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A&WMA Ontario Section Air and Acoustic Monitoring Conference

Evaluating the Statistical Significance of Baseline Noise Monitoring Results

26 October 2016



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Agenda

Part 1: What is a “baseline”

Part 2: What is the existing guidance/precedent

Part 3: What does the data say

Part 4: Key messages

What is a “baseline”

Merriam – Webster, Online:

“a usually initial set of critical observations or data used for comparison or a control”



Key considerations

- ▶ Why collect Baseline data?
 - ▶ To establish the existing conditions as a basis for comparison during impact assessment.

- ▶ What value does this data represent?
 - ▶ The data could be used to establish due diligence and support the finding of a favourable impact assessment.

- ▶ How critical is the data quality?
 - ▶ If the baseline data can be disputed or attacked then any derivative impact assessment can also.

- ▶ Why are there few prescriptive standards in this regard?
 - ▶ Perhaps due to the varied environments and conditions which would be expected? Not sure.

What is a typical baseline study

- ▶ Monitor 1-hour L_{EQ} for 48 hours and select the lowest value for each of day, evening and night.
 - ▶ This amounts to collecting 2 data points for each period.

- ▶ Monitor 24-hour L_{EQ} for 24 hours.
 - ▶ This amounts to 1 data point.

- ▶ Monitor 1-hour L_{EQ} for 1 week to establish values at each hour of the day.
 - ▶ If day of the week variations are disregarded: This amounts to 7 data points for each hour.
 - ▶ If weekday and weekend are considered separately: This amounts to 5 weekday data points and 2 weekend data points for each hour.
 - ▶ Finally if each day of the week is considered independently: that's one data point.

Considerations for designing baseline studies

- ▶ What are the objectives of the study?
 - ▶ Adjustment of impact assessment criteria?

- ▶ What is the environment and it's inherent variability?
 - ▶ Urban, Suburban or Rural
 - ▶ Remote
 - ▶ Industry / Transportation

- ▶ How valuable is the data?

- ▶ How much data should be collected?

What is the existing Guidance

Let's have a look



Canadian Guidance (not exhaustive)

▶ British Columbia

▶ Noise Control Best Practices Guideline (BC Oil & Gas Commission)

▶ L_{Aeq} (15/9h)

▶ “An ambient sound monitoring survey consists of a **24-hour continuous sound monitoring survey**, with measured ASLs presented for daytime and nighttime periods, conducted 15 m from the nearest dwelling or dwelling most likely to be affected and under representative conditions.”

▶ Alberta

▶ Directive 038: Noise Control (Alberta Energy Regulator)

▶ L_{Aeq} (15/9h)

▶ “An ambient sound monitoring survey consists of a **24-hour continuous sound monitoring survey**, with measured ASLs presented for the daytime and nighttime periods, that is conducted 15 m from the nearest or most impacted dwelling unit and under representative conditions.”

▶ Rule 012: Noise Control (Alberta Utilities Commission)

▶ L_{Aeq} (15/9h)

▶ “A comprehensive sound survey consists of sound and weather measurements for **at least a full 24-hour period**. An extended survey of more than 24 hours may be required to ensure that representative conditions have been met (see Section 4.4).”

Canadian Guidance (not exhaustive)

▶ Ontario

▶ NPC-300 (B5) – MOECC

▶ L_{Aeq} (1h)

- ▶ “If the background sound level is to be established by means of monitoring, the monitoring should be performed **over a minimum period of 48 hours** and should be conducted during times when the background sound level is at its lowest level. The lowest hourly L_{eq} value should be selected to represent the background sound level. In general, the sound level data included in an impact assessment needs to be representative of the background conditions and the predictable worst case noise impact from the stationary source.”

▶ Nova Scotia

▶ Guidelines for Environmental Noise Measurement and Assessment (Nova Scotia Environment and Labour)

▶ L_{Aeq} (12/4/8h)

- ▶ “In order to be sure that a representative sample is gathered during any one of the periods, **a minimum of two continuous representative hours of data in one period is required**, unless the sound being generated is reasonably steady and the L_{eq} is not expected to change drastically.”

A Continuum of Soundscapes

- ▶ Most guidance is focused on the proposed source of noise rather than the existing environment.
- ▶ Sampling is on the order of 1-2 discrete measurements of the potential criteria altering value.
- ▶ Limited sampling reflects the assumption that the existing environment is not particularly variable and is predictable.
 - ▶ This might be true for urban and perhaps suburban areas;
 - ▶ Probably not true for rural and remote areas;
 - ▶ Only way to know is to collect enough data to assess.

A Continuum of Soundscapes

- ▶ Despite assumptions the discrete identifiers urban/suburban/rural represent the continuum of soundscapes in the real world.
- ▶ Timescales to consider include hourly, daily, weekly, monthly and seasonal variations in the soundscape. These variations are not necessarily easily predicted a priori.

Work Focused on Natural Environments

▶ U.S. National Parks Service

- ▶ Daniel Mennitt, Kurt Fristrup, Kirk Sherrill, and Lisa Nelson, "Mapping sound pressure levels on continental scales using geospatial sound model", Internoise 2013, Innsbruck, Austria.
- ▶ “While the duration of measurements in **natural areas are typically 25 days or longer** to obtain statistics representative of **the entire season**, the city measurements were over a 24 hour period only. This is in accordance with the assumption that sound levels in developed areas are relatively consistent given the dominating contribution from human activity.”

