



CAMS27: CAMS funding for NDACC

Bavo Langerock & Martine De Mazière

CAMS



**Validation report of the CAMS
near-real time global
atmospheric composition service**

September - November 2017

Issued by: KNMI

Date: 7/3/2018

Ref: CAMS84_2015SC3_D84.1.1.10_2017SON_v1

- copernicus atmosphere monitoring service
- <http://atmosphere.copernicus.eu/>
- NDACC data is used for in quarterly validation reports
requires data of
1/ sufficient quality (QC)
2/ delivered within 1 month after measurement (RD)



4.3 Validation against FTIR observations from the NDACC network

In this section, we compare the CO profiles of the CAMS models with FTIR measurements at Maido (21°S, 55°E, i.e. southern tropics, altitude 2.2km) and Lauder (46°S, 169.7°E, altitude 370m). These ground-based, remote-sensing instruments are sensitive to the CO abundance in the troposphere and lower stratosphere, i.e. between the surface and up to 20 km altitude. Tropospheric CO profiles and columns are validated (up to 10km). A description of the instruments and applied methodologies can be found at <http://nors.aeronomie.be>.

Table 4.3.1 and Fig. 4.3.1 show that the tropospheric columns of CO agree well. The o-suite underestimates CO at Lauder with values around 2%, which is within the measurements uncertainty range (6%). At Maido the o-suite underestimates the CO abundance (approx. -6%, underestimation seems to decrease in time). The mean uncertainty on these measurements is 5%, so the observed o-suite biases are now only slightly larger than the measurement uncertainty). During the biomass burning season (SON) the bias of the control run decreases. For both stations, the control run overestimates the background CO with MBs between 20%-30%, clearly showing the positive effect of assimilation.

Table 4.3.1: Seasonal relative mean bias (MB, %), standard deviation (STD, %) for the considered period and number of observations used (NOBS), compared to NDACC FTIR observations at Lauder and Maido (mean bias and stddev in %). The overall uncertainty for the CO measurements at Lauder and Maido is approximately 5%.

| | | DJF | | | MAM | | | JJA | | | SON | | |
|---------|--------|-------|--------|------|-------|--------|------|-------|--------|------|-------|--------|------|
| | | MB | stddev | nobs |
| o-suite | Lauder | 0.93 | 6.27 | 168 | -0.29 | 6.65 | 160 | 5.89 | 3.94 | 135 | 0.01 | 4.61 | 221 |
| control | Lauder | 44.32 | 10.46 | 168 | 54.65 | 7.04 | 160 | 42.47 | 7.63 | 133 | 20.80 | 8.28 | 221 |
| o-suite | Maido | -5.14 | 10.12 | 324 | -2.04 | 5.64 | 457 | -5.06 | 3.67 | 234 | -3.20 | 3.93 | 337 |
| control | Maido | 42.79 | 6.77 | 324 | 43.05 | 7.86 | 457 | 24.95 | 7.78 | 234 | 6.44 | 11.34 | 337 |

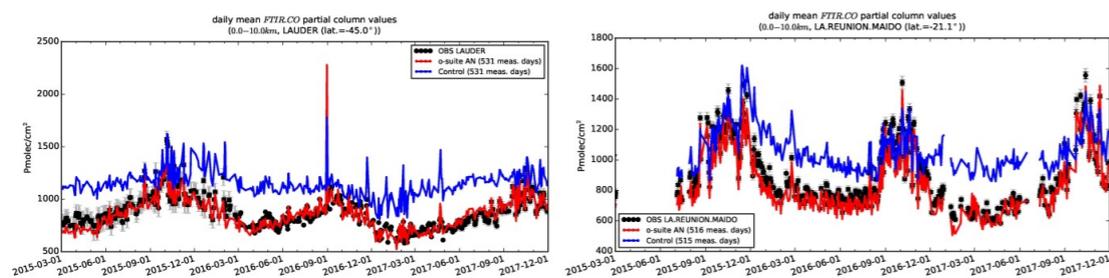


Figure 4.3.1: Daily mean values of tropospheric CO columns (till 10km) by the o-suite (red) and the Control run (blue) compared to NDACC FTIR data at Lauder, New Zealand (45°S, 169.7°E) (left) and Maido (21°S, 55°E) (right) for the period March 2015-December 2017. The number of measurement days is indicated in the legend. In Lauder a spike is seen at the end of August 2016. This is caused by a drifting fire source in the model, as discussed in a previous report.

- Limited number of stations in reports: CO -> Lauder (Dan Smale) & Maido

- O3: 2 MWR and 2 LIDAR

- ...



CAMS27

Support for The Provision Of NDACC Observations

- CAMS provides support to NDACC for **rapid delivery** of **quality** data to NDACC DHF for
 - FTIR:** CH₄, CO, O₃
 - UVVIS zenith:** NO₂, O₃
 - MWR:** O₃
 - LIDAR:** O₃
 - UVVIS offaxis:** HCHO, NO₂, Aerosol
- Start/End = July 2017 - July 2021
- First Service Contract: July 2017 - December 2018
- NDACC data stream monitoring in place since March 1 2018
- funding for submission (x€/y) and for development (5k€)
- **QC because differences in site-to-site biases must be due to model performance (not retrieval settings eg)**

During Jan 2018:

- 80% out of 256 submitted files were QC ok
- 40% out of 256 submitted files were RD ok
- 16 instruments actively contributing

During March 2018:

- 95% out of 544 submitted files were QC ok
- 96% out of 544 submitted files were RD ok
- 32 instruments actively contributing (will increase)
- PI's can consult the status of their submission on cams27.aeronomie.be

FTIR March - June 2018:

53/1800 files

- 96% out of 53 submitted files were QC ok
- 90% out of 53 submitted files were RD ok
- 9 instruments actively contributing (will increase)

- ftir.co_awi001(Ny-Ålesund): 2/2 = 100.00%
- ftir.co_awi028(Paramaribo): 7/7 = 100.00%
- ftir.co_bira.iasb003(Mt Maido): 9/9 = 100.00%
- ftir.co_iup001(Bremen): 6/6 = 100.00%
- ftir.co_niwa001(Lauder): 2/2 = 100.00%
- ftir.co_niwa004(Arrival Heights): 0/2 = 0.00%
- ftir.co_spbu001(St Petersburg): 4/4 = 100.00%
- tir.co_ulg002(Jungfrauoch): 2/4 = 50.00%
- ftir.co_unam001(Altzomoni): 4/4 = 100.00%
- ftir.co_utoronto001(Eureka): 5/6 = 83.33%
- ftir.co_utoronto002(Toronto): 5/7 = 71.43%

online QC check

Dr. Bavo Langerock (baval@oma.be)

| | |
|---|-------------------------|
| Period | 2018-01-23 - 2018-05-10 |
| Succesfull reports/Total Reports | 1361/2497: 55% |
| Failed Quality Assurance checks/Total Reports | 422/2497: 17% |
| Failed Rapid Delivery checks/Total Reports | 972/2497: 39% |



QC Reports in HTML format

Station: -- Select Station --
 Country: -- Select Country --
 Target: -- Select Target --
 Network: -- Select Network --
 DataProduct: -- Select DataProduct --
 Week: Latest weekly data

