An assessment of the applicability of ambient NH_3 instrumentation under field conditions

M.M. Twigg[1], M. Anderson[1], S. Berkhout[2], N. Cowan[1], S. Crunaire[3], E. Dammers[4], V. Gaudion[3], V. Gros[5], M. Haaima[2], C. Häni[6], L. John[7], M. R. Jones[1], B. Kamps[8], J. Kentisbeer[1], T. Kupper[6], S. R. Leeson[1], D. Leuenberger[9], N.Luettschwager[10], U. Makkonen[11], N. Martin[12], D. Missler[13], D. Mounsor[7], A. Neftel[14], C. Nelson[15], R. Oudwater[15], J-E. Petit[13] N. Redon[3], J. Sintermann[16], A. Stephens[1], R. Zijlmans[8] and C. F. Braban[1]

[1] NERC Centre Ecology and Hydrology, United Kingdom
[2] National Institute for public health and the environment (RIVM), Netherlands
[3] Mines Douai, SAGE, France
[4] VU University Amsterdam
[5] Laboratoire des Sciences du Climat et de l'Environnement, France
[6] Bern university of applied sciences, Switzerland
[7] Environnemental Technologies Ltd, UK
[8] LSE monitors BV, The Netherlands
[9] Federal Institute of Metrology (METAS), Switzerland
[10] PTB, Germany
[11] Finnish Meteorological Institute, Finland
[12] National Physical laboratory, UK
[13] Air Lorraine, France
[14] Neftel Research Expertise, Switzerland
[15] Tiger Optics, USA
[16] FOEN Office of Waste, Water, Energy and Air; Switzerland

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MetNH3

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Study aim:

Produce a series of recommendations for the best practices of the measurement of ambient NH_3 under field conditions.

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Why recommendations required?

- Global emissions expected to increase from 65 Tg N yr^{-1} (1990) to 135 Tg N yr^{-1} (2100)[a]
- Essential ambient NH_3 is monitored:
  - uncertainties in the predicted emissions
  - impact on the environment and human health

EMEP-EEA air pollutant emission inventory guidebook – 2013, Part A, Chapter 5, Table 3-3

NFR	SOURCE CATEGORY	SO2	NH3
1.A.1	Public power, cogeneration and district heating	A	
1.A.2	Industrial combustion	A	
1.A.3.b	Road transport	C	E
1.A.3.a 1.A.3.c 1.A.3.d 1.A.3.e	Other mobile sources and machinery	C	
1.A.4	Commercial, institutional and residential combustion	B	
1.B	Extraction and distribution of fossil fuels	C	
2	Industrial processes	B	E
3	Solvent use		
4	Agriculture activities		D
6	Waste treatment	B	
6	Disposal activities	C	E
-	Nature	D	E

D: 100 to 300 %
E: order of magnitude

[a]Fowler *et al. 2015 ACP.*

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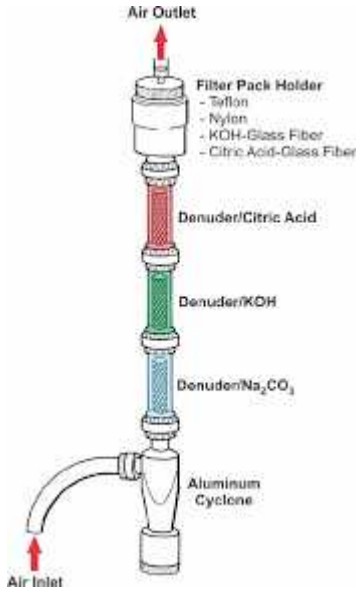
Why recommendations required?

- Both in the European Monitoring and Evaluation Program (EMEP) and the US EPA:
  - Reference methods written in 1996 and 1999, respectively.
  - Methods are labour intensive
  - Requires specialist knowledge

- Great advancements in technology in the last 20 years

- Now a number of commercial instruments available measuring to ppt range and no longer (*in theory*) require specialised operators

Annular denuder system



Images taken from URG annular denuder system

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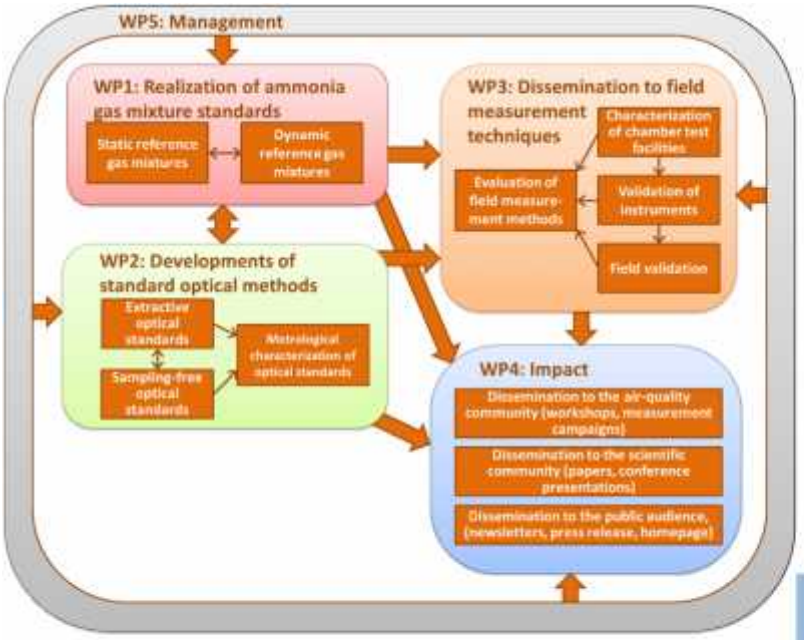
Metrology for NH_3 in ambient air

- 1st June 2014: metrology for NH_3 in ambient air ($MetNH_3$) project started
- Project aim:

  Developing metrological traceability for the measurement of NH_3 in air from primary gas mixtures and instrumental standards to field application



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MetNH3

EMRP
European Metrology Research Programme
Programme of EURAMET

The EMRP is jointly funded by the EMRP participating countries within EURAMET and the European Union

METAS

DFM
Danish National Metrology Institute

VSL
Dutch Metrology Institute

PTB
Physikalisch-Technische Bundesanstalt
Braunschweig und Berlin

Umwelt Bundesamt

NPL
National Physical Laboratory

VTT
MIKES METROLOGY

BAM
Federal Institute for Materials Research and Testing

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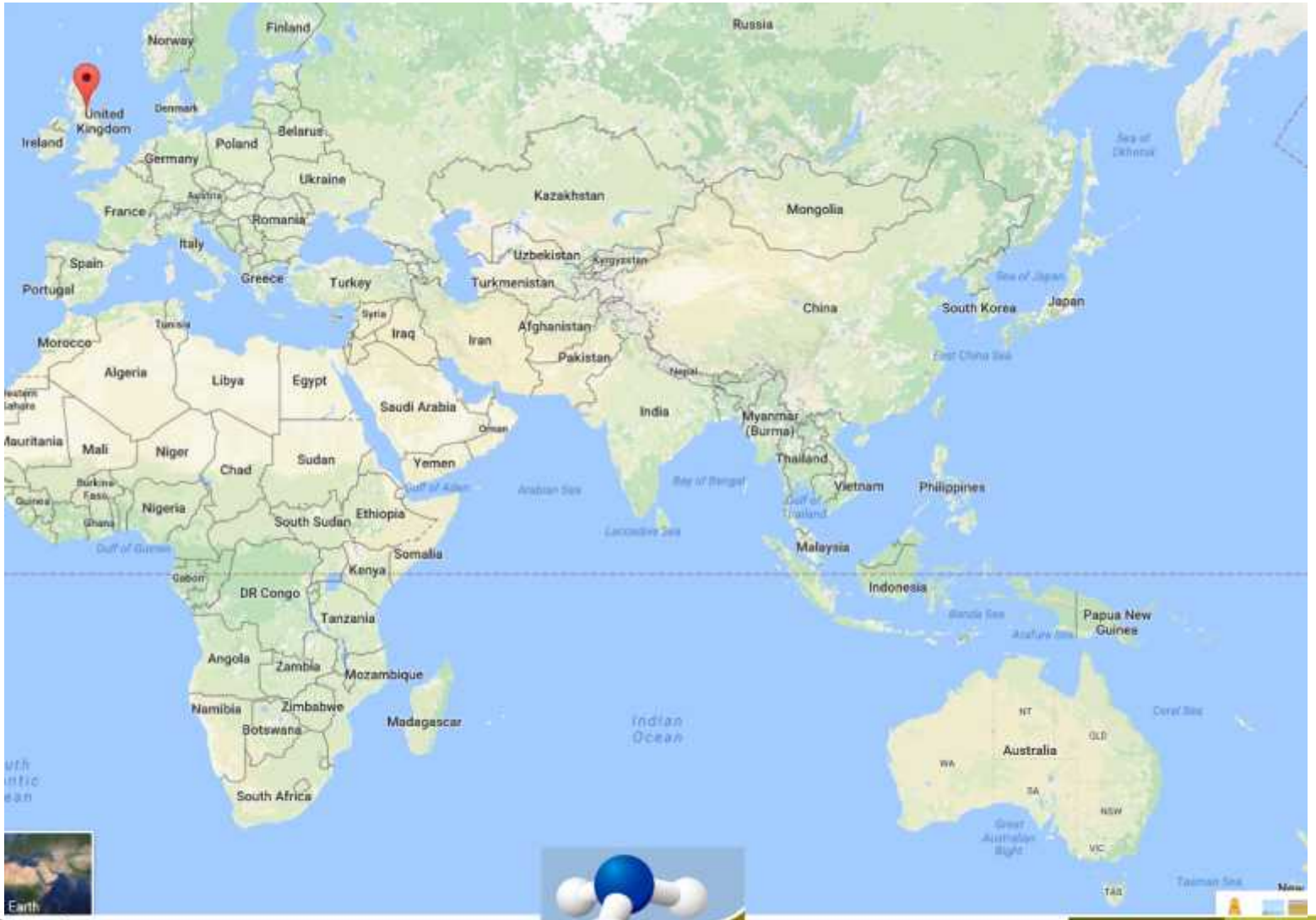
Field site description



