

CINDI-2 intercalibration campaign



Michel Van Roozendael

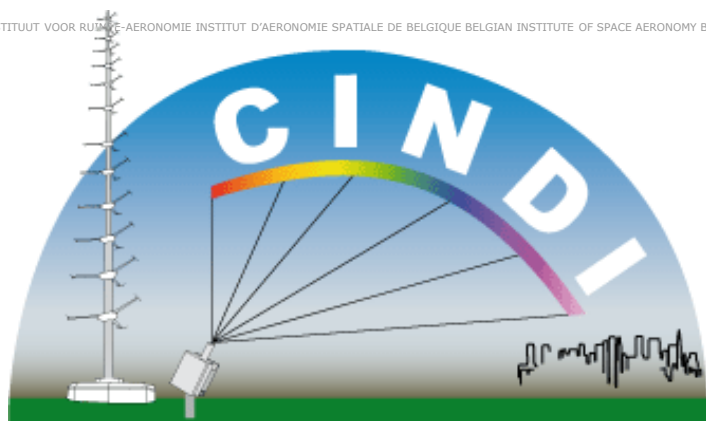
BIRA-IASB

Heritage – CINDI-I 2009

www.atmos-meas-techn.net/043/2012/

doi:10.5194/amt-5-457-2012

© Author(s) 2012. CC Attribution 3.0 License.



The Cabauw Intercomparison campaign for Nitrogen Dioxide measuring Instruments (CINDI): design, execution, and early results

A. J. M. Piters¹, K. F. Boersma^{1,2}, M. Kroon¹, J. C. Hains³, M. Van Roozendaal⁴, F. Wittrock⁵, N. Abuhassan^{6,7}, C. Adams⁸, M. Akrami⁸, M. A. F. Allaart¹, A. Apituley^{10,11}, S. Beirle²⁴, J. B. Bergwerff¹⁰, A. J. C. Berkhout¹⁰, D. Brunner¹¹, A. Cede^{12,7}, J. Chong¹³, K. Clémer⁴, C. Fayt⁴, U. Frieß¹⁴, L. F. L. Gast¹⁰, M. Gil-Ojeda⁹, F. Goutail¹⁵, R. Graves¹⁶, A. Griesfeller¹⁵, K. Großmann¹⁴, G. Hemerijckx⁴, F. Hendrick⁴, B. Henzing¹⁷, J. Herman^{12,7}, C. Hermans⁴, M. Hoexum¹⁰, G. R. van der Hoff¹⁰, H. Irie¹⁸, P. V. Johnston¹⁹, Y. Kanaya¹⁸, Y. J. Kim¹³, H. Klein Baltink¹, K. Kreher¹⁹, G. de Leeuw^{17,20,27}, R. Leigh¹⁶, A. Merlaud⁴, M. M. Moerman¹⁷, P. S. Monks¹⁶, G. H. Mount²¹, M. Navarro-Comas⁹, H. Oetjen²², A. Pazmino¹⁵, M. Perez-Camacho⁹, E. Peters⁵, A. du Piesanie¹, G. Pinardi⁴, O. Puentedura⁹, A. Richter⁵, H. K. Roscoe²³, A. Schönhardt⁵, B. Schwarzenbach¹¹, R. Shaiganfar²⁴, W. Sluis¹, E. Spinei²¹, A. P. Stolk¹⁰, K. Strong⁸, D. P. J. Swart¹⁰, H. Takashima¹⁸, T. Vlemmix¹, M. Vrekoussis^{5,26}, T. Wagner²⁴, C. Whyte⁸, K. M. Wilson^{10,1}, M. Yela⁹, S. Yilmaz¹⁴, P. Zieger²⁵, and Y. Zhou¹¹

¹Royal Netherlands Meteorological Institute (KNMI), De Bilt, The Netherlands

²Technical University Eindhoven (TUE), Eindhoven, The Netherlands

³Maryland Department of the Environment (MDE), Baltimore, MD, USA

⁴Belgian Institute for Space Aeronomy (BIRA-IASB), Brussels, Belgium

⁵Institute of Environmental Physics (IUP), University of Bremen, Bremen, Germany

⁶Morgan State University (MSU), Baltimore, MD, USA

⁷NASA/Goddard Space Flight Center (GSFC), Greenbelt, MD, USA

⁸Department of Physics, University of Toronto, Toronto, Ontario, Canada

⁹National Institute for Aerospace technology (INTA), Madrid, Spain

¹⁰National Institute for Public Health and the Environment (RIVM), Bilthoven, The Netherlands

¹¹Swiss Federal Laboratories for Materials Science and Technology (EMPA), Dübendorf, Switzerland

¹²University of Maryland, Baltimore County (UMBC), Catonsville, MD, USA

¹³Gwangju Institute of Science and Technology, Gwangju, Republic of Korea

¹⁴Institute of Environmental Physics, University of Heidelberg, Heidelberg, Germany

¹⁵Laboratoire Atmosphères, Milieux, Observations Spatiales (LATMOS), Guyancourt, France

