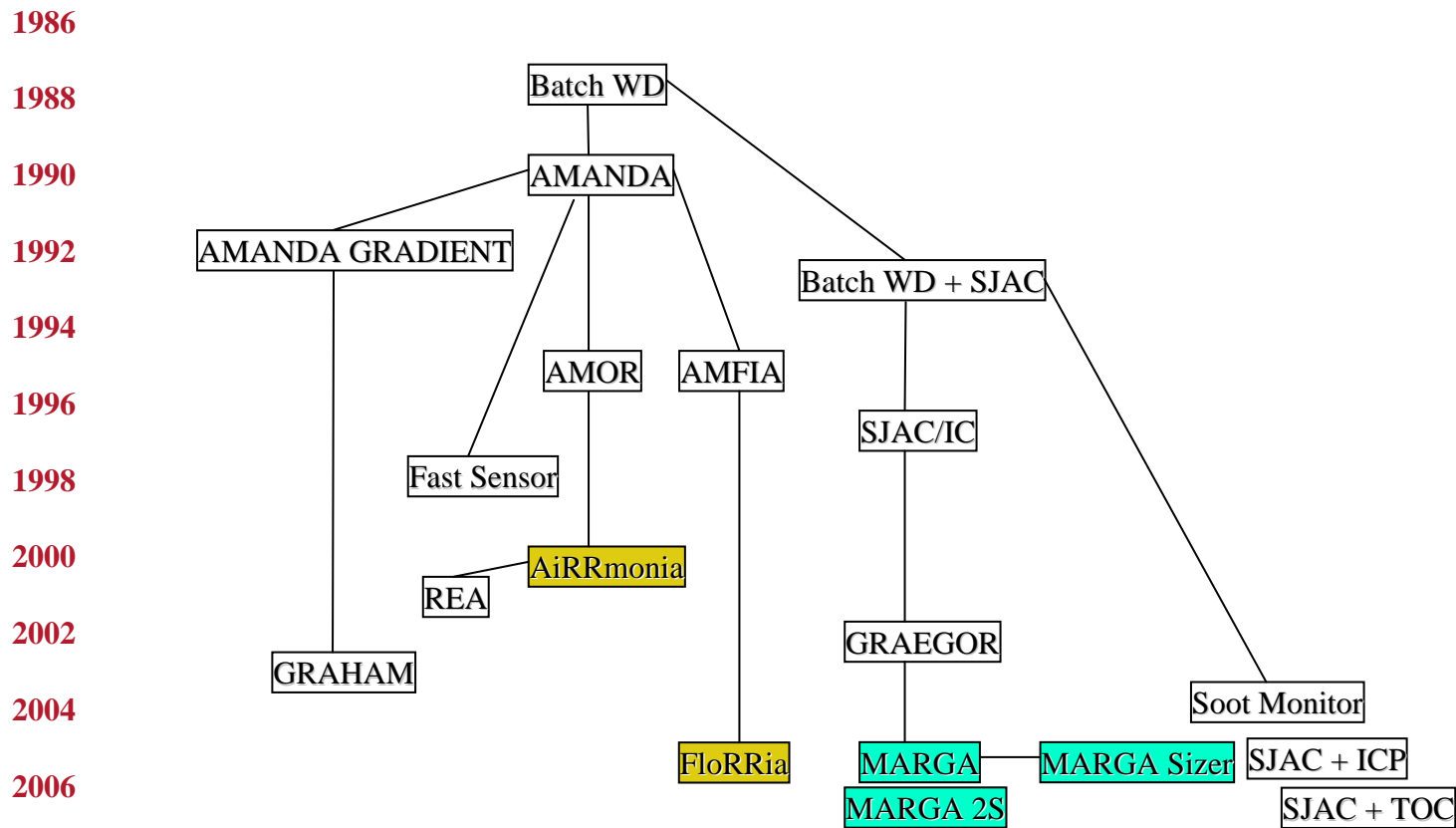


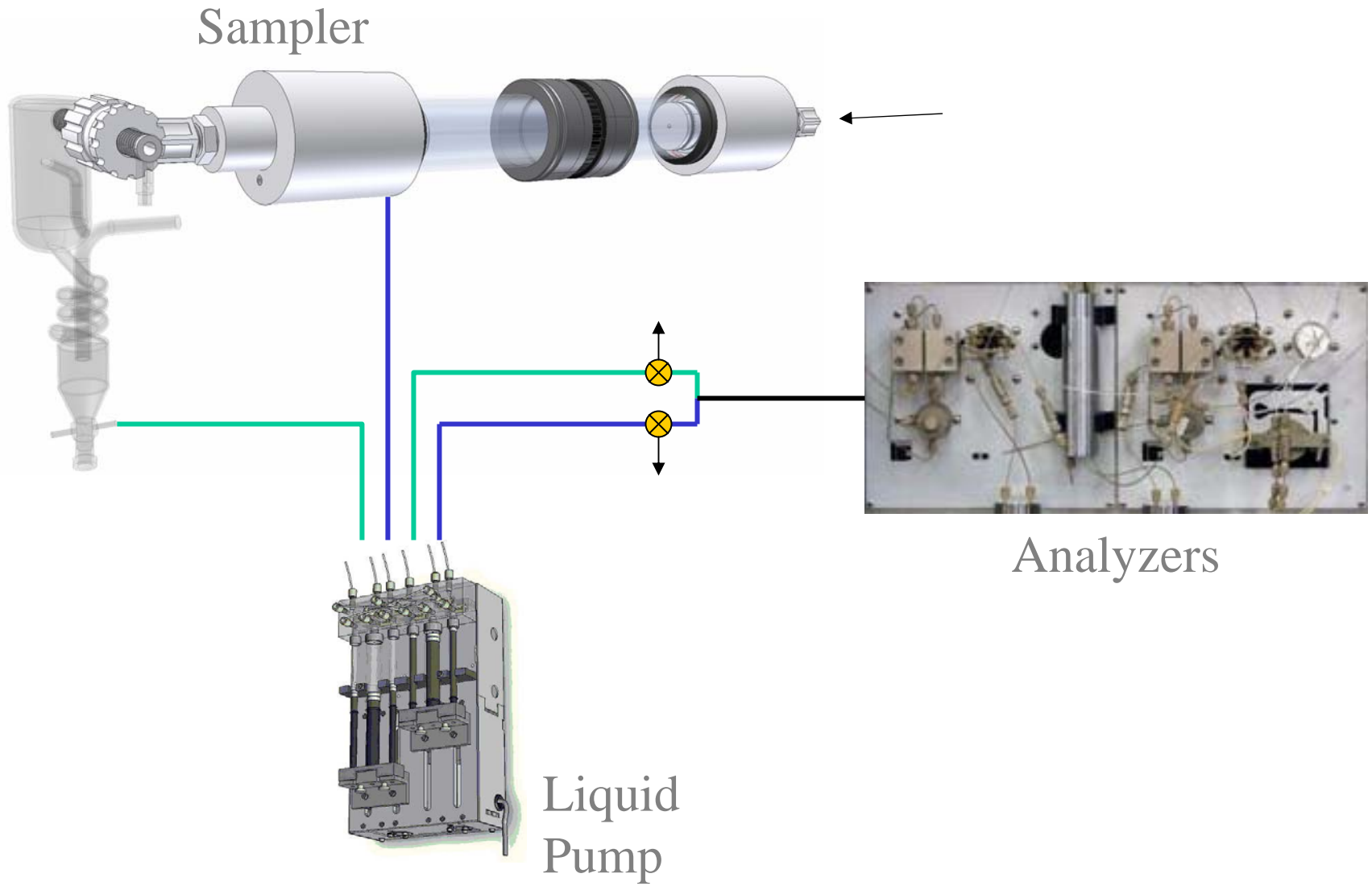
by René Otjes, Netherlands






Content

- Instrument Development at ECN
- GRAHAM – Analyzer for Ammonia gradients
- GRAEGOR – Analyzer for gas and aerosol gradients
- MARGA for CASTNET





