GEOPHYSICAL VALIDATION OF TEMPERATURE RETRIEVED BY THE ESA LEVEL 2 PROCESSOR FROM MIPAS/ENVISAT MEASUREMENTS

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ABSTRACT

The Michelson Interferometer for Passive Atmospheric Sounding (MIPAS) is operating on the ESA ENVIronmental SATellite since March 2002. The high resolution (0.025 cm^{-1}) limb-emission measurements acquired by MIPAS in the first two years of operations constitute a self-consistent set of data with very good geographical and time coverage. These measurements have been re-processed by ESA up to Level 2, with the most recent versions of both Level 1b and Level 2 algorithms. The products of the ESA Level 2 algorithm are geolocated profiles of temperature and of volume mixing ratio of six key atmospheric constituents: H_2O, O_3, HNO_3, CH_4, N_2O and NO_2. As for all the measurements made with innovative instruments and techniques, this data set requires a thorough validation.

During the last year, a large team of scientists spent great efforts in the validation of this data set. In particular, the authors of this paper have focused their activities on the validation of temperature. The validation was carried-out by comparing MIPAS retrieved temperature with correlative measurements made by radiosondes, lidars, in-situ and remote sensors operated either from stratospheric balloons or satellites. Preliminary results show that MIPAS profiles are affected by a bias generally consistent with their a-priori estimated systematic error component. This bias is usually localized at the edges of the altitude range covered by the MIPAS scan (6 – 68 km).

1. BACKGROUND

MIPAS (Michelson Interferometer for Passive Atmospheric Sounding) is a middle-infrared Fourier Transform Spectrometer operating since March 2002 on the ESA developed ENVIronmental SATellite (ENVISAT). The high resolution (0.025 cm^{-1}) limb-emission measurements acquired by MIPAS in the first two years of operations constitute a self-consistent set of data with very good geographical and time coverage. These measurements have been re-processed by ESA up to Level 2, with the most recent versions of both Level 1b and Level 2 algorithms (data technically labelled with version 4.61). The products of the ESA Level 2 algorithm are geolocated profiles of temperature (T) and of volume mixing ratio of six key atmospheric constituents: H_2O, O_3, HNO_3, CH_4, N_2O and NO_2. As for all the measurements made with innovative instruments and techniques, this data set requires a thorough validation.

The results shown in this paper concern MIPAS temperature validation. The validation is carried-out by comparing MIPAS temperature with correlative measurements made by radiosondes, lidars, in-situ and remote sensors operated either from stratospheric balloons or satellites.

2. BIAS AND PRECISION ESTIMATES

Assuming bias-free correlative measurements, an estimate of the bias of MIPAS profiles is provided by the average difference between MIPAS and correlative measurements. The root mean square (*RMS*) of the profile differences about their average value estimates the precision of the difference itself. If the random error associated with the correlative measurements is much smaller than that of MIPAS, this *RMS* provides directly an estimate of the MIPAS precision. The error affecting the MIPAS bias determined with the above procedure is estimated as $RMS / N^{1/2}$ where N is the size of the sample of profiles being intercompared.

Whenever the correlative measurements available for validation have instrument response functions very different from that of MIPAS (as e.g. for radiosonde and lidar measurements), the *smoothing error* [1] applicable to the difference between intercompared profiles is significant. In this case, if the MIPAS averaging kernels (AKs, pre-calculated for standard atmospheric conditions) are considered representative of the actual measured atmosphere, the smoothing error is avoided by adapting to the MIPAS perception (i.e. by convolving with the MIPAS AKs and by using a common a-priori state [1]) the high-resolution correlative measurements. Whenever the available MIPAS AKs are not considered representative of the actual atmosphere encountered in the intercomparison, the profiles have been directly intercompared by calculating the difference and, whenever significant, the smoothing error has been included in the error budget of this difference.

3. COINCIDENCE CRITERIA

The coincidence criteria recommended for the intercomparison were initially set to 300 km and 3 hours. Some individual research groups involved in the validation work presented here have used more relaxed criteria whenever justified on the basis of test attempts.

