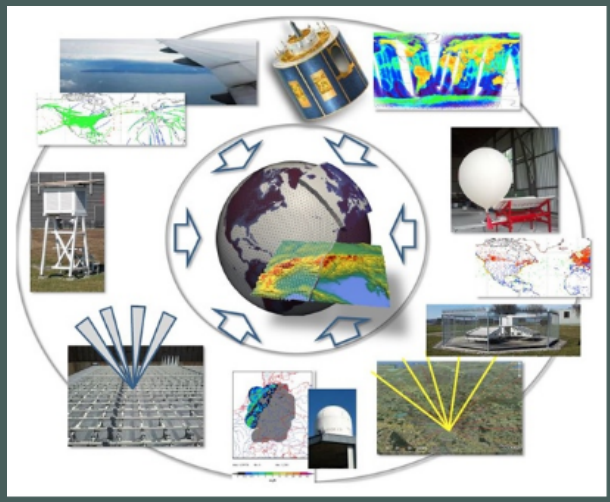
Introduction to climate data sources

Miquel De Cáceres, Victor Granda

Ecosystem Modelling Facility

2022-11-30



Outline

1. Preliminaries

a. What do I need?

b. Climate models

c. Climate data formats

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2. Historic climate

a. Point data sources

b. Gridded data sources

c. Interpolating by yourself

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a. Point data sources

b. Gridded data sources

c. Interpolating by yourself

3. Future climate

a. Climate scenarios and uncertainty

b. Downscaling projections

c. Projection data sources

1a. Preliminaries: What do I need?

What kind of climate information do I need?

- **Weather** - What actually *happens* in the atmosphere
- **Climatology** - Statistical distribution for a given period (typically 30 years): What you *expect* in the atmosphere
- **Climate anomalies** - Comparison of what happened vs. what you expected

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What is the temporal extent and temporal resolution?

- **Historical** - Before present
- **Short-term forecast** - Few days/weeks in advance
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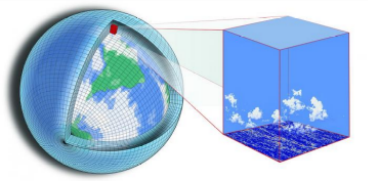
What is the spatial extent and resolution?

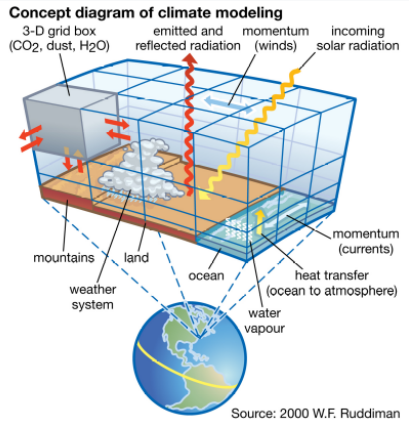
- **Point locations** - E.g. forest plots or sampling locations
- **Gridded** - Cells of a given resolution over a target area
- **Area-wise means** - Area-average statistics

1b. Preliminaries: Climate models

What are climate models?

- **General Circulation Models** (GCMs) comprise atmosphere, ocean and sea ice components





- They are a subset of **Earth System Models** (ESMs), which also include land use changes, carbon cycle, vegetation dynamics, …

1b. Preliminaries: Climate models

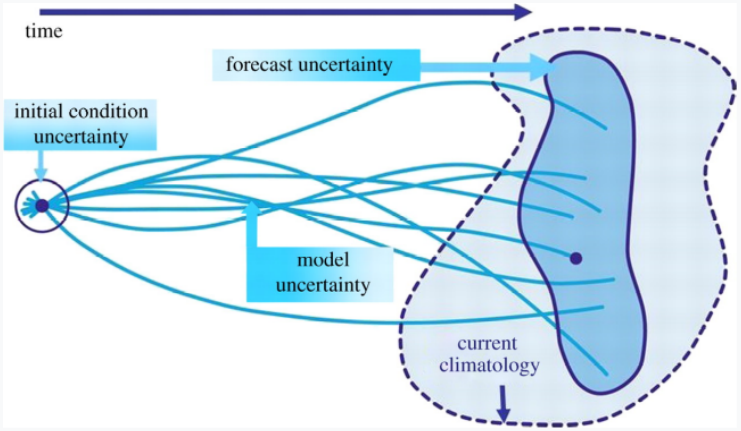
What are they used for?

