



GSE – PROMOTE 2

**C6 Validation Report
Foreword & Final Audit**

REF : C6
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PAGE : 1 of 37

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TITLE:

GMES SERVICE ELEMENT PROMOTE 2

C6 Validation Report

**Foreword and final audit of PROMOTE service
validation**



GSE – PROMOTE 2

C6 Validation Report
Foreword & Final Audit

REF : C6
ISSUE : 1
DATE : 30.12.2009
PAGE : 2 of 37

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GSE – PROMOTE 2

**C6 Validation Report
Foreword & Final Audit**

REF : C6
ISSUE : 1
DATE : 30.12.2009
PAGE : 3 of 37

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GSE – PROMOTE 2

C6 Validation Report

Foreword & Final Audit

REF : C6

ISSUE : 1

DATE : 30.12.2009

PAGE : 4 of 37

LIST OF TABLES

Table 1.	Chapters of the PROMOTE C6 Validation Report.	11
Table 2.	New products in Phase 3.....	12
Table 3.	Products for which no Phase 3 validation record is available.	12
Table 4.	Products for which the validation record was unchanged in Phase 3.....	13
Table 5.	Product standard characteristics.	13
Table 6.	Products for which no evaluation reference is available.	15
Table 7.	Summary of product referenced evaluations performed.....	15
Table 8.	SLA compliance score of products evaluated on the basis of a small number of constraints.	19
Table 9.	Proportion of products achieving a score higher than 80%.	24
Table 10.	List of PROMOTE products and parameters.....	30



GSE – PROMOTE 2

C6 Validation Report

Foreword & Final Audit

REF : C6

ISSUE : 1

DATE : 30.12.2009

PAGE : 5 of 37

LIST OF FIGURES

Figure 1.	Overview of validation tasks, quality control mechanisms and feedback loops.	9
Figure 2.	PROMOTE 2 validation cycle.....	10
Figure 3.	Product modifications in Phase 3.	14
Figure 4.	Number of characteristic types assessed per product.	16
Figure 5.	Occurrence frequency of S5 specifications.	17
Figure 6.	Occurrence frequency of SLA requirements.	17
Figure 7.	Product score in terms of compliance with <i>a priori</i> specifications for Phases 2 and 3.	20
Figure 8.	Product score in terms of compliance with user requirements for Phases 2 and 3.....	20
Figure 9.	Agreement with <i>a priori</i> specifications (in number of products) for a total of 50 products.....	22
Figure 10.	Agreement with user requirements (in number of products) for a total of 50 products.	23
Figure 11.	Score of products evaluated jointly against <i>a priori</i> specifications and user requirements.	24
Figure 12.	Product full or partial compliance (joint evaluation).....	25
Figure 13.	Parameter name accuracy.....	26
Figure 14.	Parameter definition accuracy.	26
Figure 15.	Parameter name and unit consistency.....	27



GSE – PROMOTE 2

C6 Validation Report

Foreword & Final Audit

REF : C6

ISSUE : 1

DATE : 30.12.2009

PAGE : 6 of 37

LIST OF ABBREVIATIONS AND ACRONYMS

AQ	Air Quality
AUTH	Aristotle University of Thessaloniki
CERC	Cambridge Environmental Research Consultants
CGS	Carlo Gavazzi Space
DLR	Deutsches Zentrum für Luft- und Raumfahrt
DMI	Danish Meteorological Institute
DWD	Deutscher Wetterdienst
EPA	Environment Protection Agency
EU	Europe / European
FMI	Finnish Meteorological Institute
GAS	GMES Atmospheric Service
GMES	Global Monitoring for the Environment and Security
IASB-BIRA	Belgian Institute for Space Aeronomy
INERIS	Institut National de l'Environnement industriel et des Risques
INSPIRE	Infrastructure for Spatial Information in the European Community
KNMI	Koninklijk Nederlands Meteorologisch Instituut
NRT	Near Real Time
PROMOTE	PROtocol MOniToring for the GMES Service Element: Atmosphere
QA	Quality Assessment
QA/Val Office	Quality Assessment and Validation Coordination Office
RIU	Rhenish Institute for Environmental Research
SACS	Support to Aviation Control Service
SLA	Service Level Agreement(s)
TNO	The Netherlands Organisation
UV	Ultra-Violet
VITO	Vlaamse Instelling voor Technologisch Onderzoek




GSE – PROMOTE 2

C6 Validation Report
Foreword & Final Audit

REF : C6
ISSUE : 1
DATE : 30.12.2009
PAGE : 7 of 37

TABLE OF CONTENTS

DOCUMENT STATUS SHEET	2
DOCUMENT CHANGE RECORD	3
LIST OF TABLES	4
LIST OF FIGURES	5
LIST OF ABBREVIATIONS AND ACRONYMS	6
TABLE OF CONTENTS	7
VALIDATION REPORT – FOREWORD AND FINAL AUDIT	8
1 Foreword.....	8
1.1 Context and goals	8
1.2 Objectives	8
1.3 Method.....	8
2 Introduction to the C6 Validation Final Report	10
2.1 Report structure	10
2.2 Audit scope	11
2.3 Material.....	12
3 Validation summary and audit	13
3.1 Overall assessment	13
3.1.1 Product characteristics	13
3.1.2 Phase 3 achievements	14
3.2 Product validation against <i>a priori</i> specifications and user requirements	15
3.2.1 Products scoped	15
3.2.2 Constraints	15
3.2.3 Score definition	18
3.2.4 Limitations.....	18
3.2.5 Validation results.....	19
3.3 Terminology and units.....	25
3.3.1 Physical parameter names	25
3.3.2 Physical parameter definition	26
3.3.3 Units	27
4 Perspectives for the GMES Atmospheric Service (GAS).....	27
5 References.....	28
5.1 Electronic references and online data access paths	28
5.2 Bibliographic references.....	29
6 Annex - PROMOTE 2 products and parameters	30

	GSE – PROMOTE 2 C6 Validation Report Foreword & Final Audit	REF : C6 ISSUE : 1 DATE : 30.12.2009 PAGE : 8 of 37
---	--	--

VALIDATION REPORT – FOREWORD AND FINAL AUDIT

1 Foreword

1.1 Context and goals

A keystone in the implementation of the GMES Atmospheric Service (GAS), PROtocol MOniToring for the GMES Service Element Atmosphere (PROMOTE) [E 1] has developed seventeen lines of core and downstream services from prototype to operational stage, addressing five major topical areas of the GAS: atmospheric ozone, surface ultraviolet radiation, air quality, climate change and volcanic eruption monitoring in support to aviation control. Service validation was a crucial cross-cutting activity within PROMOTE 2 (November 2006 – December 2009) since it endeavoured to ensure the quality of the services delivered, established the founding basis of the validation methodology to be applied throughout the GAS and defined the key elements of the GMES data quality strategy.

1.2 Objectives

The PROMOTE coordinated service validation aimed at warranting

- the scientific quality of the data (i.e. the provision of an assessment of their degree of reliability);
- the fitness-for-purpose of the data;
- the fitness-for-purpose of the validation procedures applied to the data;
- the transparency and traceability of the data and of their validation procedures (i.e. the completeness, accuracy, intelligibility of the accompanying metadata and documentation);
- harmonisation of the validation procedures applied throughout the GAS;
- adequacy and sustainability of the distribution channels, frequency and format;
- compliance with applicable international standards and high level regulations, e.g. the INSPIRE Directive [E 2 to E 5].

1.3 Method

The underpinning thread to service validation, which allowed the above objectives achievement, was the PROMOTE C5 Validation Protocol [B 1], designed, refined and applied throughout the project duration. The Protocol identifies four validation areas corresponding to an ideal sequence of four stages of service development, as depicted in Figure 1 :

- (1) The *validation of individual components* documents the datasets, uncertainty estimators and algorithms used in generating the end product.
- (2) The *validation against specifications* evaluates to which extent the product fulfils the original plans of its designers, as stated in the S5 Service Portfolio Specifications [B 2].
- (3) The *validation against user requirements* assesses how closely the product meets the users' expectations, as formulated in the relevant SLA.
- (4) The *quality assessment and control* activity sets up routine procedures to guarantee the sustained quality of a service at operational stage.

The audit included in the present C6 Validation Report documents the service compliance with the C5 Validation Protocol [B 1].

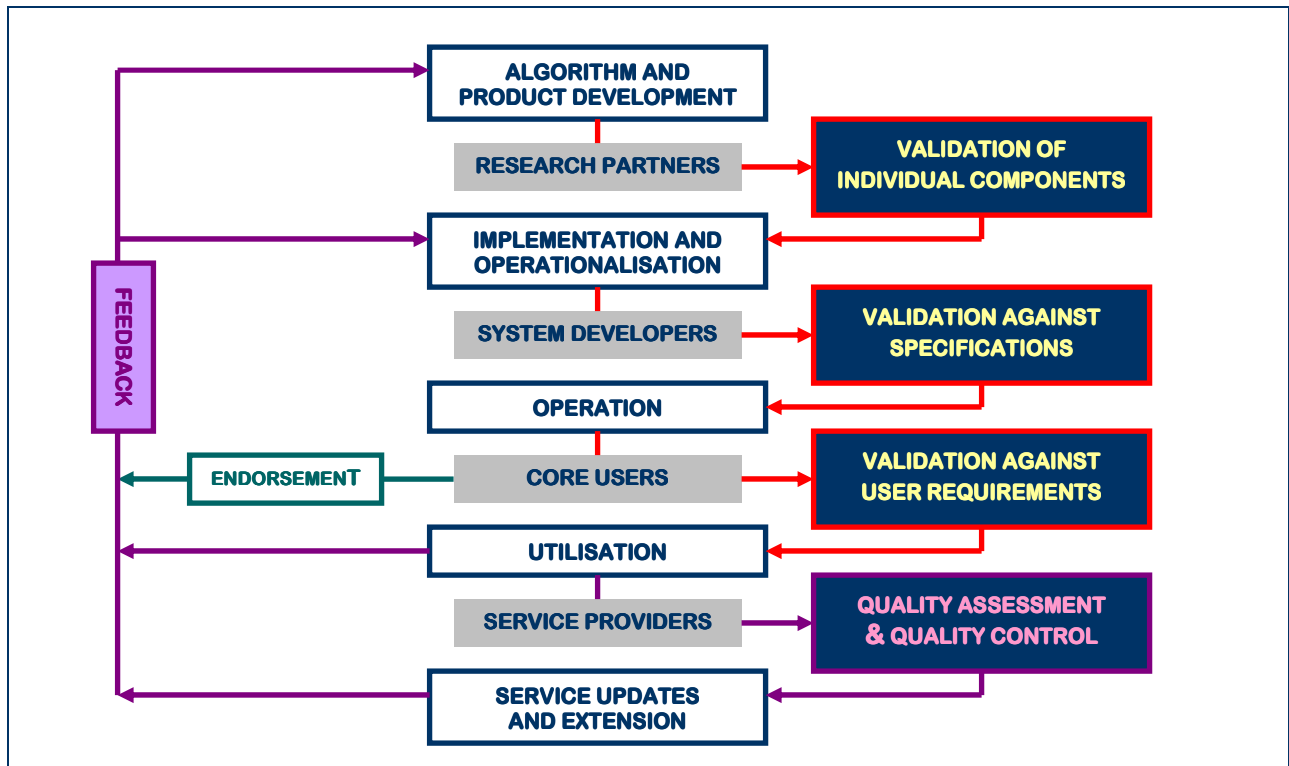


Figure 1. Overview of validation tasks, quality control mechanisms and feedback loops.

