Overview of the progress achieved by the NDACC UV-vis Working Group during the NORS project

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OUTLINE

- Harmonization of DOAS retrievals (O_3, NO_2, HCHO)
- Detection and characterization of clouds using DOAS
- Spatial representativeness of DOAS measurements
- Data format homogeneisation

Harmonization of DOAS retrievals

« Standardisation of retrieval settings and parameters »

Ensure the consistency of the data sets provided to the NORS validation server

DOAS method based on two steps:

1. **Spectral inversion giving the slant column densities (SCDs)**
2. **Vertical column and/or profile retrieval from SCDs:**

Twilight zenith-sky:

Total O_3 and stratospheric NO_2 vertical columns

MAX-DOAS:

Tropospheric profiles (NO_2, HCHO, aerosols)

Harmonisation of spectral inversion: Ex. NO_2

	RECOMMENDED SETTINGS	COMMENTS
Fitting interval	425-490 nm	Settings adequate for simultaneous NO_2 and O_4 retrieval with MAXDOAS instruments. For UV instruments, the alternative 400-450 nm interval is recommended.
Wavelength calibration method	Calibration based on reference solar atlas	The Chance and Kurucz (2010) solar atlas is recommended as wavelength registration reference
Cross-sections		
NO_2	Vandaele et al. (1998), 220 K	This reference is the one included in the HITRAN data base. For stratospheric NO_2 columns, fine adjustment of temperature effects can eventually be performed in a post-processing step using a simple monthly zonal climatology of temperature profiles. For tropospheric NO_2 columns, the temperature dependence of the NO_2 cross sections should be taken into account, at least by selecting cross sections at the appropriate temperature or by adding a second (pseudo) cross sections set.
O_3	Bogumil et al, (2003), 223 K	O_3 absorption cross-sections measured with the SCIAMACHY flight-model instrument.
H_2O	Harder and Brault (1997)	
O_4	Hermans et al. (2003)	
Ring effect correction method	Chance and Spurr (1997)	It is recommended to use of an effective Ring cross-section. A high resolution Ring effect cross-section source (generated after Chance and Spurr, 1997) is provided on the NDACC web site. Note that this approach neglects the impact of the Ring effect on the NO_2 absorption itself (molecular Ring effect).
Polynomial term	Polynomial of order 3 to 5 maximum	
Intensity offset correction	Slope	The intensity offset parameter corrects for spectral stray-light effects and for the wavelength dependence of the probability of Raman scattering (Ring effect). One usually recommends a slope correction (linear).
Data filtering for clouds	Enhancement of O_4 and/or H_2O absorption	Clouds have a small effect on stratospheric NO_2. However, it is recommended to remove measurements showing large enhancements of O_4 and/or H_2O slant columns.

Harmonisation of spectral inversion: Ex. NO_2

- ***O_3 and NO_2:***
  - ***Recommendations + cross-sections data sets made available from the NDACC UVVIS WG website***
  - ***Hendrick et al., ACP (2011) for O_3***
- ***HCHO:***
  - ***Pinardi et al., AMT (2013)***

	RECOMMENDED SETTINGS	COMMENTS
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Harmonisation of total O_3 and stratospheric NO_2 vertical columns retrieval

$$VCD(\theta) = \frac{SCD(\theta)}{AMF(\theta)}$$

Recommended AMFs for the SCD → VCD conversion:

- Look-up tables of O_3 and NO_2 AMFs generated by BIRA and made available with extraction tools at http://www.ndacc.org

O_3

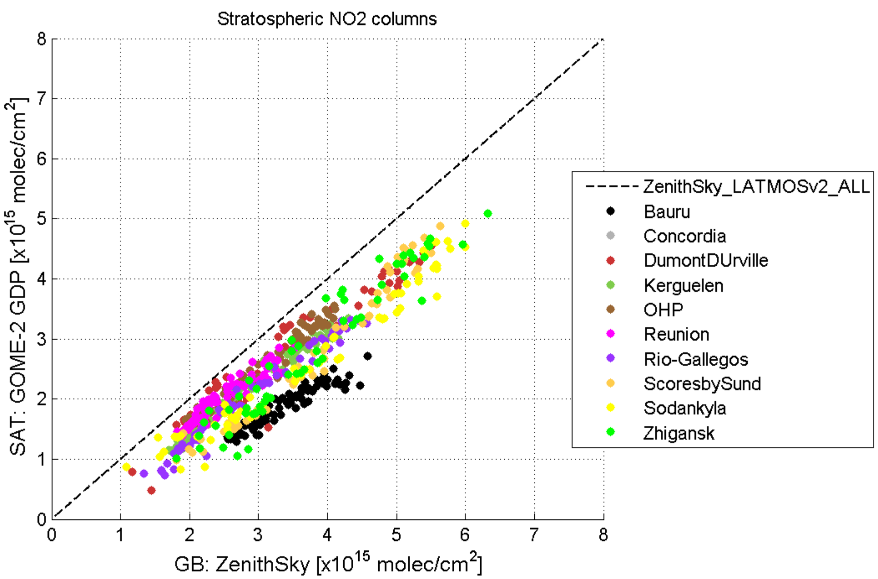
Parameter	Value
O_3 profile	TOMS TV8: -Latitude: 85°S to 85°N step 10° -Month: 1 (Jan) to 12 (Dec) step 1 -Ozone column: 125 to 575 DU step 50 DU
Wavelength	440 to 580 nm step 35 nm
Surface albedo	0 and 1
Station altitude	0 and 4 km
SZA	10, 30, 50, 70, 80, 82.5, 85, 86, 87, 88, 89, 90, 91, and 92°

