MIPAS OZONE ASSIMILATION

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ABSTRACT/RESUME

Four data assimilation systems have been working extensively on MIPAS ozone data. These are: DARC, ECMWF, GMAO and BASCOE. All assimilations systems were prepared to contribute to the CAL/VAL workshop. The MIPAS data are version 4.61. The Data Assimilation Research Centre (DARC), European Centre for Medium – Range Weather Forecasts (ECMWF) and the Global Modelling and Assimilation Office (GMAO), assimilated MIPAS ozone data in addition to other observations containing ozone information. BASCOE (Belgian Assimilation System of Chemical Observations from Envisat) assimilated only MIPAS observations. The overall findings are a better MIPAS ozone quality, with less contaminated data. The MIPAS data lead to an overall improvement of the ozone analyses with respect to independent data.

1. INTRODUCTION

The use of data assimilation in the framework of instrument validation is a new methodology, introduced for chemical species for Envisat. Since four different assimilation systems have contributed to these results having only very limited time, a very short description of the assimilation set-up will introduce the results. A joint conclusion will end this report.

It must be stressed that assimilating new products requires a considerable effort, since the assimilation system has to be set up and executed. Therefore this is only a concise summary of the most relevant results.

2. DARC

The Data Assimilation Research Centre has made preliminary assimilation experiments with the new reprocessed MIPAS L2 ozone data (v4.61 offline products) for September 2002. MIPAS temperature and ozone data are assimilated into a stratosphere-troposphere version of the Unified Model, along with all the routine Met Office operational data such as ATOVS and sonde. In addition to MIPAS ozone observations, HIRS channel 9 provides ozone information in the upper troposphere and lower stratosphere. Analysed ozone distributions are also influenced by the model's dynamics and the ozone parameterisation

(Cariolle and Deque 1986). Results are presented for the period 12-17th September but will be affected by spinup as the new MIPAS data takes effect.

Observation minus background statistics are used to provide a first test of the assimilation system and the MIPAS ozone observations. Fig. 1 shows O-B histograms for data with mean pressure 140hPa, roughly corresponding to the 15km MIPAS retrieval level. This shows that obvious cloud-clearing problems in the lowermost stratosphere that were seen in the

Proceedings of the Second Workshop on the Atmospheric Chemistry Validation of ENVISAT (ACVE-2)
ESA-ESRIN, Frascati, Italy, 3-7 May 2004 (ESA SP-562, August 2004) EMI01DF

