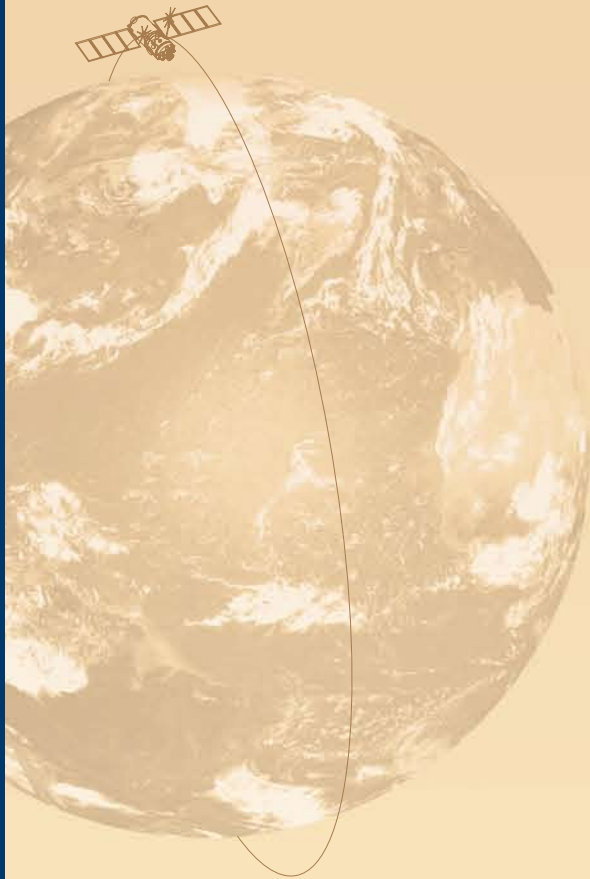


WMO Space Programme
SP-4



Status of the availability and use of
satellite data and products by
WMO Members
For the period 2004–2005



**World
Meteorological
Organization**

Weather • Climate • Water

WMO-TD No. 1423

**STATUS OF THE AVAILABILITY AND USE
OF
SATELLITE DATA AND PRODUCTS
BY
WMO MEMBERS**

FOR THE PERIOD 2004 - 2005

SP-4

TECHNICAL DOCUMENT
WMO/TD No. 1423

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EXECUTIVE SUMMARY

The Commission for Basic Systems (CBS) Open Programme Area Group on Integrated Observing Systems (OPAG-IOS) has the strategic goal to improve systematically the utilization of the capabilities of the space-based component of the Global Observing System (GOS) with emphasis on improving the utilization of satellite data and services in developing countries. This should be assisted by means of a recurring review and monitoring activity, based on information obtained from a dedicated biennial questionnaire.

This document provides the results of an analysis of the responses to a questionnaire that was distributed in 2006 to WMO Members in order to assess the status of the availability and use of satellite data and products during the period 2004 - 2005.

An overview of the approach adopted to analyze the responses is contained in section 2. Section 3 provides information related to the participation of WMO Members in the surveys. Sections 4, 5, 6 and 7 contain in-depth analyses of the responses to the various sections of the questionnaire from the different WMO Regions. Recommendations are shown as the relevant items are discussed in the associated sections, and are listed again in Appendix D. Key findings, extracted from the analysis, are shown in the section to which they refer and are listed again in Appendix E.

All data and supporting tables are contained in Excel work book files. These files are accessible from the WMO Space Programme web pages and hyperlinks are included in this document. The web pages also contain a glossary of terms and acronyms along with WMO Technical Document No. 1177 (The Role of Satellites in WMO Programmes in the 2010s). The latter contains illustrations of many of the systems and the types of products they provide.

1. INTRODUCTION

The WMO Commission for Basic Systems (CBS) Open Programme Area Group on Integrated Observing Systems (OPAG-IOS) has the strategic goal to improve systematically the utilization of the space-based component of the Global Observing System's capabilities with emphasis on improving utilization of satellite data and services in developing countries.

One of the means to achieve this is through active monitoring and review of the availability and use of satellite data. The review and monitoring process is performed continuously by means of a dedicated questionnaire. The first questionnaire for this purpose was issued in 1996, a second edition in 1999, a third in 2001, a fourth edition in 2003 and the present edition in 2006. While each edition has been somewhat different, they have become more concise.

A preliminary evaluation of the latest questionnaire was performed by the OPAG-IOS Expert Team on Satellite Utilization and Products (ET-SUP) and the results and conclusions from that evaluation form the basis for this report. All data and supporting tables are contained in Excel work book files. These files are accessible from the WMO Space Programme web pages with hyperlinks included in this document. It is important to note that the data sheets and graphs included in the Excel work book files refer to the current edition of the questionnaire as the "2005 edition" (since this title was recorded in the underlying database) whereas this report refers to it as the "2006 edition" (since 2006 was the actual year of issue).

2. OVERVIEW

The current (2006) edition of the questionnaire covered a period (2004-2005) during which several changes to the space-based component of the Global Observing System (GOS) occurred and during which significant changes to the available means of data access were introduced. These latter changes are summarized in the following section.

2.1 Changes to the means of access to satellite data

The means of data access in the past (i.e. relevant to prior editions of the questionnaire) included:

- LEO direct broadcast data access:
 - APT (analogue),
 - LRPT (digital),
 - HRPT (digital);
- GEO direct broadcast data access:
 - WEFAX (analogue),
 - LRIT (digital),
 - High Resolution Direct Broadcast (HRIT, VISSR, etc) (digital);
- Dissemination of data by other means:
 - GTS,
 - MDD,
 - Off-line media (CD-ROM, DVD, tapes, etc.);

Major changes introduced during the period covered by the questionnaire (2004-2005) included:

- Introduction of dissemination methods based on commercial satellites:
 - EUMETCast became fully operational,
 - Introduction of EARS,
 - Development of other national systems (RETIM, NUBIS, DWDSAT, etc.);
- PUMA was fully implemented (WMO RA I);

- Improved performance of Internet based distribution systems;
- Additional data sources becoming available:
 - MSG Programme became fully operational and MSG-2 was launched,
 - MTSAT-1R,
 - FY-2C,
 - QUIKSCAT,
 - MODIS (more products becoming available),
 - AIRS (more data becoming available),
 - TRMM (easier access),
 - ENVISAT (easier access);
- Expanded activities of key Programmes and groups, such as:
 - Joint Center for Satellite Data Assimilation (JCSDA),
 - Short term Programme for operational Research and Transition (SPORT),
 - EUMETSAT Satellite Application Facilities (SAF) Operational phase,
 - WMO Virtual Laboratory.

2.2 Identifying trends

A vital aspect of the analysis of responses is the identification of trends. Such trends provide evidence of the extent to which efforts to improve access and increase the utilization of satellite data and products are succeeding, or otherwise. However, trends can only be meaningfully described if questions remain consistent from one edition of the questionnaire to the next, which is sometimes not the case given that the structure of successive editions is modified as necessary to remain relevant to the changing world of satellite meteorology. Consequently, in the 2006 edition and in future editions, specific questions are included to ask users to identify whether changes have occurred during the two-year period of the questionnaire.

The 2006 edition of the questionnaire covered the period 2004 - 2005 and this was explicitly stated in the questionnaire form. Previous editions were somewhat ambiguous in this respect, a fact which suggests caution when concluding on possible trends. Furthermore, quantitative results should generally be used with caution in looking for trends across editions due to the inhomogeneity of the data sets. For example, only 45 of the respondents to the 2006 edition also provided a response to the 2003 edition and 36 of the respondents to the 2006 edition did not respond to the 2003 edition. The multi-edition comparisons thus only described what was reported in each edition.

