Test data set generation for S4 verification and first results

Y.J. Choi, J. Pukite, S. Beirle, T. Wagner
MPI for Chemistry, Mainz, Germany

- Specific challenges of verification activties for S4
- Products and involved institutions
- Generation of test data sets (TDS)

Specific challenges of the S4 mission

The first geostationary atmospheric composition mission.

⇒ The simulation and interpretation of the atmospheric radiative transfer is different compared to previous missions in many respects:

- The same ground scenes will be observed under varying solar illumination conditions (SZA and relative azimuth angle) during the course of the day (and also for different seasons).
- BRF-Effects (for trace gas, but also for cloud and aerosol products) have to be considered.
- Limited spatial coverage: new ‚reference regions' and reference techniques have to be found for trace gas retrievals (e.g. to estimate stratospheric NO2).

Specific challenges of the S4 mission

Because S4 is the first geostationary atmospheric chemistry mission, no measurement data with the same properties can be used.

=> Verification activities focus on synthetic data!
(**Generation and analysis of test data set, TDS)**

Diurnal and seasonal variations of atmospheric properties have to be covered:

- trace gases
- aerosols
- clouds

(amount and profiles, more details are given later)

Realistic surface reflectance data (BRF) have to be considered.

Specific MPIC S4 tasks

- Lead of the verification activities

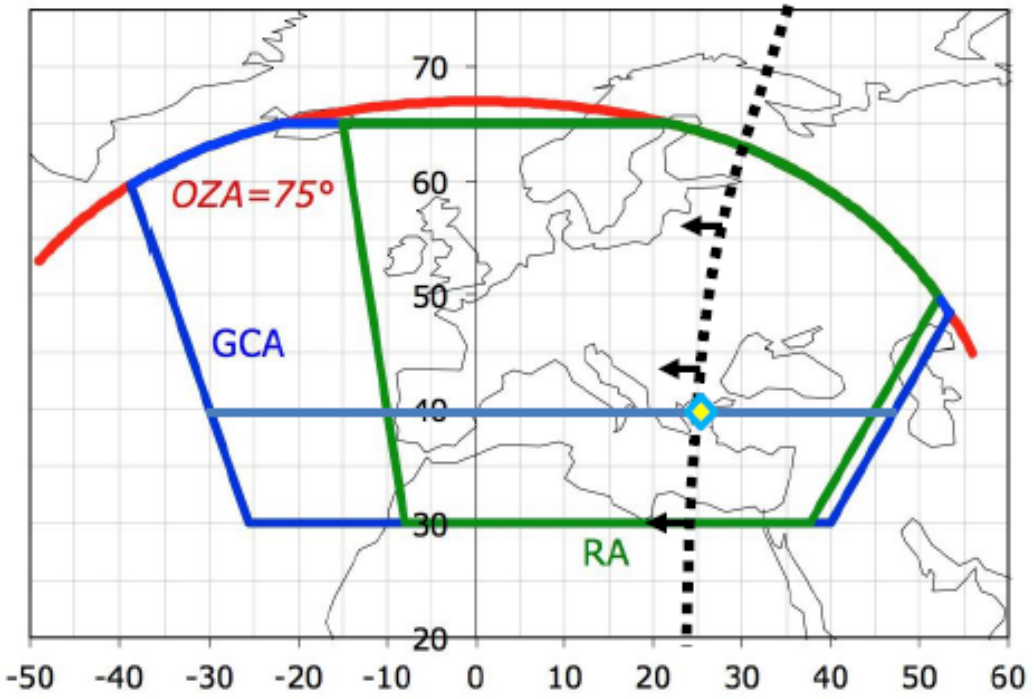
- Generation of test data set (TDS)

