



Odor landscapes in turbulent environments

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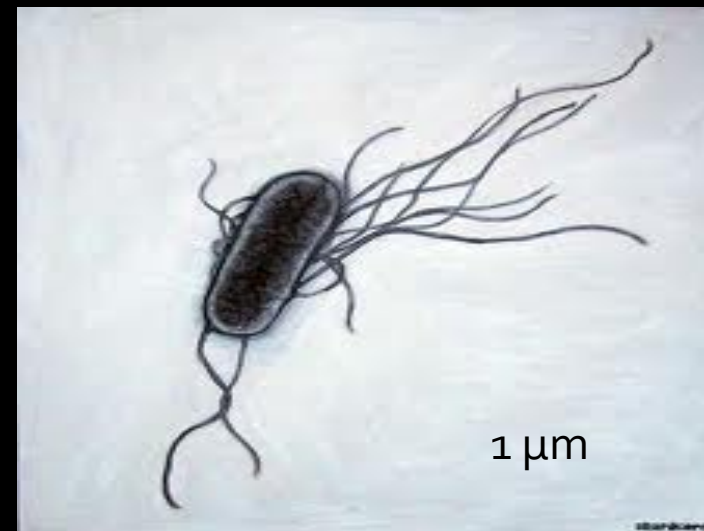
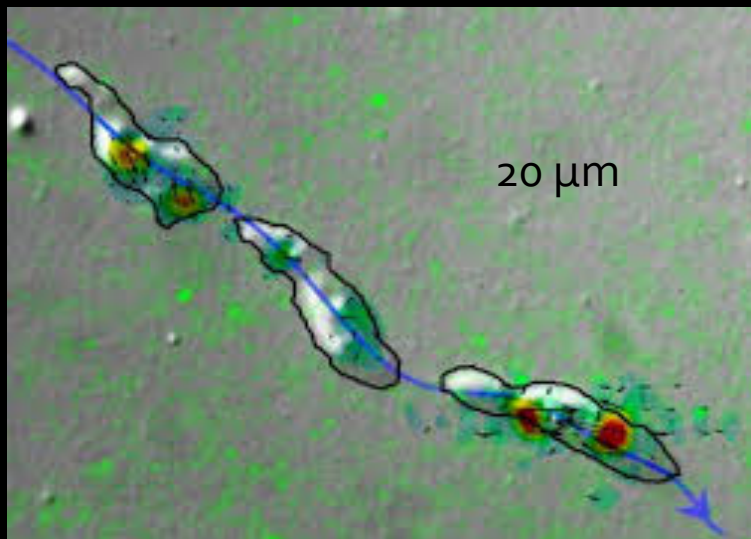
Phys Rev X (2014)

Senses



Allegory of the five senses
Pietro Paolini (1603-1681)

