The circadian rhythm of corn (*Zea mays L.*) pollen dispersal into the atmosphere and its relation with local meteorological conditions

BIOCOMPLEXITY

Instrumentation to measure the emission and transport of biological aerosols in the atmosphere: Linking across scales from microns to kilometers

R.van Hout*, J. Smith, M. Chamecki, C. Higgins, J. Katz*, M. Parlange, G. Brush

**Department of Mechanical Engineering, The Johns Hopkins University, Baltimore, MD 21218 USA*

Department of Geography and Environmental Engineering, The Johns Hopkins University, Baltimore, MD 21218 USA

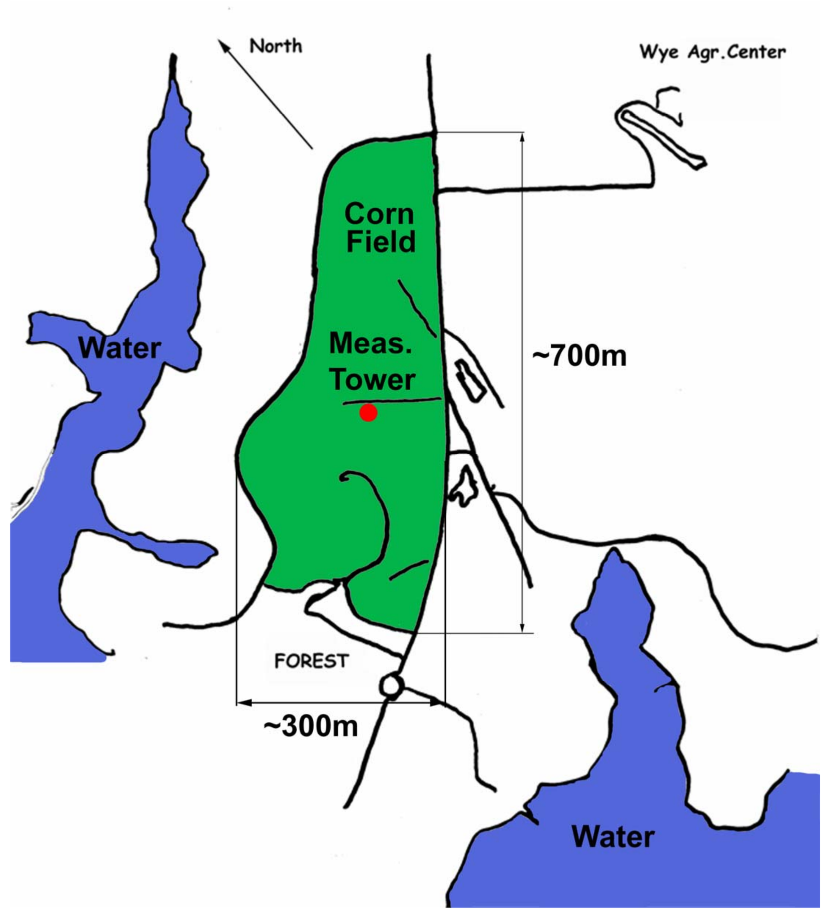
E-mail: vanhout@poseidon.me.jhu.edu

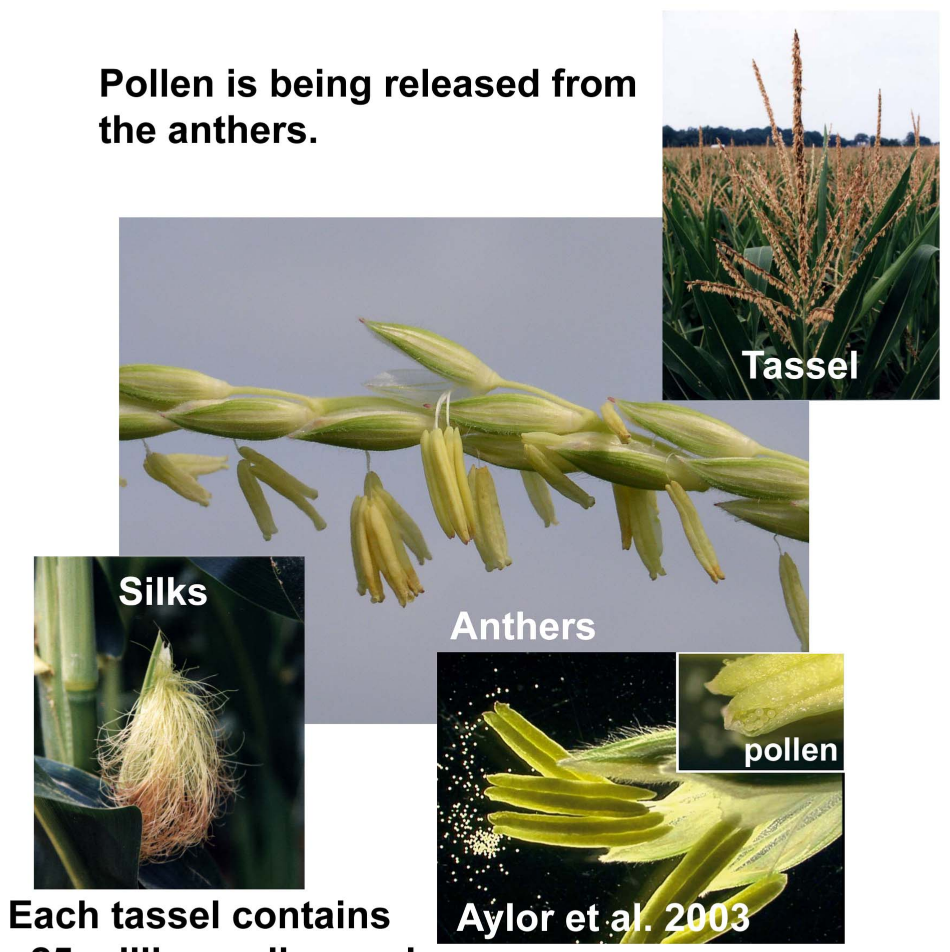
Abstract

Field measurements of the diurnal cycle of corn (*Zea Mays L.*) pollen release into the atmosphere and synchronized measurements of the local meteorological conditions, i.e. wind speed, turbulence characteristics, temperature, relative humidity and energy balance terms, were performed in the middle of a 50 acre corn field on the eastern shore of the Chesapeake Bay, Maryland. Hourly and two-hourly averaged pollen concentrations at four different elevations were measured using Rotorod samplers. Pollination started the 12th of July 2004 and lasted until the 21st of July with peak pollen concentrations on the 16th of July. Initial daily release of pollen into the atmosphere occurred after sunrise and closely depended on radiation and relative humidity, as well as on sufficiently strong winds necessary to entrain the grains. Pollen concentrations were highest close to canopy height and decreased to ~30% at twice the canopy height. Vertical pollen concentration distributions were well described by a power law taking into account a vertical pollen flux. The first pollen concentration peak occurred during the morning hours and coincided with the peak value in radiation hitting the anther, assuming that it is oriented vertically with the stomatic opening on the bottom. Furthermore, on four consecutive days from the 14th to the 17th of July, bi-modal diurnal pollen release patterns were obtained with a second peak in pollen concentration occurring at the same time each day. In the afternoon pollen release tapered off and negligible night time pollen concentrations were measured except for one night with low relative humidity and high wind speeds.

