.0	0.1587	moderately dry (-1.5 < SPI < -1.0)
-0.5	0.3085	near normal
0.0	0.5000	near normal
0.5	0.6915	near normal
1.0	0.8413	moderately wet (1.0 < SPI < 1.5)
1.5	0.9332	very wet (1.5 < SPI < 2.0)
2.0	0.9772	extremely wet (2.0 < SPI)

Positive SPI values indicate greater than median precipitation, and negative values indicate less than median precipitation.

CID category: DROUGHT

The timescales (or time windows) are defined in terms of number of months:

- SPI-1 to SPI-3: When SPI is computed for shorter accumulation periods (e.g. 1 to 3 months), it can be used as an indicator for immediate impacts such as reduced soil moisture, snowpack, and flow in smaller creeks. (≈Meteorological droughts)
- SPI-3 to SPI-12: When SPI is computed for medium accumulation periods (e.g. 3 to 12 months), it can be used as an indicator for reduced stream flow and reservoir storage. (≈Agricultural droughts)
- SPI-12 to SPI-48: When SPI is computed for longer accumulation periods (e.g. 12 to 48 months), it can be used as an indicator for reduced reservoir and groundwater recharge. (≈Hydrological droughts)

CID category: DROUGHT

SPI-6: the Standardized Precipitation Index (for a time window of 6 months): a drought starts in the month when SPI-6 falls below −1 and it ends when SPI-6 returns to positive values for at least two consecutive months, as in Spinoni et al. (2014).

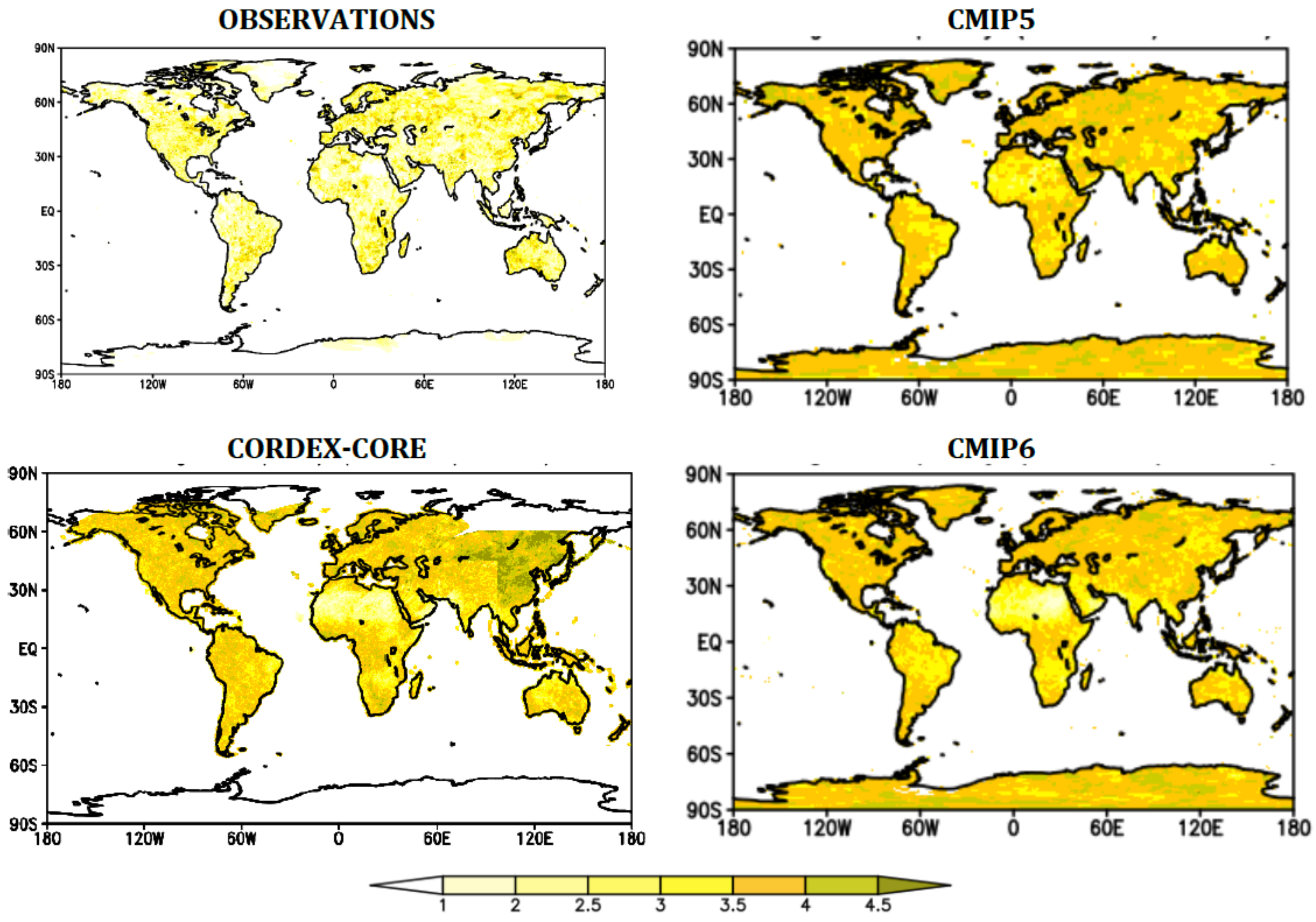


Fig. 9: The same as in Fig. 2 but for the Drought Frequency (DF). Units are N. of events / decade.

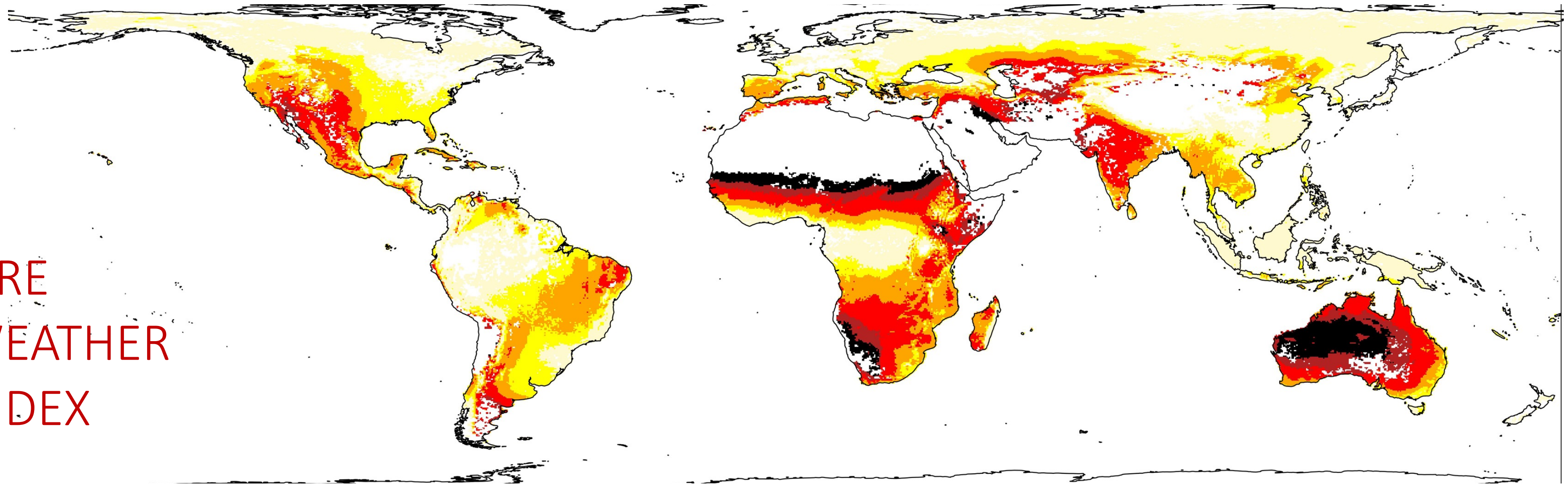
Drought Frequency (DF): the total number of drought events

Input: monthly precipitation!

