MERIS Products Quality Status Report
MEGS7.4 and IPF 5

Issue: Version 1.

Prepared by the MERIS Quality Working Group

1. Scope of the Document

This document reports the quality of the products processed by MEGS 7.4 processor or IPF 5 processor. MEGS 7.4 and 7.4.1 have been used for the 2st MERIS reprocessing. They are strictly identical in terms of products, the only differences being the values of some reference fields in the Products Headers. MEGS 7.4.1 and IPF 5 are equivalent.

2. Level 1

Radiometric quality:

The onboard calibration is performed at the orbital South Pole where diffuser plates are deployed by rotating a selection disk. The sun illuminates a characterised white diffuser plate inserted in the field of view and calibration coefficients are derived from the corresponding MERIS measurements. A second white diffuser plate is deployed every 3 months to monitor the degradation of the frequently used one. The diffuser plates have been fully characterized before launch (ref. 1 to 3) to an accuracy of better than 1%. A model (ref 5) was used to fit its geometrical dependency, with an accuracy of better than 1%. The cross calibration between the two plates indicates a slight ageing effect on the first panel, from less than 1% at 412 nm to none from 510 nm toward infrared (figure ?). The onboard calibration is used to equalize all the detectors. The analysis of the onboard calibration reveals that MERIS is very stable (ref. 4). Monitoring of the calibration coefficients shows a slow degradation of the instrument response in the visible up to 560 nm of 3% max at 412 nm (see e.g. MERIS Cyclic Report #45 at http://earth.esa.int/pcs/envisat/meris/reports/). This degradation with time is modelled to an accuracy of 0.5%. For more details, please refer to the EMRIS Instrument Calibration paper in the proceedings of MERIS/AATSR Validation Team Meeting of 2006, available on the ESA web site (http://envisat.esa.int/workshops/). The calibration coefficients are implemented in conjunction with the instrument degradation model applied on a continuous basis.

Vicarious calibration activities have been conducted as well. Absolute vicarious calibrations consist in the comparison of MERIS measured TOA radiances with others sources, including simulations and other instruments measurements. The onboard calibration only is used to produce the MERIS level1 radiances. Vicarious calibration results are used for validation purposes, and confirm the on board calibration both over dark ocean (ref. 6, 7 and 10) and over bright land (ref. 8 to 11) with the expected accuracy of such methods (between 2 to 6 percent according to the different authors).

Spectral calibration quality:

The spectral bands central wavelengths vary within the cameras field of view (< 1 nm) and in between cameras by up to 1.5 nm.. This so-called smile effect is present in the Level 1b product where all bands are calibrated with the exact spectral characteristics of each pixel. Any processing needed to minimise its impact on the geophysical products is performed in the Level 2 processing.

In order to minimize the overall spectral variations within the field of view, in particular in the blue, camera four was re-aligned electronically by one pixel (1.25 nm) toward the NIR . This was done at orbit 846 (29-Apr-2002), after analysis of the first in-flight spectral calibration data.

In order to achieve a better accuracy for the pressure retrieval, band 11, centred on the Oxygen absorption feature (761 nm), has been shifted by one pixel towards the NIR on 24-Dec-2002.

Geolocation quality:
Before the 12th of December 2003, the on-board law was not optimal. A degradation in the attitude was observed. That led to a slow degradation in the MERIS Geolocation. The mean error in the absolute geolocation was about 500 meters. The error was mainly in the across-track direction (440 meters). On 12th December 2003, the attitude onboard software change resulted in an immediate improvement of the geolocation to around 230 meters. An improvement of the MERIS pointing auxiliary data took place on January 2005 that further improved geolocation performance of standard products to less than 160 m. The report on the geolocation can be found at:
http://earth.esa.int/pcs/envisat/meris/documentation/

NB:
1. the coastline provided in the product is derived from a CIA database. The accuracy of this coastline is sometime rough, and therefore it can not be used to derived the precise MERIS geolocation accuracy.
2. geolocation information (longitude, latitude) provided at the Tie Points is determined at 0 altitude (WGS 84 ellipsoid surface). First order parallax corrections terms are provided to account for altitude through the longitude_correction and latitude_correction fields.

3. Level 2

3.1 Major changes with respect to IPF (Instrument Processing facility) v 4.10

Following the recommendations from various forums (Science Advisory Group, MERIS User Workshop, MERIS AATSR Validation Team (MAVT)), the MERIS Quality Working Group has decided to apply changes in the initial MERIS processing. Those changes have been implemented in the processor and associated auxiliary files. The complete archive of MERIS data (2002-2005) has been reprocessed. IPF 5.01 shall be in operations starting April 3rd 2006.

