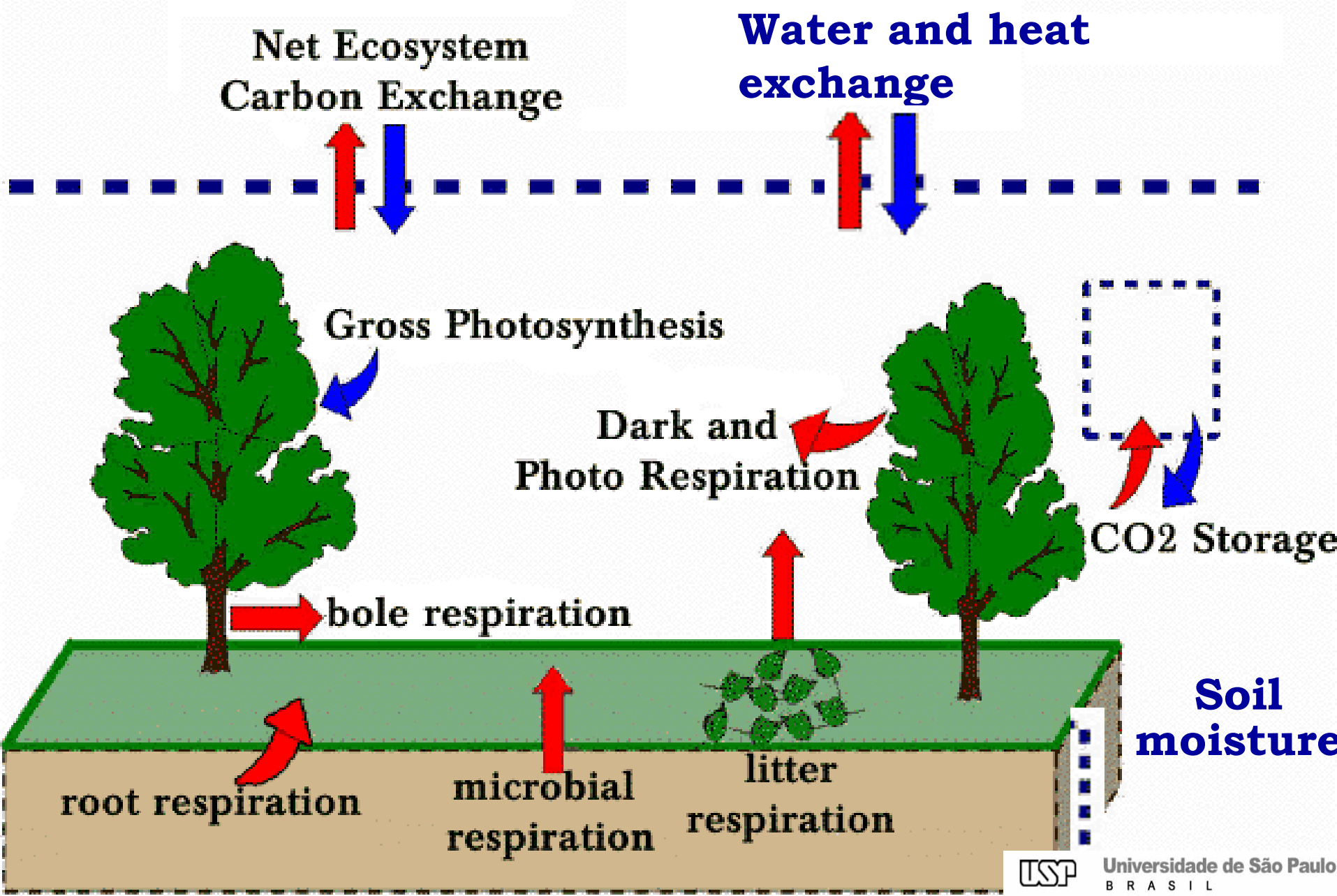
SUMMARY

1. Issues tower flux sites can contribute
Regional and global climate changes
Role of the biosphere in the global C cycle
Mitigation of greenhouse effect and the C market
Ecosystem and climate models, Interdisciplinary scientific projects
2. Measuring surface exchanges: the eddy covariance method
Surface balance (radiation, water, energy)
The eddy covariance method used in flux towerx
3. Instrumentation
4. Estimating ecosystem fluxes
The concept of fetch, Spectral relationships, Averaging options
Webb correction, Energy closure
Diel and seasonal variability
Biometric stock changes
5. Monitoring sites over tropical ecosystems
Tropical forest
Savanna
Agrosystem (sugar cane)