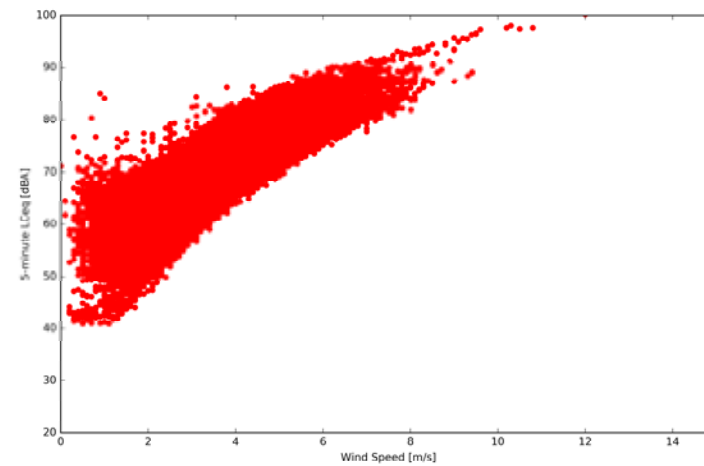
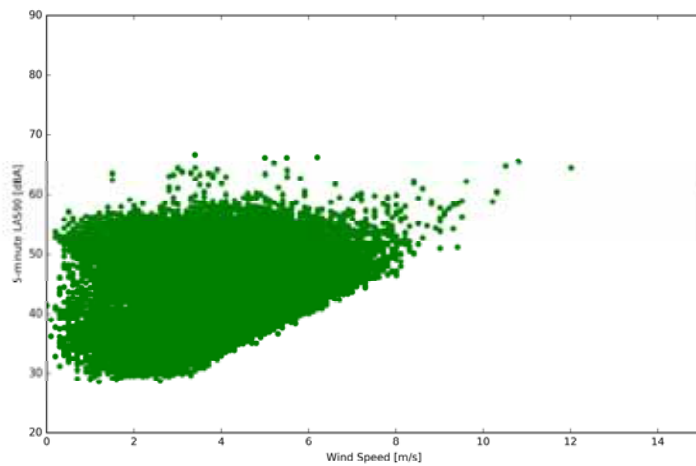
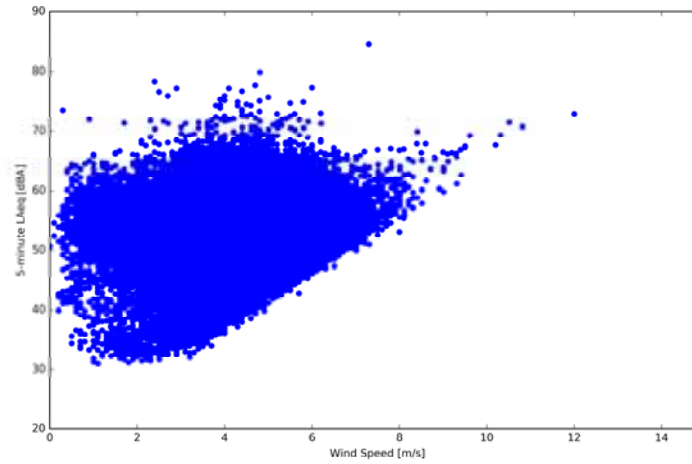
What does the data say



General Description of Data Collection

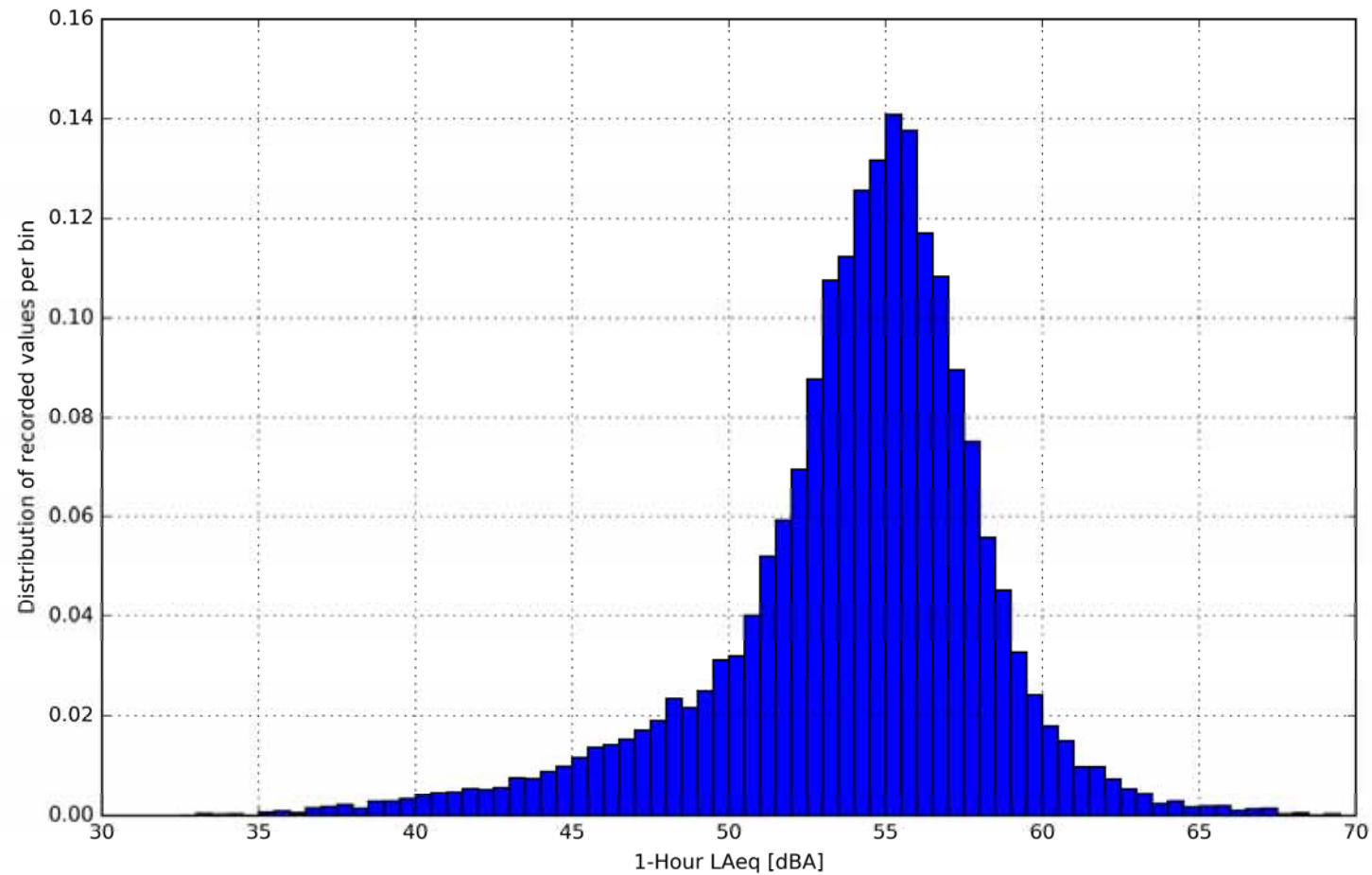
- ▶ Metrics collected in 5 min intervals
- ▶ L_{Aeq} , L_{AS90} , Wind speed, Wind direction, Temperature, Relative humidity and Precipitation
- ▶ Equipment:
 - ▶ Brüel & Kjær 2250 in environmental enclosure
 - ▶ Vaisalla weather station for each location
- ▶ Data collected continuously from March 2016 to October 2016
 - ▶ 7 months of data
- ▶ Statistical analysis is based on measured values. (not a prediction of the population).

