

***Interactive comment on “The MIPAS2D database
of MIPAS/ENVISAT measurements retrieved with a
multi-target 2-dimensional tomographic approach”
by B. M. Dinelli et al.***

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article color

First of all we would like to thank the reviewer for his useful comments and careful check of the paper’s text. To ease the reading of our answers we have reported the reviewer comment in red and our answers in black.

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1 Reviewer 1 General comments:

1) As a whole, this paper serves as "an introduction" to the dataset but contains neither an algorithm description (already published in Carlotti et al) nor any significant validation, except for some qualitative plots of the data and a comparison between the NOM and GRD horizontal grids. Possibly the authors plan a later validation paper, but if I were a potential user of this dataset I would at least like to see comparison with with the established and validated ESA L2 products from 2002-2004, and preferably some demonstration of the superiority of this dataset (apart from the additional molecules and extended time range, in any case the ESA processor is expected eventually to be applied to the data since 2005).

Indeed we plan validation papers for the retrieval targets reported in the database. The present manuscript is needed for presenting the data to the community and start the collaborations for the required validation. For the full resolution part of the mission a first validation has been carried out and reported in Ceccherini et al. 'Geophysical Validation Tests' technical note IFAC-GA-2004-18-SC of the study Development of Algorithms for the Exploitation of MIPAS Special Modes Measurements'ESA-ESRIN Contract No: 16700/02/I-LG. The reference has been added and discussed in section 3 of the revised text. We do not focus our paper on the superiority of our database but rather introduce the results obtained avoiding the assumption of horizontal homogeneity of the atmosphere: the importance of modelling the horizontal variability of the atmosphere is recognized within the limb-observations community (see e.g. von Clarmann et al 2009) and, to date, no other MIPAS database has this feature and a full comparison to other datasets will be required to study the advantages and shortages of the adopted method. In our understanding publication of this kind of results is needed and falls within the AMT aims. Similar works on MIPAS products have been published on AMT without detailing the possible advantages or shortages of the data (Ref. Clarmann et al., AMT 2009).

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2) There should be some acknowledgement of the 2D retrieval which has been employed by the Aura/MLS team since launch, which predates this work. While this is a microwave instrument rather than infrared, the principles are essentially similar.

In the revised version of the paper we have added references to MLS instrument and the 2-D level 2 code in the introduction.

2 Minor comments/queries

P2641, L22-24: Limb-scanning infrared instruments since the 1980s (on Nimbus 7 & UARS) have always had a sampling of around 500km, although often sideways viewing rather than along-track direction. There have been "recent improvements" in this 500km horizontal sampling, notably by MLS and HIRDLS on the Aura satellite, but not really by MIPAS or SCIAMACHY.

OK. We have removed "recent improvements" from the revised version of the paper. However MIPAS new observation modes sample the atmosphere at steps smaller than 500 km .

P2642, L5-8: see general comment (2) regarding MLS.

OK. A reference to MLS has been added in the introduction.

P2646, L21: This is not the case, ESA have provided a limited set of L2 data from the OR mode for validation purposes.

Only 140 orbits of MIPAS OR measurements were processed so far by ESA up to Level 2. This is a very small fraction of the whole set of OR data acquired by MIPAS. Furthermore, this small set of orbits was processed for validation purposes with the prototype code, not with the official ESA IPF ground processor. The revised version of the paper will be modified to acknowledge the existence of this small dataset.

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P2643, L8: "to fade out"? I doubt if the measurements will fade out, it is more likely that the instrument will just be switched off. But you should also say what determines this end date, ie the de-orbiting of the Envisat satellite.

MIPAS mission has been approved up to the end of 2013 and the instrument will measure continuously up to then. Afterwards, since the satellite fuel will be exhausted, the ENVISAT orbit will drift, and since MIPAS cannot measure when the Sun is in the LOS, the rest of the mission will be on-off from that time on-ward. This is the meaning of fade-out. Of course if the instrument will no longer work it will be suddenly switched off, but this is not the forecasted ending of MIPAS mission. However we have changed the words fade out into gradually stop after the end of 2013.