Measuring ecosystem surface exchanges

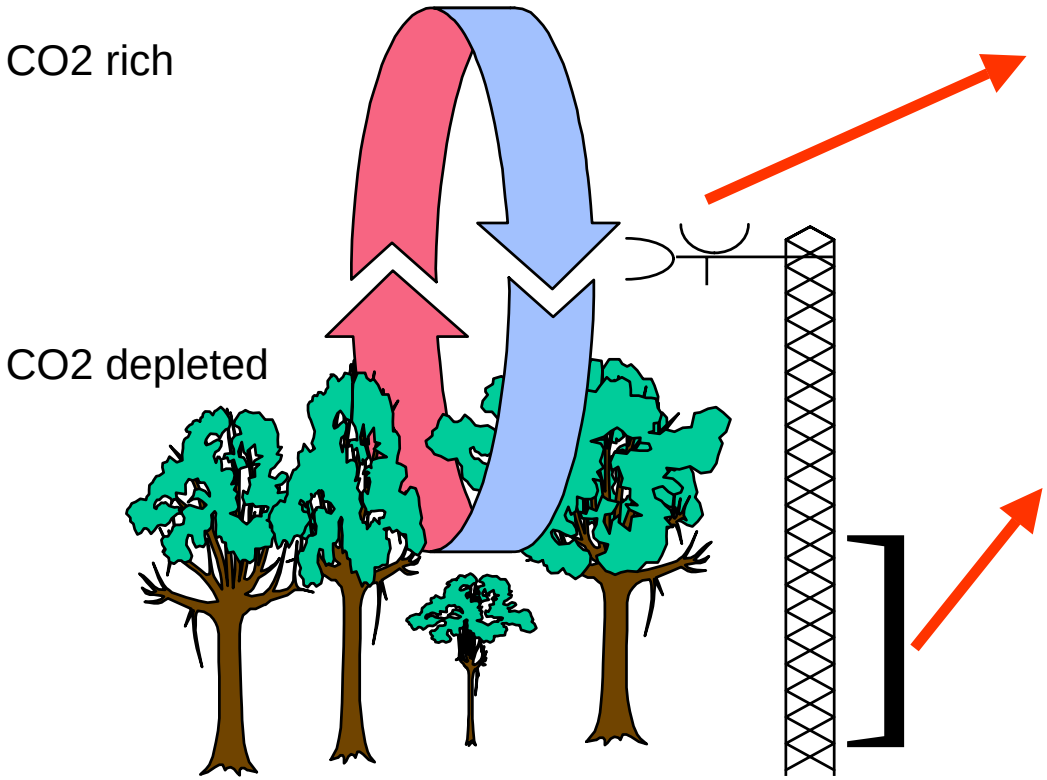
The eddy covariance technique

Canopy Carbon and Energy Balance



Eddy correlation method

- measures CO2 exchanges between surface and atmosphere



CO2 turbulent flux

$F = \langle w \rho_c \rangle$

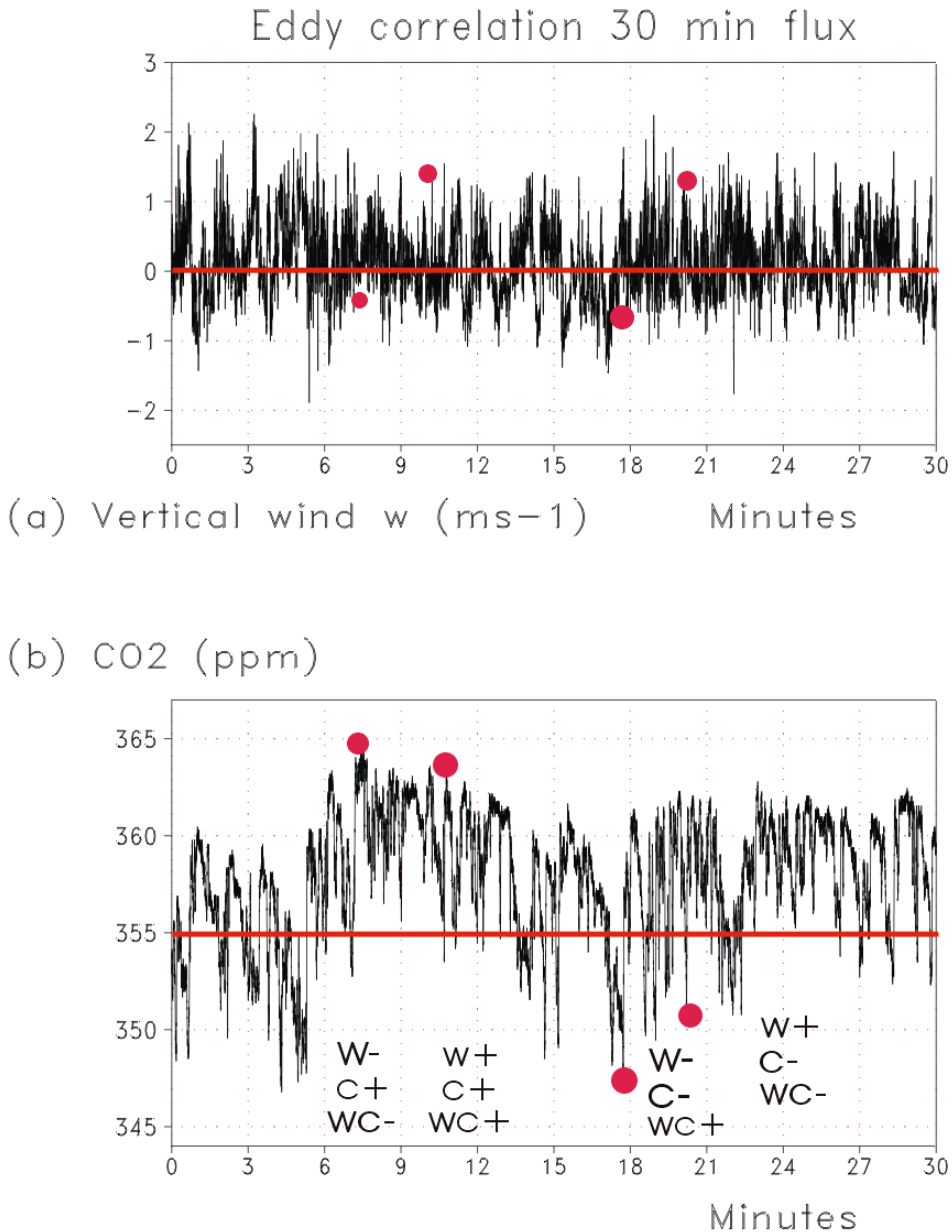
w = veloc vertical wind

ρ_c = concentration CO2

Non turbulent flux

$S = \Delta \rho_c / \Delta t$

$$\text{Ecosystem flux} \cong F + S$$



Fluxes measured over a tower

$$F_c = \rho \overline{w'c'}$$ **CO2**

