Climate indices and bias adjustment

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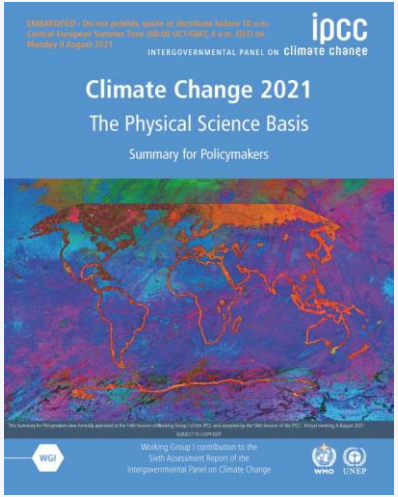
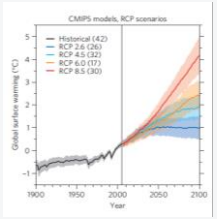
Swedish Meteorological and Hydrological Institute (SMHI)

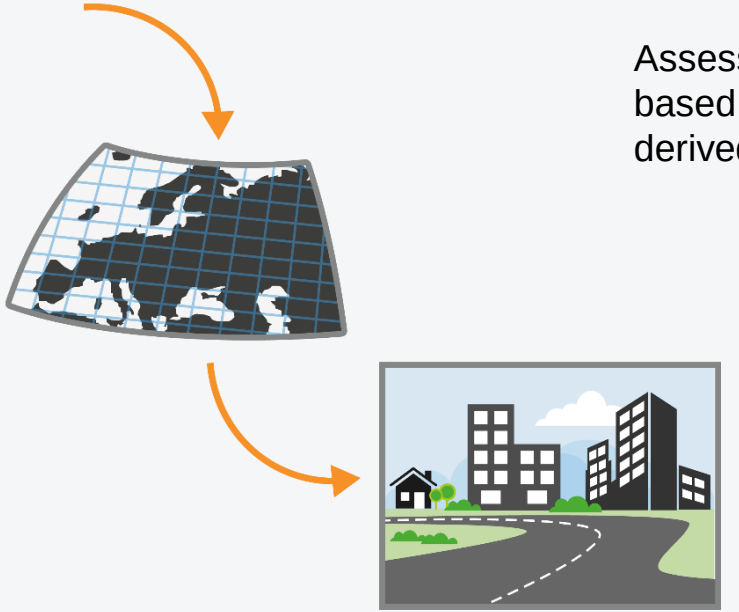
Web course on regional training on CORDEX Climate data analysis tool, June 22, 2022

From global warming to regional and local impacts





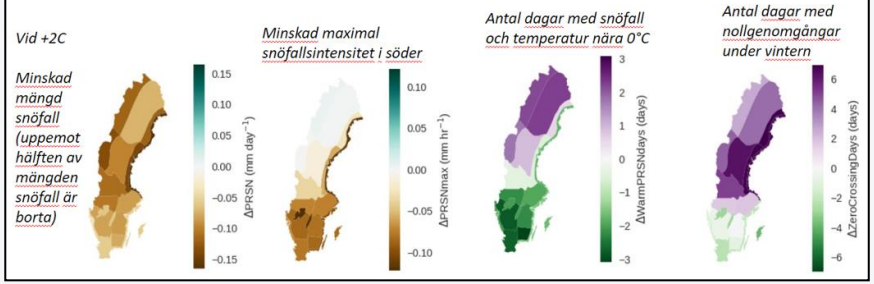
Addressing impacts by using model output



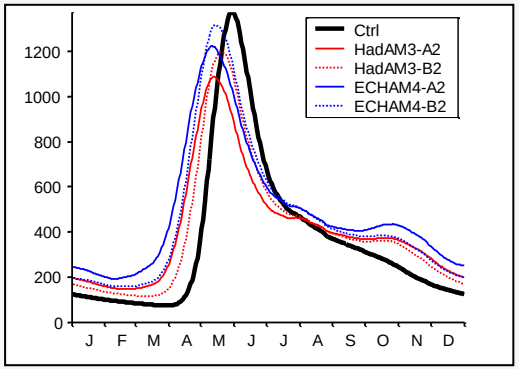
Assessing impacts based on model derived indicators

Wet snow (”blötsnö”)

Likely with less problems in the south.
Risk of increasing problems during winter in the north



Model output used to force impact models

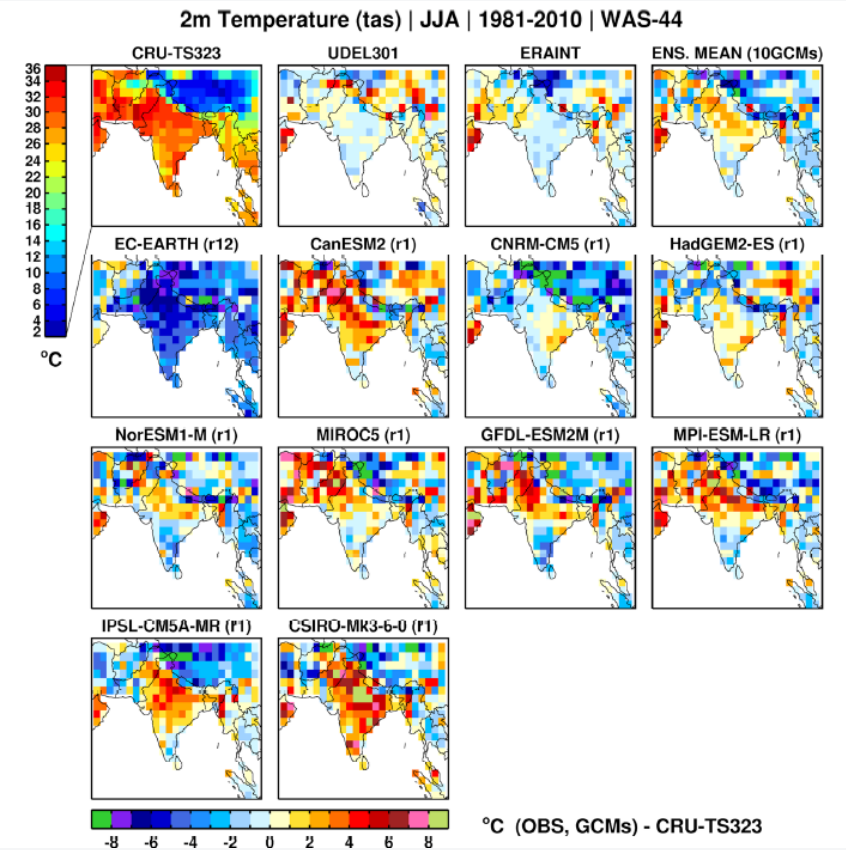


Are climate models up to it?

- Evaluation requires good observations
- Bias adjustment?
- Are results representative?

