GEO Task US-09-01a: Critical Earth Observations Priorities

Final Report to the UIC - Cross-SBA Analysis

GROUP ON EARTH OBSERVATIONS

User Interface Committee

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Group on Earth Observations

GEO Task US-09-01a:
Critical Earth Observation Priorities – Cross-SBA Report

Analysts

The following people served as lead Analysts and primary authors of the individual SBA reports indicated. The Analysts organized their respective Advisory Groups, collected and analyzed relevant documents, authored their respective reports, and contributed to development of the Cross-SBA analysis methodology.

SBA	Completion Date	Analyst	Affiliation
Agriculture	August 2010	Allan SOMMER	Battelle, USA
Agriculture/ Forests	August 2010	Glynis LOUGH	Battelle, USA
Biodiversity	October 2009	Greg SUSANKE	U.S. Environmental Protection Agency, USA
Climate	February 2010	Molly MACAULEY	Resources for the Future, USA
Disasters	Part 1: January 2010, Part 2: July 2010	Stephanie WEBER and Amy HUFF	Battelle, USA
Ecosystems	Part 1: January 2010, Part 2: August 2010	Glynis LOUGH and Harry STONE	Battelle, USA
Energy	January 2010	Erica ZELL	Battelle, USA
Health/ Aeroallergens	December 2009	Hillel KOREN	University of North Carolina at Chapel Hill, USA
Health/ Air Quality	December 2009	Rudolf HUSAR	Washington University at St. Louis, USA
Health/ Infectious Diseases	December 2009	Pietro CECCATO	Columbia University, USA
Water	January 2010	Sushel UNNINAYAR	University of Maryland Baltimore County, (onsite at NASA), USA
Weather	February 2010	Michael NYENHUIS	University of Bonn, Germany

Erica ZELL (Battelle, USA) served as the Cross-SBA Analyst and is lead author of this report. Ms. Zell holds an M.S. in Environmental Engineering and has 13 years of experience in the environmental field, including significant international experience with the application of satellite data for energy and air quality applications. Ms. Zell was supported by Adam CARPENTER and Amy HUFF (both Battelle, USA).

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GEO Task US-09-01a

Lawrence FRIEDL (USA/NASA) is the Task Lead for GEO Task US-09-01a; he is a member of the GEO User Interface Committee.

Amy Jo SWANSON (USA/Science Systems and Applications, Inc) is the US-09-01a Task Coordinator, providing logistics and coordination amongst the Analysts.

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Summary

This report summarizes the results of the Cross-SBA analysis with Group on Earth Observations (GEO) Task US-09-01a, with the objective of identifying critical Earth observation priorities across the nine GEO Societal Benefit Areas (SBAs). This report is to the Task Lead, who manages the task, and to the GEO User Interface Committee (UIC), which oversees the task for GEO. The report provides information on the process and methods used. This report describes aspects of the process in detail and is largely for internal use by the Task Lead and UIC. Under the guidance of the UIC, the Task Lead will produce a public version of the results, findings, and recommendations.

The critical Earth observation priorities identified in this report are based on input from 167 Advisory Group members and an analysis of over 1,700 publicly available documents, many of which were produced by GEO Member Countries and Participating Organizations.

Task US-09-01a began with the UIC assigning an Analyst for each SBA. In turn, those Analysts identified an Advisory Group of respected experts in the field, representing both developing and developed countries. The Analysts and Advisory Groups defined the scope of the SBA analyses, identified and reviewed existing documents that address user needs for Earth observations, established meta-analysis methods and priority setting criteria, and summarized the results in individual SBA reports. Subsequently, the Cross-SBA Analyst reviewed the SBA reports, gathered input from the SBA Analysts, and developed a statistically robust ensemble of methods to identify the most critical Earth observation priorities from across the individual SBA reports. The Cross-SBA analysis method consisted of four variations of frequency analysis and identification of key observation parameters. This report presents the results of each of these prioritization methodologies individually, and concludes with an average ranking for each observation along with the variance depicted as the range of rankings for each observation.

Because this is a report on user needs, the Analysts took great care to utilize user terminology to describe their needs. Note that there are several instances where users were not specific and described concepts rather than details. Hence, many of the required observation parameters discussed in this report are phenomena of interest to a user (e.g., urbanization) rather than technical specifications of a observation as discussed in the remote sensing or in situ measurement communities (e.g., reflectance of a specific bandwidth of light). The ranking of an observation in the Cross-SBA results does not imply objective importance of that observation as much as commonality in need. The 20 highest-ranked critical Earth observation parameters, in approximate order of priority, are listed in Table S-1.

The Analysts took great care to overcome some inherent limitations in performing a Cross-SBA analysis. Note that observation parameters that do not make the final list of Cross-SBA priorities may still be critical for certain SBAs and users.

User needs vary within an SBA, by region, and also by the geographic scale of focus of the users. Despite identification and review by Analysts of over 1,700 publicly available documents, the Analysts found that users' Earth observation needs are not universally well documented,

particularly for national and regional scale interests. The observation parameter characteristics needed by users vary, and in many cases, are not quantified. In order to preserve the intent of the original user requests, this document uses the user's terminology when discussing observations. The UIC can use the results to this analysis in dialogues with communities of users and gather additional information on user needs.

Table S-1. Critical Earth Observation Parameters* across all SBAs

Rank	Observation Parameter
1	Precipitation
2	Soil Moisture
3 (tie)	Surface Air Temperature
3 (tie)	Surface Wind Speed
5	Land Cover
6	Surface Humidity
7	Vegetation Cover
8	Surface Wind Direction
9 (tie)	NDVI
9 (tie)	Sea Surface Temperature (SST)
11	Urbanization
12	Vegetation Type
13	Land Surface Temperature
14	Surface Atmospheric Pressure
15 (tie)	Glacier/Ice Sheet Extent
15 (tie)	Leaf Area Index
17	Upper Level Humidity
18	Elevation
19 (tie)	Stream/River Flow
19 (tie)	Upper Level Winds

*"Observation Parameter" here captures user terminology. Some observation parameters represent derived phenomena based on multiple raw observations. Refer to Figure 7 for a more extensive listing of critical observation parameters and depictions of variance.

1. Introduction

This report articulates Earth observation priorities across the nine SBAs, based on input from 167 Advisory Group members and an analysis of almost 1,700 publicly available documents, many of which were produced by GEO Member Countries and Participating Organizations.

1.1. GEO and Societal Benefit Areas

GEO[1] is an intergovernmental organization working to improve the availability, access, and use of Earth observations to benefit society. GEO is coordinating efforts to build a Global Earth Observation System of Systems (GEOSS)[2]. GEOSS builds on national, regional, and international observation systems to provide coordinated Earth observations from thousands of ground, in situ, airborne, and space-based instruments. GEO is focused on enhancing the development and use of Earth observations in nine SBAs: Agriculture, Biodiversity, Climate, Disasters, Ecosystems, Energy, Health, Water, and Weather[3].

1.2. Task US-09-01a

The objective of GEO Task US-09-01a is to establish and conduct a process to identify critical Earth observation priorities within each SBA and those common to the nine SBAs. Many countries and organizations have written reports, held workshops, sponsored projects, conducted surveys, and produced documents that specify Earth observation needs. Task US-09-01a compiles information on observation parameters from a representative sampling of these existing materials and analyzes across the materials to determine the priority observations.

This task includes ground, in situ, airborne, and space-based observations. The focus is on both observed and derived observation parameters as well as model products. This task seeks to identify Earth observation needs across a full spectrum of user types and communities both within each SBA and across all SBAs, including observation needs from a variety of geographic regions and significant representation from developing countries.

GEO will use the Earth observation priorities resulting from Task US-09-01a to determine, prioritize, and communicate gaps in current and future Earth observations. GEO Member Countries and Participating Organizations can use the results in determining priority investment opportunities for Earth observations individually and collaboratively.

1.3. Purpose of Report

The purposes of this report are to:

1) Articulate the critical Earth observation priorities across the nine SBAs,
2) Explain the underlying Cross-SBA meta-analysis methodology,

[1] GEO Website: *http:// www.earthobservations.org*
[2] GEO 10-Year Implementation Plan: *http://www.earthobservations.org/documents.shtml*
[3] There are 9 SBAs within GEO. The Biodiversity report analyzed documents and produced a report; however, it did not identify and articulate Earth observation priorities. There are three separate reports for the Health SBA. See Chapter 2 for more details.

3) Provide important context for interpretation of the Earth observation priorities articulated in this report, and
4) Make recommendations for future GEO processes to determine Earth observation priorities.

The primary audiences for this report are the US-09-01a Task Lead, who is managing the task, and the GEO UIC, which is overseeing the task for GEO. The Task Lead and GEO UIC will use the results of this report to make recommendations to the GEO Secretariat, Committees, Member Countries, Participating Organizations, Observers, and Communities of Practice on critical Earth observation priorities from a user's perspective.

1.4. Scope of Report

The focus of this report is on the Cross-SBA analysis methodology and resulting overall Earth observation priorities. This report also provides a brief overview of each of the individual SBA reports, including the methodologies employed by the Analysts and their results. For additional details on SBA-specific Earth observation priorities, reference the individual SBA reports.

The Cross-SBA analysis report focuses on Earth observation priorities, independent of any specific technology or collection method. Thus, the report addresses the "demand" side of observation needs and priorities. By design, the report does not address the specific source of the observations or the sensor technology involved with making, collecting, or reporting on the observations. Discussion of visualization tools, decision support tools, integrative models or system processing characteristics are beyond the scope of this report.

In this report, the term "Earth observation" refers to observation parameters and variables (e.g., physical, geophysical, chemical, biological) sensed or measured, derived observation parameters and products, and related observation parameters from model outputs. Because this is a report on user needs, the Analysts took great care to utilize user terminology to describe their needs. Hence, many of the required observation parameters discussed in this report are phenomena of interest to a user rather than technical specifications of an observation as discussed in the remote sensing or in situ measurement communities, as further discussed in Section 2.2.2. The term "Earth observation priorities" refers to the observation parameters deemed of higher significance than others, as determined through the methodologies described within. The report uses the terms "user needs" and "user requirements" interchangeably to refer to Earth observations that are articulated and desired by the groups and users in the cited documents. The term "requirements" is used generally in the report to reflect users' wants and needs; its use in this report does not imply technical, engineering specifications. Follow-on activities would be needed to determine technical specifications and engineering requirements for any specific observation.

To develop this Cross-SBA report, the lead author worked collaboratively with individual SBA Analysts – collectively referred to as "we" or "our task team" herein. This report discusses the overall approach and the "ensemble of methods" methodology employed for this Cross-SBA analysis in Chapter 2. Chapter 3 presents the priority Earth observations determined by the individual SBA reports. Chapter 4 presents the priority Earth observations resulting from the Cross-SBA analysis. Chapters 5 and 6 present critical context for report interpretation and recommendations for future GEO processes to identify Earth observation priorities. The appendices contain a list of acronyms used throughout the report (Appendix A), a list of user types for each SBA (Appendix B), additional data utilized in the various ranking methodologies (Appendices C and D), and a master list of the Advisory Group members for each SBA report (Appendix E).

2. Methodology

For GEO Task US-09-01, individual SBA Analysts prepared individual reports on the critical Earth observation priorities for users associated with their SBA. Throughout the report preparation process, the SBA Analysts participated in monthly teleconferences and two in-person Analysts meetings (February 2009 and February 2010) to facilitate coordination among the Analysts. At the second Analysts meeting, the Cross-SBA Analyst facilitated a discussion on the Cross-SBA analysis; based on this discussion, the Cross-SBA Analyst developed this Cross-SBA report. Due to the diverse nature of the Health SBA, three separate reports (Air Quality, Infectious Diseases, and Aeroallergens) were prepared by separate Analysts, and the results of these reports were merged and treated as a single SBA report for the purposes of this Cross-SBA analysis. Also, a separate report was prepared by a separate Analyst for the Agriculture/Forests sub-area, the results of which were merged into components of both the Agriculture and Ecosystems SBA, as appropriate, for this Cross-SBA analysis. For categorization, we list Agriculture/Forests under the Agriculture SBA. Finally, due to the breadth of topics in the Disasters and Ecosystems SBAs, the US-09-01a UIC Task Lead directed that two iterations of reports be prepared, each covering a set of three sub-areas that were determined in coordination with the respective Advisory Groups. A Biodiversity report was completed in time for this analysis, but it did not contain observation priorities usable for Cross-SBA analysis[4]. The methodology for the individual SBA reports and the Cross-SBA analysis are described in this Chapter.

2.1. Individual SBA Report Methodology

The basic methodology for identifying critical Earth observation priorities within an SBA relied on an Analyst working in coordination with an Advisory Group to select the scope of the analysis, identify and analyze relevant documents, and finally extract and prioritize relevant Earth observation parameters. The GEO UIC established a general process for each of the SBA Analysts to follow in order to ensure some consistency across the SBAs. This general process for each SBA involves 9 steps, as summarized in the following list:

Step 1: UIC Members identify Advisory Groups and Analysts for each SBA
Step 2: Determine scope of topics for the current priority-setting activity
Step 3: Identify existing documents regarding observation priorities for the SBA

[4] A report was prepared for the Biodiversity SBA, but the report did not specify specific parameters needed by users, despite repeated requests by the UIC Task Co-Leads. Therefore, the results of the Biodiversity SBA report could not be incorporated into this Cross-SBA analysis. As such, Earth observation priorities needed by the range of biodiversity users are only included in this Cross-SBA analysis to the extent that there is overlap between the Biodiversity SBAs and other SBAs.

Step 4: Develop analytic methods and priority-setting criteria
Step 5: Review and analyze documents for priority Earth observations needs
Step 6: Combine the information and develop a preliminary report on the priorities
Step 7: Gather feedback on the preliminary report
Step 8: Perform any additional analysis
Step 9: Complete the report on Earth observations for the SBA.

A detailed description of the general US-09-01a process is available at the Task website *http://sbageotask.larc.nasa.gov* or the GEO website. While all the Analysts followed the overall process, each SBA Analyst was given some latitude to work with his or her Advisory Group to implement the nine steps as most appropriate for the assigned SBA, such as using unique analytic methods and priority-setting criteria. Because each SBA Analyst implemented the steps slightly differently, some reports present final observation parameters in a ranked or tiered order while others present an unordered set of priority observations. For the SBA reports, the Task Lead provided a report template for each of the SBA Analysts to follow.

2.1.1. Analysts and Advisory Groups

Table 1 lists the Analysts and their affiliations for each of the SBA reports. Members of the UIC committee identified and supported the Analysts.

Table 1. SBA Analysts and Affiliations

SBA	Analyst	Affiliation
Agriculture	Allan SOMMER	Battelle, USA
Agriculture/ Forests	Glynis LOUGH	Battelle, USA
Biodiversity	Greg SUSANKE	U.S. Environmental Protection Agency, USA
Climate	Molly MACAULEY	Resources for the Future, USA
Disasters	Stephanie WEBER and Amy HUFF	Battelle, USA
Ecosystems	Glynis LOUGH and Harry STONE	Battelle, USA
Energy	Erica ZELL	Battelle, USA
Health/ Aeroallergens	Hillel KOREN	University of North Carolina at Chapel Hill, USA
Health/ Air Quality	Rudolf HUSAR	Washington University at St. Louis, USA
Health/ Infectious Diseases	Pietro CECCATO	Columbia University, USA
Water	Sushel UNNINAYAR	University of Maryland Baltimore County, (onsite at NASA), USA
Weather	Michael NYENHUIS	University of Bonn, Germany

Each Analyst assembled an ad hoc Advisory Group, which consisted of between 6 and 23 members. The members had technical, scientific, management, or policy expertise and are respected in their fields. Table 2 lists the number of Advisory Group members per SBA.

Table 2. Number of Advisory Group Members for Each SBA Report

Report	Number of Advisory Group Members
Agriculture	12
Agriculture/ Forests	6
Biodiversity	8
Climate	7
Disasters/ Earthquakes, Landslides, Floods	13
Disasters/ Tropical Cyclones, Wildfires, Volcanoes	23
Ecosystems/ Forests, Coastal and Near-Shore Marine Systems, Watersheds	11
Ecosystems/ Tundra, Inland Waters, Islands and Archipelagos	17
Energy	14
Health/ Aeroallergens	16
Health/ Air Quality	11
Health/ Infectious Diseases	19
Water	14
Weather	8
TOTAL	**167***

* The sum of the individual advisory groups does not equal the total number of Advisory Group members because there were some individuals who served on two Advisory Groups.

The Advisory Group members were from both developed and developing countries, and encompassed all regions of the world. The members included people from GEO Member Countries and Participating Organizations as well as people outside of GEO. For solicitation of Advisory Group members, the UIC Task Co-Lead for US-09-01a, Lawrence Friedl (NASA), sent a request to the UIC via email soliciting participation. Individual Analysts also coordinated with contacts at the GEO Secretariat, relevant GEO Communities of Practice, former IGOS Themes, and other organizations such as the Committee on Earth Observation Satellites (CEOS) and the World Meteorological Organization (WMO). The selection of Advisory Group members was at each Analyst's discretion, based on the task methodology requirement to maximize breadth of expertise and geographic representation. The responsibilities of the Advisory Groups were to help identify relevant documents, comment on the analytic methods and priority-setting criteria utilized, and review the Analysts' findings, priorities, and reports. Communication was conducted primarily via emails and group teleconferences, with limited face-to-face meetings arranged to capitalize on conferences which a critical mass of Advisory Group members had planned to attend for other purposes.

2.1.2. Scope, Users, and Documents

Each Analyst worked with his or her Advisory Group to determine the scope of each SBA report, including the sub-areas of focus which helped organize and bound the analyses. In general, the Analyst and Advisory Group selected sub-areas to represent either logical sub-topics within their SBA (e.g., types of disasters for the Disasters SBA), or different topics on which users may focus (e.g., famine early warning within the Agriculture SBA). The Analysts referred to the GEO 10-year Implementation Plan for a description and summary of topics within each SBA. Table 3 identifies the sub-areas of focus for each SBA report, and the number of documents (further described in this section) incorporated into the US-09-01a analysis.

In selecting the sub-areas of focus, and subsequently searching for relevant documents, each Analyst considered the range of users associated with a specific SBA. In general, each Analyst sought documents representing the broad range of users. Appendix B contains preliminary lists developed by each Analyst of user types by SBA. The users identified by the Analysts can be categorized in a number of different ways, but are typically divided into users who work with "raw" data, and multiple tiers of users who work with higher-order data products and derived produced as well as tools, models, and targeted information. Users span a wide range of sectors, including the public sector, the private sector, academia, and the media, and are interested in a variety of timescales including historical trend analysis, operational tactical decisions, and strategic planning and forecasting.

Many Analysts described the users as functioning in a progression. For example, the Health SBA Infectious Diseases Analyst and Advisory Group identified a "chain of users" starting from the research community and ending at the decision-makers, with entities identified as boundary organizations providing an informational link between the two endpoints of the user chain. Many Analysts also noted the overlap among the users, such that many users require information associated with several different SBAs. This overlap was particularly highlighted by the Climate, Water, and Weather Analysts. For example, the Water SBA users include, but are not limited to, those involved in agriculture, reservoir management, water resource management, irrigation scheduling, urban water supply, drinking water utilities, waste/storm water utilities, the energy sector, transportation, forestry and ecosystem management, natural disaster prevention and mitigation, and the health sector. Similarly, Weather SBA users include those in the disasters, health, agriculture, and energy sectors, among others. Through the interaction among the SBA Analysts, each SBA Analyst sought to focus on issues that were unique to his or her SBA and sought to minimize duplication of topics addressed in other SBA reports.

As noted in each individual SBA report, some Analysts explicitly conducted analyses to ascertain needs according to user type and identify any gaps in representation of users. Other Analysts simply referenced a user type list to help guide their document search.

The Task US-09-01a methodology required examination of a wide range of sources for potentially relevant, publicly available documents, including:

- International, regional, and national documents focused on data sources, applications, or research priorities

- Project reports (e.g., findings from major regional/national projects)
- Surveys (e.g., of users of solar resource data)
- Workshop and conference summaries
- Peer-reviewed journal articles.

The SBA Analysts used a twofold methodology for identifying potentially relevant documents: (1) literature and online searches, and (2) requests for Advisory Group members to suggest documents. Some Analysts (for example, the Weather, Water, and Health/Aeroallergens with Analysts) also conducted targeted interviews with subject matter experts at universities and governmental decision-makers. In order for a SBA Analyst to deem a document relevant for inclusion in the Analysis, the document had to include one or both of the following: (1) specification of Earth observation parameters *needed by users* (preferred), or (2) reference to Earth observation parameters *currently in use*, with some indication of the *adequacy* of the observation parameter characteristics[5] as currently provided. The availability of these two classes of documents varied by SBA; information on specific data gaps found in the literature according to SBA is summarized in Chapter 5 and detailed in the individual SBA reports.

