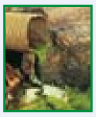
Essential Climate Variables

The Global Terrestrial Observing System (GCOS) identified 47 Essential Climate Variables (ECVs) considered to be technically and economically feasible for systematic observation. While some of the variables consist of global measurements, most represent geographically distributed data. They are divided into three categories : atmospheric, ocean, and terrestrial. Below are the 13 terrestrial ECVs

(*for more information see :* http://www.wmo.int/pages/prog/gcos/index.php?name=essentialvariables).

River discharge



Freshwater discharge from rivers into oceans influences the climate system and can affect oceanic circulation patterns. Monitoring is important to detect changes resulting from climate change.

Lake levels

Information on water volume changes and monitoring is crucial for water resources management and regional and global water-cycle studies. It can provide critical indicators of climate change in the region.

Ground water

Nearly 30 % of global freshwater resources are taken from groundwater supplies and in some developing countries this accounts for the greatest part of their supply. As a result of a changing climate and a growing population, these resources are threatened with depletion, salinization and contamination. Despite its importance, ground water is rarely monitored.

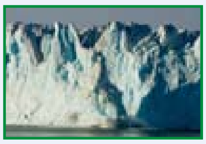
Water use

Fresh water is used in agricultural, industrial and household activities, as well as for maintaining ecosystems. In developing countries, irrigation accounts for more than 90 % of the water taken. Water is therefore crucial for food production and security, and reliable observations are essential to predict the effects of climate change on food production.

Snow cover

Over 50 % of the Earth's land surface can be covered by snow during the winter of the Northern Hemisphere. Snow affects the surface's albedo and energy balance, as well as modifying the overlying atmospheric thickness and surface temperature. Its characteristics will determine the state of permafrost (continuously frozen land), as well as the depth and timing of seasonal freezes and thaws, glaciers, ice sheets and sea ice.

Glaciers and ice caps



Glaciers react strongly to climatic changes and therefore constitute a good source for monitoring changes. Glacier shrinking could affect sea-level rise, fresh water resources and human activities.

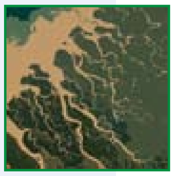
Permafrost and seasonably frozen ground

Earth materials that remain frozen for at least two years in a row are referred to as permafrost. As the globe warms, permafrost landscapes begin to thaw and erode. Permafrost temperature provides a useful indicator of terrestrial climate changes.

Albedo and reflectance anisotropy

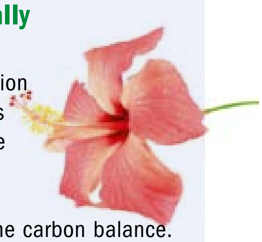
Land surface albedo is a key parameter that controls the planetary radiative energy budget. Changes in snow cover and flooding patterns for instance are linked to changes in land albedo.

Land cover



Land cover refers to the observed surface of the earth, whether vegetation or human settlements. Observations are important for ensuring a sustainable management of natural resources, understanding and mitigating climate change, addressing food security, and other important issues.

Fraction of Absorbed Photosynthetically Active Radiation (FAPAR)



Referring to the photosynthetically active radiation absorbed by vegetation canopy, FAPAR, provides a reliable variable for monitoring seasonal cycle and variability of vegetation activity related to photosynthesis. This is important for the energy balance of ecosystems and the estimation of the carbon balance.

Leaf Area Index (LAI)

Referring to the amount of leaf material in ecosystems, this variable is important for monitoring the growth and strength of vegetation on the planet.

Biomass

Biomass refers to the mass of all organic matter at a specific moment, and is affected by photosynthesis (produces biomass) and fires (destroys biomass). It acts as a carbon sink during through photosynthesis, and is increasingly used for generating bioenergy. Forests are an important source of biomass, playing a crucial role in reducing carbon dioxide and mitigating the effects of climate change. Deforestation on the other hand, is the largest source of greenhouse gas emissions in developing countries.

