

# **Transdisciplinary Nature Conservation:**

**The IUCN Red List of Threatened Species from evaluation to  
practice**

**Luca Bütkofer, 15.09.2022**

# **Luca Bütkofer**

## **Spatial- Agro- Macro- Ecologist**

### **Studies:**

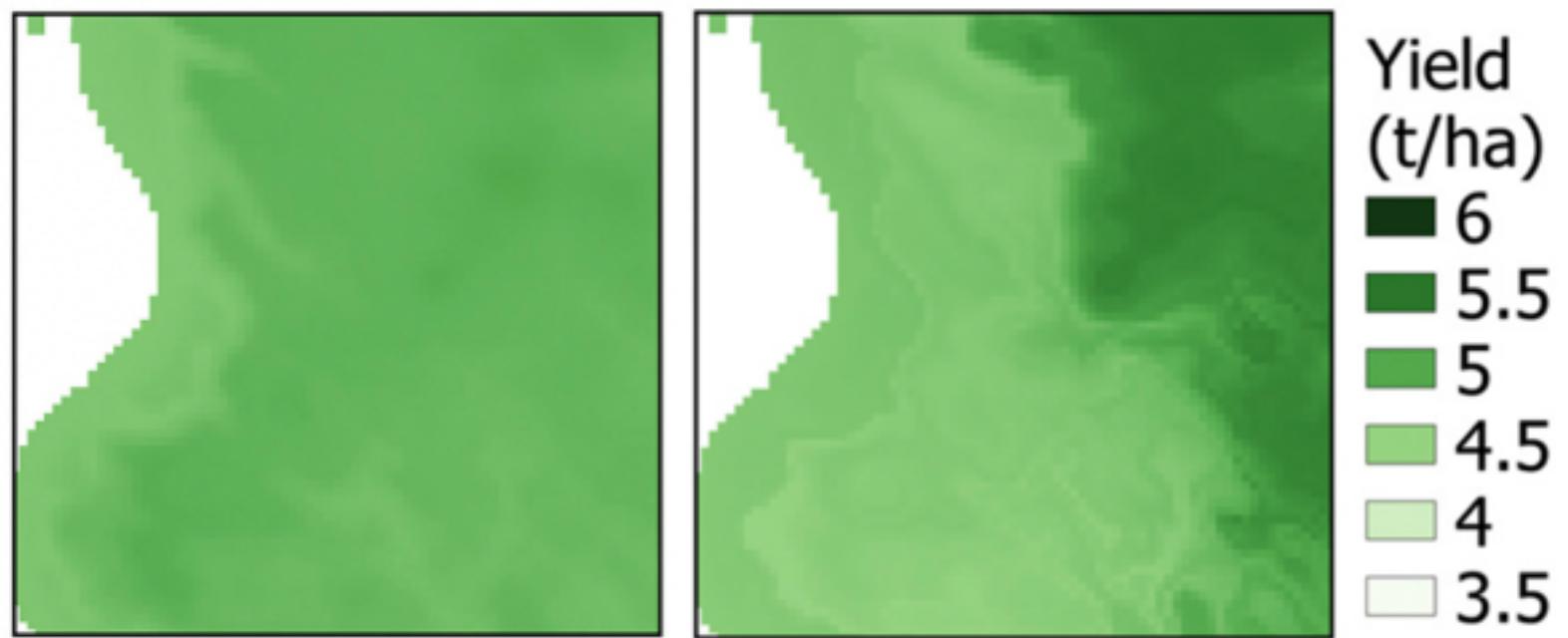
- BSc & MSc University of Pavia (Italy)
- PhD Massey University (New Zealand)
- PostDoc University of Exeter (UK)
- PostDoc Rothamsted Research (UK)

[www.lucabutikofer.name](http://www.lucabutikofer.name)



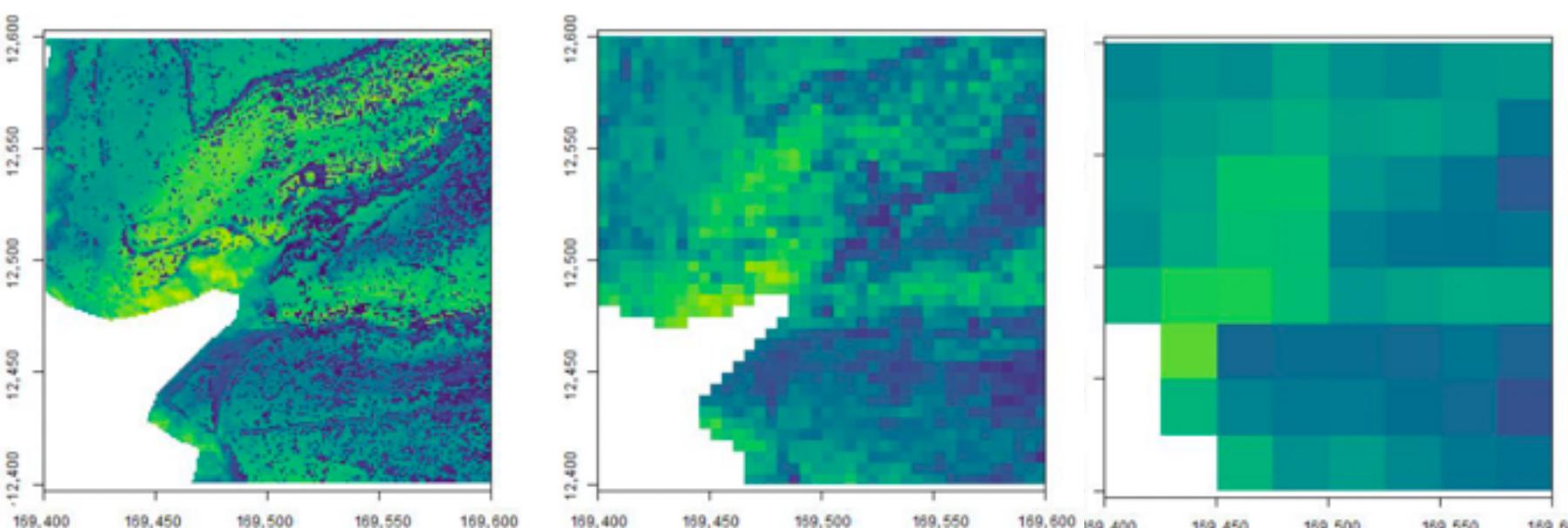
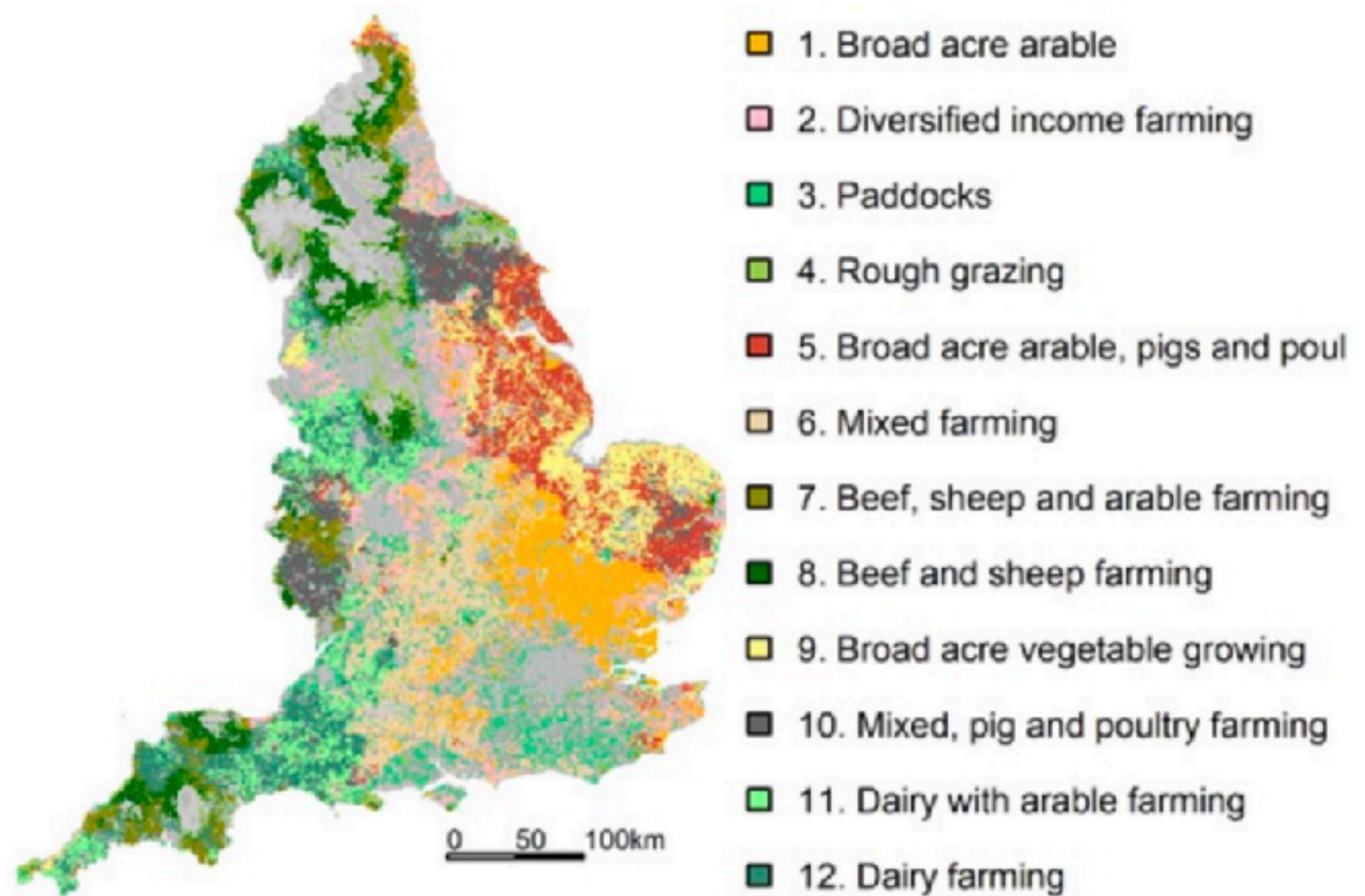
# Luca Bütkofer

## Spatial- Agro- Macro- Ecologist



### PostDoctoral research:

- Scale in biological systems
- Microclimate and agriculture
- Farming system's sustainability and ecosystem services
- Land-use change



# **Environmental Data**

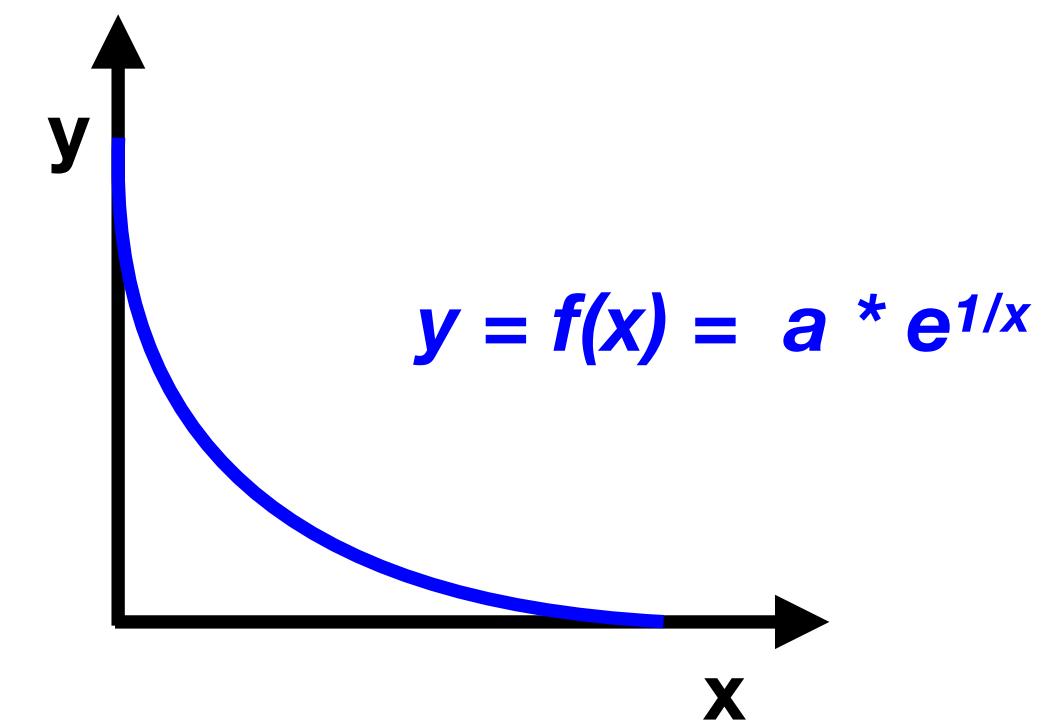
**Wallace Component “3 Env Data”**

# Environmental Data

These are the model's explanatory variables

What explains the distribution of the species?

- y: number of mice observations
- x, explanatory variable: proximity to cheese
- a: steepness of decay
- e: 2.71828 (constant)



# **Environmental Data**

**These are the model's explanatory variables**

What determines the species distribution?

- Typical examples:

# Environmental Data

These are the model's explanatory variables

What determines the species distribution?

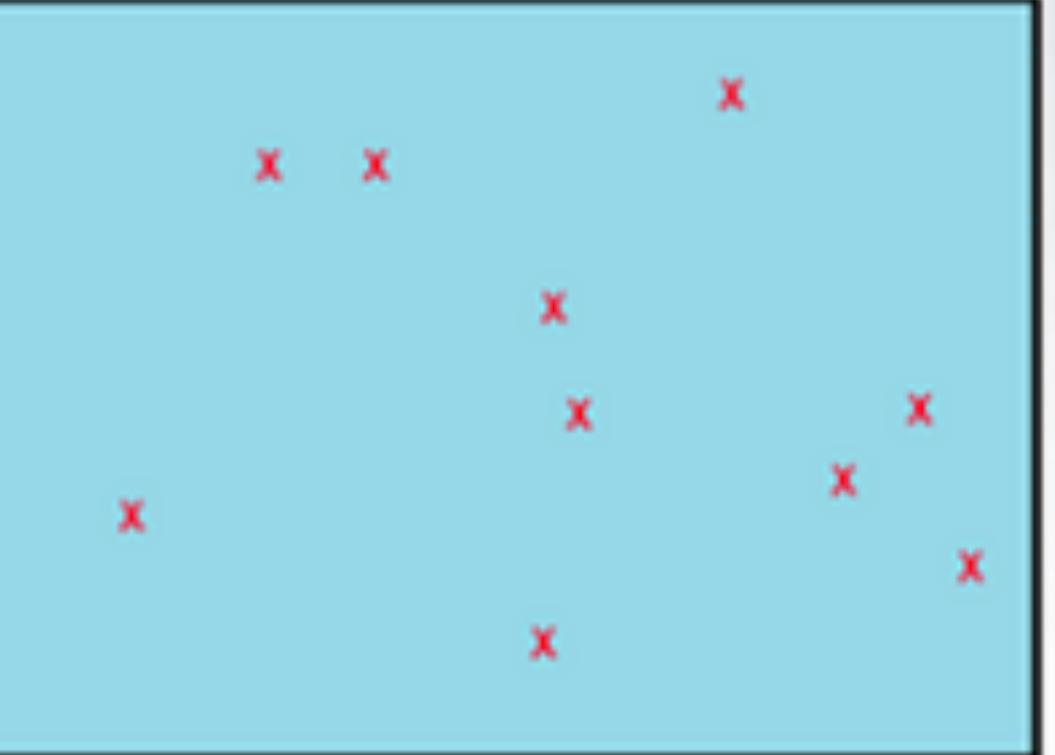
- Typical examples:
  - Climate
  - Geology
  - Soil
  - Hydrology
- Land-use / land-cover
- Distance to...
- Moving windows

# Environmental Data

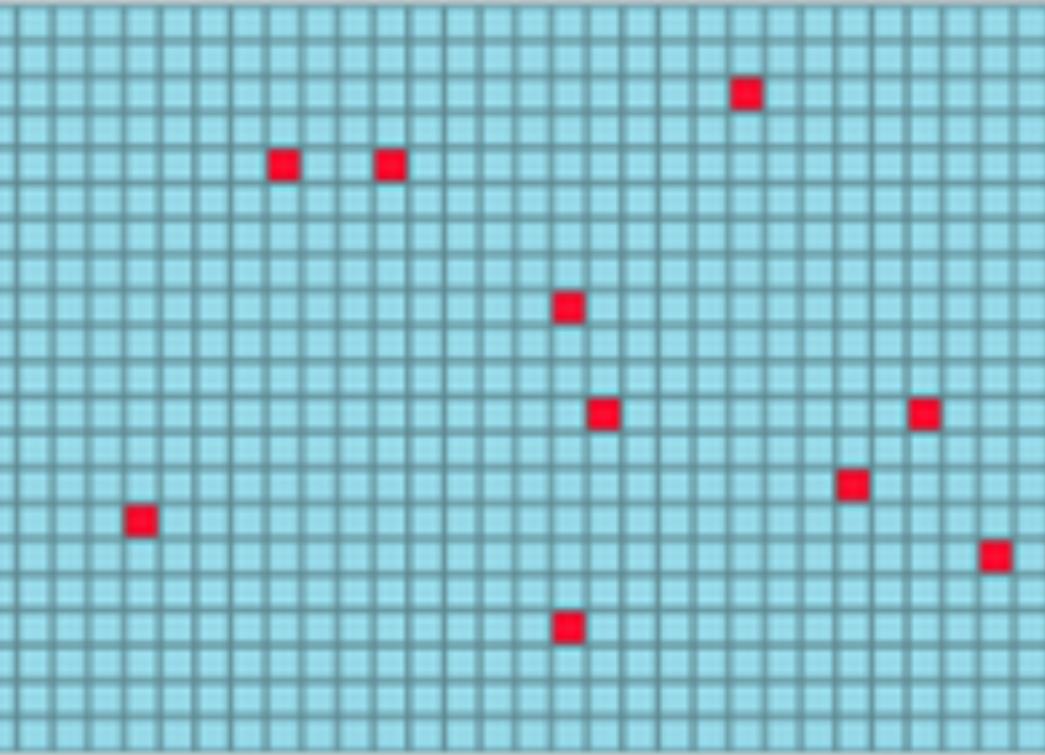
## The raster format

Two main geographic data formats:

