The Impact of Simplified Window and Exhaust Fan Assumptions on Model-Based Predictions of Inter-Zonal Air Flow and Contaminant Transport in Multifamily Buildings

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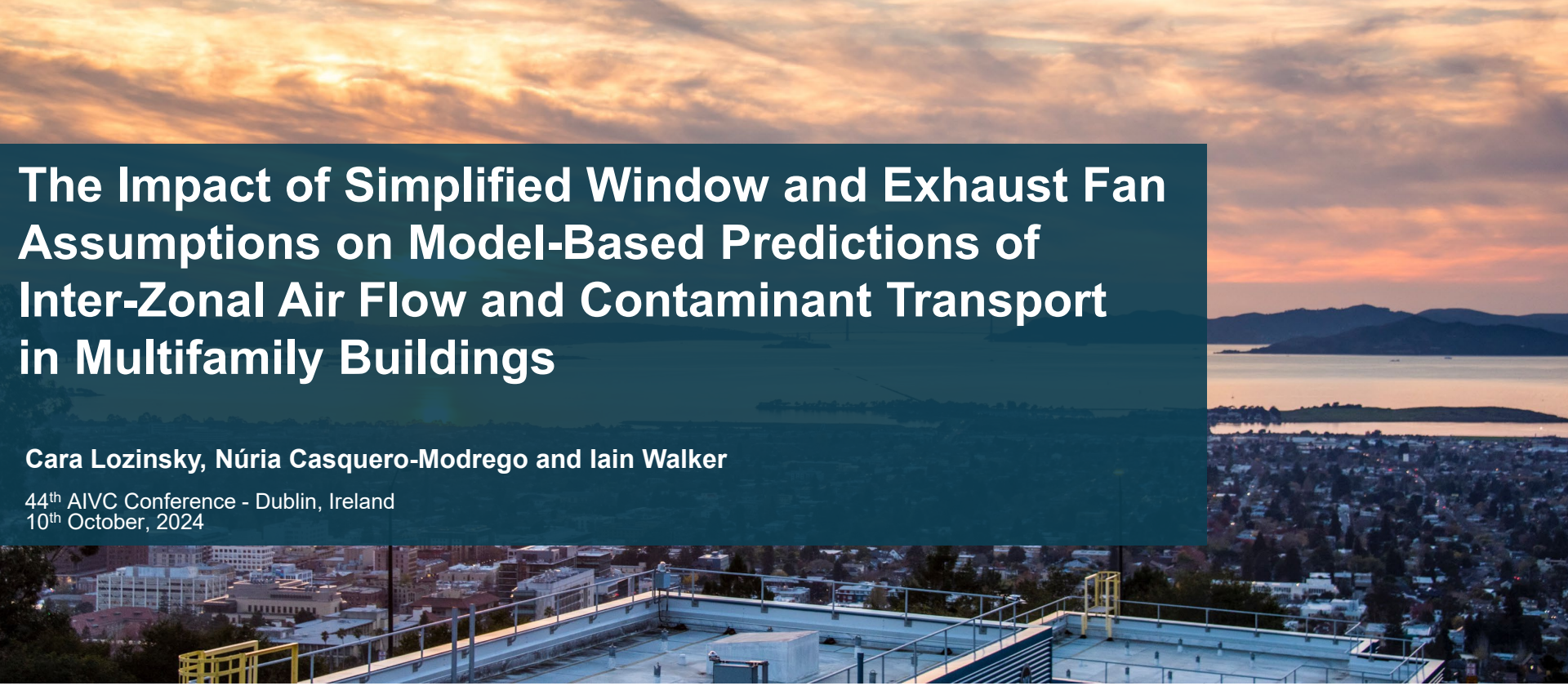