Fieldsite

Eastern shore of the Chesapeake Bay, Maryland





Each tassel contains ~25 million pollen grains

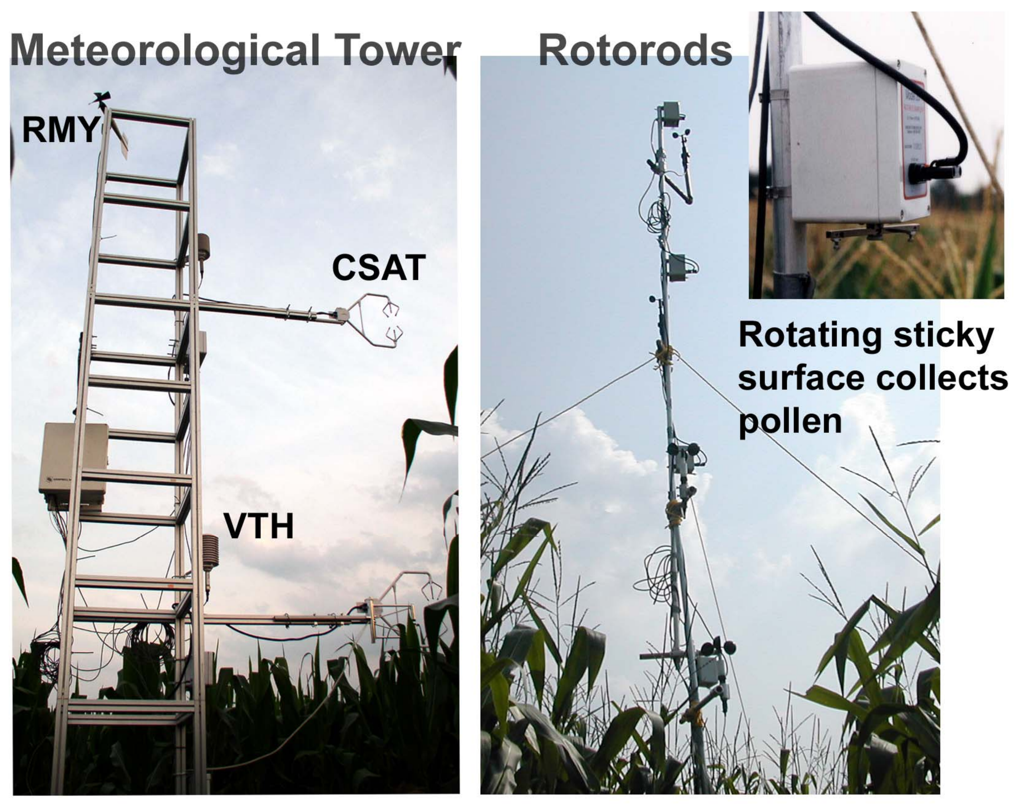
Setup

Pollen sampling tower of 6m height containing:

- 4 Rotorod samplers mounted at z/h = 1, 1.25, 1.5 and 2 where h = 3m is the canopy height
- Cup anemometers at same height as Rotorods.

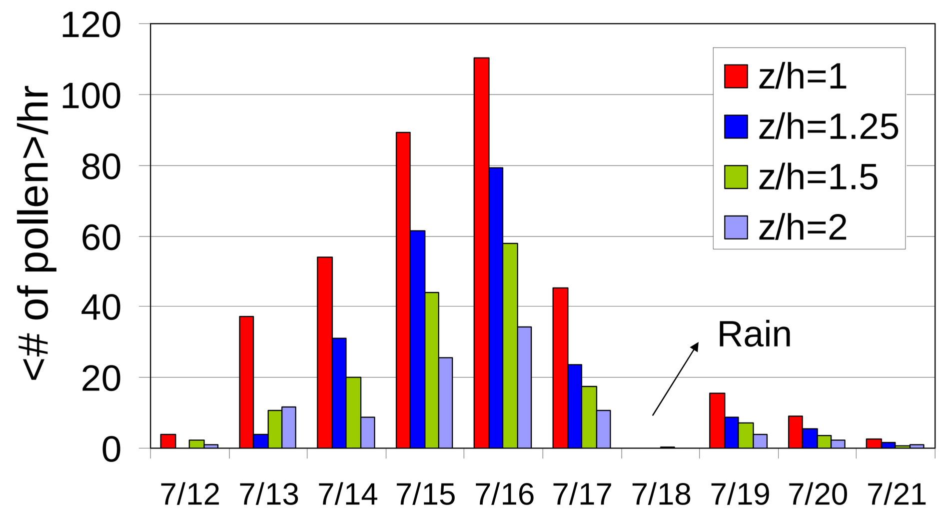
Meteorological Tower containing:

- 2 Campbell Scientific 3D Sonic Anemometers (CSAT), *z/h* = 1 and 1.5
- 2 Vaissala Thermometers/Hygrometers (VTH) , *z/h* = 1 and 1.7
- 1 Young Propeller windvane (RMY), z/h = 2
- 1 Rain gauge
- 1 Krypton hygrometer
- 4 Soil heat flux plates



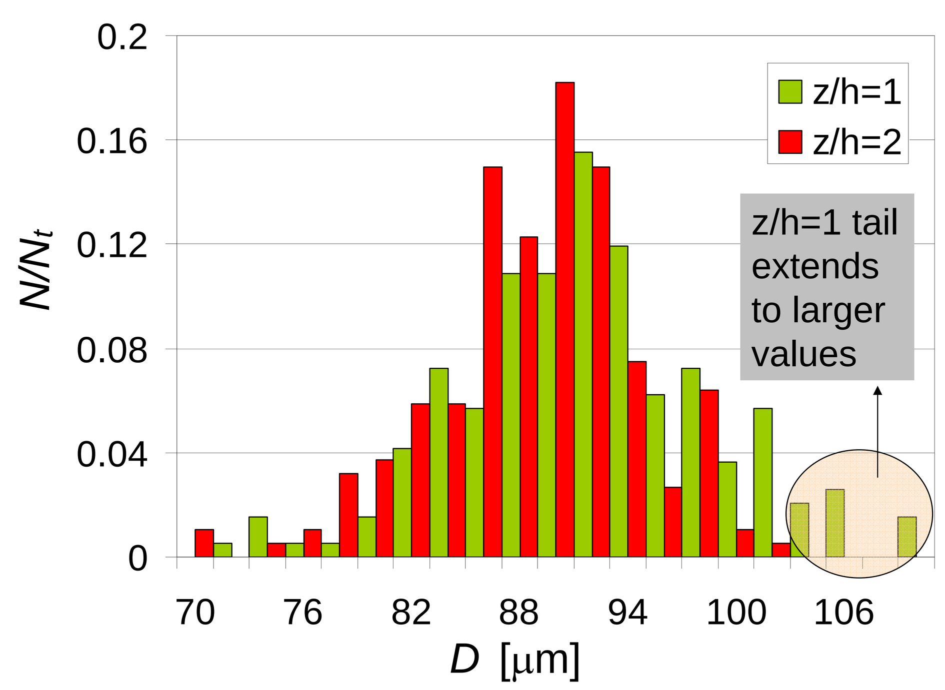
Daily averaged pollen counts

Peak release on the 16th of July 2003.



