The challenge of achieving Data Quality Objectives in the WMO-GAW N_2O network

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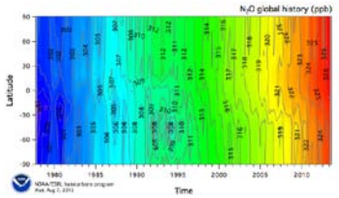
http://imk-ifu.kit.edu/wcc-n2o/

World Meteorological Organization
Working together in weather, climate and water

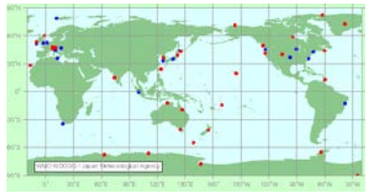
GLOBAL ATMOSPHERE WATCH

Outline

- **Nitrous oxide in the global atmosphere**



- **Data compatibility in the GAW N_2O network**



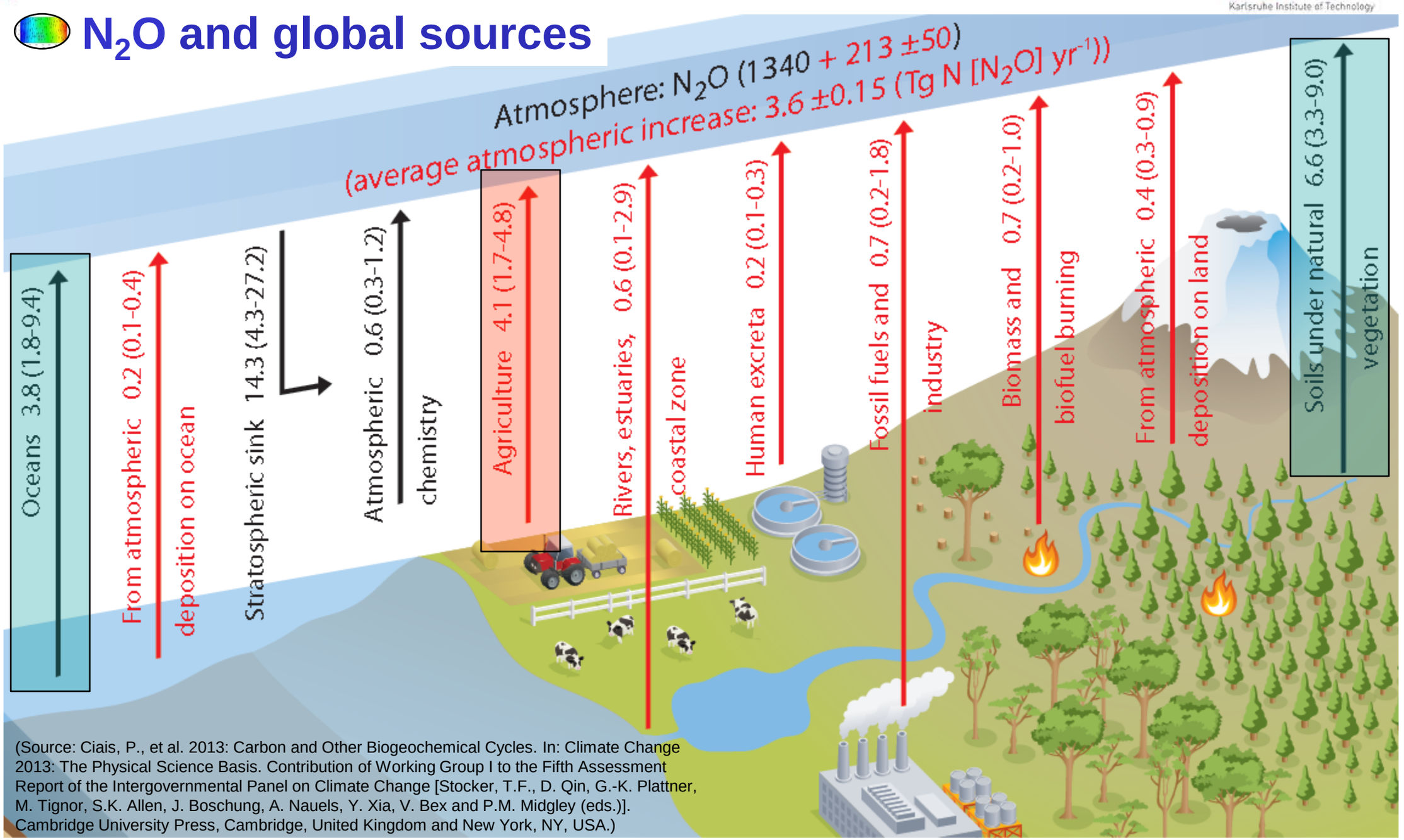
- **Challanges to achieve N_2O Data Quality Objectives**

- **High-precision spectroscopic technologies**

- **Summary and conclusions**

Nitrous oxide in the global atmosphere

N_2O and global sources

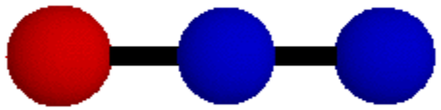


(Source: Ciais, P., et al. 2013: Carbon and Other Biogeochemical Cycles. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.)

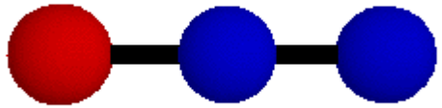
Nitrous oxide in the global atmosphere

N_2O in the atmosphere: Characteristic Vibrations

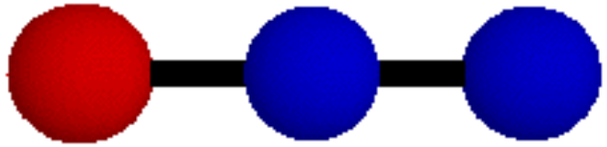
$o_1 = 1298.3\ cm^{-1}$



$o_2 = 596.3\ cm^{-1}$



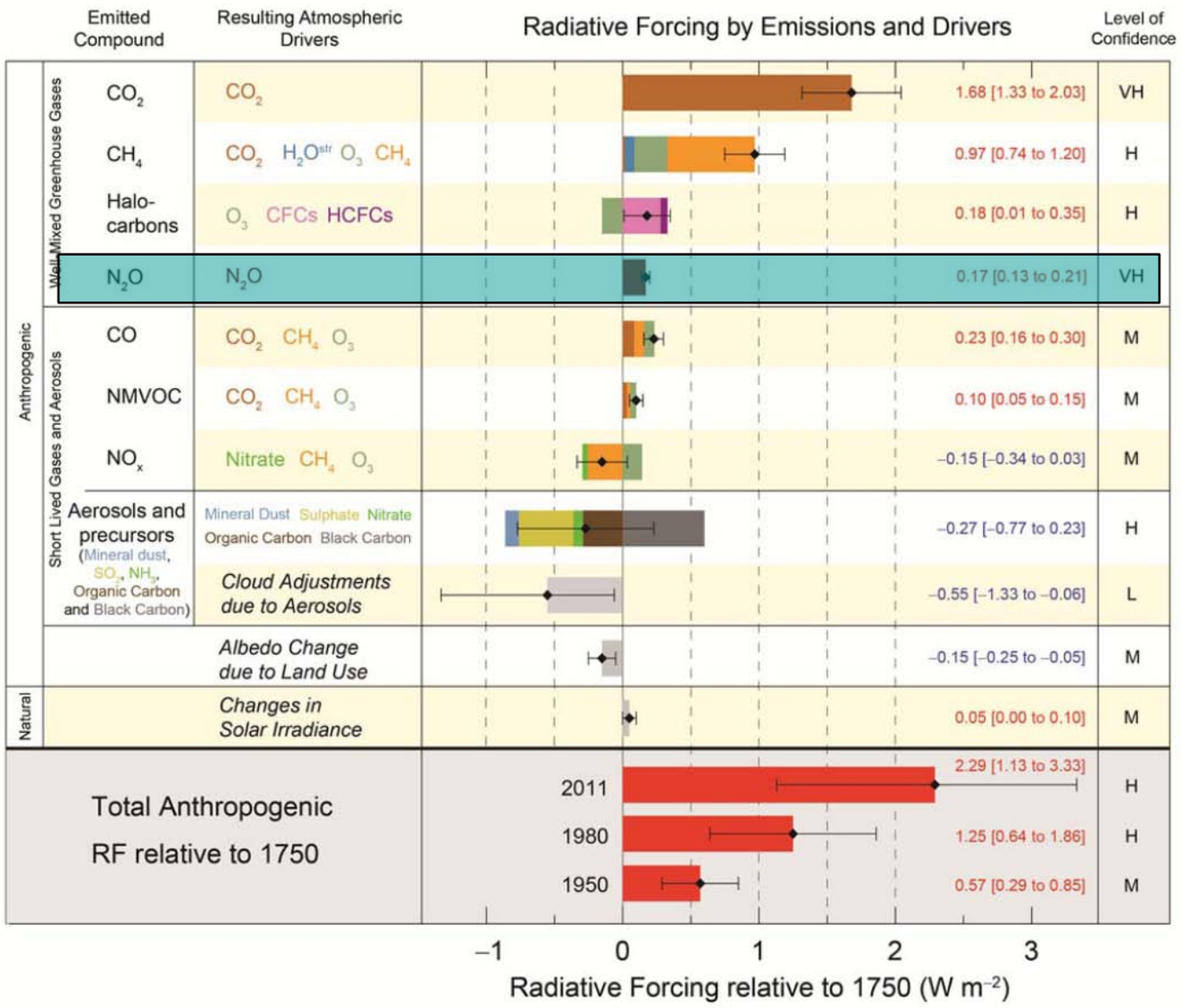
$o_3 = 2282.2\ cm^{-1}$



(source:http://www2.ess.ucla.edu/~schauble/MoleculeHTML/N2O_html/N2O_page.html)

Nitrous oxide in the global atmosphere

N_2O and global warming

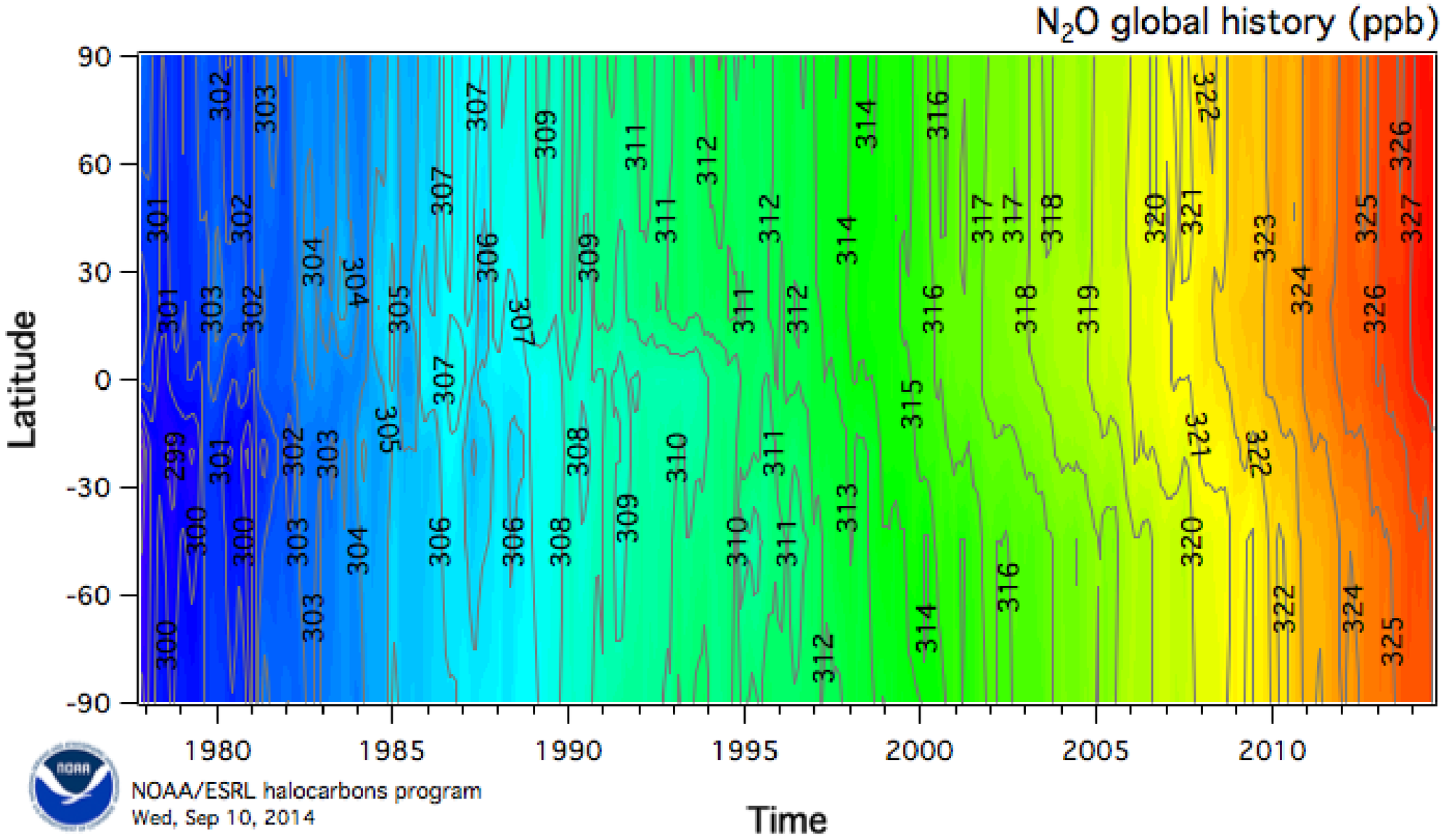


N_2O contributes 7.4% to total anthropogenic Relative Forcing relative to 1750

(IPCC, 2013)