L_{Aeq} , L_{Ceq} and L_{AS90} vs. Wind Speed

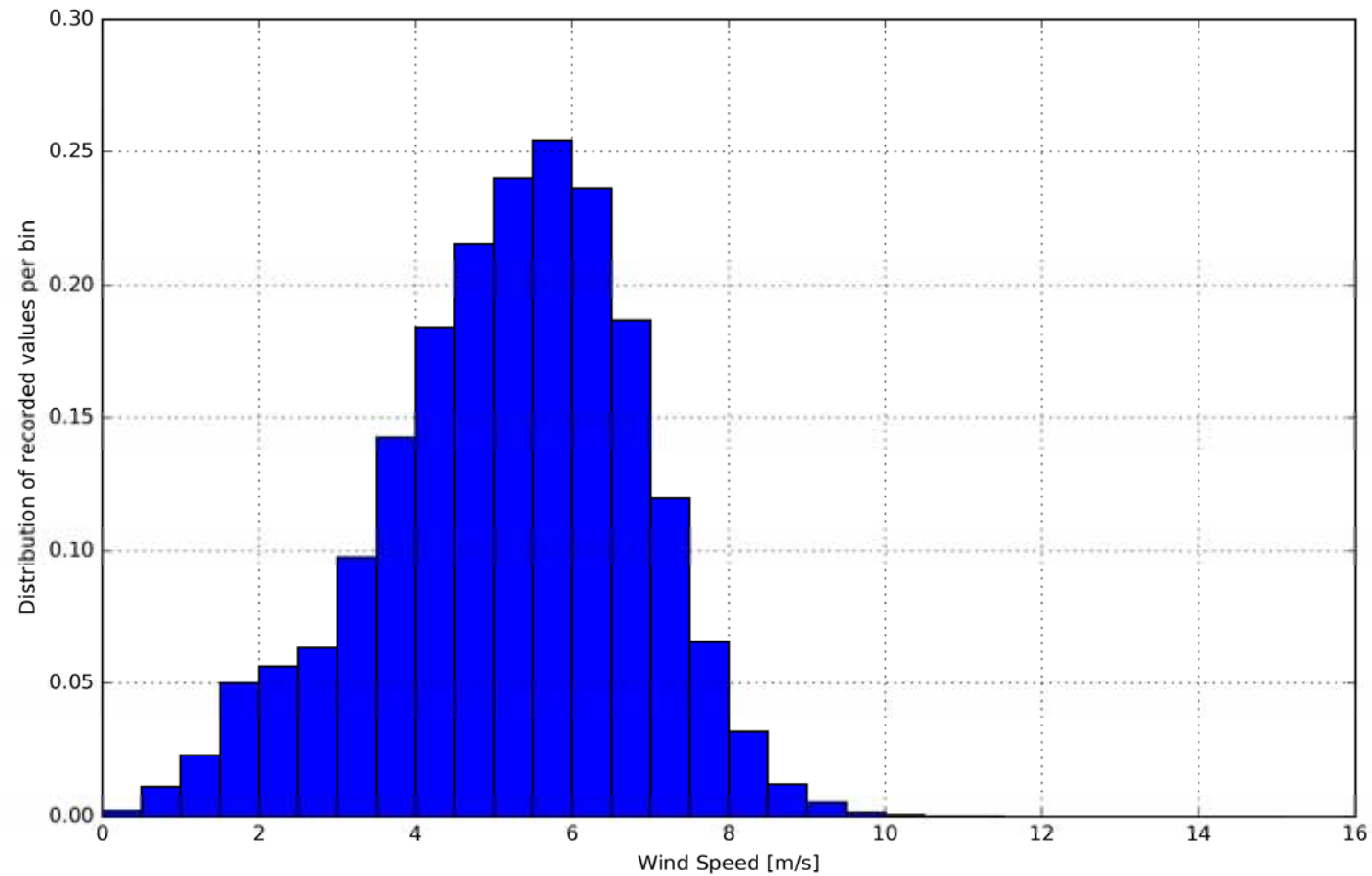




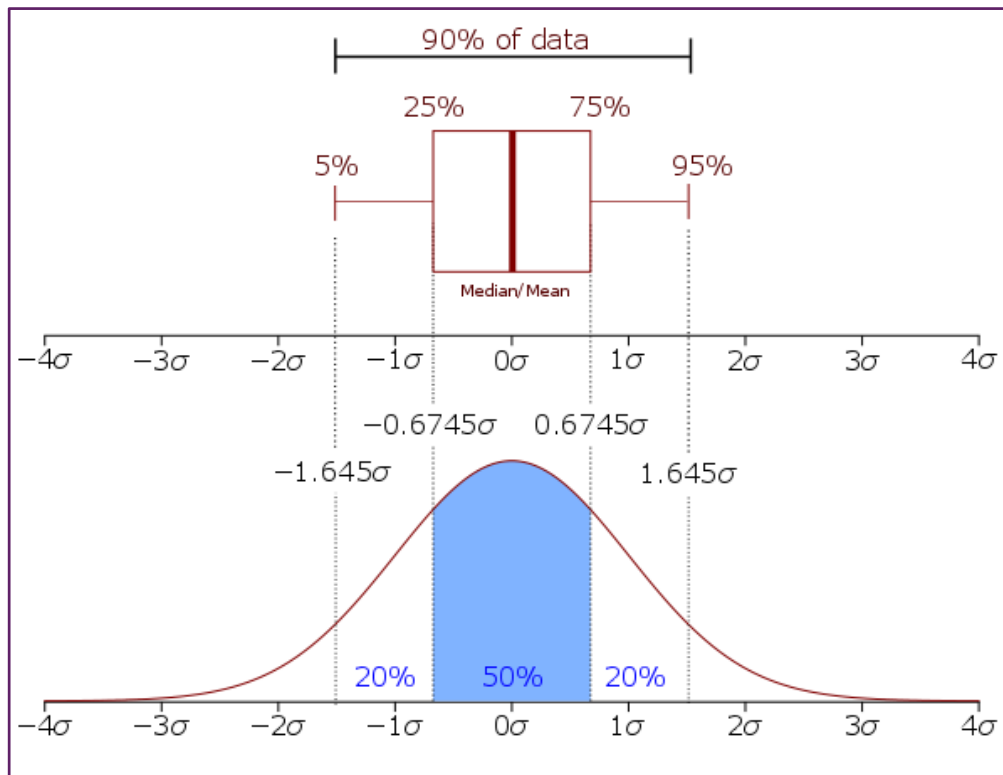
Normalized frequency distribution (1-hour L_{Aeq})