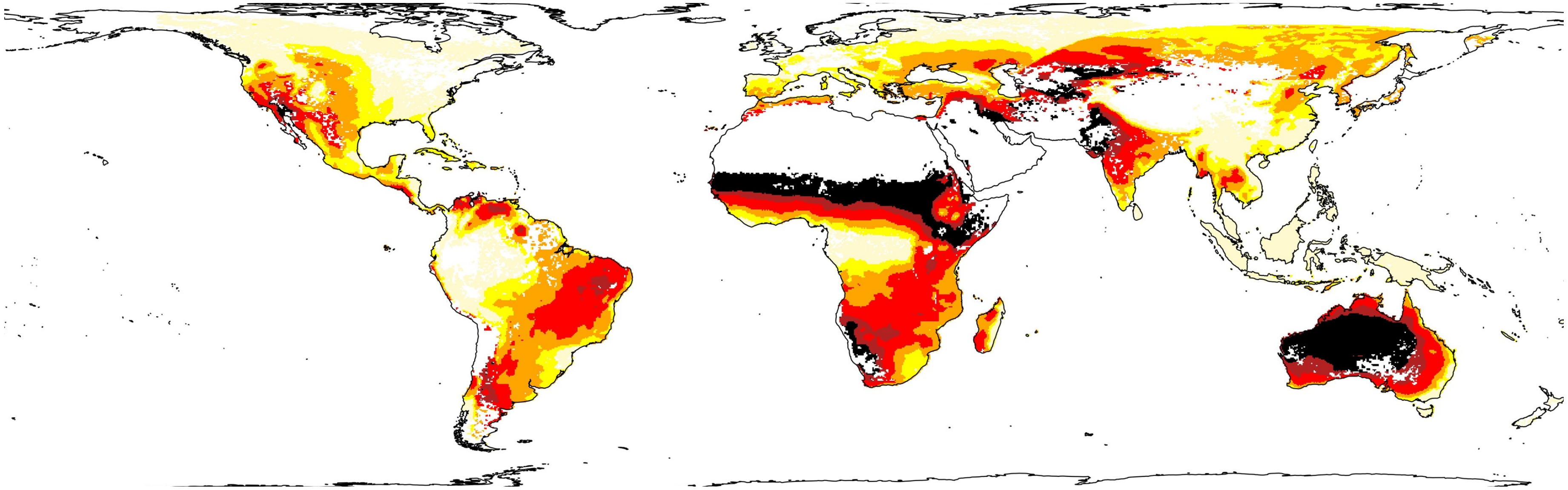
Coppola. *et al.* Climate hazard indices projections based on CORDEX-CORE, CMIP5 and CMIP6 ensemble. *Clim Dyn* (2021). https://doi.org/10.1007/s00382-021-05640-z

FIRE WEATHER INDEX

ERA5 1980-2010



CORDEX-CORE 1980-2010



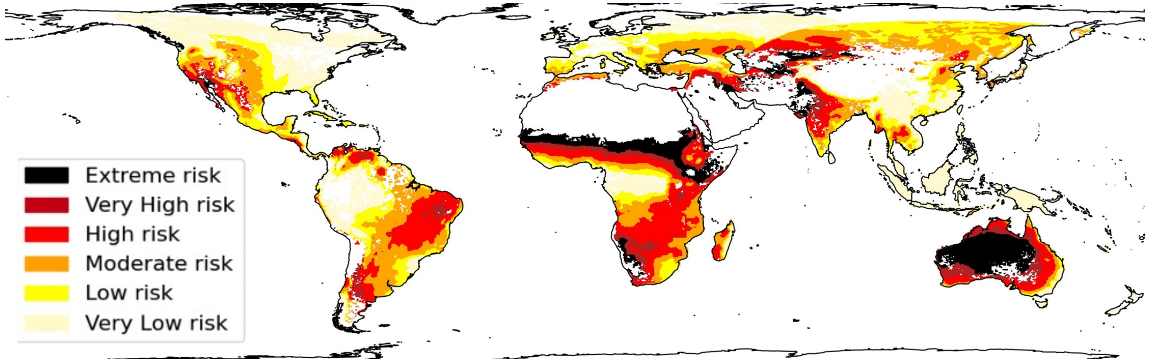
Input: daily precipitation, maximum temperature, relative humidity and maximum wind speed

Fire Danger Classes	FWI ranges
Very low	< 5.2
Low	5.2 - 11.2
Moderate	11.2 - 21.3
High	21.3 - 38.0
Very high	38.0 - 50.0
Extreme	>= 50.0

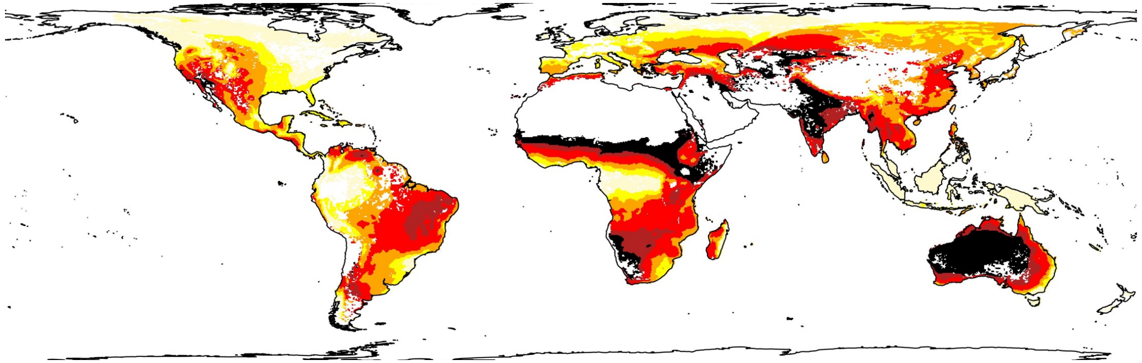
Van Wagner et al, 1985

(thanks to Rita Nogherotto)

