Exploitation of the Mesosphere (MesosphEO)

ESA MesosphEO

Product Specification Document for Odin/SMR MesosphEO data sets

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1. Introduction

The Sub-Millimetre Radiometer (SMR), aboard the Odin satellite, has been in operation since 2001 and performs passive limb measurements of the atmosphere, mainly at frequencies around 500 GHz. From these measurements, profiles of species that are of interest for studying stratospheric and mesospheric chemistry and dynamics can be derived. These profiles are referred to as Level 2 (L2) products. SMR has several frequency modes. One product can sometimes be retrieved from different frequency modes.

O_3, CO, NO, H_2O and temperature mesospheric products were created in the framework of the MesosphEO project, using the version 3 of the L2 processor. Level 3 (L3) data products have also been produced, corresponding to zonal monthly averages of the L2 products, calculated on predefined latitude, pressure and time grids.

The aim of this document is to provide an user-friendly description of these specific data sets.

2. File formatting

2.1. File naming

Level 2

The files are in netCDF format. Each file corresponds to one month of measurements, for one given product and one given frequency mode. They are named as follows:

OdinSMR-L2-meso-<product>-FM<fm>-<gridZ>-<YYYYMM>.nc

Where <product> is the retrieved chemical species or temperature, <fm> is the frequency mode, <gridZ> indicates which vertical grid was used (either „std“: retrieval pressure grid, or „grid“: predefined pressure grid used in the O3-CCI project, as described in MesosphEO WP4.1 preparatory works), and <YYYYMM> gives the month under consideration.

Level 3

Each netCDF files contains zonal monthly averaged data covering the whole operational period of Odin, for one given product and one given frequency mode. They are named as follows:

OdinSMR-L3-meso-<product>-FM<fm>.nc

Where <product> and <fm> have the same meaning as explained above.

2.2. NetCDF format

Level 2

The L2 netCDF files contain global attributes, dimensional information and data variables. The data variables are collected into five categories and are described in the following tables. N_{prof} is the number of profiles and N_{lev} is the number of pressure levels.

Geolocation		
Variable and unit	***Dimension***	***Description***
time (days since 1900-01-01 00:00:00)	$N_{prof} \times 1$	mean time of the scan
latitude (degrees north)	$N_{prof} \times 1$	mean latitude of the scan
longitude (degrees east)	$N_{prof} \times 1$	mean longitude of the scan
pressure (hPa)	$N_{lev} \times 1$	vertical coordinate, air pressure

Retrieval results		
Variable and unit	***Dimension***	***Description***
l2_value (N/A or K)	$N_{lev} \times N_{prof}$	retrieved volume mixing ratio or temperature
l2_error (N/A or K)	$N_{lev} \times N_{prof}$	total retrieval error (thermal noise and smoothing errors)
vertical_resolution (km)	$N_{lev} \times N_{prof}$	FWHM of the averaging kernel

Specific data for selection		
Variable and unit	***Dimension***	***Description***
quality (N/A)	$N_{prof} \times 1$	quality flag (see Sect. 3.1)
measurement_response (N/A)	$N_{lev} \times N_{prof}$	measurement response (see Sect. 3.1)
averaging_kernel (N/A)	$N_{lev} \times N_{lev} \times N_{prof}$	averaging kernel matrix
local_time (hours)	$N_{prof} \times 1$	mean local time of the scan
geomagnetic_latitude (degrees north)	$N_{prof} \times 1$	mean geomagnetic latitude* of the scan
geomagnetic_longitude (degrees east)	$N_{prof} \times 1$	mean geomagnetic longitude* of the scan
valid_vertical_range (hPa)	$2 \times N_{prof}$	lower and upper limits of the valid pressure range for each profile

Satellite specific data		
Variable and unit	***Dimension***	***Description***
orbit (N/A)	$N_{prof} \times 1$	Odin orbit number
scanID (N/A)	$N_{prof} \times 1$	Odin scan ID number
freqmode (N/A)	$N_{prof} \times 1$	Odin frequency mode
latitude (degrees north)	$N_{lev} \times N_{prof}$	latitude of each spectral measurement
longitude (degrees east)	$N_{lev} \times N_{prof}$	Longitude of each spectral measurement

A priori		
Variable and unit	***Dimension***	***Description***
l2_apriori (N/A or K)	$N_{lev} \times N_{prof}$	used a priori data for VMR or temperature

* The conversion from spherical geographic coordinates to spherical geomagnetic coordinates has been done using magnetic field calculations from the IGRF-12 internal field model (Thébault et al., *International Geomagnetic Reference Field: the 12th generation*, Earth, Planets and Space 67(1), 1-19, doi:10.1186/s40623-015-0228-9, 2015.)