NO_2

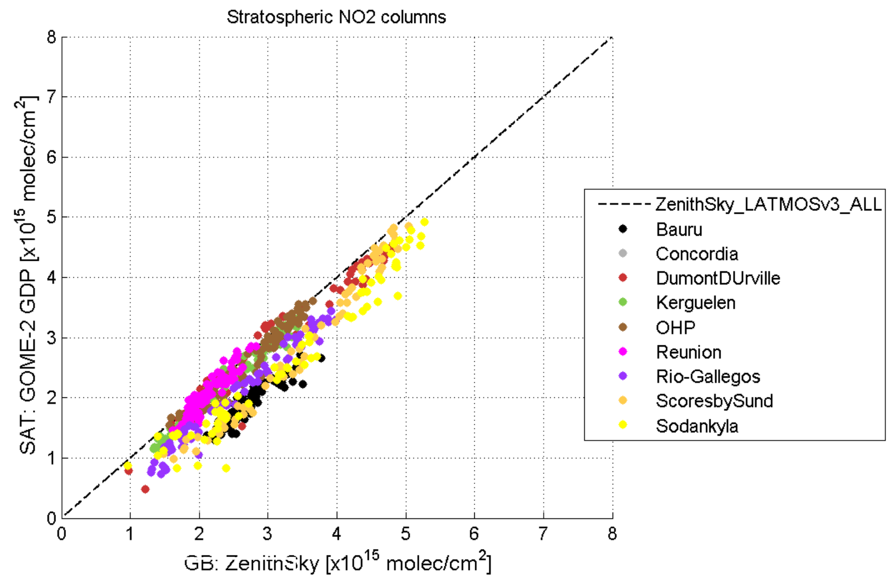
Parameter	Value
NO_2 profile	20-60km: HALOE, POAM-III (Lambert et al.'s climatology) -Latitude: 85°S to 85°N step 10° -Month: 1 (Jan) to 12 (Dec) step 1 -Sunrise and sunset 12-20km: SAOZ balloon climatology -Latitude: tropics, mid-, and high-latitudes -Resolved in seasons
Wavelength	350 to 550 nm step 40 nm
Surface albedo	0 and 1
Station altitude	0 and 4 km
SZA	10, 30, 50, 70, 80, 82.5, 85, 86, 87, 88, 89, 90, 91, and 92°

Stratospheric NO_2 VCD: SAOZ/GOME-2 comparison (2007-2014)

LATMOS/SAOZ V2
(single AMF based on yearly mean profiles for Tropics, Mid-latitudes or Polar regions)



LATMOS/SAOZ V3
(new AMF climatology)



Mean bias:

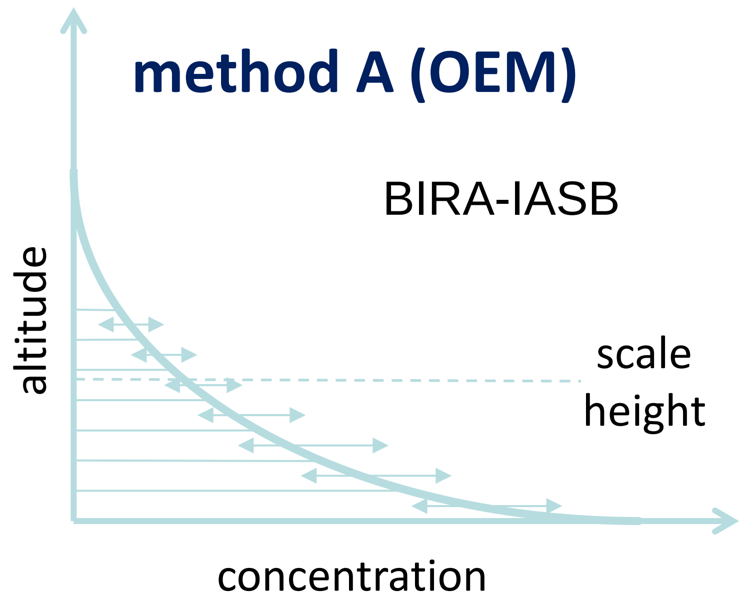
	V2	V3
	($x10^{15}$ molec/cm^2)	
SH	-1.02	-0.34
NH	-0.37	-0.44

