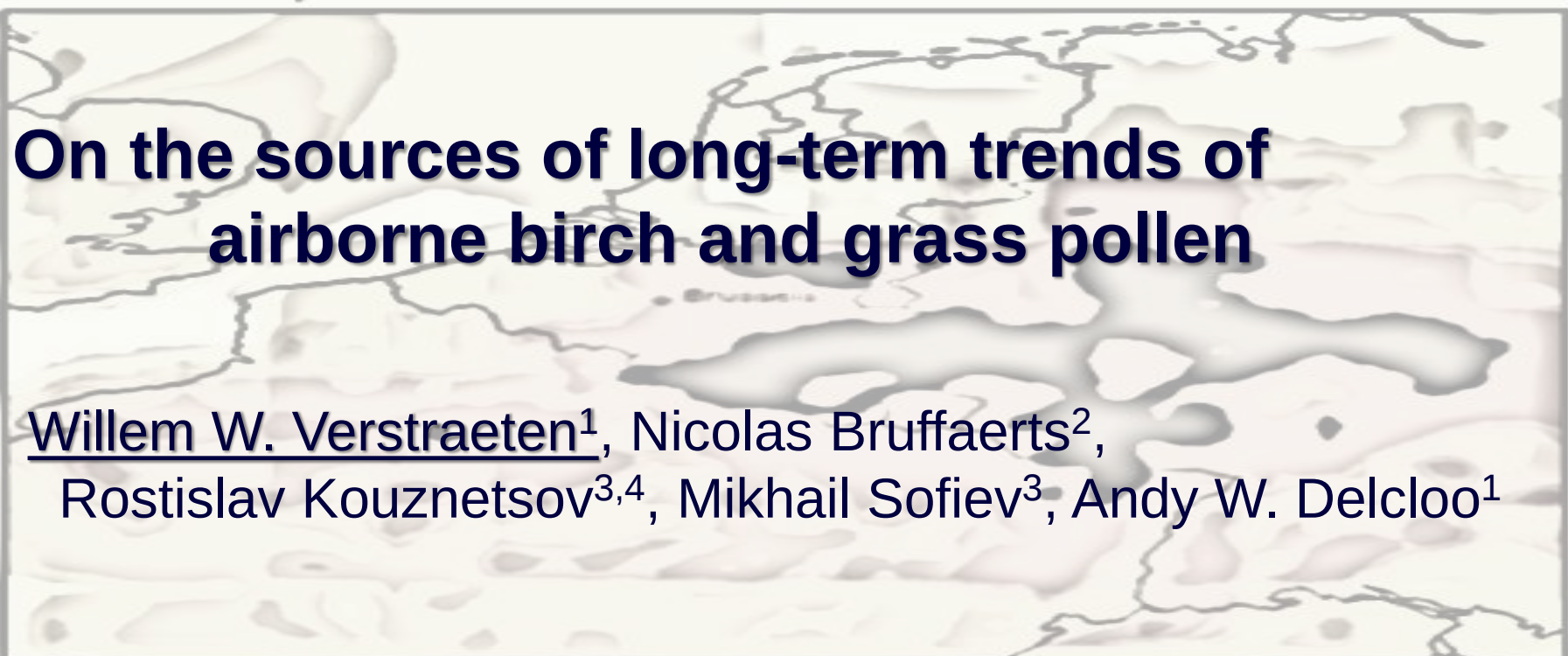
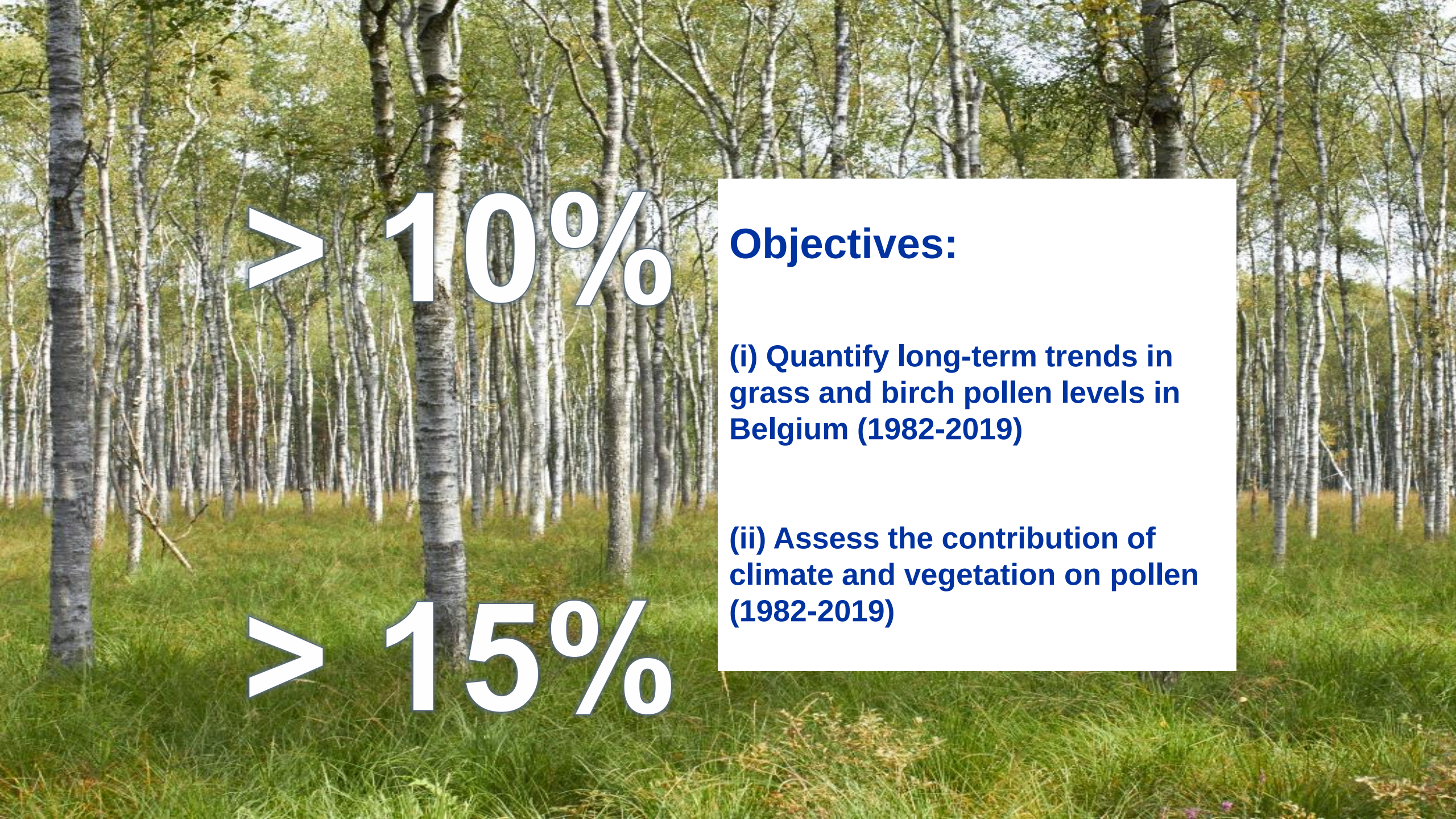




