ESA Climate Change Initiative
aerosol_cci

Mineral Aerosol Profiling from Infrared Radiances (MAPIR)
Algorithm Theoretical Basis Document (ATBD)

Version 3.5

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EXECUTIVE SUMMARY

The MAPIR algorithm provides dust vertical profiles following the well-known Optimal Estimation (OE) method, using three spectral windows in the so-called atmospheric window (800-1200cm^{-1}). The surface temperature is retrieved together with dust aerosols. The information about aerosol altitude is given both by its emission temperature (impacting the spectral baseline in general, with a wide V-shape in the atmospheric window) and its impact on low tropospheric gas absorption (mainly water vapour). In general the retrieved vertical profiles contain two pieces of information, meaning that the retrieval is able to separate two dust layers.

The specificity of these desert dust retrievals with respect to all other current IASI aerosol retrievals is that a vertical profile of aerosol concentration from 1 to 6 km altitude is inverted. The total column and aerosol optical depth (AOD) are then computed by integration of this vertical profile and conversion using the extinction cross-section at the required wavelength.

All radiative transfer computations for the retrievals are undertaken using the advanced code LIDORT (Spurr, 2008), which allows accurate representation of multiple scattering. There is however one drawback to this choice: LIDORT is computationally demanding, being responsible for most of the ~20 seconds necessary for each retrieval.

Using the OE iterative method, our algorithm requires knowledge of all radiatively important parameters that are not retrieved and a priori knowledge of the parameters that are retrieved. The uncertainties on all those parameters is the main source of problems during the retrievals, and on uncertainty on the retrieval results. Therefore, the necessary ancillary data is filtered as best as possible to avoid retrievals that would anyway end with a bad result. Furthermore, retrievals are only attempted for clear-sky conditions (maximum cloud cover of 10%).
Quality of the retrieval is currently assessed based on the root mean square of the spectral residuals (RMSSR). Retrievals with RMSSR of the order of the estimated noise in IASI measurements are considered very good.

Uncertainty estimations are provided, but they do not yet contain the uncertainty due to ancillary parameters uncertainties. They are therefore most probably extremely underestimated.

Issue	Date	Modified Items / Reason for Change
1.0	26.11.2014	First submission
1.1	18.02.2015	Change in section 5 Implementation: those were necessary after some tests, to reach better results (in particular, the change of surface temperature dataset is important) Better description of some pre- and post-filtering Minor error corrections

2.0	25.08.2015	Changes in section 5 Implementation: we have added surface temperature to the state vector
3.0	10.11.2015	Changes in section 5 Implementation: we have modified the retrieval window for surface temperature, we have modified the dust presence filter, we have removed the ice cloud filter. Some additional minor corrections or details added
3.1	01.03.2017	Corrections of the executive summary,

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1 INTRODUCTION

This document describes the theoretical basis for the mineral dust aerosol retrieval algorithm developed by BIRA-IASB for the IASI (Infrared Atmospheric Sounding Interferometer) instruments on board of EUMETSAT's Metop satellites. This algorithm is referred to as MAPIR (Mineral Aerosol Profiling using Infrared Radiances).

1.1 Scope

This ATBD aims to provide an overview of the MAPIR algorithm with detailed references, with summaries of the issues that are important for the aerosol_cci work. It will not be a comprehensive compilation of all existing literature on the topic of hyperspectral infrared aerosol retrieval.

Scientific publications referred to within this document describe earlier algorithm versions and do not necessarily reflect the latest changes (also those within aerosol_cci as an outcome of the project work) implemented into the scheme and documented within this ATBD. All references to MAPIR within Aerosol_cci should thus include the citation of this ATBD.

1.2 References

1.2.1 Applicable Documents

[AD1] Statement of Work "ESA Climate Change Initiative Stage 1, Scientific user Consultation and Detailed Specification", ref EOP-SEP/SOW/0031-09/SP. Issue 1.4, revision 1, dated 9 November, 2009, together with its Annex C "Aerosols" (altogether the SoW).