The first version of the C5 Validation Protocol [B 1] was issued at the start of the project by the Quality Assessment and Validation Office (QA/Val Office). The QA/Val Office was also in charge of coordinating service validation performed by the service leaders, collecting validation results recorded in the individual service validation reports and auditing the whole validation process, which was based on a one-year cycle, as summarised in Figure 2. An overall Validation Report (C6 PROMOTE Document) including an account of the validation status in the current phase was issued at the term of each of the three validation cycles of PROMOTE 2. The present document is the third and last of these Validation Reports. The C5 Validation Protocol [B 1] was also updated to take into account lessons learnt at the occasion of each validation iteration.

The adoption of a cyclic validation process had the following advantages.

- It favoured an informed tuning of the validation procedures by highlighting weak or insufficient elements of the method and allowing the design of remedies in the course of the project.
- It provided room for user - provider interaction and feedback, and time for iterative improvement of the services in terms of compliance with product specifications and user requirements.
- It allowed monitoring of the validation progress by measuring the service and service validation improvement from phase to phase.

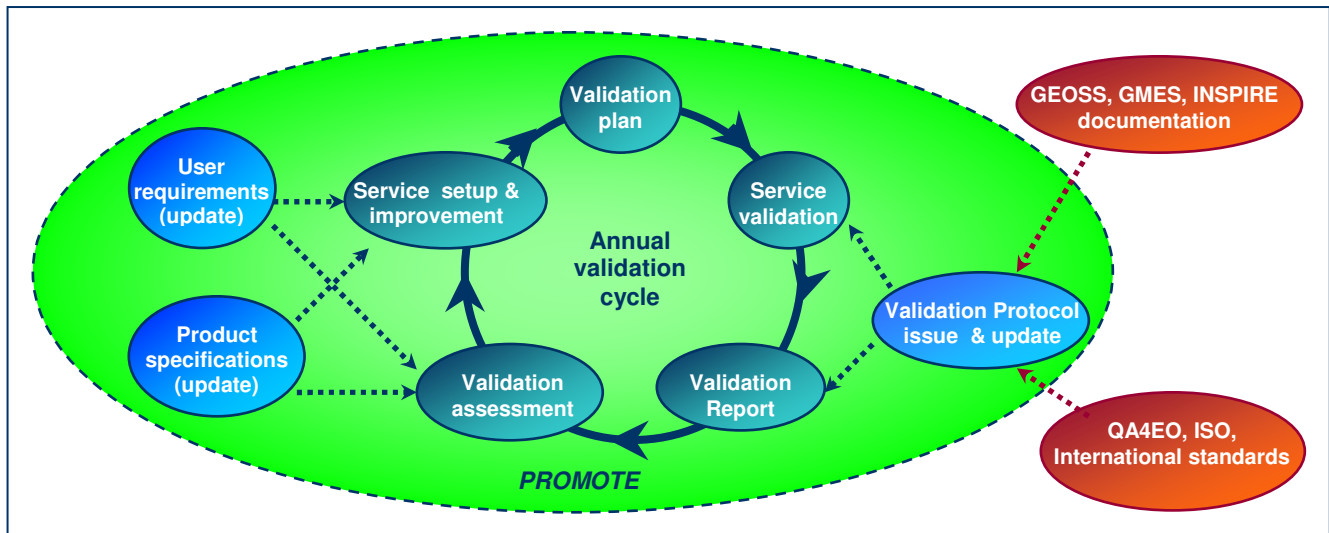


Figure 2. PROMOTE 2 validation cycle.

2 Introduction to the C6 Validation Final Report

2.1 Report structure

The final PROMOTE C6 Validation Report is the outcome of a common effort involving the product providers, service leaders, product users and the QA & Validation Office. It is made out of

- the current foreword and validation final audit,
- the introduction to the Phase 2 issue [B 3],
- sixteen independent chapters.

Each chapter corresponds to one service of the PROMOTE portfolio, as listed in Table 1. One service appearing in the portfolio, the “UV Forecast by DWD” PROMOTE associated service, did not take part to the validation process.

Electronic versions of the above introductions and chapters can be downloaded from the PROMOTE Validation website [E 6].

Within each chapter (or service validation report), products are described and validated according to the general principles and criteria stated in the C5 Validation Protocol [B 1]. For each of them, the information is divided into the following sections.

- (1) **Product characterisation.** Basic description of the product, including parameter name and unit, typical range, reference to applicable standards.
- (2) **Validation plan and validation data.**
- (3) **Validation of individual components.**
- (4) **Validation against *a priori* specifications and user requirements,** respectively referring to the S5 Service Portfolio Specifications [B 2] and the relevant provider-user SLA.
- (5) **Quality assessment and control procedures** applying to services in operation.



GSE – PROMOTE 2

C6 Validation Report Foreword & Final Audit

REF : C6
ISSUE : 1
DATE : 30.12.2009
PAGE : 11 of 37


Every of the above five sections includes a table template intended to record standard information about the product (see [B 3], Section 2, pp. 4-15), with the triple aim of harmonising, as far as possible, the procedures applied throughout the set of services, of allowing product inter-comparison (with notable limitations due to inherent differences, as underlined in Section 3.2.4) and of easing the evaluation of progress from phase to phase. Apart from minor modifications, the table templates used in Phase 3 were identical to the ones that had been fixed in Phase 2.

Table 1. Chapters of the PROMOTE C6 Validation Report.

PROMOTE theme	Chapter number	PROMOTE service	Abbreviation used in this document
OZONE	1	Total Ozone	OZ-Column
	2	Three-dimensional Ozone	OZ-Profile
ULTRA-VIOLET	3	UV Information	UV-Info
	4	Long-term Multisensoral UV Record	UV-Record
	5	UV Service for Greenland	UV-Greenland
AIR QUALITY	6	Air Quality Record	AQ-Record
	7	European Platform for Integrated AQ Analysis and Forecast	AQ-EUPlatform
	8	Regional AQ Forecast	AQ-RegForecast
	9	Local AQ Forecast	AQ-LocForecast
	10	Urban and regional AQ Assessment	AQ-Assessment
	11	Satellite-Based Particulate Matter Demonstration	AQ-SatPM
	12	Desert Dust Awareness	AQ-DesertDust
	13	Pollen Observation and Forecast	AQ-Pollen
CLIMATE STUDY	14	Tropospheric Aerosol and GHG	CS-Tropo
	15	Stratospheric Aerosol and Gas	CS-Strato
AVIATION	16	Support to Aviation Control	AV-SACS

2.2 Audit scope

Like its previous issue [B 3], the present final audit focuses (Section 3.2) on the product compliance with *a priori* specifications as recorded in the S5 Service Portfolio Specifications [B 2] and with the user requirements as formulated in the relevant user-provider SLA, which constitutes, however with some reservations (see Section 3.2.4 below), the measurable part of the validation exercise. A key outcome of the Phase 2 C6 Introduction [B 3] was an evaluation of the progress made in this respect during Phase 2 by the twenty products that already existed in Phase 1, as far as the applied criteria (which had evolved from Phase 1 to Phase 2) were comparable. Likewise, this final audit includes an assessment of the evolution of the 45 Phase 2 products during Phase 3 in terms of agreement with *a priori* specifications and user requirements, this time based on the same set of standard specifications. However, in order to

	<p align="center">GSE – PROMOTE 2</p> <p align="center">C6 Validation Report</p> <p align="center">Foreword & Final Audit</p>	REF : C6 ISSUE : 1 DATE : 30.12.2009 PAGE : 12 of 37
---	--	---

disentangle the various factors that have contributed to this evolution, the product progress is first assessed by itself, with no reference to the S5 Service Portfolio Specifications [B 2] or the applying SLA (Section 3.1).

Another focus of the audit which follows (Section 3.3), which was not examined in the previous C6 issue [B 3], is the accuracy of variable names, definitions and units as reported in the first section (*Product Characterisation*) of each service report.

2.3 Material

The current report is based on the input from the leaders of the services listed in Table 1. By the end of PROMOTE Phase 3, the 16 considered services were providing some 161 parameters grouped into 50 products, as listed in the Annex (Table 10). In what follows, product and parameter numbers refer to Columns 3 and 6 of Table 10.

Five products were absent or embryonic in Phase 2 (see Table 2), bringing down to 45 the number of products assessed in Phase 2.

Table 2. New products in Phase 3.

Service		Product	
8	AQ-RegForecast	AQ Forecast for Bavaria	19
9	AQ-LocForecast	AQ Forecast for Portugal - AirCast Level 2	26
10	AQ-Assessment	AQ Record for Portugal - AirCast Level 2	34
15	CS-Strato	Stratospheric Aerosol Extinction	46
		Stratospheric Aerosol Optical Depth	47

On the other hand, two services, AQ-EUPlatform and AQ-DesertDust, did not provide a validation report in Phase 3 (the corresponding chapters include their Phase 2 reports). Consequently, their product performance in terms of agreement with *a priori* specifications and user requirements was not assessed for this last phase. This was also the case of the “AQ Forecast for Denmark” product, for which no information was provided in the relevant service report (AQ-RegForecast). Products in this situation are listed in Table 3.

Table 3. Products for which no Phase 3 validation record is available.

Service		Product	
7	AQ-EUPlatform	Integrated EU platform for AQ analysis	15
		Integrated EU platform for AQ forecast	16
8	AQ-RegForecast	AQ Forecast for Denmark	21
12	AQ-DesertDust	Desert Dust Iberian Peninsula	37
		Desert Dust Italian Peninsula	38

Finally, some product or service providers signalled that validation had been completed as well as possible in Phase 2, or did not update their Phase 2 validation results in Phase 3 for any other reason. Products known to be in that situation are listed in Table 4. Their Phase 3 performance in terms of agreement with *a priori* specifications and user requirements was assessed based on their Phase 2 record.

Table 4. Products for which the validation record was unchanged in Phase 3.

Service		Product	
3	UV-Info	UV Check	7
9	AQ-LocForecast	YourAir & AirTEXT	29
16	AV-SACS	Global tropo SO ₂	49
		SACS	50

3 Validation summary and audit

3.1 Overall assessment

3.1.1 Product characteristics

Every product validation report includes a list of standard characteristics which, compared to the corresponding *a priori* specifications and user requirements, will provide (see Section 3.2.5 below) a notion of how closely the product meets its designers' and users' expectations. In general, only a subset of these standard characteristics applies to a single product. The complete set of characteristics considered is listed in Table 5, where they are grouped into six specification categories numbered A to F.

Table 5. Product standard characteristics.