Biases and bias adjustment

Climate models show biases

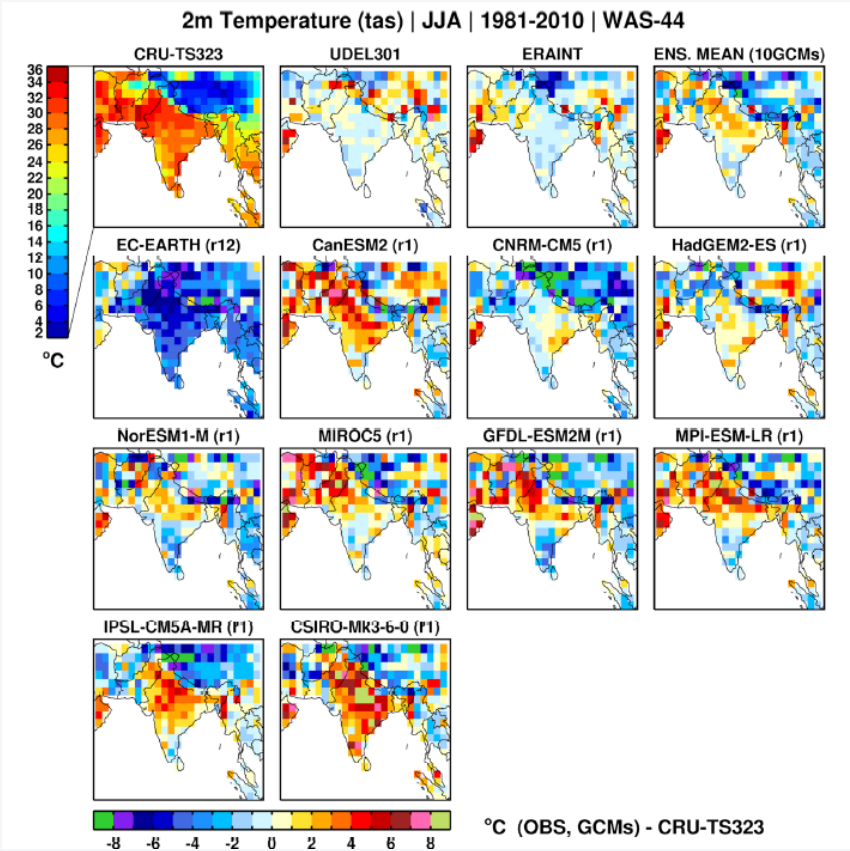


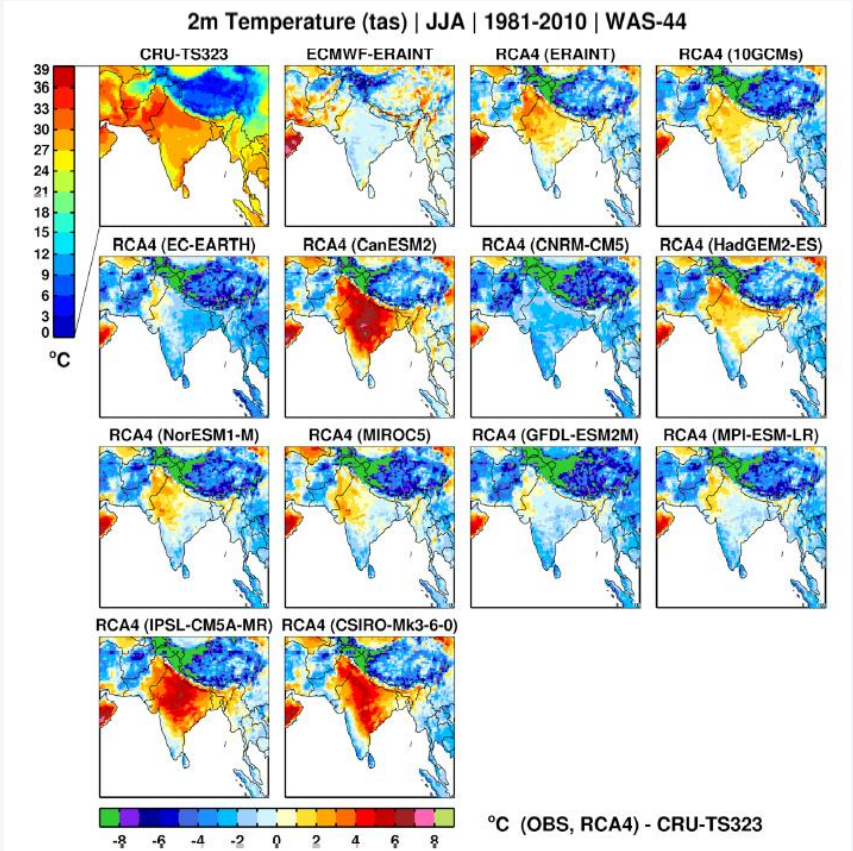
Biases in 2m temperature (JJA) in 10 different GCMs

- Observational products differ
- Individual models differ substantially
- The ensemble mean performs relatively well

Rana et al., Clim Dyn 2020

Downscaling changes the biases



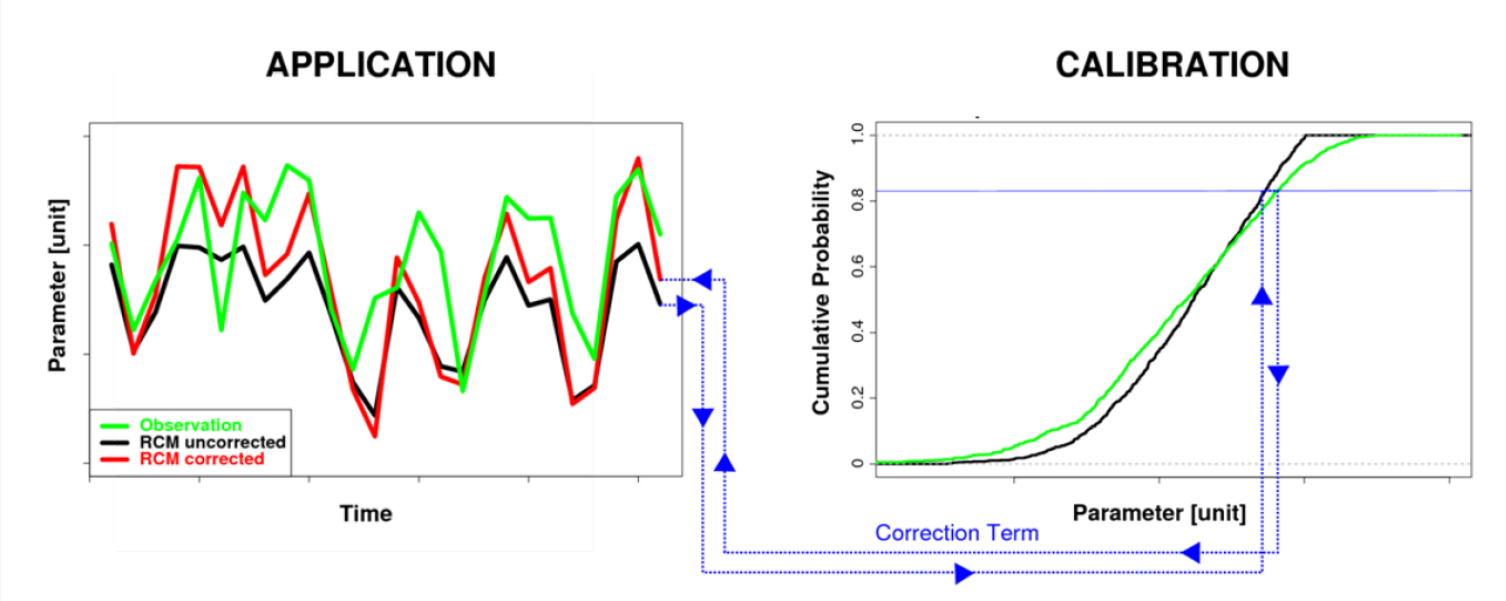


Why are biases problematic?

- Processes may be misrepresented
- Reduces confidence in models
  - ”if they can’t even reproduce today’s climate how can they be trusted for the future”?
- Problematic for studying impacts – notably those related to thresholds
- There could also be problems with the observations
  - errors, too sparse, not representative

