MIPAS Quality Working Group #40
Summary of the Meeting + Action Items List
CNR-IFAC Firenze, 02 – 04 November 2015

A summary of the main conclusions of the meeting and the list of the new Action Items for Level 1b and Level 2 are provided in the present document.

Next appointments:
- *week 8-12 February 2016: QWG WebEx teleconference on final V7 validation results and L2 V8 NetCDF format;*
- *7-8 March 2016: Limb Workshop, in Bologna – CNR;*
- *week 4-8 April 2016: QWG meeting #41 + Level 2 Phase F Mid Term Review, in ESRIN.*

Mid Term Review of MIPAS Level 1b Phase F project:

- Introduction of Angelika Dehn (ESA), who recalls the strict schedule for Phase F projects:
  - Level 1b v8 MTR: today (02 November 2015)
    baseline verification: April 2016
    processor delivery: October 2016
  - Level 2 v8 MTR: April 2016
    baseline verification: October 2016
    processor delivery: April 2017
- Gaétan Perron (ABB) explains the main items of the Phase F contract:
  - Project breakdown structure and related schedule
  - Milestones and deliverables
  - Algorithm improvements to be implemented to MICAL V8
    - New non-linearity correction
    - Reduction of the weekly gain variation
    - Offset improvements (validation approach and altitude dependence)
    - Review of ILS parameters (together with Level 2 team)
    - Altitudes biases (investigation on L2 corrected altitudes and sideways mispointing)
    - Others: spectral calibration, extended wavenumber range, transmission flag, WCC sweep removal.
- Then he reviews the investigations done since previous QWG teleconference (16/09/2015). The main issue remains the correction of detectors' non-linearity response.

AI_L1_40.01: About the investigation on the offset variation with altitude, ABB to check the instrument temperatures and day/night flags for different seasons.
AI_L1_40.02: ABB to provide final ILS parameters to the Level 2 team by the end of the year.

- A Technical Note describing latest results of the non-linearity characterization issue was prepared by Anne Kleinert (KIT) and Manfred Birk/George Wagner (DLR) and circulated before the QWG meeting on 30/10/2015.
- During the meeting, Manfred Birk (DLR) summarizes the results of the non-linearity characterization applied to IPF V7, i.e., which was used for the MIPAS Level 1b version 7

data set released in May 2015. MB reports about the investigations performed since then leading to a new non-linearity correction approach to be implemented in MICAL V8:

- o   In the implementation of IPF V7, the non-linearity parameters were corrected by means of MIPAS in-flight calibration measurements (Black Body, Deep Space) and RAW mode scenes acquired along the whole mission, and validated using the inter-channel gain ratios method (based on the study of the overlapping spectral regions of adjacent detector bands). However the analysis of Level 2 V7 dataset showed that an artefact temperature trend was introduced in the data.
- o   Further investigations performed by DLR showed in fact some deviations in the non-linearity parameters validation with the inter-channel gain ratios method. In order to improve the non-linearity parameters to be applied in V8 processor (the so-called "V7 2nd step method"), actions were raised during previous QWG#39: study the influence of the 3rd order artefacts in A2/B1 and the ADCmaxmin dependence of the inter-channel radiance slopes.
- o   Results of final investigations (in agreement with Anne Kleinert – KIT): the inter-channel gain ratios method can't be used for the characterization of non-linearity behaviours, but only as validation of the chosen method.
- o   Another method, the DCzero method, was proposed for the non-linearity characterization in absence of DC values; this was never validated before using on-ground experimental data. However DLR recently decided to qualify the method by using measurements taken from their in-house Bruker instrument. The Bruker measurements showed a perfect agreement with results from MIPAS DC interferograms, using a theoretical value of the modulation efficiency = 96%.
- o   Unfortunately it seems that the modulation efficiency of MIPAS was tested during on-ground tests but documentation is not available, therefore the real value is now unknown. DLR tested the new DCzero methods for different modulation efficiency estimations, above the theoretical requirements (i.e. 0.88).
- o   Overall conclusion: the recommendation for the implementation of MICAL V8 is to use the non-linearity parameters deduced from in-flight calibrations (as for IPF V7), but with an improved estimate of the modulation efficiency derived from the DCzero method.