Table 3. Sub-Areas of Focus and Number of Documents Used[1] for SBA Reports

Report	Sub-Areas of Focus	Number of Documents
Agriculture	Famine Early Warning Agriculture Production Seasonal/Annual Agriculture Forecasting and Risk Reduction Aquaculture Production	54
Agriculture/ Forests	Timber, Fuel, and Fiber Management Forest Perturbations and Protection Carbon and Biomass	16
Biodiversity	Ecosystems Species	60
Climate	Atmosphere Oceans Lands	40
Disasters	Earthquakes Floods Landslides Tropical Cyclones Volcanic Eruptions Wildfires	85
Ecosystems	Coastal and Near-Shore Marine Systems Forests Inland Waters Oceanic Islands and Archipelagos	115

[5] The parameter characteristics that were sought by the Analyst are as follows: Coverage/Extent, Temporal Resolution, Spatial resolution, Timeliness, and Accuracy/Precision.

Report	Sub-Areas of Focus	Number of Documents
	Tundra Watersheds[2]	
Energy	Hydropower Wind Energy (land-based and offshore) Bioenergy (Including Transportation Biofuels) Solar Energy Geothermal Energy	54
Health[3]	Aeroallergens Air Quality Infectious Diseases	1,093
Water	Surface Waters Ground Waters Forcings (on the Terrestrial Waters) Water Quality/Water Use	200
Weather	Global Numerical Weather Prediction Regional Numerical Weather Prediction Synoptic Meteorology Nowcasting and Very Short Range Forecasting Seasonal and Inter-annual Forecasts Aeronautical Meteorology Atmospheric Chemistry Ocean Applications Agricultural Meteorology Hydrology	25
TOTAL		**1,742**

[1]Analysts reviewed many potentially relevant documents; the number here represents those documents deemed relevant (i.e., containing information on user needs).
[2]Watersheds was selected to capture the land-based mix of ecosystem elements, such as wetlands, impervious surfaces, biological communities, and lands highly affected by non-native species, and the impact that intermingling of these elements has on functioning of specific ecosystem types.
[3]Health numbers are a sum across three sub-reports: Aeroallergens, Air Quality, and Infectious Diseases.

2.1.3. Meta-Analysis Methods and Prioritization

The Analysts reviewed the relevant documents and entered information on Earth observation priorities and needs into custom databases or spreadsheets. In addition to recording the Earth observation needs, some Analysts recorded information on required observation parameter characteristics, the type of document, the user community represented, and any methods employed within the document.

The Analysts developed prioritization methods for the Earth observation parameters in coordination with their Advisory Groups. The prioritization methods employed were a combination of quantitative and qualitative approaches and included one or more of the following types for each SBA report: frequency or bibliometric analysis, evaluation of cross-cutting applicability to SBA sub-areas (listed in Table 3), consideration of document types, Advisory Group input, and health effects[6]. Based on these methodologies, each Analyst developed a list of critical Earth observation priorities – some ordered or grouped by importance, and some unordered – for his or her SBA. The number of critical Earth observations varied, by design, to allow for the inherent differences in the SBAs, and ranged from 15 to 77 observation parameters. Each Analyst subsequently prepared a Preliminary Draft Report for Advisory Group review, made revisions as necessary, and prepared a Final Report.

2.2. Cross-SBA Report Methodology

2.2.1. Analysts Meeting

All of the SBA Analysts attended the second Analysts Meeting in Washington, DC on February 23, 2010. The purposes of the meeting were to:

1) Enable Analysts to share analysis methodologies and results and provide context for individual SBA report results interpretation,
2) Discuss Cross-SBA report methodology options, report content, and priorities list, and
3) Develop collective feedback on GEO Task US-09-01a, the process, and methodologies.

The SBA Analysts noted that context-setting information must be included in the Cross-SBA report (see Chapter 5). The Analysts generally agreed that each SBA should be treated as equally important – that is, no SBA should receive double or triple weighting in the Cross-SBA analysis. The Analysts also agreed, however, that some SBAs require more observation parameters than others, so there should not be limits or penalties for SBA reports that include longer lists of priority observation parameters. The Analysts carefully weighed the pros and cons of multiple types of Cross-SBA analysis and jointly developed the Cross-SBA methodology described in the following section.

The Cross-SBA analysis draws upon input from each SBA Analyst based on his or her respective SBA report. The specific inputs for the Cross-SBA analysis are in an appendix in each individual SBA report. Upon receiving input from the SBA Analysts, the Cross-SBA Analyst reviewed the priorities to combine observation parameters that are the same or very similar but with different names. Accounting for these differences in observation terminology across the SBAs, the effective number of observations incorporated into the Cross-SBA analysis for each SBA varied slightly from the number identified by each SBA Analyst. In some cases, observation parameters that were listed together (e.g., Land Cover/Land Use) in a single SBA list were separated into two separate observation parameters for the Cross-SBA analysis. Similarly, some observation parameters that were listed separately (e.g., precipitation intensity and precipitation duration) in an SBA list were combined into a single observation parameter for the Cross-SBA analysis. To the extent possible, the Cross-SBA Analyst focused on retaining the observation parameter terminology employed by the majority of the SBAs, to minimize

[6] One report, the Health / Infectious Diseases Sub-Report, directly incorporated human health effects into parameter prioritization. This report relied upon the Disease Burden list produced by United Nations (UN) World Health Organization (WHO. 2005. *Ecosystems and Human Well-Being: Health Synthesis.* World Health Organization Geneva, Switzerland) for parameter prioritization based on disability-adjusted life years (DALYs).

regrouping and splitting of observations. The Cross-SBA analyst noted where such grouping and splitting of observations occurred, to retain the components/specifications of a given observation in a transparent, traceable manner.

Definition of an Observation Parameter

Since the task assesses user needs, the Analysts took great care to utilize user terminology. Hence, many of the required observation parameters discussed in this report are phenomena of interest to a user (e.g., Urbanization) rather than technical specifications of an observation parameter as discussed in the remote sensing or in situ measurement communities (e.g., reflectance of a specific bandwidth of light). Also, the SBA Analysts had a discussion at the Analysts meeting on how narrowly to define an observation parameter. For example, for water quality, there are hundreds of chemicals and properties that could be measured, but these measurements could also be treated as a single "water quality" observation parameter. In addition, SBAs had different levels of specificity for the same observation parameter. For example, a dozen cloud properties may be needed in detail for meteorologist users, whereas solar energy facility operators may need a single cloud index. Based on the input of the SBA Analysts, the Cross-SBA Analyst struck a balance between grouping observation parameters to such a degree that specifics are absent and listing hundreds of observation parameters separately such that the resulting list is unmanageable. Some SBA Analysts also noted that some observation parameters are most useful when measured concurrently with certain other observation parameters.

Direct vs. Indirect Observation Parameters

Many observation parameters are not measured directly, but rather are derived from other observations. In fact, some observations that may not be directly measurable with today's technology may be directly measurable with future technology. To the extent possible, the SBA Analysts included the underlying direct observations in their SBA analysis that support critical modeled or indirect observations. For example, the Disasters SBA Analysts identified secondary product priorities such as medium- and long-term forecast models that are built on observations and hazard maps that are created through the aggregation of multiple Earth observations. In many instances, the observations that underlie these secondary products are captured in the required observations list for each disaster type, such as accumulated seismic measurements for calculation of the secondary product of earthquake frequency maps. The Cross-SBA Analyst requested input from the Analysts at the Analysts meeting to ensure that all underlying and modeled or derived observations were included in the individual SBA results, and subsequently incorporated into the Cross-SBA Analysis.

2.2.2. Cross-SBA Ensemble Analysis Methodology

Of the prioritization methods employed for the individual SBA reports, two major types of prioritization methods could be applicable for the Cross-SBA analysis:

- **Frequency analysis** to capture observation parameters that support multiple SBAs, with or without rankings provided in the individual SBA reports, and
- **Key observation parameters analysis** to capture the most important observation parameters for a single SBA.

Both of these methods require subsequent ordering of the observation parameters in some manner, and extraction of the "highest priority" observation parameters from that ordered list (i.e., down-selection) to obtain a list of critical Cross-SBA priorities. The benefits and limitations of the frequency analysis and the key observation parameters methods are highlighted in Section 2.2.3. At the Analysts Meeting, the SBA Analysts decided that the Cross-SBA analysis should consist of several variations of frequency analysis and the key observation parameters method. This report presents the results of each of these four prioritization methodologies individually and concludes in Section 4.2 with an average ranking for each observation parameter along with the uncertainty depicting the range of rankings for each observation parameter. This methodology essentially represents a sensitivity analysis, which sheds light on the degree to which the outcome is dependent upon the individual methods. The Cross-SBA methodologies employed are as follows:

Method 1: Tally of All Priorities
This frequency analysis method is a tally of the SBAs that require a given observation. In this method, the number of critical Earth observation priorities for each SBA was allowed to vary to allow for inherent differences among SBAs. In Appendix C, the observation parameters indicated as priorities by each SBA Analyst for a particular SBA are marked as such.[7] The Cross-SBA Analyst ordered the observation parameters according to the number of SBAs which specified an observation as a priority. For presentation purposes only (in Table 11), the Analyst chose to include the observations that are required by five or more SBAs.

Method 2: Weighted Sum of All Priorities
This weighted frequency analysis method is a weighted sum of the number of SBAs that require a given observation, taking into account the high/medium/low importance assigned by the SBA Analysts. This analysis also allowed the number of priorities identified for each SBA to vary widely. In Appendix D, the observation parameters indicated as high, medium, and low priority by each SBA Analyst for a particular SBA are marked as such. In Method 2, the Cross-SBA Analyst assigned a weights of 3 for high, 2 for medium, and 1 for low priorities (with the understanding that "high," "medium," and "low" are relative, and that "low" priorities may still be critically important for many users). These numerical weights for high, medium, and low (for Methods 2 and 3) were agreed upon among the SBA Analysts at the SBA Analyst meeting. For SBA Analysts that did not rank their results in their SBA reports, the Cross-SBA Analyst requested rankings from the SBA Analysts for this analysis.

For presentation purposes only (Table 14), the Cross-SBA Analyst ordered the observation parameters according to their weighted scores.

Method 3: Weighted Sum of All Priorities
This weighted frequency analysis method is a weighted sum of the number of SBAs that require a given observation, taking into account the high/medium/low importance assigned by the SBA

[7] The same set of 146 parameters (listed in Appendix C) was incorporated for Methods 1, 2, and 3. The rankings (high-medium-low) indicated in Appendix C apply only for the weighted tallies of Methods 2 and 3.

Analysts. This analysis also allowed the number of priorities identified for each SBA to vary widely. In Appendix D, the observation parameters indicated as high, medium, and low priority by each SBA Analyst for a particular SBA are marked as such. In Method 2, the Cross-SBA Analyst assigned a weight of 6 for high, 3 for medium, and 1 for low priorities.

For presentation purposes only (Table 14), the Cross-SBA Analyst ordered the observation parameters according to their weighted scores.

Method 4: "15 Most Critical" Observation Priorities by SBA
This method is based on the SBA Analysts preparing a list of the "15 Most Critical" observations for their SBA. Method 4 employed a frequency analysis which is a tally of the number of SBAs for which an observation is on the "15 Most Critical" list. For presentation purposes, Table 15 presents the observation parameters which are on a "15 Most Critical" list for two or more SBAs.

2.2.3. Methodology for Agriculture& Health SBA Sub-Reports

Incorporation of Agriculture SBA/ Forests Sub-Report into the Cross-SBA Analysis
A separate Agriculture SBA sub-report on Forests was prepared by a separate Analyst. The results of this sub-report were merged with the Agriculture SBA report for the purposes of this Cross-SBA analysis. In addition, the Forests Analyst specified a subset of the priority observations from the Forests sub-report to be incorporated into the Ecosystems SBA priorities.

For Methods 1-3 of the Cross-SBA Analysis, the Agriculture SBA contributed a single integrated list of observation priorities. This single list is essentially a blending of the dedicated Agriculture SBA priority observations and the Forests sub-report priority observations. The high/medium/low rankings for the observation parameters on this single list were based on the higher of the two rankings by the Agriculture SBA and Agriculture SBA/ Forests Analysts. Similarly, the "15 Most Critical" observation list for the Agriculture SBA (Method 4) was prepared collectively by the Agriculture SBA, Agriculture SBA/ Forests, and Cross-SBA Analysts based on the commonality across the 2 reports' "Most Critical" observation lists.

A subset of the priority observations from the Agriculture SBA/Forests Sub-report were also incorporated into the Ecosystems SBA results. The Task Team included this step to reflect the overlap between the Agriculture and Ecosystems SBAs in the area of forests. The specific priority observations to be incorporated into the Ecosystems results were selected collectively by the Agriculture SBA/Forests and Ecosystems Analysts based upon their reports.

Incorporation of Health SBA Sub-Reports into the Cross-SBA Analysis
Three separate sub-reports (Air Quality, Infectious Diseases, and Aeroallergens) were prepared for the Health SBA by separate Analysts. The results of these sub-reports were merged and treated as a single SBA report for the purposes of this Cross-SBA analysis. That is, the Health SBA contributed a single integrated list of observation priorities for Methods 1-3 of the Cross-SBA Analysis. This single list is essentially a blending of the three sub-reports' priority lists. The high/medium/low rankings for the observation parameters on this single list were determined based on the highest ranking assigned to an observation parameter across the 3 Health SBA Analysts. Similarly, the "15 Most Critical" observation list for the Health SBA was

prepared collectively by the Health Analysts and Cross-SBA Analyst based on the commonality across the 3 sub-report "Most Critical" observation lists.

3. Earth Observation Priorities for Individual SBAs

This Chapter lists the critical Earth observation priorities for each SBA, based on the results of the individual SBA reports and subsequent consultation with the SBA Analysts to standardize the results. As noted in Chapter 2, the natural variation in analysis methods among the SBA Analysts resulted in some reports that ranked critical Earth observation priorities in order of importance, and others that produced an unordered list, in some cases specifying different priorities for global, regional, and local levels. Based on the Cross-SBA Analysts meeting, each SBA Analyst provided a list of priority observations (unlimited number) to the Cross-SBA Analyst, and also provided designations of high/medium/low priority. Tables 4 through 12 contain the final priority lists as provided by the SBA Analysts of completed reports. Designations of high, medium, and low priorities by SBA can be found in Appendix C.

3.1. Agriculture SBA

The Agriculture SBA report addresses the sub-areas of famine early warning, agriculture production, seasonal/annual agriculture forecasting and risk reduction, and aquaculture production. In this effort, the Agriculture Analyst enlisted the help of twelve Advisory Group members from a wide geographic distribution. The Agriculture Analyst identified 102 documents potentially relevant to these sub-areas of the Agriculture SBA, and ultimately determined that 54 documents (out of 102) contained relevant Earth observation information. The Agriculture Analyst sought documents from prominent national and international organizations to locate international and national reports related to the chosen sub-areas. Such organizations included the United Nations Food and Agriculture Organization, the International Fund for Agricultural Development, and the World Food Program. Additionally, the Agriculture Analyst conducted a comprehensive literature search of academic and trade journals and reviewed the websites of credible organizations. Finally, the Agriculture Analyst requested documents from the Advisory Group. Cumulatively, Advisory Group members contributed approximately 50 of the reports considered for the analysis.

The Agriculture Analyst extracted detailed data from the documents on the applicable agriculture type(s), the region of interest of the document, the type of document, and the desired physical characteristics of the observation, where available. Using an indexing scheme that weighted observation categories by the frequency with which they were identified as observation priorities, as well as the type of document and cross-area applicability, the Agriculture Analyst generated a list of priority observation categories. Because aquaculture is different from the other sub-areas analyzed, priorities for aquaculture were determined and displayed separately, and also incorporated into the overall Agriculture SBA priority list, per the advice of the Advisory Group. The 18 overall priority observation categories for the Agriculture SBA are listed in Table 4.

Table 4. Agriculture SBA Priority Observations (Most to Least Important)

Observation Category	Observation Parameters
Vegetation Indices	NDVI Vegetation Productivity Indicator LAI (leaf area index)
Crop Area	Crop Area Identification Cultivated Area Cultivated Lands Crop Types
Disturbances	Disease Drought Drought Stress Flood Insect Infestation
Precipitation	Precipitation
Evapotranspiration	Actual Evapotranspiration Relative Evapotranspiration
Air Temperature	Temperature Stress Day Air Temperature Temperature
Solar Radiation	Solar Radiation
Wind Characteristics	Wind Speed Wind
Weather*	Weather
Soil Chemistry	Soil Nitrogen Soil Salinity Soil Mineral Content
Crop Residue	Tillage Crop Residue Cover Crop Residue
Hydrology	Water Hydrology Water Balance Water Budget Stream/River Discharge Surface Water Stream Flow River Discharge Water Bodies
Bathymetry	Bathymetry Shoreline Position Reef Maps
Land Cover	Land Cover
Crop Yield	Crop Yield
Water Supply	Water Use Outfalls/Drains Freshwater Supply Brackish Water Supply Water Availability

Observation Category	Observation Parameters
Crop Emergence	Crop Emergence
Land Surface Temperature	Land Surface Temperature

* Weather is listed generically to reflect the fact that many documents noted a general need for weather observations, rather than specific weather components. More specific components of weather were listed as such when the documents were more specific.

3.1.1. Agriculture SBA/ Forests Sub-Report

As noted previously, the Task Team prepared a report for Task US-09-01a focused solely on critical Earth observation parameters for forests. The results of the Agriculture SBA/Forests Report were integrated with the Agriculture SBA results (refer to Chapter 2 for details). The Forests Analyst worked with the Advisory Group to select the following sub-areas for the forests report: Timber, Fuel, and Fiber Management; Forest Perturbations and Protection; and Carbon and Biomass. Working with the Advisory Group, the Analyst identified 31 documents that were potentially relevant, and ultimately included 16 documents in the analysis, most of which were consensus documents. The prioritization took into account the applicability across forest sub-areas included in the analysis, priorities recommended by the consensus documents, and recommendations by the Advisory Group members. Through this prioritization, the Forests Analyst identified the priority observation parameters shown in Table 5.

The 49 priority observations for the Agriculture SBA and the Forests sub-report listed in Tables 4 and 5, respectively, were the basis for the input to Methods 1-3 of the Cross-SBA analysis. Accounting for differences in observation terminology across the SBAs, the Agriculture SBA effectively contributed 61 observations for Methods 1-3 of the Cross-SBA analysis. For Method 4 of the Cross-SBA Analysis, the Agriculture SBA Team identified the "15 Most Critical" observations. Again, accounting for differences in terminology, the Agriculture SBA Team effectively contributed 35 observations for Method 4 of the Cross-SBA analysis. Appendices of the Agriculture SBA and Agriculture SBA/Forests reports provide details on the input to the Cross-SBA analysis.

Table 5. Agriculture SBA/ Forests Priority Observations
(Most to Least Important; Grouped Observations Have Equal Importance)

Observation Parameter
Afforestation/Reforestation Degradation Forest Area, Forest Area Change Land Cover, Land Cover Change
Carbon Stocks (soil organic matter, aboveground vegetation, belowground biomass, dead wood, harvested wood, litter) Fire Intensity/Burn Intensity/ Fire Radiative Power
Active Fires Biomass (above ground) Canopy Damage Carbon Emissions (net) Carbon Stocks (change) Deforestation Flood (extent, duration), Flooded Forest Forest Type (heterogeneity, local variation) Forest Use (forest management practices) Fragmentation, Clearings, Land Disturbance Fuel Loading (g/m^2) Infrastructure (human settlements, roads, logging infrastructure) Land Cover Type or Land Cover Use Classification Species Composition, Biodiversity Vegetation (cover, type)
Burned Area
Canopy Cover, Canopy Density Fire Frequency Soil Moisture
Combustion Factor (g/g, biomass consumed) Disease (presence, extent) Emission Factor (g/g, emissions per burned mass) Insects (presence, extent) Forest structure, Vegetation structure
Stand Height

3.2. Biodiversity SBA

As explained in the GEOSS 10-Year Implementation Plan, biodiversity is organized on the genetic, species, and ecosystem levels. Issues relevant to the Biodiversity SBA include the condition and extent of ecosystems, distribution and status of species, and genetic diversity in key populations. The Biodiversity Team focused on the Earth observation needs of users involved in technical, policy, management, and decision-making activities. In order to provide a broad overview of the observation needs for the Biodiversity SBA, the Analyst chose to focus on observations for species and ecosystems, and he did not select specific sub-areas for analysis.

