Challenges in using climate data for impact studies

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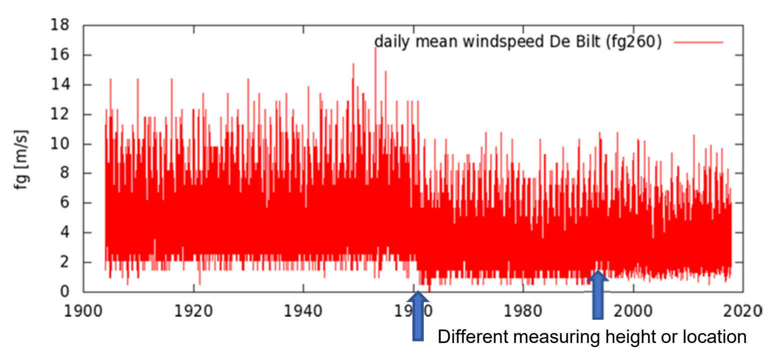
Observational data

- **Inhomogeneities:** apparent changes in averages, statistics, etc. due to physical causes e.g. change of instruments, re-locations, etc.): homogenisation needed
- **Mixing data from different networks**
  Sometimes different measuring networks for variable (different instruments: systematically higher/lower values)



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Observational data

- Difficult to compare point data (from weather stations) to areal average data (from radar, satellites or models)
  - ✓ At a point much more/less rainfall than in area
  - ✓ Point may not be representative for an area, or a lot of spatial variation
- Translation of radar/satellite signals to climate variables introduces uncertainties
  - ✓ Translate surface temperature from satellites to air temperature
  - ✓ Very extreme rainfall not always measured well with radar

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Extremes

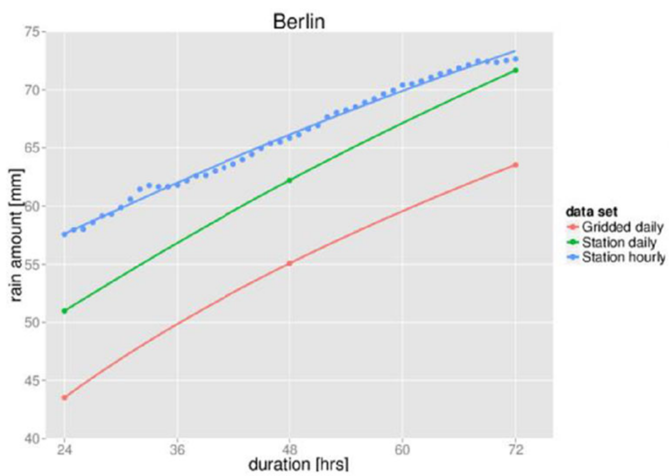
- **Calculation and interpretation of statistics**

Daily data is not the same as “24 hours”-data

Different sources for climate data may give different statistics

- Calculation and interpretation of **point and areal statistics**

Station vs gridded data



Intensity-Duration-Frequency curves for once in 10 year events for different rainfall durations
Source: RAIN project D2.5

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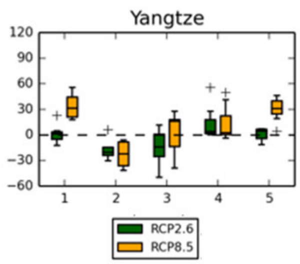
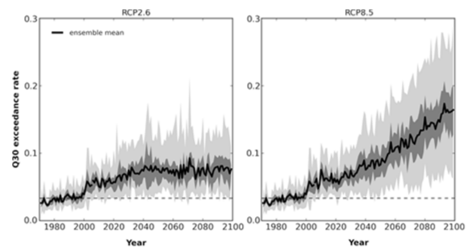
Extremes

- Acknowledge the limitations of your data
  - Rule of thumb: 30-year timeseries can be used to robustly estimate a 10y return level, but not really more extreme
- Use established methods from extreme value statistics to estimate the uncertainty range around your estimate of an extreme
- Scale up to larger regions for more robust patterns





Source: Dankers & Kundzewicz , 2020

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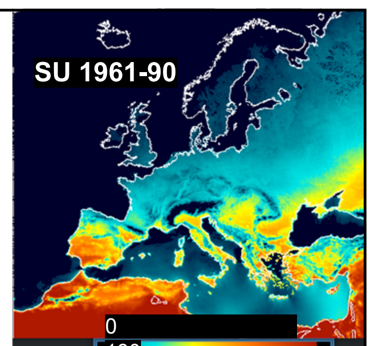
Climate indices

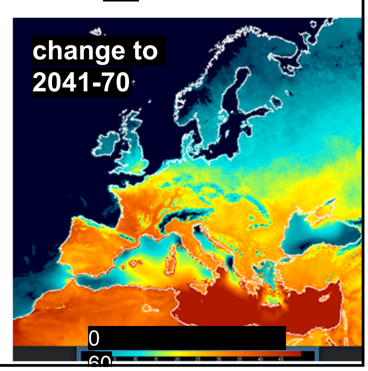
Arise from diversity of available options and lack of common terminology and standards:

- Multitude of alternative indices
- Inconsistent definitions and software
- Data sources (observations, models, indices)
- No standard data format and conventions
- Not always clear what is what

  Example: heat wave index – probably 15+ different definitions

- Many indices are sensitive to model biases
  – esp. indices based on thresholds and/or extremes





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Codes and abbreviations

Codes used for climate variables:
- Tavg, Tmean, T2m all refer to temperature
- P, RR used for rainfall

Codes used for data sources
- E-OBS: gridded version of the station data in Europe
- ERA5: most recent re-analysis from EWMCF

Codes used for weather stations
- Station 260 (Netherlands): Automatic weather station De Bilt
- Station 550 (Netherlands): precipitation station De Bilt

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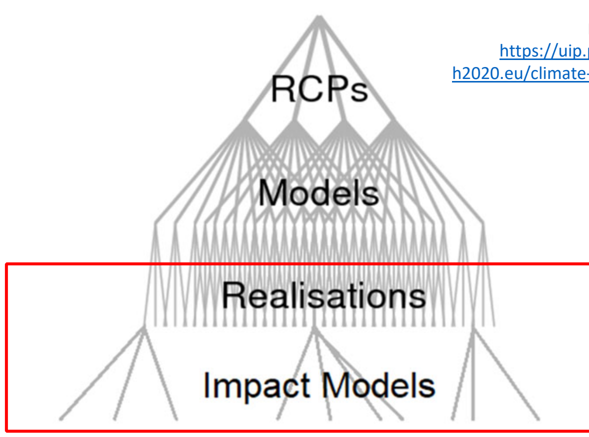
Uncertainties and ensembles

- Climate model output as input for impact models
- Hence existing uncertainties propagate further
- Also uncertainties in impact models (may be > than uncertainties from climate data)
- .

More info: https://uip.primavera-h2020.eu/climate-factsheets

Schematic cascade of uncertainty, from RCP scenarios, climate models and realizations to impact models.
After Hawkins, www.climate-lab- book.ac.uk/2014/cascade-of-uncertainty/



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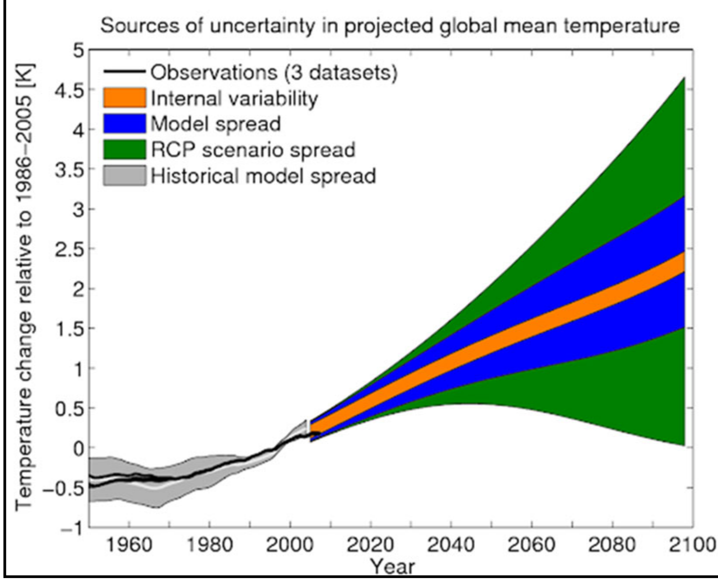
Uncertainties and ensembles



- **Internal variability**: with ensemble of one model (different initial conditions)
- **Model uncertainty**: ensemble of models with same emission scenario (multi-model ensemble and perturbed physics ensemble)
- **Scenario uncertainty**: difference between averages for different emission scenarios

Use of ensembles requires a lot of time

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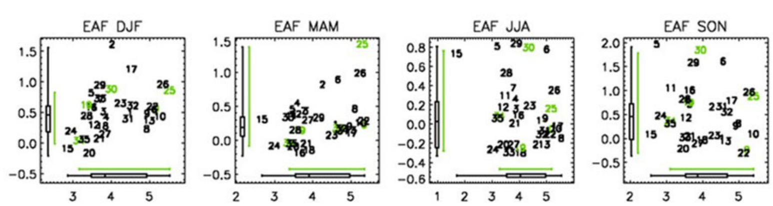
Common issues: model selection

Often too limited time/resources to use large ensemble

Criteria for selecting a subset of models or scenarios:
- Realism in simulating historical climate (model performance)
- Representative of spread in future projections
- Independence of models ("model family tree/lineage")

'Optimal' set of models will be different per region/variable.
Methods for selecting models have also been proposed in the literature.
Some C3S (in particular SIS) datasets have done the work for you.

