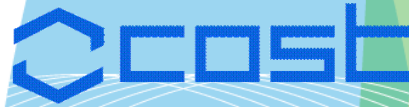




ILMATIETEEN LAITOS
METEOROLOGISKA INSTITUTET
FINNISH METEOROLOGICAL INSTITUTE



Challenges in pollen modelling and forecasting

*I know that I know nothing,
which is anyway more than my teacher knows
(a schoolboy)*

M.Sofiev, M.Prank, P.Siljamo,
J.Soares, J.Vira, R.Kouznetsov,

COST EUROL consortium

HIALINE project team

EAN data providers

Outlook



- What we know...
- ... and know that we do not know
- What next?
 - 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
 - Climate change: are we ready?
 - How to use the pollen modelling results?
- Conclusions

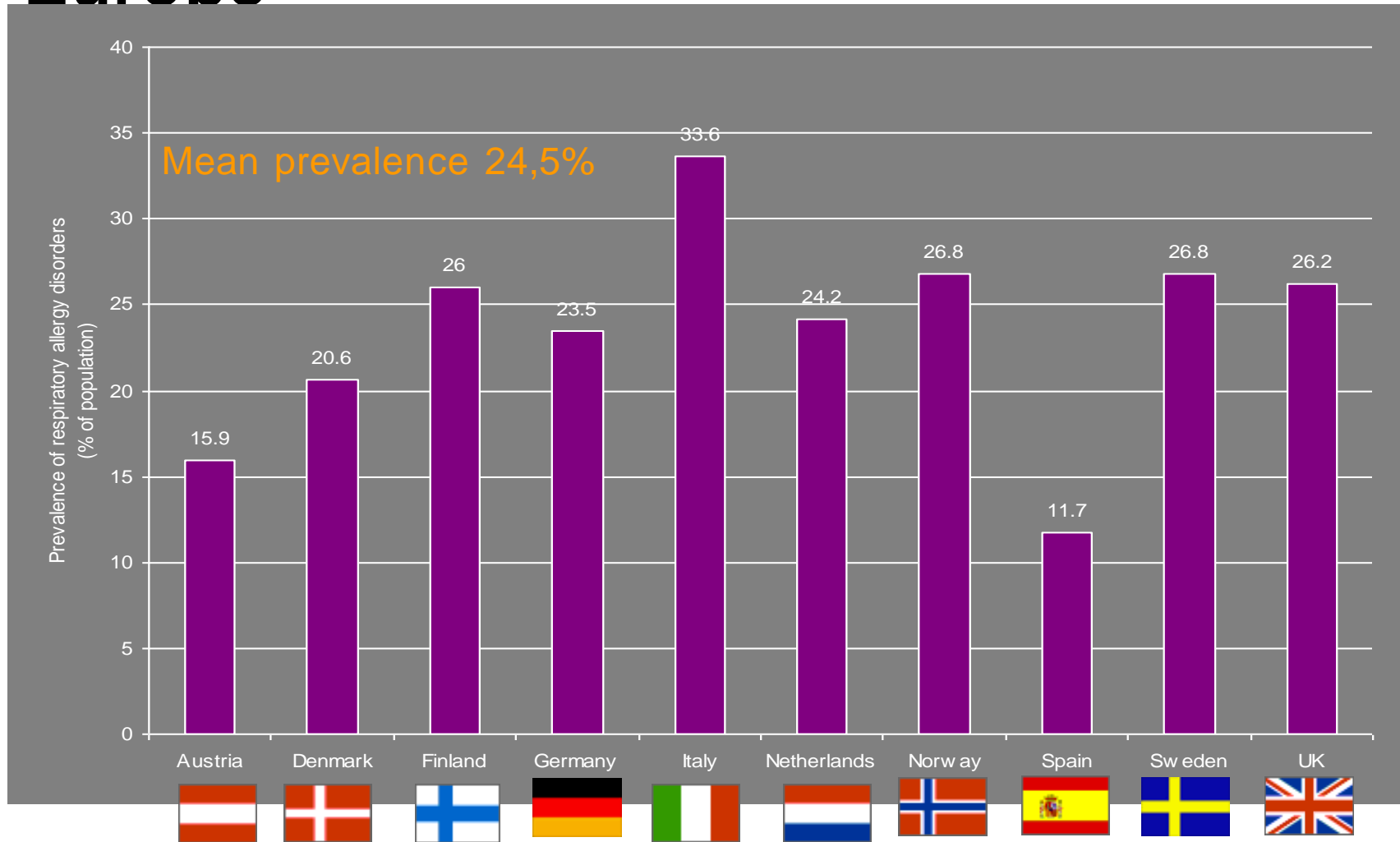


What we know

- or think that we know



Prevalence of allergic rhinitis in Europe



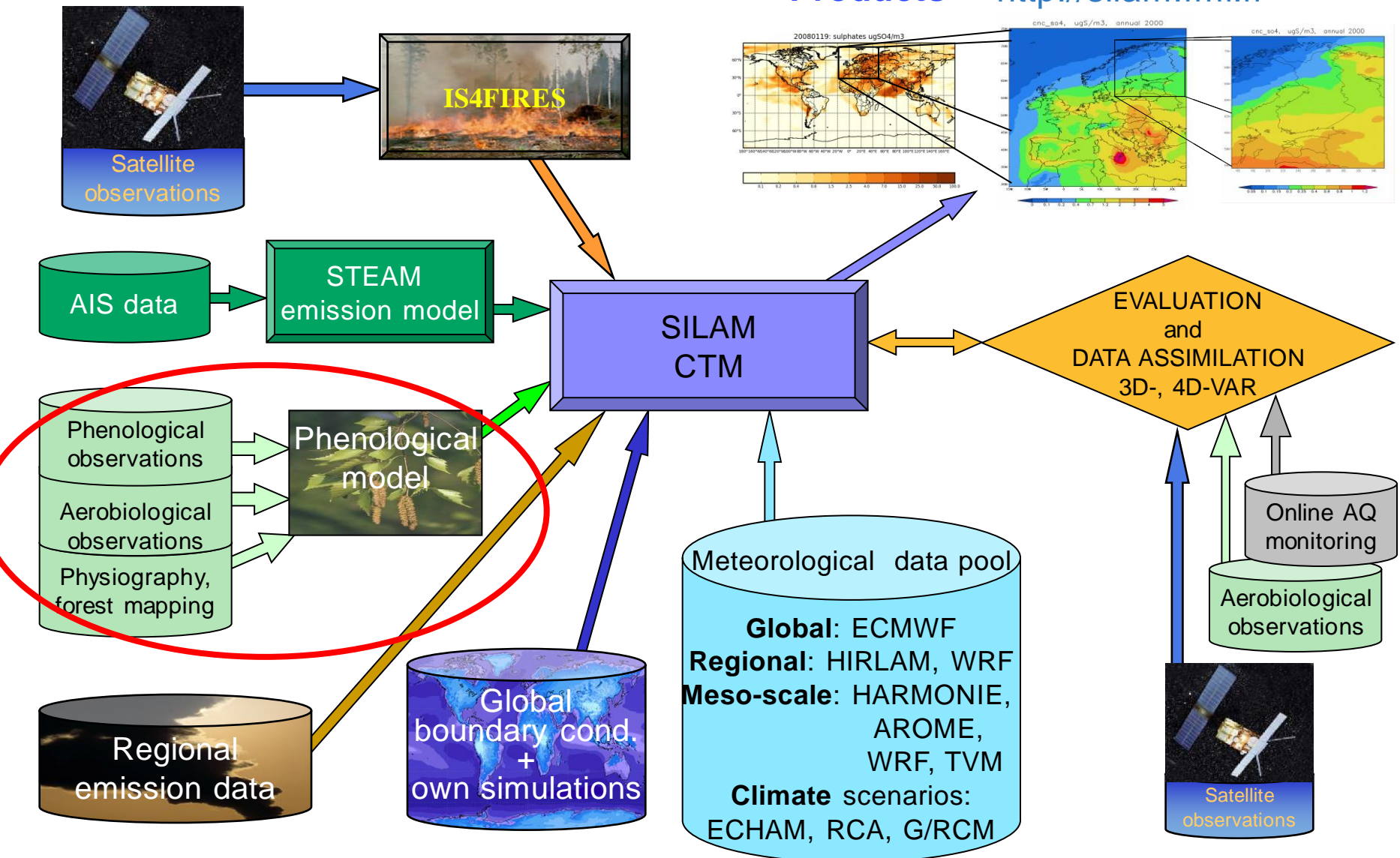
Adapted from Dahl, de Monchy, Chivato, Valovirta *et al.* Respir Med 2004; 98: 398-403