2.3 Approach to the analysis

At their 2006 meeting, ET-SUP reaffirmed that the questionnaire has the potential to be a powerful tool to assess the status and requirements for satellite data access and use as well as education and training. This potential would only be realized, however, if the participation by Members was substantially increased. A high level of participation in the survey is the key for deducing a representative picture of the situation and constructive conclusions from the answers. The questionnaire should play a key role in a structure of information gathering that addresses the satellite system operators, the system users and the WMO Programmes that support them both. This structure has depended upon the questionnaire series to pinpoint the successes, gaps and needs within that second component, the community of users within each WMO Member. Because the participation has not been high enough to ensure true truly representative of the results, the survey series has not been as useful as it could be.

ET-SUP formed working groups that undertook a detailed analysis of the questionnaire with a view to identifying the quantitative statistics that were valid to extract directly, and examined other ways to determine the status and requirements in cases where the statistical data were insufficient. The session proposed that the analysis could be complemented by formulating hypotheses about expected trends which could then be tested using the questionnaire in combination with other information. The hypotheses would be based on the knowledge of major changes in satellite systems, instruments,

processing, training or other related input that had been introduced during the period since the previous edition of the questionnaire. ET-SUP developed some preliminary hypotheses for the 2006 edition and tested them where possible against the preliminary results (see Appendix B). They noted that, for many hypotheses, the 2006 questionnaire alone did not contain information sufficient for testing. They therefore confirmed the need to revisit the hypotheses for future editions as well as the potential value of a further complementary analysis, involving other sources of information, in providing a more complete view of the status of satellite data access, data use and training among the Members and the degree to which the activities address the WMO Space Programme Implementation Plan/Strategy. ET-SUP identified other potential sources of complementary information for this purpose for the future (see Appendix C).

- (R1) **Recommendation:** Periodic analysis of the status of availability and use of satellite data and products should be accomplished through a combination of an objective analysis of a questionnaire completed by the Members complemented by an analysis based on information gathered from other sources related to satellite data accessing, processing and training.
- (R2) **Recommendation:** An evaluation of the reasons for low levels of participation should be conducted, so that measures can be implemented to overcome any identified impediments.
- (R3) **Recommendation:** For future analysis of the status of availability and use of satellite data and products, actions should be taken to seek to engage every WMO Member and relevant WMO Programme through its lead Technical Commission and their infrastructure organizations of OPAGs and Expert Teams as well as Executive Council Panels where appropriate, e.g. for Education and Training and Natural Disaster Prevention and Mitigation. The Regional Association Rapporteurs to the WMO Space Programme should also be involved.
- (R4) **Recommendation:** WMO Programmes should give added attention to the techniques and systems for use of digital satellite data in operational applications within their Programmes' areas of focus, and stress them through their support activities to enhance Members' services.
- (R5) **Recommendation:** A mechanism should be established to address any questions and concerns raised by Members in their responses to the questionnaire.
- (R6) **Recommendation:** The questionnaire should be streamlined further, and a more user-friendly version of the questionnaire should be adopted. For instance, providing an electronic version (either online or on CD) could facilitate Members' task of collecting the information from the different services and managing the answers.

3. PARTICIPATION IN THE SURVEY

Supporting charts and tables for this section are contained in the Excel work book file, "Participation pivot tables", on the WMO Space Programme web pages at:

<http://www.wmo.int/pages/prog/sat/Questionnaire/documents/Participationpivottables.xls>

3.1 General Comments on Participation

The participation level for the 2006 edition of the questionnaire was low but was, nevertheless, the second highest of all editions with 76 of 187 Members (41%). The first edition of the questionnaire (1996) remains the most popular of all editions with 82 of the Members (46%) returning a completed questionnaire. Participation has showed a rising trend for each year after the lowest point of 33% in 1999.

In considering responses for all five editions of the questionnaire, a response was received for at least one edition from 135 out of a possible 187 WMO Members.

[K1] **Key finding:** Fifty-two (52) Members have never submitted a response, and only 15 Members have answered every edition.

3.2 Participation Trends by Region

Table 1 describes participation in percentage of total possible returns for all editions of the questionnaire broken down by WMO Region.

	Participation in 2006 edition	Participation in 2003 edition	Participation in 2001 edition	Participation in 1999 edition	Participation in 1996 edition
RA I	35%	15%	17%	29%	27%
RA II	41%	38%	41%	41%	56%
RA III	67%	42%	50%	50%	58%
RA IV	41%	36%	27%	9%	27%
RA V	32%	33%	39%	11%	44%
RA VI	43%	52%	56%	46%	65%
TOTAL	41%	35%	37%	33%	46%

Table 1. Participation trends across questionnaire editions in each Region

[K2] **Key finding:** The level of response from RA III was far higher than any other WMO Region.

4. ACCESS TO SATELLITE DATA (questionnaire section 1)

Supporting charts and tables are contained in the Excel work book file, "Data Access pivot tables" on the WMO Space Programme web pages at:

<http://www.wmo.int/pages/prog/sat/Questionnaire/documents/DataAccesspivottables.xls>

4.1 General Comments on Data Access

Taking all regions together, access to analogue data continued to decline while access to digital data increased. For the first time use of the Internet to access data has become a factor.

[K3] **Key finding:** As described in an ET-SUP hypothesis (see Appendix B), the introduction of data dissemination services that use commercial satellites (DVB-S systems) and which significantly lower reception station costs may have been a stimulus for the significant increase of the use of quantitative data accessed in all regions, particularly RA I and RA IV, since 2001. During the same period, the use of direct broadcast analogue systems significantly decreased.

(R7) **Recommendation:** WMO Regional Associations should be encouraged to promote the use of dissemination services that use commercial satellites (DVB-S systems) that would be linked into an Integrated Global Data Dissemination Service (IGDDS). WMO Members should be encouraged to access satellite data and products via IGDDS systems when available.

Many Members accessed digital data received from a third party as well as from the Internet, but it was difficult to observe a trend due to non-matching questions between the 2006 survey and previous editions. The same was true for accesses of analogue data via a third party and via the Internet.

Reports of satellite data accessed via the GTS were relatively few in the 2006 edition, but continued the increasing trend of the preceding two editions.

Many WMO Members processed satellite data themselves. Exchange of processed data between Members was considerable. Furthermore, in each Region the tendency to use digital satellite data

rather than analogue satellite data was true for data from both geostationary and polar satellites as well as selected R&D satellite missions.

- (R8) **Recommendation:** In view of the expectations of positive impacts of major initiatives such as PUMA and EUMETCast, evaluations should be conducted of the correlation of the projects' milestones to the reported availability and use of satellite data and products.

4.2 Technical information regarding data access aspects of the questionnaire

The identity of the WMO Members that have answered the questionnaire has varied considerably from one edition to another. To allow comparisons a summary database was constructed of questions that are substantially similar to those in the 2006 edition, which contains data from relevant questions in each of the preceding editions. However, due to the insufficient participation to provide overall representativeness, compounded by the variation in the particular Members or units that responded from edition to edition, it is recommended that the multi-edition summary and resulting graphics be viewed for comparisons only and care should be used in inferring any trends.

Summaries of the questions in which Members are asked to identify trends, such as Question 4 which asks the extent to which access has changed, provide the Member's direct observations and thus should be treated as more accurate trend information.

The degree of information that was requested in the Data Access section of the 2006 edition provided respondents with additional categories with which to describe their accesses. In some ways it seems that the additional data may artificially imply a growth trend. That issue probably will be resolved with the next edition, if the categories remain constant.

4.3 Overall data access trends in each Region (Question 4)

Table 2 shows the extent to which access to satellite data and/or products changed in Regions over the period of the questionnaire. The table entries refer to the number of Members who responded and the percentage figures refer to the number of received responses rather than the maximum possible number of responses.