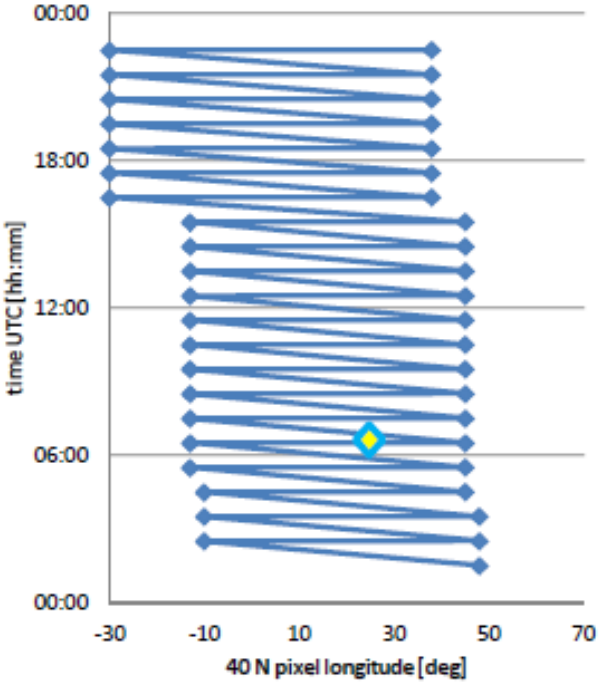
Verification will be performed by comparison of results from verification teams to those from ‚breadboarding teams‘.

MPIC coordinates and evaluates the verification activities.

S4 scanning and data acquisition

GCA = Geographic Coverage Area
RA = Reference Area
IFOV = Instantaneous Field Of View





- SSD ~8 km in E/W and in N/S at ref point (45N lat, lon of SSP)
- Angular sampling grid ~evenly spaced in Field Angle and Scan Angle
- **SSD varies spatially** across GCA with distance sat-target and VZA at target

The verification is done for selected locations

The verification will be carried out for locations, which cover the whole range of atmospheric scenarios and viewing geometries.

Location	Latitude	Longitude	Specific properties
Helsinki	60.17°N	24.93°E	high latitude
Moscow	55.75°N	37.62°E	high latitude (winter), east side of the S4 area
Copenhagen	55.68N	12.51E	High latitude, full seasonal coverage
North Atlantic	55°N	345°E	(south-east of Iceland), north-west side of the S4 area
Cabauw	51.98°N	4.93°E	high NO_2, relatively low aerosols
Milano	45.47°N	9.18°E	high NO_2, high HCHO, high aerosols
Atlantic	46°N	357°E	(west of France) ocean, clean air
English Channel	50.20°N	0°E	ocean, polluted air
Desert	32°N	2°E	desert, low latitude
Cairo	30.05N	31.23E	south-west part of S4 area
Rabat	33.97N	-6.83W	south-east part of S4 area
Kaiserslautern	49.35N	7.85E	forest
North-East Germany	53.92°N	12.75°E	rural background station over land
Benkovski	42.42N	25.92E	farm land
Paris	48.85°N	2.35°E	urban surface
Madrid	40.42°N	356.3°E	high altitude
Bolzano	46.5°N	11.35°E	surrounded by high mountains

Preparation of the input data for the TDS

1) Atmospheric data

A) Diurnal variations of trace gas concentration profiles of NO_2, HCHO and O_3 are taken from model simulations:

- 0 to 3.5km:

  Lotos-EUROS, high spatial resolution (MACC domain (15°W-35°E, 35°N-70°N) with about 7 km horizontal resolution).

- above 3.5km and outside MACC domain:

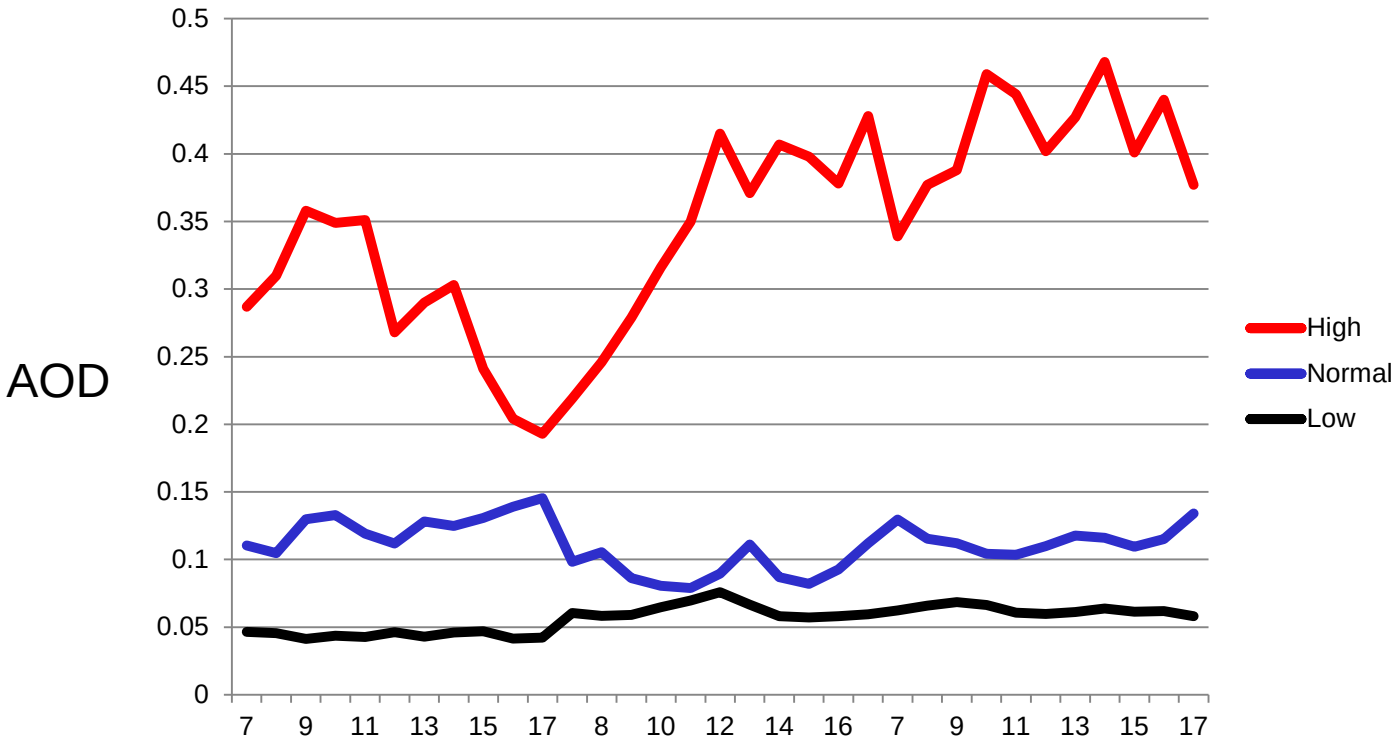
  TM5, lower spatial resolution (1°x1°, covering the area from 80°W to 85°E and 14°N to 86°N).

(model data from Isotrop project, Henk Eskes pers. comm.)

B) For SO_2 prescribed scenarios for Boundary layer pollution and various volcanic emissions/eruptions are used.

2) Aersosols:

A varying diurnal aerosol load (based on AERONET observations) is used in the simulations, see example below). Simulations were performed for different aerosol loads (low, medium, high).



3) Clouds:

- typical cloud scenarios (clear, partly cloudy, totally overcast) will be assumed.
- the independent pixel approximation (IPA) will be used.
- broken cloud fields are based on high resolution satellite images.

=> details see next slide

4) Temperature and pressure profiles

is taken from the TM5 model.

5) Surface BRF data

- on land:

  BRF kernels are based on the Ross-Li parameterisation (3 kernels obtained from POLDER observations).
- over ocean:

  Cox-Munk parameterisation.

6) Surface elevation

To be consistent with the model data surface elevation is taken from the model data LOTOS-EUROS & TM5).

Detailed timelines for standard scenarios (all stations)

day	Day 1, Am	Day 1, Pm	Day 2, Am	Day 2, Pm	Day 3, Am	Day 3, Pm	Day 4, Am	Day 4, Pm	Day 5, Am	Day 5, Pm
model input	day 1	day 1	day 2	day 2	day 3	day 3	day 1	day 1	day 2	day 2
cloud scenario	clear	100% cloud cover	broken cloud Seviri distribution, 70%	broken cloud Seviri distribution, 30%	broken cloud Seviri distribution, 50%	broken cloud Seviri distribution, 50%	100% cloud cover	clear	broken cloud North_South orientation	broken cloud West-East orientation
clear sky simulation	high AOD with elevated desert dust layer (3-5 km altitude OD=2)	no clear sky simulation	medium AOD	medium AOD	low AOD	low AOD	no clear sky simulation	low AOD with elevated desert dust layer (3-5 km altitude OD=2)	low AOD	high AOD
cloud simulation	no cloud simulation	High cloud, COD20	low cloud, COD5	medium cloud, COD5	medium cloud, COD20	high cloud, COD20	low cloud, COD20	no cloud simulation	low cloud, COD20	hgh cloud, COD5

