



GSE – PROMOTE 2

C6 Validation Report

Total Ozone

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GMES SERVICE ELEMENT PROMOTE 2

C6 Validation Report


**Chapter 1
TOTAL OZONE SERVICE**

Version 3

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Version 3		
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LIST OF ABBREVIATIONS AND ACRONYMS

ACC	Anomaly Correlation Coefficient
CTM	Chemistry Transport Model
DLR	German Aerospace Centre
DOAS	Differential Optical Absorption Spectrometry
DWD	Deutscher Wetterdienst
ECMWF	European Centre for Medium-Range Weather Forecasts
FRESCO	Fast Retrieval Scheme for Cloud Observables
GOME	Global Ozone Monitoring Instrument
HDF	Hierarchical data format
KNMI	Royal Netherlands Meteorological Institute
MEDSUN	Mediterranean sun protection service
NRT	Near Real Time
OMF	Observation Minus Forecast
RIVM	Rijksinstituut voor Volksgezondheid en Milieu (National Institute of Public Health and the Environment, The Netherlands)
S5	Service Portfolio Specification Document
SCIAMACHY	SCanning Imaging Absorption spectroMeter for Atmospheric Cartography
SPARC	Stratospheric Processes and their Role in Climate (a WCRP core project)
SZA	Solar Zenith Angle
TEMIS	Tropospheric Emission Monitoring Internet Service
UV	Ultra Violet
WHO	World Health Organization
WMO	World Meteorological Organization

N/A	Not Available
n.a.	not applicable
n.s.	not specified



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1 TOTAL OZONE SERVICE VALIDATION

1.1 Service overview

PROMOTE-2 products dealing with ozone records, monitoring and forecast, are provided by two services: the Total Ozone Service, providing ozone columns (i.e. vertically integrated ozone concentrations), and the demonstration 3-D Ozone Service, providing ozone concentration profiles. Figure 1.1-1 shows the structure of the PROMOTE-2 Ozone services.

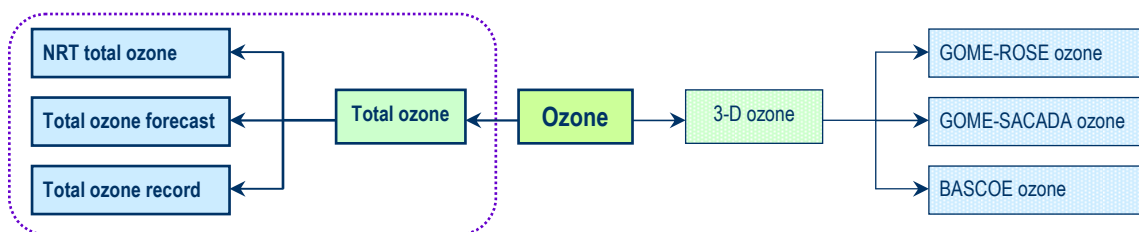


Figure 1.1-1. The Total Ozone service within the PROMOTE-2 Ozone theme

The Total Ozone service provides three products referred to by their unique identifiers as follows.

- GSE-PRO2-TO3-N: near real time ozone observations;
- GSE-PRO2-TO3-F: forecasts of ozone fields;
- GSE-PRO2-TO3-R: a long-term consistent global total ozone dataset obtained by assimilation of the available total ozone satellite datasets into a chemical transport model driven by meteorological analysis.

Contractual users of these products include the following.

- NRT total ozone: ECMWF – for assimilation in operational numerical weather prediction.
- Total ozone forecast: DWD – as input to their UV forecast service.
- Total ozone long-term records: RIVM – for their long-term UV analysis.

1.2 NRT Total Ozone Column [GSE-PRO2-TO3-N]


Description: This service provides NRT (i.e. within 3-9 hours) access to GOME, SCIAMACHY and OMI level-2 data. The total ozone column is retrieved from OMI, SCIAMACHY and GOME data by means of DOAS-type algorithms, namely, OMDOAO3 for OMI, TOSOMI for SCIAMACHY and GOFAP for GOME.

