Report to the 33rd session of the Subsidiary Body for
Scientific and Technological Advice

A Framework for Terrestrial Climate-Related Observations and The Development of Standards for the Terrestrial Essential Climate Variables:

Proposed Workplan

(Full Report)

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Submitted by the Secretariat of the
Global Terrestrial Observing System
on behalf of its Sponsors
(FAO, ICSU, UNEP, UNESCO, WMO)

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Executive Summary

Recognizing the importance of systematic terrestrial observations for the United Nations Framework Convention of Climate Change (UNFCCC), the Subsidiary Body on Scientific and Technological Advice (SBSTA) requested that the Global Terrestrial Observing System (GTOS) and its Sponsors take two specific steps: "*develop a framework for the preparation of guidance materials, standards and reporting guidelines for terrestrial observing systems for climate, and associated data and products*"; and "*assess the status of the development of standards for each of the essential climate variables in the terrestrial domain*". In 2009, the SBSTA "*encouraged the GTOS secretariat and the GTOS sponsoring agencies to implement the framework*" proposed as a joint effort of the GTOS Sponsors and the International Organization for Standardization (ISO); and to "*elaborate a workplan for developing observational standards and protocols for the 13 terrestrial ECVs assessed*".

Based on previous studies and analyses of issues involved in standardizing Essential Climate Variables (ECV) for the terrestrial domain, this report presents a workplan for the development of such standards. The workplan consists of two main phases, the implementation of the organizational Framework and the standardization of individual ECVs. Both overall approach and specific tasks have been described. The proposed workplan is consistent with SBSTA decisions on this matter and with results of previous discussions among the UN agencies and the ISO.

While most of the standard development work under the Framework will be carried out by technical bodies and experts, the overall effort requires substantial logistical, management and administrative support. The establishment of the Framework and coordination through the proposed JSG Secretariat has been estimated to require approximately US$970,000 annually until 2015 when the bulk of the standards should be completed. This estimate assumes that ISO members and other participants will fund the costs of their participation, consistently with the current ISO practice.

It is concluded that:

1. Sufficient information and technical resources are available to undertake the development of standards for ECVs to be addressed during the initial period, while progress continues to be made in other cases where standardization is less urgent.
2. The standardization should focus on *in situ* observation methods but since the resulting data will in many cases (~45-82% of ECV 'Observables') be used for the preparation of satellite-based information products, the needs of the latter must be built into the initial standards where feasible.
3. The specific issues and questions meriting standardization differ substantially among ECVs. Consequently, although a common architecture for the standards is desirable and should be defined at the outset, the standards development must address ECV- specific issues such as those identified in this report.
4. Significant financial resources are required if the Framework is to succeed in producing effective standards within the proposed time frame.

The following recommendations are made:

1. That SBSTA endorse this workplan, in present form or modified as appropriate.
2. That SBSTA requests:
    a) GTOS and its Sponsors together with ISO to implement the workplan.
    b) Parties to respond to the financial requirements of the standardization framework and to resource GTOS Secretariat to implement the workplan.
    c) Space agencies and the scientific community to continue developing capabilities for observing and delivering integrated terrestrial ECV information products from *in situ* and satellite data.
    d) GTOS report on the progress at the 35^{th} session of the SBSTA.

1. Introduction and objectives

Reliable assessment of global and regional environmental changes - both natural and human-induced - requires systematic, sustained observations. The need for consistent and comprehensive global observations is particularly critical in case of climate change, due to the climate system affecting the environment and the society at all scales, from local to global. While such need exists in all three parts of the global system (atmosphere, oceans, land), it continues to be least satisfied for the land component. This problem was first articulated by the Global Climate Observing System in preparing its implementation plan (GCOS, 2003, 2004). Among others, the GCOS identified a need for *"a mechanism for establishing standards, regulatory material and guidelines for terrestrial observing systems"*. In its second adequacy report, GCOS (2003) also identified essential climate variables for atmospheric, oceanic and terrestrial domains *"that are both currently feasible for global implementation and have high impact with respect to the UNFCCC and IPCC requirements"*.

The deficiencies in land observations have subsequently been recognized by the Subsidiary Body on Scientific and Technological Advice (SBSTA) of the United Nations Framework Convention on Climate Change (UNFCCC). The SBSTA therefore requested (Decision 11/CP.9; UNFCCC, 2003) that the sponsoring agencies of the Global Terrestrial Observing System (GTOS) take action "*to develop a framework for the preparation of guidance materials, standards and reporting guidelines for terrestrial observing systems for climate, and associated data and products"*. At its 23rd session SBSTA "*also called on the GTOS secretariat to assess the status of the development of standards for each of the essential climate variables in the terrestrial domain*" (SBSTA, 2006, p. 16).

The above SBSTA requests initiated a series of actions by the GTOS and responses by the SBSTA (refer to SBSTA (2009a) for details). Based on these developments, the GTOS submitted a report (SBSTA, 2009a) summarizing steps taken to date, and then presenting (i) an approach to developing the Framework requested in SBSTA Decision 11/CP.9, and (ii) a status of the standards for the Essential Climate Variables (ECVs) in the terrestrial domain.

The proposed Framework involves a joint effort of the specialized agencies of the United Nations (UN) and the International Organization for Standardization (ISO). The proposal builds upon existing mechanisms and institutions, thus minimizing the incremental costs of establishing and operating the Framework. It is based on a collaborative arrangement between UN agencies and the ISO, formalized through a Memorandum of Understanding; Joint Steering Group, a new coordination entity with representation from the Framework's sponsoring agencies; and the conduct of the standards development work taking advantage of the mechanisms and processes established by the ISO. As well as complying with the criteria identified by the SBSTA, the Framework also meets other criteria regarding efficiency, effectiveness and flexibility.

Regarding the status of ECV standardization, SBSTA (2009a) analyzed individual ECVs according to the following criteria: Specific measurements to be made; Candidate measurement methods, standards and guides; Feasibility of developing an international standard; Wider relevance of such a standard; and Candidate lead scientific/ technical groups for the development of a standard.

At its 30th session, the SBSTA (SBSTA, 2009b) "*welcomed the proposal contained in the updated progress report for a joint terrestrial framework mechanism between relevant agencies of the United Nations and the International Organization for Standardization, and encouraged the GTOS secretariat and the GTOS sponsoring agencies to implement the framework. The SBSTA also invited the GTOS secretariat and the GTOS sponsoring agencies to elaborate a workplan for developing observational standards and protocols for the 13 terrestrial ECVs assessed. It invited the GTOS secretariat to report on the results of the implementation of the framework and its elaboration of the workplan at SBSTA 33.*"

The present report contains a workplan for developing observational standards and protocols for the terrestrial ECVs which covers both aspects of the SBSTA's (2009b) request.

While this report is focused on the needs of the UNFCCC it should be noted that the ECVs are also relevant to other UN Conventions (Biodiversity, Desertification), and in a broader context may be thus termed 'Essential Terrestrial Variables'. Consequently, results of an ECV standardization process should have substantial impacts beyond climate- related issues, at both global and national levels.

Two comments on terminology employed in this report:

a) The term 'standard' is used throughout this document for brevity. It should be understood that this term represents *guidance materials, standards and reporting guidelines* as specified by the SBSTA request (UNFCCC, 2003) and as may be appropriate for a particular ECV.

b) As discussed in section 2.2.2.2, the terrestrial ECVs are in reality compound variables, each consisting of one or more specific types of observation. In this report, "ECV X" denotes the compound Essential Climate Variable X (GCOS, 2004); and "Observable" refers to a specific measurement required for that ECV. As an example, ECV Snow Cover requires measurements of four observables (snow cover extent, snow depth, snow water equivalent, and snow cover duration; refer to Annex 6.3).

2. Proposed workplan

The workplan outlined below addresses a) implementation of the Framework necessary for the development of ECV standards; and b) standardization issues for individual ECVs.

2.1 Organizational aspects

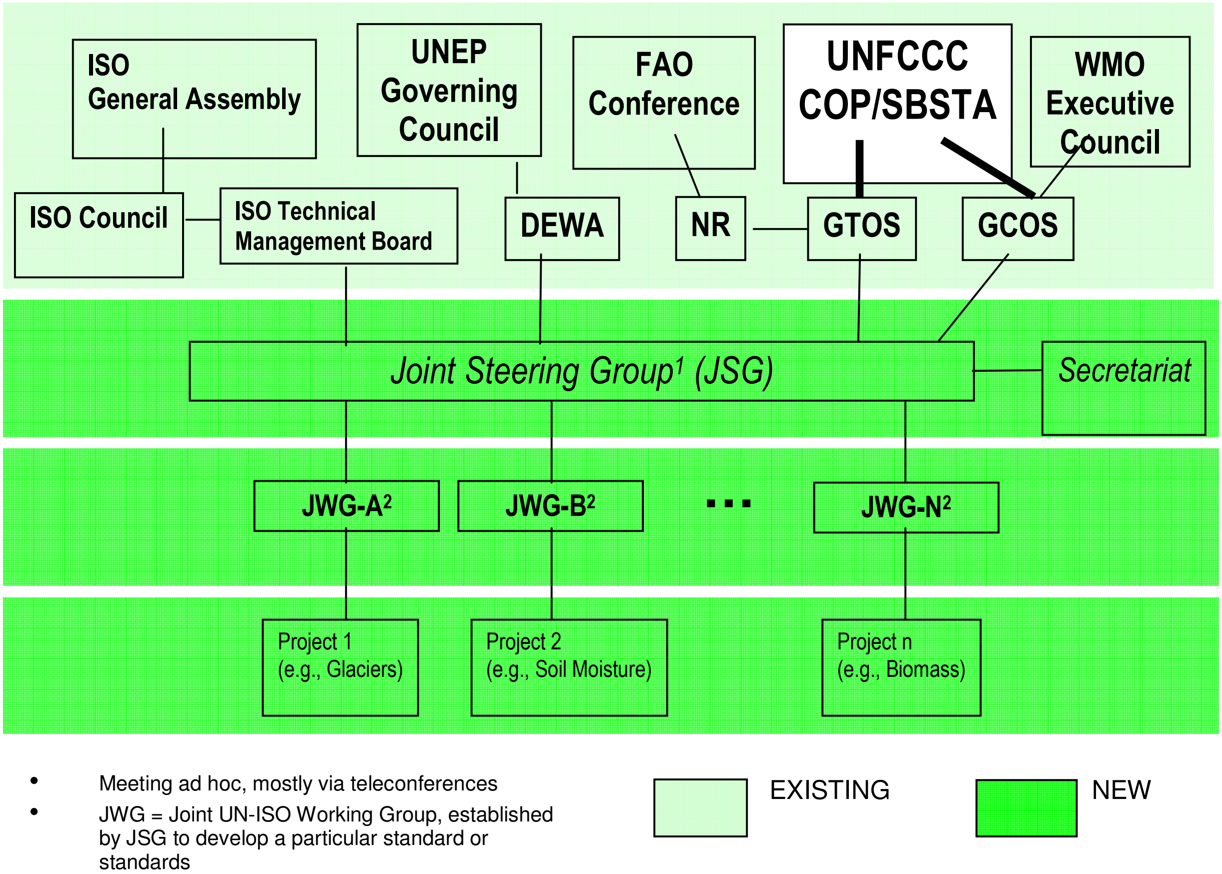
The 2009 report (SBSTA, 2009a) proposed an organizational structure which, in a modified form, is the basis for the planned implementation as described below.