Normalized frequency dist. (Wind Speed)



Box Plots

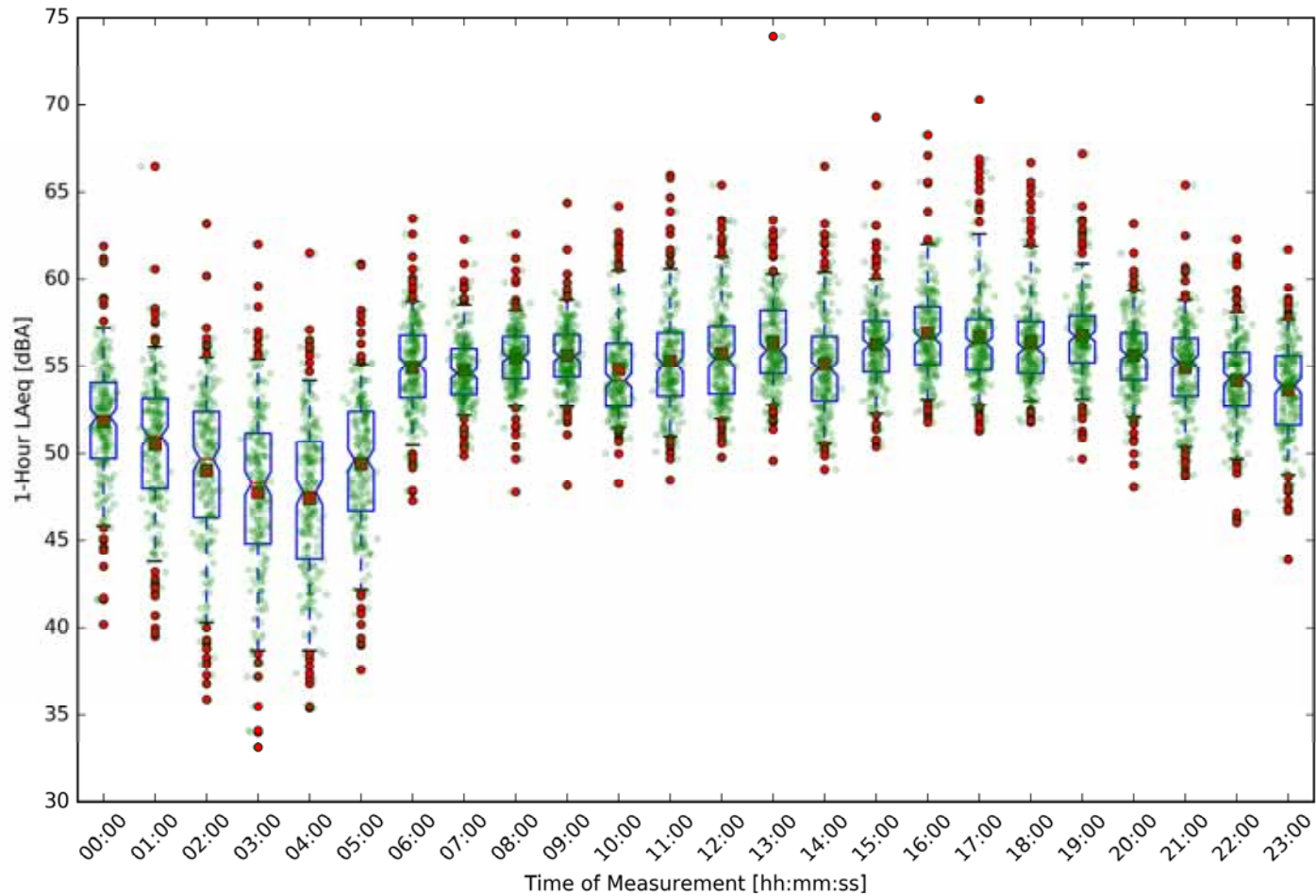


Adapted from:

Jhguch at en.wikipedia [CC BY-SA 2.5 (<http://creativecommons.org/licenses/by-sa/2.5>)], from Wikimedia Commons

- ▶ Box plots describe the sample and make no representation or assumptions regarding the population.
- ▶ Box plot data need not be normally distributed as represented in this figure.

