EXPERIMENTAL CHARACTERISATION OF DOMINANT DRIVING FORCES AND FLUCTUATING VENTILATION RATES FOR A SINGLE SIDED SLOT LOUVER VENTILATION SYSTEM

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Background & Context

- Increased need for assessment of cooling demand and overheating risk with well insulated airtight buildings
- Ventilative cooling an important strategy for to deal with these situations (particularly in temperate climates)
- Single sided ventilation attractive strategy for external retrofit of existing cellular isolated spaces
- purpose provided Louvre vent components can address barriers to ventilative cooling (noise, rain ingress, security)
- Investigate modified geometry compared to plain openings

Objectives

- To Investigate any modification in effect of conditions contributing to ventilation rates for a retrofit louvre system
- consider the combined effect of momentum and buoyancy forces and the character of the ventilation rate using a fluctuation parameter, σ_c

How?

- Use full scale testing – data not exhaustive for architectural louvre components / testbed available
- Compare measurements of a retrofit space with an existing un-refurbished control space

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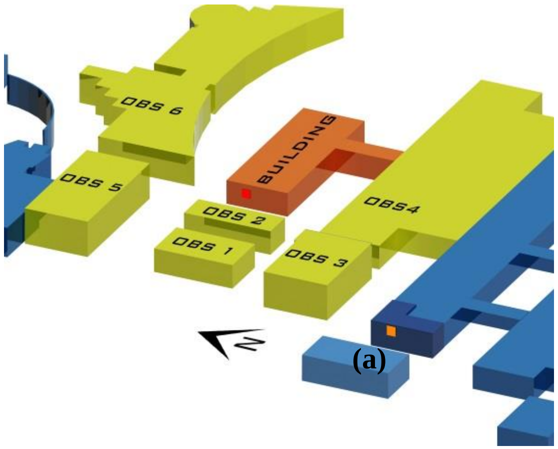
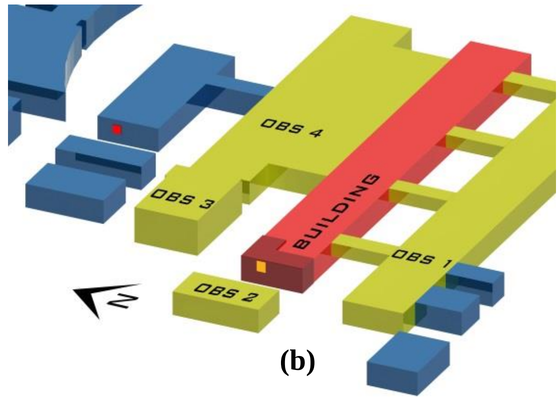
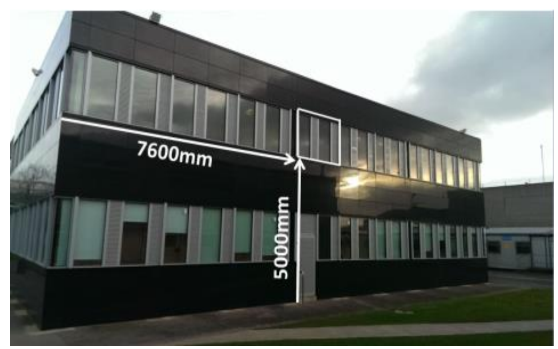
Experimental Setup