On the sources of long-term trends of airborne birch and grass pollen

Willem W. Verstraeten¹, Nicolas Bruffaerts²,
Rostislav Kouznetsov^{3,4}, Mikhail Sofiev³, Andy W. Delcloo¹

1. KMI, Belgium
2. Sciensano, Belgium
3. FMI, Finland
4. Obukhov Institute, Russia



> 10%

Objectives:

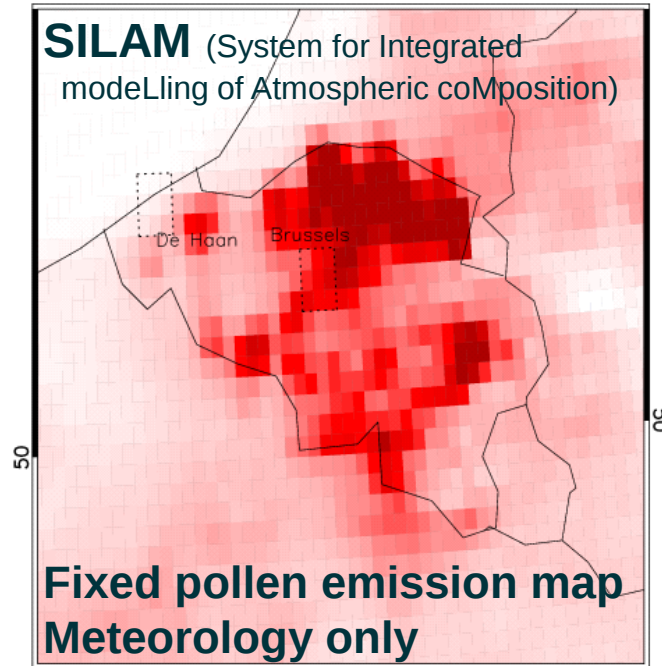
(i) Quantify long-term trends in grass and birch pollen levels in Belgium (1982-2019)

(ii) Assess the contribution of climate and vegetation on pollen (1982-2019)

> 15%

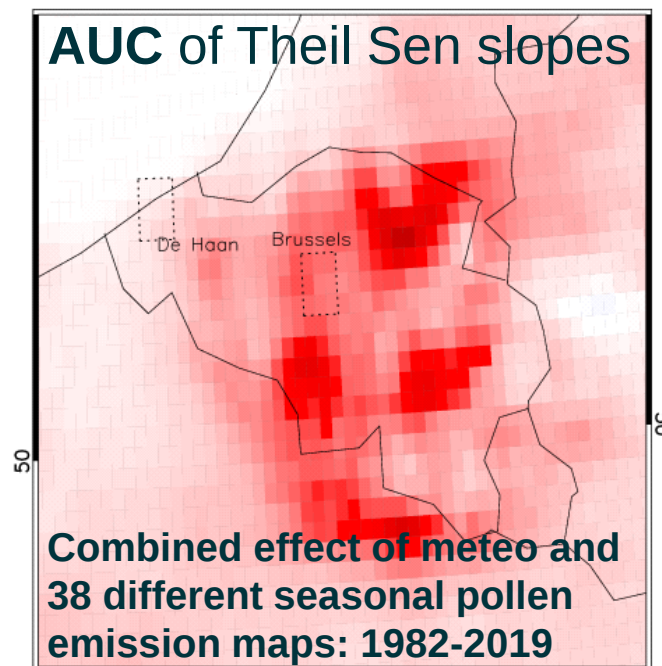
Trends in airborne birch pollen levels (1982-2019)

(a) Reference scenario



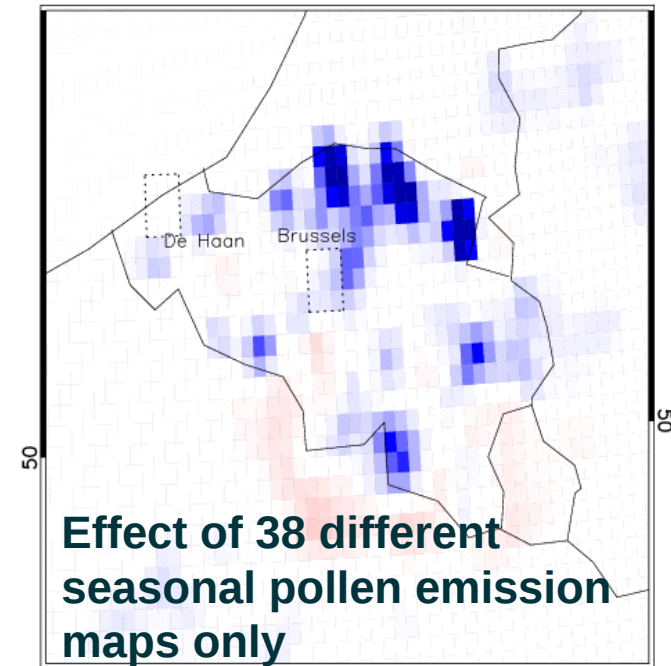
$AUC_{REF}: 335.583 \pm 343.918$

(b) Advanced scenario



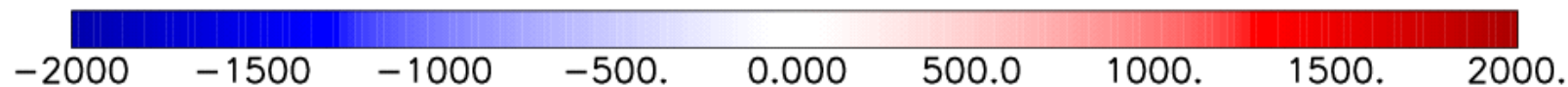
$AUC_{ADV}: 315.071 \pm 282.960$

(c) Difference (ADV-REF)



