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Envisaging a world with greener cities

Effect of temperature on cross-ventilation

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Lab Experiments

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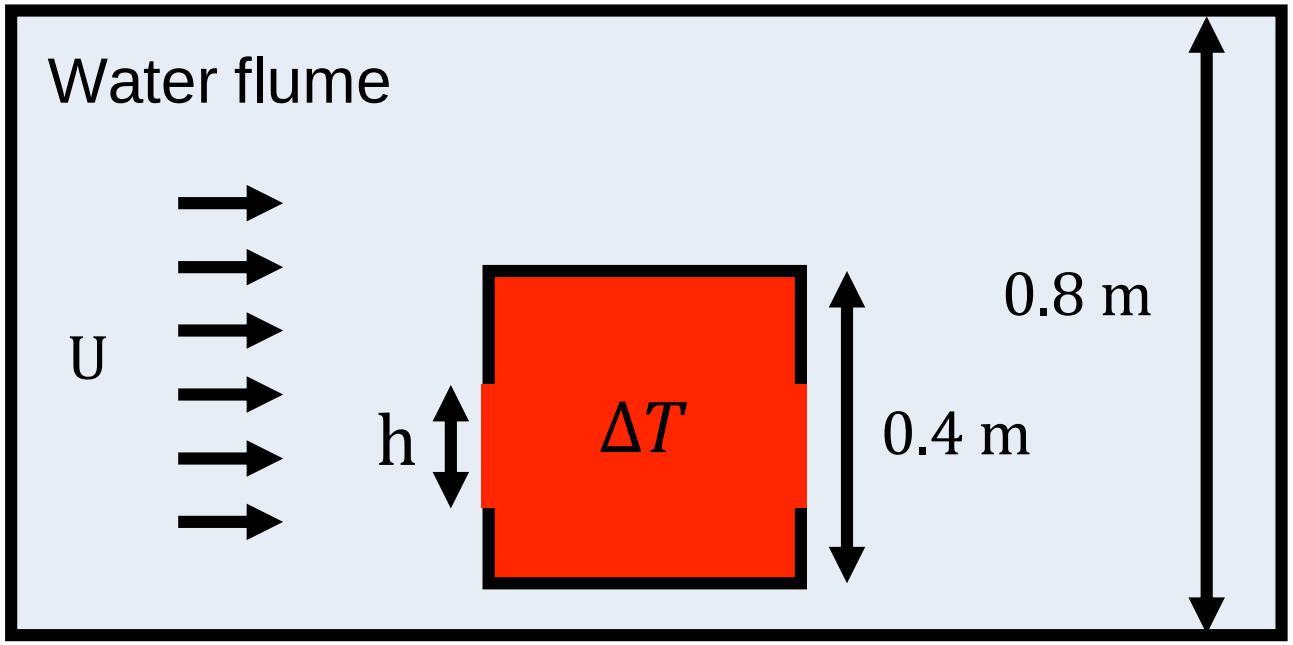

$$Fr = \frac{U}{\sqrt{g'h}}$$

$$g' = \Delta T\ \beta\ g$$

Measure: ventilation rate and temperature profiles

Cross-ventilation

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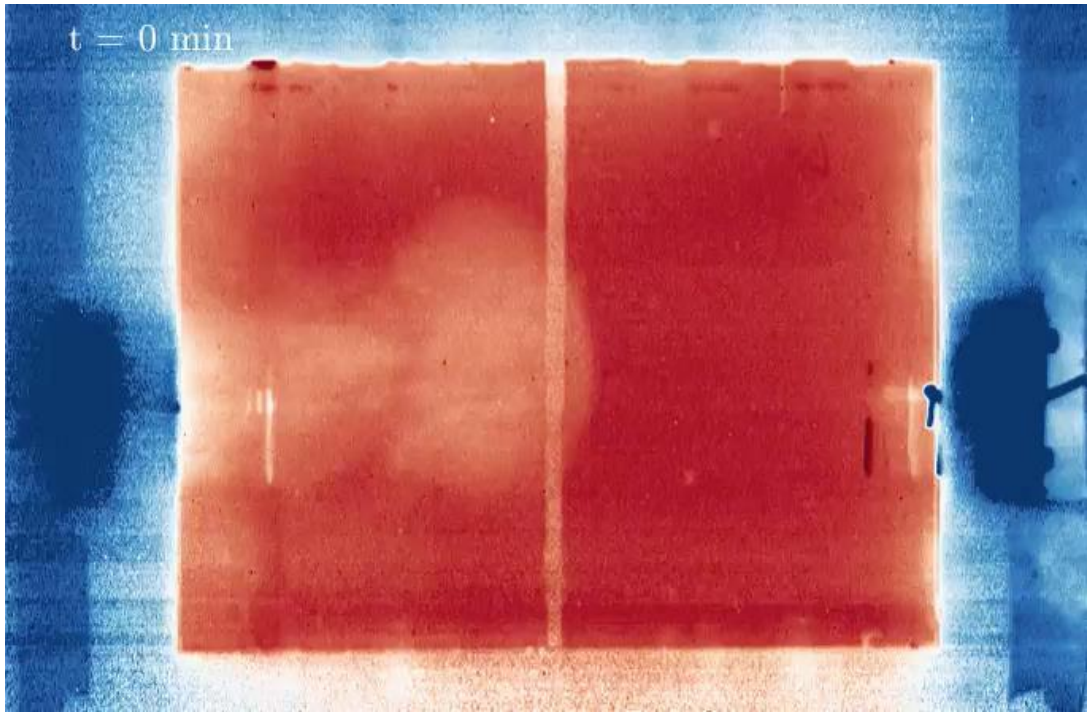
$U = 2.5\ \mathrm{cm/s}$