Chemical sensing

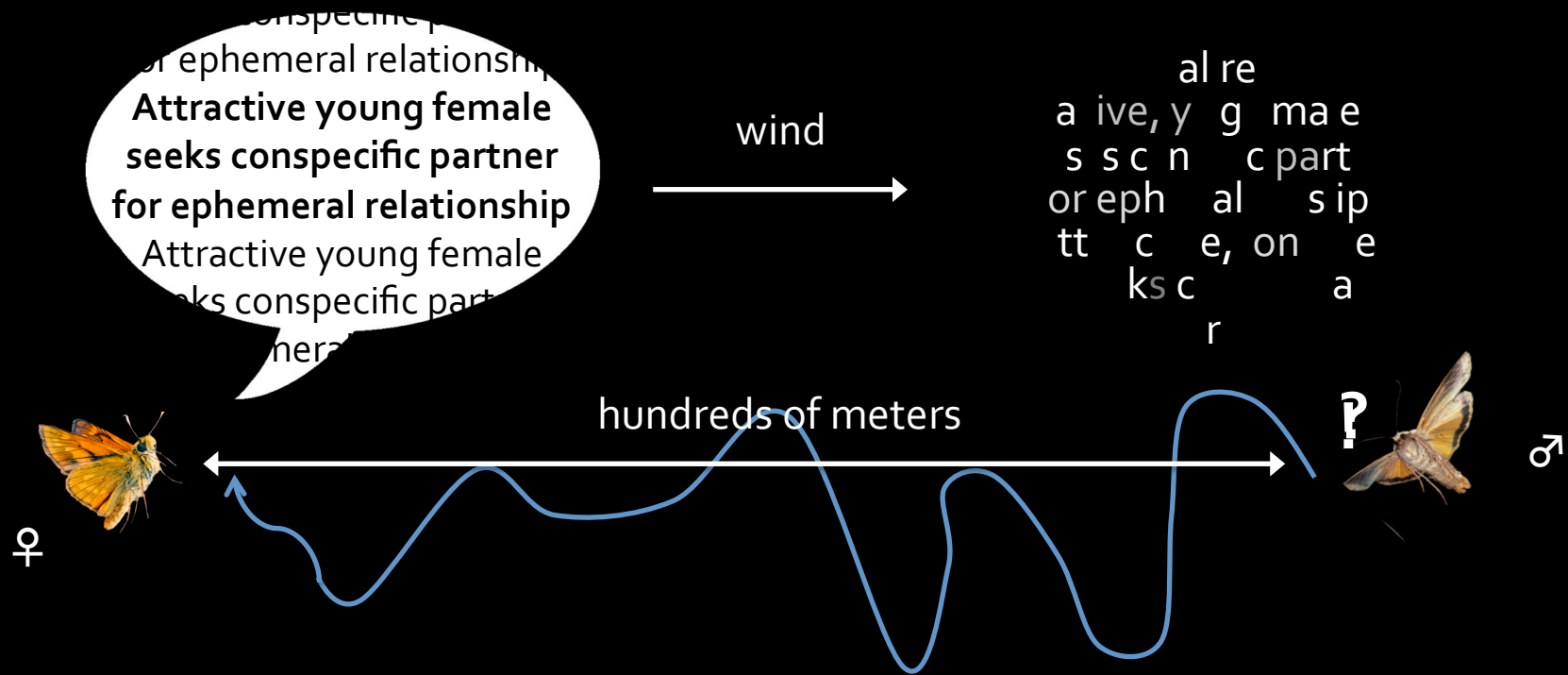


Pheromones: a tale of sex and death



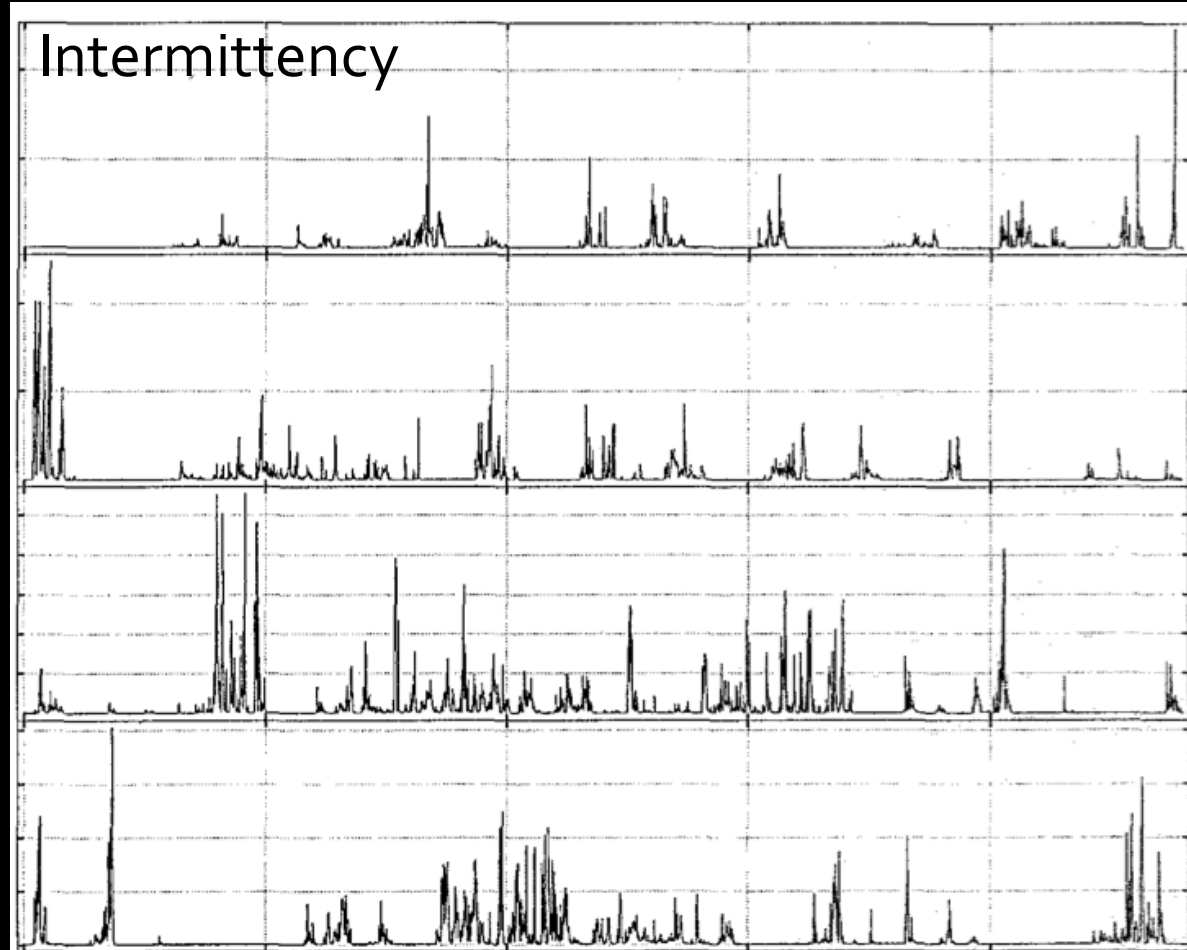
Actias selene

