ILMATIETEEN LAITOS
METEOROLOGISKA INSTITUTET
FINNISH METEOROLOGICAL INSTITUTE

HIALINE
Health Impacts of Airborne Allergen Information Network

Towards forecasting of biochemical air quality

Understanding the atmospheric allergens, their features and interactions with chemical pollutants

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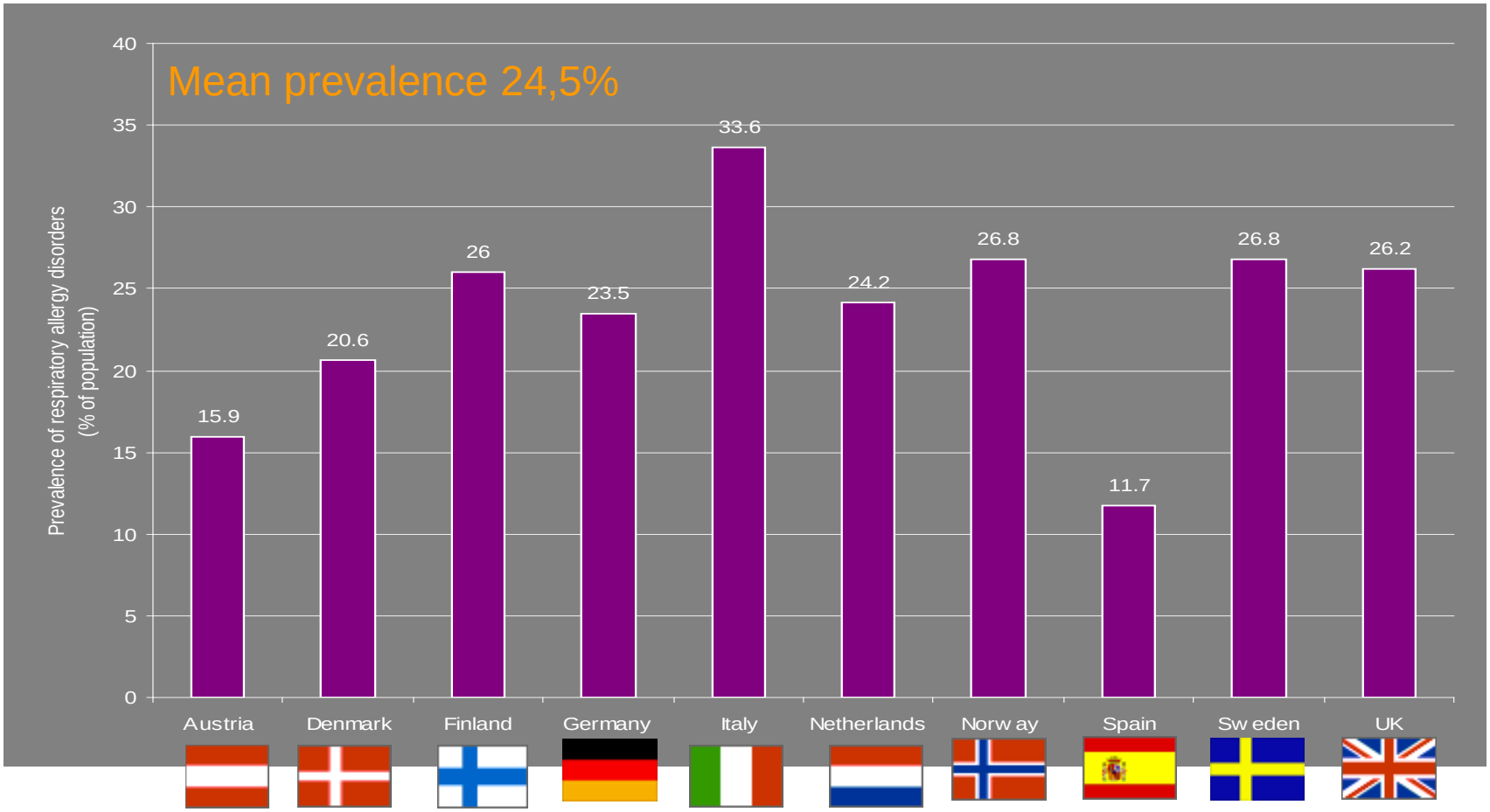
COST EUPOL consortium

HIALINE project team

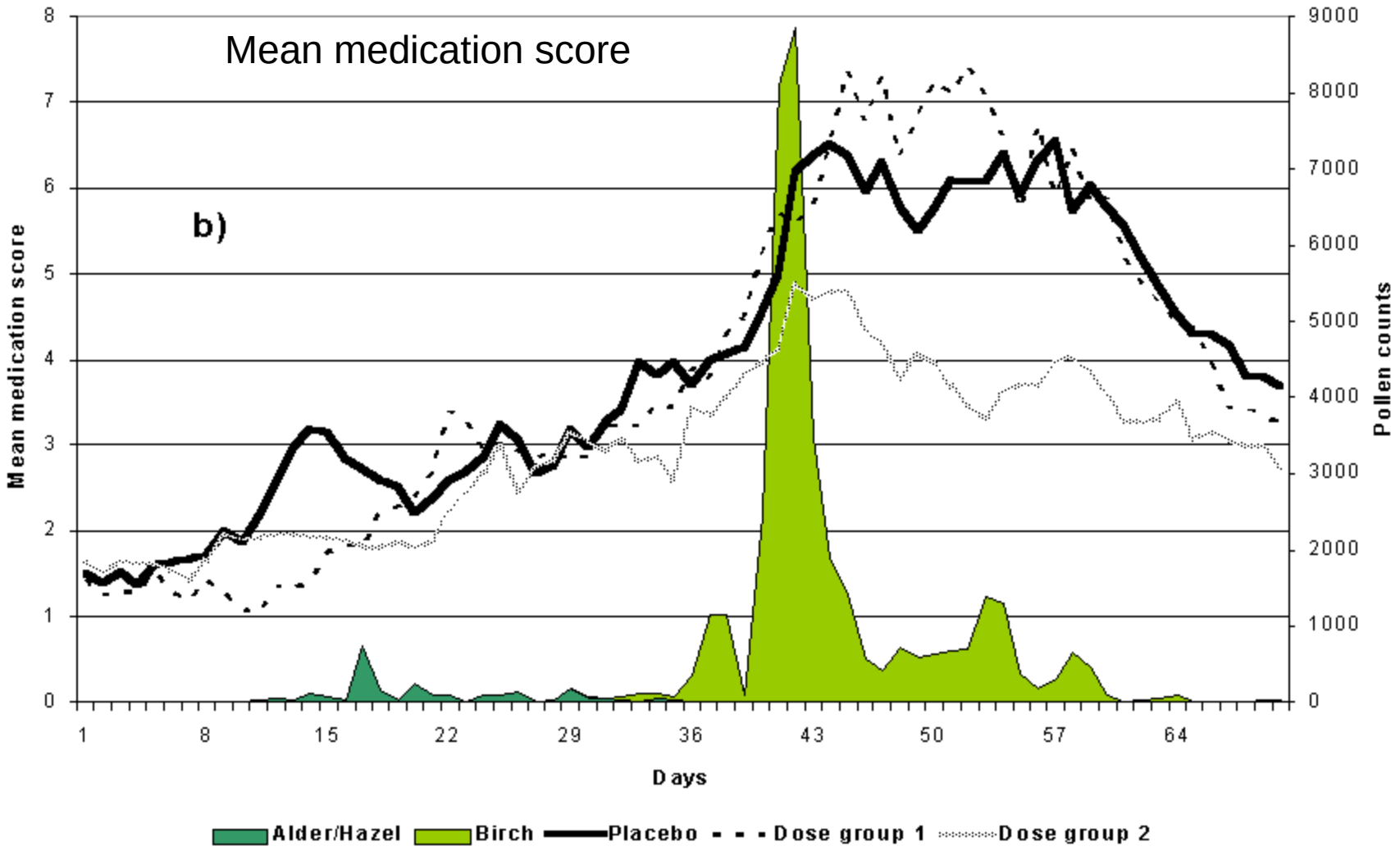
Outlook

- Introduction: what we know
  - … and know that we do not know
- What next?
  - Ambrosia forecasting system
  - Pollen or allergen? Free allergen in air?
  - Interaction with chemical and aerosol pollutants?
- Mechanisms of interaction with chemical and aerosol air pollutants
- Modelling experiment on allergen and diesel particles interaction
- Conclusions

Prevalence of allergic rhinitis in Europe



Adapted from Dahl, de Monchy, Chivato, Valovirta *et al*. Respir Med 2004; 98: 398-403


Mean medication score
b)
Mean medication score
Pollen counts
Days
0
1
2
3
4
5
6
7
8
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
1
8
15
22
29
36
43
50
57
64
Alder/Hazel
Birch
Placebo
Dose group 1
Dose group 2