$$\lambda E = \lambda \overline{w'q'}$$ **water vapour (or latent heat)**

$$H = \rho c_p \overline{w'T'}$$ **sensible heat**

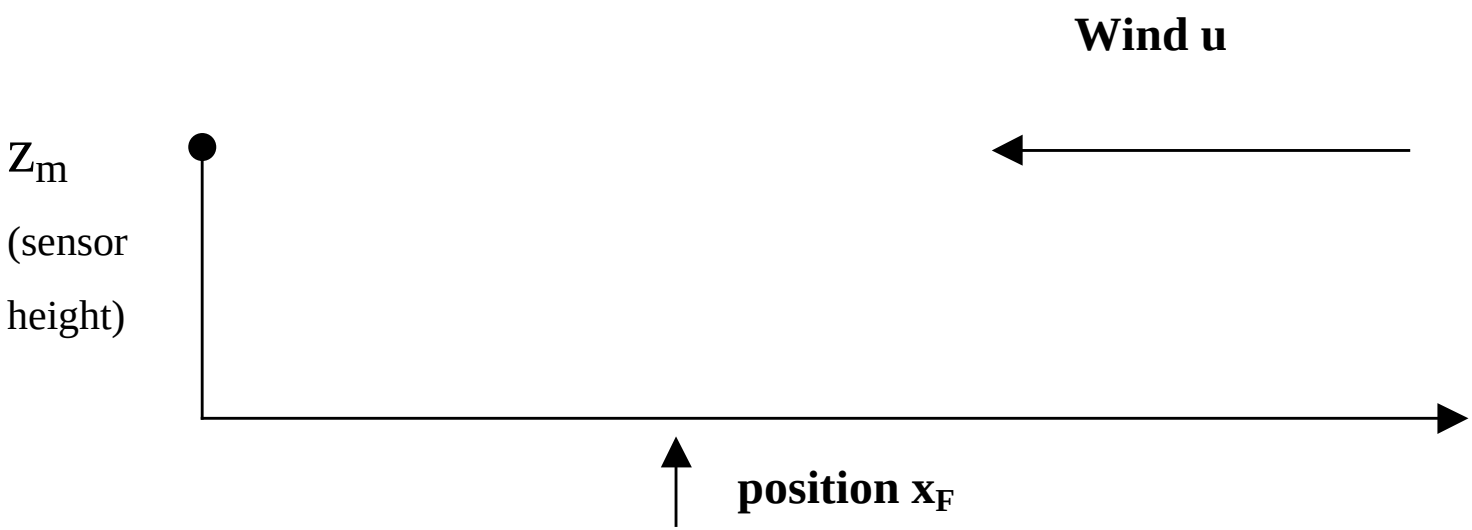
$$\zeta = \rho(\overline{w'u'}^2 + \overline{w'v'}^2)^{1/2} = \rho u_*^2$$ **momentum**

where u_* = friction velocity

The tower footprint

Gash (1986), Bound Layer Meteo, 35, p. 409
Schuepp (1992), J of Geophys Research, 97, D17, pg 18455

For a source along the x-axis, what is the contribution at the position xF, measured by sensor at z_m ?