- **Paleoclimate reconstruction** - Past climatology according to conditions on earth
- **Historical reanalysis** - Generate historical 3D weather fields to complete observations
- **Short-term forecast** - Operational weather prediction few days/weeks in advance
- **Mid-term predictions** - Seasonal to decadal climate predictions
- **Climate projections** - Long-term predictions of future climatology

1b. Preliminaries: Climate models

Initial conditions vs. boundary conditions

Effect of initial conditions



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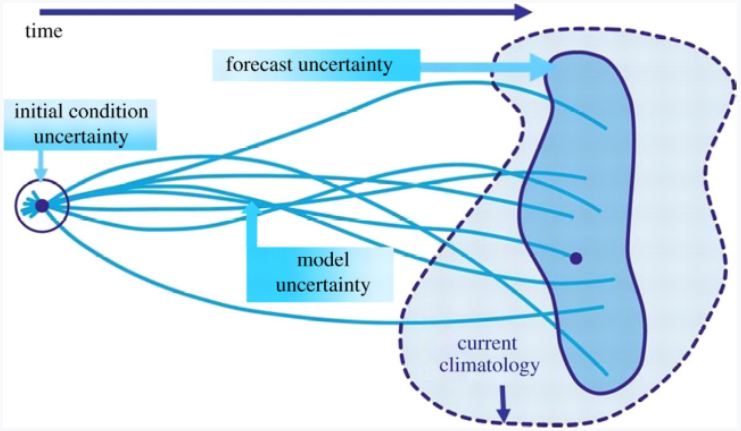
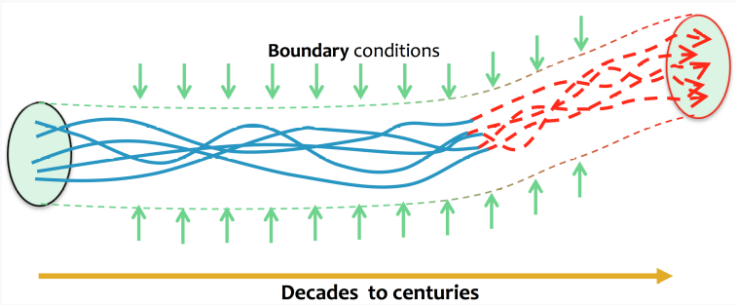