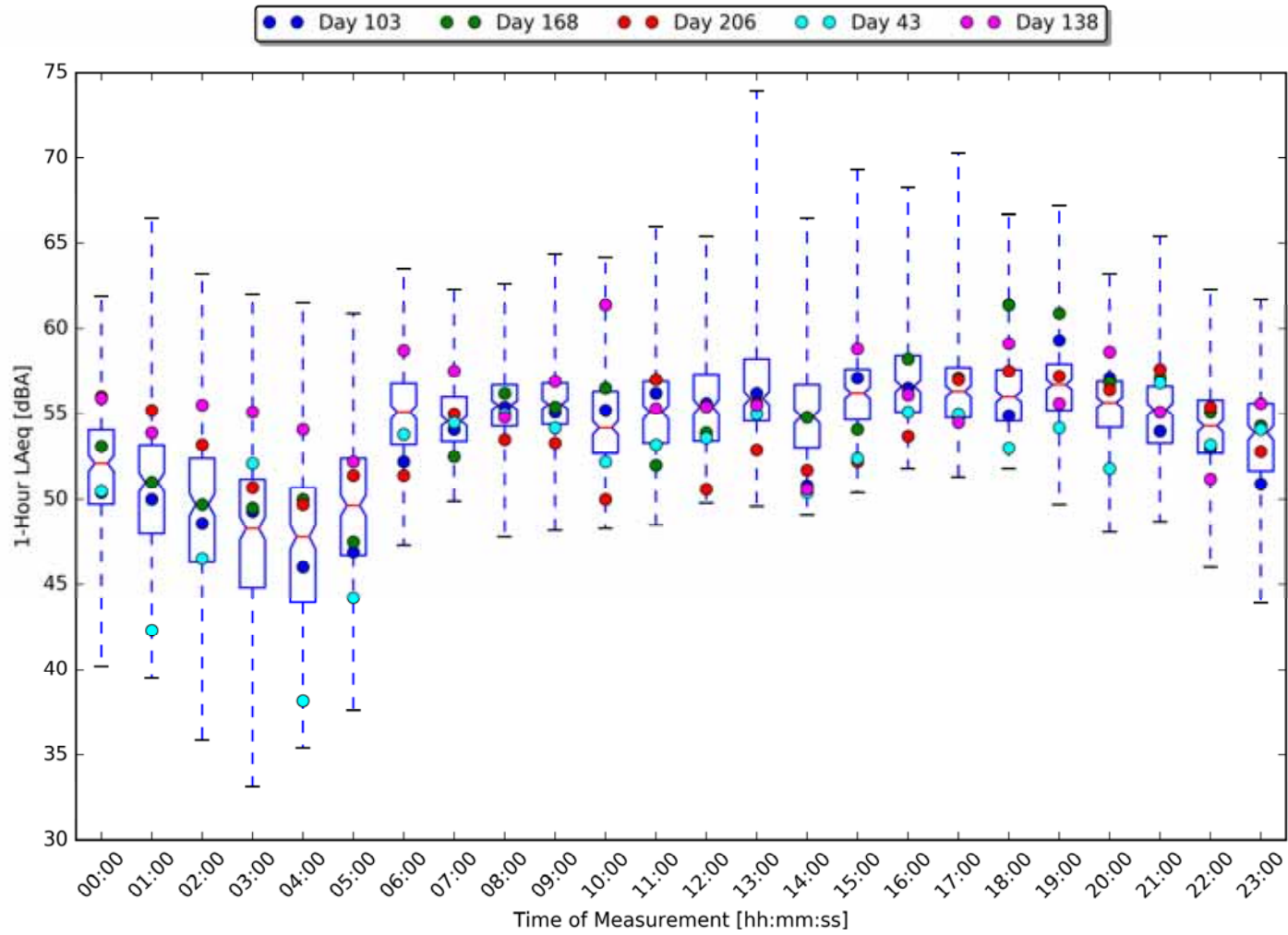
24-hour distribution of hourly L_{Aeq}



5/95% tails



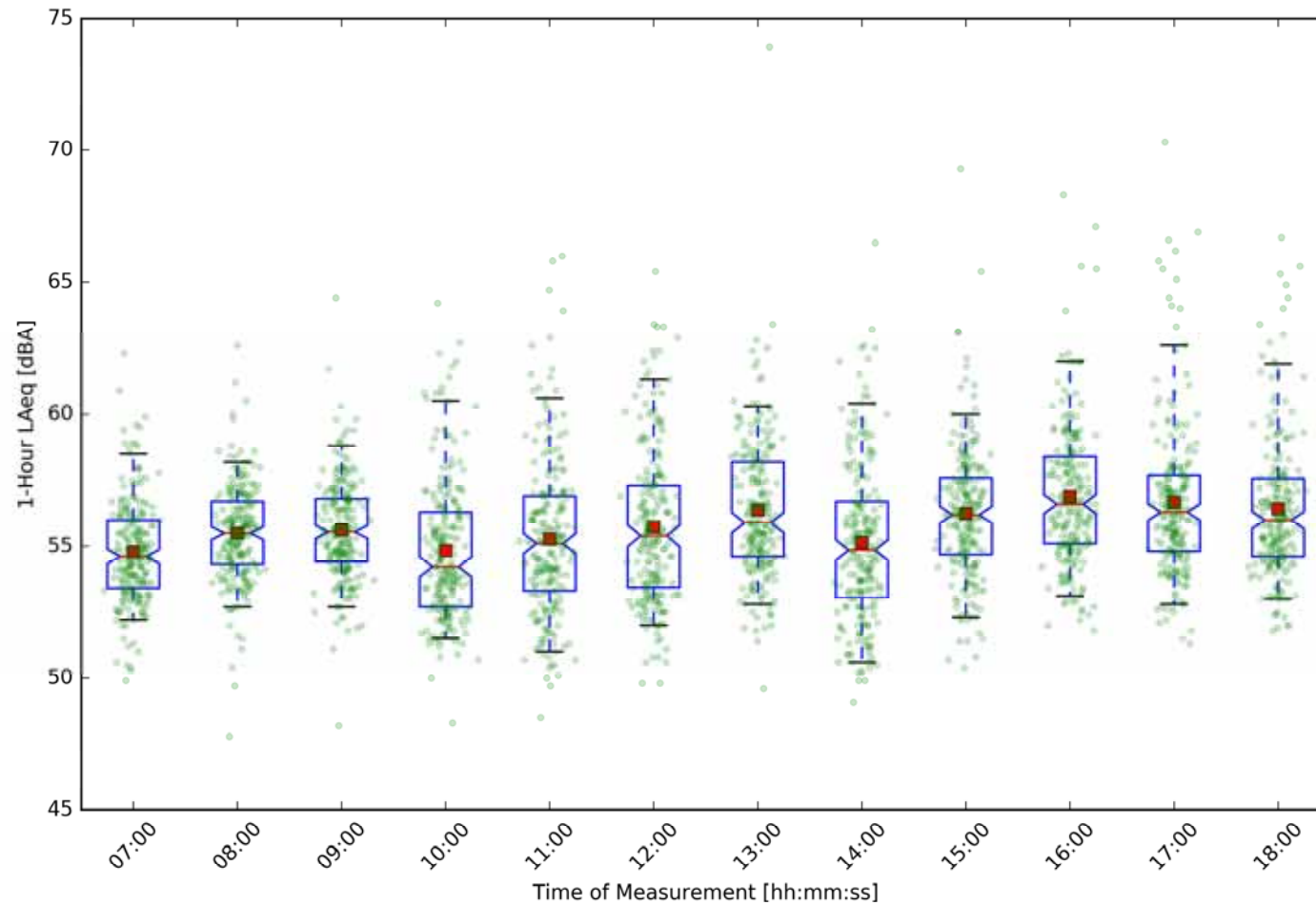
Random Days



Min/Max tails

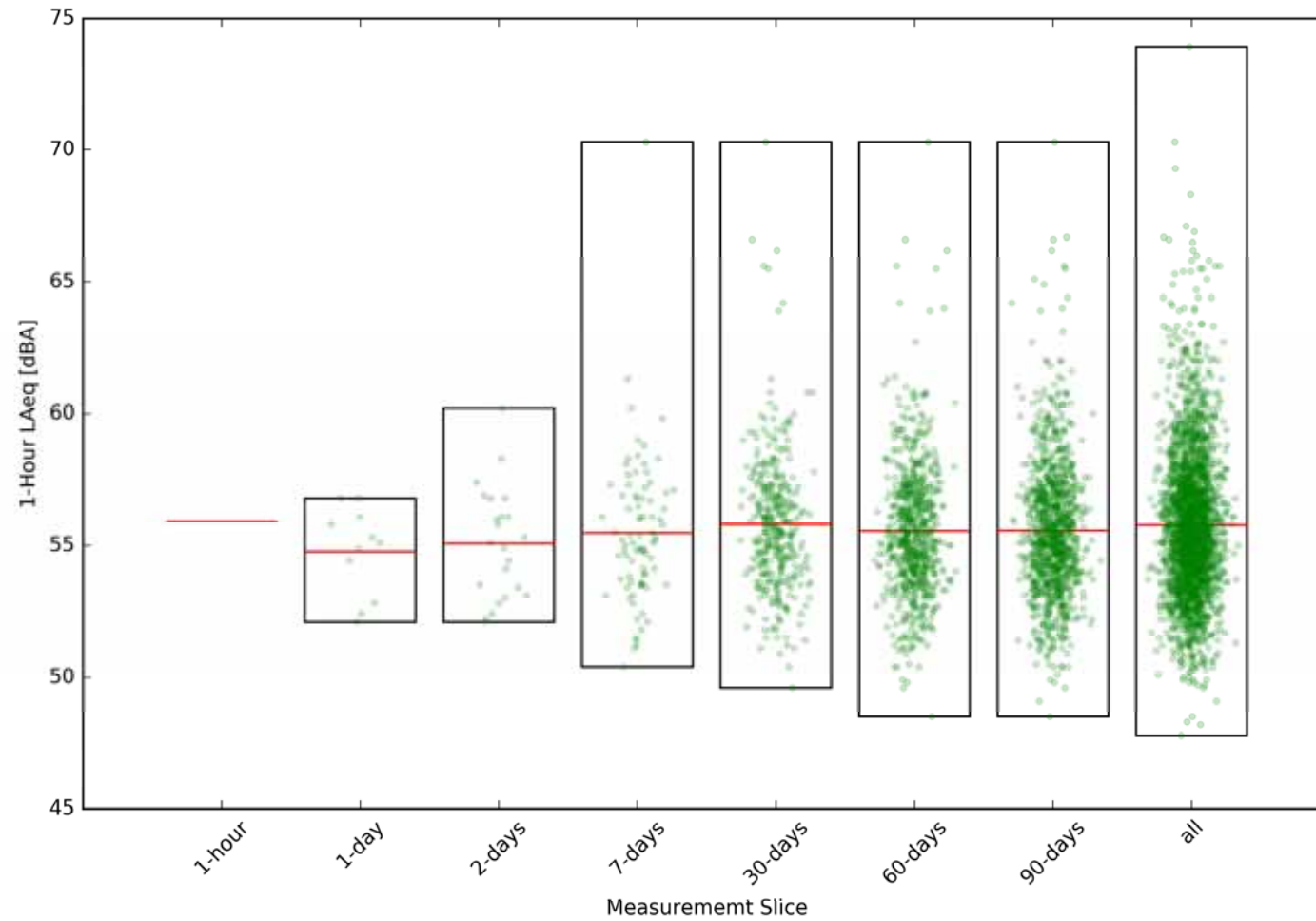


Day-time distribution of hourly L_{Aeq}



5/95% tails

Effect of Measurement Duration – Day L_{Aeq}



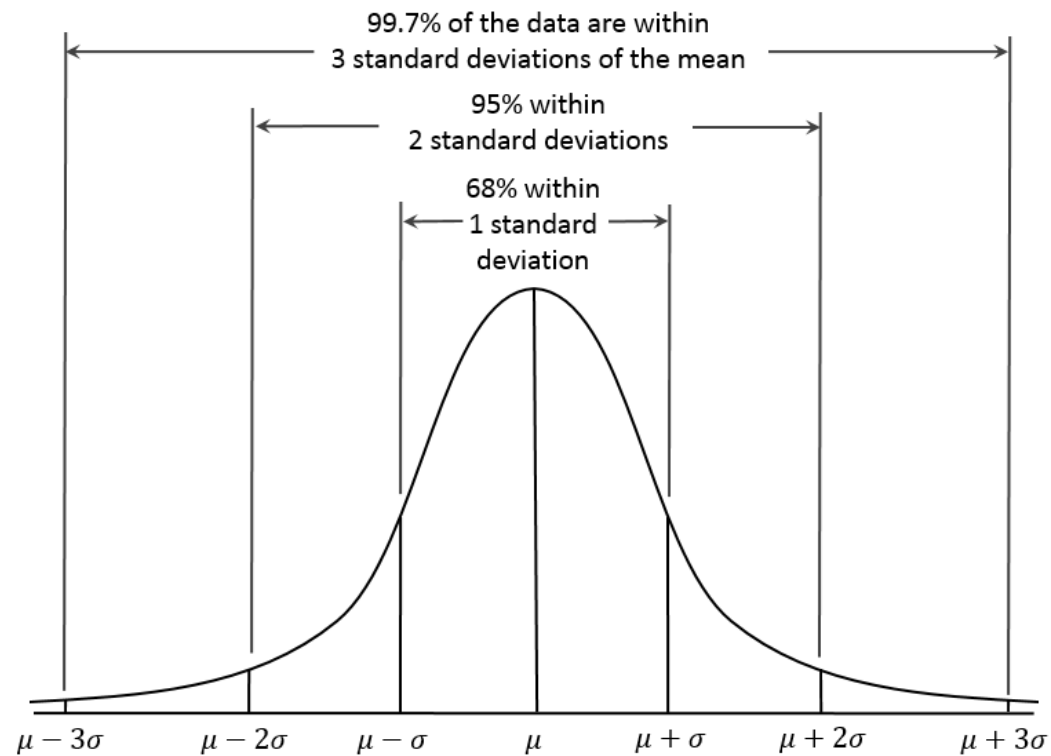
The story thus far...

- ▶ Box plots describe the sample and make no representation or assumptions regarding the population.
- ▶ However, if a great deal of data is collected the sample may accurately represent the population (the existing environment).
- ▶ Box plot data need not be normally distributed (a key assumption in predictive statistics).

The story thus far...

