Sydney Metro

PITT STREET SOUTH OVERSTATION DEVELOPMENT

Response to Submissions

State Significant Development, Development Application (SSD DA)

Prepared for **Pitt Street Developer South Pty LTD**

1 September 2020

Version [01]

SMCSWSPS-CPP-OSS-PL-REP-000001

Natural ventilation study for

PITT STREET SOUTH OSD

Sydney, Australia

CPP PROJECT: 13824

September 2020

PREPARED FOR:

Pitt Street Developer South Pty Ltd

PREPARED BY:

Christian Rohr, CFD Manager

CPP Pty Ltd

Unit 2, 500 Princes Highway

St Peters, NSW 2044

info-syd@cppwind.com

www.cppwind.com

EXECUTIVE SUMMARY

Computational Fluid Dynamics modelling has shown that the casement windows proposed for the south façade of the development and set in deep recesses between adjacent GRC columns cause additional flow resistance compared with a simple opening. This agrees with commentary provided by both City of Sydney and the DPIE. The resistance is removed if the casement windows are reversed to swing inwards. Equivalent areas of the various systems have also been provided.

Flow rates of outside air due to natural ventilation driven by wind have been calculated for representative apartments in the proposed development at each half hour for the time between 2010 and 2018. Despite the increase in resistance caused by the south-facing casement windows, all tested apartments significantly exceed the criteria provided in the City of Sydney draft guideline for natural ventilation in noisy environments (City of Sydney, 2018).

DOCUMENT VERIFICATION

Date	Revision	Prepared by	Checked by	Approved by
31/08/20	Draft report	CR	AVD	PB
01/09/20	Added cover pages	CR	CR	CR

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1 INTRODUCTION

This anaylsis report has been prepared in response to the requirements contained within the Department of Planning, Infrastructure and the Environment (DPIE) Response to Submission (RTS) dates 8 July 2020. Specifically, this report has been prepared to respond to the DPIE and City of Sydney requirements in relation to the developments ability to provide adequate natural ventilation. The relevant responses to submission are reproduced below:

Department of Planning, Infrastructure and the Environment

(d) Demonstrate a reasonable level of privacy and amenity can be maintained between the proposed building and adjoining Princeton Apartments, including further consideration of:

** the appropriateness of the location and design of the proposed communal open space adjacent to the Princeton Apartments on Level 6*

** any potential maintenance and acoustic issues from the proposed ventilation slots for south facing units*

Review and revise the proposal with respect to compliance with SEPP 65 and the Apartment Design Guidelines (ADG) (as required by Condition B3(h) of the Concept Approval), including further consideration and illustration of:
** how the proposed light-well, window and balcony designs will achieve adequate ventilation and natural cross-ventilation*

City of Sydney

"The proposed full height casement (operable) windows to the residential living rooms do not provide adequate natural ventilation, as the opening is only 125mm and is obstructed by the deep reveal within 2m of the opening. The window design should be revised to provide the maximum natural ventilation possible whilst reducing external noise."

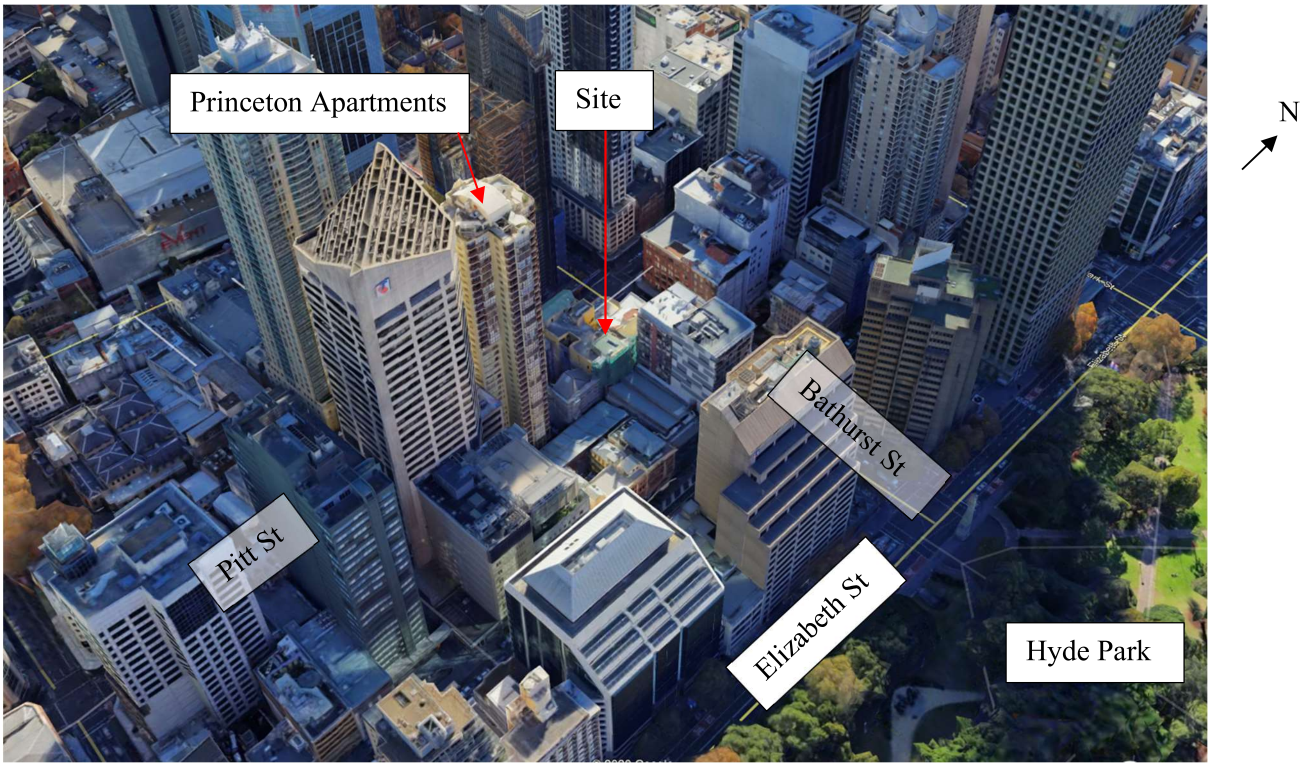


Figure 1: Site Context (Google Earth, 2020)

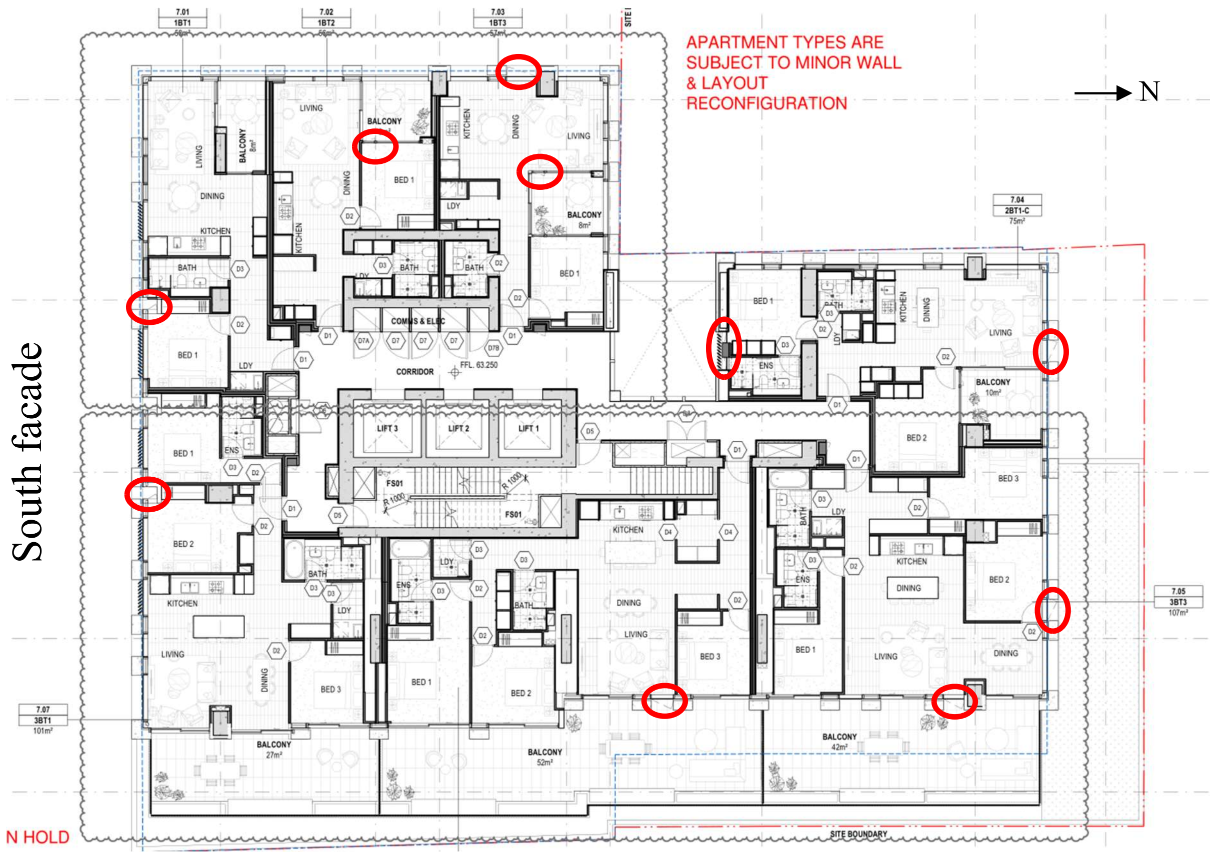


Figure 2: Level 7 floor plan (casement windows circled red)

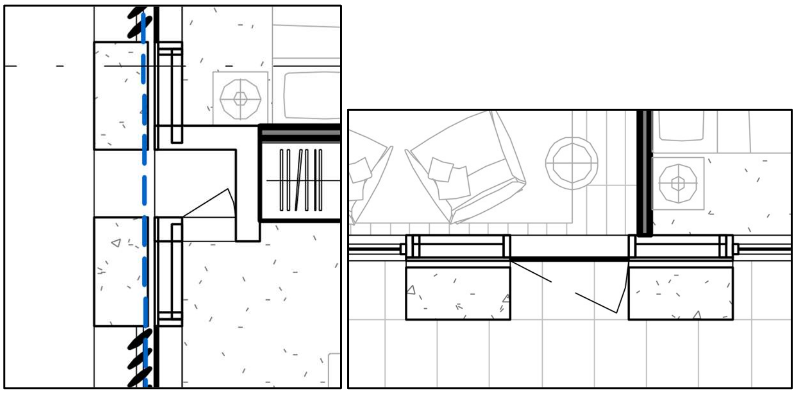


Figure 3: Casement window detail on south (L) and east façade (R)

A full list of apartments and their opening types is provided in Table 2. The opening types are described in Table 1. Pressure loss coefficients are derived from a Computational Fluid Dynamics (CFD) study detailed in Section 2.