Nitrous oxide in the global atmosphere

N_2O and global distribution



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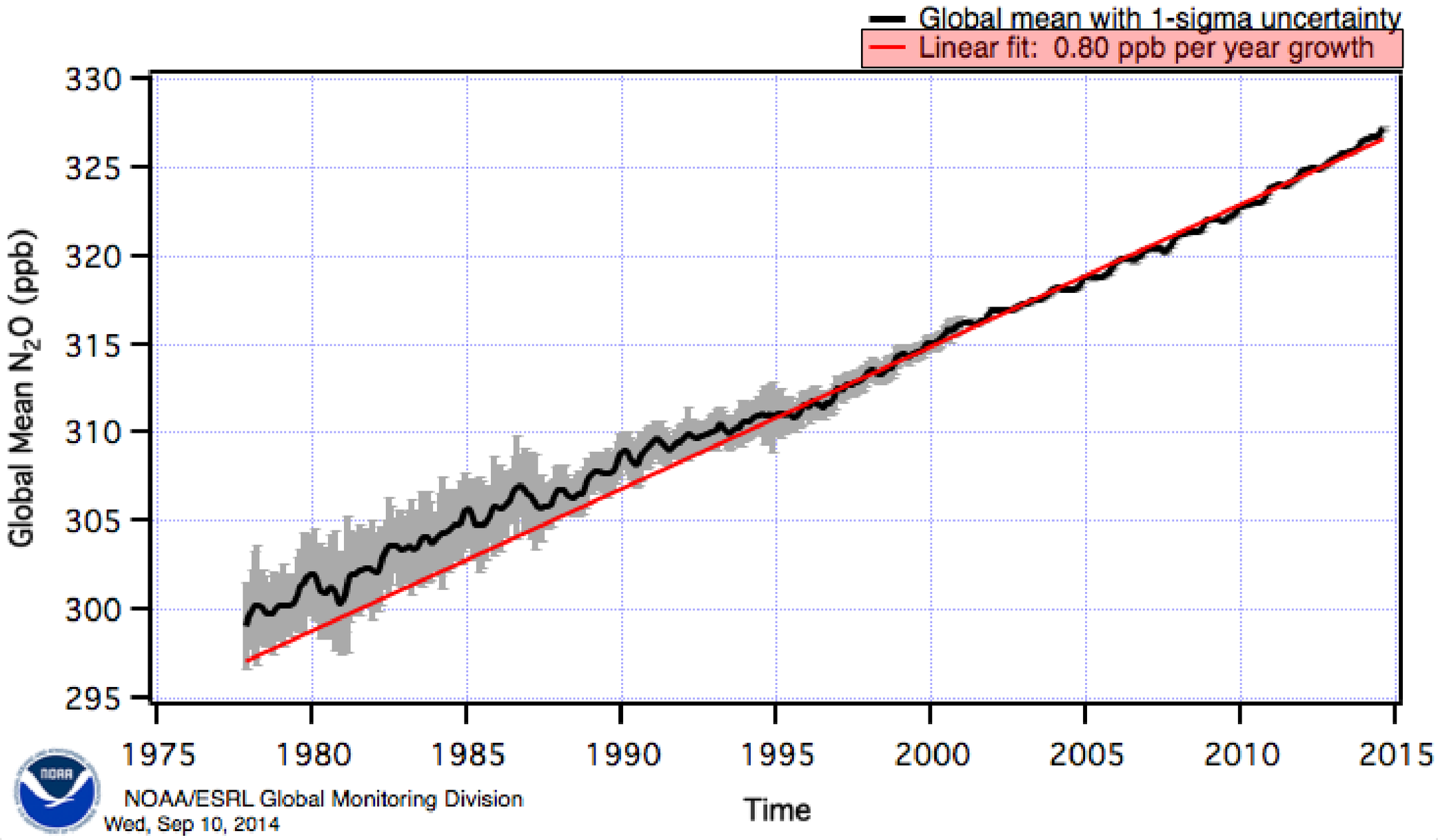
Nitrous oxide in the global atmosphere

N_2O and global trend



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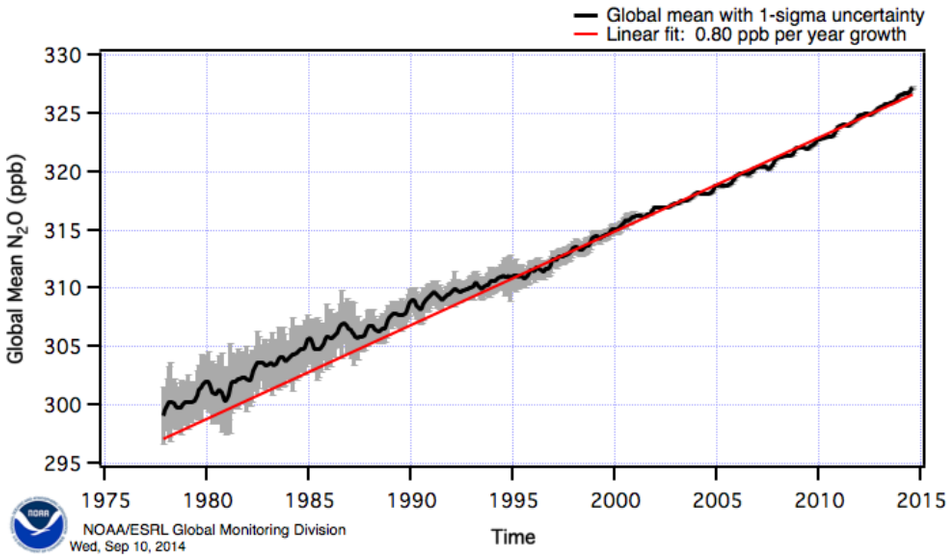
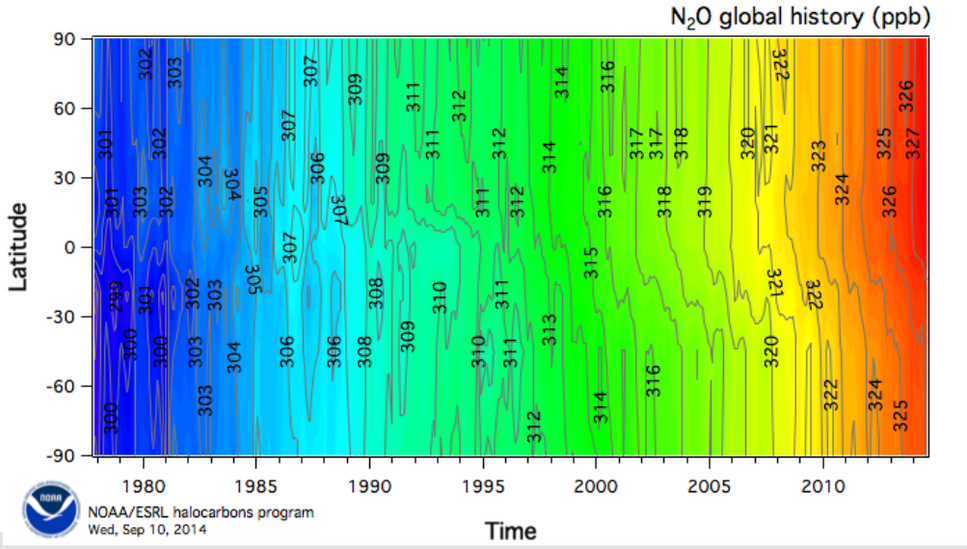
Nitrous oxide in the global atmosphere

N_2O global trends and hemispheric differences



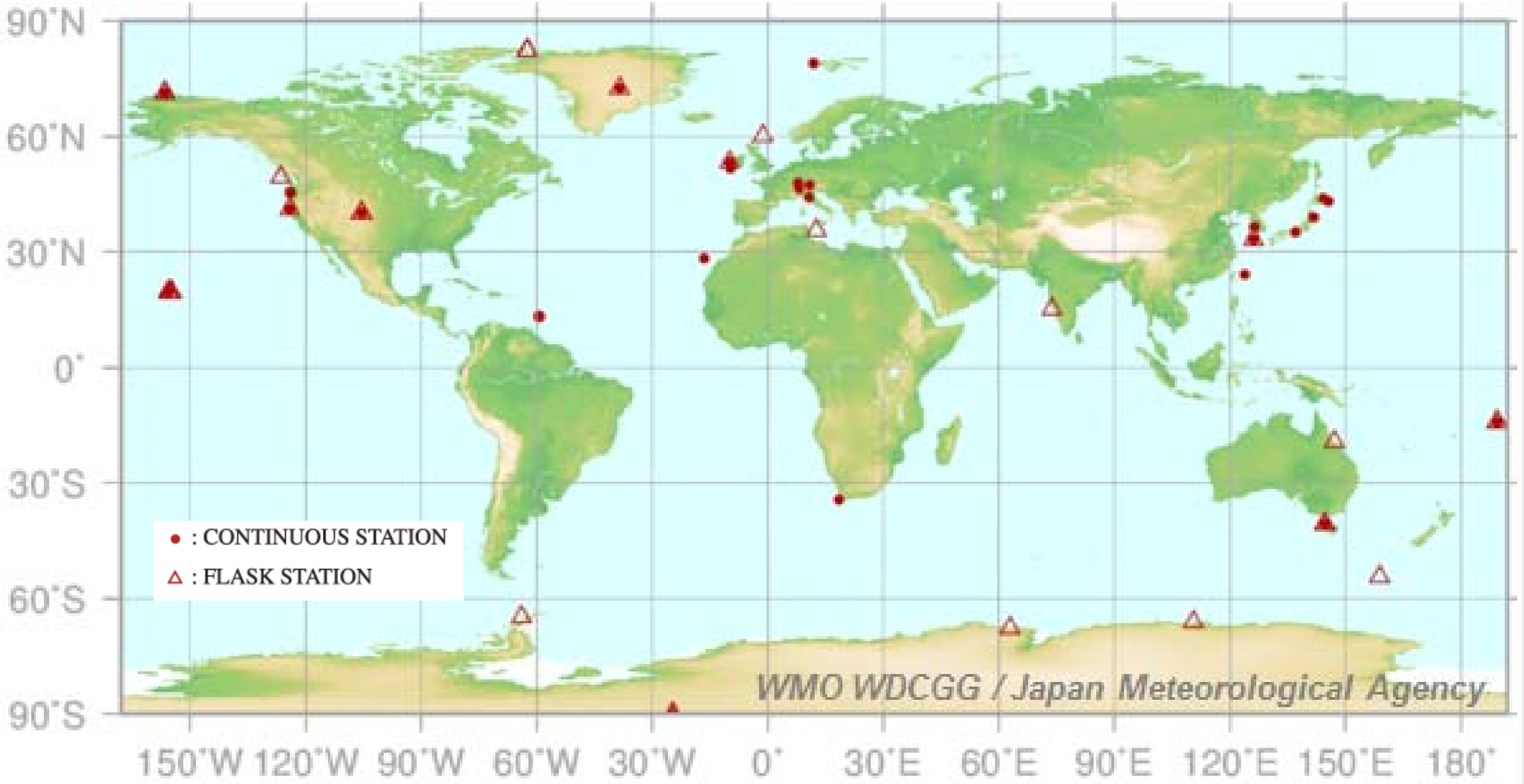


- **Understanding** the role of greenhouse gases for climate change, to **develop** balanced and scientifically sound actions on emissions control and to **monitor** there effects on global distributions requires integrated global greenhouse gas observing systems such as **GAW**.

- **Data compatibilty** should match scientific requirements for trend analysis.

