IBC 2024 XX International Botanical Congress Madrid Spain

LIÈGE université

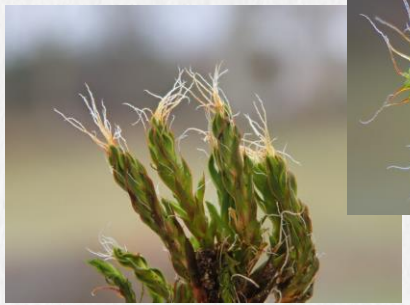
# What role have changes in climatic conditions and atmospheric pollution played in the spatio-temporal variation of epiphytic bryophyte communities?

Virginie Hutsemékers, **Lea Mouton**, Hannah Westenbohm, Flavien Collart, Alain Vanderpoorten

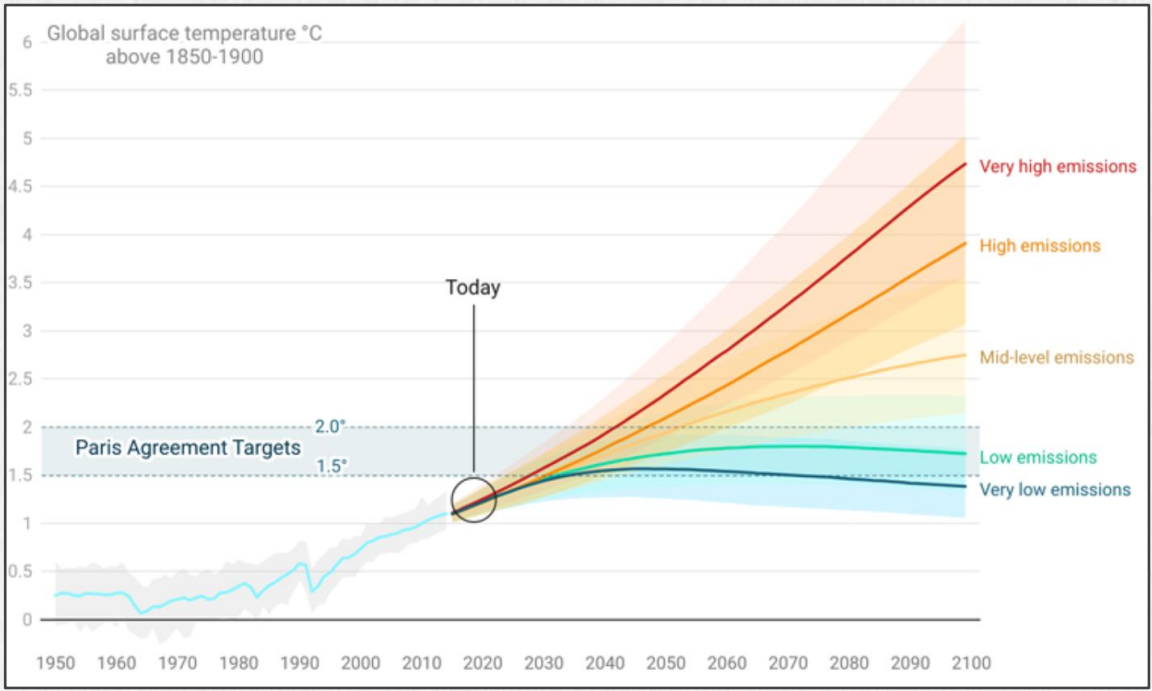
# Introduction

## Climatic change

- Sensitive epiphytic bryophytes
- No stomata
- No roots
- No water content regulator system



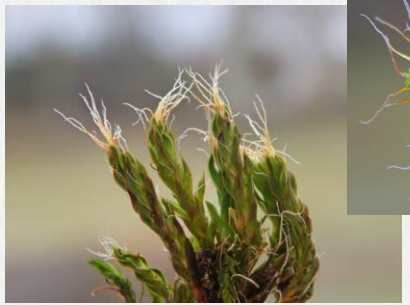
Observed and predicted increase in temperatures compar
to the pre-industrial period (IPCC 2018)



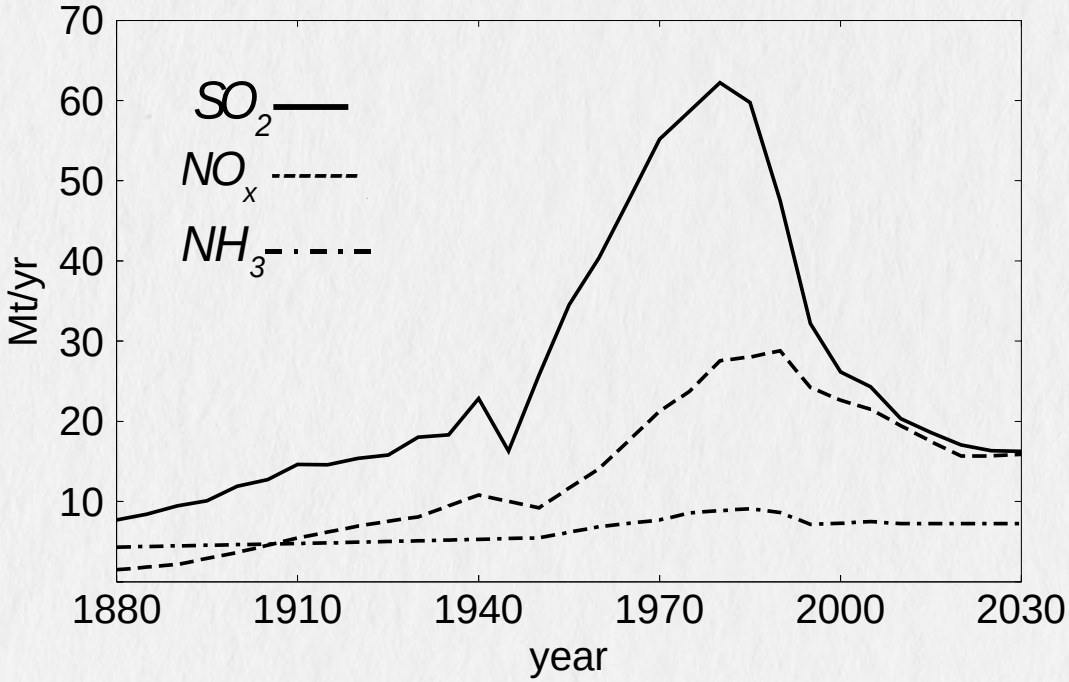
# Introduction

## Atmospheric pollution

- Sensitive epiphytic bryophytes
- Industrial period
- 1950-1980 pollution peak
- Primary sanitary concern in Europe

