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A Comparison of Background Noise Levels Collected at the Portland Wind Energy Project in Victoria, Australia

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ABSTRACT

The New Zealand Standard 6808:1998 *Acoustics - The assessment and measurement of sound from wind turbine generators* (the "New Zealand Standard") is currently used in the State of Victoria, Australia to assess noise emissions from wind farms.

The New Zealand Standard requires that background noise monitoring be undertaken at the nearest affected residential properties before the wind farm is operational. The measured background noise levels are then correlated with wind speed data collected on site to determine noise limits.

Once the wind farm is operational, ambient noise levels must be measured at the same location as was used for background noise monitoring. The background noise levels are then subtracted from the measured ambient noise levels to determine the derived "wind farm only" noise levels.

In practice, background and ambient noise levels are usually measured a few years apart.

For their approved Portland Wind Energy Project (PWEP), developers Pacific Hydro carried out the required background noise monitoring at nearby residential properties for a minimum 10 day period during 2004/2005 before submitting their planning application. In addition, they have carried out further background noise monitoring campaigns at the same residential properties during 2005 to 2008, in order to collect a more comprehensive dataset and determine whether seasonal variations significantly affect the noise impact assessment.

This paper presents a comparison of background noise levels measured at the PWEP together with the respective wind roses. It discusses changes in background noise levels and the impact of those changes on the noise impact assessment.

1. INTRODUCTION

As part of their planning permit application for the development of the Portland Wind Energy Project (PWEP) in Victoria, Australia, developers Pacific Hydro have undertaken background noise monitoring at selected properties in the vicinity of the proposed site between 2004 and 2005. In addition to this monitoring, they have repeated background noise monitoring at the same properties between 2005 and 2008 in order to collect a more comprehensive dataset and determine whether seasonal variations significantly affect the noise impact assessment.

The results of this extensive background noise monitoring campaign have been analysed and are presented in this paper.

2. SITE DESCRIPTION

The PWEP is located in south western Victoria and comprises the following four projects:

- Yambuk (PWEP I)
- Cape Bridgewater (PWEP II)
- Cape Nelson South (PWEP III)
- Cape Nelson North and Cape Sir William Grant (PWEP IV)

Yambuk (PWEP I) has not been included in this study as background noise monitoring was only undertaken once at properties in the vicinity of this site, for the noise impact assessment.

The Cape Bridgewater wind farm can be considered to comprise two sites. With the two sites also considered for PWEP IV, a total of five sites, across 3 wind farms, are considered in this paper. These sites are presented in Figure 1.

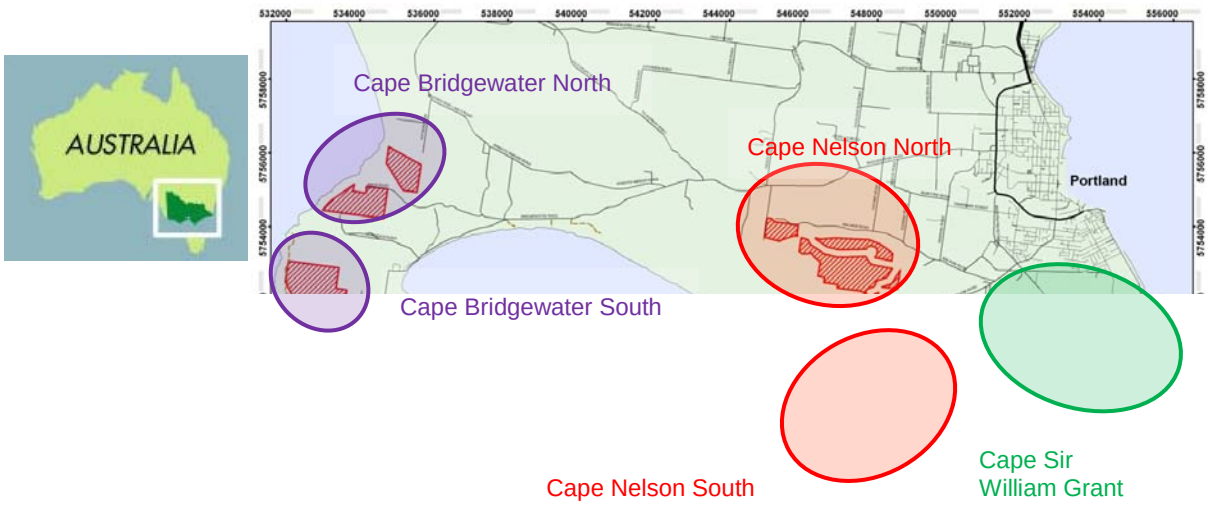

Figure 1 – Study sites location

The Cape Bridgewater wind farm covers a significant proportion of Cape Bridgewater along its western side. It comprises **Cape Bridgewater North (CBN)** and **Cape Bridgewater South (CBS)**. The coastal escarpment on the west is 30 to 40m above sea level, and away from it the area features a gently undulating landscape. The north area offers a slightly more complex topography than the south area. Most native vegetation has been cleared from this site and there is predominantly introduced vegetation, mainly in the form of grazing pasture.

The **Cape Nelson South (CNS)** wind farm is located in a coastal headland surrounded by coastal cliffs and escarpments which rise between 40 to 70m above sea level. The cape itself undulates slightly, generally rising up to Picnic Hill in the centre at 110m, and from this point the landform slopes downwards undulating gradually inland to the north east at an average height of 70-80m before dropping down to around 30m closer to Portland. In general, the area has a reasonably undulating pastoral landscape character. Although predominantly open, the pastoral setting supports scattered, stands of low remnant vegetation. The western coastal edge and southern section of the Cape have a dense cover of low remnant vegetation.

The **Cape Nelson North (CNN)** site is situated 2 km to the east of Portland northwards of Cape Nelson and approximately 3 km inland. Generally the site shows strong undulating character and is dominated by low sand dunes which forming irregular ridges. The average elevation above sea level is 65m. The site is divided along the south-western direction from the beach zone by a massive dune system with elevation up to 110m above sea level.

The **Cape Sir William Grant (CSWG)** site is located approximately 3 km to the south of Portland and shows generally coastal landscape character. The area consists of the cape itself and some narrow sections along the coastline which are delimited to the seaside by partially steep escarpments. The top of the cape is predominantly flat and features large cleared areas. From the edge of the cape the landform rises very gradually inland towards the north, containing of undulating and swampy areas before descending back down to the township of Portland. The easterly part of the site is dominated by the infrastructure of the Portland Aluminium Smelter which is situated between Portland and Cape Sir William Grant. Significant re-vegetation has occurred around the smelter in the past and has since given way to a dense cover of low coastal vegetation.

Dwellings located in the vicinity of the study sites along with the noise monitored locations are shown in the site plans of Appendix A.

3. THE NEW ZEALAND STANDARD

The New Zealand Standard 6808:1998 *Acoustics - The assessment and measurement of sound from wind turbine generators* (referred herein as "The New Zealand Standard") is currently used in the State of Victoria to assess noise emissions from wind farms.

Section 4.5 of the New Zealand Standard details recommended methodology for measurement of background noise levels at selected properties in the vicinity of a proposed wind farm site.

The New Zealand Standard recommends collecting 10 minute L_{A95} noise levels for a period of at least 10-14 days in order to give a suitable range of data (typically 1,400 data points). Furthermore, the data should be obtained for the wind speed range of 5-8m/s.

Concurrently, 10 minute averaged wind speeds should be measured on the wind farm site.

In Section 4.5.5, the New Zealand Standard requires that background noise measurements be correlated with wind speeds and that a regression curve is to be used to describe the average background noise level versus the wind speed.

Noise emissions from the proposed wind farm must comply with the background noise level plus 5dBA or 40dBA, whichever is the greater.

Background noise levels are therefore extremely important for the pre-construction noise assessment as different background noise levels will lead to different noise limits.

Furthermore, background noise levels are also subtracted for the post-construction noise levels to obtain a derived "wind farm only" noise level.

4. WIND DATA

Wind speed data used for this analysis has been measured using the wind monitoring masts (met masts) presented in Table 1.

Table 1

Met masts

Site	Met mast	10m AGL wind dataset	Period

CBN	CBN45	10m extrapolated from 30m	2005 - Feb 2007
	CBS70	10m extrapolated from 50m	Feb 2007 - 2008
CBS	CBS70	10m extrapolated from 50m	2005 - 2008
CNN	CNN50	*Climatronics* 10m measured	2004
	CNN70	10m extrapolated from 20m	2008
CNS	CNS50	*NRG* 10m measured	2004 - Apr 2007
	CNS50	10m extrapolated from 50m	Apr 2007 – Jun 2007
	CNS50	10m measured	Jun 2007 - 2008
CSWG	CSWG50	10m measured	2004 – 2008

All wind speed data has been measured with calibrated **Risø** anemometers unless otherwise indicated and has been referenced to 10m above ground level (AGL). When measured 10m AGL data was not available, wind speeds were extrapolated using the average roughness factor for the site.

For each of the monitoring periods, wind roses based on frequency and mean wind speed sector distributions are presented in Appendix B, while average and maximum wind speeds for each period are reported in Appendix C.

5. BACKGROUND NOISE LEVELS

Background noise monitoring was undertaken in accordance with the New Zealand Standard at selected properties in the vicinity of the PWEP between October 2004 and June 2008. The monitored properties together with the monitoring periods are presented in Appendix C.

Background noise levels and wind speeds have been correlated and a regression curve of 2nd or 3rd order has been fitted for each monitoring period. Furthermore, a regression curve has been fitted for the set of *all* data points for each house, which we shall refer to as the *all data regression curve*. Equations for the regression curves are presented in Appendix C together with the coefficients of determination (R^2) and the correlation coefficients.

The correlated data together with the regression curves are provided in Appendix B.

6. DATA ANALYSIS

Background noise levels in rural areas are dependent on many variables, such as:

- Wind generated noise through surrounding vegetation
- Wind generated noise around surrounding buildings
- Traffic noise
- Animal noise (dogs, cows, birds, insects, frogs, etc.)
- Farming activities
- Ocean noise

The influence of wind generated noise on background noise levels may depend on the following:

- Wind speed
- Wind direction
- Meteorological conditions
- Changes in surrounding buildings
- Changes in surrounding vegetation

Whilst the New Zealand Standard assumes the same background levels would be found whenever logging occurs, this may not always be the case.

Indeed, these factors can vary between monitoring periods, seasons and years, potentially affecting the resulting background noise levels. For this paper, we have limited our assessment to the influence of seasonal changes

6.1. Seasonal changes

At each property, the background noise level regression curves for each monitoring period have been compared to the all data regression curve. By considering seasonal variation in this way, it is implied that the all data regression curve is representative of the long term average background noise level. The results of the comparisons are presented in Appendix B.

Wind turbine sound power levels are commonly given for wind speeds between 6 and 10m/s, therefore it is for this range that noise limits and hence background noise levels are the most critical during pre-construction noise assessments.

In order to provide a summary of seasonal variations across all monitored properties, the difference between each seasonal noise level and the average noise level has been averaged over the wind speed range of 6 to 10m/s. The results are presented in Figure 2 below.

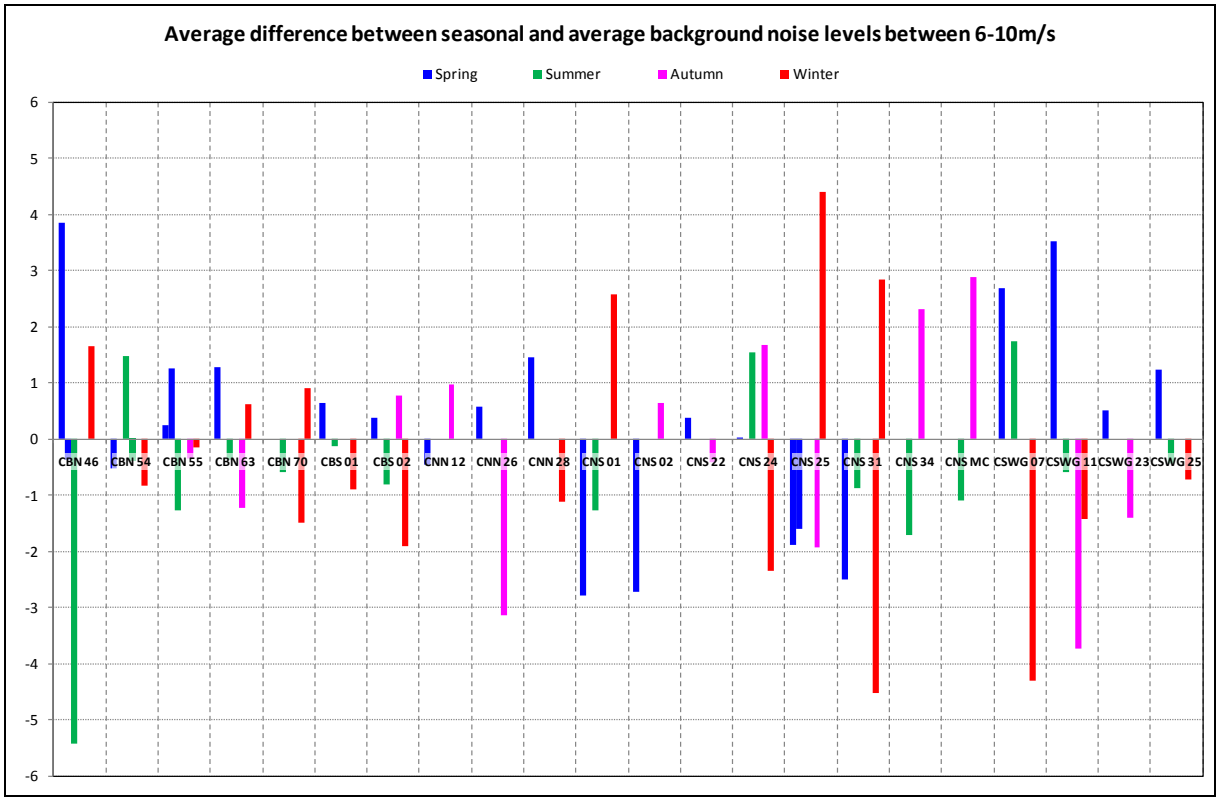

Figure 2 – Seasonal background noise levels comparison

It can be seen from Figure 2 that there no obvious trends in seasonal variations. For a given season, background noise levels are at times higher than the average background noise levels and at other times lower.

It can even be seen that the levels of the same season may be higher than the average background noise level during one year and lower during another. This is shown for the winter seasons at Houses CBN 70 and CNS 31.

In Figure 3, the average differences shown in Figure 2 are plotted as a time history.

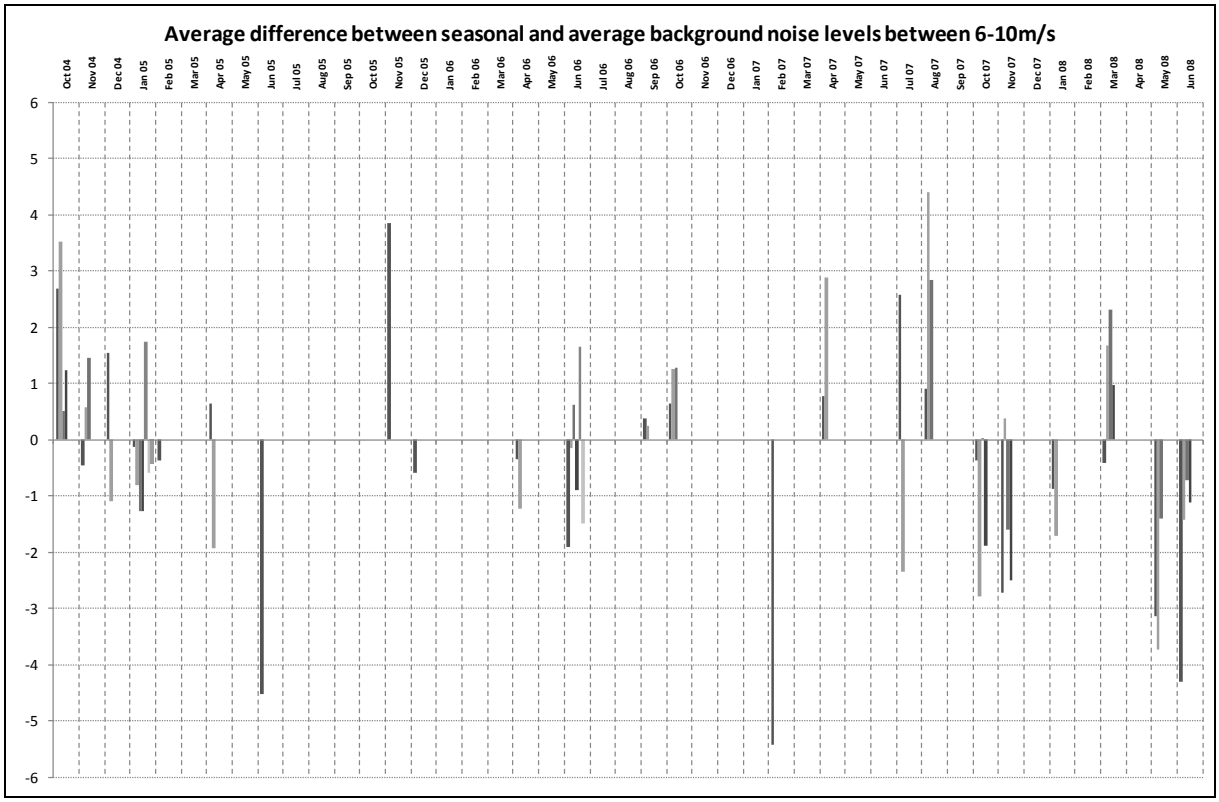

Figure 3 – Seasonal background noise levels comparison – time history

It can be seen from Figure 3 that certain survey periods consistently provide lower or higher seasonal background noise levels (ie: Oct 04, Oct 07, Nov 07, May 08 and June 08). However background noise levels measured during the same month can be higher than the average background noise levels one year (Oct 04) and lower during another (Oct 07).

Attempts have also been made to analyse the effect of wind direction, including consideration of vegetation near the noise monitor as the likely dominant noise source for each direction quadrant to explain the variations in background noise levels. This did not lead to any obvious trends for the houses analysed and therefore an extensive wind direction analysis of the data has not been carried out.

Panorama and aerial photos are only available for some periods and therefore such a detailed study across the sites is beyond scope of this study.

6.2. Wind speed distribution

During the seasonal changes analysis, background noise levels scatters at some houses presented interesting trends, when the wind speed range varied across the monitoring periods. Selected examples are presented in Figure 4 and 5.

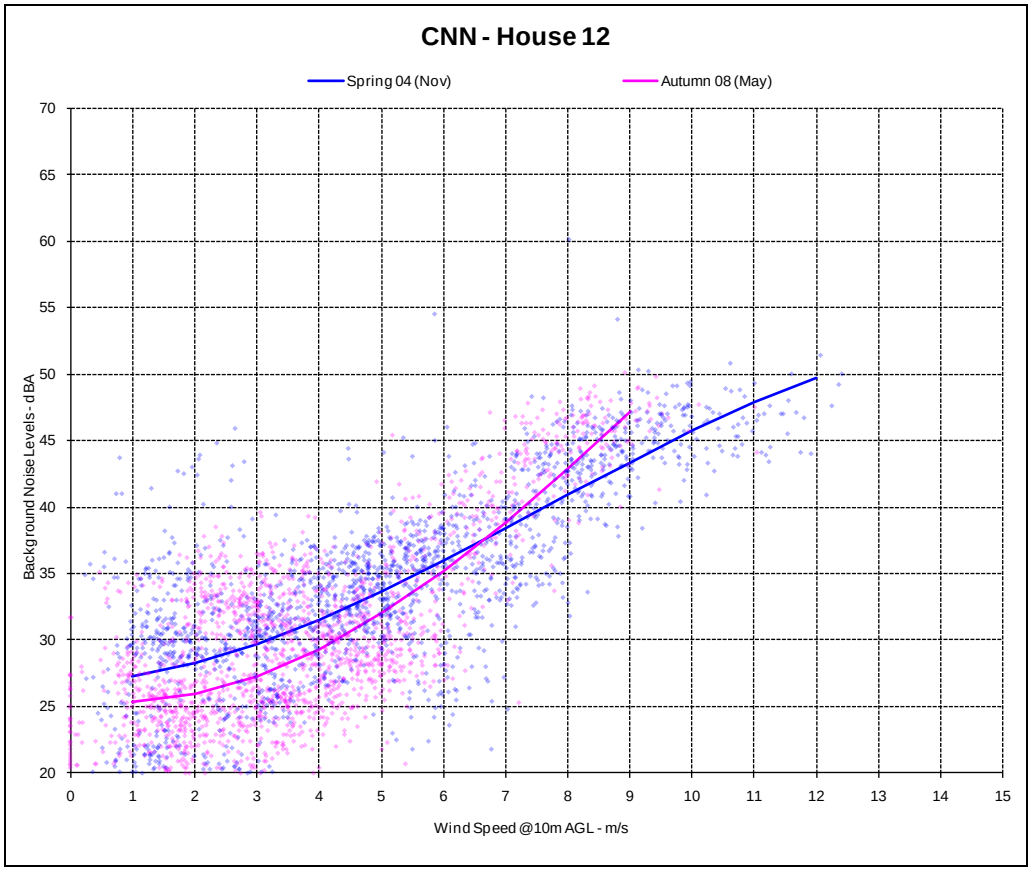

Figure 4 – Background noise levels at CNN 12

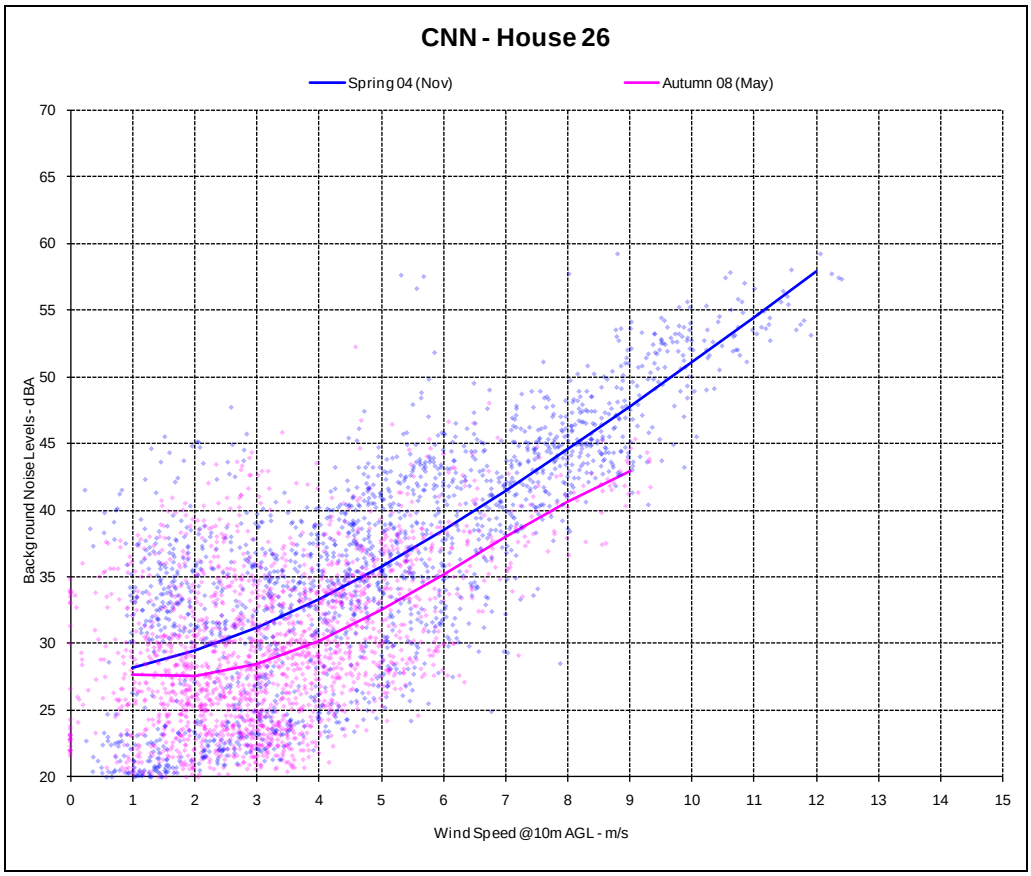

Figure 5 – Background noise levels at CNN 26

It can be seen from Figures 4 and 5 that wind speeds during the Spring 04 period exceeded 12m/s at both CNN 12 and CNN 26 whereas wind speeds during the Autumn 08 period rarely exceeded 9m/s. Both measurements complied with the wind speed range requirement of the New Zealand Standard (5-8m/s).

