EnviroInfo 2007 (Warschau)
Environmental Informatics and Systems Research
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Pollen: A Challenge for Environmental Information Services

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Abstract

Diseases due to aeroallergens, such as rhinitis and asthma, are among major causes of loss of productivity and demand for healthcare. The adverse health effects of allergens can be significantly reduced by either pre-emptive medical measures or behavioural adaptation of the outdoor activity. However, their planning requires reliable allergy-related forecasts several days ahead. Such forecasts should include the start time of pollen season, expected pollen concentration, area of exposure to a particular pollen type, timing of the peak concentrations and durations of the high season. This paper presents a current status of the Finnish Pollen Forecasting system. The system has been already used for operational pollen forecasts during spring of 2007 and also the systematic re-analysis of historical periods is ongoing.

1. Introduction

Actual pollen concentrations in air are obtained from aerobiological observations performed by many European countries, which supply the information to a common database of European Aeroallergen Network, operating an electronic system for the remote data submission, handling and acquisition. Information about timing of phenological phases, in particular, of the offset of pollen seasons needed for the pollen evaluation and forecasting is deduced from phenological monitoring mainly performed by national phenological networks. More than 30 such networks over the globe are partners of the European Phenological Network, that holds a metadatabase of national observations. Indirect information, comes from satellites in a form of various leaf-area indices. Research studies in Nordic countries have proved usability of this information for evaluation of the phenological phases over large territories.

Analysis of the above information at various spatial scales has shown that characteristics of pollen seasons is drastically influenced by the long-range atmospheric transport of pollen, which causes sudden increases of pollen concentrations that can occur up to a month before the start of the local pollen season. Many countries produce pollen assessments and short-term forecasts for the needs of general public awareness, action planning by health-related authorities, medical organizations and hospitals. However, today they are based solely on local observations and do not consider the exchange of pollen between different regions. More integrated approaches based on dynamic atmospheric transport models and aimed at including all main parts of pollen life cycle, from production to release, transport and deposition, are under development in several countries, i.e. Finland, Denmark, Germany, and France.

2. The modeling system SILAM

2.1 General description

The current operational version of the modelling system SILAM is based on a Lagrangian dispersion model that applies an iterative advection algorithm and a Monte Carlo random-walk diffusion representation. The system can directly utilize the meteorological data from either the HIRLAM or ECMWF numerical weather prediction models and dynamically adjust pre-processing routines in accordance with the availa-

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bility and completeness of the input variables. The model can treat the following pollutants and source categories:

- sulphur oxides originated from anthropogenic and natural sources
- primary particulate matter originated from anthropogenic sources (both fine particulate matter with diameter below 2.5 μm, PM2.5, and the coarse fraction with diameter from 2.5 to 10 μm, PM2.5-10)
- primary PM2.5 originated from biomass burning
- birch pollen originated from birch forests during the flowering season

