4A.2 EVIDENCE FOR LONG-RANGE TRANSPORT OF VIABLE MAIZE POLLEN

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1. INTRODUCTION

Most experiments on the dispersal of maize pollen have been performed using ground-based systems with pollen traps located at various distances downwind from a source (Jarosz et al., 2003; Aylor et al., 2003). Such measurements can only provide information on short-range dispersal in the surface boundary layer (*i.e.*, within horizontal distances not exceeding a few hundred metres). However during the pollination period there is frequent convective activity in the first 1-2 km of the atmosphere, the so-called convective boundary layer (CBL), that may result in mass transport to occur over much longer distances. In order to investigate whether this applies to maize pollen, we study here the presence and viability of pollen within the boundary layer.

2. MATERIALS AND METHODS

A series of ten flights spanning six days was performed with a light aircraft (Cessna 180) above a 4000 ha set of maize fields embedded in the Landes pine forest (South-West France) in July 2002 and 2003, during the pollination period. Each flight consisted in 12 km long legs made at a maximum of seven altitudes between 150 m and 1800 m, i.e. within and above the CBL for most of the time.

A sampling device was built to collect pollen grains by impaction onto a set of 8 Petri dishes located around the main axis of a plastic tube set up under the wing and facing forward. A Pitot tube was used to monitor the air flow rate in the tube. Total and germinated pollen grains were counted under a microscope after each flight was completed. Corrections for non-isokinetic sampling and untrapped pollen were performed to estimate pollen concentration in the atmosphere. Radio-soundings were made simultaneously to characterize the structure of the CBL.

3. RESULTS AND DISCUSSION

The radio-soundings performed each day around noon reveal a range of atmospheric conditions from moderate to strong convective activity (CBL height from 800 to 2000 m, respectively). The air temperature close to the ground surface was between 25 and 34°C.

A grand total of about 1500 maize pollen grains were collected during the campaign. During each flight at least a few grains were found at all heights, with average concentrations across the CBL ranging from 0.2 to 1.1 grains m^{-3}. Such concentrations are of the same order as those found near the ground at distances as short as 40 m downwind from a source (*e.g.*, Raynor et al., 1972).

The vertical variation in pollen concentration is variable. Most of the time it shows a clear decrease over the first two or three measurement altitudes, then it remains roughly constant and decreases at the highest levels (Figure 1). On the days when several flights were performed the time variation of the vertical profiles are as expected: as the boundary layer grows the concentration increases throughout the CBL (Figure 1).

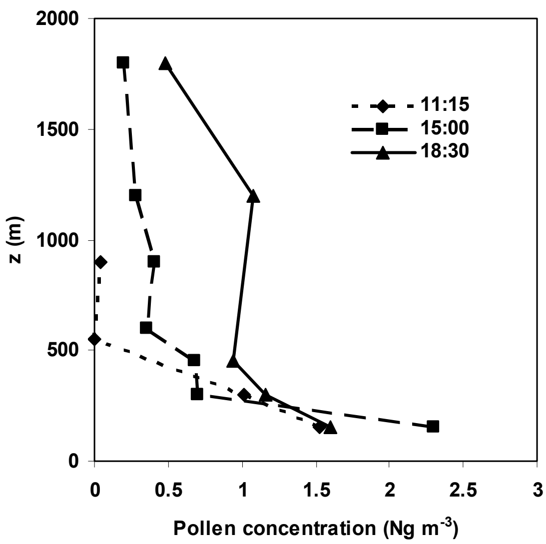

Figure 1. Vertical variation in pollen concentration at three times of the day (July 12, 2003).

In order to get a clearer picture the average concentration profile over all flights is plotted in Figure 2. Here the height above ground z is normalized by the height of the CBL h, measured or calculated at the time of each flight. For each flight the pollen concentration C is normalized by the mean concentration C_{av} in the CBL. The horizontal bars indicate the standard deviation associated with each value. It can be seen that, despite the strong variability in observed concentrations, the vertical variation is typical of the structure of a CBL: the pollen concentration decreases up to z/h ~ 0.2, then remains approximately constant throughout the mixed layer; above the top of the CBL it decreases again towards low values. Maize pollen, that is considered to be a large particle (its diameter is of the order of 90-100 μ),

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therefore seems to behave like a gas or small particles. Its settling velocity, of the order of 20-30 cm s^{-1}, is in fact small compared with the vertical velocities found in a convective boundary layer.