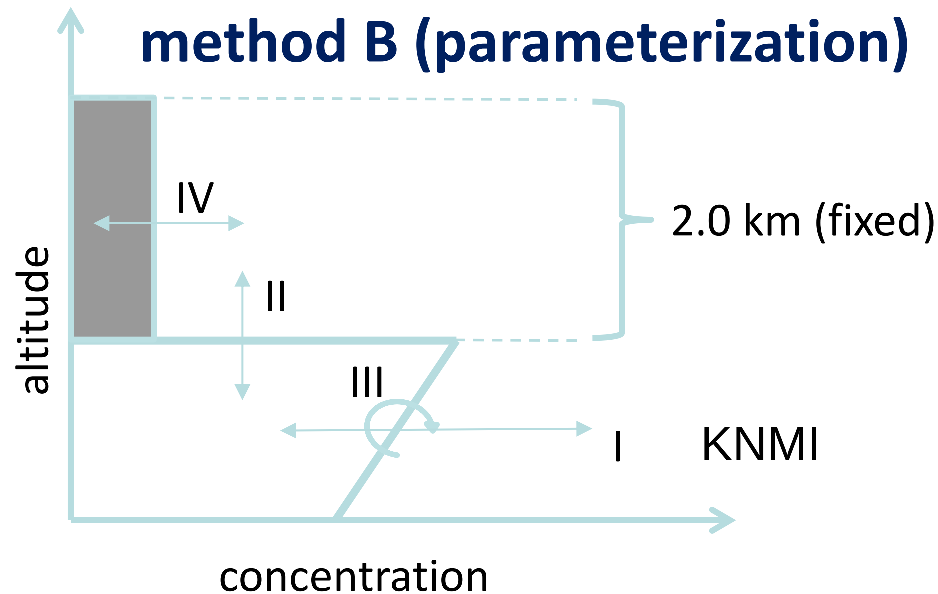
Courtesy G. Pinardi

Method:
SAT extracted within 150km radius and mean value for every day
GB: AM VCD photochemically converted to SAT ovp time (considering the effective SZA of the air-masses) and corrected for different NO2 xs T°
Compare only common days and then do monthly means of the daily comparisons

Performance of profiling methods: Optimal Estimation Method *versus* parameterization

Two alternative profile parameterizations:





- 13 layers (0-4 km)
- On-line radiative transfer
- Exponentially decreasing a priori profile (SH={0.5,1.0, 1.5 km})

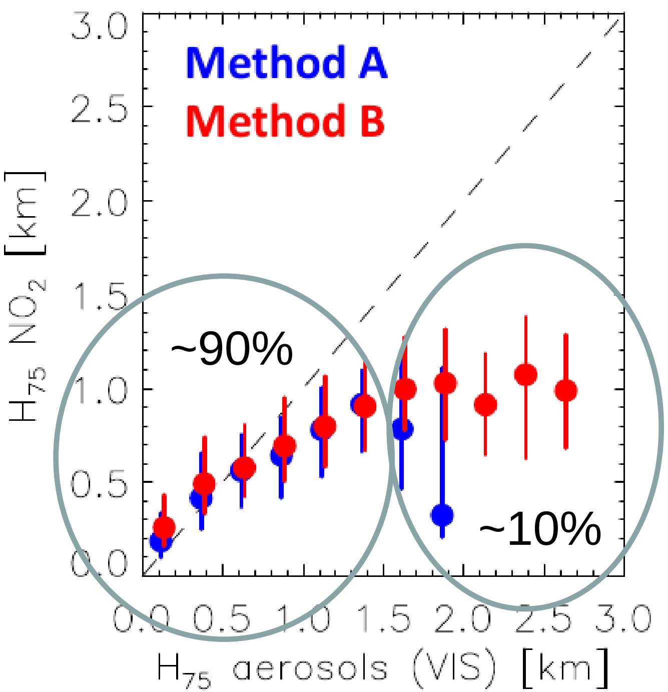
- 2-4 parameters defining profile shape
- Least Squares Fit + ensemble approach (50 runs)
- Forward simulations: Look-up table
- No a priori information

Vlemmix et al., AMTD, 2014

OEM *versus* parameterization: Application to MAX-DOAS observations at Xianghe

H_{75}: Height below which 75% of the tropospheric column resides

NO_2 and aerosols (visible)



- Method B has a larger dynamical range (higher H_{75} values can be retrieved) than method A
- In contrast, method A is found to be generally more robust/stable
- Quite good agreement between the two methods in the visible, especially for 90% of the data set where method B finds aerosol profiles below 1.5 km (H_{75}<1.5km)
- Important study for future improvements of MAX-DOAS retrieval algorithms

Vlemmix et al., AMTD, 2014

How to detect clouds from MAX-DOAS observations ?

MAX-DOAS trace gas retrievals can be strongly affected by clouds (and aerosols)