Figure 1 shows the overall setting within which the ECV standardization will take place:

- The UNFCCC/SBSTA is the principal client for the desired standards but other UN organizations are also involved, both as participants in the development and as beneficiaries of the completed standards. It should be emphasized that the FCCC Parties are also a major beneficiary of the proposed standardization.
- The working tasks will be considered by the Joint Steering Group (JSG), a new entity established to consider and approve the plan of work, to coordinate the development of ECV standards, and to deal with numerous overarching or other issues that may arise. The JSG is inter-agency group external to the ISO's technical structure. It reports to the sponsoring UN organizations as well as to the ISO Technical Management Board (TMB). The JSG terms of reference are defined in Annex 6.1.
- The development of standards will be carried out by Joint Working Groups (JWG). JWGs and their terms of reference will be established by the JSG. Principal JWG tasks will be the preparation of Draft International Standards (DIS), Final DIS (FDIS), or other document formats as decided by the JSG. JWG membership will include appropriate representation of ISO Technical Committees, of UN organizations and their programs, and of other specialist bodies such as international scientific programs or projects. JWGs will be responsible to the JSG for the conduct and reporting of their work. The JWG terms of reference are described in Annex 6.2.

Steps to be taken toward establishment of the JSG and JWGs are described in section 3.

Figure 1. Organizational arrangement for the Framework: existing and new components.



2.2 ECV standardization

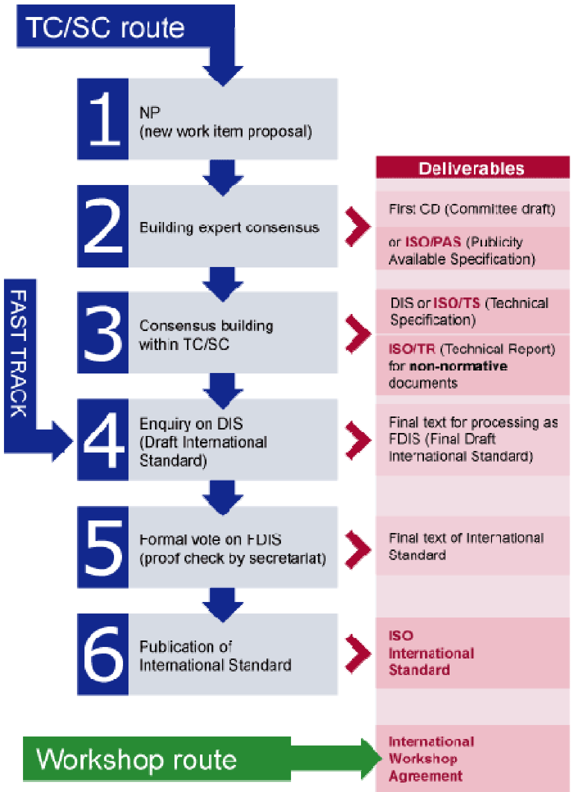
2.2.1 Standardization process

The preparation of international standards is fundamentally a consensus- building process. For the resulting ECV standards to be applicable at national and sub-national levels as well as internationally this process requires the identification, evaluation of options, and resolution of various technical and practical issues.

The International Organization for Standardization (ISO) is the world's largest developer and publisher of International Standards (IS). A non-governmental organization with national standards institutes of 159 countries as members, the ISO forms a bridge between the public and private sectors, enabling a consensus to be reached on solutions that meet the requirements of business as well as the broader needs of society.

Over the years, the ISO elaborated and refined the process of developing effective international standards that is capable of resolving the attendant complexities. Three standardization options are employed (Figure 2): the nominal (Technical Committee, TC) route, Fast track route, and Workshop route. Among the three, the TC route is the most effective in building consensus but also the lengthiest (the development of one standard typically takes several years). The Workshop route is the fastest but the resulting product (International Workshop Agreement) is less effective. The Fast track option is both relatively rapid, produces full international standards, and will be able to take advantage of the expertise available through ISO TCs.

Figure 2. ISO procedure for standards development: options and main phases.



For UNFCCC/SBSTA purposes and to maximize the usefulness of data collected for tracking climate change evolution and impacts, rapid progress toward ECV standardization is an essential requirement. Therefore, the Fast track (and Workshop) routes are to be strongly preferred. The Fast track option bypasses initial steps involved in a) building consensus on the need for an international standard, and b) achieving consensus on the technical aspects of the standard (Figure 2). It is therefore appropriate in cases where the need has been agreed to and the technical issues have been previously addressed. Since both conditions are met for a good portion of the ECVs (refer to Annex 6.3), the Fast track route should be the primary option employed for ECV standardization. Where consensus has not yet been achieved on technical issues but there is urgent need to have a standard in place, the Workshop route should be considered as an approach that produces an interim solution. The joint UN-ISO character of the JSG and its position outside the ISO technical structure will also facilitate use of the most efficient and effective route among the existing ISO options. These ISO mechanisms also enable countries to contribute expertise and financial resources to accelerate the process and ensure its effectiveness.

Essential Climate Variables (ECV) are environmental parameters considered to be the most important for understanding, detecting, monitoring, and assessing the impact of climate change. As such, the list of variables can be expected to evolve. For the terrestrial domain, the initial list consisted of 13 variables (GCOS, 2004). Soil moisture was recognized as an emerging ECV in 2004 and added since (SBSTA, 2009c), and Soil Carbon and Terrestrial biodiversity and habitat properties were proposed as candidate ECVs in 2009 (SBSTA, 2009c). This plan addresses 14 ECVs for which have been considered for standardization so far, namely: Albedo, Biomass, FAPAR, Fire disturbance, Glaciers, Ground water, LAI, Lake levels and reservoir storage, Land cover, Permafrost, River discharge, Snow cover, Soil moisture, Water use.

2.2.2 Considerations and factors

The workplan must reflect both the need for ECV standards and the availability of knowledge, experience and expertise that together will determine if a standard may be successfully and promptly completed. The large number of ECVs and the urgency in developing standards are important factors and constraints for the workplan. Given the large number of ECVs and the finite resources available for this work, the development process needs to be sequential, and it should begin with important ECVs that are 'ripe' for standardization. However the urgency of the requirement for standardization means that several standards need to be under development at any one time.

In developing a plan for standardizing individual ECVs, a key challenge will be to identify the specific issues a standard must address. Given that the goal of this process is to track the evolution and impacts of climate change in the terrestrial domain, the most important questions concern the extent/ coverage, characteristics/ quality, consistency (including compatibility), and availability/ accessibility of the observations (and information on these attributes) for individual ECVs.

Although the issue of standardization initially arose in the context of *in situ* observations, many terrestrial ECVs require use of satellite data (GCOS, 2010). Thus ideally, the ECV standards should encompass both *in situ* and satellite data. However, a good portion of the satellite- based techniques is at an experimental stage, variously focusing on product validation, algorithm development, or sensor development.

The desired number of deliverables from each ECV standardization project and the scope of each are also an important consideration. ISO experience has shown that the preparation and approval of a complex, comprehensive standard is more difficult and lengthier than of several simpler standards addressing components of the problem.

The status of standardization for individual ECVs was previously described at several levels of detail, including GTOS reports to SBSTA (refer to SBSTA (2009a) for the list), reports by the Global Climate Observing System (GCOS, 2004, 2010; SBSTA, 2009c), and detailed reports prepared by the GTOS for individual ECVs (available at http://www.fao.org/gtos/pubs.html). In preparing this workplan, the previously collected information was used to identify critical issues that need to be addressed during the standardization process. Specifically, for each ECV a brief summary was provided of:

- Importance and urgency;
- Readiness and feasibility;
- Available documentation (to use in drafting the standards);
- Existing expertise (specialized scientific/ technical groups, committees).

A brief summary under these headings is provided for each ECV in Annex 6.3.

In the following sections, three important above issues are addressed in more detail: prioritization of ECVs for standardization, standardization for *in situ* and satellite observations, and specific questions to be considered in developing standards for individual ECVs.

2.2.2.1 Prioritization

Given the large number of terrestrial ECVs and the finite resources available for standardization, prioritization is a key step and a way to maximize effectiveness of the process. In preparing this workplan, individual terrestrial variables were therefore assessed using two types of criteria:

a) <u>Urgency and importance:</u>
   - How critical (in relative terms) is the need for a standard becoming available during the next 2-4 years?
   - Are some standards, guides or similar documents in place which can serve in the interim?
   - Are only few groups/ organizations involved who are already collaborating/ sharing methodologies (thus lessening the urgency for a standard)?

b) <u>Readiness and feasibility:</u>
   - Has the observation methodology developed sufficiently to enable definition of an international standard? In relation to the Fast track route as the preferred option (section 2.2.1) this question can be rephrased as, does sufficient documentation exist upon which a Draft International Standard could be built?
   - Are there candidate groups for providing technical expertise in the development of a standard?

Based on information available for individual ECVs (Annex 6.3 and materials referred to therein) the resulting relative ratings are summarized in Table 1. Using this and other supporting information (SBSTA (2009a) and references provided there), the 14 ECVs were placed into three priority tiers:

Tier 1: High priority: ECV ready for standardization to begin now;
Tier 2: Medium priority: standardization to begin in ~3 years;
Tier 3: Low priority: standardization to begin after ~3-4 years.

Tier 1 is further divided into two groups on the basis of urgency, i.e. existence of documentation and/ or of ongoing collaboration through which convergence to standard approaches is already evolving.

The resulting ECV groups are as follows, summarized in Table 1:

<u>Tier 1</u> (High (H) – Medium (M) urgency, H-M readiness):
<u>Tier 1a</u> = initial set: 5 ECVs:
- ECV Biomass
- ECV Glaciers and Ice Caps
- ECV Land Cover
- ECV Permafrost
- ECV Soil Moisture

<u>Tier 1b</u> = coincident with *Tier 1a* (provided resources are available):
- ECV Leaf Area Index
- ECV River Discharge

<u>Tier 2</u> (M-Low (L) urgency, H-M readiness):
- ECV Albedo
- ECV Fraction of Absorbed Photosynthetically Active Radiation
- ECV Snow Cover

<u>Tier 3</u> (L urgency or L readiness):
- ECV Fire Disturbance
- ECV Lake Levels and Reservoir Storage
- ECV Ground Water
- ECV Water Use.