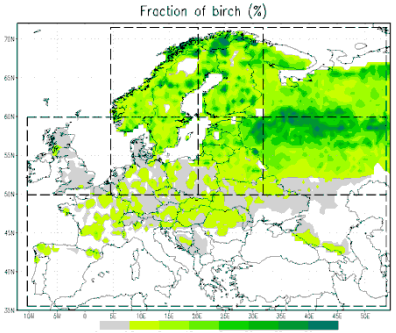
Motivation

- High burden to the society, increasing
- By far the most-direct impact among the air pollutants
- Zero legislation at European level, very little at national one
- Limited but EXISTING mitigation possibilities
- Abundant adaptation options
- Measures must be taken prior to exposure => forecast is needed

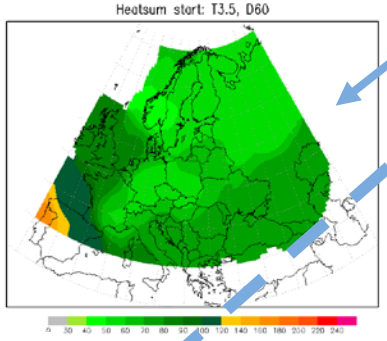
What we know

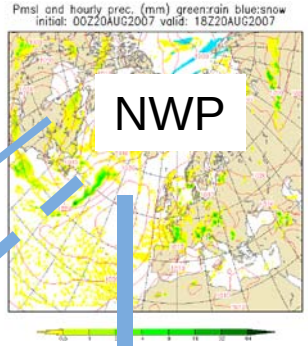
SILAM-BIRCH/OLIVE-POLLEN forecasting system

Birch fraction map



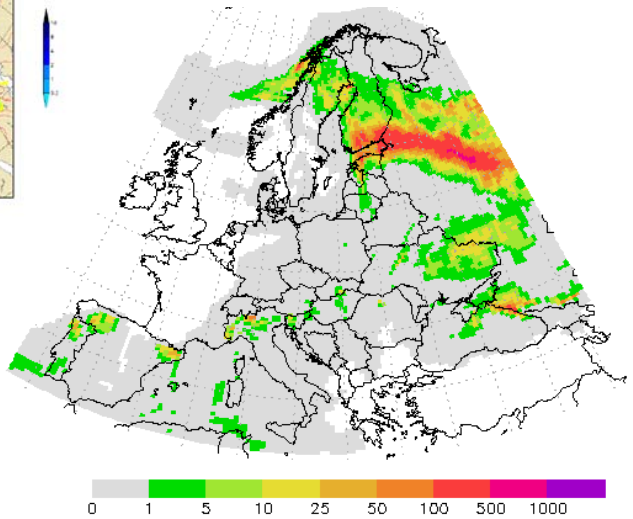
Start of flowering
Temp. sum threshold



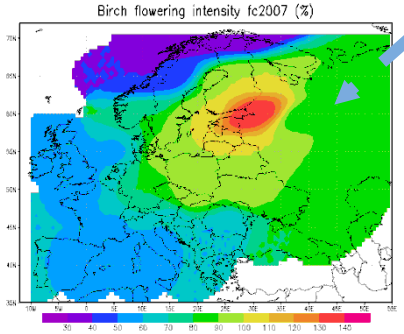


NWP

Pollen concentr.[#/m3]



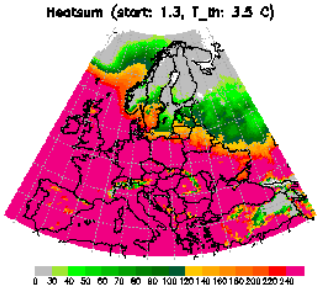
Nbr of pollen grains
(% vs normal)

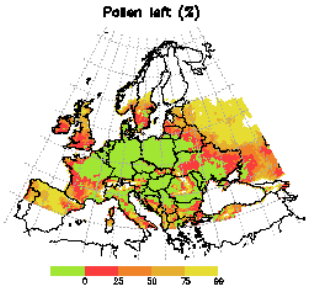


Temperature sum difference: TS(end)-TS(start)

Dispersion model
SILAM
(3 talks, 2 posters @ITM)

release
transport
sinks





Courtesy of S.Jaeger, data: EAN

Temp. sum

pollen still in catkins, %

What we know that we do not know (WK_WDK)

Birches in Helsinki, Finland, October 29, 2006

Photo: P.Siljamo

WK_WDK: phenological uncertainty

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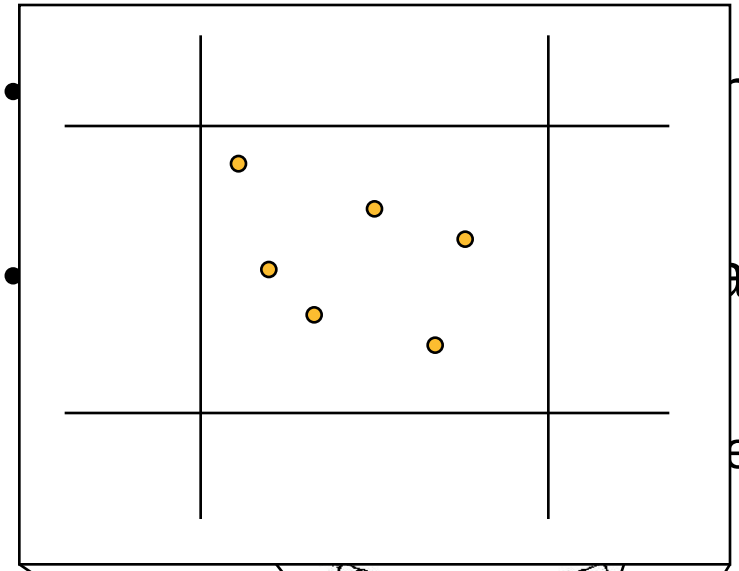
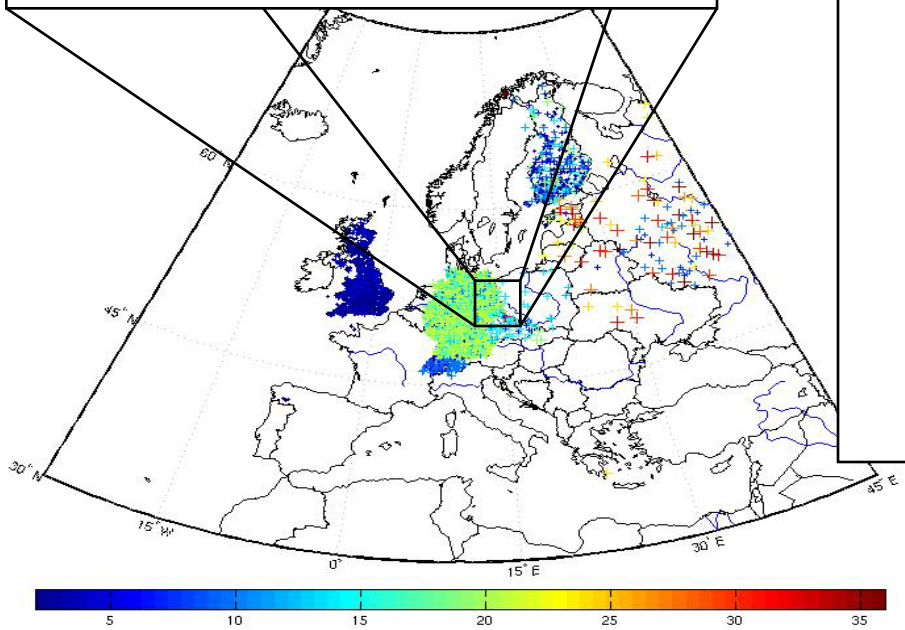
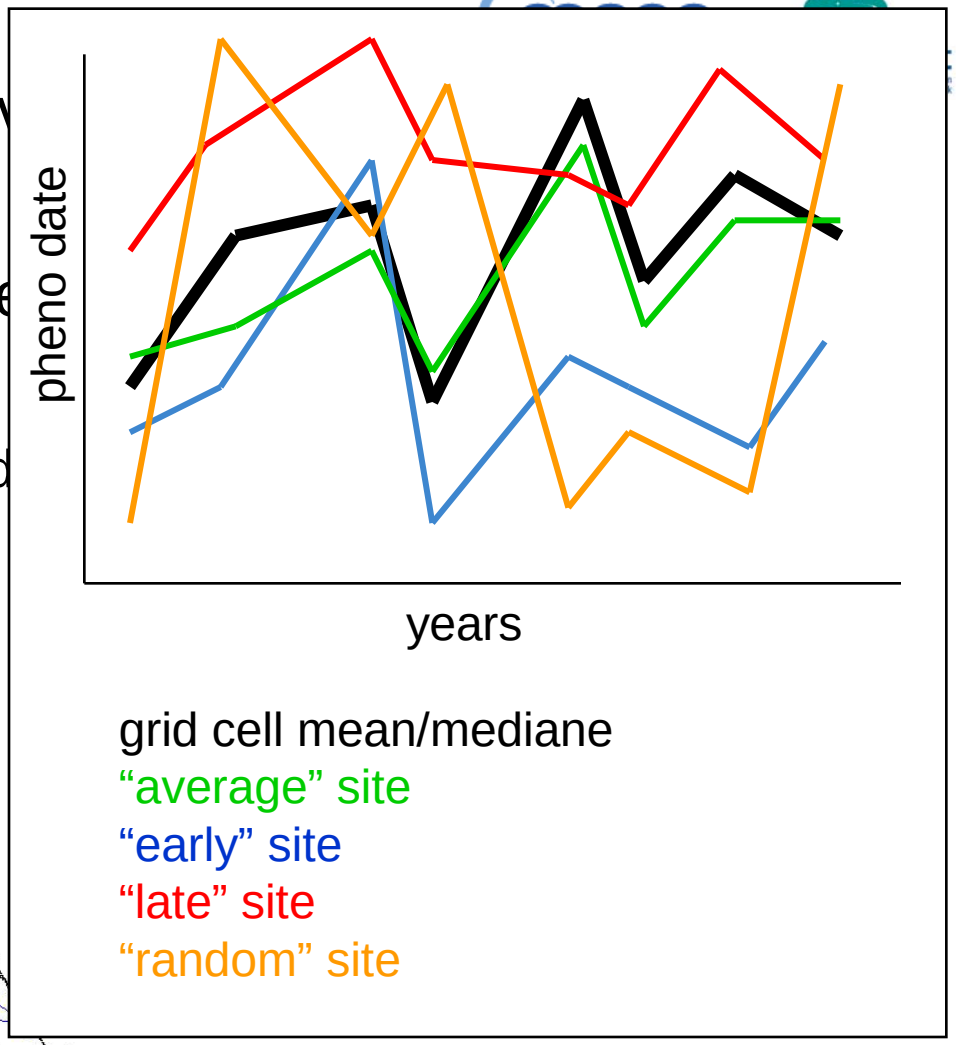