	No significant change	Slight increase	Significant increase	Slight decrease	Significant decrease
RA I	0	1	14	0	0
RA II	3	3	5	0	2
RA III	2	3	1	0	0
RA IV	2	0	1	0	0
RA V	1	2	3	0	0
RA VI	3	3	14	0	0
TOTAL	11 (17%)	12 (19%)	38 (60%)	0	2 (3%)

Table 2. Data access trends in each Region

- [K4] **Key finding:** Taking all regions together, 60% of responses indicated a significant increase in satellite data access during the period of the questionnaire and a further 19% indicated a slight increase. Two Members from RA II reported they had significantly decreased their access. Only two Members responded that they do not access satellite data and have no plans to do so.

- (R9) **Recommendation:** Responses to trend questions (asking for changes observed during the period of the questionnaire) should be made mandatory in future editions.

4.4 Data reception mechanisms and trends in each Region (Question 5)

Information about the data reception mechanisms has been analyzed in isolation from the associated satellite type/name in recognition of the importance of this aspect. Comparisons with previous editions of the questionnaire are summarized in Table 3 for each Region. For other subject areas such comparisons across editions are available via the pivot tables in the Excel work book files.

[K5] **Key finding:** In RA I and RA VI the significant increases of accessing digital data via another satellite clearly stem from the EUMETCast service. For RA I this also implies a positive benefit resulting from the PUMA Project.

In RA II accesses for digital data via another satellite decreased from four in the 2003 edition to two in the 2006 edition. No obvious explanation for this trend, which is at odds from that apparent in other Regions, is apparent.

		2006 edition	2003 edition	2001 edition	1999 edition	1996 edition
Digital data disseminated via the satellite itself	RA I	12	5	6	9	9
	RA II	11	8	8	10	12
	RA III	6	3	4	5	3
	RA IV	2	3	2	1	2
	RA V	6	4	5	2	6
	RA VI	15	19	22	18	22
	All regions	52	42	47	45	54
Digital data disseminated via another satellite	RA I	16	3	1	0	0
	RA II	2	4	3	0	0
	RA III	2	0	1	0	0
	RA IV	2	1	0	0	0
	RA V	0	0	0	0	0
	RA VI	18	9	2	0	0
	All regions	40	17	7	0	0
Digital data received from a third party	RA I	3	0	0	0	0
	RA II	2	0	0	0	0
	RA III	1	0	0	0	0
	RA IV	4	0	0	0	0
	RA V	2	0	0	0	0
	RA VI	7	0	0	0	0
	All regions	19	0	0	0	0
Digital data obtained from the Internet	RA I	3	0	0	0	0
	RA II	4	0	0	0	0
	RA III	1	0	0	0	0
	RA IV	8	0	0	0	0
	RA V	3	0	0	0	0
	RA VI	5	0	0	0	0
	All regions	24	0	0	0	0
Analogue data disseminated via the satellite itself	RA I	3	2	5	13	11
	RA II	4	5	9	11	18
	RA III	0	1	4	5	6
	RA IV	0	4	4	1	3
	RA V	0	2	4	1	8
	RA VI	2	12	12	17	27
	All regions	9	26	38	48	73
Analogue data disseminated via another satellite	All regions	0	0	0	0	0
Analogue data received from a third party	All regions	1	0	0	0	0
Analogue data obtained from the Internet	RA I	2	0	0	0	0
	RA II	6	0	0	0	0
	RA III	1	0	0	0	0
	RA IV	1	0	0	0	0
	RA V	0	0	0	0	0
	RA VI	4	0	0	0	0
	All regions	14	0	0	0	0
Data received via the GTS	RA I	2	0	0	0	0
	RA II	2	1	1	0	0
	RA III	1	0	0	0	0
	RA IV	2	0	0	0	0
	RA V	1	2	0	0	0
	RA VI	3	3	4	0	0
	All regions	11	6	5	0	0
Other	All regions	6	17	6	8	2

Table 3. Data reception mechanism trends across questionnaire editions for each Region

4.5 Data access by satellite name (Question 5)

Supporting charts and tables are contained in the Excel work book file, “Data Access pivot tables add1 – Satellites used and requested” on the the WMO Space Programme web pages at:

<http://www.wmo.int/pages/prog/sat/Questionnaire/documents/DataAccesspivottablesAdd1--satellitesusedandrequested.xls>

Since the responses to this question involve combinations of satellite names and data access mechanisms, it is not straightforward to represent them in concise summary tables. Therefore they are described in the following sections and illustrated in the associated Excel work book files.

4.5.1 Operational geostationary satellites (GEO)

Members reported that, for almost all GEO satellite systems, the most accessed data type was digital, and by far the most frequently used access mechanisms were digital data dissemination via another satellite and digital dissemination via the satellite itself. Analogue data disseminated via the satellite itself (e.g. WEFAX) and via the Internet accounted for very little of the accesses. Members in several Regions reported third party dissemination as a significant component of their means of accessing digital data.

4.5.2 Operational low-Earth orbit satellites (LEO)

Members reported the great majority of accesses to the NOAA series, compared with the FY-1 and METEOR series. The greatest reported accesses by far were those using digital data mechanisms such as HRPT disseminated via the satellite (38 for NOAA series and nine (9) for FY-1), with more responses than digital data via the Internet, digital data via another satellite and data received via the GTS combined.

4.5.3 Research and Development (R&D) and other environmental satellites

The most often reported data type was digital data and the access mechanism cited by most Members was obtaining digital data via the Internet. The “R&D and environmental” satellite category showed the highest number of responses for Analogue data obtained from the Internet, data received via the GTS, and digital data received from a third party.

4.6 Satellites which Members do not access but would like to receive (Question 5)

This item was added to the latest edition of the questionnaire. While the majority of responses related to R&D and other environmental satellites (122), there were a significantly high number of responses indicating a desire to access operational satellites (96). A number of Members in most regions would like to have access to data from geostationary satellites that provide coverage outside the Member’s Region. Adding the number of responses per satellite gives a ranking order as shown in Table 4.

Ranking position	Satellite(s)	Number of responses
1	TRMM	20
2	NOAA series	19
3	ERS series	18
4	Terra/Aqua	17
5	ENVISAT	15
6=	DMSP series, METEOR series	14
8	JASON-1	13
9=	FY-1, INSAT	12
	Others	9 or less

Table 4. Satellites that Members would like to receive

[K6] **Key finding:** Responses to which satellites Members did not access but would like to, environmental R&D satellites dominated the responses.

5. USE OF SATELLITE DATA AND PRODUCTS (questionnaire Section 2)

Supporting charts and tables are contained in the Excel work book file, "Data Access pivot tables" on the WMO Space Programme web pages at:

<http://www.wmo.int/pages/prog/sat/Questionnaire/documents/DataAccesspivottables.xls>

5.1 Data processing and usage (Question 6)

Table 5 shows numbers of responses on data processing and usage summed across all Regions for the 2006 edition of the questionnaire. Breakdowns of responses by Region along with comparisons with previous editions are contained in the associated Excel work book files.

	Data / product	Used		specify if used by assimilation in numerical model
		Produced in your country	produced elsewhere	
Level 1 data ⁽¹⁾	Image data rendered graphically	48	24	1
	Imager data (VIS, IR, Microwave) used quantitatively	45	27	7
	Sounder data	20	18	12
	Other	1	0	2
Level 2/3 products ⁽¹⁾	Atmospheric Motion Vectors	18	30	12
	Temperature / humidity profiles	28	24	8
	Cloud products	36	32	6
	Sea surface products	27	23	10
	Land surface products	27	19	12
	Precipitation products	26	29	7
	Other	14	6	3

Table 5. Data processing and usage

⁽¹⁾ Level 1 data are basic instrument data, possibly having undergone calibration, earth location and/or quality control correction, usually expressed in radiance or brightness temperature units. Level 2 products are earth located, derived geophysical parameters based on the processing of level 1 data (and possibly also using ancillary data) and Level 3 products are gridded point geophysical products, possibly on a multi-pass basis.