It can be seen that background noise level scatters below 9m/s are fairly similar during each period for both houses. However, in each case, a lack of data points above 9m/s during the Autumn 08 period leads to a very different regression curve of best fit compared to the Spring 04 regression curve.

Considering that wind farm noise emissions are usually predicted between 6 and 10m/s, the shape of the regression curve of best fit within this range is most critical as it can change the noise limit significantly. For example, in the case of CNN 12, monitoring during Autumn 08 would have lead to a noise limit at 9m/s 5dBA higher than the actual noise limit, which was derived from the Spring 04 data.

Based on these observed trends, to obtain a representative background noise level regression curve for the critical wind speed range of 6-10m/s, we recommend that a significant amount of data be collected both above and below this wind speed range. For example, to obtain a representative background noise level curve at the higher wind speeds of 9-10m/s, it may be necessary to obtain monitoring data up to at least 12m/s, with a suitable number of data points (say 30) at each of the 11 and 12m/s wind speed bins.

7. UNCERTAINTIES

Whilst remaining mainly within the requirements of the New Zealand Standard, the analysis employs a number of uncertainties. These are presented below.

7.1. Wind data

Uncertainties linked to the wind data are as follows:

- measured 10m wind speed data is highly affected by terrain and roughness, in some sites this has a more significant impact than others
- data extrapolated to 10m height, using an average site roughness factor (and not time series)
- for some dwellings the met mast used and anemometer level was not consistent throughout seasons
- met masts may not be in the most appropriate location for all dwellings
- instrument mounting arrangements have not been consistent for all monitoring masts

7.2. Noise data

Uncertainties linked to the noise data are as follows:

- some minor changes to logger locations (from A to B locations) throughout seasons (as shown in the Site Plans and Summary Parameters) , namely at;
    - CBS – House2
    - CNS – House 31
    - CNS – MC
    - CNN – House 28
    - CSWG – House 11
    - CSWG – House 23
    - CSWG – House 25

- data points potentially affected by rain were removed using rainfall data provided by the nearest Bureau of Meteorology weather stations located at Portland and Cape Nelson
- whilst rain affected measurements were removed, measured background noise levels were also influenced by non wind related sources, mostly at lower wind speeds

7.3. Correlations

Uncertainties linked to correlation between background noise levels and wind speeds are as follows:

- datasets with correlation coefficients inferior to 0.4 were not included in this study
- a visual assessment of the shape of the data scatter was performed to choose between using 3rd or 2nd order regressions
- use of the all data regression curve as representative of the long-term average background noise level
- outlier data points have not been removed from the analysis

8. FURTHER WORK

This paper mainly focuses on seasonal variations in background noise levels. However we recognise that this extensive amount of data could be further analysed.

For example:

- Further assessment on effect of wind speed distribution
- Determination of background data collection guidelines

    - is there a “real” background noise dataset?
    - should we aim to collect as much data as possible, or to capture representative conditions (long term wind speed and direction distributions of site) or ‘worst case’ conditions?
- Statistical regression guidelines
    - what distribution of wind speeds should be included in the regression curve analysis
    - what order regression should be used?
- Suitability of using representative data from proximate dwellings
- Detailed study of the effect of vegetation and wind direction

Acknowledgments

We would like to thank Pacific Hydro for releasing the background noise and wind speed data and Daniel Griffin for his very valuable contribution.

APPENDIX A

SITE PLANS


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533000
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KITTSON RD
AMOS RD
PEACOCKS RD
BLOWHOLES RD
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CBN45
55
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46
B
A
2
1
CBN70
N
DRAFT
Dwellings
Noise Logger Locations
Monitoring Mast
Site Boundary
10m Contours
Cadastral Boundaries
Roads
PROJECT
PWEP II: Cape Bridgewater, Australia
TITLE
Noise Logger & Dwelling Locations
CREATED BY
M.Barnett
DATUM
MGA 94
DATE
04/05/09
CLEARANCE BY
D.Walsh
SCALE
1:25,000
DRAWING NO
PH-0236
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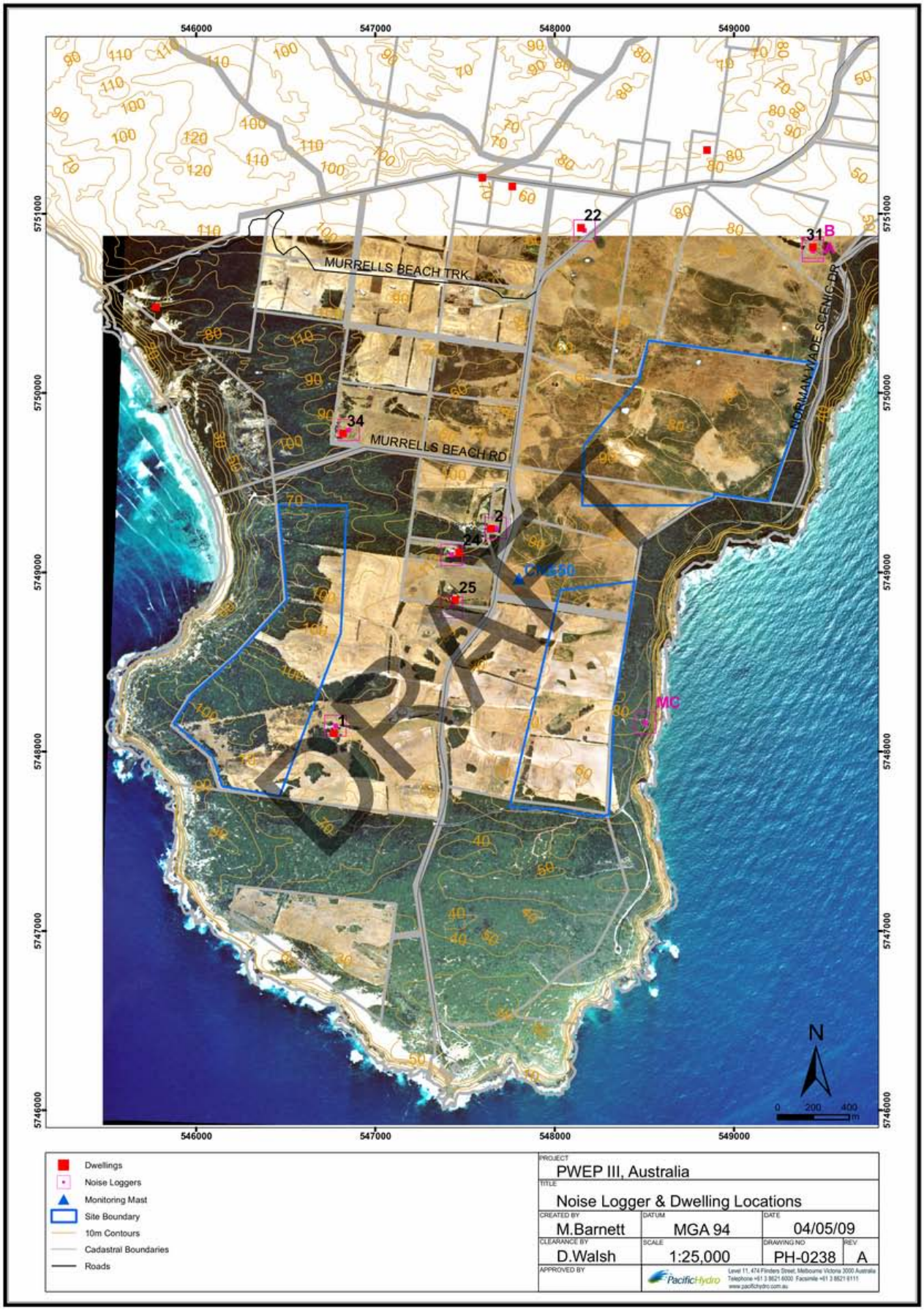
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Dwellings
Noise Loggers
Monitoring Mast
Site Boundary
10m Contours
Cadastral Boundaries
Roads
PROJECT
PWEP III, Australia
TITLE
Noise Logger & Dwelling Locations
CREATED BY
M.Barnett
DATUM
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CLEARANCE BY
D.Walsh
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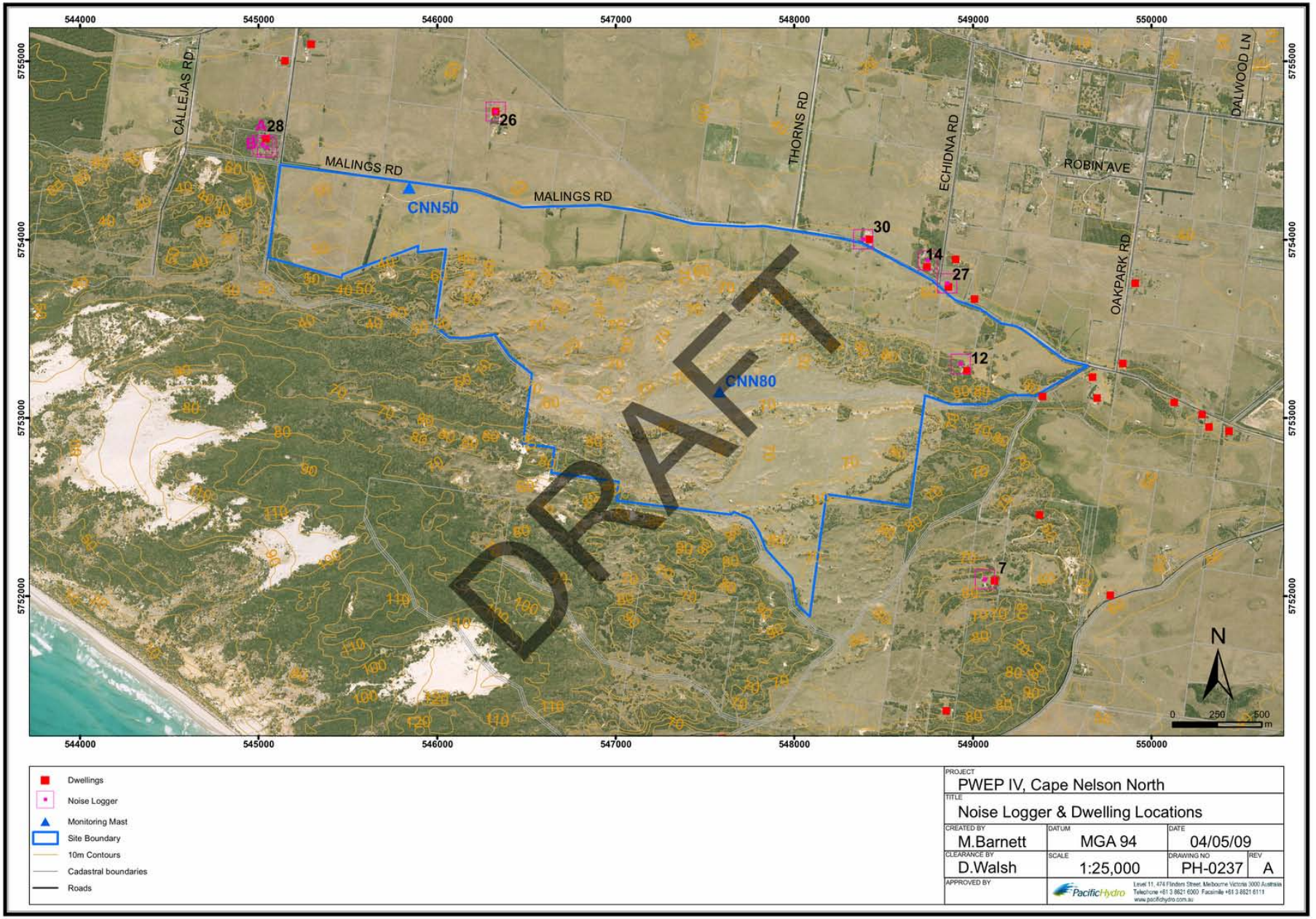
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Dwellings
Noise Logger
Monitoring Mast
Site Boundary
10m Contours
Cadastral boundaries
Roads
PROJECT
PWEP IV, Cape Nelson North
TITLE
Noise Logger & Dwelling Locations
CREATED BY
M.Barnett
DATUM
MGA 94
DATE
04/05/09
CLEARANCE BY
D.Walsh
SCALE
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DRAWING NO
PH-0237
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MALINGS RD
CAPE NELSON RD
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WELLINGTON RD
BARKLY ST
AMITY RD
REBECCA RD
GREAT SOUTH WEST WALK
MADEIRA PACKET RD
OLERIA RD
TECOMA RD
THISTLE RD
QUARRY RD
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Dwellings
Noise Logger
Monitoring Mast
Site Boundary
10m Contours
Cadastral Boundaries
Roads
PROJECT
PWEP IV, Cape Sir William Grant
TITLE
Noise Logger & Dwelling Locations
CREATED BY
M.Barnett
DATUM
MGA 94
DATE
04/05/09
CLEARANCE BY
D.Walsh
SCALE
1: 25,000
DRAWING NO
PH-0239
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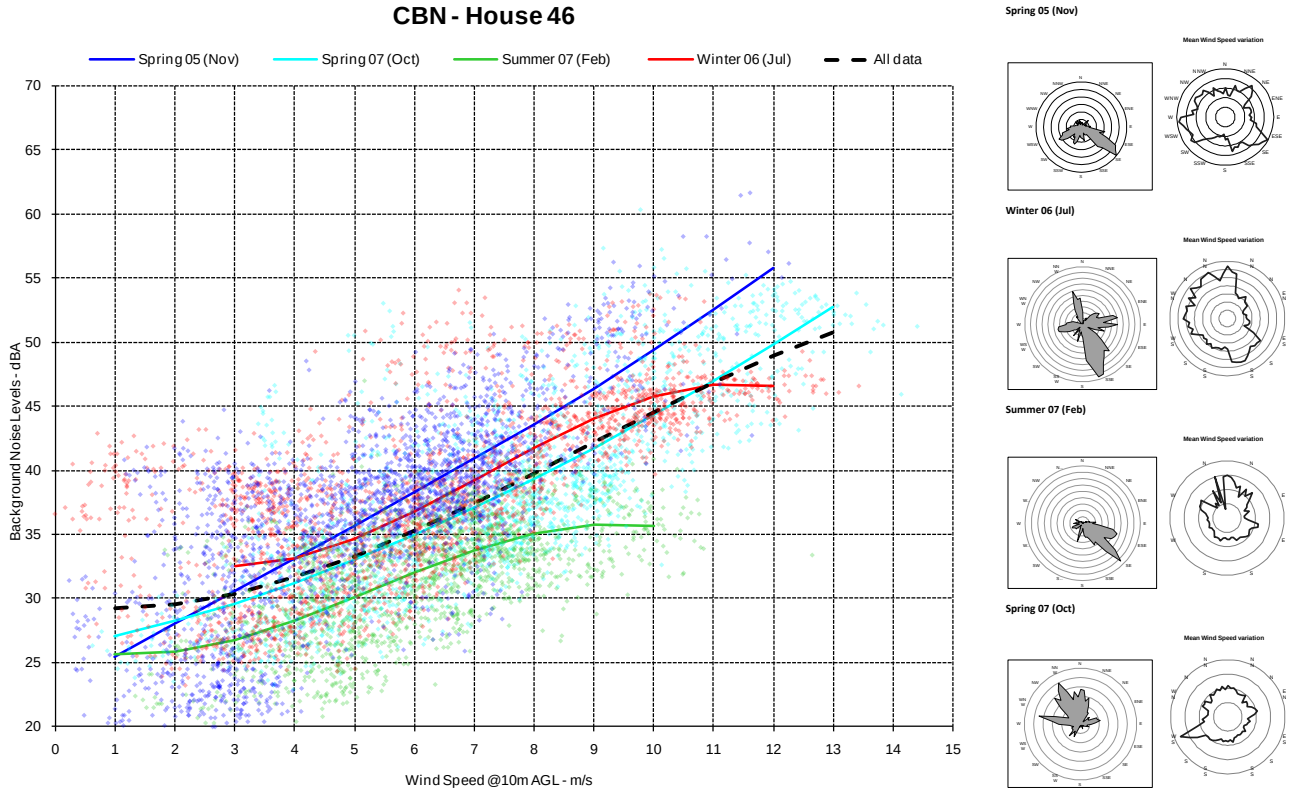
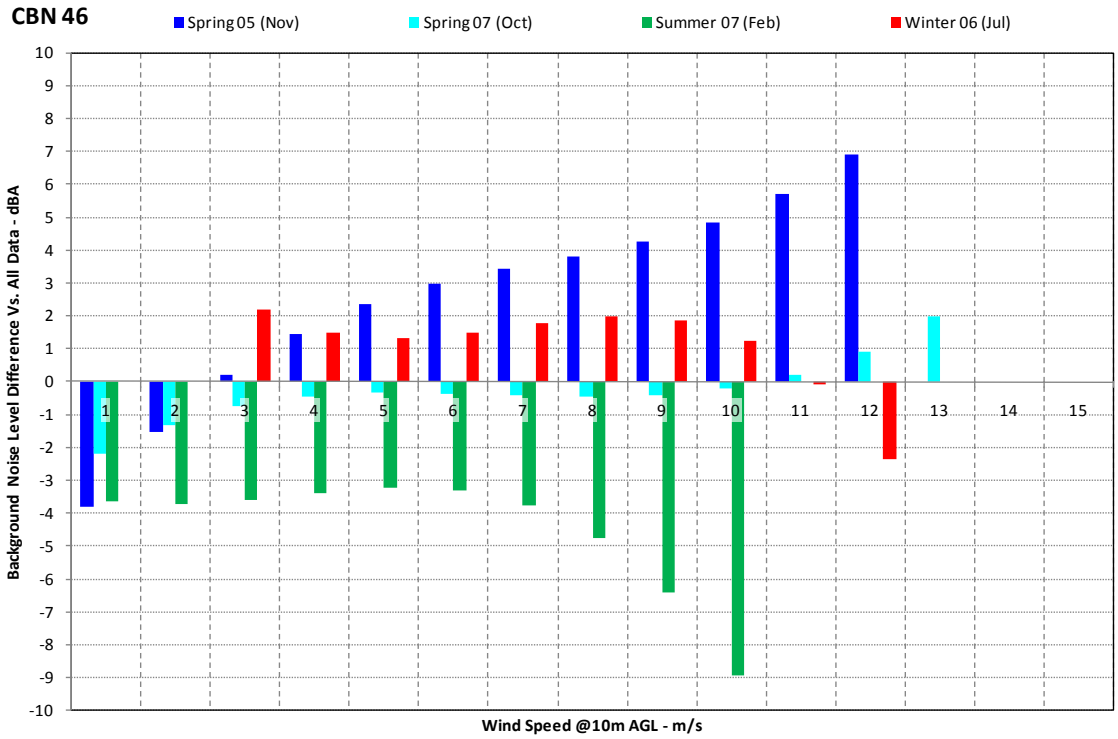
APPENDIX B

SEASONAL BACKGROUND NOISE LEVELS


CBN - House 46
Spring 05 (Nov)
Spring 07 (Oct)
Summer 07 (Feb)
Winter 06 (Jul)
All data
Background Noise Levels - dBA
Wind Speed @10m AGL - m/s
Mean Wind Speed variation
Spring 05 (Nov)
Winter 06 (Jul)
Summer 07 (Feb)
Spring 07 (Oct)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Spring 07 (Oct)
Summer 07 (Feb)
Winter 06 (Jul)
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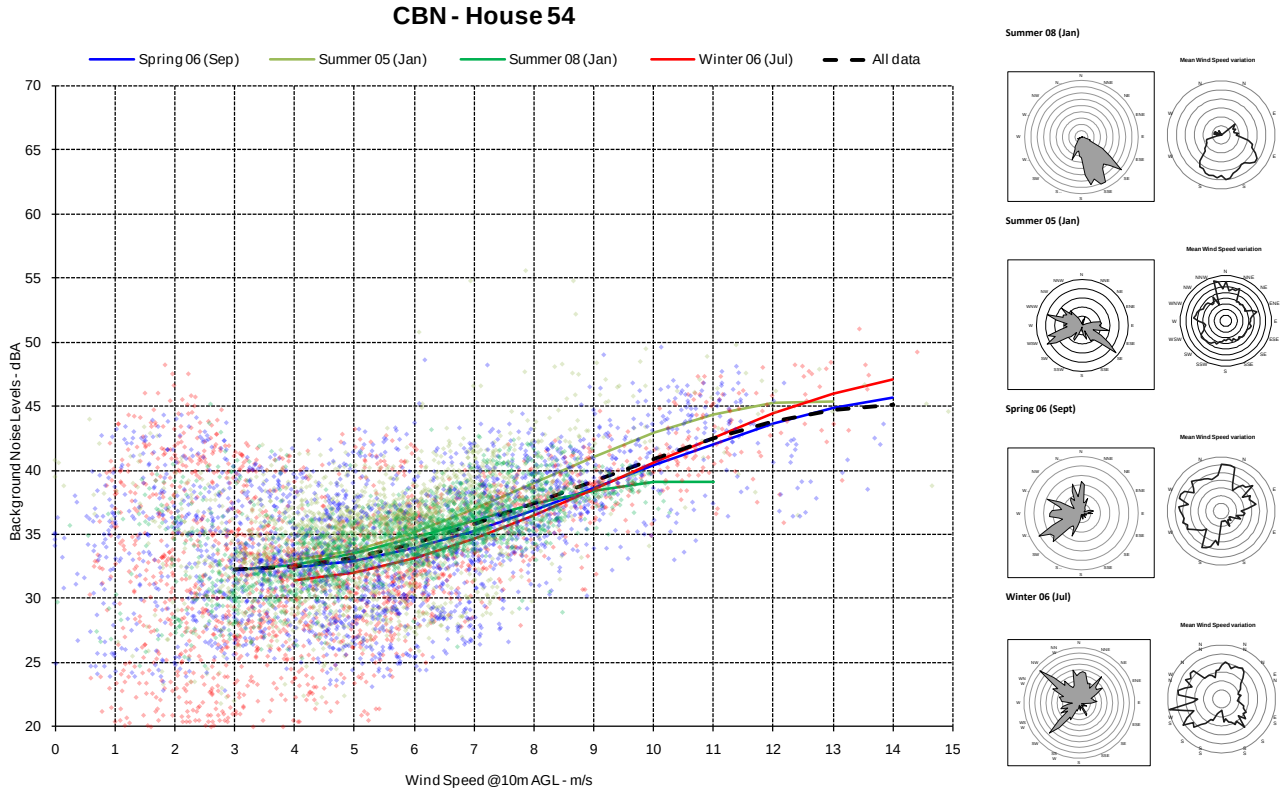
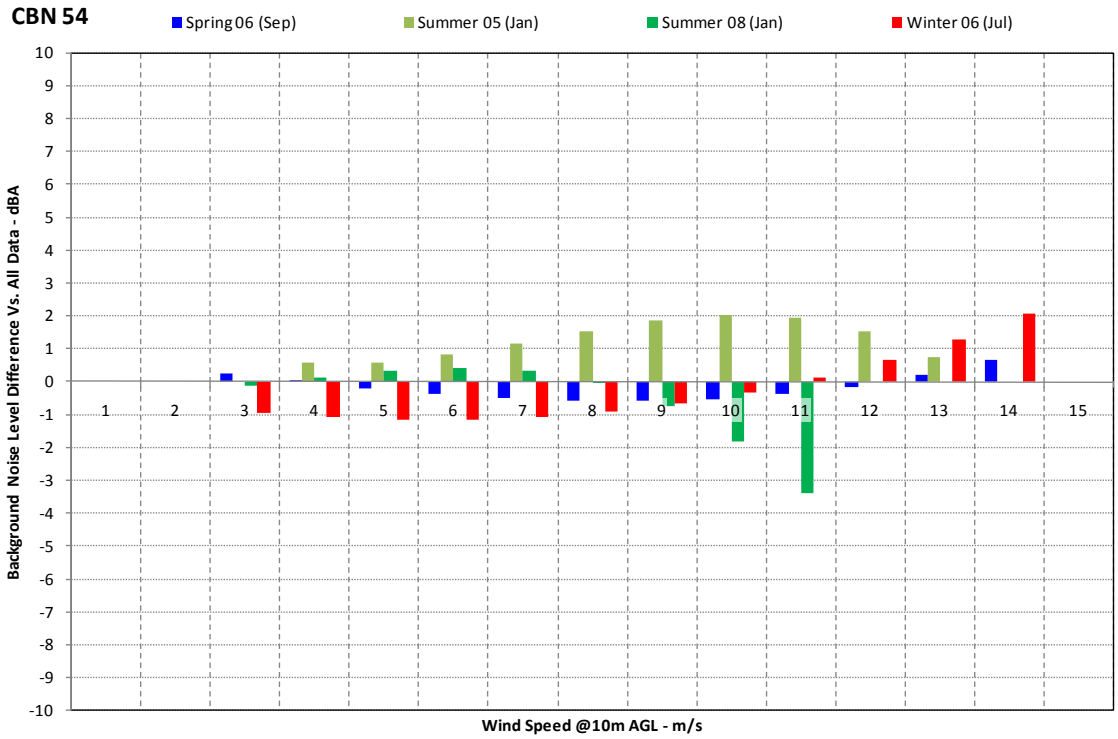
Wind Speed @10m AGL - m/s