Table 1. Summary of ECV standardization aspects: urgency, readiness, and priority tier[1]

Terrestrial ECV	**Importance/ Urgency**	**Readiness/ Feasibility**	**Tier**
Biomass	H[2]	H-M[2]	1a
Glaciers and Ice Caps	H	H	1a
Land cover	H	H	1a
Soil Moisture	H	H/L[2]	1a
Permafrost	H	M	1a
LAI	M	H	1b
River Discharge	M	H	1b
Albedo	M	H	2
FAPAR	M	M	2
Snow cover	L	H	2
Fire Disturbance	H	H/L	3
Ground Water	L	M	3
Lake Levels and Reservoir Storage	L	H	3
Water Use	H	L	3

1) Refer to Annex 6.3 for further information
2) H= High, M= Medium, L= Low

The above analysis implies that the first five variables (ECV Biomass, ECV Glaciers and Ice Caps, ECV Land Cover, ECV Soil Moisture, and ECV Permafrost) should form the initial standardization cohort. If sufficient resources are available, this cohort should be expanded by adding ECV Leaf Area Index and ECV River Discharge.

2.2.2.2 Satellite vs. *in situ* observations

The descriptions of individual ECVs (Annex 6.3) show that in most cases, an ECV encompasses several different types of observations. These may differ in kind as well as spatial and/ or temporal attributes. Thus, the ECVs are in reality compound variables for which one or more observables need to be obtained. As noted in section 1., the term "Observable" is used in this report to distinguish these specific measurements from their respective ECVs. Spatially, the various *in situ* observables may or may not be taken at exactly the same spot on the ground; and may be expressed as a point (a site possibly with several sub-sites), a line, or a polygon (a boundary delineating a homogenous patch). To various degrees, the ECVs require *in situ* and satellite- based observables, the latter typically derived using gridded spatial coverage.

Table 2 provides a preliminary analysis of this aspect, including required observables by ECV, the relative contributions of *in situ* and satellite data, and (for satellite techniques) the relative importance (compared to *in situ*) and the current status of development. The 14 ECVs considered in this workplan represent 38 different observables. Using *in situ* techniques, roughly 23 (60%) are taken as point measurements, 14 (37%) as polygons, and one (glacier front variation) as a line (it should be noted that the numbers depend somewhat on the measurement technique, e.g. some 'point' measurements may actually be taken along a line). Regarding the relative importance of *in situ* and satellite observations, satellite data are a primary data source for the final ECV product in 17 cases (45%) and play supporting role in 14 (37%). Seven observables (18%) rely on *in situ* observations alone, and will likely continue so for the foreseeable future because most of these measurements are concerned with subsurface properties. A number of the satellite approaches are under active development.

Table 2. Characteristics of specific observables for terrestrial ECVs.

ECV	In situ observations			Role of satellite data[1]	Source of in situ observations[2]
	Specific observation type needed	Spatial dimension	Exactly co-located in situ?		
BIOMASS	Above-ground biomass (all living biomass above the soil)	Point	Yes	Supporting (upscaling via land cover); Primary under development	NMP[2]
	Below-ground biomass (all living biomass of live roots)	Point		Supporting (upscaling via land cover)	
	Dead mass (all non-living woody biomass not contained in the litter)	Point		Supporting (upscaling via land cover)	
	Litter (all non-living biomass above the mineral or organic soil)	Point		Supporting (upscaling via land cover)	
GLACIERS .	Glacierized area	Polygon	Yes	Primary	NMP/SP[2]
	Specific mass balance	Polygon		Supporting (under development)	
	Glacier front variation	Line		Primary	
LAND COVER	Land cover type/ category	Patch/ Polygon	Yes	Primary	NMP
	Land cover attribute (e.g., fraction of tree canopy cover)	Patch/ Polygon		Primary	
	Change in land cover type/category or attribute(s)	Patches/ Polygon		Primary	
PERMAFROST	Thermal state of permafrost	Point	Yes	None	NMP/SP

	Active-layer thickness	Point		None	
	Permafrost areal extent	Polygon	No	Supporting (via land cover properties)	
	Seasonally frozen ground	Polygon		Primary	
SOIL MOISTURE	Profile moisture distribution	Point	No	None	NMP/SP
	Landscape moisture distribution	Areal distribution		Primary (under development)	
LAI	Total leaf area	Patch/Site	Yes	Primary	SP
	Canopy clumping index	Patch/ Site		Supporting (via land cover, multiangular observations)	
RIVER DISCHARGE	Velocity of water	Point	Yes	None	NMP
	Riverbed profile	Point		None	
ALBEDO	Direct, diffuse and total incoming solar radiation	Point	Yes	Primary	SP
	Reflected radiation	Point		Primary	
FAPAR	PAR measurements above & below canopy	Patch/ Site	Yes	Primary	SP
SNOW COVER	Snow depth	Point	Yes	Supporting (under development)	NMP
	Snow water equivalent	Point		Supporting (under development)	
	Snow cover extent	Polygon	No	Primary	
	Snow cover duration	Polygon		Primary	
FIRE DISTURBANCE	Active fires	Polygon	Yes	Primary	NMP/SP
	Radiated power	Polygon		Primary	
	Total burned area	Polygon		Primary	
GROUND	Groundwater	Point		Supporting	NMP

WATER	level		Yes	(gravity missions, under development)	
	Recharge and discharge	Point		Supporting (gravity missions, under development)	
	Well level	Point		Supporting (gravity missions, under development)	
	Water quality	Point		None	
LAKE LEVELS and RESERVOIR STORAGE	Lake- specific area-volume curve	Site	Yes	Supporting (area measurement)	NMP
	Water level	Point		Supporting (under development)	
WATER USE	Area of irrigated land	Polygon	No	Primary	NMP
	Amount of water used for irrigation	Point		None	

NOTES:

1) Describes the role of satellite data in preparing the final information product for that observation over the spatial domain of interest (global, regional):

Primary: final product is prepared using satellite measurements as primary source, with *in situ* observations providing quantifying/ validation information.

Supporting: final product relies on *in situ* observations, with satellite supporting upscaling to areal coverage.

Note that some satellite techniques are presently under development, including experimental satellite missions that have been launched.

2) A likely source of *in situ* observations:

NMP = national monitoring program (agencies presently collect such data, at least in some countries);

SP= science programs and projects (existing programs/ projects collect such observations; continuity uncertain). Some scientific observations and resulting networks may be eventually transformed into ongoing monitoring programs (this has been the case in ocean observations).

Where both modes are indicated: both types of organizations currently collect such data (or potentially could do so in the future).

The analysis shown in Table 2 indicates that standards for *in situ* observations must in most cases consider, and respond to, the needs of satellite- based information products. This need not dampen the progress in standardization for those observables, even where satellite- based methods or algorithms are still under development. The reason is that the requirements for *in situ* observations (in support of satellite- based products preparation) are quite well understood for most of the ECVs concerned.

The last column of Table 2 indicates the typical present suppliers of *in situ* observables, either actual or potential. The 'coverage' is neither global nor uniform, and so the designation should be taken as indicative rather than definitive. [For example, national biomass inventories contain information on above ground forest biomass, not other forest biomass pools and no other vegetation types. Nevertheless, national monitoring programs (as opposed to science projects) were listed in Table 2 as the likely source because if such *in situ* observations were to be routinely provided, they would have to be collected by national agencies.] Table 2 does indicate that both NMPs and SPs play important roles in providing *in situ* observations. Depending on the ECV, one or both of these are presently the main supplier of such data. This situation may be expected to continue into the future, as operational observing systems evolve fairly gradually.

In terms of standardization, an important implication of the last column in Table 2 is that where the *in situ* data are collected through national monitoring programs, the procedures are more likely to differ among countries (compared to science programs which tend to be more coordinated). Furthermore, they are likely embedded in existing national protocols, thus complicating the development of an acceptable international standard. One solution to this challenge has been demonstrated by ISO Technical Committee 211 which, in preparing a standard for land cover, focused on the development of a common meta-language as a tool to formalize the meaning of any existing land cover classification/legend. Given current data collection programs and practices, the NMP/SP issue may also be important for the following ECVs: Biomass, River Discharge, Snow Cover, Fire Disturbance, Ground Water, Water Use.

2.2.3 ECV- specific issues

As evident from the previous sections, the 14 terrestrial ECVs differ substantially in various aspects relevant to standardization. To make the process efficient and the resulting standards effective, the most important aspects need to be identified and addressed during the standard development process. These will not only differ among ECVs, but are also likely to change over time (e.g., as *in situ* and satellite measurement techniques evolve).

As a step in this direction and to develop a workplan that would reflect the needs of individual ECVs, the following items were addressed for each ECV:

- Key issues and questions to be resolved in a standardization process; and
- Suggested action within the UN-ISO Framework.

The results are presented below for ECVs in the three priority tiers (defined in section 2.2.2.1).

a) Tier 1

ECV Biomass

a) Key issues for standardization:

- How specific (in terms of the measurement methodology) should the standard be? Should only principles be defined, or should acceptable alternative measurement approaches also be included?
- Can a standard be based on numerical representation (biomass/unit area), or is a more complex approach required that permits translation of existing national inventories into a common scheme (or both)?
- Should the standardization effort focus on *in situ* traditional methods, or should satellite- based approaches also be considered at this time?
- What other information is required for standardization (e.g., vegetation type/map), and how is this information to be standardized?
- What are acceptable (biomass pool- dependent where applicable) methods for selecting sample sites and for upscaling site measurements?
- How should biomass information be reported (including differences in reporting format and content among pools and vegetation types where applicable)?
- How should uncertainties be minimized and reported?

b) Suggested action:

1. Establish a JWG to develop an ISO International Standard for obtaining and reporting biomass information for climate- related purposes.
2. Continue the development and validation of satellite- based biomass measurement methods and products.

ECV Glacier and Ice Caps

a) Key issues for standardization:

- How specific (in terms of the measurement methodology) should the standard be? Should only principles be defined, or should acceptable alternative measurement approaches also be included?
- How to ensure that the three observables constituting this ECV (glacierized area, specific mass balance, glacier front variation) are mutually consistent for reporting and analysis?
- Should the standard be developed at the measurement level or representation/ metadata level?
- How should the information be reported (reporting format and content)?
- Is it feasible to develop standards for satellite- derived products at this time, and at which level (principles, output products, candidate methods)?
- How should uncertainties be minimized and reported?

b) Suggested action:

1. Establish a JWG to develop an ISO International Standard for obtaining and reporting glacier and ice caps observations for climate- related purposes.

ECV Land Cover

a) Key issues for standardization:

- Completion of the International Standard ISO/DIS 19144-2 currently being developed by the ISO Technical Committee 211 (it is at the Draft International Standard stage).
- Are other/ additional standards required?
- Is it feasible to begin development of standardization tools for a) fractional land cover type products, and for b) assessing and reporting land cover change?

b) Suggested action:

1. Complete the preparation of ISO international standards for land cover (currently underway).
2. Assess the current feasibility of standardizing fractional land cover products using Fast track or Workshop ISO mechanisms.

