

Rate of Change (Trend)

Δ PPM, PPM/day or PPM/Year

What make sense?

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IEEE Transformer Committee
Fall 2013 Meeting
C57.104
St-Louis, October 20 – 24, 2013



Fall 2012

- Luiz Cheim presentation (On the Web)
- Review of work done to date
- Review of factors influencing limits
- Presentation also covered various aspect of rate computation

Rate of Gas Increase (ppm/year) vs Sampling Interval???

Days Between Samples	H2	CH4	90th Percentile			CO
			C2H2	C2H4	C2H6	
60 - 90	122	77	0	45	76	505

Rate of Gas Increase (ppm/year) vs Sampling Interval???

Days Between Samples	90th Percentile					
	H2	CH4	C2H2	C2H4	C2H6	CO
MT 365	14	9	0	7	8	113

Rate of Gas Increase (ppm/year) vs Sampling Interval???

Days Between Samples	90th Percentile					
	H2	CH4	C2H2	C2H4	C2H6	CO
LT 3	6,935	4,015	365	4,015	2,555	18,250
03 - 05	4,106	2,190	122	2,068	1,217	6,242
05 - 10	3,143	1,768	73	1,236	980	3,375
					422	2,336
					255	1,313
					141	884
60 - 90	122	//	0	45	76	505
90 - 120	80	53	0	28	52	386
120 - 180	57	33	0	24	35	290
180 - 240	39	25	0	16	26	217
240 - 365	21	13	0	10	12	146
MT 365	14	9	0	7	8	113

Food for Thought...

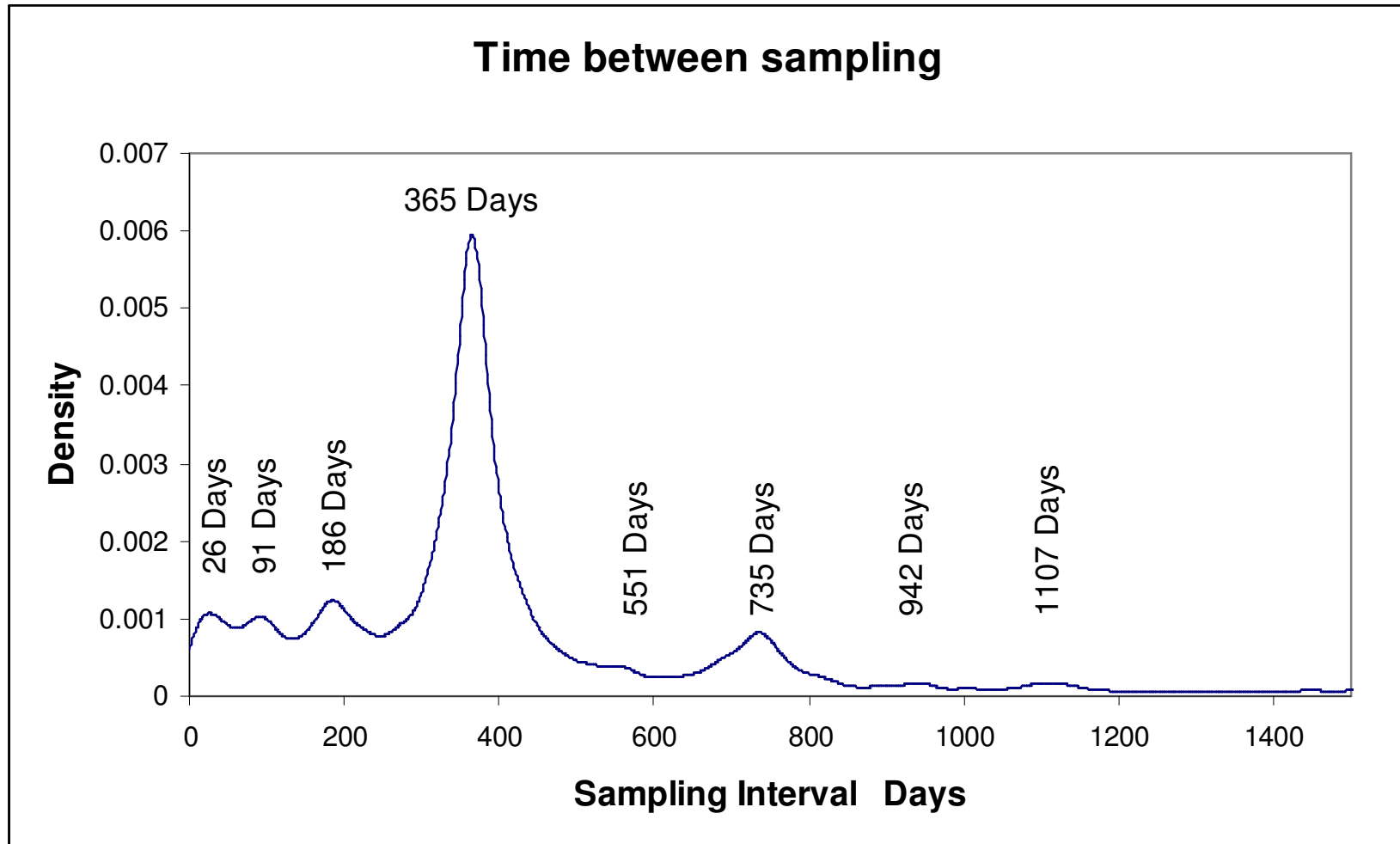
Further work to clarify this question

- Study of a new set of data
- Single source (one lab)
- North America
- Mix of industrial and utilities

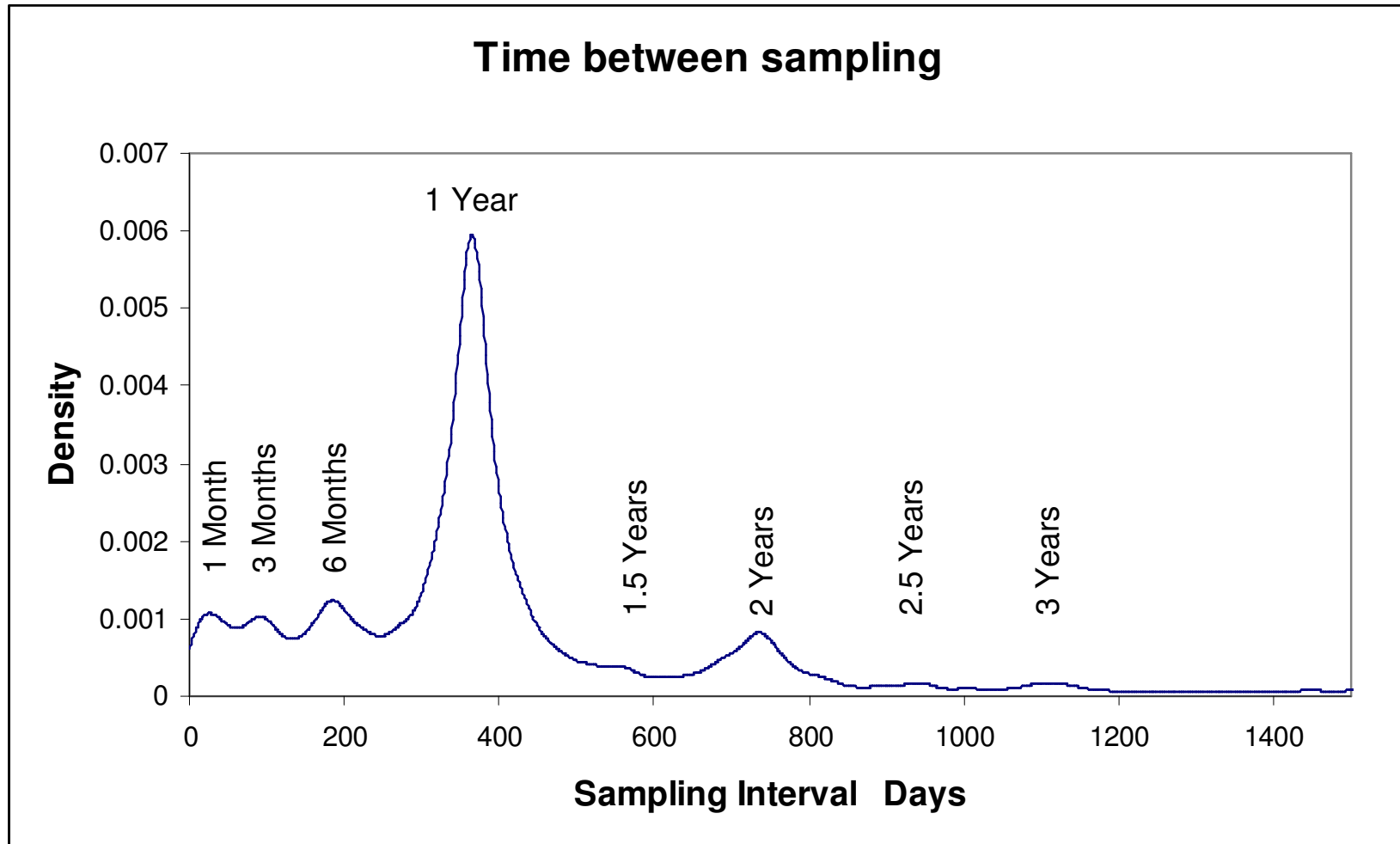
Data set

- One source
- 123 469 DGA
- 44 266 Transformers
- Delta computed between actual and previous DGA
- 78 660 pairs of DGA
- All Gas + TDCG

Sampling Interval



Sampling Interval



Data set

- Table 3 use TDCG rates of 10 - 30 ppm/day
- ppm/year or ml/day is also used to evaluate gassing rate
- Preliminary study (last meeting) has been done in ppm/year
- 1 ppm/day = 365 ppm/year
- 10 ppm/day = 3650 ppm/year
- 30 ppm/day = 10950 ppm/year

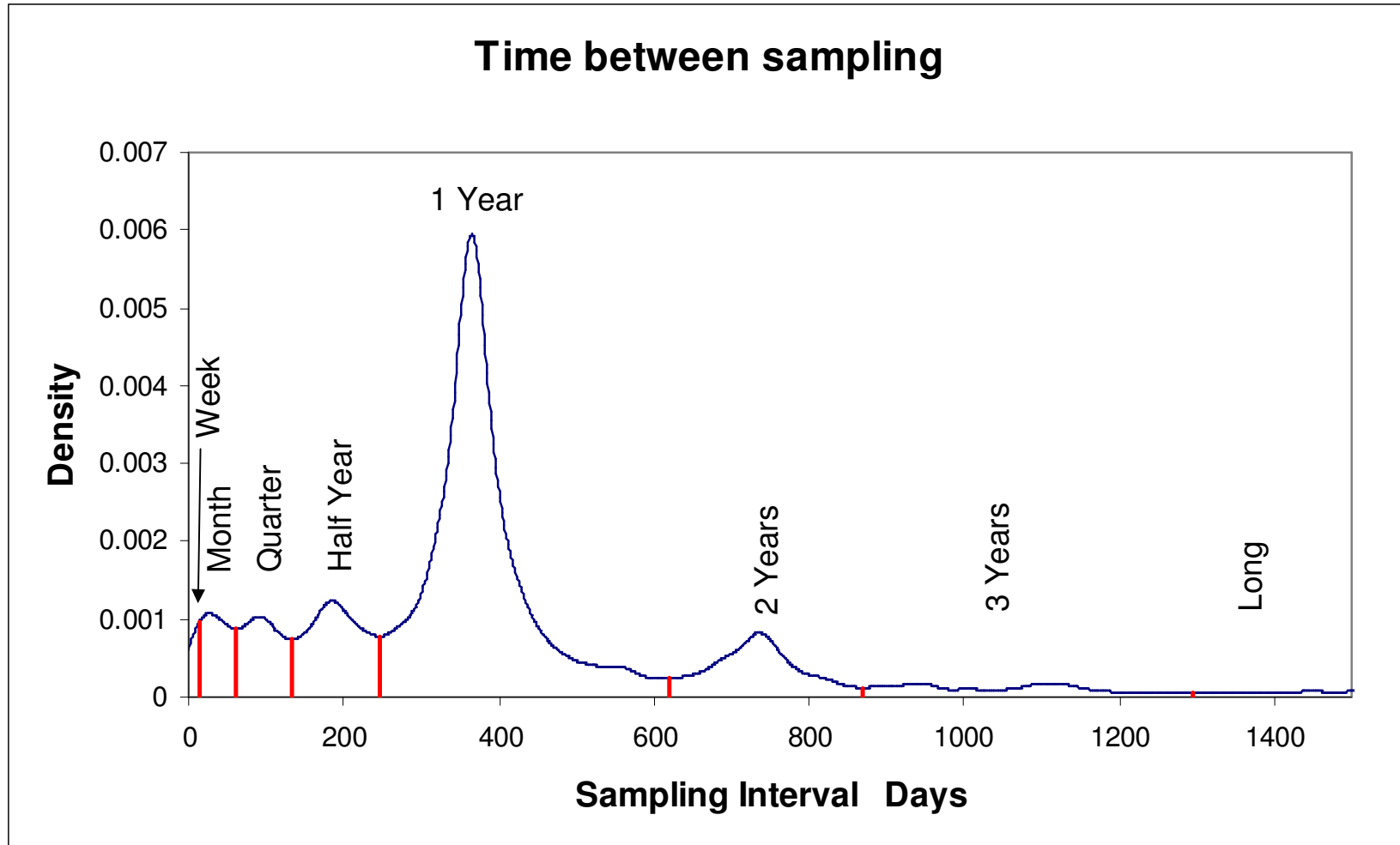
DGA “Noise”

- Oil sampling, transport and analysis do introduce DGA variations from one sample to the next
- The same difference between two samples could give different ppm/day (or ppm/year) depending of the period between samples
- It is of particular importance for on-line data
- How that affect interpretation?

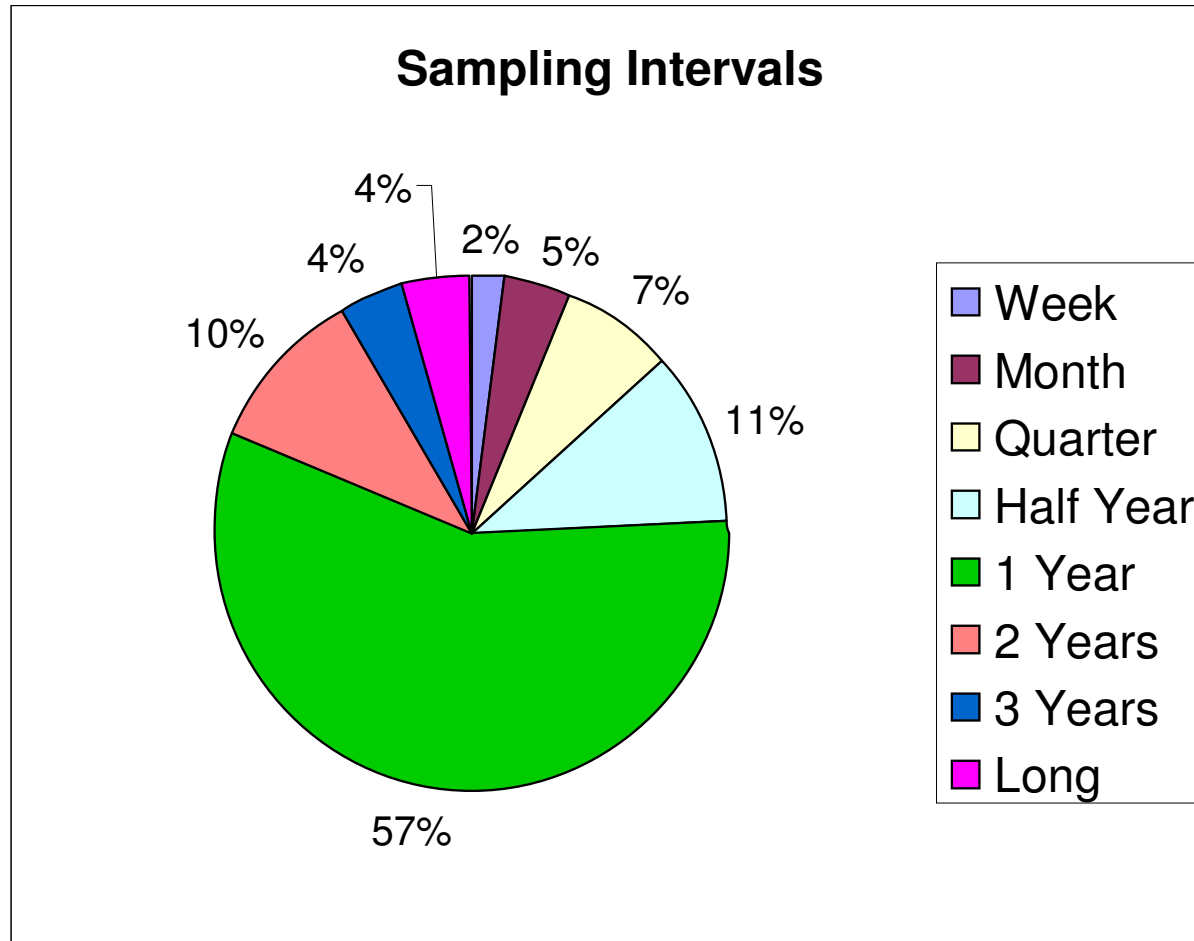
An Example: CH₄

- The data set was splits in 8 Groups corresponding to 8 different average sampling periods
- Week, Month, Quarter, Half-Year, Year, 2 Years, 3 Years and > 4 years
- For each DGA, ppm/year was computed
- For each groups, a standard statistic study was performed

