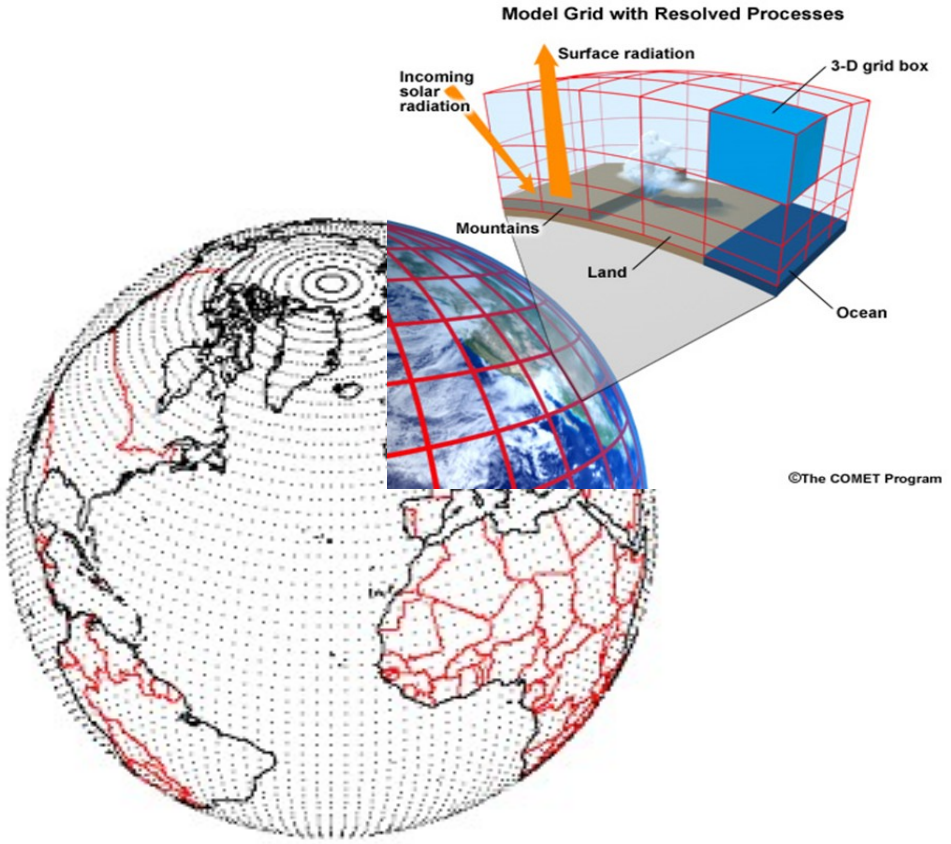
Instituto de Física de Cantabria

Downscaling and Bias Correction in climate4R

University of Buenos Aires, 31 August 2022

Introduction



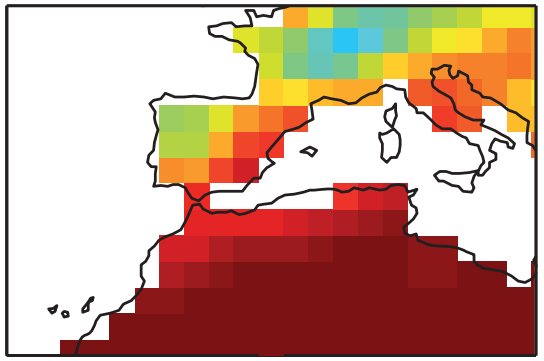
$$
\begin{cases}
\dfrac{d\boldsymbol{v}}{dt} &= -\alpha\boldsymbol{\nabla}p - \boldsymbol{\nabla}\phi + \boldsymbol{F} - 2\boldsymbol{\Omega}\times\boldsymbol{v} \\
\dfrac{\partial\rho}{\partial t} &= -\boldsymbol{\nabla}\cdot(\rho\,\boldsymbol{v}) \\
p\,\alpha &= R\,T \\
Q &= C_p\dfrac{dT}{dt} - \alpha\dfrac{dp}{dt} \\
\dfrac{\partial\rho\,q}{\partial t} &= -\boldsymbol{\nabla}\cdot(\rho\,\boldsymbol{v}\,q) + \rho\,(E-C)
\end{cases}
$$