Fire disturbance

Fire can transform land cover as well as produce atmospheric emissions. It's also an important land management practice. This information is used for estimating atmospheric emission, developing assessments and for planning and operation of fire management and preparedness.

Measurements to know and understand our world

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Our planet is a complex, dynamic system that continuously undergoes adjustments. So how and with what certainty can we know that the earth's climate is changing, and at what speed ? How can we establish whether this rate of change is increasing or decreasing, or whether it is due to natural variability or human influence (anthropogenic variability) ?

All these questions can only be determined scientifically through systematic measurements that are then compared to historical records and the "stone tape"[1]. We therefore need to know what to measure, how, where and when to measure it.

Standards ensure that measurements and comparisons are meaningful and sustainable. For instance, by providing guidelines for

- making, documenting and interpreting measurements,
- integrating, archiving and disseminating data,
- reporting results, and
- managing processes.

ISO Technical Committee ISO/TC 211, *Geographic information/Geomatics,* is developing a suite of standards for geographic information that forms a basis upon which geomatics – the measurement of the earth – can be performed. Already, a number of standards from various ISO technical committees contribute to this task, but many remain to be developed.

Global Climate Observing System

The 2007 Nobel Peace Prize was awarded to the Intergovernmental Panel on Climate Change (IPCC) and Al Gore "for their efforts to build up and disseminate greater knowledge about man-made climate change, and to lay the foundations for the measures that are needed to counteract such change".

IPCC was established in 1988 by the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO). Its mandate is not to conduct new research or monitor climate-related data. Rather, it assesses on a comprehensive, objective, open and transparent basis the scientific, technical and socio-economic information relevant for the scientific understanding of the risk of human-induced climate change. In this way, it analyses the potential impact of climate change and options for adaptation and mitigation.[2]

To support IPCC, UNEP and WMO established the Global Climate Observing System (GCOS) in 1992, in collaboration

1) Records from the geological past embedded in glaciers, ocean and lake sediments, fossils, and growth rings in trees, coral and stalactites.

2) See : **http://www.ipcc.ch/**

with the Intergovernmental Oceanographic Commission (IOC) and the International Council for Science (ICSU). Its aim is to ensure that the observations and information necessary for addressing climate-related issues are available to all their potential users.[3)]

Cutting across disciplines

Monitoring climate change is one of the most important tasks facing humanity today. If we want to reduce or, even more difficult, to reverse, the effect that humans are having on climate, we need to know with precision the status and development of the climate. This information will allow us to understand the situation and respond adequately.

For this purpose, GCOS has identified 47 Essential Climate Variables (ECVs) that are technically and economically feasible for systematic observation. Some of these variables consist of global measurements, and most represent geographically distributed data. In such a dispersed context, geographic information standards allow ECVs to be consistently integrated, compared and represented.

Many ECVs can be measured using satellite remote sensing, but others must be determined from terrestrial, atmospheric or oceanographic sampling (in situ sampling) and can make use of sensor web standards. The standards required to measure these variables therefore cut across a variety of disciplines and must be specific to each type of measurement.

Because of its multi-disciplinarity, the task of standardization in this domain needs to be spread over several ISO technical committees and other international professional, scientific and intergovernmental organizations. Some ECVs, such as land cover, are primarily geographic and fall directly under the scope of ISO/TC 211. Others will concern other additional ISO technical committees, such as ISO/TC 207, *Environmental management,* for green house gas accounting and verification measurements. Furthermore, some variables fall under the mandate of UN organizations such as the WMO. ECVs that are geographically distributed can be addressed by a combination of measurement standards from one source, and the geographic information standards from ISO/TC 211.