Service is/will be operational since: 2002

Research partners: none

Provider(s): KNMI

Validation contact: Ronald van der A (KNMI) and Marc Allaart (KNMI)

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1.2.1 Product Characterisation

PRODUCT CHARACTERISATION	
Near real time O₃ column	
Parameter	Vertically integrated ozone concentration
Typical range	90-500 DU (above 150 DU outside the Antarctic)
Determination of the typical range (Method, criteria)	Analysis of historical data
Maximum range	50-700 DU
Units	Dobson units (DU)
<i>Standards</i>	<i>none</i>

Table 1.2-1. Characterisation of the NRT Total Ozone Product


1.2.2 Validation plan and validation data

VALIDATION PLAN

Phase 1: The level 2 data from the near-real time algorithm was validated using ground-based observations. This level 2 data is retrieved from GOME and SCIAMACHY observations.

Phase 2: Comparison of OMI collection 3 ozone columns with ground data.

VALIDATION DATA	
Ground based observations	
Brewer/Dobson/ DOAS/SAOZ Phase: 1+2	Data availability and access: Access via WOUDC or NILU databases. Time period depends on station. Spatial coverage and resolution: More than 100 hundred locations over the world. Temporal coverage and resolution: Daily or weekly observations. Location(s) (coordinates): Global distribution of location Accuracy: about 1%
In-situ observations	none
n.a.	
EO Data	

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GOME-2	Data availability and access: via EUMETSAT UMARF system Spatial coverage and resolution: Global coverage Temporal coverage and resolution: Daily at 9.30 local time Orbits: all orbits Accuracy: about one percent
TOMS/SBUV Phase: 1+2	Data availability and access: via KNMI Spatial coverage and resolution: Global coverage Temporal coverage and resolution: Daily sampling Orbits: all orbits Accuracy: about one percent

Table 1.2-2. Data used for the validation of the products of the NRT Total Ozone Column sub-service

1.2.3 Validation of individual components

VALIDATION METHODS APPLIED


Phase 1: The level 2 data from the near-real time algorithm was validated using ground-based observations. This level 2 data is retrieved from GOME and SCIAMACHY observations.

The level 2 data quality depends on the quality of the level 1 data and FRESCO results. Therefore, the validation of these components is included.

First results of the validation can be found on the webpage of the ozone service http://www.gse-promote.org/services/ozone_nrt/index.html, the web page of FRESCO <http://www.temis.nl/fresco/> and for level 1 data on the SCIAMACHY validation page <http://www.sciamachy.org/validation/>.


Phase 2: The level 2 data has been compared to ground-based observations around the world. This comparison has been done for the complete period that OMI has made observations to identify possible trends in the results.

VALIDATION OF INDIVIDUAL COMPONENTS [GSE-PRO2-TO3-N]	
Uncertainty estimators	
Best estimator:	Bias or Mean offset
Error bar	RMS
Mean offset	Bias
Quality assessment	
DOAS quality checks	Range total ozone = [10, 900] Solar zenith angle < 85 degree
Level-1 data sanity checks	Existence of spectra check Range satellite height = [700,900] km

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	Range earth radius = [6000,7000] km Range satellite latitude = [-90.,90.] degree Range satellite longitude = [-180.,180.] degree Range solar zenith angle = [10.,180.] degree Range solar azimuth angle = [-360.,360.] degree Range viewing zenith angle = [-40.,40.] degree Range viewing azimuth angle = [-360.,360.] degree
DOAS fitting precision quantification	Convergence check
MODELS/ASSIMILATION TOOLS	
ECMWF Temperature fields (operational version)	Temperature correction of the ozone cross-sections
RETRIEVALS	
FRESCO+ Cloud information Version SC-v5	Correction of the amount of ozone below the clouds Cloud fraction and cloud pressure (see documentation/references on http://www.temis.nl/fresco/)
OMI total O ₃ OMDOAO3 v.3	RMS = 9.4 DU: collocated ground data (Allaart et al., in preparation) Mean offset = -1.2 DU; collocated ground based data (Allaart et al, in preparation) <u>Degradation = -0.36 DU / year since 2004</u>
TOSOMI total O ₃ version 0.43	RMS = 9.8 DU: collocated ground data (Allaart et al., in preparation) Mean offset = -1.8 DU; collocated ground based data (Allaart et al, in preparation) <u>Degradation = +1.04 DU / year since 2000</u>
GOME-FD total O ₃ v1.0 (GOFAP)	Total ozone columns based on EGOI data (see documentation on http://www.gse-promote.org/services/ozone_nrt/index.html)