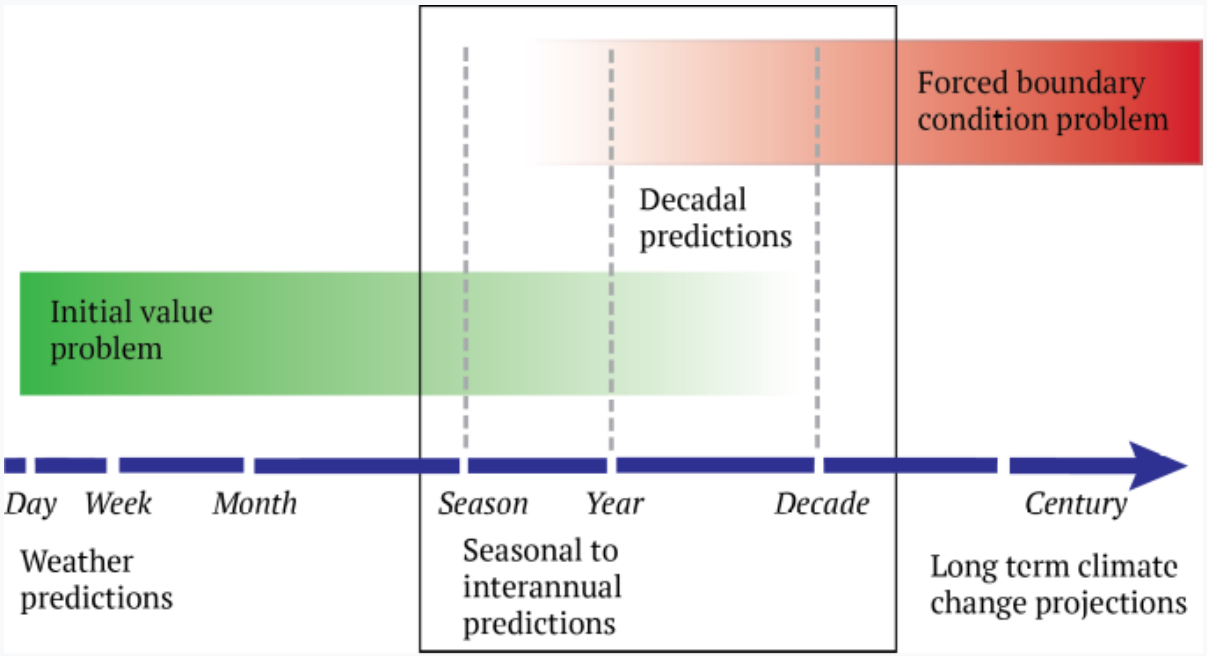
Effect of boundary conditions



1b. Preliminaries: Climate models

Initial conditions vs. boundary conditions

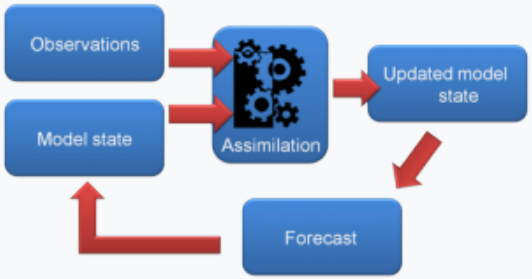
Initial conditions are very relevant for **short-term** weather forecasts, whereas *boundary conditions* are very relevant for **long-term** climate simulation

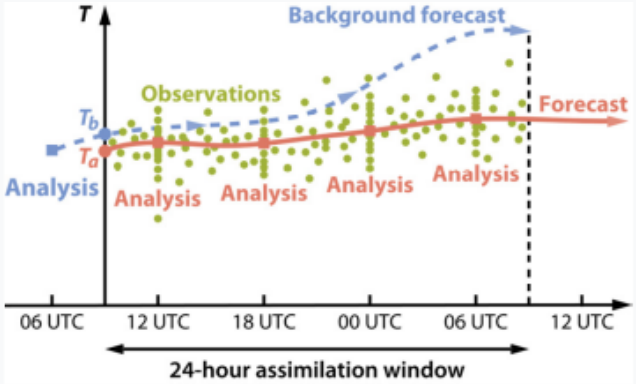


1b. Preliminaries: Climate models

Data assimilation

Both **weather forecast** and **historical reanalysis** products use **data assimilation** techniques to *constrain* climate model predictions with observations:





1c. Climate file formats

Formats specific for climate data

- **GRIB - Gridded Binary** by World Meteorological Organization
- **NetCDF - Network Common Data Format** by Unidata (UCAR/NCAR)
- **HDF - Hierarchical Data Format**.

The netCDF user communities have numerous conventions for creating the contents of netCDF files, in particular, the commonly used CF conventions

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General-purpose GIS data formats

- **GeoTIFF** for raster data
- **Geopackage**
- …

2a. Historic climate: Point data sources

What should I know about point data sources?

- They are provided by national weather services (or non-professional networks)
- Quality control is important (sensors may fail or produce wrong data)
- Not all stations are made available
- User registration is sometimes needed