¹⁶Department of Chemistry, University of Leicester, Leicester, UK

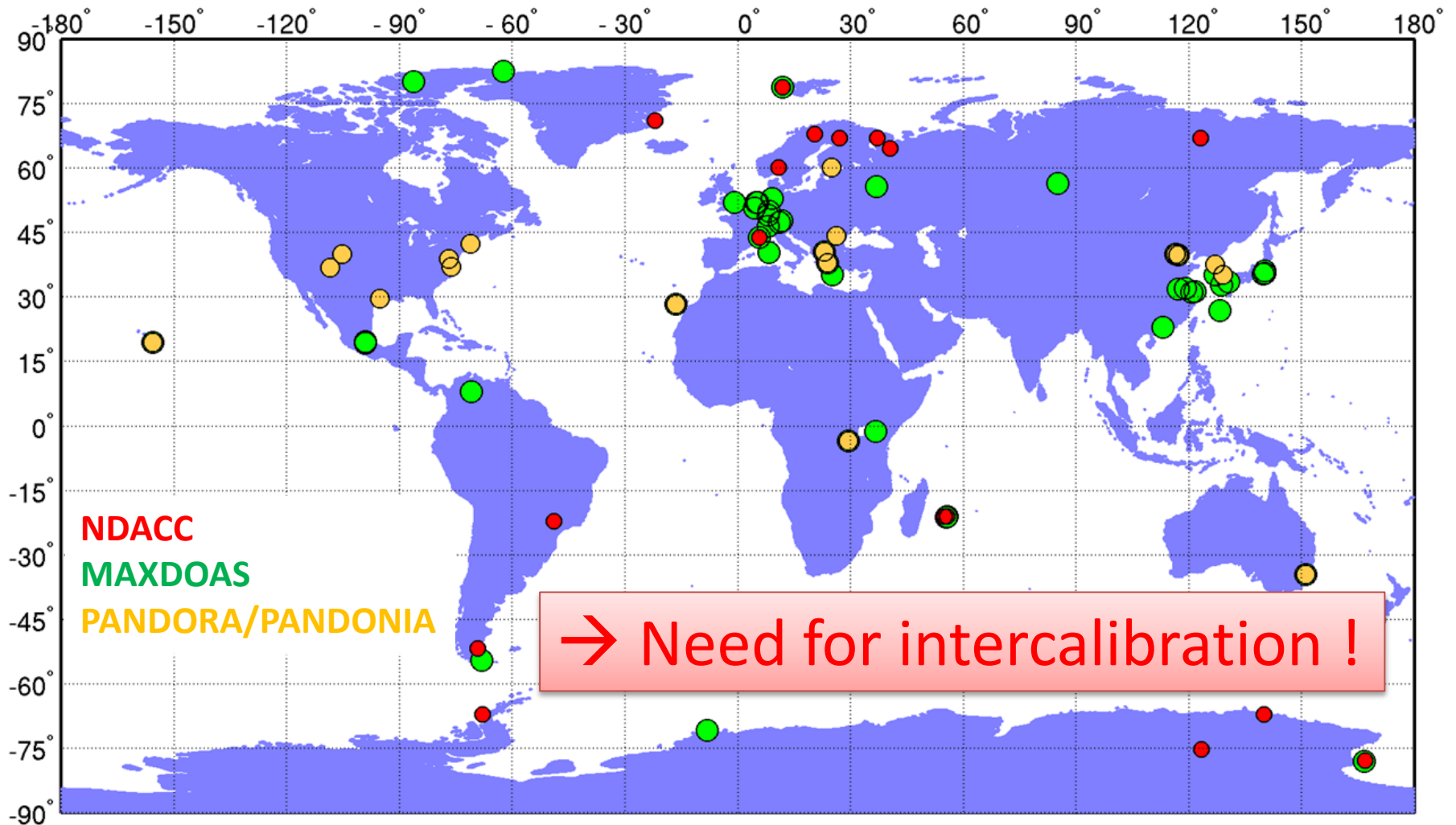
¹⁷Netherlands Organisation for Scientific Research (NWO), Bilthoven, The Netherlands



June-July 2009

Piters et al., AMT, 2012

Emerging capacity for NO₂ monitoring



CINDI-2 participants



Participants already involved in CINDI-1

#	Institute	Country	Contact Person	Proposed instrumentation	
1	BIRA-IASB	Belgium	M. Van Roozendael	3D-MAXDOAS, CAPS, car-DOAS	
2	IUP Br	13 CSIC, Madrid	Spain	A. Saiz-Lopez	MAXDOAS
3	KNMI	14 AUTH, Thessaloniki	Greece	A. Bais	PHAETON
4	RIVM	15 Boku	Austria	S. Schreier	3D-MAXDOAS
5	Unive	16 Belarus University	Belarus	I. Bruchkouski	MAX-DOAS (MARS-B)
6	INTA	17 University of Montevideo	Uruguay	E. Frins	Mini-DOAS
7	CEReS	18 DLR-IMF	Germany	N. Hao	Mini-DOAS + Pandora
8	MPIC-	19 St. Petersburg University	Russia	D. Ionov	Zenith-sky Ocean Optics
9	LATM	20 CU-Boulder	USA	R. Volkammer	3D-MAXDOAS
10	Unive	21 IAP	Russia	O. Postlyakov	IAP 2-port DOAS spectrometer
11	Luftbl	22 AIOFM	China	P. Xie	2D-MAXDOAS, mini-DOAS, CE-DOAS
12	Unive	23 Munich University	Germany	M. Wenig	EnVimes 2D-MAXDOAS
		24 University of Galati	Romania	D. Constantin	Avantes car-DOAS
		25 Environmental Institute of Islamabad	Pakistan	M. F. Khokhar	Mini-DOAS
		26 Melbourne Met-Office	Australia	M. Tully	MAXDOAS
		27 Indian Institute of Science Education and Research	India	V. Sinha	Mini-DOAS
		28 DWD	Germany	R. Holla	MAXDOAS
		29 University of Delft	NL	T. Vlemmix	Mobile NO ₂ -sonde
		30 FMI, Helsinki	Finland	H. Saari	VTT hyperspectral camera

New in CINDI-2

CINDI-2

1-28/09/2016



Instrumental deployment



BELGISCH INSTITUUT VOOR RUIMTE-AERONOMIE INSTITUT D'AERONOMIE SPATIALE DE BELGIQUE BELGIAN INSTITUTE OF SPACE AERONOMY BELGISCH INSTITUUT VOOR RUIMTE-AERONOMIE INSTITUT D'AERONOMIE SPATIALE DE BELGIQUE BELGIAN INSTITUTE OF SPACE AERONOMY BELGISCH INSTITUUT VOOR RUIMTE-AERONOMIE INSTITUT D'AERONOMIE SPATIALE DE BELGIQUE BELGIAN INSTITUTE OF SPACE AERONOMY

Trace gases

- MAXDOAS 20
- Mini-DOAS 8
- PANDORA 6
- SAOZ 2
- LP-DOAS 1
- CE-DOAS 1
- I-DOAS 1
- Mobile-DOAS 3



MAXDOAS

42



In-situ

- CAPS 2
- NO₂ analysers 2
- NO₂ sondes 5



Other

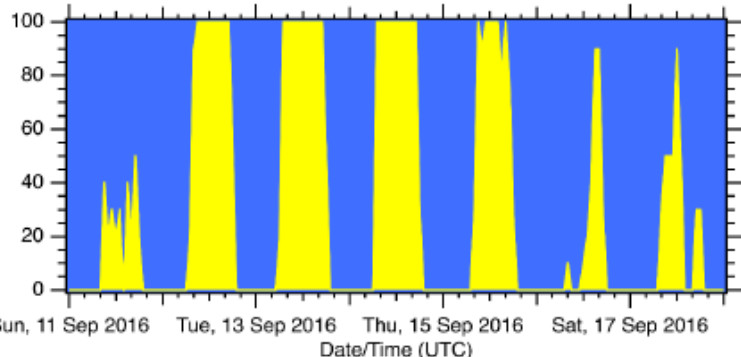
- RIVM Raman lidar
- VELETA lidar
- Sun photometer
- Ceilometer
- Ozone sondes
- In-situ ozone monitor
- Meteorological parameters
- TSI (all-sky imager)