Table 1.2-3. Validation of the individual components of the NRT Total Ozone Column sub-service

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1.2.4 Validation against service specifications and against user requirements

*Requirements written in *italics* were not compulsory in Phase 2.

VALIDATION AGAINST SERVICE SPECIFICATIONS & USER REQUIREMENTS [GSE-PRO2-TO3-N]			
SPECIFICATION	S5	REQUIRED*	ACTUAL
Product	O ₃ column: Ozone column level-2 product based on SCIAMACHY and GOME observations		
Accuracy			
Uncertainty	~2% for SZA < 75°	-	~2%
Uncertainty minimum	n.s.	< 10%	< 5 %
Uncertainty target	n.s.	n.s.	1 %
Spatiotemporal characteristics			
Spatial coverage	Global, swath 2800 km (OMI), 960km (SCIAMACHY), 14 orbits per day	Global	Global, swath 2800 km (OMI), 960km (SCIAMACHY), 14 orbits per day
Horizontal resolution	Mostly 13x24 km, depending on instrument, latitude and viewing angle	100 x 100 km ² (after provider) << 25x25 km ²	Mostly 13x24 km, depending on instrument, latitude and viewing angle
Vertical resolution	n.a.	n.a.	n.a.
Grid/Projection	Orbits	n.s.	Orbits
Temporal coverage	Global in 1 day	n.s.	Global in 1 day
Temporal resolution	n.s.	n.s.	n.s.
User Interfaces			
PROMOTE Web	Operational complete and up to date	Operational complete and up to date	Operational, complete and up to date
ftp	Operational	Operational	Operational
On demand	n.s.		
Data formats and data delivery			



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Data availability	Operational implementation based on SCIAMACHY measurements since early 2004	n.s.	Operational implementation based on SCIAMACHY measurements since early 2004
Data access	On line access within few hours after measurement	On line access within few hours after measurement	On line access within few hours after measurement
Delivery Mode	NRT	NRT	NRT, 3 to 9 hours after observation, depending on location
Delivery frequency	n.s.	n.s.	Per orbit. , 3 to 9 hours after observation
Data Format	HDF, ascii	ascii	HDF, ascii
Historical archive	Ozone column retrievals available online	n.s.	Historical ozone column data available online
Visualization	GIF Global images	n.s.	GIF Global images
REMARKS			
None			

Table 1.2-4. Validation against specifications and against user requirements of the SCIAMACHY and GOME Ozone column (NRT Total Ozone Column sub-service)


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1.2.5 Quality assessment and control procedures

*Requirements written in *italics* were not compulsory in Phase 2.

QUALITY ASSESSMENT AND CONTROL PROCEDURES				
Service delivery start date:				
SPECIFICATIONS	S5	REQUIRED*	ACTUAL	N checks/Delivery period
Quality checks	DOAS Quality Checks, level 1 data sanity tests	n.s.	DOAS Quality Checks, level 1 data sanity tests	Phase 3: For each observation/ per orbit
Product confidence interval	n.s.	n.s.	unknown	n.a.
Error bar definition and representation	RMS	<i>Total error; 1 sigma error bar per sample</i>	Total error; 1 sigma error bar per sample	Phase 3: For each observation/ per orbit
Representation of missing data	Indicated in the browse menus	n.s.	Indicated in the browse menus	n.a.
Documentation of process failure	DOAS Quality Checks, level 1 data sanity tests	n.s.	Major periods (more than 2 days) are directly communicated by e-mail	No process failure in Phase 2 One period of process failure has been reported in phase 3
Version control mechanisms and representation	CVS has been used for software version control. Updates of the software is communicated with a change history document on the web.	<i>Numbering scheme to be defined in the Product Specification Document</i>	CVS has been used for software version control. Updates of the software is communicated with a change history document on the web.	N/A