A total of 8 experts served on the Biodiversity SBA Advisory Group, including representatives from 4 GEO Member Countries and 1 Participating Organization. The Analyst and Advisory Group identified 60 documents that provided relevant information for the analysis. Approximately half of these relevant documents were from organizations. The remaining half of the documents consisted of peer-reviewed journal articles. The Analyst only included documents in the analysis that are publicly available and were published from 2000 to 2009, since observation needs identified before 2000 were considered by the Analyst to be outdated.

The Biodiversity Team identified 153 observation needs related to the biodiversity of species and ecosystems. The "needs" were broadly interpreted as desired improvements in the biodiversity community (e.g., data management, data sharing) rather than specific observation parameters (e.g., precipitation). [8] The Analyst then characterized the needs. Each observation need was characterized using the following categories: Biodiversity Organizational Level, Biome Type, Spatial Scale, Observation Type, User Type, and the Drivers-Pressures-State-Impacts-Responses (DPSIR) Assessment Framework. (The DPSIR framework conceptually links interactive processes in a continuous causal chain, and it can help describe interactions between society and the environment.)

The Analyst found that characterizing observation needs using the DPSIR framework was the most useful approach because it allowed for aggregation of similar needs into the five DPSIR categories of Drivers, Pressures, State, Impacts, and Responses. The DPSIR framework categorization also allowed for further aggregation of needs into two levels of subcategories. Using the DPSIR framework categorization, the Biodiversity Team found that the 153 overall observation needs corresponded to the DPSIR categories as follows: 0% Drivers, 5% Pressures, 46% State, 10% Impacts, and 39% Responses. The Analyst assigned the category with the highest percentage of observation needs as biodiversity priority areas; thus, priority observation needs are those addressing the State of biodiversity. The Analyst did not prioritize specific observation parameters as part of the Biodiversity SBA analysis.

The Biodiversity Team found that observation needs relevant to both ecosystems and species were the most prevalent in the documents, as they accounted for 37% of the total needs identified. The subset of documents that were journal articles identified the State of biodiversity as the highest priority (60% of total needs identified). This finding may be a consequence of the

[8] The format of the biodiversity report did not include any Earth observation prioritization. Despite requests for a prioritization consistent with the US-09-01a methodology from the Task Lead, the Analyst did not provide one. Therefore, the Cross-SBA analysis does not incorporate Earth observation priorities from the Biodiversity SBA.

nature of journals, which include articles focused on research actions to address the State of biodiversity. In contrast, the subset of documents prepared by organizations indicated that Responses by the biodiversity community are the highest priority (54% of total needs identified). Responses can address issues at the organization (data collection), system (data sharing), data management, and program evaluation levels.

3.3. Climate SBA

Working together with the Climate Advisory Group, the Climate Analyst chose to focus on three sub-areas of the Climate SBA: the atmosphere, the oceans, and lands. These three sub-areas are consistent with the treatment of climate in many of the source documents identified for the Climate SBA analysis. The Climate Analyst and the Advisory Group together identified 40 relevant documents on user Earth observation needs, from which the Analyst extracted the relevant information. The Climate Analyst focused on the Earth observation needs of direct, raw data users (involved in modeling and scenario development), policy users (at all levels, engaged in climate change mitigation and adaptation), and business and economic users (facing climate risk-related decisions). The Climate Analyst noted that the Earth observations of indirect observation users (such as those in resource science and management who rely on model and scenario results) would be covered by other Task US-09-01a reports, and thus, she did not focus on the Earth observation needs of such users in the Climate SBA report.

Many international and regional organizations have defined clear Earth observation priorities for examining the climate system. For example, Earth observations specified as essential climate variables (ECVs) by the Global Climate Observing System (GCOS) and its supporting agencies are specified in the *Implementation Plan for the Global Observing System for Climate in Support of the UNFCCC* (GCOS 2004). For the Climate SBA report, the Climate Analyst identified and reviewed these consensus reports, and augmented them with sources representing the diverse set of users noted above. The Climate Analyst used a bibliometric method for identifying Earth observation priorities, involving tabulations by the Analyst of the relative frequency with which specific requirements were cited in the source material, with some adjustments to avoid double-counting of overlapping document authorship. Table 6 lists the critical Earth observation priorities for climate users, as presented by the Climate Analyst in the Climate SBA report.

The 26 priority observations for the Climate SBA listed in Table 6 were the basis for the input to Methods 1-3 of the Cross-SBA analysis. Accounting for differences in observation terminology across the SBAs, the Climate Team effectively contributed 33 observations for Methods 1-3 of the Cross-SBA analysis. For Method 4 of the Cross-SBA Analysis, the Climate Team identified the “15 Most Critical” observations. Again, accounting for differences in terminology, the Climate Team effectively contributed 22 observations for Method 4 of the Cross-SBA analysis. An appendix of the individual Climate SBA report provides details on the input to the Cross-SBA analysis.

Table 6. Climate SBA Priority Observations (Unordered)

Observation Parameter	Global/Regional Priority	Applicable Regions
Sub-Area #1: Atmosphere		
Aerosol Properties	Both	North America, Africa, Asia
Air Temperature	Both	North America, Asia, Pacific Islands
Precipitation	Both	North America, Africa, Europe, Mediterranean Basin
Precipitation Extreme Events	Both	North America, Central and South America, Caribbean, Africa, Asia, Pacific Islands, Mediterranean Basin
Air Pressure	Regional	North America, Pacific Islands
Carbon Dioxide	Global	N/A
Methane	Global	N/A
Other Long-Lived Greenhouse Gasses	Global	N/A
Surface Radiation Budget	Global	N/A
Water Vapor	Global	N/A
Sub-Area #2: Oceans		
Sea Ice	Both	North America and Europe
Sea Level	Both	North America and Pacific Islands
Sea Surface Temperature	Both	North America, Central and South America, Caribbean, Africa, South and Southwest Asia, Pacific Islands
Carbon Dioxide partial Pressure	Global	N/A
Sea Surface Salinity	Global	N/A
Subsurface Carbon	Global	N/A
Sub-Area#3: Lands		
Glaciers and Ice Caps: Area Maps and Elevation Changes	Both	North America, Central and South America, Caribbean, Asia, Europe
Land Cover Change Maps	Both	North America, Central and South America, Caribbean, Africa, Europe, Asia, Mediterranean Basin
Land Cover Type Maps	Both	North America, Central and South America, Caribbean, Africa, Europe, Asia, Mediterranean Basin
Snow Cover Area	Both	North America, Central and Southeast Asia, Europe
Water Use	Both	North America, Africa, Pacific Islands, Mediterranean Basin

Observation Parameter	Global/Regional Priority	Applicable Regions
Groundwater	Regional	North America, Africa, Europe
Lakes/Reservoirs Level and Surface Temperature	Regional	North America, Africa, Pacific Islands, Europe
Permafrost and seasonally adjusted frozen ground	Regional	Not Specified
River Discharge	Regional	North America, Africa, Pacific Islands, Europe
Soil Moisture	Regional	North America, Africa, Pacific Islands, Europe

3.4. Disasters SBA

The Task Team prepared two reports on critical Earth observation priorities for the Disasters SBA, each with its own Analyst and Advisory Group. The first Disasters SBA report focused on earthquakes, landslides, and floods, and the second report focused on tropical cyclones, wildfires, and volcanic eruptions. The two Disasters Analysts recruited a total of 36 Advisory Group members – 13 for earthquakes, landslides, and floods, and 23 for tropical cyclones, wildfires, and volcanic eruptions. The Disasters Team identified a total of 85 relevant documents which focused primarily on global observation needs. The documents also highlighted regional observation needs in Asia/Pacific, North America, and Europe. No relevant documents focused specifically on Earth observation priorities for Africa or South/Central America. The Disasters Analysts noted this literature gap for the many developing nations on these continents.

For both reports, the Disasters Analysts extracted detailed data from the relevant documents on the applicable disaster type(s), the region of interest of the document, the type of document[9], and the desired physical characteristics of the observation, where available. The Analysts identified 40 observation parameters that are common to the six sub-areas of analysis. The Disasters team used a weighted indexing method to prioritize these observations based on three factors. The weighting scheme accounted for the number of times that the observation is mentioned in all documents as a priority, assuming that higher priority observations are mentioned more frequently. The scheme also considered the type of document, giving greater weight to consensus documents such as those representing the collective output of organizations. Finally, the scheme weighted more highly parameters that are needed by end users of more than one sub-area, such as parameters that required for both earthquakes and volcanic eruptions. In order to account for the risk of disasters to human life and property, the Analysts used globally-averaged information on observed disasters from the past 30 years to conduct additional weightings on the

[9] The Disasters SBA gave the highest weight to international working group or consensus documents, less weight to national-level government or working group documents, and the least weight to journal articles, conference presentations or proceedings, and unpublished studies.

40 observation parameters. The Analyst Team included data in the parameter weighting scheme on worldwide estimated damage in US$, the number of people affected, and the number of people killed for each of the six disasters sub-areas during the period 1981-2010.

The Disasters Analysts also identified a number of indirect product priorities in the documents that are not observations themselves, but that derive from Earth observations. Examples of these indirect product priorities include medium- and long-term forecast models that are built on observations and hazard maps created through the aggregation of multiple Earth observations. In many instances, the observation parameters that underlie these indirect products are captured in the required observation parameters list for each disaster type. For example, the secondary product of earthquake frequency maps relies upon accumulated seismic measurements, which are included in the analysis. Table 7 lists the critical Earth observation categories and observation parameters across all six disaster sub-areas analyzed in the Disaster SBA reports. An appendix of the second individual Disasters SBA report provides details on the input to the Cross-SBA analysis.

Table 7. Disasters SBA Priority Observations (Most to Least Important)

Observation Category	Observation Parameter
Elevation/Topography	Elevation
	Bathymetry
	Slope Angle, Length, Position
	Curvature
Precipitation Properties	Precipitation Intensity
	Precipitation Duration
	Precipitation Amount
Surface Deformation	Slip
	Slope Movement
	Strain
	Surface Deformation
Wind Properties	10-m Wind
	20-ft Wind Peak
	20-ft Wind Speed
	Land Surface Winds
	Mountain Winds
	Ocean Surface Wind Direction
	Ocean Surface Wind Velocity
	Outer Wind Radii
	Radius of Gales
	Tropospheric Winds
	Wind Direction
	Wind Speed
Soil Parameters	Soil Moisture

Observation Category	Observation Parameter
	Soil Composition and Thickness
	Pore Pressure
	Rock Strength, Permeability, Spacing, Orientation
Seismic Properties	Seismicity
	Magnitude
	Type of Earthquake
Atmospheric Properties	Air Mass Boundaries
	Air Mass Differences
	Atmospheric Moisture
	Atmospheric Profile
	Atmospheric Temperature
	Atmospheric Water Vapor
	Cloud Structure
	Cloudiness
	Dew Point/Humidity
	Relative Humidity
Flood Monitoring Properties	Location of Flood
	Flood Development
	Flood Peak
Wave Properties	Surface Wave Height
	Wave Currents
	Wave Heights
	Wave Patterns
	Sea State
	Storm Surge
Stream/River Properties	Stream/River Height
	Stream/River Stage
	Stream/River Flow
	Stream/River Discharge
	Stream/River Volume
	Sea Level
Gravity Field	Changes in Gravity
	Gravity Field
Water Properties	Water Chemistry
	Water Level
	Water Temperature
	Water Volume
Ice/Snow Properties	Ice Volume
	Snow Cover Depth
	Snow Cover Duration
	Snow Cover Extent

Observation Category	Observation Parameter
Magnetic Field	Magnetic Field
Thermal Properties	Hotspot Detection
	Thermal Emissions / Flux Characterization
	Thermal Feature Characterization

3.5. Ecosystems SBA

The Task Team prepared two reports on critical Earth observation priorities for the Ecosystems SBA. Working together with the first Advisory Group (consisting of 11 members), the Ecosystem Analysts chose to focus the first Ecosystems SBA report on three sub-areas that dominated the relevant literature: forests, coastal and near-shore marine systems, and watersheds. Although it is not an ecosystem type, watersheds was selected to capture the land-based mix of ecosystem elements, such as wetlands, impervious surfaces, biological communities, and lands highly affected by non-native species, and the impact that intermingling of these elements has on functioning of specific ecosystem types (e.g., for natural resource land managers). Subsequently, the second Advisory Group (consisting of 17 members, 4 of whom also served on the first Ecosystems SBA Advisory Group) identified tundra, inland waters, and islands and archipelagos as priority topics to be addressed in the second Ecosystems SBA report. The Analysts for each report were different but coordinated with one another to ensure consistency between the two reports. The Ecosystem Analysts and Advisory Groups focused on identification and prioritization of Earth observation parameters for ecosystem health, function, and change.

For the first Ecosystems SBA report, the Analysts and Advisory Group identified 75 relevant documents, including 11 documents representing the consensus views of international or regional organizations. Three factors determined the overall priority of observations: 1) the raw frequency with which observational parameters appeared in documents, 2) the applicability of observation parameters across multiple ecosystem sub-areas in the report, and 3) Advisory Group recommendations for high-priority observation parameters. The Analysts consulted published consensus documents to confirm that the analysis process produced ecosystem observation priorities that were in agreement with previous efforts.

For the second Ecosystems SBA report, the Analysts and the Advisory Group identified 40 documents, which included 11 consensus and review documents. Using the same prioritization method as for the first Ecosystems SBA report, the Analysts first identified priority observation parameters for the second Ecosystems SBA report, and then conducted a master prioritization across both Ecosystems SBA reports. Table 8 shows the combined master list of critical Earth observations for ecosystems.

Table 8. Ecosystems SBA Priority Observations (Most to Least Important)*

Observation Parameter
Permafrost condition and dynamics (degradation, reduction)
Vegetation cover, changes
Disturbance (including fire, drought, and land clearing) (urbanization+desertification+cultivation+ deforestation)
Extent, location, and fragmentation of ecosystem and habitat types (including stream and riparian habitat structure and condition)
Soil carbon
Forest fragmentation
Land use, land cover
Mangrove extent
Biomass (phytomass), biomass spatial distribution, biomass moisture content
Vegetation indices (NDVI+SAVI+EVI)
Carbon: Dissolved organic carbon (content, flux, cycling), dissolved inorganic carbon, particulate organic carbon
Forest cover
Glacier extent, glacier mass balance
Ocean circulation patterns
Tree line location, tree line advance
Erosion (reefs, sandbars)
Fish harvest intensity
Chlorophyll
Permafrost active layer thickness
Permafrost temperature, deep bore-hole temperature
Primary production (net, gross), community production
Leaf Area Index
Permafrost thickness
Riparian zone landscape structure and condition; standing biomass
Temperature (air)
Wetland, lakes, reservoirs, ponds, rivers, and streams - location and classification
PAR, fPAR FAPAR
Sea level
Non-native aquatic, wetland, or riparian species; Invasive species population, range
Storm events, storms, storm surges
Precipitation (rain, snow)
Species composition; species distribution (plants, animals); fisheries trophic index; index of biotic integrity, at-risk species and communities
Depth (shallow, near-shore)
Nutrients in soil, nutrient availability, nutrient cycling
Biodiversity

Observation Parameter
Aquatic ecosystem condition (fish to bacteria; phytoplankton community; algal blooms; eutrophic zones)
Canopy cover, canopy density
Ecosystem demand for water; conservation demand for water
Ecosystem function, ecosystem dynamics, vegetation health
Groundwater salinity
Ice cover
Landscape structure
Migration patterns
Shrub cover and extent
Thermokarst (presence)
Aquatic keystone species
Atmospheric CO_2
Coral Reef Classification
Insects (outbreaks, expansion of range and activity)
Soil moisture, soil water table level
Hydrology
Inundated vegetation (forests, grasses, and forbs), including impounded streams
Water elevation (lake)
Carbon (aboveground, storage, uptake, CO_2 and CH_4 flux)
Pollutants (load, concentration)
Salinity (water)
Water availability
Weather pattern changes
Albedo
Wind speed
Phenology
Evaporation; evapotranspiration
Atmospheric circulation
Community metabolism (reef)
Date of soil thaw
SST, water temperature, sea surface thermodynamics
Excess production (Biomass accumulation or export)
Topography, slope, aspect
Fire fuel load, fire regime, fuel characteristics
Impervious surface
Date of snowmelt
Herbaceous, woody cover
Groundwater amount, Groundwater recharge rate
Suspended solids/ sediment loads; Sedimentation
Aquatic nutrients (load, concentration)

Observation Parameter
Forest structure (Canopy height, Canopy structure, Canopy volume, Stand volume, Stand density)

3.6. Energy SBA

Within the Energy area, the analysis and report focused on renewable energy. The Analyst made the decision to focus on this topic through consultation with the Task Lead and the Advisory Group. Based on the International Energy Agency's World Energy Outlook (IEA 2008) which projects the world energy mix out to 2030, the Analyst narrowed the renewable energy topic to focus on the most prominent renewable energy types: hydropower, land-based wind energy, offshore wind energy, bioenergy (including biofuels for transportation), solar power, and geothermal power. The Advisory Group noted that different sub-areas are important to different regions, and certain sub-areas are especially relevant in developing countries. In particular, several Advisory Group members encouraged the inclusion of bioenergy and hydropower (particularly micro- and small-scale) as important sub-areas for developing countries. In addition, the Energy Analyst noted that documents describing transportation biofuels tended to focus on developing countries, and thus the Energy Analyst included transportation biofuels in the analysis.

The Energy Analyst and Advisory group identified 54 relevant documents, and extracted information on Earth observation needs from each of these documents. The prioritization method employed by the Energy Analyst was two-fold: (1) based on literature emphasis and Advisory Group input, the Energy Analyst selected key observation parameters for the most prominent renewable energy types. These observation parameters were deemed to be of "High" priority. (Key observation parameters are those that are the main determinant of the renewable energy potential or output of a particular renewable energy sub-area, such as wind speed at turbine hub height for wind energy). (2) The Analyst identified observation parameters which are required across multiple renewable energy-types, offering some economy of scale. These observation parameters were deemed to be of "Medium" priority. Table 9 lists the critical Earth observation priorities for energy users, as presented by the Energy Analyst in the Energy SBA report.

The 12 priority observations for the Energy SBA listed in Table 9 were the basis for the input to Methods 1-3 of the Cross-SBA analysis. Accounting for differences in observation terminology across the SBAs, the Energy Team effectively contributed 15 observations for Methods 1-3 of the Cross-SBA analysis. For Method 4 of the Cross-SBA Analysis, the Energy Team identified the "15 Most Critical" observations. Again, accounting for differences in terminology, the Energy Team effectively contributed 17 observations for Method 4 of the Cross-SBA analysis. An appendix of the individual Energy SBA report provides details on the input to the Cross-SBA analysis.

Table 9. Energy SBA Priority Observations (Most to Least Important)

Observation Parameter
Water Run-Off
Wind Speed
Land Cover
Normalized Difference Vegetation Index (NDVI)
Net Primary Productivity (NPP)
Global Horizontal Irradiation (GHI)
Direct Normal Irradiation (DNI)
Elevation/Topography
Air Temperature
Surface Temperature
Relative Humidity
Cloud Cover (cloud index)

3.7. Health SBA

The Health SBA was addressed in three separate sub-reports for Task US-09-01a: Aeroallergens, Air Quality, and Infectious Diseases. The resulting Earth observation priorities from the Health reports were merged to a single list, as detailed in Chapter 2, for the purposes of this Cross-SBA analysis.

Aeroallergens

An important contribution of Earth observations for the area of aeroallergens and allergic disease is their utility for forecasting the type and concentration of allergen, allowing affected populations and public health officials to act in a timely fashion and prevent disease. A second key contribution stems from the fact that aeroallergens respond to warming and increased carbon dioxide effects, and therefore, are good proxies to provide further evidence for climate change. Thus, the Aeroallergens Analyst and Advisory Group focused on the most common Earth observation needs reported among the documents reviewed for prediction of allergic airway disease and value in forecasting, risk assessment, and disease prevention. The Aeroallergens Analyst identified 160 of the most relevant documents, the majority of which were papers from the scientific literature. The Aeroallergen Analyst noted that Earth observations from aerobiology and phenology networks as well as those from meteorological and air quality networks are needed for users. The emphasis of the Aeroallergens Report was on the former two, as air quality and meteorology were covered by separate health reports under GEO Task US-09-01a. The Aeroallergens Analyst employed a combination of quantitative and qualitative approaches to prioritize the Earth observations, based on a custom database populated from the 160 relevant documents. Using a series of queries and data sorts, the Analyst identified the most common Earth observation needs reported among the documents acquired in addition to those needs reported by data users during direct inquiries via e-mail with a select subset of agencies and organizations.

