LIFE08 ENV/IT/436

PROJECT ACT

ADAPTING TO CLIMATE CHANGE IN TIME

Downscaling through empirical-statistical modelling: methodologies and planned activities

A. Toreti

Rome July 2010

ISPRA Institute for Environmental Protection and Research

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OUTLINE

- ✓ Introduction
- ✓ Methods
- ✓ Downscaling: precipitation and temperature
- ✓ Planned activities

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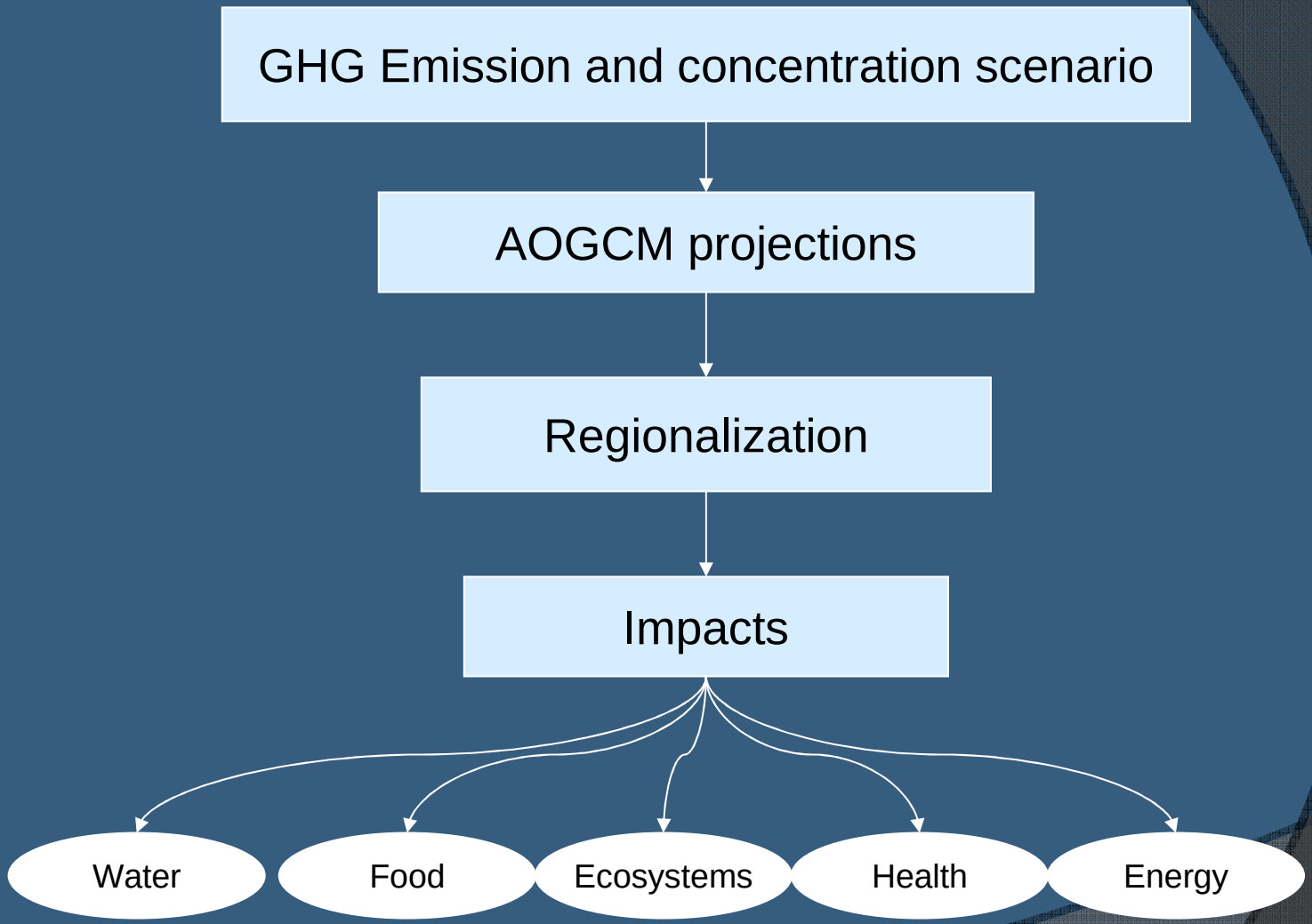
Introduction



Adapted from Giorgi, 2008

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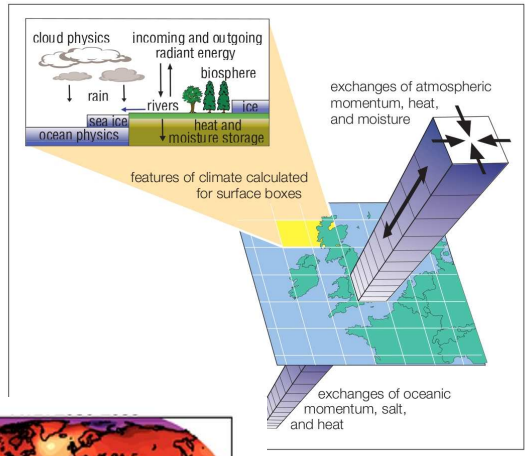
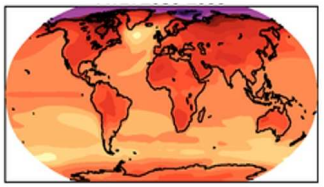
Introduction

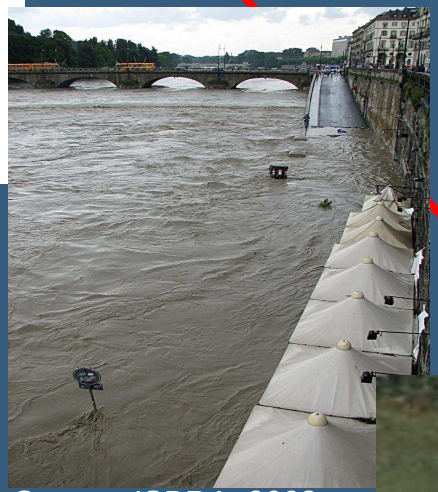
Downscaling attempts to resolve the scale discrepancy between climate change scenarios and the resolution required for impact assessment[1]





Source: Stardex

Source: IPCC, 2007



Source: ISPRA, 2008

From the global (~300 Km) to the local scale (1 - 25 km)

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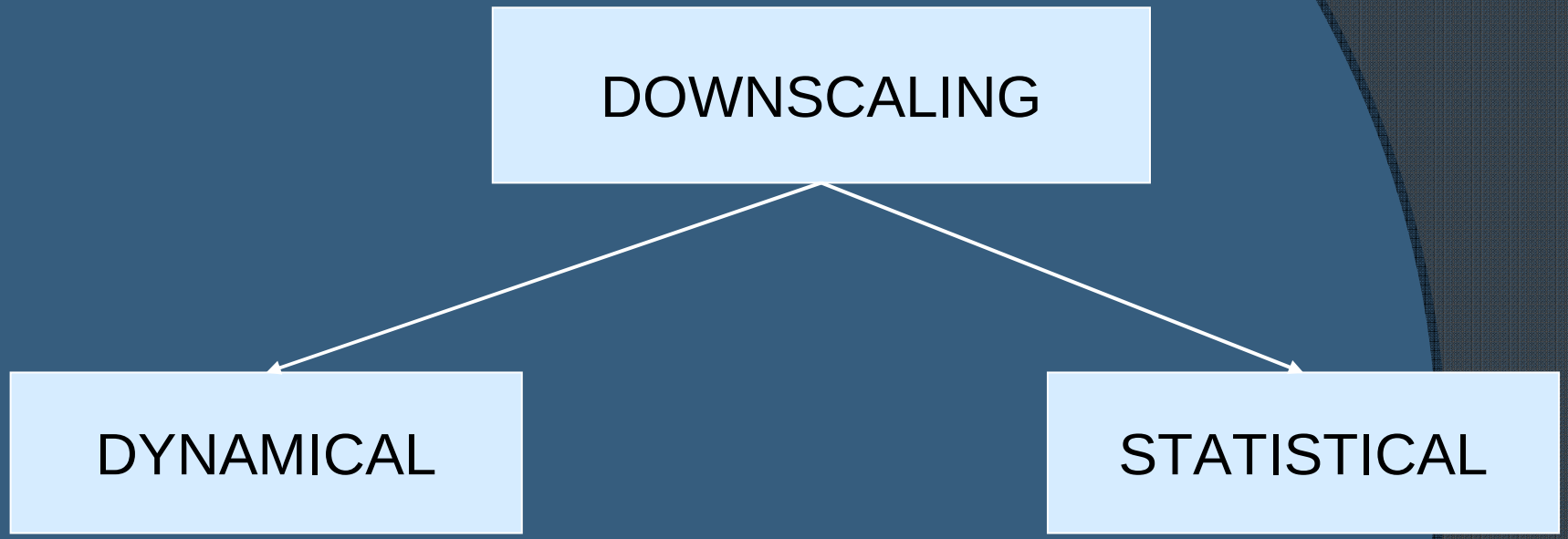
1 Maraun et al., 2010

Introduction



….in the last years combined approaches have been developed + high resolution GCMs

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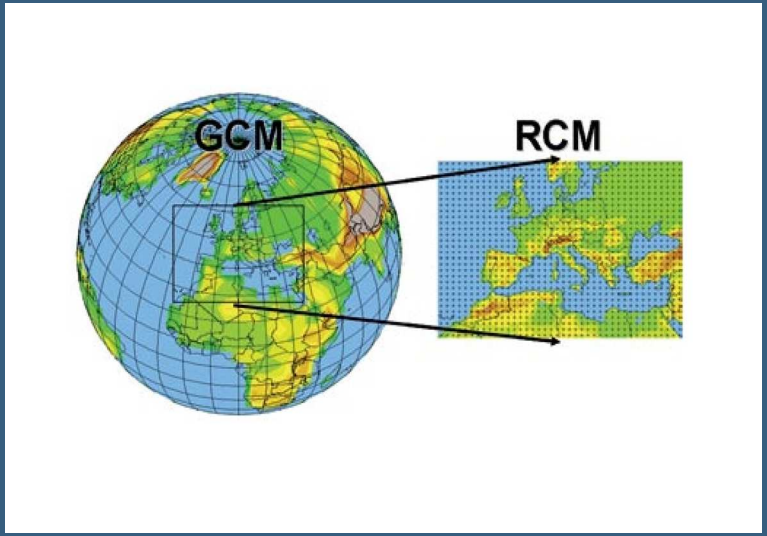
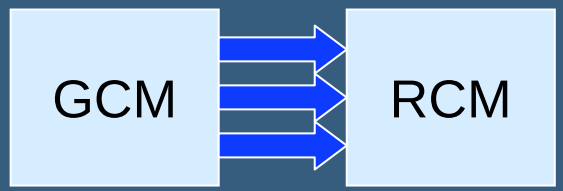
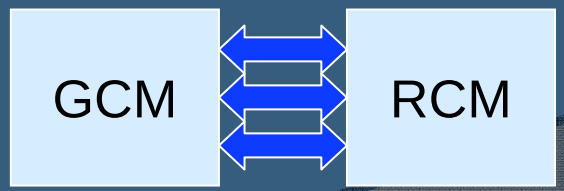
Introduction – Dynamical approach

