

# Radon Ventilation

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## Project Objectives

Quantify the dose to neighbourhood residents from sidewall radon ventilation from residential buildings.

## Rationale

Sub-slab radon mitigation systems have a positive impact on mitigating indoor radon concentrations. In Canada, there are many practical reasons for opting for discharging gases out of the basement sidewall. However, gases often have high ( $>10 \text{ kBq/m}^3$ ) radon concentrations. The goal of this project is to evaluate the dilution and impact of sidewall discharge systems.

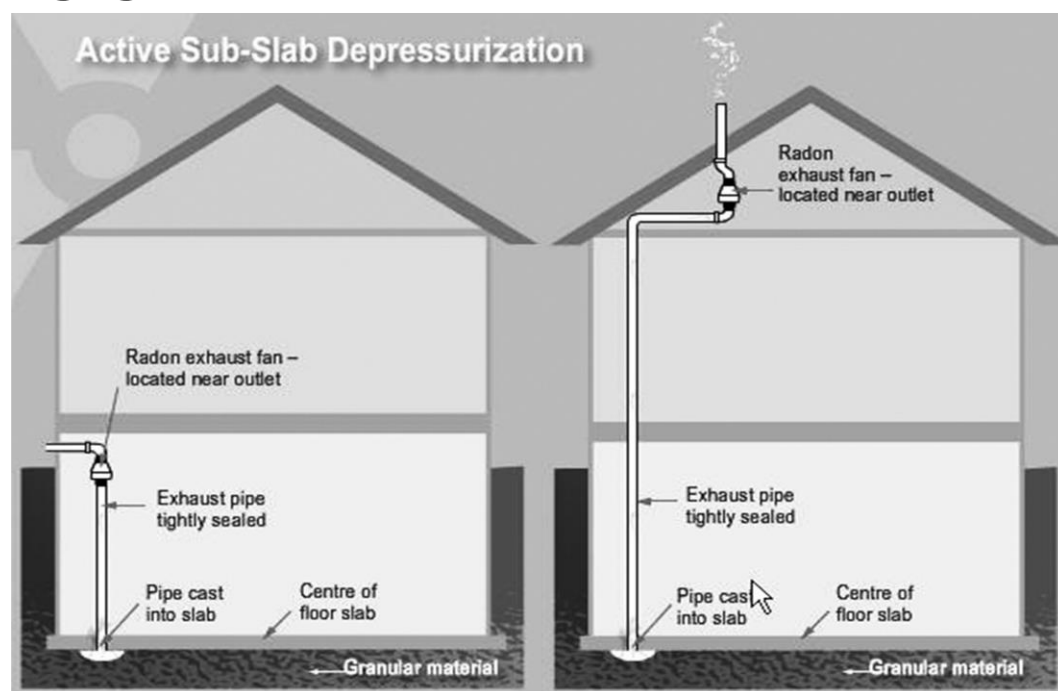


Figure: Illustration of sub-slab depressurization systems discharge modes, from Brossard et al. (2015)