- Vectorial
  - Point
  - Line
  - Polygon
- Raster



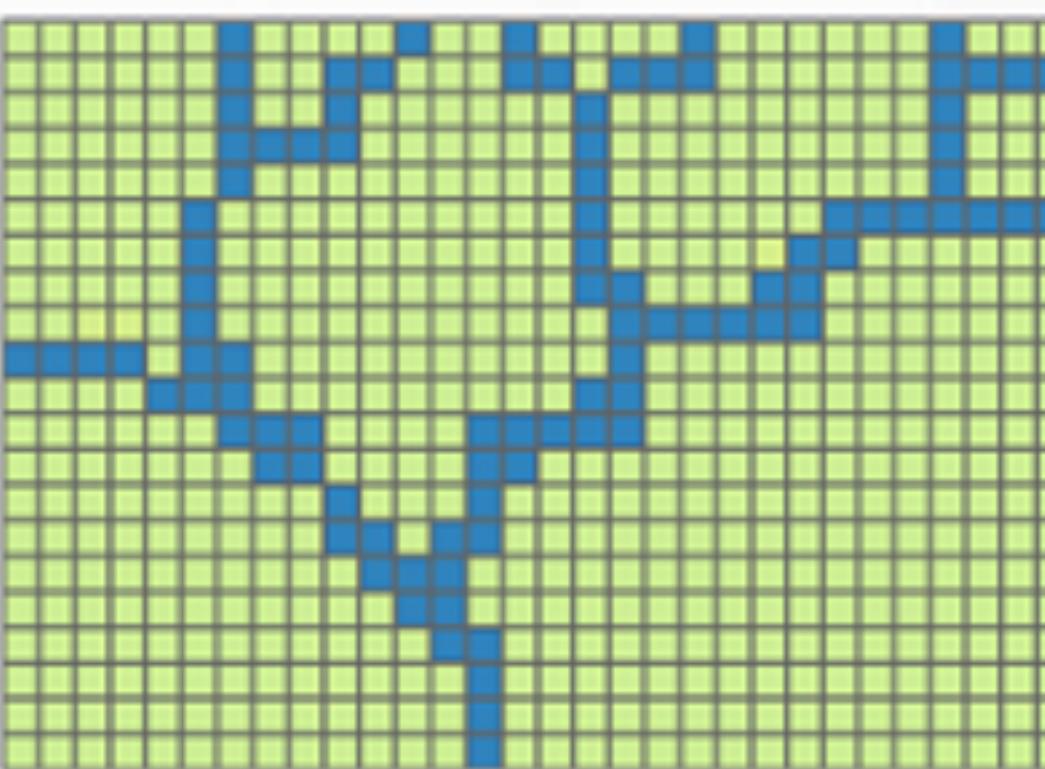
Point features



Raster point features



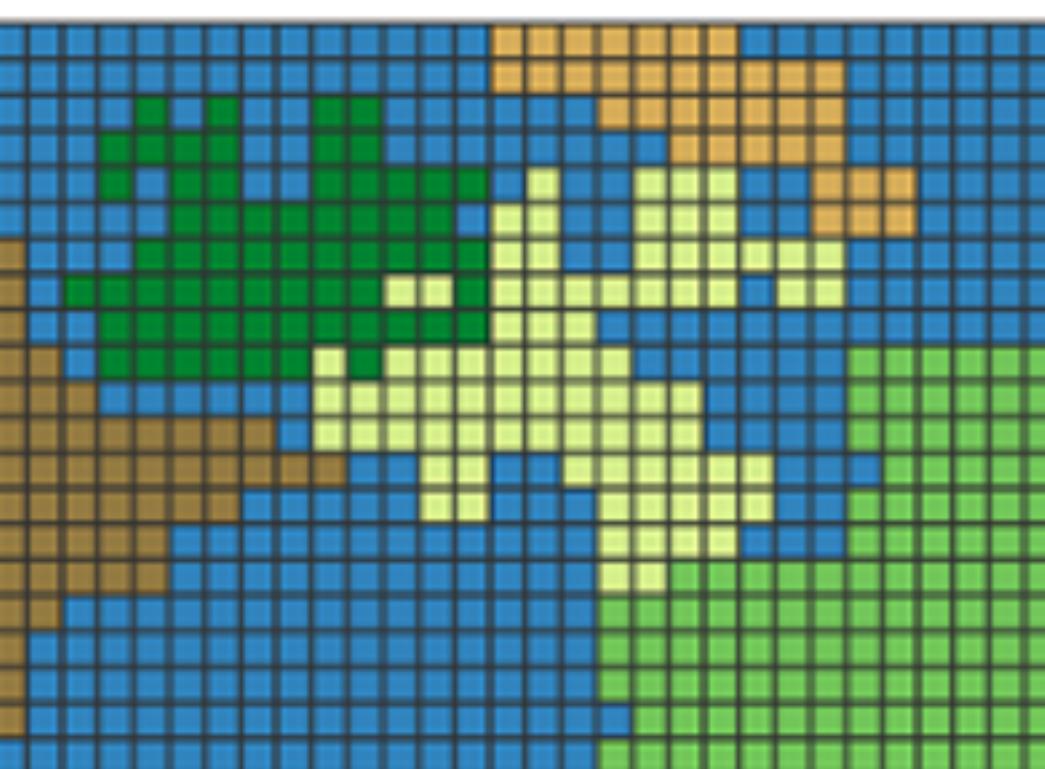
Line features



Raster line features



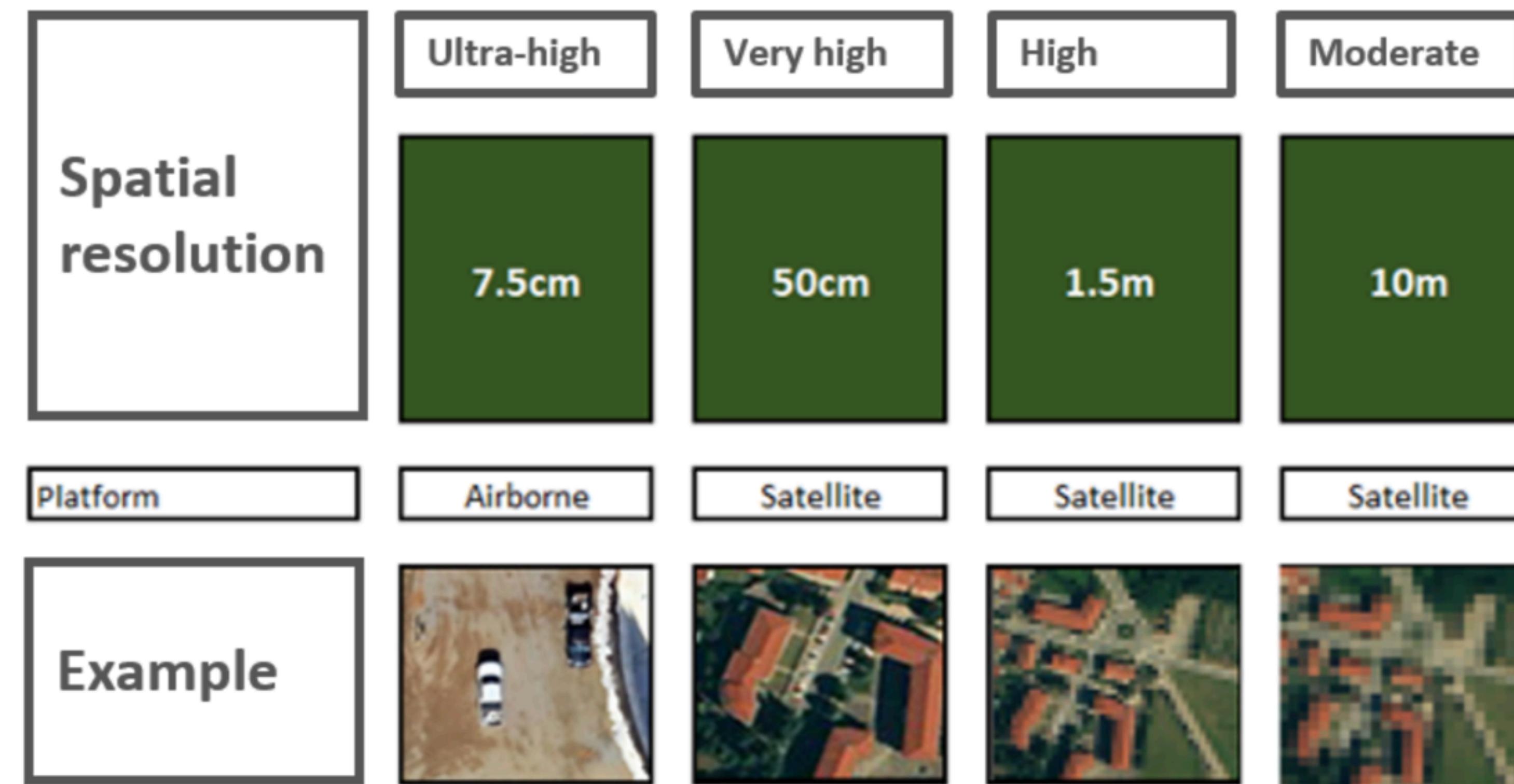
Polygon features



Raster polygon features

# Environmental Data Scale

Work at the **characteristic scale** of the phenomenon you are modelling



# Environmental Data Scale

Don't know the resolution?

- Multiple scales
- Scale-based decomposition of landscape features into different variables

JOURNAL OF GEOPHYSICAL RESEARCH  
**Earth Surface**

AN AGU JOURNAL

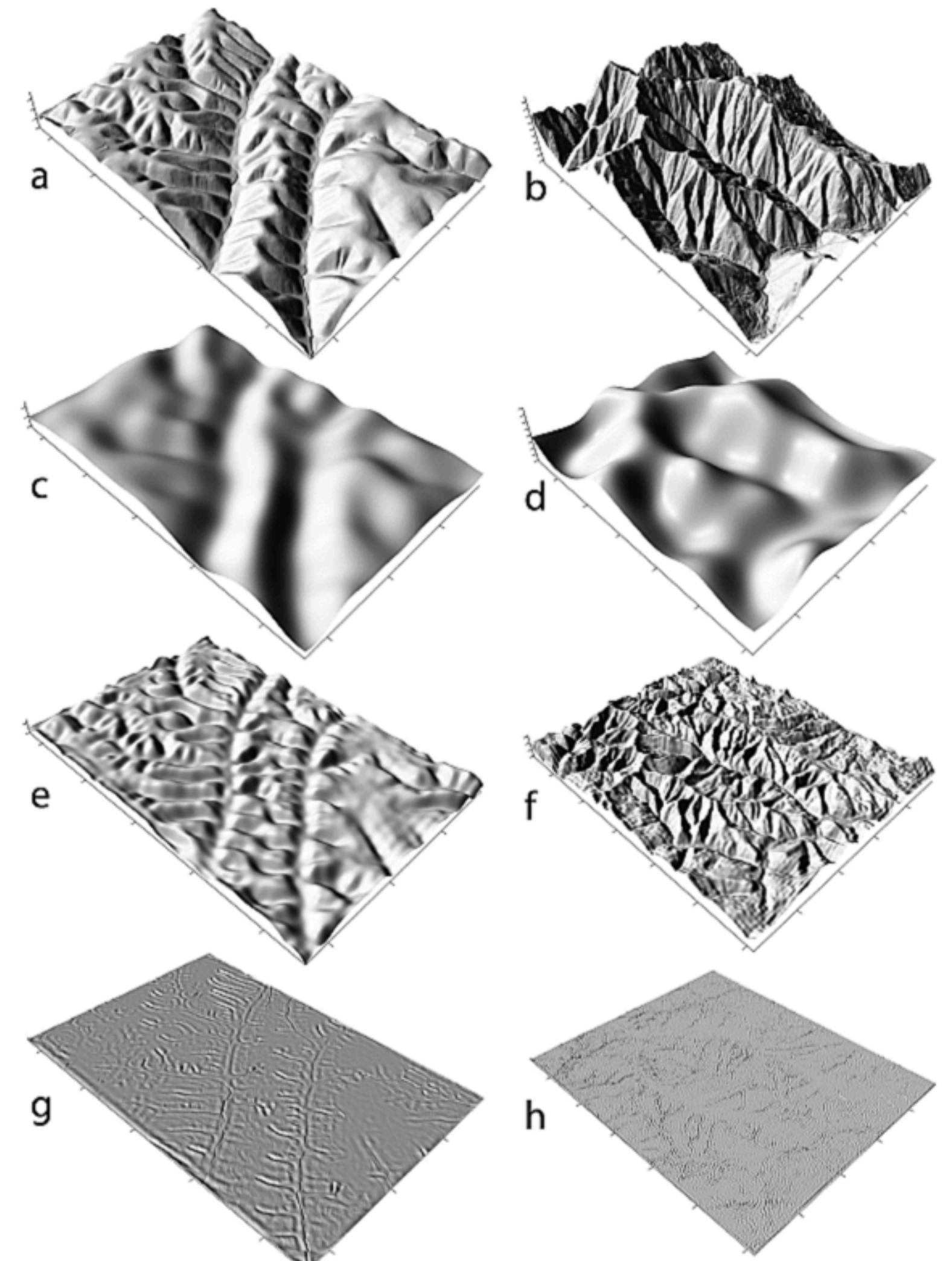
|  Free Access

Spectral signatures of characteristic spatial scales and nonfractal structure in landscapes

J. Taylor Perron , James W. Kirchner, William E. Dietrich

First published: 07 October 2008 | <https://doi.org/10.1029/2007JF000866> | Citations: 111

Example landscapes:



Large valleys:

Smaller valleys:

Terrain roughness:

# Environmental Data

## Climatic variables

WorldClim Bioclims:

- From the monthly temperature and rainfall values to generate more biologically meaningful variables.
- Annual trends (e.g., mean annual temperature, annual precipitation)
- Seasonality (e.g., annual range in temperature and precipitation)
- Extreme or limiting environmental factors (e.g., temperature of the coldest and warmest month, and precipitation of the wet and dry quarters)

BIO1 = Annual Mean Temperature

BIO2 = Mean Diurnal Range (Mean of monthly (max temp - min temp))

BIO3 = Isothermality (BIO2/BIO7) (\* 100)

BIO4 = Temperature Seasonality (standard deviation \*100)

BIO5 = Max Temperature of Warmest Month

BIO6 = Min Temperature of Coldest Month

BIO7 = Temperature Annual Range (BIO5-BIO6)

BIO8 = Mean Temperature of Wettest Quarter

BIO9 = Mean Temperature of Driest Quarter

BIO10 = Mean Temperature of Warmest Quarter

BIO11 = Mean Temperature of Coldest Quarter

BIO12 = Annual Precipitation

BIO13 = Precipitation of Wettest Month

BIO14 = Precipitation of Driest Month

BIO15 = Precipitation Seasonality (Coefficient of Variation)

BIO16 = Precipitation of Wettest Quarter

BIO17 = Precipitation of Driest Quarter

BIO18 = Precipitation of Warmest Quarter

BIO19 = Precipitation of Coldest Quarter

# Environmental Data

## Climatic variables



### WorldClim

WorldClim is a set of global climate layers (gridded climate data) with a spatial resolution of about 1 km<sup>2</sup>. These data can be used for mapping and spatial modeling.

The new **Version 2.0** is now available (current climate only --- more coming soon)

The old version is **Version 1.4**.

For this version you can get data for past, current and future climates.

[Read more](#)

# Environmental Data

## Climatic variables

### Alternatives to Bioclims

- CHELSA, <https://chelsa-climate.org>

Home      Downloads      Daily timeseries      Monthly timeseries      Bioclimate / Köppen-Geiger      Future

Paleo Climate      Climate diagrams



*Climatologies at high resolution for the earth's land surface areas*

# Environmental Data

## Land-use / land-cover

ESA WorldCover data set at 0.3-seconds resolution (<https://esa-worldcover.org/en>)



### Worldwide land cover mapping

WorldCover provides a new baseline global land cover product at 10 m resolution for 2020 based on Sentinel-1 and 2 data that was developed and validated in almost near-real time and at the same time maximizes the impact and uptake for the end users.

A tremendous step forward towards the joint use of Sentinel satellite data for worldwide land cover mapping.

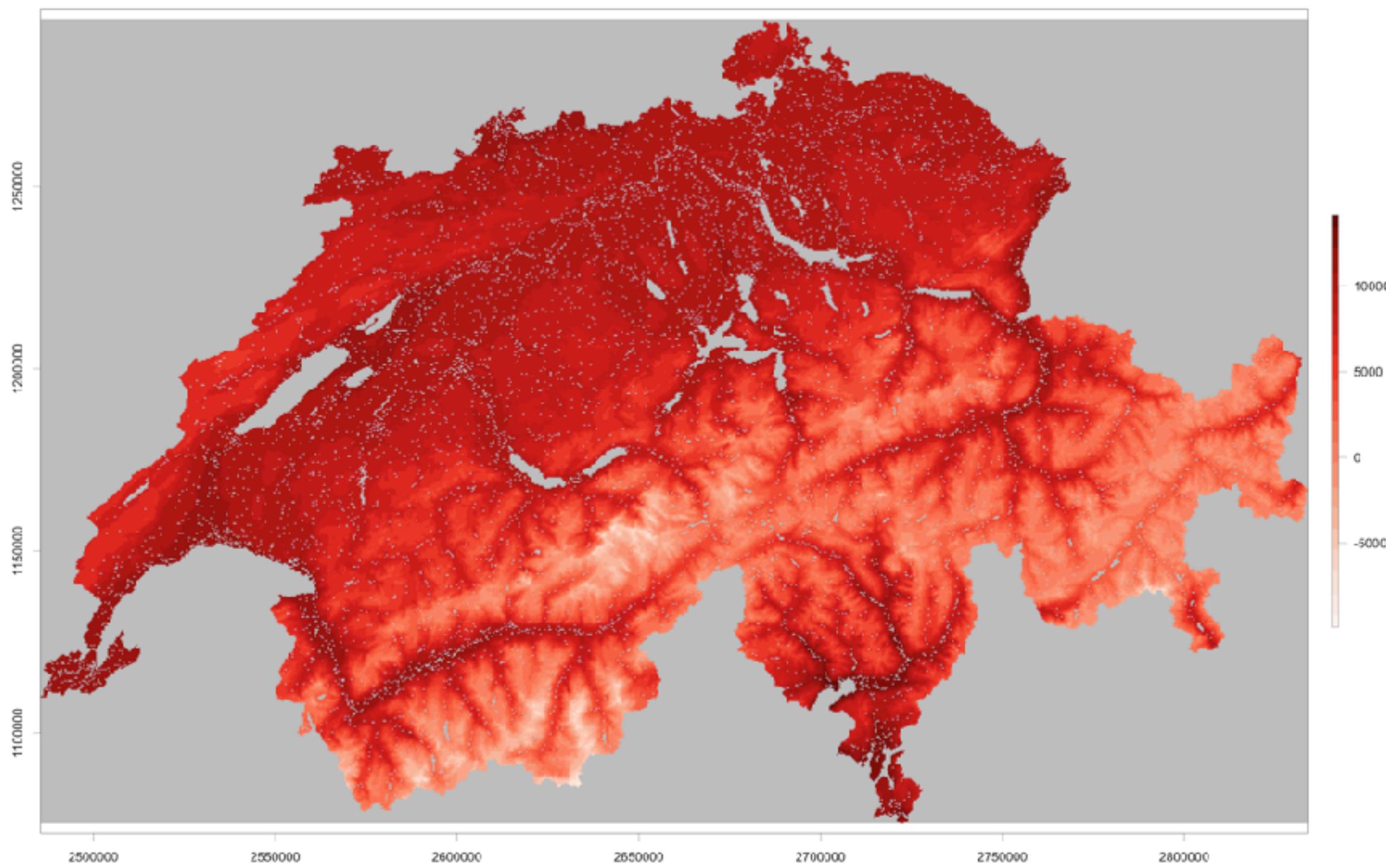
[EXPLORE >](#)



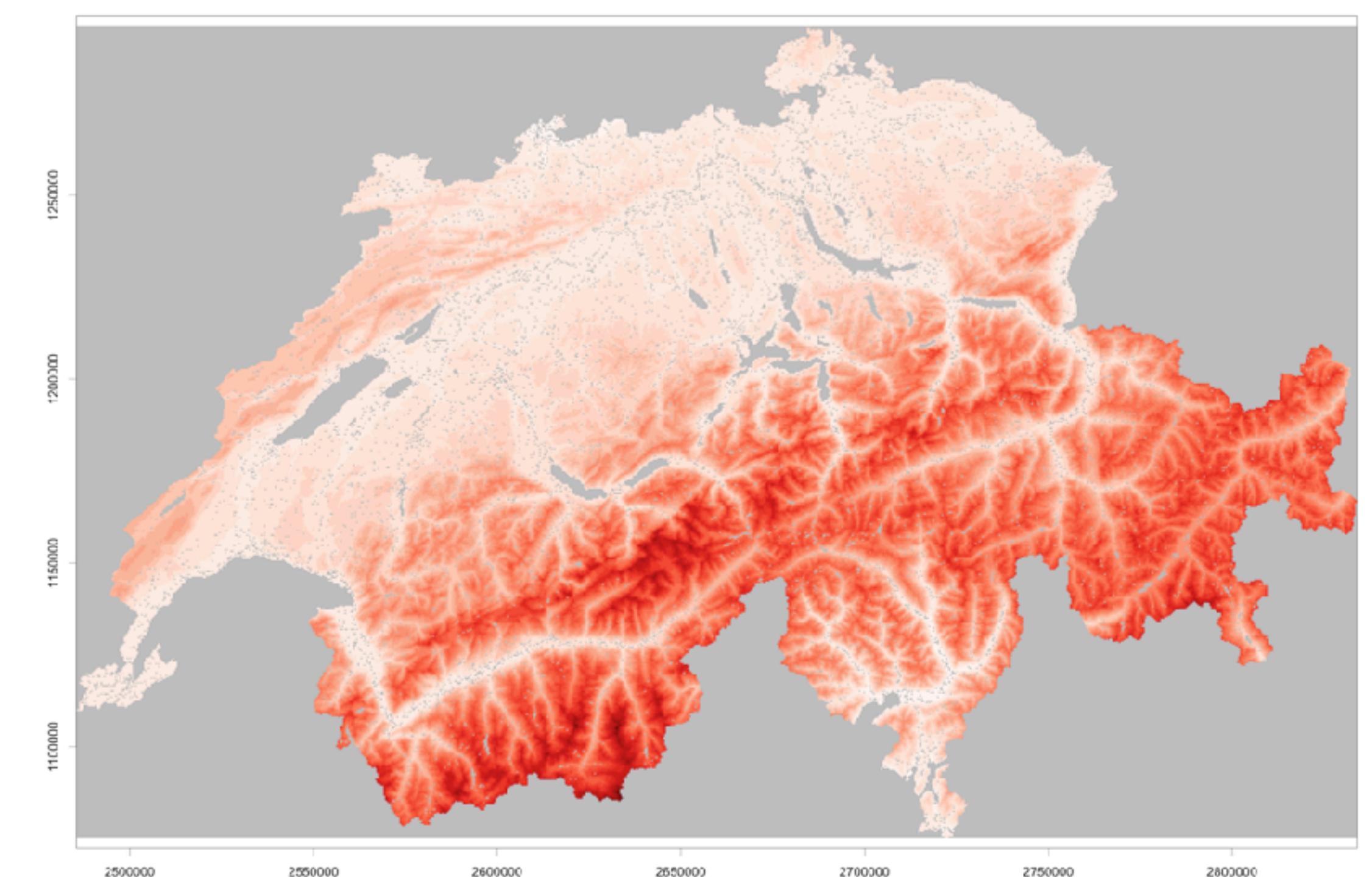
# Environmental Data

Notice anything suspicious about these two variables?