Sampling Interval



Data Set



Some Definitions

95 Percentile: 95% of the samples are below that value

Absolute Change (Delta)

$$\text{Delta PPM} = \text{PPM}_{\text{now}} - \text{PPM}_{\text{last sample}}$$

Normalised Change (Trend)

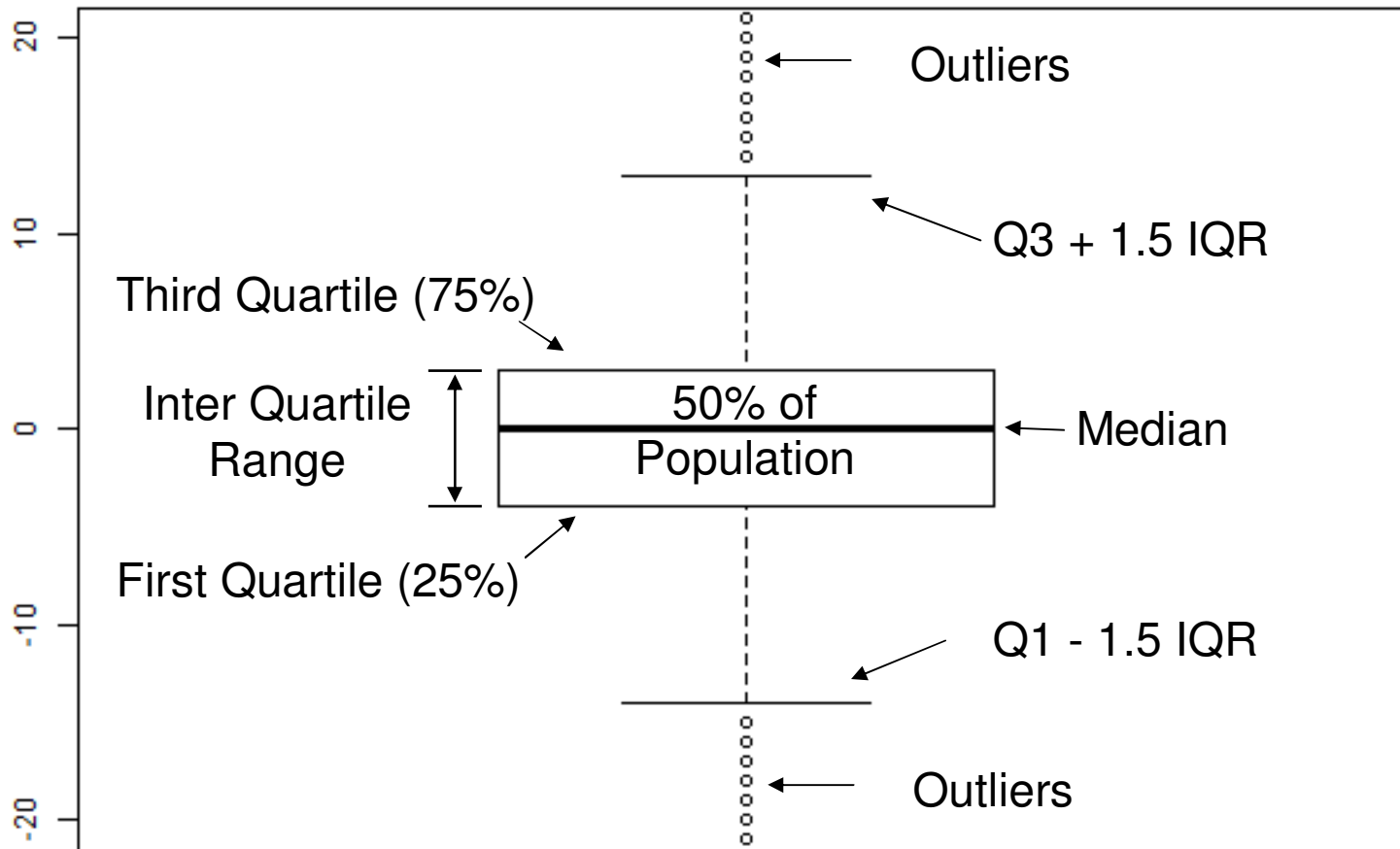
$$\text{Trend} = \text{Delta PPM} / (\text{Date}_{\text{now}} - \text{Date}_{\text{last sample}})$$

in PPM/Day

in PPM/Year (PPM/Day * 365)

BoxPlot Graph

BoxPlot Graph

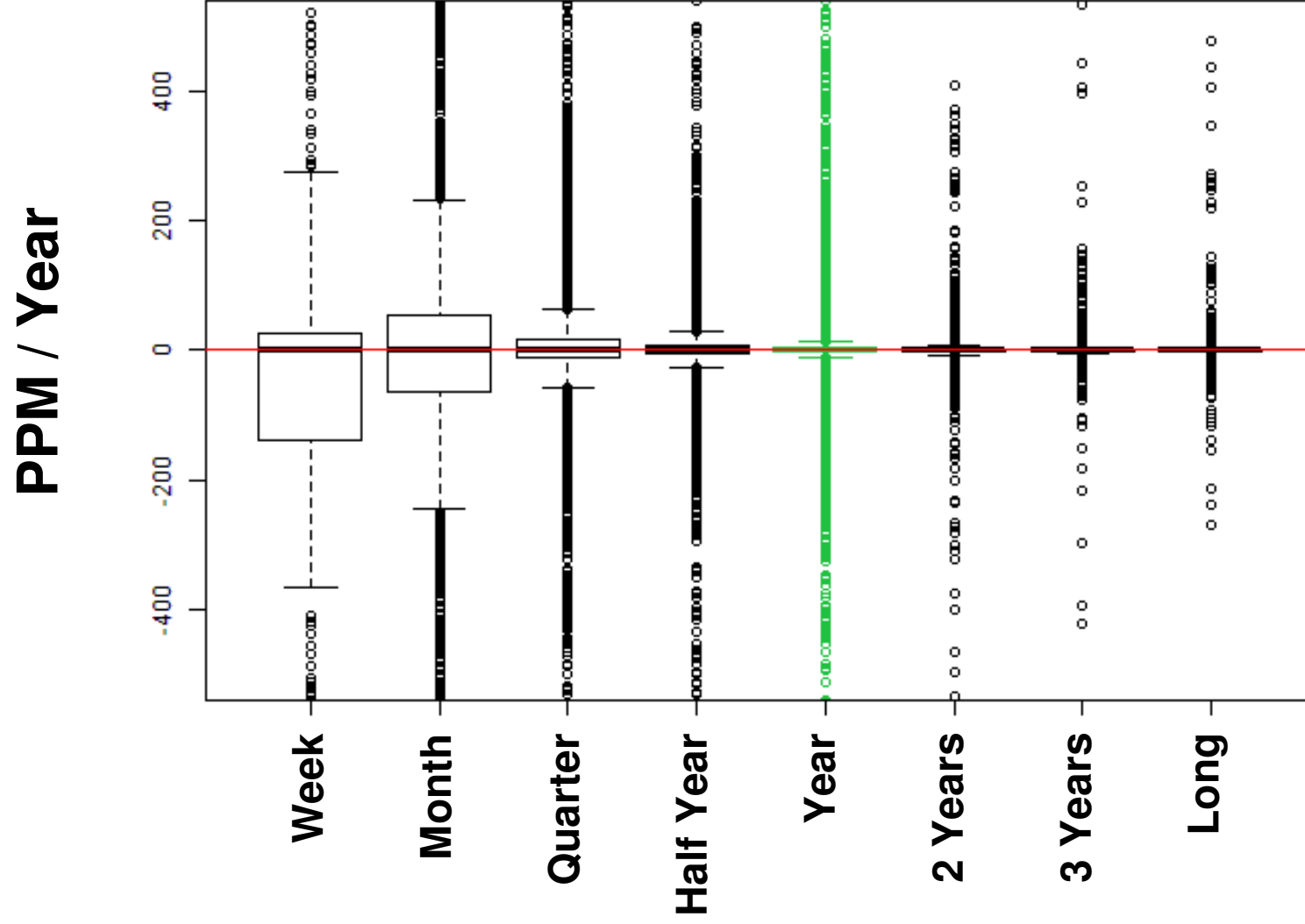


BoxPlot Graph

- Usefully to visually evaluate a group of data
 - Spread of data
 - Middle Value
 - Symmetry of distribution
 - Outliers
- Easy to compare several groups of data
- So, what do we have with trend data ?