[AD2] The Prime Contractor's Baseline proposal, ref. 3003432, Revision 1.0, dated 16 June 2010, and the minutes of the July 26, 2010 kick-off meeting

1.2.2 Reference Documents

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2 IASI INSTRUMENT CHARACTERISTICS

2.1 The Metop satellites

The European Polar System (EPS) consists of three Metop satellites with Metop-A in orbit since October 2006 and Metop-B since 2012. The launch of Metop-C is scheduled for 2018. EPS is the European contribution to the Initial Joint Polar System (IJPS) agreed upon by EUMETSAT and NOAA.

The European and American satellites of the IJPS carry a set of identical sensors: AVHRR/3, AMSU-A, HIRS/4 and MHS.

The European EPS satellites as well carry an additional set of sensors: IASI, ASCAT, GOME-2 and GRAS. Moreover they operate the Argos Advanced Data Collection System (A-DCS). The design of the Metop satellites is depicted in figure 2.1-1.

Equator crossing time of the EPS satellites is 09:30 local solar time at an altitude of 817km and an inclination of 98.7°.

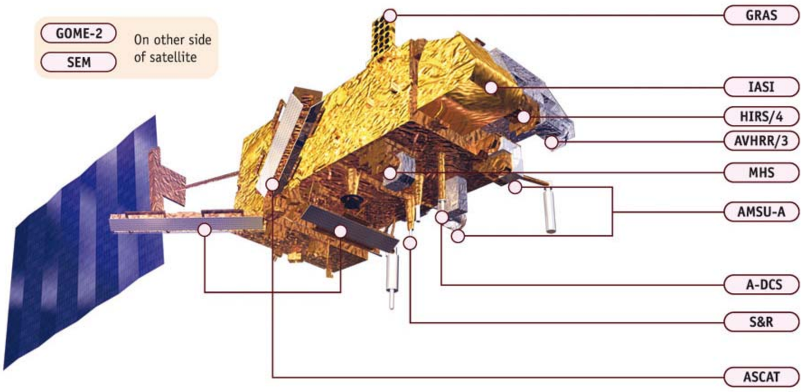

Figure 2.1-1: Design of the Metop EPS satellites. © EUMETSAT

2.2 IASI instrument overview

On board of the Metop satellites is the Infrared Atmospheric Sounding Interferometer (IASI), a scanning Michelson interferometer with very fine spectral resolution in the thermal infrared designed for observation of atmospheric temperature and humidity profiles. It observes infrared radiance spectra in the 3.7µm – 15.5µm spectral range (in three overlapping bands, Table 2.2-1) at 12km nadir ground resolution and a swath of 48.3° (2200km). It scans the earth with four detectors simultaneaously and each swath (scanline) is divided into 30 2x2 scan matrices, i.e. each scanline contains 60 fields-of-view (FOV). The scan principle is shown in figure 2.2-1 schematically. The ground resolution of 12km is a tradoff between radiometric performance and the statistical likelihood of valid measurement acquisition in dependence of cloud cover.

8461 channels in the terrestrial infrared result in a spectral resolution of <0.5cm-1 (figure 2.2-2). Instrument stability is very high, namely 0.3K at an absolute accuracy of 0.5K.

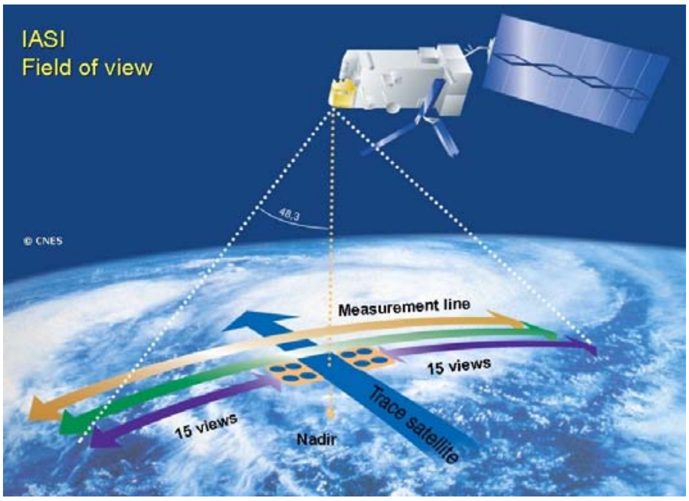

Figure 2.2-2: Schematic view of the IASI measurement principle and FOV alignment. © CNES.

