The FP7 NORS project and way forward:

The evolution of NDACC and perspectives for satellite validation.

De Mazière Martine
Belgian Institute for Space Aeronomy
Coordinator of NORS
Co-chair of NDACC

Rationale

- Short- and long-term satellite validation is a MUST!
  ↔ **continuous validation** is a wearisome business
- The ***procedures*** for validation must be '***standardized***' and **traceable**

⇒ automatic processes

- Validation requires availability of ***(network) reference data***
  - Ensure long-term quality:
    ⇒ Quality assurance protocols
  - Network consistency
  - Timely data delivery
  - Data characterisation and documentation
    ⇒ Metadata, guide for use,
    quantitative and documented *uncertainties*
- Similar needs exist for model validation, e.g., Copernicus Atmosphere Service data products

An answer ? NORS

NORS : Demonstration Network Of ground-based Remote Sensing Observations in support of the Copernicus Atmospheric Service (MACC-II)

EU FP7 project, coordinator: M. De Mazière

- **Start**: Nov. 1, 2011
- **Duration**: 33 months, i.e., up to July 2014
- **Objective:**
  - **To perform the required research and developments for optimizing the NDACC data for the purpose of supporting the quality assessments of the CAS**

    ⇒ ***Research part***
  - **To develop and implement a Web-based Validation Server of the MACC-II (CAS) products using the NORS data products**

    ⇒ ***Operational part***

NORS builds on NDACC

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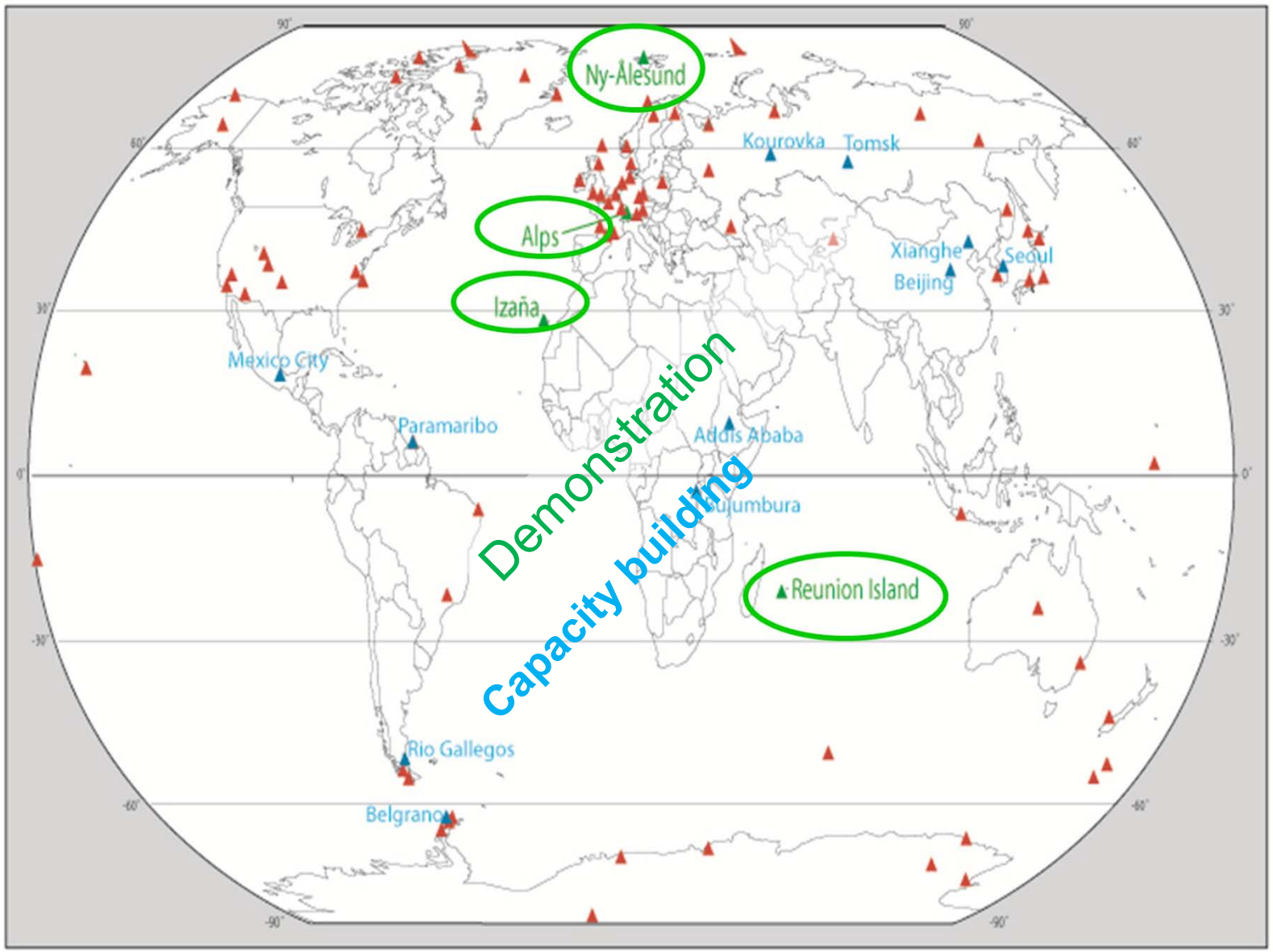
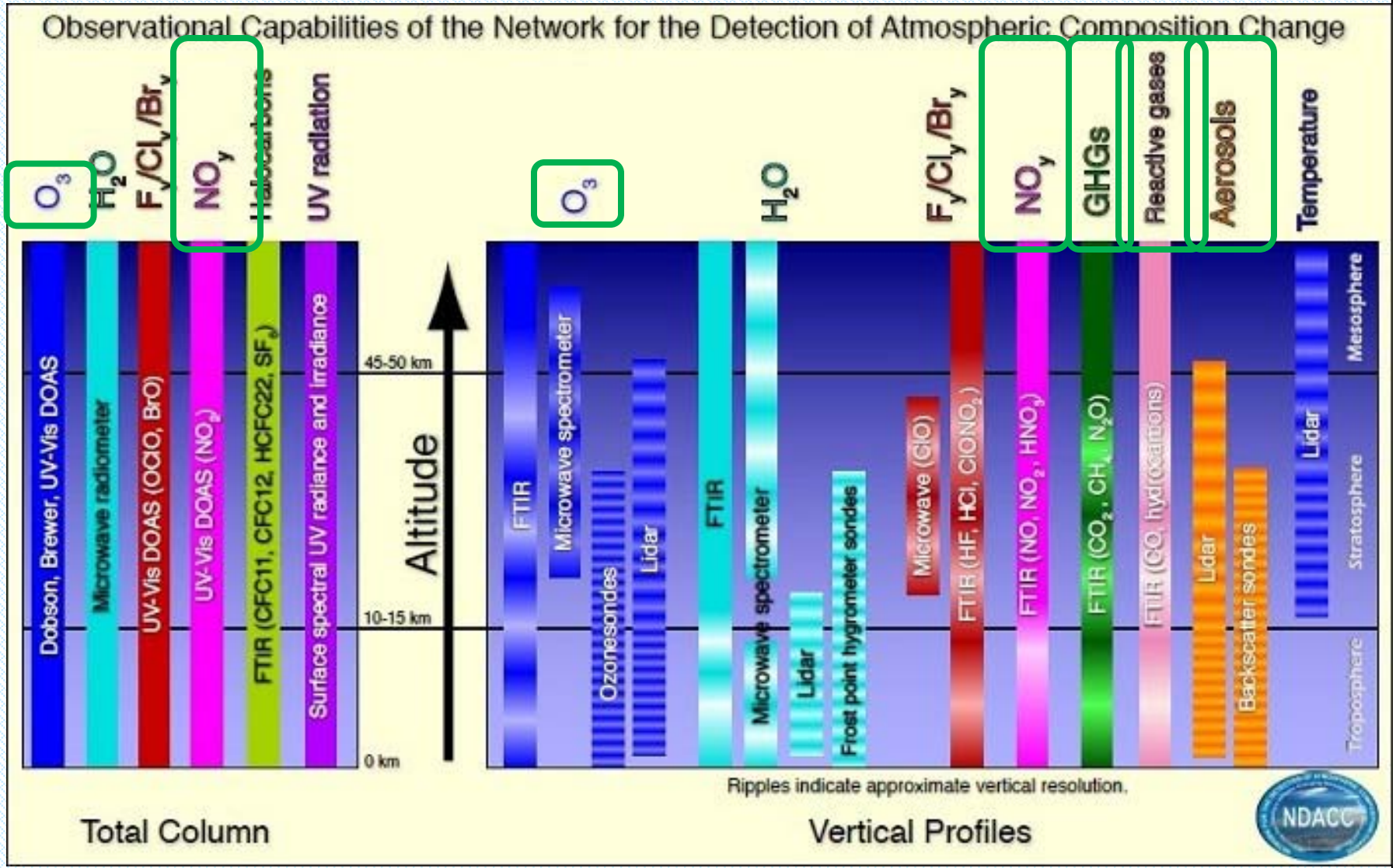


NORS builds on NDACC capabilities

Techniques: LIDAR, FTIR, UV-Vis DOAS, MW, Dobson, Brewer, O3 sondes
Spectral UV



NORS data products & techniques

- Target NORS data products
  - tropospheric and stratospheric ozone columns and vertical profiles up to 70 km altitude
  - tropospheric and stratospheric NO_2 columns and profiles
  - lower tropospheric profiles of NO_2, HCHO, aerosol extinction
  - tropospheric and stratospheric columns of CO
  - tropospheric and stratospheric columns of CH_4

- 4 NDACC observation techniques + in-situ surface monitoring:

  Lidar, MicroWave, FTIR, UV-VIS DOAS

  + in-situ surface monitoring

Partner	Participant organisation name / Short name in the proposal	Country
1	Belgian Institute for Space Aeronomy	BE
2	Eidgenoessische Materialpruefungs- und Forschungsanstalt	CH
3	Instituto Nacional de Tecnica Aeroespacial	ES
4	Universitaet Bern	CH
5	Karlsruher Institut fuer Technologie	DE
6	Centre National de La Recherche Scientifique	FR
7	Universitaet Bremen	DE
8	Université de Liège	BE
9	Max Planck Gesellschaft zur Foerderung der Wissenschaften	DE
10	Ruprecht-Karls-Universitaet Heidelberg	DE
11	Science and Technology B.V.	NL

Research results

Research (1)

- Development of a methodology for integrating ground-based data sources to provide consistent ozone vertical distribution time series as well as tropospheric and stratospheric ozone columns (WP6)

  ⇒ to provide full vertical information that is representative of, e.g., alpine station

- Validation and integration of tropospheric composition measurements (in-situ surface and remote-sensing measurements) (WP5)

  ⇒ for comparison to satellite data

- (MAX)DOAS technique:
  - Advances in cloud detection and filtering techniques
  - Advances in tropospheric NO2 and aerosol measurements
  - …

  ⇒ for delivering new/improved data products from the network

Research (2)

- Consistency checks between DOAS and FTIR data for NO_2 (presented in 1st year) and HCHO

  ⇒ complementarity between techniques

- Consistency checks between CO from NDACC (MIR) and TCCON (NIR) observations

  ⇒ use of both networks for validation of satellite and MACC data

- Advances in uncertainty budget evaluations and reporting

  ⇒ E.g., in FTIR community: Workshop in January 2013 to discuss common (to network) uncertainty evaluations tools (S/W codes integrated in data processing codes)

- Consistency checks between NORS products and satellite data used in MACC

  ⇒ Better understanding of quality of MACC assimlilation analyses

Research (3)

- Significant progress in characterisation of data representativeness (i.e., location and volume of probed airmass)
  - Especially for MAXDOAS and FTIR observations

- **Documentation**
  - Data User guide
  - Uncertainty budgets
  - Data representativeness

These documents are available on NORS and NDACC Webpages

Operational part

Operational part (1)

- ***Rapid delivery*** – within < 1 month after data acquisition) of the NORS (NDACC) data to the RD directory on the NDACC DHF

- Consolidated data and reanalysis data are submitted to usual station directories on NDACC DHF

- Requirement: ***GEOMS HDF format*** according to templates (including uncertainties)

Operational part (2)

Index of ftp://ftp.cpc.ncep.noaa.gov/ndacc/

Up to higher level directory

Name	Size
GEOMS.xml.gz	3456 KB
RD	
RD_readme.txt	2 KB
ames	
ls-IR.gz	749 KB
manual	
meta	
ncep	
ndacc.csv	106 KB
ndacc_csv_for_geomon.txt	12333 KB
station	

Operational part (3)

Development of generic, advanced and consistent ***intercomparison tools*** for NDACC versus model data

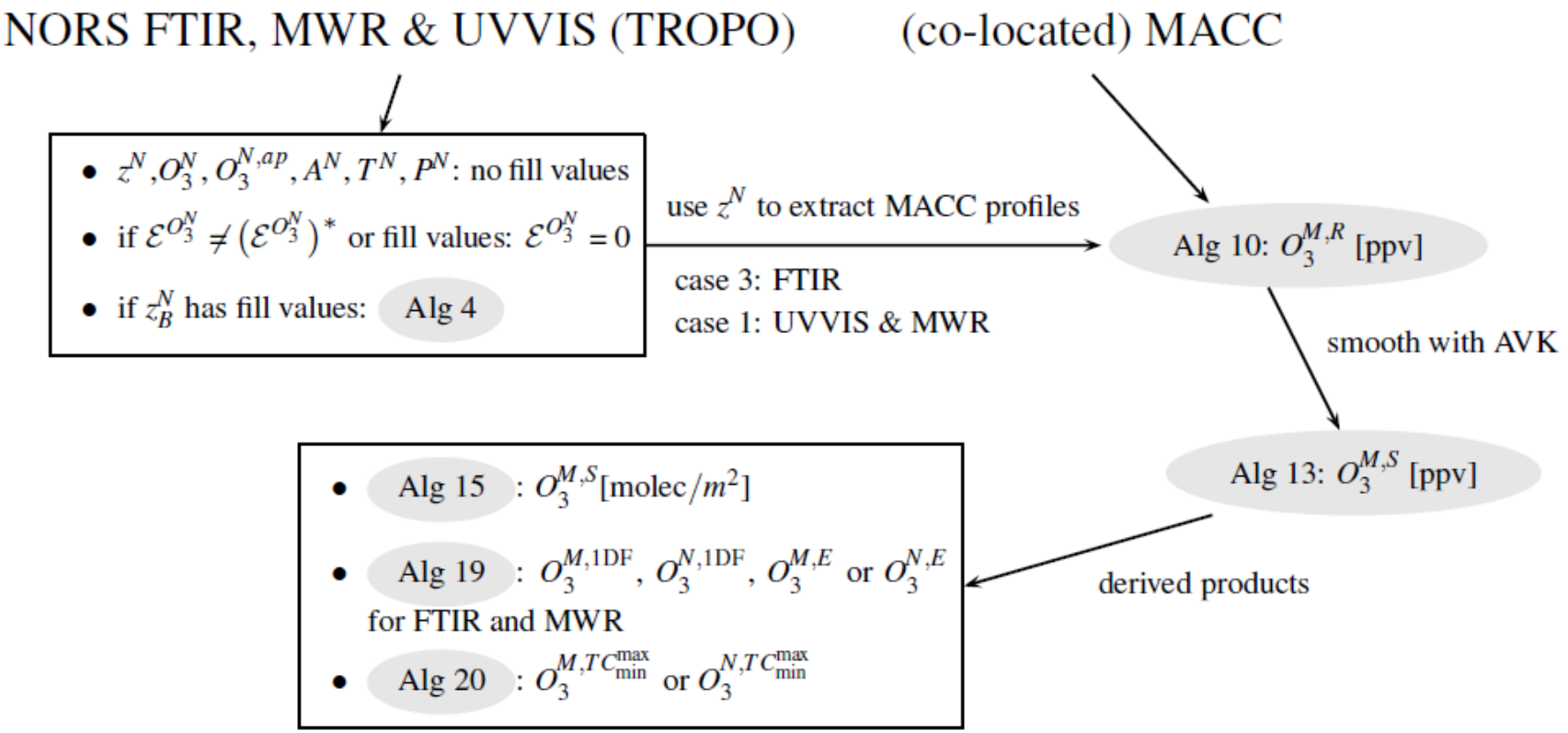
- e.g., Accounting for vertical averaging (AVK)
- e.g., accounting for data representativeness
- e.g., accounting for diurnal variation of strato- NO2
- e.g., consistent interpolation and regridding methods
- e.g., consistent reporting
- e.g., uncertainties included
- …..