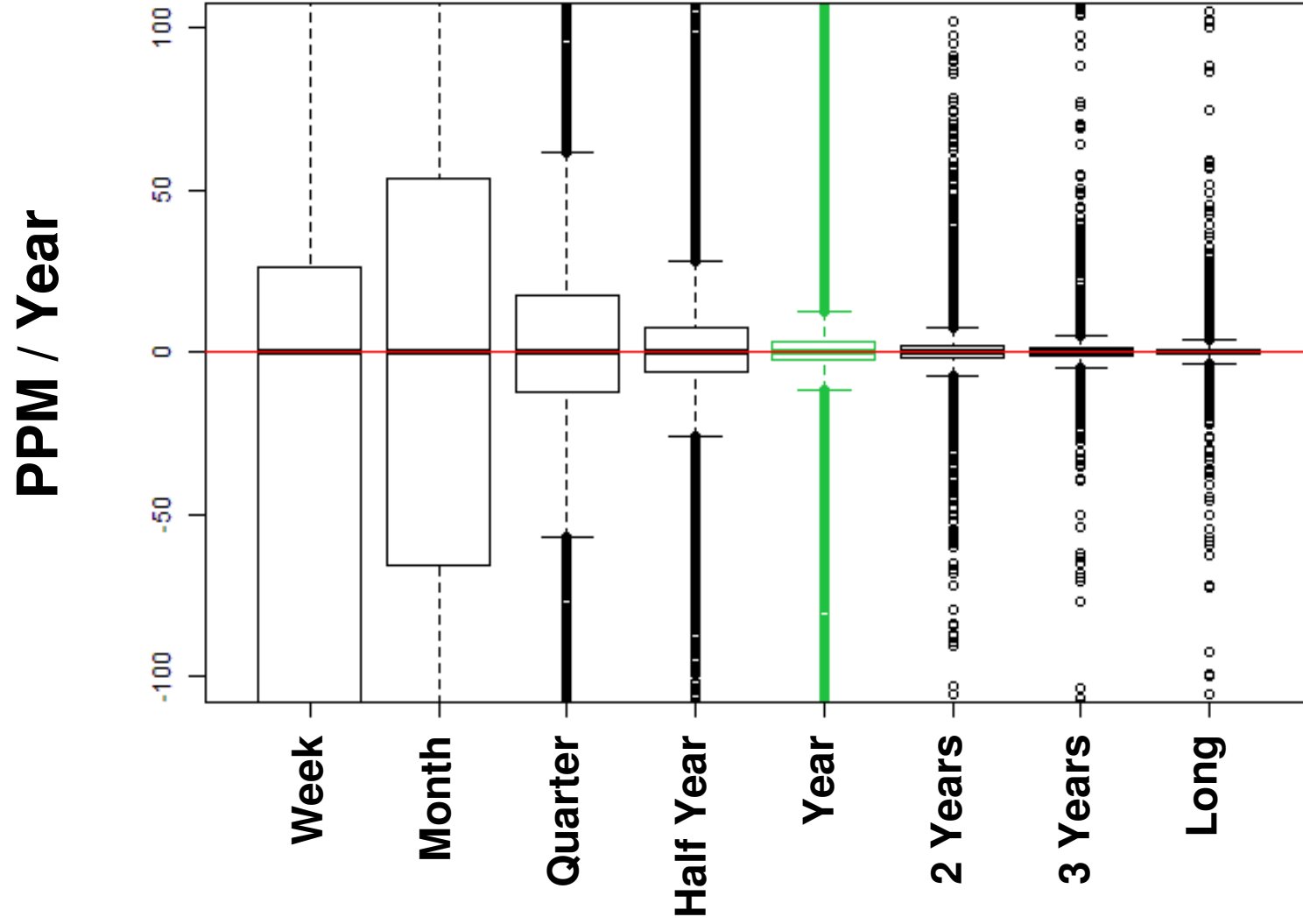
CH₄ Normalised Rate

CH₄

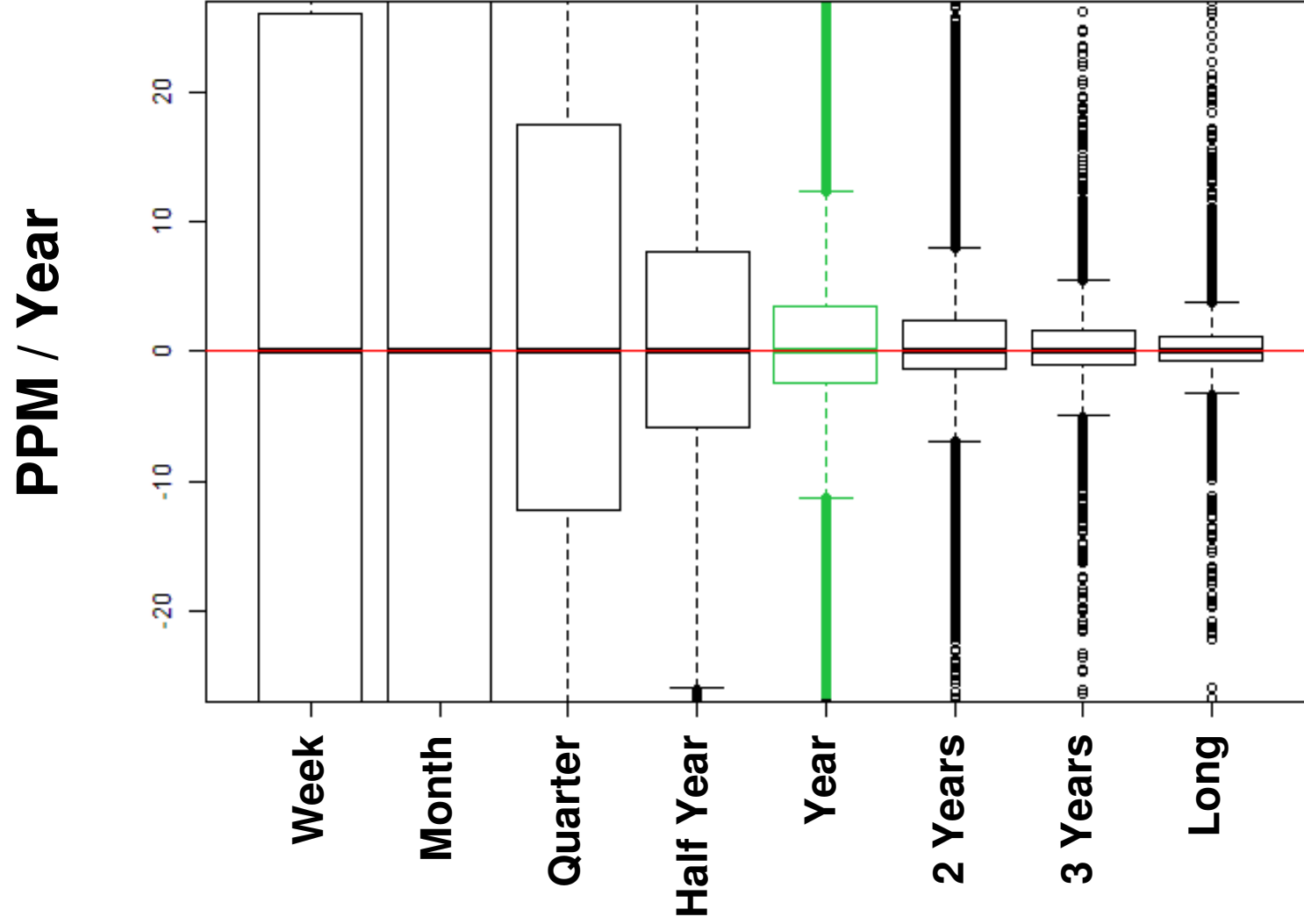


CH₄ Normalised Rate

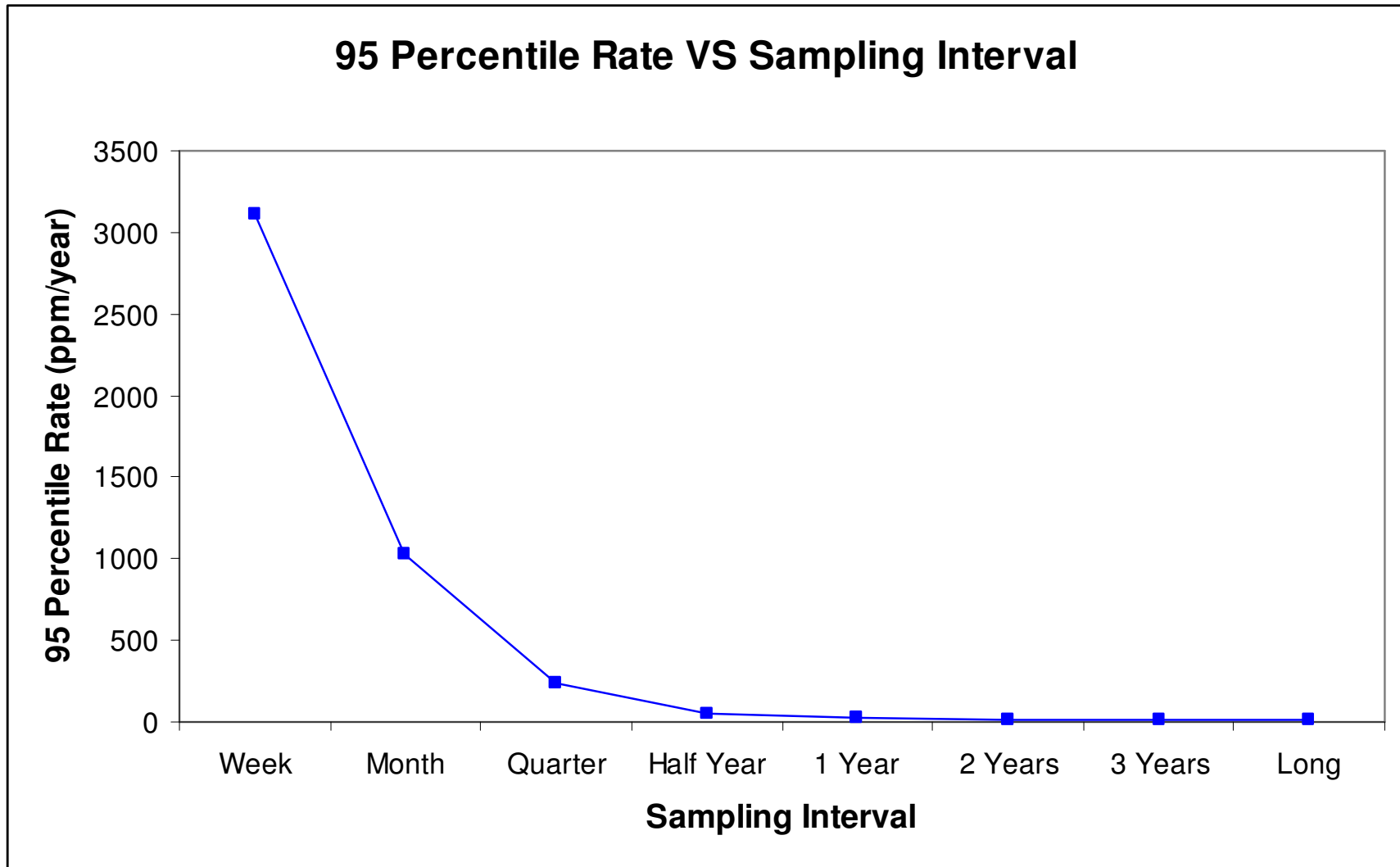
CH₄



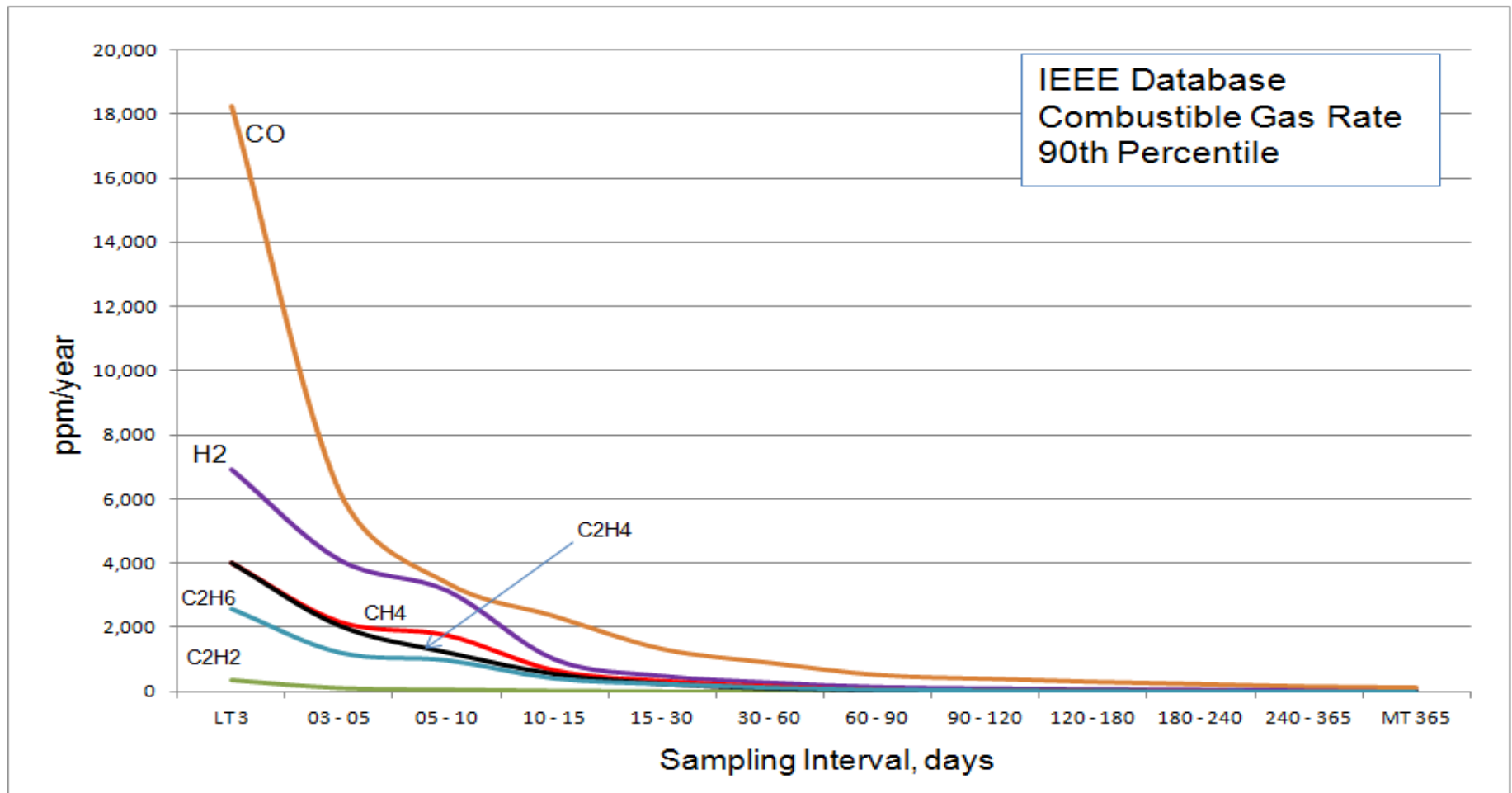
CH₄ Normalised Rate



CH₄ Normalised Rate



From Last Presentation



CH₄ Normalised Rate

95 Percentile of Rate		
Sampling Period	PPM/Year	PPM/Day
Week	3115	8.5
Month	1028	2.8
Quarter	235	0.64
Half Year	55	0.15
1 Year	19	0.052
2 Years	12	0.033
3 Years	8.3	0.023
Long	6.7	0.018

A ratio of 463 between “weekly” and “long term” sampling !!

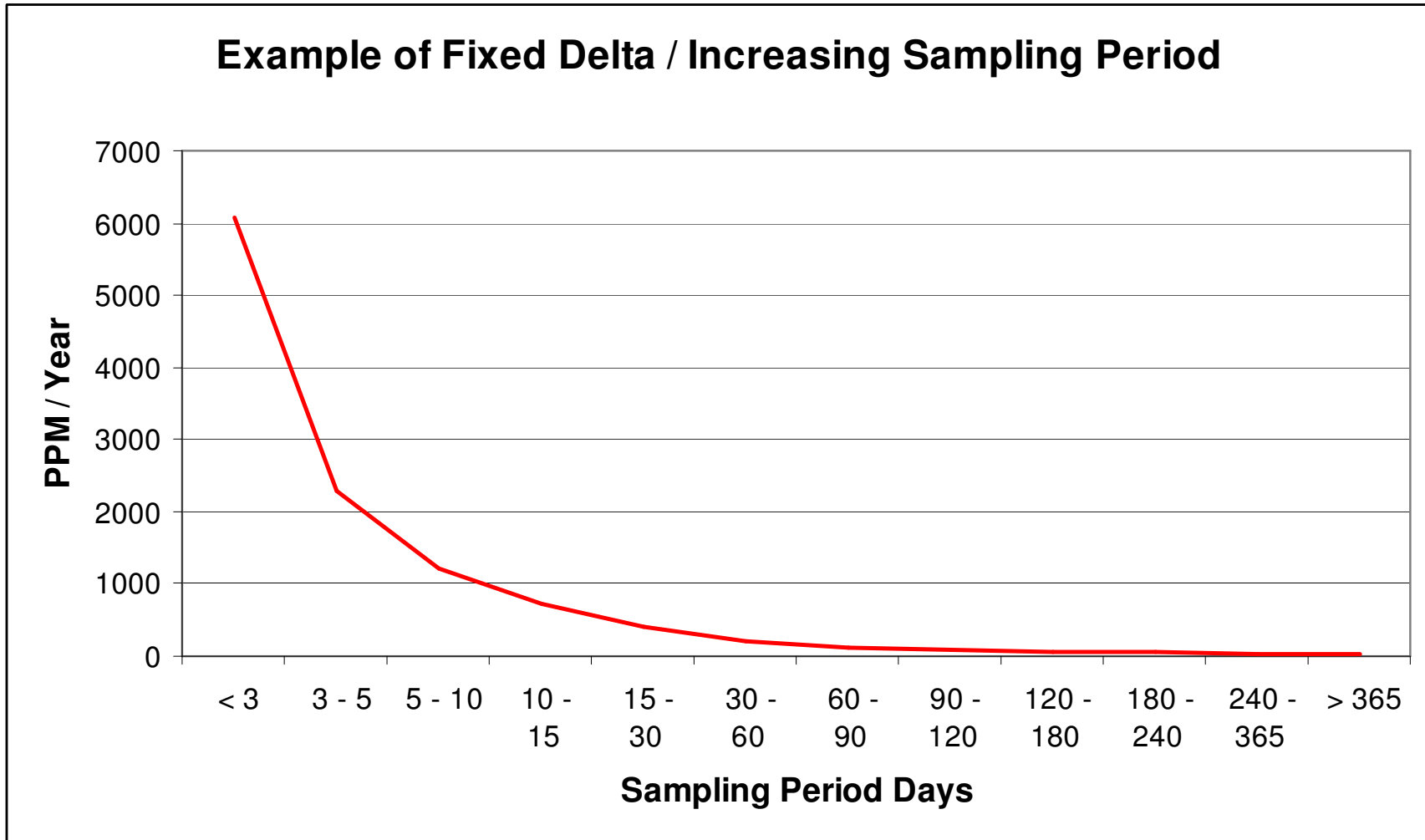
CH₄ Normalised Rate

- If we want to use PPM/year (or PPM/Day) we obviously need a method to handle this spread
- Should we have a table for each period?
- Which periods ?
- How many ?
- How complex ?
- Added to the “other” complexities ?

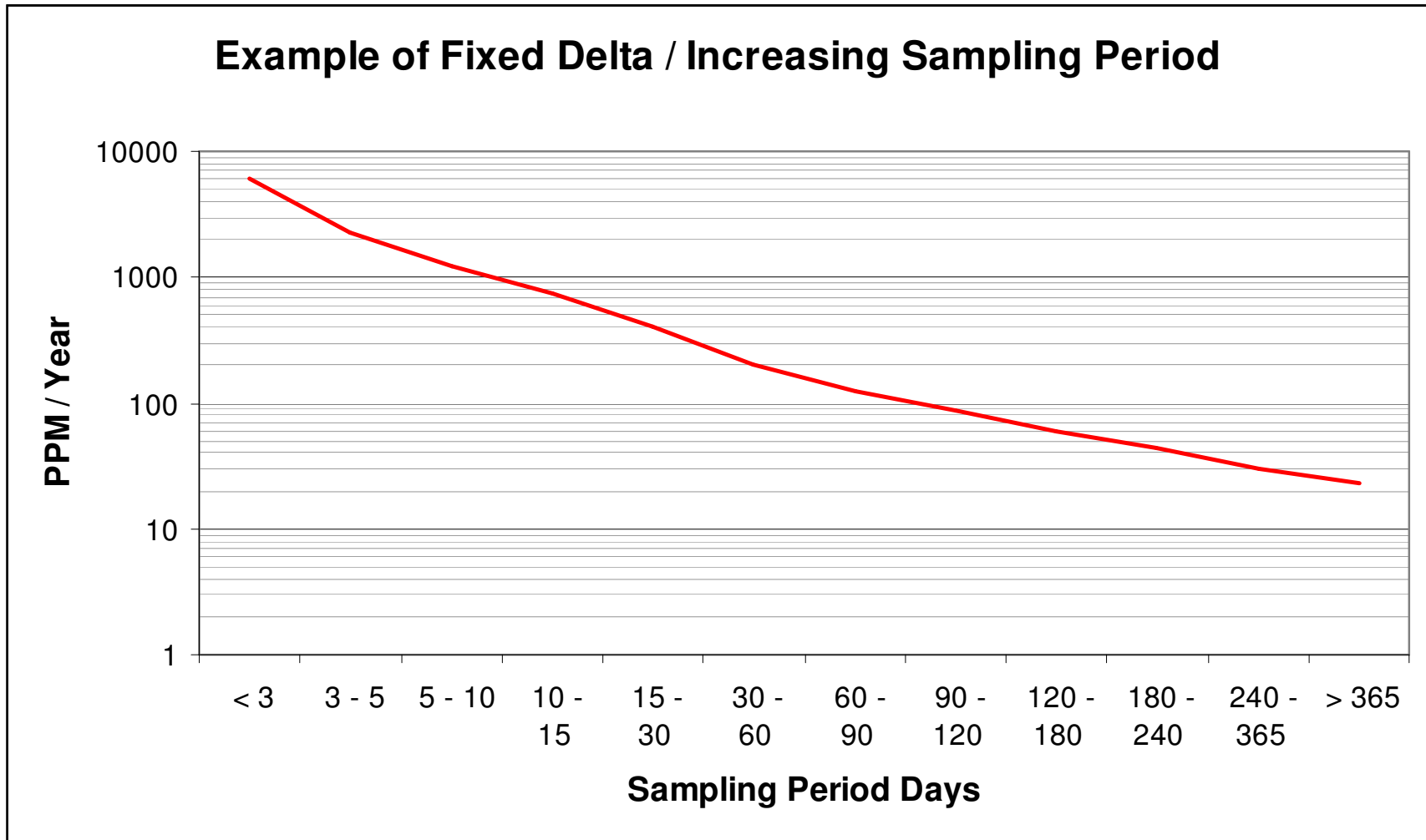
Normalised Rate and noise

- Maybe we are looking at it the wrong way ?
- If we have noise in the data, it would probably be the same for short and long period
- If we divide a fixed value by an increasing period, we will obtain a log like curve
- As an example, let take 25 ppm / 1 day, /7 days, /14 days ... to ppm / year.....
- Then:

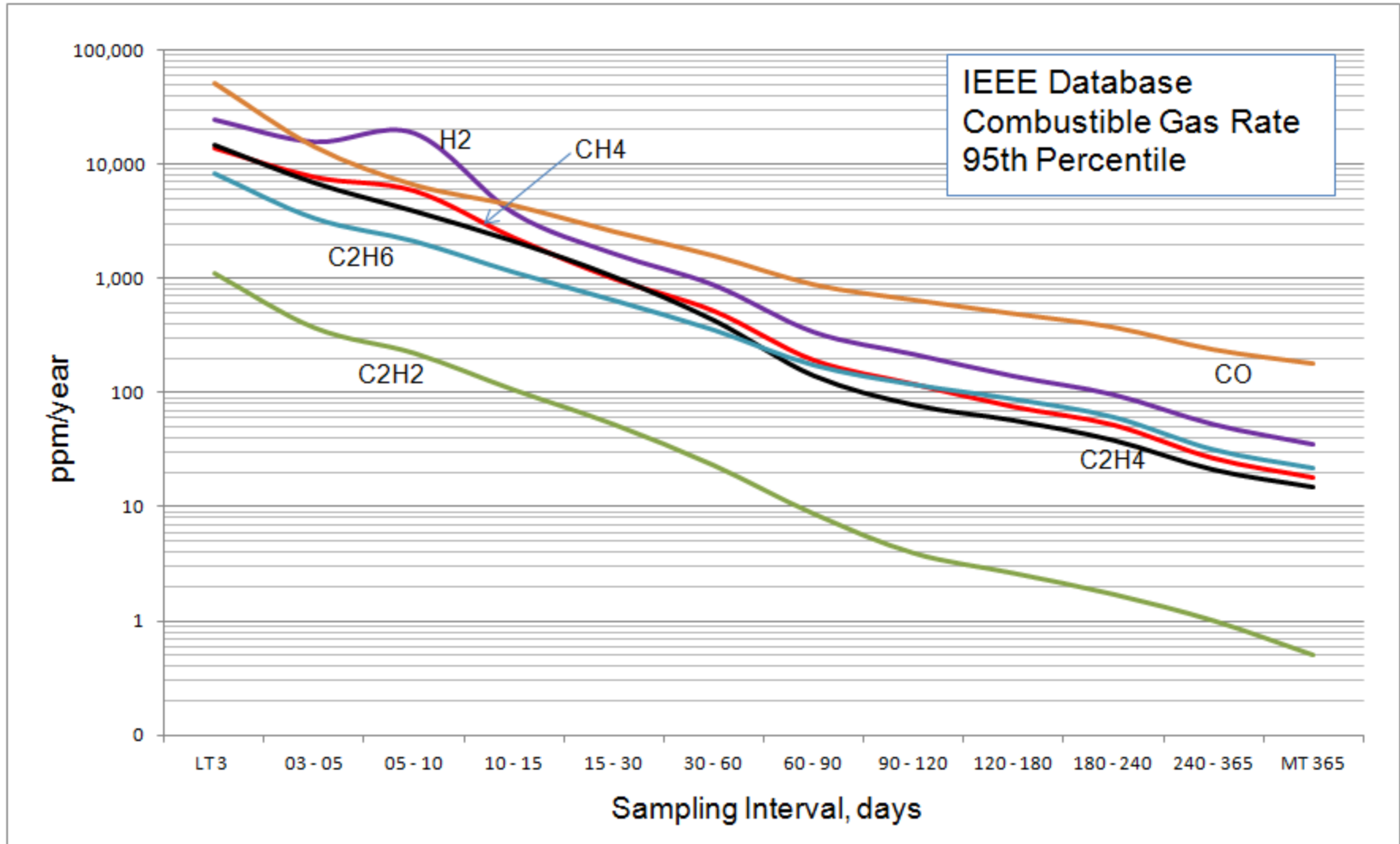
Simulation of a Constant PPM Delta



Simulation of a Constant PPM Delta



From Previous Presentation

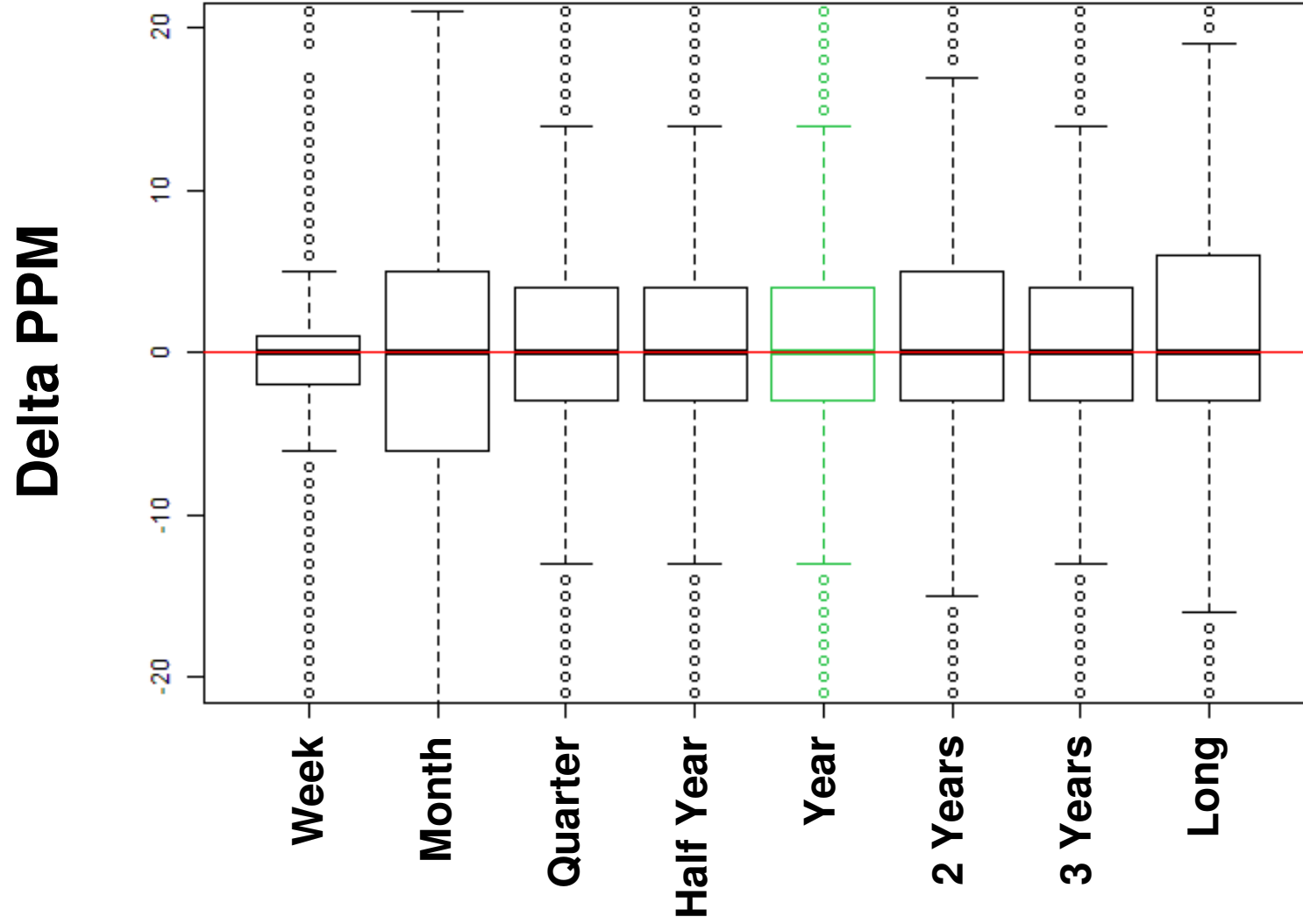


Change of Perspective

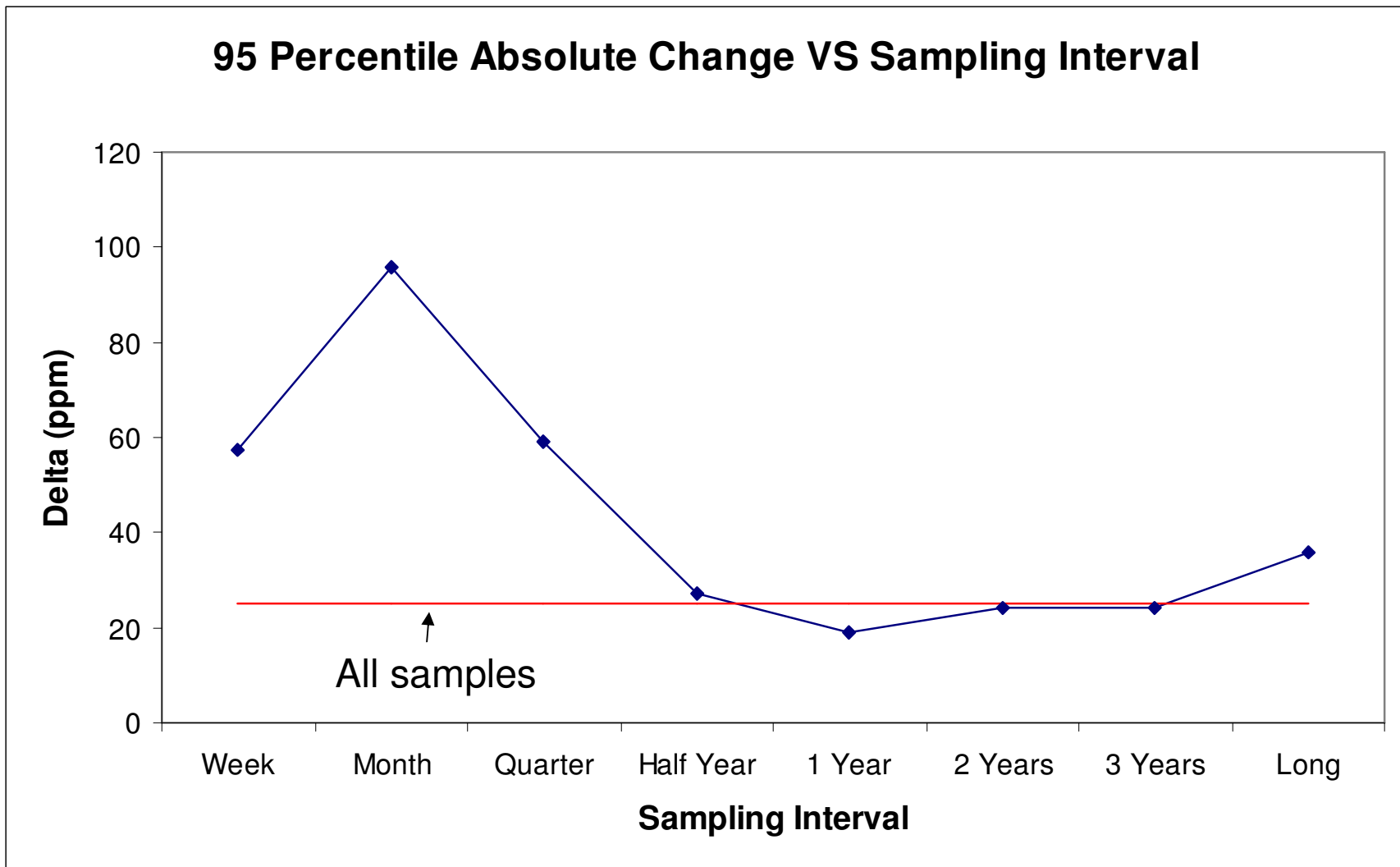
- So, let try to drop the notion of normalised rate (Trend) (PPM/day or PPM/year)
- Let look at the **ABSOLUTE** difference (in PPM) between two samples (Delta)
- Let group results by sampling period, as a few slides before
- What do we have ?

CH₄ Absolute Change

CH₄



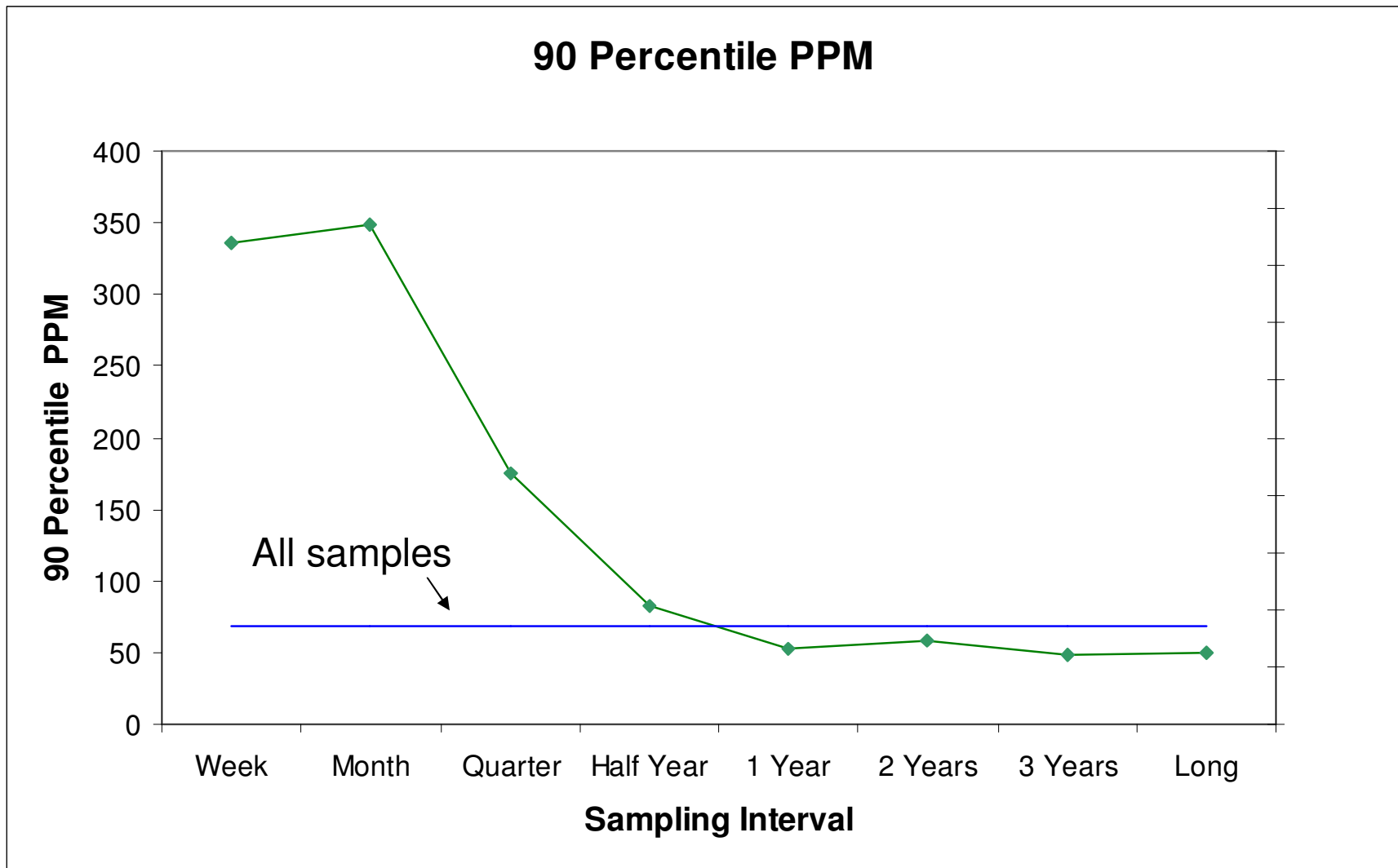
CH₄ Absolute Change



CH₄ Absolute Change

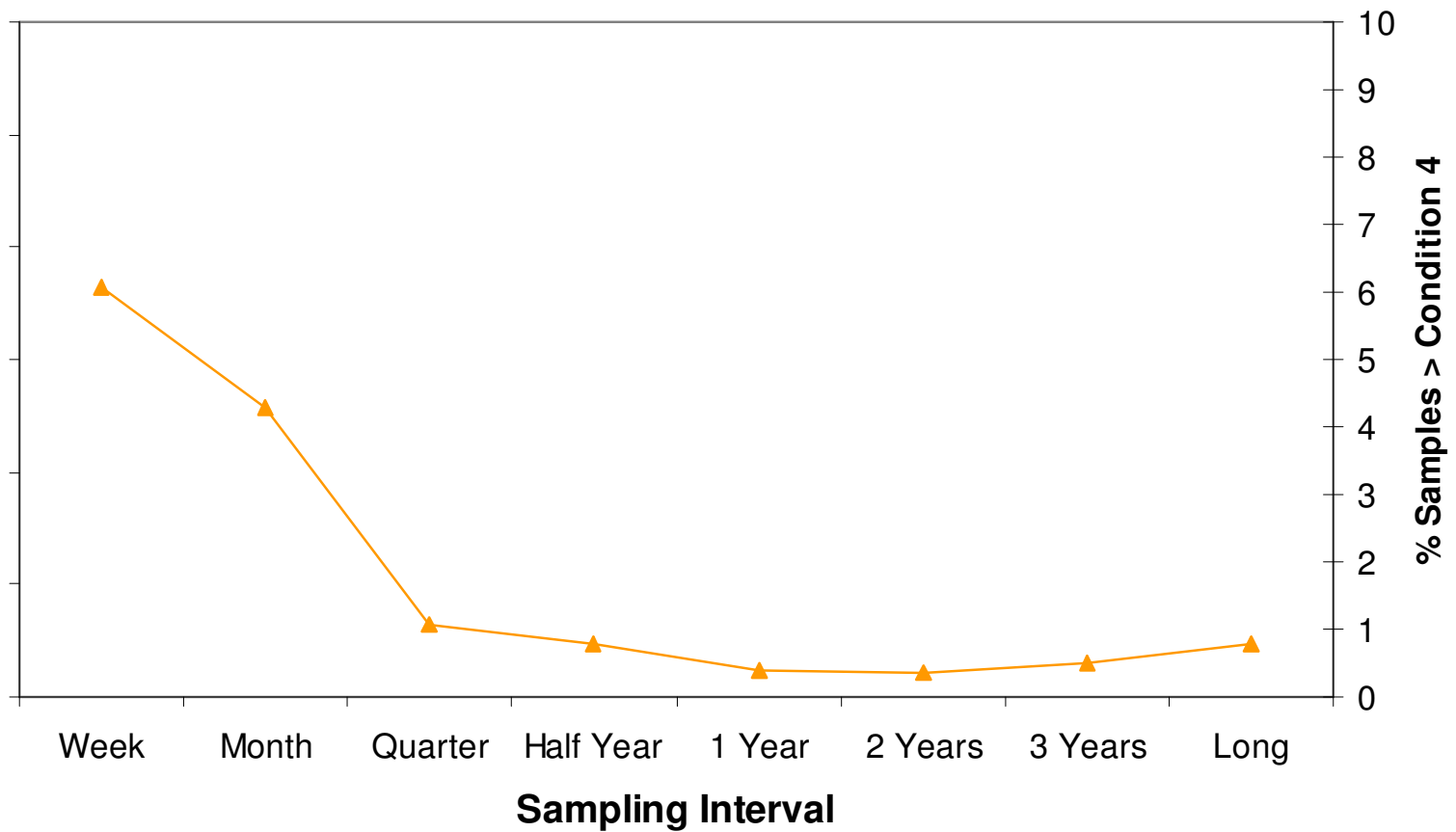
- Ratio has been reduced by a factor of 100
- A lot more manageable !!
- The use of absolute variation between consecutive samples, without day or year normalisation, give more uniform results and is simpler to use
- What else could we learn from this data set ?