Table 1.2-5. Quality assessment and control procedures for the NRT Total Ozone Column sub-service

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1.3 Total Ozone Forecast

Description: Up to 9 days (medium-range) forecasts of the total ozone distribution. Forecasts are started from ozone analyses based on SCIAMACHY and OMI near-real time ozone columns (See Section 1.2 [GSE-PRO2-TO3-N])

Service is/will be operational since/after: February 2004

Research partners: none

Provider(s): KNMI

Validation contact: R. J. van der A

1.3.1 Product Characterization

PRODUCT CHARACTERISATION	
O₃ column forecast	
Parameter	9-day forecast of the total ozone field
Typical range	90-500 DU (above 150 DU outside Antarctica)
Determination of the typical range (Method, criteria)	Analysis of historical data
Maximum range	50-700 DU
Units	Dobson units
<i>Standards</i>	<i>none</i>

Table 1.3-1. Characterization of the products of the Total Ozone Forecast sub-service


1.3.2 Validation Plan and Validation Data

VALIDATION PLAN

Phase 1-3: For this product only the forecast abilities will be tested, since the ozone product itself is already validated within the total ozone records. The forecasts will be validated by comparison between forecast for n days with the analysis made with the actual observations. For this the anomaly correlation coefficient as function of time will be analysed.

The ACC is the correlation between the forecast (f) and analysed (a) deviations from climatology (c).

The ACC is defined as
$$\frac{(a - c)(f - c)}{(a - c)(f - c)}$$

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The ACC can be regarded as a skill score with reference to the climatology.


The ACC is sensitive to similarities in forecasts and analysed patterns, rather than their absolute values. In contrast to RMSE the ACC has a tendency to score large and "good" values during meridional flow situations, small and "bad" values during periods of predominantly zonal flow. This is particular the case in zonal situations when the forecast and observed positions of shallow waves are out of phase. ACC displays a weaker seasonal and annual variability than RMSE.

It has been found empirically that the level ACC=60% corresponds to the limit where the forecast does not exhibit any significant synoptic skill. It can be shown mathematically that ACC=50% corresponds to a categorical forecast for which the RMSE score is equally to a climatological statement.

This ACC will strongly depend on the ACC of the meteorological information from ECMWF used in the forecasts.

VALIDATION DATA	
EO Data	
SCIAMACHY Phase: 1+2	Data availability and access: since August 2002 via KNMI Spatial coverage and resolution: Global coverage Temporal coverage and resolution: Daily at 10.00 local time Orbits: all orbits Accuracy: about one percent
OMI Phase: 1+2	Data availability and access: via KNMI Spatial coverage and resolution: Global coverage Temporal coverage and resolution: Daily at 13.30 local time Orbits: all orbits Accuracy: about one percent

Table 1.3-2. Data used for the validation of the Total Ozone Forecast sub-service

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1.3.3 Validation of individual components

VALIDATION OF INDIVIDUAL COMPONENTS [GSE-PRO2-TO3-F]	
Uncertainty estimators	
Observation minus Forecast	OmF=Observation minus Forecast
Error bars	RMS
Quality assessment	
TM3-DAM forecast minus analysis for 9 days	Forecast (day n) – Analysis (day 0) Anomaly Correlation Coefficient (<i>Eskes et al., ACP, 2, 271, 2002</i>)
MODELS/ASSIMILATION TOOLS	
ECMFW (Wind, pressure, Temperature) operational version (OD)	Anomaly Correlation Coefficient
TM3-DAM (O ₃ Forecast) version 4.12	Bias (day = n) = Forecast (day n) – Analysis (day 0) Number of days with anomaly correlation > 0.6 (<i>Eskes et al., ACP, 2, 271, 2002</i>) for different regions in the world
RETRIEVALS	
TOSOMI (O ₃ Column) version 0.42	See total ozone record.