The chapter below describes at high level the changes performed.

- **Classification**:
  The classification at Level 1 is performed using a predefined land/sea mask. At Level 2, the data are re-classified using the pixel radiometry at two wavelengths (665 and 865 nm). The re-classification is now performed for each pixel over land. It allows to well classify the inland waters. The reclassification of a priori water pixel is still restricted to those close to the coastline (within 0.2 degrees).

- **Surface pressure:**
  The surface pressure P over Land is now retrieved through a polynomial expression of $\log(MP^2)$ instead of MP^2 as before, where M is the air mass.

- **Water Vapour:**
  The water vapour retrieval over water has been updated in order to account for Sea surface roughness through the wind speed.

- **Land branch:**
  - Land Aerosol Remote Sensing
    The Dense Dark Vegetation concept has been extended to less dark vegetation. A new set of look-up-tables has been generated including seasonal and geographical dependencies, the aerosol database has been extended and the cloud shadow is now screened out.
    Aerosol optical thickness over Land is now provided at 442 nm instead of 865 previously, i.e. where it is determined with maximum reliability.

  - MERIS Terrestrial Chlorophyll Index
    A new Vegetation Index has been added to the MERIS Products: the MTCI, derived from Rayleigh corrected reflectance at 681, 709 and 753 nm. It is stored in the BOAVI (Bottom of atmosphere vegetation index) field and replaces the former NDVI (normalised differential vegetation index).

- **Water branch:**
  - **water confidence checks:**
    A test at 412 nm was added to screen out the bright targets not classified as clouds. For more information see Nobileau et Antoine, 2005 (Ref 14).

    Statistical description of Sea surface roughness as a function of wind is taken from Ebuchi and Kizu, 2002 (Ref 15) instead of Cox and Munk 1956 (Ref 16) previously.

    Turbid Water Screening includes determination of a White Scatterer Flag identifying very bright waters.

  - **Atmospheric correction pre-processing above bright water:**
    The Bright Pixel Atmospheric Correction (BPAC) is now applied to all pixels.
    The CASE_2S flag has been modified. It is raised now when the BPAC is on and when the total backscatter in the near infrared is above a certain threshold.

  - **Atmospheric Correction above water:**
    The ATBD has been revised according to the changes described below. It can be found on-line at:
    [http://envisat.esa.int/instruments/meris/atbd/atbd_2_07.pdf].

    The aerosol database has been completely changed, according to recent publications and MAVT findings. It includes, in addition to the Maritime, Coastal and Rural families (Shettle and Fenn 1979, Ref 17), three families of Dust-like (absorbing) aerosols (Moulin et al, JGR, 2001, Ref 18) and the so-called Blue family of theoretical Junge distribution aerosols with steep spectral dependency of scattering.
    The atmospheric correction over ocean allows all aerosols except absorbing ones in the first pass. Absorbing aerosols are used in additional passes, **over**

Case 1 waters only, if triggered by a test on the water leaving reflectance at 510 nm as compared to a climatology.

- **Aerosol product (over water)**
  The Angstrøm coefficient replaces the Epsilon coefficient.
  The Angstrøm coefficient is defined as follow:
  alpha = log(AOT(779)/AOT(865)) / log(779/865)
  Aerosol optical thickness is (still) provided at 865 nm.

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- **Case 1 water processing:**
  The look-up tables accounting for the bi-directional effects of reflectance have been updated according to Morel et al. 2002, Ref 19
  The Algal-1 pigment index determination is now based on a single polynomial expression using the maximum band ratio among {ρ442/ρ560, ρ490/ρ560, ρ510/ρ560}, similarly to the OC4V4 algorithm.
  The corresponding ATBD is under revision (ATBD 9)

- **Case 2 water processing:**
  A new neural net has been trained with an optimised set of inherent optical properties based on MAVT measurements. The concentration range was extended to lower and higher concentration ranges. The net has been further trained to work also in cases when MERIS water leaving reflectances are below a reliable value or even negative.
  The Yellow Substance product is now coded on a logarithmic scale in the Level 2 product. This allows to provide high resolution at low values.
  The details are described in Doerffer and Schiller, 2006 [MERIS special issue of IJRS]