SILAM AQ assessment and forecasting platform



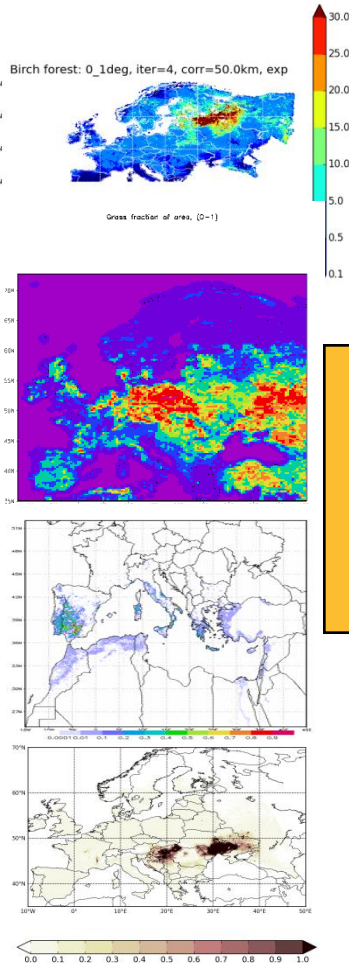
Products

<http://silam.fmi.fi>



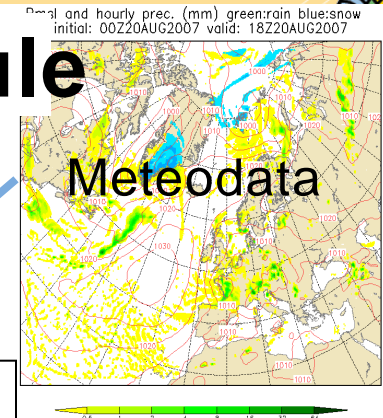
Inside SILAM phenological module

Habitation maps



Multi-factor multi-threshold model

- Parameters with taxon-specific weight
 - heat sum: no flowering until a season-start threshold reached
 - day length: no flowering when day is too long/short
 - calendar day: no flowering before/after some date
 - humidity: no flowering if too high
 - soil water: no flowering if too dry
 - rain: no flowering
 - frost: no flowering
- Parameters modulating flowering intensity
 - actual ambient temperature
 - wind and turbulence
 - humidity, if below the no-flowering threshold

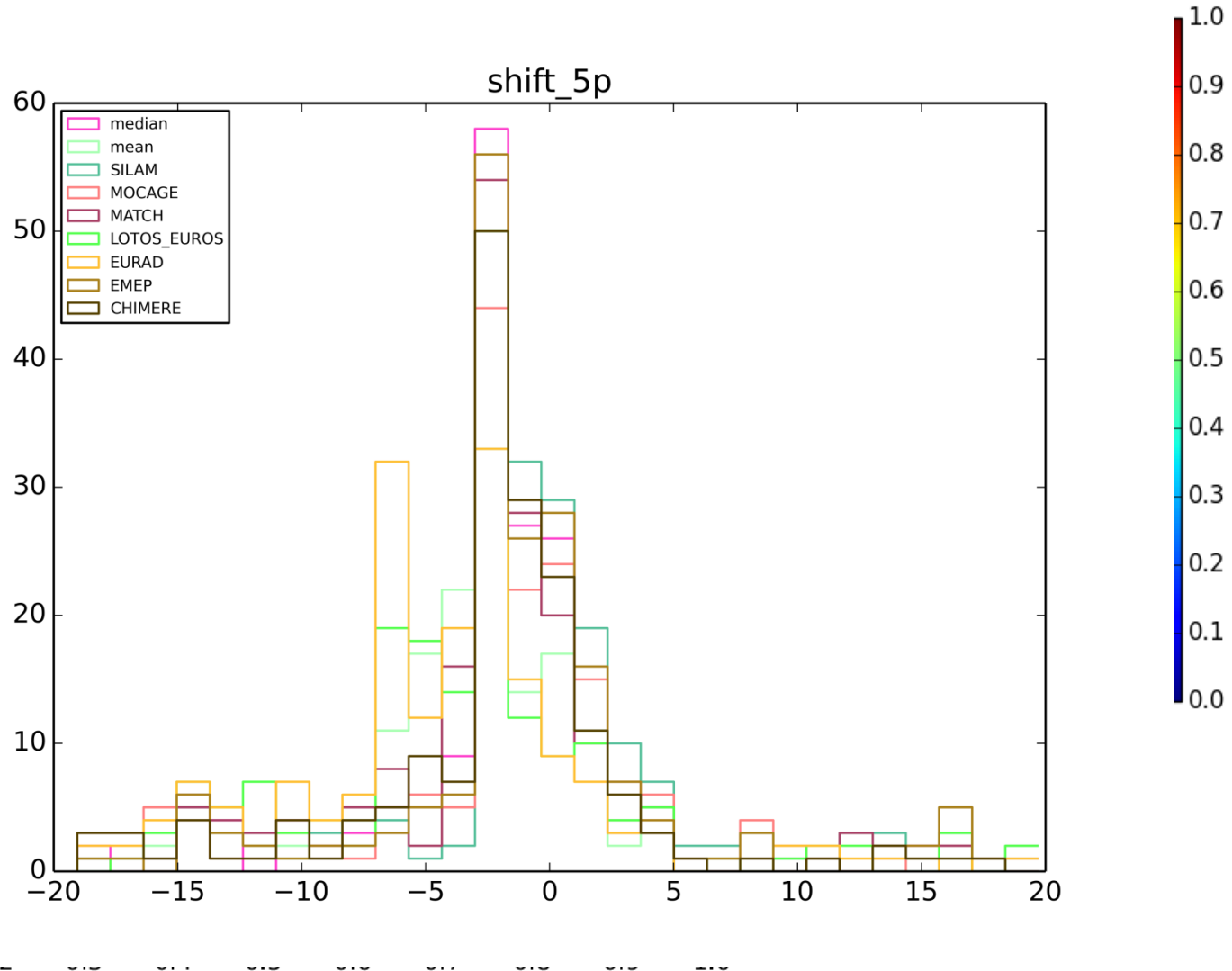
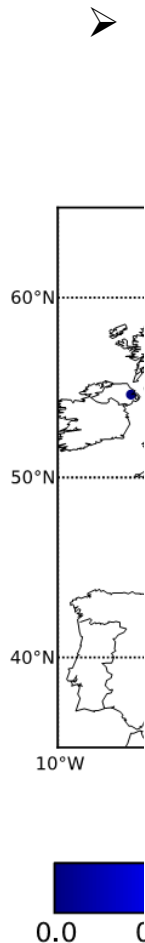


To
dispersion modules
of
SILAM
release
transport
sinks

Short-term pollen forecasts: feasible!

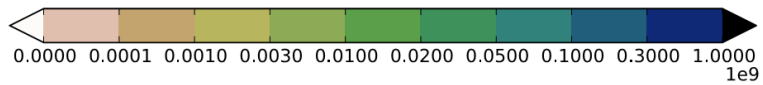
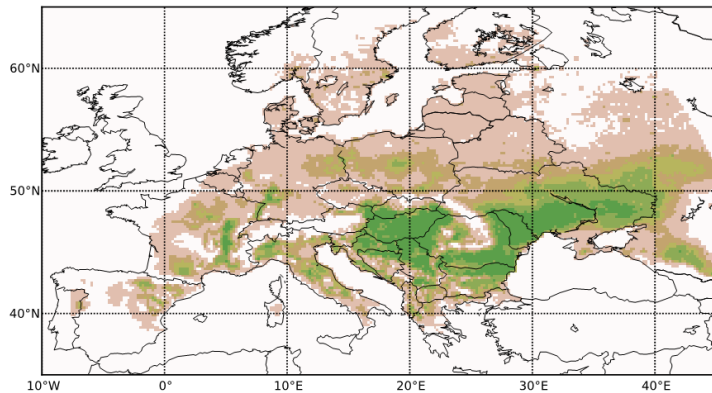


- SIL

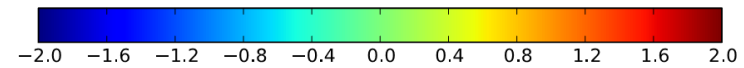
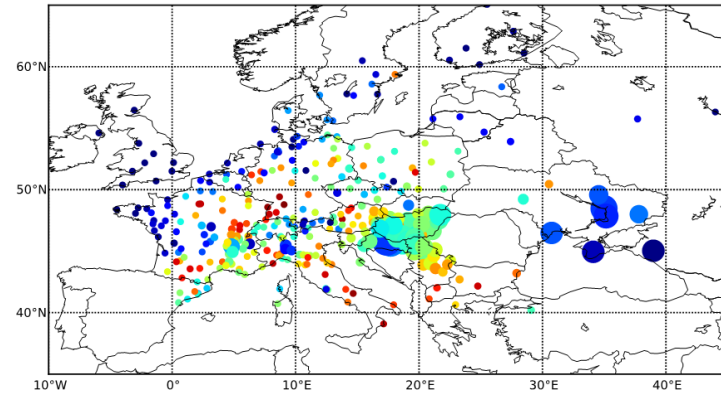




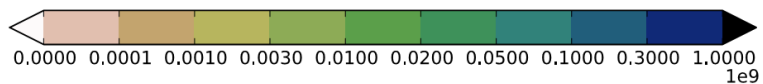
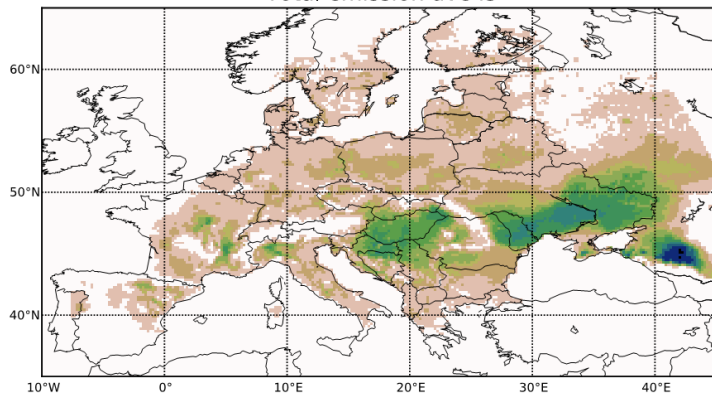
Total emission ave i0