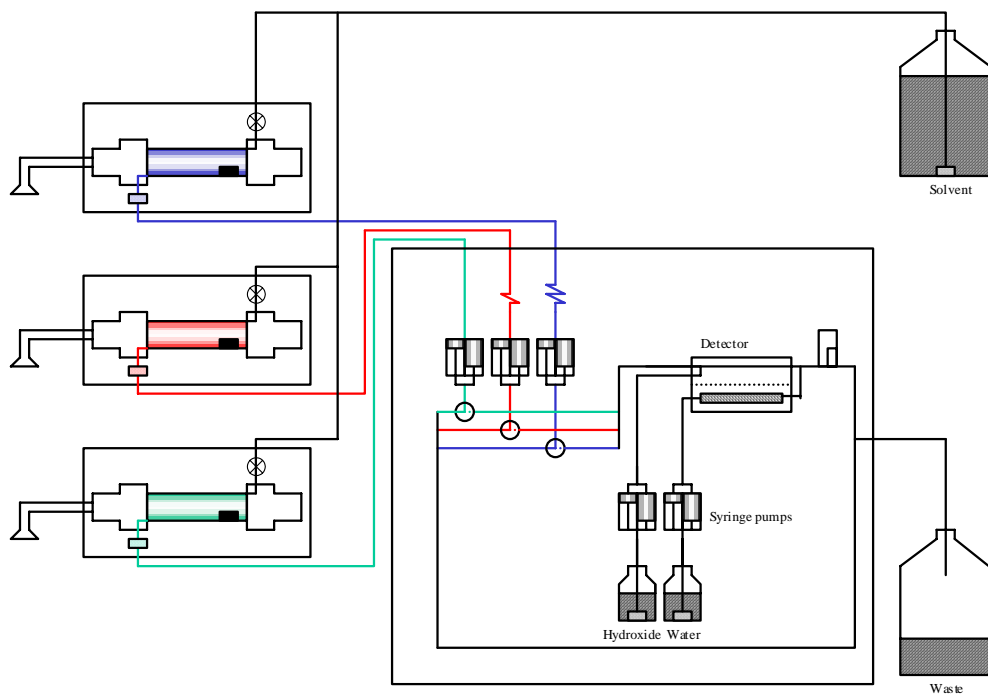
| Sampler | Liq. Pump | Analyzer |
|-----------------------------|---------------------------|---------------------------|
| A Wet Denuder | A Peristaltic Pump | A Sample Exchanger |
| B SJAC | B Syringe Pump | B Anion IC |
| C Wet Denuder + SJAC | C Micropump | C Cation IC |
| D Membrane Sampler | | D NH4 detector |
| E Etched Tube | | E Cuvet Tube |
| F Parallel Moudi | | F TOC analyzer |
| G Sample Exchanger | | G ICP |

| | | |
|---|-----------------|-----------------|
| | Batch WD | AAA |
| | AMANDA | AAD |
| | Batch WD + SJAC | ABAA |
| | SJAC/IC | ABAB |
| | Soot Monitor | BBE |
| | SJAC + ICP | BAG |
| | SJAC + TOC | ABBF |
|  | AMANDA GRADIENT | 3AAD |
|  | GRAHAM | 3A2BD |
| | REA | 2DAD |
| | GRAEGOR | 2A2B3BBD |
| | Fast Sensor | EAD |
| | MARGA 2S | 2A2B2BBC |
| | MARGA Sizer | FABBBC |
| | AMOR | AAD |
| | Amina | DCD |
| | AMFIA | GAD |
| | FloRRia | GAD |
| | AiRRmonia | DBD |
|  | MARGA | ABBBC |

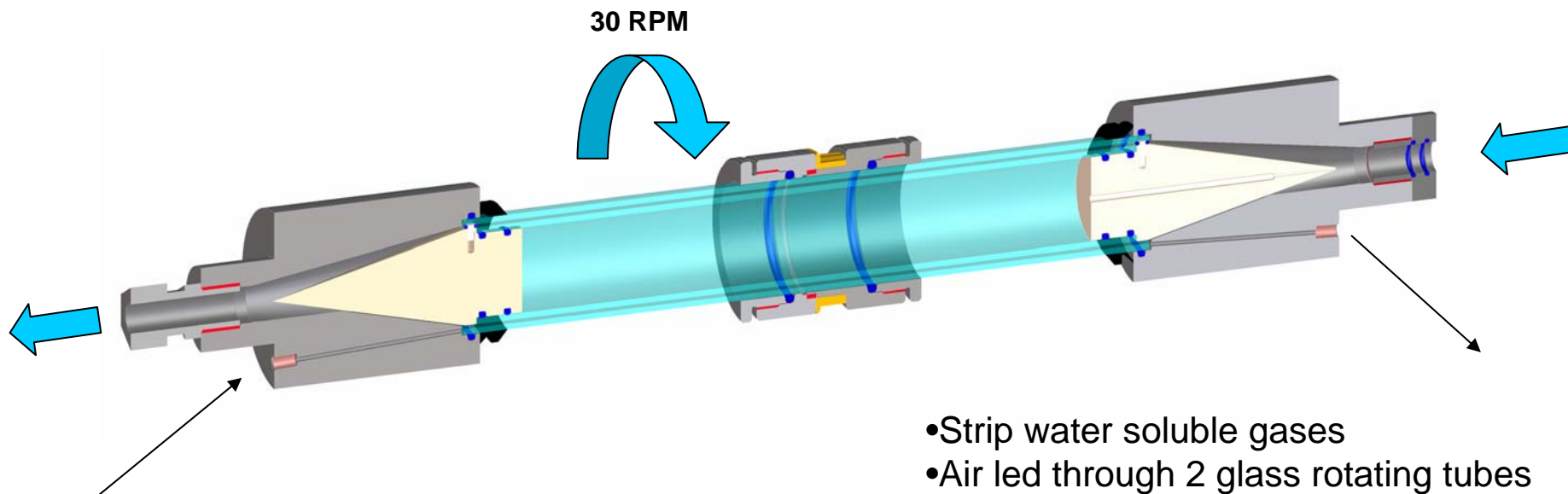


Our construction team

Vertical Gradient Analyzer for NH₃

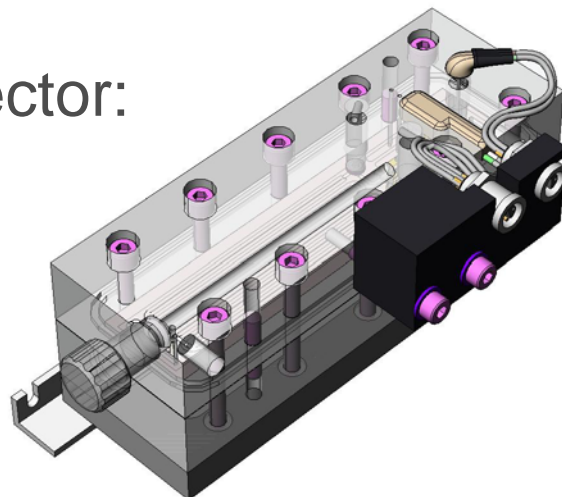


For the best precision 3 sampling boxes are connected to one detector. To minimize systematic deviation.