Cross-ventilation

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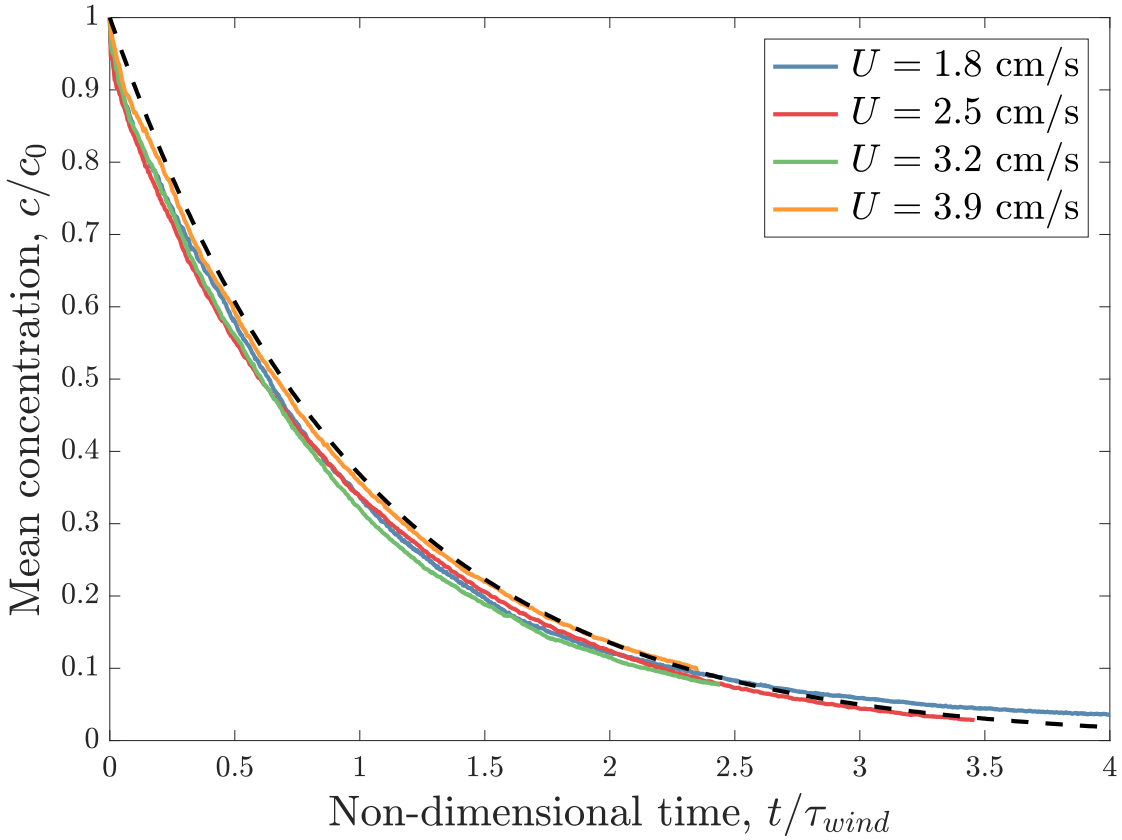

$$\frac{c}{c_0} = e^{-t/\tau}$$

$$\tau_{wind} = \frac{V}{C_d A U}$$

$$C_d = 0.6$$

Exchange ventilation

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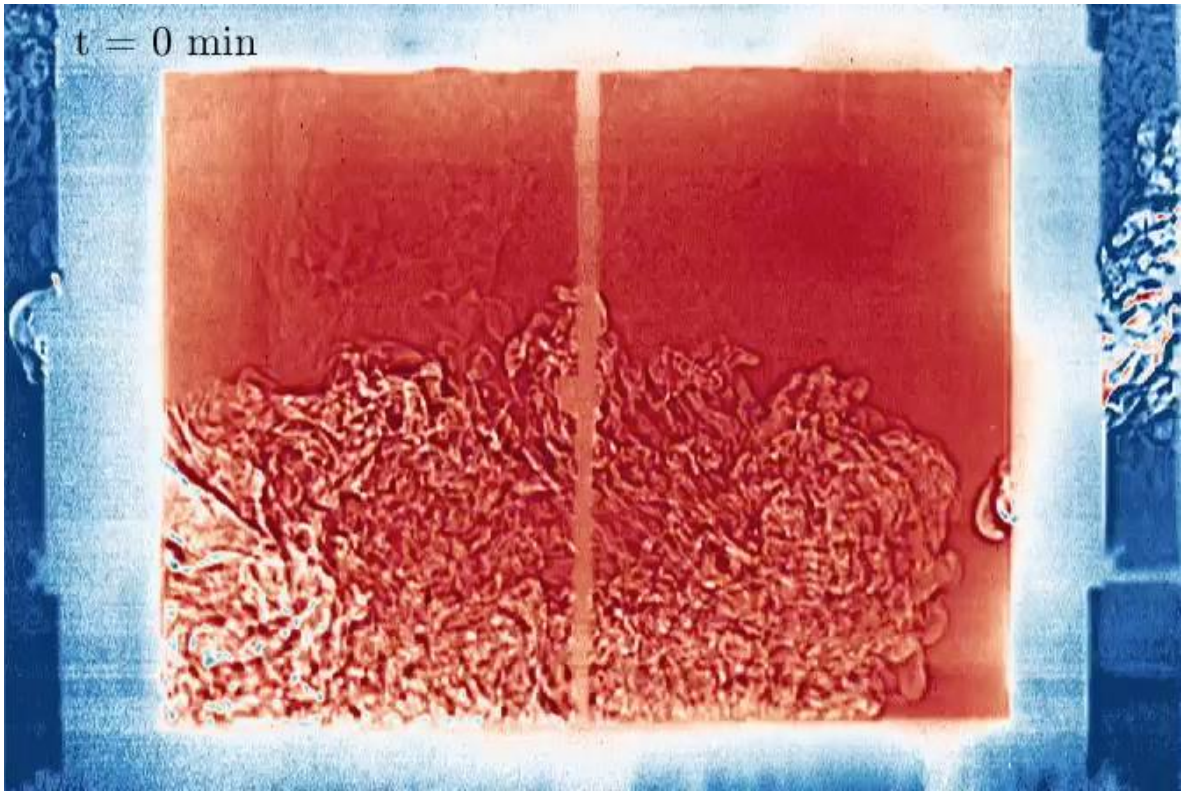
$U = 0$