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Field site description

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Instrumentation

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Instrumentation

Instrumentation

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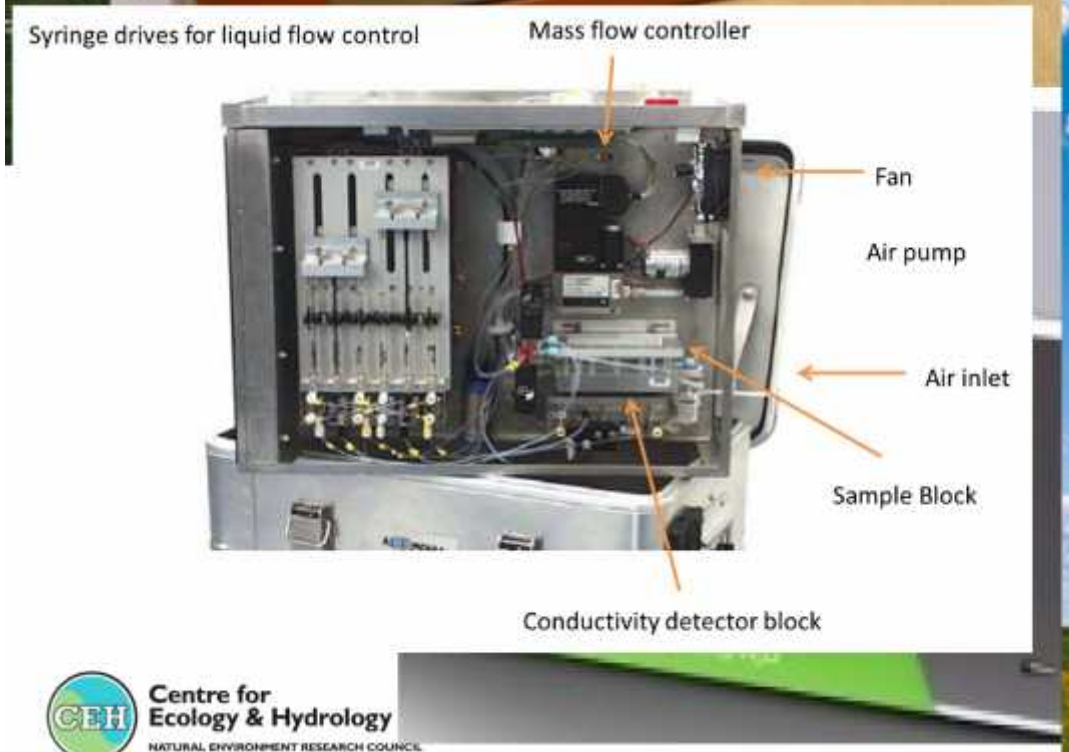

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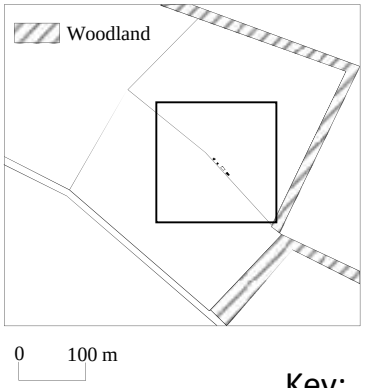
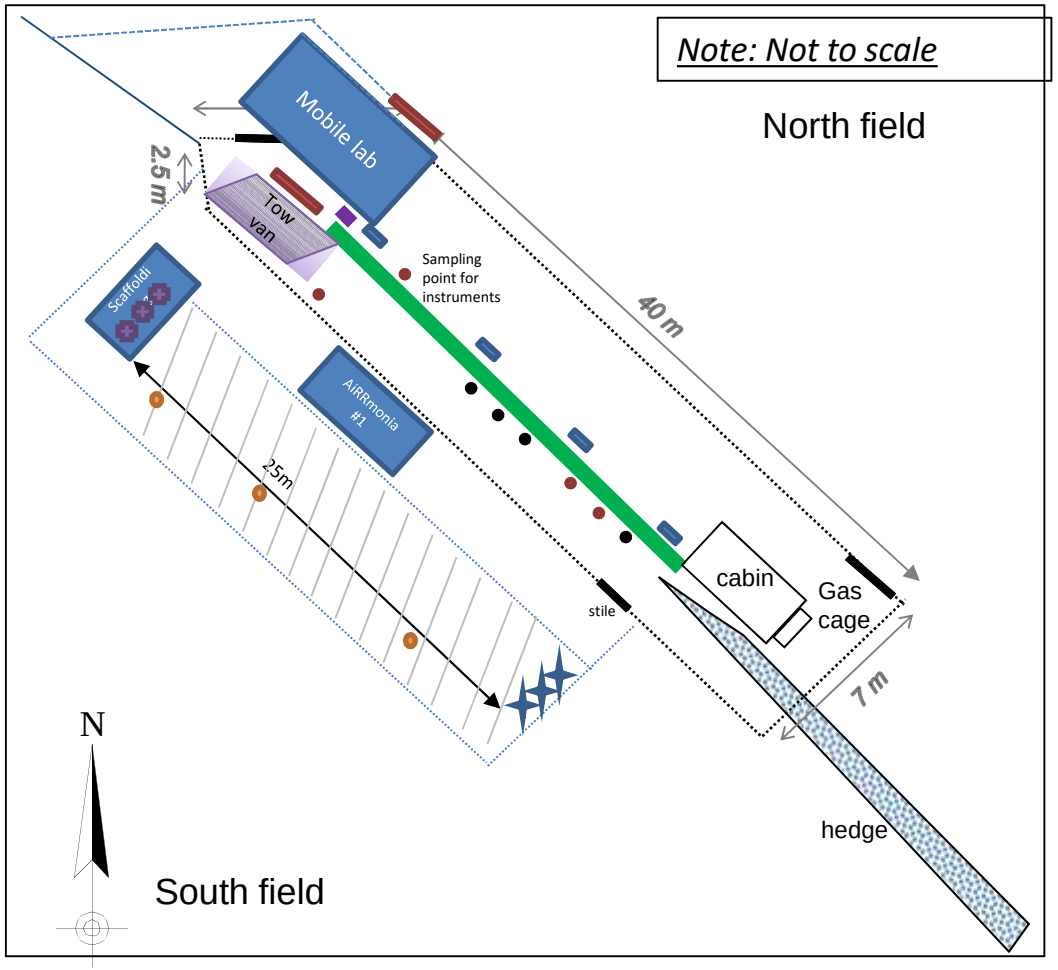
Field site Description: Layout