5.2 Distribution to Other Users (Question 7)

There were more respondents who indicated they distribute satellite data to others (45) than there were those who noted they do not (35). Only RA I and RA III reported more "No" responses than "Yes".

5.3 Limiting Factors in the Use of Satellite Data and Products (Question 8)

Supporting charts and tables are contained in the Excel work book file “Utilisation Pivot tables” on the WMO Space Programme web pages at:

<http://www.wmo.int/pages/prog/sat/Questionnaire/documents/UtilisationPivottables.xls>

Table 6 describes the occurrences of various factors limiting the use of satellite data and products.

	No significant limiting factors	Insufficient knowledge	Technical difficulties	Financial difficulties
RA I	1	10	14	11
RA II	0	6	11	10
RA III	2	3	5	2
RA IV	0	6	5	8
RA V	0	4	5	3
RA VI	8	5	11	10
TOTAL	11 (8%)	34 (24%)	51 (36%)	44 (31%)

Table 6. Limiting factors in data usage for each Region

[K7] **Key finding:** The most commonly reported limiting factor in the use of satellite data and products report was technical difficulties, reported by 36% of respondents; followed by financial difficulties, reported by 31%.

Other reported factors limiting the use of satellite data and products are shown in Excel work book file “Utilisation Pivot tables” on the WMO Space Programme web pages.

5.4 Change in usage by Region (Question 9)

Table 7 shows the extent to which usage of satellite data and/or products changed in Regions over the period of the questionnaire.

	No significant change	Slight increase	Significant increase	Slight decrease	Significant decrease
RA I	0	5	13	0	0
RA II	3	3	5	0	1
RA III	2	1	4	0	0
RA IV	4	2	5	0	0
RA V	1	3	2	0	0
RA VI	5	8	13	0	0
TOTAL	15 (19%)	22 (27%)	42 (53%)	0	1 (1%)

Table 7. Change in data usage over the period of the questionnaire for each Region

[K8] **Key finding:** Eighty percent (80%) of respondents reported an increase in data usage with 53% reporting a significant increase and 27% reporting a slight increase.

5.5 Major Changes Planned (Question 10)

Sixty-two (62) respondents described the changes planned in their units in the coming years as a result of new satellite systems, new processing systems, new requirements or specific projects. The majority described activities underway, with the expectation of significant advances in their capacity to provide high quality information services for their Members. Only two responses indicated that no changes are planned. Three explicitly noted their need for external resources to implement their plans, to acquire hardware and software and to implement training (interpretation and applications, software, system administration).

6. APPLICATIONS OF SATELLITE DATA AND PRODUCTS (questionnaire section 3)

6.1 Important (“Mandatory”) Parameters (Question 11)

Supporting charts and tables are contained in the Excel work book file “Applications Pivot tables” on the WMO Space Programme web pages at:

<http://www.wmo.int/pages/prog/sat/Questionnaire/documents/Applicationspivottables.xls>

6.1.1 General Tendencies

To illustrate the general caution against using the trends through these editions as objective measures, it should be noted that only 45 of the respondents to the 2006 edition also provided a response to the 2003 edition. Thirty-six (36) of the respondents to the 2006 edition did not respond to the 2003 edition. The multi-edition comparisons simply describe what was reported in each edition. However, within application areas, parameters that occupied three of the top five or six positions over all three editions for which trend tracking has been done are likely to be the consensus of that community, regardless of the specific reporting units in each edition. In both the 2006 and 2001 editions of the survey results, eight of the parameters in the top 10 positions of the overall “Mandatory” parameters list were also in the top 10 positions of the “Useful” parameters list. In the 2003 edition, seven of the “Mandatory” top 10 were also in the “Useful” top 10.

(R10) **Recommendation:** For simplicity in the next questionnaire, the three columns of “Useful” parameters could be omitted.

The responses from the 2006 edition demonstrate a considerable variability, with many more parameters clustering near the top in most application areas’ lists. This is felt consistent with what is expected with broadened use of high capacity technologies for data accessing, processing, and/or displaying satellite information. Three newly added parameters received notations as being in the top three “Mandatory” parameters: imager radiances (15 notations), sounder radiances (13) and sea ice type (3). Soil moisture stayed high among the “Most required but not available” parameters and, while it was well down the list of “Mandatory” parameters overall, it was included on the mandatory lists of six application areas by 15 respondents.

6.1.2 Mandatory parameters in each application area

Table 8 describes the distribution of “Mandatory” parameters for each application area. To restrict the table size parameters with less than 14 reports are excluded although these may nevertheless be significant in application areas with naturally low numbers of responses or where reports were widely, but thinly, spread. These details and also comparisons with previous editions are shown in the associated Excel work book files.

Overall ranking	Parameter	Nowcasting & (VSRF)	Synoptic meteorology	Global and regional NWP	Aeronautical meteorology	Marine meteorology	Agricultural meteorology	Hydrology	Atmospheric chemistry	Climatology & climate change	Environmental applications	Disaster monitoring and security	Research applications	Public Weather Service (PWS)	TOTAL
1	Cloud imagery	29	39	1	25	15	6	10	-	6	3	16	13	34	197
2	Cloud cover	18	25	1	11	7	2	6	3	11	1	4	2	15	106
3	Cloud type	24	20	-	21	7	-	2	-	4	-	4	5	11	98
4	Precipitation rate	10	2	5	1	2	6	22	-	4	1	13	3	9	78
5	Cloud top temperature	16	18	5	12	4	1	1	-	-	-	4	4	6	70
6	Sea surface temperature	-	4	10	1	25	-	-	-	12	2	-	4	-	58
7	Wind profile	7	11	7	11	-	2	-	2	2	2	1	1	2	48
8	Cloud top height	8	9	-	19	1	-	-	-	1	-	3	2	3	46
9	Temperature profile	2	10	11	4	-	3	-	1	6	3	-	4	1	45
10	Atmospheric instability index	7	11	-	7	1	-	-	1	1	3	2	2	3	38
11	Fires	1	-	-	1	-	4	-	3	-	7	15	3	2	36
12	NDVI	-	-	-	-	-	16	-	-	3	4	4	5	2	34
13	Precipitation index	6	3	1	-	-	3	10	-	3	-	2	1	2	31
14	Rain profile	3	4	2	-	-	1	11	-	3	1	-	1	4	30
15	Wind speed over sea surface	1	-	2	1	19	-	-	-	1	-	-	2	1	26
16	Wind vector over sea surface	-	3	5	1	10	-	-	-	1	-	1	3	-	25
17=	Cloud base height	4	5	-	10	-	-	-	-	-	-	1	-	-	20
17=	Snow cover	-	-	2	-	-	1	7	-	3	2	2	2	1	20
19=	Aerosol total column	-	1	-	1	-	-	-	7	1	7	-	1	1	19
19=	Land cover	-	-	1	-	1	2	5	-	1	4	-	2	3	19
19=	Ozone profile	-	-	-	-	-	-	-	11	4	3	-	1	-	19
19=	Volcanic ash	-	-	-	7	-	-	-	2	-	3	5	2	-	19
23	Land surface temperature	2	1	1	-	-	4	1	-	6	-	-	-	2	17
24	Ozone total column	-	-	-	-	-	-	-	9	4	2	-	1	-	16
25=	Imager radiances	3	2	7	-	-	1	-	-	1	1	-	-	-	15
25=	Significant wave height	-	1	1	-	12	-	-	-	-	-	1	-	-	15
25=	Soil moisture	1	-	2	-	-	5	4	-	-	1	-	2	-	15
25=	Specific humidity profile	-	2	5	1	-	-	-	1	-	-	1	3	2	15
29=	Vegetation type	-	-	-	-	-	6	2	-	-	3	2	1	-	14
29=	Lightning detection	4	3	-	2	1	-	-	-	-	-	2	1	1	14
	Other														<14

Table 8. Mandatory parameters for each application area

The analysis shows the top three parameters considered “Mandatory” were cloud field parameters with precipitation being the fourth most important. The respondents selected a wide set of “Mandatory” parameters for some application areas.