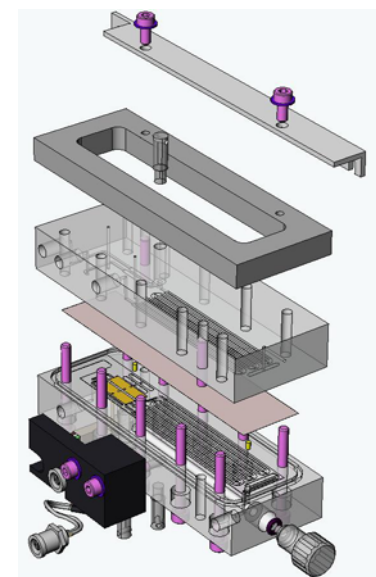


- Strip water soluble gases
- Air led through 2 glass rotating tubes
- Absorption solution in annulus
- Aerosols pass due to laminar flow

NH₄ detector:



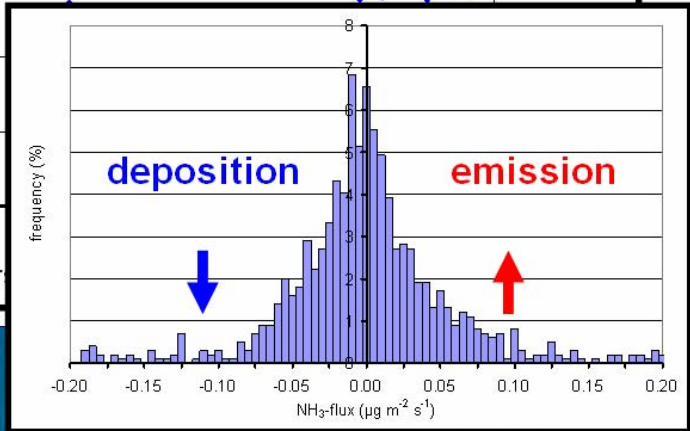
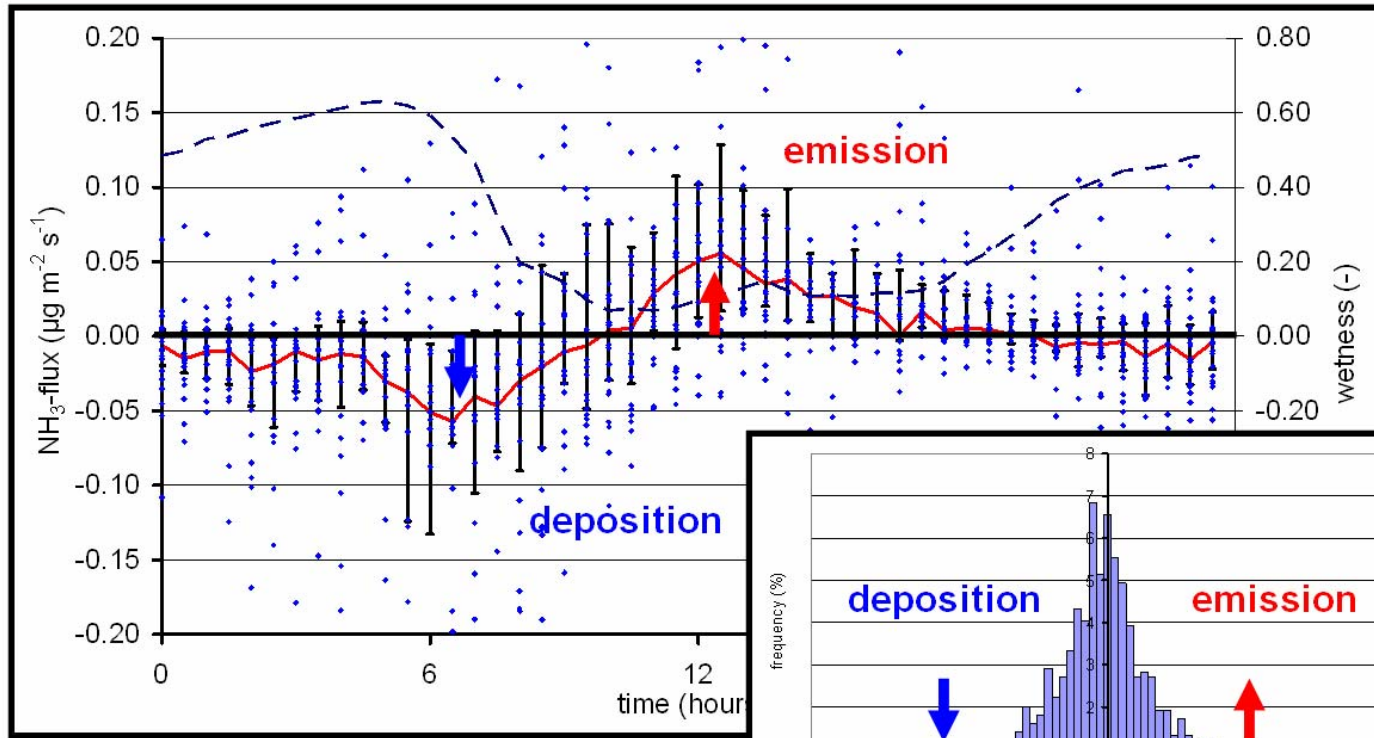
Detection by conductivity
after membrane permeation