Bias correction / adjustment

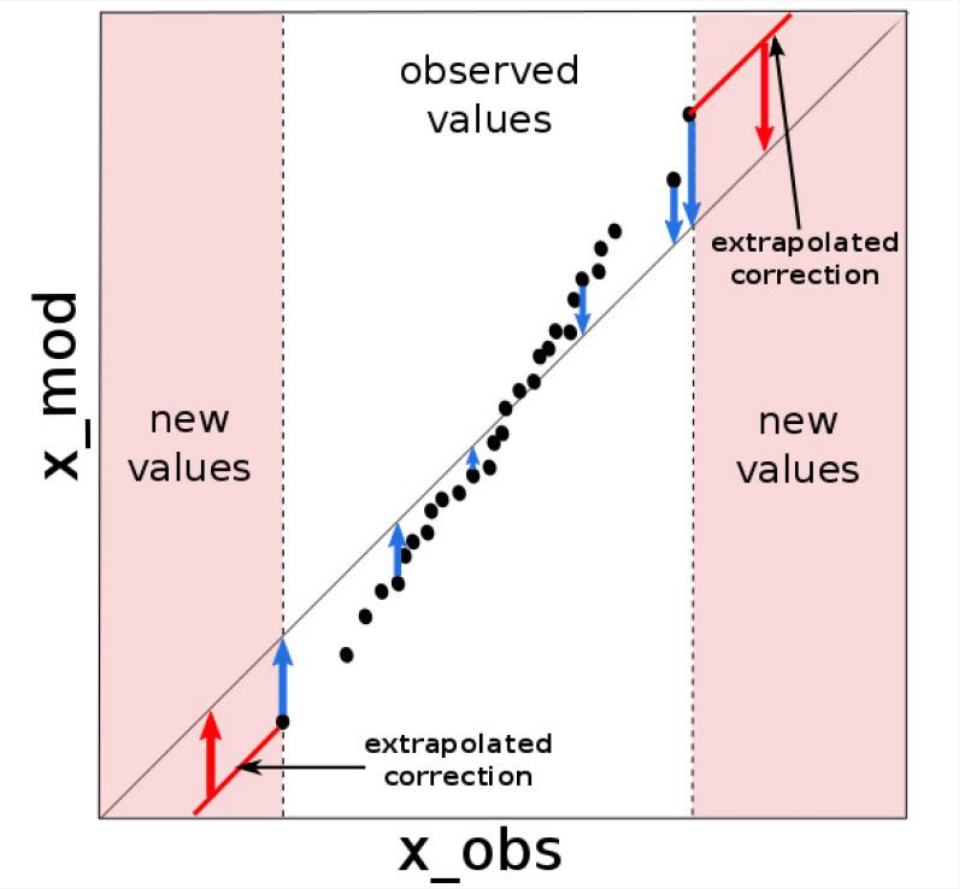
The figure shows an example of empirical quantile-mapping



Other methods involve simple ”mean shifts” (where the average is added), distribution-based scaling functions (where predefined functions are used)

Some problems

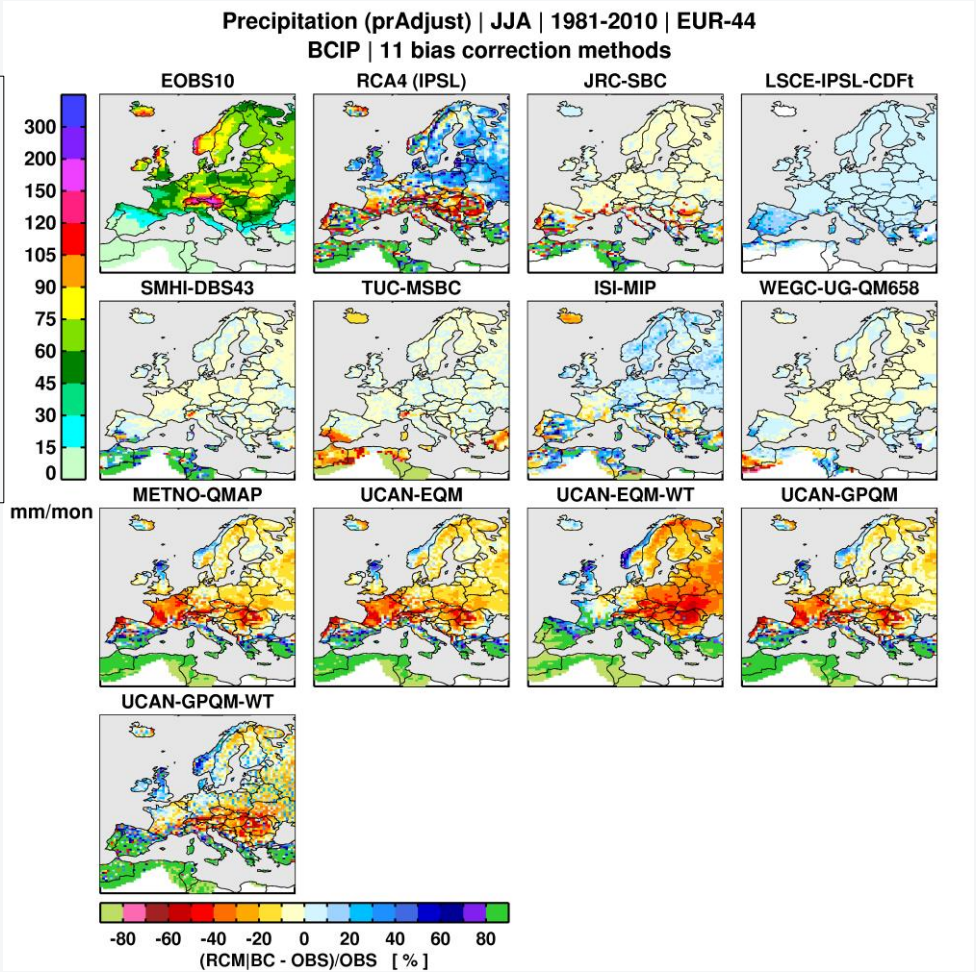
- Which observations to use?
- Correct one month at the time, one season, the full year?
- How to handle data outside of the observed pdf?
- Are biases stationary? If not, how to handle trends?



1981-2010: JJA seasonal mean

BCIP project

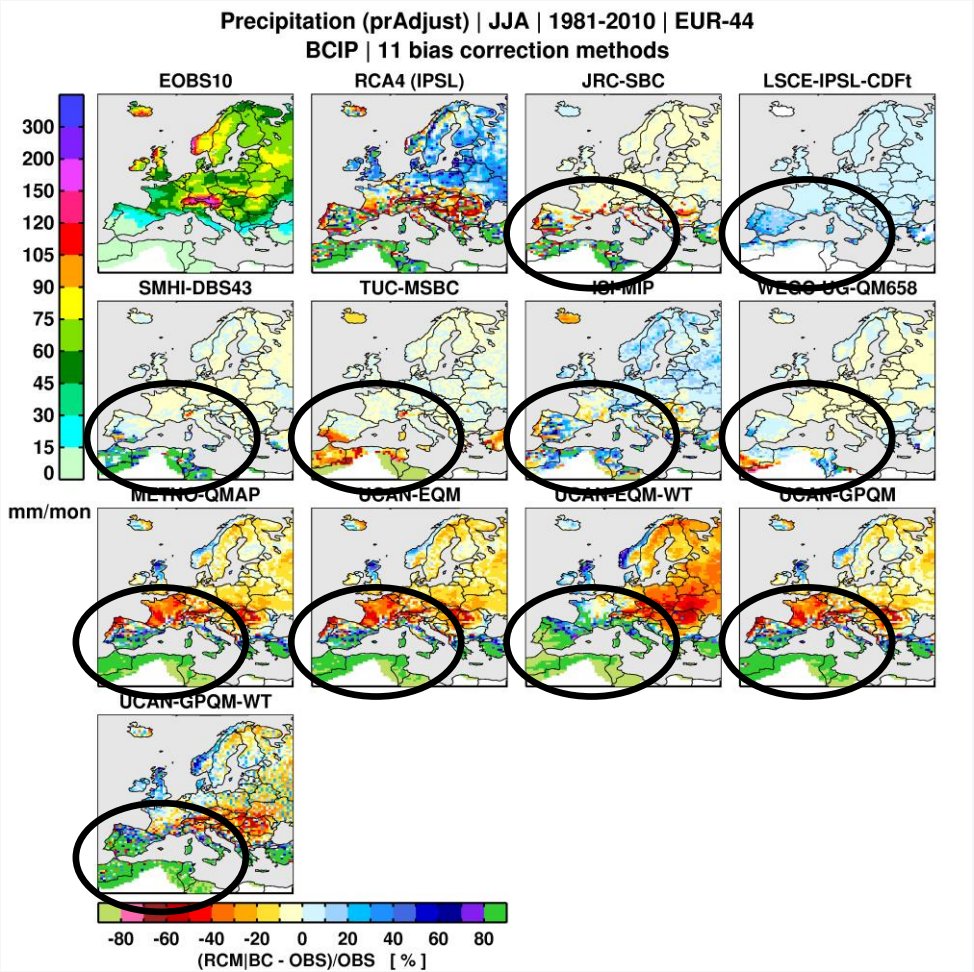
7 European groups comparing different methods