$AUC_{ADV-REF}: -21.738 \pm 150.476$

Area Under the Curve, AUC

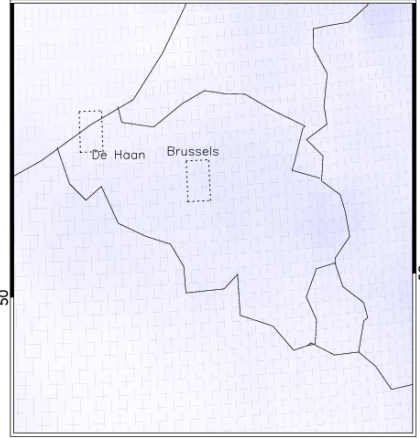


Area Under the Curve, AUC

Trends (AUC) in meteo for birch pollen season

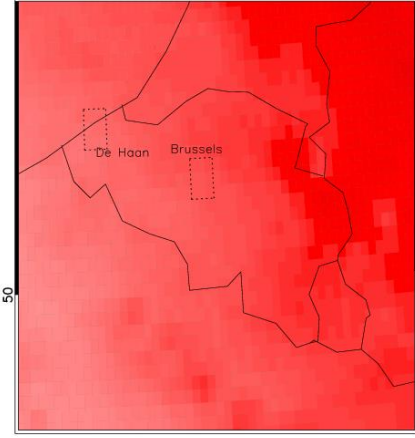
Meteorological data
=> ECMWF, ERA5

(a) Precipitation



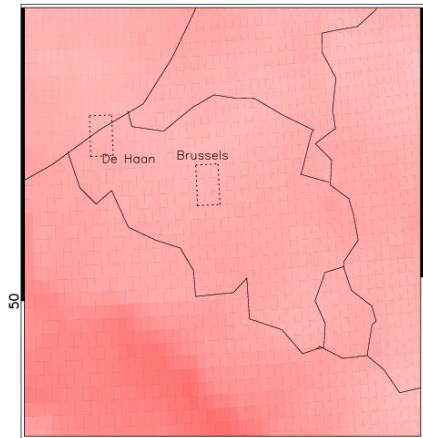
AUC: -11.560 ± 7.205

(b) Mean temperature



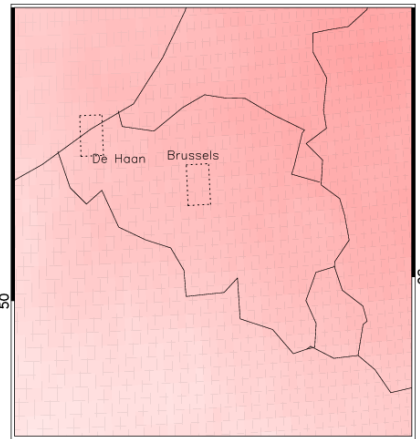
AUC: 113.748 ± 20.173

(c) Dew point temperature



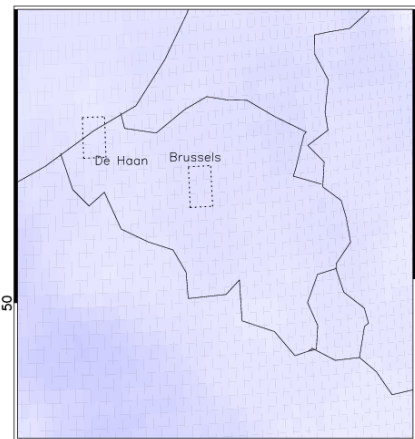
AUC: 76.164 ± 16.020

(d) Radiation



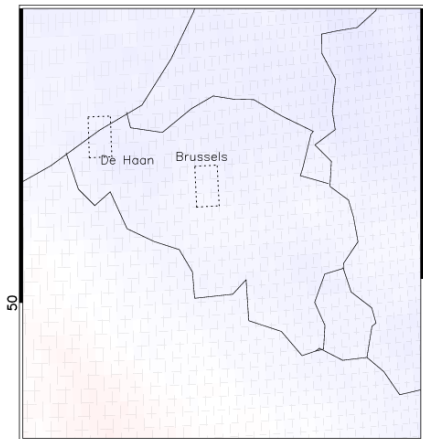
AUC: $4.53E+09 \pm 1.67E+09$

(e) WU



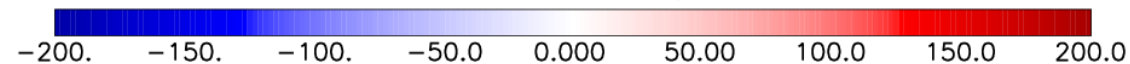
AUC: -19.976 ± 11.391

(f) WV



AUC: -7.090 ± 8.956

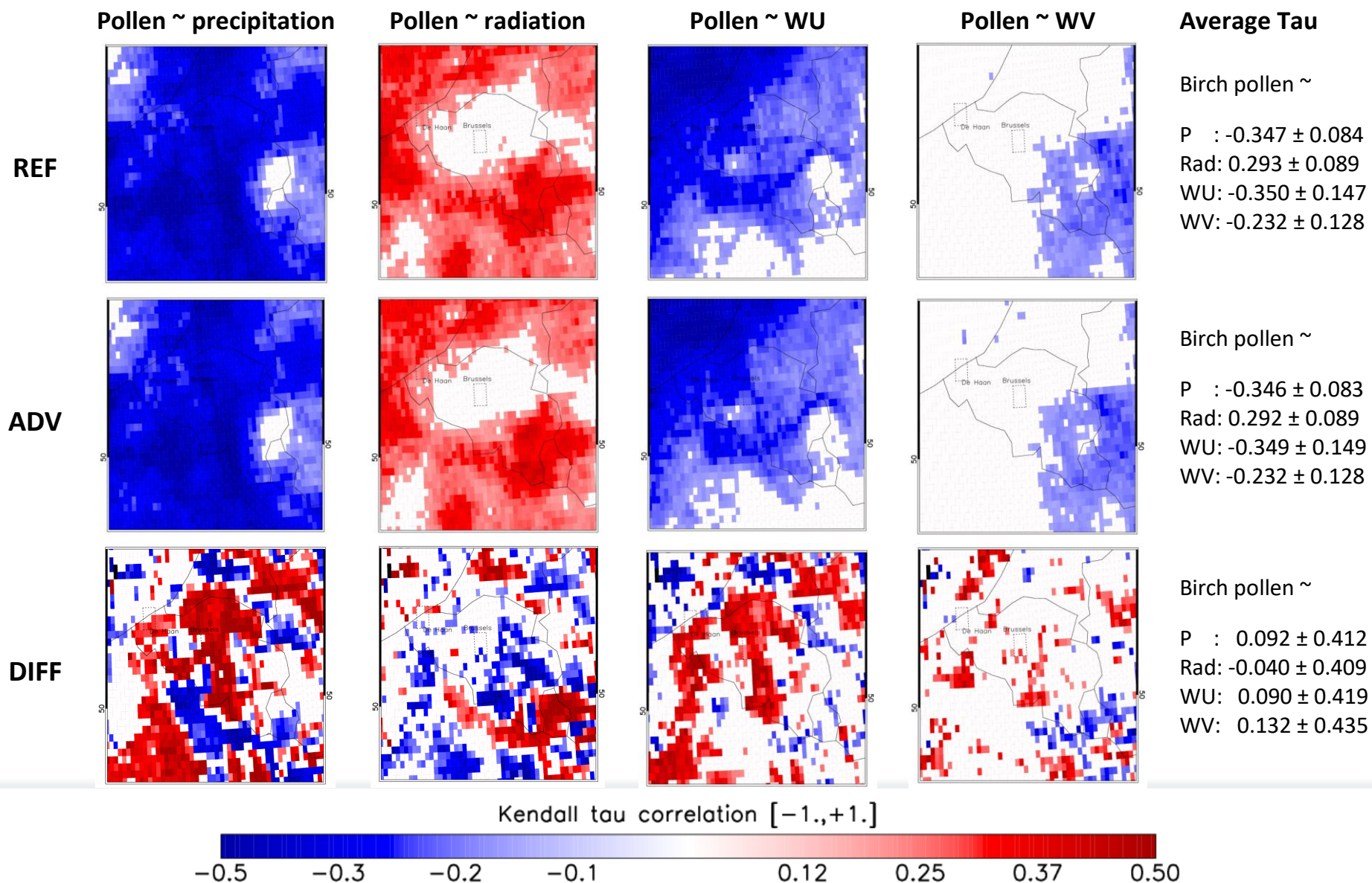
Area Under the Curve, AUC



Association between birch pollen & meteo (1982-2019)

Associations pollen
trends with meteo

Kendall Tau



What did we learn?



By analyzing SILAM runs for airborne birch and grass pollen in Belgium for the period 1982-2019 we learned that there is:

1. A substantial **increase** in **birch** pollen amounts over 38 years
2. Decreasing precipitation and increasing temperature
4. The climatology driven increase is lowered by the change in pollen emission patterns in time and space (7% for birch, 3.5X for grasses)

Verstraeten et al., 2019 in Aerobiologia
Verstraeten et al., 2021 in Science Tot. Env.
Verstraeten et al., 2022 in AFM

THANKS!

Questions? => willem.verstraeten@meteo.be

Sources & references (selection)

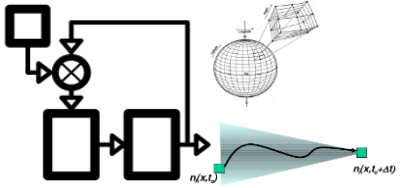
- The Noun Project for free icons
- D'Amato G., Cecchi L., Bonini S. et al. (2007). Allergenic pollen and pollen allergy in Europe. *Allergy*, 62, 976–990. doi:10.1111/j.1398-9995.2007.01393.x.
- ECMWF, <https://www.ecmwf.int/en/newsletter/147/news/era5-reanalysis-production>