- Described in ***"Description of algorithms for the NORS Validation server"*** *(to be published)*
- Available as python routines
- Implemented in NORS Validation Server (NVS)

This development can easily be re-used for development of a generic tool for satellite validation

Example

Validation scheme for NORS products with AVK



QA4EO cal/val best practices , implemented in real life

Operational Part (4)

NORS Validation Server

http://nors-server.aeronomie.be

It takes

HDF data from the NDACC database

& MACC-II model data from the MARS archive,

⇒ creates **automatic validation reports generation**

+ on-demand comparisons (other data, other models, other validation parameters, ….) and reports for VIP users

- Publicly available
- linked to the MACC-II Webpages

http://www.copernicusatmosphere.eu/services/aqac/global_verification

Operational Part (5)

Automatic means what ?

As soon as new NDACC data are available in NDACC station directories or RD directory on NDACC DHF,

in GEOMS HDF,

they will show up on the Validation Server

and intercomparison reports will be available on NVS

Plus +

Immediate feedback to data providers

The NORS Validation Server

On this NORS validation website you can browse and view intercomparison reports that use remote sensing data from NDACC network stations to validate models produced by the MACC project.

NORS (*Demonstration Network Of ground-based Remote Sensing Observations in support of the Copernicus Atmospheric Service*) is an FP7 R&D project that is funded in support of the pre-operational Copernicus Atmosphere Service (CAS), with the aim of improving the Service.

NORS Portal

From this portal page, there are a number of avenues to explore:

Browse the Validation Server intercomparison reports

Visit the NORS project home page

Learn about the Models, Instruments, and Parameters used in NORS

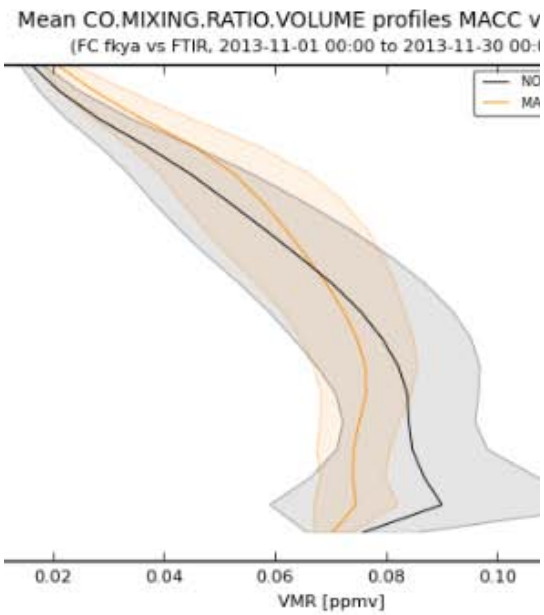
Read the full NORS mission statement

Download MACC validation reports

RS Validation
VS)

oduct files

R, [ALL]@[ALL]: 2013-11



R, KIT@IZANA: 2013-11

CEOS WGCV-

Intercomparison Selection

PARAMETER	
AEROSOL	2
CH2O	3
CH4	1
CO	3
NO2	3
O3	13

MODEL TYPE	
fkya	6
fnyp	9
fsd7	10

INSTRUMENT TYPE	
FTIR	10
LIDAR	3
MWR	3
UVVIS.DOAS	5
UVVIS.DOAS.OFFAXIS	2
UVVIS.DOAS.ZENITH	2

Filter Options

LOCATION	
[ALL]	38
BERN	6
EUREKA	6
HAUTE.PROVENCE	6
IZANA	64
JUNGFRAUJOCH	22
LA.REUNION	6
LA.REUNION.MAIDO	9
LAUDER	25
MAUNA.LOA.HI	22
NY.ALESUND	31
XIANGHE	12
ZUGSPITZE	30

AFFILIATION	
[ALL]	16
BIRA.IASB	31
CNRS.LATMOS	6
IUP	31
KIT	64

NVS reporting examples

⇒ Profile, partial column and total column intercomparisons always limited to sensitive altitude range

⇒ +report including statistics

⇒ Care for traceability

NORS Validation Server

Currently viewing

REPORT PROPERTIES

Intercomparison	CO-fkya-FTIR
Period	MONTHS
Start	01 Nov 2013
End	30 Nov 2013
Location	LA.REUNION.MAIDO
Affiliation	BIRA.IASB
Generated	19 Dec 2013, 17:28h

Report actions

DOWNLOAD ACTIONS

Download report as PDF file

Download report as zip archive

Related reports

OTHER MODELS

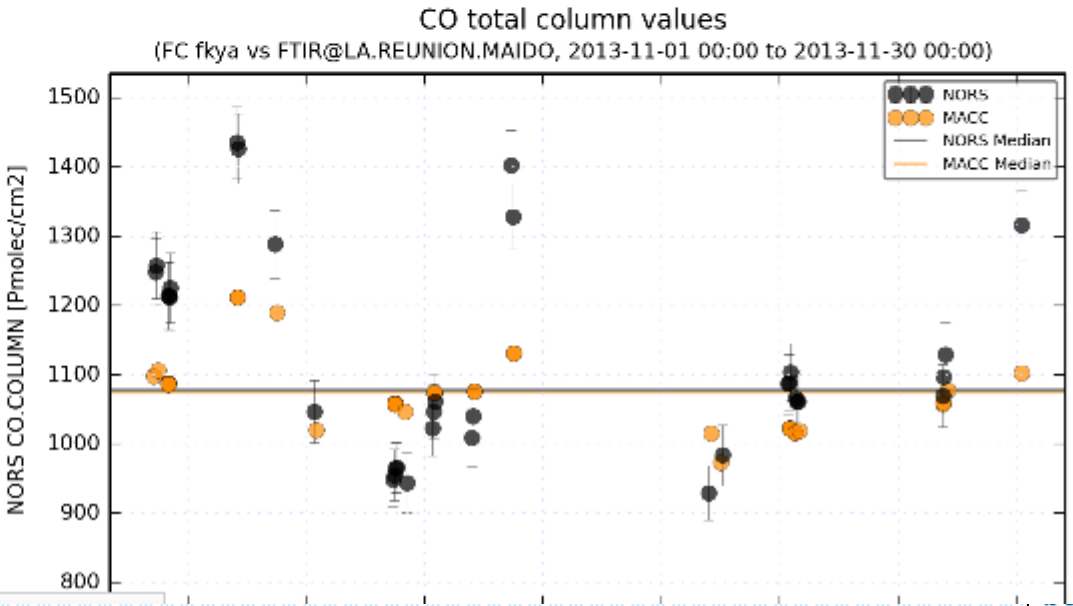
fsd7

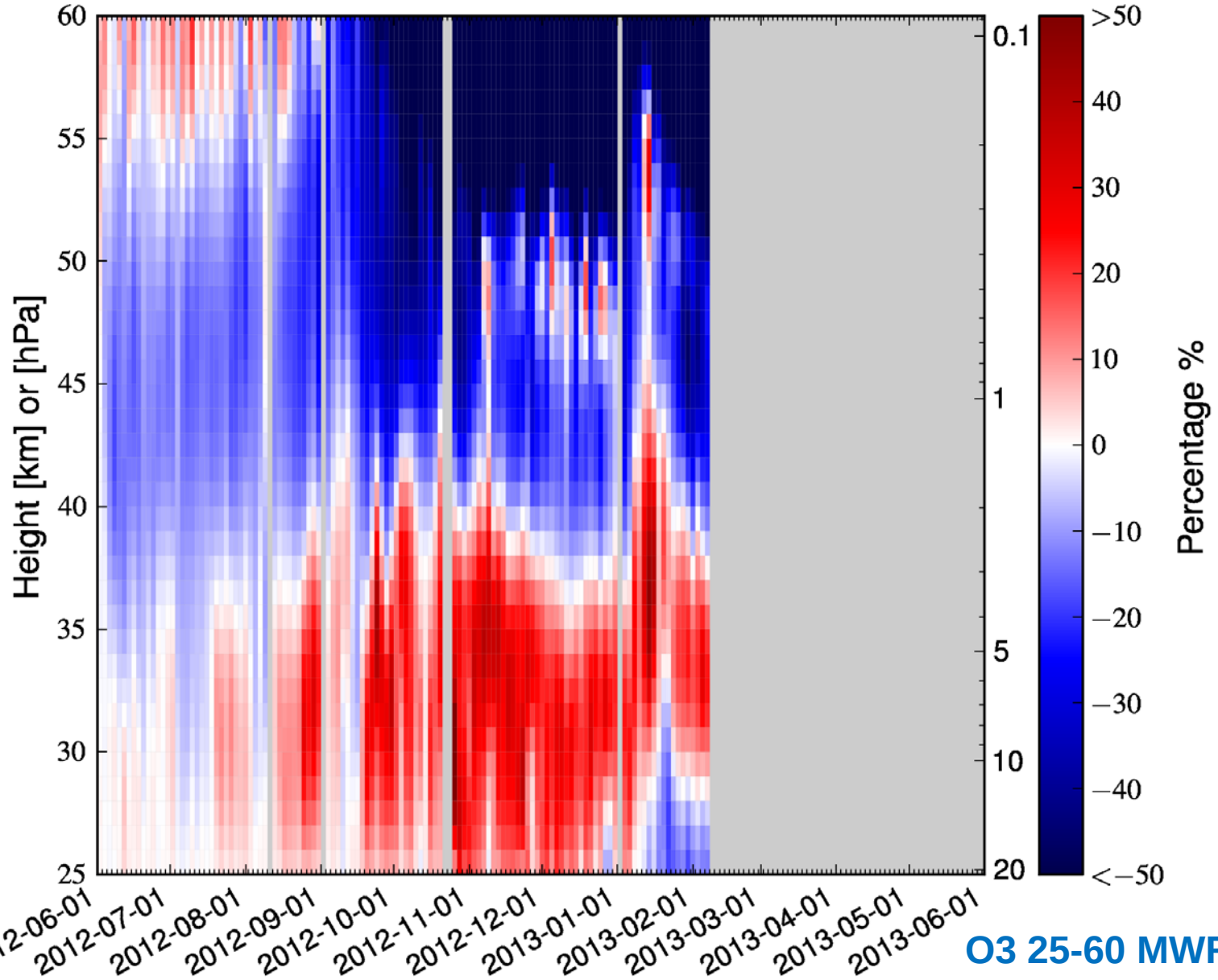
Intercomparison Report

NORS Report: MACC fkya vs NORS FTIR - CO

MACC vs NORS CO - Intercomparison Statistics

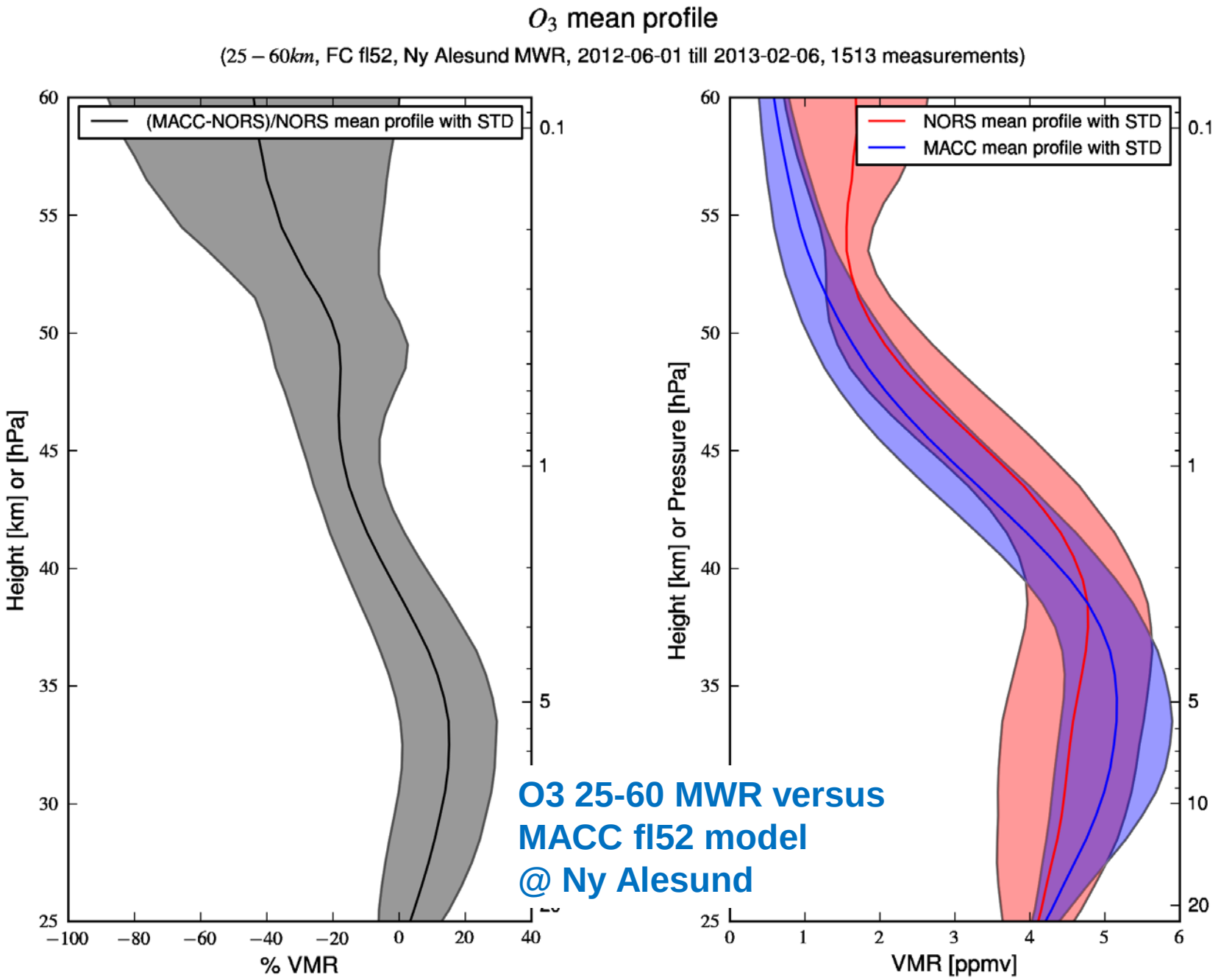
f (predicted variable)	MACC CO.COLUMN [Pmolec/cm2]
o (observed variable)	NORS CO.COLUMN [Pmolec/cm2]
# measurements	34
median bias	-46.895
B (mean bias)	-51.262
RMSE (root mean square error)	105.817
MNMB (modified normalized mean bias)	-0.0398903
FGE (fractional gross error)	0.0852018
R (correlation coefficient)	0.802744
RS (Spearman rank correlation coefficient)	0.734759