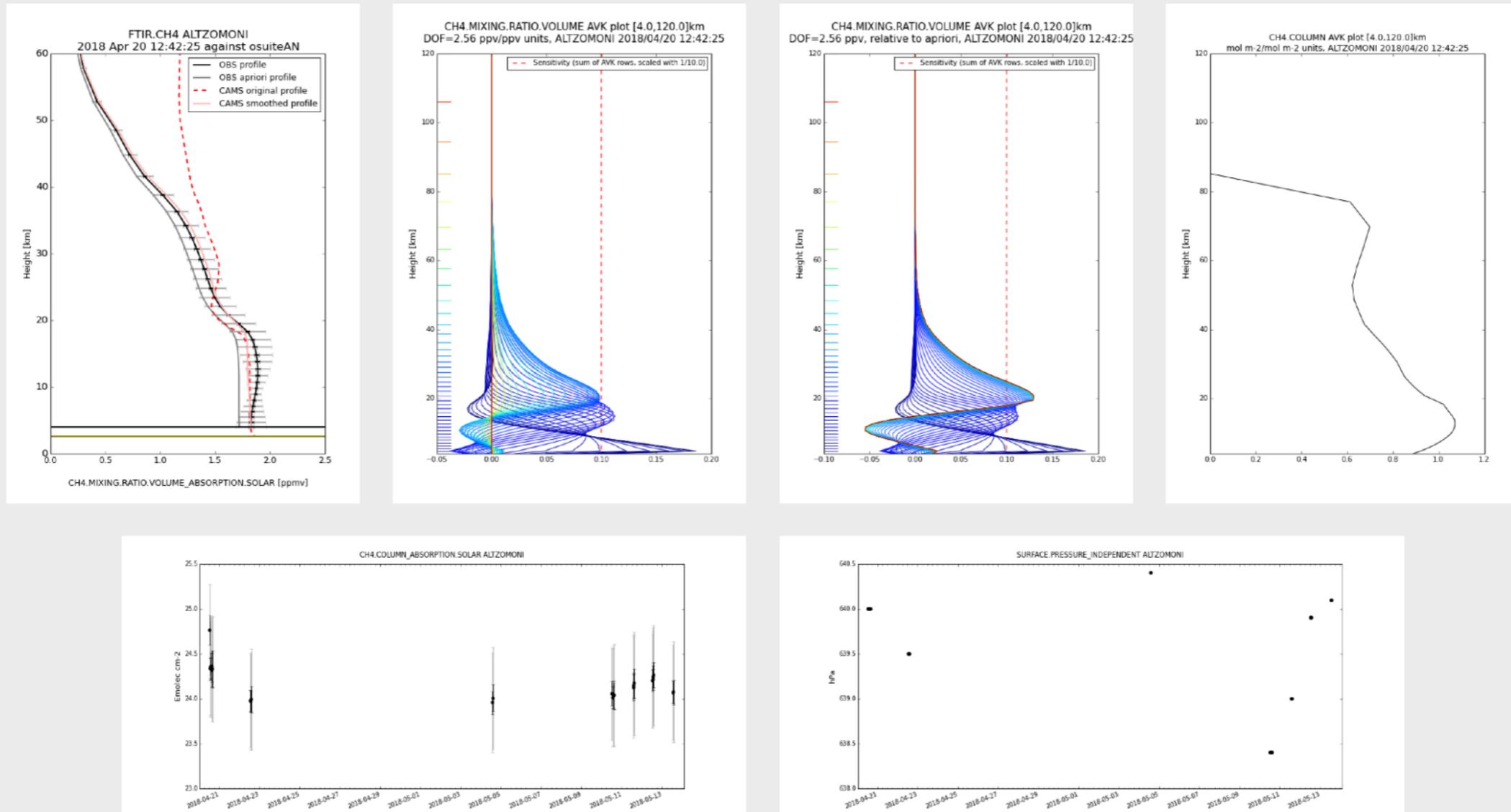
Filters:

REPORTS

| SUBMISSION DATE | PRODUCT ID | FILENAME | RD | QA | REPORT |
|-----------------|--------------------------------------|---|----|----|--------|
| 2018-05-10 | ftir.ch4_ulg002 | groundbased_ftir.ch4_ulg002_jungfrauoch_20180308t073904z_20180325t090506z_005.hdf | 🔴 | 🟢 | 📄 |
| 2018-05-10 | ftir.co_ulg002 | groundbased_ftir.co_ulg002_jungfrauoch_20180314t072523z_20180325t112154z_005.hdf | 🔴 | 🟢 | 📄 |
| 2018-05-10 | lidar.o3_dwd001 | groundbased_lidar.o3_dwd001_hohenpeissenberg_20180506t194449z_20180507t024704z_001.hdf | 🟢 | 🟢 | 📄 |
| 2018-05-10 | lidar.o3_dwd001 | groundbased_lidar.o3_dwd001_hohenpeissenberg_20180507t195759z_20180508t024457z_001.hdf | 🟢 | 🟢 | 📄 |
| 2018-05-10 | uvvis.doas.zenith.no2_cnrs.latmos013 | groundbased_uvvis.doas.zenith.no2_cnrs.latmos013_haute.provence_20180504t043000z_20180504t183835z_013.hdf | 🟢 | 🟢 | 📄 |
| 2018-05-10 | uvvis.doas.zenith.no2_cnrs.latmos020 | groundbased_uvvis.doas.zenith.no2_cnrs.latmos020_la.reunion.stdenis_20180504t023954z_20180504t134934z_013.hdf | 🟢 | 🟢 | 📄 |
| 2018-05-10 | uvvis.doas.zenith.o3_cnrs.latmos013 | groundbased_uvvis.doas.zenith.o3_cnrs.latmos013_haute.provence_20180504t043000z_20180504t183835z_013.hdf | 🟢 | 🟢 | 📄 |
| 2018-05-10 | uvvis.doas.zenith.o3_cnrs.latmos020 | groundbased_uvvis.doas.zenith.o3_cnrs.latmos020_la.reunion.stdenis_20180504t023954z_20180504t134934z_013.hdf | 🟢 | 🟢 | 📄 |
| 2018-05-09 | ftir.ch4_awi001 | groundbased_ftir.ch4_awi001_ny.alesund_20180417t061717z_20180503t180524z_005.hdf | 🟢 | 🟢 | 📄 |
| 2018-05-09 | ftir.co_awi001 | groundbased_ftir.co_awi001_ny.alesund_20180417t064107z_20180426t124855z_005.hdf | 🟢 | 🟢 | 📄 |
| 2018-05-09 | mwr.o3_ubern001 | groundbased_mwr.o3_ubern001_bern_20180422t000017z_20180422t235935z_009.hdf | 🟢 | 🟢 | 📄 |
| 2018-05-09 | mwr.o3_ubern001 | groundbased_mwr.o3_ubern001_bern_20180423t000003z_20180423t235953z_009.hdf | 🟢 | 🟢 | 📄 |
| 2018-05-09 | mwr.o3_ubern001 | groundbased_mwr.o3_ubern001_bern_20180424t000023z_20180424t235958z_009.hdf | 🟢 | 🟢 | 📄 |
| 2018-05-09 | mwr.o3_ubern001 | groundbased_mwr.o3_ubern001_bern_20180425t000028z_20180425t235939z_009.hdf | 🟢 | 🟢 | 📄 |