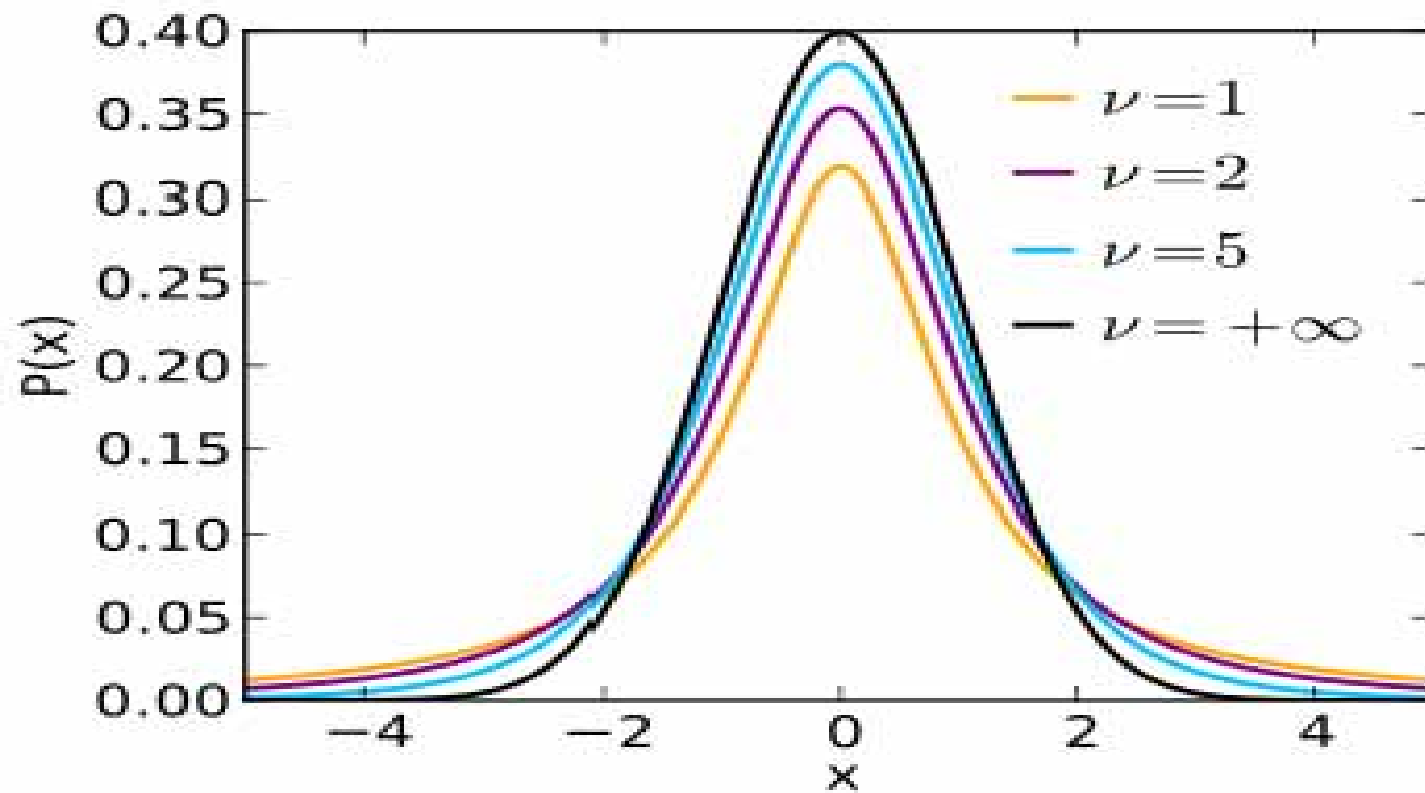
- ▶ It is not always possible to collect this quantity of data. Nor is it necessary in every case.
 - ▶ “...it is somewhat apparent that the more data you have, the better the overall assessment will be.” – Anonymous Colleague.
- ▶ If we accept the assumption of a normal distribution we can utilize a smaller sample to describe the population.
 - ▶ You don't measure the diameter of every ball bearing!

Normal distribution - 3 sigma rule



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Student t-distribution



By Skbkakas (Own work) [CC BY 3.0 (<http://creativecommons.org/licenses/by/3.0>)], via Wikimedia Commons

Interpreting samples using statistical tools

- ▶ Using the properties of the Student t-distribution we can estimate the prediction interval of a population based on a sample.

