CoolVent

A multizone airflow and thermal analysis simulator for natural ventilation in buildings

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SimBuild 2008, Berkeley, CA. *July 31st, 2008.*

Today

- Motivation behind CoolVent
- Model description
- User interface
- Results
- Limitations and future work
- Conclusions

Natural ventilation

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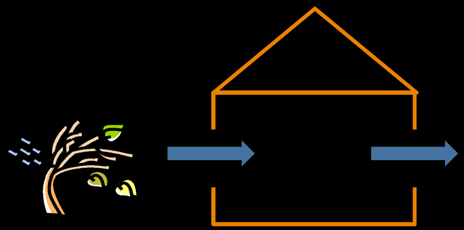
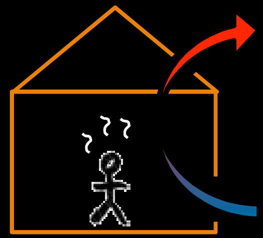
wind-driven



buoyancy-driven



Advantages:

- **<u>Considerable</u>** reduction on the (HVAC) energy consumption
- Wider occupant comfort ranges
- Improved occupant productivity

Natural ventilation (cont’d)

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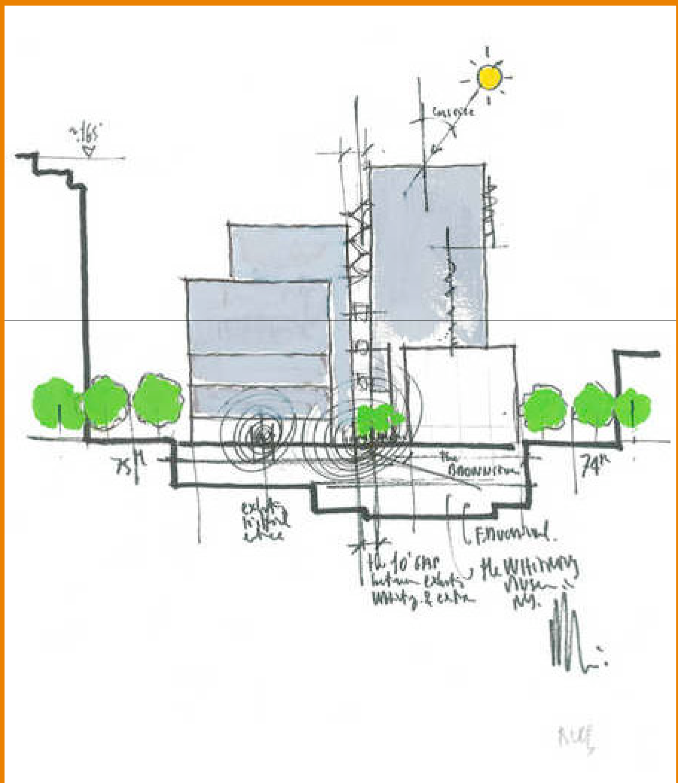

Challenges:

- Highly dependent on:
  - weather conditions
  - building shape and orientation

The natural ventilation strategy should ideally be defined at the early stages of building design.

- Lack of simple simulations tools
- T_room = *f* (air flowrate)
  air flowrate = *g* (T_room)

