On Essential and Shared Variables

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Introduction

This short statement is a spin-off from a community-effort facilitated recently by the World Meteorological Organization (WMO) Global Cryosphere Watch (GCW) Project Office. The community effort aimed at changing the structure of the Sea Ice Essential Climate Variable (ECV) of the Global Climate Observing System (GCOS). From lessons learned in this exercise, that was focusing on only one GCOS ECV, we formulate here some more general ideas about the concept of shared and/or essential variables, in the hope that they can contribute to more consistency between the various flavours of Essential Variables (EV) that have been prepared by various actors, including for the Arctic. We start by summarizing the sea-ice community effort towards the GCOS, then introduce the more general aspects.

The sea-ice community effort towards GCOS in 2021

The following text is adapted from the abstract to Lavergne, Kern, et al. (2022) and is a summary of the sea-ice community effort towards GCOS. *Climate observations inform about the past and present state of the climate system. They underpin climate science, feed into policies for adaptation and mitigation, and increase awareness of the impacts of climate change. WMO GCOS assesses the maturity of the required observing system and gives guidance for its development. The ECVs are central to GCOS and the global community must monitor them with the highest standards in the form of Climate Data Records (CDR). Today, a single ECV - the sea ice ECV - encapsulates all aspects of the sea-ice environment. In the early 1990s it was a single variable (sea-ice concentration) but is today an umbrella for four variables (adding thickness, edge/extent, and drift). In this contribution, we argue that GCOS should from now on consider a set of seven ECVs (sea-ice concentration, thickness, snow-depth, surface temperature, surface albedo, age, and drift). These seven ECVs are critical and cost-effective to monitor with existing satellite Earth Observation capability. We advise against placing these new variables under the umbrella of the single sea ice ECV. To start a set of distinct ECVs is indeed critical to avoid adding to the sub-optimal situation we experience today, and to reconcile the sea ice variables with the practice in other ECV domains. An upcoming opportunity for GCOS to revise its list of ECVs is with its next Implementation Plan in 2022.*

General remarks concerning Essential Variables

Some terminology is introduced upfront to avoid possible confusion in different communities. A *geo-variable* is a physical, chemical or biological variable of the Earth's environment that can be measured (e.g. air temperature, sea-ice concentration, glacier velocity, snow depth, Chl-A concentration, etc…). A *data product* holds measurements of a geo-variable; it is a particular realization of a geo-variable. There will typically be several data products of a geo-variable, from different techniques, data producers, etc… The *Essential Variables* (EVs) are a way for planning agencies, interest groups or scientific communities (hereafter referred collectively as *stewards*) to prioritize, organize, cluster, and promote the geo-variables that are of main interest for their missions. Implementation and funding agencies, operational services, and the scientific communities (hereafter referred collectively as *implementers*) use the recommendations and requirements prepared by the stewards to initiate and realize activities to prepare fit-for-purpose data products. Table 1 shows how the concepts and terminology above correspond with the case of the GCOS ECVs.

Concept	Steward	Essential Variable	Geo-variable	Implementer	Data product
Example	GCOS	ECV	ECV product	ESA, NOAA, research groups,...	CDR, ICDR

Table 1: Examples of how the concepts and terminology introduced above translate in the case of the GCOS ECVs.

A key purpose for stewards is to increase the number of state-of-the-art, sustained, fit-for-purpose data products needed to fulfill their missions. To achieve this, they use EVs as an interface to the implementers.

First concept: EVs first role : to identify a pool of geo-variables. The first role for EVs is to identify a pool of geo-variables that are of key interest to fulfill the mission of the steward. Here we use the term “pool” to stress that the selected geo-variables are each in equal focus and are seen on their own (not as clusters). Together with their users, stewards define the pool of geo-variables, define observation requirements for each of them, regularly assess the status (number and maturity for corresponding data products), and regularly highlight needed implementation actions to improve the maturity of the observation system. Implementers can be put to work to prepare data products solely on the basis of this pool of geo-variables and their requirements. This is a more “scientific” role of the EV.