In this context, the approach must involve the integration of standards from various ISO committees and external organizations into a coherent system of standards. This system would consist of a set of measurement standards within a geographic information structure. The set of measurements can be represented as a coverage.[4)]

State-of-the-art framework for measurements and data

ISO/TC 211 was established in 1994 and has currently published nearly 40 International Standards and other deliverables within the field of geographic information and geomatics. Another set of 20 is under development or revision. The work of the committee has provided a solid state-of-the-art framework for establishing, documenting, integrating, archiving, disseminating and interpreting measurements and data.

"Standards ensure that measurements and comparisons are meaningful and sustainable."

ISO/TC 211 provides a structure for representing standardized measurements in a consistent manner. It includes the geodetic framework for identifying where measurements were taken and for encoding and disseminating data (e.g. over the Internet), and metadata for documenting the provenance, history and quality of data. The ISO process for standardizing how to measure and represent ECVs, provides an open, public method for establishing necessary measurement standards.

"ISO/TC 211 standards are being used to describe data of fundamental importance to environmental policy making."

Work has already begun in ISO/TC 211 on one of the ECVs – land cover. The committee is establishing a generic classification standard for all types of coverages (as ECVs collection in this manner can vary continuously over space), as well as a standard for the representation of the Land Cover Classification System (LCCS) developed by the Environment, Climate Change, and Bioenergy Division (NRC) of the Food and Agricultural Organization of the United Nations (FAO). Mechanisms to coordinate standardization activities for ECVs among ISO, UN and others are already underway.

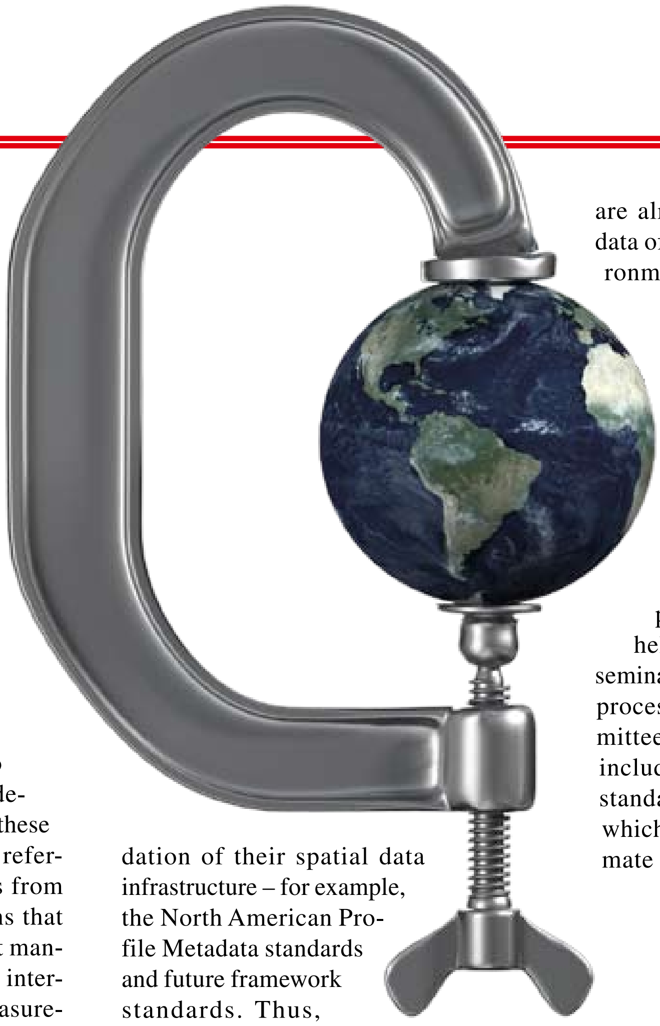
Unambiguous data description, including semantic aspects, is essential for making assertions and reasoning about our environment. The ISO 19100 family of International Standards on geographic information includes data content description requirements, as well as the services used to access this content.

The committee has a significant focus on metadata (i.e. data about data). International Standards in this area will facilitate the assessment of current data, so that user communities can establish its fitness for use, as well as the conditions for the employment and retrieval of this data.