Generation of test data sets (TDS)

- **High resolution spectra**:

  They will be provided to ESA as input to S4/UVN instrument simulations and for the calculation of synthetic L1b data.

  High resolution spectra will also be provided to project partnes for specific tasks, e.g. to investigate the effect of heterogenous scenes on the L1b spectra.

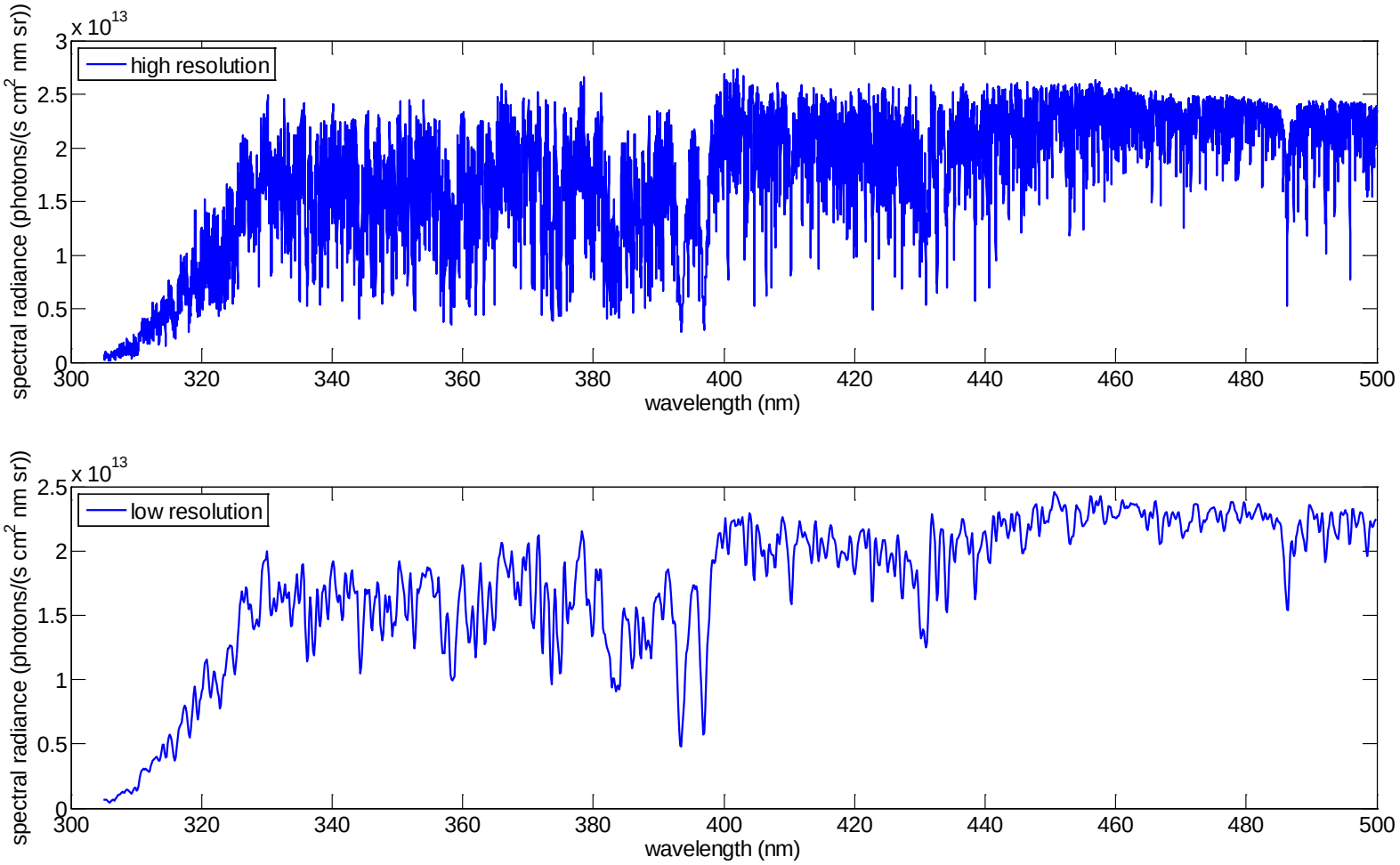
- **S4 spectra**:

  spectral resolution (L1b) of the S4 instrument.