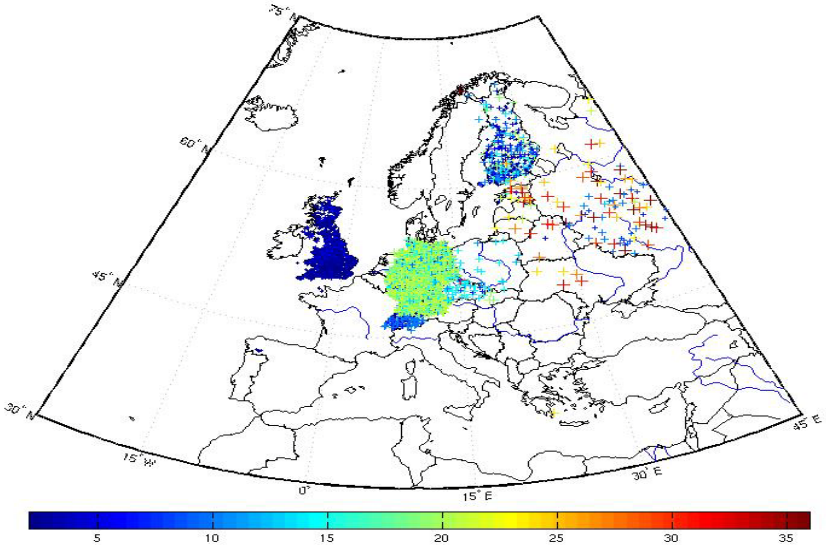
years



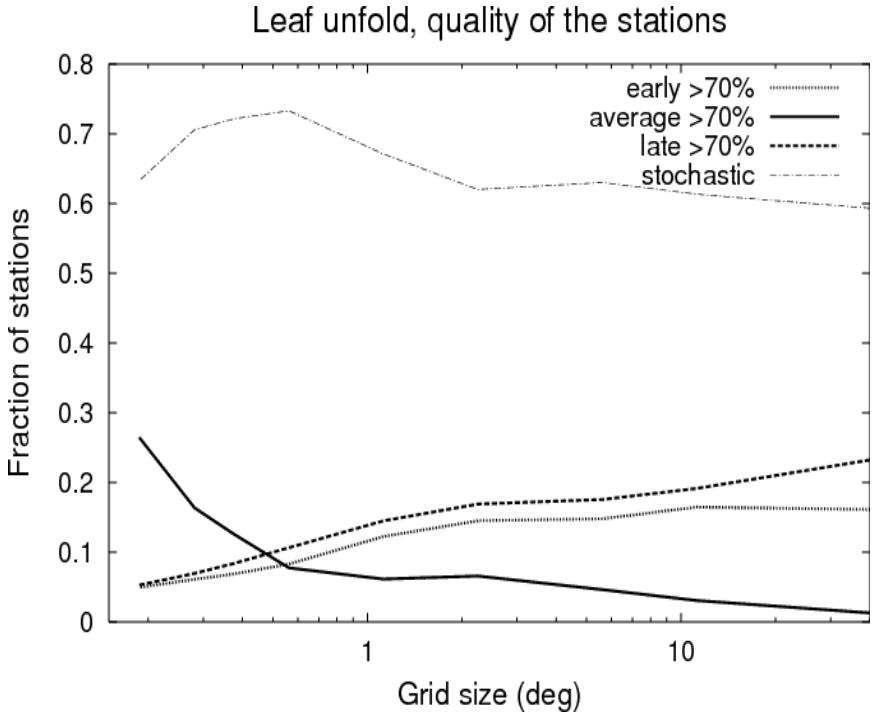
WK_WDK: phenological uncertainty

Proportion of the stations in the grid cell that in 70% case report:

early dates: > 2 days earlier than median over the corresponding grid cell
late dates: > 2 days later than median
representative (average): median+/- 2 days
random (stochastic): no clear behaviour with regard to the grid-cell median



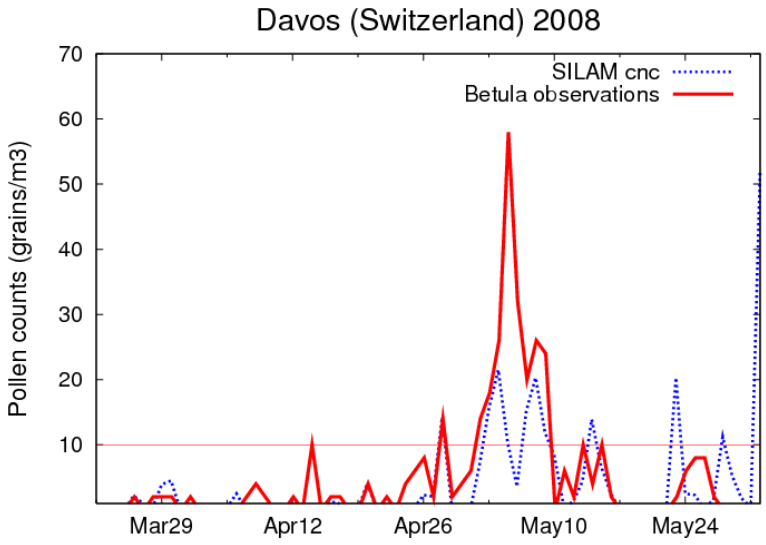
years

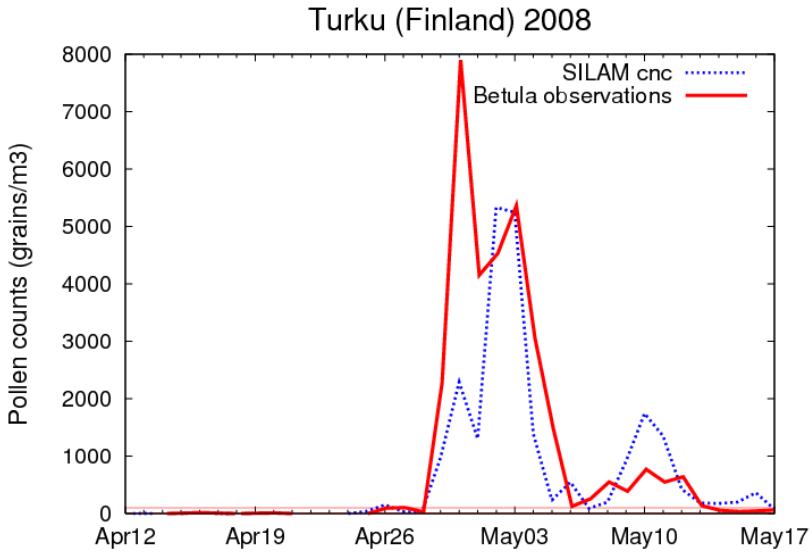


The smaller grid cell the bigger amount of “good” stations **BUT 60% ARE RANDOM**