Beauty is in the nose of the sniffer



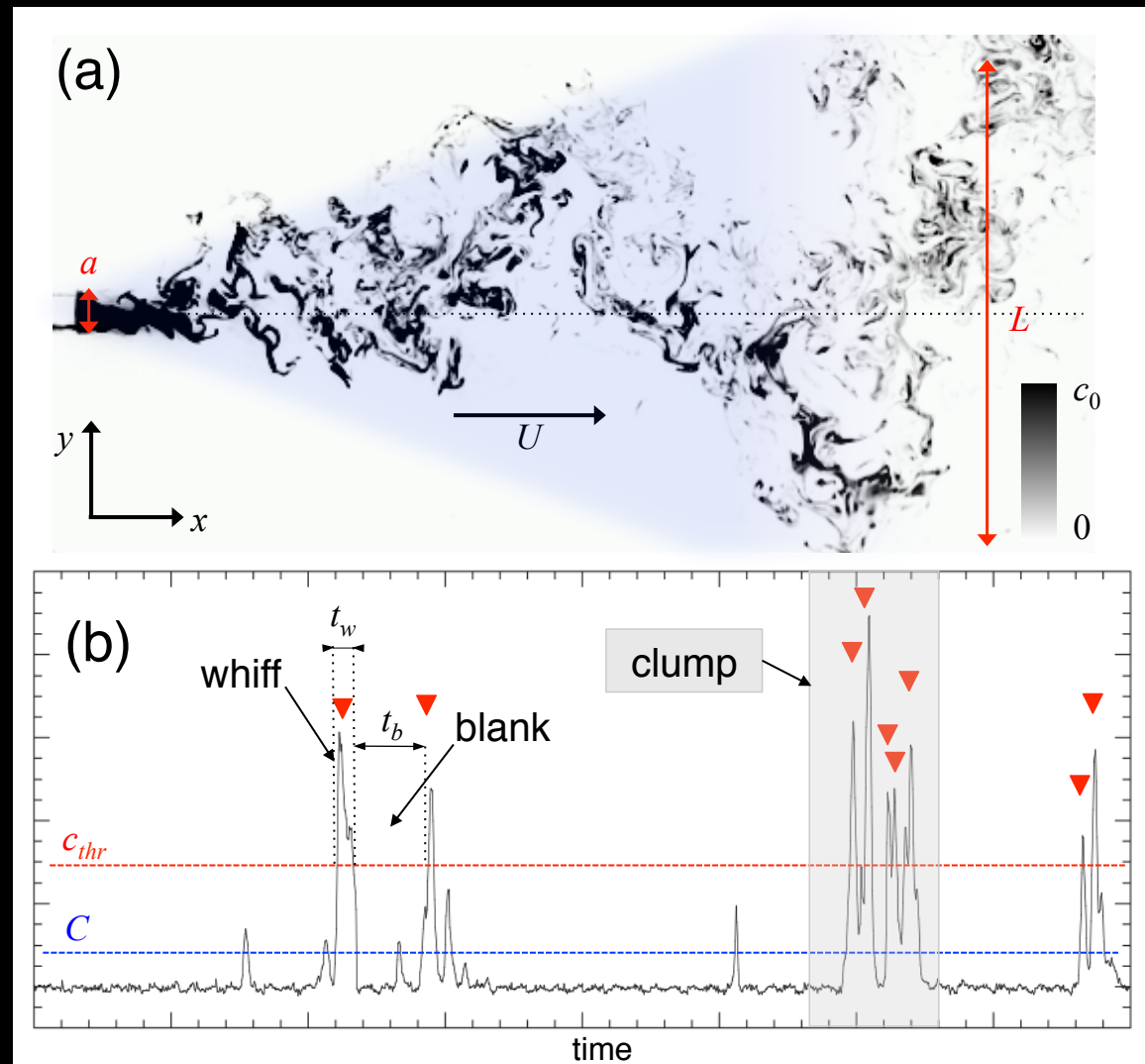
The olfactory landscape:
intensity, quality and structure of the signal