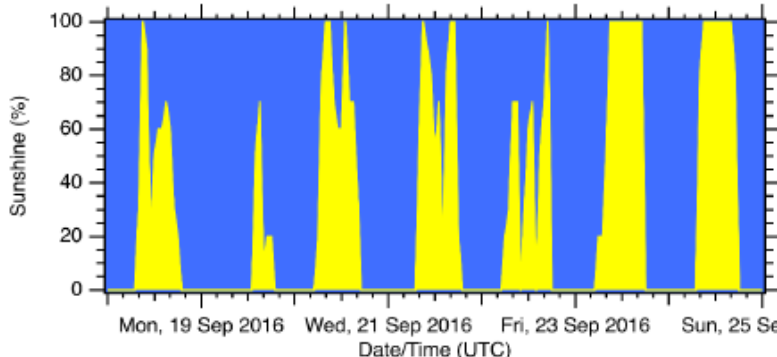
- **+ Modelling support**
 - **AQ forecast (CAM5)**
 - **Weather forecast**



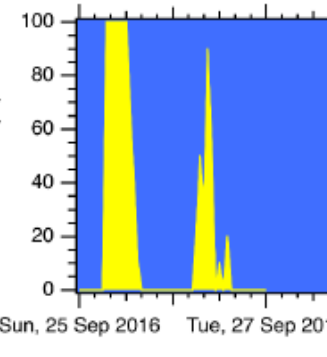
Sunshine Duration per Hour
Cabauw



Sunshine Duration per Hour
Cabauw



Sunshine Duration per Hour
Cabauw



Data product	Typical wavelengths
NO ₂ (VIS range)	425 – 490 nm
NO ₂ (UV range)	338 – 370 nm
O ₄ (VIS range)	425 – 490 nm
O ₄ (UV range)	338 – 370 nm
HCHO	336.5-359nm or 324.5 – 359 nm
O ₃ (Chappuis bands)	450 – 550 nm
O ₃ (Huggins bands)	320 – 340 nm
Relative intensity	340, 380, 440, 500 nm
Colour Index	To be defined

Viewing angles

- 1d: 287

- 2d: 287, 355, 45, 95, 135, 195, 245

Data products included in the semi-blind intercomparison exercise



Ermioni
Dimitropoulou

Karin
Kreher



Cabauw, The Netherlands

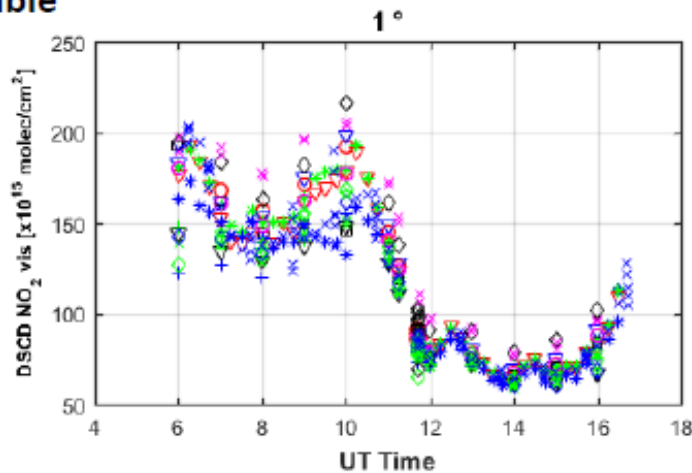
Semi-blind intercomparison

25 August – 7 October 2016

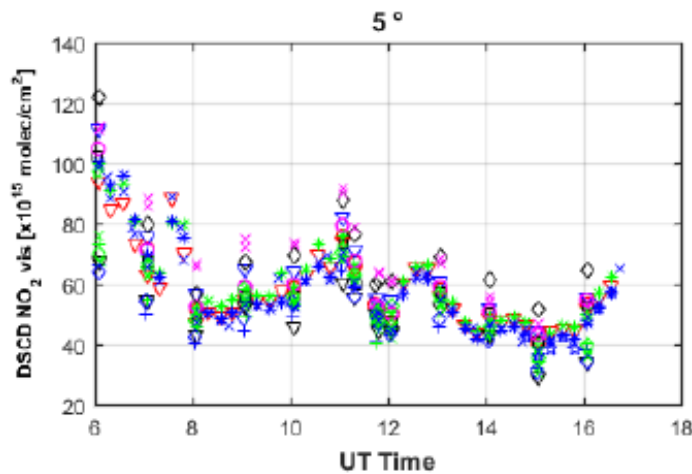
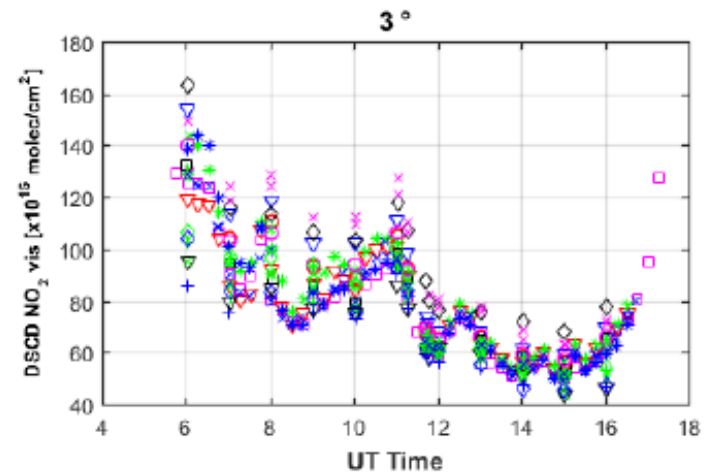
CINDI-2 semi-blind daily results

BELGISCH INSTITUUT VOOR RUIMTE-AERONOMIE INSTITUT D'AERONOMIE SPATIALE DE BELGIQUE BELGIAN INSTITUTE OF SPACE AERONOMY BELGISCH INSTITUUT VOOR RUIMTE-AERONOMIE INSTITUT D'AERONOMIE SPATIALE DE BELGIQUE BELGIAN INSTITUTE OF SPACE AERONOMY BELGISCH INSTITUUT VOOR RUIMTE-AERONOMIE INSTITUT D'AERONOMIE SPATIALE DE BELGIQUE BELGIAN INSTITUTE OF SPACE AERONOMY