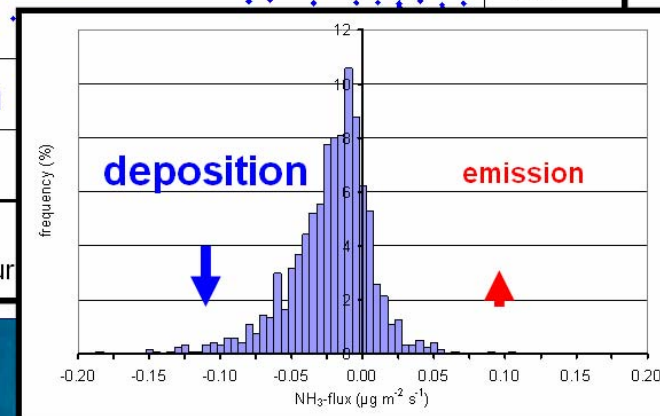
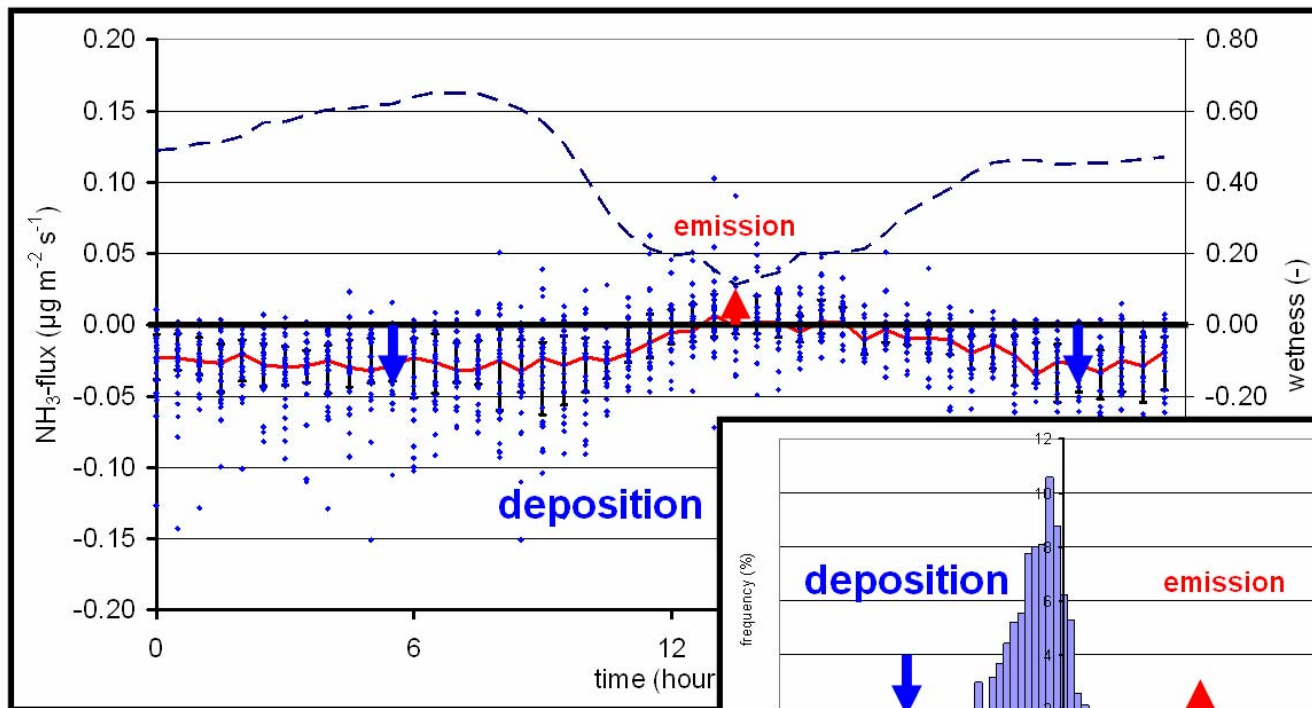


In order to correct for residual systematic deviation a reference pipe is used.

Flux measurements summer period



Flux measurements autumn period



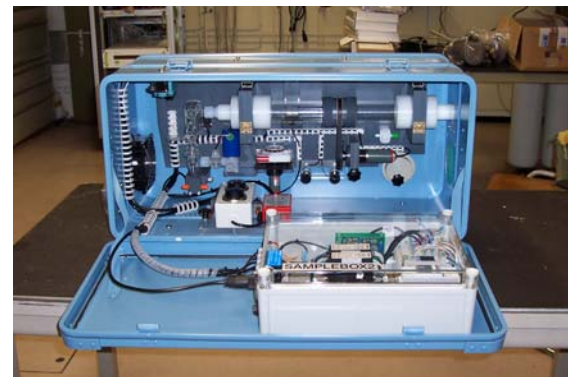
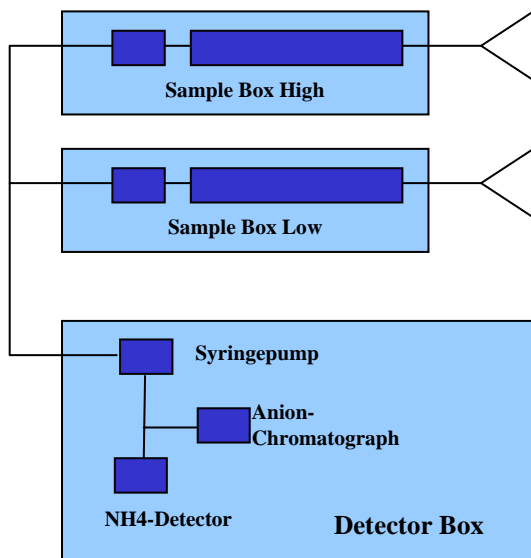
WAGENINGEN UR
For quality of life

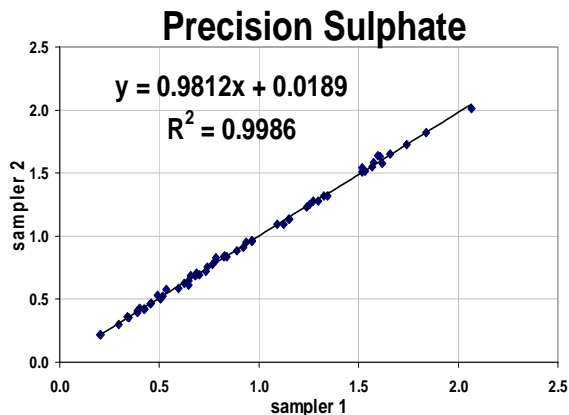
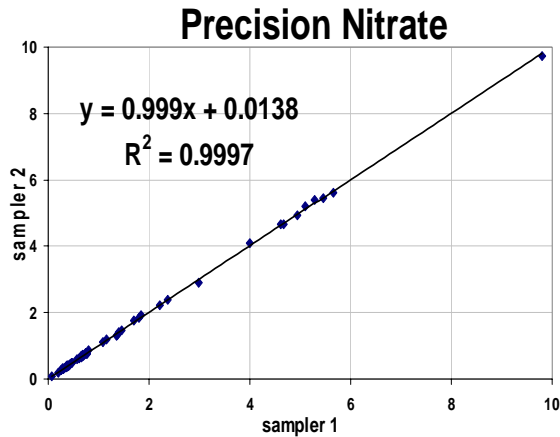
voor Volksgezondheid
en Milieu