It is based on Regional Climate Models - RCMs



Source: Giorgi, 2008





Most of RCMs are one way nested, 2-way nesting has been tested in recent years

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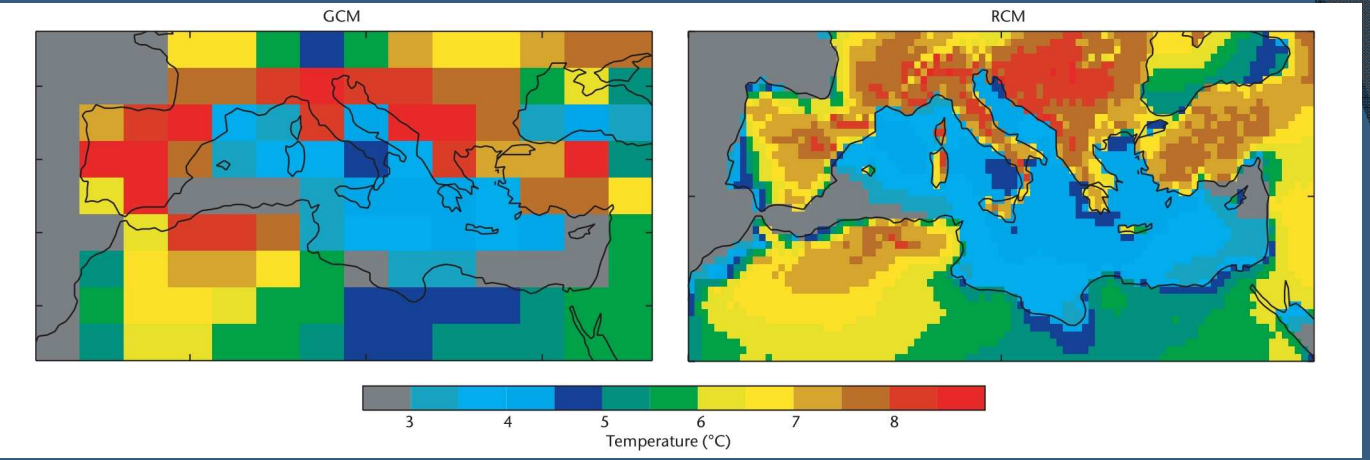
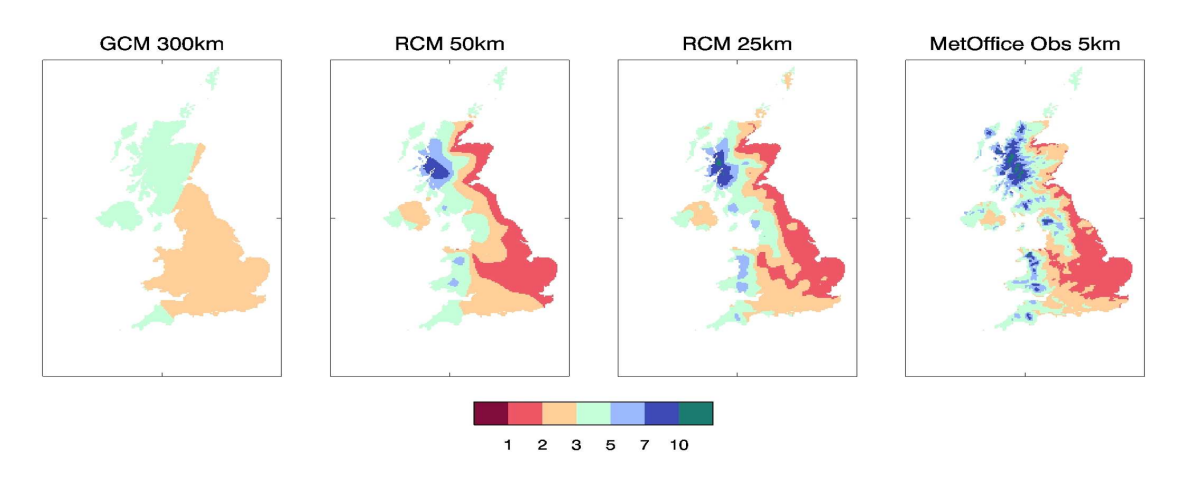
Introduction – Dynamical approach

GCM and RCM: Temperature and Precipitation



Source: Precis



Source: Maraun et al., 2010

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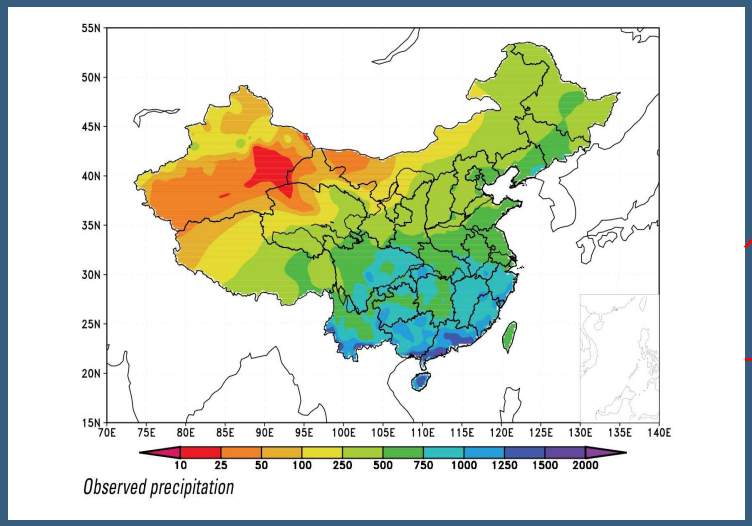
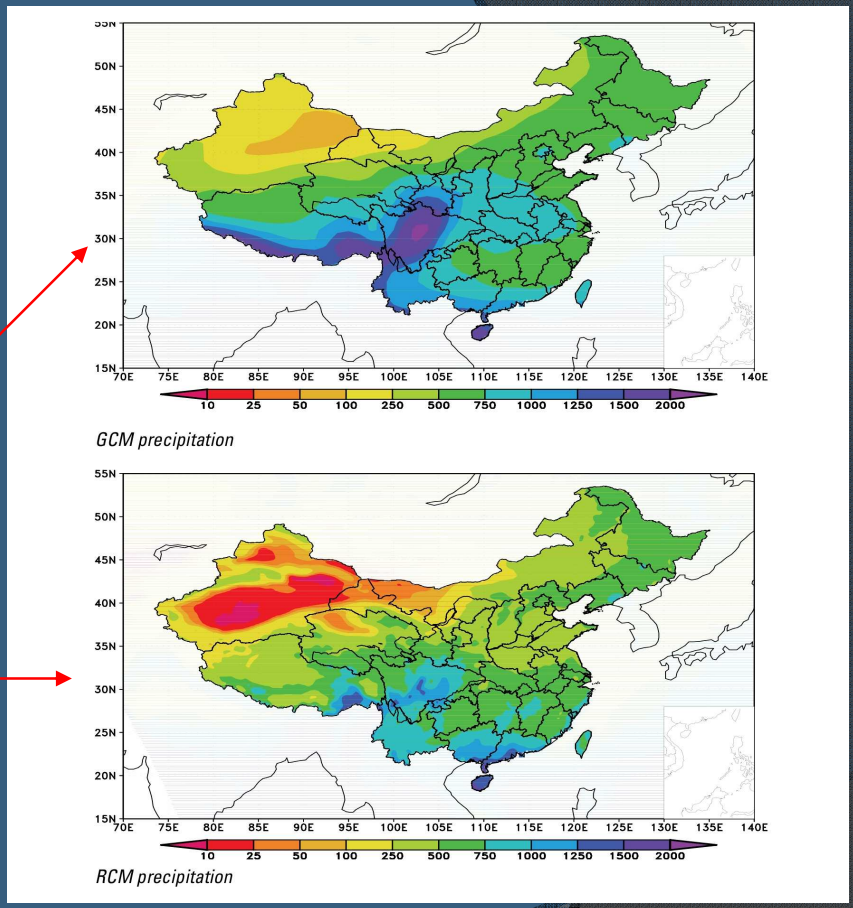
Introduction – Dynamical approach

GCM – RCM: precipitation





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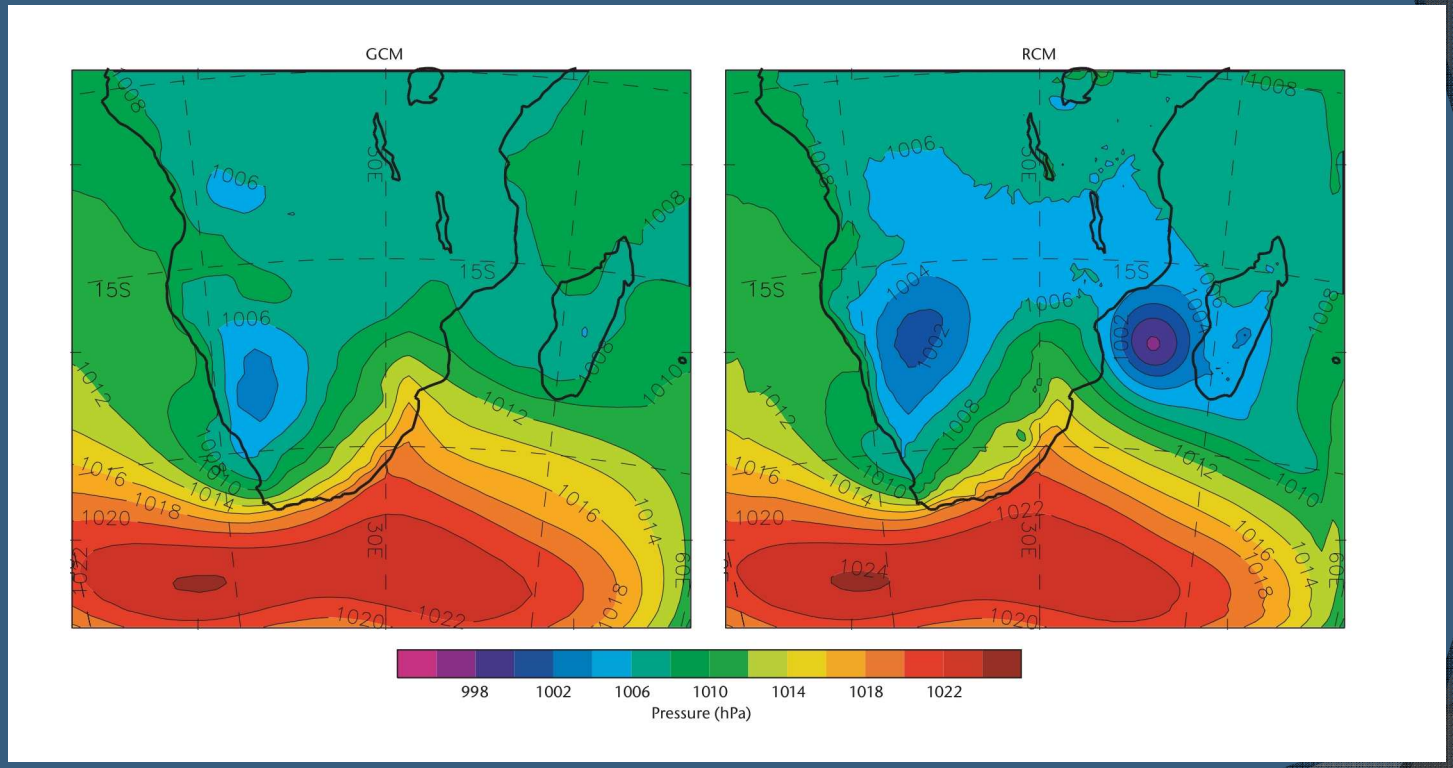
Source: Gao et al., 2008