Air Quality

The Air Quality Analyst chose to focus on direct Earth Observation needs because the data products and information required by the public and managers are derived from the direct Earth observations. The Air Quality Analyst identified three types of users of Earth observations related to health impacts of air quality: the general public, air quality managers, and scientists. The Air Quality Analyst identified over 110 relevant documents. The methodology employed by the Air Quality Analyst focused on multiple independent measures directed toward supporting Earth observations prioritization for air quality and health, from three perspectives: (a) which pollutants should be measured; (b) the required spatial and temporal coverage, and (c) the aspect(s) of air quality management that the Earth observations should support. The Air Quality Analyst performed the prioritization along three independent dimensions: (1) air pollutant observation parameter; (2) observation coverage, and (3) observation utility. The list of air pollutants that are the main causal factors in health effects was taken from the World Health Organization (WHO) Guidelines. The Air Quality Analyst determined observation utility based on the reusability of specific Earth observations for multiple segments of the air quality system.

Infectious Diseases

The Infectious Diseases sub-report focuses on the identification of observations required by users for vector-borne and non-vector-borne diseases that are influenced by climate and environmental factors. The Infectious Diseases Analyst and Advisory Group identified a "chain of users" starting from the research community and ending at the decision-makers, with entities identified as boundary organizations providing an informational link between the two endpoints of the user chain. The Infectious Diseases Analyst and Advisory Group identified user needs by analyzing the decision-making processes in which they are involved (i.e., forecast activities; prevention, early warning, early response; response after the occurrence of the disease; and post-mortem evaluation). The Infectious Diseases Analyst conducted searches for relevant documents written in English, Chinese, Spanish, Portuguese, and French, and also contacted several universities and government agencies worldwide for input. The Infectious Diseases Analyst determined that 823 documents were relevant to the task and could be used in the priority setting analysis. Based on a workshop discussion focused on the Task US-09-01a Infectious Diseases report, the Advisory Group members present collectively agreed to rely upon the Disease Burden list produced by United Nations (UN) World Health Organization (WHO 2005) for observation parameter prioritization. In the UN WHO (2005) document, the overall burden of disease is assessed using the disability-adjusted life year (DALY), a time-based measure that combines years of life lost due to premature mortality and years of life lost due to time lived in states of less than full health. Several diseases of interest did not have a quantified global burden value on this list. For the purposes of this study, the Infectious Diseases Analyst assumed a DALY value of at least one. The Infectious Diseases Analyst determined which Earth observation parameters supported which diseases, and then ranked the observation parameters based on the cumulative DALY impact.

Table 10 lists the critical Earth observation priorities for human health users, as presented by the three Health Analysts in the Aeroallergens, Air Quality, and Infectious Diseases sub-reports.

Table 10. Health SBA Priority Observations
(Most to Least Important by Sub-Report)

Aeroallergens Observations	Air Quality Observations	Infectious Diseases Observations
Aeroallergens	Surface $PM_{2.5}$	Population Density*
Surface Air Temperature*	Surface SO_2	Precipitation*
Relative Ambient humidity*	Surface NO_2	Infrastructure/Urbanization
Precipitation*	Surface O_3	Temperature*
Thunderstorms	Surface PM_{10}	Humidity*
Air Pollution (e.g., ozone, $PM_{2.5}$)*	Column $PM_{2.5}$	Land Use
Land Cover (Phenologic parameter)	Column SO_2	Vegetation
Ice Cover (Phenologic parameter)	Column NO_2	Water Bodies
Wind Direction*	Column O_3	Sea Surface Temperature
Wind Speed*	Column PM_{10}	Wind*
Wind Persistence*	Population*	Sea Surface Height
Population Density*	Surface Temperature*	Topography
NDVI	Surface Humidity*	Vector Population
Leaf Area Index	Surface $PM_{2.5}$ Composition	Dust
Photosynthetically Active Radiation	Surface VOCs	Biodiversity
Gross Primary Productivity		Source of Drinking Water
Continuous Field Tree Cover*		Surface Water pH
Field Cover (Continuous)		Salinity
Land Cover Dynamics		Access to Health Care
		Algal Blooms
		Forest Cover*
		Pathogen Population Dynamic
		Soil Type
		Density of Animal Host
		Soil Moisture
		Deforestation
		Sunshine Radiation

*Indicates common priorities across two or more Health SBA sub-areas.

In accordance with the methodology described in Section 2.2.3, the Health SBA contributed a single integrated set of observation priorities for the Cross-SBA analysis. The single list represents the union of the three sub-report priority lists in Table 10. Hence, the combination of the 15 observation priorities for Air Quality, the 19 for Aeroallergens, and the 27 for Infectious Diseases resulted in 61 observation priorities for the Health SBA for input to Methods 1-3 of the Cross-SBA analysis. 10 observations, marked with * in Table 10, are repeats across the sub-reports, and were not double-counted in this summation. Accounting for differences in observation terminology across the SBAs, the Health Team effectively contributed 46 observations for Methods 1-3 of the Cross-SBA analysis. For Methods 2 and 3, the high/medium/low rankings were determined based on the highest ranking assigned to an observation parameter across the 3 Health SBA Analysts. This resulted in 16 of the observations being ranked high, 14 ranked medium, and 16 ranked low.

Similarly, the “15 Most Critical” observation list for the Health SBA was prepared collectively by the Health Analysts and Cross-SBA Analyst. This integrated list was based on the commonality across the 3 sub-report “15 Most Critical” observation lists. Accounting for differences in observation terminology across the SBAs, the Health Team effectively contributed 32 observations for Method 4 of the Cross-SBA analysis.

3.8. Water SBA

The focus of the Water SBA Report is on system state variables, forcing and feedback variables, and derived or computed observation parameters. The report takes into account the various types of decisions made by users, ranging from operational/tactical (real-time and near-real-time) decisions to strategic and policy decisions. Basic and applied research scientists in various water cycle and related disciplines are users of direct, unprocessed data. Users of water cycle data and information include those involved in a broad range of end-applications sectors, including but not limited to reservoir management, water resource management, irrigation scheduling, urban water supply, energy sector, transportation, water allocation permitting authorities, and land use management and zoning. The report focuses on the management of terrestrial water resources and the terrestrial water cycle, especially at the basin or watershed scale, in order to minimize overlap with the Climate and Weather SBA reports.

Working together with the Advisory Group, the Water Analyst identified and reviewed 202 papers, reports, programs, and project descriptions, including observation prioritizations completed for the Global Terrestrial Observing System (GTOS), the Integrated Global Water Cycle Observations (IGWCO) theme of the Integrated Global Observing Strategy-Partners (IGOS-P), and the WMO’s Hydrology and Water Resources Programme (HWRP). The Water Analyst employed a semi-quantitative methodology that incorporated multiple factors, with rankings made by the Analyst in consultation with the Advisory Group. The Water Analyst organized the analysis around four categories: Surface Waters, Ground Waters; Forcings on Terrestrial Hydrological Elements; and Water Quality/Water Use. The prioritization methodology began with a weighting on observational priorities already established for various elements of the global water cycle, and incorporated new findings from the meta-data analysis, such as observation parameters currently unavailable because of technological limitations, observation parameters needed to derive information products for applied users, and the critical observations needed to understand the water cycle. The Water Analyst noted that the observation parameters identified represent macro-parameters/variables, which could be expanded into a broader range of detailed sub-elements. Table 11 lists the critical Earth observation priorities for water users, as presented in the Water SBA report.

The 24 priority observations for the Water SBA listed in Table 11 were the basis for the input to Methods 1-3 of the Cross-SBA analysis. Accounting for differences in observation terminology across the SBAs, the Water Team effectively contributed 49 observations for Methods 1-3 of the Cross-SBA analysis. For Method 4 of the Cross-SBA Analysis, the Water Team identified the “15 Most Critical” observations. Again, accounting for differences in terminology, the Water Team effectively contributed 28 observations for Method 4 of the Cross-SBA analysis. An appendix of the individual Water SBA report provides details on the input to the Cross-SBA analysis.

Table 11. Water SBA Priority Observations (Unordered)*

Observation Parameter
Sub-Area 1: Surface Waters
Precipitation (liquid, solid and mixed phase)
Soil Moisture
Soil Temperature
Evaporation/ Evapotranspiration
Stream and River Flows/Stage/Runoff/Infiltration/Percolation
River Discharge
Lakes, Reservoirs and Other Surface Storages
Snow/Ice
Glaciers/Ice Sheets/Permafrost/Frozen Ground
Sub-Area 2: Ground Waters
Ground Water Table
Aquifer Levels
Soil Type/Texture/Porosity/ Conductivity/Composition
Sub-Area 3: Forcings on Terrestrial Hydrological Elements
Surface Radiation Budget
Cloud Properties
Surface Air Temperature
Surface Air Moisture/Humidity
Surface Winds
Surface Pressure
Vegetation Cover/Type
Land Cover/Use
Topography/Geology
Sub-Area #4: Water Quality/ Water Use
Water Quality/Composition
Nutrient and Contaminant Effluents/Fluxes
Water Sources/Demand/Draw/Use/Regulation

* Refer to the Water SBA report for global, regional, and local rankings.

3.9. Weather SBA

The Analyst focused the report on the following sub-areas, derived from WMO Statements of Guidance: Global Numerical Weather Prediction, Regional Numerical Weather Prediction, Synoptic Meteorology, Nowcasting and Very Short Range Forecasting, Seasonal and Inter-annual Forecasts, Aeronautical Meteorology, Atmospheric Chemistry, Ocean Applications, Agricultural Meteorology, and Hydrology.

The Weather Analyst identified users of weather information and services in a variety of application areas. The Weather Analyst noted that weather information also plays a key role for transportation activities, and that many application areas are not yet able to express direct and precise requirements for weather data. From a wide array of potentially relevant documents identified, the Weather Analyst selected 25 documents as providing critical information that could be used in the priority setting analysis. The document search included web pages of relevant international organizations (i.e., United Nations organizations, other international organizations, space agencies, etc.). To close apparent information gaps in existing documents, the Weather Analyst also conducted interviews with selected experts for specific application areas. The Weather Analyst noted that there are many existing comprehensive requirement studies (e.g., the Rolling Requirements Review of the WMO) in the weather domain, and therefore, focused the meta-analysis on building on these existing studies. The Weather Analyst prioritized the Earth observation parameters, to narrow down to the list reported as critical Earth observation priorities in this Cross-SBA report. The Analyst assigned high priority to those observation parameters which: 1) are identified as "high priority" in the identified documents; 2) are relevant for at least two different application areas, including Global Numerical Weather Prediction, Regional Numerical Weather Prediction, Nowcasting and Very Short Range Forecasting, or Seasonal and Inter-annual Forecasts; and 3) have specification of the required observation characteristics (e.g., resolution) by CEOS, WMO, and/or EUMESTAT. Table 12 lists the critical Earth observation priorities for weather users, as presented in the Weather SBA report.

The 29 priority observations for the Weather SBA listed in Table 12 were the basis for the input to Methods 1-3 of the Cross-SBA analysis. Accounting for differences in observation terminology across the SBAs, the Weather Team effectively contributed 28 observations for Methods 1-3 of the Cross-SBA analysis. For Method 4 of the Cross-SBA Analysis, the Weather Team identified the "15 Most Critical" observations. Again, accounting for differences in terminology, the Weather Team effectively contributed 17 observations for Method 4 of the Cross-SBA analysis. An appendix of the individual Weather SBA report provides details on the input to the Cross-SBA analysis.

Table 12. Weather SBA Priority Observations (Unordered)

Observation Parameter	
3D humidity field	Snow (cover)
3D temperature field	Snow water equivalent
Cloud Cover	Soil moisture
Cloud water/ice amounts (3D distribution)	Surface air humidity
Fraction of absorbed PAR (fAPAR)	Surface air temperature
Land surface (skin) temperature	Surface pressure (over land)
Leaf Area Index (LAI)	Surface wind
Ocean topography	Vegetation cover
Ozone	Vegetation type
Precipitation	Wave direction
Sea surface salinity	Wave height
Sea surface temperature	Wave period
Sea-ice (cover)	Wind (3D) - horizontal component
Sea-ice surface (skin) temperature	Wind (3D) - vertical component
Sea-ice thickness	

4. Cross-SBA Overall Priority Earth Observations

4.1. Results of Methods 1 Through 4

As explained in Chapter 2, Method 1 for the Cross-SBA analysis is an unweighted tally of all observation parameters across the SBAs. This prioritization method is based on a simple count of how many SBAs specified that observation. Upon the combination of similar observation parameters as described in Chapter 2, a total of 146 observation parameters were identified in the SBA reports as Earth observation priorities.

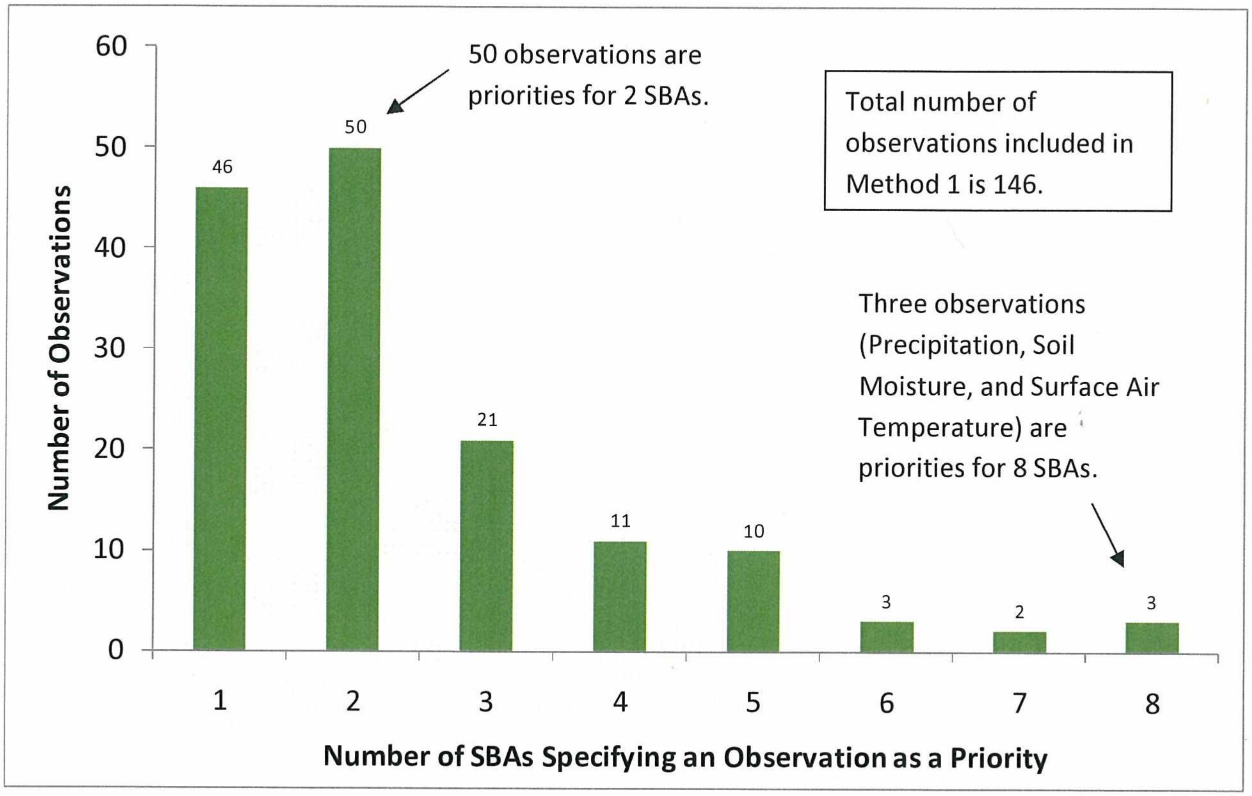
A summarization of the results of Method 1 is shown in Table 13, which lists the observation parameters that are applicable to five or more SBAs.

Table 13. Method 1: Highest Ranked Observation Parameters (applicable to 5 or more SBAs; X indicates SBA applicability)

Observation Parameter	Agriculture	Climate	Disasters	Ecosystems	Energy	Health	Water	Weather	# SBAs
Surface Air Temperature	X	X	X	X	X	X	X	X	8
Precipitation	X	X	X	X	X	X	X	X	8
Soil Moisture	X	X	X	X	X	X	X	X	8
Surface Humidity	X		X	X	X	X	X	X	7
Surface Wind Speed	X		X	X	X	X	X	X	7
Surface Atmospheric Pressure	X	X	X	X			X	X	6
Surface Wind Direction	X		X	X		X	X	X	6
Land Cover	X	X		X	X	X	X		6
Upper Level Humidity	X	X	X	X				X	5
Urbanization	X			X	X	X	X		5
Snow Cover Extent		X	X	X			X	X	5
Elevation			X	X	X	X	X		5
Land Surface Temperature	X		X		X		X	X	5
Leaf Area Index	X			X		X	X	X	5
Normalized Difference Vegetation Index (NDVI)	X			X	X	X	X		5
Vegetation Cover	X			X		X	X	X	5
Vegetation Type	X			X		X	X	X	5
Sea Surface Temperature (SST)		X	X	X		X		X	5

Figure 1 further details the results of Method 1 by indicating how many observations are priorities for multiple SBAs. Of the 146 observations included in Method 1, only 3 of them are required by all 8 SBAs, whereas 50 are required by only 2 SBAs and 46 by only 1 SBA.

Figure 1. Method 1: Distribution of Observations by Number of SBAs



The results of Methods 2 and 3 are shown in Table 14. The weighting schemes differ between Method 2 and Method 3, as follows:

Method 2: High = 3, Medium = 2, Low = 1
Method 3: High = 6, Medium = 3, Low = 1

The highest-ranked observation parameters from Methods 2 and 3 are essentially the same. The observation parameters are listed in Table 14 in order from most to least important according to Method 2. The Analyst selected a score of 10 in Method 2 as the cut-off for inclusion in this table as a natural breakpoint.

Table 14. Methods 2 and 3: Highest Ranked Observation Parameters (with highest weighted score)

Observation Parameter	Method 2: Total Weighted Score (3-2-1 Weights)	Method 3: Total Weighted Score (6-3-1 Weights)
Precipitation	24	48
Surface Wind Speed	18	33
Soil Moisture	18	32
Surface Air Temperature	18	31
Land Cover	17	32
Surface Humidity	15	26
Vegetation Cover	14	27
Surface Wind Direction	13	23
Sea Surface Temperature	13	25
Urbanization	13	25
NDVI	13	25
Vegetation Type*	12	22
Land Surface Temperature	11	20
Leaf Area Index	11	20
Surface Atmospheric Pressure	10	15
Land Use	10	19

The distribution of scores from Method 2 can be seen in Figure 2. Generally, more observations were clustered in the lower scores, indicating that relatively few parameters stood out as higher priority based upon this method.

The distribution of scores from Method 3 can be seen in Figure 3. The distribution was roughly equivalent to, although not equal to, the results of Method 2 shown in Figure 2.

For Method 4, each SBA Analyst was asked to identify the “15 Most Critical” Earth observation priorities for his or her SBA. There were a total of 97 observation parameters in the combined list of “15 Most Critical” observation priorities (reduced from the original list of 146 observation parameters). Many of the observation priorities indicated on the “15 Most Critical” lists were actually aggregated observation categories, such as Vegetation Indices, or Land Use/Land Cover. When the Cross-SBA Analyst disaggregated the observation categories, the number of individual observations for a single SBA ranged from 17 to 35.

Figure 4 shows the distribution of the “15 Most Critical” observations from Method 4 by number of SBAs specifying an observation as among the most critical. The trend of the distribution (i.e., that most observations are required by only 1 or 2 SBAs) is similar to the trend of the distribution for Method 1 (Figure 1). Precipitation is the only observation to make the "15 Most Critical" list for all 8 SBAs.