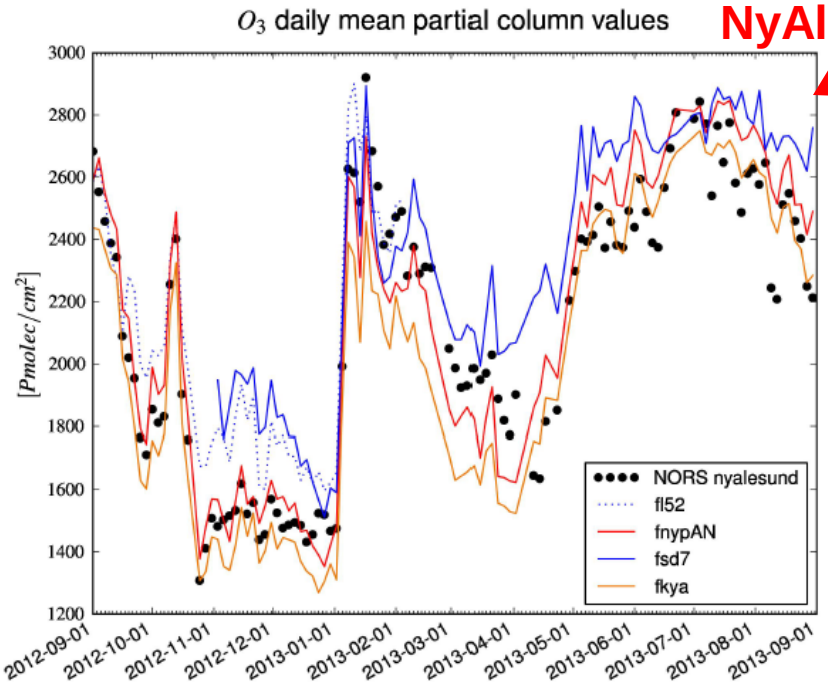


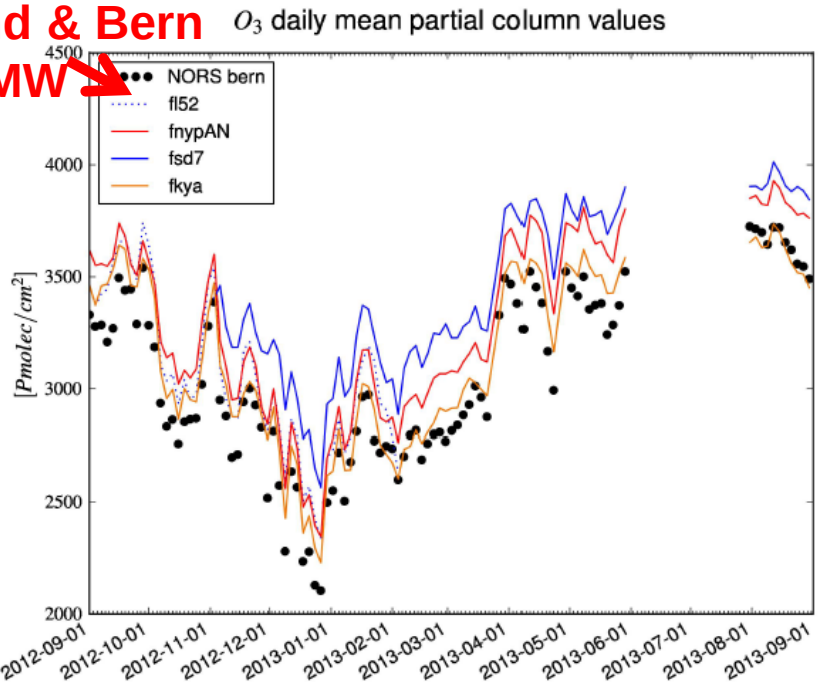
O3 25-60 MWR versus MACC fl52 model @ Ny Alesund

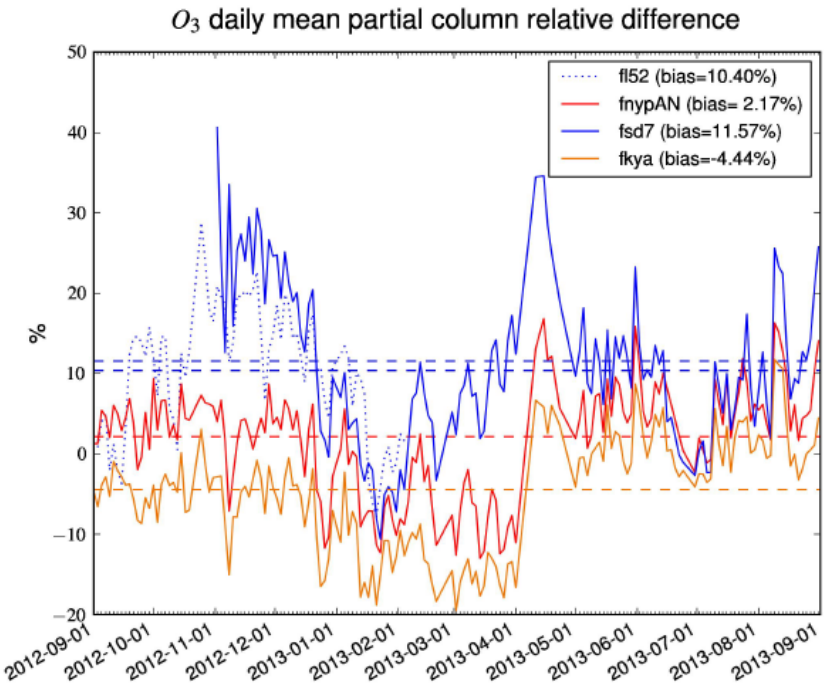
aeronomie.be

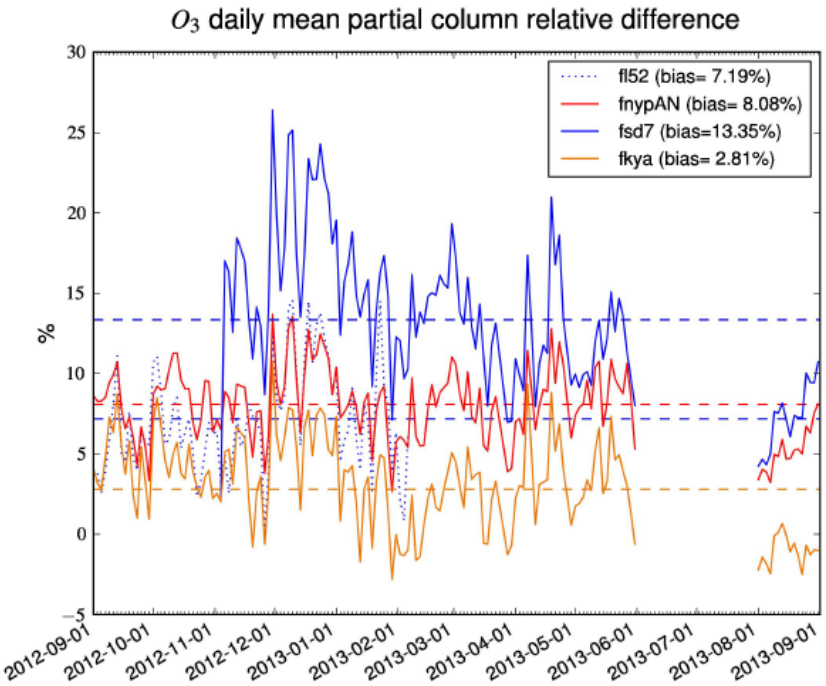

O_3 mean profile
(25 – 60km, FC fl52, Ny Alesund MWR, 2012-06-01 till 2013-02-06, 1513 measurements)
(MACC-NORS)/NORS mean profile with STD
Height [km] or [hPa]
% VMR
NORS mean profile with STD
MACC mean profile with STD
Height [km] or Pressure [hPa]
VMR [ppmv]
O3 25-60 MWR versus
MACC fl52 model
@ Ny Alesund

NyAlesund & Bern MW





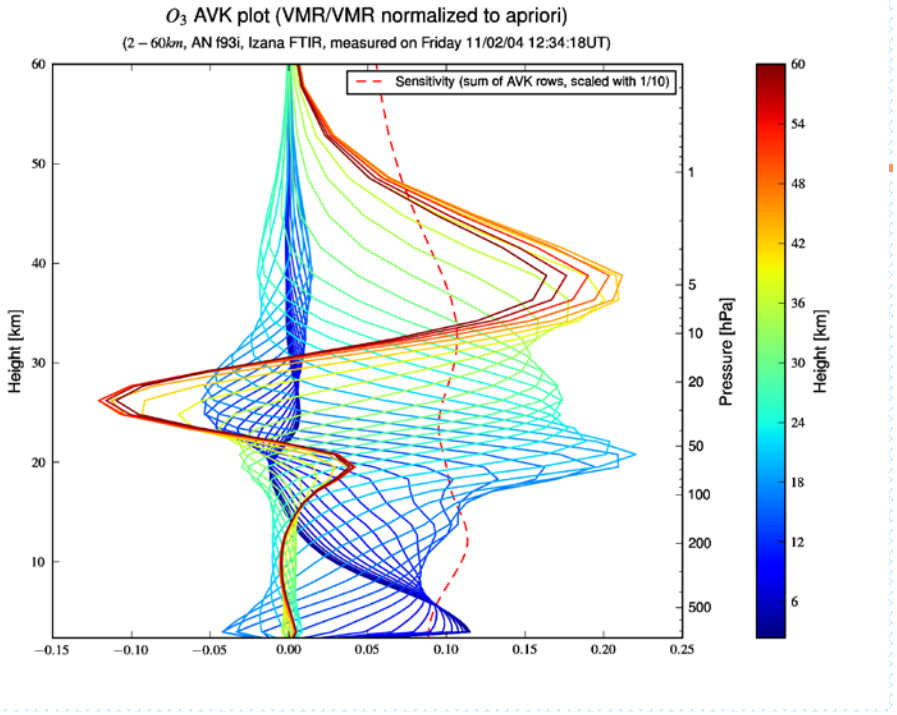


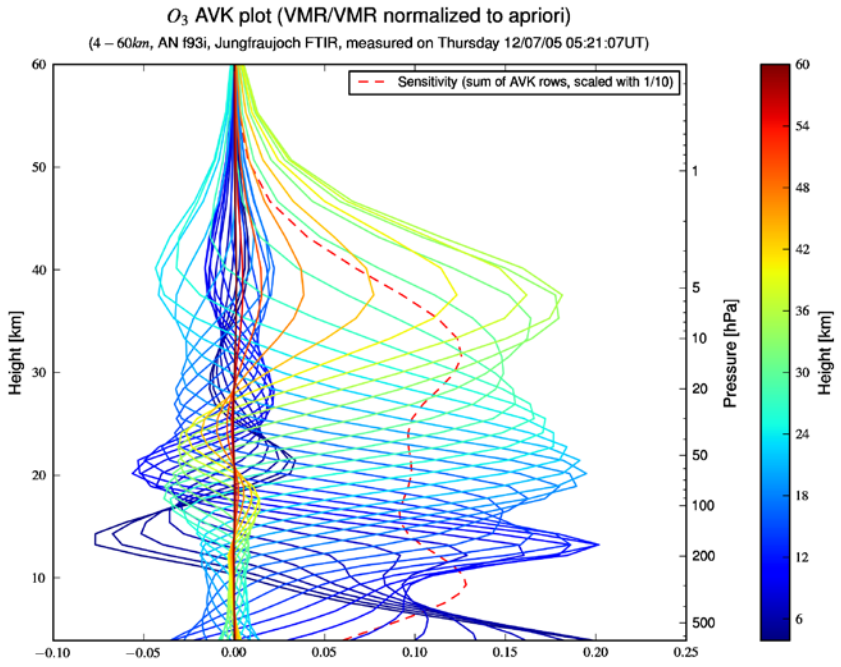


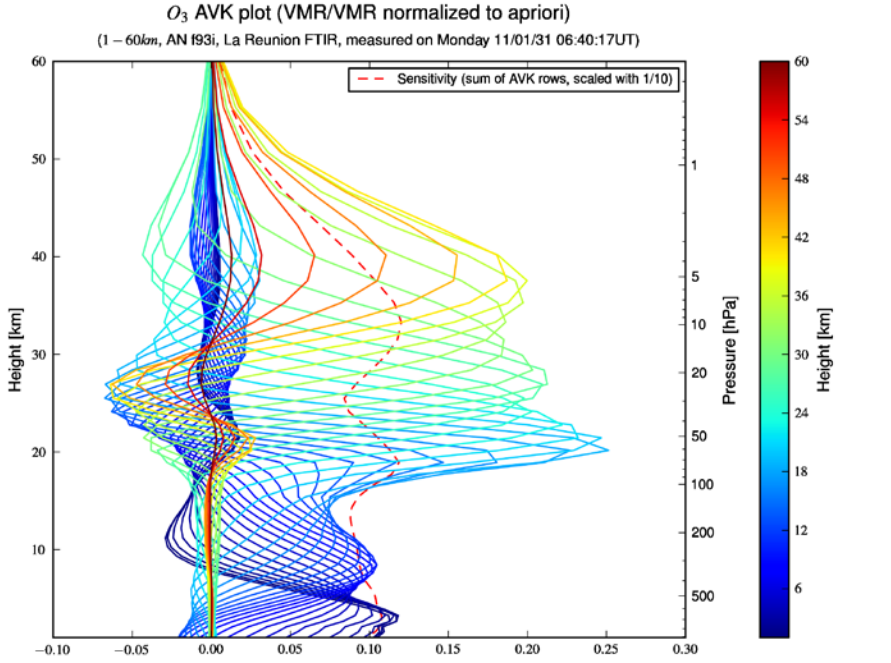
aeronomie.be

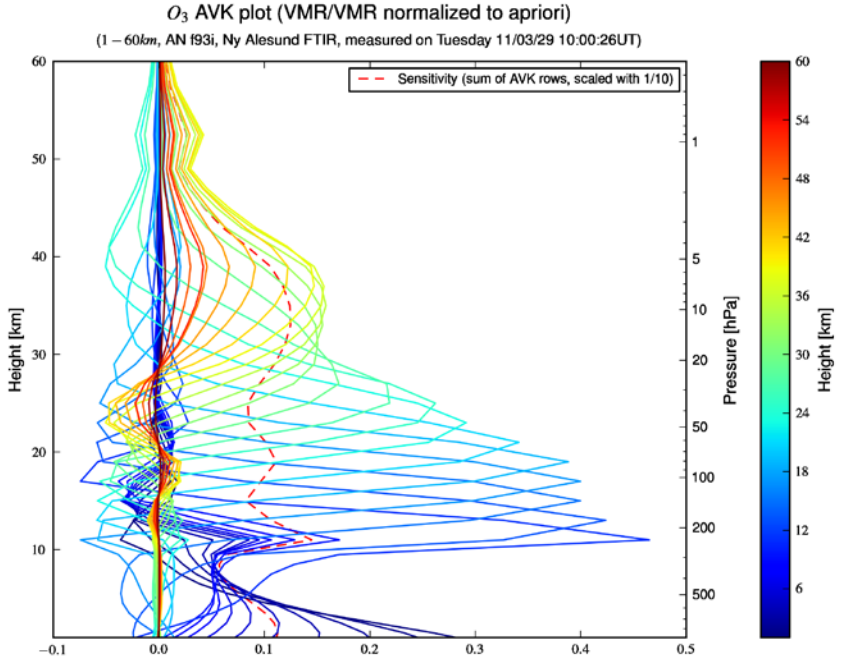
belspo

.be

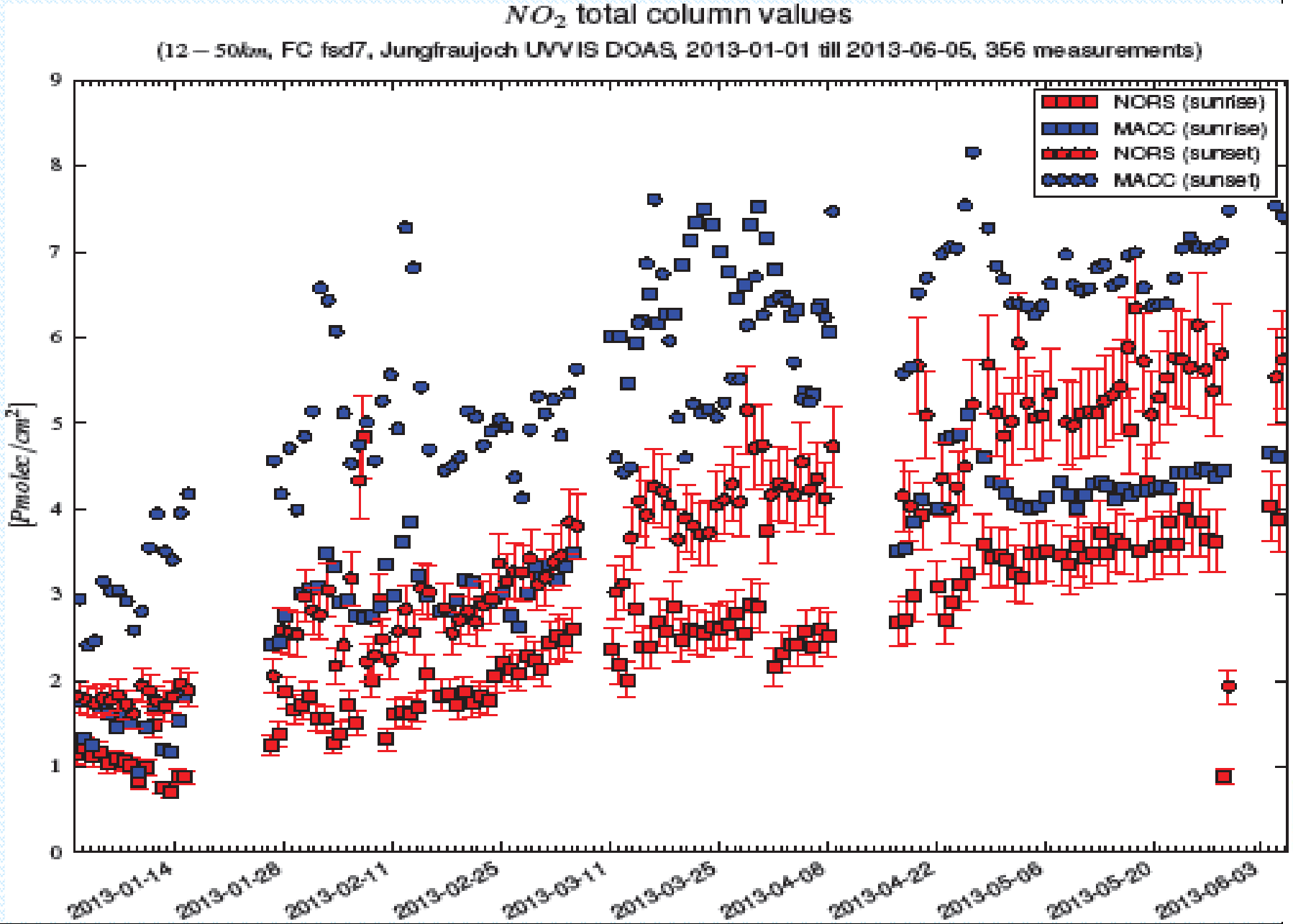

O_3 AVK plot (VMR/VMR normalized to apriori)
(2 – 60km, AN f93i, Izana FTIR, measured on Friday 11/02/04 12:34:18UT)
Sensitivity (sum of AVK rows, scaled with 1/10)
Height [km]
Pressure [hPa]
Height [km]