AI_L1_40.03: DLR to provide the "new non-linearity parameters for V8" as soon as possible;
AI_L1_40.04: ABB to re-process the 62 orbits TDS (including the 14 reference obits) before Christmas.
AI_L1_40.05: Level 2 team to analyse the temperature drifts and trends with respect to previous datasets by end of February.

- o   DLR and KIT agree that anyway the correction is around 1-2% therefore within the error budget; Daan Hubert (BIRA) confirms that in UTLS is difficult to evaluate such small trends in temperature.
- Anne Kleinert (KIT) provides her answers to some action items raised during the previous QWG#39 meeting (AI_L1_39.04 and AI_L1_39.07).
- Gaétan Perron (ABB) concludes the presentation of the Level 1b Phase F Mid Term Review by confirming that all high/medium priority tasks for algorithm improvement coming from the initial brainstorming will be taken on-board the L1b processor V8 (except the pointing jitter – R-70):

Priority	Req	Description	Type	Satus	Comments
High	R-59	The contractor shall investigate and implement improvements relative to the radiometric calibration, which is impacted by an ice layer in the optical output path (i.e. MIPAS band A around 880 cm-1).	Radiometric	Completed	Processing of all gain measurements, error will be reduced by a factor 4
High	R-60	The contractor shall assess and investigate the products for errors, in particular in view of the quality of the resulting Level 2 products.	All	In progress	Gain variation, offset done
High	R-62	The contractor shall investigate and improve the radiometric error by implementation of a detector non-linearity correction. This is an activity continued from the previous contract where a first step of the non-linearity correction has been implemented.	Radiometric	In progress	Investigation done. Need confirmation from L2 validation
Medium	R-54	The contractor shall investigate and implement improvements on the refraction computation	Pointing	Not started	Was waiting for new L2 V7
Medium	R-55	The contractor shall assess for the investigation [R-54] the approach used for the GOMOS instrument. For GOMOS the refraction calculation is based on pressure and temperature, using the values provided by the ECMWF auxiliary files (i.e. AUX_ECA, ERA_interim).	Pointing	Not started	
Medium	R-58	The contractor shall investigate and implement improvements relative to the MIPAS instrument pointing, using information from other ENVISAT instruments (e.g. SCIAMACHY), in order to improve the pitch error of MIPAS along the mission.	Pointing	Not started	
Medium	R-61	The contractor shall investigate and implement improvements relative to the gain calibration, using interpolation in time.	Radiometric	Completed	Processing of all gain measurements, interpolation only for problematic period
Medium	R-63	The contractor shall perform a validation of the detector non-linearity implemented, by comparison of the ozone trend of MIPAS versus other satellite instruments, like MLS	Radiometric	In progress	Done with ASMU for temperature
Medium	R-66	The contractor shall extend the IF16 raw data, which currently exists of 50 orbits processed.	Data	Not started	Not complete orbits
Priority	Req	Description	Type	Satus	Comments
Medium	R-67	The contractor shall investigate the quality of the current spectra. In particular the contractor shall investigate and characterise offsets that were reported in band A and band D	Radiometric	In progress	Need to try to evalute at low altitude
Medium	R-70	The contractor shall perform a pointing jitter analysis throughout the mission The analysis shall be compared to on-ground and in-flight FOV measurements.	ILS	Not started	
Medium	R-73	The contractor shall optimise the currently implemented wavenumber range through an extension of the wavenumbers	Data	Completed	Extended by 10 wavenumbers
Low	R-56	The contractor shall investigate and improve the pointing correction for MIPAS measurements scanning in sideways view	Pointing	Not started	
Low	R-57	The contractor shall consider for the technical solution of [R-56], the implementation as part of the algorithm evolution and an updated set of MIPAS auxiliary files	Pointing	Not started	
Low	R-65	The contractor shall investigate and implement spike correction of the Level 1b algorithm	Radiometric	Not started	
Low	R-68	The contractor shall investigate and characterise a saturation behaviour observed in raw mode for high radiance scenes, in order to draw conclusions on impacts the detector non-linearity characterisation	Radiometric	Not started	
Low	R-69	The contractor shall investigate and characterise the occurrence of microvibrations. In case the feasibility study demonstrates that a significant improvement in the data quality can be achieved an implementation into the Level 1b algorithm shall be performed	Radiometric	Not started	
Low	R-71	The contractor shall investigate the MIPAS measurements with respect to forward/reverse differences throughout the mission	Radiometric	Not started	
Low	R-72	The contractor shall implement latitude and longitude errors in the Level 1b product	Data	Not started	