P2643, L26: MIPAS IFOV is a trapezium, so *approx* 3km in height.

OK. Added the word approximately

P2644, L8: the last FR observations were acquired in March 2004, not April 2004.

Therefore the measurements were suspended in April, in March the instrument was still measuring. In the revised version of the paper we will mention the exact date of the MIPAS switch off.

P2644, L21: full-time operations started in Dec 2007, not Jan 2008 (also P2665, L4).

It was started at the end of December 2007 so we did not regard December 2007 as operating full-time. We have introduced the exact date in the paper.

P2644, L25: duty cycle includes 1 day "Middle Atmosphere" mode and 1 day "Upper Atmosphere" mode, not 2 days UA mode as stated.

The measuring modes for the two days has been changed recently. The sentence was only indicative since the database reported in the paper was for the GMTR analysis on the nominal observation mode only. We have changed the sentence in the revised version of the paper.

P2645, L19: "As expected from radiometric considerations". If it was expected, you should be able to quantify the expected change in magnitude that accompanied the change in resolution rather than just say it was reduced.

After the analysis we have found some discontinuities in the final chi-test of the retrievals between the OR and FR mission and also within the OR mission. These discontinuities are correlated with the noise behaviour. That's why we are showing this figure. The sentence refers to the fact that the reduction in noise can be explained and it was expected when MIPAS observations were resumed. What was not expected was the exponential increase of the noise. The quantification of the reduction will not add anything to the results discussed in the paper, but we have quantified the reduction in the revised text.

P2647, L20-25: I don't see why item 3 is a "shortcoming" (or "shortage") of the retrieval method. For some applications this may be a good thing since it maximises the horizontal and vertical resolution of the retrieval.

We say 'that CAN lead to shortages' not that they definitely cause problems. However we have removed the sentence that can lead to shortages in the retrieved data: The use of the measurement grid DOES NOT maximize the horizontal and vertical resolution of the retrievals because it can mask out correlations between the retrieved values (For instance if you use a measuring grid closer than the FOV width)

P2650, L1: It's not so much the variations in refractive index of the atmosphere that lead to the variation in vertical grid, it's more variations in satellite pitch and the local earth radius of curvature around the orbit.

The refractive index of the atmosphere plays a role in the variation of the vertical grid, because MIPAS pointing is commanded in such a way to correct (not succeeding completely) for the other effects. We have clarified the issue in the new version of the manuscript.

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P2650, L22: "where the maximum information is expected". Doesn't this depend on the parameter retrieved? Eg HNO₃ is likely to be at a different altitude to N₂O. Presumably you don't have different locations for different molecules. What convention do ESA adopt for geolocating their retrieved profiles: eg lat/lon at some particular nominal altitude? Is there any good reason for not using the same?

For the horizontal domain, the maximum information is expected close to the tangent points (see T. von Clarmann, C. De Clercq, M. Ridolfi, M. H^opfner, J.-C. Lambert, The horizontal resolution of MIPAS. Atmos. Meas. Tech. 2, 47-54 (2009).), regardless of the target. ESA assumes horizontal homogeneity of the atmosphere; target quantities are retrieved at tangent pressures and the average position of tangent points is used to geolocate the retrieved profiles., As discussed in Sect. 3.1 we cannot use the same approach, however we have removed "maximum information" from the revised text.

P2650, L27: the clustering around particular latitudes is not coincidental: it arises because, during MIPAS FR observations, the scan patterns within each orbit were synchronised to start at a particular latitude crossing. This is probably worth mentioning.

OK. Added a sentence in Sect. 3.1

P2651, L3: "as used by models". The authors overstate the importance of a fixed latitude grid. Many models use data assimilation which incorporates measurements at their (arbitrary) locations - indeed this is their preference rather than using interpolated data (which introduces undesirable correlations between different profiles - this is actually be a drawback of the 2D tomographic approach compared to a 1D scheme). Other models may have particular latitude grids which are not regular and even models with regularly spaced latitude grids are unlikely to use the same latitude grid as the MIPAS2D database, so will require an additional re-interpolation of the data anyway.

