ALGOM

GOMOS Level 2 algorithm evolution studies

GOMOS One-step UTLS Input / Output Data Definition

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Version: 1.02 (first release)
Processor: FMI GOMOS One-step

1. GENERAL DESCRIPTION

Global Ozone Monitoring by Occultation of Stars (GOMOS) is a space-based instrument onboard the ENVISAT platform which was in operation during 2002–2012. During its lifetime, GOMOS performed about 880 000 stellar occultations, from which about half were during nighttime. These GOMOS occultation measurements are further processed to vertical profiles of various geophysical quantities like ozone, nitrogen dioxide, nitrogen trioxide, and aerosols. This is the IODD document for the GOMOS One-step ozone dataset that is created for the upper troposphere—lower stratosphere (UTLS) studies in the framework of ALGOM project funded by the European Space Agency. In the one-step algorithm, the spectral and the vertical inversions of the operational two-step algorithm are executed simultaneously. See [1—4] for more discussion about the One-step algorithm, dataset and file format.

2. Processed occultations in the GOMOS onestep dataset

• Only the data in 'full dark' — i.e., solar zenith angle > 104° — are processed.

• Processing is limited to the 'good stars' only: all stars in new ALGOM 'bad star list' are removed (see [2] for more details).

• In addition, also occultations that have no data below 50 km, or more than 150 vertical lines (tangent points) are removed.

• The whole dataset contains 243 883 profiles.

3. Input Data Definition

• The One-step dataset is processed using GOMOS Level 2 products (GOM_EXT_2P and GOM_NL_2P), generated with the Instrument Processor Facility (IPF) v. 6.01 as input (https://earth.esa.int/web/sppa/mission-performance/esa-missions/envisat/gomos/products-and-algorithms/products-information). The filenames used are reported in output files. See [5] for IODD details.

• The main input is residual extinction and its error estimate from GOM_EXT files.

• Parameters from GOM_NL files are also used as input. These include, but are not limited to tangent altitude, pressure, temperature, star and occultation characteristics, solar zenith angles.

• Formally the One-step algorithm is called as

```
out2    = gomos_onestep(data,one_options);
```

Where data and options are summarized in the tables below:

one_options

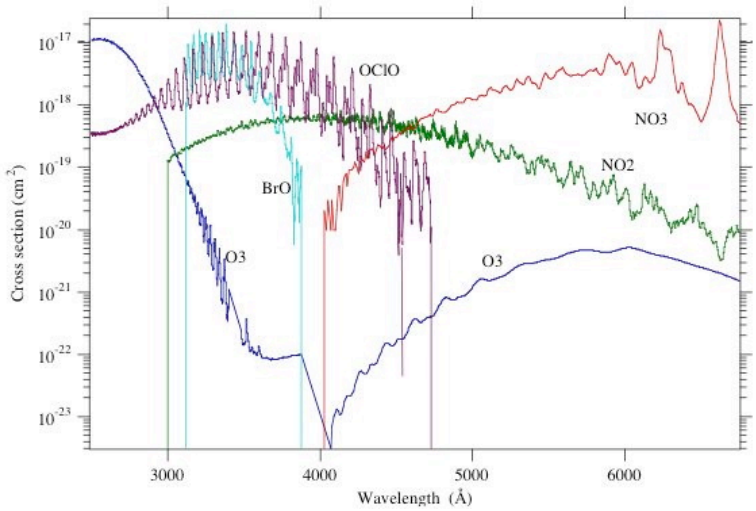
trace:	3
maxiter:	35
rho0:	[48x5 double]
modelnum:	1
phi:	[]
usefcm:	0

data

class:	'gomos_data'
wavel:	[1416x1 double]
heights:	[48x1 double]
gasnames:	{'O3' 'NO2' 'NO3' 'Air' 'Aerosols'}
aweight:	[48x48 double]
ecmwfair:	[48x1 double]
weights:	{1x48 cell}
cross:	{1x48 cell}
trans:	{1x48 cell}
transmodel:	{1x48 cell}
scale:	{1x48 cell}
o3:	[48x1 double]
no2:	[48x1 double]
no3:	[48x1 double]
aer:	[48x1 double]
air:	[48x1 double]
o3std:	[48x1 double]
no2std:	[48x1 double]
no3std:	[48x1 double]
aerstd:	[48x1 double]
airstd:	[48x1 double]
No3:	[48x1 double]
Nno2:	[48x1 double]
Nno3:	[48x1 double]
Naer:	[48x1 double]
Nair:	[48x1 double]
airmu:	[48x1 double]
Nairmu:	[48x1 double]