Temperature



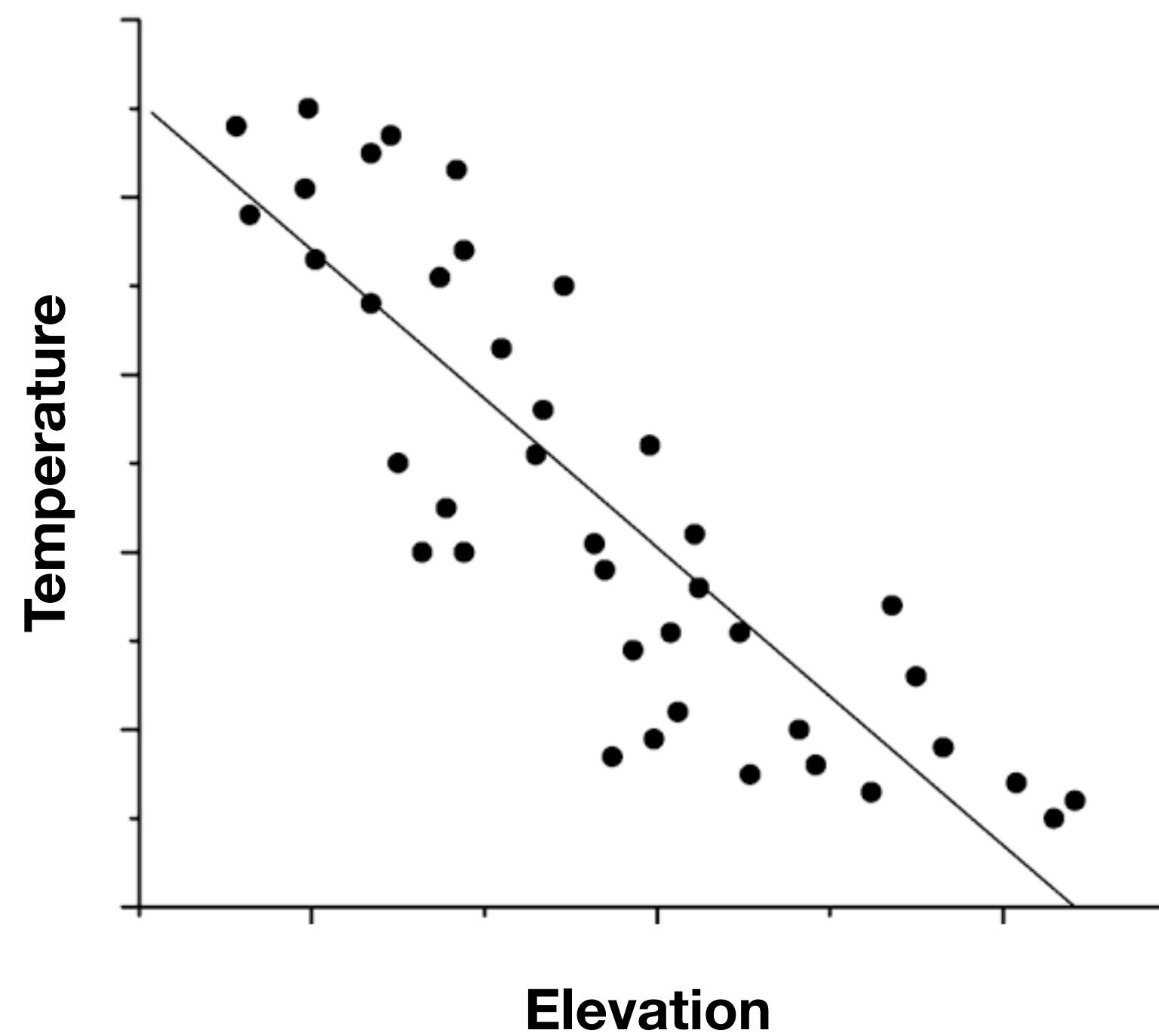
Elevation



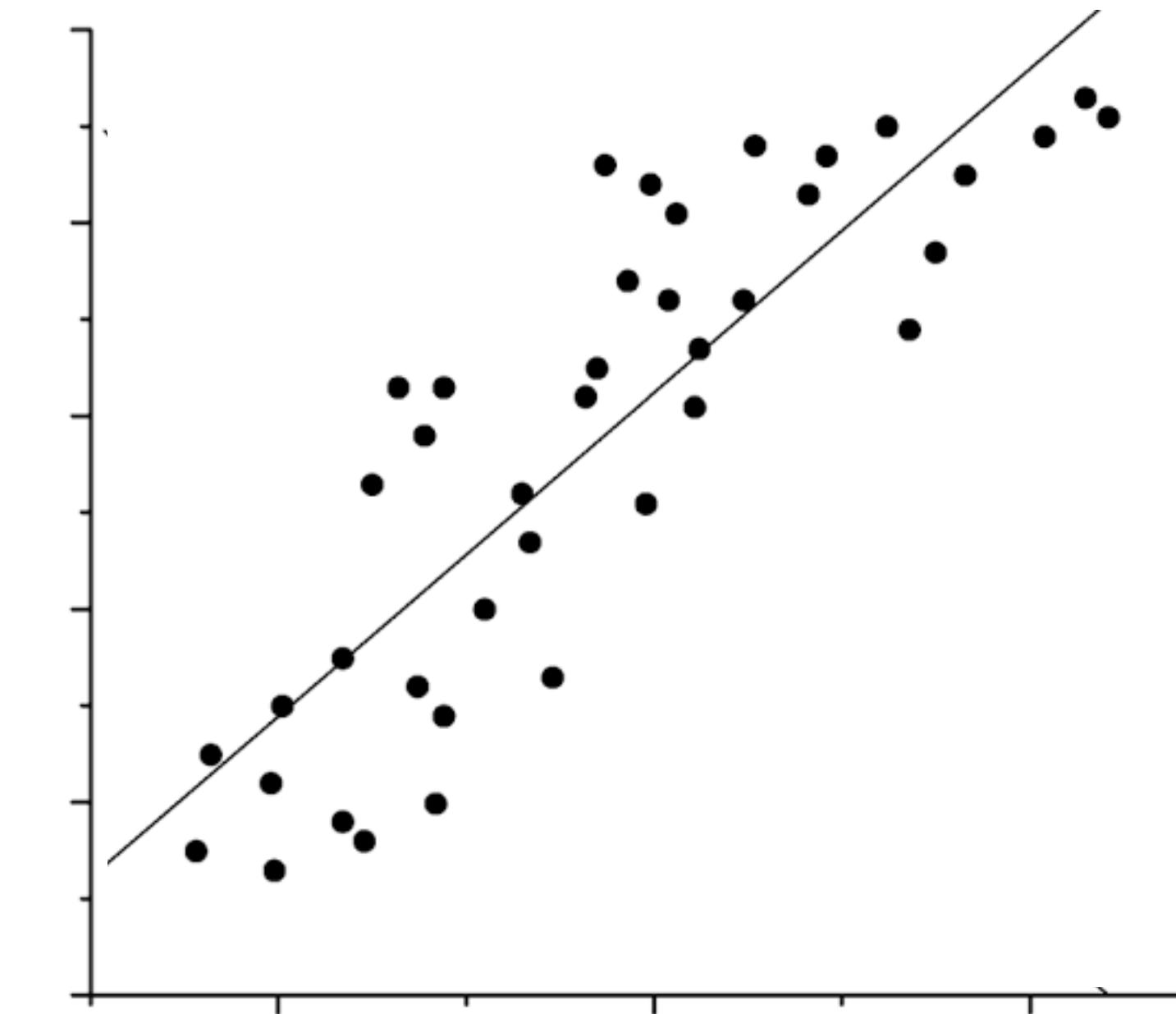
# Environmental Data

## Variables correlation

Negative correlation

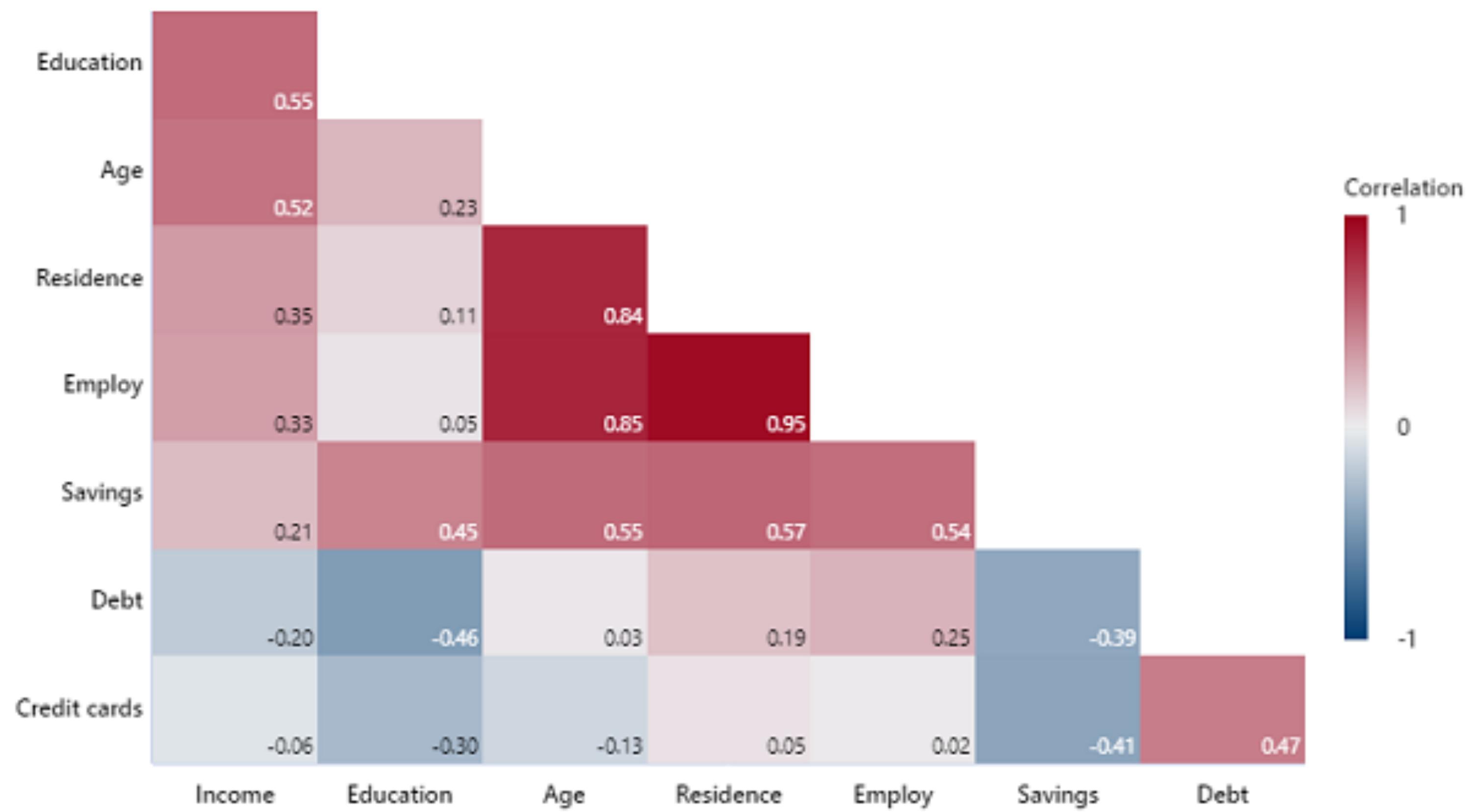


Positive correlation



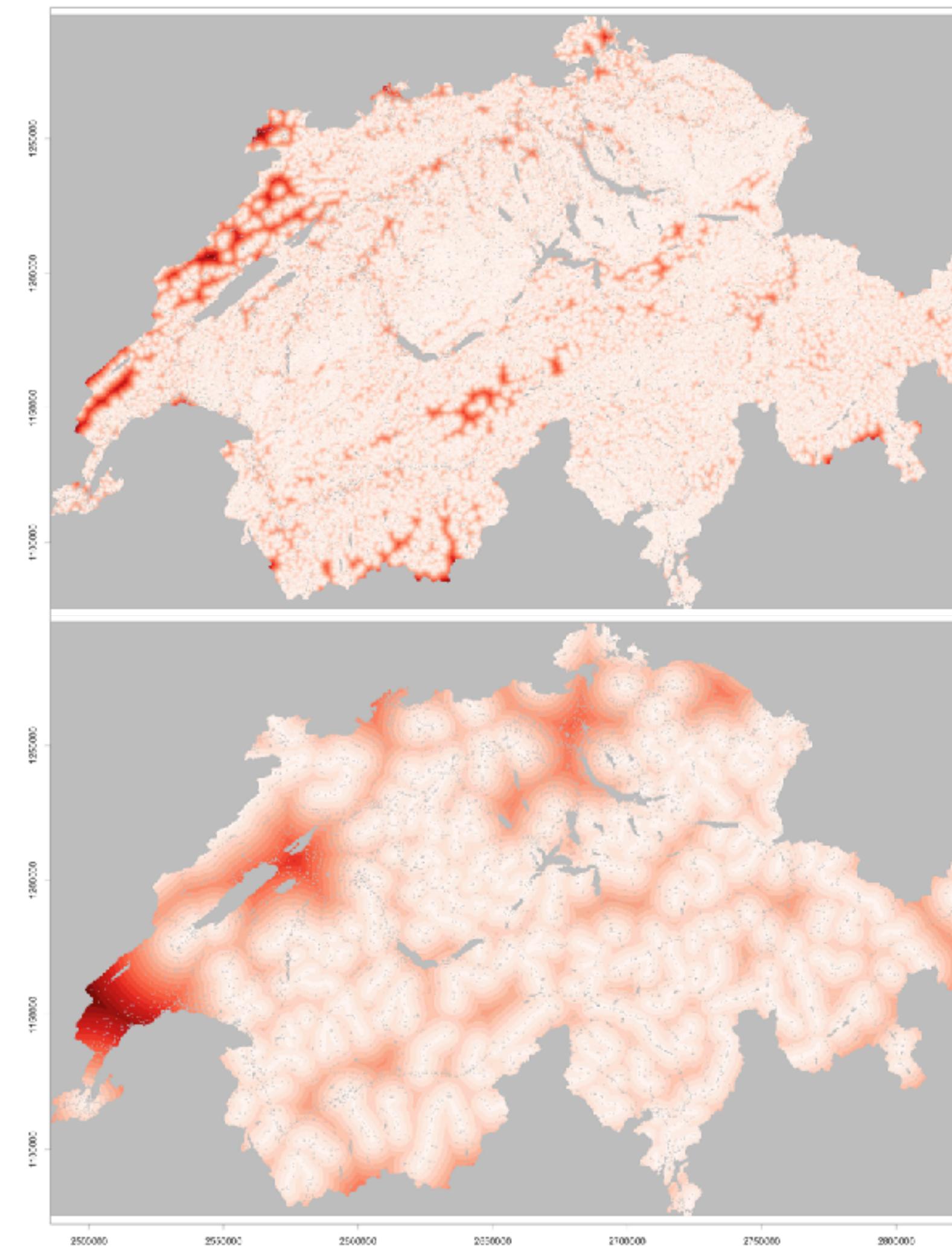
# Environmental Data

## Variables correlogram

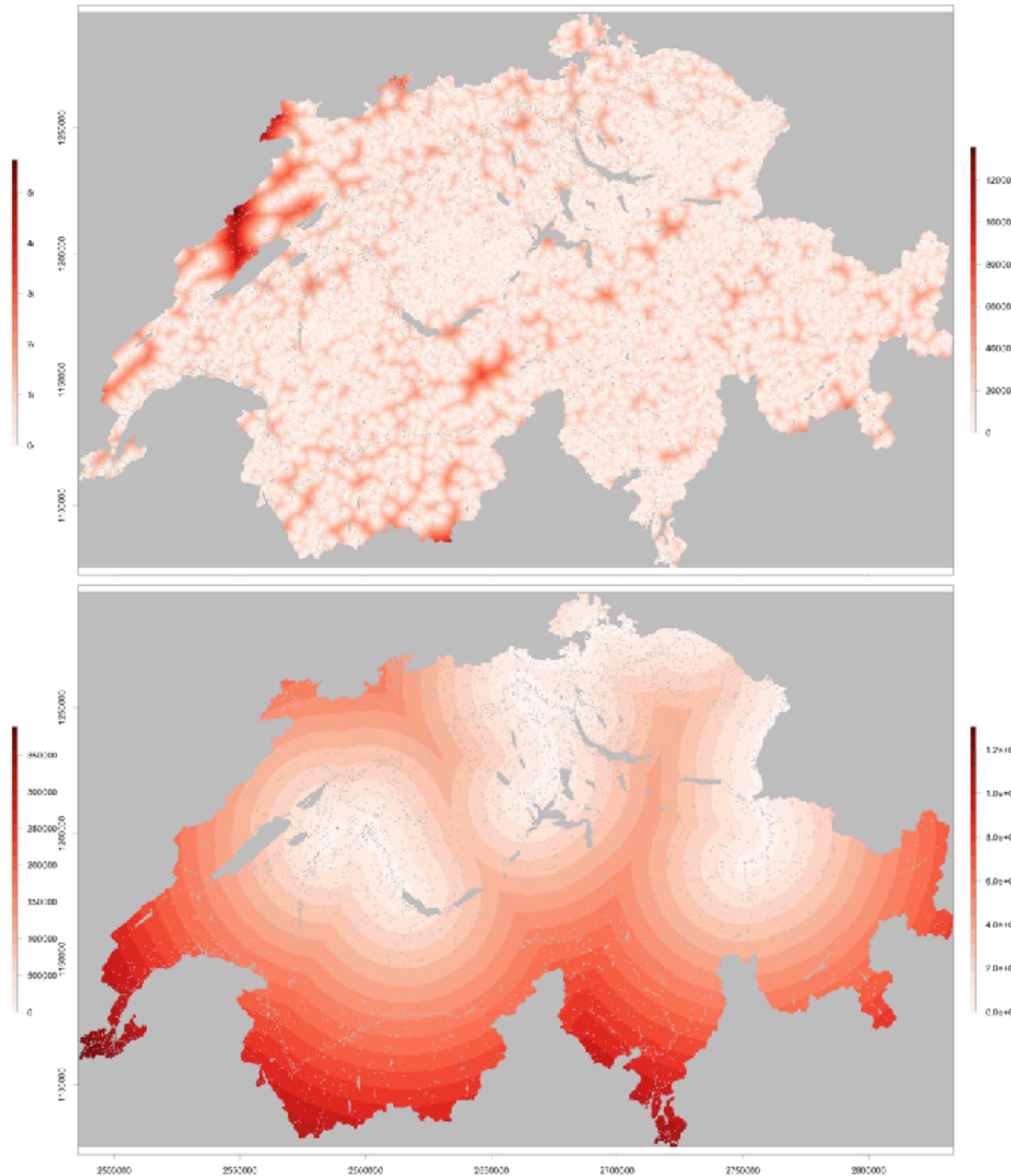


# Environmental Data

Distance to...

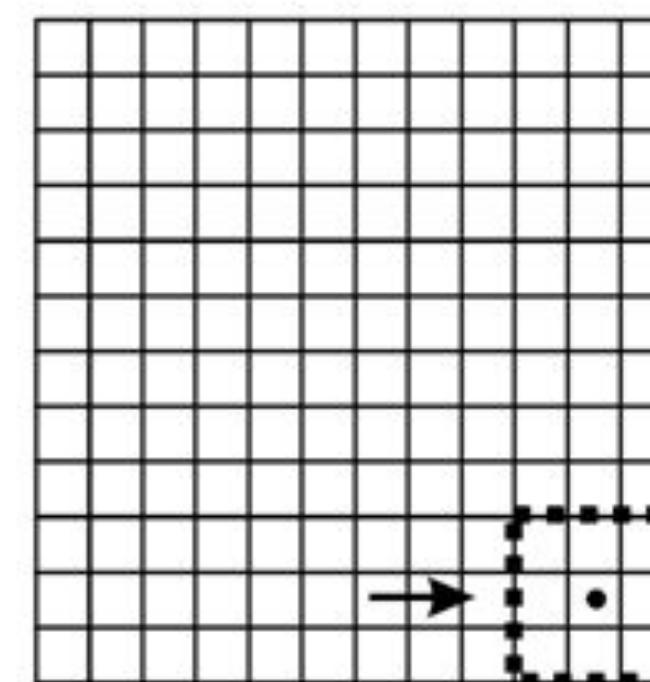
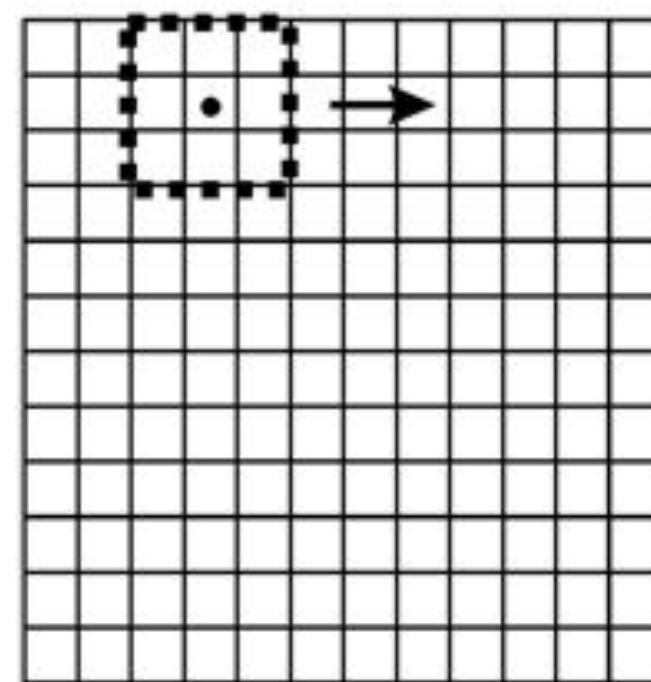
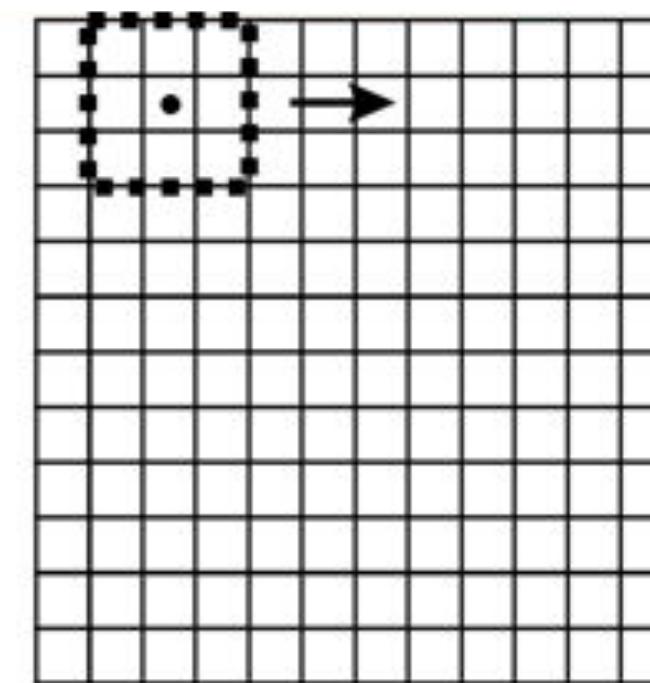
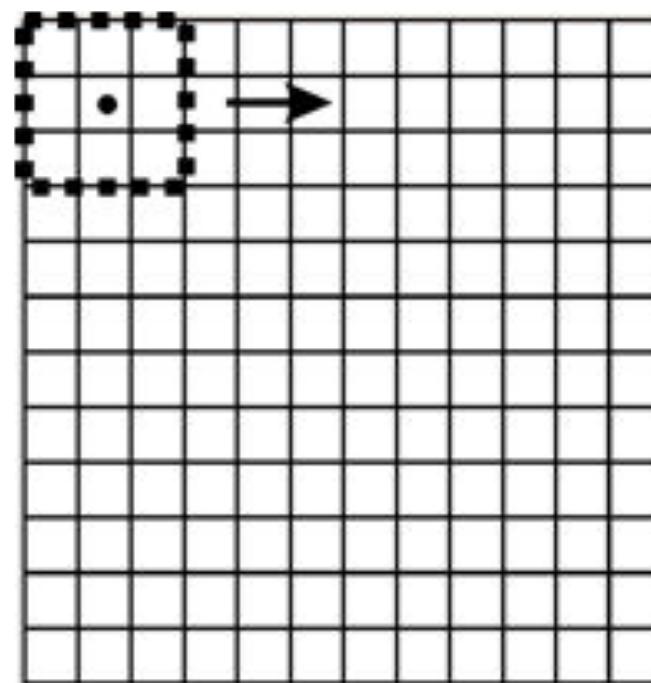


