Essential Climate Variables

John Townshend

Definition

- The Global Climate Observing System (GCOS), in consultation with its partners, developed, in 2004, the GCOS Implementation Plan at request of FCCC-SBSTA
- Provides those global observations of the Essential Climate Variables (ECVs) and their associated products that are required by the Parties to the United Nations Framework Convention on Climate Change (UNFCCC).
- CEOS has taken responsibility on behalf of space agencies to respond in terms of ensuring adequacy of satellite observations.

Purpose of GIP

- Characterize the state of the global climate system and its variability;
- Monitor the forcing of the climate system, including both natural and anthropogenic contributions;
- Support the attribution of the causes of climate change;
- Support the prediction of global climate change;
- Project the information provided by global climate models down to regional and national scales; and
- Characterize extreme events important in impact assessment and adaptation, and to assess risk and vulnerability.

GCOS/GTOS ECVs

T1 River Discharge
T2 Water Use
T3 Ground Water
T4 Lake level
T5 Snow Cover
T6 Glaciers and Ice Caps
T7 Permafrost and Seasonally-Frozen Ground

T8 Albedo
T9 Land Cover
T10 Fraction of absorbed photosynthetically active radiation - fAPAR
T11 Leaf Area Index - LAI
T12 Biomass
T13 Fire disturbance

Assembling information on ECVs

1. Identify potential sources of information. Depending on the case, these included searches of the lists of publications by
   - FAO, UNEP, UNESCO, WMO and IGBP;
   - International or important national data centers (e.g. WDCs, GOSIC, GRDC, etc.);
   - Large agencies producing or archiving terrestrial data sets (e.g. NASA, USGS);
   - Large research programmes with information available on the web (e.g. DAACs);
   - The scientific community - international scientific panels (e.g. CEOS and GTOS), international projects (e.g. GOFC-GOLD), and other international organizations or research programmes.
2. Identify documents that might be relevant to the development of standards for the terrestrial ECVs.
   - This includes documents describing standards, guidelines, measurement or processing protocols, or
   - guides that address the terrestrial ECVs directly or indirectly (e.g. documents that might contain relevant information, e.g. WMO guides dealing with hydrological measurements).
3. Obtain these documents where available (the majority through the Internet), review and extract relevant information.
4. Compile this information in a consistent format, adding conclusions and recommendations based on the reviewed materials.

Assessing the Status of the Development of Standards for the Essential Climate Variables in the Terrestrial Domain

Progress Report to the 26th Meeting of the Subsidiary Body for Scientific and Technological Advice (SBSTA)

March 2007

Prepared and submitted by the Secretariat of the Global Terrestrial Observing System (GTOS)

5.0

Status for ECVs depending on satellite observations (2007)

- In case of ECVs relying primarily on satellite measurements, the methods are evolving and often vary among programs or satellite missions.
- However, the progress towards common or comparable methodologies and products has been accelerating through various projects and CEOS-supported initiatives, especially for
  - Albedo,
  - Fraction of absorbed photosynthetically active radiation (FAPAR),
  - Leaf area index,
  - Fire disturbance,
  - Land cover
- Efforts have so far resulted in
  - best practice guidelines (e.g. for Land cover), in documents describing various measurement procedures and
  - their proper use (e.g. for Leaf area index),
  - convergence of approaches to the generation of global products (e.g. Fire disturbance).
- So far, in most cases these procedures represent the view of a scientific community (or its subset) and do not have a “formal” stamp of approval.

Guideline for the Generation of Satellite-based Datasets and Products meeting GCOS Requirements

