

FREQUENTLY ASKED QUESTIONS

1. BACKGROUND

QUESTION	ANSWER
What is GCOS?	<p>GCOS is an international programme established in 1992 by the World Meteorological Organization (WMO), the Intergovernmental Oceanographic Commission of the United Nations Educational, Scientific and Cultural Organization (IOC-UNESCO), the United Nations Environment Programme (UNEP), and the International Science Council (ISC). GCOS works to guarantee that essential observations for climate are sustained, preserved, coordinated and improved, and that access to climate data is comprehensive, free and open. GCOS is acknowledged by the United Nations Framework Convention for Climate Change (UNFCCC) as the leading independent reference in defining requirements for climate observations, and the related networks and data repositories. GCOS is responsible for identifying the principal observations to be addressed by space-based and in-situ observing systems: the Essential Climate Variables (ECVs). GCOS is governed by a Steering Committee and works through Science Panels and a Secretariat.</p>
What are Essential Climate Variables (ECVs) and how have they been used to date?	<p>An <i>ECV</i> is a physical, chemical or biological variable (or group of linked variables) that critically contributes to the characterization of Earth's climate, its changes and related impacts. Very importantly, observations of ECVs must be feasible and, and economically affordable at the global scale (Bojinski et al., 2014¹). There are currently 55 ECVs which are associated with 3 Earth system domains: atmospheric (16), oceanic (19) and terrestrial (20). GCOS experts are responsible for defining observational requirements for each of the ECV quantities.</p> <p>ECV datasets derived from in-situ and space-based observations provide the empirical evidence needed to: (i) quantify, understand and predict the evolution of climate, (ii) describe and monitor</p>

¹Bojinski et al., 2014. The concept of Essential Climate Variables in support of climate research, applications and policy.
<https://doi.org/10.1175/BAMS-D-13-00047.1>

	<p>ongoing changes, (iii) guide the mitigation and adaptation policies, (iv) assess risks and early warnings due to extreme meteorological events and enable attribution of climate events to underlying causes, and (v) underpin climate services. They are required to support the work of the UNFCCC and the IPCC.</p> <p>ECVs have facilitated the implementation of the observing system through a user-driven design process, guiding investment decisions and sustaining observations. They have been utilized to assess the observing system's fitness for purpose, identify gaps, and establish standards and global practices for long-term monitoring and related data management. Additionally, ECVs serve as a powerful communication tool, mobilizing climate observing communities.</p>
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2. ABOUT THIS REVIEW PROCESS

QUESTION	ANSWER
Why is GCOS undertaking the review of the list of ECVs?	<p>When GCOS first developed the ECVs in the late 1990s, their list of essential variables was relatively small. Over time, the list has evolved to reflect advancements in both observing systems and the complexity of climate monitoring needs. As part of an ongoing review, key questions have emerged:</p> <ul style="list-style-type: none"> • Are all 55 current ECVs still relevant? • Is the current categorization of ECVs optimal? • Are the ECVs consistently handled across the different domains? • Are the processes for adding or changing ECVs sufficiently transparent and coherent? <p>The list of the ECVs is a living topic, adaptable over time to the scientific knowledge and data needs of climate applications. It is basic good housekeeping to take stock.</p>
How does the public review work?	<p>The public review is your chance to have a say on the new list of ECVs and ECV quantities, and on the updated process for the adoption of new ECVs / ECV quantities or their modification. Please use the portal and follow the instructions there to ensure uptake of your comments. The public review will be open until the 8th of September 2025.</p>
Why should I take part in this review?	<p>To improve the ECV list and the associated governance processes we need your help. As GCOS moves forward with refining the ECV list, it is crucial that the new set of ECVs reflect the scientific community's views as to what is essential to observe and understand in our rapidly</p>

	changing climate system. Your input is invaluable to ensuring that the process is robust and well-informed.
How will you use the outputs of my review?	We will carefully consider all input received via the public review process in order to reach a final list of ECVs and ECV quantities and a final governance process. While the proposal has been prepared by a carefully selected group of experts, we fully recognize that there are gaps in expertise that need to be addressed to sharpen and hone the new approach. This is where your review comments can really help.

3. BASIC CONCEPTS AND PRINCIPLES FOR ECVs

QUESTION	ANSWER
How do you decide what makes an ECV essential?	The ECVs should constitute the minimum set of variables required to comprehensively monitor changes in the global climate system. Not everything can be deemed 'essential' otherwise the word becomes meaningless. Beyond that as outlined in Bojinski et al. (2014) measurements of the ECV must be feasible and cost-effective.
What is the difference between an ECV and an ECV quantity?	<p>An Essential Climate Variable (ECV) is a singular quantity or a collective set of well-defined quantities that critically contributes to the characterization of Earth's climate.</p> <p>An ECV quantity is a property of phenomenon, body, or substance, where the property has a magnitude that can be expressed as a number and a reference. A reference can be a measurement unit, a measurement procedure, a reference material, or a combination of such.</p> <p>An ECV may be described by one or more such quantities. ECV quantities can be physical, chemical or biological. Categorical quantities are possible (e.g. precipitation type, land cover type).</p> <p>Take the example of Lakes. Lakes is the variable or phenomenon that we want to monitor (an ECV). But an actual measurement of 'Lakes' does not exist. What we can monitor are measurable quantities such as lake water level, lake water extent or lake ice cover (ECV quantities).</p>
Can an ECV quantity be a categorical variable? (e.g., types, or 0-1)	Yes, ECV quantities can be categorical variables, i.e. representing a type or other unitless quantity. Examples are, for instance, the type of precipitation (rain, snow, hail, ...), or the type of the land surface (barren, open shrubland, evergreen needleleaf forest, ...). They can also be expressed as a percentage (e.g. sea ice concentration). Like