architecture.nyc-arts.org/projects/slides?project_id=21&si=3&

Current simulation tools

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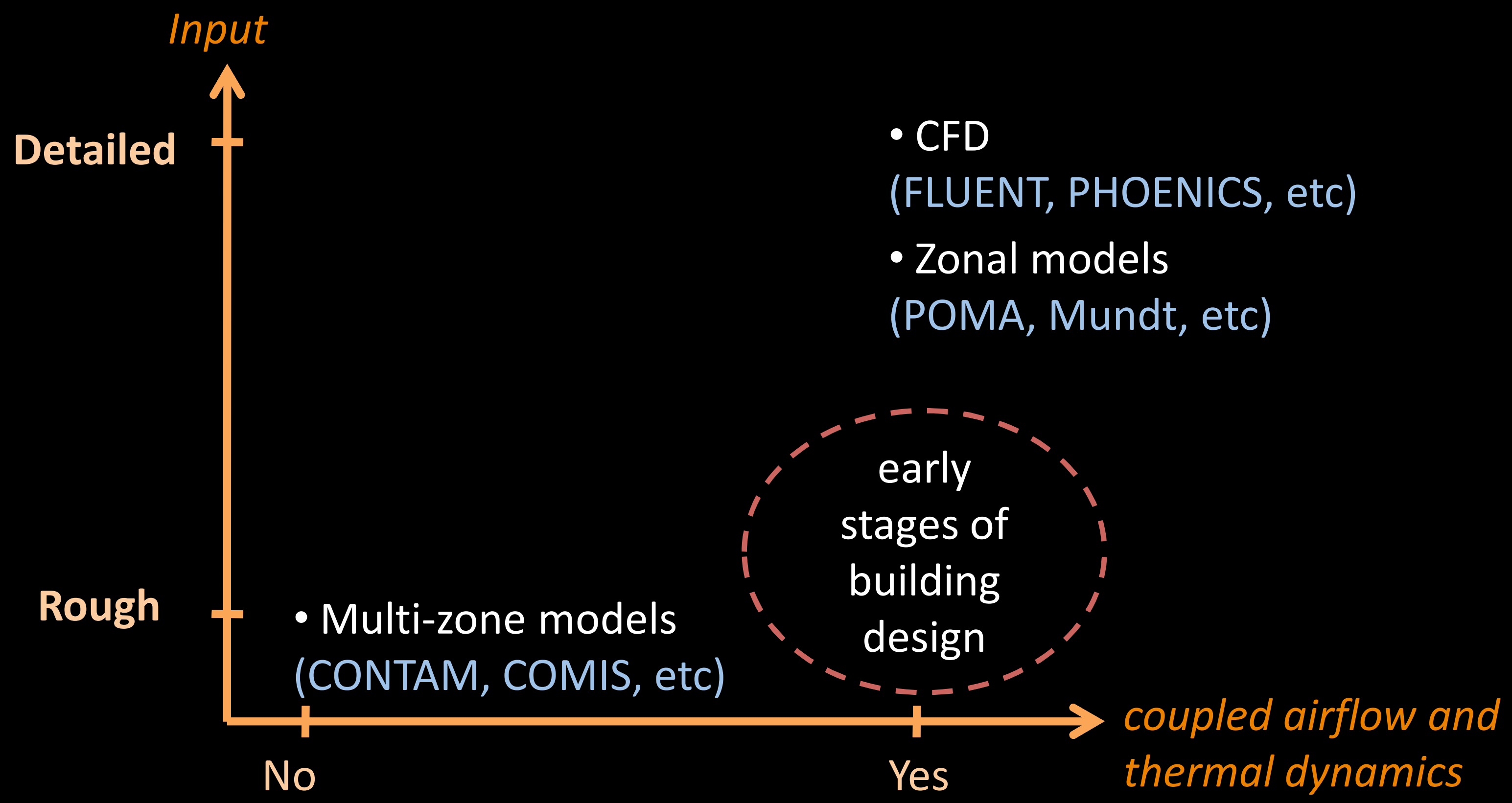
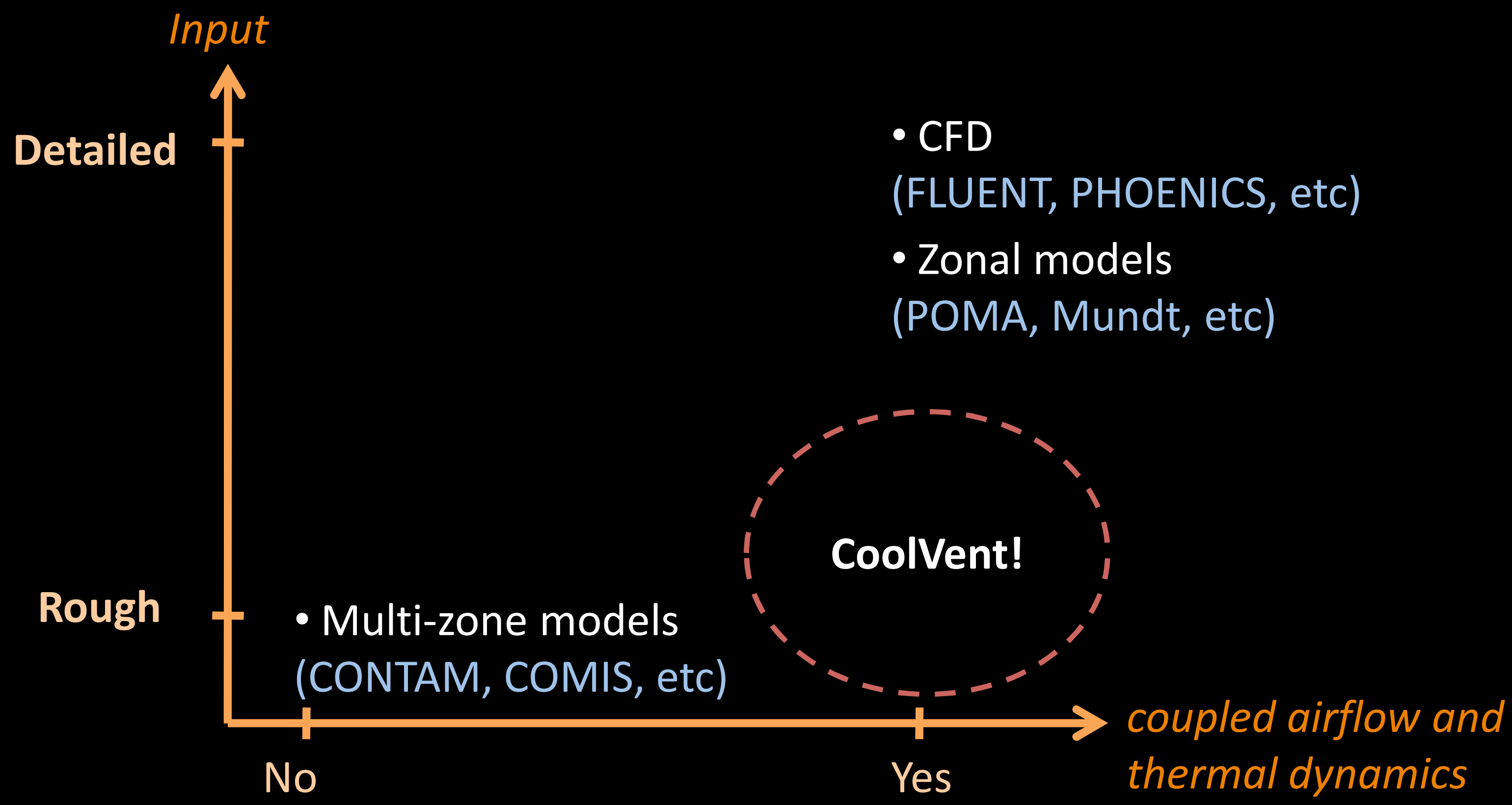