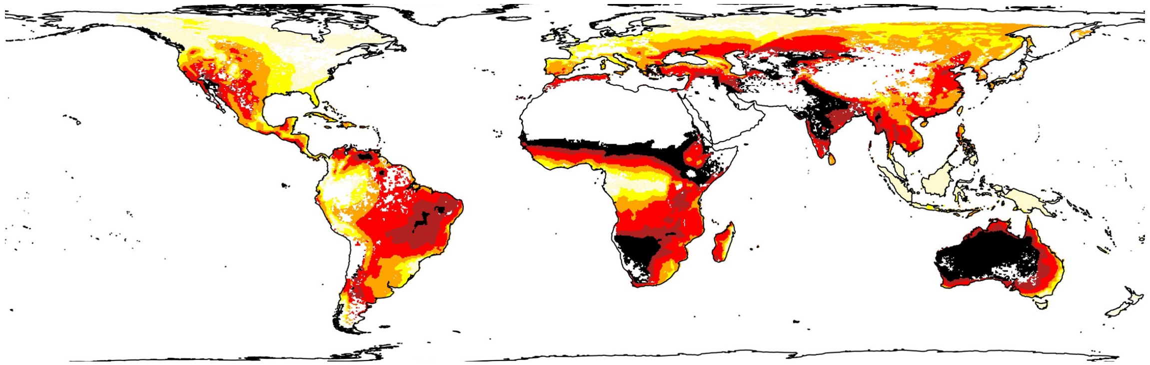
FWI Historical CORDEX-CORE



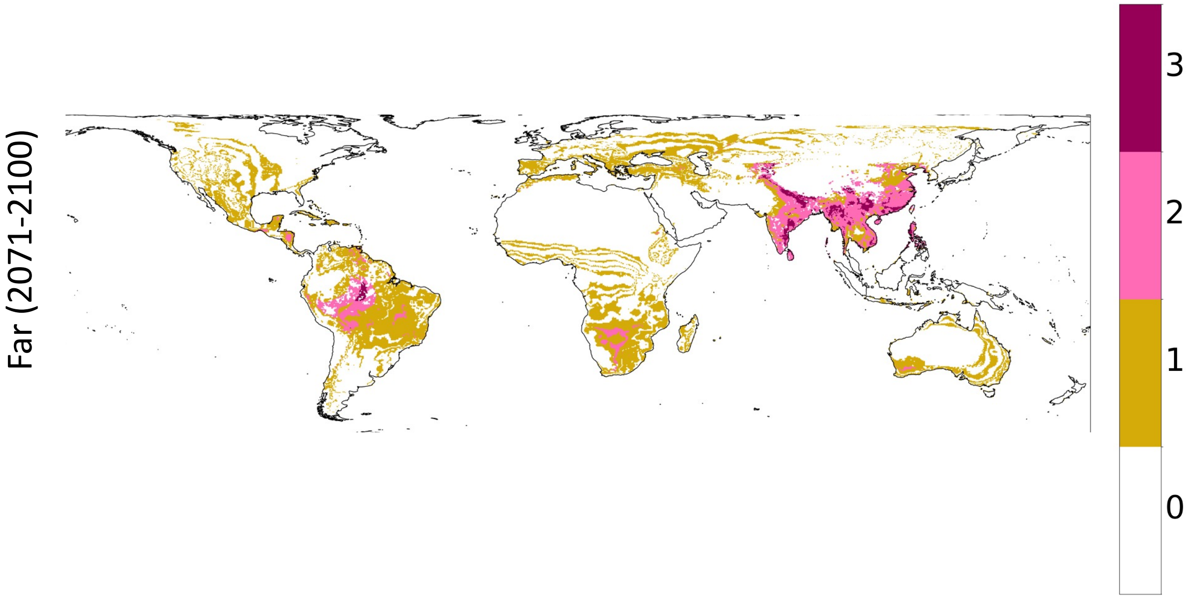
FWI Mid Future (2041-2070) CORDEX-CORE

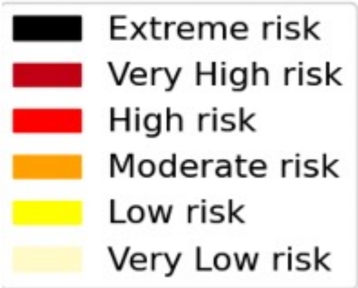


FWI Far Future (2071-2100) CORDEX-CORE



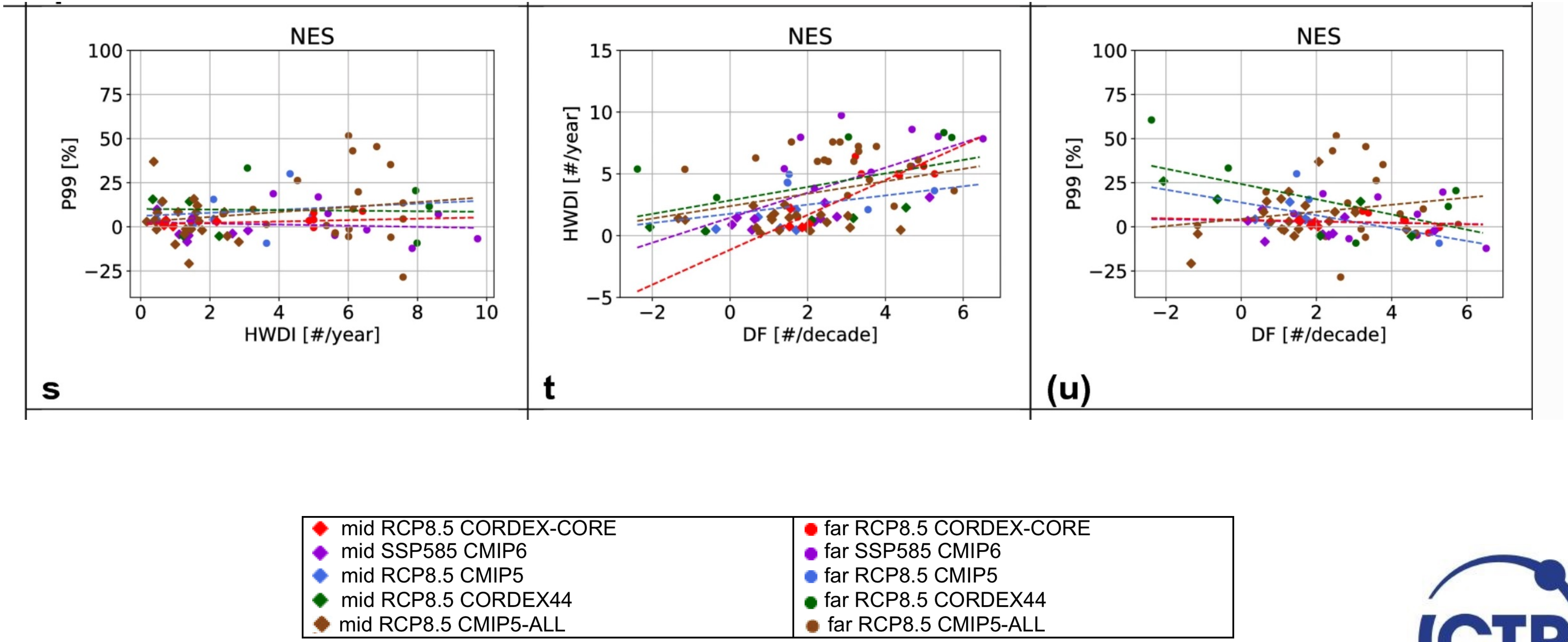
FWI CATEGORY CHANGE





(thanks to Rita Nogherotto)

Compounded hazards hot spots!



Coppola. *et al.* Climate hazard indices projections based on CORDEX-CORE, CMIP5 and CMIP6 ensemble. *Clim Dyn* (2021). https://doi.org/10.1007/s00382-021-05640-z