Source: *McSweeney & Jones, 2016*



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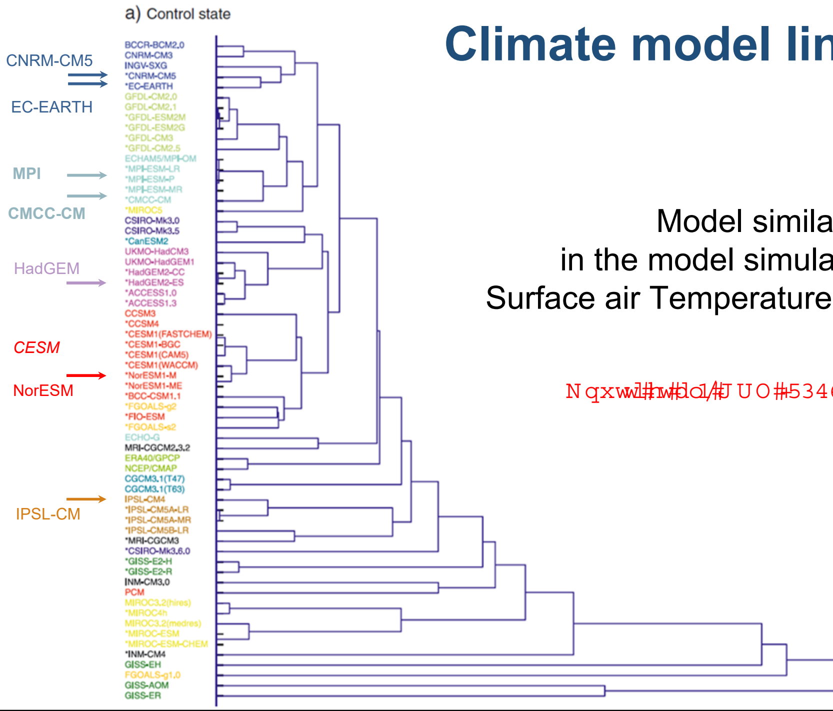
Climate model lineage



Model similarity
in the model simulated fields:
Surface air Temperature & Precipitation

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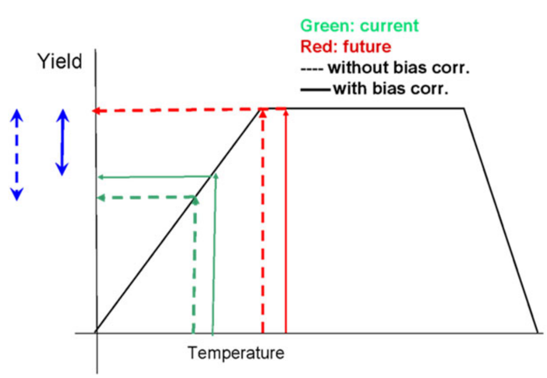
Biases in climate model data

- Climate models contain biases: systematic deviations from reality
- Generally, climate model data have to be corrected/adjusted before they can be used in impact models that are calibrated with observations
- Therefore, never compare “raw” climate model projections for future directly with observations to get potential change
- Use of raw climate model data in impact models may also result in incorrect estimations of potential change



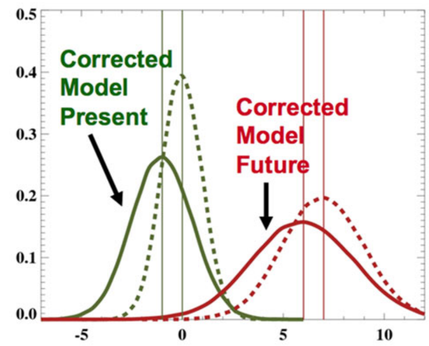
Some practical advice

Recommended steps:

- Start with one projection and one scenario (historical + future period)
- Check how projection compares with observations for historical period, even if results are bias-adjusted
  – statistical sense,
  – NOT time-series agreement !!!

✓ If not bias-adjusted, bc may be necessary, although not a silver bullet
  – many methods (some fairly similar)
  – do not use bias adjustment as a black box "just press the button and then we're done" thing

- Determine change by comparing bias-adjusted historical and future period
- Select projections from various models and/or scenarios and repeat steps



Probability Density Functions

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Some practical advice

Some checks!

- Do all data/projections have same units for same variables (it should be, but better to check!)
- Do all projections cover the same periods, past and future (some finish in 2099, or 2049!)
- Do all projections (in case of daily data) have same calendar (some use 360- or 365- day calendar, sometimes software take care of this, better to check!
- Try to cover different scenarios with a same number of projections (not 10 for RCP8.5 and 2 for RCP4.5)

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Some practical advice

- In general, various scenarios are presented for the future to show the uncertainties, and to make it easier for users to deal with uncertainties for the future: do not average climate scenarios or use one scenario only
- the “middle” scenario is not the most probable one (although often implicitly assumed)
- When using climate model output, use periods of multiple years, not single years; this also applies to historical climate simulations!

When in doubt, consult an expert!!

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