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Background

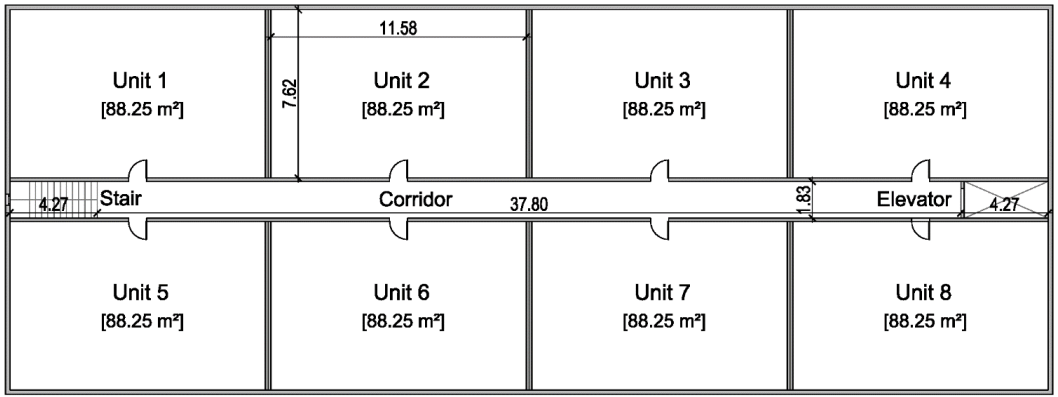
- Occupant behaviours (exhaust fan operation and window operation) are often highly variable and impact indoor air quality
- In building performance simulation, occupant behaviours use fixed schedules that do not reflect reality

Research Questions

1. How do occupant behaviors, specifically window and exhaust fan operation, impact air flow and contaminant transport in multifamily residential buildings?
2. Is it OK to use simplifying assumptions, such as, using the same schedules for all units?

Methodology

- Coupled CONTAM-EnergyPlus simulations
  - Annual simulations, 3-min time-steps
- Parametric Variables
  - Building prototype: Height (4/20 story) + 3 story no corridor
  - Climate zone: hot humid, mixed humid, very cold
  - Ventilation system: supply, exhaust, balanced (ASHRAE 62.2 compliant)
  - Dwelling unit air leakage: 5.1, 1.5 & 0.25 l/s/m^2
- Contaminant emissions
- Sensitivity Analysis
  - Exhaust fan operation schedules
  - Window operation



Exhaust Fan Operation Schedule

Base Case Assumption (no open windows)

Start and End Times	Activities	Kitchen Fan L/s (cfm)	Bathroom Fan L/s (cfm)	Laundry Fan L/s (cfm)
07:00 – 07:30	Showering	0	25 (53)	0
07:30 – 08:00	Cooking and Showering	50 (106)	25 (53)	0
11:45 – 12:15	Cooking	50 (106)	0	0
18:00 – 18:30	Cooking	50 (106)	0	0
21:30 – 22:00	Laundry	0	0	37.5 (79)