- Final non-linearity recommendation for V8 implementation
  - Re-characterization of non-linearity parameters with the DCzero method using an instrument modulation efficiency of 91%
  - Usage of the inter-channel method for consistency validation only
  - Consolidation of last findings on the 3rd order effect
- Level 2 teams report about the analysis performed on four different L2 datasets of 14 reference orbits, processed by ABB by applying the non-linearity corrections corresponding to L1b V5, V5+1st step correction, V7 (1st step correction), oldV8 (old 2nd step correction).
  - Enzo Papandrea (ISAC): none of the L1b dataset is the official V7 delivered dataset; the L2 products have been processed with the GMTR processor. For all plots, the difference seen in L1b radiance is reflected in L2 retrieved temperature. Difference oldV8-V5: no visible trend along the mission, but there is a hot bias around 0.5-1 K (1K at 10hPa/30Km).

- o Piera Raspollini (IFAC): same L1b datasets used by ISAC but L2 products processed with ORM processor. Preliminary results: oldV8 correction introduces a bias almost constant along the mission with respect to V7 and V5. However the correction applied to oldV8 is of the same order of magnitude of V7 but the opposite sign: that results in an oldV8 drift very similar to V5.

Validation and quality assessment of ML2PP v7.03 dataset:
- Marc Schwaerz (WEGC) presents his work on the validation of MIPAS V6 and V7 datasets against the radio-occultation measurements.
  - o The main results are that there is almost no difference between MIPASv6.0 and v7.03 temperatures; instead the difference between in pressure is about 1% to 2%.
  - o Question from the QWG team: which altitude scale has been used for the comparison: the engineering LOS, the MIPAS retrieved altitudes or the ECMWF corrected altitudes? Also probably the differences in pressure are due to the engineering altitude improvements applied in V7 dataset.

AI_L2_40.01: M. Schwaerz (WEGC) to check which Level 2 altitudes have been used for the temperature and pressure validation.

- Daan Hubert (BIRA) presents his work on the validation of temperature and altitude of MIPAS V6 and V7 datasets against ozone-sondes and lidars measurements.
  - o In the FR mission, V7 temperature is generally worse (i.e. bigger negative bias) than V6 wrt to ground stations in all cases, except few pressure levels at some latitudes bands (20hPa at tropics). In the OR mission there isn't a clear difference between V6 and V7, biases and spreads are very similar.
  - o The validation of the altitudes has been done using the MIPAS retrieved altitudes, not ECMWF corrected altitudes. In the FR it seems that V7 bias and spread are smaller than V6; in the OR the V7 data quality is worse than V6, showing larger bias, spread and long-term drift.

AI_L2_40.02: D. Hubert (BIRA-IASB) to repeat the validation of L2 V7 dataset using the ECMWF corrected altitudes (if available). [Post-meeting note: action closed by presentation circulated via email on 17/11/2015]

- Hermann Oelhaf (KIT) presents their work on the validation of temperature and species with UFRA in-situ sensor BONBON and MIPAS-balloon.
  - o Comparison with BONBON is only available for MIPAS V6 dataset; comparison with MIPAS-balloon is available for V6 (all flights) and V7, but only one flight for FR mission (mid-latitudes) and one flight for OR mission (Arctic latitudes). Work on the other balloon flights in on-going and will be provided by end of the year/begin 2016.
  - o In general the results show a better agreement of MIPAS-E with MIPAS-B in the OR mission data wrt to FR mission.
  - o For temperature and stratospheric species, there is a slightly reduced agreement with MIPAS-B particularly in FR, but in general there is no significant change.
  - o Instead there is an improved agreement of V7 wrt V6 for tropospheric source gases CH4, N2O, CFC-11, and CFC-12.
- Daan Hubert (BIRA) presents on behalf of Anne van Gijsel (KNMI) the work she performed on the validation of temperature and ozone of MIPAS v7.01 (Diagnostic Dataset) and v7.03 (full mission) datasets against lidar and sonde measurements.