GRadient of AErosol and Gas - Online Registrator

Gases: NH_3 , HNO_3 , HCl , HONO , SO_2

Aerosol: NH_4^+ , NO_3^- , Cl^- , NO_2^- , SO_4^{2-}





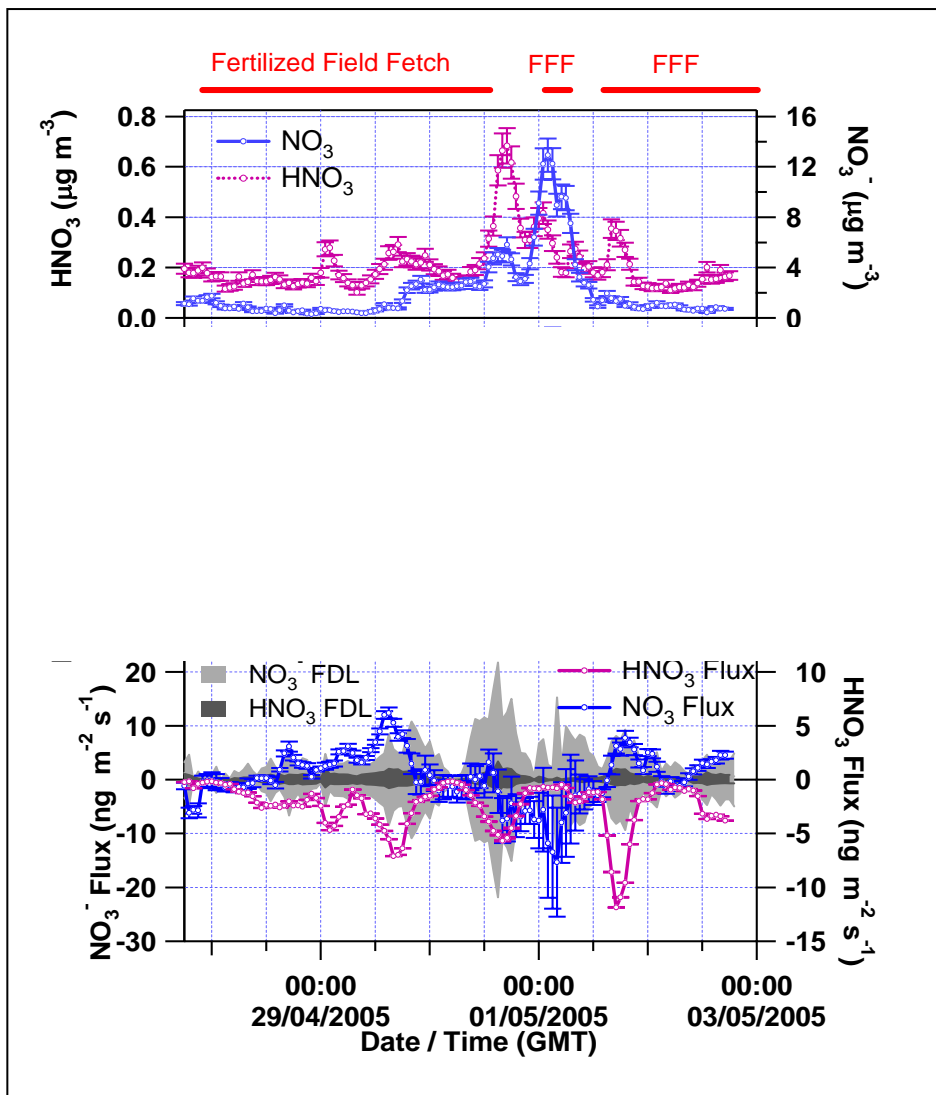
Precision

| | <1% ppb | <2% ppb | <3% ppb | <4% ppb | <5% ppb | Systematic Deviation ppb |
|----------------|------------|------------|------------|------------|------------|--------------------------------|
| Aerosol | | | | | | |
| Ammonium | 8 - 4 | 4 - 2 | 2 - 1 | 1 - 0.5 | | -0,07 |
| Nitrate | 10 - 2 | 2 - 0.3 | | | | -0,01 |
| Sulphate | 2 - 1 | 1 - 0.3 | | | | -0,002 |
| Chloride | | 0.8 - 0.3 | 0.3 - 0.1 | | | 0,01 |

Gas

| | | | | | | |
|-------------------|--|-----------|-----------|------------|---------|-------|
| Ammonia | | | 4 - 1 | | | 0,04 |
| Nitric Acid | | | 0.6 - 0.2 | | | 0,01 |
| Nitrous Acid | | 0.7 - 0.3 | 0.3 - 0.2 | 0.2 - 0.05 | | 0,002 |
| Sulpherdioxide | | 4 - 2.5 | 2.5 - 2 | 2 - 1.5 | 1.5 - 1 | 0,05 |
| Hydrochloric Acid | | | 4 - 3 | 3 - 1 | 1 - 0.2 | -0,04 |

based on 65 data points



Measurements at GRAEGOR campaign in Scotland.