- Sciensano. <https://airallergy.sciensano.be/> (accessed on 9 July 2018), section of the Belgian aerobiological surveillance network.
- Verstraeten, W.W., Dujardin, S., Hoebeke, L., Bruffaerts, N., Kouznetsov, R., Dendoncker, N., Hamdi, R., Linard, C., Hendrickx, M., Sofiev, M. & Delcloo, A.W. (2019). Spatio-temporal monitoring and modelling of birch pollen levels in Belgium. *Aerobiologia*. <https://doi.org/10.1007/s10453-019-09607-w>. And references herein.
- Verstraeten, W.W., Hoebeke, L., Bruffaerts, N., Kouznetsov, R., Sofiev, M. & Delcloo, A.W. (2021). Modelling grass pollen levels in Belgium. *Science of the Total Environment*. And references herein.
- Verstraeten, W.W., Kouznetsov, R., Hoebeke, L., Bruffaerts, N., Sofiev, M. & Delcloo, A.W. (2022). Reconstructing multi-decadal airborne birch pollen levels based on NDVI data and a pollen transport model. Accepted in *Agricultural and Forest Meteorology*
- Respirit Brain project.
- RETROPOLLEN Brain project

Reconstruction of 1982-2019 emission maps for birch & grass pollen sources: reference map combined with NDVI data in a Random Forest framework

Simulation of airborne birch and grass pollen levels using **SILAM** (System for Integrated modeLling of Atmospheric coMposition) and **ECMWF** ER5 meteorological data

Time series analysis: Theil-Sen slopes on 38 years of daily pollen levels of every day of the pollen season, and on the corresponding meteorological parameters, Area Under the Curve (AUC), Association (Kendall-Tau) pollen with meteorology

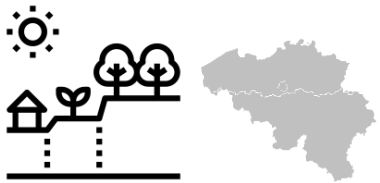
Pollen on the run: what do we need?



SILAM (System for Integrated modeLling of Atmospheric coMposition) => requires timely spatio-temporal inputs



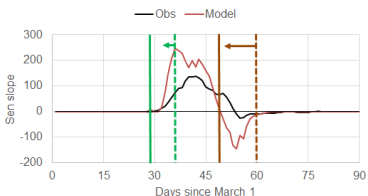
Meteorological data => ECMWF!