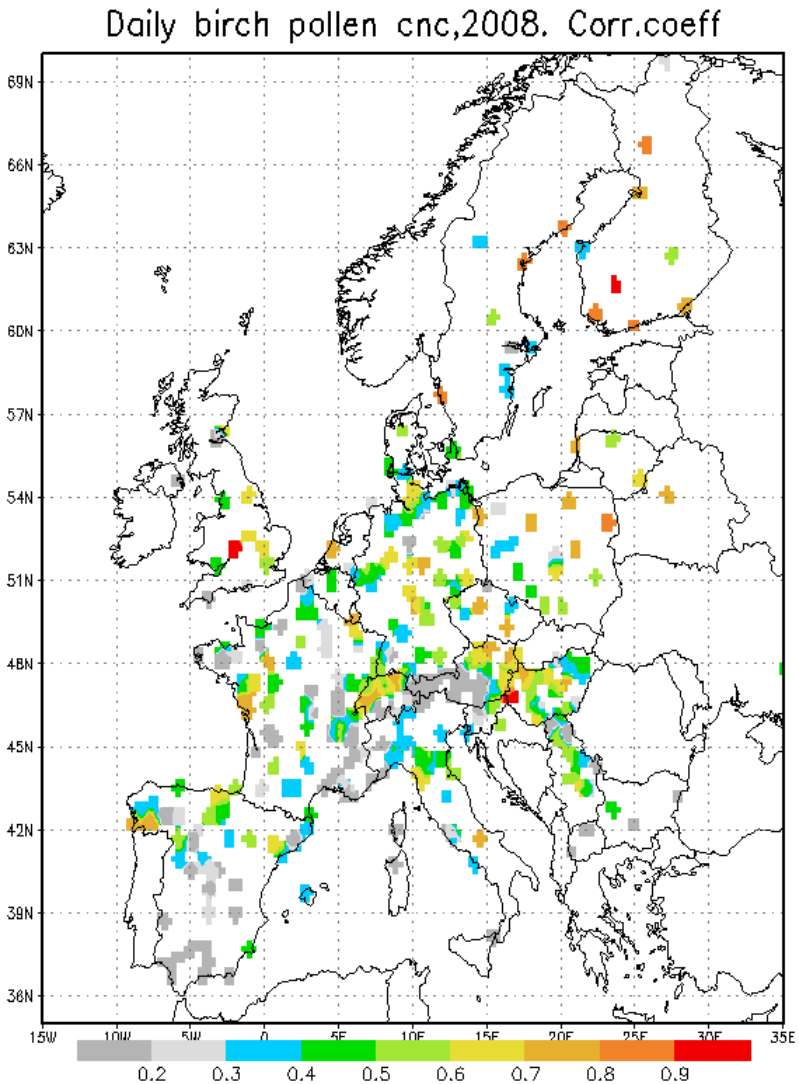
WK_WDK: modelling uncertainty

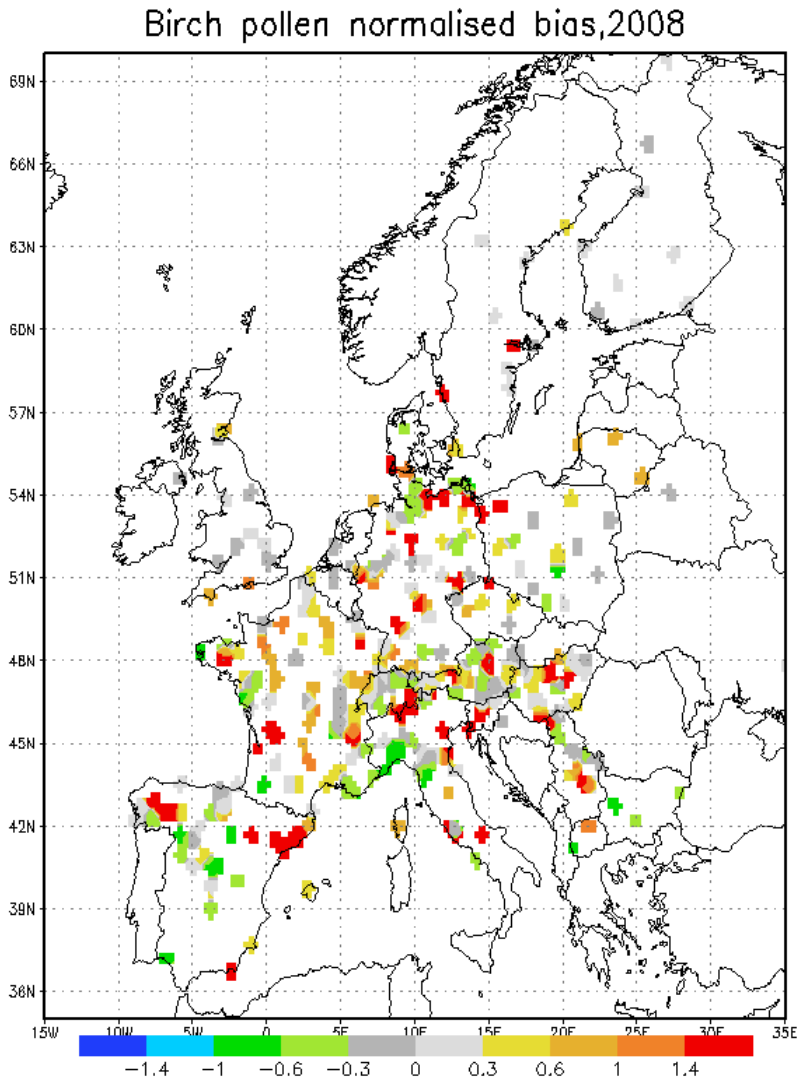
- Spring 2008
- Birch
- ECMWF NWP data
- Combination heat sum map
- Probabilistic blurring of the source term
- SILAM v4.0 dispersion
- Observations: European Aeroallergen Network





Use and abuse of data assimilation





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Outlook

- Introduction: what we know
- **What next**?
  - Ragweed forecasting system
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Next species: ragweed

- Q
  -
  -
  -
- St
  -
  -
  -
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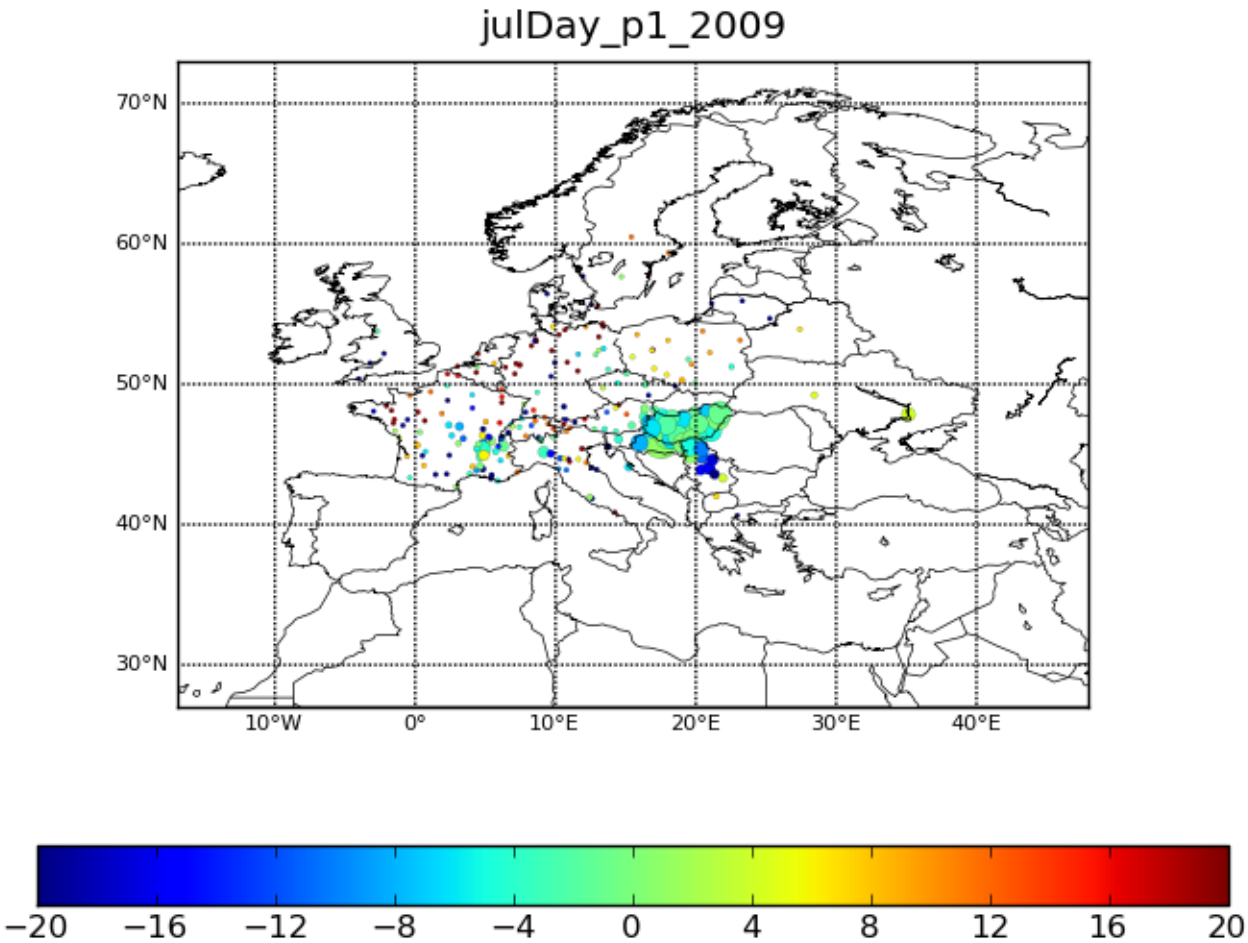