[K9] **Key finding:** Three parameters related to clouds were rated clearly of highest importance overall, in the following ranking order: cloud imagery, cloud cover, and cloud type. Cloud imagery ranked first in six application areas. Precipitation rate was the highest parameter from outside the area of cloud detection/analysis.

6.2 Required but not available parameters

Supporting charts and tables are contained in the Excel work book file “Applications Pivot tables” on the WMO Space Programme web pages at:

<http://www.wmo.int/pages/prog/sat/Questionnaire/documents/Applicationspivottables.xls>

In nearly all of the applications areas, some of the parameters selected as “Most required but not available” were also listed in the top of the “Mandatory” lists. If that type of matched report for the same parameter is from the same respondent, it may imply that the non-availability is due to insufficient accuracy, timeliness or resolution. But, if it is from different respondents, there is no clear implication to be drawn.

(R11) **Recommendation:** In future editions of the questionnaire the question concerning applications should be restructured to enable the distinction between parameters which are required and available, those which are required but not adequate in terms of insufficient accuracy, timeliness or resolution, and those which are not available at all.

Taken across all application areas and all Regions, adding the occurrences of parameters reported as “Most required but not available” gives the ranking order shown in Table 9. A breakdown of responses for each application and Region (and also comparisons across editions) are in the associated Excel work book files.

Ranking position	Parameter(s)	Number of responses
1	Precipitation rate	80
2	Lightning detection	77
3	Wind profile	68
4	Atmospheric instability index	48
5	Soil moisture	45
6=	Precipitation index, rain profile	42
8	Temperature profile	41
9	Cloud base height	36
10	Aerosol total column	31
11=	Specific humidity profile, ozone profile	28
13	Fires	26
14=	Trace gases, wind vector over sea surface, ocean currents, sea surface temperature	25
18=	Wind speed over sea surface, land surface temperature	24
20=	Wave period/direction, significant wave height	22
22=	Vegetation type, cloud water profile	20
	Others	<20

Table 9. Required but not available parameters

[K10] **Key finding:** Precipitation rate, which was ranked fourth of the most often reported “Mandatory” parameters was also ranked first for the “Most required but not available” parameters.

[K11] **Key finding:** Lightning detection, which was added to the list of parameters for this edition, was the second most reported in the list of the “Most required but not available” parameters. It was also selected as one of the top three “Mandatory” parameters, by one or more respondents in seven of the application areas.

(R12) **Recommendation:** WMO Space Programme should take note of those parameters reported as “Most required but not available” and ensure that satellite operators are made aware of these unfulfilled requirements.

(R13) **Recommendation:** Considering the implications of low- and mid-level smoke in climate and weather services that address human health, surface and air traffic hazards, and climate change, its potential inclusion as a separate parameter should be investigated for future editions.

7. TRAINING IN SATELLITE METEOROLOGY (questionnaire section 4)

Supporting charts and tables are contained in the Excel work book file “Education and Training Pivot tables” on the WMO Space Programme web pages at:

<http://www.wmo.int/pages/prog/sat/Questionnaire/documents/EducationandTrainingpivottables.xls>

7.1 Technical Information

The 2006 edition changed the reference period of the initial question (number 12) to “the past two years (2004-2005)”. By doubling the period, it meant that numerical comparisons to the responses in previous editions were not valid, because the previous editions only asked for the information related to “the past year.” Multi-year “stacked bar” charts which are included on the WMO web pages should be used simply to compare the proportions of segments within each bar, for each edition-year.

7.2 Training in each Region (Question 12)

Analysis of responses within the report has been limited to tabulating below the number of reported staff trained per institution per Region and the number of reported staff trained per skill per Region, as shown in Tables 10 and 11 respectively. A full breakdown of the responses is available in the associated Excel work book files.

7.2.1 Number of staff trained by institution

	RMTC	WMO (other than RMTC)	University / industry	Internal	Through bilateral agreement with other WMO Member	Other
RA I	170	20	15	70	22	5
RA II	19	14	77	1590 ⁽¹⁾	46	21
RA III	8	7	22	125	52	12
RA IV	2	100	26	2590 ⁽²⁾	2	3
RA V	2	0	21	167 ⁽³⁾	6	15
RA VI	123	4	34	1561 ⁽⁴⁾	45	120
TOTAL	324	145	195	6103	173	176

Table 10. Number of staff trained by institution for each Region

⁽¹⁾ 1420 reported by a single RA II Member

⁽²⁾ 2400 reported by a single RA IV Member

⁽³⁾ 116 reported by a single RA V Member

⁽⁴⁾ Total dominated by the reports from three RA VI Members (1021, 243 and 120 respectively)

7.2.2 Number of staff trained by skill

	Equipment operation & maintenance	Software development	Physical basis for remote sensing	Satellite image interpretation	Other
RA I	54	6	89	151	2
RA II	586	34	88	1056	3
RA III	24	32	98	70	2
RA IV	14	8	865	533	1303 ⁽⁵⁾
RA V	29	8	89	85	0
RA VI	51	65	578	1067	126
TOTAL	758	153	1807	2962	1436

Table 11. Number of staff trained by skill for each Region

⁽⁵⁾ 1300 of these staff were reported by a single RA IV Member and covered topics described as “Sounder Products, Winds, and Satellite weather briefs”.

7.3 Training Methods (Question 12)

Analysis of responses within the report has been limited to tabulating the number of responses per skill per training method, as shown in Table 12. A full breakdown of the responses is available in the associated Excel work book files.

	Classroom based presentations	Computer Assisted Learning (CAL)	Distance learning	Other
Equipment operation & maintenance	29	10	3	3
Software development	8	4	0	3
Physical basis for remote sensing	24	13	4	1
Satellite image interpretation	56	37	9	3
Other	2	2	1	1
TOTAL	119	66	17	11

Table 12. Training methods employed

Note: Given that tele-briefing / tele-training are activities within the “distance learning” category, it was felt likely that there is more distance learning going on than indicated by the responses. Indeed, one Member in RA IV reported a large amount of tele-training and tele-briefing under the “other” category.

There are many interpretations of what distance learning is and this may be indicated by the following responses to the questionnaire:

- 58 (out of 83 returned responses on questionnaires) are aware of VL;
- 40 (of 58 ticking a box of the specific VL question on the questionnaire) reported to at least occasionally using VL resources.

Thus it was concluded that there is actually a general increase in use of distance learning technology (VISITview tele-briefing / tele-training, Web-based modules (COMET, CALMet, etc.).

(R14) **Recommendation:** Participants at upcoming VL training events should be requested to ensure that their countries respond to the most recent edition of the questionnaire.

7.4 Virtual Laboratory Usage Reported from each Region (Questions 13 and 14)

Table 13 shows the awareness and usage of the Virtual Laboratory (VL) reported from each Region.

	Aware of VL	Not aware of VL	Use VL regularly	Use VL occasionally	Never use VL
RA I	9	8	1	4	4
RA II	11	3	1	5	5
RA III	7	2	6	0	1
RA IV	9	2	5	3	1
RA V	5	1	1	2	2
RA VI	17	9	0	12	5
TOTAL	58 (70%)	25 (30%)	14 (24%)	26 (45%)	18 (31%)

Table 13. Awareness and usage of the VL for each Region

[K12] **Key finding:** This edition was the first in which awareness of the VL was queried. With around 70% of respondents being at least aware of the VL this pays tribute to the advances in that area achieved in recent years. Furthermore, it is possible that the awareness and use may appear artificially low due to respondents not identifying material that was not explicitly labelled as such.