Key:

- Mast/mast base (black-available, red in use)
- 2 x 240V sockets (13 Amp)
- Conduit for cables from/to cabin
- 2 commando sockets (240 V, 16 Amp)
- Temporary fencing
- Mini DOAS reflectors
- Pump box
- Passive NH_3 samplers

Approximate sampling height 1.7 m



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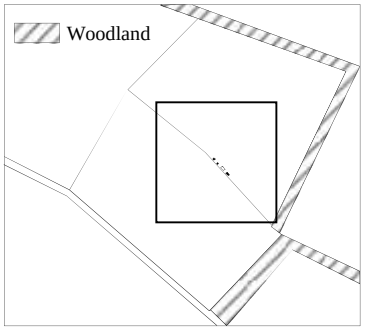

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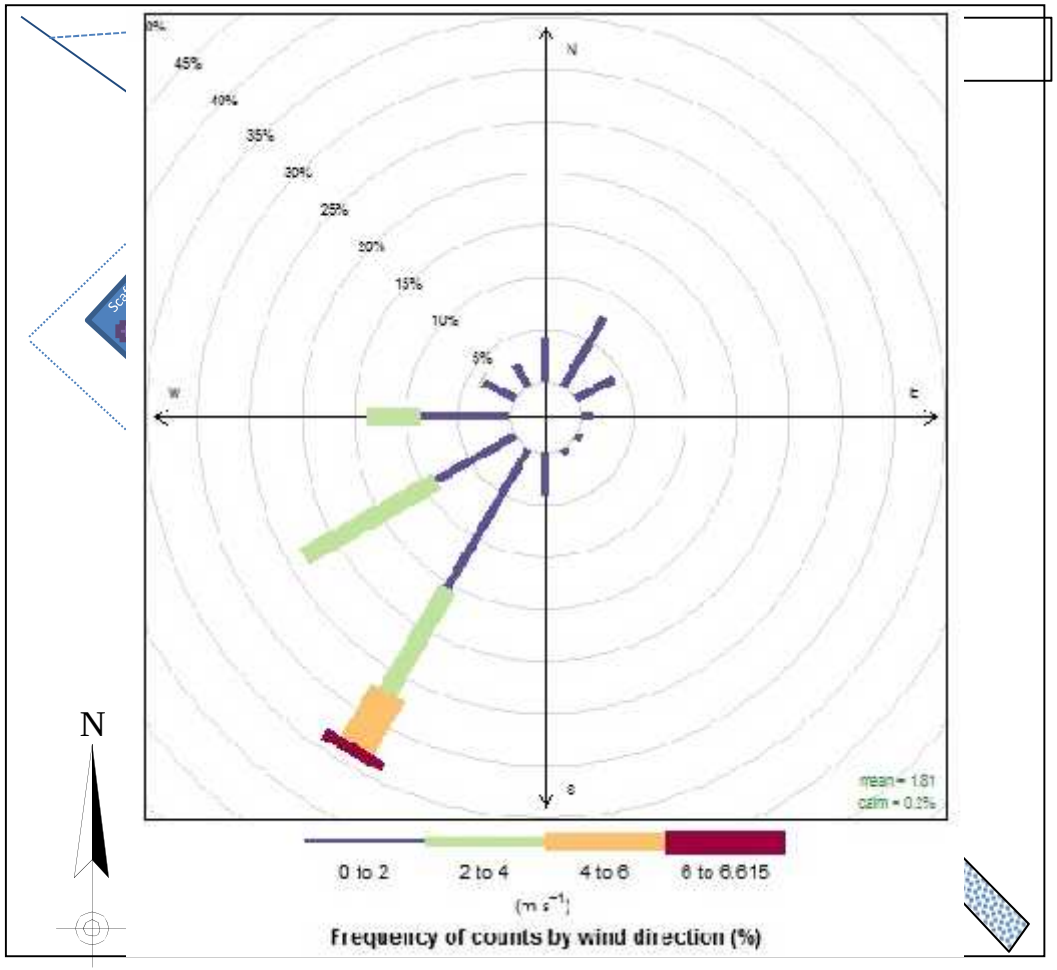
Mean wind speed = 1.81 m s^{-1}



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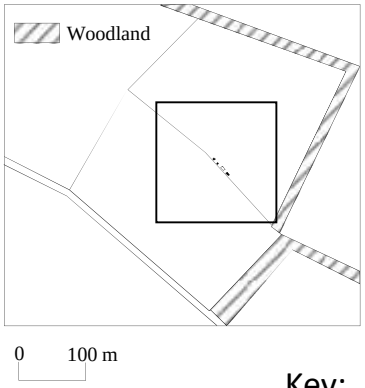

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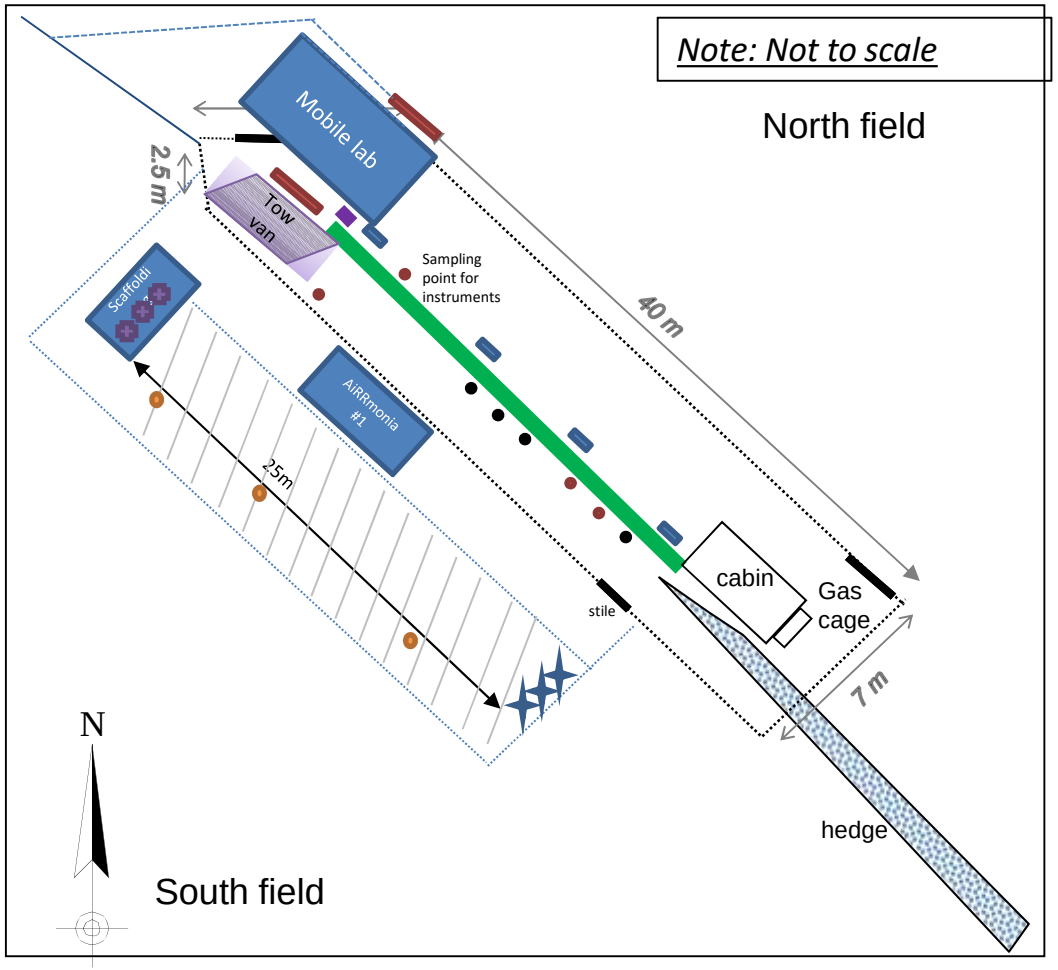