- Clouds are bright

=> use **measured radiance**

- Clouds are white

=> use **colour index ($CI=I_{\lambda,low}/I_{\lambda,high}$)**

- Clouds change atmospheric radiative transfer

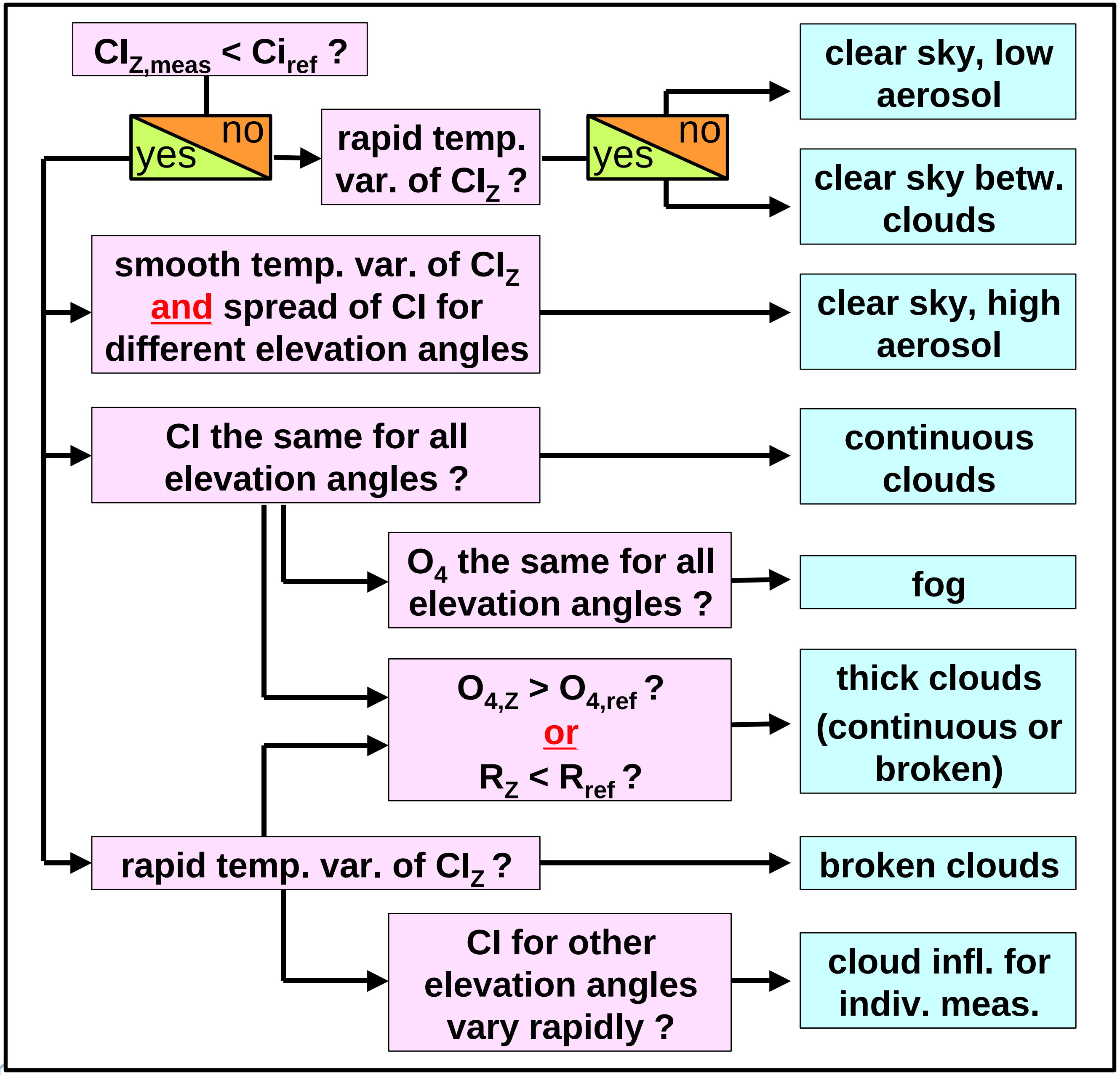
=> use **O_4 absorption and Ring effect**

Wagner et al., AMT, 2013; see also U. Friess' talk tomorrow

MPIC/Mainz cloud screening method

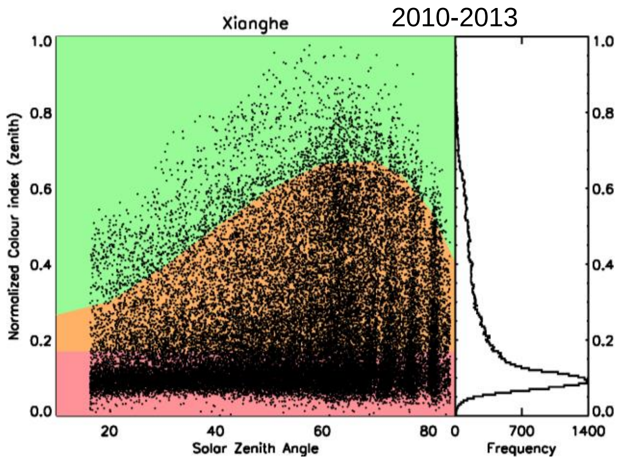
Cloud classification scheme

Wagner et al., AMT, 2013

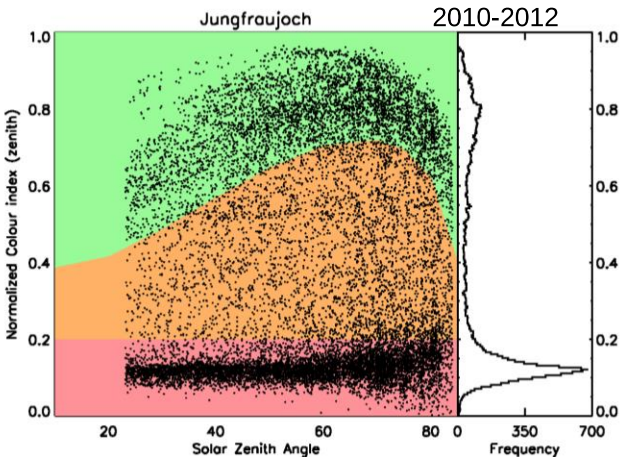


BIRA cloud screening method (1)

Cloud screening flag (zenith only)