O_3 AVK plot (VMR/VMR normalized to apriori)
(4 – 60km, AN f93i, Jungfraujoch FTIR, measured on Thursday 12/07/05 05:21:07UT)
Sensitivity (sum of AVK rows, scaled with 1/10)
Height [km]
Pressure [hPa]
Height [km]

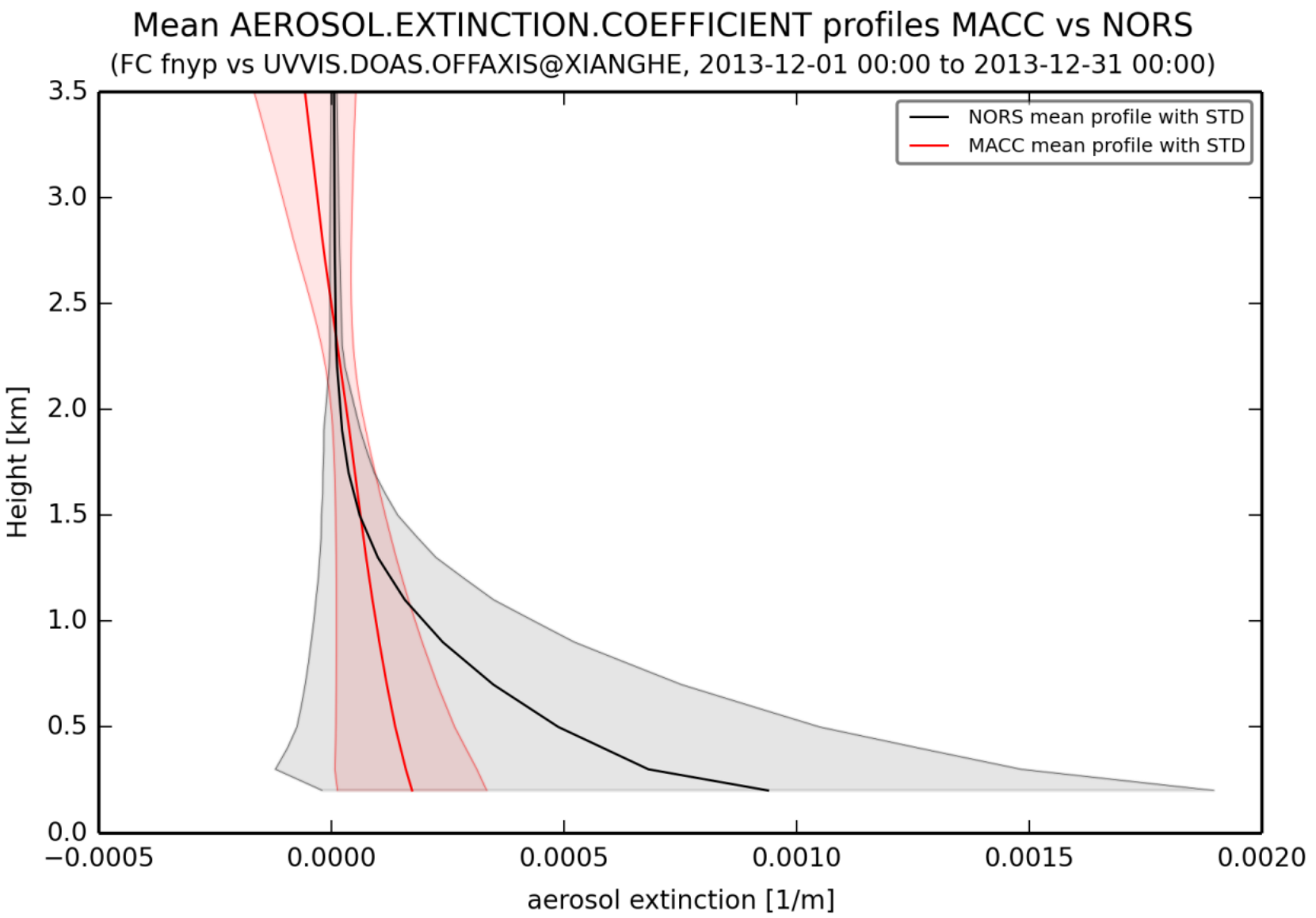

O_3 AVK plot (VMR/VMR normalized to apriori)
(1 – 60km, AN f93i, La Reunion FTIR, measured on Monday 11/01/31 06:40:17UT)
Sensitivity (sum of AVK rows, scaled with 1/10)
Height [km]
Pressure [hPa]
Height [km]


O_3 AVK plot (VMR/VMR normalized to apriori)
(1 – 60km, AN f93i, Ny Alesund FTIR, measured on Tuesday 11/03/29 10:00:26UT)
Sensitivity (sum of AVK rows, scaled with 1/10)
Height [km]
Pressure [hPa]
Height [km]

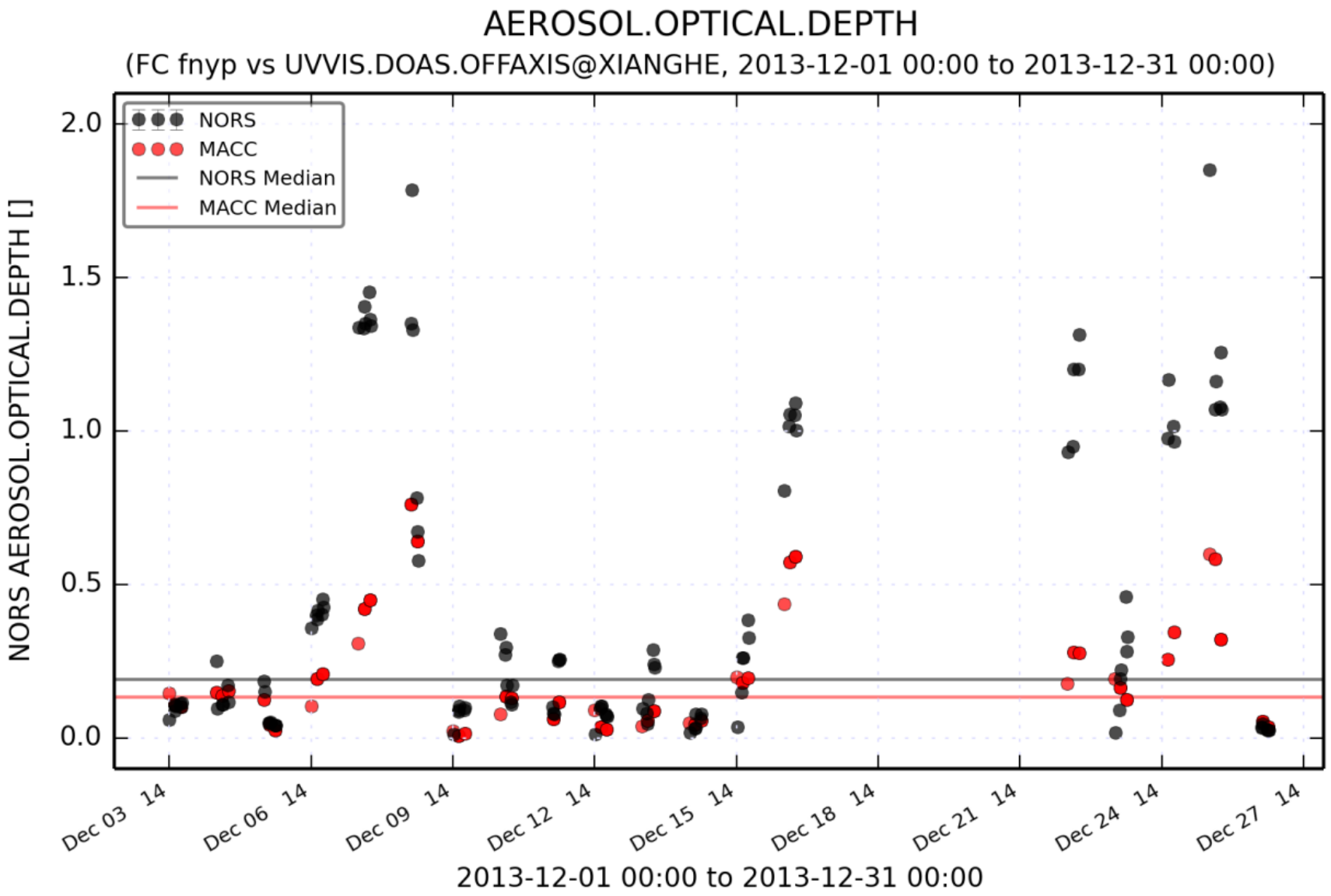
NO2 stratospheric columns



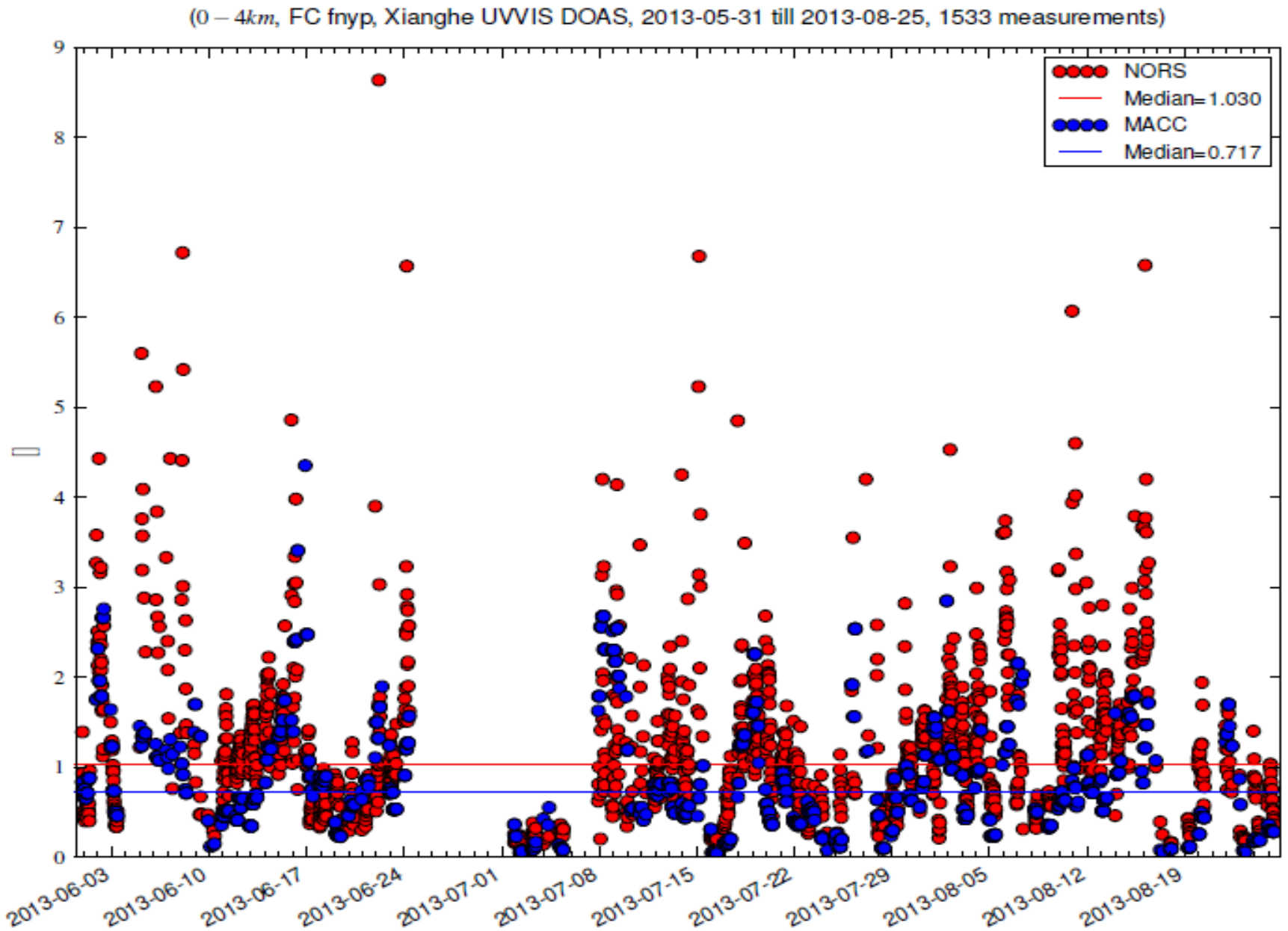
MAXDOAS aerosol extinction @ Xianghe



MAXDOAS AOD (0-4km) @ Xianghe



MAXDOAS AOD (0-4km) @ Xianghe



Future (1/4) ?

1. a. More NDACC stations and candidate NDACC stations (e.g., Xhianghe, Addis Abeba, …) are joining the effort

1. b. Expand target products, e.g., H2O from microwave radiometers

2. ***Question of sustainability***

(a) between FP7 and Copernicus operational phase

⇒ ***MACC-III***

(b) in the operational phase of the CAS

⇒ of the server and the NDACC data themselves ?