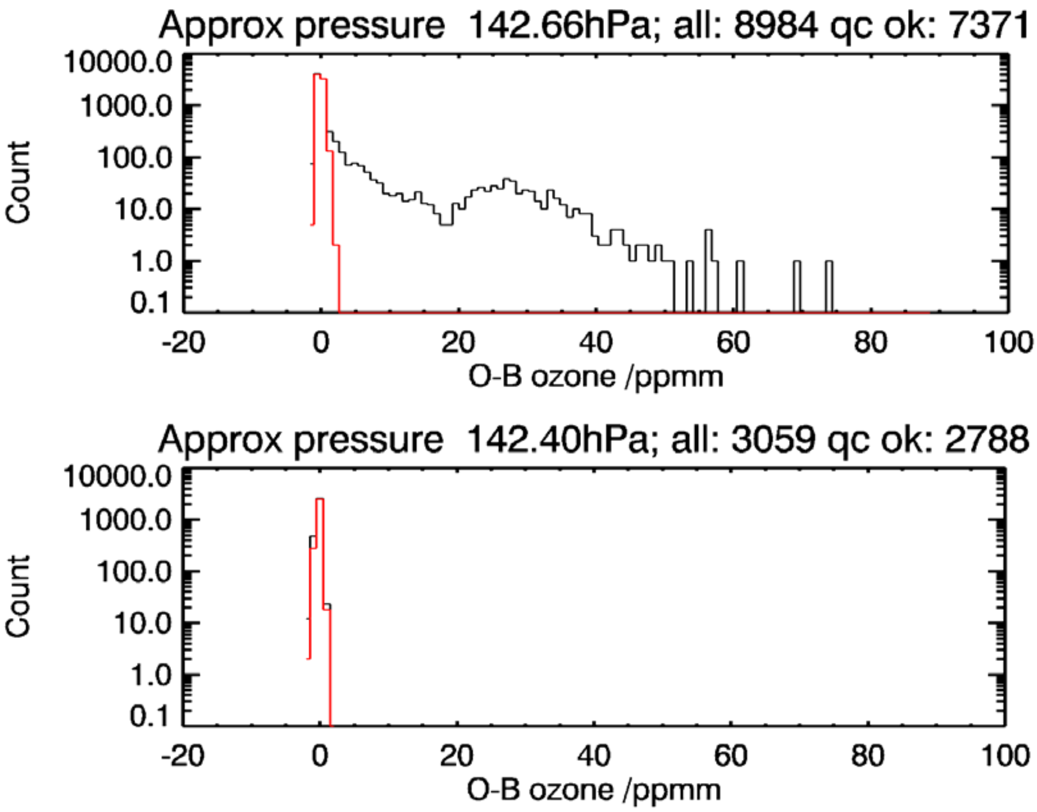


Fig. 1: Observation minus background histograms at 142 hPa for near real time data (top) and offline data (bottom). The black line denotes the data that are rejected, the red line gives the accepted amount of data.

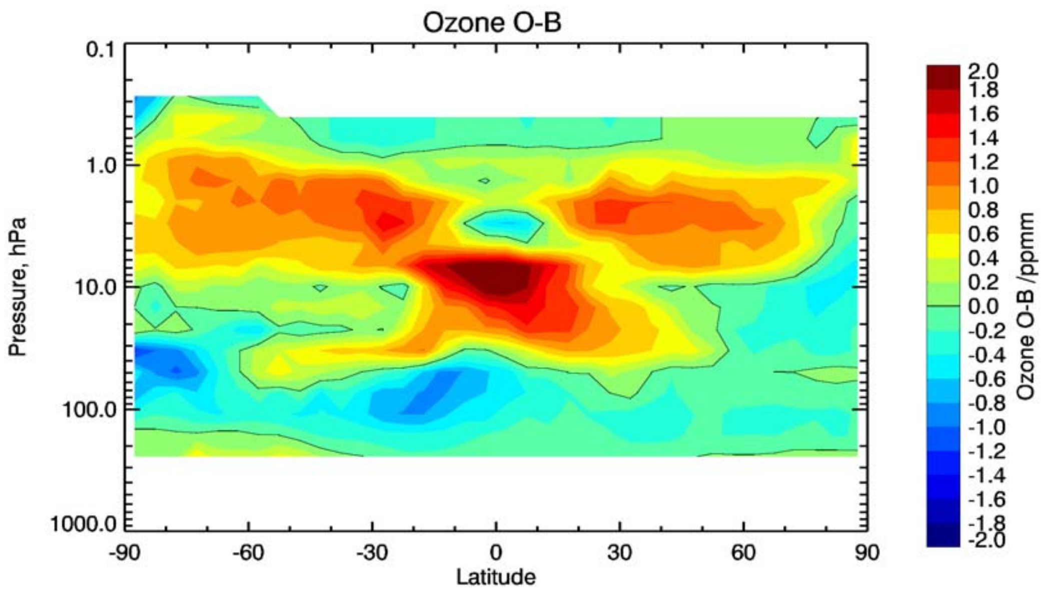


Fig. 2: Zonally averaged Observations minus background.

original Near Real Time data have been entirely eliminated from the reprocessed data. Mean values of O-B can be binned against pressure and latitude. These figures show that MIPAS ozone observations are consistent with the model, typically well within +/-2 ppmm. The most obvious discrepancies in tropical regions can be explained by known problems with the UM vertical transport, and hence are not problems in the MIPAS data (Fig. 2).
To produce more quantitative results, we require a longer assimilation time period and comparisons against independent data. That work is currently ongoing. However, preliminary findings are that the new MIPAS data are broadly consistent with known features in the Unified Model and that quality is much improved over the original Near Real Time retrievals.