Error in determination of date of the pollen season start, [day]

What next ?

- Pollen is easy n
  - but counting
  - but Hirst tra nty
  - but allergen
- People react
  - but measur h flaws
  - but modelli n
- Can allergen en?
  - "…we are c her big es, w lergen particles lease ed…"

Grote & al 2003, J Allergy Clin Immunol 111:1017-23

ergen ns, I could not find any in t from pollen only… "

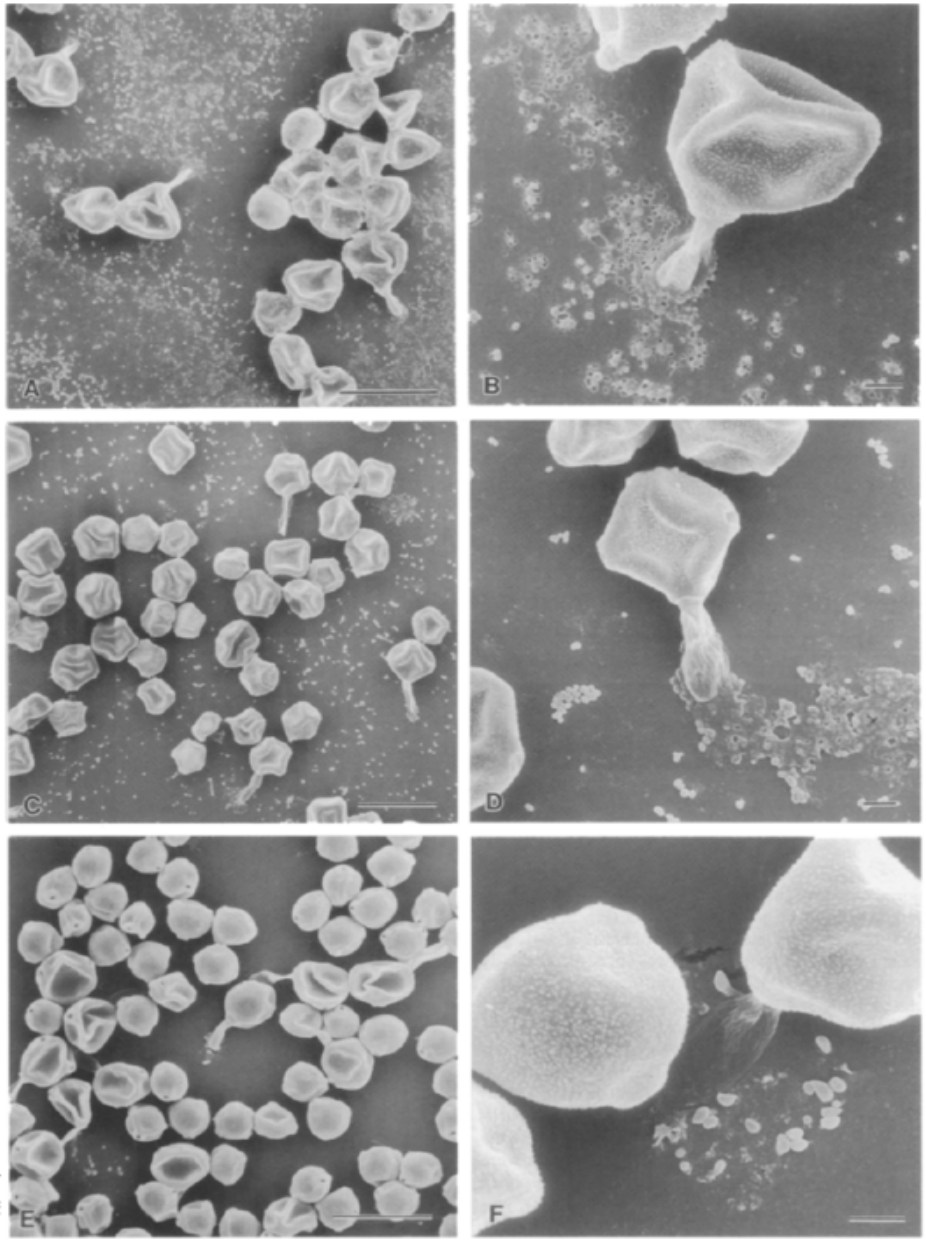


FIG 1. Conventional scanning electron micrographs of hazel (**A** and **B**), alder (**C** and **D**), and birch (**E** and **F**) pollen grains after hydration in rainwater. **A, C,** and **E** show surveys of hydrated pollen preparations at low magnification. Bar = 50 µm. **B, D,** and **F** show details of germination tubes. Bar = 5 µm.

Interaction mechanisms to rule out

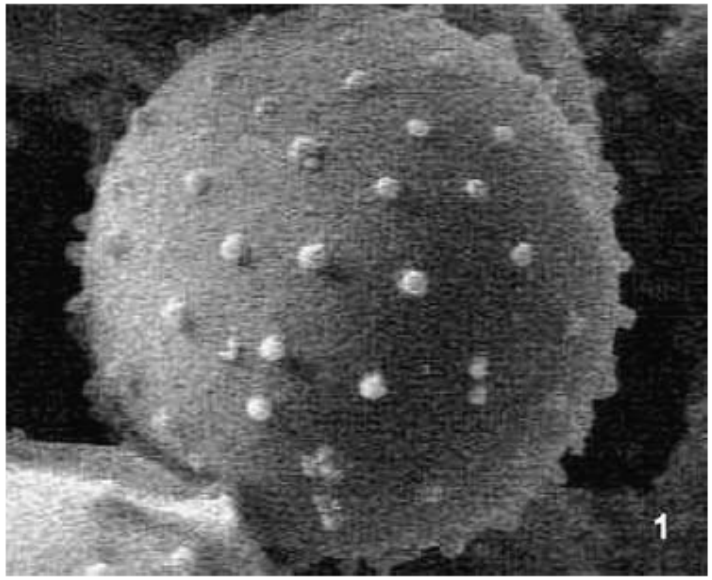


Figure 1. Scanning micrograph of *Canna* pollen grains that collected from non-polluted regions. Pollen grains are spherical having small mast as the tectum (1700 X).

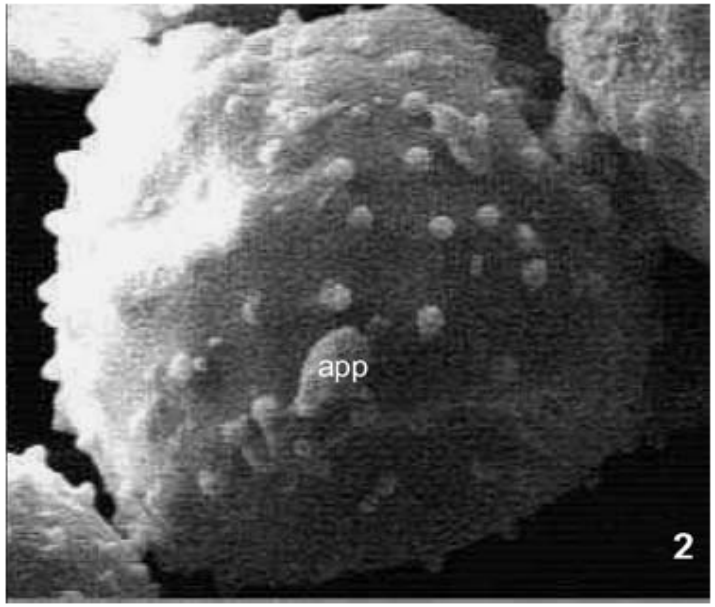


Figure 2. Scanning micrograph of *Canna* pollen grains that collected from polluted regions. Pollen grains be came folded, the tactum disrupted and air born particles accumulated in the surface of pollen grains. app, air pollutant particles (1700 X).

