



## **PM<sub>2.5</sub> measurement results with the reference method and Modelling for 2008 in The Netherlands**

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# Status end 2007

- automatic PM2.5 measurements using TEOM
- TEOM: equivalence with reference not shown (presumably difficult)
- several partners (RIVM, GGD Amsterdam, DCMR, provinces) preferred to buy the same instrument
- Careful selection and testing necessary
- Impossible to perform before 1/1/2008
  
- however new directive requires starting at 1/1/2008
- Results shall be comparable until 2020 in order to demonstrate 15-20% reductions

# Status end 2007

Conclusion: Quality requirements can not be met within this period of time

Decision: Start measurements with the reference method

How to find the necessary equipment/ (weighing) capacity locations ? -> National corporation



# Strategy/ corporation

Area	Owner/ operator	location	type
Aggl. Heerlen	RIVM	Heerlen-Deken Nicolayestraat	Urban background
Zone Zuid	RIVM	Breda-Bastenakenstraat	Urban background
Aggl. Den Haag	RIVM	Den Haag-Rebequestraat	Urban background
Aggl. Rotterdam	RIVM	Rotterdam_Schiedamsevest	Urban background
Zone Noord	RIVM	Groningen-Neijensteinheerd	Urban background
Aggl. Rotterdam	DCMR	Schiedam	Urban background
Zaandam	GGD-Amsterdam	Zaandam	Urban background
Amsterdam	GGD-Amsterdam	Overtoom	Urban background
Zone Zuid	RIVM	Vredepeel	regional
Zone Zuid	Prov. N. Brabant	Fijnaart	regional
Zone Midden	RIVM	Wieringerwerf	regional
Zone Midden	RIVM	Wekerom	regional
Zone Noord	RIVM	Kollumerwaard	regional
Aggl. Rotterdam	RIVM	Rotterdam-Bentinckplein	trafic
Zone Zuid	RIVM	Breda-Tilburgseweg	trafic
Aggl. Heerlen	RIVM	Heerlen-Looijerstraat	trafic
Zone Midden	RIVM	Breukelen	trafic
Aggl. Amsterdam	GGD-Amsterdam	A'dam A10 zuid	trafic