Change signal

Heat&
Cold

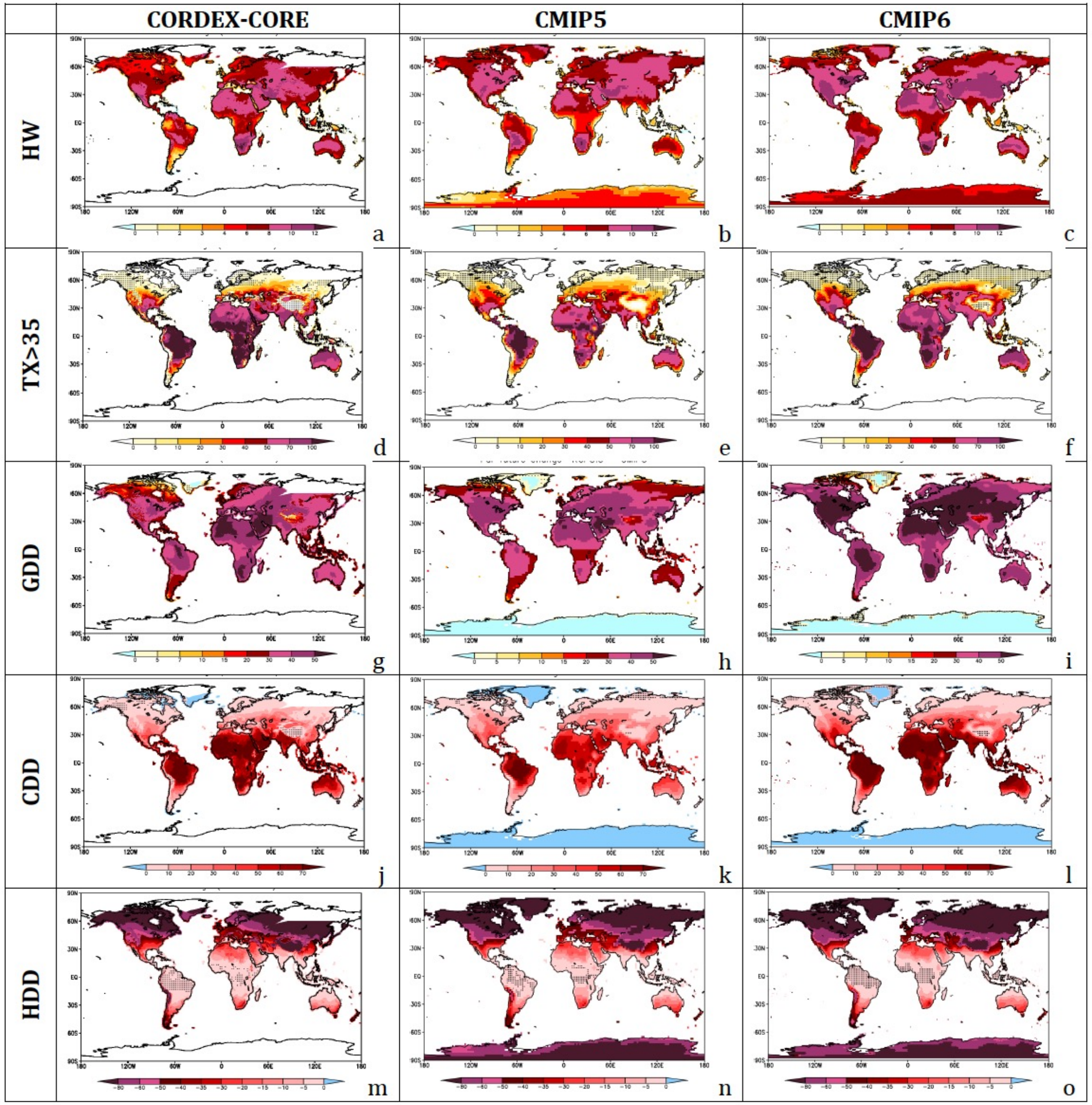


Fig. 10: Far future change for RCP8.5 (SSP585 for CMIP6) for Temperature and Heat indicators. Little black dots indicate areas where the change signal is not significant.

Coppola. *et al.* Climate hazard indices projections based on CORDEX-CORE, CMIP5 and CMIP6 ensemble. *Clim Dyn* (2021). https://doi.org/10.1007/s00382-021-05640-z

Wet&
Dry

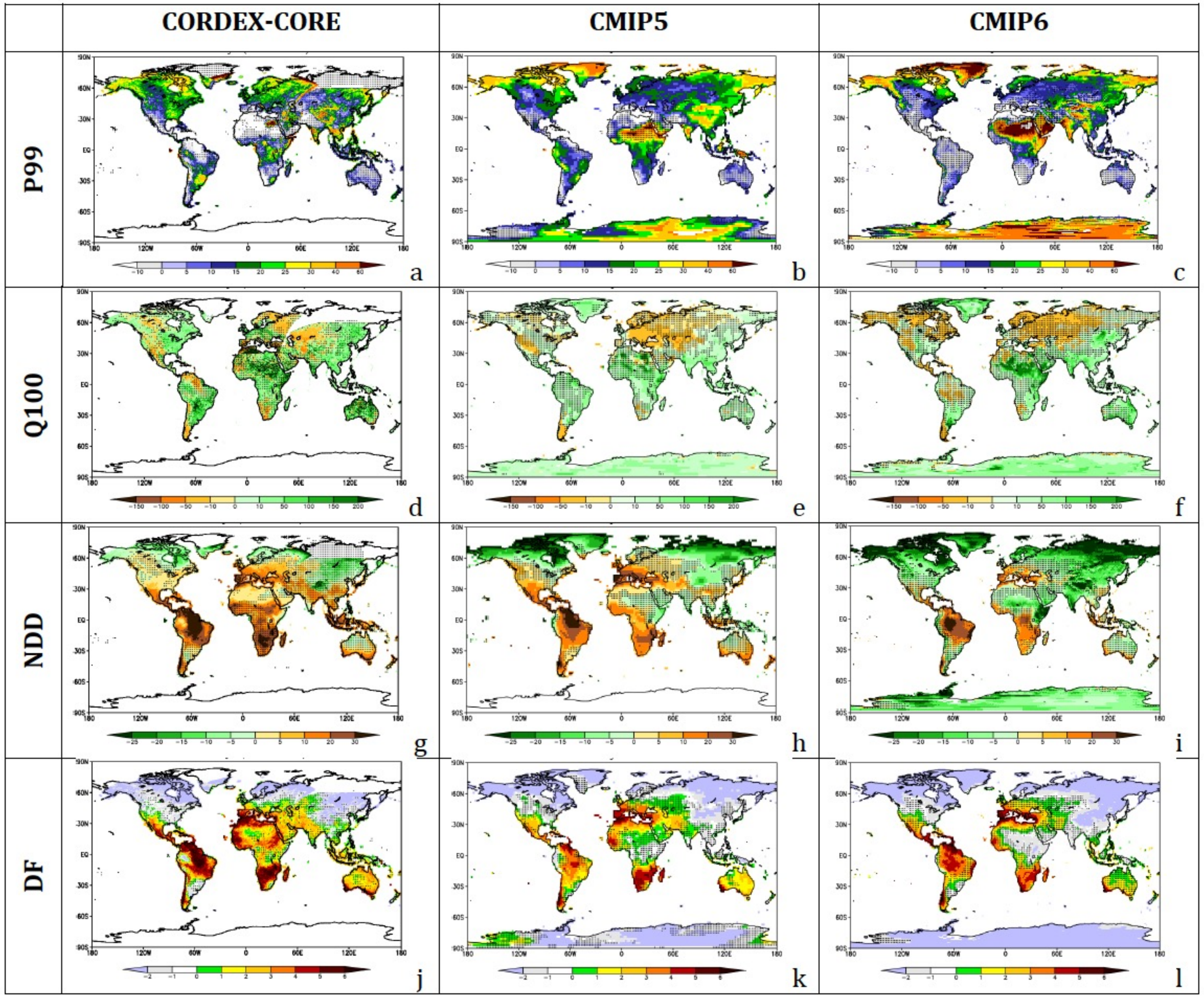


Fig. 11: Far future change for RCP8.5 (SSP585 for CMIP6) for Dry and Wet indicators. Little black dots indicate areas where the change signal is not significant.

Coppola. *et al.* Climate hazard indices projections based on CORDEX-CORE, CMIP5 and CMIP6 ensemble. *Clim Dyn* (2021). https://doi.org/10.1007/s00382-021-05640-z