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Summary of setup

Location	Instrument	Total Inlet Length (m)	Flowrate
Scaffold 1	Mini DOAS #1	Not applicable	Not applicable
	Mini DOAS #2	Not applicable	Not applicable
	Mini DOAS #3	Not applicable	Not applicable
Scaffold 2	AiRRmonia #1	0.05	1.0
Tow van	QCL (Aerodyne)	3	13
	AP2E	4.69	1.0
	AiRRmonia #2	6.40	1.0
	Picarro #1	4.88	0.8
	Low cost sensors	3.7	2.0
Green mobile laboratory	*LGR#1 (Economical Ammonia Analyser)	2.0	0.25
	*LGR#2(Economical Ammonia Analyser)	1.45	2.30
	*Picarro#2	2.15	1.35
	*Tiger optics	2.64	0.48
	*LSE monitors	1.12	0.10
	MARGA	8.46	16.7
Posts	Alphas	Not applicable	Not applicable

* Instruments which are on the common manifold (Inlet to common manifold length 3.5m, with a flowrate of ~45L/min)

Summary of setup

Location	rate
Scaffold 1	
Scaffold 2	
Tow van	
Green mobile laboratory	
Posts	

* Instruments w ifold length 3.5m,
with a flowrate

Photo of site set up:

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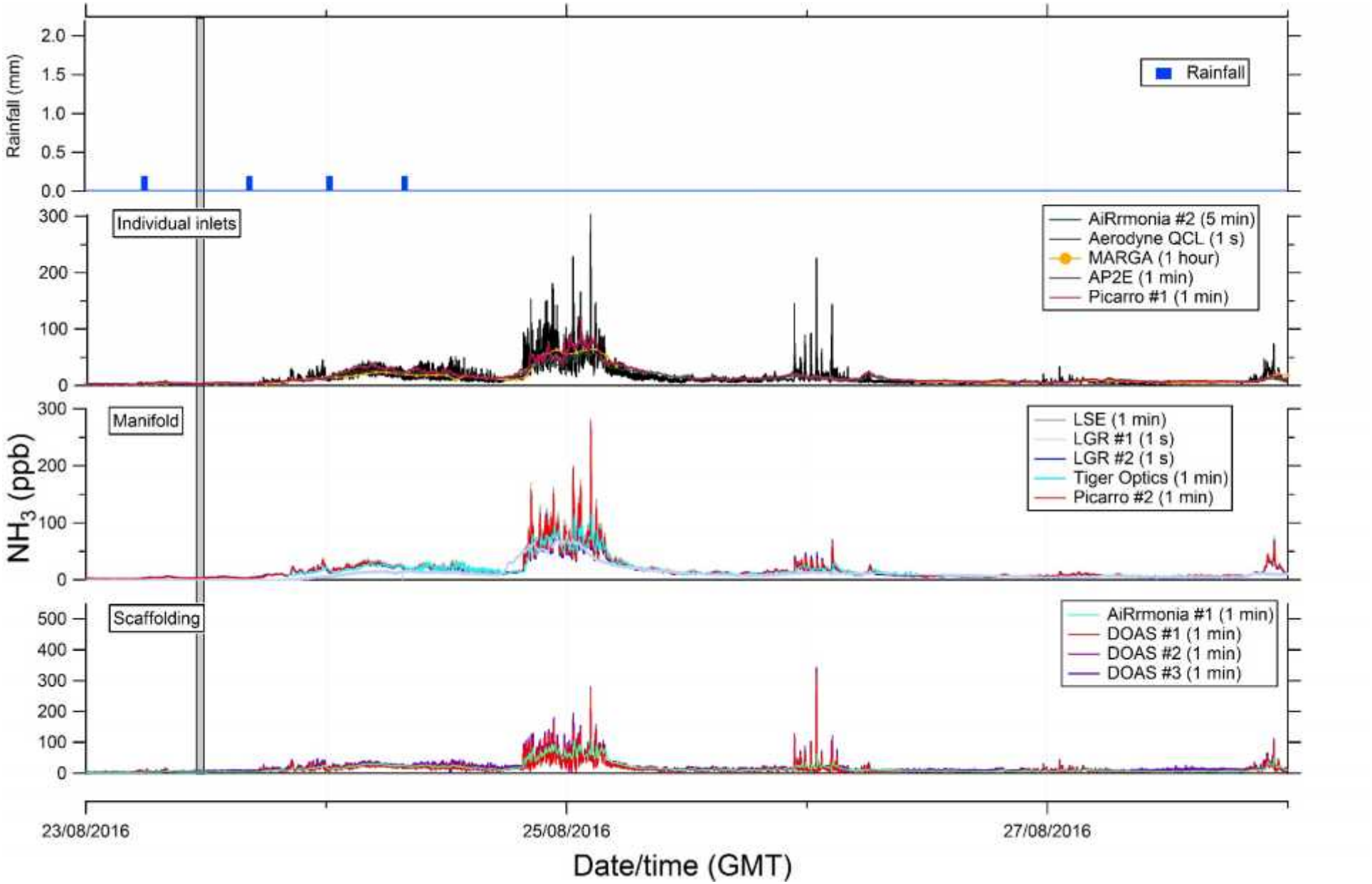
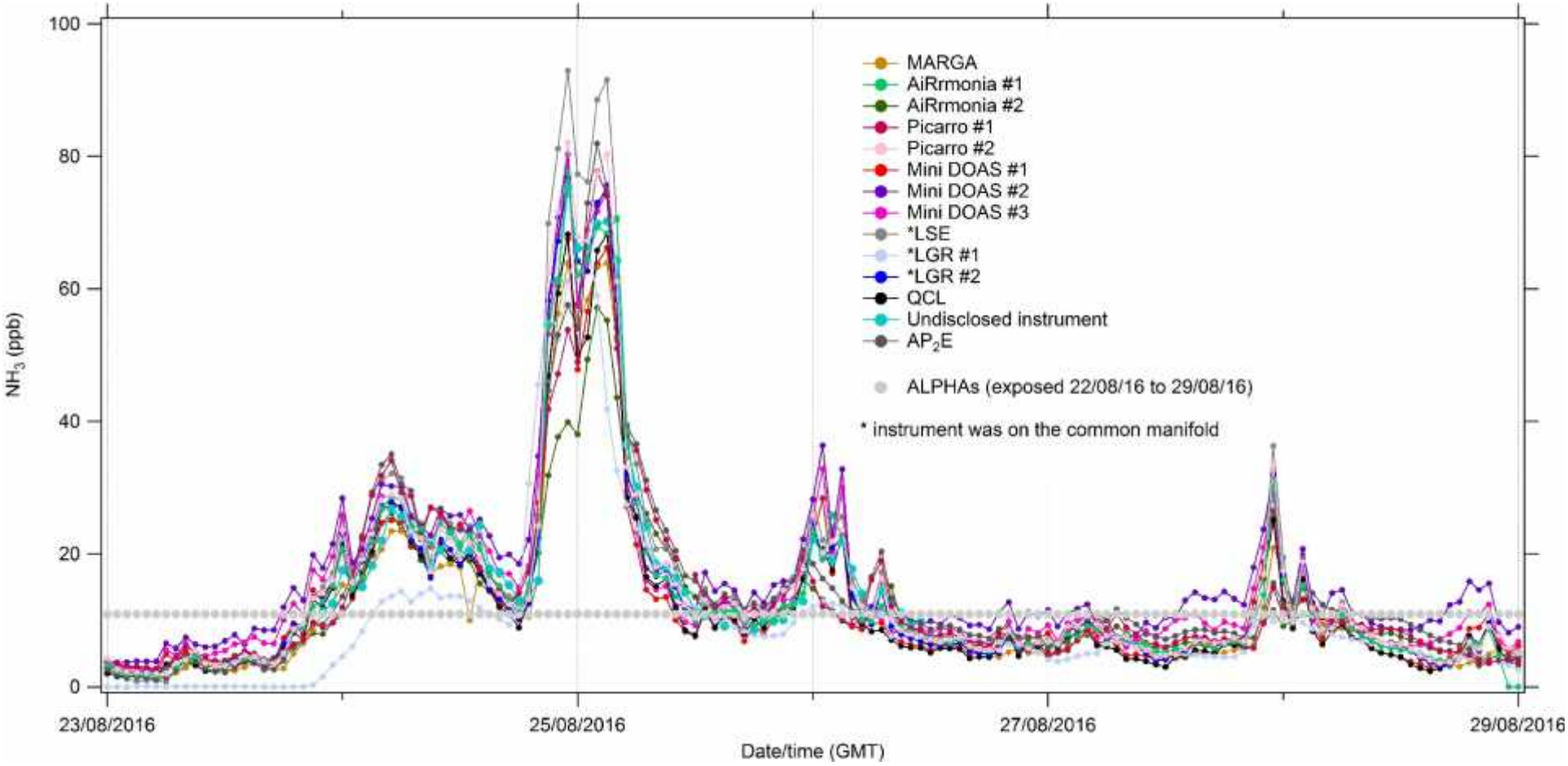
Time series results