MARGA - Monitoring Instrument for AeRosols and GAses



Gases

NH_3

SO_2

HCl

HNO_3

HONO

PM

NH_4

SO_4

Cl

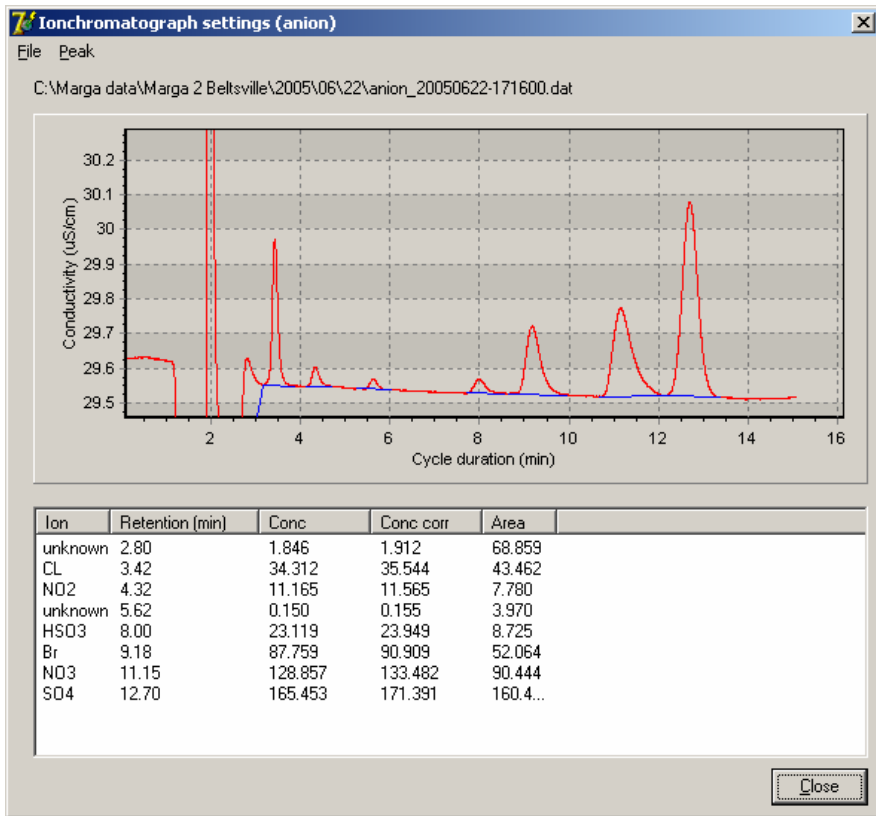
NO_3

Na

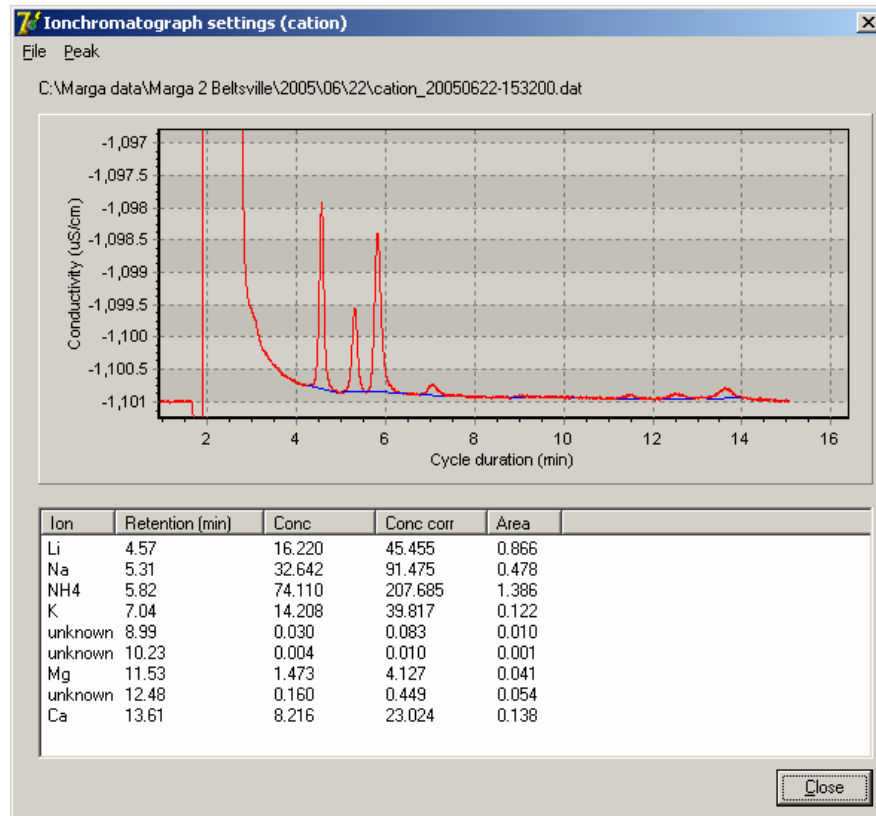
K

Mg(d)

Ca(d)



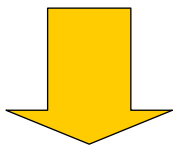
Typical anion chromatogram for a gasphase sample



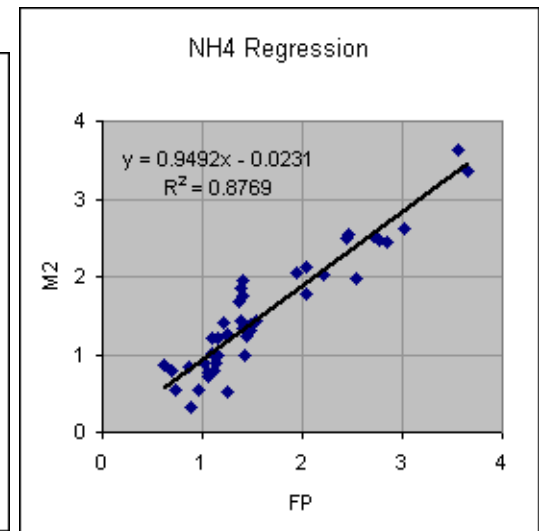
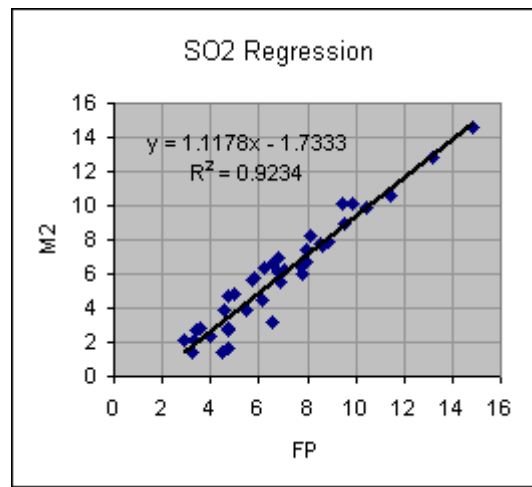
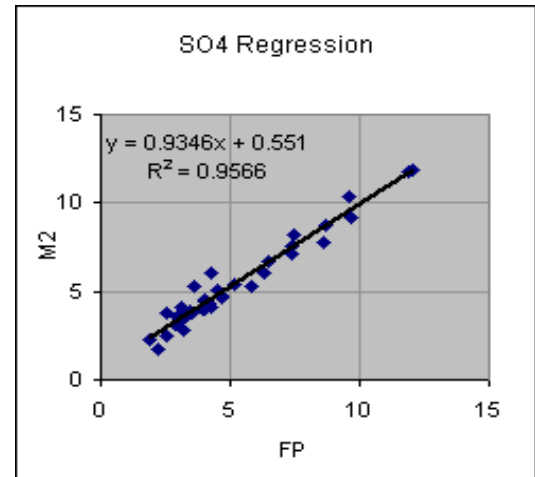
Typical cation chromatogram for an aerosol sample

A standard solution of LiBr is added is for QA purposes

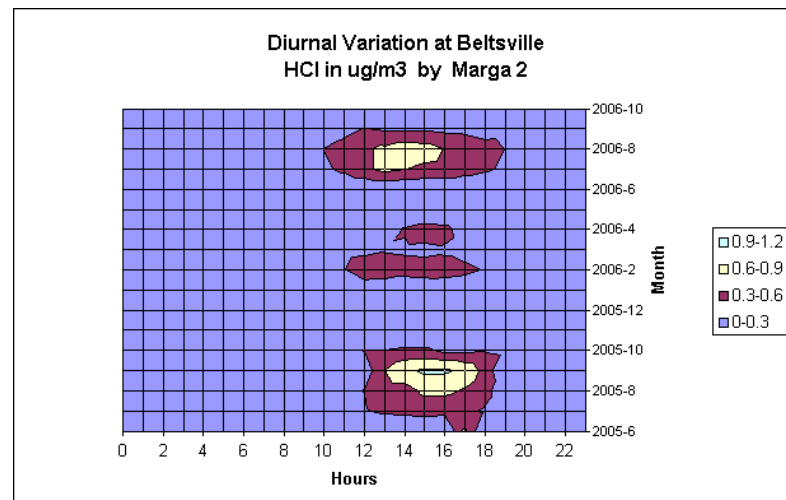
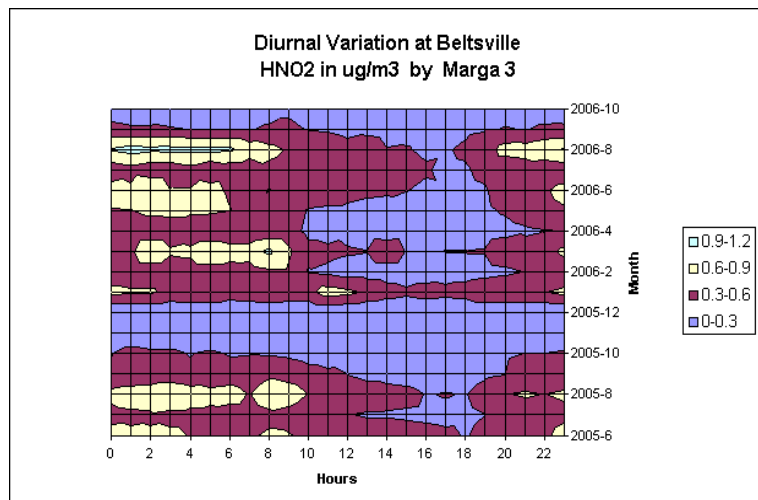
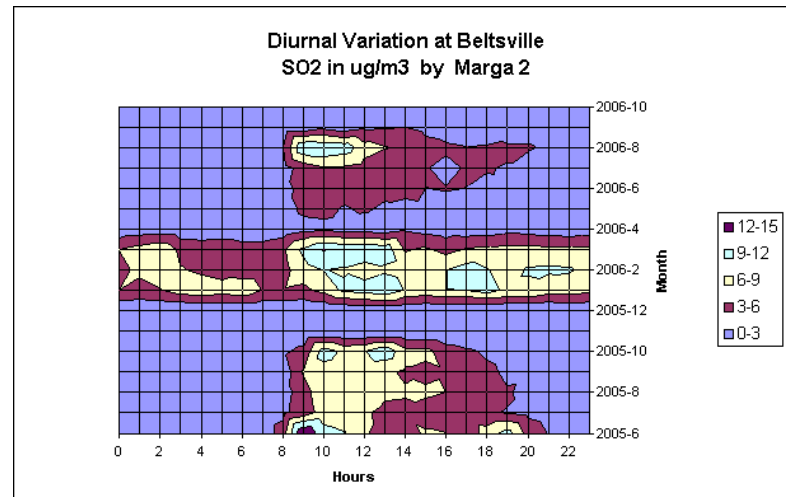
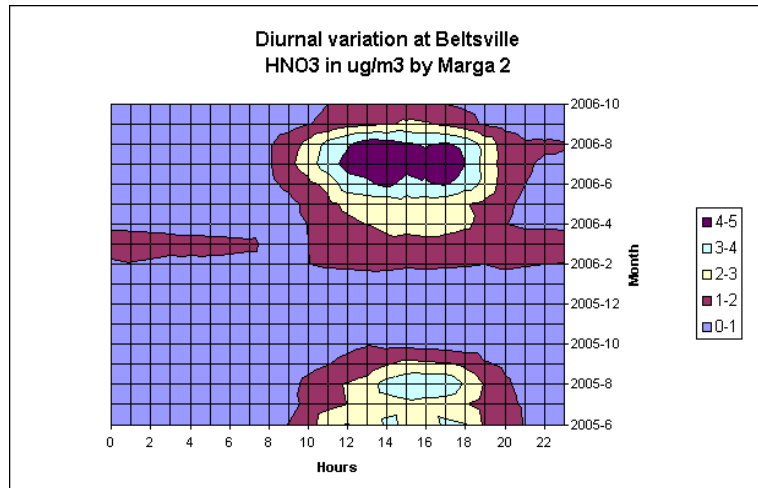
2 Marga's were deployed in Beltsville for 16 months