$\Delta T = 4°C$



Exchange ventilation

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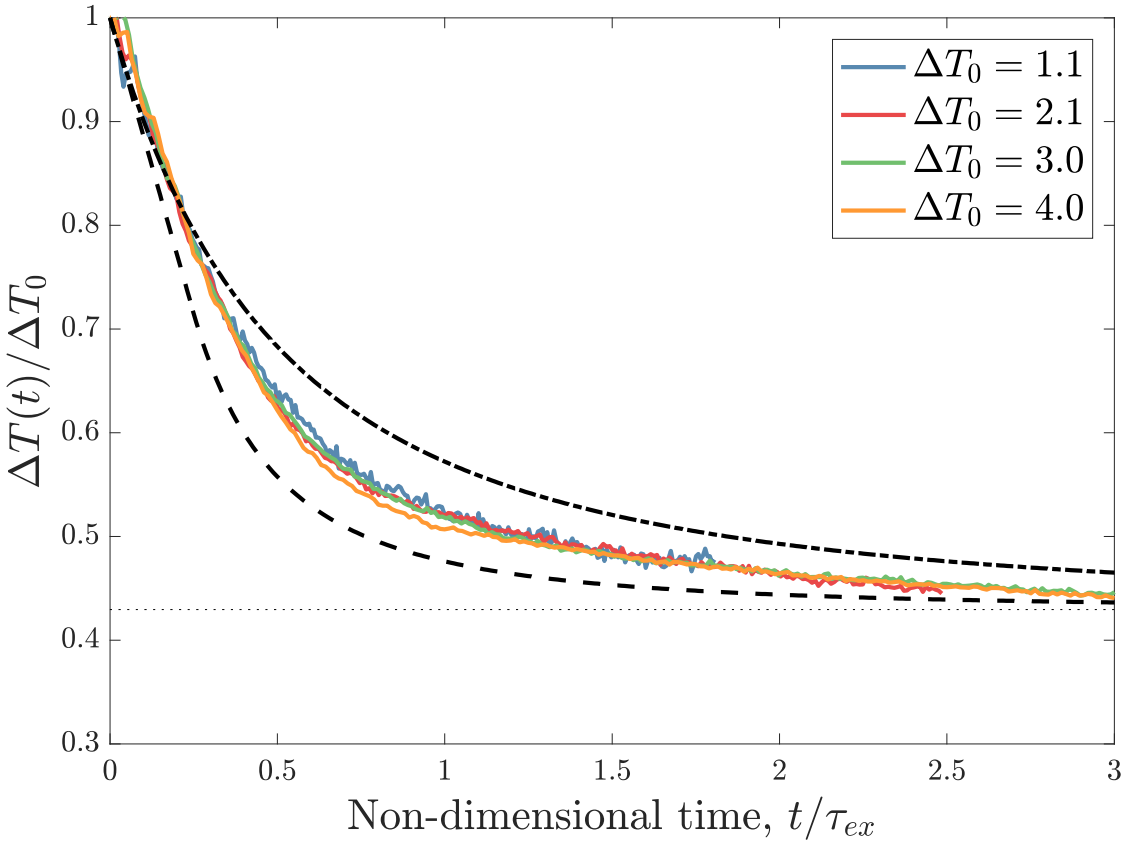

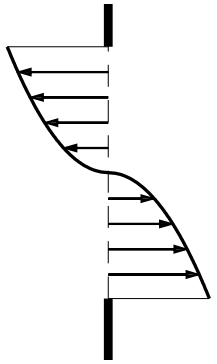

Well-mixed theory (Linden *et al*, 1990; Brown & Solvason, 1962)