# Measurement strategy

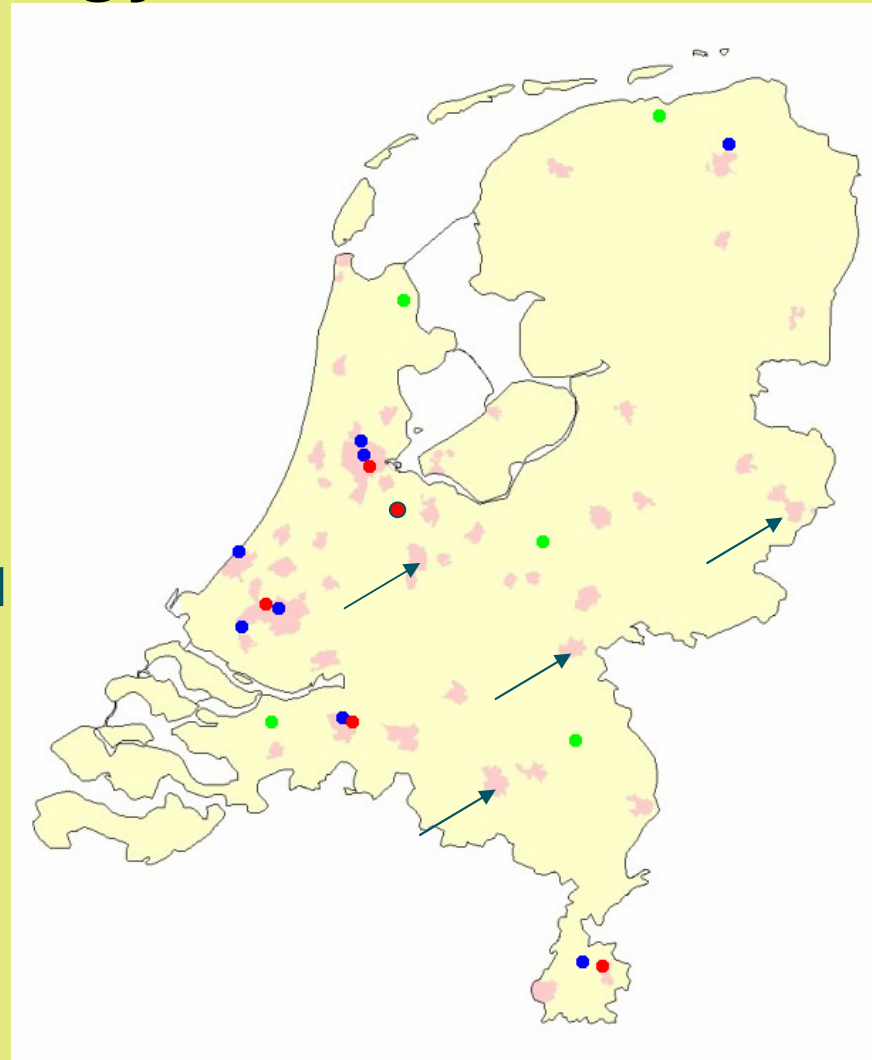
1/1/ 2008

8 urban background

5 traffic

5 regional

In the course of 2008 extended  
with 4 until 12 urban background



# Results

Location	Type	Average 2008	availability			
014 Amsterdam GGD	urban	14.8	82%		14.8	
018 Amsterdam GGD	traffic	16.5	92%			16.5
701 Zaandam GGD	urban	14.3	89%		14.3	
131 Vredepeel	regional	17.5	40%	17.5		
136 Heerlen	traffic	20.1	25%			20.1
137 Heerlen	urban	16.2	93%		16.2	
230 Biest Houtakker	regional	17.2	11%	17.2		
240 Breda	traffic	19.8	8%			19.8
241 Breda	urban	17.6	93%		17.6	
246 Fijnaart	regional	16.4	77%	16.4		
404 Den Haag	urban	17.0	87%		17.0	
418 Rotterdam	urban	17.5	91%		17.5	
433 Vlaardingen	traffic	17.3	65%			17.3
444 De Zilk	regional	14.0	45%	14.0		
448 Rotterdam	traffic	18.3	77%			18.3
10 Schiedam DCMR	urban	15.9	59%		15.9	
538 Wieringerwerf	regional	13.1	22%	13.1		
620 Cabauw	regional	16.3	50%	16.3		
641 Breukelen	traffic	16.1	13%			16.1
738 Wekeron	regional	17.5	17%	17.5		
742 Nijmegen	urban	22.1	10%		22.1	
807 Hellendoorn	regional	14.5	29%	14.5		
934 Kollumerwaard	regional	13.4	27%	13.4		
938 Groningen	urban	18.8	96%		18.8	
				regional	urban	traffic
Average		16.8		15.5	17.1	18.0

# Alternative approach for missing data

Previous approach: result missing data are skipped

Alternative approach : impute missing data by value which is consistent with the level for that day and that location

$$x_{ij} = \bar{x}_i \frac{\bar{x}_{.j}}{\bar{x}}$$

with

$$\bar{x}_i = \frac{\sum_{j=1:k} x_{ij}}{k}, \quad \bar{x}_{.j} = \frac{\sum_{i=1:366} x_{ij}}{366} \text{ en } \bar{\bar{x}} = \frac{\sum_{j=1:k, i=1:366} x_{ij}}{366k}$$

Uncertainty in yearly average is estimated with the assumption that correlation between the uncertainty of daily values may exist