- o Temperature: a bias increasing with altitude is found for mid-latitudes and tropics, and to some extent in the polar regions of the OR period. Differences between OR and FR periods appear to be substantial, but the amount of collocations is not very large.
- o Ozone: definitive conclusions are not available yet, however, the results obtained so far are consistent with those of the v7.01 delta-validation dataset analysis.

AI_L2_40.03: D. Hubert (BIRA-IASB) and A. van Gijsel (KNMI) to identify the reasons of the differences between the results of temperature validations that they have performed (especially at polar regions).

Discussion on Level 2 V7 data release:

- Marta De Laurentis (IDEAS/ESA) recalls, during her presentation, that the MIPAS L2 v7.03 Readme File has to be prepared and statements coming from the validation works shall be reported on it.
- Angelika Dehn (ESA) comments about the validation results and the differences between them. Some steps and activities have to be completed and it must be defined what to suggest and recommend to the users: give clear recommendations, also reviewing the L1b v7.11 Readme File.
- During the discussion the following points are agreed:
  - o The main issue is the quality of Level 1b data for the MIPAS FR mission. The OR mission is OK and also the Level 2 V7 processor is better than V6 (e.g. better convergence, better validation for minor species, additional minor species).
  - o However the Level 1b v7.11 dataset of the full mission (including FR period) has been already released to the users, therefore it wouldn't help the missing publication of L2 V7 data for FR.
  - o In general, it is better to release data with clear recommendations on the usage, instead of not releasing data at all, as they can be used for many different studies (than the Temperature trends).
  - o In this case, although the validation work has to be completed still, there is evidence only of bias in FR Temperature and maybe H2O; the other species and the OR data don't show major deviations.
  - o Next QWG WebEx teleconference in February shall have as objective the decision on the way forward on L2 V7 data release, and a list of clear recommendations to the users.

Progress results of MIPAS Level 2 Phase F project:

- The results of on-going studies/investigations foreseen for the Phase F project are presented by Level 2 teams.
- Marco Gai (IFAC) shows his preliminary results (using V7 dataset) on the identification of possible approaches for flagging profiles and the definition of new data quality flags.
  - o The analysis confirms that the retrieval error (max value of the error of each profile) could be used as outlier detector in addition to the chi-square.
- Piera Raspollini (IFAC) shows the results of a study of the residuals of 24 orbits processed with ORM V7 (3 orbits per season in FR + 2007-OR), with the objective of checking the

correctness of the used error spectra, and searching possible systematic errors in the retrieved profiles due to interfering species, non-LTE, spectroscopic errors, offset.

- o The analysis of the residuals shows that the new spectroscopic database V4.45, to be used in V8 reprocessing, significantly reduces some residuals. In general it is recommended to mask the spectral lines strongly affected by non-LTE, and in particular to revise a H_2O MW at 68 km and NO_2 MW at 62 Km (OR). Some residuals remain anyway unexplained.
- Marco Ridolfi (UB) shows the results of a complementary study of the residuals and their improvement achieved with the new spectroscopic lines database v4.45.
  - o The improvement is relevant in several microwindows, but some problems remain unchanged. Question: how to deal with residuals which still exceed the noise level? He proposes to manually modify the spectral masks for last V8 reprocessing.
  - o The Technical Note on the new spectroscopic database and a summary of the results of the residuals analysis is in preparation.
- Piera Raspollini (IFAC) describes the proposed structure of MIPAS Level 2 V8 products in NetCDF format.
  - o The V8 output will be organized in two files: a simplified file and a detailed one. They will be both in NETCDF4 and when possible they will use the Climate and Forecast Metadata conventions.
  - o The structure and the content of the files are described in the technical note circulated before the QWG#40 meeting, "MIPAS L2 V8 output data definition". An example of simplified file has been also circulated within the MIPAS QWG.
  - o A discussion took place about possible additional information to be included in the simplified file; some issues are still open and need to be clarified.
- Luca Sgheri (IAC) reports on the modifications of the ORM multi-target retrieval and first results after the introduction of the horizontal gradients managing routines.
  - o When the HG are set to 0, the results are very consistent with the real data (i.e. original ORM MTR), when adding the horizontal Temperature gradient the results are worse and show ascending/descending differences.
  - o Debugging of the code is needed; also the oscillations in the T gradients coming from previous processing could be the origin of such differences, therefore a regularization of the T gradients themselves may be needed.
- Manuel Lopez-Puertas (IAA) reports about the updates of the vibrational temperatures (VTs) database V3 and corresponding non-LTE errors.
  - o The previous VTs database V2 was delivered in 2009, consisting in 5 reference atmospheres: polar summer, polar winter, mid-latitude day, mid-latitude night, equator); the VTs db V3 (delivered in September 2015) contains updates of vibrational temperatures useful for non-LTE study, but there are no changes in the microwindows selected for MIPAS retrievals.
  - o The remaining work consists in: to check if new CH_4 VTs are consistent with the MIPAS study, to revise H_2O NLTE, to revise the new non-LTE errors calculated by Anu Dudhia (OU) and to write a technical note.
- Piera Raspollini (IFAC) describes the status of the work on Level 2 Phase F project. She makes an overview of the activity plan with a description of the current status of the project.