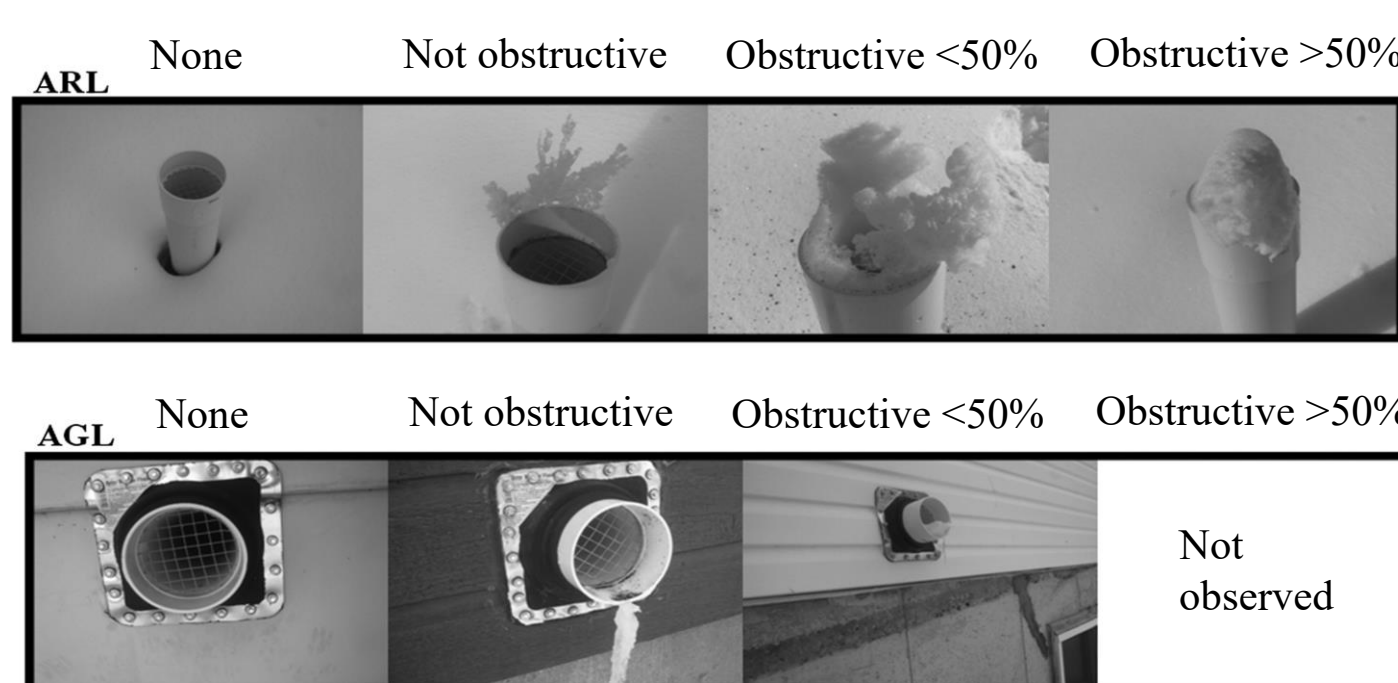


Figure: Representative pictures used to categorize icing gradation, from Brossard et al. (2015)

## Approach

- Use tracer experiments to assess the airflow complexity and provide benchmark for Computational Fluid Dynamics (CFD)
- Merge benchmarked CFD with simple probabilistic safety assessment model (PSA) in the far field
- Evaluate airflow sensitivities using CFD
- Evaluate all met scenarios using PSA model merged to CFD



Figure: Setup for 2018 tritium tracer experiment

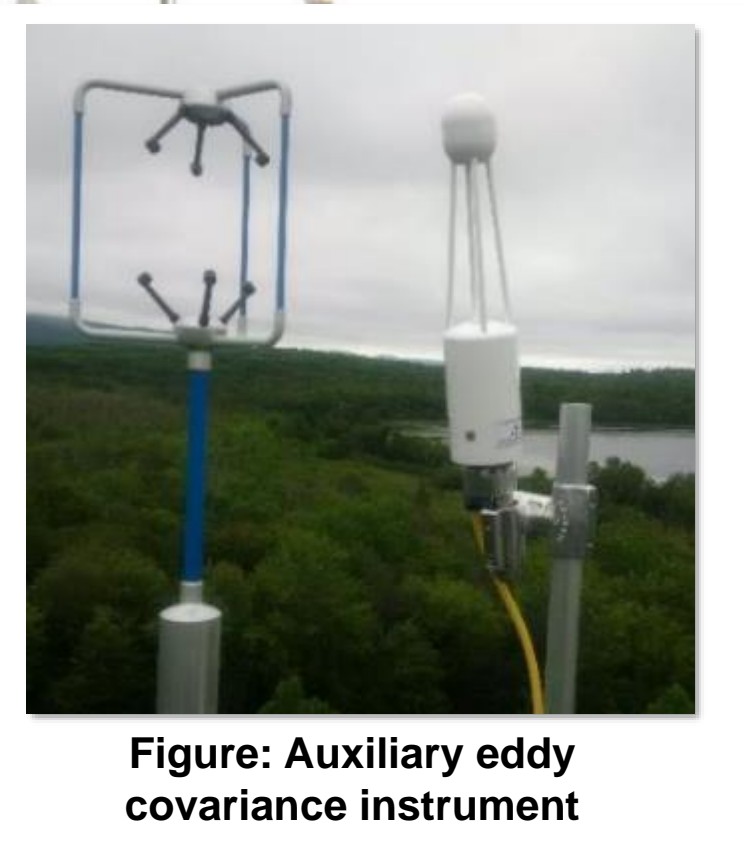


Figure: Auxiliary eddy covariance instrument



Figure: Setup for 2019 CO<sub>2</sub> tracer experiment

## Flow-field statistics for boundary conditions

**Velocity and Turbulence** (profile parameters extracted for typical "calm", "regular", and "windy" conditions from data):