Hourly data



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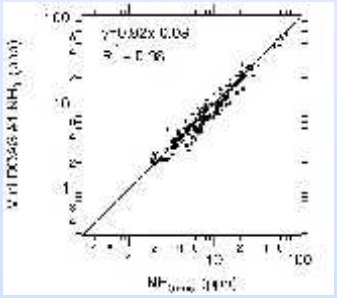
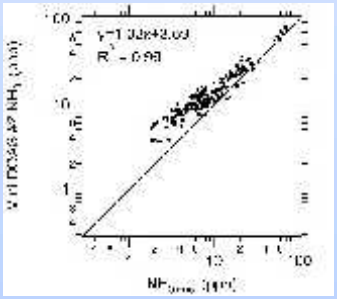
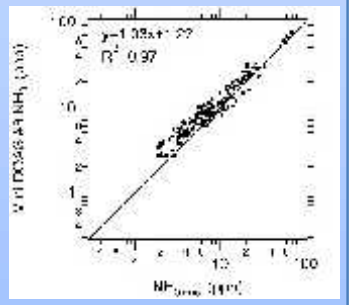
Instruments vs Ensemble average (23/08 -28/08)

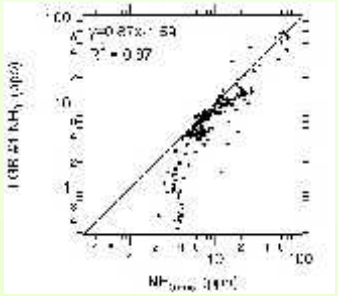
Mini DOAS

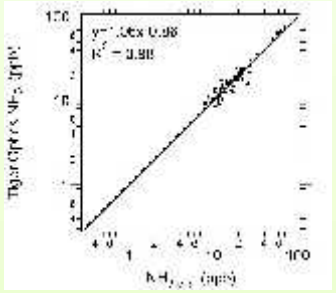


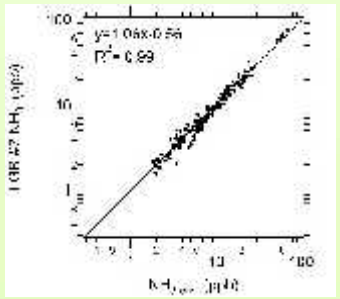


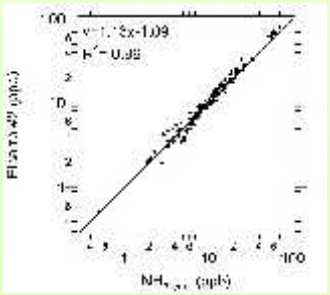


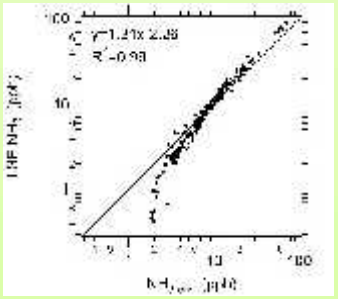
Manifold



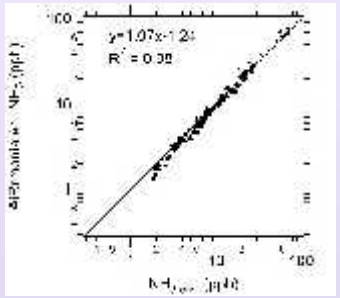


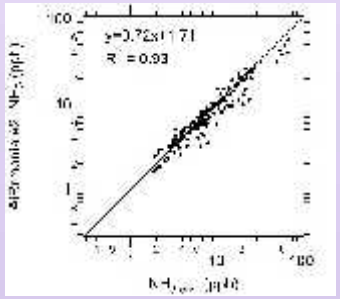


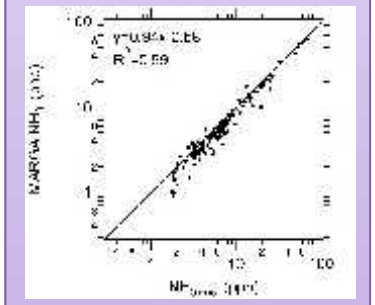




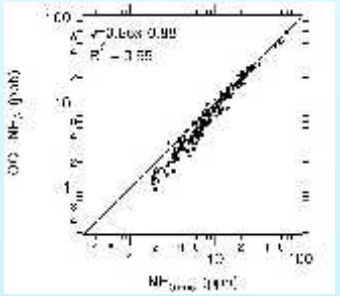
Wet chemistry

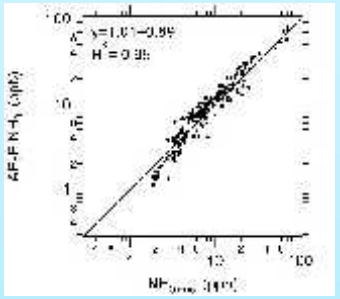


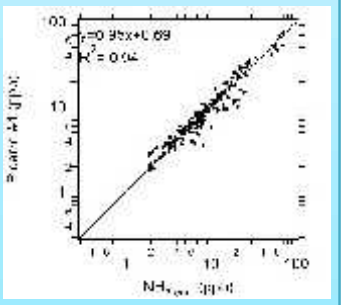




Individual inlets







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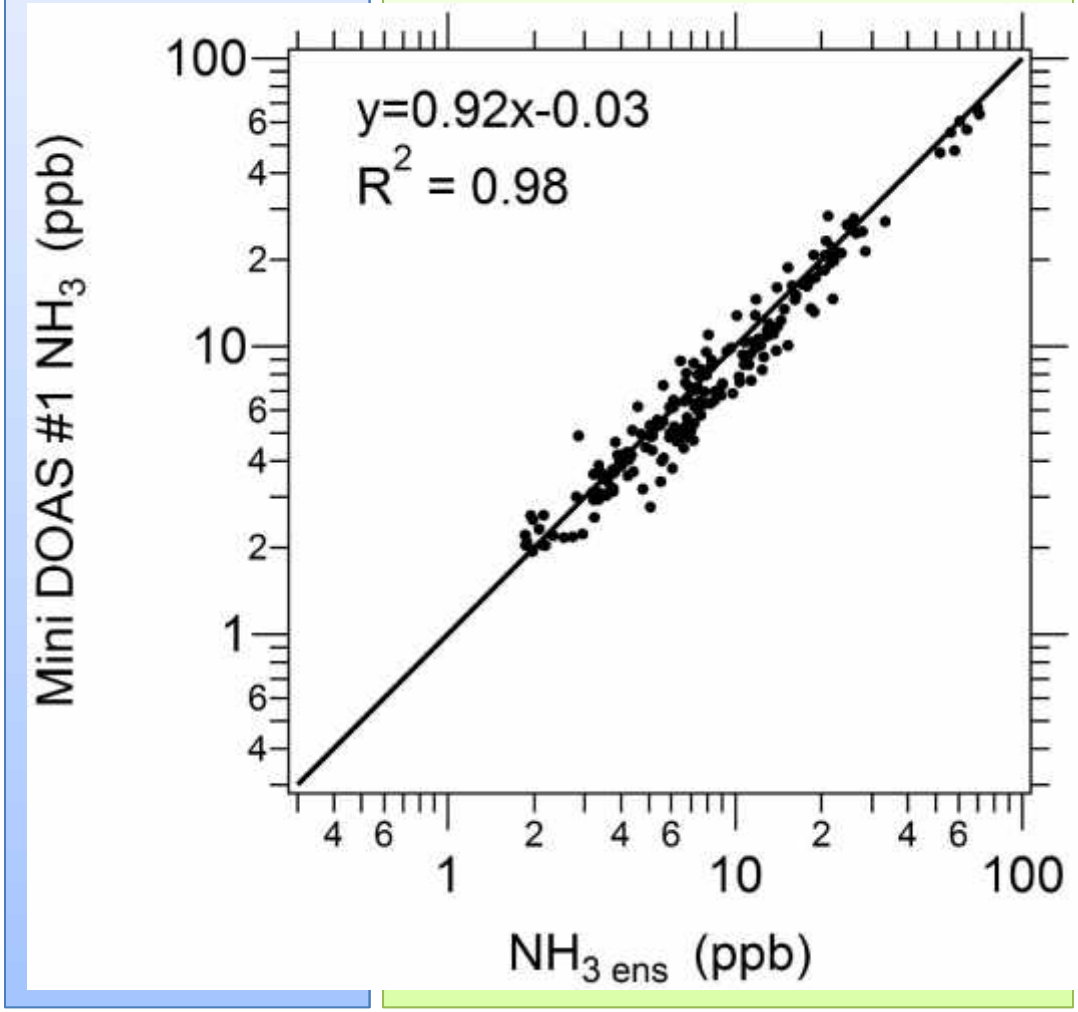
Instruments vs Ensemble average (23/08 -28/08)