Emission maps:

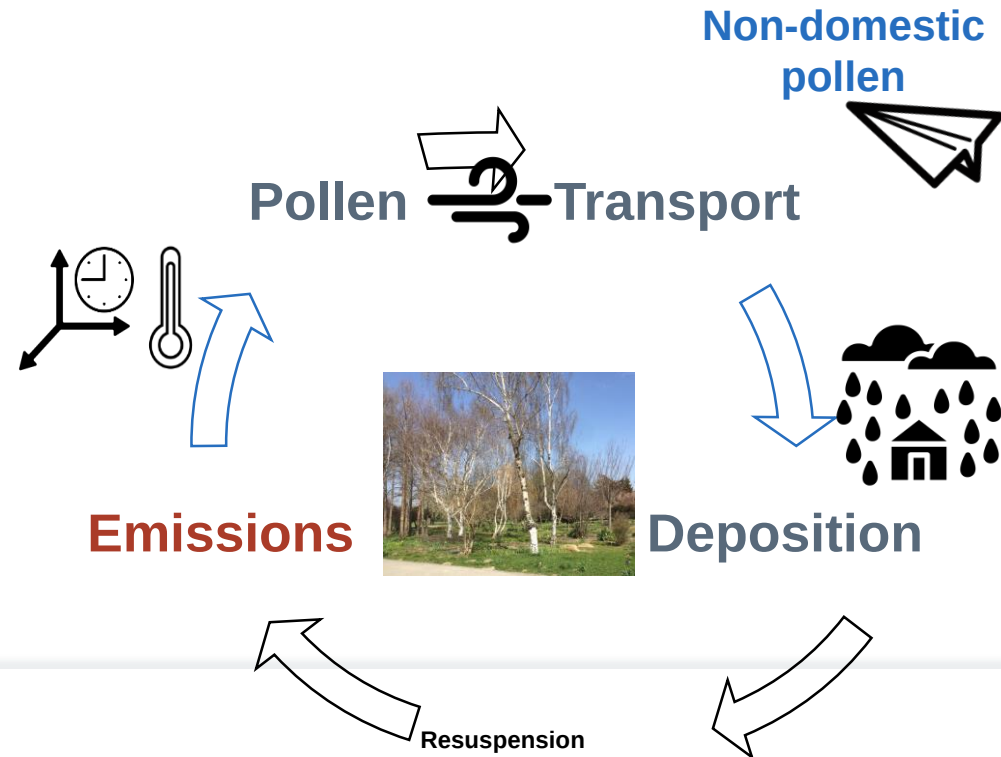
spatial distribution of pollen sources

Multi-decadal datasets based on NDVI,
forest inventory data and grass
distribution maps for 1982-2019

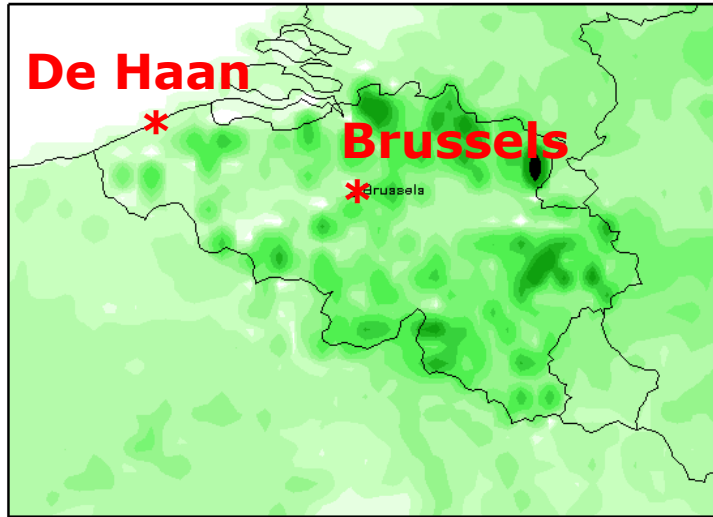


Temporal trends, Theil-Sen slope, AUC
Association, Kendall Tau

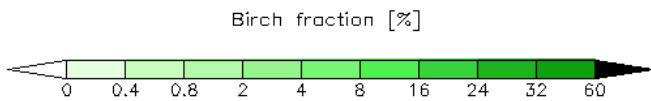
Involved processes



Reconstruction of birch fraction maps

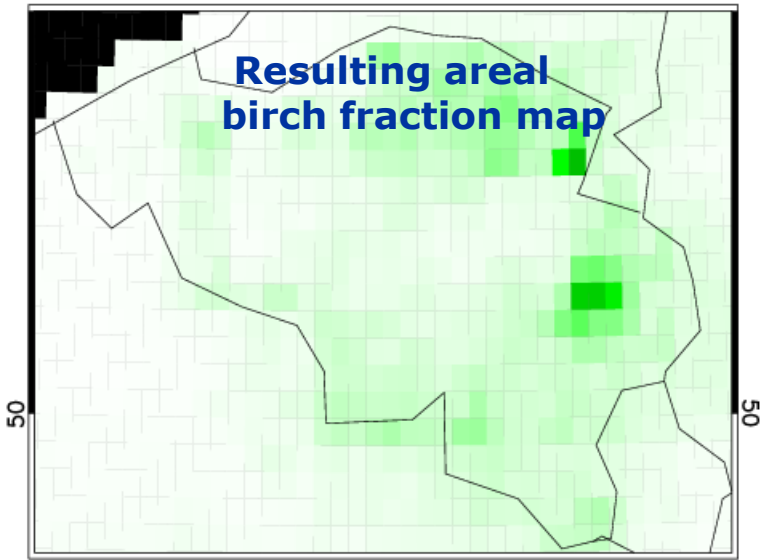
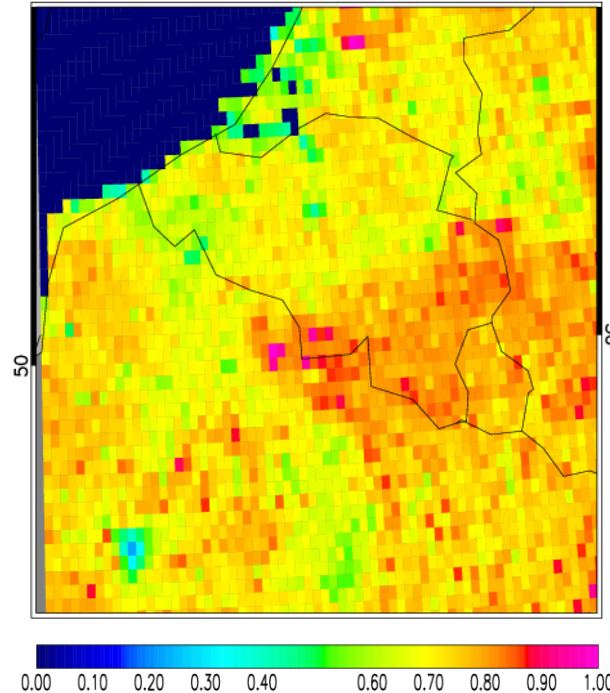