ECV Permafrost

a) Key issues for standardization:

- How to ensure that the four observables constituting this ECV (thermal state of permafrost, permafrost areal extent, active-layer thickness subject to annual thawing and freezing, seasonally frozen ground) are mutually consistent for analysis and reporting?
- Should the standard be developed at the measurement level or representation/ metadata level?
- How specific (in terms of the measurement methodology) should the standard be for each variable? Should only principles be defined, or should acceptable alternative measurement approaches also be included?
- What upscaling approaches are acceptable for the individual variables?
- How should the information be reported (reporting format and content)?
- What other information is required for standardization (e.g., soil information, land cover, climate), and how should this be standardized?
- How should uncertainties be minimized and reported?

b) Suggested action:

1. Establish a JWG to develop an ISO International Standard or an ISO Guide for making and reporting permafrost observations for climate- related purposes.

ECV Soil Moisture

a) Key issues for standardization:

- How specific (in terms of the measurement methodology) should the standard be? Should only principles be defined, or should acceptable alternative measurement approaches also be included?

- What are the measurements required per site (soil moisture and ancillary)?
- What criteria for upscaling should be met and what are the possible approaches?
- What other information is required for standardization (e.g., satellite images, terrain information), and how is this to be standardized?
- How should the information be reported at both site and upscaled levels (reporting format and content, ancillary information, etc.)?
- How should uncertainties be minimized and reported?

b) Suggested action:

1. Organize an international workshop(s) to complete an ISO Workshop Agreement on the preparation and reporting of site- and landscape- level soil moisture information.

ECV Leaf Area Index

a) Key issues for standardization:

- What are acceptable methods of site selection and specific measurements for the two variables (total leaf area, clumping index), both principles and candidate techniques?
- What criteria for upscaling (to a stand/patch or landscape levels) should be met and what are the possible approaches?
- What other information is required for standardization (e.g., land cover, vegetation type/map), and how is this information to be standardized?
- How should the information be reported (reporting format and content, ancillary information, etc.)? How should uncertainties be minimized and reported?
- Should satellite- derived products be standardized at this time? What would be the appropriate level of standardization (principles, guidelines, specific methods)?

b) Suggested action:

1. Define an ISO International Standard or an ISO Guide encompassing: making LAI measurements *in situ*, the preparation of satellite- based products making use of *in situ* data, and reporting LAI information for climate change- related purposes (all subject to the availability of resources).

ECV River Discharge

a) Key issues for standardization:

- How specific (in terms of the measurement methodology) should the standard be for the two observables (channel profile, velocity of water moving through the profile)? Should only principles be defined, or should acceptable measurement approaches also be included?
- Can a standard be based on numerical representation (volume/time), or is a more complex approach required that permits translation of national measurements and reports into a common scheme (or both)?
- How should the information be reported (reporting format and content)? How should uncertainties be minimized and reported?

- What other information is required for standardization (e.g., geographic/ watershed information), and how is this information to be standardized?

b) Suggested action:
1. Establish a JWG to prepare an ISO International Standard for climate- related purposes that will bring together and build upon existing standards and guides.

b) Tier 2

ECV Albedo

a) Key issues for standardization:
- Are existing standards for *in situ* albedo measurements sufficient for use with satellite- based observations?
- What methods are appropriate for making and reporting upwelling radiation reflected by the surface and for the characterization of surface anisotropy?
- What are the principles and acceptable methods for upscaling from site measurements to a landscape level?
- How should albedo information be reported (format and content) for use in generating satellite- based products? How should uncertainties be minimized and reported?
- What other information is required for standardization (e.g., land cover, vegetation type, terrain variables, surface anisotropy), and how is this information to be standardized?
- What are the principles and acceptable methods for generating albedo products that incorporate both satellite and *in situ* observations?

b) Suggested action:
1. Establish and ad hoc group to evaluate the urgency and feasibility of completing an ISO international standard for albedo products generated from *in situ* and satellite data; and to recommend a plan of action (section 3.2.1).
2. If appropriate and subject to the availability of resources, implement the plan.

ECV Fraction of Absorbed Photosynthetically Active Radiation

a) Key issues for standardization:
- What are the principles to be used in selecting sample sites? What primary observations are required and what are alternative techniques for obtaining these measurements?
- Should the standard be developed at the measurement level or representation/ metadata level?
- What are the principles and acceptable methods for upscaling site values to a patch/stand or landscape levels?
- How should the information be reported (reporting format and content), particularly for optimum use in generating satellite- derived products?
- How should uncertainties be minimized and reported?
- What ancillary information is required for standardization (e.g., land cover, vegetation type/map), and how is this information to be standardized?

- Should satellite- derived products be standardized at this time? What would be the appropriate level of standardization (principles, guidelines, specific methods)?

b) Suggested action:

1. Establish an ad hoc expert group to prepare a proposal and a timetable for completing an ISO Guide for FAPAR information products for climate- related purposes, including an outline of the proposed standard and a timetable that encompasses *in situ* and satellite- based observations.

ECV Snow Cover

a) Key issues for standardization:

- How specific (in terms of the measurement methodology) should the standard be for the four observables (snow cover extent, snow depth, snow water equivalent, snow cover duration)?
- Should only principles be defined, or should acceptable alternative measurement strategies also be included? How to ensure that the four variables are observed and described consistently for reporting and analysis?
- Can a standard be based on numerical representation (depth,…), or is a more complex approach required that permits translation of existing national methodologies into a common scheme (or both)?
- How should the information be reported (reporting format and content, including differences among the four variables)? How should uncertainties be minimized and reported?
- What other information is required for standardization (e.g., terrain information, land cover, vegetation type), and how is this information to be standardized?
- Should satellite- derived products be standardized at this time? What would be the appropriate level of standardization (principles, guidelines, specific methods, specific products)?

b) Suggested action:

1. Establish and ad hoc group to evaluate the urgency of completing an ISO International Standard for snow cover products that are based on *in situ* and satellite data; and to recommend a plan of action (section 3.2.1).
2. If appropriate and subject to the availability of resources, implement the plan.

c) Tier 3

ECV Fire Disturbance

a) Key issues for standardization:

- How specific (in terms of the measurement methodology) should the standard be for each observable? Should only principles be defined, or should acceptable alternative measurement approaches also be included?
- How to ensure that the three observables are mutually consistent for reporting and analysis?

- Can a standard be based on numerical representation (mass/unit area), or is a more complex approach required that permits translation of existing nationally collected data into a common scheme (or both)?
- How should the information be reported (including differences in reporting format and content among vegetation types where applicable)?
- What other information is required for standardization (e.g., land cover, vegetation type), and how is this information to be standardized?
- How should the information be reported (reporting format and content)? How should uncertainties be minimized and reported?
- Should satellite- derived products be standardized at this time? What would be the appropriate level of standardization (principles, guidelines, specific methods)?

b) Suggested action:

1. Establish and ad hoc group to (i) evaluate the urgency and feasibility of completing an ISO Guide or Workshop Agreement for *in situ* fire disturbance information and for the preparation of satellite- based products using both types of observations; and (ii) recommend a plan of action (section 3.2.1).
2. If appropriate and subject to the availability of resources, implement the plan.
3. Continue the development of techniques for quantifying fire radiated power and the definition of validation protocols.

ECV Ground Water

a) Key issues for standardization:

- What are the principles and best practices for establishing a ground water monitoring network?
- Can a standard be based on numerical representation (volume), or is a more complex approach required that permits translation of existing national inventories into a common scheme (or both)?
- How specific (in terms of the measurement methodology) should the standard be for each of the four observables (groundwater level, recharge and discharge, well level, water quality)? Should only principles be defined, or should acceptable alternative measurement approaches also be included?
- How should the ground water information be reported (reporting format and content)?
- Are existing standards and guides sufficient for climate- related purposes?
- How should uncertainties be minimized and reported?

b) Suggested action:

1. Establish an ad hoc group to: (i) analyze the adequacy of existing standards and guides for climate- related purposes; and (ii) if appropriate, develop a plan of action (section 3.2.1).

ECV Lake Levels and Reservoir Storage

a) Key issues for standardization:

- What are the principles and best practices for establishing a lake/ reservoir monitoring network?
- How specific (in terms of the measurement methodology) should the standard be for the two observables? Should only principles be defined, or should acceptable alternative measurement approaches also be included?
- How should the two observables be reported (reporting format and content)?
- What other information should be included in the reporting (e.g., water temperature), and in what format?
- How should uncertainties be minimized and reported?
- Are existing standards and guides fully sufficient for climate- related purposes?

b) Suggested action:

1. Establish an ad hoc expert group to: (i) analyze the adequacy of existing standards and guides for climate- related purposes; and (ii) if appropriate, develop a plan of action (section 3.2.1).

ECV Water Use

a) Key issues for standardization:

- Availability of *in situ* networks, reporting mechanisms and resources at local, national and regional/ watershed levels.
- Best practices in combining *in situ* and satellite- based observations to generate water use products.
- What other information is required for standardization (e.g., land cover, vegetation types), and how is this information to be standardized?

b) Suggested action:

Standardization action should be deferred pending developments in AQUASTAT.

3. Implementation

The overall implementation involves two phases: implementation of the organizational Framework, followed by the development of ECV standards within this Framework.

3.1 Framework implementation

The foundations for the Framework are SBSTA's endorsement of the GTOS 2009 proposal (SBSTA, 2009a) and a Memorandum of Understanding (MOU) between the GTOS Sponsors and the ISO. A draft MOU has been completed and is ready for signature, conditional upon SBSTA's endorsement of this workplan. The MOU defines the Framework organization and operation at a high level, and the details provided in the current report are consistent with it.

It is envisioned that the following steps will be required to implement the Framework, assuming SBSTA's endorsement of this report and its recommendations:

- MOU signing by the GTOS Sponsors (FAO, ICSU, UNEP, UNESCO, WMO) and the ISO;
- Establishment of the Joint Steering Group (JSG), including and specifying a consistent way to represent GTOS Sponsors;
- Adoption of the JSG terms of reference (refer to Annex 6.1), nomination of its members, and establishment of the JSG Secretariat;
- Establishment of a resource and support mechanism for the JSG, including the Secretariat (refer to Appendix ??).
- Adoption of workplan by the JSG (based on this report and after modifications as required).

Once the workplan is adopted the stage will be set for the development of ECV standards.

3.2 ECV Standards

The overall approach consists of:

- Adopting a common format/ architecture for the ECV standards (section 3.2.1) and an overall plan for sequencing the standards development work;
- Specifying the content and a strategy for standards development based on proposals of the approach to be adopted for each ECV (section 3.2.2); and
- Executing the approved proposals, tracking progress and modifying the developmental strategy as appropriate.

3.2.1 Common format

The various ECV standards to be developed are intended to be used for a common purpose, supporting the needs of the UNFCCC. Collectively, they also describe one domain, the terrestrial component of the Earth environment. It is therefore desirable that the individual standards share a general structure and conform to a common 'look-and-feel'. The definition of such common architecture is a task for the JSG and should precede the preparation of ECV- specific proposals.

Existing ISO standards of similar type should be used and modified as necessary to better match the needs of the ECVs.