The GAW network for N_2O

Status 2014



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WMO GLOBAL ATMOSPHERE WATCH

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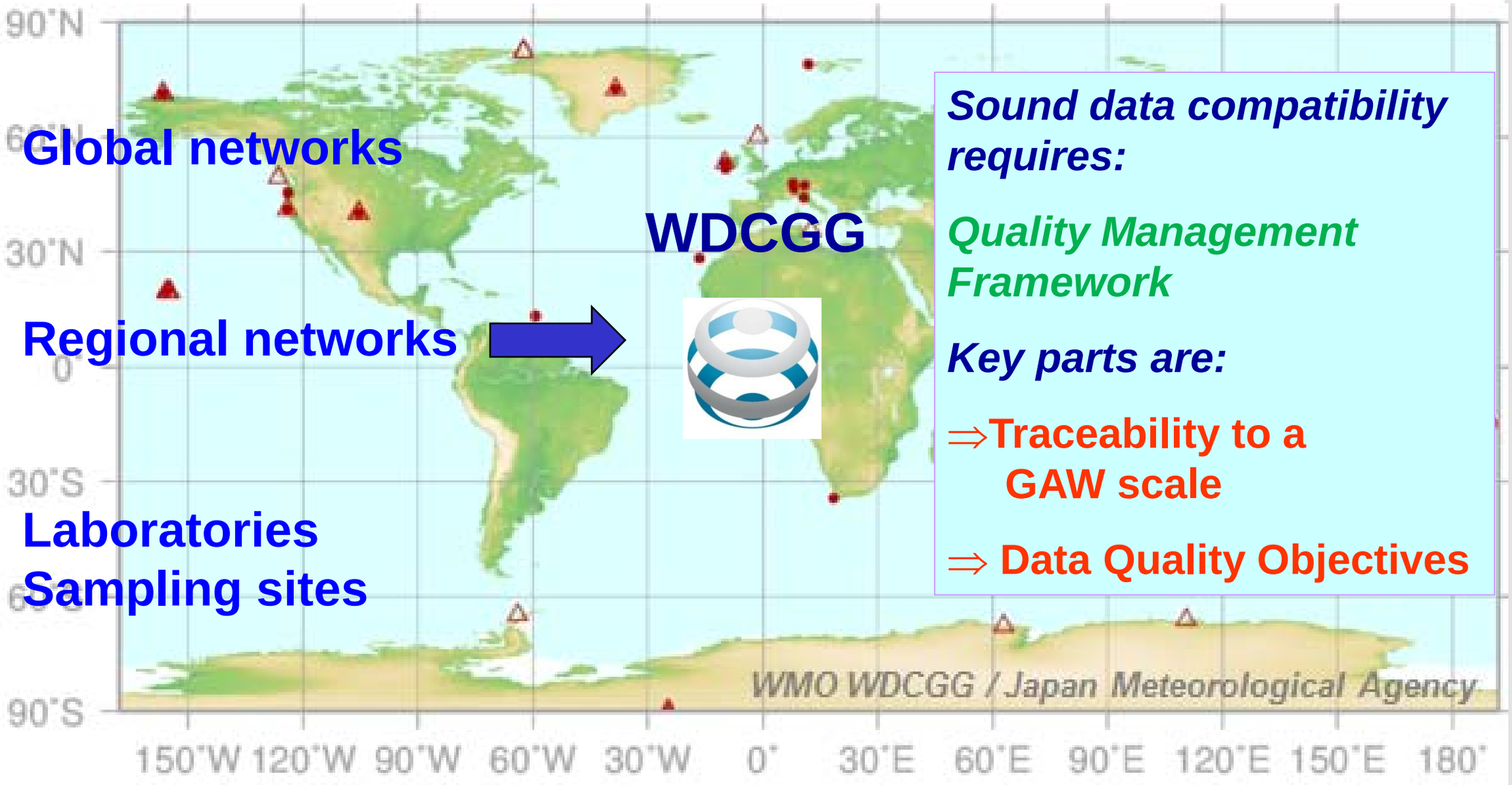
The GAW network for N_2O

Contributors



Global networks

Regional networks

Laboratories
Sampling sites

WDCGG

Sound data compatibility requires:

Quality Management Framework

Key parts are:

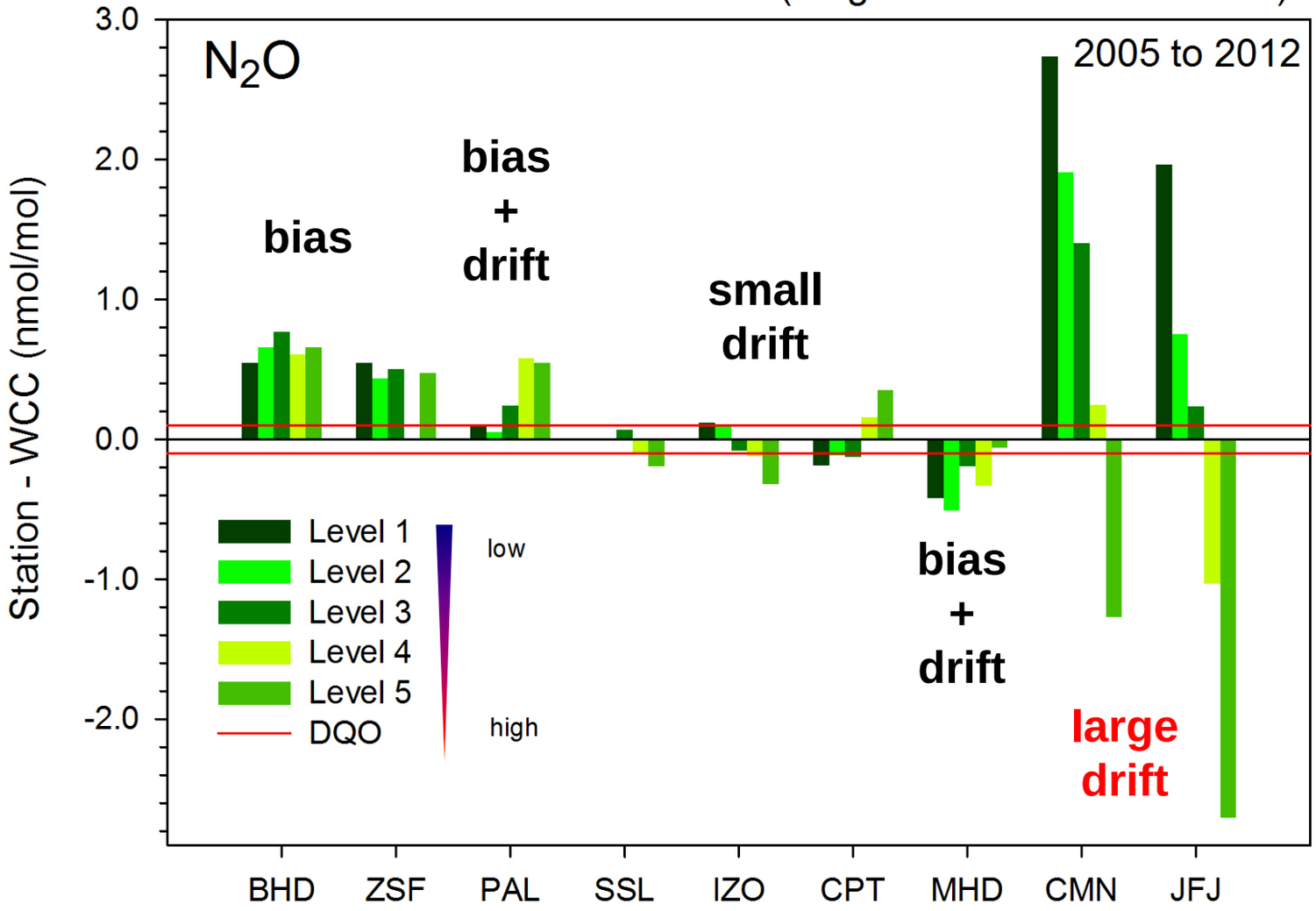
⇒Traceability to a GAW scale

⇒ Data Quality Objectives

The GAW network for N_2O

Data compatibililty

Performance Audits by the WCC-N_2O with 5 Travelling Standards
(range: 296 to 347 nmol/mol)

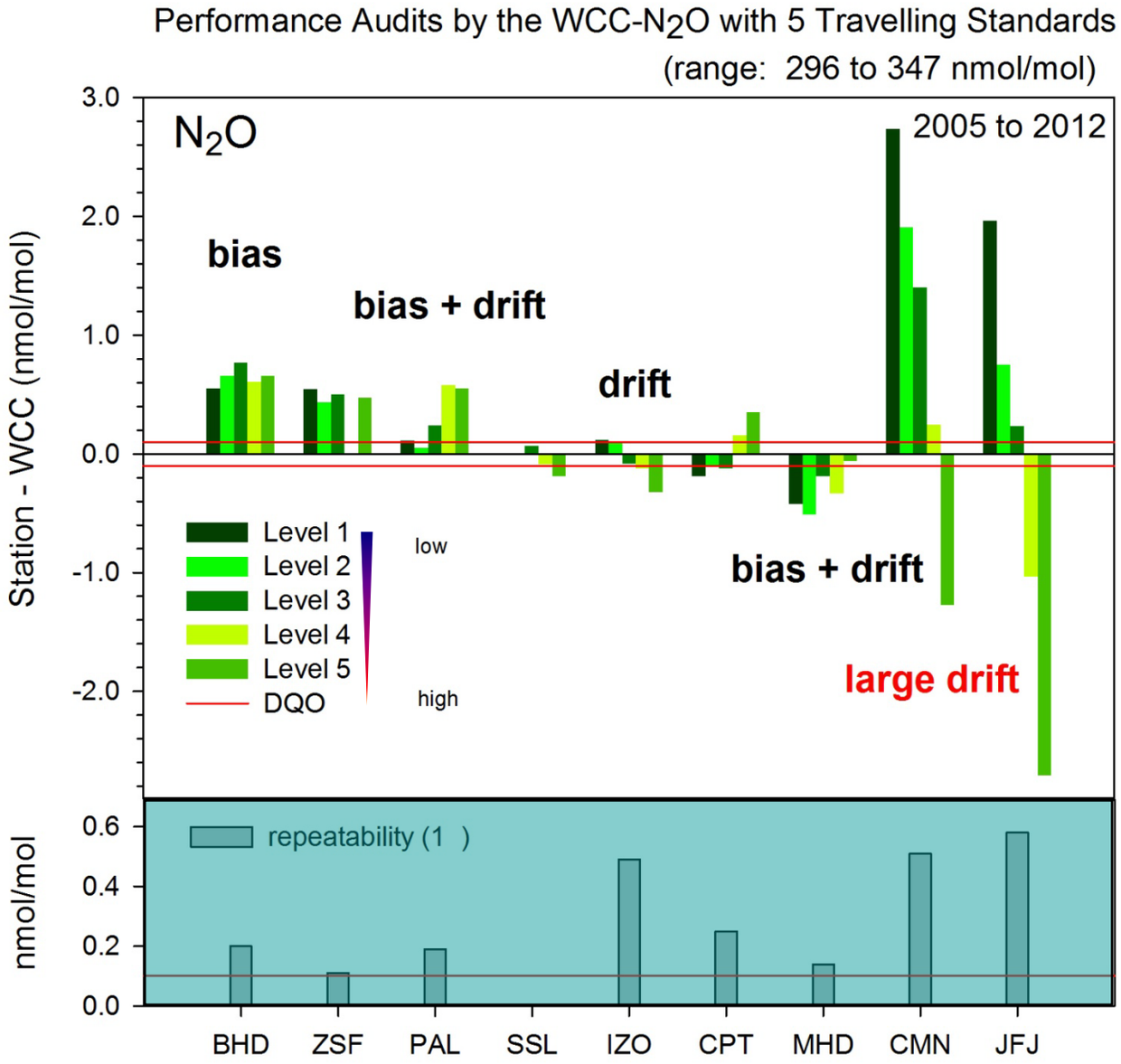


Data quality objectives for N_20: 0.1 nmol/mol

Technique:

The GAW network for N_2O

Data compatibililty

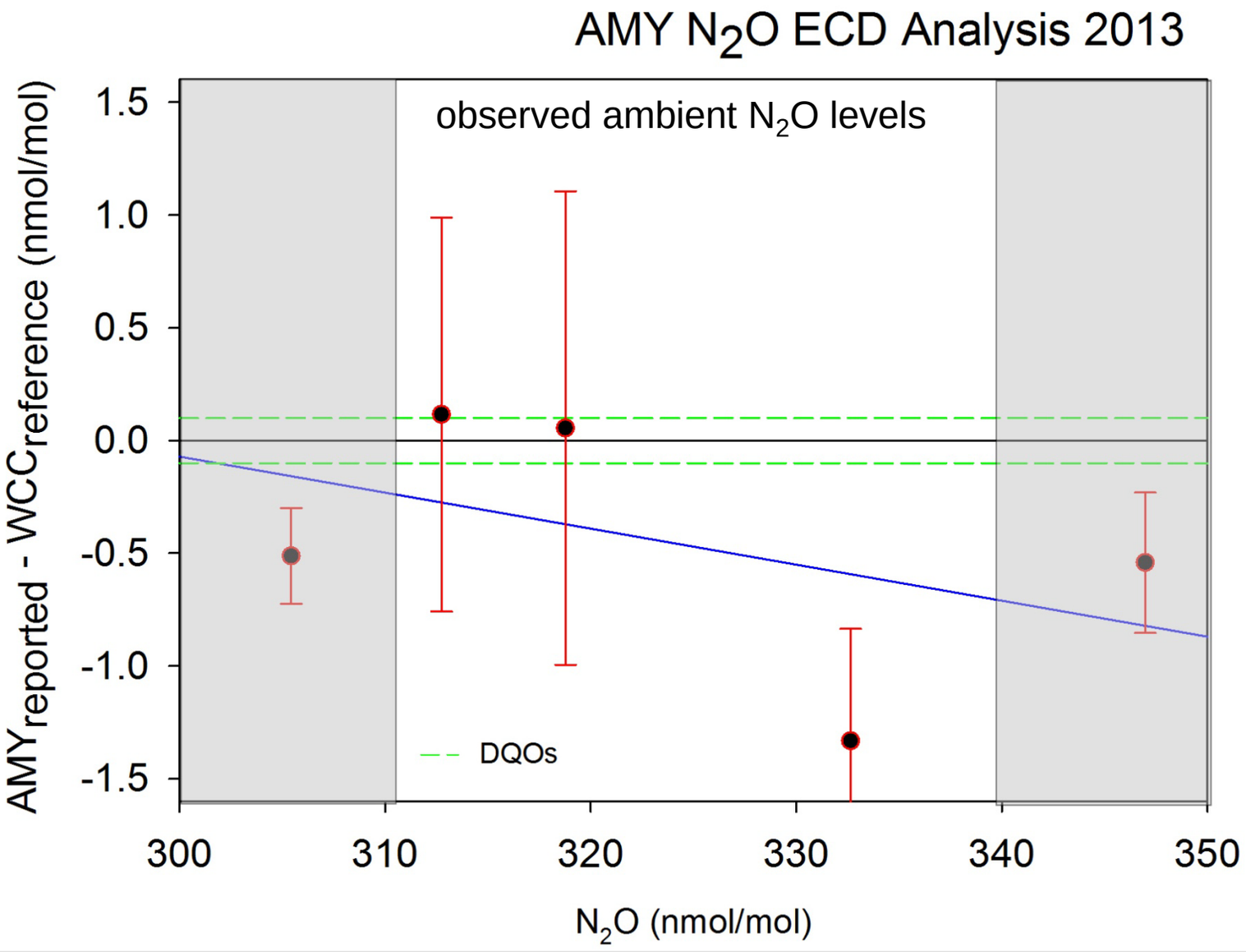


Data quality objectives for N_20: 0.1 nmol/mol

Technique:

The GAW network for N_2O

Data compatibililty regional GAW station Anmyeon-do



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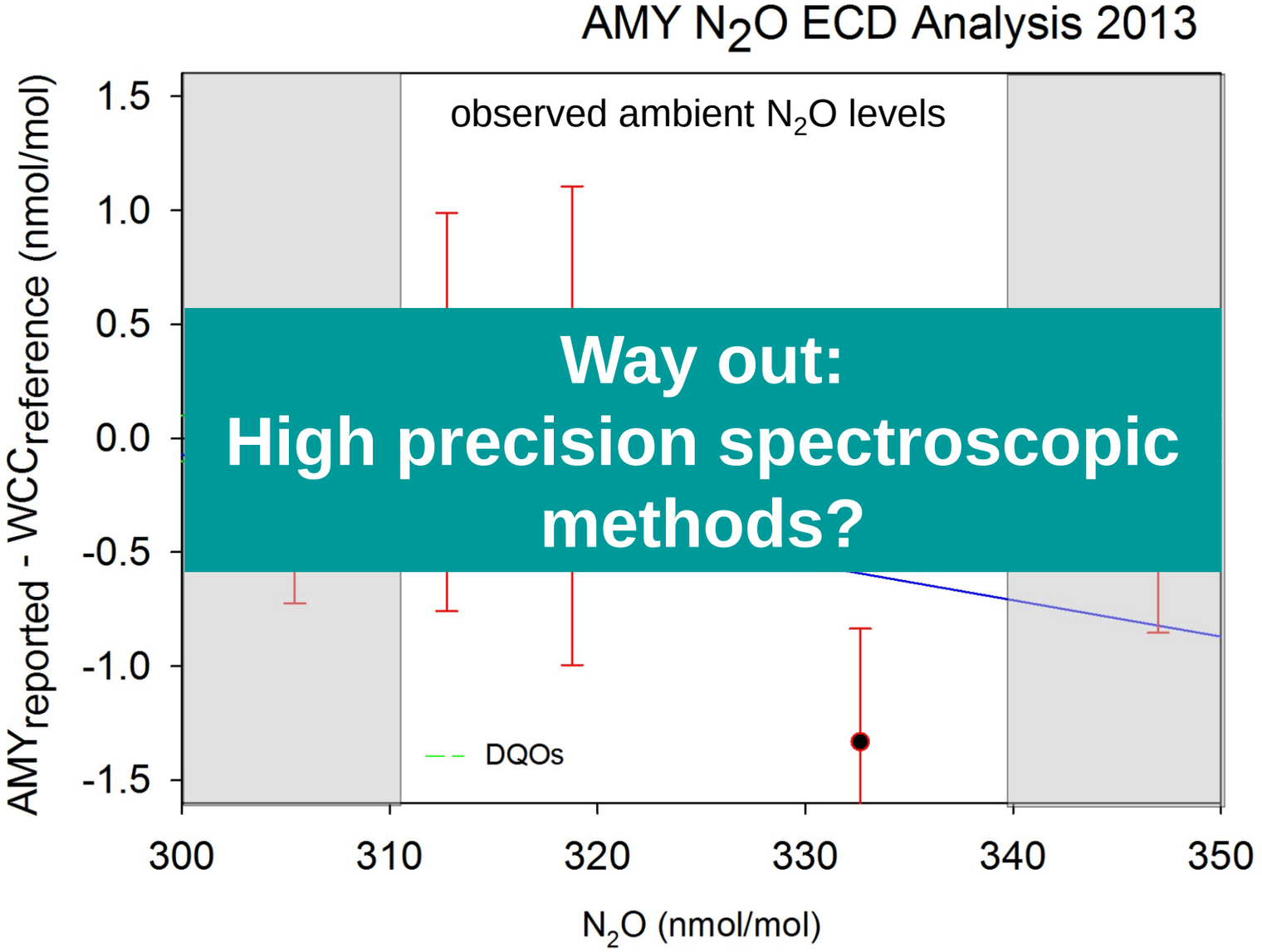
The GAW network for N_2O

Data compatibililty regional GAW station Anmyeon-do

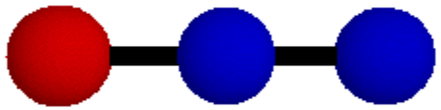


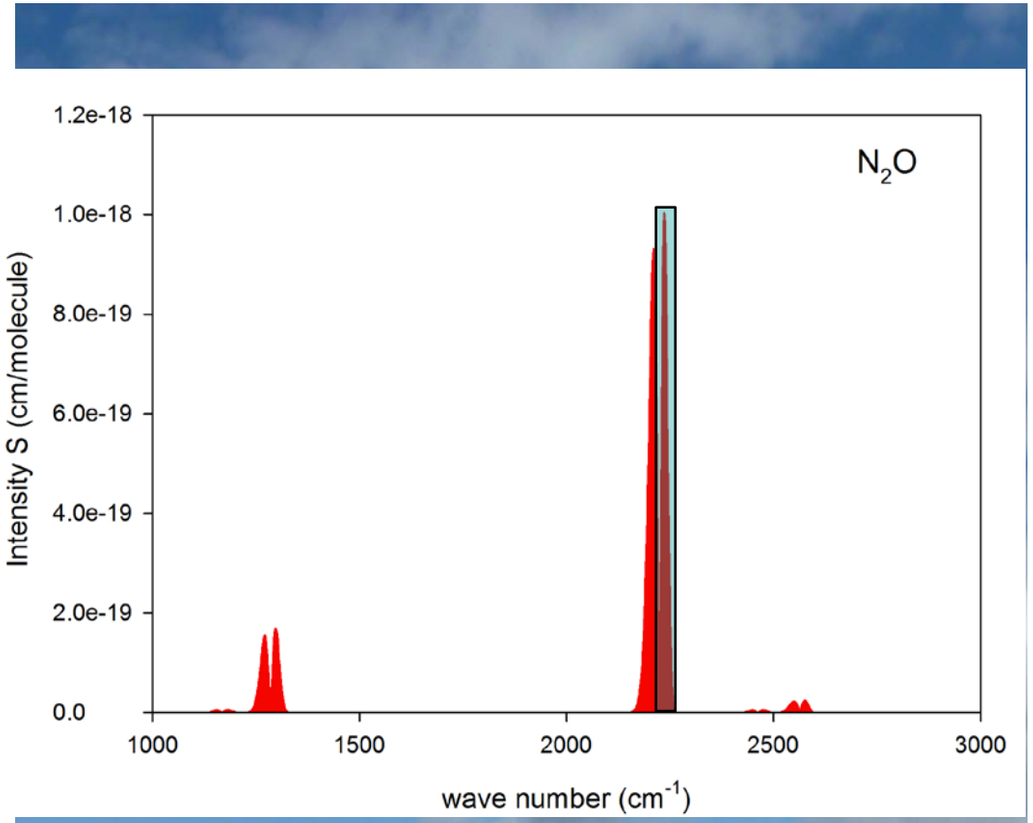
Way out:
High precision spectroscopic methods?

High precision spectroscopic methods

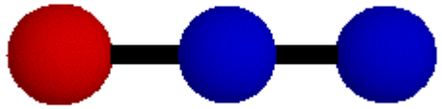
Quantum Cascade Lasers

$o_1 = 1298.3\ cm^{-1}$





$o_2 = 596.3\ cm^{-1}$



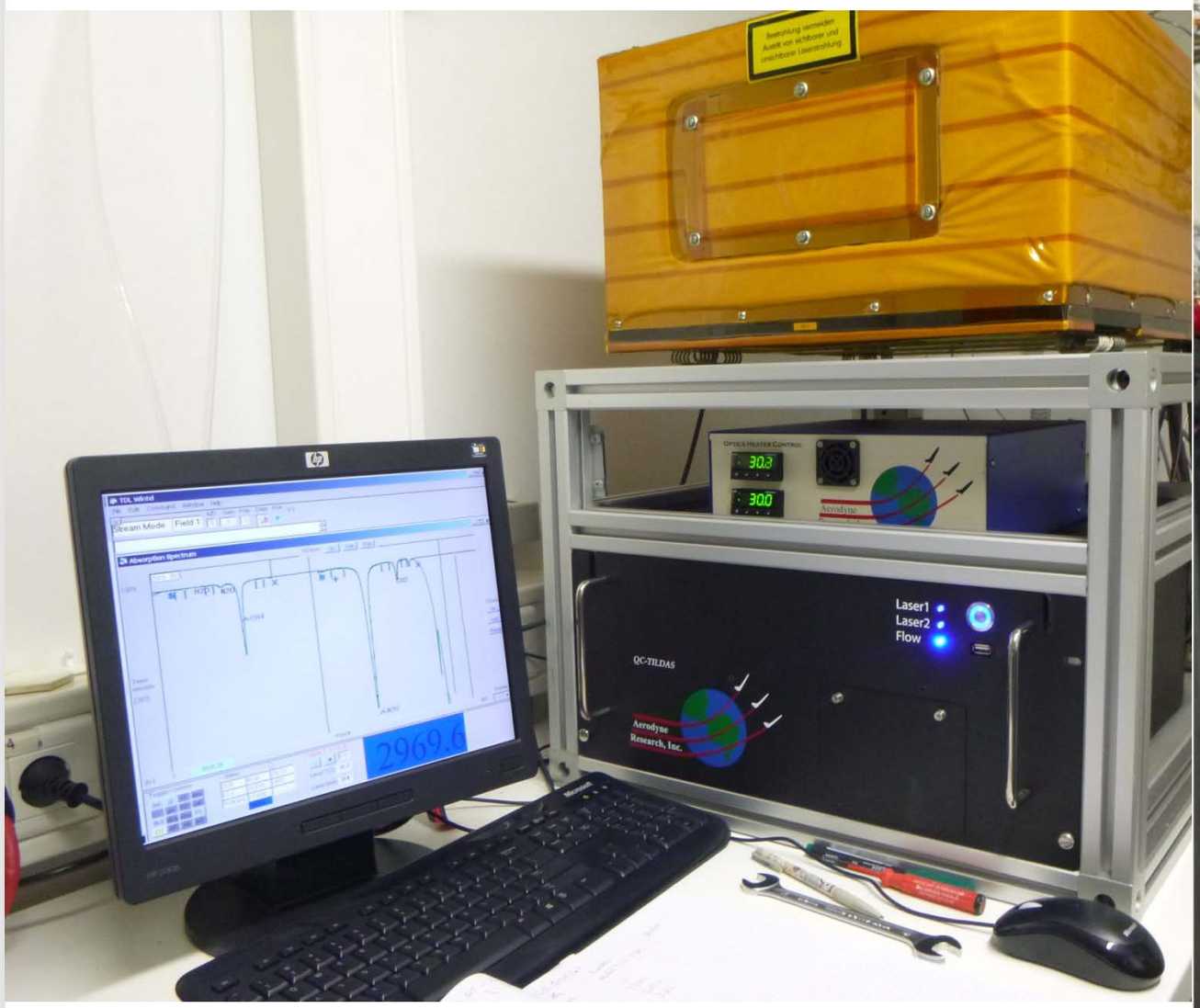
$o_3 = 2232.2\ cm^{-1}$

Rothman et al. , The HITRAN 2008 molecular spectroscopic database, Journal of Quantitative Spectroscopy & Radiative Transfer 110 (2009) 533–572

(adapted from:http://www2.ess.ucla.edu/~schauble/MoleculeHTML/N2O_html/N2O_page.html)