Figure 1. Method 2: Distribution of Observations by Method 2 Weighting

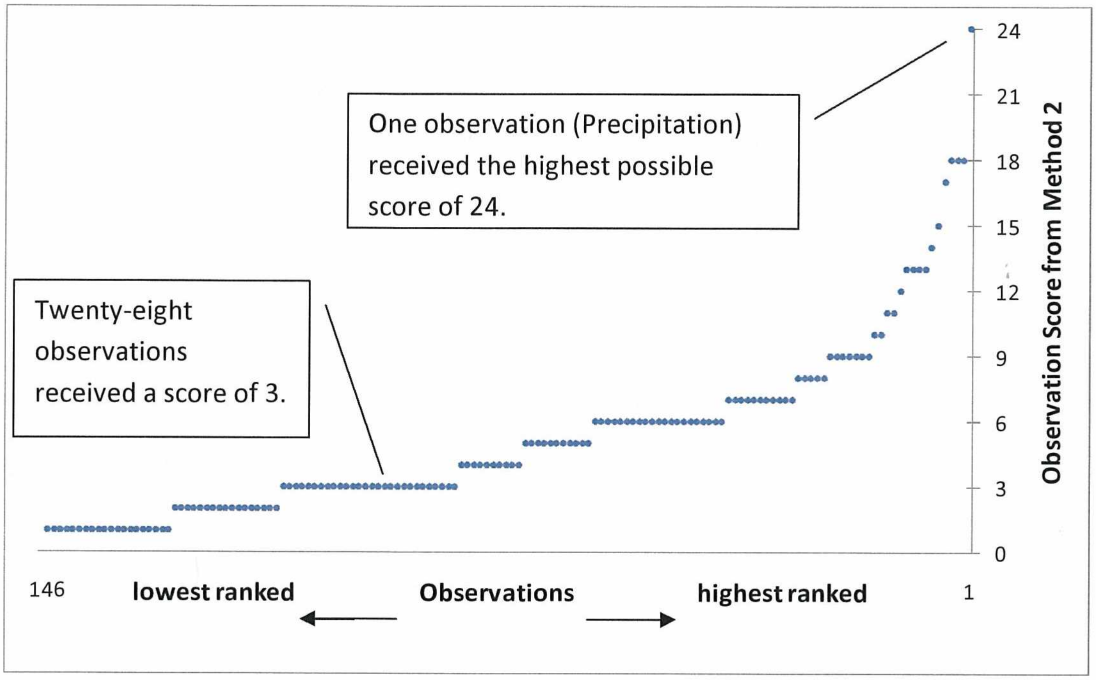


Figure 2. Method 3: Distribution of Observations by Method 3 Weighting

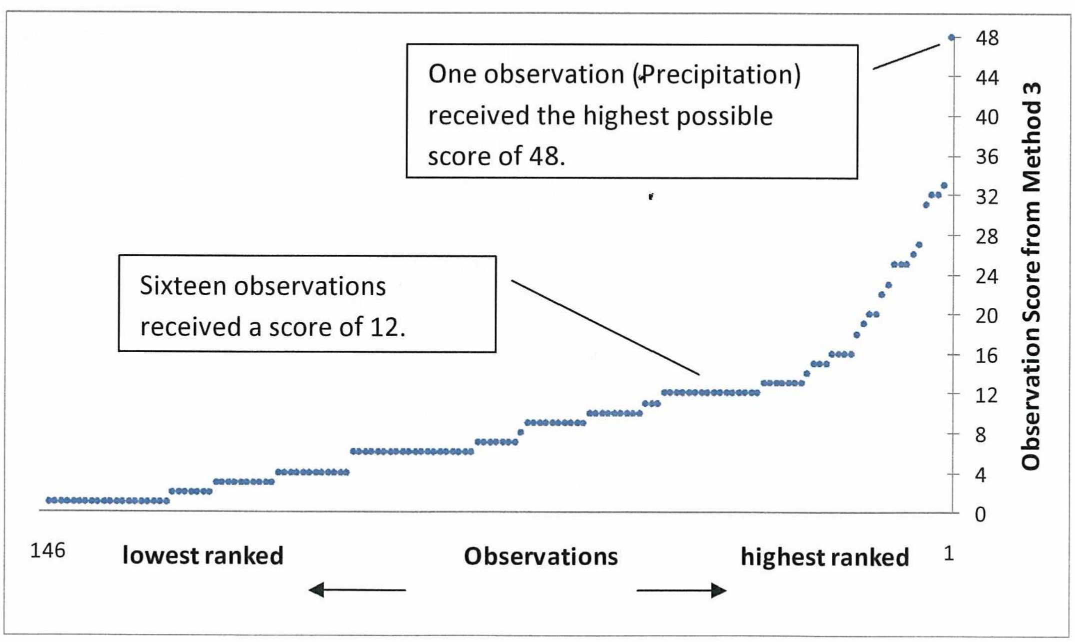
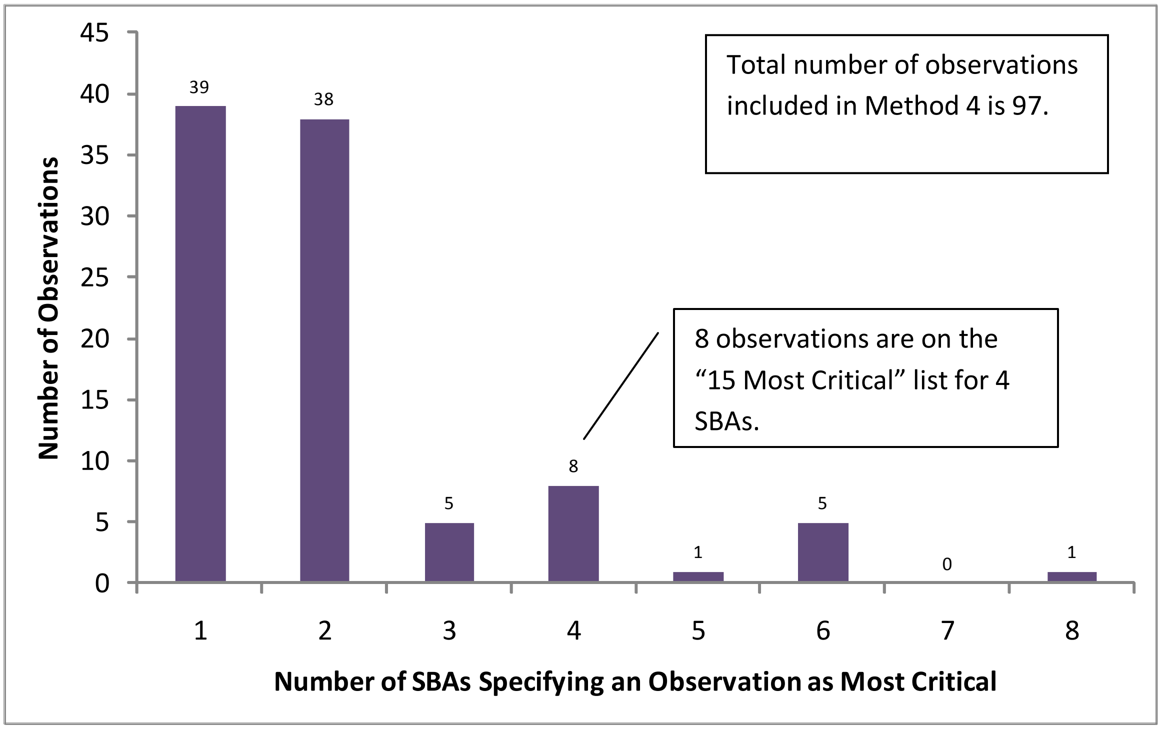


Figure 4. Distribution of 15 "Most Critical" Observations by Number of SBAs



Based on discussion at the Analysts meeting, the combined "15 Most Critical" observations list is intended to take an alternate approach to assessing the cross-cutting applicability of observation parameters, by focusing on the highest needs for each SBA and making those a priority. The complete list of the 97 observation parameters on the combined list of "15 Most Critical" observations is included in Appendix D. To further narrow priorities, the Cross-SBA Analyst identified 20 (out of 97) of the "15 Most Critical" observations that made the most critical priorities list for at least three SBAs, as shown in Table 15. This approach of tabulating the number of SBAs by observation is also used in the following chapter to combine the Method 4 results with those of Methods 1-3.

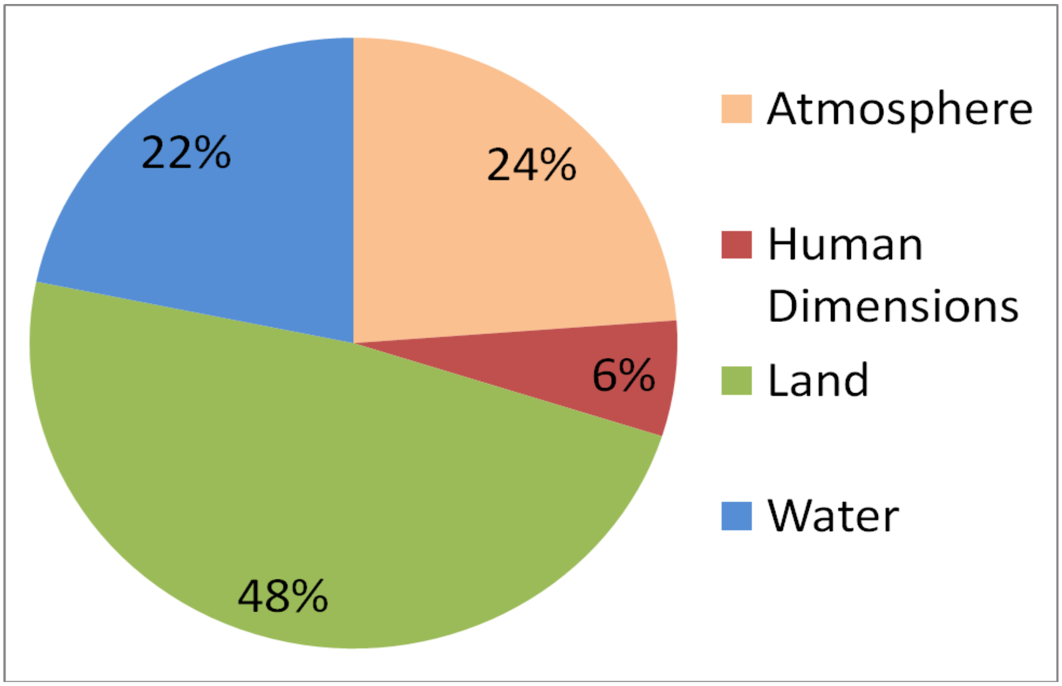
With some degree of overlap, the 146 critical Cross-SBA parameters fall into four basic categories that reflect the four types of Earth systems: land, atmosphere, water, and human dimensions. **Land** parameters include observations of vegetation and animal species, soil and surface properties, land cover, and magnetic and gravity fields. **Atmosphere** parameters include observations of atmospheric constituents, surface and upper level meteorology, and radiation and energy. **Water** parameters include observations of the oceans, surface water, and ground water. **Human dimensions** parameters include observations of such factors as land use, population, urbanization, cultivation, and source of drinking water.

Figure 5 shows the breakdown of the 146 critical cross-SBA parameters by these four Earth systems categories. Almost 50% of the parameters fit into the land category, while only 7% fall into the human dimensions category. The remaining parameters are split approximately evenly between the atmosphere and water categories. Although this breakdown is sensitive to the aggregation of parameters within each category and the achievement of broad user group representation, it provides insight into the overall needs of end users, which are predominantly focused on land observations.

Table 15. Method 4: Highest-Ranked Observation Parameters

Earth Observation Parameter	Number of SBAs on "15 Most Critical" Priorities List
Precipitation	8
Surface Air Temperature	6
Surface Humidity	6
Surface Wind Speed	6
Soil Moisture	6
Land Cover	6
Surface Wind Direction	5
Glacier/Ice Sheet Extent	4
Elevation	4
Vegetation Cover	4
Vegetation Type	4
Urbanization	4
Sea Surface Temperature (SST)	4
Land Surface Temperature	4
Normalized Difference Vegetation Index (NDVI)	4
Cloud Cover (cloud index)	3
Groundwater	3
Sea Level	3
Stream/River Flow, Discharge, Height, Stage	3
Ocean Topography	3

Figure 5. Percentage by Category of Combined List of 146 Observation Parameters from Individual SBA Reports



4.2. Final List of Critical Earth Observation Priorities

Based on Methods 1 through 4, the Cross-SBA Analyst calculated the mean rank and the range of ranks for all 146 observation parameters across these four methods. The results are listed in Appendix C. The Cross-SBA Analyst noted a natural break point between the highest-ranked 30 observation parameters and the remaining observation parameters. In order for the most important observation parameters to have a high "score" rather than a low rank (e.g., rank of 1 for the most imporant observation), the Cross-SBA Analyst calculated a score for each observation by subtracting the observation's rank from 147 to make the highest-ranked observation parameter have a score of 146. For example, Precipitation has a rank of 1, which equates to a score of 146. The lowest-ranked observation parameters have a score of 33; if there were no ties, the lowest score would have been 1. Figure 6 shows the results for the highest-ranked 30 observation parameters, indicating the mean score and the range (minimum and maximum) of scores for each observation across Methods 1 through 4.

For the observation parameters shown in Figure 6, the observation parameters with the highest scores generally also have the smallest range in rank, indicating agreement among the outcomes of the four methods on the most critical priorities. The highest-ranked 10 critical Earth observation observation parameters, in approximate order of importance, are:

- **Precipitation**. This parameter includes observations of the phase, amount, frequency, and duration of precipitation; precipitation in thunderstorms; and extreme precipitation events.

- **Soil Moisture.** Soil Moisture is on the list of priorities for the 8 SBAs in the Cross-SBA analysis. Observation needs include surface and sub-surface soil moisture.

- **Surface Air Temperature.** Surface Air Temperature is on the list of priorities for the 8 SBAs in the Cross-SBA analysis. The related Land Surface Temperature is on the list of priorities for 5 SBAs and is within the 30 highest-ranked parameters.

- **Surface Wind Speed.** Surface Wind Speed is on the list of priorities for 7 SBAs. Users typically distinguish between a need for surface wind direction vs. speed. The parameter Upper Level Winds is related and is a priority for 4 SBAs.

- **Land Cover.** Land Cover is on the list of priorities for 6 SBAs. As a derived parameter, Land Cover draws on multiple data sources. The parameter Urbanization is related and is within the 30 highest-ranked parameters.

- **Surface Humidity.** Surface Humidity is on the list of priorities for 7 SBAs. The related parameter of Upper Level Humidity is within the 30 highest-ranked parameters. Together, these two parameters are critical for global numerical weather prediction models.

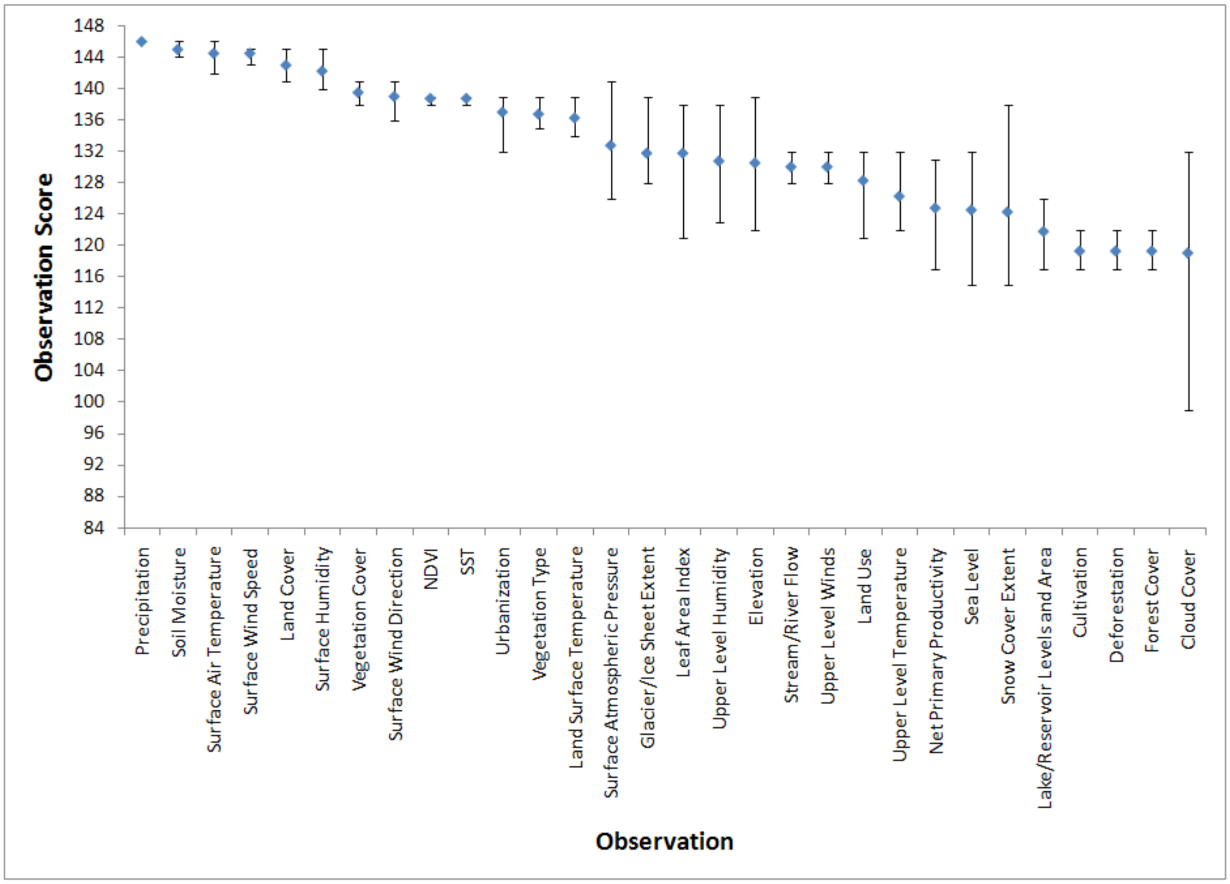
- **Vegetation Cover.** Vegetation Cover is on the list of priorities for 5 SBAs, including Agriculture, Ecosystems, Health, Water, and Weather. Some users require additional information such as Vegetation Type and Vegetation Indices.

- **Surface Wind Direction.** Surface Wind Direction is on the list of priorities for 6 SBAs. In the overall rankings shown here, this parameter is slightly less critical than Surface Wind Speed.

- **Normalized Difference Vegetation Index (NDVI).** Normalized Difference Vegetation Index is on the list of priorities for 5 SBAs. NDVI is often used as a surrogate for vegetation parameters such as biomass, status, greenness, and moisture, which may be the underlying user data needs.

- **Sea Surface Temperature (SST).** Sea Surface Temperature is on the list of priorities for 5 SBAs. SST is critical for seasonal to long-range forecasts. Other ocean parameters such as Ocean Topography and Sea Level also are within the 30 highest-ranked parameters.

Figure 6. Overall Critical Earth Observation Priorities in Order of Importance (defined and sorted by Score)



◆ Score of Observation Parameter across Methods 1-4

Minimum and Maximum Score of Observation Parameter across Methods 1-4

5. Context for Cross-SBA Results Interpretation

The Cross-SBA Analyst presents the following items as important information to understand regarding the implementation of the process. Any prioritization process has strengths and limitations. The use of an ensemble approach was intended to capture the strengths of different methods and minimize their limitations.

Throughout the course of this US-09-01a analysis, several themes emerged from discussion among the SBA Analysts. The process of taking a broad set of users and SBAs and narrowing

Earth observation parameters down to a relatively short list of critical priorities fostered spirited debate among the SBA Analysts. To capture the relevant issues, the following presents important, context-setting information within which this Cross-SBA report should be interpreted.

The SBA Analysts went to great length to emphasize the strengths of such a multidisciplinary priority setting activity. Task US-09-01a seeks to identify a single set of critical Earth observation priorities. Whether conducted as a frequency analysis to identify cross-cutting observation parameters focused on key observation parameters for each SBA or conducted following other methodologies, no method is perfect. This Cross-SBA analysis is designed to be transparent, to test multiple methodologies for analysis, and to foster discussion about options for future activities to identify critical Earth observation priorities.

Other potential Cross-SBA prioritization methodologies include identifying "enabling" observation parameters (those that most directly affect strategic decisions). SBA Analysts noted that one of the potential drawbacks of picking and choosing individual observation parameters as priorities is the potential to interfere with the interdependency of *sets* of priorities identified by other organizations. Hence, highlighting these limitations and the ways in which the Analysts sought to address them boosts the scientific credibility of this analysis.

Priorities of a single SBA may not be on the Cross-SBA list. Task US-09-01a focused on the commonality of priority observations to many SBAs. Thus, some observations of critical importance to a particular SBA do not appear in the Cross-SBA list of priority observations. The ranking of an observation in the Cross-SBA list does not imply objective importance of that observation as much as commonality in need. The combined set of "15 Most Critical" observations from individual SBAs totals 97, compared to the 146 observations from the combination of the individual lists. Of these 97 observations, 39 appear on the "15 Most Critical" observations lists of only one SBA. While these 39 observations are priorities to users associated with a single SBA, they are not as critically important to other users. The individual SBA reports have information on critical Earth observations for their respective SBAs.

User needs vary by region, and also by the geographic scale of focus of the users. Several SBA Reports (notably Water, Ecosystems, and Climate) assess the importance of Earth observation parameters separately for users with a global focus vs. those with a national or local focus. Observation parameters that are of high priority for one group of users (e.g., international organizations) may be of low priority for another group (e.g., local land use planners). In addition, critical Earth observation priorities vary by region and country. For example, the endowment of renewable energy resources and types varies geographically, and therefore, the observation parameters of importance vary accordingly.