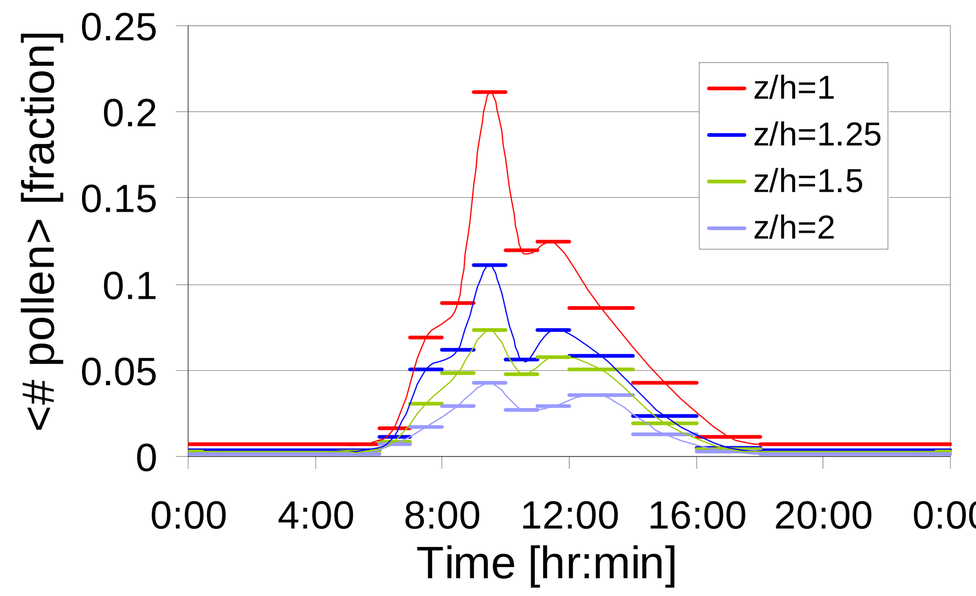
Pollen Size Distribution

Pollen diameter D is based on the projected area as imaged by a Leica optical microscope at 10x.



Weighted averaged diurnal pollen release cycles

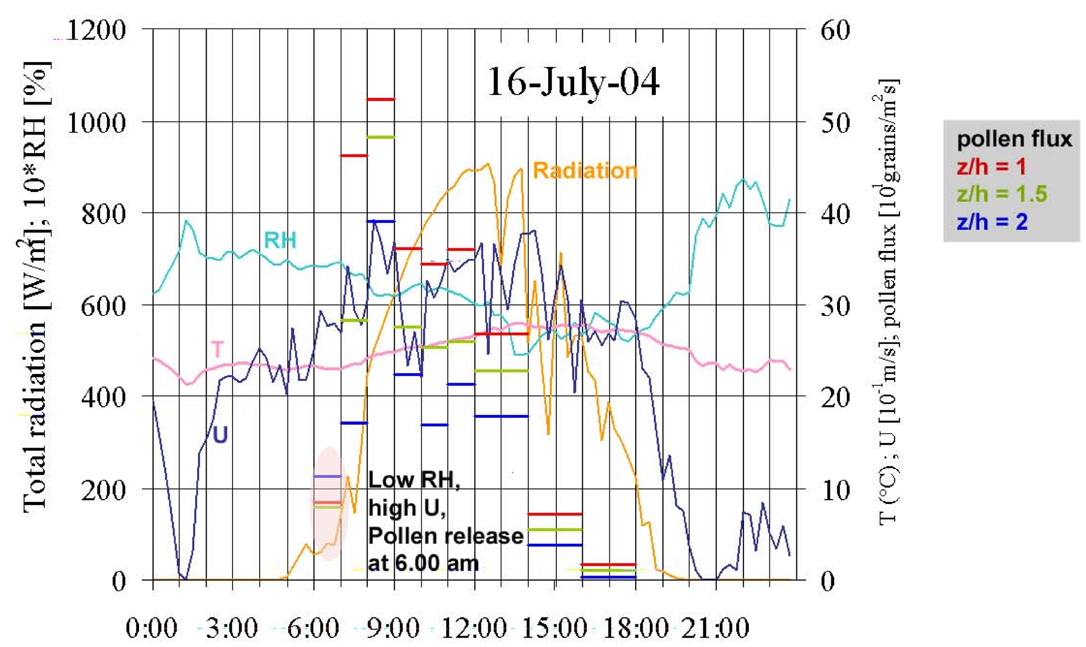
- Bi-modal distributions at all heights. First peak in pollen release between 0900-1000 EDT. Second peak between 1100-1300 EDT
- Pollen counts decrease with increasing height.