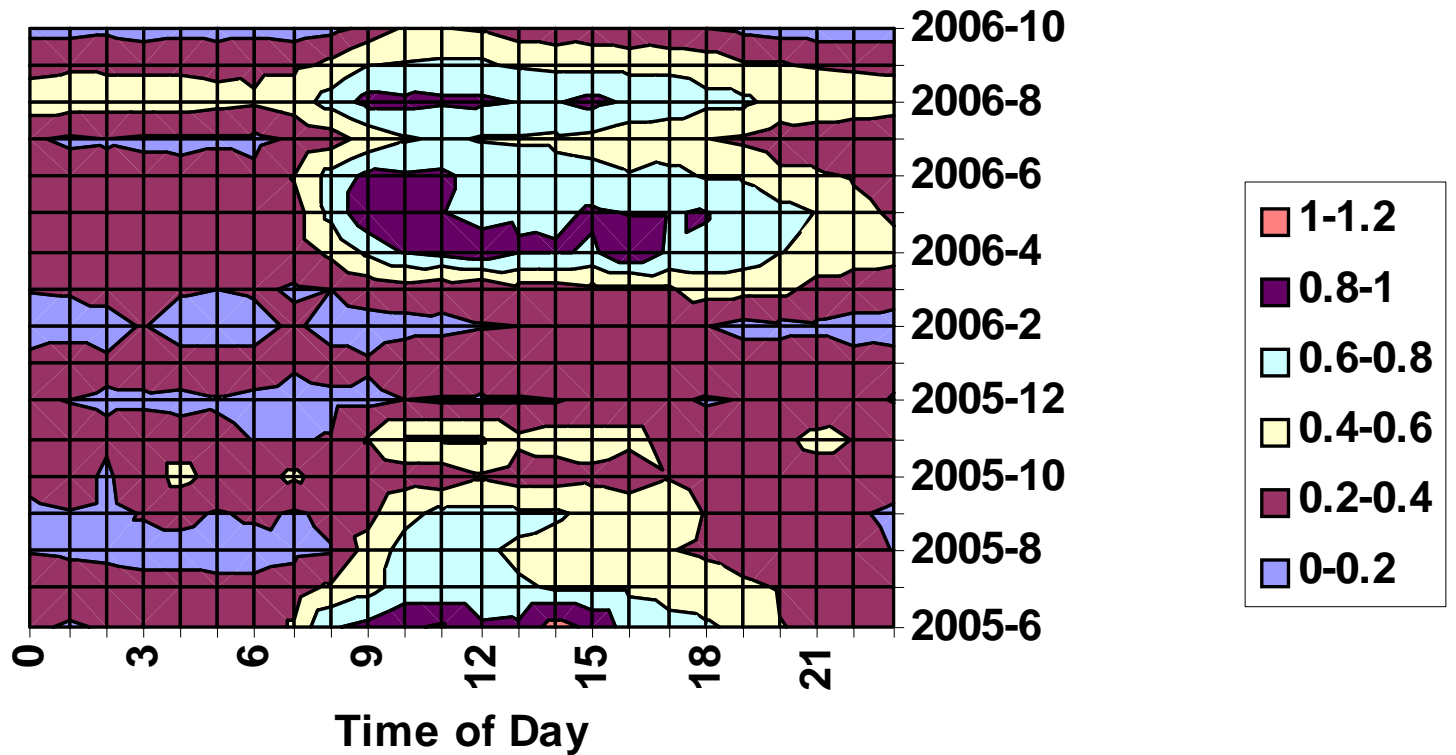
| |
|---------------------|
| Teflon |
| Nylon |
| Impregnated Whatman |

