

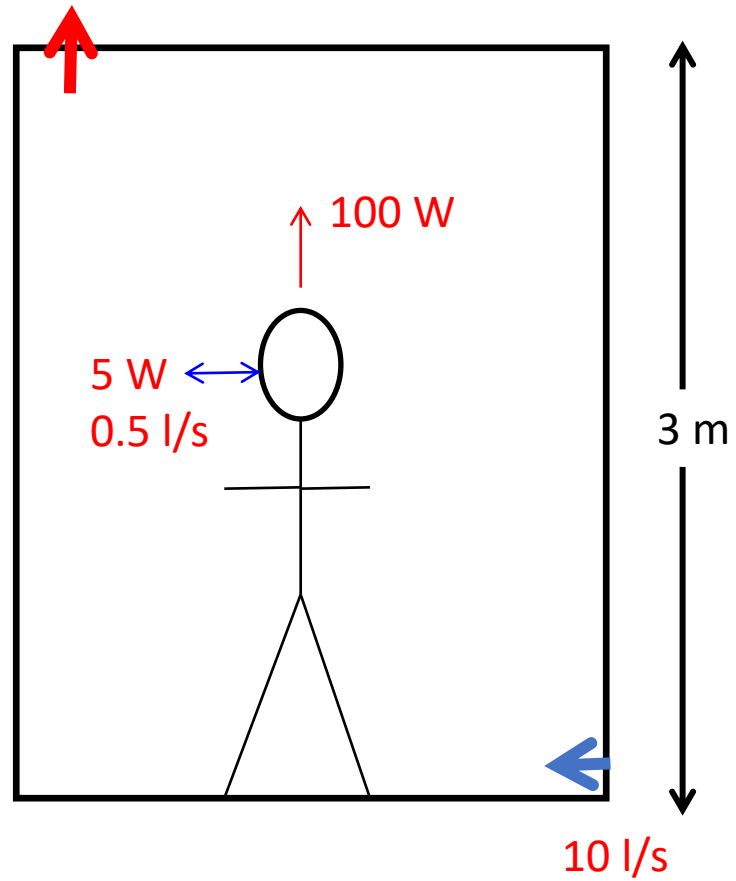
# Built and Indoor Environments

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Some numbers: space 4m x 3m x 3m



# Air change rates

N air changes per hour (ACH)