Current simulation tools



CoolVent

- Multi-zone simulation tool
- Solves for airflow and temperature simultaneously
- Accounts for thermal mass effects
- Performs steady and hour-by-hour transient simulations
- Output:
  - Air flowrate
  - Temperature

- Simple interface
- Allows to test several designs in an easy, fast way
- Requires little information about the building

CoolVent (cont'd)

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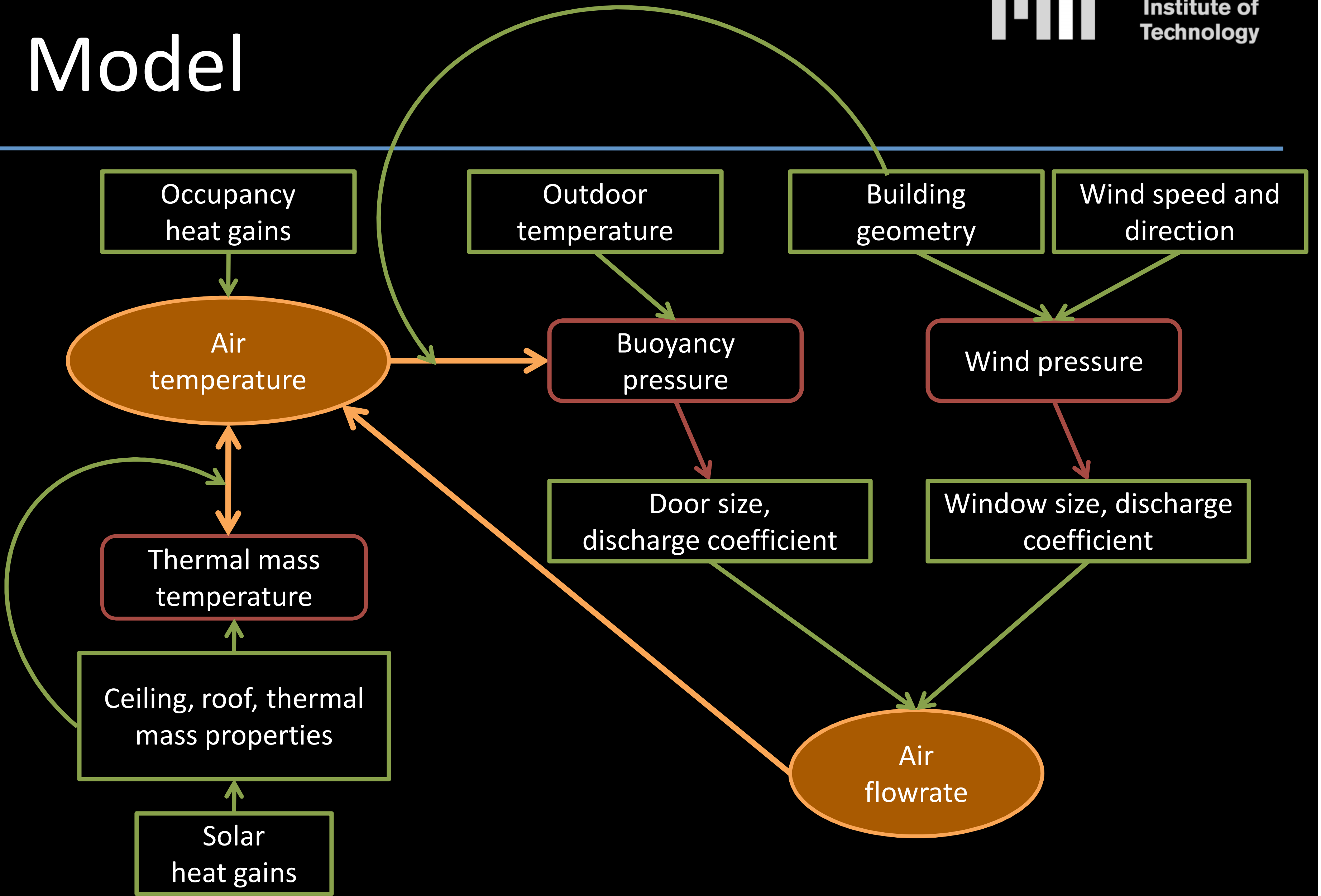
Goals:

- Define natural ventilation potential for a specific design
- Select the best natural ventilation strategy
- Chose a basic, rough geometry of the building