NO₂ visible
24 Sep
2016

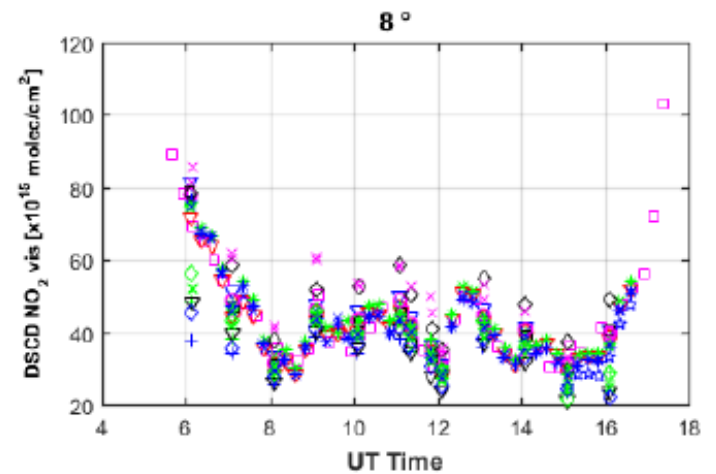


Azimuth Angle=287°

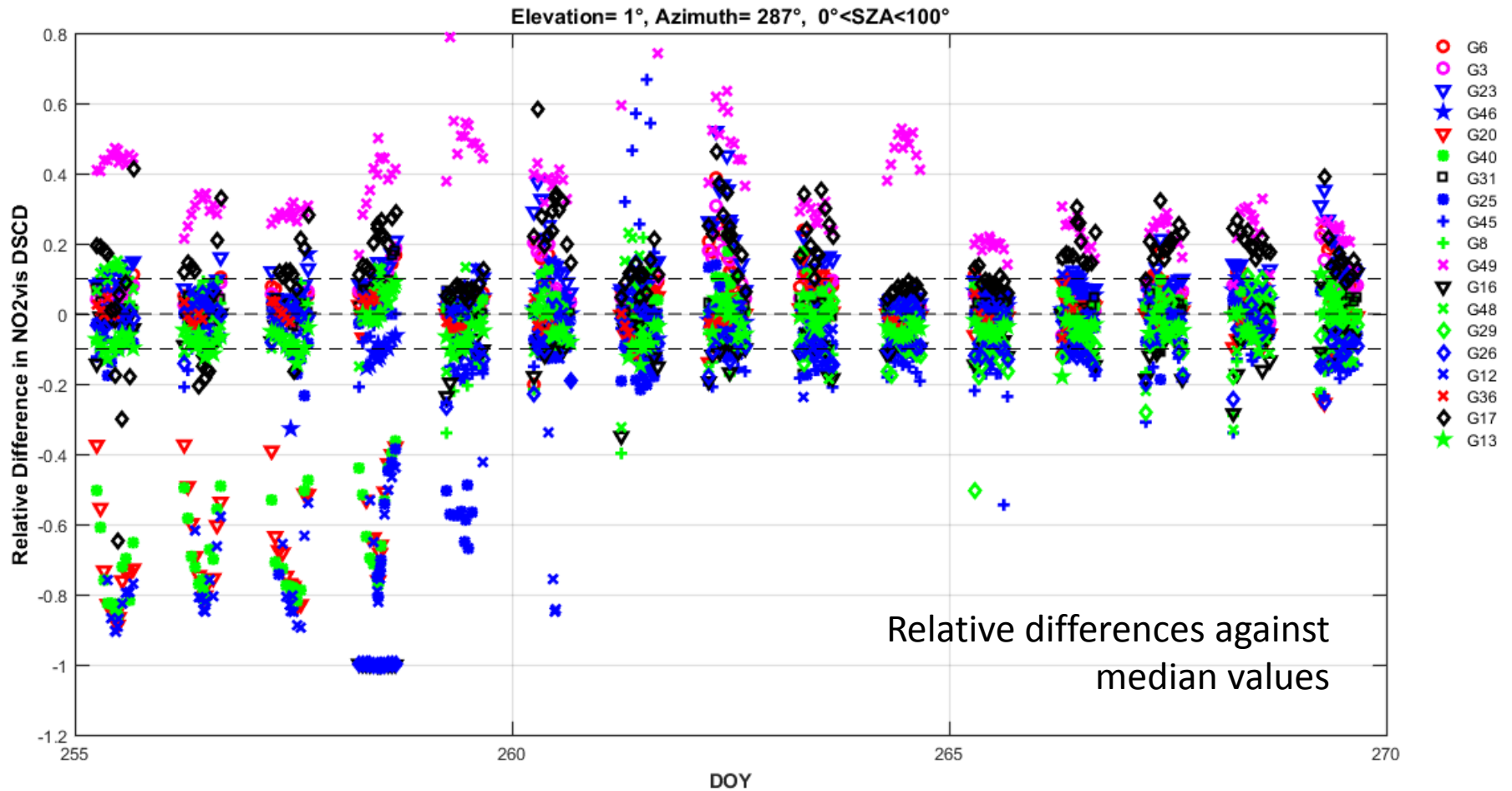


- (G6)
- ▽ (G23)
- ☆ (G27)
- △ (G20)
- ★ (G40)
- (G31)
- (G3)
- ★ (G25)
- +
- ◇ (G45)
- ◇ (G17)
- +
- ▽ (G16)
- × (G49)
- × (G48)
- ◇ (G29)
- ◇ (G26)
- ★ (G13)
- × (G12)

- (G6)
- ▽ (G23)
- ☆ (G27)
- △ (G20)
- ★ (G40)
- (G31)
- (G3)
- ★ (G25)
- +
- ◇ (G45)
- ◇ (G17)
- +
- ▽ (G16)
- × (G49)
- × (G48)
- ◇ (G29)
- ◇ (G26)
- ★ (G13)
- × (G12)