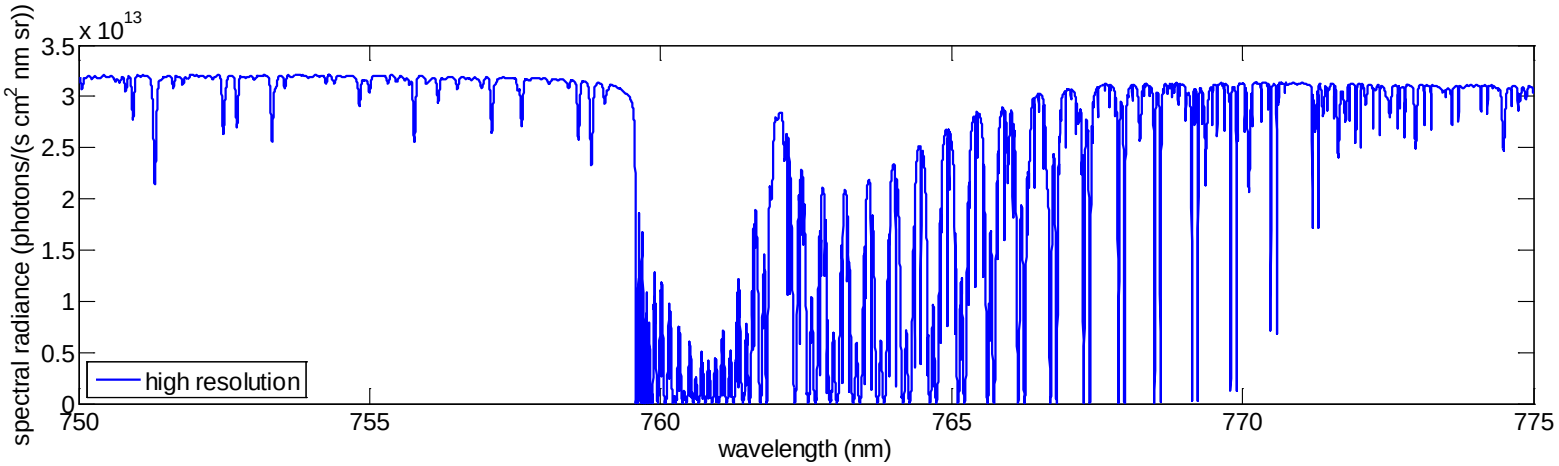
  They are derived from high resolution spectra by convolution and resampling according to the spectral properties of the S4 instrument.