CBN - House 54
Spring 06 (Sep)
Summer 05 (Jan)
Summer 08 (Jan)
Winter 06 (Jul)
All data
Background Noise Levels - dBA
Wind Speed @10m AGL - m/s
Summer 08 (Jan)
Summer 05 (Jan)
Spring 06 (Sept)
Winter 06 (Jul)
Mean Wind Speed variation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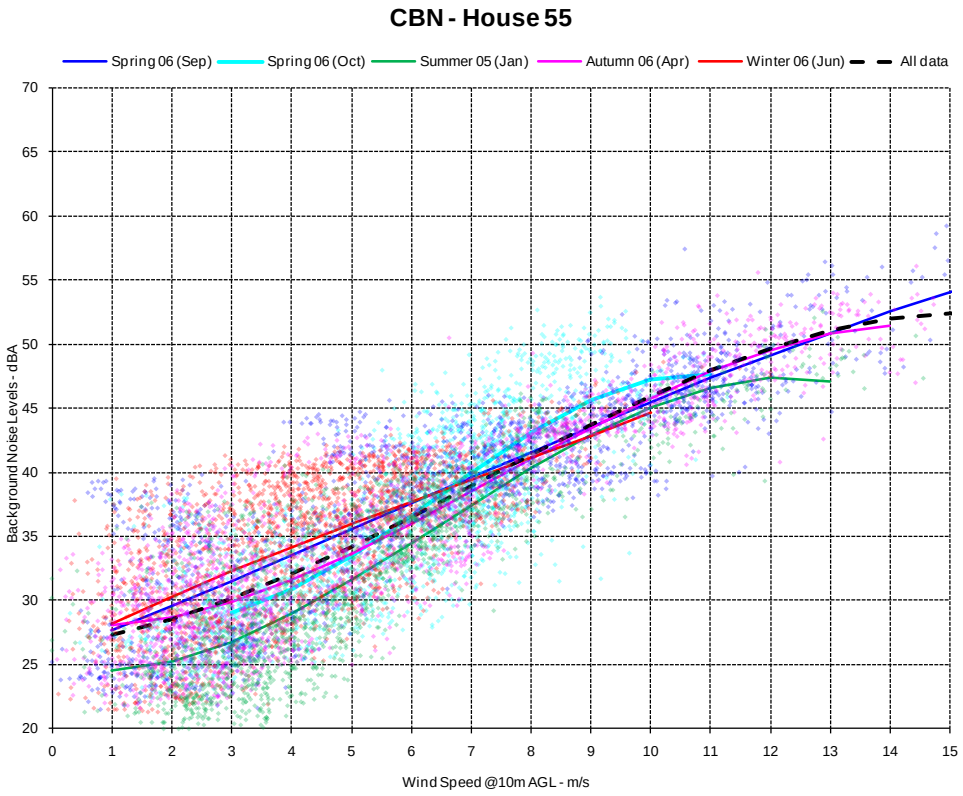
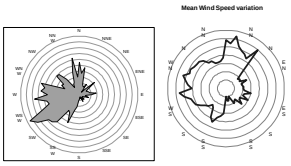
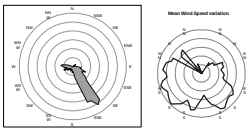
Background Noise Level Difference Vs. All Data - dBA
Wind Speed @10m AGL - m/s



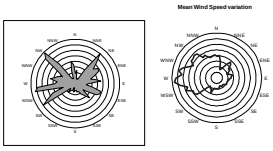
Spring 06 (Sept)



Spring 06 (Oct)



Autumn 06 (Apr)



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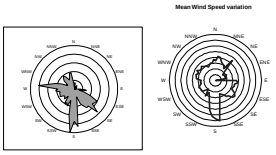
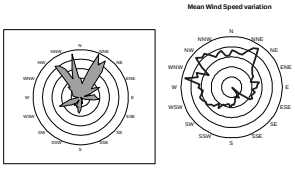
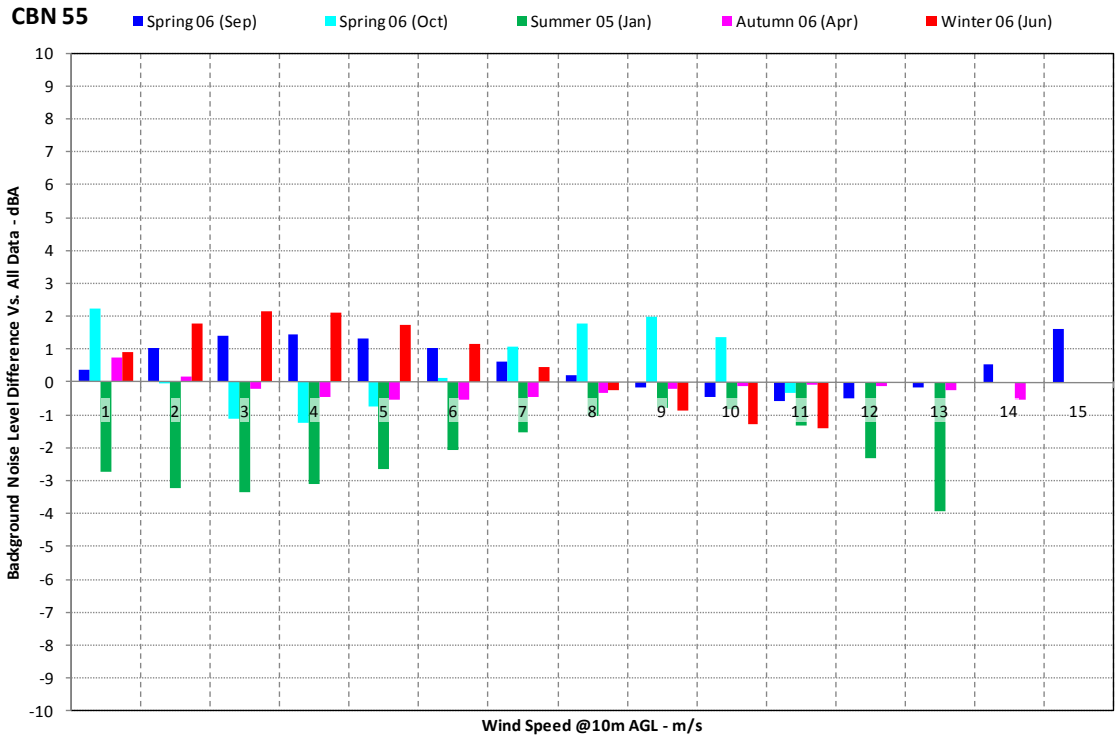
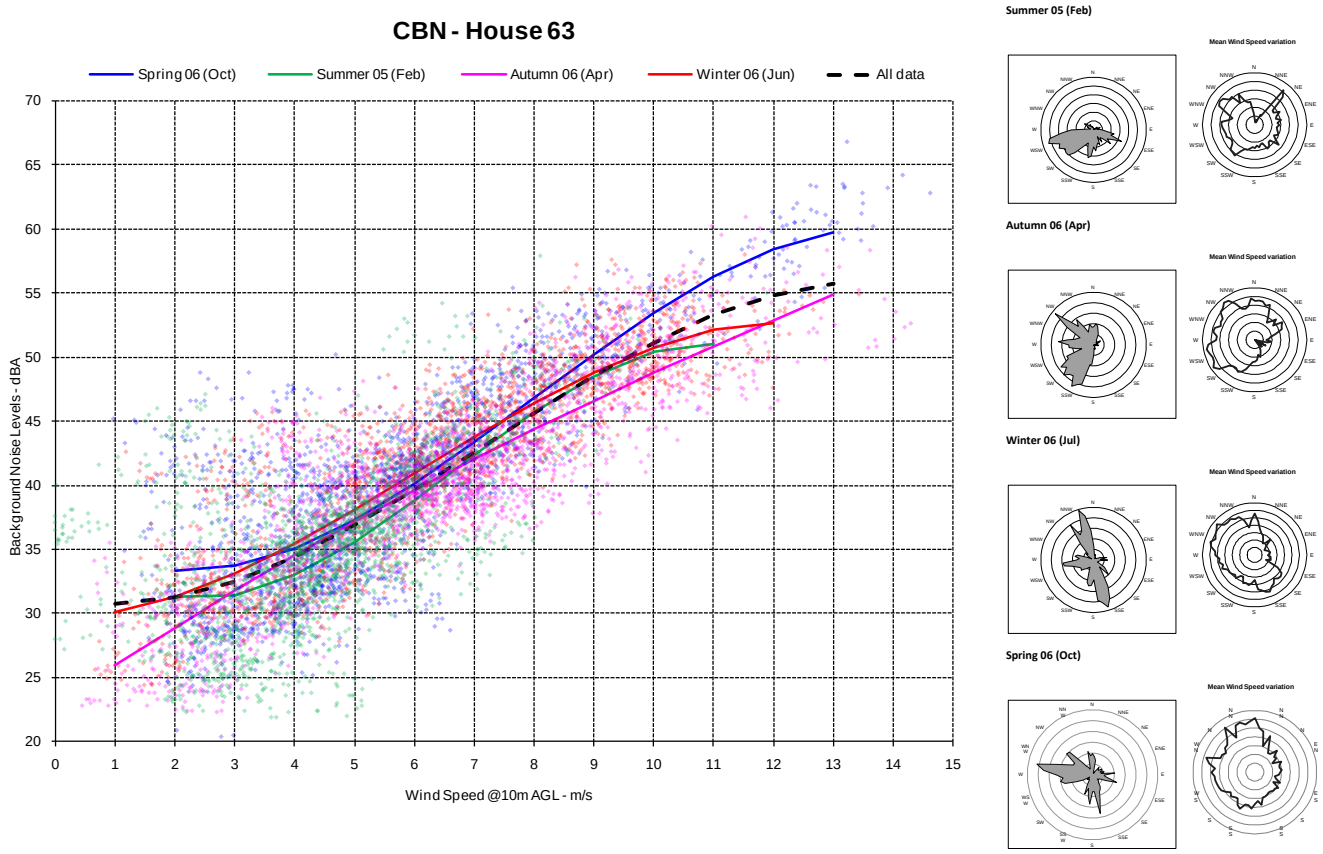


Winter 06 (Jun)






CBN - House 63
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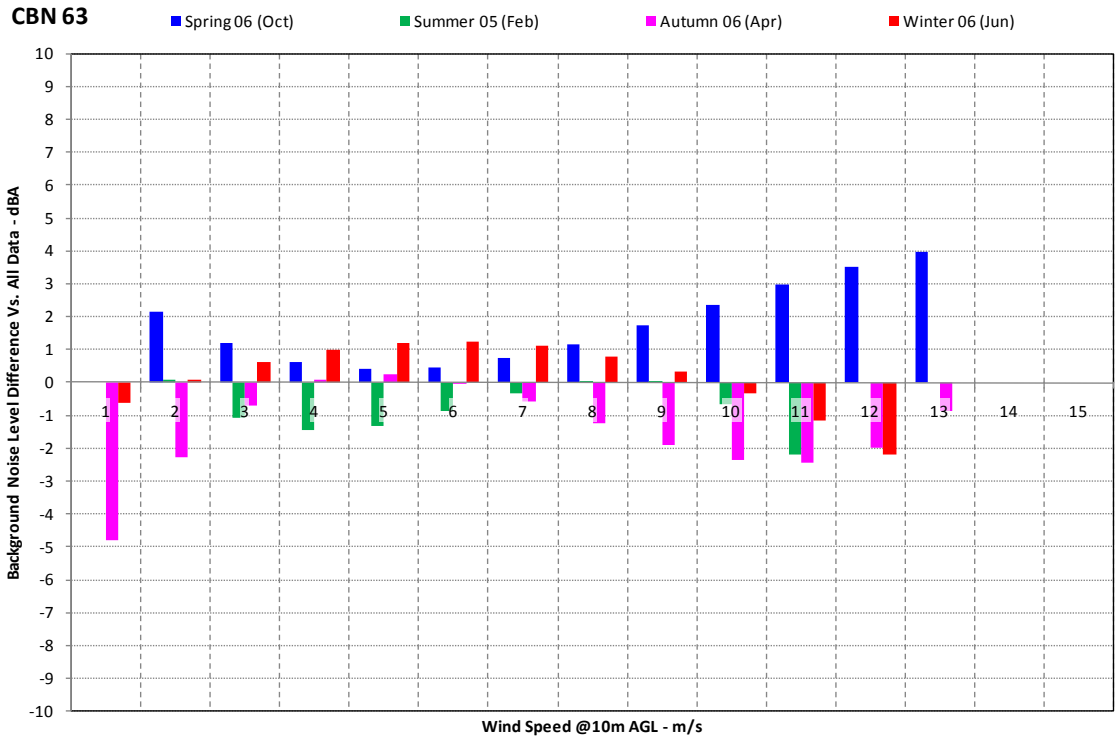
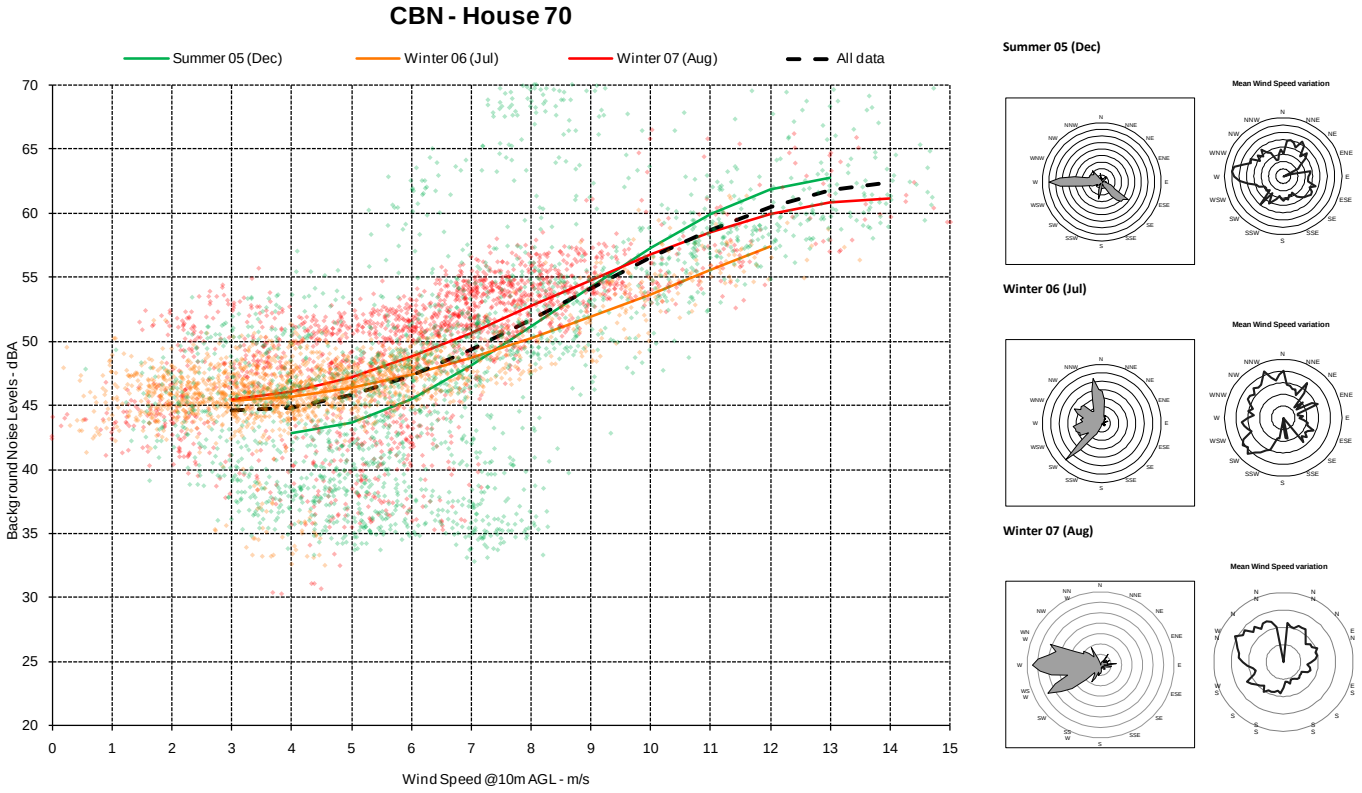
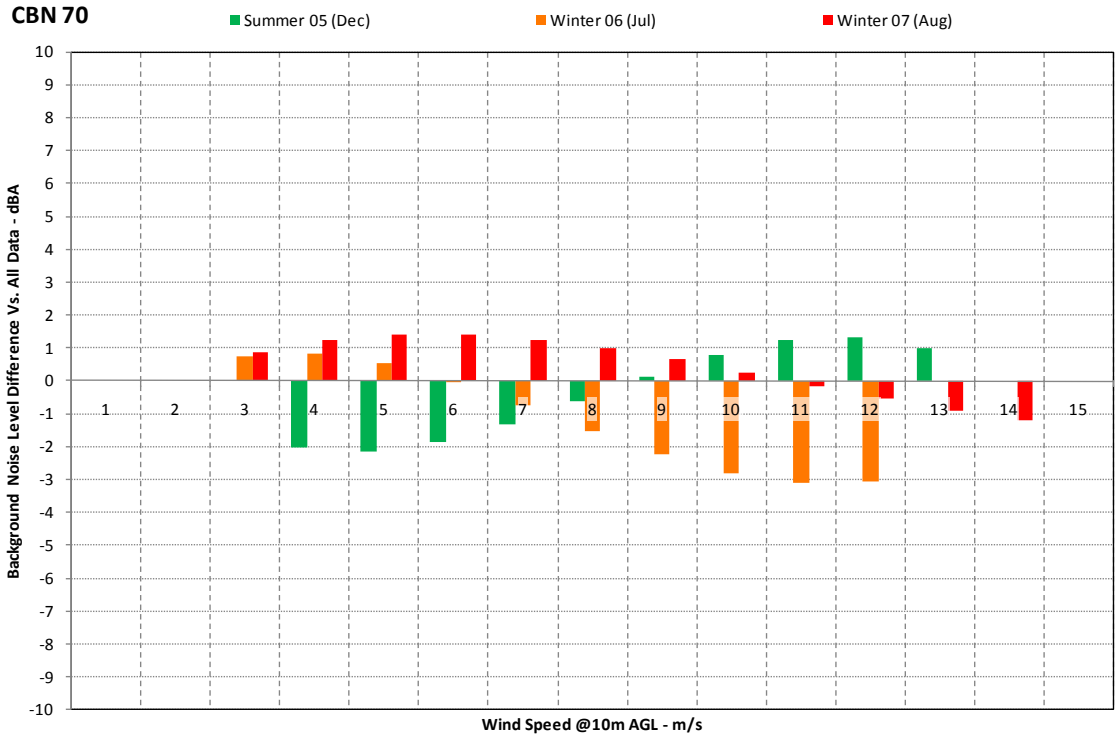
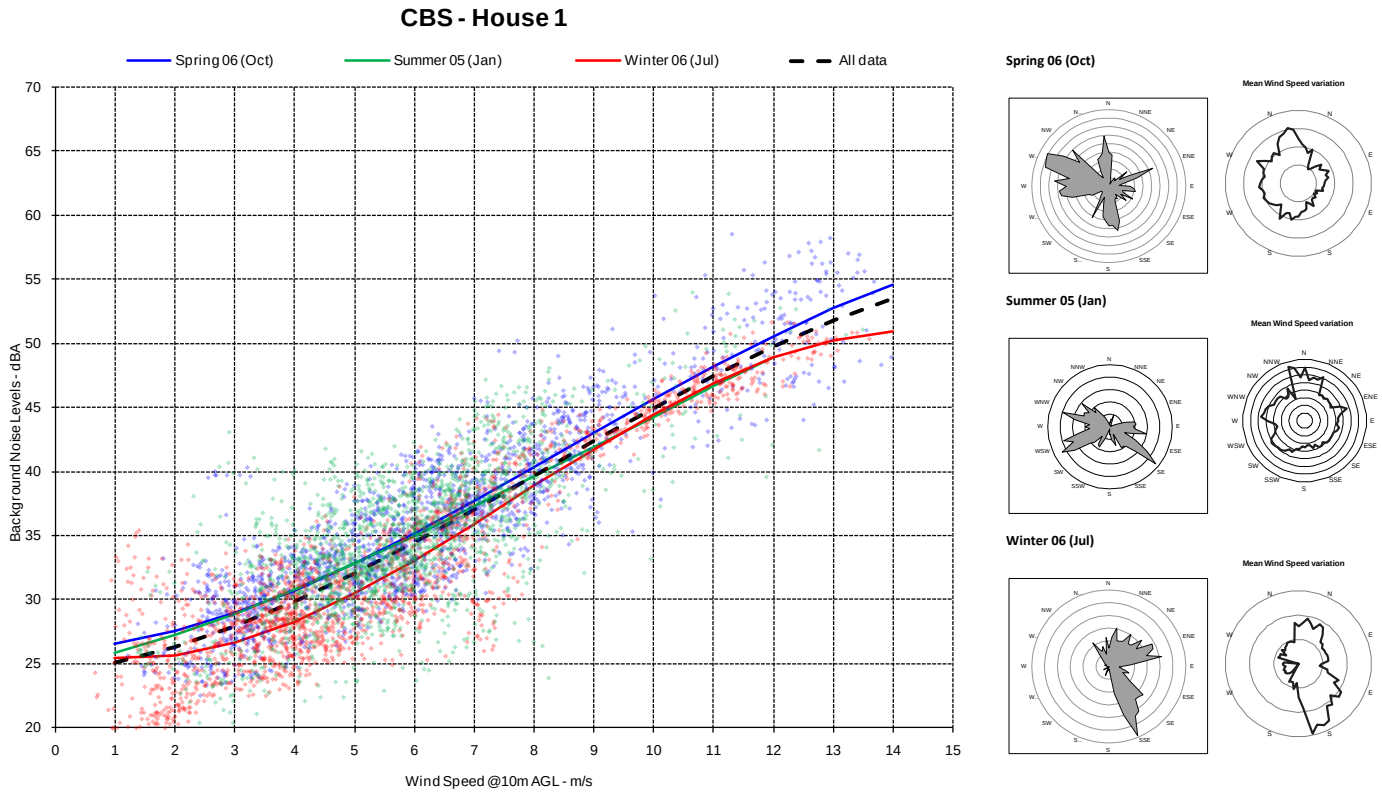
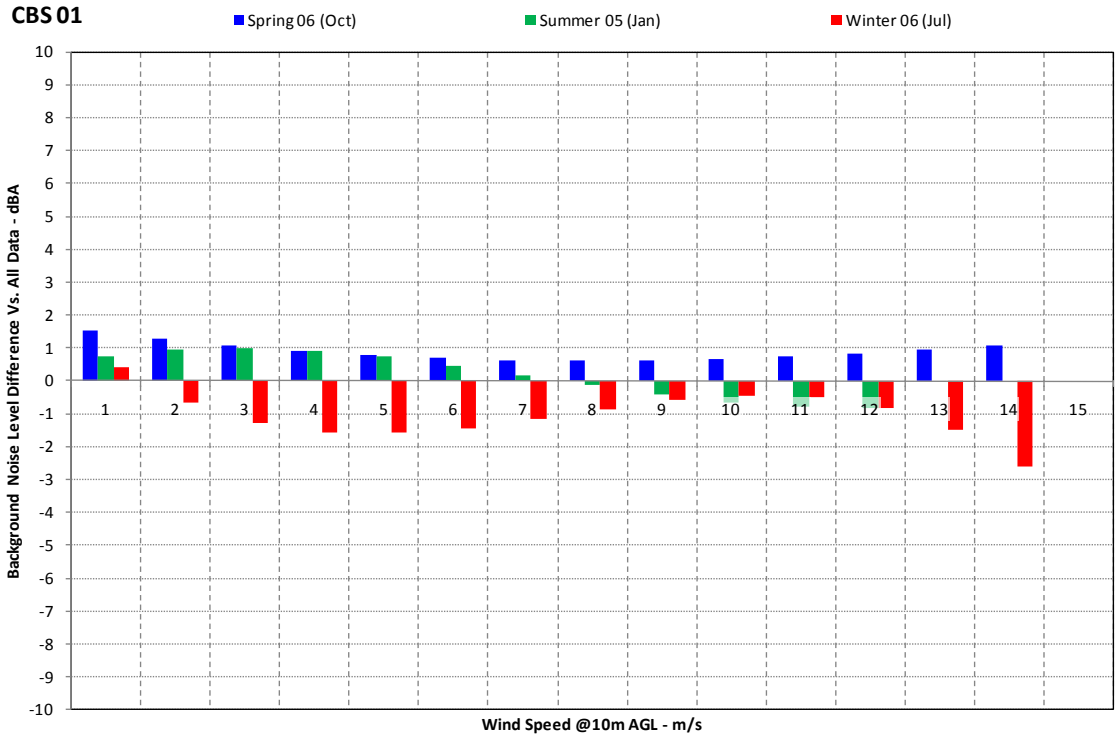
Summer 05 (Feb)
Autumn 06 (Apr)
Winter 06 (Jun)
All data
Background Noise Levels - dBA
Wind Speed @10m AGL - m/s
Summer 05 (Feb)
Mean Wind Speed variation
Autumn 06 (Apr)
Winter 06 (Jul)
Spring 06 (Oct)