Introduction – Dynamical approach

Pressure patterns simulated by a RCM and its driving GCM



Source: Precis

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Introduction – Classical statistical approach

It is based on:

✓ regional climate is influenced by large scale and local factors;

✓ the development of a statistical relationship between a local scale predictand Y (e.g. temperature) and a large scale predictor X (e.g. geopotential height at 500 hPa)

$$E(Y|X)=f(X,\beta)$$

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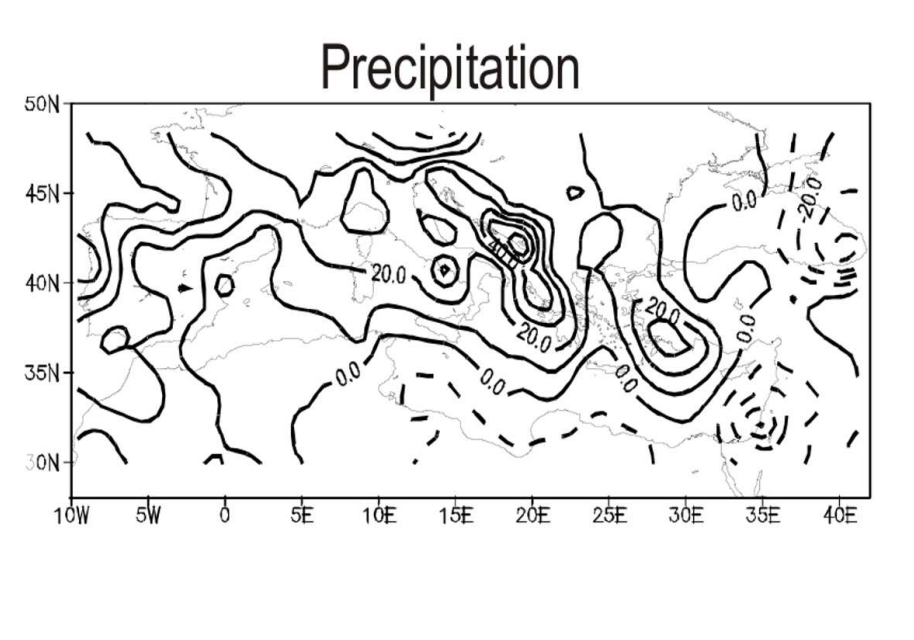
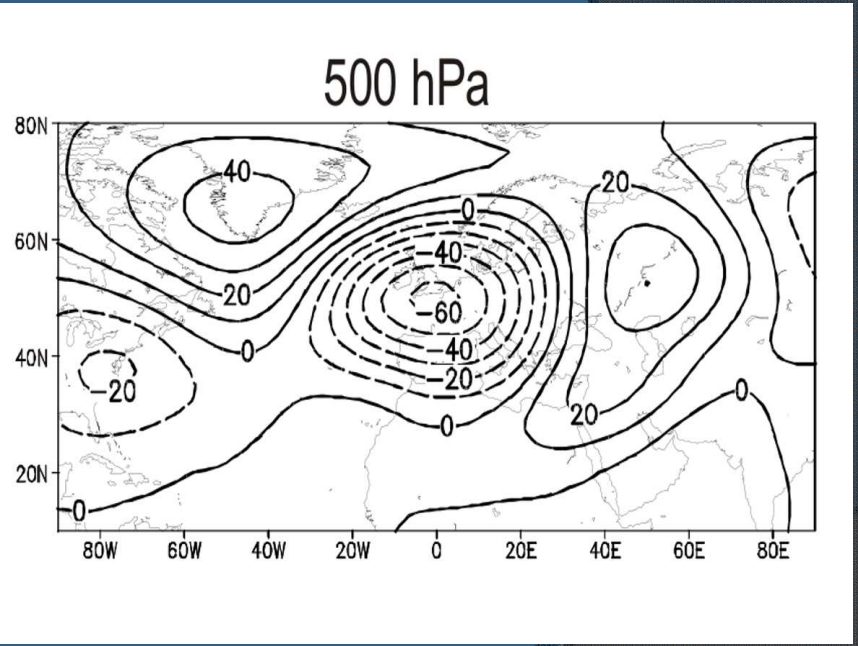
Introduction – Classical statistical approach

First CCA of the winter precipitation and geopotential height at 500 hPa (anomalies)





Source: Xoplaki, 2002

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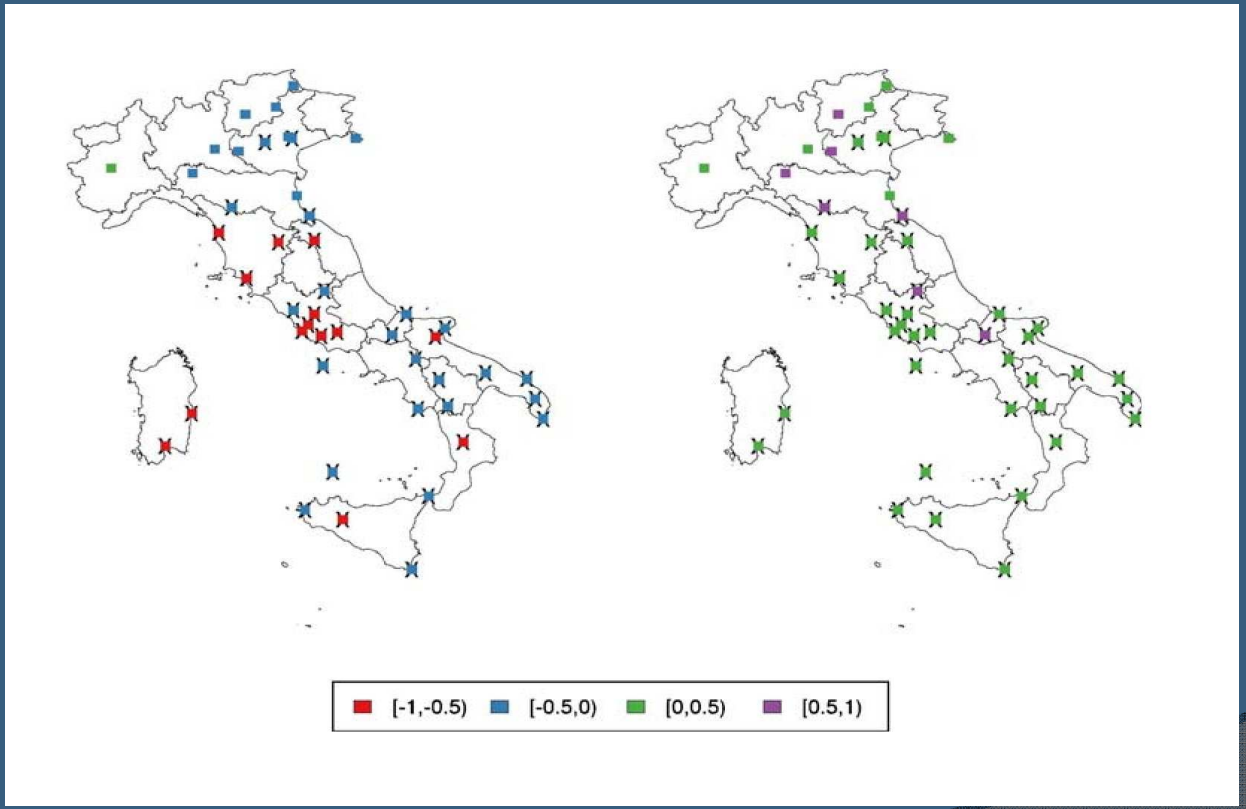
Introduction – Classical statistical approach

Winter composites of temperature anomalies for positive EA (right) and negative EA (left)



Source: Toreti et al., 2010

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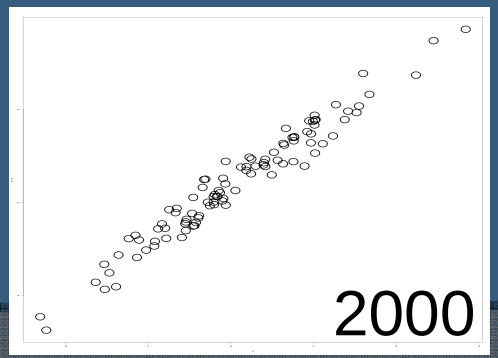
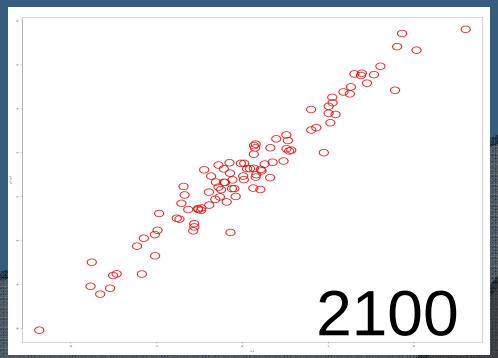
Introduction – Classical statistical approach

The main assumptions of SD are:

- ✓ the statistical relationship between the local scale predictand and the large scale predictor is stable
- ✓ Predictors provide a representation of the climate signal
- ✓ Predictors are adequately reproduced by GCMs
- ✓ Predictors do not lie outside the range of the climatology used for the calibration





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Introduction – Classical statistical approach

Advantages

- ✓ computationally inexpensive
- ✓ can be applied to outputs of different GCMs
- ✓ provides local and specific information

Drawbacks

- ✓ the stability of the regression relationship cannot be verified
- ✓ availability of observational datasets