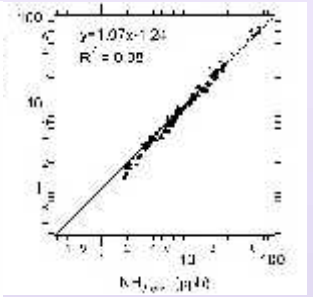
Mini DOAS

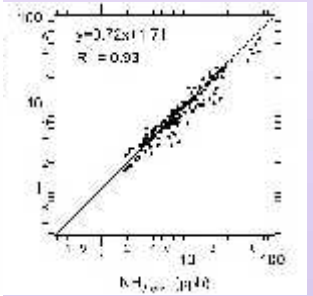
Manifold

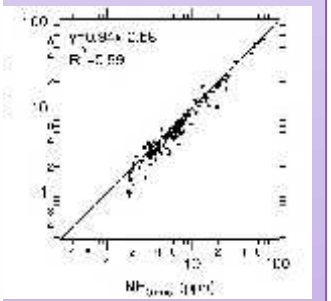
Wet chemistry

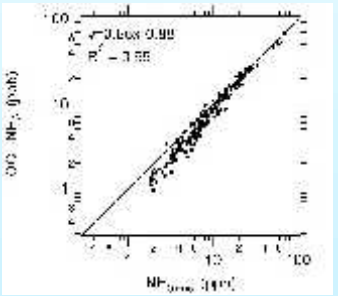
Individual inlets

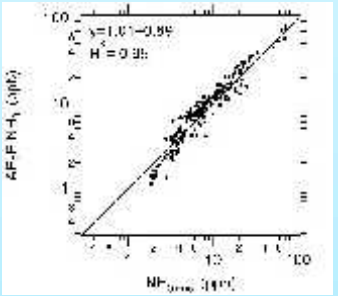


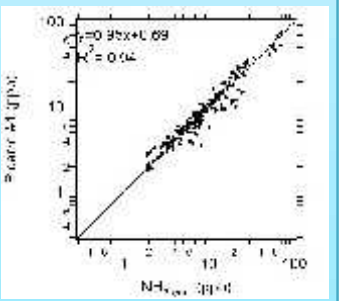












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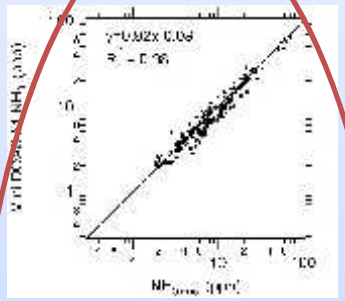

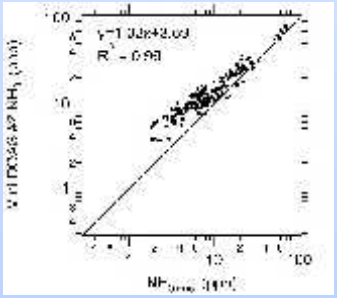

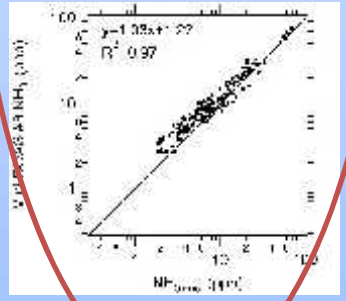

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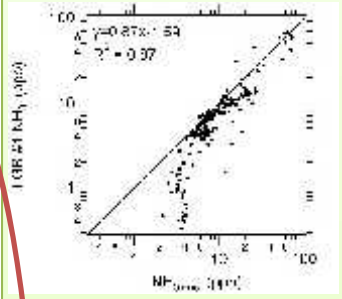
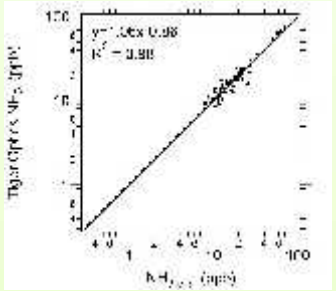
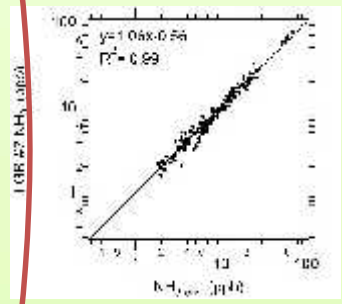
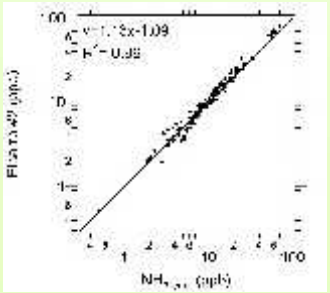
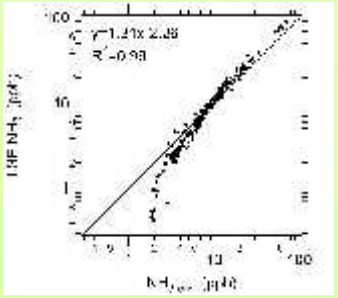


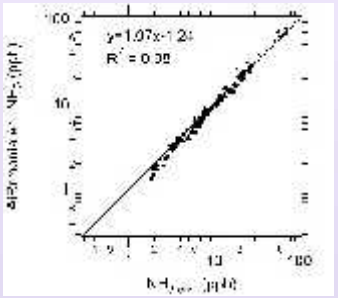


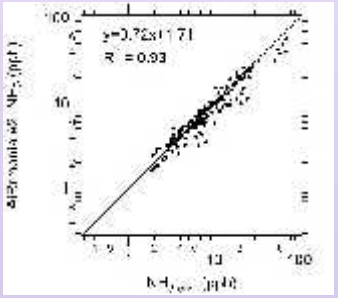


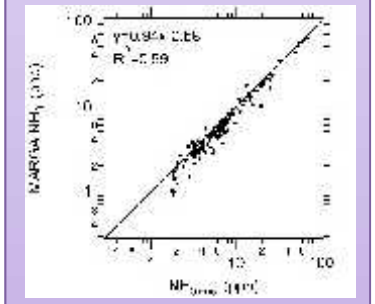




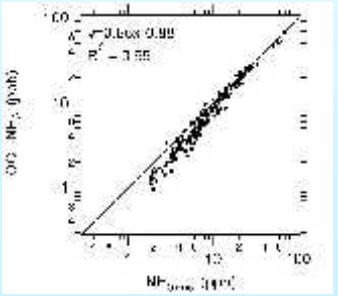
Wet chemistry

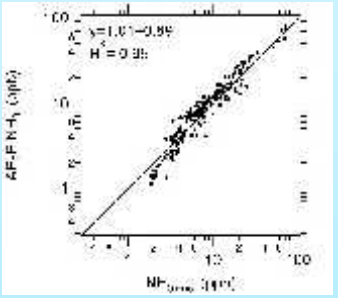


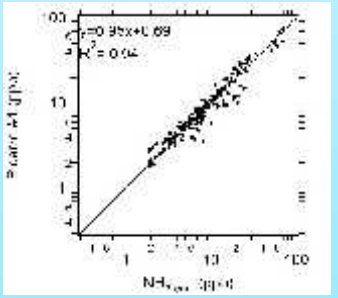




Individual inlets







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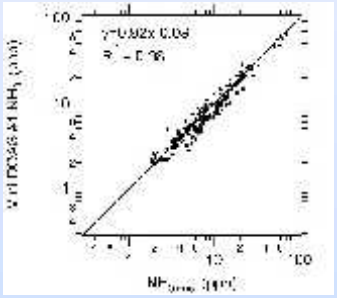
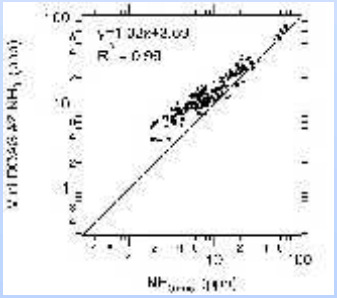
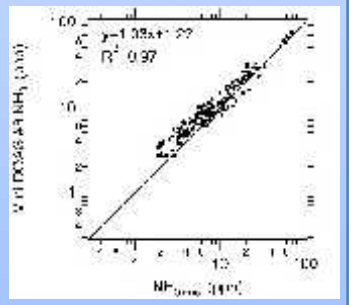
Instruments vs Ensemble average (23/08 -28/08)