Table 2.2-1: IASI spectral bands and covering spectral ranges

Band	Range (cm-¹)	Range (µm)
1	645 to 1210	15.5 to 8.26
2	1210 to 2000	8.26 to 5
3	2000 to 2760	5 to 3.62

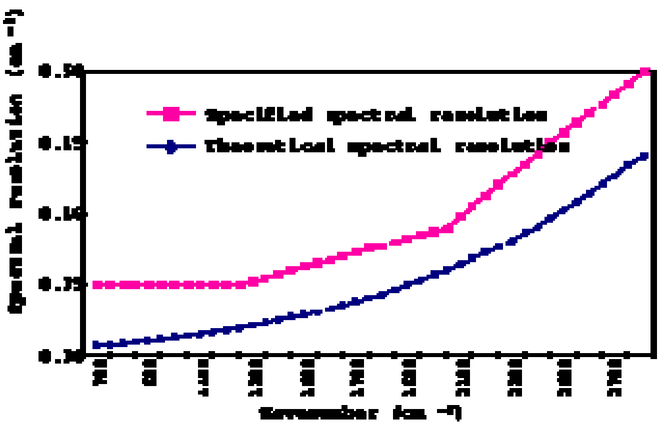

Figure 2.2-3: IASI specified and theoretical spectral resolution (from http://smsc.cnes.fr/IASI/spectral_res.htm) © CNES

3 SCOPE OF THE PROBLEM

Windblown mineral dust from arid areas is the most prominent type of aerosols in the troposphere, present mainly in the Tropics, at altitudes up to about 6km. Dust particles absorb, scatter and emit radiation. They are therefore responsible for radiative forcing, both directly and indirectly through their impact on clouds. Mineral dust is therefore an important actor in the climate system.

The presence of dust particles in the air also impacts its quality: due to their size (and in some cases the bacteria they transport), the transported dust particles may be harmful to the respiratory system.

Mineral dust shows strong and typical spectral features in the Thermal Infrared (TIR) atmospheric window (800-1200cm^{-1}), allowing the retrieval of dust atmospheric load and properties (particle size, mineral composition,...). At those wavelengths, the radiative sources are thermal emissions from the Earth's surface and its atmosphere (solar radiations are negligible). Therefore, the surface properties (conditioning its emissivity) and temperature, and the atmospheric temperatures are crucial parameters. The MAPIR algorithm also relies on the impact of dust aerosols on water vapour absorption to obtain dust vertical information. Therefore, the atmospheric water vapour content is also a crucial parameter. Ozone absorbs strongly in the atmospheric window (around 9.6µm), but the windows selected for the dust retrievals are outside this absorption band.

In addition to these foreseen difficulties linked to the necessary ancillary parameters, dust itself varies a lot in abundance (and altitude), particle size distribution, composition (therefore refractive index). All these condition the dust radiative effects.

In the best (imaginary) retrieval scheme, all these important parameters would be retrieved from each IASI measurement. In practice, this is not feasible and assumptions must be made. For the MAPIR algorithm, only the desert dust vertical concentration (6 points vertical profile) and surface temperature are currently retrieved. Future plans include the search for aerosol particle size and/or refractive index retrievals, but require a lot more work.

4 SCIENTIFIC BACKGROUND

MAPIR is based on the algorithm described in [RD1] (which we now refer to as version 0), with numerous adaptations and improvements since the time of the publication. Some parts of the text may be similar to the algorithm description in that publication. This ATBD describes the current algorithm.

