Alan G. Davenport Wind Engineering Group

NIST/TTU Cooperative Agreement - Windstorm Mitigation Initiative: Further Experiments on Generic Low Buildings

T.C. E. Ho, D. Surry & M. Nywening

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The Boundary Layer Wind Tunnel Laboratory
The University of Western Ontario, Faculty of Engineering
London, Ontario, Canada N6A 5B9; Tel: (519) 661-3338; Fax (519) 661-3339
Internet: www.blwtl.uwo.ca; E-mail: info@blwtl.uwo.ca

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The current testing program to provide a generic low building database was initiated by Dr. Emil Simiu of the National Institute of Standards and Technology and Dr. Kishor Mehta of Texas Tech University and is guided by an advisory committee. The cooperation of Drs. Simiu and Mehta, as well as the members of the advisory committee, is greatly appreciated.

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SUMMARY

This study is part of the NIST/TTU Cooperative Agreement – Windstorm Mitigation Initiative, jointly sponsored by the National Bureau of Standards and Technology and Texas Tech University. It forms part of a larger scope of generic low building testing and analysis.

The first part of the UWO Experimental wind tunnel work on 5 generic model configurations is reported in [1]. The current test program consists of a total of 6 different model or model variations. A detailed summary of the test parameters is included in the report.

1. A generic building model, 200'x100' in plan dimensions with a gable roof slope of 1:24, was tested at two different heights, in two upstream exposures, in simulated 1:200 scale winds.

2. The same generic building model as in item 1, with an addition of 3' high parapets at the roof edges, was tested at two different heights, in two upstream exposures, in simulated 1:200 scale winds.

3. The same generic building model as in item 1 was tested at two different heights, in two upstream exposures, in simulated 1:100 scale winds. Based on the length scale, the equivalent full scale building dimensions are 100'x50'.

4. The same generic building model as in item 3, with an additional module 75' in length, was tested at two different heights, in two upstream exposures, in simulated 1:100 scale winds. The overall dimensions of the model are 175'x50'.

5. A generic building model, 187.5'x120' in plan dimensions with a gable roof slope of 1:12, was tested at five different heights, in two upstream exposures, in simulated 1:100 scale winds.

6. A generic building model, 125'x80' in plan dimensions with a gable roof slope of 6:12, was tested at four different heights, in two upstream exposures, in simulated 1:100 scale winds. Internal pressures were measured for this model.

Details of the test parameters and procedures are provided in this report, together with general data checks to ensure that the data are consistent with current and previous generic model test results.

The data from the above tests form part of the overall generic low building database and will be made available to the public using a standardized archival system described in [1]. Some of the data, along with accepted data from other facilities, will also be used as a benchmark for certification of further wind tunnel facilities contributing to the low building database.

1 INTRODUCTION

As part of the "NIST/TTU Cooperative Agreement - Windstorm Mitigation Initiative", a testing program was initiated to create a low building database for the purpose of providing time series of wind load data for public access. The data may be used in the dynamic design of low buildings. A first phase was carried out [1] that included the following generic building models:

- 125'x80', 4 heights, 1:12 roof slope, 2 exposures
- 125'x80', 4 heights, ¼:12 roof slope, 2 exposures
- 125'x80', 4 heights, 3:12 roof slope, 2 exposures
- 250'x160', 4 heights, 1:12 roof slope, 2 exposures
- 62.5'x40', 4 heights, 1:12 roof slope, 2 exposures

In addition, as part of the quality control program, three models of the TTU full scale building were also tested:

- 45'x30'x13', 1:48 roof slope, 2 exposures (3 models)

The three models included a 1:50 scale model primarily for local point pressure measurements, a 1:100 scale model primarily for structural load evaluation and a test of the 1:100 scale model built by Colorado State University (CSU). Details for the above generic model tests and the tests of the TTU Building models are reported elsewhere [1].

Part of the current experimental program is an extension to the Phase 1 testing (Tests 5 and 6 below) and part of the study is an extension to the first generic model testing commissioned by NIST in 1999 [2] (Tests 1 to 4 below).

The current testing program has a total of 6 different model or model variations:

Test 1. 200'x100', 2 heights, 1:24 roof slope, 2 exposures, 1:200 scale
Test 2. 200'x100', 2 heights, 1:24 roof slope, 2 exposures, 1:200 scale (with 3' parapets)
Test 3. 100'x50', 2 heights, 1:24 roof slope, 2 exposures, 1:100 scale
Test 4. 175'x50', 2 heights, 1:24 roof slope, 2 exposures, 1:100 scale
Test 5. 187.5'x120', 5 heights, 1:12 roof slope, 2 exposures, 1:100 scale
Test 6. 125'x80', 4 heights, 6:12 roof slope, 2 exposures, 1:100 scale

Details of the model variations are described in Section 2.2.

This report provides basic information on the test parameters used in these wind tunnel tests and describes the data quality control checks undertaken.

The data from all of the tests described above form part of the overall generic low building database. Some of the data, along with accepted data from other facilities, will also be used as benchmarks for certification of further wind tunnel facilities contributing to the low building database.

Detailed time series of all the pressure data are available through the standard archival system developed within the TTU/NIST Cooperative Agreement [1].

2 GENERIC MODEL TESTS

2.1 The modelling of the wind

2.1.1 Terrain modelling

The basic tool used is the Laboratory's boundary layer wind tunnel. The tunnel is designed with a long test section, which allows extended models of upwind terrain to be placed in front of the model of the building under test. The wind flow then develops characteristics which are similar to the wind over the different terrain conditions.

Two typical terrain cases were used; namely, the open and suburban exposures, defined as having roughness length, z_o, of 0.03 m and 0.3 m respectively. Simulated winds at two different scales, 1:100 and 1:200, were used in the current set of experiments. For both terrain cases and for both scale simulations, three 5-foot high spires were placed at the entrance of the wind tunnel as well as a 1.25-foot high barrier across the wind tunnel immediately downstream of the spires. These two devices produce the large scale wind gusts in the wind tunnel. Various heights of roughness elements were used along the 100-foot wind tunnel section to provide mixing of the wind gusts and generate the boundary layer characteristics for the two terrain conditions in two different length scales.

Note that the required roughness elements tend to be higher compared to the building height in model scale than in full scale. For this reason, it is unrealistic to continue these roughness elements right up to the model. In practice, smaller roughness elements are used close to the model and some distortion of flow turbulence modelling at low heights is accepted in order to maintain better overall flow homogeneity over the model. Views of the 1:200 simulation in the wind tunnel is shown in Figure 1. Similarly, Figure 2 shows the simulation of the 1:100 scale wind in the wind tunnel.

2.1.2 Characteristics of the modelled wind

The simulation of the typical open and suburban exposures at the site of the building model was based on the wind characteristics described by ESDU 82026 [3], 83045 [4] and 74031[5] for mean wind speed profile, turbulence intensity and wind spectrum respectively. Figures 3 and 4 present 1:200 scale vertical profiles of the mean speed and of the intensity of the longitudinal component of turbulence for the open country and suburban terrains, respectively. The profiles were measured without any building model present at a location 18" (model scale) upstream of the center of the turntable; approximately at the leading edges of the models. Similarly, Figures 5 and 6 show the wind characteristics in 1:100 scale. The target characteristics determined using ESDU are superimposed. Based on the comparison of turbulence intensities, the simulated exposures match the target roughness lengths, z_o, of 0.03 m and 0.3 m for open and suburban exposures respectively.

Figures 7, 8 and 9 show the normalized longitudinal, lateral and vertical wind spectra respectively, measured in open exposure at 32' (full scale) above ground. At this height, $\sigma_v / \sigma_u = 0.68$ and $\sigma_w / \sigma_u = 0.4$ where u, v and w denote the longitudinal, lateral and vertical directions respectively.

The longitudinal turbulence scale is shown to have a mismatch by about a factor of two based on the shift in the high frequency end of the spectra. This level of mismatch is likely to be inconsequential for local pressures. The scale mismatch would be expected to have more importance for area or frame loads where the spatial correlation of the loads are important; however, even here a factor of two in scale is moderated dramatically when translated into an area integral (see Surry [6] for example). Typically, the order of error associated with a scale mismatch of a factor of two should be in the 5 to 10% range.

2.2 The Measurements of Local Pressures

2.2.1 Model instrumentation

A total of 6 different model or model variations have been tested. Table 1 summarizes the model and test parameters.

The model used in Tests 1 to 3 and the basic module used in Test 4 was the same model used in a previous experimental program for NIST [2]. Additional pressure taps were instrumented on the model to provide complete coverage on the entire building. In the current tests, the total number of pressure taps is 625 for Tests 1 to 3. Figure 10 shows the tap layout for Tests 1 and 2, while Figure 11 shows the tap layout of Test 3. Test 4 used the basic building module in Tests 1 to 3 with an extension of 75'. This extended model has overall dimensions of 175'x50', instrumented with a total of 864 active taps. The tap layout for Test 4 is shown in Figure 12. Views of the models used in Test 1 to Test 4 are shown in Figures 13 to 16.

The models used in Tests 5 and 6 follow a series of generic models that have been tested in Phase 1 of the TTU-NIST initiative [1]. Phase 1 tests included buildings of 125'x80' of various building heights at 1:12, ¼:12 and 3:12 roof slopes. They also included twice-sized (250'x160') and half-sized (62.5'x40') models at 1:12 roof slope. The Test 5 model is an intermediate sized model (187.5'x120') for further investigation into the interpolation of the pressure information in the generic low building database. This model has 694 pressure taps. Figure 17 shows the pressure tap layout of the Test 5 model. Views of the model in the wind tunnel are shown in Figure 18.

The Test 6 model has the basic plan dimensions of 125'x80' but with a larger roof slope of 6:12. This provides the upper limit of roof slope tested within this program to date. Internal pressures due to distributed leakage were measured on this model. The distributed leakage is about 0.1% of the total wall areas, represented by 84 - 1/16" (model scale) diameter holes distributed over the wall areas. As the building height is reduced, the leakage openings are also reduced, maintaining the approximate leakage ratio. In order to be able to measure the dynamic internal pressures, the interior volume of the model is exaggerated approximately following on the volumetric scaling.

$$\lambda_{\text{vol}} = \frac{\lambda_L^3}{\lambda_{\text{vel}}^2} \approx \frac{(1/100)^3}{(1/4)^2} = \frac{1}{62500}$$

The actual model internal volume, including the volume of the model and the sealed chamber extended below the turntable, was 6.36 ft^3 for the 6:12 roof slope model. The model volumes required for the 6:12 model are 3.52 ft^3 and 8 ft^3 for the 12 ft and 40 ft building heights respectively. Using the total available volume, the model volume is approximately correct for a 30 ft high building. This same volume is used for all testing for simplicity.

There are a total number of 704 pressure taps on the model including three (3) pressure taps connected to the interior volume of the model.

Diagrams showing the pressure tap locations for Test 6 are shown in Figure 19. Close-up views of the modelled internal volume are shown in Figure 20. Views of the models are shown in Figure 21. The tap layout and tap nomenclature for all tests are included in Appendix A for reference.

2.2.2 Wind tunnel measurements

A high speed solid state pressure scanning system was used to take the pressure measurements. Measurements were taken at 37 wind angles over the range of 180^0 at 5^0 increments. For Tests 1 to 4, the tested angles are between 0^0 and 180^0. For Tests 5 and 6, the tested angles are between 180^0 and 360^0 (see Figures 10, 11, 12, 17 and 19 for the definition of wind angles).

Tests 1 and 2 were carried out in a 1:200 wind simulation. The reference speed in the wind tunnel was nominally 60 ft/sec. Pressures were sampled at 400 samples per second for 60 seconds. Based on a full-scale roof height wind speed of 84 mph, the sampled data are equivalent to about 6 samples per second for 1.0 hour in full scale for the open exposure tests and equivalent to about 8 samples per second for 0.81 hours in full scale for the suburban exposure tests.

Tests 3 and 4 were carried out in a 1:100 wind simulation. The reference speed was nominally 60 ft/sec. Pressures were sampled at 400 samples per second for 120 seconds. Again based on a full-scale roof height wind speed of 84 mph, the sampled data are equivalent to about 14 samples per second for 0.93 hours in full scale for the open exposure tests and equivalent to about 19 samples per second for 0.70 hours in full scale for the suburban exposure tests. All of the samples were stored.

For Tests 5 and 6, parameters used for other generic model tests in Phase 1 of the current test program [1] were used. The upper level reference speed is nominally 45 ft/sec. Pressures were sampled at 500 samples per second for 100 seconds. Based on a full scale wind speed of 84 mph at 33 ft, the sampled data are equivalent to about 22 samples per second for 0.64 hours in full scale for the open exposure tests and equivalent to about 26 samples per second for 0.53 hours in full scale for the suburban exposure tests.

All instrumented taps were measured essentially instantaneously. The measurements taken within the sampling cycle have a maximum time lag of 15/16 of the sampling rate. In the case of sampling at 500 Hz, the maximum time lag is approximately 15/16x0.002 seconds = 1.875 milliseconds. The data are corrected for the time lag by linear interpolation of the data within the same sample cycle.

The model and testing parameters are summarized in data sheets in Appendix B.

In addition, the maximum, minimum, mean and rms pressure from these time histories were calculated and reviewed as a data quality check.

2.2.3 Aerodynamic data

All the time series files were stored in an archive to be accessible by electronic means. The raw data were referenced to the dynamic pressures taken at an upper reference level in the wind tunnel. Conversion factors, specific to the ratio of the roof height to reference height dynamic pressures resulting from the wind simulation in the wind tunnel, are required to convert these aerodynamic data to roof height reference.

The roof height referenced pressure coefficients are defined using the following expression:

$$C_{p_H} = C_{p_{\text{ref}}} \left(\frac{V_{\text{ref}}}{V_H} \right)^2$$

where $\left(\frac{V_{\text{ref}}}{V_H} \right)^2$ is obtained from the wind tunnel experiments and is the ratio of the dynamic pressure at the reference height in the wind tunnel where upper level wind speed is taken (subscript ref) and the dynamic pressure at roof (eave) height (subscript H). Because of high turbulence near roof height, the measurements taken at this level have large variability. Further discussion of the uncertainties and variability of this factor and wind tunnel testing on low buildings can be found in Ho, et al. [1] and Kopp, et al. [7] respectively.

The pressure coefficients presented in this report are referenced to the mean roof height dynamic pressure. Table 2 summarizes the factors used for re-referencing the pressure coefficients to roof height dynamic pressures.

The aerodynamic data and related information are available in the standard archive developed for this project. The tap layout and tap nomenclature for the respective tests are included in Appendix A for reference.

The maximum and minimum pressure coefficients included in this report have been Lieblein-fitted and are more statistically stable quantities than the measured peaks. This involves dividing the record into 10 parts, using the Lieblein BLUE formulation [8] with the 10 individual peaks to estimate the mode and dispersion of the Type I extreme value distribution, and using these to obtain the “best” expected peak for the entire record.

3 DATA QUALITY CHECKS

3.1 General

General checks have been carried out to ensure consistency of the current data with other data sets. In some cases, data from similar tests were used for comparison. All wind tunnel experiments are expected to have inherent uncertainties; further discussion on the topic of experimental uncertainties can be found in Kopp, et al. [7].

3.2 Overall data checks

For an isolated low building, the pressure variations on the building are directly related to the energy in the incident wind. The total fluctuating energy measured on the building will vary with wind direction because of the detailed aerodynamics but Holmes [9] has suggested that the variation can be expected to be slow. Thus, the calculation of the overall sum of variances at all point measurements and its variation with wind direction offers a simple way of checking the overall data consistency.

$$E_{\text{var}}(\alpha) = \sum_{\text{all taps}} \sigma^2_{C_p}(\alpha)$$

An alternative measure is the sum of mean square values about zero over all pressure taps. This is related to the total energy rather than just the fluctuating energy from the mean inherent in the above expression.

$$E_{\text{mean square}}(\alpha) = \sum_{\text{all taps}} \left[\overline{C^2_p(\alpha,t)}\right] = \sum_{\text{all taps}} \left[\sigma^2_{C_p}(\alpha) + \overline{C}^2_p(\alpha)\right]$$

The sum of variances and the sum of mean square values were calculated for all data sets and their variations with wind direction are shown in Appendix C.

The sum of mean square values are seen to be slightly less variable than the sum of variances. As far as the variation with wind direction is concerned, it was found that most of the data sets appear to be well behaved. In a few occasions, the sum of variances indicates large variation with wind direction whereas the sum of mean squares shows a much smoother behaviour. Nevertheless, data sets showing a large change in the variance summation have been examined; however, no clear reason for the deviation is obvious. Since equal weighting is given to each tap, some of the variability may be due to the non-uniform tap resolution. The figures in Appendix C can be used as a guide for a general level of reliability of the data within the data sets.

3.3 Comparison between 1997 NIST data set and the current data set

The model used for Tests 1 to 4 was the same model used in the 1997 NIST experiments. It was shown in the report of the 1997 experiments [2] that the simulation of the open exposure had much higher turbulence intensity than suggested by ESDU. The simulation of turbulence intensity in suburban exposure is much closer to that suggested by the ESDU documents. Figures 22 and 23 are excerpted from the 1997 report [2].

Appendix D shows the comparisons of pressure coefficients referenced to roof height mean dynamic pressures from both the earlier and the current Test 1. It is shown that the mean pressure coefficients match very well. The peak pressure coefficients are higher from the earlier tests. The good agreement in the mean coefficients suggests that there is no systematic or procedural error in the two tests. The differences in the peak coefficients reflect the difference in the turbulence intensity in the wind simulation. Specifically, the differences in the data set for the open exposure are much larger because the turbulence intensities in the earlier tests are much higher for the open exposure when compared to the target ESDU value.

3.4 Comparison between the cases with and without the parapets

Tests 1 and 2 are identical except for the 3' parapet around the roof edges in Test 2. Appendix E shows the comparison of pressure coefficients from the two tests.

The comparison shows that the data from the two sets are consistent except for the pressure taps close to the edges and corners of the roof; e.g. Taps 1901, 1902 and 2001, as well as other taps along the roof edges. Positive pressures are observed for some wind directions; e.g. Taps 1901 to 1915.

3.5 Comparison of data from different length scale simulation

Tests 1 and 2 were carried out in simulated 1:200 winds in the wind tunnel. Tests 3 and 4 used the same model but with simulated 1:100 winds in the wind tunnel. In both cases, the simulated winds model appropriate open and suburban exposures defined by full scale roughness lengths.

For roof taps, because the same model was used for tests at both scales, the tap locations relative to roof height match between the 32' tall building in 1:200 scale (Test 1) and the 16' tall building in the 1:100 scale (Test 3). It is generally expected that the aerodynamic data on a building roof is a function of the ratio of distance from the edge over the building height. Appendices F and G compare the pressure coefficients for similar tap locations relative to roof height tested at the two scales. It is generally shown that the data collapse quite well, suggesting the effect of length scale on local pressures are not significant. Further comparison of other generic low building test data are available in Ho, et al. [10,11].

For wall taps, the comparison is carried out based on the relative locations of the pressure taps to the building height for the two buildings with similar heights; 20 ft building in 1:200 scale and 16 ft building in 1:100 scale. There are no matching rings of taps on the buildings but the second line of taps for the 1:200 test is selected to compare with the third line of taps in the 1:100 scale building. The results for open exposure are very similar but the results for the suburban exposure show larger differences with the 1:100 results generally higher. This may be a result of the increased difficulty in maintaining the simulations down to the surface in the suburban case (see Figures 4 and 6).

3.6 Comparison of data from generic model tests on different size buildings

In addition to Test 5 of the current experiments, a number of different sized generic building models have been tested. Comparisons of the pressure coefficients from the other generic building model tested can be found in Ho, et al. [10,11]. An excerpt of the data from Ho, et al. is shown in Figures 24 and 25 with examples of data from the current intermediate-sized building superimposed. The comparison is based on the pressure coefficients as a function of the building height.

It can be seen that data from the current intermediate-sized building are similar to the data from the other three different sizes when compared in this form. It shows consistency among the different data sets. Further suggestions for the extrapolation of the aerodynamic data on low buildings can be found in Chen, et al. [12,13] and is beyond the scope of this experimental program.

3.7 Comparison of data from generic model tests on buildings with different roof slopes

Figures 26 and 27 show differences in pressure coefficients obtained for buildings with different roof slopes. As expected, the roof pressures on the 6:12 roof slope are positive while the roof pressures at the leading edge of the roof are negative for the other roof slopes. Except for the low roof slope cases, the normalizing parameter of x / H , does not work well for larger roof slope buildings.

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TABLES

TABLE 1 TEST CONFIGURATIONS

Test	Plan Dimensions	Heights	Roof Slope	Length Scale	Remarks
1	200'x100'	20', 32'	1:24	1:200	
2	200'x100'	20', 32'	1:24	1:200	With 3' parapet on all roof edges
3	100'x50'	12', 16'	1:24	1:100	
4	150'x50'	12', 16'	1:24	1:100	
5	187.5'x120'	12', 16', 18', 24', 40'	1:12	1:100	
6	125'x80'	12', 18', 24', 40'	6:12	1:100	Internal pressure measurements (see note 3 below

Notes:

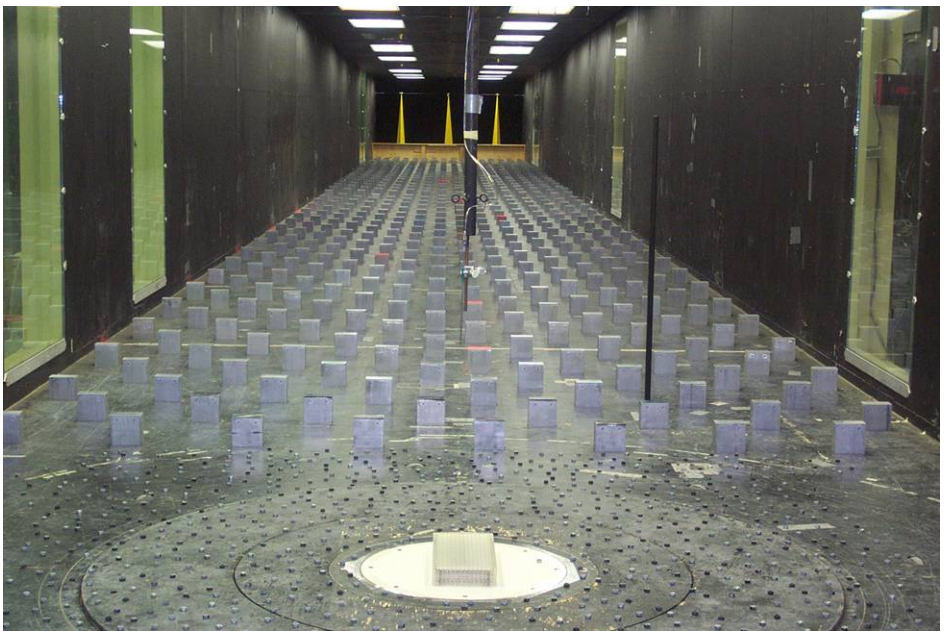
1. Tests 1 to 3 used the same model.
2. Test 4 used the same model as 1 to 3 with a 50' extension.
3. Test 6 included internal pressure measurements due to distributed leakage.

TABLE 2 FACTORS FOR RE-REFERENCING PRESSURE COEFFICIENTS TO ROOF HEIGHT DYNAMIC PRESSURES

Test	Building Height (ft)	Exposure 1	Exposure 2
		Open	Suburban
1 and 2	20	2.86	4.56
	32	2.46	3.82
3 and 4	12	2.98	5.37
	16	2.7	4.84
5 and 6	12	2.98	5.37
	16	2.7	4.84
	18	2.58	4.67
	24	2.37	4.22
	40	2.04	3.53

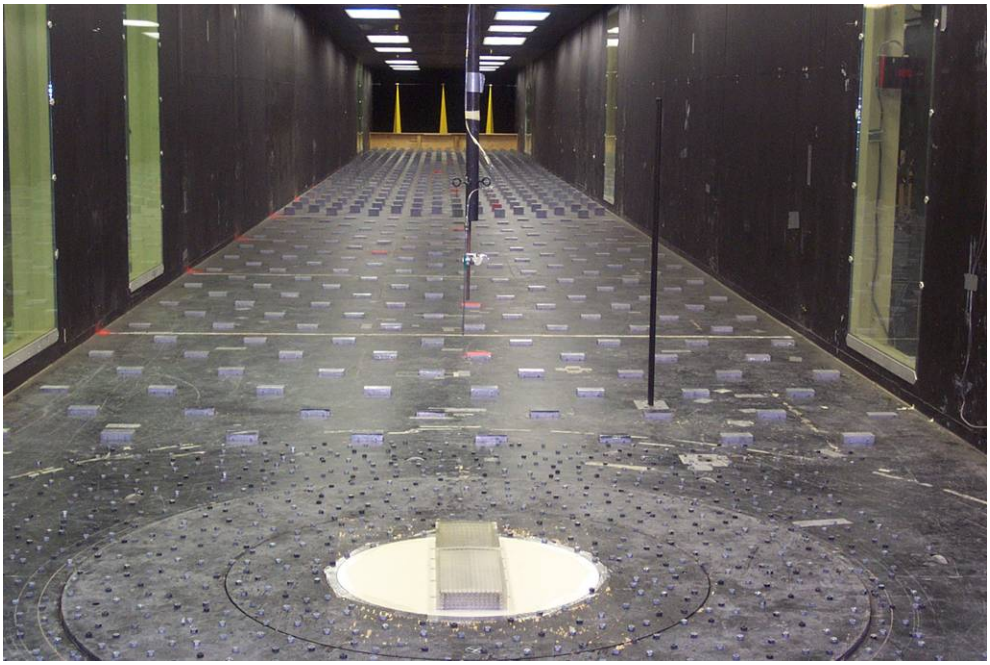
FIGURES

EXPOSURE 1

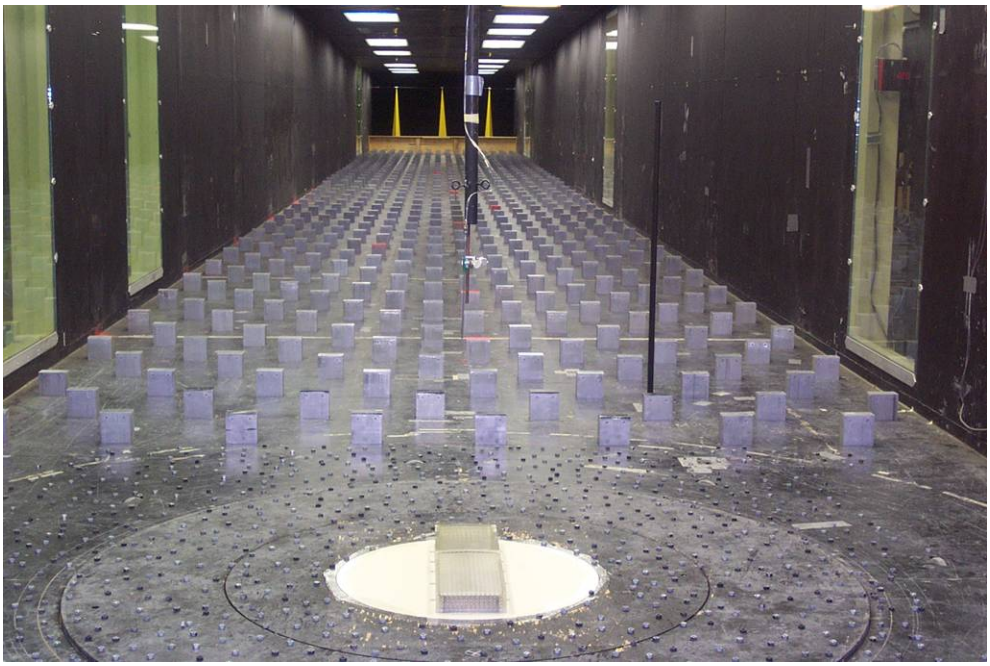


EXPOSURE 2

FIGURE 1 VIEWS OF THE 1:200 MODEL IN THE WIND TUNNEL



EXPOSURE 1



EXPOSURE 2

FIGURE 2 VIEWS OF THE 1:100 MODELS IN THE WIND TUNNEL

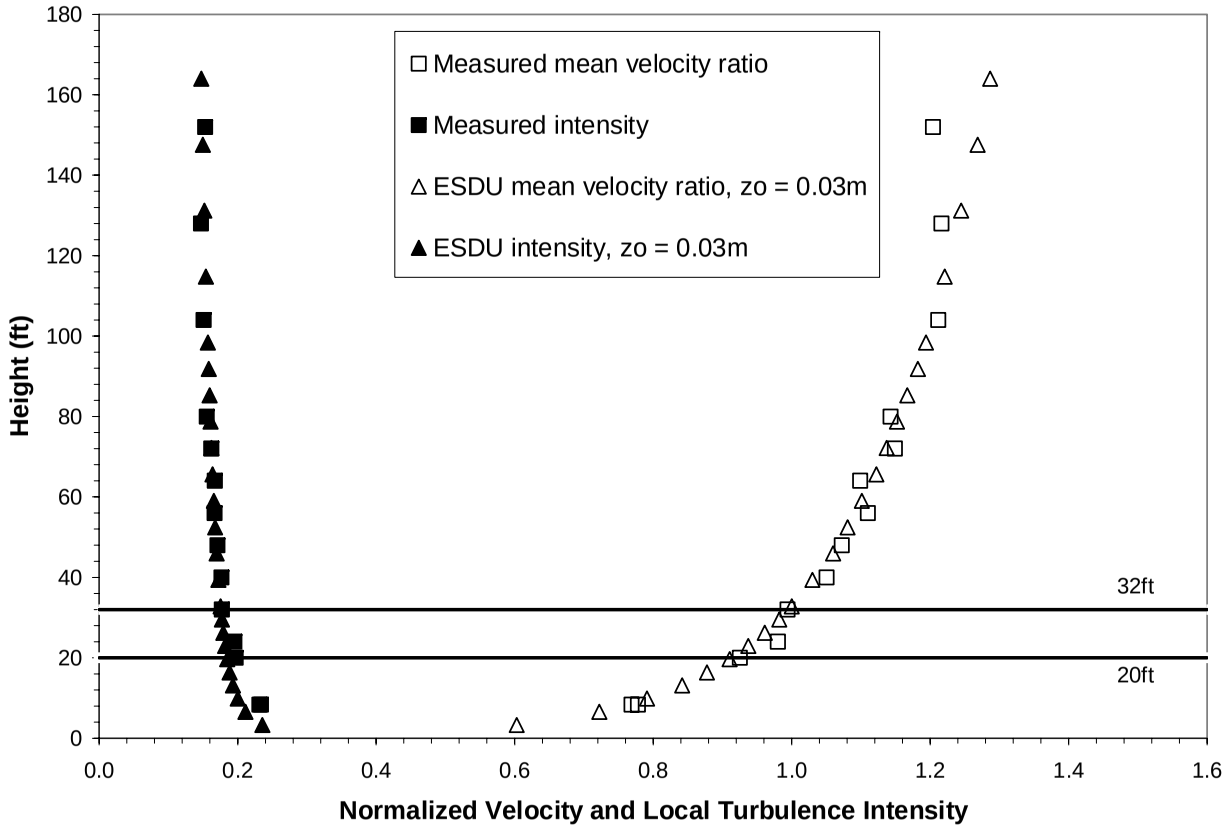


FIGURE 3 WIND SPEED AND TURBULENCE INTENSITY PROFILE. OPEN EXPOSURE – 1:200 SCALE WIND SIMULATION

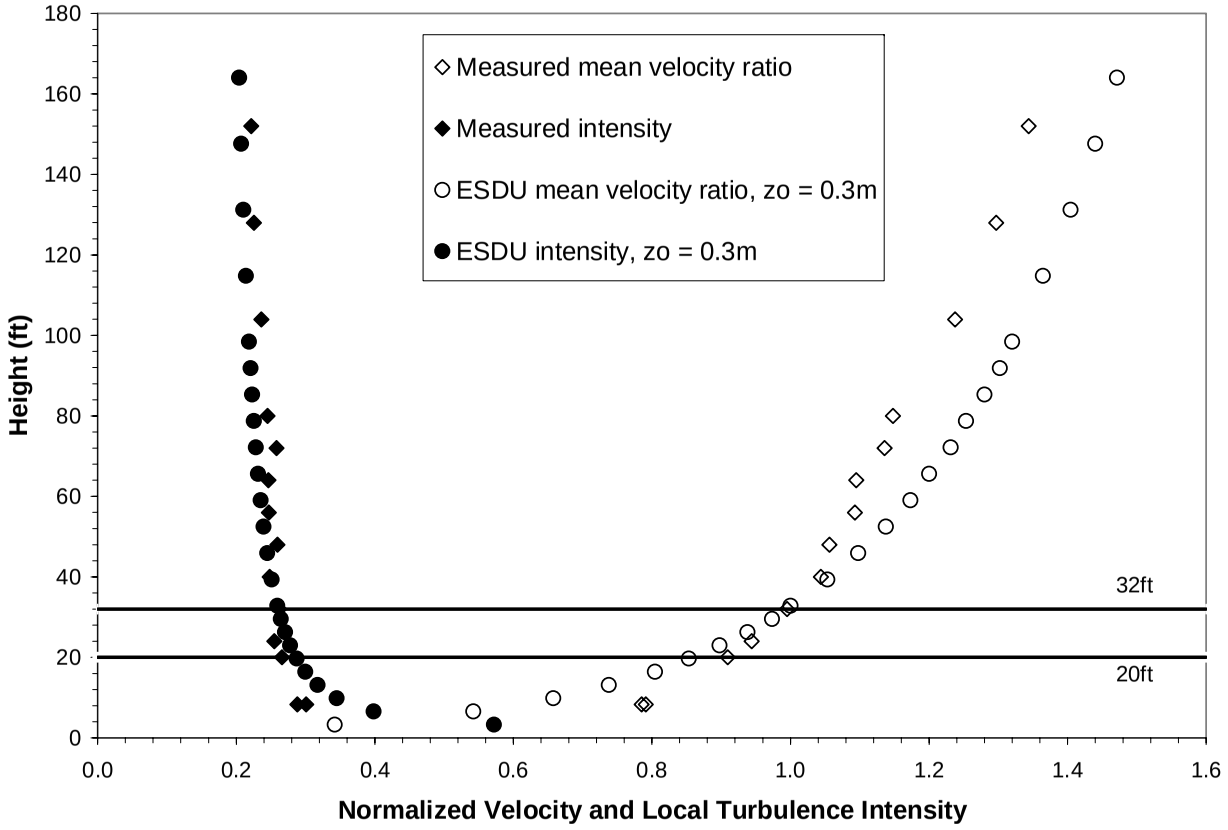


FIGURE 4 WIND SPEED AND TURBULENCE INTENSITY PROFILE. SUBURBAN EXPOSURE – 1:200 SCALE WIND SIMULATION

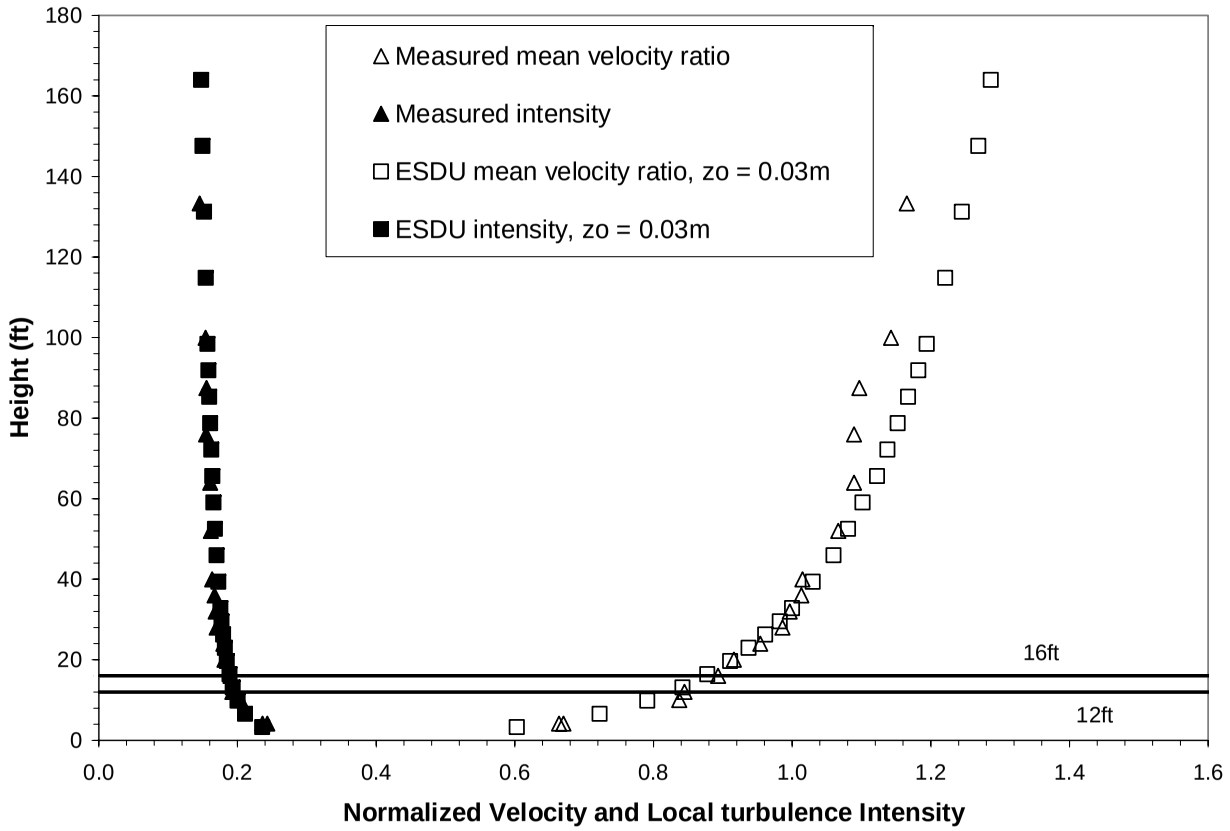


FIGURE 5 WIND SPEED AND TURBULENCE INTENSITY PROFILE, OPEN EXPOSURE – 1:100 SCALE WIND SIMULATION

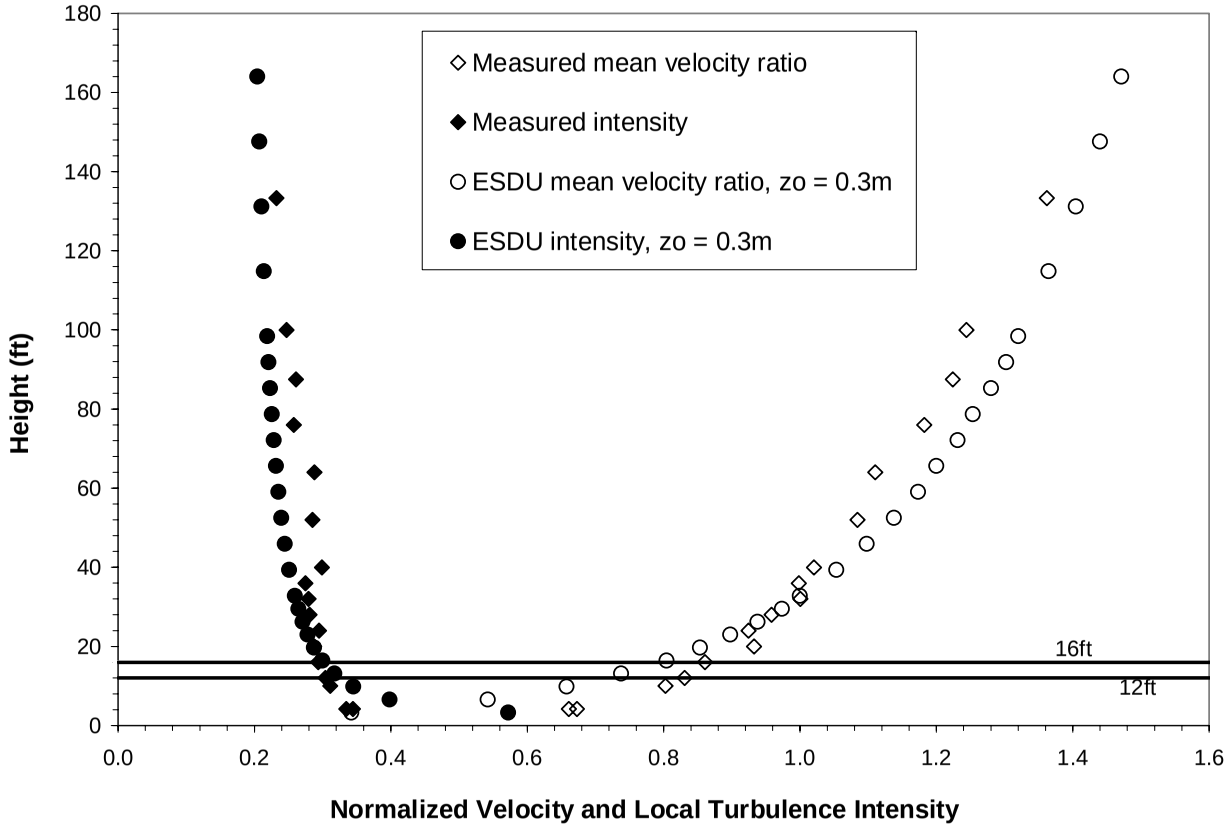


FIGURE 6 WIND SPEED AND TURBULENCE INTENSITY PROFILE, SUBURBAN EXPOSURE – 1:100 SCALE WIND SIMULATION

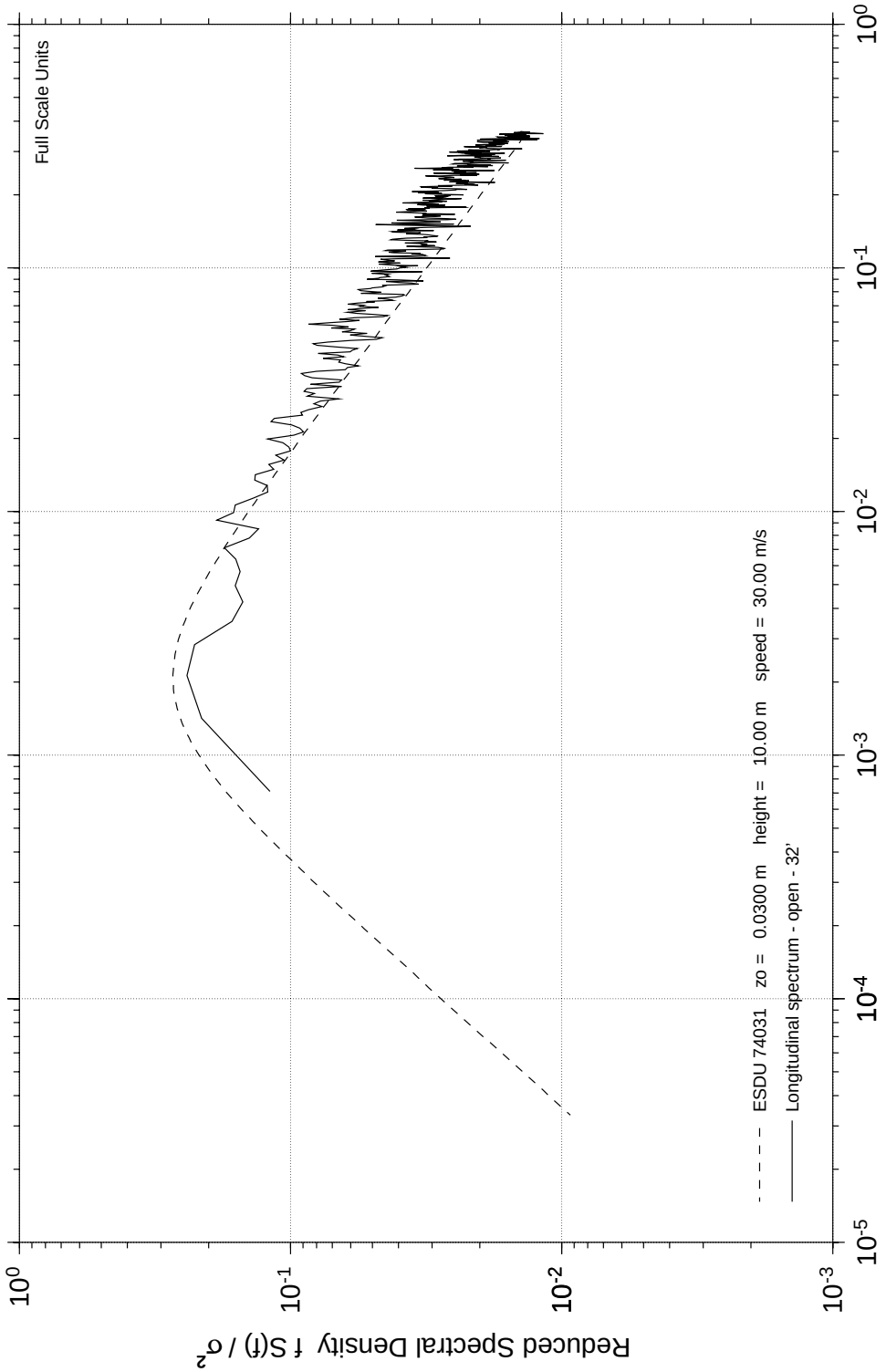


FIGURE 7 LONGITUDINAL WIND SPECTRA

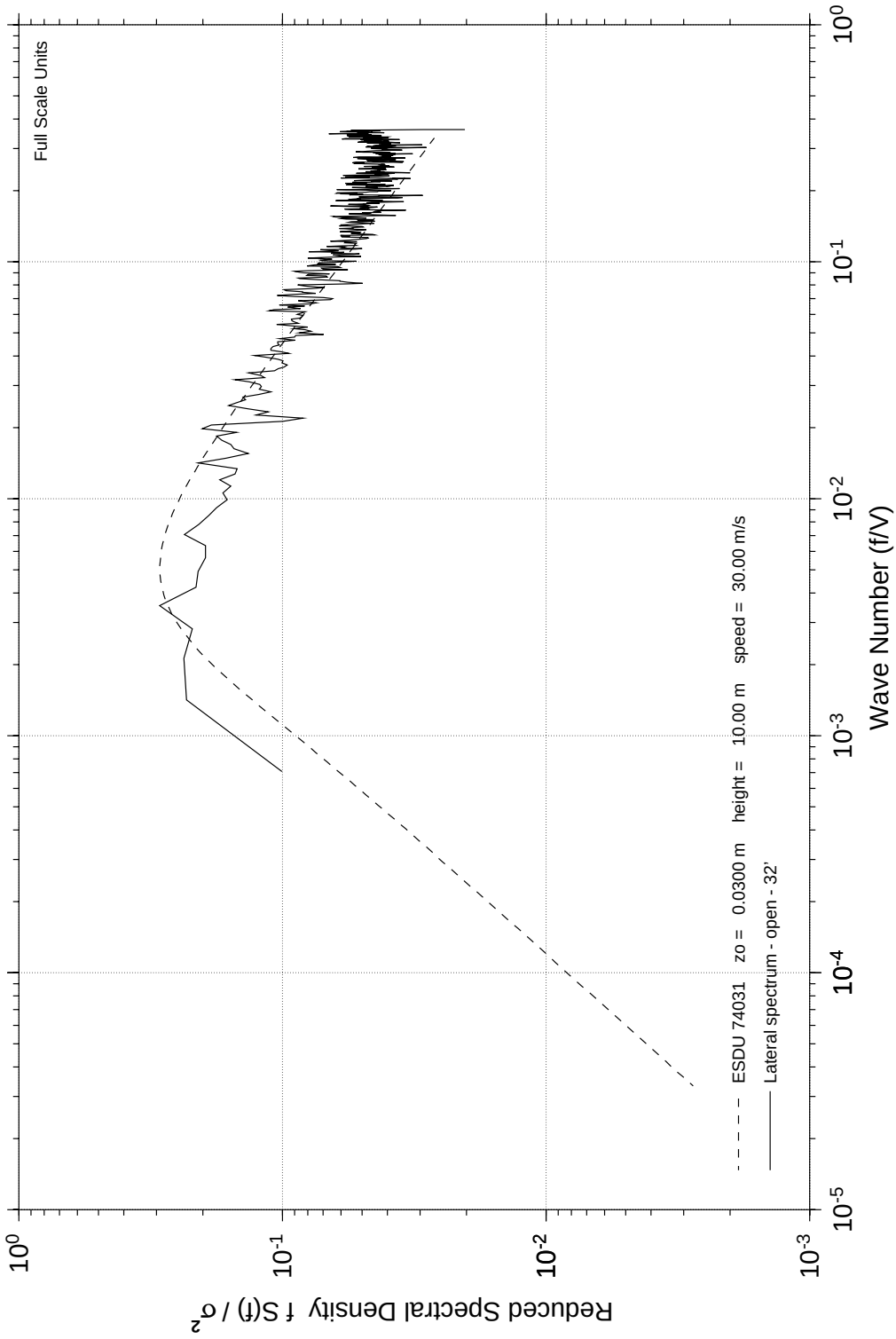


FIGURE 8 LATERAL WIND SPECTRA

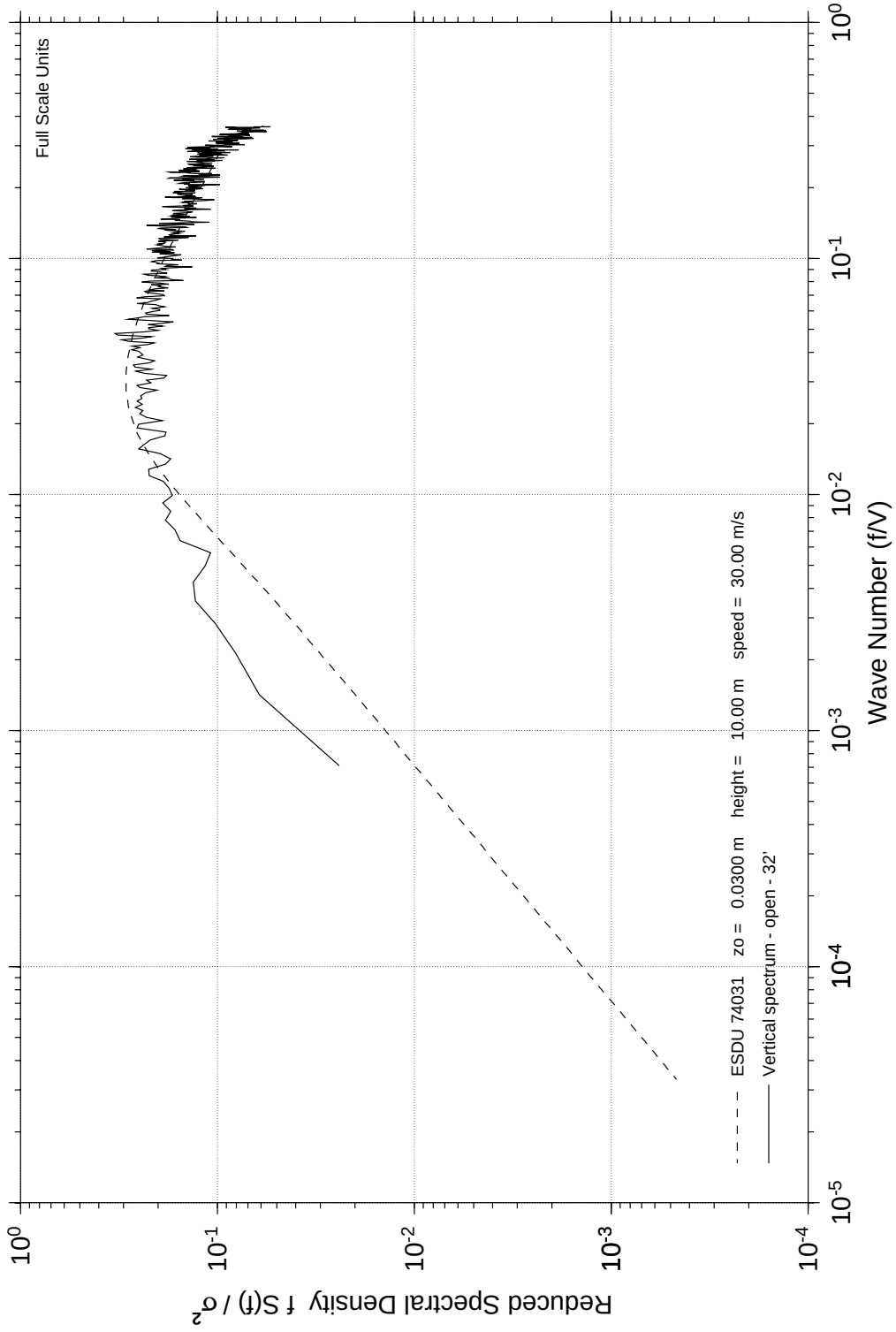


FIGURE 9 VERTICAL WIND SPECTRA

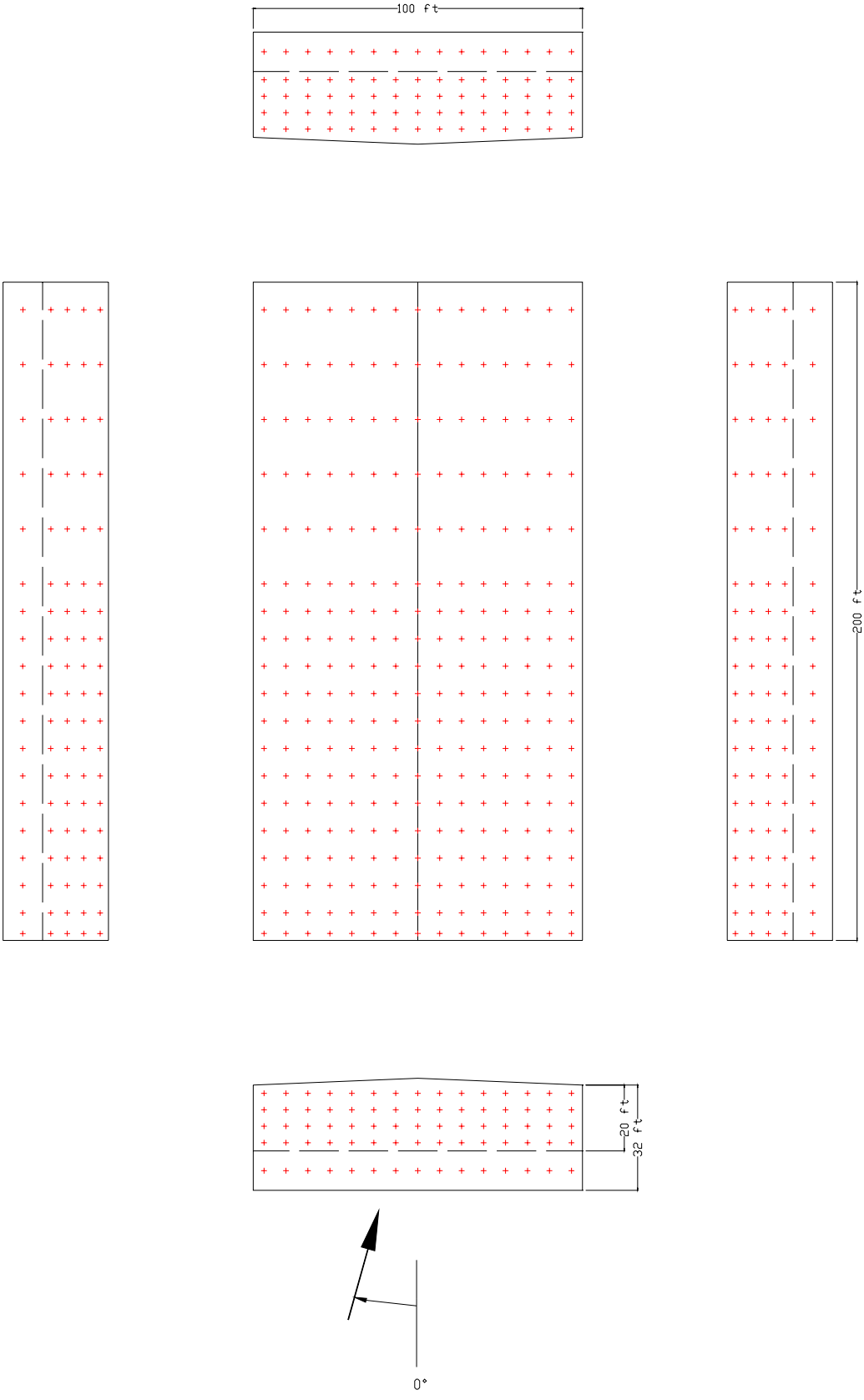


FIGURE 10 PRESSURE TAP LAYOUT – TESTS 1 AND 2

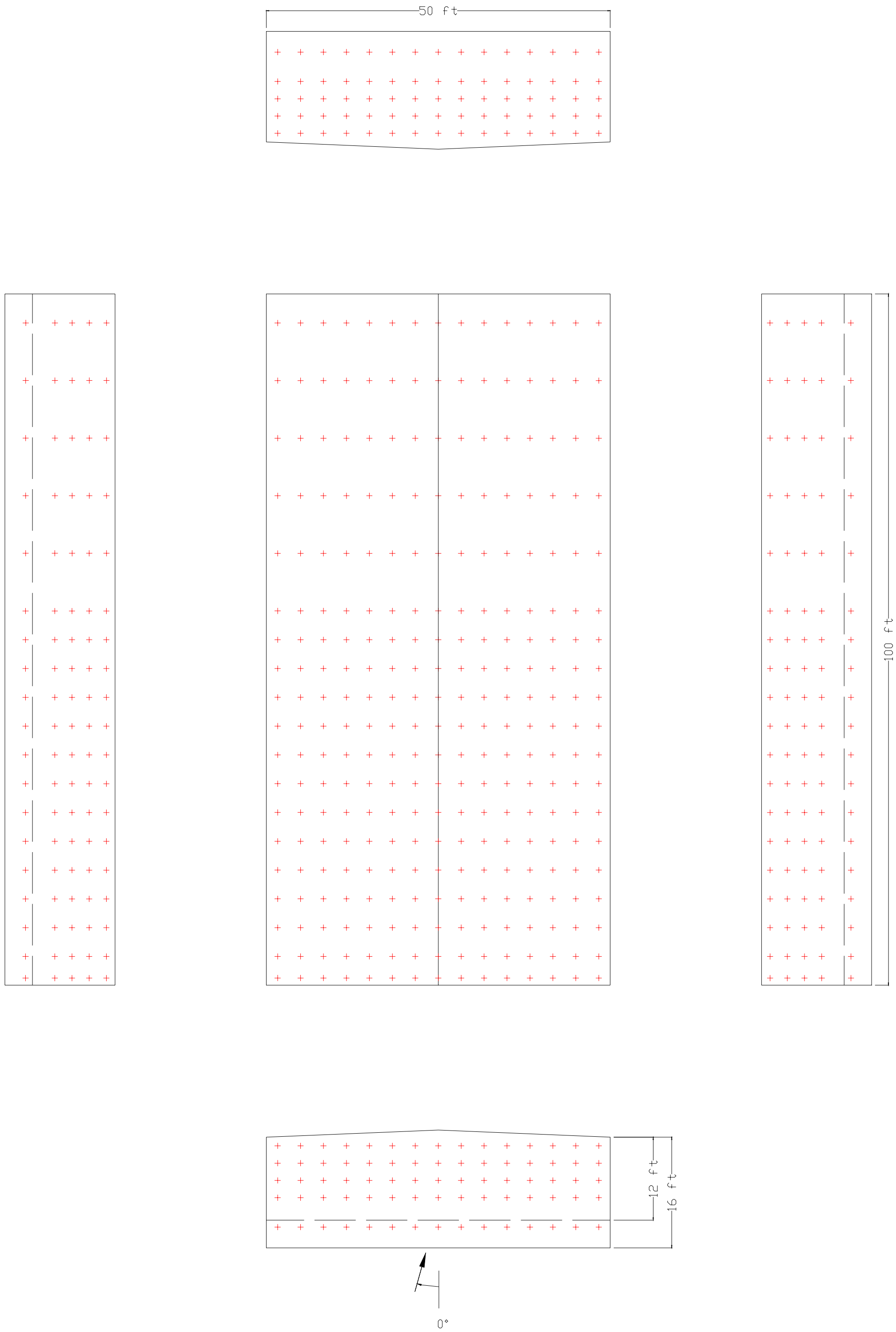


FIGURE 11 PRESSURE TAP LAYOUT – TEST 3

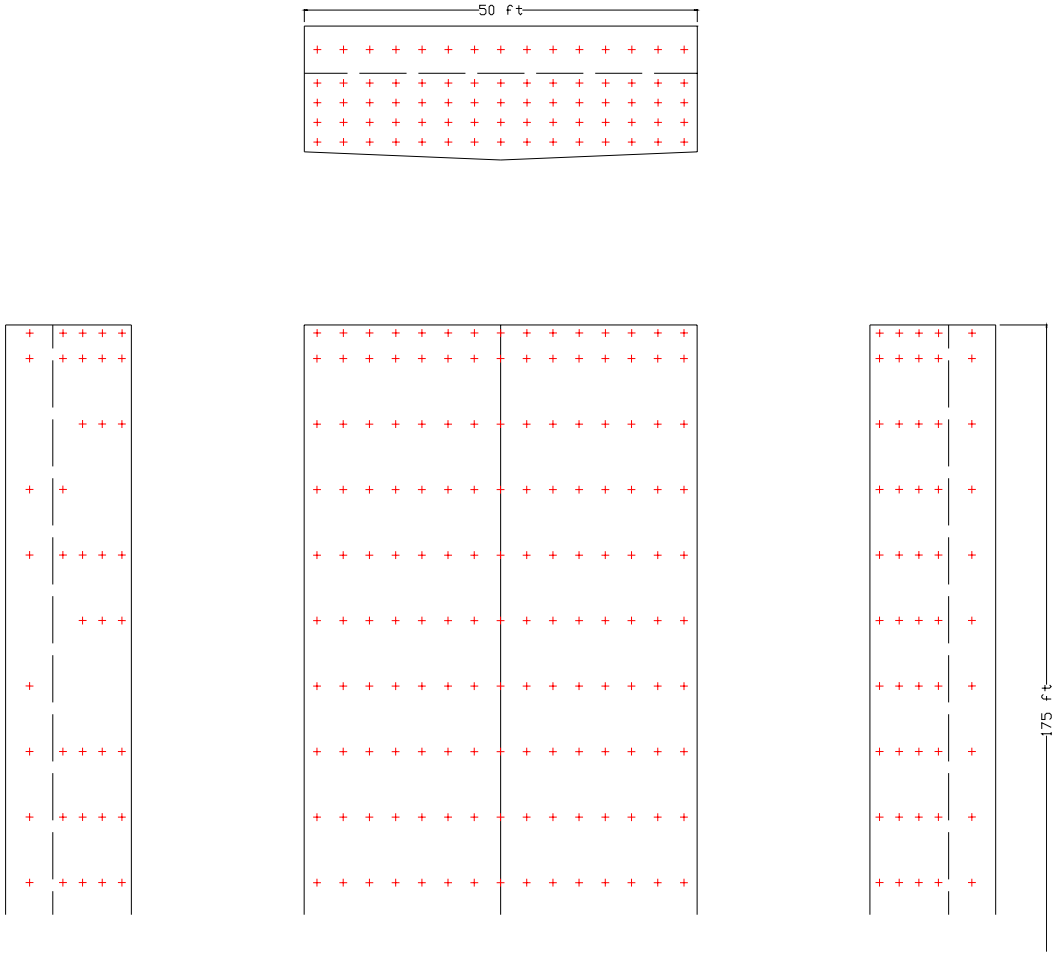


FIGURE 12 PRESSURE TAP LAYOUT – TEST 4

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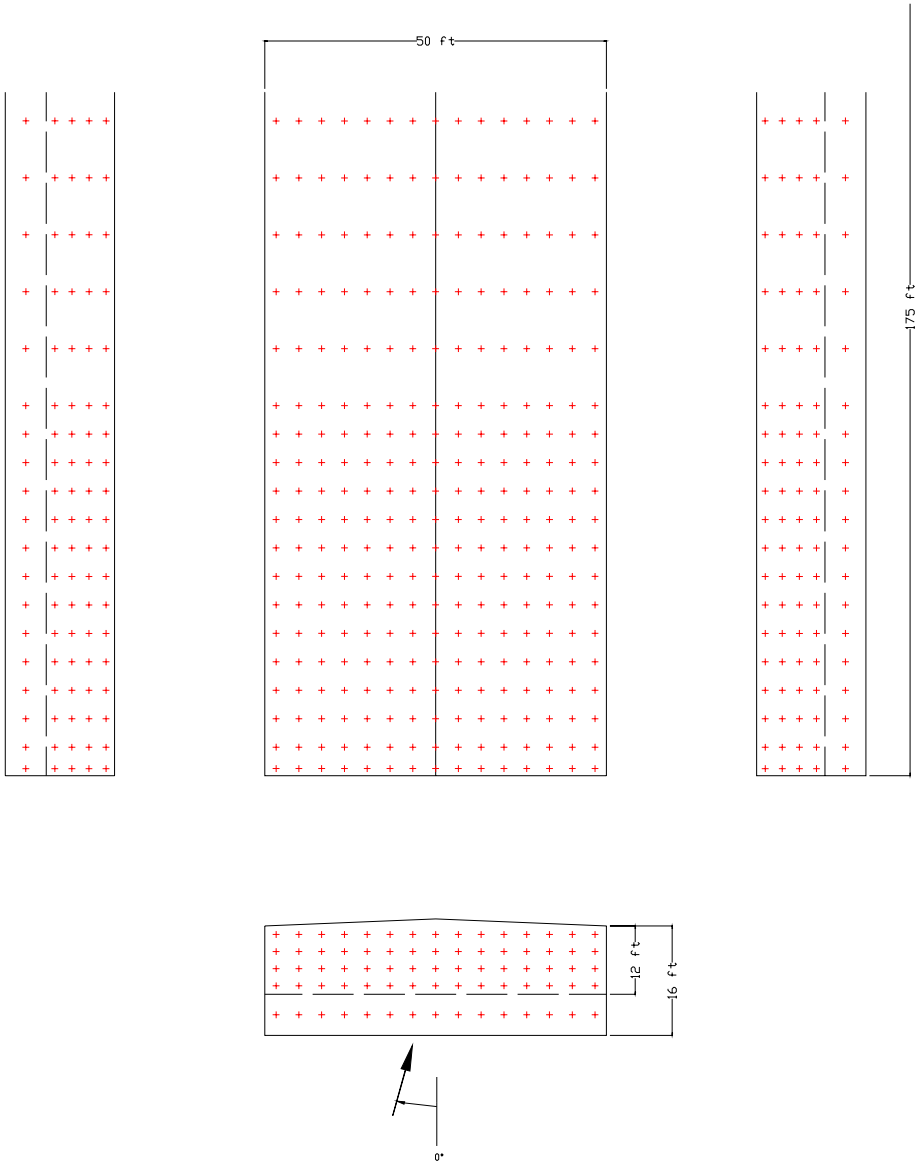
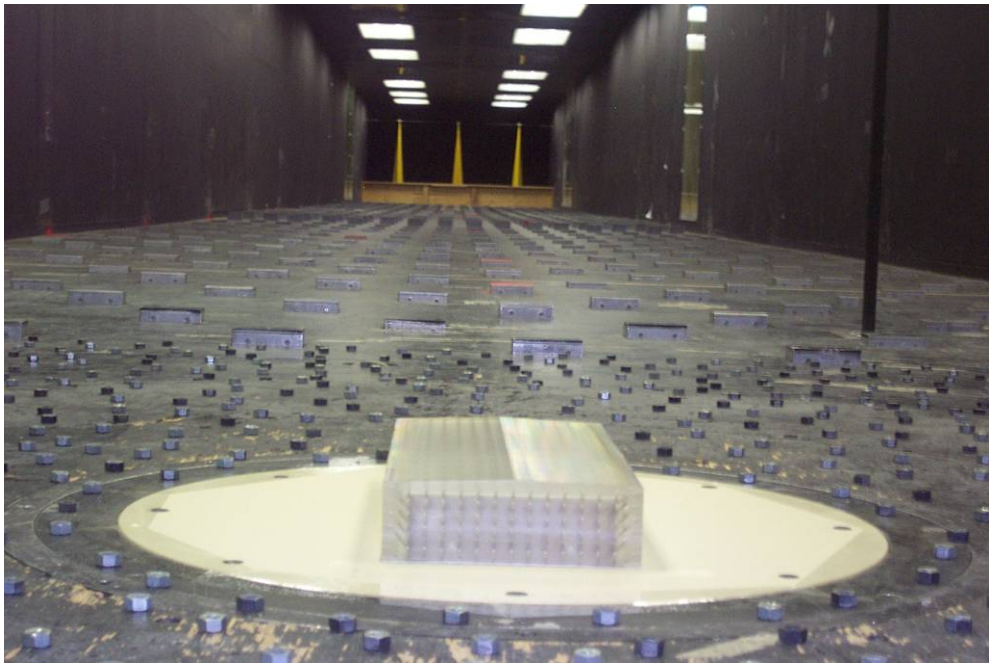




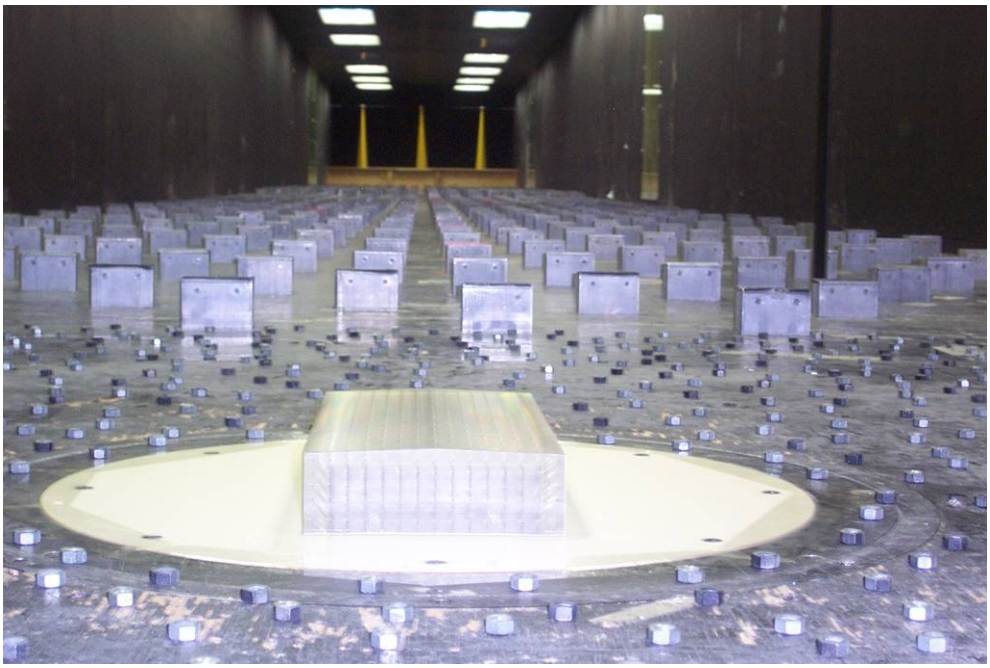
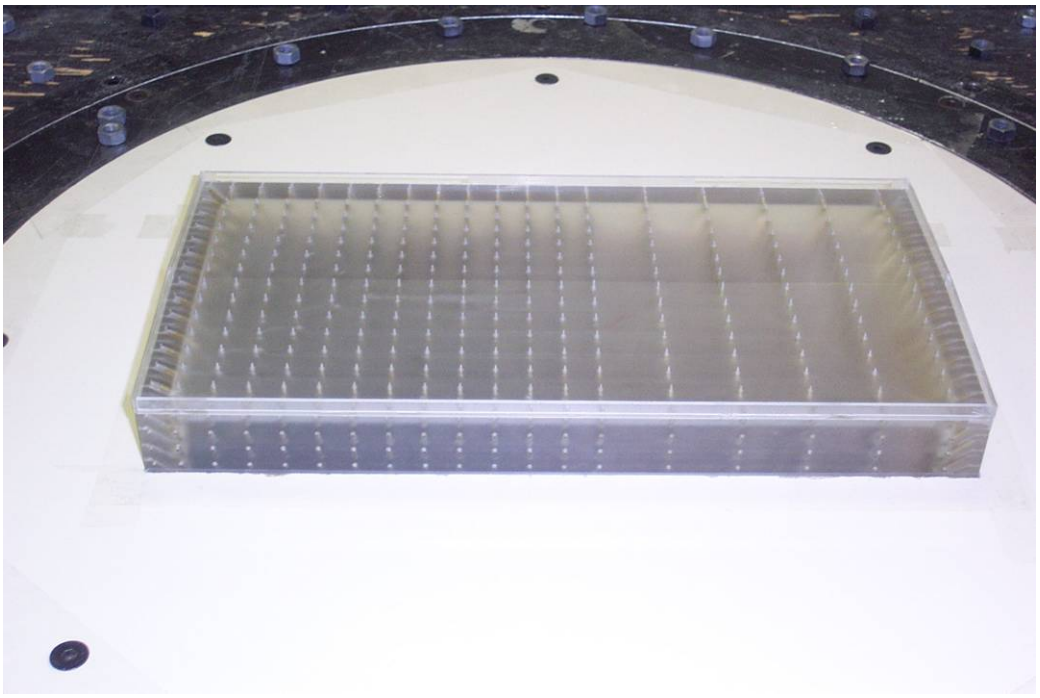