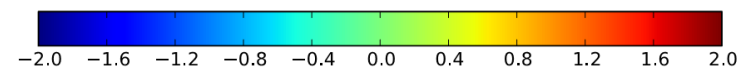
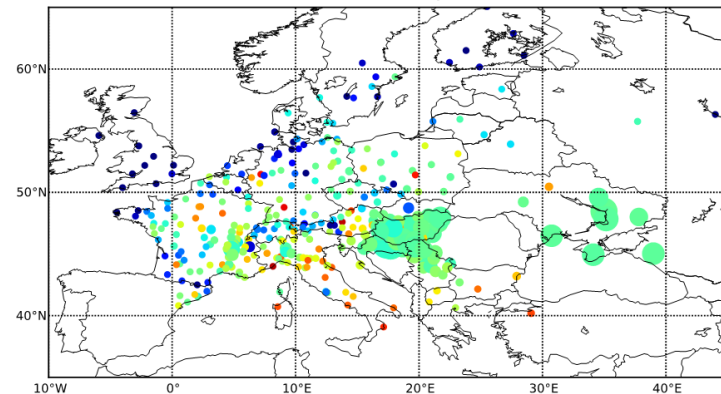
Fractional bias of seasonal pollen count ave i0



Total emission ave i3



Fractional bias of seasonal pollen count ave i3



What we know that we do not know (WK_WDK)



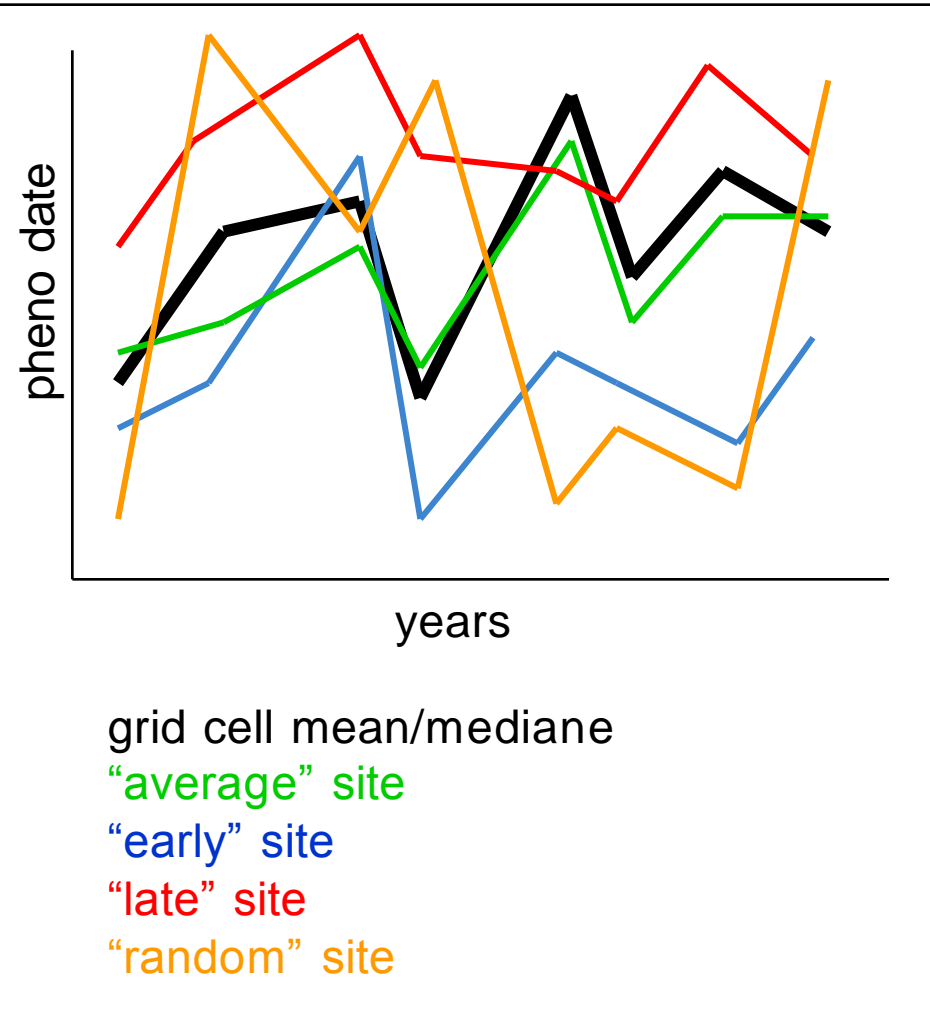
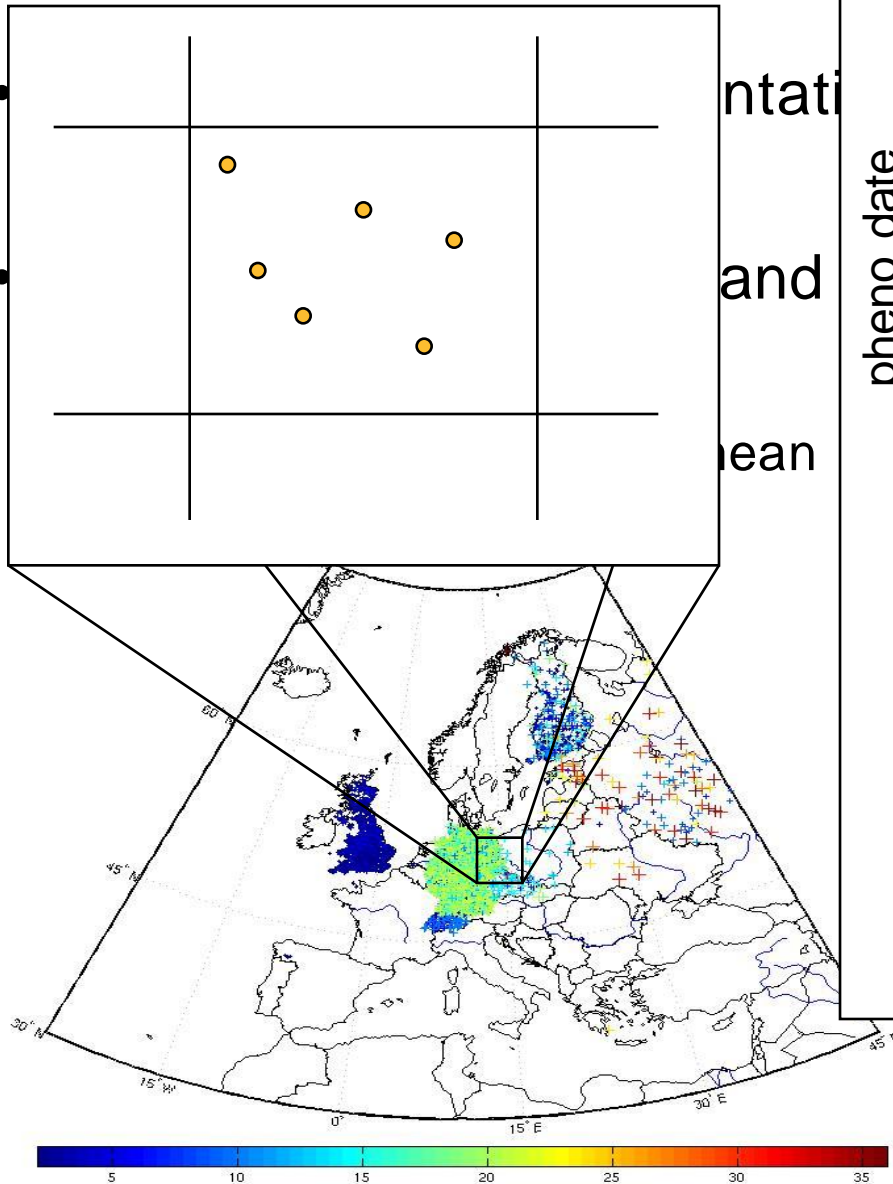
Birches in
Helsinki,
Finland,
October 29,
2006