$\boldsymbol{v} = (u, v, w)$, T, p, $\rho = 1/\alpha$ y q

General Circulation Models (GCM) simulate the evolution of the climate system by solving numerically a set of partial differential equations over a spatio-temporal grid. These simulations are forced with different possible emission scenarios of greenhouse gases up to the end of the 21st century.

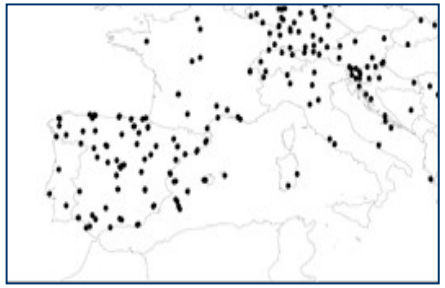
Motivation

Model's World

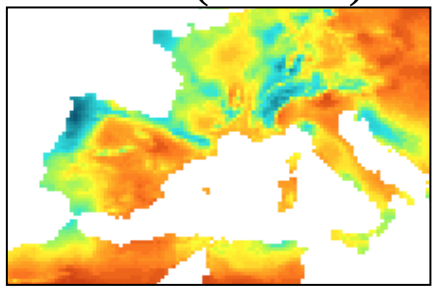


"Real" World

Locations

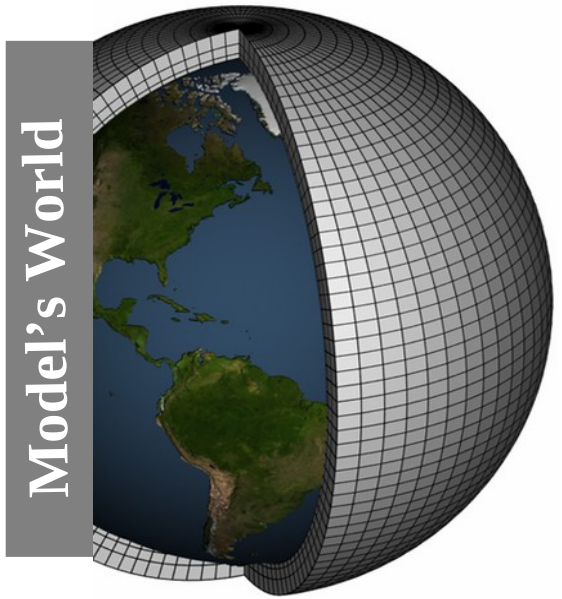


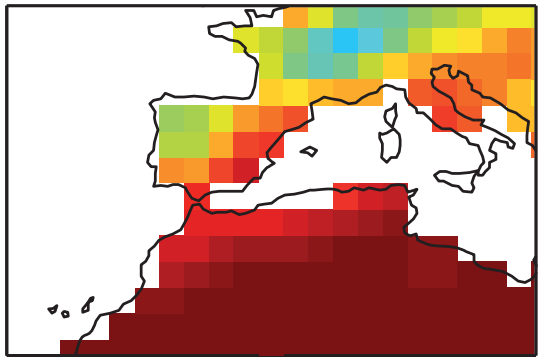
Gridded (**~10km**)



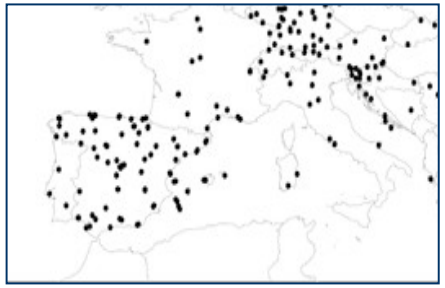
The gap in resolution and the existence of model biases prevents climate data from GCMs to be usable by certain socio-economic sectors (e.g., energy, agriculture, hydrology)