Rivers of different sizes

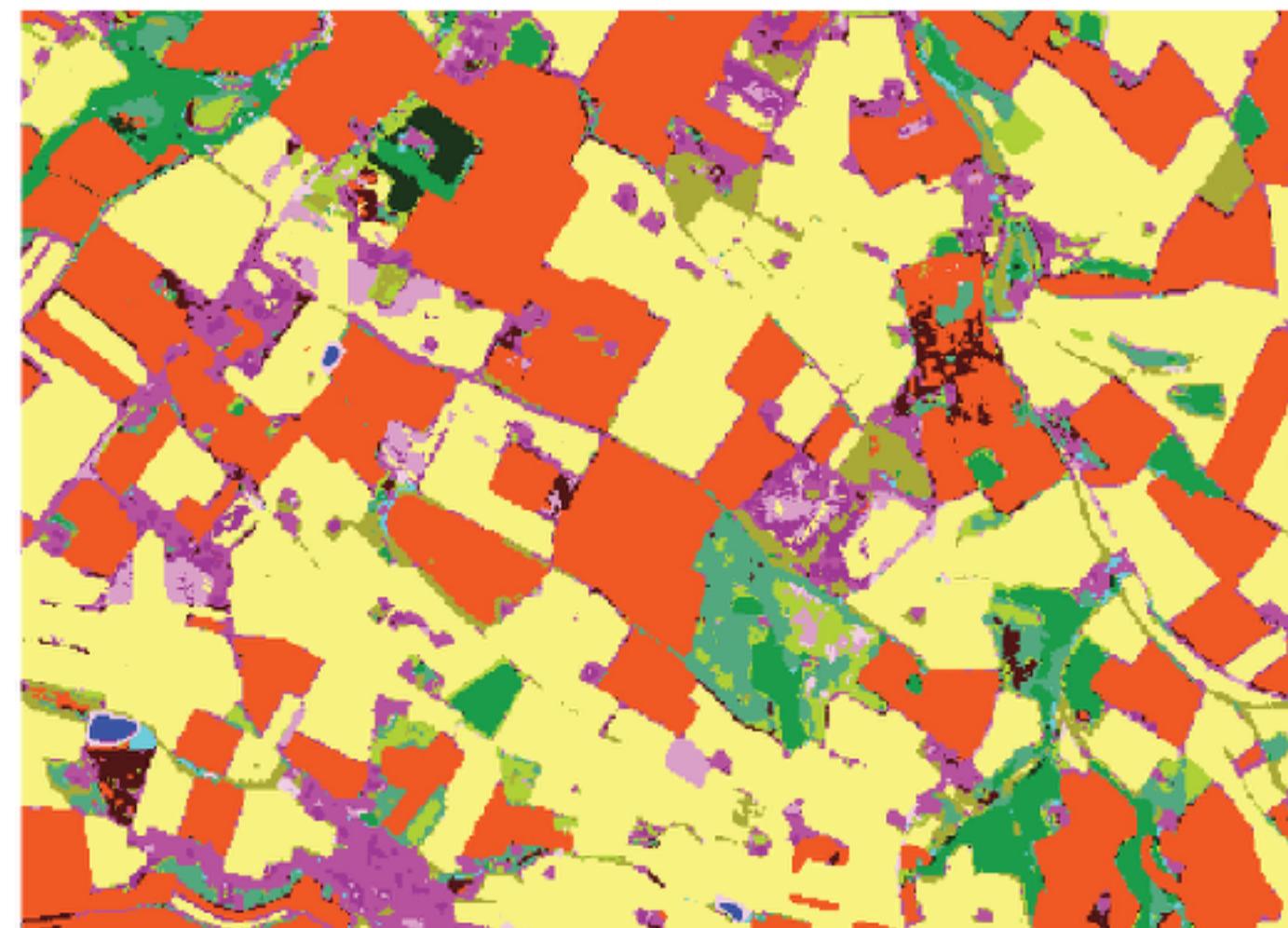


# Environmental Data

## Moving windows

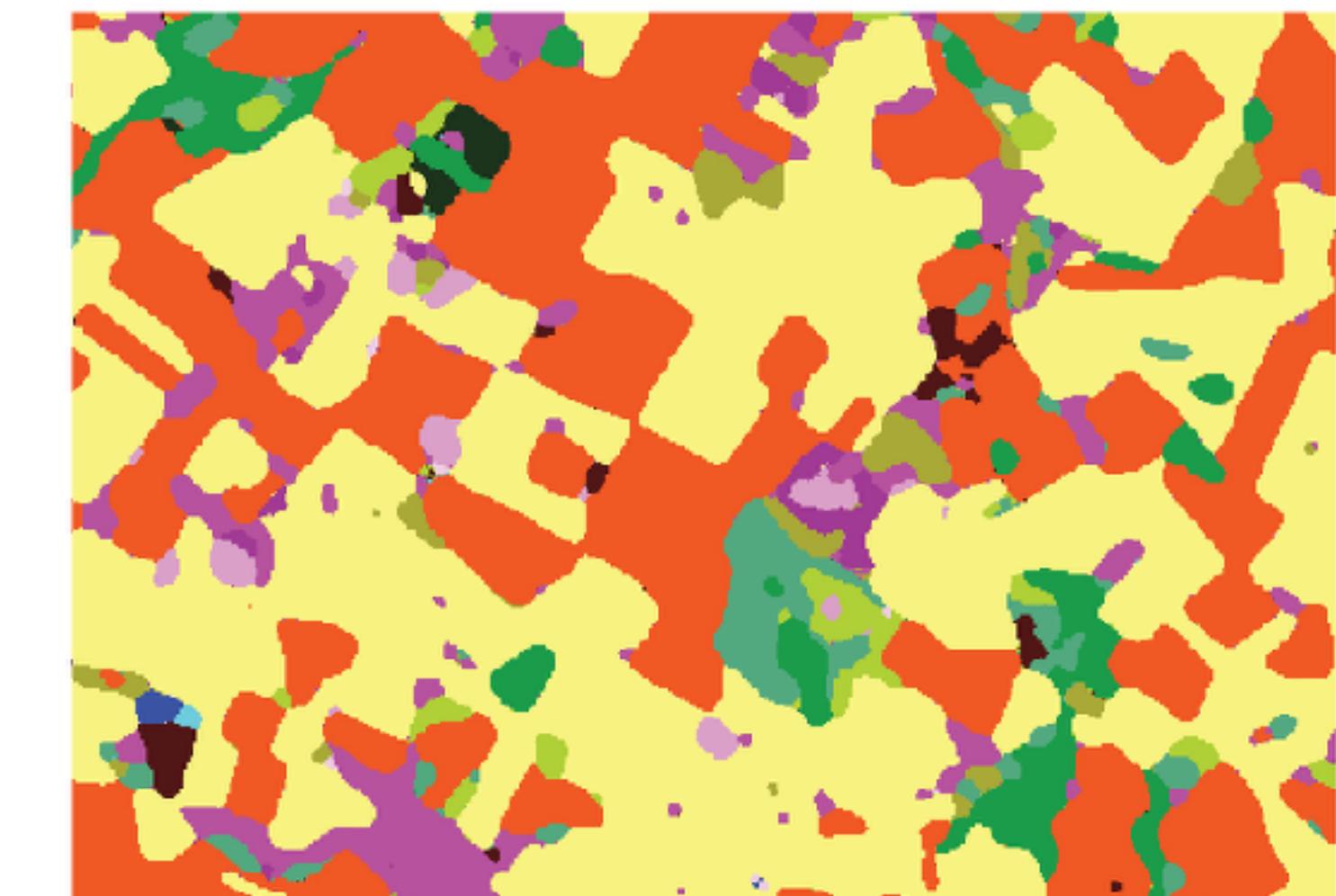


Original



Noise reduction

11x11 px.  
Moving Window Majority



Open Access Article

A Metric for Evaluating the Geometric Quality of Land Cover Maps Generated with Contextual Features from High-Dimensional Satellite Image Time Series without Dense Reference Data

by Dawa Derkaen<sup>1\*</sup>, Jordi Ingla<sup>1,2</sup> and Julien Michel<sup>2</sup>

ORCID

<sup>1</sup> CESBIO, CNES, CNRS, IRD, UPS, Université de Toulouse, 31400 Toulouse, France

<sup>2</sup> Centre National d'Etudes Spatiales, 18 avenue Edouard Belin, 31400 Toulouse, France

\* Author to whom correspondence should be addressed.

Annual Summer Crops	Continuous Urban Fabric
Annual Winter Crops	Discontinuous Urban Fabric
Orchards	Industrial or Commercial Units
Vineyards	Road Surfaces
Intensive Grasslands	Woody Moorlands
Natural Grasslands	Coniferous Forests
Water Bodies	Broad-Leaved Forests

# **Processing Environmental Data**

**Wallace Component “Process Env”**

# Processing Environmental Data

## Presence-background SDMs

**Presence-absence**

X	Y	Pres_Abs
50.4082	13.2343	1
49.2938	12.1341	1
51.9349	11.1233	0
52.9392	13.2303	0

**Presence-only or presence-background**

X	Y
50.4082	13.2343
49.2938	12.1341
51.9349	11.1233
52.9392	13.2303

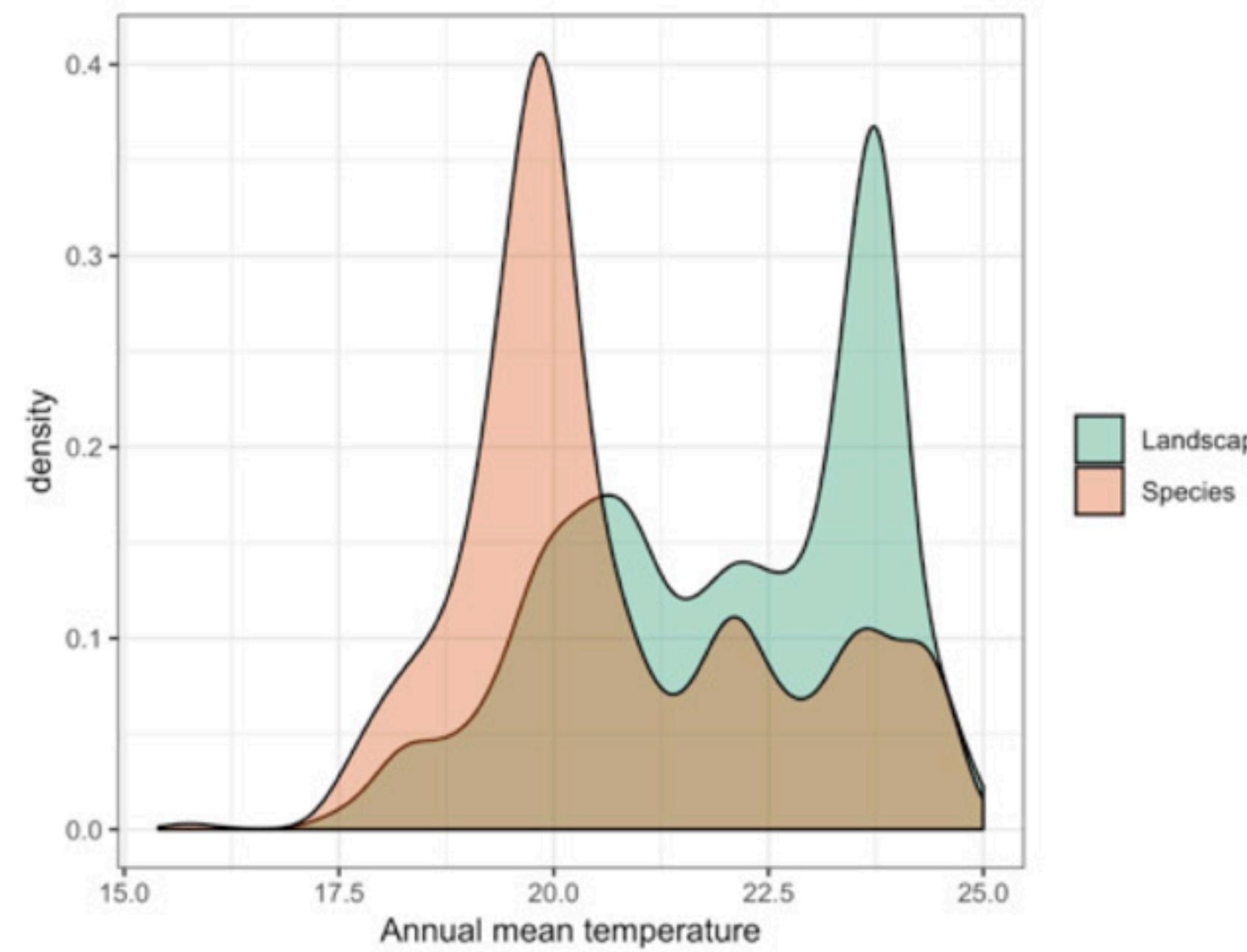
# Processing Environmental Data

## False negatives (false absences) in presence-absence



# Processing Environmental Data

## Presence-background SDMs



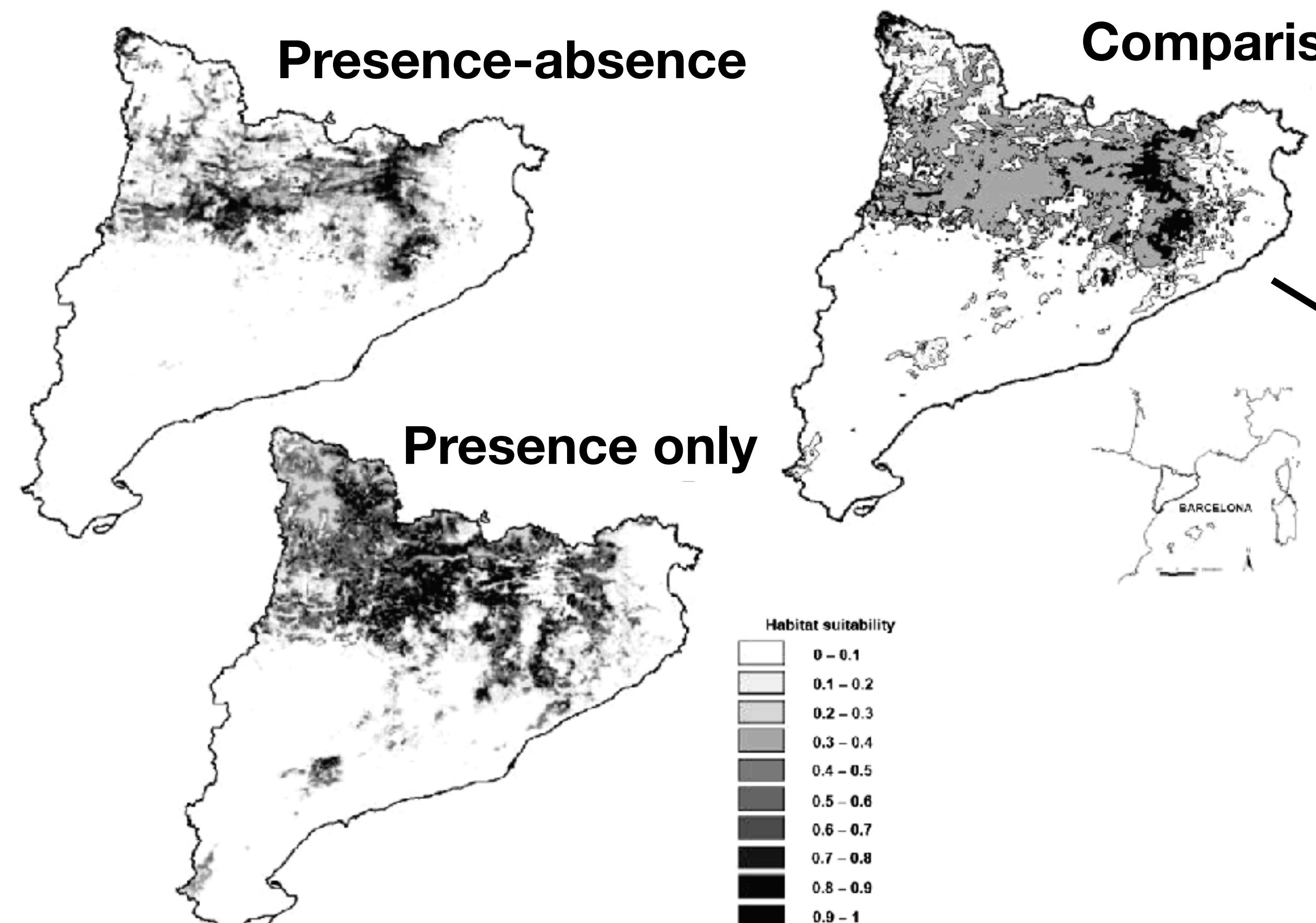
*Biodiversity Informatics*, 15, 2020, pp. 69-80

### PRESENCE-ONLY AND PRESENCE-ABSENCE DATA FOR COMPARING SPECIES DISTRIBUTION MODELING METHODS

JANE ELITH<sup>1\*</sup>, CATHERINE H. GRAHAM<sup>2</sup>, ROOZBEH VALAVI<sup>1</sup>, MEINRAD ABEGG<sup>2</sup>, CAROLINE BRUCE<sup>3</sup>, ANDREW FORD<sup>4</sup>, ANTOINE GUISAN<sup>5</sup>, ROBERT J. HIJMANS<sup>6</sup>, FALK HUETTMANN<sup>7</sup>, LUCIA LOHMANN<sup>8</sup>, BETTE LOISELLE<sup>9</sup>, CRAIG MORITZ<sup>10</sup>, JAKE OVERTON<sup>11</sup>, A. TOWNSEND PETERSON<sup>12</sup>, STEVEN PHILLIPS<sup>13</sup>, KAREN RICHARDSON<sup>14</sup>, STEPHEN E. WILLIAMS<sup>15</sup>, SUSAN K. WISER<sup>16</sup>, THOMAS WOHLGEMUTH<sup>2</sup>, NIKLAUS E. ZIMMERMANN<sup>2</sup>

# Processing Environmental Data

## Presence-background VS. Presence-absence



ECOGRAPHY 27: 437–448, 2004

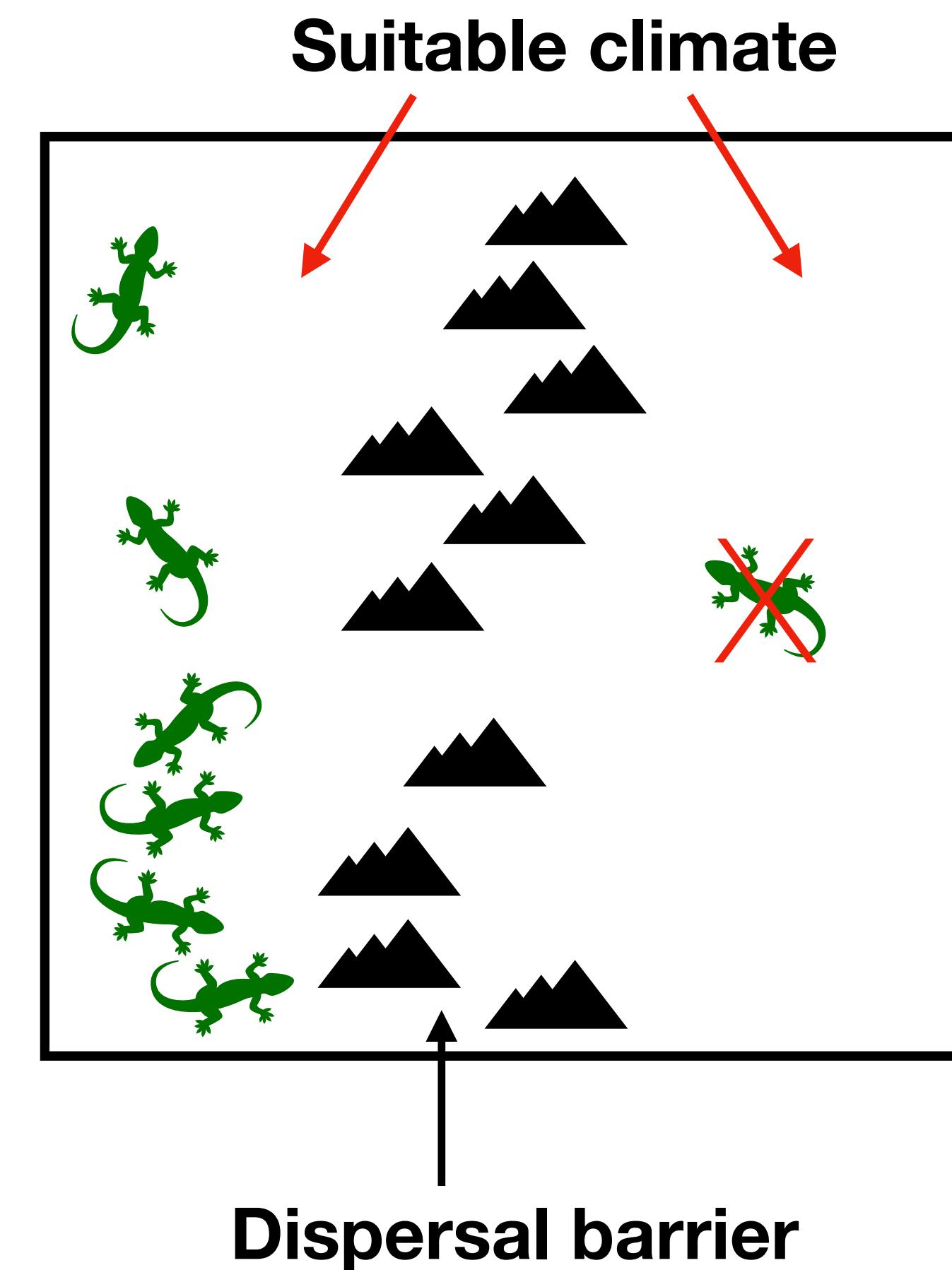
Presence-absence versus presence-only modelling methods for predicting bird habitat suitability

Lluís Brotons, Wilfried Thuiller, Miguel B. Araújo and Alexandre H. Hirzel

- Black: presence-only predicted species absence and presence-absence presence.
- Light grey (difficult to see): presence-only predicted presence and presence-absence absence.
- Dark grey: coincidence in model predictions.

