MIPAS Assimilation By BASCOE

Q. Errera, S. Chabrillat, F. Daerden and S. Bonjean

Belgian Institute for Space Aeronomy (BIRA-IASB), Brussels, Belgium

Email: quentin@oma.be

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Introduction: BASCOE (the Belgian Assimilation System for Chemical Observations of Envisat) is a 4D-Var assimilation system descended from that described in Errera and Fonteyn (2001). This system is based on a 3D chemical transport model driven by operational ECMWF analysis. MIPAS observations of O3, HNO3, NO2, N2O, CH4 and H2O have been assimilated from October 2002 until March 2004 (18 months). The model calculates the evolution of 57 chemical species taking into account the advection, the chemistry and the PSC microphysics. The model extends from the surface up to 0.1 hPA using 37 levels with an horizontal resolution of 5° in longitude and 3.75° in latitude. Data assimilation is done using 4D-Var with an assimilation window of one day. The background error standard deviation is set as 20% of the background field. No correlation are taken into account, the background covariance matrix is then diagonal.
Additional to the MIPAS random error, an error of representation of 8.5% that takes into account the difference of resolution between BASCOE and MIPAS has been specified for each assimilated observations (Ménard et al., 2000). Finally, an OI quality control filter (Gauthier et al., 2002) has been implemented.

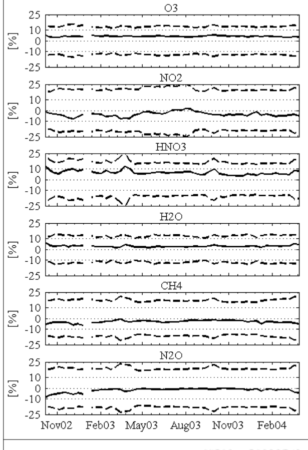


Fig. 1 show the evolution of the global bias MEAN((MIPAS–BASCOE)/MIPAS) (solid line) and the associated standard deviation (std, dashed line) for each observed species, for an interval of ten days and without any particular range selection in altitude or latitude. For two periods, in Mar03 and Sep03, bias of HNO3 and std of HNO3, CH4 and N2O increase. This is due to problem that occurred in the minimization. NO2 bias evolution shows two minimum in Mar03 and Jan04 and a maximum in Aug03. The origin of this bias is not yet determined and could be linked to thermospheric production of NOx transported to the polar stratosphere. Elsewhere, bias and std evolution are stable and are comparable to the MIPAS total errors (Raspollini et al., 2006). The remaining bias for active chemical species O3, NO2 and HNO3 could indicate a bias between the model chemistry and MIPAS.

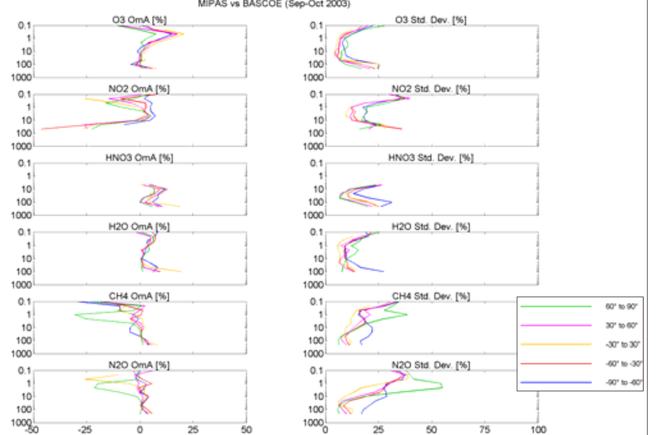
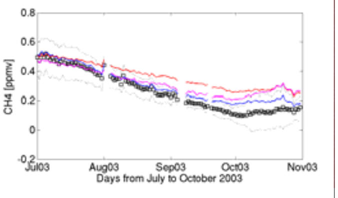


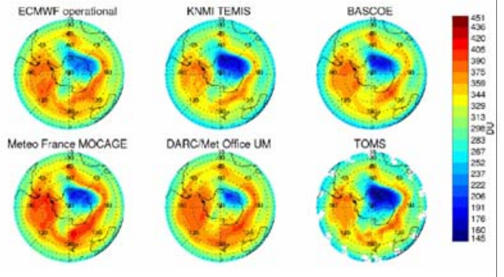
Fig. 2: Bias and std between MIPAS and BASCOE for a period of two months (Sep-Oct 03) for five latitude bands and twelve pressure layers (3 layers per pressure decade).
- In general, bias and std are comparable to the MIPAS total error (Raspollini et al., 2006).
- For O3, N2O, H2O and CH4, biases are inside the interval of +/-5% except in the higher stratosphere, at the tropopause (O3 and H2O), around 3 hPa at the EQ and SP (N2O and CH4, see Fig. 3) and in the SP lower stratosphere (H2O, CH4 and N2O).
- Above 1 hPa, the model (photo) chemistry is unable to reproduce the O3 observations (maximum bias is 20%). Comparisons with HALOE show a lower bias (up to 15%).
- Large biases and standard deviations are generally found in regions where the abundance of the constituent is weak (*e.g.* NO2 and HNO3)

Fig. 3: Evolution of mean CH4 at SP and at MIPAS level 5 (3hPa in July to 1.5hPa in Nov.) for: MIPAS (squares), the associated std (dashed line), BASCOE MIPAS analyses (blue), BASCOE control run (red) and BASCOE high resolution free model run (2.5° lon by 1.875° lat).
The agreement between BASCOE analyses and MIPAS is good until mid Sep. Then, during the SP vortex formation, BASCOE starts to over-estimates MIPAS (see also Fig. 2). Does increasing the resolution would solve the problem?



