Odin/SMR

# Verification Dataset: Technical Note

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# Contents

# Chapter 1 | Introduction

## 1.1 Aim and scope of this document

Odin/SMR performs passive limb measurements of the atmosphere, mainly at wavelengths and frequencies around 0.6 mm and 500 GHz, respectively. From these measurements, profiles of $O_3$, ClO, $N_2O$, $HNO_3$, $H_2O$, CO, and isotopologues of $H_2O$, and $O_3$, that are species that are of interest for studying stratospheric and mesospheric chemistry and dynamics, can be derived. Odin/SMR has been in operation for approximately 14 years, and thus, the Level2 dataset can potentially be applied for scientifically interesting trend analysis.

A new Odin/SMR Level2 product dataset will be generated, and this dataset will be based on updated/revised processing algorithms and input data. A verification dataset (VDS) will be used as a tool to verify the new processing system / Level2 products. The aim of this document is to describe this VDS. The VDS mainly consists of colocated correlative measuerments.

## 1.2 Document structure

This document is organized as follows: Chapter 2 describes the Odin/SMR Level2 data products. Chapter 3 describes the VDS.

# Chapter 2 | Odin/SMR Level2 data products

## 2.1 The Odin mission

Text from RBD: this should be modified a bit

The Odin satellite was launched on the 20th of February 2001, into a sun-synchronous 18:00 hour ascending node orbit, carrying two co-aligned limb sounding instruments: OSIRIS (Optical spectrograph and infrared imaging system) and SMR (Sub-millimetre radiometer) (Murtagh et al., 2002). Originally, Odin was used for both atmospheric and astronomical observations, but since 2007 only its aeronomy mission is active. Odin is a Swedish-led project, in cooperation with Canada, France and Finland. Both of Odin's instruments are still functional, and the present operation of the satellite is partly performed as an ESA third party mission.

## 2.2 The SMR instrument

The Odin/SMR package is highly flexible (Frisk et al., 2003). In short, the four main receiver chains can be tuned to cover frequencies in the ranges 486–504 GHz and 541–581 GHz, but the maximum total instantaneous bandwidth is only 1.6 GHz. This bandwidth is determined by the two auto-correlation spectrometers (ACs) used for atmospheric observations. The two ACs can be coupled to any of the four front-ends, but only two or three front-ends are used simultaneously. The ACs cover 400 or 800 MHz per front-end, depending on configuration. In the configuration applied for atmospheric sounding, the channels of the ACs have a spacing of 1 MHz, while the frequency resolution is only 2 MHz. To cover all molecular transitions of interest (see Table 2.1 and Table 2.2 for an overview), a number of "observation modes" have been defined. Each observation mode makes use of two or three frequency bands. Single sideband operation is obtained by tunable Martin–Pupplet interferometers. The nominal sideband suppression is better than 19 dB across the image band.

Odin/SMR also has a receiver chain around the 118 GHz oxygen transition that was heavily used during Odin's astronomy mission. For the atmospheric mission, this front-end was planned to be used for retrieving temperature profiles, but a technical problem (drifting LO frequency) and the fact that the analysis requires treatment of Zeeman splitting have given these data low priority. This ATBD focuses on the processing of the sub-millimetre data, but comments on the adaptions required to also handle the 118 GHz data are given.

The main reflector of Odin/SMR has a diameter of 1.1 m, giving a vertical resolution at the tangent point of about 2 km. The vertical scanning of the two instruments' line-of-sight is achieved by a rotation of the satellite platform, with a rate matching a vertical speed

Table 2.1: Characteristics of Odin/SMR Level2 main data products.

| Product | Frequency [GHz] | Vertical coverage | Vertical resolution | Precision | Reference |
|---|---|---|---|---|---|
| $O_3$ | 501.5 | ∼19–50 km | ∼2 km | 0.5–2 ppmv | (Urban et al., 2005) |
| ClO | 501.3 | ∼19–67 km | 1.5–2 km | 0.15–0.2 ppbv | (Urban et al., 2005) |
| $N_2O$ | 502.3 | ∼15–70 km | ∼1.5 km | 15–35 ppbv | (Urban et al., 2005) |
| $O_3$ | 544.9 | ∼18–70 km | ∼1.5 km | 0.2–0.4 ppmv | (Urban et al., 2005) |
| $HNO_3$ | 544.4 | ∼21–67 km | 1.5–2 km | 1 ppbv | (Urban et al., 2005) |

Table 2.2: Characteristics of Odin/SMR Level2 science data products.