2a. Historic climate: Point data sources

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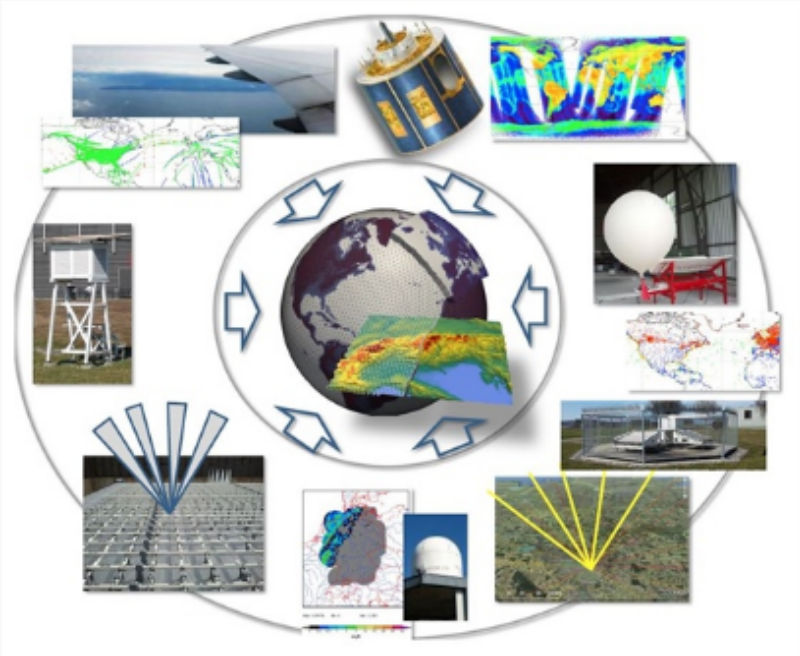
R packages to access historic point data networks

Spatial extent	Network(s)	R package	Access
Global	NOAA Integrated Surface Database (ISD)	`worldmet`	CRAN
Canada	Environment and Climate Change Canada (ECCC)	`weathercan`	Ropensci
Spain	AEMET, SMC, MeteoGalicia, RIA, MeteoClimatic	`meteospain`	CRAN
Germany	German Weather Service	`rdwd`	CRAN
United States	NOAA National Climatic Data Center	`rnoaa`	CRAN

2b. Historic climate: Gridded data sources

How was the gridded data generated?

- **Statistical estimation** - performs an estimation of weather at new locations from available point observations. Can be used to obtain fine-grained grids, but the real resolution is defined by reference weather data.
- **Reanalysis** - involves dynamic climate models that simulate historic climate constrained by observations (more about this later). It is more physically consistent, but spatial resolution is often coarser.



2b. Historic climate: Gridded data sources

Gridded data sources

Source	Spatial extent	Spatial resolution	R package
WorldClim	Global	20 km	`geodata`
PaleoClim	Global	5 km	
DayMet	United States	1 km	`daymetr`
Copernicus Data Store	Europe		`ecmwfr`
Moreno & Hasenauer 2016	Europe	1 km	`easyclimate`
AEMET	Spain		

2c. Historic climate: Interpolation by yourself

What do I need to know about weather interpolation?

1. There are several interpolation methods (distance-based, krigging,…)
2. Interpolating climatological means is easier than interpolating actual weather
3. Interpolation quality depends on data quality and quantity (inhomogeneities)
4. Some variables (e.g. temperature) are easier than others (e.g. precipitation)

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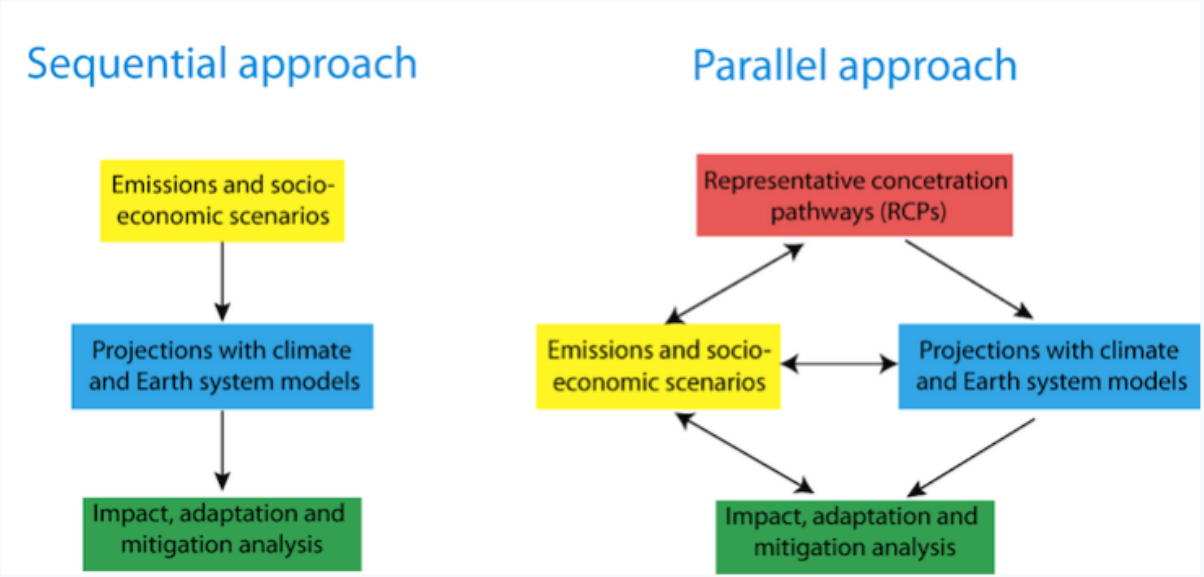
When do I need to resort on interpolation?