Photo: P.Siljamo



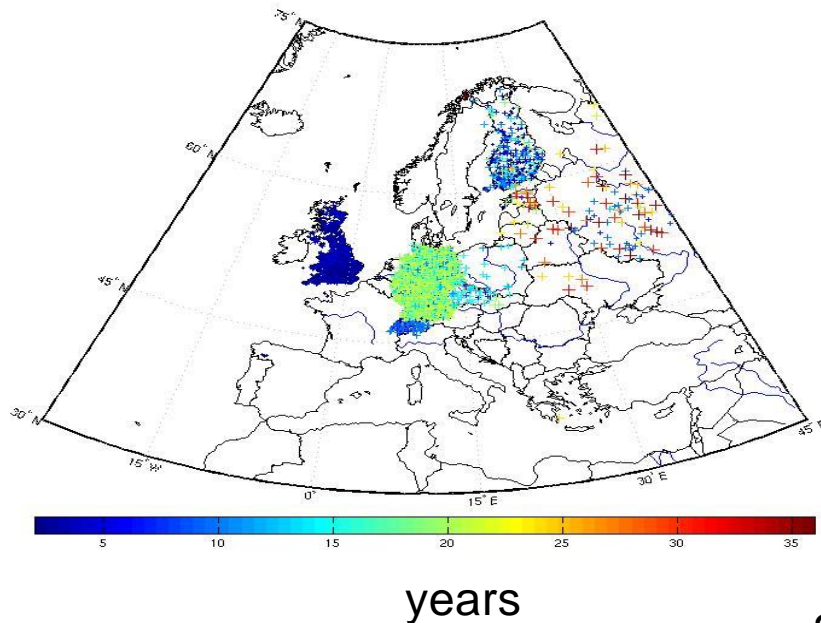
WK_WDK: phenological uncertainty



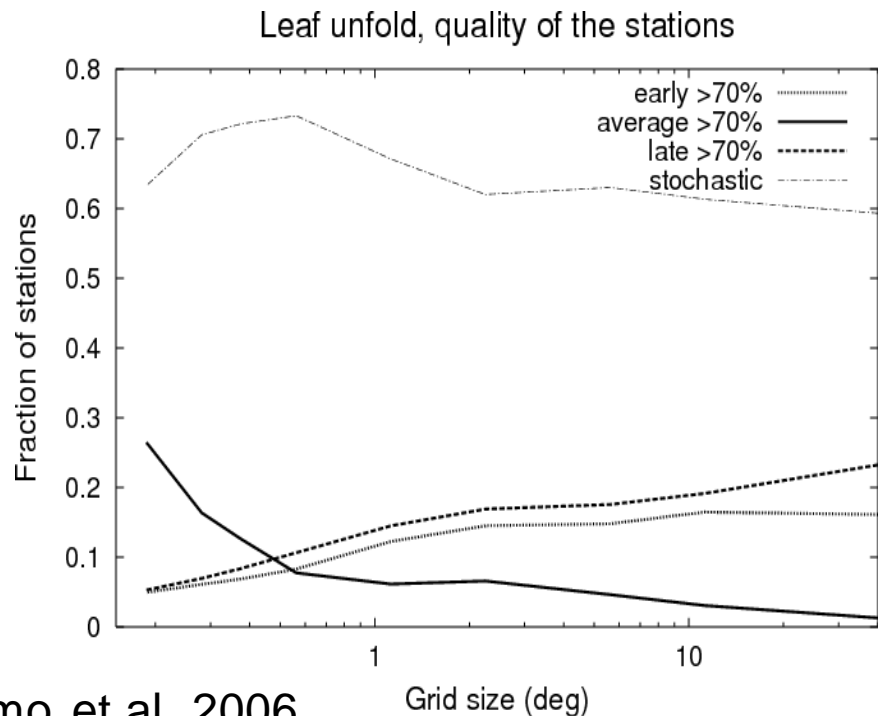


WK_WDK: phenological uncertainty

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



Siljamo et al, 2006



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

Outlook

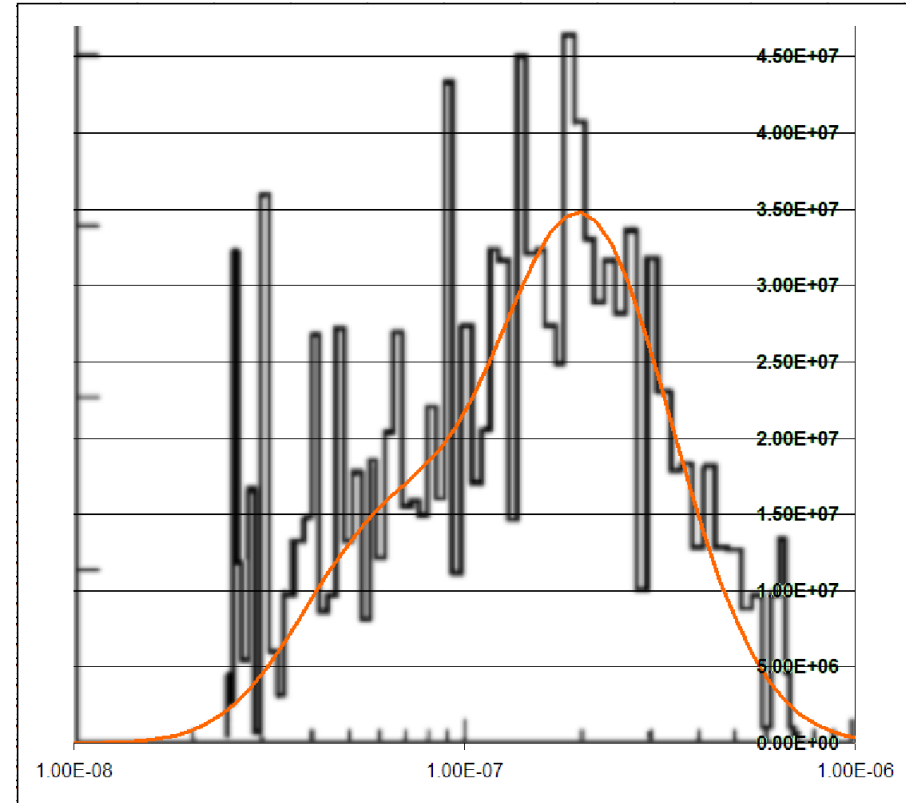


- What we know...
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- Conclusions



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%



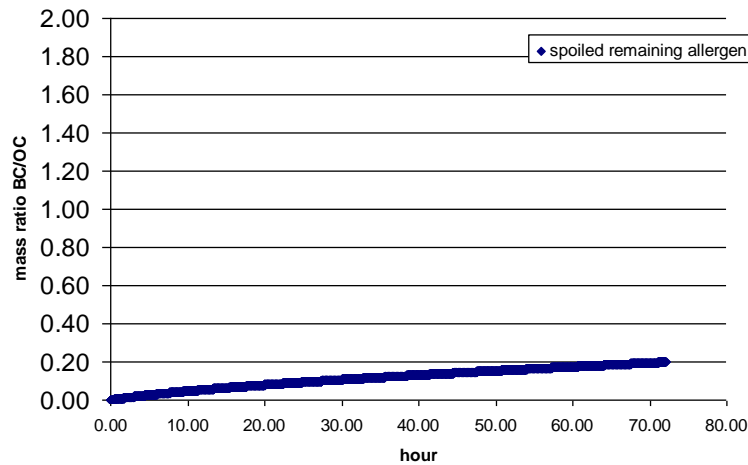
Initial size distribution of allergen.
Black: Taylor *et al*, 2004 observed
Orange: SILAM-ABD approximation