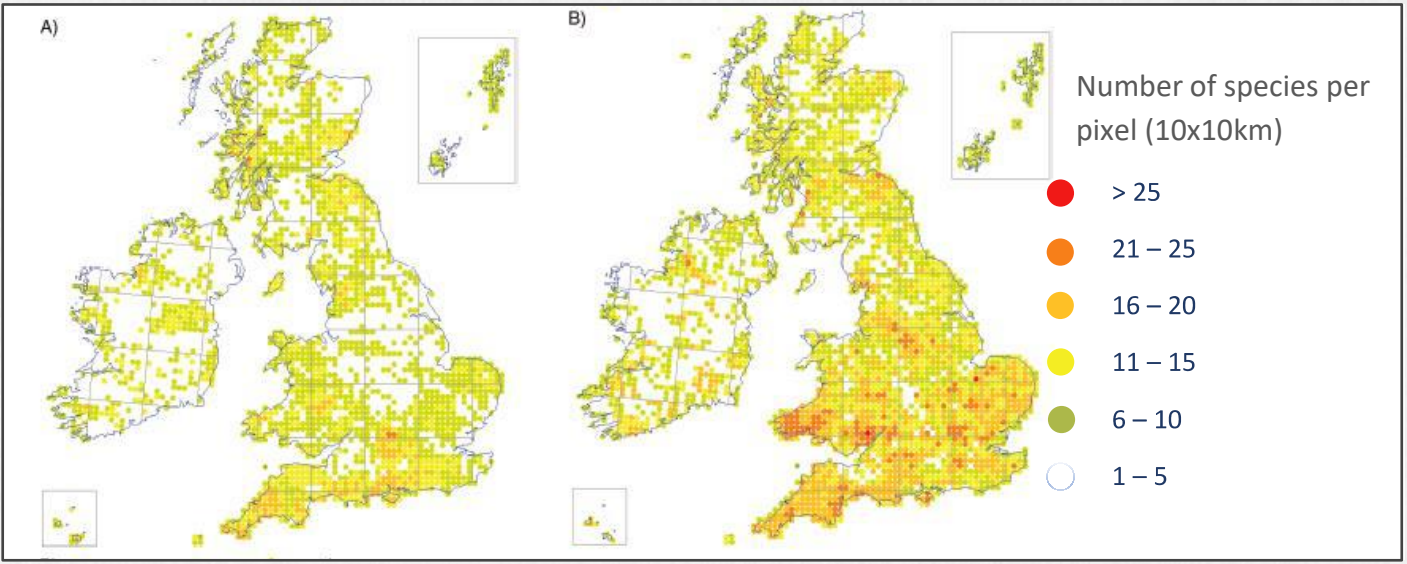


Variation in emission of major atmospheric pollutants 1880-2030 in Europe (Schöpp et al. 2003, Hydrol. Earth Syst. Sci.)



# Introduction

## The spectacular expansion of epiphytic flora



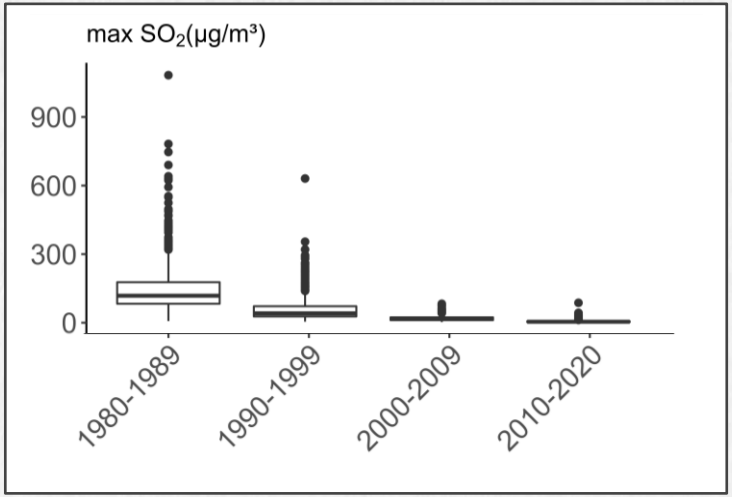

1960-1980

1990-2010

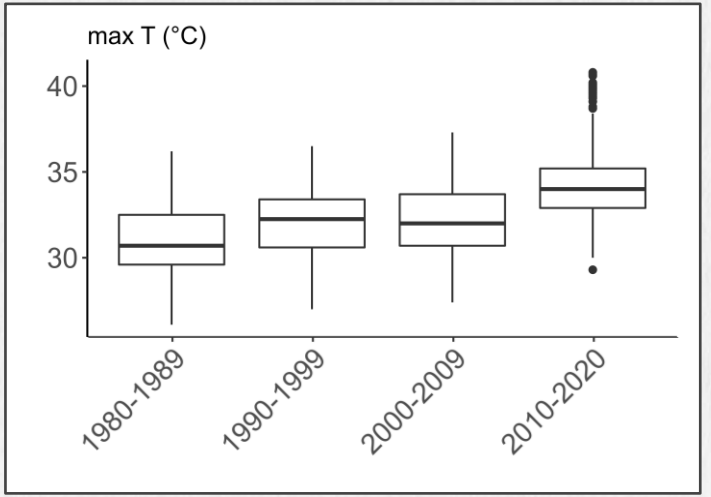
Frequency of 28 species of epiphytic bryophytes in 1960-1980 (A) and 1990-2010 (B) in Great Britain (Hill et Preston 2014).

# Concomitance of climate change and variation in air quality

## Objective




To disentangle the relative impact of climate change and variation in air pollution on the temporal shifts of epiphytic bryophyte species composition



# Study area

- South of Belgium = Wallonia

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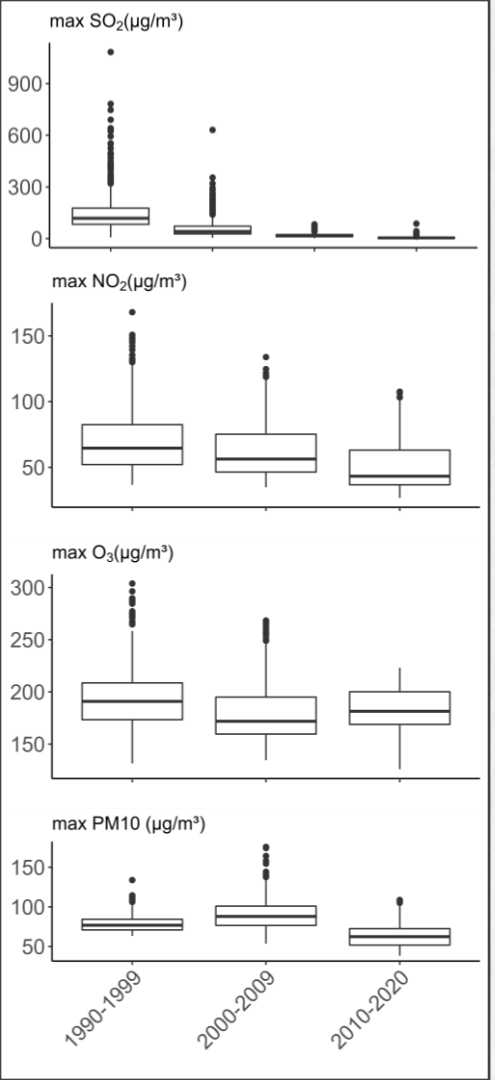
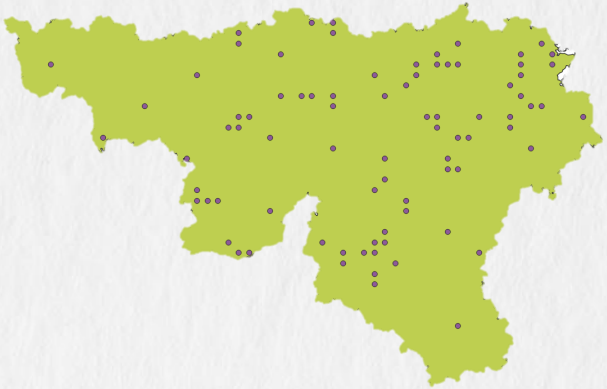



# Method

- South of Belgium = Wallonia
- Bryophytes records from 1980-1990-2000-2010 and 2015-2020.
- Atmospheric pollutants : from 1980 for $SO_2$, 1990 for $NO_2$, $O_3$, PM10, interpolated (stored by the Belgian Interregional Environment Agency, IRCEL—CELINE).
- Climatic data were provided daily since 1980 by the Royal Meteorological Institute of Belgium (RMI).