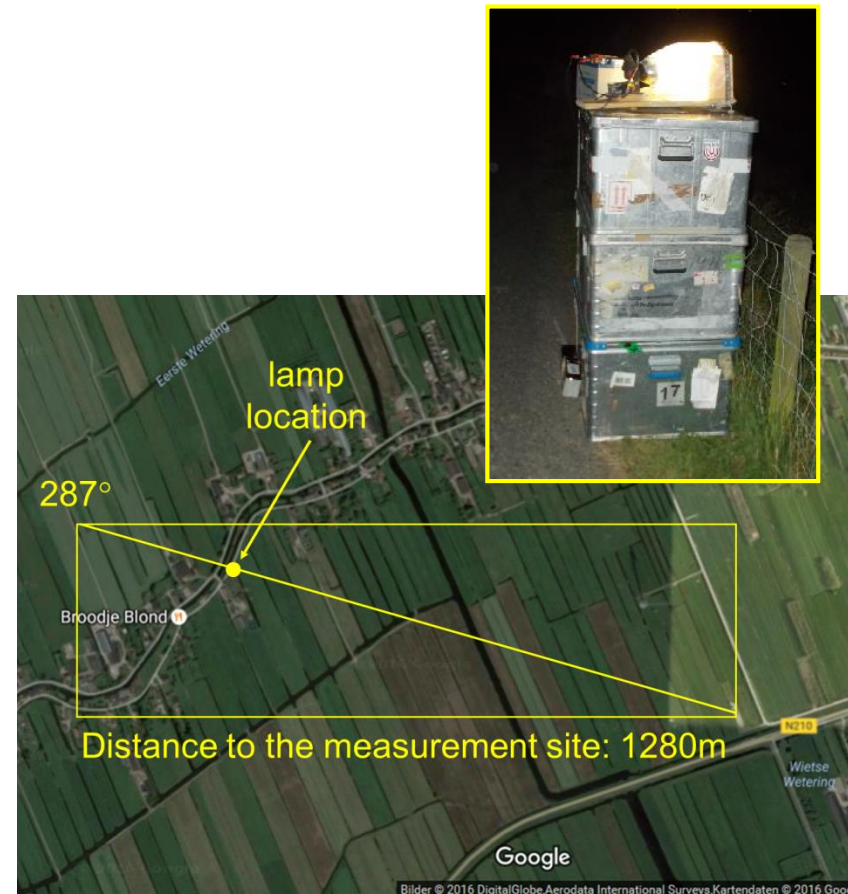
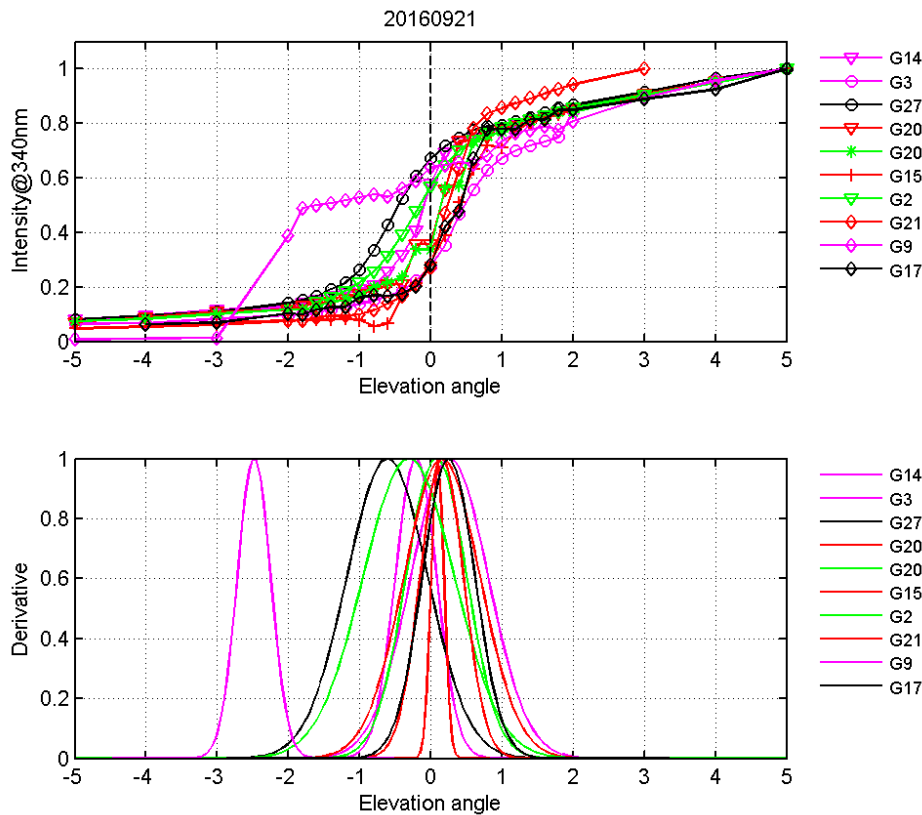


Evolution of agreement during the course of the campaign (NO₂)