A. Accuracy	
1	Uncertainty estimators (definition and values)
B. Spatiotemporal coverage and resolution	
2	Spatial coverage
3	Horizontal resolution
4	Vertical resolution
5	Type of 2D projection
6	Temporal coverage
7	Temporal resolution
C. Data completeness and availability	
8	Data continuity and flow
9	Growth, maintenance and availability of historical archive
D. Delivery	
10	Distribution channels and access conditions
11	Operational distribution by FTP
12	On demand data or service delivery
13	Warning system
14	Delay between data production and delivery
15	Delivery schedule and frequency
E. Documentation and communication	
16	Reference to specific applicable standards
17	Use of specific languages
18	Status of PROMOTE service webpage
19	Use of specific external website
F. Formats and support facilities	
20	Data, image and documentation formats
21	Data subsetting tools
22	Graphic visualisation tools
23	Helpdesk



GSE – PROMOTE 2

C6 Validation Report

Foreword & Final Audit

REF : C6

ISSUE : 1

DATE : 30.12.2009

PAGE : 14 of 37

3.1.2 Phase 3 achievements

Over a total of 40 products for which Phase 3 validation results could be compared to Phase 2, improvements in the six areas defined in Table 5 have been achieved by 21 products, as shown in Figure 3, where one unit on the y axis indicates a change in one of the Table 5 characteristics (a positive change witnesses a product upgrade, a negative change a product downgrade). Four products with positive changes also had one downgraded characteristic. The remaining 19 products (among which the 4 products listed in Table 4) did not report any change in any of the standard characteristics. Figure 3 shows that, based on the information collected, PROMOTE products went through an overall improvement from Phase 2 to Phase 3.

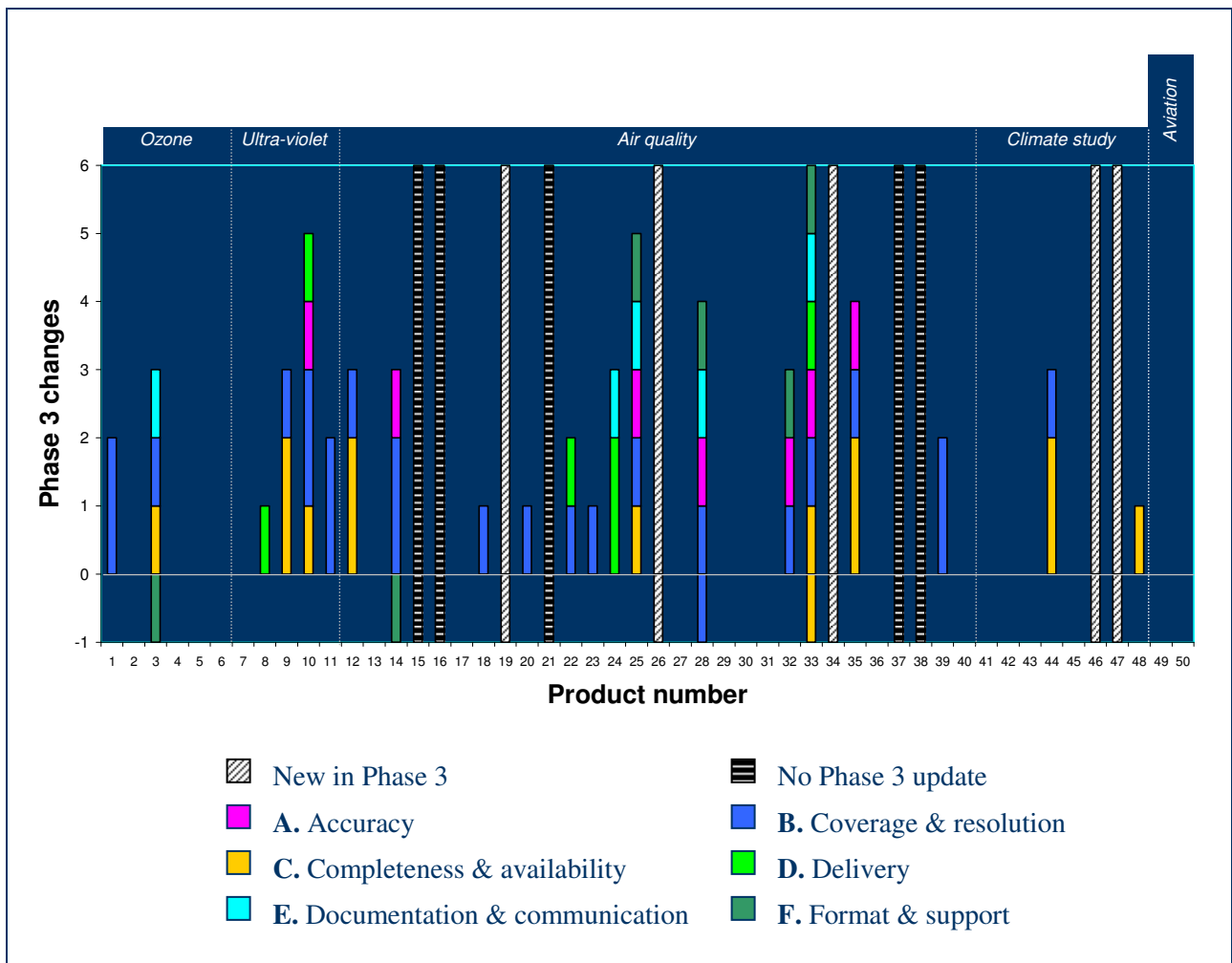


Figure 3. Product modifications in Phase 3.

3.2 Product validation against *a priori* specifications and user requirements

3.2.1 Products scoped

In addition to gaps corresponding to the products listed in Table 2 (not assessed for Phase 2) and in Table 3 (not assessed for Phase 3), product evaluations listed in Table 6 were not performed due to the absence of one reference set of constraints (i.e., *a priori* specifications or user requirements).

Table 6. Products for which no evaluation reference is available.

Phase	Missing reference	Service		Product	
2	<i>A priori</i> specifications	8	AQ-RegForecast	AQ Forecast for Denmark	21
	SLA				
	SLA	15	CS-Strato	BASCOE H ₂ O & CH ₄	48
SLA					
3	SLA	8	AQ-RegForecast	AQ Forecast for Bavaria	19

Combining together the information recorded in Table 2, Table 3 and Table 6, Table 7 provides a summary of the assessments performed for each product.

Table 7. Summary of product referenced evaluations performed.

Products	Phase 2		Phase 3	
	S5	SLA	S5	SLA
21 - AQ Forecast for Denmark				
19 - AQ Forecast for Bavaria			✓	
48 - BASCOE H ₂ O & CH ₄	✓		✓	
26 - AQ Forecast for Portugal - AirCast Level 2			✓	✓
34 - AQ Record for Portugal - AirCast Level 2			✓	✓
46 - Stratospheric Aerosol Extinction			✓	✓
47 - Stratospheric Aerosol Optical Depth			✓	✓
15 - Integrated EU platform for AQ analysis	✓	✓		
16 - Integrated EU platform for AQ forecast	✓	✓		
37 - Desert Dust Iberian Peninsula	✓	✓		
38 - Desert Dust Italian Peninsula	✓	✓		
Remaining 39 products	✓	✓	✓	✓
Number of products assessed (over a total of 50):	44	43	45	43

3.2.2 Constraints

As stated above, the set of 23 standard characteristics of Table 5 does not usually apply in its entirety to any given product (for example, vertical resolution is of no relevance to a surface dataset, etc.). When comparing actual product characteristics to *a priori* specifications or user requirements, this set is even further reduced by the removal of specification types which, although potentially applicable, are not



GSE – PROMOTE 2

C6 Validation Report

Foreword & Final Audit

REF : C6

ISSUE : 1

DATE : 30.12.2009

PAGE : 16 of 37

subject to any particular requirement. This is particularly marked for user requirements, less systematic and complete than original S5 product specifications, which themselves do not necessarily cover all components describing a specific product.

As shown in Figure 4, no more than 15 characteristic types per product are constrained by either the S5 Service Portfolio Specifications [B 2] or the SLA, with a Phase 2 average of 11.8 characteristics per product when referring to the S5 Specifications and of 8.9 when referring to the relevant SLA. The discrepancy was partially compensated in Phase 3, which saw a stronger increase in the number of user requirements than in the number of S5 specifications, bringing the average per product up to 12 for the S5 specifications and 10.7 for the SLA requirements. In the case of the S5 specifications, the slight increase in numbers is essentially due to the supply in new products, which happens to overbalance the abandon of some Phase 2 products in the evaluation process, while the significant increase in the average number of SLA requirements is essentially related to the requirement upgrade that took place in Phase 3, a facet of which being that some requirements formulated in Phase 2 only became mandatory in Phase 3. The latter not only affected the number of requirements per product, as is visible in Figure 4, but also enhanced the requirement degree (e.g., a finer resolution could be required, etc.). It should be noted furthermore from Figure 4 that, when validated against SLA requirements, a few products (namely *GOME SACADA Ozone Profiles*, *Ozone and UV Time Series* and *Italian Peninsula Desert Dust*) had to be assessed on the basis on a very small number (2, 4, 5) of constraints.

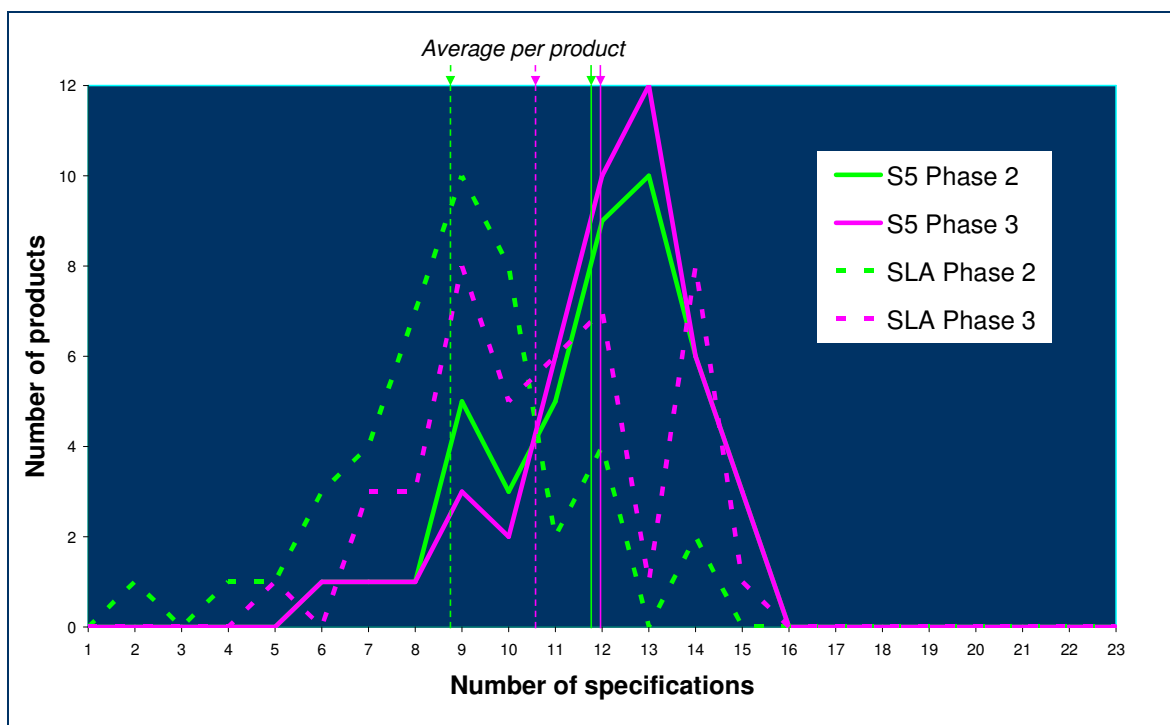


Figure 4. Number of characteristic types assessed per product.