The structure: blanks and whiffs

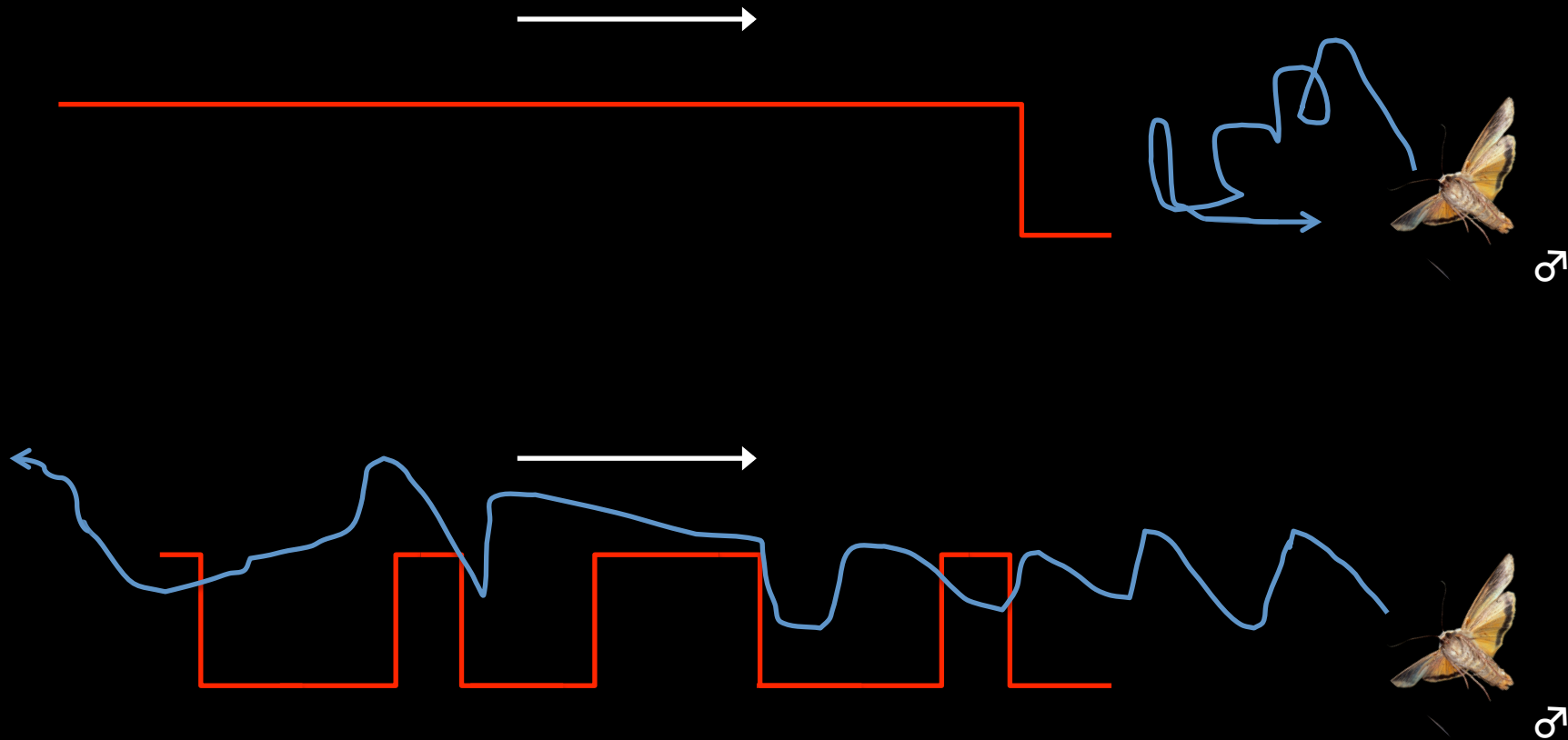


Durations from few ms to several minutes

How many whiffs can a moth catch?