Baseline areal birch fraction map

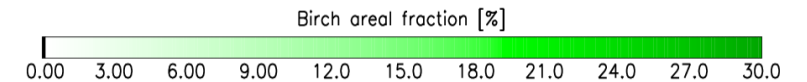


Verstraeten et al., 2019, Aerobiologia

**GIMMS AVHRR3g
1982-2015 + 2019**

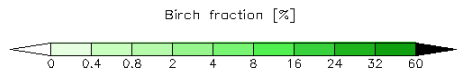
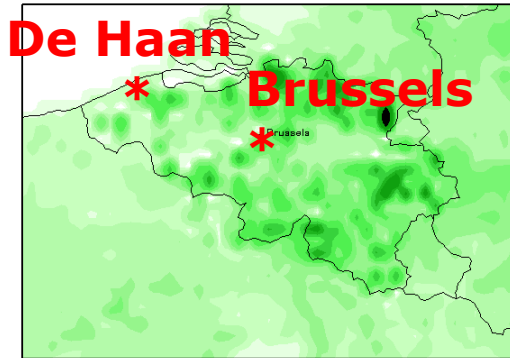


**Random Forest NDVI & baseline
areal birch fraction map**



We have reconstructed birch fraction maps for back SILAM to 1982 by combining a reference map (left figure) based on forest inventory data and the AVHRR3g NDVI data set (middle figure) that goes back to 1981 in a Random Forest statistical approach (right figure).

Reconstruction of birch fraction maps

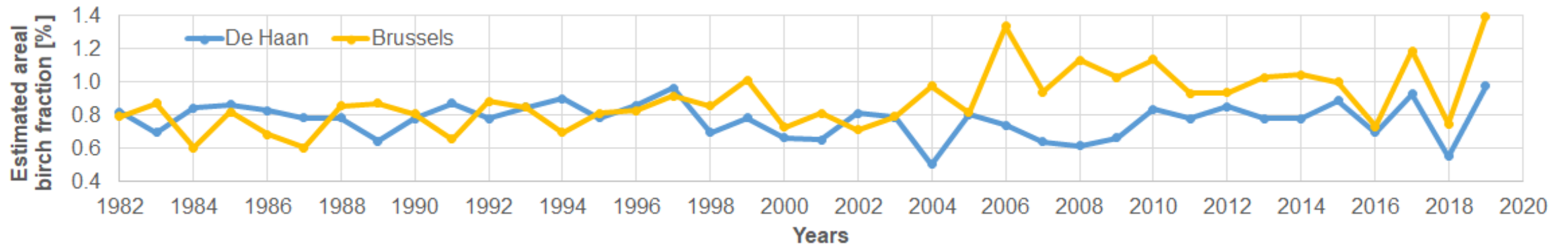


The result of the reconstruction is shown in the time series extracted from the cell grid of De Haan and Brussels (see also left map for location).

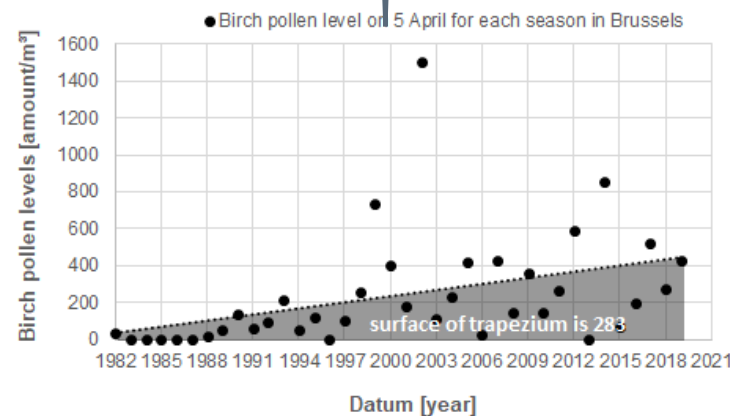
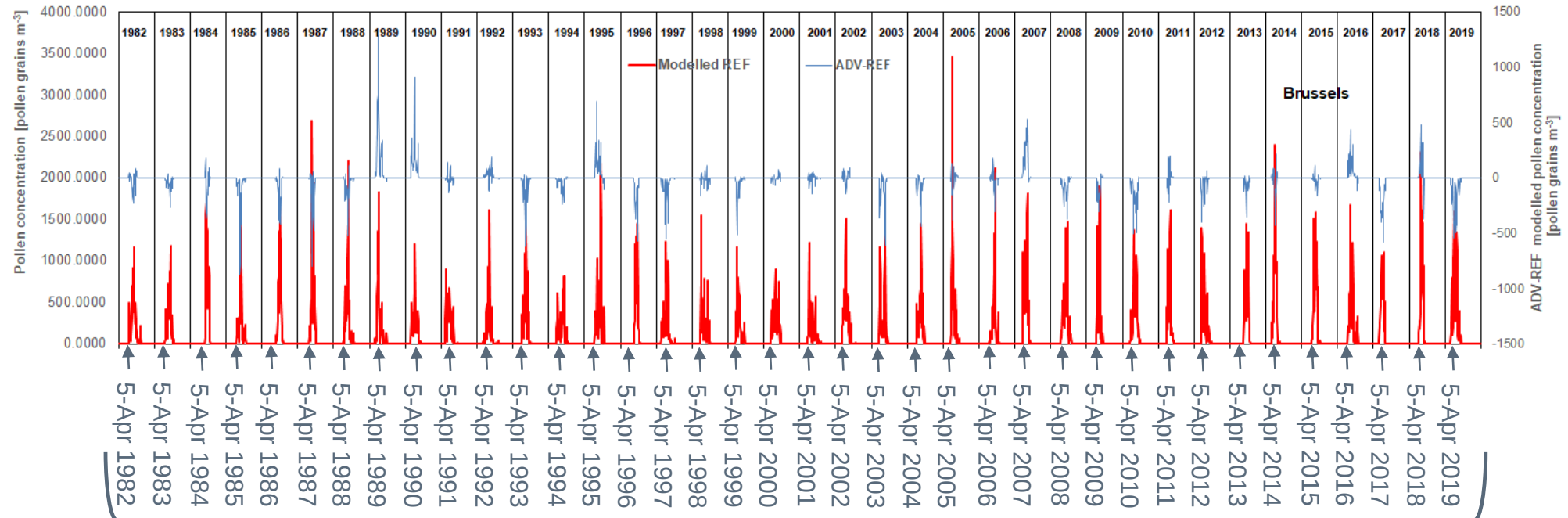
Warning!