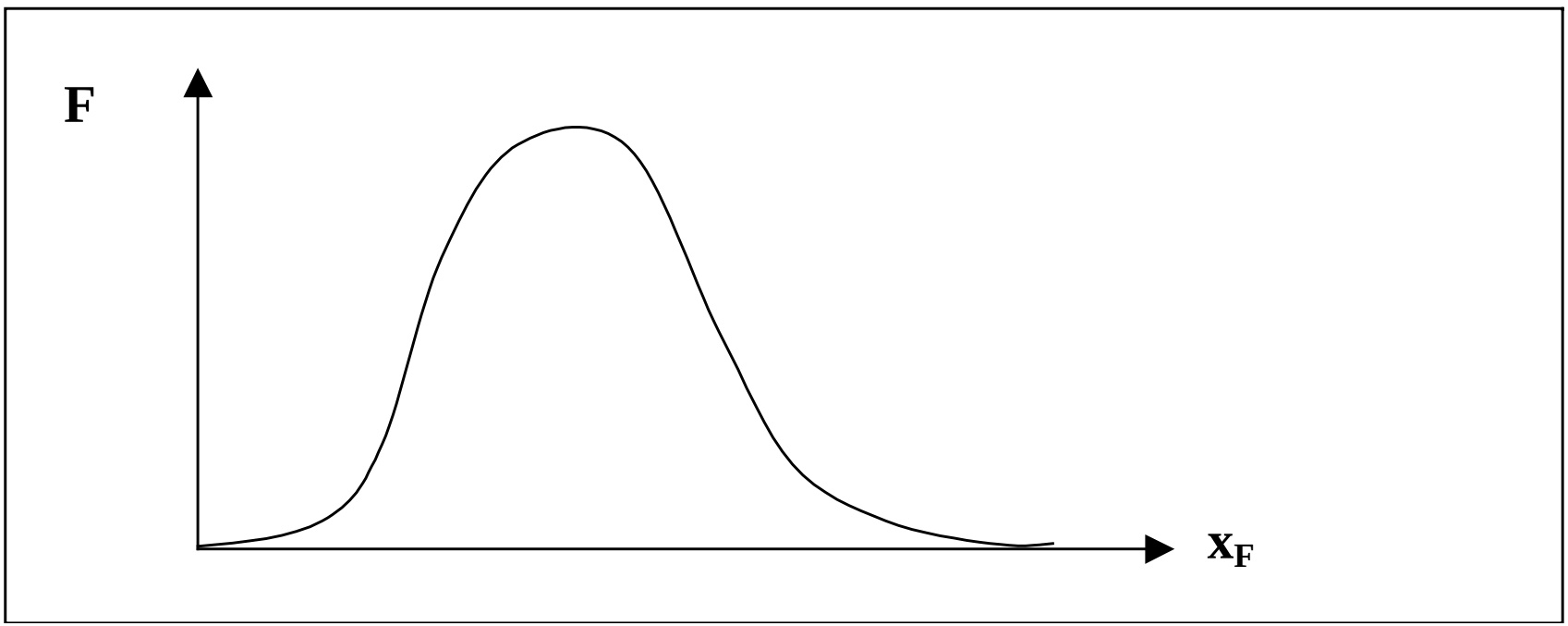


The fraction of the source (F) at position x_F is

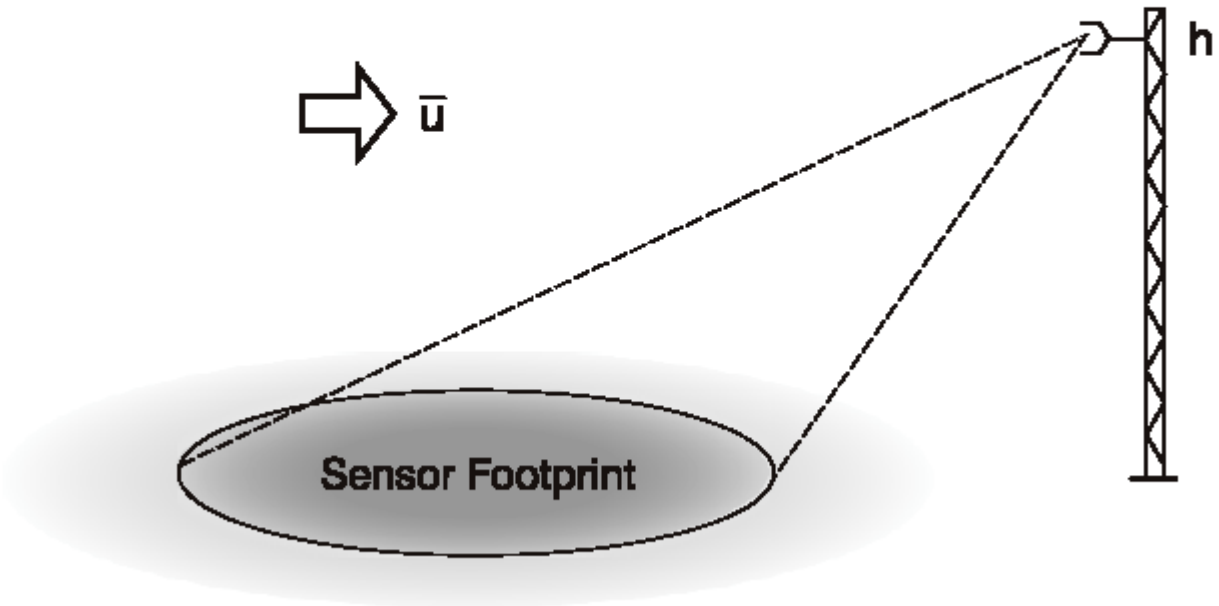
$$F \cong \exp\left(\frac{-Uz_m}{u_* k x_F}\right)$$

Fetch is usually called the entire source-area influencing the measurements at a height zm.

The footprint is the specific contribution at a distance from the measurament height.
Footprint is affected by atmospheric instability (Schuepp 1995).



19.3 Sketch of tower sensor footprint. The solid line defines an X% probability contour. X% of the concentration (or flux) measured at the sensor is influenced by the surface sources within this contour.