3.2.2 ECV- specific proposals

Given the complexities and differences among the terrestrial ECVs, the standardization process needs to be carefully designed to match the various ECV- specific issues. Therefore, individual proposals need to be prepared and reviewed before the standards development work begins. The proposals should build on the discussion presented in this report by exploring in detail the issues raised (and others relevant to a particular ECV) so that a standard is properly focused, covers the important aspects, and can be completed efficiently and in timely manner. It is suggested that proposals for ECV standardization use the following table of content, and be limited in length (to no more than ~3-4 pages):

1. *Objectives (*succinctly stated*):*
   1.1. *Target output (*standard, guide, workshop agreement,....*)*
   1.2. *Target principal users*

2. *Scope of proposed standard:*
   2.1. *Specific observation types to be standardized (*Table 2, Annex 6.3*)*
   2.2. *Level of standardization (*principles, reporting format, alternative measurement methods, specific/recommended methodology*)*
   2.3. *Source data employed, target product(s) (*in situ, satellite, both (i.e., integrated product), role/relationship among different data sources*)*
   2.4. *List of technical issues the standard should deal with*

3. *Applicable existing standards, guides and other sources (*to be employed*):*
   3.1. *Existing ISO, UN standards*
   3.2. *Other existing applicable standards*
   3.3. *Gaps to be filled and proposed steps*

4. *Approach to implementation (with rationale):*
   4.1. *General strategy (*for the development and target output products*)*
   4.2. *Main phases and associated milestones*
   4.3. *Participants (*groups/ projects to be represented; candidate names*)*
   4.4. *Proposed schedule*
   4.5. *Other outstanding issues/ decisions required (*if any*)*

NOTE: Sections 2., 3., 4. should address by individual observables (Table 2., Annex 6.3), as/ where appropriate.

The above table of content should be finalized and approved by the JSG. The proposals for ECV standardization should then be prepared by ECV coordinators within the GTOS, with contributions by experts familiar with ISO standards development (refer to Annex 6.3 for candidate groups).

3.2.3 Standards development, approval and endorsement

Considering the differences among ECVs and the need for various types of input and expertise, it is proposed that a Joint Working Group (JWG) be established for each ECV to be standardized. The terms of reference for the JWG would be tailored to the needs of that ECV. They would be based on the general JWG Terms of Reference (Annex 6.2), supplemented or modified as appropriate to ensure the ECV- specific issues are dealt with. The ECV- specific JWG, its terms of reference, membership and reporting should be specified by the JSG following the consideration and approval of the ECV proposal (section 3.2.2). The actual development and approval process will follow procedures and practices of the ISO (refer also to Annex 6.1, 6.2).

The approved standards will be presented by the GTOS and its Sponsors to the UNFCCC/SBSTA for endorsement as ‘meeting the requirements of the UNFCCC’. They will be published and made available in a way consistent with the UN-ISO Memorandum of Understanding, and maintained using ISO procedures and practices.

3.3 Tasks and timetable

Figure 3 shows an overview of the standard development process and also indicates the main agencies/agents to be responsible for completing the individual steps.

Following the UNFCCC/SBSTA decision regarding this proposed workplan, the next priority actions are the establishment of the JSG and the finalizing the format for developing ECV-specific proposals for standardization. Immediately after (and possibly overlapping in time with JSG deliberations) ECV coordinators would start the preparation of specific proposals for Tier 1 (or 1a only) ECVs (Table 1). The completed proposals will be submitted to the JSG for consideration and approval, after which the JSG will take steps to establish the required JWGs and to implement the proposed standardization for the selected ECVs. Once the above actions are underway, an analysis and preparations for standardizing other ECVs may proceed in parallel or delayed mode.

Figure 3. Main steps and actors in developing standards for terrestrial ECVs.

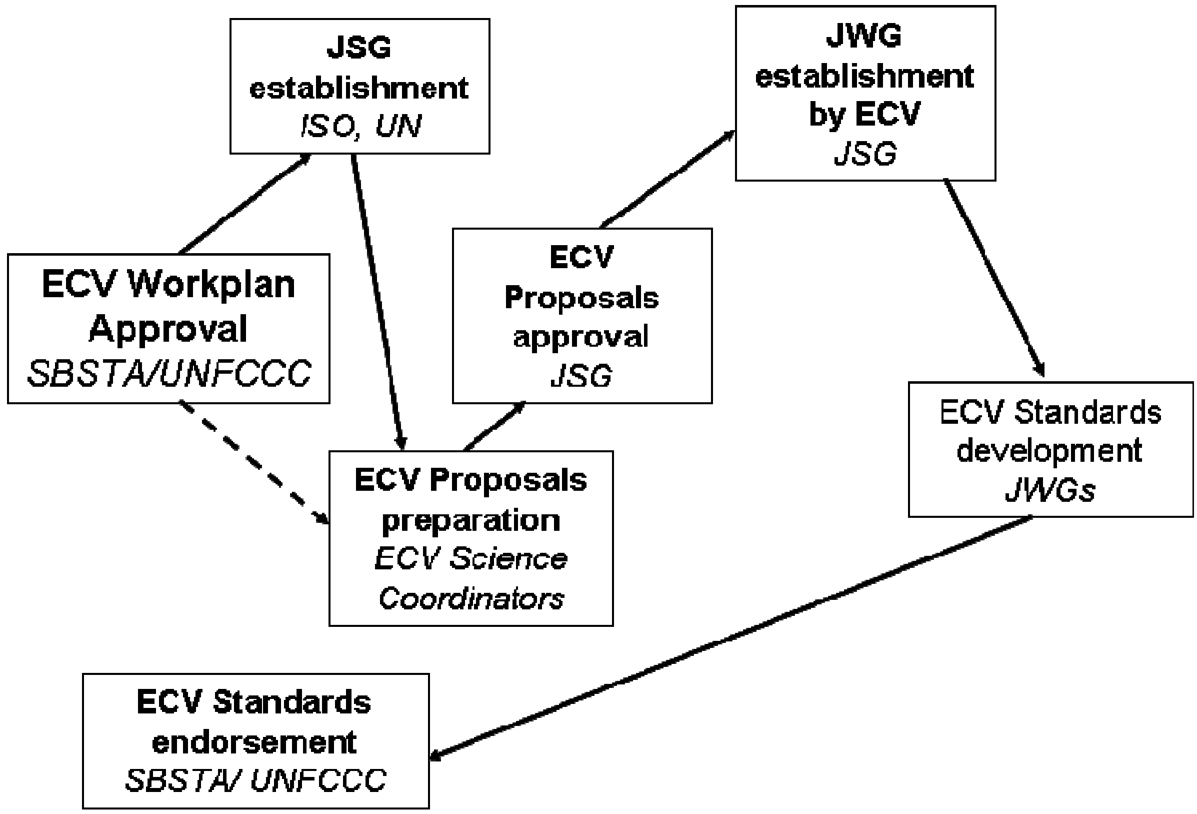


Table 3 contains a more detailed list of actions in the end-to-end ECV standards development/ endorsement process and the actors responsible for completing these actions. Tasks 4-7 are to be undertaken for each ECV Tier, and tasks 8a through 8h for each ECV. According to ISO procedures, individual standards are regularly reviewed and updated as appropriate. This review and update function is also provided for in the implementation (Table 3).

Table 3. Summary of actions and groups/ leads responsible for implementation

Task	Action led/ by
1. Signing MOU	ISO, GTOS Sponsors
2. Creation of JSG, appointment of Chair, establishment of JSG Secretariat	ISO, GTOS Sponsors
3. Development of common format/ architecture for ECV standards	JSG
4. Finalizing, approving and issuing request for proposals re initial ECV standards development	JSG
5. Preparation of proposals for ECV standard development	ECV Coordinators/

	GTOS
6. Finalizing and approving ECV standard preparation procedures, including JWG terms of reference and operating procedures	JSG
7. Evaluating received proposals for ECV standards preparation, and finalizing program of work for the initial series of ECVs	JSG
8. For each ECV selected:	
a) Establishment of the JWG	JSG
b) Completing preparation of the ECV standard document[1] for voting	JWG
c) Submission of the DIS to voting ('Enquiry')	ISO Secretariat
d) Revision of DIS and preparation of the Final DIS (FDIS)	JWG
e) Formal voting on FDIS	ISO Secretariat
f) Endorsement of FDIS	SBSTA, GTOS Sponsors
g) Publication of IS	ISO
h) Periodic review and revision of IS	JSG on the advice of ECV Science Leads/GTOS
9. Prepare proposals for Tier 2 and later Tier 3 ECVs (in parallel)	As above
10. Repeat steps 5. through 8., adjusting priorities and procedures as appropriate	As above

NOTE:
1) Assumed to be Draft International Standard (DIS); the steps may differ depending on the form of the standard document.

An approximate timetable for the Tier 1a ECVs is as follows, assuming SBSTA's approval of this workplan in November 2010:

2011:
- Signing UN-ISO MOU
- JSG establishment
- Preparation of ECV proposals for priority ECVs
- JSG decision on initial standards to be developed, establishment of JWGs, JWG work begins

2012-2015:
- Development, approvals and publication of ECV standards for priority ECVs
- Preparation of proposals for other ECVs
- JSG decisions on other standards to be developed, establishment of appropriate JWGs, JWG work underway.

At this point it is difficult to estimate when the bulk of the ECV standards will have been completed. The speed and efficiency involved in the initial set will provide an indication of the degree of complexity and thus likely duration of each standard development task. The level of financial and human resources will also play a key role in determining the overall time requirement.

3.4 Resources for implementation

While most of the standard development work under the Framework will be carried out by technical bodies and experts, the overall effort requires substantial logistical, management and administrative support.

Previous experience shows that the development of effective international standards requires substantial support for coordination activities. Contributions to drafts of working documents, project management, and organization and execution of meetings are among the functions of an ISO Technical Committee Secretariat (ISO, 2008). For the terrestrial ECVs, the task is further complicated by the precedent- setting establishment of the Framework structure, the thematic diversity of the needed standardization documents, and by the need to develop and publish the standards over a short time period so that the harmonization of global terrestrial observations may proceed as expeditiously as possible. These circumstances imply a high degree of administrative activities over the next few years.

Within ISO, each TC has a Secretariat maintained by a willing ISO member. The proposed JSG Secretariat will require a higher initial - and similar ongoing - level of support. A more detailed analysis has shown that approximately US$970,000 will be required annually for the establishment of the framework and for ECVs development, until 2015 when the bulk of the standards should be completed. This estimate assumes that (i) the participation of country representatives and other TC members will be funded by ISO member countries following the current practice; (ii) UN agencies or other organizations (e.g., international scientific organizations) that wish to contribute to developing a standard will fund their representatives; and (iii) the overhead administrative cost of the proposed Fast track route will be much reduced compared to the standard TC route. Additional funds may also be required to support the participation of developing countries and to enhance the level of activities of the most directly implicated ISO Technical Committees.

4. Conclusions and Recommendations

This report analyzes issues involved in standardizing Essential Climate Variables in the terrestrial domain to prepare a workplan for the development of such standards within a Framework endorsed by the UNFCCC/ SBSTA. The proposed workplan consists of two main phases, the implementation of an overall organizational Framework and the standardization of individual ECVs. The overall approach as well as specific tasks for each phase have been elaborated, and a timetable described. The proposed workplan is consistent with SBSTA decisions on this topic and with results of previous discussions among UN agencies and the ISO.