4.1 Mineral dust

Mineral dust has a typical signature in the thermal infrared (TIR) atmospheric window: a V-shape peaking at around 1050cm^{-1} (9.5µm). This particular spectral shape of dust absorption is due to its mineralogical composition (quartz, clays), and of course linked to the microphysical description of the particles. In cases where the dust is in an atmospheric layer significantly hotter than the surface, the dust thermal emissions might exceed the extinction (absorption and scattering), therefore resulting in an inversed V-shape signature. This occurs regularly over deserts during nights.

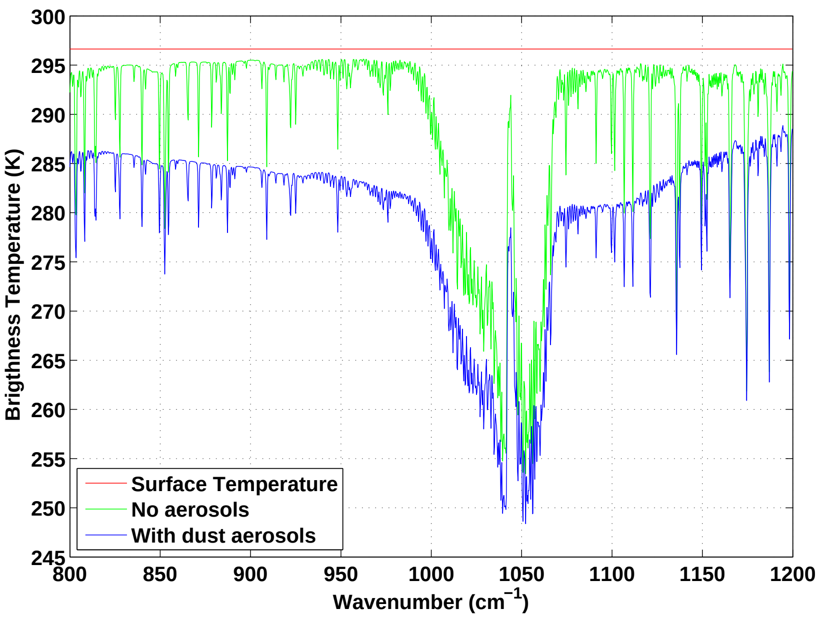

Figure 4.1-1: Example of modelled atmospheric window spectra in absence and presence of aerosols (1km-thick layer between 4 and 5km at a concentration of 250 particle/cm3)

Refractive indices of a number of substances, including desert dust aerosols, are available in databases like the Optical Properties of Aerosols and Clouds [RD2], Gestion et Etudes des Informations Spectroscopiques Atmosphériques [RD3], the High-resolution Transmission database [RD4-5] or the more recent Aerosols Refractive Index Archive (ARIA, http://www.atm.ox.ac.uk/project/RI/index.html). Refractive indices for desert dust found in those databases are mutually significantly different, which is most probably due to measurement uncertainties and sample composition variation. For MAPIR, we have selected the GEISA-HITRAN dust-like data set, gathered by Massie [RD4]; Massie and Goldman [RD5] from measurements by Volz [RD6-7] and Shettle and Fenn [RD8] on transported Saharan dust.

The particle size distribution (PSD) for advected dust is usually represented by lognormal distributions. There are typically two modes in dust PSDs, with median radius of about 0.4 µm and about 2 µm, and a geometric standard deviation of about 1.6 and 1.7, respectively [RD9]. These modes roughly match the mineral transported and coarse modes of OPAC dust particle number size distributions [RD2]: median radius of 0.5 and 1.9 µm, respectively, geometric standard deviation of about 2.2 for both. The relative importance of these two modes may vary from one dust event to another, and with the distance from the source. For example, measurements at Cape Verde during the second phase of the SAMUM campain [RD9] show that the ratio between the number of particles in the two dust modes is about 15 to 20, with more particles in the smallest mode. However, it is unclear if the observed coarse mode particles are transported from the Sahara or locally produced.