- Spatial resolution of available data is too coarse
- You want to account for local topographic effects on weather (depends on the method)
- Density of reference point data is enough

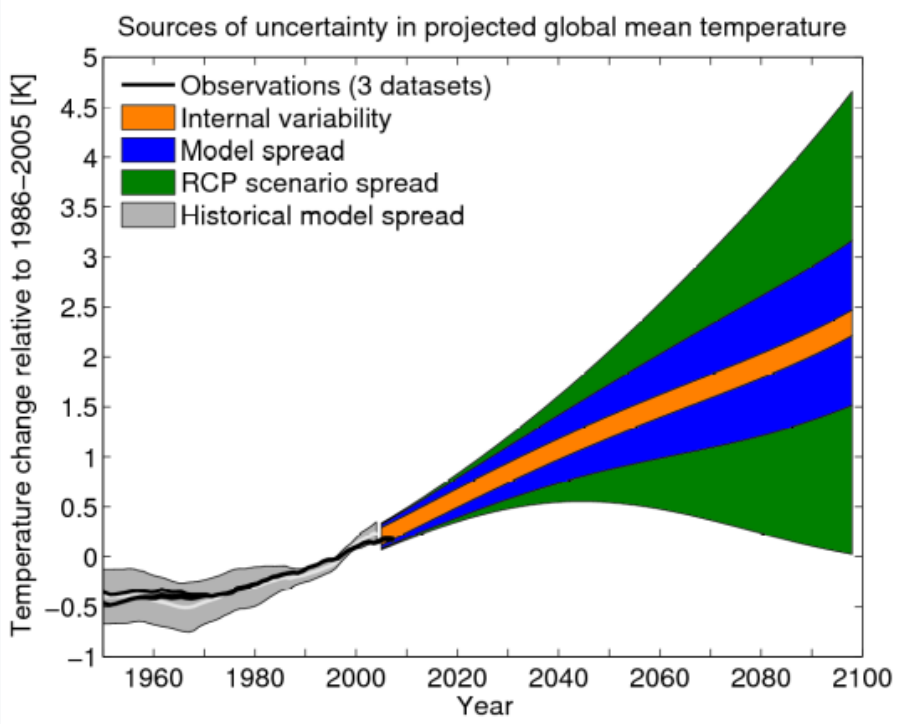
3a. Future climate: Scenarios and projection uncertainty

Climate scenarios (SRES – IPCC AR4 vs RCPs – IPCC AR5)