| Product | Frequency [GHz] | Vertical coverage | Vertical resolution | Precision | Remark |
|---|---|---|---|---|---|
| CO | 578.6 | ∼17–110 km | 3–4 km | 25 ppbv–2 ppmv | (Dupuy et al., 2004) |
| $H_2{}^{16}O$ | 556.9 | ∼40–100 km | ∼3 km | 0.5–1 ppmv | (Urban et al., 2007) |
| $H_2{}^{16}O$ | 488.5 | ∼20–70 km | ∼3 km | 0.5–1 ppmv | (Urban et al., 2007) |
| HDO | 490.6 | ∼20–70 km | 3–4 km | 0.5 ppbv | (Urban et al., 2007) |
| $H_2{}^{18}O$ | 489.1 | ∼20–65 km | 3–4 km | 20-30 ppbv | (Urban et al., 2007) |
| $H_2{}^{17}O$ | 552.0 | ∼20–70 km | ∼3 km | 0.4 ppbv | (Urban et al., 2007) |
| NO | 551.7 | ∼40–100 km | ∼7 km | 40 % | (Sheese et al., 2013) |
| ${}^{16}O\,{}^{18}O\,{}^{16}O$ | 490.4 | ∼27–41 km | 4–6 km | 25 % | (Urban et al., 2013) |
| ${}^{16}O\,{}^{16}O\,{}^{18}O$ | 490.0 | ∼25–45 km | 3–4 km | 25 % | (Urban et al., 2013) |
| ${}^{16}O\,{}^{16}O\,{}^{17}O$ | 490.6 | ∼31–39 km | 5–6 km | 25 % | (Urban et al., 2013) |

of the tangent altitude of 750 m/s. Measurements are performed during both upward and downward scanning. The lower end of the scan is typically at about 7 km, the upper end varies between 70 and 110 km, depending on observation mode. In correspondence, the horizontal sampling ranges from 1 scan per 600 km to 1 scan per 1000 km. Measurements are in general performed along the orbit plane, providing a latitude coverage between 82.5°S and 82.5°N. Since the end of 2004 Odin is also pointing off-track during certain periods, e.g. during the austral summer season, allowing the latitudinal coverage to be extended towards the poles.

## 2.3 Odin/SMR Level2 data products

In this section an overview of Odin/SMR Level2 data products and requirements are given. Table 2.1 and Table 2.2 describe characteristics of the main and science Level2 products. The main products are retrieved from the so called "stratospheric" observation mode of Odin/SMR. In this mode spectra in frequency bands around 501 and 544 GHz are collected, and this mode is the most commonly applied mode. The science data products are derived from less frequently applied observation modes (typically applied a few days per month).

### 2.3.1 Main data products

Ozone, ClO, $N_2O$, and $HNO_3$ profiles are the main Odin/SMR Level2 products. ClO and $N_2O$ profiles are retrieved from spectra covering transitions around 501 GHz, and $HNO_3$ from spectra around 544 GHz. Ozone can be retrieved from both the 501 and the 544 GHz band. Table 2.1 describes characteristics of these Level2 products that has been derived from earlier Odin/SMR Level2 data studies. The characteristics can not be expected to be changed/improved dramatically for a new Level2 data product, because these characteristics depend on the physics of the measurement and the sensor.

Possibly more important than the characteristics described in Table 2.1 are the accuracy and stability of the profiles, since the latter enable trend studies. The overall aim of the new Level2 data processing also reflects this aspect, and the objective is therefore that the accuracy and stability outperforms that from earlier Odin/SMR Level2 data products.

A requirement is therefore that an inventory/review is performed of the Level1B algorithm and data, and all other input data, applied in the Level2 processing (see Chapter **??**). A further requirement is that the new Level2 dataset is validated by comparison to correlative datasets, both during the development phase and and in its final stage

### 2.3.2 Science data products

Profiles of $H_2O$, CO, NO and isotopologues of $H_2O$, and $O_3$ are considered as science data products for Odin/SMR, and characteristics of these products are described in Table 2.2. Observations covering the science data products are performed on a less frequent basis than the main data products. The aim of the Level2 processing of the science data products is in principle identical to that for the main data products, although the main data products will be given a higher priority.

# Chapter 3 | Verification Dataset

## 3.1 Overview

## 3.2 Aura/MLS

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## 3.3 Correlative measurements

### 3.3.1 ENVISAT/MIPAS

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### 3.3.2 ISS/JEM/SMILES

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### 3.3.3 Odin/OSIRIS

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### 3.3.4 Meteor3M/SAGEIII

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