The SBA Analysts reviewed over 1,700 documents with broad geographic coverage, from both developed and developing countries, to capture as many documented user needs as possible. The SBA Analysts reviewed a broad collection of peer-reviewed literature, international organization priority setting reports, regional and local documents, websites, and project reports. In doing so, the SBA Analysts noted that user needs are not universally well documented. Many SBA Analysts identified data gaps in the documentation of user needs, as listed in Table 16. In some cases, regional and national needs documents may be available in languages other than English, but in most cases, such documents were not uncovered by this analysis. This US-09-01a analysis focused primarily on documents in English, based on a collective decision by the SBA Analysts on the best approach.

Table 16. Data Gaps in Documentation of User Needs

SBA Report	Data Gaps
Agriculture	• Limited documentation on Earth observation needs for famine early warning. • Limited documentation on user needs in South and Central America, South Asia, the Middle East, and to some extent, Africa.
Agriculture/ Forests	• Limited documentation for regional observation needs. Of the 16 relevant documents, the Analyst identified 15 as having a global focus.
Biodiversity	• Not addressed
Climate	• Limited documentation on regional and national scale priority observations.
Disasters	• No relevant documentation found that focused specifically on Earth observation priorities for Africa or South America.
Ecosystems	• General lack of specificity on observational attributes to serve user needs.
Energy	• Limited documentation on user needs for bioenergy, geothermal energy, and hydropower.
Health	• For the Aeroallergens sub-area, a limited number of documents were found from collaborative projects conducted by national or regional agencies or organizations. • For the Infectious Diseases sub-area, documents describing operational applications are less numerous than research papers describing the potential of using Earth observations. • For the Air Quality sub-area, there was a general lack of specificity on user needs.
Water	• No gaps identified.
Weather	• Lack of documentation on regional and national needs.

The SBA Analysts extracted all available information on observation characteristics needed by users from the reviewed documents, but found some information to be lacking. Some of the documents identified by the SBA Analysts included quantitative information on the required characteristics (coverage, spatial/temporal resolution, timeliness, precision and accuracy) of critical observation parameters, while other documents lacked such information. Where such information was available, the SBA Analysts noted that the required observation characteristics vary widely, according to user and application. In addition, some SBA Analysts (e.g., for the Ecosystems SBA) found that the documents focused more on improvements in the ability to apply the observation parameters rather than on the specifics of the observation parameters themselves. Thus, the collective decision of the SBA Analysts was to exclude observation characteristic information in this Cross-SBA report. The individual SBA reports address observation characteristics to the extent possible; a separate study on required observation characteristics would be needed prior to any observation collection campaign or instrument design.

Users need historical records to put current and future observations in perspective. That is, users need long-term historical records, statistics, and forecasts. In addition to needs related to specific Earth observation parameters, many documents reviewed by the SBA Analysts highlighted the need to detect changes via long-term time series data (30 to 100+ yrs), statistics on recurrence frequencies and extreme events, and forecasting of observation parameters. For example, for the Energy SBA, the documents and Advisory Group members highlighted the growing role of forecasting for solar and wind resources. The need for forecasted observation parameters gives added importance to the need for observation of meteorological observation parameters that drive the forecast models.

The SBA Analysts conducted technology-neutral searches for user needs. In doing such, for certain SBAs, the SBA Analysts noted that there may be a bias in the literature toward satellite focused user needs. The SBA Analysts conducted their literature searches and analyses without regard to observing technologies. However, in the course of establishing their priority lists of observation needs, the Weather, Ecosystems, and Disasters SBA Analysts noted that many of their documents approached user needs from a satellite-based perspective (i.e., focused on users accustomed to working with satellite data), and therefore, the resulting analysis may be slightly biased toward satellite (vs. ground-based, in situ, or airborne) observing technologies. For example, for the Weather SBA, many documents focused on certain satellite missions or have been drafted under the WMO space program. For the Disasters SBA, a large number of the documents focused on remote sensing applications. For the Ecosystems SBA, large-scale observations were discussed commonly in literature, while small-scale (bacteria and microbial) processes, which form the basis of all larger ecosystems, were discussed less often in the literature. As a result, observation categories that are typically based on measurements from ground-based sensors may be underrepresented in the final assessment of observation priorities.

6. Recommendations for Future Processes to Determine Priority Earth Observations

The nine-step process that was outlined by the UIC for Task US-09-01a proved to be effective. In addition to the document-based approach of the nine-step process, there are other valid approaches for establishing critical Earth observation priorities such as formal expert elicitation. Given that each approach has strengths and weaknesses, the Analysts recommend that the UIC pursue a combination of several prioritization methods to minimize error in the prioritization. The following focuses on improvements to the document-based approach, and includes a suggestion for an increased degree of expert involvement.

With regard to the UIC-established document-based approach, the SBA Analysts appreciated having the nine steps and a detailed report template provided to them by the GEO UIC Task Co-Lead. In-person meetings of the SBA Analysts and monthly teleconferences were very valuable to facilitate the progress of the analysis. The Analysts recommend such activities (or similar) in future endeavors. This section discusses some of the challenges faced by the SBA Analysts and Cross-SBA Analyst and makes recommendations ***(in bold italics)*** for future activities to identify critical Earth observation priorities. The challenges primarily focused on:

- Limitations of the available documents,
- Engagement of the Advisory Group,
- SBA Report scope narrowing and organization,
- Standardization among the SBA reports, and
- Need for consistent funding and coordination for the Cross-SBA analysis.

The following discussion is organized according to the Task US-09-01a Steps, followed by discussion of the Cross-SBA analysis process, and general comments and recommendations. These recommendations are organized for the UIC. Because some of these recommendations are UIC-specific and do not apply to the GEO community and public as a whole, recommendations are organized differently in the public SBA report, with the goal of providing insights on the Task overall.

Step 1: UIC Members identify Advisory Groups and Analysts for each SBA.
The UIC selected the Analysts; the breadth of expertise and funding resources required for Task US-09-01a dictated that multiple organizations provide the Analysts. ***In the future, a single large umbrella organization overseeing funding and technical analysis would be useful for keeping the reports coordinated and on schedule.*** With regard to Advisory Groups, some SBA Analysts had more difficulties than others in assembling an Advisory Group, but this activity was not generally problematic. The more challenging activity was keeping the Advisory Group members engaged throughout the task. As the analyses progressed, some SBA Analysts noted that it was necessary to have more than the suggested 6-10 members (suggested in the 9-step process) to obtain adequate breadth of engagement. ***We recommend that future priority setting efforts should include about 15 Advisory Group members. Also, the UIC should consider having the GEO Secretariat directly invite Advisory Group members to raise the visibility of this activity (similar to the invitations issued by the Task US-09-01a Co-Lead). The UIC should also consider paying a small honorarium, particularly to representatives from developing countries, and pursuing in-person meetings of Advisory Group members at a conference (which was included in Step 8 but only implemented for one SBA due to funding and logistical constraints).*** Funding delays for certain SBA reports caused a break in communication with Advisory Groups, which may have contributed to disengagement from some members.

Step 2: Determine scope of topics for the current priority-setting activity.
Narrowing the scope of each of the SBA reports (and selecting sub-areas of focus) after the selection of the Advisory Groups was challenging. In many cases, Advisory Group members were experts on only a subset of the SBA focus, and thus, lobbied for the importance of their sub-area and then disengaged if their expertise did not align with the sub-areas selected by the group. ***The UIC should instruct Analysts on specific sub-areas to be covered in the future, prior to organization of Advisory Groups.*** In the current Task US-09-01a, the sub-areas for some SBAs are sub-types of the SBA (e.g., ecosystems). For other SBAs, the sub-areas are organized around user areas of focus. Some SBA Analysts suggested that, since this is a user-focused (demand-side) study, it would be more logical to structure the reports around very

specific management issues. The trade-off is that more reports (and resources) would be required to achieve a broad survey of critical Earth observation priorities if report topics are narrowed too much.

Step 3: Identify existing documents regarding observation priorities for the SBA.
The existence of relevant documents that specifically address user needs and priorities varies widely among the SBAs. For some SBAs, such as the Water, Weather, and Climate SBAs, such documents were relatively abundant, at least on a global scale. For other SBAs, such as Health, documents on user needs were less plentiful. In many cases, the SBA Analysts inferred user needs from statements of the adequacy of currently available observations. In addition, the SBA Analysts in some cases identified relevant content on websites that was not part of an officially published document. The expectation that the Advisory Groups would be a fertile source of relevant documents was not met in many cases, despite explanations of the types of documents sought. This shortcoming is likely due to an overall limited number of relevant documents, and in some cases, limited engagement by the Advisory Group. ***The UIC should provide additional financial resources so that the intent of the nine steps, which included conducting targeted interviews (part of Step 8), could be carried out.*** In the current Task US-09-01a, only a few SBA Analysts went beyond document analysis to conduct interviews. Even for SBAs for which documents were readily available, it would be useful to contact additional developing country representatives to discuss their national priorities.

Step 4: Develop analytic methods and priority-setting criteria.
The implementation of Task US-09-01a was intentionally conducted as a "natural experiment" to allow SBA Analysts to devise analytic methods creatively. As an experiment, this approach was successful in that it generated a wide variety of methods. For example, some SBA Analysts developed conceptual models to depict the relationship between an observation and a specific decision process; other Analysts looked at health outcomes to develop rankings. Each SBA lends itself to certain methods. The Health SBA Analysts focused observation needs based on specific public health-related decision processes, whereas the Ecosystems SBA Analysts interpreted the task scope as agnostic of any specific decision process. Giving equal weight to all possible Earth observations enabled the Ecosystems SBA Analysts to represent the widest possible range of needs, but the relative importance or priority of ecosystem observations could only be derived via bibliometrics. ***The UIC should specify the desired analytic method to be used, allowing for some variation in method across the SBAs. Ideally a combination of bibliometric or other quantitative literature-based methods should be combined with expert elicitation (formal or informal), as was done for several SBAs currently.***

If specific decision processes had been selected as part of the charge to each SBA Analyst, then each potential Earth observation could be ranked in priority based on its importance to satisfying those specific decision makers' objectives based on data quality attributes (e.g., precision, accuracy, representativeness, reproducibility, and completeness). Without specific decision processes as a focus, each potential Earth observation can be described according to topical relevance, but not necessarily absolute importance to a specific purpose or decision. On the other hand, focusing on specific decision processes would have narrowed the broad applicability of the results. ***The UIC should consider setting forth several completed SBA Reports as***

examples to future Analysts. Many of the SBA Analysts employed bibliometric approaches, and they were careful to highlight the limitations of such approaches. Those Analysts that did not perform bibliometric approaches or incorporated rankings from Advisory Group members, found it difficult to defend the apparent subjectivity of their methods. ***The appropriateness of the bibliometric approach versus Advisory Group rankings or other methods is an issue on which the UIC should provide clear guidance to SBA Analysts in the future.***

Step 5: Review and analyze documents for priority Earth observations needs.
The process of reviewing the documents and extracting required observation parameters was relatively straightforward. The SBA Analysts whose teams started first independently converged on a fairly straightforward database structure to track literature, cross-references and observation attributes. Depending on the number of documents identified by the SBA Analyst, the process took longer than originally anticipated. Extracting observation characteristics, however, was more difficult, due to a lack of information (and widely varying information) on specific user needs. In addition, one SBA Analyst noted that the required report structure of examining characteristics such as spatial resolution lent itself better to satellite-based measurements than to ground-based measurements. ***In the future, the review of required observation characteristics may be best performed in a separate targeted study on a specific set of related observation parameters.***

Step 6: Combine the information and develop a preliminary report on the priorities.
Once the detailed report template was provided, this step was relatively straightforward to implement. There are no recommendations for the UIC on this step.

Step 7: Gather feedback on the preliminary report.
Input from the Advisory Group members (and in most cases, the UIC Task Co-Lead) was received on the preliminary reports. Although Advisory Group engagement was strong, it could be strengthened in the future by implementing the recommendations listed under Step 1. ***The UIC should consider supporting interim face-to-face meeting among the Analysts at an early to middle stage in the process.*** Such a "mid-term workshop" could be held to have presentations of initial results, and to discuss methods and results in breakout groups for each of the SBAs and, if necessary, application areas. Experts, such as personnel from the GEO Secretariat or other GEO committees, could be identified to support the workshop and increase participation and interest in the Task.

Step 8: Perform any additional analysis.
This step was generally straightforward to implement. ***The UIC should consider providing a flexible amount of resources for responding to comments to ensure an even more comprehensive response to comments.*** Additional resources would also allow a second iteration of the reports, as needed (and in fact, a second or revised preliminary iteration did occur for some of the SBA Reports).

Step 9: Complete the report on Earth observations for the SBA.
This step was straightforward to implement. Several SBA Analysts commented on the need to confirm the report results with additional recognized experts and/or other studies (i.e., get a

"reality check"). Some suggestions for this check are to compare the reports to other similar priority setting reports (which likely were inputs to these US-09-01a reports). In fact, the Disasters SBA Analyst completed such a comparison for the first Disasters SBA report. ***The UIC should consider working with the relevant GEO Communities of Practice to review and begin dialogue on the results, or develop a targeted work plan to fill gaps identified in the reports (e.g., through targeted author interviews and user surveys).***

Cross-SBA Analysis

The Cross-SBA analysis process generally went smoothly. Holding a meeting with all SBA Analysts at the start of the Cross-SBA analysis (February 2009) was essential to gain collective momentum and specific feedback from each Analyst. The second SBA Analysts meeting (February 2010) also highlighted other potential methods for a Cross-SBA analysis, as discussed in Chapter 5. Having the Cross-SBA Analyst work closely with statisticians ensured a robust meta-analysis. Due to funding limitations, most of the Cross-SBA Analysts were not still under contract to their funding organizations to provide input on the draft Cross-SBA report. ***The UIC should ensure that all SBA Analysts are funded through completion of the Cross-SBA analysis***. Feedback from the UIC on this Cross-SBA report would be helpful to further shape any future Cross-SBA analyses.

Next Steps

Overall, the SBA Analysts stated that US-09-01a was successful. The SBA Analysts recommend that the UIC conduct outreach to communities of users to review and begin dialogue on the results, gather information to fill gaps in documentation of user needs, and develop a process for keeping the user priorities updated. The SBA Analysts emphasized that future identification of critical Earth observation priorities should continue to involve Communities of Practice as vehicles for gathering, evaluating and communicating user requirements. Other logical steps that follow the gathering of user critical priorities are conducting a gap analysis between currently available (or planned) and needed observations and developing practical "guides" to the design and deployment of local, national, and trans-boundary observation networks for the management of specific resources. Other parts of GEO are already working on similar initiatives. To complement the Task US-09-01a methodology's top-down, document-based approach, the follow-up emphasis should be on targeted end-user interaction, whether face-to-face, online, or through printed media.

- **Outreach to Review Results.** The SBA Analysts recommend that the results of Task US-09-01a be discussed with users. Whether through established forums such as GEO Communities of Practice, side events at conferences, or targeted workshops (e.g., with users associated with SERVIR nodes), such outreach is essential to obtain direct user feedback and perspectives. To supplement this report, the UIC should develop case studies for use in outreach, both for user sectors and focused on the multiple uses of a single observation, such as soil moisture. The UIC should consider professional translation of this Cross-SBA report and eventual case studies into several languages and should enlist UIC members to distribute and gather feedback on the report and case studies. The UIC should also support publishing this Cross-SBA report and the individual SBA reports through multiple gateways, to gain publicity and input. Such gateways should include online wikis, targeted articles in trade magazines of users (e.g., public health officials, insurance industry), articles in the gray-literature, and peer-reviewed journal articles.

- **Compare User Needs with Current and Planned Earth Observations.** The SBA Analysts recommend that the results of this Cross-SBA analysis on critical Earth observation priorities be compared with currently available and planned Earth observations. Such a comparison would help highlight current and future gaps to be addressed by the GEO community.

- **Fill Gaps in Documentation of User Needs.** As indicated in Table 16, there is still a considerable gap in the documentation of user needs, particularly at a regional and national level. The UIC should attempt to fill this gap through a combination of outreach to regional and national authorities to uncover previously undiscovered documents, and through targeted research and workshops (as discussed above).

- **Identify Process for Updating Users Critical Earth Observation Priorities.** Given the continuous evolution of user needs and Earth observations, the UIC should develop a process for periodic updates. Such a process should involve a combination of the meta-analysis conducted in Task US-09-01a, intermixed with outreach to vet results, fill gaps, and get users' perspectives. The meta-analysis should be followed by up to a year of outreach. The entire cycle should be repeated approximately every 3 years. Other options that the UIC should consider are a database where users enter their needs (e.g., concurrently with publication of a gray literature or journal article), and standard bi-annual presentations and surveys for GEO Communities of Practice, both of which would require additional outreach.

Appendix A: Abbreviations and Acronyms

BPA	Bisphenol-A
CCN	Cloud Condensation Nuclei
CEOS	Committee on Earth Observation Satellites
DALYs	Disability-adjusted life years
DNA	Deoxyribonucleic Acid
DNI	Direct Normal Irradiation
ECVs	Essential Climate Variables
EO	Earth Observation
EVI	Enhanced Vegetation Index
FAPAR	Fraction of Absorbed PAR
fPAR	Fraction of Photosynthetically Active Radiation
GCOS	Global Climate Observing System
GEO	Group on Earth Observations
GEOSS	Global Earth Observation System of Systems
GHI	Global Horizontal Irradiation
GHG	Greenhouse Gas
GTOS	Global Terrestrial observing Systems
HWRP	Hydrology and Water Resources Programme
IGOS	Integrated Global Observing Strategy
IGWCO	Integrated Global Water Cycle Observations
LAI	Leaf Area Index
LW	Longwave
NASA	National Aeronautics and Space Administration
NDVI	Normalized Difference Vegetation Index
NPP	Net Primary Productivity
OLR	Outgoing Longwave Radiation
PAR	Photosynthetically Active Radiation
SAVI	Soil-Adjusted Vegetation Index
SBA	Societal Benefit Area
SST	Sea Surface Temperature
SW	Shortwave
SWE	Snow Water Equivalent
TOA	Top of Atmosphere
UIC	User Interface Committee
UN	United Nations
USA	United States of America
VOCs	Volatile Organic Compounds
WHO	World Health Organization
WMO	World Meteorological Organization

Appendix B: User Types

The following lists were produced by the SBA Analysts and provide examples of major user types. These lists are not exhaustive. Forests user types from the Agriculture SBA/Forests sub-report are included in the user lists for the Agriculture and Ecosystems SBAs.