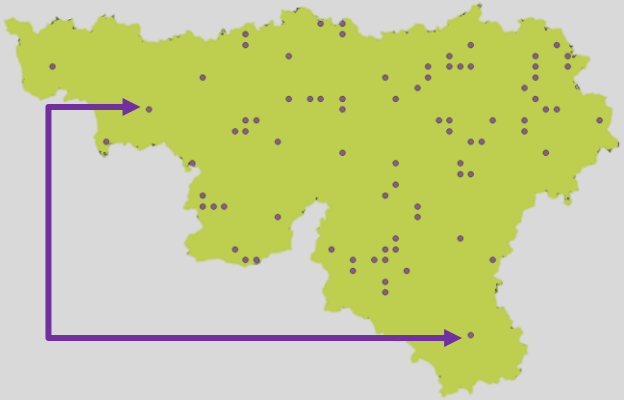
1980-2010



2015-2020

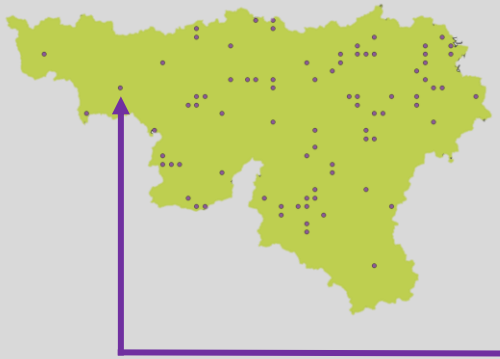
# Beta diversity

spatial β

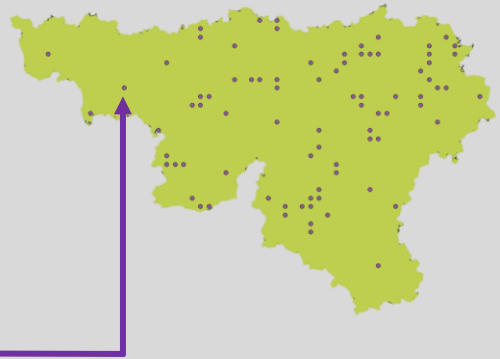


temporal β

1980-1990-2000-2010

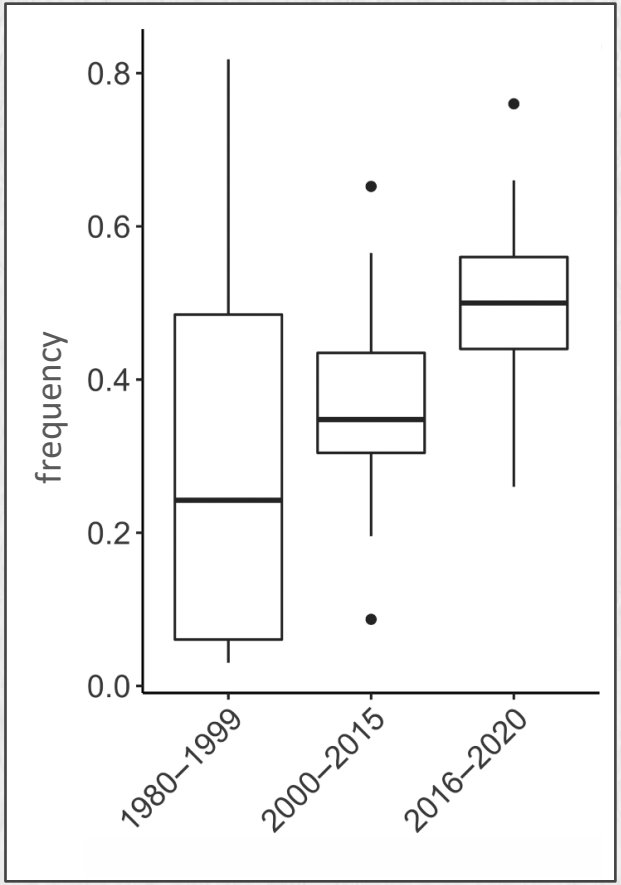


2015-2020



# Results

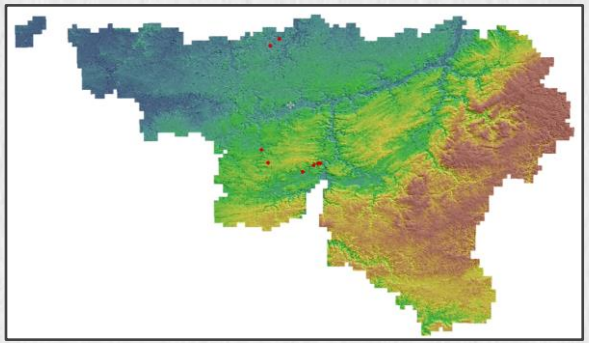
Temporal variation of species frequency

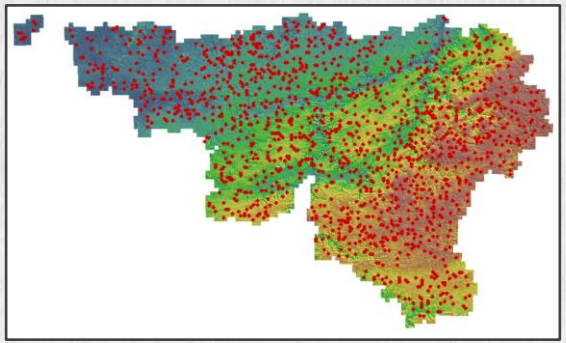


1980-1985

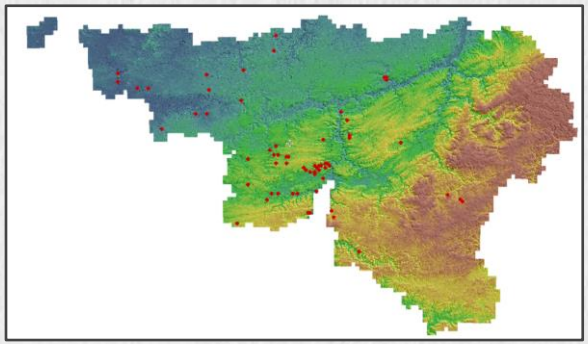
2015-2020

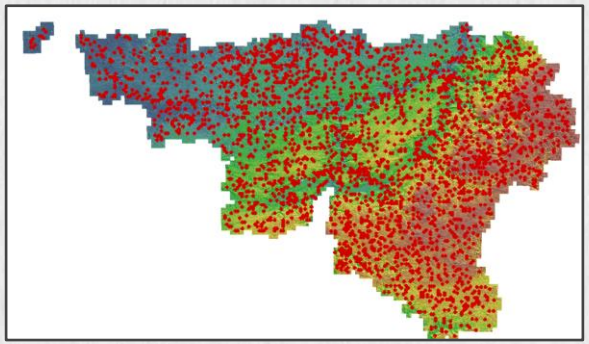
*Cryphaea heteromalla*





x200





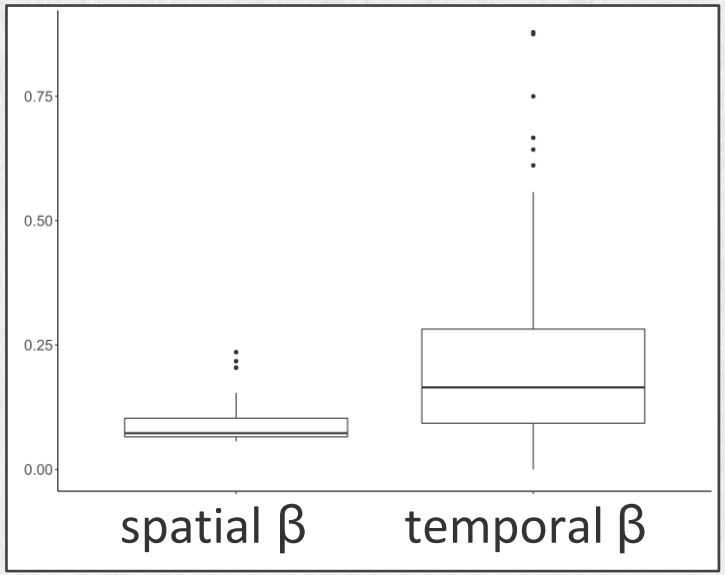
x50

*Lewinskya affine*

# Results

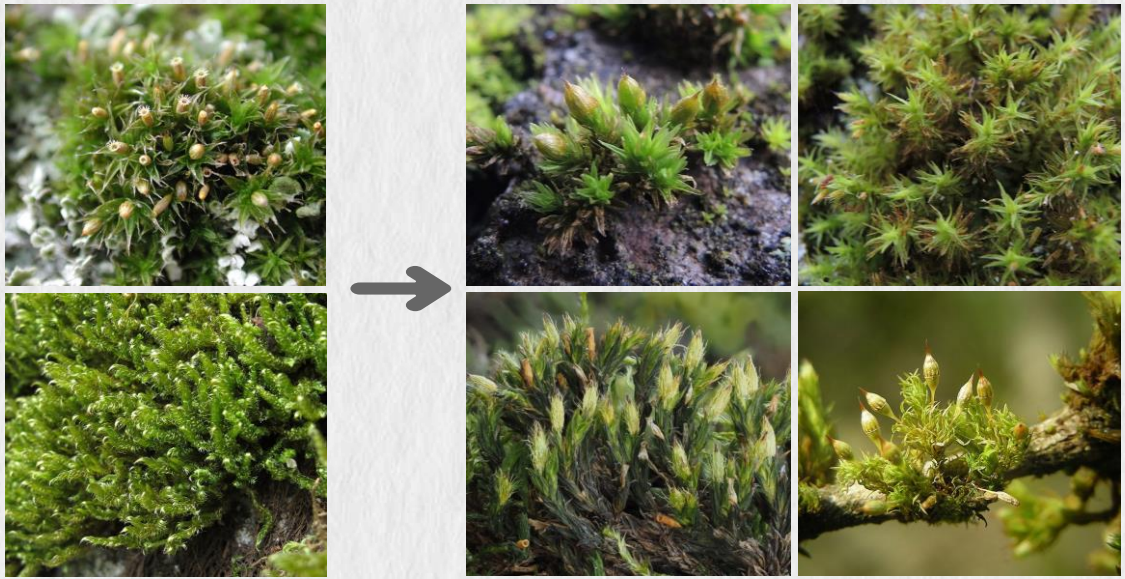
temporal β

Temporal *vs* spatial variation of the bryophyte community composition