Space Agencies and the Copernicus initiative should contribute to supporting the in-situ component for calibration/validation

Future (2/4)

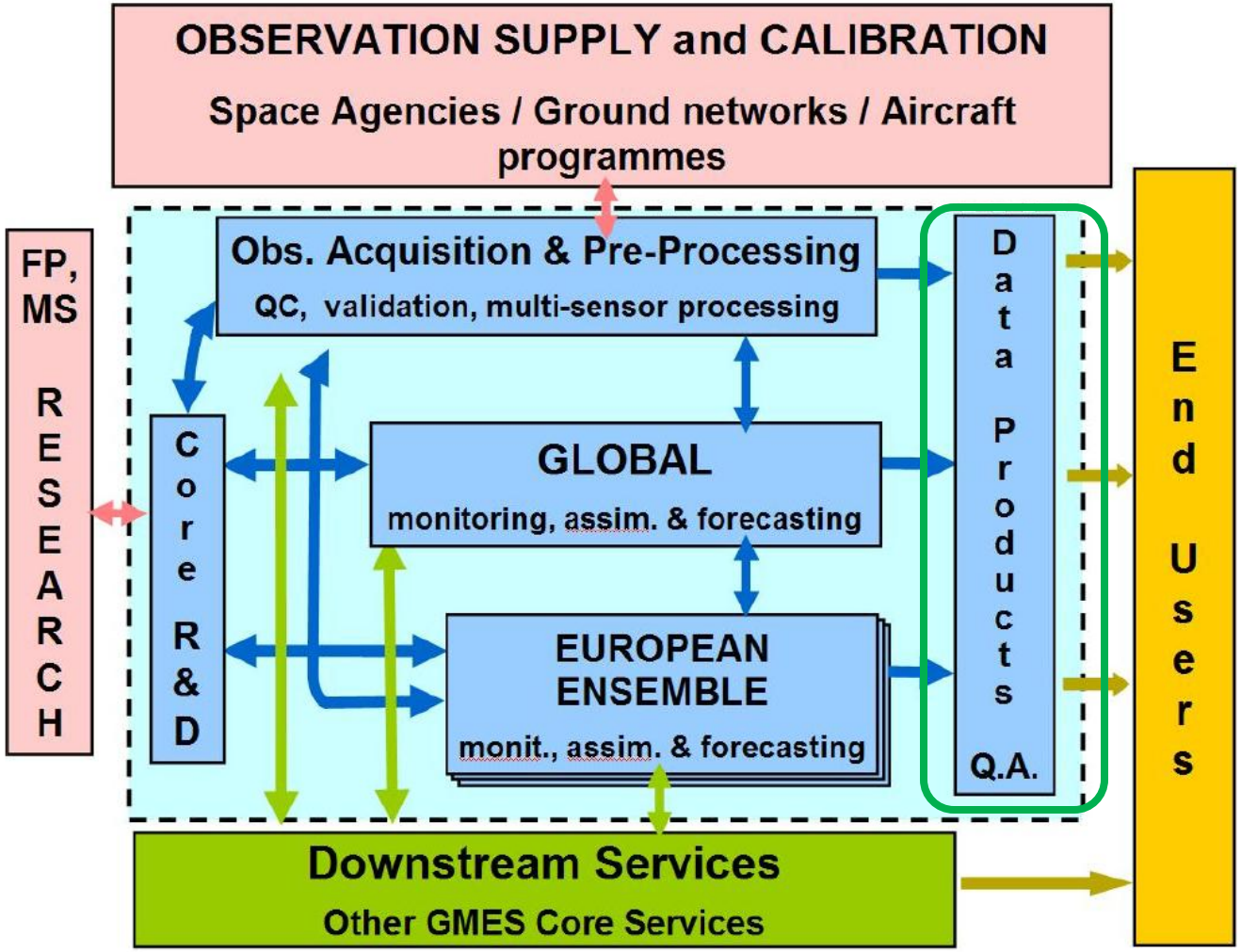


Figure 1: GAS functional architecture

" Cal/val activities in relation to Core Service products fall entirely within the GACS"

GMES Atmosphere Core Service (GACS) Implementation Group – Final Report', April 2009.

Future (2/4)

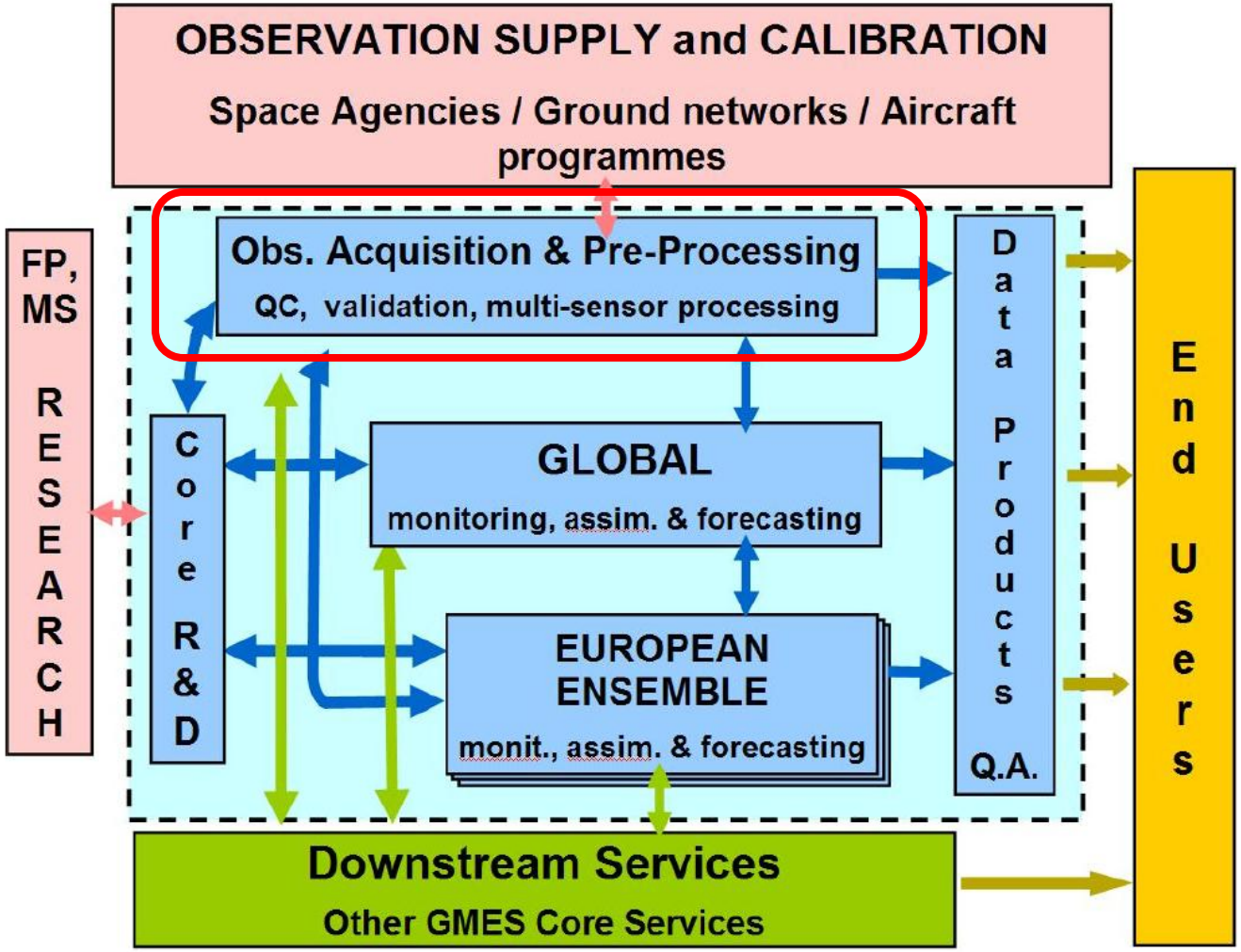


Figure 1: GAS functional architecture

GMES Atmosphere Core Service (GACS) Implementation Group – Final Report', April 2009.

Future (3/4) ?

It states explicitly

(1) that the validation activities of CAS products are an integral part of the GACS (blue in figure):

"Cal/val activities in relation to Core Service products fall entirely within the GACS"

(2) that the validation of the upstream satellite data is the responsibility of the Space Agencies:

"Monitoring the observations quality and availability is part of the (Copernicus Atmosphere) Core Service", and, "Space agencies should be responsible for cal/val activities with regard to (single-instrument) space observations."

Future (4/4) ?

3. Build on NORS developments
(algorithms, server design concept, QA4EO best practices)
to develop a more comprehensive validation environment

⇒ Expand the reference data set to other datacenters

⇒ Expand the products to be validated to satellite data

- ✓ by adding the read tools and collocation tools for satellite data that were developed previously in the frame of GECA (ESA Generic Environment for Calibration/Validation Analysis)

⇔ Achieve finally a comprehensice calibration/validation environment for the EO atmosphere component
with Copernicus support (EU and ESA)
+ EU H2020 support for R&D for extension
+ additional agencies (CEOS) support ?

NORS
Network of Remote Sensing Ground-Based Observations for the GMES Atmospheric Service

- **Acknowledgements:** The NORS project has received funding from the European Community's 7th Framework Programme (2007-2013) under grant agreement 284421

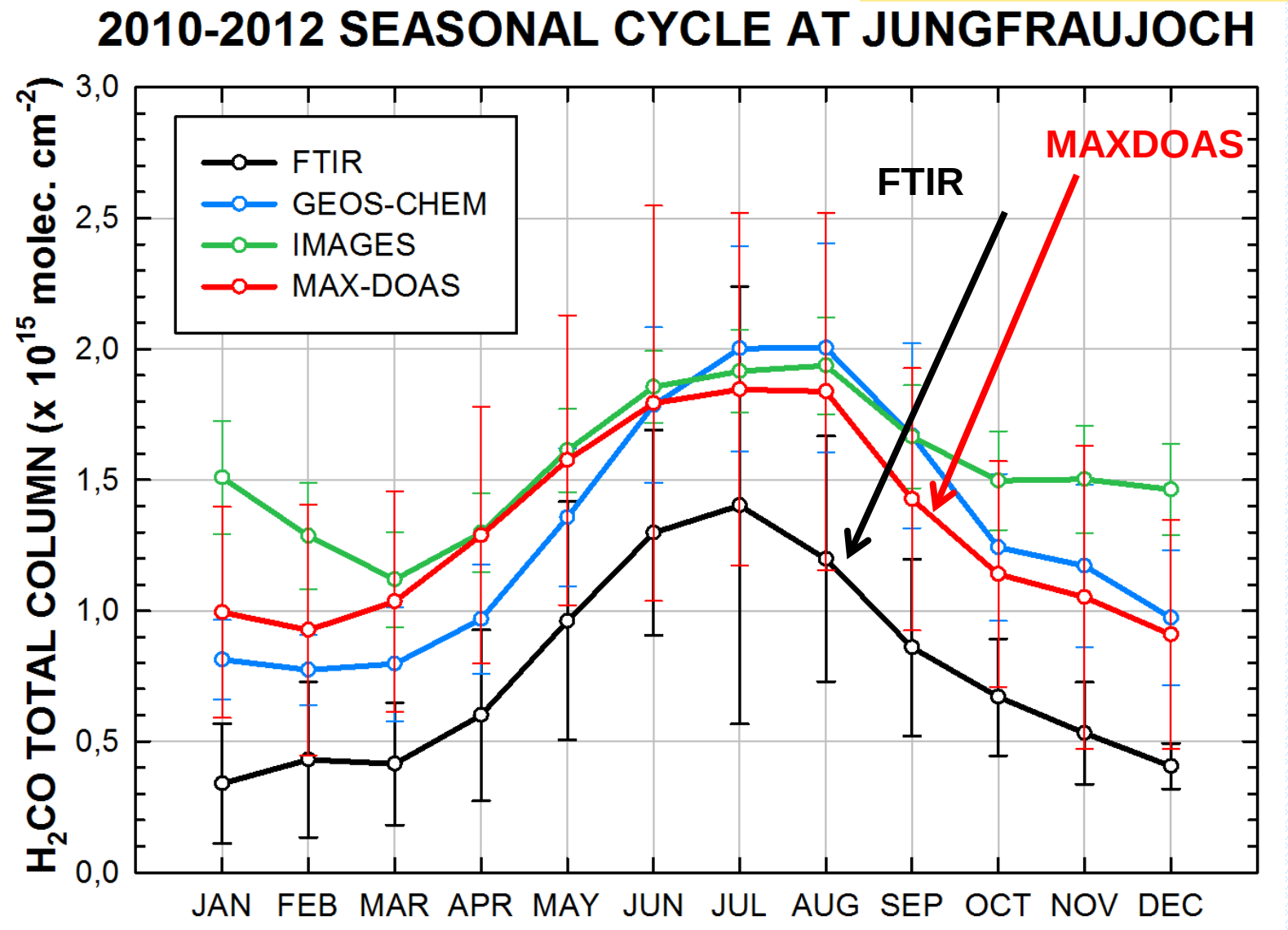
- **Acknowledgements:** ESA GECA

NVS Design (cont.)

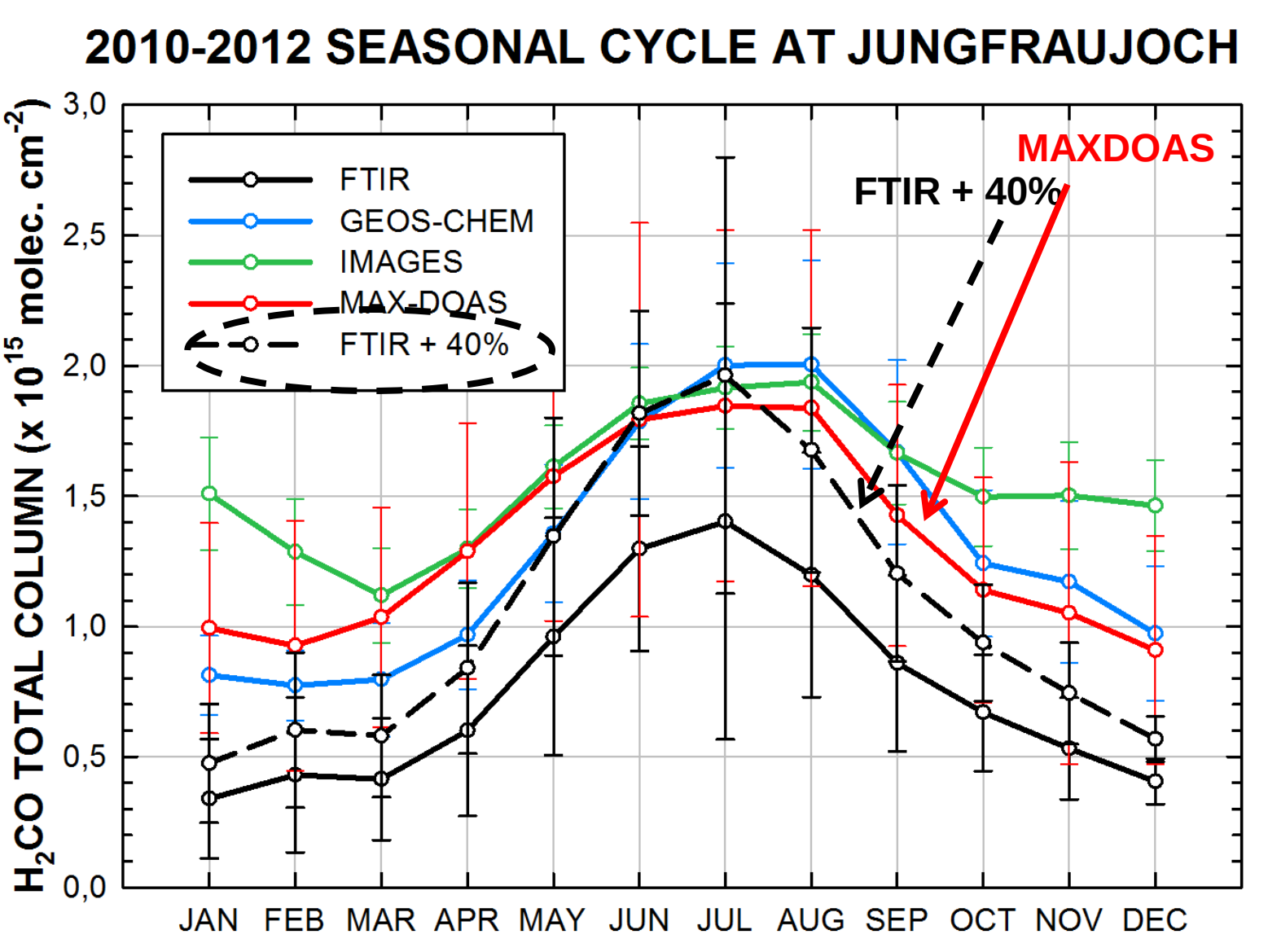
- Server back-end retrieves model data from MACC, NORS data from NDACC; extracts and maintains metadata catalog
- Arrival of new products triggers incremental validation process that generates database of intermediate results and outputs
- Core validation chain algorithms built on top of an expanded GECA intercomparison set of command-line tools
  - Includes tools for NO_2 diurnal correction (under development) and effective airmass calculations (already available for FTIR observations)
  - And others in future….
- Server provides web application front-end that supports all use cases: user can browse outputs, generate default reports, request custom reports