7.5 Limiting Factors in Education and Training in each Region (Question 15)

Table 14 shows the limiting factors in Education and Training in satellite meteorology for each Region.

	No limiting factors	Insufficient access to E&T opportunities	Technical difficulties	Financial difficulties	Other reasons
RA I	1	9	6	15	4
RA II	3	9	9	10	0
RA III	1	4	3	7	1
RA IV	0	5	2	8	1
RA V	1	3	3	3	3
RA VI	7	3	4	13	5
TOTAL	13 (9%)	33 (23%)	27 (19%)	56 (39%)	14 (10%)

Table 14. Limiting factors in education and training for each Region

[K13] **Key finding:** The most commonly reported limiting factor in the education and training in satellite meteorology was financial difficulties, reported by 39% of respondents.

7.6 Changes in Education and Training in each Region (Question 16)

Table 15 shows the extent to which Education and Training in satellite meteorology changed in Regions over the period of the questionnaire.

	No significant change	Slightly more training	Significantly more training	Slightly less training	Significantly less training
RA I	2	9	4	0	1
RA II	6	4	2	2	1
RA III	2	1	4	0	0
RA IV	4	5	1	1	0
RA V	3	3	0	0	0
RA VI	13	8	4	1	0
TOTAL	30 (37%)	30 (37%)	15 (19%)	4 (5%)	2 (2%)

Table 15. Change in level of training over the period of the questionnaire for each Region

[K14] **Key finding:** 56% of respondents reported increased training while only 7% reported less.

8, CONCLUSIONS

The hypotheses made by ET-SUP are analyzed in Appendix B. Suggestions for collecting complementary data and information are contained in Appendix C.

The recommendations and key findings are listed in Appendices D and E respectively.

APPENDIX A

2006 QUESTIONNAIRE ON THE AVAILABILITY AND USE OF SATELLITE DATA AND PRODUCTS

INTRODUCTORY NOTE

This questionnaire is distributed to all WMO Members by the WMO Secretariat every two years. The purpose of the questionnaire is to monitor the availability and usage of existing satellite data and products, to track trends in availability and usage and to identify any associated difficulties or limiting factors including identifying the needs of WMO Members for new or improved satellite data and products. The returns from this survey are analyzed by the WMO Space Programme Office and the results are used in the ongoing discussions with the satellite operators who are part of the spaced-based component of the Global Observing System (GOS) as well as forming a basis for related activities in other WMO Programmes.

The analysis of previous surveys can be accessed at:

<<http://www.wmo.int/pages/prog/sat/Techdocuments.html>> the latest being WMO Technical document (Status of the Availability and Use of Satellite Data and Products by WMO Members, 2005", (WMO/TD No. 1296 SP-2).

The questionnaire has four sections covering the following subjects:

- (1) The way in which satellite data and products are accessed by your unit;
- (2) The way in which satellite data and products are used in your unit;
- (3) Application areas and geophysical parameters retrieved from satellite data that are important or potentially important to your unit;
- (4) The involvement of your unit in education and training in satellite meteorology;

Your suggestions for improving the questionnaire are also invited at the end of the document.

Please enter your details below.

Name of Country: _____

WMO Region: _____

Does this response represent the whole National Meteorological and Hydrological Service (NMHS) or just part of it (when several responses are prepared within a NMHS) or an external entity ⁽¹⁾?

Whole NMHS or organizational part of the NMHS or external entity

Name of the "unit": _____

⁽¹⁾ Note: If the present response is the unique return from a given WMO Member, then the answers in the following pages shall refer to the whole NMHS, whereas if a WMO Member organizes the response to be provided from different organizational units (e.g., regional services), then the answers should only refer to each individual organizational unit responding. Consolidation will be made by WMO if necessary. The word "unit" is used in the questionnaire to mean either the whole NMHS, or one of its organizational parts, or an individual external entity, as appropriate.

SECTION 1 – ACCESS TO SATELLITE DATA AND PRODUCTS

This section focuses on the way in which you access satellite data and products.

1. **Does your unit routinely obtain satellite data and products from any source?**

Yes No

If you answered “Yes” to question 1 please proceed directly to question 4 below.

If you answered “No” to question 1 please proceed with question 2.

2. **Do you have plans to routinely obtain satellite data and/or products for use in your unit in the next two years?**

Yes No

If you answered “Yes” to question 2 please now proceed directly to SECTION 2, Use of Satellite Data and Products.

If you answered “No” to question 1 and question 2, please answer question 3 below and then jump to SECTION 4, Education and Training.

3. **Please complete Table 1 below to indicate what is/are the primary reason(s) that your unit does not access satellite data and/or products.**

[multiple answers are allowed]

Table 1

Reason	Indicate below if statement applies
We have no identified need for satellite data and products	
We have insufficient knowledge of what satellite data and products are available	
We have no satellite data reception capability	
We have technical difficulties preventing access to satellite data and products	
We have financial difficulties preventing access to satellite data and products	
Other reason(s) – please specify	

4. **Please indicate the extent to which access to satellite data and/or products has changed in your unit over the past 2 years (2004-2005).** [select one box]

No significant change Slightly increased Significantly increased
 Slightly decreased Significantly decreased

5. Please indicate in Table 2 below which satellites you RECEIVE data from and which satellites you do NOT receive data from but WOULD LIKE to. Indicate the corresponding reception mechanism(s) by using the codes from Code Table 1 in Annex 1.

Table 2

Sat. Type	Satellite name	Indicate below if data are RECEIVED	Reception mechanism(s) (use codes from Code Table 1 in Annex 1)	Indicate below if data are NOT received but you WOULD LIKE to receive
Operational geostationary satellites	METEOSAT (0°)			
	METEOSAT (63°E)			
	GOES-E (75°W)			
	GOES-W (135°W)			
	MTSAT (140°E)			
	FY-2 (105°E)			
	INSAT (83°E)			
	KALPANA (94°E)			
	GOMS (76°E)			
	Other - please specify			
Operational polar orbiting satellites	NOAA series			
	METEOR series			
	FY-1 series			
	Other - please specify			
R/D & other environmental satellites	ERS series			
	DMSP series			
	SPOT series			
	ENVISAT			
	Quikscat			
	Terra / Aqua			
	TRMM			
	JASON-1			
	Other - please specify			

SECTION 2 – USE OF SATELLITE DATA AND PRODUCTS

6. Please indicate in Table 3 below how satellite data and products are used in your unit.

Table 3

	Data / product	Used		specify if used by assimilation in numerical model	Not used
		Produced in your country	produced elsewhere		
Level 1 data ⁽²⁾	Image data rendered graphically				
	Imager data (VIS, IR, Microwave) used quantitatively				
	Sounder data				
	Other - please specify				
Level 2/3 products ⁽²⁾	Atmospheric Motion Vectors				
	Temperature / humidity profiles				
	Cloud products				
	Sea surface products (specify below)				
	Land surface products (specify below)				
	Precipitation products				
	Other - please specify				

⁽²⁾ Level 1 data are basic instrument data, possibly having undergone calibration, earth location and/or quality control correction, usually expressed in radiance or brightness temperature units. Level 2 products are earth located, derived geophysical parameters based on the processing of level 1 data (and possibly also using ancillary data) and Level 3 products are gridded point geophysical products, possibly on a multi-pass basis.