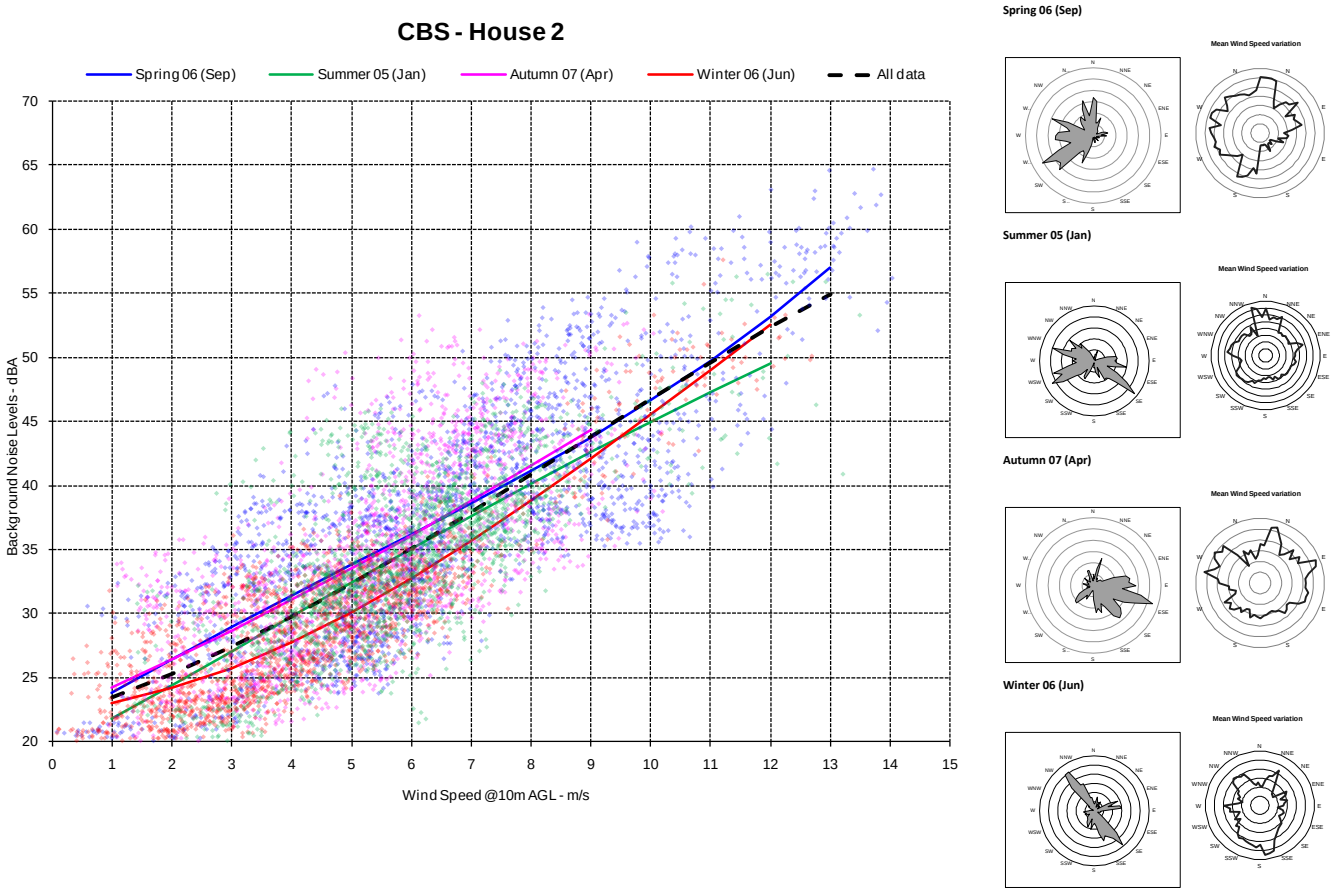

CBN 63
Spring 06 (Oct)
Summer 05 (Feb)
Autumn 06 (Apr)
Winter 06 (Jun)
Background Noise Level Difference Vs. All Data - dBA
Wind Speed @10m AGL - m/s

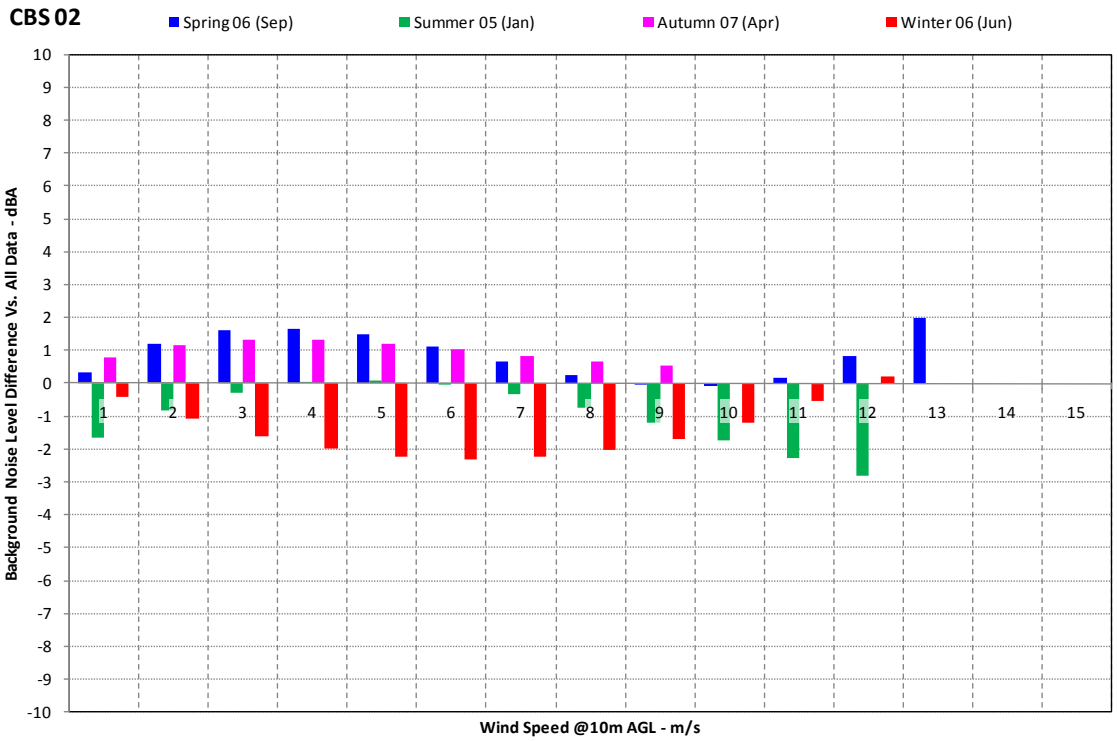

CBN - House 70
Summer 05 (Dec)
Winter 06 (Jul)
Winter 07 (Aug)
All data
Background Noise Levels - dBA
Wind Speed @10m AGL - m/s
Summer 05 (Dec)
Mean Wind Speed variation
Winter 06 (Jul)
Mean Wind Speed variation
Winter 07 (Aug)
Mean Wind Speed variation

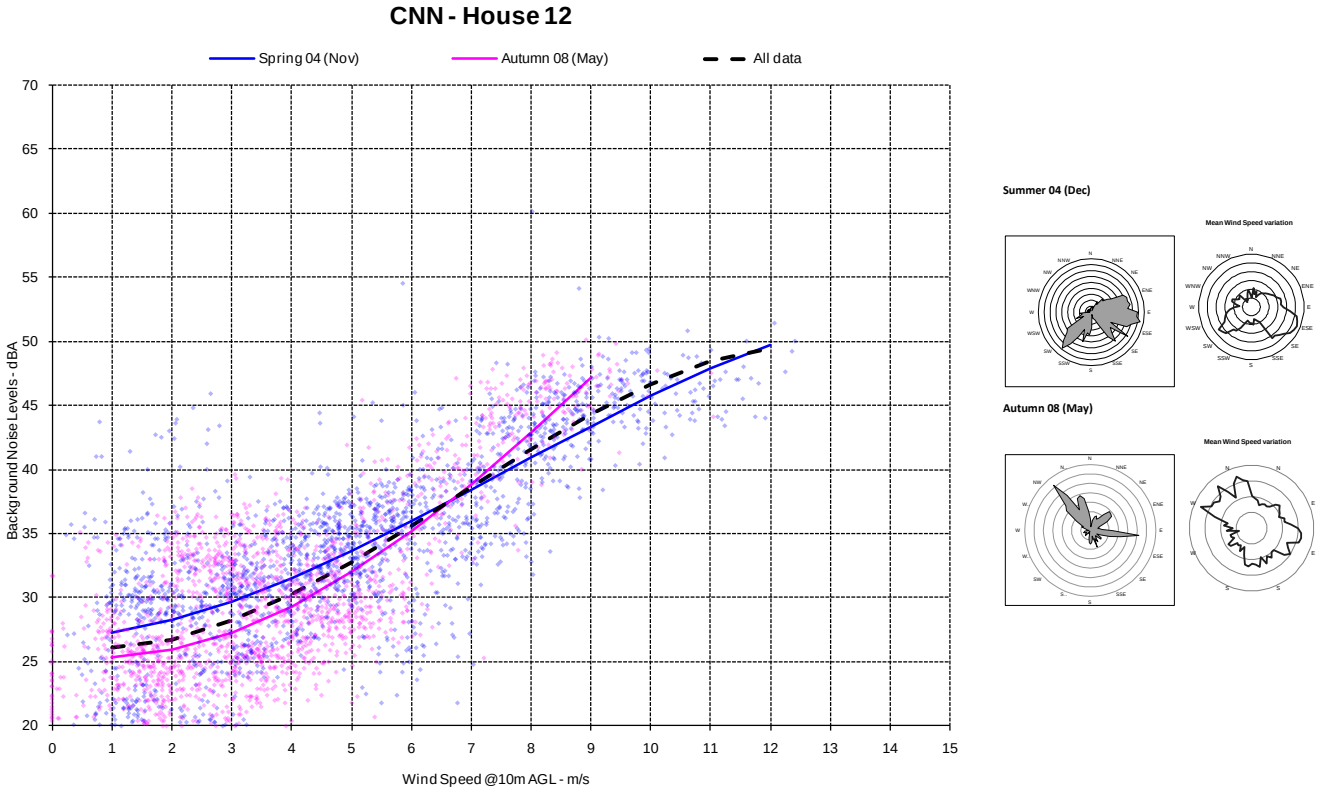

CBN 70
Summer 05 (Dec)
Winter 06 (Jul)
Winter 07 (Aug)
Background Noise Level Difference Vs. All Data - dBA
Wind Speed @10m AGL - m/s

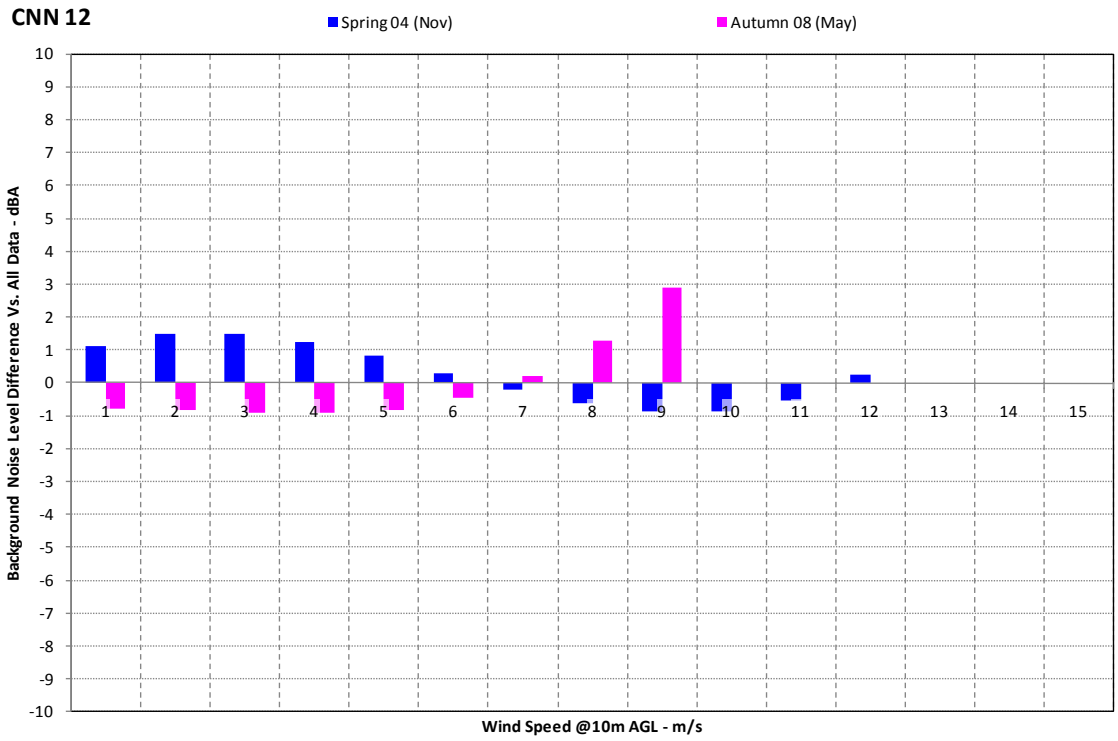

CBS - House 1
Spring 06 (Oct)
Summer 05 (Jan)
Winter 06 (Jul)
All data
Background Noise Levels - dBA
Wind Speed @10m AGL - m/s
Spring 06 (Oct)
Summer 05 (Jan)
Winter 06 (Jul)
Mean Wind Speed variation

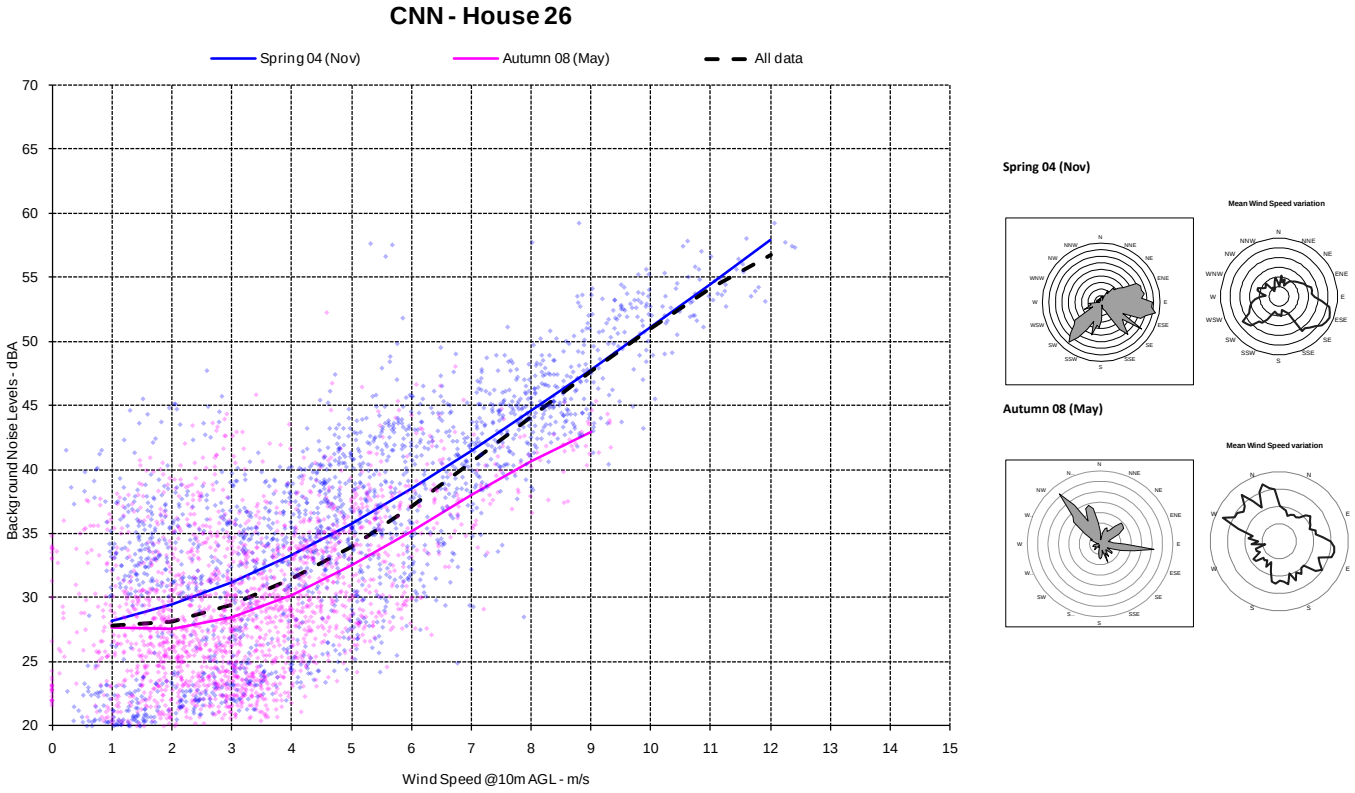

CBS 01
Spring 06 (Oct)
Summer 05 (Jan)
Winter 06 (Jul)
Background Noise Level Difference Vs. All Data - dBA
Wind Speed @10m AGL - m/s

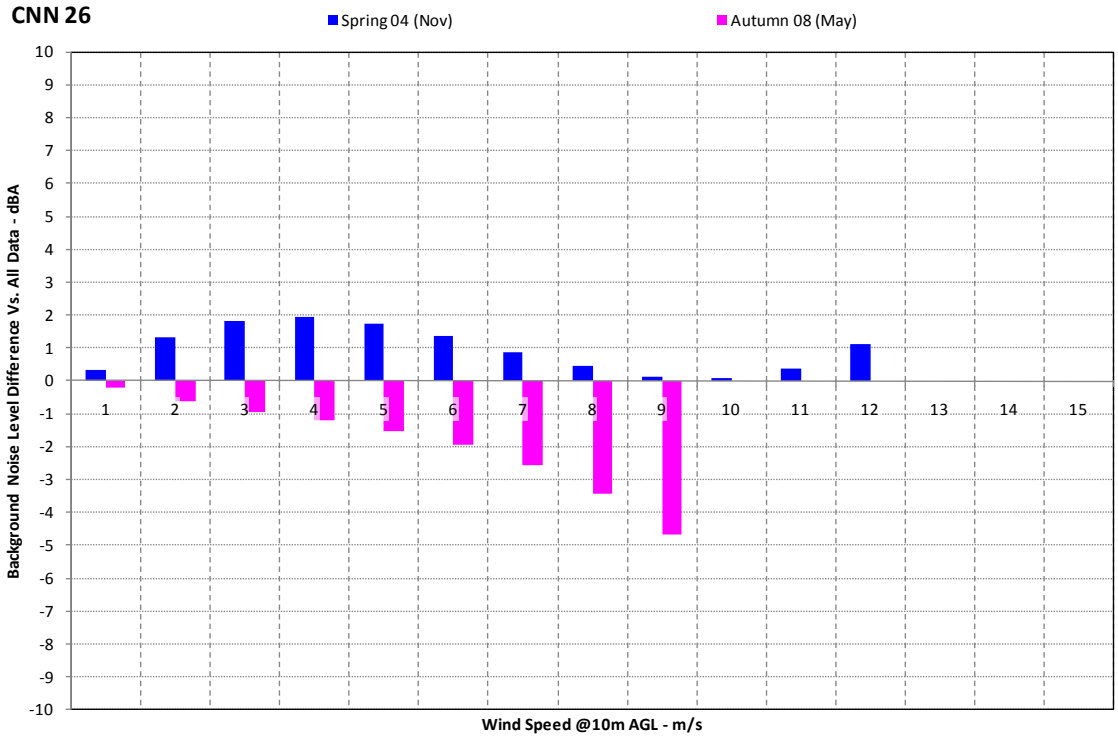

CBS - House 2
Spring 06 (Sep)
Summer 05 (Jan)
Autumn 07 (Apr)
Winter 06 (Jun)
All data
Background Noise Levels - dBA
Wind Speed @10m AGL - m/s
Spring 06 (Sep)
Mean Wind Speed variation
Summer 05 (Jan)
Mean Wind Speed variation
Autumn 07 (Apr)
Mean Wind Speed variation
Winter 06 (Jun)
Mean Wind Speed variation

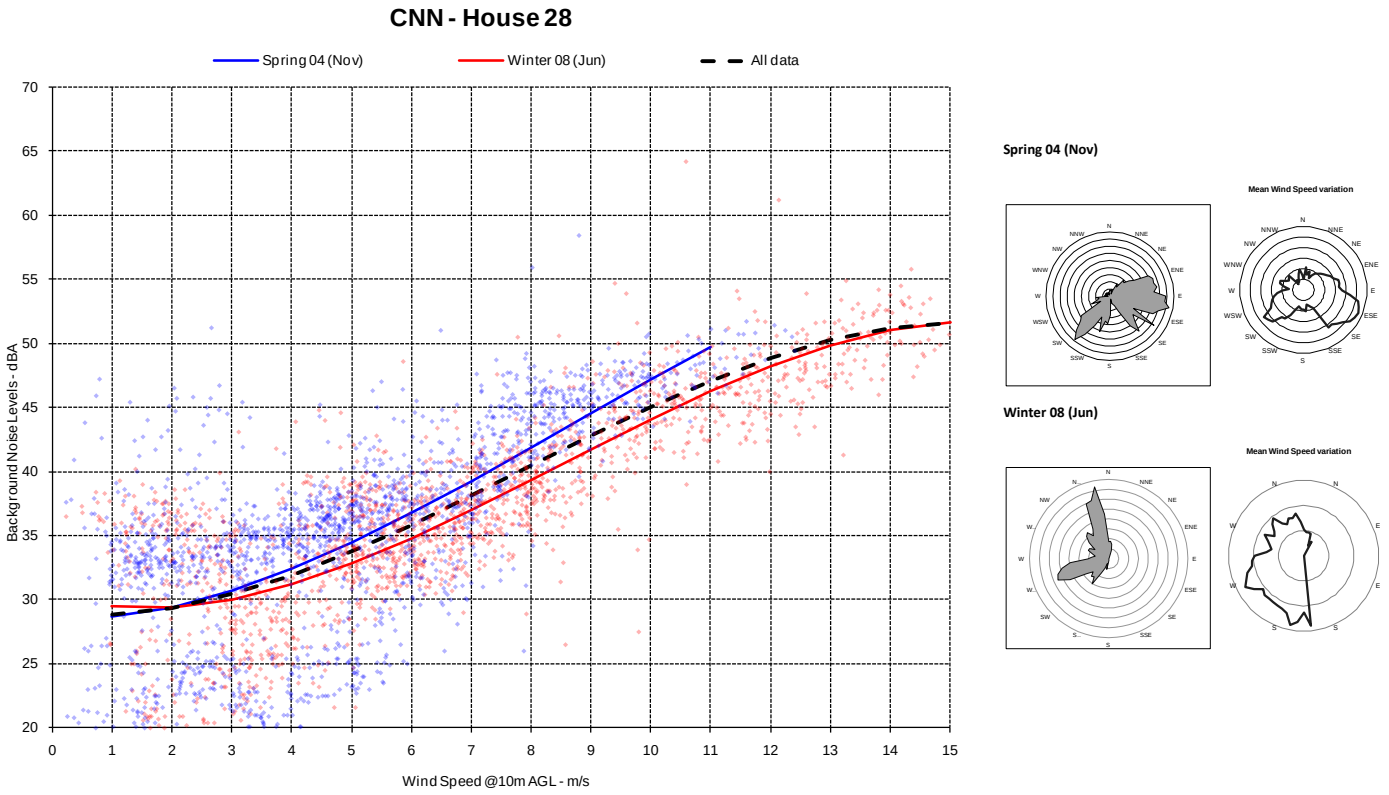

CBS 02
Spring 06 (Sep)
Summer 05 (Jan)
Autumn 07 (Apr)
Winter 06 (Jun)
Background Noise Level Difference Vs. All Data - dBA
Wind Speed @10m AGL - m/s