BC mass fraction mixed into allergen particles



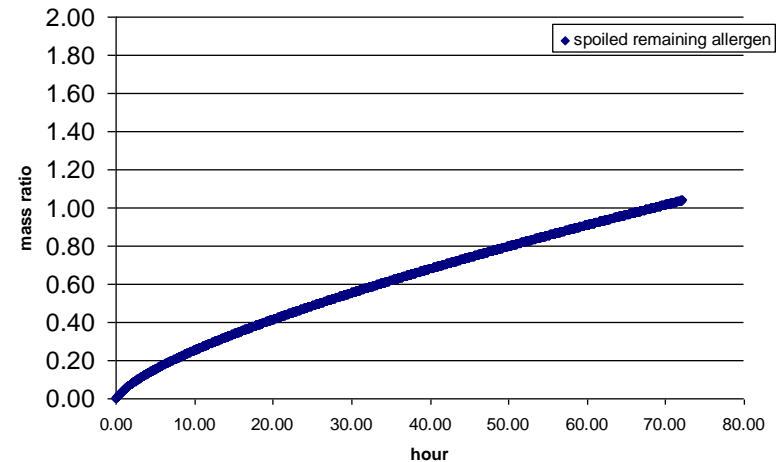
Clean city, dry air

sum BC / sum OC



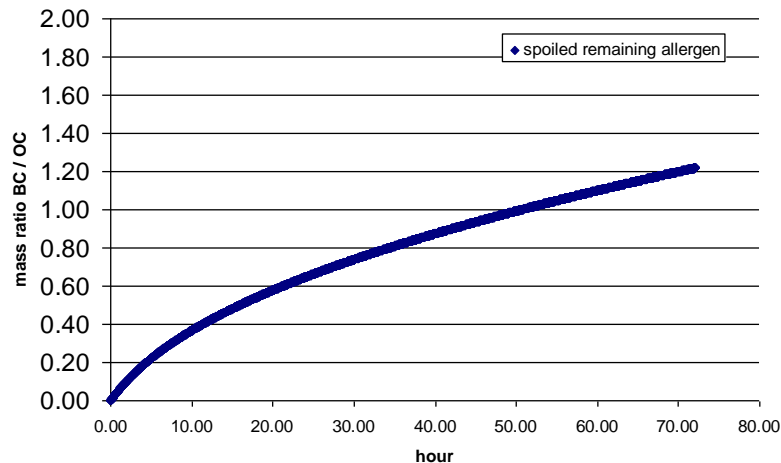
Polluted city, dry air

sum BC / sum OC



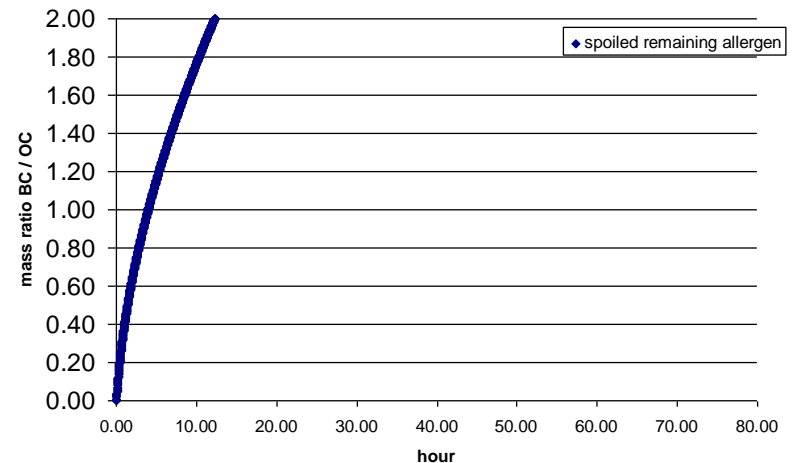
Clean city, 70% rel.humid.

sum BC / sum OC



Polluted city, 70% rel.humid

sum BC / sum OC





Are we ready for the new climate?

- Long-term trends: do we represent the climate-change fingerprints?
- Model accuracy over long periods: any climate-related trends?



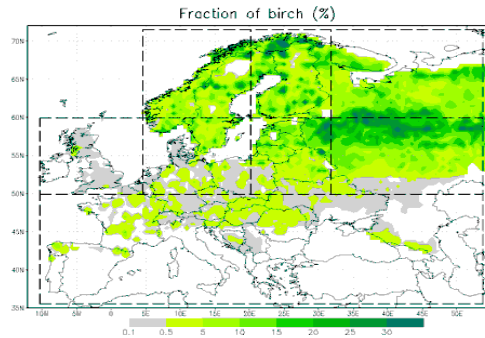
Parameterizations: a vulnerable part

- Quantify apparent relationships, which may or may not hold outside the considered region and time period
- Based on past conditions
- Rarely include mechanistic model to formulate the shape of dependencies

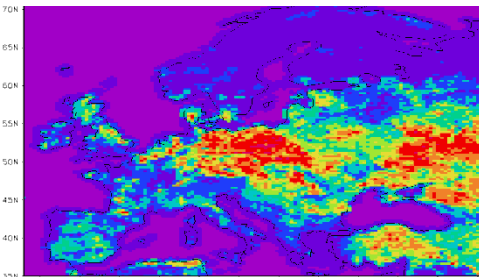
SILAM: habitat maps and flowering parameters