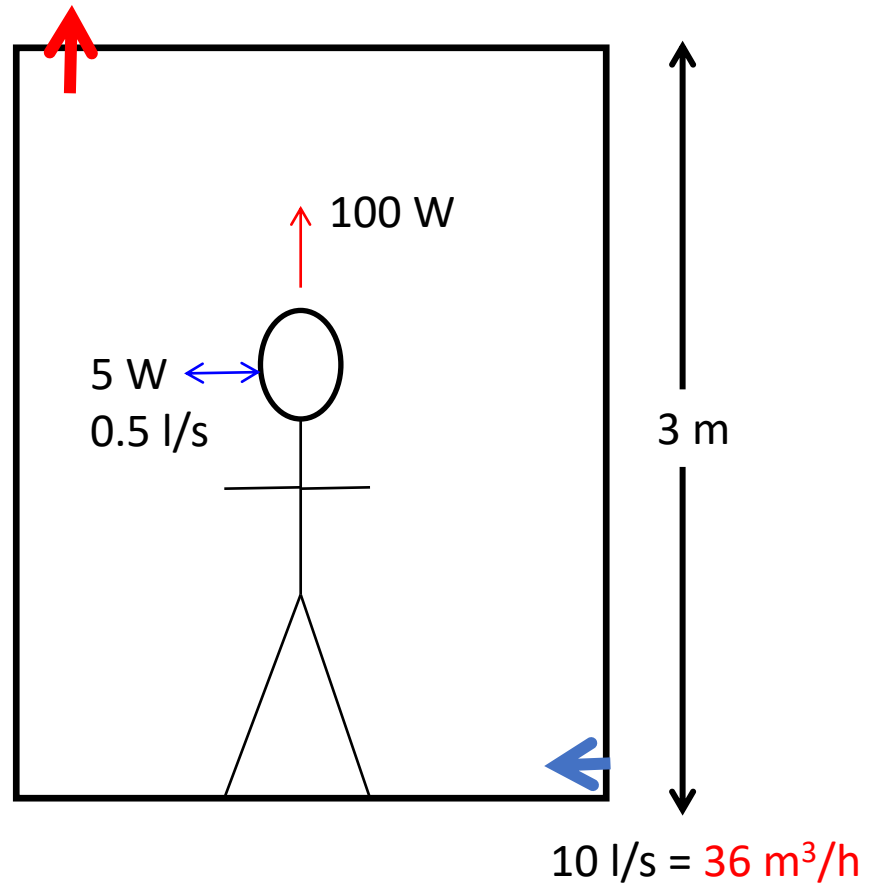
$$10 \text{ l/s} = 1 \text{ ACH}$$

Volume average flow speed

$$V = N \times \text{height of the room}$$

$$= 4 \text{ mm/s for 5 ACH}$$

$$= 8 \text{ mm/s for 10 ACH}$$



# Droplet fall speeds

N air changes per hour (ACH)

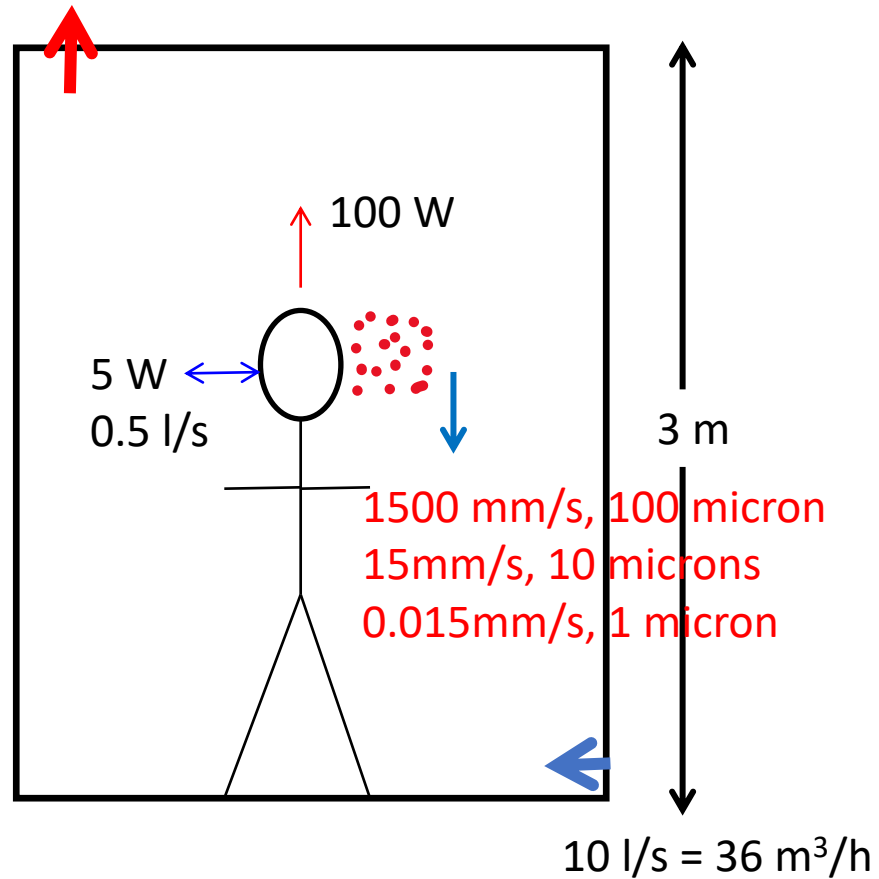
10 l/s = 1 ACH

Volume average flow speed

$V = N \times \text{height of the room}$

= 4 mm/s for 5 ACH

= 8 mm/s for 10 ACH



# Inlet 0.5 m x 0.5 m

N air changes per hour (ACH)