4. EXAMPLES OF PRELIMINARY RESULTS OF MIPAS TEMPERATURE VALIDATION

In this section we report some examples of preliminary results of MIPAS temperature validation. At this stage the validation activities of the individual participating groups are already in a quite advanced phase, however great efforts have still to be made to homogenize both the adopted intercomparison methods and the strategies for presentation of the results. The final results of this validation work are planned for publication in [2].

4.1 Intercomparison of MIPAS against radiosonde and lidar measurements at Esrange

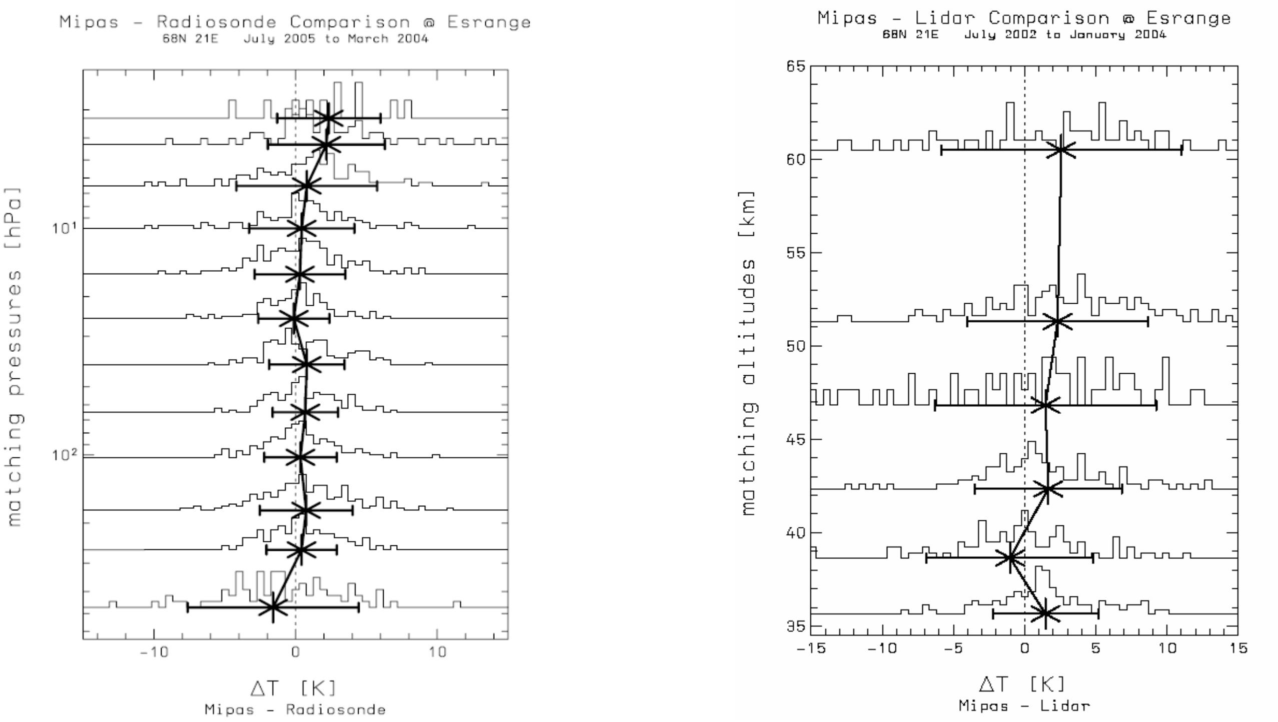

Fig. 1: Intercomparison of MIPAS against Esrange radiosonde (left) and lidar (right) measurements. The crosses are average differences, error bars represent the *RMS* of the differences.