Zero mixing theory

Wind and buoyancy

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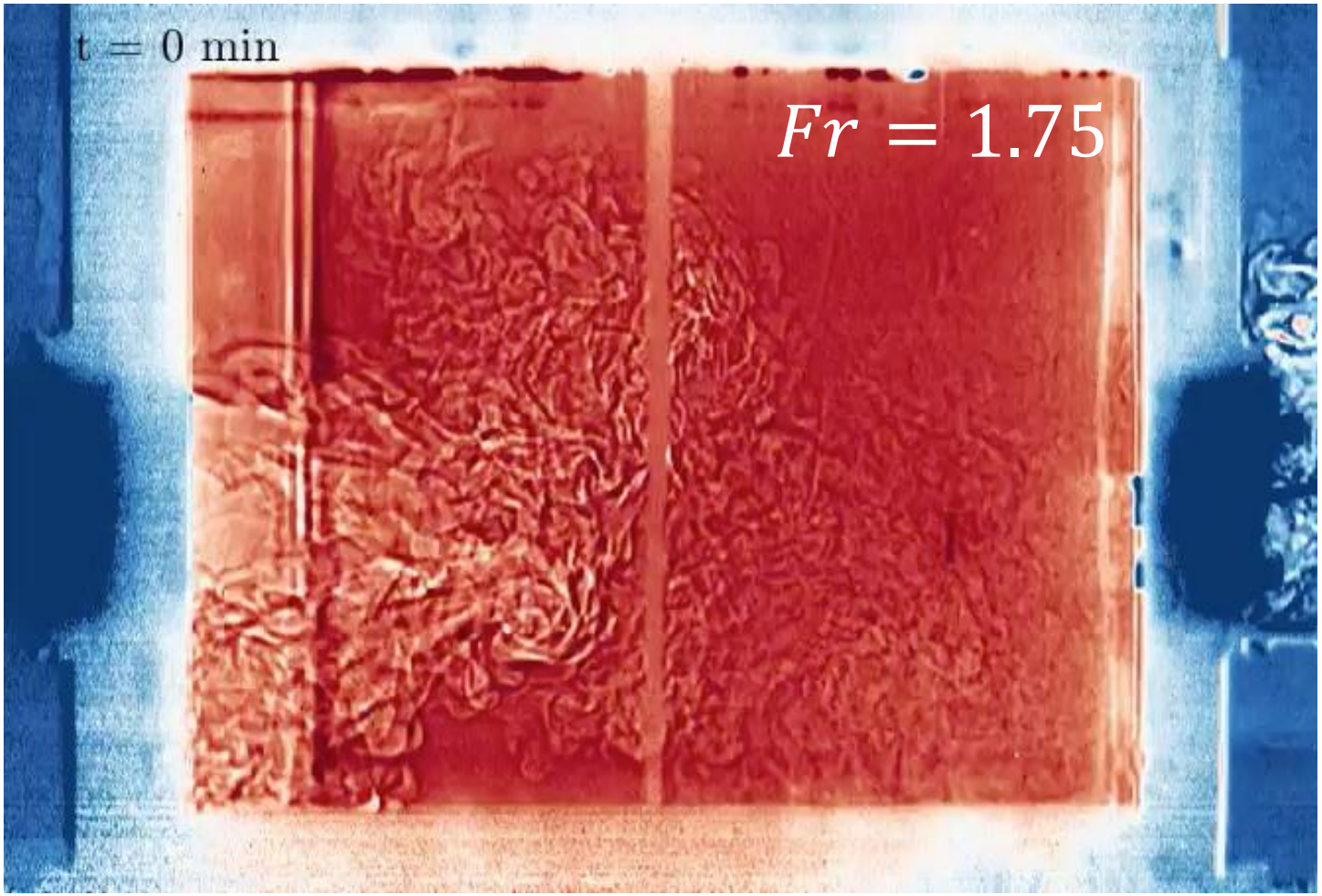

Wind and buoyancy

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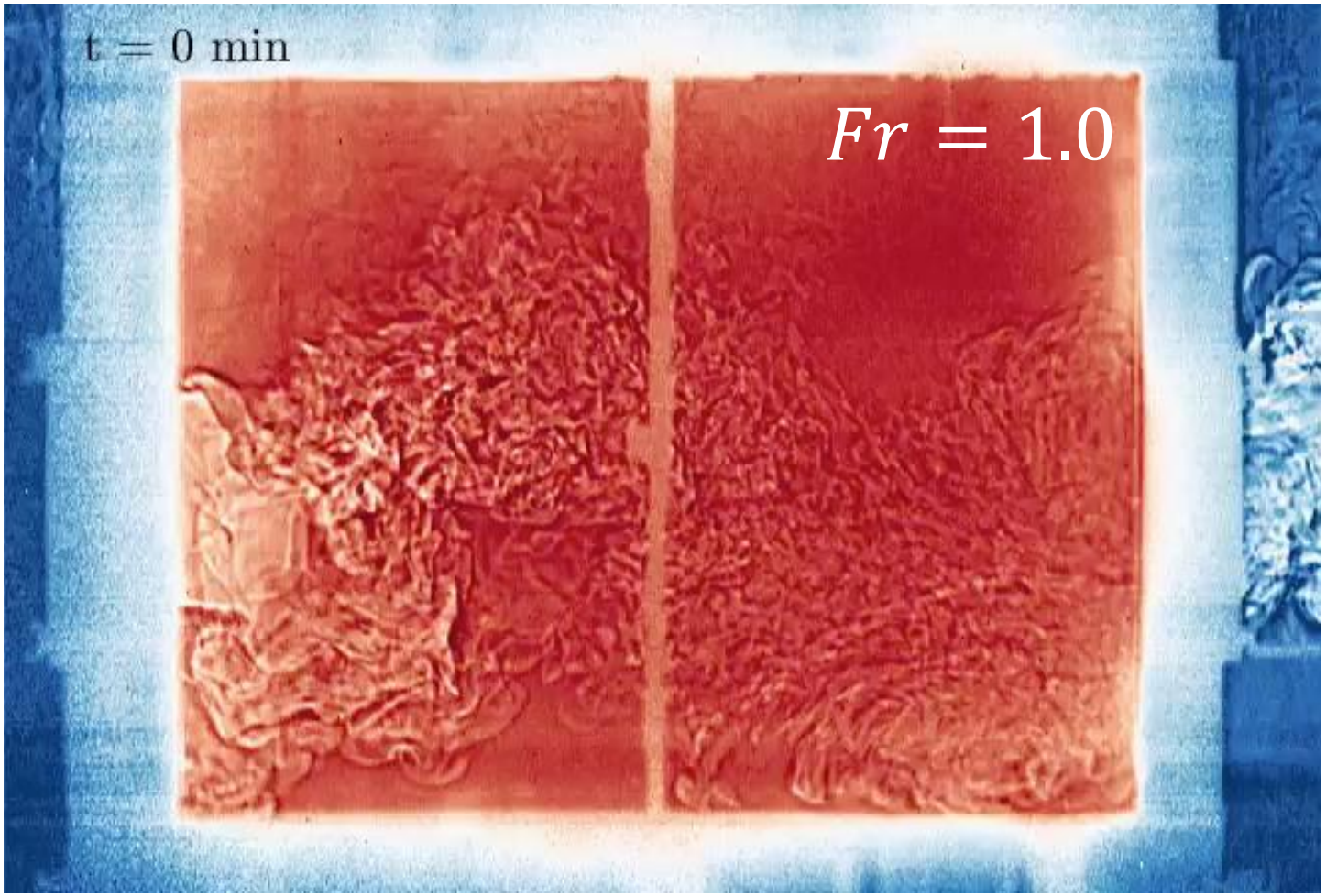