groundbased_ftir.ch4_unam001_altzomoni_20180420t124225z_20180513t141535z_002.hdf

DATA VISUALISATION

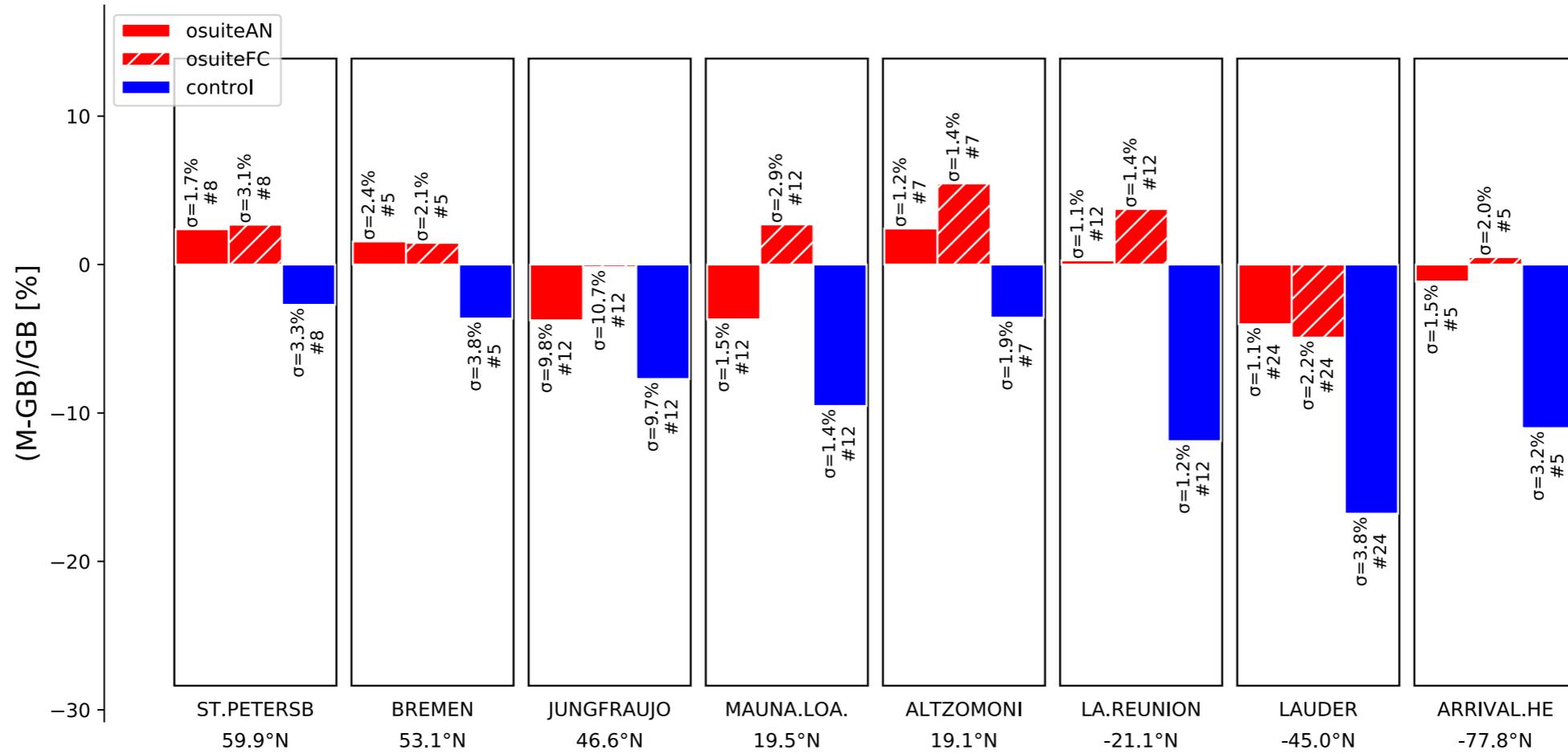
**SUMMARY**

no problems found

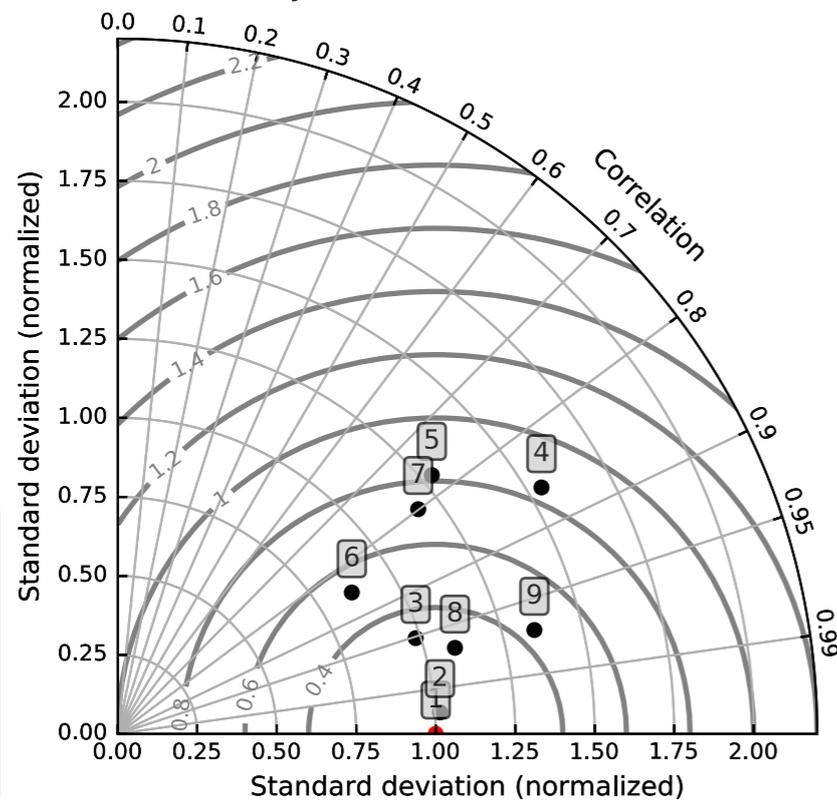
check on data contents:

- consistency between solar position & time
- AVK shape
- conversion (profile -> columns)
- uncertainties

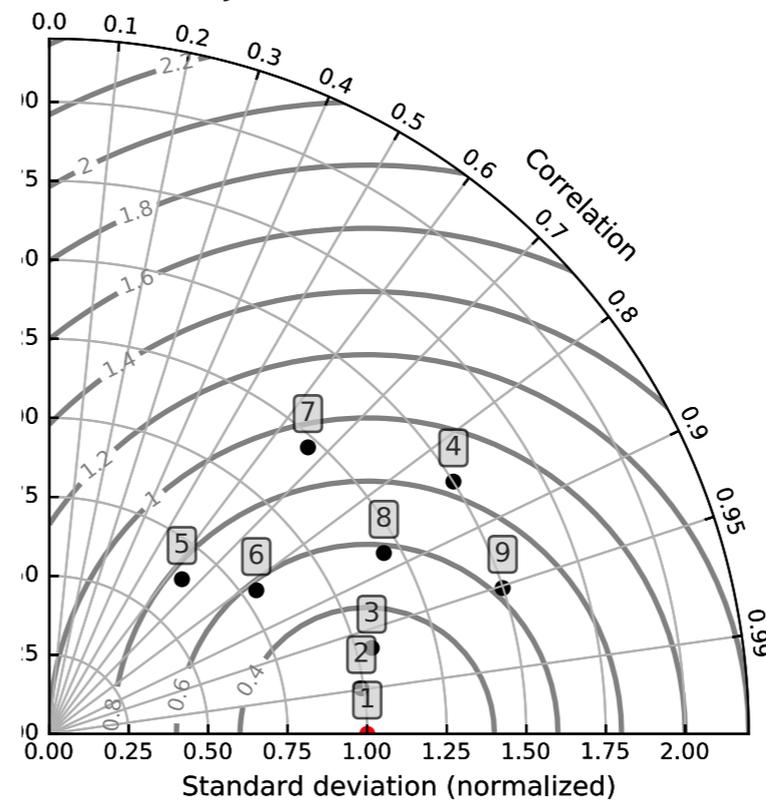
Histogram plot of relative differences (M-O)/O for daily mean FTIR.O3 timeseries 2017DJF