- Statistics from sonic anemometers
- Located near dispersion experiment
- Sonic anemometers @0.3 m 1.0 m (2D) and @3 m (3D)
- 20 days of data collection in November 2018
- Velocity,  $k$ - $\epsilon$  turbulence profile defined by two parameters:
- Friction velocity,  $u_*$
- Foughness length,  $z_0$

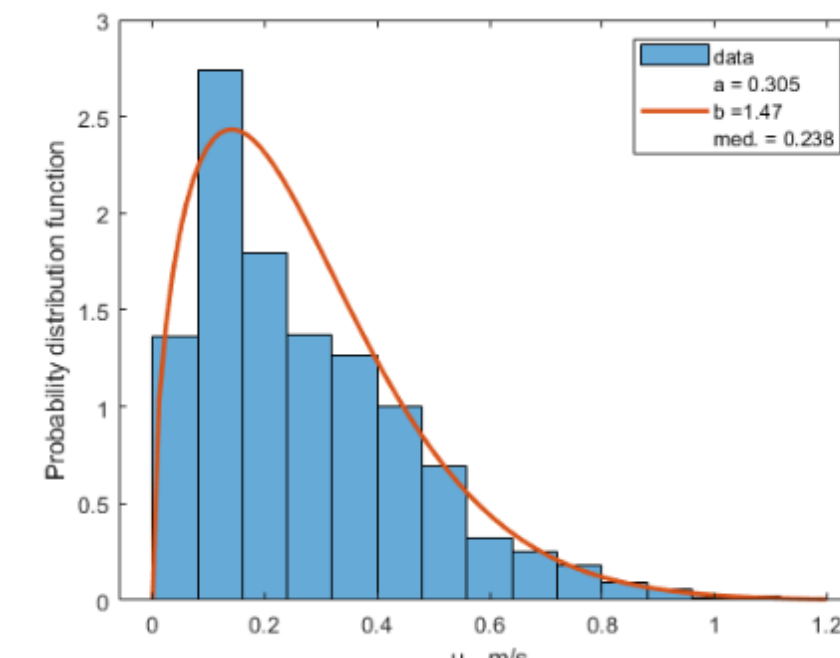


Figure: Histogram of  $u_*$  parameter from collected sonic anemometer data

**Temperature and Atmospheric Stability** (parameters extracted for typical "stable", "neutral", and "unstable" conditions during summer, spring/fall, and winter from data):

- Perch Lake Tower
- $\sim 2 \text{ km}$  from dispersion experiment
- Wind vane anemometers @30m, 60m
- Temperature @0m, 30m, 60m
- Continuous measurements (all of 2018 used in analysis)
- Seasonal average temperatures
- Stability parameters, depending on heat flux,  $q_w$

## CFD Physics Models:

- Steady state
- Constant density gas flow
- Segregated flow and fluid temperature solvers
- Boussinesq model with gravity for buoyancy effects
- $k$ - $\epsilon$  RANS turbulence model
- Passive scalar model for radon-laden exhaust gas