11 bias correction methods based on “similar” types of quantile mapping

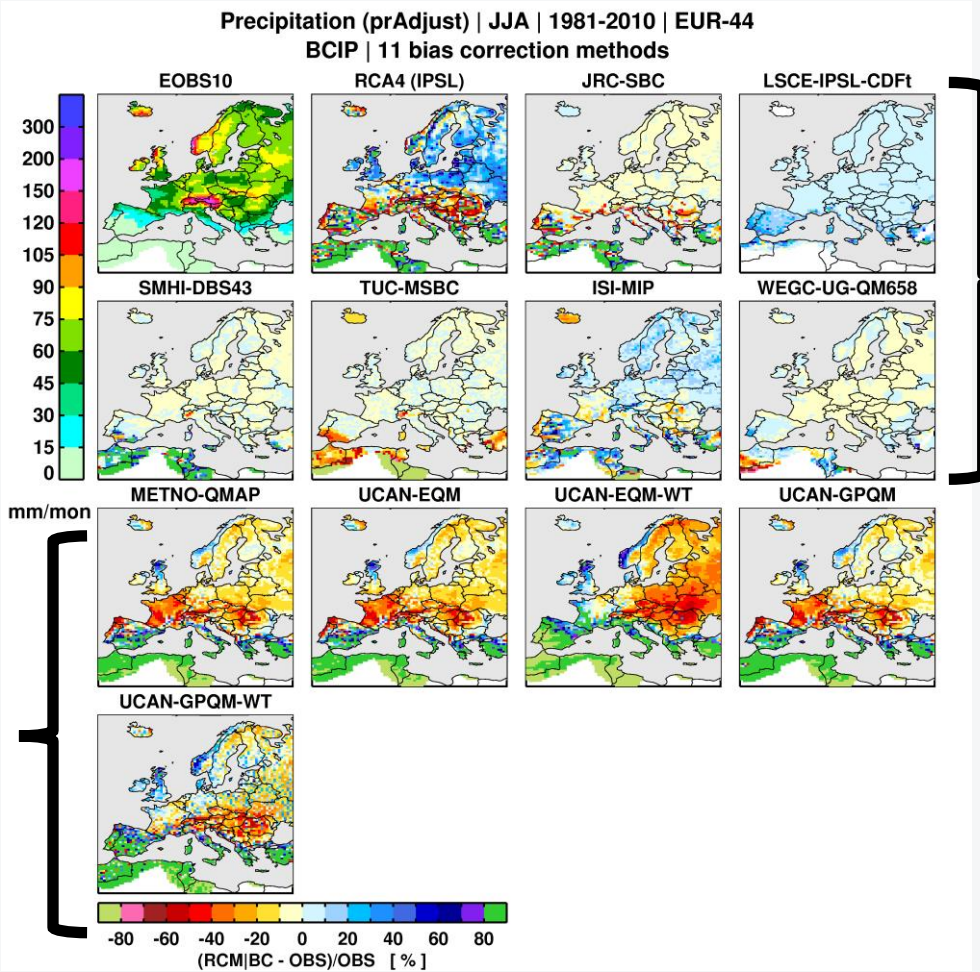
differ in details (parametric and non-parametric, number of wet days, seasons etc.)

1981-2010: JJA seasonal mean



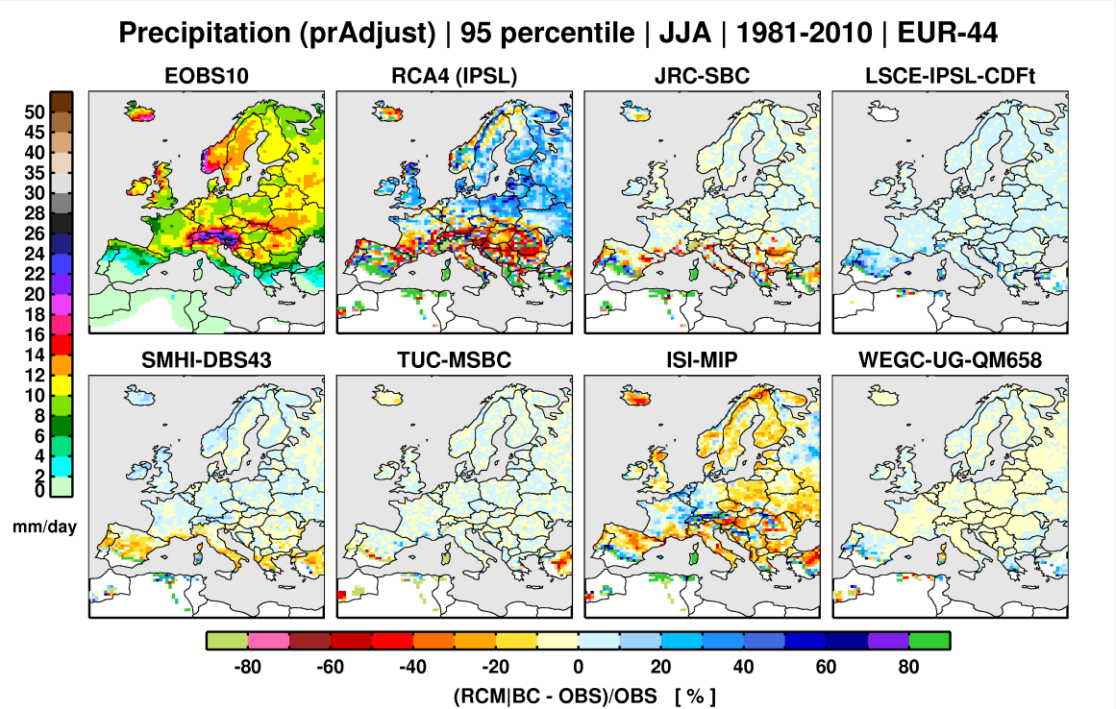
- differencies in dry regions

1981-2010: JJA seasonal mean



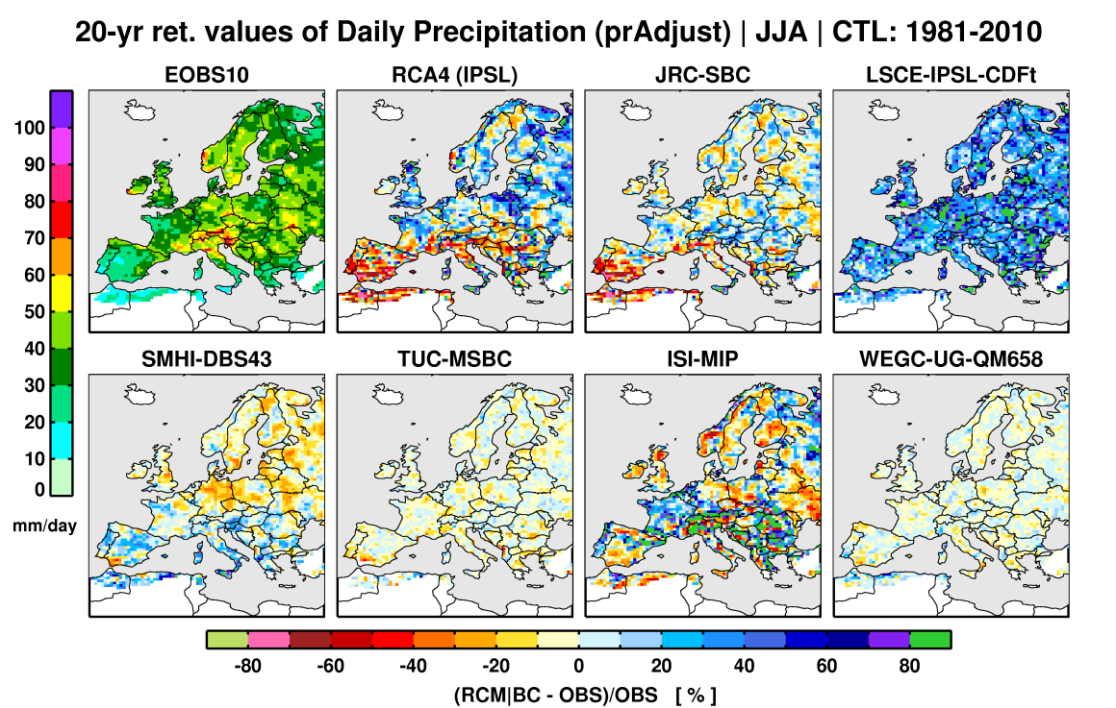
- differencies in dry regions
- taking seasonality into account