1980-1985

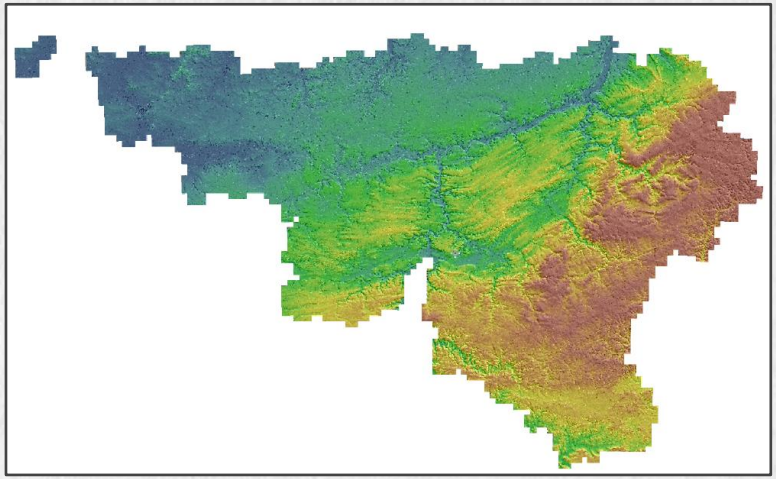
2015-2020



# Results

spatial β

Temporal *vs* spatial variation of the bryophyte community composition



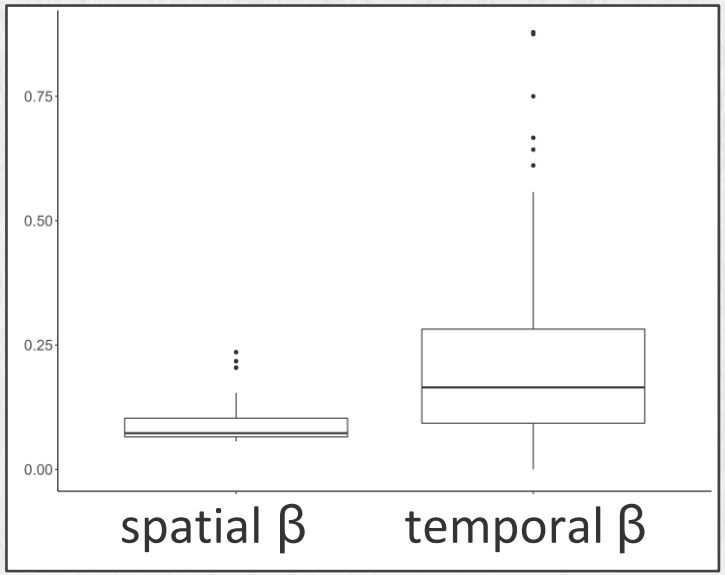
Low land

High land

# Results

MDS

## Temporal *vs* spatial variation of the bryophyte community composition

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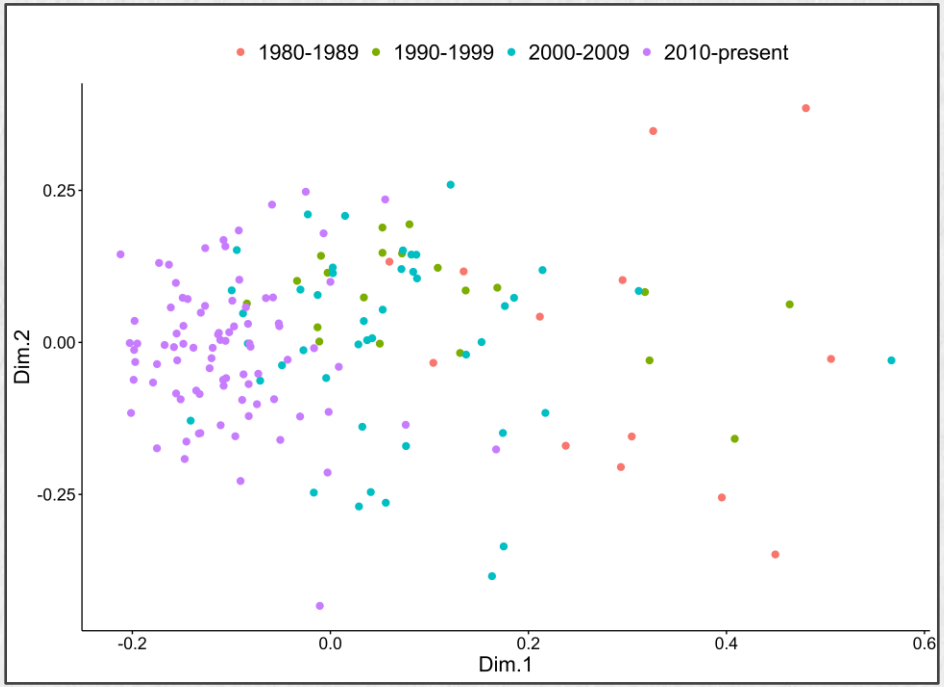



MDS ordination of 81 of 16 km$^2$ pixels in southern Belgium based on a Sorensen distance matrix of their composition in epiphytic bryophytes

# Results

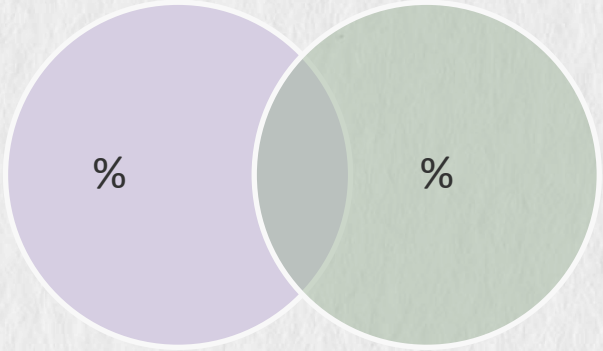
## Variance partitioning

Drivers of temporal variation of the epiphytic bryophytes communities