Agriculture Earth Observation User Types

Forest Protection Officers and Forest Firefighters
Urban Foresters and Arborists
Microbiologists
Watershed Manager
Conservationists
Biologist
Ecologists
Forest and Land Use Planners
Forest Health Specialists and Surveyors
Land Use Managers
Land Developers
Natural Resource Extraction (Loggers, Miners, Oilman)
Protected Area Managers
Park Ranger
Plant Pathologist
Recreation and Tourist Specialist
Tourists

Biodiversity Earth Observation User Types

Fish & Wildlife Biologists/Managers
Forest Managers
Protected Area Managers
Botanists
Taxonomists
Conservationists
Ecologists
Land Use Planners
Land Use Managers
Land Developers
Natural Resource Extraction (Loggers, Miners, Oilman)
Policy Makers (National, State, and Local Governments; NGOs)
Academicians
Researchers
Community Based Monitoring Groups
Concerned Citizens (e.g., bird watchers/groups)
Private Land Owners

Climate Earth Observation User Types

<table>
<tr><td colspan="2">PRIMARY USE OF CLIMATE OBSERVATIONS

Modeling and Scenario Development
- Climate modelers
- Integrated assessment modelers (e.g., IMAGE, DICE, MINICAM, MERGE)
- Meteorologists
- Intergovernmental Panel on Climate Change (IPCC) of the WMO and UNEP by way of the international research community contributing to these periodic assessments</td></tr>
<tr><td>SECONDARY USERS

Model and scenario results in turn used by:

Marine biologists
Hydrologists
Ecologists
Energy researchers
Geographers
Earth system scientists
Environmental scientists
Conservationists, Etc.</td><td>POLICY USERS

Science and management results in turn used by:
National and sub national governments and international efforts in policy design for GHG stabilization, verification, monitoring, and adaptation

Infrastructure managers, planners and investors (such as the World Bank, UNDP, US Army Corps of Engineers, energy planners)

Etc.</td></tr>
</table>

Disasters Earth Observation User Types

Research - University Professors - Graduate Students - Researchers at research centers - Environmental Consultants	**Emergency Management and Public Outreach** - Risk Mitigation Managers - Emergency Managers - Hospitals & Disaster Response Organizations
Forecasting and Monitoring - Weather Forecasters and Modelers - Wildfire Forecasters and Modelers - Volcanic Eruption Forecasters and Modelers - Hurricane/Typhoon Forecasters and Modelers - Satellite Analysts - Volcanologists, Geologists - Hydrologists - Meteorologists	**Public Outreach** -Weather Service Providers -Print Media -Broadcast Media (Radio and TV) -Online Media -Local Law Enforcement/Fire Department Officers
Infrastructure and Risk Assessment Civil Engineers Environmental Engineers Water Resource Manager	City Planners and Zoners Regional Planners Insurance Assessors Risk Assessors

Ecosystems Earth Observation User Types

Water resources managers
Natural resources managers
Wildlife managers
Coastal planners and developers
Land use planners
Agricultural managers
Policymakers (local, state, national, Environmental Protection Departments)
Researchers (climate, ecosystem function, biological invasion, disease, future change)
Climate impacts analysts

Energy Earth Observation User Types

Researchers -Resource Assessment (e.g., at a national lab, studying solar energy potential) -Technology Development (e.g., wind turbine designer) -Energy model developer (e.g., for analysis of likely future biomass scenarios)	**Energy Facility Developers and Operators** -e.g., Biofuels refinery planner, for plant siting and operations logistics -e.g., Wind farm developer, for plant siting and operations logistics -e.g., State utility, developing plans for how to meet a renewable portfolio standard -e.g., Water resources manager, deciding how to operate a hydropower facility
Energy Policy Developers -e.g., Energy Department official studying renewable portfolio standard options	
Energy Regulators -e.g., Energy Commission official responsible for overseeing grid integration	**Private Users** -e.g., Rural village leader, utilizing renewable energy tools, to optimize village energy system including options such as micro-hydropower -e.g., Citizen determining whether to purchase a solar water heater
Electric Grid Operators -e.g., Independent System Operator (ISO) trying to predict how much wind power they will need to integrate into their regional grid system on a given day	**Building Designer or Engineer** -e.g., American Society of Heating, Refrigeration, and Air Conditioning Engineer (ASHRAE), to minimize building heating/cooling costs

Health: Aeroallergens Earth Observation User Types

User Types (Involved directly or indirectly in the protection of public health)
Air quality model and systems developers/providers
Air quality scientists
Health care providers
Health outreach and education professionals
Health risk analysts
Interested/aware/concerned members of the public, including sensitive populations
Public health organizations
Public health policy organizations
Public health managers and decision-makers
Public health policy makers
Non-governmental organizations (NGOs) and advocacy groups
Health scientists (e.g., epidemiologists, immunologists)
Weathercasters

Health: Air Quality Earth Observation User Types

<table>
<tr><td rowspan="3">Use of Assessments and Forecasts to Promote Health Protection

-National and Sub national Policy Makers in Environmental and Public Health Sectors
-National and Sub national Air Quality Managers
-National and Sub national Public Health Managers and Decision-makers
-Health Care Providers
-Weathercasters
-Health Outreach and Education Professionals
-Interested/Aware/Concerned Members of the Public
-Businesses Supporting Local Clean Air Programs
-NGOs and Advocacy Groups</td><td>Direct Use of Earth Observations (EO)

-Air Quality Researchers
-Environmental Scientists</td></tr>
<tr><td>Use of EO to Develop and Populate Integrative Systems, Analytical Tools, and Models

-Air Quality Model and Systems Developers/Providers
-Public Health Specialists</td></tr>
<tr><td>Use of Tools and Models to Assess and Forecast Air Quality

-Air Quality Scientists
-Environmental Process Modelers and Researchers
-Public Health Specialists</td></tr>
</table>

Health: Infectious Disease Earth Observation User Types

ENVIRONMENTAL CHANGE*	HEALTH PROTECTION
Direct Use of Earth Observations (EO)	
▪ Climate Scientists* ▪ Environmental Scientists (Ecologists, Land Use/Cover Specialists, etc.)*	▪ International Public Health Organizations (e.g., WHO Global Health Observatory) ▪ National and Sub national Public Health Policy Makers
Use of EO to Develop and Populate Integrative Systems, Analytical Tools, and Models	
▪ Environmental Process Modelers and Systems Developers*	▪ Public Health Risk Modelers and Systems Developers ▪ Environmental Benefits Valuation Specialists
Use of Tools and Models to Assess and Forecast Disease Incidence and Trends	
	▪ Health Risk Analysts ▪ Public Health Scientists (e.g., Epidemiologists, Infectious Disease Specialists)
Use of Assessments and Forecasts to Promote Health Protection	
▪ National and Sub national Policy Makers in Environmental Sectors* ▪ NGOs and Advocacy Groups* ▪ Infrastructure Managers, Planners and Investors*	▪ International Public Health Policy Organizations ▪ National and Sub national Public Health Policy Makers ▪ National and Sub national Public Health Managers and Decision-makers ▪ Health Care Providers ▪ Health Outreach and Education Professionals ▪ Interested/Aware/Concerned Members of the Public ▪ NGOs and Advocacy Groups

*Assume these users are covered by work under other SBA areas (e.g., weather, climate, ecosystems, and biodiversity) and therefore are not within the scope of the health SBA.

Water Earth Observation User Types (by job titles)

Climate Scientist	Fire Prevention Planner
Climate Forecaster	Fire Fighter
Weather Forecaster	Environmental Protection Manager
Hydrologist	Nat. Disaster Manager
Flood Forecaster	Drought Monitor
Drought Forecaster	Drought Mitigation Manager
Water Resource Manager	Flood Control Manager
Water Res. Allocator	Flood Control Planner
Urban Water Supplier	Nat. Hazards Risk Assessor
Agronomist/Farmer	Insurance purveyor
Hydro Power Engineer	Land Use Planner
Energy (other) Engineer	Epidemiologists
Heating/cooling Engineer	Disease Outbreak Forecaster
Irrigation Scheduler	Pollution Forecaster
Forest Manager	Water Quality Manager
Forest Conservationist	Urban Planners
Ecologist	City Development Zoner
Environmental Engineer	Environmental Impact Assessor

Weather Earth Observation User Types (by job titles)

Public organizations

Civil protection agencies and organizations:
Warning systems operator
Crisis / disaster / emergency manager
Risk manager
Fire department officer
Police officer

National meteorological and hydrological services (NMHS); regional continental weather centers:
Weather forecaster
Meteorologist (e.g. scientific applications, systematic climatologic monitoring)
Climate modeler
Flood modeler, flood forecaster

Miscellaneous:
Water resource manager
Water resource scientist

Private users

Agriculture:
Farmer

Aviation:
Pilot
Balloonist

Shipping:
Yachtsman

Miscellaneous private users:
Hobby meteorologist

Scientific organizations

Universities and research centers:
Scientists from various geoscientific and Earth system science disciplines

Private companies

Aviation:
Airport / aerodrome operator
Air traffic controller / control tower operator
Pilot

Civil engineering:
Building engineer (e.g., optimization of heating technology)

Commercial shipping and offshore industry:
Captain
Nautical engineer
Offshore facility engineer
Ship owner

Energy industry:
Renewable energy consultant (e.g., assessment of available energies)
Renewable energy project manager (e.g., planning of photovoltaic or wind installations)

Health care:
Health resort manager
Health clinic manager
Doctor (e.g. dermatologist)

Media:
Weatherman

Meteorological service providers:
Weather forecaster
Meteorologist

Telecommunication:
Telecommunication engineer (e.g., calculation of microwave telecommunication signal losses)

Tourism:
Hotel keeper
Travel agent
Event manager

Appendix C: Method 1 (Observation Parameters Needed) and Methods 2 and 3 (Observation Parameters Needed with High, Medium, and Low Priorities) as Defined by Each SBA Analyst

Earth Observation Parameter	Agriculture	Climate	Disasters	Ecosystems	Energy	Health	Water	Weather
Aerosol Properties		H						
Ambient Nitrogen Dioxide Concentration						H		
Ambient Ozone Concentration						H		H
Ambient Particulate Matter (fine) Composition		H				H		
Ambient Particulate Matter Composition (coarse)		H				H		
Ambient Particulate Matter Concentration (coarse)		H				H		
Ambient Particulate Matter Concentration (fine)	L	H				H		
Ambient Sulfur Dioxide Concentration						H		
Ambient Volatile Organic Compounds						L		
Animal activity (range, season length, migration patterns)				M				
Aquatic Ecosystem Condition				M				
Bathymetry	L		H	M				
Biodiversity	M			M		M		
Biomass	H			H				
Burned Area/Fires	H			H				
Carbon (stores, uptake, flux)	H			L				
Carbon Dioxide Concentration	L	L		L				
Carbon Dioxide Partial Pressure		L						
Carbon in Subsurface Ocean		L						
Chlorophyll				H				
Cloud Cover (cloud index)			M		L		L	H
Cloud Parameters (Other)			M				L	

Earth Observation Parameter	Agriculture	Climate	Disasters	Ecosystems	Energy	Health	Water	Weather
Cloud Water/Ice Amounts (3D Distribution)			M				L	H
Column Nitrogen Dioxide Concentration						M		
Column Ozone Concentration						M		H
Column Particulate Matter Concentration (coarse)		H				M		
Column Particulate Matter Concentration (fine)	L	H				M	L	
Column Sulfur Dioxide Concentration						M		
Contaminants/Pollutants (Inorganic/Organic)				L			H	
Coral Reef Classification/Metabolism				L				
Crop Emergence	L							
Crop Residue	L							
Crop Yield	L							
Cultivation	H			H			L	
Currents			M	H				
Curvature			H					
Deforestation	H			H		L		
Density of animal hosts						L		
Desertification	H			H				
Direct Normal Irradiation (DNI)	M				M			
Ecosystem demand for water				M				
Ecosystem Function/Dynamics	M			M				
Elevation				L	M	M	H	
Emissivity							M	
Erosion (reefs, sandbars)				H				
Evaporation	M			L			H	
Evapotranspiration	M			L			H	
EVI	H			H				
Field Cover (Continuous)						L		

Earth Observation Parameter	Agriculture	Climate	Disasters	Ecosystems	Energy	Health	Water	Weather
Fish Harvest Intensity				H				
Floods	H		M					
Forest Cover	H			H		L		
Forest Litter	H		H					
Forest management practices	M			M				
Forest Structure	L			M				
Fraction of Absorbed Photosynthetically Active Radiation (FAPAR)	H			M				
Fraction of Photosynthetically Active Radiation (fPAR)	H			M			H	L
Fuel Load/Characteristics	L			L				
Geologic Stratification			L				L	
Glacier/Ice Cap Elevation		M		H				
Glacier/Ice Sheet Depth				H			H	
Glacier/Ice Sheet Extent		M		H		L	H	
Global Horizontal Irradiation (GHI)	M				M	L	M	
Gravity Field			L					
Gross Primary Productivity	H			H		L		
Groundwater		M		L			H	
Health Care Access						L		
Hydrology	L			L				
Ice			L	M			M	
Ice Depth							M	L
Impervious Surface Extent	L			M				
Inundated vegetation				L				
Lake/Reservoir Levels		H		M			H	
Land Cover	H	H	L	H	H	L	H	
Land Surface Temperature	L		H		L		H	H

Earth Observation Parameter	Agriculture	Climate	Disasters	Ecosystems	Energy	Health	Water	Weather
Land Use	H			H		H	L	
Leaf Area Index	H			H		L	H	L
Magnetic Field			L					
Methane Concentration		L		L				
NDVI	H			H	H	L	H	
Net Primary Productivity (NPP)	H			H	H			
Non-native species	H			M				
Nutrients (Phosphorous, Nitrogen, Potassium, Nitrates, Sulfates)				L			H	
Ocean Salinity		L		H				L
Ocean Topography		M	M			M		L
Other long-lived GHGs		L						
Outgoing Longwave Radiation (Top of Atmosphere)							M	
Pathogen Population Dynamic						L		
Permafrost		L	L	H			M	
Phenology				L		L		
Photosynthetically Active Radiation (PAR)	H			M		L		
Population	M					H		
Pore Pressure			H					
Precipitation	H	H	H	H	H	H	H	H
Rock Strength, Permeability, Spacing, orientation			H					
SAVI	H			H				
Sea Ice Cover		M						L
Sea Ice Surface (Skin) Temperature								L
Sea Level		M	M	M		M		
Sea Surface Temperature (SST)		H	L	H		H		H
Seismicity			H					

Earth Observation Parameter	Agriculture	Climate	Disasters	Ecosystems	Energy	Health	Water	Weather
Slip			H					
Slope Angle			H	L				
Slope Movement			H					
Snow Cover Extent		M	L	L			H	L
Snow Depth							H	
Snow Water Equivalent (SWE)							H	L
Soil Carbon	H			H				
Soil Composition	M		H				M	
Soil Moisture	M	M	H	L	H	L	H	H
Soil Thaw				L				
Soil Thickness	M							
Soil Type	M		H			M	M	
Source of Drinking Water						M		
Species Composition	M			M				
Stand Density/Height	L			L				
Strain			H					
Stratospheric Ozone								L
Stream/River Flow, Discharge, Height, Stage		H	M	L			H	
Surface Air Temperature	M	L	M	M	M	H	H	H
Surface Albedo				L			M	
Surface Atmospheric Pressure	M	L	M	L			L	H
Surface Deformation			H					
Surface Humidity	M		M	L	L	H	H	H
Surface Radiation Budget		L					M	
Surface Wind Direction	M		H	L		L	H	H
Surface Wind Speed	M		H	M	H	M	H	H

Earth Observation Parameter	Agriculture	Climate	Disasters	Ecosystems	Energy	Health	Water	Weather
Suspended particulates/turbidity/Water attenuation coefficient				L			L	
Thermokarst				M				
Upper Level Humidity	M	L	M	L				H
Upper Level Temperature	M		M	L				H
Upper Level Winds	M		H	L				H
Urbanization	H			H	H	H	L	
Vector Population			L			M		
Vegetation Cover	M			H		H	H	H
Vegetation Type	M			H		H	H	L
Water Algal blooms						L		
Water Bodies (location)				L		H		
Water Depth (Shallow Near-Shore)				H				
Water Infiltration/Percolation-Land Surface.							L	
Water Quality & Composition, pH and salinity, Dissolved Oxygen Content				H		M	L	
Water run-off					H		H	
Water Use		M					H	
Wave Direction			M					L
Wave Height			M					L
Wave Period			M					L

H indicates high priority, M indicates medium priority, and L indicates low priority.

* The Agriculture SBA/Forests Analyst designated high, medium, and low priority observations for the Agriculture SBA/Forests sub-report. In accordance with the Cross-SBA methodology, the designated observation parameters were integrated into the Agriculture and Ecosystems SBA requirements, and therefore, they are not included here.

**The Weather SBA Analyst indicated that all weather observations are of high priority. Therefore, for consistency with Cross-SBA analysis methodology, the Cross-SBA Analyst assigned "high" and "low" to observation parameters based on inclusion or exclusion of the observation parameter in the "15 Most Critical" observations list by the Weather SBA Analyst for Method 4.

Appendix D: Method 4 – "15 Most Critical" Observation Priorities for Each SBA as Defined by each Analyst*

Earth Observation Parameter	Agriculture	Climate	Disasters	Ecosystems	Energy	Health	Water	Weather
Aerosol Properties		X						
Ambient Nitrogen Dioxide Concentration						X		
Ambient Ozone Concentration						X		X
Ambient Particulate Matter (fine) Composition		X				X		
Ambient Particulate Matter Composition (coarse)		X				X		
Ambient Particulate Matter Concentration (coarse)		X				X		
Ambient Particulate Matter Concentration (fine)		X				X		
Ambient Sulfur Dioxide Concentration						X		
Ambient Volatile Organic Compounds						X		
Bathymetry			X					
Biodiversity						X		
Biomass	X			X				
Burned Area/Fires	X			X				
Carbon (stores, uptake, flux)	X							
Cloud Cover (cloud index)			X		X			X
Cloud Parameters (Other)			X					
Cloud Water/Ice Amounts (3D Distribution)			X					X
Column Nitrogen Dioxide Concentration						X		
Column Ozone Concentration						X		X
Column Particulate Matter Concentration (coarse)		X				X		
Column Particulate Matter Concentration (fine)		X				X		
Column Sulfur Dioxide Concentration						X		
Contaminants/Pollutants (Inorganic/Organic)							X	
Cultivation	X			X				

Earth Observation Parameter	Agriculture	Climate	Disasters	Ecosystems	Energy	Health	Water	Weather
Currents			X	X				
Curvature			X					
Deforestation	X			X				
Desertification	X			X				
Direct Normal Irradiation (DNI)	X				X			
Elevation			X		X	X	X	
Evaporation	X						X	
Evapotranspiration	X						X	
EVI	X			X				
Floods	X		X					
Forest Cover	X			X				
Forest management practices	X							
Forest Structure	X							
Fraction of Absorbed Photosynthetically Active Radiation (FAPAR)	X							
Fraction of Photosynthetically Active Radiation (fPAR)	X						X	
Fuel Load/Characteristics	X							
Glacier/Ice Cap Elevation		X		X				
Glacier/Ice Sheet Depth				X			X	
Glacier/Ice Sheet Extent		X		X		X	X	
Global Horizontal Irradiation (GHI)	X				X			
Gross Primary Productivity	X							
Groundwater		X			X		X	
Lake/Reservoir Levels		X					X	
Land Cover	X	X		X	X	X	X	
Land Surface Temperature	X				X		X	X
Land Use				X		X		

Earth Observation Parameter	Agriculture	Climate	Disasters	Ecosystems	Energy	Health	Water	Weather
Leaf Area Index	X						X	
Net Primary Productivity (NPP)	X				X			
Non-native species	X							
Normalized Difference Vegetation Index (NDVI)	X			X	X		X	
Nutrients (Phosphorous, Nitrogen, Potassium, Nitrates, Sulfates)							X	
Ocean Salinity				X				
Ocean Topography		X	X			X		
Photosynthetically Active Radiation (PAR)	X							
Population						X		
Pore Pressure			X					
Precipitation	X	X	X	X	X	X	X	X
Rock Strength, Permeability, Spacing, orientation			X					
SAVI	X			X				
Sea Ice Cover		X						
Sea Level		X	X			X		
Sea Surface Temperature (SST)		X		X		X		X
Seismicity			X					
Slip			X					
Slope Angle			X					
Slope Movement			X					
Snow Cover Extent		X					X	
Snow Depth							X	
Snow Water Equivalent (SWE)							X	
Soil Carbon				X				
Soil Composition			X					
Soil Moisture	X	X	X		X		X	X

Earth Observation Parameter	Agriculture	Climate	Disasters	Ecosystems	Energy	Health	Water	Weather
Soil Thickness			X					
Strain			X					
Stream/River Flow, Discharge, Height, Stage		X	X				X	
Surface Air Temperature	X		X		X	X	X	X
Surface Atmospheric Pressure			X					X
Surface Deformation			X		X			
Surface Humidity	X		X		X	X	X	X
Surface Radiation Budget		X						
Surface Wind Direction	X		X			X	X	X
Surface Wind Speed	X		X		X	X	X	X
Upper Level Humidity			X					X
Upper Level Temperature			X					X
Upper Level Winds			X					X
Urbanization	X			X	X	X		
Vector Population						X		
Vegetation Cover				X		X	X	X
Vegetation Type	X			X		X	X	
Water Bodies (location)						X		
Water Quality & Composition, pH and salinity, Dissolved Oxygen Content				X				
Water run-off					X		X	
Water Use		X					X	

Appendix E: Master List of Advisory Group Members

Agriculture SBA

Name	Country or Organization	Affiliation	Geographic Region	Area of Expertise/ Specialty
Samira Omar ASEM	Kuwait	Kuwait Institute for Scientific Research	Asia/Middle East	Famine Early Warning
Mark BRUSBERG	United States	United States Department of Agriculture	North America	Broad agriculture expertise
Carmela CASCONE	Italy	Institute for Environmental Protection and Research Sustainable Use of Natural Resources Service	Europe	Broad agriculture expertise
Jinlong FAN	GEO	GEO Secretariat	Europe	Broad agriculture expertise
Marie-Hélène FORGET	Canada	Bedford Institute of Oceanography	North America	Aquaculture Production
Mike GRUNDY	Australia	Australian Commonwealth Scientific and Research Organization	Oceania/Australia	Broad agriculture expertise
Chris JUSTICE	United States	University of Maryland	North America	Agriculture Production
Johnson OWARO	Uganda	Disaster Preparedness and Refugees Transition and Recovery Programme for North and Eastern Uganda	Africa	Global Agricultural Monitoring
Jai S. PARIHAR	India	Space Applications Centre	Asia/Middle East	Global Agricultural Monitoring
Basanta SHRESTHA	ICIMOD	The International Centre for Integrated Mountain Development	Asia/Middle East	Broad agriculture expertise
Robert STEFANSKSI	WMO	World Meteorological Organization	Europe	Global Agricultural Risk Reduction
Prasad THENKABAIL	United States	United States Geological Survey	North America	Global Agricultural Monitoring