Second concept: EVs second role : be tools for the stewards. Once the pool of geo-variables are put at the center of a steward’s mission (first role of the EVs), the steward may further use EVs to organize, cluster, and promote the subset of geo-variables that are key to fulfilling its mission. EVs are thus a tool, at the discretion of the steward. EVs can correspond to a single geo-variable (e.g. the sea-surface temperature ECV holds a single geo-variable: the sea-surface temperature), a group of linked variable (e.g. the sea ice ECV holds four geo-variables: sea-ice concentration, thickness, drift, extent/edge), a general concept (e.g. an EV temperature could hold any temperature geo-variable be it on land, in the sea, at the ice surface, in the upper air, etc…), a whole domain (Cryosphere, Terrestrial,

etc…), or any other organization. This second role of EVs is more of an “administrative” role, and should not directly impact the implementers.

Third concept: A steward should seek internal consistency of its EVs. Although EVs can be any grouping of geo-variables (second concept), we argue that the stewards should seek internal consistency. In particular, it might be suboptimal to have a majority of EVs corresponding to single geo-variables, and other EVs corresponding to larger collections of geo-variables. This is because implementation agencies will often operate with a “unit of funding per EV” concept, and EVs with many geo-variables will lose traction compared to single-variable EVs when they have to cover more data products with the same funding. An imbalance in the progress in developing more high-level data products and ascertaining their maturity can be the result. Another issue arises when reporting status and defining implementation actions for EVs that are groupings of geo-variables with different maturity or observation techniques. The need for internal consistency is one of the motivations behind the work of Lavergne and Kern et al. (2022) (see section 1).

Discussions about Essential and Shared Variables

In the previous section, we introduced terminology and three concepts: the first role of EVs (a pool of geo-variables), the second role of EVs (administrative organization of the pool by the steward), and internal consistency.

We think the clear distinction between the two roles of EVs can help discussions when implementers and stewards discuss the structure of the EVs, their revision (e.g. Lavergne and Kern et al., 2022), the addition of geo-variables to the pool, etc… Hopefully, this can also contribute to the discussion when the Sustaining Arctic Observing Networks (SOAN, https://www.arcticobserving.org/) now defines and populates the Essential Arctic Variables (EAVs) or Shared Arctic Variables (SAVs), one of the topics of AOS 2022 and the EU project Arctic Passion (https://arcticpassion.eu/).

With the clear distinction between the two roles EVs have in mind, we can discuss what should be “shared” between different stewards, e.g. SAON and GCOS. The geo-variables themselves (e.g. sea-ice concentration, temperature at the top of the permafrost, Chl-A concentration) are the same for the two stewards (same physical definition, same SI unit, etc…). However, which geo-variables enter the pool of Essential Variables (first role of EVs) might be different (a geo-variable might be critical for understanding the climate system, but not critical for the missions of SAON). In any case, if a geo-variable enters the pool of EVs of both SAON and GCOS, they will most certainly not have the same requirements, and thus might require different observation strategies[1]. If the pool of geo-variables is not shared, it might not be relevant to share the clustering and grouping of variables in EVs (second role of EVs).

[1] Here we note that from IP-22 (GCOS’ Implementation Plan 2022, in prep.) requirements for the ECV products can be specified as a Goal, several Breakthrough, and a Threshold value. Different applications within climate monitoring (monitoring trends, detecting extremes, driving regional reanalyses, etc…) will have different requirements. This concept could in principle be used as a bridge to other non-climate application areas (community adaptation, weather forecasting, etc…)

Take home messages

- From a series of expert meetings organized by the WMO Global Cryosphere Watch in 2022 emerged a community-proposal to 1) add missing sea-ice variables to the list of GCOS ECVs, and 2) change the structure of the Sea Ice ECV to align it with the other components domains of GCOS (Lavergne, Kern, et al., 2022).

- From this experience, we introduce here concept and terminology and define three concepts: the first role of Essential Variables (a pool of geo-variables), the second role of EVs (administrative organization of the pool by the steward), and internal consistency of the EVs. We think the clear distinction between the two roles of EVs can facilitate exchanges when implementers and stewards discuss the structure and implementation of EVs.

- We finally reflect on what could be shared in terms of EVs between two stewards, taking the Shared Arctic Variables of SAON and Essential Climate Variables of GCOS as an example.

References

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