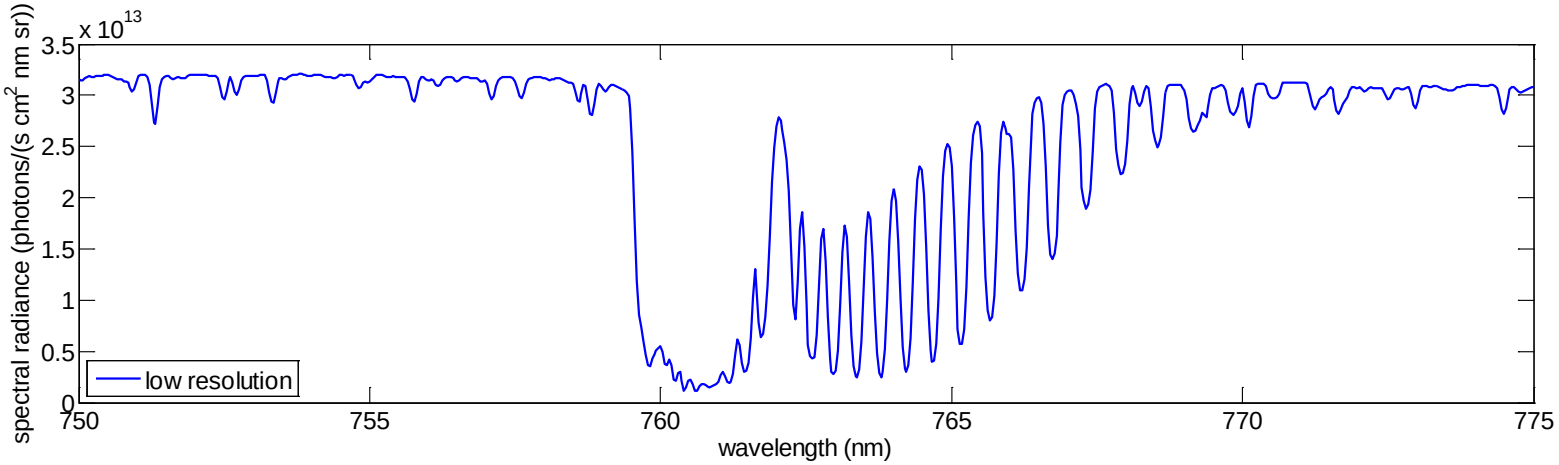
  Noise will be calculated based on the simulated radiance and the instrumental properties

Examples of UV/VIS high and low resolution spectra



Examples of NIR high and low resolution spectra

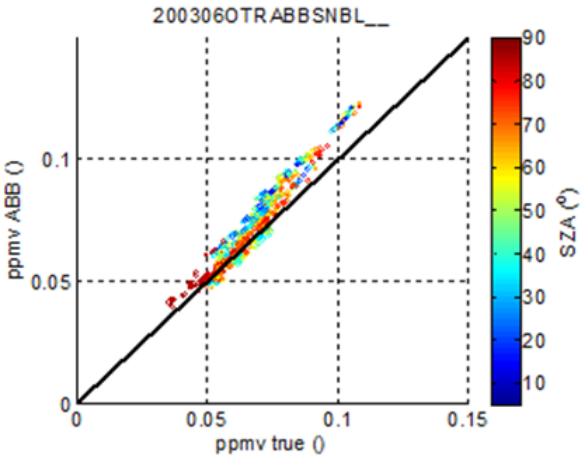




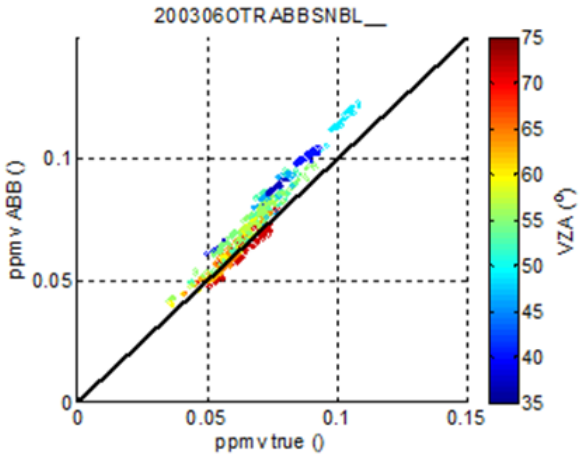
Examples of verification results (initial verification)

Retrieved **tropospheric ozone** versus input values

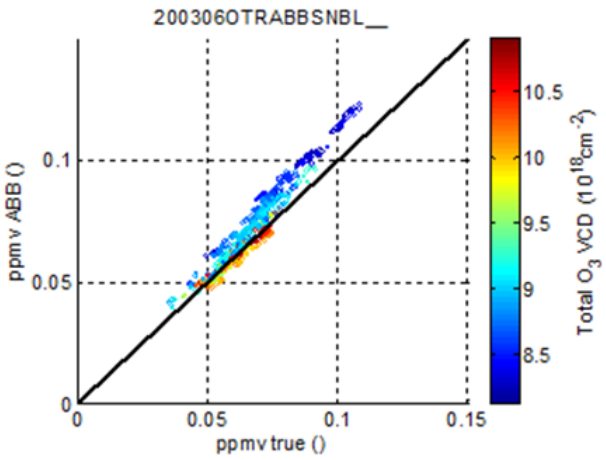
(no clouds and aerosols included)