- ▶ $\bar{x} \pm t(\nu, p)\sigma\sqrt{1 + 1/n}$

- ▶ \bar{x} – sample mean

- ▶ $t(\nu, p)$ – two sided Student t – distribution value

- ▶ $\nu = n - 1$ – degrees of freedom

- ▶ p – percentile

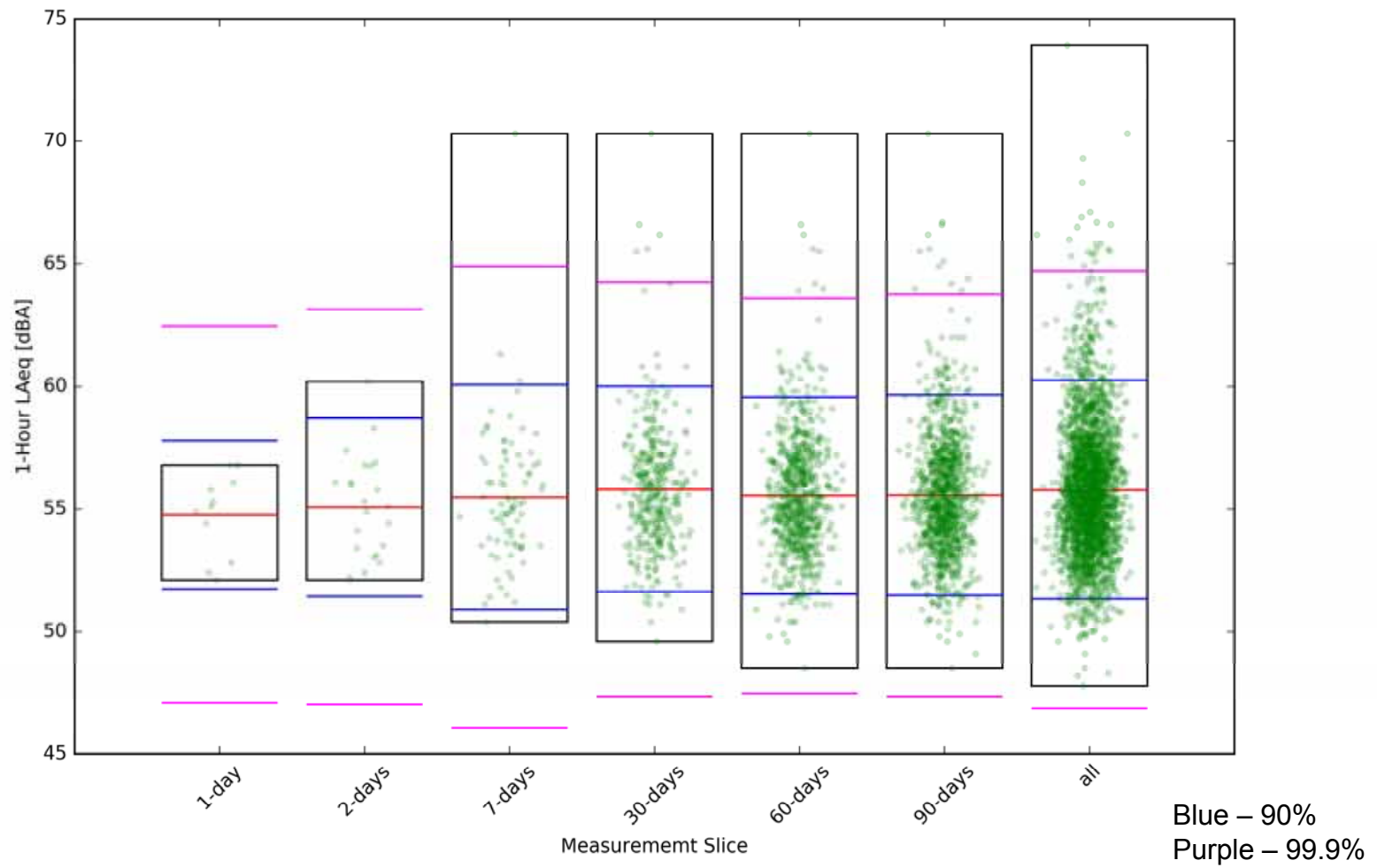
- ▶ σ – sample standard deviation

- ▶ n – number of data points in sample

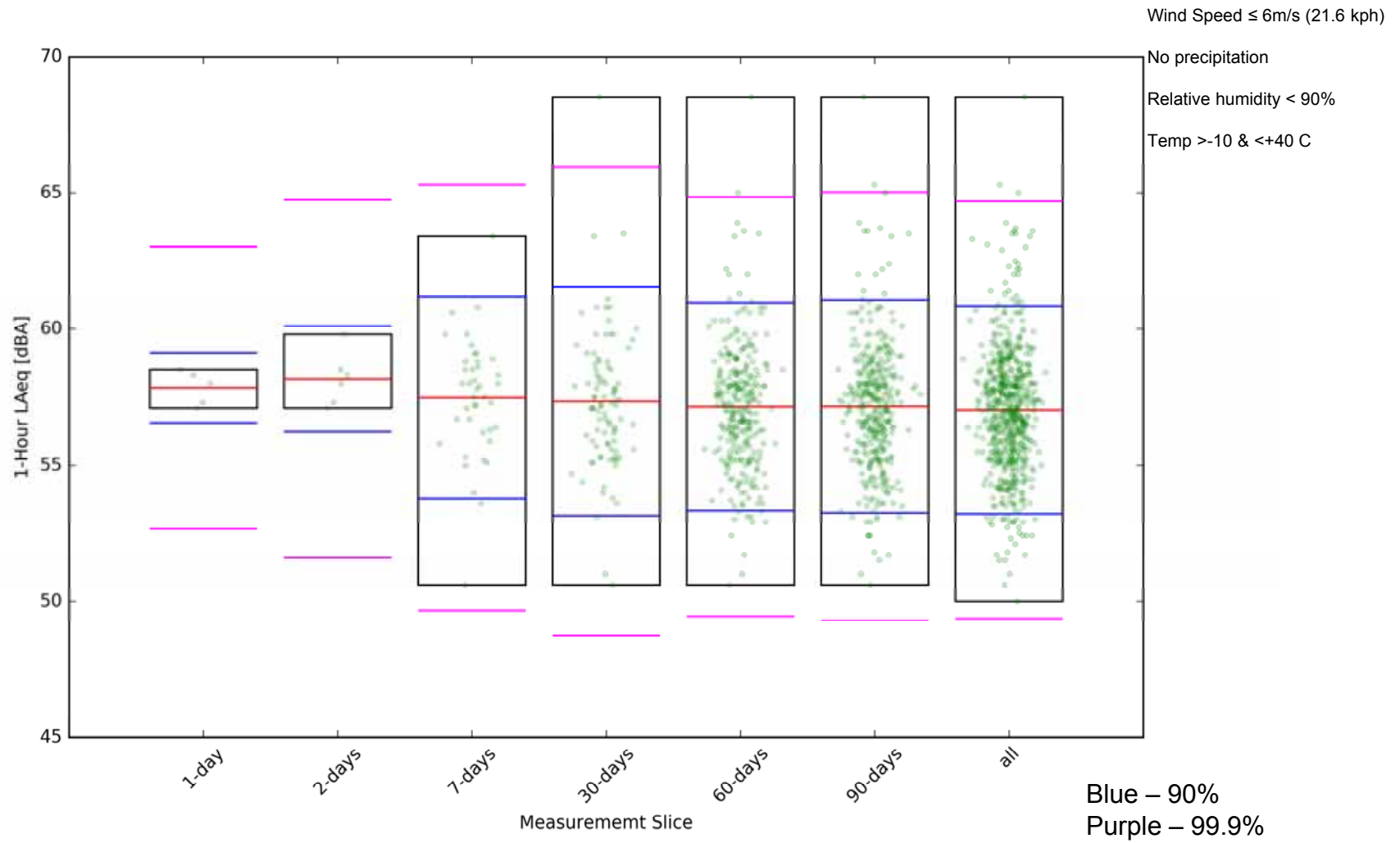
Interpreting samples using statistical tools

- ▶ Be aware of the inherent assumption that the data is normally distributed about the mean/median.
- ▶ Your data may represent overlapping normally distributed data. Are weekdays and weekends represent substantially different soundscapes? Perhaps these need to be assessed separately.
- ▶ External influences such as wind, traffic, etc. May introduce skew into the data and this needs to be addressed.

Prediction Intervals – Day L_{Aeq}



Prediction Intervals – after data conditioning



Key messages



Conclusion

- ▶ Baseline data is an initial set of critical observations or data used for comparison or a control.

- ▶ The existing noise assessment and measurement guidance is not focused on baseline data collection.

- ▶ Collection of more data can be beneficial.
 - ▶ “...it is somewhat apparent that the more data you have, the better the overall assessment will be.” – anonymous colleague

- ▶ However, limited datasets can be statistically assessed and used to represent much larger populations. Provided care is taken in the design of the sampling.

The path forward

- ▶ Guidelines are necessary to help ensure consistency in baseline assessments completed in support of regulatory applications.
- ▶ In the absence of guidance professionals need to consider how they design baseline studies and what conclusions can be drawn from the data collected.
- ▶ Technology has advanced such that remote collection of large noise monitoring datasets is both feasible and cost effective.

Thank you for your attention