FIGURE 13 VIEWS OF THE TEST 1 MODEL IN THE WIND TUNNEL



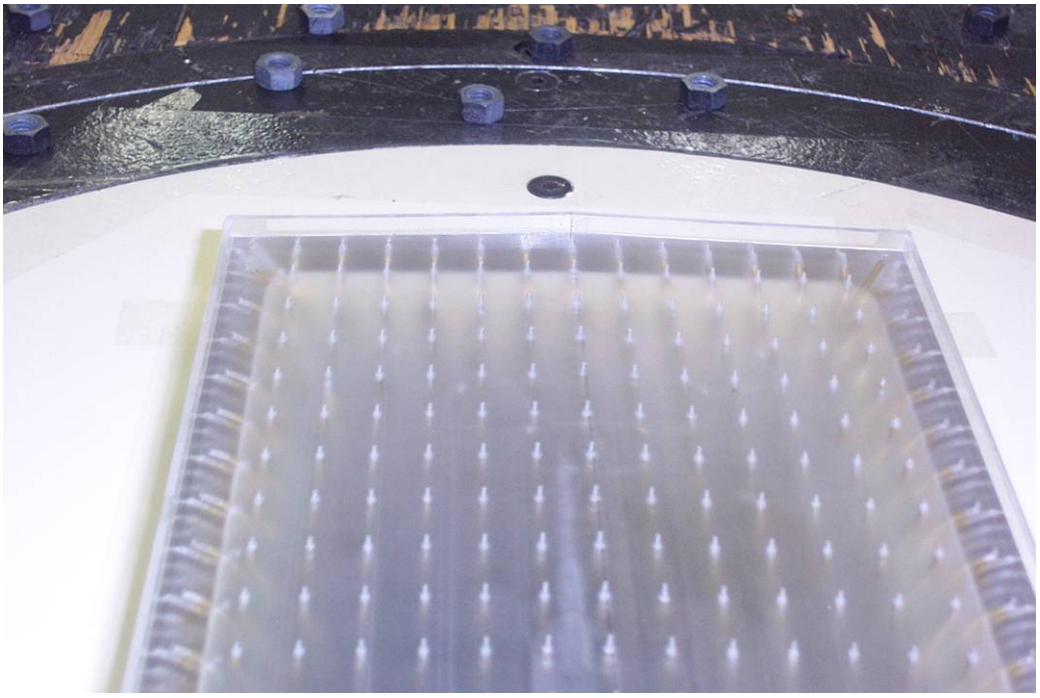


FIGURE 14 VIEWS OF THE TEST 2 MODEL IN THE WIND TUNNEL

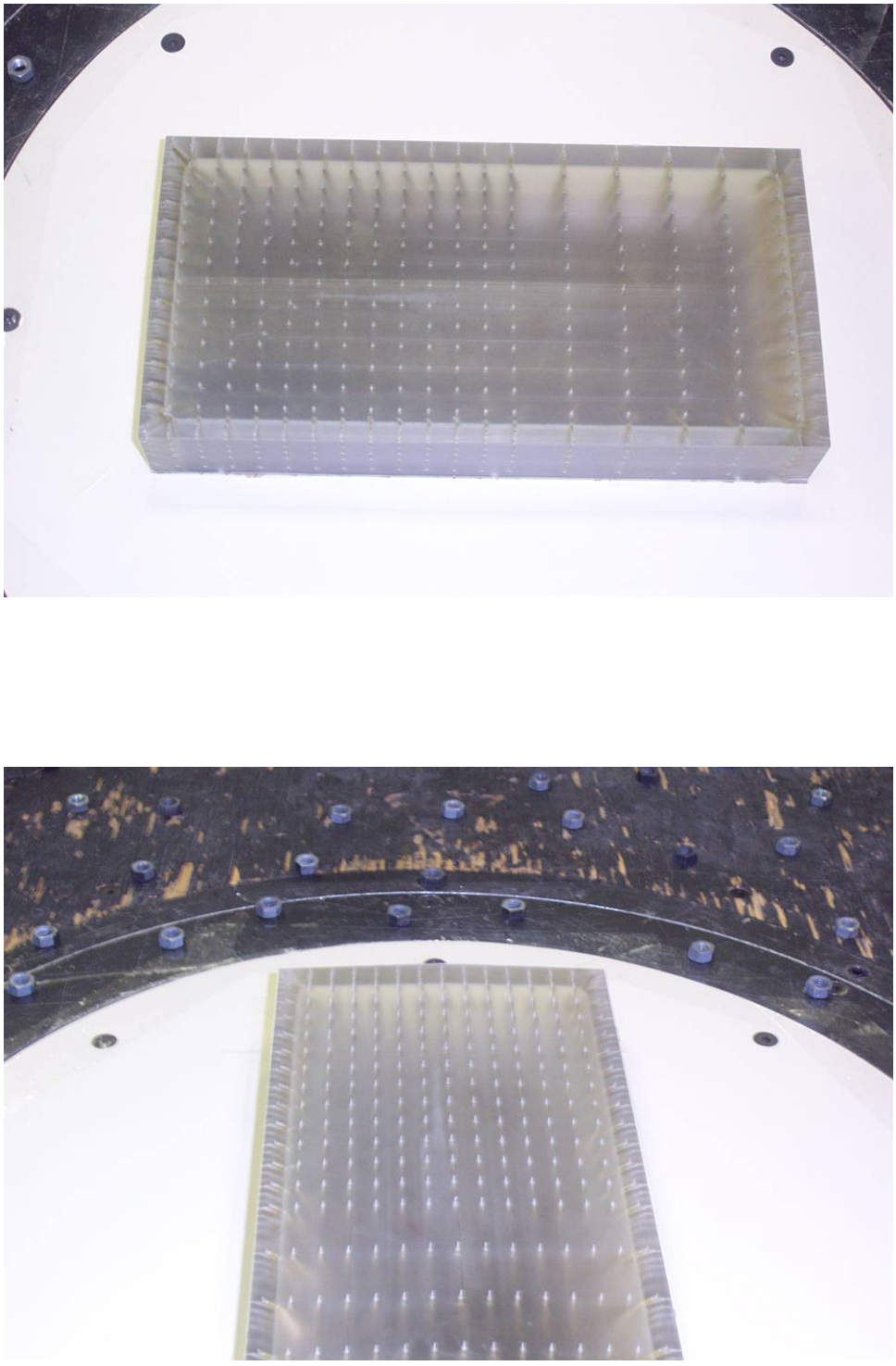


FIGURE 15 VIEWS OF THE TEST 3 MODEL IN THE WIND TUNNEL

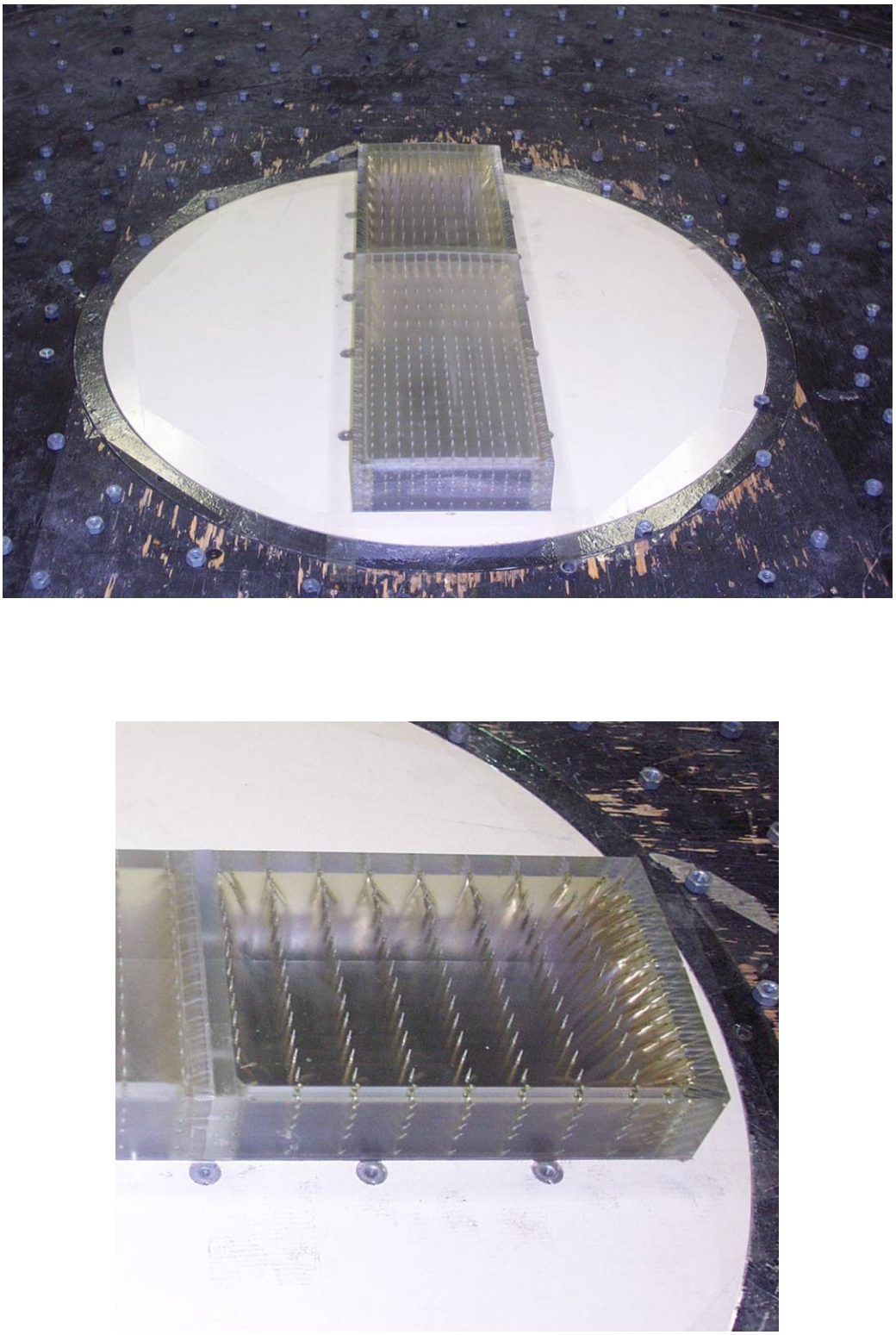


FIGURE 16 VIEWS OF THE TEST 4 MODEL IN THE WIND TUNNEL

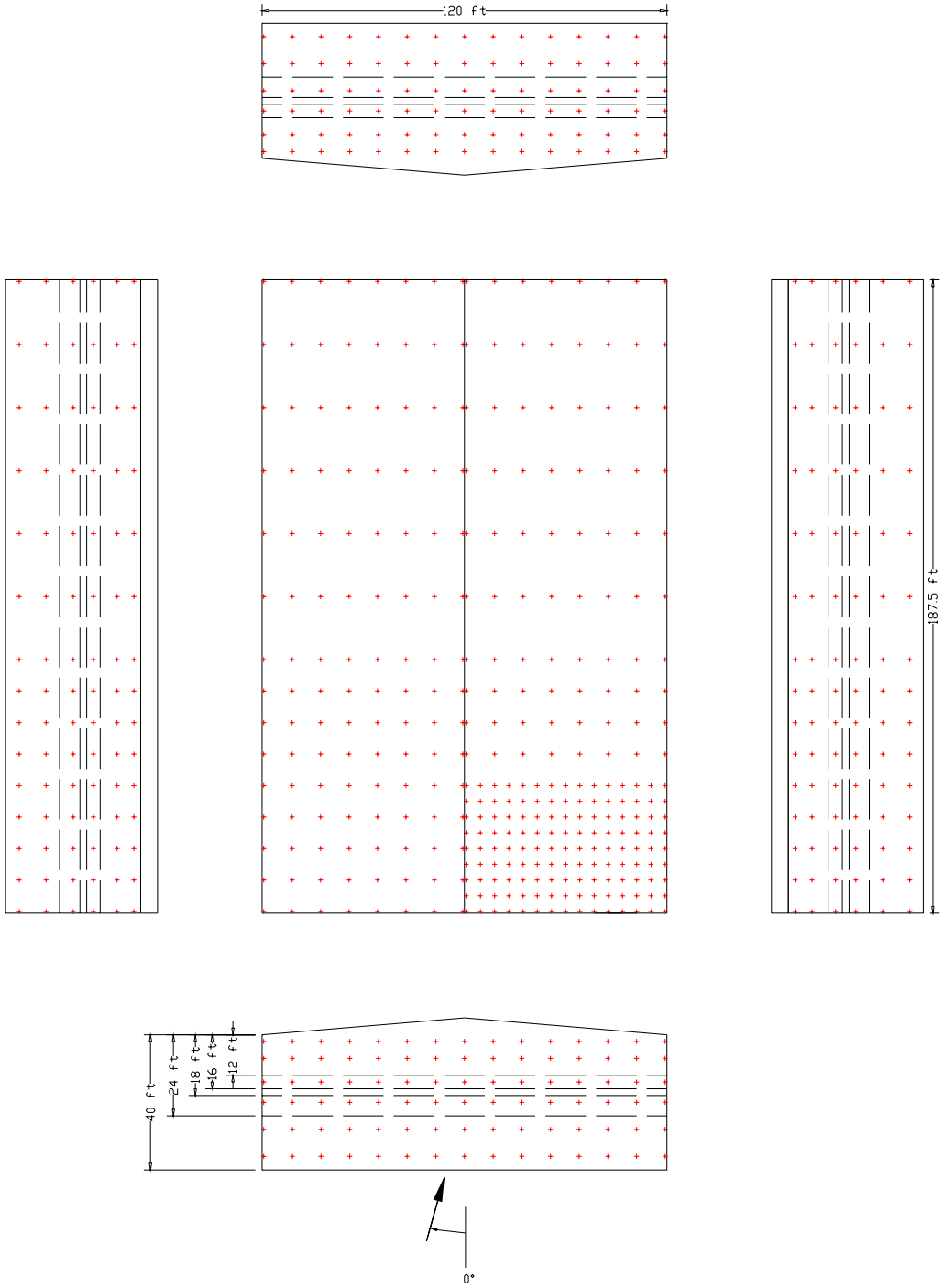


FIGURE 17 PRESSURE TAP LAYOUT – TEST 5

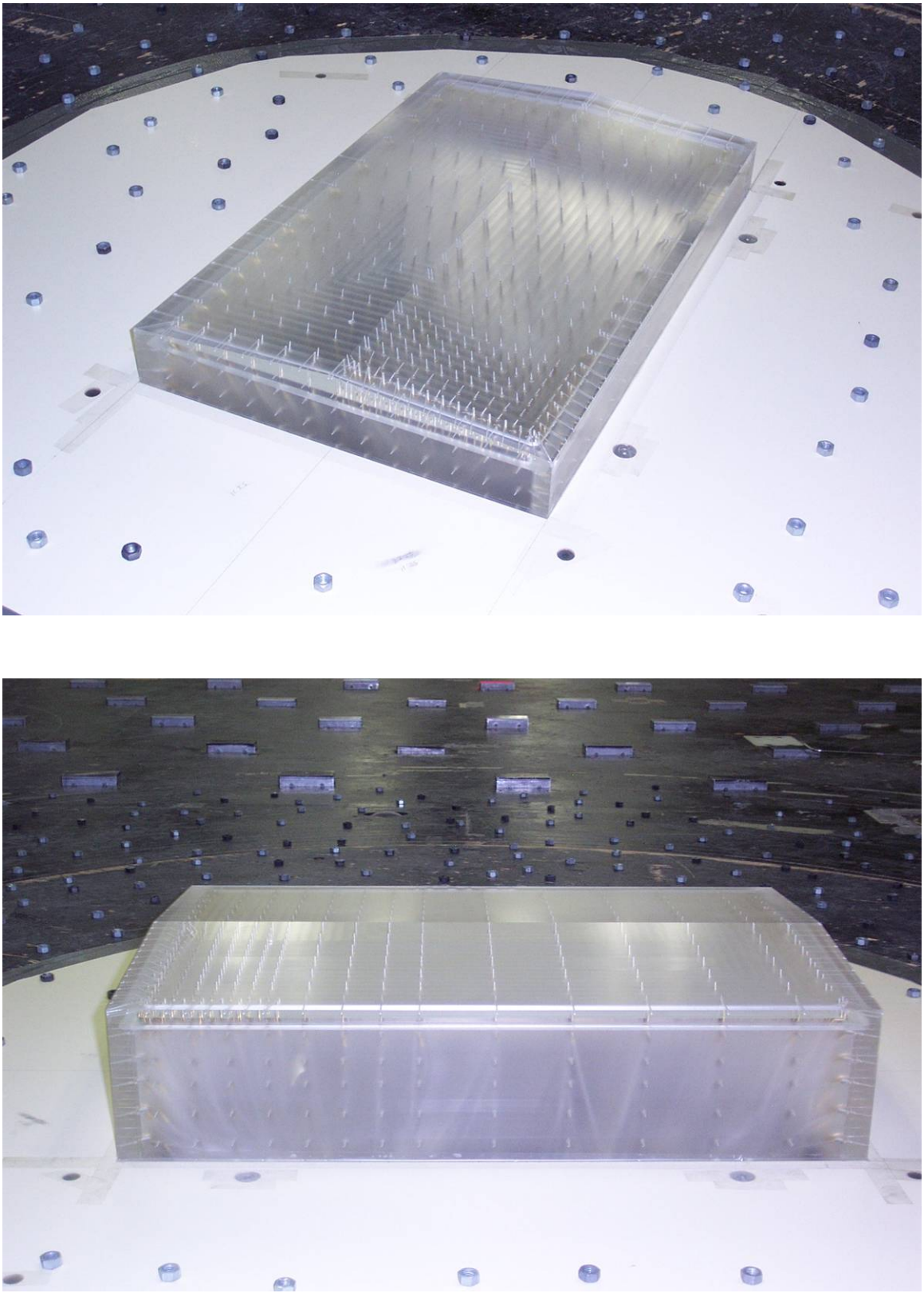


FIGURE 18 VIEWS OF THE TEST 5 MODEL IN THE WIND TUNNEL

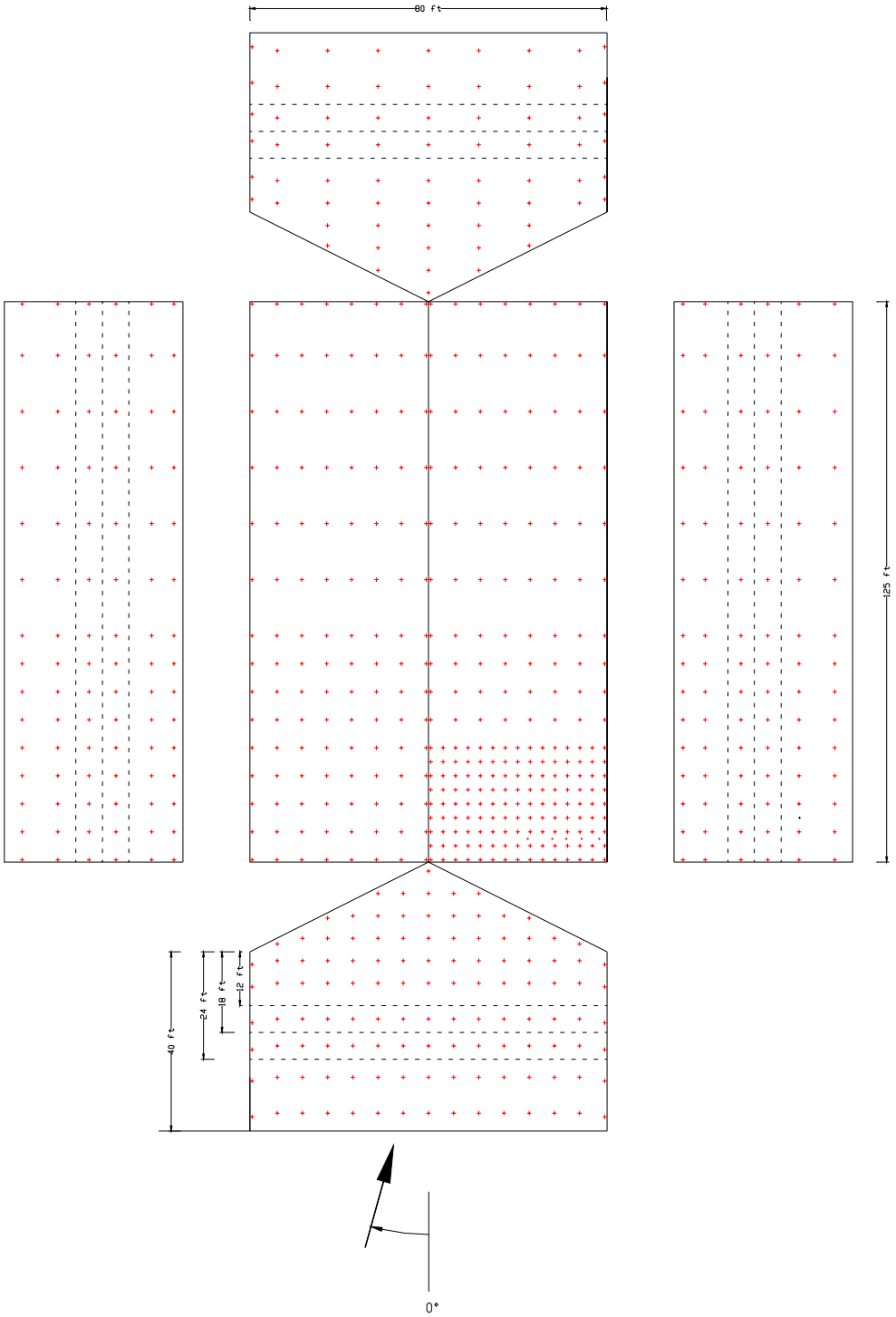


FIGURE 19 PRESSURE TAP LAYOUT – TEST 6

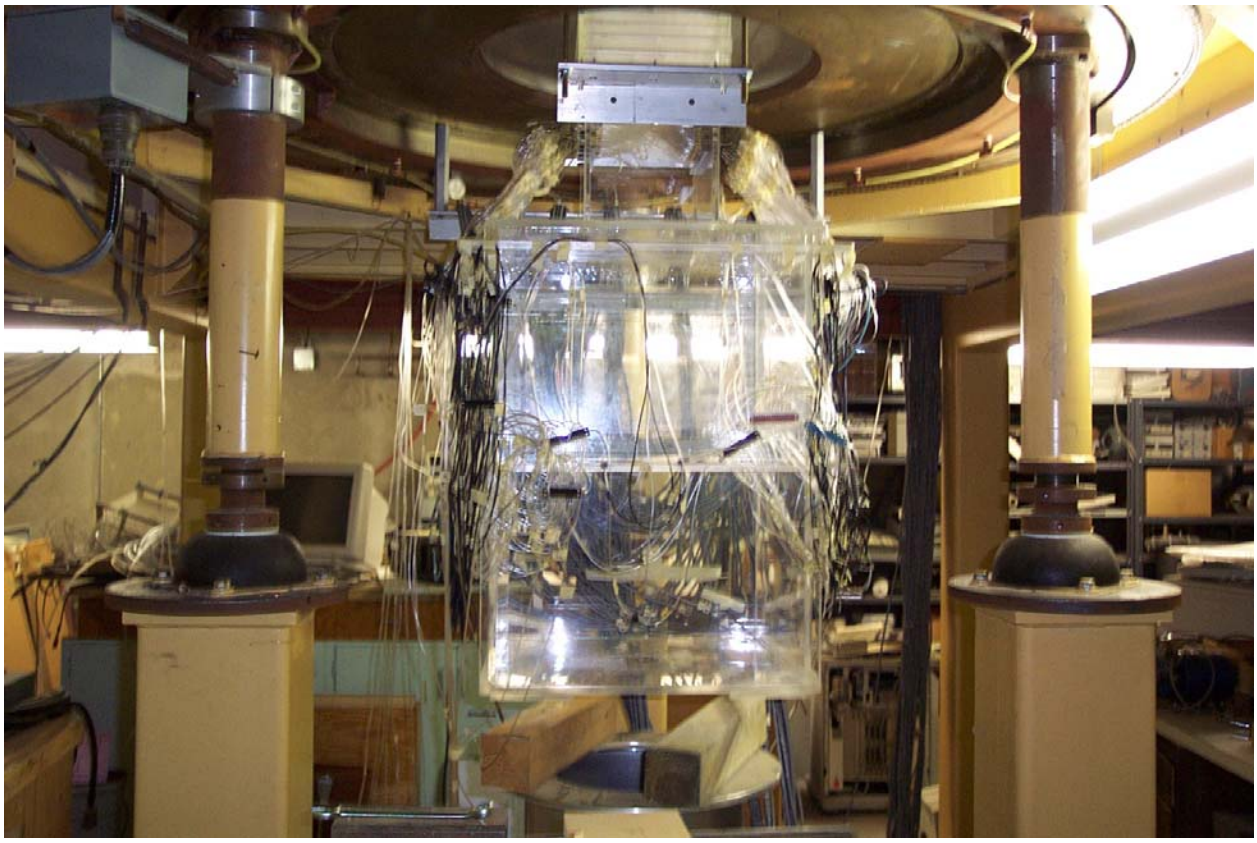


FIGURE 20 VIEW OF THE EXAGGERATED INTERNAL VOLUME CHAMBER

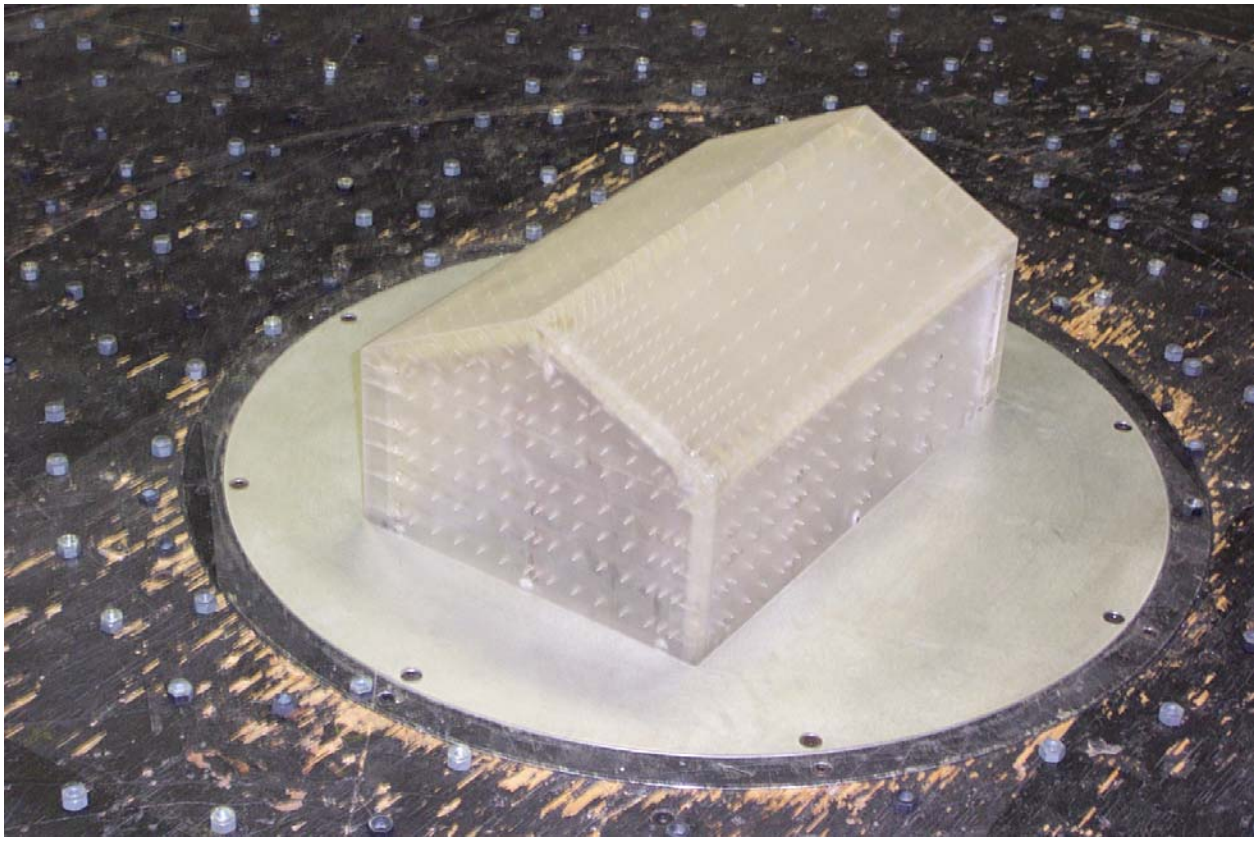


FIGURE 21 VIEWS OF MODEL FOR TEST 6

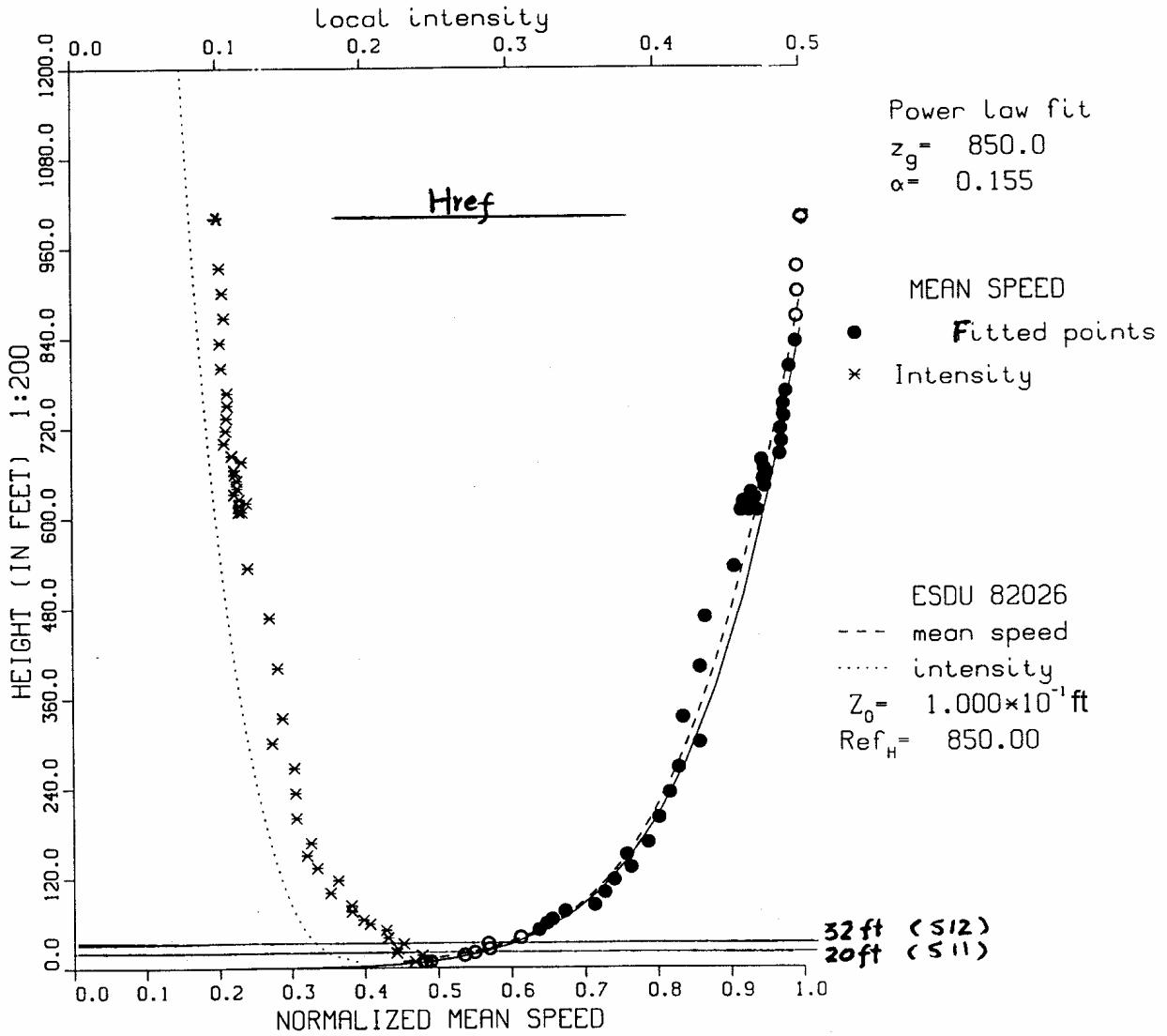


FIGURE 22 WIND SPEED AND TURBULENCE INTENSITY PROFILES FROM THE 1997 NIST EXPERIMENTS – OPEN EXPOSURE (AFTER [2])

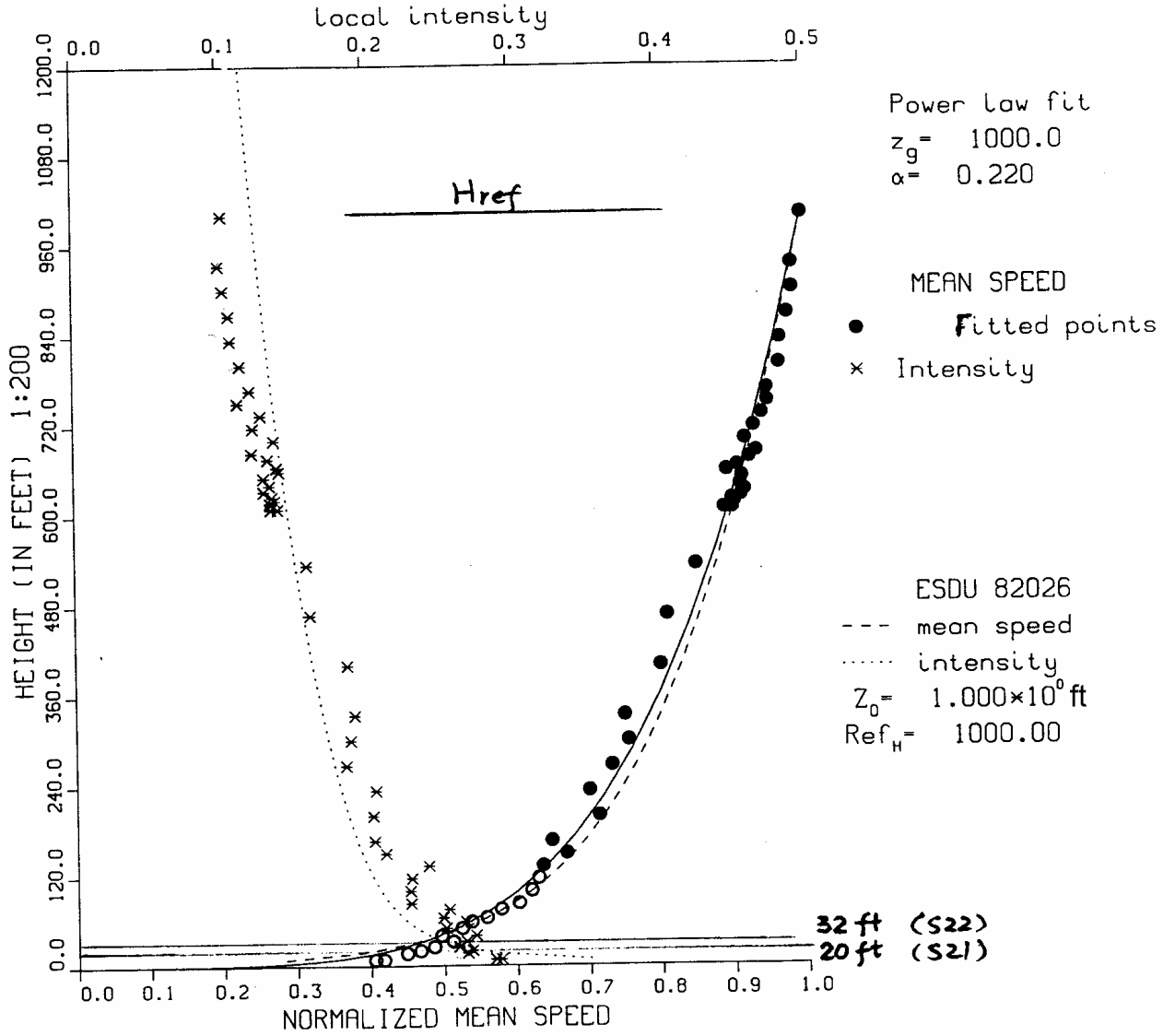


FIGURE 23 WIND SPEED AND TURBULENCE INTENSITY PROFILES FROM THE 1997 NIST EXPERIMENTS – SUBURBAN EXPOSURE (AFTER [2])

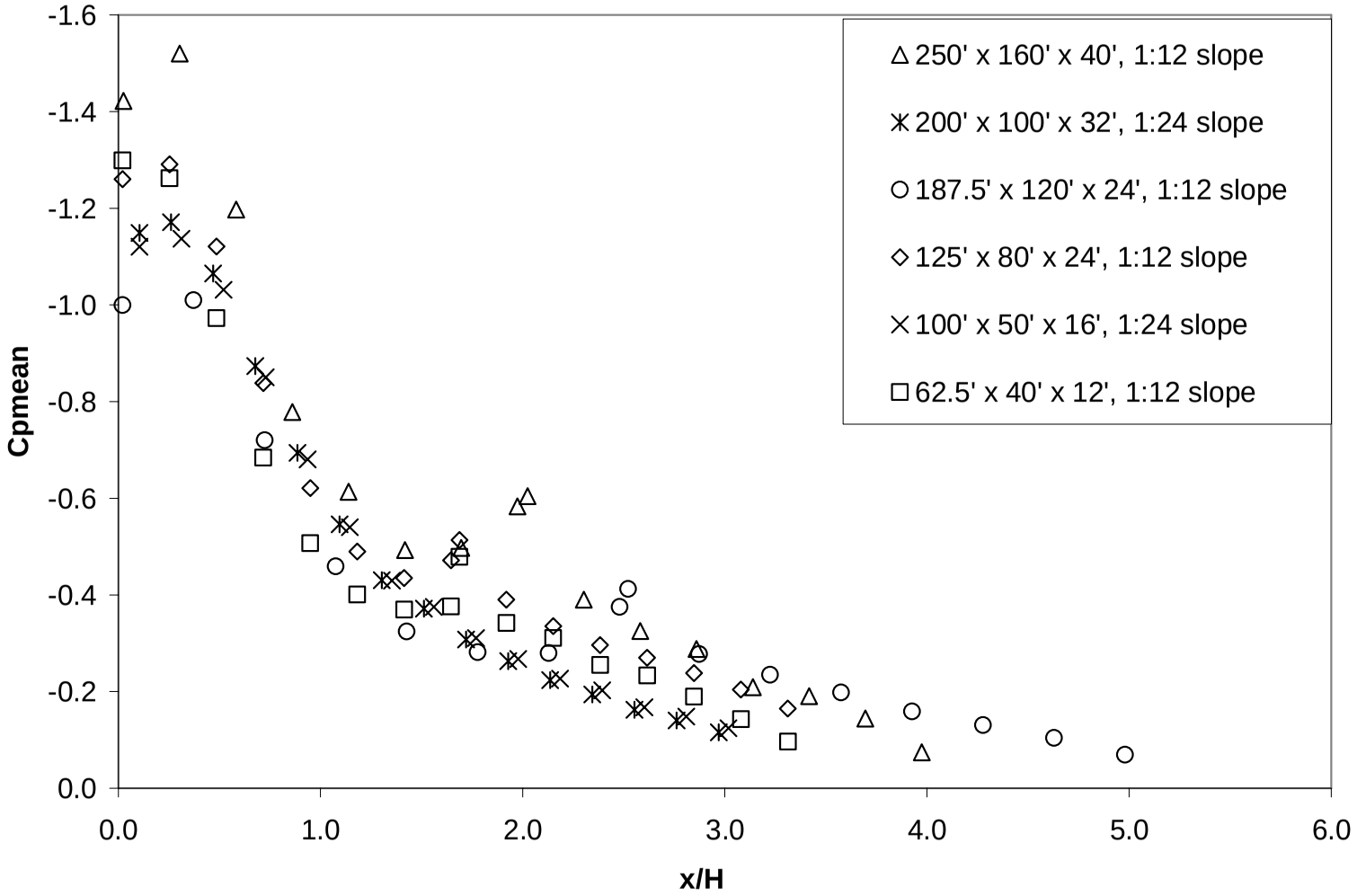


FIGURE 24 COMPARISON OF MEAN PRESSURE COEFFICIENTS, OBTAINED AT MIDSPAN FOR MODELS OF VARYING DIMENSIONS IN OPEN COUNTRY TERRAIN

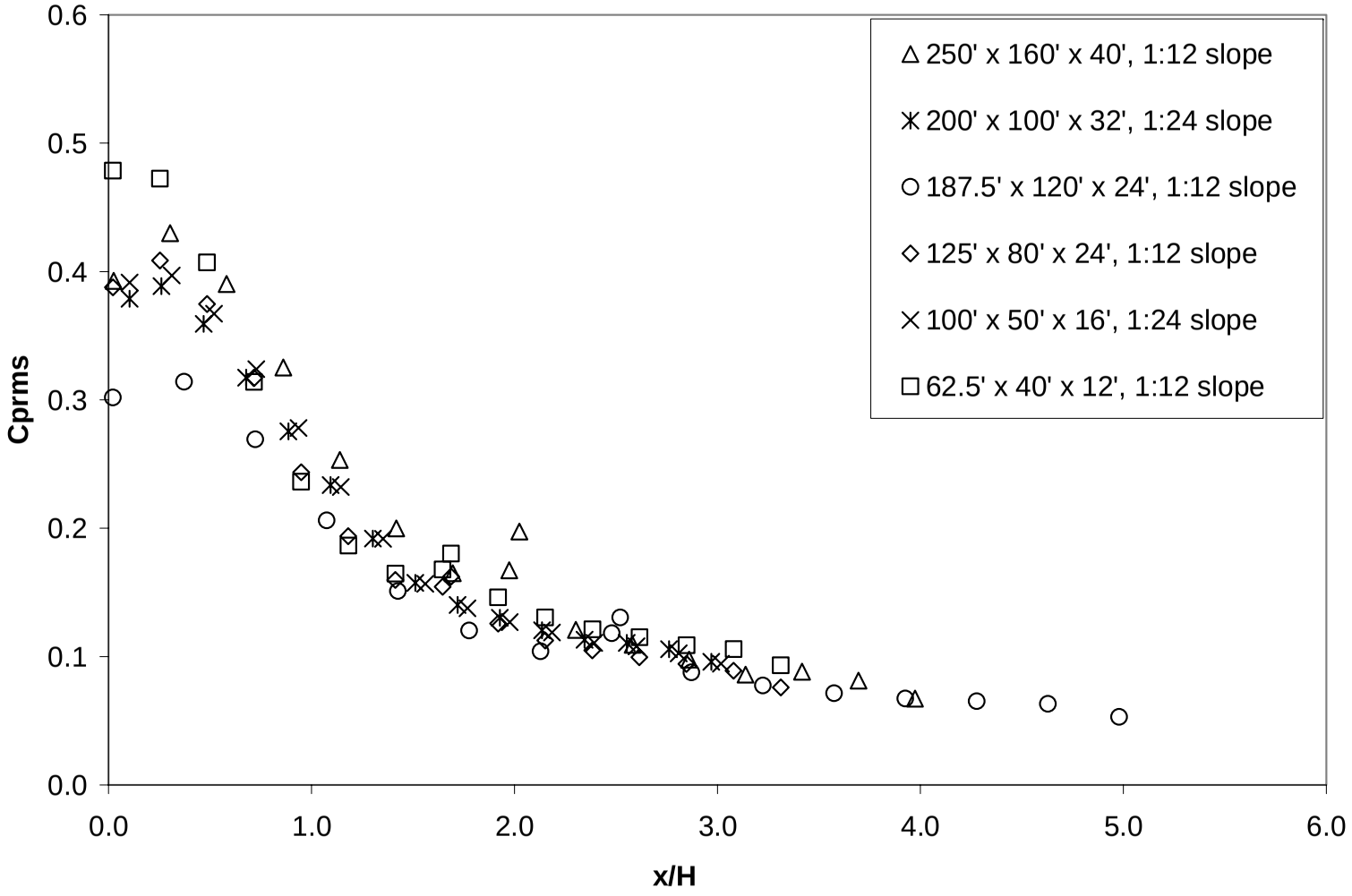


FIGURE 25 COMPARISON OF RMS PRESSURE COEFFICIENTS, OBTAINED AT MIDSPAN FOR MODELS OF VARYING DIMENSIONS IN OPEN COUNTRY TERRAIN

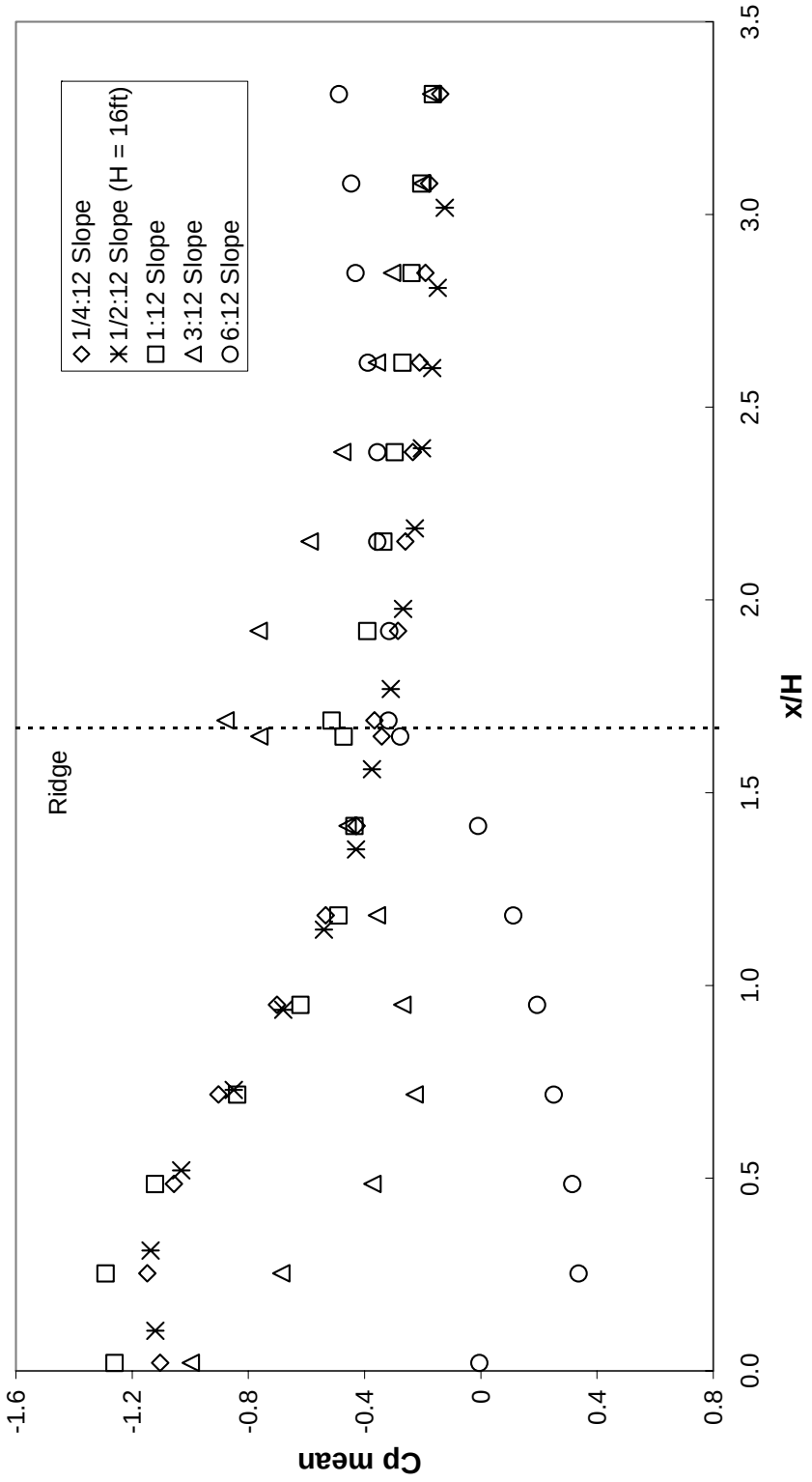


FIGURE 26 COMPARISON OF MEAN PRESSURE COEFFICIENTS, OBTAINED AT MIDSPAN FOR MODELS OF VARYING ROOF SLOPE FOR H=24FT IN OPEN COUNTRY TERRAIN

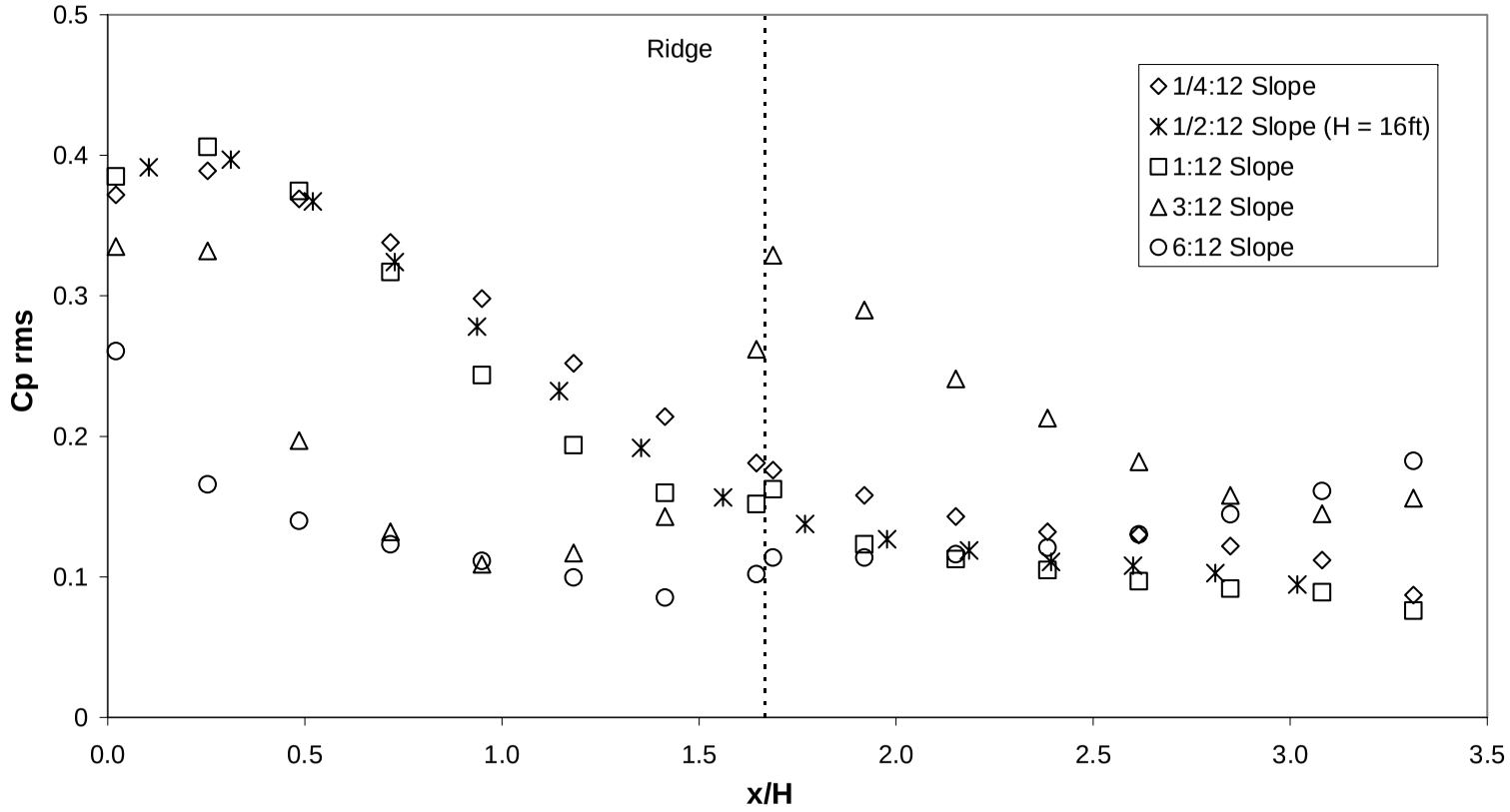
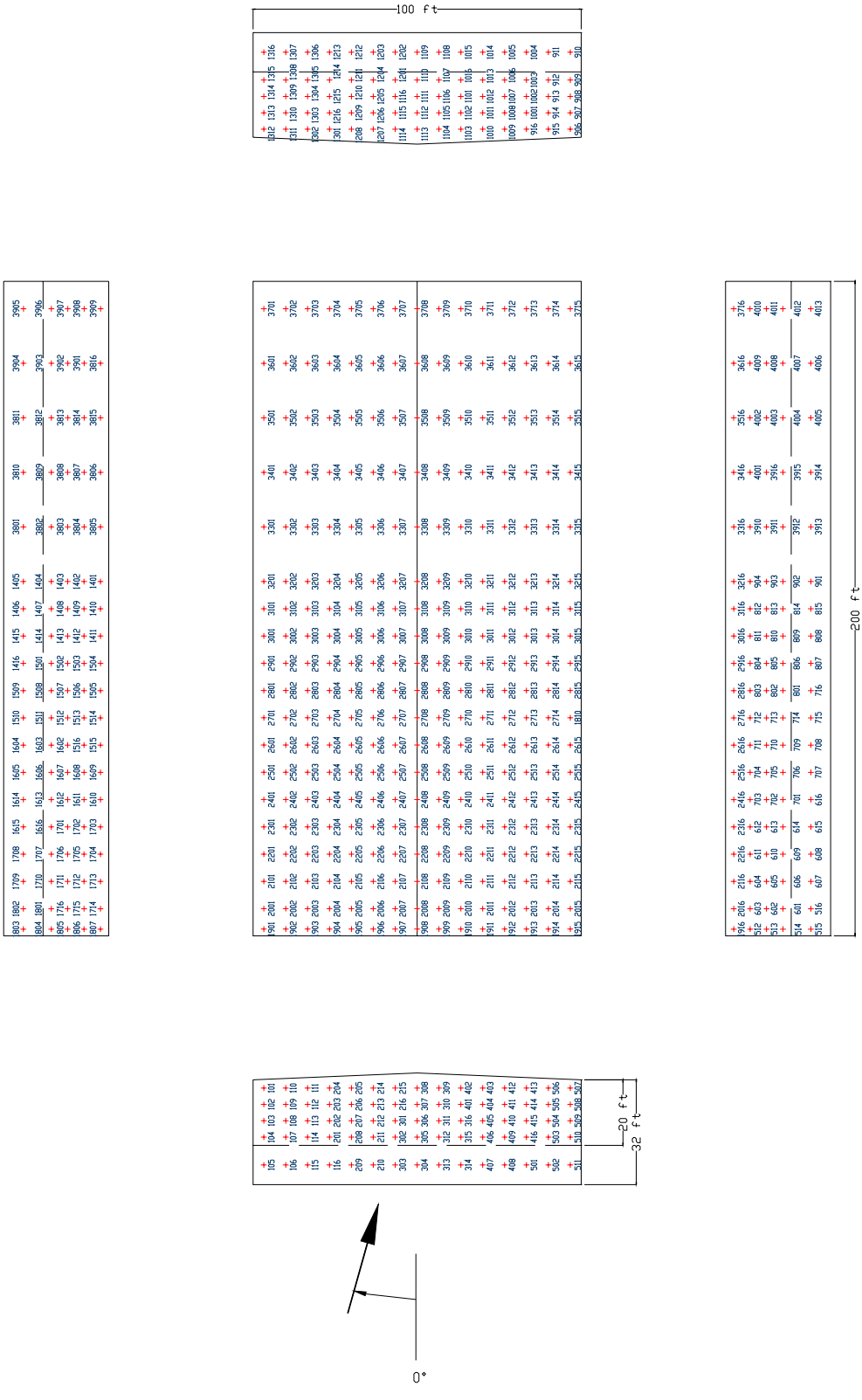


FIGURE 27 COMPARISON OF RMS PRESSURE COEFFICIENTS, OBTAINED AT MIDSPAN FOR MODELS OF VARYING ROOF SLOPE FOR H = 24FT IN OPEN COUNTRY TERRAIN

APPENDIX A

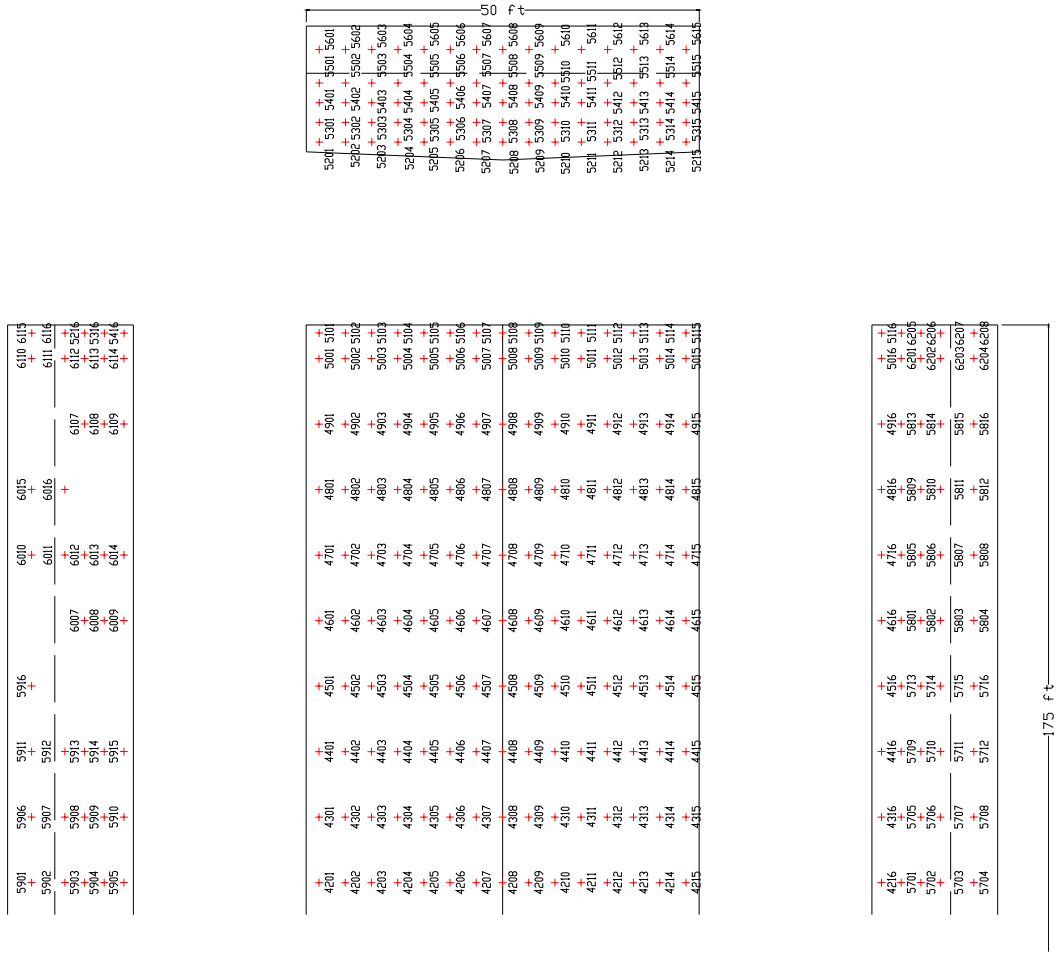
PRESSURE TAP LAYOUT AND NOMENCLATURE

Tests 1 and 2



Test 3

Test 4



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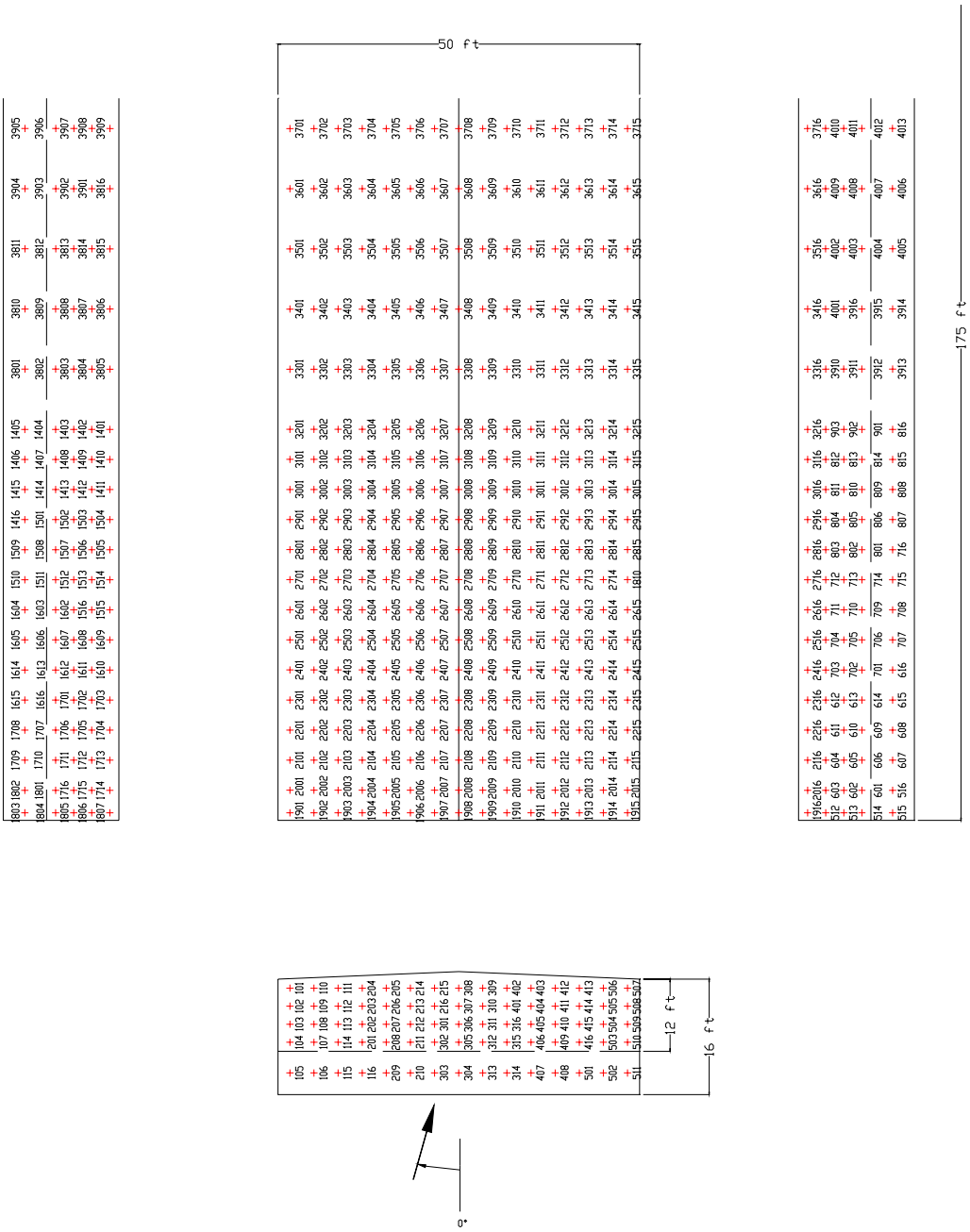
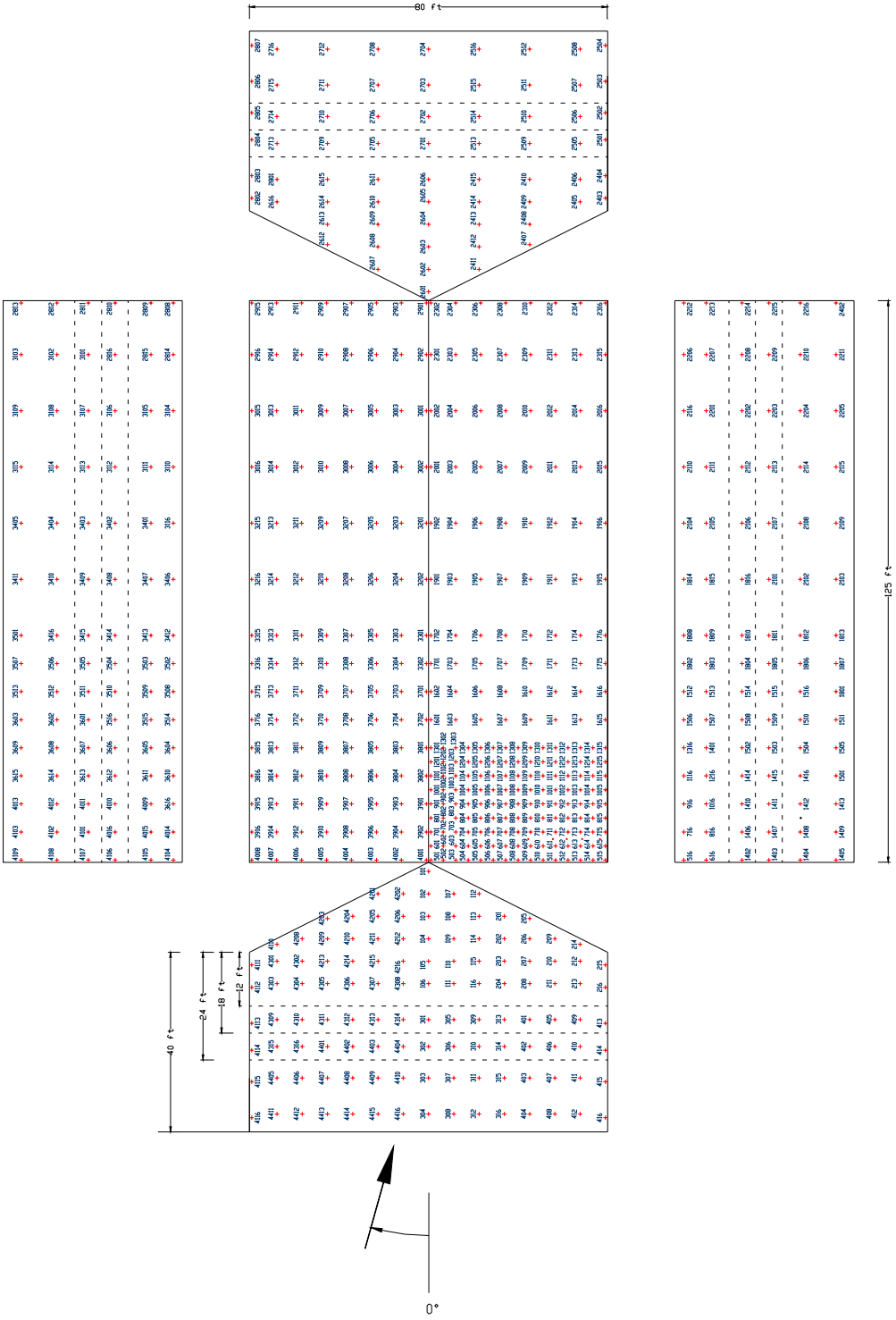


Test 5

Test 6



APPENDIX B

SUMMARY DATA SHEETS

SUMMARY DATA SHEET

TESTS 1 and 2 – GENERIC MODEL (200'x100', 1:24 ROOF SLOPE, WITH AND WITHOUT PARAPET)

Building dimensions		200' x 100' x two different eave heights; 1:24 roof slope gable roof	
Model scale		1:200	
Number of pressure taps		625 external taps	
Sampling frequency		400 Hz	
Sampling period		60 seconds	
Reference wind tunnel speed		60 fps, nominal (see note)	
Test angles		Every 5^{o} between 0^{o} and 180^{o} (inclusive)	
Upstream exposure		1	2
Exposure description		Open country	Suburban
Ratio of roof to reference wind speed	H=20'	0.591	0.468
	H=32'	0.638	0.512
Nominal roof height wind speed, V_{Hm}, in fps (see note)	H=20'	35	28
	H=32'	38	31
Full scale mean wind speed at roof height (fps)		V_H	
Equivalent full scale sampling frequency (Hz)		$\frac{2\,V_{Hm}}{V_H}$	
Equivalent full scale sampling duration (seconds)		$\frac{12000\,V_{Hm}}{V_H}$	
Test file identifications:			
No parapet	H=20'	Q11___	Q12___
	H=32'	Q21___	Q22___
With 3' parapet	H=20'	R11___	R12___
	H=32'	R21___	R22___

Note:

Actual wind speeds are within 5% of 60 fps at reference level. Pressure coefficients have been normalized based on actual wind tunnel speeds. For the determination of time scaling, nominal wind speed of 60 fps has been used.

SUMMARY DATA SHEET

TEST 3 – GENERIC MODEL (100'x50', 1:24 ROOF SLOPE)

Building dimensions		100' x 50' x two different eave heights; 1:24 roof slope gable roof	
Model scale		1:100	
Number of pressure taps		625 external taps	
Sampling frequency		400 Hz	
Sampling period		120 seconds	
Reference wind tunnel speed		60 fps, nominal (see note)	
Test angles		Every 5^{o} between 0^{o} and 180^{o} (inclusive)	
Upstream exposure		1	2
Exposure description		Open country	Suburban
Ratio of roof to reference wind speed	H=12'	0.579	0.432
	H=16'	0.609	0.455
Nominal roof height wind speed, V_{Hm}, in fps (see note 1)	H=12'	35	26
	H=16'	37	27
Full scale mean wind speed at roof height (fps)		V_H	
Equivalent full scale sampling frequency (Hz)		$\frac{4\,V_{Hm}}{V_H}$	
Equivalent full scale sampling duration (seconds)		$\frac{12000\,V_{Hm}}{V_H}$	
Test file identifications:			
	H=12'	T11___	T12___
	H=16'	T21___	T22___

Note:

Actual wind speeds are within 5% of 60 fps at reference level. Pressure coefficients have been normalized based on actual wind tunnel speeds. For the determination of time scaling, nominal wind speed of 60 fps has been used.

SUMMARY DATA SHEET

TEST 4 – GENERIC MODEL (175'x50', 1:24 ROOF SLOPE)

Building dimensions		175' x 50' x two different eave heights; 1:24 roof slope gable roof	
Model scale		1:100	
Number of pressure taps		864 external taps	
Sampling frequency		400 Hz	
Sampling period		120 seconds	
Reference wind tunnel speed		60 fps, nominal (see note)	
Test angles		Every 5^{o} between 0^{o} and 180^{o} (inclusive)	
Upstream exposure		1	2
Exposure description		Open country	Suburban
Ratio of roof to reference wind speed	H=12'	0.579	0.432
	H=16'	0.609	0.455
Nominal roof height wind speed, V_{Hm}, in fps (see note)	H=12'	35	26
	H=16'	37	27
Full scale mean wind speed at roof height (fps)		V_H	
Equivalent full scale sampling frequency (Hz)		$\frac{4\,V_{Hm}}{V_H}$	
Equivalent full scale sampling duration (seconds)		$\frac{12000\,V_{Hm}}{V_H}$	
Test file identifications:			
	H=12'	V11___	V12___
	H=16'	V21___	V22___

Note:

Actual wind speeds are within 5% of 60 fps at reference level. Pressure coefficients have been normalized based on actual wind tunnel speeds. For the determination of time scaling, nominal wind speed of 60 fps has been used.

SUMMARY DATA SHEET

TEST 5 – GENERIC MODEL (187.5'x120', 1:12 ROOF SLOPE)

Building dimensions		187.5' x 120' x five different eave heights; 1:12 roof slope gable roof	
Model scale		1:100	
Number of pressure taps		694 external taps	
Sampling frequency		500 Hz	
Sampling period		100 seconds	
Reference wind tunnel speed		45 fps, nominal (see note 1)	
Test angles		Every 5^o from 270^o to 360^o and from 0^o to 90^o (inclusive)	
Upstream exposure		1	2
Exposure description		Open country	Suburban
Ratio of roof to reference wind speed	H=12'	0.579	0.432
	H=16'	0.609	0.455
	H=18'	0.623	0.463
	H=24'	0.650	0.487
	H=40'	0.700	0.532
Nominal roof height wind speed, V_{Hm}, in fps (see note)	H=12'	26	19
	H=16'	27	21
	H=18'	28	21
	H=24'	29	22
	H=40'	32	24
Full scale mean wind speed at roof height (fps)		V_H	
Equivalent full scale sampling frequency (Hz)		$\frac{5\,V_H}{V_{Hm}}$	
Equivalent full scale sampling duration (seconds)		$\frac{10000\,V_{Hm}}{V_H}$	
Test file identifications:			
No leakage or dominant openings	H=12'	P11___	P12___
	H=16'	P21___	P22___
	H=18'	P31___	P32___
	H=24'	P41___	P42___
	H=40'	P51___	P52___

Note:

Actual wind speeds are within 5% of 45 fps at reference level. Pressure coefficients have been normalized based on actual wind tunnel speeds. For the determination of time scaling, nominal wind speed of 45 fps has been used.

SUMMARY DATA SHEET

TEST 6 – GENERIC MODEL (125'x80', 6:12 ROOF SLOPE)

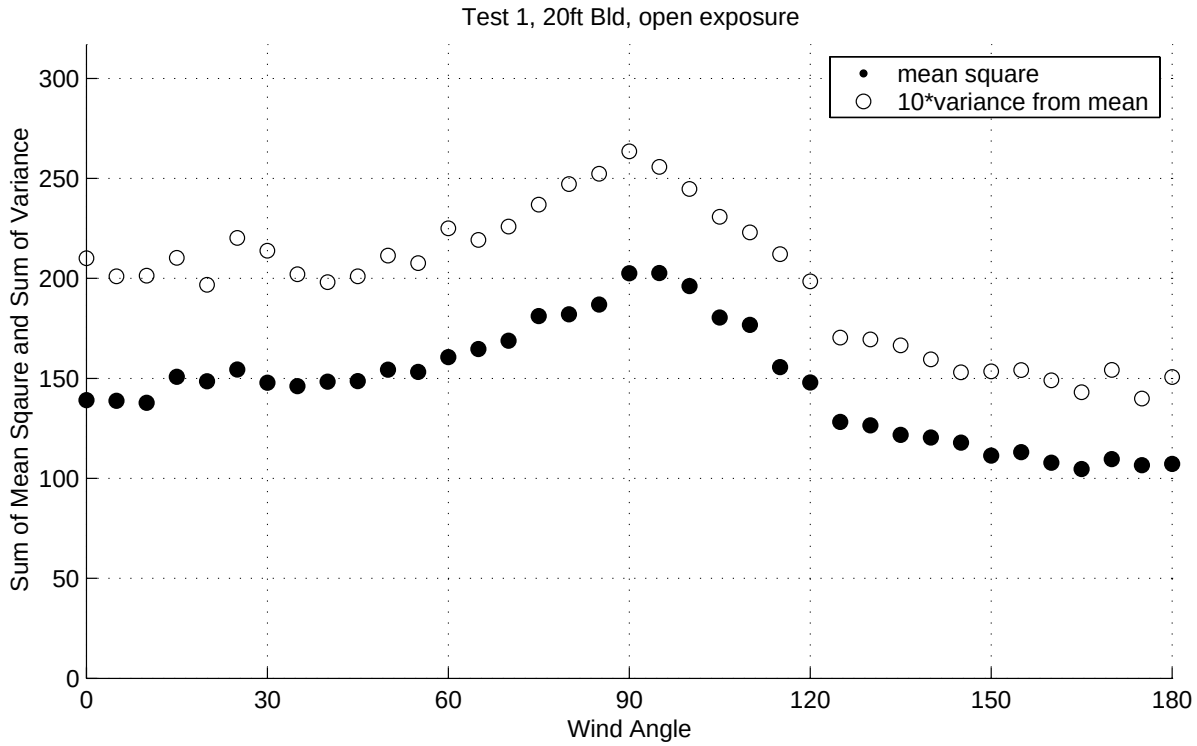
Building dimensions		125' x 80' x four different eave heights; 6:12 roof slope gable roof	
Model scale		1:100	
Number of pressure taps		701 external taps + 3 internal taps	
Sampling frequency		500 Hz	
Sampling period		100 seconds	
Reference wind tunnel speed		45 fps, nominal (see note 1)	
Test angles		Every 5° from 270° to 360° and from 0° to 90° (inclusive)	
Upstream exposure		1	2
Exposure description		Open country	Suburban
Ratio of roof to reference wind speed	H=12'	0.579	0.432
	H=18'	0.623	0.463
	H=24'	0.650	0.487
	H=40'	0.700	0.532
Nominal roof height wind speed, V_{Hm}, in fps (see note)	H=12'	26	19
	H=18'	28	21
	H=24'	29	22
	H=40'	32	24
Full scale mean wind speed at roof height (fps)		V_H	
Equivalent full scale sampling frequency (Hz)		$\frac{5\,V_H}{V_{Hm}}$	
Equivalent full scale sampling duration (seconds)		$\frac{10000\,V_{Hm}}{V_H}$	
Test file identifications:			
Distributed leakage	H=12'	Y11___	Y12___
	H=18'	Y21___	Y22___
	H=24'	Y31___	Y32___
	H=40'	Y41___	Y42___

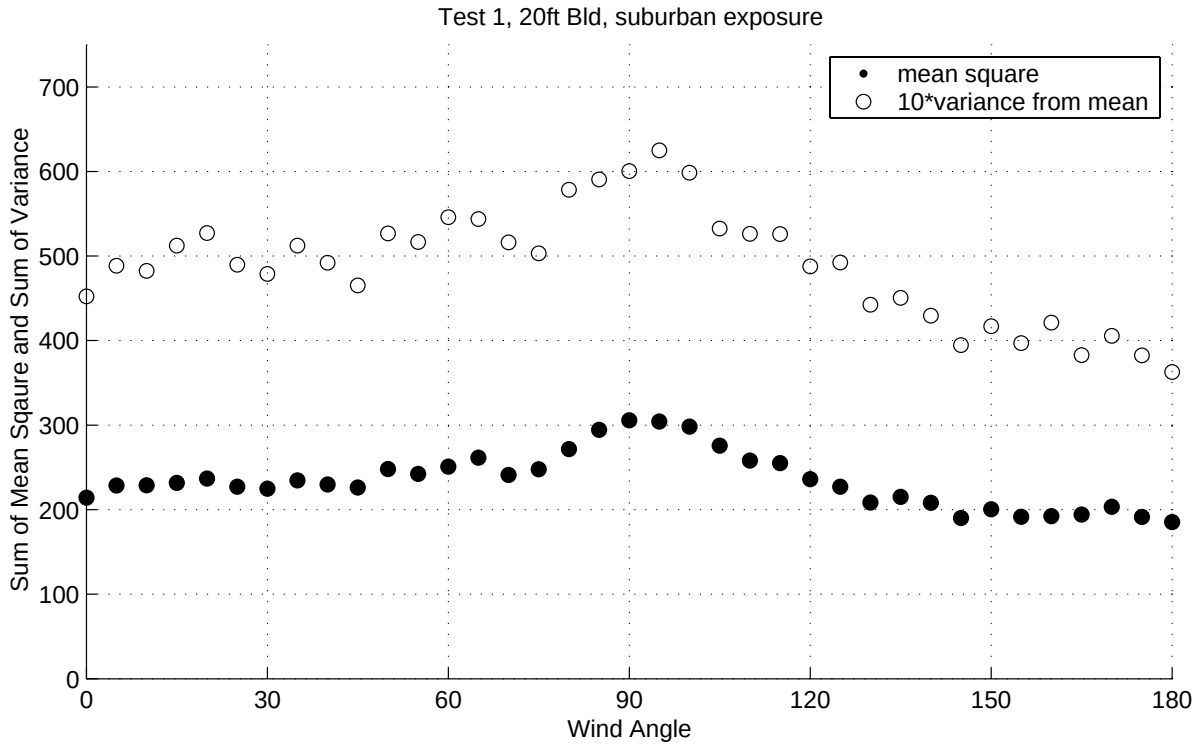
Note:

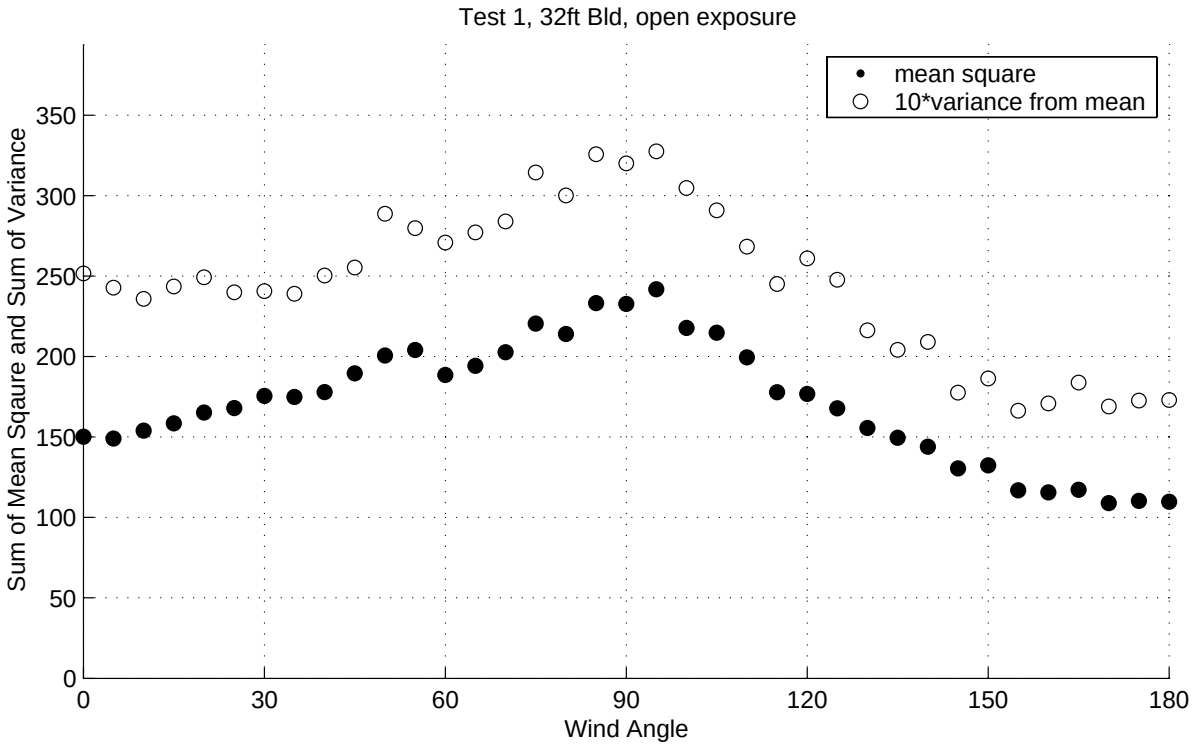
Actual wind speeds are within 5% of 45 fps at reference level. Pressure coefficients have been normalized based on actual wind tunnel speeds. For the determination of time scaling, nominal wind speed of 45 fps has been used.