The outputs of models, even if they assimilate the data at their geolocations, report the final results on constant lat/long grids. The 1-D retrievals suffer by horizontal correlations. They usually do not account properly for these correlations unless the 2D av-

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eraging kernels are calculated for the 1D retrieval (T. von Clarmann, C. De Clercq, M. Ridolfi, M. Hoepfner, J.-C. Lambert, The horizontal resolution of MIPAS. Atmos. Meas. Tech. 2, 47-54 (2009)) The tomographic approach properly accounts for correlations through the full 2D VCM and averaging kernel matrices.

P2651, L15: "...would require the use of a regularization scheme". If you're using OE you already have a regularization scheme, even with FR mode retrievals, so this is not really an argument against changing the grid.

We agree that this sentence may be misleading. What we meant is that the OR measurements strongly oversample the atmosphere both in vertical and horizontal. Therefore a retrieval grid (like the NOM one) that emulates the sampling grid would make the inversion severely ill-conditioned. To recover this ill-conditioning, constraints stronger than those applied (with OE) in the FR retrievals would be necessary, hence making the results of the analysis not easily comparable with those of the FR. In the revised manuscript we will reword the sentence accordingly.

P2652, L6-7: It is probably worth mentioning that this sequence is the same as used by ESA's operational processor for these molecules.

OK. Added in Sect. 4.1

P2652, L12: Do you really mean "absorption coefficients" of continuum? An absorption coefficient is usually multiplied by an absorber density but it is not clear what the "absorber" is for continuum. For this reason, continuum absorption is usually represented just as an extinction coefficient.

Yes. We multiply the retrieved absorption coefficients by the total column density (including all gases).

P2652, L12: The standard ESA retrieval also retrieves a radiometric offset for each microwindow. Is that not retrieved here, or was that just omitted from the text?

No. We do not retrieve radiometric offset since it was found to be negligible in the

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operational retrievals.

P2652, L25: Note that N2O5 also has a significant diurnal variation, but you do not seem to explicitly account for this.

Actually, since for this species we did not have data from 1-D analysis of MIPAS spectra, we decided to use a large constant part and a large % part as well. For future releases we will consider the use of different a-priori information for daytime and nighttime observations also for other diurnally varying species.

P2653, L7: "The sensitivity ..." I do not understand what this sentence means. Do you mean sensitivity of the CI threshold (which doesn't seem to be mentioned in 4.3) or other parameters? And isn't it the sensitivity of the retrieval to these parameters that is discussed in section 4.3, and not vice-versa?

To other parameters. The sentence has been rewritten in the revised text.

P2653, L6: Do you include or exclude the UTLS1 mode, which was extensively used 2005/2006, in your MIPAS2D retrievals?

The results shown in the paper are only for the nominal mode. We are currently extending the analysis also to the UTLS-1 mode.

P2654, L15-24: Why don't you use the previously retrieved orbit, or the previous day's retrieval from GMTR as your initial guess? It would presumably be better than climatology.

The analysis is performed automatically processing the orbits on different CPUs so that we don't know the sequence in which the orbits are processed. This is the reason why we do not use the suggested strategy for the initial guess. However the climatology is used in a very limited number of orbits, where the other strategy leads to unstable results.

P2656, L12-19: Although it is stated that these are reported in the files, it would be

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useful to give some indication in this paper of the leading systematic errors are for the GMTR retrieval. For example, for the ESA retrievals the impact of unmodelled horizontal gradients is often the major systematic error but presumably that disappears in a 2D retrieval. Also there is no mention of the size of the random error for comparison.

OK. We have introduced a new table reporting the total systematic errors for all targets. The size of the random errors is reported in every file and it is not constant along the whole database.

P2657, L3: I assume that the subscript j means a particular profile point in the horizontal/vertical domain of the retrieval, and not a profile of points. This could be made a bit more explicit than just saying "parameter j ".

Ok we have changed the text in the revised manuscript.