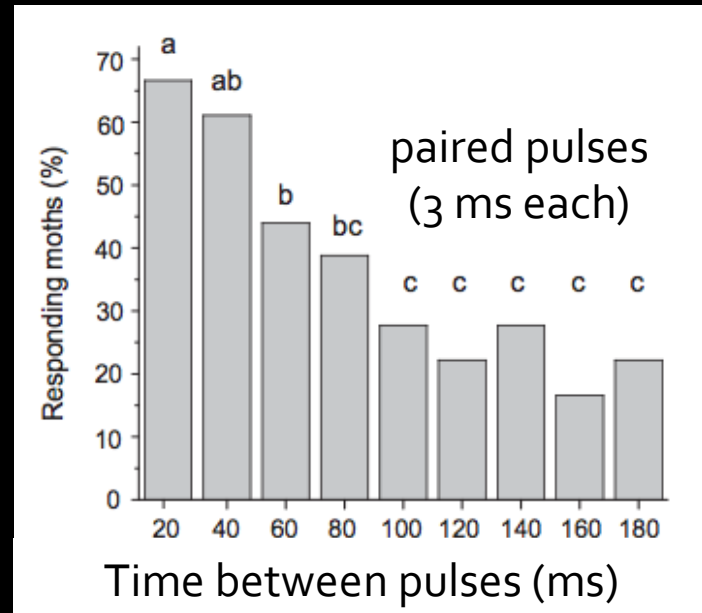
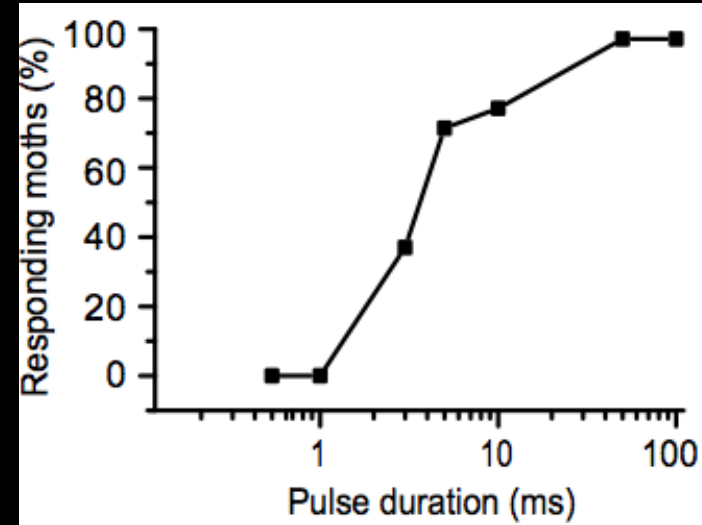
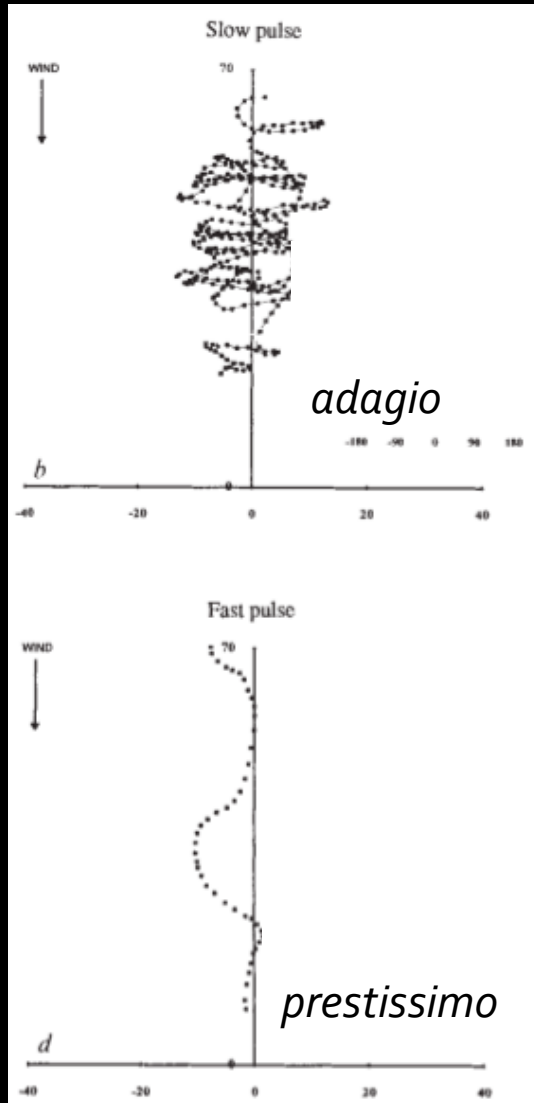