3. ECMWF

At ECMWF MIPAS ozone v4.61 was re-assimilation in addition to SBUV data for ozone for the period Sept. 12 – 28, 2002. The most relevant results are listed.
A comparison with ozone sondes revealed a better agreement. Consistent with this finding, the ozone analyses show a better agreement with TOMS. At ECMWF, a comparison was also made with GOME ozone profiles retrieved by the Rutherford Appleton Laboratory. The ozone analyses compare better with these ozone profiles.
The ECMWF's overall findings show that the offline v4.61 ozone data are of better quality that Near Real Time data (v4..53). There are fewer signs of cloud contamination in the offline products.

4. GMAO

Validation of the MIPAS reprocessed data performed at NASA's Global Modeling and Assimilation Office (GMAO) involves calculation of effects that arise from inserting stratospheric ozone profiles from MIPAS in an existing assimilation system. Those impacts are subsequently evaluated against observations from independent data sources.
The Ozone Data Assimilation System (ODAS) developed at the GMAO comprises three main components: the on-line ozone transport within the GEOS-4 General Circulation Model (GCM), a set of chemistry modules, and a sequential data analysis module. The transport is built into the GEOS-4 finite volume Data Analysis System (fvDAS), and therefore it is driven by assimilated winds. The chemistry modules include monthly stratospheric production and loss rates, daily tropospheric rates from the GEOS-CHEM model, and a "cold tracer" scheme for polar heterogeneous reactions. In the control configuration the ODAS assimilates the total and partial column ozone from the Solar Backscattered Ultra-Violet 2 (SBUV/2) instrument onboard satellite NOAA 16. The partial columns are provided in nine layers that extend from 64 hPa to the top of the atmosphere.
The monthly mean output of the control run is compared with an assimilation experiment in which ozone profiles from MIPAS are assimilated along with the SBUV/2 data. The system uses MIPAS profiles on 13 levels from about 100 hPa up to about 0.2 hPa. The validation focuses on the lower stratosphere in November 2002. Fig. 3 shows the zonally averaged mean difference of the two assimilation runs. The largest impact of the MIPAS ozone is seen in the northern high latitudes poorly covered by SBUV/2. An increase (up to 10%) between 100 hPa and 40 hPa pressure levels brings the assimilated mean profile to an excellent agreement with observations from the Polar Ozone and Aerosol Measurement (POAM) instrument. A smaller increase in the 50 hPa - 20 hPa layer is present in the tropical (30S – 30N) zonal mean. Comparison against averaged data from selected profiles provided by the Halogen Occultation Experiment (HALOE) instrument provides evidence of improvement in that region as well. The results of these comparisons are shown in Fig. 4.
In conclusion, the stratospheric level 2 ozone data from MIPAS brings a positive contribution to the analysis results in the regions and timeframe selected for this validation project.

5. BASCOE

For this CAL/VAL workshop, the BASCOE latest version was used to assimilate all MIPAS chemical observations, both the offline (v4.61) and NRT (v4.53) data for comparison purposes. The latest BASCOE version contains a more elaborate quality check based on the background of the model. The NRT data for beginning Sept. 2002 suffered from spurious systematic biases and these were absent in the offline data.
A detailed assessment of the assimilation revealed that the ozone analyses show a systematic bias with respect to the observations in the higher stratosphere.
Unfortunately the coverage of the offline products and the NRT data not always coincide. This makes an assessment of the data quality of both data sets difficult, taking into account data rejection.
More relevant for the CAL/VAL is the comparison with independent data. We have selected the HALOE data, since they are well known. In a first instance a comparison was made with sunset and sunrise events separately. This comparison showed that both data sets have a consistent behaviour.
The systematic bias between ozone analyses and observations makes a direct comparison between HALOE and the ozone analysis only useful when a