P2657, L14-26: It seems to me that a user is more likely to want to know the a priori error ($\sqrt{S_{aj}}$) assumed for each point rather than the information gain. I assume that the retrieval random error ($\sqrt{S_{rj}}$) is also given in the database so, if the information gain is required, it could be easily constructed from these two numbers from the formula provided. Also, US satellite instruments (UARS and Aura) seem to have adopted the convention of attaching a negative flag to the retrieval random error to indicate where the a priori contribution is large - this conveys the same information as attaching a negative number to your information gain and avoids trying to establish a new convention here.

The database was produced with 20 months of CPU time and a new format of the output files for this release would require a whole reprocessing (the stored information gain are rounded to two significant digits). In order to ease the users we shall consider the reviewer suggestions for the next release of the database.

P2658, L23: "Since GMTR does not retrieve pointing information". Presumably it *does* retrieve pointing information in the sense of retrieving the tangent point pressure

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for each sweep and some hydrostatic constraint to provide, implicitly, relative altitudes between sweeps. The only thing that should be missing is the absolute altitude which cannot be determined independently from infrared limb sounders. So is this just saying that there is an uncertainty in the absolute altitudes assigned to the vertical grid at each horizontal location? Since the vertical grid is essentially arbitrary anyway (especially for the OR measurements) why not just use pressure as the vertical coordinate? For Fig.10 the data are in fact plotted on the 31.5hPa surface rather than 24km which is presumably the vertical coordinate in the database (also Figs 13-15).

Unlike the ESA Level 2 retrieval code, GMTR does not retrieve pressure at tangent points. See reference Carlotti 2006. GMTR does not assume hydrostatic equilibrium. GMTR retrieves pressure at the altitudes of the retrieval grid. It is impossible for the GMTR retrieval system to use pressure as vertical coordinate because we need to perform a geometrical ray-tracing that can only be made if altitudes and latitudes are used to describe the retrieval grid and the atmospheric discretization.

P2659, L5-8: "The 2-D approach reduces the impact of the pointing error". If the pointing error is predominantly an altitude offset, which varies slowly along an orbit, then the 2-D approach doesn't help. Or are you referring to pointing errors from one scan to the next? In this case the GMTR approach only helps in the sense that it may retrieve pressure more accurately than the 1-D retrieval but I don't see how it can ever improve the absolute altitude assigned to sweeps.

The pointing error (that is the difference between true tangent altitude and nominal the tangent altitude reported in the level 1b files) is a random value associated to each observation geometry. In a geo-fit the value of the target quantity at a given altitude is determined from all the observations that depend on that value irrespective of the limb-scan they belong to. The combination of the pointing random errors of these observations results in a compensation effect (that has been verified in simulated retrievals) that is a characteristics of the geo-fit approach. (See Carlotti 2001).

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P2659, L25 (& elsewhere): What is the "weighted ESD"?

Here we meant the 'statistical error of the weighted average' This error is equal to $1/\text{SQRT}(\text{SUM}_i(1/\sigma_i^2))$ where σ_i is the statistical error on the i -th element of the average. In the revised text we will reword this sentence and the term 'weighted ESD' will be avoided.

P2660, L16: What does "poor" Level 1b data mean? (and again on P2661, L6)

There are L1b data of poor quality because of a failure in the L1 processor. Usually the L1b processor flags out the poor L0 data, but misses if the Fourier Transform did not work correctly.

P2660, L24: Add some reference to "normalized L2 noise weighted norm..."

OK added reference to Ridolfi et al. ACP, 7, 4459 (2007)

P2661, L16-18: The chi2 statistic is not a reliable indicator of the magnitude of systematic error contributions to the retrieval. It tells you that the residuals are of similar size but tells you little about the contribution of systematic errors to the retrieval. Those systematic errors which seriously affect the retrievals (eg temperature errors) don't appear in the residuals because the retrieval has adapted to remove their signatures.

There are systematic errors that can never be compensated by the retrieval, i.e. a wrong position of an interfering line or a wrong concentration of an interfering molecule. These are the systematic errors we are talking about. We have added a sentence clarifying the issue in the revised text. .

P2662, L13: "about 1 hour". Presumably "about 100 minutes" is more accurate?

OK we have changed it in the revised text

P2663, L12: If the data is on altitude surfaces (ie 24km) why

No, the data are as reported in the paper on a pressure surface.