CH₄ Gas Level in PPM



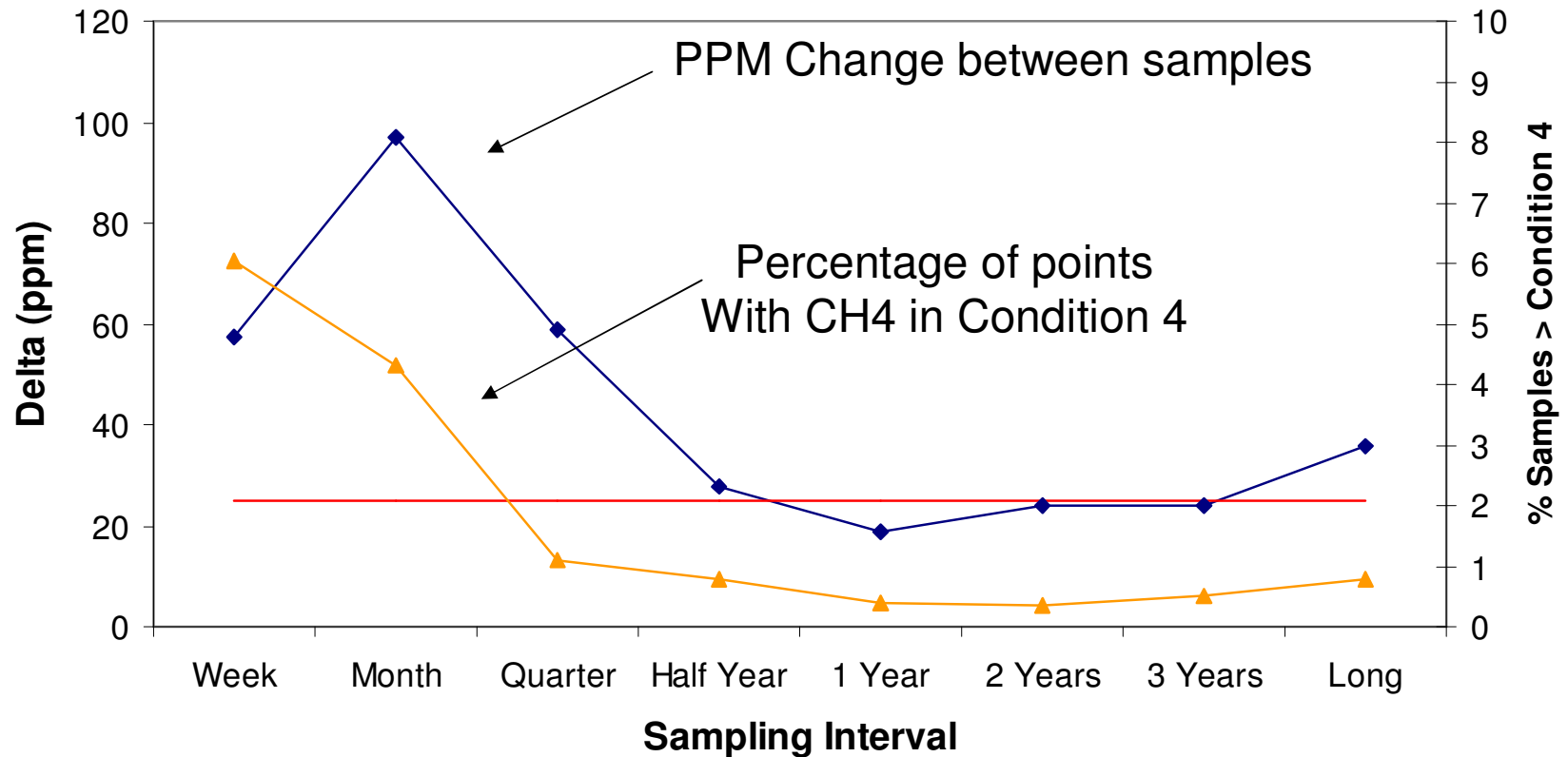
CH₄ Gas Level in PPM

Percentage of Samples above condition 4

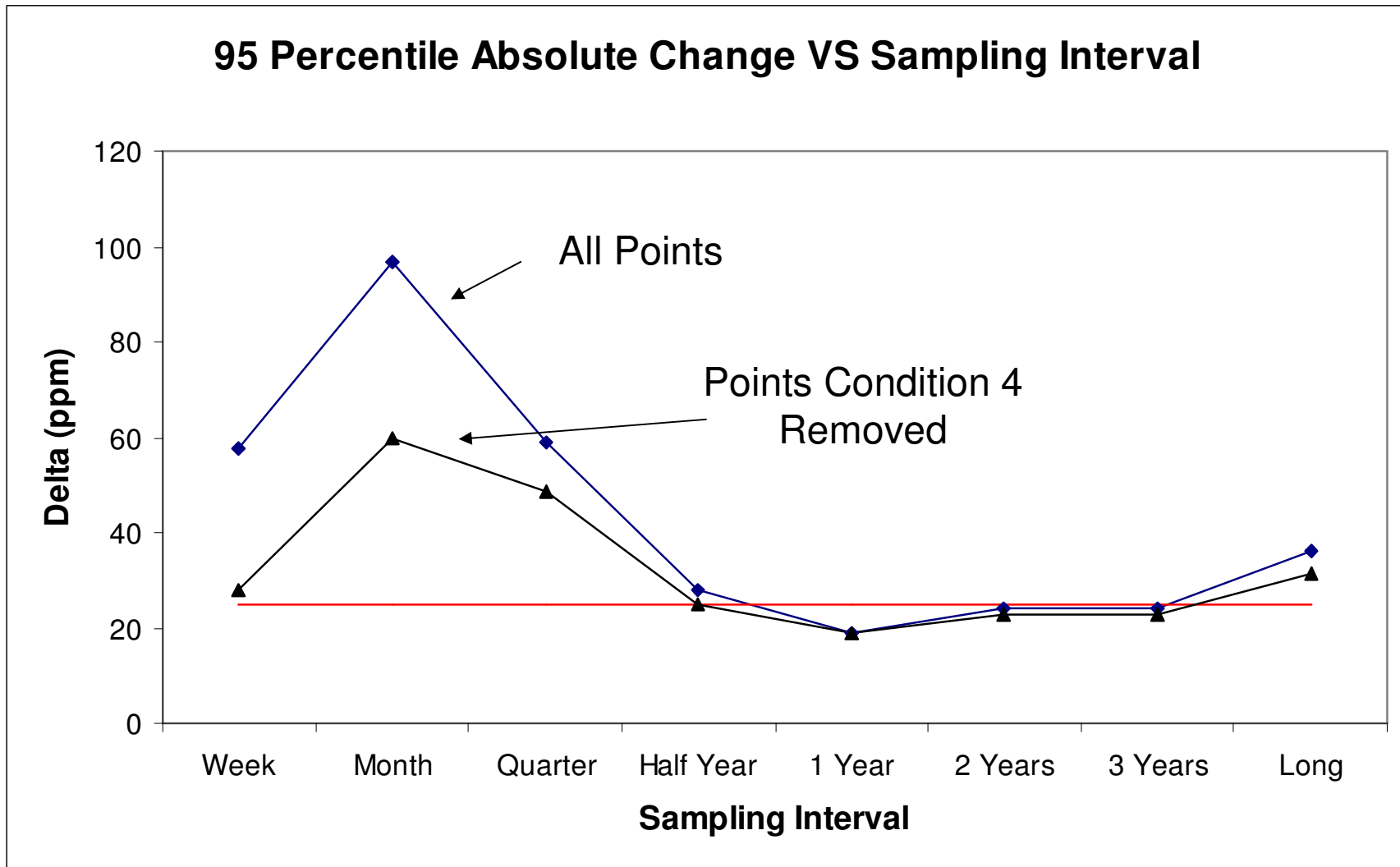


CH₄ Absolute Change

95 Percentile Absolute Change and % of Samples above Condition 4

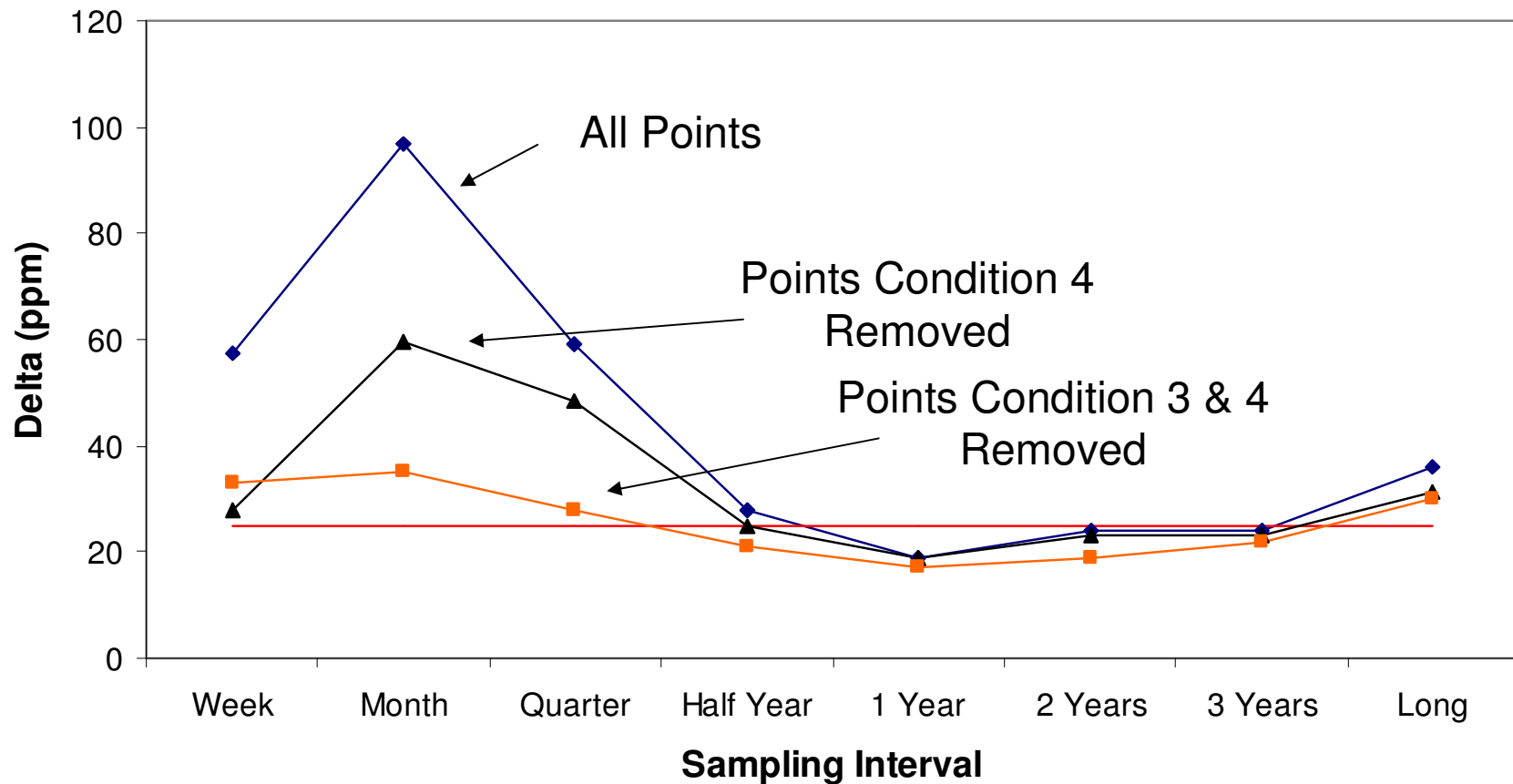


CH₄ Absolute Change



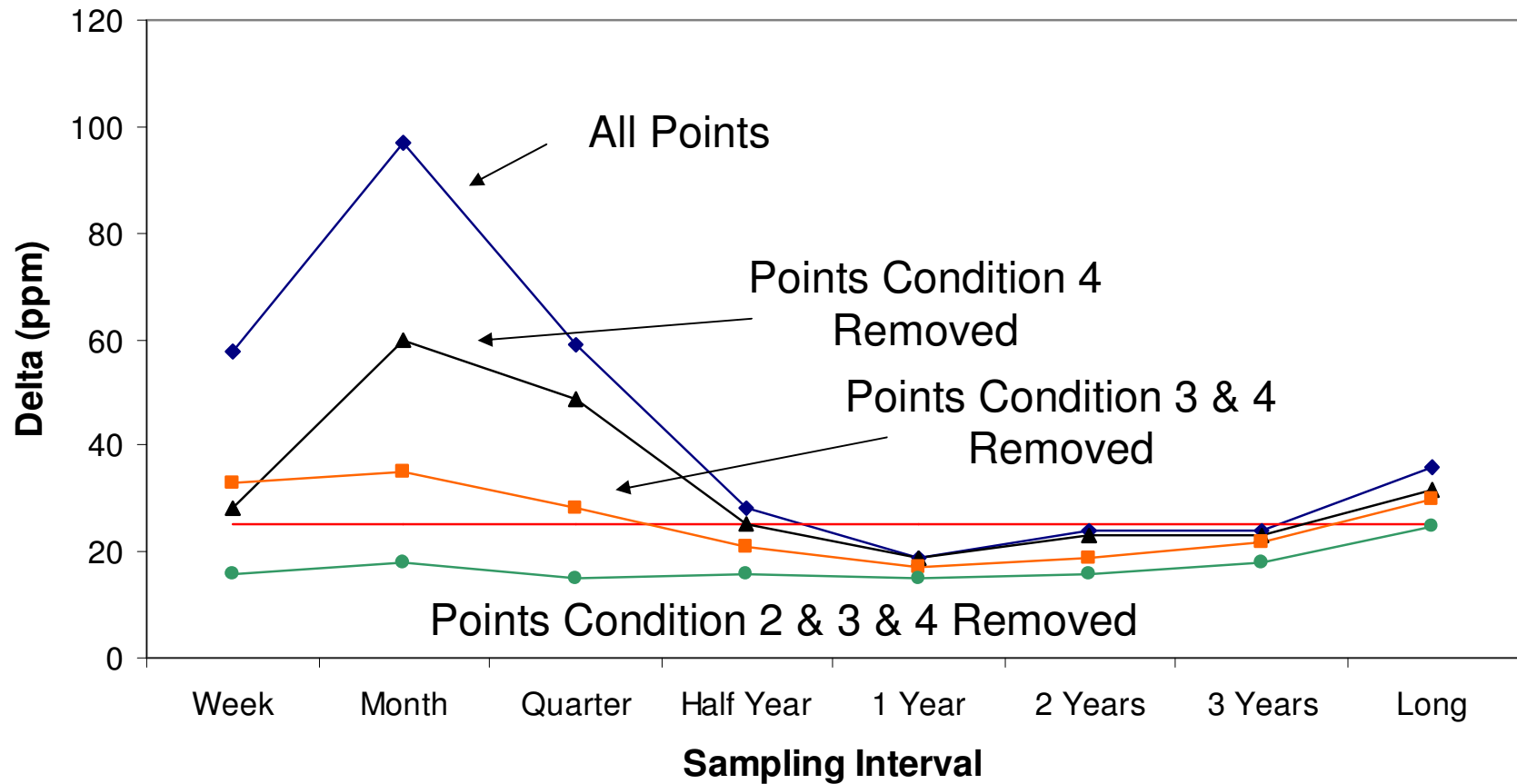
CH₄ Absolute Change

95 Percentile Absolute Change VS Sampling Interval



CH₄ Absolute Change

95 Percentile Absolute Change VS Sampling Interval



Other Gas

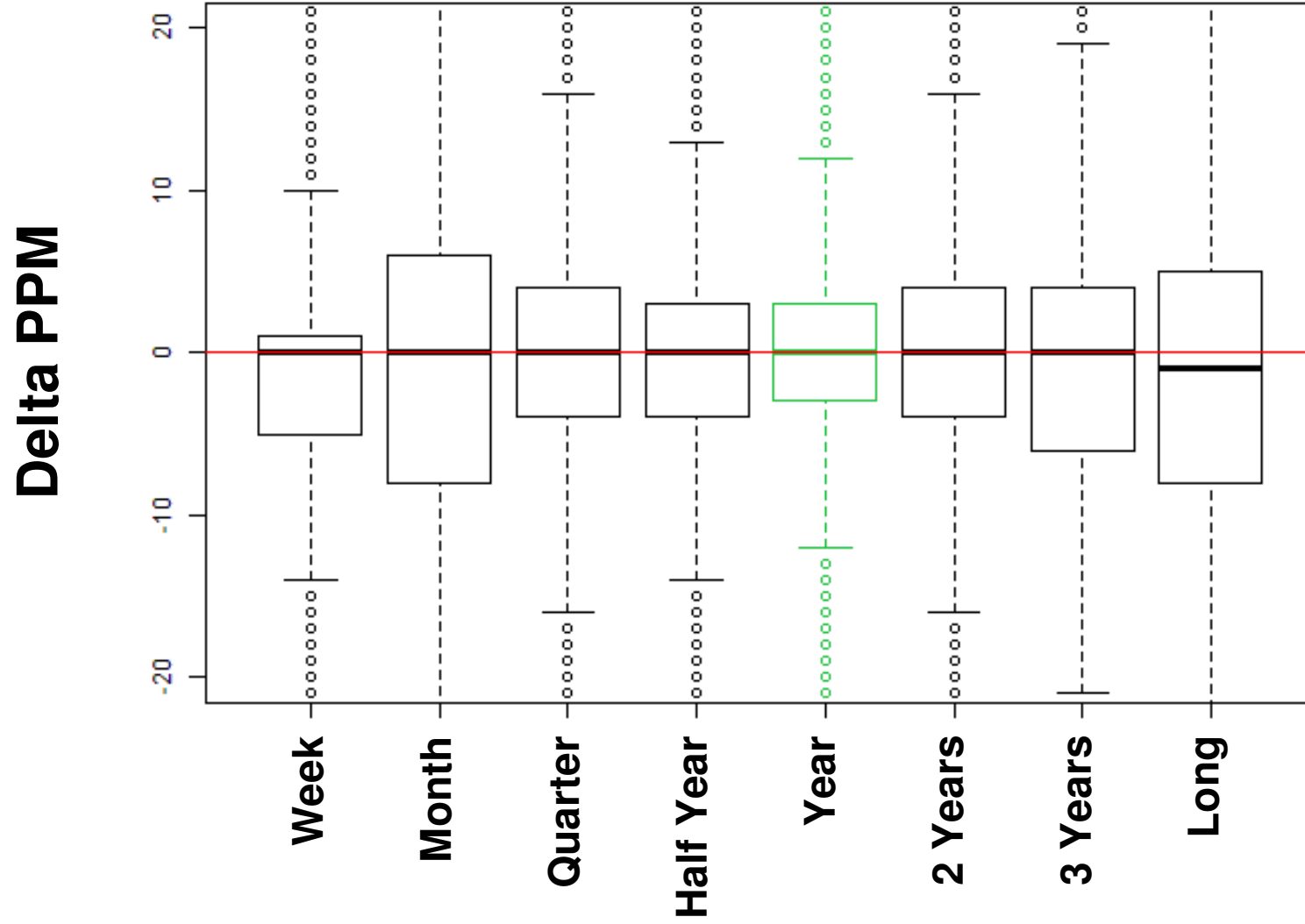
- H_2 , C_2H_4 and C_2H_2 have the same type of distribution
- CO and CO_2 form a different group
- C_2H_6 and TDCG are between the two groups