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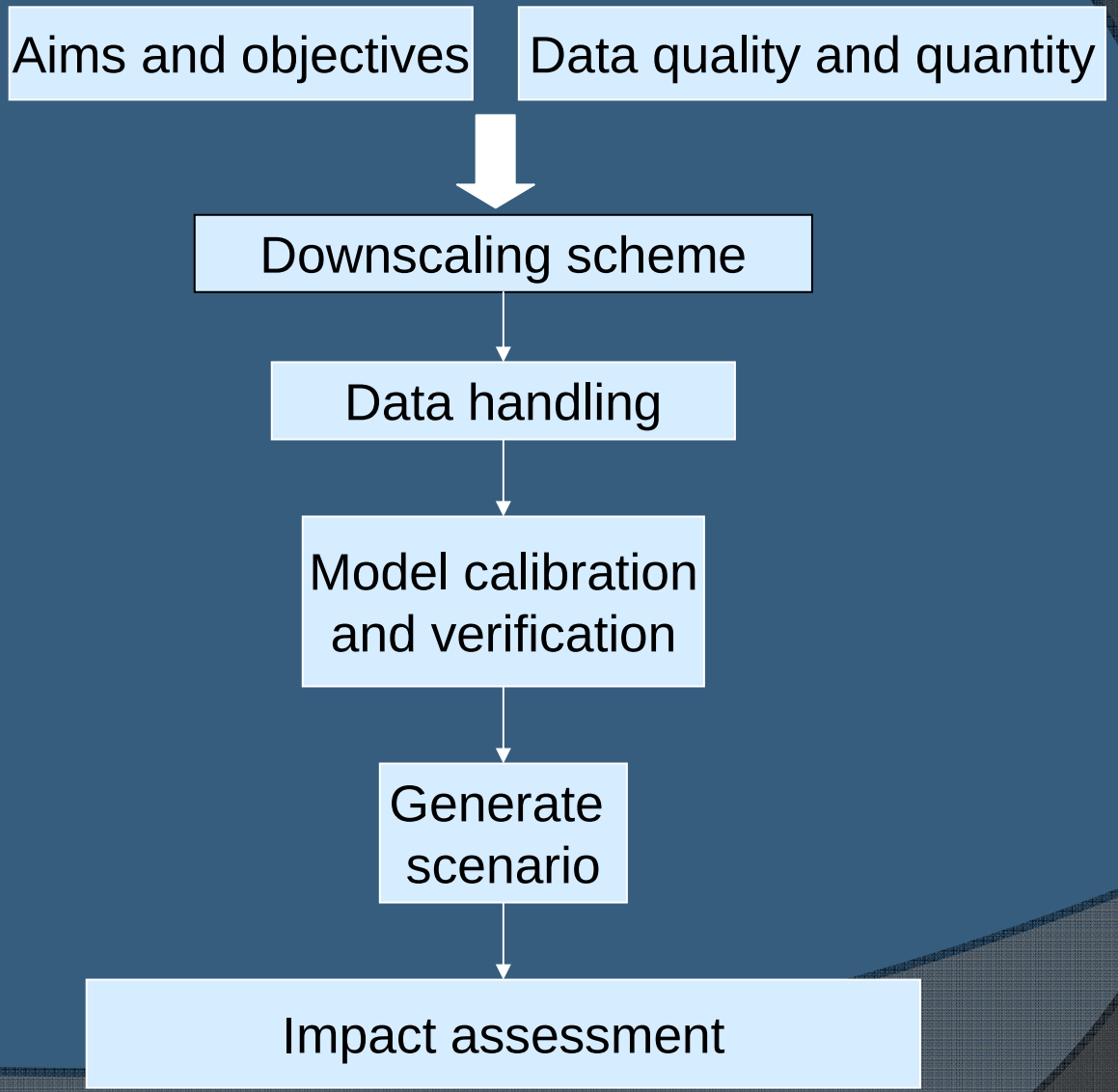
Introduction – Classical statistical approach



Adapted from Wilby et al., 2004

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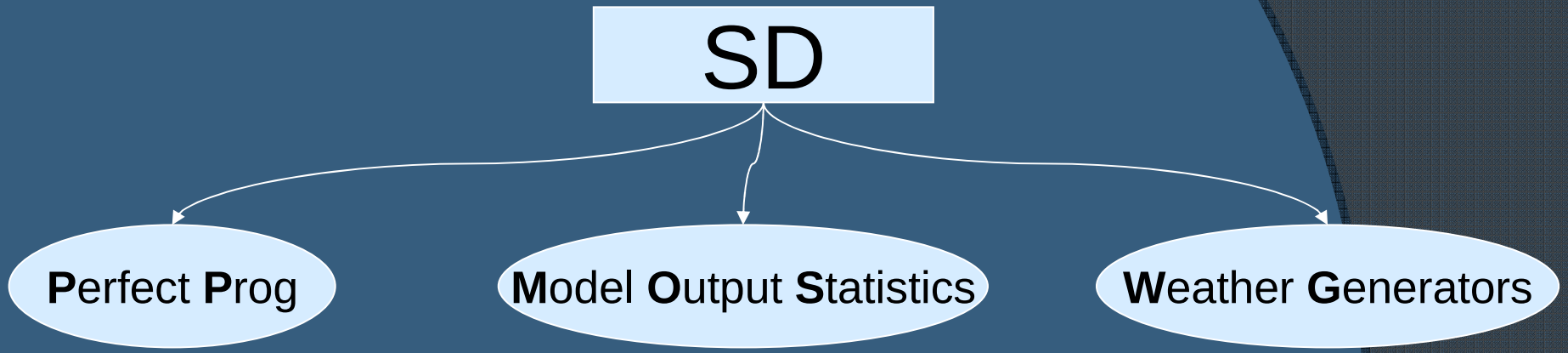
Methods

CLASSIFICATION[1]



Statistical relationship between large-scale variables and local-scale variables

Statistical relationship between RCM-simulated variables and local-scale observations to correct RCMs.

Generate local scale weather series

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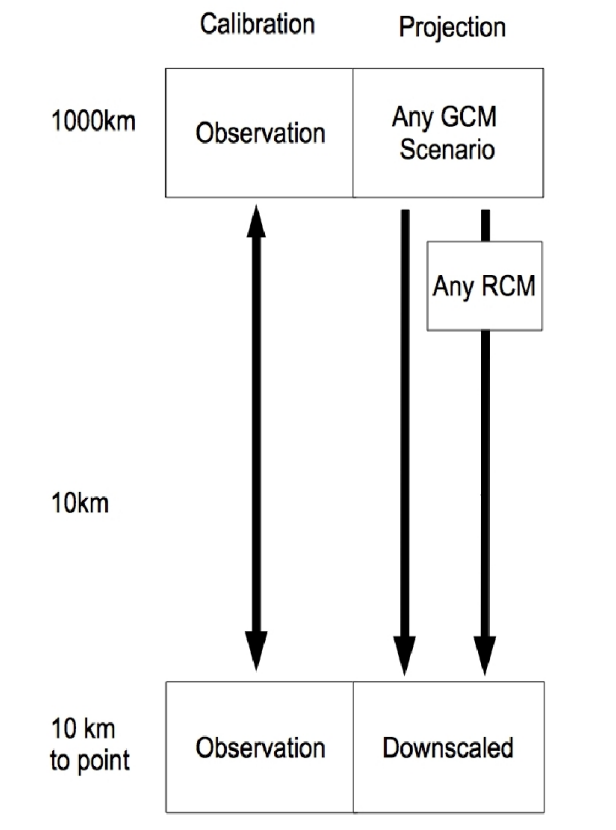
1 Maraun et al., 2010

Methods - PP



Source: Maraun et al., 2010

- ✓ Large scale observations are usually represented by reanalysis
- ✓ Predictors:
  - ✓ temperature: Z500, SLP, T850…
  - ✓ precipitation: Z500, SLP, SH…
- ✓ Transformation: reduction of dimensionality, i.e. PCA, CCA, Weather types,..
- ✓ Available models: linear model, generalized linear model, weather type model, artificial neural network…

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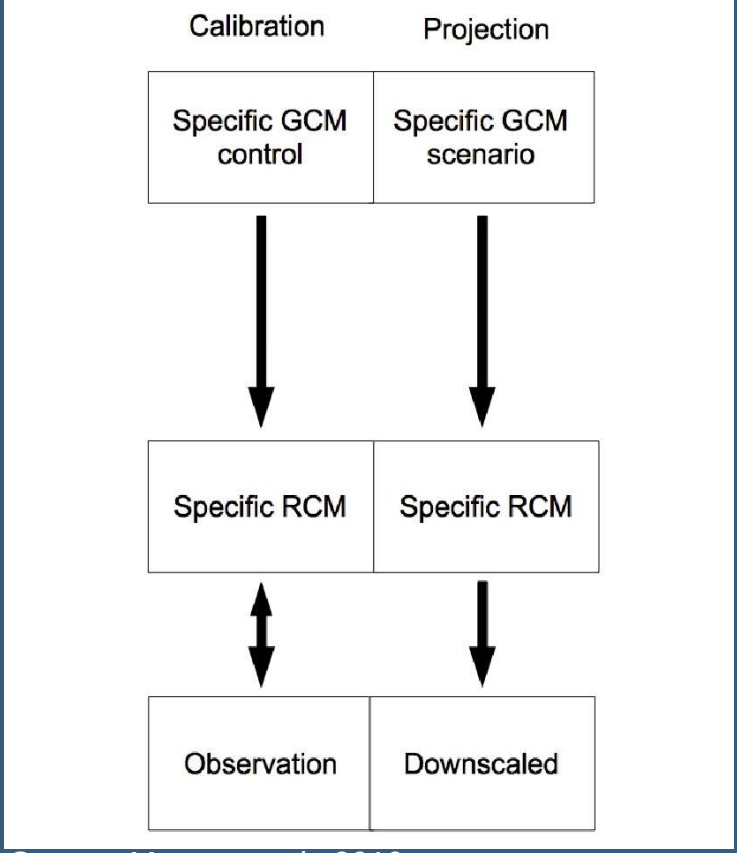
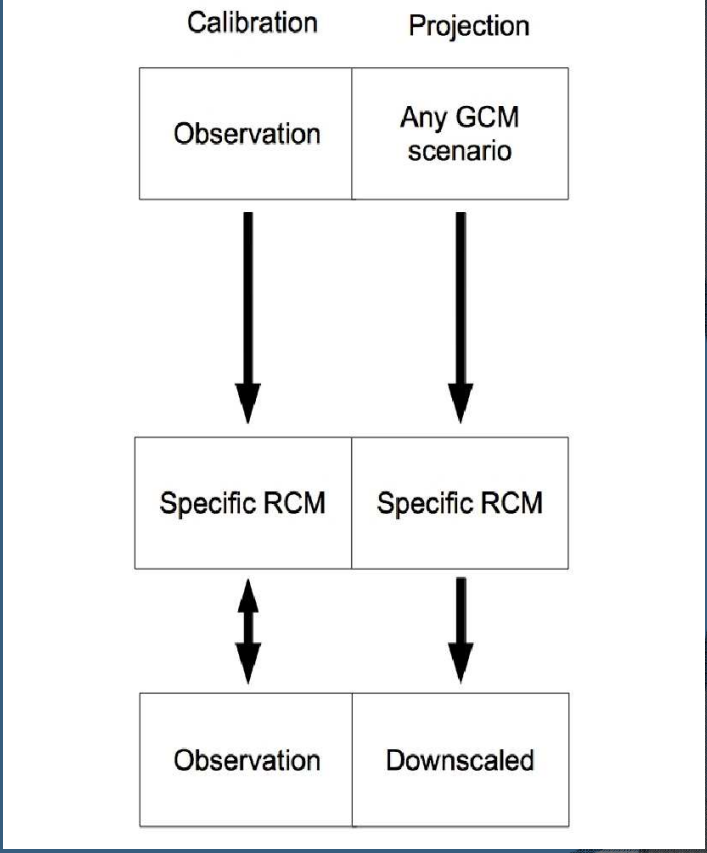
Methods - MOS