- **Flags:**
  The check on the solar zenith angle (> 70 deg) has been removed from all the PCD. This condition is now available as a science flag LOW_SUN.
  The flag ABSOA_CONT has been removed and is replaced by a new flag AODB (out of aerosol database) indicating that the spectral dependency of the actual aerosol could not be reproduced with the available set of models.
  The ABSOA_DUST flag is now raised only if an absorbing aerosol has been used in the atmospheric correction. In the previous processing, it indicated the potential of the existence of an absorbing aerosol.
  The CASE2_S flag is now indicating a sediment loaded Case 2 water. It is triggered if the total backscatter in the near infrared is above a certain threshold.
  A new flag BPAC_ON has been introduced which indicates that the atmospheric correction pre-processing over bright water has been activated. Note that in the current setting, this is the case for all water pixels (see above) so that this flag is raised everywhere.
  A new White Scatterer Flag, identifying very bright waters, has been added.
  The meaning of the DDV flag has been extended to include less dark vegetation and now indicates that an aerosol retrieval over land has been attempted (Land Aerosol Remote Sensing).
  The flag P_Confidence has been deleted.

3.2 Known problems

Despite the major improvement with respect to the IPF version 4.10, some problems are still present within this processor version.
The major problems are:

Water products:

1. Water leaving reflectance over Case I waters in the MERIS Level 2 products is overestimated in the blue and red parts of the spectrum. For more details, please refer to the proceedings of MERIS/AATSR Validation Team Meeting of 2006 that are available on the ESA web site (http://envisat.esa.int/workshops/)
2. In a coastal fringe approximately 10 km wide the atmospheric correction may be invalid due to adjacency effects.
3. Over Case-II waters the short wavelengths bands are sometimes overcorrected, leading partially to negative reflectances.
4. The cut-off reflectance for the Case II NN has been set to a constant value for all bands. For the red and NIR bands a cut-off does not cause problems, because it occurs mainly under case-1 water conditions, for which these bands are not needed. In contrast, if the cut-off is set in the blue bands due to high pigment and yellow substance absorption and an underestimation of the water reflectance, then these two components cannot be retrieved. However, these conditions, where band 1 or band 1 and 2 water leaving reflectances are above 0 but below the cut-off, are not flagged. The user does not get warning information about these pixels.

Land Products:

5. The AOT over Land provided in the re-processed data (MEGS 7.4 and 7.4.1) do not correspond to 442 nm as it should be but to 412 instead.

The table in chapter 3.3 will detail the quality status for each parameter:

3.3 Detailed status

Parameter	Quality				Comment
	Goal[1]	Source[2]	Status[3]	Date[4]	
Pixel Classification					
Land flag	Reclassification of uncharted inland waters and islands, tidal flats and correction of map	ATBD 2.17 Iss. 5 June. 2005	The reclassification is now performed over each land	13/03/06	The reclassification is based on the Level 2 radiometry that is corrected from Rayleigh and gaseous

[1] The accuracy that shall be achieved.
[2] The origin of the quality goal.
[3] Present status of quality
[4] Date of the present status

Parameter	Quality				Comment
	Goal[1]	Source[2]	Status[3]	Date[4]	
	inaccuracies		pixel using the radiometry. The inland waters are now well classified. There is no distortion by high glint.		absorption. Over land, at high altitude, this correction may be wrong introducing wrong classification (ex: Top of Hawai mountain classified as water).
Water flag	As land flag		As land flag	13.03.06	
Cloud flag (over ocean)	Detection of clouds		Thin clouds are hardly detected. Ice is often classified as cloud.	13.03.06	Separation of snow and ice from clouds does not work well. The purpose of this flag is to identify pixels which are useful for the cloud processing. In order to dismiss any cloudy pixel this flag should be used in complement with the ICE/HAZE flag that detects the thin clouds.
Cloud flag (over land)			Thin clouds are hardly detected.	13.03.06	Ice, snow often detected as clouds.
Pixel classification science flags					
Pressure confidence			no longer available in the product It has been reused for LOW_SUN	13.03.06	removed from the product
Low pressure			Validation on-going	13.03.06	It is raised mainly over clouds pixel.
Cloud parameters					
Surface reflectance 1-13	See L1b radiometry	QWG 25.9.03	over clouds simple conversion into TOA reflectances works well. Saturation in bands 779 and 865 can be observed – correctly flagged.	13.03.06	
PCD_1_13			OK	13.03.06	
Cloud top pressure (CTP)	20 hPa	ATBD 2.3, Iss 4.1 Feb 2000	Goal is reached over strato cumulus clouds. Other clouds need further validation. At low clouds camera transitions, with a step ~40	13.03.06	Validation campaign, e.g. with Lidar, has been performed. Further campaigns are required. The problem of camera interfaces still needs to be further investigated.