**Climate change**

Past-present

- temperature min
- temperature max
- precipitations




**Variation of air quality**

Past-present

- $SO_2$ mean
- $SO_2$ max
- $NO_2$ mean
- $NO_2$ max
- …

# Results

## Variance partitioning

Drivers of temporal variation of the epiphytic bryophytes communities

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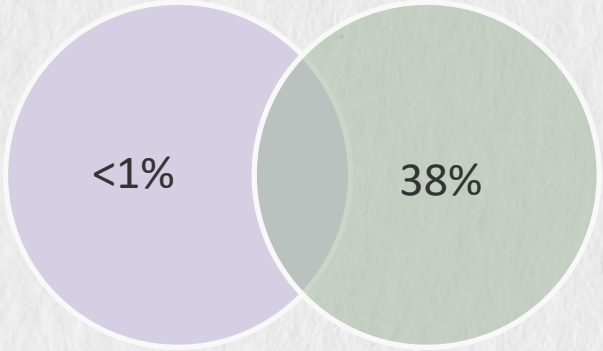


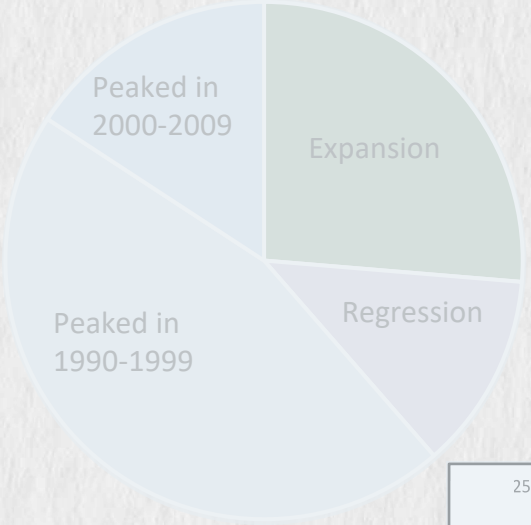

**Variation of air quality**

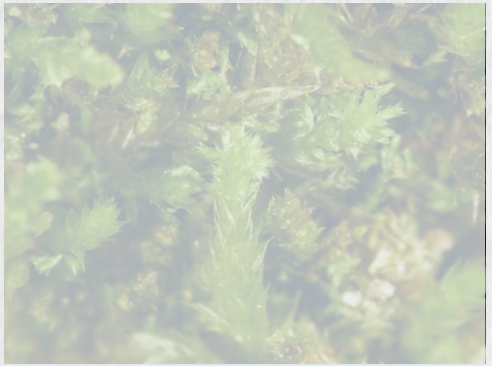
Past-present

- $SO_2$ mean
- $SO_2$ max
- $NO_2$ mean
- $NO_2$ max
- …

→ Negligible impact of variations of  temperature and precipitation.

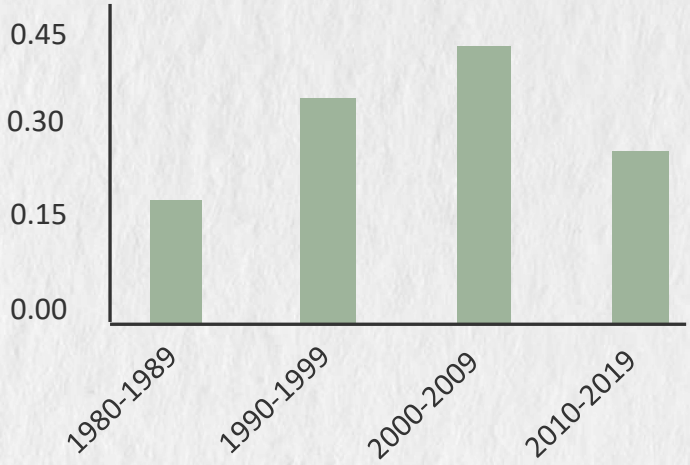
# Glory of epiphytes in the 2000s, then decline