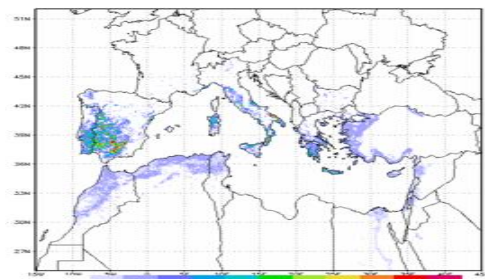
Birch



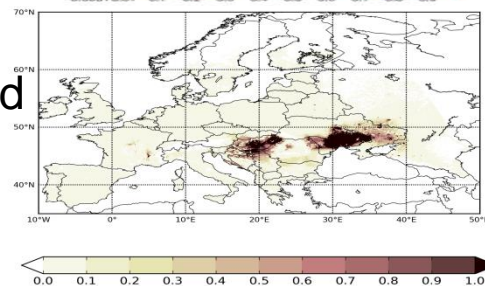
Grass



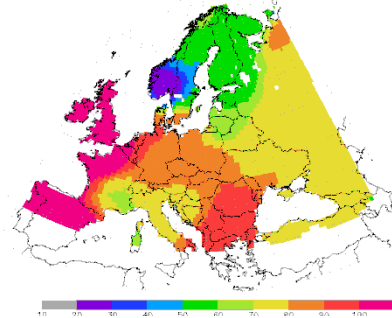
Olive



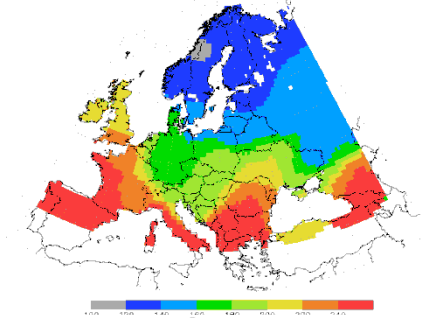
Ragweed



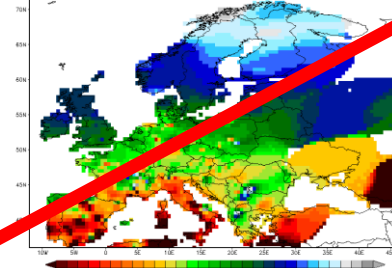
Temperature sum Start



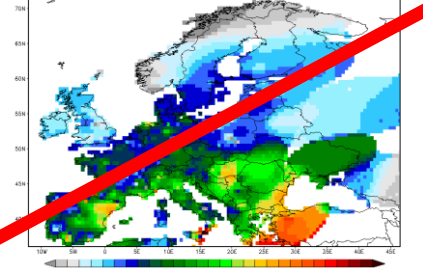
Temperature sum End



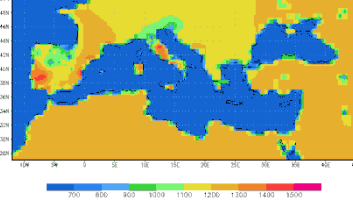
Poaceae Start 1998-2007



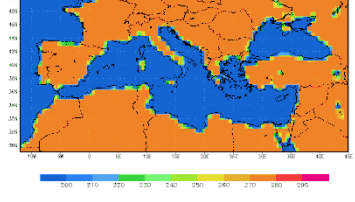
Poaceae Length 1998-2007



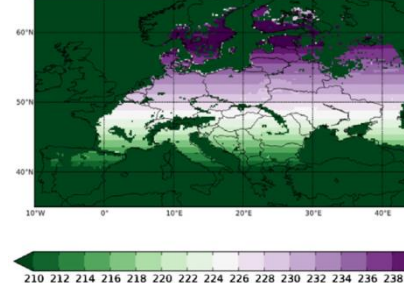
start heatsum threshold, olive, dd



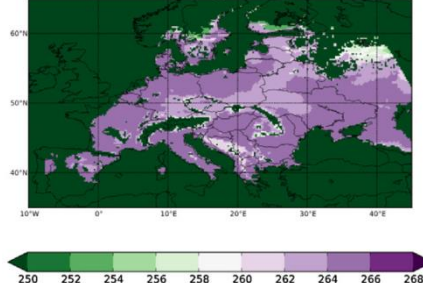
start-end diff olive, dd



Ems p9 5 % ave 3



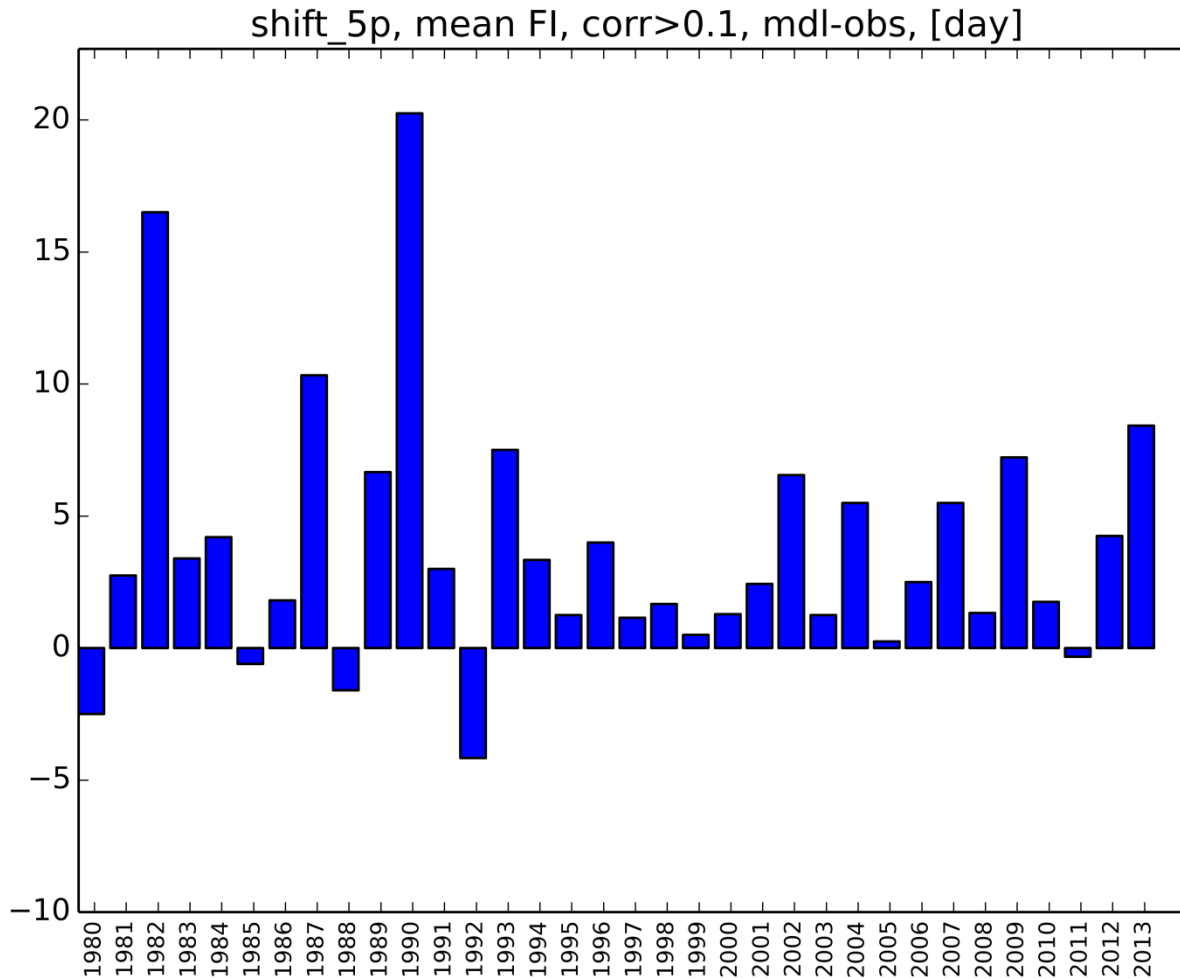
Ems p9 5 % ave 3



Test of long-term birch model performance

- Datasets to check
 - map: start-of-flowering heat sum threshold
 - map: end-of-flowering heat sum threshold
- Datasets fixed:
 - birch habitat map and productivity of birch (no inter-annual variability!)
 - cut-off temperature 3.5°C and start of heat accumulation: 1 March
- Actualized input information
 - Meteorological fields of ERA-Interim: ECMWF IFS meteomodel with massive data assimilation, 1980-c.m.
 - EAN pollen observations
- Criterion of model quality: absolute error of start and end of flowering, [day]

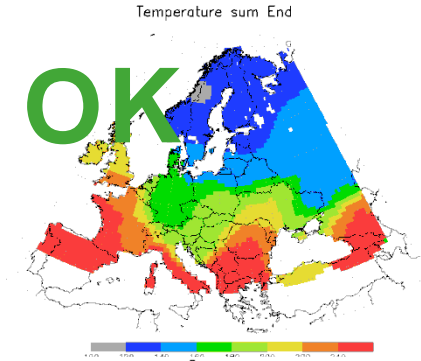
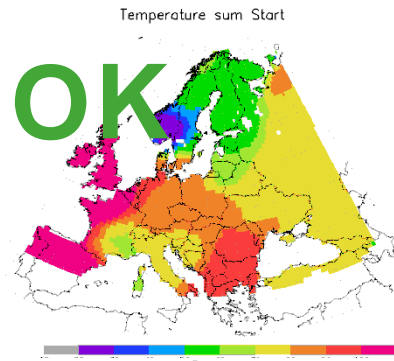
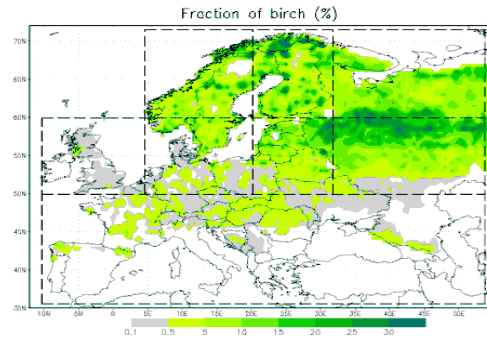
Season start in Finland



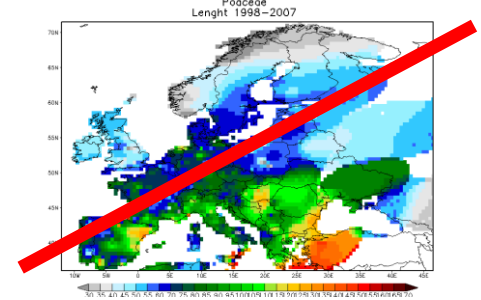
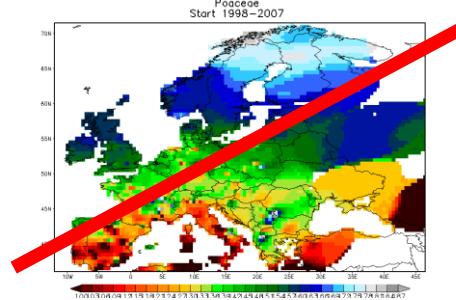
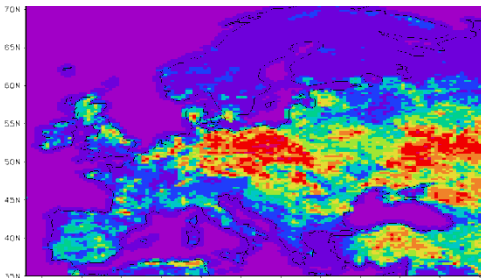


Conclusions on timing: no trends for birch

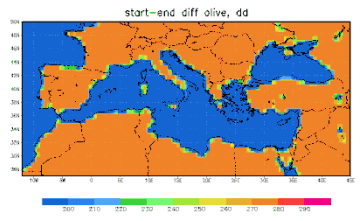
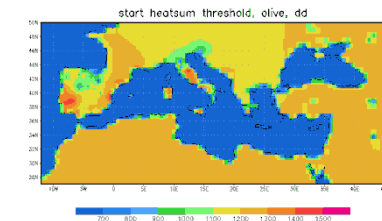
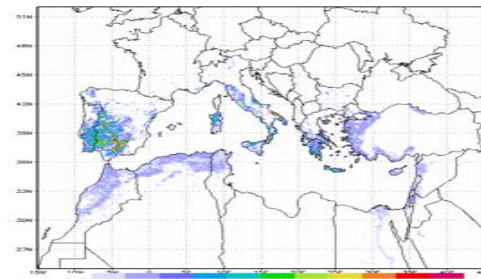
Birch



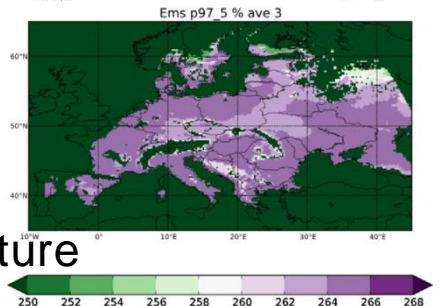
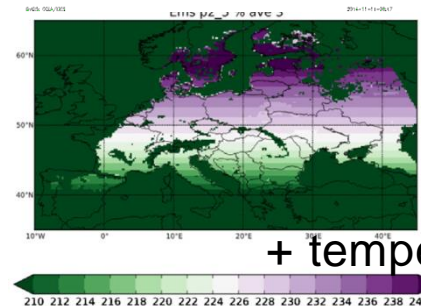
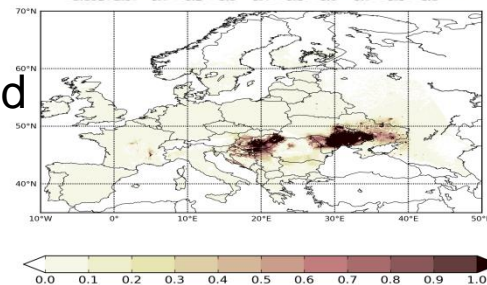
Grass