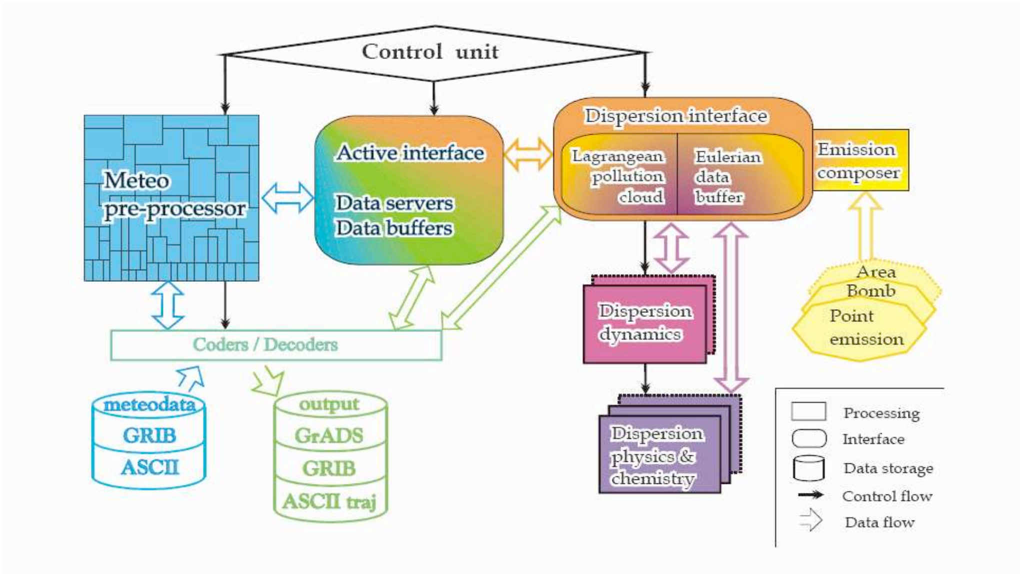

Figure 2.1.1: SILAM modelling framework

The model has been previously validated against the data of the European Tracer Experiment (Sofiev et al., 2006A), as well as the data of the Chernobyl and Algeciras releases. The model has also been executed for a period of three years (2000-2002) for the whole of Europe in its operational configuration, and the predictions were compared with the measured data of the air quality network of the European Monitoring and Evaluation Programme (EMEP). The model predictions for sulphates and SO2, and for the primary particulate matter (in case of stations, for which the chemical composition was also measured) were overall in a fairly good agreement with the measured data.
For a more detailed description of the model, the reader is referred to http://silam.fmi.fi.

2.2 Emission model for pollen

The major challenge in forecasting pollen concentrations is modelling the pollen emissions. The output of the emission module is the release of flux of pollen grains E(t) as the number of grains emitted from a unit area of birch forest within a unit time period or scaled to a model time step.

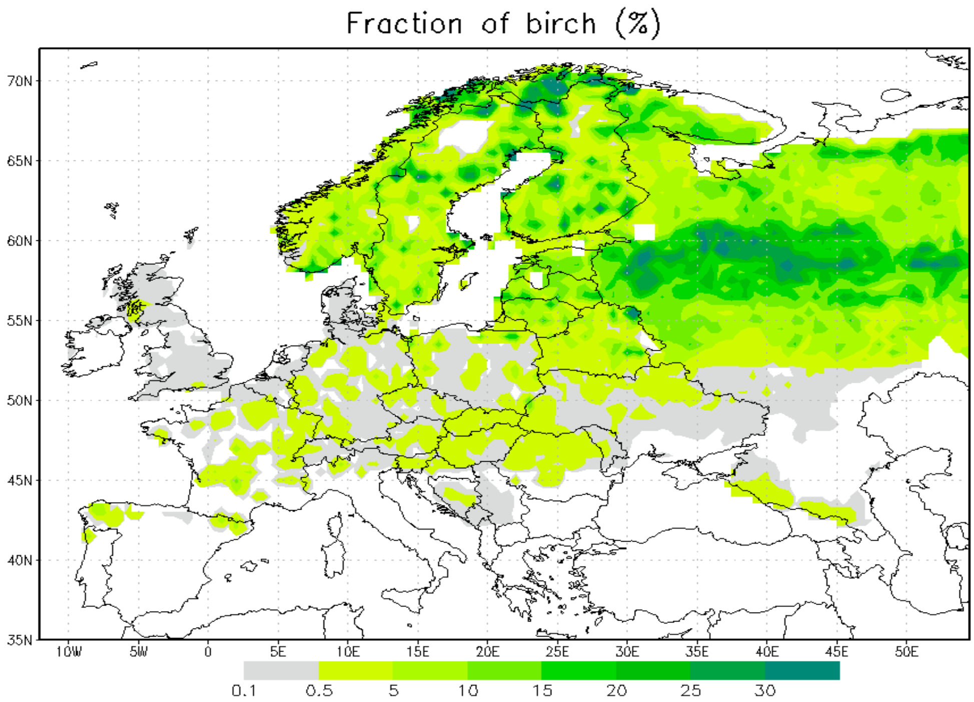

Figure 2.2.1: Map of birch forests in Europe (from: http://pollen.fmi.fi/pics/birch_d05v2.gif)

For actual computations, the modelled emission flux E_{model} is obtained from this value multiplied with the fraction of the birch forest $\phi(i,j)$ (Figure 2.2.1) in a specific grid cell (i,j) and with the grid cell area $S(i,j)$:

$$E_{model} = E(t)\phi(i,j)S(i,j) \tag{1}$$

The development of the flowering follows a principle of “two heat-sums”, which suggests that there is a linear dependence of the accumulated heat and fraction of the total pollen released R. In particular, when the heat-sum H reaches the flowering-start threshold Hflower-start the release fraction of the pollen emitted so-far is zero because the season just starts. While H grows, the fraction of the so-far released pollen grows finally reaching 1 when H=Hflowering-end – the second heat-sum, which corresponds to the end of the season. It is assumed, of course, that this end-season heat sum exists and stable from year to year.