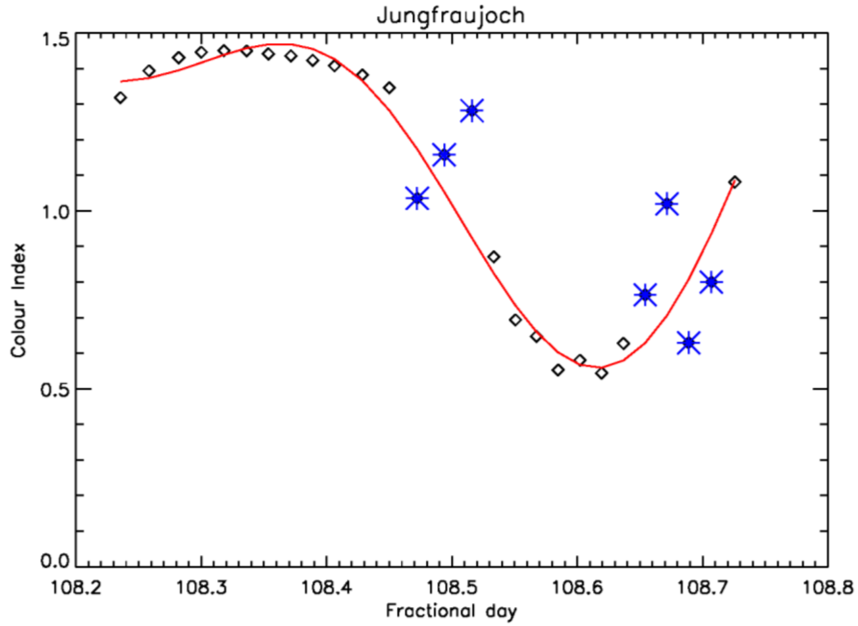
$$CI = \frac{I_{405nm}}{I_{670\,nm}}$$



$$CI = \frac{I_{405nm}}{I_{550\,nm}}$$

- **Use of CI simulations to define different sky regimes: clear sky, intermediate, fully cloudy**

Broken cloud flag (zenith only)

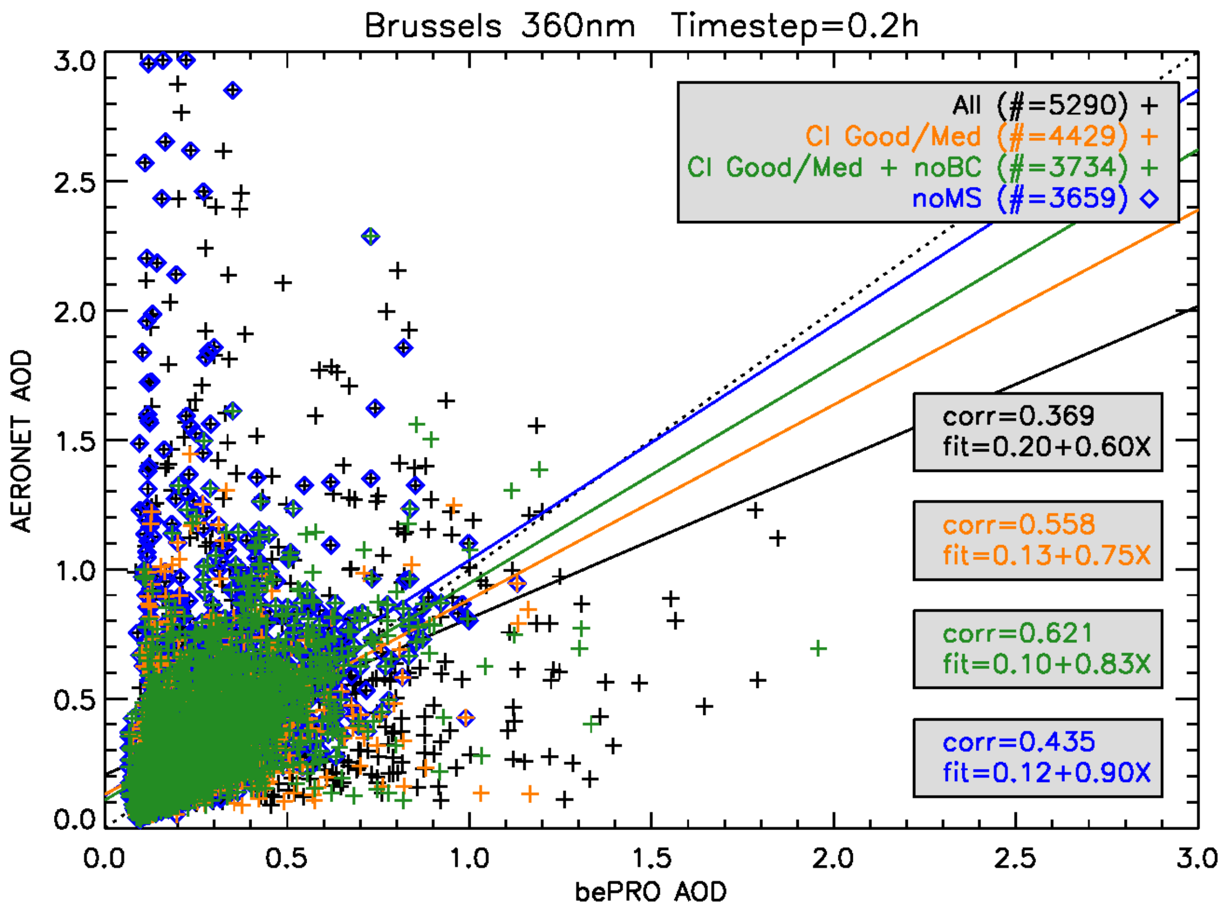


- **Fitting of a double-sine function**
- **Outliers: presence of broken clouds**

Gielen et al., AMT, 2014

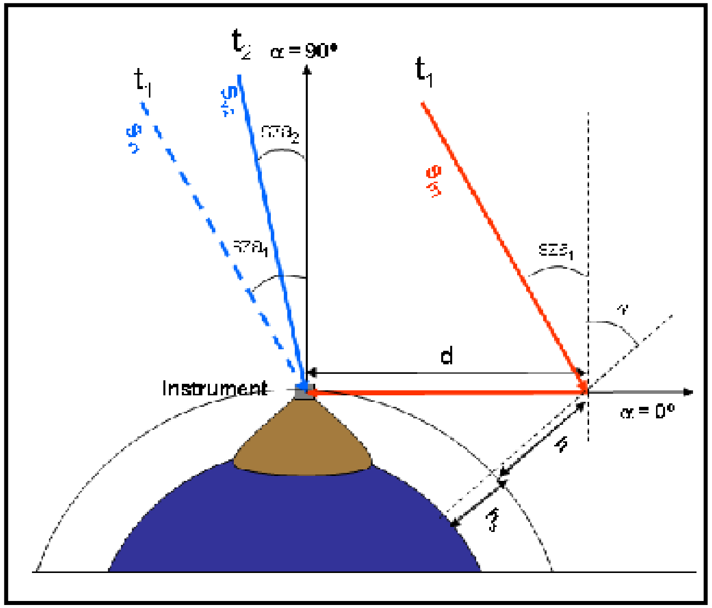
BIRA cloud screening method (2)