Motta & al 2004

Impact of air pollutants: plant stress

- Plants in polluted environment are under chemical stress
  - Single grai ... ostances in urban envi
- Total pollen ... plants seems to be
  - or higher? ... nt and # grains per m2 of a ... sually smaller
- Wayne *et al* ... ric CO2 concentratic ... duction by 61% (*P* = 0.

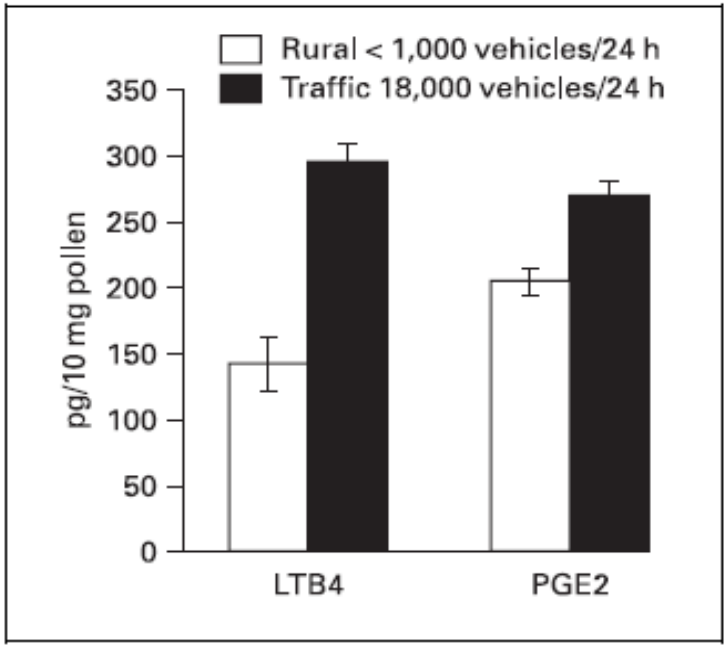
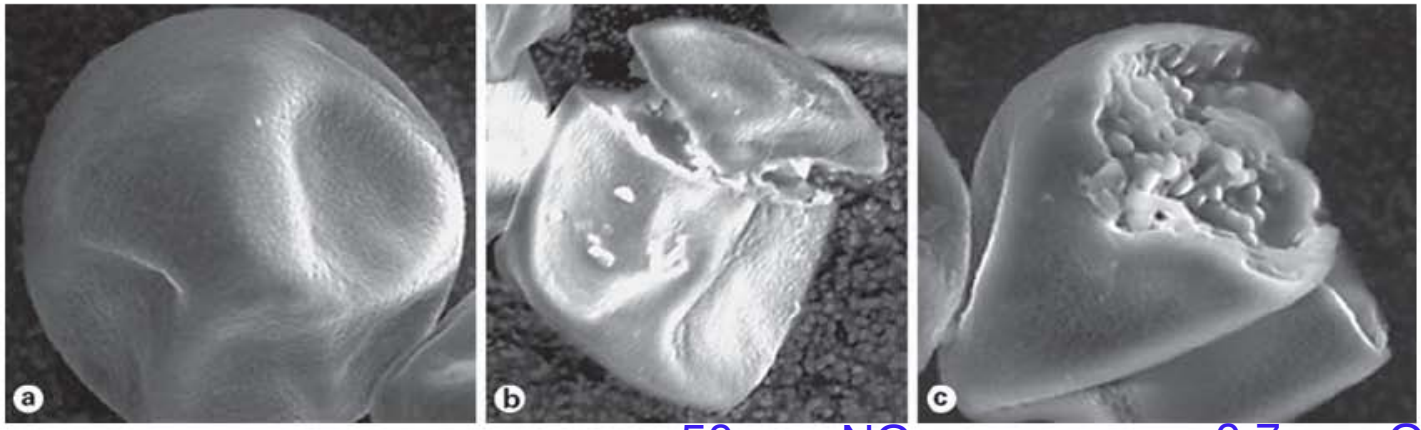


Fig. 3. Enhanced release of eicosanoid-like substances from *P. pratense* pollen freshly collected from a high-traffic area as compared to a rural meadow, indicating stronger proinflammatory activity.

Impact of air pollutants: break the grains

- High concentrations of air pollutants, (NOx, O3, PM) can lead to faster release of allergen from the pollen grains
  - mainly by damaging the grain
- Behrendt & Becker (2001): To trigger responses in humans, allergens must become bioavailable and the role of air pollutants — for example diesel-exhaust particles — in this process is causing concern



50ppm NO_2 0.7ppm O_3

Fig. 1. Examples of damaged pollen grains. Treatment of pollen samples to air or pollutants can induce structural damage of the grains. **a** Intact pollen. ×7,540. **b** Pollen damaged following treatment to 50 ppm NO_2. ×3,000. **c** Pollen damaged following treatment to 0.7 ppm O_3. PCG can be seen inside the broken grain. ×6,000.