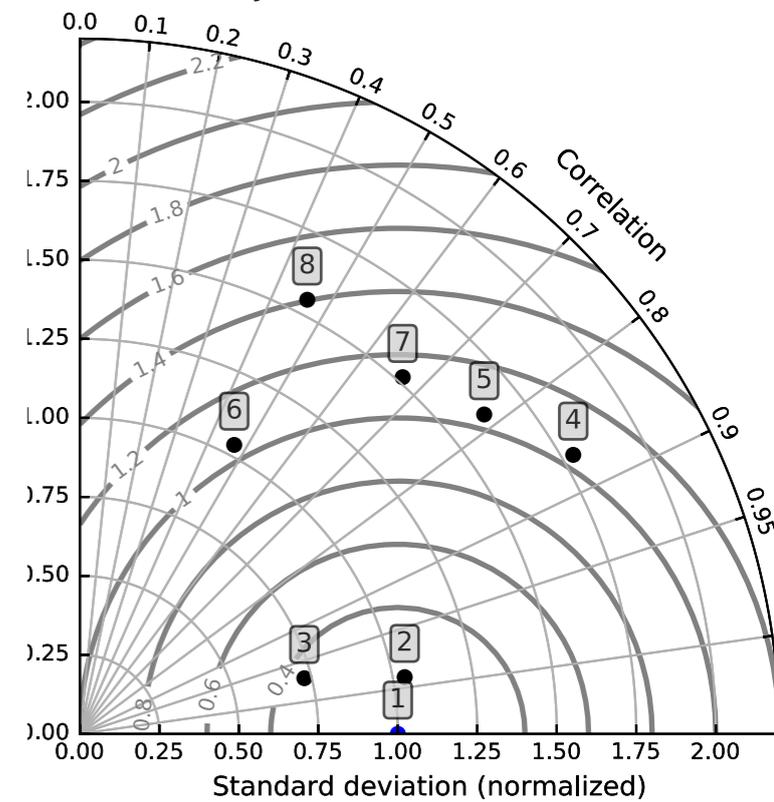
Taylor diagram for daily mean FTIR.O3 timeseries 2017DJF



l for daily mean FTIR.O3 timeseries 2017DJF

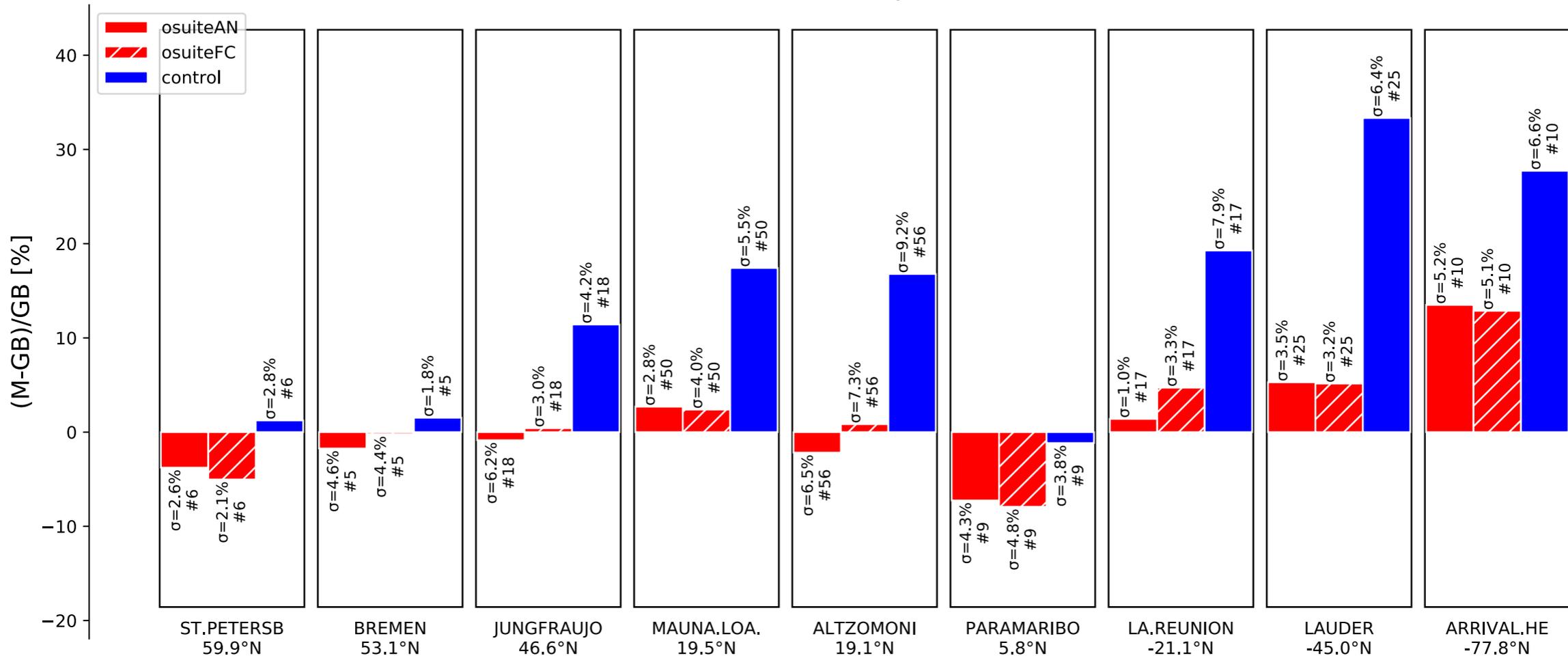


m for daily mean FTIR.O3 timeseries 2017DJF



- 1: o-suite AN
- 2: ST.PETERSBURG (8)
- 3: BREMEN (5)
- 4: JUNGFRAUJOCH (12)
- 5: MAUNA.LOA.HI (12)
- 6: ALTZOMONI (7)
- 7: LA.REUNION.MAIDO (12)
- 8: LAUDER (24)
- 9: ARRIVAL.HEIGHTS (5)