Control Space

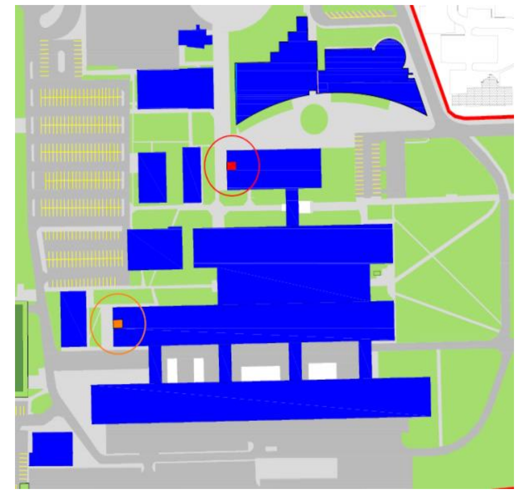


Retrofit Space





Site Plan



TNO Webapplications
Cp Generator

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Materials and Methods

- Concentration Decay Method used with ACH calculated using linear regression technique and C_N
- 25 ACH retrofit space / 13 ACH control space tests completed
- Full scale, normal operation modes for all tests
- Test method, experimental set up and ACH results published in IJV and not discussed further here

Ventilation rate test results published in IJV:

Paul D O Sullivan and Maria Kolokotroni (2014) Time-averaged single sided ventilation rates and thermal environment in cooling mode for a low energy retrofit envelope system. *International Journal of Ventilation:* September 2014, Vol. 13, No.2, pp. 153-168

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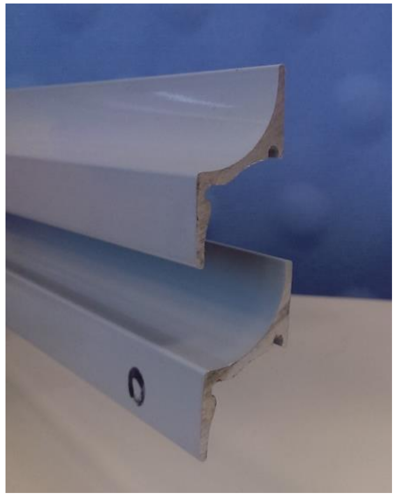
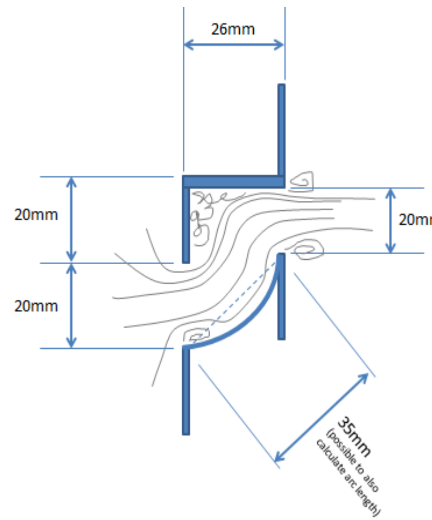
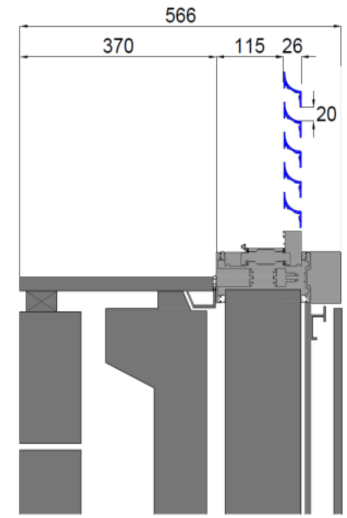
Ventilation Component