This is not a real areal birch fraction map. Rather it is an effective fraction map that reflects the variation in potential pollen emission.

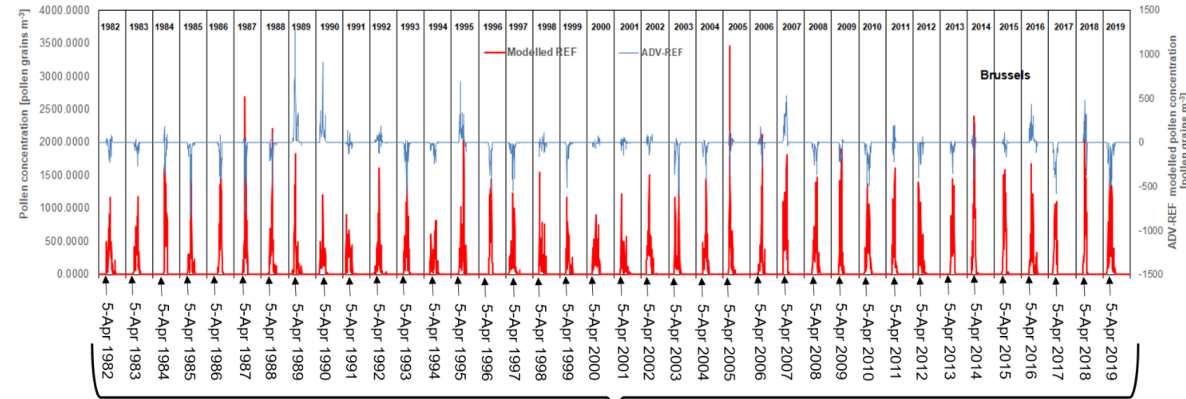
But what about the variation in meteorology in 40 years?



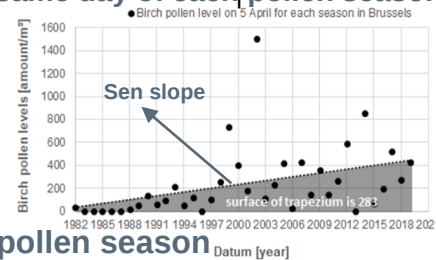
Procedure: pollen time series, daily Theil-Sen slopes, AUC, Kendall tau correlation



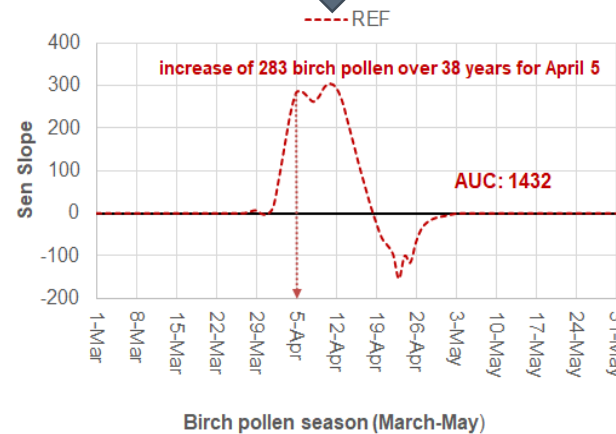
Procedure



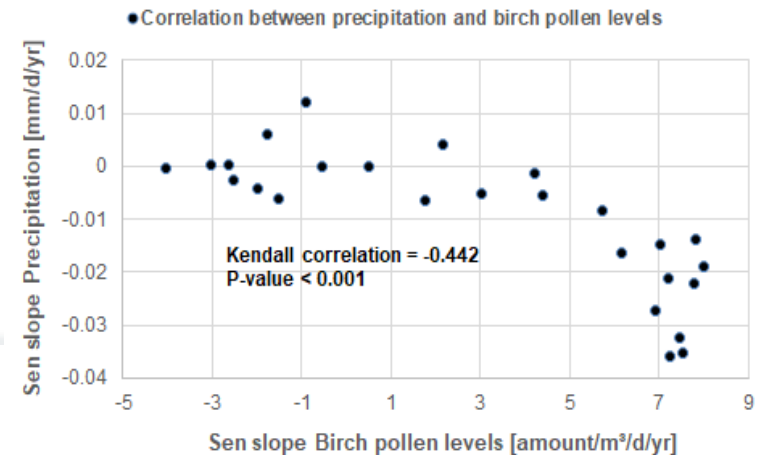
Select the same day of each pollen season (5 April as example)



For all days of the birch pollen season



Sen slopes of birch pollen levels vs. the corresponding Sen slopes of the meteorological Quantity (i.e. precipitation)