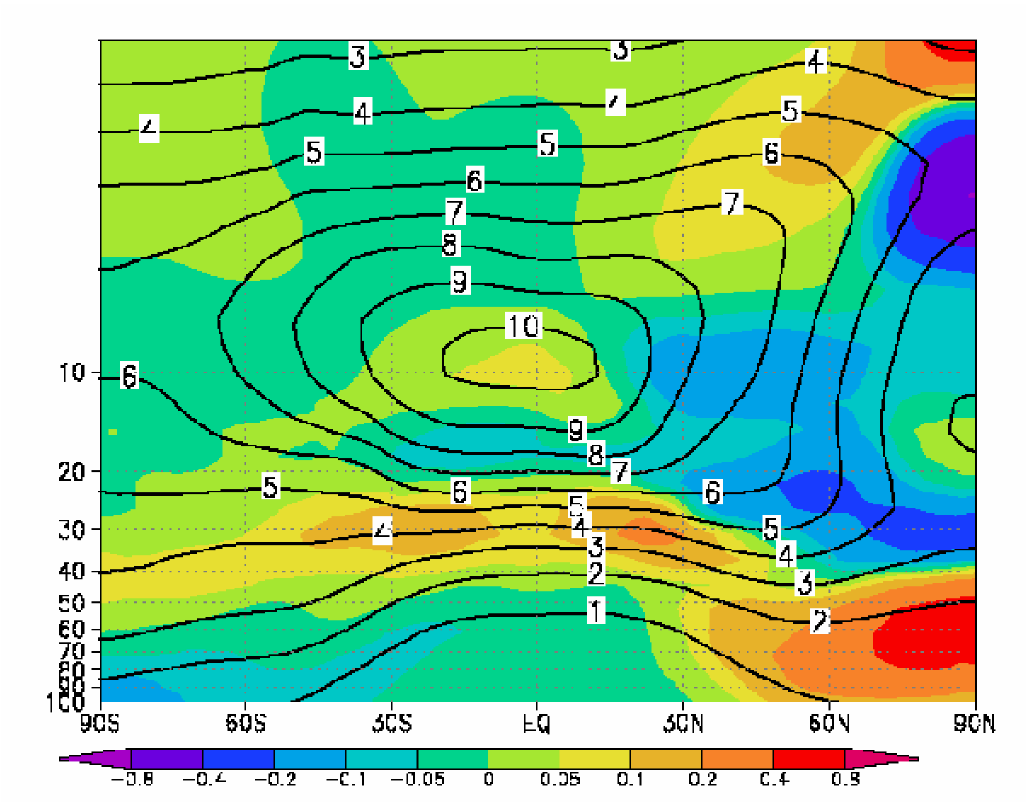


Fig. 3: Zonal mean ozone from SBUV assimilation for Nov. 2002 (full lines). The color shading represents the difference be MIPAS/SBUV and SBUV ozone analyses for the same period.