***Platygyrium repens***

% occurrence of epiphytes among all observations per decade

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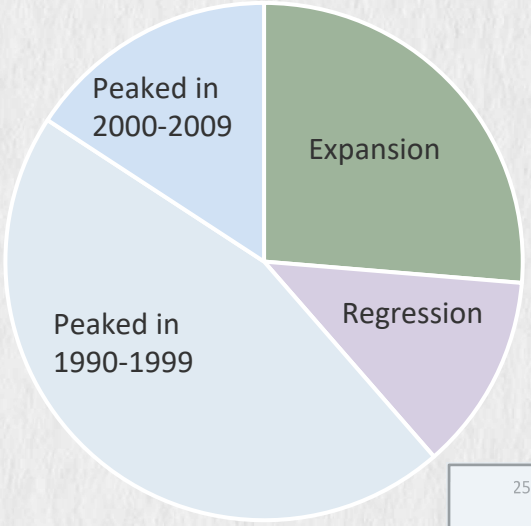
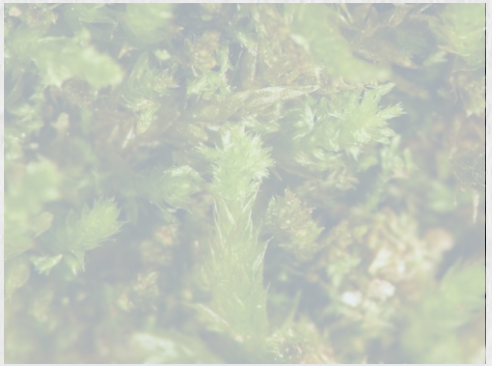
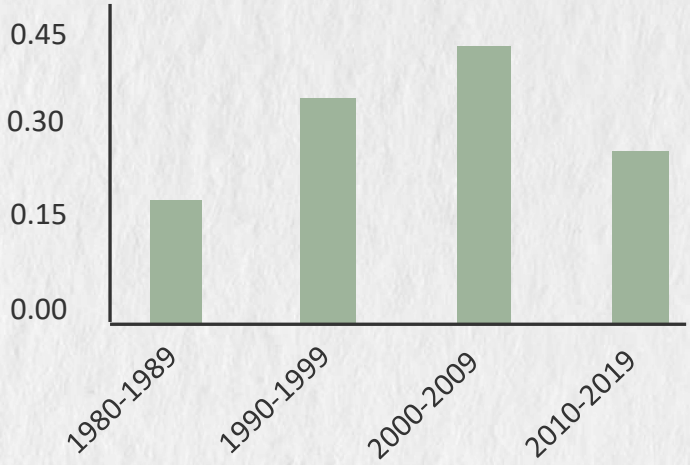


*Platygyrium repens*

% occurrence of epiphytes among all observations per decade

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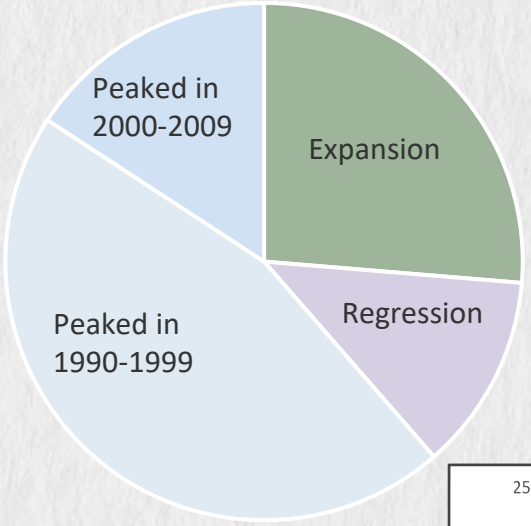


***Platygyrium repens***

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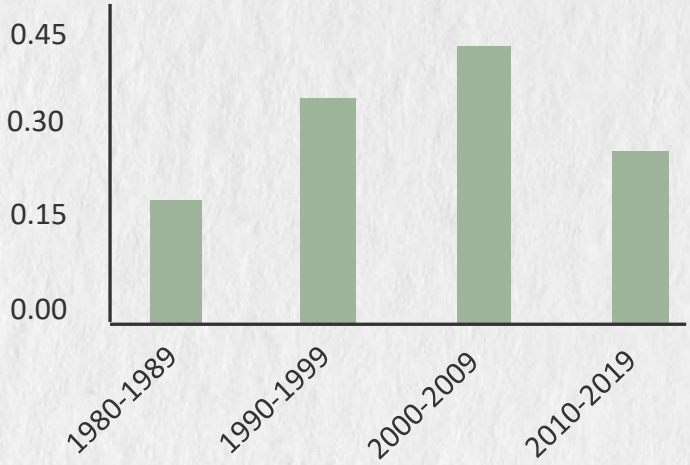


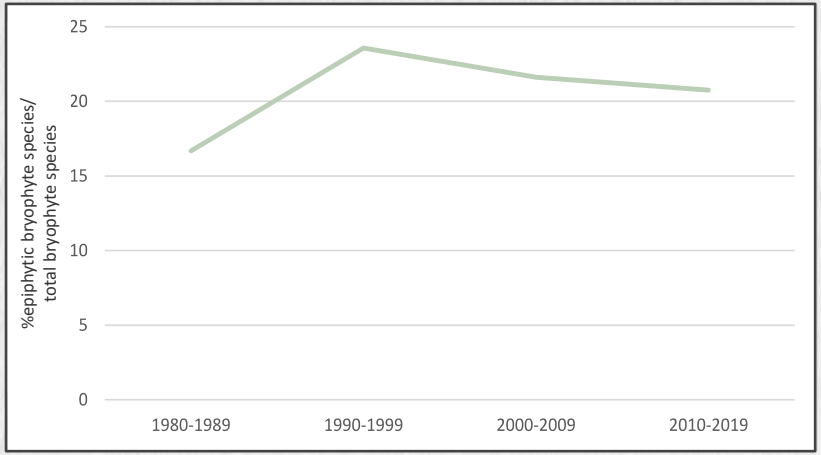

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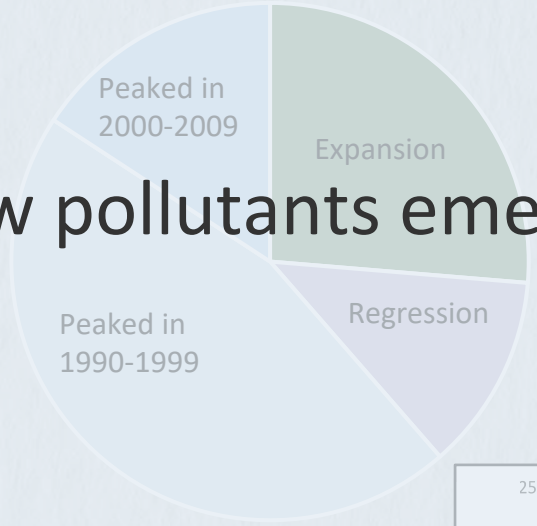
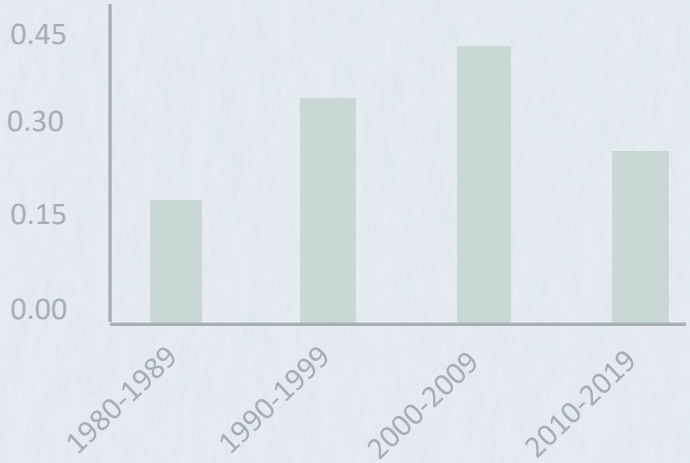