10 l/s = 1 ACH

Volume average flow speed

$V = N \times \text{height of the room}$

= 4 mm/s for 5 ACH

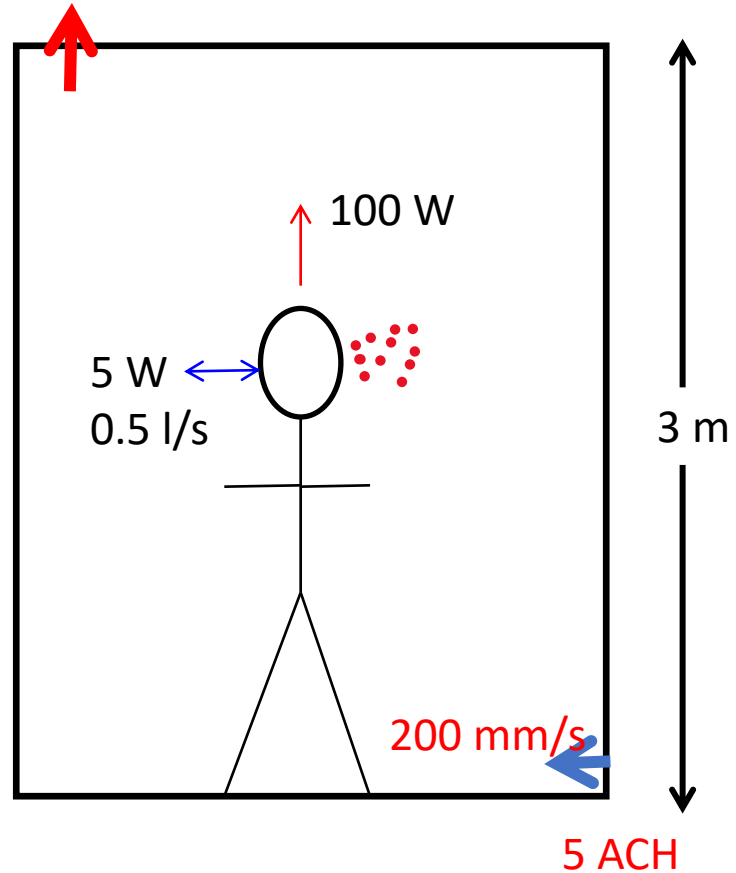
= 8 mm/s for 10 ACH

Droplet fall speeds

1500 mm/s, 100 micron

15 mm/s, 10 microns

0.015 mm/s, 1 micron



# Human plume



Settles et al. 1995 Proc. Intl. Symp. Flow Vis.