We have investigated the sensitivity of TIR radiances to the transported and coarse dust modes and to small radius changes (details in [RD1]). It revealed a different sensitivity to particle size between 800 and 950 cm^{-1}, and above 1000 cm^{-1}. The single scattering albedo in this wavelength interval is about 0.6, mainly increasing for increasing particle sizes. Above 1125 cm^{-1} the scattering efficiency diminishes drastically. Spectrally, the particle size mainly affects the slopes of the V-shape (maximum difference is found in the right part of the V-shape, around 1100cm^{-1}), this effect being more important for aerosols at a higher altitude. Our studies suggest that the sensitivity to aerosol PSD, even between completely different modes, is about one degree of magnitude lower than the sensitivity to the AOD. They also suggest that it would be possible to retrieve the particle size in a second step, once the vertical profile of dust concentration is known.

In the current version of the algorithm, a fixed PSD is used, corresponding to transported particles (therefore probably too small close to the dust sources): mean radius of 0.6µm, geometric standard deviation of 2 (corresponding to an effective size of 2µm).

4.2 Altitude information

The vertical profile of dust aerosols in the atmosphere, even though not being the target of the aerosol_cci, is inherently part of the MAPIR retrieval. The altitude information comes from two different and complementary effects. The first effect is a broadband extinction effect, due to aerosol absorption and scattering, but partly compensated by aerosol thermal emission. This effect therefore depends on altitude because it depends on the aerosol emission temperature. The second effect of the dust aerosol altitude is an impact on the low tropospheric gases absorption lines (in the selected windows, water vapour only is concerned). The lower the aerosols in the atmosphere, the lower the gas absorption, explained by the high extinction due to the presence of aerosols, reducing the amount of light available for gas absorption above the aerosol layer.

Mathematically, altitude sensitivity is described by derivatives of the top of atmosphere radiance with respect to the aerosol concentration at each altitude of the retrieval grid (0 to 6km, with steps of 1km), further referred to as “Jacobians”.

4.3 Radiative transfer and retrieval algorithms

All computations are done using the ASIMUT software package [RD10] combined with the advanced radiative transfer code LIDORT [RD11] and the SPHER Mie code [RD12]. In this combination, SPHER is used to compute aerosol single scattering albedo, extinction cross section and expansion coefficients for Mie scattering using refractive index and PSD data; LIDORT is used for radiative transfer (including multiple scattering) and Jacobians computations; ASIMUT handles input/output, computes gas absorption parameters (line-by-line or using cross sections, and continua) and performs the retrieval part, following the Rodgers optimal estimation (OE) formalism [RD13].

5 IMPLEMENTATION

5.1 External / ancillary data necessary

5.1.1 Aerosol description (optical parameterization and a priori)

As described in the previous section, in the current version of the algorithm the particle size distribution and the refractive index have been fixed: the GEISA-HITRAN dust-like refractive index and mean radius of 0.6µm, geometric standard deviation of 2 (corresponding to an effective size of 2µm).

A priori information is required by the OE at all retrieval levels (1 to 6km altitude, steps of 1km; the aerosol concentration is hard set to 0 above 7 km). MAPIR uses a climatology derived from CALIOP measurements (LIVAS [RD14]). From this climatology, we use the monthly mean vertical profile of dust extinction at 532nm, and the standard deviation from the monthly mean total dust optical depth (standard deviation is not available on the profile products), all on a 1°x1° horizontal grid. Version 3.5 of MAPIR uses the latest LIVAS climatology, v0.3.1.7 The following steps are undertaken in order to use the data in our retrievals:

- The LIVAS high-resolution vertical profiles are linearly interpolated on the MAPIR retrieval grid (1:1:6km).

- As CALIOP measurements are very sparse, it occurs that no data is available in the climatology for a specific grid cell and the continuity between adjacent cells is not guaranteed (the data might well come from different CALIOP days). Therefore, in version 3.2 onwards, we have decided to use, as a priori for the MAPIR retrievals, a running mean of LIVAS along 5°*5° computed from the 1°*1° climatology.

- The LIVAS climatology was available to us until year 2014 included. For dust retrievals after that, we use an average of the monthly data for years 2007-2014.