The difference between the ways in which the S5 Specifications and the SLA constrain the products is made even more apparent by comparing Figure 5 and Figure 6, which show the number of products submitted to any given type of requirement, from the S5 Specifications and the SLA respectively, in the PROMOTE last two phases. For one given characteristic type, the number of products subject to some a

priori specification is generally larger than the number of products subject to an equivalent user requirement, and the number of products to which a constraint type applies is more variable in the case of the user requirements than in the case of the S5 Specifications, which partly denotes the diversity of users' interests and competences. Figure 6 also translates, in terms of number of products subject to constraints, the important Phase 3 upscale of user requirements with respect to Phase 2.

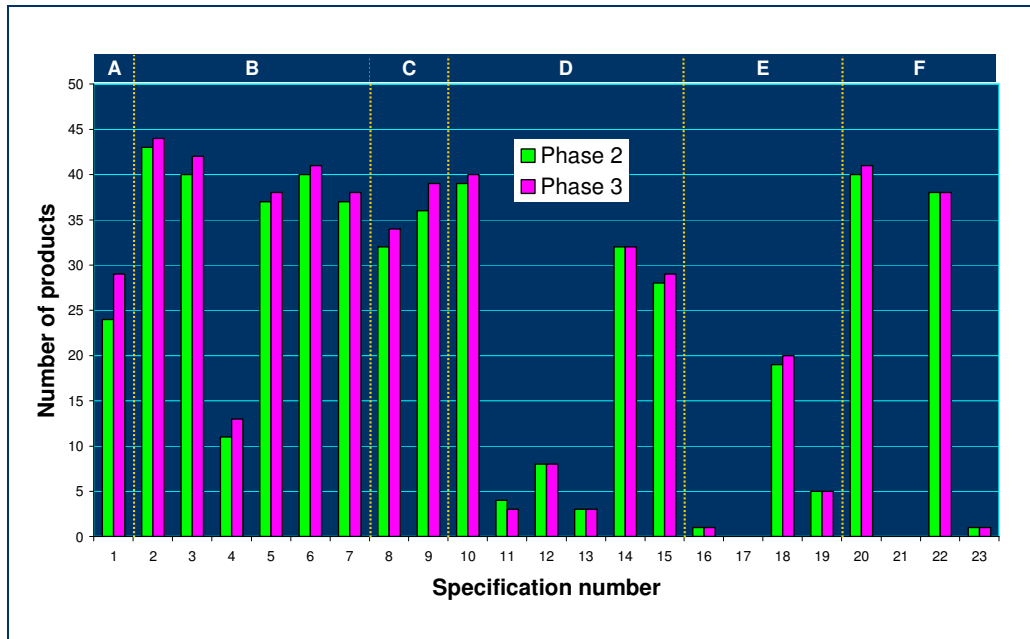


Figure 5. Occurrence frequency of S5 specifications.

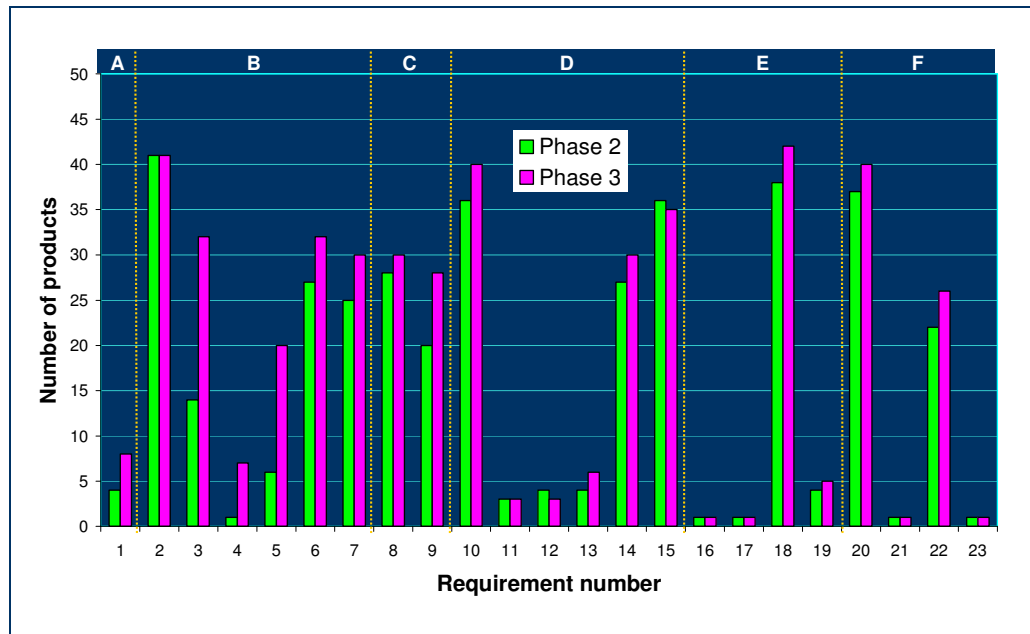



Figure 6. Occurrence frequency of SLA requirements.

	GSE – PROMOTE 2 C6 Validation Report Foreword & Final Audit	REF : C6 ISSUE : 1 DATE : 30.12.2009 PAGE : 18 of 37
---	--	---

3.2.3 Score definition

While the Phase 2 validation audit [**B 3**] was based, for each product, on the evaluation of its full or partial compliance with either set of constraints (S5 and SLA), the Phase 3 assessment uses a more nuanced approach. Each product is scored according to the proportion of requirements met in the following way.

For each specification of a given set of constraints (S5 or SLA), the corresponding product characteristic is given a granular score of

- 0 if the actual product characteristic and the specification do not match;
- ½ if they match partially;
- 1 if there is a perfect match.

Granular scores pertaining to a single product are added up and the sum is divided by the number of characteristics assessed to provide the product agreement score as a percentage. This score is calculated, whenever applicable, by reference to each set of specifications and for the 2 phases, so that the majority of the products (39 of them) are attributed a set of 4 scores (one for each phase and each reference set of specifications).

3.2.4 Limitations

Before analysing validation results, it is important to formulate a number of warnings regarding limitations inherent in the nature of the material or the adopted approach. These limitations should be kept in mind when interpreting the results presented in Section 3.2.5 below.

Limitations affecting product inter-comparison and global statements

- Products are made out of a number of parameters ranging from 1 to 11 (see Table 10), so that contributions from voluminous [small] products are under- [over-] estimated in statistical calculations. The obstacle would ideally be turned round by applying the evaluation method to parameters instead of products, but this solution could not be practically envisaged since it was very time consuming, the more so that specifications, requirements and actual product characteristics were generally presented globally (e.g., a single uncertainty value could apply to all parameters of a given product). The recourse to some weighing function to compensate this bias would not have improved the reliability of the statistics, due to the heterogeneity of parameter status within a single product.
- Likewise, the score defined in Section 3.2.3 measures the product compliance based on a number of criteria ranging from 2 to 15 (see Figure 4). Products assessed on the basis of a small number of constraints could be of a very high overall quality but fail to meet the only requirements against which they are evaluated, or the other way around. In this respect, product validation against *a priori* specifications is more reliable (because more uniformly exhaustive) than validation against user requirements, which is generally based on a smaller number of criteria depending on highly variable user's information and expectations. Although this feature is theoretically intended to improve the fitness-for-purpose of the services and their user-driven quality, it introduces some dissymmetry in the comparison of product performances.

Limitations affecting phase to phase progress assessment

- While products were upgraded in Phase 3, user requirements became more demanding both in number and in degree, so that actual progresses achieved by the services may be obliterated in the calculation of the compliance score. This should particularly be kept in mind when comparing Phase 3 performances to their Phase 2 counterparts. It also explains why the progress from phase to phase assumed such a different magnitude in terms of compliance with S5 Specifications and SLA requirements.
- The set of products assessed in Phase 3 was not identical to the set of products assessed in Phase 2, even though both sets included the same number of products in the case of evaluation against user requirements (see Table 7).

Limitation affecting comparison of product performances against S5 and SLA

- In both phases, the set of products evaluated for their compliance with S5 specifications was larger than (and included) the set of products evaluated for their compliance with user requirements (see Table 7).

The last two points should be taken into account when comparing numbers of products achieving a given score.

3.2.5 Validation results

Figure 7 and Figure 8 show the product performance measured as explained in Section 3.2.3 against *a priori* specifications and user requirements respectively. The gaps in Figure 7 and Figure 8 correspond to the shaded cells in Table 7. Results shown in Figure 7 and Figure 8 are translated in Figure 9 and Figure 10 into numbers of products achieving a given score range.

Average scores indicated on Figure 7 and Figure 8 are calculated taking into account only the evaluated products, i.e. 44 and 45 products assessed against S5 specifications in Phases 2 and 3 respectively, and 43 products against SLA requirements. The averaged S5 agreement score increases from 84.2% to 89.3% from Phase 2 to Phase 3 while the averaged SLA agreement score decreases from 81.5% to 80.2%. As underlined in Section 3.2.4, products have equal weights in the calculation of the averaged scores, which obliterates their different sizes in terms of number of parameters. The contributions of products evaluated on the basis of a small number of constraints to the averaged SLA compliance scores are listed in Table 8. They appear, as expected, to belong to the highest or lowest score groups.

Table 8. SLA compliance score of products evaluated on the basis of a small number of constraints.