Agriculture / Forests Sub-Report

Name	Country or Organization	Affiliation	Geographic Region	Area of Expertise/ Specialty
Michael BRADY	Canada	Natural Resources Canada	North America	Fire disturbance
Alex HELD	Australia	Commonwealth Scientific and Industrial Research Organisation (CSIRO)	Oceana/ Australia	Forest cover and change monitoring
Martin HEROLD	Netherlands	Global Observation of Forest and Land Cover Dynamics (GOFC- GOLD)	Europe/ Global	Remote sensing
Håkan OLSSON	Sweden	Swedish University of Agricultural Sciences	Europe	Forest remote sensing
Kevin RYAN	United States	United States Department of Agriculture (USDA) Forest Service	North America/ Global	Forest fire science, ecophysiology
John TOWNSHEND	United States	University of Maryland	North America/ Global	Land cover dynamics

Biodiversity SBA

Name	Country or Organization	Affiliation	Geographic Region
Daniel P. FAITH	DIVERSITAS	DIVERSITAS-bioGenesis, and The Australian Museum	Oceania/ Australia
Dorothy AMWATA	Tunisia	Observatoire du Sahara et du Sahel	Africa
Eva SPEHN	DIVERSITAS	DIVERSITAS-GMBA (Global Mountain Biodiversity Assessment), and the University of Basel	International
Patrick N. HALPIN	United States	Duke University – Nicholas School of the Environment	North America
Santiago MADRINAN (Madriñán)	Colombia	Universidad de los Andes	South/Central America
Sebastian K. HERZOG	Bolivia	Asociación Armonía - BirdLife International, and the Museo de Historia Natural Alcide d'Orbigny Cochabamba,	South/Central America
Tim O'CONNOR	South Africa	SAEON (South African Environmental Observation Network)	Africa
Yongyut TRISURAT	Thailand	Kasetsart University	East Asia

Climate SBA

Name	Country or Organization	Affiliation	Geographic Region / Country
Kwabena A. ANAMAN	Ghana	Institute of Economic Affairs	Africa
Ghassam ASRAR	World Climate Research Program (WCRP)	World Climate Research Program	Global
Stephan BOJINSKI	Global Climate Observing System (GCOS)	Global Climate Observing System	Global
Greg FLATO	Canada	Environment Canada	North America
Mitch GOLDBERG	United States	National Oceanic and Atmospheric Administration	North America
Teruyuki NAKAJIMA	Japan	University of Tokyo	Asia
Alexander ZAYTSEV	Russia	Voeikov Main Geophysical Observatory	Russia

Disasters SBA / Earthquakes, Landslides, Floods

Name	Country or Organization	Affiliation	Geographic Region	Area of Expertise/ Specialty
Rosario ALFARO	Costa Rica	Instituto Meteorologico Nacional	South/Central America	Broad Disasters Experience
Jay BAKER	United States	Florida State University	North America	Hurricanes/Floods
Jerome BEQUIGNON	European Space Agency	European Space Agency	Europe	Disasters
George CHOY	United States	United States Geological Survey (USGS)	North America	Seismic Hazards
Silvia Burgos SOSA	Paraguay	Paraguayan Institute for Environmental Protection	South/Central America	Broad Disasters Experience
Nicola CASAGLI	Italy	International Consortium on Landslides	Europe	Landslides
Mumba Dauti KAMPENGELE	Zambia	National Institute for Scientific and Industrial Research	Africa	Broad Disasters Experience
Ivan KOULAKOV	Russia	Institute of Petrol Geology and Geophysics	Europe	Seismic Hazards
Goneri LE COZANNET	France	French Geological Survey	Europe	Disasters
William LEITH	United States	USGS	North America	Seismic Hazards
Warner MARZOCCHI	Italy	World Organization of Volcano Observatories	Europe	Volcanoes

Name	Country or Organization	Affiliation	Geographic Region	Area of Expertise/ Specialty
V. Madhava RAO	India	National Institute of Rural Development	Asia/Middle East	Broad Disasters Experience
Kaoru TAKARA	Japan	International Consortium on Landslides	East Asia	Floods/Landslides

Disasters SBA / Tropical Cyclones, Wildfires, Volcanoes

Name	Country or Organization	Affiliation	Geographic Region	Area of Expertise/ Specialty
Mr. Jérôme BÉQUIGNON	ESA	European Space Agency (ESA)	Europe	Broad Disasters Experience
Dr. CHENG Cho-ming	China	Hong Kong Observatory	East Asia	Tropical Cyclones
Mr. Emil CHERRINGTON	CATHALAC	Water Center for the Humid Tropics of Latin America and the Caribbean (CATHALAC)	Central/South America	Broad Disasters Experience
Dr. George CHOY	United States	United States Geological Survey (USGS)	North America	Seismic Hazards
Mr. Francisco DELGADO	CATHALAC	Water Center for the Humid Tropics of Latin America and the Caribbean (CATHALAC)	Central/South America	Broad Disasters Experience
Mr. Farai DONDOFEMA	South Africa	Environmental Consultant	Africa	Wildfires
Ms. Andrea Ferraz YOUNG	Brazil	National Institute for Space Research (INPE)	Central/South America	Landslides, Floods, Sea Level Rise
Dr. Diana GREENSLADE	Australia	Centre for Australian Weather and Climate Research (CAWCR)	Oceana/Australia	Tropical Cyclones
Dr. Bruce HARPER	Australia	Systems Engineering Australia Pty Ltd	Oceana/Australia	Tropical Cyclones
Mr. Jamie KIBLER	United States	NOAA SSD, Satellite Analysis Branch	North America	Wildfires and Volcanic Eruptions
Mr. Gonéri LE COZANNET	France	French Geological Survey	Europe	Broad Disasters Experience
Dr. Warner MARZOCCHI	Italy	World Organization of Volcanic Observatories (WOVO)	Europe	Volcanic Eruptions
Dr. Enrico (Eric) PARINGIT	Philippines	University of the Philippines	East Asia	Tropical Cyclones
Dr. Matthew PATRICK	United States	Hawaiian Volcano Observatory	Oceana/Australia	Volcanic Eruptions
Dr. Andrés PÁVEZ	Chile	University of Chile	Central/South America	Volcanic Eruptions

Name	Country or Organization	Affiliation	Geographic Region	Area of Expertise/ Specialty
Dr. Hans-Peter PLAG	United States	Nevada Bureau of Mines and University of Nevada, Reno	North America	Seismic Hazards
Dr. Marino PROTTI	Costa Rica	National University	Central/South America	Volcanic Eruptions
Dr. Guy SÉGUIN	CEOS	Committee on Earth Observing Satellites (CEOS)	North America	Broad Disasters Experience
Dr. Narisara THONGBOONCHOO	Thailand	King Mongkut's Institute of Technology	East Asia	Wildfires
Dr. Richard THORNTON	Australia	Bushfire Cooperative Research Centre	Oceana/Australia	Wildfires
Dr. Dewald VAN NIEKERK	South Africa	North West University	Africa	Broad Disasters Experience
Dr. Eutizio VITTORI	Italy	Geological Survey of Italy	Europe	Broad Disasters Experience
Dr. Tsehaie WOLDAI	Netherlands	International Institute for Geoinformation Sciences & Earth Observation (ITC)	Africa	Broad Disasters Experience

Ecosystems SBA / Forests, Coastal and Near-Shore Marine Systems, Watersheds

Name	Country or Organization	Affiliation	Geographic Region	Area of Expertise/ Specialty
Ana Laura Lara DOMINGUEZ	Mexico	Instituto de Ecologia A.C.	North America	Coastal/Estuarine ecology and management
Hussam HUSEIN	Syria	General Commission for Scientific Agricultural Research	Asia/Middle East	Soils and GIS
Sevda IBRAHIMOVA	Azerbaijan	National Aerospace Agency	Europe	Land use and GIS
Anna KOZLOVA	Ukraine	Scientific Centre for Aerospace Research of the Earth	Europe	GIS and Remote Sensing, forest ecosystems
Jorge LÓPEZ-PORTILLO	Mexico	Instituto de Ecologia A.C.	North America	Coastal/Estuarine ecology and management
Stuart PHINN	Australia	University of Queensland	Oceania/Australia	Biophysical remote sensing
Mukund RAO	India	ESRI India	Asia/Middle East	Remote sensing and GIS
Roger SAYRE	United States	U.S. Geological Survey	North America	Biogeography and remote sensing
Gray TAPPAN	United States	U.S. Geological Survey	North America	Biogeography, remote sensing, and monitoring specializing in Africa

Name	Country or Organization	Affiliation	Geographic Region	Area of Expertise/ Specialty
Mphethe TONGWANE	Lesotho	Lesotho Meteorological Services	Africa	Applied Meteorology, Land Use, Climate Change
Andrea Ferraz YOUNG	Brazil	Population Studies Centre	South America	Land use, population issues

Ecosystems SBA / Tundra, Inland Waters, Islands and Archipelagos

Name	Country or Organization	Affiliation	Geographic Region	Area of Expertise/ Specialty
R. J. ASSAKO	Cameroon	University of Douala	Africa	Urban development and lake pollution
Neil DAVIES	French Polynesia	ED, Gump Station Moorea	Oceania/Australia	Broad ecosystems expertise
Ana Laura Lara DOMINGUEZ	Mexico	Instituto de Ecologia A.C.	North America	Coastal/Estuarine ecology and management
Scott J. GOETZ	United States	Woods Hole Research Center	North America	Aquatic ecosystem research
Anna KOZLOVA	Ukraine	Scientific Centre for Aerospace Research of the Earth	Europe	GIS and Remote Sensing, forest ecosystems
Murari LAL	Fiji	PACE-SD, The University of the South Pacific	Oceania/Australia	Water resource management and landscape ecology
Jorge LÓPEZ-PORTILLO	Mexico	Instituto de Ecologia A.C.	North America	Landscape ecology
Gabriel OLCHIN	United States	Council for Regulatory Environmental Modeling Office of the Science Advisor US Environmental Protection Agency	North America	Large-scale ecosystem processes and modeling policy; remote sensing and high latitude ecosystems
Deb PETERS	United States	Lead Principle Investigator, Jornada Basin LTER, USDA-ARS	North America	Broad ecosystems expertise
Stuart PHINN	Australia	The University of Queensland	Oceania/Australia	Geography, planning, and environmental management
Mui-How PHUA	Malaysia	Universiti Malaysia Sabah	Oceania/Australia	Landscape-level conservation planning
Humberto REYES	Mexico	University of San Luis Potosí	North America	Ecosystems and natural resources management
Erick SANCHEZ	Mexico	Universidad Autónoma de Ciudad Juárez	North America	Remote Sensing and Spatial Analysis
Ashbindu SINGH	UNEP	United Nations Environmental Programme	North America	Environment Early Warning & Assessment

Name	Country or Organization	Affiliation	Geographic Region	Area of Expertise/ Specialty
Nicki VILLARS	The Netherlands	Deltares	Europe	Optical remote sensing data for calibrating and validating water quality models
Anton VRIELING	The Netherlands	University of Twente	Europe	Remote sensing, soil erosion, time series analysis, phenology
Frans-Emil WIELGOLASKI	Norway	University of Oslo	Europe	Fennoscandian Tundra Ecosystems

Energy SBA

Name	Country or Organization	Affiliation	Geographic Region	Area of Expertise/ Specialty
Charlotte Bay HASAGER	Denmark	Risoe National Laboratory, Technical University of Denmark	Europe	Wind
Amit KUMAR	India	The Energy and Resources Institute (TERI)	Asia/Middle East	Broad renewable energy
Ellsworth LE DREW	IEEE	IEEE and University of Waterloo, Canada	North America	Chair of GEOSS Energy COP
Maxwell MAPAKO	South Africa	Natural Resource and Environment, CSIR	Africa	Broad renewable energy
Pierre-Philippe MATHIEU	ESA	European Space Agency	Europe	Broad renewable energy
Richard MEYER	Germany	EPURON GmbH	Europe	Solar
Monica OLIPHANT	Australia	International Solar Energy Society	Oceania/Australia	Solar
Enio PEREIRA	Brazil	INPE (Brazilian National Agency for Space Research)	South/Central America	Broad renewable energy
Thierry RANCHIN	France	Ecole des Mines de Paris and Co-Chair of the GEO Energy Community of Practice	Europe	Broad renewable energy
David RENNE	United States	Department of Energy, National Renewable Energy Laboratory	North America	Solar and wind
Scott SKLAR	United States	Stella Group	North America	Broad renewable energy
Gerry SEHLKE	United States	Department of Energy, Idaho National Laboratory	North America	Hydropower
Han WENSINK	The Netherlands	ARGOSS	Europe	Ocean
Gu XINGFA	China	Institute of Remote Sensing	East Asia	Broad

Name	Country or Organization	Affiliation	Geographic Region	Area of Expertise/ Specialty
		Applications		renewable energy

Health SBA / Aeroallergens Sub-Report

Name	Country or Organization	Affiliation	Geographic Region	Area of Expertise/ Specialty
Heidrun BEHRENDT	Germany	Technical University Munich, Center for Allergy and Environmental Medicine	Europe	Allergotoxicology; allergy; phenology as related to allergy
Kashinath BHATTACHARYA	India	Visva-Bharati University, Department of Botany	Asia/Middle East	Aerobiology; allergy; palynology
Abdolkarim CHEHREGANI	Iran	Bu-Ali Sina University, Iran	Asia/Middle East	Air pollution and allergy; diesel exhaust particles and pollen allergy
Xiaoqiu CHEN	China	College of Urban and Environmental Sciences, Physical Geography	East Asia	Phenology and biometeorology
Bernard CLOT	Switzerland	MeteoSwiss	Europe	Aerobiology; phenology; biometeorology; botany
Simon HALES	Switzerland	WHO	International	Epidemiologist
Stein-Rune KARLSEN	Norway	Northern Research Institute Tromsø	Europe	Remote sensing; GIS; phenology
Connie KATELARIS	Australia	University of Western Sydney and Campbelltown Hospital, Immunology and Allergy	Oceania/Australia	Clinical immunology/allergy; aerobiology as it relates to respiratory allergy
Cassim MOTALA	South Africa	UCT and Red Cross War Memorial Children's Hospital, School of Child and Adolescent Health	Africa	Allergology
Maria Gabriela MURRAY	Argentina	Universidad Nacional del Sur	South/Central America	Aerobiology; phenology
Hallvard RAMFJORD	Norway	Norwegian University of Science and Technology NTNU	Europe	Allergology; aerobiology; remote sensing
Christine ROGERS	United States	University of Massachusetts, School of Public Health and Health Science	North America	Global climate change effects on aeroallergens; forecasting; long-distance transport; health effects
James SCOTT	Canada	University of Toronto,	North America	Bioaerosol

Name	Country or Organization	Affiliation	Geographic Region	Area of Expertise/ Specialty
		Dalla Lana School of Public Health		measurement and characterization; environmental microbiology; fungal ecology
Mikhail SOFIEV	Finland	Finnish Meteorological Institute	Europe	Remote sensing; aerobiology modeling
Arnold van VLIET	Netherlands	Wageningen University, Environmental Systems Analysis Group	Europe	Biometeorology; aerobiology; phenology
Richard WEBER	United States	National Jewish Health	North America	Asthma, rhinitis, and sinusitis management; allergen aerobiology; pollen cross-reactivity

Health SBA / Air Quality Sub-Report

Name	Country or Organization	Affiliation	Geographic Region	Area of Expertise/ Specialty
Jeff BROOK	Canada	Environment Canada	North America	Air Quality
Jack FISHMAN	United States	NASA Langley	North America	Air Quality
Barry JESSIMAN	Canada	Health Canada	North America	Air Quality Health
Patrick KINNEY	United States	Columbia University	North America	Air Quality Health
Jim MEAGHER	United States	NOAA	North America	Air Quality
Rashmi S. PATIL	India	IIT Bombay	Asia	Air Quality Health
Leonora ROJAS	Mexico	National Institute of Ecol ogy	North America	Air Quality Health
Paulo SALDIVA	Brazil	University of São Paulo	South America	Air Quality Health
Rich SCHEFFE	United States	EPA OAR/OAQPS	North America	Air Quality
Kjetil TORSETH	Norway	Norwegian Institute of Air Research	Europe	Air Quality
Michael GATARI	Kenya	University of Nairobi	Africa	Air Quality

Health SBA / Infectious Diseases Sub-Report

Name	Country or Organization	Affiliation	Geographic Region	Area of Expertise/ Specialty
Ulisses E.C. CONFALONIERI	Brazil	FIOCRUZ	South America	Remote sensing, Public Health, Infectious Disease Ecology
Stephen J. CONNOR	WHO	IRI - WHO - PAHO	Africa, South America, Asia	Remote sensing, Environment, Infectious Diseases
Pat DALE	Australia	Griffith University	Australia	Remote sensing, Environment, Infectious Diseases
Joaquim DASILVA	WHO	WHO - AFRO	Africa	Medicine, Public Health, Disease Control Systems
Ruth DEFRIES	United States	Columbia University	Africa, South America, Asia	Remote Sensing, Land Cover Change
Gregory GLASS	United States	JHBSPH	North America, South America	Modeling Infectious Disease Risk
John HAYNES	United States	NASA	North America, South America	Meteorology, Remote Sensing
Darby JACK	United States	MSPH	Africa, North America	Development, Economics, Environmental Health
Isabelle JEANNE	France	Consultant	Africa	GIS, Remote Sensing and Spatial Analysis for Health
Erick KHAMALA	Kenya	RCMRD	Africa	Remote Sensing
Patrick KINNEY	United States	MSPH	Africa, North America	Public Health
Uriel KITRON	United States	Emory University	Africa, South America	Infectious Diseases Ecology, GIS, Remote Sensing
Murielle LAFAYE	France	CNES	Europe, Africa, Asia, South America	Health Applications, Remote Sensing, Telecommunication
Forrest MELTON	United States	CSUMB	North America, South America	Remote Sensing, Ecosystem Modeling, Decision Support System
Jacques André NDIONE	Senegal	CSE	Africa	Climatologist Working on Environment Changes and Health Issues
Masami ONODA	Switzerland	GEO Secretariat	International	Environmental Policy, Satellite Program Management and Data Policy
David ROGERS	Switzerland	HCF	Africa, North America, South America	In-Situ Observation and Utilization of EO Information
Leonid ROYTMAN	United States	NOAA-CREST	Asia	Remote Sensing for Infectious Diseases
Juli TRTANJ	United States	NOAA	North America	Health, Oceans

Water SBA

Name	Country or Organization	Affiliation	Geographic Region	Area of Specialty
Abou AMANI	UNESCO	UNESCO Africa Regional Office	Africa	Hydrology & Water Resources
Douglas CRIPE	GEO	GEO Secretariat Water	International	Hydrology & Water Resources
Maria DONOSO	UNESCO	UNESCO Paraguay Regional Office	South America	Hydrology & Water Resources
Jay FAMIGLIETTI	United States	University of California	North America	Hydrology & Climate
Wolfgang GRABS	WMO	WMO Hydrology and Water Resources	International & Regional (WMO Regions I to VI)	Hydrological Forecasting & Water Resources Development
Steven GREB	United States	State of Wisconsin Department of Water Resources	North America	Hydrology and Water Quality
Rick LAWFORD	Canada	University of Winnipeg	North America & International (IGWCO)	Hydrology & Water Resources; Hydrometeorology
Annukka LIPPONEN	Switzerland	UNECE	Balkans, Caucasus, Central Asia	Hydrology; Trans-boundary Waters
Jinping LIU	WMO	UN-ESCAP & WMO Typhoon Committee	Asia & Pacific	Hydrology, Meteorology, Typhoon
Massimo MIMENTI	ESA	ESA	Europe & Global	Remote Sensing, Hydrology and Water Resources Management
Wellens MENSAH	Ghana	Ghana Hydrological Services & WMO	Africa	Hydrology and Water Resources
Osamu OCHIAI	Japan	JAXA & CEOS Water	Asia & Global	Remote Sensing
Masami ONODA	GEO	GEO Secretariat	International	International Coordination
Bruce STEWART	Australia	Australia Bureau of Meteorology	Asia & Pacific--Oceania / Australia	Agrometeorology, Weather, Hydrology & Water Resources

Weather SBA

Name	Country or Organization	Affiliation	Geographic Region
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Paul COUNET	CEOS	EUMETSAT	International
Robert HUSBAND	CEOS	EUMETSAT	International
Jochen DIBBEM	EUMETNET	Network of European Meteorological Services	Europe
Jerome LAFEUILLE	WMO	WMO Space Observing Systems Division, OBS Department	International
Geoffrey LOVE	WMO	WMO Weather and Disaster Risk Reduction Department (WDS)	International
Wenijan ZHANG	WMO	WMO Observing and Information Systems Department	International
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Stephan BOJINSKI	GCOS	GCOS Secretariat	International