- Extinction at 550nm is converted to concentration using an extinction cross-section computed with a Mie code and the median radius from the PSD and the refractive index described here above; this conversion factor is 500 if the concentration is expressed in particles/cm^3. If the whole PSD is used (instead of the median radius), the conversion factor is 140. However, dust concentration is highly variable and the LIVAS climatology is based on CALIOP measurements with a very sparse geographical coverage (therefore a limited number of measurements within each grid cell). The retrievals seem to work better when starting with an a priori value being too high than too low, most probably because the 100% variance covers a concentration divided by a factor 3, but not multiplied by a factor 3. Therefore, we decided to keep using the conversion factor 500.

- If data is missing (after the running mean process) or extinctions are equal to 0, those are replaced by the mean of extinction along the whole retrieval geographic area (0-40°N, 80°W to 120°E)The standard deviation is always set to 100

- Retrieval points below the surface elevation are set to a null concentration

The retrieval grid has been set from 1 to 6km altitude. Dust concentration is set to 0 from 7km upwards. Indeed, in [RD14] it is shown that above Sahara or Europe there is very few dust occurrences above 6km and almost none above 7km. The layer at 0km altitude previously included in the retrievals (only above oceans) has been removed because of the extremely low sensitivity of the TIR radiance to that layer.

5.1.2 Surface description

As the MAPIR retrieval is based on thermal infrared radiances, the surface thermal emission is the most important term that conditions the modelled spectrum. Surface emission is conditioned by the surface emissivity and temperature.

When the emitting surface is the ocean, the surface properties are well characterised. Surface emissivity is close to 1, with a slight spectral variation. Here we use the published sea surface emissivity of Newman et al [RD15].

For land surfaces, the emissivity varies spectrally and slowly as a function of time, depending on the surface composition, humidity, vegetation, … We decided to use the emissivity database from D. Zhou [RD16], obtained from IASI measurements. Those emissivities are sometimes “contaminated” by the presence of dust (emissivity is lower than reality because dust is always present in the measurements used to retrieve surface emissivity), especially above deserts, which could lead to underestimation of the AOD, or rejection of the scene in the pre-filtering detailed here under. In the future, we will also look at the land surface emissivity database from Capelle et al [RD17].

The sea surface temperature varies with a small amplitude along the day and seasons and different sources can be considered reliable, as ECMWF data (skin temperature), or the IASI level 2 operational retrievals (from version 5 and newer – version 4 gave many “unexpected values”). Land surface temperatures may vary a lot with seasons and during the day, especially for deserts. To our knowledge no database provides good estimates of the daytime desert surface temperature, resulting in a lot of problems for our retrievals which are extremely sensitive to that parameter. Since version 2.0, MAPIR includes a surface temperature retrieval. MAPIR version 2.0 used the retrieval window from 830 to 834cm^{-1}. It appeared after further research that this window resulted in significant differences in retrieved AODs for day and night-time, linked to issues in the surface temperature retrievals. In version 3.0 this retrieval window has been replaced by another window, less sensitive to dust aerosols (but non insensitive to them): 1202-1204 cm^{-1}. The surface temperature is retrieved simultaneously with the dust aerosols. The a priori surface temperature comes from IASI operational level 2 data if its version is at least v5.0. For previous versions of that data set (before 14 September 2010), the surface temperatures are too unrealistic and we use the ECMWF ERA interim reanalyses skin temperature.

5.1.3 Atmosphere description

The vertical profiles of atmospheric temperature and water vapour are the two really important parameters of the atmospheric state, conditioning our retrievals. Those are taken from IASI level 2 operational products from the EUMETSAT (procession version number depends on the date of the data set, quality described in [RD19]).

Other relevant (for which the accuracy is less important) atmospheric gas profiles (CO_2, O_3, N_2O, CH_4 and HNO_3) are taken from the US Airforce Geophysics Laboratory tropical climatology [RD20].

5.2 Pre-filtering

Here under is a list of all operations undertaken prior to launching the dust retrievals on a IASI scene. Currently, not enough data is available for statistics on the rejection causes, but this will be added as soon as possible.

5.2.1 Radiance

The used spectral windows are tested for the presence of negative radiance values (which are not even within noise in that spectral band). Spectra with at least one negative radiance value are rejected (pre_quality_flag set to bad).