Table 1.3-3. Validation of the individual components of the Total Ozone Forecast sub-service



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1.3.4 Validation against specifications and against user requirements


*Requirements written in *italics* were not compulsory in Phase 2.

VALIDATION AGAINST SERVICE SPECIFICATIONS & USER REQUIREMENTS [GSE-PRO2-TO3-F]			
SPECIFICATION	S5	REQUIRED*	ACTUAL
Parameters	Daily ozone analysis based on SCIAMACHY observations Ozone forecasts for days 1-9		
Accuracy			
Uncertainty	2D accuracy fields, typically ~3%	-	n.a. Anomaly correlation as function of time is here the only useful parameter
Uncertainty minimum	n.s.	5%	n.a.
Uncertainty target	n.s.	≤ 2%	n.a.
Spatiotemporal characteristics			
Spatial coverage	Global	Global	Global
Horizontal resolution	1° Lat. x 1.5° Long.	<i>Minimum: 2.8° Lat. x 2.8° Long.</i> <i>Target: < 50 Km for lower troposphere</i>	1° Lat. x 1.5° Long.
Vertical resolution	n.s.	n.s.	35 layers
Grid/Projection	Lat-long, various projections possible	<i>Lat-long, T42</i>	Gridded on 1° x 1.5° grid cells
Temporal coverage	9 days	n.s.	9 days
Temporal resolution	Hourly	Daily	Hourly
User Interfaces			
PROMOTE Web	Operational, complete and up-to-date	Operational, complete and up-to-date	Operational, complete (includes link to NRT for data delivery) and up-to-date

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Data formats and data delivery			
Data availability	Operational implementation based on SCIAMACHY ozone measurements since February 2004	As long as possible, better if more than 20 years without gaps are included	Data is available
Data access	n.s.	Freely available and downloadable from website	Images available at PROMOTE web-site. Data is available via FTP.
Delivery Mode	NRT; Offline for reanalysis runs	<i>NRT Forecast</i>	NRT Forecast
Delivery frequency	Daily	n.s.	Daily
Data Format	ASCII, HDF	ASCII, HDF	ASCII, HDF
Historical archive	Global ozone analysis and forecasts since August 2002	n.s.	Global ozone analysis and forecasts since August 2002
Visualization	GIF Images for North and South Hemispheres and globe.	n.s.	GIF Images for North and South Hemispheres and globe.
REMARKS			
No remarks			

Table 1.3-4. Validation against specifications and against user requirements of the Total Ozone Forecast sub-service


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1.3.5 Quality assessment and control procedures

*Requirements written in *italics* were not compulsory in Phase 2.

QUALITY ASSESSMENT AND CONTROL PROCEDURES				
Service delivery start date: Phase 1				
SPECIFICATION	S5	REQUIRED*	ACTUAL	N checks/Delivery period
Quality checks	Routine monitoring of forecast production chain during working hours Overall performance of the ozone forecasting system is studied by a-posteriori comparison of the forecast with the corresponding verifying analyses	n.s.	Routine monitoring of forecast production chain during working hours	Phase 2: once a day (for working days)
Product confidence data	n.s.	n.s.	N/A	N/A
Error bar definition and representation	RMS	<i>Total error; 1 sigma error bar per sample</i>	Anomaly correlation	n.a.
Representation of missing data	n.s.	<i>n.s</i>	n.a.	n.a.
Documentation of process failure	n.s.	n.s.	N/A	none
Version control mechanisms and representation	n.s.	<i>Numbering scheme to be defined in the Product Specification Document</i>	CVS, Version in Product Specification Document and HDF metadata	N/A

Table 1.3-5. Quality assessment and control procedures for the final products of the Total Ozone Forecast sub-service.