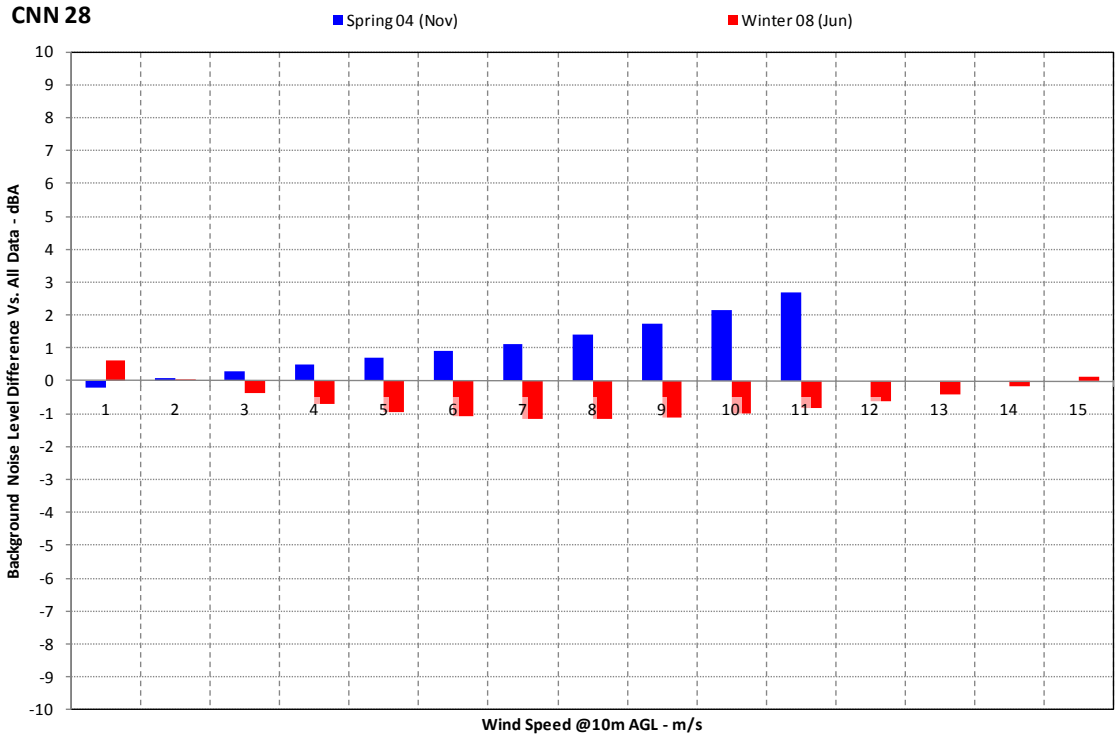

CNN - House 12
Spring 04 (Nov)
Autumn 08 (May)
All data
Background Noise Levels - dBA
Wind Speed @10m AGL - m/s
Summer 04 (Dec)
Mean Wind Speed variation
Autumn 08 (May)
Mean Wind Speed variation

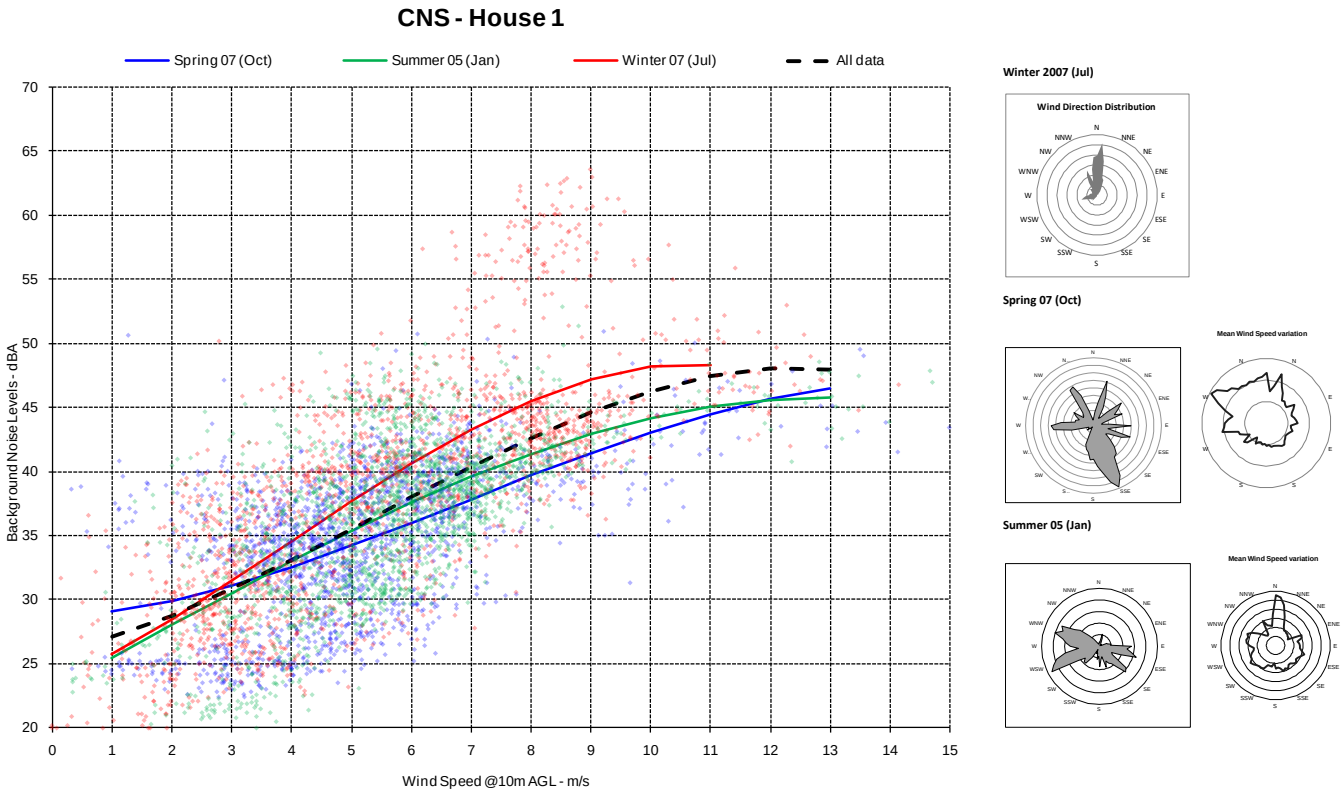

CNN 12
Spring 04 (Nov)
Autumn 08 (May)
Background Noise Level Difference Vs. All Data - dBA
Wind Speed @10m AGL - m/s

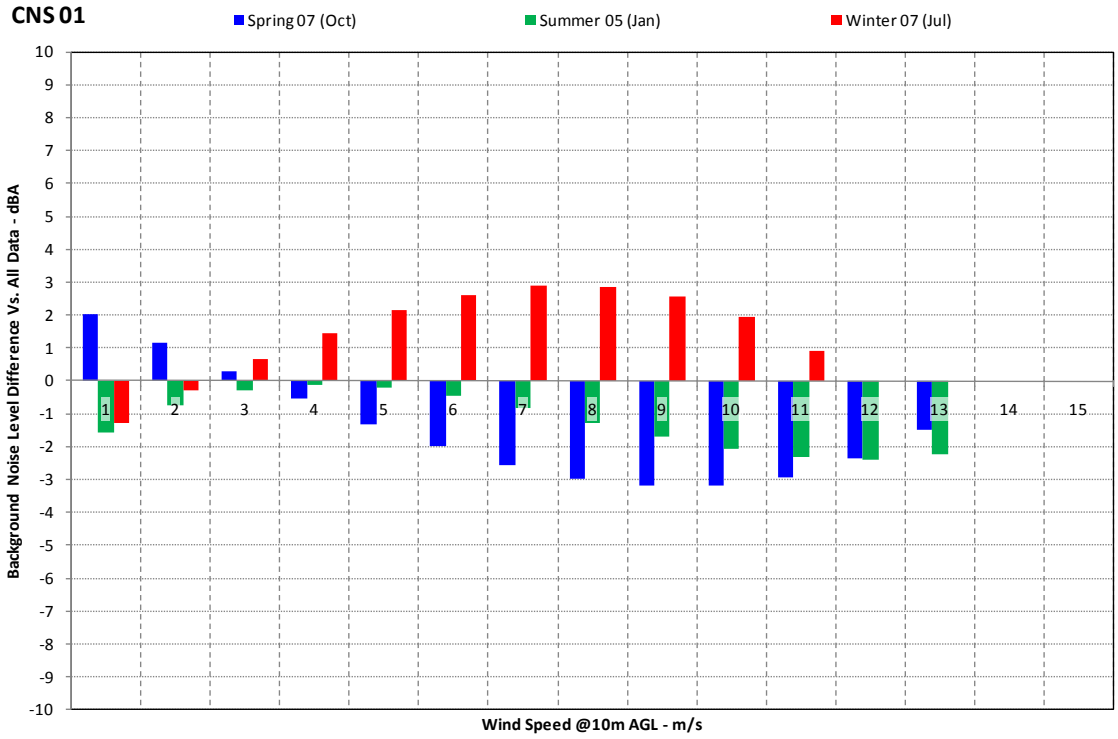

CNN - House 26
Spring 04 (Nov)
Autumn 08 (May)
All data
Background Noise Levels - dBA
Wind Speed @10m AGL - m/s
Spring 04 (Nov)
Mean Wind Speed variation
Autumn 08 (May)
Mean Wind Speed variation

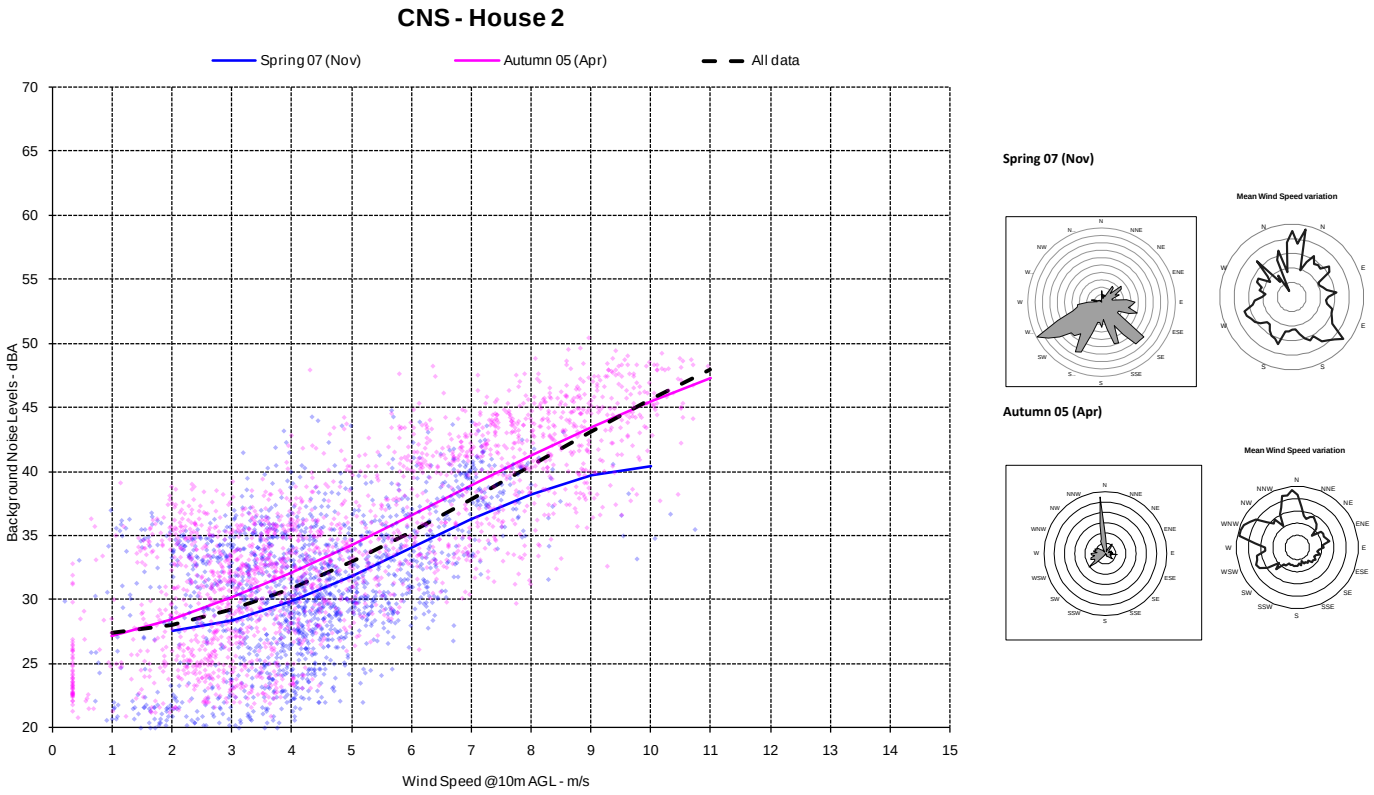

CNN 26
Spring 04 (Nov)
Autumn 08 (May)
Background Noise Level Difference Vs. All Data - dBA
Wind Speed @10m AGL - m/s

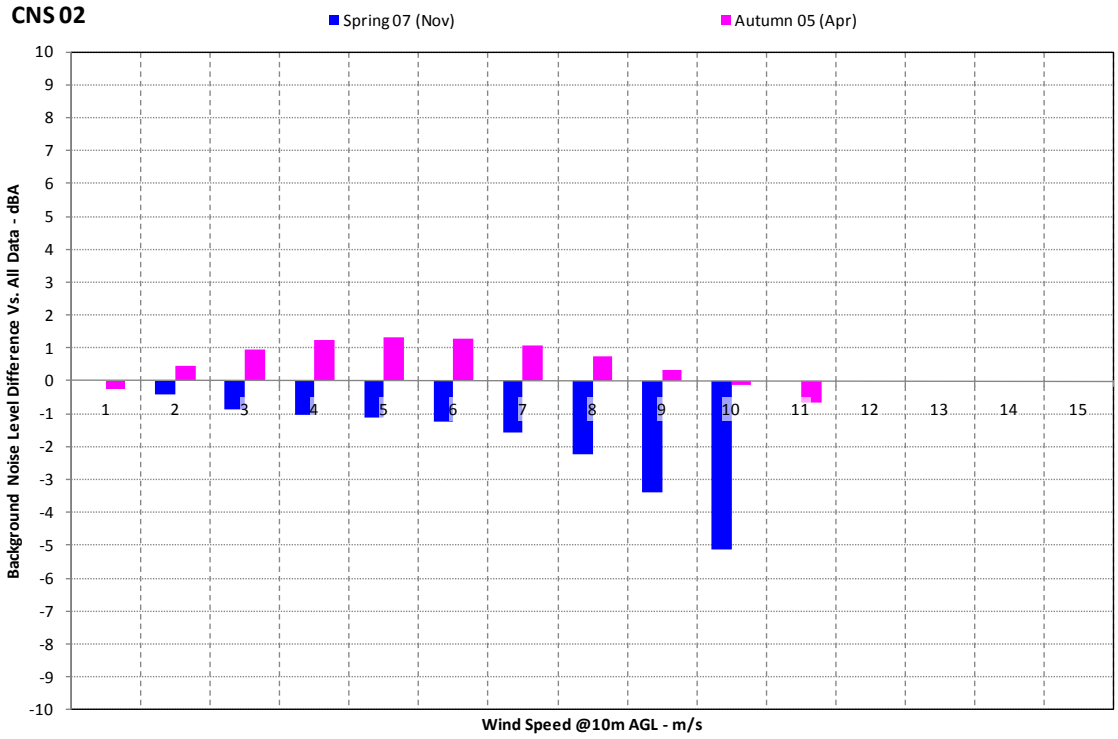

CNN - House 28
Spring 04 (Nov)
Winter 08 (Jun)
All data
Background Noise Levels - dBA
Wind Speed @10m AGL - m/s
Spring 04 (Nov)
Mean Wind Speed variation
Winter 08 (Jun)
Mean Wind Speed variation

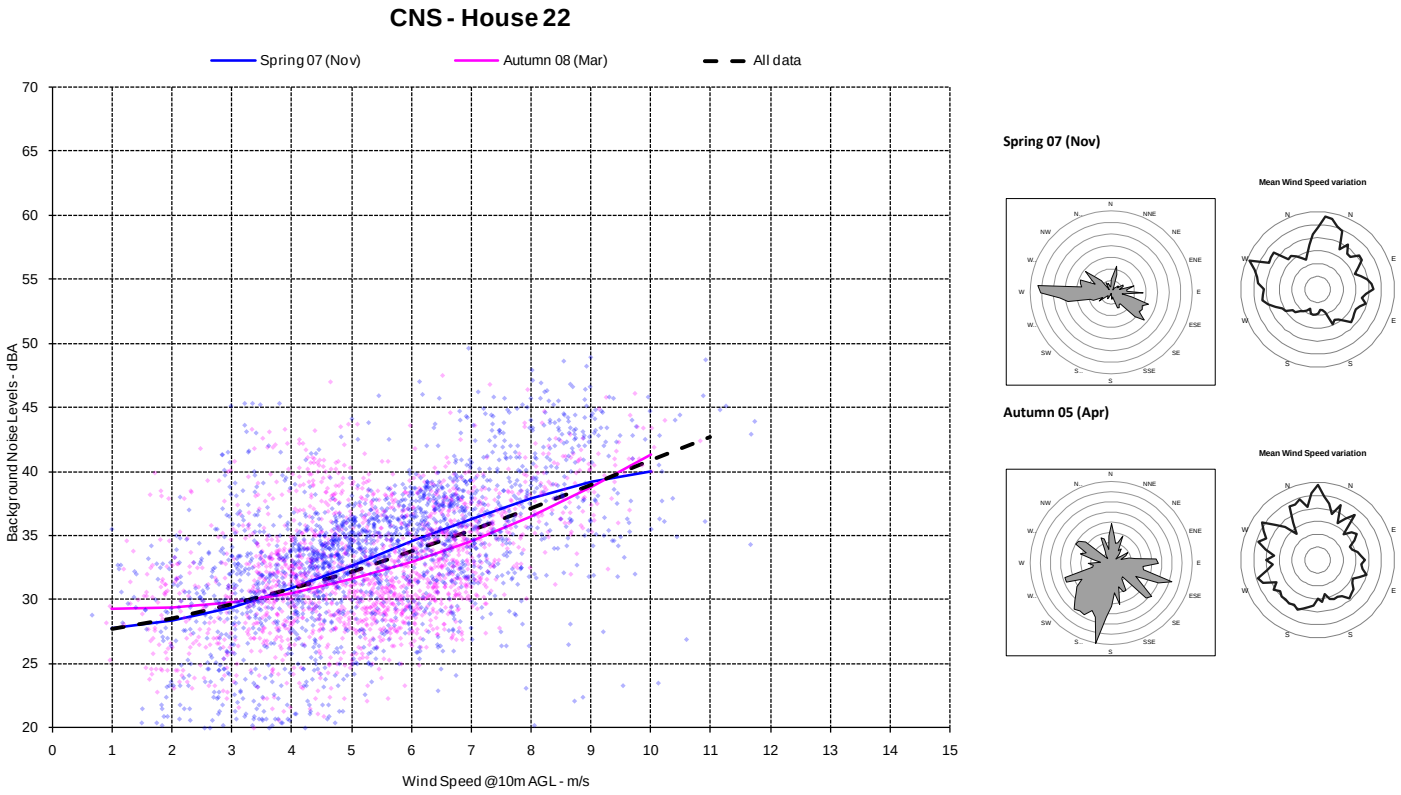

CNN 28
Spring 04 (Nov)
Winter 08 (Jun)
Background Noise Level Difference Vs. All Data - dBA
Wind Speed @10m AGL - m/s

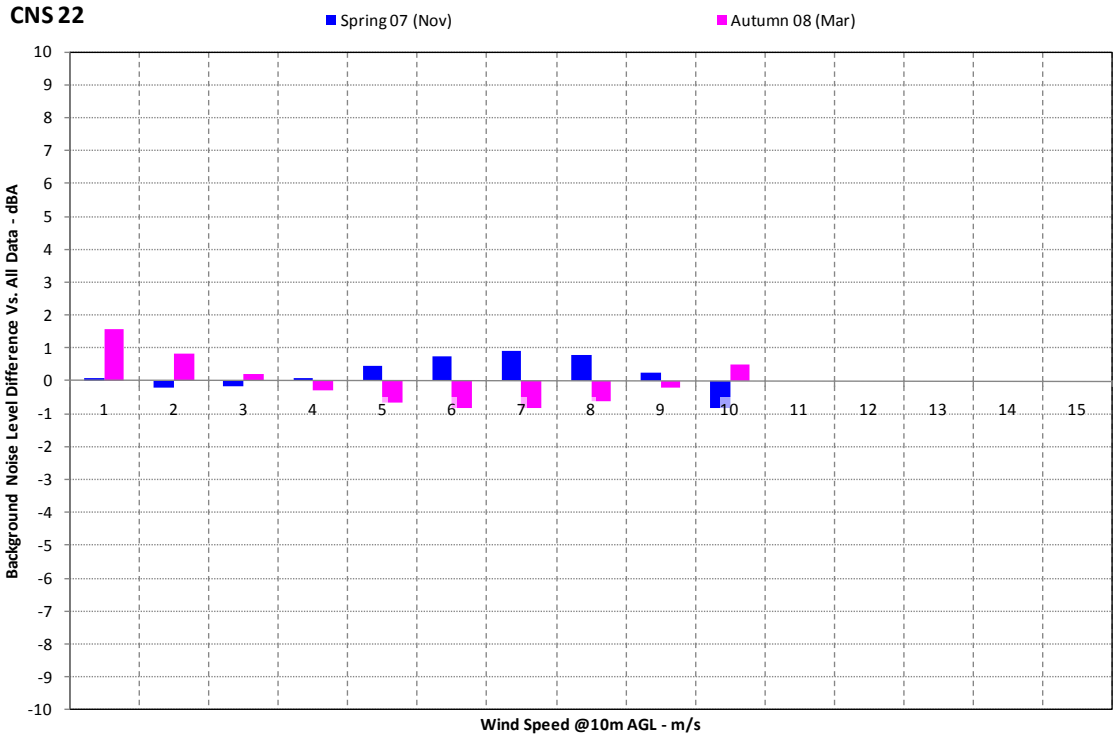

CNS - House 1
Spring 07 (Oct)
Summer 05 (Jan)
Winter 07 (Jul)
All data
Background Noise Levels - dBA
Wind Speed @10m AGL - m/s
Winter 2007 (Jul)
Wind Direction Distribution
Spring 07 (Oct)
Mean Wind Speed variation
Summer 05 (Jan)
Mean Wind Speed variation