HCHO from FTIR and MAXDOAS

Courtesy: B. Franco et al., ULg

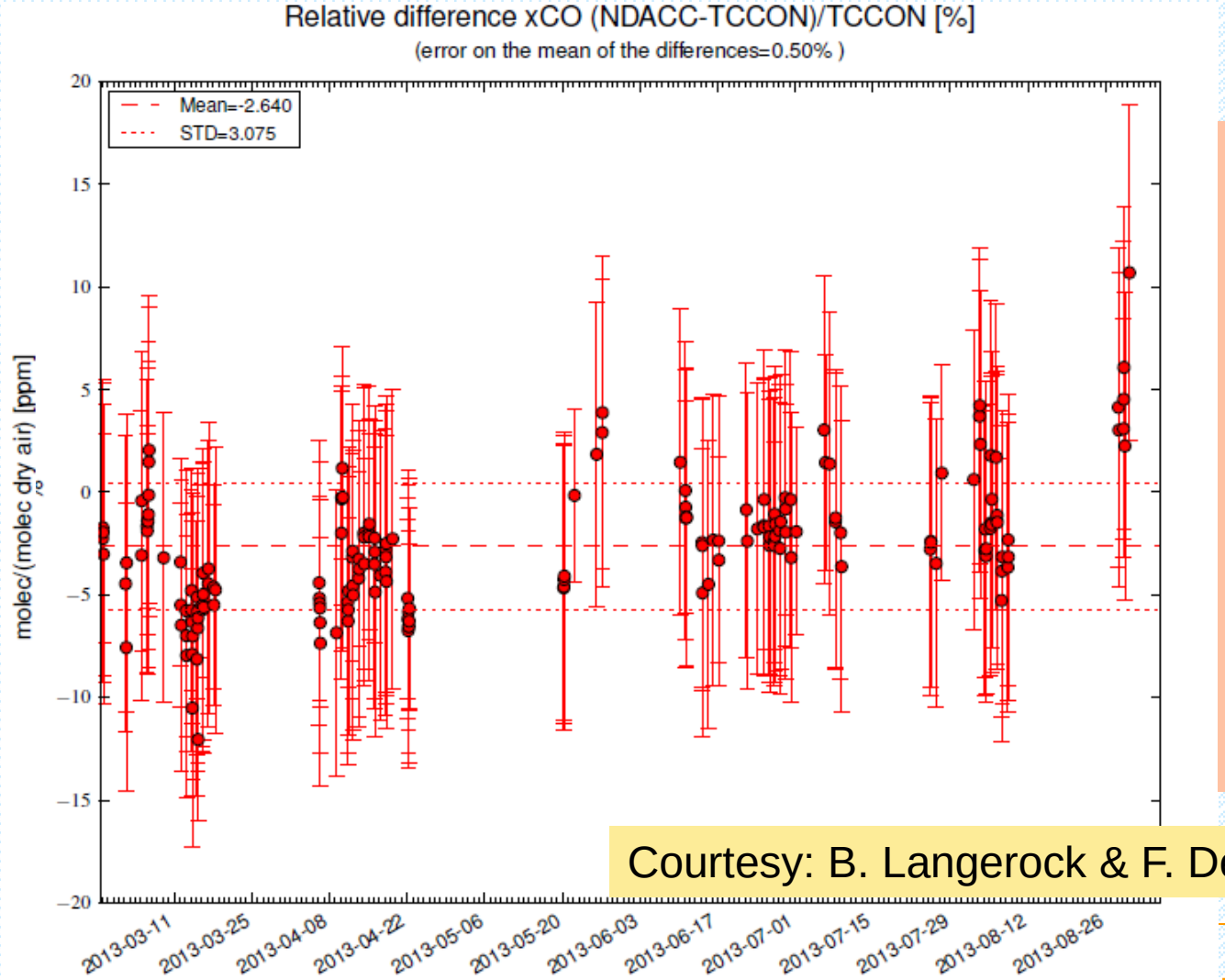


HCHO from FTIR and MAXDOAS



CO from FTIR MIR and NIR

- Consistency checks between CO from NDACC (MIR) and TCCON (NIR) observations

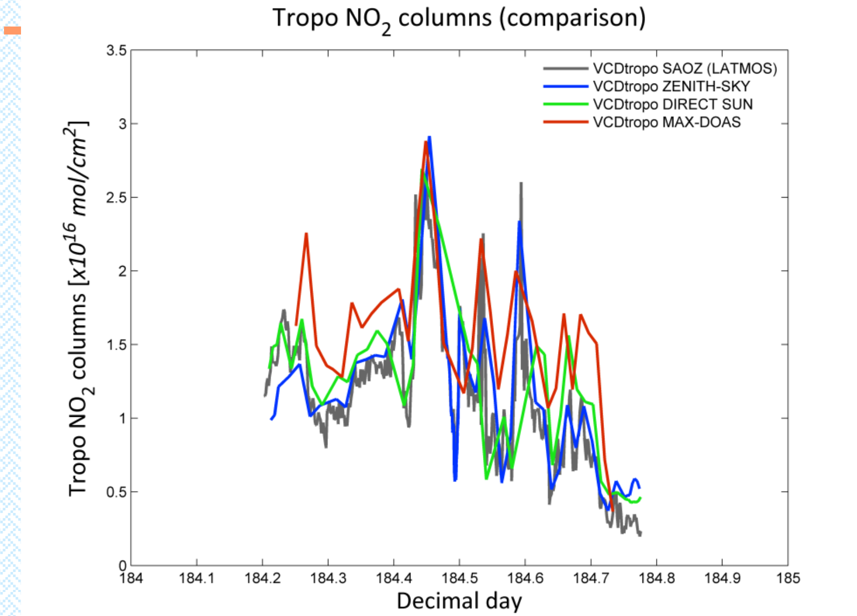


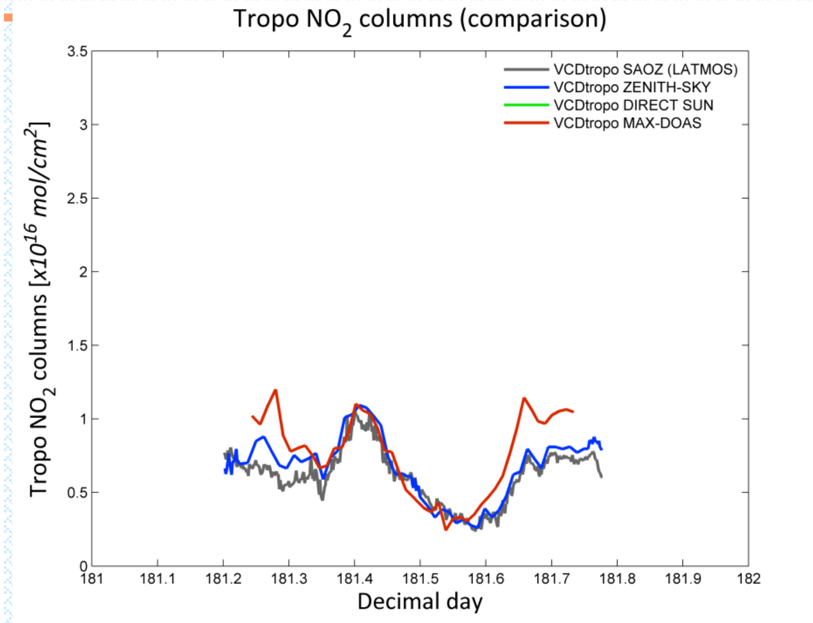
Prelimlinary direct comparison without accounting for AVK

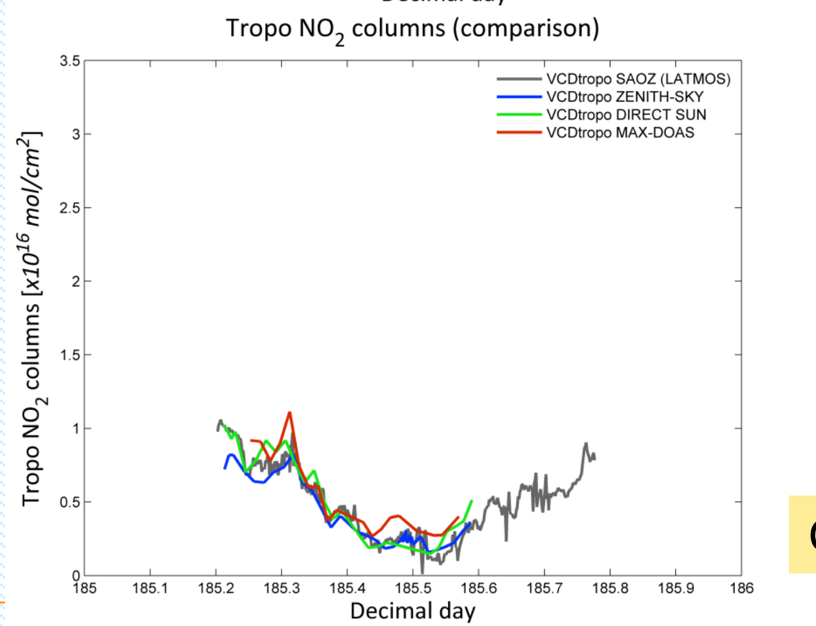
Very good agreement

Courtesy: B. Langerock & F. Desmet, BIRA

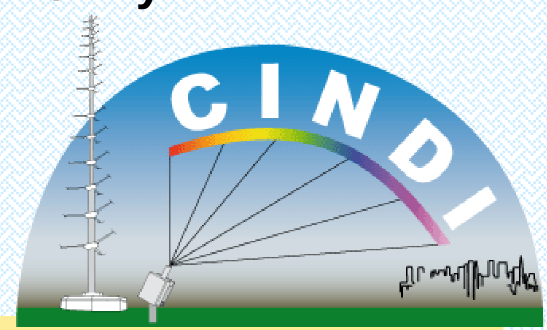
Tropospheric NO_2 from DOAS







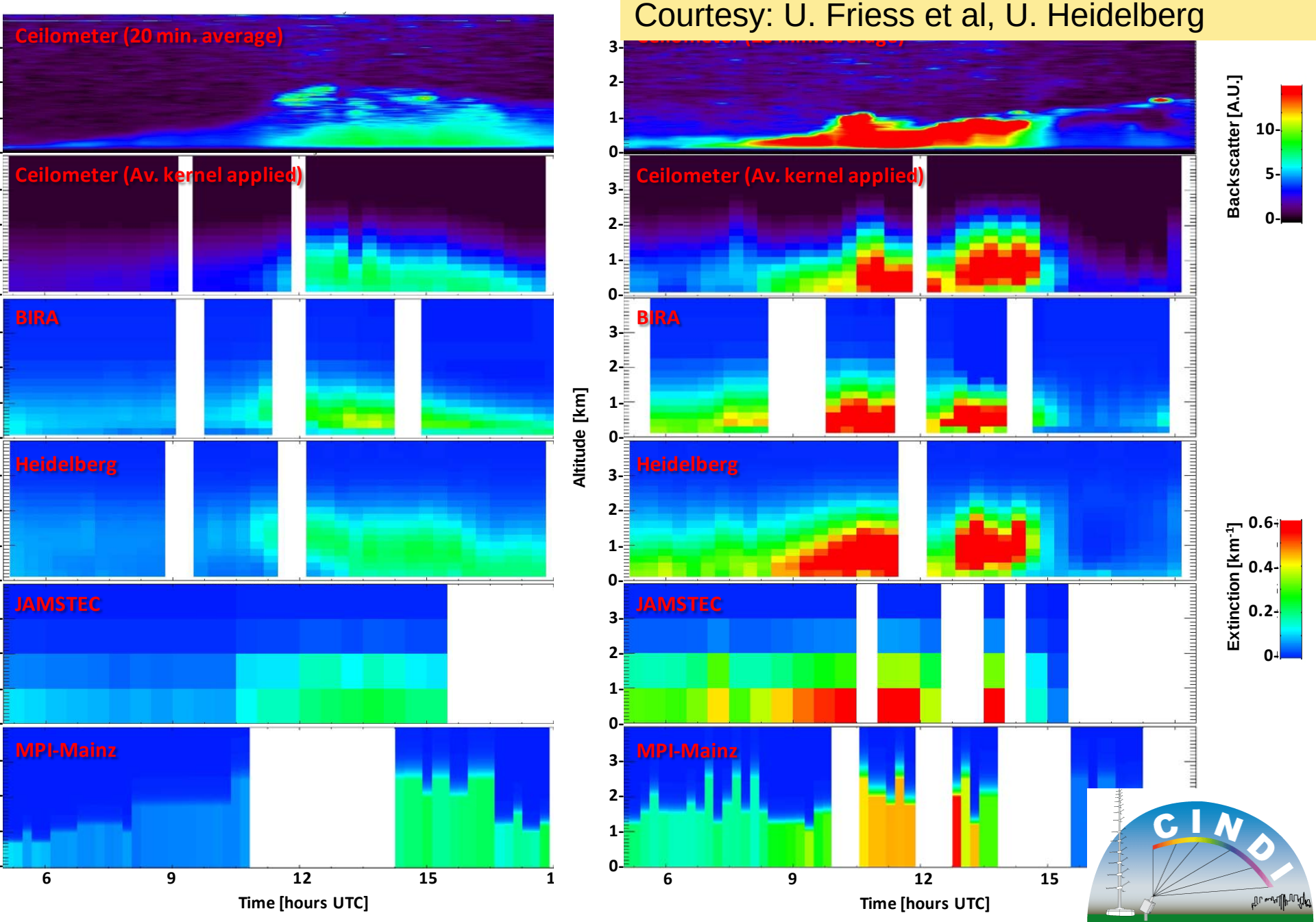
Data taken during Cindi campaign, Cabauw, June/July 2009



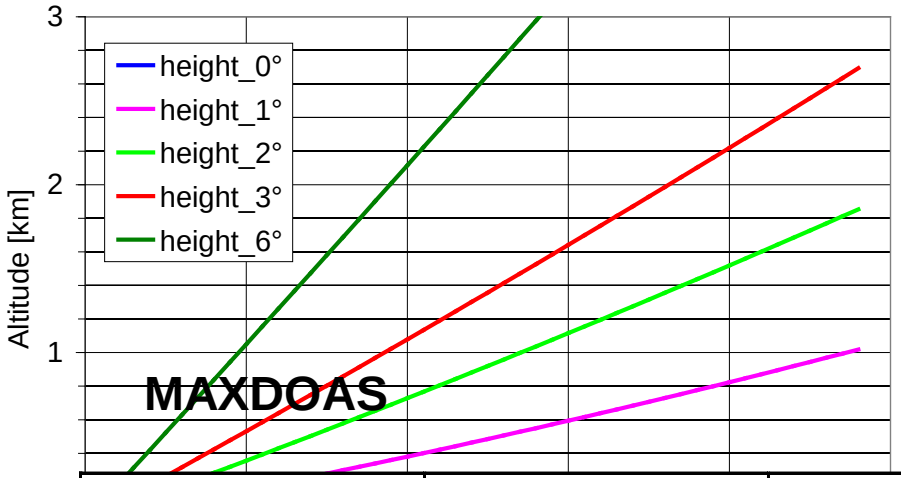
Courtesy: F. Hendrick et al, BIRA

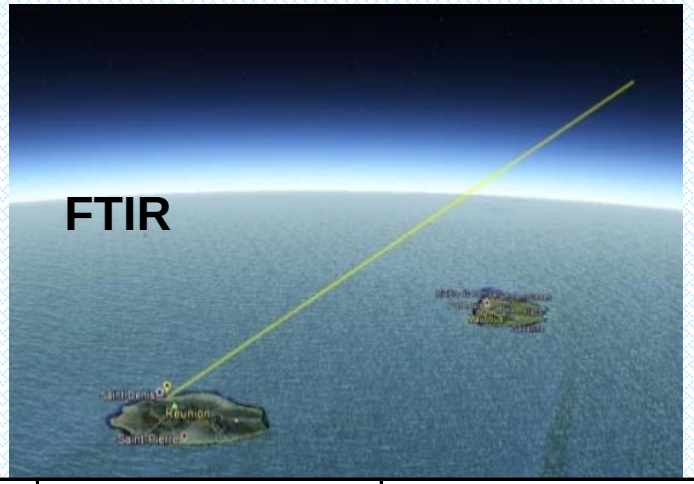
June 24, 2009 Aerosol extiction July 3, 2009