N air changes per  
hour (ACH)  
 $10 \text{ l/s} = 1 \text{ ACH}$

Volume average flow speed

$V = N \times \text{height of the room}$

= 4 mm/s for 5 ACH

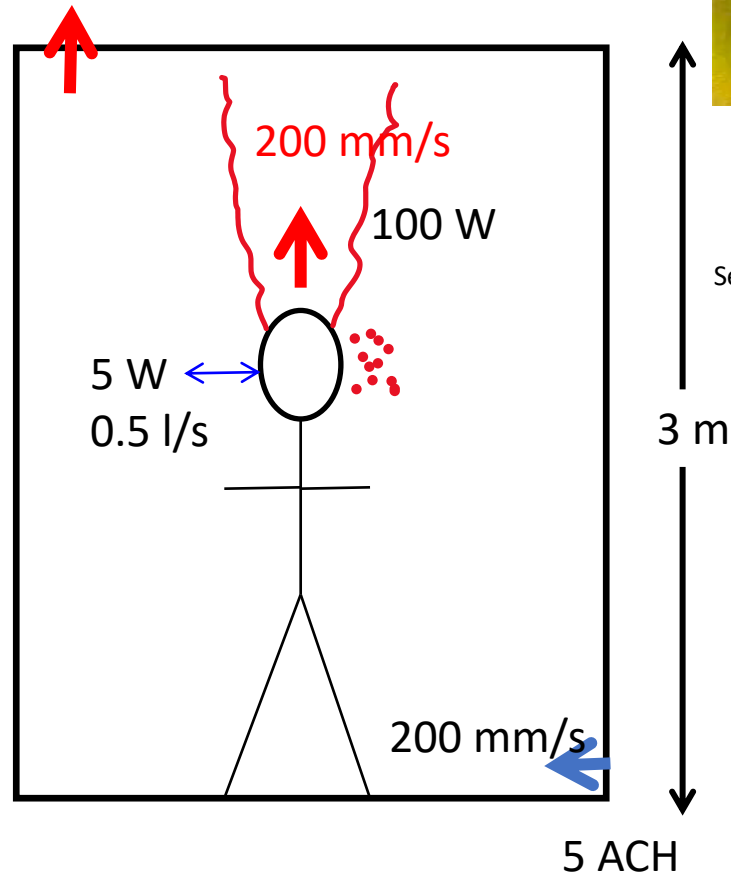
= 8 mm/s for 10 ACH

Droplet fall speeds

1500 mm/s, 100 micron

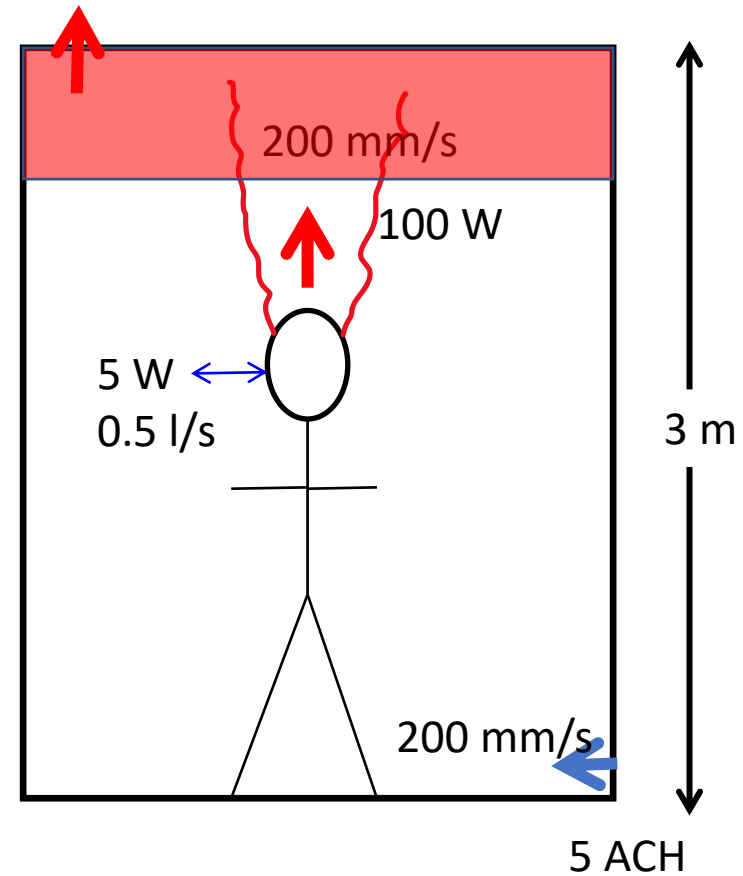
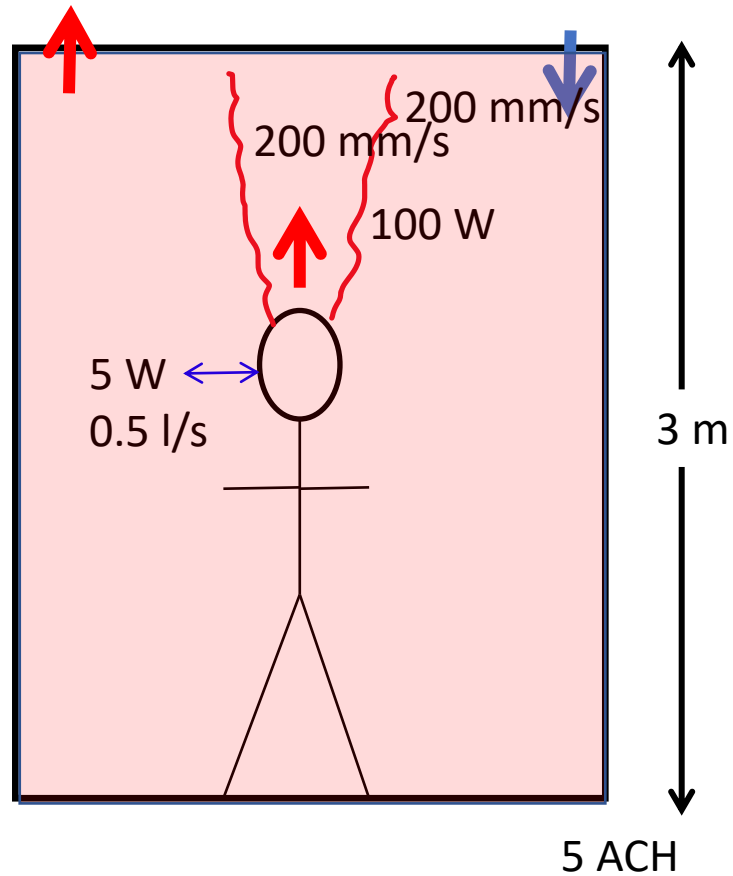
15mm/s, 10 microns