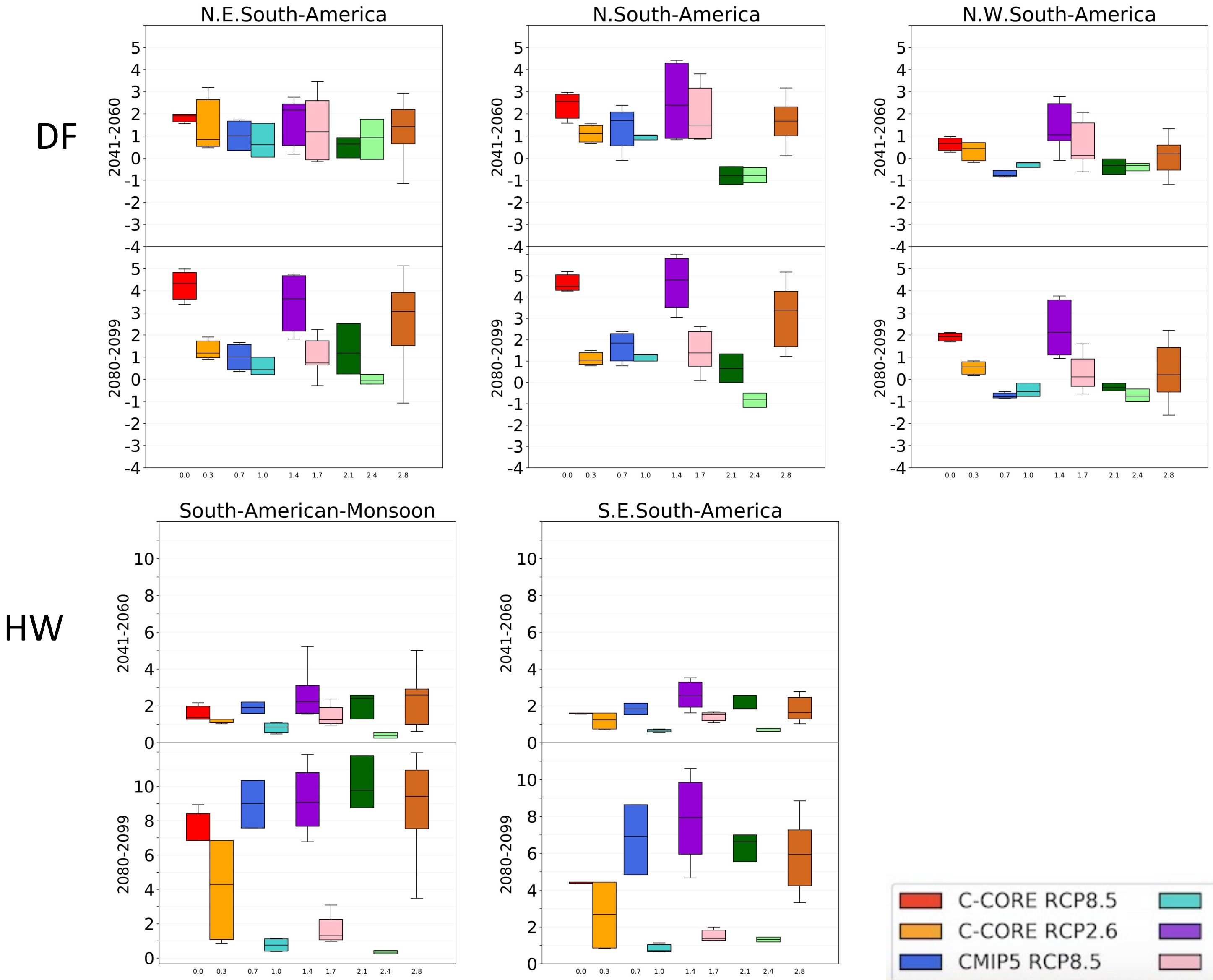
Robustness of SIGNAL

CONDITIONS FOR ROBUSTNESS (from WGI):

- at least 66% of the models have a signal-to-noise ratio greater than one;
- at least 80% of them agree on the sign of change.

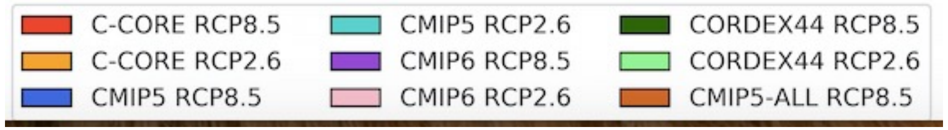
The signal-to-noise ratio is estimated for each model from the ratio between the change and the standard deviation of non-overlapping 20-year means of the corresponding pre-industrial simulation;
for Regional simulations, the reference period for the standard deviation will be 1970-1999.

Model consensus



- Drough Frequency (units = N. events / decade) and Heat Waves (units = N.events/year) indices changes for mid (2041–2060) and far (2080–2099) future.

- Colored bars represent the model spread between the 25th and 75th percentiles, while the black bars indicate the 5th, the 50th and 95th percentiles.



Coppola. *et al.* Climate hazard indices projections based on CORDEX-CORE, CMIP5 and CMIP6 ensemble. *Clim Dyn* (2021). https://doi.org/10.1007/s00382-021-05640-z

The approach based on **Global Warming Levels (GWLs)** is applied, in order to overcome the dependency from the emissions pathways and the single models.

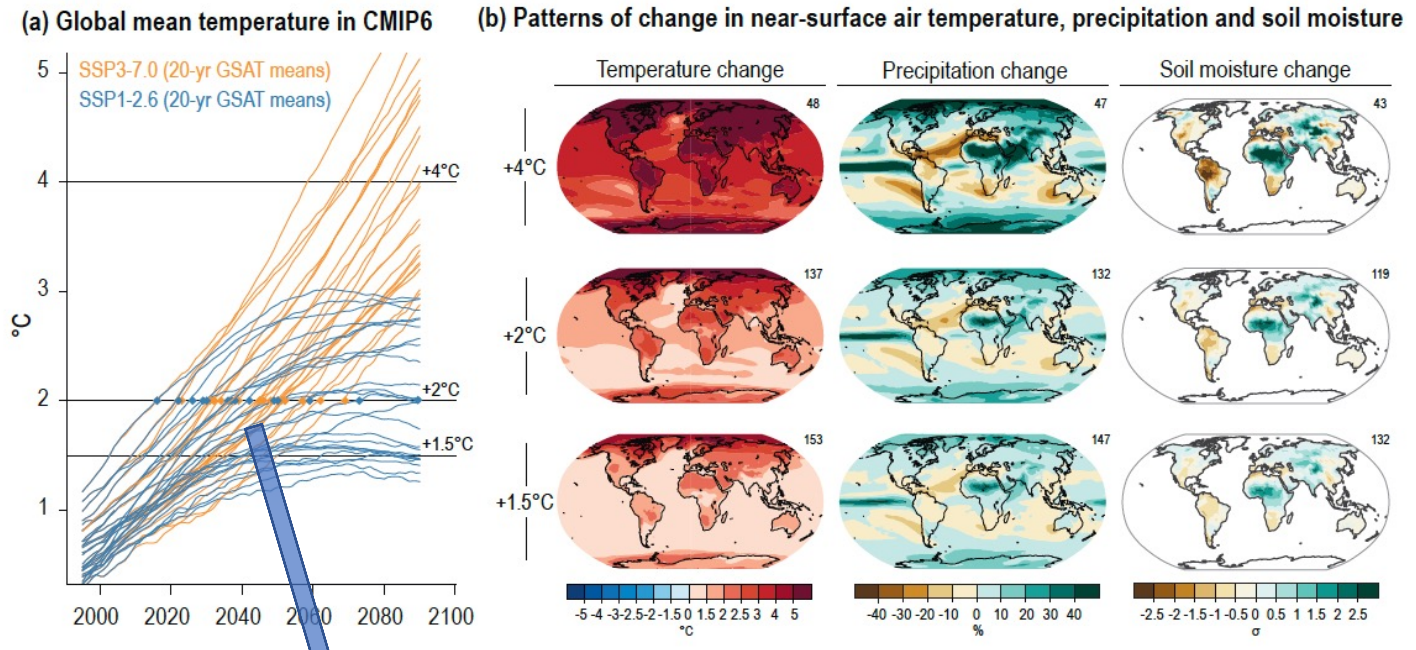
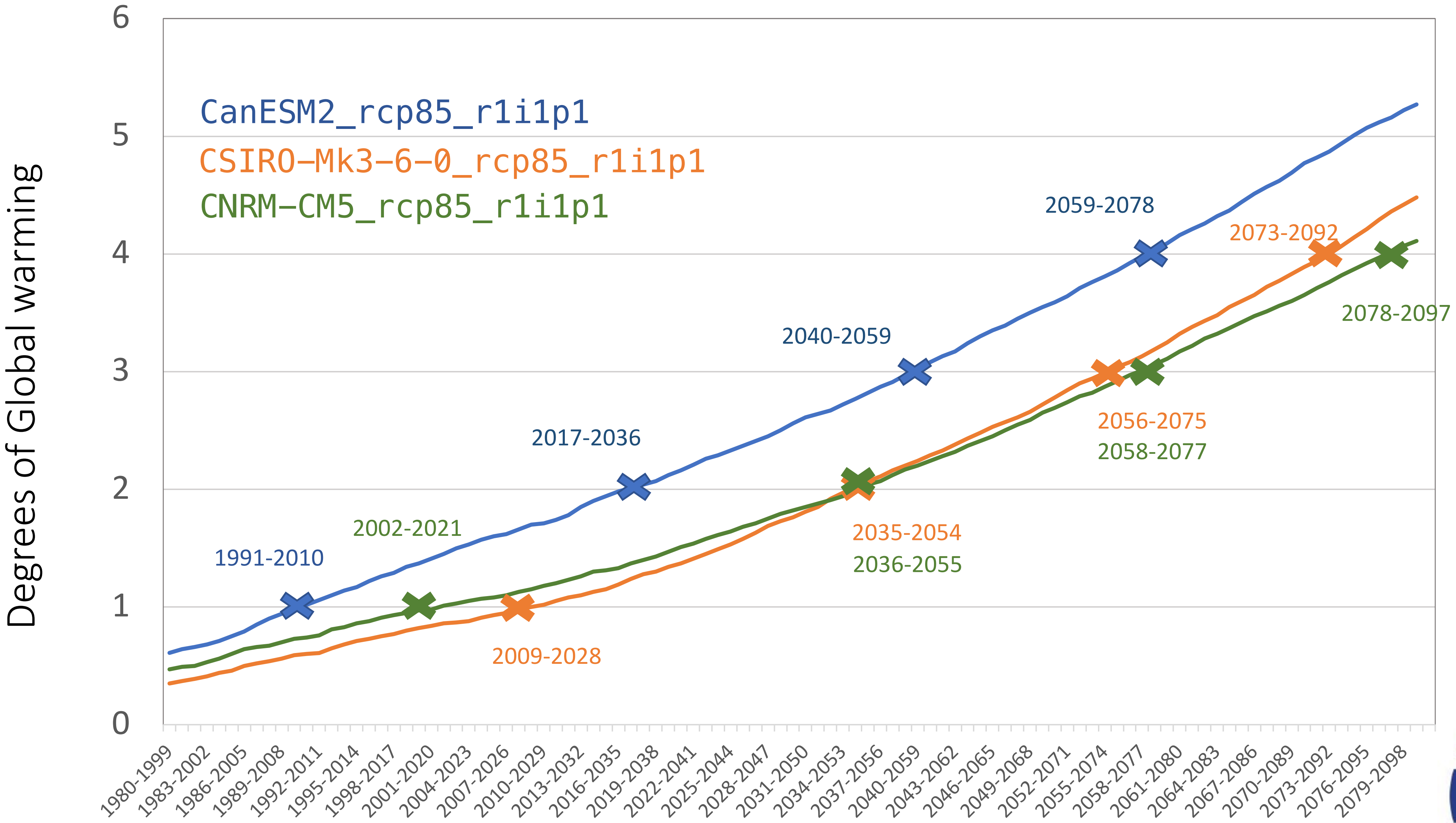