BASCOE ozone analyses have been validated by Geer et al. (2006) who present intercomparison of ozone analyses from different assimilation systems (including BASCOE) and cross-validation with independent observations (ozone sondes, HALOE and TOMS) (Fig. 4). Through most of the stratosphere (50 to 1 hPa) biases compare to sondes and HALOE are +/-10%. Larger values occur at the tropical tropopause and in the higher stratosphere.
BASCOE HNO3 and N2O have been intercompared with ground-based FTIR for five NDSC stations (Vigouroux et al., 2006). Outside polar winter conditions, BASCOE N2O agree very well with FTIR: biases are inside [0,-1]% and std. dev. are inside [2,4]%. HNO3 bias between BASCOE and MIPAS (see Fig. 5) are difficult to interpret due to the different spectroscopic parameters used for the inversion of FTIR and MIPAS data. Anyway, biases are in the range [2,10]% and std. dev. in the range [5,9]%.

Fig. 4: Comparison between BASCOE total O3, TOMS and four other data assimilation systems.



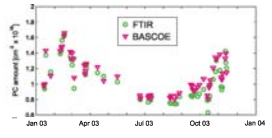
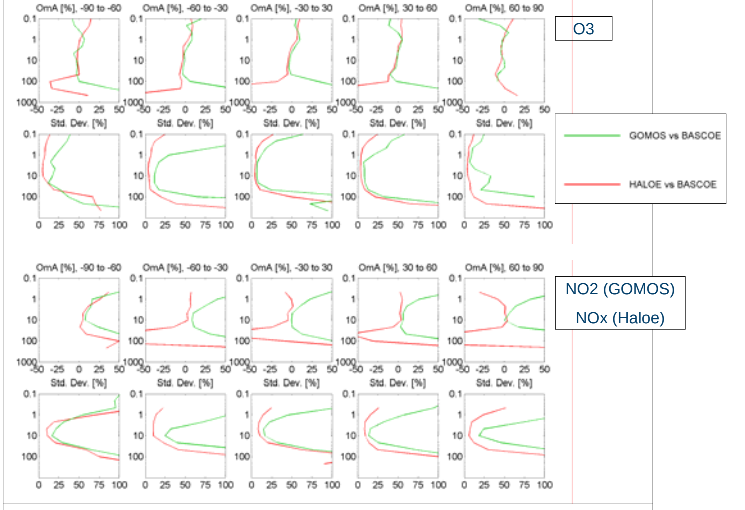


Fig. 5: Comparison between BASCOE HNO3 partial column with ground-based FTIR at Jungfraujoch station (46.5°N, 8°E)

During MIPAS assimilation, BASCOE has also monitor HALOE and GOMOS (Fig. 6). This has allow to validate analyses wrt to HALOE and GOMOS (dark limbs). For O3, comparison with HALOE are very good and stable for latitude to latitude. Between 1hPa and the tropopause bias and std are arround 5%. Above, bias increas to arround +10% and confirms results from Fig. 2. Bias between BASCOE and GOMOS between the tropopause and 1hPa are also arround 5%. Above 1hPa, the bias are less stable from latitude to latitude with values between 1% to 20%. Std are higher than for HALOE comparison and varies from latitude band to latitude band. This could indicate the importance of the star properties (*e.g.* magnitude or temperature) or the angle of the star raising/setting in the quality of GOMOS data.
For NO2 (NOx in the case of HALOE), this is an opportunity to check assimilation of a short lived chemical species. As for Fig. 2, bias and std are minimum at pressure where NO2 vmr is maximum. At this level, for HALOE, bias and std are arround 5% and 10%, resp. For GOMOS, bias and std are arround 10% and 15%, resp. However, std very much higher than HALOE outside the NO2 vmr maximum. Again, does star properties or angle of the raising/setting influence the comparison?



Conclusion: BASCOE has assimilated six MIPAS/ESA chemical species for 18 months. In general, analyses agree well with MIPAS. The bias and std are in general smaller or equivalent to MIPAS total error (Raspollini et al., 2006). However, analyses of long lived tracers shows higher bias and std that could come from the coarse spatial resolution of BASCOE. In the high stratosphere, O3 underestimates MIPAS (up to 20%) and HALOE (up to 10%). Does model photochemistry should be improve or does MIPAS data overestimates the reality?
Monitoring of GOMOS by BASCOE offer the opportunity to evaluate GOMOS wrt to BASCOE/MIPAS. BASCOE O3 compare well with GOMOS on average but with a higher variability than for HALOE comparison. For NO2, the agreement between BASCOE and GOMOS are good where the NO2 profile is maximum but, again, shows a higher variability.

References & Further Reading:

- Daerden et al.: A 3D-CTM with detailed online PSC-microphysics: analysis of the Antarctic winter 2003 by comparison with satellite observations, *ACPD*, 2006
- Errera, Q. and D. Fonteyn, Four-dimensional variational chemical assimilation of CRISTA stratospheric measurements, *J. Geophys. Res.*, 2001.
- Gauthier et al., Quality control: methodology and applications, *in* Data assimilation for the earth system, edited by Swinbank et al., NATO Science Series, Kluwer Academic Pub.
- Geer et al., The ASSET intercomparison of ozone analyses: method and first results, *ACPD*, 2006
- Raspollini et al., MIPAS level 2 operational analysis, *ACPD*, 2006
- Ménard et al.: Assimilation of Stratospheric Chemical Tracer Observations Using -a Kalman Filter. Part I: Formulation, *Mon. Weather Rev.*, 2000.
- Vigouroux et al., Comparison between ground-based FTIR and MIPAS N2O and -HNO3 profiles before and after assimilation in BASCOE, *ACPD*, 2006.