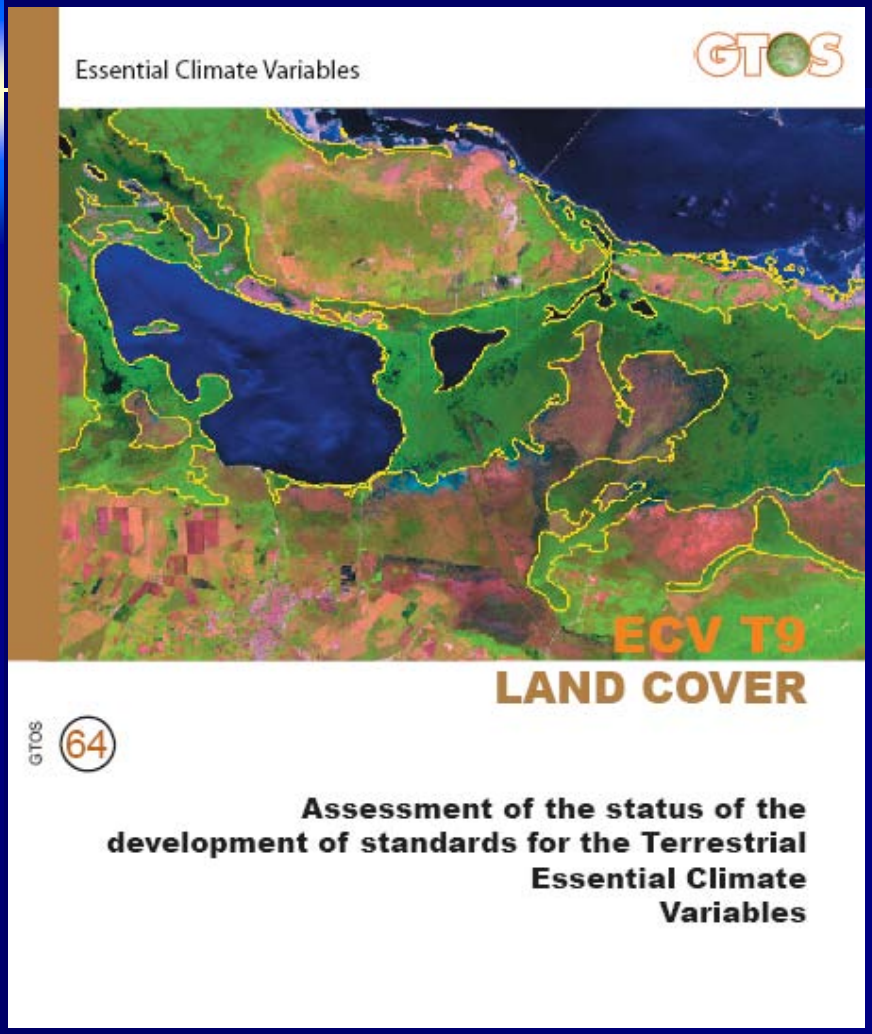
March 2009

GCOS Secretariat

Standards

- Standards for the terrestrial ECVs includes:
  - (i) the environmental variables involved;
  - (ii) the geographic coverage and diversity of these variables leading to different measurement approaches;
  - (iii) the types of documents or formats relevant to the development of standards (standards, guides, protocols, guidelines);
  - (iv) the areas in principle requiring standardization (initial measurements, data processing, analysis, final product);
  - (v) the need for *in situ* as well as satellite measurements in most cases, requiring conceptually different approaches;
  - (vi) the number and dispersal of sources where information relevant to standardization may be generated or archived
    - (national monitoring agencies, national or international research programmes, international scientific programmes, intergovernmental or international organizations, organizations focusing on standardization of measurements, world data centers), and others.

Land Cover



ECV T9: Land Cover

Assessment of the status of the development of standards for the Terrestrial Essential Climate Variables

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PLEASE NOTE THAT THE CURRENT DOCUMENT IS A DRAFT WHICH IS UNDER REVIEW AND TO BE COMPLETED. A FINAL DOCUMENT WILL BE SUBMITTED AT SBSTA 30. FEEDBACK AND COMMENTS ARE ENCOURGAED.

GTOS 64

Global Terrestrial Observing System, Rome, 2008

Land cover

- Establish international standards and specifications for the production of land-cover characterization maps.
- Produce reliable accepted methods for land-cover map accuracy assessment.
- Commit to continuous 10-30m resolution optical satellite systems with data acquisition strategies at least equivalent to the Landsat 7 mission for land cover.
- Develop an in situ reference network and apply CEOS WGCV validation protocols for land cover.
- Generate annual products documenting global land-cover characteristics at resolutions between 250m and 1km, according to internationally-agreed standards and accompanied by statistical descriptions of the maps' accuracy.
- Generate maps documenting global land cover at resolutions between 10m and 30m every 5 years, according to internationally-agreed standards and accompanied by statistical descriptions of the maps' accuracy.
- *Increasing emphasis on land cover change where standards and procedures are much less well developed.*