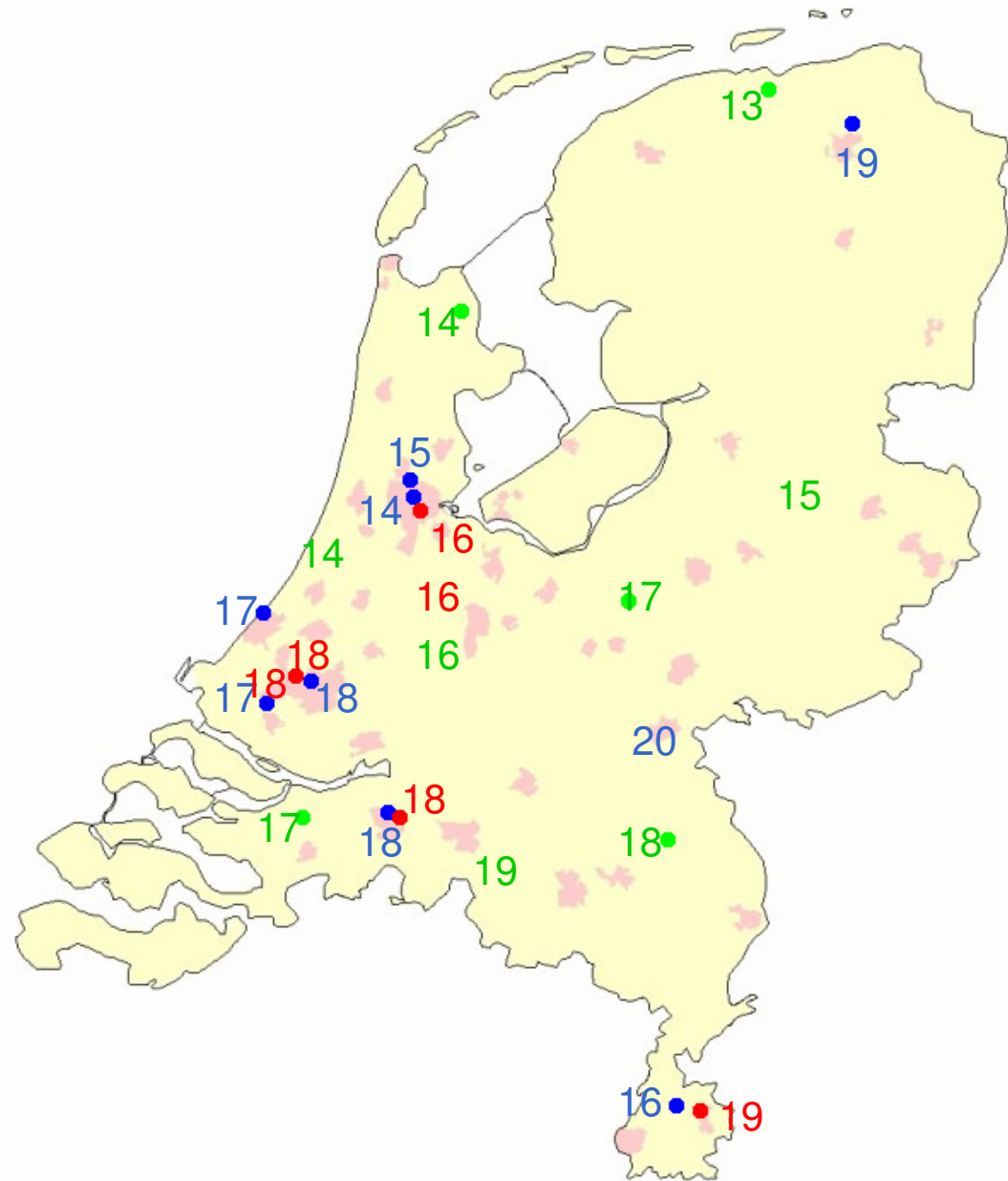
Location	Type	Average		uncertainty on limit (25 µg/m3)	Average (imputing (skipping) )		
		(skipping) )	(imputing)		regional	urban	traffic
014 Amsterdam GGD	urban	14.8	14.5	10%	14.5		
018 Amsterdam GGD	traffic	16.5	16.2	5%			16.2
701 Zaandam GGD	urban	14.3	15.1	5%	15.1		
131 Vredepeel	regional	17.5	18.4	20%	18.4		
136 Heerlen	traffic	20.1	18.5	40%			18.5
137 Heerlen	urban	16.2	16.3	6%	16.3		
230 Biest Houtakker	regional	17.2	18.9	22%	18.9		
240 Breda	traffic	19.8	18.2	35%			18.2
241 Breda	urban	17.6	18.0	5%	18.0		
246 Fijnaart	regional	16.4	16.7	8%	16.7		
404 Den Haag	urban	17.0	17.0	8%	17.0		
418 Rotterdam	urban	17.5	18.2	5%	18.2		
433 Vlaardingen	traffic	17.3	18.3	11%			18.3
444 De Zilk	regional	14.0	13.2	18%	13.2		
448 Rotterdam	traffic	18.3	18.5	7%			18.5
10 Schiedam DCMR	urban	15.9	16.5	9%	16.5		
538 Wieringerwerf	regional	13.1	13.9	23%	13.9		
620 Cabauw	regional	16.3	15.9	19%	15.9		
641 Breukelen	traffic	16.1	17.1	19%			17.1
738 Wekeron	regional	17.5	17.4	23%	17.4		
742 Nijmegen	urban	22.1	20.3	43%			20.3
807 Hellendoorn	regional	14.5	15.1	26%	15.1		
934 Kollumerwaard	regional	13.4	13.2	31%	13.2		
938 Groningen	urban	18.8	18.7	5%			18.7
Average		16.8	16.8		regional 15.9	urban 17.2	traffic 17.8