Calibration of pointing accuracy

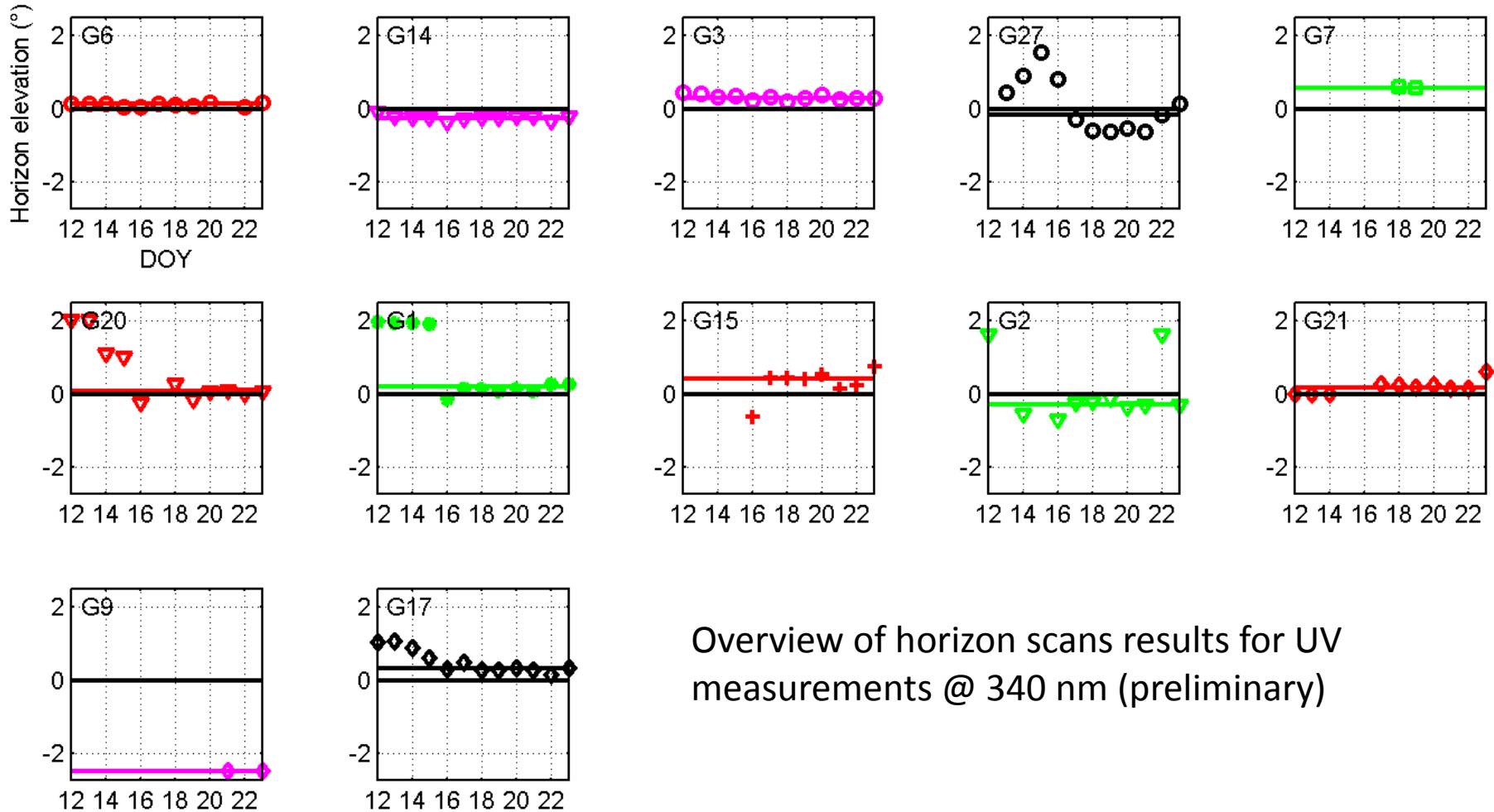
- Horizon scans plus lamp measurements



Calibration of pointing accuracy (2)

BELGISCH INSTITUUT VOOR RUIMTE-AERONOMIE INSTITUT D'AERONOMIE SPATIALE DE BELGIQUE BELGIAN INSTITUTE OF SPACE AERONOMY BELGISCH INSTITUUT VOOR RUIMTE-AERONOMIE INSTITUT D'AERONOMIE SPATIALE DE BELGIQUE BELGIAN INSTITUTE OF SPACE AERONOMY BELGISCH INSTITUUT VOOR RUIMTE-AERONOMIE INSTITUT D'AERONOMIE SPATIALE DE BELGIQUE BELGIAN INSTITUTE OF SPACE AERONOMY

Horizon scan analysis based on Intensity@340nm



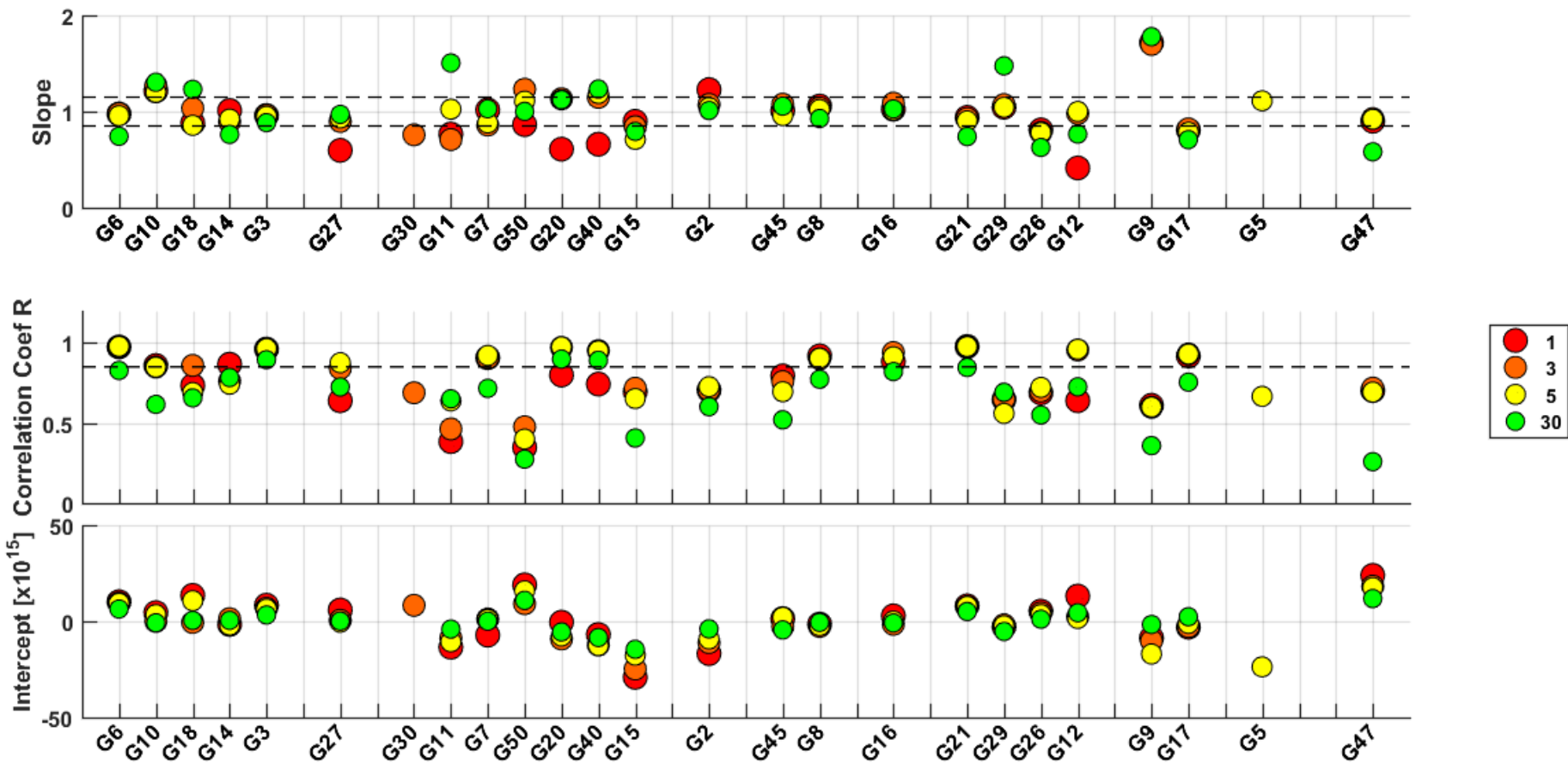
Overview of horizon scans results for UV measurements @ 340 nm (preliminary)