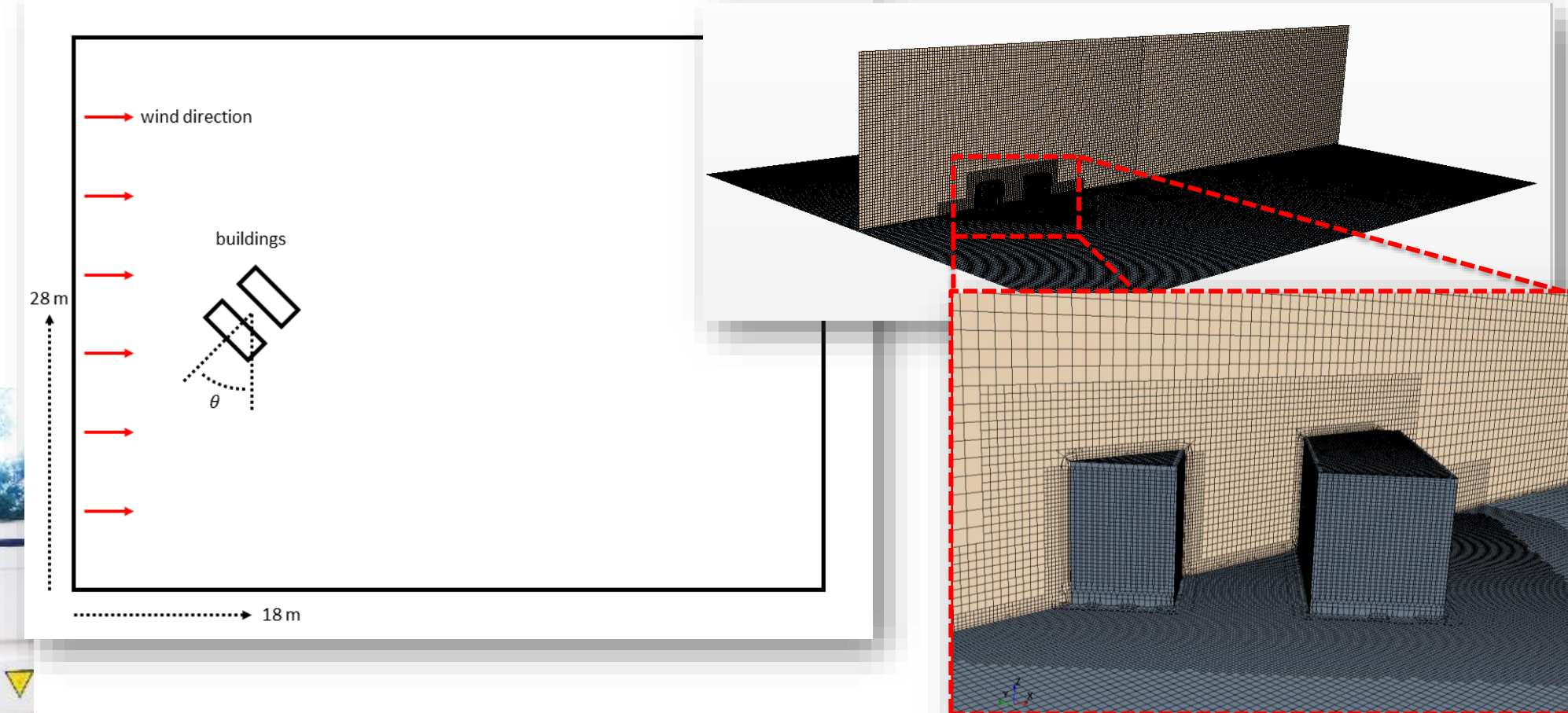
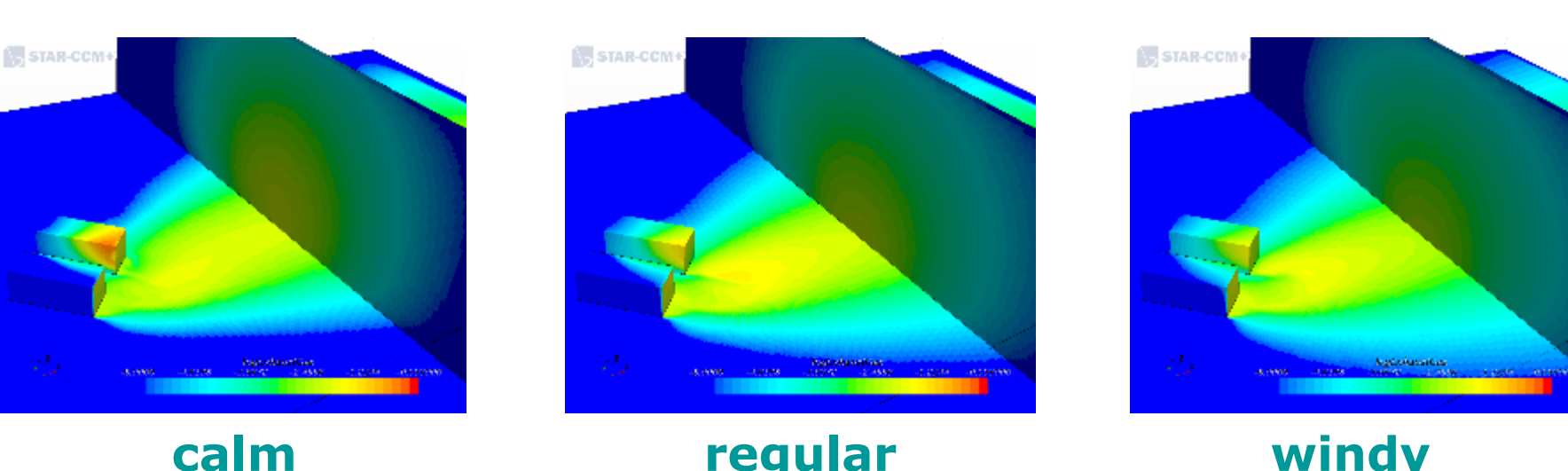