## Did new pollutants emerge?

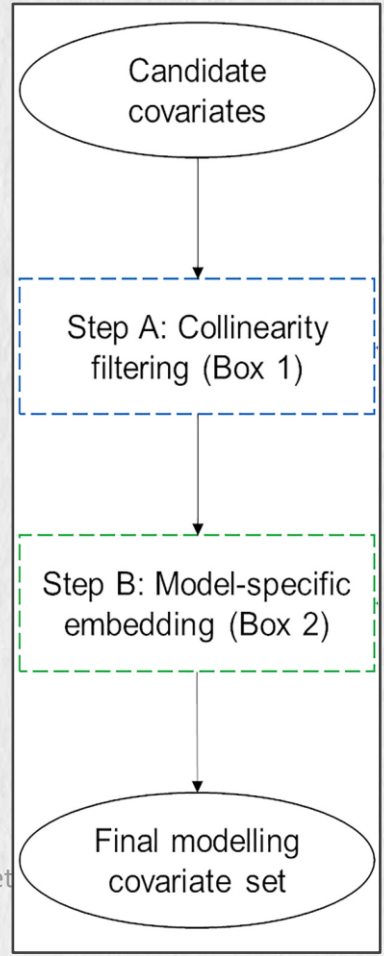
***Platygyrium repens***

% occurrence of epiphytes
among all observations per decade



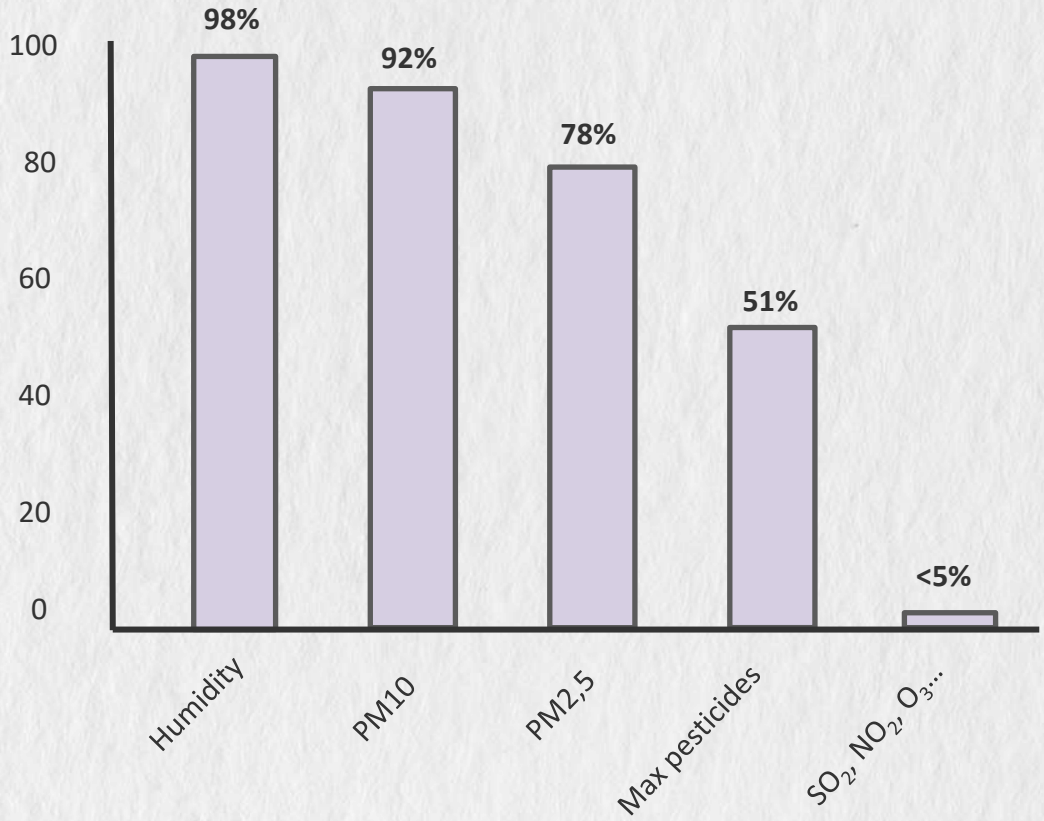

# Impact of new air pollutants on extant species with SDM

| Climatic variables | Major pollutants | New pollutants |
|---|---|---|
| Temperature | $NO_2$ | Pesticides |
| Precipitation | $SO_2$ | Heavy metals |
| Relative humidity | $O_3$ | Black carbon |
| | PM10 and PM2,5 | |




Covariate selection procedure (Adde et al. 2023. Ecol. Inform.)

# Contemporary spatial variation of new pollutants with SDM




- Climatic variation prevail over major pollutants
- Emergence of alternative pollutants: fine particles and pesticides.

# Conclusion : little impact of climate change ?

- No impact of climate change from 1980 to 2020
- Extant species distributions is largely driven by spatial variation in climatic conditions

- A flora on the edge of its climatic tolerance threshold?
- A debt of extinction?
- Emergence of new air pollutants