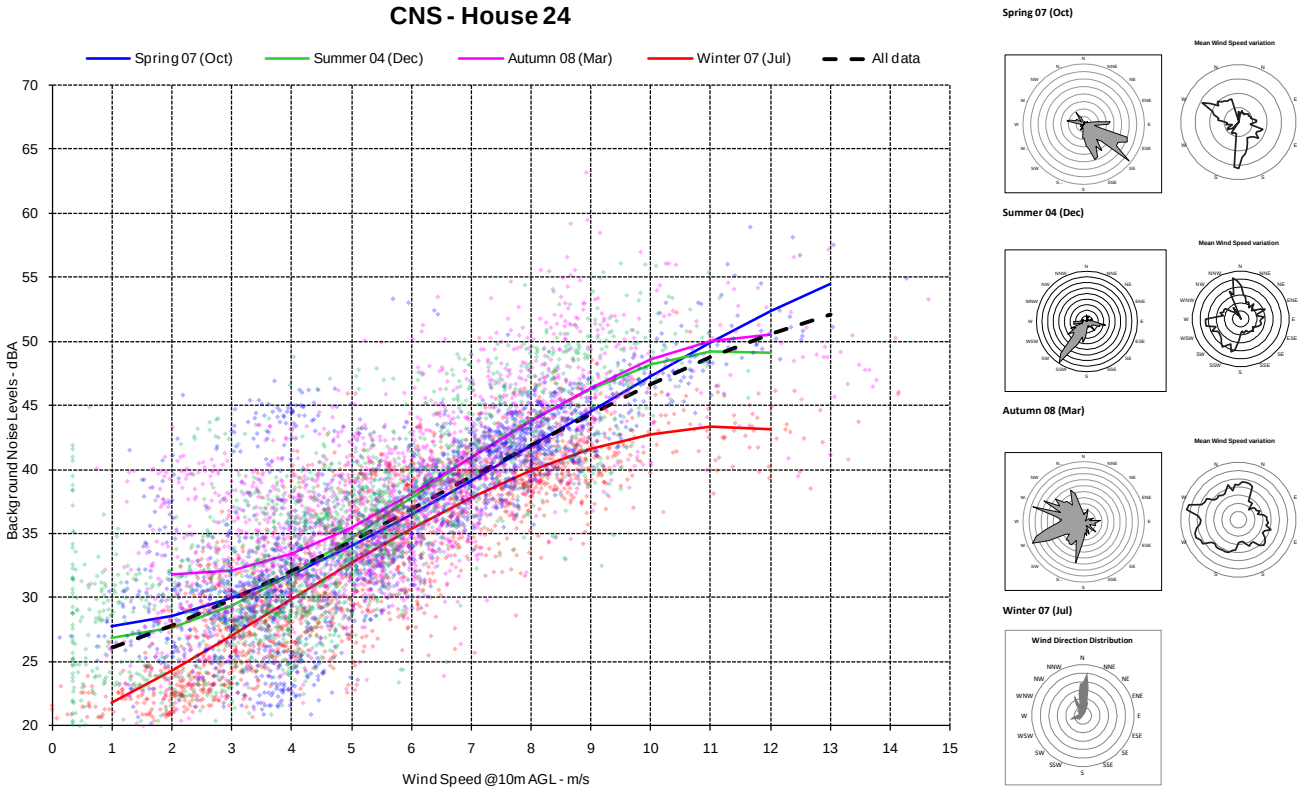

CNS 01
Spring 07 (Oct)
Summer 05 (Jan)
Winter 07 (Jul)
Background Noise Level Difference Vs. All Data - dBA
Wind Speed @10m AGL - m/s

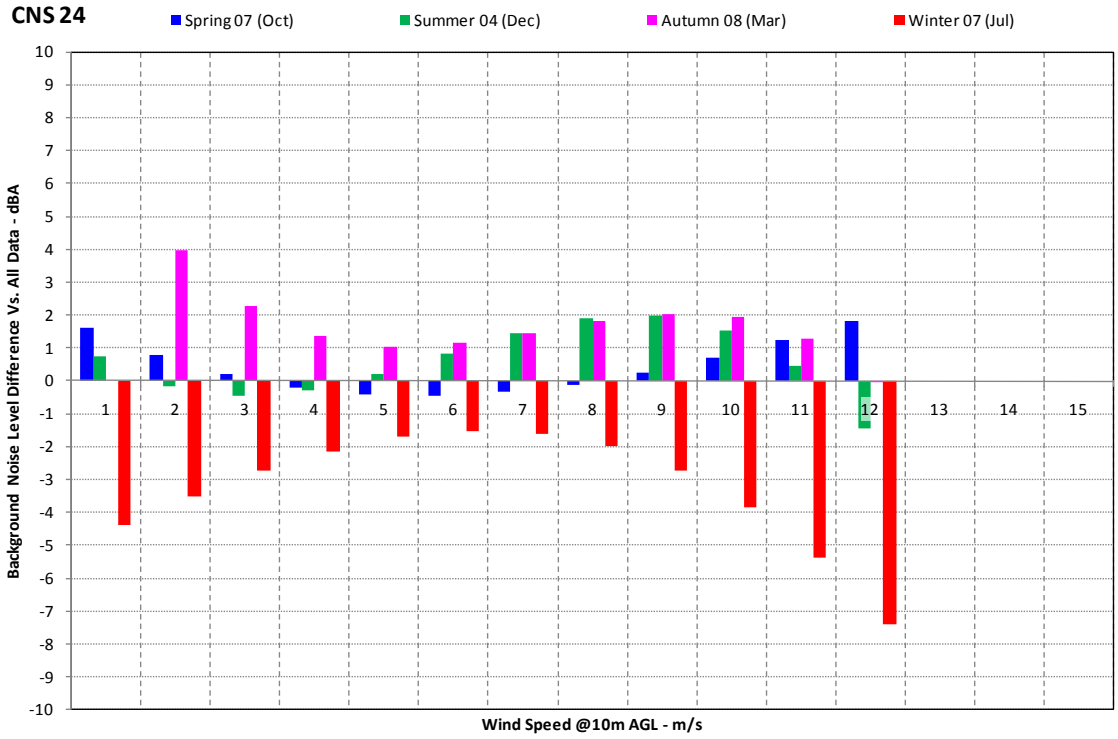

CNS - House 2
Spring 07 (Nov)
Autumn 05 (Apr)
All data
Background Noise Levels - dBA
Wind Speed @10m AGL - m/s
Spring 07 (Nov)
Mean Wind Speed variation
Autumn 05 (Apr)
Mean Wind Speed variation

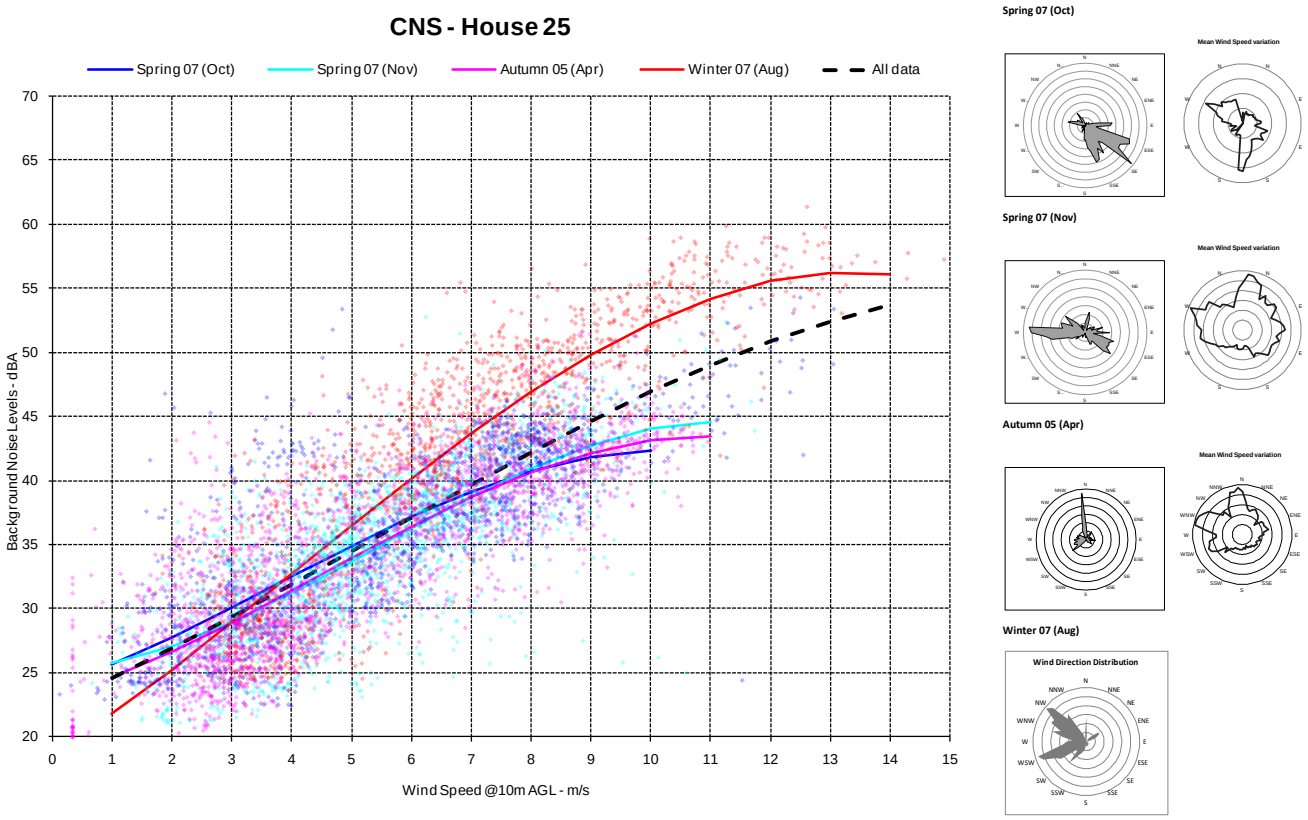

CNS 02
Spring 07 (Nov)
Autumn 05 (Apr)
Background Noise Level Difference Vs. All Data - dBA
Wind Speed @10m AGL - m/s

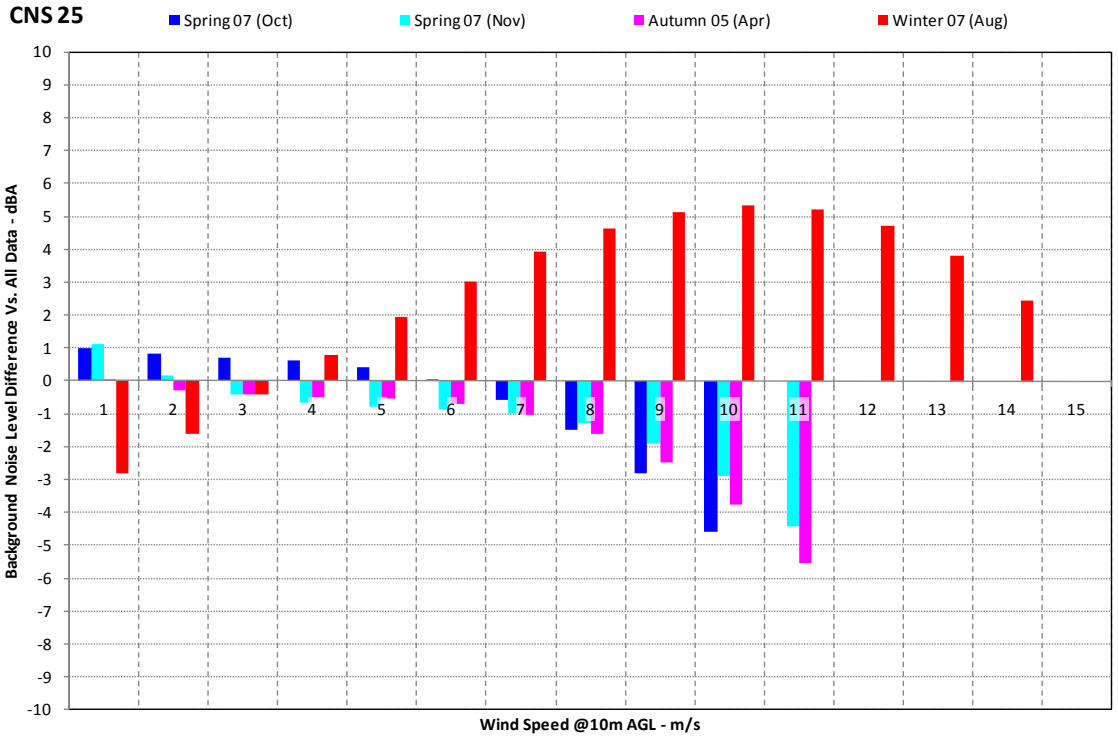

CNS - House 22
Spring 07 (Nov)
Autumn 08 (Mar)
All data
Background Noise Levels - dBA
Wind Speed @10m AGL - m/s
Spring 07 (Nov)
Mean Wind Speed variation
Autumn 05 (Apr)
Mean Wind Speed variation

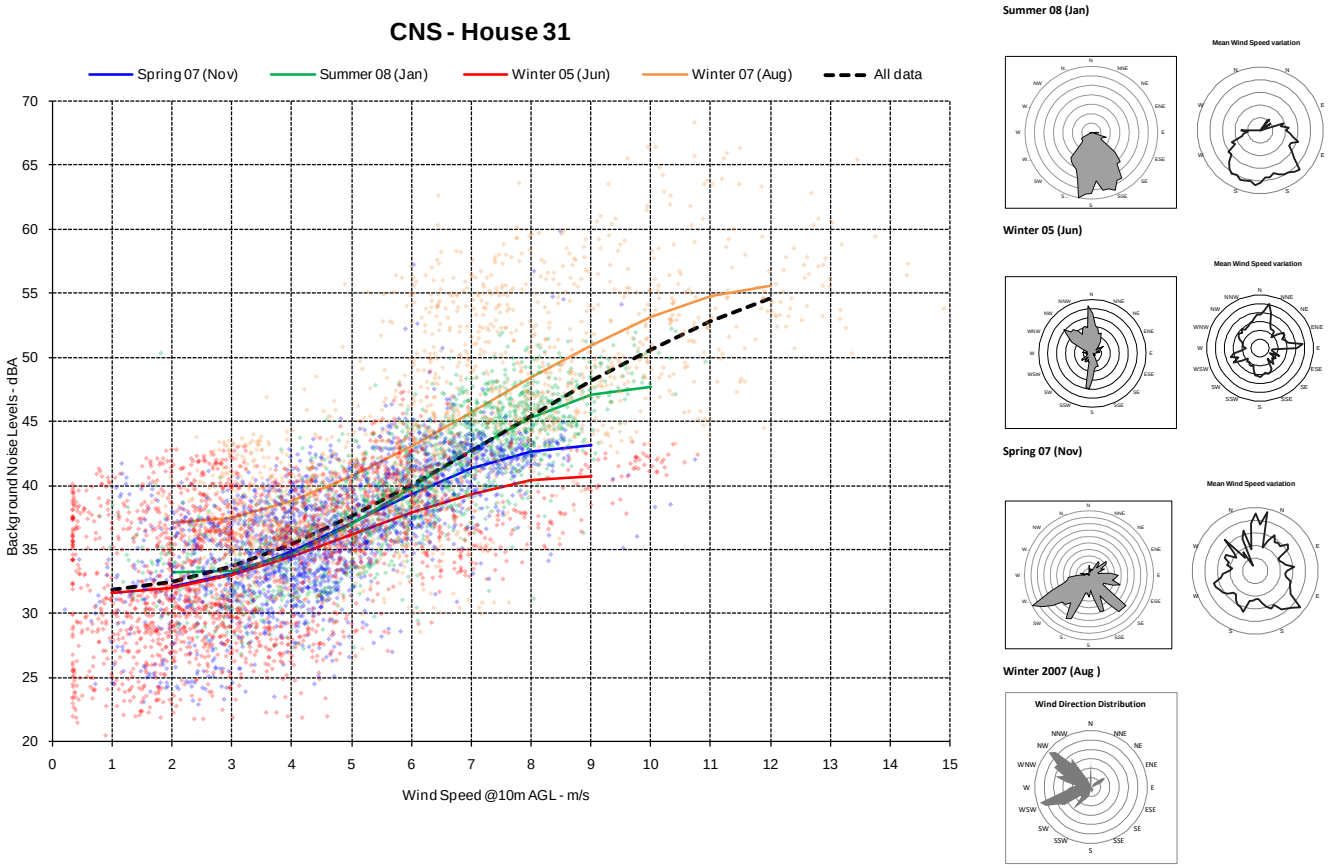

CNS 22
Spring 07 (Nov)
Autumn 08 (Mar)
Background Noise Level Difference Vs. All Data - dBA
Wind Speed @10m AGL - m/s

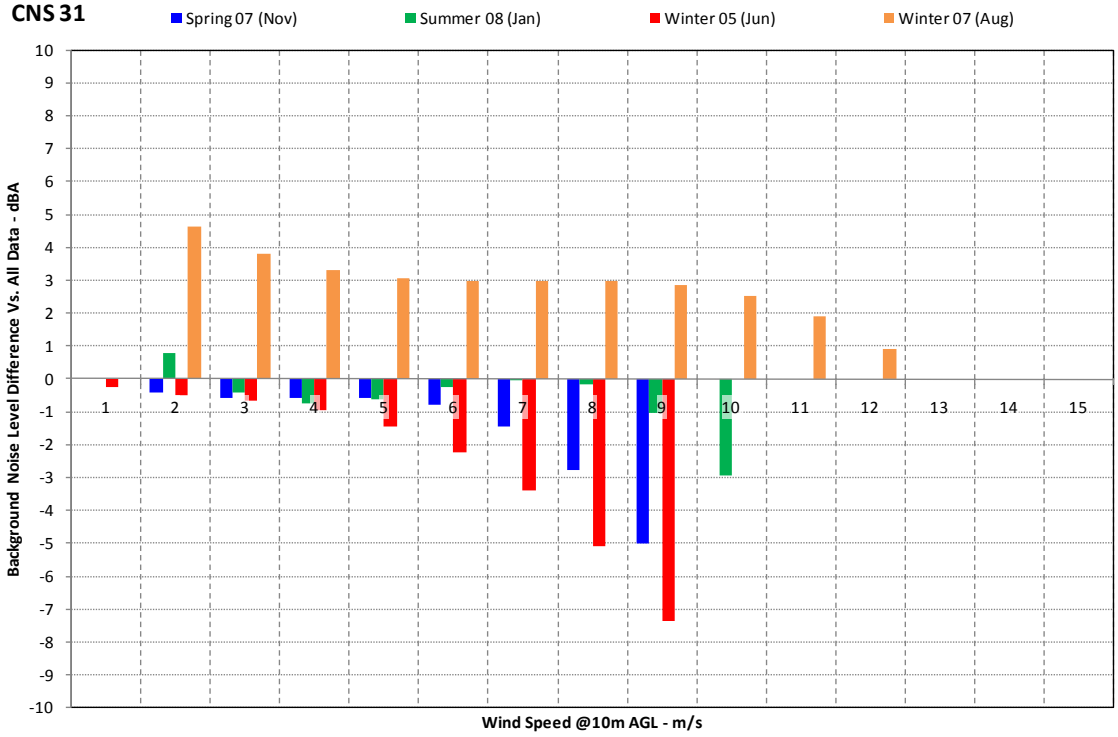

CNS - House 24
Spring 07 (Oct)
Summer 04 (Dec)
Autumn 08 (Mar)
Winter 07 (Jul)
All data
Background Noise Levels - dBA
Wind Speed @10m AGL - m/s
Spring 07 (Oct)
Summer 04 (Dec)
Autumn 08 (Mar)
Winter 07 (Jul)
Mean Wind Speed variation
Wind Direction Distribution

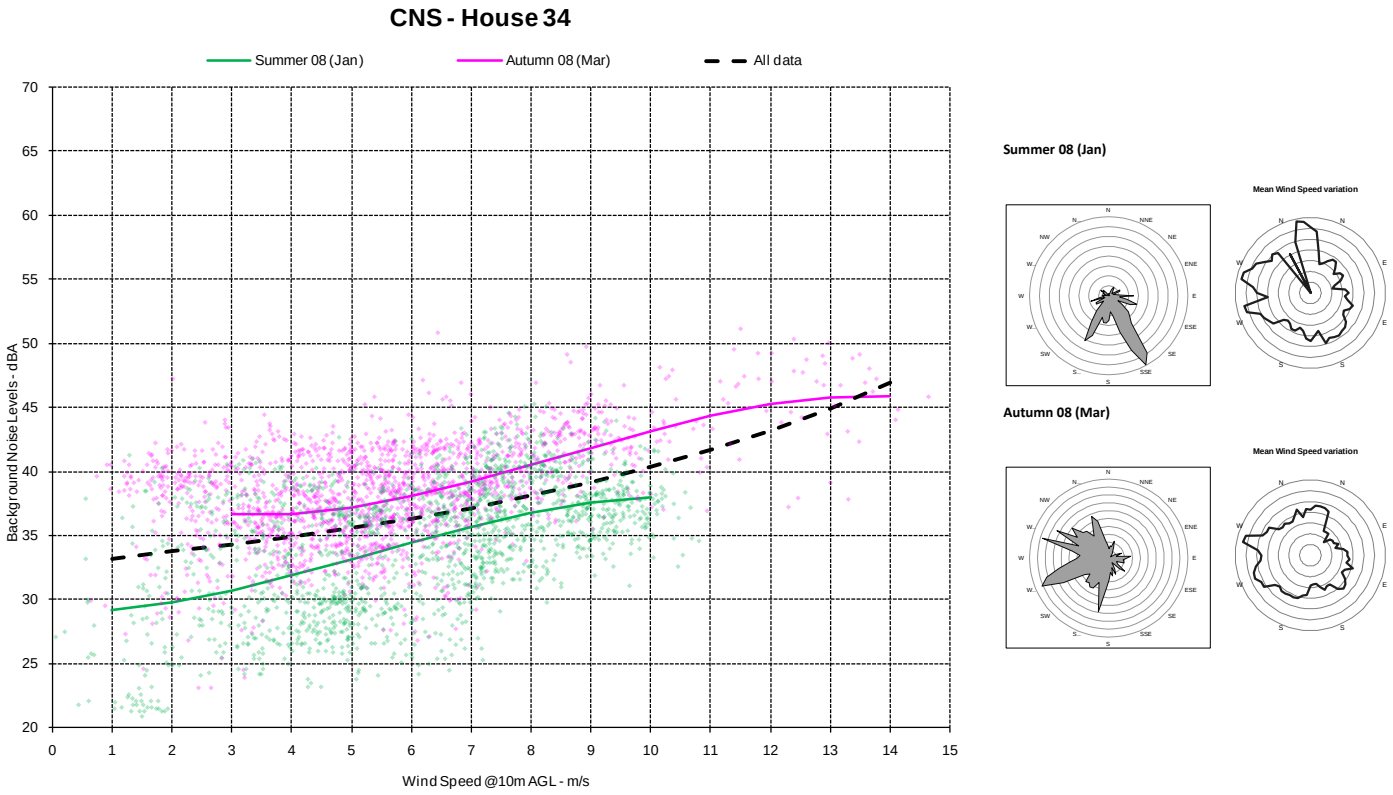

CNS 24
Spring 07 (Oct)
Summer 04 (Dec)
Autumn 08 (Mar)
Winter 07 (Jul)
Background Noise Level Difference Vs. All Data - dBA
Wind Speed @10m AGL - m/s

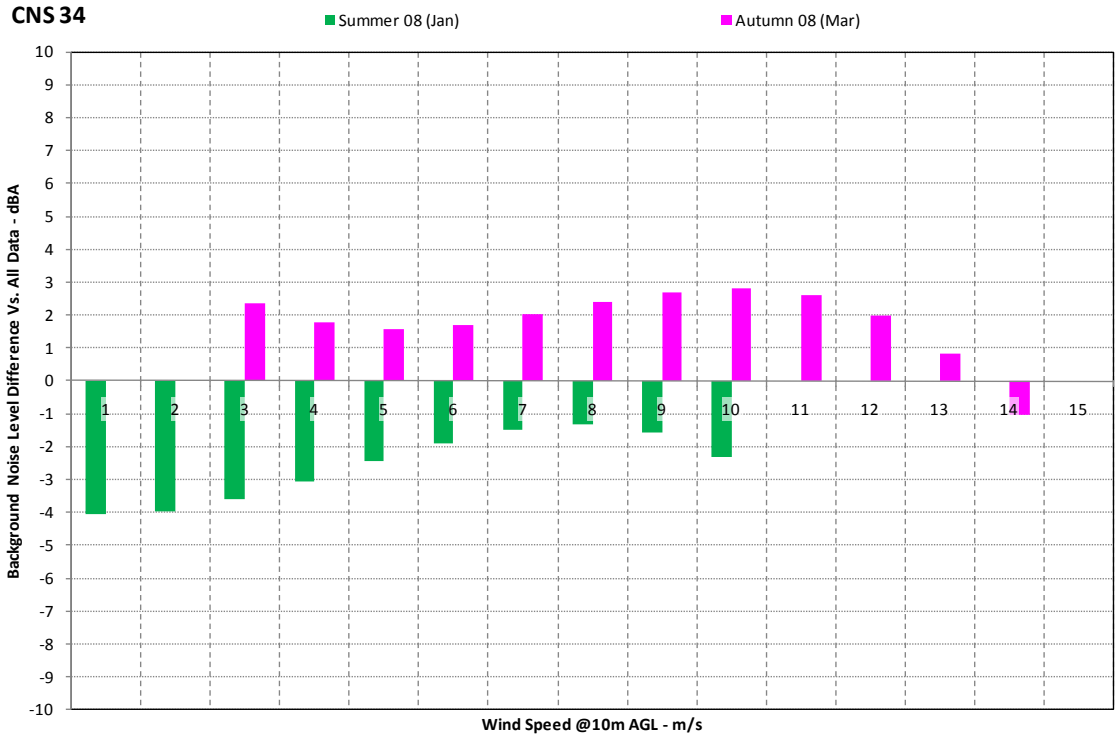

CNS - House 25
Spring 07 (Oct)
Spring 07 (Nov)
Autumn 05 (Apr)
Winter 07 (Aug)
All data
Background Noise Levels - dBA
Wind Speed @10m AGL - m/s
Spring 07 (Oct)
Mean Wind Speed variation
Spring 07 (Nov)
Mean Wind Speed variation
Autumn 05 (Apr)
Mean Wind Speed variation
Winter 07 (Aug)
Wind Direction Distribution