5.2.2 Cloud flag (meteorological)

Only scenes with a maximum of 10% (not including that value) cloud fraction from the level 2 cloud product are retained for the retrieval. In version 5 of the IASI level 2 cloud algorithm (which data is used here), this means only cloud-free pixel as no value between 0 and 10% cloud fraction exists in the data. After examining a first one-year dataset, it would seem that intense dust clouds are sometimes flagged as clouds in that product, leading to missing data in our dataset.. However, the design of a dedicated cloud flag within MAPIR would require non-negligible additional developments and is currently not implemented.In case the level 2 cloud fraction data was missing, the cloud_flag is set to the missing value, and the pre_quality_flag is set to bad (no retrieval), again possibly leading to missing data in our dataset.

5.2.3 Dust flag

The dust flag is set after the retrieval, simply based on an AOD threshold of 0.1

5.3 Retrieval set-up

The retrieval is undertaken following the OE formalism, as stated before. The Jacobians are computed only during the first and last steps of the retrieval. The forward modelling is computed with a 0.25 cm^{-1} spectral step and with a Gaussian instrument line shape (0.5 cm^{-1} full width at half maximum), as to properly reproduce the sampling and resolution of level 1c IASI data. No refraction is included (not relevant for IASI viewing geometry), no solar sources are considered (not relevant in the selected spectral windows). The noise level is set to 4 10^{-7} $W/cm^2/Sr/cm^{-1}$, which is about seven times higher than the instrument's spectral noise in that window. This value was empirically selected (the lowest allowing retrievals to converge in most cases for a selection of dusty scenes with good ancillary data) and is necessarily higher than the instrument noise to account for the part of "noise" due to model uncertainties (which are currently neither quantified nor taken into account otherwise).

The desert dust retrievals are undertaken using two spectral windows, on both sides of the V-shape: 905-927cm^{-1} and 1098-1123cm^{-1}. Altitude sensitivity is present in both windows, and water vapour absorption lines sensitivity to aerosols is higher in the second one. The sensitivity to PSD is almost non-existent in the first window, and high in the second window, allowing one to detect in the retrieval residues a mismatch between the real PSD and the one used to model dust in the retrievals. There is currently no automatic action taken in such mismatch cases. A third retrieval window from 1202 to 1204cm^{-1} has been added for the retrieval of surface temperature (together with the dust vertical profiles).

Molecules included in the atmosphere are H_2O, CO_2, O_3, N_2O, CH_4 and HNO_3. Line parameters come from the HITRAN 2012 database. Continua are computed using the MT_CKD 2.5 formalism.

Lidort computations are set-up with 4 quadrature streams in the cosine half-space, using the delta-m approximation for the aerosol phase function (suited in case that phase function is highly non-symmetrical), and under the assumption of lambertian surface (the surface albedo is computed as 1-emissivity).

The retrieval output is a vertical profile of dust concentration every 1km from 1 to 6km altitude (and the corresponding averaging kernels, providing also the number of degrees of freedom, generally around 2) and the surface temperature. When the surface altitude is higher than one (or more) retrieval altitude(s), the dust concentration at that (those) altitude(s) is set to 0 prior to retrieval (and can not deviate from this value during the retrieval). The final optical depth is obtained by integration of the dust profile to a total column, and conversion using the extinction cross-section at the desired wavelength. This approach is valid in the spectral range of the retrieval. Conversion to visible optical depth is done using an estimated (Mie) extinction cross-section of the dust aerosols at the required wavelength. The conversion factor for the selected PSD and refractive index is 1.78. It is important to note here that this conversion factor is extremely dependent on the choice of PSD and refractive index (a lot more than the 10µm AOD itself), being probably the most important error source in the 550nm dataset.

The uncertainties on the retrieved values are also obtained from the Rodgers formalism [RD13], for each point of the vertical profile. The current way to convert them to an OD uncertainty is to integrate/convert them as for the vertical profile itself. At this point those uncertainties have not yet been looked at, and it is very difficult to know if they are representative.