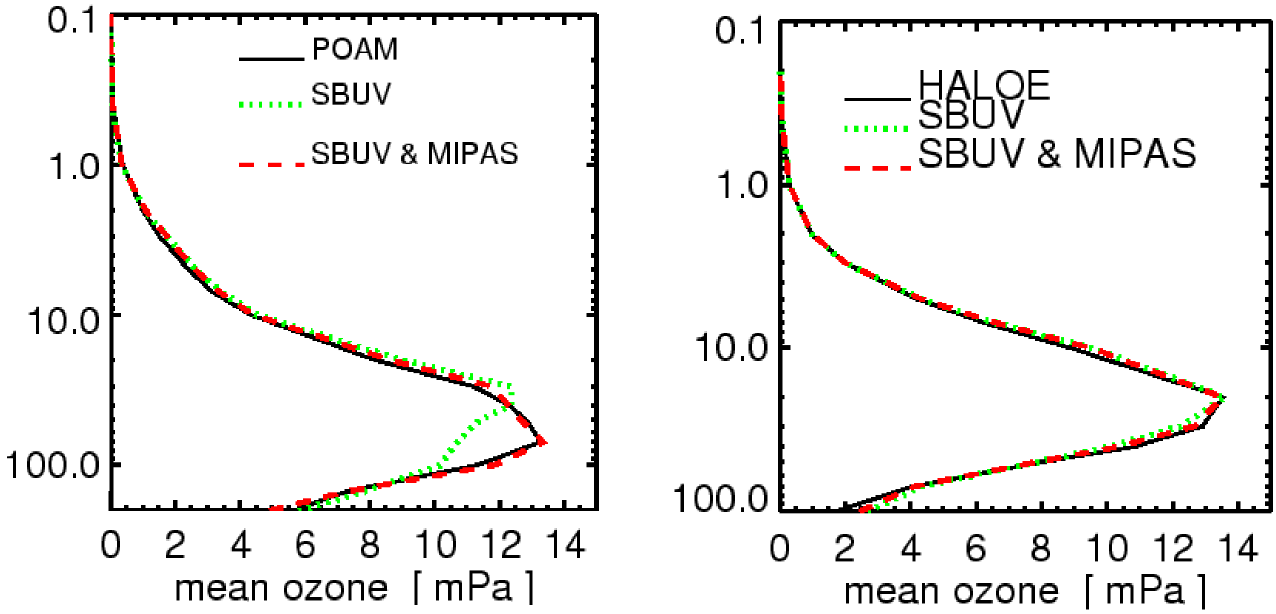
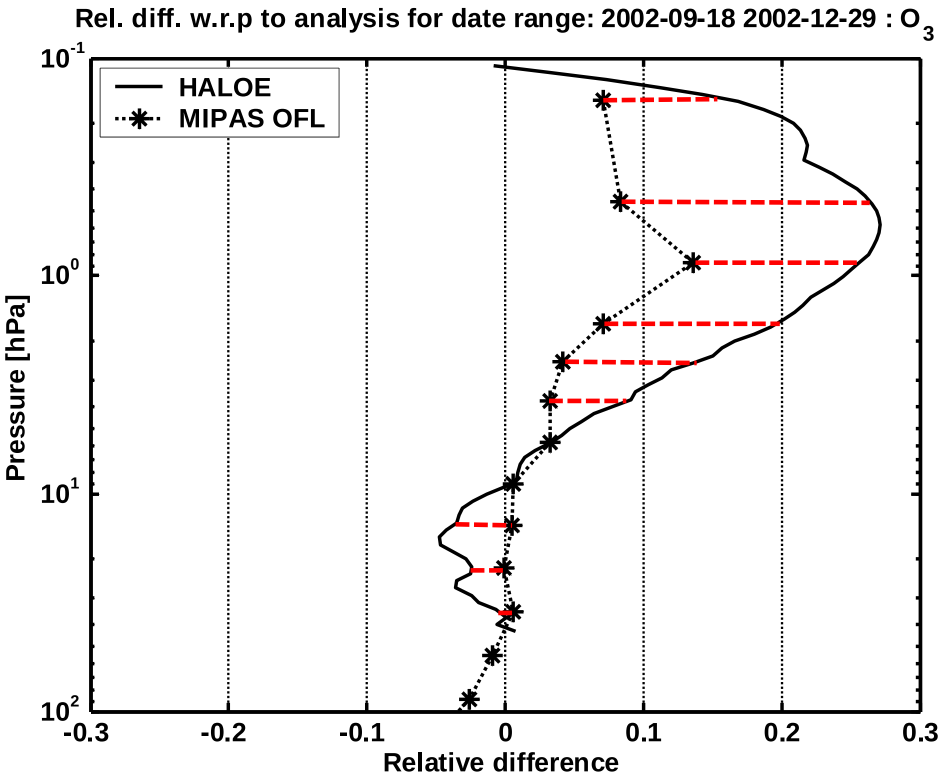


Fig. 4: Mean ozone profiles for POAM (left) and HALOE (right). The co-located ozone analyses from SBUV (green dotted) and SBUV/MIPAS (red dashed) assimilation are shown for comparison