Average 2008 ( $\mu\text{g}/\text{m}^3$ )

rural  $16 \pm 4$

urban  $17 \pm 3$

traffic  $18 \pm 2$



# Multiple imputation (preliminary results)

- Impute missing values with starting data
  - Model data for first location using the other locations
  - Impute missing data by prediction + random uncertainty
  - Than 2<sup>nd</sup> location etc.
  - After all locations (1 iteration) start again at first location
  - 4 cycles assuming normal distributed model deviations
  - 4 cycles assuming log normal distributed model dev.
  - Continue until cycles mix
- 
- Using extreme starting conditions (f.e. 1 cycle missing data are set at 100 and another at 1).

Location	Type	average multiple imputation	2 stdev on limit (25 µg/m3)	dif with skipping	dif with single imp.
014 Amsterdam GGD	urban	14.6	1%	-0.2	0.1
018 Amsterdam GGD	traffic	16.3	0%	-0.1	0.1
701 Zaandam GGD	urban	14.9	1%	0.7	-0.1
131 Vredepeel	regional	18.3	2%	0.8	-0.1
136 Heerlen	traffic	19.3	3%	-0.8	0.8
137 Heerlen	urban	16.4	1%	0.2	0.1
230 Biest Houtakker	regional	18.0	3%	0.8	-1.0
240 Breda	traffic	19.2	4%	-0.6	1.0
241 Breda	urban	17.8	1%	0.2	-0.2
246 Fijnaart	regional	16.8	1%	0.3	0.0
404 Den Haag	urban	16.6	1%	-0.4	-0.3
418 Rotterdam	urban	18.1	1%	0.5	-0.1
433 Vlaardingen	traffic	17.9	2%	0.6	-0.3
444 De Zilk	regional	13.2	2%	-0.8	0.0
448 Rotterdam	traffic	18.6	1%	0.3	0.1
10 Schiedam DCMR	urban	16.8	2%	0.9	0.2
538 Wieringerwerf	regional	14.2	5%	1.1	0.3
620 Cabauw	regional	16.6	2%	0.3	0.7
641 Breukelen	traffic	17.4	3%	1.3	0.3
738 Wekerom	regional	17.5	4%	0.0	0.1
742 Nijmegen	urban	20.5	6%	-1.6	0.1
807 Hellendoorn	regional	14.6	3%	0.1	-0.5
934 Kollumerwaard	regional	14.4	8%	1.0	1.2
938 Groningen	urban	18.8	1%	-0.1	0.1