Wind and buoyancy

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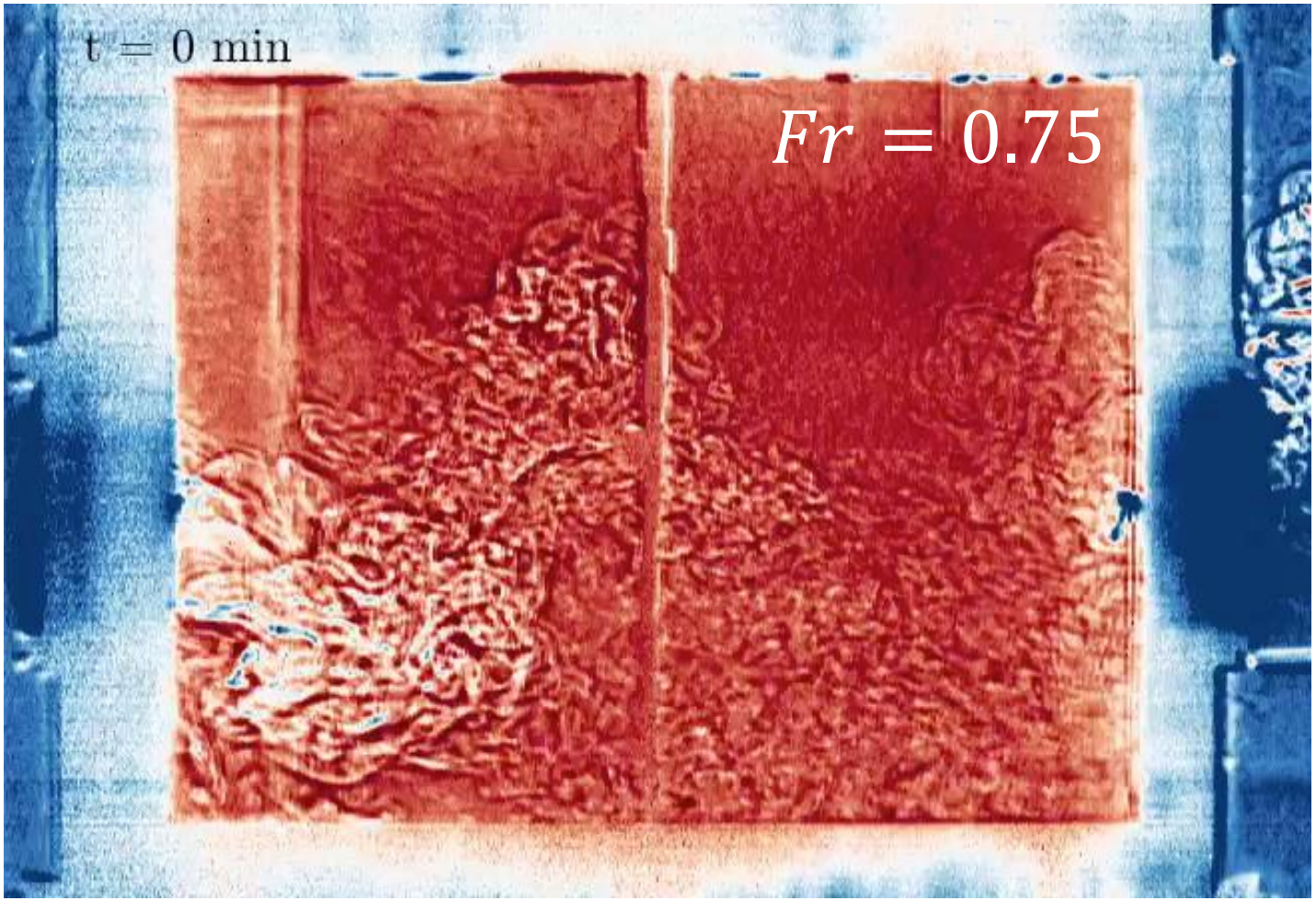