The mean altitude is the one separating the total column in two equal parts. It is computed directly from the vertical profile of concentration and is therefore a real mean altitude, not a radiatively equivalent altitude as usually the case with thermal infrared retrievals. Those altitudes are expected to be different, depending on the vertical distribution.

5.4 Post-filtering and quality flags

5.4.1 No convergence

In some cases, the retrieval simply does not converge after 25 iterations. The result is then discarded (value set to the fill value, post_quality_flag bad).

5.4.2 Root Mean Square of the Spectral Residuals (RMSSR)

The quality flag (post_quality_flag) for all converging retrievals is based on the RMSSR. This represents how close the modelled spectrum after the dust retrieval is to the observed one (on average). If that value is below twice the IASI spectral noise in that window (about 0.5K), the result may be considered extremely good. The cut-off values used for the post_quality_flag are 2K above land, and

1K above sea. A higher RMSSR is accepted for land cases because of the higher uncertainties about the surface emissivity and possible additional problems in the temperature and water vapour profiles (operational IASI product) over deserts. Retrieved data will be provided even when the post_quality_flag is set to bad. The RMSSR might also be higher close to source areas because of a difference in the “real” PSD and the one used in the retrievals.

6 IMPORTANT INFORMATION TO USERS

Here under is a list of the currently known issues affecting the quality of the retrieval results (in order of estimated importance), and how we think it affects the results. Users should also remain conscious that MAPIR is a relatively young algorithm, with a lot of potential for improvements.

- Land (especially desert) surface emissivity: this dataset is retrieved from IASI measurements, inherently using the same windows we then use for our retrieval. In case of places where dust is almost always present as aerosol, those surface emissivities will probably be biased low, which would lead to an underestimation in our dust aerosol retrievals close to the sources, and could lead to less scenes detected as "dusty".

- Mineral dust model: the PSD and refractive index are fixed, while the real ones vary with the dust source, the transport distance, … This should not affect the final 10µm AOD too much, because changes in those parameters affect the aerosol extinction/emission, that change being partly compensated by a change in the retrieved aerosol concentration. However, those aerosol parameters also impact the slopes of the V-shape as described earlier, therefore affecting the RMSSR. As those are currently used as quality indicator, the quality may be considered "bad" in case the AOD is very reasonable but the dust optical properties were not realistic. Also, the conversion to 550nm is greatly affected by the dust model.

- Volcanic ash presents a TIR signature close to that of desert dust, and our dust filter currently is not able to discriminate between both aerosol types. Therefore in the presence of ash, we will compute a dust AOD with possible altitude problems given that ash may be a lot higher than 6km.

An additional point of attention to users is the fact that, as this algorithm retrieves a vertical profile, it is able to retrieve two separate dust layers, and therefore to "see" dust close to the surface together with transported dust higher in the troposphere. In those cases, other TIR-based algorithms would probably place the dust layer somewhere in the middle of the two real layers. In those cases, our algorithm will most probably deliver a very different dust AOD than the one-layer retrievals. Indeed, in those retrievals the altitude of this layer is critical to the computation (it conditions the dust thermal emission), and in a two-layer dust case the one-layer model is obviously wrong. Furthermore, dust close to the surface usually has a low radiative effect (because its thermal emission is high, almost compensating for the absorption and scattering), but counts the same as dust at any altitude in the total AOD. We therefore think that our retrievals might deliver higher AODs than the other IASI-based dust retrievals. This does not especially mean that there is a bias.

7 CONCLUDING REMARKS

The MAPIR retrieval algorithm provides vertical profiles of desert dust concentration, using the optimal estimation formalism and an advanced radiative transfer model (LIDORT) accounting for multiple scattering. For the aerosol_cci requirements, these profiles are integrated in a total column and converted to aerosol optical depth.

This document contains the description of the algorithm, inputs, outputs in its current state, and will be updated before each processing undertaken within the aerosol_cci project. This document (and its version) have to be mentioned when referring to any dataset produced under the aerosol_cci project.

This ATBD also contains a small description of the currently known issues / causes of problems in the retrieval results, and important information to users.

End of the document