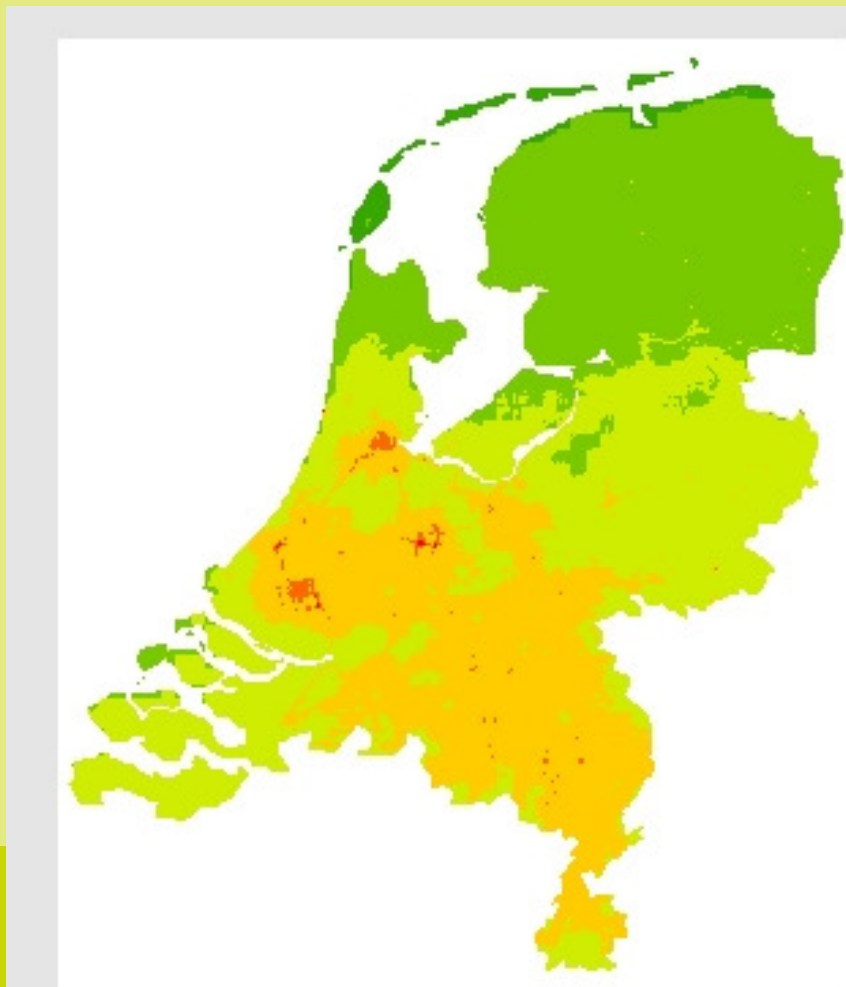
Average		16.9		0.2	0.1
			stdev	0.7	0.5

# Model calculation

Emission data

Dispersion (OPS model)