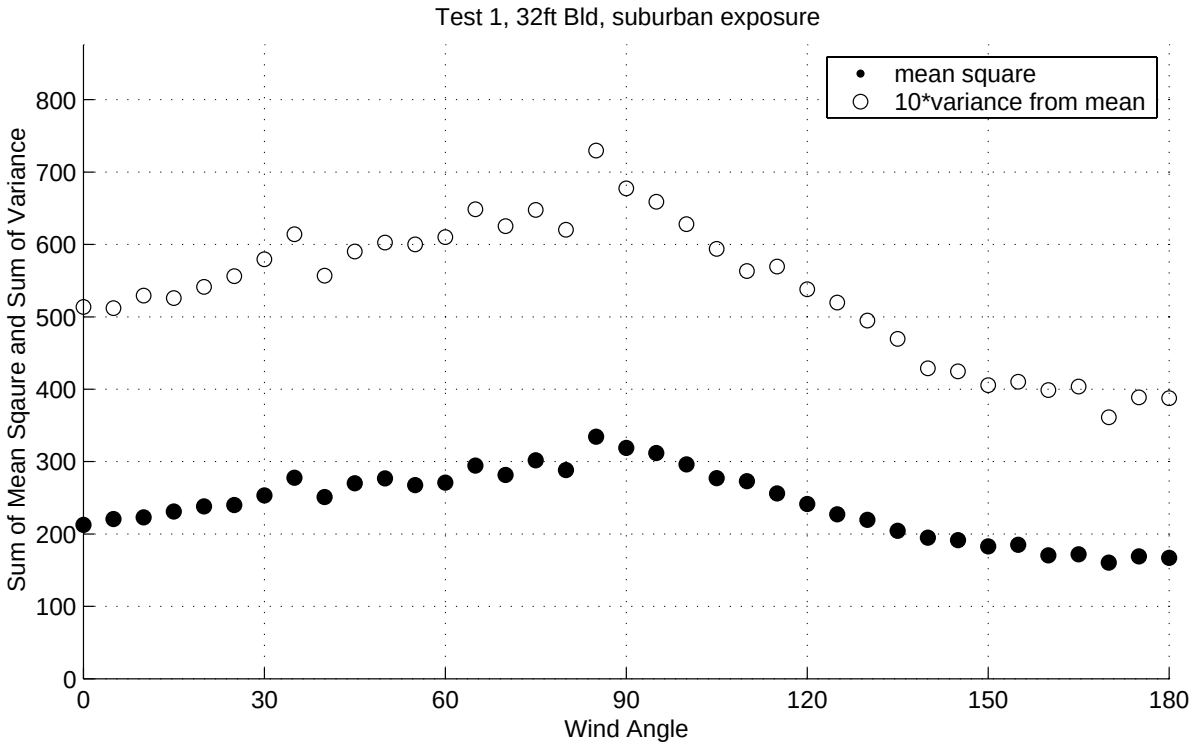
APPENDIX C

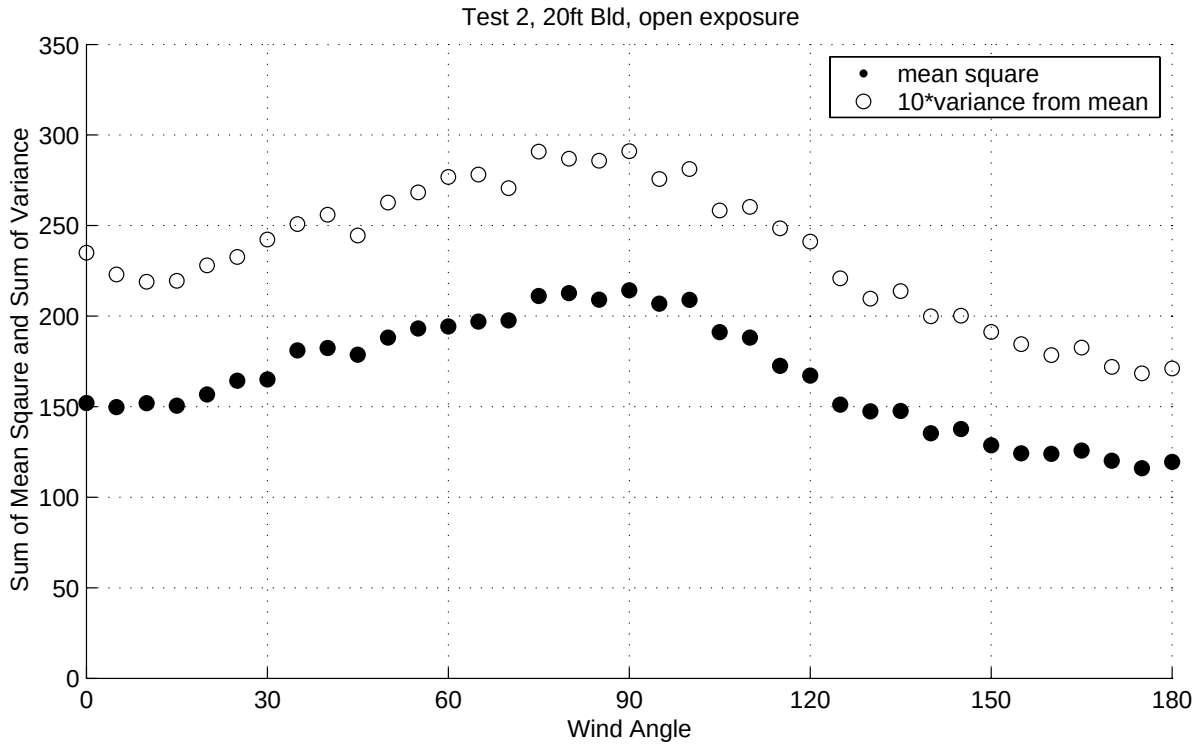
SUM OF MEAN SQUARES AND SUM OF VARIANCES FOR ALL TESTS

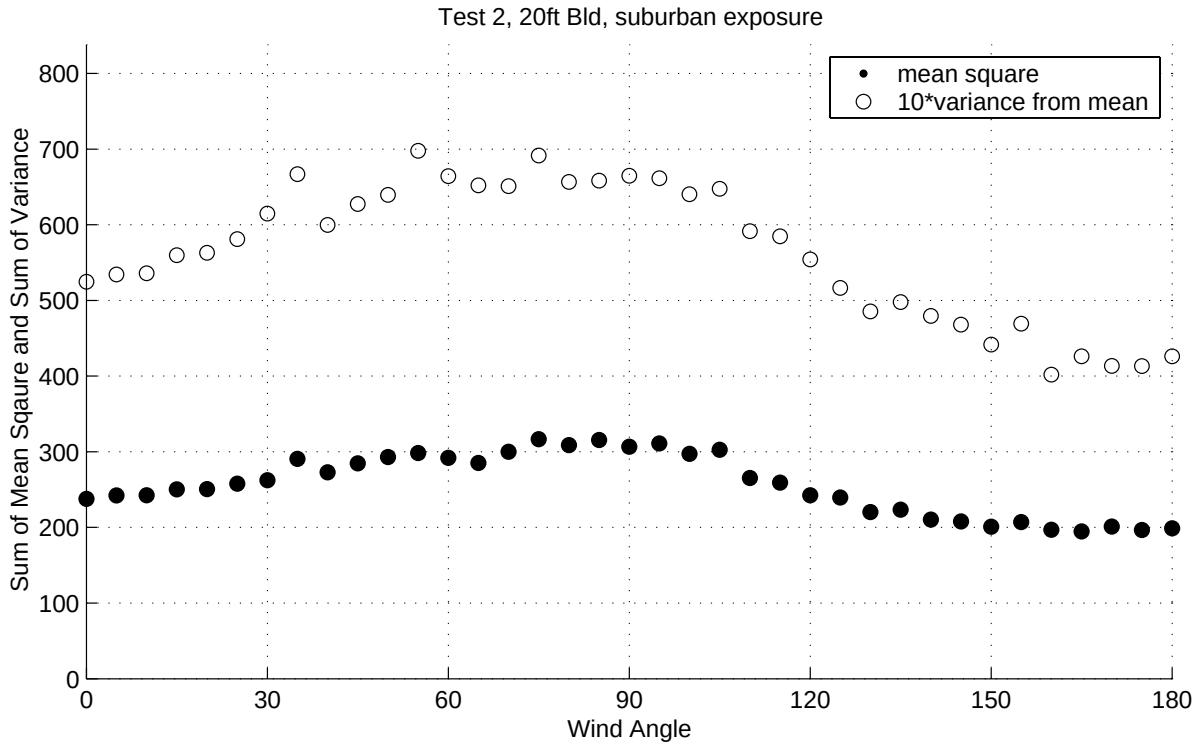

Test 1, 20ft Bld, open exposure
mean square
10*variance from mean
Sum of Mean Sqaure and Sum of Variance
Wind Angle
0
50
100
150
200
250
300
0
30
60
90
120
150
180

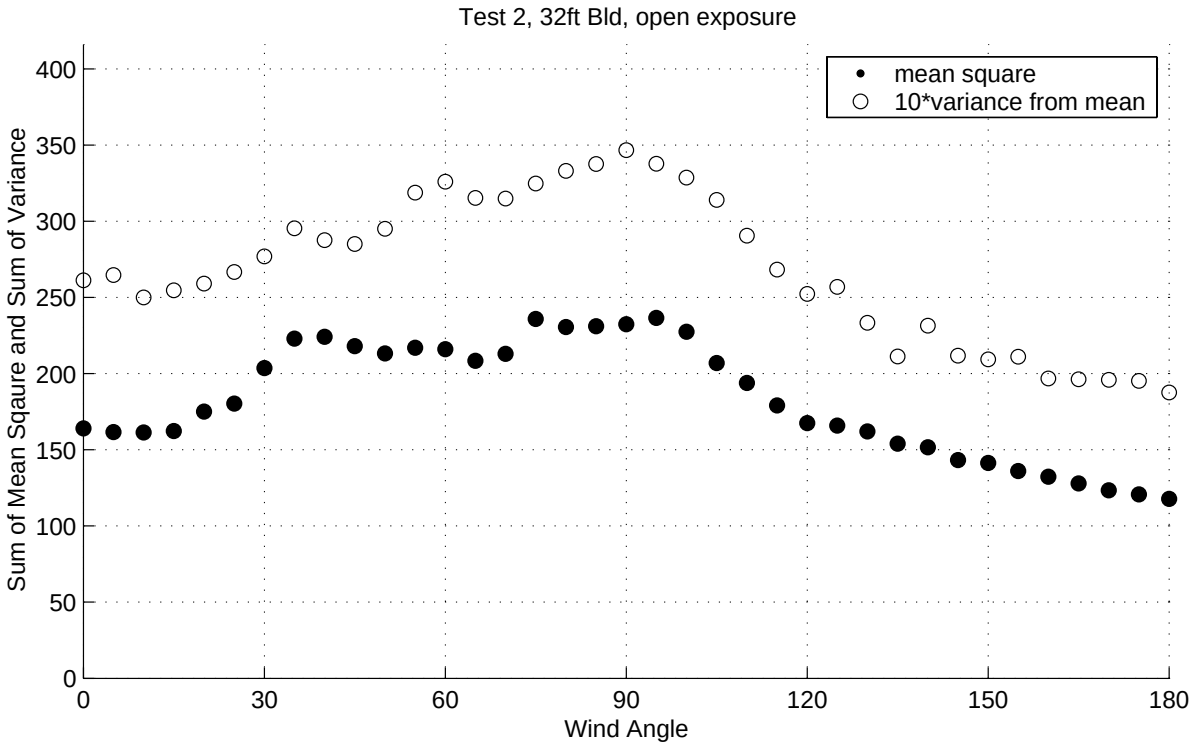

Test 1, 20ft Bld, suburban exposure
mean square
10*variance from mean
Sum of Mean Sqaure and Sum of Variance
Wind Angle
0
100
200
300
400
500
600
700
0
30
60
90
120
150
180

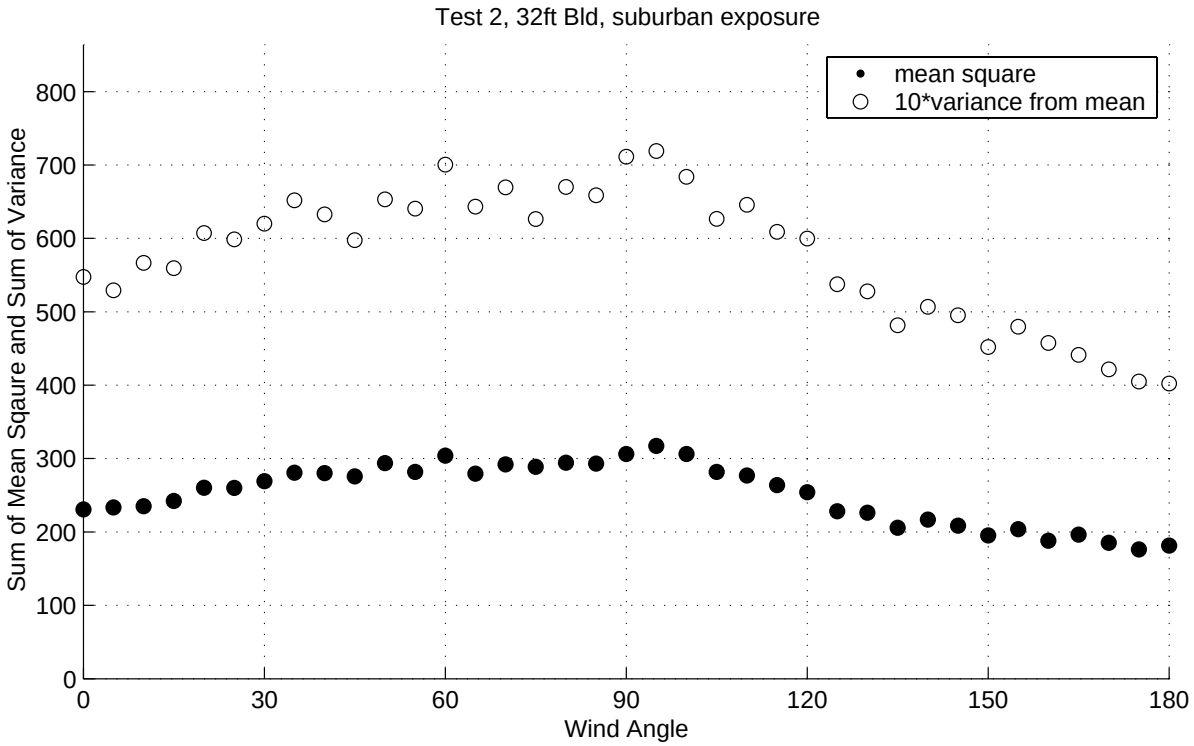

Test 1, 32ft Bld, open exposure
mean square
10*variance from mean
Sum of Mean Sqaure and Sum of Variance
Wind Angle
0
50
100
150
200
250
300
350
0
30
60
90
120
150
180

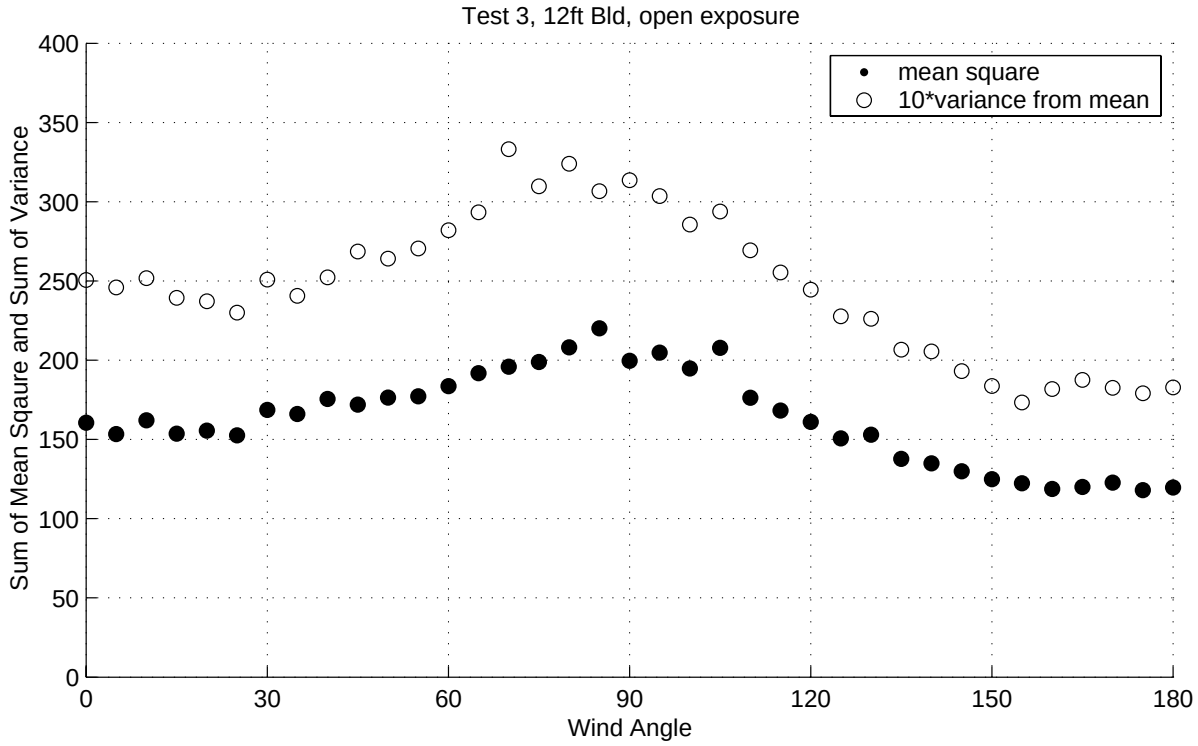

Test 1, 32ft Bld, suburban exposure
mean square
10*variance from mean
Sum of Mean Sqaure and Sum of Variance
Wind Angle
0
100
200
300
400
500
600
700
800
0
30
60
90
120
150
180

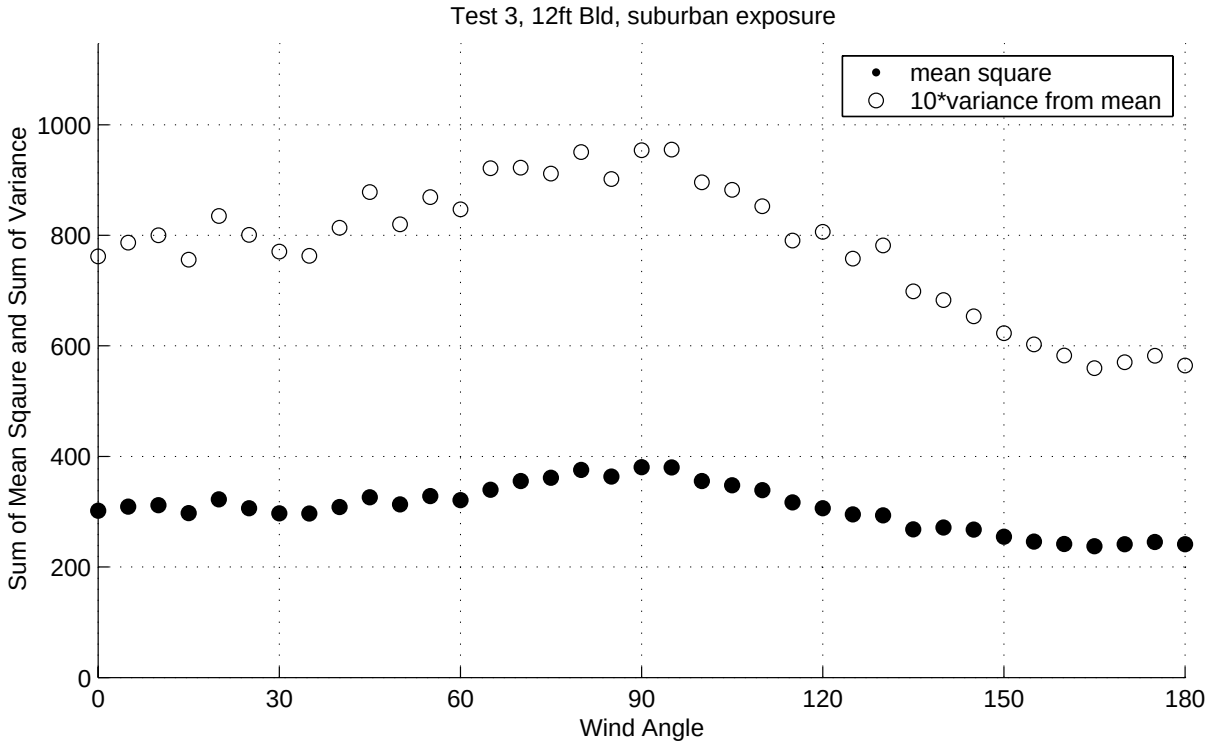

Test 2, 20ft Bld, open exposure
mean square
10*variance from mean
Sum of Mean Sqaure and Sum of Variance
Wind Angle
0
50
100
150
200
250
300
350
0
30
60
90
120
150
180

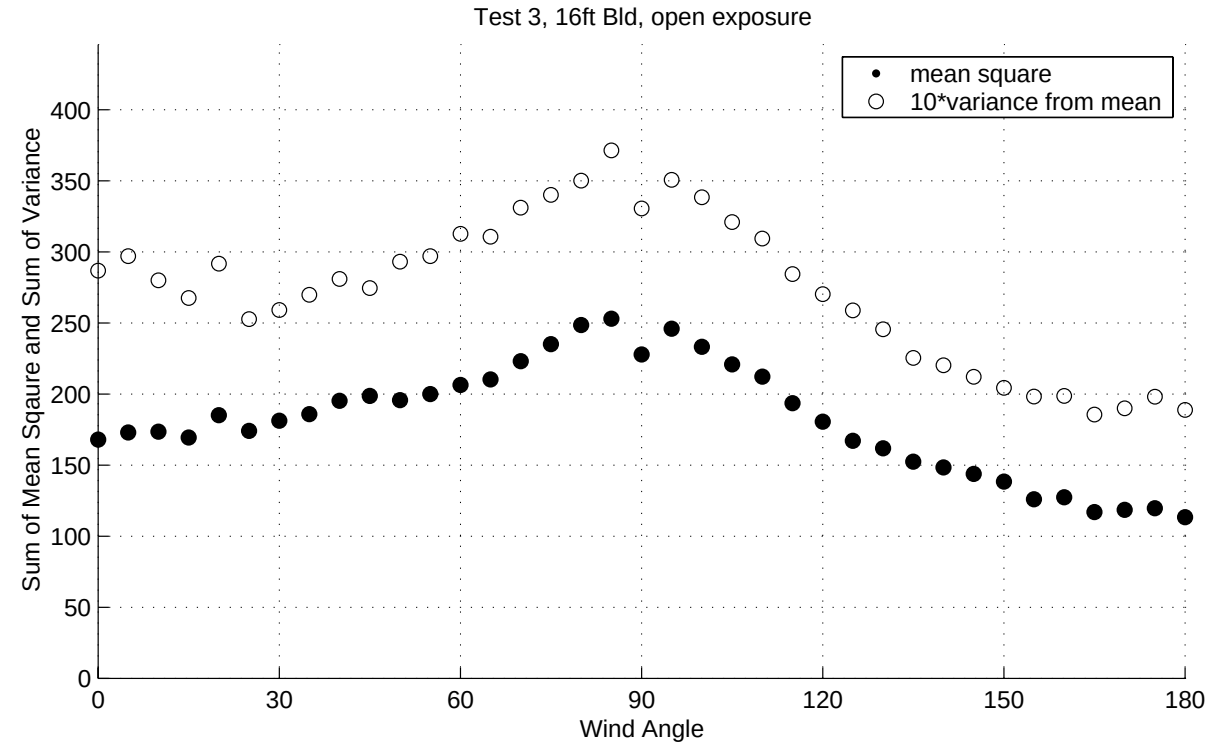

Test 2, 20ft Bld, suburban exposure
mean square
10*variance from mean
Sum of Mean Sqaure and Sum of Variance
Wind Angle
0
100
200
300
400
500
600
700
800
0
30
60
90
120
150
180

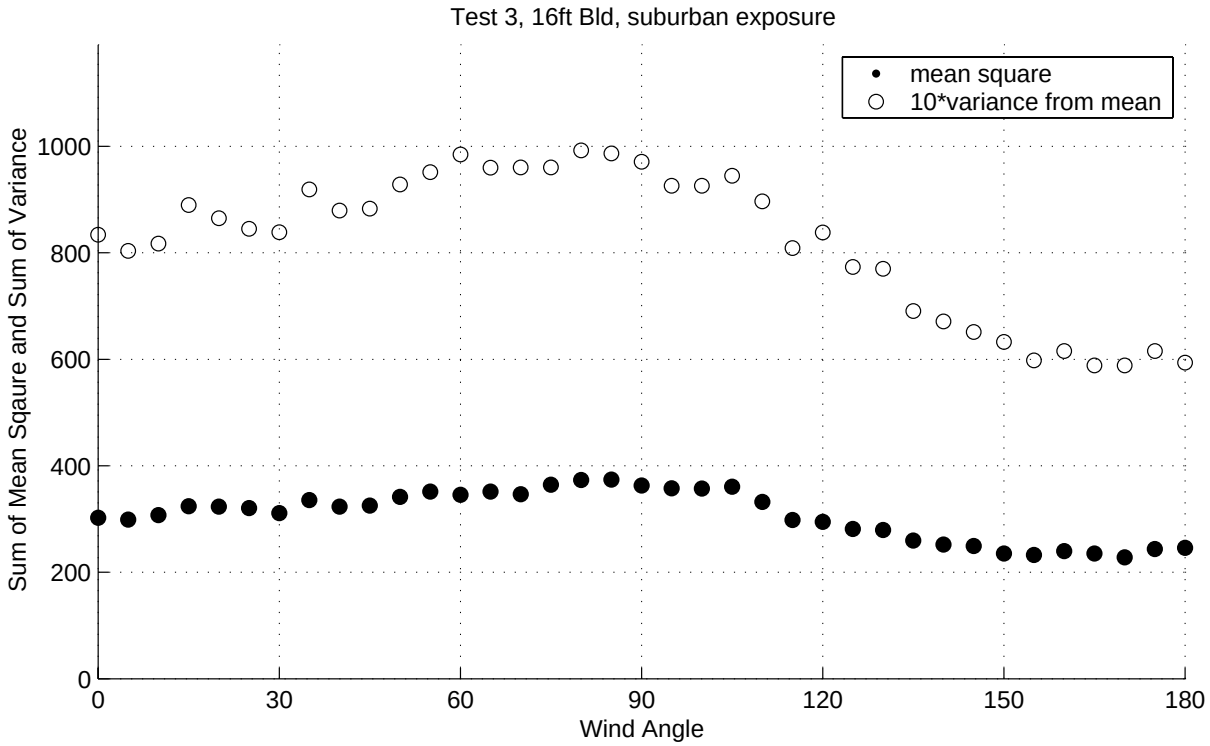

Test 2, 32ft Bld, open exposure
mean square
10*variance from mean
Sum of Mean Sqaure and Sum of Variance
Wind Angle
0
50
100
150
200
250
300
350
400
0
30
60
90
120
150
180

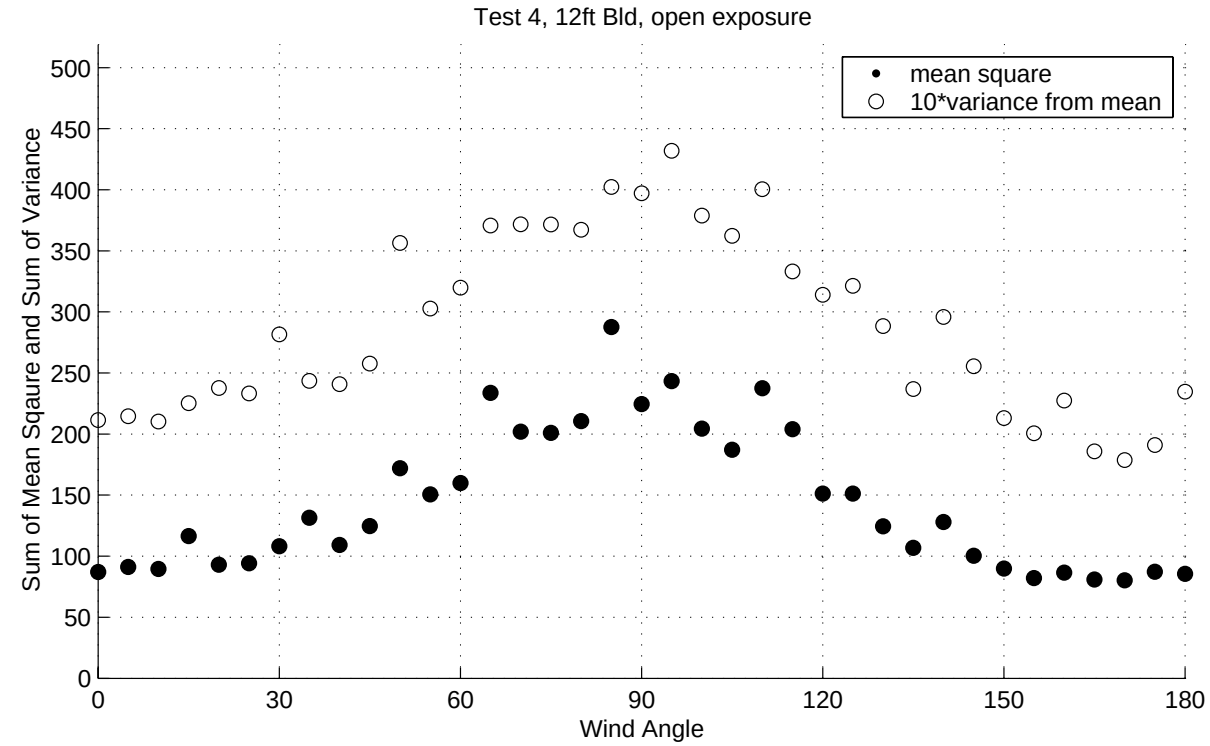

Test 2, 32ft Bld, suburban exposure
mean square
10*variance from mean
Sum of Mean Sqaure and Sum of Variance
Wind Angle
0
100
200
300
400
500
600
700
800
0
30
60
90
120
150
180

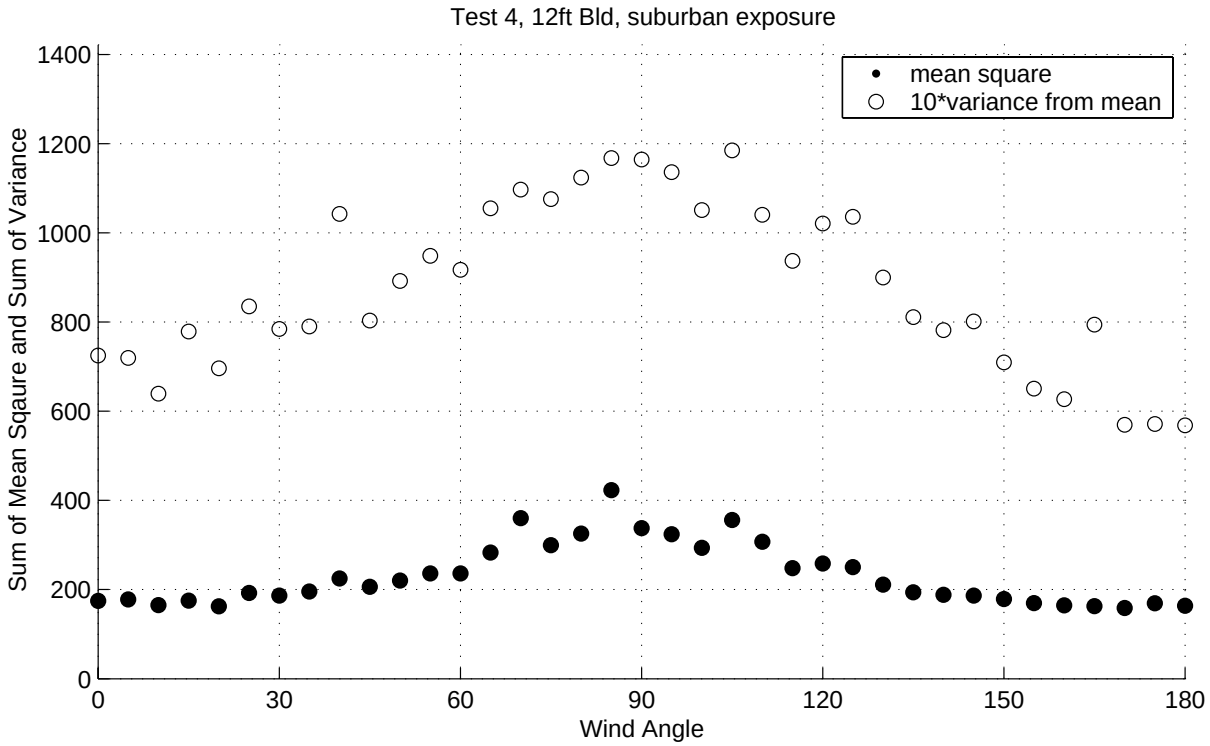

Test 3, 12ft Bld, open exposure
mean square
10*variance from mean
Sum of Mean Sqaure and Sum of Variance
Wind Angle
0
50
100
150
200
250
300
350
400
0
30
60
90
120
150
180

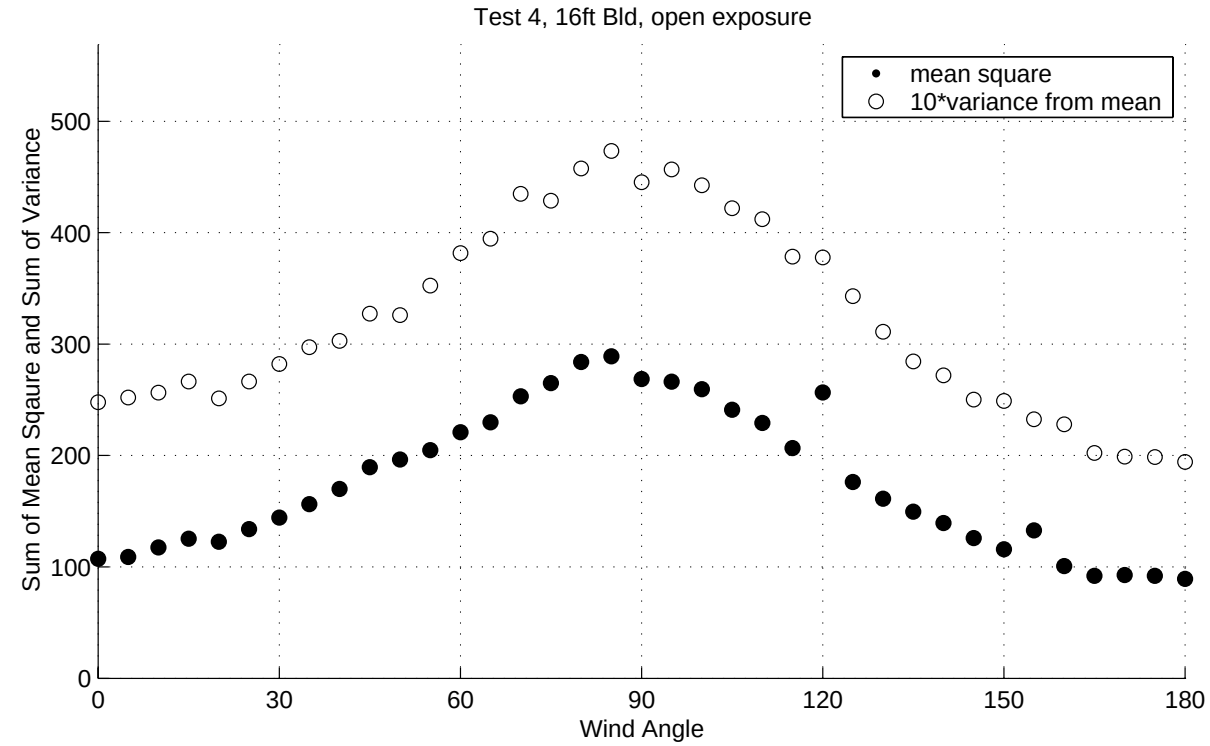

Test 3, 12ft Bld, suburban exposure
mean square
10*variance from mean
Sum of Mean Sqaure and Sum of Variance
Wind Angle
0
200
400
600
800
1000
0
30
60
90
120
150
180

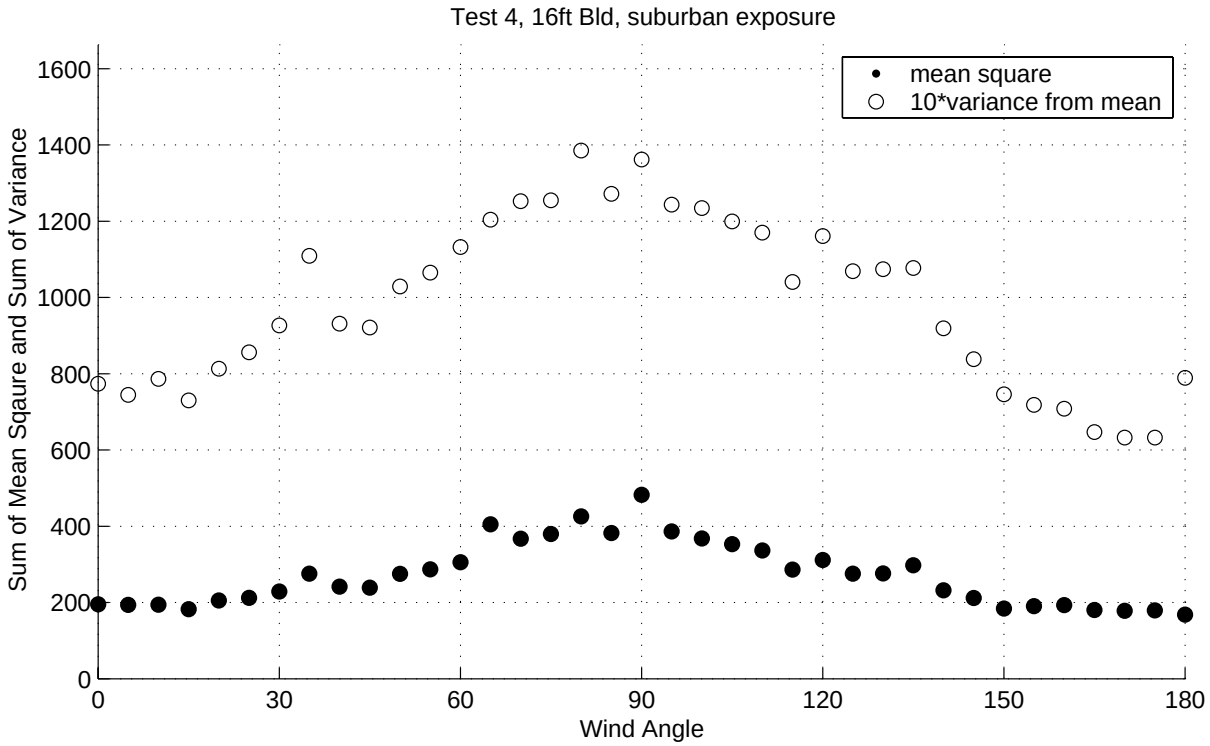

Test 3, 16ft Bld, open exposure
mean square
10*variance from mean
Sum of Mean Sqaure and Sum of Variance
Wind Angle
0
50
100
150
200
250
300
350
400
0
30
60
90
120
150
180

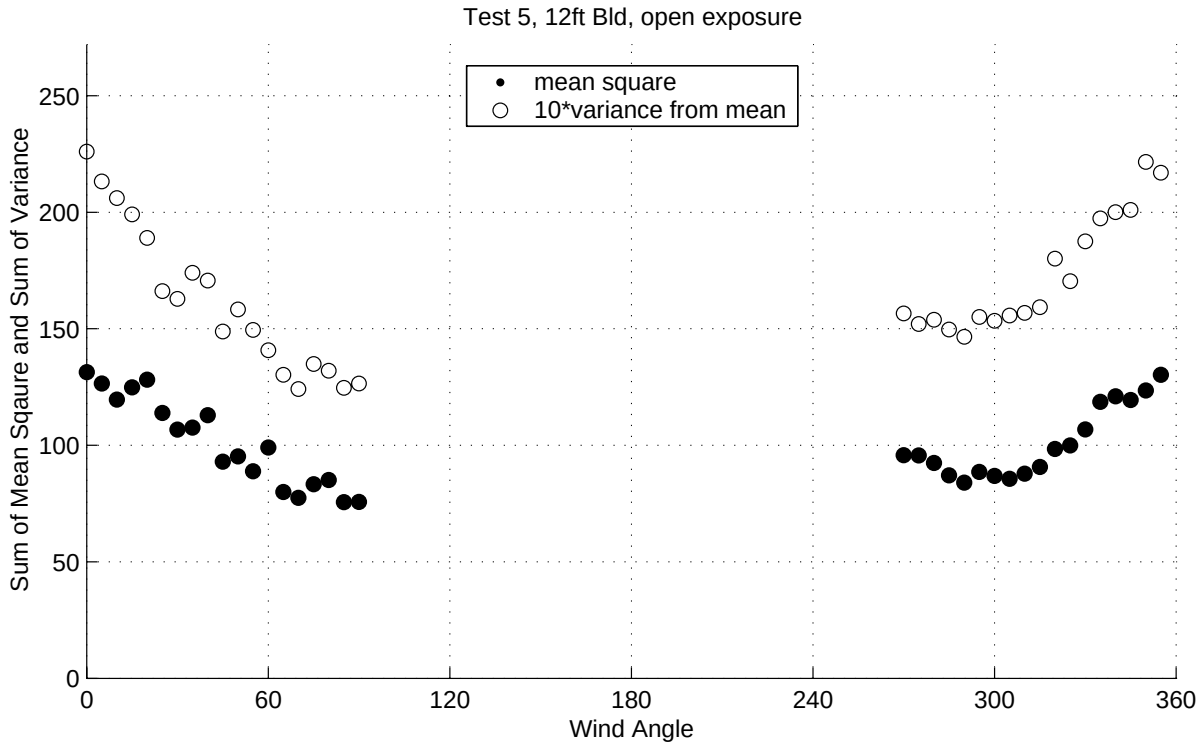

Test 3, 16ft Bld, suburban exposure
mean square
10*variance from mean
Sum of Mean Sqaure and Sum of Variance
Wind Angle
0
200
400
600
800
1000
0
30
60
90
120
150
180

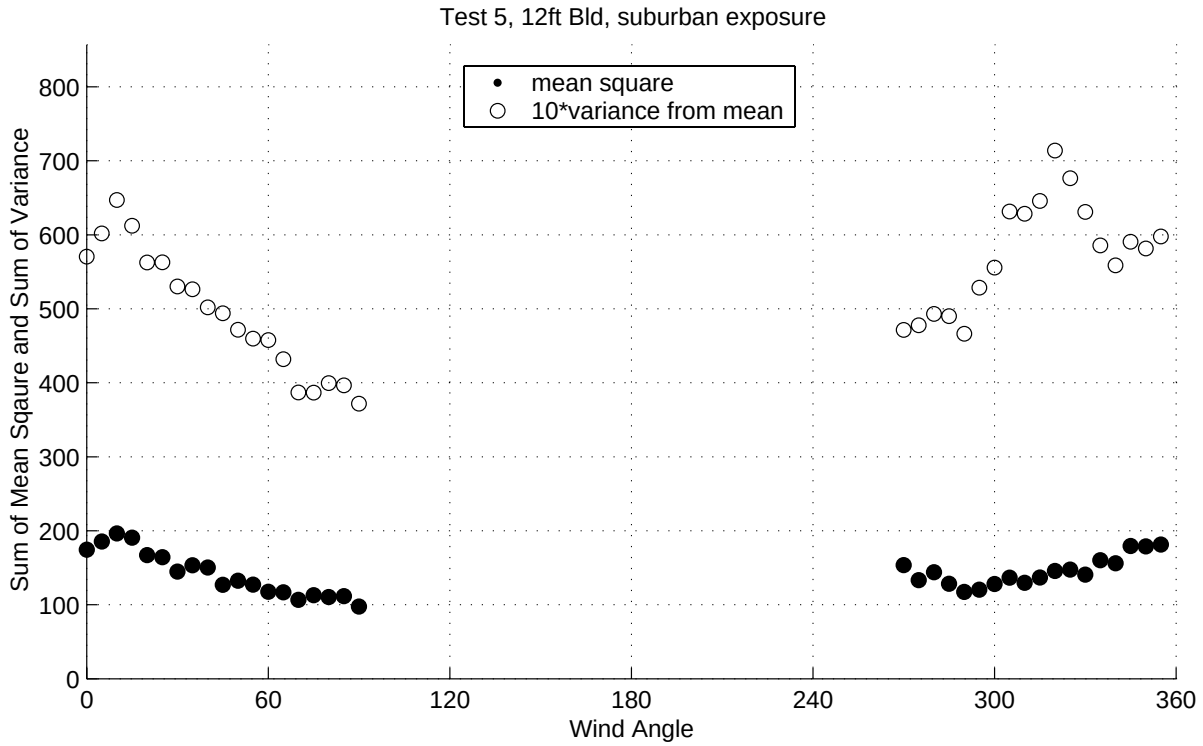

Test 4, 12ft Bld, open exposure
mean square
10*variance from mean
Sum of Mean Sqaure and Sum of Variance
Wind Angle
0
50
100
150
200
250
300
350
400
450
500
0
30
60
90
120
150
180

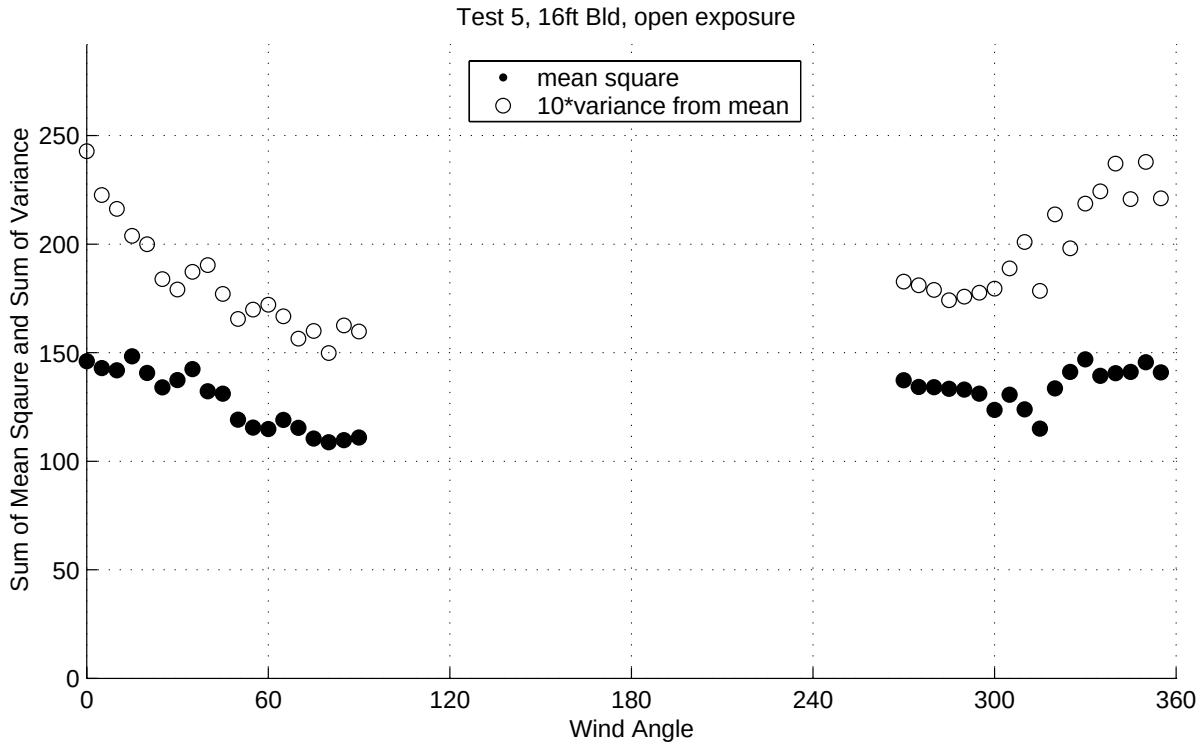

Test 4, 12ft Bld, suburban exposure
mean square
10*variance from mean
Sum of Mean Sqaure and Sum of Variance
Wind Angle
0
200
400
600
800
1000
1200
1400
0
30
60
90
120
150
180

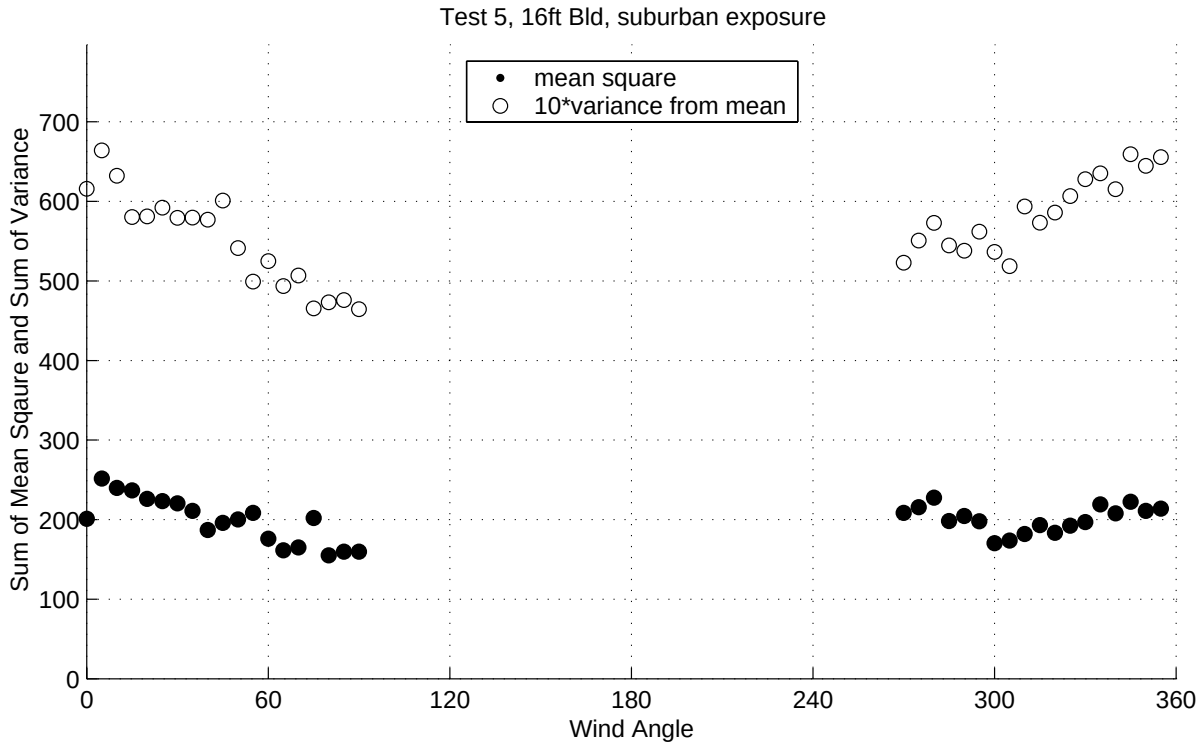

Test 4, 16ft Bld, open exposure
mean square
10*variance from mean
Sum of Mean Sqaure and Sum of Variance
Wind Angle
0
100
200
300
400
500
0
30
60
90
120
150
180

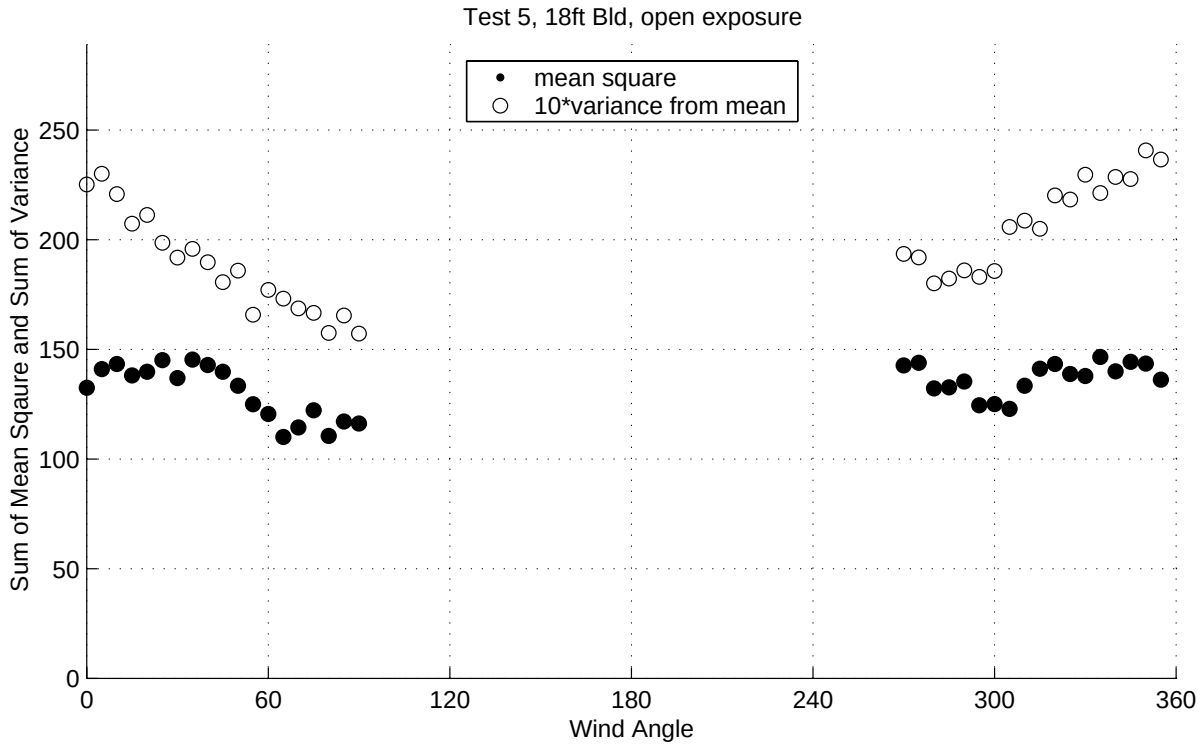

Test 4, 16ft Bld, suburban exposure
mean square
10*variance from mean
Sum of Mean Sqaure and Sum of Variance
Wind Angle
0
200
400
600
800
1000
1200
1400
1600
0
30
60
90
120
150
180

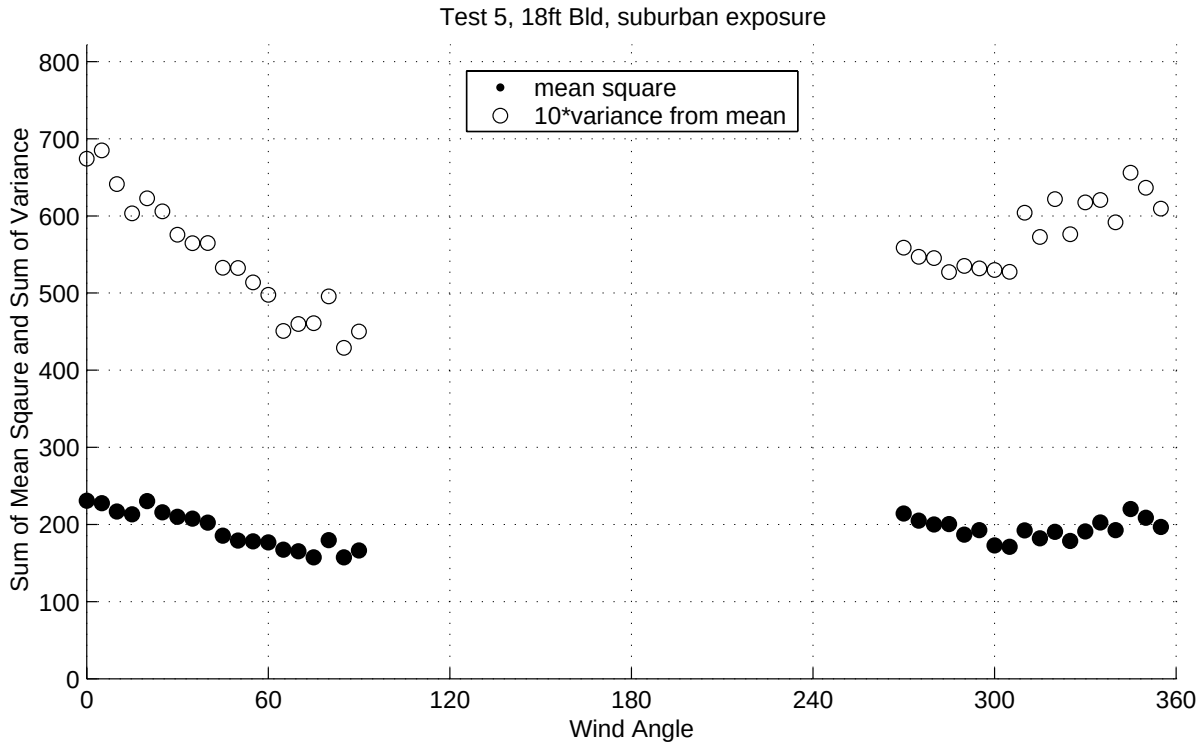

Test 5, 12ft Bld, open exposure
mean square
10*variance from mean
Sum of Mean Sqaure and Sum of Variance
Wind Angle
0
50
100
150
200
250
0
60
120
180
240
300
360

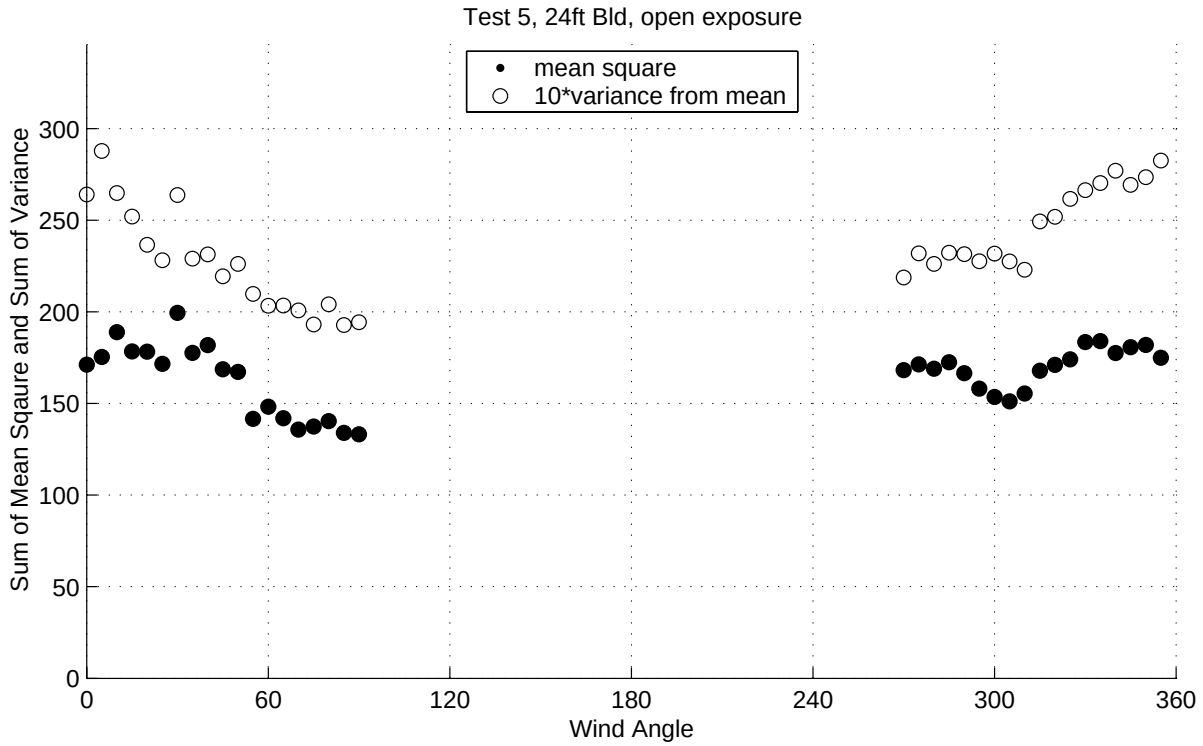

Test 5, 12ft Bld, suburban exposure
mean square
10*variance from mean
Sum of Mean Sqaure and Sum of Variance
Wind Angle
0
100
200
300
400
500
600
700
800
0
60
120
180
240
300
360

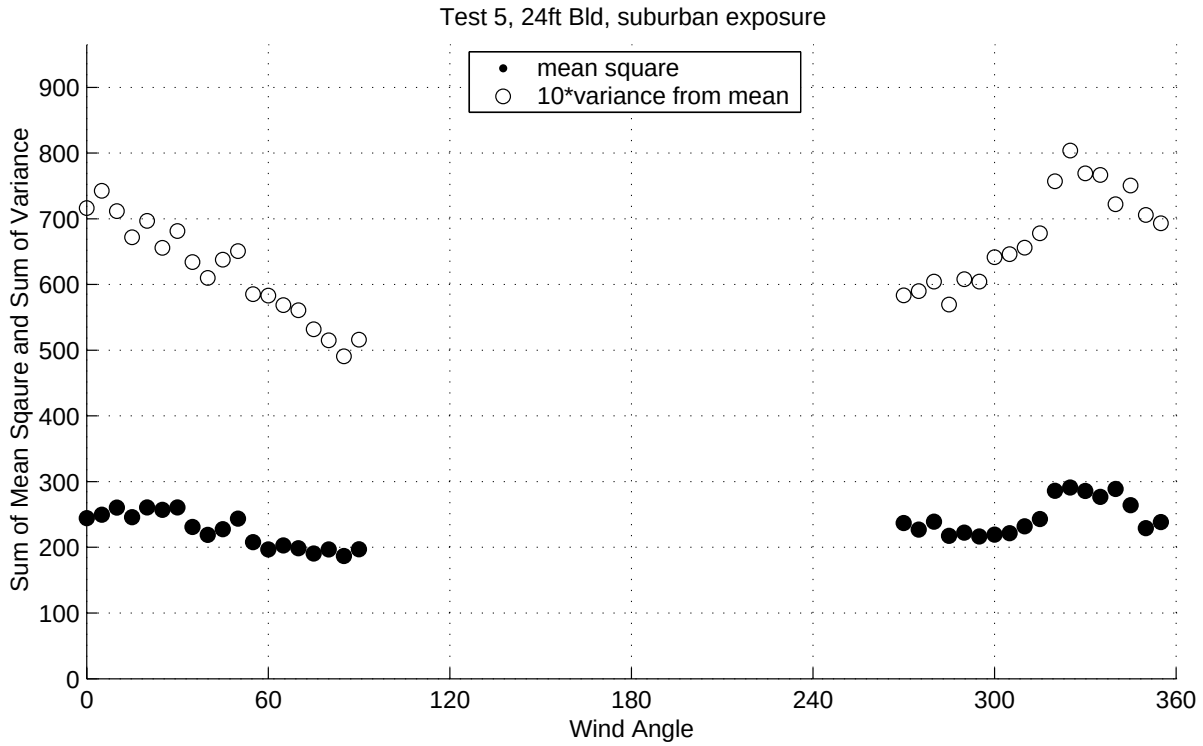

Test 5, 16ft Bld, open exposure
mean square
10*variance from mean
Sum of Mean Sqaure and Sum of Variance
0
50
100
150
200
250
0
60
120
180
240
300
360
Wind Angle

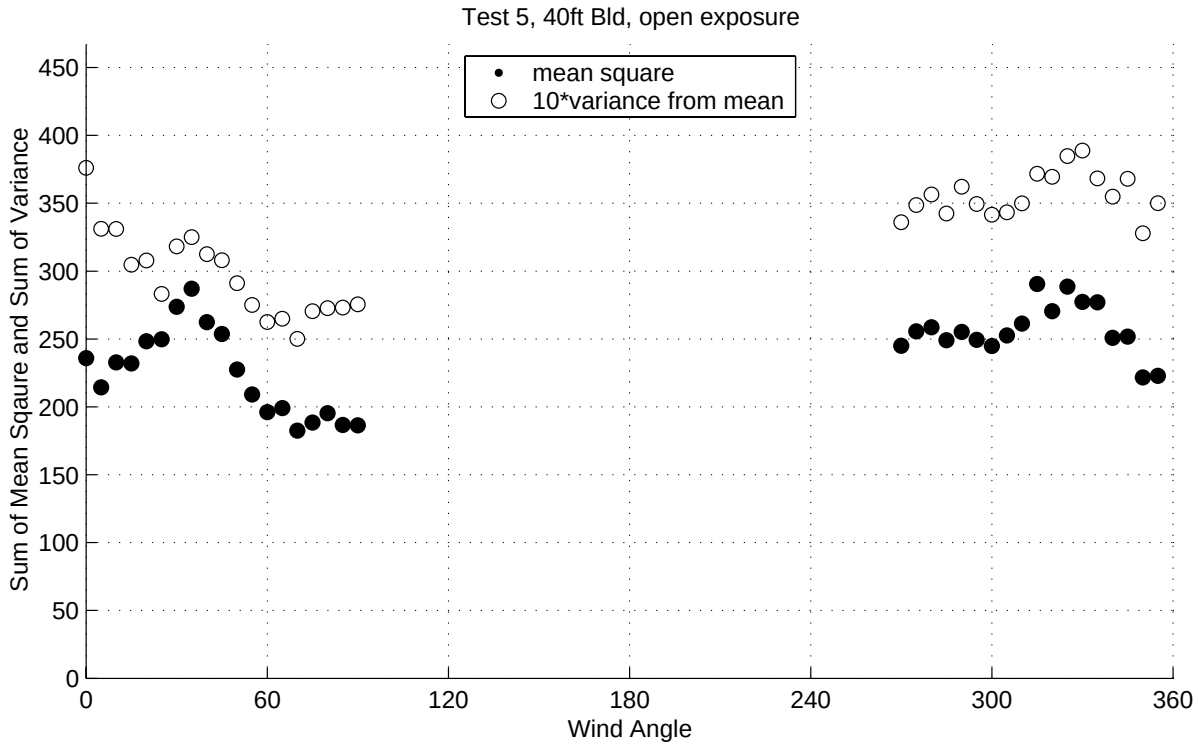

Test 5, 16ft Bld, suburban exposure
mean square
10*variance from mean
Sum of Mean Sqaure and Sum of Variance
0
100
200
300
400
500
600
700
0
60
120
180
240
300
360
Wind Angle

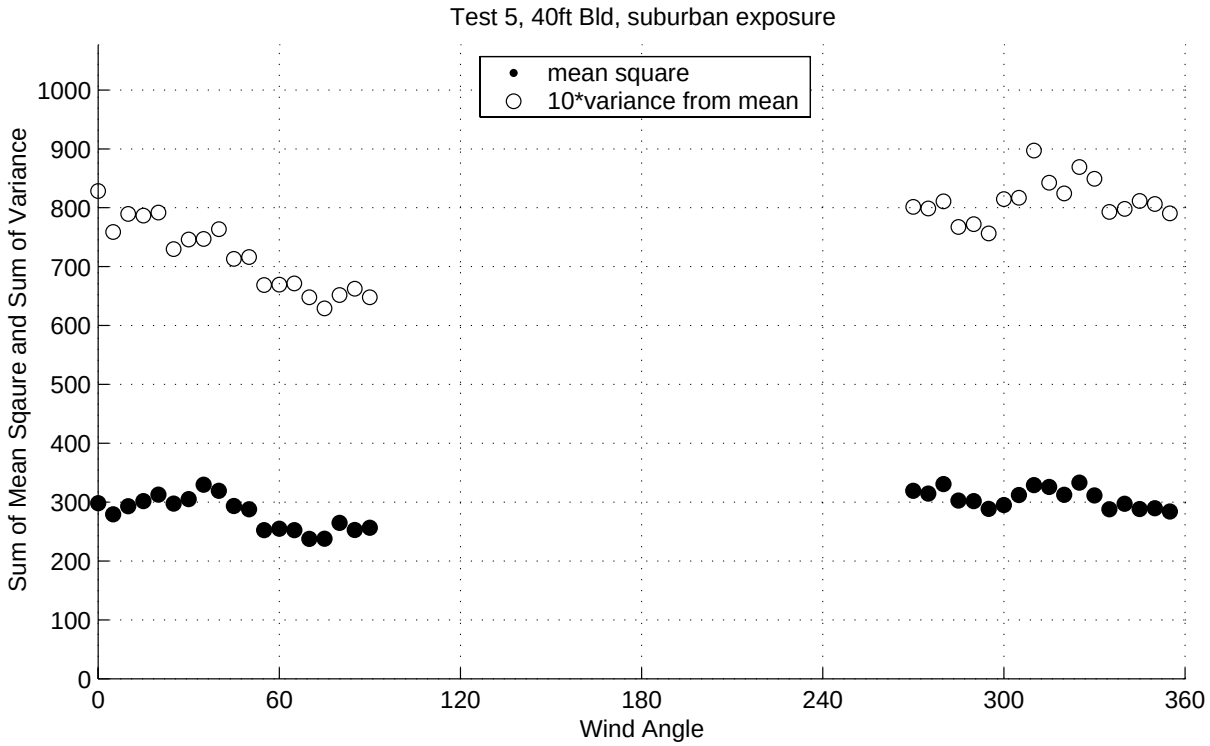

Test 5, 18ft Bld, open exposure
mean square
10*variance from mean
Sum of Mean Sqaure and Sum of Variance
Wind Angle
0
50
100
150
200
250
0
60
120
180
240
300
360

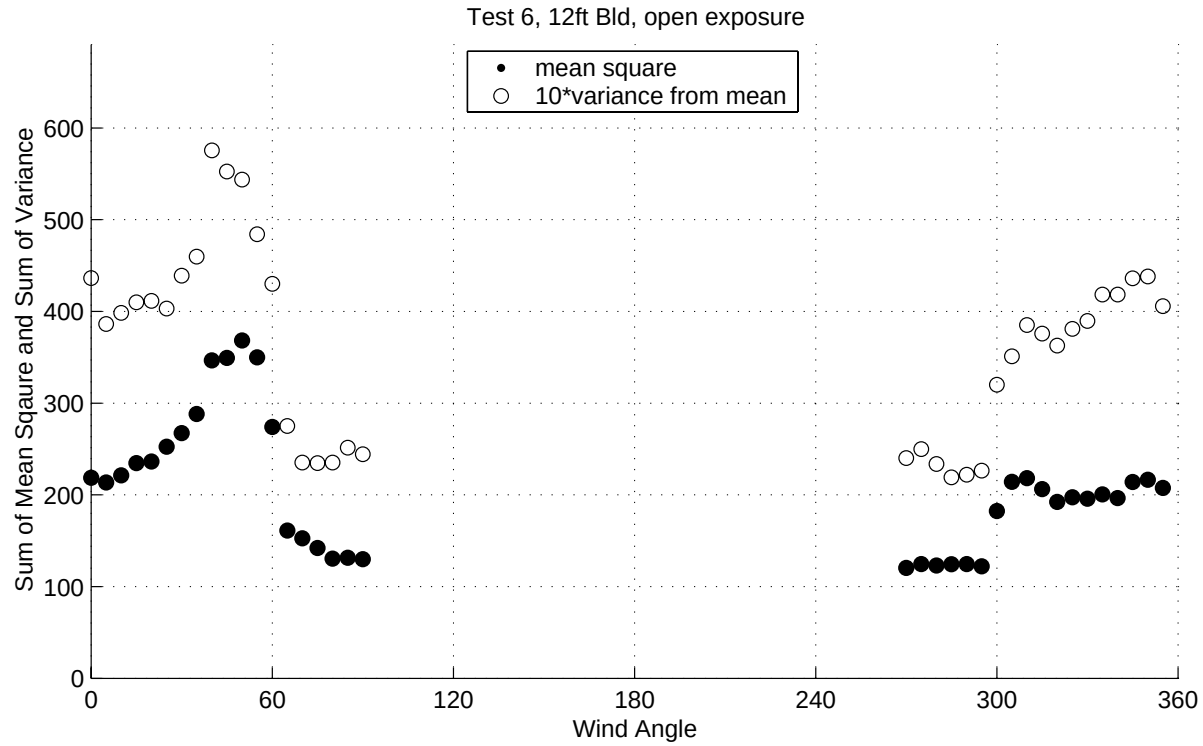

Test 5, 18ft Bld, suburban exposure
mean square
10*variance from mean
Sum of Mean Sqaure and Sum of Variance
Wind Angle
0
100
200
300
400
500
600
700
800
0
60
120
180
240
300
360

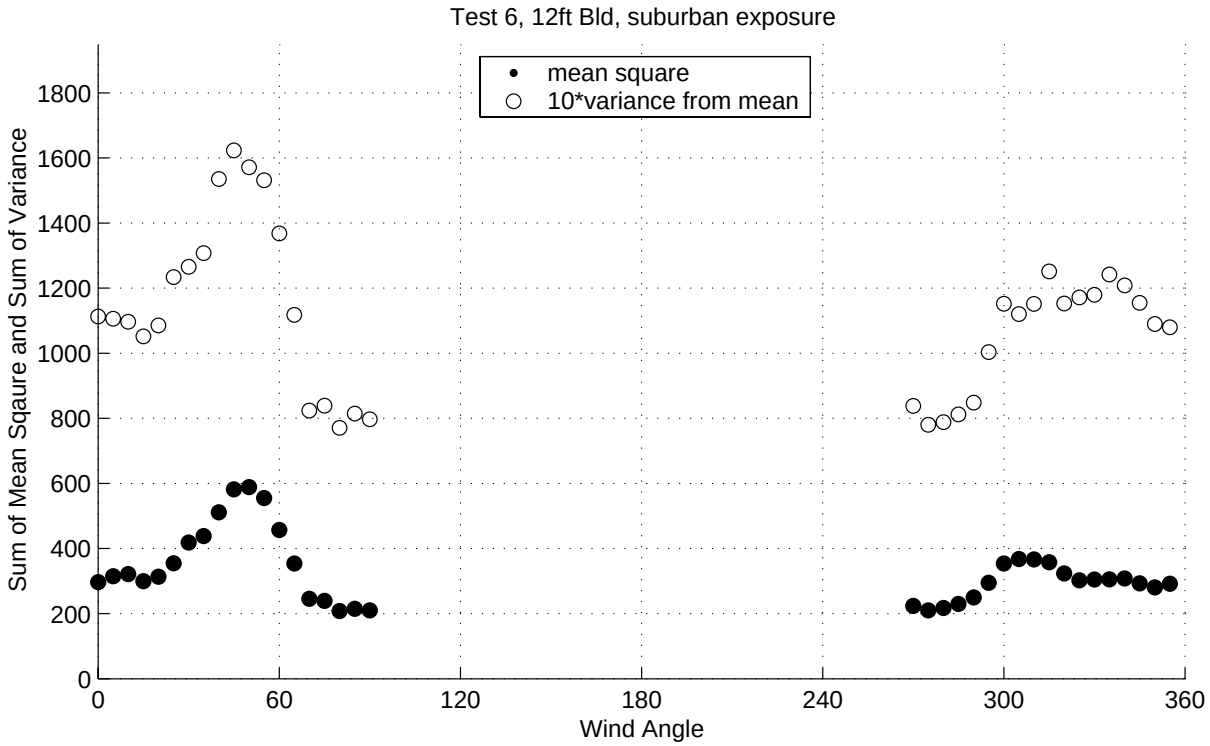

Test 5, 24ft Bld, open exposure
mean square
10*variance from mean
Sum of Mean Sqaure and Sum of Variance
Wind Angle
0
50
100
150
200
250
300
0
60
120
180
240
300
360

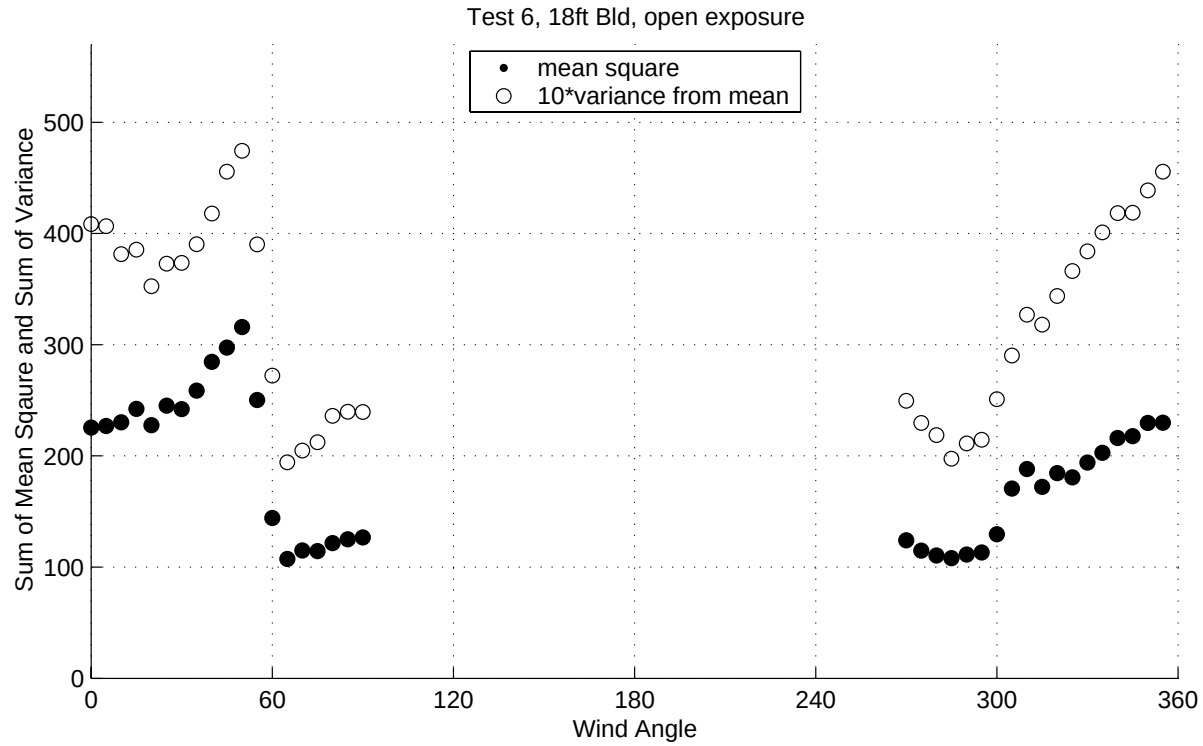

Test 5, 24ft Bld, suburban exposure
mean square
10*variance from mean
Sum of Mean Sqaure and Sum of Variance
Wind Angle
0
100
200
300
400
500
600
700
800
900
0
60
120
180
240
300
360

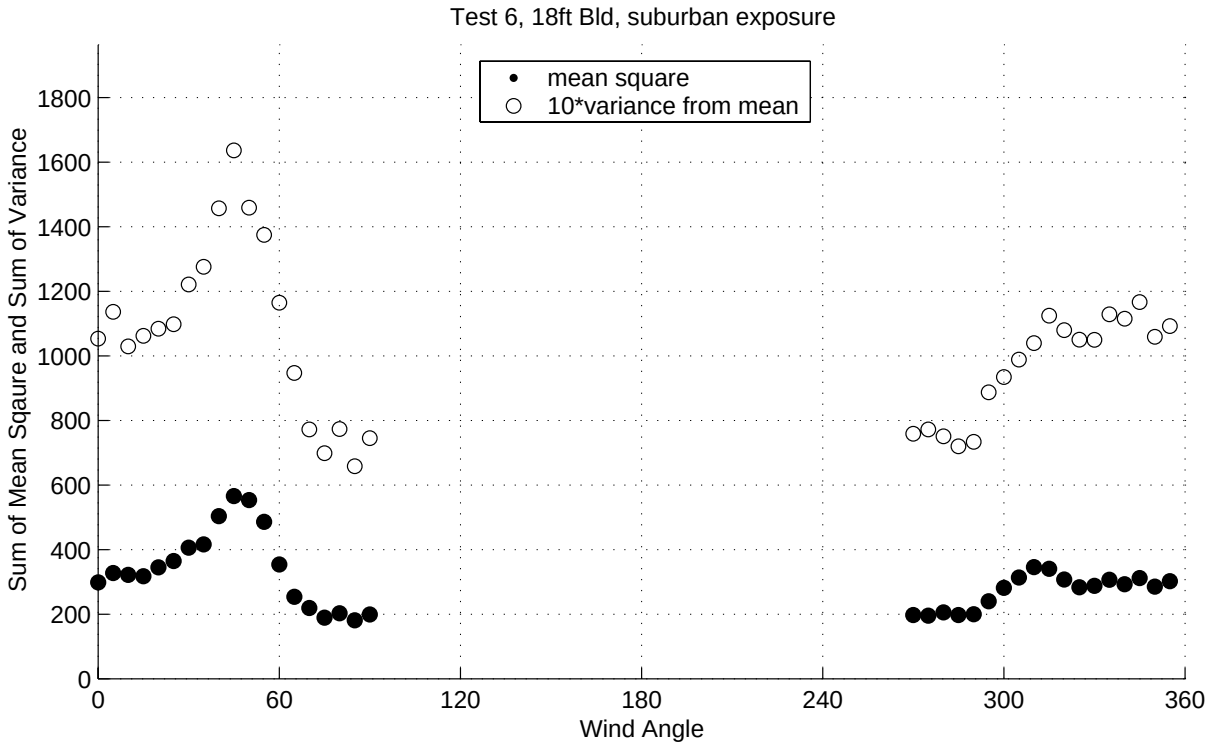

Test 5, 40ft Bld, open exposure
mean square
10*variance from mean
Sum of Mean Sqaure and Sum of Variance
Wind Angle
0
50
100
150
200
250
300
350
400
450
0
60
120
180
240
300
360

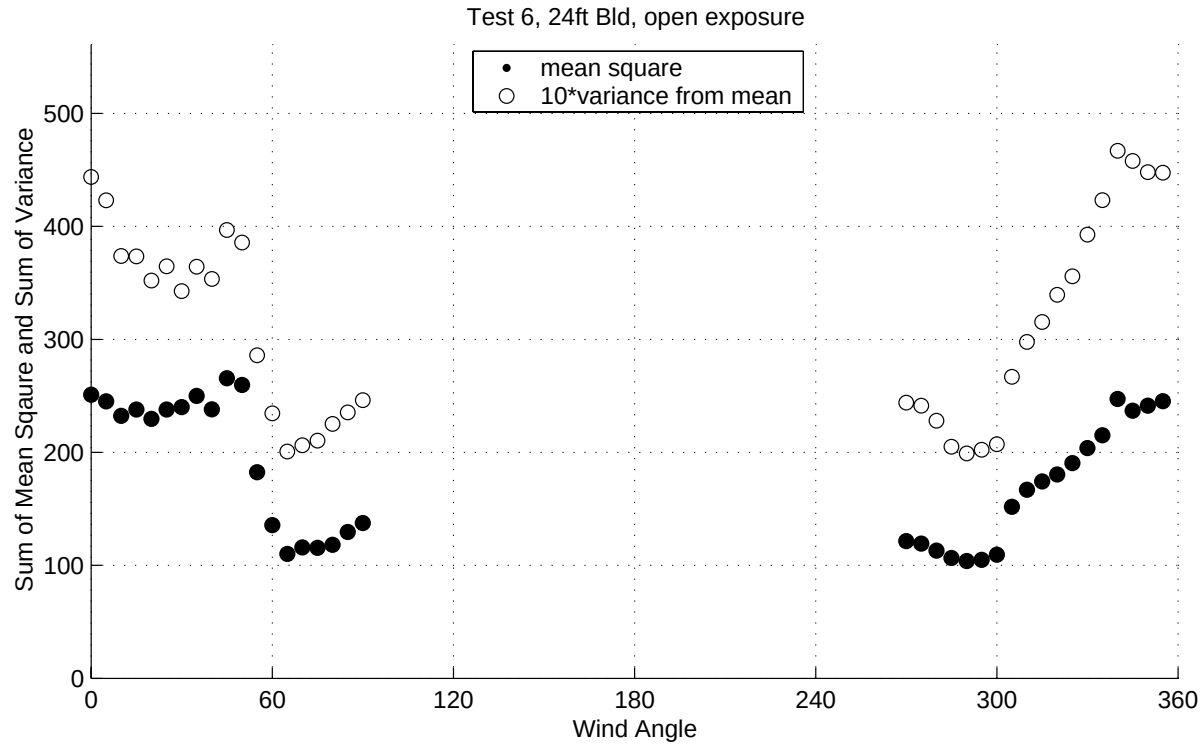

Test 5, 40ft Bld, suburban exposure
mean square
10*variance from mean
Sum of Mean Sqaure and Sum of Variance
Wind Angle
0
100
200
300
400
500
600
700
800
900
1000
0
60
120
180
240
300
360

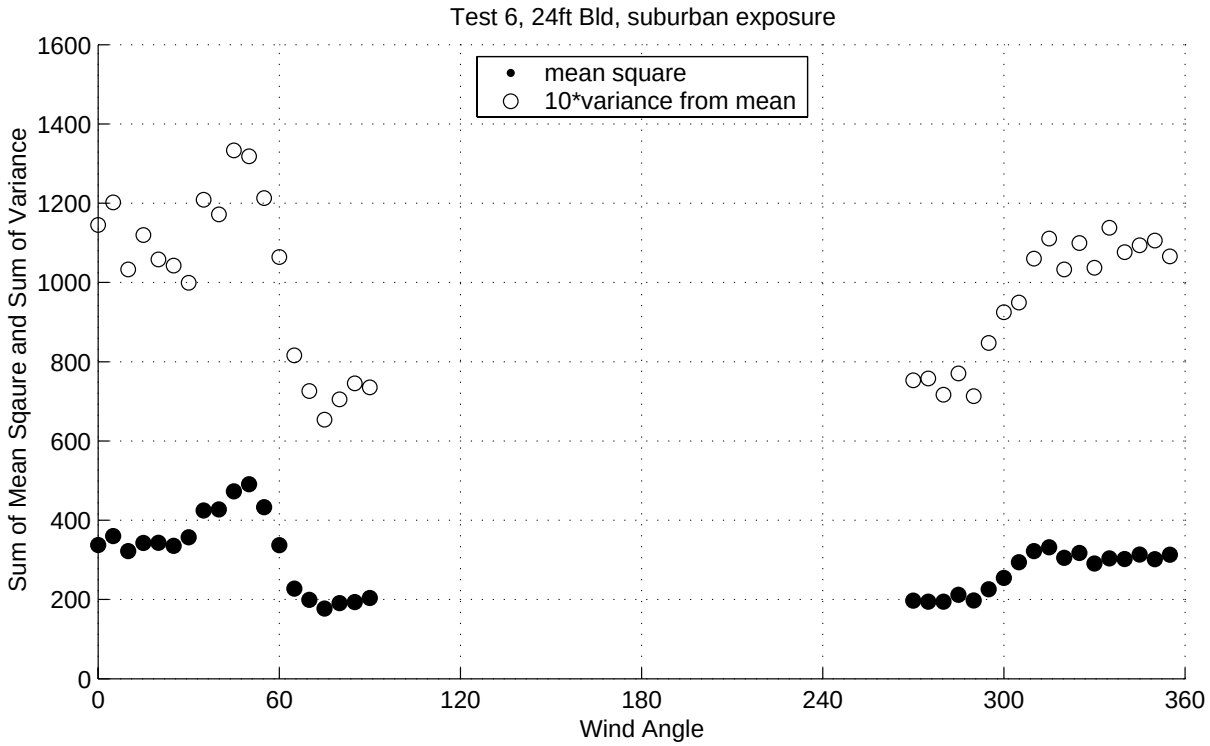

Test 6, 12ft Bld, open exposure
mean square
10*variance from mean
Sum of Mean Sqaure and Sum of Variance
0
100
200
300
400
500
600
0
60
120
180
240
300
360
Wind Angle

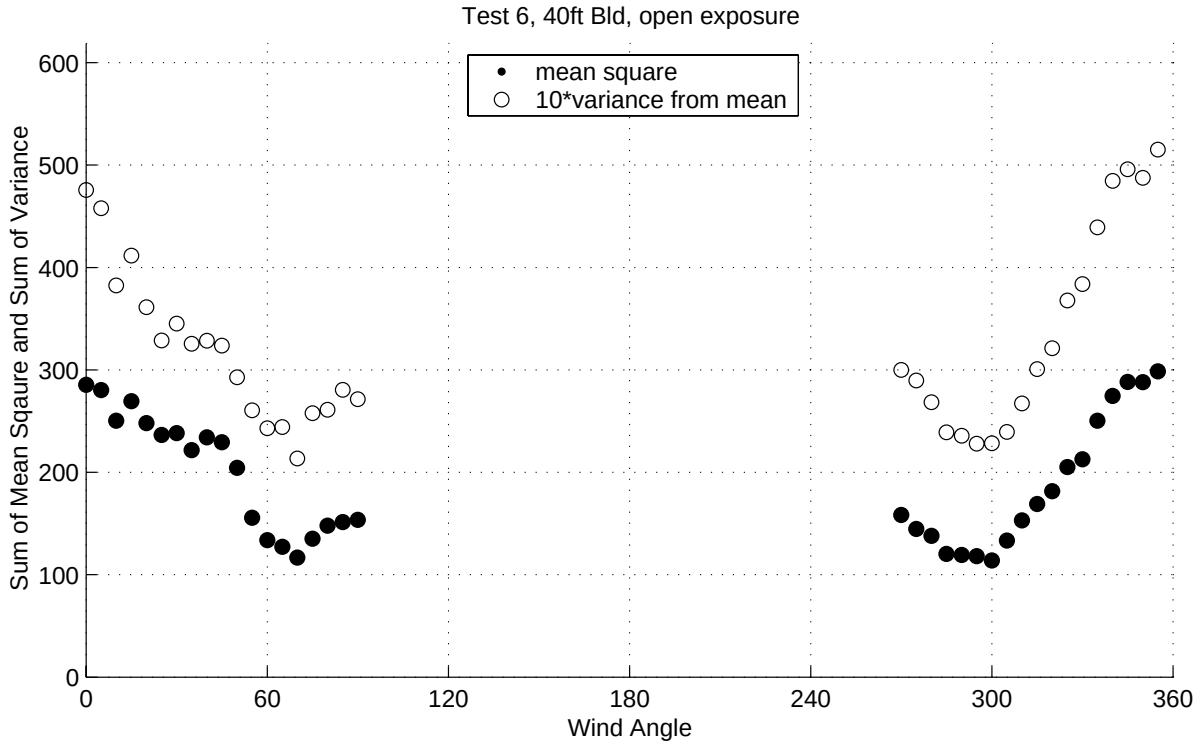

Test 6, 12ft Bld, suburban exposure
mean square
10*variance from mean
Sum of Mean Sqaure and Sum of Variance
0
200
400
600
800
1000
1200
1400
1600
1800
0
60
120
180
240
300
360
Wind Angle

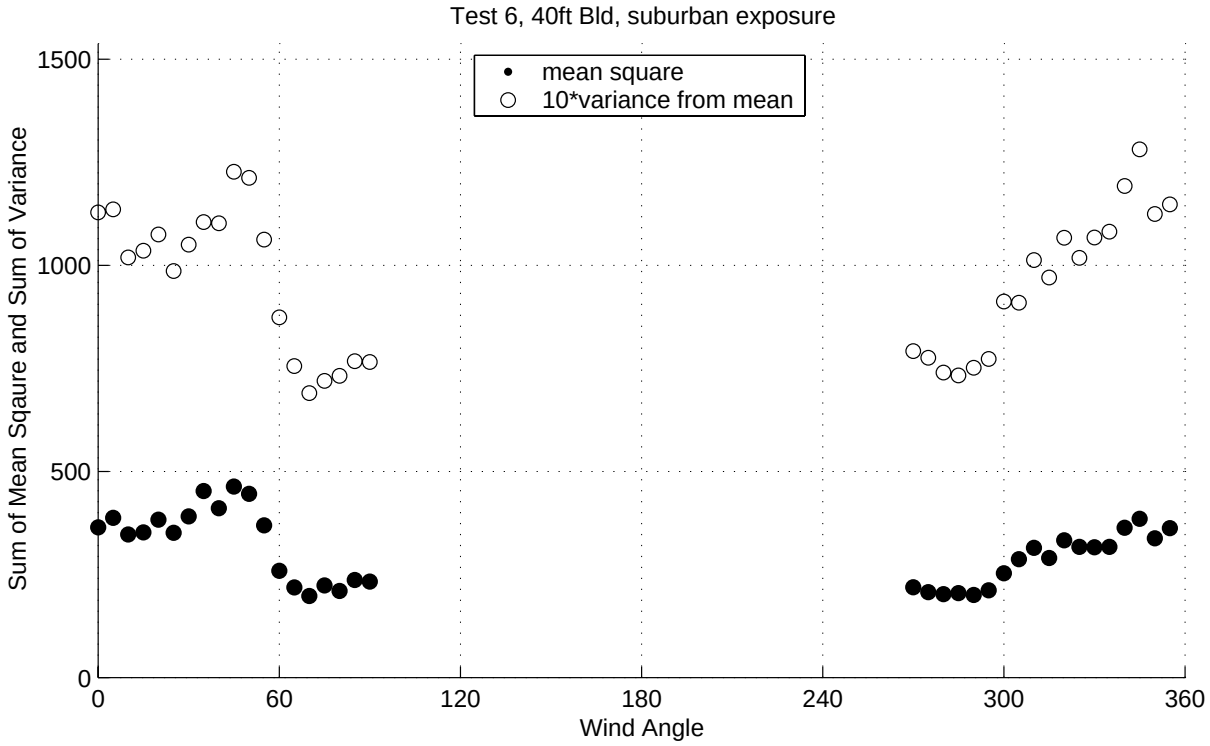

Test 6, 18ft Bld, open exposure
mean square
10*variance from mean
Sum of Mean Sqaure and Sum of Variance
0
100
200
300
400
500
0
60
120
180
240
300
360
Wind Angle