Table 1: Opening sizes and pressure loss coefficients for analysis

Name	Height Dimension (m)	Open Dimension (m)	Open Area (m^2)	Pressure loss coefficient
Casement South	2.60	0.13	0.33	5.67
Casement	2.60	0.13	0.33	1.81
Casement Balcony	2.60	0.35	0.91	1.81
Casement Double	2.60	0.25	0.65	1.81
Slider big	2.60	1.00	2.60	2.81
Slider small	2.60	0.60	1.56	2.81

Table 2: Apartment opening details, coloured by façade

Note		Façade 1	Façade 2	Bed 1	Bed 2	Bed 3	Living A	Living B	Living C
With terraces on east side	L7.01	South	West	Casement South			Slider big		
	L7.02	West		Casement Balcony			Slider big		
	L7.03	West	North	Casement Balcony			Casement	Casement Balcony	Slider Big
	L7.04	West	North	Casement Double	Casement Balcony		Casement	Slider Big	
	L7.05	North	East	Slider small	Casement		Slider small	Casement	Slider small
	L7.06	East		Slider big	Slider big	Slider small	Casement	Slider small	
	L7.07	East	South	Casement South	Casement South	Slider small	Slider small	Slider small	
As below but with balconies instead of terraces	L8.01	South	West	Casement South			Slider big		
	L8.02	West		Casement Balcony			Slider big		
	L8.03	West	North	Casement Balcony			Casement	Casement Balcony	Slider Big
	L8.04	West	North	Casement Double	Casement Balcony		Casement		
	L8.05	North	East	Slider small	Casement		Slider small	Casement	Slider small
	L8.06	East			Casement balcony	Slider small	Casement	Slider small	
	L8.07	East	South	Casement South	Casement South	Slider small	Slider small	Slider small	
East side adds 2 apartments by splitting L8 05, 06 and 07	L9-10.01	South	West	Casement South			Slider big		
	L9-10.02	West		Casement Balcony			Slider big		
	L9-10.03	West	North	Casement Balcony			Casement	Casement Balcony	Slider Big
	L9-10.04	West	North	Casement Double	Casement Balcony		Casement	Slider Big	
	L9-10.05	North	East	Casement Balcony			Slider big	Casement	Casement
	L9-10.06	East		Slider small			Casement	Slider small	
	L9-10.07	East		Slider small			Casement	Slider small	
	L9-10.08	East		Casement Balcony			Slider small		
	L9-10.09	East	South	Casement South	Casement South		Slider small	Slider small	
As below	L11-13.01	South	West	Casement South			Slider big		
	L11-13.02	West		Casement Balcony			Slider big		
	L11-13.03	West	North	Casement Balcony			Casement	Casement Balcony	Slider Big
	L11-13.04	West	North	Casement Double	Casement Balcony		Casement	Slider Big	
	L11-13.05	North	East	Casement Balcony			Slider big	Casement	Casement
	L11-13.06	East		Slider small			Casement	Slider small	
	L11-13.07	East		Slider small			Casement	Slider small	
	L11-13.08	East		Slider small			Slider small		
	L11-13.09	East	South	Casement South	Casement South		Slider small	Slider small	
Apartments enlarged and removed on east side	L14-32.01	South	West	Casement South			Slider big		
	L14-32.02	West		Casement Balcony			Slider big		
	L14-32.03	West	North	Casement Balcony			Casement	Casement Balcony	Slider Big
	L14-32.04	West	North	Casement Double	Casement Balcony		Casement	Slider Big	
	L14-32.05	North	East	Slider small	Casement Balcony		Slider big	Casement	Casement
	L14-32.06	East		Slider small	Casement Balcony		Casement		
	L14-32.07	East		Slider big	Casement Balcony		Slider big		
	L14-32.08	East	South	Casement South	Casement South		Slider small	Casement	
As below	L33-34.01	South	West	Casement South			Slider big		
	L33-34.02	West		Casement Balcony			Slider big		
	L33-34.03	West	North	Casement Balcony			Casement	Casement Balcony	Slider Big
	L33-34.04	West	North	Casement Double	Casement Balcony		Casement	Slider Big	
	L33-34.05	North	East	Slider small	Casement Balcony		Slider big	Casement	Casement
	L33-34.06	East		Slider small	Casement Balcony		Casement		
	L33-34.07	East		Slider big	Casement Balcony		Slider big		
	L33-34.08	East	South	Casement South	Casement South		Slider small	Casement	

2 VENTILATION EFFECTIVENESS OF OPENINGS

Airflow into an apartment through any opening is driven by differential pressures induced at the opening by wind flowing around the exterior of the development. The flow rate through an opening such as a sliding door, window, or other contraction can be approximated with the following equation:

$$Q = A\sqrt{\frac{2(p_{outside} - p_{inside})}{\rho k}}\, m^3/s$$

Where A is the area's opening size, and k is a pressure loss coefficient relating average speed through the opening to pressure drop induced by flow passing through the opening. Pressure is always lost when flow passes through an opening, so the differential pressure in the flow direction is always positive.

Discharge coefficient is sometimes used in place of the pressure loss coefficient. It represents the reduction in flow rate due to the resistance (or pressure loss) created by the opening. A sash window can be represented as a sudden contraction followed by a sudden expansion (an orifice). The discharge coefficient of such an opening is approximately 0.6-0.7, although this can vary depending on the details of the orifice and the size of the two connected volumes. In other words, if an orifice of area A were placed in a duct, the flow rate would reduce to 60-70% of the flowrate originally passing through that area A. Discharge coefficient is usually denoted as C_d despite drag coefficient sharing the same symbol.

$$C_d = \frac{1}{\sqrt{k}}$$

Extending the concept of discharge coefficient by normalising against the value for a typical orifice, an effective aerodynamic area or area ratio can be derived. This is the effective size of the opening when the loss created by the opening details is accounted for. As such, a typical opening would have an effective area ratio of 1. An opening which smoothly passes flow in and out of a room could have a ratio greater than 1, while a very lossy opening with many 90° bends would have a ratio less than 1.

A CFD analysis of the deep window in both an in and out-swinging configuration has been conducted, along with a simple opening (emulating a sash window to the recess), the more shallow recess casement window of non-south facades (and balcony casement windows), and simple orifices to represent sliding doors.

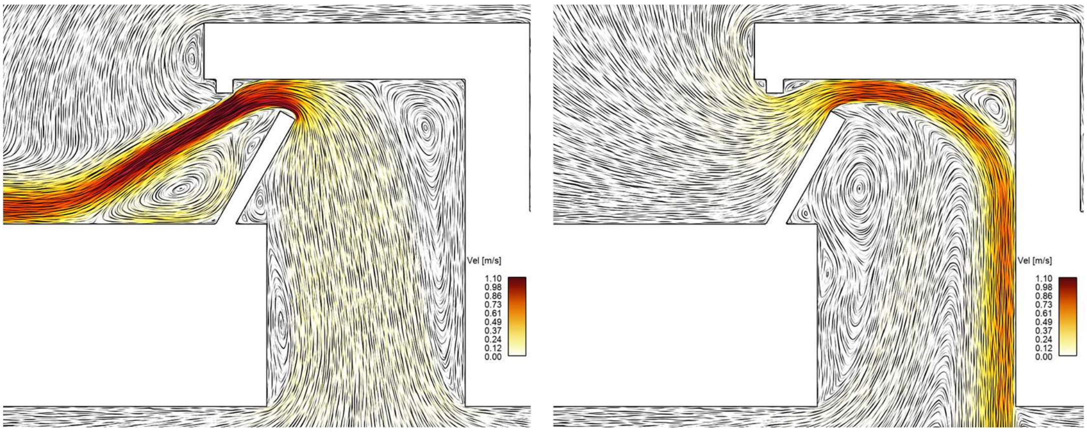


Figure 4: Flow in and out of an out-swinging casement window in a deep recess with 125 mm opening

Table 3: Predicted aerodynamic performance of different opening types

Opening Type	Pressure loss coefficient			Min. Discharge Coefficient	Min. Area Ratio
	Flow in	Flow out	Max		
Casement, deep	5.06	5.67	5.67	0.42	0.64
Casement inswing, deep	1.89	1.96	1.96	0.71	1.09
Sash, deep	3.74	3.32	3.74	0.52	0.79
Casement, non-south	1.81	1.50	1.81	0.74	1.13
Sliding Door	2.31	2.31	2.31	0.66	1.00
Casement, non-south, no GRC	1.54	1.79	1.79	0.75	1.14

It is evident from results provided in Table 1 that the deep recess casement windows do cause additional resistance against flow compared to a simple sash window in the same recess, with the flow rate reduced by about 20% when an out-swinging casement window with the same open area is used. However, all of this deficit can be eliminated with an in-swinging casement window which shows a significant reduction in resistance, also outperforming the sash window opening. This is due to the specific flow path creating a more gradual contraction and expansion with fewer sharp bends, in both flow directions.

The casement windows not located within deep recesses but still framed by two GRC columns perform as well or better than a simple opening of the same size. These were simulated with the window extending out past the line of the columns to create a 125 mm opening. No significant change in resistance was noted when the obstructing GRC column (opposite the hinge) was removed.

Summary:

For equal flow rate through a deep recess casement window compared to a standard opening such as a sliding door or sash window not located within a recess, any of the following changes could be made:

- Increase open area by 56%
- Switch to a sash window and increase open area by 27%
- Switch to an in-swinging casement window with no increase in area required

The casement windows do not restrict airflow on other facades provided a 125 mm opening exists between the window and the columns.

3 AIRFLOW ANALYSIS

A bulk airflow analysis for each apartment shown in Table 1 has been conducted. This analysis simulates airflow through all apartment openings as a function of external pressures, opening areas, and pressure loss coefficients. Mean pressure coefficient data was collected at available pressure tap locations from wind tunnel testing previously conducted by CPP for cladding design (CPP, 2020). A small number of apartments required the use of pressure taps that were slightly displaced from the actual opening location. This is not expected to significantly alter the results. For apartment types spanning multiple levels, a set of pressure taps in the middle of the level range was selected. Pressure tap locations and coefficients (referenced to the site approach wind speed at 200 m) are provided in Appendices 2 and 3, reproduced from CPP (2020).

Pressure coefficients referenced to the site's approach wind speed and atmospheric boundary layer conditions were combined with corrected Sydney Airport data from the 2010-2018 period to generate a time series of external pressures at each opening of each apartment at half hourly increments. An iterative procedure was used to determine the balanced internal pressure for each combination of external pressures, before solving for the flow rate through each opening. The cumulative probability distribution function of flow rates into each apartment was generated from the time series of flow rates and subsequently interpolated to calculate flow rates achieved 90% of the time as an indicative metric of performance.

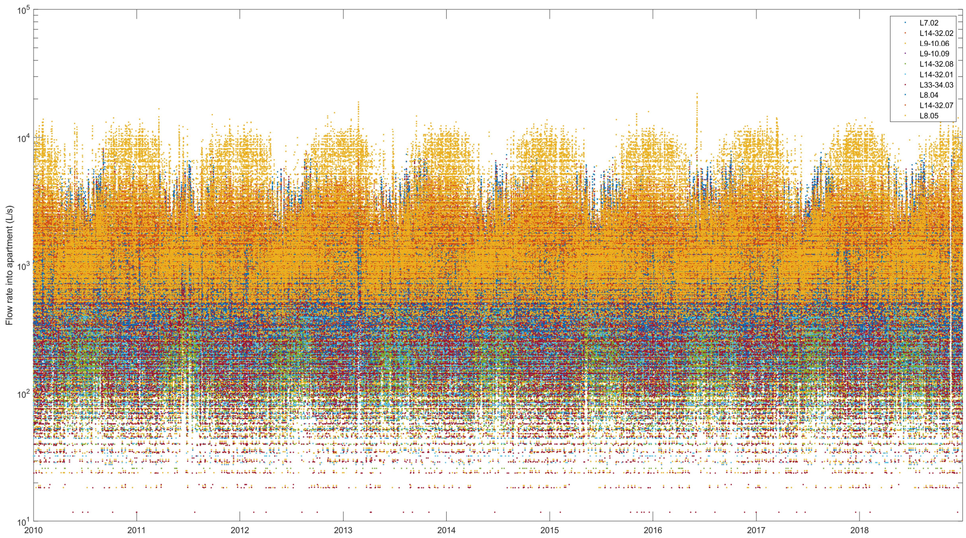


Figure 5: Example time series showing temporal evolution of flow rates

Data is summarized in Figure 6, with apartments relying on casement windows in deep recesses on the south façade highlighted in blue. The plot is presented on a logarithmic scale (some apartments have many more openings than others). The lowest performing "blue" apartment is 11-13.01, which has a single south-facing casement window and a single slider to a balcony. This apartment provides 83 L/s of fresh air at least 90% of the time, which is significantly more than the requirements of the draft guideline from the Sydney DCP for acoustically challenged apartments of 10 L/s/(bedroom+1).