- In particular, Anu Dudhia (OU) has to provide new LUTs on the basis of the new spectroscopic database v4.45; he is also requested to manually mask the line affected by large non-LTE errors and repeat the analysis of the error budget.
- One of the targets for the Mid Term Review is putting together all pieces of the pre-processor and ORM code; also it shall be decided which are the new species to be retrieved in V8 and starting testing them.

AI_L2_40.04: M. De Laurentis (IDEAS-ESA) to send information regarding the work environment of the pre-processor and the retrieval component library.
AI_L2_40.05: A. Dudhia (OU) to mask the lines with large residuals due to NLTE error identified by P. Raspollini (IFAC) and to repeat the analysis of the error budget.

Discussion on the Limb Workshop:

- Angelika Dehn (ESA) refers about the status of the Science Exploitation Plan WP of the MIPAS Level 2 Phase F project. The idea of the MIPAS Science Exploitation workshop has been revisited together with B. Bojkov and it has moved away from the MIPAS mission towards the inclusion of other limb instruments. The rationale behind this is to be in a better position to enable future funding after the MIPAS QWG Phase F project will finish in 2017. As it is more difficult to justify further funding for a non-operational mission like MIPAS, new concepts are being defined on ESA side currently that will still allow to continue working on historic data set improvements, including Level 1b. The outcome and recommendations from the Limb Expert meeting will therefore be an important input for the preparation of the next Ministerial conference foreseen at the end of year 2016, for which the new concepts need to be presented.
- Piera Raspollini (IFAC) comments that a feedback from John Remedios on the related document is expected by the end of the month.
- Discussion about Limb Expert Meeting with specific focus on content of the breakout sessions:
  - Hermann Oelhaf (KIT) doesn't understand the purpose of the workshop, the theme of the meeting. Angelika Dehn (ESA) answers that the purpose of the meeting is giving recommendations in order to define future implementation of dedicated working groups related to Limb sounders. In this context the focus is the elaboration and further improvement of existing data sets from the historic missions like MIPAS, GOMOS SCIAMACHY, but also the data from Third Party Missions, like MLS, ODIN etc.
  - Marco Ridolfi (UB) suggests a session on "forward and retrieval algorithms".
  - Hermann Oelhaf (KIT) comments that besides spectroscopy aspects, Level 1b issues are difficult to be discussed between people working with different instruments, as they have different configurations and constraints. It is instead OK to discuss how to combine Level 2 datasets.
  - John Remedios (UL) agrees with him that the main target should be to combine synergies on the scientific studies. The focus should be how to use the scientific products.
  - Bruno Carli (IFAC) adds some examples of discussions to be done during the workshop: for example a common agreement on the retrieval grid to be used between the different instruments: a user defined grid or the instrument grid? At the beginning of the MIPAS mission, after a long discussion, it was decided to retrieve species using the instrument grid, but then it was discovered not being the best

choice, because in that way comparison and synergies with other instruments is difficult.

- o John Remedios (UL) says this is a good topic and could be a very useful outcome of the workshop.
- o Bruno Carli (IFAC) suggests another example of topic: the assimilation of atmospheric data for the models must be done by radiances or profiles? There is the need to reach a common view on some basic topics.
- o Piera Raspollini (IFAC): "data fusion" of different mission and instruments could be another topic.
- o John Remedios (UL): another topic could be the definition of the cloud filtering.

- There is a final comment from Hermann Oelhaf (KIT) about the fact that modelling people seems to be missing in the list of key-players to be invited. This is agreed and was simply forgotten in the slide overview.