Figure TS.5 | Scenarios, global warming levels, and patterns of change. *The intent of this figure is to show how scenarios are linked to global warming levels (GWLs) and to provide examples of the evolution of patterns of change with global warming levels.* **(a)** Illustrative example of GWLs defined as global surface temperature response to anthropogenic emissions in unconstrained Coupled Model Intercomparison Project Phase 6 (CMIP6) simulations, for two illustrative scenarios (SSP1-2.6 and SSP3-7.0). The time when a given simulation reaches a GWL, for example, +2°C, relative to 1850–1900 is taken as the time when the central year of a 20-year running mean first reaches that level of warming. See the dots for +2°C, and how not all simulations reach all levels of warming. The assessment of the timing when a GWL is reached takes into account additional lines of evidence and is discussed in Cross-Section Box TS.1. **(b)** Multi-model, multi-simulation average response patterns of change in near-surface air temperature, precipitation (expressed as percentage change) and soil moisture (expressed in standard deviations of interannual variability) for three GWLs. The number to the top right of the panels shows the number of model simulations averaged across including all models that reach the corresponding GWL in any of the five Shared Socio-economic Pathways (SSPs). See Section TS.2 for discussion. {Cross-Chapter Box 11.1}

The climate response pattern for the 20-year period around when individual simulations reach a given GWL are averaged across all models and scenarios that reach that GWL.

The time when a given simulation reaches a GWL, for example, +2C, relative to 1850–1900 is taken as the time when the central year of a 20-year running mean first reaches that level of warming. See the dots for +2C, and how not all simulations reach all levels of warming.

An example of GWLs calculation:



Let’s see a practical example for computing the change in a particular CID in terms of GWLs

We need:

- daily time series of climatic variables (i.e.: maximum temperature and precipitation) for the historical period and the future scenario;
- GWLs timeslices of each model of my ensemble;
- Computation of indices

If we want to compute the change in extreme indices in terms of GWL

- Reference period (fixed): 1980-1999
- Time slice in the future according to the GWL for a given scenario.
- Compute the change between the two periods for each member.

CDO-ECA

We are going to use a set of CDO operators to compute climate indices of daily temperature and precipitation extreme developed in the frame of European Climate Assessment (ECA) project.

Climate indices with CDO:
https://earth.bsc.es/gitlab/ces/cdo/raw/b4f0edf2d5c87630ed4c5ddee5a4992e3e08b06a/doc/cdo_eca.pdf

2.0.1 ECACDD - Consecutive dry days index per time period

Synopsis

eca_cdd[,*R*] `ifile ofile`

Description

Let `ifile` be a time series of the daily precipitation amount RR, then the largest number of consecutive days where RR is less than R is counted. R is an optional parameter with default $R = 1$ mm. A further output variable is the number of dry periods of more than 5 days. The date information of a timestep in `ofile` is the date of the last contributing timestep in `ifile`. The following variables are created:

- consecutive_dry_days_index_per_time_period
- number_of_cdd_periods_with_more_than_5days_per_time_period

Parameter

R	FLOAT	Precipitation threshold (unit: mm; default: R = 1 mm)

Example

To get the largest number of consecutive dry days of a time series of daily precipitation amounts use:

```
cdo eca_cdd rrfile ofile
```

CDD: maximum number of consecutive days with less than a threshold R (1 mm) of precipitation per day per time period

Select the reference period

>cdo selyear,1980/1999 pr_mmday_region_model_historical_1951-2005.nc pr_mmday_region_model_historical_1980-1999.nc

>cdo eca_cdd pr_mmday_region_model_historical_year.nc CDD_region_model_historical_year.nc

We can merge all the years and we will have the index computed for the reference period.

We will need to average in the reference period.

RX1DAY: maximum 1-day precipitation amount per time period

Analogously,

>cdo eca_rx1day pr_mmday_region_model_historical_year.nc RX1DAY_region_model_historical_year.nc

TX35: Number of days with TMAX > 35 degrees

For this index we need tasmax

```
>cdo selyear,1980/1999 tasmax_region_model_historical.nc outfile_1980-1999.nc
```

*might need to convert from K to C

```
>cdo subc,273.15 outfile_1980-1999.nc outfile1.nc
>cdo  gtc,35 outfile1.nc outfile2.nc
>cdo yearsum outfile2.nc TX35_region_model_1980-1999.
```

Extreme changes based on GWL:

We are going to use one of the warming levels: 4.0 and one future scenario: rcp8.5

There is a table where you can find the time slice for each GWL, for each GCM member.

>vi cmip5_warming_levels_all_ens_1850_1900_MIX.csv

And check the time slice for that warming level:

```
model, ensemble, exp, warming_level, start_year, end_year
HadGEM2-ES r1i1p1 rcp85 4.0 2063 2082  ←
HadGEM2-ES r2i1p1 rcp85 4.0 2063 2082
HadGEM2-ES r3i1p1 rcp85 4.0 2063 2082
HadGEM2-ES r4i1p1 rcp85 4.0 2060 2079
IPSL-CM5A-LR r1i1p1 rcp85 4.0 2056 2075  ←
IPSL-CM5A-LR r2i1p1 rcp85 4.0 2057 2076
IPSL-CM5A-LR r3i1p1 rcp85 4.0 2056 2075
IPSL-CM5A-LR r4i1p1 rcp85 4.0 2054 2073
IPSL-CM5A-MR r1i1p1 rcp85 4.0 2057 2076
IPSL-CM5B-LR r1i1p1 rcp85 4.0 2075 2094
MPI-ESM-LR r1i1p1 rcp85 4.0 2072 2091  ←
MPI-ESM-LR r2i1p1 rcp85 4.0 2071 2090
MPI-ESM-LR r3i1p1 rcp85 4.0 2071 2090
MPI-ESM-MR r1i1p1 rcp85 4.0 2073 2092
```