It is concluded that:

1. Sufficient information and technical resources are available to undertake the development of standards for ECVs to be addressed during the initial period, while progress continues to be made in other cases where standardization is less urgent.
2. The standardization should focus on *in situ* observation methods but since the resulting data will in many cases (~45-82% of the ECV observables) be used for the preparation of satellite- based information products, the needs of the latter must be built into the initial standards where feasible.
3. The specific issues and questions meriting standardization differ substantially among ECVs. Consequently, although a common architecture for the standards is desirable and should be defined at the outset, the standards development must address ECV- specific issues such as identified in this report.
4. Significant human and financial resources are required if the Framework is to succeed in producing effective standards within the proposed time frame.

The following recommendations are made:

1. That SBSTA endorse this workplan, in present form or modified as appropriate.
2. That SBSTA requests:
    - a) GTOS and its Sponsors together with the ISO to implement the workplan.
    - b) Parties to respond to the financial requirements of the standardization framework and to resource GTOS Secretariat to implement the workplan.
    - c) Space agencies and the scientific community to continue developing capabilities for observing and delivering integrated terrestrial ECV information products from *in situ* and satellite data.
    - d) GTOS report on the progress at the 35th session of the SBSTA.

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6. Annexes

6.1 Joint Steering Group Terms of Reference (DRAFT)

Revised from: SBSTA (2009a)

a) Purpose and Scope

1. The Joint Steering Group (JSG) is an inter-agency group.
2. The mandate of the JSG is to design and oversee the implementation of the development of standards for terrestrial observations. The initial emphasis will be placed on the development of standards for Essential Climate Variables (ECVs) in support of the United Nations Framework Convention on Climate Change (UNFCCC) and of the objectives of the related UN agencies and parties of the Convention.
3. The initial JSG terms of reference are approved by the agencies sponsoring the UN-ISO Framework for the development of standards for terrestrial observations. The mandate, sponsoring agencies and terms of reference may subsequently be modified subject to agreement among the JSG sponsoring agencies.
4. The JSG accepts requests for standardization from UN governing bodies, initially from the UNFCCC; and it accepts both solicited and volunteered inputs from ISO technical committees, international scientific programs and projects, and from other technical groups.
5. In its deliberations, the JSG will determine how to develop the requested standards in the most efficient and effective manner.
6. JSG decisions will be reported to UN sponsoring agencies and to the ISO Technical Management Board.

b) Membership

1. The JSG includes representatives of:
   i. The UN agencies. For the development of ECV standards, the representation is provided through the GTOS and the GCOS at Programme Director and Chairman level and includes supporting scientific panel representatives, as required.
   ii. A representative of the ISO Technical Management Board.
   iii. The ISO Technical Committees. For the development of ECV standards, four TCs are represented at Chair level: TC 113, TC 190, TC 207, TC 211.
   iv. Representatives of other agencies may be added with mutual consent of the sponsoring agencies.
2. The JSG is chaired by a representative of a UN sponsoring agency. For the initial period dealing with the ECVs, the GTOS representative is the JSG chair.

c) Operation

1. The JSG operates as a ‘virtual’ committee, deliberating as and when required. It conducts its business efficiently and economically, making extensive use teleconferences and web services.
2. The Chair will be responsible for the agenda and program of the JSG, ensuring responsive actions to the requests for standardization.
3. The JSG principal responsibility is to develop, approve and ensure successful implementation of a workplan for developing standards for terrestrial ECVs. Within this overall scope JSC will, upon advice provided by existing ISO and UN organizational entities:

i. Develop and approve an overall strategy that meets the needs of the SBSTA/ UNFCCC;
ii. Define the approach, expected deliverables, and tasks to be carried out in standardizing individual ECVs;
iii. Establish and define the mandate, tasks and membership of individual Joint Working Groups;
iv. Develop common guidelines for the operation of Joint Working Groups;
v. Ensure that human and financial resources are available for the tasks accepted for execution;
vi. Approve changes to the workplan that may be proposed during the execution phase;
vii. Ensure coordination among the various ECV- related standardization activities under JSC purview as required;
viii. Ensure appropriate coordination among the ECV- related and other standardization activities carried out by the ISO and by UN organizations, including effective and appropriate use of existing standards.

4. In its deliberations regarding standard development for individual terrestrial variables, the JSG will address the following (and other) issues as appropriate:
   i. What should be the form of the target standard (International Standard, Publicly Available Specification, Technical Specification, Technical Report, International Workshop Agreement, Guide)?
   ii. What specific issues should the target document address (refer to section 2.2.3 for examples and candidates)? Should the standard be developed at the measurement level, representation/ metadata level, or both?
   iii. To what level of detail should geographic and data management standardization be defined?
   iv. To which degree should an integrated standard (i.e., *in situ* plus satellite observations) be considered for that ECV, and what are the main issues to be addressed?
   v. Should a particular standard be developed through the regular process, fast-tracked, or a workshop route?
5. The costs of participation in the JSG will be carried by the agencies of the respective JSG members.
6. For matters other than specified above, the JSG follows the ISO rules (ISO, 2008).
7. To more efficiently and effectively perform its functions, the JSG may decide to establish an advisory group, with the primary role of advising the JSG on technical issues. Unless specified otherwise by the JSG, the Advisory Group's establishment and operation will be governed by the rules established for ISO Ad hoc groups (ISO/IEC Directives Part 1, 2008, section 1.).

d) Secretariat

1. The mandate of the JSG Secretariat is to support the work of the JSG in general and the Chair in particular.
2. The Secretariat is provided and funded by the home agency of the JSG Chair.

Secretariat resourcing issues are addressed in section 3.4.

6.2 Joint Working Group Terms of Reference (DRAFT)

a) Purpose and Scope

1. A Joint Working Group (JWG) is established by the Joint Steering Group (JSG).
2. The primary role of a JWG is the development of an instrument/ instruments for standardizing the acquisition and/or reporting of a terrestrial variable.
3. The terms of reference for a JWG are established by the JSG.
4. The task(s) and the format for the target output(s) of a JWG's work are decided by the JSG. Normally an International Standard will be the target format but the JSG may select other options among those available under ISO Directives (ISO, 2008).

b) Membership

1. The JWG membership and terms of reference are decided by the JSG.
2. JWG consists of representatives of the ISO Technical Committees and of UN organizations that are parties under the Memorandum of Understanding. The JWG members will be selected for their expertise in the topic/ ECV under consideration.
3. In selecting members for the JWG, the JSG will ensure that sufficient expertise is available to address the technical issues for the ECV under consideration.
4. All JWG members have equal status.

c) Operation

1. The procedures and operation of the JWG will generally follow ISO/IEC Directives (ISO, 2008), unless specified otherwise by the JSG.
2. The costs of participation in the JSG will be carried by the agencies of the respective JSG members.

6.3 Status of ECVs

This Annex provides a brief description of the status and standardization needs for Essential Climate Variables (ECVs). The discussion is based on previous detailed analysis of the issues involved in standardizing individual ECVs, as described in SBSTA (2009a), in reports published by the Global Terrestrial Observing System (GTOS;); http://www.fao.org/gtos/pubs.html), and in reports by GCOS (GCOS, 2004, 2010). It highlights factors that are relevant to ascertaining the urgency and readiness for prioritization purposes. It also provides an initial list of the ECV-specific issues and questions that should be addressed through standardization. For the definition of tiers, refer to section 2.2.2.1.

6.3.1 Tier 1

ECV Biomass

a) Importance and urgency

Biomass is the primary measure of the carbon content/stocks of vegetation canopies and an important input into vegetation growth models. The carbon pools of terrestrial ecosystems involving biomass are conceptually divided into above-ground biomass (all living biomass above the soil including stem, stump, branches, bark, seeds, and foliage); below-ground biomass (all living biomass of live roots); dead mass (all non-living woody biomass not contained in the litter - standing, lying on the ground, or in the soil); and litter (all non-living biomass in various states of decomposition above the mineral or organic soil).

Biomass measurement methods are typically standardized through an inventory design at the national level. Many countries have national inventories that include biomass information, but almost exclusively for forests only and based on regionally- specific (allometric) relationships. The soil biomass component is usually estimated as a fraction of the aboveground total biomass, based upon plot- based stratified sampling. Management- oriented forest inventories in many countries contain volume information that would allow for wide-area biomass conversion. However, these datasets suffer from various limitations, such as: they are not always publicly available, represent differing time periods, are not spatially exhaustive (covering only commercially relevant forest lands), and others.

Because of the logistical and conceptual difficulties in obtaining global biomass inventories over time, satellite data are playing increasingly important roles. However, their proper use requires *in situ* biomass data for the calibration and validation of satellite- based products, and consequently a methodology which is internationally consistent to permit intercomparisons and cross-validation. This need is growing rapidly in importance due to the growing policy needs (e.g., the REDD initiative; http://www.un-redd.org/) and various satellite missions (Canada, Europe, Japan; others in advanced preparation stages) that provide data suitable for biomass estimates.

b) Feasibility and readiness

Reconciling the various nationally- based inventory designs or the resulting information is generally difficult and inevitably produces inaccurate results. In addition, some inventory designs are inherently less suited for ECV purposes than others, depending for example on how biomass change is defined and measured (GTOS, 2008). However, in principle the standardization of biomass measurements is feasible. Such effort would also benefit from the evaluation of various biomass estimation approaches currently underway through the UN-REDD (Reduce Emissions from Deforestation and forest Degradation) Programme (http://www.fao.org/climatechange/unredd/63224/en/).

c) Available documentation

A candidate methodology, developed through international scientific collaboration, has been produced (Law et al., 2008). It is consistent with procedures previously employed in projects undertaken in various countries, mostly in various forest or grassland ecosystems, to determine biomass content of trees/overstory woody biomass, overstory foliage, understory and ground cover, litter, soil and roots.

d) Technical expertise

Standard preparation: Within ISO, TC207 is the most closely related group. The Forestry and Natural Resources Departments of FAO has probably the most experience with standardizing forestry reports based on national inventories and inputs to UN-REDD.
Technical input: Three existing international groups possess the needed technical expertise: the FLUXNET team that authored the above report (Law et al., 2008); the IPCC team that compiled the Good Practice Guidelines (IPCC, 2003); and the GOFC-GOLD Biomass Working Group (http://www.gofc-gold.uni-jena.de/).