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P2663, L3: Weighting by noise error is dangerous when constructing geographical averages. Data acquired in low temperature regions tends to have a larger noise (due to the lower radiance signal) and is therefore reduced in weight when contributing to the average.

It is true that low temperatures translate in large random errors of the retrieved quantities due to the reduced radiances and then to the reduced S/N. In the averaging process a correct way to account for this effect is to weight the averaged elements using their random errors. In doing this we neglect systematic components but the goal of this section is only to provide examples. We investigated the impact of adopting weighted averages as opposed to simple averages. We studied the dependence of the weights on temperature and compared the averages obtained in the two ways. The analysis showed that indeed the weights assigned to data coming from warmer regions can be much larger than those from cold regions (even by a factor 10). However, the final 5-day or 1-month averages within IG2 latitude bands have mostly negligible differences apart from differences up a few percent sharply localised in a few regions e.g. of low ozone (above 1 hPa at northern latitudes – having a high relative uncertainty of comparable magnitude) or bins with high standard deviation (e.g. northern mid-latitude stratosphere), where the average itself has little meaningfulness in describing the field. Even then, the magnitude of the difference in the averages does not appear to be large enough to avoid using weighted averages, then risking to include poor data with high ESD.

P2663, L10: Even when the duty cycle was low, MIPAS was generally operated for full orbits rather than fractions of orbits, so it is not clear how the reduced duty cycle creates an extensive data gap.

Because most of the low duty cycle orbits were not measured in the Nominal Observation mode, and we have analysed only the nominal mode so far.

P2663, L14/15: The Antarctic ozone depletion isn't correlated with the break up of the

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polar vortex: the second event is what terminates the first.

OK. We changed the sentence into " ending at the breaking up of the vortex"

P2664, L14-23: Perhaps add some comment on the behaviour of the minor species as depicted in Fig 16.

OK. Added discussion in the revised version of the paper

Table 1: Not clear whether it is the larger of these two criteria which are used or, for example, just a simple sum.

Simple sum, we have clarified it in the revised text

Table 2: Incomplete. What about the microwindows for the other retrieved species?

Added in Table 2

Figure 2: left axis: what is "MW noise"?

Is the noise level at 690 cm⁻¹. Label has been changed

Figure 5: Is this plot for a particular atmospheric profile, or some sort of global average?

The MWMAKE algorithm provides the systematic errors as a global value that should be applied to the retrieved values at a specific altitude (it is latitude independent).

Figure 8: Too small, and seemingly of poor quality reproduction.

Figure modified

Figs 13-16: In the captions, give actual latitude range rather than just, say, "antarctic region".

OK

Figure 16: Too small.

We will check whether it is possible to enlarge it

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3 Typographical/Grammatical

P2641, L11: change "contest" to "context"

ok

P2641, L14: change "permits to obtain..." to "permits us to obtain..." or "permits full geographic coverage to be obtained" or "permits the acquisition of full geographic coverage".

OK

P2641, L15: change "However, not only obtaining observations is" to "However, not only is obtaining"

ok

P2641, L16: change "ability of" to "ability to"

ok

P2641, L18: change "bury inside" to "contain"

ok

P2642, L20: suggest "combining" rather than "joining"

ok

P2642, L22: change "enables to properly account ..." to "enables the horizontal variability to be accounted for properly".

ok

P2643, L20: explain "LT"

In the original manuscript it was local time. It has been changed by the editor into LT (I

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assume is a standard notation)

P2644, L1: the average distance is "about 500km", not "500km in latitude".

OK

P2644, L1: suggest changing "5 latitude degrees" to "5 degrees latitude".

OK

P2644, L2: suggest changing "observations were acquired" to "observations are acquired" - these special mode observations are still ongoing. Alternatively, if you are just referring to the special observations during the FR measurements, I don't think any of these were used for volcanic eruptions or used the sideways-viewing capability.

In the FR mission some orbits were acquired using the across track capability. We have changed "were" with "were and are"

P2644, L7: suggest changing "interferometric" to "interferometer"

OK

P2644, L13: change "3 to 70km" to "6 to 70km".