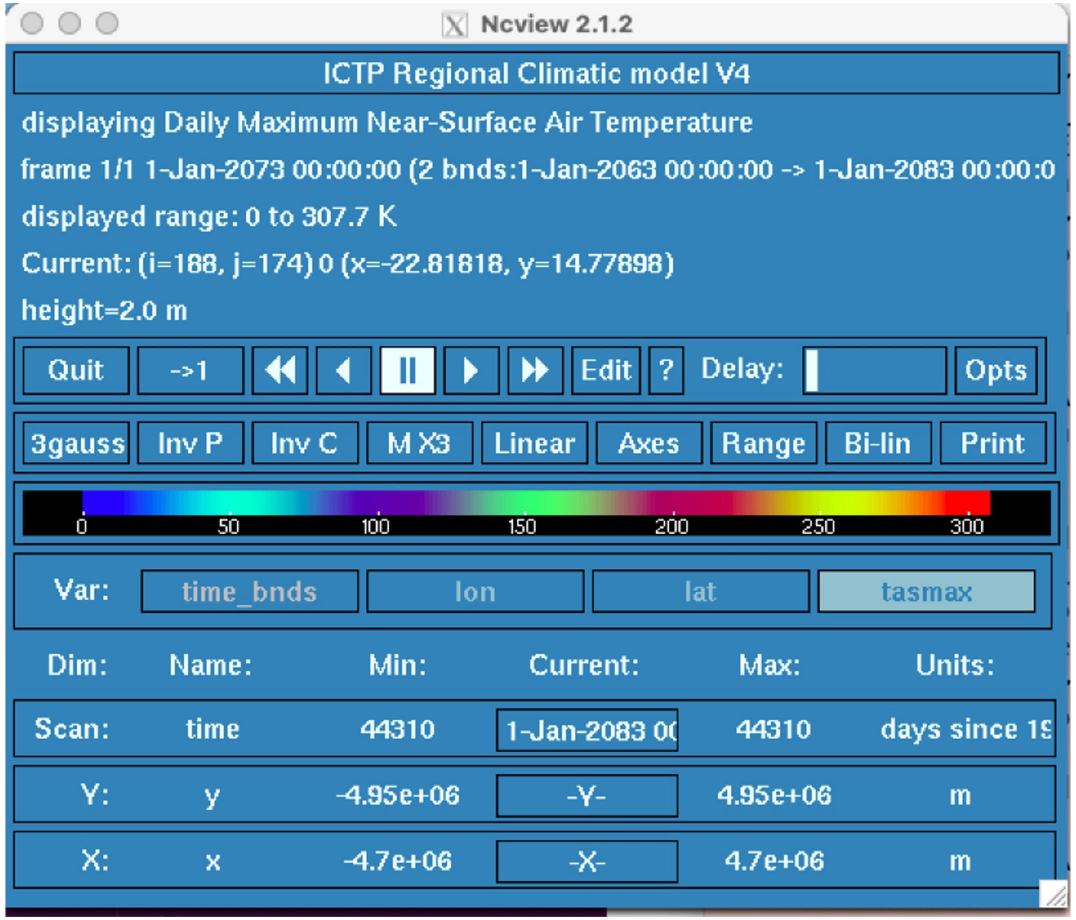
Period in the future:

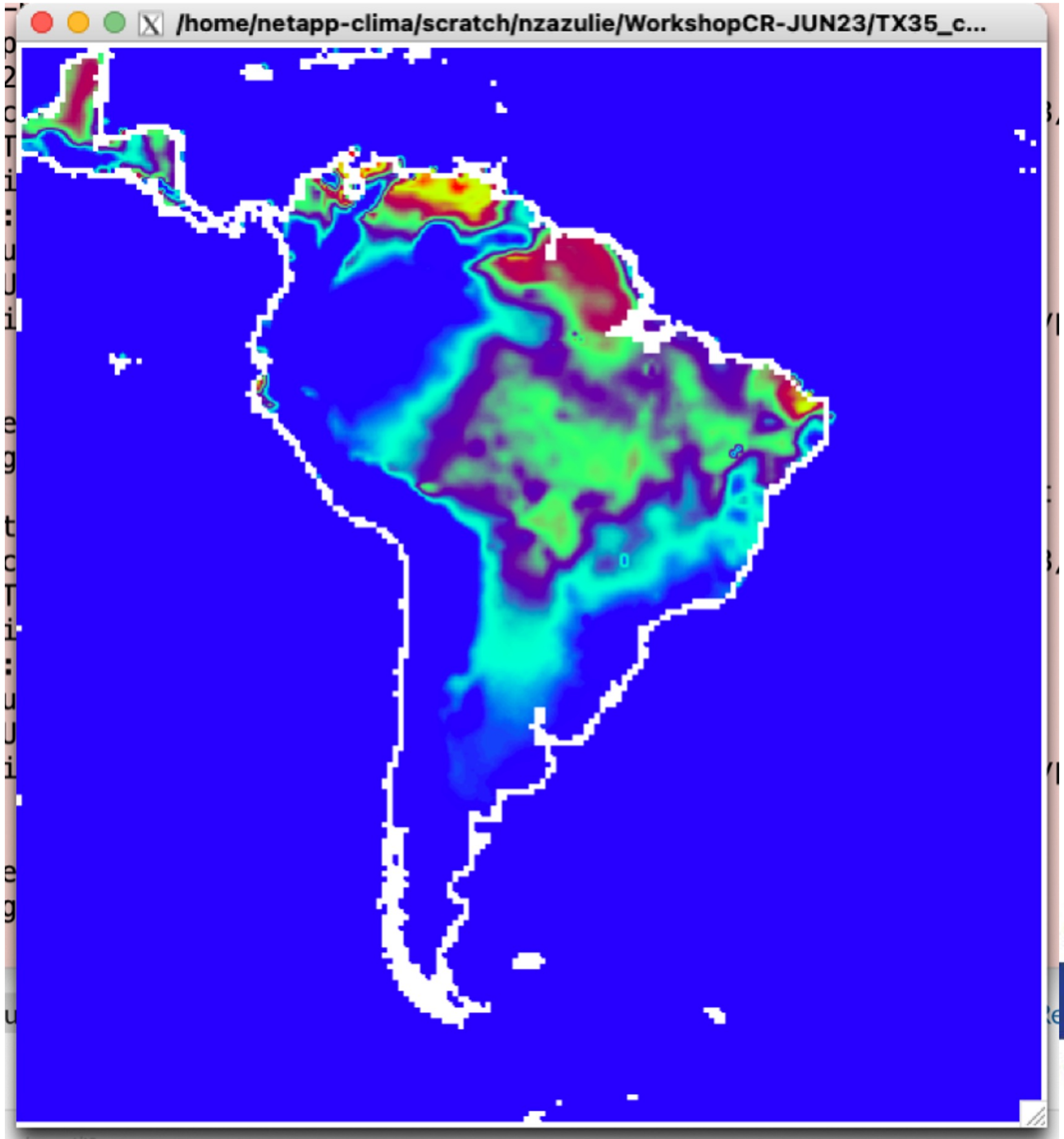
We repeat the calculation of the indices but for the future time slice for the driving model, experiment and member selected.

We finally compute the change:

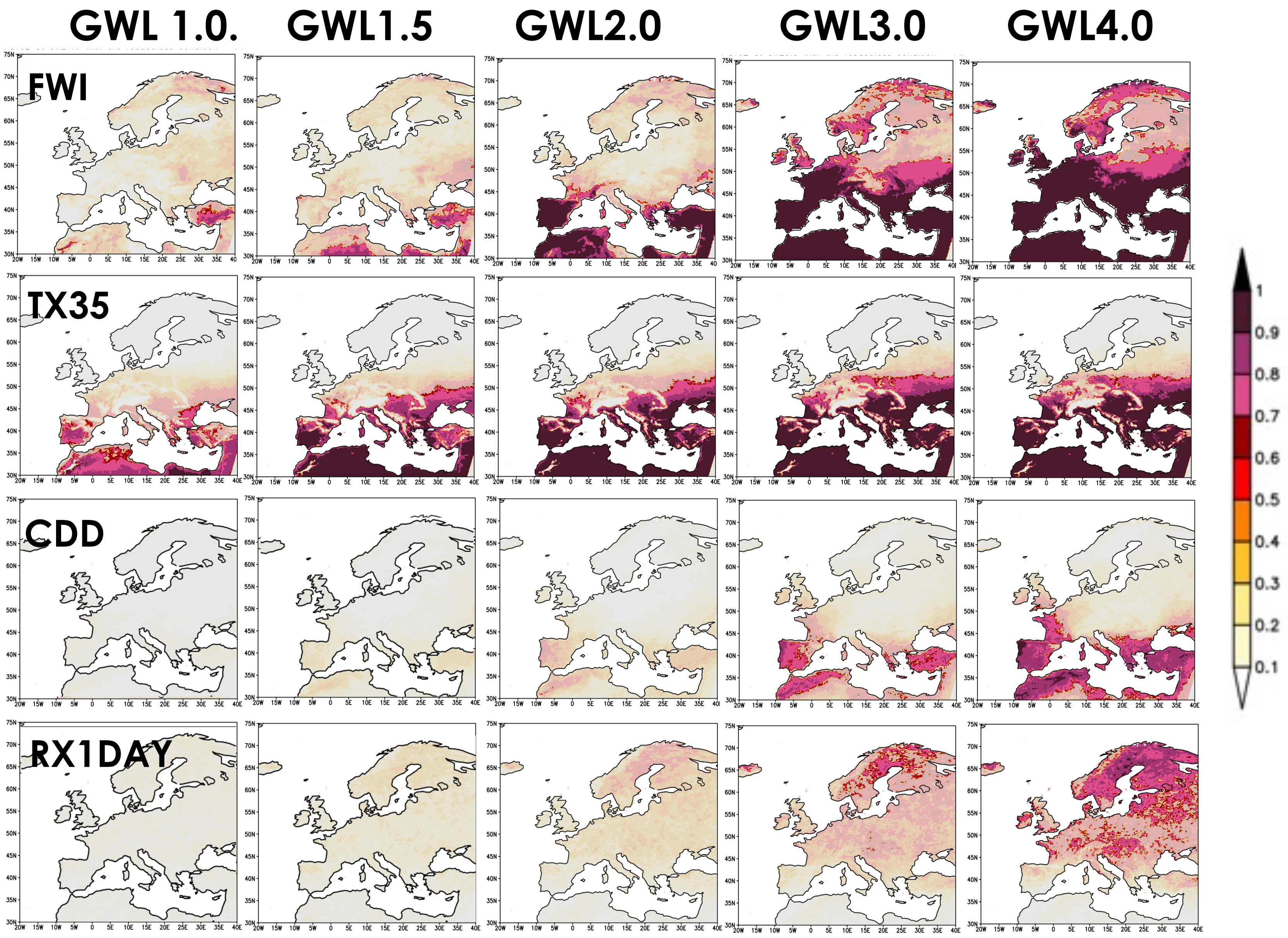
```
>cdo sub index_future_time_slice.nc index_reference.nc index_change.nc
```

TX35 change for 4C global warming for HadGEM2-ES_rcp85_r1i1p1_ICTP-RegCM4-3





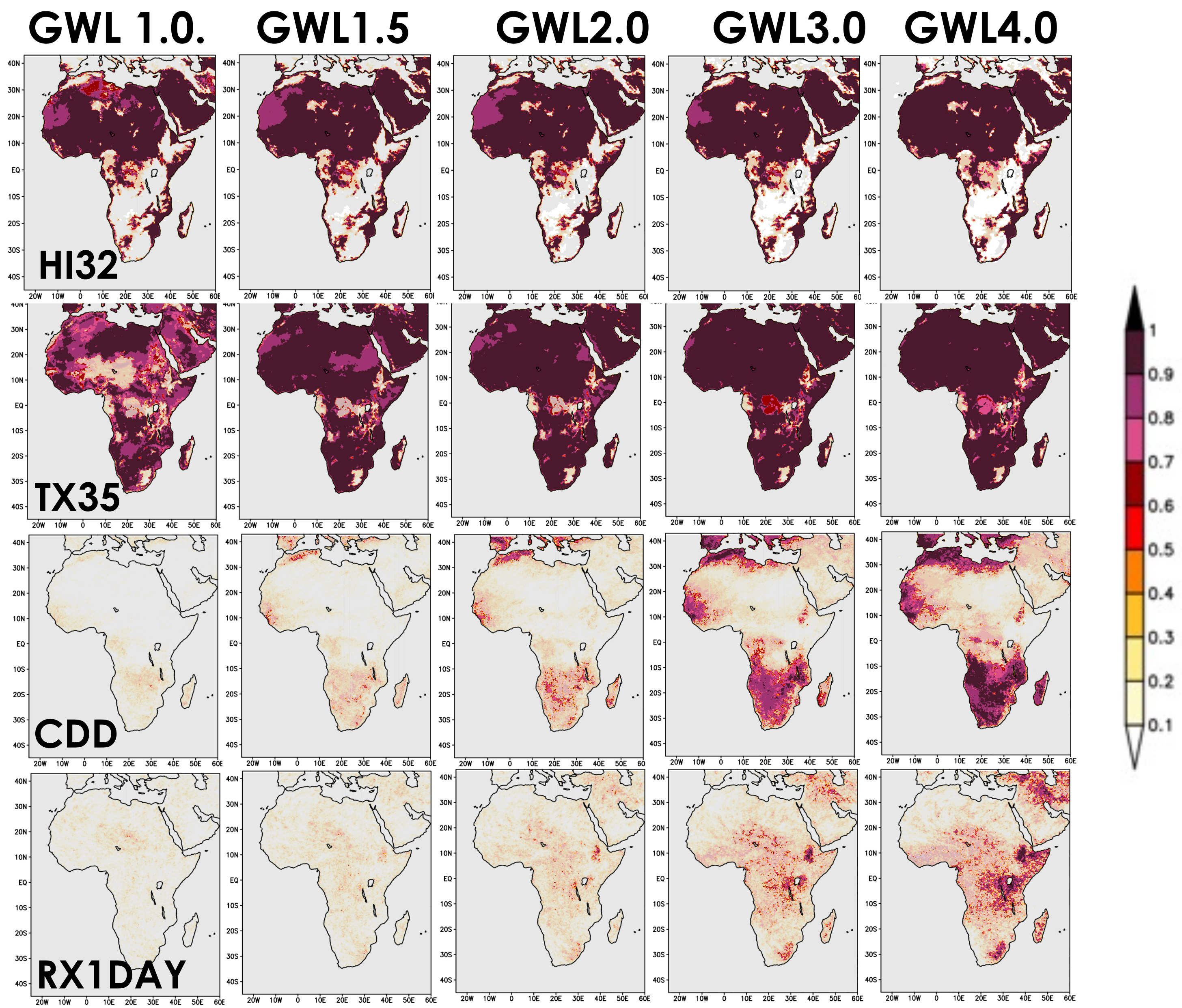
Probability of reaching a specific GWL threshold for each CID enriched with the condition of robustness



CORDEX EUR-11
67 Members

ICTP

Probability of reaching a specific GWL threshold for each CID enriched with the condition of robustness



CORDEX AFR-22
10 Members

If you want to try this calculation:

You can acces the repository with your user account:

`/home/esp-shared-a/GlobalModels/CMIP5/daily`

If you want to try this calculation:

Get the data at a ESGF node

https://esgf-node.ipsl.upmc.fr/projects/esgf-ipsl/

Search Data

The following projects require an **ESGF Account** (create account) and some also require a **Group Registration** (see links in table below) to access their data.

Search data for...	Register to...	Organized with...
All projects	(See below for project-specific registration details)	
CMIP6 *Coupled Model Intercomparison Project Phase 6*	No registration required.	Archive guidance
CMIP5 *Coupled Model Intercomparison Project Phase 5*	No registration required.	Data Reference Syntax
CORDEX *Coordinated Regional Climate Downscaling Experiment*	CORDEX Research CORDEX Commercial	Archive Specification
obs4MIPs *Observations for Climate Model Intercomparisons*	No registration required.	Data Requirements
C3S-Energy *Energy indicators for Copernicus Climate Change Service*	No registration required.	Data Management Plan
C3S-CMIP5-Adjust *Downscaled CMIP5 projections - Copernicus Climate Change Service*	Send email to the IPSL datanode manager.	Data Reference Syntax
CMIP6-Adjust *Downscaled CMIP6 projections*	Send email to the IPSL datanode manager.	Data Reference Syntax

If you do not find want you are looking for, enable '**Show All Replicas**' in the faceted search engine to increase the chances of finding a suitable federated node in the grid that hosts the data of your interest. Please, visit the Data Nodes Status to find the nodes that are down.

For more information about the projects, please use the links on the right (under "Child Projects").

The facetted data search is accessible from the "*Search and Download Data*" widget on the right of the page through the "*Search with options*" link.