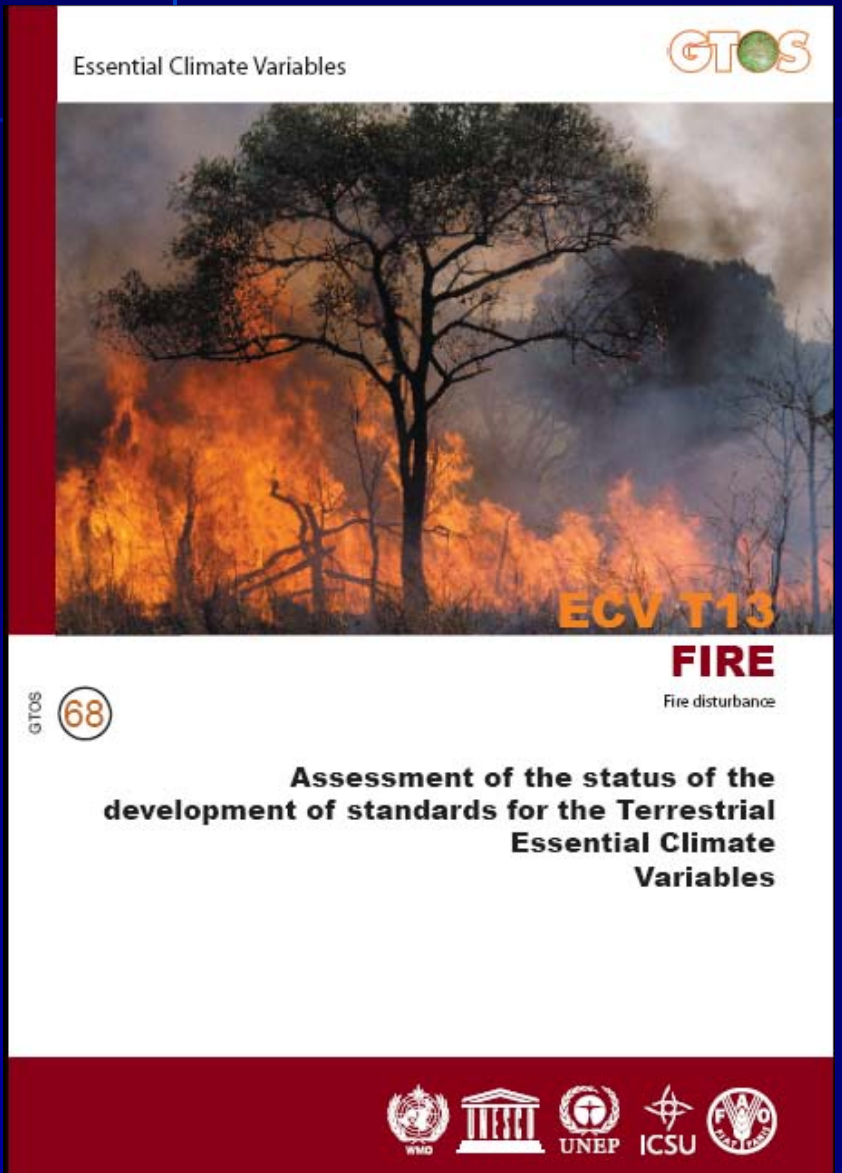
Current data, products, and capabilities

- Quasi-operational global land cover monitoring integrate information from three common observation scales:
  - moderate resolution satellite data (e.g. MODIS- or MERIS–type satellite sensor);
  - fine resolution satellite data (from LANDSAT- and SPOT-type satellite sensors), and
  - in situ observations (or very high resolution satellite data).
- Continuity of observations and consistency for land cover characterization is required for all these scales.

Current data, products, and capabilities

- The UN Land Cover Classification System (LCCS) currently provides a comprehensive, internationally accepted, and flexible framework for thematic land cover characterization. LCCS uses classifiers enabling compatibility between existing datasets and for future global monitoring systems.
- Global mapping efforts (i.e. MERIS-based GlobCover and those from MODIS) are ongoing to provide consistent and validated land cover data and land cover change indicators worldwide at moderate-resolutions.
- Land cover change estimates require multi-temporal fine resolution satellite observations. Archived image data (i.e. global Landsat mosaics) and methods are available to implement a global land cover change monitoring system. Regional and national programs (e.g. CORINE, PRODES) and international initiatives such as the Forest Resources Assessment for 2010 of the FAO use multiple data sources for regional and global assessment of historical forest change processes.
- An independent accuracy assessment using a sample of ground-reference data is an integral part of any land cover monitoring effort. Standard methods for land cover validation have been developed by the international community.