Other Gas

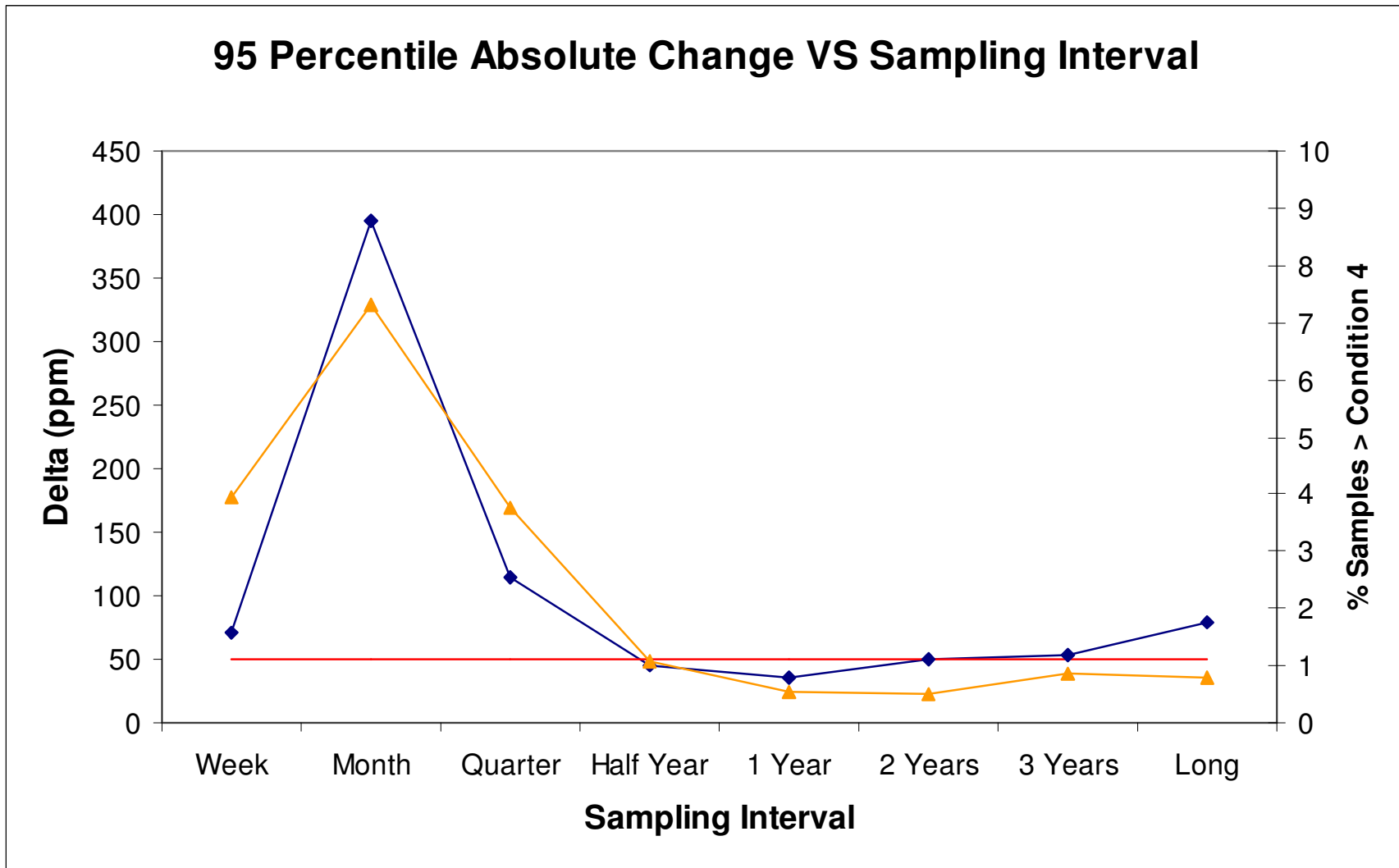
- “Type I”
- Short Term Rate Higher than long term
- Short Term Level Higher than long term
 - Hydrogen
 - Methane
 - Ethylene
 - Acetylene