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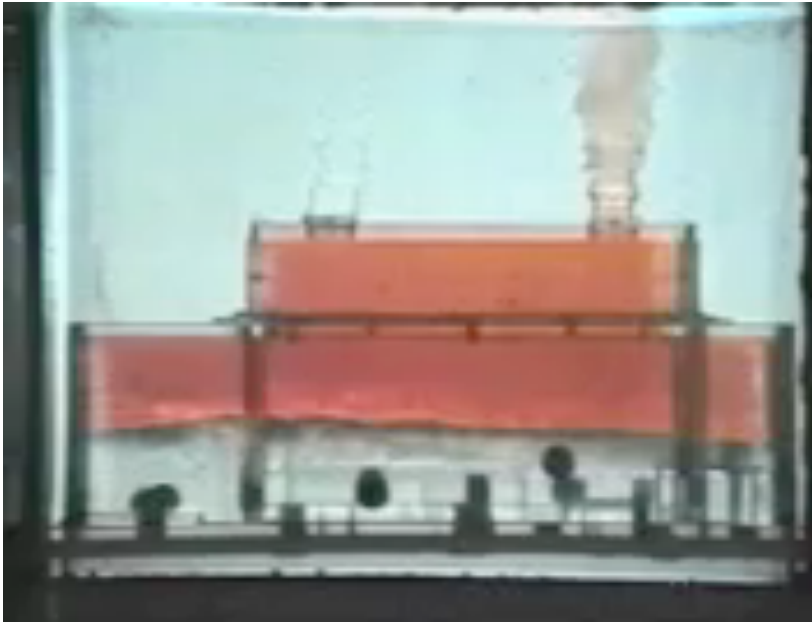
**Individual flow elements much more important than the average flow**