Cross-sections

In order to retrieve atmospheric parameters from GOMOS data, the so-called cross-sections are needed. The One-Step algorithm cross-sections are taken from the GOMOS cross-section database where they are ordered through species, temperature, and wavelength. The cross-sections are obtained from laboratory measurements. See GOMOS IPF 6.01 ATBD and IODD for more details (https://earth.esa.int/web/sppa/mission-performance/esa-missions/envisat/gomos/products-and-algorithms/products-information). For aerosols, cross-section model $1/\lambda$ is selected.



Cross-section database.

A priori data

Currently there are no absolute priors or priors for first derivative. Only the smoothes a priori (second derivative) are used. The values used are presented in the table below. There are modest smoothness requirements for ozone, and almost no regularization at all for aerosols.

A priori standard deviation for second derivative (smoothness) per km.

Altitude [km]	O_3	NO_2	NO_3	Aerosol
1	2×10^8	10^8	10^6	10^{-2}
10	2×10^8	10^8	10^6	10^{-2}
15	2×10^11	10^8	10^6	10^{-2}
20	$2 \times 10^{11.5}$	10^8	10^6	10^{-2}
25	$2 \times 10^{10.5}$	10^8	10^6	10^{-2}
30	$10^{10.5}$	10^8	10^6	10^{-2}
40	$10^{10.5}$	10^8	10^6	10^{-2}
120	$10^{8.5}$	10^8	10^6	10^{-2}
160	$10^{8.5}$	10^8	10^6	10^{-2}

4. Output Data Definition

• The One-step dataset is in NetCDF data format (one file per occultation).

• The NetCDF format follows the 'user friendly' format created in ALGOM project, see [2] for details.

• The filename syntax is 'ESA_ALGOM-L2-GOMOS-FMI_onestep-,date,T,hourminsec-R,orbitnumber-S,starnumber,-fv,fileversion,.nc'.

• Example filename: ESA_ALGOM-L2-GOMOS-FMI_onestep-20080820T013701-R33838-S001-fv001.nc.

• The main outputs are ozone and aerosol profiles profile, and their error estimates and resolution. Output also include occultation and star characteristics, but these are copied from input files, see again [5] for details.

• Note the "ncdisp" in next section.

5. Disclaimer

• Although, NO2 and NO3 processed along ozone and aerosols they are not reported in data files, because we cannot rigorously recommend using them for scientific analysis.

6. Summary of the variables in the NetCDF files

In the table below there is a "ncdisp" print of a GOMS one-step NetCDF file.

```
Source:
            ESA_ALGOM-L2-GOMOS-FMI_onestep-20021231T221155-R04378-S012-fv001.nc
Format:
           netcdf4
Dimensions:
           n_alt  = 53
           oneval = 1
```

/geolocation_group/	
Variable	
time	Size: 1x1 Dimensions: /oneval Datatype: double Attributes: long_name = 'mean Modified Julian Date' standard_name = 'time' units = 'days since 1858-11-17 00:00:00' description = 'Mean Modified Julian Date between altitudes 20 and 50 km'
latitude	Size: 1x1 Dimensions: /oneval Datatype: double Attributes: long_name = 'mean latitude'

	standard_name = 'latitude' units = 'degrees_north' description = 'Mean latitude between tangent altitudes 20 and 50 km'
longitude	Size: 1x1 Dimensions: /oneval Datatype: double Attributes: long_name = 'mean longitude' units = 'degrees_east' standard_name = 'longitude' description = 'Mean longitude between tangent altitudes 20 and 50 km'
time_start	Size: 1x1 Dimensions: /oneval Datatype: double Attributes: long_name = 'first measurement Modified Julian Date' units = 'days since 1858-11-17 00:00:00'
time_end	Size: 1x1 Dimensions: /oneval Datatype: double Attributes: long_name = 'last measurement Modified Julian Date' units = 'days since 1858-11-17 00:00:00'
latitude_start	Size: 1x1 Dimensions: /oneval Datatype: double Attributes: long_name = 'first measurement latitude'
latitude_end	Size: 1x1 Dimensions: /oneval Datatype: double Attributes: units = 'degrees_north' long_name = 'last measurement latitude'
longitude_start	Size: 1x1 Dimensions: /oneval Datatype: double Attributes: long_name = 'first measurement longitude' units = 'degrees_east'
longitude_end	Size: 1x1 Dimensions: /oneval