Wind-dominated

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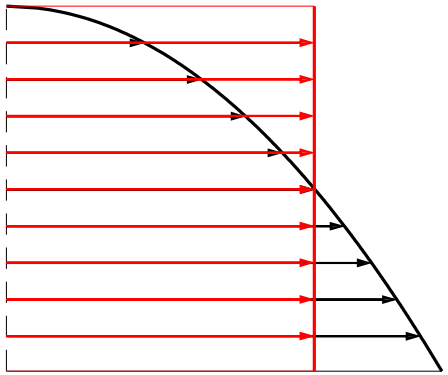
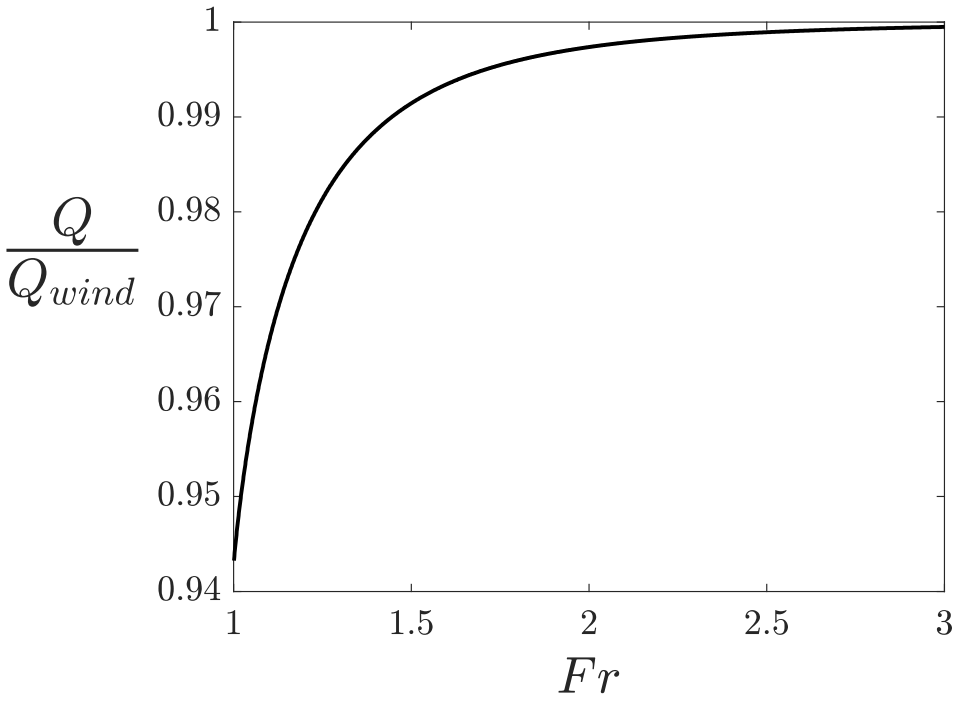
Buoyancy slightly suppresses ventilation

$$\frac{Q}{Q_{wind}} = \frac{(Fr^2+1)^{\frac{3}{2}} - (Fr^2-1)^{\frac{3}{2}}}{3\,Fr}$$



$Fr = \infty$ $Fr = 1$



Wind-dominated

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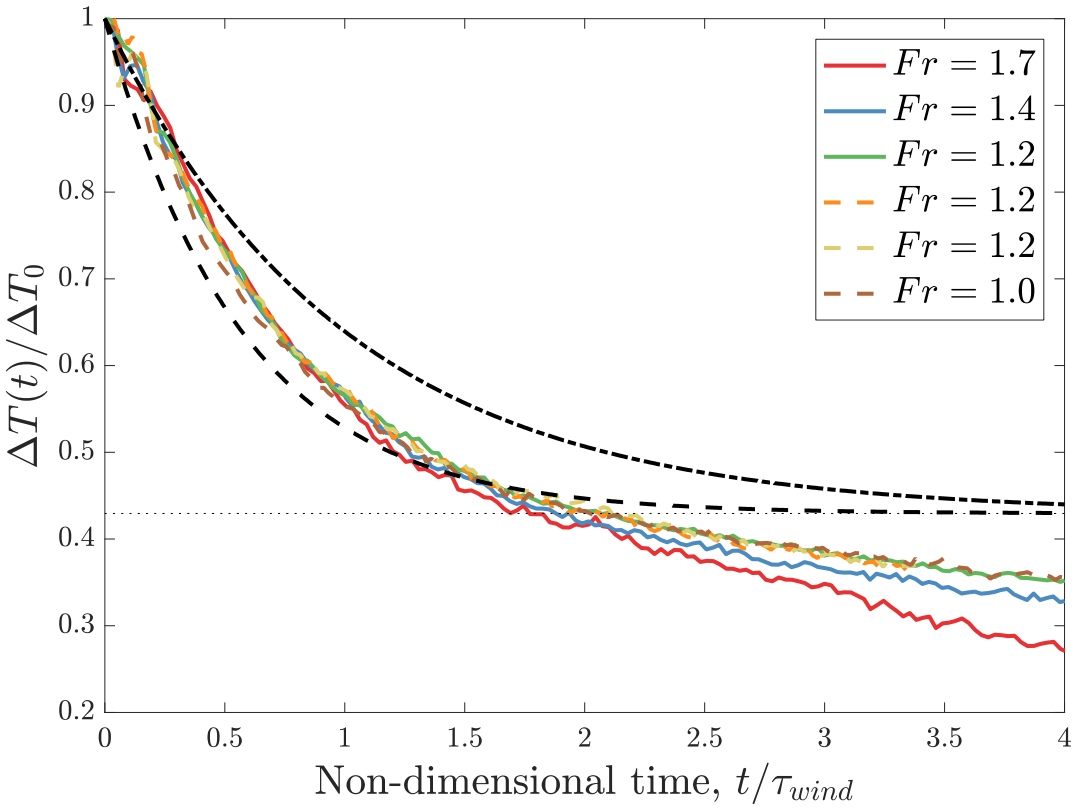
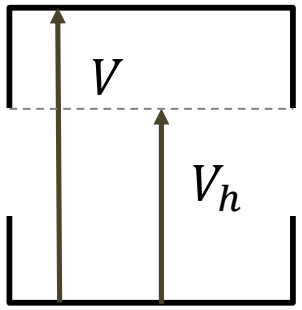
Model using exponential decay with reduced room volume