H₂ Absolute Change

H₂

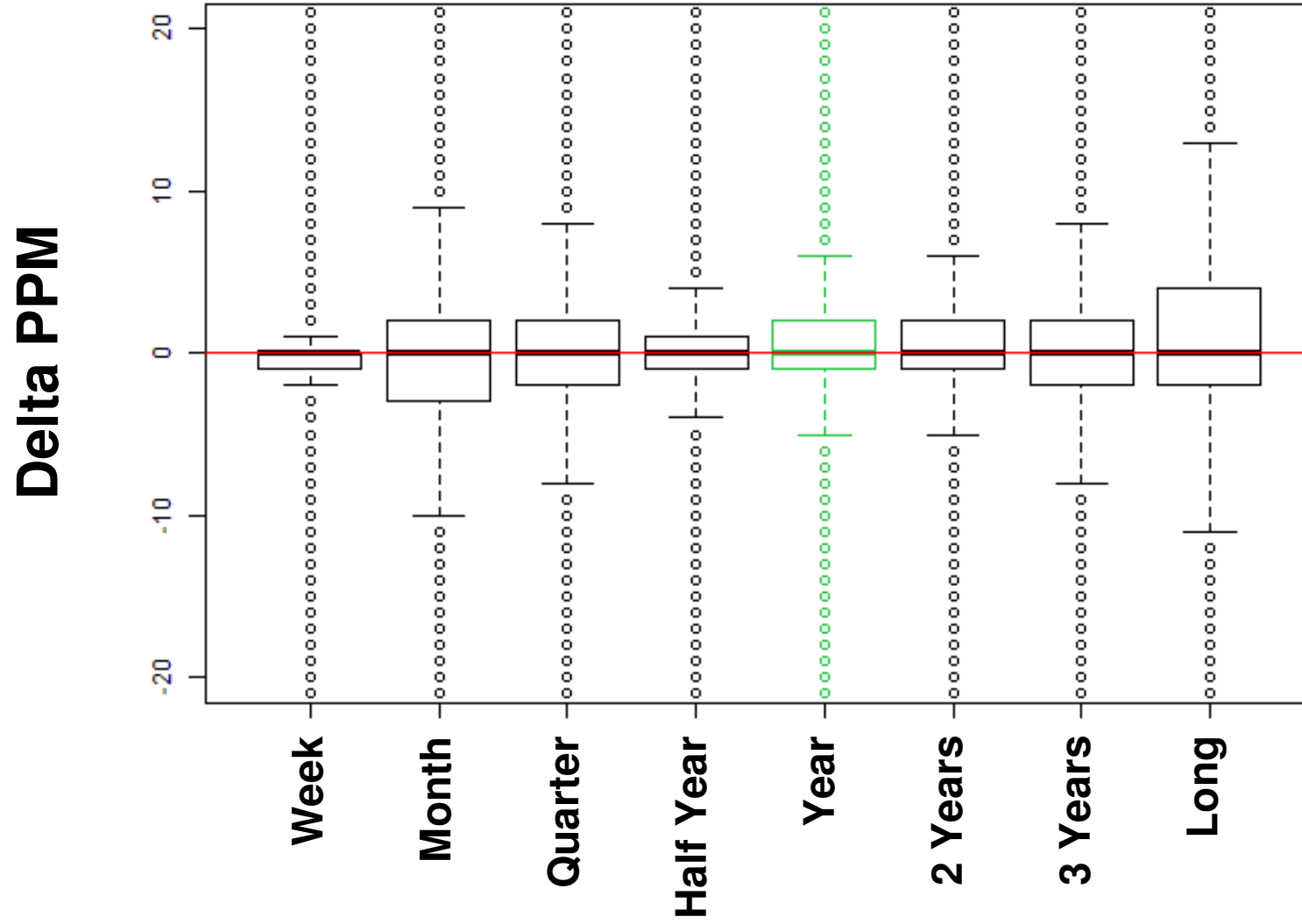


H₂ Absolute Change

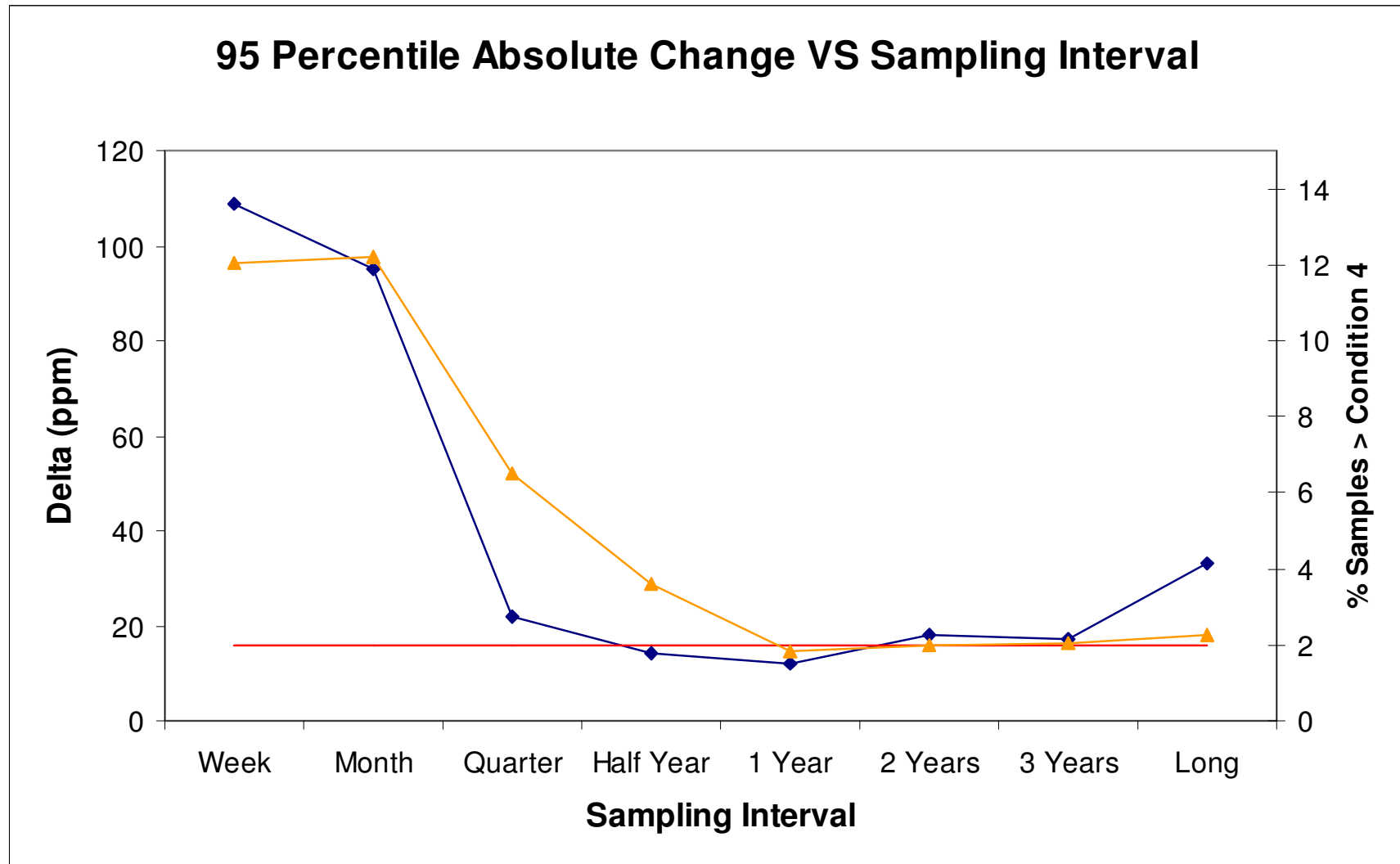


C₂H₄ Absolute Change

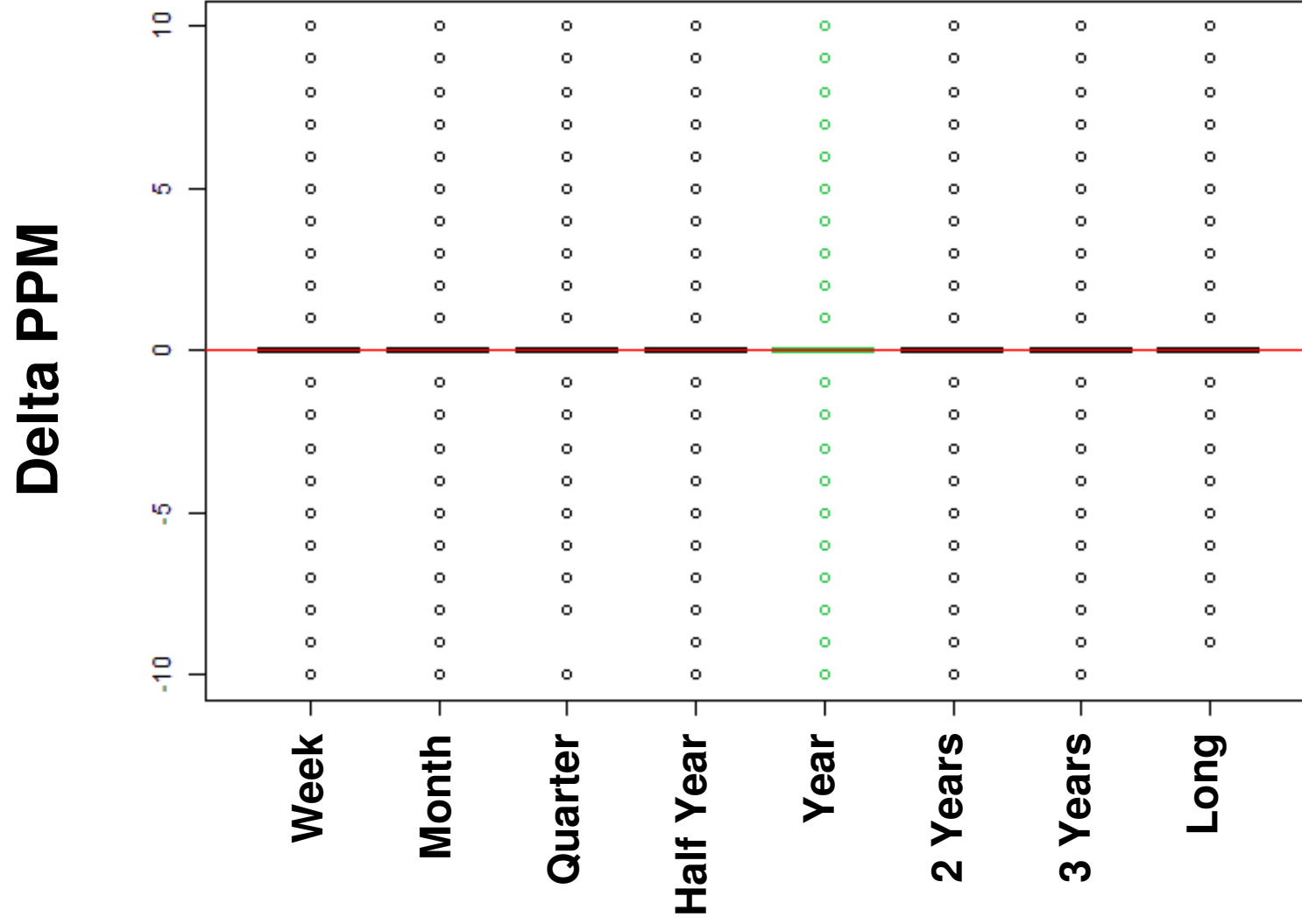
C₂H₄



C₂H₄ Absolute Change

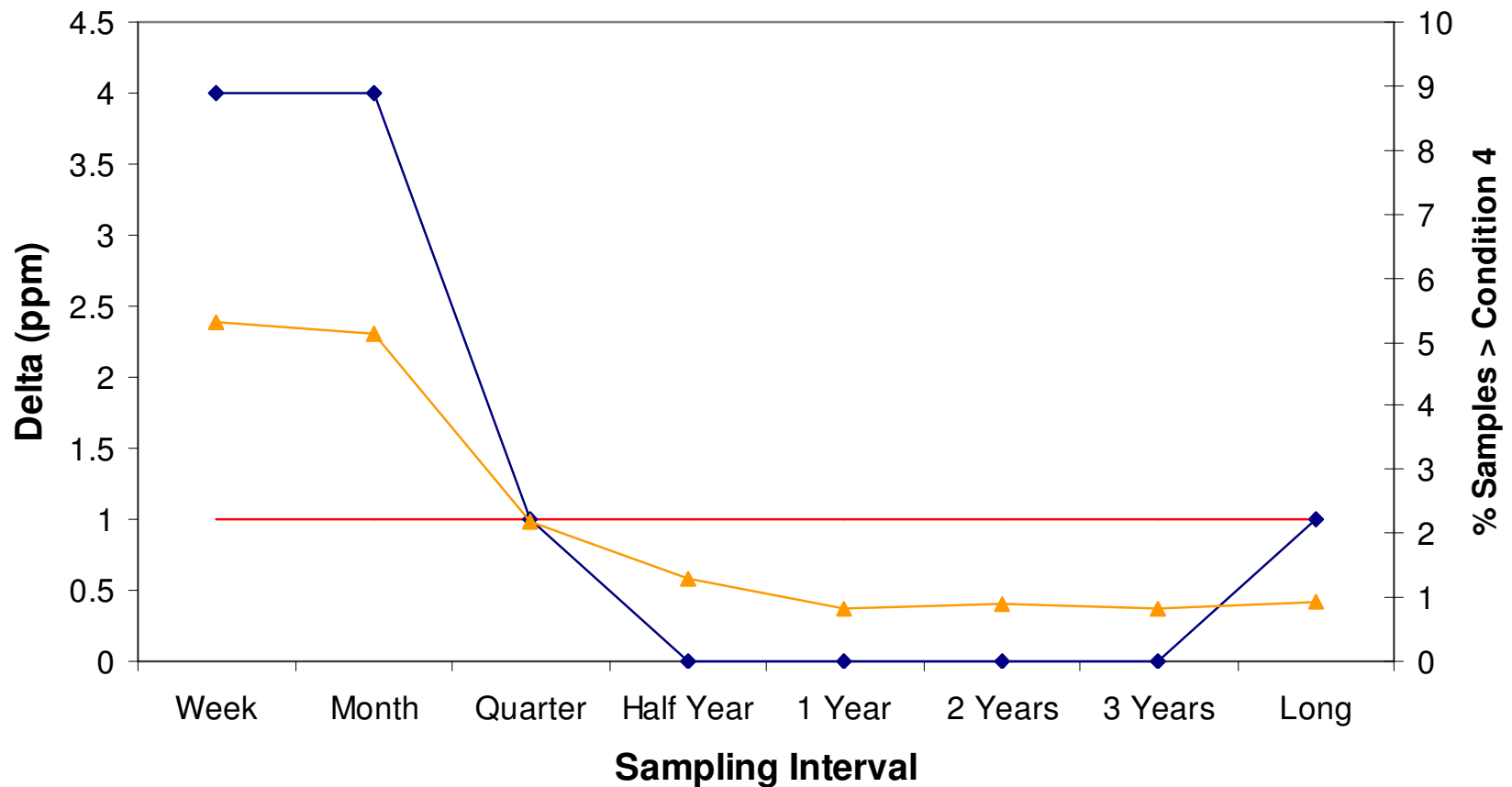


C₂H₂ Absolute Change



C₂H₂ Absolute Change

95 Percentile Absolute Change VS Sampling Interval

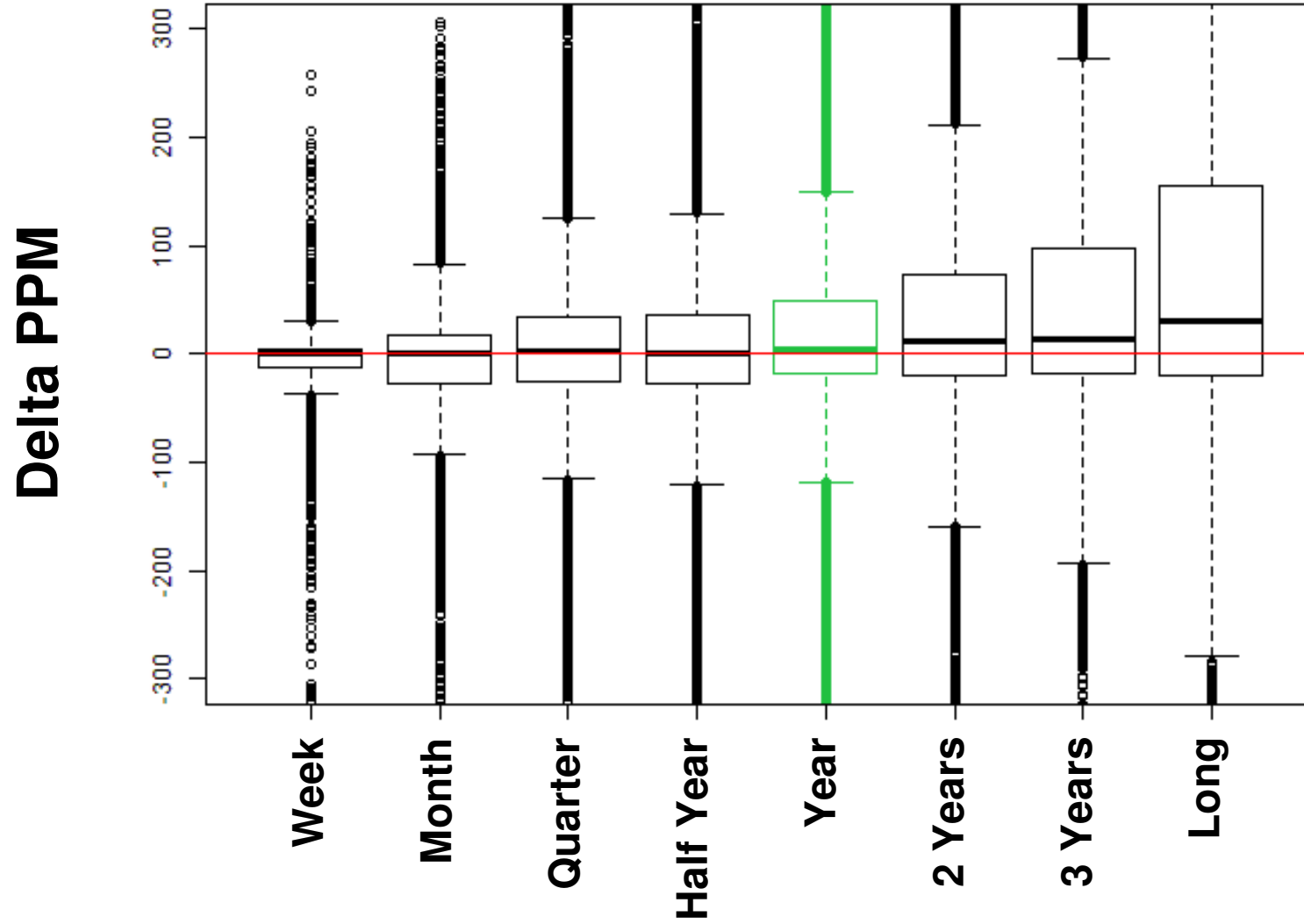


Other Gas

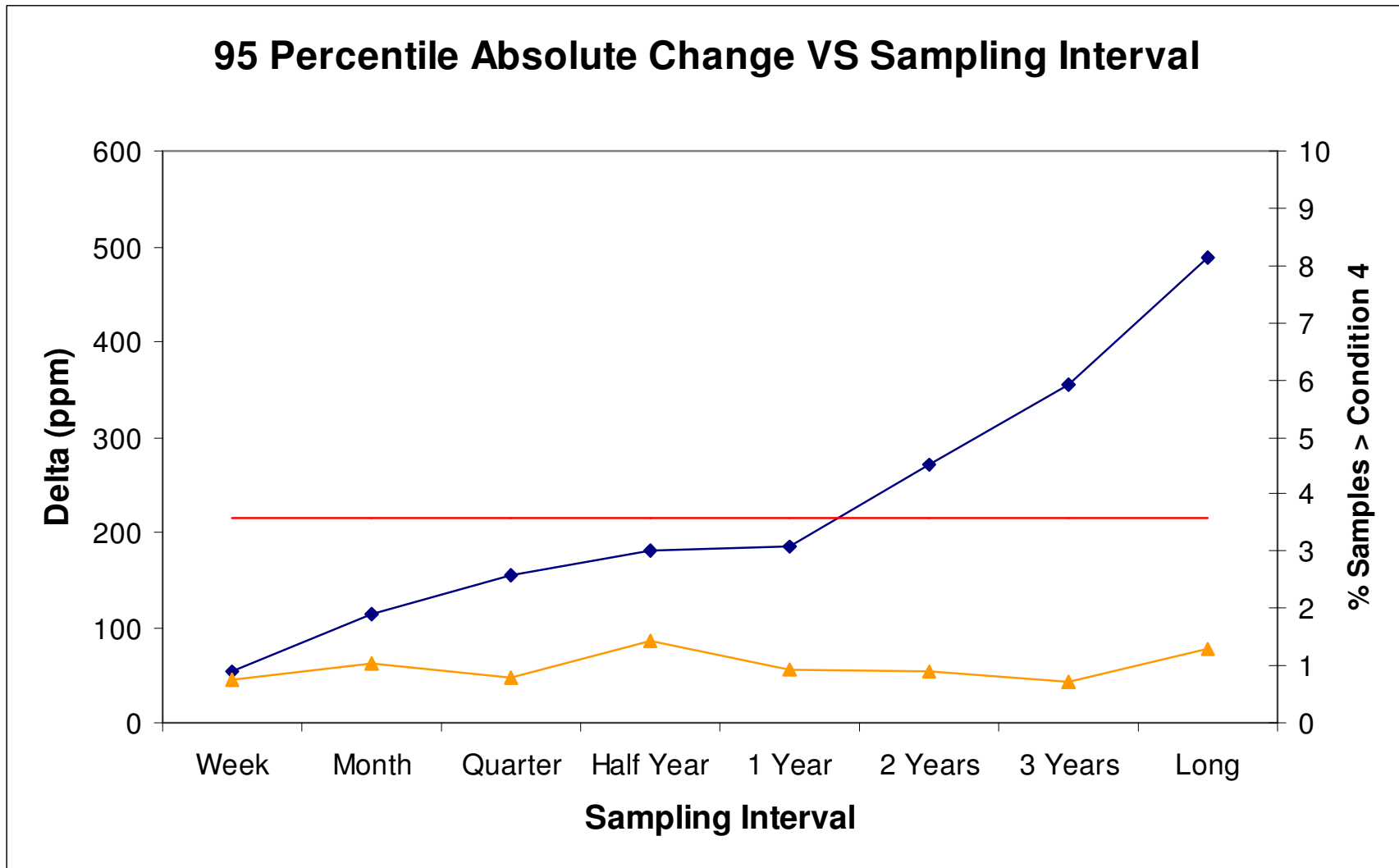
- “Type II”
- Short Term Rate Lower than long term
- Short Term Level similar to long term
 - Carbon Monoxide
 - Carbon Dioxide