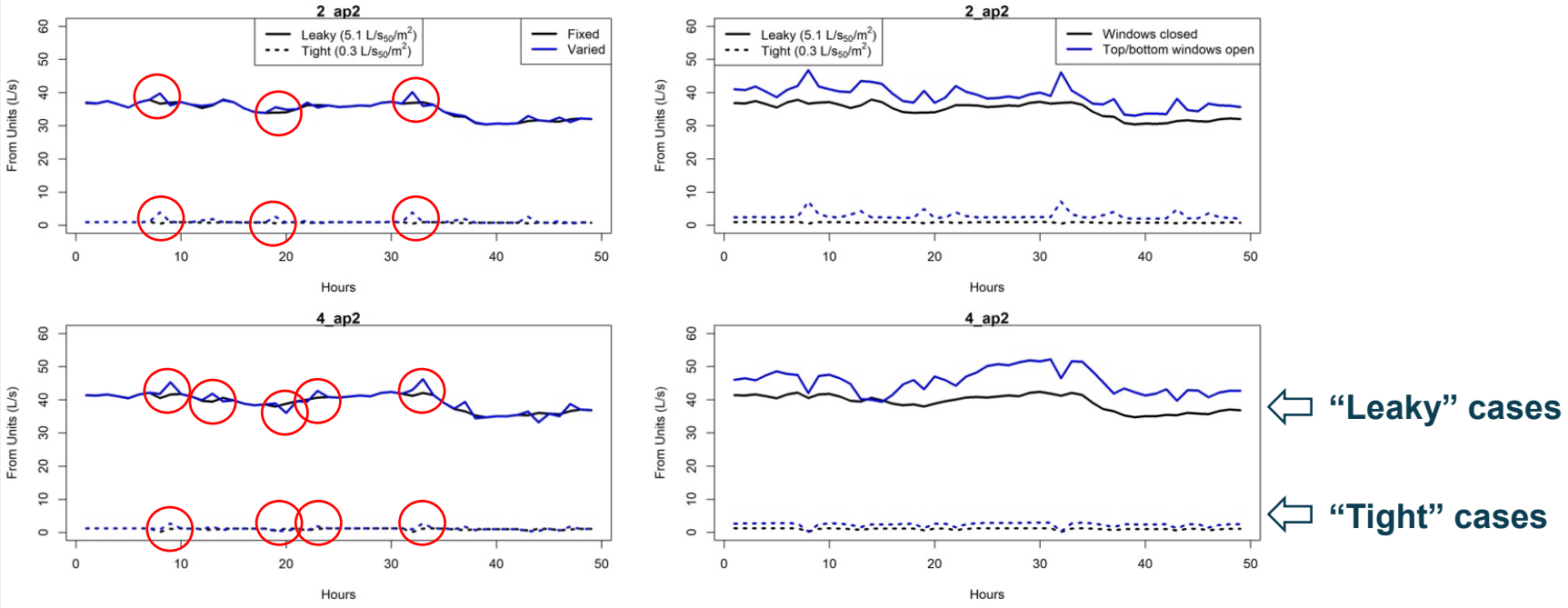
Variable Operation

- Three fan operation profiles, assigned in continuous rotation
- Ground and top floor open windows

Results

Direct Air Flow from Adjacent Units: Short-Term Effects

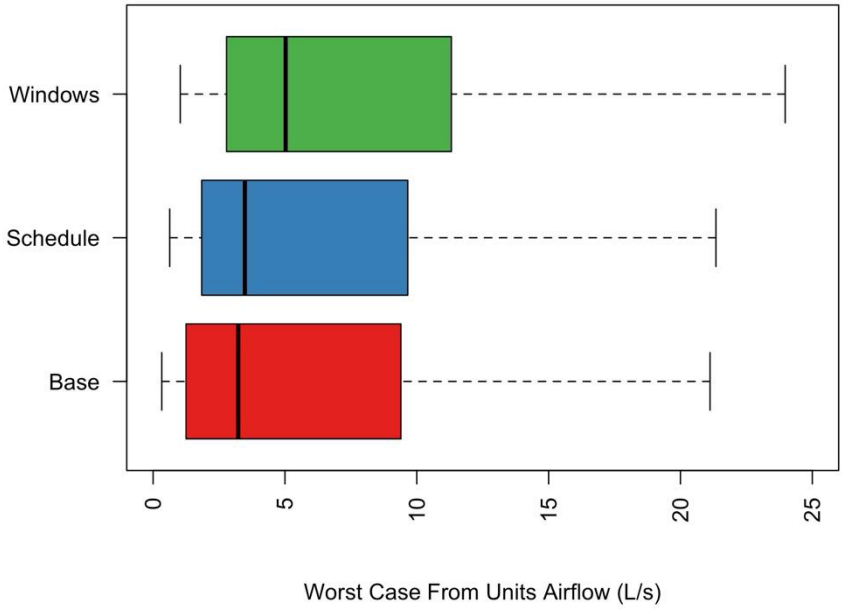
Occupant activity schedule and window operation impacts from adjacent units for the mid-rise common corridor prototype.