Product		Phase	Number of requirements	Score (%)
5	GOME SACADA Ozone Profiles	2	4	100
38	Italian Peninsula Desert Dust	2	5	100
11	Ozone & UV Time Series for Greenland	2	2	50
		3	5	60



GSE – PROMOTE 2

C6 Validation Report

Foreword & Final Audit

REF : C6

ISSUE : 1

DATE : 30.12.2009

PAGE : 20 of 37

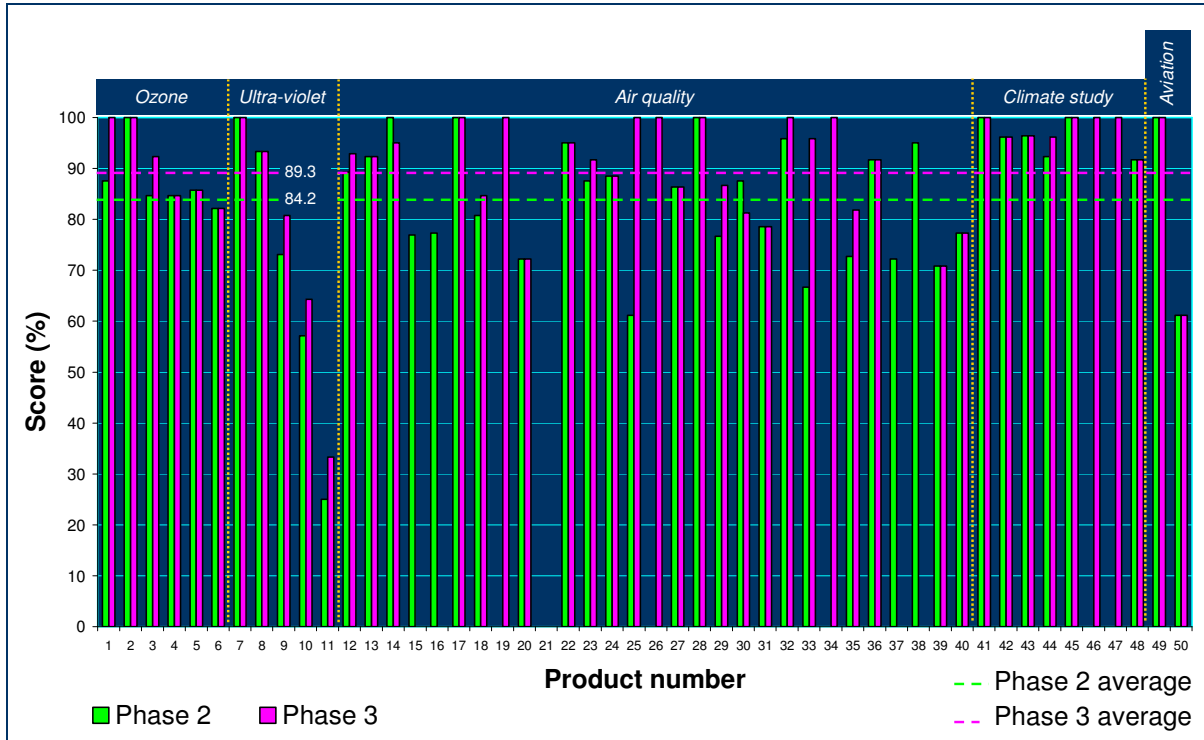


Figure 7. Product score in terms of compliance with *a priori* specifications for Phases 2 and 3.

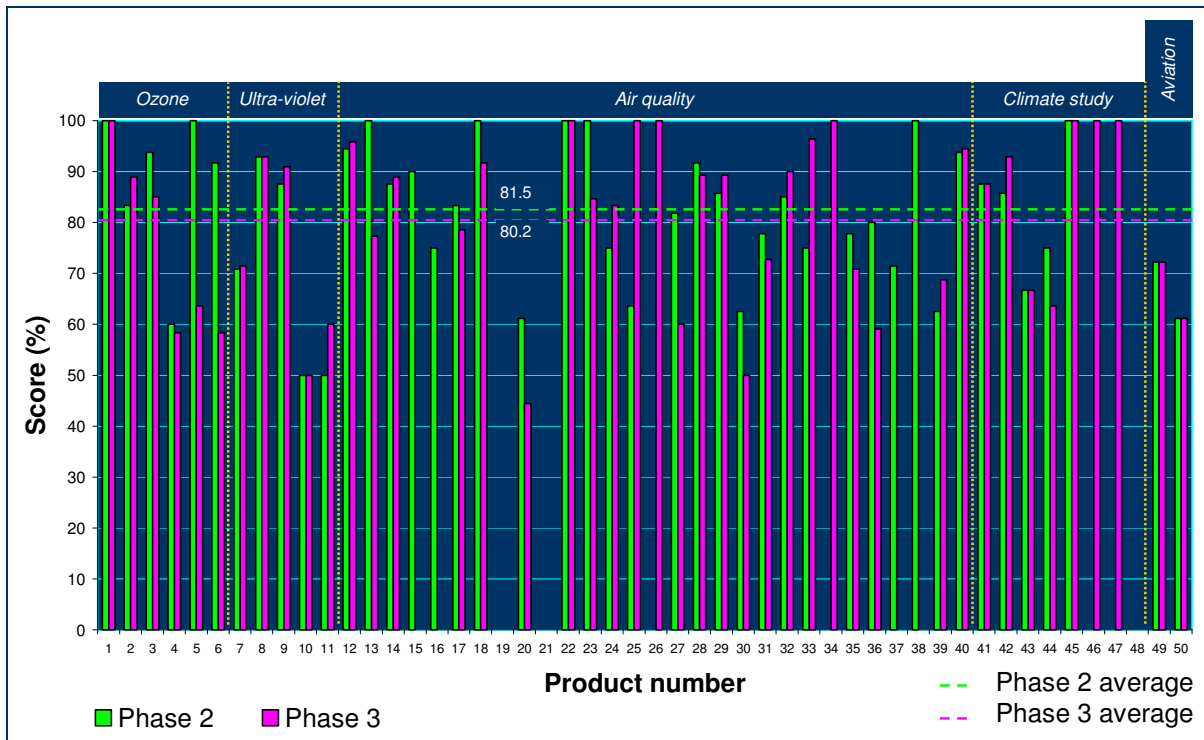



Figure 8. Product score in terms of compliance with user requirements for Phases 2 and 3.

	GSE – PROMOTE 2 C6 Validation Report Foreword & Final Audit	REF : C6 ISSUE : 1 DATE : 30.12.2009 PAGE : 21 of 37
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Individual product behaviour : Agreement with SLA versus agreement with S5

The number of products evaluated jointly against S5 specifications and the SLA was 43 in both phases but the two sets of products do not coincide (the common subset includes 39 products).

Comparison between Figure 7 and Figure 8 reveals that products score generally less well when referred to user requirements than when referred to *a priori* specifications, with less products reaching a 100% compliance, which reflects the usually (but not always) higher degree of constraint of the user requirements (e.g., horizontal resolution could be required by the user to be finer than stated in the *a priori* specification, etc.).

Individual product behaviour : Phase 2 to Phase 3 evolution

40 products were evaluated against the S5 specifications in the 2 phases and 39 (the same set less BASCOE H₂O & CH₄) against the SLA.

Apart from two exceptions, individual product scores against S5 specifications remain stationary or are slightly higher in Phase 3 than in Phase 2 (Figure 7), which is to be related to the improvements mentioned in Section 3.1.2 (Figure 3). The two AirCast Level 1 products (n° 25 - Forecast - and n° 33 - Record) perform significantly better in Phase 3 than in Phase 2.

The situation is rather different for product score against user requirements (Figure 8): in spite of their actual upgrade (cf. Section 3.1.2), products do not appear to improve systematically in Phase 3 with respect to Phase 2. This is due to the parallel Phase 2 to Phase 3 upscale of many user requirements, not only in terms of increased numbers, but also in terms of more constraining (and perhaps in some cases less realistic) conditions that were not mandatory until Phase 3 but remained unmet by the targeted services.

The individual product score evolution from Phase 2 to Phase 3 is represented in terms of numbers of products in Figure 9 (c) and Figure 10 (c), where only the products evaluated in the two phases are scored.

Overall assessment

In Phase 3, 84% of the products assessed (38 over 45) agree by more than 80% with *a priori* specifications [Figure 9(b)], which represents a noticeable progress with regard to Phase 2 (29 products over 44, i.e. 66%) [Figure 9(a)]. Some 56% of the assessed products (24 over 43) agree by more than 80% with the Phase 3 user requirements [Figure 10(b)], which is stationary with respect to Phase 2 [Figure 10(a)].

The above numbers are displayed in Table 9, which also combines, in the last three rows, information from Figure 7 and Figure 8 to provide the proportion of products evaluated jointly against S5 and SLA and scoring more than 80% for at least one set of constraints. These last numbers are illustrated by Figure 11.



GSE – PROMOTE 2

C6 Validation Report

Foreword & Final Audit

REF : C6

ISSUE : 1

DATE : 30.12.2009

PAGE : 22 of 37

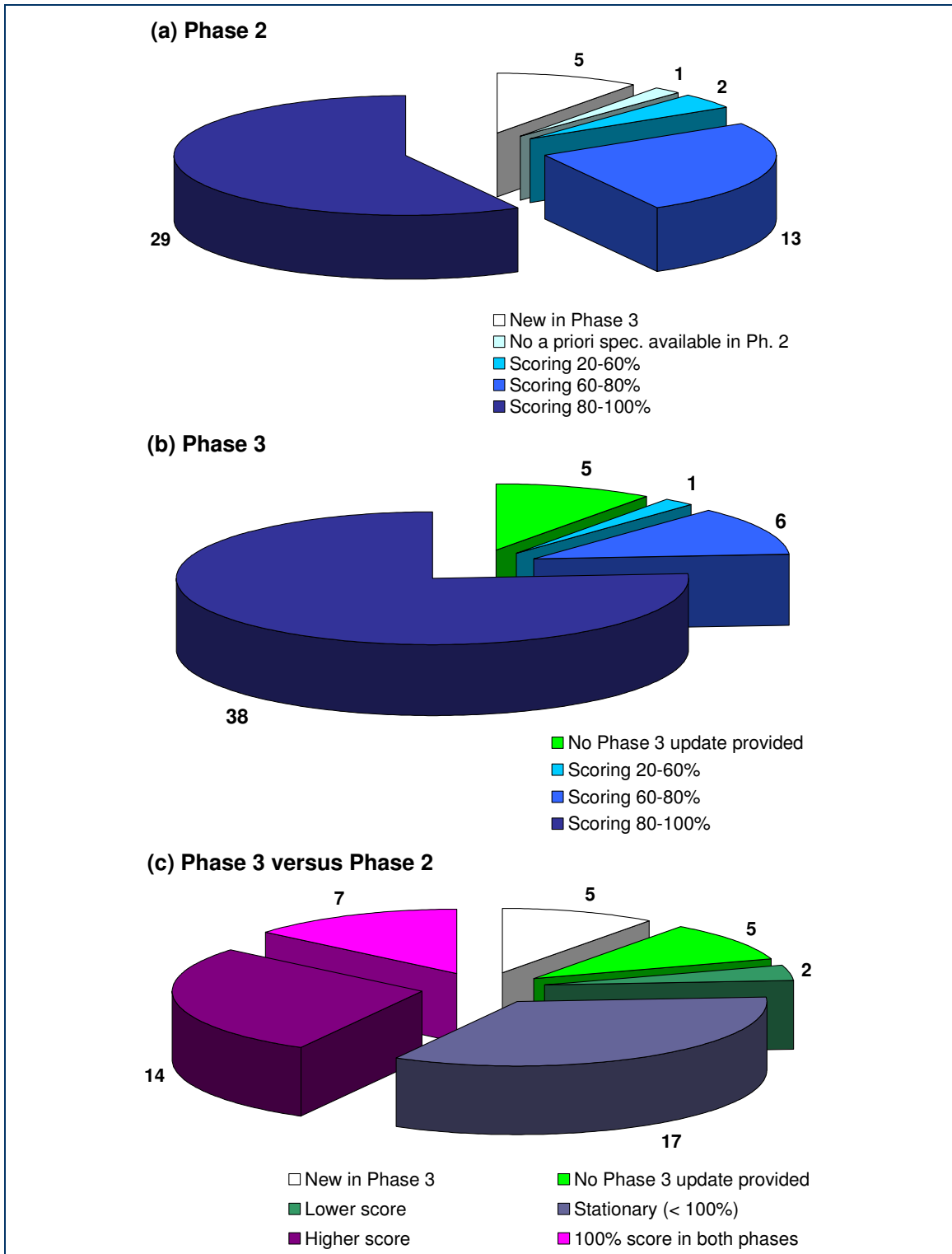


Figure 9. Agreement with *a priori* specifications (in number of products) for a total of 50 products.