4.2 Intercomparison between MIPAS and ECMWF

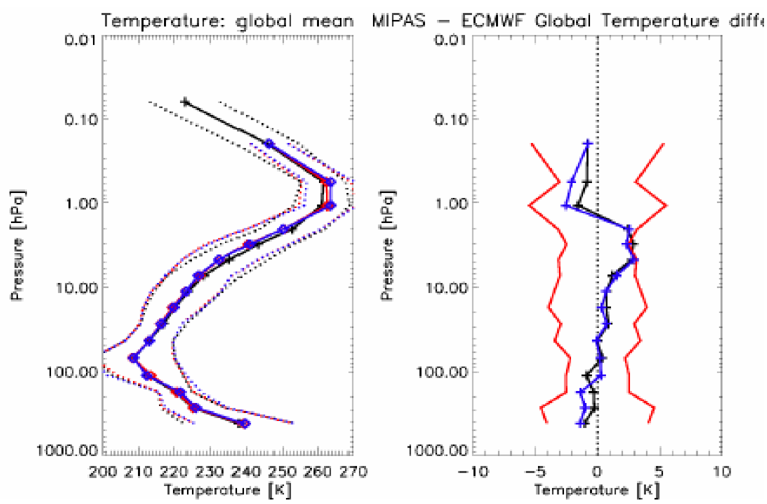

Fig. 2: Intercomparison between MIPAS and ECMWF: Example of global mean for March 2004. Left panel: Mean temperature profiles of MIPAS (solid black) and ECMWF on the MIPAS grid, both with (solid blue line) and without (solid red line) averaging kernels applied. The 1-sigma standard deviation is shown by the dotted lines. Right panel: mean of the differences between MIPAS and ECMWF with (blue line) and without (black line) AKs applied. The expected MIPAS systematic error is shown by the red lines. The random error is assumed small in comparison to the systematic error due to the large number of profiles averaged.

4.3 Intercomparison of MIPAS against IMAA and University of L'Aquila radiosoundings

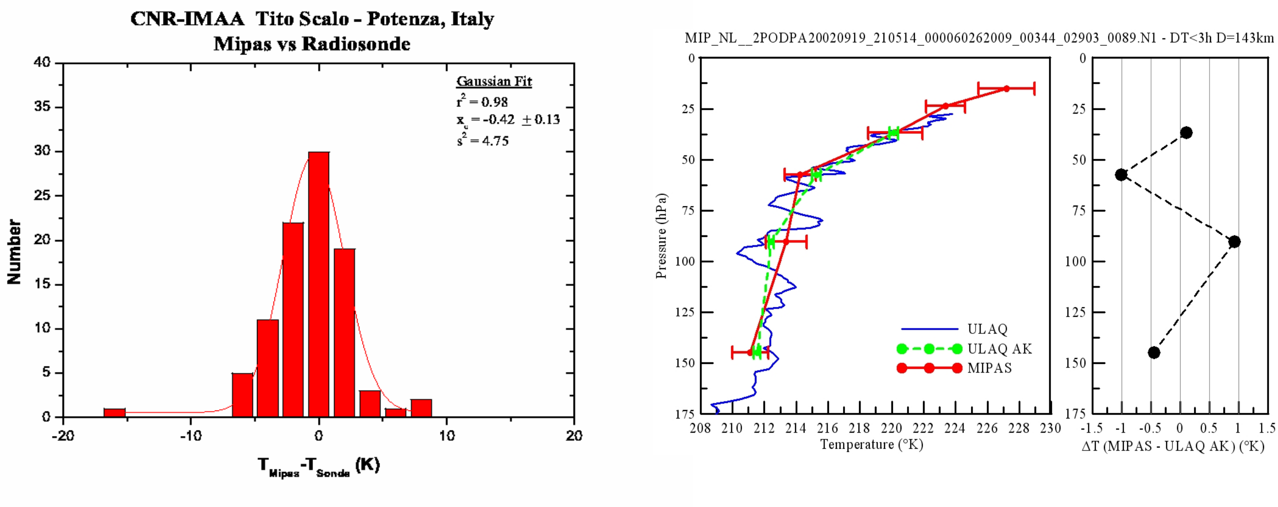

Fig. 3: Intercomparison of MIPAS against IMAA and University of L'Aquila radiosoundings. Left plot: global distribution of the difference T_{MIPAS} - T_{sonde} for IMAA radiosoundings with MIPAS AKs applied. Center plot: comparison between MIPAS (red) and L'Aquila radiosounded temperature (blue); the green line is the sonde profile with MIPAS AKs applied. Right plot: difference "red – green" of the center plot.