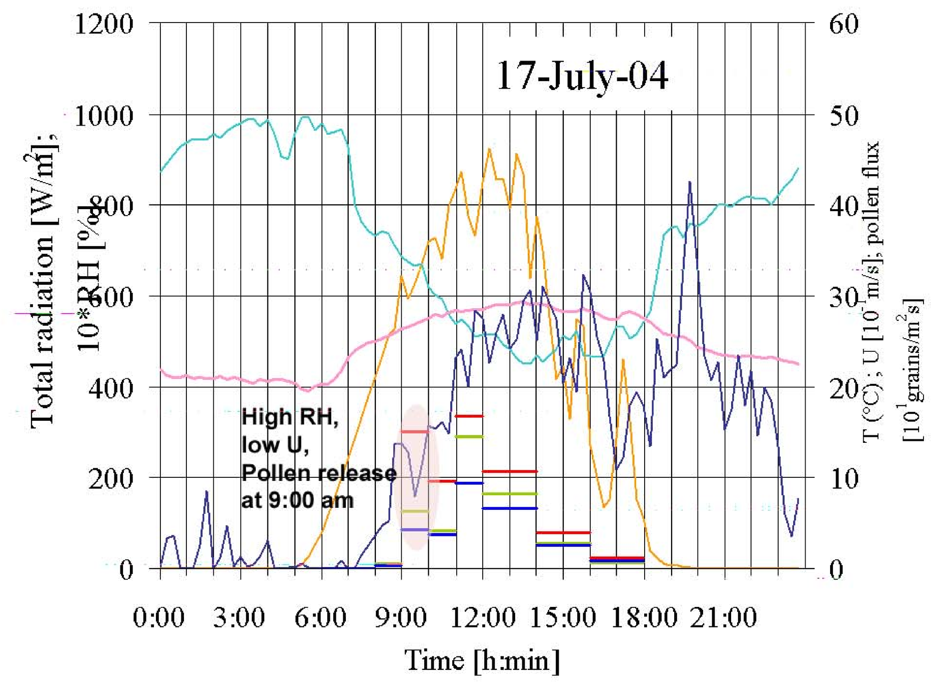


Diurnal cycle of pollen release and local weather conditions

Pollen fluxes are plotted together with 15 min. averaged total radiation, temperature (T), relative humidity (RH) and velocity (U).

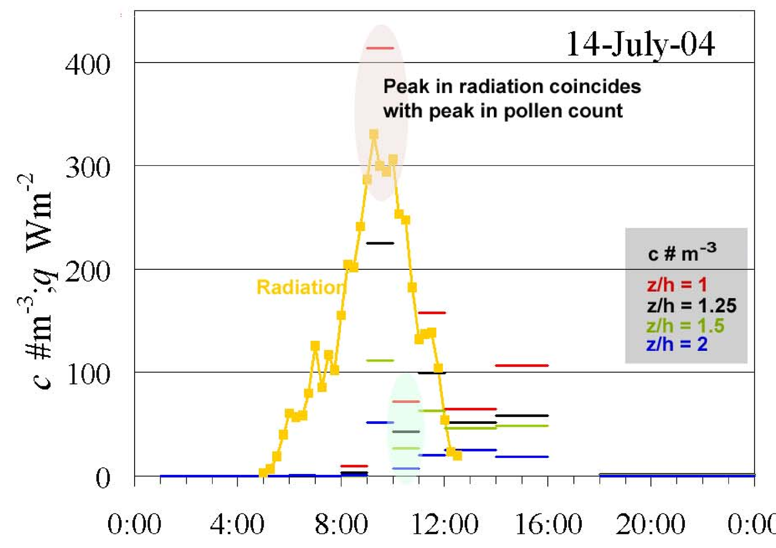
- Low RH and high U causes pollen to be dispersed at sunrise.
- Night time pollen dispersal is not observed except for one night with low RH and high U. Possibly re-entrainment.
- Pollen release clearly depends on the drying rate of the anthers.