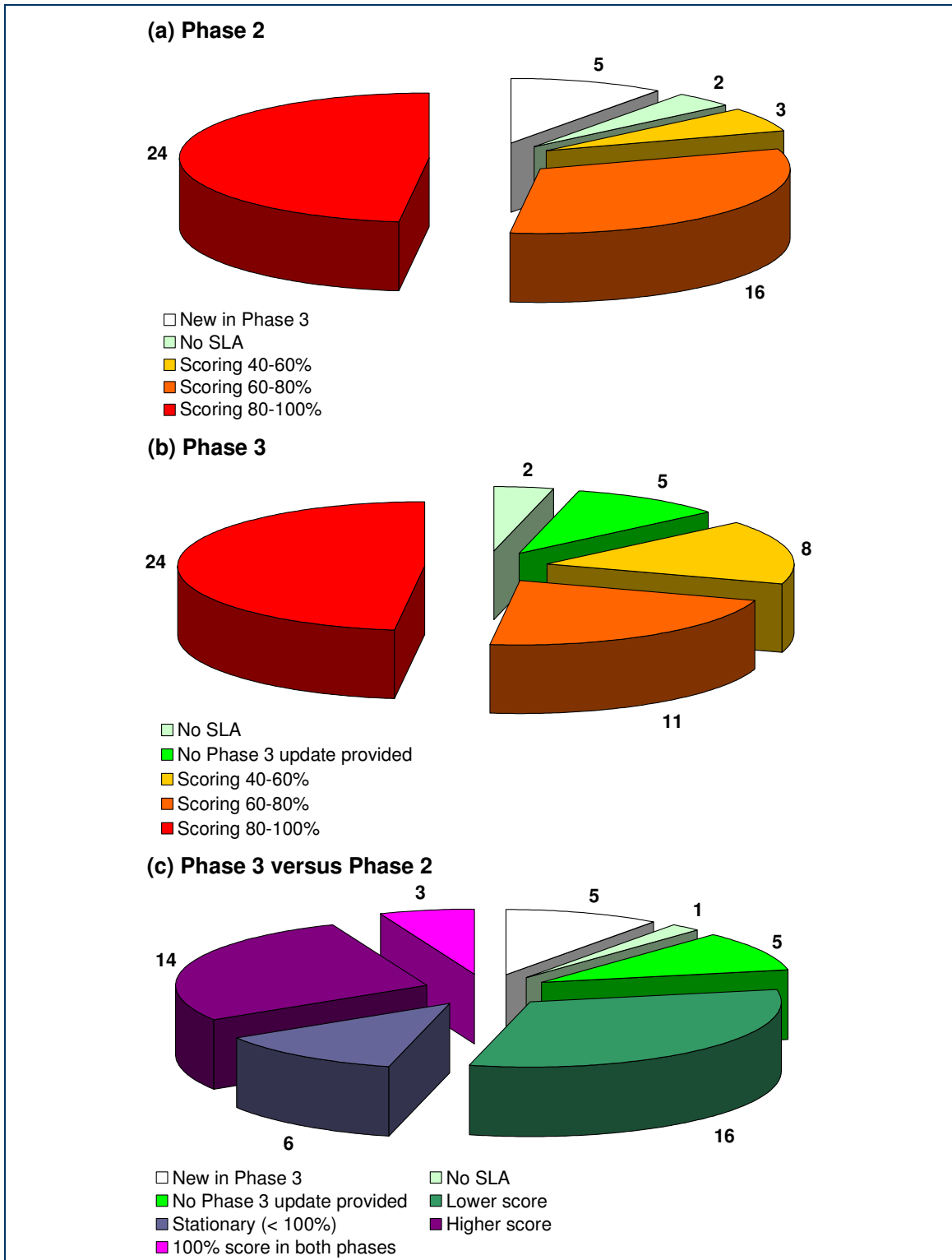


Figure 10. Agreement with user requirements (in number of products) for a total of 50 products.



GSE – PROMOTE 2

C6 Validation Report

Foreword & Final Audit

REF : C6

ISSUE : 1

DATE : 30.12.2009

PAGE : 24 of 37

Table 9. Proportion of products achieving a score higher than 80%.

Reference	Phase 2				Phase 3			
	Score	Number of products	Percentage of products		Score	Number of products	Percentage of products	
S5	> 80% & < 100%	21 over 44	48%	66%	> 80% & < 100%	23 over 45	51%	84%
	= 100%	8 over 44	18%		= 100%	15 over 45	33%	
SLA	> 80% & < 100%	16 over 43	37%	56%	> 80% & < 100%	16 over 43	37%	56%
	= 100%	8 over 43	19%		= 100%	8 over 43	19%	
At least one of the sets of specifications (S5 or SLA)	Both scores < 100% with at least one score > 80%	17 over 43	39%	74%	Both scores < 100% with at least one score > 80%	22 over 43	51%	86%
	One 100% score	14 over 43	33%		One 100% score	8 over 43	19%	
	Two 100% scores	1 over 43	2%		Two 100% scores	7 over 43	16%	

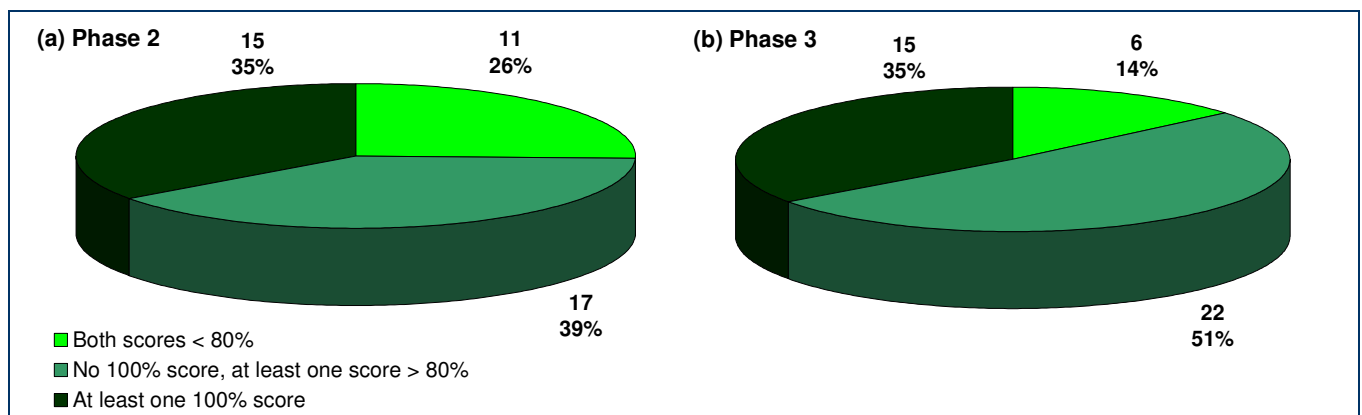


Figure 11. Score of products evaluated jointly against *a priori* specifications and user requirements.

Full compliance

Products that have achieved full compliance (100% score) with one set of constraints in Phase 2 do not always remain fully compliant with it in Phase 3. This is especially true for the validation against SLA constraints (Figure 8) and is due to the more demanding requirements.

Full compliance with the S5 Specifications is achieved by 8 products (over 44 assessed) in Phase 2 and 15 products (over 45 assessed) in Phase 3 (Figure 7). Full compliance with the relevant SLA is achieved by 8 products (over 43 assessed) in both phases (Figure 8).

The new Phase 3 products all achieve full compliance with either set (with the restriction that AQ Bavaria was not evaluated against user requirements).

Figure 12 shows the numbers of products achieving partial or full compliance with one of the two sets of constraints for all products evaluated jointly against both sets.

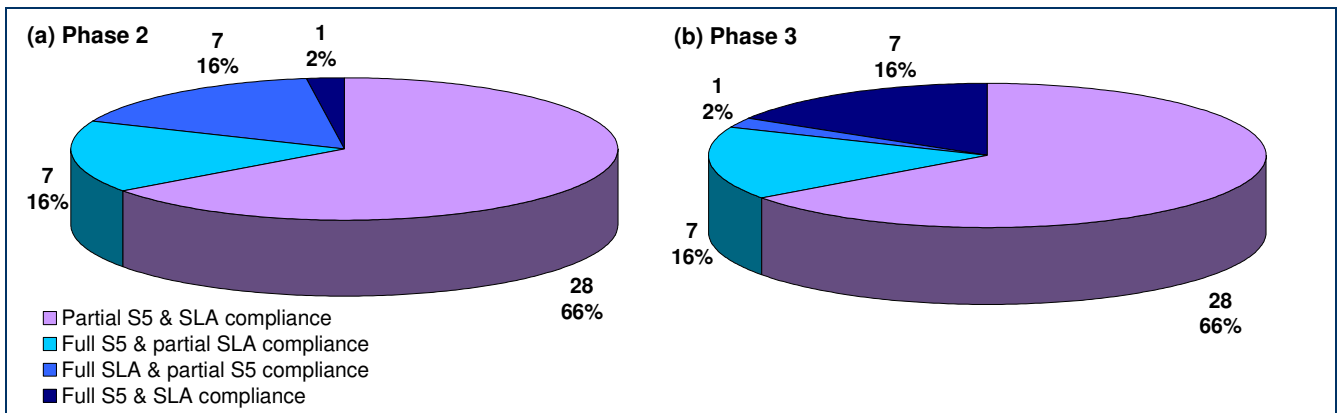


Figure 12. Product full or partial compliance (joint evaluation).

3.3 Terminology and units

The first section of each PROMOTE product validation report (*Product Characterisation*) includes a standard table where basic information about the product is recorded [B 3, Section 2.2, p. 5]. The pieces of information provided include, for every parameter composing the product, the parameter name, its unit or whether it is dimensionless, and sometimes some additional definition. These elements have been examined for the 161 parameters listed in Table 10. Some conclusions are presented in this section. In the legends of the charts below, “not a measurable quantity” stands for a product component which consists in a message issue (warning, alert, ...).

3.3.1 Physical parameter names

Throughout the product spectrum, one single variable may assume several names depending on which sub-service distributes it. More than half of the parameters screened are called a name which leaves their nature uncertain (Figure 13). For example, the parameter is commonly said to be an atmospheric constituent such as “ozone” or “NO₂”, but the exact nature of the corresponding physical quantity

(concentration, volume mixing ratio or partial pressure, integrated concentration, ...) remains obscure until it can be inferred from some additional information (e.g., the unit) met through further reading.