Correlations and statistical analysis

BELGISCH INSTITUUT VOOR RUIMTE-AERONOMIE INSTITUT D'AERONOMIE SPATIALE DE BELGIQUE BELGIAN INSTITUTE OF SPACE AERONOMY BELGISCH INSTITUUT VOOR RUIMTE-AERONOMIE INSTITUT D'AERONOMIE SPATIALE DE BELGIQUE BELGIAN INSTITUTE OF SPACE AERONOMY BELGISCH INSTITUUT VOOR RUIMTE-AERONOMIE INSTITUT D'AERONOMIE SPATIALE DE BELGIQUE BELGIAN INSTITUTE OF SPACE AERONOMY

HCHO DSCD

Regression analysis for HCHO, Azimuth= 287



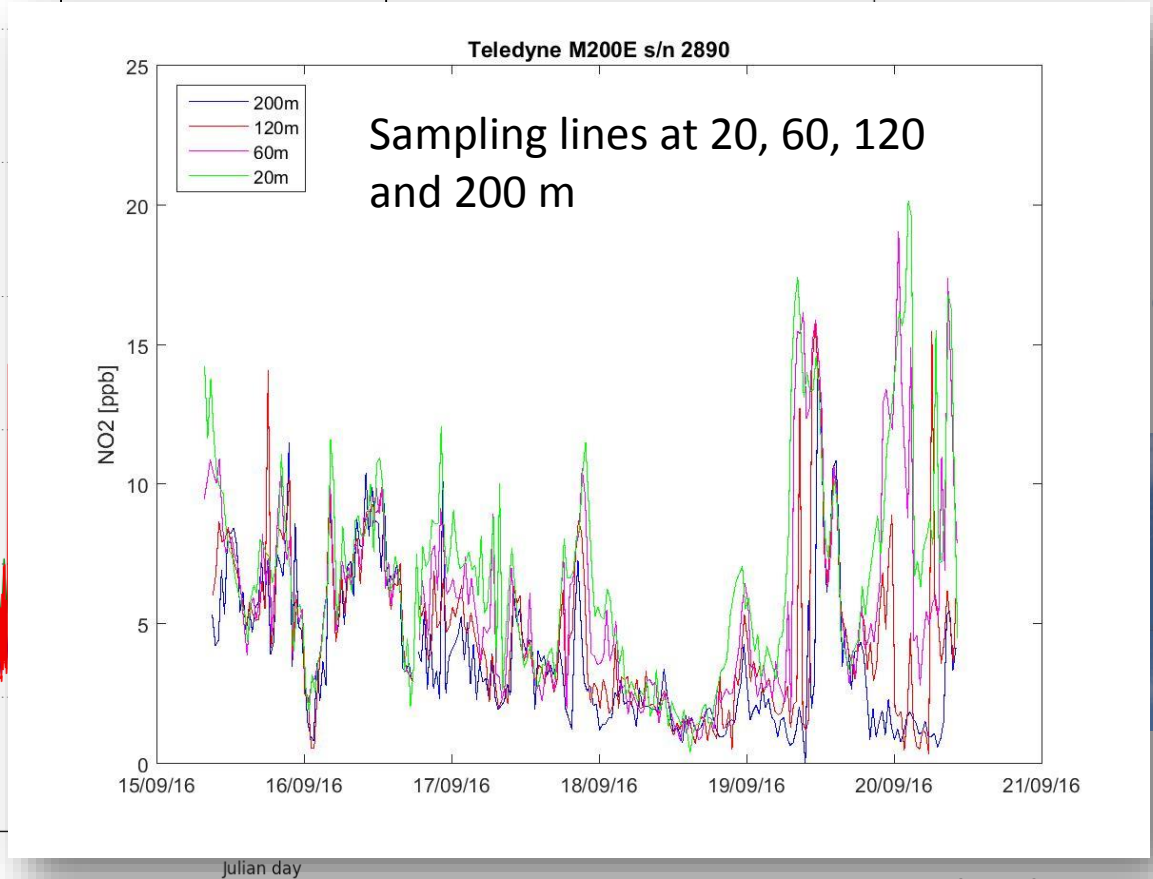
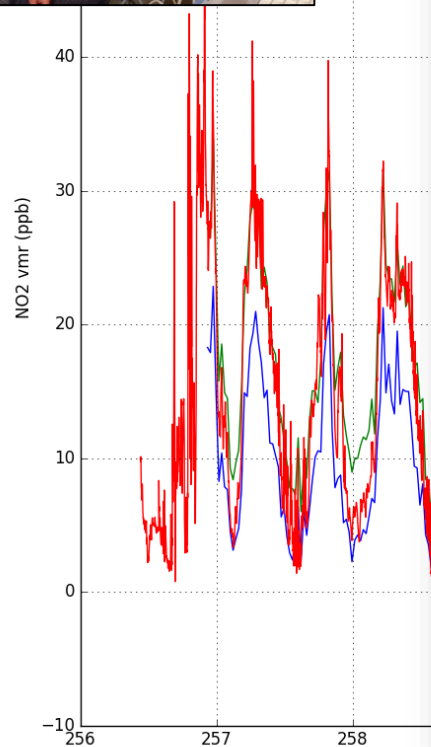
In-situ measurement systems comparison

BELGISCH INSTITUUT VOOR RUIMTE-AERONOMIE INSTITUT D'AERONOMIE SPATIALE DE BELGIQUE BELGIAN INSTITUTE OF SPACE AERONOMY BELGISCH INSTITUUT VOOR RUIMTE-AERONOMIE INSTITUT D'AERONOMIE SPATIALE DE BELGIQUE BELGIAN INSTITUTE OF SPACE AERONOMY BELGISCH INSTITUUT VOOR RUIMTE-AERONOMIE INSTITUT D'AERONOMIE SPATIALE DE BELGIQUE BELGIAN INSTITUTE OF SPACE AERONOMY BELGISCH INSTITUUT VOOR RUIMTE-AERONOMIE INSTITUT D'AERONOMIE SPATIALE DE BELGIQUE BELGIAN INSTITUTE OF SPACE AERONOMY