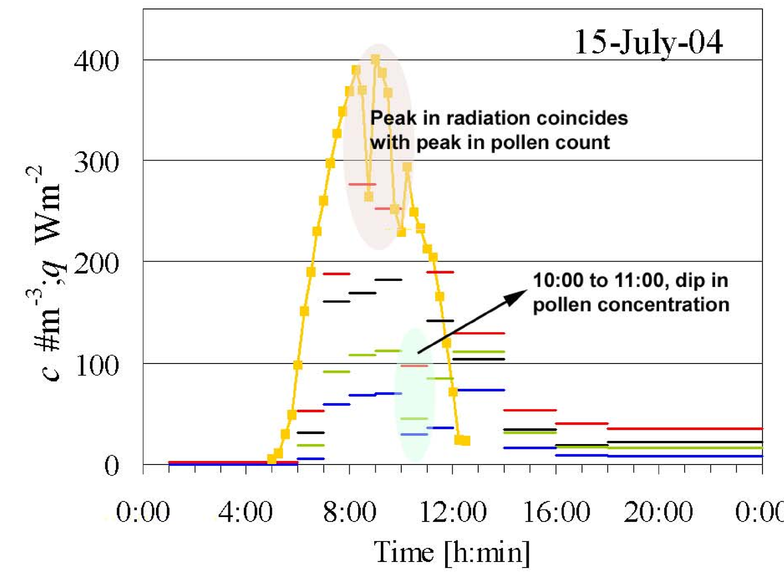




Correlation of first peak in pollen release with radiation

The pollen release peak is correlated with direct radiation hitting the anther assuming it is vertically hanging down, i.e. when the sun is at its highest position direct radiation on the anther is minimized.



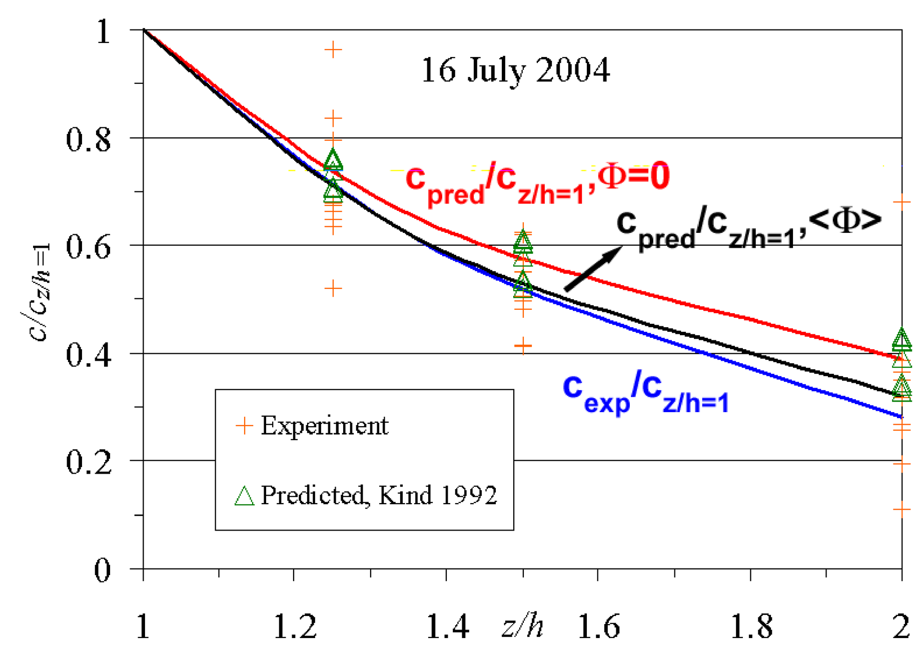


Vertical pollen distribution and comparison to model (Kind, 1992)

Steady conditions, particle diffusion equal to eddy viscosity, $U_3 = 0$

$$\frac{c}{c_{z/h=1}} = \left(\frac{\Phi u^*}{c_r u_s}+1\right)\left(\frac{z}{z_r}\right)^{-u_s/\kappa u^*} - \frac{\Phi u^*}{c_r u_s}$$

where c is the corn pollen concentration, u^* is the friction velocity, Φ is the vertical pollen flux, u_s = 0.27 m/s is the settling velocity of a corn pollen in still air.



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