The medium is the message



The *tempo* of odor signaling

Mafra-Neto & Cardé, Nature 1994

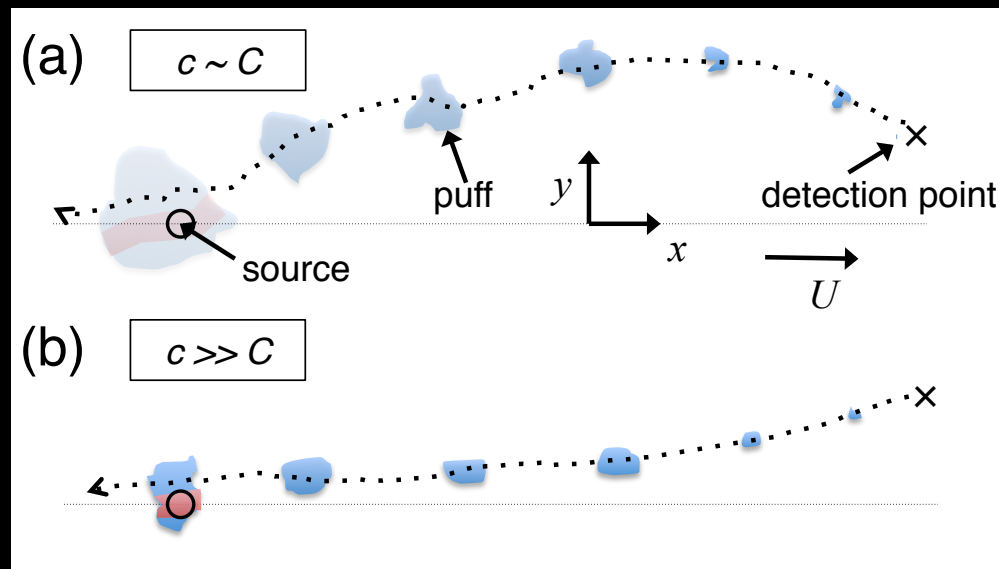


Kanzaki's group, PNAS 2013

From fields to particles: the Lagrangian approach

$$\frac{\partial c}{\partial t} + \mathbf{v} \cdot \nabla c = \kappa \nabla^2 c + J h_a(\mathbf{x})$$

$$c(\mathbf{x}, t) = J \int_{-\infty}^t dt' \int d\mathbf{x}' h_a(\mathbf{x}') p(\mathbf{x}, t | \mathbf{x}', t')$$



Do the math

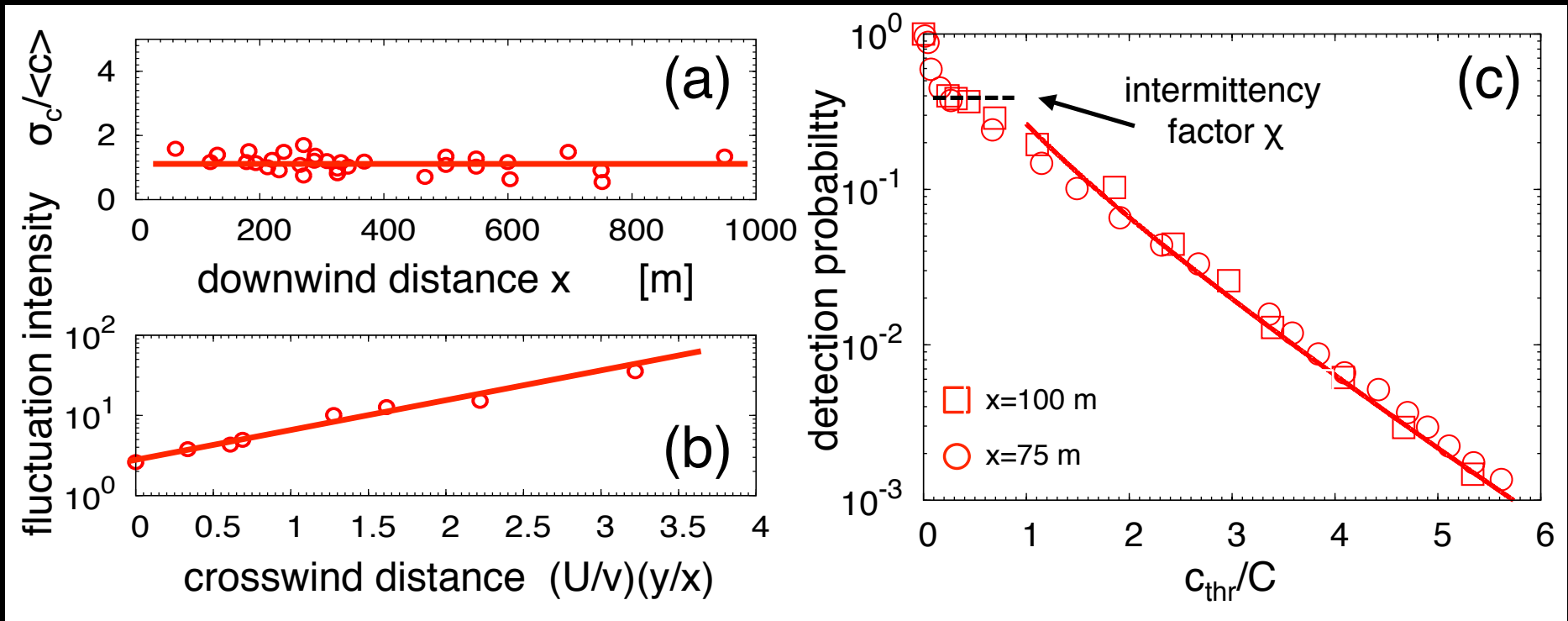
$$\chi = \text{Prob}(c > 0) \sim \left(\frac{k' x^{1-\gamma}}{U} \right)^{(3-\alpha)/\gamma} f \left(\frac{U y^\alpha}{kx} \right)$$
$$C = \langle c | c > 0 \rangle \sim \frac{J}{k} \left(\frac{k' x}{U} \right)^{-(3-\alpha)/\gamma}$$