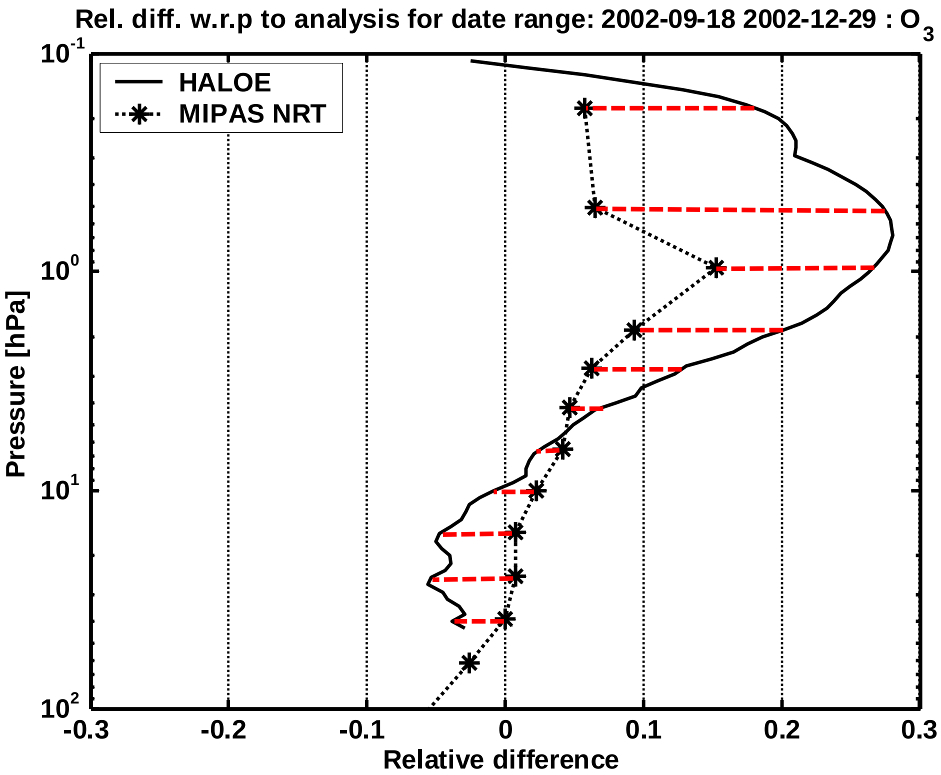


Fig. 5: Relative difference of HALOE (full line), MIPAS (dotted) with chemical BASCOE ozone analyses. Top figure: offline products and bottom figure NRT product assimilation. The red dashed lines indicate difference between MIPAS and HALOE.

similar comparison between the MIPAS and analysis ozone is shown. In Fig. 5, the relative differences between HALOE, MIPAS and ozone analysis is given. Fig. 5 top and Fig. 5 bottom give the result from the respective offline (v4.61) and NRT (v4.53) assimilation.
From this figure it is clear that the offline products are of better quality. The offline data are more consistently assimilated than the NRT data, especially in the lower stratosphere. Both data sets lead to generally the same features in the comparison with HALOE.
The quantitative results from the comparison between MIPAS and HALOE can indirectly be assessed (red dashed lines) and are summarized in the following table:

Pressure		
p < 4 hPa	MIPAS < HALOE	≈ 10%
4 < p < 10 hPa	MIPAS ≈ HALOE	
p > 10 hPa	MIPAS > HALOE	≈ 5 %

Overall these differences are not large and resulting ozone analyses from the NRT and offline data show the same behaviour in the comparison with HALOE. A more detailed analysis of the comparison with independent data is needed to quantify the quality of the MIPAS data.

6. CONCLUSION

Although in very short time period, the data assimilation contributors were nevertheless able to re-assimilate the new offline (v4.61) MIPAS observations. A first important conclusion, obtained by all groups was the improved data quality of the offline MIPAS ozone product. More data are accepted by the quality check algorithms and this is due to less cloud contamination within the retrieved ozone profiles.
It is also shown that when MIPAS ozone is assimilated in addition to other ozone observations, the quality of the resulting ozone analyses improves. Generally, the obtained ozone analyses are in good agreement with independent observations.
A first effort quantifying the difference between HALOE and MIPAS ozone reveals that in the lower stratosphere (pressure > 10 hPa), MIPAS overestimates HALOE by approximately 5 %. In the higher stratosphere (pressure < 4 hPa), MIPAS underestimates HALOE ozone by about 10 %.
To fully benefit from data assimilation, full coverage MIPAS observations over an extended period are needed to address a more detailed study.