Courtesy: U. Friess et al, U. Heidelberg



Representativeness

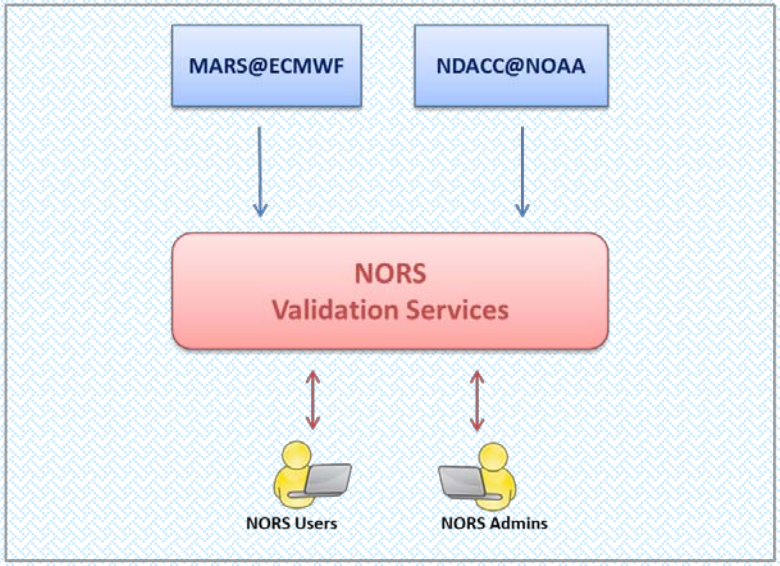


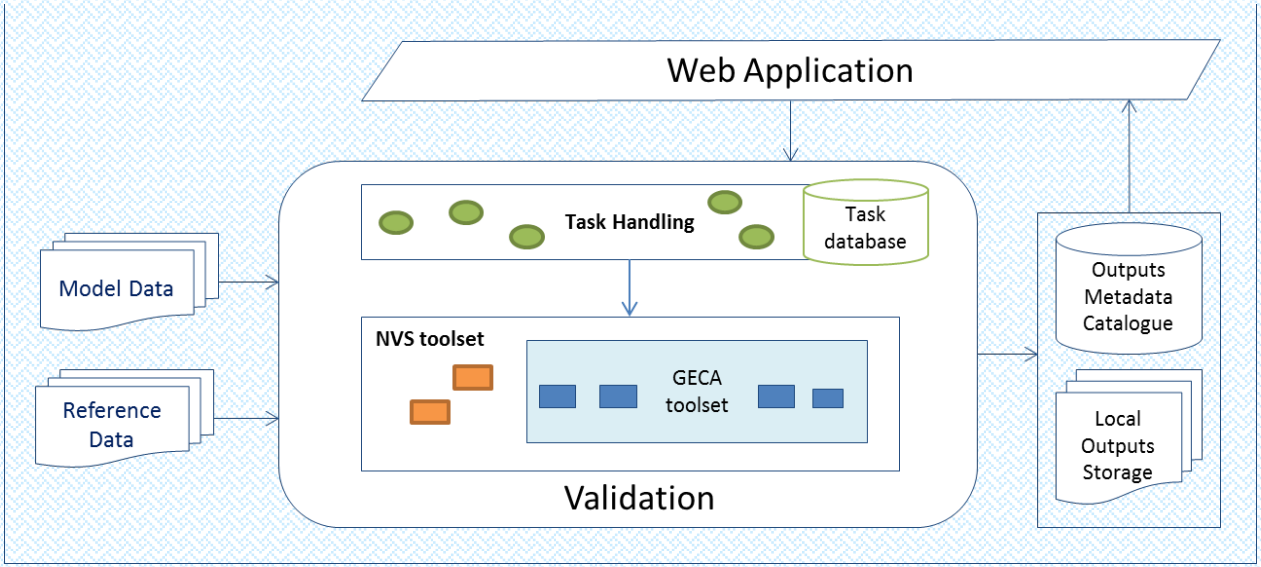


Percentage of column	Latitude (°)	Longitude East (°)	Altitude (km)	Distance (km)
0	-20,900	55,480	0,05	0,0
20	-20,906	55,511	1,8	3,3
40	-20,912	55,546	3,8	7,0
60	-20,921	55,596	6,6	12,3
80	-20,934	55,666	10,6	19,7

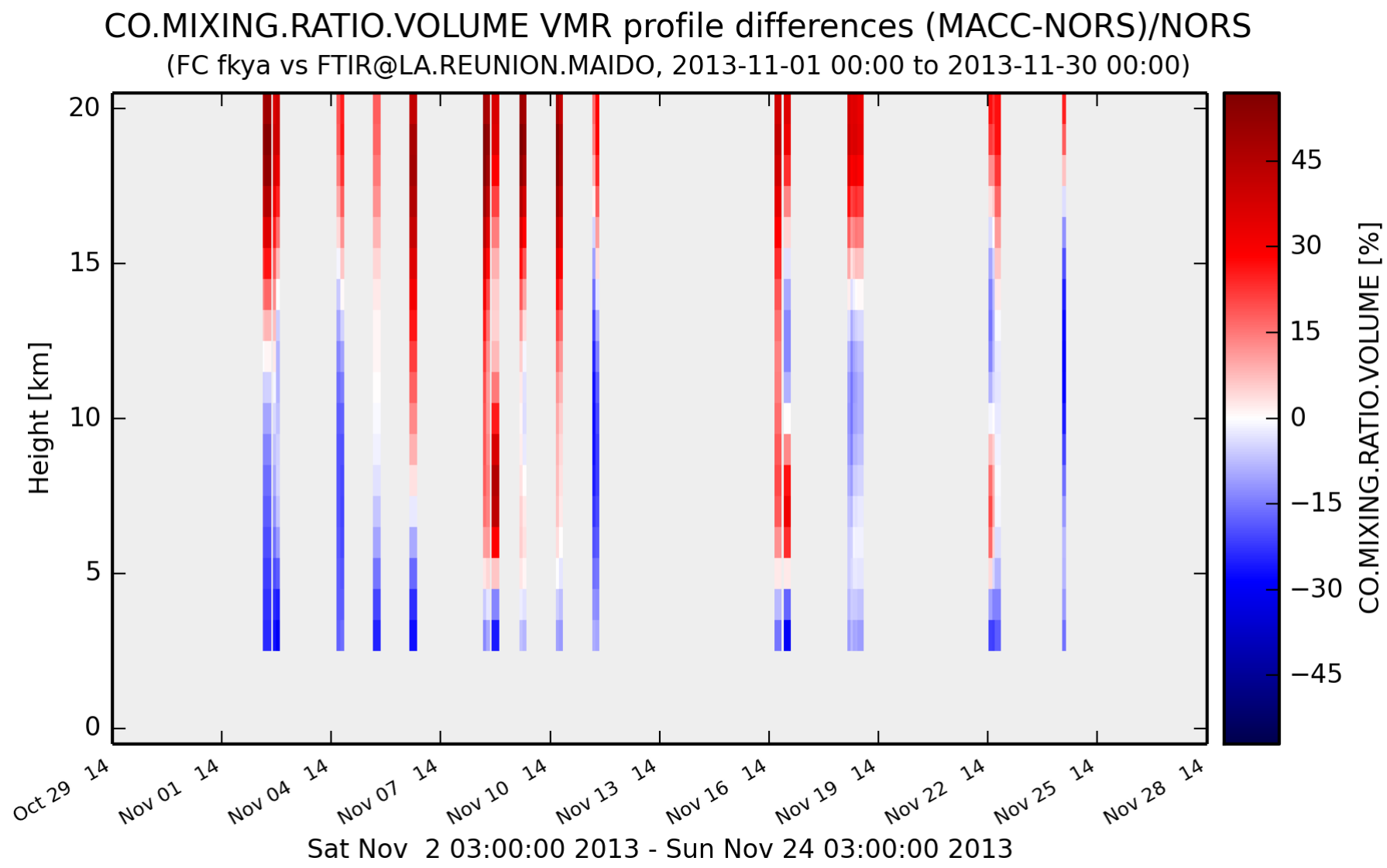
Table 1. Example of a ray tracing output for an FTIR measurement of CH_4 at St Denis (-20.9°S, 55.5°E), Ile de La Réunion, on 25/1/2011 04:04 UT for a solar zenith angle of 62° and an azimuth angle of 101° measured from N (0°) to E (90°). The Table provides the geographical location of the points along the line of sight corresponding to a percentage of the total CH_4 column.

NVS Design

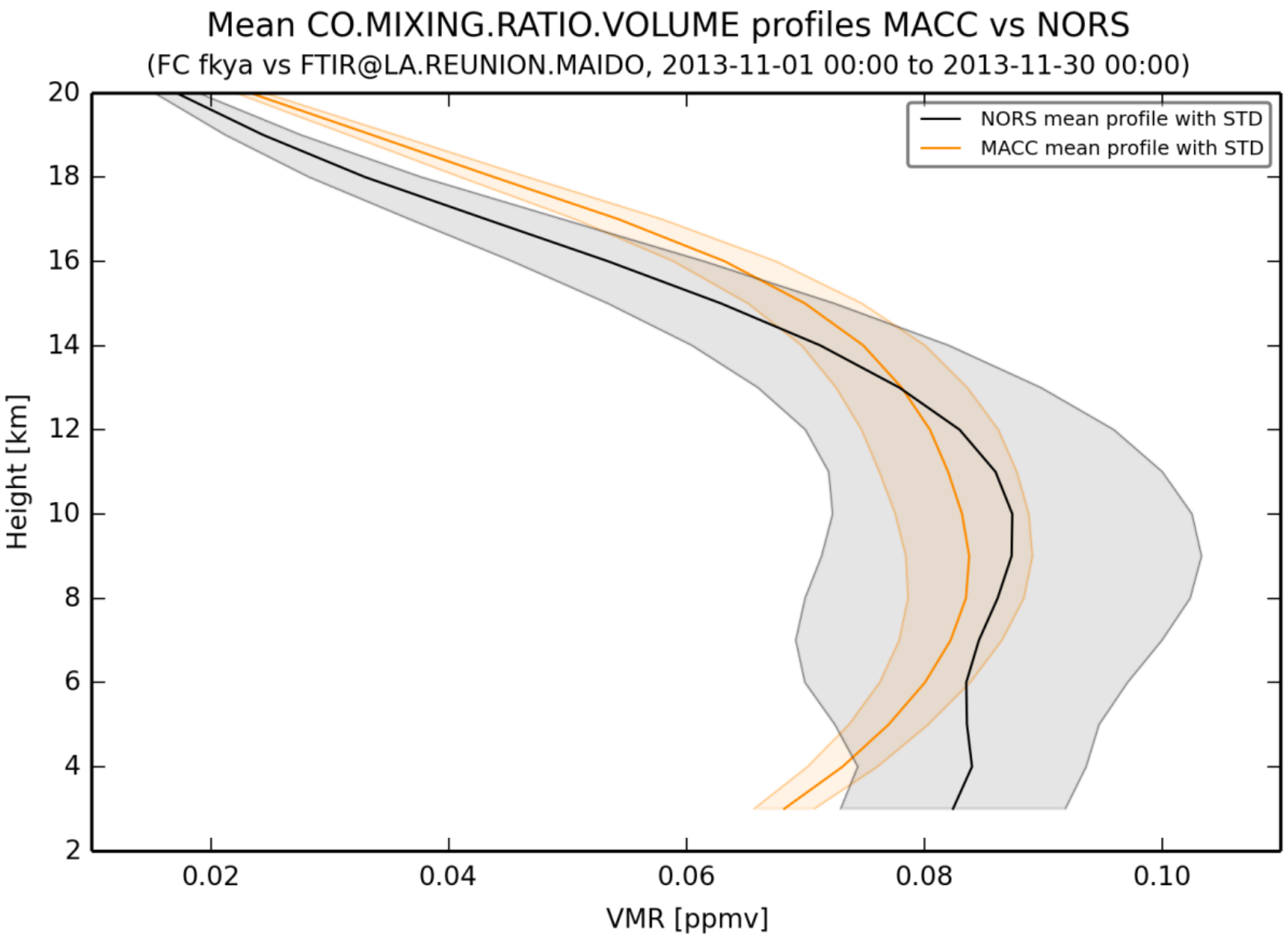

MARS@ECMWF
NDACC@NOAA
NORS
Validation Services
NORS Users
NORS Admins


Web Application
Task Handling
Task database
Model Data
Reference Data
NVS toolset
GECA toolset
Validation
Outputs Metadata Catalogue
Local Outputs Storage

Examples: CO FTIR profiles



Examples: CO FTIR profiles



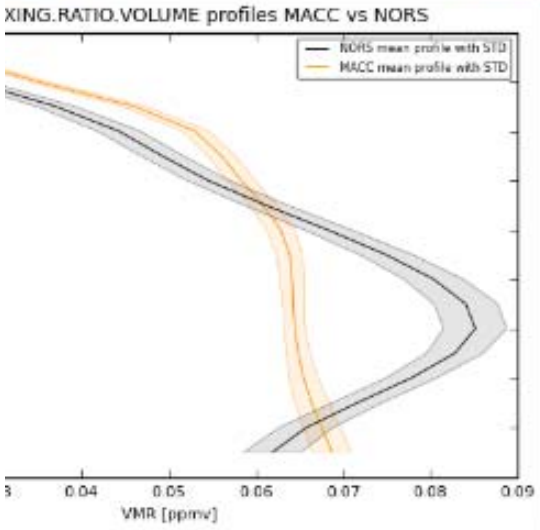
s Validation S

PARAMETER	
AEROSOL	1
CH2O	3
CH4	1
CO	3
NO2	1
O3	12

MODEL TYPE	
fkya	6
fnyp	7
fsd7	8

INSTRUMENT TYPE	
FTIR	7
LIDAR	3
MWR	3
UVVIS	8

: 2013-10 zip pdf



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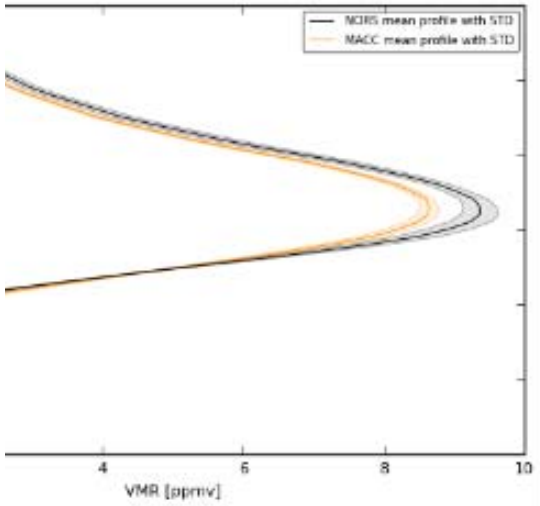

LOCATION	
[ALL]	84
BERN	40
EUREKA	6
HAUTE.PROVENCE	23
IZANA	73
JUNGFRAUJOCH	79
LA.REUNION	46
LA.REUNION.MAIDO	35
LAUDER	24
MAUNA.LOA.HI	19
NY.ALESUND	27
XIANGHE	19
ZUGSPITZE	35

AFFILIATION	
[ALL]	72
BIRA.IASB	100
CNRS.LATMOS	28
IUP	27
KIT	73
KIT.IMK.IFU	35
NIWA.ERI	6
UBERN	40
ULG	79
UMASS	49
UTORONTO	6

PERIOD TYPE	
Months	379

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NORS Validation Server

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REPORT PROPERTIES

Intercomparison	O3-fnyp-MWR
Period	MONTHS
Start	01 Mar 2013
End	31 Mar 2013
Location	NY.ALESUND
Affiliation	IUP
Generated	30 Sep 2013, 14:09h