$$p_c(c) \sim \frac{\chi}{C} \left(\frac{c}{C} \right)^{-2 + \frac{\beta\gamma}{(3-\alpha)}} \exp \left[- \left(\frac{c}{C} \right)^{\frac{\beta\gamma}{(3-\alpha)}} \right]$$

$$p_w(t_w) \sim \tau^{-1} (t_w/\tau)^{-3/2} \exp \left[- (t_w/T_w)^\beta \right]$$

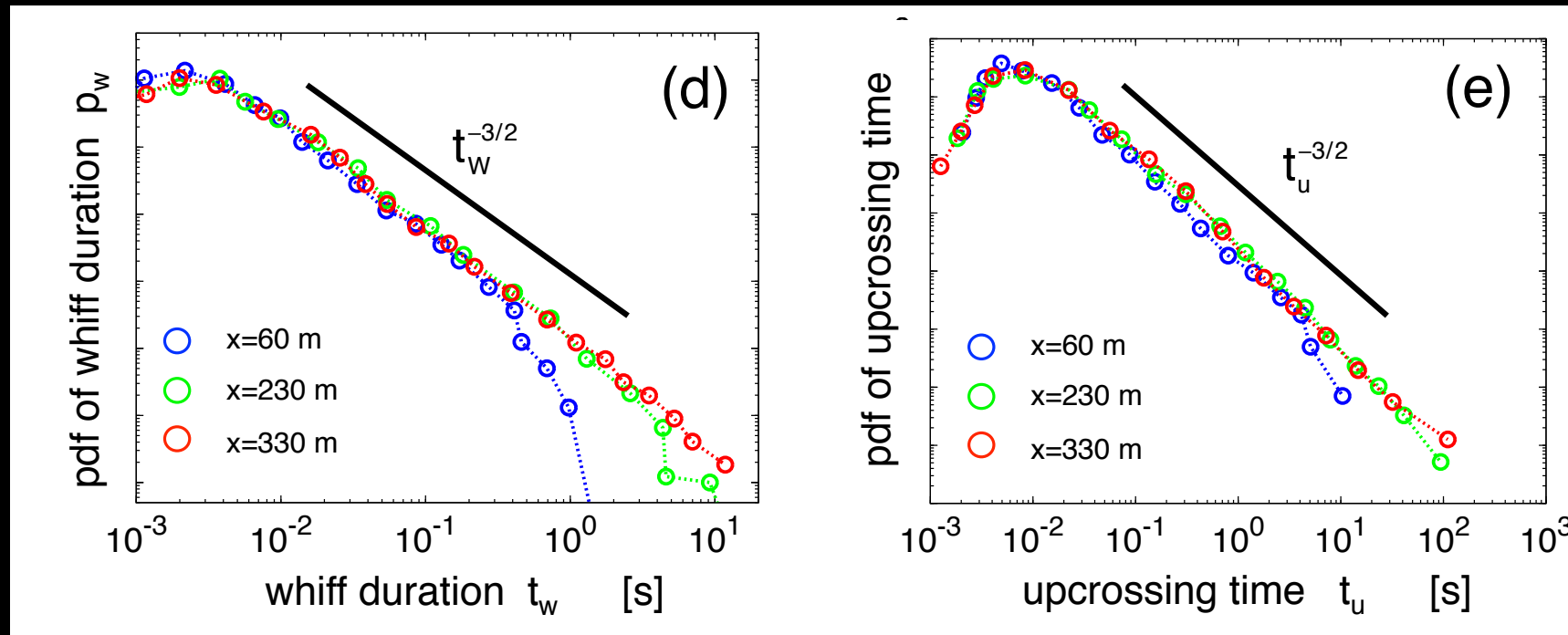
$$p_b(t_b) \sim \tau^{-1} (t_b/\tau)^{-3/2} g_b(t_b)$$

Atmospheric surface layer



Data from Mylne & Mason QJR Met Soc 1991, Yee et al BLM 1993, 1995, 1998

How many whiffs can a moth catch?