(a) Variable exhaust fan schedule

(b) Window operation

Direct Air Flow from Adjacent Units: Long-Term Effects

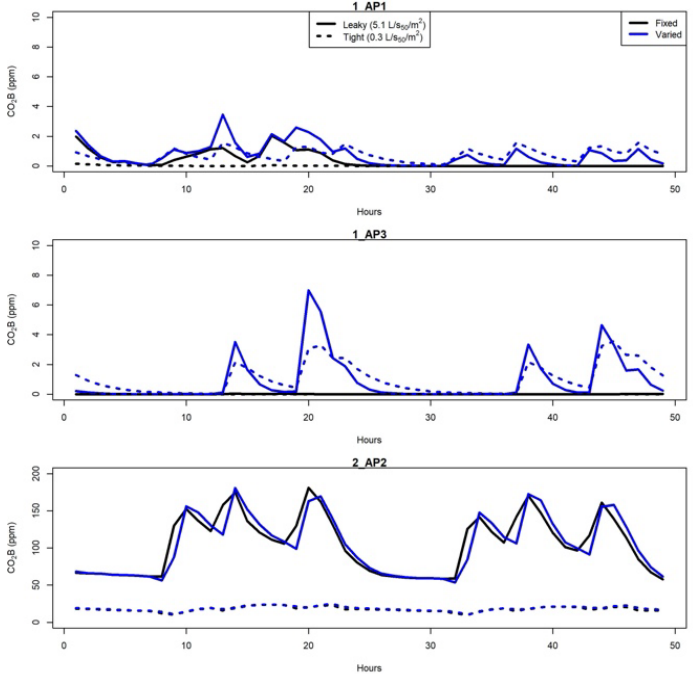


Worst-Case, Annual Average "From Units" Air Flow (L/s) from Each Simulation Case

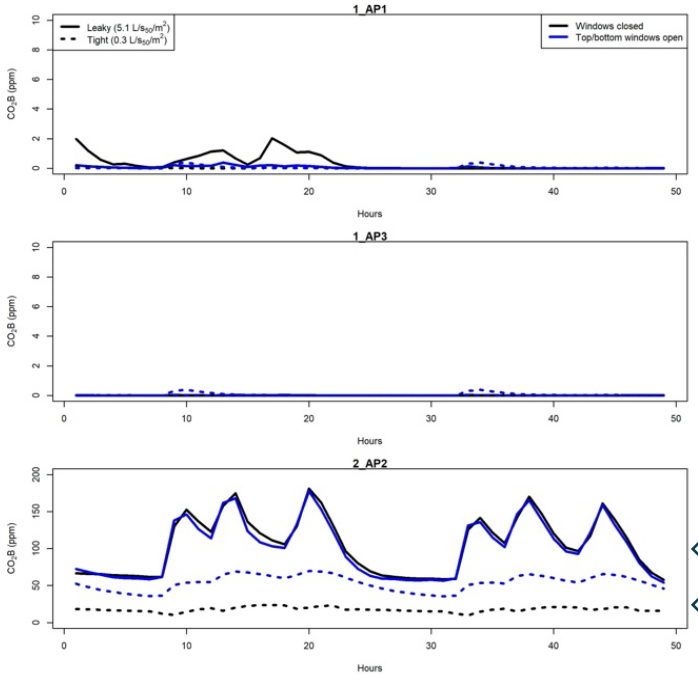
- Window operation had a greater impact (~2 L/s or 4 cfm) compared to exhaust fan schedules (<1 L/s or 2 cfm). Bigger impacts in leakier buildings.
- Building prototype (mid- and high-rise) had minimal influence on air flow results.
- The changes in air flow were small relative to the total mechanical system flow of 27.5 L/s (58 cfm), with typical variations being even smaller.

Contaminant Transport

Shadow contaminant concentrations of CO2 in zones directly adjacent to the shadow contaminant source zone (1_ap2)



(a) Variable exhaust fan schedule impacts on shadow contaminant concentrations of CO_2.



(b) Window operation impacts on shadow contaminant concentrations of CO_2.

⇦ **“Leaky” cases**

⇦ **“Tight” cases**

Conclusions

- Incorporating window operation had a more significant effect on both inter-unit air flow and contaminant transport than variable exhaust fan schedules:
  - Variable exhaust fan schedules increased worst-case inter-unit air flow by ~1L/s (2cfm)
  - Window operation increased worst-case inter-unit air flow by 2L/s (4cfm)
  - Air flow changes were minor, representing a small portion of the overall mechanical system flow (27.5 L/s (58cfm))
- Contaminant concentration changes were generally under 5%
- Overall, the study supports using simplified, static approaches to modeling airflow and air quality in multi-zone buildings

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Questions