The modelling of the end of the season is based on two quantities: total amount of pollen accumulated in catkins from previous year Ntotal and the integrated release rate $E(t)$. This rate is dynamic and driven by meteorology and other parameters. It continues until the expiration of pollen grains in catkins. The total amount of pollen developed in catkins is estimated prior to the start of the new season using previous-year data: (i) meteorological conditions, (ii) amount of pollen released, and (iii) phenological observations performed after the end of the last-year season. At present, it is introduced into the model as a prescribed fixed map.

Several meteorology-dependent correction functions have been introduced for the dynamic release rate E(t): corrections for wind speed, relative humidity and precipitation rate. The meteorological data utilized is originating from Numerical Weather Prediction model (HIRLAM;ECMWF) fields.

The emission formulations do not include any diurnal variation in an explicit form. It was assumed that natural variations of temperature, humidity and wind speed will suppress the night-time emission to a sufficiently low level. Preliminary runs of the model through spring of 2006 generally confirmed this suggestion.

3. The operative pollen information system - current status and future plans

The pollen forecasting system is still under extensive development and further evaluation, but the results of the current development version of the system are already publicly available at http://pollen.fmi.fi. An example of birch pollen predictions for Europe is presented in Figure 3.1.1.

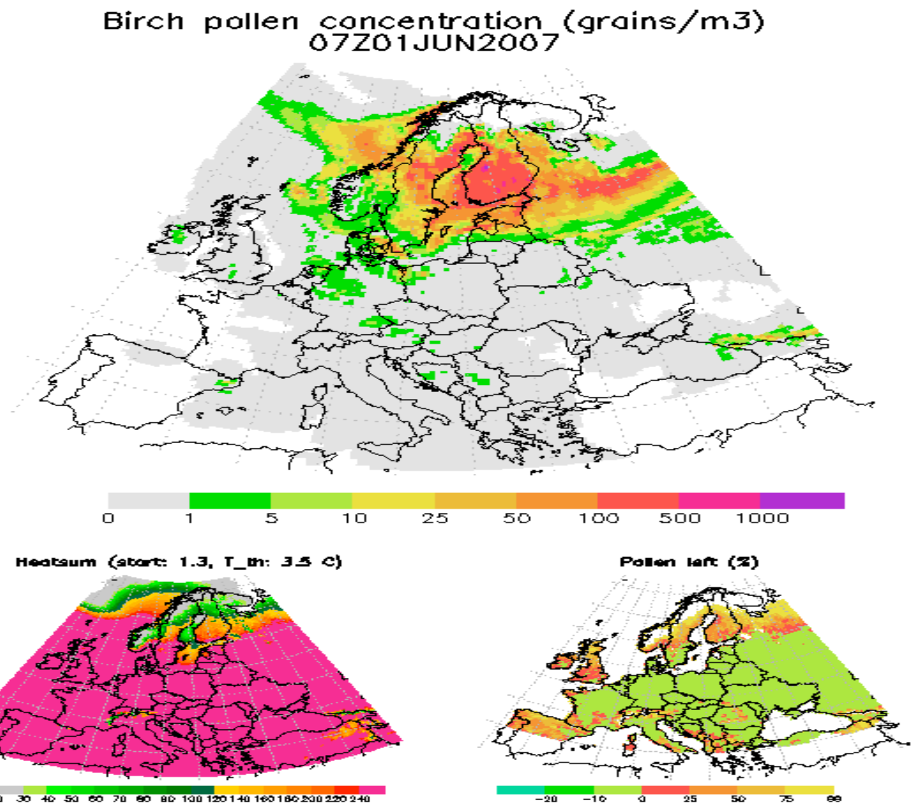

Figure 3.1.1: Operative pollen forecast (http://pollen.fmi.fi)

The information provided includes the predicted pollen concentrations (grains/m^3), accumulated heat sum (threshold 1.3 ^{o}C; start date 1/3/2007) and modeled estimate for the percentage of pollen grains remaining (%) in the emitting birches. The further development of the model, especially the work in the area of effective utilization of satellite data in the emission model will continue, but even at this early stage of operation the system has proved its potential (e.g. Sofiev et al, 2006B, Siljamo et al, 2007).

In the future the birch pollen forecast products will be integrated with the recently opened Finnish Air Quality portal (http://www.ilmanlaatu.fi) providing comprehensive real time air quality information in Finland . With all the enhancements provided by MARQUIS-project (www.marquisproject.net) for the dissemination of multimodal and multilingual environmental information the pollen forecast products are expected to form a crucial component in future cross-border air pollution information products.

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