SECTION 3 – APPLICATIONS OF SATELLITE DATA AND PRODUCTS

11. For each application area in Table 5 below, please indicate, using the codes from Code Table 2 in Annex1, the most important geophysical parameters (up to six) relevant to the activities of your unit and those parameters (up to three) that you would like to use but are not available⁽³⁾.

Table 5

Application area		Using the codes from Code Table 2 in Annex 1, list the most important parameters (up to six) and the most required but not available ⁽³⁾ parameters (up to three) relevant to the activities of your unit								
		Six most important						Three most required but not available ⁽³⁾		
		Mandatory			Useful					
Methods	Nowcasting & VSRF									
	Synoptic meteorology									
	Global and regional NWP data assimilation									
Applications / Services	Aeronautical meteorology									
	Marine meteorology									
	Agricultural meteorology									
	Hydrology									
	Atmospheric chemistry									
	Climatology & Climate change									
	Environmental applications									
	Disaster monitoring and Security									
	Research applications									
	Public Weather Services (PWS)									

⁽³⁾ In this context “not available” means either completely unavailable or not available with sufficient accuracy, timeliness or resolution to meet your requirements.

SECTION 4 – EDUCATION AND TRAINING

12. For each satellite meteorology skill given in Table 6 below, please indicate how many staff members have received training in that skill during the past two years (2004-2005). Please also indicate the type of institution that provided the training and what training methods were used.

Table 6

Skills	Number of staff trained by institution (enter approx. number of staff)						Training method(s) used (check one or more boxes)			
	RMTC	WMO (other than RMTC)	University / Industry	Internal	Through bilateral agreement with other WMO Member	Other – please specify	Classroom based presentations	Computer Assisted Learning (CAL)	Distance learning	Other – please specify
Equipment operation & maintenance										
Software development										
Physical basis for remote sensing										
Satellite image interpretation										
Other – please specify										

13. Are you aware of the Virtual Laboratory (VL) for Training in Satellite Meteorology?

Yes No

14. Do you use the VL to support training activities?

Regularly Occasionally Never

15. Please indicate in Table 7 below what is/are the primary limiting factor(s) in your unit influencing education & training in satellite meteorology.
[multiple answers are allowed]

Table 7

Reason	Indicate below if statement applies
We can identify no significant limiting factors	
We have insufficient access to education & training opportunities	
We have technical difficulties limiting education & training opportunities	
We have financial difficulties limiting education & training opportunities	
Other reason(s) – please specify	

16. Please indicate the extent to which staff training in satellite meteorology has changed in your unit over the past 2 years (2004-2005). [select one box]

No significant change
 Slightly more training
 Significantly more training
 Slightly less training
 Significantly less training

ANNEX 1 – Code Tables**Code Table 1 – Reception mechanisms** (codes to be used in answer to question 5)

Code	Reception mechanism
1	Digital data disseminated via the satellite itself (e.g. HRI, HRPT)
2	Digital data disseminated via another satellite (e.g. HRIT on EUMETCast)
3	Digital data received from a third party
4	Digital data obtained from the Internet
5	Analogue data disseminated via the satellite itself (e.g. WEFAX)
6	Analogue data disseminated via another satellite
7	Analogue data received from a third party
8	Analogue data obtained from the Internet
9	Data received via the GTS
10	Other

Code Table 2 – Parameters (codes to be used in answer to question 11)

Code	Parameters	Code	Parameters
1	Aerosol total column	31	Sea-ice cover
2	Apparent Thermal Inertia	32	Sea-ice surface temperature
3	Atmospheric Instability Index	54	Sea-ice type
4	Cloud base height	33	Sea Level
5	Cloud cover	34	Sea surface temperature
6	Cloud ice total column	35	Short-wave outgoing rad. TOA
7	Cloud imagery	36	Short-wave irradiance at surface
8	Cloud top height	37	Significant wave height
9	Cloud Top Temperature	38	Snow cover
10	Cloud type	39	Snow melting conditions
11	Cloud water profile	40	Soil moisture
12	Cloud water total column	41	Specific humidity profile
13	Fires	42	Specific humidity total column
14	Height of tropopause	43	Temperature Profile
15	Icebergs	44	Trace gases
16	Land cover	45	Tropopause temperature
17	Land surface features	46	Vegetation Type
18	Land surface temperature	47	Wave period/direction
19	Leaf Area Index (LAI)	48	Wind profile
20	Long-wave surf. emissivity	49	Wind speed over sea surface
21	Long-wave outgoing rad. TOA	50	Wind vector over sea surface
52	LW incoming surface radiation	51	Volcanic ash
22	Norm. Diff. Veg. Index (NDVI)		Other geophysical parameter– please specify:
23	Ocean currents	55
24	Ozone profile	56
25	Ozone total column	57
26	Precipitation index	58
27	Precipitation rate	59	Sounder radiances
28	Rain profile	60	Imager radiances
53	Lightning detection		
29	Salinity		

APPENDIX B

ANALYSES OF HYPOTHESES

The hypotheses developed by ET-SUP-2 related to the changes that had occurred during the period of the current Questionnaire and are listed below. The analyses of the hypotheses, where this has been possible from information available, are shown *italicized thus*.

1. It was hypothesized that for data access (2004-2005):
 - The number of NMHSs obtaining - or planning to obtain - satellite data and products will increase; *Hypothesis proved – 79% of responses indicated an increase in access to data (see section 4.3).*
 - The number of NMHSs reporting problems of knowledge how to access satellite data and products will decrease; *Hypothesis can only be tested in future editions since the associated question was not asked in the previous edition.*
 - The number of NMHSs reporting significant decrease in access to satellite data and products will decrease; *Hypothesis can only be tested in future editions since the associated question was not asked in the previous edition.*
 - The number of NMHSs reporting increase in access to satellite data and products will increase; *Hypothesis can only be tested in future editions since the associated question was not asked in the previous edition.*
 - The number of NMHSs reporting reception of analogue data will decrease considerably; *Hypothesis proved – see section 4.4.*
 - The number of NMHSs reporting reception via ADMs will increase; *Hypothesis proved – see section 4.4.*
 - The number of NMHSs reporting access to R&D satellite data and products will increase. *Hypothesis proved – see Excel work book associated with section 4.5.*
2. It was further hypothesized for data use (2004-2005) that:
 - Qualitative estimation by respondents of the extent of use of satellite data/products would increase across questionnaire editions; *Hypothesis proved – see Excel work book associated with section 5.5.*
 - The number of satellite sensors assimilated into NWP models would increase across questionnaire editions; *There is insufficient evidence to test this hypothesis from the Questionnaire alone – it requires additional information from NWP Centres and evidence from future editions.*
 - The number of satellite observations (soundings, AMVs, radiances, surface winds) assimilated into NWP models would increase across questionnaire editions; *There is insufficient evidence to test this hypothesis from the Questionnaire alone – it requires additional information from NWP Centres and evidence from future editions.*
 - The number of satellite products used would increase across the questionnaire editions as a result of increased numbers of satellite sensors; *There is insufficient evidence to test this hypothesis from the Questionnaire alone – it requires additional information from future editions.*
 - The number of products produced in the latest questionnaire edition not previously produced would increase (e.g., image products, temp/profiles, products, AMVs, cloud products, sea surface products, land, precipitation); *Hypothesis partially proved – see section 5.1 and associated Excel work book.*

- The number of products available from R&D satellites would increase across editions; ***There is insufficient evidence to test this hypothesis from the Questionnaire alone – it requires additional information from future editions.***
 - The number of satellite products on the GTS would increase over time (can test outside of questionnaire); ***There is insufficient evidence to test this hypothesis from the Questionnaire alone – it requires additional complementary information and evidence from future editions.***
 - The number of hits on satellite web pages (e.g. number of users downloading an image) would increase across questionnaire editions (test using data from NMHSs and WMO SP); ***There is insufficient evidence to test this hypothesis from the Questionnaire alone – it requires complementary information and evidence from future editions.***
 - The implementation of PUMA (Preparing Users for MSG in Africa) would result in an increase in satellite data/product usage in RA I (Africa). ***Hypothesis proved – see section 4.4.***
3. Given that tele-briefing / tele-training is part of distance learning category, it was hypothesized that there is more distance training going on than indicated by responses to the current version of the Questionnaire. ***There is insufficient (or ambiguous) evidence to test this hypothesis from the Questionnaire alone – it requires complementary information and evidence from future editions.***

APPENDIX C

SOURCES OF COMPLEMENTARY DATA AND INFORMATION

Examples of complementary data sources to improve status reporting by the WMO Space Programme identified by ET-SUP are tabulated below. Other sources of data include the International Precipitation Working Group (IPWG), the International ITOVS Study Conference (ITSC), the International Winds Workshop (IWW) and reports and activities of their Working Groups. ET-SUP noted that collecting and analyzing these complementary data was considered to be an intersessional activity to be led by the WMO Space Programme and acknowledged that associated responsibilities and resources needed to be investigated.

