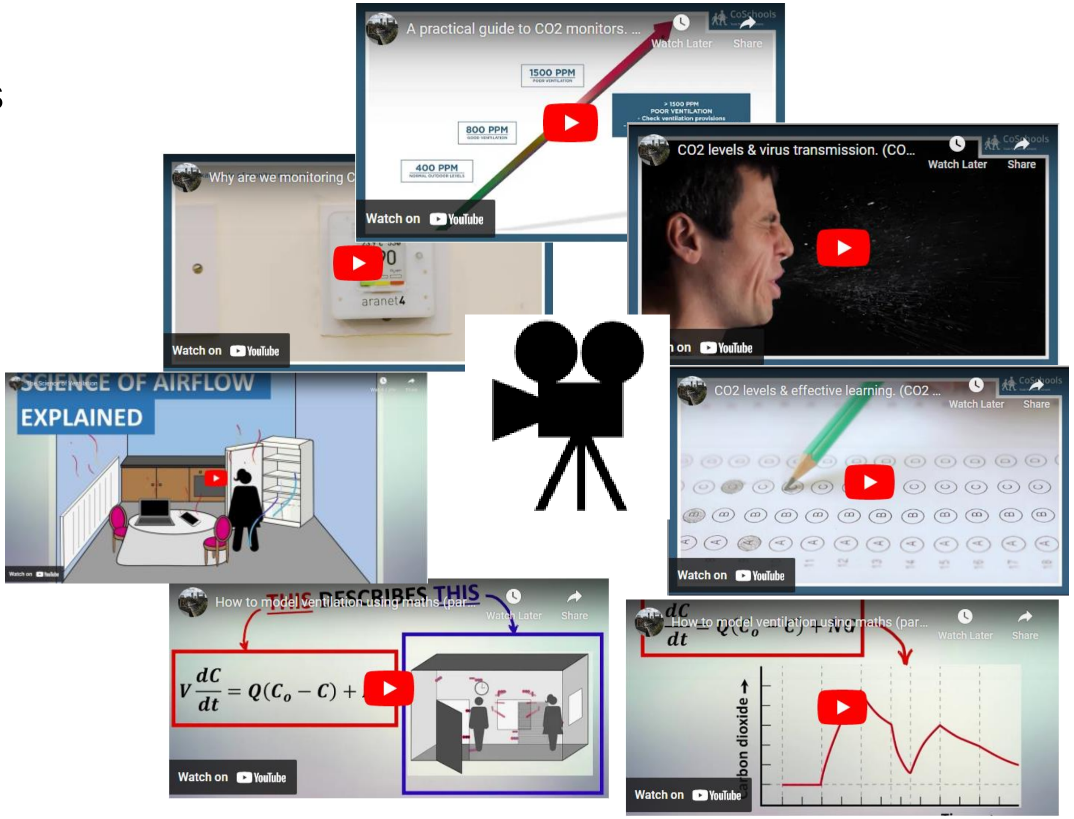
Work Package 1.2

CO-TRACE
Healthy schools through air-quality science

Output summary

- Journal:
    1. (*in preparation*) "Displacement ventilation: effects of the position of buoyancy sources and ventilation openings"
    2. (*in preparation*) "Inferring Ventilation from CO_2 Measurements in Schools"

- Conference:
    1. The effect of outlet height in displacement ventilated rooms. *The 9th International Symposium on Stratified Flows (ISSF),* 31st Aug 2022, University of Cambridge, UK.
    2. Targeted extraction of exhaled breath to reduce potential virus exposure . *UK Fluids Conference*, 6-8th September 2022, University of Sheffield, UK.