GCM + RCM



RCM



Source: Maraun et al., 2010

Link between simulated predictors and observed predictands, e.g. simulated large scale preci and observed preci

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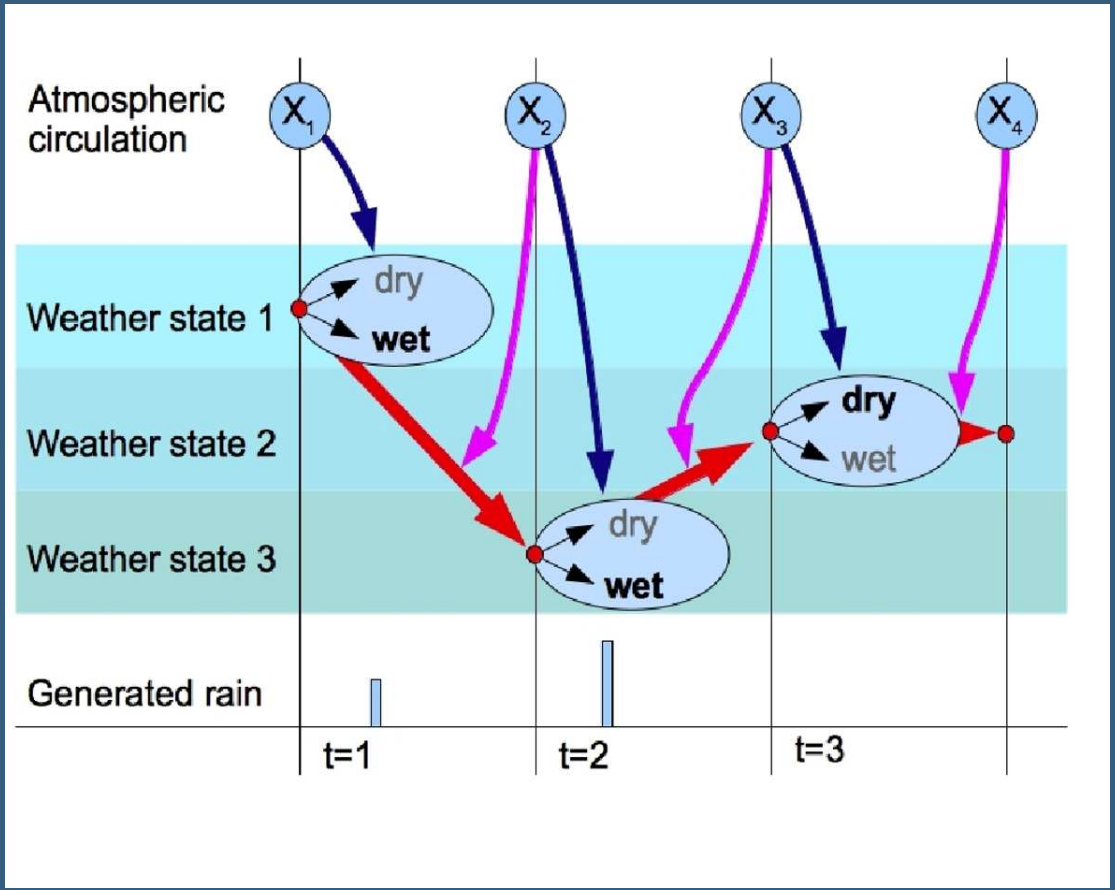
Methods - WGs



Source: Maraun et al., 2010

Unconditional WGs can be considered as MOS

WGs with covariates can be considered as PP

Complex WGs

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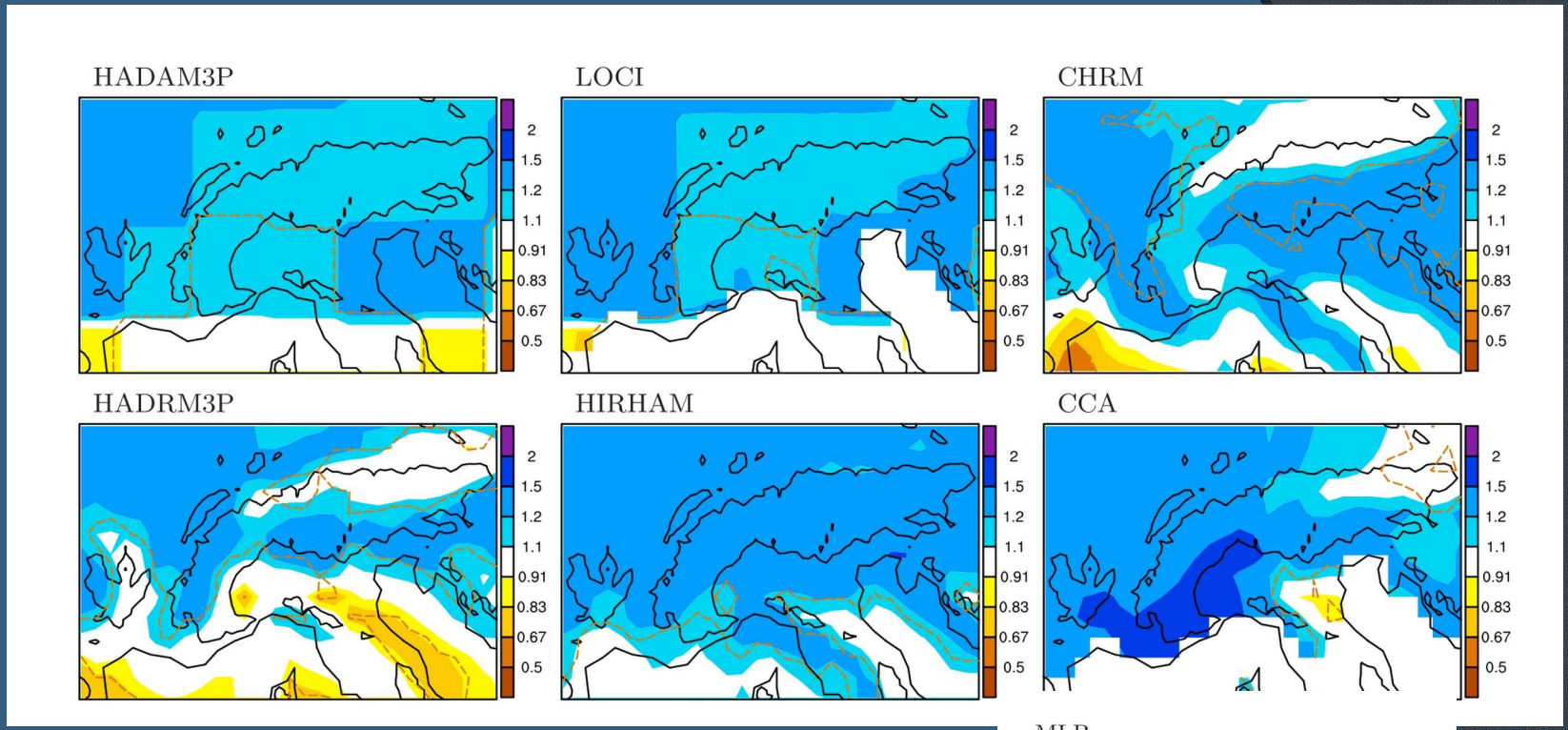
Downscaling - preci

Source: Schmidli et al., 2007



2071-2100(A2)/1961-1990(cntrl). Mean winter (DJF) precipitation. 1 GCM, 3 RCMs and 3 SD methods.

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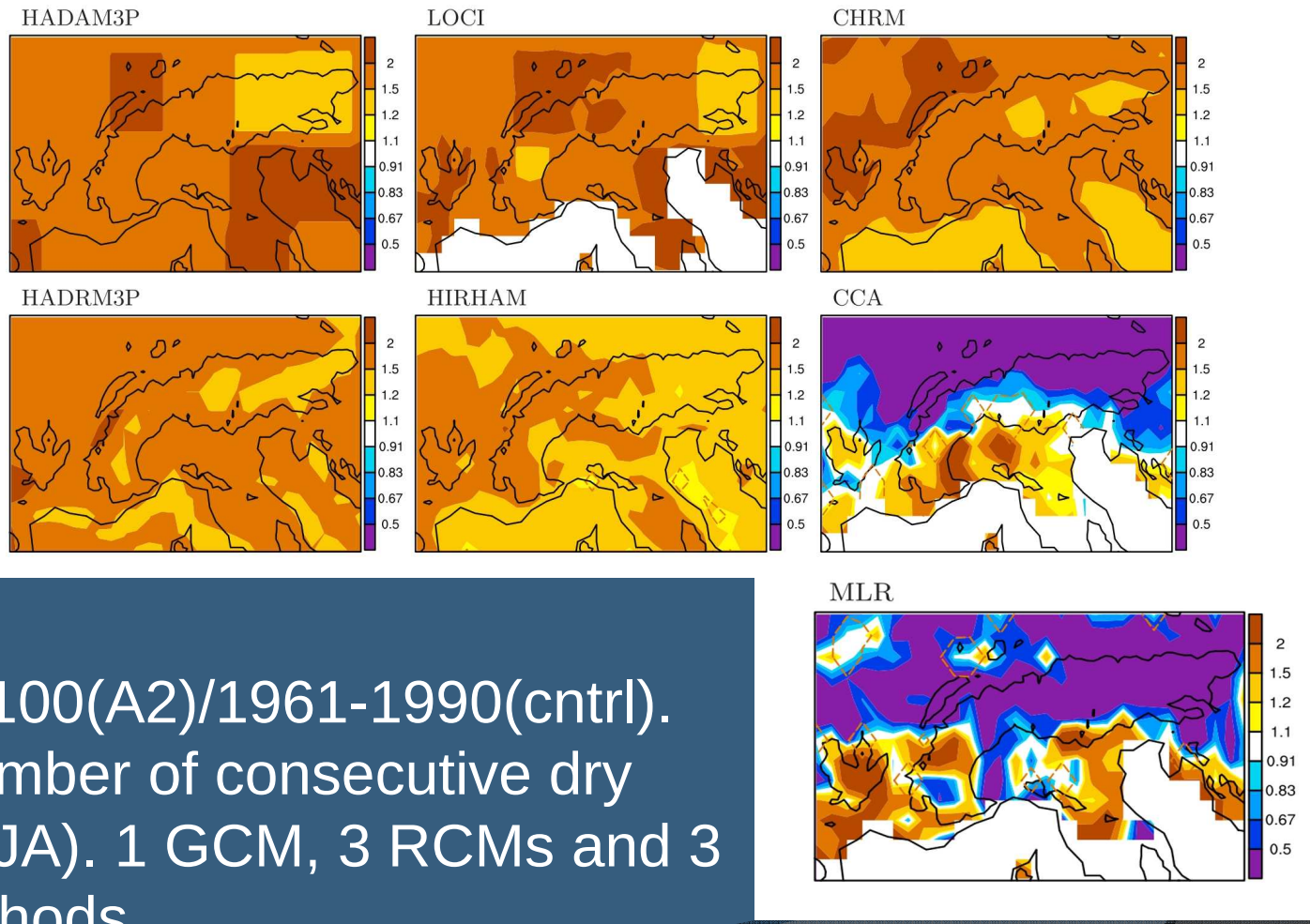
Downscaling - preci

Source: Schmidli et al., 2007



2071-2100(A2)/1961-1990(cntrl). Max number of consecutive dry days (JJA). 1 GCM, 3 RCMs and 3 SD methods.