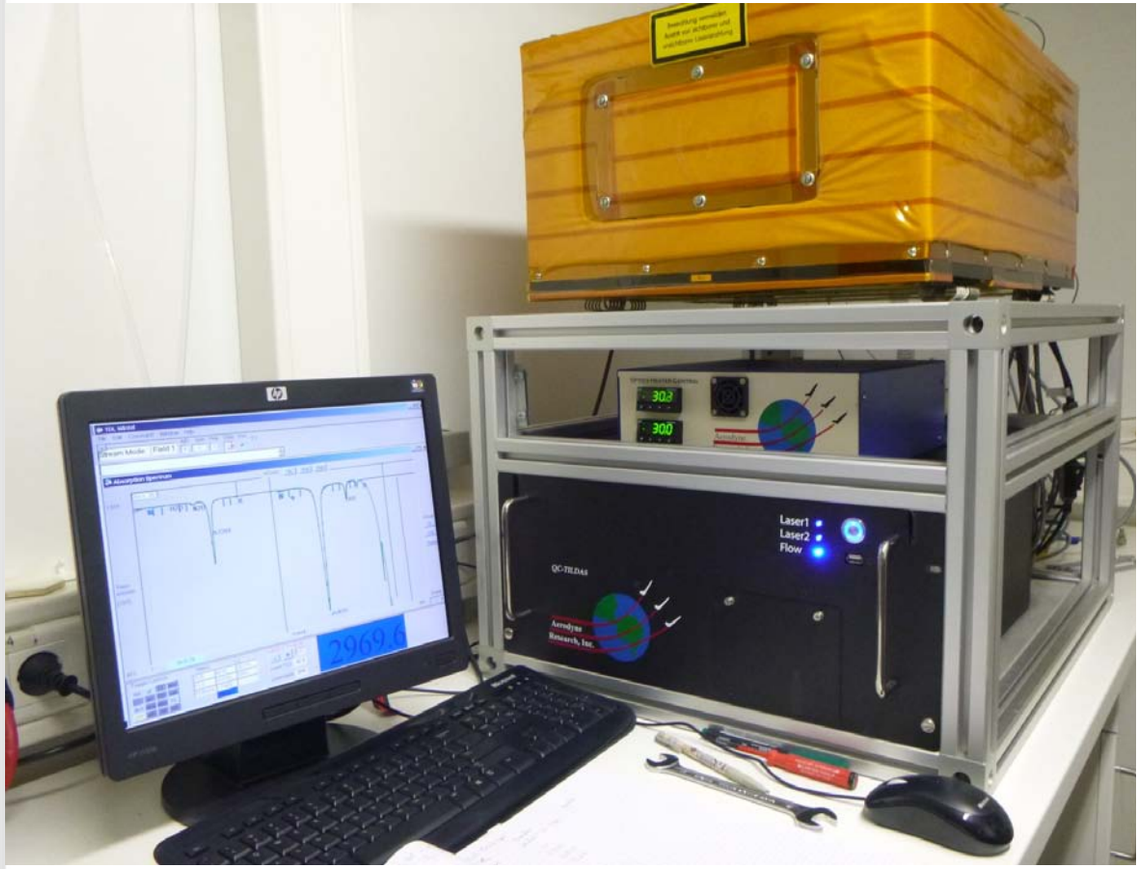
High precision spectroscopic methods

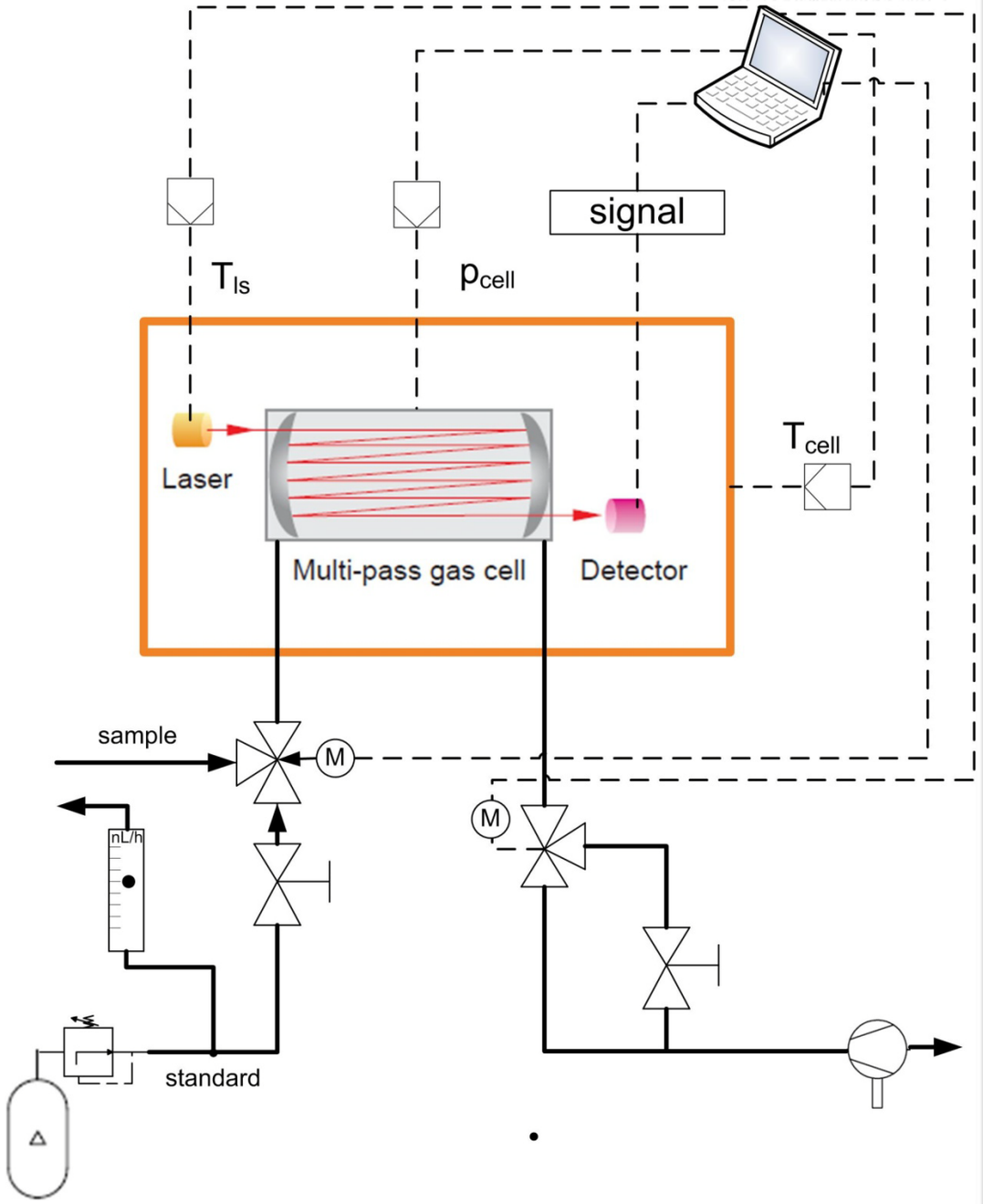
Quantum Cascade Lasers



High precision spectroscopic methods

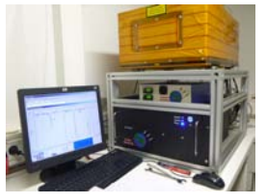
Contineous Wave Quantum Cascade Lasers (CW-QCL)