Reference period: 95th percentile



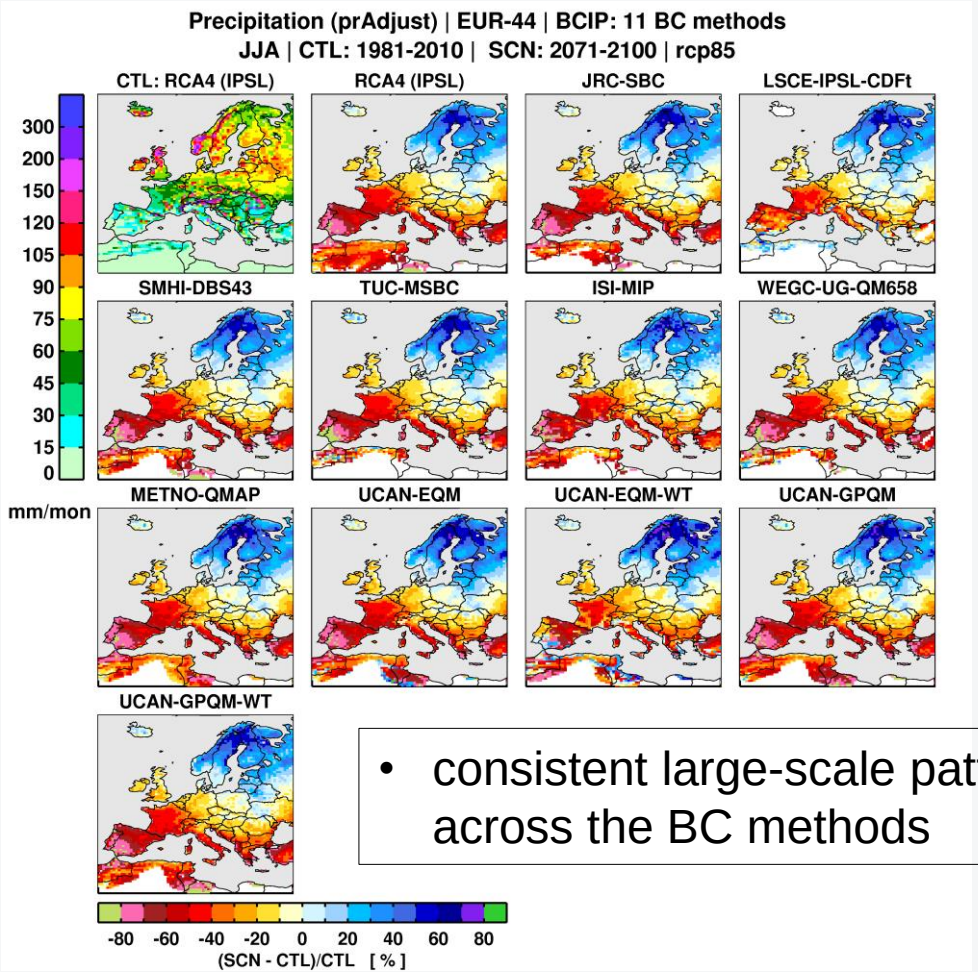
- in general a dry bias southern Europe (**SMHI-RCA4)** is pretty well adjusted (some smaller-scale differences)

Reference period: 20-yr return levels



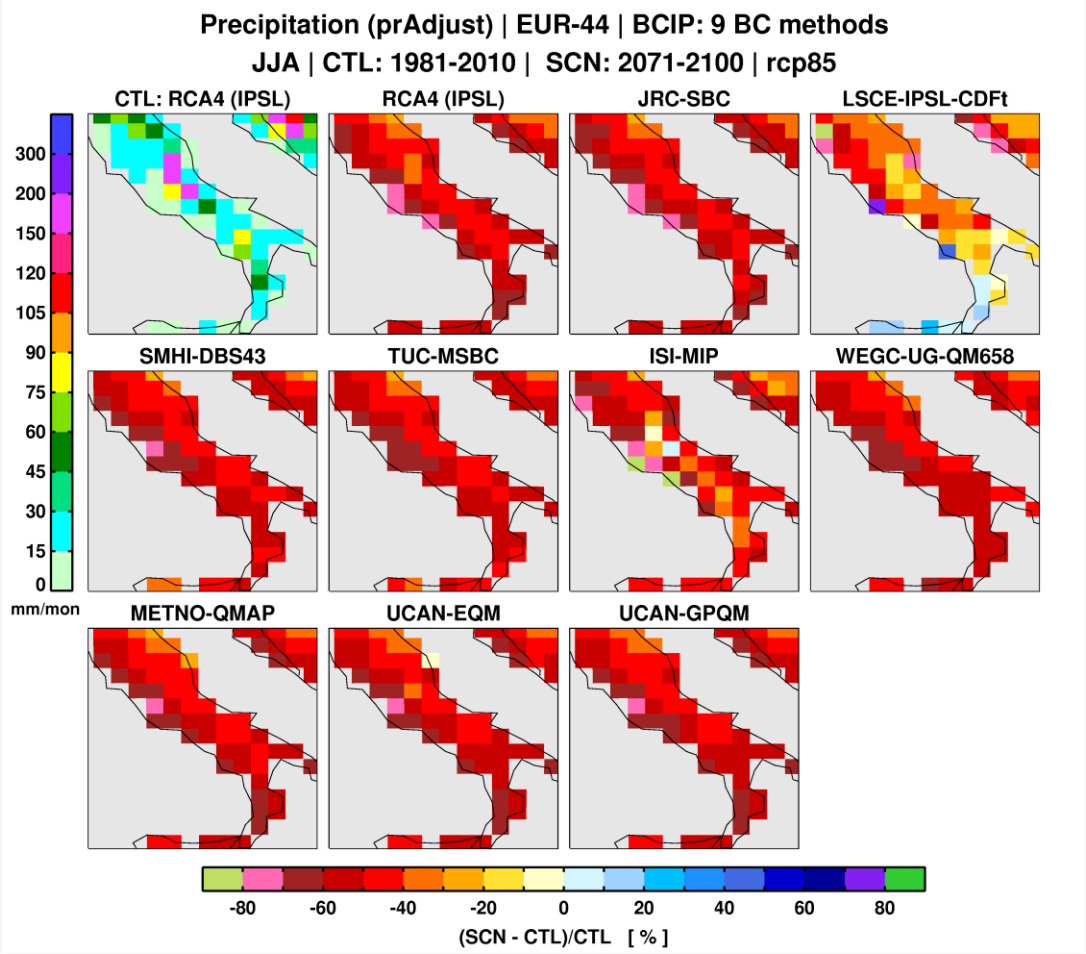
- some methods show good results in adjusting the 20-yr return levels (determined by GEV)