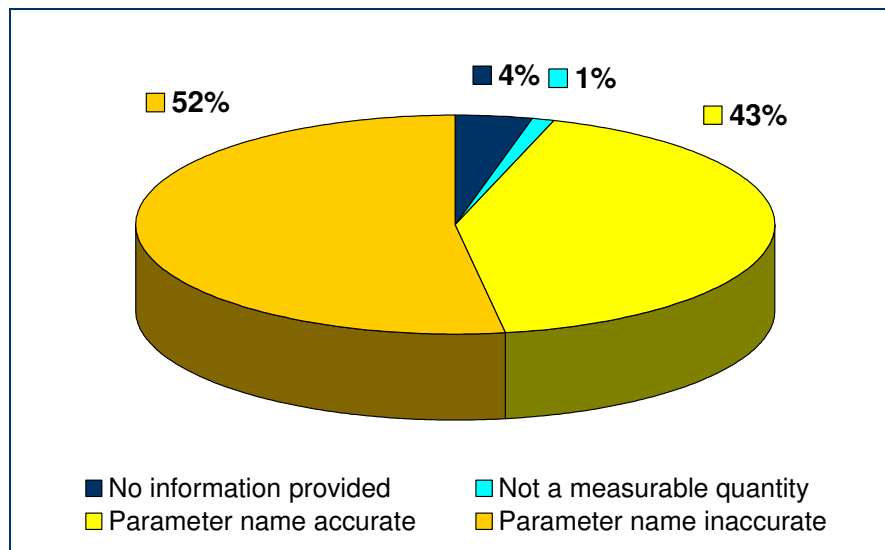


Figure 13. Parameter name accuracy.

3.3.2 Physical parameter definition

In most of the 52% cases above, the ambiguity affecting the parameter name is removed by some additional piece of information provided in the table, e.g. the unit or some definition. In a number of cases (12%), however (Figure 14), these additional elements are absent or unclear, such as a hermetic definition or the reference to a missing webpage or a webpage in a national language other than English. *Ad hoc* parameters are particularly vulnerable in this respect since their nature cannot be inferred from experience.

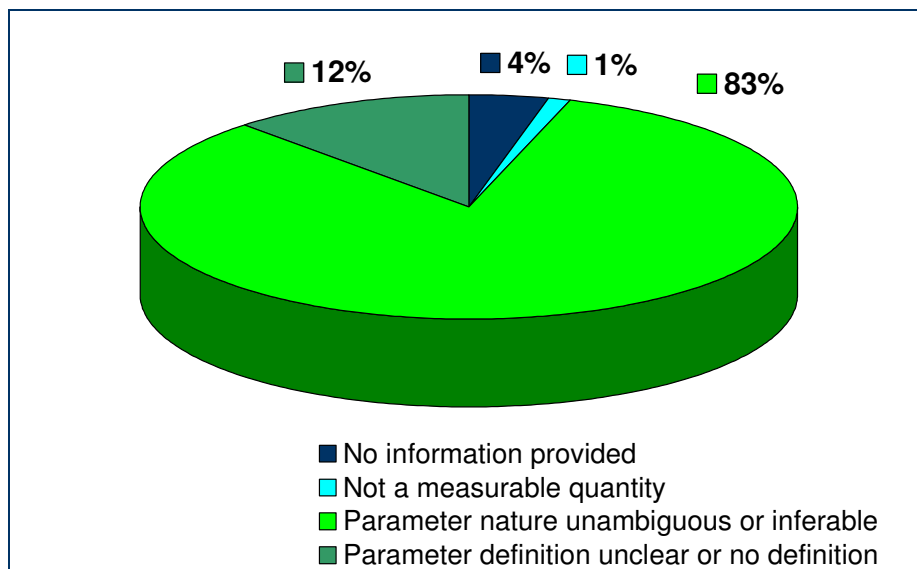



Figure 14. Parameter definition accuracy.

	<p align="center">GSE – PROMOTE 2</p> <p align="center">C6 Validation Report</p> <p align="center">Foreword & Final Audit</p>	REF : C6 ISSUE : 1 DATE : 30.12.2009 PAGE : 27 of 37
---	--	---

3.3.3 Units

Finally, as shown in Figure 15, inconsistency between name and unit was found in 8% of the parameters (dimensionless quantities with no indication of unit were counted as belonging to the “*Parameter name consistent with unit*” category). The most common example of inconsistency met was the association of *ppmv* or *ppbv* to chemical number densities.

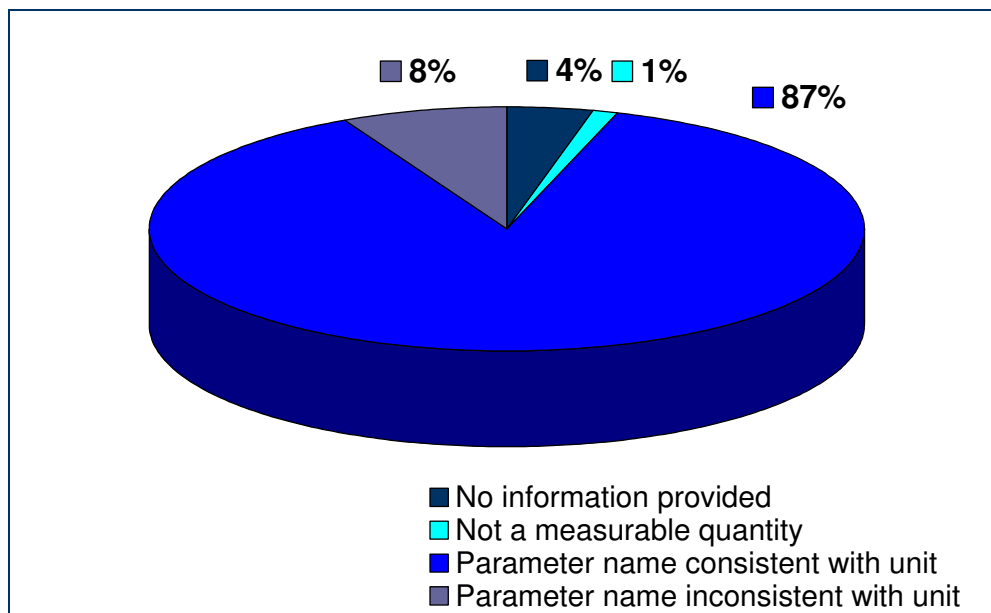


Figure 15. Parameter name and unit consistency.


4 Perspectives for the GMES Atmospheric Service (GAS)

Components of the GAS developed under PROMOTE had flourished rapidly in the project Phase 2. Phase 3 was a period of consolidation during which improvements slowed down but continued at a steadier pace. Although the validation audit showed that room is left for improvement and that further product validation is required, it must be recognised that services came significantly closer to the original specifications and did improve their compliance with users’ expectations in spite of the significant upscale of the requirements.

As regards the service validation method, one should underline the key roles of the C5 Validation Protocol [B 1] and of validation central coordination in warranting

- homogeneous validation criteria and assessment to be applied throughout the GAS;
- data and service quality, improvement and maintenance;
- connection and conformity to external international practices and initiatives.

The adoption of an iterative validation process (see Section 1.3) proved an effective way of triggering positive feedback between providers and users, Validation Office and providers, atmospheric services and

	GSE – PROMOTE 2 C6 Validation Report Foreword & Final Audit	REF : C6 ISSUE : 1 DATE : 30.12.2009 PAGE : 28 of 37
---	--	---

the international context (e.g., the INSPIRE European initiative). The duration of the life cycle, which was of one year during PROMOTE, could however be adapted in the future to fit better the requirements of service running.

The concept of a set of user-driven services is central to the GAS and PROMOTE achievements were of consequence in this regard. As shown by the validation audit, formulation and fulfilment of user requirements yet remain areas needing further improvement, in which all actors (providers, users, coordinators) will find a role. Among other factors of improvement, user formation, enhanced user-provider communication channels, SLA template design, etc., could be beneficial to the GAS.

Finally, of particular importance to the GAS, lessons learnt by the PROMOTE QA/Val Office in terms of validation practices include the following.

- In the collection of information from service providers, careful questionnaire design and accurate wording are required to avoid inadequate frameworks, misunderstandings and ambiguous or inconsistent answers.
- As highlighted in Section 3.3 about the issue of variable names and units, an effort is needed to improve the accuracy of the wording (and hence the information content) of the metadata supplied by the product providers. The recourse to some international standard (e.g., the Climate Forecast Convention [E 7] or a similar relevant terminology standard) and/or to a data model would considerably help to improve the accuracy and completeness of the metadata, and consequently contribute to broaden the service usefulness, popularity and usage.
- Automation of at least part of the information flow between service providers and validation coordinators is highly desirable, as well as automation of the information archival and processing. The current sizes of the GAS and the community of its users are already a challenge to manual processing.

5 References

5.1 Electronic references and online data access paths

E 1. PROMOTE Portal

<http://www.gse-promote.org>

E 2. Text of the INSPIRE Directive

<http://eur-lex.europa.eu/JOHtml.do?uri=OJ:L:2007:108:SOM:EN:HTML>

E 3. Text of the INSPIRE Metadata Regulation

<http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32008R1205:EN:NOT>

E 4. Text of the Commission Decision as regards the INSPIRE Monitoring and Reporting

<http://eur-lex.europa.eu/JOHtml.do?uri=OJ%3AL%3A2009%3A148%3ASOM%3AEN%3AHTML>

E 5. Text of the Commission Regulation as regards the INSPIRE Network Services

<http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:274:0009:0018:EN:PDF>



GSE – PROMOTE 2

C6 Validation Report
Foreword & Final Audit

REF : C6
ISSUE : 1
DATE : 30.12.2009
PAGE : 29 of 37

E 6. PROMOTE QA and Validation Office website

http://www.oma.be/PROMOTE_validation_office/Home.htm

E 7. NetCDF Climate and Forecast (CF) Metadata Convention

<http://cf-pcmdi.llnl.gov/>

5.2 Bibliographic references

Applicable documents

B 1. Lambert J.C., C5 PROMOTE 2 Atmospheric Services Validation Protocol, Version 3, October 2009.

B 2. S5 PROMOTE Service Portfolio Specifications.

Reference documents

B 3. Delgado R. and Lambert J. C., GMES Service Element PROMOTE 2, C6 Validation Report, Introduction and Summary, Version 2, August 2008.



GSE – PROMOTE 2

C6 Validation Report

Foreword & Final Audit

REF : C6
 ISSUE : 1
 DATE : 30.12.2009
 PAGE : 30 of 37

6 Annex - PROMOTE 2 products and parameters

Sixteen PROMOTE 2 services were validated during the project duration. Each of them offers a number of products. Each product consists in a set of physical parameters. Table 10 lists the 50 PROMOTE products and the 161 associated parameters.

Table 10. List of PROMOTE products and parameters.