CS.01

RS.02

RS.03

RS.04

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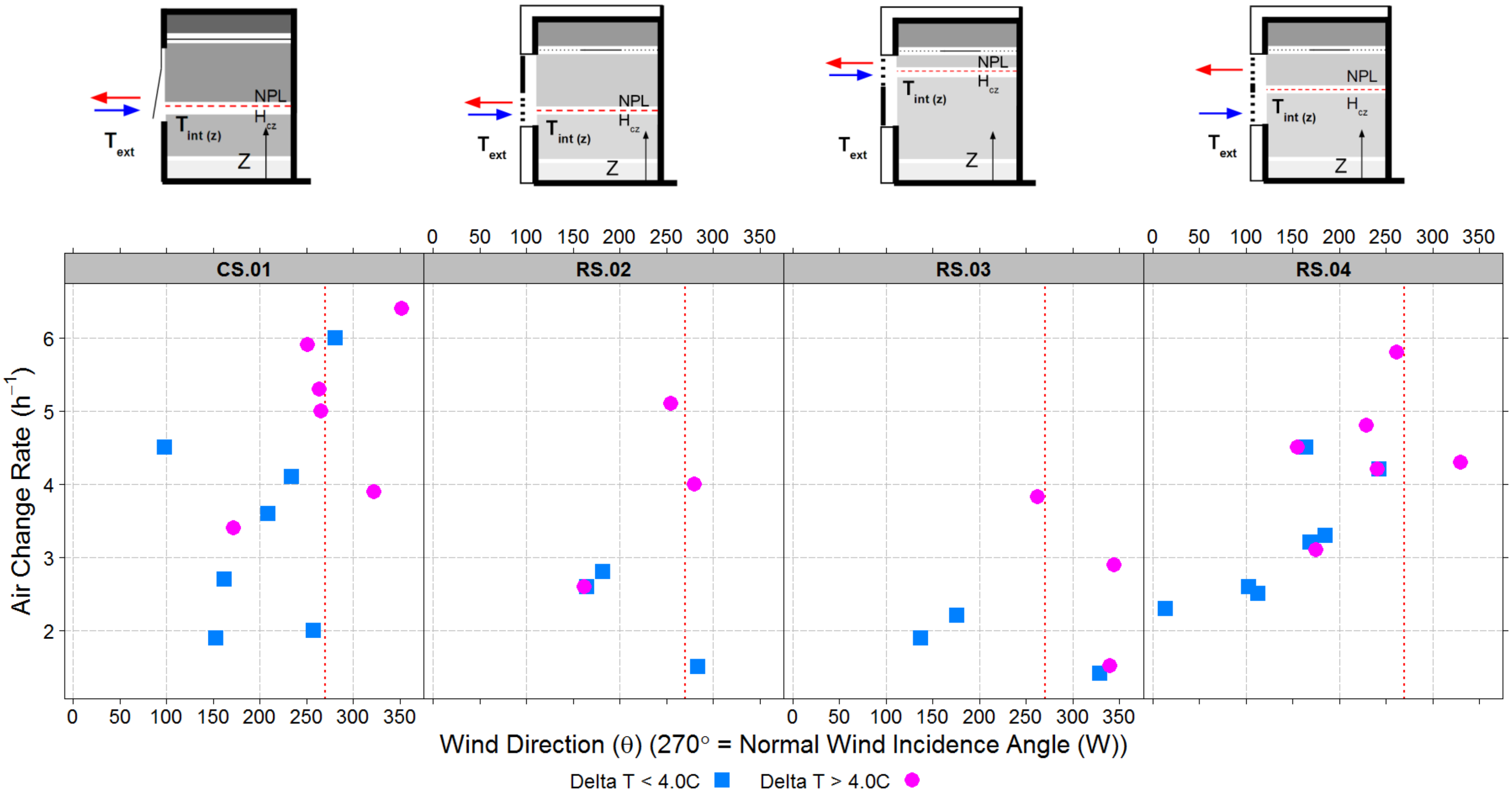
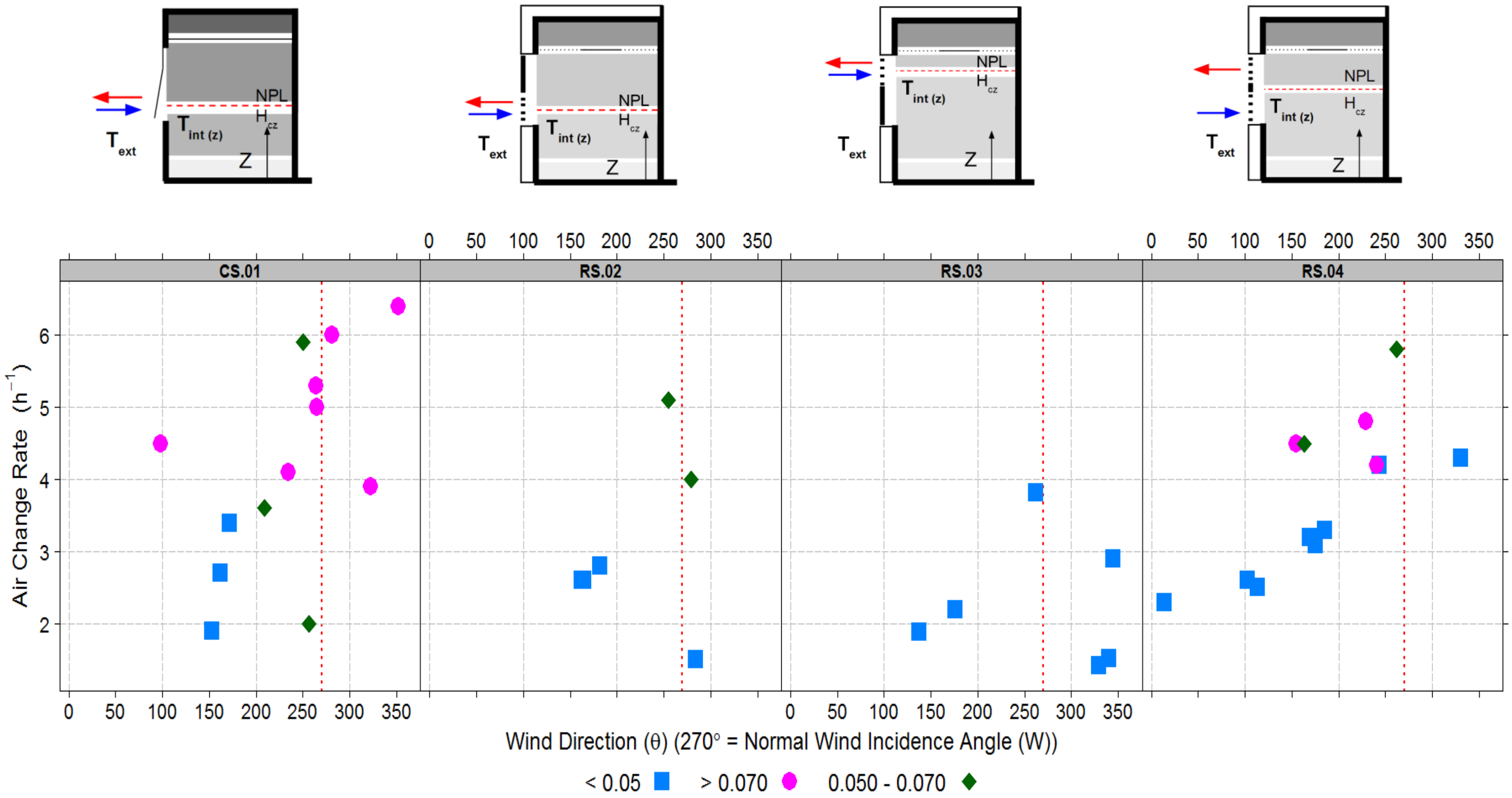
Results - ΔT_{ie}