Projections: JJA seasonal mean

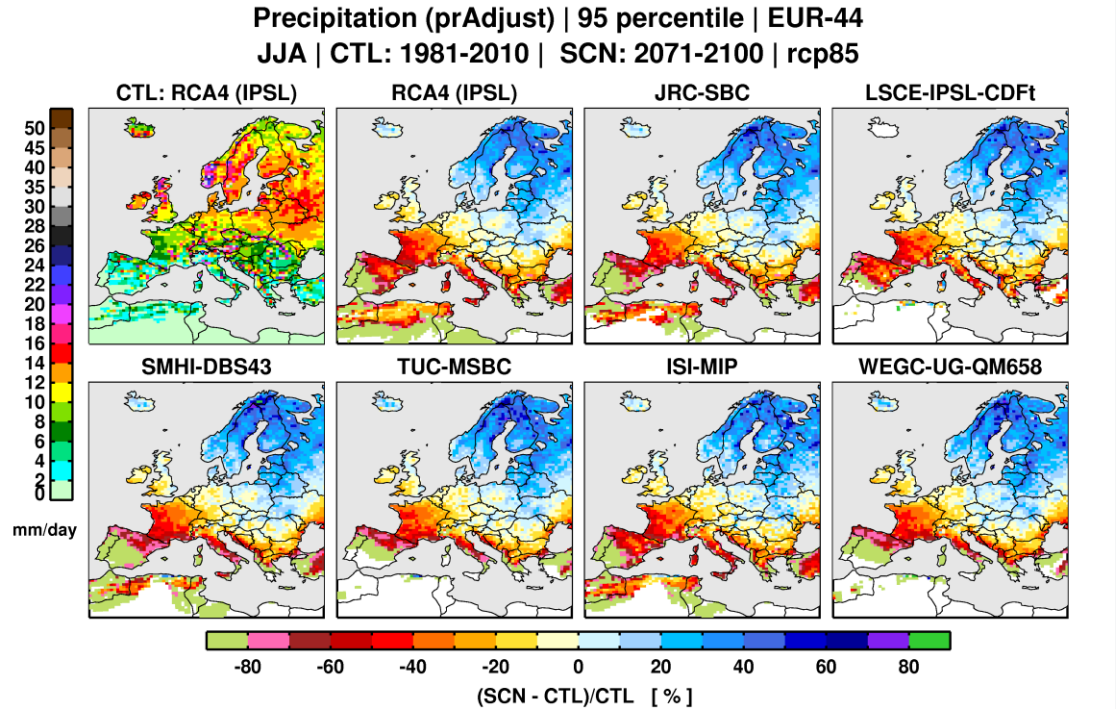


- consistent large-scale patterns across the BC methods

Projections: JJA seasonal mean

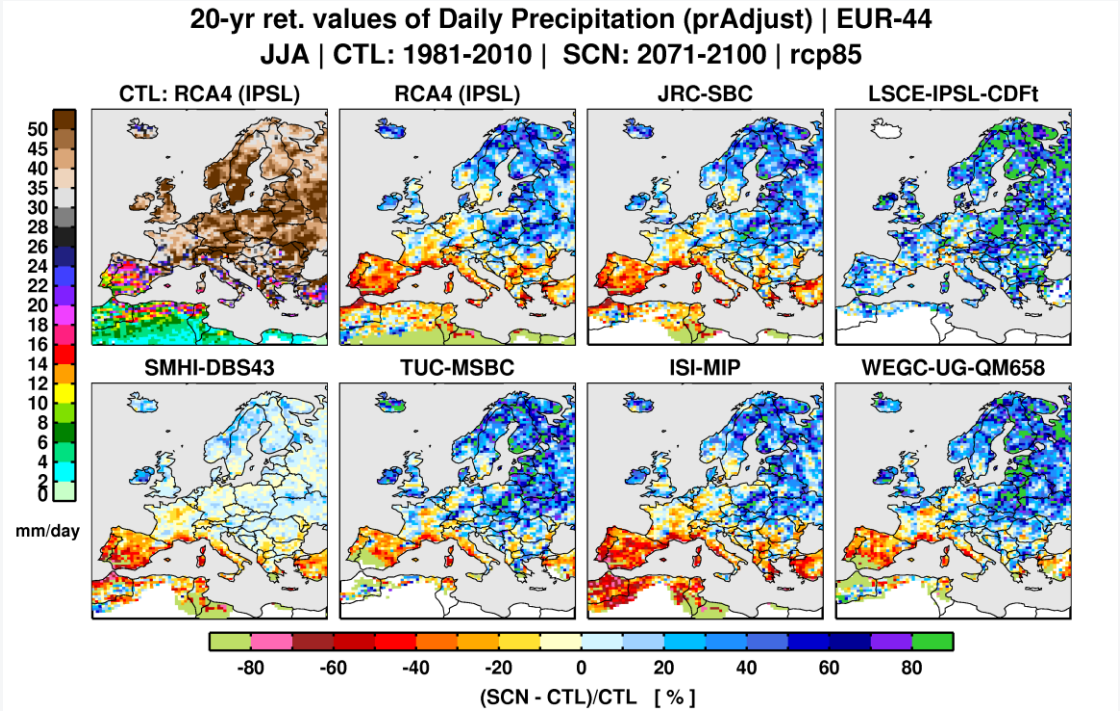


Projections: 95th percentile



- consistent projected changes across the BC methods

Projections: 20-yr return levels



- amplification in some BC methods
- future change is strongly reduced in SMH-DBS43

Questions to consider for users of bias adjustment

SMHI

- Are the models good enough? Do they represent the right processes?
- Are the observational data good enough?
- Method needs to be fit for purpose – averages/extremes? monthly-seasonal/annual?
- Are there reasons to believe that biases are not stationary in a changing climate?

Climate indices

Climate indices = simple diagnostic quantities used to describe climate [impact] oriented towards users' needs

Alternative terms:

- derived statistics (CF)
- climate indicators (e.g. Copernicus)
- climate impact indicators
- tailored climate parameters
- indices of climate extremes

irrespective of term they typically target either some extreme condition or/and impact

Different 'tiers' (from EU-CLIPC):

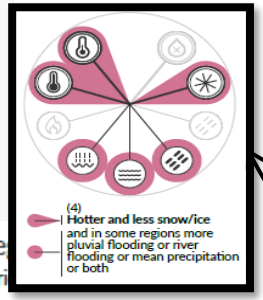
***Tier 1*: based only on geophysical data**
==>> informs about climate drivers

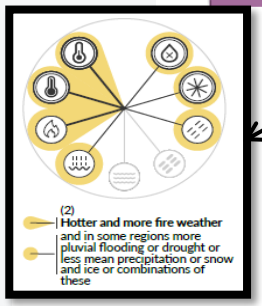
Tier 2: geophysical data + data on impacts
==>> informs about climate impacts

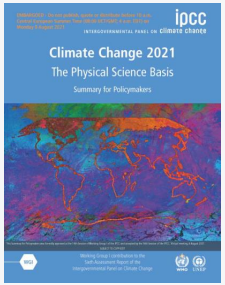
Tier 3: geophys. + impacts data + monetary valuation
==>> informs about economical ramifications

An example of climate impact drivers

SMHI

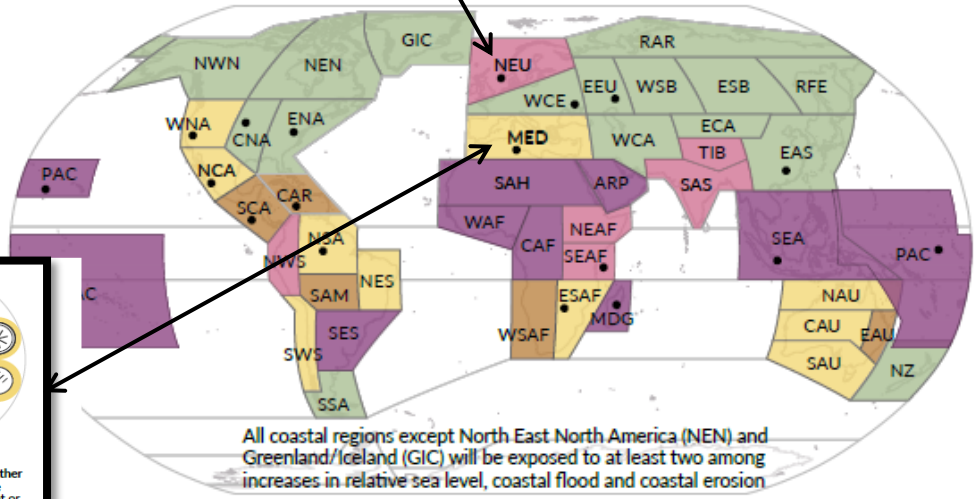






a) World re… …sters, each one based on a combination of changes in climatic impact-drivers

Reference peri… …compared to a climatological reference period included within 1960-2014



1) Hotter and drier

2) Hotter and drier and in some regions wetter extremes

3) Hotter and wetter extremes and in some regions more precipitation or fire weather