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1.4 Total Ozone Records

Sub-service description: This service provides long-term daily records of assimilated ozone distributions from GOME-2, OMI, SCIAMACHY, GOME, SBUV and TOMS.

Service is/will be operational since/after: 2002, but has been completed in March 2009

Research partners: none

Provider(s): KNMI

Validation contact: Ronald van der A, Marc Allaart

1.4.1 Product Characterization

PRODUCT CHARACTERISATION	
O₃ column	
Parameter	Total ozone concentration (assimilated)
Typical range	90-500 DU (above 150 DU outside the Antartics)
Determination of the typical range (Method, criteria)	Analysis of historical data
Maximum range	50-700 DU
Units	Dobson units
<i>Standards</i>	<i>none</i>

Table 1.4-1. Characterization of the products of the Total Ozone Records sub-service

1.4.2 Validation plan and validation data


VALIDATION PLAN

For the total ozone records the OmF (Observation minus Forecast) and the OmA (Observation minus Analysis) will be analysed and the ozone data will be validated against ground-based data.

Data assimilation parameters

The OmF, OmA and the forecast error will be analysed as function of latitude, longitude, solar zenith angle, viewing angle, cloud fraction, surface albedo and the ozone column amount. Systematic biases will be identified.

Overlap period

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Ground-based data


Ground-based data will be used for the absolute validation of the assimilated fields similar as with the ozone level 2 data.

VALIDATION DATA	
Ground based observations	
Brewer/Dobson/ DOAS/SAOZ Phase: 1+2	Data availability and access: Access via WOUDC or NILU databases. Timeperiod depends on station. Spatial coverage and resolution: More than 100 hunderd locations over the world. Temporal coverage and resolution: Daily or weekly observations. Location(s) (coordinates): Global distribution of location Accuracy: about 1 percent
EO Data	
GOME-2, OMI, SCIAMACHY, GOME, SBUV, TOMS Phase: 1+2	Data availability and access via TEMIS portal, UMARF (EUMETSAT), and NASA DISC. Spatial coverage and resolution: Global coverage Temporal coverage and resolution: Daily Orbits: all orbits Accuracy: about 3 percent

Table 1.4-2. Data used for the validation of the Total Ozone Records sub-service

1.4.3 Validation of individual components

VALIDATION OF INDIVIDUAL COMPONENTS [GSE-PRO2-TO3-R]	
Uncertainty estimators	
Best estimator: Bias	Global bias between data assimilation results and ground observations
RMS	RMS
Quality assessment	
Ozone	Versus ground observations. As function of latitude, longitude, solar zenith angle, viewing angle, cloud fraction/pressure, total ozone amount, surface albedo.
OmF	OmF as function of time, latitude, longitude, solar zenith angle, viewing angle, cloud fraction/pressure, total ozone amount, surface albedo
Models	

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ECMFW (Wind, pressure, Temperature) version	N/A
Retrievals	
TOMS cloud information version 8	Cloud fraction and pressure (TOMS algorithm version 8)
FRESCO Cloud information, version SC-v5	Cloud fraction and pressure (Wang et al., 2006)
OMI Cloud algorithm OMCLDO2 version 1.0.1	Cloud fraction and pressure (Joiner et al., 2006)
GDP total O ₃ version 4.1	Total ozone level 2 from GOME (Balis, 2003)
TOSOMI (O ₃ Column) version 0.42	Total ozone level 2 from SCIAMACHY (Eskes et al., 2005)
OMDOAO3 total O ₃ version 1.0.1	Total ozone level 2 (Veefkind et al., 2006)
TOGOMI version .1.2	Total ozone level 2 from GOME (Valks et al., 2004)
SGP Version 3	Total ozone level 2 from SCIAMACHY (Lerot et al., 2009)
GOME-2	Total ozone level 2 from GOME-2
SBUV version 8	Total ozone level 2 from SBUV
TOMS version 8	Total ozone level 2 from TOMS

Table 1.4-3. Validation of the individual components of the Total Ozone Records sub-service

1.4.4 Validation against specifications and user requirements

*Requirements written in *italics* were not compulsory in Phase 2.