	Datatype: double Attributes: long_name = 'last measurement longitude' units = 'degrees_east'
altitude	Size: 53x1 Dimensions: /n_alt Datatype: double Attributes: long_name = 'tangent height above mean sea level' standard_name = 'altitude' units = 'km' description = 'Tangent altitude'
altitude_min	Size: 1x1 Dimensions: /oneval Datatype: double Attributes: long_name = 'minimum tangent altitude reached by the occultation' units = 'km'
altitude_parameters	Size: 1x1 Dimensions: /oneval Datatype: double Attributes: long_name = 'parameter averaging altitude range' units = 'km' description = 'Mean tangent altitude for mean values of parameters. Usually parameters are mean over 20-50 km.'
duration	Size: 1x1 Dimensions: /oneval Datatype: double Attributes: long_name = 'duration of the occultation' units = 'sec'
obliquity	Size: 1x1 Dimensions: /oneval Datatype: double Attributes: long_name = 'obliquity of the occultation' units = 'degrees' description = 'Obliquity of the occultation: Obliquity is the angle between the vector velocity of the line of sight in the atmosphere and the local vertical at altitude 35 km.'
/radiation_group/	

Variable	
sza_tangentpoint	Size: 1x1 Dimensions: /oneval Datatype: double Attributes: long_name = 'mean solar zenith angle at tangent poir standard_name = 'solar_zenith_angle' units = 'degrees' description = 'Mean solar zenith angle between tange altitudes 20 and 50 km at tangent point'
illumination_flag	Size: 1x1 Dimensions: /oneval Datatype: int32 Attributes: long_name = 'illumination flag' description = 'Illumination conditions flag: 0=dark, 1=bright, 2=twilight, 3=stray light, 4=stray+twilight'
sza_satellite	Size: 1x1 Dimensions: /oneval Datatype: double Attributes: long_name = 'mean solar zenith angle at satellite' units = 'degrees' description = 'Mean solar zenith angle at satellite location between tangent altitudes 20 and 50 km'
saa_flag	Size: 1x1 Dimensions: /oneval Datatype: int32 Attributes: long:name = 'south Atlantic Anomaly-flag' description = 'South Atlantic Anomaly-flag: 0=outside SAA, 1=inside SAA'
/startarget_group/	
Variable	
star_id	Size: 1x1 Dimensions: /oneval Datatype: int32 Attributes: long_name = 'star identification number' description = 'Star number in the GOMOS star catalog
star_temperature	Size: 1x1 Dimensions: /oneval Datatype: double

	Attributes: long_name = 'star effective temperature' units = 'K' description = 'Target star effective temperature in the GOMOS star catalogue'
star_magnitude	Size: 1x1 Dimensions: /oneval Datatype: double Attributes: long_name = 'star visual magnitude' description = 'Star visual magnitude in the GOMOS star catalogue'
/o3_density_group/	
Variable	
o3_density	Size: 53x1 Dimensions: /n_alt Datatype: double Attributes: long_name = 'ozone number density at tangent altituc units = 'cm-3'
o3_density_std	Size: 53x1 Dimensions: /n_alt Datatype: double Attributes: long_name = 'ozone number density error estimate at altitude' units = 'cm-3'
o3_vert_res	Size: 53x1 Dimensions: /n_alt Datatype: double Attributes: long_name = 'o3 vertical resolution' units = 'km' description = 'O3 vertical resolution'
/aerosol_group/	
Variable	
aerext_500	Size: 53x1 Dimensions: /n_alt Datatype: double Attributes: lon_name = 'aerosol extinction at 500 nm at tangent units= '1/km'
aerext_500_std	Size: 53x1