Motta et al 2006

Pollen damage by NO2 and O3

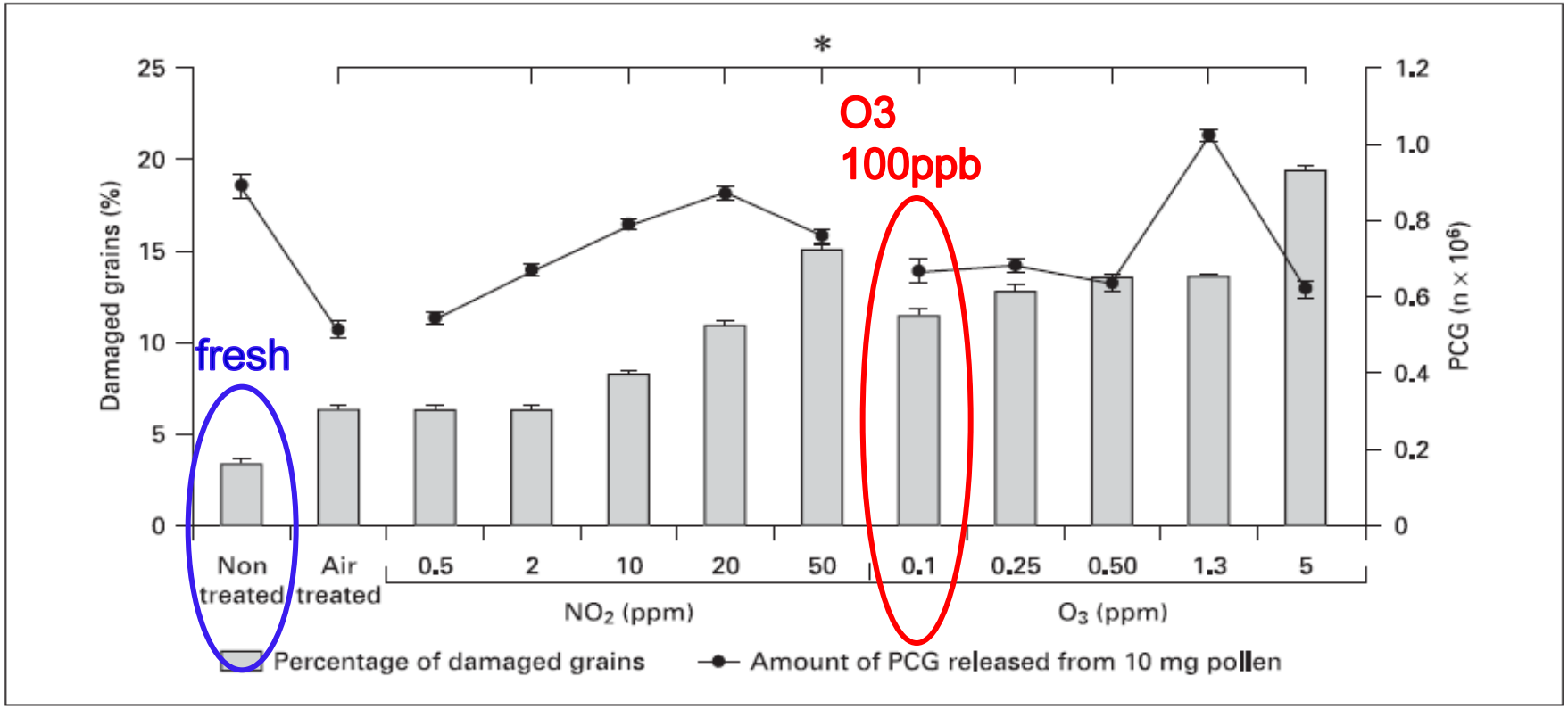
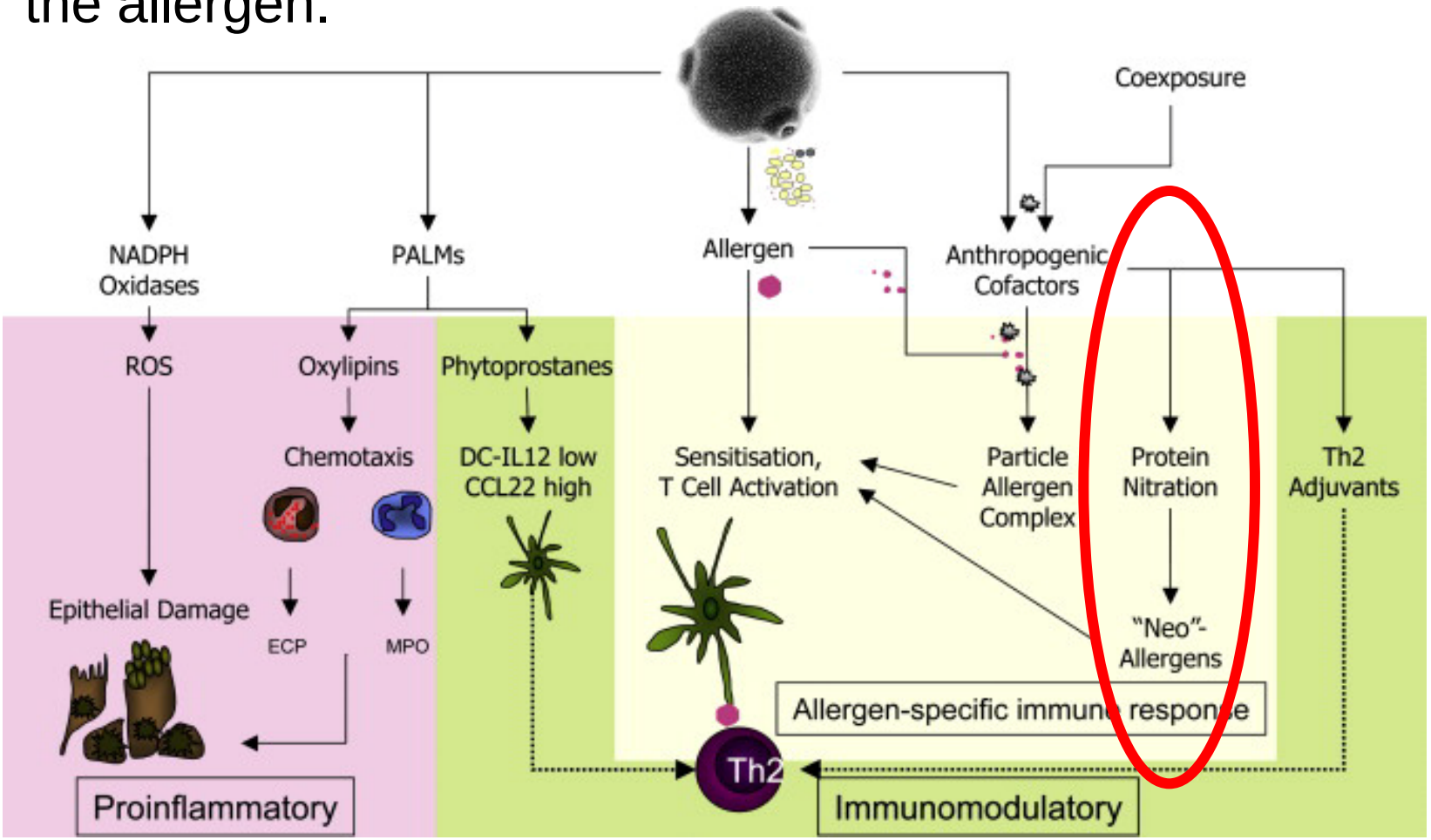


Fig. 3. Effect of exposure to air or pollutants on the proportion of damaged pollen grains and on the release of PCG following contact with water. Pollen samples were exposed to several concentrations of NO_2 or O_3. The proportion of damaged pollen was observed with ESEM (left axis, bars ± confidence intervals of probability estimated under the binomial distribution assumption) and the PCG released from the remaining intact grains contained in 10 mg pollen suspended in 500 µl of distilled water were counted (right axis, points ± SEM, * $p < 0.01$, $n = 5$).

Allergen in air: nitration

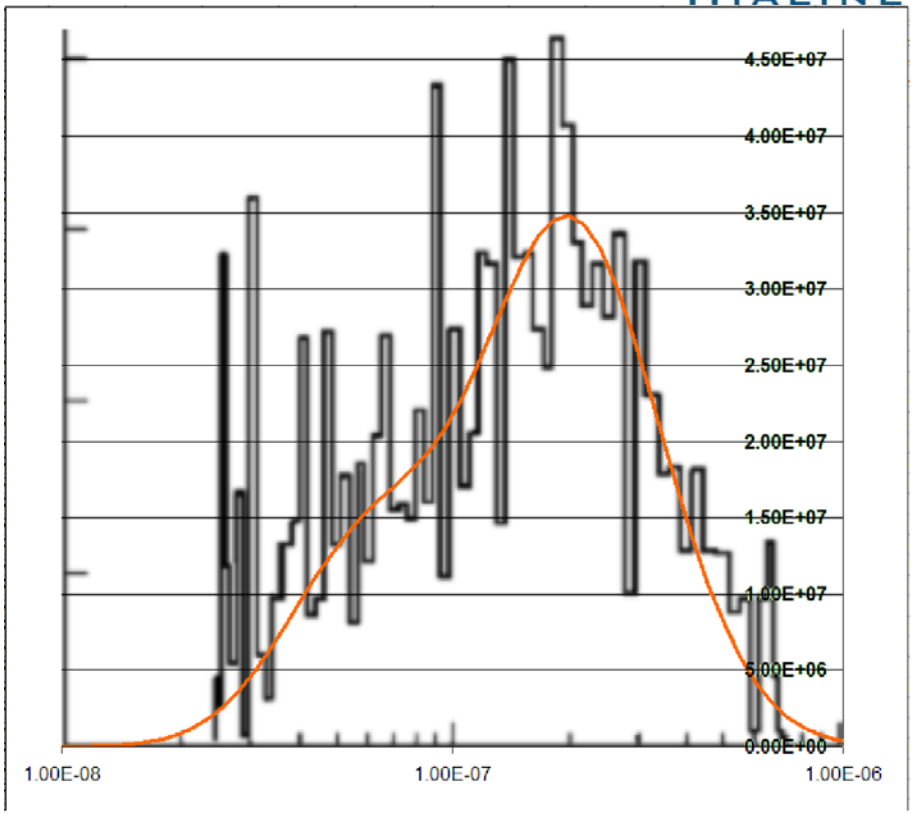
- Nearly the only process suggested (so far) is nitration of the allergen.



Traidl-Hoffmann & al 2009

Allergen + BC: coagulation experiment

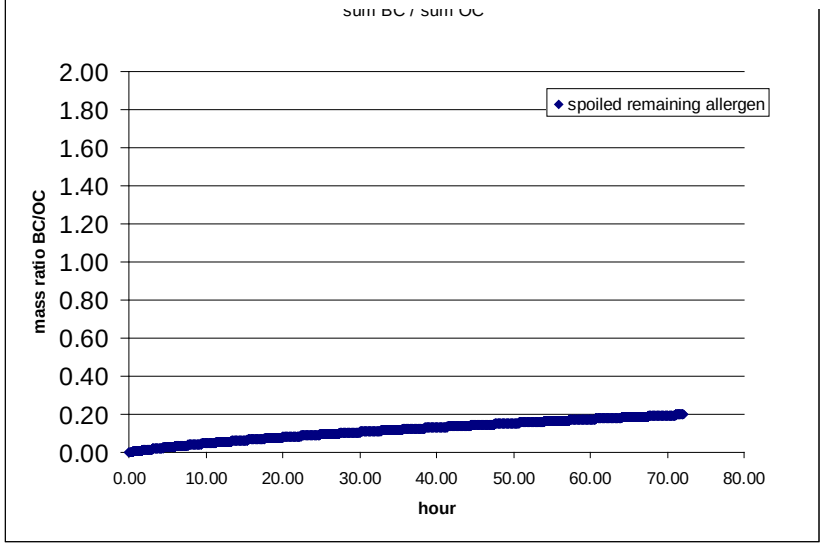
- SILAM Basic Aerosol Dynamics
  - coagulation-only simulations
- Allergen: 1 ng / m3
  - approximation of distribution of Taylor et al, 2004
- Diesel particles: 1 μg / m3 and 10 μg / m3
  - typical low- and high-pollution city levels
- Atmospheric humidity: 0% and 70%