Test Config ventilation rates (h^{-1}) as a function of wind direction grouped according to ΔT_{ie}

Results - σ_c



Test Config ventilation rates (h^{-1}) as a function of wind direction grouped according to σ_c

Summary of Findings

- Largest ACH at $\Delta T_{ie} > 4.0°K$ in retrofit and control spaces
- Wind direction influenced magnitude of ACH for RS config
- Wind direction influence magnitude of σ_c for RS config
- However, consistently higher σ_c values in control space
- ACH a function of ΔT_{ie} & σ_c irrespective of wind direction & opening geometry

Analysis of Driving Forces

Archimedes number, $Ar = (Gr/Re^2)$ described as:

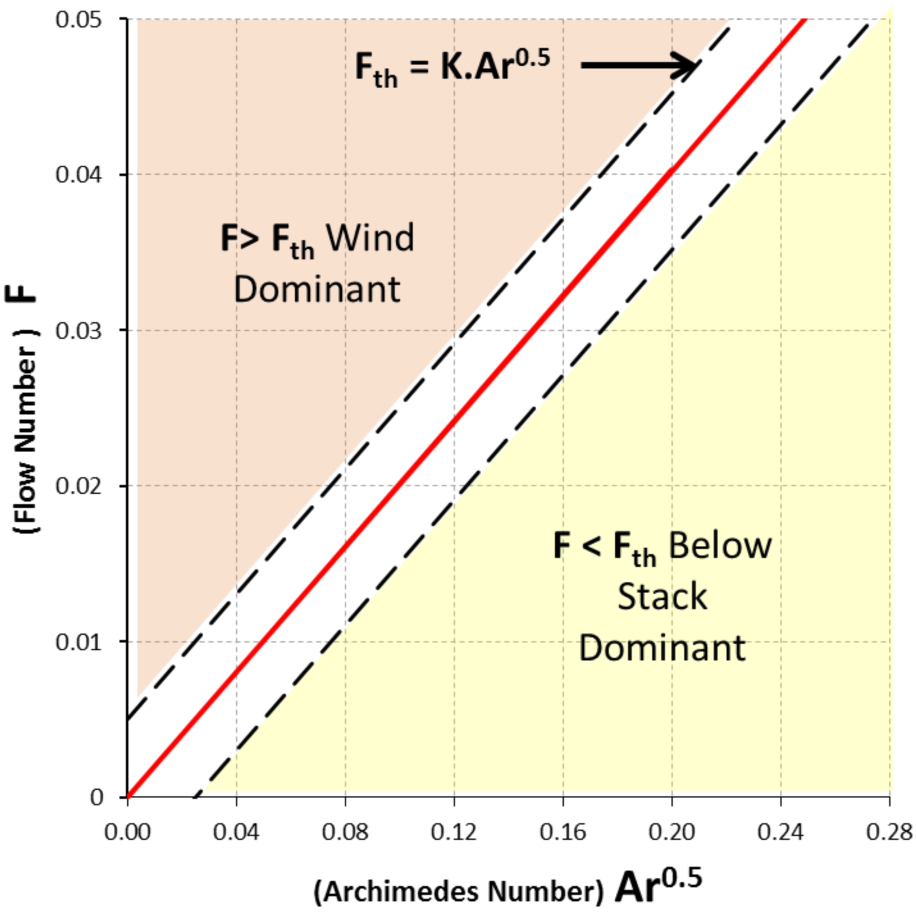
$$Ar^{0.5} = \frac{\Delta T g H}{T v_{wind}^2}$$

Dimensionless Flow number, F, described as:

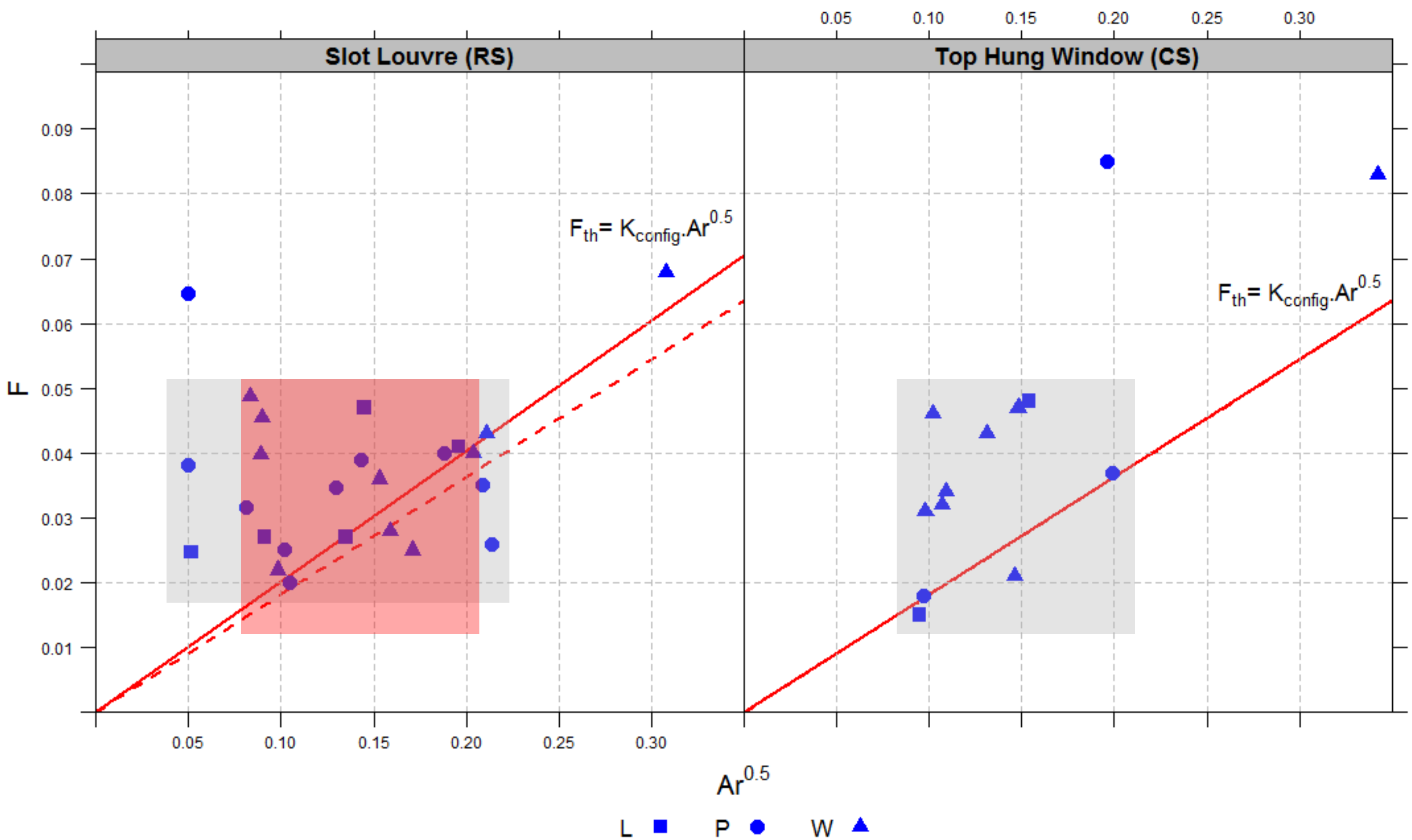
$$F = \frac{q_{ACH}}{A_{eff} v_{wind}}$$

The use of a flow number due to thermal stack effect alone, F_{th}, is introduced to the plot.