Any questions ?
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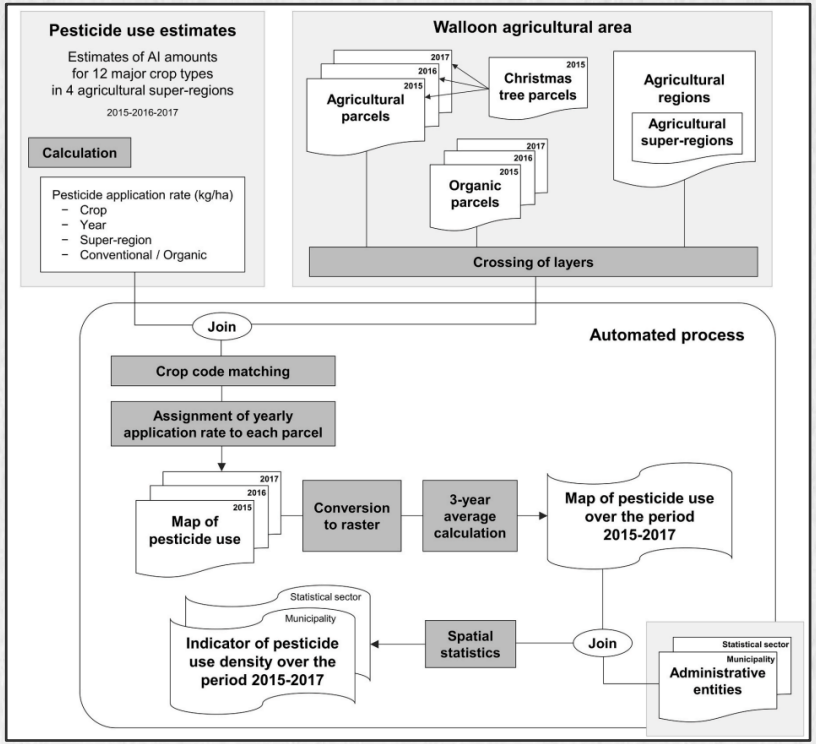
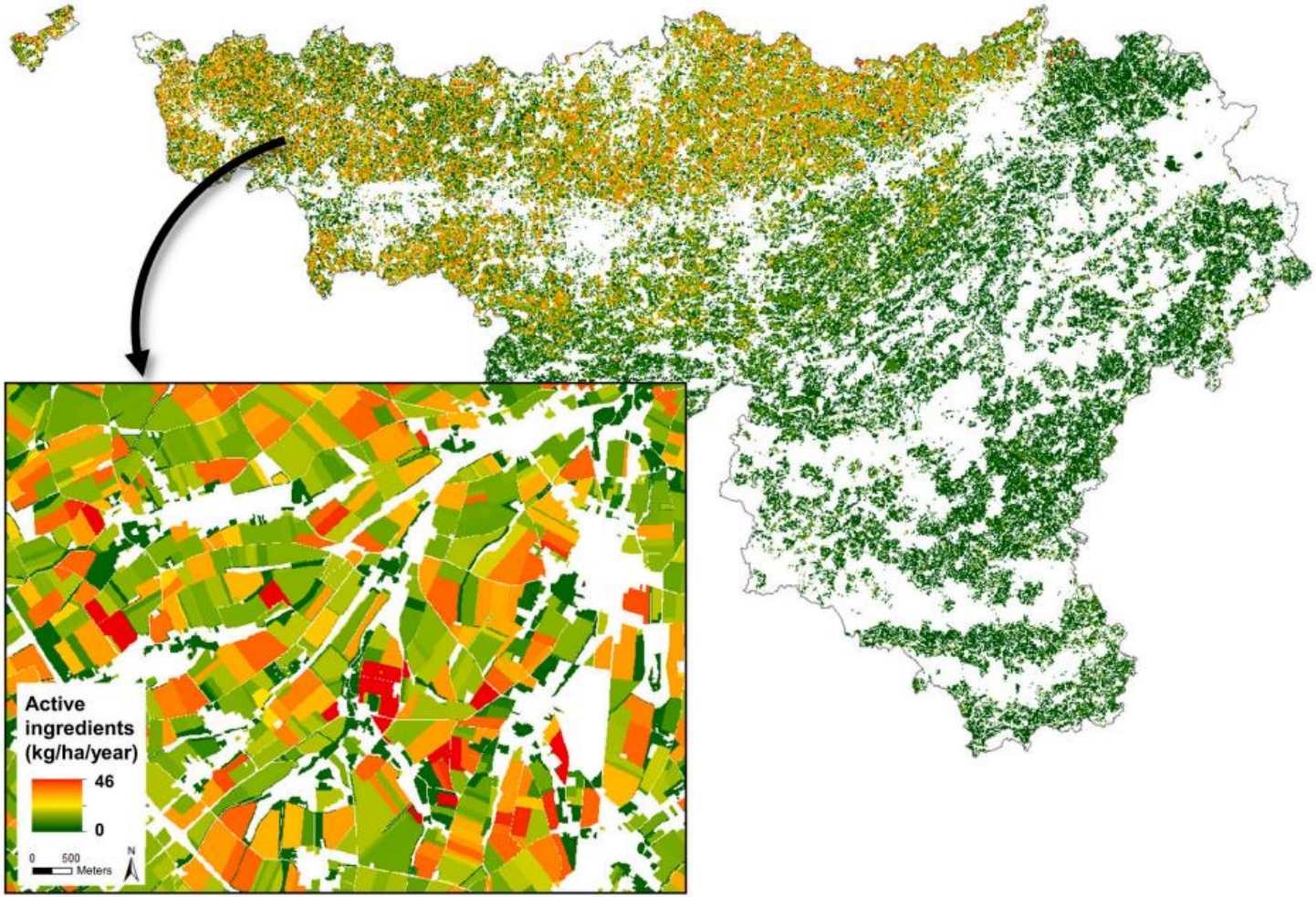
Sarah Habran , Christelle Philippart, Pierre Jacquemin, Suzanne Remy

# Mapping agricultural use of pesticides to enable research and environmental health actions in Belgium



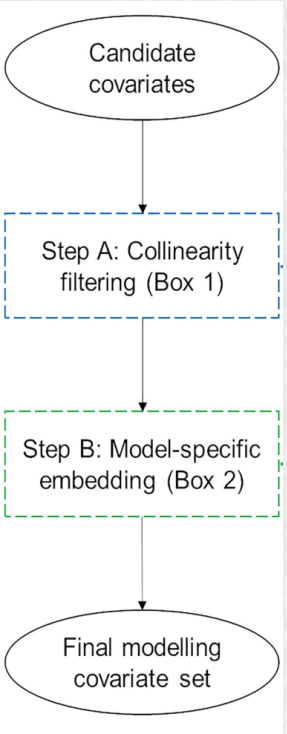

- Max amount of pesticides legally authorized
- Crop type (corn, wheat, beet, potato, …)
- Organic/non-organic
- Region of Wallonia
- Over 3 years to consider crop rotation


Active
ingredients
(kg/ha/year)
46
0
0
500
Meters
N

Antoine Adde, Pierre-Louis Rey, Fabian Fopp, Blaise Petitpierre, Anna K. Schweiger, Olivier Broennimann, Anthony Lehmann, Niklaus E. Zimmermann, Florian Altermatt, Loïc Pellissier, Antoine Guisan

# Embedded covariate selection procedure for species distribution modelling with the covsel R package

Two-step “embedded” covariate selection procedure. The procedure combines a collinearity-filtering algorithm (Step A) with three model-specific embedded regularization techniques (Step B), including generalized linear model with elastic net regularization (GLM-EN), generalized additive model with null-space penalization (GAM-NP), and guided regularized random forest (RF-GR).




In Step A (Collinearity filtering), a panel of many candidate covariates is reduced in number after collinearity analyses. Collinearity analyses are usually based on variance inflation factors (VIFs) or correlation tests. Principal components analysis (PCA) is also applied for reducing the dimensionality of covariate spaces.

Step B (Model-specific embedding) algorithms are doing covariate selection at the same time as model fitting, allowing to account early-on for the specificities of the algorithms and the multivariate context. Furthermore, they have a more reasonable computational cost and limit overfitting.

# Interpolation : RIO model

These data served to calibrate the RIO model. RIO is an interpolation model based on land use, a semivariogram based on the distances to the nearest measuring stations and the levels of air pollution, which was employed to compute, on an hourly basis, the background concentrations at the centroid of all the investigated pixels. Based on the interpolated data, the maximum hourly concentration and annual average concentration of each pollutant were computed every year for each pixel. (Hutsemékers et al., 2023)

- Around 20 measuring stations
- Distance to the nearest measuring station
- Level of air pollution

# The spectacular expansion of epiphytic flora

The significant increase both in frequency and cover of the liverwort Metzgeria furcate (Friedel & Müller, 2004).

The bryophytes Hypnum cupressiforme,Brachythecium rutabulum and Plagiothecium laetum var.laetum/denticulatum have significantly (Friedel & Müller, 2004).

Increase in cover and number of species of epiphytic bryophytes on forest ecosystem monitoring areas in North Rhine-Westphalia (western Germany) between 1999 and 2001 (Stapper, 2002).

The increase of nitrophytic species suggests that the problem of air pollution due to sulphur inputs may have shifted to a problem of nitrogen fertilization (Frahm, 2001).