CO Absolute Change

co

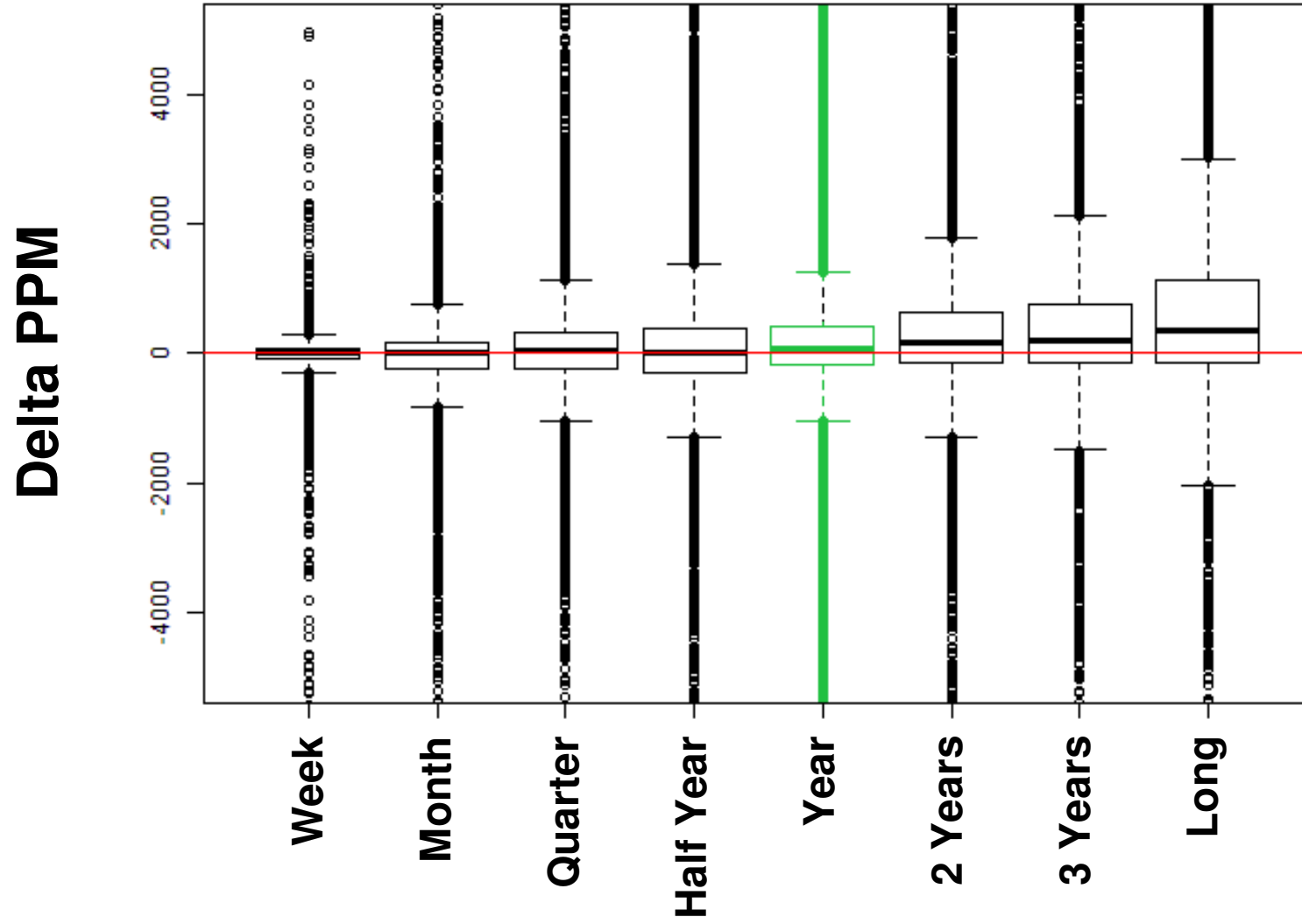


CO Absolute Change

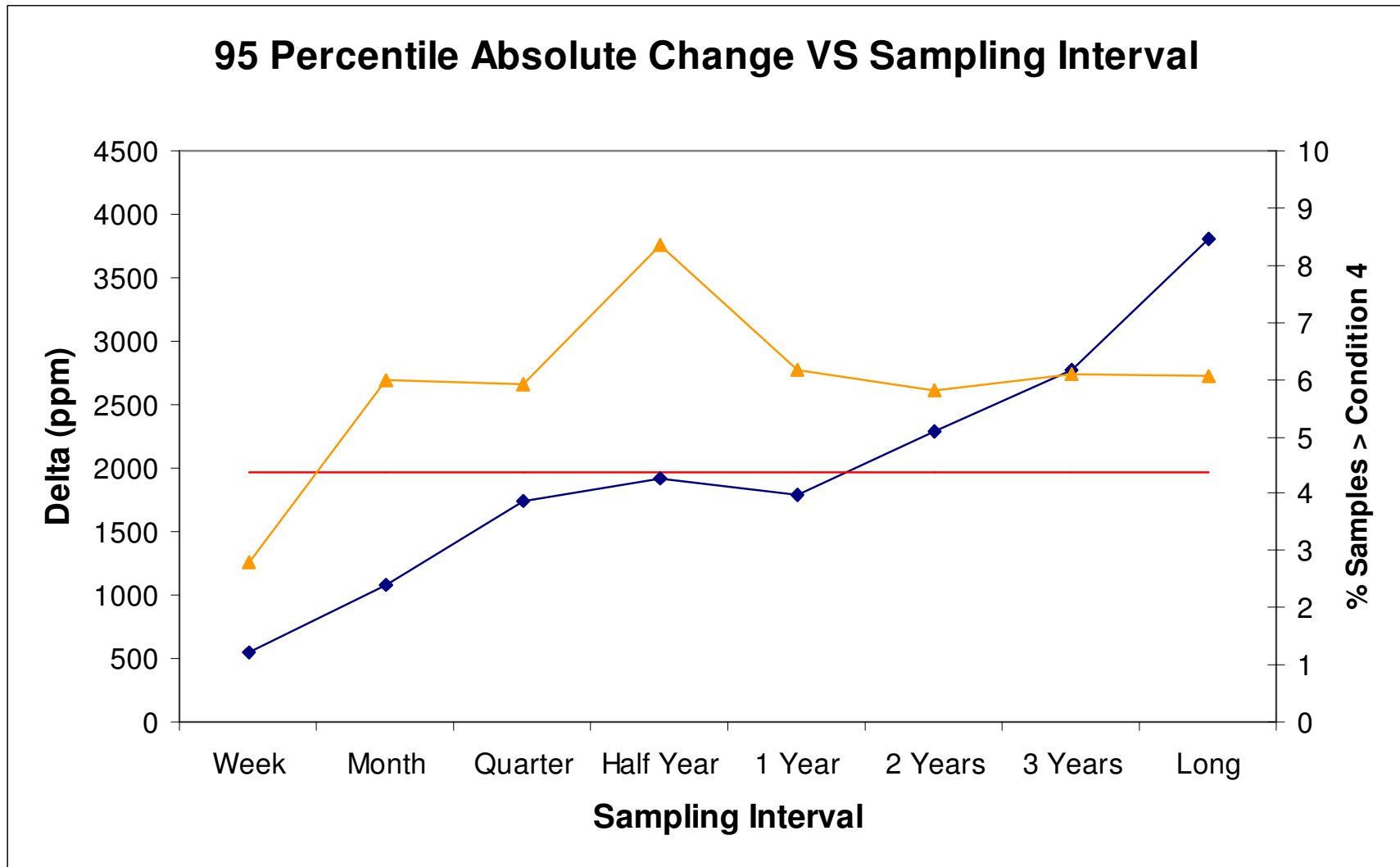


CO₂ Absolute Change

CO₂



CO₂ Absolute Change

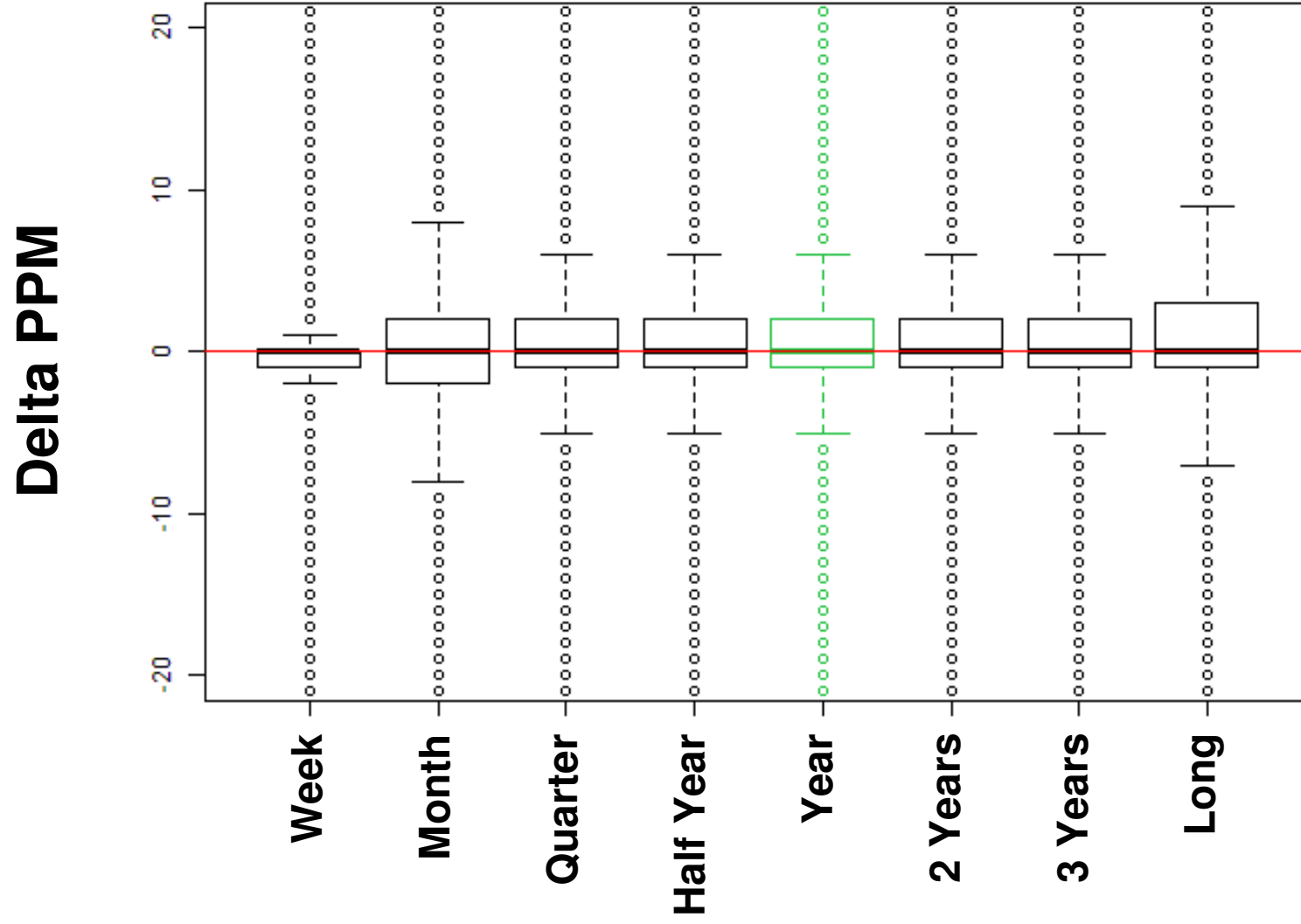


Other Gas

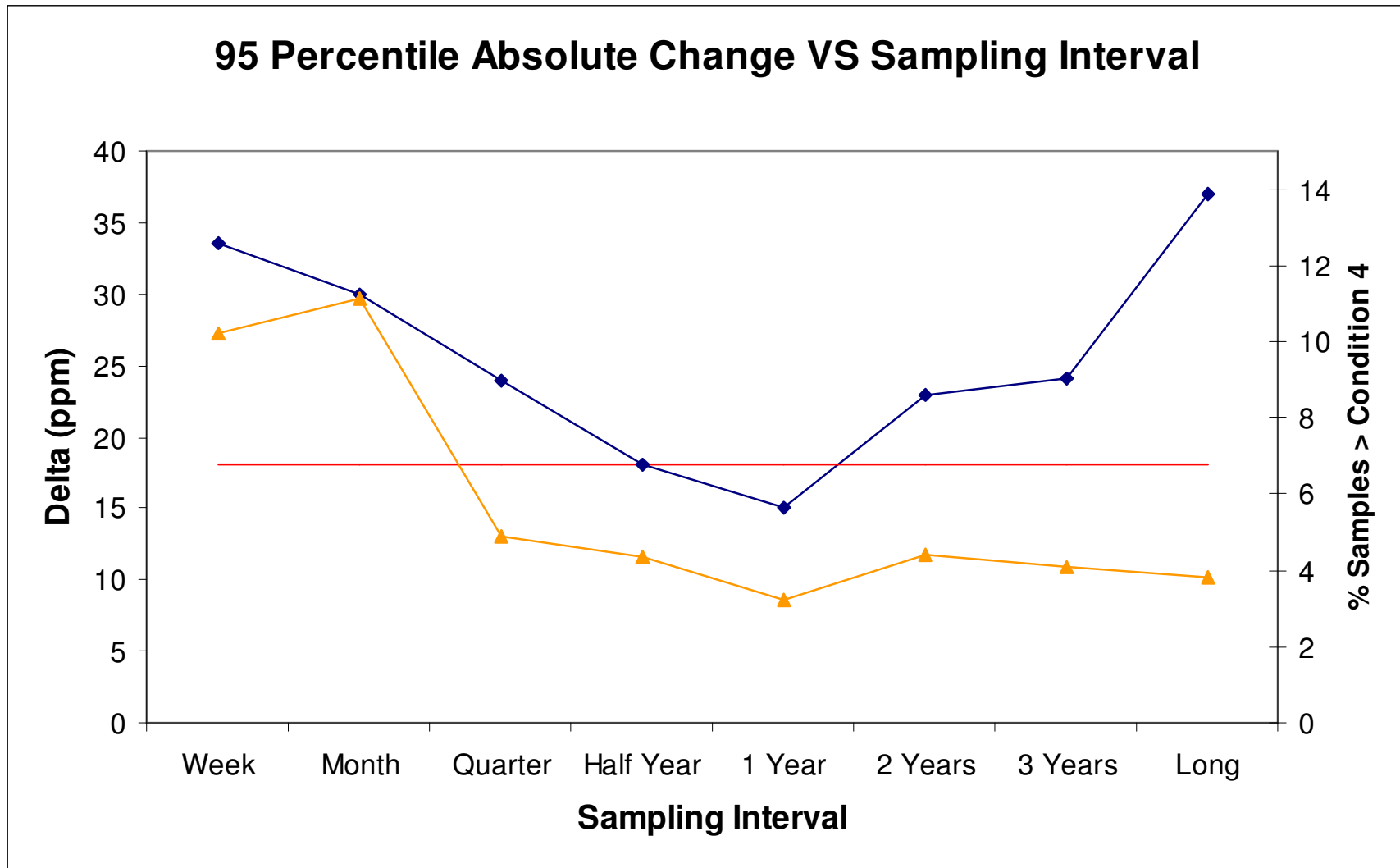
- “Type III”
- Middle Term Rate Lower than shorth and long term
- Short Term Level lower than long term
 - Ethane
 - TDCG

C₂H₆ Absolute Change

C₂H₆

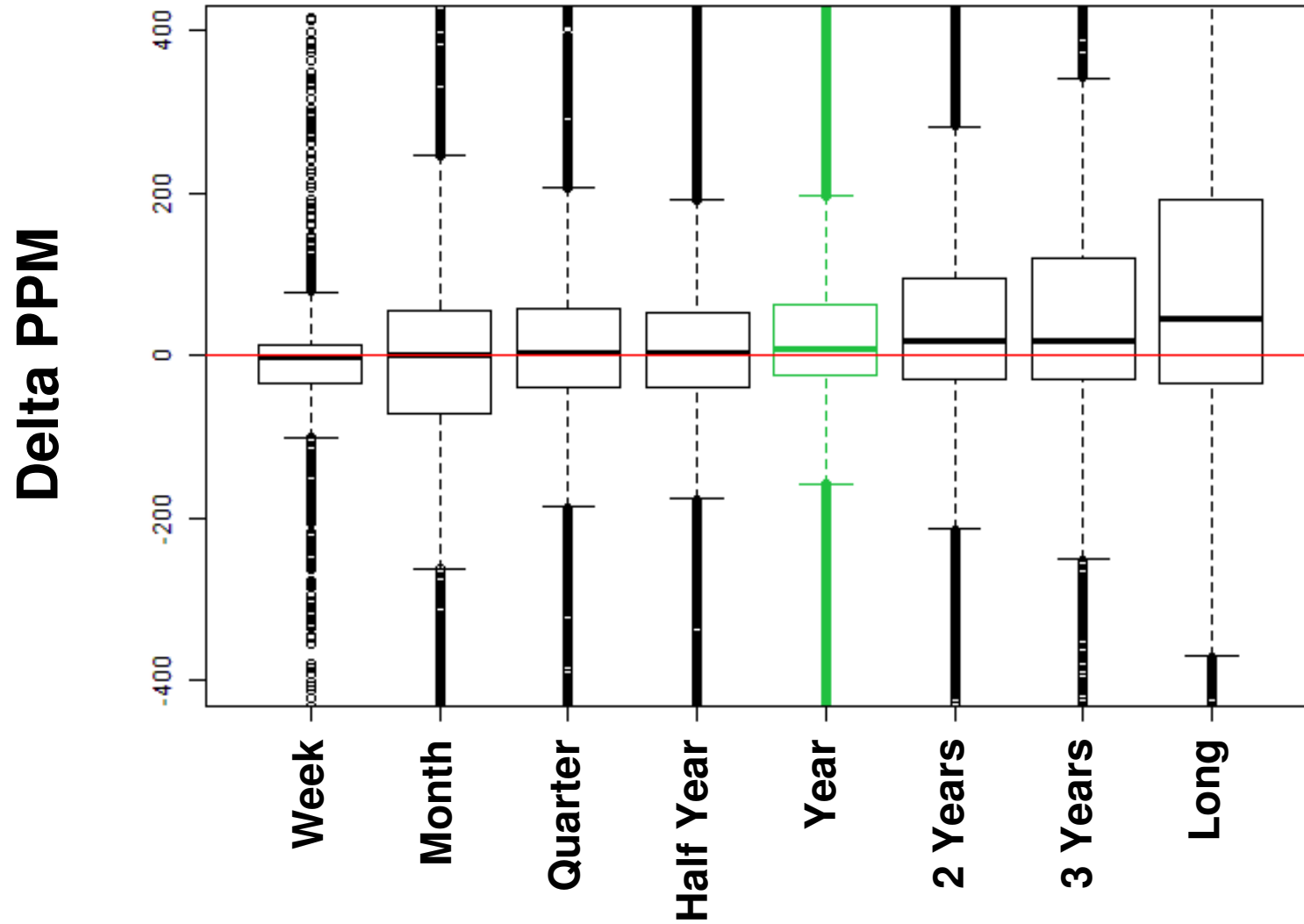


C₂H₆ Absolute Change

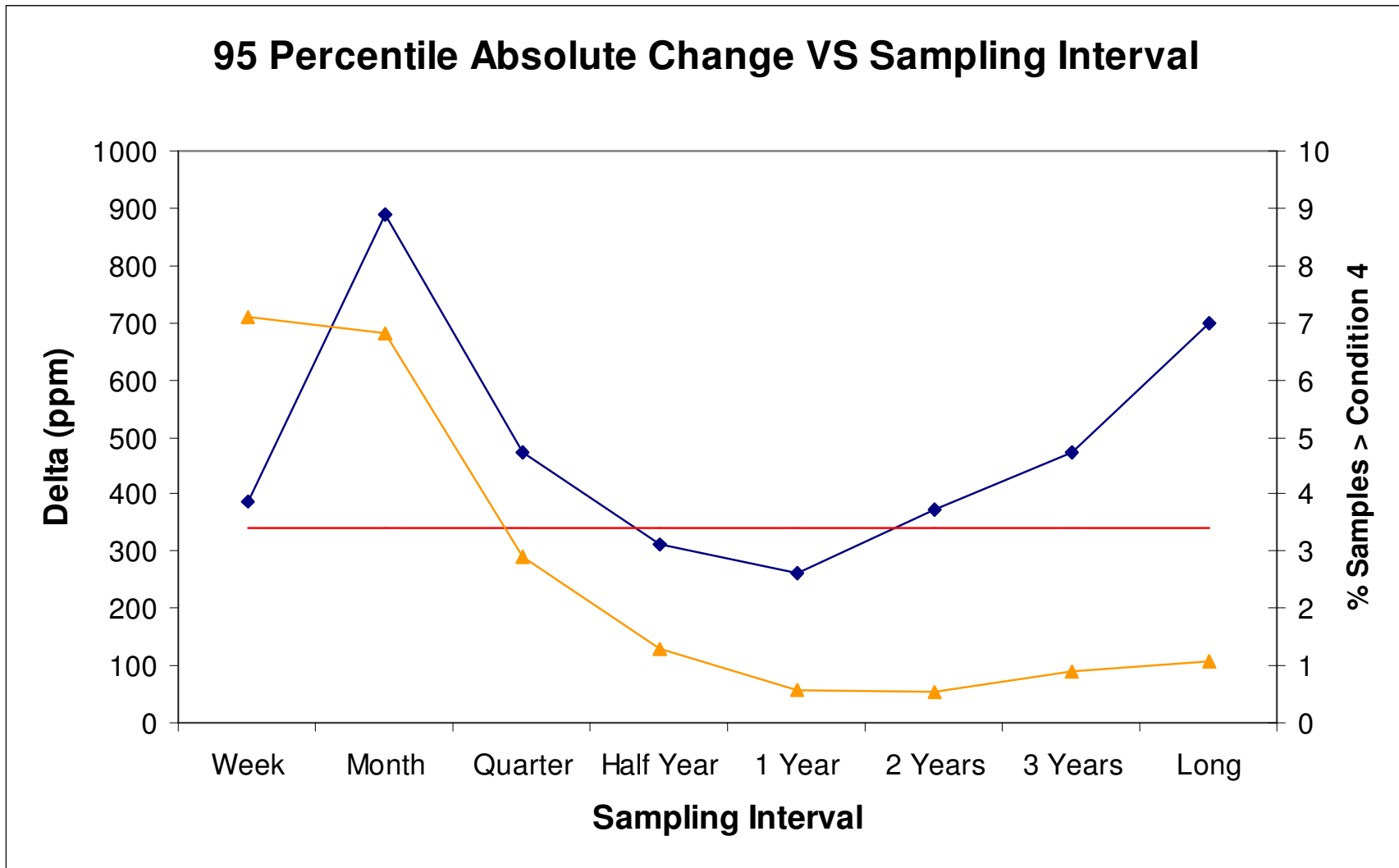


TDCG Absolute Change

TDCG



TDCG Absolute Change



Conclusion

- Use Delta PPM directly without Normalisation (no ppm/day)
- Use 90 or 95 Percentile of the whole population (maybe excluding > cond X ?)
- Determine sampling frequency on actual level ppm value (Similar to actual Table 3)
- Adjust Value per period for CO, CO₂ and maybe for C₂H₆ and TDCG

Conclusion

- A possible table could look like:

Maximum PPM variation between sample			
Period:	<= 1.5 Year	1.5 - 2.5 Years	>= 2.5 Years
H₂	40		
CH₄	25		
C₂H₄	15		
C₂H₂	1		
C₂H₆	15	25	30
CO	200	300	400
CO₂	2000	2500	3000
TDCG	300	400	500

Questions ?

- To Be continued....