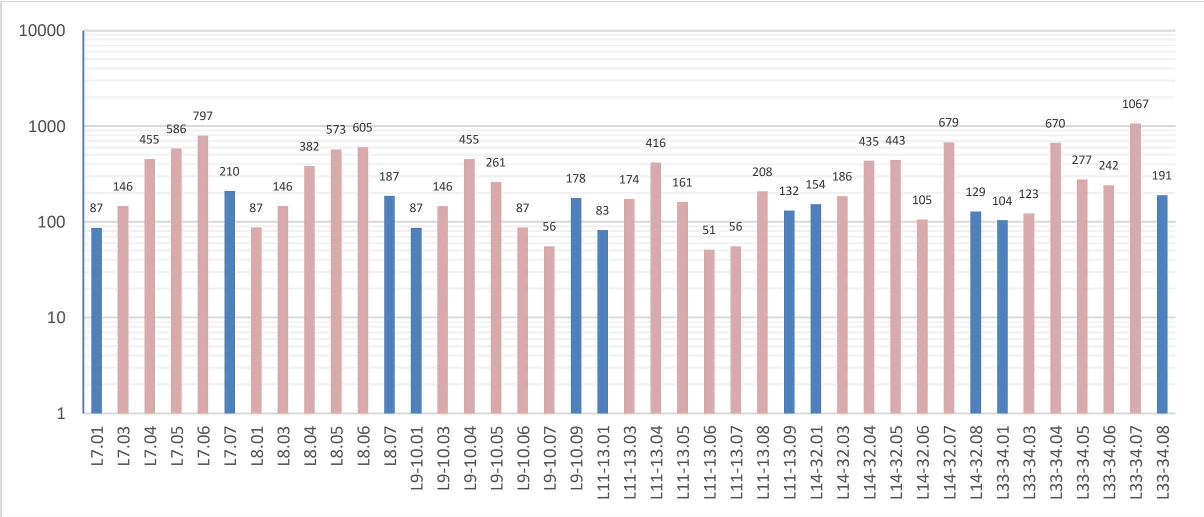


Figure 6: Flow rates into apartments exceeded 90% of the time, L/s

4 REFERENCES

Architectural drawing package provided 25-08-2020:

Type	Name
Elevations	SMCSWSPS-BAT-OSS-AT-DWG-300104-P1
	SMCSWSPS-BAT-OSS-AT-DWG-300101-P1
	SMCSWSPS-BAT-OSS-AT-DWG-300102-P1
	SMCSWSPS-BAT-OSS-AT-DWG-300103-P1
Slot Detail	Southern ventilation slot_preliminary detail
	Soutern ventilation slot inwards_preliminary detail
Plans	SMCSWSPS-BAT-OSS-AT-DWG-213341-A0
	SMCSWSPS-BAT-OSS-AT-DWG-210741-A4
	SMCSWSPS-BAT-OSS-AT-DWG-210841-A4
	SMCSWSPS-BAT-OSS-AT-DWG-210941-A4
	SMCSWSPS-BAT-OSS-AT-DWG-211141-A4
	SMCSWSPS-BAT-OSS-AT-DWG-211441-A4

New South Wales Government (2015), Department of Planning and Environment, *"Apartment Design Guide"*.

New South Wales Government (2015), Department of Planning and Environment, *"State Environmental Planning Policy No 65 – Design Quality of Residential Apartment Development (SEPP 65)"*

CPP (2020), Façade Pressure Wind Tunnel Tests for Pitt Street South OSD, April 2020. CPP Project 13824.

City of Sydney (2018), Alternative natural ventilation of apartments in noisy environments: Performance pathway guideline (draft)

APPENDIX 1: ADDITIONAL CFD RESULTS

Figures of local velocity as a ratio to velocity at narrowest point, for each test case.

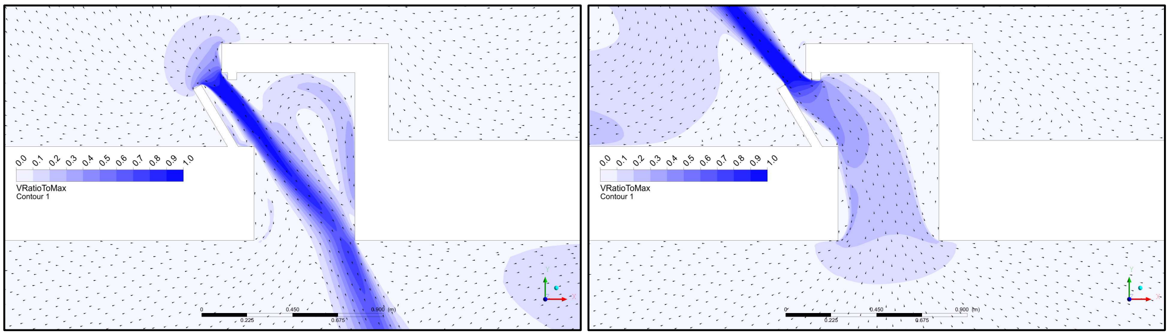


Figure 7: Relative velocity, deep in-swing casement

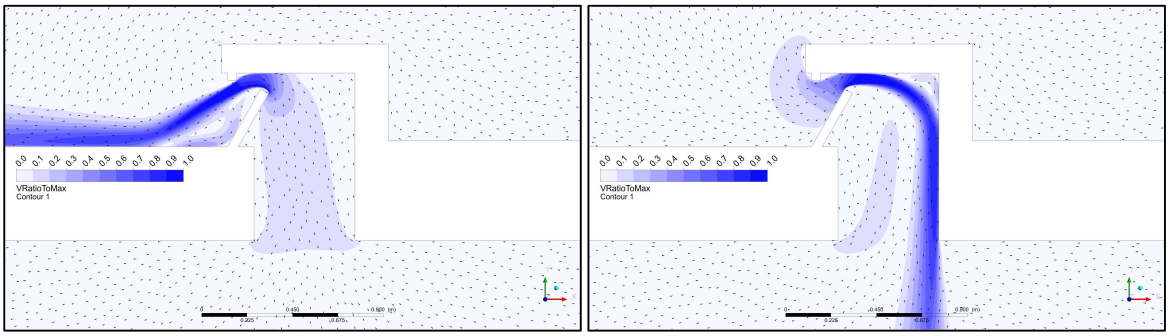


Figure 8: Relative velocity, deep out-swing casement

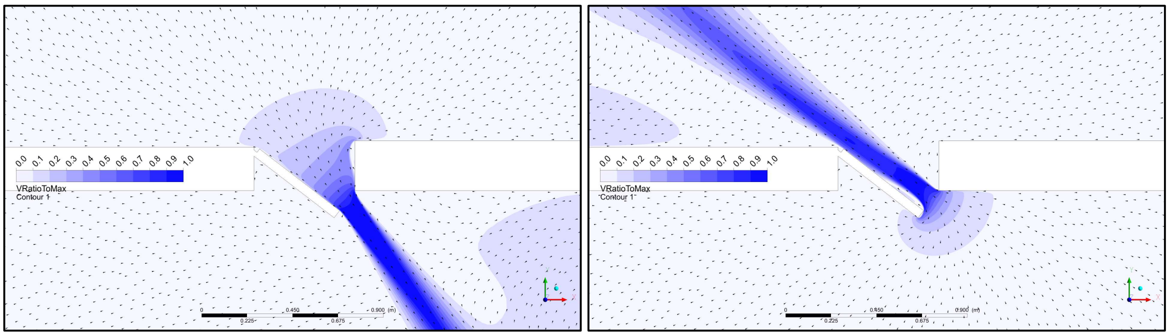


Figure 9: Relative velocity, shallow out-swing casement

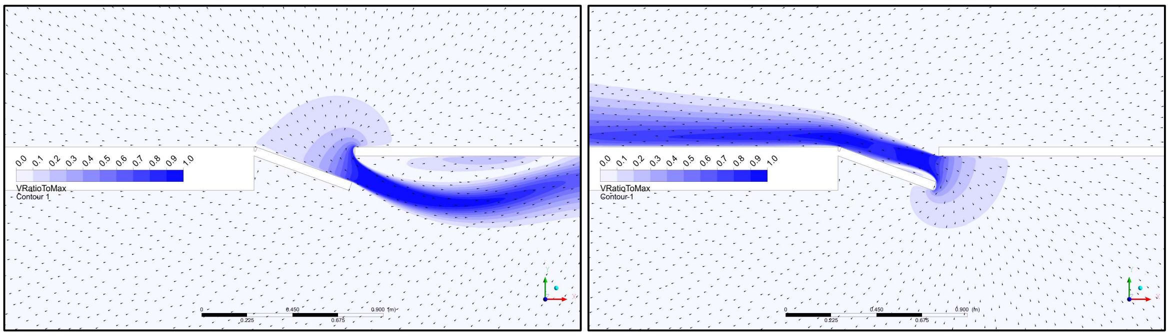


Figure 10: Relative velocity, shallow out-swing casement with no obstruction

Figures of local total pressure lost from supply:

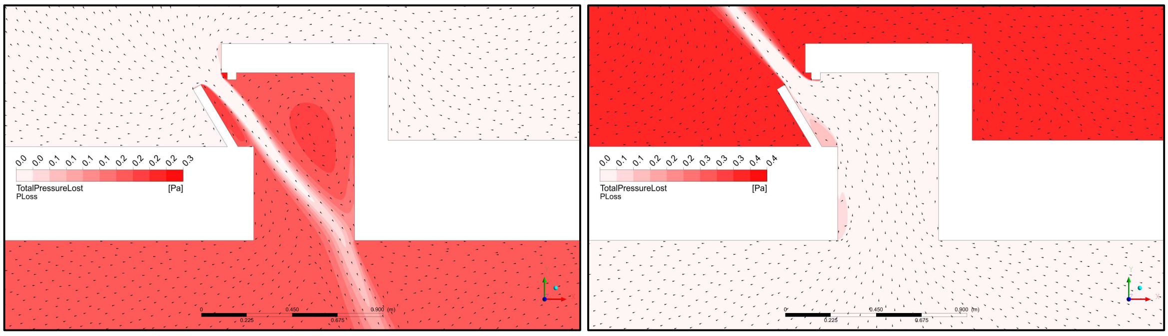


Figure 11: Relative velocity, deep in-swing casement

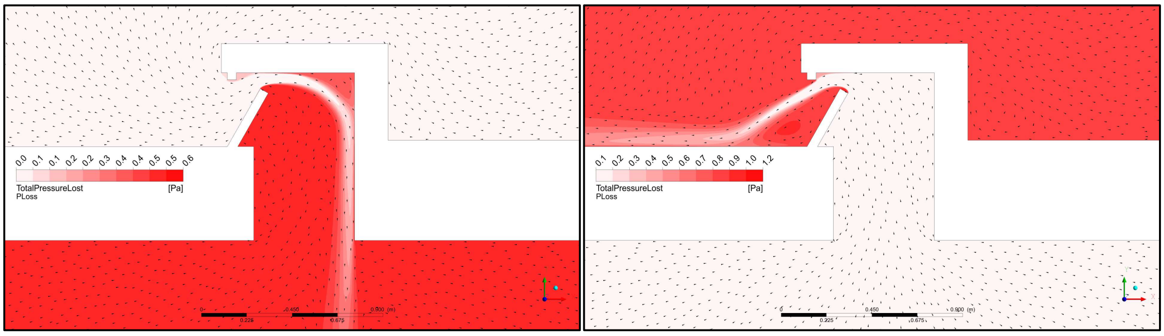


Figure 12: Relative velocity, deep out-swing casement

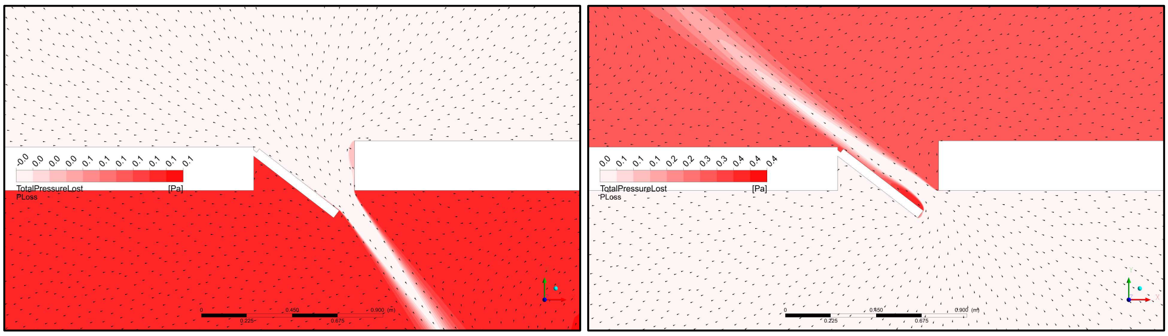


Figure 13: Relative velocity, shallow out-swing casement

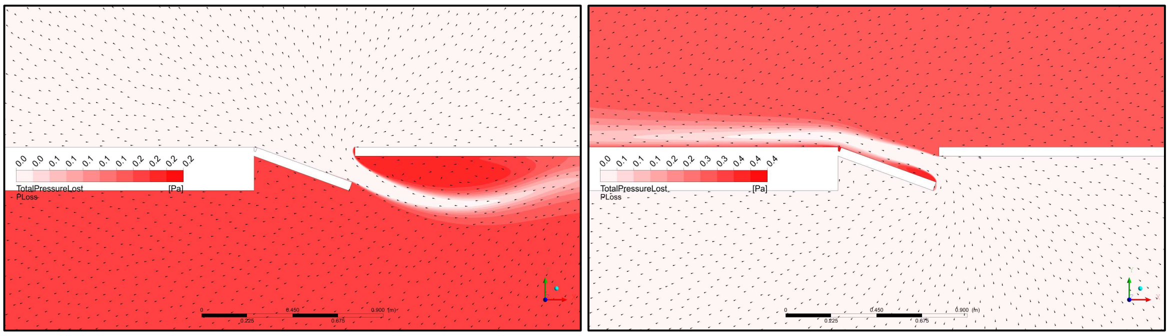


Figure 14: Relative velocity, shallow out-swing casement with no obstruction

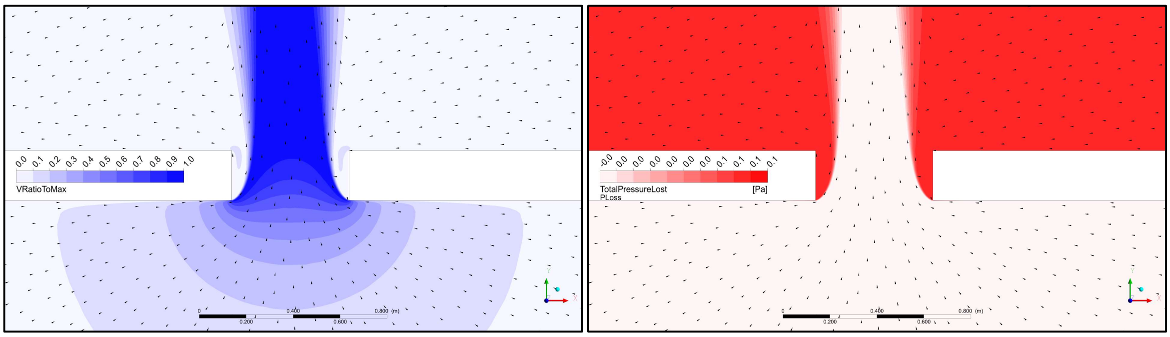


Figure 15: Example of flow through thick-walled orifice

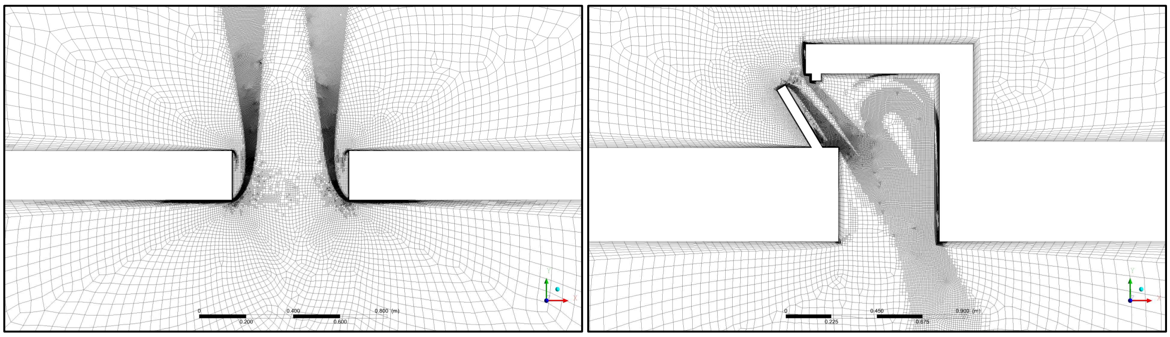
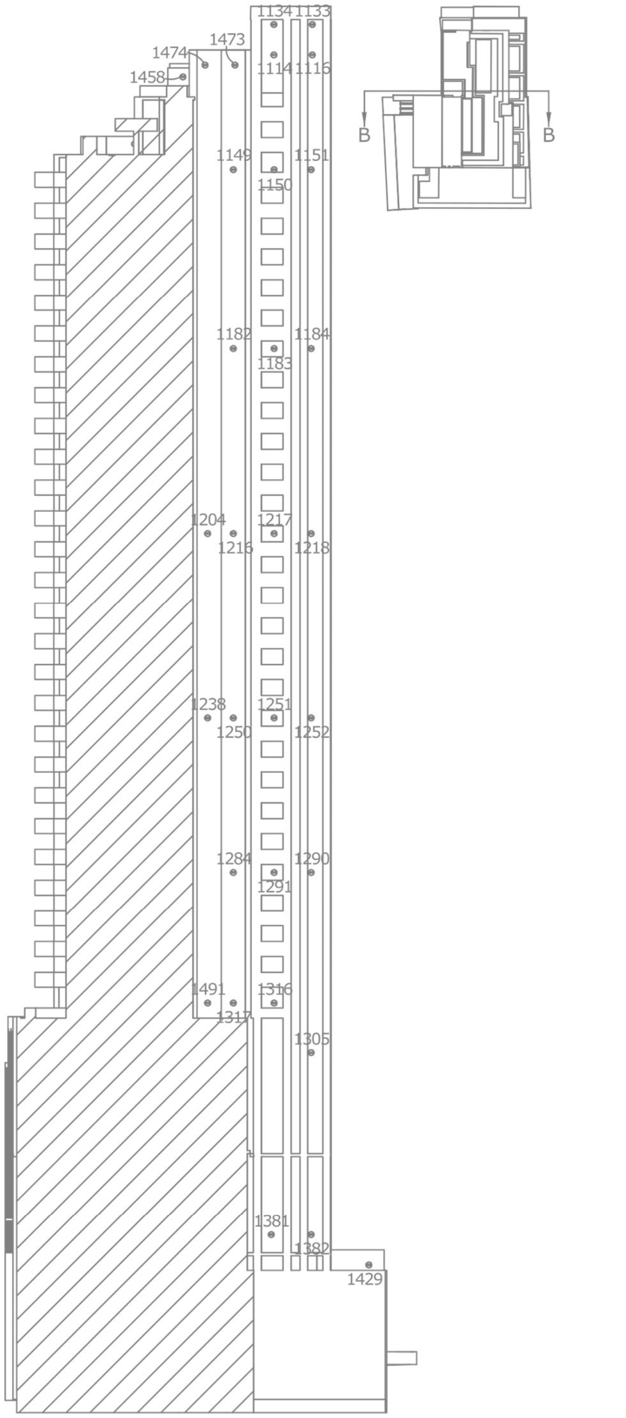


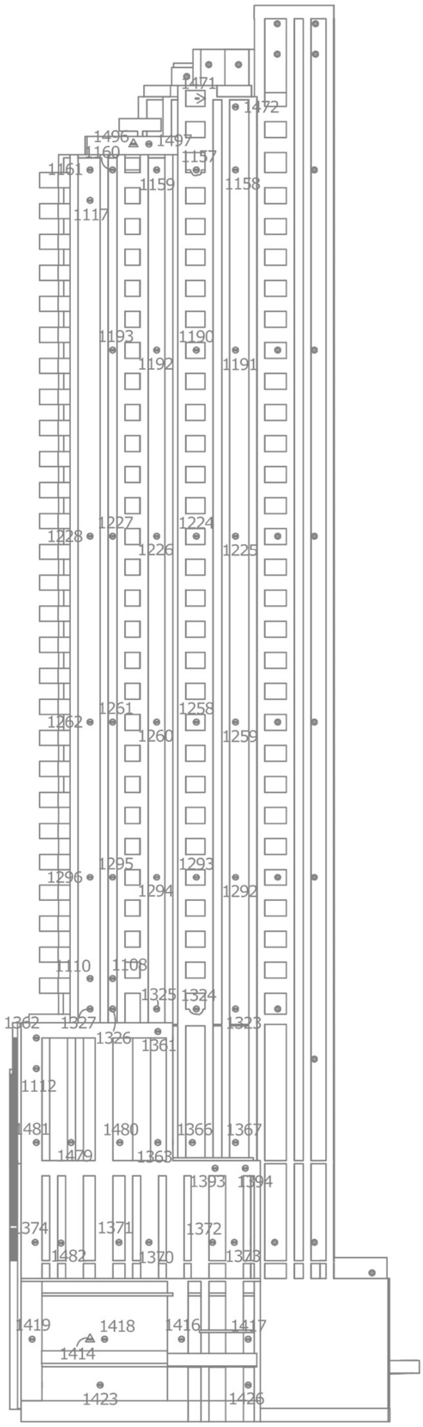
Figure 16: Examples of computational meshes with local adaptive refinement

APPENDIX 2: PRESSURE TAP LOCATIONS



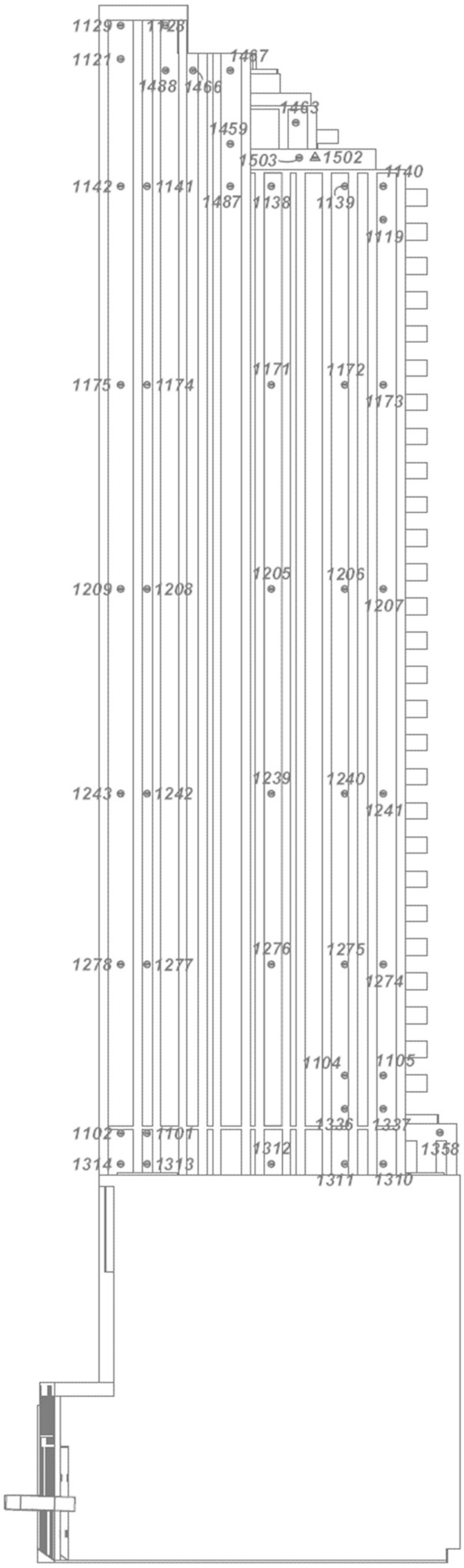
- Black taps represent taps seen and numbered on another view.
- Carets (<, >, ^ or v) indicate tap locations on a perpendicular surface.
- Δ indicates tap location on soffit or opposite side of surface shown.