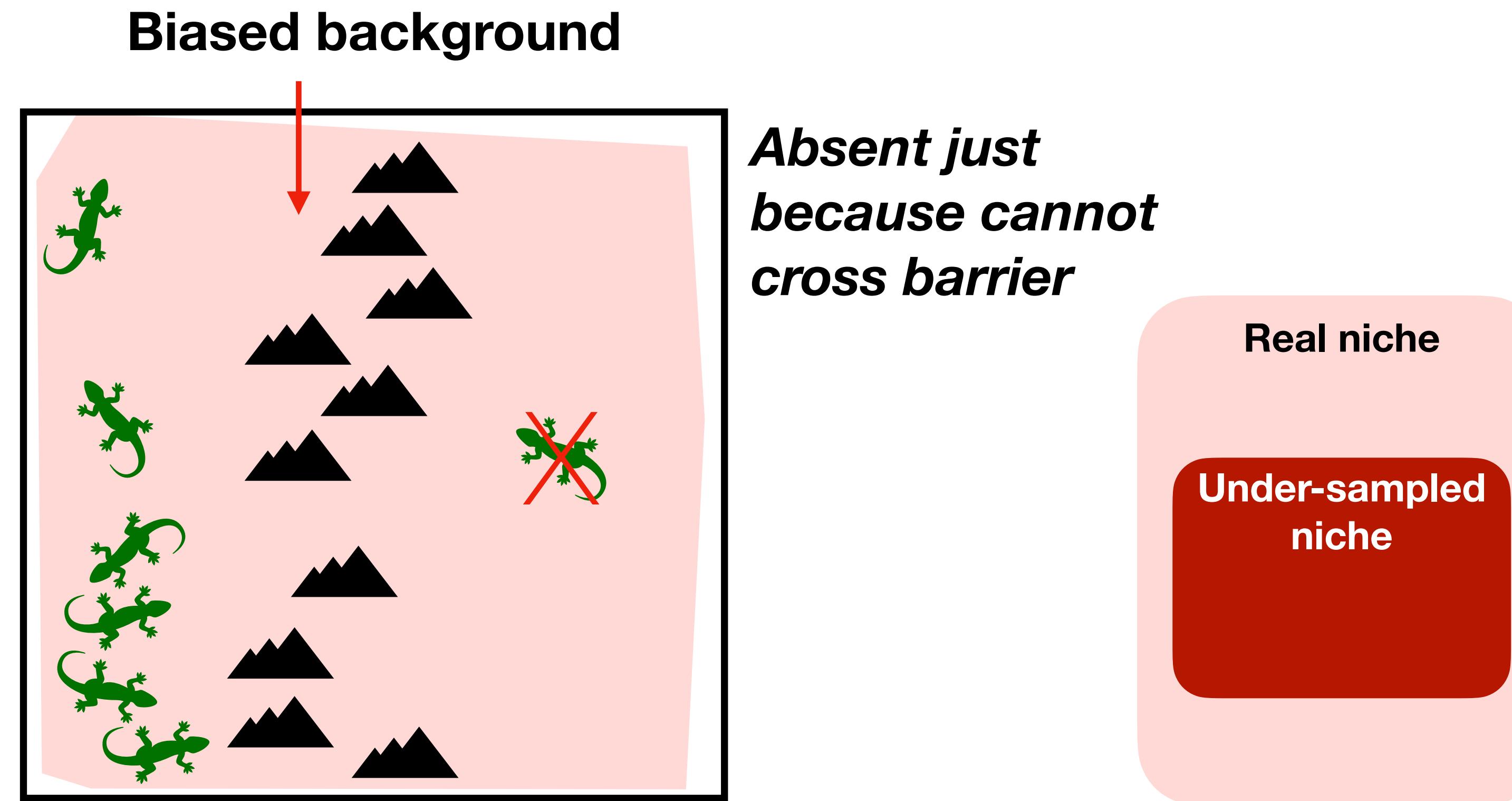
# Processing Environmental Data

## Historical dispersal and background selection



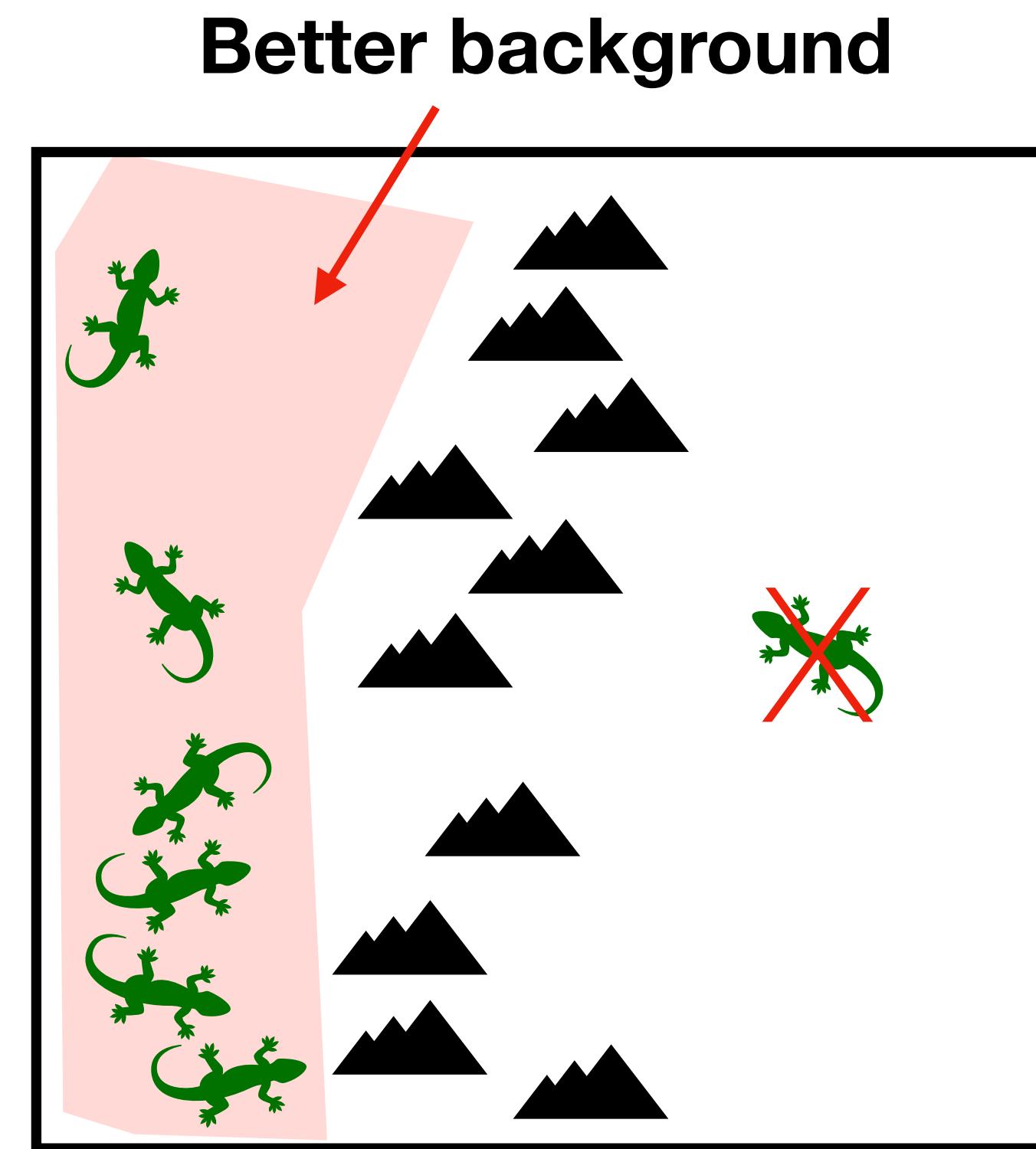
# Processing Environmental Data

## Historical dispersal and background selection



# Processing Environmental Data

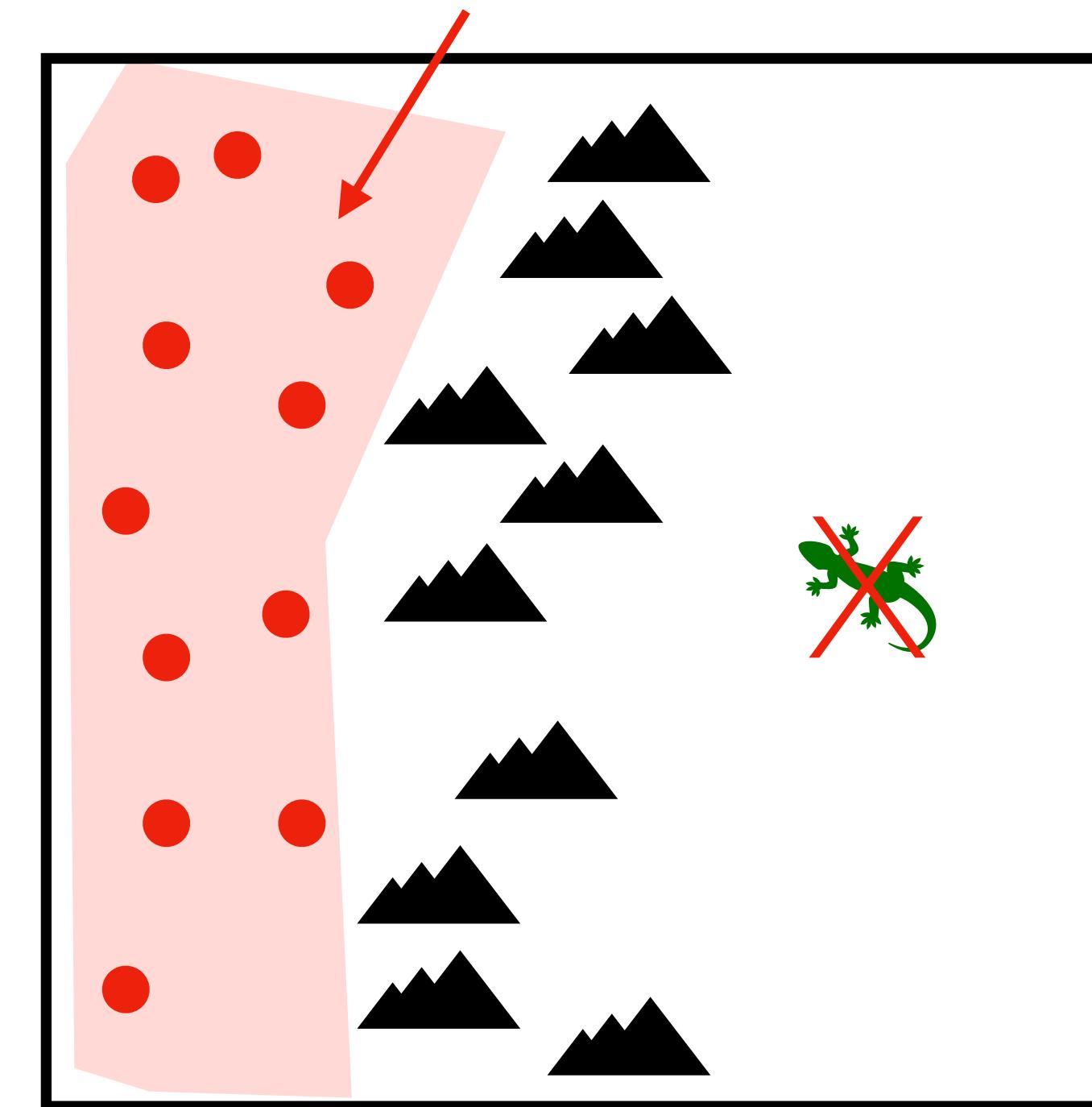
## Historical dispersal and background selection



# Processing Environmental Data

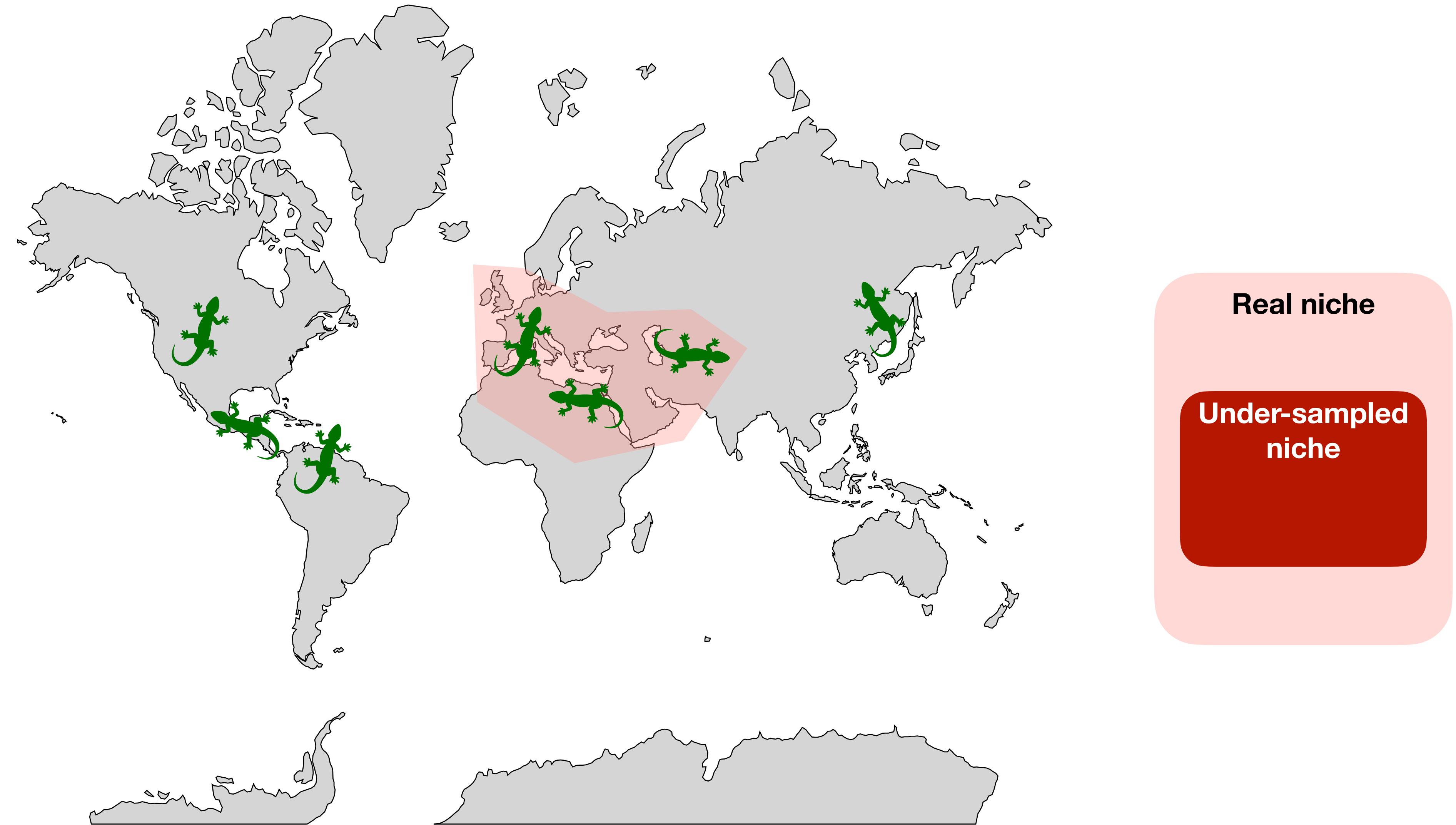
## Historical dispersal and background selection