Motivation





Locations



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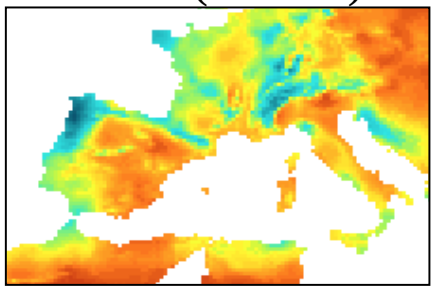


Downscaling bridges the scale gap between the model and the real world. There are 2 conceptually different downscaling approaches:

- Dynamical downscaling
- **Statistical downscaling**

Statistical downscaling (SD) establishes empirical relationships between large-scale atmospheric (predictors) and local (predictands) variables with large observational records.

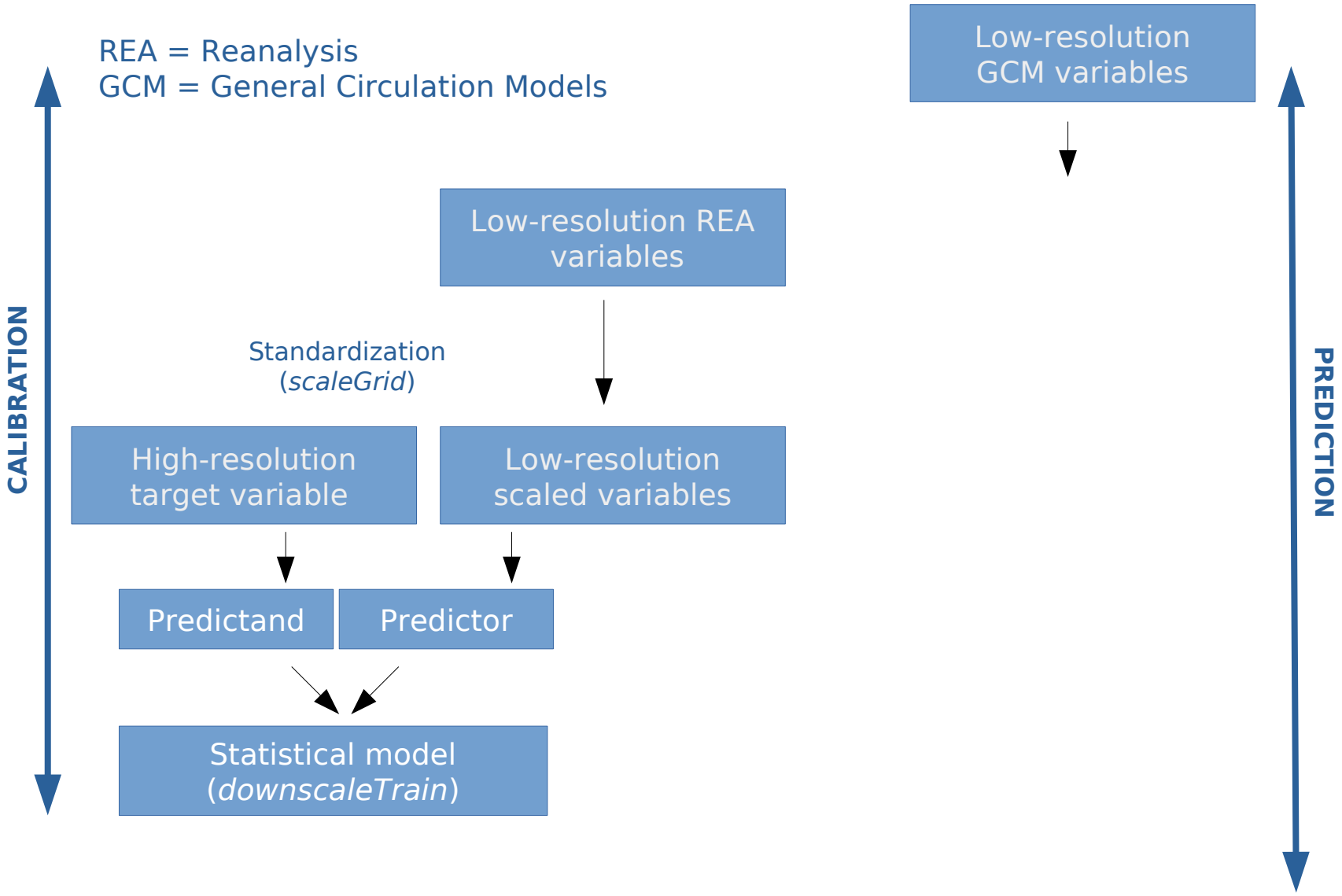
↓ Perfect-prognosis

↓ Bias-correction

↓ Stochastic Weather Generators

Perfect-Prognosis

REA = Reanalysis
GCM = General Circulation Models



Perfect-Prognosis

REA = Reanalysis
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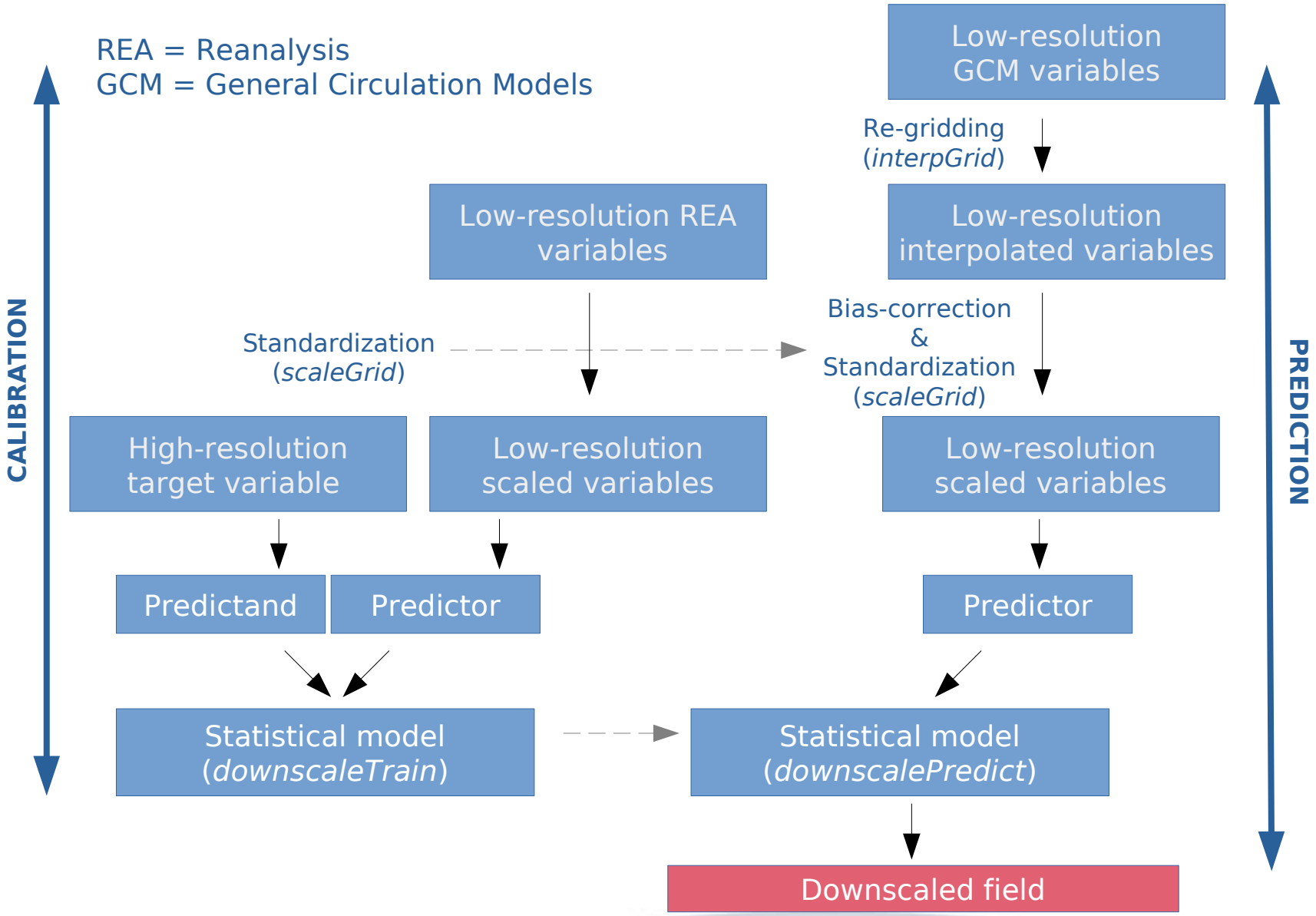