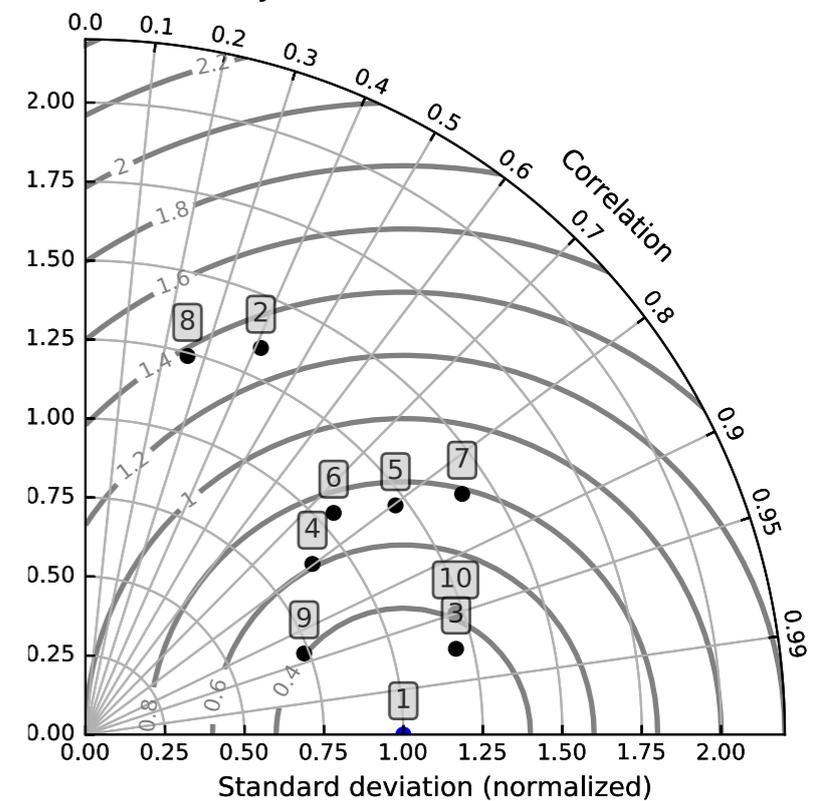
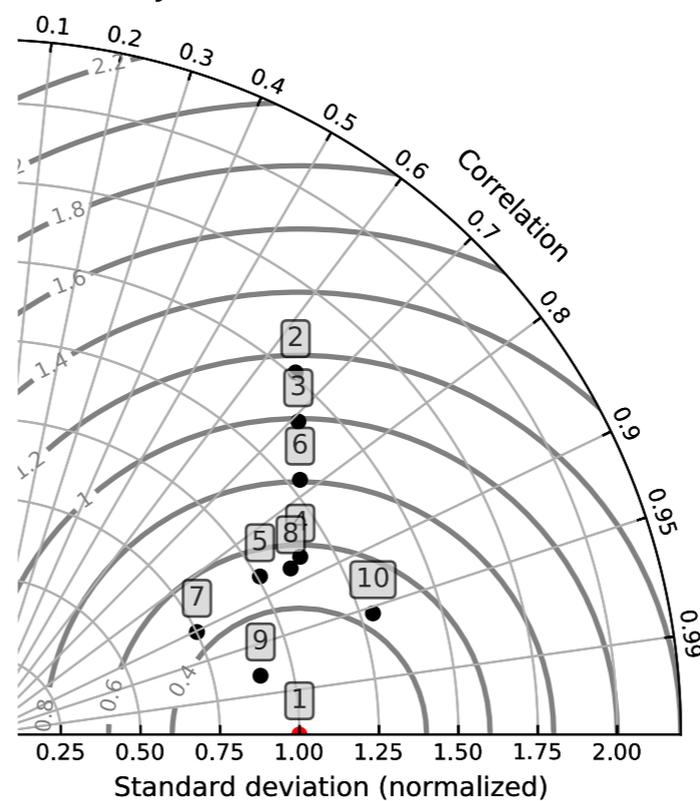
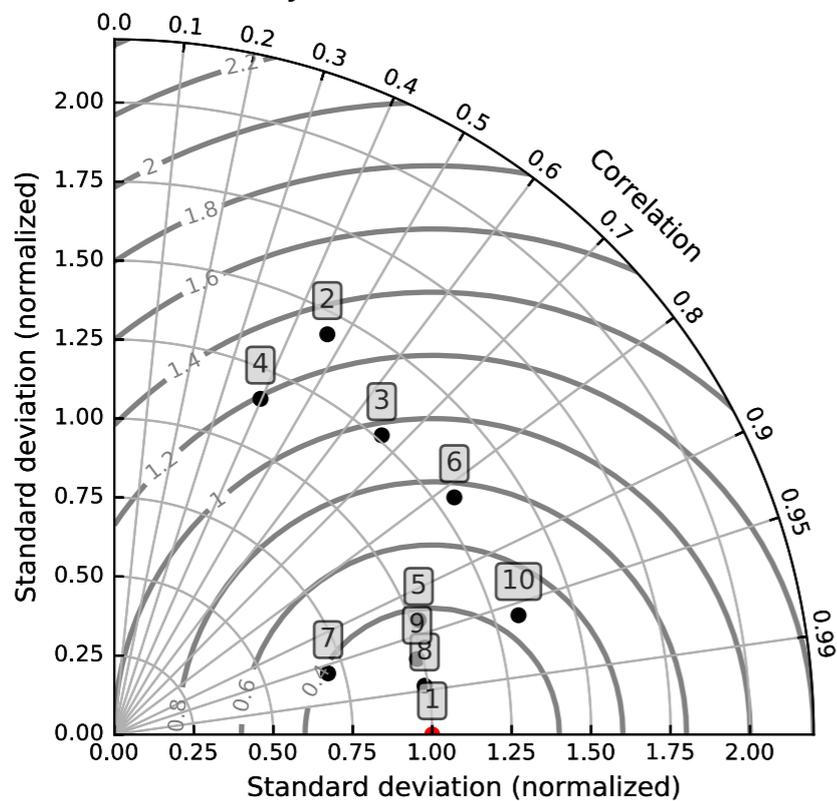
Histogram plot of relative differences (M-O)/O for daily mean FTIR.CO timeseries 2017DJF



Taylor diagram for daily mean FTIR.CO timeseries 2017DJF

daily mean FTIR.CO timeseries 2017DJF

im for daily mean FTIR.CO timeseries 2017DJF



- 1: o-suite AN
- 2: ST.PETERSBURG (6)
- 3: BREMEN (5)
- 4: JUNGFRAUJOCH (18)
- 5: MAUNA.LOA.HI (50)
- 6: ALTZOMONI (56)
- 7: PARAMARIBO (9)
- 8: LA.REUNION.MAIDO (17)
- 9: LAUDER (25)
- 10: ARRIVAL.HEIGHTS (10)

FTIR RD status

- altzomoni
- AH, lauder
- bremen, ny alesund, paramaribo
- **Garmish/zugspitze**
- eureka/toronto
- **harestua**
- jungfraujoch
- maido
- **Mauna loa / thule (wip)**
- sodankyla
- st petersburg
- **wollongong (wip)**

Status of 5k€ funding for tool development

| Payment | Activities covered by payment | |
|---------|--|-----------|
| 1 | Development for KNMI sites (PI is A. PETERS) | 5000,00 € |
| 2 | Development for UToronto sites (PI is K. Strong) | 5000,00 € |
| 3 | Development for Eureka LIDAR (PI is A. Tikhomirov) | 5000,00 € |
| 4 | Development for Harestua FTIR (PI is J. Mellqvist) | 5000,00 € |
| 5 | Development for Hohenpeissenberg LIDAR (PI W.) | 5000,00 € |
| 6 | Development for Jungfraujoch FTIR (PI E. Mahieu) | 5000,00 € |
| 7 | Development for NIWA sites (PI R. Querel) | 5000,00 € |
| 8 | Development for Lauder LIDAR (PI D. Swart) | 5000,00 € |
| 9 | Development for Mauna Loa UVVIS (PI R. Volkamer) | 5000,00 € |
| 10 | Development for UBremen sites (PI M. Palm) | 5000,00 € |
| 11 | Development for Rio Gallegos LIDAR (PI J. Salvador) | 5000,00 € |
| 12 | Development for LATMOS sites (A. Pazmino) | 5000,00 € |
| 13 | Development for Wollongong FTIR (PI N. Jones) | 5000,00 € |
| 14 | Development for Zugspitze FTIR (PI R. Sussmann) | 5000,00 € |
| * ECMWF | | |

QC check

- **Consistency of reported variables:**

conversions of VMR profile -> partial column profile
profiles -> integrated data

uncertainty covariances -> standard deviations on integrated data

AVK's acting on profile -> column AVK's

conversions and reported ancillary data (eg partial column of air and pressure/temperature)

- **Uncertainties:**

covariances should be symmetric and semi-positive definite

std's should be strictly positive

std's should be within expected values (to be defined)

random and systematic uncertainty variables must contain physical data (no fill values!)