Random sampling of background



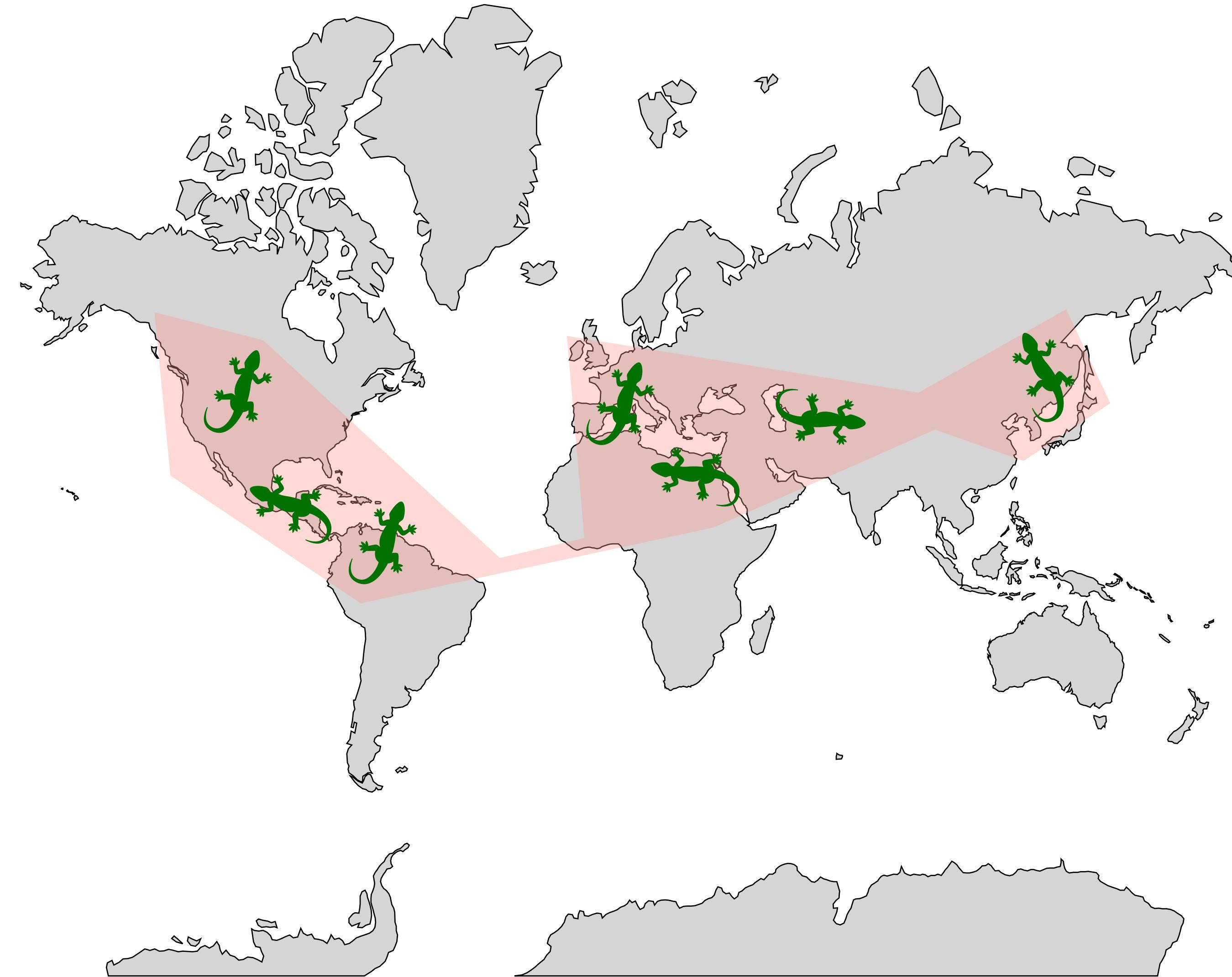
# Processing Environmental Data

## Niche truncation



# Processing Environmental Data

## Better background selection



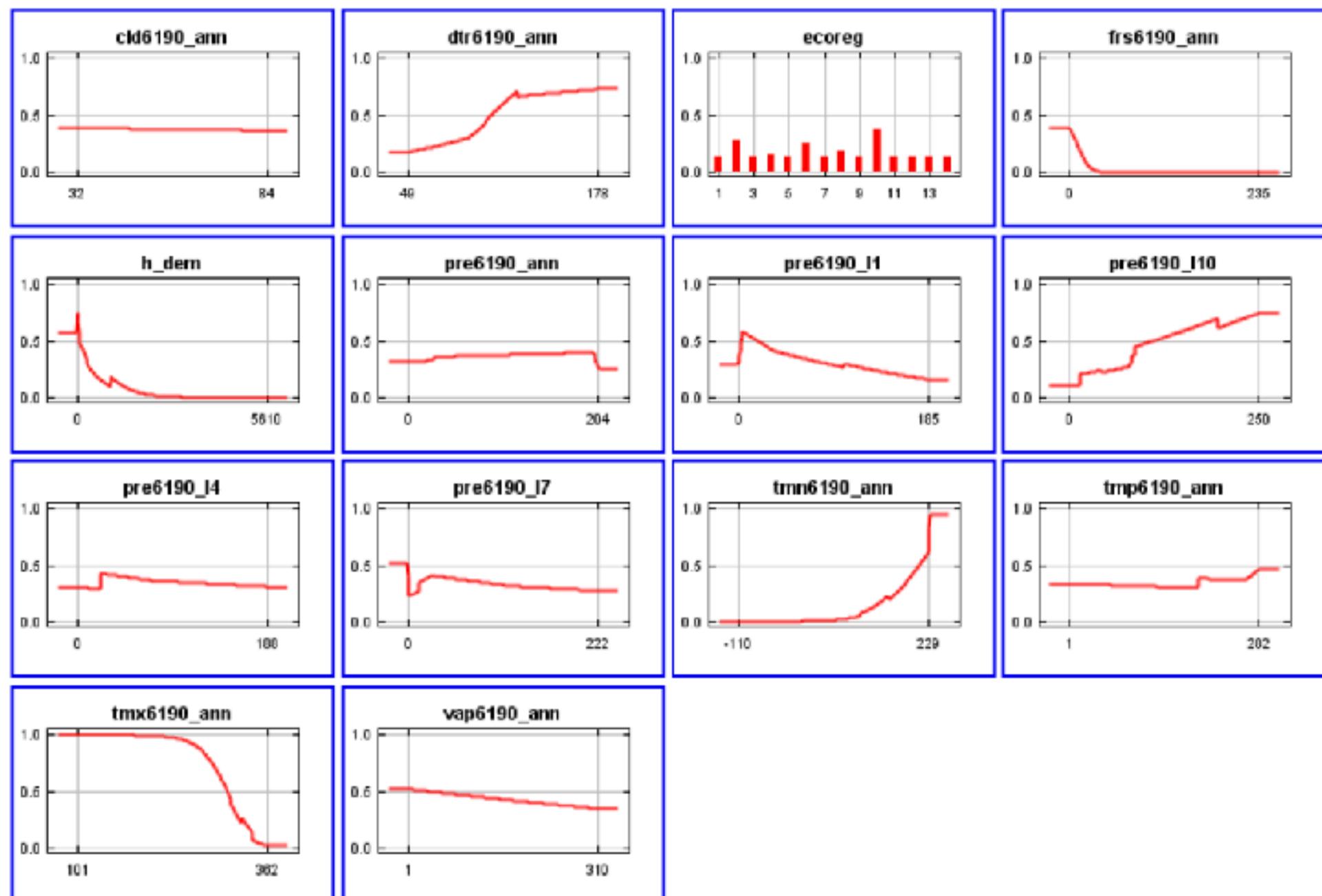
# **Model Outputs**

**Wallace Component “7 Visualise”**

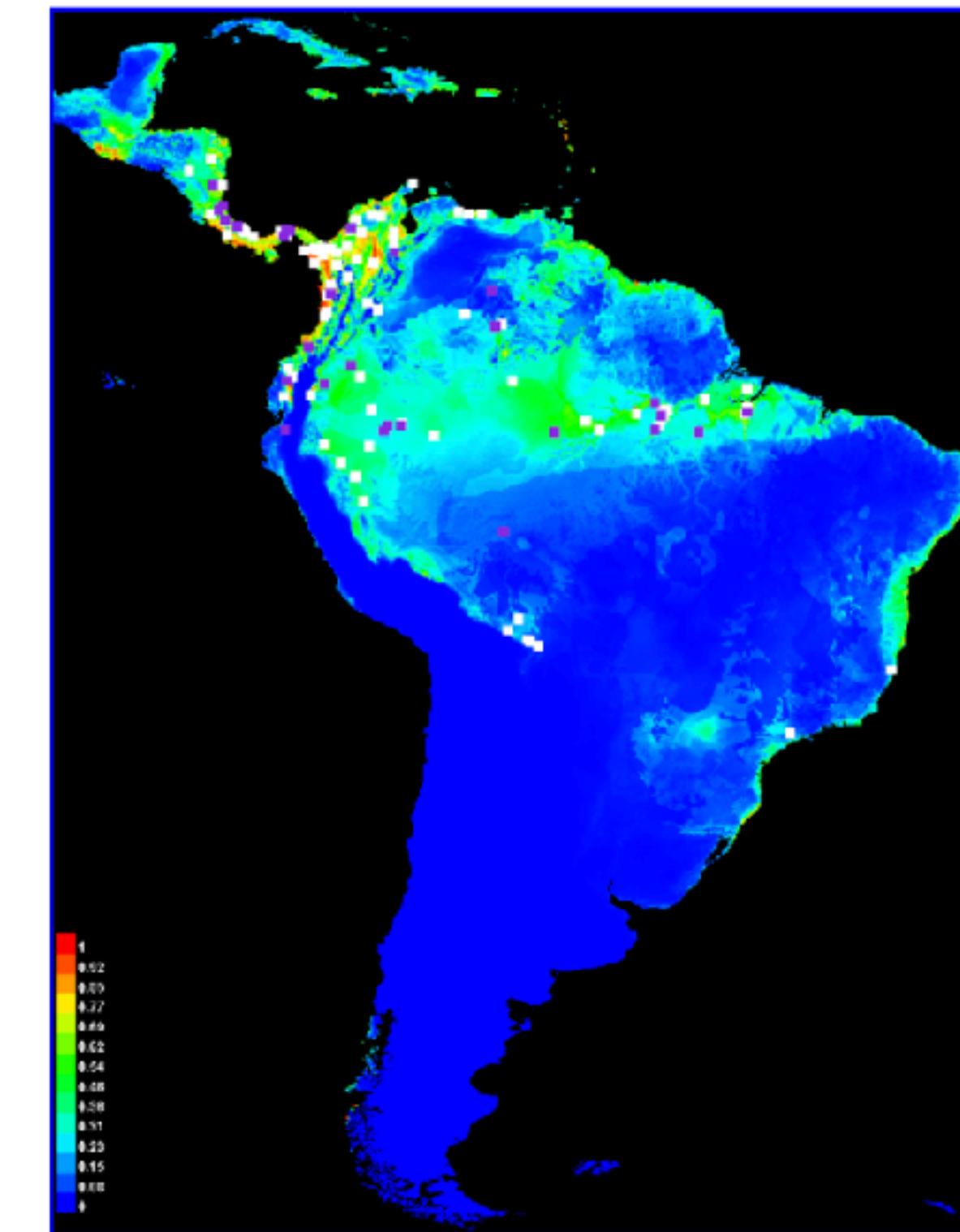
# Model Outputs

MaxEnt evaluation plots, 2 kinds of visualisations

Environmental variables space

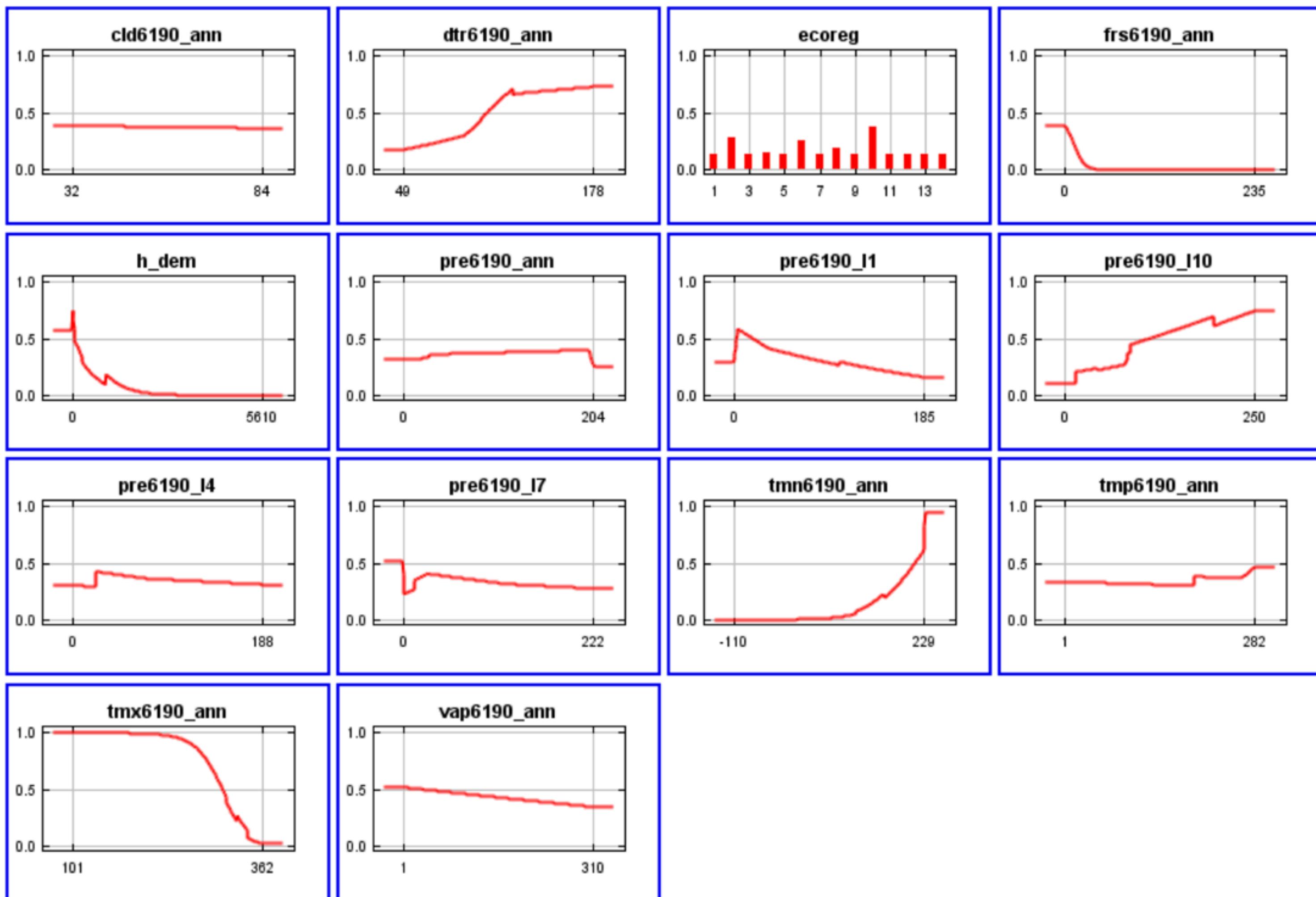


Geographic space

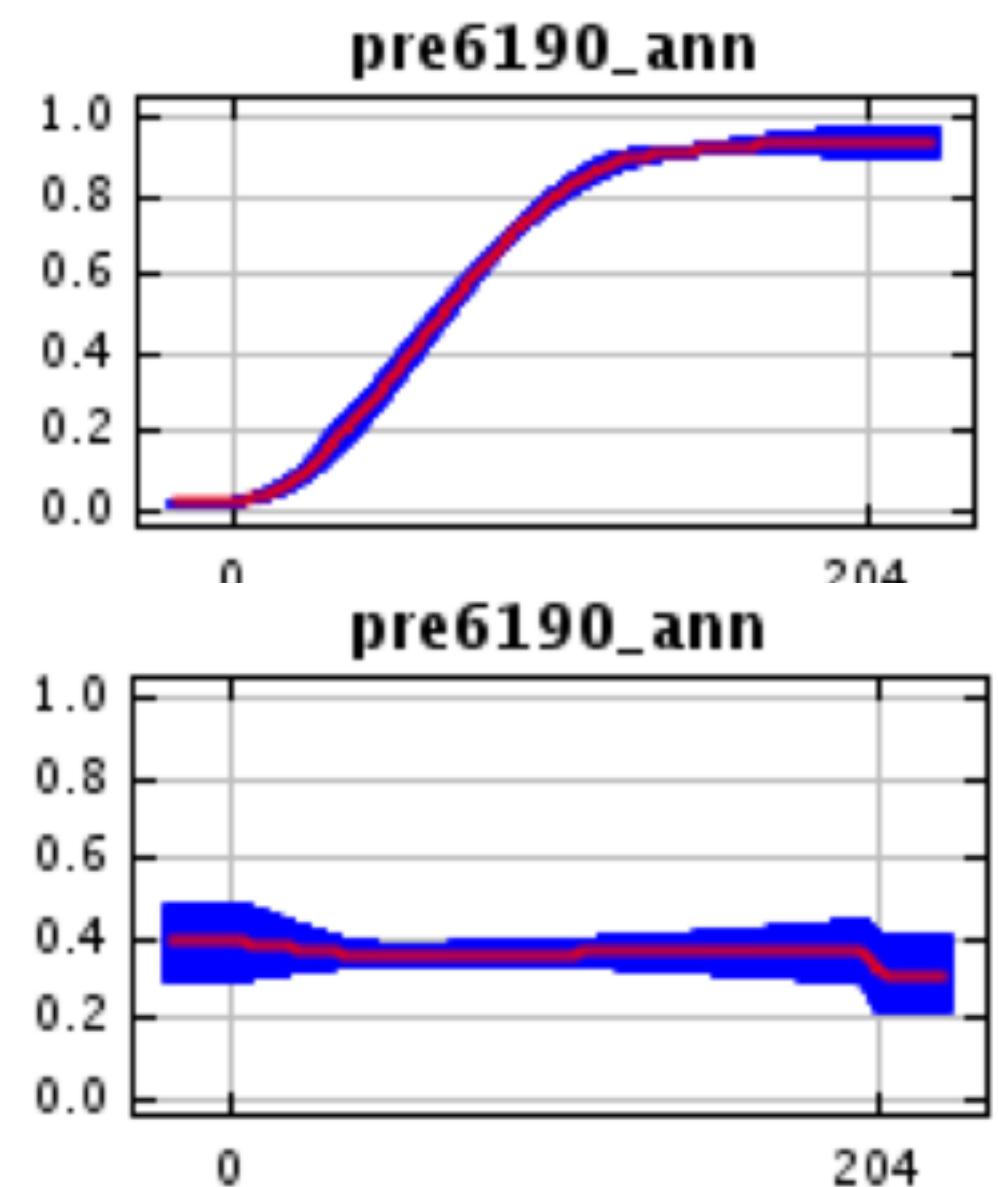


# Model Outputs

## Response curves



**For replicated runs:**



# Model Outputs

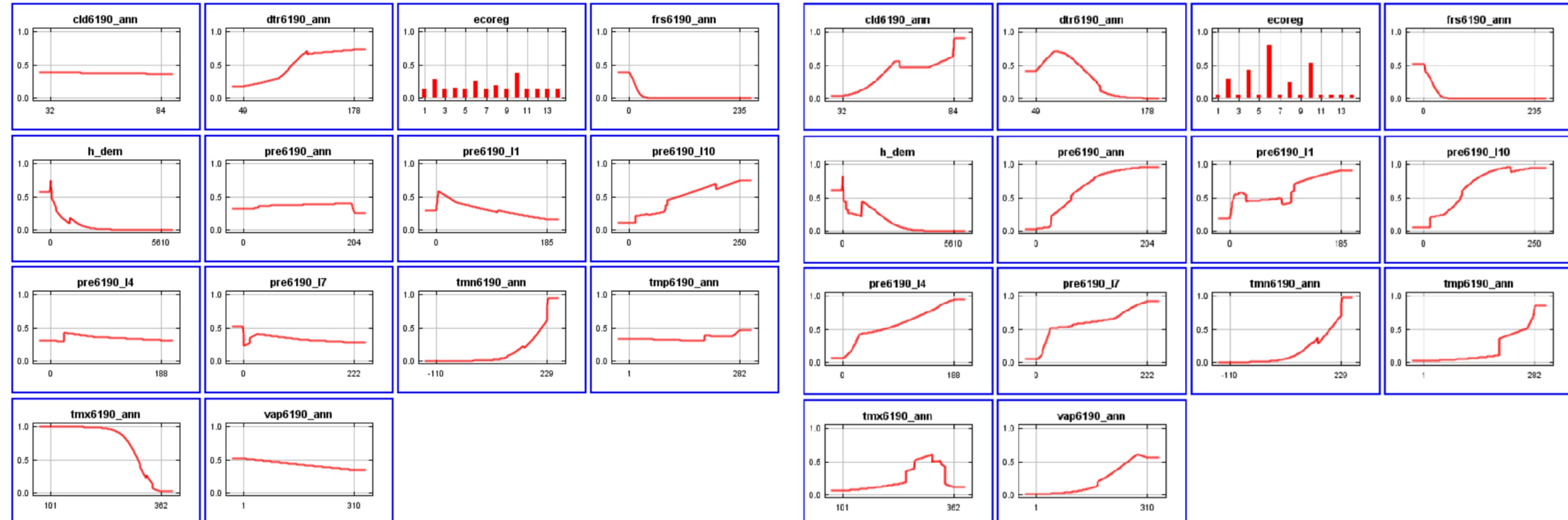
## Response curves in the presence of variables correlation

### Marginal

Varying one variable while maintaining other ones at their mean value.  
Biased by variables correlation

### “Individual”

A model is built with only one variable.



# Model Outputs

## Variables contribution

Which variables matter most?

- Percentage contribution
  - At each iteration of the MaxEnt algorithm, the increase or decrease in gain caused by each variable is summed. >> *Euristic, inconsistent, MaxEnt specific.*
- Permutation importance
  - For each variable, the values of training presence and background are randomly permuted.
- Jackknife test
  - For each variable, the model is iterated without and with only that variable.