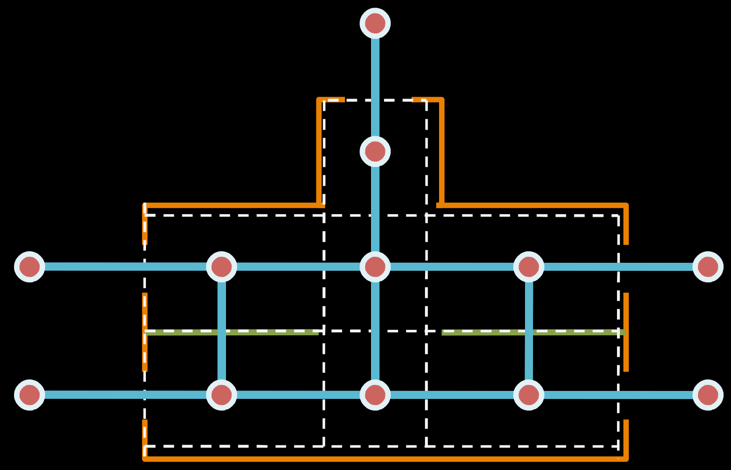
Model



Occupancy heat gains
Outdoor temperature
Building geometry
Wind speed and direction
Air temperature
Buoyancy pressure
Wind pressure
Door size, discharge coefficient
Window size, discharge coefficient
Thermal mass temperature
Ceiling, roof, thermal mass properties
Solar heat gains
Air flowrate

Assumptions

- Whithin a zone
  - Fully mixed air
  - Static pressure
  - No flow resistance
- Heat transfer
  - Conduction only through floor slabs
  - Radiation: solar → floor slabs



CoolVent demo

user interface and results

Additional results
Effect of thermal mass

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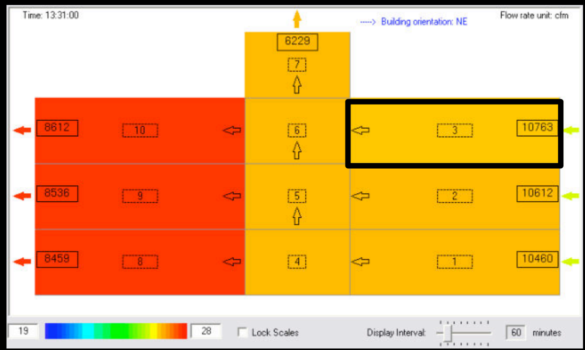
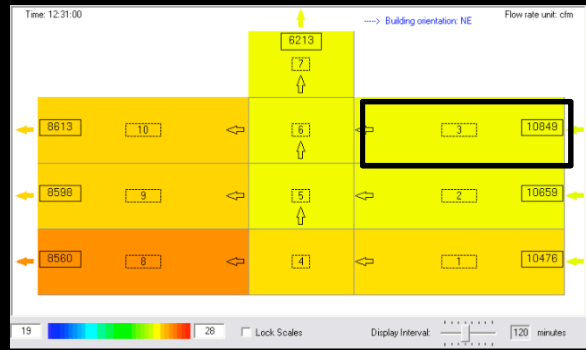
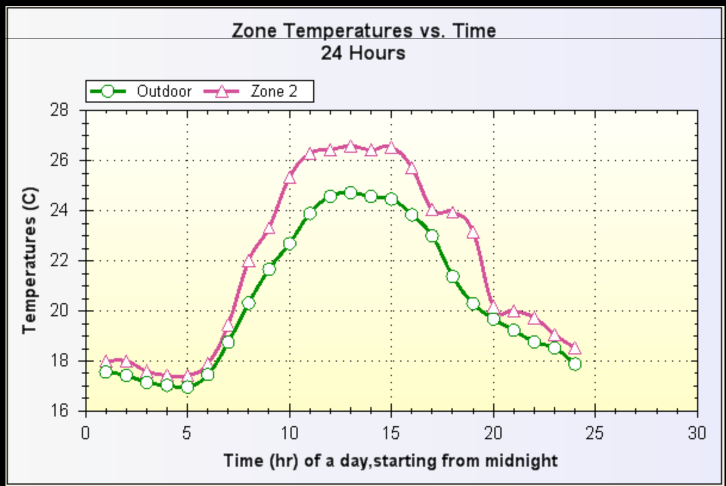
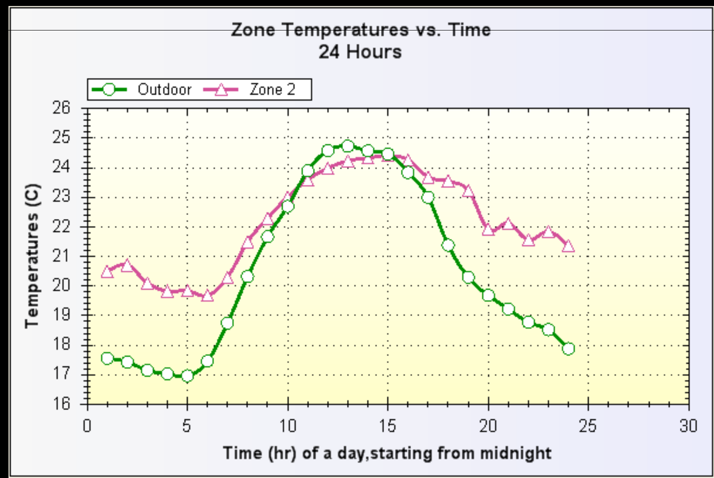