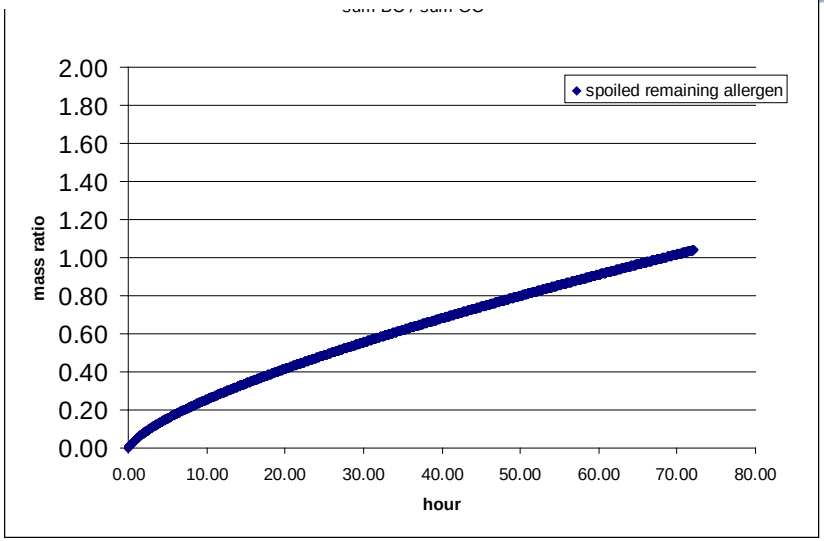
Initial size distribution of allergen.
Black: Taylor *et al*, 2004 observed
Orange: SILAM-ABD approximation

BC mass fraction mixed into allergen particles

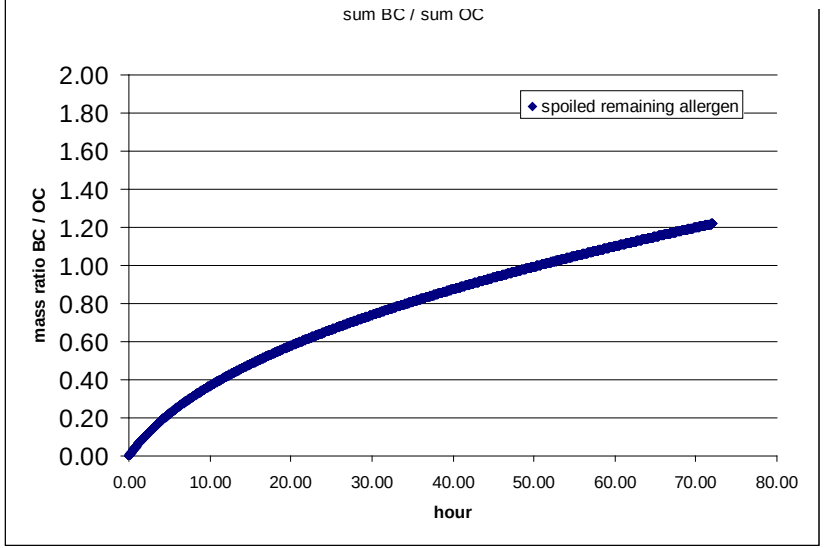
Clean city, dry air



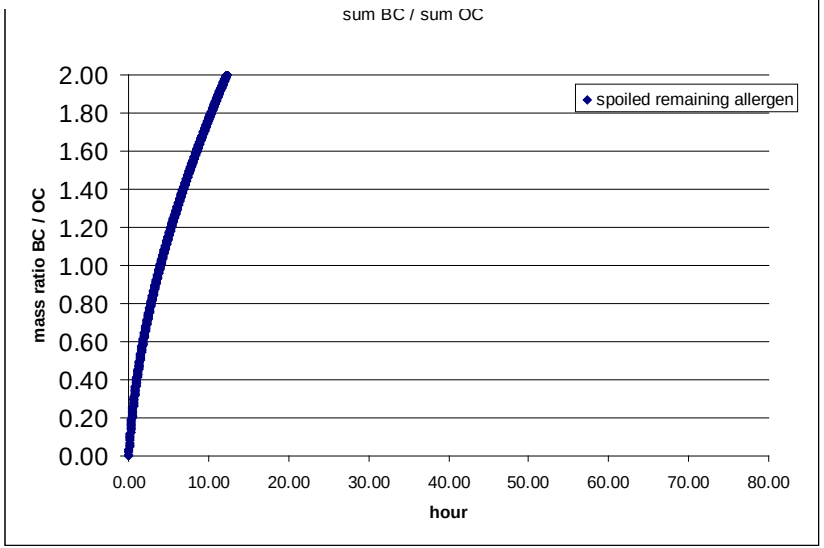
Polluted city, dry air



Clean city, 70% rel.humid.



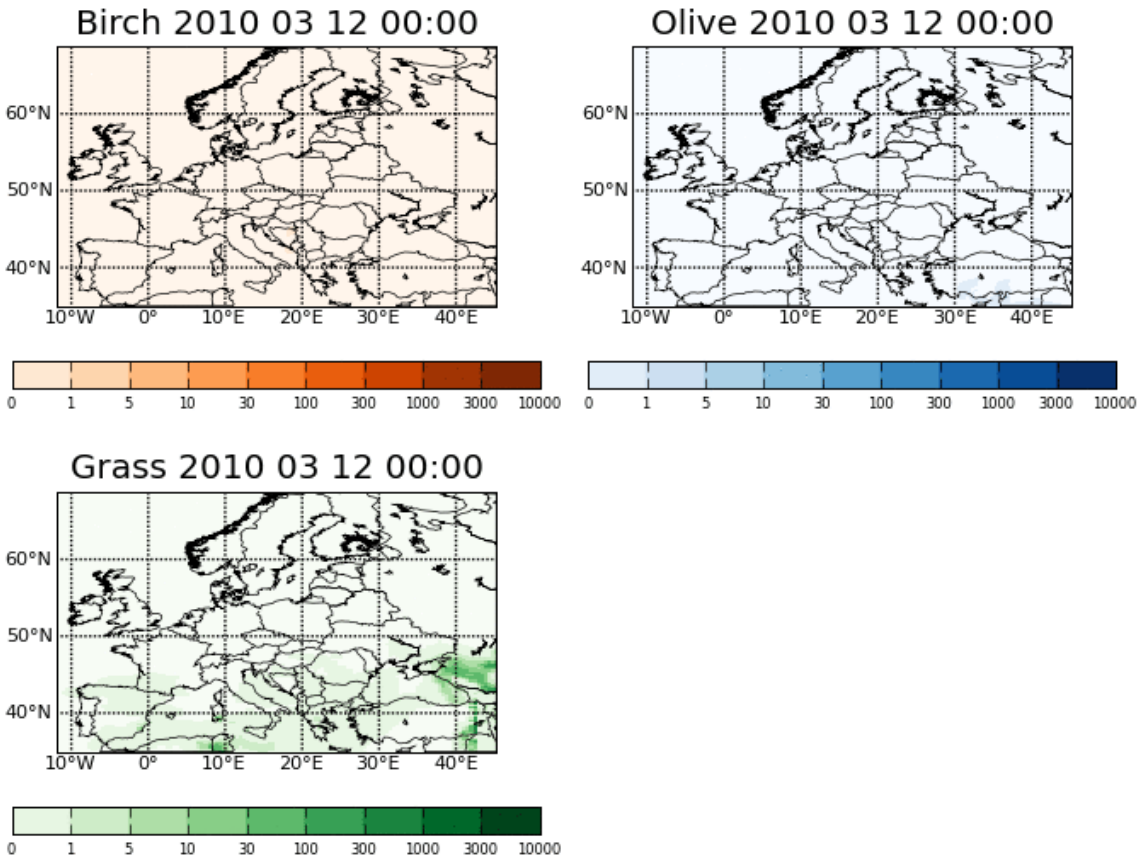
Polluted city, 70% rel.humid



Conclusions

- Current knowledge is sufficient for quantitative pollen forecast a few days ahead at a continental scale
  - combination of local observations, dispersion modelling, and human expertise seems mandatory. Time for automatic forecasts has not yet come
- New research directions include
  - allergen vs pollen
  - interaction with chemical pollutants
  - keep an eye on climate change

Many thanks to

- Siegfried Jaeger
- Hanna Ranta
- Auli Rantio-Lehtimaki
- Heidrun Behrendt
- Jeroen Buters
- Carmen Galan
- Tapio Linkosalo
- Data suppliers of European Aeroallergen Network
- …and many-many others who invested their time in teaching (aero)biology to mathematicians and physicists

Birch, grass, olive seasons 2010