Source: Finnigan et al 2002

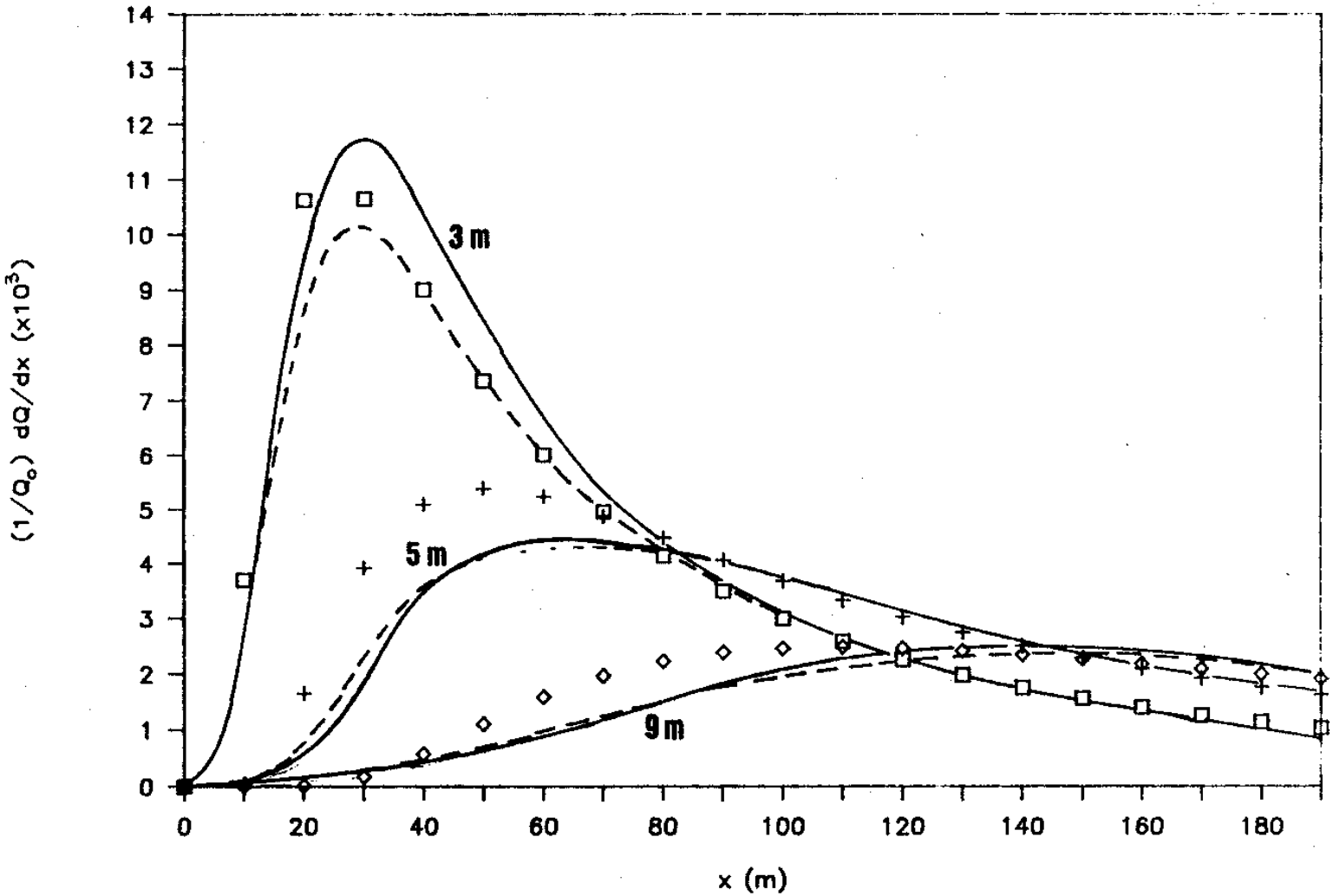


Fig. 3. Footprint predictions from Equations (9) and (6) (symbols) and numerical predictions (lines) for observation heights of 3, 5 and 9 m, with $d = 0.3$ m and $z_0 = 0.065$ m. Dashed lines correspond to adjusted U/u_* ratios as described in the text.