Test 6, 18ft Bld, suburban exposure
mean square
10*variance from mean
Sum of Mean Sqaure and Sum of Variance
0
200
400
600
800
1000
1200
1400
1600
1800
0
60
120
180
240
300
360
Wind Angle


Test 6, 24ft Bld, open exposure
mean square
10*variance from mean
Sum of Mean Sqaure and Sum of Variance
Wind Angle
0
100
200
300
400
500
0
60
120
180
240
300
360


Test 6, 24ft Bld, suburban exposure
mean square
10*variance from mean
Sum of Mean Sqaure and Sum of Variance
Wind Angle
0
200
400
600
800
1000
1200
1400
1600
0
60
120
180
240
300
360


Test 6, 40ft Bld, open exposure
mean square
10*variance from mean
Sum of Mean Sqaure and Sum of Variance
Wind Angle
0
100
200
300
400
500
600
0
60
120
180
240
300
360

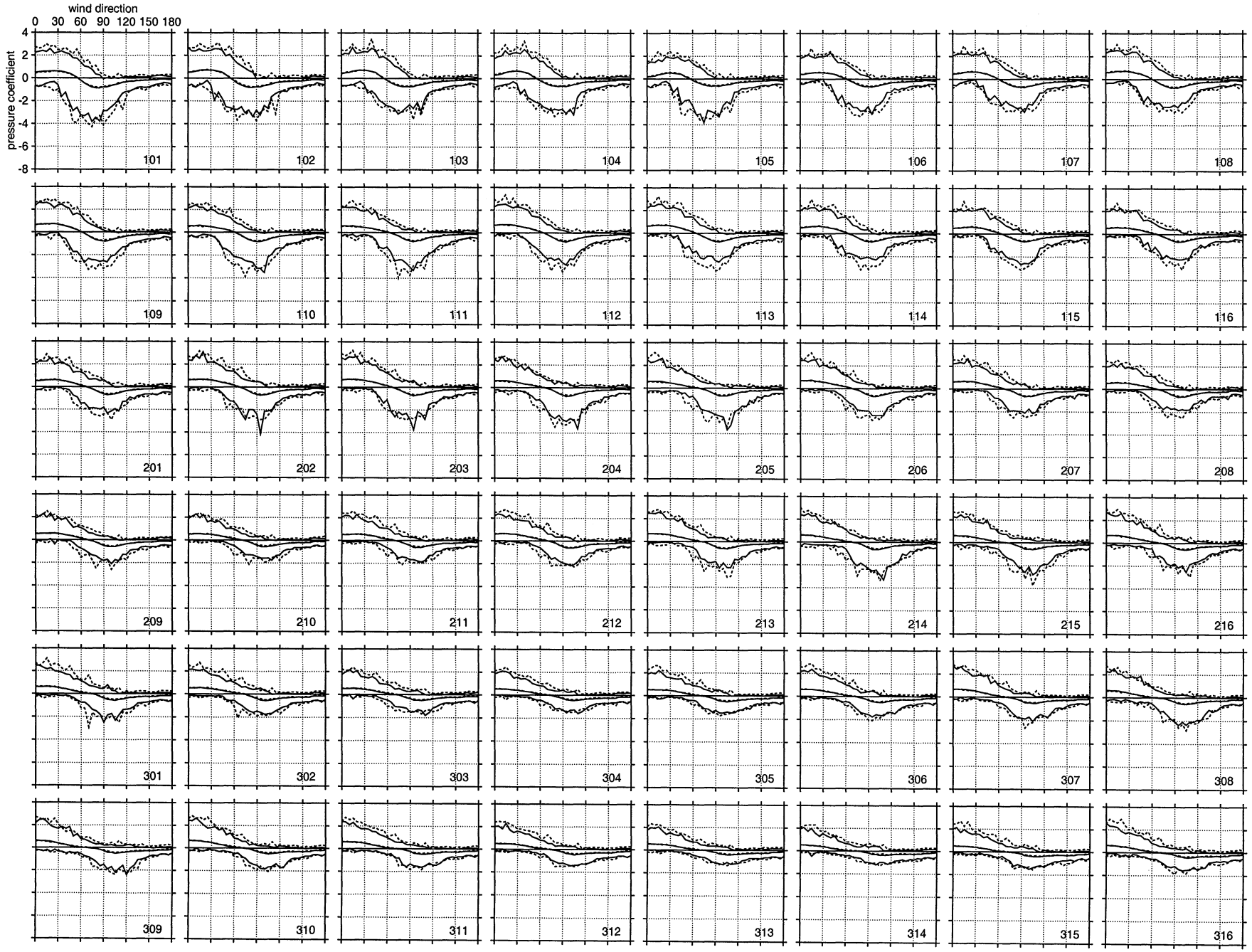

Test 6, 40ft Bld, suburban exposure
mean square
10*variance from mean
Sum of Mean Sqaure and Sum of Variance
Wind Angle
0
500
1000
1500
0
60
120
180
240
300
360

APPENDIX D

COMPARISON OF PRESSURE COEFFICIENTS BETWEEN TEST 1 AND 1997 NIST DATA SET

- Length scale: 1:200
- Model dimensions: 200'x100'
- Roof slope: 1:24
- Building heights: 20', 32'

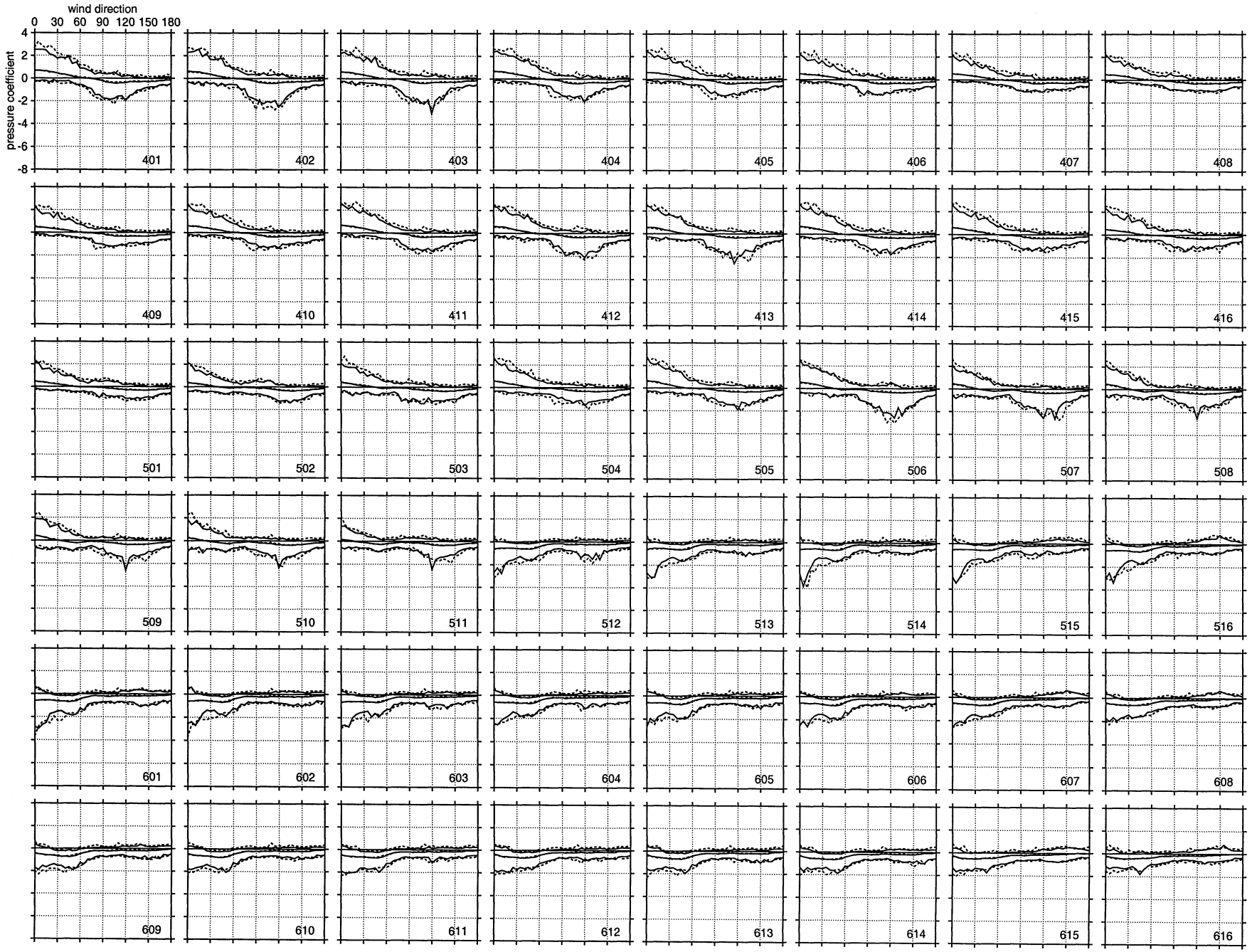
32 ft Building – Open Exposure



NIST 2003 - 32ft Bld Open Country - No Parapet

NIST (Lin & Surry) - 32ft Building - Open Country

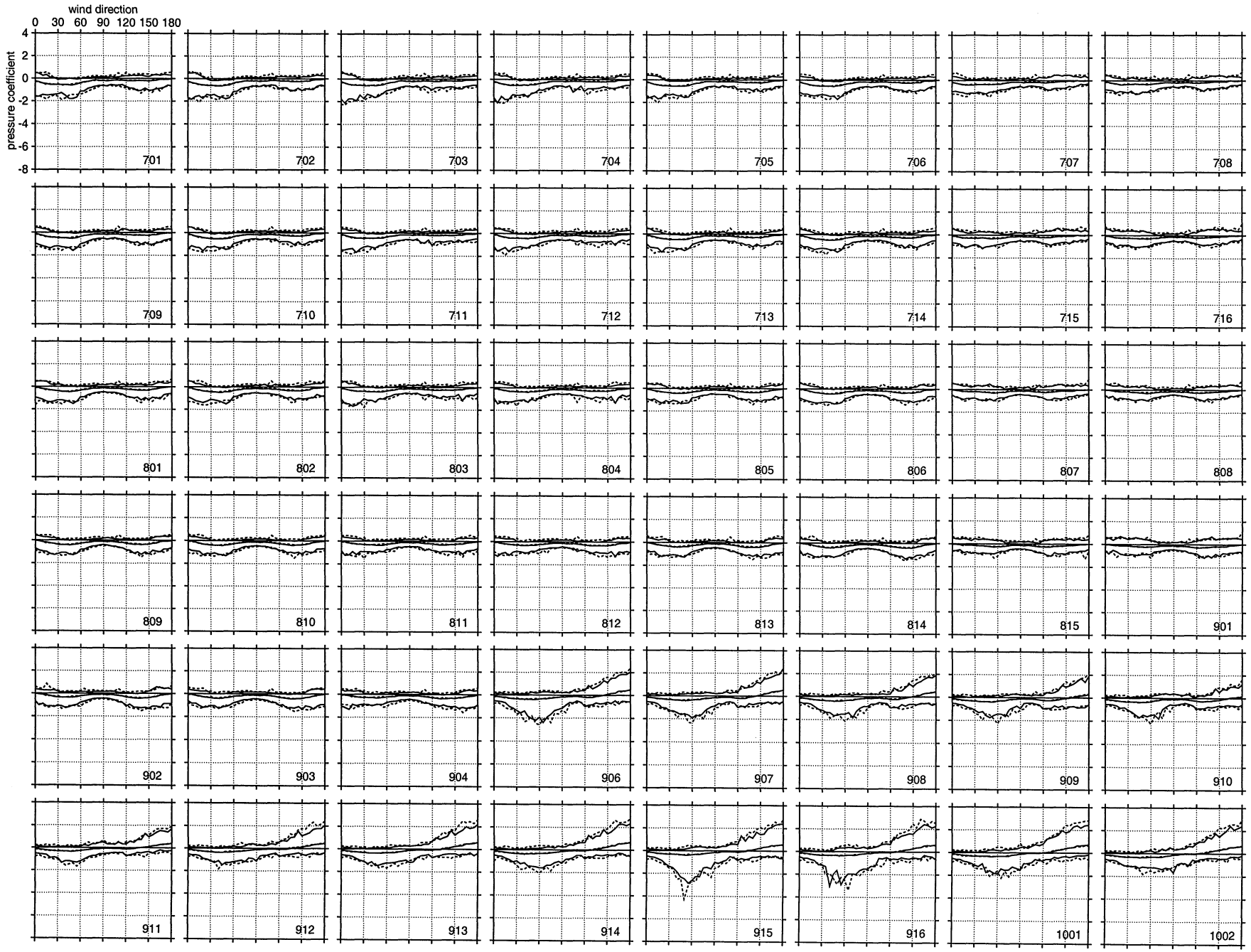
Sep. 24, 2003



NIST 2003 - 32ft Bld Open Country - No Parapet

NIST (Lin & Surry) - 32ft Building - Open Country

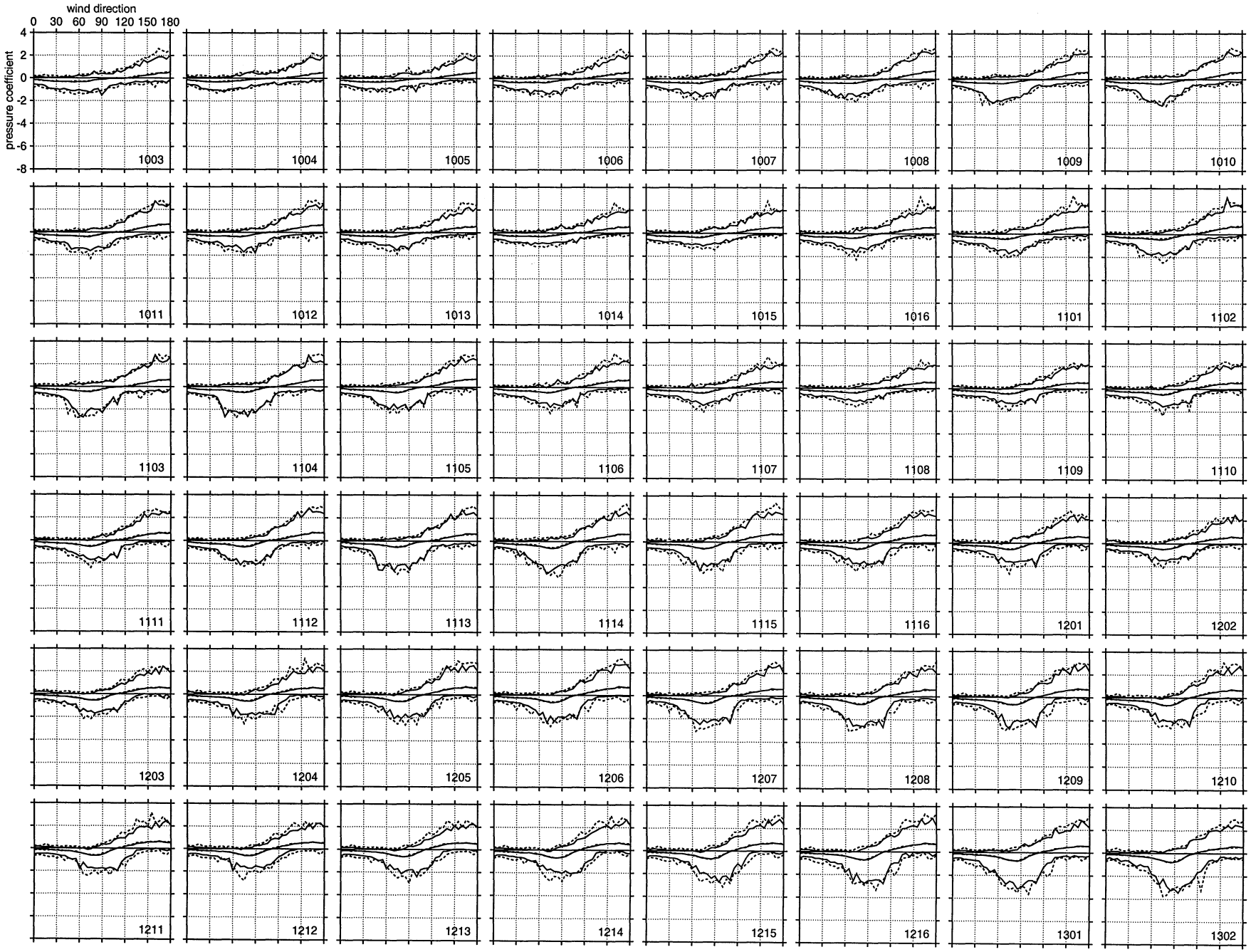
Sep. 24, 2003



NIST 2003 - 32ft Bld Open Country - No Parapet

NIST (Lin & Surry) - 32ft Building - Open Country

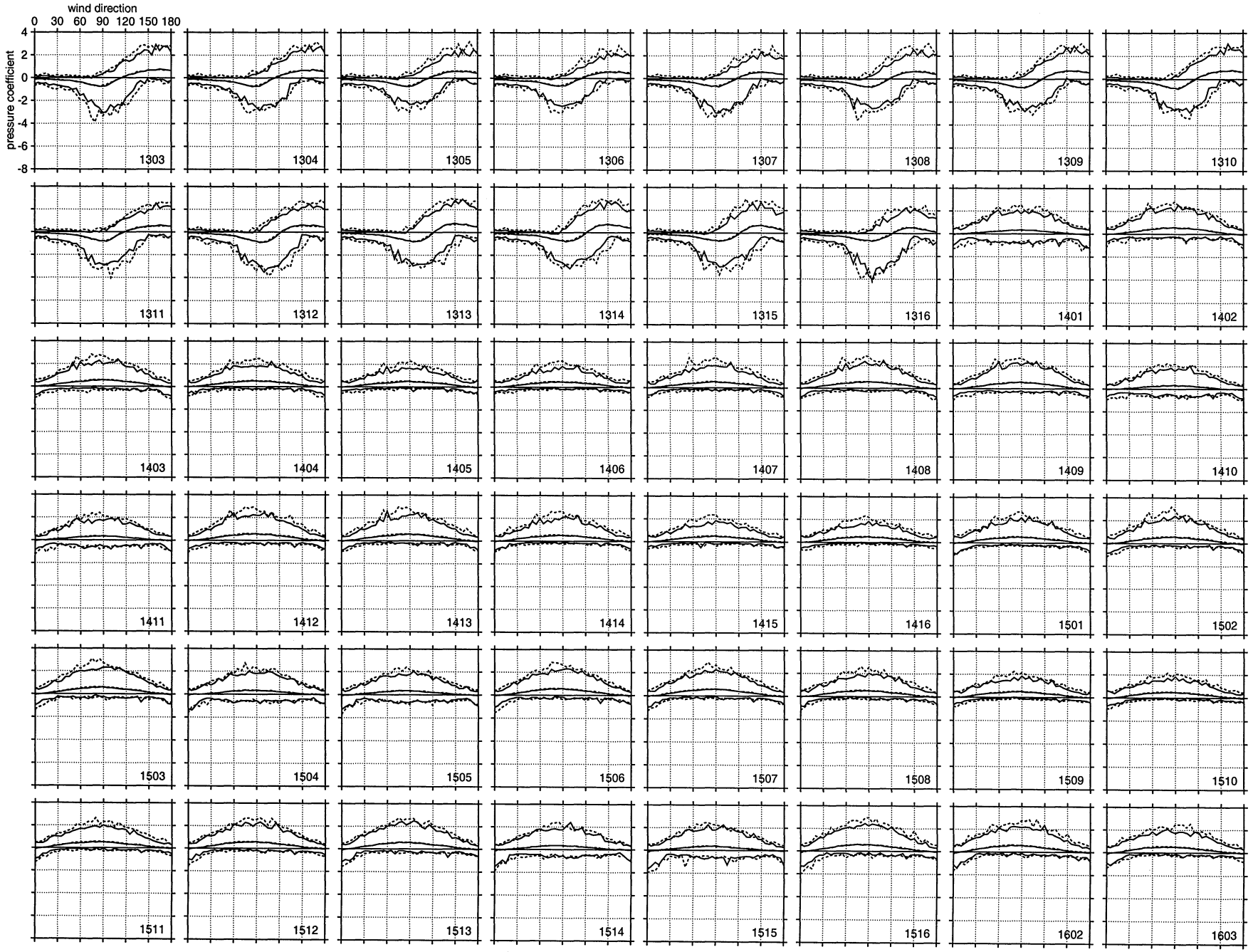
Sep. 24, 2003



NIST 2003 - 32ft Bld Open Country - No Parapet

NIST (Lin & Surry) - 32ft Building - Open Country

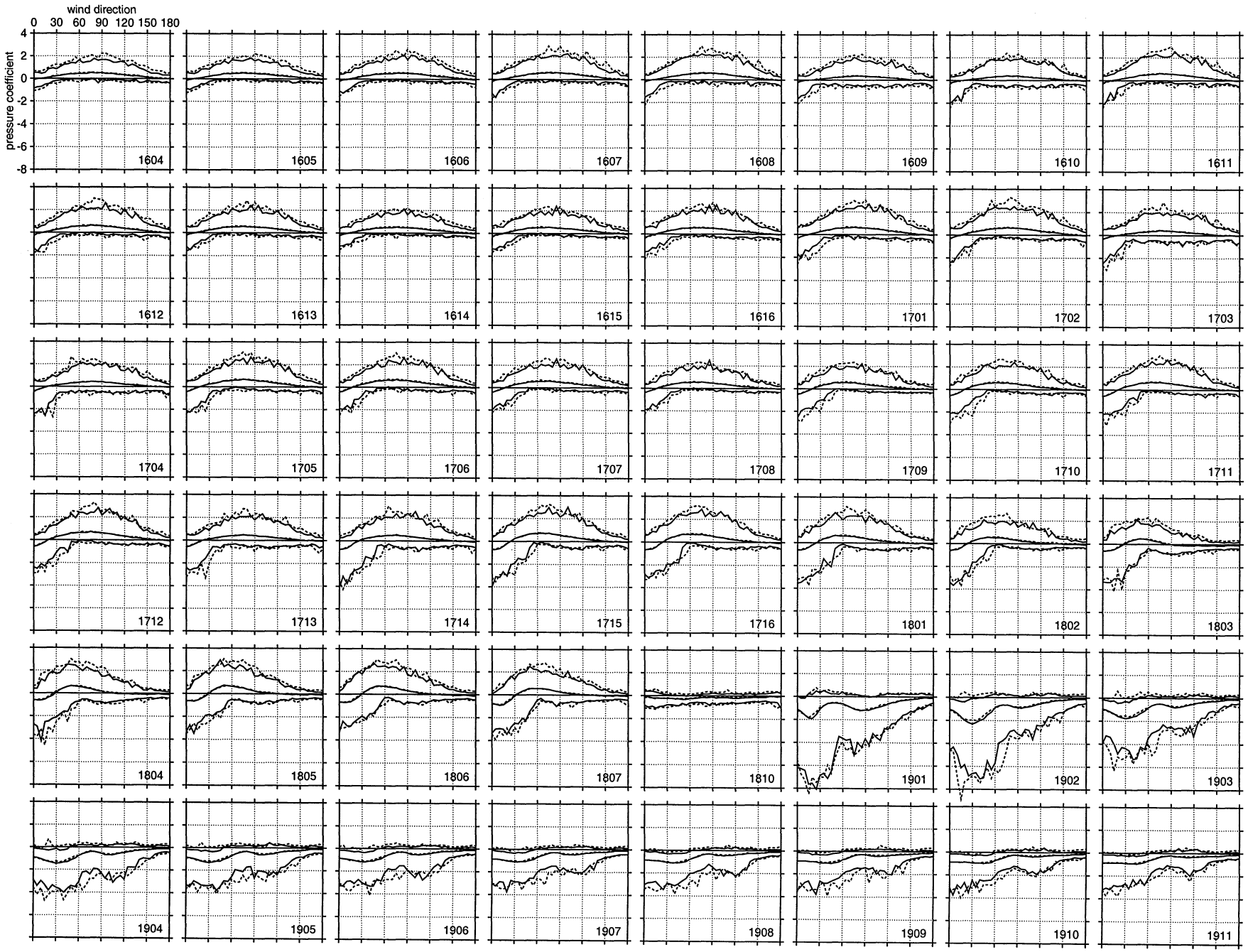
Sep. 24, 2003



NIST 2003 - 32ft Bld Open Country - No Parapet

NIST (Lin & Surry) - 32ft Building - Open Country

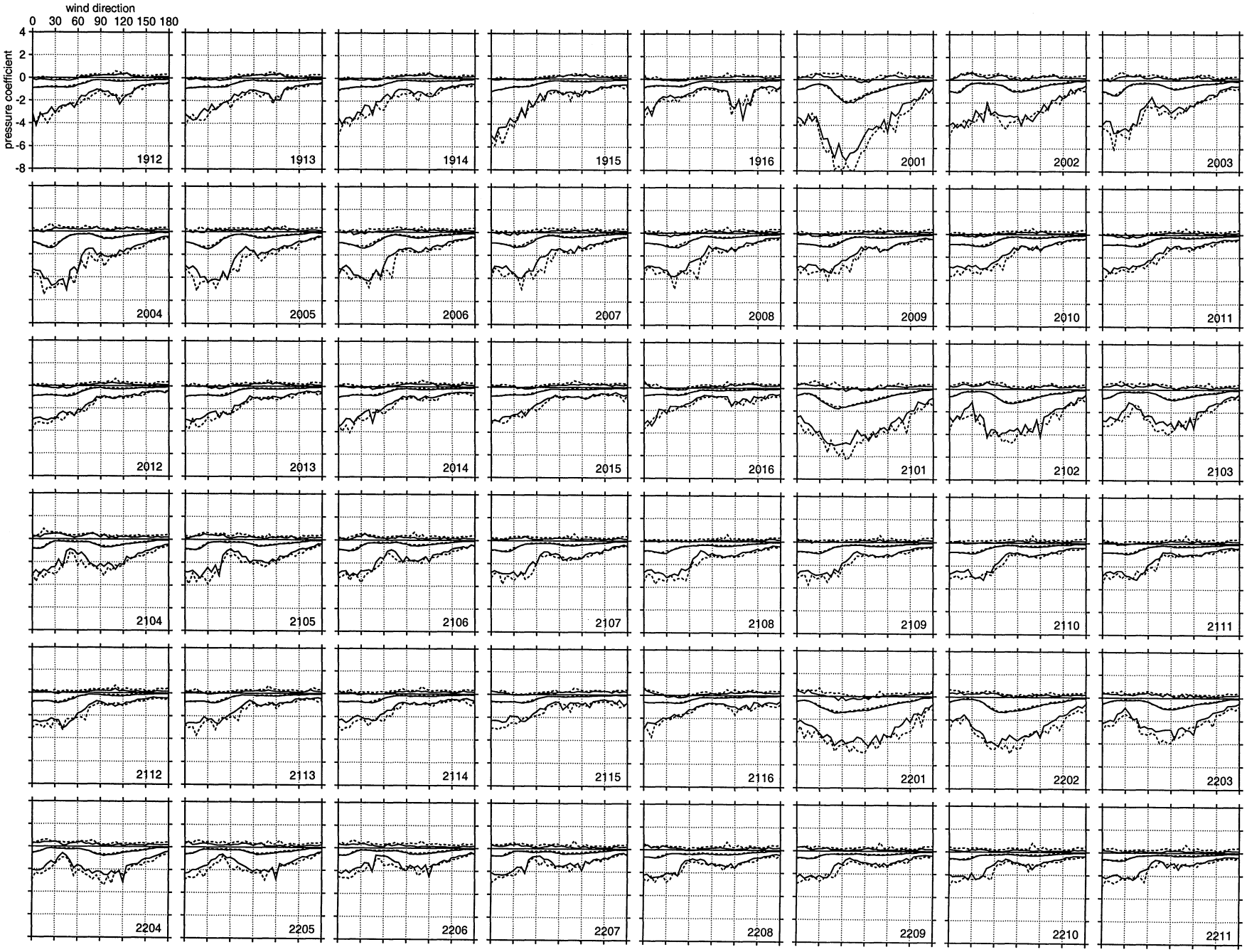
Sep. 24, 2003



NIST 2003 - 32ft Bld Open Country - No Parapet

NIST (Lin & Surry) - 32ft Building - Open Country

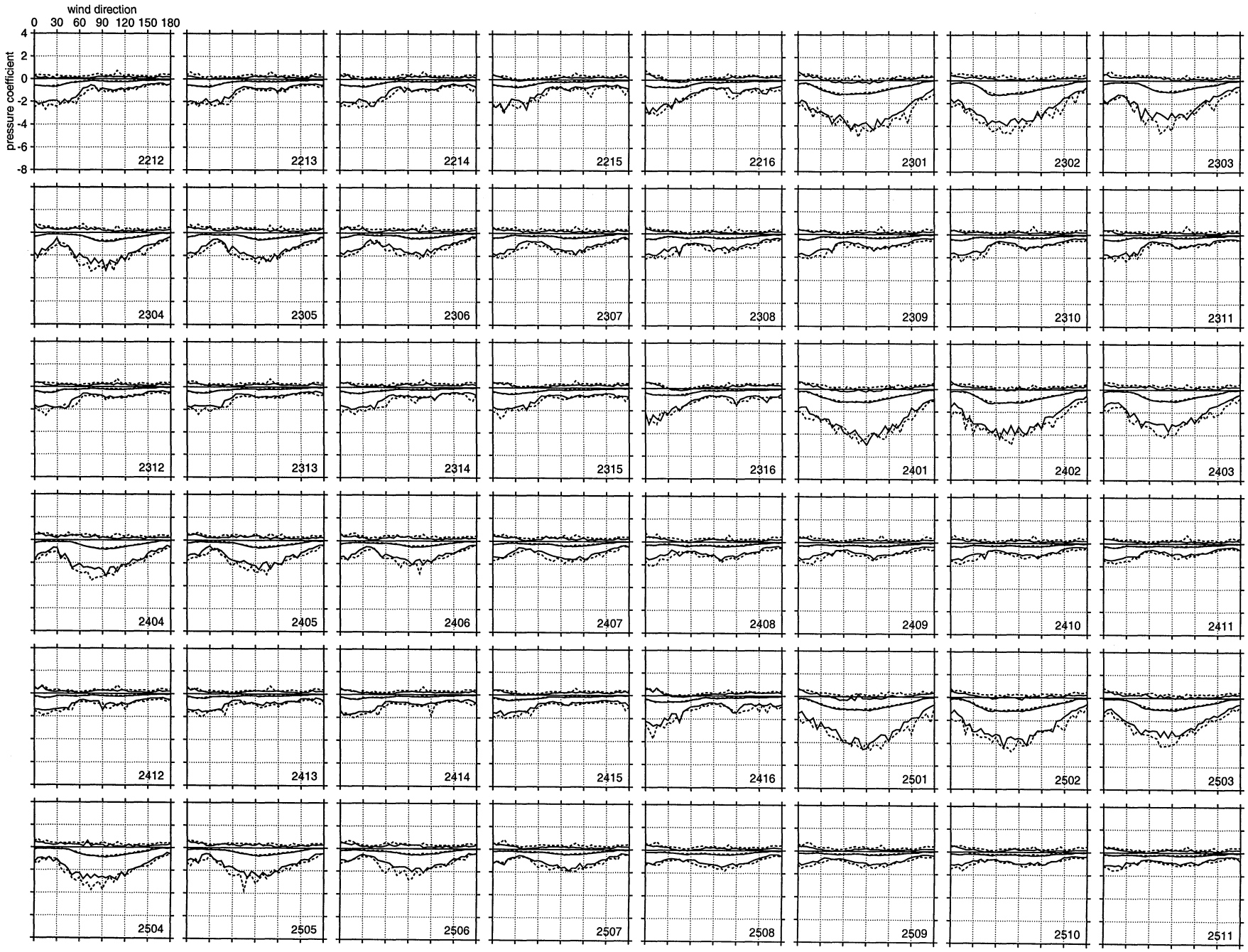
Sep. 24, 2003



NIST 2003 - 32ft Bld Open Country - No Parapet

NIST (Lin & Surry) - 32ft Building - Open Country

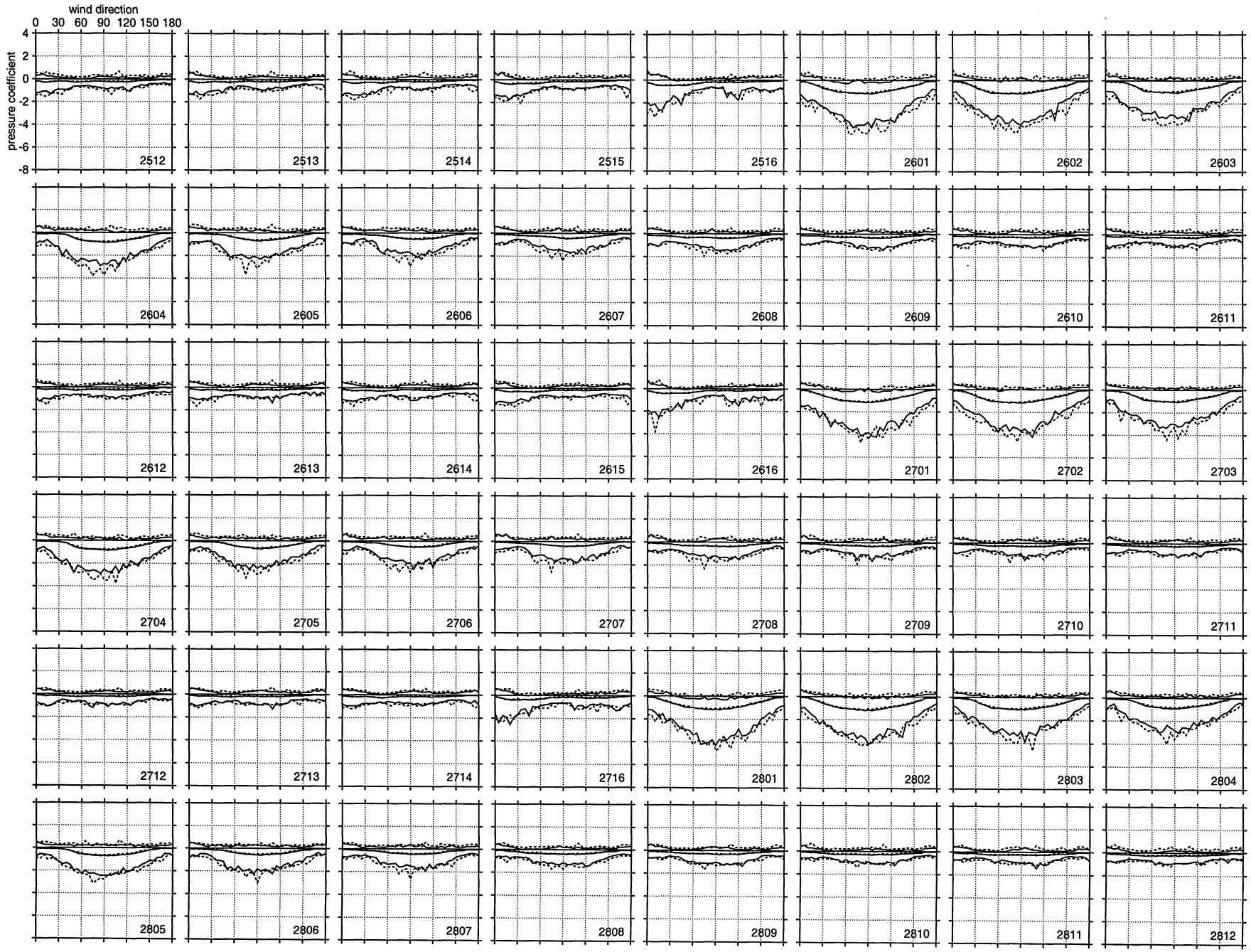
Sep. 24, 2003



NIST 2003 - 32ft Bld Open Country - No Parapet

NIST (Lin & Surry) - 32ft Building - Open Country

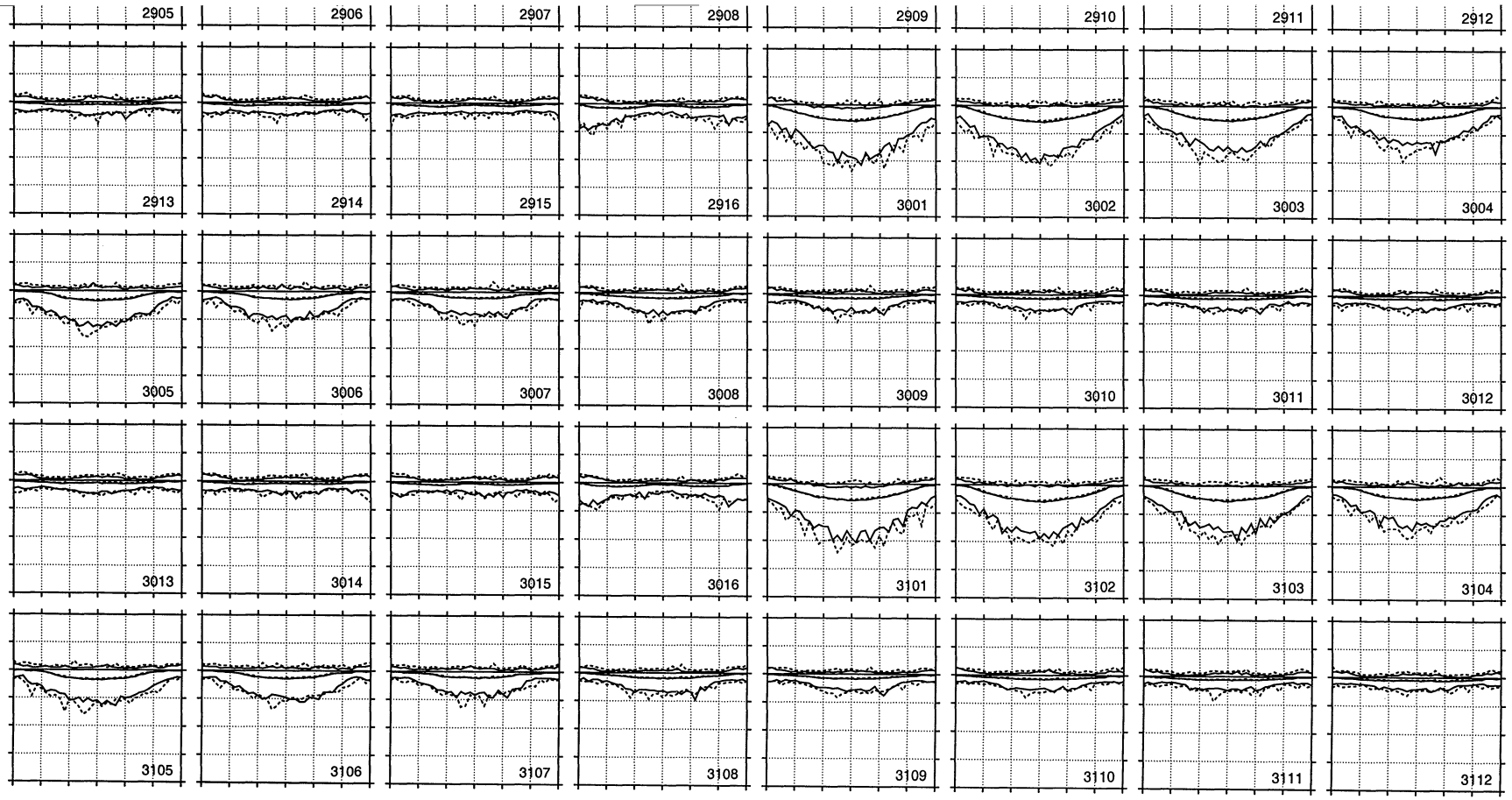
Sep. 24, 2003



NIST 2003 - 32ft Bld Open Country - No Parapet

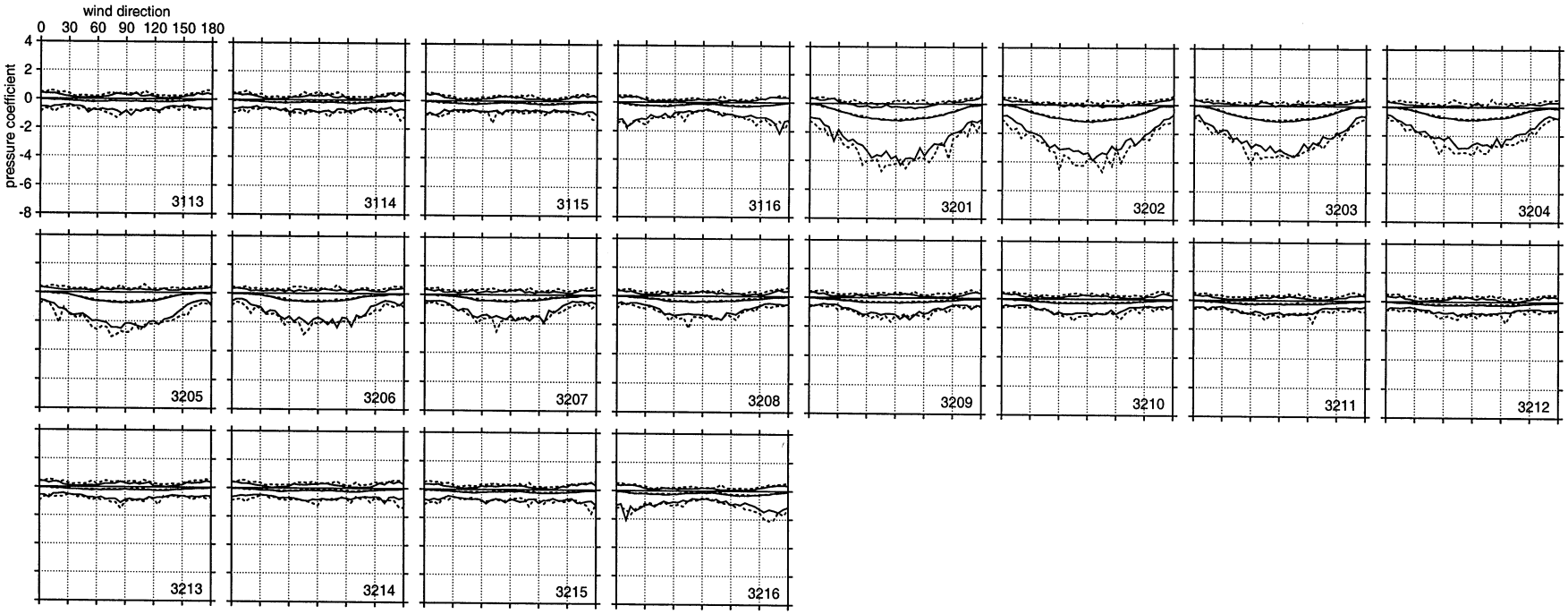
NIST (Lin & Surry) - 32ft Building - Open Country

Sep. 24, 2003



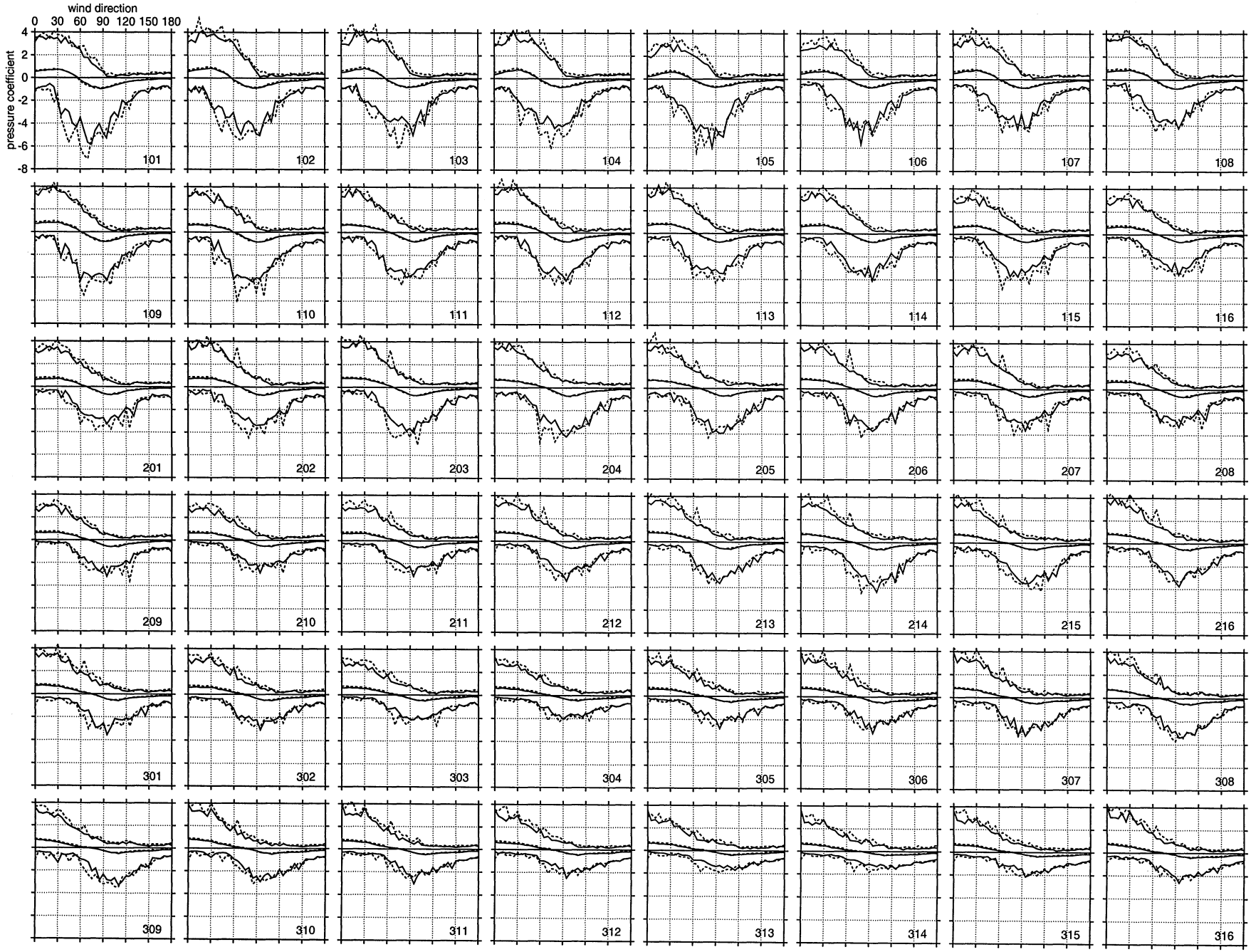
——— NIST 2003 - 32ft Bld Open Country - No Parapet

------- NIST (Lin & Surry) - 32ft Building - Open Country


wind direction
0 30 60 90 120 150 180
pressure coefficient
4
2
0
-2
-4
-6
-8
3113
3114
3115
3116
3201
3202
3203
3204
3205
3206
3207
3208
3209
3210
3211
3212
3213
3214
3215
3216
NIST 2003 - 32ft Bld Open Country - No Parapet
NIST (Lin & Surry) - 32ft Building - Open Country

Sep. 24, 2003

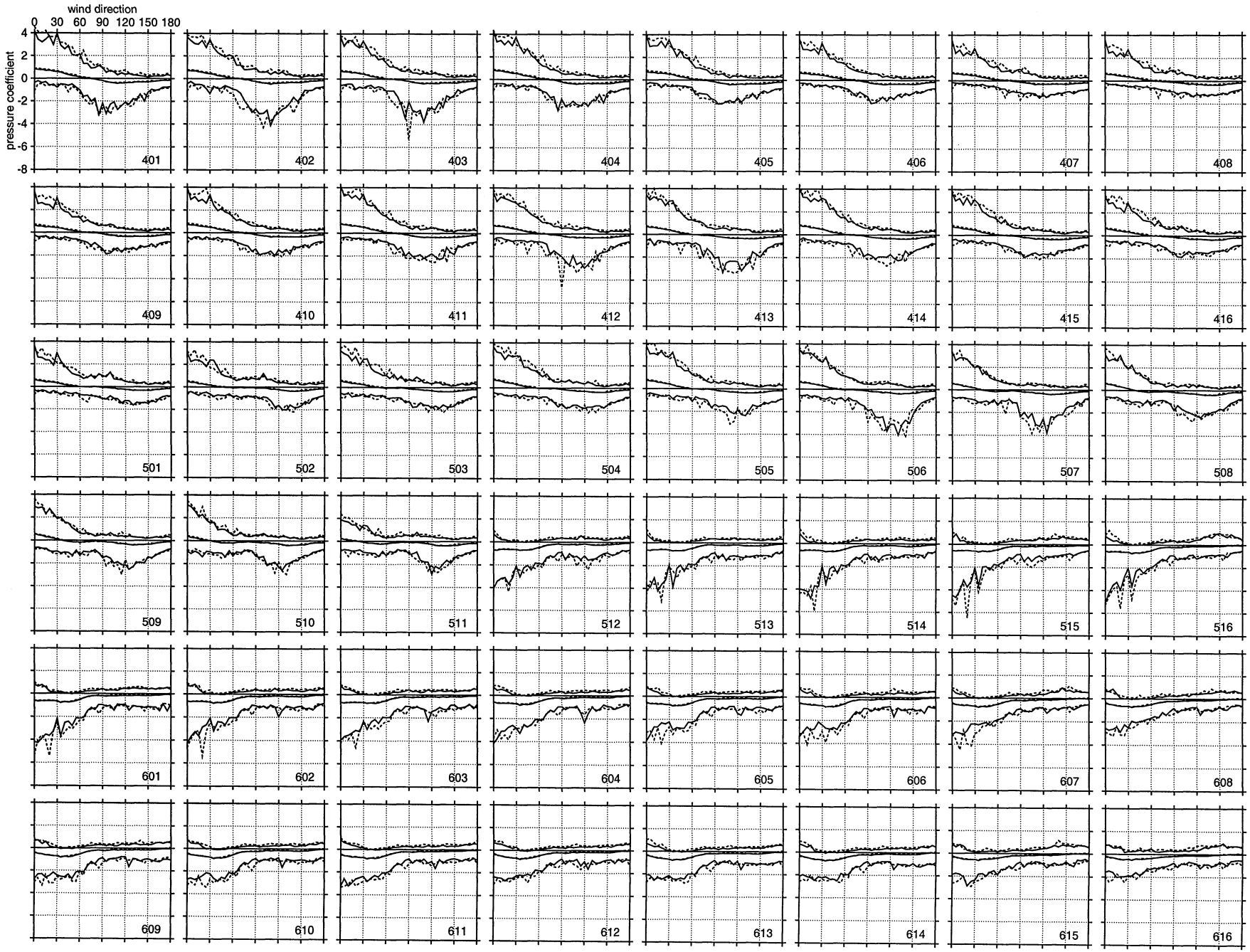
32 ft Building – Suburban Exposure



NIST 2003 - 32ft Bld Suburban - No Parapet

NIST (Lin & Surry) - 32ft Building - Suburban

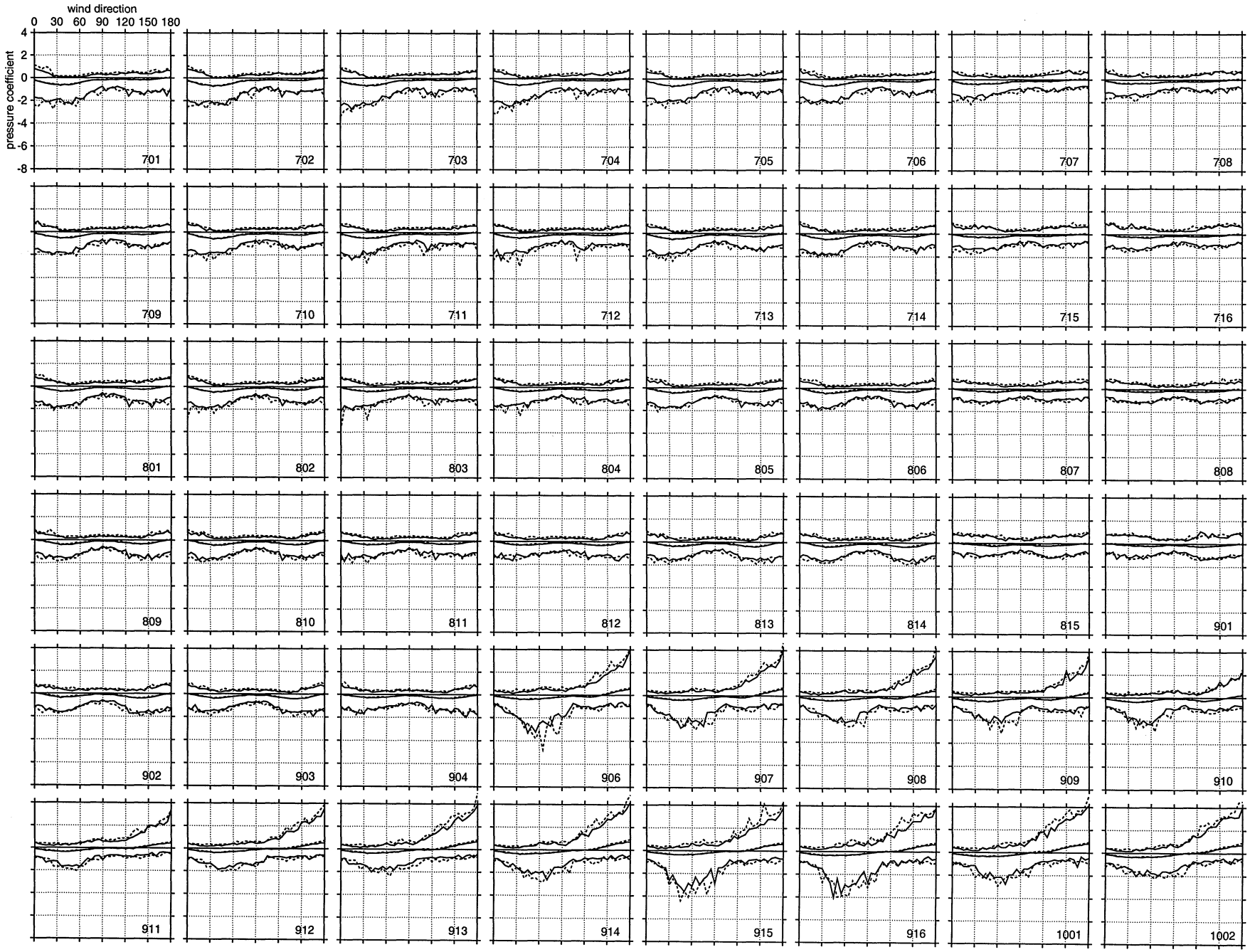
Sep. 24, 2003



NIST 2003 - 32ft Bld Suburban - No Parapet

NIST (Lin & Surry) - 32ft Building - Suburban

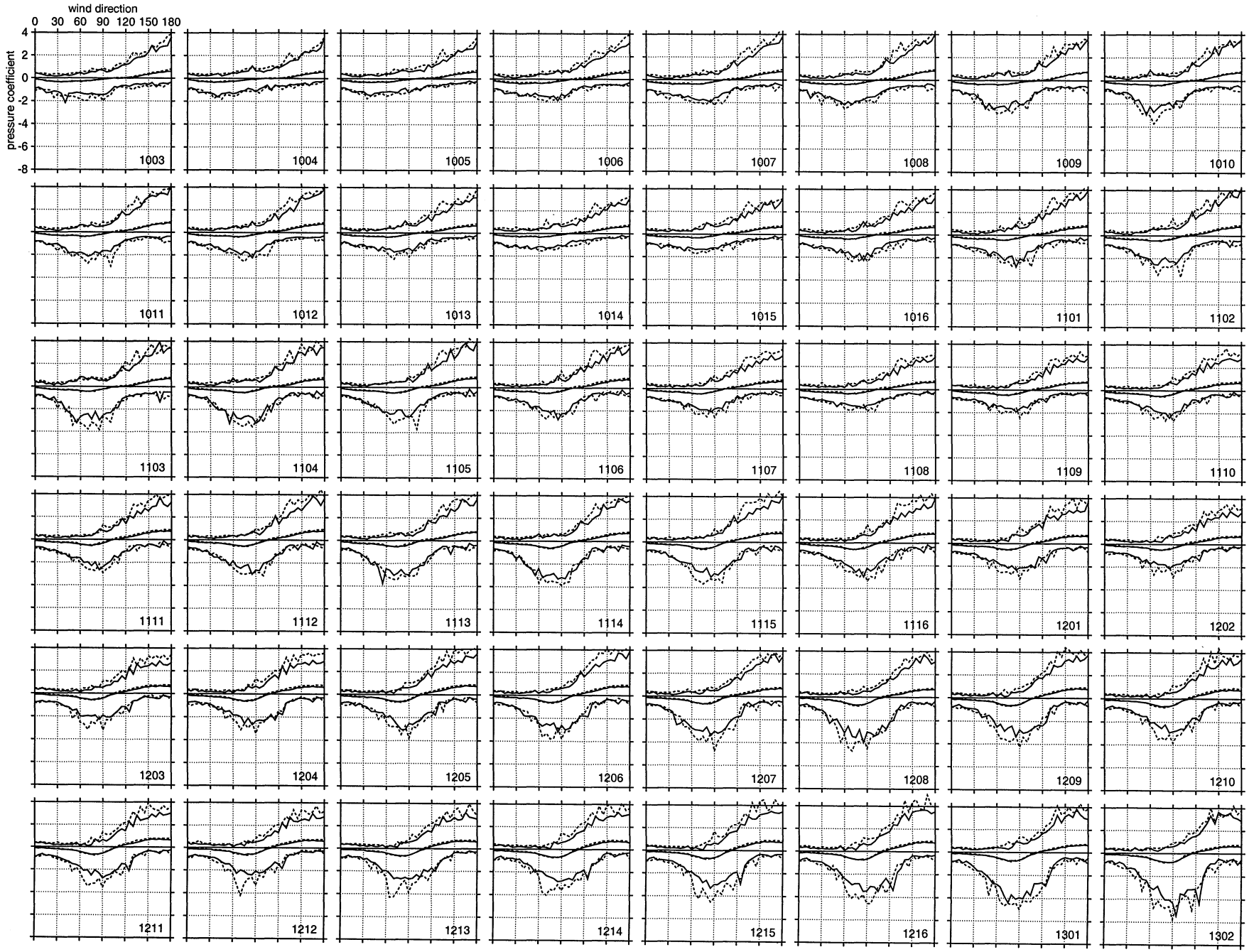
Sep. 24, 2003



NIST 2003 - 32ft Bld Suburban - No Parapet

NIST (Lin & Surry) - 32ft Building - Suburban

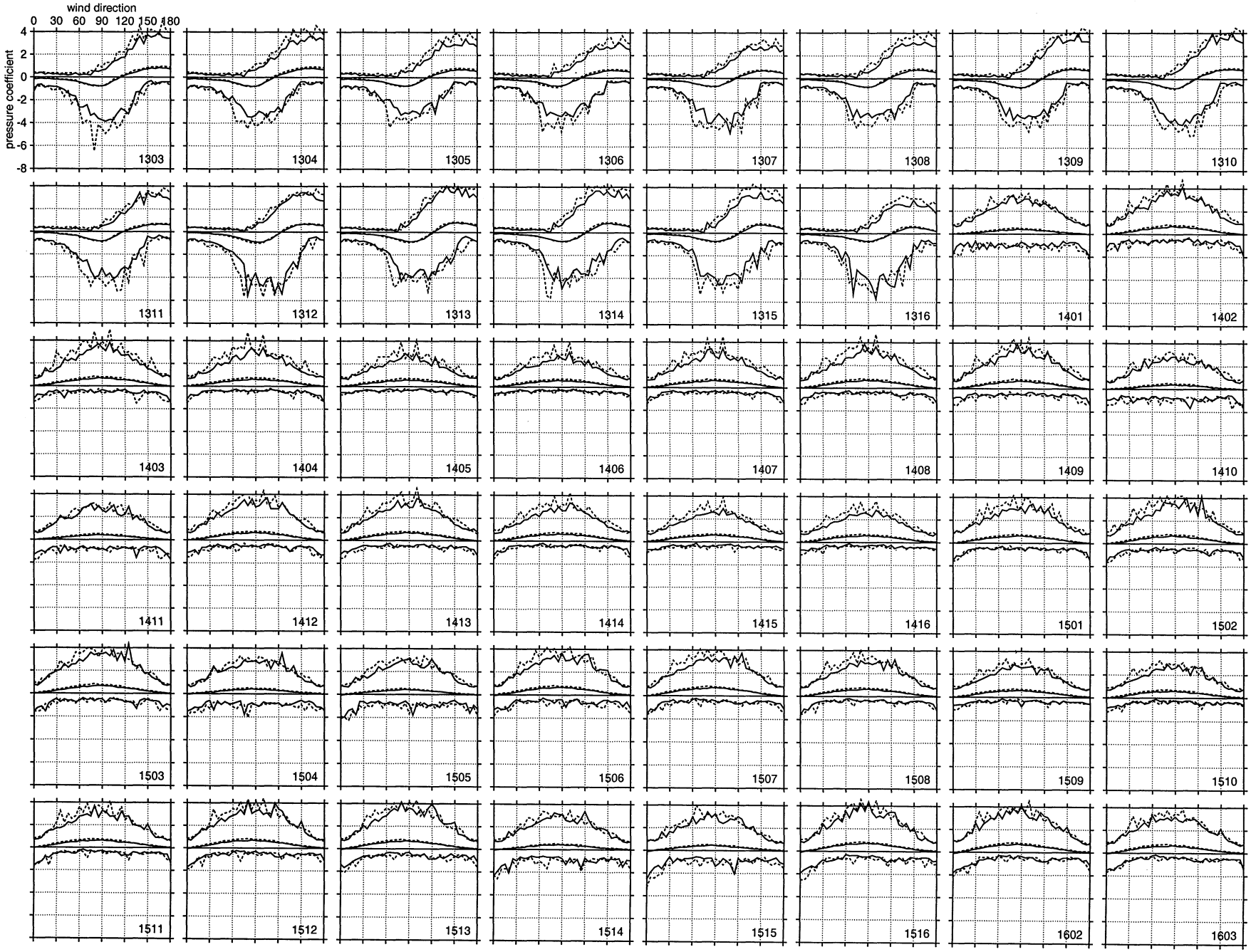
Sep. 24, 2003



NIST 2003 - 32ft Bld Suburban - No Parapet

NIST (Lin & Surry) - 32ft Building - Suburban

Sep. 24, 2003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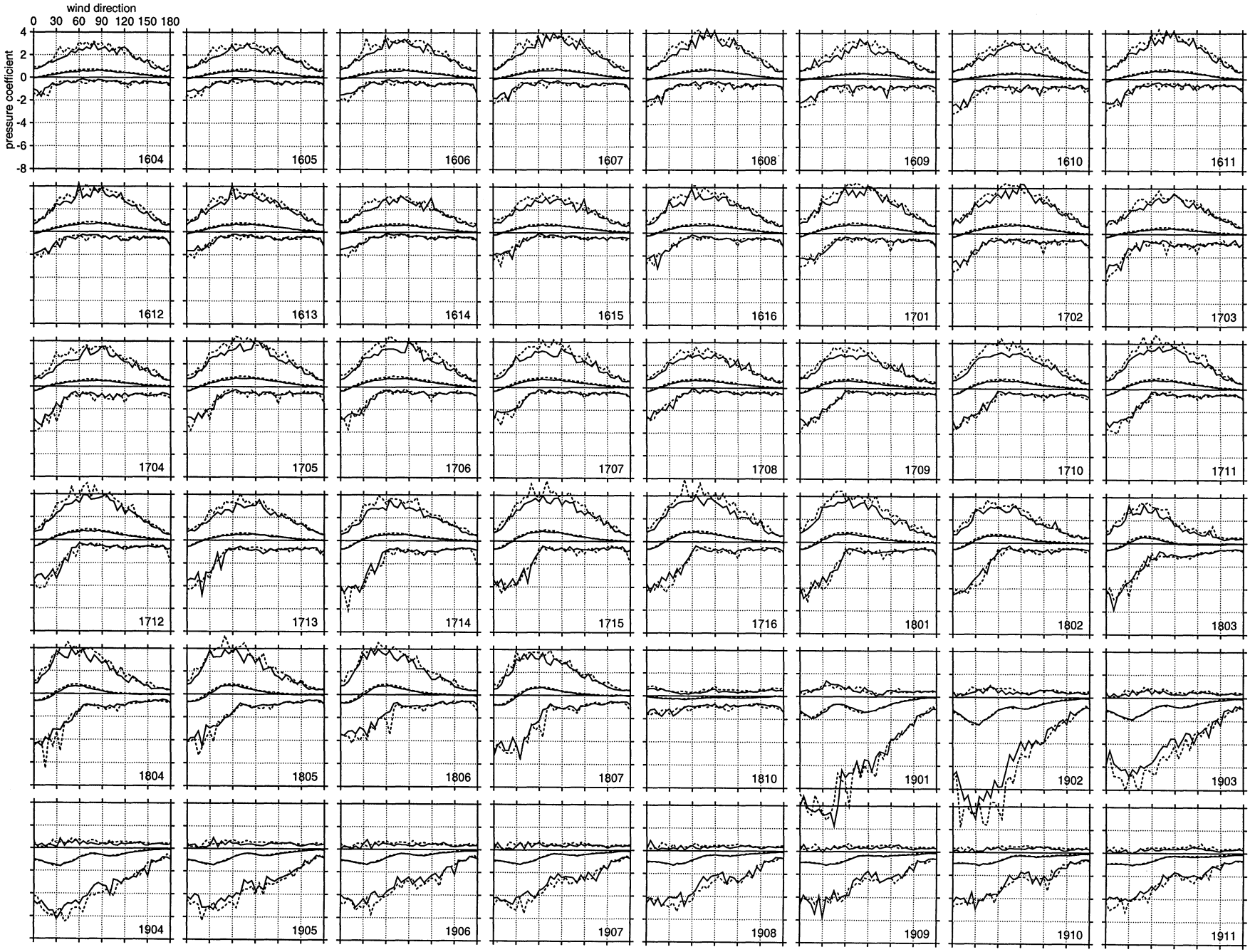
NIST 2003 - 32ft Bld Suburban - No Parapet
NIST (Lin & Surry) - 32ft Building - Suburban

Sep. 24, 2003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pressure coefficient
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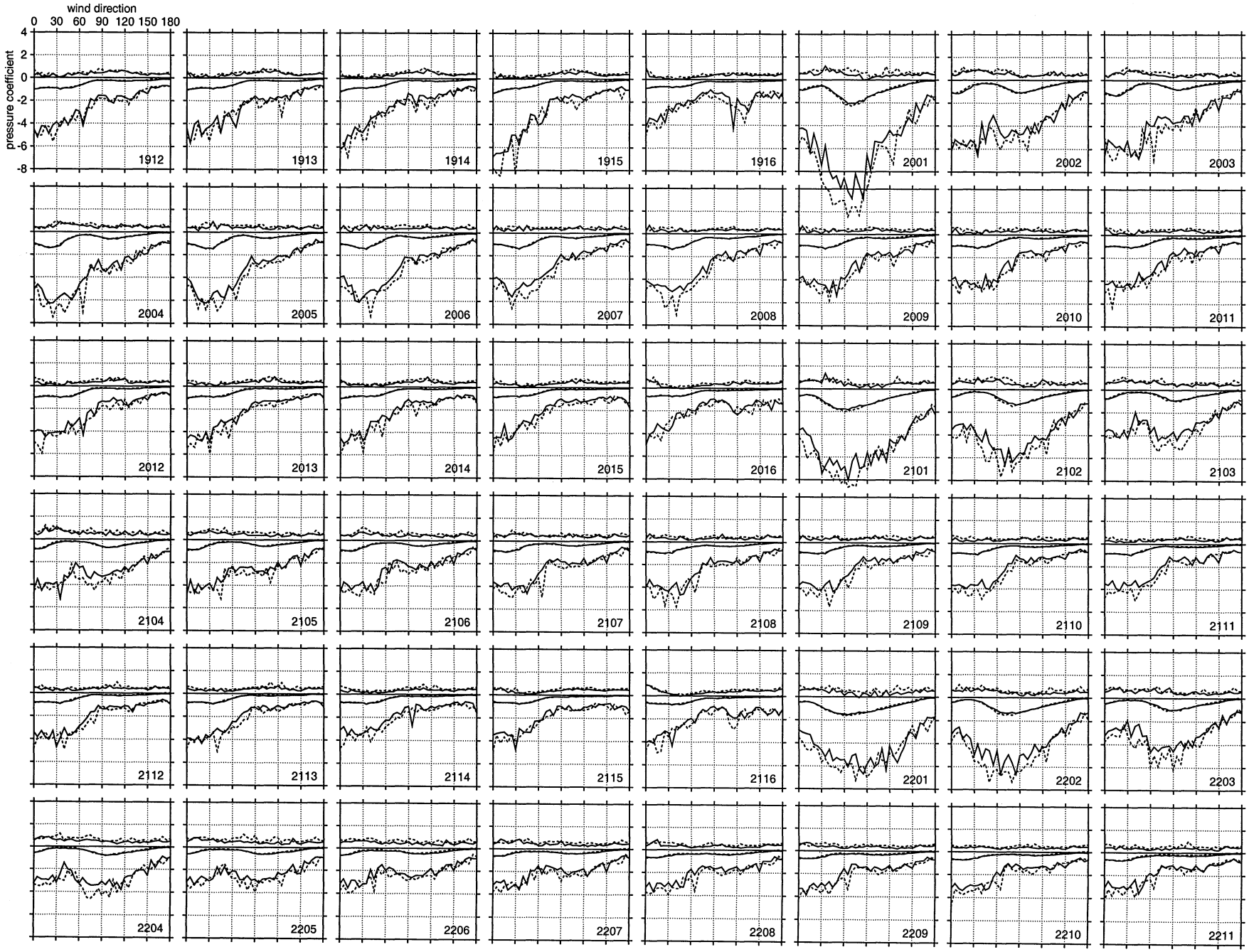
NIST (Lin & Surry) - 32ft Building - Suburban

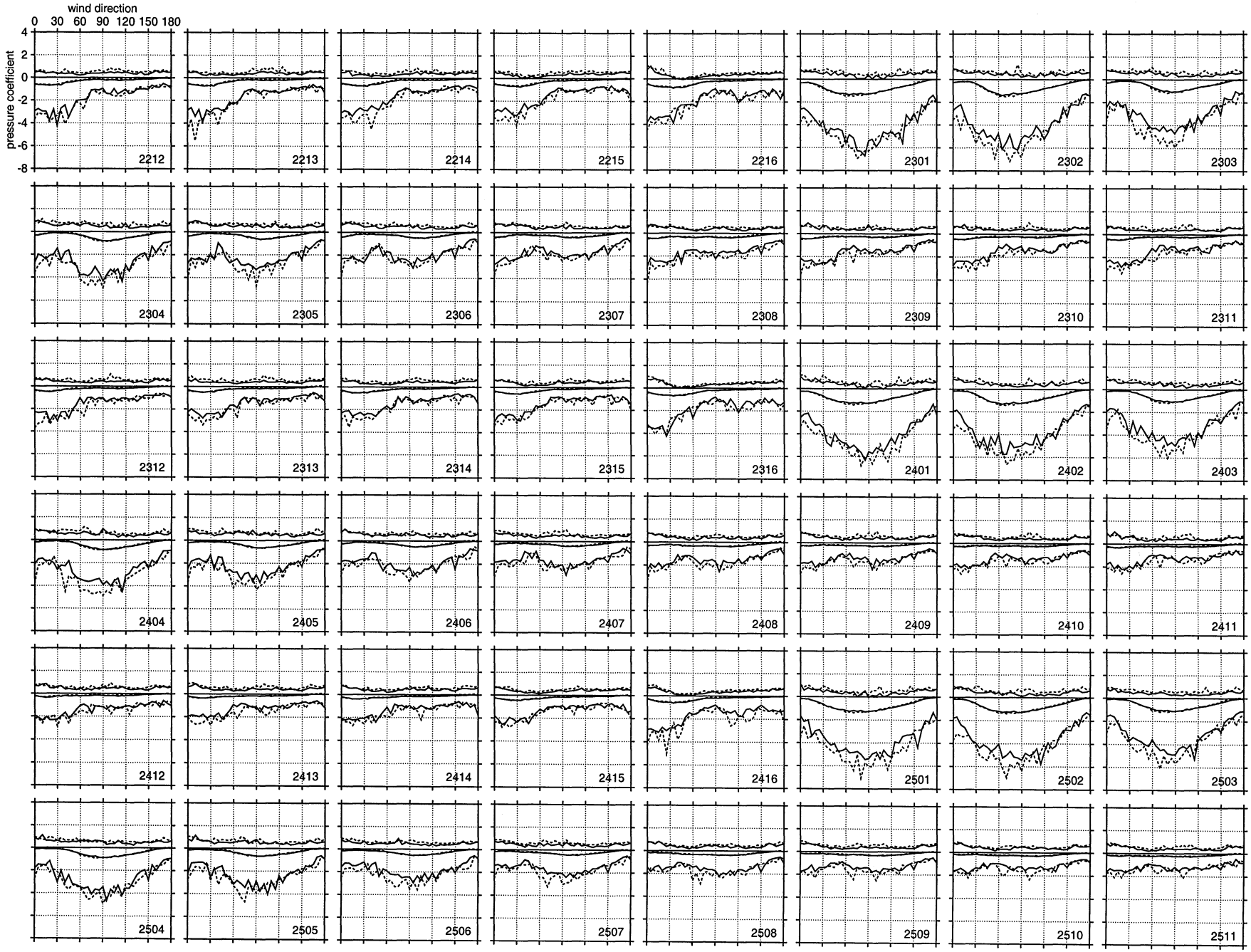
Sep. 24, 2003



NIST 2003 - 32ft Bld Suburban - No Parapet

NIST (Lin & Surry) - 32ft Building - Suburban

Sep. 24, 2003



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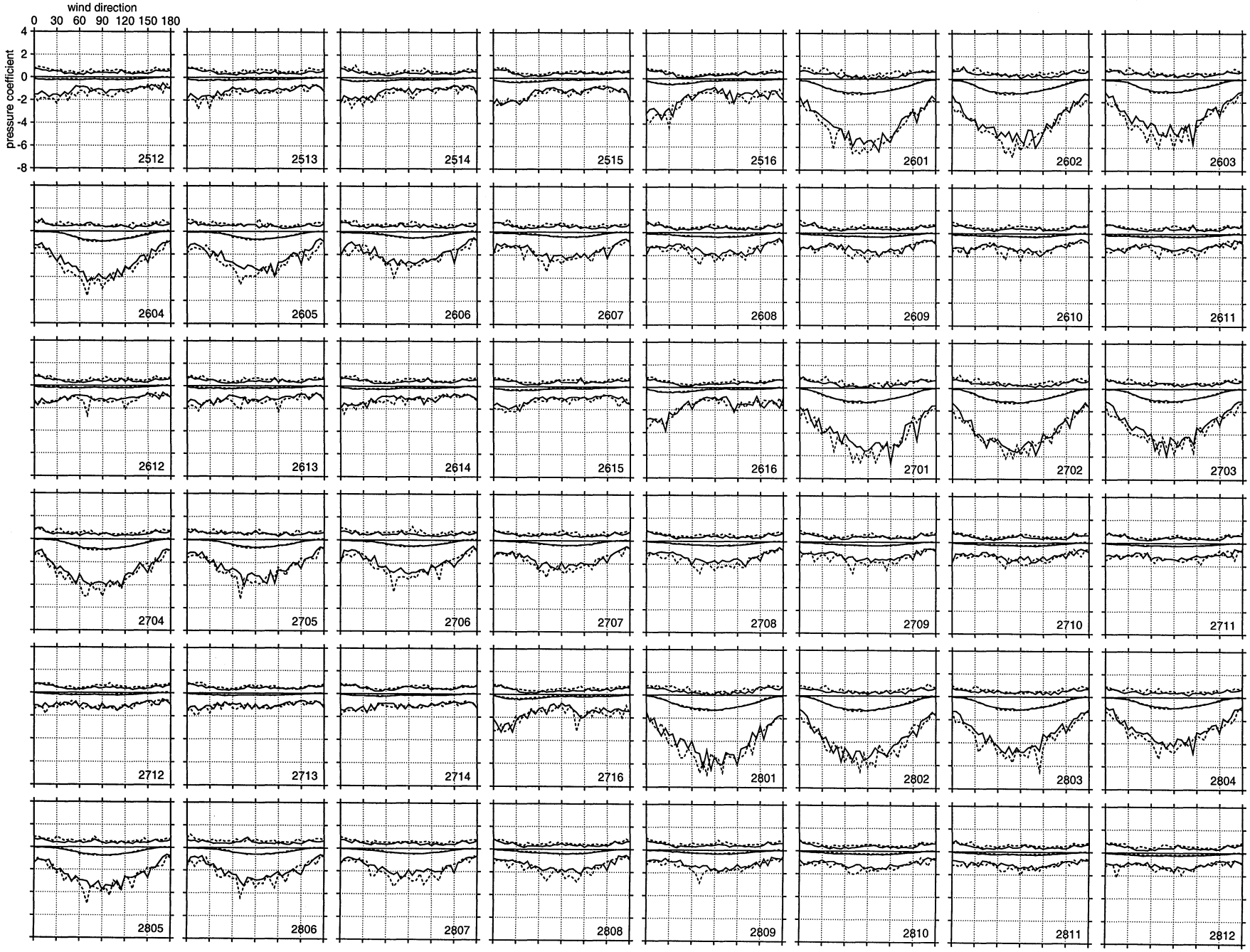
NIST (Lin & Surry) - 32ft Building - Suburban

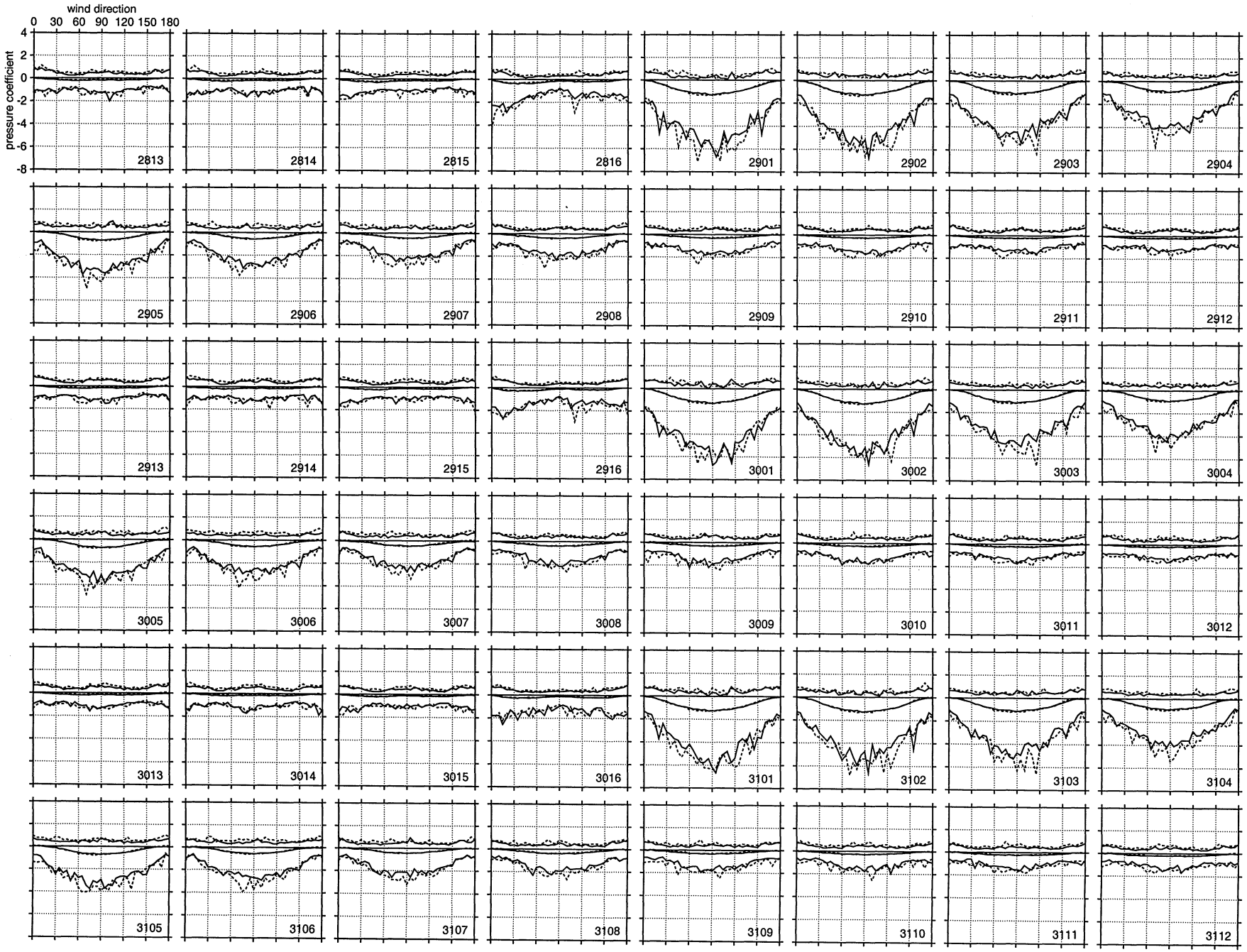
Sep. 24, 2003



NIST 2003 - 32ft Bld Suburban - No Parapet

NIST (Lin & Surry) - 32ft Building - Suburban

Sep. 24, 2003



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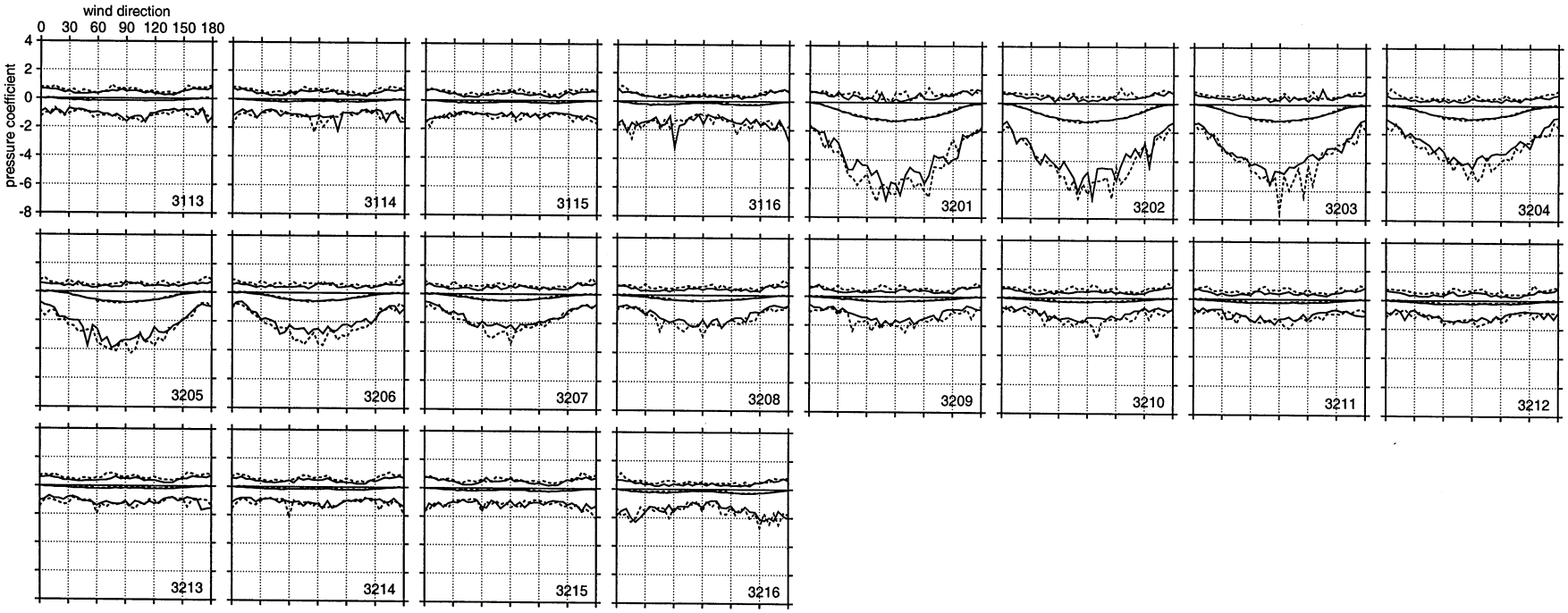
NIST (Lin & Surry) - 32ft Building - Suburban