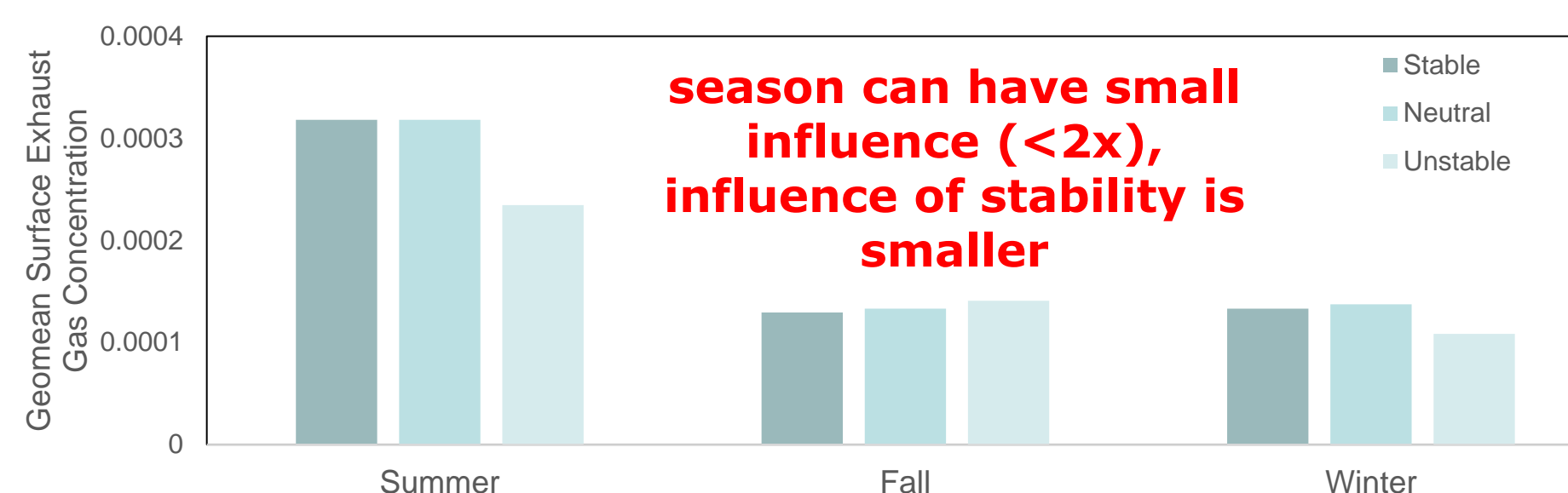
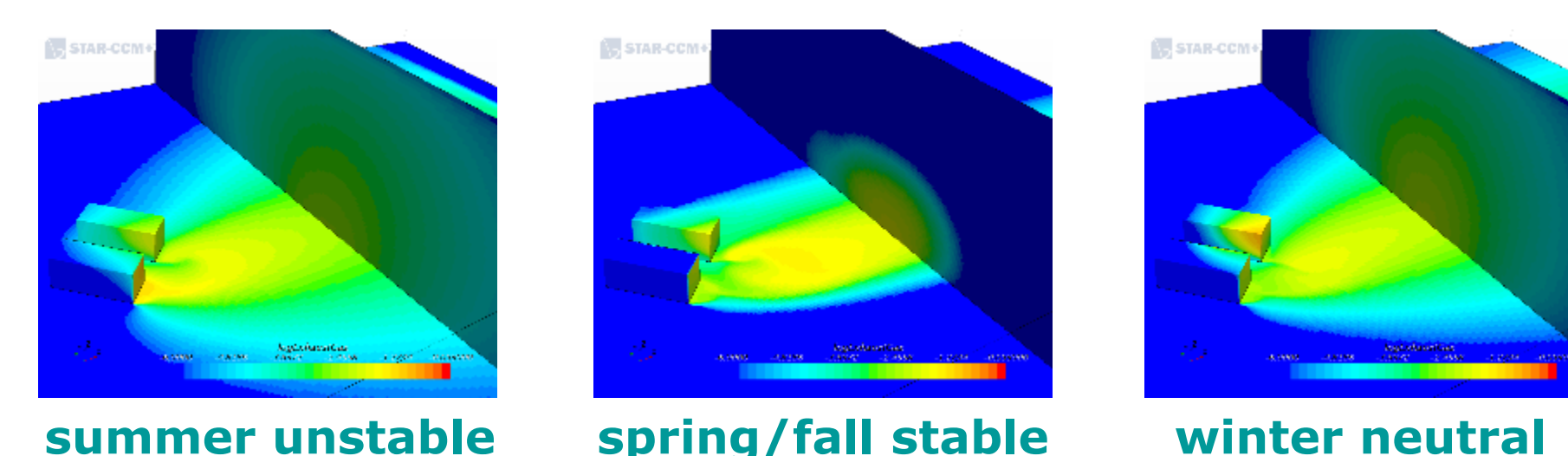