Comparison MAX-DOAS/AERONET_v1.0



Gielen et al., AMT, 2014

Horizontal representativeness: MAX-DOAS

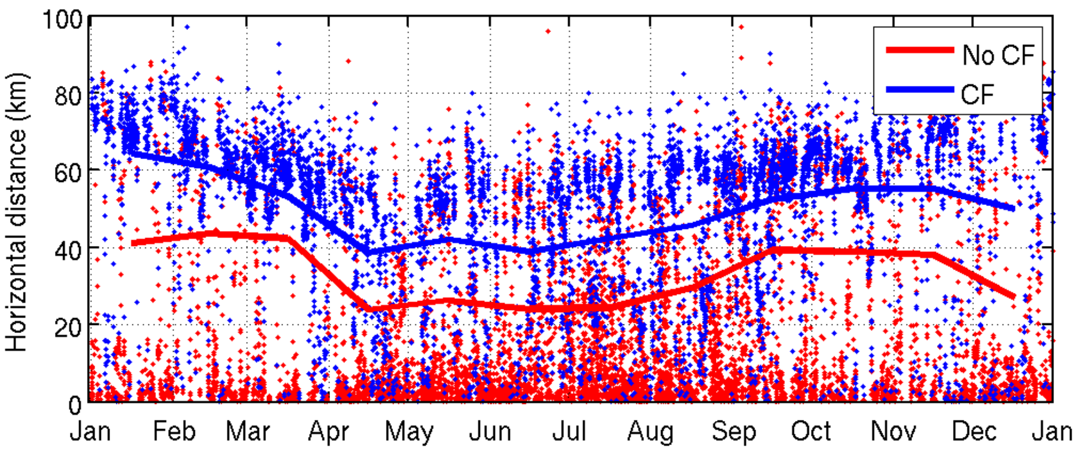


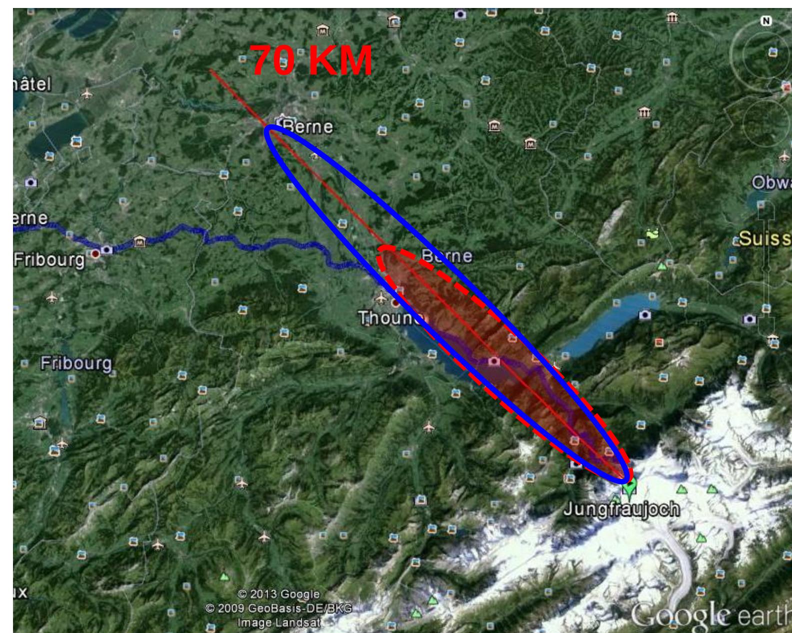
Modified geometrical approach:

$$d = \frac{SCD_{O_4}(\alpha{=}0°, SZA1, t1) - SCD_{O_4}(\alpha{=}90°, SZA2, t2)f}{[O_4]_{station}}$$

Gomez et al., AMT, 2014

Application to Jungfraujoch (477 nm)