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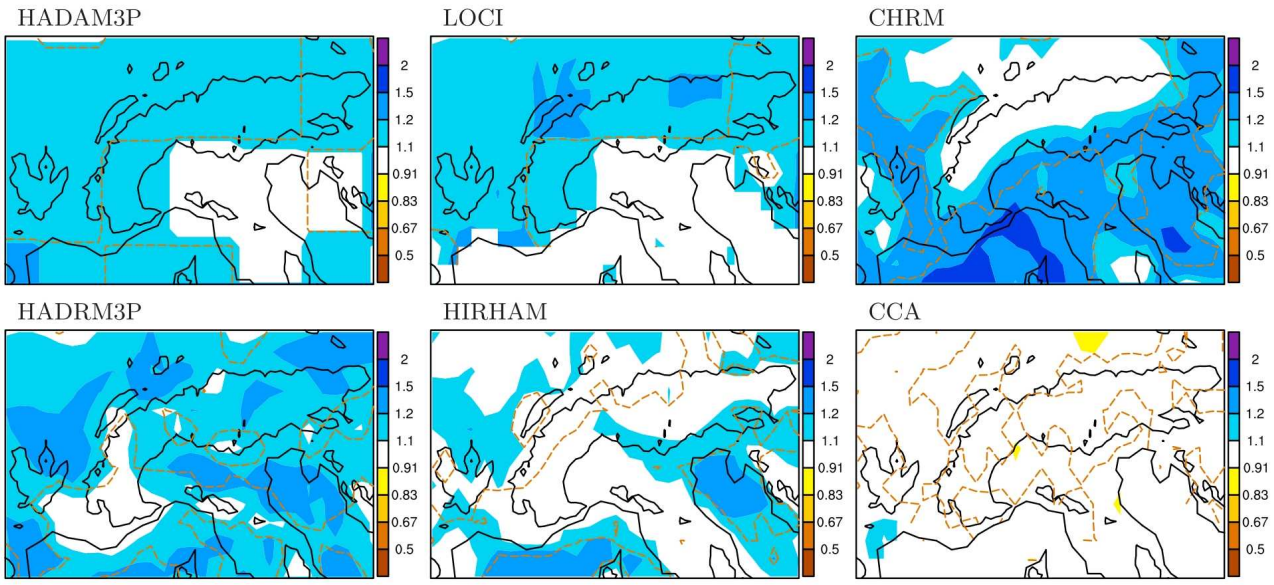
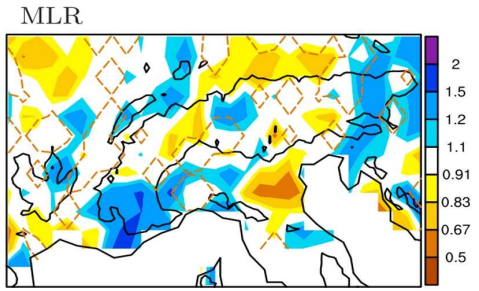
Downscaling - preci

Source: Schmidli et al., 2007





2071-2100(A2)/1961-1990(cntrl). 90th percentile (wet days SON). 1 GCM, 3 RCMs and 3 SD methods.

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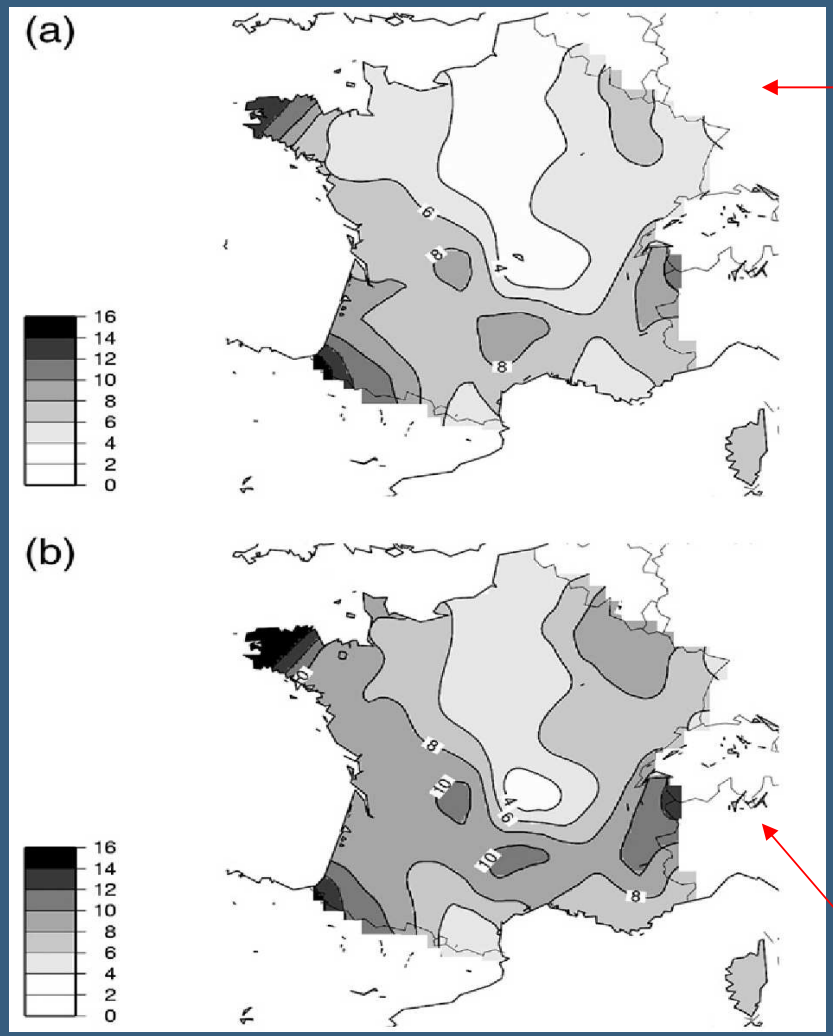
Downscaling - preci



Source: Déqué, 2007

CNTRL

RCM (ARPEGE) + MOS.

1961-1990 and 2071-2100 (A2)

Number of winter days with precipitation above 10 mm

SCENARIO

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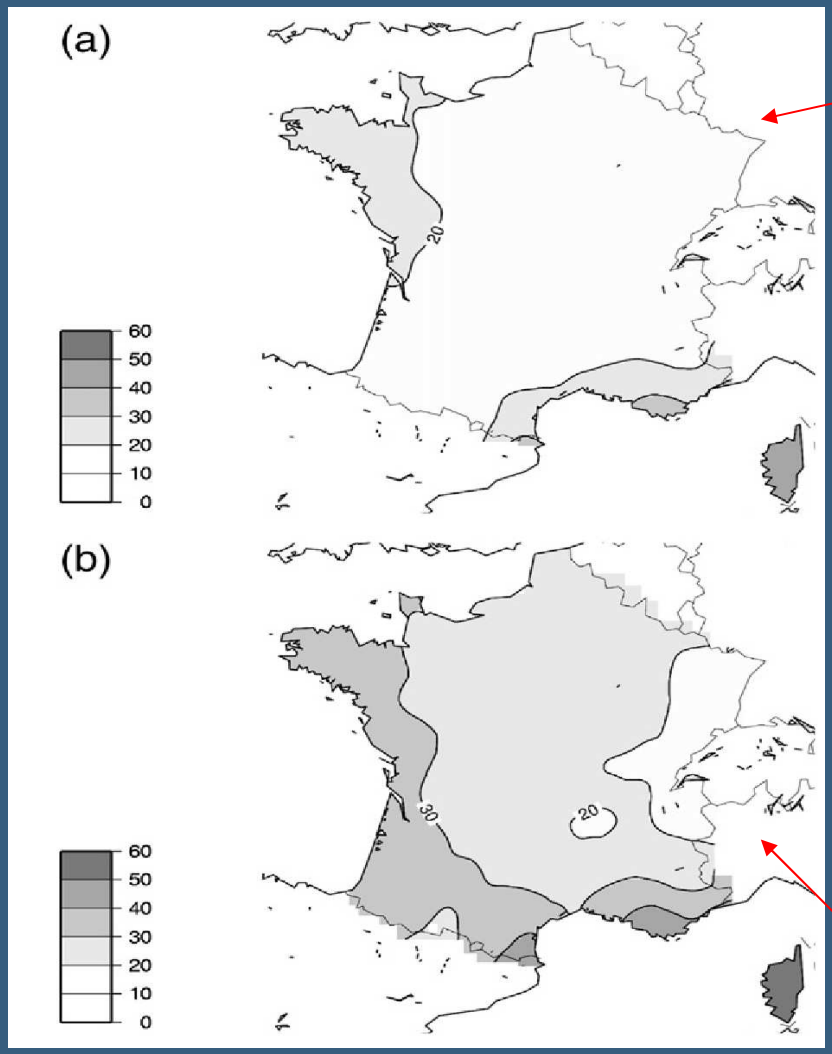
Downscaling - preci



CNTRL

RCM (ARPEGE) + MOS.