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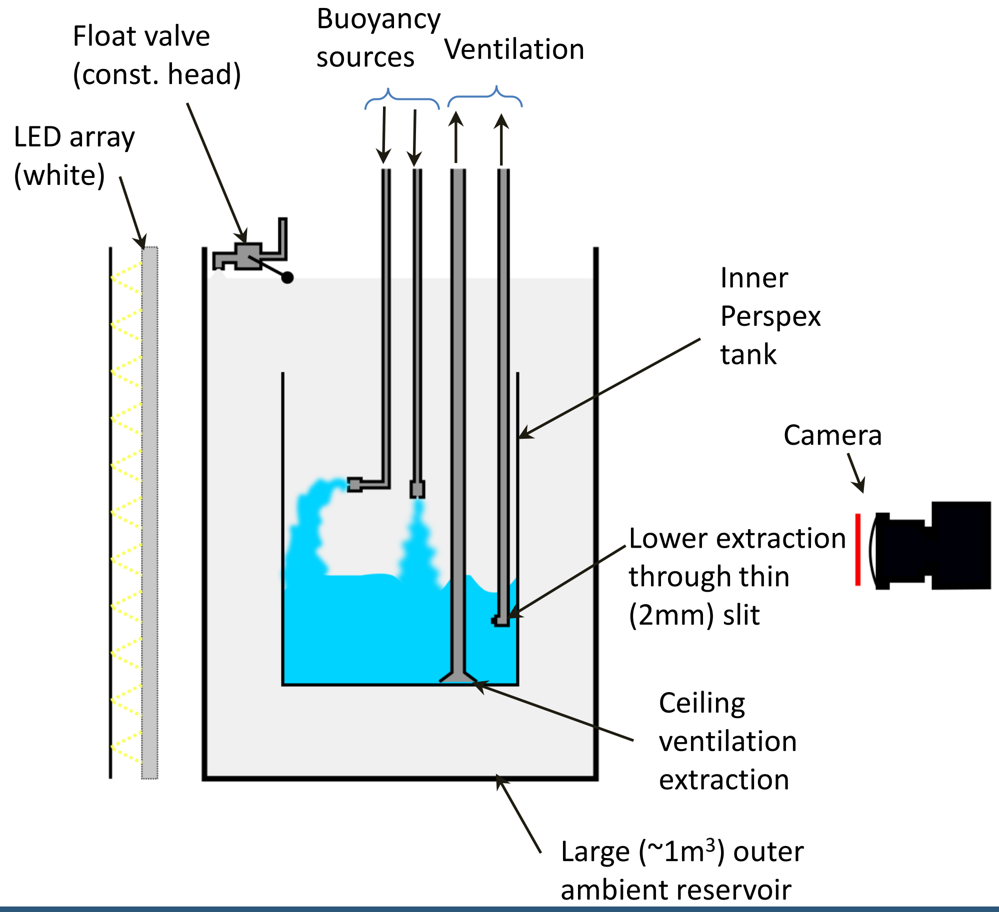
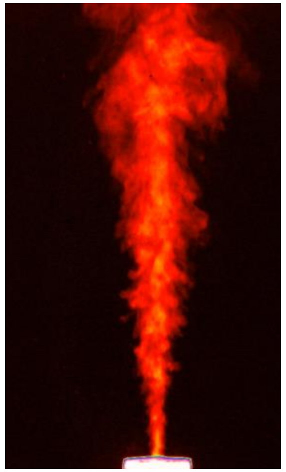
Displacement ventilation: effects of the position of buoyancy sources and ventilation openings

Experiment Setup



Buoyancy sources



Turbulent plume

Steady buoyant jet

Intermittent buoyant jet

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Displacement ventilation: effects of the position of buoyancy sources and ventilation openings (cont.)

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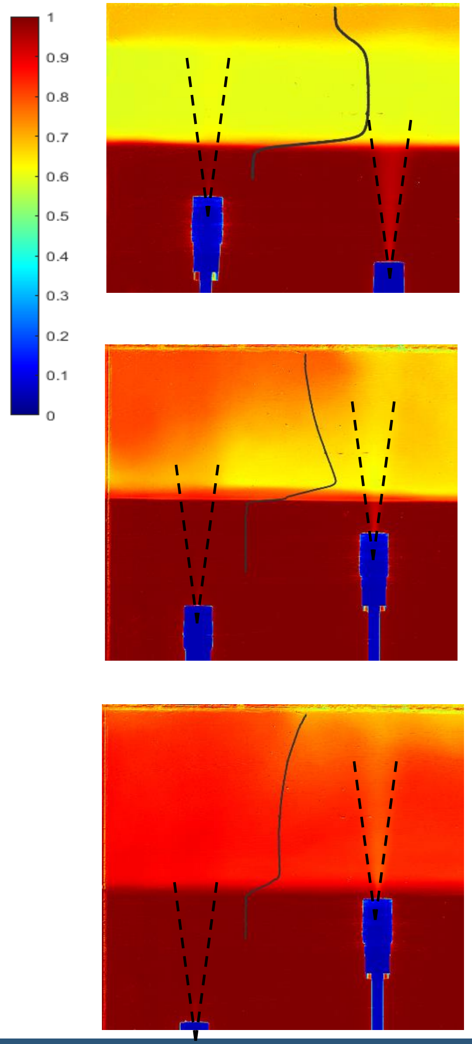


Weaker plume on r.h.s contains dye. Plume strength ratio 3.5:1.