Olive

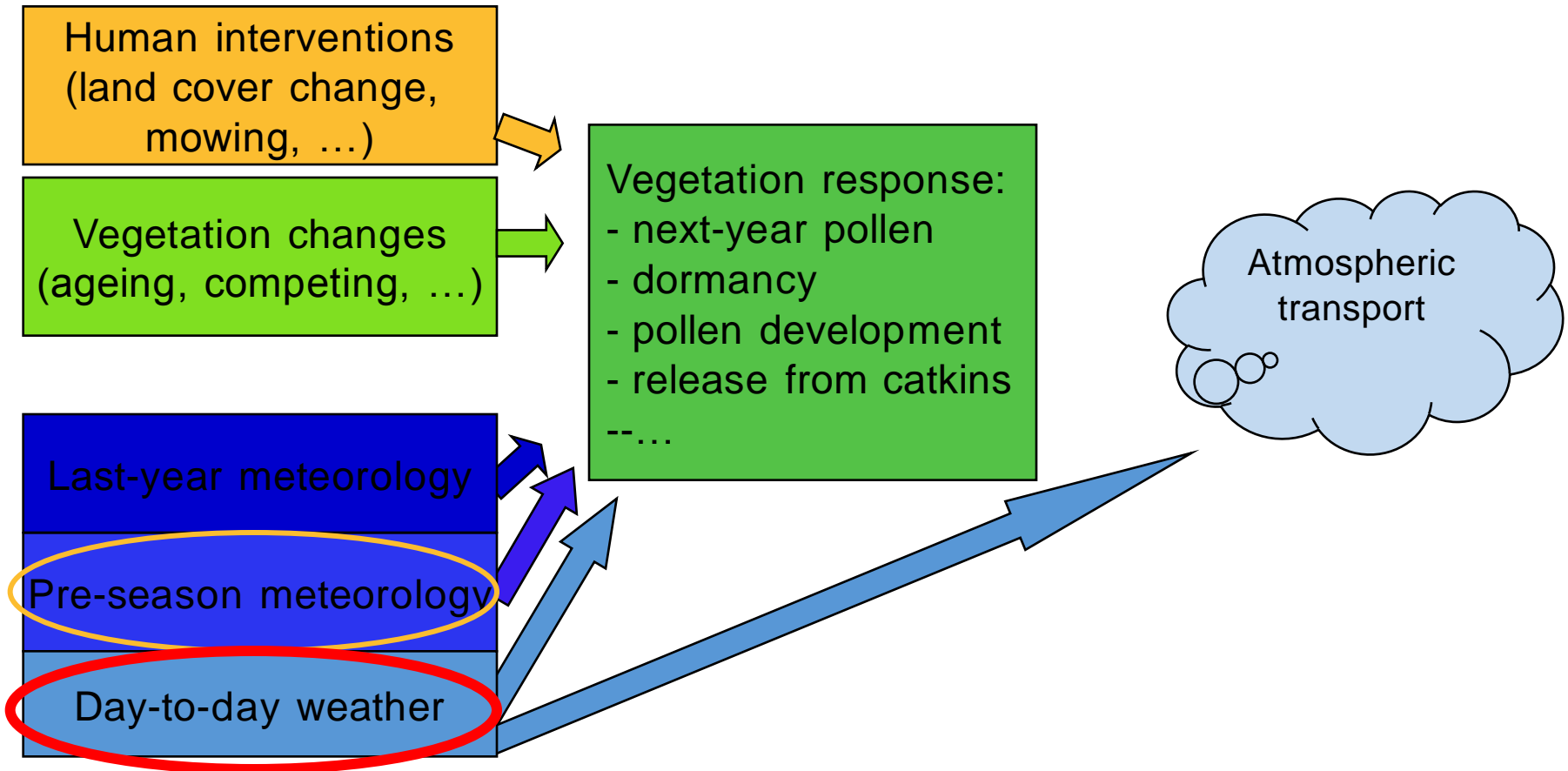


Ragweed



+ temperature

Processes affecting pollen count variability





Modelling experiment: reanalysis

- Objectives
 - To evaluate the impact of meteorological transport factors
 - ...
- Setup
 - SILAM model v.5.3. Standard pollen source term **without any year-specific corrections**
 - Meteodata: ERA-Interim re-analysis, 1980-2012 (80km spatial resolution, heavy data assimilation → close to real weather)
- Output
 - hourly pollen concentrations and deposition fluxes
 - birch, grass, olive, ragweed: 20km resolution over Europe

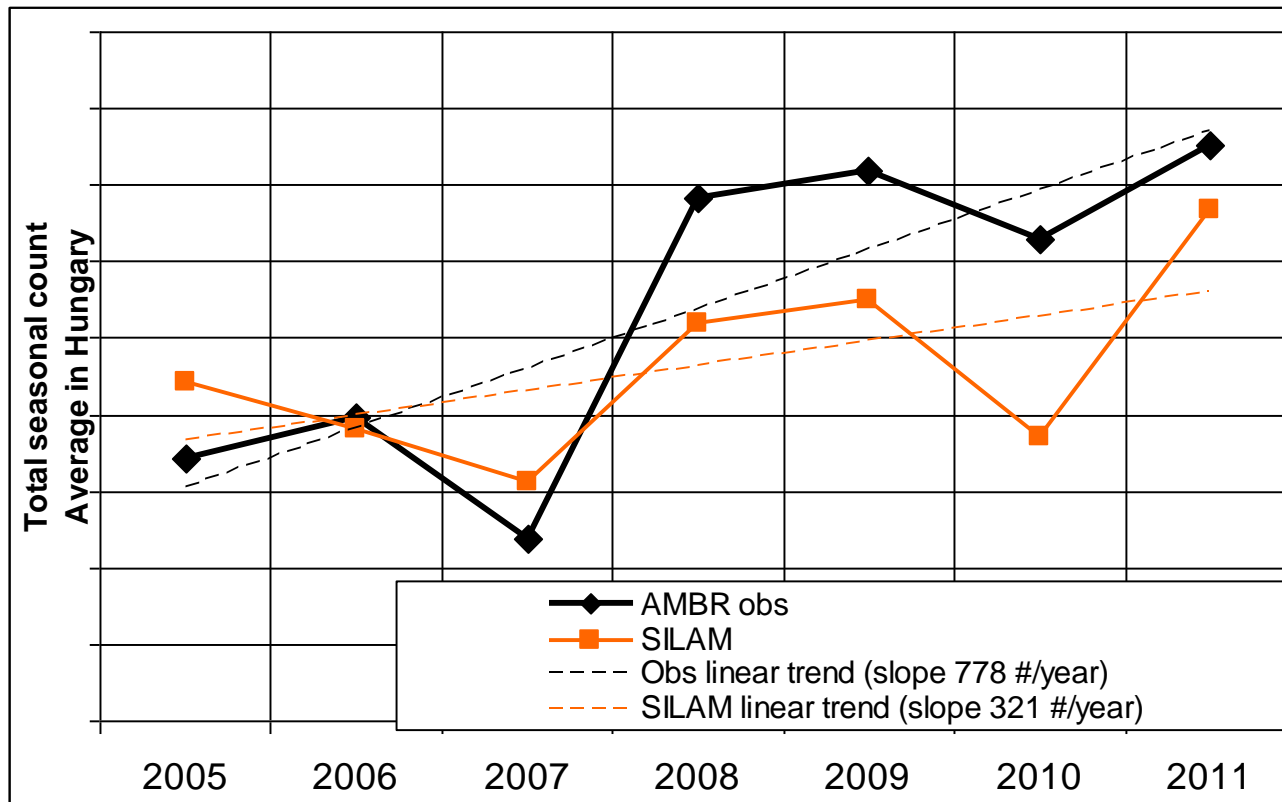


Analysis of the re-analysis

- Inter-annual variability
 - How large fraction is due to meteorological transport factors?
 - Regional specific?
 - temporal break-points?
- Trends
 - Do we have a fingerprint of climate change in pollen atmospheric transport alone?
 - How the modelled meteo-only trends agree with observed ones?
- ...



Ragweed trends: invasion or...?