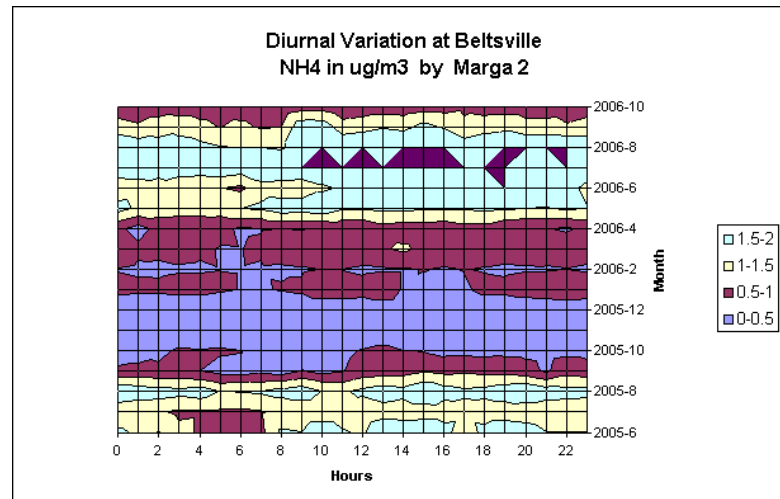
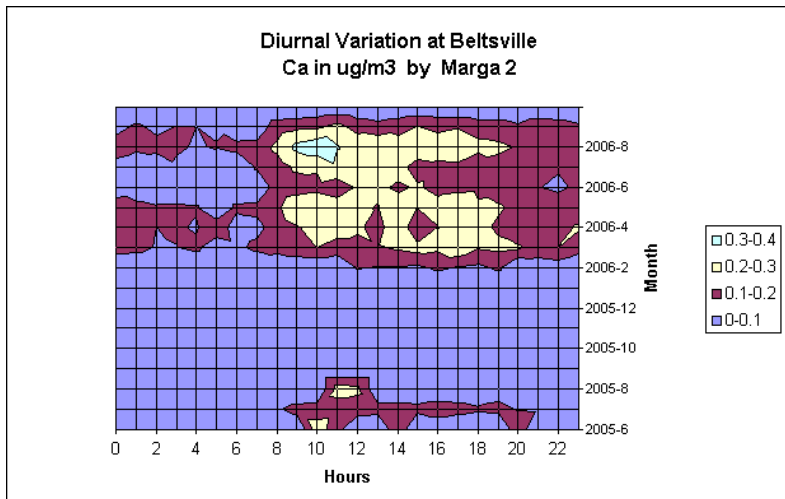
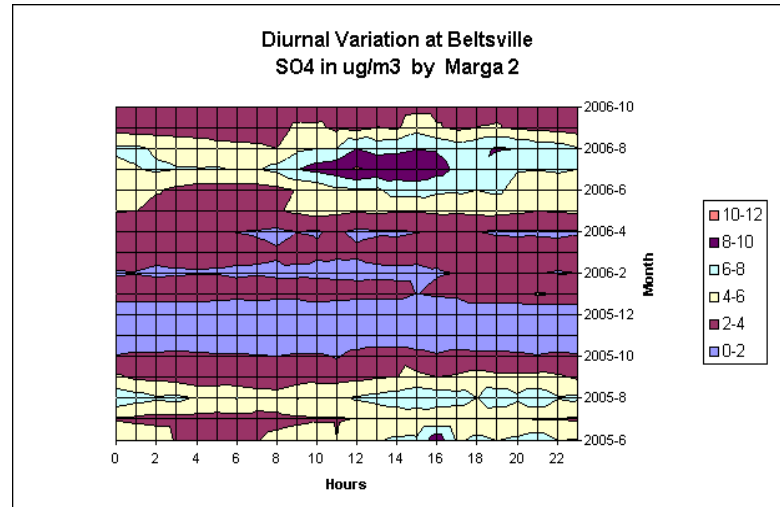
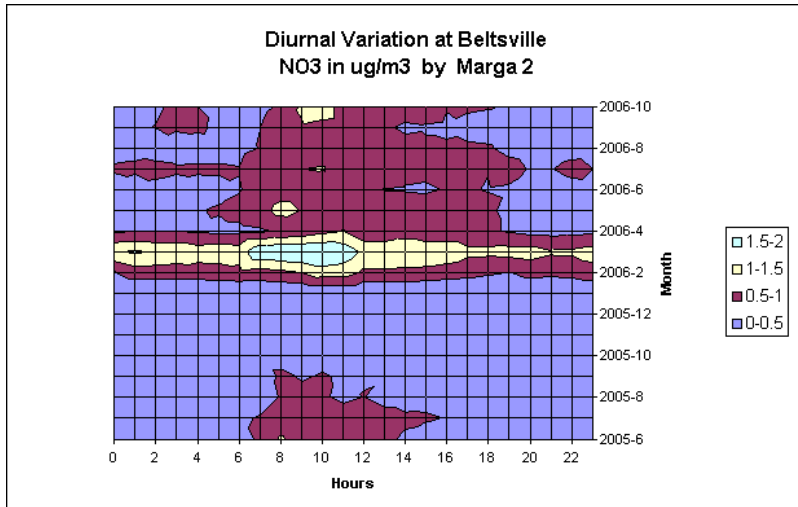


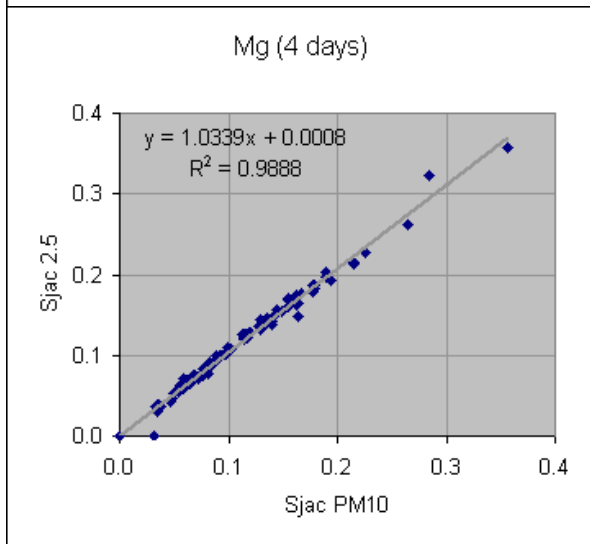
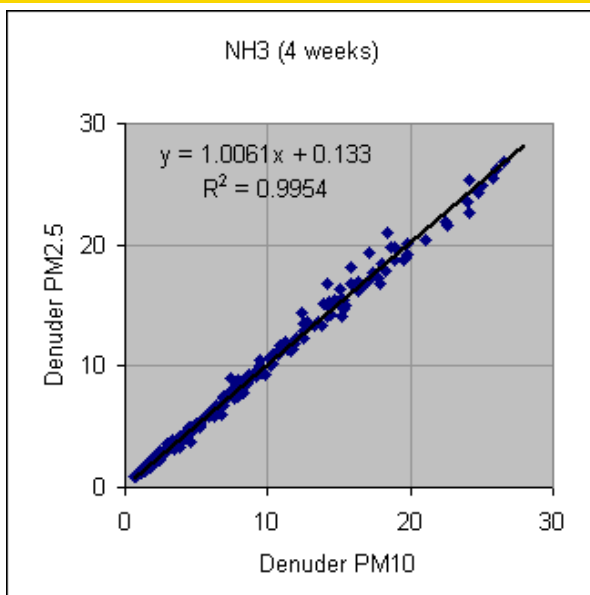
Median concentration per hour of the day per month



NH₃ in ug/m³ by MARGA at Washington DC







- Comparing 2 samplinx boxes with ambient air
- Use of concentrator columns to improve sensitivity by factor of 10
- Ment to compare PM10 and PM 2.5
- Mind the max concentration

| | Regr Coeff | R ² | Max conc |
|------------------|------------|----------------|----------|
| Cl | 1.00 | 0.995 | 5 |
| NO ₃ | 0.99 | 0.998 | 6 |
| SO ₄ | 1.04 | 0.978 | 2 |
| NH ₄ | 0.99 | 0.994 | 2 |
| Na | 0.99 | 0.992 | 2 |
| K | 0.97 | 0.76 | 0.2 |
| Mg | 1.03 | 0.989 | 0.4 |
| Ca | 1.02 | 0.81 | 0.2 |
| | | | |
| HNO ₃ | 0.98 | 0.75 | 0.4 |
| HNO ₂ | 1.00 | 0.993 | 3 |
| NH ₃ | 1.01 | 0.995 | 28 |
| SO ₂ | 0.95 | 0.994 | 8 |
| HCl | 0.92 | 0.35 | 0.4 |

Special thanks to

- RIVM for their GRAHAM data and figures
- CEH, MPI for their GRAEGOR data and figures
- CASTNET, Applikon for their MARGA data and figures

And to you for your attention