Mode 1: intermediate layer has greatest dye concentration – classic “lock up layer”

Transitional regime: Layers are mostly mixed with very blurred boundaries. Some horizontal features.

Mode 2: Concentration gradient reverses as dye increases in concentration at the ceiling

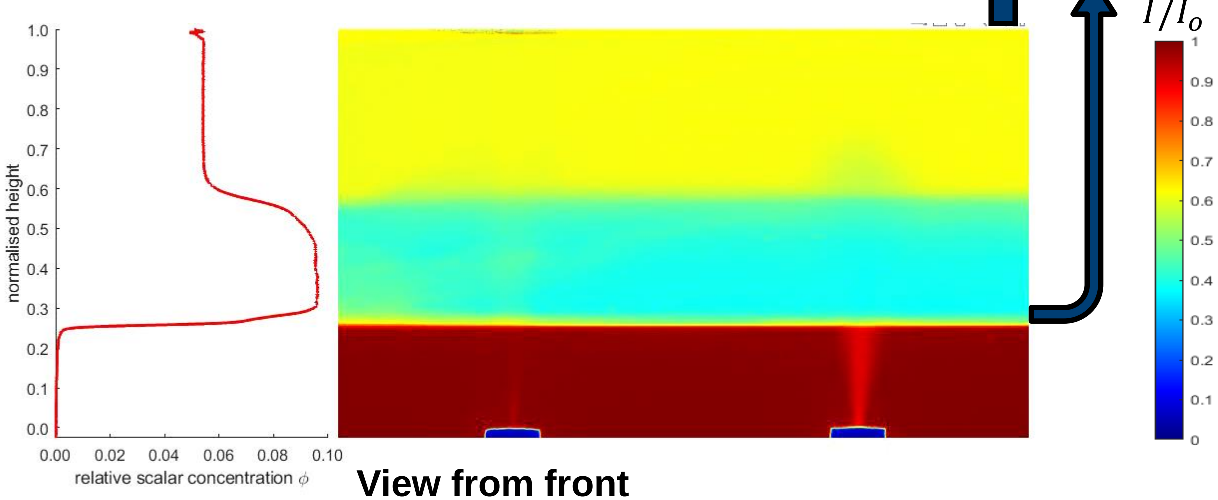
—— Instantaneous distribution
Steady distributions:

- $Q_r = 1$
- $Q_r = 0.75$
- $Q_r = 0.5$
- $Q_r = 0.25$
- $Q_r = 0$

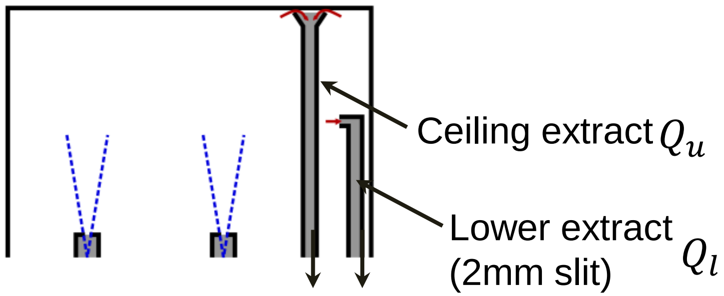
Lower ventilation fraction: $Q_r = \frac{Q_l}{Q_u+Q_l}$

$Q_{vent} = Q_u + Q_l = 38$ cm^3 s^{-1}

Q_u Q_l



View from front



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Inferring Ventilation from CO2 Measurements in Schools