Parameter	Quality				Comment
	Goal[1]	Source[2]	Status[3]	Date[4]	
			hPa, can be observed. Algorithm overestimate Cloud Top Pressure below 200 hPa		
PCD_15			Ok	13.03.06	
Cloud albedo	accuracy of 0.01 albedo	ATBD 2.1, Iss 4.1 Feb 2000	Ok		The accuracy of the products is determined by the radiometric accuracy.
PCD_18			OK	13.03.06	
Cloud optical thickness	accuracy of 0.1 – 5.0 (worse with increasing OT)	ATBD 2.2, Iss. 4.2 Feb 2000	OK	25.06.04	
Cloud type			OK	13.03.06	Verification ongoing. It needs a statistically significant number of products.
PCD_19 (cloud opt. th. and type)			OK	13.03.06	
Water Vapour parameter					
Water vapour content (ocean)	Less than 20% rel. to WV. Over glint: 10%	ATBD 2.4, Iss 5.0 March 2005	OK. Agreement with ENVISAT-MWR shows bias of 0.05 and RMSE of 0.49 g/cm^2	13.03.06	Sharp transition can be observed over sun glint where S/W switches to land algorithms.
PCD_14 (ocean)			Ok	13.03.06	
Water vapour content (land)	10% relative. to WV amount		OK Agreement with GPS shows a bias of 0.03 and a RMSE of 0.17 g/cm^2	13.03.06	The water vapour products also show a good agreement when comparing with radio sounding, microwave radiometers or MODIS data.
PCD_14 (land)			OK	13.03.06	
Water vapour content (cloud)	Not specified in ATBD		OK	13.03.06	Pending validation
PCD_14 (cloud)			OK	13.03.06	
Ocean parameter					
Surface reflectance 1-13	Case1: accuracy 0.002 marine reflectance in the blue. Case2: accuracy 5%	ATBD 2.7 Iss 5 Dec. 2005 ATBD 2.6 Iss 4.1 Feb 2000	See numbers in section 3.2 A fringe of negative reflectances exists around most coastlines (Case 1 & 2) Overcorrection of the first 3 bands in Case-II water occurs sometimes. Reflectance at	13.03.06	The atmospheric correction above bright water in the Infra Red works well, however the extrapolation seems to overestimate sometimes the path radiance with decreasing wavelengths leading even to negative values at low reflectance. The negative reflectances next to the coast are probably due to adjacency effect.

Parameter	Quality				Comment
	Goal[1]	Source[2]	Status[3]	Date[4]	
			681 is not corrected for smile and may be affected diversely depending on the fluorescence activity. Reflectance at 709 is corrected for smile, however gaseous absorption correction does not account for smile, which may lead to erroneous values at low reflectance levels.		
PCD_1_13			OK	13.03.06	The PCD_1_13 is raised in most cases for good reasons: high sun glint or thin clouds (ICE_HAZE flag) are the cause in ~ 80% of the cases when PCD_1_13 is raised. In the coastal area due PCD_1_13 could be raised due to environmental effect.
Aerosol optical thickness	Accuracy 15% or 0.02 for moderate values (~0.1 – 0.2)	ATBD 2.7 Iss 5 Dec. 2005	Systematic overestimation with respect to Aeronet	13.03.06	Further validation required
Aerosol Angstrom coefficient (alpha)	Not specified in ATBD	ATBD 2.7 Iss 5 Dec. 2005	OK	13.03.06	
PCD_19 (aer. opt. th. and alpha)			OK	13.03.06	
Algal pigment index 1	Accuracy 10 classes per decade (~13%), covered range: 0.01 – 30 mg/m³ over Case1 waters	ATBD 2.9 Iss 4.2 Feb 2000 (under revision)	OK	13.03.06	Quantitative error accuracy assessment is on going.
PCD_15			OK	13.03.06	PCD15 is raised (among other reasons) if any of the reflectances used in the chlorophyll 1 retrieval is out of range (e.g. negative), which makes it less restrictive than PCD1_13.