Data: Mylne & Mason QJR Met Soc 1991, Yee et al BLM 1993, 1995, 1998

The olfactory landscape

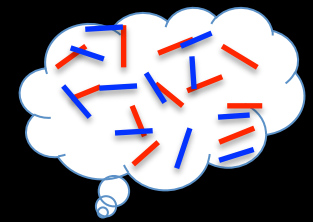
- attraction range $\approx a(U/v)(c_{\text{thr}}/c_0)^{-1/2} \approx 1000 \text{ m}$
- shortest whiff $\approx (a/v)(c_{\text{thr}}/c_0)^{1/2} \approx 1 \text{ ms}$
- longest whiffs \approx clumps $\approx (a/v)(c_{\text{thr}}/c_0)^{-1/2} \approx 1000 \text{ s}$
- blanks \approx whiffs [within the cone $y/x < v/U$]
- blanks \gg whiffs [outside the cone]

Genuine blends only, please

O. nubilalis E

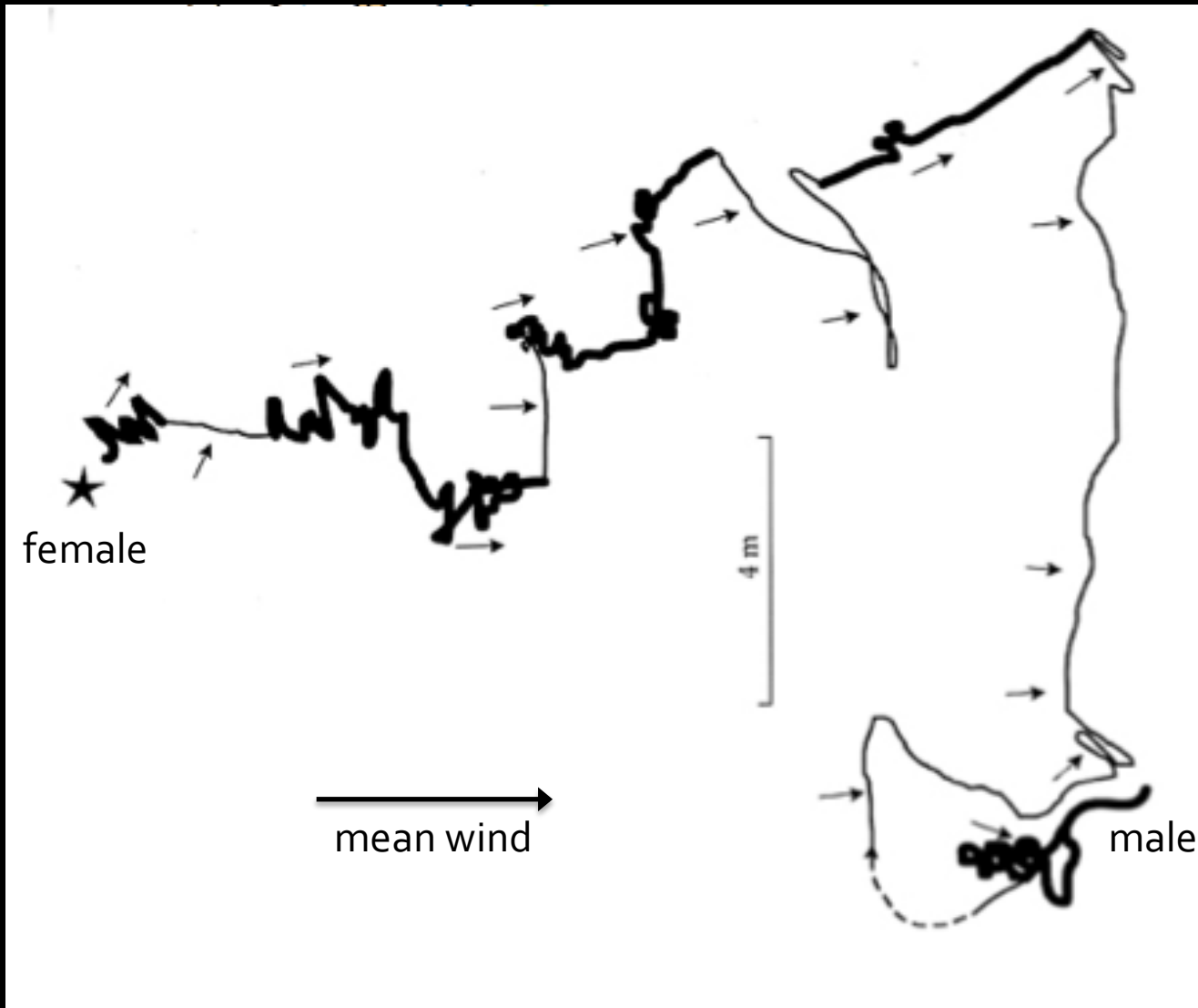


O. nubilalis Z



$$c_{thr} > c_o (a/d)^2$$

Olfactory search



David, Kennedy, Ludlow, Nature 1993

Post-doctoral positions available

Quantitative Life Sciences at ICTP (Trieste)

ictp.it/research/qls.aspx > Opportunities