Level 3

The L3 netCDF files also contain global attributes, dimensional information and data variables. The data variables are collected into three categories and are described in the following tables. N_{time} is the number of time cells, corresponding to the number of months under consideration. N_{lev} is the number of pressure levels. The pressure grid is the same as the one used for the L2 vertically gridded data (the O3-CCI predefined grid). N_{lat} is the number of latitude bins (10 degrees from -90° to +90°).

Grids		
Variable and unit	***Dimension***	***Description***
time (days since 1900-01-01 00:00:00)	$N_{time} \times 1$	mid-points of the time cells (i.e. mid-months)
pressure (hPa)	$N_{lev} \times 1$	vertical pressure grid
latitude (degrees north)	$N_{lat} \times 1$	mid-points of the latitude cells
quartile (N/A)	3×1	percentage of the values lying below each quartile

Gridding results		
Variable and unit	***Dimension***	***Description***
concentration (N/A or K)	$N_{lat} \times N_{lev} \times N_{time}$	median volume mixing ratio or temperature
concentration_error (N/A or K)	$N_{lat} \times N_{lev} \times N_{time}$	estimated error of the average (SEM)
standard_deviation (N/A or K)	$N_{lat} \times N_{lev} \times N_{time}$	standard deviation corresponding to each vmr (or T) cell
quartiles (N/A or K)	$3 \times N_{lat} \times N_{lev} \times N_{time}$	three quartiles corresponding to each vmr (or T) cell
number_of_measurements (N/A)	$N_{lat} \times N_{time}$	number of profiles in each latitude-time cell
mean_measurements_response (N/A)	$N_{lat} \times N_{lev} \times N_{time}$	mean measurement response in each cell (see Sect. 3.1)

Statistical methods		
Variable and unit	***Dimension***	***Description***
average_latitude (degrees north)	$N_{lat} \times N_{time}$	mean latitude of measurements in each latitude-time cell
average_time (days since 1900-01-01 00:00:00)	$N_{lat} \times N_{time}$	Mean time of measurements in each latitude-time cell

3. User guidance

3.1. Data screening

No filtering has been applied to the data contained in both L2 and L3 netCDF files. The users should use it carefully and filter it according to the measurement response, as explained below.

The measurement response is defined as the sum of the rows of the averaging kernel matrix and indicates how much information has been derived from the true state of the atmosphere. A high measurement response ensures that the information comes primarily from the measurement and not from the contribution of the climatological a priori profile used in the Optimal Estimation Method (OEM) retrieval process. If the measurement response is low, there is a systematic bias towards the a priori state.

In the case of L2 products, data points associated with a measurement response lower than 0.75 should not be used for a scientific analysis. Moreover, in case of a study based on the average of several profiles, we recommend averaging first, and filtering then, based on the

mean measurement response, in order to avoid any low bias in the averaged data set (as low measurement responses are most often associated with low values). In the case of L3 products, all pressure-latitude-time cells characterised by a mean measurement response lower than 0.75 should not be considered.

The quality flag associated with the latest version (v3.0) of the L2 data has not been defined yet. It is currently equal to zero for each profile and should not been used. This information will be added in a next version of the data set, that will be made available on the Odin/SMR website in the near future (odin.rss.chalmers.se).

3.2. Warning! CO measurements

A failure of the Phase-Lock Loop (system controlling the fine tuning of the frequencies to be used for a limb scan) of the front-end used for the CO observations, results in a frequency shift of the whole spectral band. This technical issue has affected all CO measurements made by SMR after October 2004 (frequency modes 14, 22 and 24, 576.3 GHz). This is the reason why carbon monoxide could not be systematically retrieved up to now. An algorithm to correct the measured spectra before the retrieval process has now been developed, and applied to all the affected measurements. The netCDF files created in the framework of the MesosphEO project correspond to this first rescue attempt. However, the data should be handle with care. Many of the recovered profiles exhibit an unexplained feature (important increase in CO vmr around 3.10^{-3} hPa). This is most probably unrealistic, and has to be investigated and understood. We recommend not to use this data set for research purposes.