Figure 17: Pressure tap locations – Section B-B.



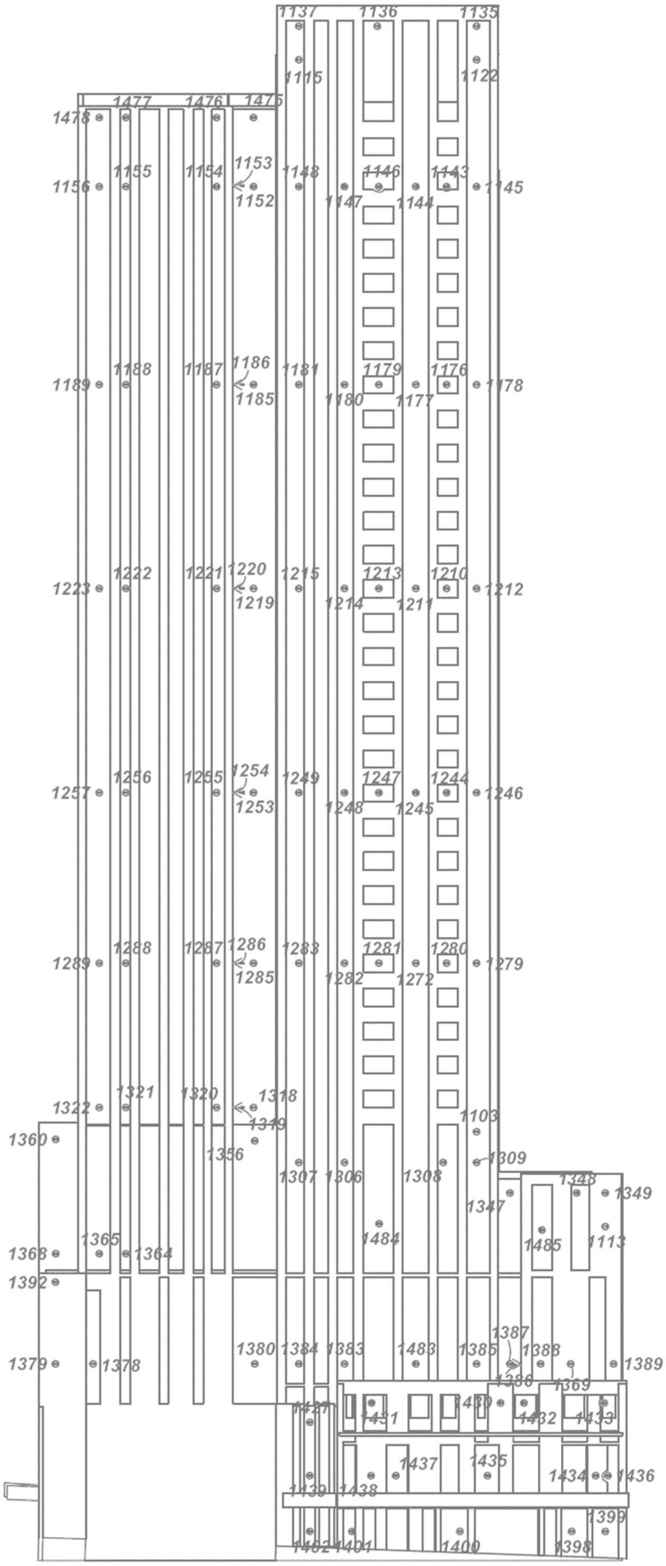
- Black taps represent taps seen and numbered on another view.
- Carets (<, >, ^ or v) indicate tap locations on a perpendicular surface.
- Δ indicates tap location on soffit or opposite side of surface shown.

Figure 18: Pressure tap locations – North elevation.



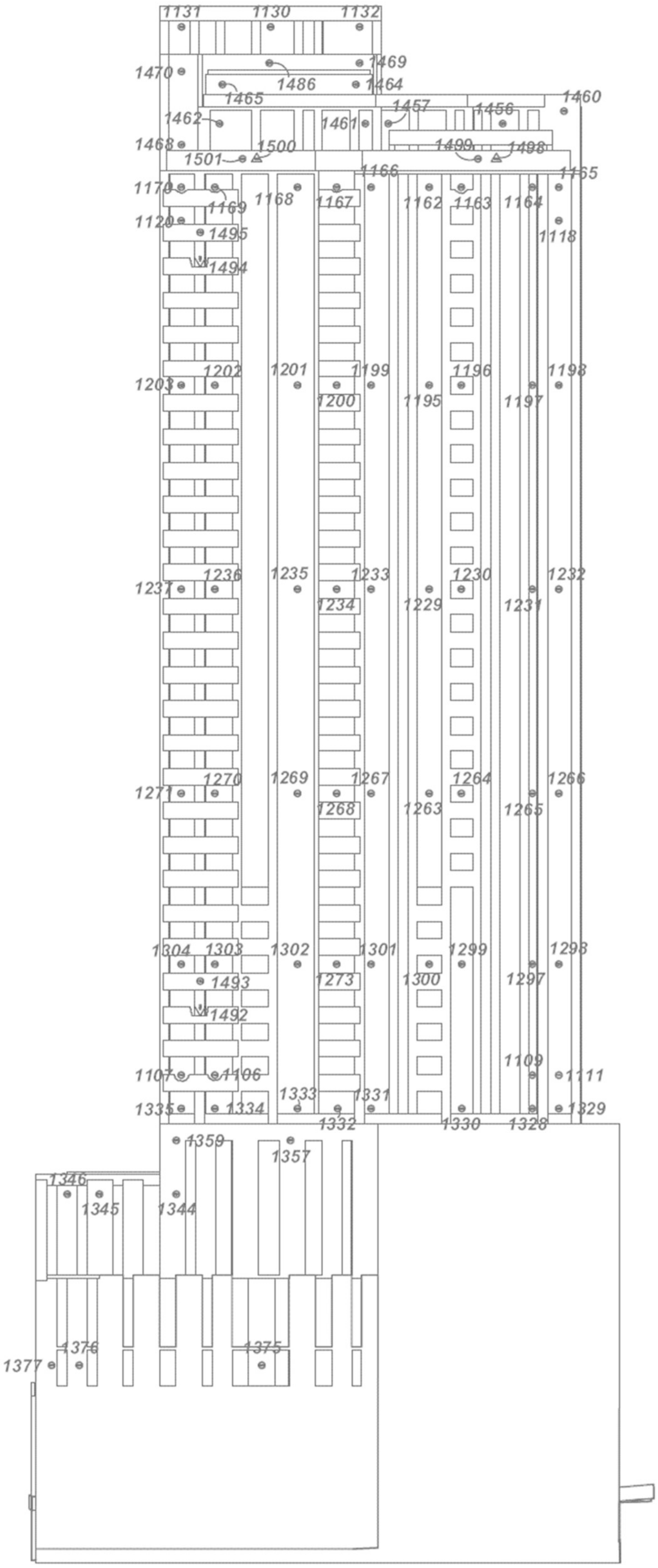
- Black taps represent taps seen and numbered on another view.
- Carets (<, >, ^ or v) indicate tap locations on a perpendicular surface.
- Δ indicates tap location on soffit or opposite side of surface shown.

Figure 19: Pressure tap locations – South elevation.



- **Black taps represent taps seen and numbered on another view.**
- **Carets (<, >, ^ or v) indicate tap locations on a perpendicular surface.**
- **Δ indicates tap location on soffit or opposite side of surface shown.**

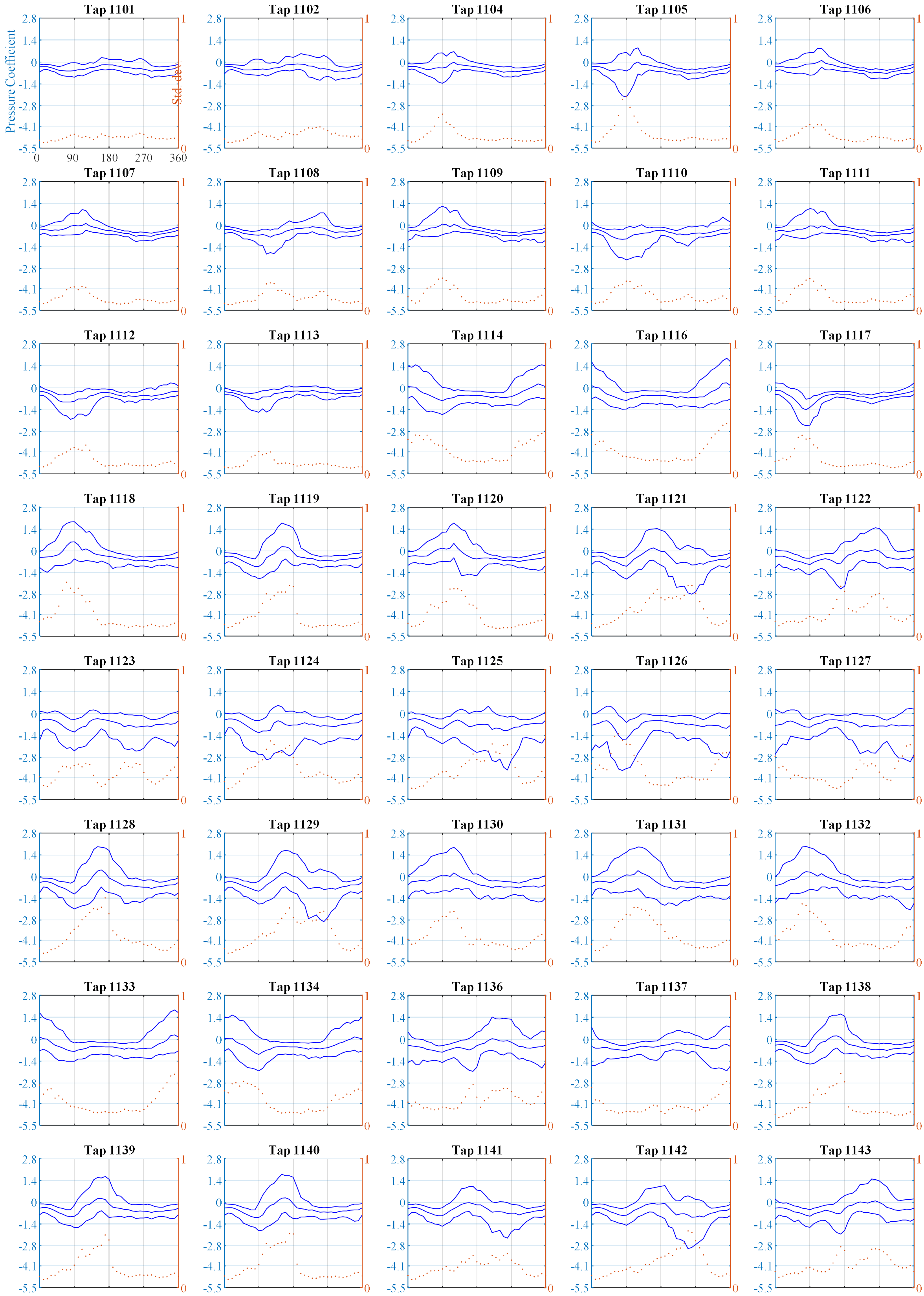
Figure 20: Pressure tap locations – West elevation.