$$F_{th} = K.Ar^{0.5} \text{ (Stack Dominant)}$$

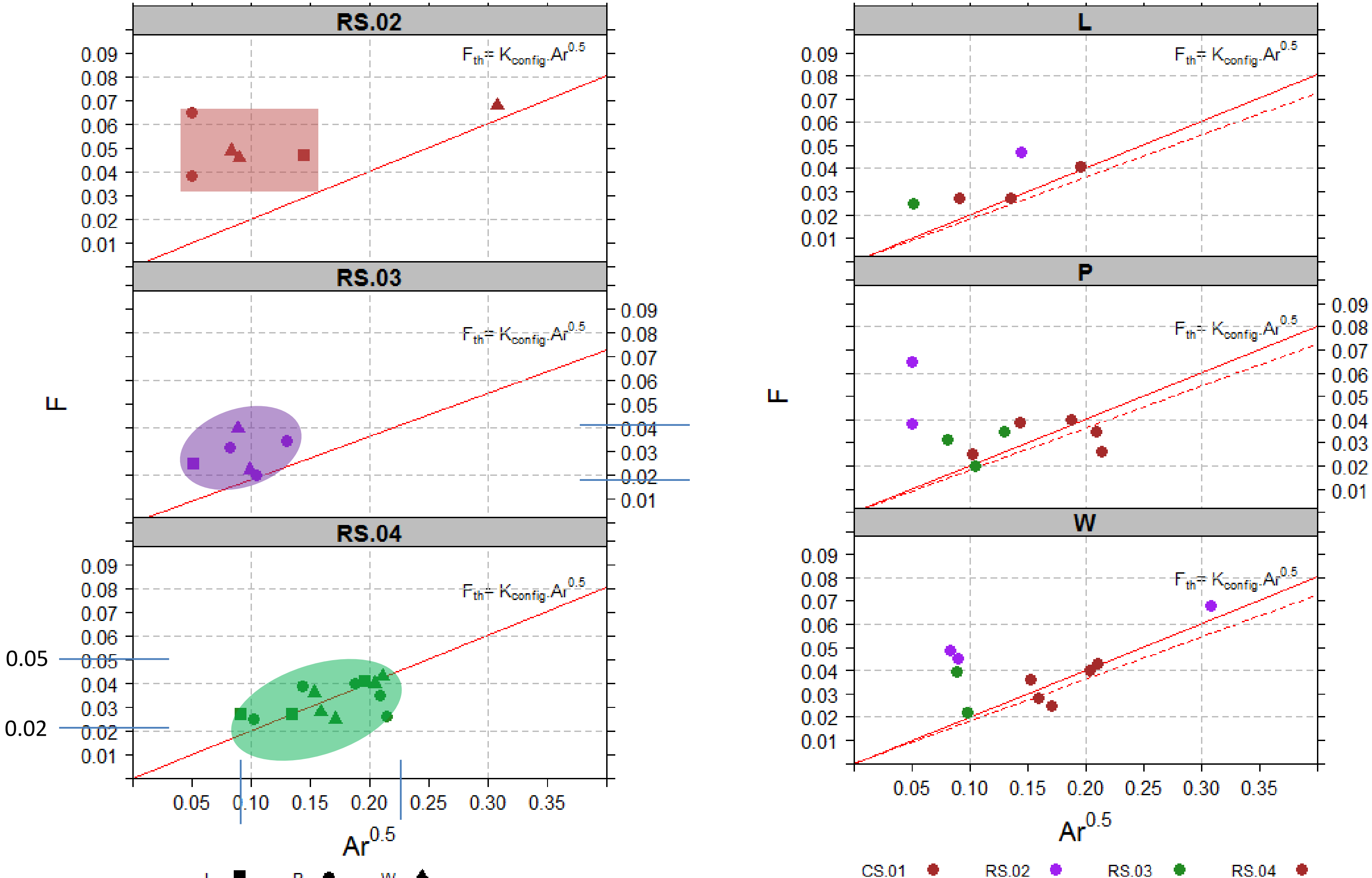


Analysis of Driving forces



Warren plots for slot louvre system in RS and top hung window in CS. (F_{th} shown in red)

Analysis of Driving Forces



Warren plot categorised according to configuration and wind direction. (F_{th} shown in red)

Overall Conclusions

- ACH generally increased according to ΔT_{ie} and σ_c for all tested spaces
- Ventilation rate and character shown to be influenced by both wind direction & opening geometry for louver ventilation system
- No substantial difference in driving forces for RS and CS
- Different driving force patterns emerge according to opening height and opening location in RS
- At Low $Ar^{0.5}$ wind incidence angle more important in determining whether wind is dominant

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Challenges & Future Work

Challenges

- Boundary conditions needed at opening – local phenomena
- Effects of complex geometry of opening insulated doors -
- Improved understanding of cause and impact of σ_c
- Translation to cooling potential of the system

Current & Future Work

- 44 additional tests completed already in summer 2014
- Boundary conditions measured at the opening
- Inc temp resolution of Velocity & Temp at opening & within space
- Single opening tested with & without louvre, retrofit space only
- CFD model planned to investigate cooling potential of the system

Thank you.