# Mixing vs displacement ventilation



# Vent location

## Boundary conditions



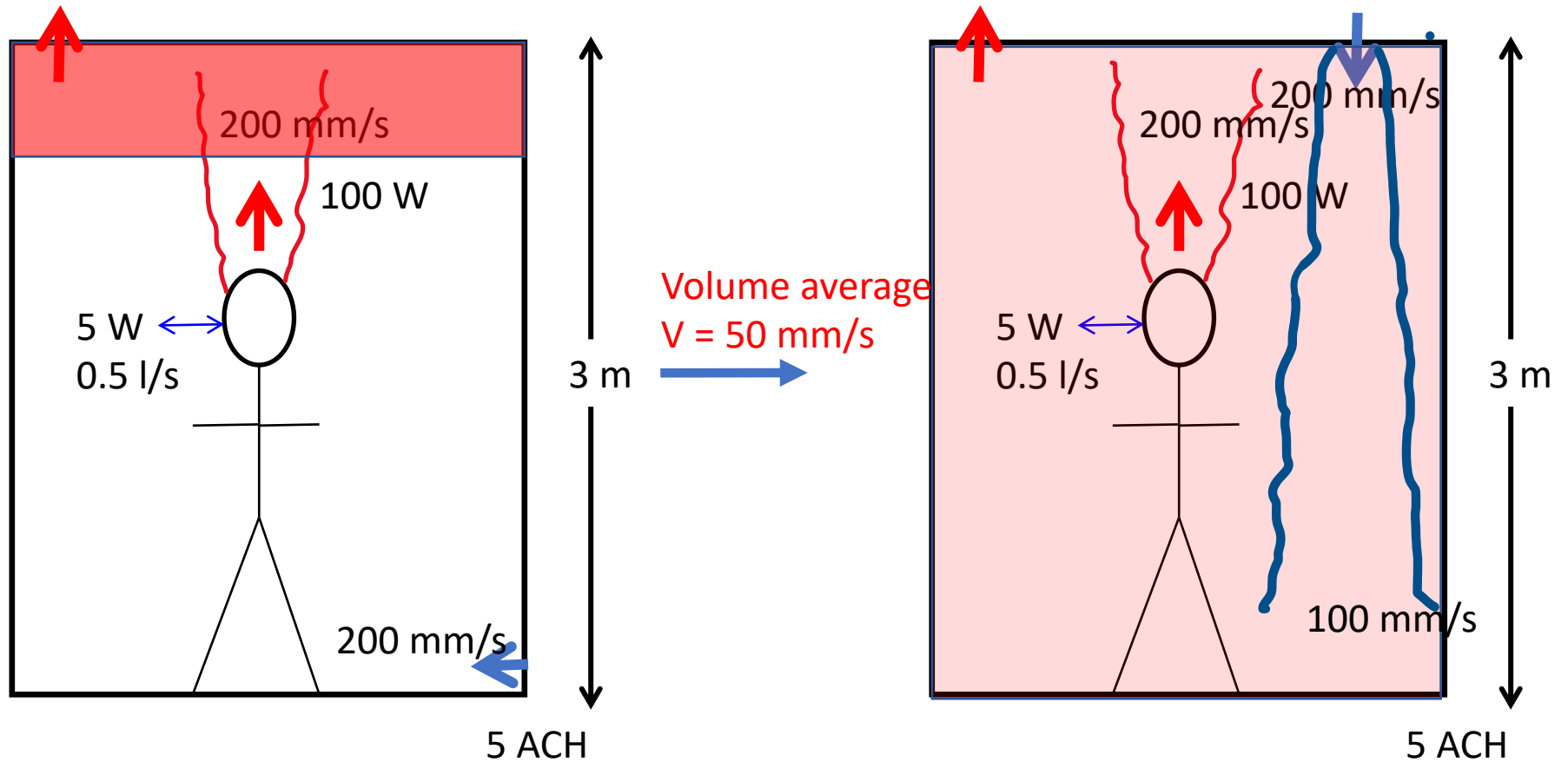
Displacement



Mixing

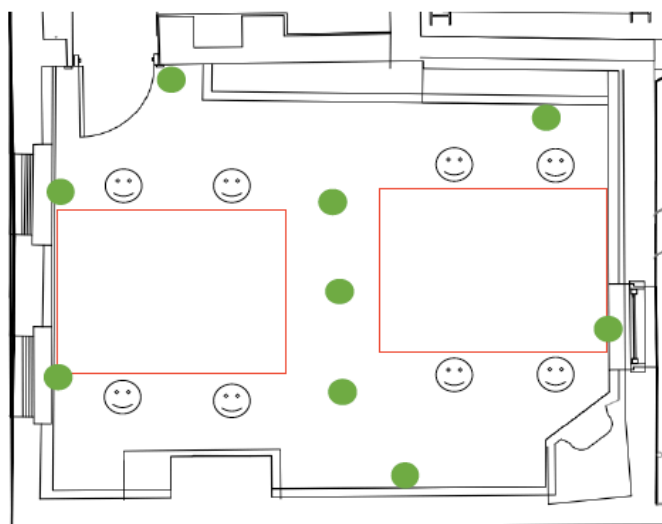