Sep. 24, 2003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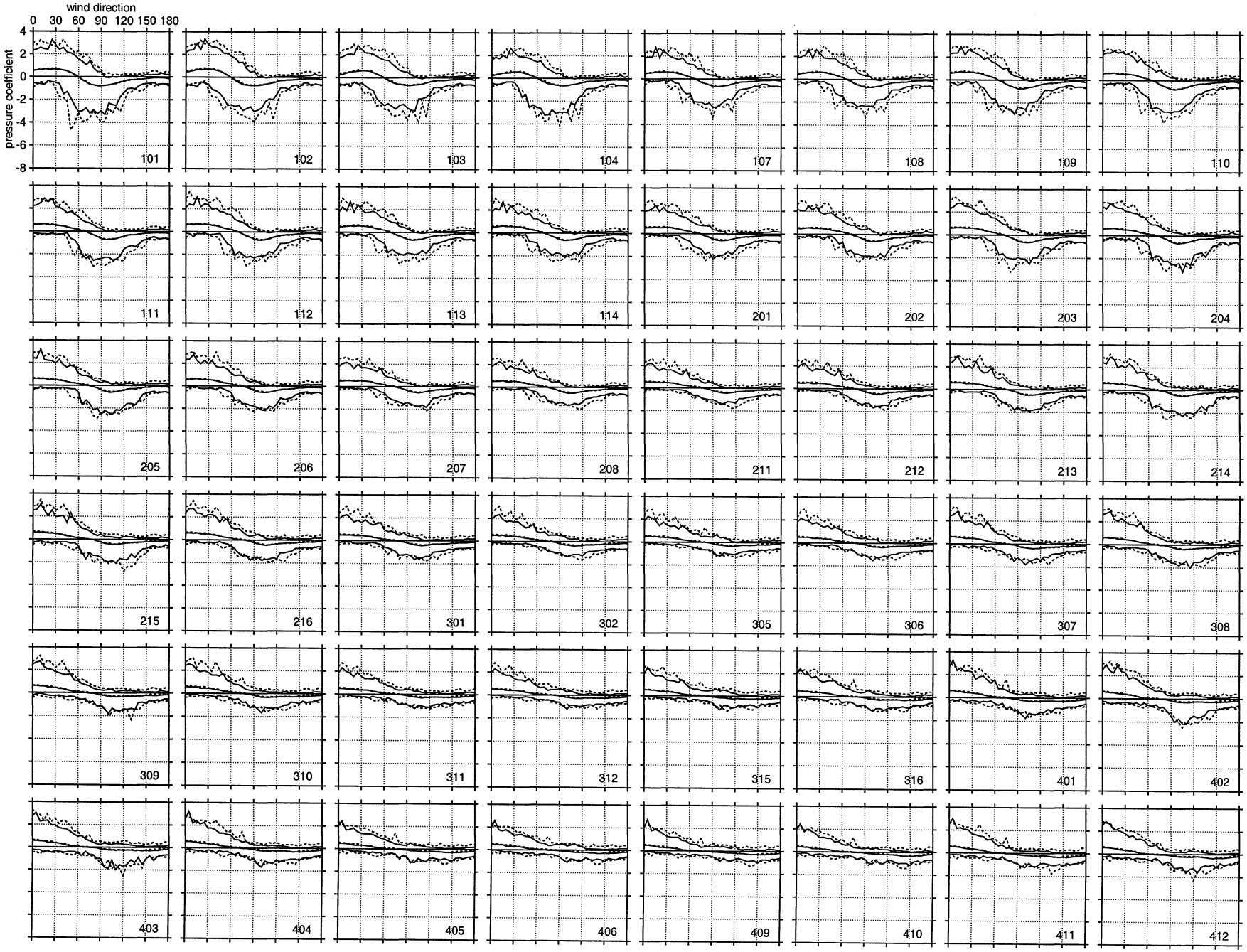
NIST 2003 - 32ft Bld Suburban - No Parapet
NIST (Lin & Surry) - 32ft Building - Suburban

Sep. 24, 2003

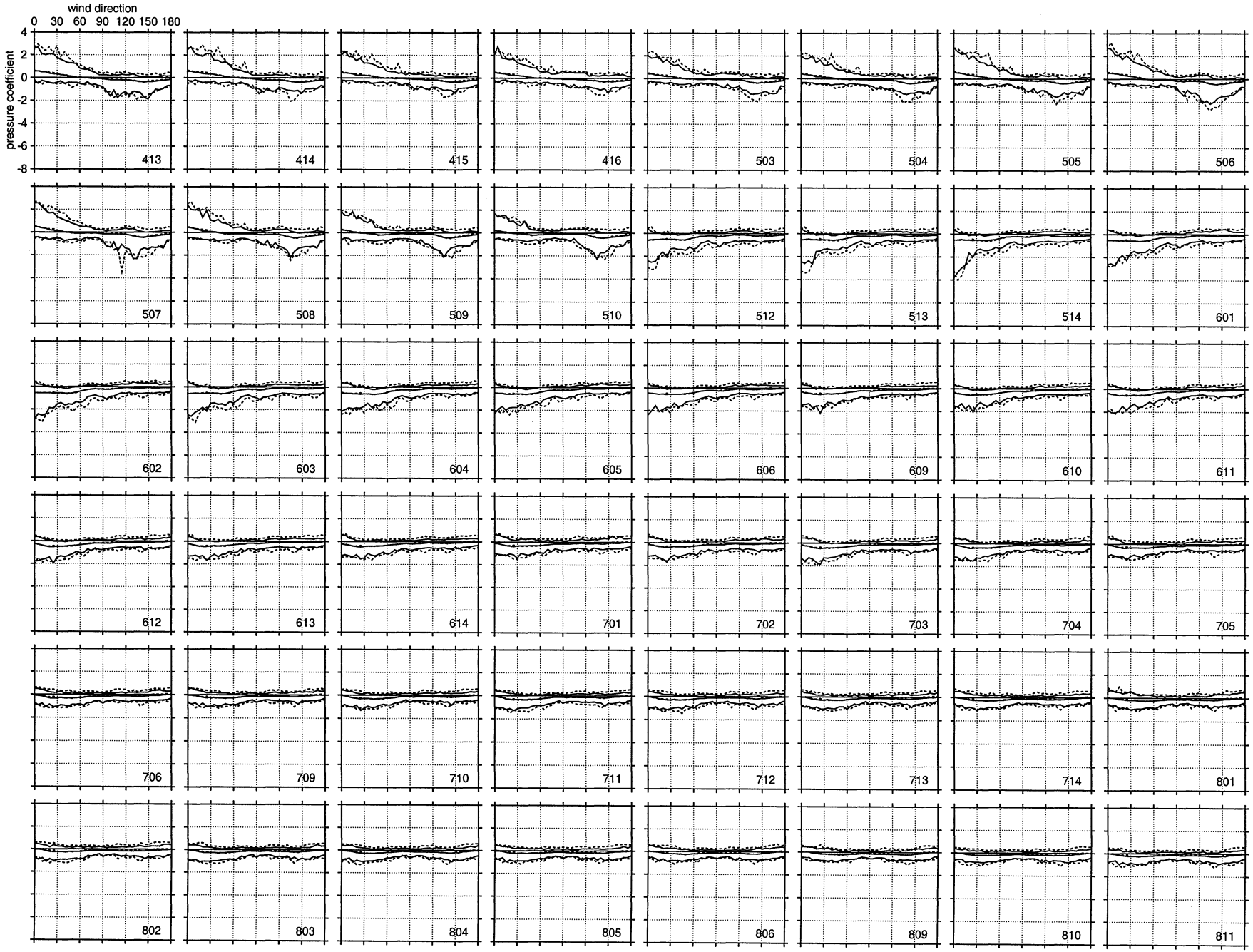
20 ft Building – Open Exposure



NIST 2003 - 20ft Bld Open Country - No Parapet

NIST (Lin & Surry) - 20ft Building - Open Country

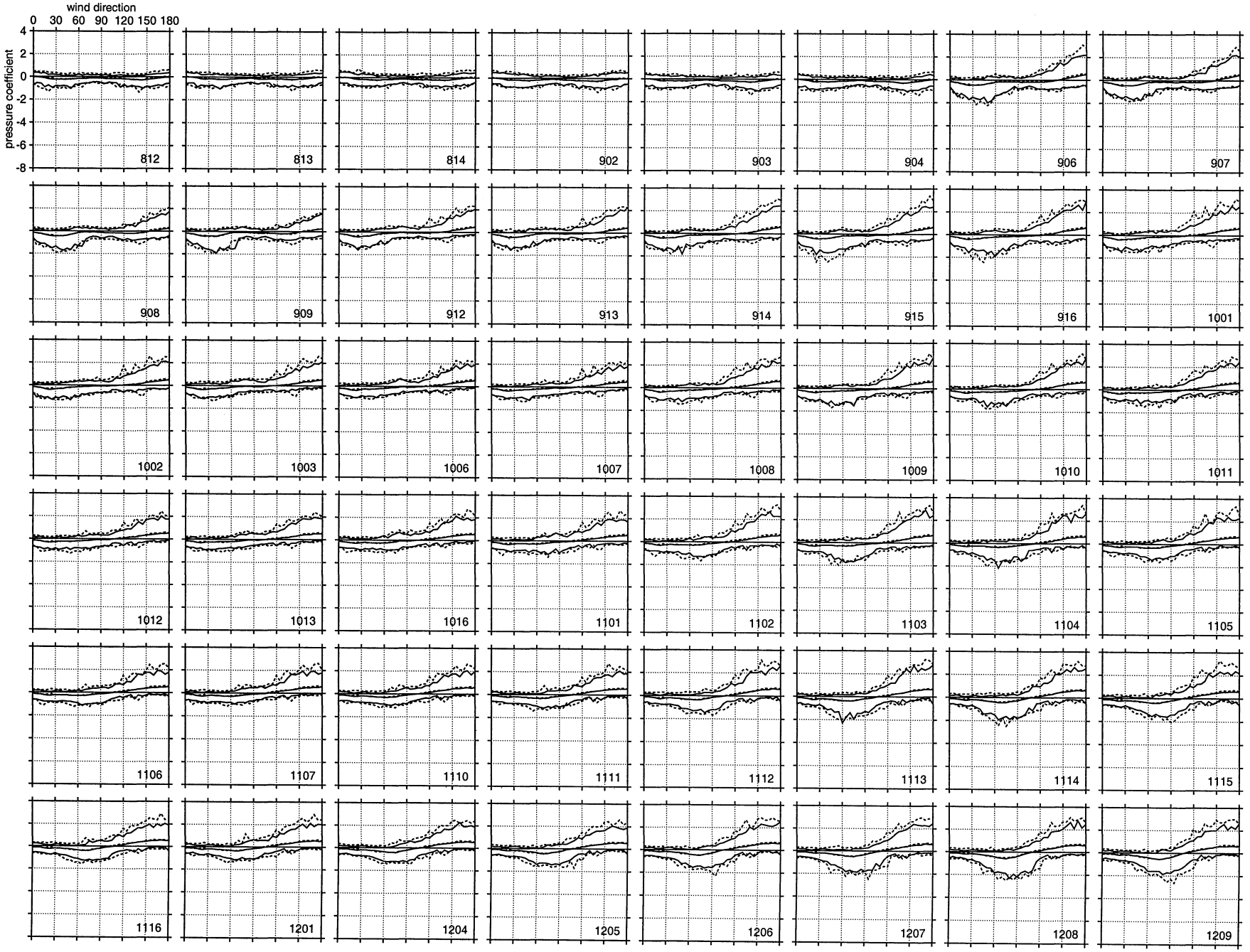
Sep. 24, 2003



NIST 2003 - 20ft Bld Open Country - No Parapet

NIST (Lin & Surry) - 20ft Building - Open Country

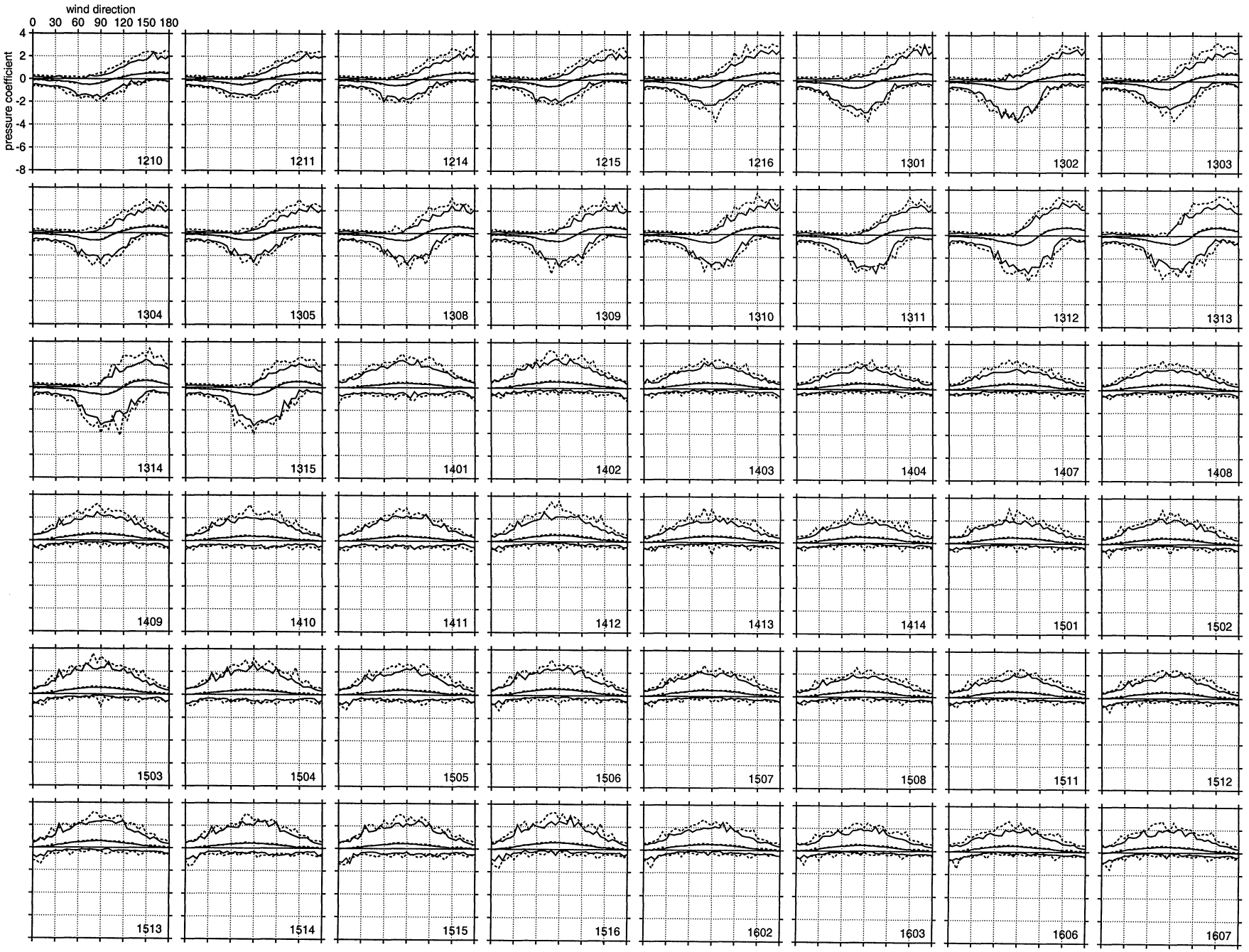
Sep. 24, 2003



——— NIST 2003 - 20ft Bld Open Country - No Parapet

------- NIST (Lin & Surry) - 20ft Building - Open Country

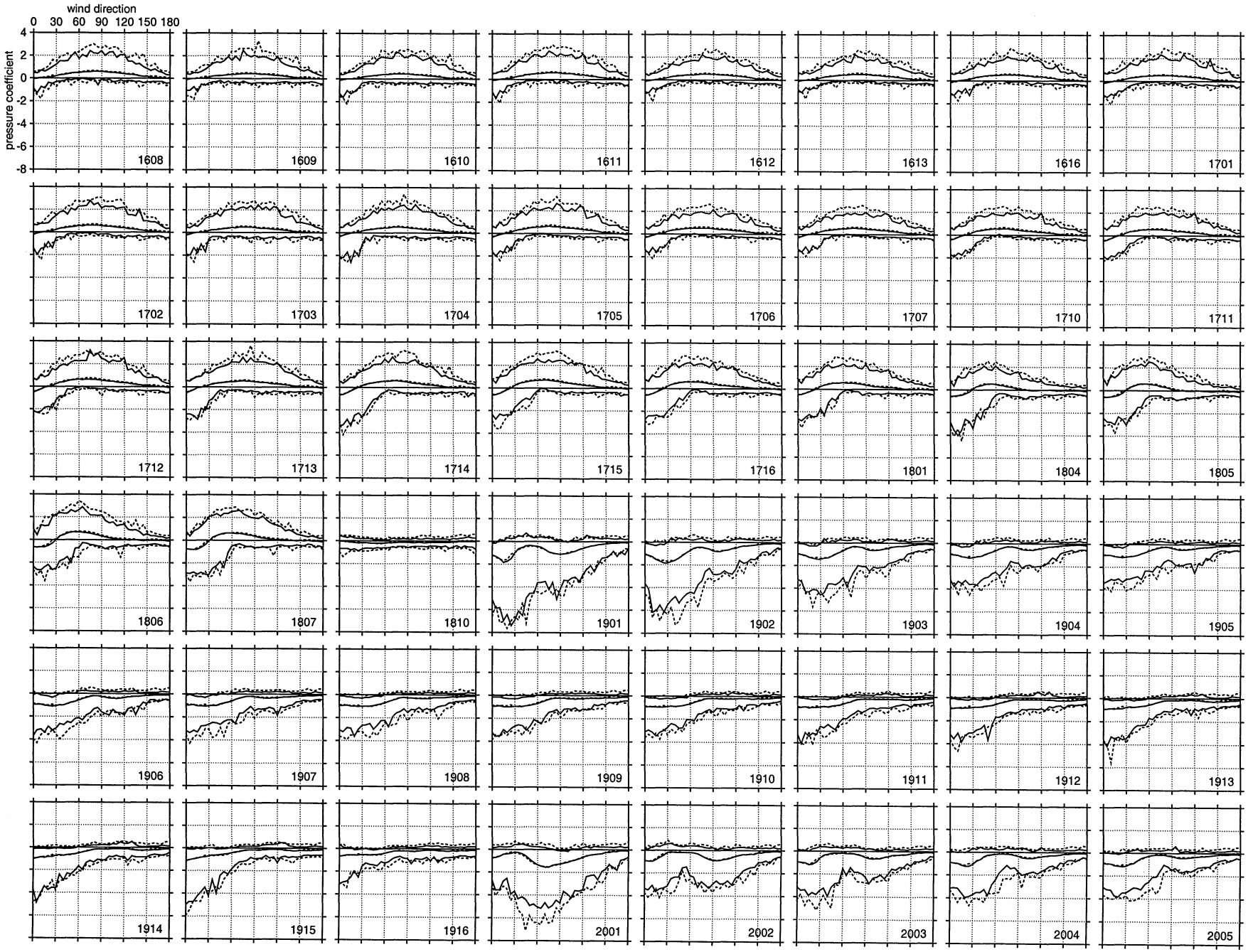
Sep. 24, 2003



NIST 2003 - 20ft Bld Open Country - No Parapet

NIST (Lin & Surry) - 20ft Building - Open Country

Sep. 24, 2003



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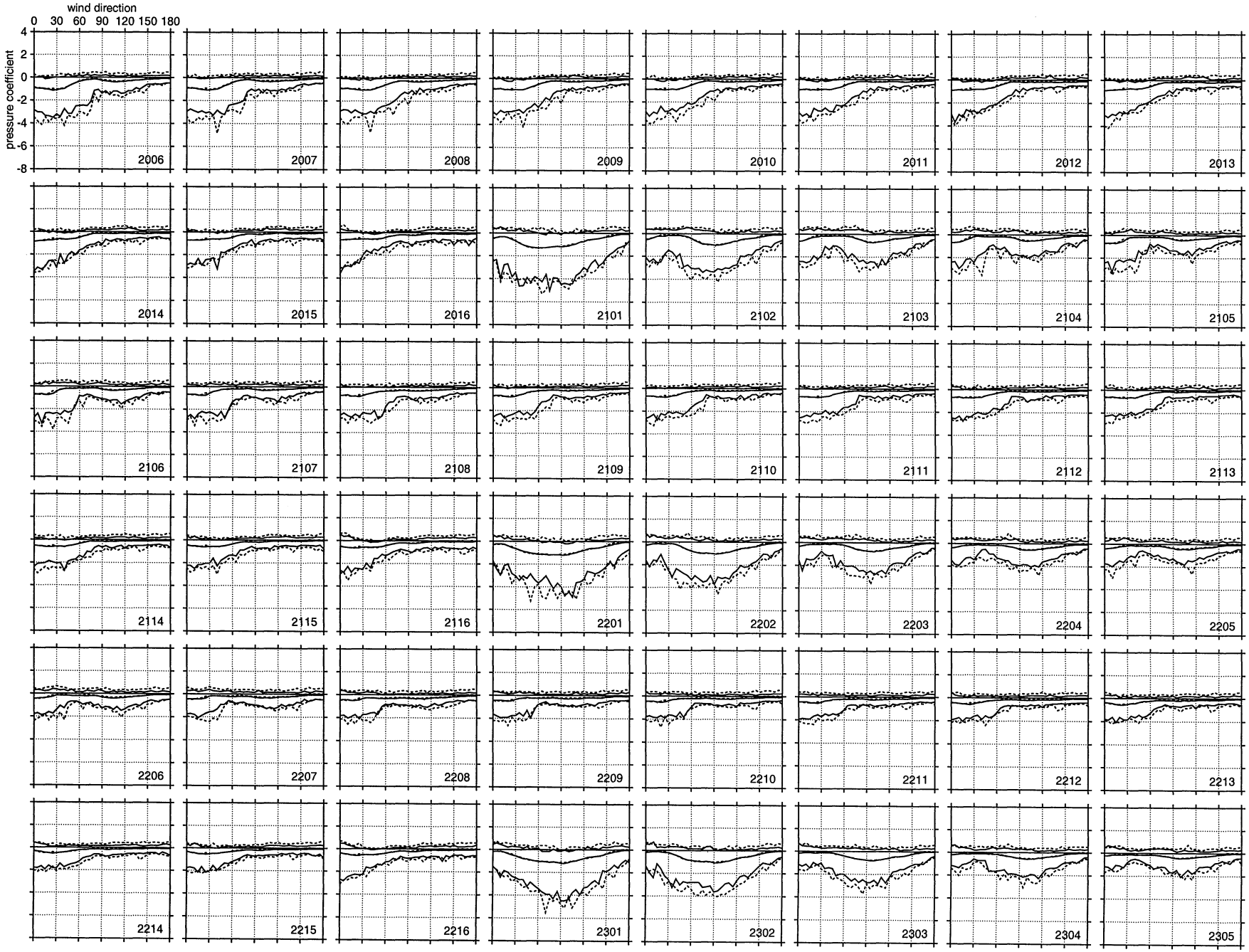
NIST (Lin & Surry) - 20ft Building - Open Country

Sep. 24, 2003



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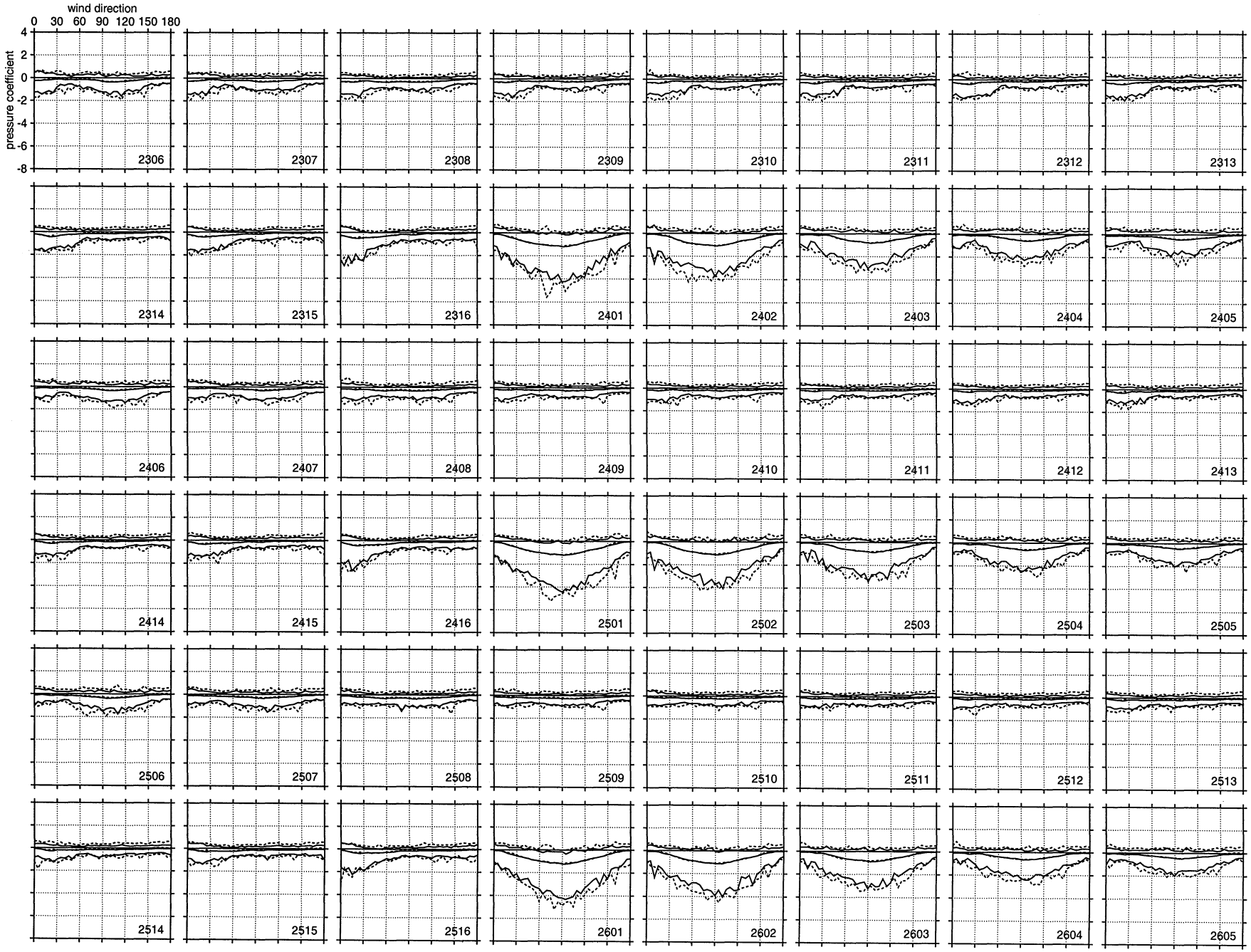
NIST (Lin & Surry) - 20ft Building - Open Country

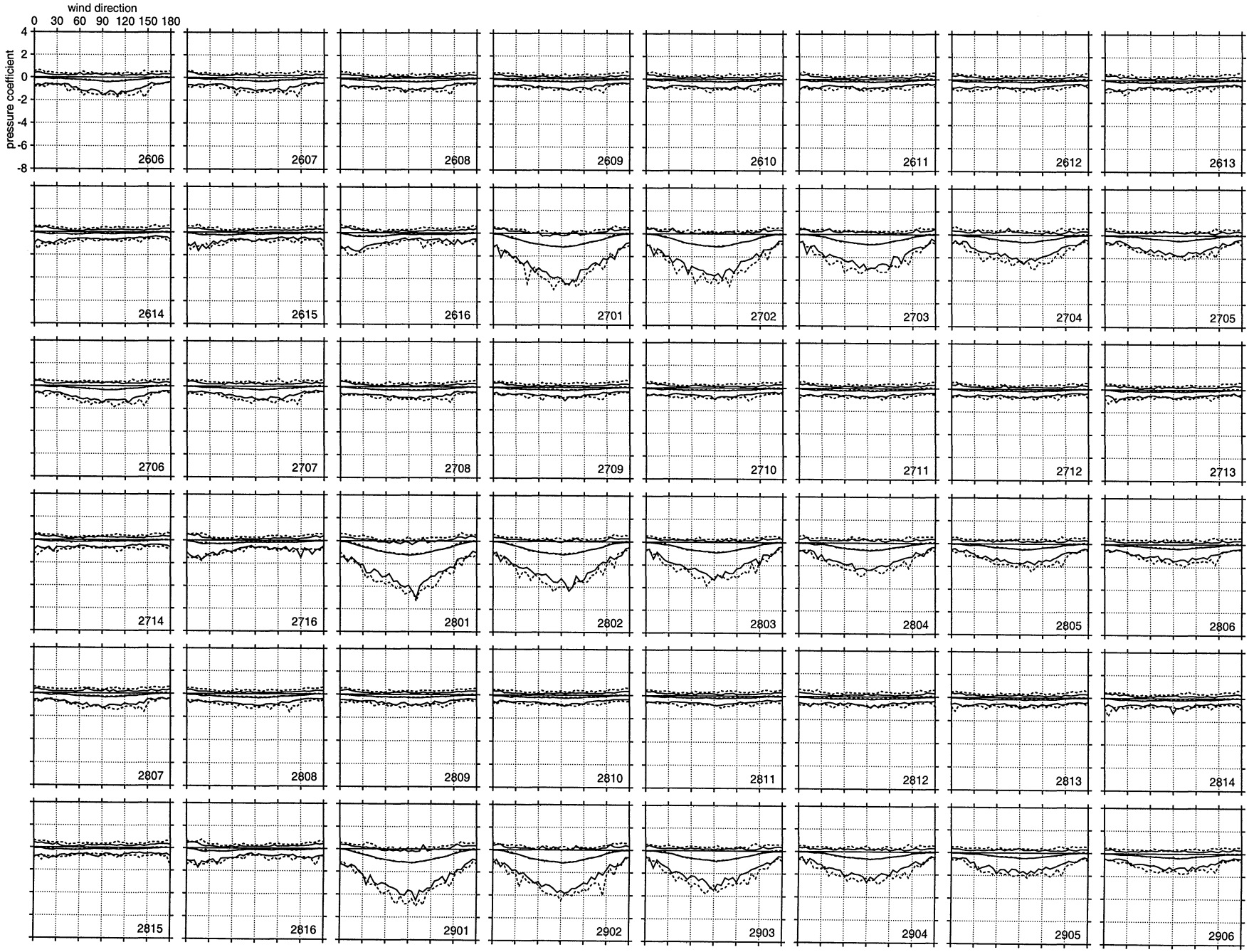
Sep. 24, 2003



NIST 2003 - 20ft Bld Open Country - No Parapet

NIST (Lin & Surry) - 20ft Building - Open Country

Sep. 24, 2003



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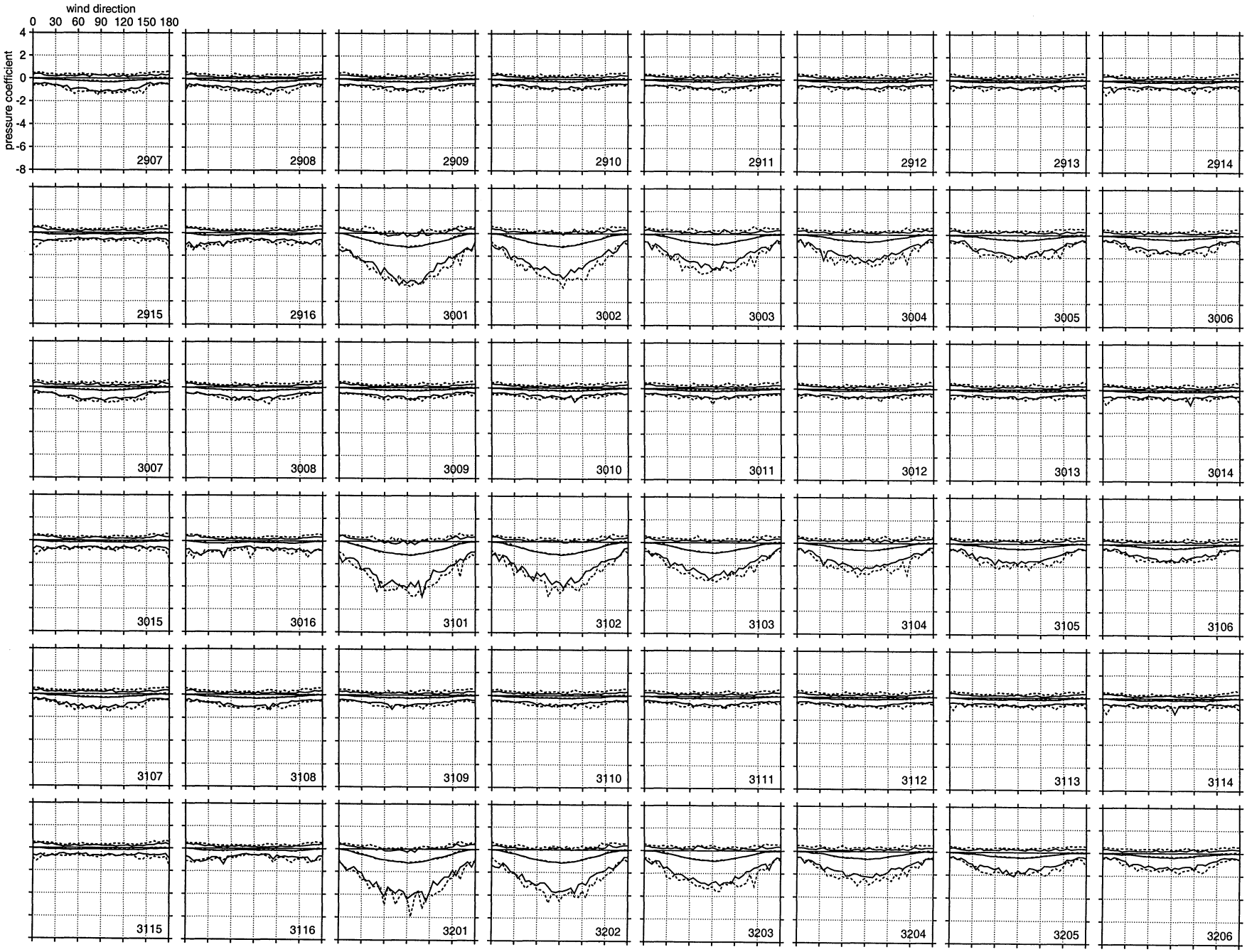
NIST (Lin & Surry) - 20ft Building - Open Country

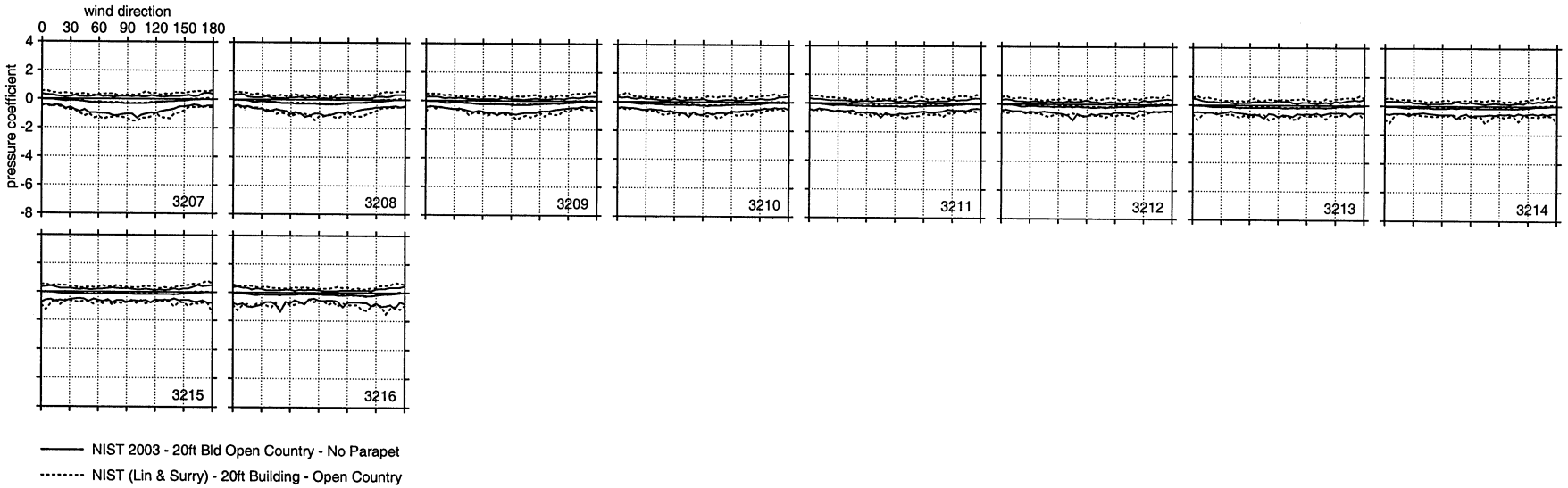
Sep. 24, 2003



NIST 2003 - 20ft Bld Open Country - No Parapet

NIST (Lin & Surry) - 20ft Building - Open Country

Sep. 24, 2003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pressure coefficient
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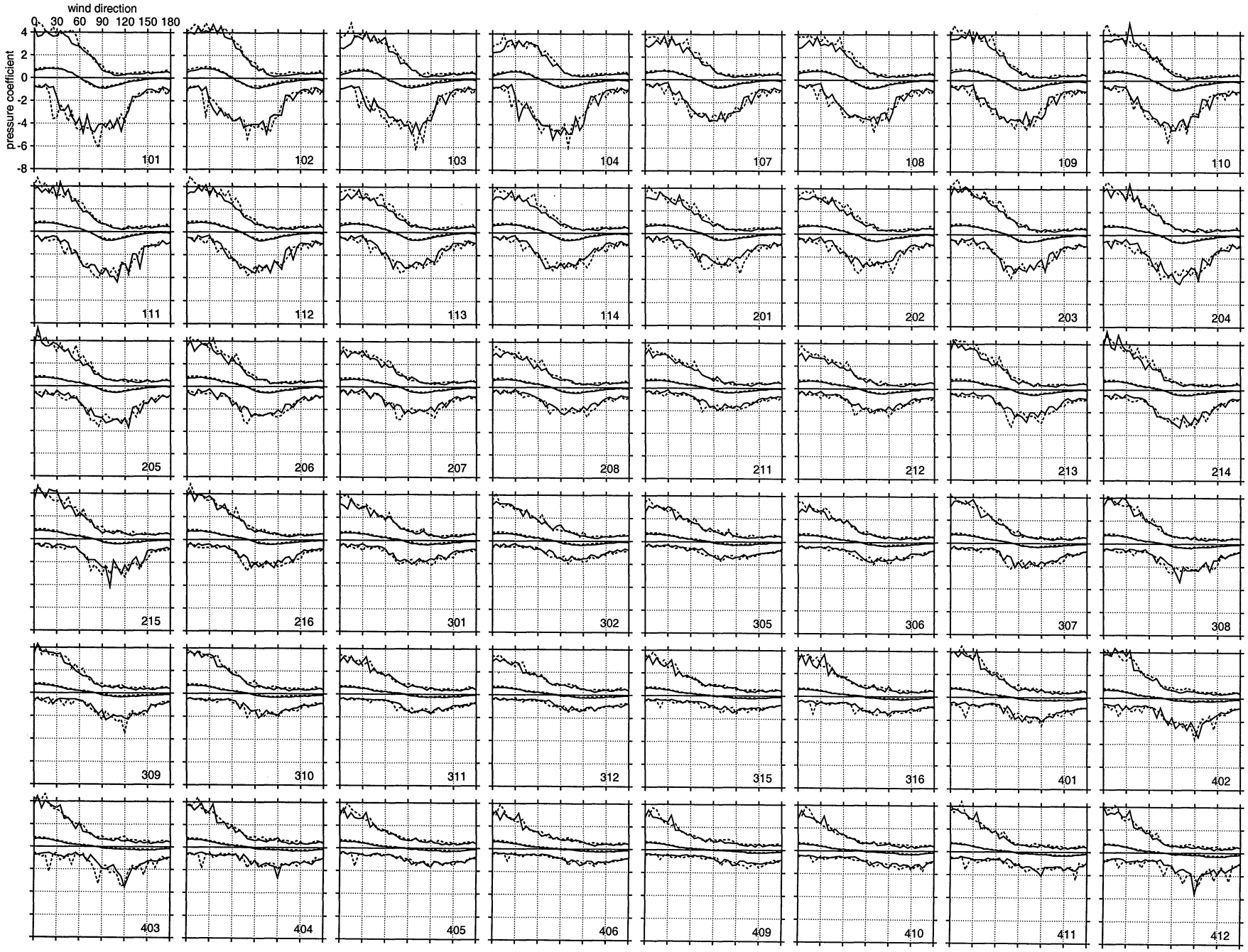
NIST 2003 - 20ft Bld Open Country - No Parapet
NIST (Lin & Surry) - 20ft Building - Open Country

Sep. 24, 2003

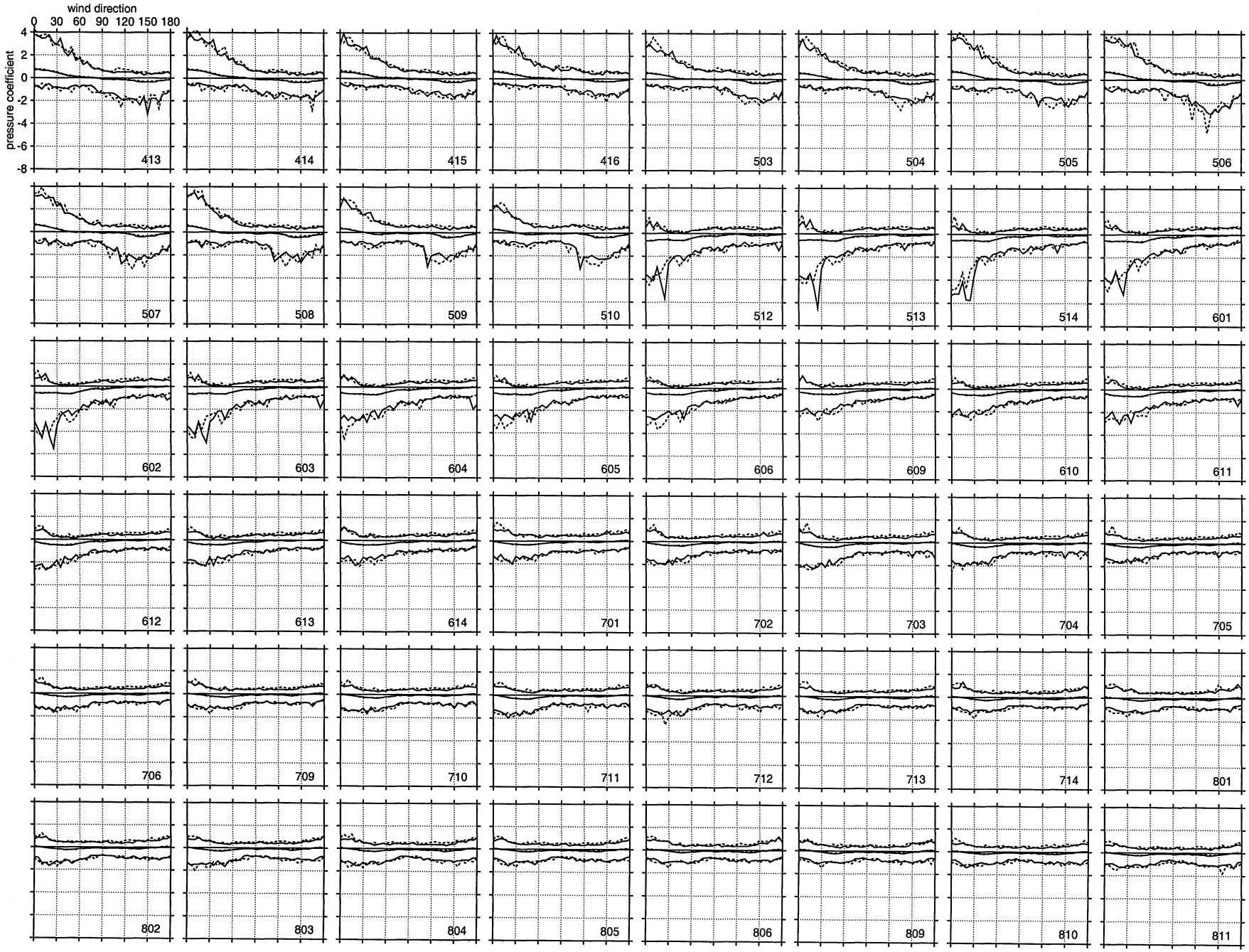
20 ft Building – Suburban Exposure



NIST 2003 - 20ft Bld Suburban - No Parapet

NIST (Lin & Surry) - 20ft Building - Suburban

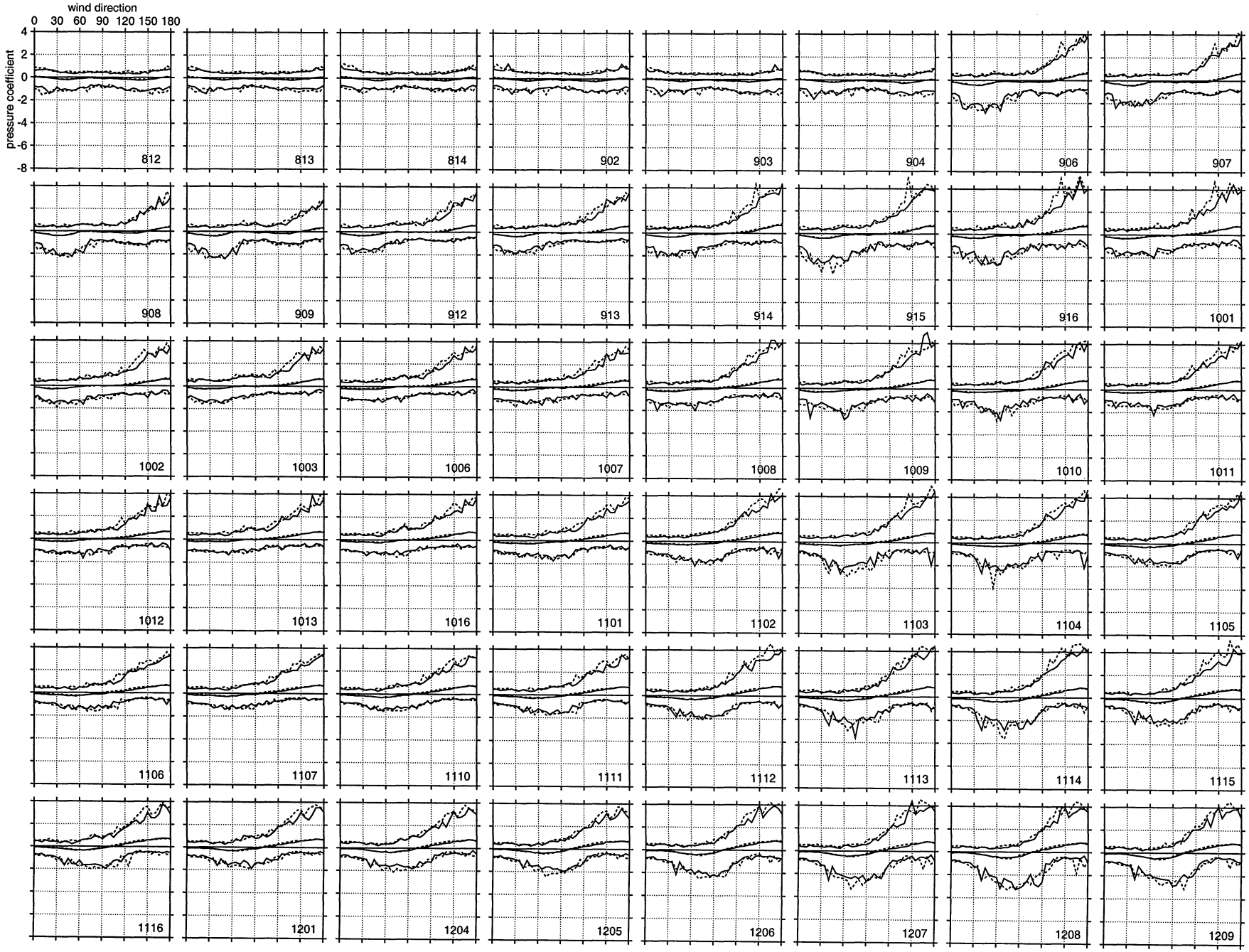
Sep. 24, 2003



NIST 2003 - 20ft Bld Suburban - No Parapet

NIST (Lin & Surry) - 20ft Building - Suburban

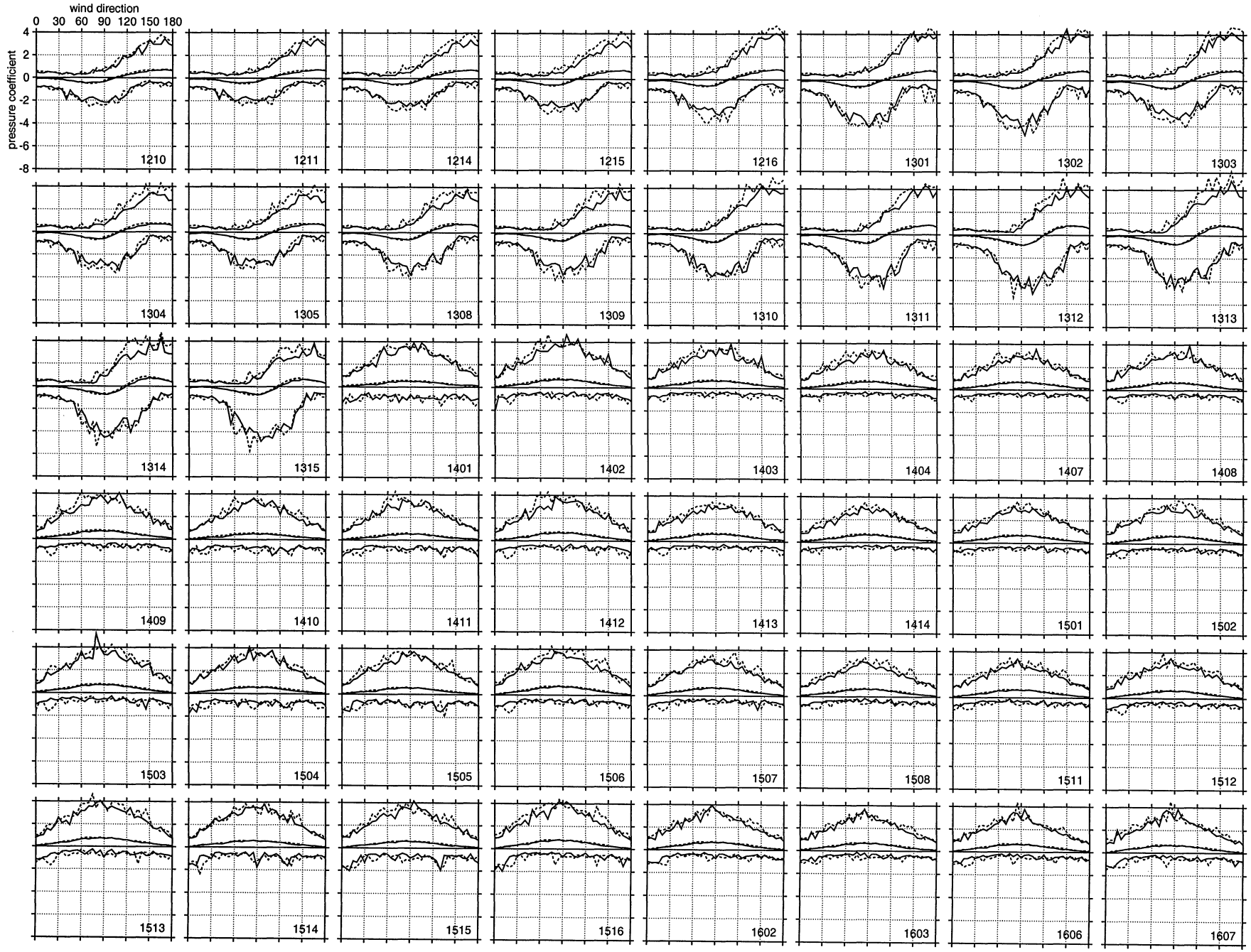
Sep. 24, 2003



——— NIST 2003 - 20ft Bld Suburban - No Parapet

-------- NIST (Lin & Surry) - 20ft Building - Suburban

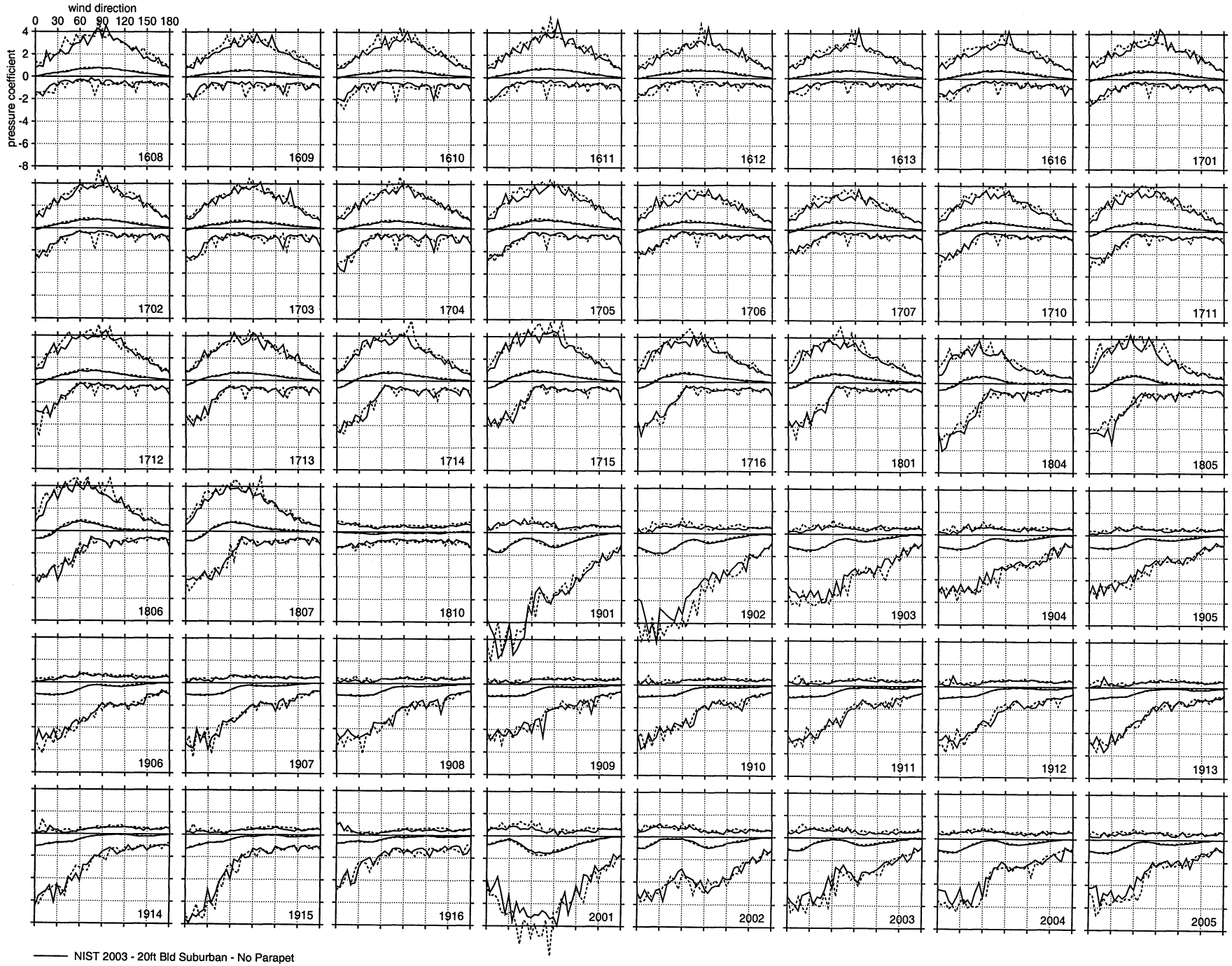
Sep. 24, 2003



NIST 2003 - 20ft Bld Suburban - No Parapet

NIST (Lin & Surry) - 20ft Building - Suburban

Sep. 24, 2003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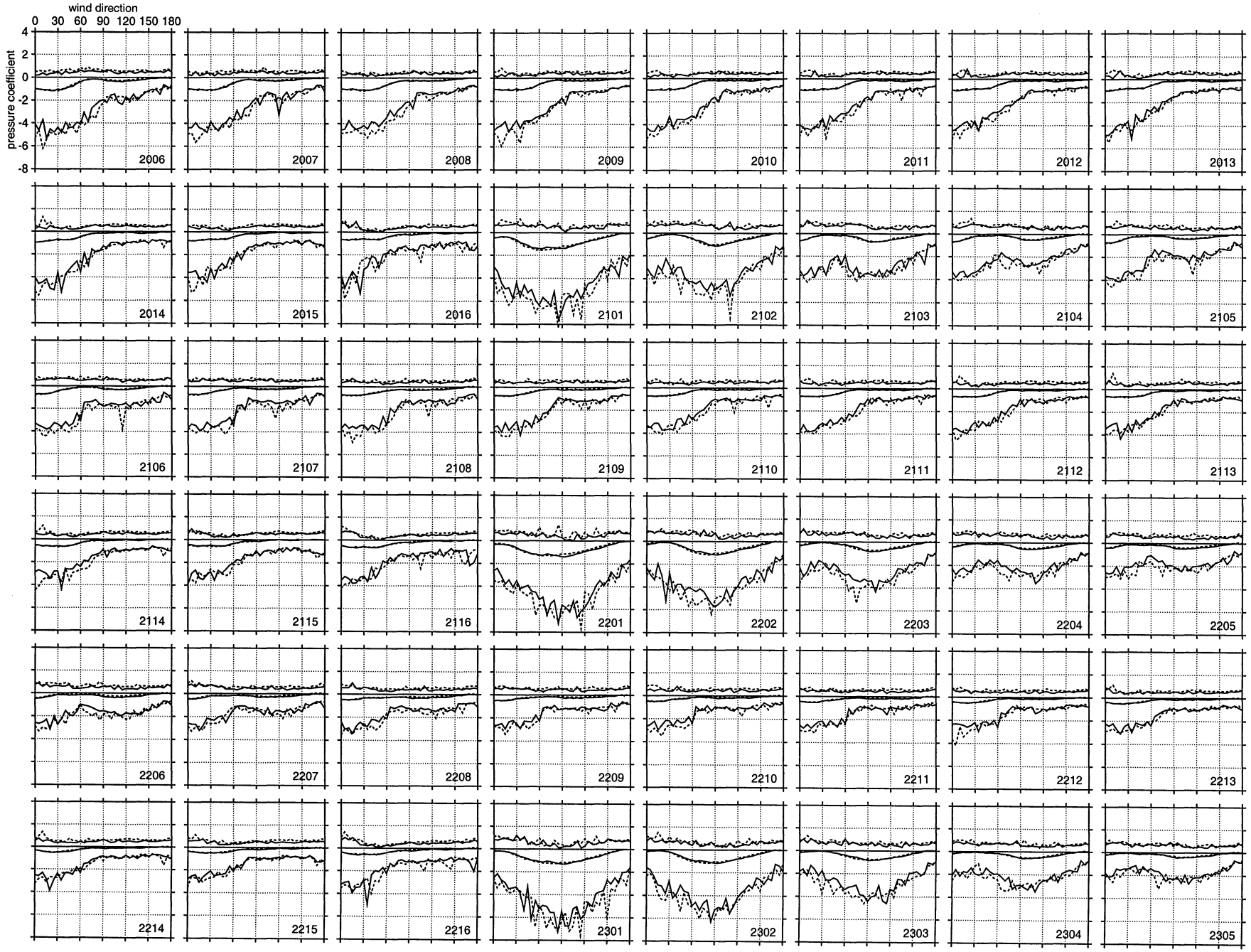
NIST 2003 - 20ft Bld Suburban - No Parapet
NIST (Lin & Surry) - 20ft Building - Suburban

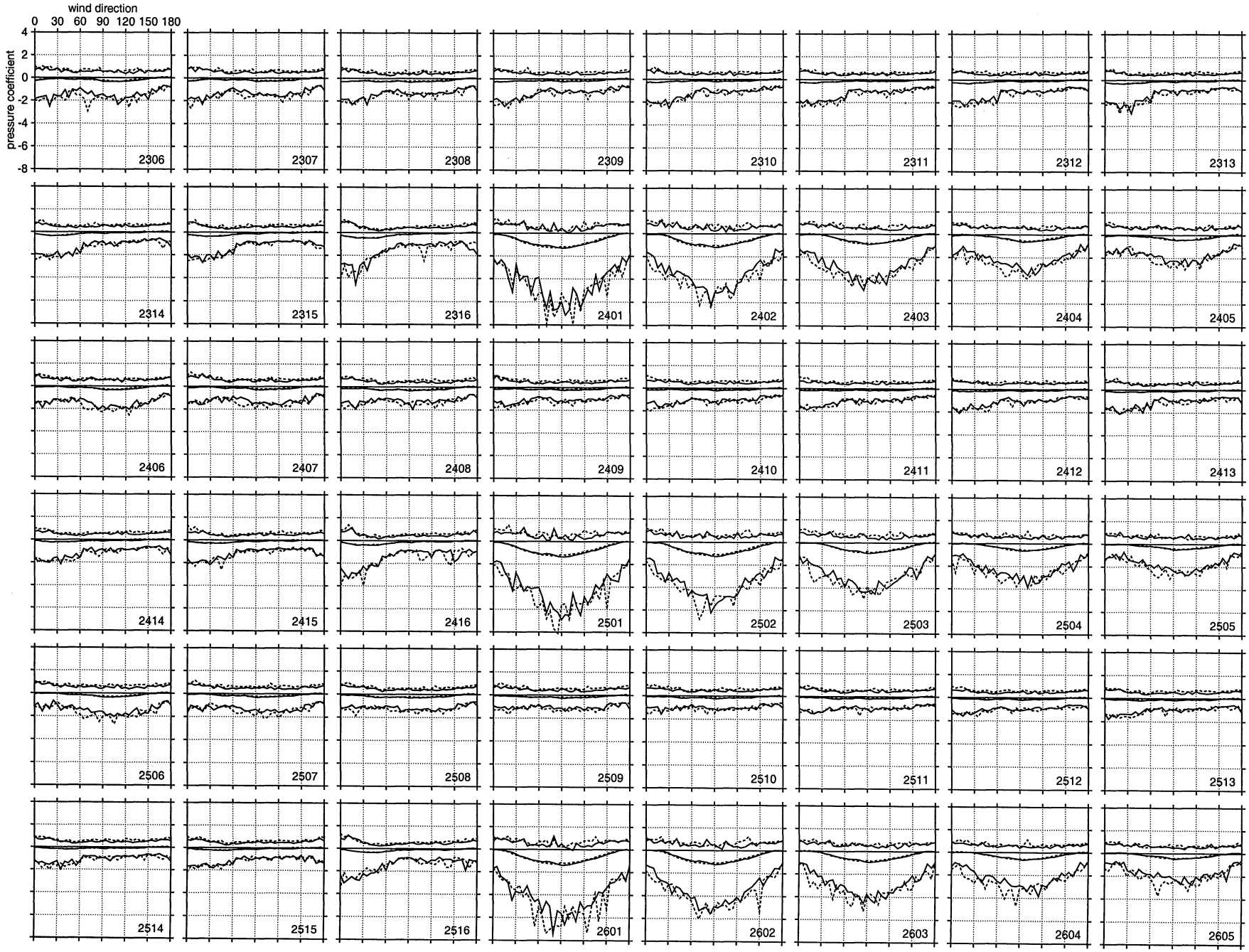
Sep. 24, 2003



NIST 2003 - 20ft Bld Suburban - No Parapet

NIST (Lin & Surry) - 20ft Building - Suburban

Sep. 24, 2003



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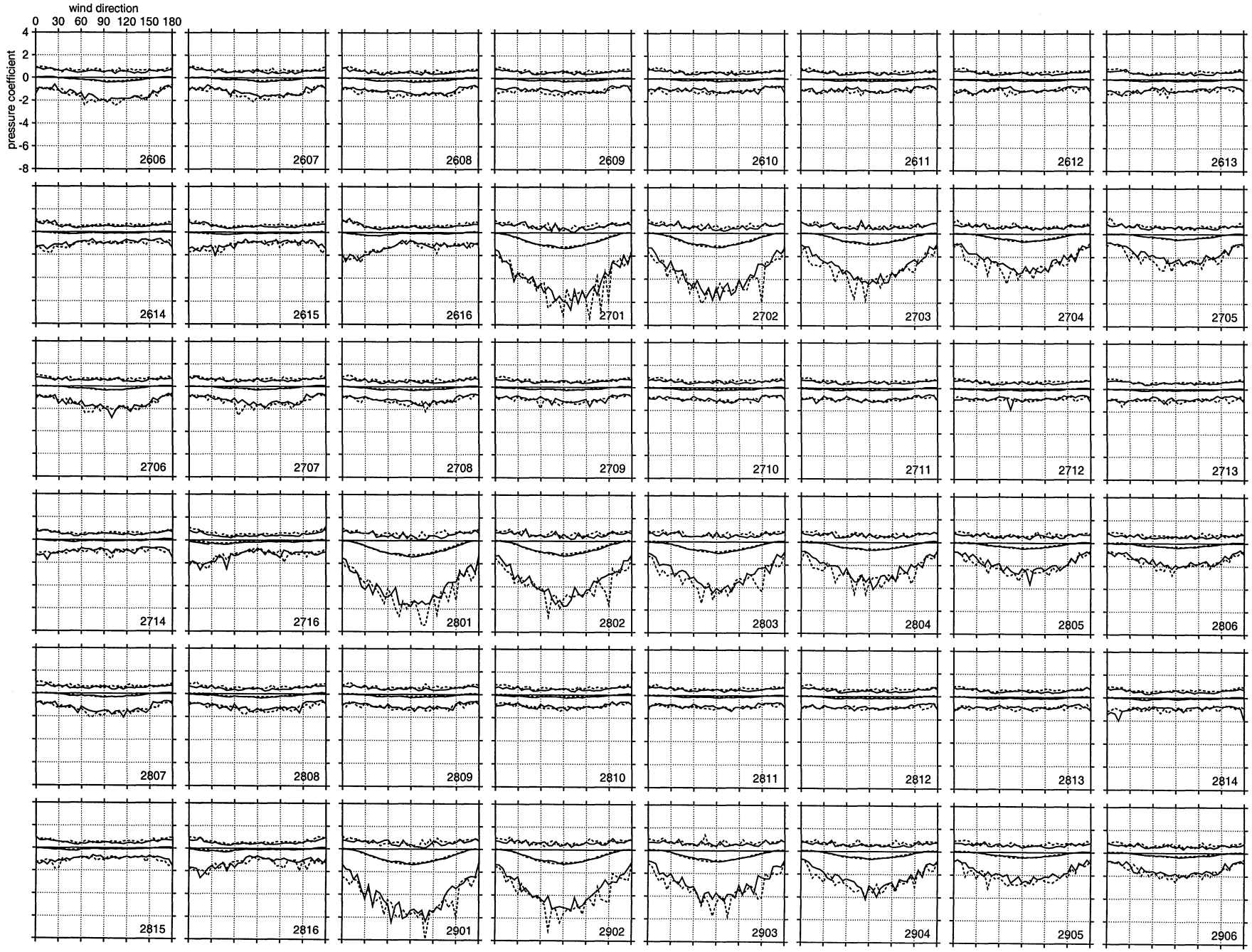
NIST (Lin & Surry) - 20ft Building - Suburban

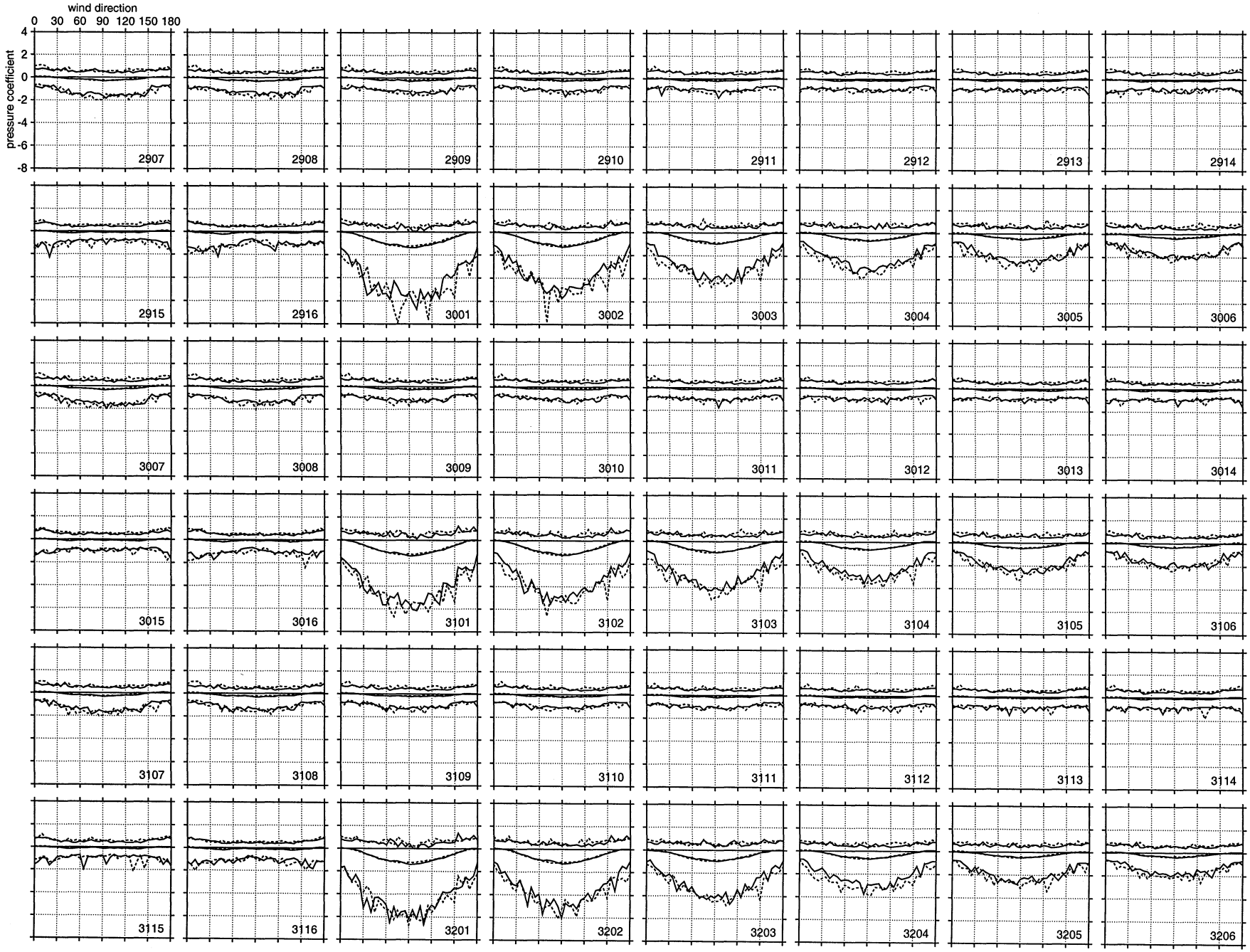
Sep. 24, 2003



NIST 2003 - 20ft Bld Suburban - No Parapet

NIST (Lin & Surry) - 20ft Building - Suburban

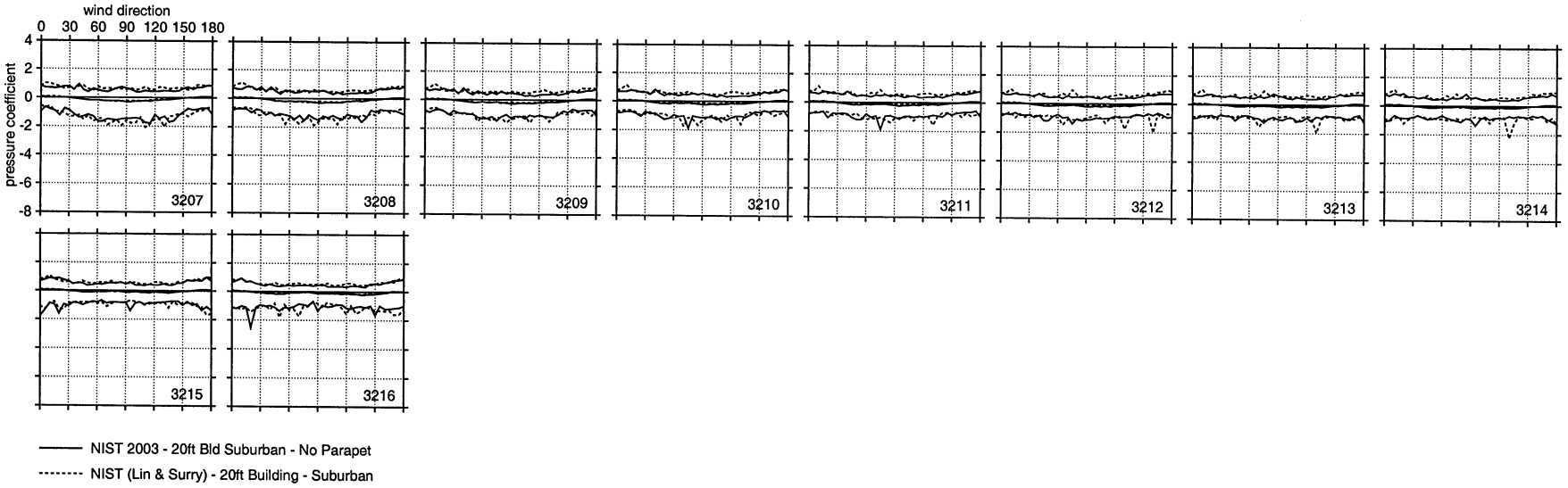
Sep. 24, 2003



NIST 2003 - 20ft Bld Suburban - No Parapet

NIST (Lin & Surry) - 20ft Building - Suburban

Sep. 24, 2003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NIST 2003 - 20ft Bld Suburban - No Parapet
NIST (Lin & Surry) - 20ft Building - Suburban

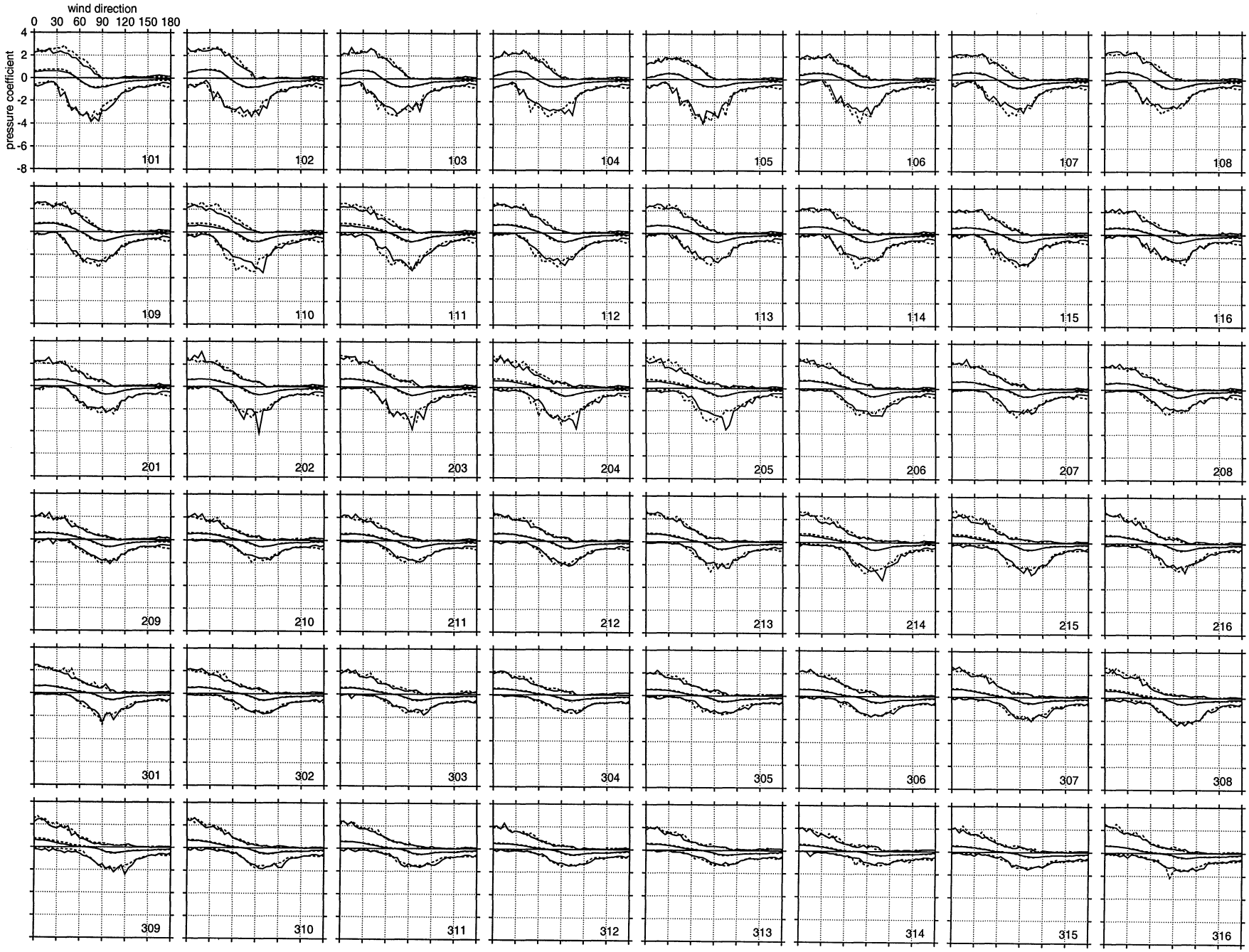
Sep. 24, 2003

APPENDIX E

COMPARISON OF PRESSURE COEFFICIENTS BETWEEN TEST 1 (WITHOUT PARAPET) AND TEST 2 (WITH 3' PARAPETS)

- Length scale: 1:200
- Model dimensions: 200'x100'
- Roof slope: 1:24
- Building heights: 20', 32'
- Test 1: without parapets; Test 2: with parapets