Parameter	Quality				Comment
	Goal[1]	Source[2]	Status[3]	Date[4]	
Yellow substance	Depends on combination of YS, SPM and chlorophyll. See ATBD for details.	ATBD 2.12 Iss 4.0 Dec 1997 Complemented by Doerffer and Schiller 2006	Values are in the expected range. Quantitative error assessment not completed	13.03.06	Case2 algorithm uses band 1-7 and 9,which makes it more sensitive to PCD1_13. It is very important not to use the products when PCD17 is raised!
Total suspended matter			OK	13.03.06	PCD17 is often raised everywhere in Case1 waters, which is in agreement with the definition range for the algorithm.
PCD_16 (YS and TSM)				13.03.06	
Algal pigment index II			OK	13.03.06	
PCD_17			OK	13.03.06	
PAR	Accuracy +/- 3%	ATBD 2.18 Iss 4.0 Dec 1997		13.03.06	Validation is on going
PCD_18			See above.	13.03.06	
Ocean Science Flags					
Out of Aerosol Database			OK	13.03.06	
Absorbing Dust aerosol	.		OK	13.03.06	Investigation in progress. The dust aerosol flag is raised only when an absorbing aerosol has been actually used in the atmospheric correction
Case2_S			Ok.	13.03.06	The Case2S flag now indicates waters with a significant total backscatter in the IR Activation of the turbid water (=bright pixel) atmospheric correction is now indicated by the BPAC_ON flag.
Case2_anom			OK	13.03.06	Raised often in all water types . Should be further validated.
Case2_Y			Not activated	25.06.04	
Ice and haze			OK	25.06.04	This flag has been redefined and is now also triggered in case of thin clouds which are not correctable by the atmospheric correction.
Medium glint	Indicate atmospheric correction could still be possible, but accuracy can be degaraded	QWG 25.9.03	OK	25.06.04	Large portions of the images over water surfaces are affected by sun glint. Threshold for glint is based on simulated data.

Parameter	Quality				Comment
	Goal[1]	Source[2]	Status[3]	Date[4]	
High glint	Indicate that atmospheric correction cannot be performed with the claimed accuracy.	QWG 25.9.03	OK	25.06.04	Users should use the products with EXTREME CAUTION under medium glint conditions. The accuracy of the results in the medium glint are not validated. Users should NOT use data when the high glint flag is raised
BPAC_ON	Indicate that the Bright Pixel Atmosphere Correction was enabled		OK	13.03.06	Currently BPAC is turned on everywhere. By systematically turning it on sharp transitions are avoided. First order study showed that it is almost neutral in clear waters; a more in-deep study is on-going.
Land Parameter					
Surface reflectance 1-13			OK	13.03.06	Correction includes Rayleigh but not aerosol correction.
PCD_1_13			OK	13.03.06	Cloud shadows are not included in PCD1_13 but in TOAVI_WS
Aerosol optical thickness			AOT at 443 nm validated for non absorbing aerosols. Need confirmation with larger dataset	13.03.06	Rejection of clouds mandatory for further use. Good land water continuity of AOT. AOT bounded to 1.5
Aerosol Angstroem coefficient (alpha).			Not Validated	13.03.06	
PCD_19 (aer. opt. thk. and alpha)			OK	13.03.06	
TOAVI (MGVI)	Not specified in ATBD	ATBD 2.10 Iss 3.0 Nov. 2004	Algorithm expected accuracies: ± 0.05. The inter sensor comparison shows an absolute difference of 0.03.	13.03.06	
PCD_15			OK	13.03.06	
BOAVI (MTCI)	Not specified in ATBD	ATBD 2.22 Iss 1.2 Sep. 2005	OK	13.03.06	Validation on-going
PCD_17			OK	13.03.06	
Rectified reflectances			OK	13.03.06	
PCD_16			OK	13.03.06	
Surface pressure			Generally ok, but camera interfaces and	13.03.06	The problem of camera interfaces is further investigated.

Parameter	Quality				Comment
	Goal[1]	Source[2]	Status[3]	Date[4]	
			striping visible		
PCD_18			Ok	13.03.06	
Land Science Flags					
DDV (also known as LARS_ON, i.e. Land Aerosol Remote Sensing ON)			OK	13.03.06	The concept of DDV has been extended to less dark vegetation in order to increase the temporal and spatial extent, so that aerosol properties are retrieved over more pixels. In that sense the term DDV is abusive. This flag is also referred to as LARS = Land Aerosol Remote Sensing On.
TOAVI_Bright			OK	13.03.06	
TOAVI_Bad			OK	13.03.06	
TOAVI_CSI			OK	13.03.06	
TOAVI_WS			OK	13.03.06	
TOAVI_Invalid_Rec			OK	13.03.06	
Additional Flags				13.03.06	
Coastline			OK	13.03.06	Coastline is taken from a static map and not reclassified using radiometry. The accuracy of the current database is not optimum. It should not be used to precisely characterise the geolocation accuracy, which is known to be around than 200 m irrespective of the coastline flag information
Cosmetic			OK	13.03.06	
Suspect			OK	13.03.06	
LOW_SUN			OK	13.03.06	

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