Perfect-Prognosis

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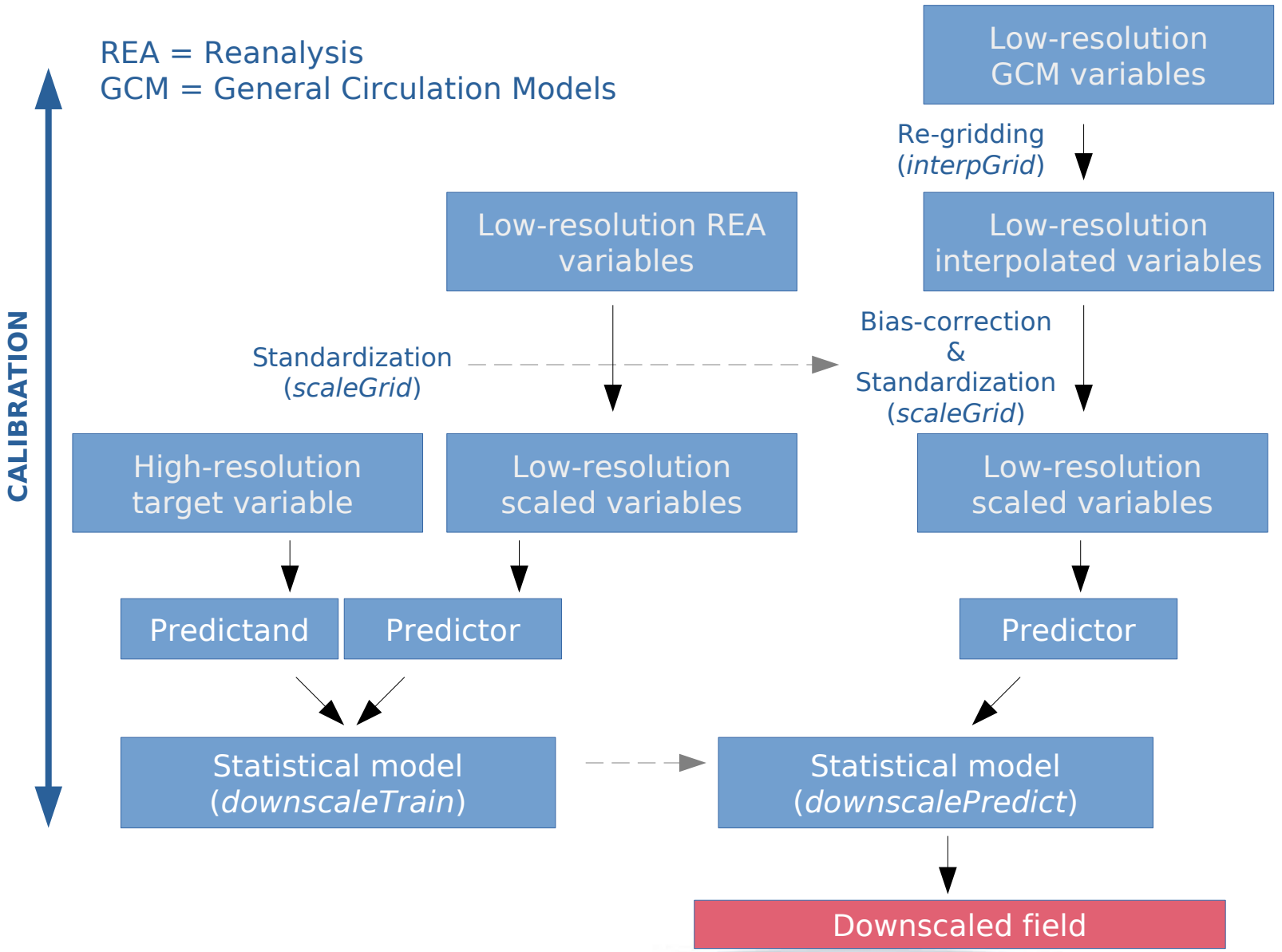
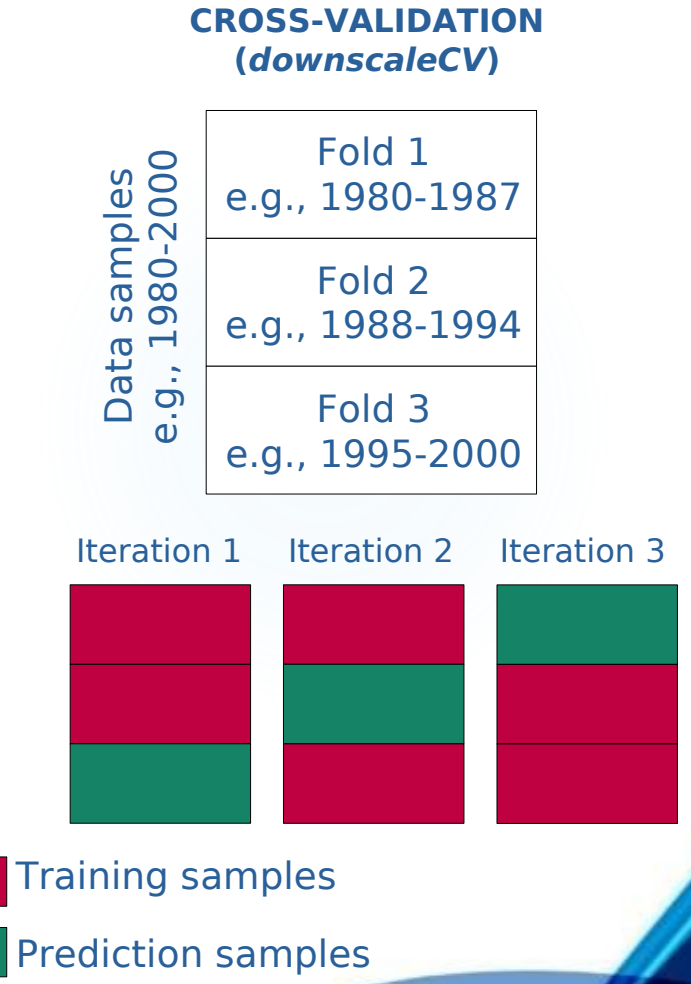




Perfect-Prognosis

REA = Reanalysis
GCM = General Circulation Models

CALIBRATION

1990-2000
2090-2100

EC-Earth (1.12º) variables

Re-gridding (*interpGrid*)

1980-2000

ERA-Interim variables (2º)