$V_{mix} = V$

$V_{mix} = V_h$

Buoyancy-dominated

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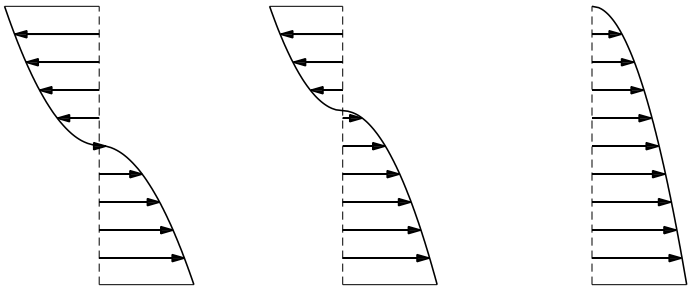
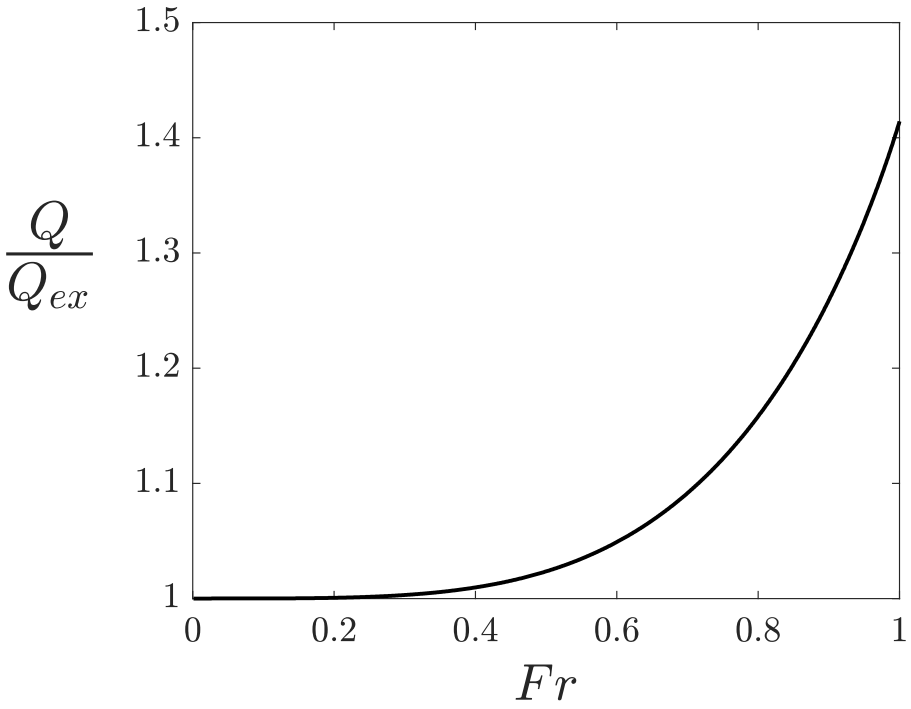
Wind enhances buoyancy-dominated ventilation

$$\frac{Q}{Q_{ex}} = \frac{(1 - Fr^2)^{\frac{3}{2}} + (1 + Fr^2)^{\frac{3}{2}}}{2}$$