- Teledyne

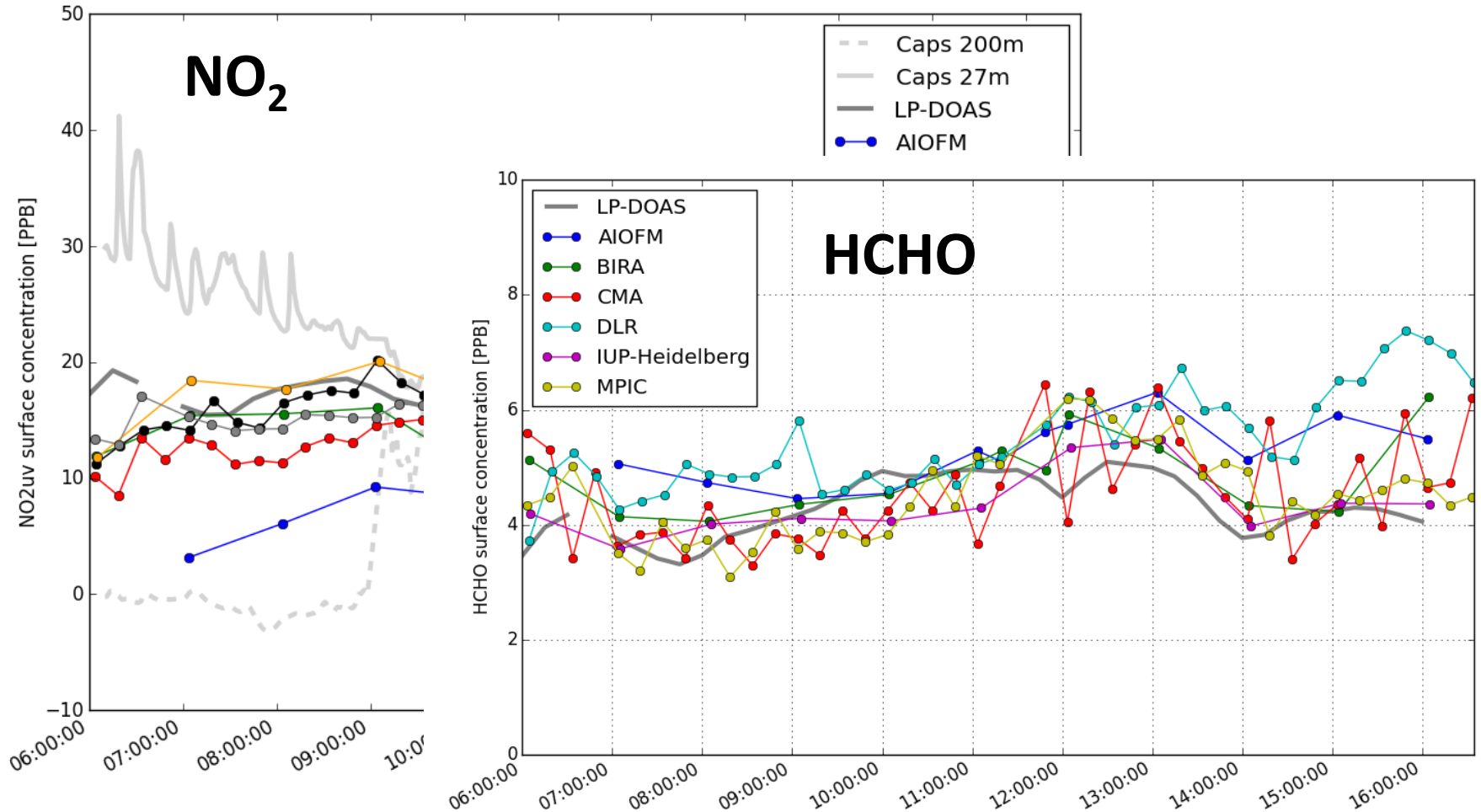
- Teledyne s/n 2891 at 27 m
- 42i at 27 m
- caps at 27 m



Courtesy A. Merlaud

First results of MAXDOAS profiling and comparison with in-situ measurements

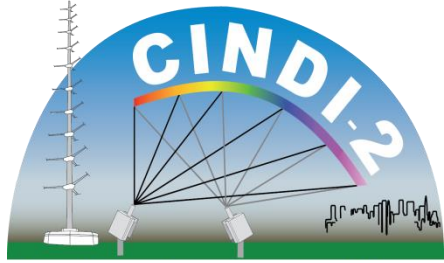
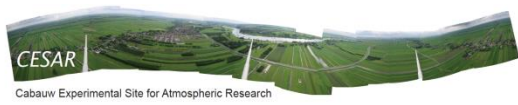
BELGISCH INSTITUUT VOOR RUIMTE-AERONOMIE INSTITUT D'AERONOMIE SPATIALE DE BELGIQUE BELGIAN INSTITUTE OF SPACE AERONOMY BELGISCH INSTITUUT VOOR RUIMTE-AERONOMIE INSTITUT D'AERONOMIE SPATIALE DE BELGIQUE BELGIAN INSTITUTE OF SPACE AERONOMY BELGISCH INSTITUUT VOOR RUIMTE-AERONOMIE INSTITUT D'AERONOMIE SPATIALE DE BELGIQUE BELGIAN INSTITUTE OF SPACE AERONOMY



Conclusions

<http://projects.knmi.nl/cindi-2>

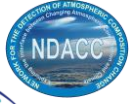
- CINDI-2 was a success!
- >40 instruments (35 DOAS) have been operated side-by-side on the Cabauw RSS during 3-4 weeks under exceptional weather conditions
- Data have been compared following a semi-blind protocol and results presented at daily meetings
- Large effort on calibration of pointing accuracy for all systems
- Data analysis in progress
- Big thanks to local organisation (Arnoud Apituley and the supporting team at KNMI, as well as the campaigns referees Karin Kreher and Ermioni Dimitropoulou) and ESA/NSO



Second Cabauw Intercomparison of Nitrogen Dioxide Measuring Instruments



Royal Netherlands Meteorological Institute
Ministry of Infrastructure and the Environment



MAX-PLANCK-INSTITUT FÜR CHEMIE



aeronomie.be



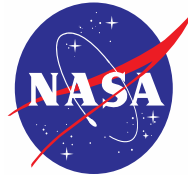
Universiteit Utrecht



National Institute for Public Health and the Environment
Ministry of Health, Welfare and Sport



DEMOKRITOS
NATIONAL CENTER FOR SCIENTIFIC RESEARCH



CHIBA UNIVERSITY



UNIVERSITY OF TORONTO



ARISTOTLE UNIVERSITY OF THESSALONIKI



University of Colorado Boulder



CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS



INDIAN INSTITUTE OF SCIENCE EDUCATION AND RESEARCH
IN PURSUIT OF KNOWLEDGE



ARISTOTLE UNIVERSITY OF THESSALONIKI



Thank you for your attention!