Mini DOAS







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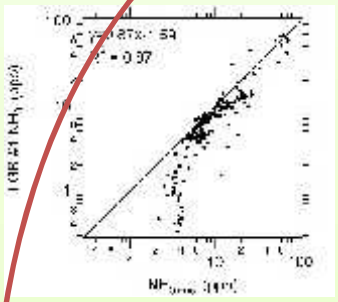

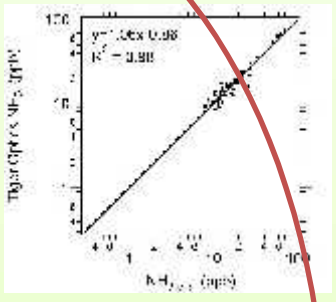

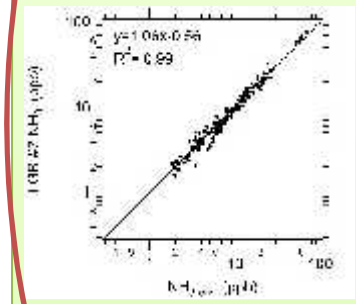

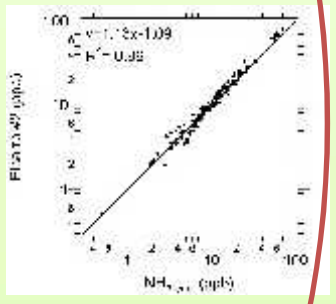

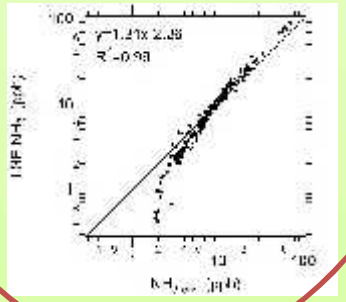

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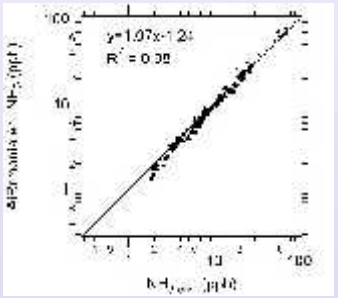

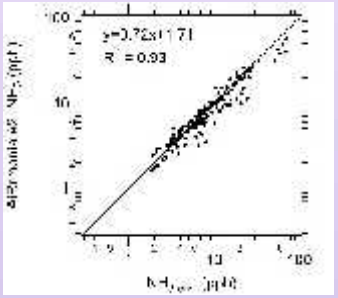

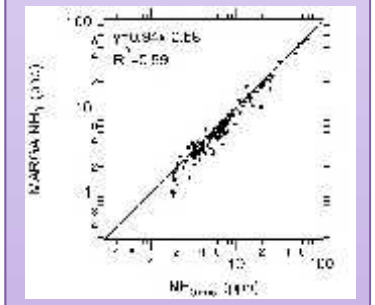

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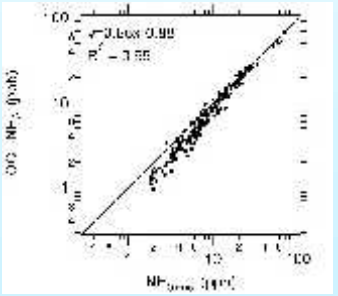

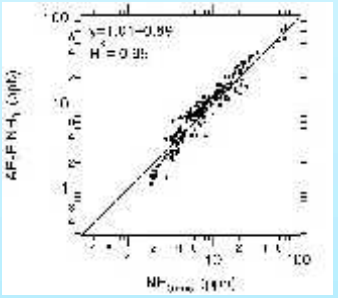

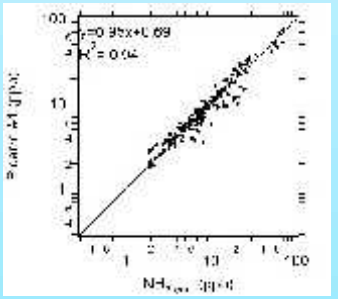

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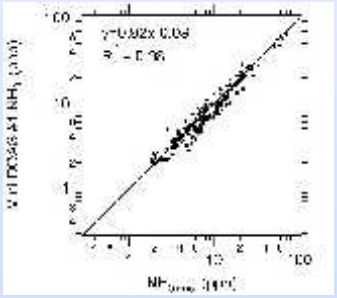
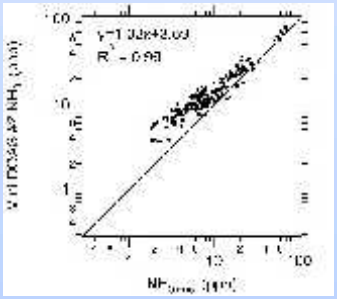
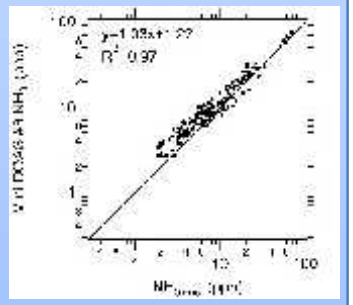
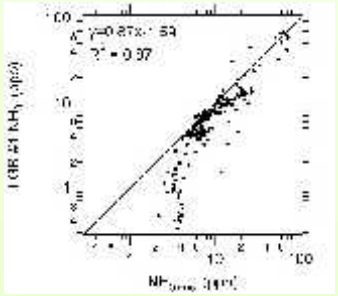
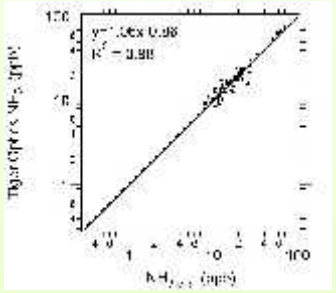