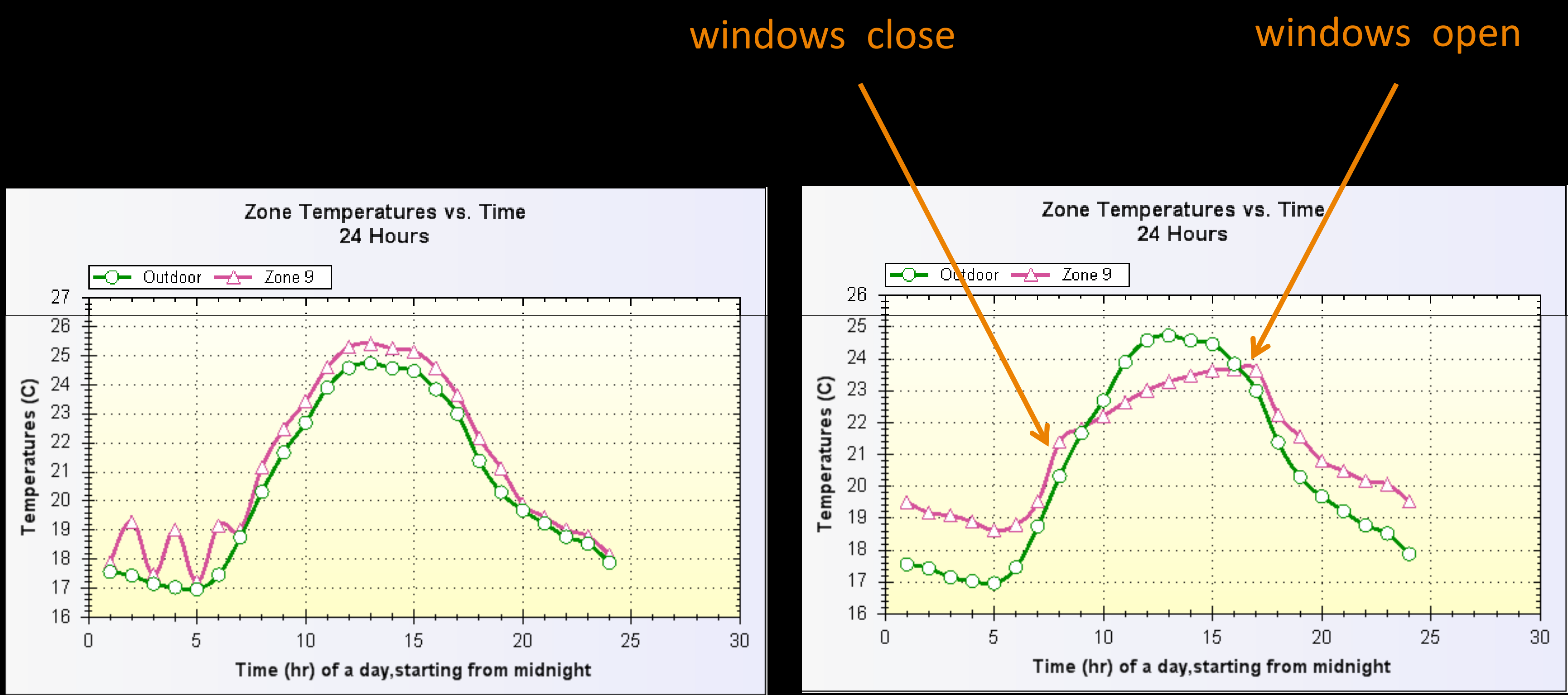






Boston. July. NE orientation. Office. Thermal mass: 20cm exposed concrete slabs.