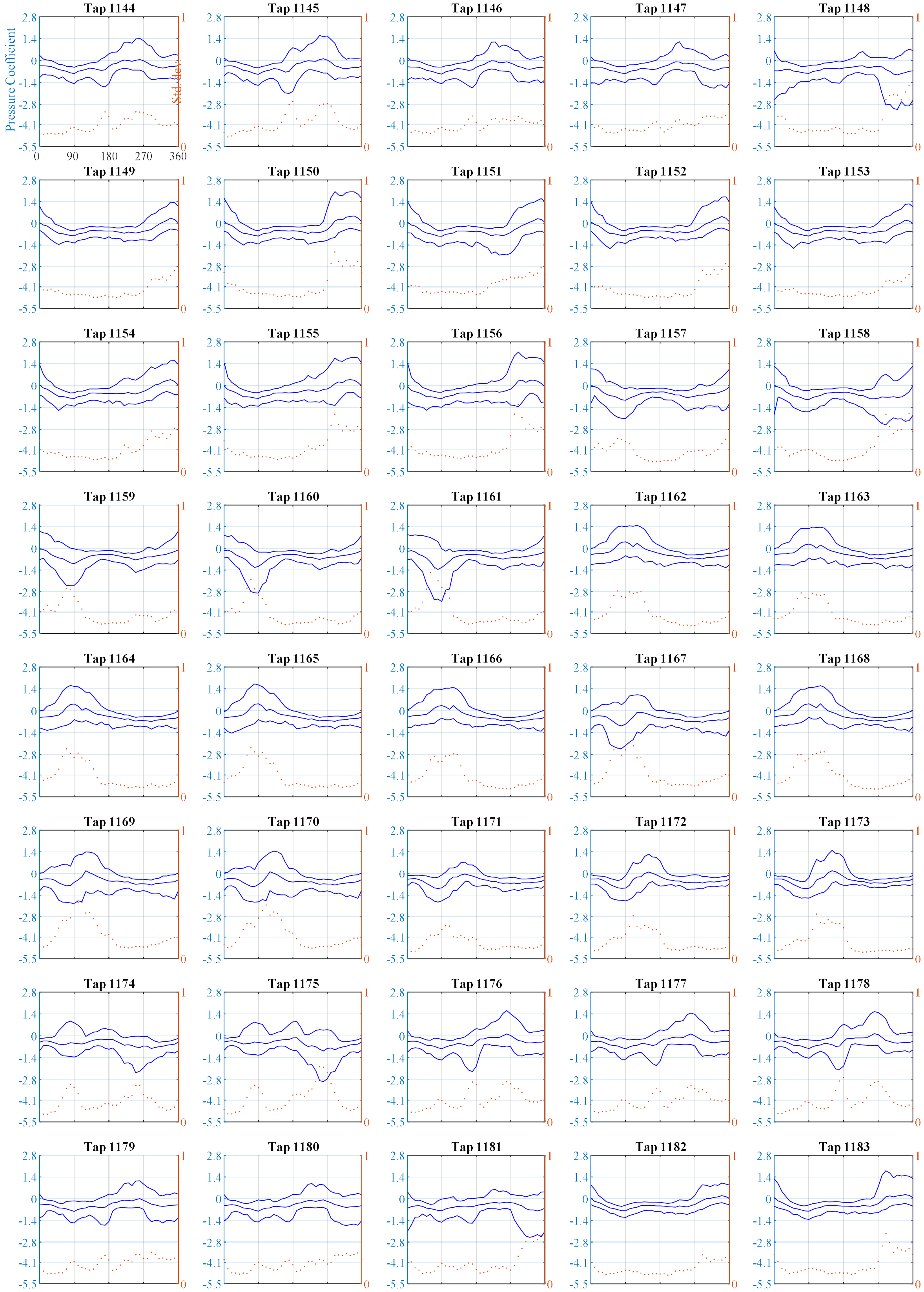


- Black taps represent taps seen and numbered on another view.
- Carets (<, >, ^ or v) indicate tap locations on a perpendicular surface.
- Δ indicates tap location on soffit or opposite side of surface shown.

Figure 21: Pressure tap locations – East elevation.