ECV Glacier and Ice Caps

a) Importance and urgency

Changes in mountain glaciers and ice caps cause serious impacts on the terrestrial water cycle and societies that depend on glacial melt water, provide some of the clearest evidence of climate change, and are key variables for early-detection strategies in global climate-related observations (GCOS, 2004). The existing literature on the standardization of glacier observations has served countries and research teams so far. As the next step, systematic global and regional glacier observations would benefit from an up-to-date document which, while building on the various sources, provides a common basis for making and reporting such observations in a consistent manner. The observations needed are glacierized area, specific mass balance in water equivalent units, and glacier front variation.

b) Feasibility and readiness

Given existing information; the importance of glaciers to monitoring environmental change; and the level of interest in the global community, the preparation of a comprehensive document is feasible.

c) Available documentation

Substantial literature exists to support this task. SBSTA (2009a) lists 14 different publications that collectively provide strong foundation for an international standard.

d) Lead group(s)

Standard preparation: Within ISO, TC207 (Environmental Management) is most closely related to measurement aspects in this thematic area. TC211 (Geographic Information/ Geomatics) has developed standards handling geospatial data that apply to glaciers as well as other environmental information.
Technical input: The GTN-G, the World Glacier Monitoring Service (WGMS) and their partners represent various research and monitoring groups, including the WMO Hydrology and Water Resources Program.

ECV Land Cover

a) Importance and urgency
Land cover and its properties are very important in many respects including climate variability and change, resource management, scientific understanding of the Earth system, and the provision of ecosystem services. Numerous national inventory and mapping systems have been developed but so far there is no agreed- upon international standard. The following information is required: land cover type/ category (e.g., forest) and/or land cover attribute (e.g., fraction of tree canopy cover), and change in land cover type/category or attribute(s).

b) Feasibility and readiness
A Land Cover Classification System (LCCS) concept for a globally applicable land cover classification and mapping has been developed in the Global Land Cover Network project originating under the precursor Africover project (Di Gregorio, 2005). It has been found suitable for scientific investigations and has been adopted as the basis for an ISO land cover classification international standard which is currently under development through the ISO Technical Committee 211. At this stage it is uncertain whether fractional land cover products and land cover change information are sufficiently mature to permit standardization; this may also depend on the level at which the standardization is approached (principles vs. specific methods, etc.)

c) Available documentation
Various relevant documents are available (refer to SBSTA, 2009a).

d) Lead group(s)
Standard preparation: Within ISO, TC211 is the lead group.
Technical input: UN FAO Natural Resources Department, Land and Water Division through GLCN is the primary group for land cover type/category mapping standardization. For fractional land cover and for satellite aspects of the monitoring procedures, the GOFC-GOLD Panel, the University of Maryland and associated groups are the main international expert bodies.

ECV Permafrost

a) Importance and urgency
Decadal changes in permafrost temperatures and depth of seasonal freezing/thawing are reliable indicators of climate change in high latitude and mountain regions. Warming may result in a reduction in the extent of permafrost and can have an impact on terrain stability, moisture and

gas fluxes, and infrastructure built on frozen ground. Standardized *in situ* measurements are essential, both to calibrate and to verify regional and global climate change. The required observations concern thermal state of permafrost, permafrost areal extent, active-layer thickness subject to annual thawing and freezing, and seasonally frozen ground.

b) Feasibility and readiness
With the existing documentation, experience and given a concentrated level of activity, the preparation of a standard should be feasible.

c) Available documentation
The measurement methods are described in diverse sources. A draft handbook resulted from an initiative by the Working Group on Periglacial Processes and Environments of the International Permafrost Association (IPA) (Humlum et al., 2003). SBSTA (2009a) lists other relevant sources.

d) Lead group(s)
Standard preparation: Permafrost monitoring is not presently dealt with in the ISO. TC 190 (Soil Quality) has a subcommittee on Physical Methods (STANDBY status). TC 182 (Geotechnics) deals with "field and laboratory testing on soil and rock" but specifically for construction/design purposes. Thus the most closely related to the measurement aspects is TC 207 (Environmental Management).
Technical input: The International Permafrost Association (IPA) and the Global Terrestrial Network for Permafrost (GTN-P; www.gtnp.org) are the principal entities that should be involved, together with associated groups, in the development of a standard for permafrost observations and reporting.

ECV Soil Moisture

a) Importance and urgency
Soil moisture is a very important environmental variable for land- atmosphere interactions as well as for agricultural and other human activities. It varies greatly in space and time, thus its measurement presents a difficult challenge. In practice, only space- based measurements are potentially capable of providing the spatial and temporal resolution required for soil moisture information to be useful for the above purposes. However, available sensing technologies can only respond to surface moisture (not soil profile), and they need to be calibrated with surface measurements. Thus both site and landscape level soil moisture information is required, and *in situ* soil moisture determination is an essential element of the overall measurement strategy.

b) Feasibility and readiness
While point soil moisture measurements are well established, the main challenge for this ECV is standardization in describing and reporting the distribution of near- surface soil moisture in support of satellite- based sensing strategies. Although methodology development in this respect has not progressed far enough to attempt standardization, a guide documenting possible approaches and their relative merits would be valuable for current and upcoming satellite missions.

c) Available documentation
Various measurement methods have been developed over time and documented in the published literature. Studies have also been conducted regarding the various methodologies and the interpretation of the measurements (refer to SBSTA, 2009a). However, no international standards or protocols have been published that deal specifically with soil moisture measurements at site or landscape levels. In the context of soil moisture as ECV the main issue is estimation of areal distribution of surface soil moisture because satellite- based estimates refer to relatively large individual cells; a key issue is therefore upscaling of point measurements to represent larger areas.

d) Lead group(s)
Standard preparation: This topic is not ready for definitive standardization. However, a guide document for upscaling options that would also address the issues with supporting measurements (e.g., sampling design) is highly desirable. Contributions to such an activity could come from international programs (e.g., GEWEX) and from projects associated with satellite soil moisture missions.
Technical input: International or national research programs contain the expertise needed for the preparation of such a guide.

ECV Leaf Area Index

a) Importance and urgency
Leaf area index (LAI) measures the amount of leaf material in an ecosystem, which imposes important controls on photosynthesis, respiration, rain interception, and other processes that link vegetation to climate. The interest in information on LAI distribution and changes has grown substantially in recent decades, due to its intrinsic importance and the emerging capability for LAI estimation over large areas using satellite measurements. Two primary measurements are required, total leaf area per unit ground area and canopy clumping index which is a measure of the heterogeneity of leaf distribution within the canopy. While direct *in situ* measurements are possible, indirect measurements are most often employed using various approaches.

b) Feasibility and readiness
The various *in situ* measurement methods have individual strengths and weaknesses and although general consensus seems to exist on the usefulness and applicability of the various approaches, no standards have been defined or accepted. However, common guidelines have been developed and used by research teams collaborating in large research programmes in various countries.

c) Available documentation
A community consensus guide for forest canopies has recently been published for indirect measurements based on remote observations (Law et al., 2008; Chen and Law, 2007). Sampling strategies for larger areas have been elaborated (Morisette et al., 2006). The performance of various measurement methods has been documented in published literature. There are no ISO standards directly applicable to LAI measurements.

d) Lead group(s)
Standard preparation: Within the ISO, TC207 is the most closely related group. The CEOS WGCV (Land Products Validation Subgroup) presently has most expertise and interest regarding LAI measurements for ECV- related purposes.
Technical input: The FLUXNET, SPECNET and VALERI research networks and the CEOS Land Products Validation Subgroup together, with associated groups, comprise the bulk of the international expertise in LAI measurement protocols.

ECV River Discharge

a) Importance and urgency
River discharge has a role in driving the climate system, as the freshwater inflow to the oceans that may influence thermohaline circulation. Its temporal trend is an indicator for climatic change and variability as it reflects changes in precipitation and evapotranspiration. It is also required for the calibration of global models, trend analysis and socio-economic investigations (GCOS, 2004). Discharge at a given time and location requires measurements of velocity of water moving through the channel profile and periodic measurements of the profile.

b) Feasibility and readiness
Given the many standards and guidance documents available, the development of a single document that would also put the others into overall context appears feasible.

c) Available documentation
Velocity measurement methods are described in WMO reports (refer to SBSTA, 2009a). ISO published many international standards that concern measurements of flow in open channels. Other publications deal with data format and exchange (SBSTA, 2009a). The WMO Commission for Hydrology (CHy) is carrying out an assessment of flow measurements and techniques (http://www.wmo.int/pages/prog/hwrp/Flow/flow_tech/index.php) which includes a collection of international and national standards and guidelines to be available on the web.

d) Lead group(s)
Standard preparation: the most suitable group appears to be ISO TC 113 (Hydrometry) due to its mandate within the ISO and the number of specific standards it already developed. The WMO CHy has been the most active group to date in preparing practical river discharge measurement guidelines for global use.
Technical input: The Global Terrestrial Network for Hydrology (GTN-H) includes representatives of various research and monitoring groups, including the WMO Hydrology and Water Resources Program (HWRP).

6.3.2 Tier 2

ECV Albedo

a) Importance and urgency

Albedo is a key variable in determining energy balance at the Earth's surface and is therefore employed in weather and climate models. Such models use parameterizations based on observations. *In situ* observations are required for the evaluation of the accuracy and reliability of the albedo products covering large areas that are derived from space measurements. They must include observations of the direct, diffuse and total incoming solar radiation as well as reflected radiation (SBSTA, 2009a). Due to the availability of standards and the ongoing collaboration and communications among active groups, the preparation of an overall standard is less urgent at this time. However, consensus needs to be developed regarding upwelling radiation measurements and the characterization of surface anisotropy.

b) Feasibility and readiness
Given the existing documentation and expertise available in active groups, the preparation of an overall standard would seem feasible.

c) Available documentation
Standards have been developed only for the measurement of the incoming (downward) solar radiation, by the World Meteorological Organization (WMO, 2008b) and by observation networks (SBSTA, 2009a). Several applicable ISO standards have also been developed (SBSTA, 2009a).

d) Lead group(s)
Standard preparation: The WMO Commission for Instruments and Methods of Observation (CIMO) is the main technical body concerned with methods for standardization.
Technical input: The CIMO includes sufficient expertise for establishing albedo measurement standards. However, it is not clear that the specific requirements of satellite programs generating albedo products have been sufficiently taken into account. These requirements are well understood by groups involved in satellite products development and validation, notably the Land Products Validation Subgroup of the CEOS Working Group on Calibration and Validation.

ECV Fraction of Absorbed Photosynthetically Active Radiation (FAPAR)

a) Importance and urgency
FAPAR measures photosynthetic activity, and indicates the presence and productivity of vegetation. Spatially-detailed descriptions of FAPAR provide information about the strength and location of terrestrial carbon sinks. Some models use FAPAR to estimate the assimilation of carbon dioxide in vegetation. FAPAR can be determined at three levels - canopy, green leaves, and chlorophyll. Due to the ongoing methodological developments and the collaboration among currently active groups, the preparation of an overall standard appears less urgent at this time.

b) Feasibility and readiness
The main issues related to *in situ* total FAPAR measurements are not concerned with the measurement itself (which is guided by WMO (2008b)) but with practical problems related to measurement and sampling design, logistics, and costs. Large research networks have accumulated significant experience in this field, such as AmeriFlux (http://public.ornl.gov/ameriflux/sop.shtml), SPECNET (http://spectralnetwork.net/), and

VALERI (www.avignon.inra.fr/valeri). AmeriFlux procedures are described in Law et al. (2008) and Chen and Law (2007). Suitable sampling strategies have also been explored (Morisette et al., 2006).

c) Available documentation

Observation programs in North America developed a consensus regarding FAPAR *in situ* measurements for forest and shrub canopies (Law et al., 2008). Proper use of specialized radiation instruments (pyranometers) is described in a World Meteorological Organization guide (WMO, 2008b). Several ISO standards for solar radiation measurements have also bee published (SBSTA, 2009a).

d) Lead group(s)

Standard preparation: The WMO Commission for Instruments and Methods of Observation (CIMO) is the main technical body concerned with methods of standardizing radiation measurements themselves. Within the ISO, TC172 (Standardization of terminology, requirements, interfaces and test methods in the field of optics and photonics) is the most closely related group. However, as noted above the radiation measurement itself is not the main challenge in standardizing the *in situ* FAPAR data acquisition. Thus the most closely related ISO group is probably TC207 (Environmental Management).