Report actions

traceability

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previous month

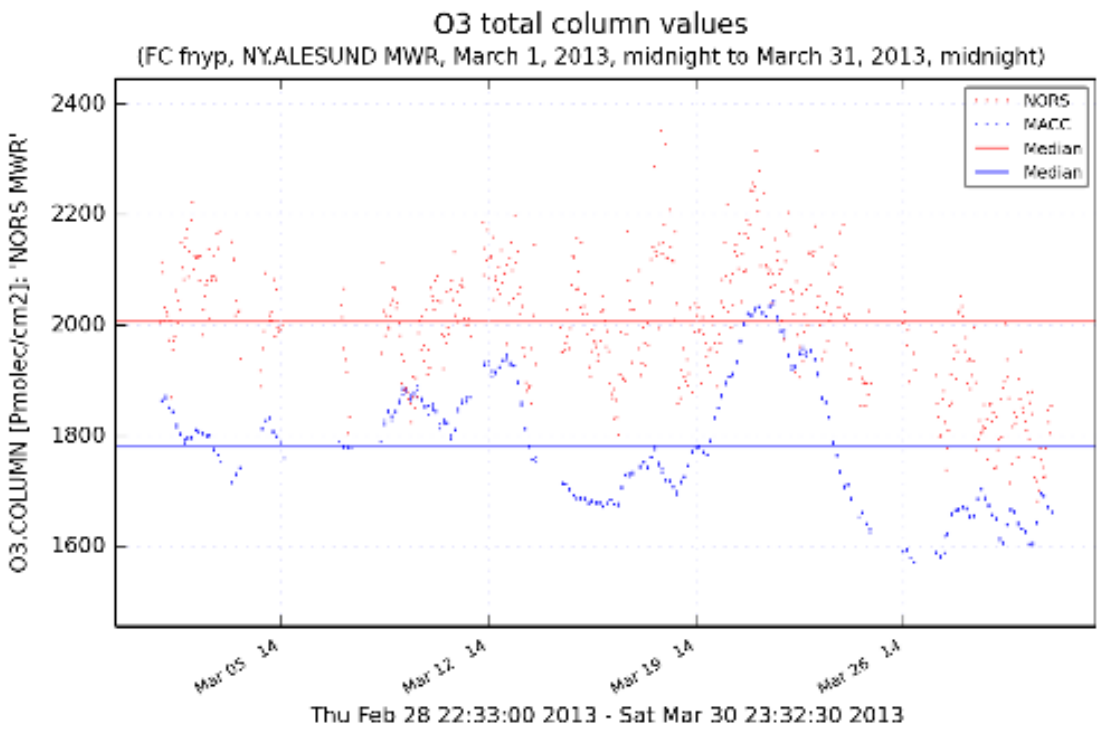
next month

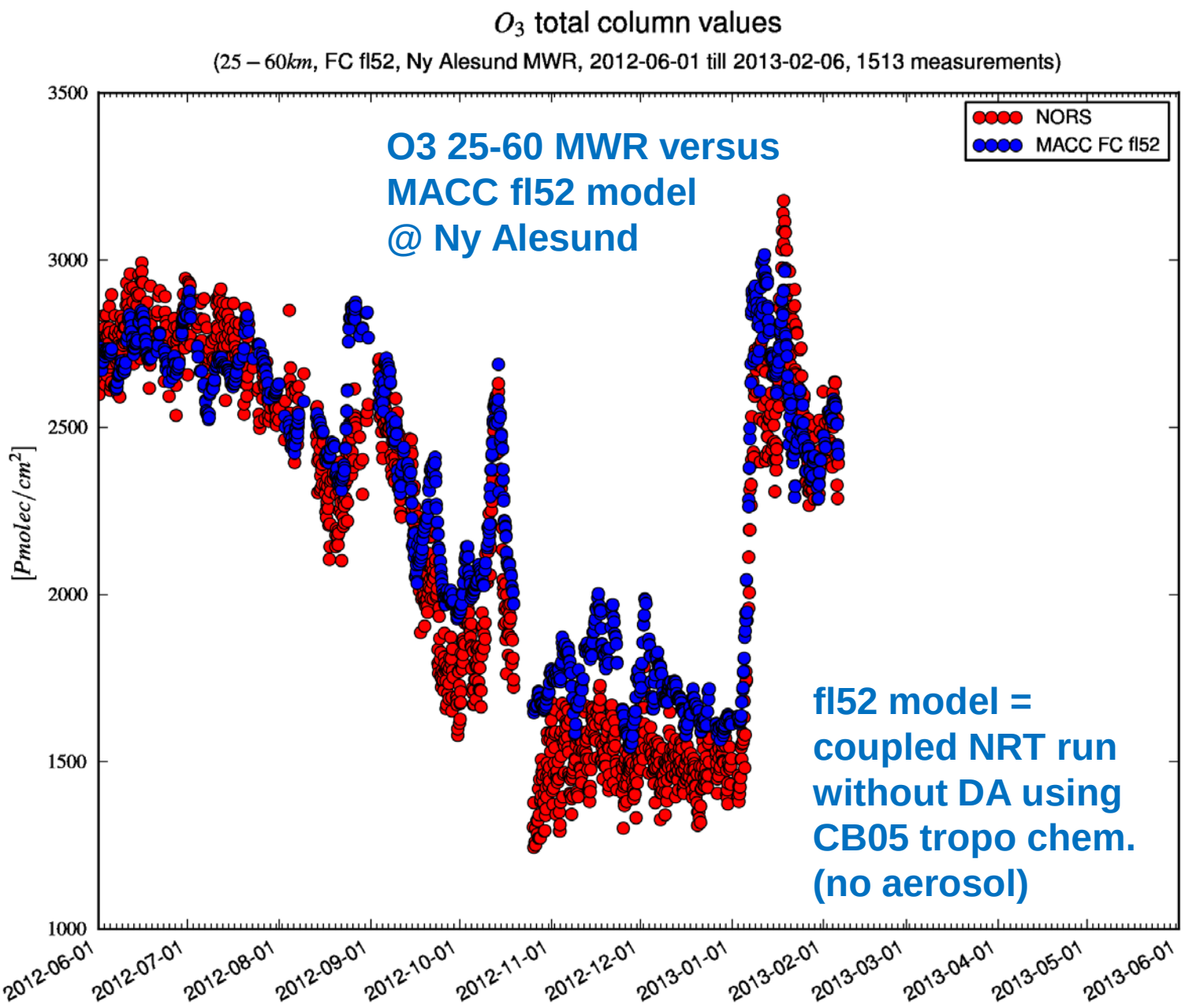
Intercomparison Report

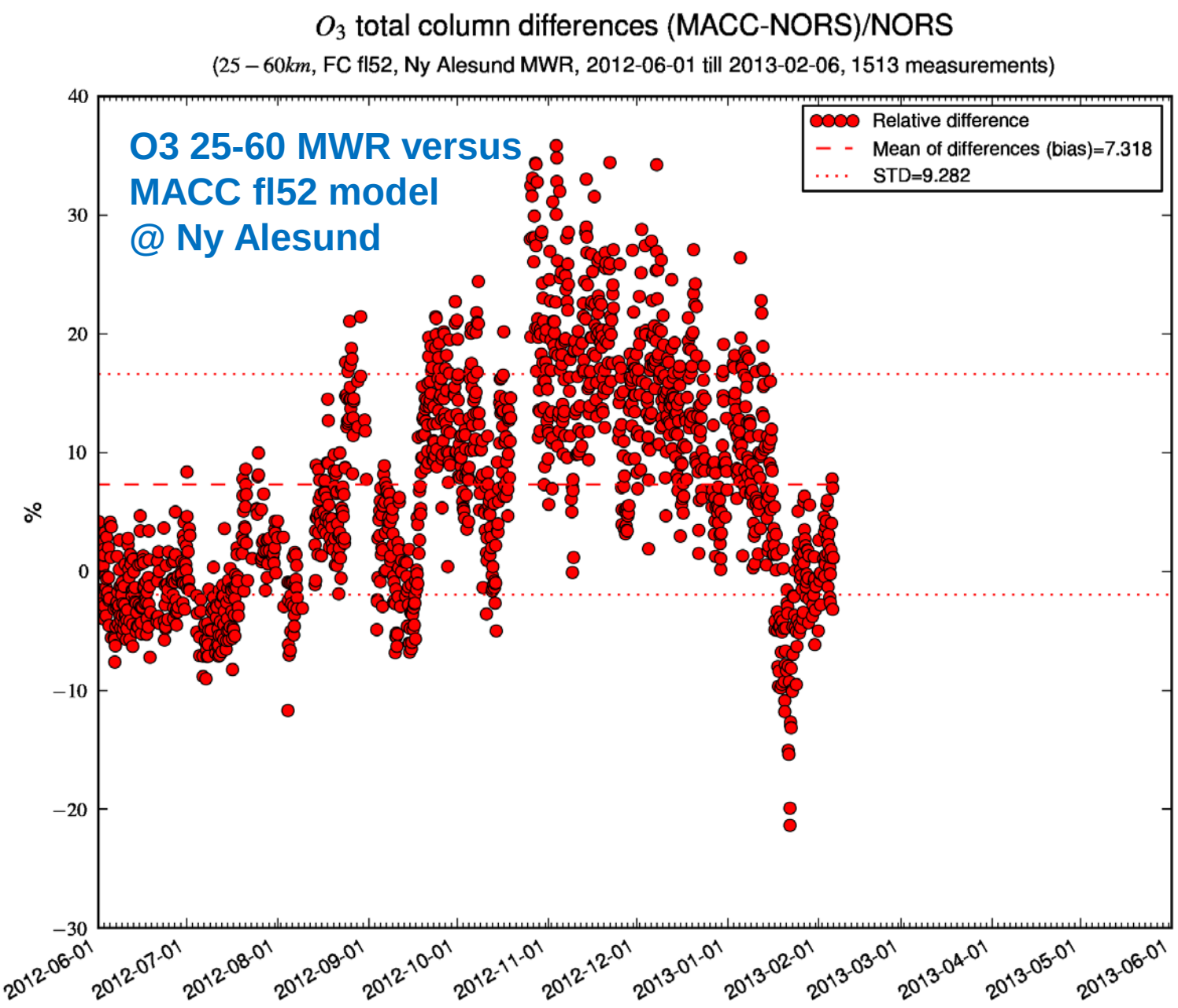
NORS Report: MACC fnyp vs NORS MWR - O3

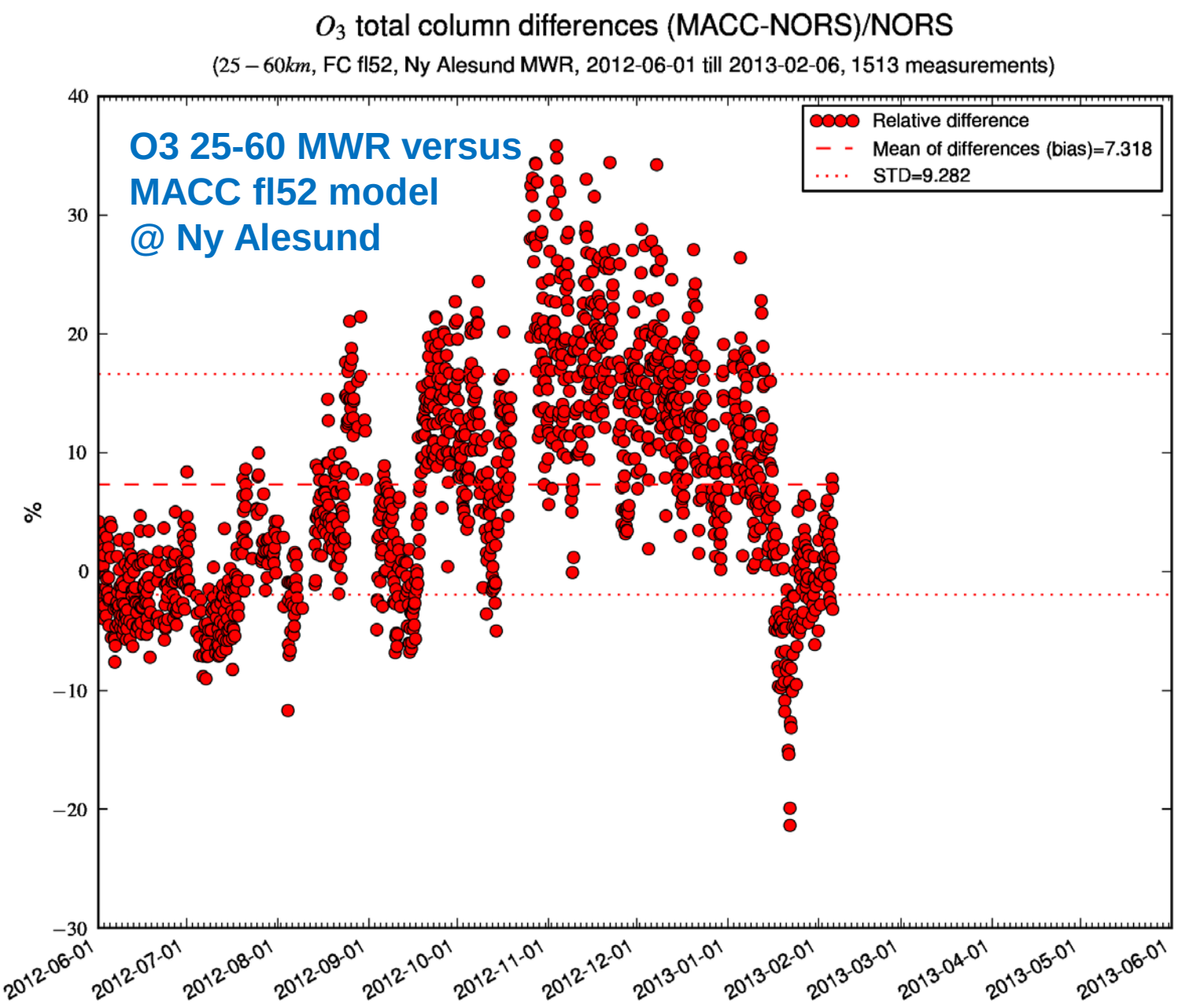
MACC vs NORS O3 Intercomparison Statistics

f (predicted variable)	O3.COLUMN [Pmolec/cm2]: 'MACC fnyp'
o (observed variable)	O3.COLUMN [Pmolec/cm2]: 'NORS MWR'
# measurements	543
median bias	-204.051
B (mean bias)	-212.975
RMSE (root mean square error)	107.092
MNMB (modified normalized mean bias)	-0.11271
FGE (fractional gross error)	0.113095
R (correlation coefficient)	0.571567
RS (Spearman rank correlation coefficient)	0.56853




O_3 total column values
(25 – 60km, FC fl52, Ny Alesund MWR, 2012-06-01 till 2013-02-06, 1513 measurements)
NORS
MACC FC fl52
O3 25-60 MWR versus
MACC fl52 model
@ Ny Alesund
fl52 model =
coupled NRT run
without DA using
CB05 tropo chem.
(no aerosol)
[$Pmolec/cm^2$]
3500
3000
2500
2000
1500
1000
2012-06-01
2012-07-01
2012-08-01
2012-09-01
2012-10-01
2012-11-01
2012-12-01
2013-01-01
2013-02-01
2013-03-01
2013-04-01
2013-05-01
2013-06-01


O_3 total column differences (MACC-NORS)/NORS
(25 – 60km, FC fl52, Ny Alesund MWR, 2012-06-01 till 2013-02-06, 1513 measurements)
O3 25-60 MWR versus
MACC fl52 model
@ Ny Alesund
Relative difference
Mean of differences (bias)=7.318
STD=9.282
%
40
30
20
10
0
−10
−20
−30
2012-06-01
2012-07-01
2012-08-01
2012-09-01
2012-10-01
2012-11-01
2012-12-01
2013-01-01
2013-02-01
2013-03-01
2013-04-01
2013-05-01
2013-06-01


O_3 total column differences (MACC-NORS)/NORS
(25 – 60km, FC fl52, Ny Alesund MWR, 2012-06-01 till 2013-02-06, 1513 measurements)
O3 25-60 MWR versus
MACC fl52 model
@ Ny Alesund
Relative difference
Mean of differences (bias)=7.318
STD=9.282
%
40
30
20
10
0
−10
−20
−30
2012-06-01
2012-07-01
2012-08-01
2012-09-01
2012-10-01
2012-11-01
2012-12-01
2013-01-01
2013-02-01
2013-03-01
2013-04-01
2013-05-01
2013-06-01