Source: Schuepp et al (1989)

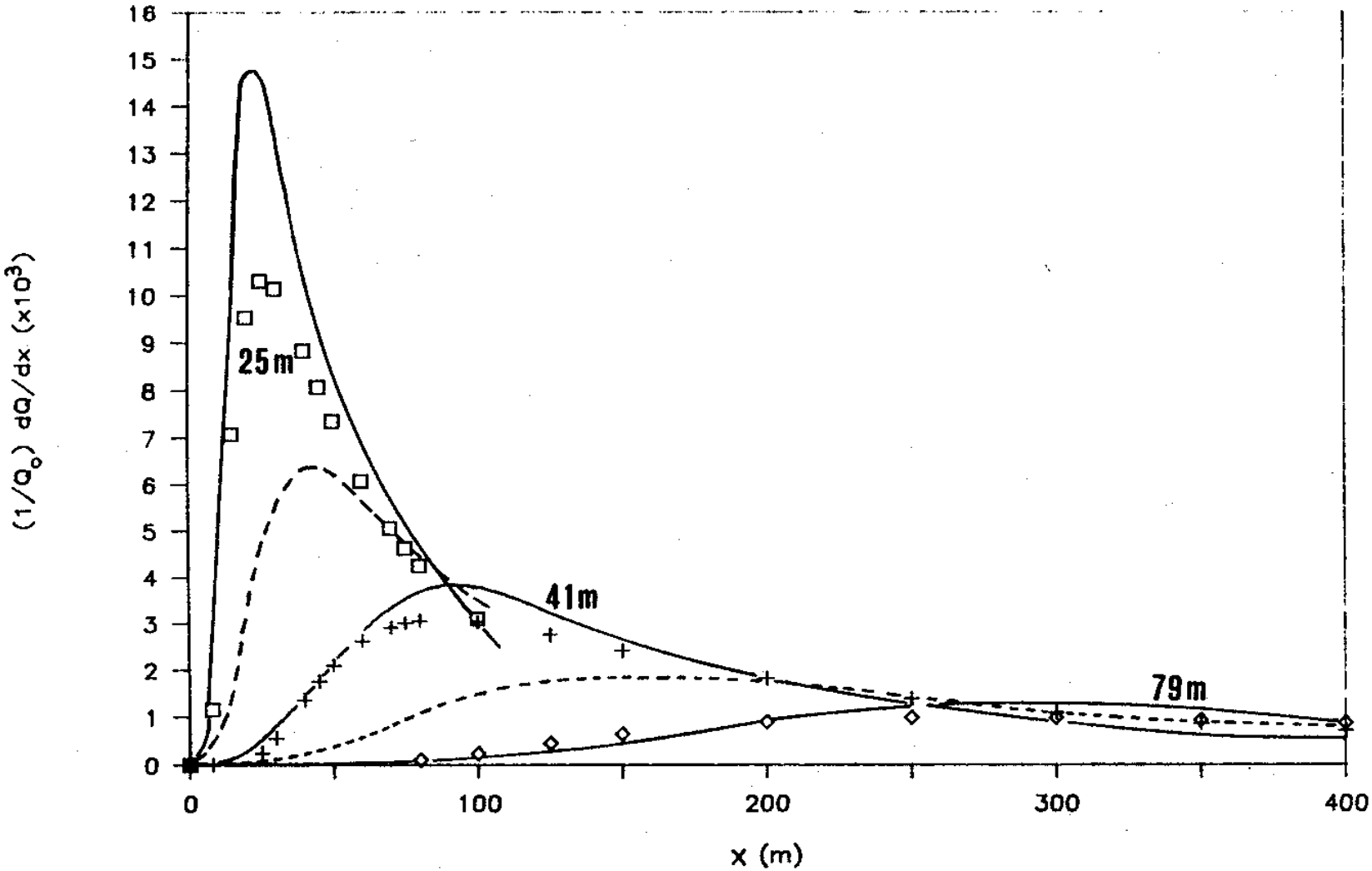


Fig. 4. Footprint predictions from Equation (9), with $U/u_* = 0.4u(z)/u_*$ (symbols), and numerical predictions (lines) for observation heights of 21, 41 and 79 m above a forest canopy, with $d = 12$ m and $z_0 = 2.6$ m. Dashed and dotted lines give results for U/u_* based on Equation (6) for 25 and 41 m, respectively.

Source: Schuepp et al (1989)