Alarm System for Insect Migration using Weather Radars

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1. Introduction

The Finnish Meteorological Institute (FMI), MTT Agrifood Research Finland and University of Helsinki (UH) are jointly studying the meteorological circumstances which are a precursor to insect migrations to Finland. The main focus is in the harmful insects such as diamond-back moth (*Plutella xylostella*) and bird-cherry aphid (*Rhopalosiphum padi*). The impact of these insects can be drastic if farmers are not able to protect their crops in time. In order to take control measures well in time it is not only essential to forecast the timing and amount of local pests but also of air-borne migrants. In an optimal case farmers can save their crop, money, and environment due to the proper timing.

Weather radars are used to monitor insect migrations in progress. The radars used in this project include FMI Doppler weather radar network, UH Doppler weather radar 32 km north of Helsinki, and the polarimetric weather radar in Helsinki. These radars all operate on C-band, and most of the clear air echoes that they detect are related to insects in the air. Weather radar information has been used in Finland in studies of insect migrations since the middle of 1980's (e.g. Nieminen et al. 2000). Doppler radars give the average direction and speed, and the polarimetric radar makes the identification of scatterers more accurate.

The summer 2008 experiment will be conducted to further confirm presumptions based on earlier 2007 results and to test a pilot alarm-service for selected farmers who will evaluate the usefulness of it. The system will also be verified against the field data on migrating insects. After the summer the results will be analyzed and required enhancements made in order to take a test mode in operation in summer 2009.

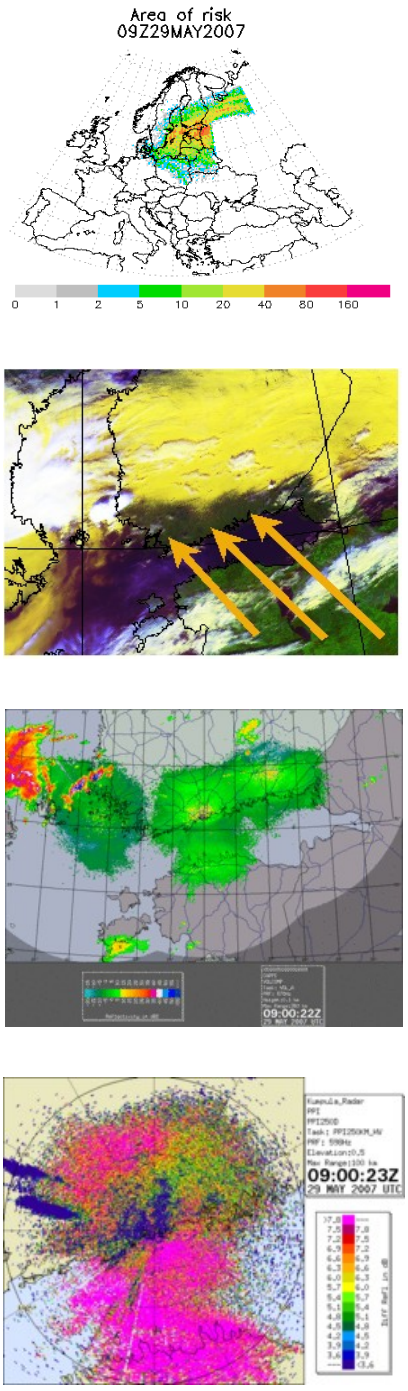

Fig 1. Insect migration from Estonia to Southern Finland

morning of 29 May 2007. Images from above: dispersion from Baltic states, AVHRR composite of clouds (orange arrows show the insect flow), C-band radar and polarimetric radar

2Summer 2007 experiment summer

After the literature survey and previous subjective experience it was possible to set up some presumptions of meteorological circumstances connected to insect migration to Southern Finland. These presumptions were tested during May and June 2007 by an experiment. Numerous insect traps were distributed to the polarimetric radar range. Weather radar data from all sites in the study area, and weather satellite imagery processed in FMI was collected to the project archive during the experiment. Numerical weather prediction model, and pollen dispersion model (Sofiev et al. 2006) information from the period was stored as well.

The material collected was analyzed during autumn 2007 and findings were classified to conceptual set of rules for insect migration. These rules form the basis for the warning system.

Fig 1 on right hand side shows a migration case. First image shows the dispersion from the Baltic countries towards southern Finland on the morning of 29th of May 2007. Second image is a satellite image composite showing fog and low stratus (yellow) in central Finland leaving southern coast cloud free. This cloudiness forms a barrier to the insect migration together with the airflow. Orange arrows show the direction of migration. The last two images are from FMI radar network and Helsinki polarimetric radar frpm the same time respectively. Green areas in FMI echo intensity image are related to insect migration. This is verified by the polarimetric radar differential reflectivity image showing mostly more than +7 dB values, especially over the sea.

3. Pilot warning service for insect migration

3.1Warning system flow

The warning system consists of automatic calculation of insect migration probability, subjective control and correction tools of the probabilities and finally the dissemination to the users via web interface and SMS messages.

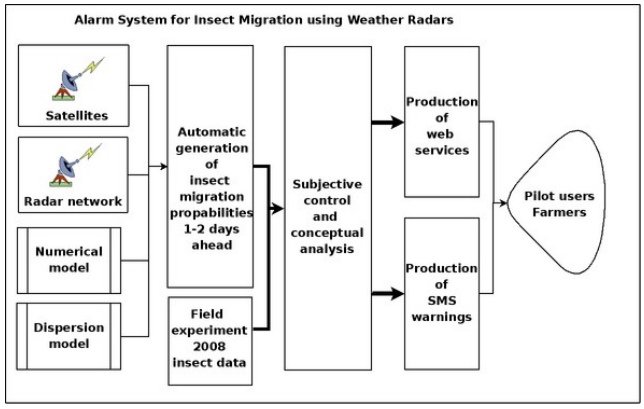

Fig 2. Process flow for the insect warning system

3.2 Data sources for the system

Basically the same data sources will be used for the insect migration analysis and forecast as was used for the experiment on summer 2007. This means in practice that weather radar data, satellite data and dispersion data will be used in the automatic analysis and prediction. For the subjective control also the field measurements, forecast model data will be used in addition.