Area of interest (satellite data usage)	Information source	Comments
NWP usage of satellite data types, sensors	NWP Centres	Agreed already by WMO Space Programme.
Data reception and access	ADM operators; Satellite operators that maintain registration DB; equipment manufacturers; WMO database	Potential commercial sensitivities on location and number of sales of reception/processing equipment; Licensing for example with EUMETCast includes information on products used; WMO receiving station database is online but needs to be updated.
Training data	Regular RTC reports	Presumably in WMO ETR Programme – extract satellite specific training that is relevant to the Questionnaire.
Satellite relevant data	WMO Programmes	WMO Space Programme is well placed to identify those Programmes and their reports or databases.
Web access information	NMHSs and WMO	Need to have statistics that are extremely specific to satellite data and products e.g. number of image downloads or number of users accessing one image.
GTS satellite products	NMHSs and WMO	RTHs could establish monitoring system.
Numbers of channels used and which channels	Questionnaire update	

APPENDIX D

RECOMMENDATIONS

- (R1) **Recommendation:** Periodic analysis of the status of availability and use of satellite data and products should be accomplished through a combination of an objective analysis of a questionnaire completed by the Members complemented by an analysis based on information gathered from other sources related to satellite data accessing, processing and training.
- (R2) **Recommendation:** An evaluation of the reasons for low levels of participation should be conducted, so that measures can be implemented to overcome any identified impediments.
- (R3) **Recommendation:** For future analysis of the status of availability and use of satellite data and products actions should be taken to seek to engage every WMO Member and relevant WMO Programme through its lead Technical Commission and their infrastructure organizations of OPAGs and Expert Teams as well as Executive Council Panels where appropriate, e.g. for Education and Training and Natural Disaster Prevention and Mitigation. The Regional Association Rapporteurs to the WMO Space Programme should also be involved.
- (R4) **Recommendation:** WMO Programmes should give added attention to the techniques and systems for use of digital satellite data in operational applications within their Programmes' areas of focus, and stress them through their support activities to enhance Members' services.
- (R5) **Recommendation:** A mechanism should be established to address any questions and concerns raised by Members in their responses to the questionnaire.
- (R6) **Recommendation:** The questionnaire should be streamlined further, and a more user-friendly version of the questionnaire should be adopted. For instance, providing an electronic version (either online or on CD) could facilitate Members' task of collecting the information from the different services and managing the answers.
- (R7) **Recommendation:** WMO Regional Associations should be encouraged to promote the use of dissemination services that use commercial satellites (DVB-S systems) that would be linked into an Integrated Global Data Dissemination Service (IGDDS). WMO Members should be encouraged to access satellite data and products via IGDDS systems when available.
- (R8) **Recommendation:** In view of the expectations of positive impacts of major initiatives such as PUMA and EUMETCast, evaluations should be conducted of the correlation of the projects' milestones to the reported availability and use of satellite data and products.
- (R9) **Recommendation:** Responses to trend questions (asking for changes observed during the period of the questionnaire) should be made mandatory in future editions.
- (R10) **Recommendation:** For simplicity in the next questionnaire, the 3 columns of "Useful" parameters could be omitted.
- (R11) **Recommendation:** In future editions of the questionnaire the question concerning applications should be restructured to enable the distinction between parameters which are required and available, those which are required but not adequate in terms of insufficient accuracy, timeliness or resolution, and those which are not available at all.
- (R12) **Recommendation:** WMO Space Programme should take note of those parameters reported as "Most required but not available" and ensure that satellite operators are made aware of these unfulfilled requirements.
- (R13) **Recommendation:** Considering the implications of low- and mid-level smoke in climate and weather services that address human health, surface and air traffic hazards, and climate change, its potential inclusion as a separate parameter should be investigated for future editions.
- (R14) **Recommendation:** Participants at upcoming VL training events should be requested to ensure that their countries respond to the most recent edition of the questionnaire.

APPENDIX E

KEY FINDINGS

- [K1] **Key finding:** Fifty-two (52) Members have never submitted a response, and only 15 Members have answered every edition.
- [K2] **Key finding:** The level of response from RA III was far higher than any other WMO Region.
- [K3] **Key finding:** As described in an ET-SUP hypothesis (see Appendix B), the introduction of data dissemination services that use commercial satellites (DVB-S systems) and which significantly lower reception station costs may have been a stimulus for the significant increase of the use of quantitative data accessed in all regions, particularly RA I and RA IV, since 2001. During the same period, the use of direct broadcast analogue systems significantly decreased.
- [K4] **Key finding:** Taking all regions together, 60% of responses indicated a significant increase in satellite data access during the period of the questionnaire and a further 20% indicated a slight increase. Two (2) Members from RA II reported they had significantly decreased their access. Only two Members responded that they do not access satellite data and have no plans to do so.
- [K5] **Key finding:** In RA I and RA VI the significant increases of accessing digital data via another satellite clearly stem from the EUMETCast service. For RA I this also implies a positive benefit resulting from the PUMA Project.
- [K6] **Key finding:** Responses to which satellites Members did not access but would like to, environmental R&D satellites dominated the responses.
- [K7] **Key finding:** The most commonly reported limiting factor in the use of satellite data and products report was technical difficulties, reported by 36% of respondents followed by financial difficulties, reported by 31%.
- [K8] **Key finding:** Eighty percent (80%) of respondents reported an increase in data usage with 53% reporting a significant increase and 27% reporting a slight increase.
- [K9] **Key finding:** Three parameters related to clouds were rated clearly of highest importance overall, in the following ranking order: cloud imagery, cloud cover, and cloud type. Cloud imagery ranked first in 6 application areas. Precipitation rate was the highest parameter from outside the area of cloud detection/analysis.
- [K10] **Key finding:** Precipitation rate, which was ranked fourth of the most often reported "Mandatory" parameters was also ranked first for the "Most required but not available" parameters.
- [K11] **Key finding:** Lightning detection, which was added to the list of parameters for this edition, was the second most reported in the list of the "Most required but not available" parameters. It was also selected as one of the top 3 "Mandatory" parameters, by one or more respondents in 7 of the application areas.
- [K12] **Key finding:** This edition was the first in which awareness of the VL was queried. With around 70% of respondents being at least aware of the VL this pays tribute to the advances in that area achieved in recent years. Furthermore, it is possible that the awareness and use may appear artificially low due to respondents not identifying material that was not explicitly labelled as such.
- [K13] **Key finding:** The most commonly reported limiting factor in the education and training in satellite meteorology was financial difficulties, reported by 39% of respondents.
- [K14] **Key finding:** 56% of respondents reported increased training while only 7% reported less.