	<p>for all other ECV quantities, their measurements need to follow scientifically validated methods to ensure consistency and reliability, and they need to comply with the requirements set out for ECVs and ECV quantities in general.</p>
<p>Can we have an ECV quantity that results from statistics or derived from models?</p>	<p>An ECV quantity needs to be based on measurements/observations, taken either in the field (in-situ) or by remote-sensing methods (including validation with field data). Statistical analyses or models should only be applied in combination with observations and clearly need to be identified as combined/merged products.</p> <p>In addition, in agreement with VIM (international vocabulary of metrology), a quantity can be derived from a set of quantities by applying a set of noncontradictory equations (system of quantities). Then, equations, statistics or models can provide final quantities if these equations, statistics or models use quantities as inputs.</p>
<p>Can there be ECVs addressing a feature of climate that is not present across the whole globe? (e.g., sea ice)</p>	<p>Yes, an ECV does not need to be globally distributed to be considered essential. Many climate variables are regionally confined but play a critical role in the global climate system. For example, sea ice extent and thickness are key ECV quantities for understanding polar climate change and its broader impacts on ocean circulation and atmospheric circulation patterns. The essential criterion for an ECV is its significance for climate monitoring, understanding, and prediction, even if it is not present everywhere on the planet.</p>
<p>Can ECV quantities be the result of combining several measurements from different technologies?</p>	<p>Yes, because the measurement of an ECV quantity is not associated to one technology in particular, and several technologies can be used to produce a global dataset of the ECV quantity of interest. Observational requirements defined by GCOS experts represent what is required to monitor the atmosphere, ocean and land, to be met by the totality of the observing system, not by any given component,.</p> <p>Take the example of upper-air temperatures. The requirements for monitoring cannot be met by radiosondes, GNSS-Radio-occultation, hyperspectral sounders, microwave sounders or aircraft in isolation. However, the combination of these techniques can meet the requirements for climate monitoring.</p>
<p>Can a variable be an ECV if it is not a driver of climate change, but mostly reflects its impact?</p>	<p>Yes, if this variable critically contributes to the characterization of Earth's climate and its changes. Often the distinction is fuzzy. Take permafrost as an example. Measuring permafrost changes is key to understanding the changing cryosphere. But permafrost changes might presage feedbacks via release of trapped greenhouse gases that in turn affect the global climate system. Permafrost changes also have local impacts on both humans and nature.</p>

4. ON THE GOVERNANCE OF THE ECV ADOPTION PROCESS

QUESTION	ANSWER
What criteria must be fulfilled by ECVs and ECV quantities submitted for adoption?	The ECVs and ECV quantities must fulfill the criteria as laid out in the governance document. They must be critical to the monitoring of our changing climate. They must be technically feasible at a global scale. And they must be able to be made in a cost-effective manner.
Who will be in charge of the cross-domain ECVs?	The cross-domain ECVs will be jointly stewarded by members from two or more of the Panels. This will ensure that perspectives from across domains are represented. The addition of cross-domain ECVs helps to address historical issues whereby stewardship and oversight of components of these ECVs was historically carried out in complete isolation from each other by the different panels.

5. ON THE ECV LIST

QUESTION	ANSWER
Why are there “profiles” and “layers” for the ECV quantities?	The distinction between “profiles” and “layers” has several reasons. Certain ECVs or ECV quantities describe a particularly well confined part of the climate system, where observation systems exist that have been optimized for these specific parts. Examples are the atmospheric layers (e.g. troposphere, stratosphere, ...). Another reason is given by the observational capabilities. Observations of a surface ECV quantity might be referenced to slightly different absolute altitudes. The “surface” temperature is one such example. For practical reasons it is therefore clearer to speak of a “near-surface layer temperature”. The third reason is that the full description of a process in the climate system that is essential to monitor in the sense of the ECV / ECV quantity definition might require efforts specifically dedicated to instantaneously resolve a vertical distribution – aka a profile of a quantity. Examples are profiles of the temperature in, e.g., the soil or permafrost.
Why has a new group of cross-domain ECVs been created?	A few ECVs or ECV quantities fall within the scope of multiple domains and so have been considered in two or three of the three existing GCOS Expert Panels for the Atmosphere (AOPC), the Ocean (OOPC) and the Terrestrial domains (TOPC). This has led to inconsistencies in definitions of quantities and their requirements. Moving these quantities into the

	new cross-domain ECV category is an attempt to increase consistency in how these are handled and requirements are set.
Why are we proposing the deprecation of anthropogenic ECVs?	<p>Following the proposed revisions to the definitions of ECVs and ECV quantities, all existing ECVs were reassessed for consistency. Significant reservations were raised around anthropogenic ground water use because it is not mainly an indicator of climate change, this does not diminish the importance of monitoring it, but it is clearly not.</p> <p>Anthropogenic GHG fluxes have been an ongoing area of discussion around whether they are measurable globally. GCOS has consulted with Global Atmospheric Watch (GAW) programme and the proposal is that observable aspects may be moved to the new cross-panel ECV on GHG.</p>