Technical input: CIMO includes sufficient expertise for establishing radiation measurement standards. Most of the expertise regarding field measurement protocols resides in the CEOS WGCV (Land Products Validation Subgroup and the Infrared and Visible Optical Sensors Subgroup), as well as in the associated projects and groups. Large science-based networks such as FLUXNET, SPECNET and VALERI should also participate in setting the required standards.

ECV Snow Cover

a) Importance and urgency

Snowfall and snow cover play a key role with respect to feedback mechanisms within the climate system (albedo, runoff, soil moisture and vegetation) and are important variables in monitoring climate change. Snow thickness and snow-cover duration affect the permafrost thermal state, the depth and timing of seasonal soil freeze/break-up, and melt on land ice and sea ice. In many regions, seasonal snowpack also supplies water essential for human activities. The following specific snow cover observations need to be made: snow cover extent, snow depth, snow water equivalent, and snow cover duration. Due to the availability of existing guidelines and ongoing activities, the preparation of an overall standard appears less urgent at this time.

b) Feasibility and readiness

The existing guides (WMO, 2008a; Fierz et al., 2008) appear to serve well both the international hydrological community and national programs. There is no present activity within the ISO related to this ECV. With the existing consensus and the available documentation of methods, the preparation of a standard should be readily feasible.

c) Available documentation

Guidelines for snow measurements have in the past been prepared by the WMO and by commissions and associations of International Union of Geodesy and Geophysics (see SBSTA, 2009a for references); the responsible groups continue to monitor new developments and undertake revisions. There may be a need to formulate a new international standard for snow measurements that would encompass both *in situ* and satellite- based measurement methodologies.

d) Lead group(s)
Standard preparation: WMO Commission on Hydrology has been the leading group in preparing documents on standardized *in situ* snow measurements. The thematically closest ISO group is probably TC207 or TC211, depending on whether the measurement itself or data handling and presentation aspects of the standard are the primary concern.
Technical input: GTN-H and its associates should be represented in the development of an *in situ* snow standard.

6.3.3 Tier 3

ECV Fire Disturbance

a) Importance and urgency
Emissions of greenhouse gases and aerosols from fires are important climate forcing factors. Fires also have a large influence on the storage and flux of carbon in the biosphere and atmosphere, can cause long-term changes in land cover and ecosystem functioning, shape landscape diversity, and influence energy flows and biogeochemical cycles. In some ecosystems, fire can lead to long-term degradation. Identification of active fires and their radiated power as well as the total burned area are the needed observations. International standardization would enable improvements in the quality and consistency of products developed by various programs or countries.

b) Feasibility and readiness
Because of the spatial and temporal dynamics of vegetation fires, satellites provide the best resource for fire detection and measurement. If made, *in situ* measurements are limited to small areas and serve to calibrate, validate and inter-compare satellite- derived products and thereby ensure their accuracy over time. No international standards have been established for satellite, aircraft or *in situ* measurement strategies. Among the many ISO standards dealing with fires, only few appear relevant (SBSTA, 2009a). Although progress has been made toward standardization of the individual variables, preparation of a comprehensive standard is not urgent, and for radiated power arguably not feasible at this time.

c) Available documentation
Standardization of *in situ* measurements in support of satellite-based fire disturbance monitoring is at an early stage of development. A burned area validation protocol was developed by the CEOS Working Group on Calibration and Validation (WGCV) Land Products Validation LPV) Subgroup (http://lpvs.gsfc.nasa.gov/PDF/BurnedAreaValidationProtocol.pdf). The various requisite methods continue to be developed as part of research efforts as well as in support of the

generation of global satellite products by several space agencies. Protocols are also beginning to be developed for high resolution validation of coarse resolution fire disturbance products.

d) Lead group(s)

Standard preparation: The CEOS WGCV Land Products Validation (LPV) Subgroup, in collaboration with the GOFC-GOLD fire team is leading the efforts to promote standardized satellite fire disturbance product validation methods. The most closely related ISO group is TC92 (Fire Safety).

Technical input: GOFC-GOLD Fire Implementation Team, the CEOS Land Products Validation Subgroup and their partners represent bulk of the expertise at the international level.

ECV Ground Water

a) Importance and urgency

Nearly 30% of the world's total freshwater resources (i.e., including snow/ice) is estimated to be stored as groundwater, and presently groundwater is the source of about one third of global water withdrawals (GCOS, 2009). One to three billion people are estimated to depend on groundwater for drinking. Global groundwater extraction grew ten-fold in the last 50 years. Groundwater storage, recharge and discharge are critical aspects of climate change impacts and adaptation. Several critical ground water variables must be considered: groundwater level, recharge and discharge, well level, and water quality.

Over the past several years, important progress has been made towards global-scale groundwater monitoring with *in situ* well observations as a foundation. With the availability of existing documentation and given that major challenges for this ECV do not include standardization, preparation of a comprehensive standard does not appear urgent.

b) Feasibility and readiness

Reconciling all the existing standards into a coherent approach would be a difficult task. However, since the measurement of water level changes is of primary importance, this more limited reconciliation should not be as difficult.

c) Available documentation

There are various sources of information describing ground water data collection methodologies. They include WMO reports (WMO, 2008a), ISO standards, a guideline on groundwater monitoring (Jousma, 2006), and various other publications by national or international agencies (refer to SBSTA, 2009a).

d) Lead group(s)

Standard preparation: The most suitable group appears to be ISO TC 113 due to its mandate within ISO, and the number of specific standards it already developed. The WMO Commission on Hydrology has much of the technical as well as user expertise.

Technical input: The International Groundwater Resources Assessment Centre (IGRAC) is probably in the best position to ensure technical inputs because of its mandate, the collaborating groups (particularly the GTN-H) and sponsors, and the projects it has undertaken to date.

ECV Lake Levels and Reservoir Storage

a) Importance and urgency

Information on changes in lake level and area is required on a monthly basis for climate assessment purposes. Globally, approximately 95% of the lake water globally is held in the 150 largest lakes (GCOS, 2004). Large open lakes are important sources of water for consumption and can have a regional impact on climate. Lake- specific area-volume curve and periodically recorded water level are the required observations.

b) Feasibility and readiness

Existing WMO and existing ISO international standards are relevant to lake level observations (refer to SBSTA (2009a) for more detail). Since the basic documents already exist, the update and integration appear readily feasible. Standards for lake and reservoir measurements have wide relevance from various perspectives – hydrological monitoring, reservoir management, water cycle studies, and climate modeling.

c) Available documentation

The measurement methods are similar to those for river discharge and are thus described in WMO technical regulations (WMO, 2006) and guides (WMO, 2008a). Numerous ISO standards have also been published (refer to SBSTA (2009a) for a list).

d) Lead group(s)

Standard preparation: Update of the WMO Guide to hydrological practices was led by the WMO Commission on Hydrology (CHy, 2008). The relevant ISO standards have been developed mostly by TC 113. Together, these groups have expertise in both the definition and the use of standards.

Technical input: In addition to the above groups, the GTN-H and its associates encompass substantial expertise regarding this ECV.

ECV Water Use

a) Importance and urgency

Freshwater plays a crucial role in food production and food security. Irrigated land contributes about 40% of total food production. Irrigated agriculture accounts for about 70% of all freshwater consumption worldwide, and more than 80% in developing countries (SBSTA, 2009c). Future food demands will require intensified production including increased irrigation of agricultural crops that is expected to raise water consumption, and hence will become more sensitive to drought. Information on the area of irrigated land and its changes as well as the amount of water used for irrigation is needed to diagnose how much changes in other terrestrial ECVs are caused by climate change, as distinct from land-use and water-use changes.

b) Feasibility and readiness

Currently, collection of data on water use is not standardized, and limited international efforts have been made in this regard. The FAO specifies input data requirements for the AQUASTAT database, and is updating the national reporting guidelines (SBSTA, 2009c).

c) Available documentation

Procedures for mapping the world's irrigated areas are discussed by Thenkabail et al. (2008). AQUASTAT information is available at http://www.fao.org/nr/water/aquastat/catalogues/index.stm.

d) Lead group(s)

The FAO and the International Water Management Institute (http://www.iwmigiam.org/info/main/index.asp) currently are the most active in the generation of global information on (agricultural) water use.

6.4 Acronyms

CEOS	Committee on Earth Observation Satellites
CIMO	Commission for Instruments and Methods of Observation
COP	Conference of the Parties
DIS	Draft International Standard
ECV	Essential Climate Variables
FAO	Food and Agriculture Organization
FAPAR	Fraction of Absorbed Photosynthetically Active Radiation
FDIS	Final Draft International Standard
GCOS	Global Climate Observing System
GEWEX	Global Energy and Water Cycle Experiment
GOFC-GOLD	Global Observation of Forest and Land Cover Dynamics
GTN-G	Global Terrestrial Network for Glaciers
GTN-H	Global Terrestrial Network for Hydrology
GTN-P	Global Terrestrial Network for Permafrost
GTOS	Global Terrestrial Observing System
HWRP	Hydrology and Water Resources Program
ICSU	International Council for Science
IEC	International Electrotechnical Commission
IGRAC	International Groundwater Resources Assessment Centre
IPA	International Permafrost Association
IS	International Standard
ISO	International Organization for Standardization
MOU	Memorandum of Understanding
JSG	Joint Steering Group
JWG	Joint Working Group
LAI	Leaf Area Index
LCCS	Land Cover Classification System
GLCN	Global Land Cover Network
LPV	Land Products Validation subgroup
MOU	Memorandum of Understanding
NMP	National Monitoring Programme
NRL	Natural Resources Department, Land and Water Division (FAO)
SBSTA	Subsidiary Body for Scientific and Technological Advice
SP	Science Programme
SPECNET	Spectral Network
TC	Technical Committee
TMB	Technical Management Board (of ISO)
UN	United Nations
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	UN Framework Convention on Climate Change
VALERI	Validation of Land European Remote sensing Instruments
WCRP	World Climate Research Programme
WG	Working Group

WGCV	Working Group on Calibration and Validation
WGMS	World Glacier Monitoring Service
WMO	World Meteorological Organization