QC check

- **Location:**

consistency between solar position variables and reported measurement time

consistency between altitude grid and instrument's height

no fill values in any lat/lon/time variable

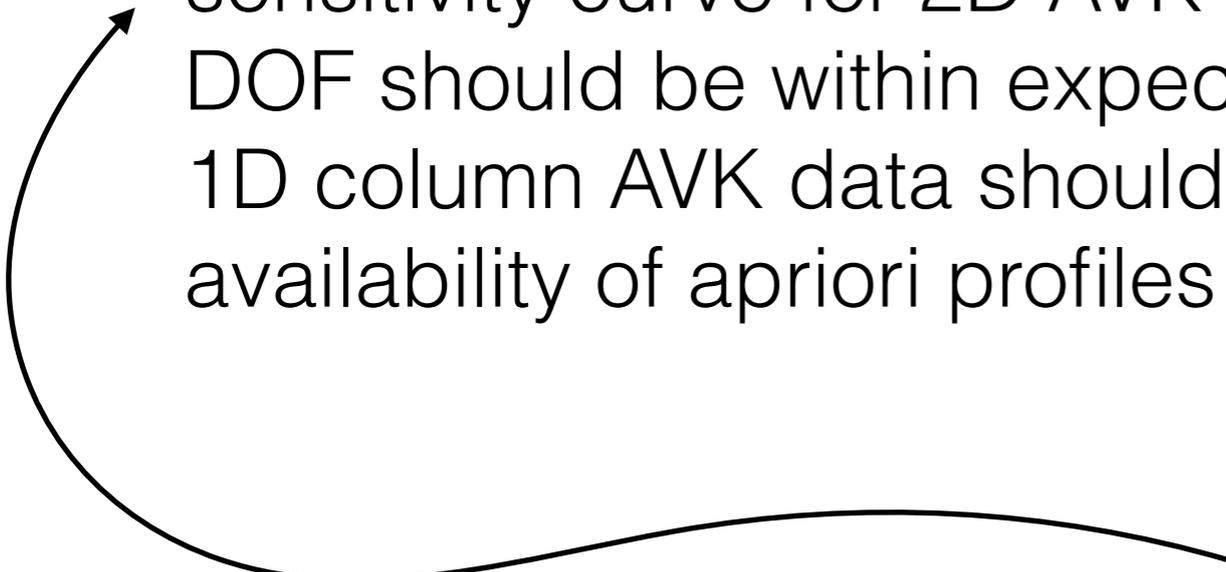
- **Averaging kernels:**

sensitivity curve for 2D AVK should not go wild ($0 <: < 1.5$)

DOF should be within expected thresholds ($\text{DOF} > 0.8$)

1D column AVK data should not go wild ($0 <: < 1.5$)

availability of a priori profiles (not only fill values!)



properties of the AVK are used to check the quality of the retrieval!

QC thresholds



James Hannigan, Martine de Mazière and the members of the NDACC IRWG
Contact: jamesw@ucar.edu

Abstract
Over the now more than 20 year time frame of the Network for the Detection of Atmospheric Composition Change (NDACC) both instrumentation and data analysis techniques have improved. Adapting to such changes has been an important effort within the Infrared Working Group (IRWG). During the last decade the data produced by an IRWG group has increased many fold. The number of required archival gases has doubled, initially these were O₃, HCl, HF, ClONO₂, and HNO₃, and recently has been increased to include N₂O, CH₄, CO, C₂H₆ and HCN. The information about each gas has increased where initially only the daily average total column and its uncertainty were delivered now profiles and their associated uncertainty covariances as well as averaging kernels are available at the archive for data users. This is done for each measurement which may be several per day. The higher vertical resolution data product places a more stringent demand on instrumentation and processing. It requires a wide, requires more homogeneous sets of instruments to obtain the desired quality of global data products.

[DEFAULTS]

#tolerance how many outliers allowed (relative to total in file)

TOL_AVK_CAVK=0.5

TOL_AVK_SENS=0.2

TOL_AVK_DOF=0.2

TOL_EIG_COV=-0.1 #eigenvalues should not be smaller than -10% of max eig

TOL_REL_STD = 0.5 #generate error if 50% or relative errors is too large

[FTIR.CO]

CO.COLUMN_ABSORPTION.SOLAR_UNCERTAINTY.SYSTEMATIC.STANDARD = [1,4]

CO.COLUMN_ABSORPTION.SOLAR_UNCERTAINTY.RANDOM.STANDARD = [0.3,4.8]

#sensitivity height limit for AVK

CO.MIXING.RATIO.VOLUME_ABSORPTION.SOLAR_AVK.SENSITIVITY.HEIGHT = [-np.inf, 3.5]

CO.MIXING.RATIO.VOLUME_ABSORPTION.SOLAR_AVK.SENSITIVITY = [0,1.5]

CO.MIXING.RATIO.VOLUME_ABSORPTION.SOLAR_AVK.DOFS.HEIGHT = [-np.inf, 3.5]

CO.MIXING.RATIO.VOLUME_ABSORPTION.SOLAR_AVK.DOFS = [1.5,3.5]

CO.COLUMN_ABSORPTION.SOLAR_AVK.HEIGHT=[-np.inf, 60e3]

[FTIR.CH4]

CH4.MIXING.RATIO.VOLUME_ABSORPTION.SOLAR_AVK.SENSITIVITY.HEIGHT = [-np.inf, 3.5]

CH4.MIXING.RATIO.VOLUME_ABSORPTION.SOLAR_AVK.SENSITIVITY = [0,1.5]

CH4.MIXING.RATIO.VOLUME_ABSORPTION.SOLAR_AVK.DOFS.HEIGHT = [-np.inf, 55e3]

CH4.MIXING.RATIO.VOLUME_ABSORPTION.SOLAR_AVK.DOFS = [1.5,3.5]

CH4.COLUMN_ABSORPTION.SOLAR_AVK.HEIGHT=[-np.inf, 60e3]

CH4.COLUMN_ABSORPTION.SOLAR_UNCERTAINTY.SYSTEMATIC.STANDARD = [2,6]

CH4.COLUMN_ABSORPTION.SOLAR_UNCERTAINTY.RANDOM.STANDARD = [0.3,6]

[FTIR.O3]

O3.MIXING.RATIO.VOLUME_ABSORPTION.SOLAR_AVK.SENSITIVITY.HEIGHT = [-np.inf, 60e3]

O3.MIXING.RATIO.VOLUME_ABSORPTION.SOLAR_AVK.SENSITIVITY = [0,1.5]

O3.MIXING.RATIO.VOLUME_ABSORPTION.SOLAR_AVK.DOFS.HEIGHT = [-np.inf, 55e3]

O3.MIXING.RATIO.VOLUME_ABSORPTION.SOLAR_AVK.DOFS = [2.5,5.8]

O3.COLUMN_ABSORPTION.SOLAR_UNCERTAINTY.SYSTEMATIC.STANDARD = [1.8,6]

O3.COLUMN_ABSORPTION.SOLAR_UNCERTAINTY.RANDOM.STANDARD = [0.2,6]