APPENDIX 3: PRESSURE COEFFICIENT DATA




Tap 1144
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Tap 1147
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Pressure Coefficient
Std dev
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1.4
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-4.1
-5.5
1
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0
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180
270
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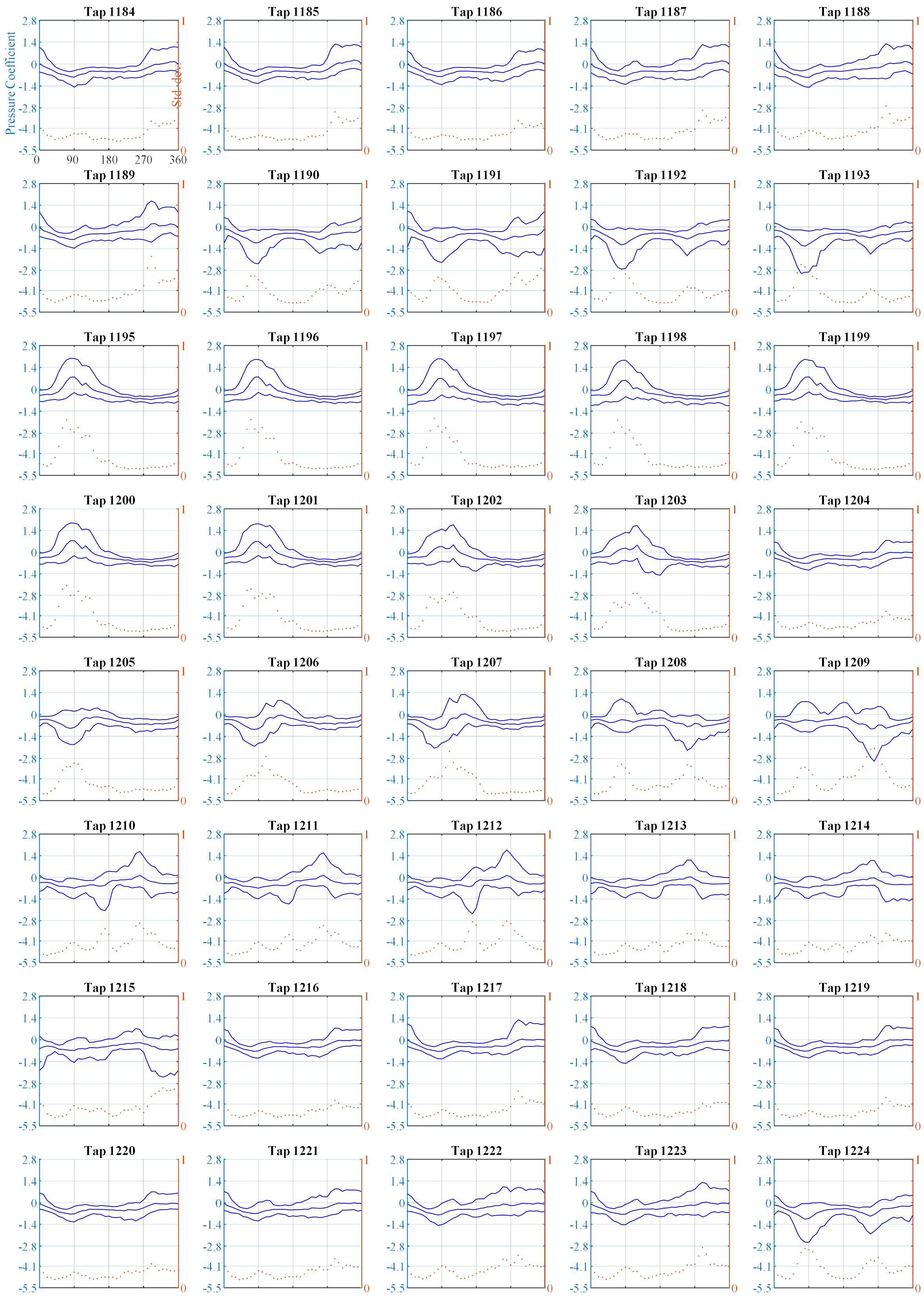
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Pressure Coefficient
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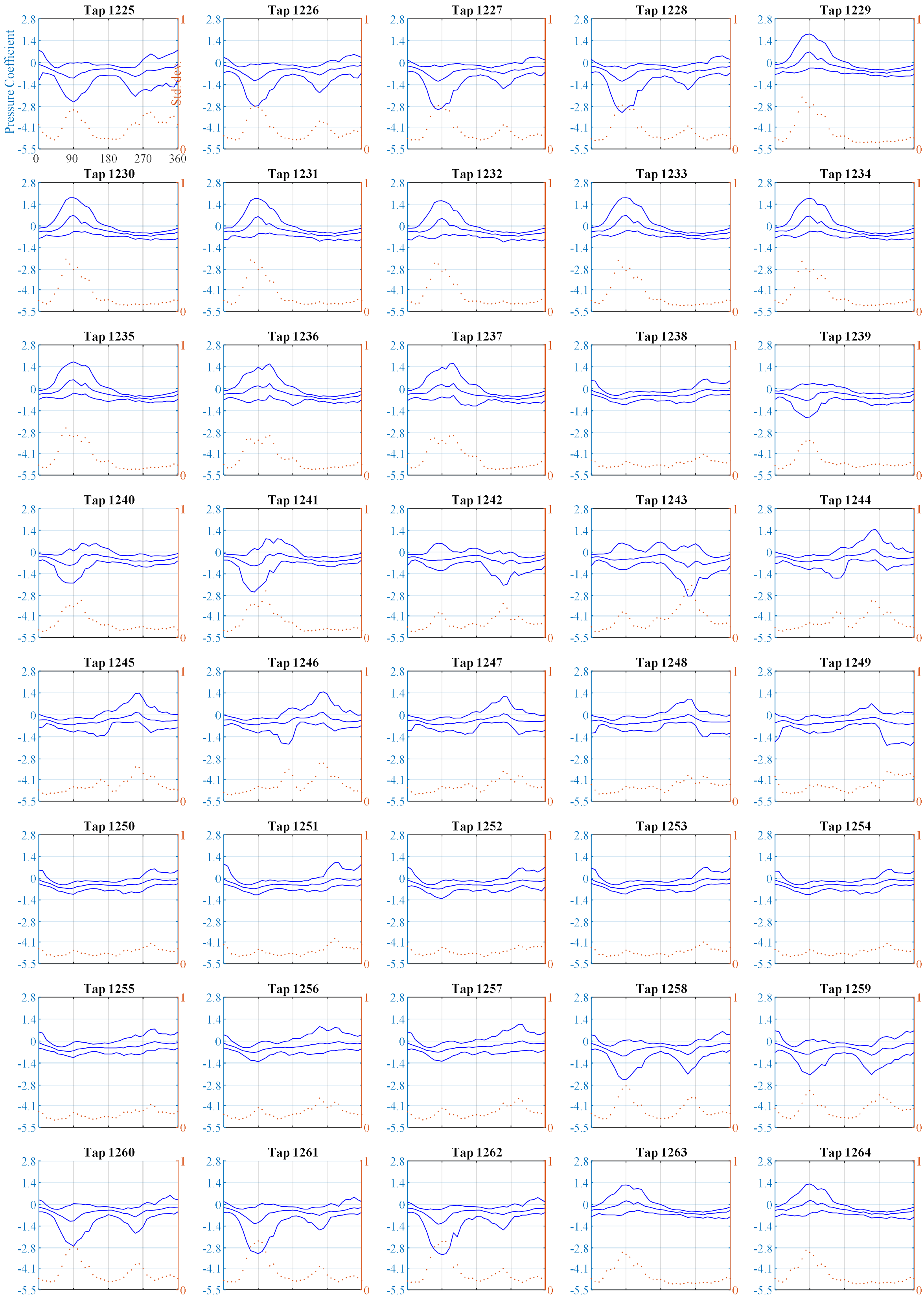
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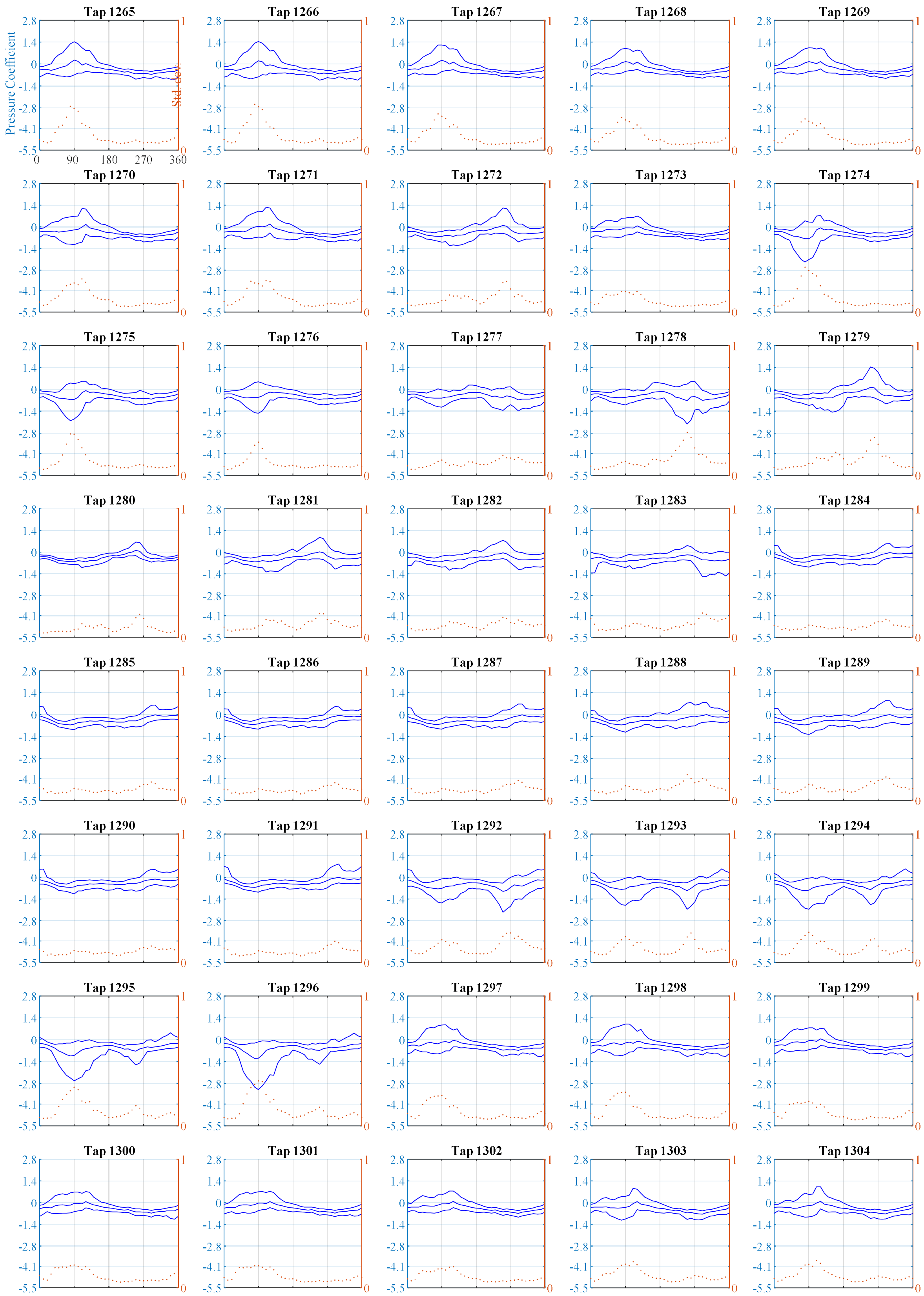