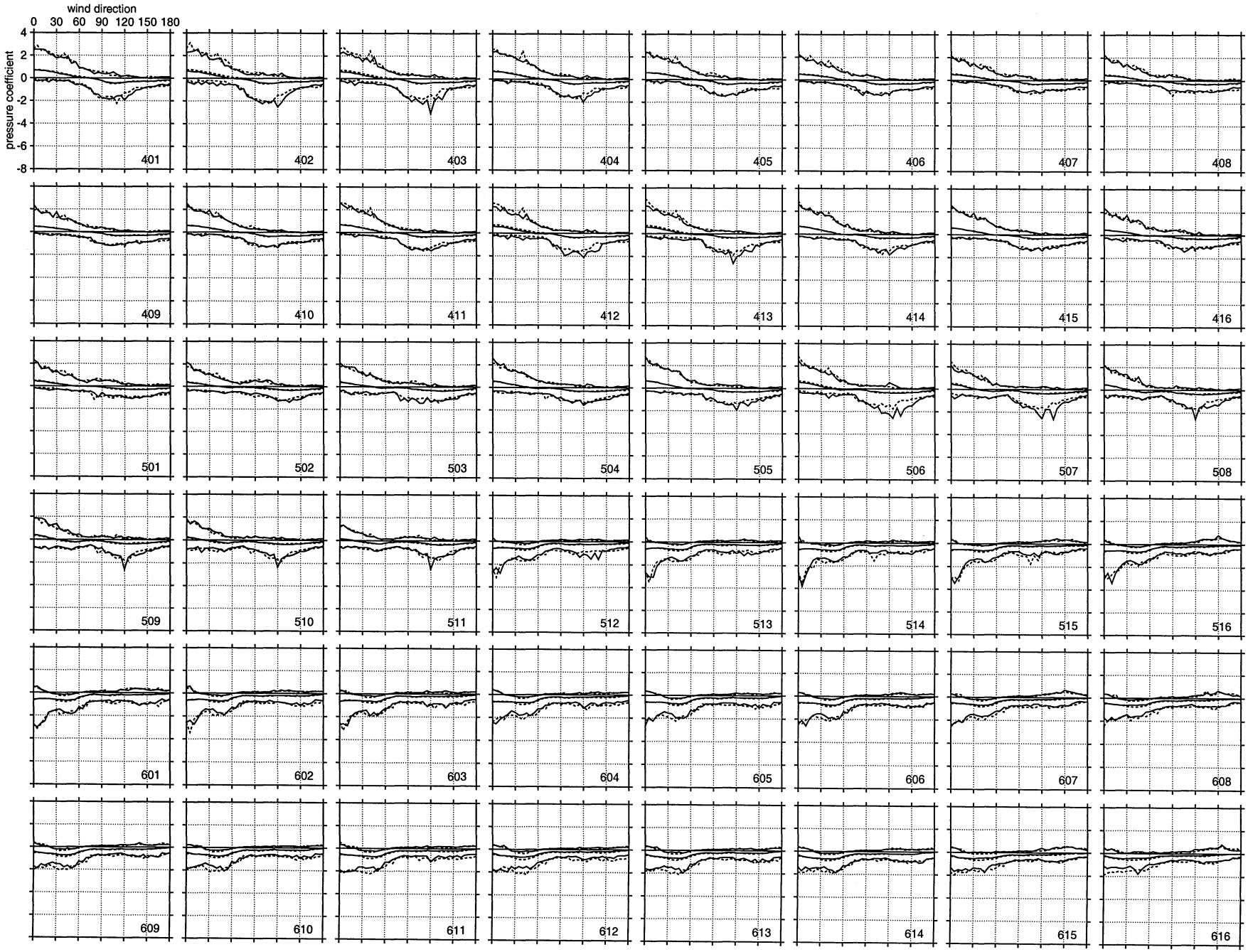
32 ft Building – Open Exposure



NIST 2003 - 32ft Bld Open Country - No Parapet

NIST 2003 - 32ft Bld Open Country - Parapet

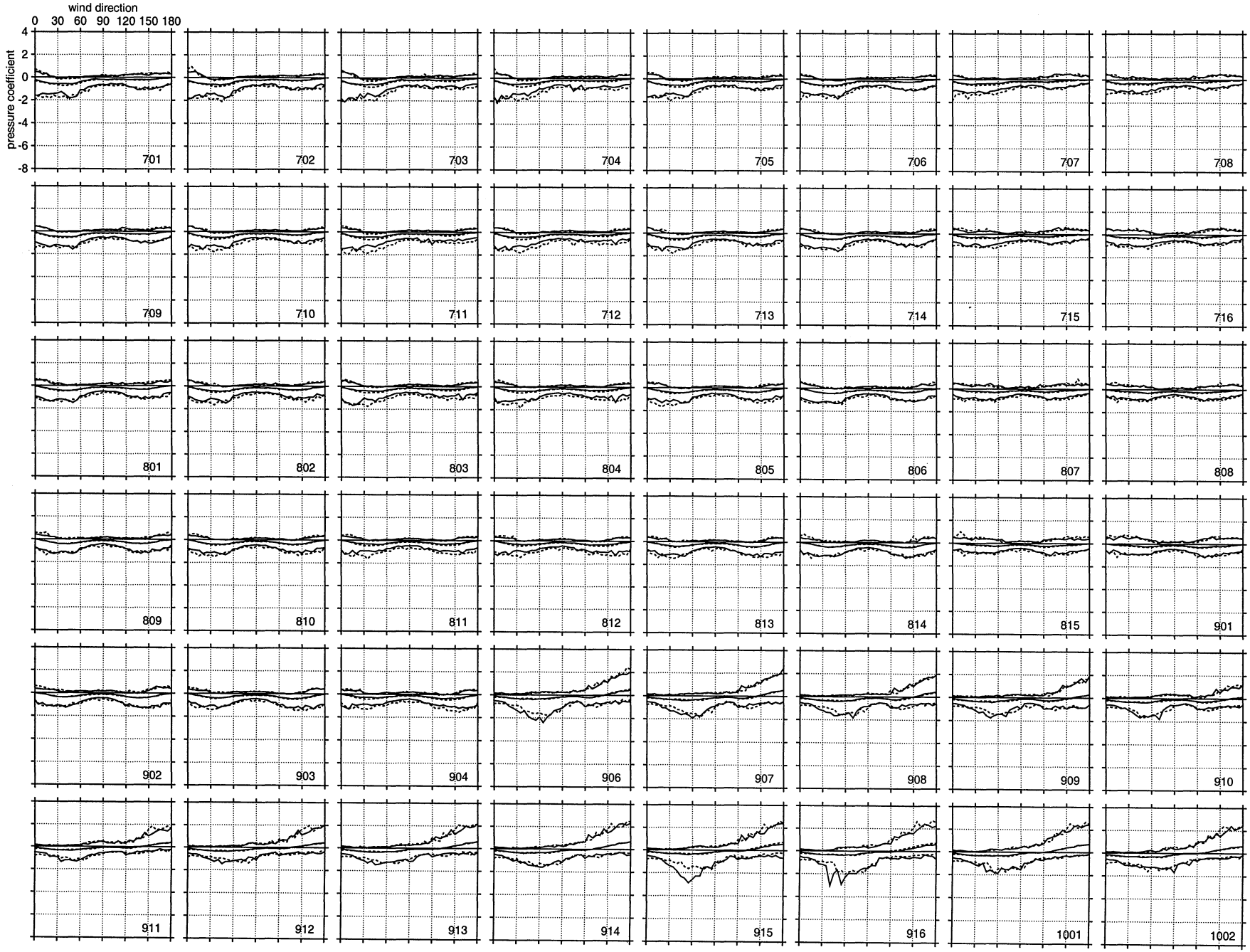
Sep. 24, 2003



NIST 2003 - 32ft Bld Open Country - No Parapet

NIST 2003 - 32ft Bld Open Country - Parapet

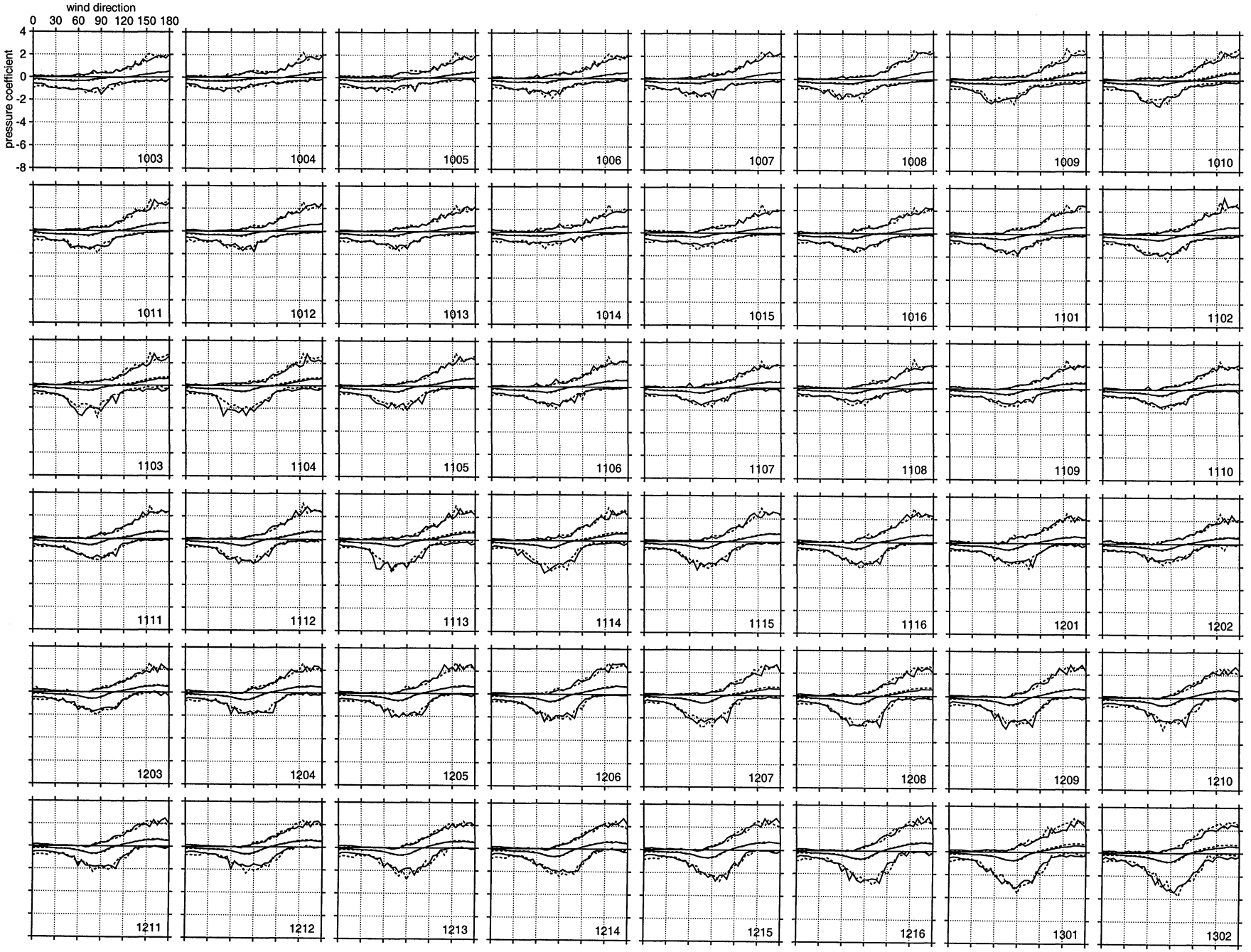
Sep. 24, 2003



NIST 2003 - 32ft Bld Open Country - No Parapet

NIST 2003 - 32ft Bld Open Country - Parapet

Sep. 24, 2003



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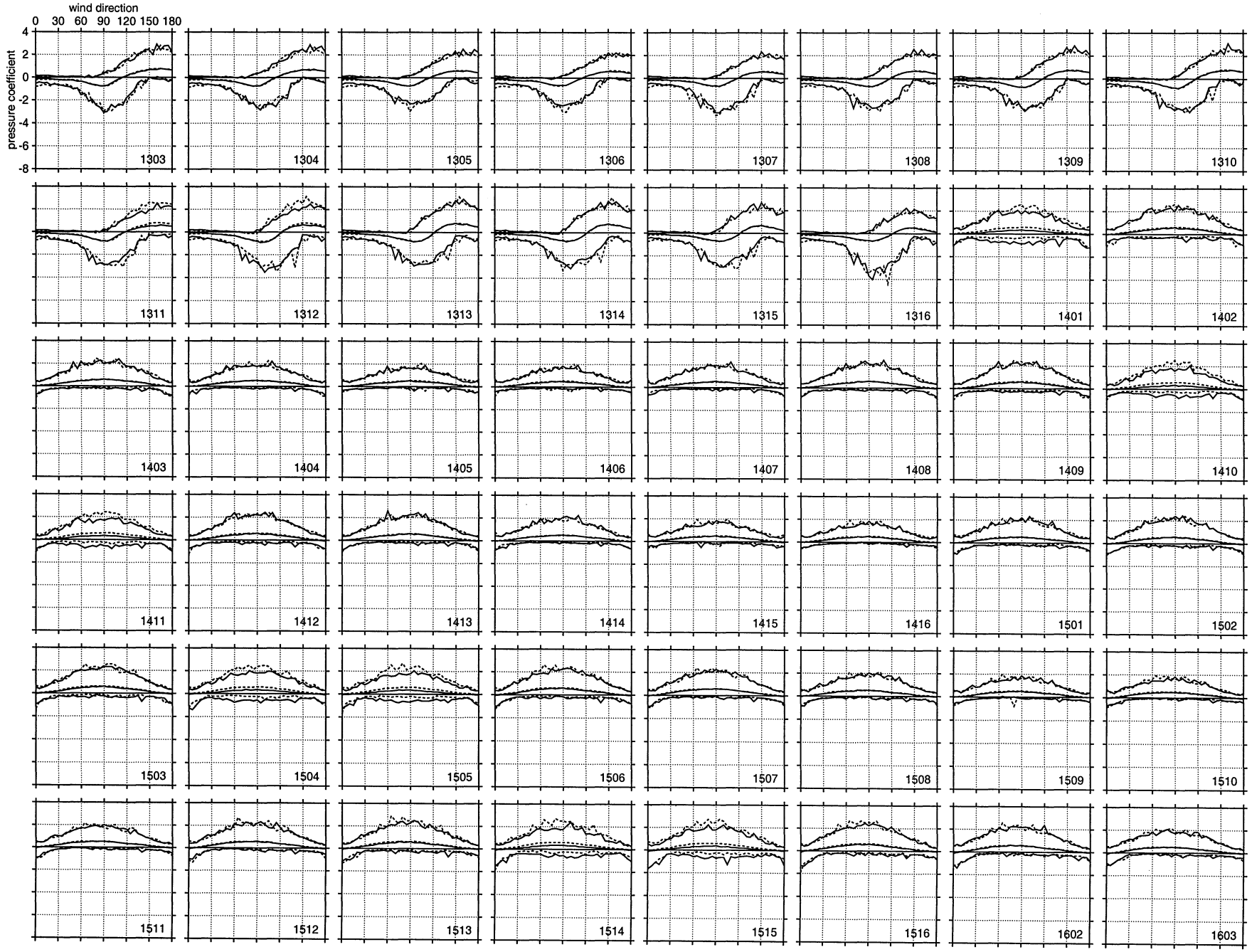
NIST 2003 - 32ft Bld Open Country - Parapet

Sep. 24, 2003



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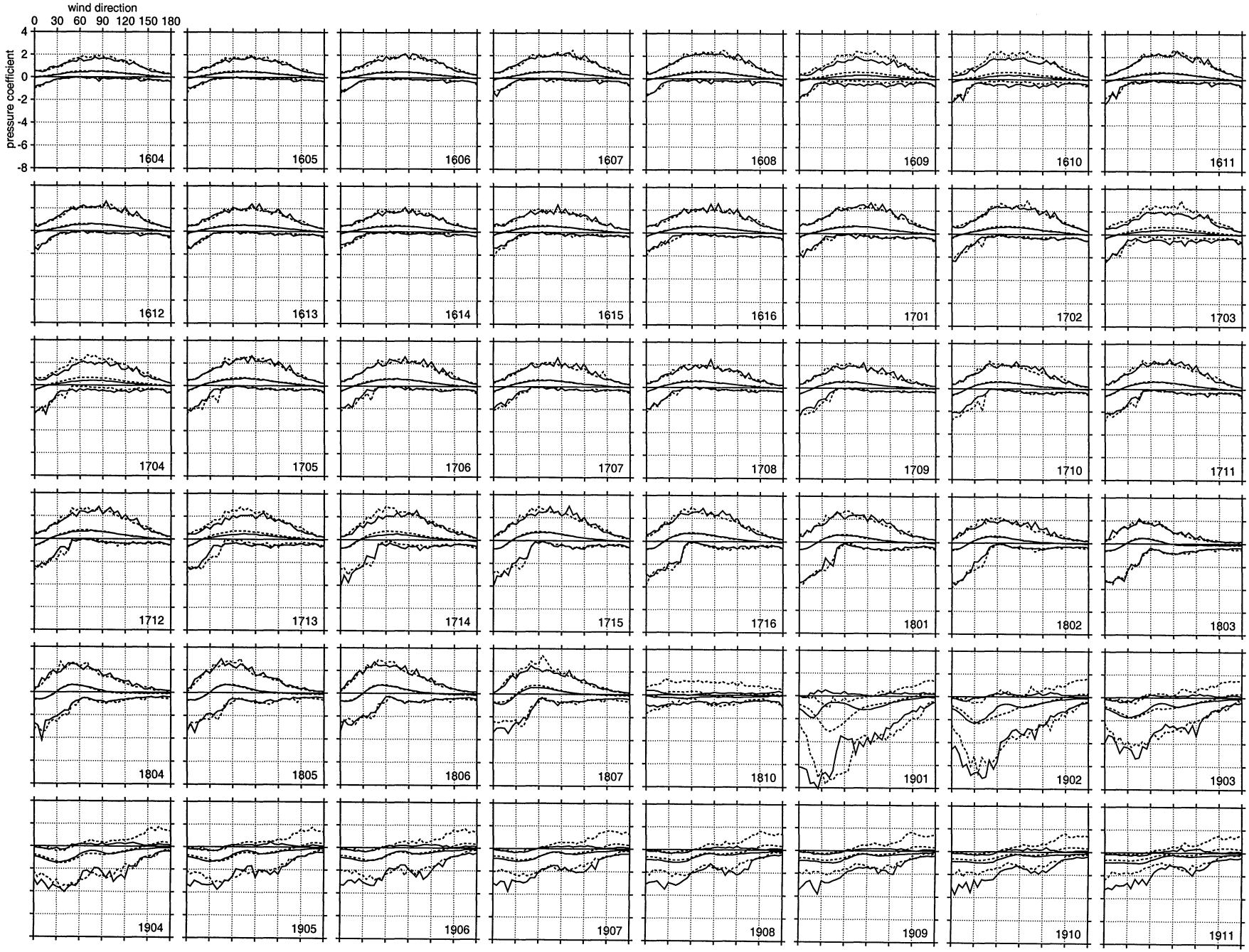
Sep. 24, 2003



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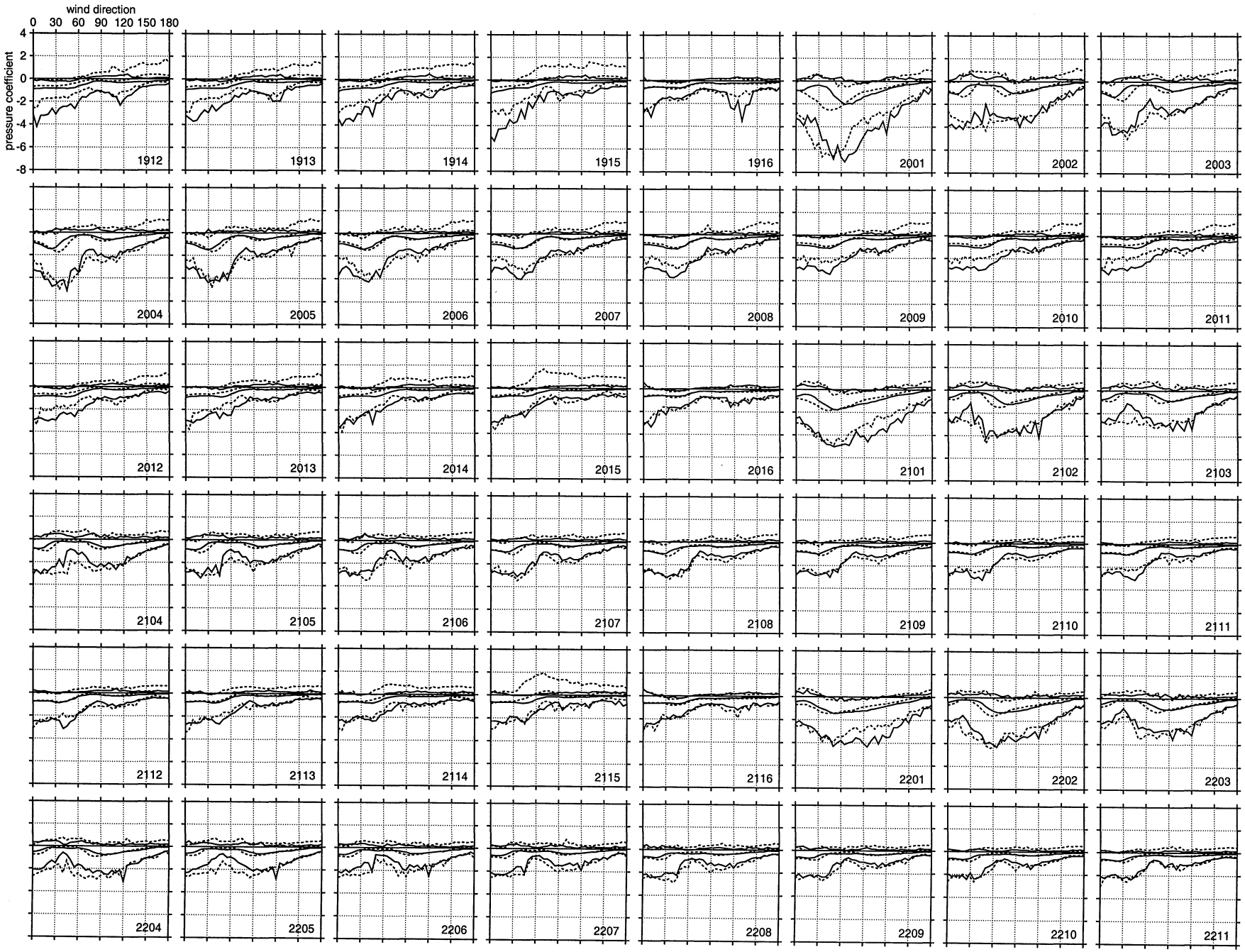
NIST 2003 - 32ft Bld Open Country - Parapet

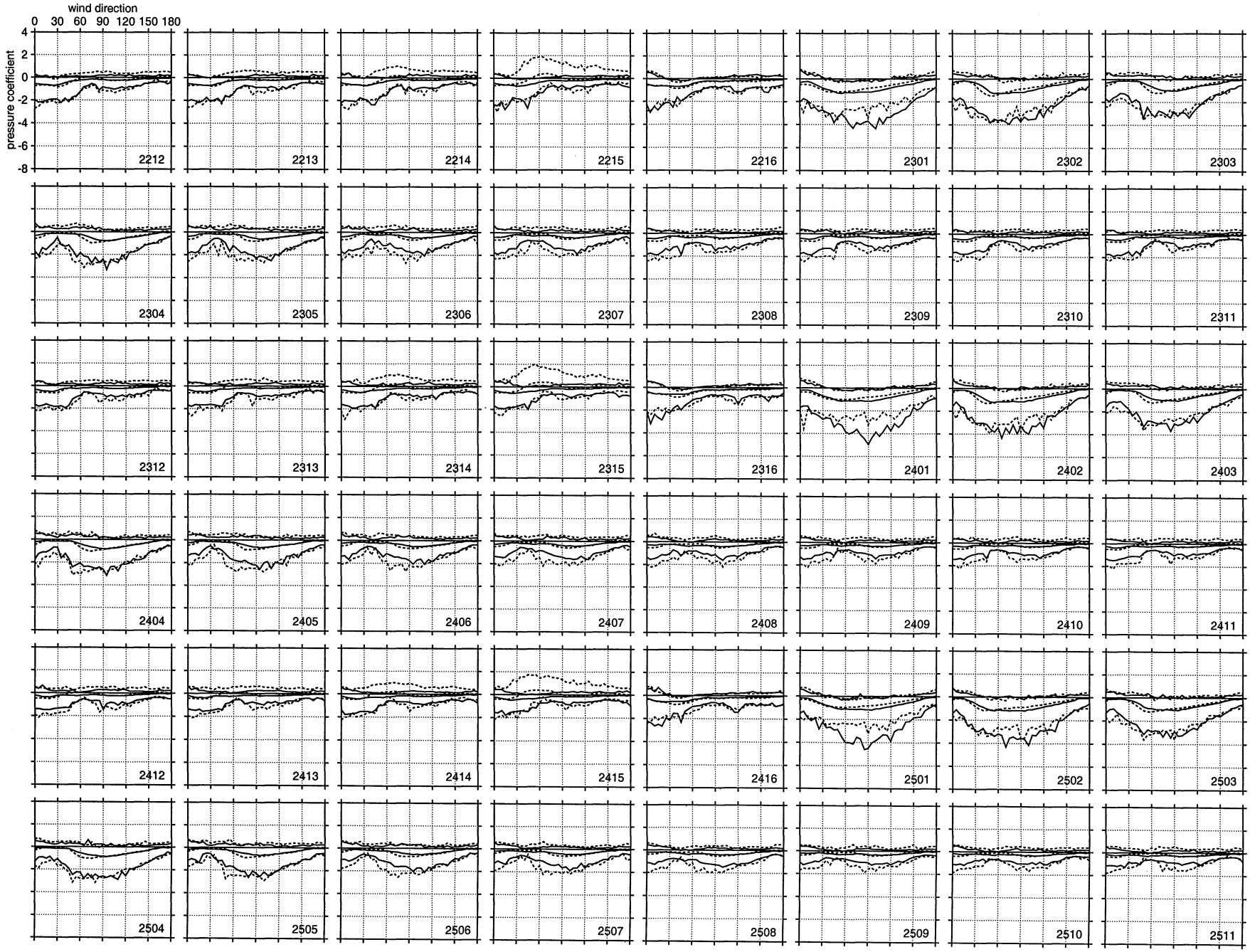
Sep. 24, 2003



NIST 2003 - 32ft Bld Open Country - No Parapet

NIST 2003 - 32ft Bld Open Country - Parapet

Sep. 24, 2003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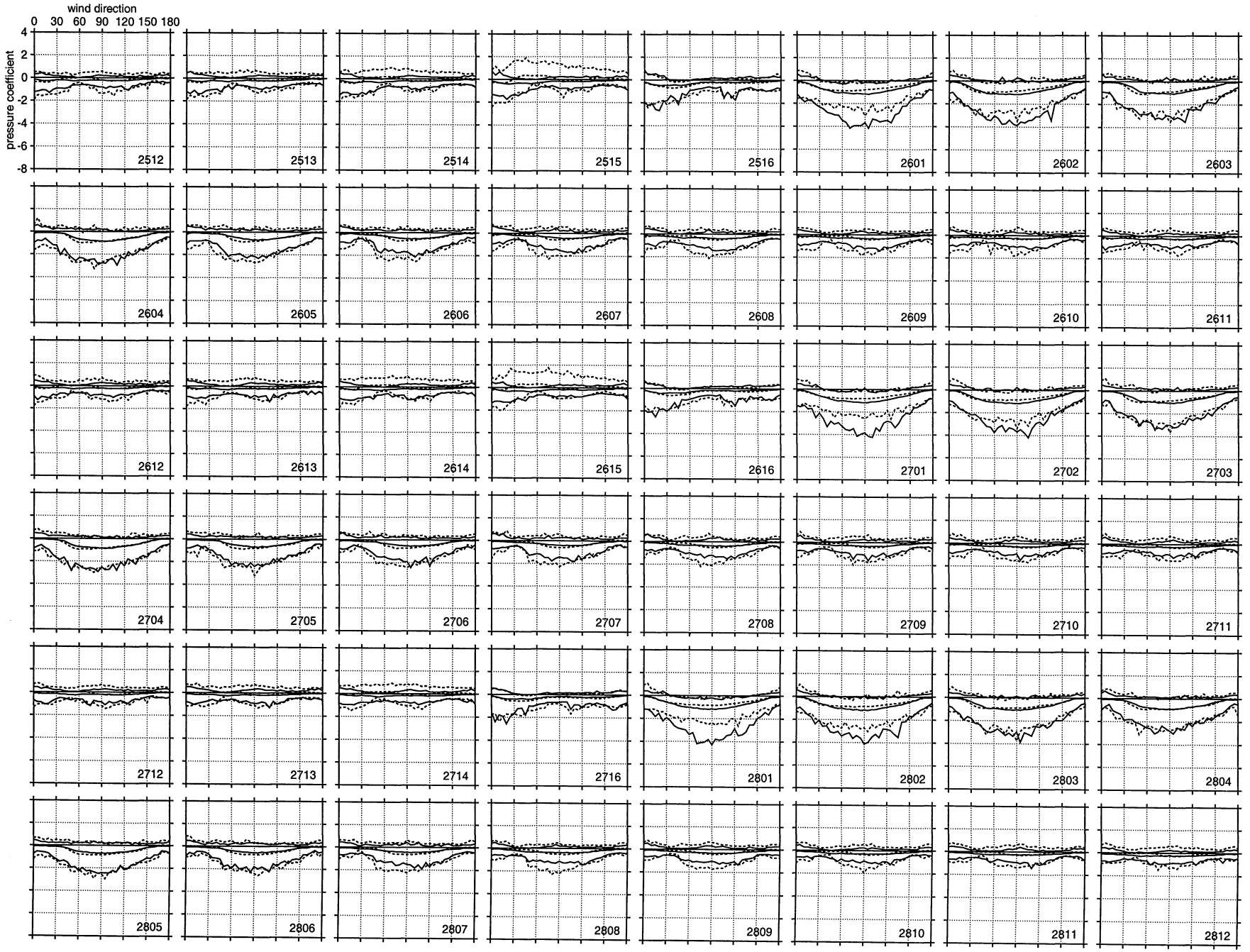
NIST 2003 - 32ft Bld Open Country - No Parapet
NIST 2003 - 32ft Bld Open Country - Parapet

Sep. 24, 2003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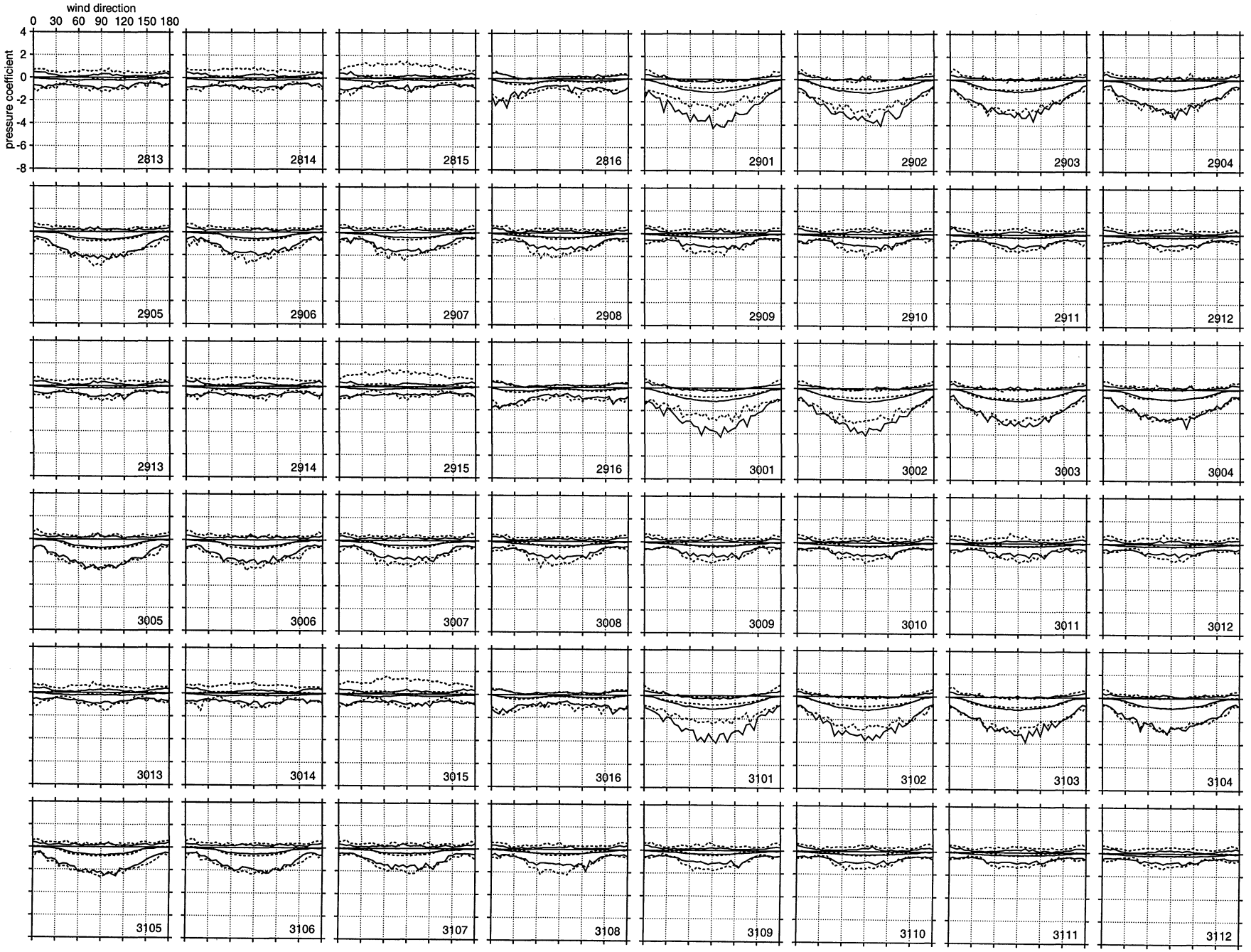
NIST 2003 - 32ft Bld Open Country - Parapet

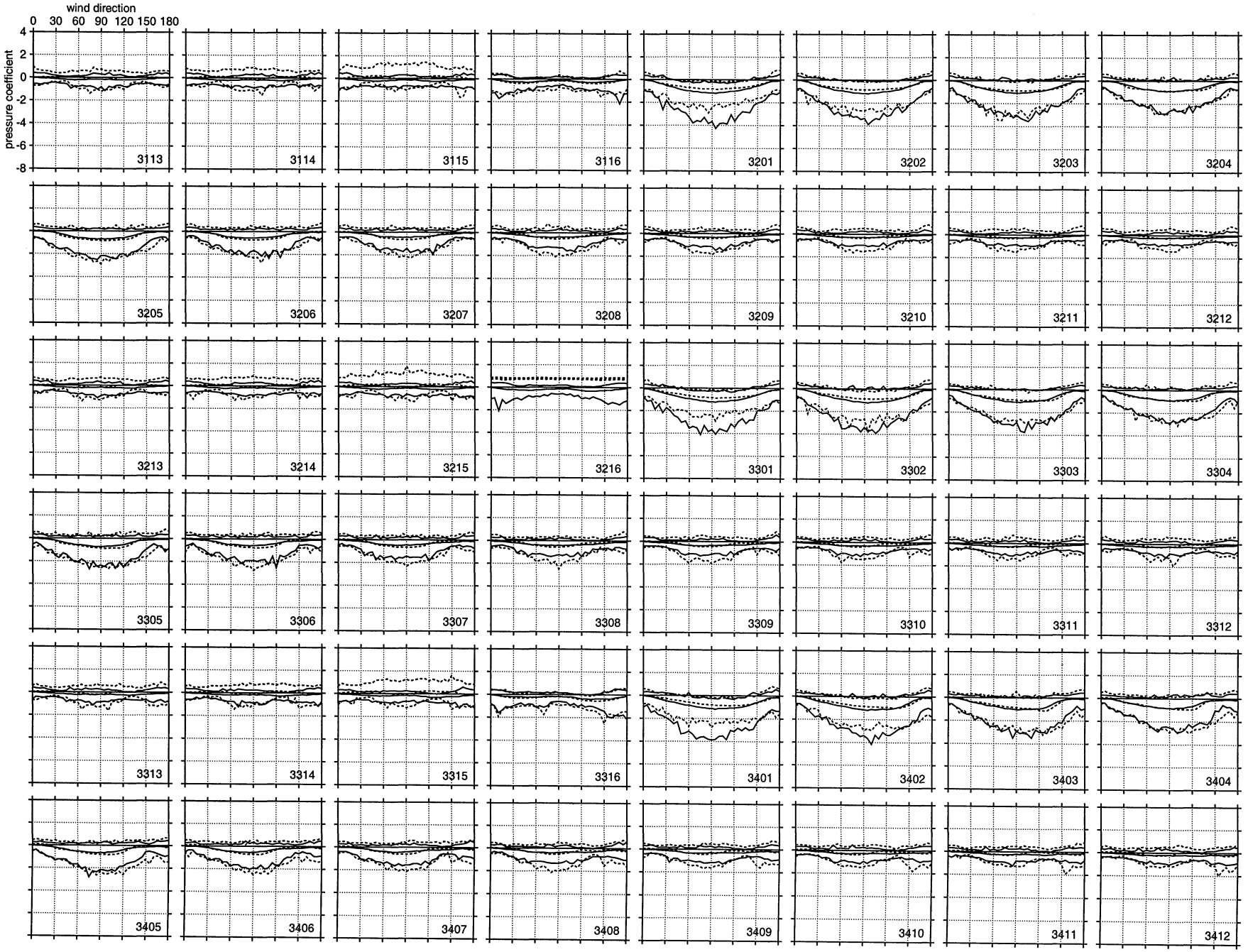
Sep. 24, 2003



NIST 2003 - 32ft Bld Open Country - No Parapet

NIST 2003 - 32ft Bld Open Country - Parapet

Sep. 24, 2003



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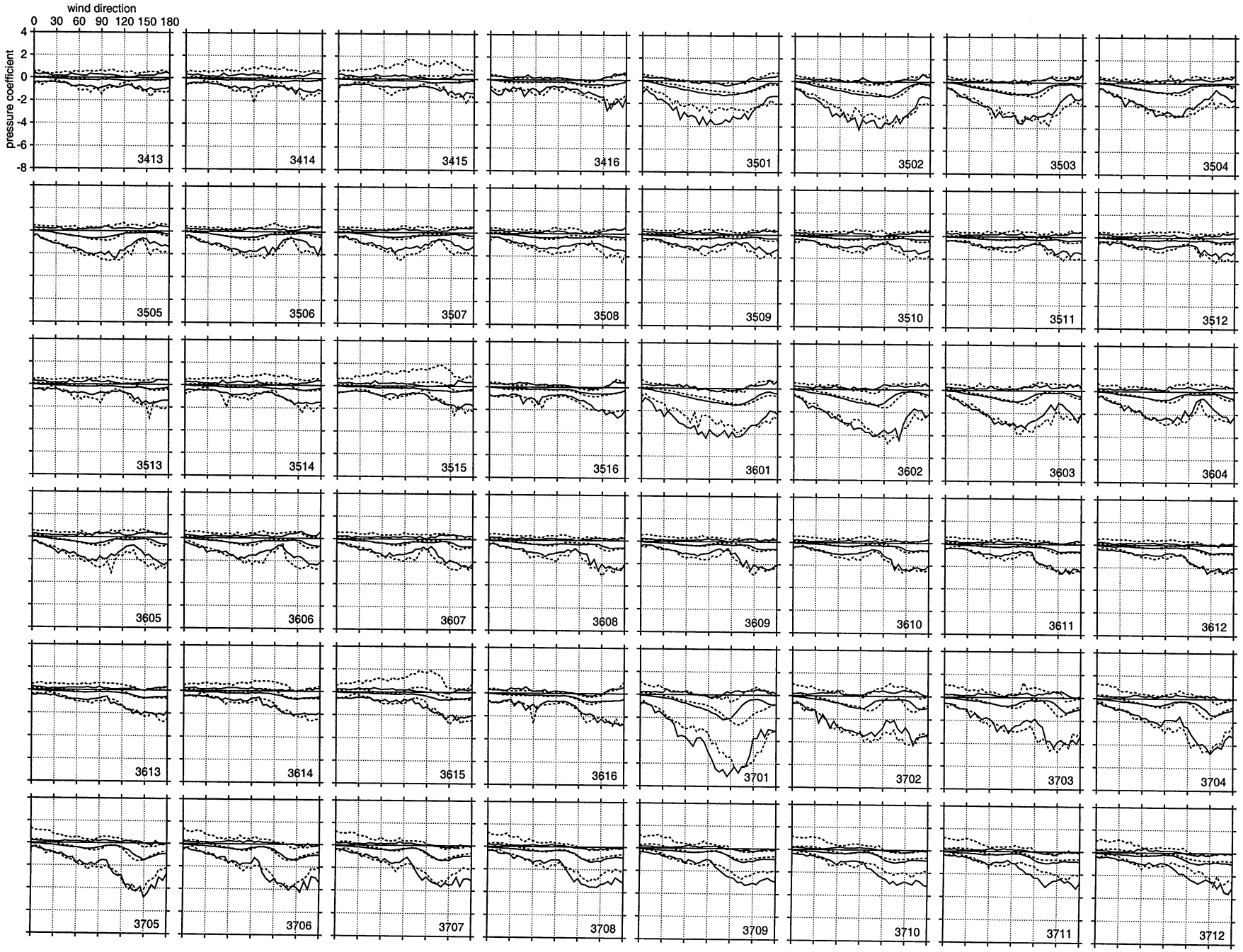
Sep. 24, 2003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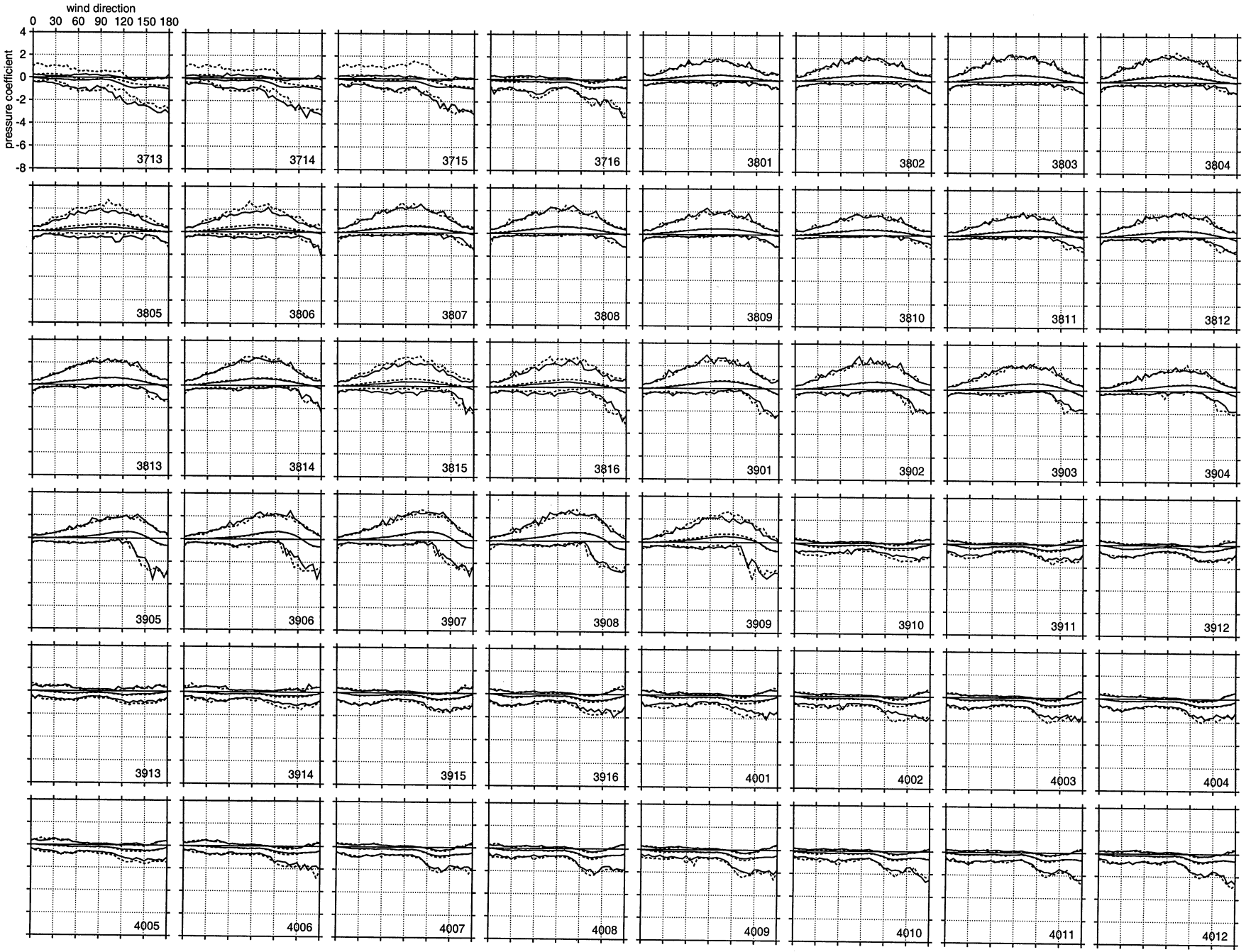
Sep. 24, 2003



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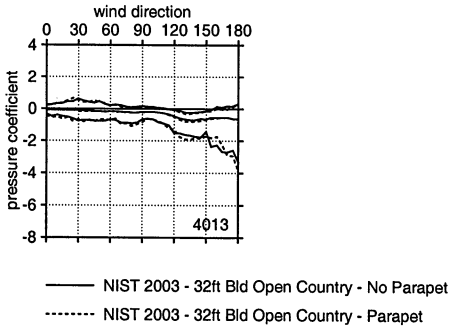
Sep. 24, 2003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pressure coefficient
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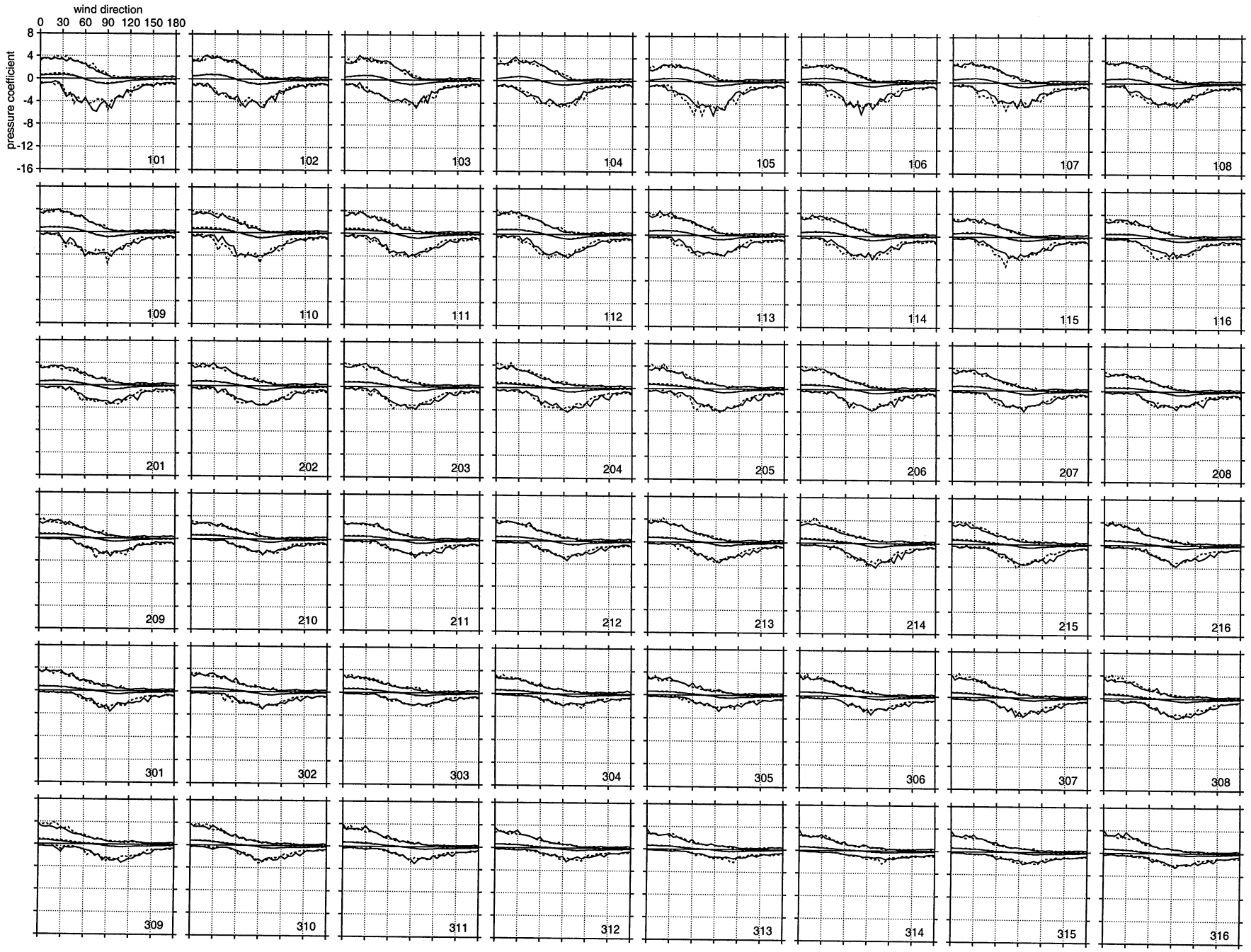
NIST 2003 - 32ft Bld Open Country - Parapet

Sep. 24, 2003

32 ft Building – Suburban Exposure



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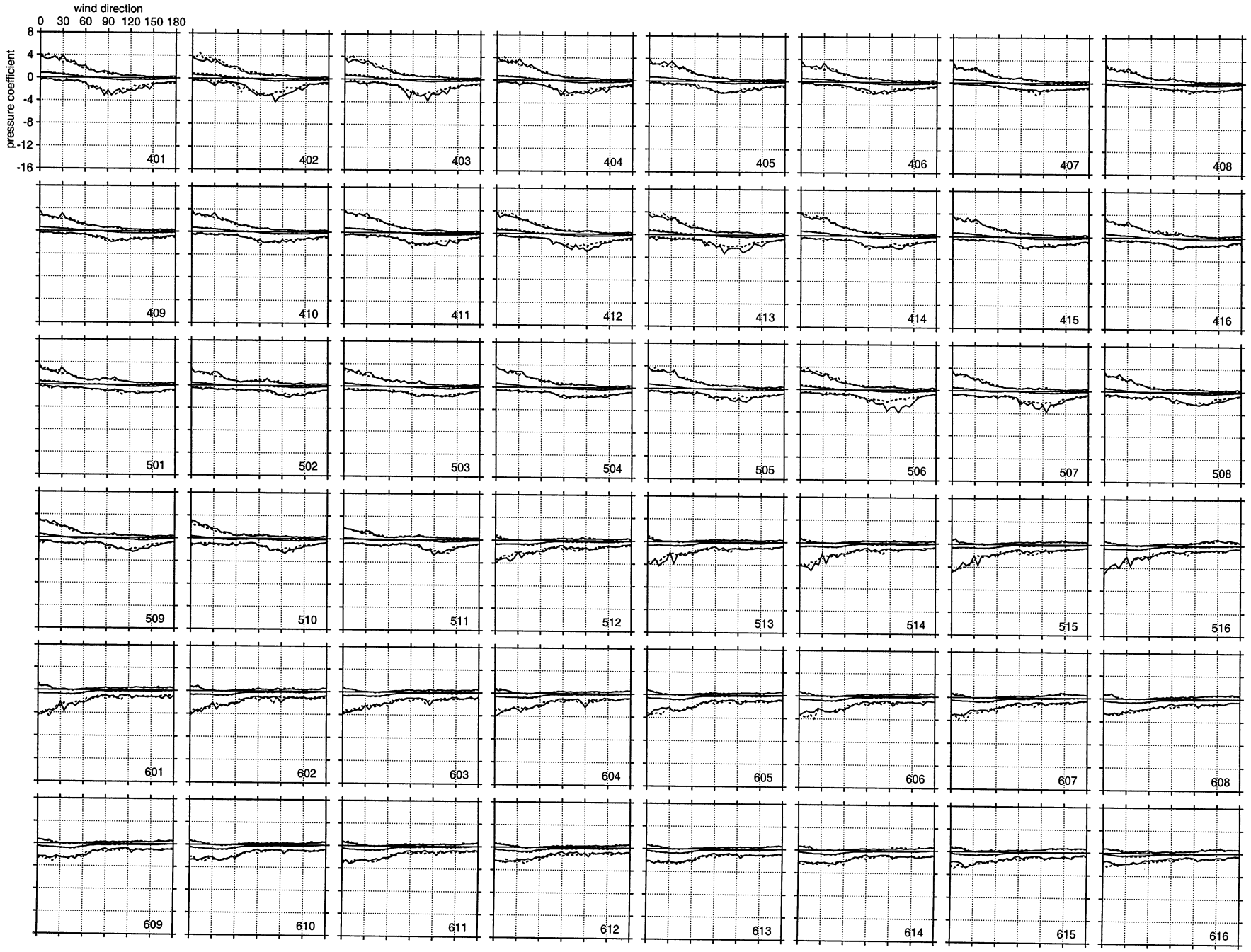
Sep. 24, 2003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pressure coefficient
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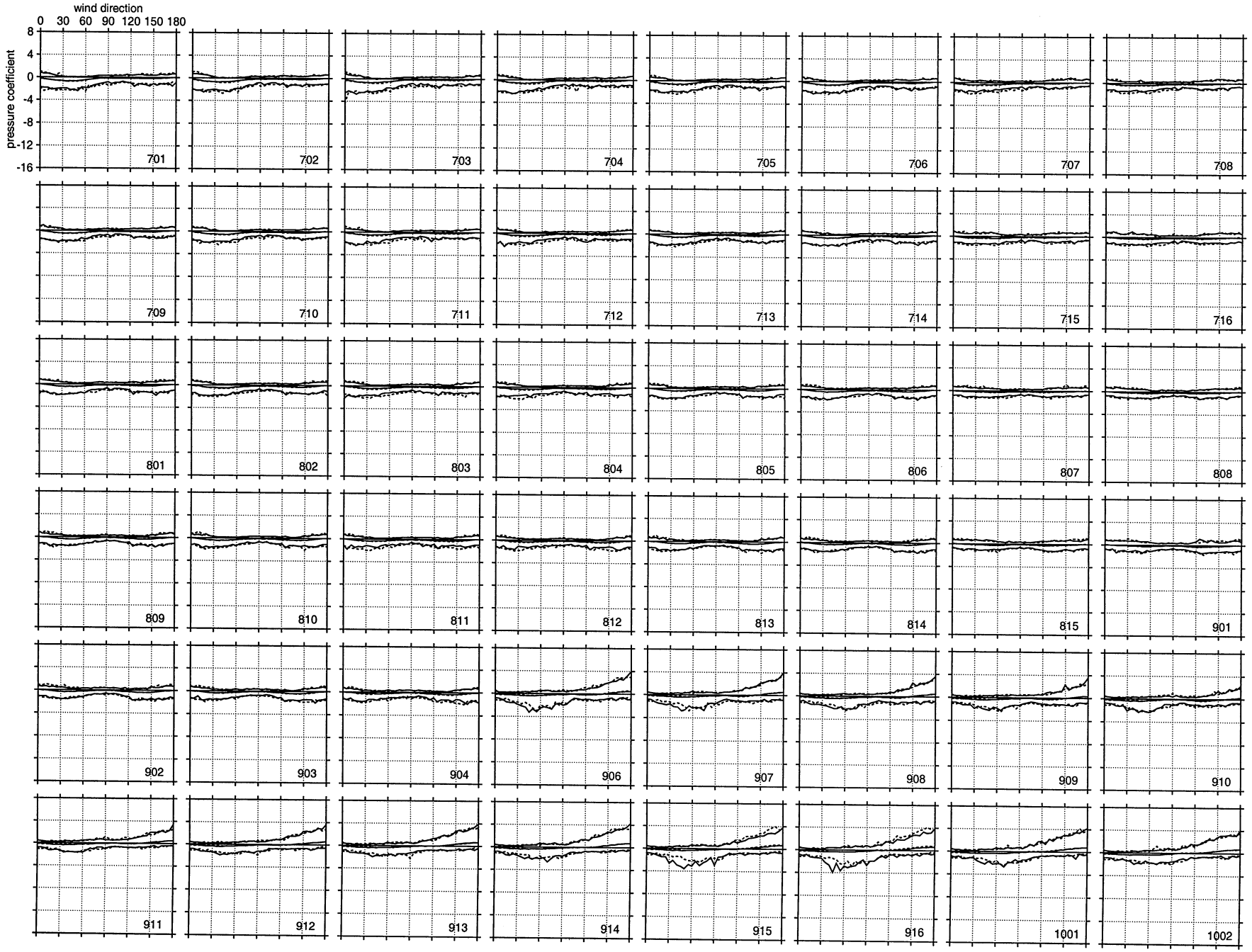
NIST 2003 - 32ft Bld Suburban - Parapet

Sep. 24, 2003



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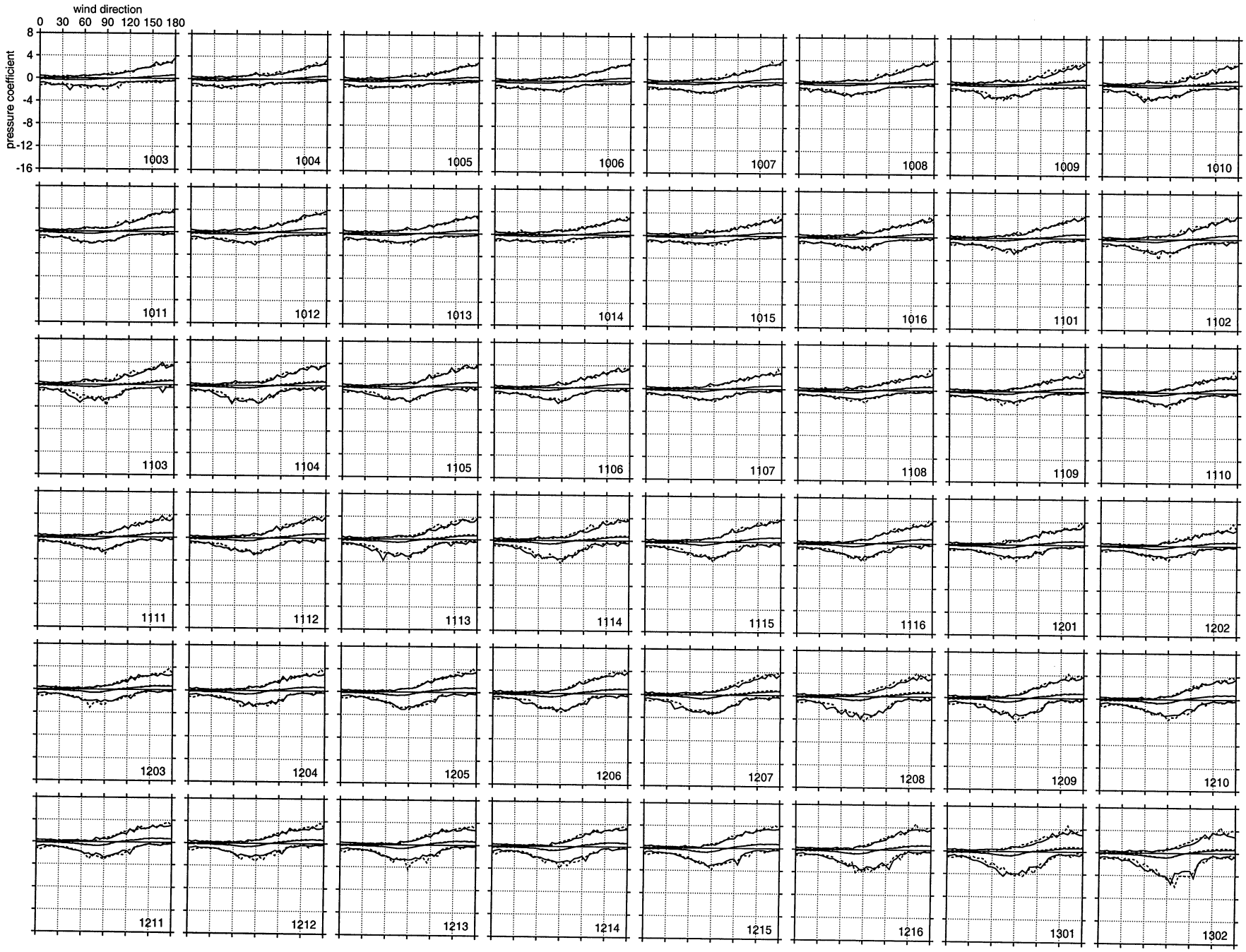

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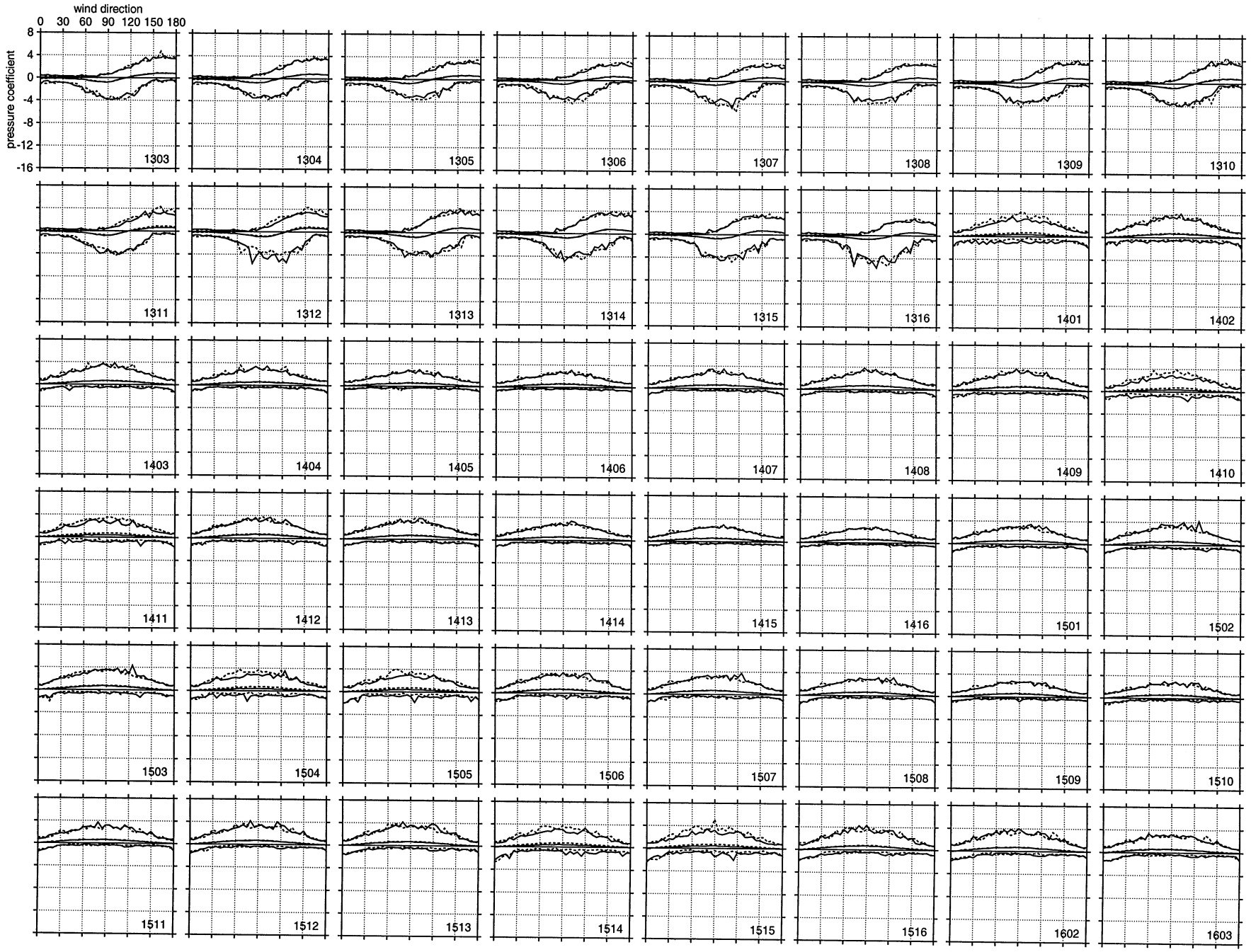

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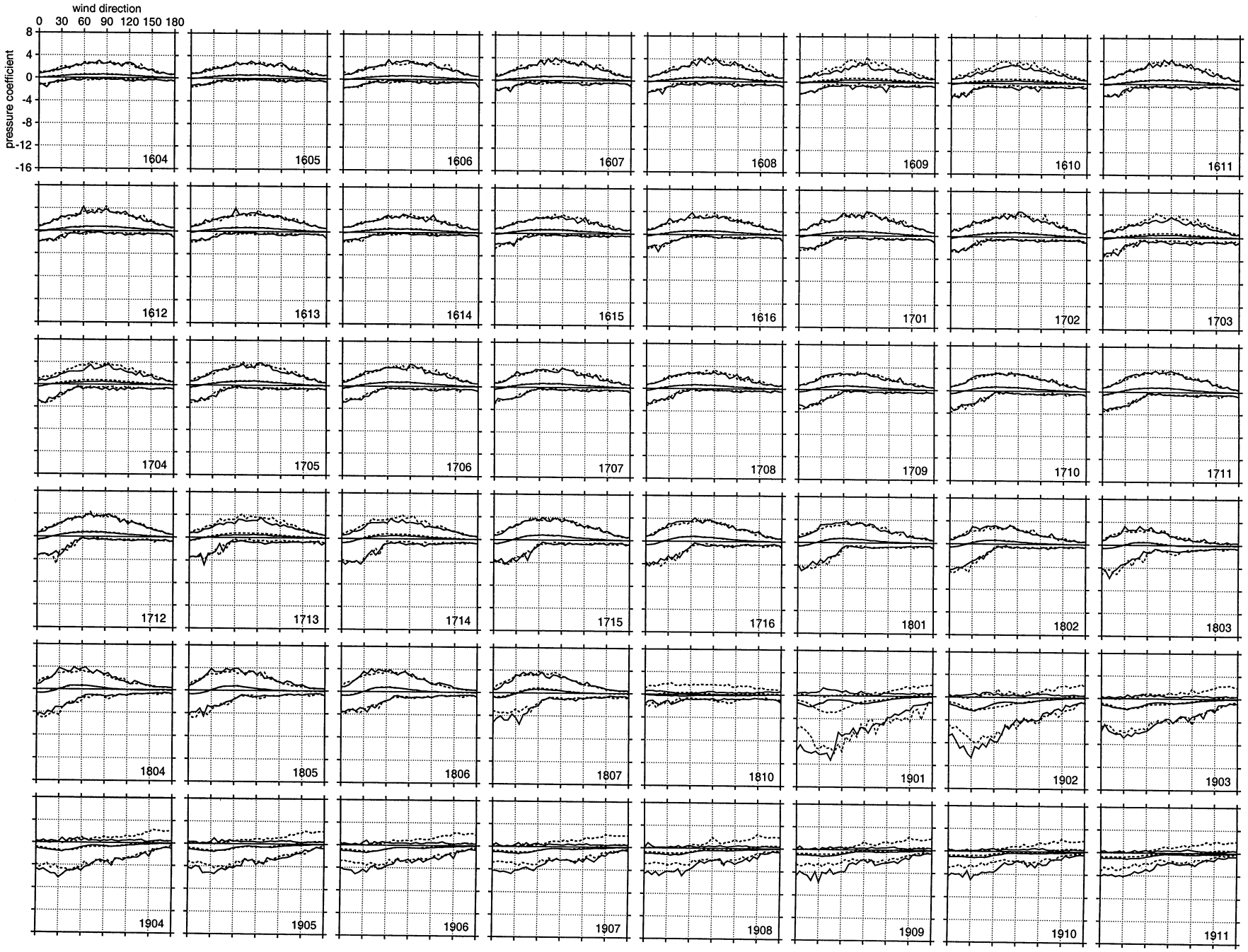
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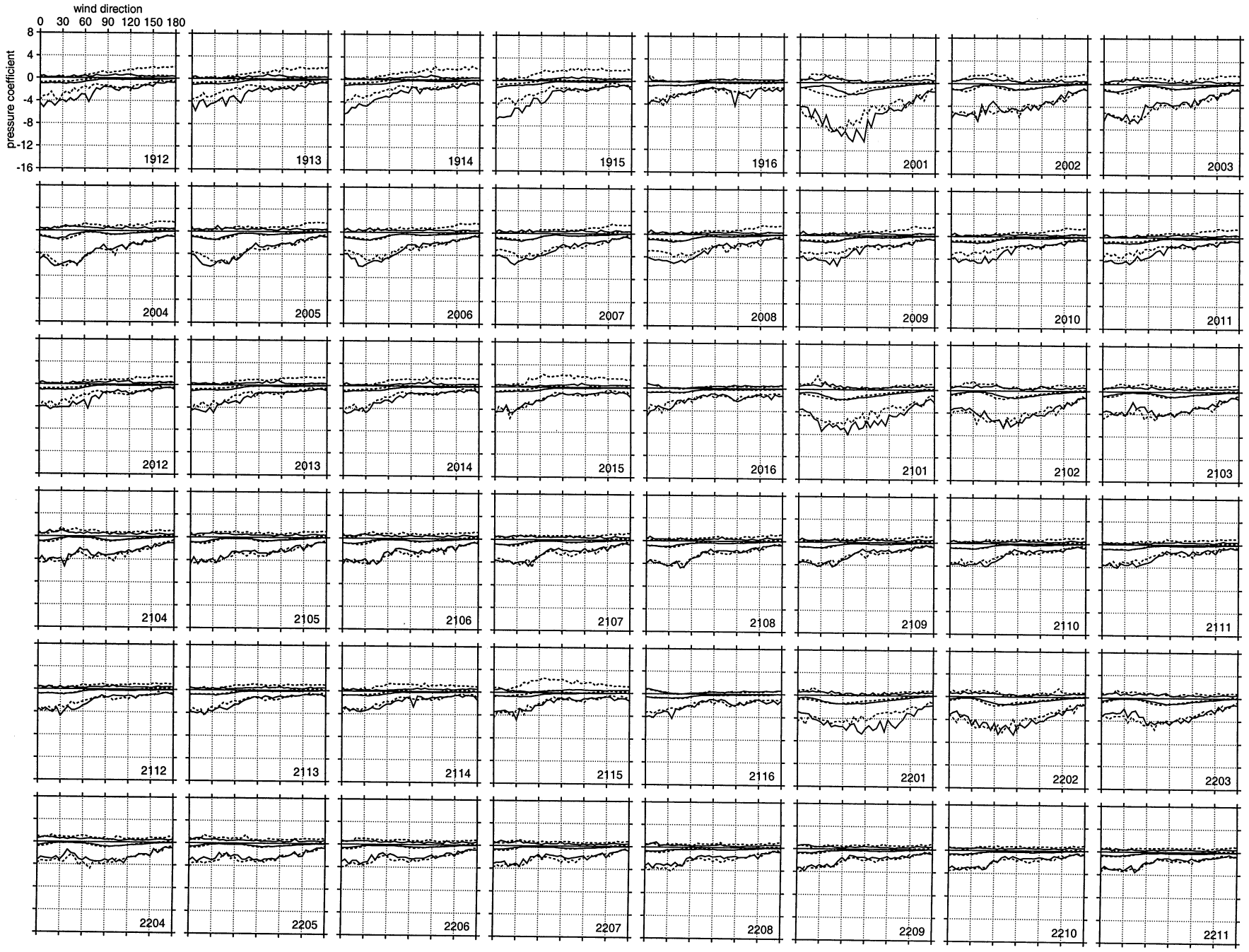
NIST 2003 - 32ft Bld Suburban - Parapet

Sep. 24, 2003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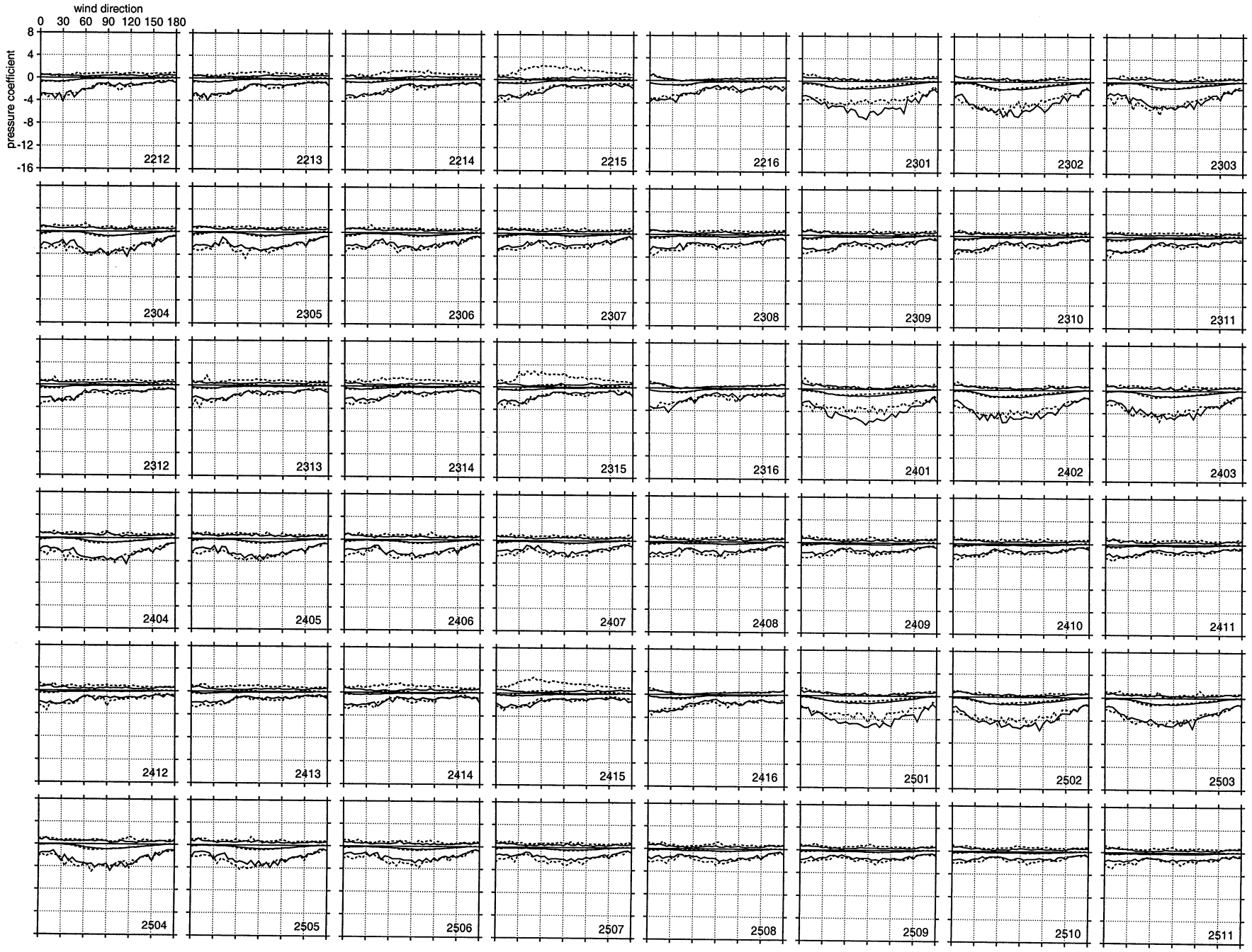
NIST 2003 - 32ft Bld Suburban - Parapet

Sep. 24, 2003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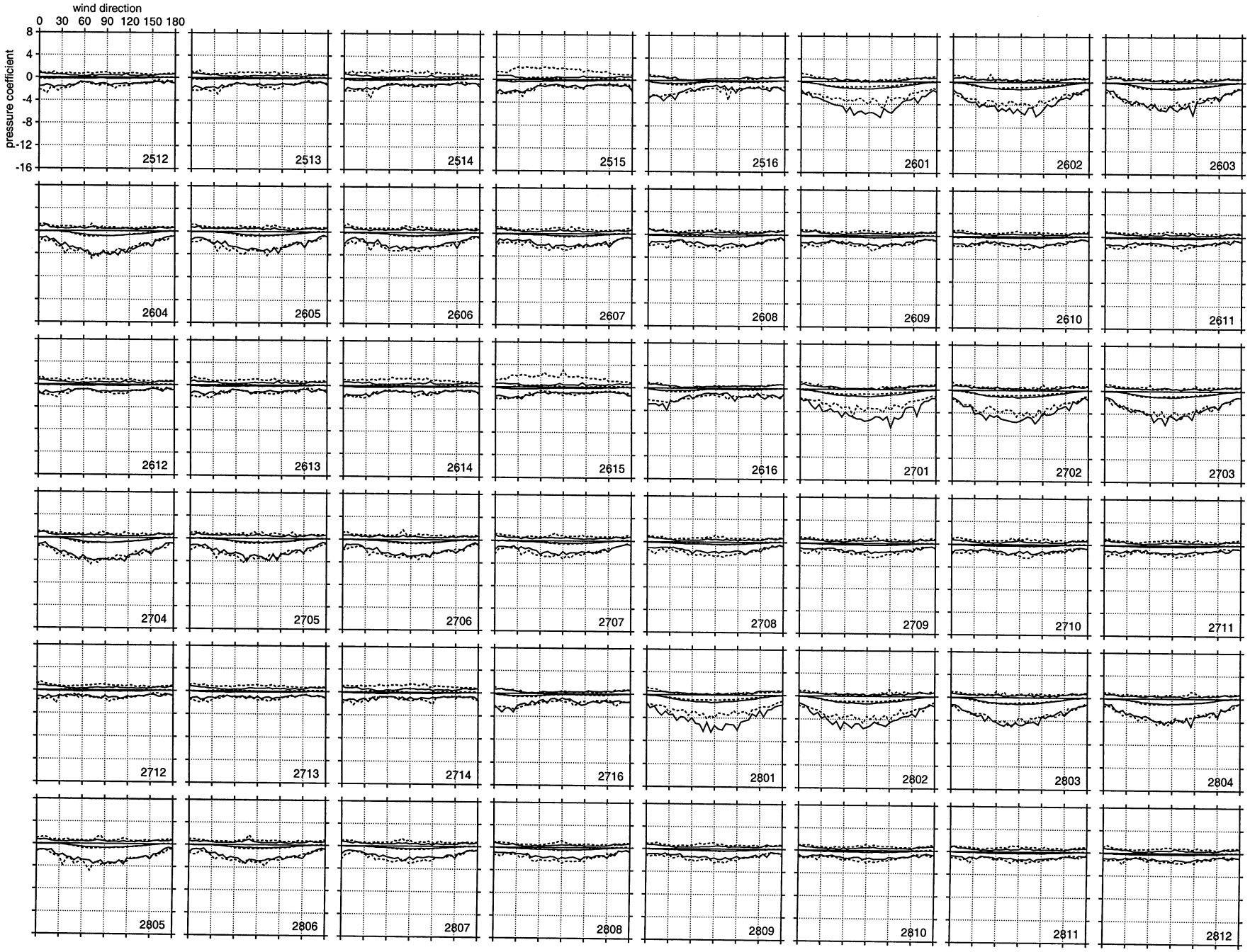
NIST 2003 - 32ft Bld Suburban - Parapet