O3.COLUMN_ABSORPTION.SOLAR_AVK.HEIGHT=[-np.inf, 80e3]

| Species | Wavenumber Range (cm ⁻¹) | Height (km) | Retrieval Method | Uncertainty Standard | DOFS |
|---------------|--------------------------------------|-------------|--|----------------------|---------|
| H2O | >180 | | WACCMV5 | | |
| H2O, O3 | 4000.86-4001.10 | | WACCMV5 | | |
| H2O, HDO, CH4 | 4109.77-4110.07 | | WACCMV5 | | |
| H2O | 780.0-780.35 | >50 | WACCMV5 | | |
| CO2, O3 | 780.0-781.3 | | WACCMV5 | | |
| H2O | 779.0-780.0 | | WACCMV5 | | |
| H2O | 867.05-870.00 | | WACCMV5 | | |
| H2O | 872.25-874.00 | | WACCMV5 | | |
| CH4 | 2613.70-2615.40 | 250 | Optimal CH4 Retrieval TBD At this Time | | 1.5 - 3 |
| CH4 | 2650.60-2651.30 | | | | |
| CH4 | 2835.50-2835.80 | | | | |
| CH4 | 2903.60-2904.03 | | | | |
| CH4 | 2921.00-2921.60 | | | | |
| CH4 | 2611.60-2613.35 | | | | |
| CH4 | 2613.70-2615.40 | | | | |
| CH4 | 2914.70-2915.15 | | | | |
| CH4 | 2941.23-2942.23 | | | | |
| CO | 2057.70-2058.00 | 250 | WACCMV5 | | 2 - 3 |
| CO | 2069.56-2069.76 | | | | |
| CO | 2157.50-2159.15 | | | | |
| C2H6 | 2976.66-2976.95 | 250 | WACCMV5* | | 1 - 2.5 |
| C2H6 | 2983.20-2983.55 | | | | |
| HCN | 3268.05 - 3268.40 | 250 | WACCMV5* | | 1.5 - 2 |
| HCN | 3287.10 - 3287.35 | | | | |
| HCN | 3299.40 - 3299.60 | | | | |
| H2O | 3277.775 - 3277.950 | | | | |
| H2O | 3286.168 - 3288.482 | | | | |
| H2O | 3301.030 - 3301.300 | | | | |
| H2O | 3304.825 - 3305.60 | | | | |

Parameters Above in Table 2 is a summary of the retrieval process. On the left are the primary parameters used in the retrieval process. The combined effect of recent advances in retrievals & uncertainty estimation, the addition new species, and the use of HDF data files provides a very large amount of new data for end users from the observational program carried out by the NDACC-IRWG. Summarizing this effort is a challenge, we have tried to show the common components of the retrieval system and representative examples of the data currently available.

Please see the data archive at: <http://ftp.cpc.ncep.noaa.gov>
The NDACC web site at <http://www.ndacc.org>
The IRWG web site at: <http://www.acd.ucar.edu/irwg/index.html>

| TAB | CH4 | | | HNO3 | | | HCN | | | C2H6 | | | O3 | | | DOFS |
|-------|------|-------|------|-------|-------|-------|------|-------|------|------|-------|-------|------|-------|-------|------|
| | MIN | MAX | DOFS | MIN | MAX | DOFS | MIN | MAX | DOFS | MIN | MAX | DOFS | MIN | MAX | DOFS | |
| 2.8 | 3.7 | 1.94 | 2.56 | 2.7 | 1.1 | 2.25 | 1.2 | 2.12 | 2.25 | 2.4 | 1.6 | 1.16 | 1.6 | 4.79 | 4.5 | 4.36 |
| 0.04 | | 0.31 | | 14.33 | 0.53 | 1.7 | | 4.59 | | | 0.95 | 1.88 | | 0.19 | 0.18 | % |
| 0.07 | | 0.51 | | 6.2 | 0.46 | 1.4 | | 4.79 | | | 1.15 | 1.12 | | 0.18 | 0.24 | % |
| <0.05 | | <0.05 | | 0.18 | <0.05 | <0.05 | | 0.4 | | | 0.18 | 0.11 | | <0.05 | <0.05 | % |
| 0.05 | | 0.05 | | 0.82 | 0.05 | 0.08 | | 4.36 | | | 0.05 | 0.1 | | 0.05 | 0.02 | % |
| 0.05 | | 0.05 | | 2.59 | 0.17 | 0.39 | | 15.55 | | | 0.22 | 0.34 | | 0.26 | 0.27 | % |
| 0.47 | | 0.32 | | 0.48 | 0.42 | 0.51 | | 0.45 | | | 0.31 | 0.6 | | 0.16 | 0.24 | % |
| 0.09 | | 0.04 | | 0.16 | <0.05 | 0.13 | | 0.06 | | | 0.02 | 0.1 | | 0.38 | 0.19 | % |
| <0.05 | | <0.05 | | 0.09 | <0.05 | <0.05 | | 9.19 | | | <0.05 | <0.05 | | <0.05 | 0.02 | % |
| 0.48 | 0.53 | 0.6 | 0.54 | .50 | 2.2 | 0.73 | 1.83 | 8.5 | 13.2 | 14.9 | 1.2 | 1.31 | 1.67 | 0.52 | 0.47 | 1.79 |
| 1.45 | | 1.51 | | 2.71 | 5.95 | 1.7 | | 10.87 | | | 10 | 12.18 | | 1.13 | 1.5 | % |
| 0.52 | | 0.6 | | 0.17 | 1.04 | 2.44 | | 11.49 | | | 3.88 | 5.88 | | 1.23 | 0.62 | % |
| 3.57 | 2.81 | 1.4 | 2.29 | 2.2 | 2.6 | 6.04 | 6.2 | 10.9 | 13.8 | 14.7 | 10.8 | 13.53 | 2.9 | 1.81 | 1.62 | 2.18 |
| 4.05 | 3.95 | 2 | 2.84 | 2.7 | 4.8 | 6.77 | 8.03 | 19.4 | 27 | 29.7 | 12 | 14.84 | 4.6 | 2.33 | 2.09 | 3.97 |
| 4.09 | | 3.71 | | 18.13 | 7.3 | 9.73 | | 23.99 | | | 13.95 | 16.72 | | 2.52 | 3.27 | % |

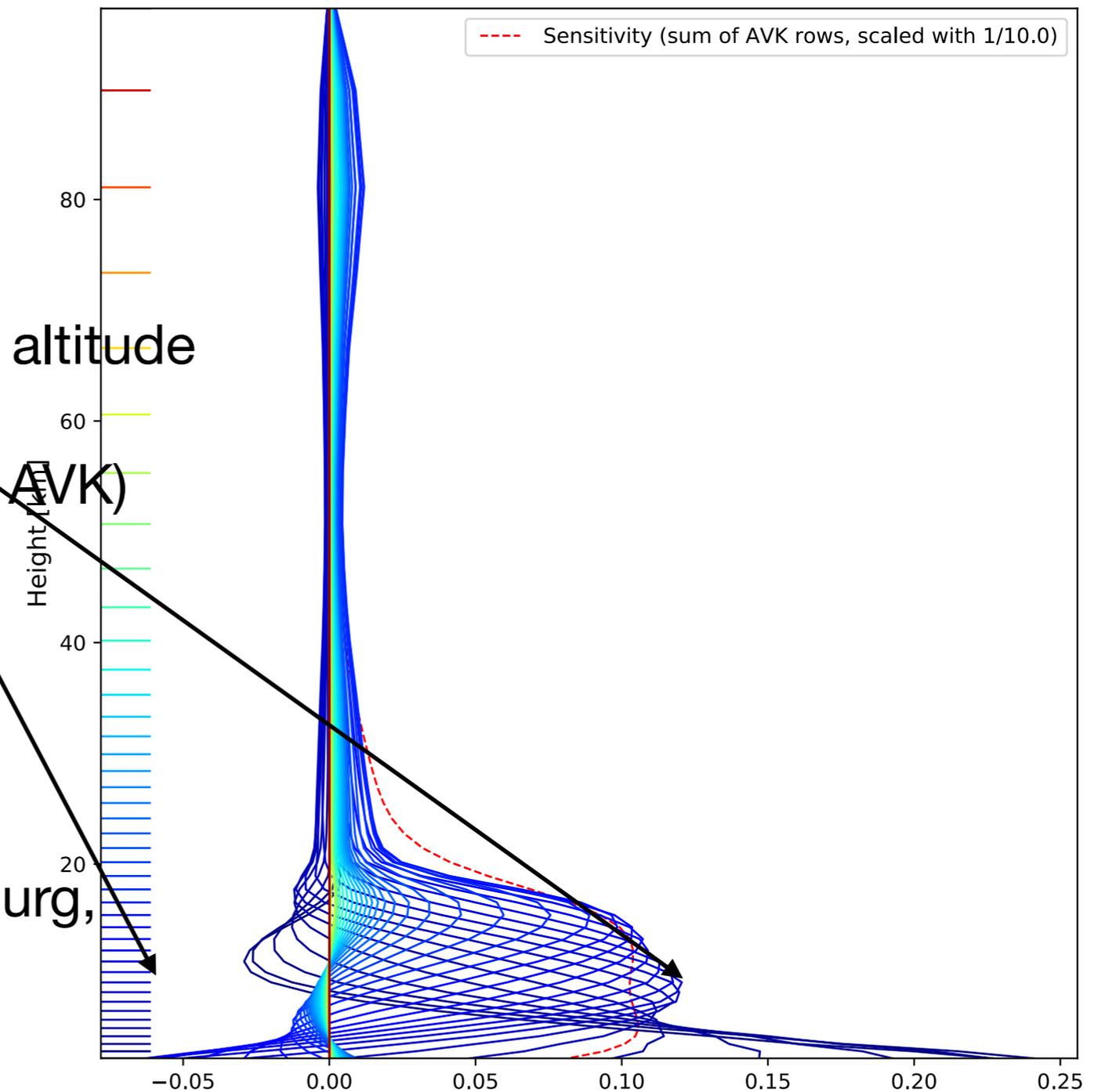
Acknowledgments We wish to thank data providers for this poster T. Blumenstock, & F. Hase IMK-AFS, M.De Mazière IASB-BIRA, E. Mahieu IAG U. Liège and the entire Membership of the NDACC-IRWG.