	Dimensions: /n_alt Datatype: double Attributes: long_name = 'aerosol extinction at 500 nm error esti tangent altitude' units = '%'
aerext_500_vert_res	Size: 53x1 Dimensions: /n_alt Datatype: double Attributes: long_name = 'aerosol extinction at 500 nm vertical r units = 'km' description = 'Aerosol extinction at 500 nm vertical resolution'
/retrieval_quality_group/	Size: 53x1 Dimensions: /n_alt Datatype: double Attributes: long_name = 'chi2 ' description = 'Chi2 from fit (normalised by the degrees of freedom)'
Variable	
chi2	Size: 53x1 Dimensions: /n_alt Datatype: double Attributes: long_name = 'chi2 ' description = 'Chi2 from fit (normalised by the degrees of freedom)'
/apriori_data_group/	
Variable	
air_density_ecmwf	Size: 53x1 Dimensions: /n_alt Datatype: double Attributes: long_name = 'a priori neutral density profile' units = 'cm-3' description = 'Neutral density from ECMWF (below altitudes 1 hPa) and MSIS90 (above altitudes 1 hPa) at tangent altitude'
air_pressure_ecmwf	Size: 53x1 Dimensions: /n_alt Datatype: double Attributes: long_name = 'a priori pressure profile'

	units = 'hPa' description = 'Pressure from ECMWF (below altitudes 1 hPa) and MSIS90 (above altitudes 1 hPa) at tangent altitude'
air_temperature_ecmwf	Size: 53x1 Dimensions: /n_alt Datatype: double Attributes: long_name = 'a priori temperature profile' units = 'K' description = 'Temperature from ECMWF (below altitudes 1 hPa) and MSIS90 (above altitudes 1 hPa) at tangent altitude'
/satellite_geolocation_group/	
Variable	
orbit_number	Size: 1x1 Dimensions: /oneval Datatype: int32 Attributes: long_name = 'ENVISAT orbit number'
latitude_satellite	Size: 1x1 Dimensions: /oneval Datatype: double Attributes: long_name = 'mean satellite latitude' units = 'degrees' description = 'Mean latitude of satellite between tangent altitudes 20 and 50 km'
longitude_satellite	Size: 1x1 Dimensions: /oneval Datatype: double Attributes: long_name = 'mean satellite longitude' units = 'degrees' description = 'Mean longitude of satellite between tangent altitudes 20 and 50 km'
latitude_satellite_start	Size: 1x1 Dimensions: /oneval Datatype: double Attributes: long_name = 'first measurement satellite latitude' units = 'degrees'
latitude_satellite_end	Size: 1x1 Dimensions: /oneval Datatype: double

	Attributes: long_name = 'last measurement satellite latitude' units = 'degrees' longitude_satellite_start
longitude_satellite_start	Size: 1x1 Dimensions: /oneval Datatype: double Attributes: long_name = 'first measurement satellitelongitude' units = 'degrees'
longitude_satellite_end	Size: 1x1 Dimensions: /oneval Datatype: double Attributes: long_name = 'last measurement satellite longitude' units = 'degrees'
/metadata_group/	
Attributes	title = 'GOMOS One-step UTLS data' source_file_EXT = 'GOM_EXT_2PRFIN20021231_221155_000000402012_00316_043 source_file_NL_ = 'GOM_NL__2PRFIN20021231_221155_000000402012_00316_043 GOMOS_OnestepUTLS_dataversion = '1.02' GOMOS_IPF_dataversion = 'GOMOS/6.01' file_creation_date= '20160128T134249' file_created_by = 'Janne Hakkarainen, janne.hakkarai project = 'ESA-ALGOM' institute = 'Finnish Meteorological Institute' value_for_nodata= 'NaN' platform= 'ENVISAT' instrument= 'GOMOS'

7. Further reading

[1] Janne Hakkarainen: Potential improvements of GOMOS retrievals in the UTLS using one-step approach. Technical Note, ESA-ALGOM project, Finnish Meteorological Institute, 2016.

[2] Erkki Kyrölä, Viktoria Sofieva, Janne Hakkarainen, and Johanna Tamminen: User friendly data sets, Technical Note, ESA-ALGOM project, Finnish Meteorological Institute, 2016.

[3] Janne Hakkarainen, Marko Laine, and Johanna Tamminen: GOMOS one-step retrieval algorithm, Remote Sensing of Clouds and the Atmosphere XVIII, Proceedings of SPIE Volume 8890, 2013, doi:10.1117/12.2027109.

[4] Janne Hakkarainen, Iolanda Ialongo, Viktoria Sofieva, Marko Laine, Johanna Tamminen, and Erkki Kyrölä: Validation and Alternative Retrievals of GOMOS Ozone Profiles in the UTLS Altitude Region, Proceedings of Advances in Atmospheric Science and Applications, ESA SP-735, 2015.

[5] Gilbert Barrot, GOMOS Input/Output Data Definition, ESA ESL, PO-RS-ACR-GS-0003,2009.