Information about our planet can be reasonably static, as in basic topography, or very dynamic, as in weather conditions. The ISO 19100 family of International Standards allows spatial and temporal aspects to be described together precisely, including quality information that is essential for making decisions based on collected information.

3) See: http://www.wmo.ch/pages/prog/gcos/index.php?name=news

4) ISO/TC 211 has established a standard for coverages, ISO 19123:2005, Geographic information – Schema for coverage geometry and functions, which describes how attribute data is distributed over an area. Coverage data sets are formed in the same manner as other geographic data sets. The metadata may contain encoded quality information (per ISO/TS 19138) and/or sensor data. Two major aspects are the metadata standards for describing and discovery of geographic data and the web mapping standards for its distribution.



The ISO/TC 211 International Standards are already in use for a similar task in Europe. The ambitious INSPIRE programme (Infrastructure for Spatial Information in the European Community), resulting from a European directive in 2007, defines 34 spatially related themes. These include land cover, soil, land use, environmental monitoring facilities, atmospheric conditions, oceanographic geographical features, biogeographical regions, habitats and biotopes, species distribution and energy resources, to mention a few. The general guidelines and methodology to develop these specifications list as normative references 20 International Standards from the ISO 19100 series. This means that their use is not only important but mandatory in order to guarantee open, interoperable and precise data and measurement specifications.

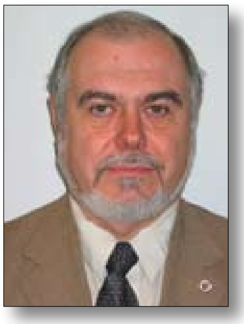
Other regions are also implementing the ISO 19100 series as the foundation of their spatial data infrastructure – for example, the North American Profile Metadata standards and future framework standards. Thus, the International Standards developed by ISO/TC 211 are already being used for describing data of fundamental importance to environmental policy making.

Enabling tools

There is an urgent need to understand the anthropogenic component of climate change. International Standards play a key enabling role in achieving this goal by allowing us to make, document and interpret climate measurements. They help us integrate, archive and disseminate data, report results and manage processes. Several ISO technical committees contribute to these standards, including ISO/TC 211 with its suite of standards for geographic information, which includes one of the essential climate variables, land cover. ■

About the authors

Olaf Østensen is the Chair of ISO/TC 211 and has been actively engaged in standards development within the field of geographic information since the early 1980s. He is the head of a technology department within the Norwegian Mapping and Cadastre Authority under the Ministry of the Environment, and is responsible for the Norwegian geoportal, an essential component of the national geospatial infrastructure serving a broad community that includes the environmental sector. Mr. Østensen has been an active contributor to the development of policies and technologies for geospatial infrastructure at the international level. He has obtained a Masters of Science.



Douglas O'Brien is Convenor of ISO/TC 211's Working Group WG 6, *Imagery*, and was instrumental in the establishment of ISO/TC 211. He is recognized internationally as a telecommunications and geomatics standards expert, active within ISO/IEC Joint Technical Committee JTC 1, *Information technology*, the International Telecommunications Union (ITU), the North Atlantic Treaty Organization (NATO) and the International Hydrographic Organization (IHO). Mr. O'Brien is President of IDON Technologies Inc., a company consulting on spatial data systems engineering. He has twice been awarded the Canadian Government's prestigious Public Service Merit Award and holds a Masters in Engineering.

Antony Cooper is Convenor of ISO/TC 211's Working Group WG 7, *Information Communities* (within which ISO 19144, *Geographic information — Classification systems*, is being developed), and Head of Delegation for South Africa to ISO/TC 211. He chairs the Commission on Geospatial Data Standards of the International Cartographic Association.
Mr. Cooper is an Operating Unit Fellow at the Council of Scientific and Industrial Research in Pretoria, South Africa.
His recent projects relate to standards, crime mapping and analysis, metadata, quality, transport modelling and modelling armour units around harbours.
He has a Masters of Science.