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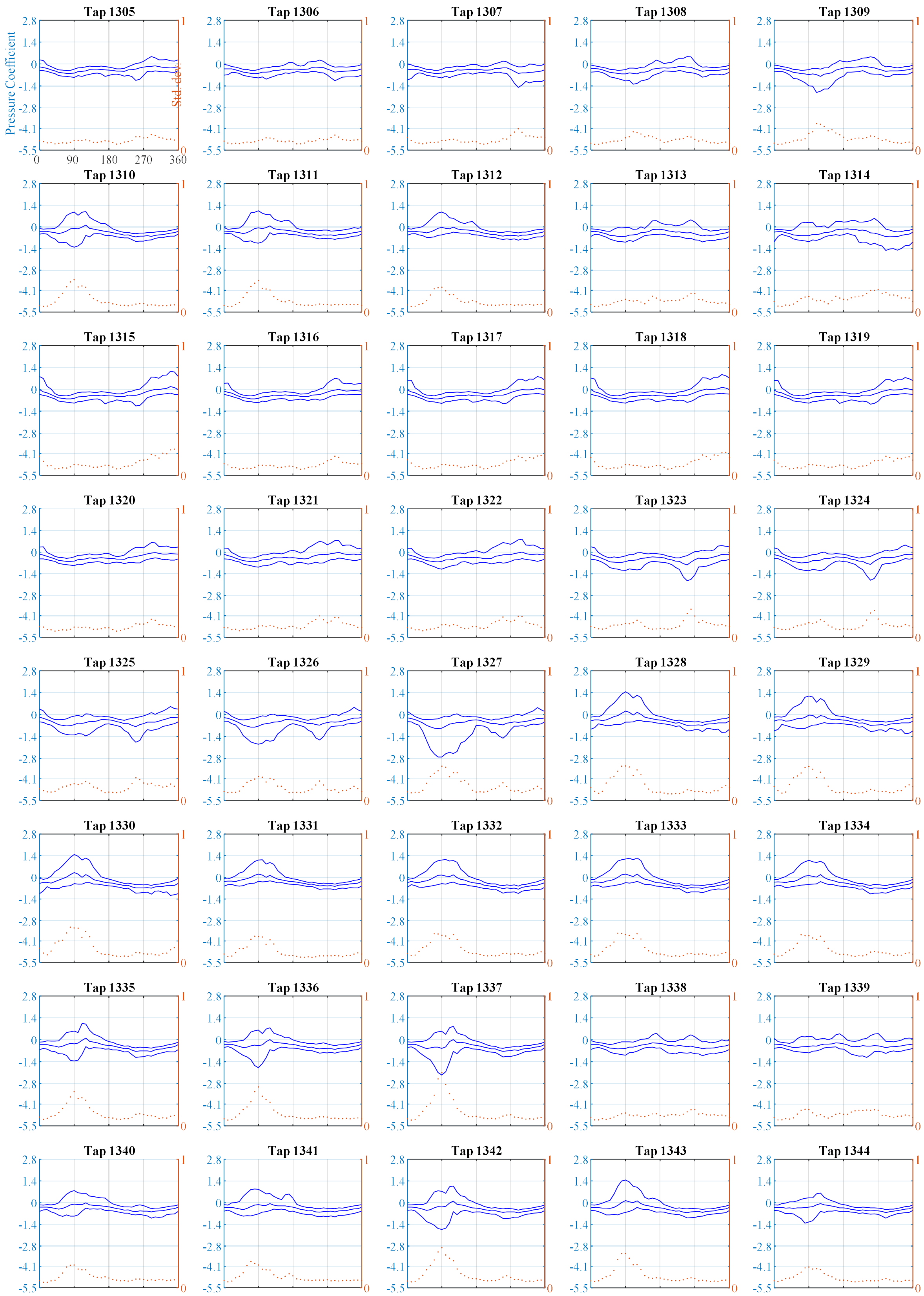
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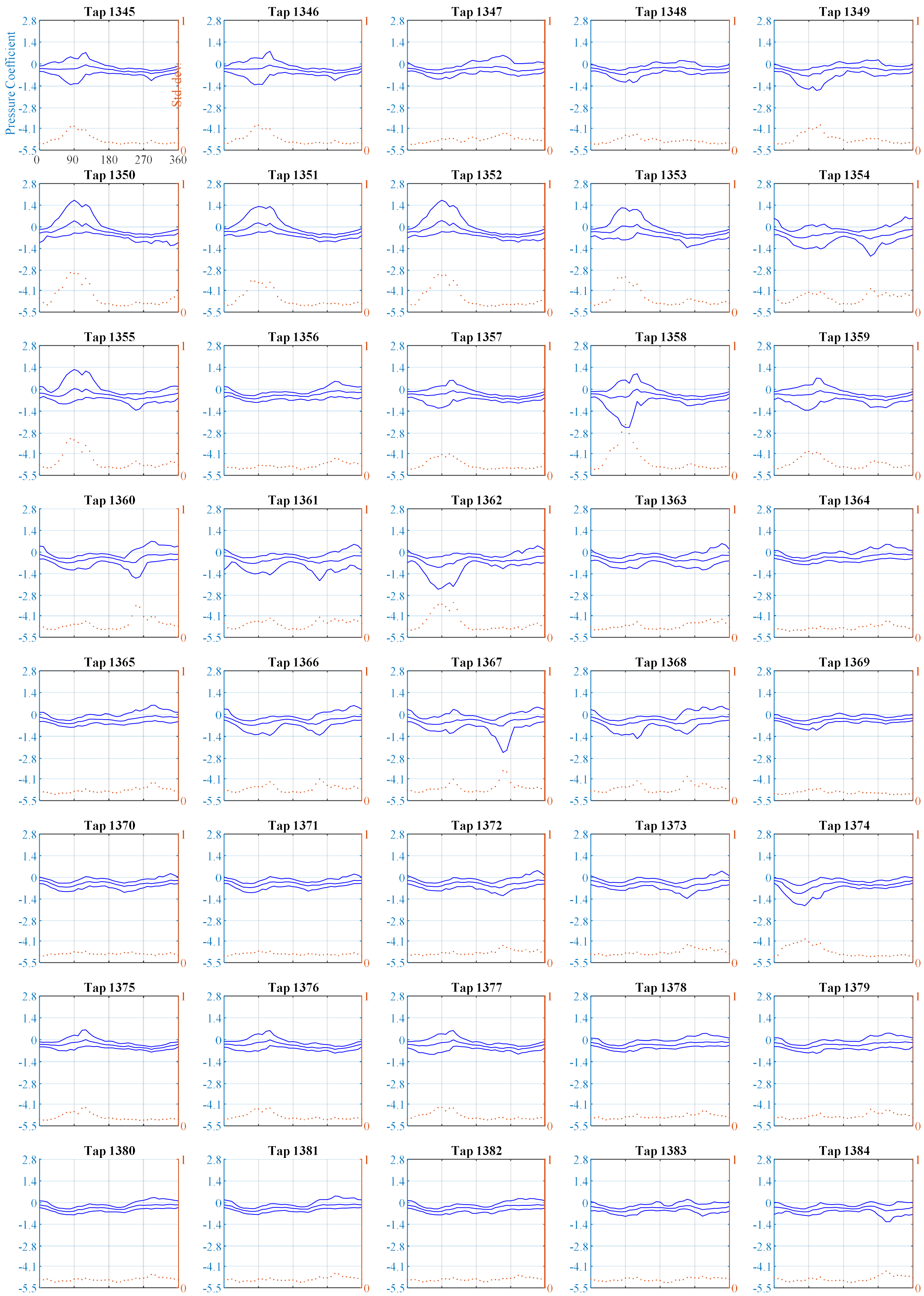
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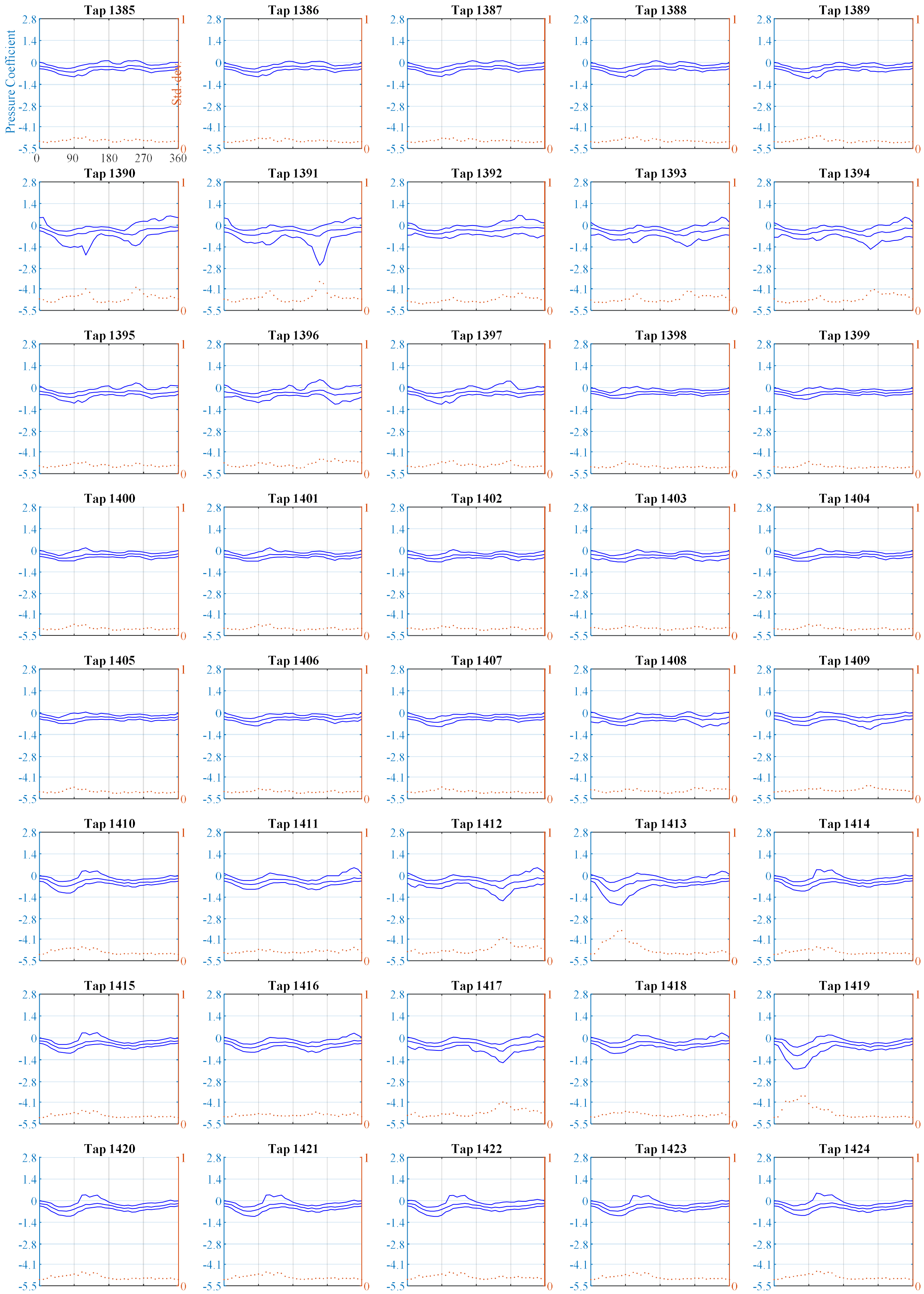
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Pressure Coefficient
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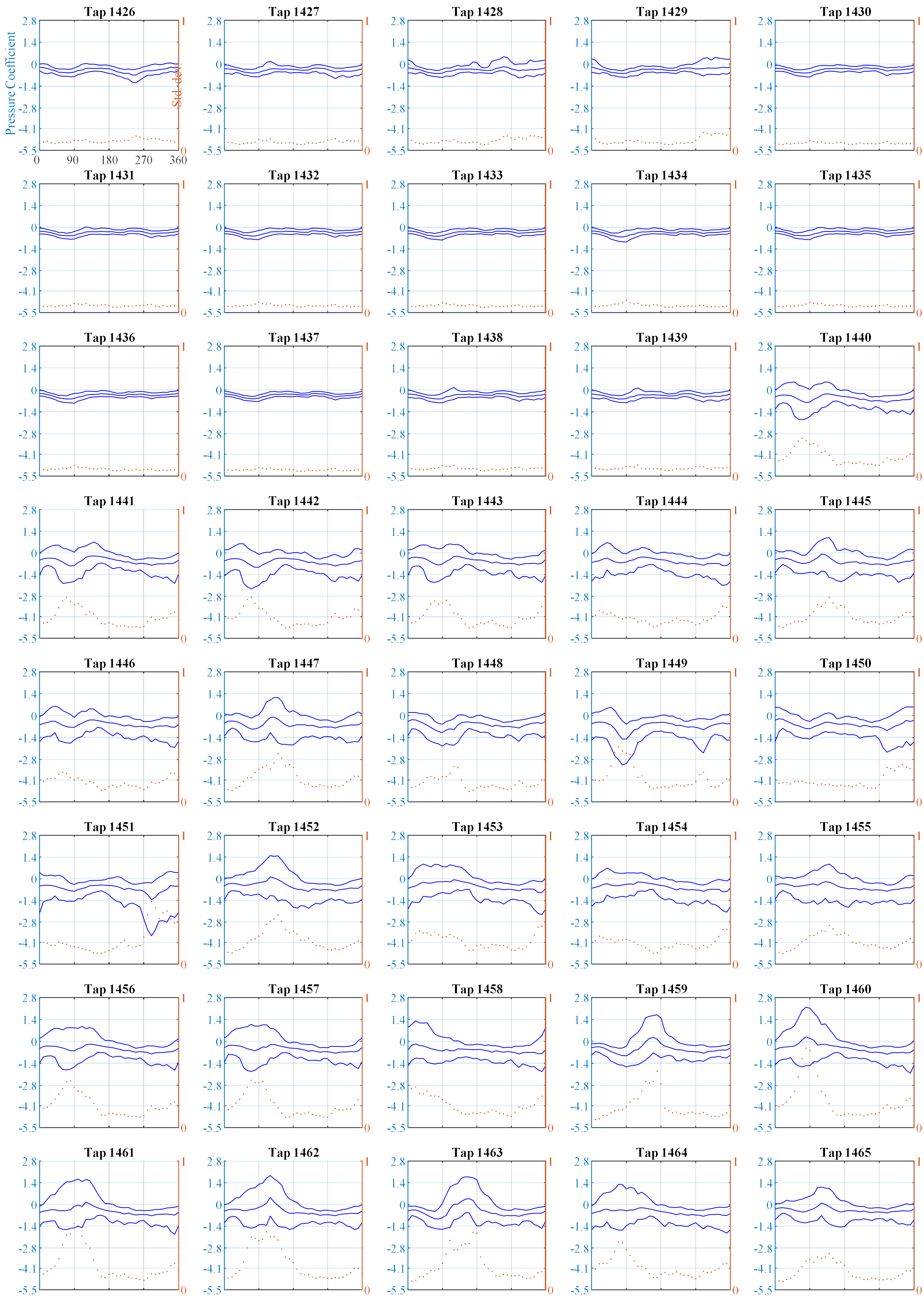
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Pressure Coefficient
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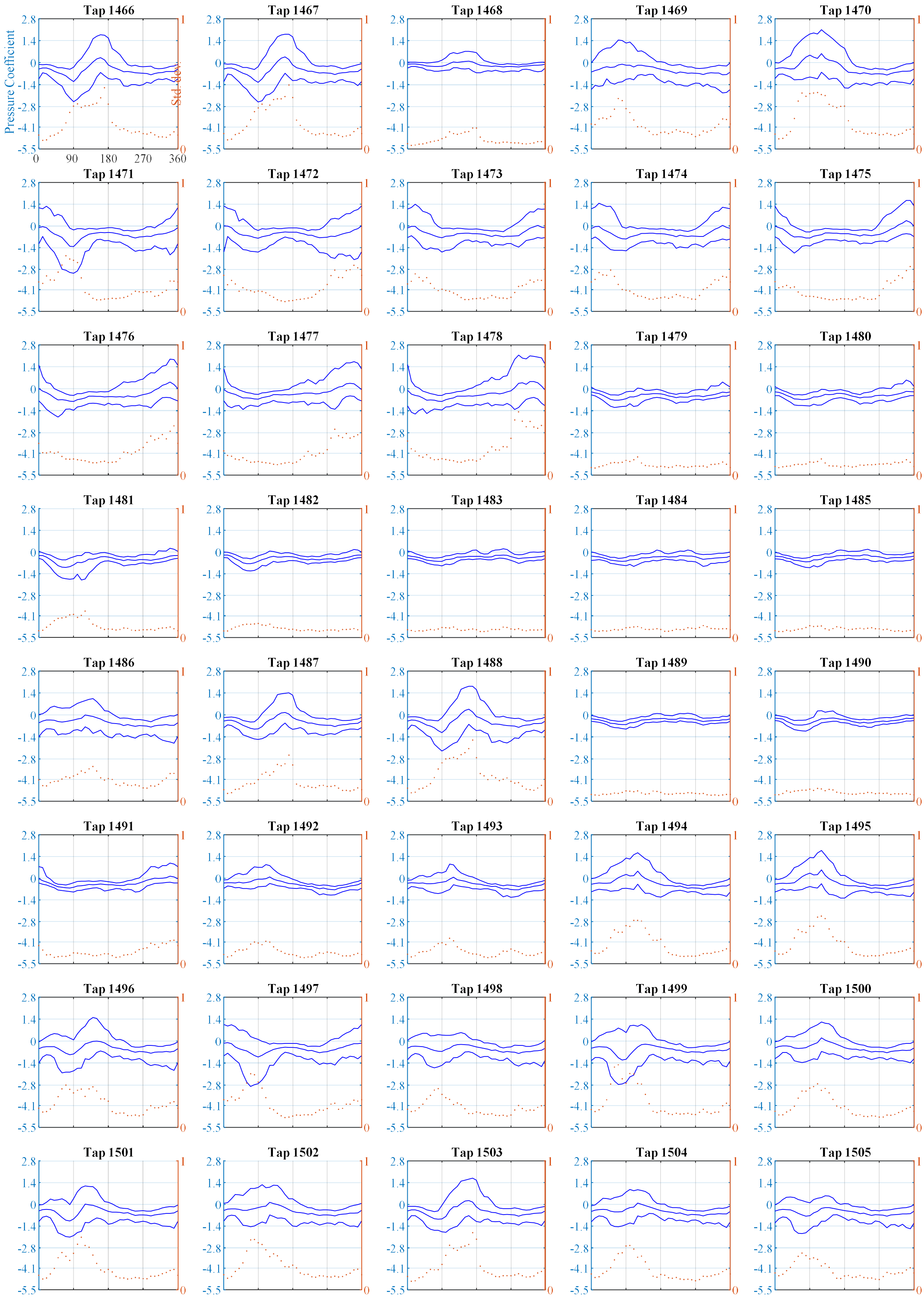
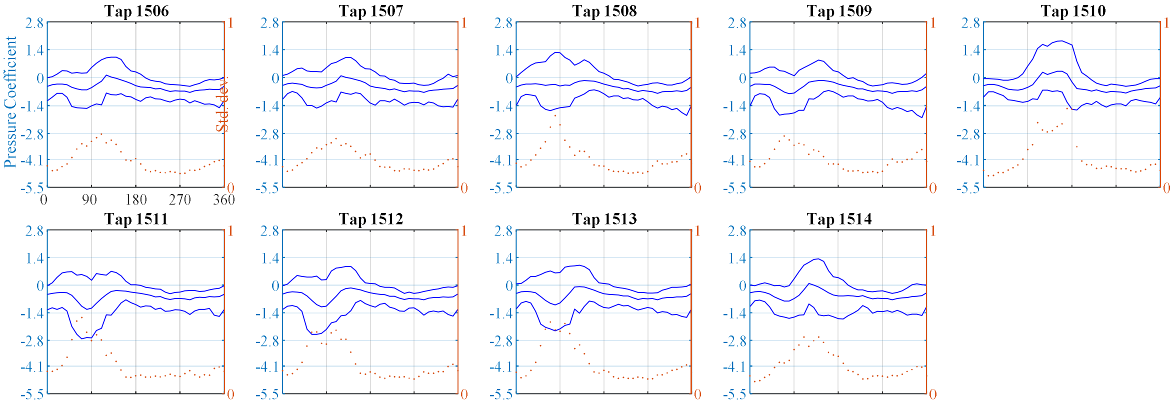


cpp
WIND ENGINEERING &
AIR QUALITY CONSULTANTS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Pressure Coefficient
Std dev
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