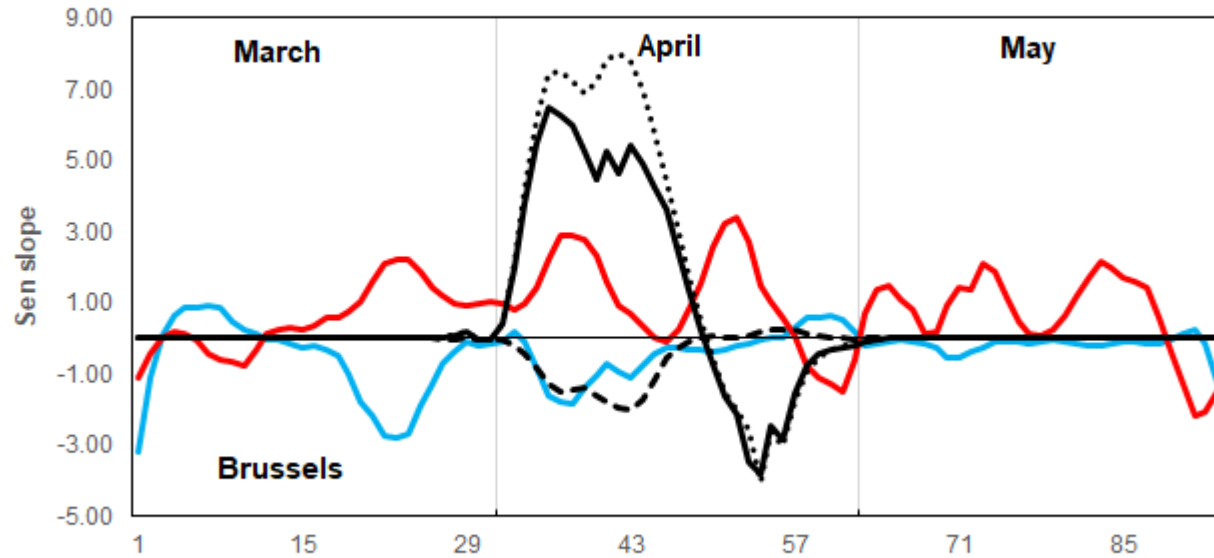
Area Under the Curve, AUC for birch pollen and for meteorological values (precipitation, wind speed, temperature, radiation, etc)

Association, Kendall tau correlations

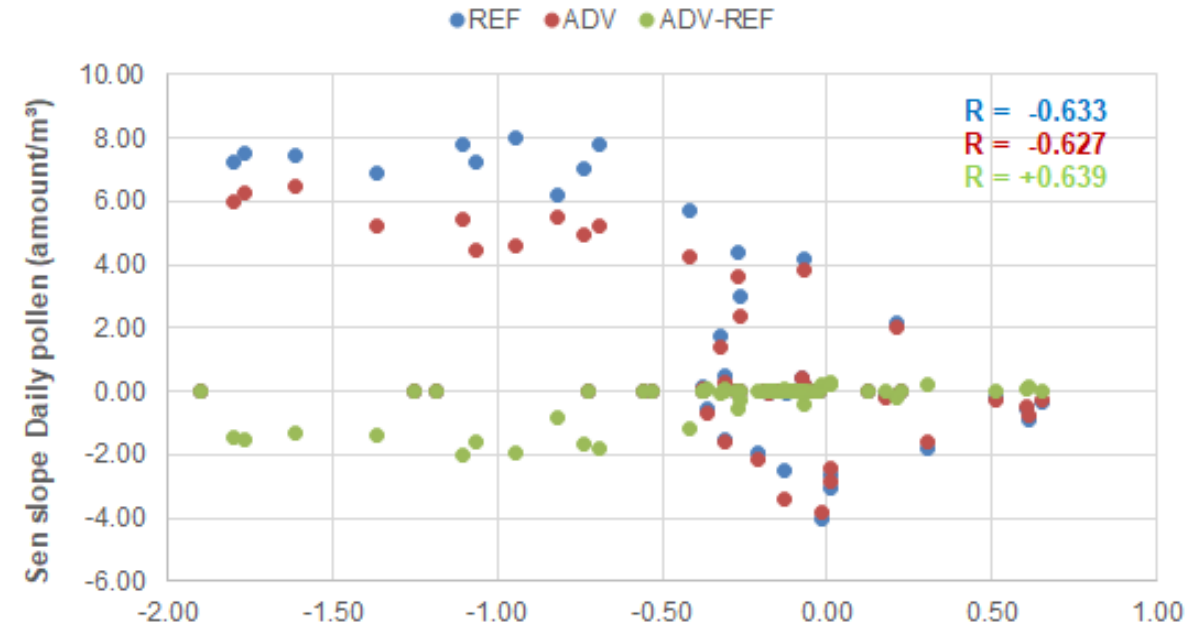
Trends in grass and birch pollen sources for 1982-2019

Associations, Brussels grid

Precipitation Radiation REF ADV ADV-REF



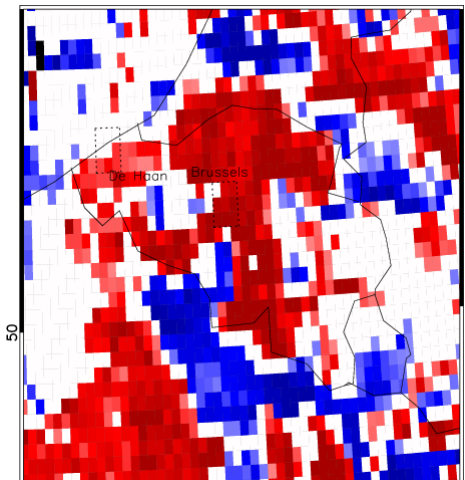
Birch pollen season March-May



Sen slope Daily precipitation [mm/yr]

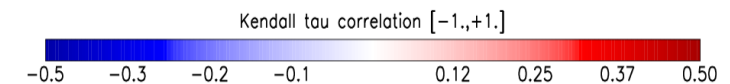
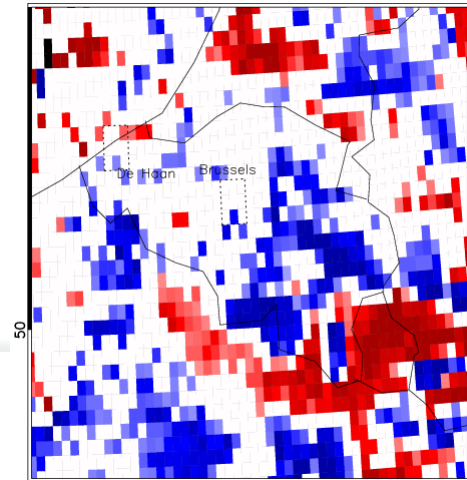
ADV-REF

Pollen ~
Precipitation



ADV-REF

Pollen ~
Radiation



Trends in birch and grass pollen sources (1982-2019)