4) Hotter and wetter and in some regions more flooding

5) Hotter and in some regions wetter extremes or more precipitation

6) Increase in Tropical cyclones intensity or Severe winds

Who define and produce climate indices

ETCCDI	*CCl/WCRP/JCOMM Expert Team on Climate Change Detection and Indices* (since early 1990s, now discontinued) **27 core indices** (old software: FClimdex, Rclimdex)
ET-SCI	*WMO/CCl Expert Team on Sector-specific Indices*: indices focussing on impacts ETCCDI core indices + indices for **drought and heat** characteristics: duration, intensity (software: CLIMPACT)
ECA&D	*European Climate Assessment & Dataset:* was an European collaboration now maintained by KNMI ETCCDI core indices + impacts (agriculture, tourism and more), mainly observations
IPCC Atlas	Selected indices based on ETCCDI core indices (IPCC has in several assessment cycles used ETCCDI indices)
Copernicus	Range of indices (*indicators*) related to different sectors (water, agriculture, health…) Many from ECA&D + derived from [global] models

Many, many more ……

At one end: simple ETCCDI indices

- **Count the number of days** when a condition is met,
  frost days "fd": tasmin < 0°C
- **Longest period of consecutive days** when a condition is met,
  consecutive dry days "cdd": pr < 1 mm/day
- **Simple statistics**, minimum/mean/maximum [daily] value during a period: e.g.
  maximum daily maximum temperature "txx": max(tasmax)
  maximum one-day precipitation amount "rx1day": max(pr)
- **Degree-days** below/above a threshold
  heating degree-days below threshold "hd17": sum(max(17°C - tas, 0°C)

Interesting extensions to simple ETCCDI indices

- Count the number of days when a condition is met,
  frost days "fd": tasmin < 0°C
  - **When does the first/last event occur?**
- Longest period of consecutive days when a condition is met,
  consecutive dry days "cdd": pr < 1 mm/day
  - **When does the longest period begin/end?**

At the other end: multi-variable complex indices

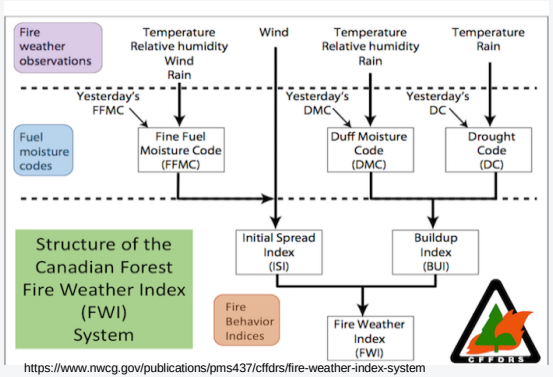
ET-SCI: several heat-wave indices **HW**** drought indices **SPI** and **SPEI**

FWI [Canadian] Fire Weather Index

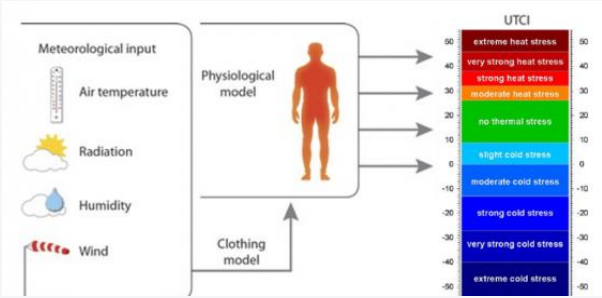
UTCI Universal Thermal Climate Index

PSDI Palmer Drought Severity Index

Gradual transition from simple derived statistics to parametrised semi-empirical process-based models

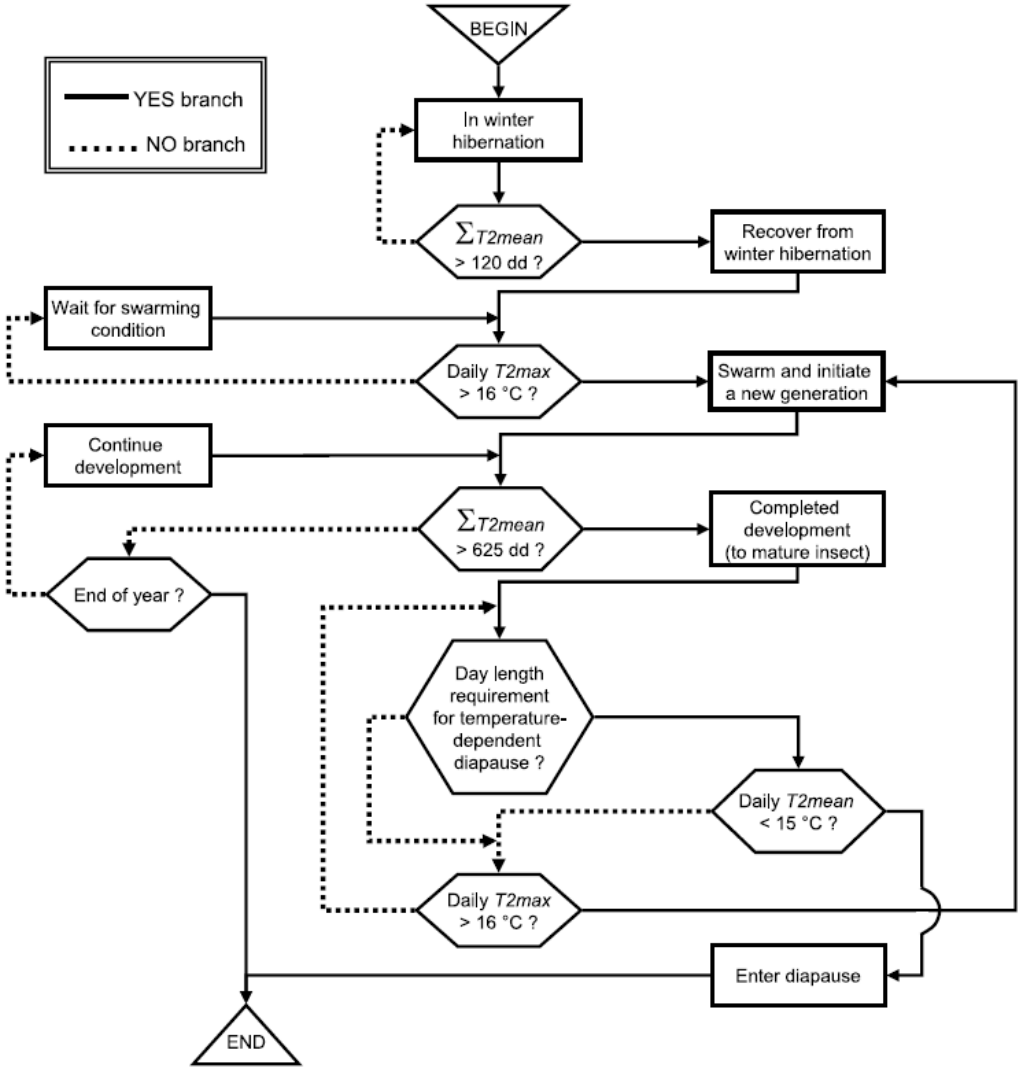


https://www.nwcg.gov/publications/pms437/cffdrs/fire-weather-index-system



http://aqua.upc.es/anywhere-catalogue-v2/?product=universal-thermal-climate-index-utci-uor