4.4 Intercomparison of MIPAS against radiosonde and lidar measurements from NDSC/GAW network

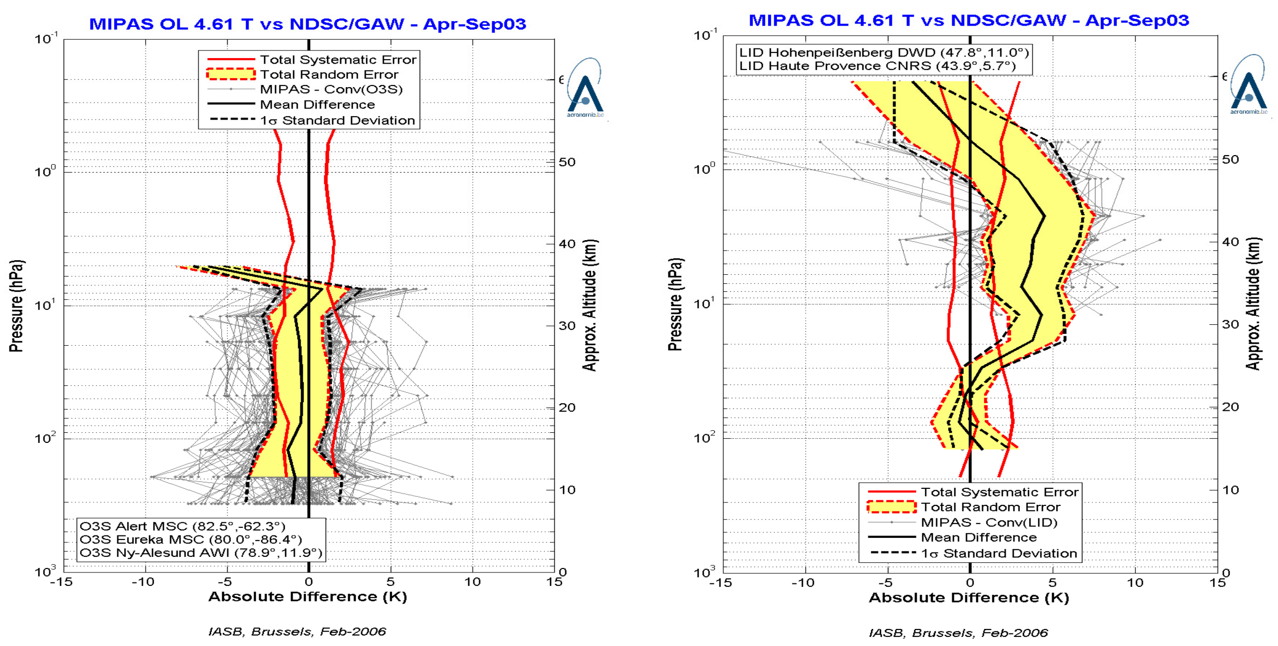

Fig. 4: Example of mean differences between MIPAS and radiosonde (left) or lidar (right) measurements collected by BIRA – IASB from NDSC/GAW ground-based network. High resolution correlative measurements have been adapted to the MIPAS perception [1] before intercomparison.