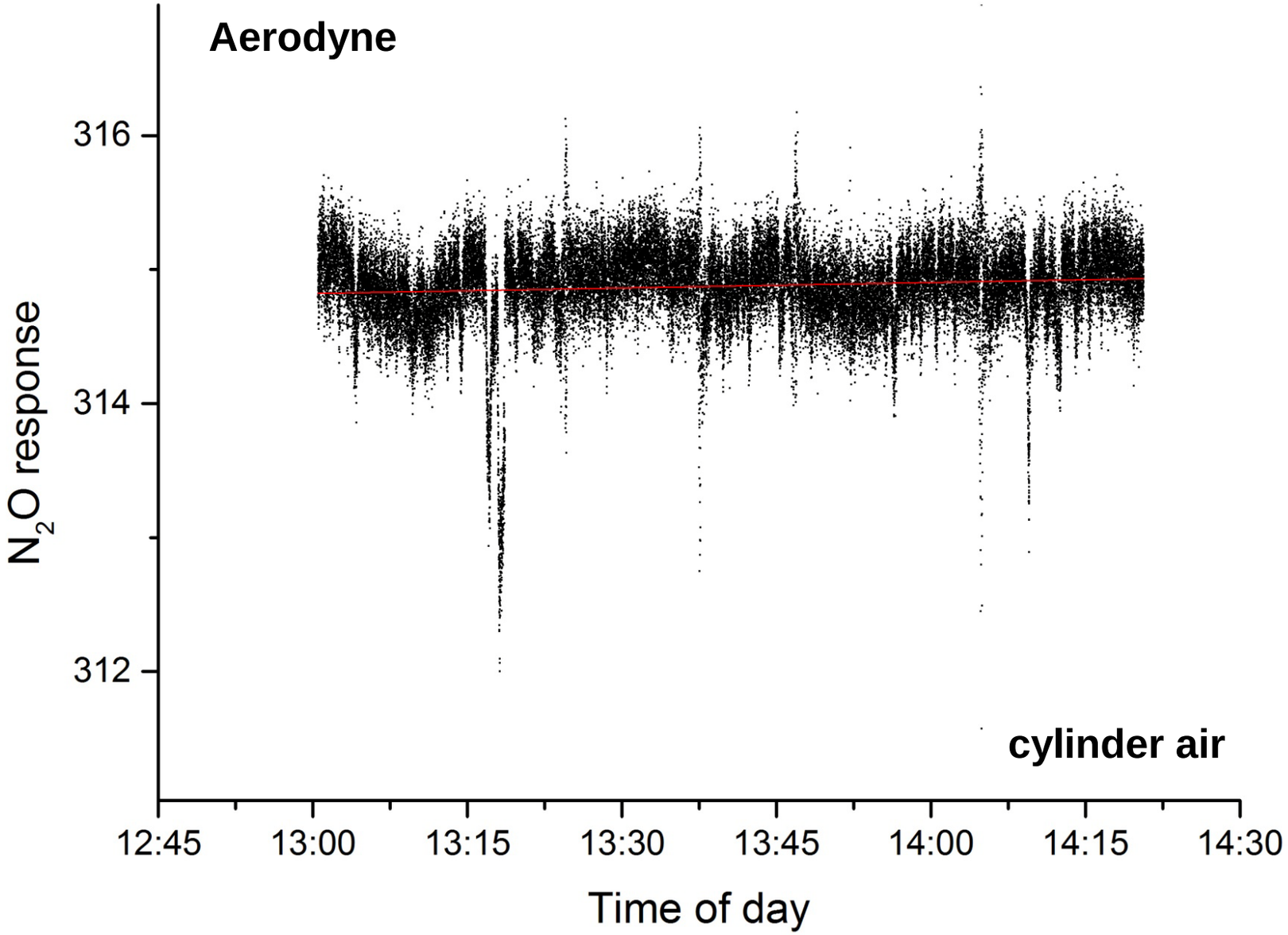




High precision spectroscopic methods

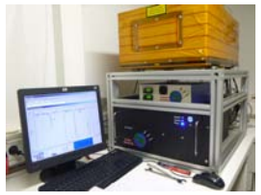
CW-QCL N_2O response: Noise

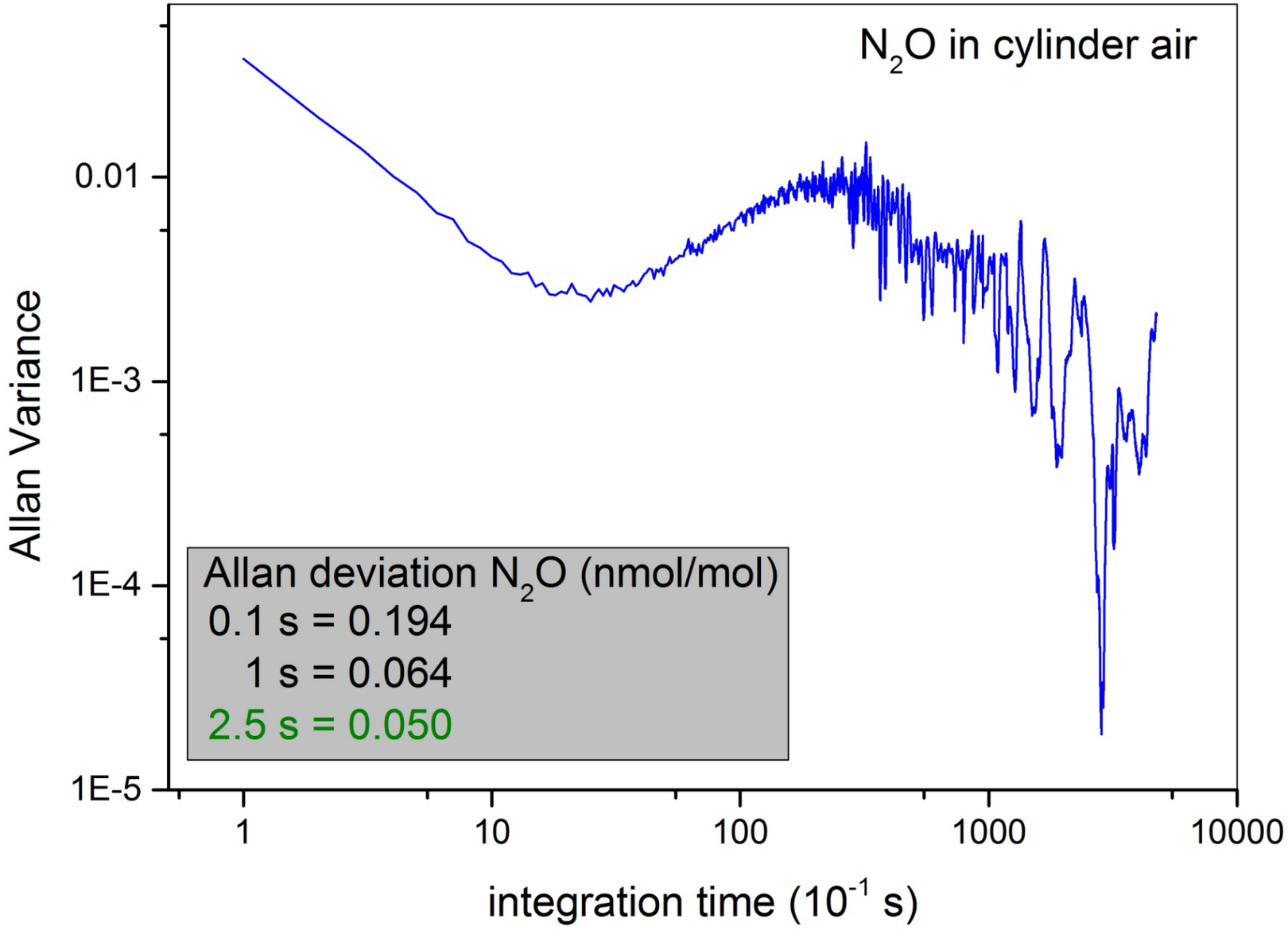




High precision spectroscopic methods

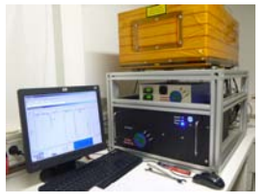
CW-QCL N_2O response: Noise

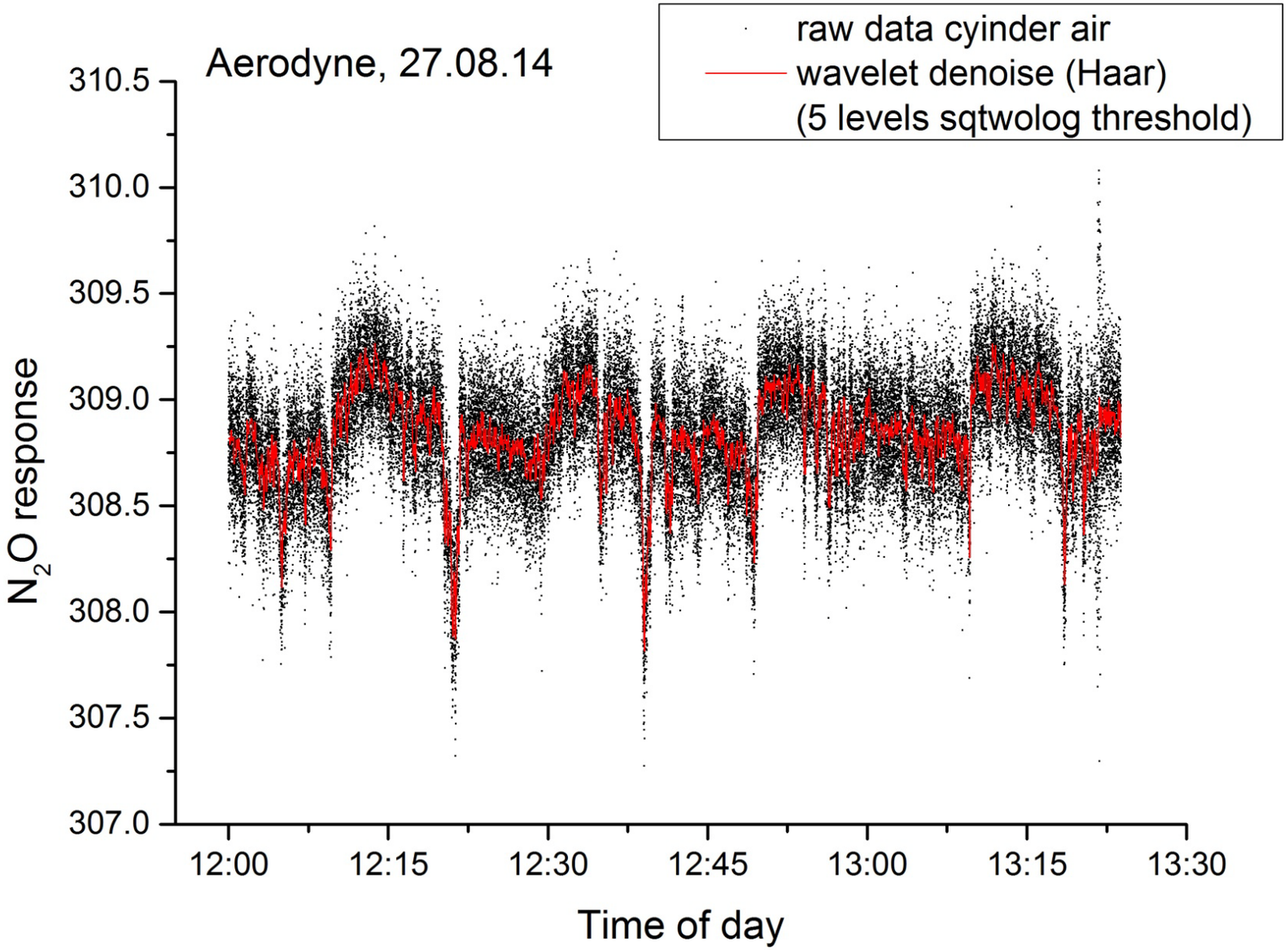




High precision spectroscopic methods

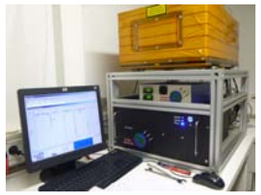
CW-QCL N_2O response: Noise

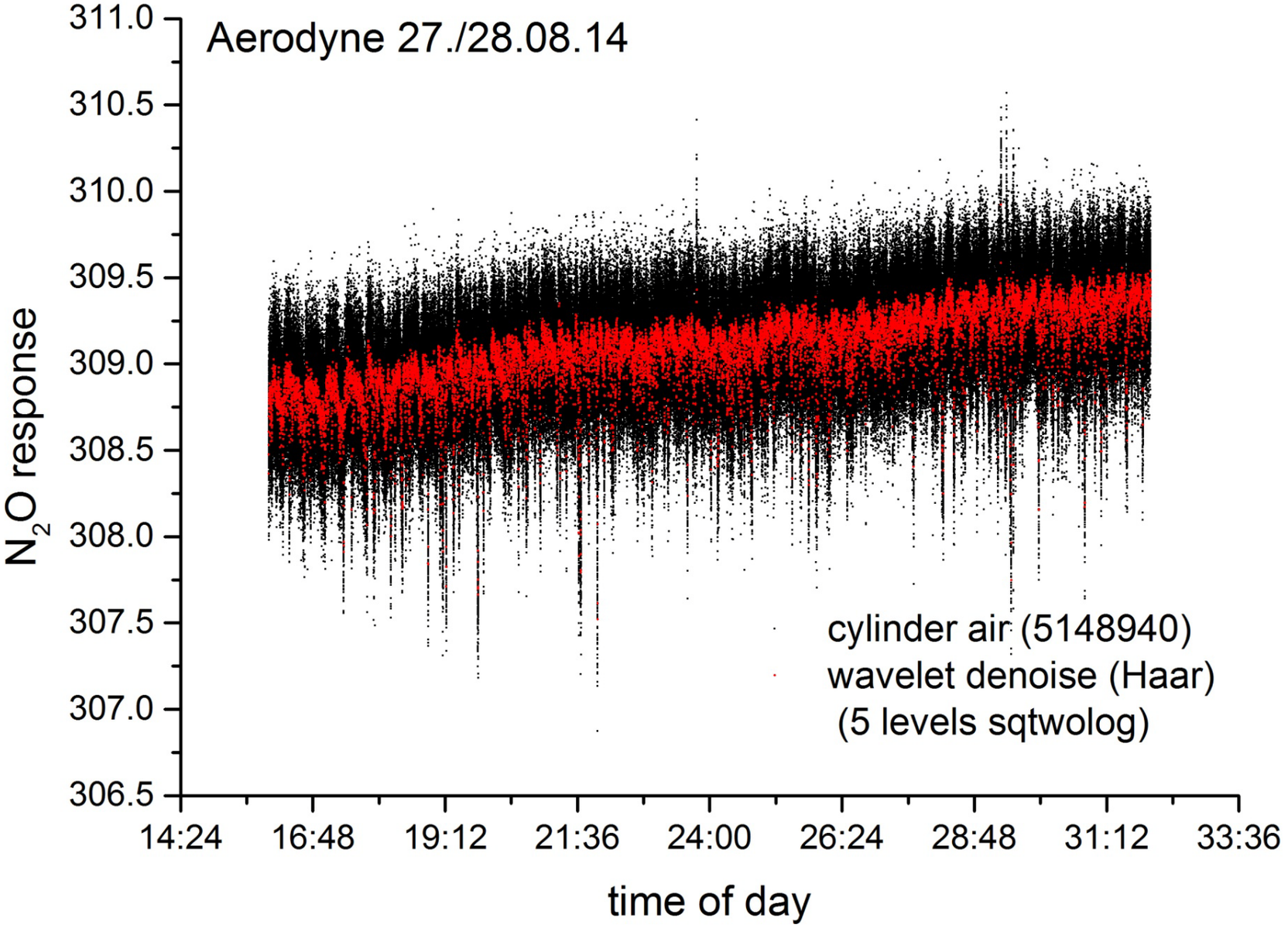




High precision spectroscopic methods

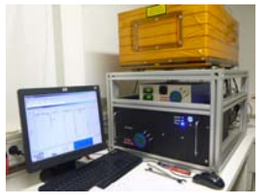
CW-QCL N_2O response: Drift

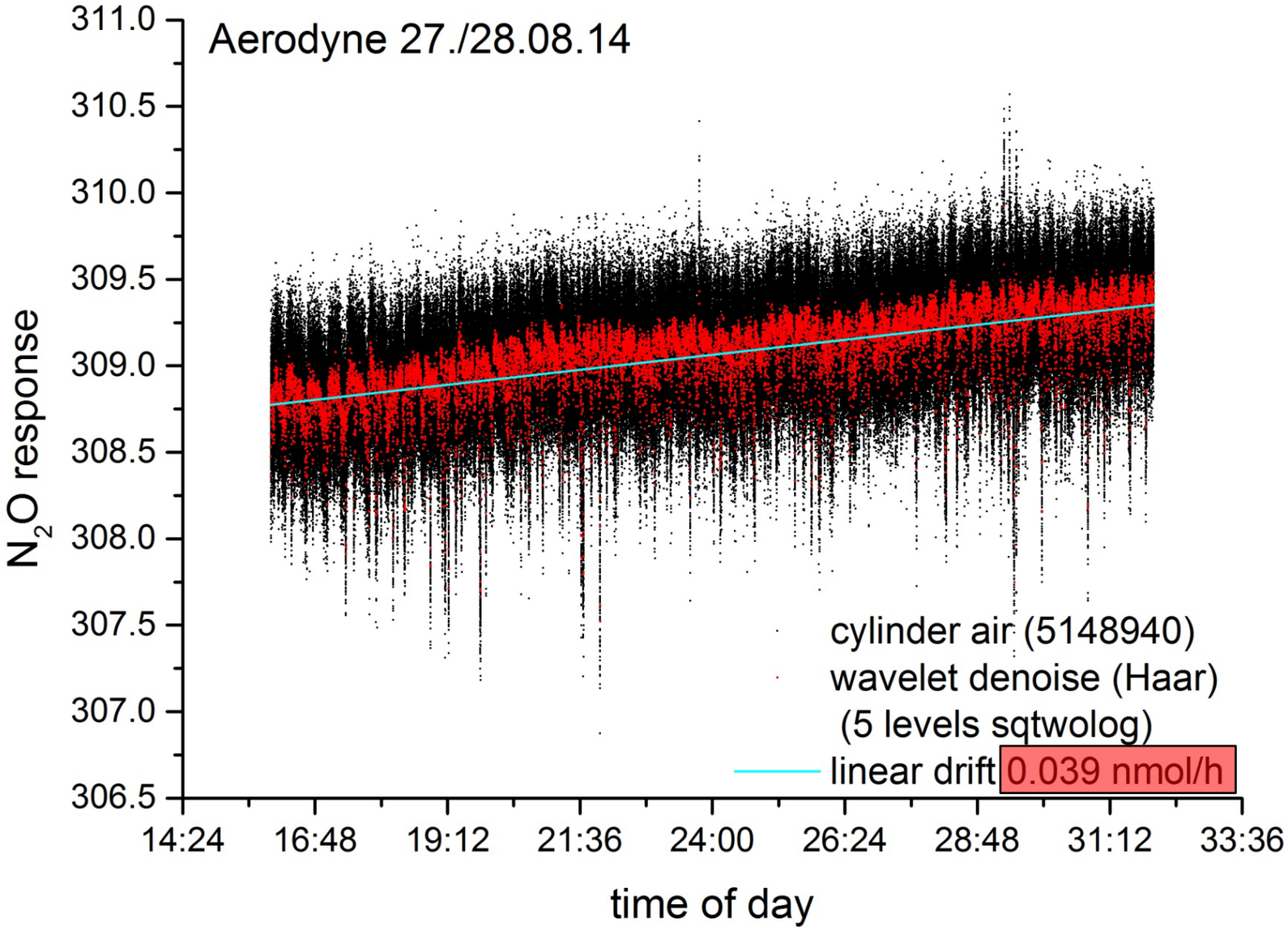




High precision spectroscopic methods

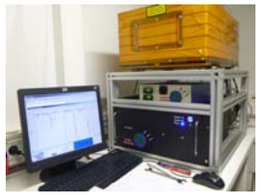
CW-QCL N_2O response: Drift

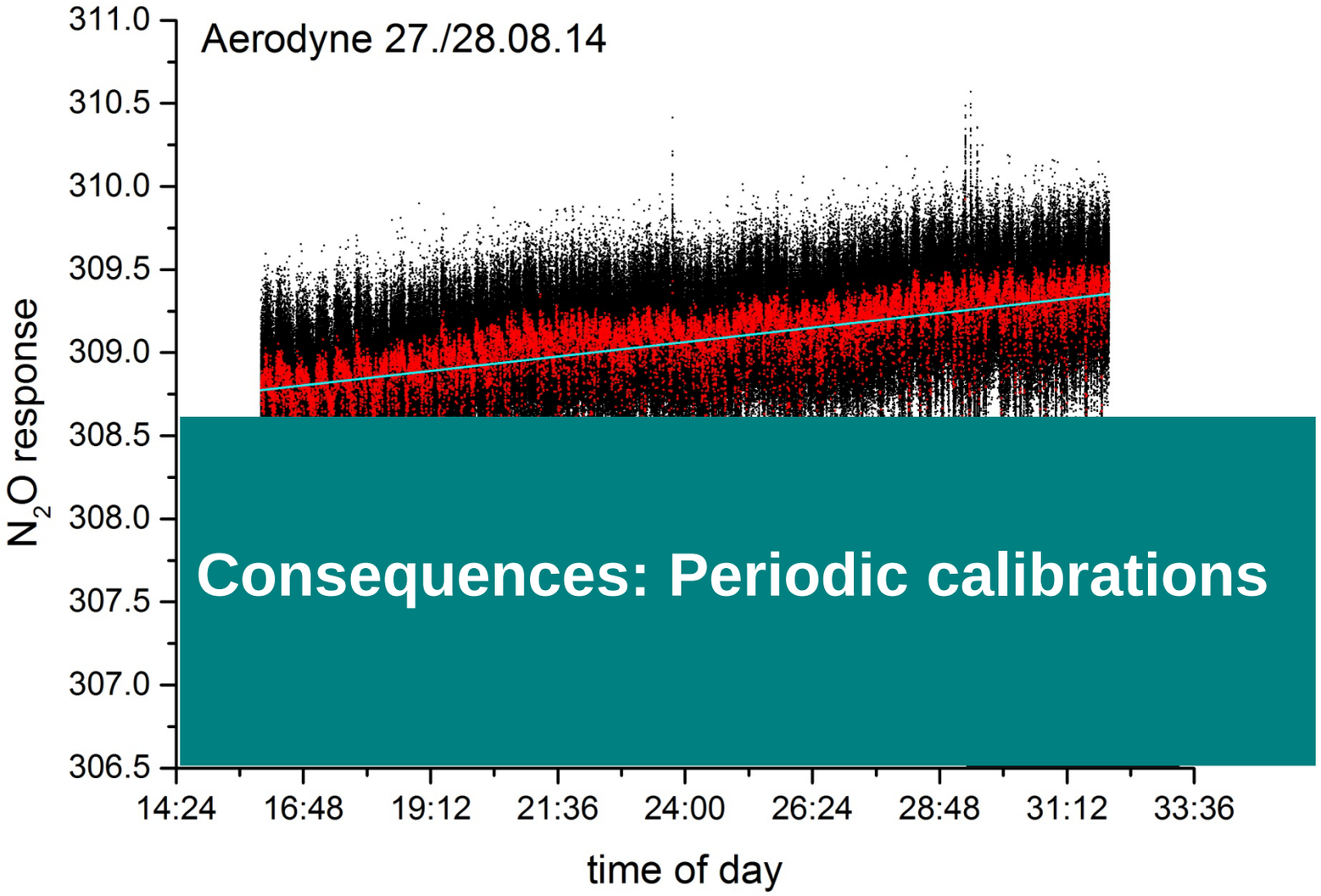




High precision spectroscopic methods

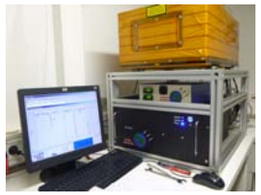
CW-QCL N_2O response: Drift

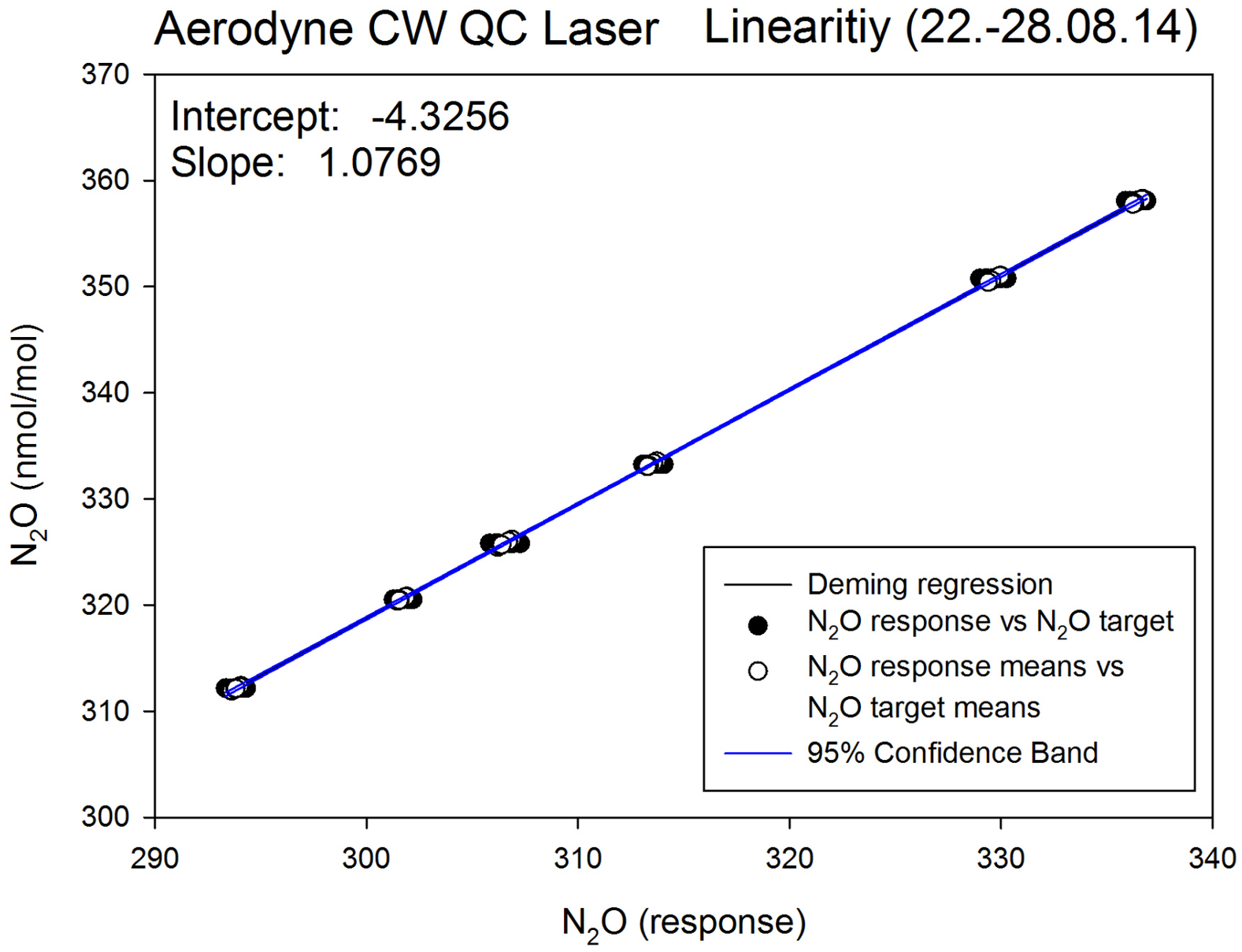




High precision spectroscopic methods

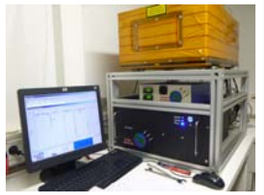
CW-QCL N_2O response: Linearity





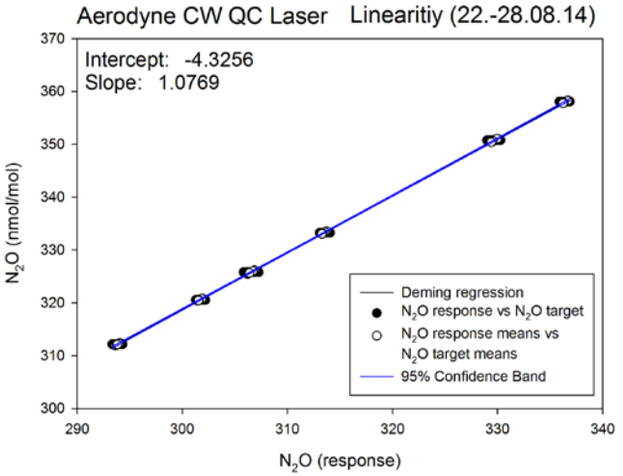