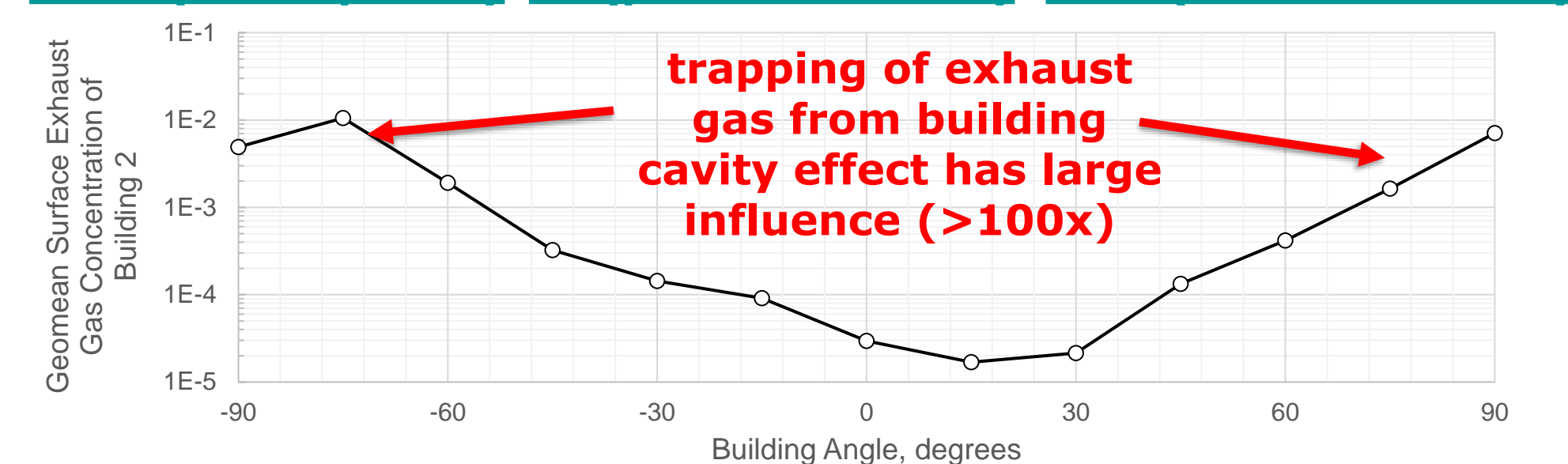
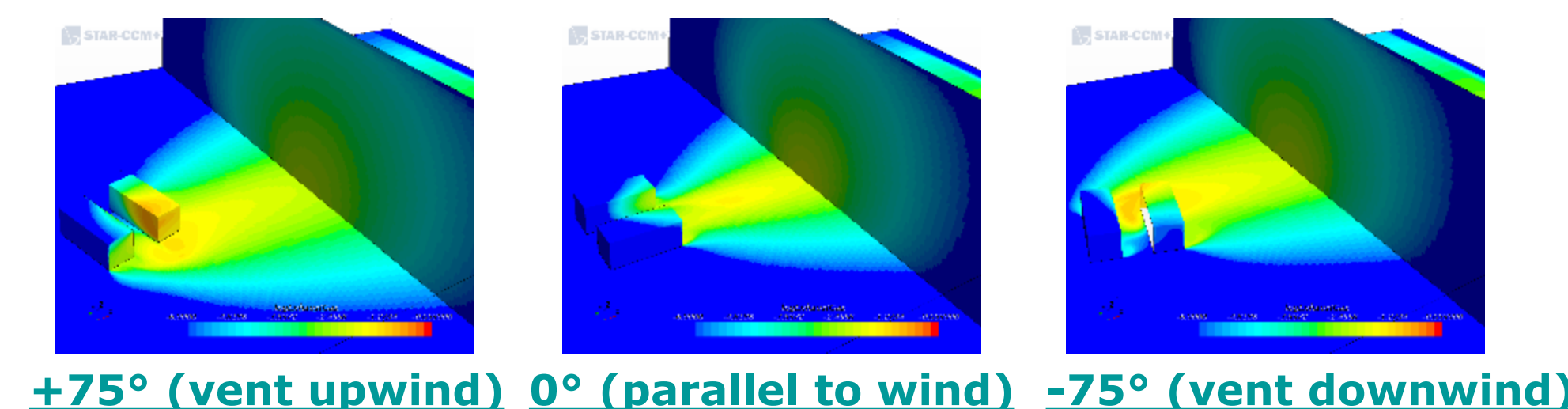