# Can we maintain a mixed environment?



# Case study room

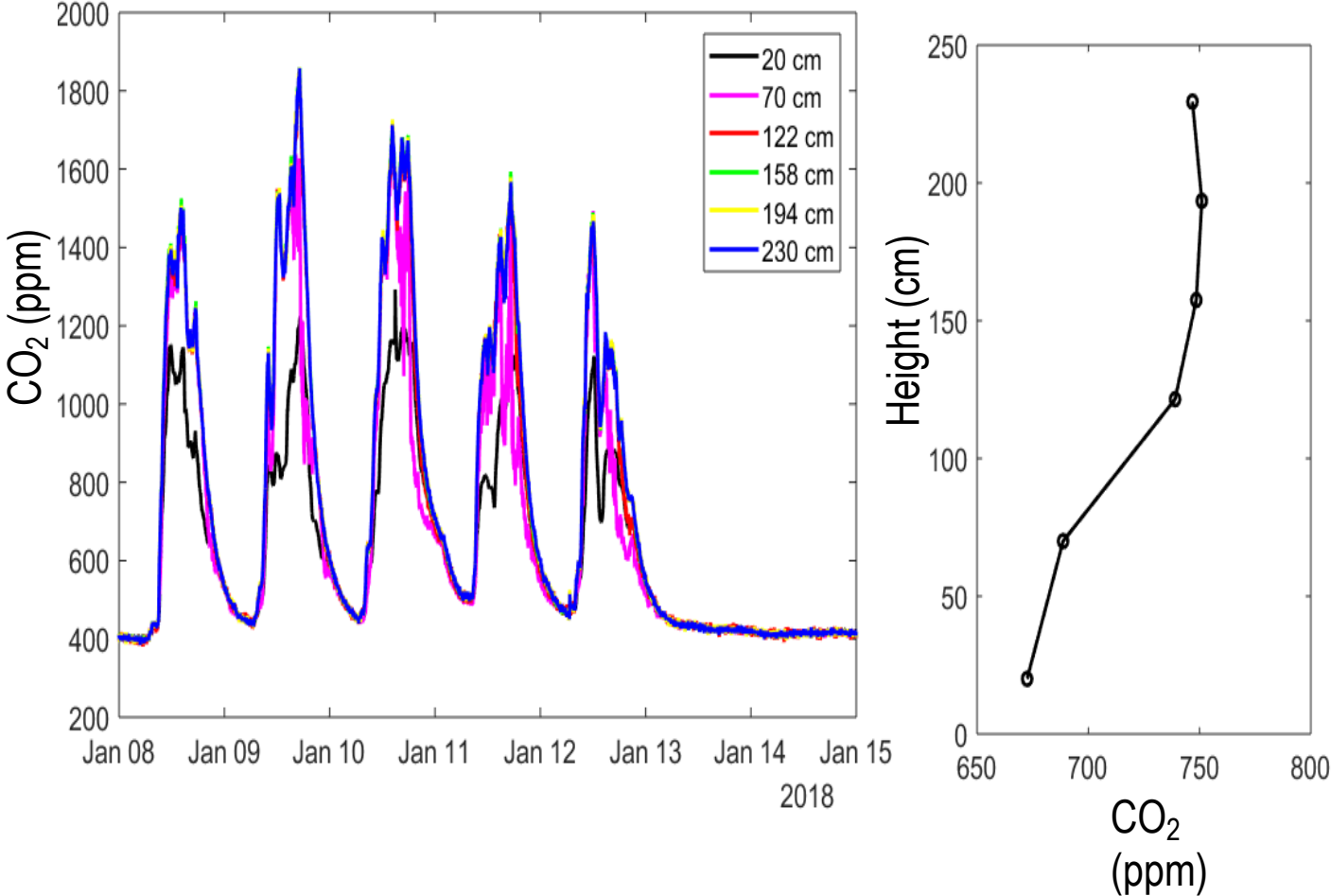
## Sensor Network



Indoor Sensor Network



# Indoor CO<sub>2</sub> Vertical Stratification



Evidence that breath accumulates near the ceiling