High precision spectroscopic methods

CW-QCL N_2O response: Long-term effects



2012

Intercept: -0.1182
Slope: 1.0194



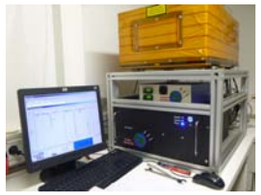
Sensitivity drop

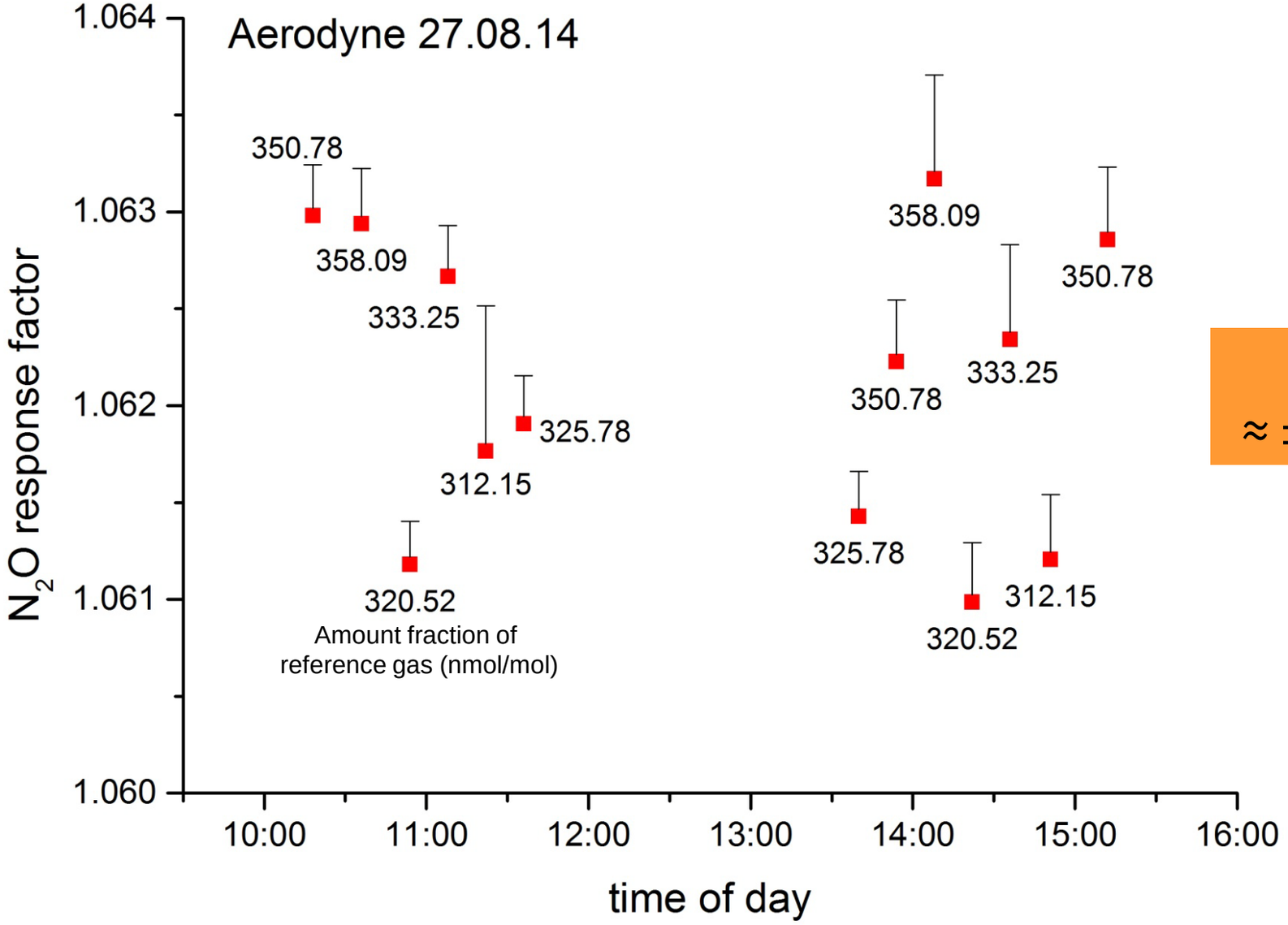
2014

Intercept: -4.3256
Slope: 1.0777

High precision spectroscopic methods

CW-QCL N_2O response: Calibration factors

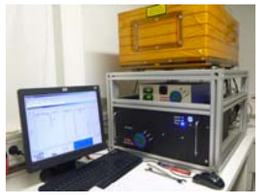


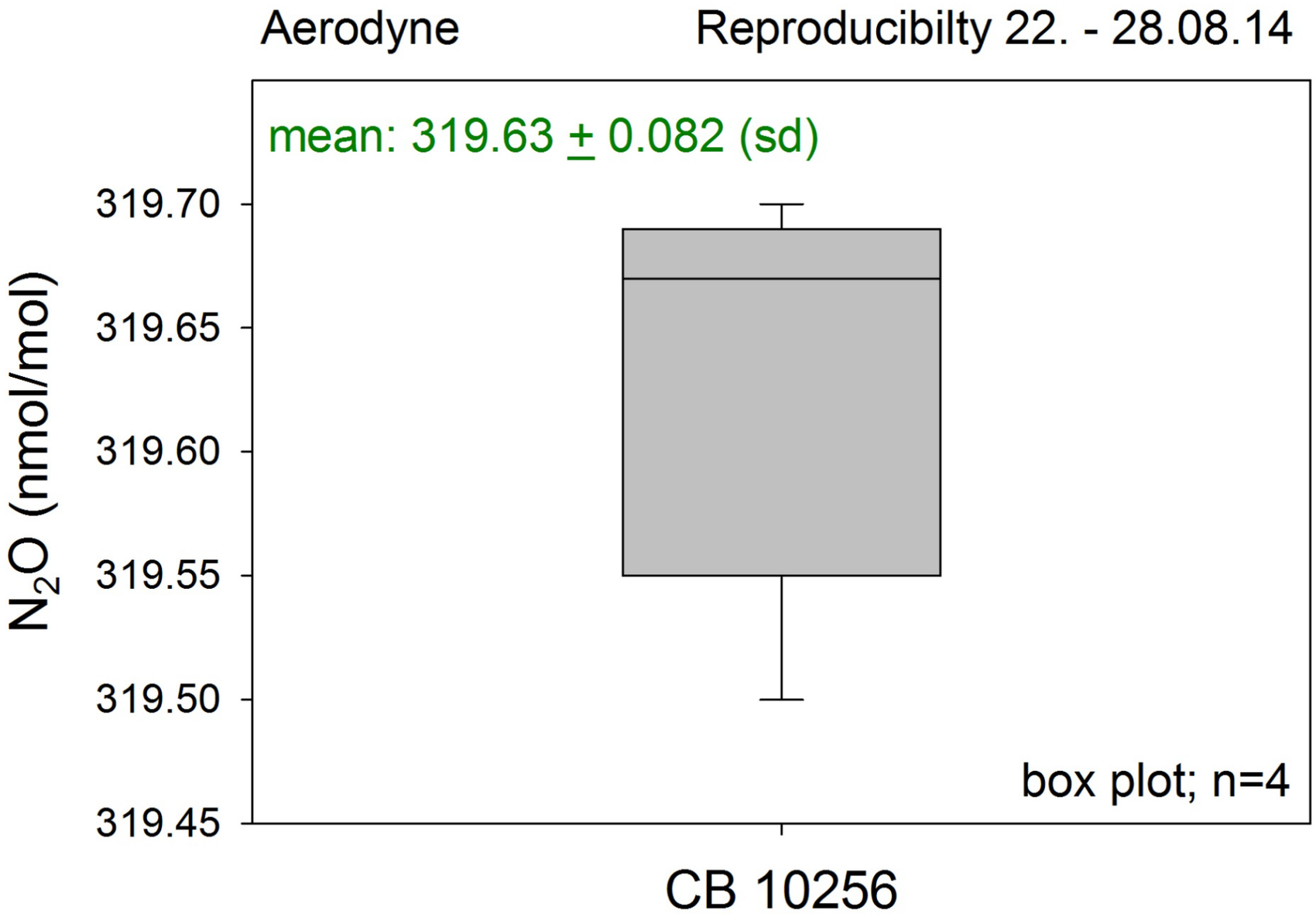


Variability:
≈ ± 0.3 nmol/mol

High precision spectroscopic methods

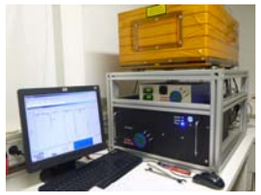
CW-QCL N_2O response: Reproducibility

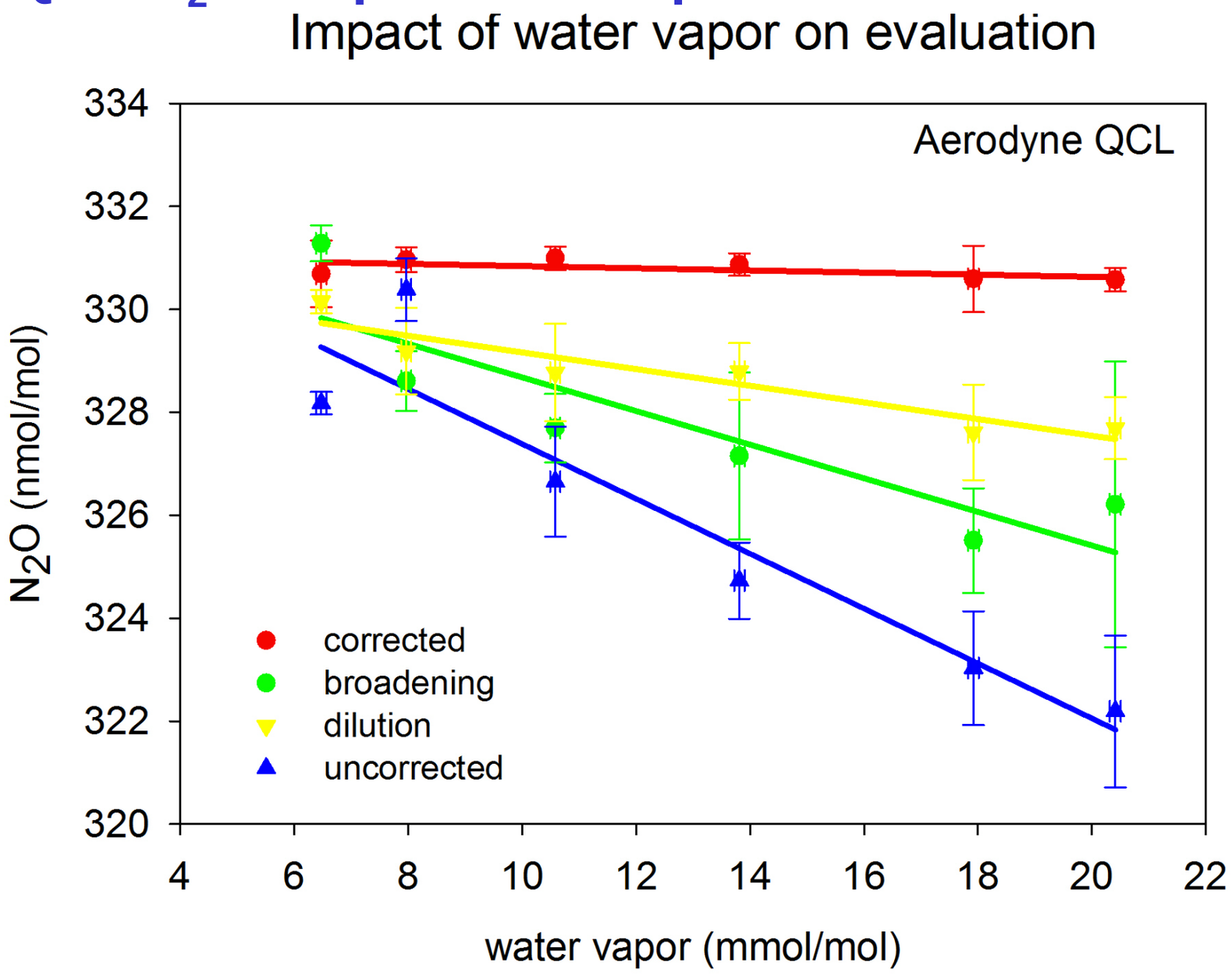




High precision spectroscopic methods

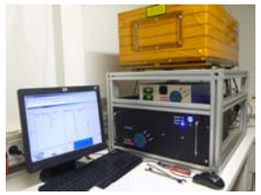
CW-QCL N_2O response: Sample water



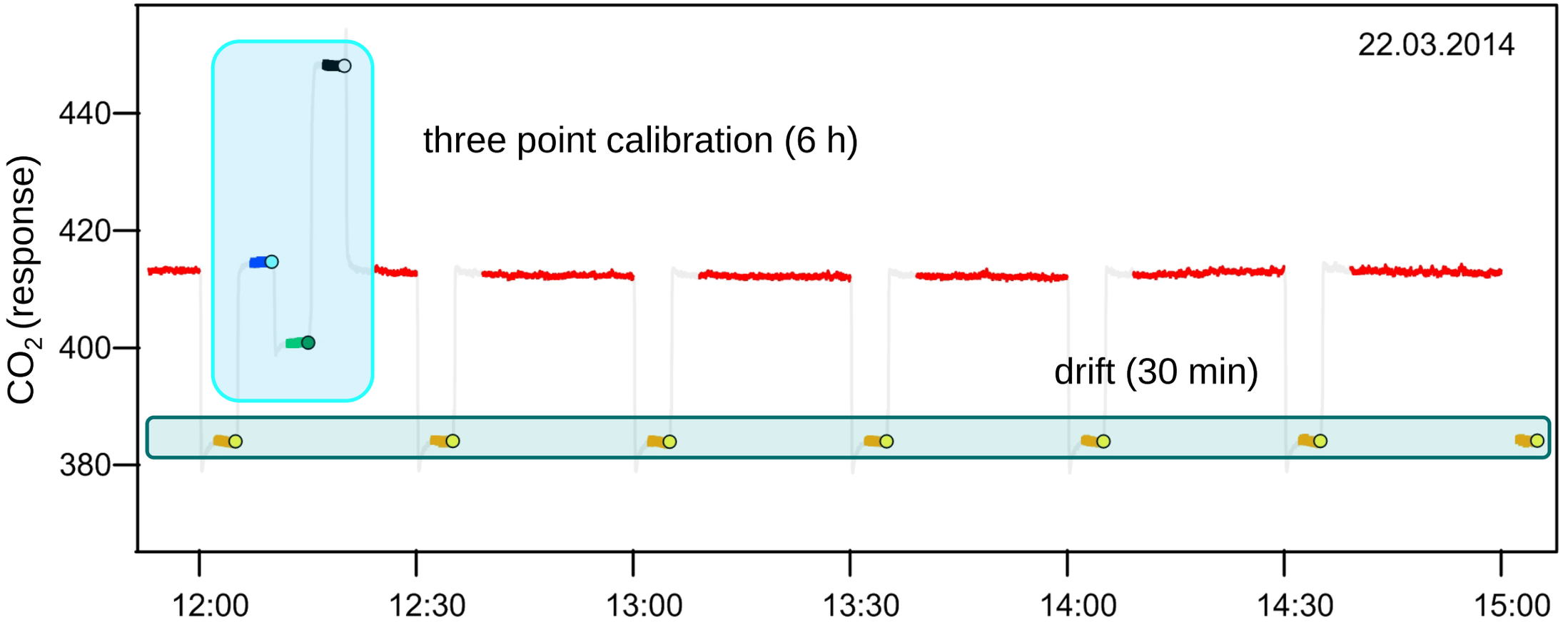


High precision spectroscopic methods

CW-QCL N_2O response: Measurement strategy



Suggestion: As developed for CO_2



(courtesy: Lukas Emmenegger, EMPA)

Summary and Conclusions

- Gobal N_2O emission increase with 0.80 nmol per year. With CO_2 emission reduction measures in place, the contribution to global warming is increasing.
- The analysis of trends, hemispheric differences, seasonal cycles, including studies on the effectiveness of N_2O emission mitigation measures requires a challenging network data compatibility of $\pm$ 0.1 nmol/mol.
- With the established GC/ECD techniques the DQOs for N_2O still remain a challenge to achieve as GAW MG are mostly not fully considered.
- Spectroscopic measurement techniques are an alternative.
- ***But***: Also with CW-QC Lasers, DQOs remain a challenge.

- ***GAW net work data compatibility with spectroscopic techniques requires noise, drift, sensitivity and water corrections of the raw signal based on GAW approved MG and standards.***

Thanks for your attention and the German Environment Agency for funding.

JeJu-Gosean, Republik Korea
(33.29 N; 126.16 E; 71 m asl)

Particular thanks goes to all GAW partners in particular:

Oksana Tarasova (GAW Secretariat)

Brad Hall (Central Calibration Laboratory, NOAA)

Christoph Zellweger, EMPA Switzerland,

and all contributing GAW station people

Anmyeon-do (AMY), Republik Korea
(36.53°N 126.33°E; (46 m asl)