Fire Disturbance



ECV T13: Fire Disturbance

Assessment of the status of the development of standards for the Terrestrial Essential Climate Variables

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GTOS 68

Global Terrestrial Observing System, Rome, 2008

Fire recommendations

- Finalize and adopt emerging consensus methods and standards for the validation of medium and coarse resolution satellite-based fire products using higher resolution spatially explicit reference data from in situ, airborne and spaceborne observations;
- Develop standards for the inter-calibration of fire products from various sensors to enable the creation of a long-term fire disturbance data record;
- Develop multi-sensor algorithms and multi-product suites for a more comprehensive characterization of fire activity;
- Develop systematic fire products from active remote sensing data;
- Develop ground and surface fire characterization methods, particularly for areas of peat;
- Coordinate linkages between surface and atmospheric ECVs and data requirements to
- Model global fire danger, fire emissions, and a global early warning system for wildland fire at various time scales; specifically, these ECVs are:
  - atmospheric ECVs: surface temperature, precipitation, wind speed, wind direction, water vapour, upper air cloudiness
  - terrestrial ECVs: aboveground biomass, burn efficiency, and snow cover (extent, duration, depth)
- Establish linkages between fire-related surface and atmospheric impacts and corresponding ECVs.

Biomass

ECV T12: Biomass

Assessment of the status of the development of standards for the Terrestrial Essential Climate Variables

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Recommendations

- Following requirements needed to improve the reliability of biomass estimates
- Encourage agencies with in situ inventories and remote sensing data to work together to allow validation and upscaling of *in situ* measurements;
- Harmonize different methodologies for data collection and analysis of continuous, standardized and geo-referenced forest biomass inventories;
- Develop the needed in situ standards and the required international validated methodology for biomass estimation from remote sensing.
- Improve the quality and quantity of *in situ* biomass estimates used in remote sensing calibration and validation;
- Extend forest biomass inventories to tropical forests, non-commercial forests, mangroves and woodlands, and increase the number of permanent plots and the periodicity of data collection;
- Develop new or improved allometric functions for biomass estimations, conversion of above-ground biomass to total biomass, and applications suited for larger geographic areas;
- Define a single classification system to be used for remote sensing estimation of biomass; a good standard is the Land Cover Classification System (LCCS) and its accepted translations for countries;
- Produce more accurate tree height measurements from field laser and from LiDAR technology that may result in improved biomass estimates, and particularly within the framework of satellite-derived forest land cover; mechanisms are needed for increased acquisition and availability of LiDAR data over large geographic areas;

Implementation

- **Working prototypes available**
  - **Land cover and land cover change**
  - **Fire products**
- **Operational responsibilities**
  - **Partially for land cover**
  - **Partially for some fire products**
  - **But in relation to international standards for ECVs multiple deficiencies**

Do we have the right performance metrics?

- Lack of specificity in many cases as to the goals to achieve satisfactory ECVs.
  - Everything needs to be better
- Reports are overly optimistic
  - Do not deal adequately with the deficiencies in standards
  - Do not articulate how to cross the valley of death from research to operations

Need for coordination mechanisms

- Note w/o ECVs NASA, NOAA and USGS can not do their science.
- Responsibilities for ECVs largely assigned to international bodies.
- Appropriate for some tasks. But not for implementation.
- Individual agencies need to step up especially in terms of longer terms commitments.
- What tasks is the US going to commit to?
- Needs to be coordination between agencies to ensure the ECVs are generated.
- Which agencies are going to commit to what?
- Some ECVs depend on data from multiple agencies.
- Not even clear who is responsible for some data sets e.g. Landsat.
- Potential difficult transfers of responsibilities e.g. MODIS > VIIRS.
- **User community needs agencies to take their ECV responsibilities seriously by setting up an inter-agency mechanism(s) so that the scientific community gets what it needs.**

Potential New ECVs

- Land Use and Land Use Change
- Fire Radiative Power
- Socio-economic variables - key to the scientific study of adaptation and mitigation
  - Population density – ambient and residential.
  - Bounding polygons for cities, towns, villages.
  - Urban land use classes (e.g. low density residential).
  - Vectors for streets and roads.
  - 3-D models of urban centers.
  - Impervious surface area.
  - Living conditions (e.g. extent of electrification, poverty).
  - Spatial distribution of fossil fuel trace gas and aerosol emissions.
  - Spatial distribution of economic activity (e.g. GDP)
  - Agricultural crops.

URLs

- www.wmo.int/pages/prog/gcos/Publications/gcos-82_2AR.pdf
- www.wmo.int/pages/prog/gcos/Publications/gcos-92_GIP.pdf
- www.wmo.int/pages/prog/gcos/Publications/gcos-107.pdf
- www.fao.org/gtos/topcECV.html
- www.wmo.int/pages/prog/gcos/documents/GCOS_Guideline_DatasetsProducts_March2009.pdf