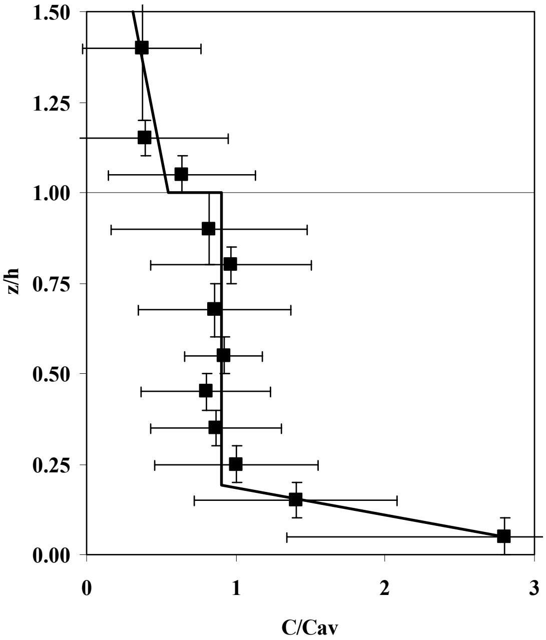

Figure 2. Vertical variation in normalized pollen concentration C/C_{av}: mean values and standard deviations over all complete flights. The vertical bars represent the size of the boxes used for averaging. The curve represents an ideal CBL profile for a passive scalar released at the ground surface.

Figure 3 shows the average vertical variation in the viability of pollen grains, as measured from all complete flights. It shows a smooth decrease from about 40-50 % close to the ground to about 15 % at the top of the CBL. In the free atmosphere above the viability is still significant (about 5 %). Here again, the values observed towards the top of the CBL or above it are similar to those observed near the ground at distances as short as a few dozens of metres downwind from a source. This smooth vertical variation can be considered as resulting from two competing effects: a decrease in viability with time, that may affect the pollen at high altitudes more than lower in the CBL, and better conservation conditions for pollen at high altitudes, where the air temperature is lower.

4. PERSPECTIVES

These results have profound implications on the possibility of long-range gene dissemination, because they show that in such climatic conditions as those encountered during the pollination period viable pollen grains can be transported over considerable distances (dozens of km) before they settle (which is likely to occur during the evening and nighttime).

Similar measurements should be performed again in July 2004, along with additional observations including horizontal transects across the region and nighttime flights. We also plan to use a mesoscale model in order to predict the dispersal of pollen at a regional scale.

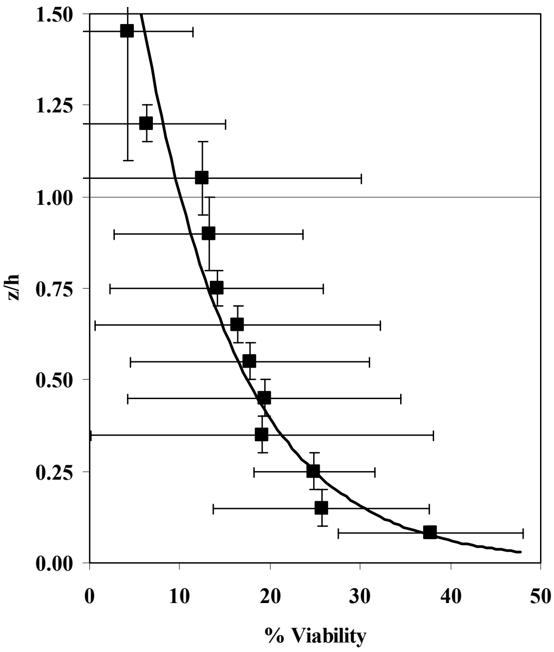

Figure 3. Vertical variation in viability: mean values and standard deviations over all complete flights. The curve is an exponential adjustment through the experimental points.

5. REFERENCES

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