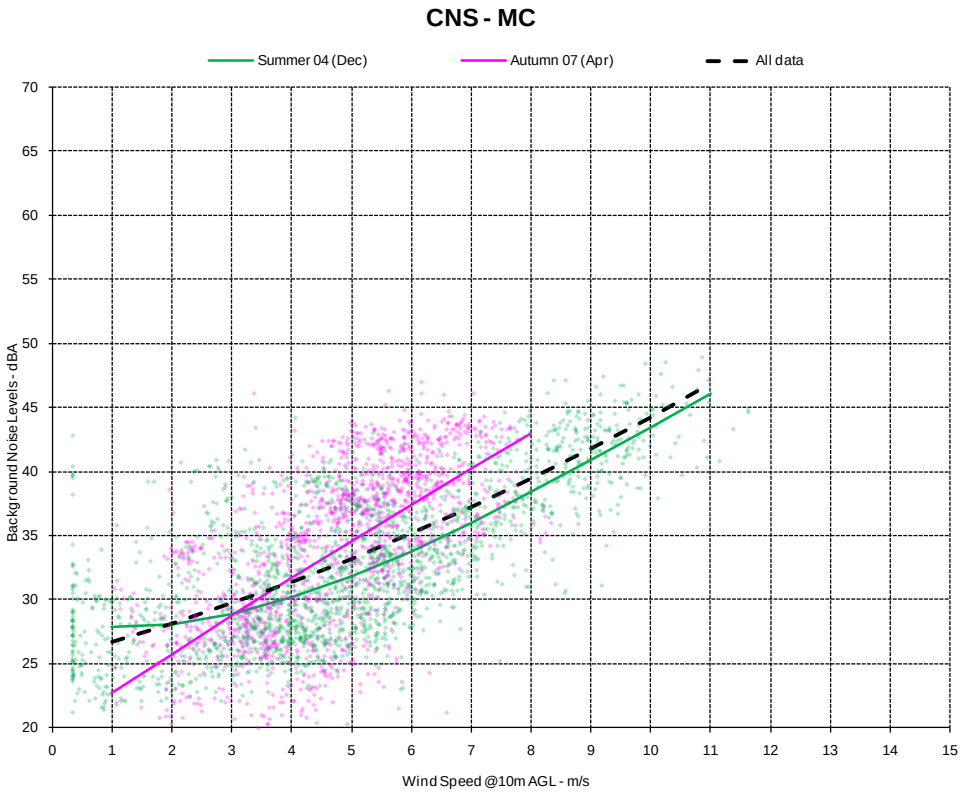

CNS 25
Spring 07 (Oct)
Spring 07 (Nov)
Autumn 05 (Apr)
Winter 07 (Aug)
Background Noise Level Difference Vs. All Data - dBA
Wind Speed @10m AGL - m/s

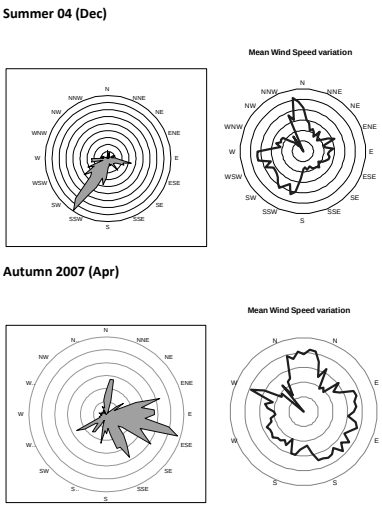

CNS - House 31
Spring 07 (Nov)
Summer 08 (Jan)
Winter 05 (Jun)
Winter 07 (Aug)
All data
Background Noise Levels - dBA
Wind Speed @10m AGL - m/s
Summer 08 (Jan)
Mean Wind Speed variation
Winter 05 (Jun)
Mean Wind Speed variation
Spring 07 (Nov)
Mean Wind Speed variation
Winter 2007 (Aug)
Wind Direction Distribution

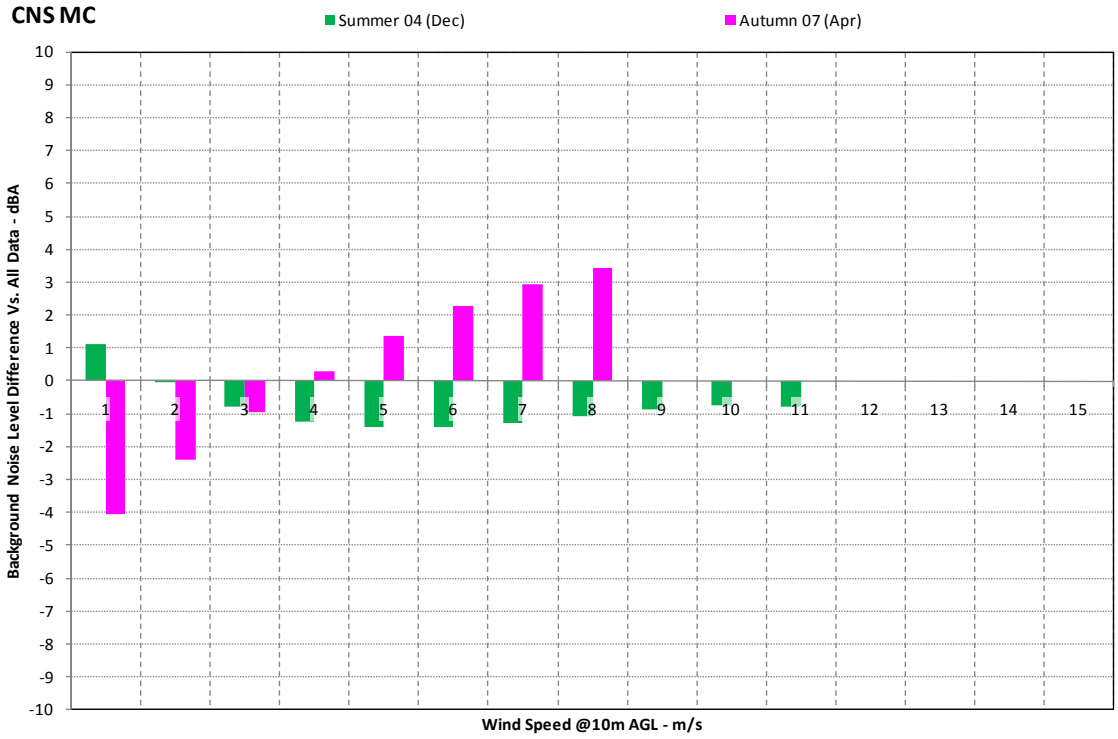

CNS 31
Spring 07 (Nov)
Summer 08 (Jan)
Winter 05 (Jun)
Winter 07 (Aug)
Background Noise Level Difference Vs. All Data - dBA
Wind Speed @10m AGL - m/s

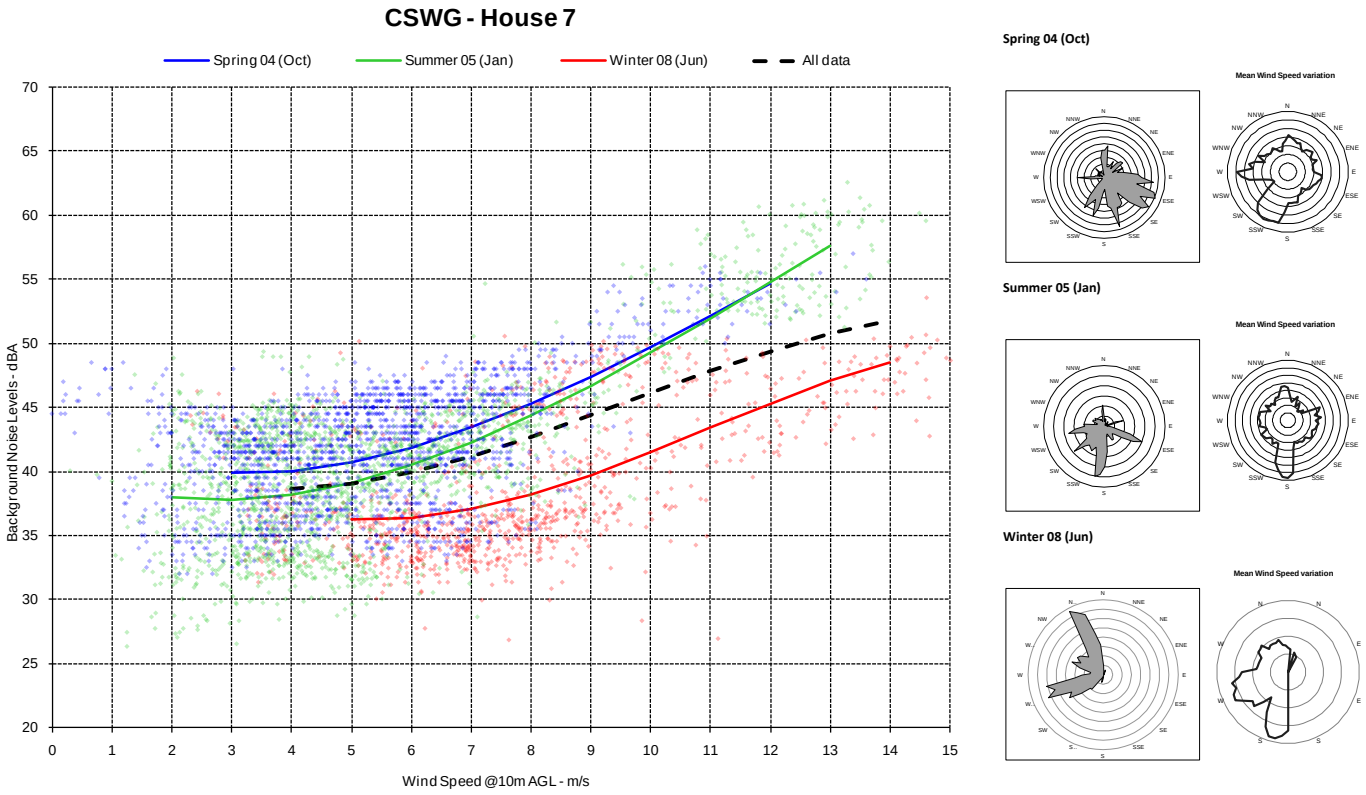

CNS - House 34
Summer 08 (Jan)
Autumn 08 (Mar)
All data
Background Noise Levels - dBA
Wind Speed @10m AGL - m/s
Summer 08 (Jan)
Mean Wind Speed variation
Autumn 08 (Mar)
Mean Wind Speed variation

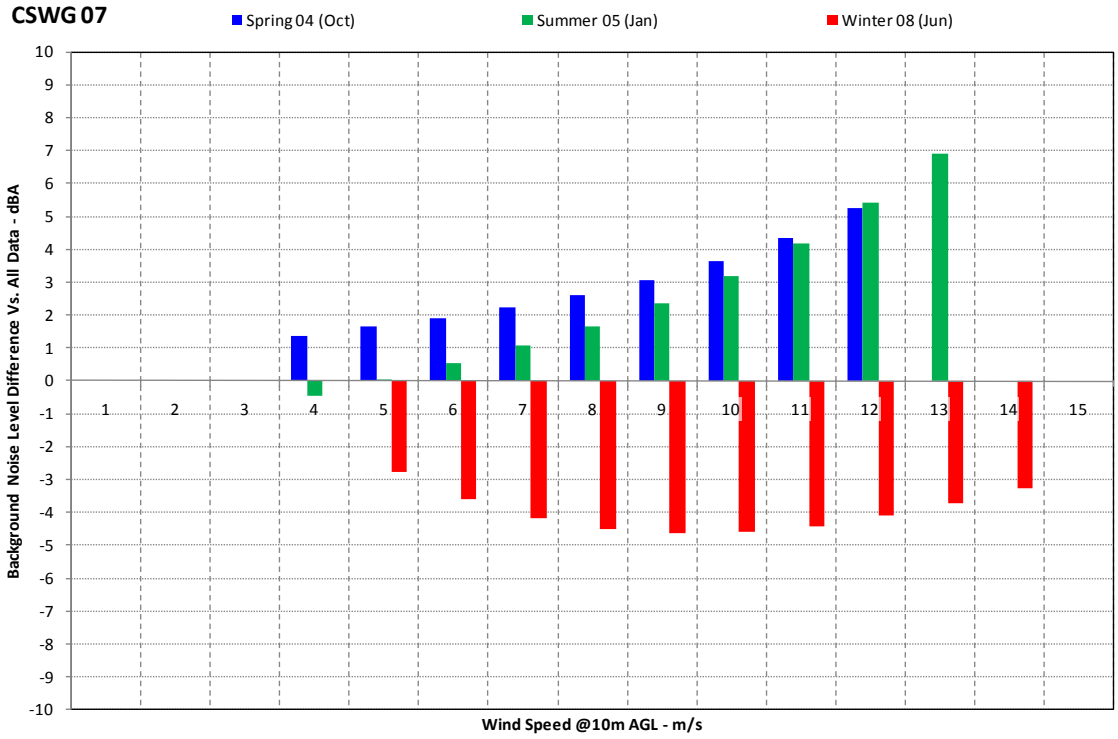

CNS 34
Summer 08 (Jan)
Autumn 08 (Mar)
Background Noise Level Difference Vs. All Data - dBA
Wind Speed @10m AGL - m/s

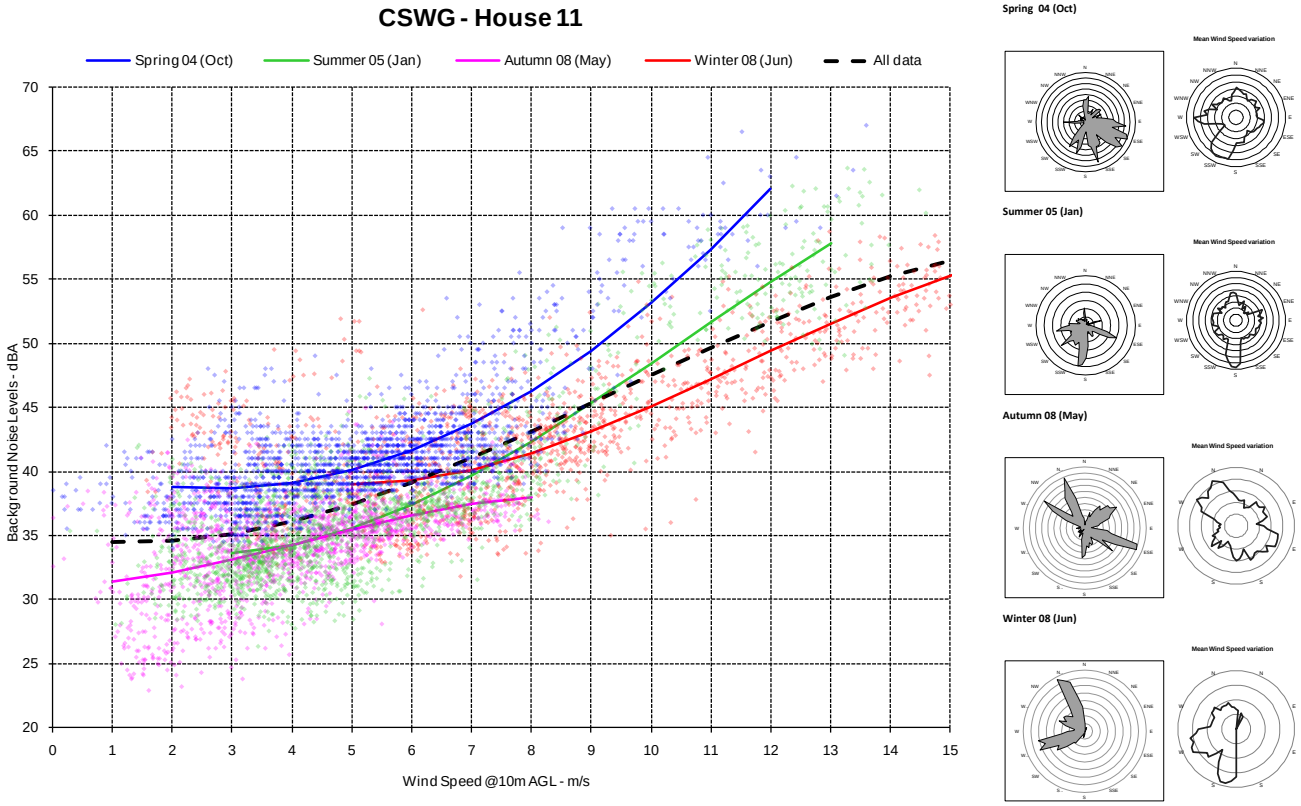

CNS - MC
Summer 04 (Dec)
Autumn 07 (Apr)
All data
Background Noise Levels - dBA
Wind Speed @10m AGL - m/s

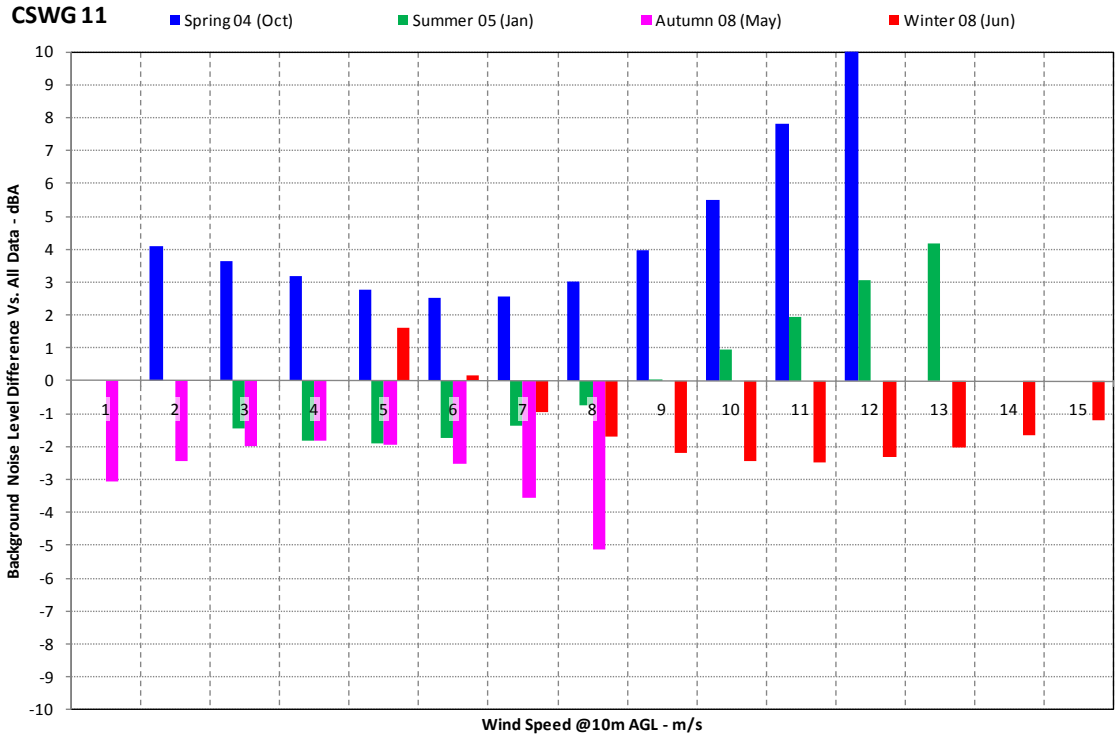

Summer 04 (Dec)
Mean Wind Speed variation
Autumn 2007 (Apr)
Mean Wind Speed variation

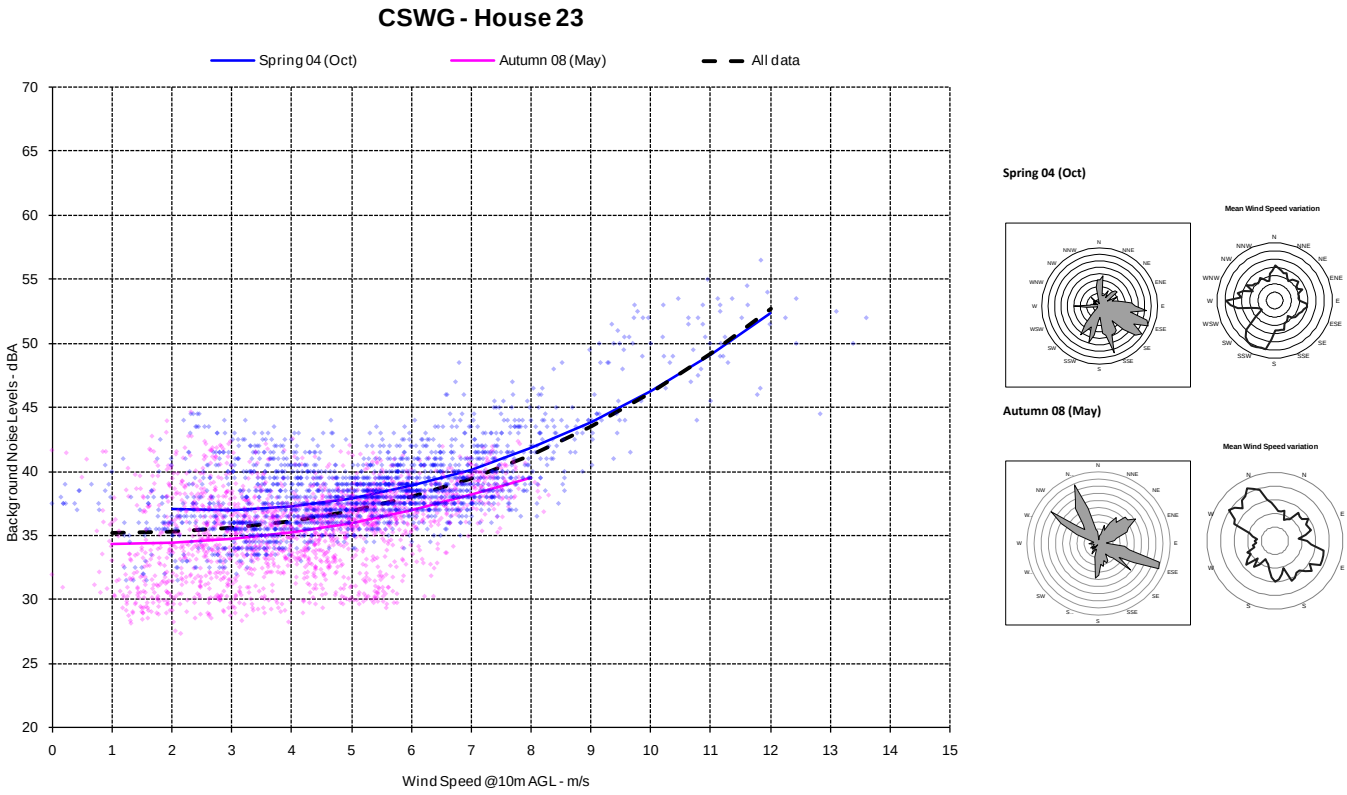

CNS MC
Summer 04 (Dec)
Autumn 07 (Apr)
Background Noise Level Difference Vs. All Data - dBA
Wind Speed @10m AGL - m/s