4.5 Intercomparison between MIPAS and lidar within the EQUAL project

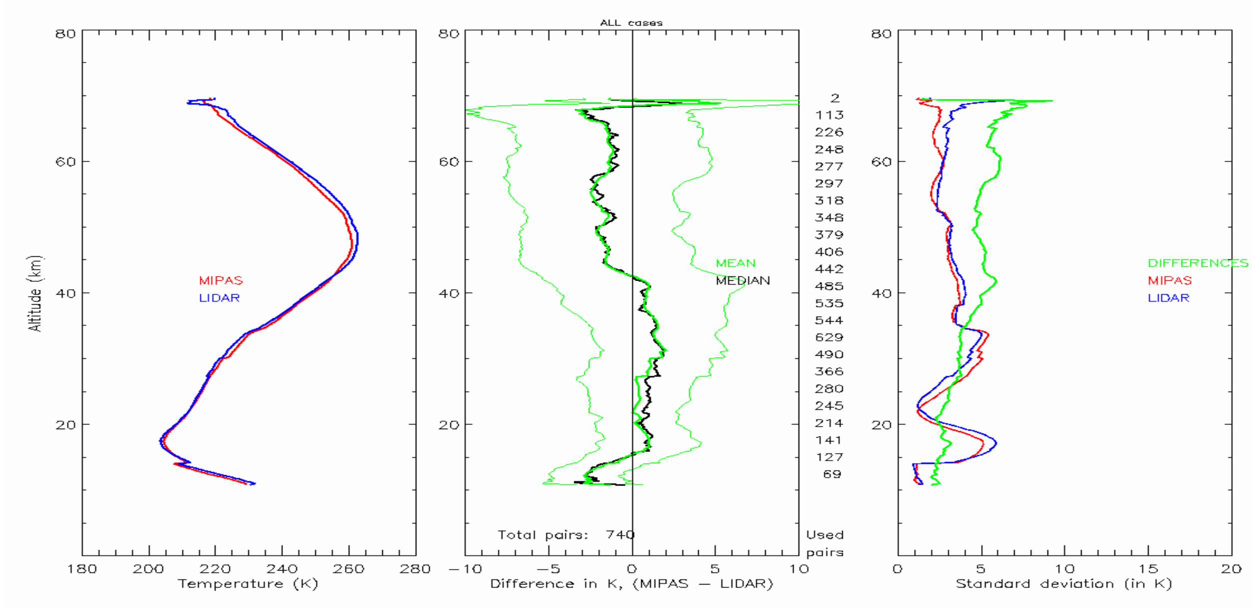

Fig. 5: Intercomparison between MIPAS and lidar within the EQUAL project (made at RIVM). Mean profiles, differences and standard deviations.

4.6 Intercomparison between MIPAS satellite and the balloon version of MIPAS

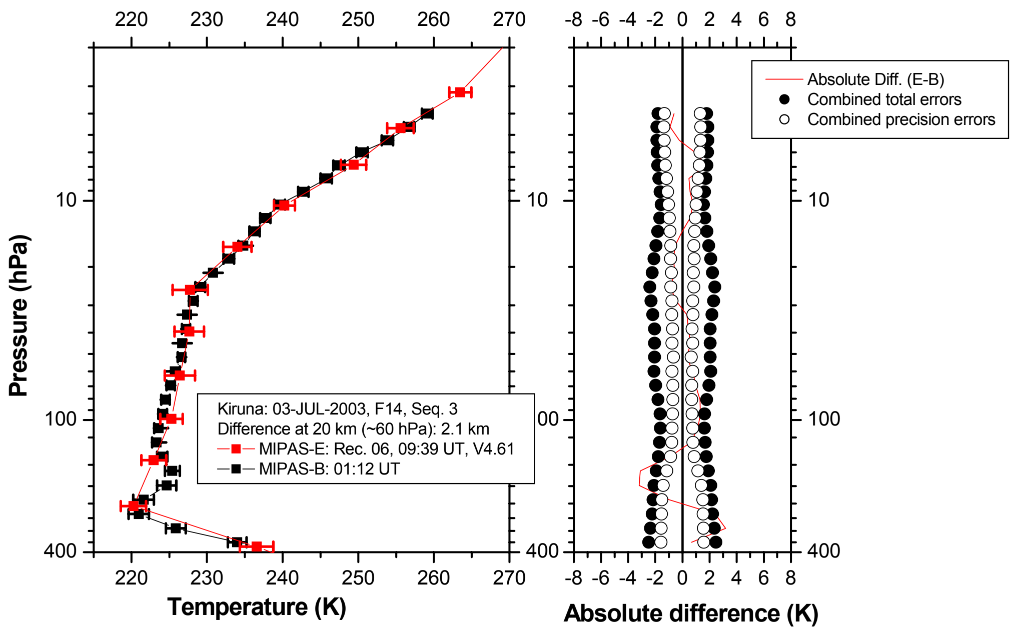

Fig. 6: Intercomparison between MIPAS satellite and the balloon version of MIPAS (MIPAS_B). Very good agreement is found whenever the time- and space- coincidence of the measurements is good, as in the case shown here.

5. SUMMARY

Preliminary results show that MIPAS temperature profiles are affected by a bias consistent with the a-priori estimated systematic error. This bias is mainly localized at the edges of the altitude range covered by the MIPAS scan (6 – 68 km). The observed *RMS* is generally larger than the predicted random error of MIPAS.

6. REFERENCES

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[2] Ridolfi et al., Geophysical validation of MIPAS temperature, *Atm. Chem. Phys*, in preparation, (2006).