The National Center for Atmospheric Research is supported by the National Science Foundation. The NCAR observation programs at Thule, GR and Mauna Loa, HI are supported under contract by the National Aeronautics and Space Administration (NASA). The Thule work is also supported by the NSF Office of Polar Programs (OPP). We wish to thank the Danish Meteorological Institute for support at the Thule site and NOAA for support of the MLO site.

Quality of the retrieval from AVK

CO.MIXING.RATIO.VOLUME AVK plot [2.5,97.2]km
DOF=2.35 ppv, relative to apriori, LA.REUNION.MAIDO 2018/04/19 10:47:22

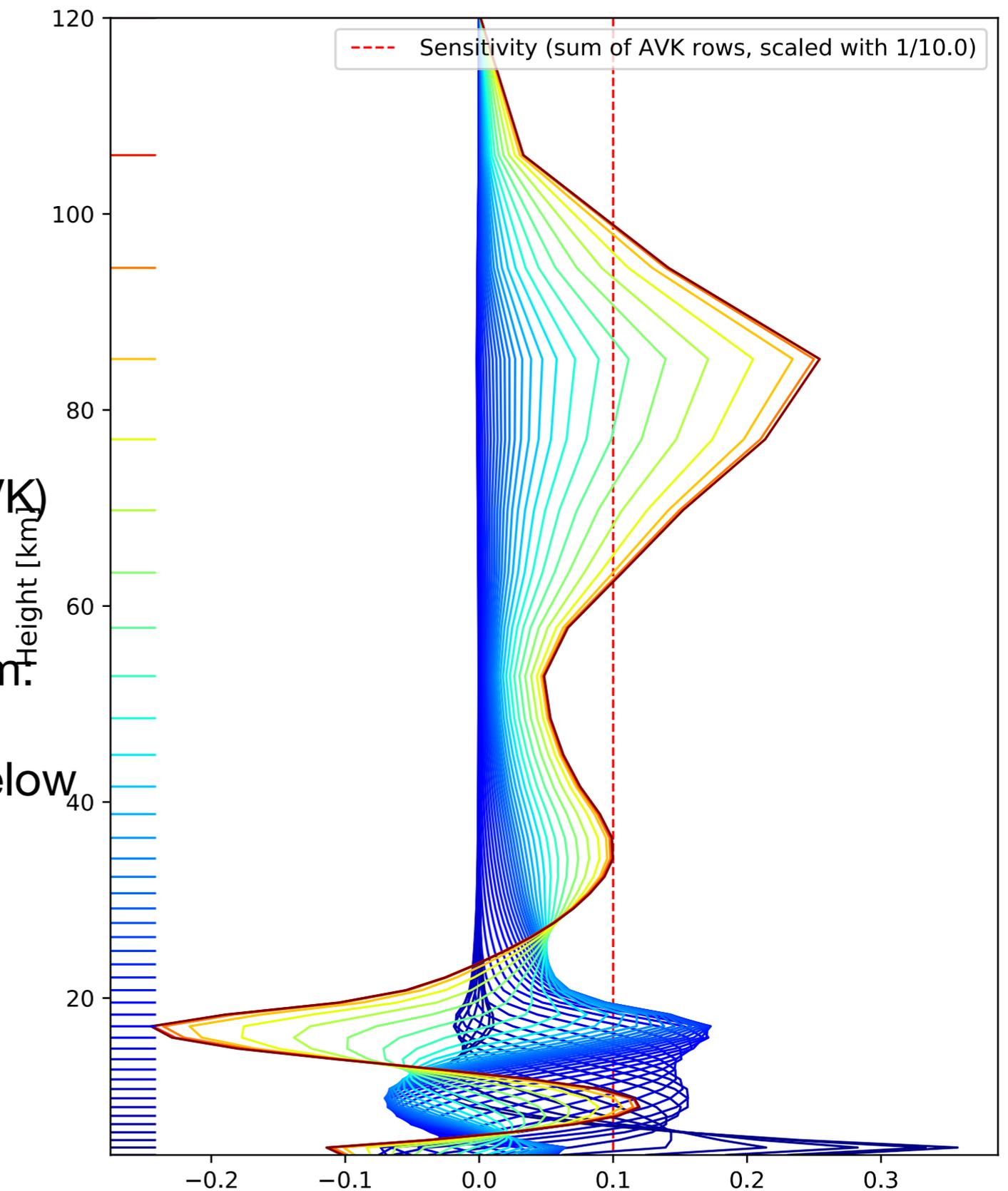
- Column AVK: shows how each layer contributes to the column:
 $0 <: < 1.5$
- Each kernel (=row of the AVK) should peak at its corresponding altitude
- Sensitivity (som of the row of the AVK) should be between 0 and ± 1
- Maido retrievals are blind above 20km
- similar avk in Bremen, St petersburg, Jungfrau, Eureka, Toronto,...



Altzomoni

CO.MIXING.RATIO.VOLUME AVK plot [4.0,120.0]km
DOF=4.14 ppv, relative to apriori, ALTZOMONI 2012/10/24 16:22

- Tikhonov retrieval: $\text{sens}=\text{cst}=1$
- Each kernel (=row of the AVK) should peak at its corresponding altitude: **OK**
- Sensitivity (sum of the row of the AVK) should be between 0 and 1: **OK**
- Altzomoni is not blind to CO at 80km. orange kernels peak at that altitude (but negative correlation with CO below 20km, which is typical for Tikhonov)
- Zugspitze has similar AVK



- Each kernel (=row of the AVK) should peak at its corresponding altitude: **not OK**
blue kernels should not extend to 80km...
- Sensitivity (sum of the row of the AVK) should be between 0 and 1: **not OK**
at 30km light blue kernels extend to 80km...
- Is this retrieval sensitive to CO at high altitudes?
 Not clear to me: CO at 80km will be smoothed to altitudes below 40km