Service	Provider	Product		Parameter	
OZ-Column	KNMI	1	Total ozone record	Total ozone	1
		2	NRT total ozone	Near real time total ozone column	2
		3	Total ozone forecast	Ozone column	3
OZ-Profile	DLR	4	GOME-ROSE ozone	3D gridded fields of synoptic ozone volume mixing ratio	4
				Gridded fields of daily accumulated ozone chemical loss rate	5
				3D gridded fields of synoptic PSC area density	6
		5	GOME-SACADA ozone	3D gridded fields of ozone volume mixing ratio	7
				3D gridded fields of ClO _x volume mixing ratio for fixed local time	8
				3D gridded fields of NO _x volume mixing ratio for fixed local time	9
	IASB-BIRA	6	BASCOE ozone	3D gridded fields of ozone volume mixing ratio	10
				3D gridded fields of Cl _y volume mixing ratio for fixed local time	11
	UV-Info	DLR	7	UV-Check	Sunburn time
UV index					13
Sun protection factor (SPF)					14
FlyBy		8	MEDSUN	Sunburn time	15
				UV index	16



GSE – PROMOTE 2

C6 Validation Report

Foreword & Final Audit

REF : C6
 ISSUE : 1
 DATE : 30.12.2009
 PAGE : 31 of 37

				Sun protection factor (SPF)	17
				Phototype	18
				UV eye index	19
UV-Record	FMI	9	Long-term surface UV record	UV index	20
				Daily erythemal UV dose	21
				Daily Vitamin D UV dose	22
UV-Greenland	DMI	10	UV index	Clear sky local noon UV index	23
				Cloud cover corrected UV index	24
				Spring time UV warning	25
		11	UV & O ₃ time series	UV index	26
				Ozone column	27
AQ-Record	RIU	12	Assimilated near surface AQ records	NO ₂ mass concentration	28
				O ₃ mass concentration	29
				SO ₂ mass concentration	30
				H ₂ CO mass concentration	31
				CO mass concentration	32
				PM _{2.5} mass concentration	33
				PM ₁₀ mass concentration	34
	KNMI	13	Global tropospheric NO ₂	Global NO ₂ tropospheric column	35
	Consortium (1)	(49)	Global tropospheric SO ₂ (see AV-SACS)	SO ₂ slant and vertical columns derived from SCIAMACHY (see AV-SACS)	(157)
				SO ₂ slant and vertical columns derived from OMI (see AV-SACS)	(158)
	KNMI	14	Global tropospheric H ₂ CO	Global H ₂ CO tropospheric column	36



GSE – PROMOTE 2

C6 Validation Report

Foreword & Final Audit

REF : C6
 ISSUE : 1
 DATE : 30.12.2009
 PAGE : 32 of 37

AQ-EUPlatform	Consortium (2)	15	Integrated AQ analysis	O ₃ mass concentration	37
				NO ₂ mass concentration	38
				PM mass concentration	39
		16	Integrated AQ forecast	<i>O₃ forecast</i>	40
				<i>NO₂ forecast</i>	41
				<i>PM forecast</i>	42
AQ-RegForecast	ACRI	17	AIRES - AQ forecast for South-East France, Corsica & East Italy	O ₃ mass concentration	43
				NO ₂ mass concentration	44
				SO ₂ mass concentration	45
	RIU	18	AQ forecast & data assimilation for Austria, Ireland, Mecklenburg-Western Pomerania, Northrhine-Westphalia, Switzerland, Turkey & Macedonia	PM2.5 mass concentration	46
				PM10 mass concentration	47
				NO ₂ mass concentration	48
				SO ₂ mass concentration	49
				O ₃ mass concentration	50
				CO mass concentration	51
				C ₆ H ₆ mass concentration	52
	User-defined air quality index	53			
	DLR	19	AQ forecast for Bavaria	O ₃ mass concentration	54
				NO ₂ mass concentration	55
	Tradewind	20	AQ forecast for Canada	Hourly O ₃ volume mixing ratio	56
				Hourly NO ₂ volume mixing ratio	57
Hourly NO volume mixing ratio				58	



GSE – PROMOTE 2

C6 Validation Report

Foreword & Final Audit

REF : C6
 ISSUE : 1
 DATE : 30.12.2009
 PAGE : 33 of 37

				Hourly CO volume mixing ratio	59
				Hourly PM2.5 mass concentration	60
	Danish EPA	21	AQ forecast for Denmark	NO ₂ mass concentration	61
				O ₃ mass concentration	62
	FMI	22	AQ analysis & forecast for Finland	Mass concentration of anthropogenic pollutants – primarily PM, SO ₄ , NO ₃ , NH ₄ , SO ₂ , NO, NO ₂ , NH ₃ , CO, O ₃ , HCHO.	63
				PM2.5 mass concentration	64
				PM10 mass concentration	65
				SO _x mass concentration	66
				NO _x mass concentration	67
				O ₃ mass concentration	68
	AUTH	23	AQ forecast for Eastern Mediterranea	Hourly O ₃ volume mixing ratio	69
				Hourly NO ₂ volume mixing ratio	70
				Hourly CO volume mixing ratio	71
				Hourly SO ₂ volume mixing ratio	72
				Hourly PM10 mass concentration	73
	KNMI	24	AQ forecast for the Netherlands	O ₃ mass concentration	74
				NO ₂ mass concentration	75
AQ-LocForecast	YDreams / IMAR	25	AQ forecast for Lisbon – AirCast Level 1	Global AQ index	76
				PM10 mass concentration	77
				O ₃ mass concentration	78
		26	AQ forecast for Lisbon – AirCast Level 2	Level 2 geostatistical and multi-regression based PM10 mass concentration daily average maps	79



GSE – PROMOTE 2

C6 Validation Report

Foreword & Final Audit

REF : C6
 ISSUE : 1
 DATE : 30.12.2009
 PAGE : 34 of 37

	VITO	27	AQ forecast for Belgium and Belgian Cities	O ₃ mass concentration	80
				NO ₂ mass concentration	81
				PM10 mass concentration	82
	BMT ARGOSS	28	AQ forecast for Zeeland	PM10 concentration charts	83
				PM2.5 concentration charts	84
				NO ₂ concentration charts	85
				NO concentration charts	86
				O ₃ concentration charts	87
				NH ₃ concentration charts	88
	CERC	29	YourAir - AQ forecast for London burroughs, Budapest, Vienna & Vilnius	O ₃ mass concentration	90
				NO ₂ mass concentration	91
				PM10 mass concentration	92
				CO mass concentration	93
				Total health index	94
	AQ-Assessment	VITO	30	Model based urban AQ indicators	SO ₂ mass concentration fields
NO ₂ mass concentration fields					96
PM10 mass concentration fields					97
CiteAir YACAQI (Year Average Common Air Quality Index) city index					98
CiteAir YACAQI (Year Average Common Air Quality Index) traffic index					99
31		Scenario tool for regional AQ policy support	Pollutant mass concentration (species on demand)	100	
			Pollutant mass concentration absolute change (species on demand)	101	



GSE – PROMOTE 2

C6 Validation Report

Foreword & Final Audit

REF : C6
 ISSUE : 1
 DATE : 30.12.2009
 PAGE : 35 of 37

			Pollutant concentration relative change (species on demand)	102	
BMT ARGOSS	32	AQ record for Zeeland	Average annual concentration, standard deviation and max. conc. of PM10	103	
			Average annual concentration, standard deviation and max. conc. of PM2.5	104	
			Average annual concentration, standard deviation and max. conc. of NH ₃	105	
			Average annual concentration, standard deviation and max. conc. of CH ₄	106	
			Average annual concentration, standard deviation and max. conc. of CO	107	
			Average annual concentration, standard deviation and max. conc. of NO ₂	108	
			Average annual concentration, standard deviation and max. conc. of NO	109	
			Average annual concentration, standard deviation and max. conc. of O ₃	110	
			Average annual concentration, standard deviation and max. conc. of SO ₂	111	
YDreams / IMAR	33	AQ record for Portugal – AirCast Level 1	Daily global AQ index	112	
			Daily PM10 mass concentration	113	
			Daily O ₃ mass concentration	114	
			Daily NO ₂ mass concentration	115	
			Daily SO ₂ mass concentration	116	
			Daily CO mass concentration	117	
			PM10 mass concentration monthly average	118	
			PM10 mass concentration annual average	119	
			36th annual maximum of PM10 mass concentration daily average	120	
	34	AQ record for Portugal – AirCast Level 2	Level 2 geostatistical and multi-regression based PM10 mass concentration daily average maps	121	
AQ-SatPM	DLR	35	Satellite particle matter - European multi-annual record	PM10 concentration record	122
				PM2.5 concentration record	123



GSE – PROMOTE 2

C6 Validation Report

Foreword & Final Audit

REF : C6
 ISSUE : 1
 DATE : 30.12.2009
 PAGE : 36 of 37

				PM1 concentration record	124
				Aerosol optical depth at 550 nm	125
	CGS	36	Satellite particle matter - Regional monitoring for Italy	Aerosol optical depth at 550 nm	126
				Small to total number particles ratio (η)	127
				Satellite derived PM content at the surface	128
AQ-DesertDust	CGS & Skysoft / GMV	37 - 38	Desert dust - Iberian peninsula & Desert dust - Italian peninsula	Desert dust indicator	129
				Aerosol speciation	130
				Aerosol optical thickness at 550 nm	131
				Aerosol optical thickness at 870 nm	132
				Ångström turbidity coefficient	133
AQ-Pollen	FMI & ACRI	39 - 40	Pollen - Mediterranean area & Pollen - Northern Europe	Cypress pollen concentration	134
				Cypress pollen risk index	135
				Olive pollen concentration	136
				Olive pollen risk index	137
				Wall-pellitory pollen concentration	138
				Wall-pellitory pollen risk index	139
				Ragweed pollen concentration	140
				Ragweed pollen risk index	141
				Birch pollen concentration	142
				Birch pollen concentration historical record	143
				Birch pollen risk index	144
CS-Tropo	DLR	41	Global CH ₄	Global column averaged CH ₄ volume mixing ratio	145
		42	Global CO ₂	Global column averaged CO ₂ volume mixing ratio	146



GSE – PROMOTE 2

C6 Validation Report

Foreword & Final Audit

REF : C6
 ISSUE : 1
 DATE : 30.12.2009
 PAGE : 37 of 37

		43	Regional CO ₂	Regional column averaged CO ₂ volume mixing ratio	147
		44	Tropospheric aerosol optical depth and speciation	Multicontinental aerosol optical depth (550 nm)	148
				Multi-continental aerosol speciation (550 nm)	149
CS-Strato	IASB-BIRA	45	Stratospheric aerosol – Particle concentration and size	Particle number density	150
				Particle median radius of the particle size distribution (lognormal)	151
				Particle number mode width of the particle size distribution (lognormal)	152
		46	Stratospheric aerosol - Extinction	Extinction	153
		47	Stratospheric aerosol – Optical depth	Optical Depth	154
		48	BASCOE H ₂ O & CH ₄	Assimilated 3D gridded fields of water vapour mixing ratio	155
Assimilated 3D gridded fields of methane mixing ratio	156				
AV-SACS	Consortium (1)	49	Global tropospheric SO ₂	SO ₂ slant and vertical columns derived from SCIAMACHY	157
				SO ₂ slant and vertical columns derived from OMI	158
	IASB-BIRA	50	Support to aviation control	Volcanic ash indicator based on SEVIRI data	159
				Back- & forward trajectories from SO ₂ concentration peaks	160
				Peak SO ₂ warning	161

(1) DLR, IASB-BIRA, KNMI

(2) ACRI, DLR, FMI, INERIS, Météo-France, TNO