This is not correct, in the OR modes some scans are acquired from 3 km upward.

P2645, L13/14: suggest "successive processing versions" (successive seems to require a plural noun).

OK

P2645, L20: change "(occurred ..." to "(which occurred ..."

OK

P2645, L27: change "this discontinuities" either to "these discontinuities" or "this discontinuity".

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OK

P2646, L5: change "These implies" to "This implies"

OK

P2646, L5: insert comma: "This implies that, ..." (to match comma after "grids")

OK

P2646, L6-14: Does this inconsistency lead to any significant differences in the retrievals if it is not properly accounted for? I.e. is it an essential correction which anyone using MIPAS L1B data v4.65/4.67 needs to know about?

Yes, since the result of this bug is an oscillation on the spectra of variable amplitude that can be mistaken with noise if small MWs are used.

P2647, L2: Change "Micro Windows" to "Microwindows" (one word).

The words are used like this to explain the used acronym

P2647, L10: Change "onto" to "on"

OK

P2647, L11: Change "shortages" to "shortcomings"

OK

P2648, L1: Suggest changing "not uncommon" to "certain" or "particular"

OK

P2648, L13: Change "shortages" to "shortcomings"

OK

P2648, L20: Suggest changing "recalled" to "summarised"

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ok

P2648, L25: Change "enables to model..." to "enables the horizontal atmospheric structure to be modelled".

ok

P2648, L27: Change "uncertainties on" to "uncertainties in"

ok

P2648, L1: Change "and on the amount of molecules" to "and in the concentrations of molecules"

ok

P2649, L5: Change "possibility to adopt" to "possibility of adopting"

OK

P2649, L5: Change "in case of lack" to "in the case of a lack"

ok

P2649, L11: Change "with LOS laying" to "with the LOS lying"

ok

P2649, L12: Change "enables to gather" to "enables the gathering of"

ok

P2649, L22: Change "measurements geolocation" to "measurements' geolocation" or "geolocation of the measurements".

OK

P2649, L24: Suggest changing "that can determine" to "that can also determine"

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OK

P2650, L3: Suggest changing "during each sweep" to "during each limb scan"

Sweep is referred to a single spectrum so we have changed sweep with limb view

P2650, L6: Suggest "complicated" rather than "challenging"

OK

P2650, L7: Inconsistent spelling: "discretization" here and "discretised" on P2649, L18.

OK

P2651, L1: Change "vary" to "varies"

OK

P2651, L13: Suggest changing "makes less meaningful ..." to "makes the GMTR... grid less meaningful"

OK

P2661, L8: Suggest changing "On the contrary" to "On the other hand".

OK

P2661, L9: Suggest changing "in coincidence with" to "coinciding with"

OK

P2661, L10: Change "kept into" to "kept in"

ok

P2661, L19: Change "A part" to "Apart"

OK

P2662, L1: Suggest change "instabilities of" to "instabilities in"

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ok

P2662, L2: Change "some parameter" to "some parameters"

OK

P2662, L8: Change "kept into" to "kept in".

OK

P2662, L11: Change "artic" to "arctic".

OK

P2662, L11: Change "derive from" to "are derived from"

OK

P2662, L25: Change "application" to "applications"

OK

P2663, L1: Change "5 days" to "5 day".

OK

P2663, L1: Suggest changing "figures but Fig.17" to "figures except Fig.17"

OK

P2663, L7: Suggest changing "data shortages" to "data gaps".

OK

P2663, L17: Change "breaking" to "breaking up"

OK

P2663, L20: Suggest changing "that" to "which"

OK

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P2663, L26/27: Use of both "day side" and "dayside".

ok

P2663, L28: The time series is "of" ozone values rather than "relative to"

ok

P2664, L23: Change "potentiality" to "potential".

OK

P2664, L28/29: Change "split up" to "split".

ok

P2665, L5: Change "cycle is back to" to "cycle was increased back up to"

OK

P2665, L12: Change "sets" to "set".

OK

P2665, L26: Change "beeing" to "being".

OK

P2684, Fig 13 caption: Change "anctartic" to "antarctic"

OK

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