Additional results
Effect of night cooling



Houston. April. S orientation. Residential. Thermal mass: 20cm exposed concrete slabs. Nightcooling: 7am – 5pm.

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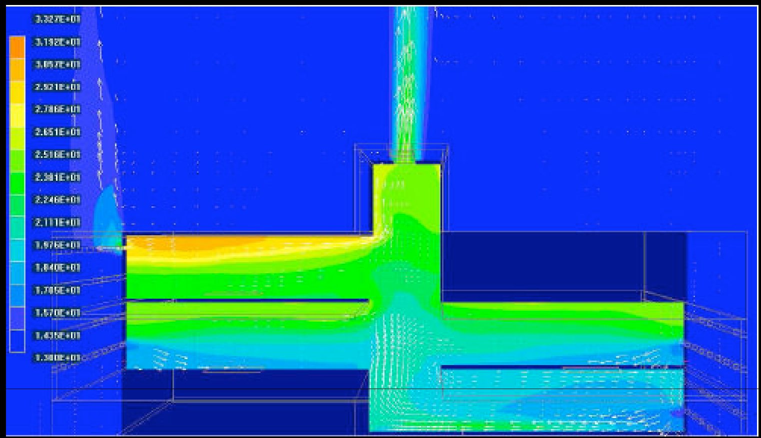
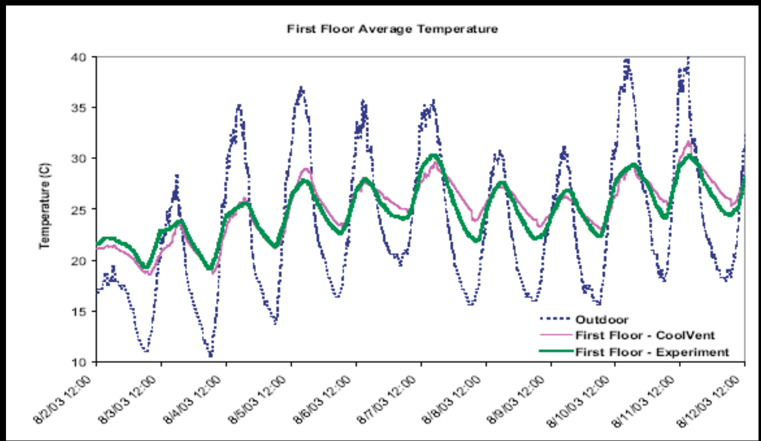
Validation





- CONTAMW
  - ✓ Airflow: error <1%
- PHOENICS (CFD)
  - ✓ Average zone temperature: error <1%
  - ✗ Airflow on hottest zones: (error ~39%)
- Transient field measurement
  - ✓ Average zone temperature (error ~10%)

Limitations and future work

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Wouldn't it be nice if CoolVent could...

- Account for air stratification
- Account for flow resistance inside each zone
- Provide information on humidity nor internal airspeed
- Allow to combine single-sided with other strategies

- Simulate a wider set of geometries / strategies
- Perform yearly runs
- Provide feedback
  - total energy savings
  - total hours per year outside comfort zone
  - fulfillment of minimum ventilation requirements
- Suggest changes in design to optimize performance

Conclusions

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CoolVent

- Simple, robust tool
- To be used during early stages of design
- Requires very little
  - input information
  - running time
- Solves for airflow and temperature simultaneously
- Accounts for themal mass effects

Impact

- Smarter, wider use of natural ventilation
- Reduction of energy consumption in buildings
- Insight for how natural ventilation works

Questions?

Thank you.

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