Sep. 24, 2003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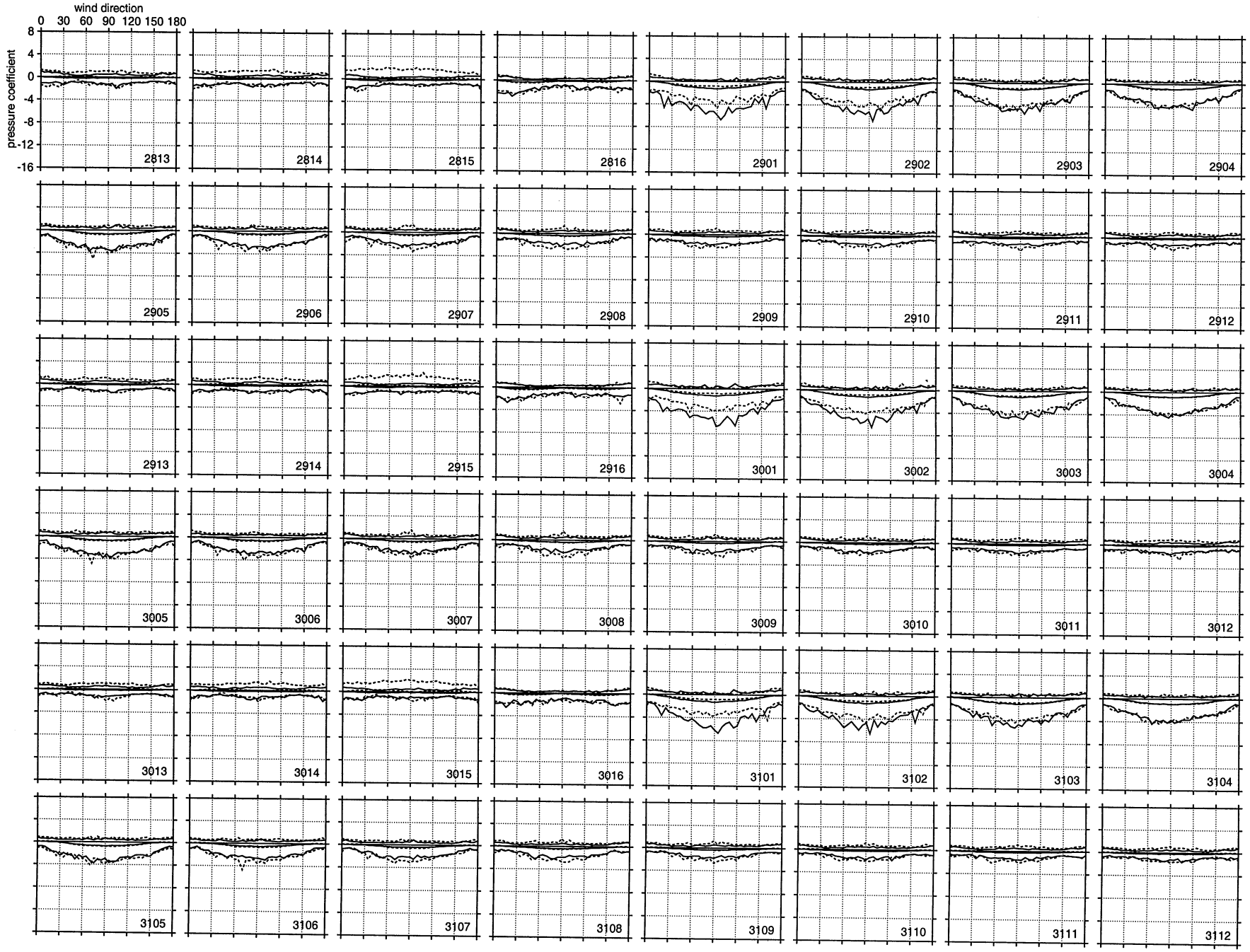
Sep. 24, 2003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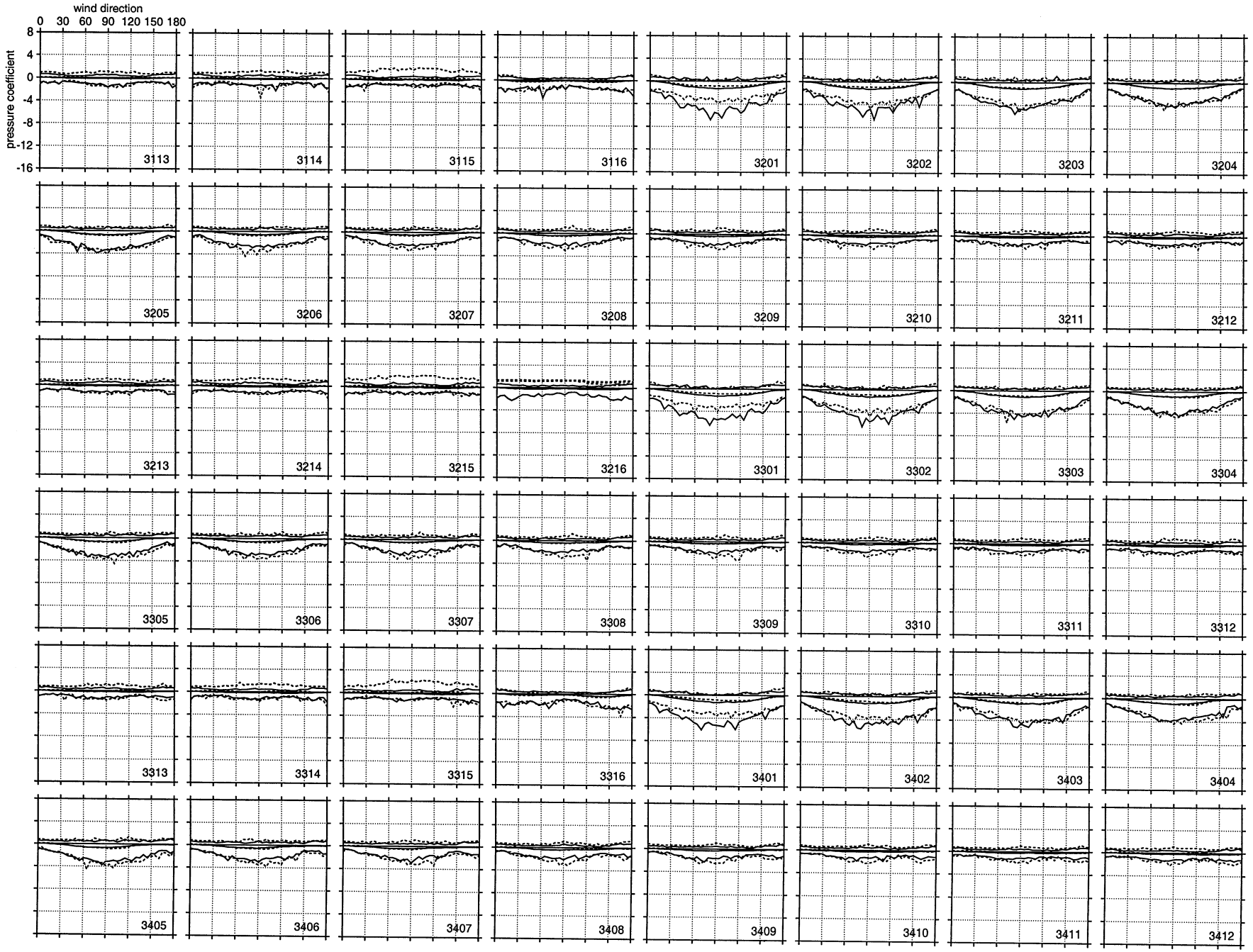
Sep. 24, 2003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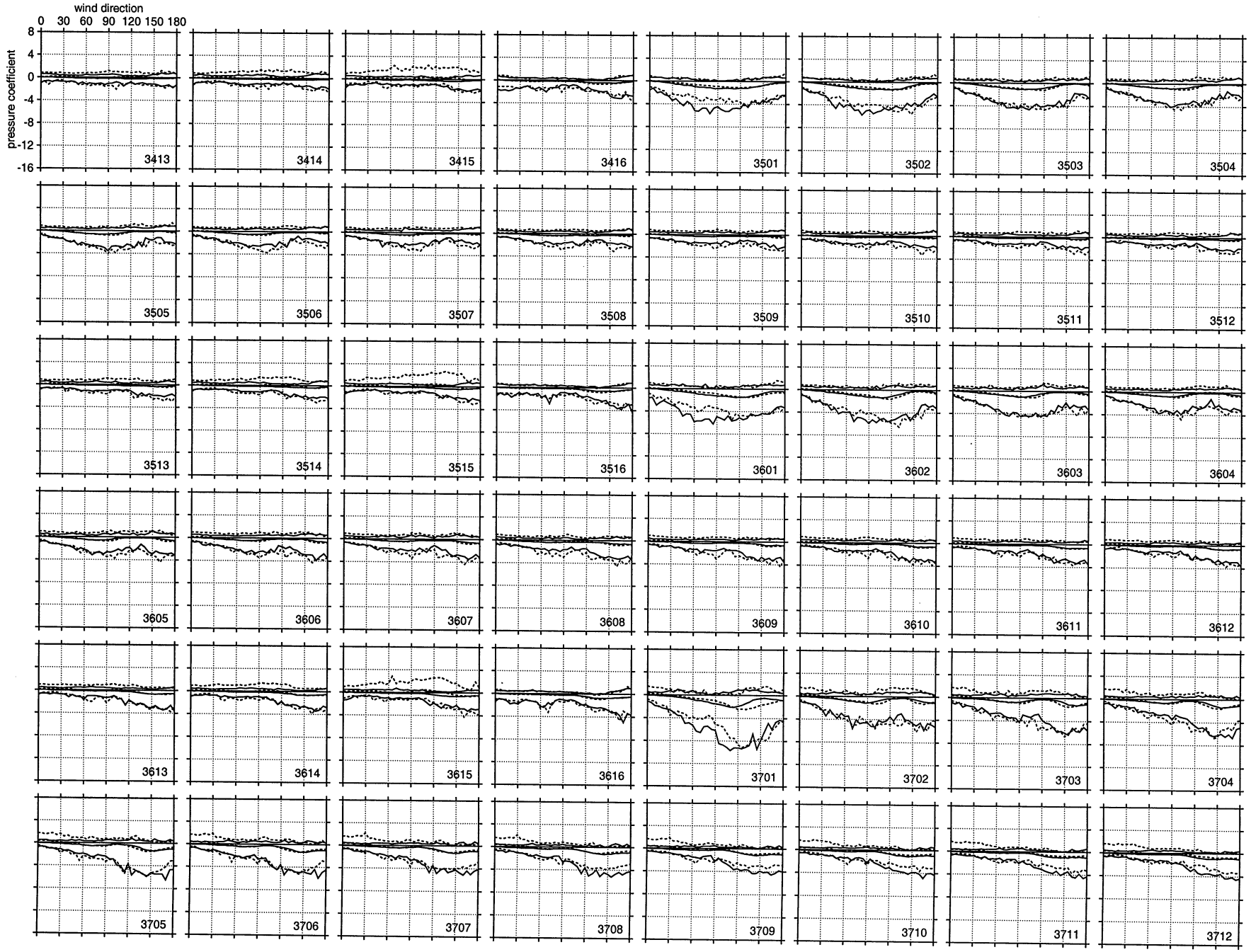
Sep. 24, 2003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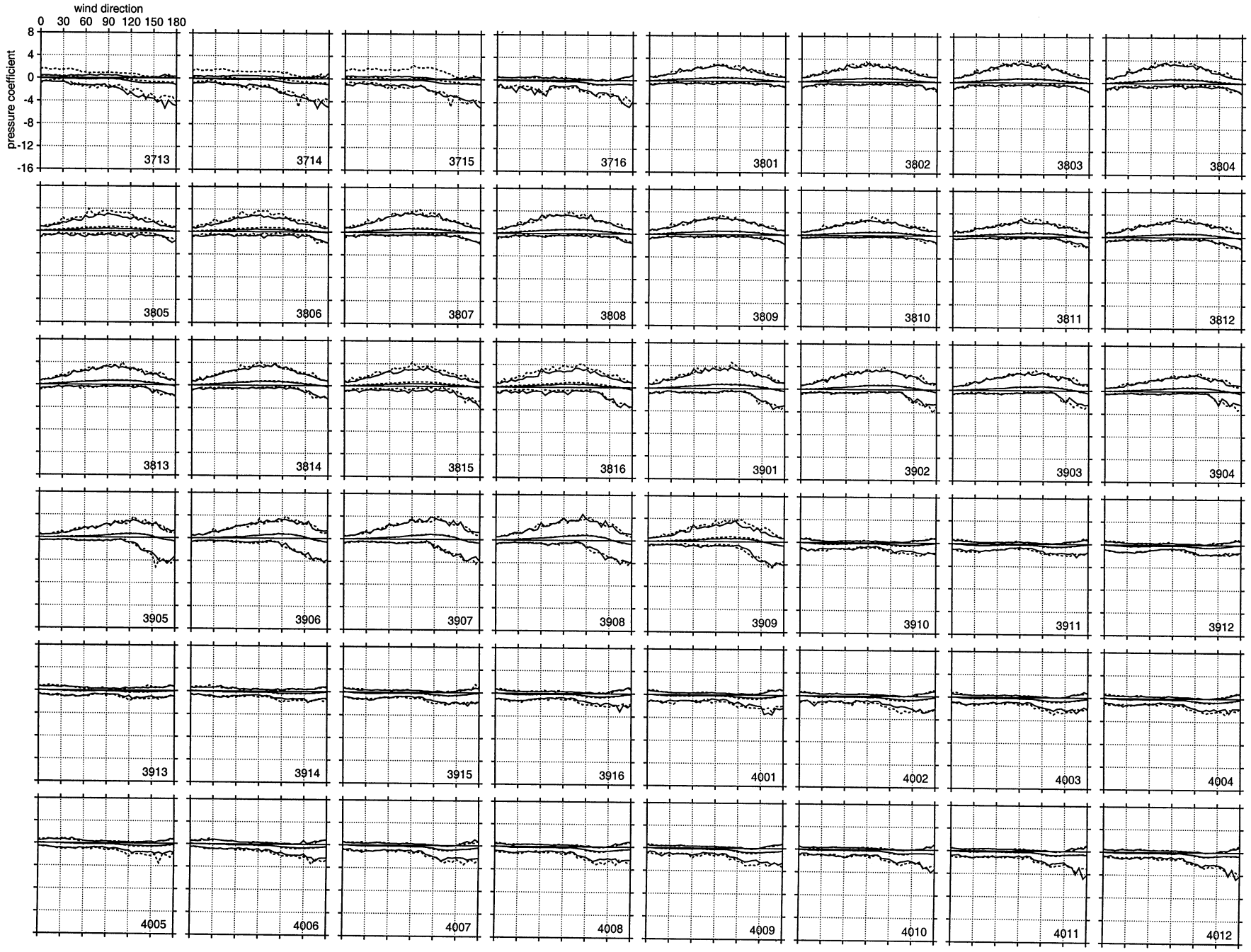
NIST 2003 - 32ft Bld Suburban - No Parapet
NIST 2003 - 32ft Bld Suburban - Parapet

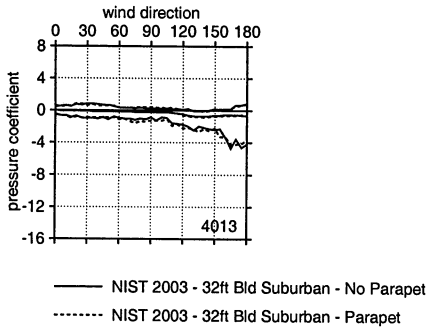
Sep. 24, 2003



NIST 2003 - 32ft Bld Suburban - No Parapet

NIST 2003 - 32ft Bld Suburban - Parapet

Sep. 24, 2003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pressure coefficient
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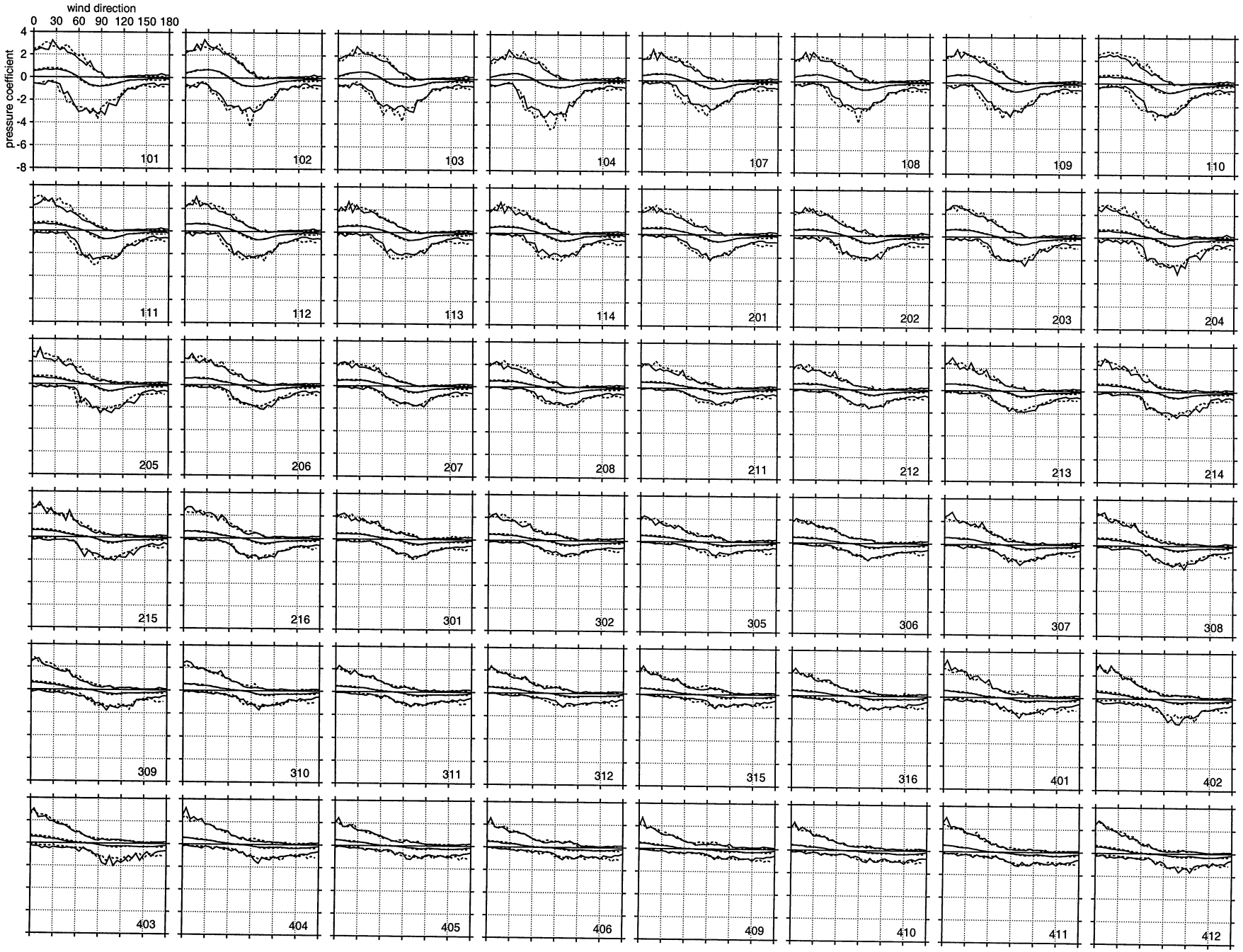
NIST 2003 - 32ft Bld Suburban - Parapet

Sep. 24, 2003

20 ft Building – Open Exposure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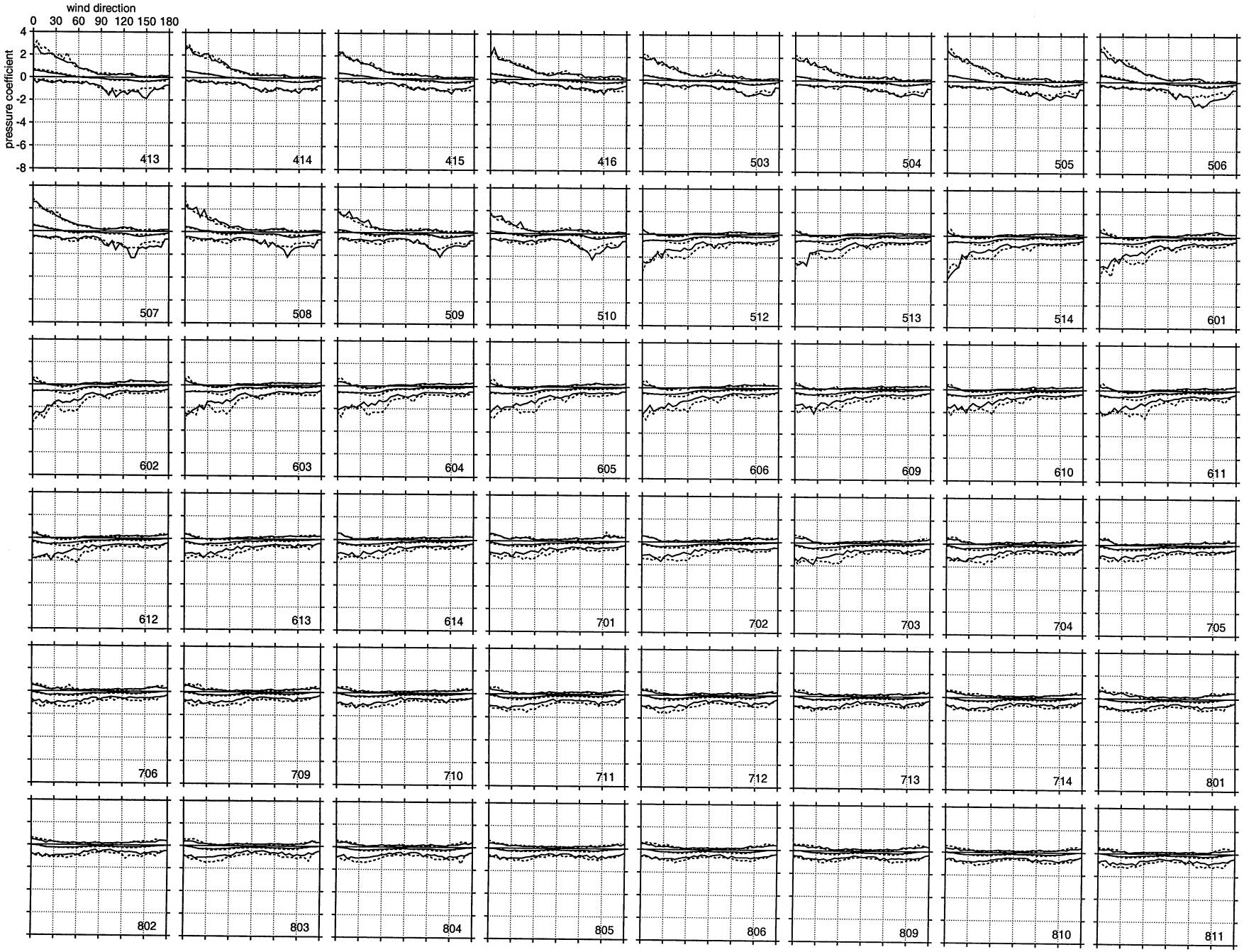
NIST 2003 - 20ft Bld Open Country - Parapet

Sep. 24, 2003



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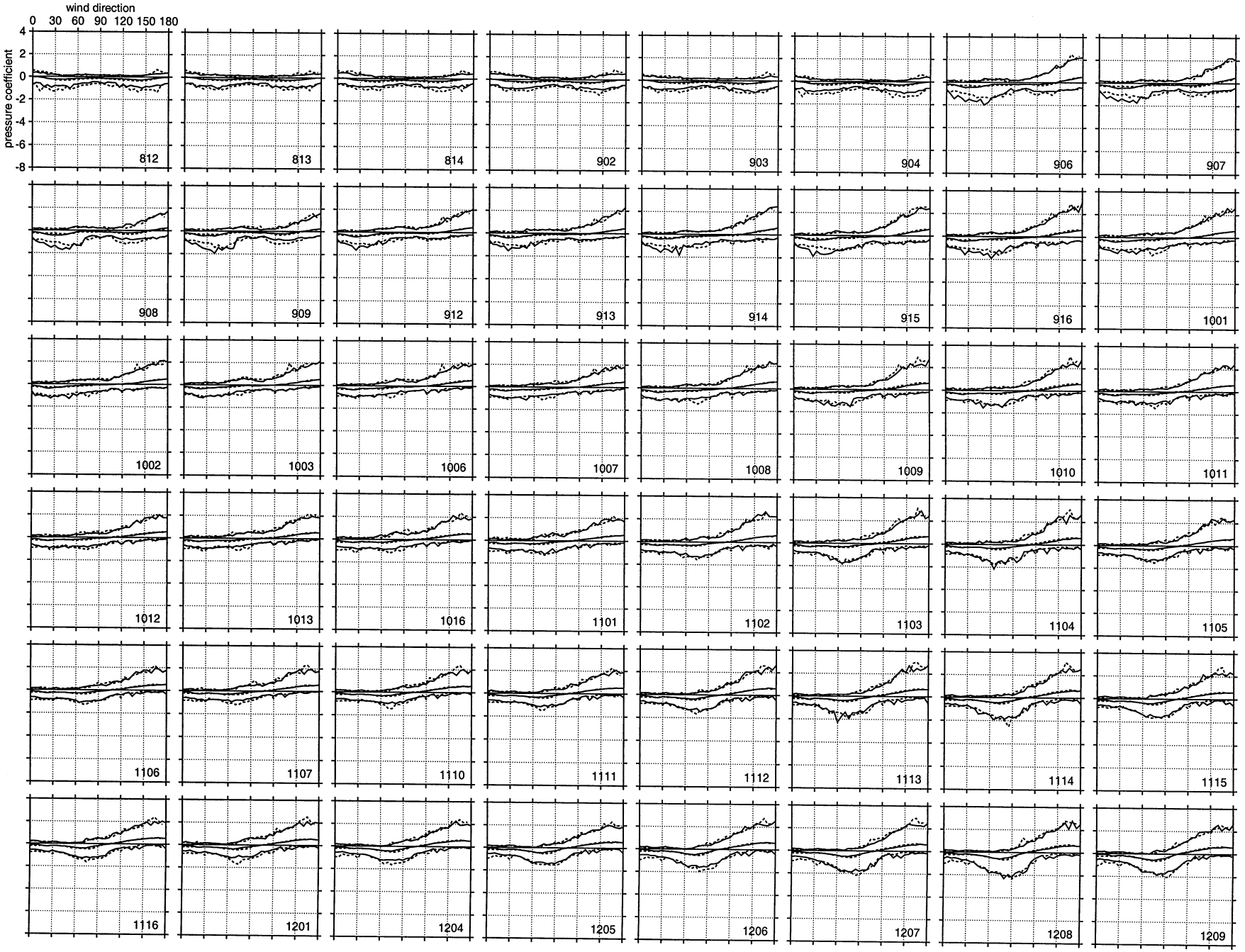
Sep. 24, 2003



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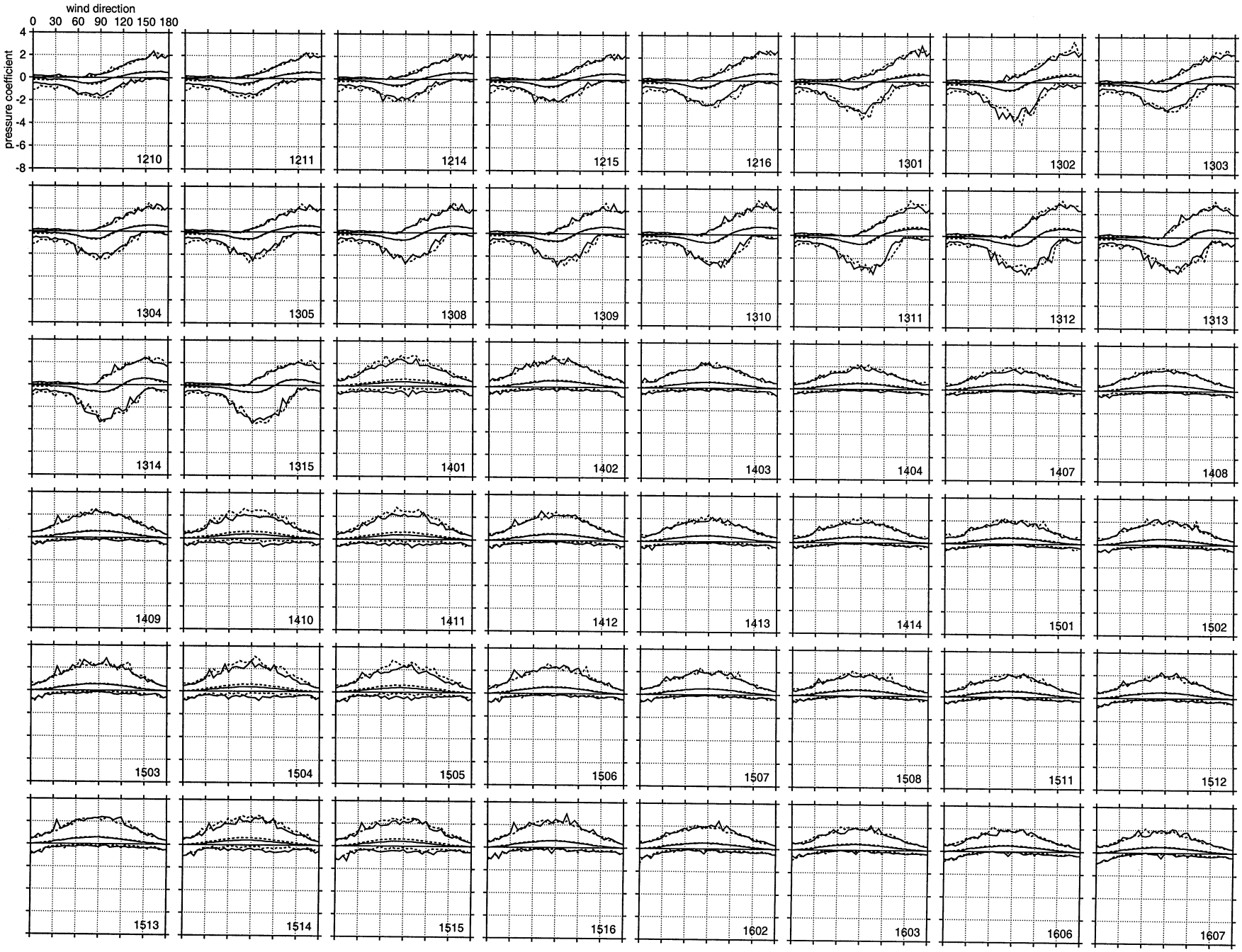
Sep. 24, 2003



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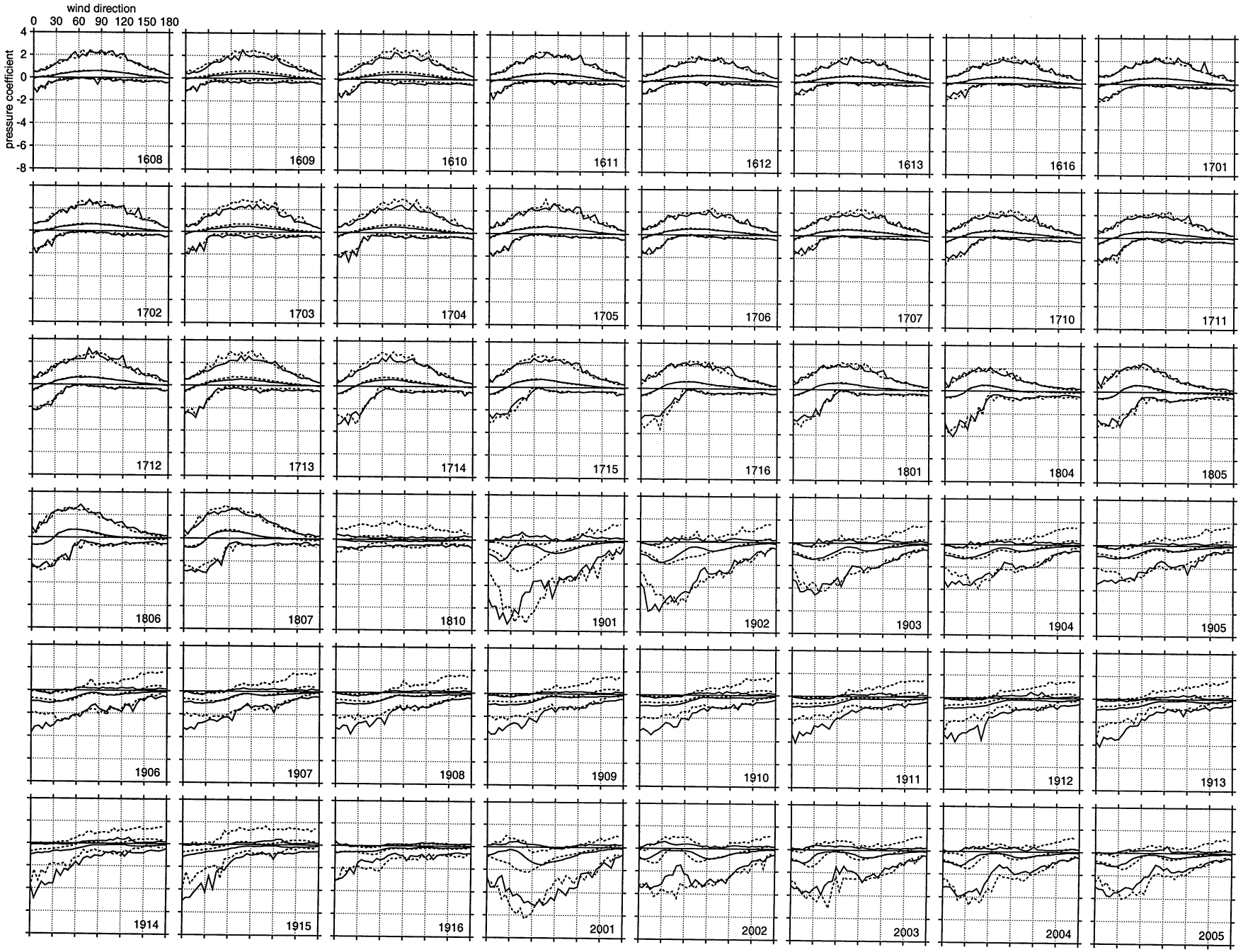
Sep. 24, 2003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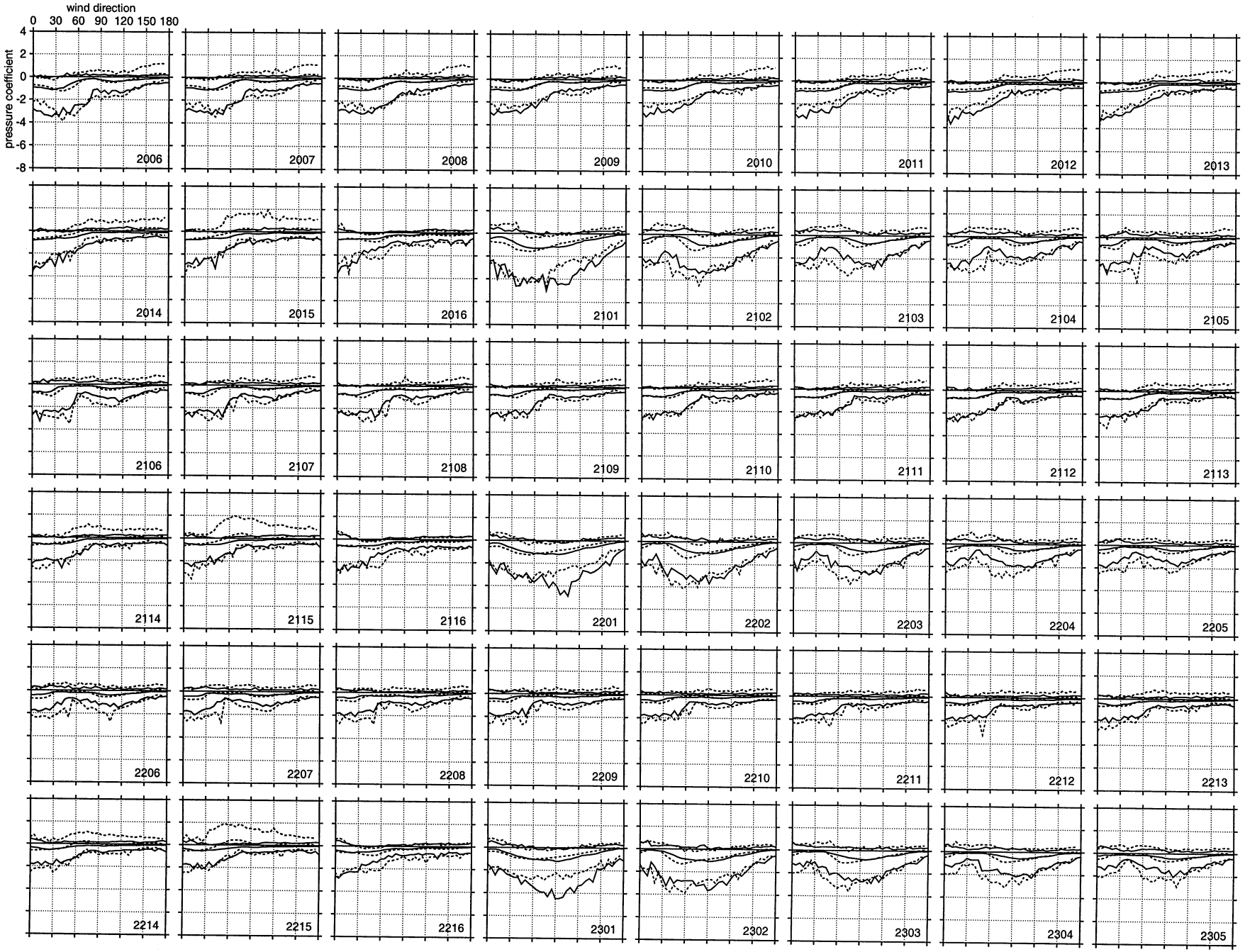
NIST 2003 - 20ft Bld Open Country - Parapet

Sep. 24, 2003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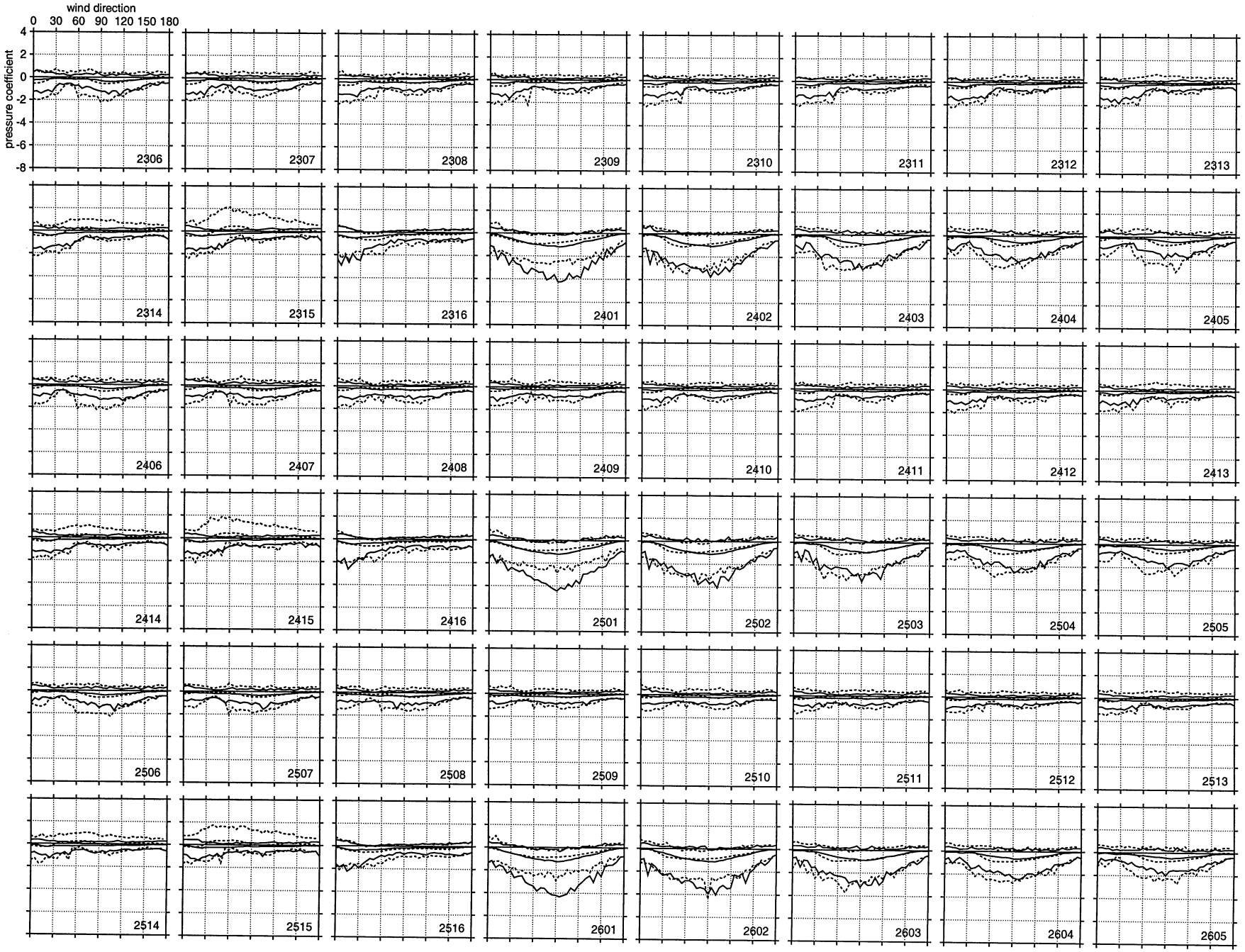
NIST 2003 - 20ft Bld Open Country - Parapet

Sep. 24, 2003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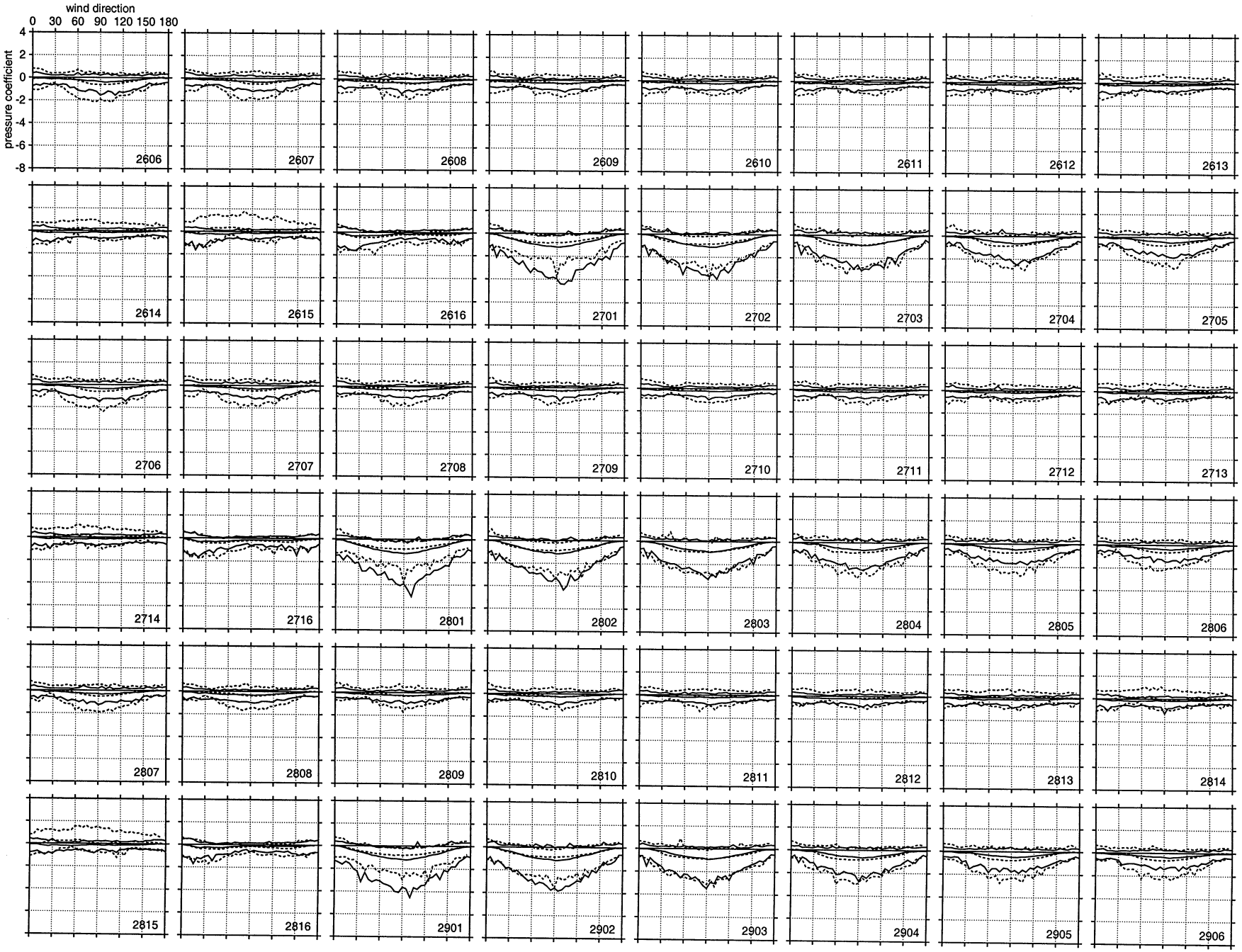
Sep. 24, 2003



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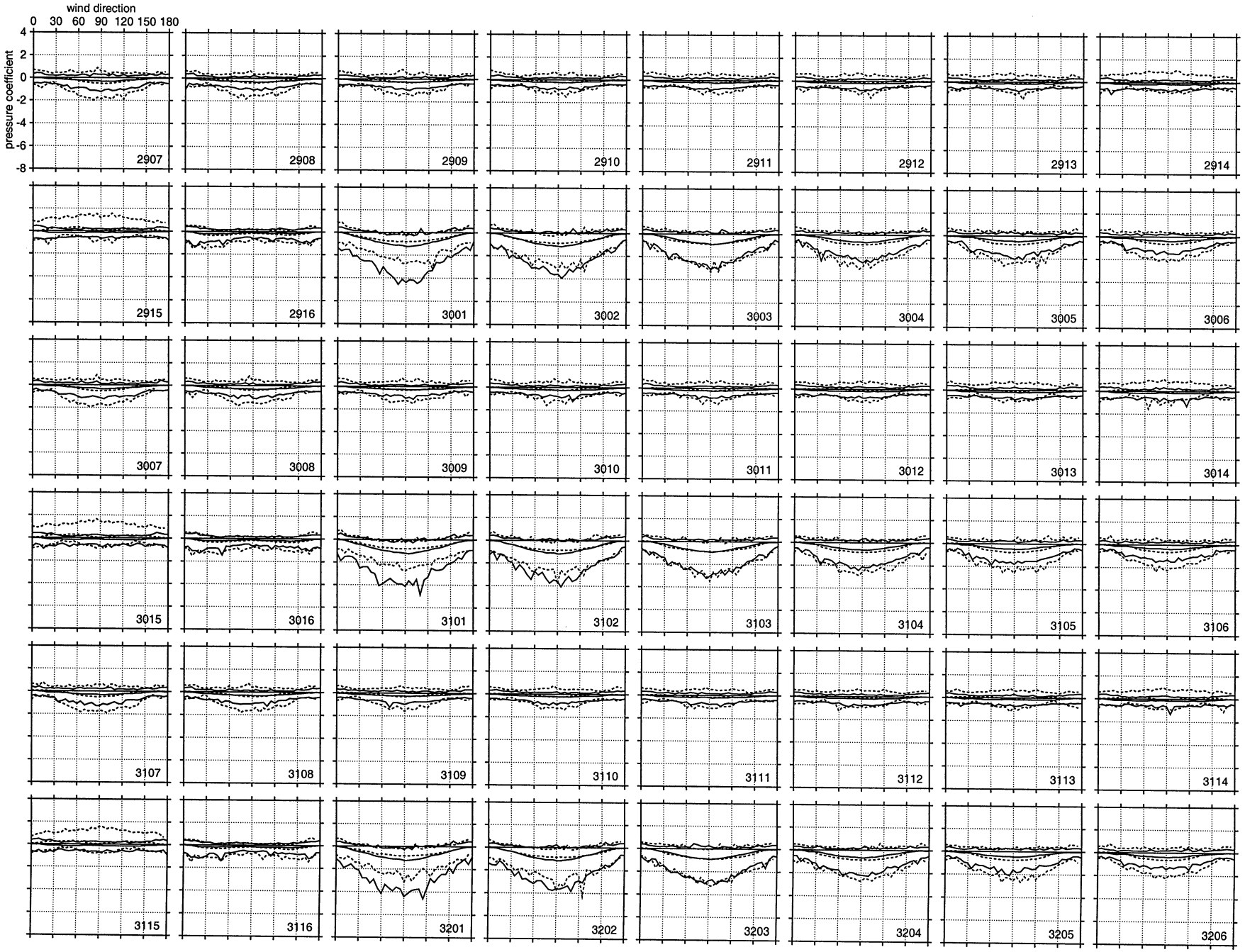
NIST 2003 - 20ft Bld Open Country - Parapet

Sep. 24, 2003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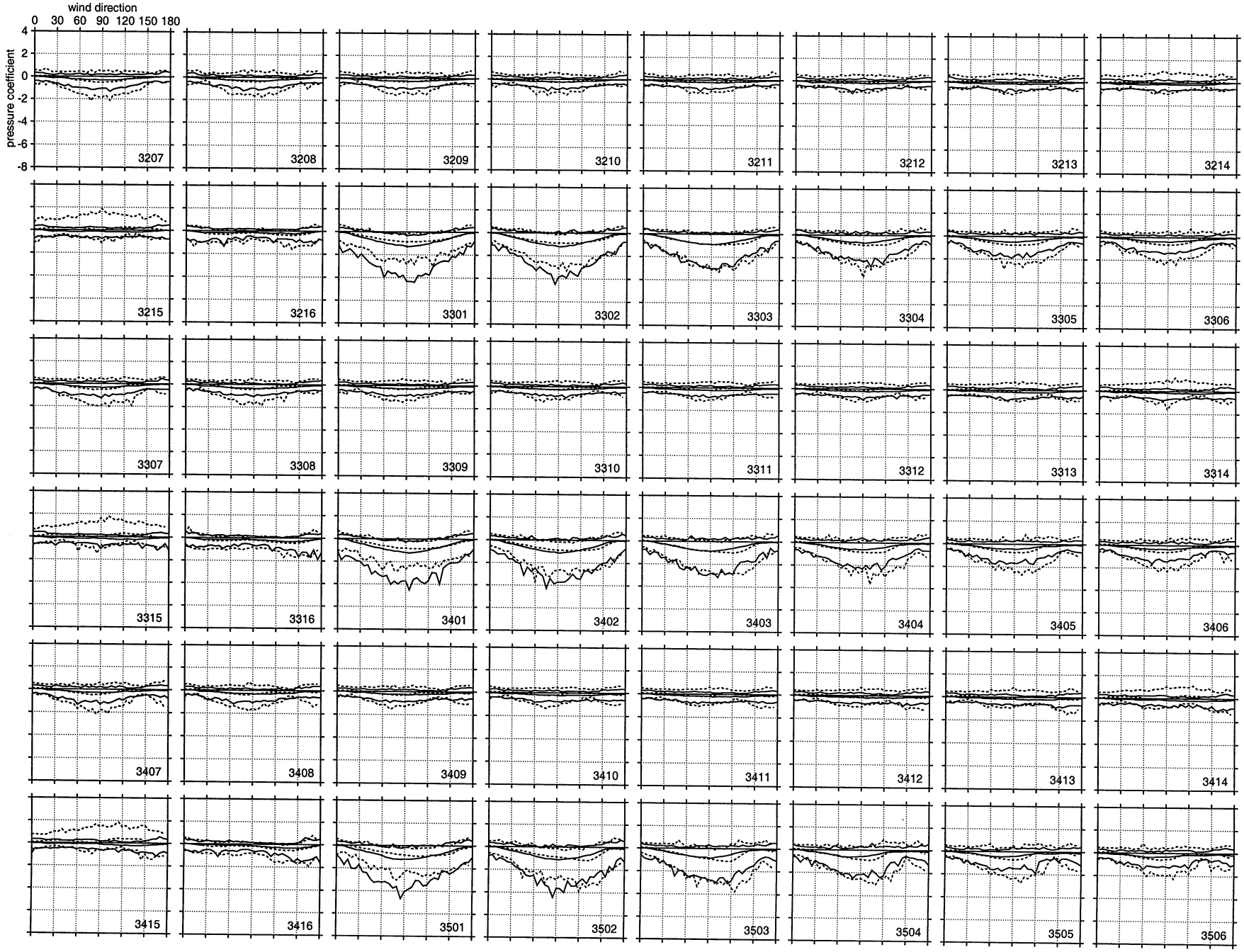
Sep. 24, 2003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3414
3415
3416
3501
3502
3503
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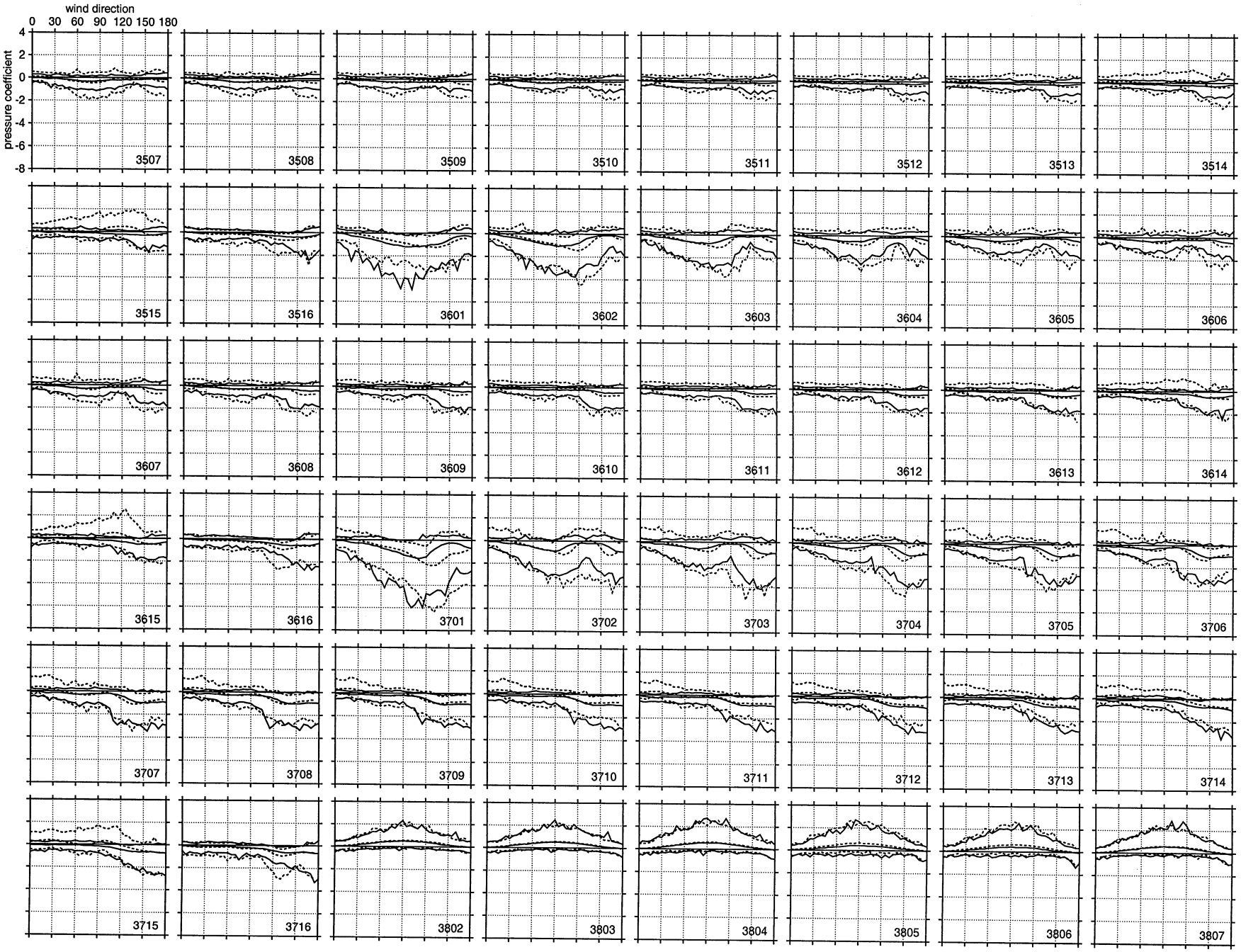
3505
3506
NIST 2003 - 20ft Bld Open Country - No Parapet
NIST 2003 - 20ft Bld Open Country - Parapet

Sep. 24, 2003


wind direction
0 30 60 90 120 150 180
pressure coefficient
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-2
-4
-6
-8
3507
3508
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3510
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3512
3513
3514
3515
3516
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3606
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3701
3702
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3711
3712
3713
3714
3715
3716
3802
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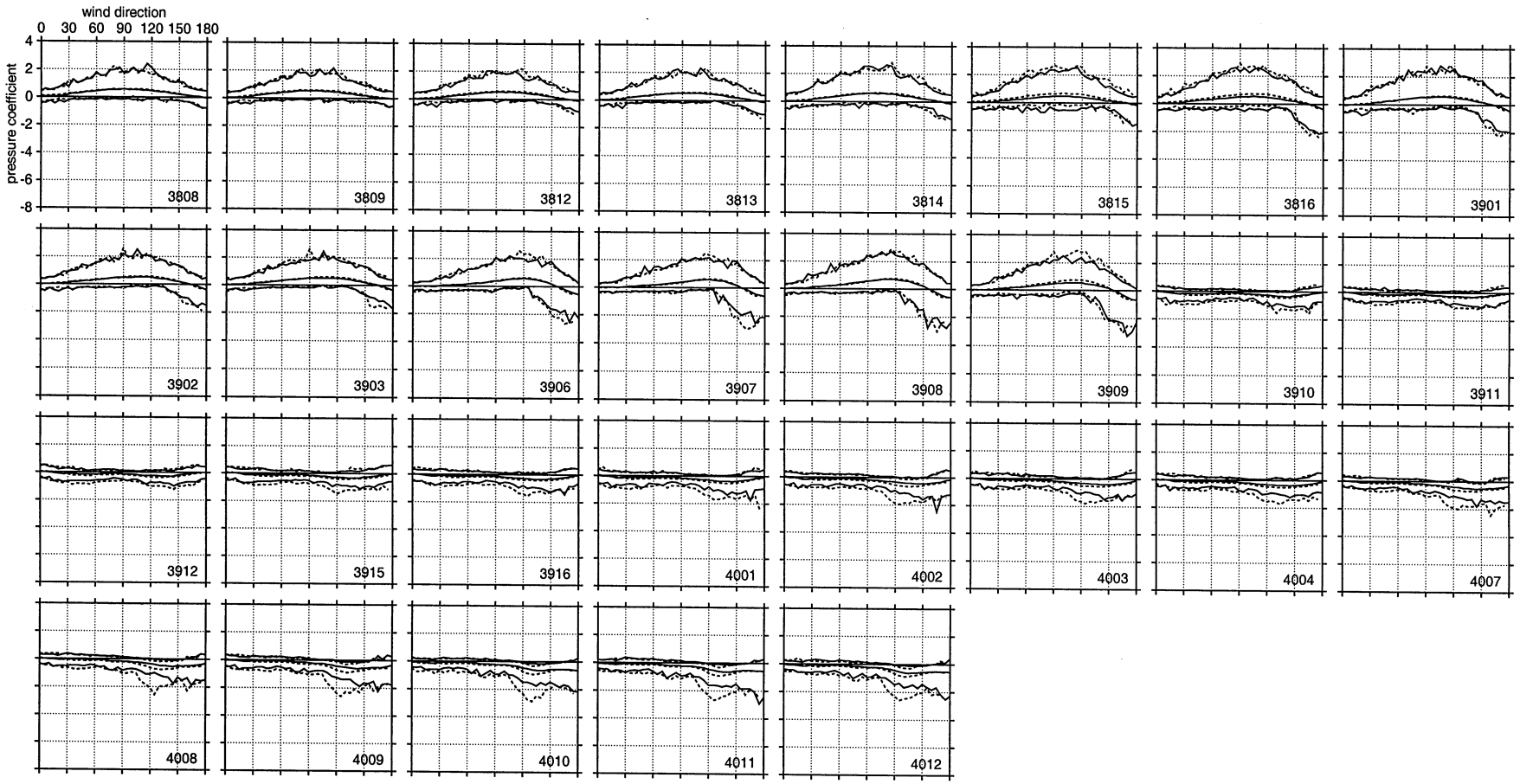
NIST 2003 - 20ft Bld Open Country - No Parapet
NIST 2003 - 20ft Bld Open Country - Parapet

Sep. 24, 2003


wind direction
0 30 60 90 120 150 180
pressure coefficient
4
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-4
-6
-8
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3812
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3815
3816
3901
3902
3903
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3907
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3909
3910
3911
3912
3915
3916
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4002
4003
4004
4007
4008
4009
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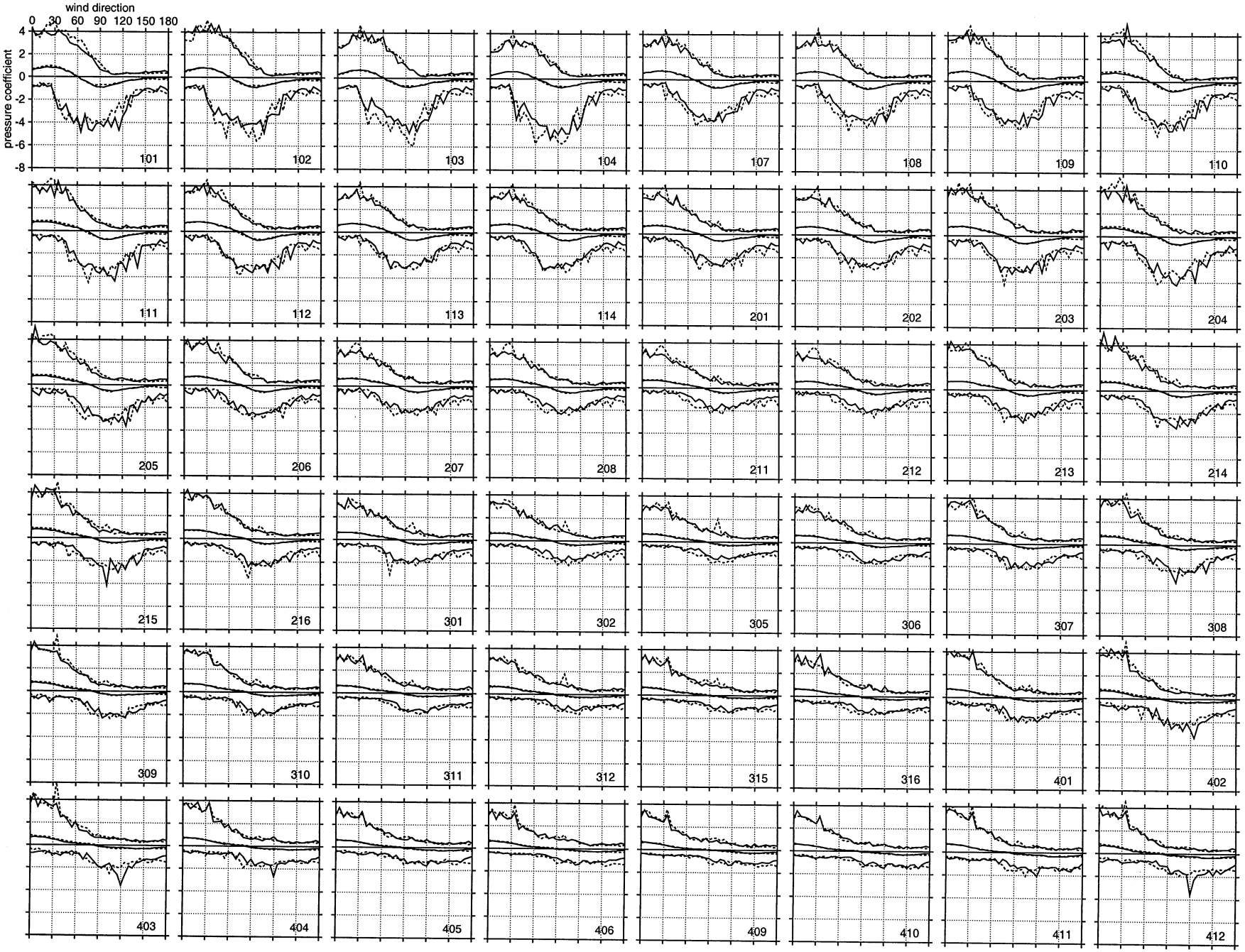
NIST 2003 - 20ft Bld Open Country - No Parapet
NIST 2003 - 20ft Bld Open Country - Parapet

Sep. 24, 2003

20 ft Building – Suburban Exposure


wind direction
0 30 60 90 120 150 180
pressure coefficient
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-4
-6
-8
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102
103
104
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110
111
112
113
114
201
202
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207
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212
213
214
215
216
301
302
305
306
307
308
309
310
311
312
315
316
401
402
403
404
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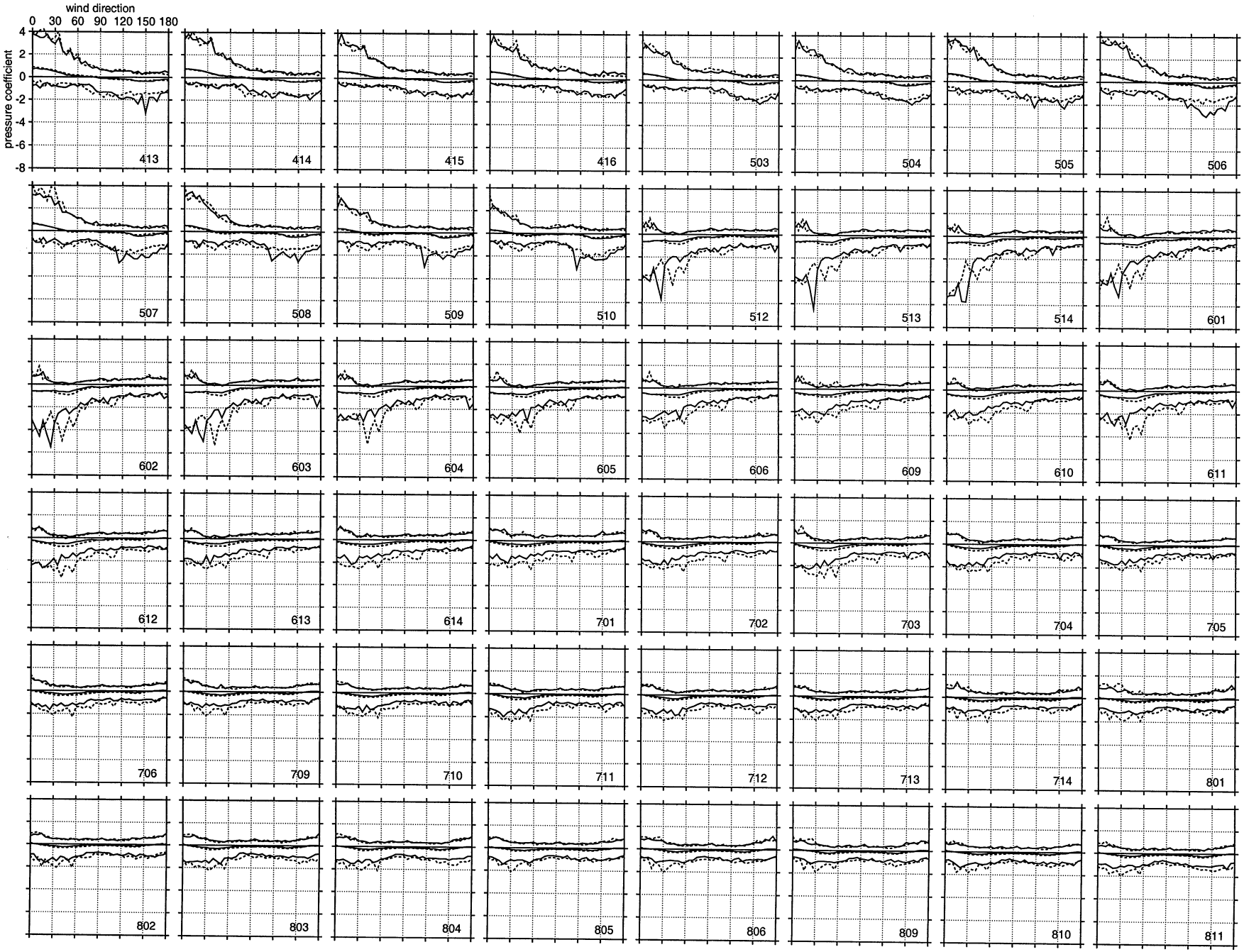
410
411
412
NIST 2003 - 20ft Bld Suburban - No Parapet
NIST 2003 - 20ft Bld Suburban Parapet

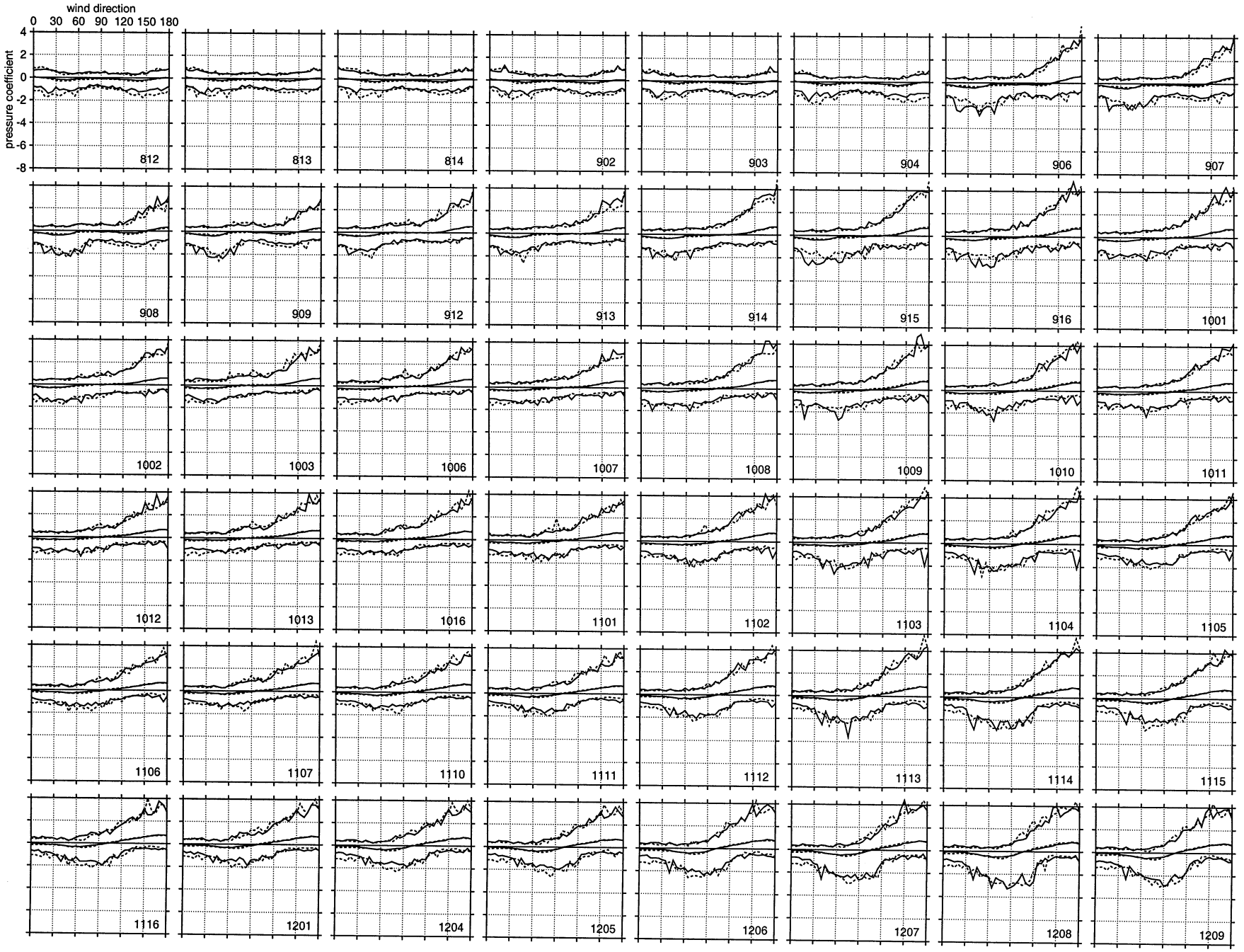
Sep. 24, 2003



NIST 2003 - 20ft Bld Suburban - No Parapet

NIST 2003 - 20ft Bld Suburban Parapet

Sep. 24, 2003



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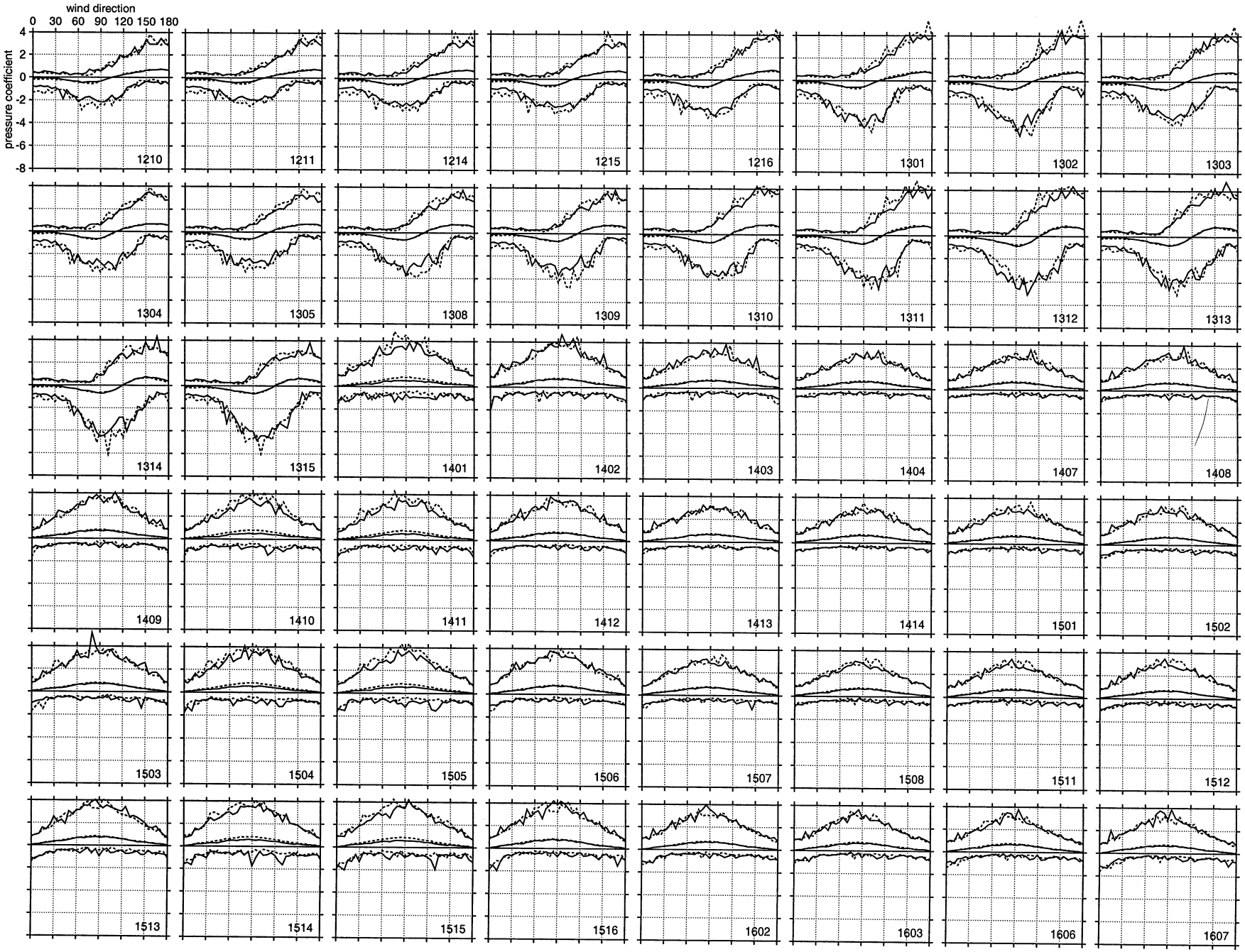
NIST 2003 - 20ft Bld Suburban Parapet

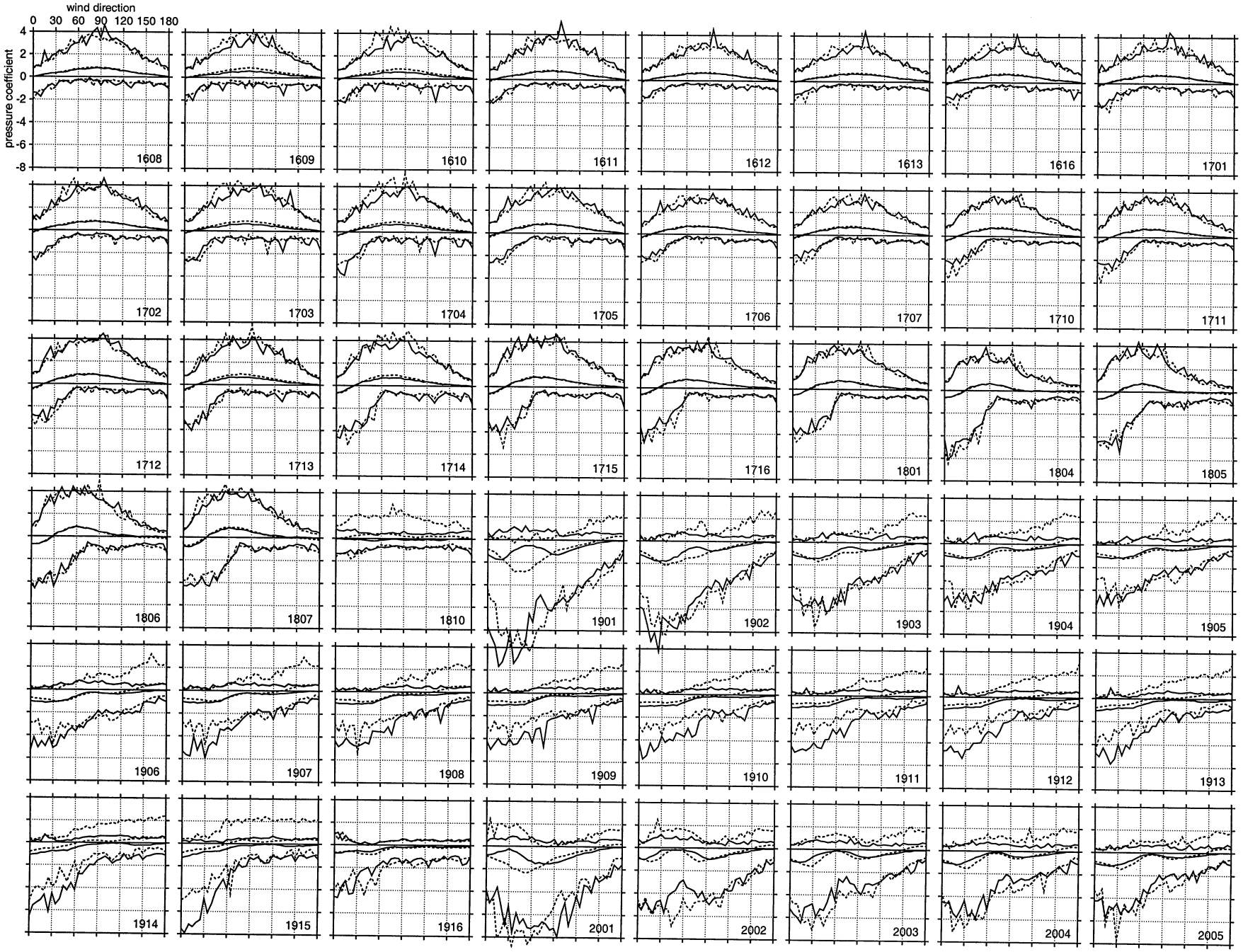
Sep. 24, 2003



NIST 2003 - 20ft Bld Suburban - No Parapet

NIST 2003 - 20ft Bld Suburban Parapet

Sep. 24, 2003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pressure coefficient
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2
0
-2
-4
-6
-8
1608
1609
1610
1611
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1701
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1911
1912
1913
1914
1915
1916
2001
2002
2003
2004
2005
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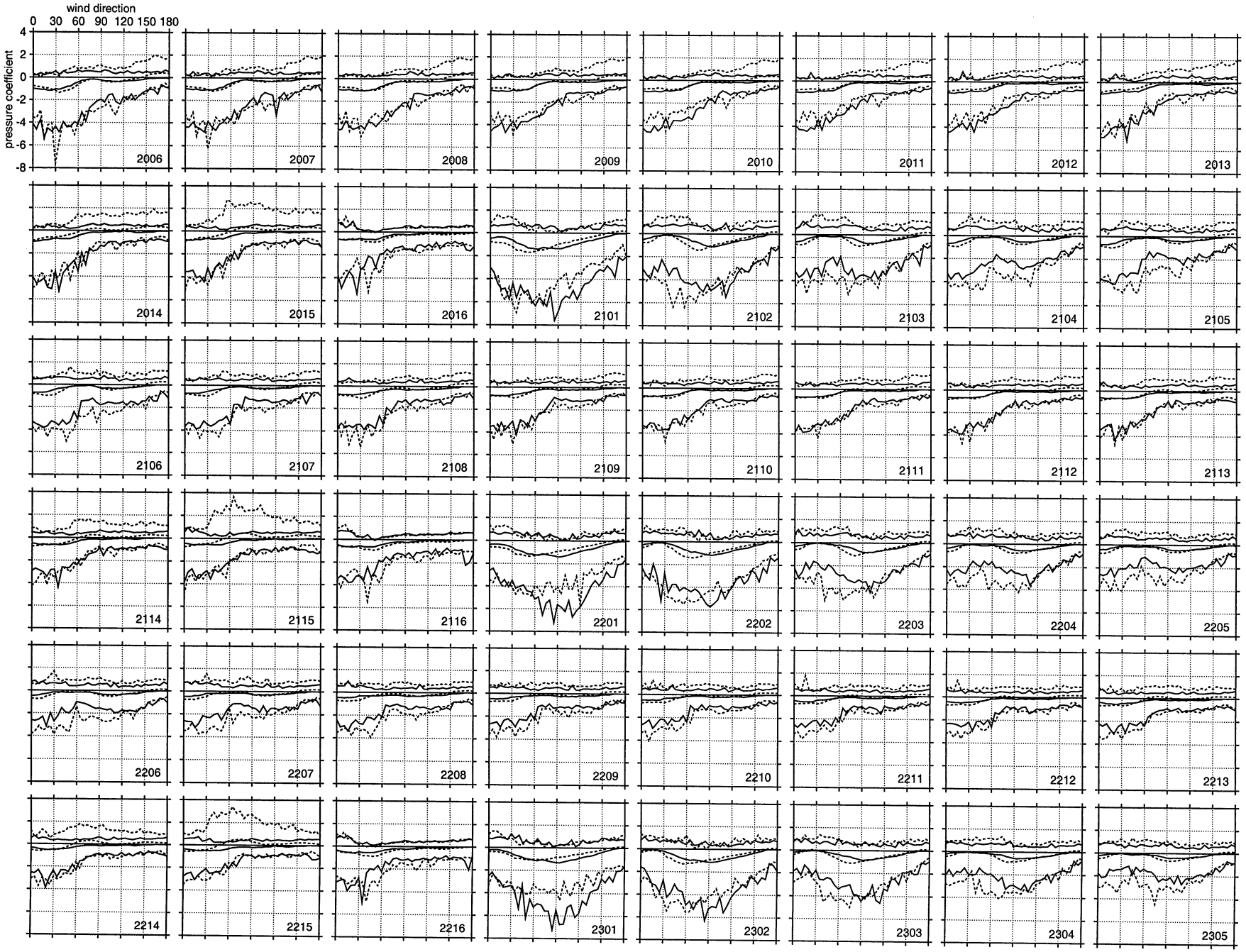
NIST 2003 - 20ft Bld Suburban Parapet

Sep. 24, 2003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pressure coefficient
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0
-2
-4
-6
-8
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2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2101
2102
2103
2104
2105
2106
2107
2108
2109
2110
2111
2112
2113
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2116
2201
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2206
2207
2208
2209
2210
2211
2212
2213
2214
2215
2216
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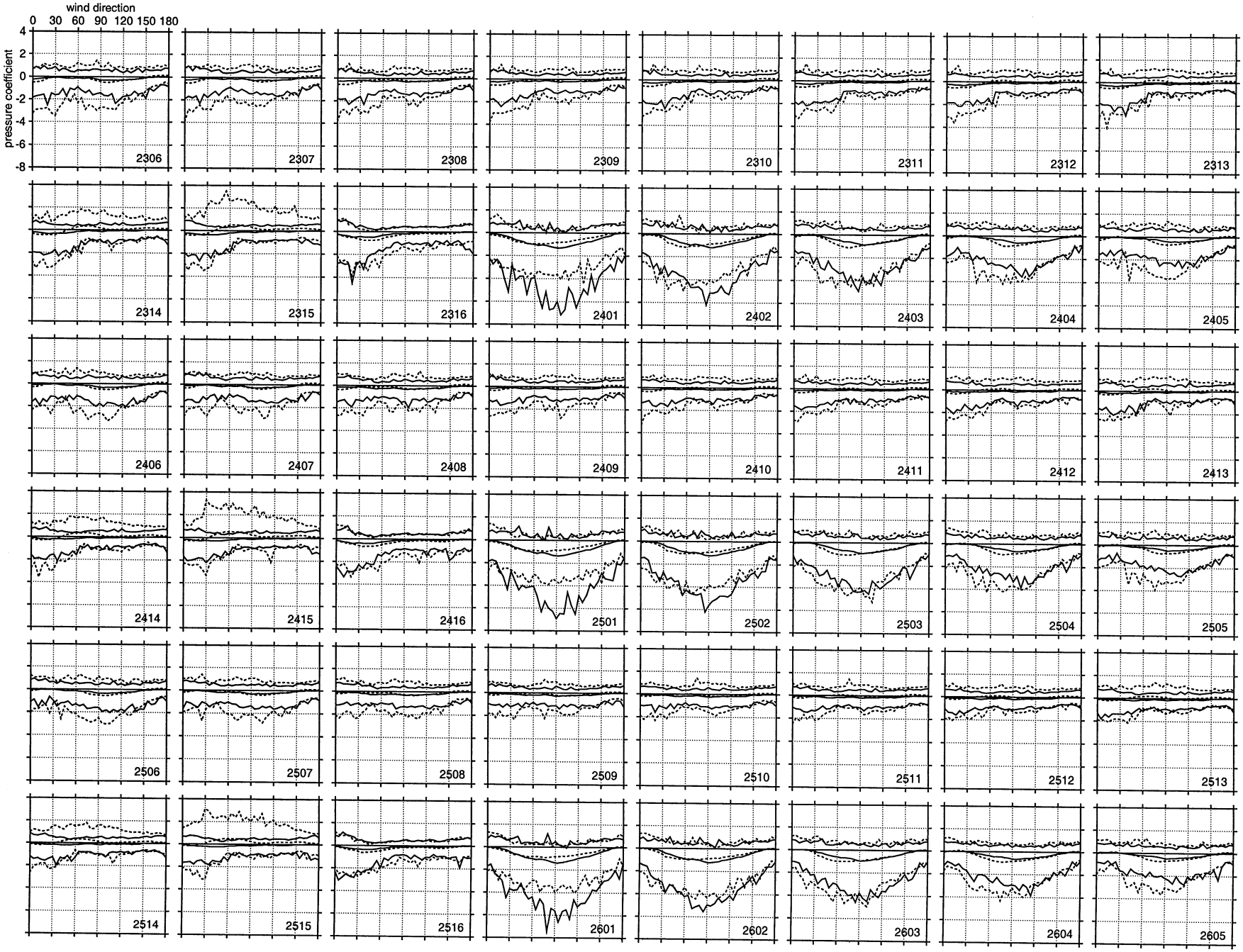
2305
NIST 2003 - 20ft Bld Suburban - No Parapet
NIST 2003 - 20ft Bld Suburban Parapet