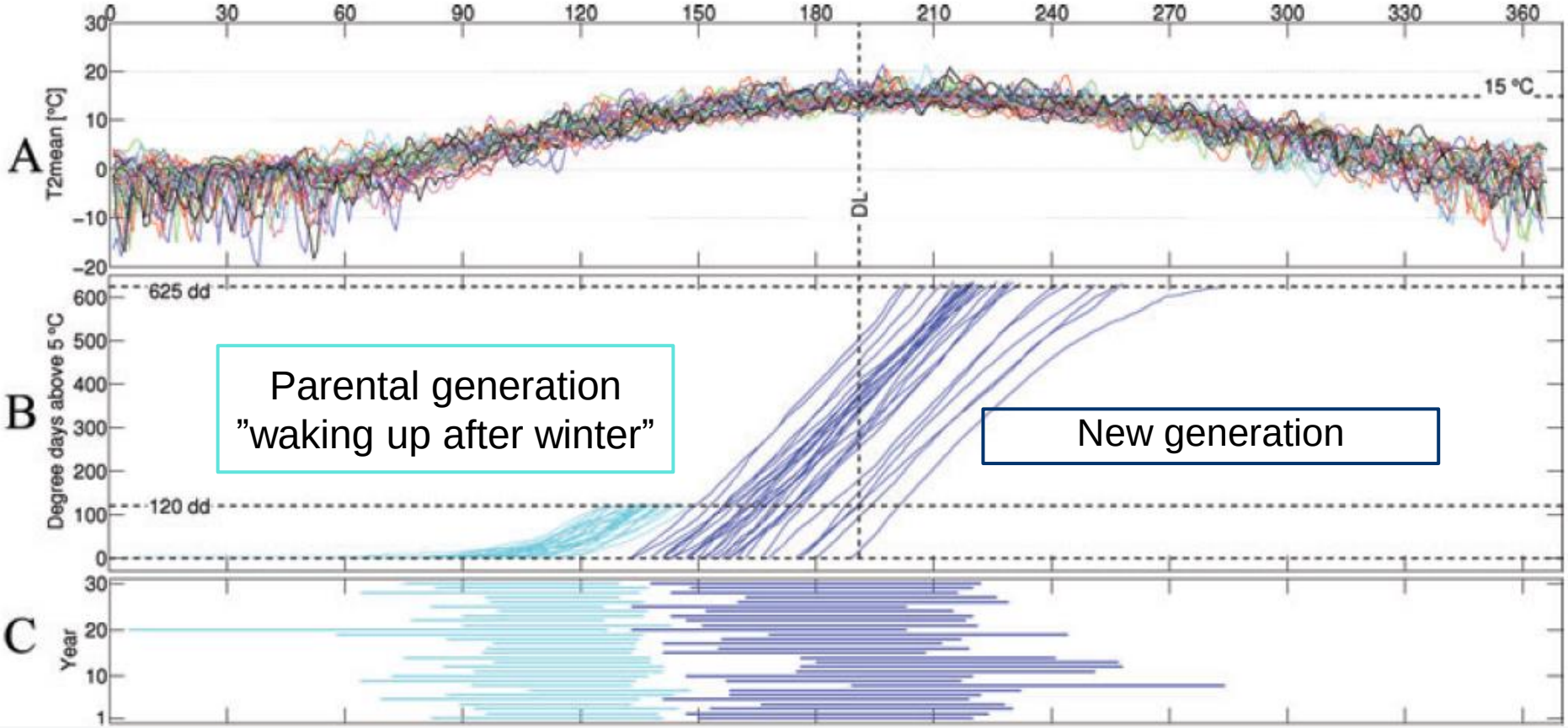
An example of a more complex index: Bark beetle model



Jönsson and Bärring, Tellus, 2011

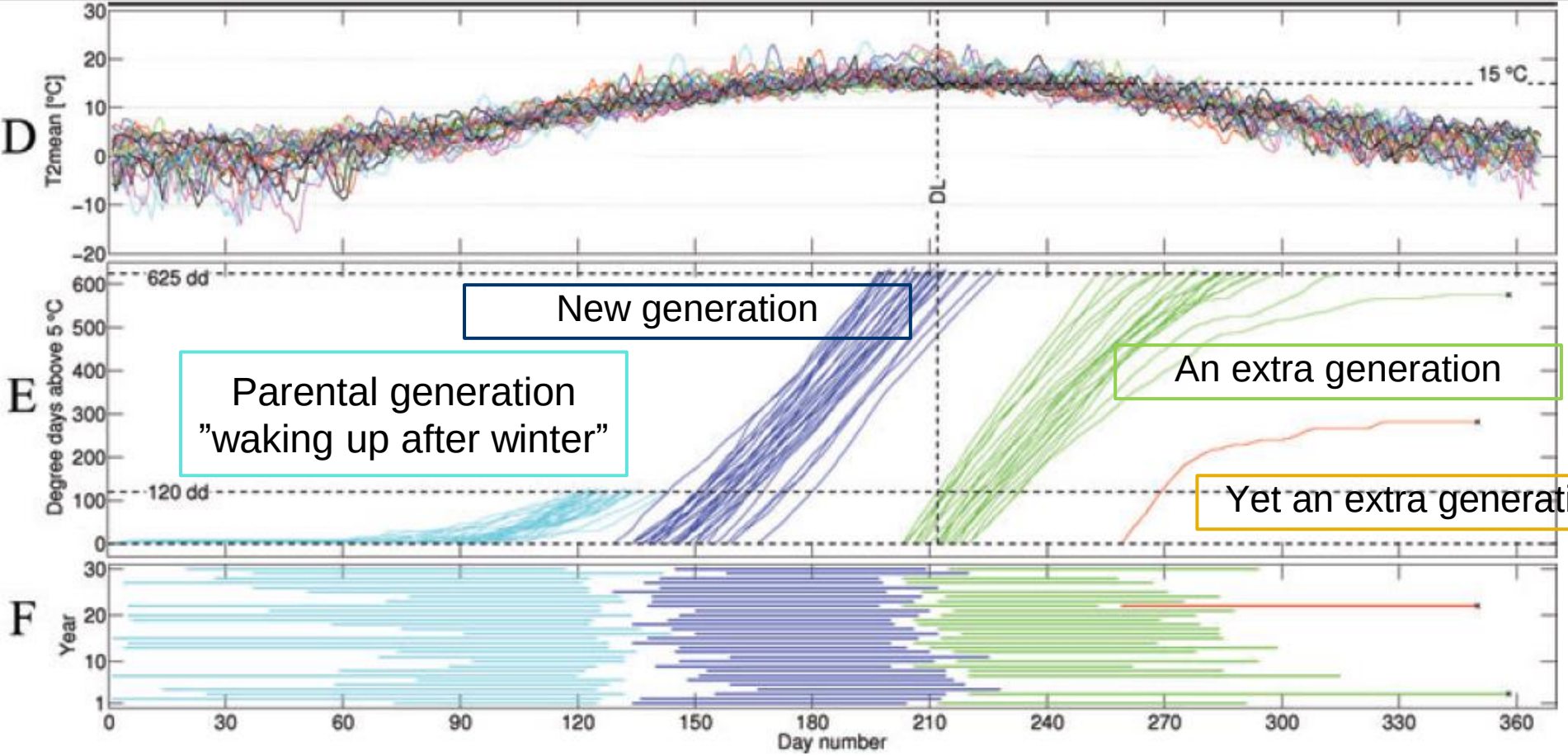
Bark beetle index in the past climate

SMHI



… and in the future

SMHI



In between: ETCCDI indices based on percentile scores

- Count the number of days when a percentile score threshold is exceeded:
  Example **tn10p**
  Percentage of days when Tmin < 10th percentile score temperature value
  Unit: *percentage* [of days]

- Count the number of days with spells of at least length N days when a percentile score threshold is exceeded:
  Example **WSDI** *Warm Spell Duration Index*
  Count of days with at least 6 consecutive days when Tmax > 90th percentile score

- 'Indirect' threshold: percentile value (different unit from data variable)

- 'Direct' threshold: the array of threshold constants is (365, nx, ny) –> substantial space vs. data variable

Multi-variable example: “nzero” Zero-crossing days
Tmin < 0 °C < Tmax

Image by Markus Sch. from Pixabay

Winter road maintenance: preventive actions against slippery roads
Geology / geotechnical: freeze-thaw cycles, slope stability
Road construction: formation of potholes
Reindeer hearding: ice-crust on snow prevents foraging
Winter tourism: avalanches: wet / icy layers in snow-pack

Image by Jacob Ode from Pixabay

Image by Наталья Коллегова from Pixaby

Image by Rex Landingham from Pixabay

Questions to consider for users of climate indices

SMHI

- Are the models good enough? Do they represent the right processes?
- Are the observational data good enough to evaluate the models? Is bias adjustment needed?
- What type of index/indices do I need? – simple/complex?