CO-TRACE

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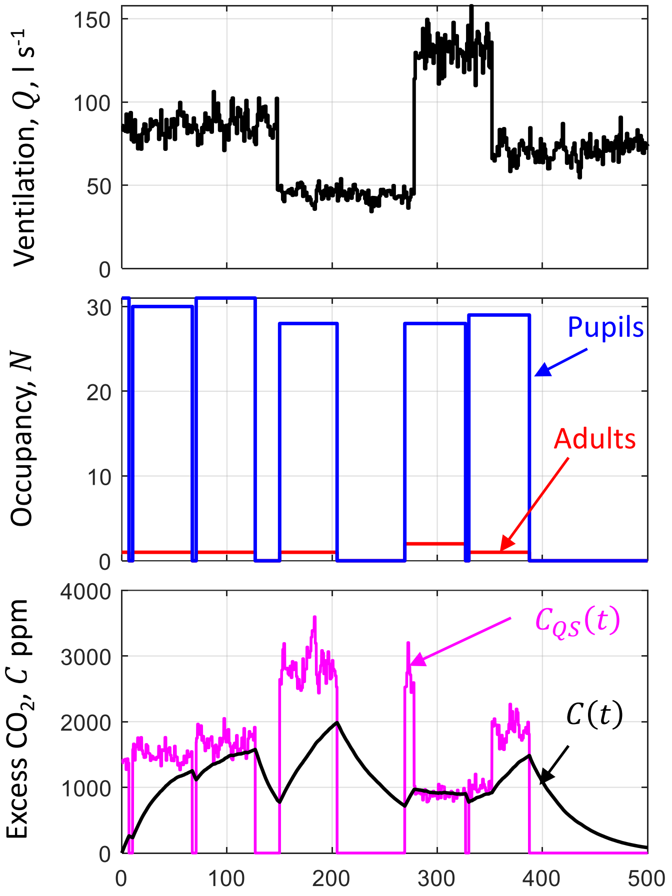
One example of the well-mixed simulation for one random school day



Random inputs

$$V\frac{dC(t)}{dt} = -Q(t)C(t) + S(t)$$

output

$V = 167\ m^3$

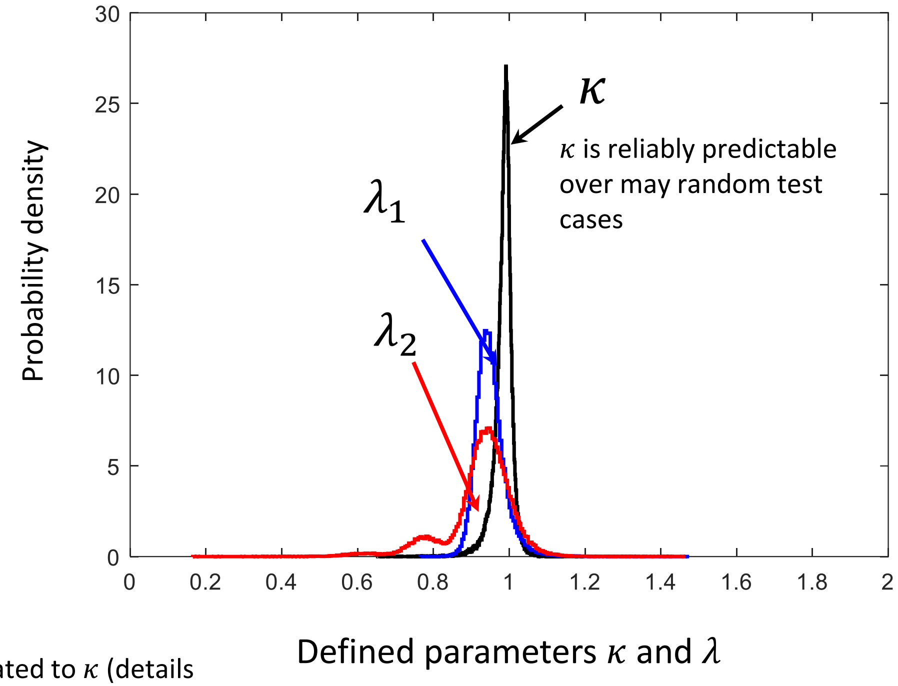
$N_{p,base} = 31$

$Q_{base} = 90\,\mathrm{l\,s^{-1}}$

$$\kappa = \frac{\int_0^T C(t)\,dt}{\int_0^T C_{QS}(t)\,dt}$$

$\kappa = 0.9950$

Results of 10^5 random school days (random classroom size, timetable, occupancy profile, generation rate profile, ventilation profile)



λ is closely related to κ (details not given here)

$$\bar{Q}_{pp} = \lambda\frac{\int_0^T \bar{G}_p(t)\,dt}{\int_0^T C(t)\,dt}$$

λ is also reliably predictable and can be used to quantify average per person ventilation rate $\bar{Q}_{pp}$ from measured CO_2 data $C(t)$

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