Figure: CFD domain and mesh

## CFD Results



wind speed can have a small influence (<2x), depending on wind angle



## Work Complete

Dilution ratios in the vicinity of the structures are modelled with CFD as a function of:

- Wind direction
- Wind speed
- Outside temperature
- Atmospheric stability
- Ventilation flow rate

Airflow complexity is partially identified in the experiment:

- Along-gap winds keep plume from dispersing into the gap and towards the neighbouring building; at small exit velocities most of the plume remained within the thin boundary layer at the wall
- Airflow between buildings is essentially 3D and requires enhanced instrumentation followed by fine-scale CFD modelling
- Real-time measurements across the gap require the other tracer and sensitive monitoring instruments

## Highlights on Current Progress

### Benchmarking CFD study:

- Tritium tracer experiment - complete,
- CO<sub>2</sub> tracer study objectives, design and field setup - complete

### Literature review and CFD modelling

- Boundary conditions have been set based on observations (measured local wind speed, turbulence, temperature, and stability conditions)
- 35 CFD cases have been run, considering key effects
- Building angle is determined to have the largest influence

## Future work

### 1. Experiments:

Tracer experiment with CO<sub>2</sub>. Focus on cross-gap wind directions. Characterization of winds at larger heights; use of the second 3D anemometer

### 2. Modelling

- Fine-scale computational fluid dynamics (CFD), including figures of merit (e.g., surface average or volume average concentrations) have to be set, and results compiled
- Future comparison of CFD results with field measurements
- New CFD model with more prototypical house-like structures to be completed in future, and possibly a study to explore LES
- Concentrations and doses at computational domain boundary for annual range of met scenarios (ADDAM)
- Evaluation of source term variability and its contribution

3. **Probabilistic characterization** of concentrations and annual dose based on PSA guidelines (ADDAM and CFD combined)

### 4. Results analysis

## Federal Stakeholders

- Health Canada (primary)



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