$Fr = 0$ $Fr = 0.5$ $Fr = 1$



Buoyancy-dominated

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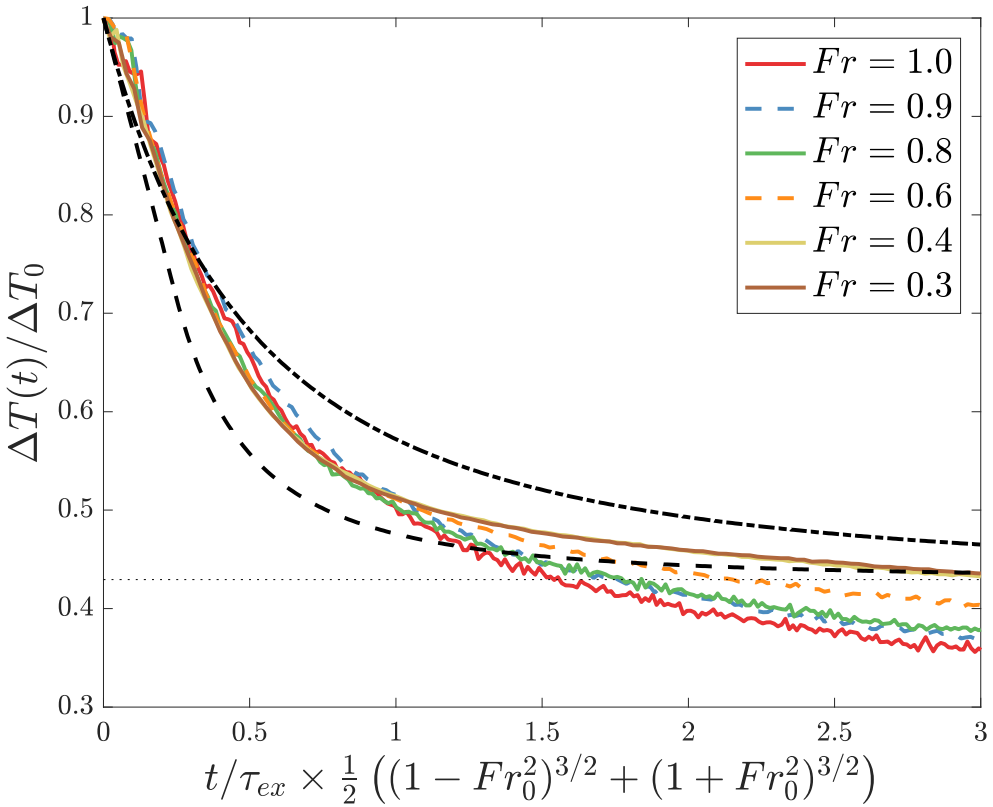
Model using a Froude number correction



Well-mixed theory (Linden *et al*,1990)

Zero mixing theory

Effect of temperature on cross-ventilation

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- **Wind-dominated (Fr > 1)**
  Model as exponential decay with reduced room volume.
- **Buoyancy-dominated (0 < Fr < 1)**
  Model as exchange ventilation with Froude number correction.

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Temperature only

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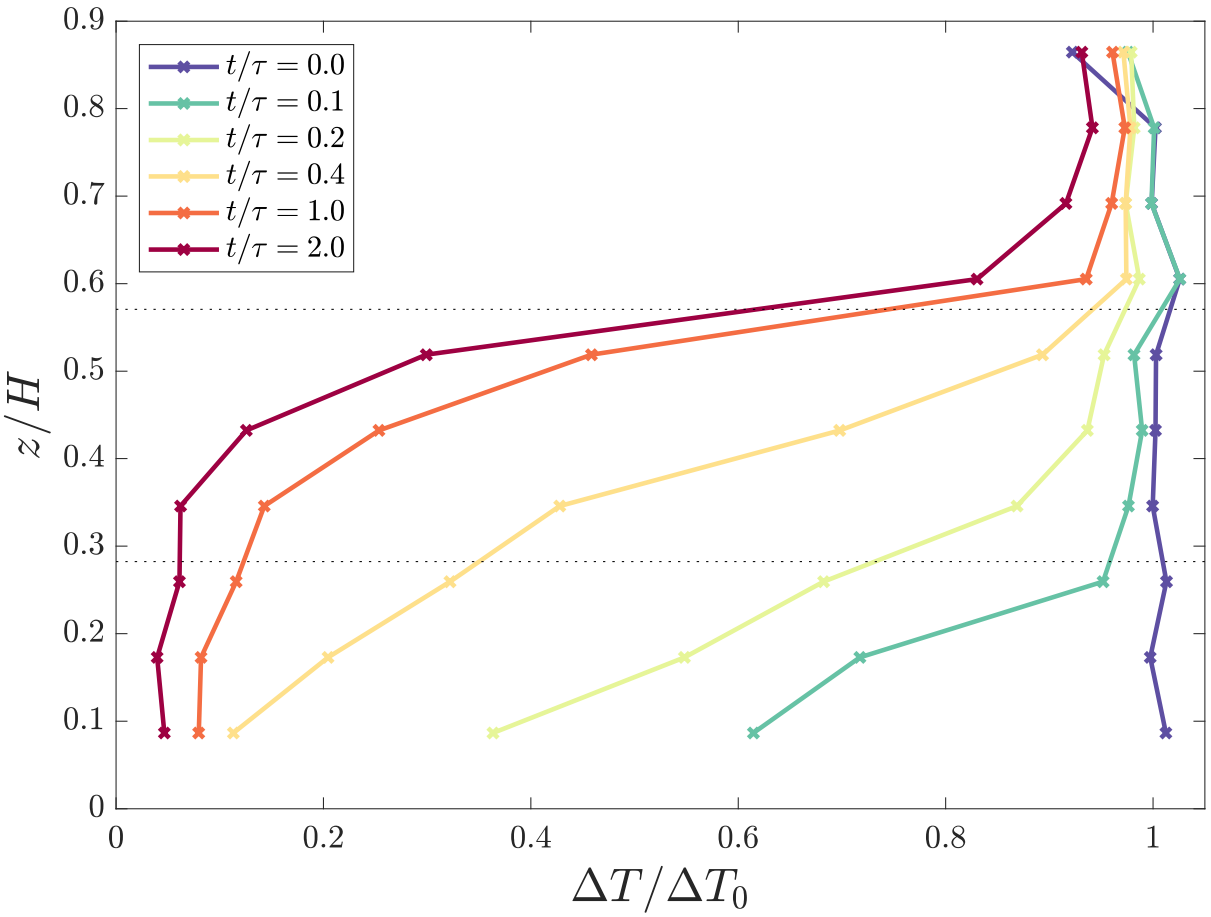

Wind only

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