3a. Future climate: Scenarios and projection uncertainty

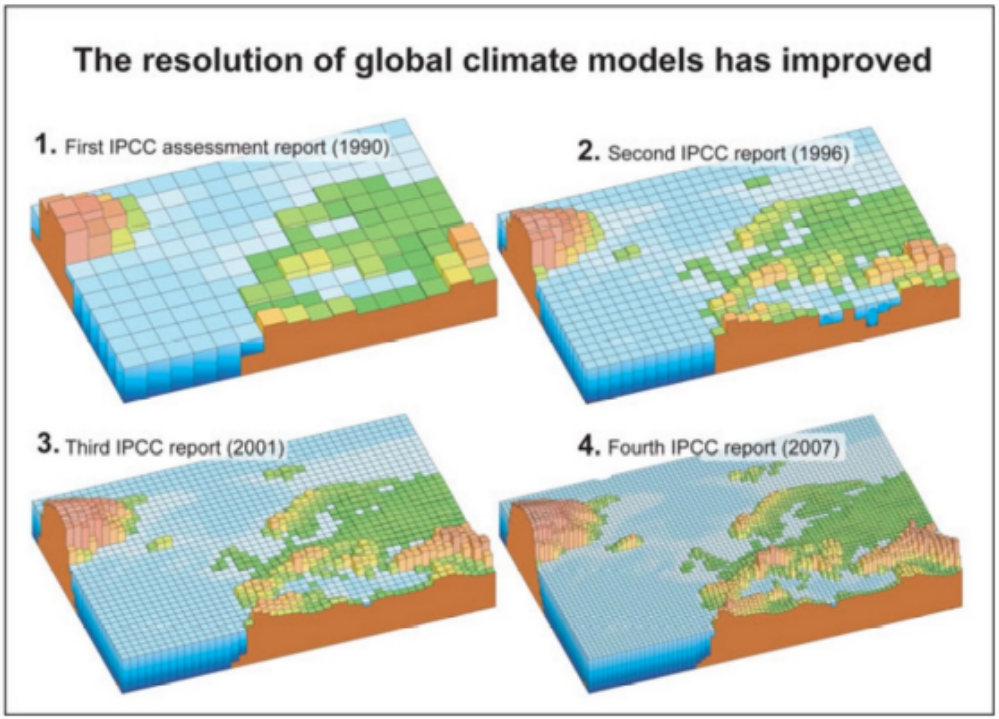
Sources of uncertainty in climate projections



These sources imply we should consider different climate models and different scenarios when assessing climate impacts.

3b. Future climate: Downscaling projections

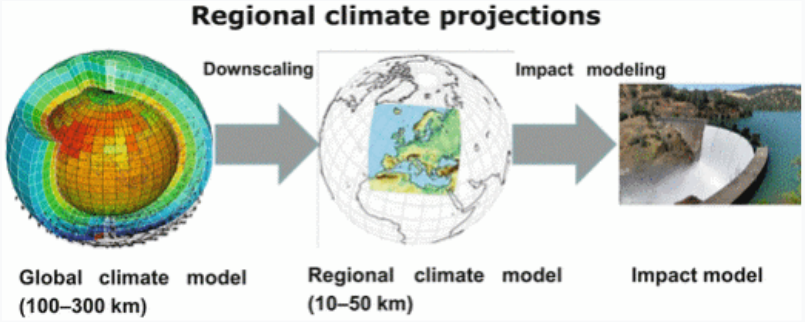
Spatial resolution of climate models increases but is limited…



… and downscaling may still be needed

3b. Future climate: Downscaling projections

Dynamic downscaling



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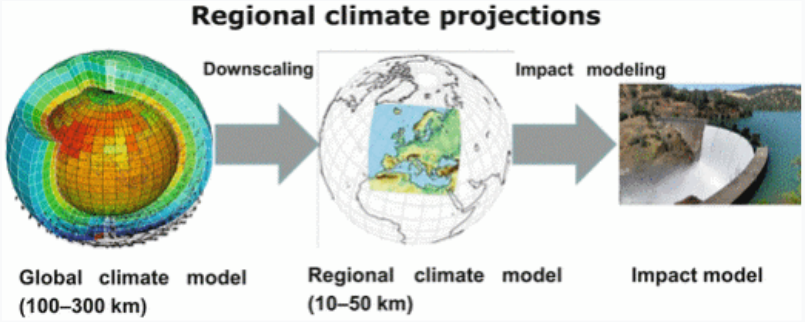

Statistical downscaling

- **Model output statistics** (bias correction) – calibrate relationships between climate model outputs (predictors) and observations (predictands) in present climate and apply them to climate projections.
- **Perfect prognosis** – calibrate relationships between large-scale predictors and local-scale predictands (both observations!) and apply them to climate projections. E.g. weather types or analogues.

3c. Future climate: Projection data sources

Projection data sources

Source	Spatial extent	CMIP	R package
WorldClim	Global	CMIP6	`geodata`
CHELSA	Global	CMIP5/CMIP6	
Copernicus Data Store	Europe	CMIP5	`ecmwfr`
AEMET	Spain	CMIP5	

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