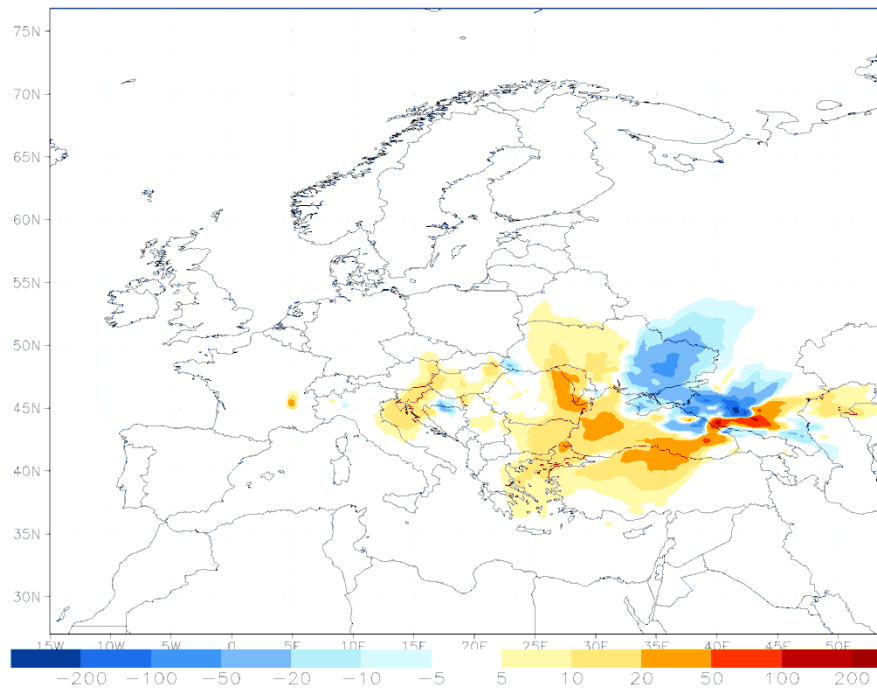


Prank et al, 2013

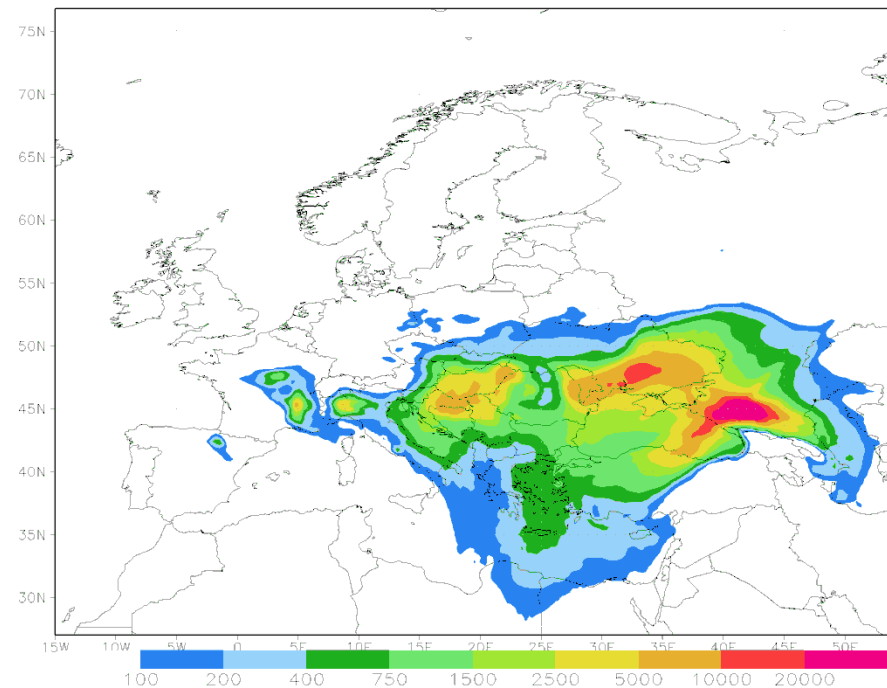
30-years modelled trends and total loads



Trend for: total_ragweed, year-1



Total ragweed load,2000,[grain day / m3]



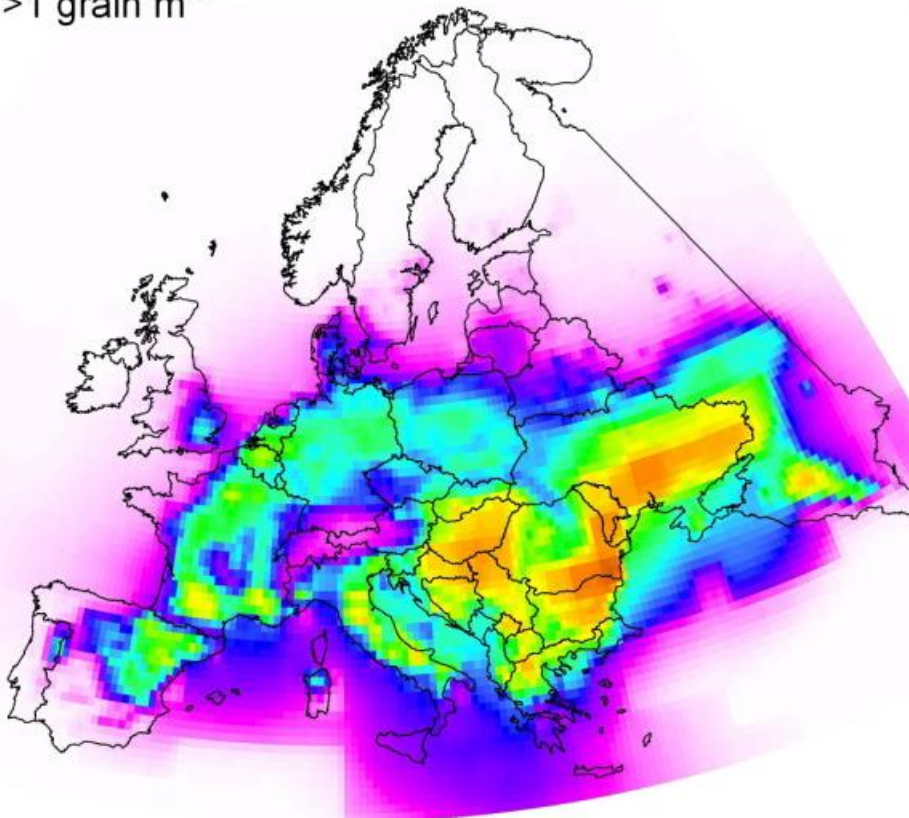


Habitat adaptation: ragweed example

Hours of exceedances above 1 #/m³:

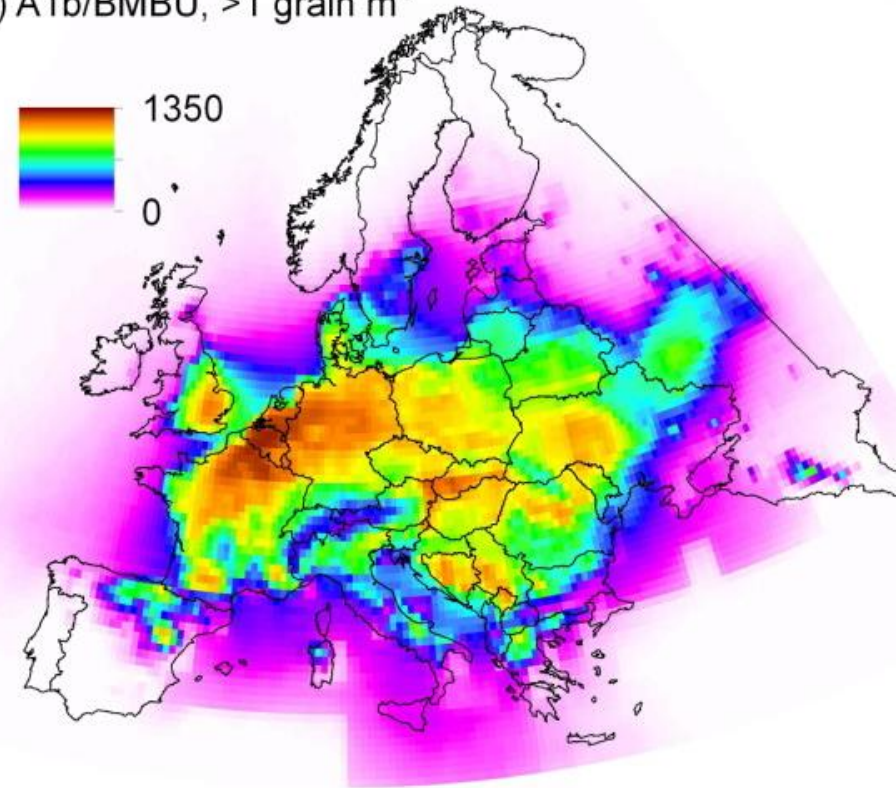
2000

(a) >1 grain m⁻³



2080 A1b

(a) A1b/BMBU, >1 grain m⁻³



How to use pollen information / forecast?



- Short time scale (forecasts)
 - Behavioral adaptation
 - Medication
 - Limited but existing possibilities for mitigation
- Long time scale (seasonal index, typical season timing)
 - Substantial mitigation options
 - Long-term adaptation measures



Pollen: anthropogenic and/or natural?

- Ornamental plants
 - birch, olive, alder, hazel, ...
 - grass
- Agriculture
 - olive
 - grasses, weeds
- Land disturbance, seed/plant traffic
 - ragweed invasion
- Anthropogenic stress
 - Urban plants tend to release more aggressive pollen
 - Pollen+EC, pollen+NO₂, etc mixtures worsen the impact
 - interaction both in air and human airways



Example mitigation/adaptation measures



- Long-term mitigation
 - city planning: ornamental plants, species used in parks, recreation zones and their location, etc
 - agriculture planning: location of fields with allergenic species with regard to cities
 - public activity planning: avoid peak-pollen days/hours
 - UK study: allergic students score worse in spring exams than in winter
 - eradication measures against invasive species (ragweed)
- Short-term mitigation
 - mowing grass – not only in parks. Goal is not only to make it looking nice, but to prevent it from flowering. Timing is crucial
 - clean streets, roofs, ventilation systems during the season
- Short-term adaptation
 - Timely medication: start shortly before the pollen season
 - Skip the local season by proper holiday travelling

...on city planning...



Next steps



- Improvement of the forecast quality and reliability
- Close interaction with EAN, support of the vital network
- Extension towards grass, olive, and ragweed
- Interaction with chemical pollution
- Proceed towards personalized forecasting service
 - Feasibility study by MUW, Charite, AUTH, and FMI

Allergy EUROPEAN JOURNAL OF ALLERGY
AND CLINICAL IMMUNOLOGY



Allergy

NEWS AND COMMENTARIES

Personalized pollen-related symptom-forecast information services for allergic rhinitis patients in Europe

U. Berger¹, K. Karatzas², S. Jaeger¹, D. Voukantsis², M. Sofiev³,
O. Brandt⁴, T. Zuberbier⁴ and K. C. Bergmann⁴

¹Medizinische Universität Wien, Universitätsklinik für Hals, Nasen
und Ohrenkrankheiten, Wien, Austria,

²Informatics Systems & Applications Group, Department of

DOI:10.1111/all.12181

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.
- New research directions include
 - allergen vs pollen
 - interaction with chemical pollutants
 - keep an eye on climate change

Thank you for your attention!



Special thanks to:

- Siegfried Jaeger
- Hanna Ranta
- Auli Rantio-Lehtimäki
- 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

2014 01 01 00:00