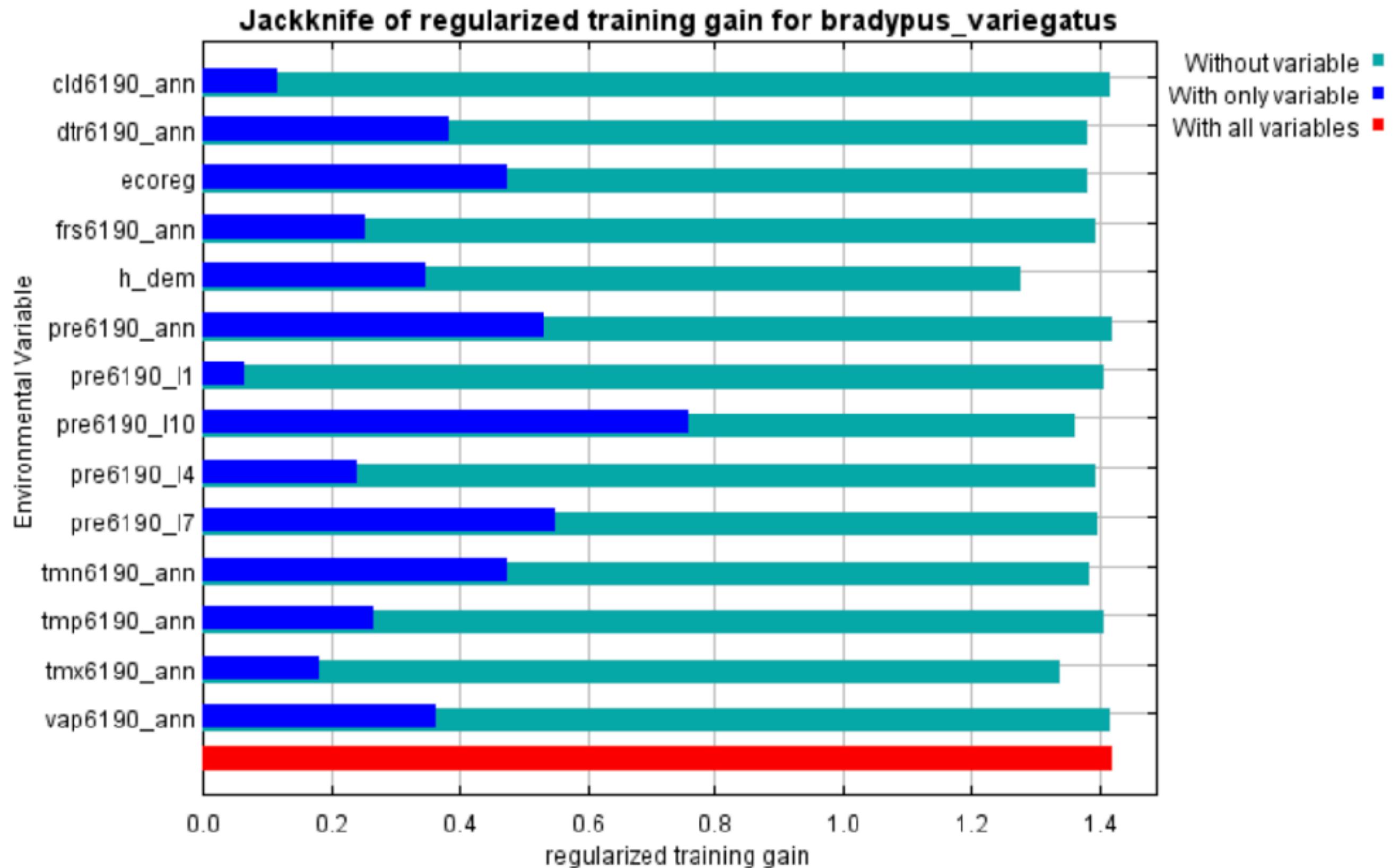
# Model Outputs

## Variables contribution

### Percentage contribution Permutation importance

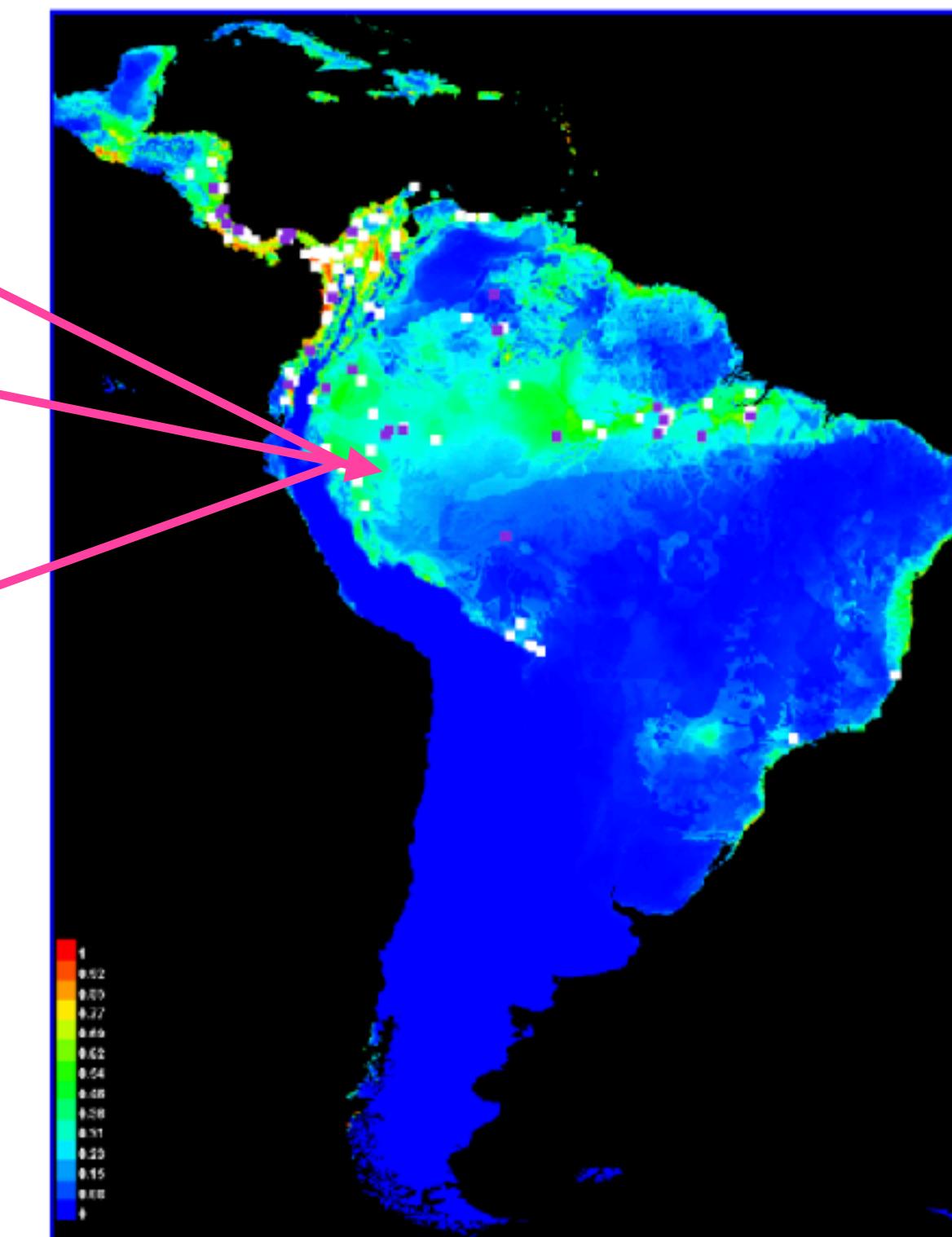
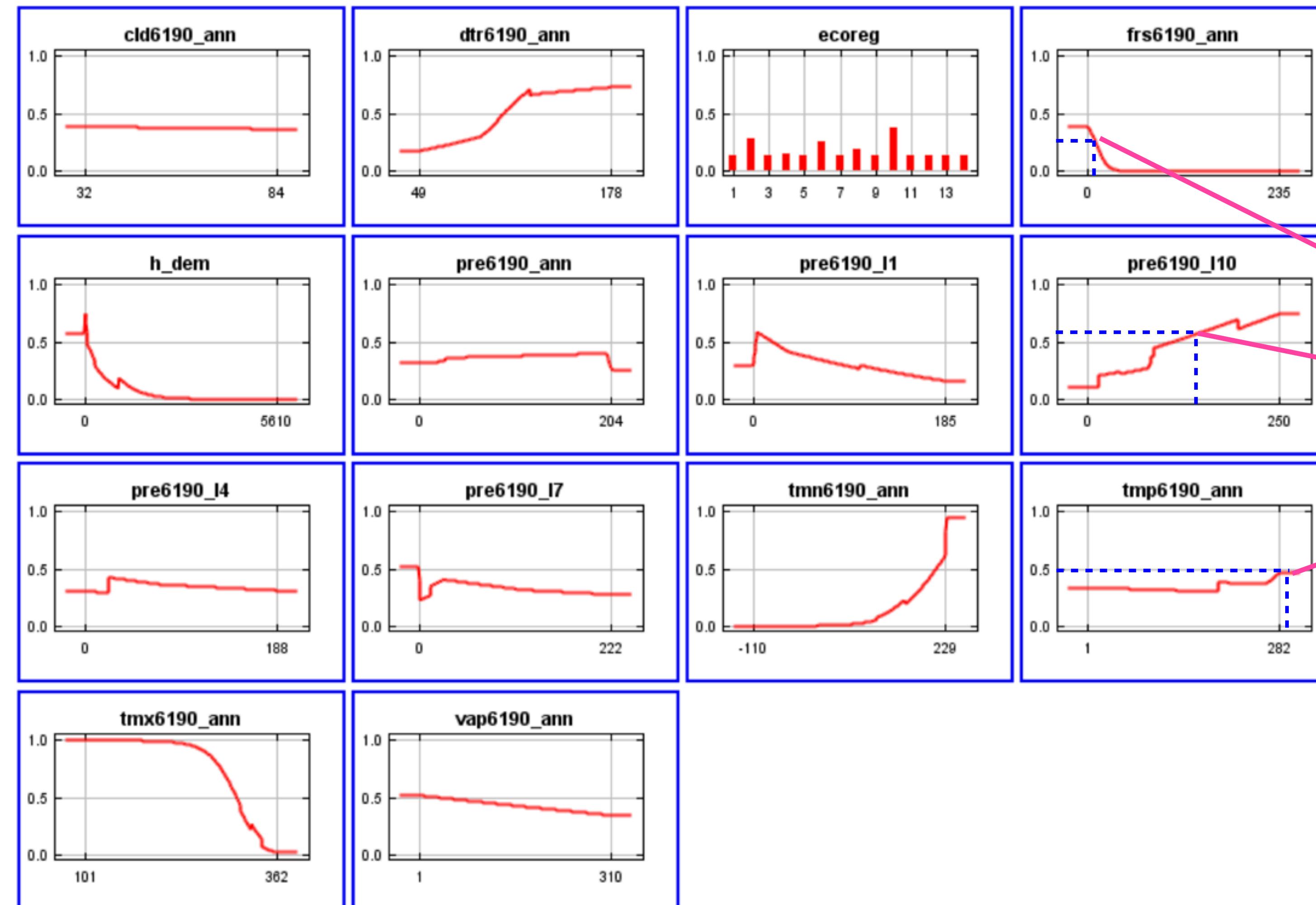
Variable	Percent contribution	Permutation importance
pre6190_110	31.1	5.4
pre6190_17	23.6	1.3
tmn6190_ann	14.7	20.6
h_dem	10.3	13.2
ecoreg	6.6	3.7
tmx6190_ann	4.3	19.6
pre6190_11	2.2	1.8
frs6190_ann	2.1	25.6
pre6190_14	1.8	3
vap6190_ann	1.6	0.3
tmp6190_ann	1.1	0.7
dtr6190_ann	0.4	4.7
pre6190_ann	0.3	0.1
cld6190_ann	0	0

### Jackknife test



# Model Outputs

## Projecting between variables and geographic spaces



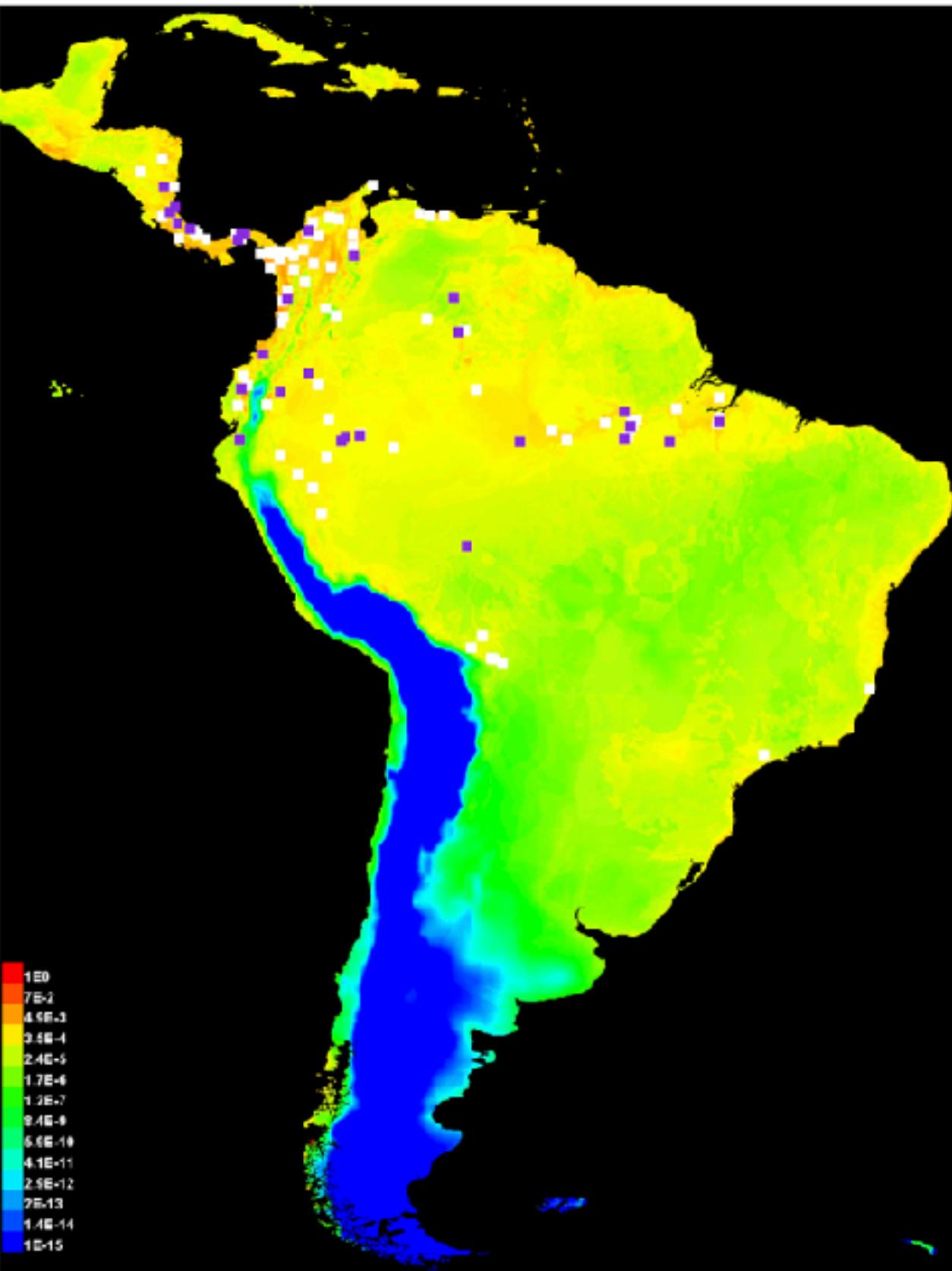
# Model Outputs

## Output formats

Opening the black box: an open-source release of Maxent

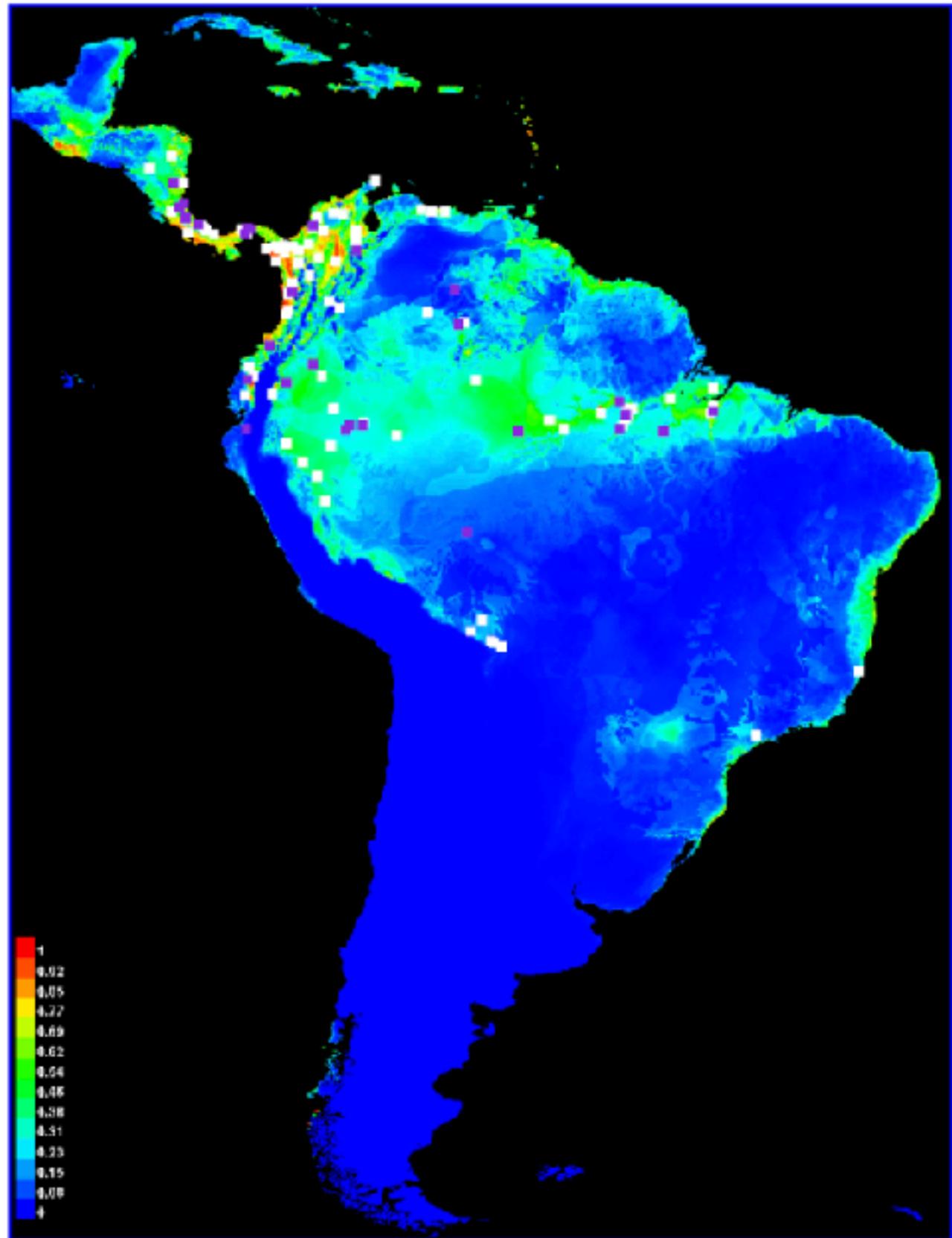
Steven J. Phillips, Robert P. Anderson, Miroslav Dudík, Robert E. Schapire and Mary E. Blair

MASSIVE ASSUMPTIONS!



### Raw

- Values of background pixels sum to 1 and can represents relative abundance
- Very few high values
- Logarithmic colour scale



### Logistic & ClogLog

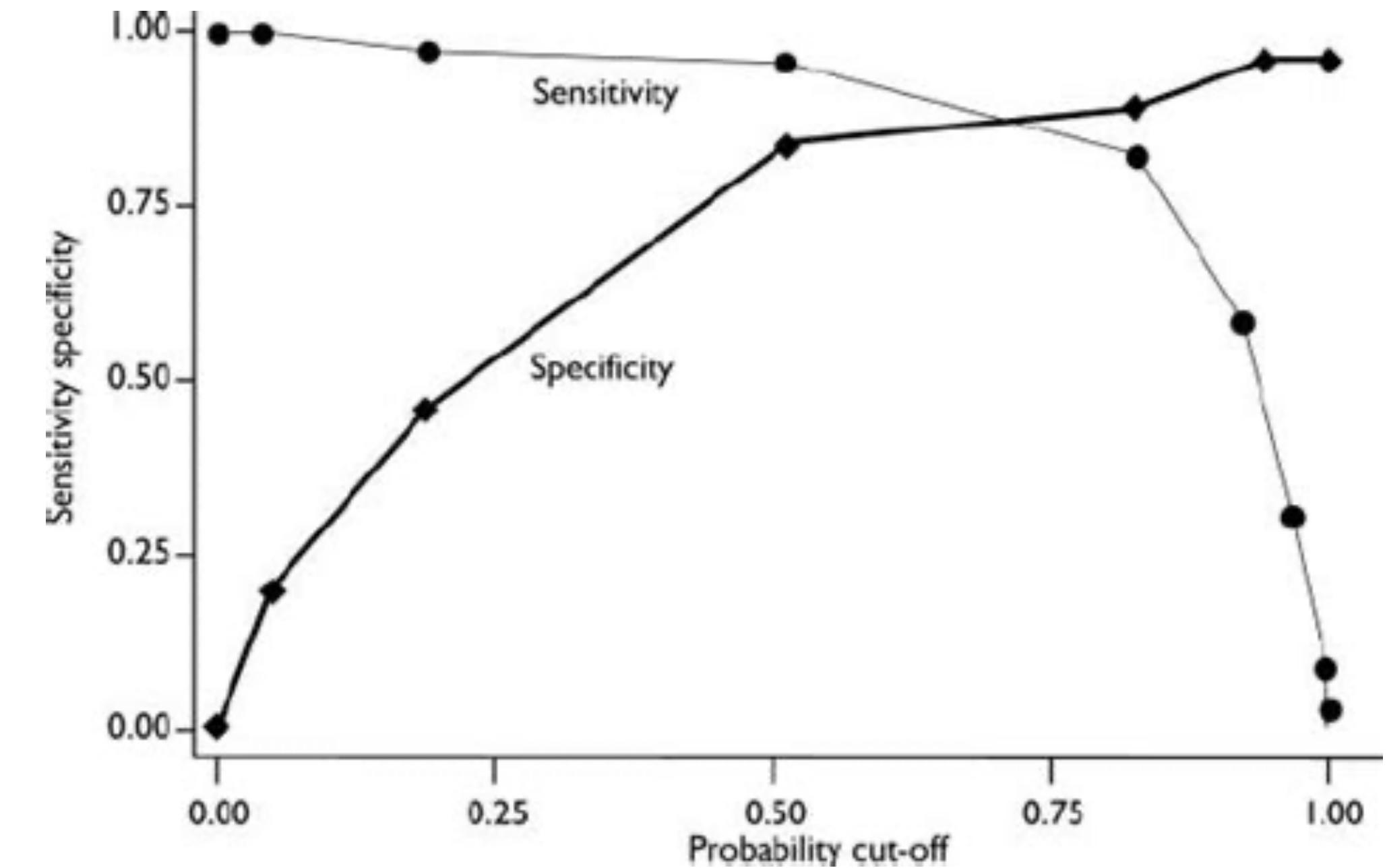
- Estimate between 0 and 1 of probability of presence
- **Logistic:** assumes that prevalence of the species equals 0.5 in locations of average suitability.
- **ClogLog:** Stronger theoretical justification. Assumptions are made regarding spatial dependence and cell size.
- Logistic and ClogLog are very similar, but cloglog tends to be higher for mid- to high-range values.