1961-1990 and 2071-2100 (A2)

Maximum number of consecutive dry days in summer

SCENARIO

Source: Déqué, 2007

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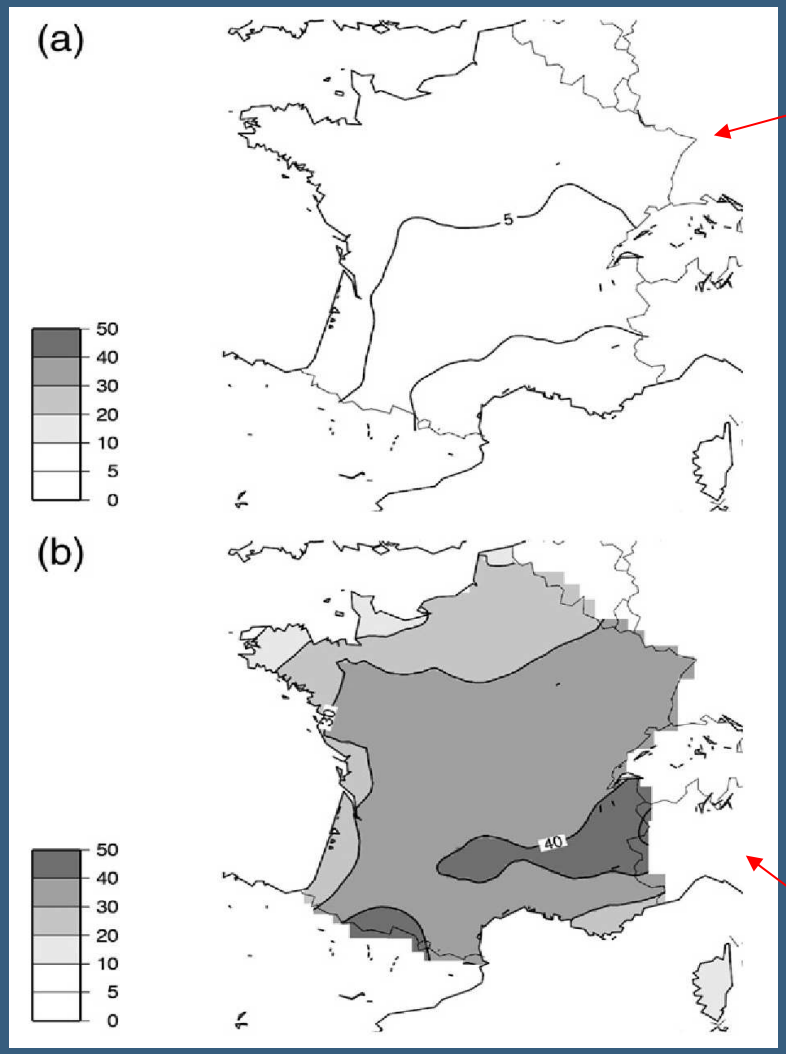
Downscaling - temp



Source: Déqué, 2007

CNTRL

RCM (ARPEGE) + MOS.

1961-1990 and 2071-2100 (A2)

Number of summer heat wave days

SCENARIO

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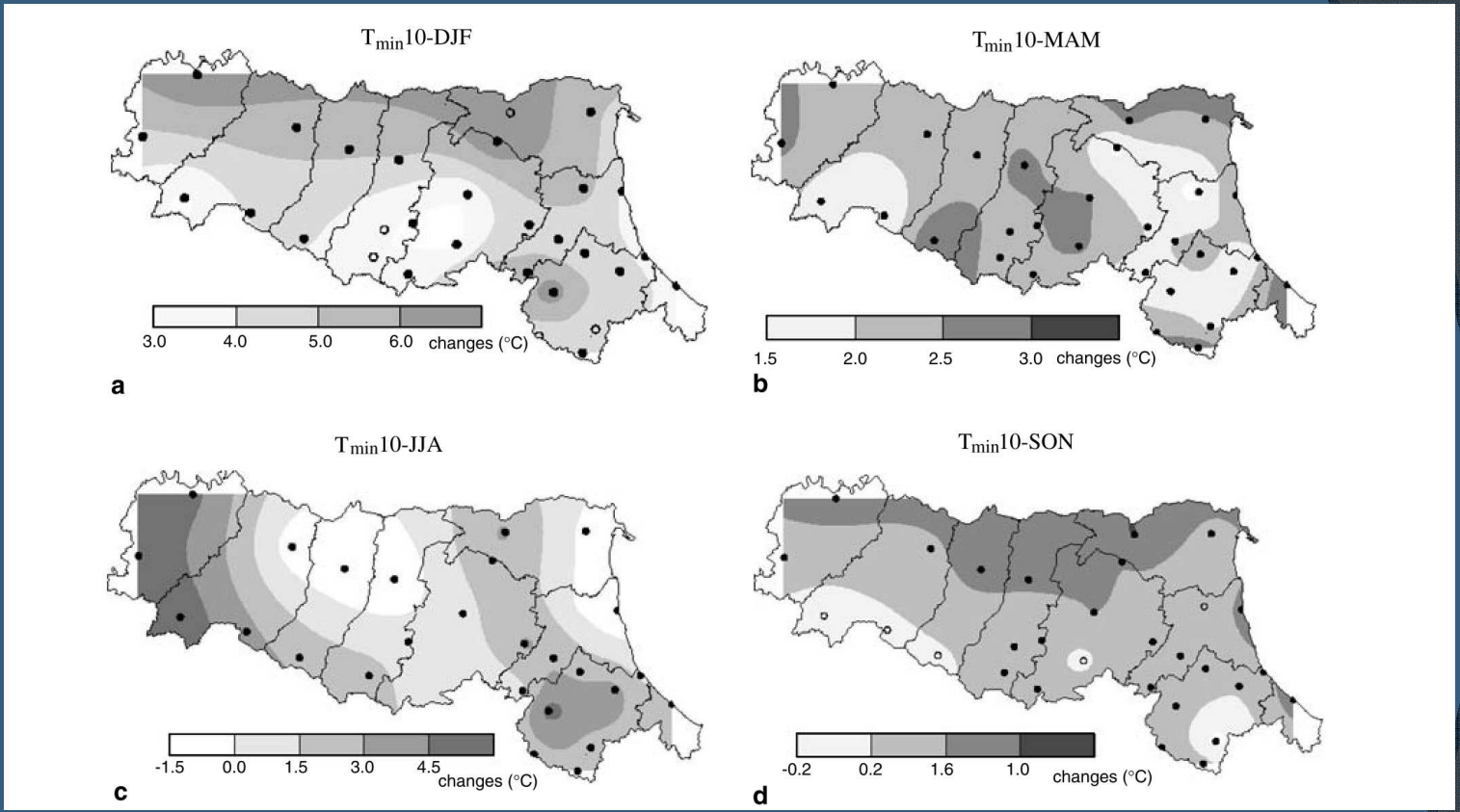
Downscaling - temp

Source: Tomozeiu et al., 2007



HadAM3P GCM + PP. 2070-2100 (A2) wrt 1960-1900. Seasonal 10th percentile of minimum temperature

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Downscaling - temp

Source: Tomozeiu et al., 2007

HadAM3P GCM + PP. 2070-2100 (A2) wrt 1960-1900. Seasonal 90th percentile of maximum temperature and heat wave duration index.

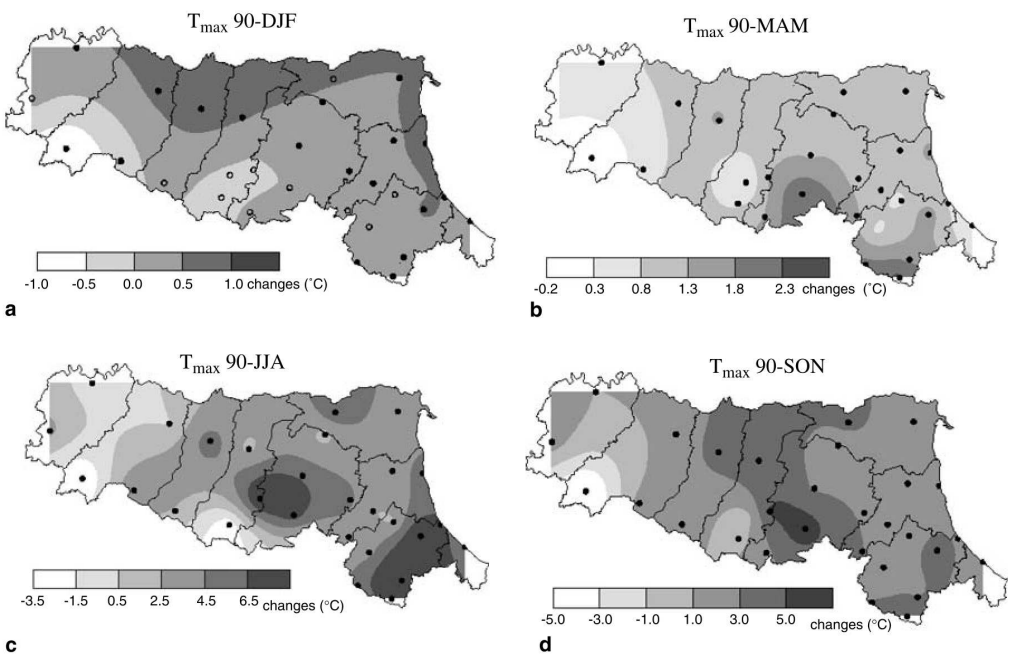
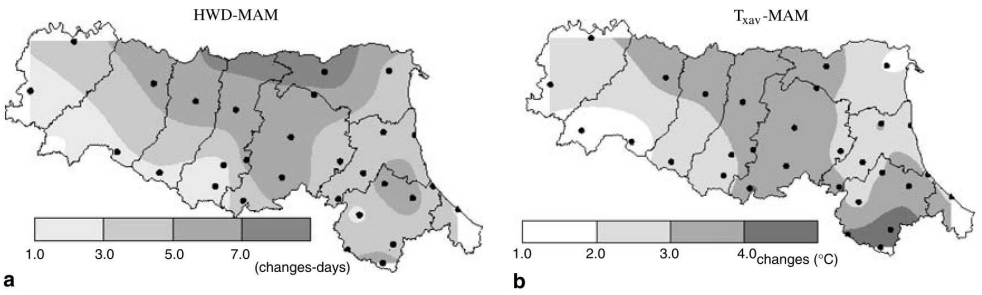


Fig. 11. As in Fig. 9, but for T_{max}90 (A2 scenario)



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Planned activities

- ✓ Data collection, quality control + homogenization
- ✓ Evaluation of available software/routines for SD
- ✓ Identification of two/three SD methods: 1 linear and one nonlinear (PP) + 1 MOS
- ✓ Implementation
- ✓ Selection of GCMs/RCMs
- ✓ Downscaling of climate scenarios

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Thank you!