Calibration on measurements

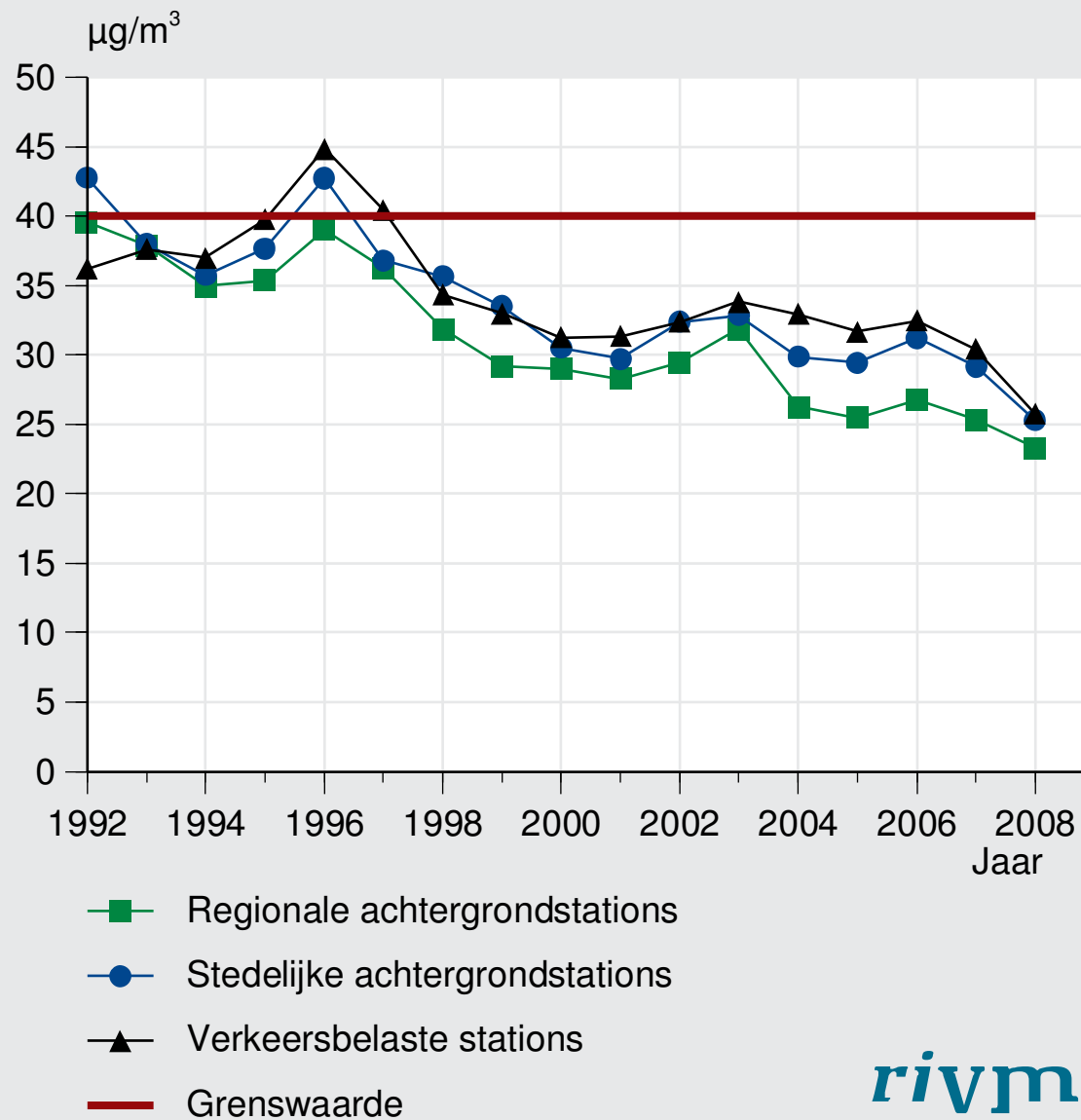


PM2.5 2008



**PM10:  
2008 relatively low**

## Ontwikkeling van de jaargemiddelde concentratie fijn stof



# Comparison with targets

2008

measurement results are all below **25**  $\mu\text{g}/\text{m}^3$  and on other spots exceedences of **25** are unlikely

Some exceedences of **20** are found both in the measurements and in the model calculation

Measured average on 9 urban background locations is **17**  $\mu\text{g}/\text{m}^3$  (and might be close to 18 over 2009-2011 )

(Be aware that PM10 in 2008 was relatively low in The Netherlands)

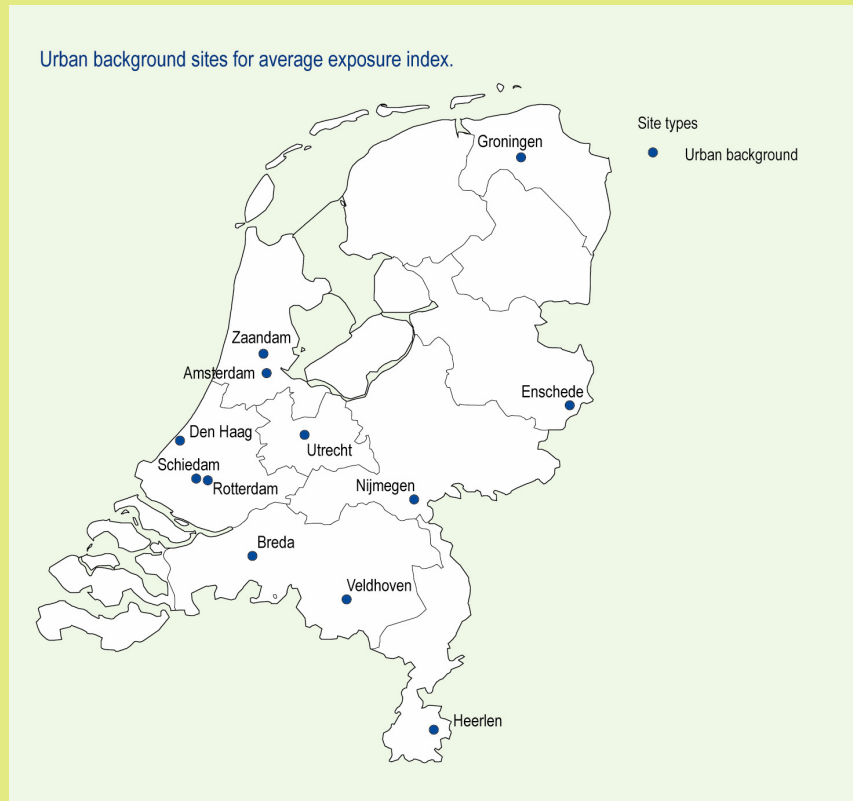
## Strategy ERT

Start = 2009-2010-2011

End = 2018-2019-2020

To do  
currently selection of  
automatic monitor  
measurement strategy for  
automatic monitor

Compared to PM10  
focus measurement strategy even more on quality rather  
than quantity (small local gradients)



# Conclusions

PM2.5 measurements started at 1/1/2008 using reference method on >20 locations

Average results ( $\mu\text{g}/\text{m}^3$ )	rural	$16 \pm 4$
	urban	$17 \pm 3$ and
	traffic	$18 \pm 2$

(based on PM10 -> 2008 may be relatively low)

90 % availability -> loss of most data

Simple imputation works well up to 30-40 % availability

First results with Multiple imputation are promising even for very small data sets

Thanks to colleagues at RIVM, GGD, DCMR and PBL etc.