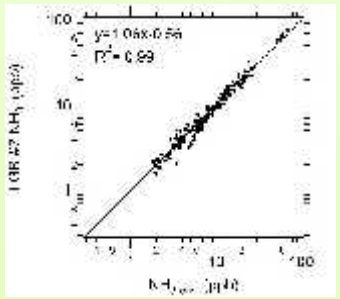


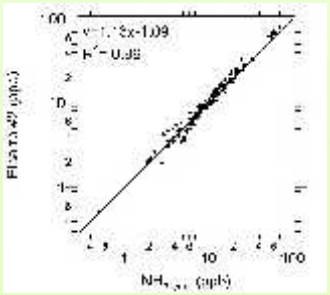


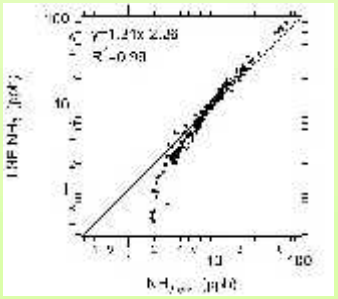
Manifold



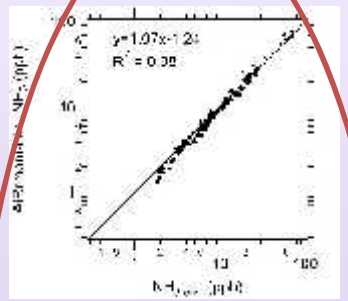


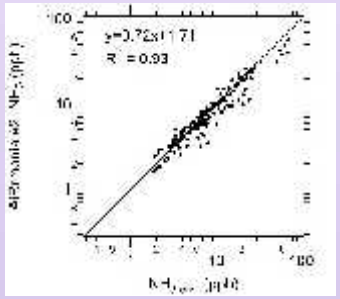


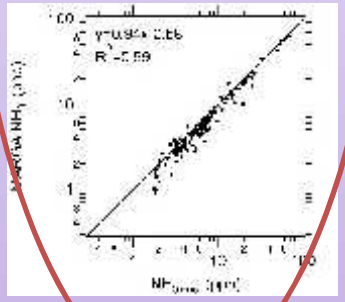




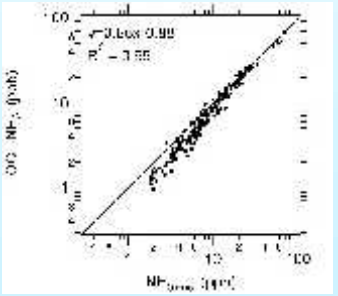
Wet chemistry

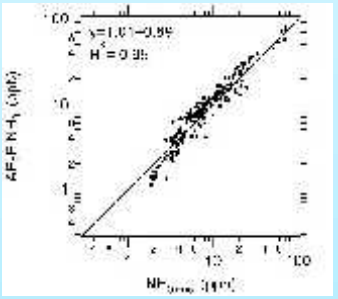


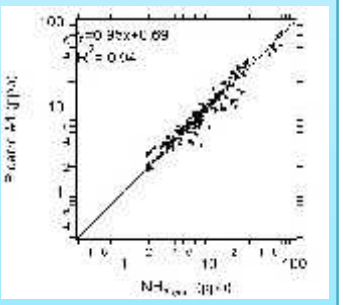




Individual inlets







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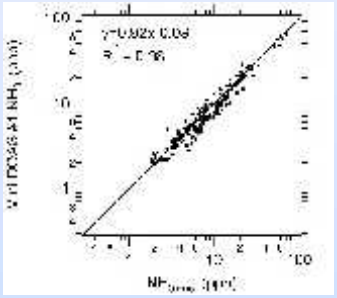
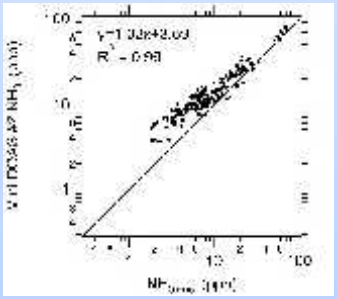
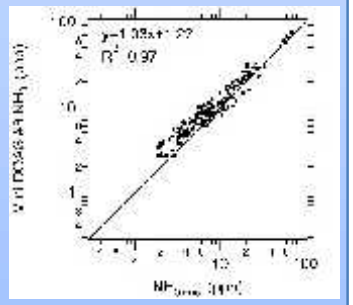
Instruments vs Ensemble average (23/08 -28/08)

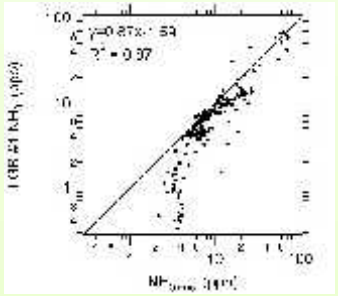
Mini DOAS

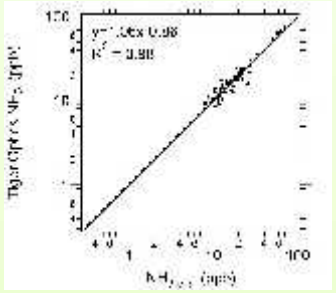


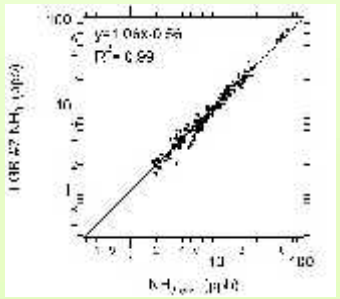


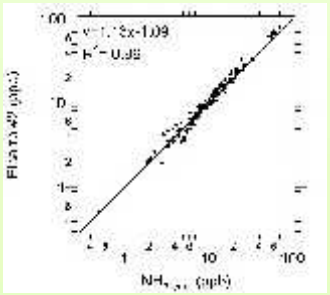


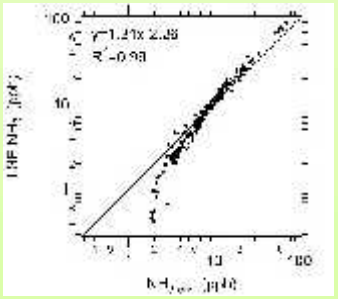
Manifold



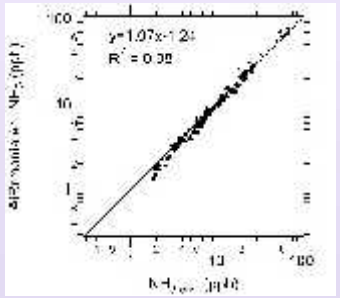


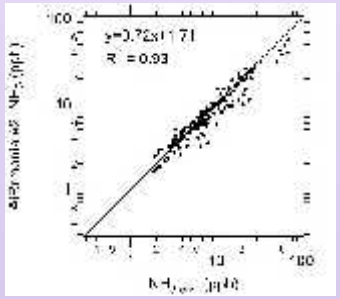


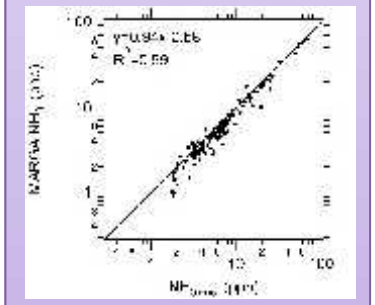




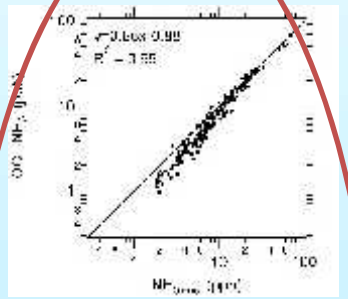
Wet chemistry

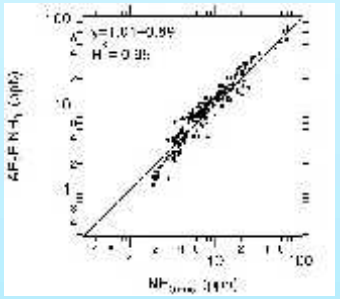


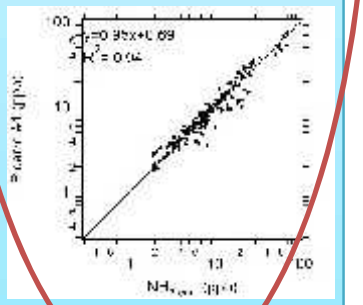




Individual inlets







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Field calibrations

- 2 dynamic and 1 static calibration systems present
- METAS traceable reference gas generator (REGAS) used to check concentrations before and after intercomparison for low flow instruments (Picarro, LGR, LSE, Tiger Optics)
- NPL static calibrator used for high flow instruments and mini DOAS
- Results still being assessed
- MetNH_3 reports will assess operational requirements and challenges for practical use of such systems in the field

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Next steps:

- Assessment on the applicability of calibration system in the field
- Evaluate the performance of instruments with the dynamic calibration system
- Produce a final series of recommendations with regards to the optimum operation for NH_3 instrumentation
- write measurement guideline documents for AQ networks, EMEP and WMO-GAW

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MetNH3

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Conclusions:

- Though technology has advanced users need some understanding in order to choose the right instrument for their application
- Low-flow instruments either need minimal inlet or a high-flow inlet with sub-sampling off for operation
- Simple measurement guidelines are needed
- Recommended that there should be a world centre for ammonia measurements for WMO-GAW.
- When measurements are undertaken quality control procedures need to be implemented

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Acknowledgements:

Co-authors acknowledgements:

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Collaborators

Stakeholders

Project partners:

Passam Takachiho, Radiello

Thank you for listening
Any Questions?

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European Metrology Research Programme
Programme of EURAMET

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