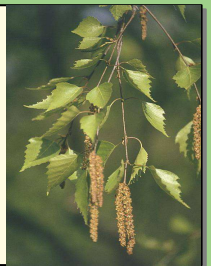




EVALUATION AND FORECASTING OF ATMOSPHERIC CONCENTRATIONS OF ALLERGENIC POLLEN IN EUROPE

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Project motivation

It is generally accepted that most of the pollen registered by observational networks comes from local sources (Keynan *et al.* 1991; Rantio-Lehtimäki 1994; Campbell *et al.* 1999; Adams-Groom *et al.* 2002). Consequently, forecasts of pollen concentrations are mainly based on in-situ aerobiological and phenological observations (Frösig & Rasmussen (2003), Severova & Polevova (1996), Porsbjerg *et al.* (2003), Rantio-Lehtimäki & Matikainen (2002), www.polleninfo.org, www.allergology.ru). However, there is convincing evidence that the long-range transport of pollen from distant regions can significantly modify pollinating seasons in many European regions. This is particularly important for Northern Europe and especially for Finland, where flowering takes place later in the spring. The example in Figure 1 shows the birch pollen counts in Finland in April 1999 (one month earlier than local birch flushing was recorded by the local phenological network), which exceeded 2000 and 3000 pollen grains m⁻³ in Turku and Oulu, respectively. Similar episodes of the long-range transport of pollen are regularly registered by aerobiological networks (Corden *et al.* 2002, Małgorzata *et al.* 2002, Hjelmroos 1992, Damialis *et al.*, 2004).

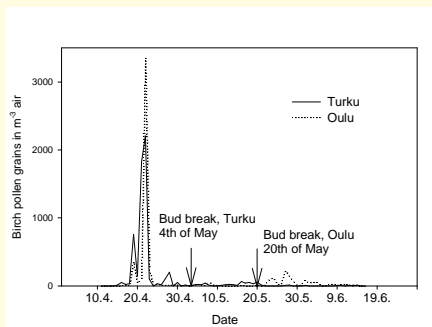


Figure 1. Atmospheric birch pollen counts in Turku (S. Finland) and in Oulu (N. Finland) in spring 1999.

Project objectives

The current project of Academy of Finland started in January 2005 and has the following goals:

- to develop an integrated modelling system for simulating and forecasting in time the natural pollen emissions and transport on an European scale
- to evaluate the spatial distributions of pollen emissions and concentrations in Europe.

We selected birch pollen as the first example due to its substantial health effects and ability to be transported over long distances.

The integrated modelling system (Figure 3) will constitute of the atmospheric transport and deposition model, pollen emission model, input modules for the in-situ and satellite-born data, meteorological pre-processor, and evaluation sub-system for comparison with aerobiological and other measurements.

Are existing dispersion models applicable?

Criterion: pollen grains must follow the turbulent eddies, i.e. have small enough relaxation time.

Checking: compare the inertia of the pollen grain with forces pushing it with the air streams. Using a spherical assumption on the grain shape, one can get that a typical relaxation time τ and distance λ depend on grain diameter d and density ρ_{part} , as well as on the air viscosity η :

$$\tau = \frac{d^2 \rho_{part}}{18\eta} \sim 10^{-3} \text{ sec}, \quad \lambda \sim 1 \text{ mm}$$

Conclusion: the (birch) grains are capable of following even small turbulent eddies. This justifies application of existing dispersion models to its transport.

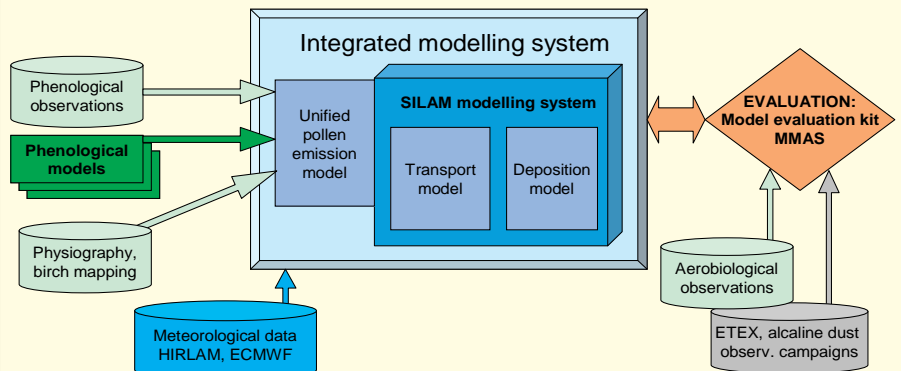


Figure 3. Configuration of the integrated pollen dispersion model and data flows

Features of birch pollen

The birch pollen is one of the most important allergen with regard to atmospheric transport due to its fairly small size and ability to be transported over large distances. There are two tree-like birch species in Europe. Downy birch (*Betula pubescens*) is the most common in the northern part of Europe, while silver birch (*Betula pendula*) is dominating in more southern regions.

Typical birch pollen grain has a size of 20-22 μm . It is fairly light (a full grain filled with protein material has a density of $\sim 800 \text{ kg m}^{-3}$), and approximately spherical (Figure 2).



Figure 2. An enlarged view of the birch pollen grains. See scale at the top-right corner of the picture.

Dry deposition. Taking a standard approach for coarse particles, one can use the Stoke's law and obtain the settling velocity for birch pollen is: $u \approx 1.2 \text{ cm sec}^{-1}$. This is by far the biggest component in the dry deposition flux of pollen grains, therefore in our study we neglected the others.

Wet deposition. There is a classical work of Chamberlain (1953) that determined the sub-cloud scavenging due to impaction, while the in-cloud microphysics is uncertain. It is known that the grains tend to dry-up during the atmospheric transport in clear-sky conditions and refill with water inside clouds but quantitative studies of such processes are lacking.

Examples of first results

Figure 4 presents the model prediction for 7 June 2005. The left-hand field shows the probability for non-zero concentrations of birch pollen (area of risk); right-hand map is concentrations scaled to unit emission. For the same day, Figure 5 shows the krigged observations from European Aeroallergen Network. It was a rare event of north-to-south transport of pollen at the end of European flowering season. At that time, the flowering was already over in Central Europe while northern birch was still emitting pollen grains, which were then transported southwards significantly extending the allergenic season there. Sofiev *et al.* (2006) depicted numerous south-to-north transport events, which are usually more common.

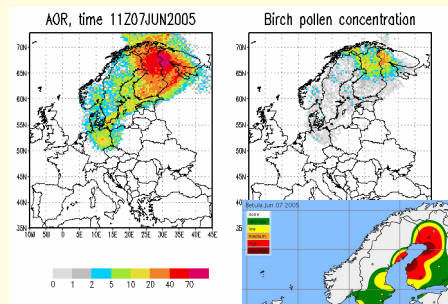


Figure 4. Pollen transport pattern for 7 June 2005. AOR=area of risk of non-zero pollen concentrations

Figure 5. Krigged pollen observations, 7 June 2005. Courtesy of S.Jaeger & EAN

Contacts

Project Web site: <http://pollen.fmi.fi>
SILAM model: <http://silam.fmi.fi>
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