Sep. 24, 2003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pressure coefficient
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-2
-4
-6
-8
2306
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2309
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2311
2312
2313
2314
2315
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2503
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2507
2508
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2510
2511
2512
2513
2514
2515
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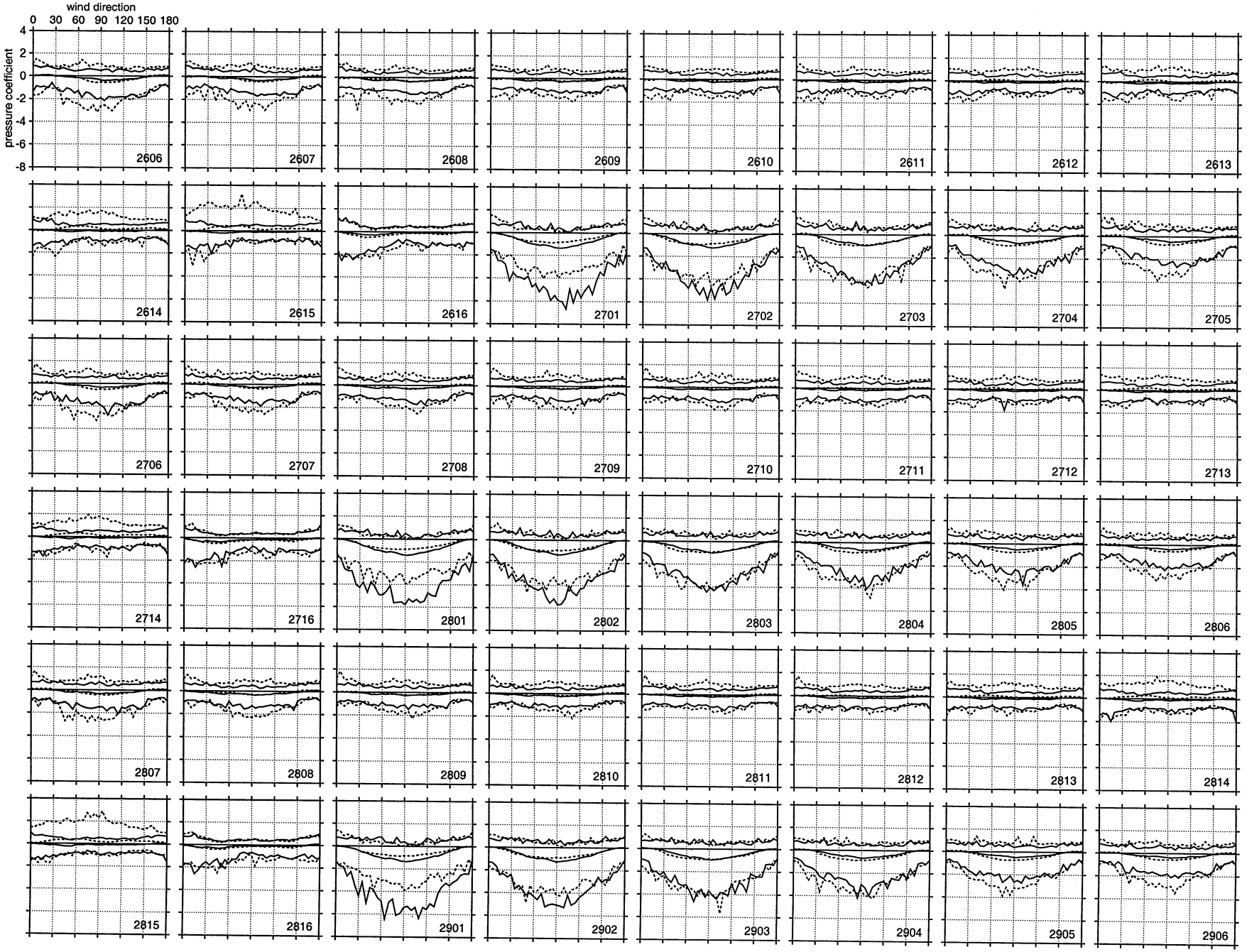
2605
NIST 2003 - 20ft Bld Suburban - No Parapet
NIST 2003 - 20ft Bld Suburban Parapet

Sep. 24, 2003


wind direction
0 30 60 90 120 150 180
pressure coefficient
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0
-2
-4
-6
-8
2606
2607
2608
2609
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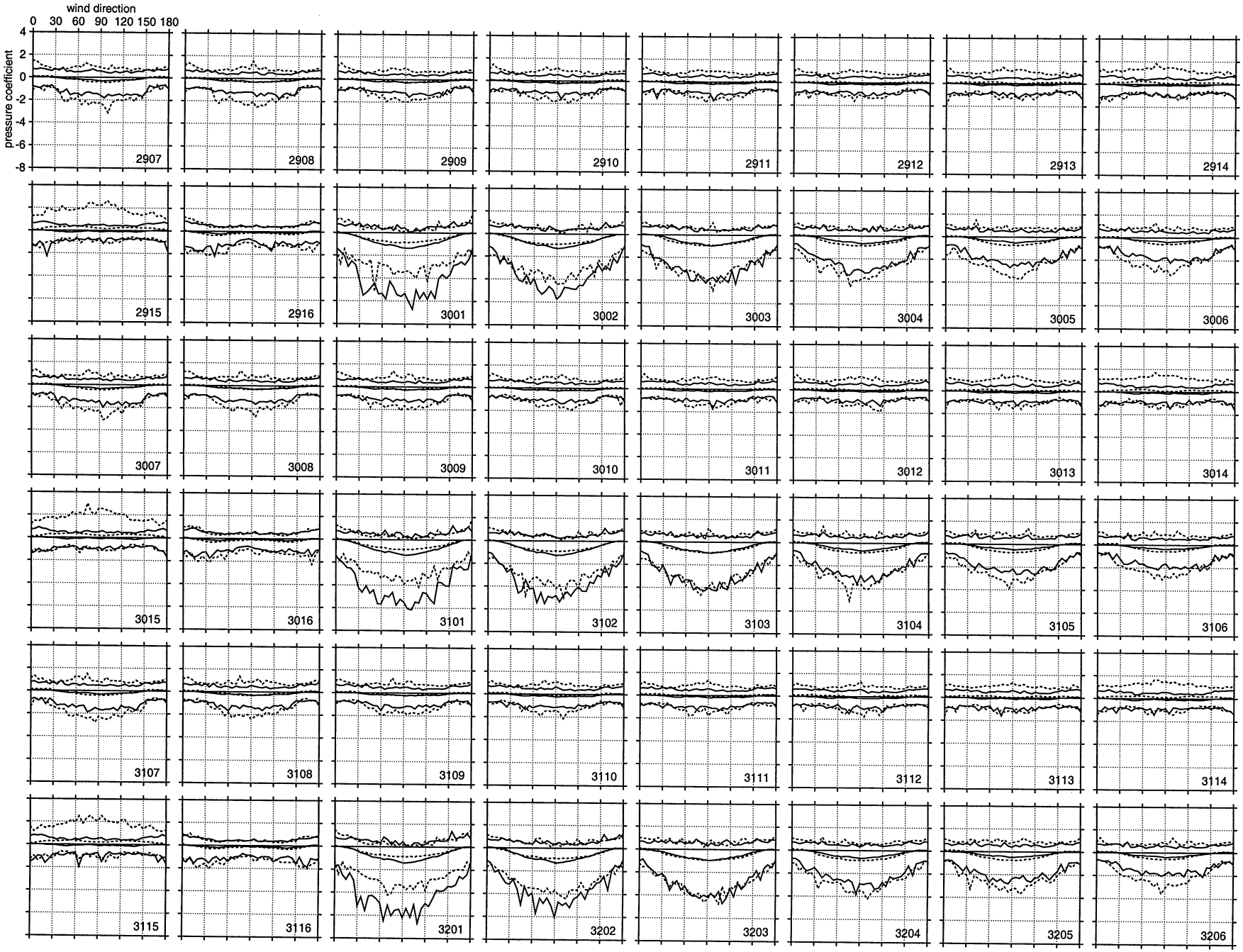
NIST 2003 - 20ft Bld Suburban - No Parapet
NIST 2003 - 20ft Bld Suburban Parapet

Sep. 24, 2003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0 30 60 90 120 150 180
pressure coefficient
4
2
0
-2
-4
-6
-8
2907
2908
2909
2910
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3111
3112
3113
3114
3115
3116
3201
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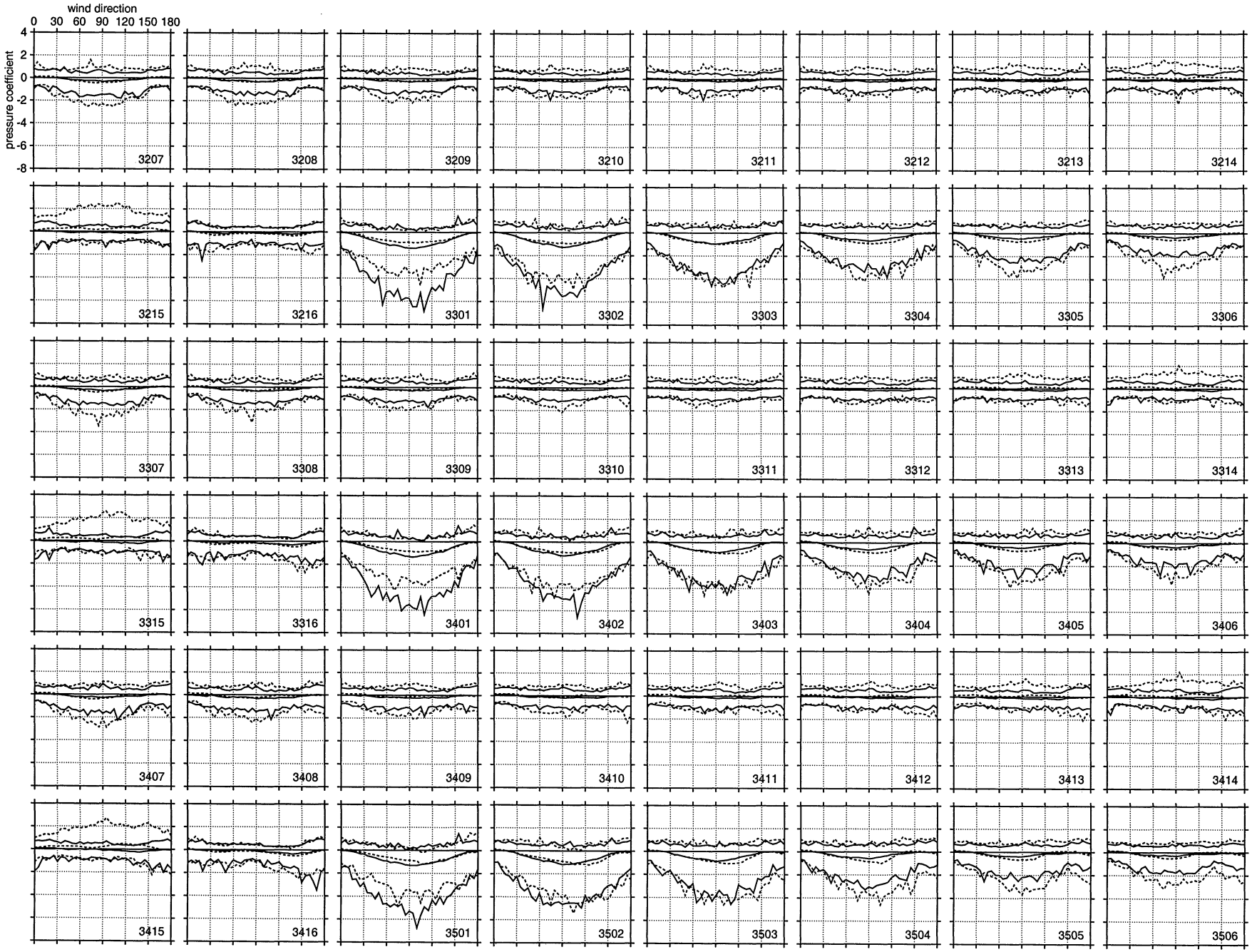
3205
3206
NIST 2003 - 20ft Bld Suburban - No Parapet
NIST 2003 - 20ft Bld Suburban Parapet

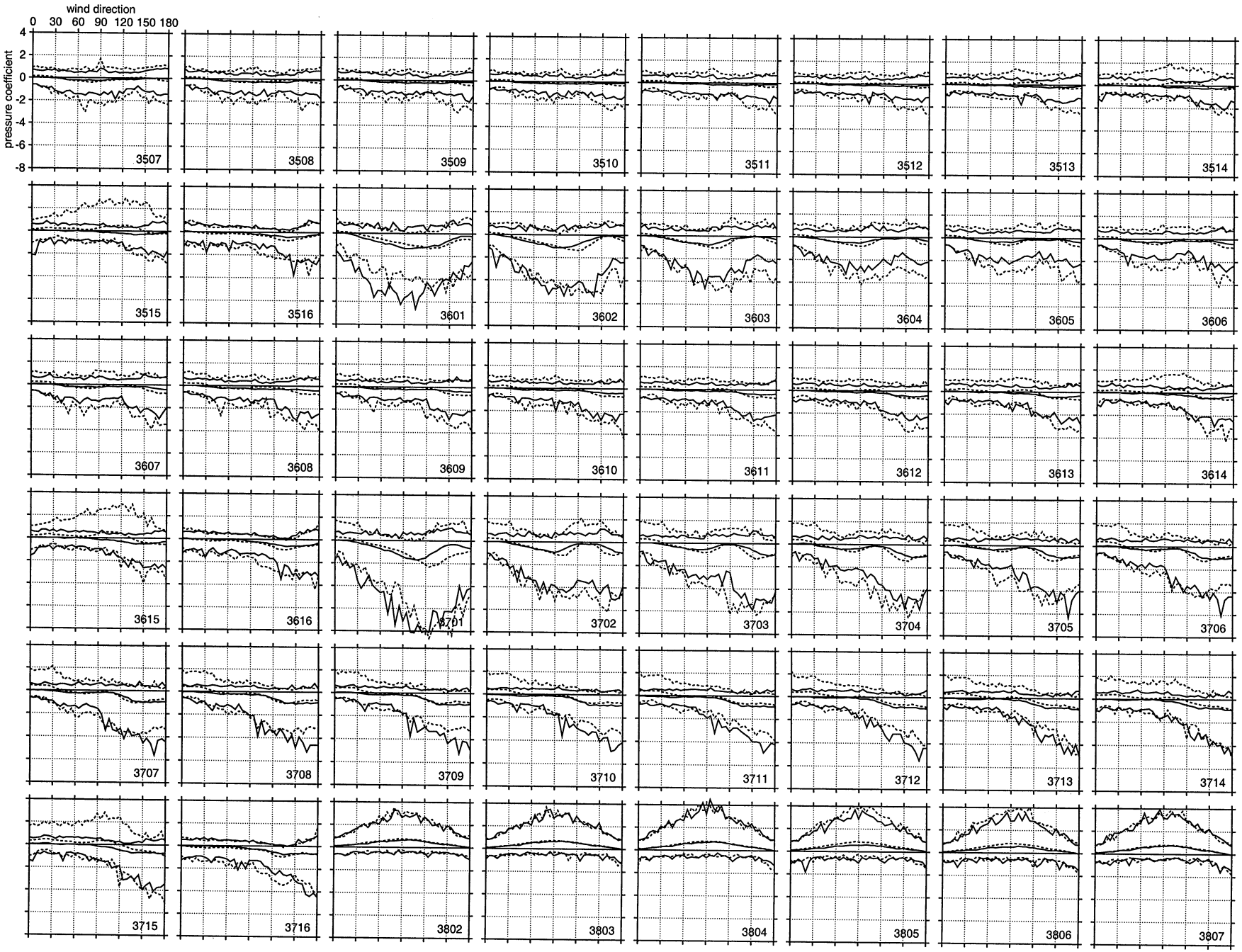
Sep. 24, 2003



NIST 2003 - 20ft Bld Suburban - No Parapet

NIST 2003 - 20ft Bld Suburban Parapet

Sep. 24, 2003


wind direction
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pressure coefficient
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2
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-2
-4
-6
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3704
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3707
3708
3709
3710
3711
3712
3713
3714
3715
3716
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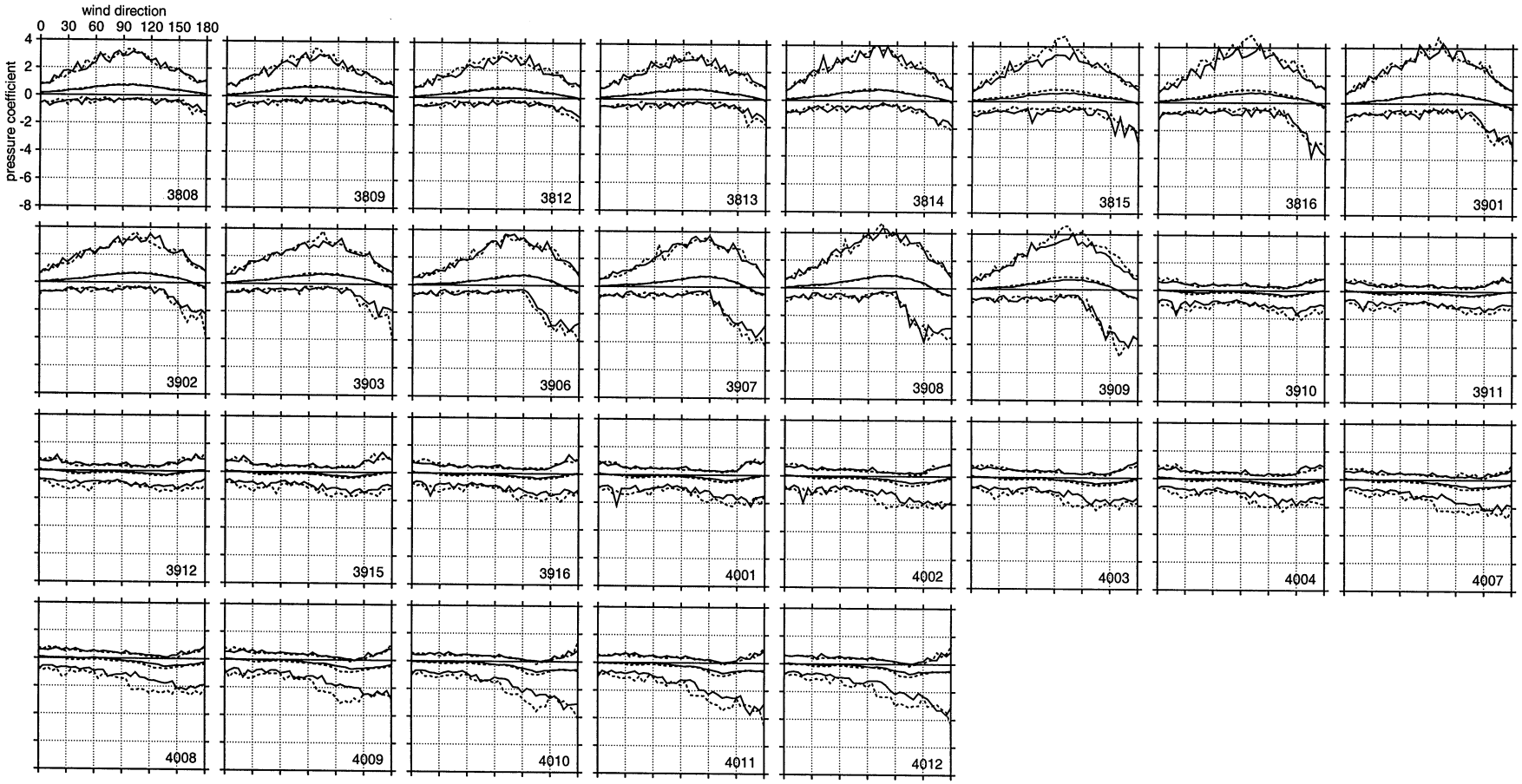
3806
3807
NIST 2003 - 20ft Bld Suburban - No Parapet
NIST 2003 - 20ft Bld Suburban Parapet

Sep. 24, 2003


wind direction
0 30 60 90 120 150 180
pressure coefficient
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2
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-2
-4
-6
-8
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3809
3812
3813
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3815
3816
3901
3902
3903
3906
3907
3908
3909
3910
3911
3912
3915
3916
4001
4002
4003
4004
4007
4008
4009
4010
4011
4012
NIST 2003 - 20ft Bld Suburban - No Parapet
NIST 2003 - 20ft Bld Suburban Parapet

Sep. 24, 2003

APPENDIX F

COMPARISON OF PRESSURE COEFFICIENTS BETWEEN TEST 1 (1:200 SCALE) AND TEST 3 (1:100 SCALE) – ROOF TAPS

Test 1

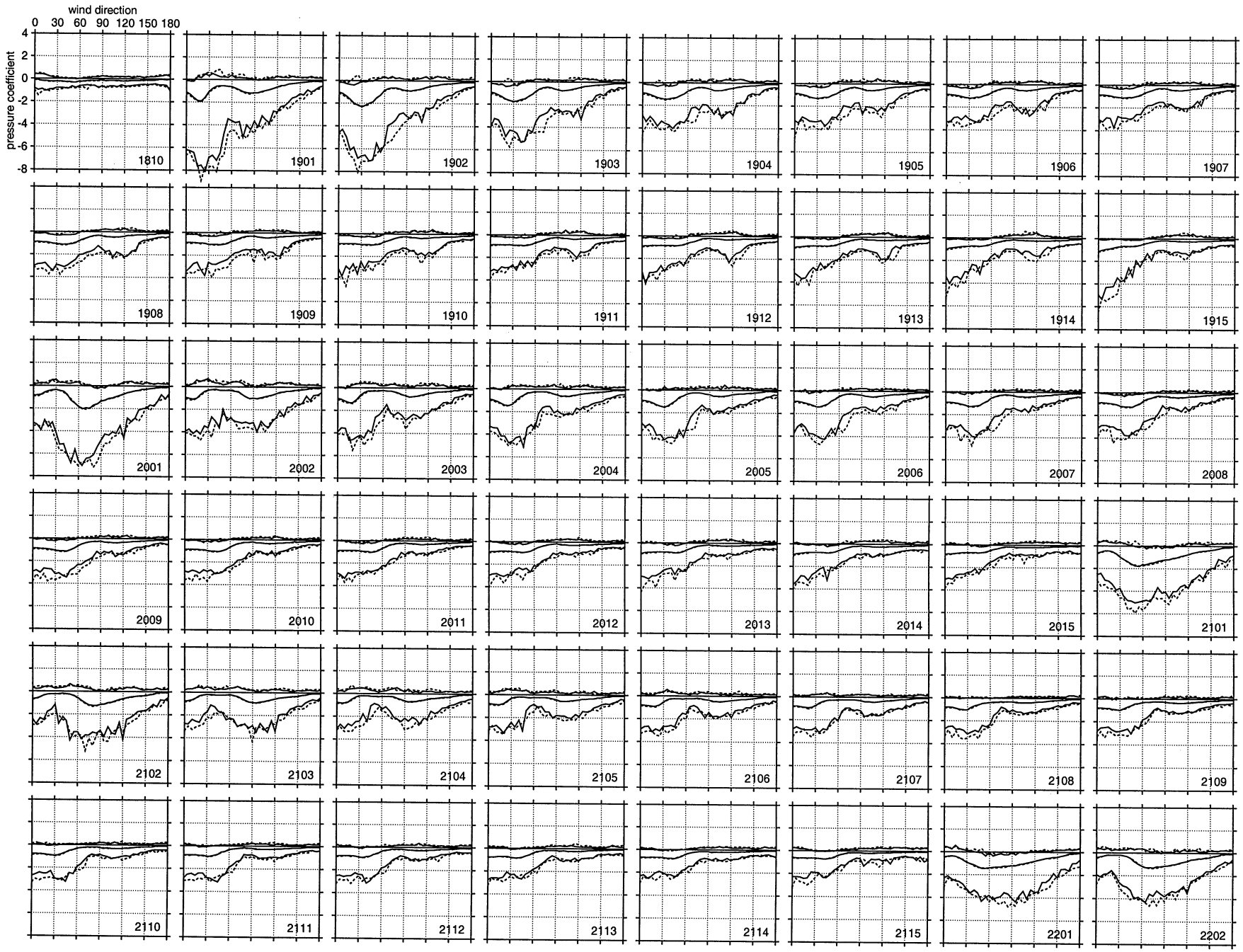
- Length scale: 1:200
- Model dimensions: 200'x100'
- Roof slope: 1:24
- Building heights: 20'

Test 3

- Length scale: 1:100
- Model dimensions: 100'x50'
- Roof slope: 1:24
- Building heights: 16'

Note that the tap locations on the roof from the two tests match when normalized by their respective building height.

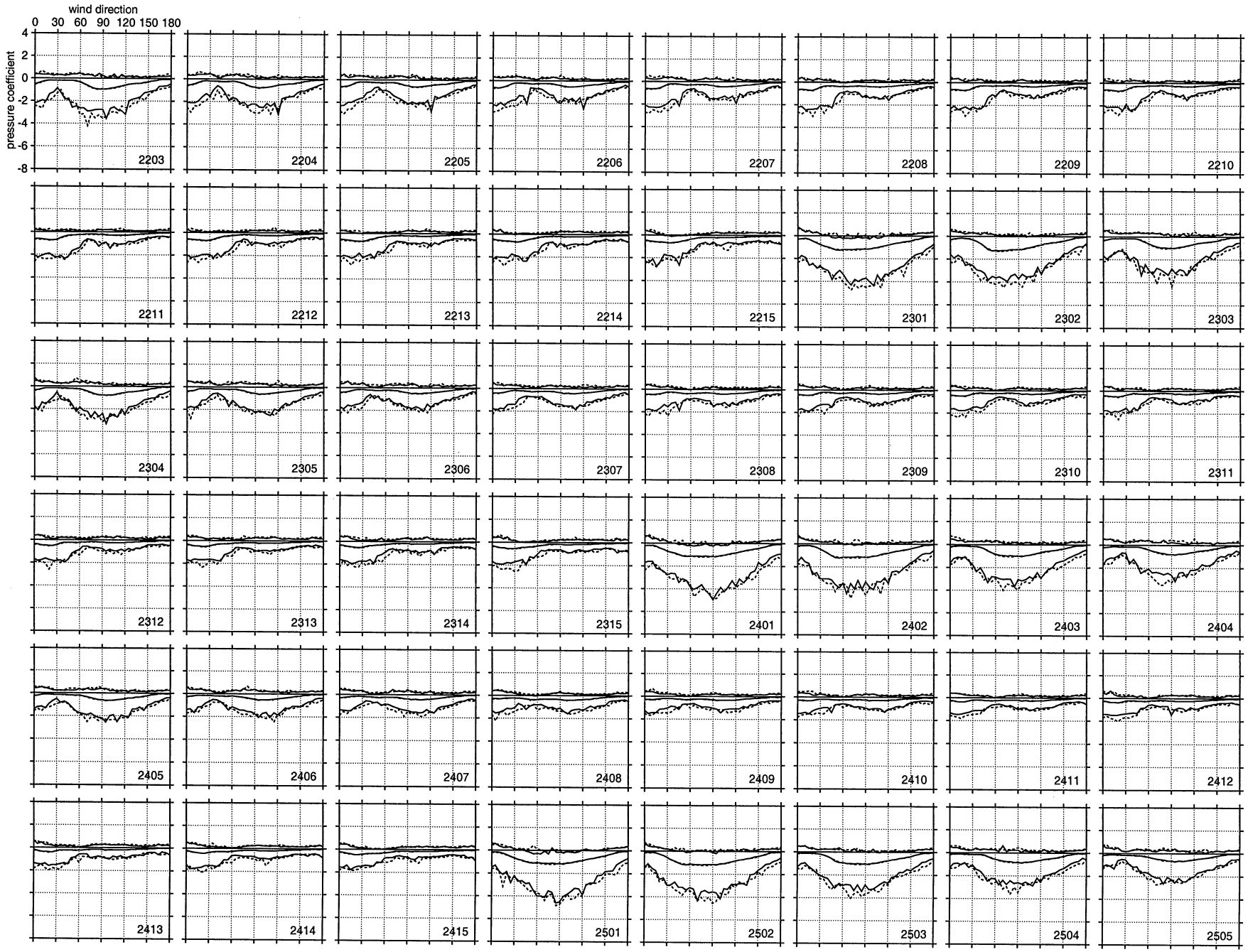
Open Exposure



NIST 2003 - 32ft Bld Open Country - No Parapet Roof taps

NIST 2003 - 16ft Bld Open Country No Extension Roof taps

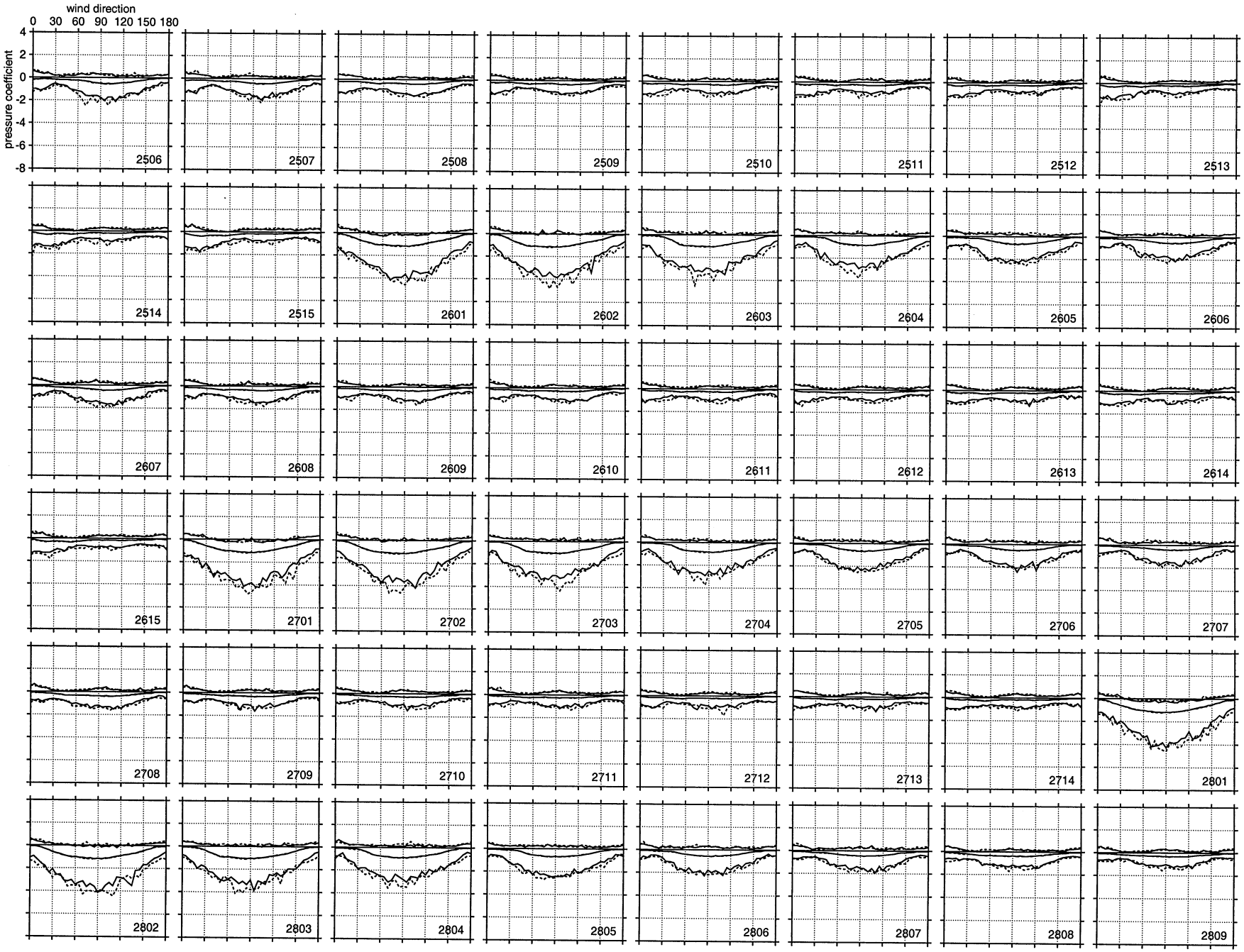
Sep. 25, 2003



NIST 2003 - 32ft Bld Open Country - No Parapet Roof taps

NIST 2003 - 16ft Bld Open Country No Extension Roof taps

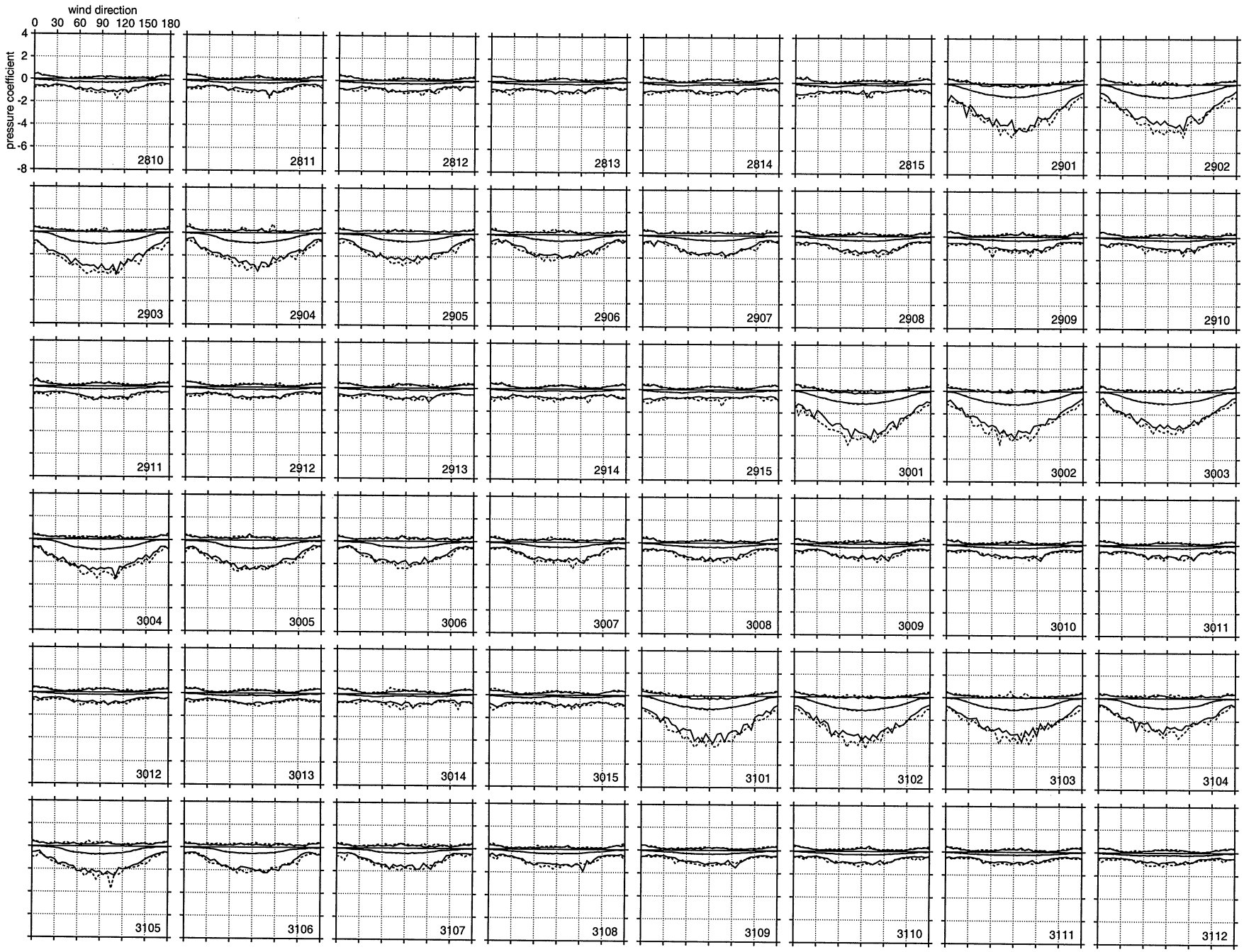
Sep. 25, 2003



NIST 2003 - 32ft Bld Open Country - No Parapet Roof taps

NIST 2003 - 16ft Bld Open Country No Extension Roof taps

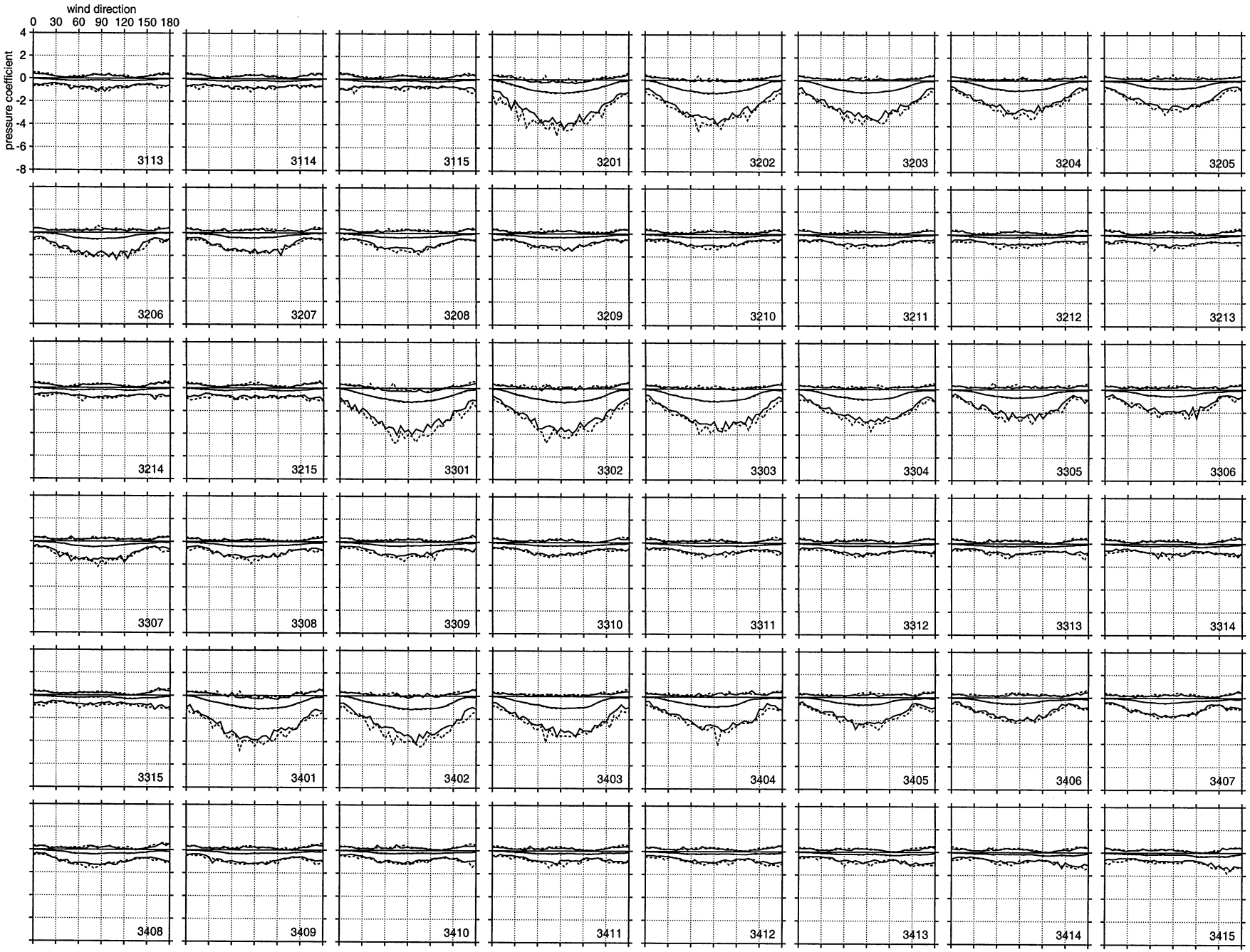
Sep. 25, 2003



NIST 2003 - 32ft Bld Open Country - No Parapet Roof taps

NIST 2003 - 16ft Bld Open Country No Extension Roof taps

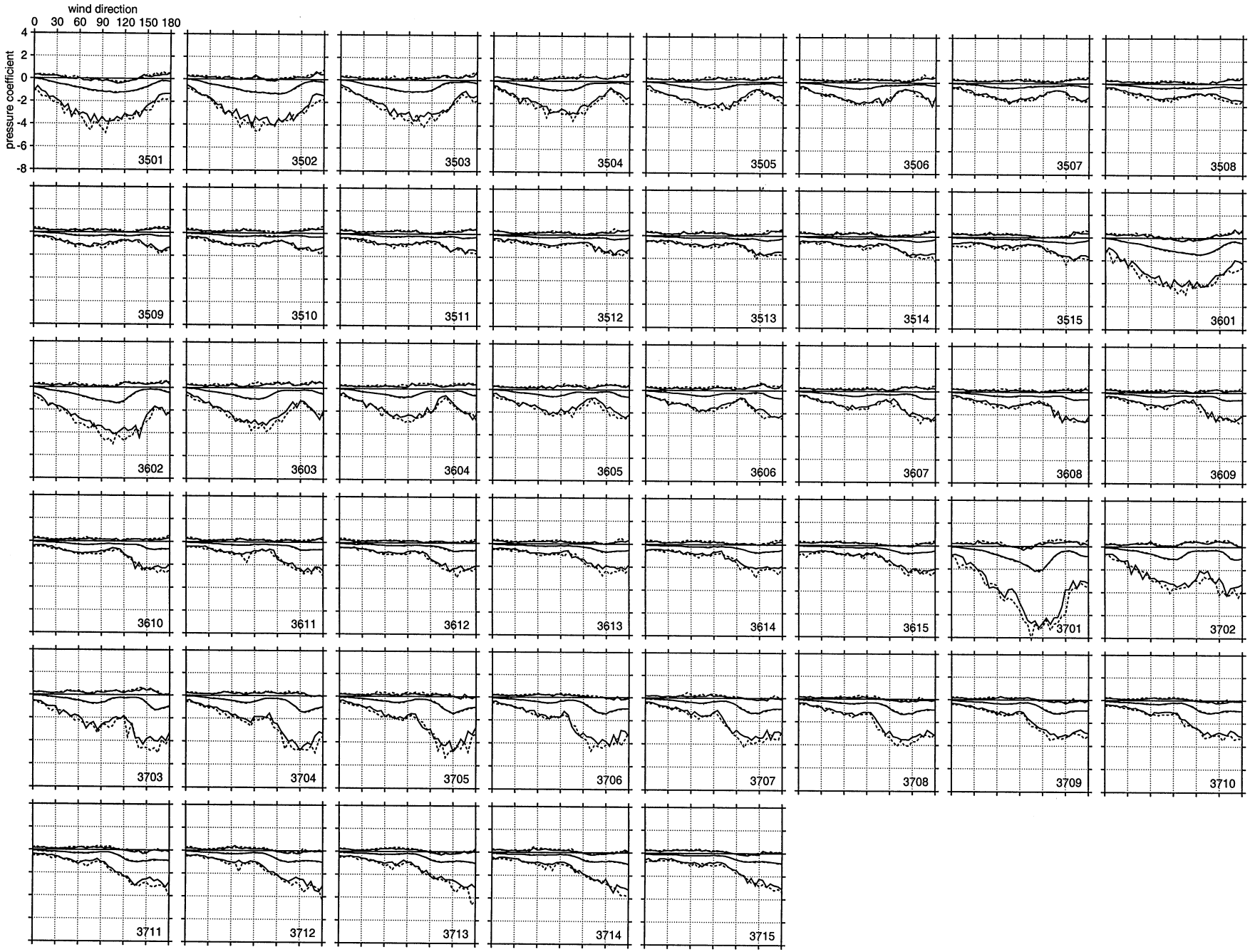
Sep. 25, 2003



NIST 2003 - 32ft Bld Open Country - No Parapet Roof taps

NIST 2003 - 16ft Bld Open Country No Extension Roof taps

Sep. 25, 2003

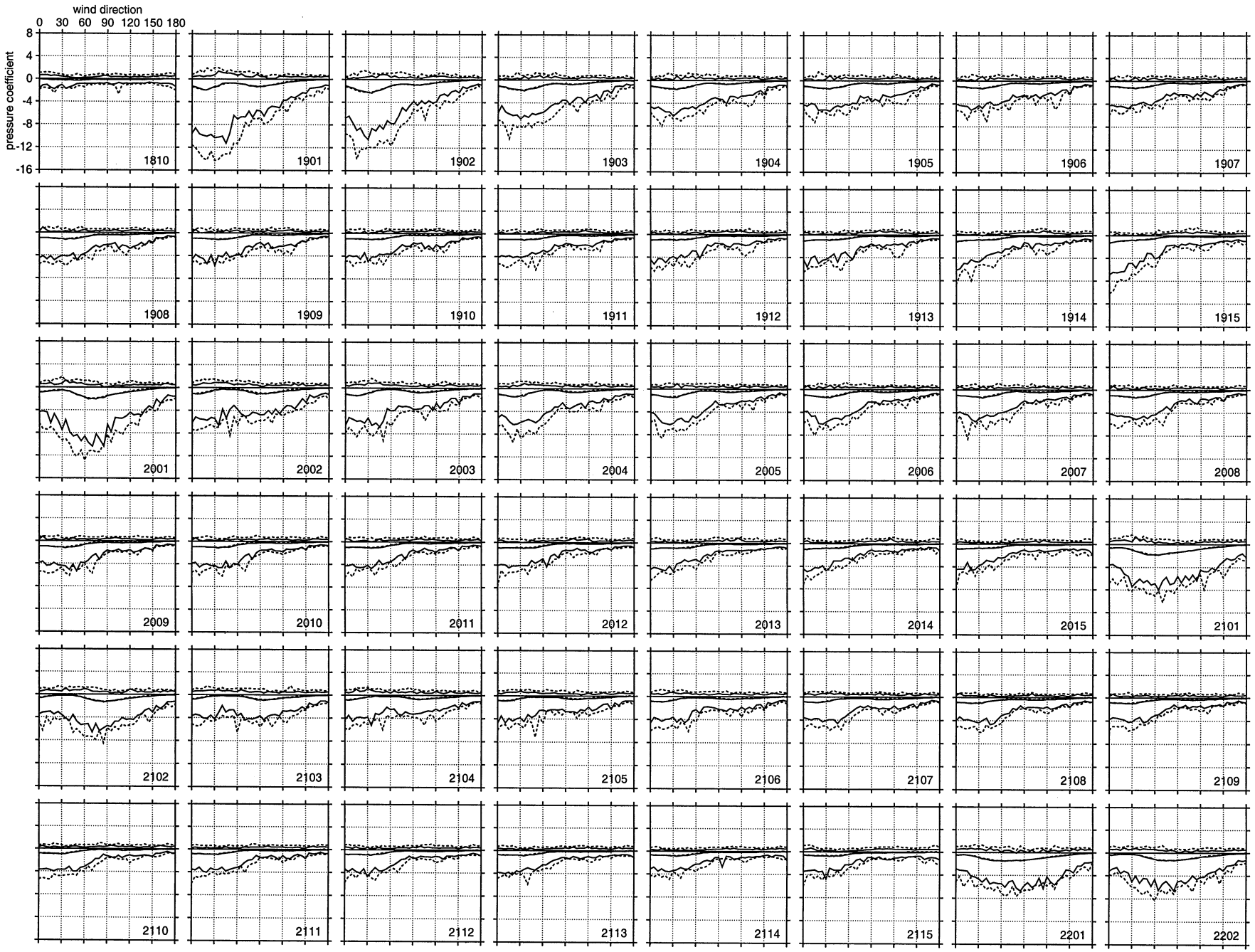


NIST 2003 - 32ft Bld Open Country - No Parapet Roof taps

NIST 2003 - 16ft Bld Open Country No Extension Roof taps

Sep. 25, 2003

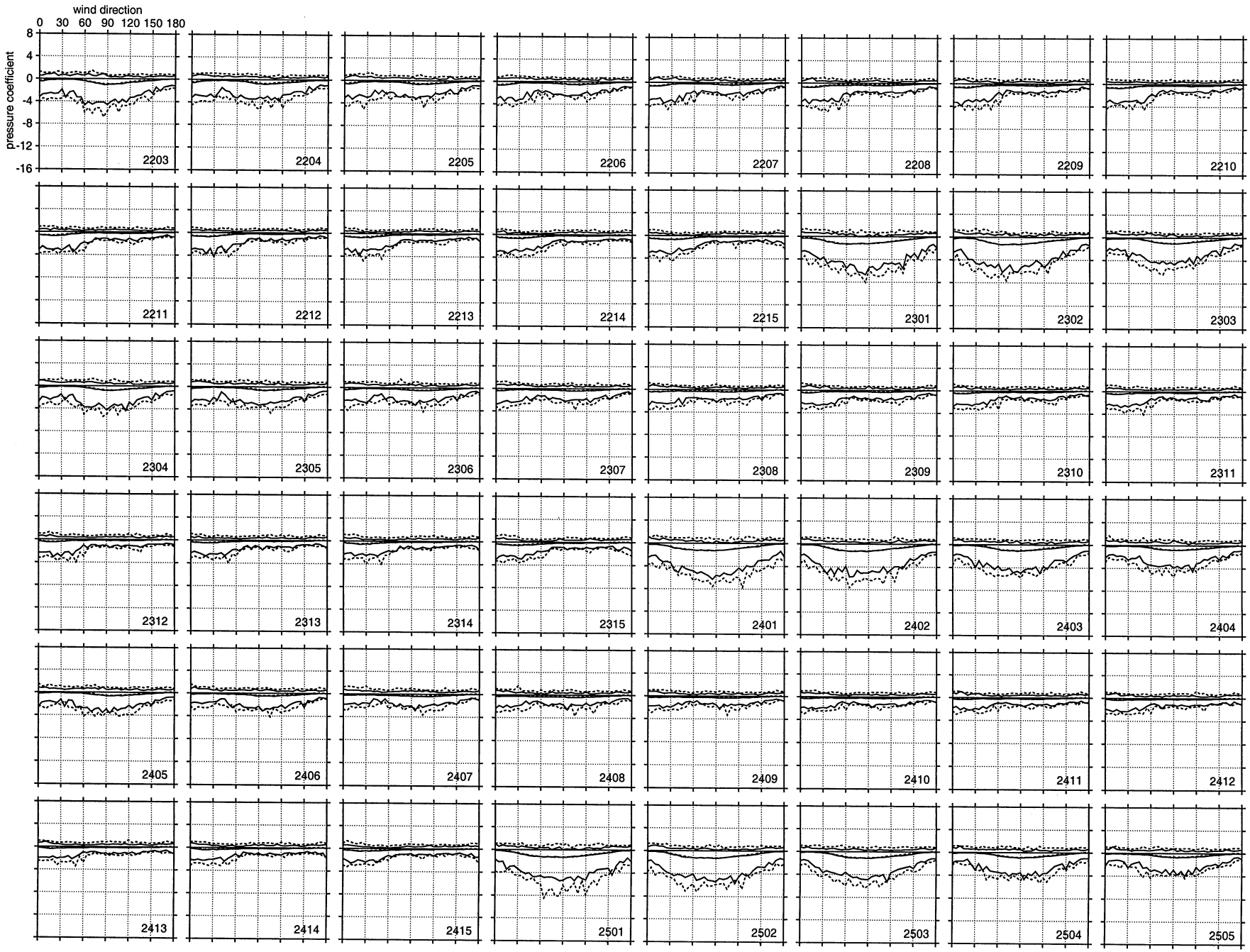
Suburban Exposure



NIST 2003 - 32ft Bld Suburban - No Parapet Roof taps

NIST 2003 - 16ft Bld Suburban No Extension Roof taps

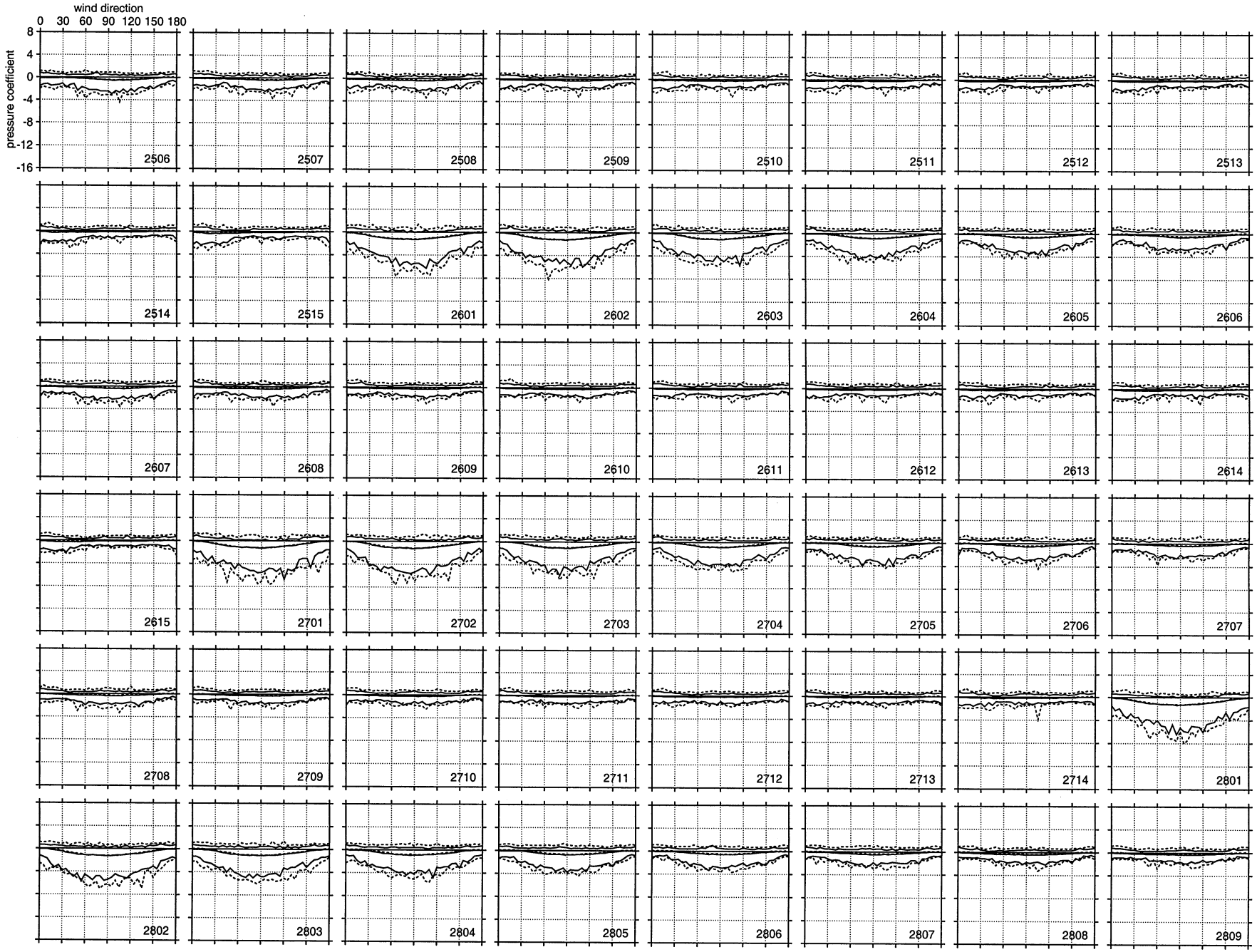
Sep. 25, 2003



NIST 2003 - 32ft Bld Suburban - No Parapet Roof taps

NIST 2003 - 16ft Bld Suburban No Extension Roof taps

Sep. 25, 2003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pressure coefficient
8
4
0
-4
-8
-12
-16
2506
2507
2508
2509
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2513
2514
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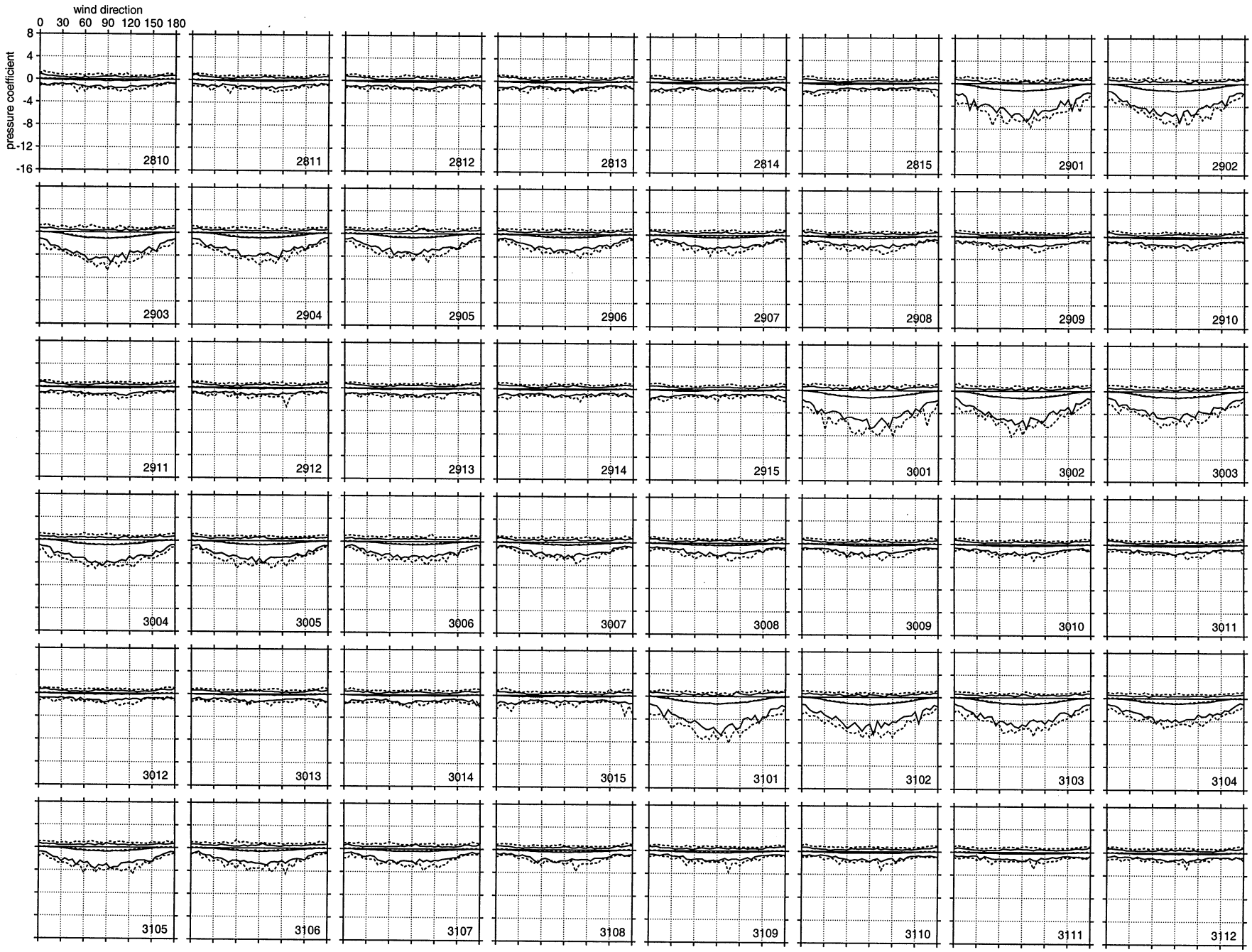
NIST 2003 - 32ft Bld Suburban - No Parapet Roof taps
NIST 2003 - 16ft Bld Suburban No Extension Roof taps

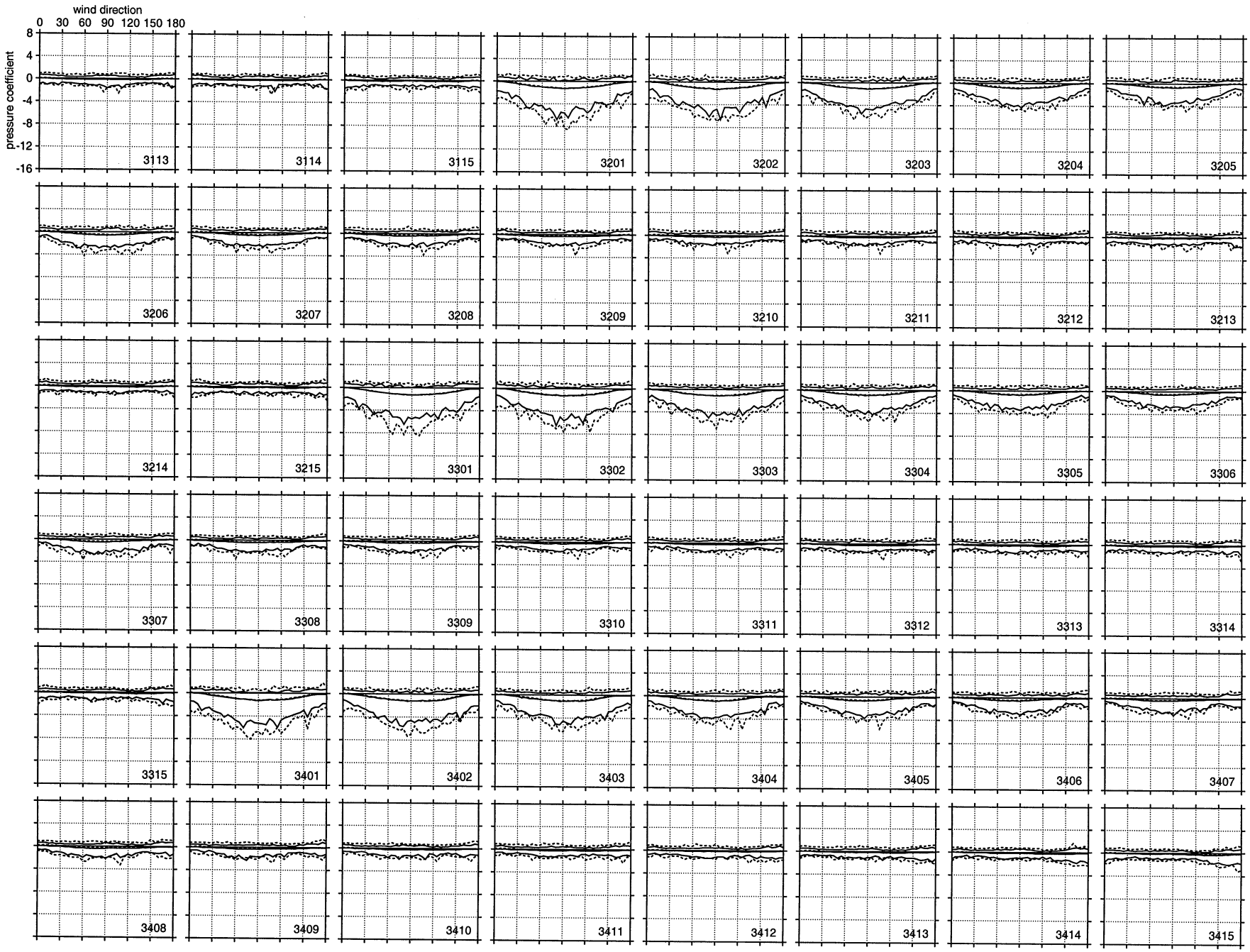
Sep. 25, 2003



NIST 2003 - 32ft Bld Suburban - No Parapet Roof taps

NIST 2003 - 16ft Bld Suburban No Extension Roof taps

Sep. 25, 2003


wind direction
0 30 60 90 120 150 180
pressure coefficient
8
4
0
-4
-8
-12
-16
3113
3114
3115
3201
3202
3203
3204
3205
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3401
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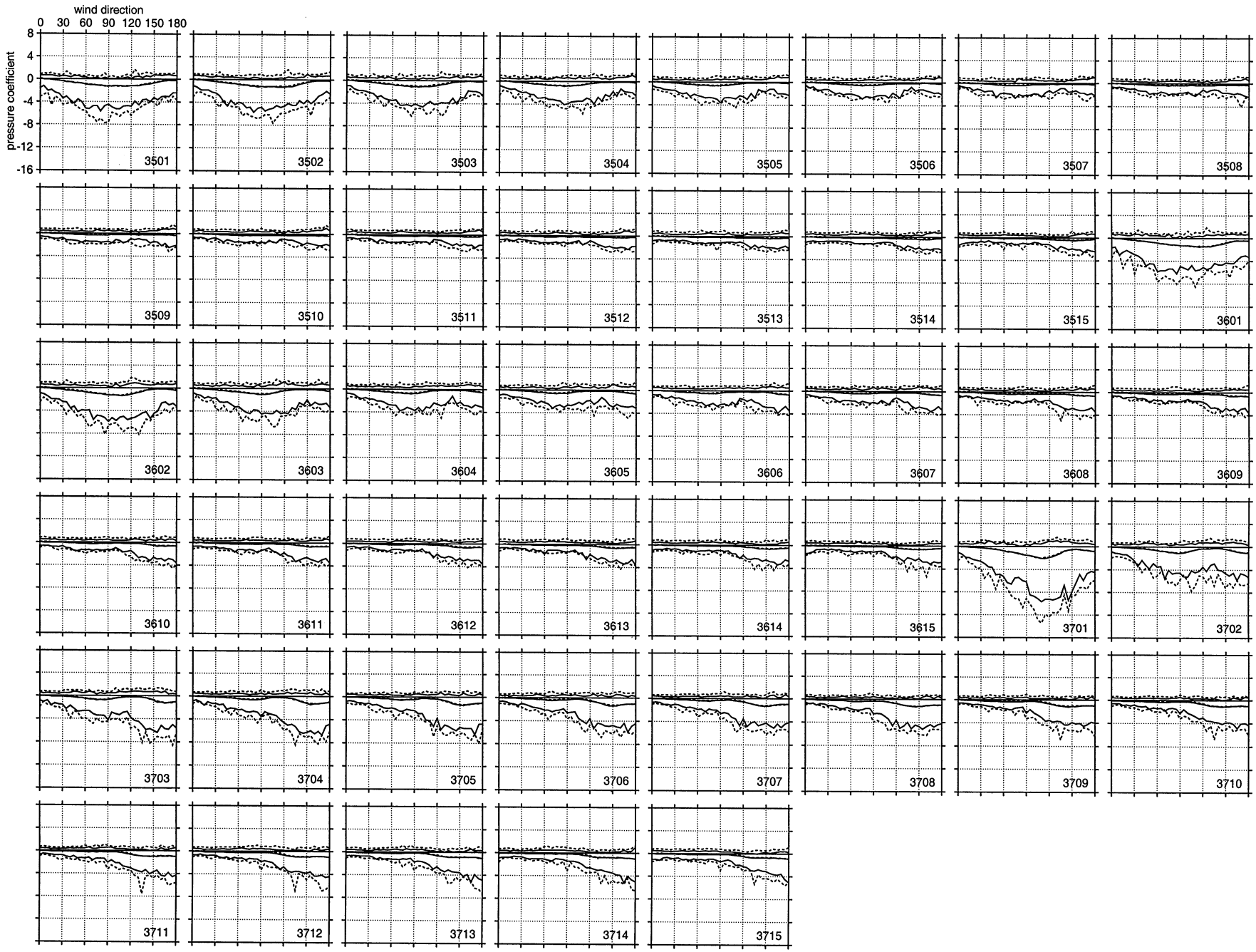
NIST 2003 - 32ft Bld Suburban - No Parapet Roof taps
NIST 2003 - 16ft Bld Suburban No Extension Roof taps

Sep. 25, 2003



NIST 2003 - 32ft Bld Suburban - No Parapet Roof taps

NIST 2003 - 16ft Bld Suburban No Extension Roof taps

Sep. 25, 2003

APPENDIX G

COMPARISON OF PRESSURE COEFFICIENTS BETWEEN TEST 1 (1:200 SCALE) AND TEST 3 (1:100 SCALE) – WALL TAPS

Test 1

- Length scale: 1:200
- Model dimensions: 200'x100'
- Roof slope: 1:24
- Building heights: 20'

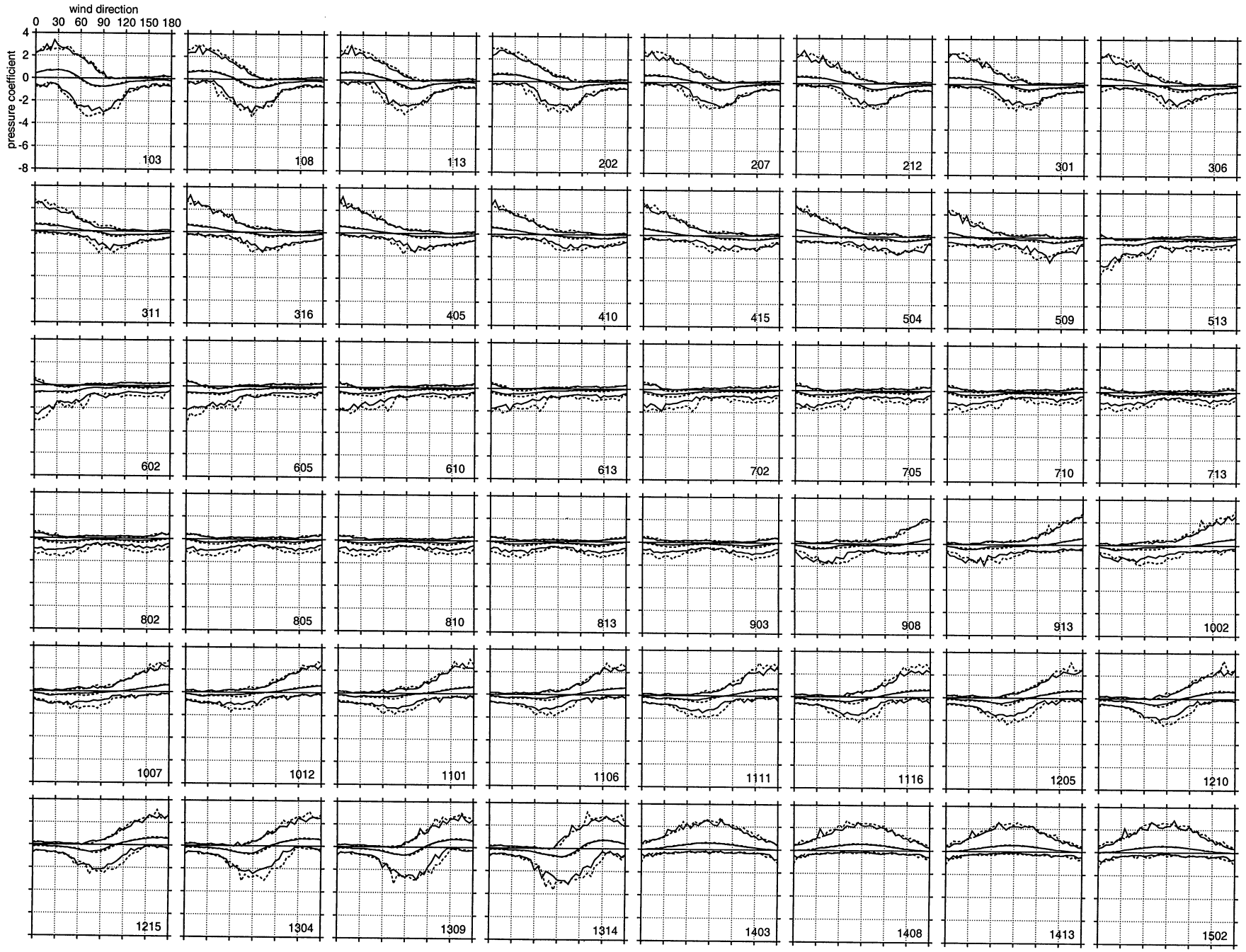
Test 3

- Length scale: 1:100
- Model dimensions: 100'x50'
- Roof slope: 1:24
- Building heights: 16'

Comparison were made on the taps from the second line from the top of the Test 1 Building and the third line of taps from the top of the Test 3 Building.

Note that the taps from the two tests were selected based on the location of the taps from ground relative to the building height. The nomenclature follows that of Test 3.

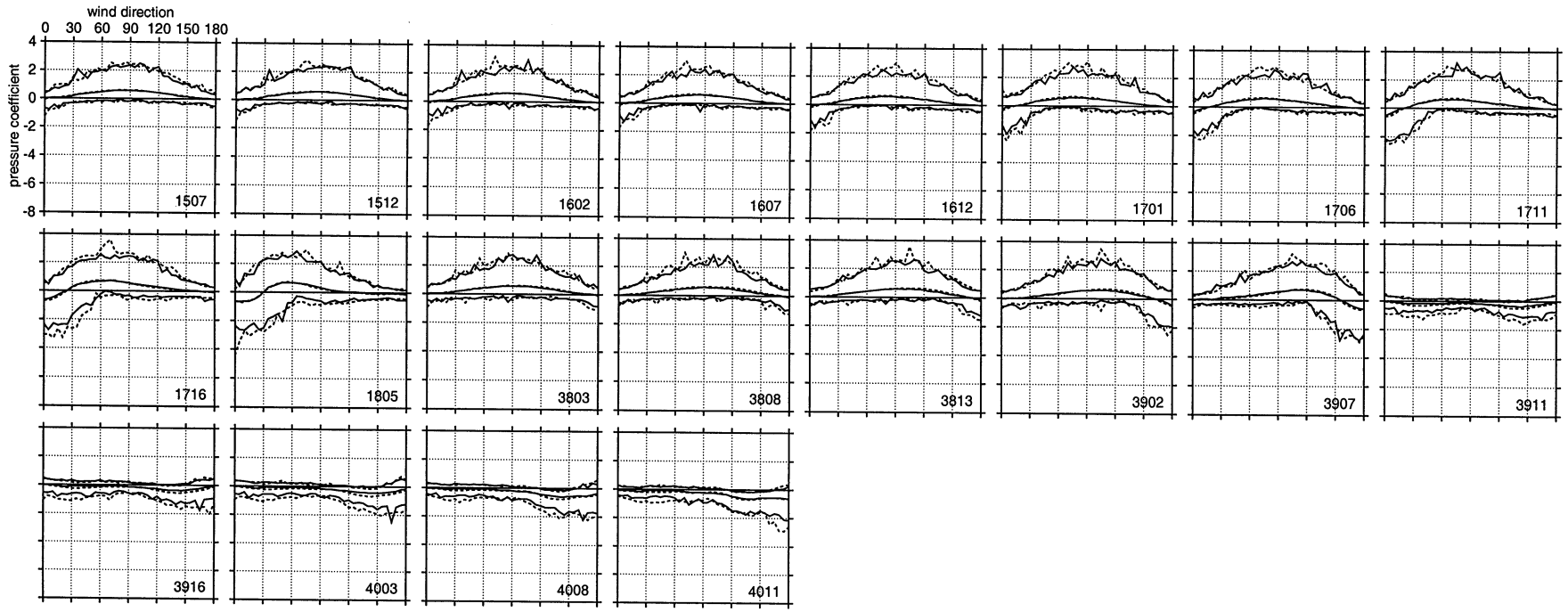
Open Exposure



NIST 2003 - 20ft Bld Open Country - 1:200

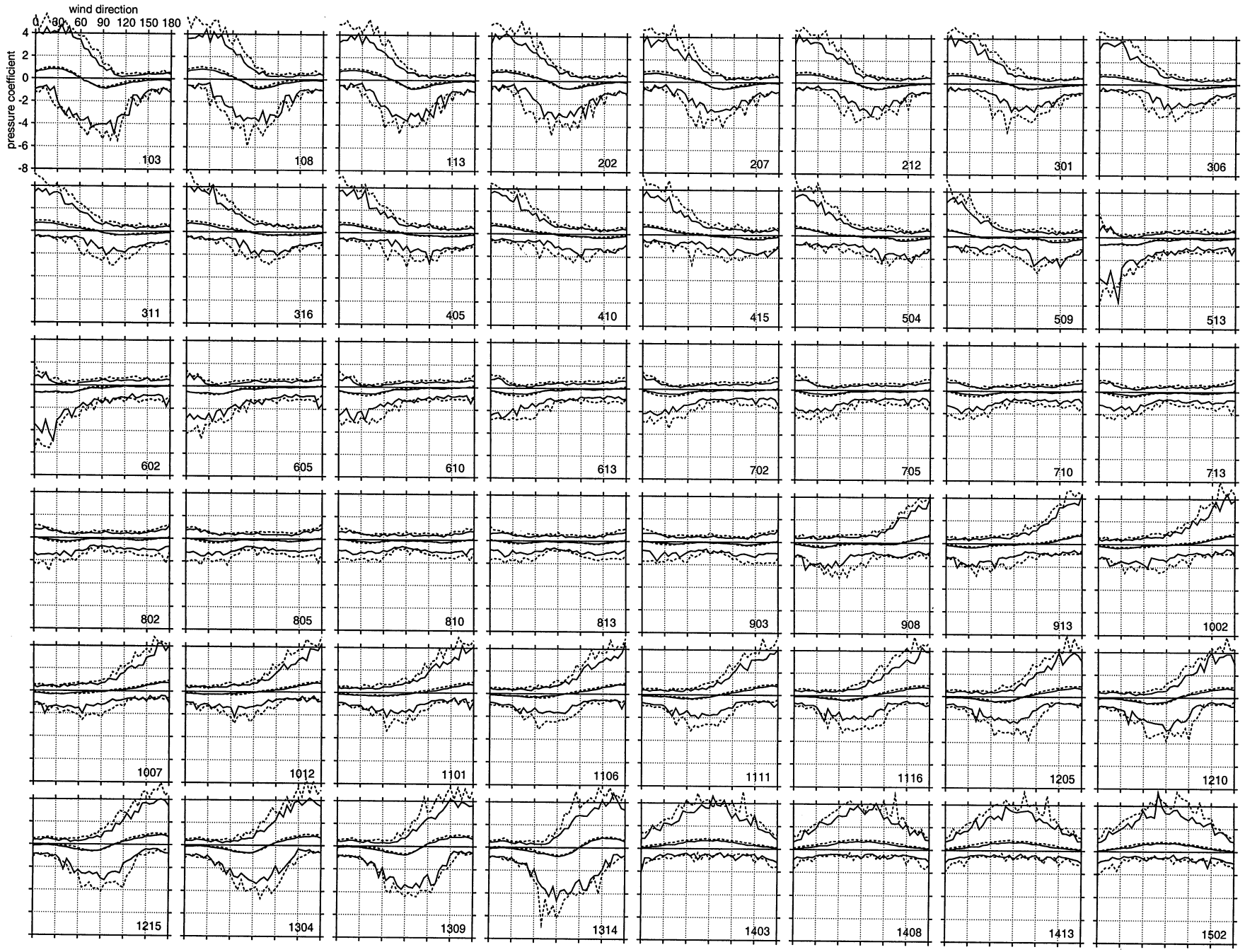
NIST 2003 - 16ft Bld Open Country - 1:100

Sep. 25, 2003


wind direction
0 30 60 90 120 150 180
pressure coefficient
4
2
0
-2
-4
-6
-8
1507
1512
1602
1607
1612
1701
1706
1711
1716
1805
3803
3808
3813
3902
3907
3911
3916
4003
4008
4011
NIST 2003 - 20ft Bld Open Country - 1:200
NIST 2003 - 16ft Bld Open Country - 1:100

Sep. 25, 2003

Suburban Exposure



NIST 2003 - 20ft Bld Suburban - 1:200

NIST 2003 - 16ft Bld Suburban - 1:100

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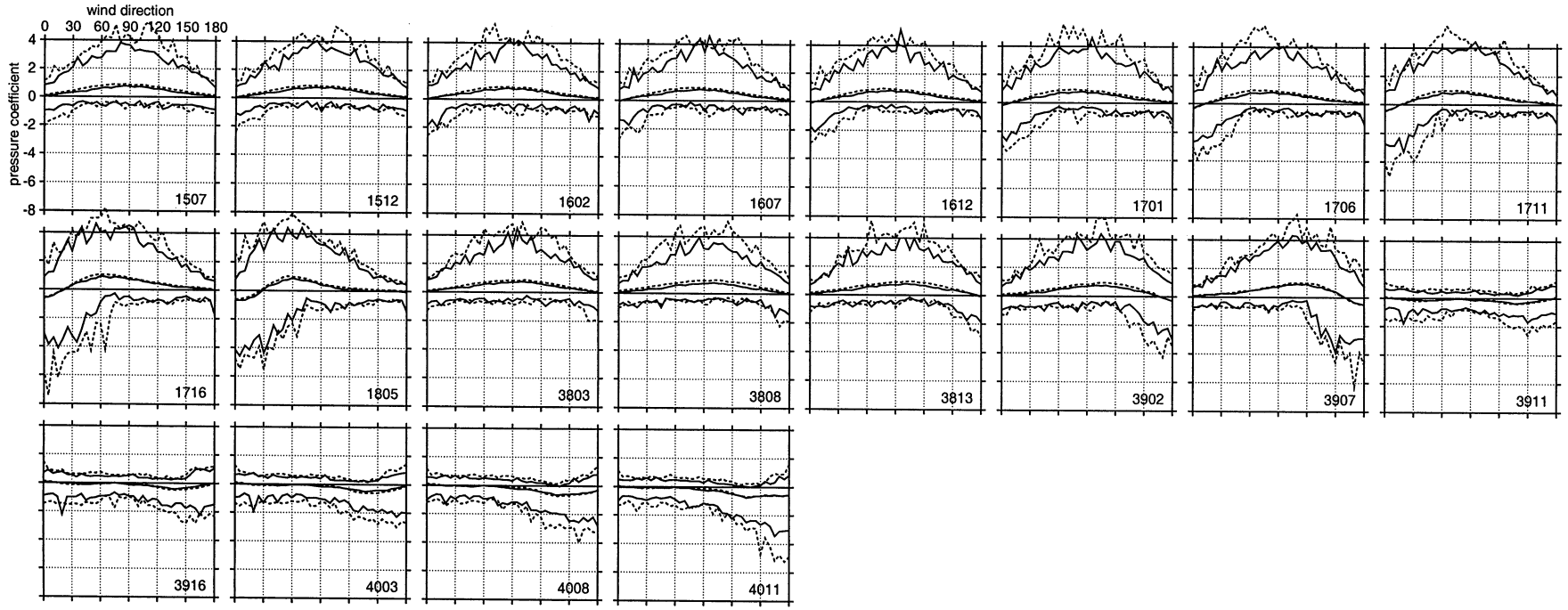
wind direction
0 30 60 90 120 150 180
pressure coefficient
4
2
0
-2
-4
-6
-8
1507
1512
1602
1607
1612
1701
1706
1711
1716
1805
3803
3808
3813
3902
3907
3911
3916
4003
4008
4011
NIST 2003 - 20ft Bld Suburban - 1:200
NIST 2003 - 16ft Bld Suburban - 1:100

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