Colours indicate SZA



Colours indicate VZA



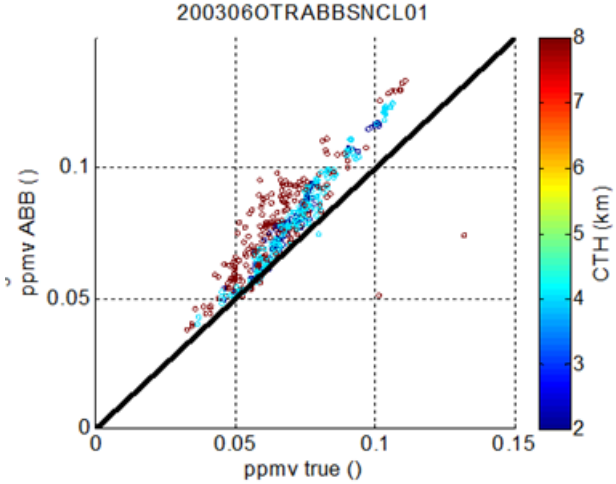
Colours indicate Total O_3 column

=> Good agreement with the input values

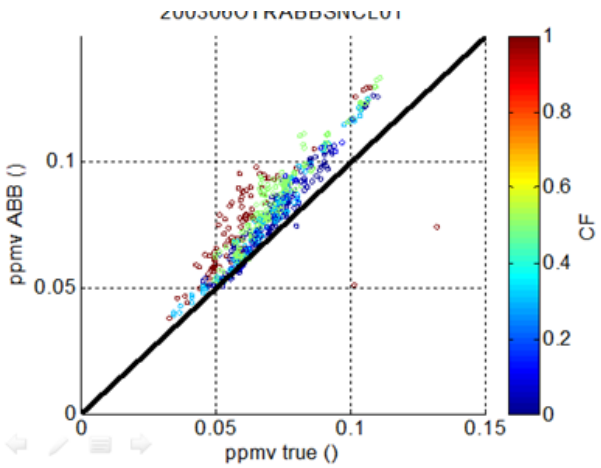
Examples of verification results (initial verification)

Retrieved **tropospheric ozone** versus input values

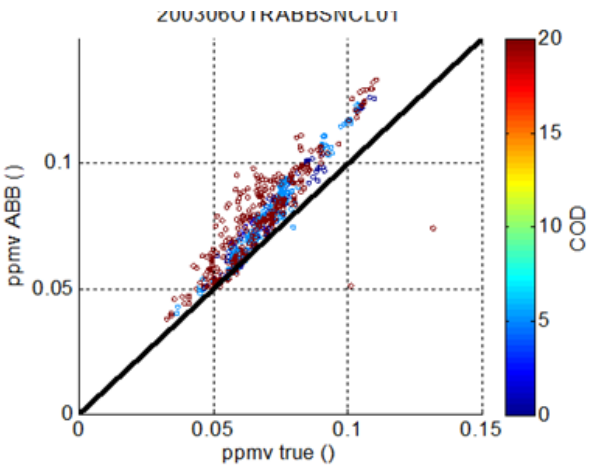
(variable clouds)



Colours indicate cloud height



Colours indicate cloud fraction



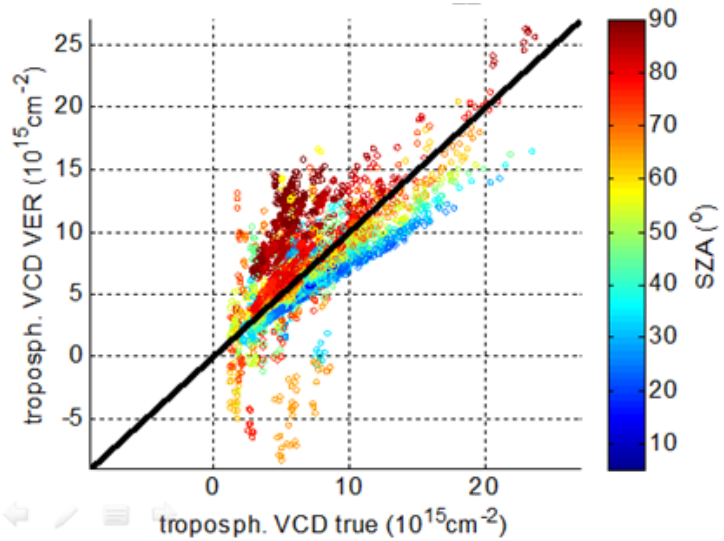
Colours indicate cloud optical depth

=> Less good agreement with the input values (effect of clouds)