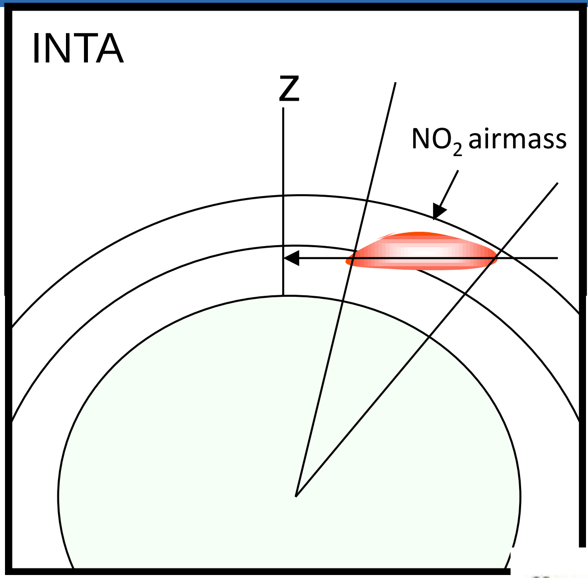




- From all scans: d~25-45km
- From cloud-filtered scans (CF): d~40-65km

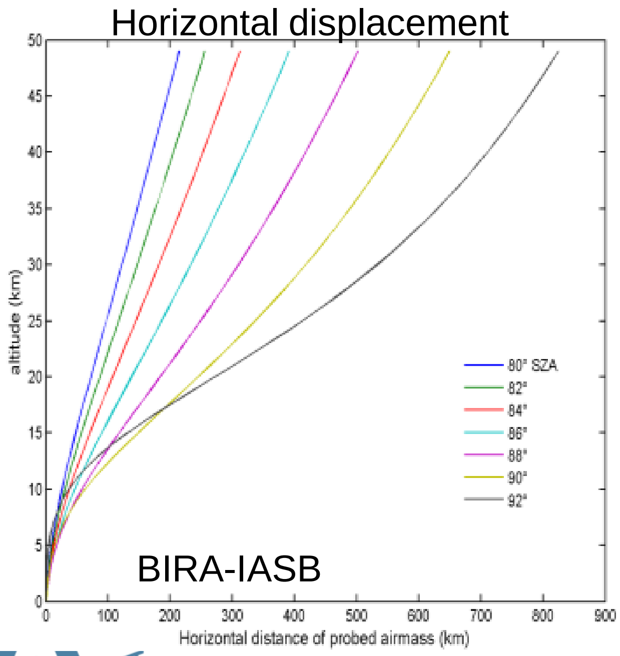
See also talks by Richter et al. and Remmers et al. tomorrow

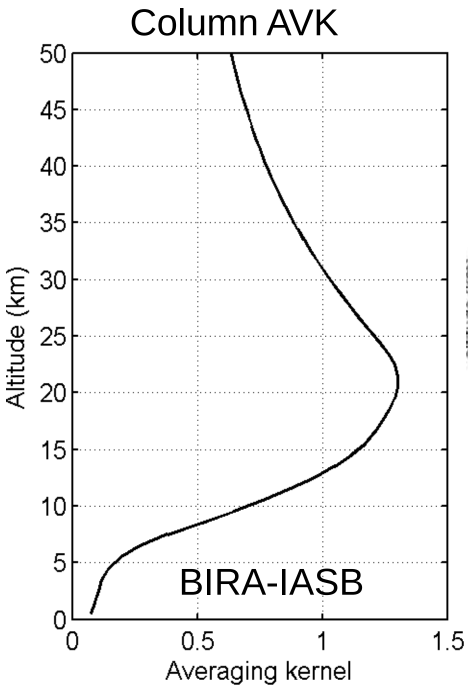
Horizontal representativeness: twilight zenith

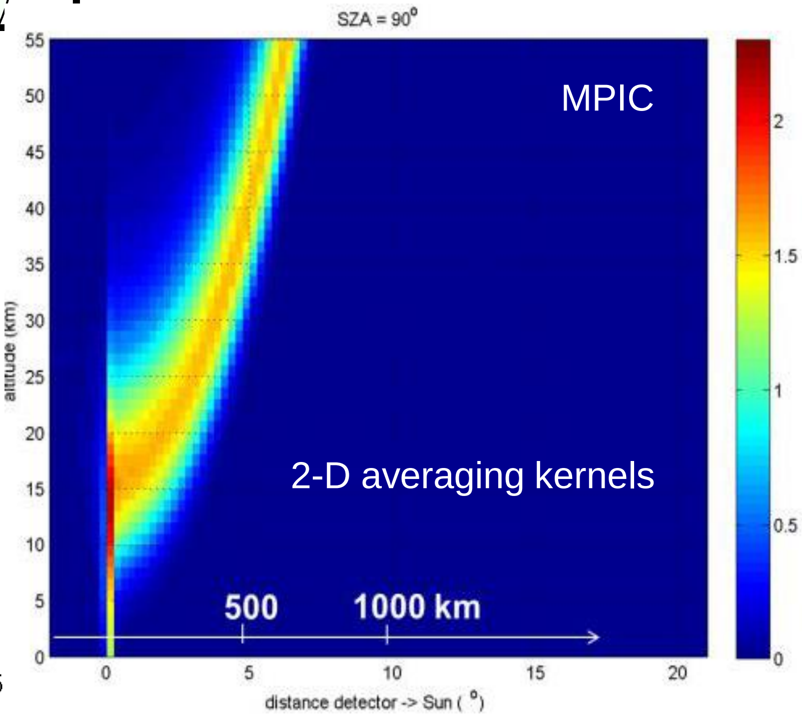


$$d(i) = \frac{\sum_{z,i=0}^{top-atmosphere} x(z,i) * WF(z)}{\sum_{z,i=0}^{top-atmosphere} WF(z)}$$