EC-Earth interpolated variables (2º)

Standardization (*scaleGrid*)

Bias-correction & Standardization (*scaleGrid*)

VALUE stations

ERA-Interim scaled variables (2º)

EC-Earth scaled variables (2º)

Predictand

Predictor

Predictor

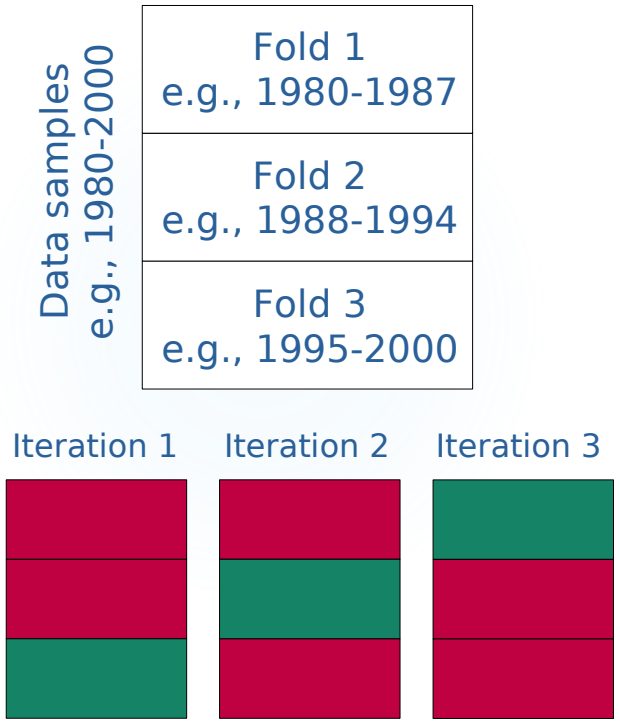
Statistical model (*downscaleTrain*)

Statistical model (*downscalePredict*)

Downscaled field

PREDICTION

CROSS-VALIDATION (*downscaleCV*)



Bias-correction

GCM = General Circulation Models

Period A = temporal period within the historical scenario

CALIBRATION

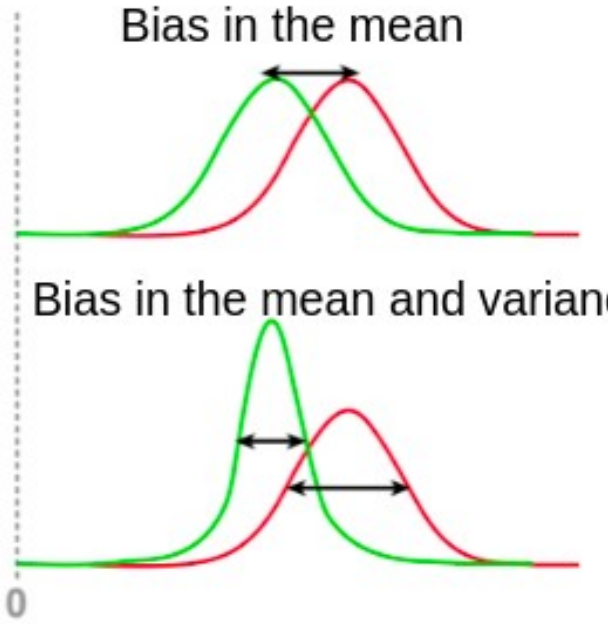
High-resolution target variable (Period A)

Low-resolution GCM variable (Period A)

Predictand

Predictor

Bias-correction (*biasCorrection*)



$$x^i_{BA} = (x^i_m - \overline{x_m}) + \overline{x_o}$$

$$x^i_{BA} = (x^i_m - \overline{x_m}) \frac{\sigma_o}{\sigma_m} + \overline{x_o}$$

Bias-correction

GCM = General Circulation Models

Period A = temporal period within the historical scenario

Period B = temporal period within the future scenario