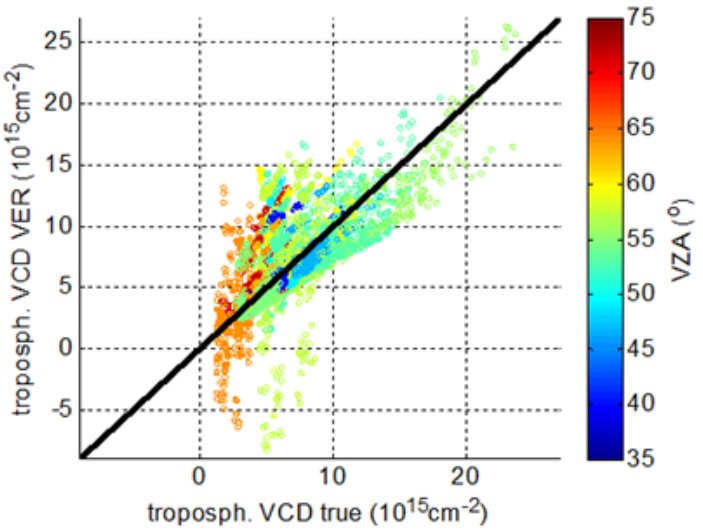
Examples of verification results (initial verification)

Retrieved **tropospheric HCHO** versus input values

(no clouds and aerosols)



Colours indicate SZA



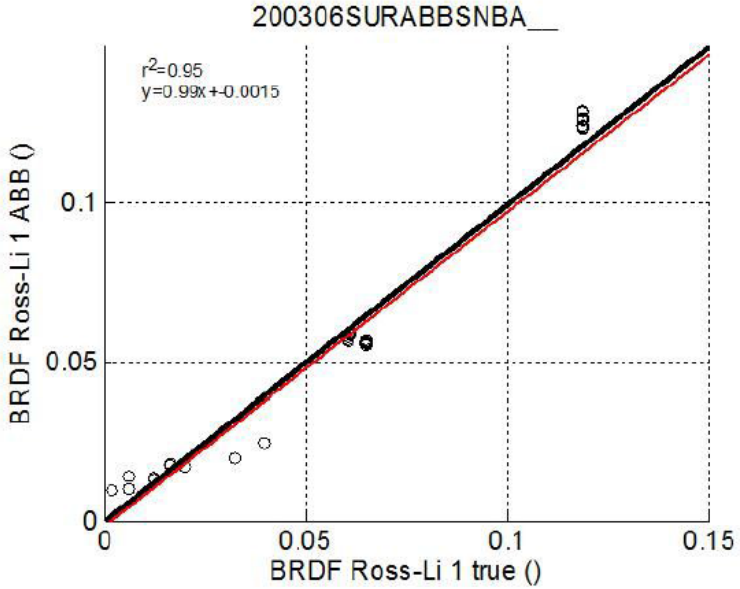
Colours indicate VZA

⇒ Less good agreement with the input values
(weak atmospheric absorption of HCHO, lower S/N ratio)

Examples of verification results (initial verification)

Retrieved **BRF** versus input values

(no clouds)



Ross-Li parameter 1

=> Good agreement with the input values

Summary

- Verification activities are crucial for testing the operational algorithms.
- For S4 (as the first geostationary chemistry mission) the verification activities are based on synthetic data.
- MPIC is responsible for the definition and generation appropriate test data sets.
- All relevant atmospheric scenarios and viewing geometries are covered.
- Bidirectional reflectance properties of the surface are considered.
- First verification results are encouraging, currently the test data set version 2 is available.