# Model Outputs

## Binary outputs

### Typical threshold selection:

- Minimum training presence
  - The lowest suitability score for any occurrence localities used to train the model.
- 10th percentile training presence
  - The lowest suitability score for any occurrence localities used to train the model after excluding the lowest 10% of them.
- Maximisation of sensitivity and specificity sum (equality of sensitivity and specificity)

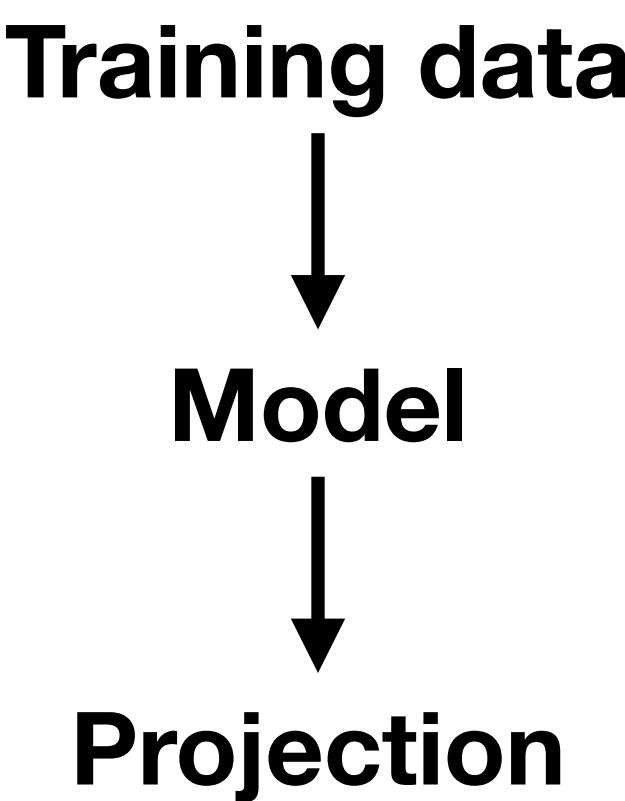


# **Model Projection**

**Wallace Component “8 Project”**

# Model Projection

## Making predictions



- New locations (e.g. for biological innovations)
- New climate scenarios (e.g. future under climate change)
- New land-use scenarios (e.g. deforestation or urbanisation)

# Model Projection

New climate scenarios: General Circulation Models (-> Global Climate Models)

General Circulation Models and Global Climate Models are used for weather forecasting, understanding the climate, and forecasting climate change.

The screenshot shows the homepage of the CESM (Community Earth System Model) website. The header features the NCAR UCAR logo and the CESM logo with the tagline "COMMUNITY EARTH SYSTEM MODEL". Below the header, the text "earth • modeling • climate" is displayed. A navigation bar includes links for "Home", "About", "Models", "Data", "Publications", and "Contact". A search bar is also present. The main content area has a large orange banner at the top with the text "CCSM4.0 PUBLIC RELEASE". Below the banner, there are sections for "CESM Models" and "CCSM4.0 PUBLIC RELEASE". The "CESM Models" section includes a link to "CCSM4.0 Public Release". The "CCSM4.0 PUBLIC RELEASE" section includes a link to "ABOUT CCSM 4.0". A detailed description of the CCSM model follows, mentioning its coupled nature and research capabilities. To the right, a "CESM PROJECT" box provides a brief overview of the model's purpose and capabilities.

Geosci. Model Dev., 9, 2077–2098, 2016  
www.geosci-model-dev.net/9/2077/2016/  
doi:10.5194/gmd-9-2077-2016  
© Author(s) 2016. CC Attribution 3.0 License.



Geoscientific  
Model Development  
Open Access  
EGU

**Atmosphere-only GCM (ACCESS1.0) simulations with prescribed land surface temperatures**

Duncan Ackerley and Dietmar Dommenget

ARC Centre of Excellence for Climate System Science, School of Earth Atmosphere and Environment, Monash University, Clayton 3800, Victoria, Australia

Correspondence to: Duncan Ackerley (duncan.ackerley@monash.edu)

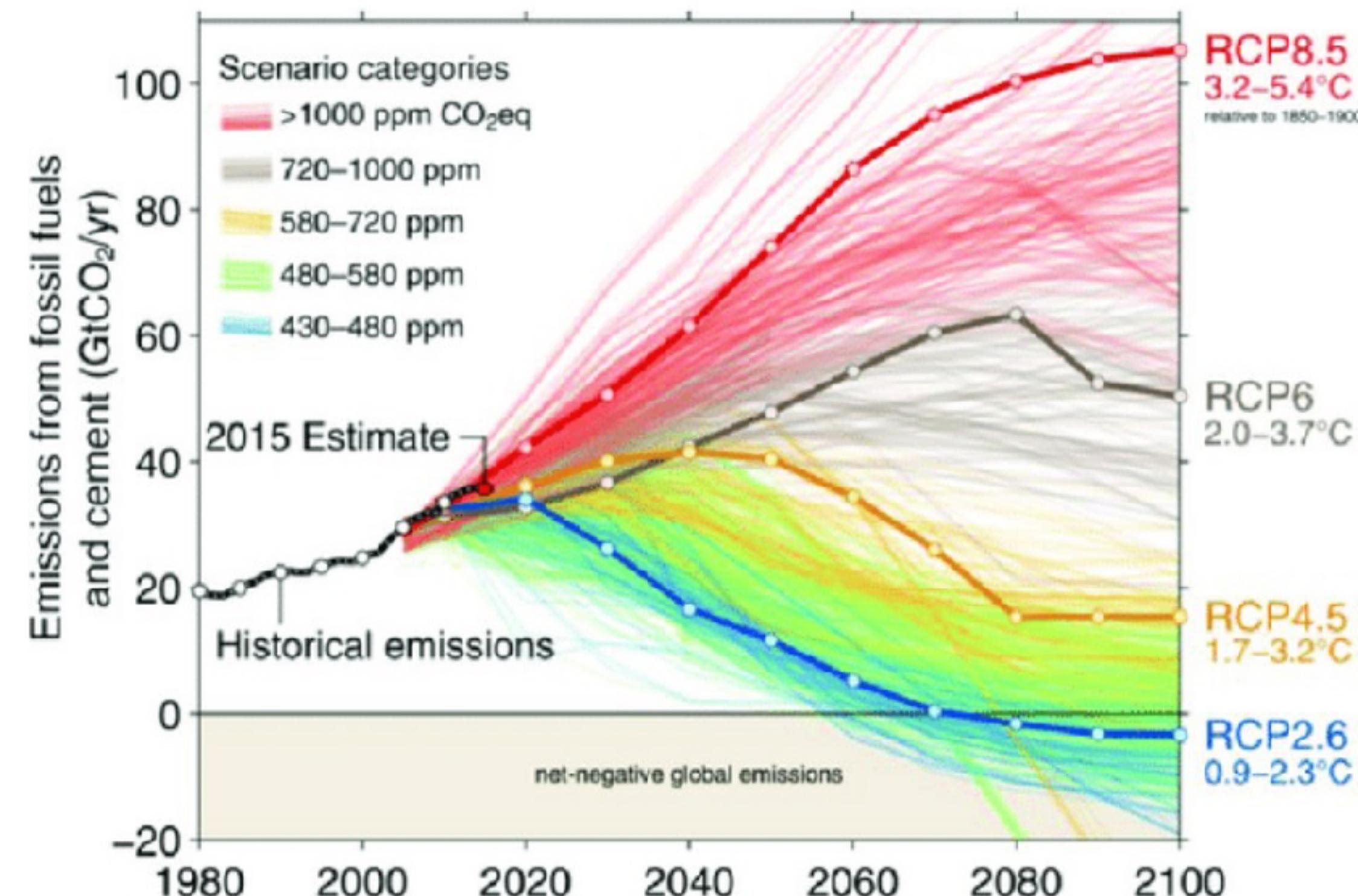
Received: 11 January 2016 – Published in Geosci. Model Dev. Discuss.: 19 January 2016

Revised: 9 May 2016 – Accepted: 20 May 2016 – Published: 7 June 2016

# Model Projection

## New climate scenarios: Representative Concentration Pathways (RCPs)

Greenhouse gas concentration (not emissions) trajectory adopted by the Intergovernmental Panel on Climate Change (IPCC).



# Model Projection

## Multivariate Environmental Similarity Surface (MESS)

Measures the similarity of any given point to a reference set of points, with respect to the chosen predictor variables.

### Methods in Ecology and Evolution



*Methods in Ecology and Evolution* 2010, 1, 330–342

doi: 10.1111/j.2041-210X.2010.00036.x

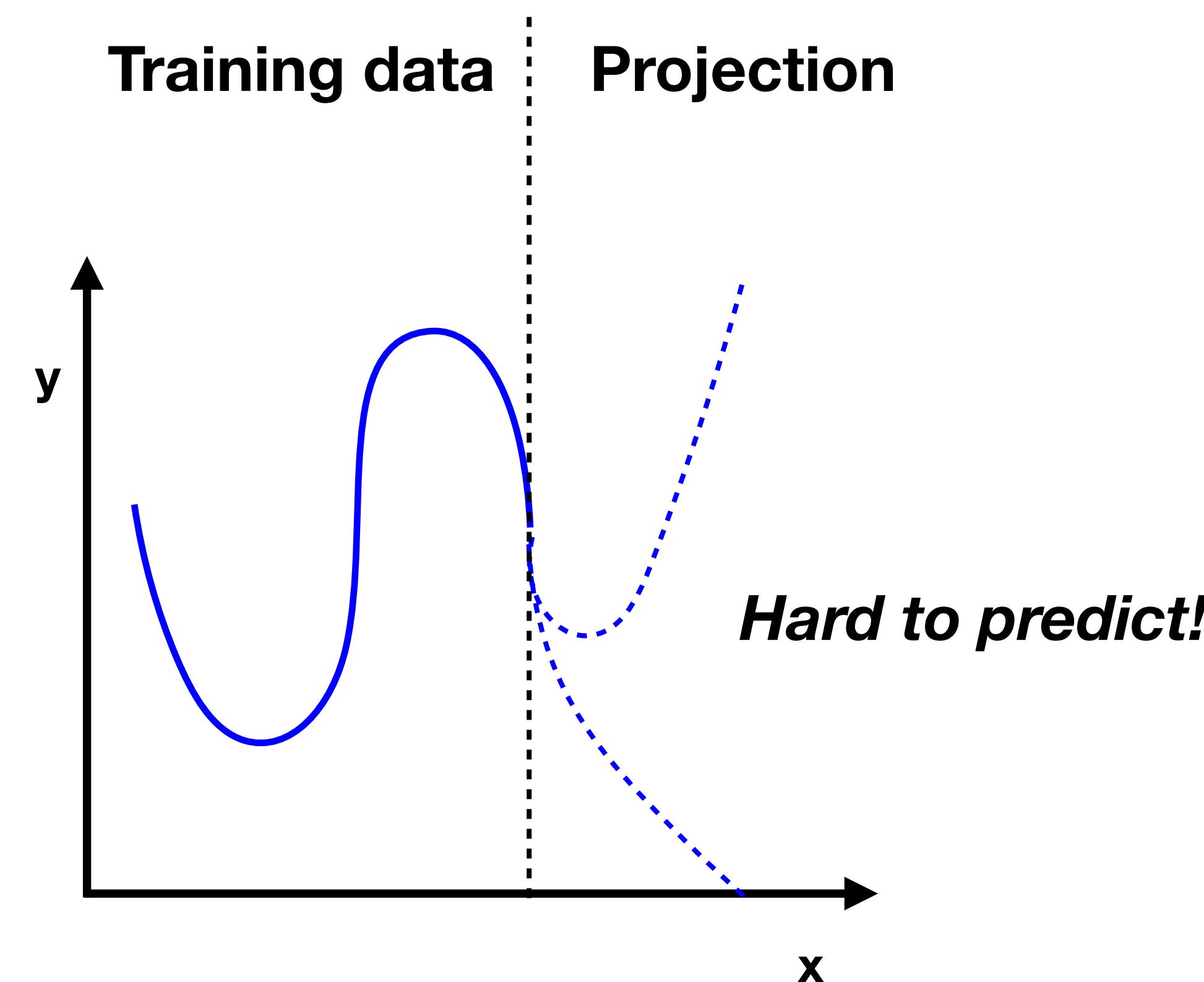
### The art of modelling range-shifting species

Jane Elith<sup>1\*</sup>, Michael Kearney<sup>2</sup> and Steven Phillips<sup>3</sup>

<sup>1</sup>School of Botany, The University of Melbourne, Parkville 3010, Australia; <sup>2</sup>Department of Zoology, The University of Melbourne, Parkville 3010, Australia and <sup>3</sup>AT&T Labs – Research, 180 Park Avenue, Florham Park, NJ 07932, USA

# Model Projection

## Uncharted land

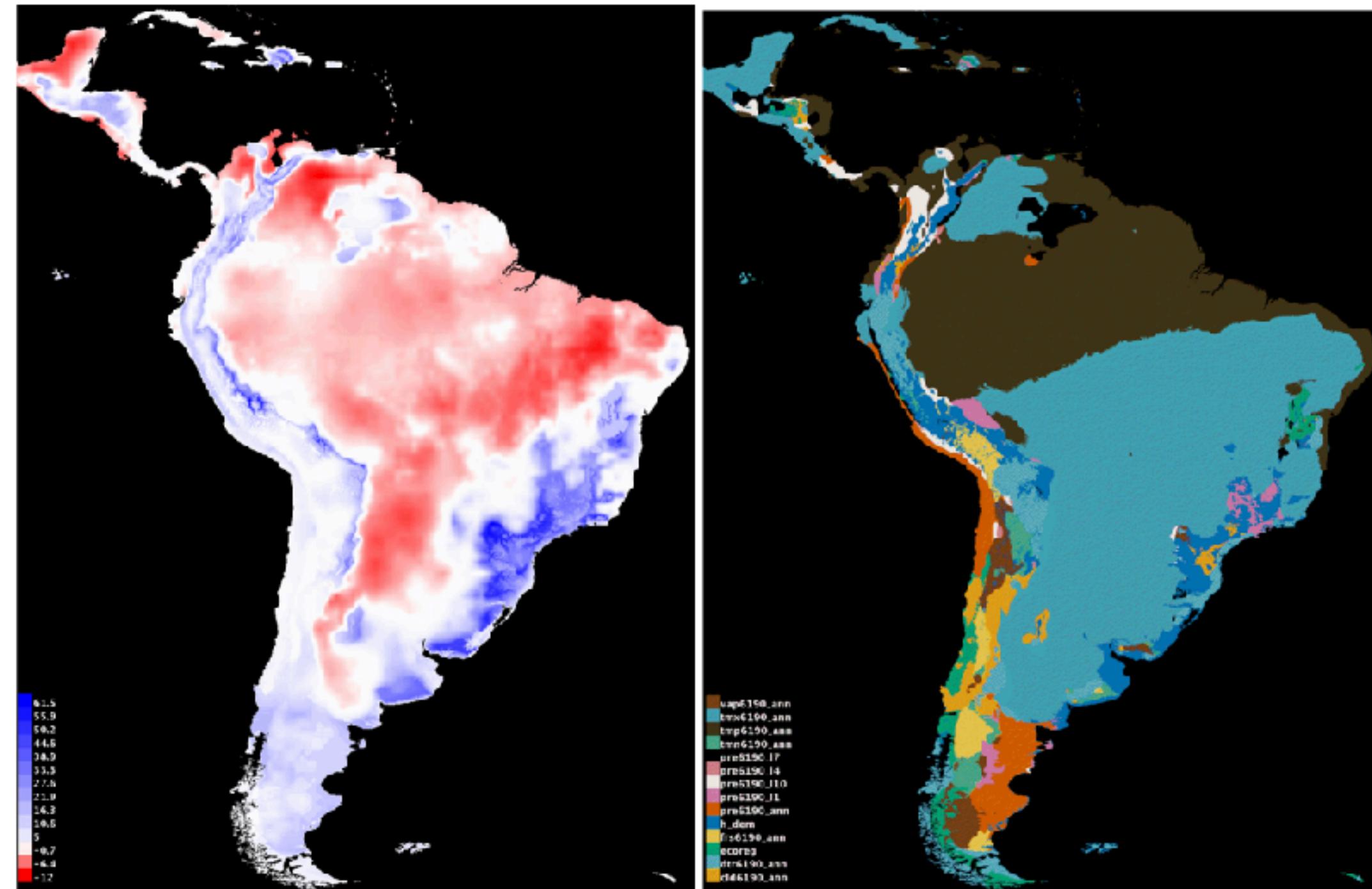


# Model Projection

## Environmental similarity

Measures the similarity of any given point to a reference set of points, with respect to the chosen predictor variables.

- Left: how different each pixel is in the new climate conditions.  
(the minimum over all predictor variables of how far out of range the point is, expressed as a fraction of the range of that variable's values.)
- Right: environmental variable that is the most different from the training range at each pixel.

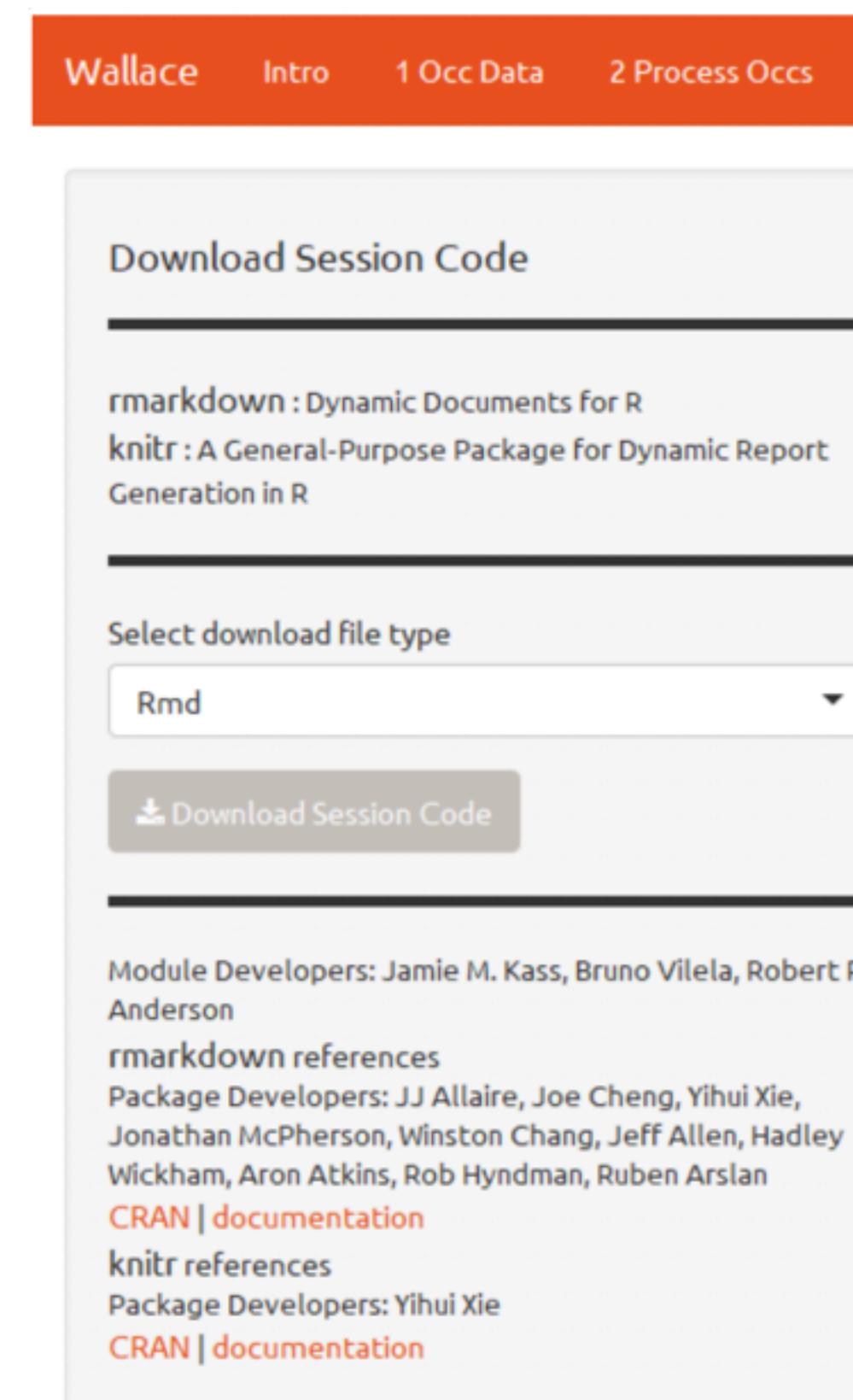


# **Extract R Code**

**Wallace Component “Session Code”**

# Extract R Code

## R Markdown



The screenshot shows a web page with a navigation bar at the top containing links: Wallace, Intro, 1 Occ Data, 2 Process Occs, 3 Env Data, 4 Process Envs, 5 Partition Occs, 6 Model, 7 Visualize, 8 Project, and Session Code. The Session Code link is highlighted in orange.

The main content area has a title "Download Session Code". Below it, there is a section about the `rmarkdown` and `knitr` packages. A dropdown menu allows selecting the download file type, currently set to "Rmd". A "Download Session Code" button is present. At the bottom, there is information about module developers and links to CRAN documentation for both packages.

**Using the R package `rmarkdown`, Wallace allows the user to download the history of actions (and underlying code) run in the current session of Wallace. This includes the formats .Rmd (R Markdown), .pdf, .html, or .doc. The .Rmd format is an executable R script file that will reproduce the analysis if run in an R session. This file is composed of plain text and R code "chunks".**

Extended functionality for R Markdown files exists in RStudio. Simply open the .Rmd in RStudio, click on "Run" in the upper-right corner, and run chunk by chunk or all at once. To learn more details, check out the RStudio [tutorial](#).

**Notes**

To generate a PDF of your session code, it is essential you have a working version of TeX installed. For Mac OS, download MacTeX [here](#). For Windows, please perform the following steps:

1. Download and Install MiKTeX [here](#).
2. Run `Sys.getenv("PATH")` in RStudio. This command returns the path where RStudio is trying to find pdflatex.exe. In Windows (64-bit), it should return `C:\Program Files\MiKTeX 2.9\miktex\bin\x64\pdflatex.exe`. If pdflatex.exe is not located in this location, RStudio gives the error code "41".
3. To set the path variable, run the following in RStudio:

```
d <- "C:/Program Files/MiKTeX 2.9/miktex/bin/x64/"
Sys.setenv(PATH=paste(Sys.getenv("PATH"), d, sep=";"))
```