Richter, A., et al., NORS Deliverable D4.4, 2013

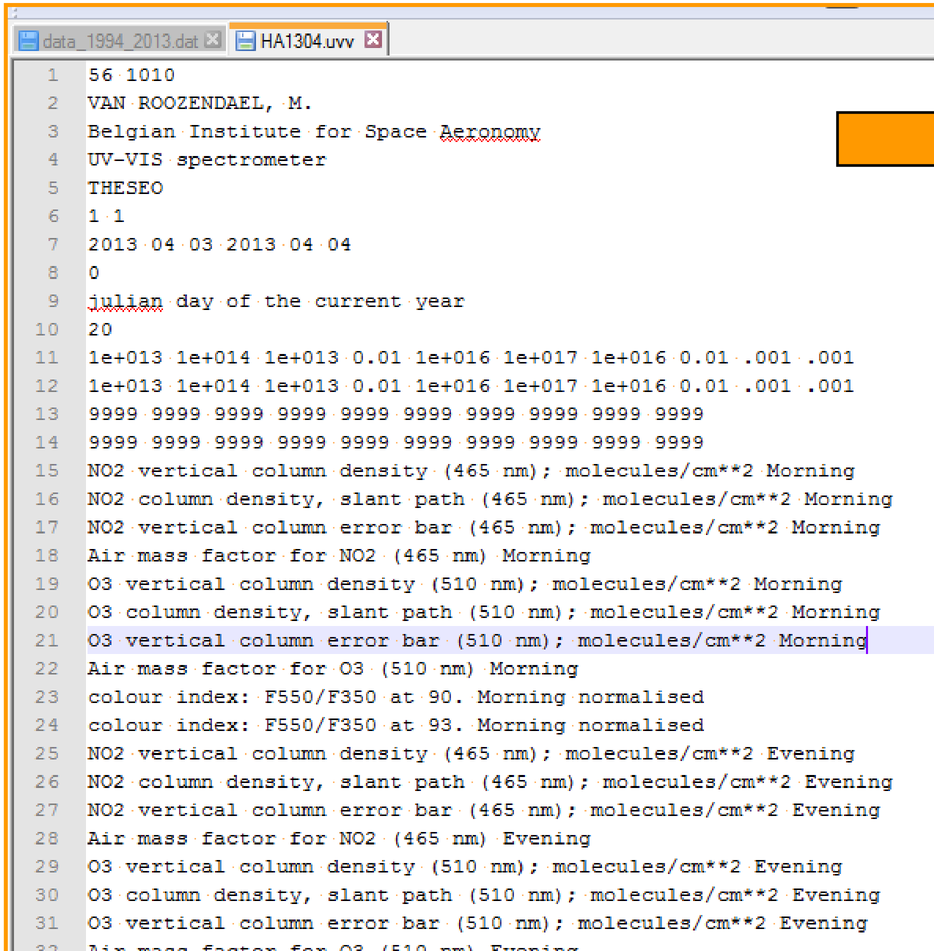


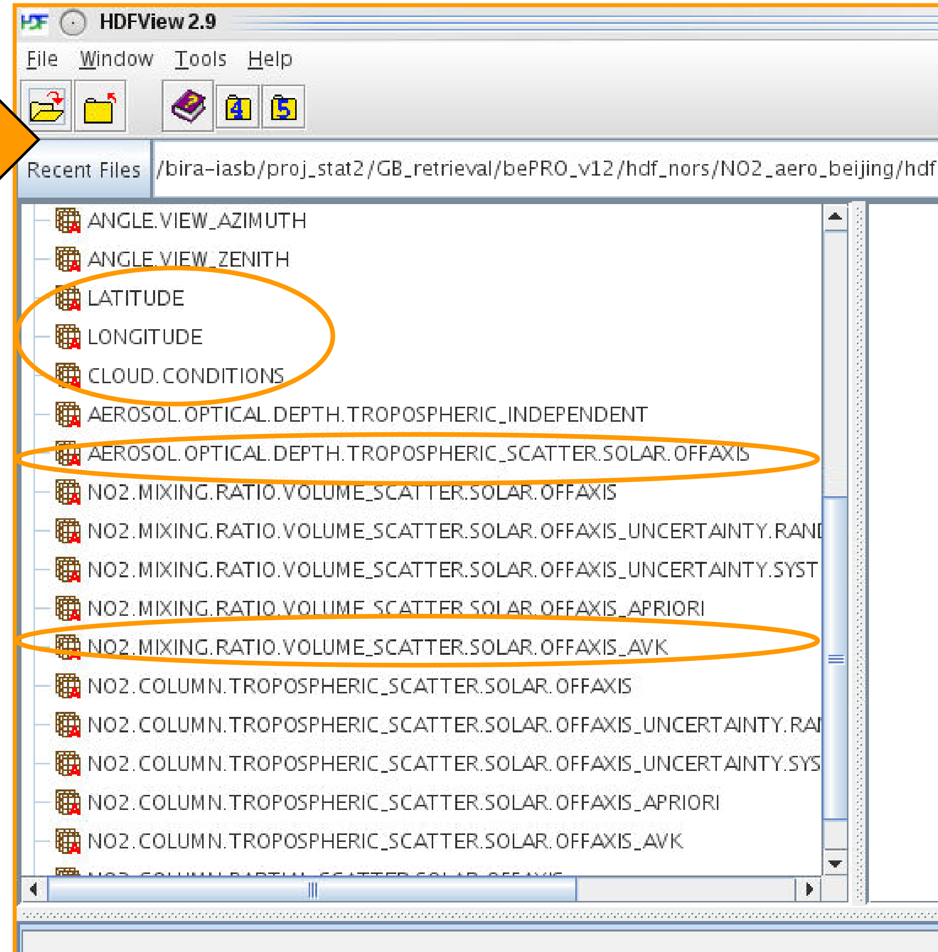




UV-vis data format homogeneization

From NASA-AMES to GEOMS hdf





Conclusions and perspectives

Significant progress have been achieved during NORS:

- **Data harmonization (recommended settings including ancillary data like e.g. cross-sections and AMF)**
- **Data quality assessment (cloud flagging, spatial representativeness)**
- **Data reporting (GEOMS hdf)**
- **Data delivery (daily submission to NORS RD database)**

➡ **This significantly improves the usability of UVVIS data for future satellite and model validation efforts (MACC-II/III, CAMS)**

Thank you for your attention !