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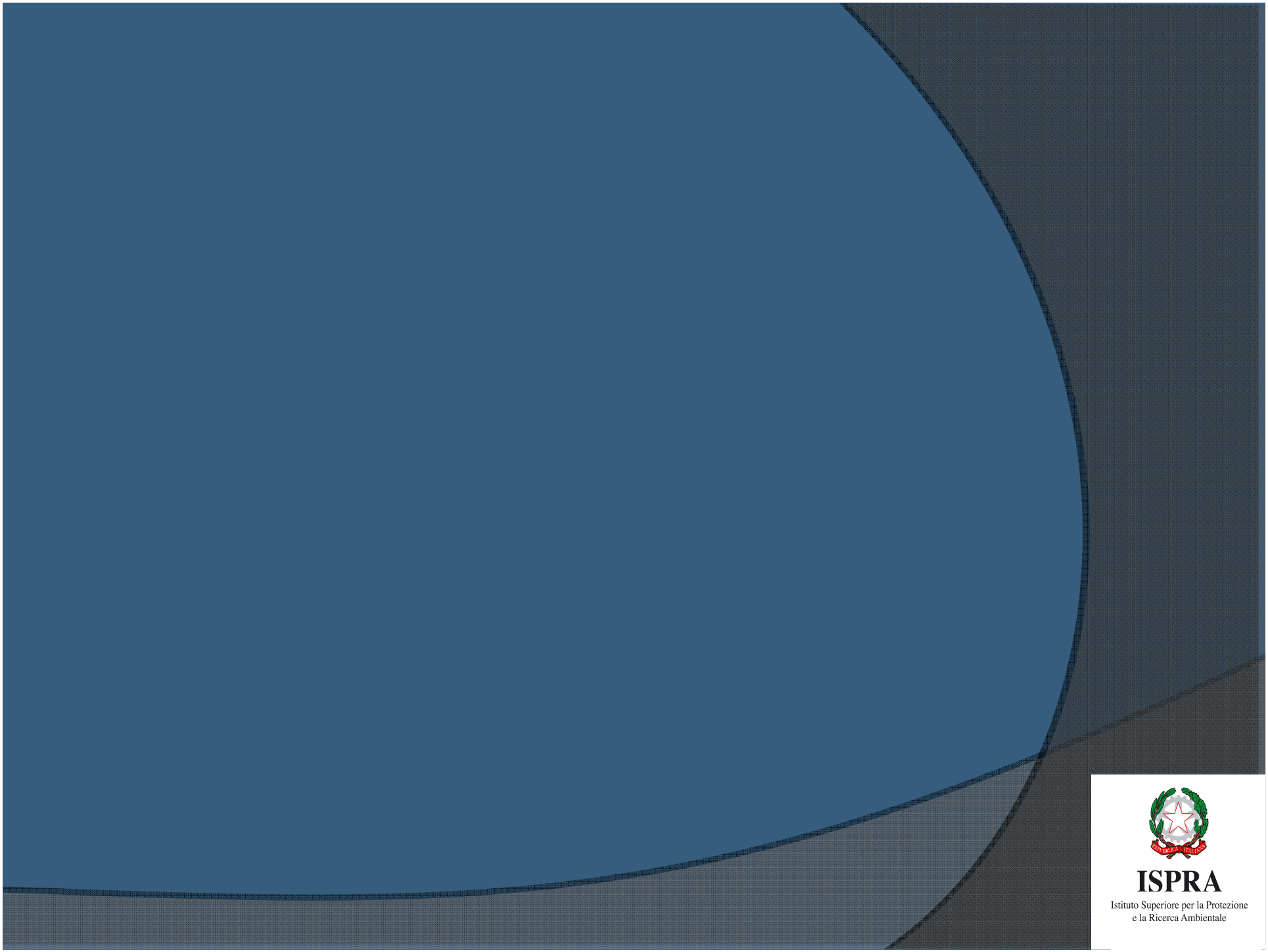

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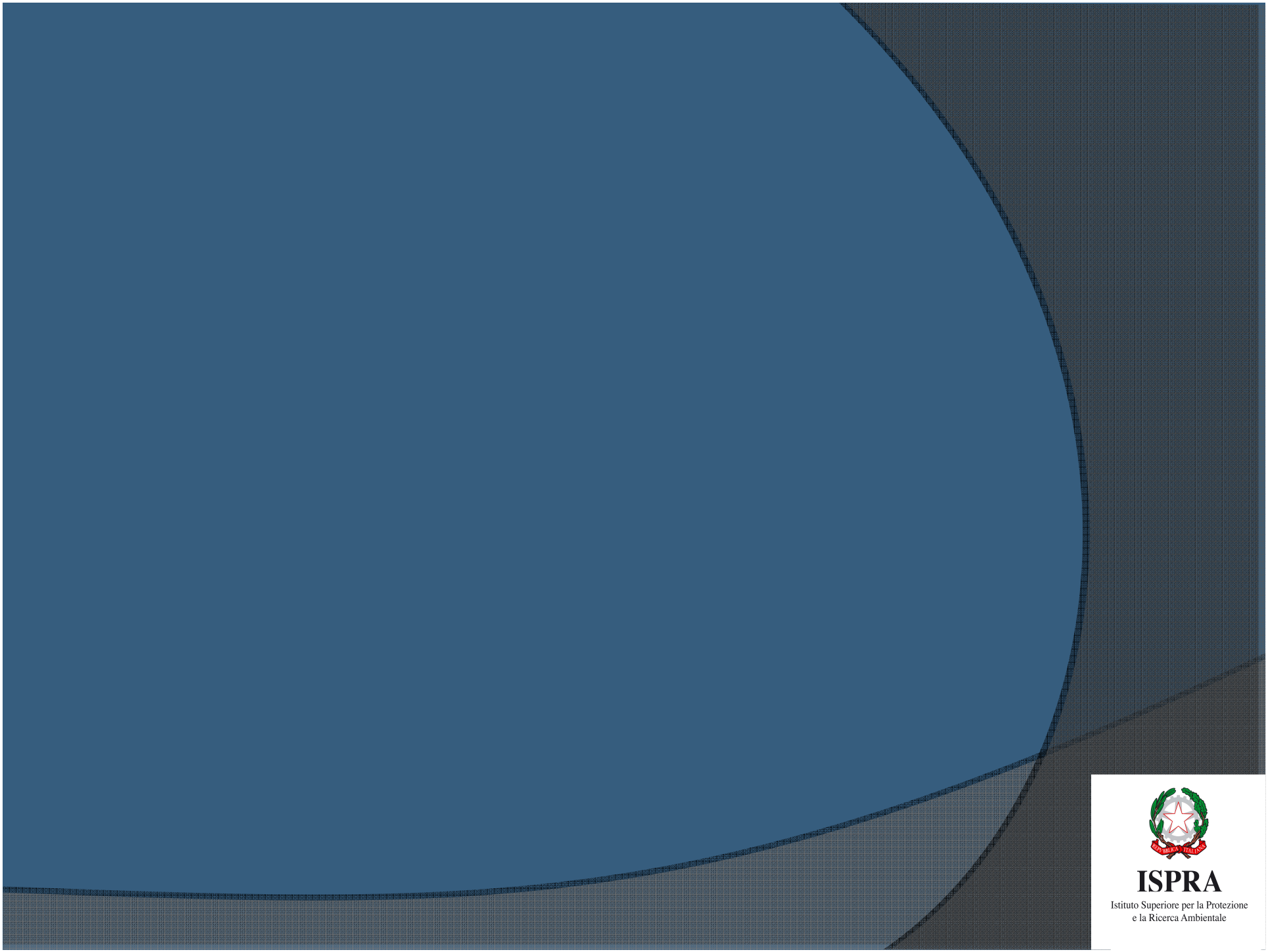

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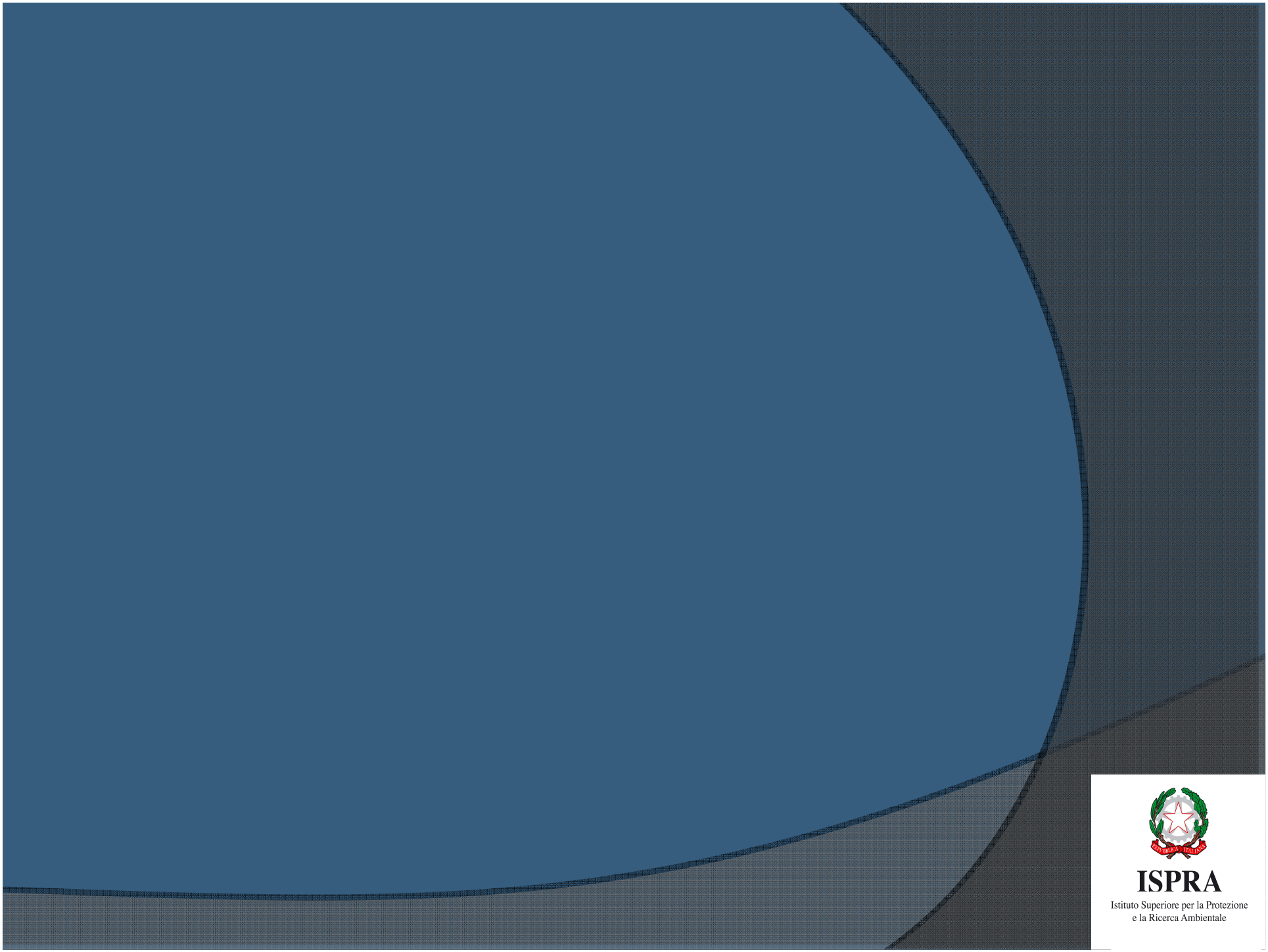

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