VALIDATION AGAINST SERVICE SPECIFICATIONS & USER REQUIREMENTS [GSE-PRO2-TO3-R]			
SPECIFICATION	S5	REQUIRED*	ACTUAL



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Parameter	30 Year record of ozone analysis based on ozone observations		
Accuracy			
Uncertainty	2D field	n.s.	N/A
Uncertainty minimum	n.s.	n.s.	n.s.
Uncertainty target	n.s.	<i>Enough to detect 1% variation trend in 10 years</i>	1 %
Spatiotemporal characteristics			
Spatial coverage	Global	Global	Global
Horizontal resolution	Two dimensional data sets on a 1 degree latitude by 1.5 degree longitude grid.	$< 25 \times 25 \text{ km}^2$	1° Lat. x 1.5° Long.
Vertical resolution	35 layers	n.a.	35 layers
Grid/Projection	n.s.	n.s.	1° Lat. x 1.5° Long.
Temporal coverage	1979-present	n.s.	1979-2008
Temporal resolution	6 hours	daily	6 hours
User Interfaces			
PROMOTE Web	Operational, complete and up-to-date	n.s.	Operational, complete and up-to-date
ftp	n.s.	n.s.	not foreseen yet
Data formats and data delivery			
Data availability	All available in 2007 Unique dataset by 2008-9	1979-present <i>Single records of more than 20 years</i>	1979 to 2008 continuous record
Data access	Through PROMOTE Web Site	<i>Freely available and downloadable from a website</i>	Through PROMOTE Web Site
Delivery Mode	Online/offline	Online/offline	Online/offline

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Delivery frequency	Daily	Daily	n.a.
Data Format	HDF	HDF	HDF
Historical archive	<i>product</i>	<i>product</i>	<i>product</i>
Visualization	GIF North, South Hemisphere and Global + IDL	GIF North, South Hemisphere, and Global + IDL	GIF North, South Hemisphere, and Global

Table 1.4-4. Validation against specifications and against user requirements of the Total Ozone Records sub-service

1.4.5 Quality assessment and control procedures

*Requirements written in *italics* were not compulsory in Phase 2.

QUALITY ASSESSMENT AND CONTROL PROCEDURES				
Service delivery start date: Phase 1				
SPECIFICATION	S5	REQUIRED*	ACTUAL	N checks/Delivery period
Quality checks	n.s.	n.s.	Visual check of results	N/A
Product confidence data	n.s.	n.s.	N/A	N/A
Error bar definition and representation	n.s.	<i>Total error; 1 sigma error bar per sample</i>	Error field of 1 sigma errors per grid cell	Phase 2: For each grid cell/ daily
Representation of missing data	Indicated in the browser	n.s.	Fill value	N/A
Documentation of process failure	n.s.	n.s.	N/A	N/A



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Version control mechanisms and representation	CVS used for software version control. Software updates are communicated with a change history document on the Web	<i>Numbering scheme to be defined in the Product Specification Document</i>	CVS used for software version control. Software updates are communicated with a change history document on the Web	n/a
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Table 1.4-5. Quality assessment and control procedures for the final products of the Total Ozone Records sub-service

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1.5 References

1.5.1 Electronic references and online data access paths

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http://www.gse-promote.org/services/ozone_nrt/index.html

http://www.gse-promote.org/services/ozone_forecast/index.html

<http://www.sciamachy.org/validation/>

<http://www.temis.nl/fresco/>

<http://www.knmi.nl/omi/research/product/Ozone/omdoao3.html>

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