3.3 Insect web services

The user will be able to examine the end product as a map with verbal comments on the web (Fig 3.)

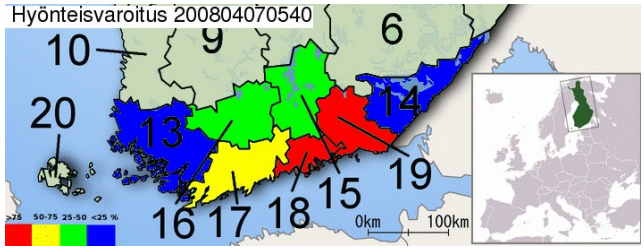

Fig 3. Example of the warning map. The colours show the severity of the warning. Pale green means no warning.

The warning is given for seven counties in Southern Finland. The severity of the warning is given as probability class. because the method is experimental and rather rude at present there are only five classes: red meaning probability of migration above 75%, yellow between 50 and 75%, green between 25 and 50%, blue below 25% and pale green no warnings issued.

The user can also examine real time C-band radar, satellite and dispersion animations on the web (Fig 4.). Summer 2008 there will be only less than ten pilot users. These users have experience to use also weather information. Therefore one aim is to get feedback from the users, how much they could improve the simple warning information but analysing the weather situation themselves.

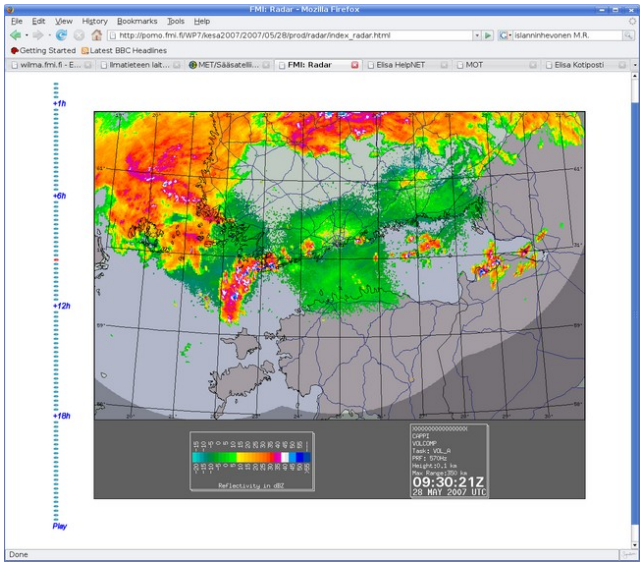

Fig 4. C-band radar animation. Green colours show weak echoes from insects and birds. Yellow to dark red colours represent rain.

3.4 Insect SMS services

The warnings will be sent to the pilot users also as SMS text messages (Fig 5).

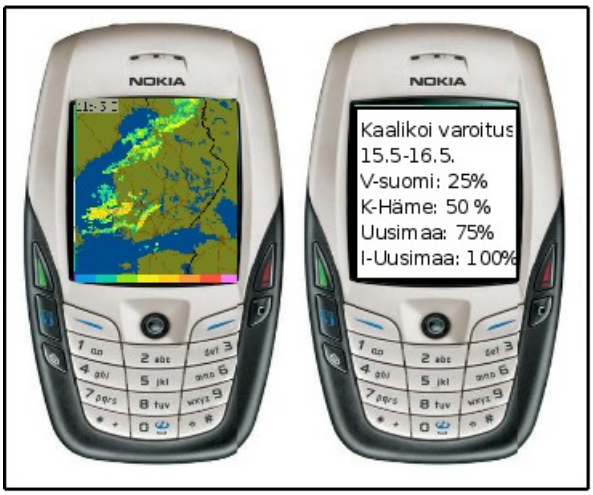

Fig 5. Example of SMS products for insect warning

Pilot users get automatically the warning SMS text message to their mobile phone. They can also use already existing services to look at the radar animations using wap services.

4. Summary

The pilot system for forecasting insect migrations to next two days will be operated during May and June 2008. Forecasts are concentrating on two major pests; namely diamond-back moth and bird cherry aphid (Fig 6). Five to ten pilot users will get automatic SMS warning messages and are able to study the situation more thoroughly via specific web pages. The pilot users report to the study team about their findings and the usefulness of the service.

The validity of the service will be tested using field traps. Figure 7 shows the locations of yellow sticky paper traps. There will be also several tow nets in the same area.

Fig 6. Diamond-back moth (left) and bird cherry aphid (right) are the target insects of the study

Fig 7. Map of yellow sticky paper traps (left) and picture of a tow net (right)

5. Conclusions

Summer 2008 will be used to study the impact of the insect warning system. The trial period will give valuable information on how to use C-band polarimetric and Doppler weather radar data to monitor insect migrations. The aim is also to test, when the warnings should be issued and, which is the feasible lead time for warnings to be useful.

Acknowledgment

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References

Nieminen, M., M. Leskinen, J. Helenius, 2000: Doppler radar detection of exceptional mass-migration of aphids into Finland. Int J Biometeorol 44: 172-181.

Sofiev, M., P. Siljamo, H. Ranta, A. Rantio-Lehtimäki, 2006: Towards numerical forecasting of long-range air transport of birch pollen: theoretical considerations and a feasibility study. Int J Biometeorol 50: 392-402.

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