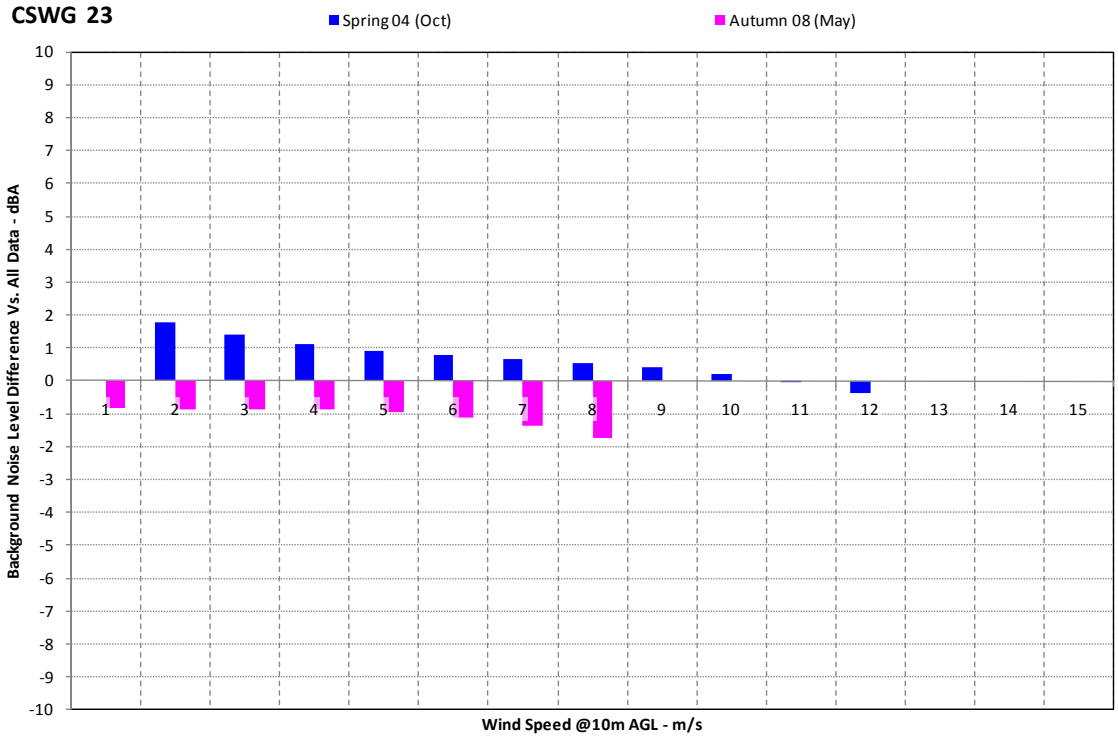

CSWG - House 7
Spring 04 (Oct)
Summer 05 (Jan)
Winter 08 (Jun)
All data
Background Noise Levels - dBA
Wind Speed @10m AGL - m/s
Spring 04 (Oct)
Mean Wind Speed variation
Summer 05 (Jan)
Mean Wind Speed variation
Winter 08 (Jun)
Mean Wind Speed variation

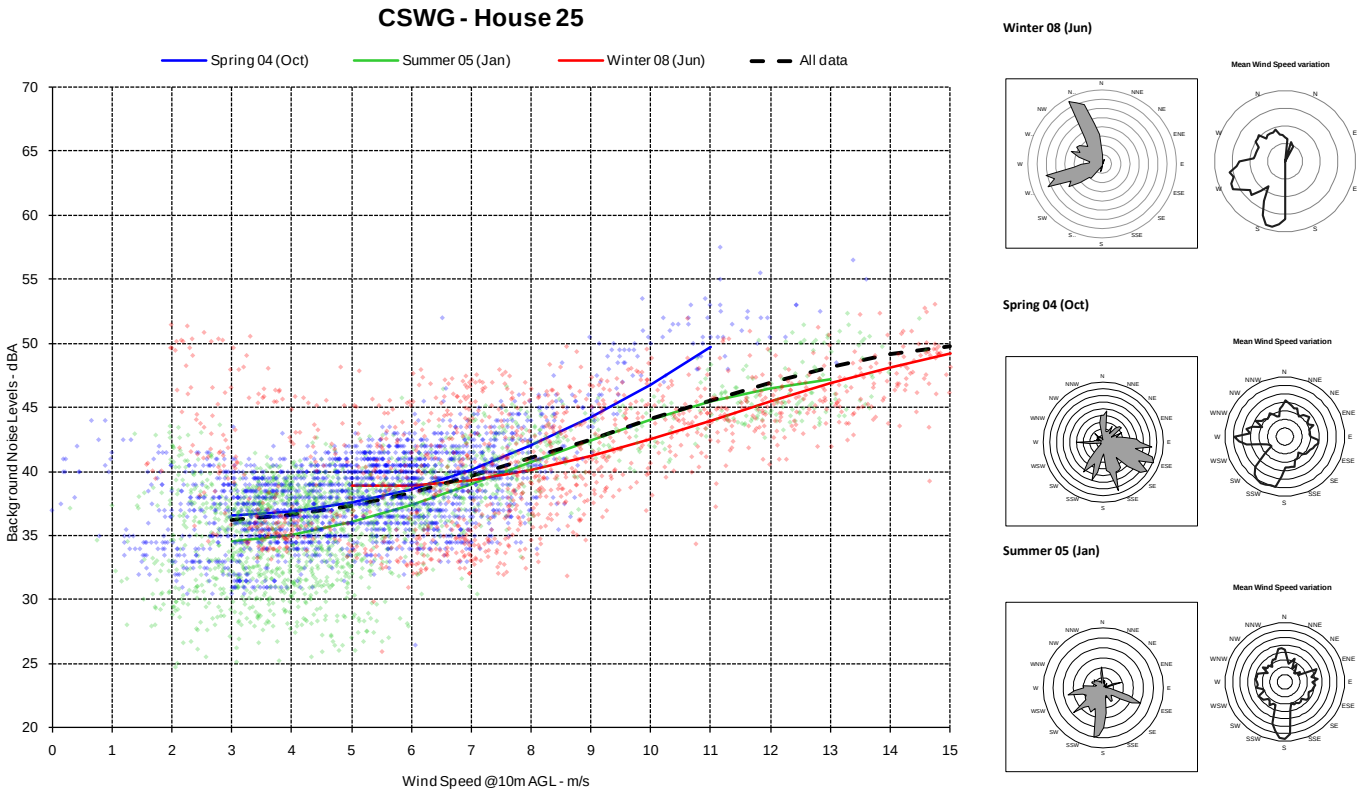

CSWG 07
Spring 04 (Oct)
Summer 05 (Jan)
Winter 08 (Jun)
Background Noise Level Difference Vs. All Data - dBA
Wind Speed @10m AGL - m/s

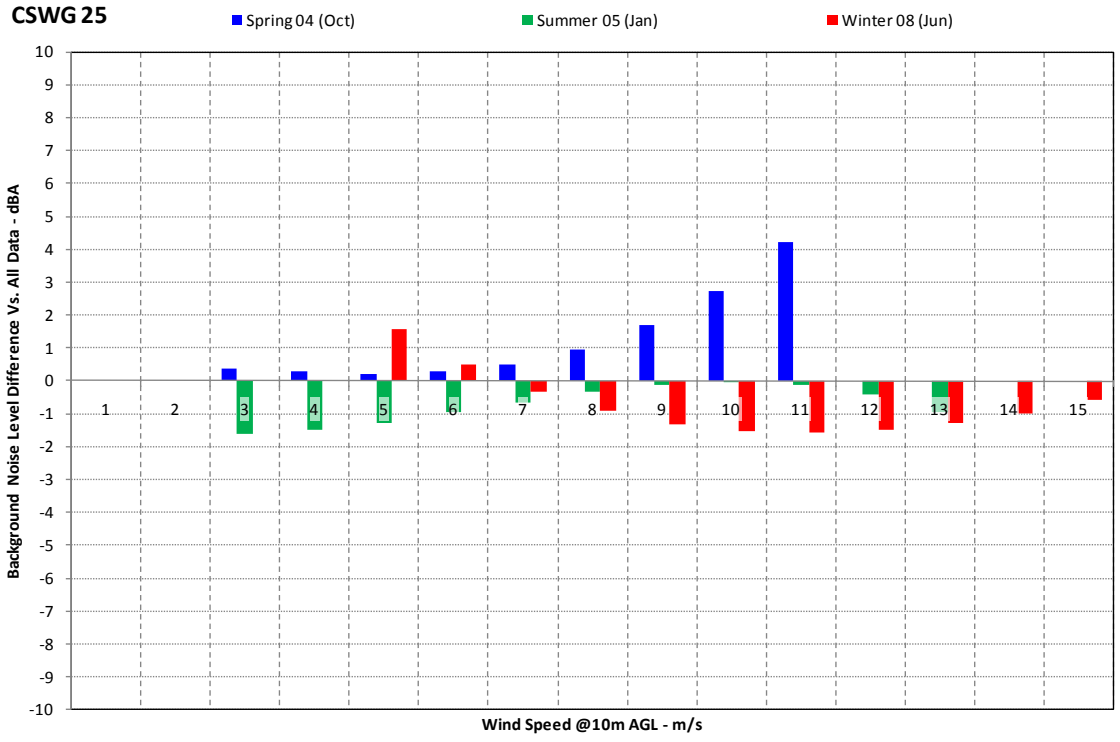

CSWG - House 11
Spring 04 (Oct)
Summer 05 (Jan)
Autumn 08 (May)
Winter 08 (Jun)
All data
Background Noise Levels - dBA
Wind Speed @10m AGL - m/s
Spring 04 (Oct)
Summer 05 (Jan)
Autumn 08 (May)
Winter 08 (Jun)
Mean Wind Speed variation


CSWG 11
Spring 04 (Oct)
Summer 05 (Jan)
Autumn 08 (May)
Winter 08 (Jun)
Background Noise Level Difference Vs. All Data - dBA
Wind Speed @10m AGL - m/s


CSWG - House 23
Spring 04 (Oct)
Autumn 08 (May)
All data
Background Noise Levels - dBA
Wind Speed @10m AGL - m/s
Spring 04 (Oct)
Mean Wind Speed variation
Autumn 08 (May)
Mean Wind Speed variation


CSWG 23
Spring 04 (Oct)
Autumn 08 (May)
Background Noise Level Difference Vs. All Data - dBA
Wind Speed @10m AGL - m/s


CSWG - House 25
Spring 04 (Oct)
Summer 05 (Jan)
Winter 08 (Jun)
All data
Background Noise Levels - dBA
Wind Speed @10m AGL - m/s
Winter 08 (Jun)
Mean Wind Speed variation
Spring 04 (Oct)
Mean Wind Speed variation
Summer 05 (Jan)
Mean Wind Speed variation


CSWG 25
Spring 04 (Oct)
Summer 05 (Jan)
Winter 08 (Jun)
Background Noise Level Difference Vs. All Data - dBA
Wind Speed @10m AGL - m/s

APPENDIX C

SUMMARY OF PARAMETERS

a, b, c and d in tables below correspond to the constant in the background noise regression curve equation.

$$y = a \cdot x^3 + b \cdot x^2 + c \cdot x + d$$

where y is the background noise level and x the wind speed.

If a does not contain any value, then a 2nd order regression was used instead of 3rd order.

R^2 is the coefficient of determination of the regression curve

PWEP II – CBS

		Monitoring period	Logger Location	Avg. wind speed	Max. wind Speed	Correlation Coefficient	a	b	c	d	R^2	Average difference between survey period and all data between 6-10m/s
CBS 01	All data	-			14	0.86	-0.01087	0.2660	0.4885	24.33	0.75	
	Summer 05 (Jan)	06.01.2005 to 19.01.2005	A	6	13	0.71	-0.00556	0.1504	1.0160	24.66	0.51	-0.1
	Winter 06 (Jul)	14.07.2006 to 28.07.2006	A	6	14	0.90	-0.02354	0.5488	-1.3110	26.26	0.83	-0.9
	Spring 06 (Oct)	11.10.2006 to 23.10.2006	A	6	14	0.90	-0.01125	0.2906	0.1675	26.15	0.81	0.7
CBS 02	All data	-			14	0.79	-0.00761	0.1958	1.2770	22.00	0.63	
	Summer 05 (Jan)	06.01.2005 to 20.01.2005	A	6	13	0.72	-0.00190	0.0163	2.6060	19.20	0.52	-0.8
	Winter 06 (Jun)	01.06.2006 to 13.06.2006	B	4	13	0.86	-0.00770	0.2704	0.3773	22.42	0.77	-1.9
	Spring 06 (Sep)	26.09.2006 to 09.10.2006	B	6	14	0.80	0.00842	-0.1272	3.0040	20.90	0.64	0.4
	Autumn 07 (Apr)	02.04.2007 to 15.04.2007	B	5	10	0.67		0.0477	2.0330	22.18	0.46	0.8

PWEP II - CBN

		Monitoring period	Logger Location	Avg. wind speed	Max. wind Speed	Correlation Coefficient	a	b	c	d	R^2	Average difference between survey period and all data between 6-10m/s
CBN 46	All data	-			14	0.67	-0.01300	0.3443	-0.6487	29.59	0.46	
	Spring 05 (Nov)	17.11.2005 to 02.12.2005	A	5	12	0.75	0.00435	-0.0490	2.7150	22.78	0.56	3.9
	Winter 06 (Jul)	07.07.2006 to 21.07.2006	A	6	13	0.68	-0.04773	1.0280	-4.8390	39.12	0.52	1.7
	Summer 07 (Feb)	23.02.2007 to 07.03.2007	A	6	13	0.60	-0.03872	0.6187	-1.3990	26.46	0.38	-5.4
	Spring 07 (Oct)	03.10.2007 to 16.10.2007		7	14	0.77	-0.00174	0.1165	0.8269	26.15	0.60	-0.4
CBN 54	All data	-			18	0.83	-0.01220	0.2627	0.5338	26.50	0.69	
	Summer 05 (Jan)	21.01.2005 to 03.02.2005	A	6	15	0.85	-0.02984	0.5828	-0.8203	24.83	0.73	1.5
	Winter 06 (Jul)	21.07.2006 to 04.08.2006	A	6	15	0.45	-0.01910	0.5446	-3.1100	36.31	0.28	-0.8
	Spring 06 (Sep)	26.09.2006 to 10.10.2006	A	5	14	0.43	-0.01804	0.5072	-2.9690	37.37	0.28	-0.5
	Summer 08 (Jan)	31.01.2008 to 13.02.2008	A	6	10	0.61	-0.03150	0.6326	-2.8620	35.93	0.41	-0.4
CBN 55	All data	-			18	0.83	-0.01220	0.2627	0.5338	26.50	0.69	
	Summer 05 (Jan)	21.01.2005 to 03.02.2005	A	5	15	0.85	-0.02984	0.5828	-0.8203	24.83	0.73	-1.3
	Autumn 06 (Apr)	24.04.2006 to 08.05.2006	A	6	15	0.89	-0.01723	0.3883	-0.3867	28.06	0.80	-0.3
	Winter 06 (Jun)	16.06.2006 to 30.06.2006	A	4	12	0.66	0.00485	-0.1014	2.4050	25.87	0.43	-0.1
	Spring 06 (Sep)	12.09.2006 to 26.09.2006	A	6	18	0.87	-0.00212	0.0364	1.8140	25.81	0.76	0.3
	Spring 06 (Oct)	27.10.2006 to 09.11.2006	A	6	11	0.81	-0.06030	1.1610	-4.1030	32.51	0.67	1.3
CBN 63	All data	-			15	0.83	-0.02585	0.5592	-1.0170	31.22	0.69	
	Summer 05 (Feb)	22.02.2005 to 08.03.2005	A	5	12	0.62	-0.06507	1.3010	-5.1500	36.93	0.47	-0.4
	Autumn 06 (Apr)	04.04.2006 to 18.04.2006	A	6	14	0.87	0.00114	-0.0705	3.1850	22.83	0.75	-1.2
	Winter 06 (Jun)	30.06.2006 to 13.07.2006	A	6	13	0.87	-0.02624	0.4811	-0.0827	29.74	0.77	0.6

	Spring 06 (Oct)	11.10.2006 to 25.10.2006	A	6	15	0.83	-0.03502	0.8363	-3.1820	36.67	0.71	1.3
CBN 70	All data	-			16	0.62	-0.02706	0.7088	-3.7530	50.24	0.44	
	Summer 05 (Dec)	22.12.2005 to 05.01.2006	A	6	16	0.63	-0.04726	1.2100	-7.1430	55.04	0.45	-0.6
	Winter 06 (Jul)	31.07.2006 to 12.08.2006	A	5	13	0.64	-0.00942	0.3109	-1.5400	47.43	0.51	-1.5
	Winter 07 (Aug)	22.08.2007 to 04.09.2007	A	6	16	0.64	-0.02211	0.5495	-2.4580	48.53	0.44	0.9

PWEP III - CNS

		Monitoring period	Logger Location	Avg. wind speed	Max. wind Speed	Correlation Coefficient	a	b	c	d	R^2	Average difference between survey period and all data between 6-10m/s
CNS 01	All data	-			18	0.66	-0.01657	0.2684	1.0170	25.80	0.45	
	Summer 05 (Jan)	06.01.2005 to 20.01.2005	A	6	15	0.63	-0.00661	0.0291	2.4880	22.98	0.41	-1.3
	Winter 07 (Jul)	19.07.2007 to 01.08.2007	A	6	14	0.74	-0.02294	0.2709	2.0520	23.50	0.57	2.6
	Spring 07 (Oct)	17.10.2007 to 29.10.2007	A	5	18	0.56	-0.01109	0.2319	0.2339	28.63	0.32	-2.8
CNS 02	All data	-			11	0.70	-0.01642	0.3901	-0.4480	27.49	0.51	
	Autumn 05 (Apr)	20.04.2005 to 04.05.2005	A	5	11	0.78	-0.01242	0.2489	0.6751	26.24	0.61	0.7
	Spring 07 (Nov)	14.11.2007 to 25.11.2007	A	4	11	0.50	-0.04046	0.7274	-2.1040	29.22	0.26	-2.7
CNS 22	All data	-			12	0.53	-0.00355	0.1235	0.4901	27.12	0.28	
	Spring 07 (Nov)	30.11.2007 to 14.12.2007	A	5	12	0.55	-0.02463	0.4227	-0.5628	27.97	0.31	0.4
	Autumn 08 (Mar)	15.03.2008 to 27.03.2008	A	5	11	0.48		0.1543	-0.3614	29.51	0.25	-0.4
CNS 24	All data	-			19	0.78	-0.01008	0.2025	1.1680	24.78	0.61	
	Summer 04 (Dec)	14.12.2004 to 28.12.2004	A	5	12	0.79	-0.03708	0.6784	-0.9787	27.20	0.65	1.5
	Winter 07 (Jul)	19.07.2007 to 01.08.2007	A	6	14	0.86	-0.01646	0.1829	2.1520	19.44	0.76	-2.3
	Spring 07 (Oct)	29.10.2007 to 12.11.2007	A	6	19	0.81	-0.01303	0.3303	-0.0104	27.43	0.67	0.0
	Autumn 08 (Mar)	20.03.2008 to 04.04.2008	A	6	15	0.71	-0.04104	0.8732	-3.2980	35.26	0.53	1.7
CNS 25	All data	-			15	0.79	-0.00703	0.1151	1.9930	22.52	0.62	
	Autumn 05 (Apr)	20.04.2005 to 04.05.2005	A	5	11	0.81	-0.02023	0.2702	1.3300	23.05	0.67	-1.9
	Winter 07 (Aug)	03.08.2007 to 14.08.2007	A	7	15	0.88	-0.01459	0.1793	3.0280	18.63	0.79	4.4
	Spring 07 (Oct)	29.10.2007 to 11.11.2007	A	6	13	0.67	-0.01989	0.2270	1.5680	23.86	0.47	-1.9
	Spring 07 (Nov)	30.11.2007 to 14.12.2007	A	5	12	0.75	-0.02594	0.4242	0.2465	25.09	0.56	-1.6

CNS 31	All data	-			15	0.45	-0.01928	0.4388	-0.6101	32.11	0.55	
	Winter 05 (Jun)	30.06.2005 to 14.07.2005	A	4	11	0.45	-0.03652	0.5501	-1.0390	32.18	0.24	-4.5
	Winter 07 (Aug)	03.08.2007 to 14.08.2007	B	7	15	0.72	-0.03438	0.7479	-2.7090	39.82	0.52	2.9
	Spring 07 (Nov)	14.11.2007 to 27.11.2007	B	5	11	0.57	-0.05557	0.8686	-2.2540	33.56	0.44	-2.5
	Summer 08 (Jan)	31.01.2008 to 12.02.2008	B	6	11	0.81	-0.07030	1.3060	-5.1490	38.89	0.69	-0.9

PWEP III – CNS (cont.)

		Monitoring period	Logger Location	Avg. wind speed	Max. wind Speed	Correlation Coefficient	a	b	c	d	R^2	Average difference between survey period and all data between 6-10m/s
CNS 34	All data	-			12	0.65		0.0653	1.2290	25.43	0.42	
	Summer 08 (Jan)	11.01.2008 to 23.01.2008	A	6	11	0.52	-0.01602	0.2541	-0.0335	28.97	0.28	-1.7
	Autumn 08 (Mar)	20.03.2008 to 03.04.2008	A	6	15	0.46	-0.01749	0.4505	-2.5070	40.65	0.26	2.3
CNS MC	All data	-			12	0.65		0.0653	1.2290	25.43	0.42	
	Summer 04 (Dec)	14.12.2004 to 28.12.2004	A	5	12	0.70	-0.01091	0.3250	-0.6253	28.15	0.53	-1.1
	Autumn 07 (Apr)	02.04.2007 to 13.04.2007	B	5	8	0.66		-0.0296	3.1550	19.55	0.44	2.9

PWEP IV - CNN

		Monitoring period	Logger Location	Avg. wind speed	Max. wind Speed	Correlation Coefficient	a	b	c	d	R^2	Average difference between survey period and all data between 6-10m/s
CNN 12	All data	-			12	0.77	-0.02824	0.5739	-0.9008	26.49	0.62	
	Spring 04 (Nov)	30.11.2004 to 13.12.2004	A	5	12	0.78	-0.01392	0.3154	0.1312	26.81	0.62	-0.5
	Autumn 08 (May)	30.05.2008 to 12.06.2008	A	4	11	0.73	-0.01277	0.4599	-0.7087	25.63	0.59	1.0
CNN 26	All data	-			12	0.72	-0.02533	0.6098	-1.3180	28.55	0.56	
	Spring 04 (Nov)	30.11.2004 to 13.12.2004	A	5	12	0.77	-0.00731	0.2453	0.6653	27.23	0.61	0.6
	Autumn 08 (May)	28.05.2008 to 11.06.2008	A	3	9	0.48	-0.03844	0.7494	-2.0790	28.99	0.27	-3.1
CNN 28	All data	-			12	0.67	-0.02667	0.5881	-1.3680	28.82	0.48	
	Summer 04 (Dec)	14.12.2004 to 28.12.2004	A	5	12	0.70	-0.01091	0.3250	-0.6253	28.15	0.53	-1.1
	Autumn 07 (Apr)	02.04.2007 to 13.04.2007	B	5	8	0.66		-0.0296	3.1550	19.55	0.44	2.9

PWEP IV - CSWG

		Monitoring period	Logger Location	Avg. wind speed	Max. wind Speed	Correlation Coefficient	a	b	c	d	R^2	Average difference between survey period and all data between 6-10m/s
CSWG 07	All data	-			21	0.51	-0.01624	0.4732	-2.8510	43.53	0.31	
	Spring 04 (Oct)	18.10.2004 to 31.10.2004	A	5	14	0.50	-0.01204	0.4170	-2.3440	43.52	0.33	2.7
	Summer 05 (Jan)	21.01.2005 to 03.02.2005	A	5	15	0.73	-0.00989	0.3725	-1.8300	40.20	0.58	1.8
	Winter 08 (Jun)	24.06.2008 to 03.07.2008	A	8	21	0.61	-0.02106	0.6905	-5.6310	49.83	0.45	-4.3
CSWG 11	All data	-			21	0.79	-0.01177	0.3310	-0.8920	35.10	0.64	
	Spring 04 (Oct)	18.10.2004 to 01.11.2004	A	5	14	0.73		0.2666	-1.4040	40.49	0.67	3.5
	Summer 05 (Jan)	21.01.2005 to 03.02.2005	A	5	15	0.85	-0.01684	0.5376	-2.5330	36.86	0.79	-0.6
	Autumn 08 (May)	30.05.2008 to 10.06.2008	A	4	8	0.50	-0.02341	0.3032	-0.0853	31.26	0.26	-3.7
	Winter 08 (Jun)	24.06.2008 to 04.07.2008	B	9	21	0.81	-0.01776	0.6161	-4.9260	50.49	0.75	-1.4
CSWG 23	All data	-			14	0.57	0.00529	0.0685	-0.1312	35.25	0.39	
	Spring 04 (Oct)	18.10.2004 to 01.11.2004	A	5	14	0.63	0.00135	0.1536	-0.8589	38.18	0.52	0.5
	Autumn 08 (May)	28.05.2008 to 10.06.2008	B	4	8	0.36		0.1100	-0.2497	34.51	0.14	-1.4
CSWG 25	All data	-			21	0.67	-0.01091	0.3075	-1.3580	37.80	0.48	
	Spring 04 (Oct)	18.10.2004 to 01.11.2004		5	14	0.60	-0.00175	0.2264	-1.2380	38.30	0.46	1.2
	Summer 05 (Jan)	21.01.2005 to 03.02.2005	A	5	15	0.70	-0.01873	0.4575	-1.9950	36.94	0.51	-0.4
	Winter 08 (Jun)	06.01.2005 to 20.01.2005	B	9	21	0.61	-0.01431	0.4907	-4.1350	49.11	0.47	-0.7