A New Structure for the Sea Ice Essential Climate Variables of the Global Climate Observing System

A community proposal summarized by

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T. Lavergne, S. Kern, and community / 29th GCOS Steering Committee Meeting, 7-9 december 2021

Background for the proposal

- This community proposal emerges from a series of meetings organized by the WMO Global Cryosphere Watch (GCW) Project Office between June and November 2021, to which OOPC participated.

- The meetings gathered 30+ experts from the sea ice community (observers and users), on all continents and both hemispheres.

- The fully argumented proposal is being submitted to BAMS.

- This presentation summarizes the proposal for the 29th GCOS SC.

A New Structure for the Sea Ice Essential Climate Variables of the Global Climate Observing System

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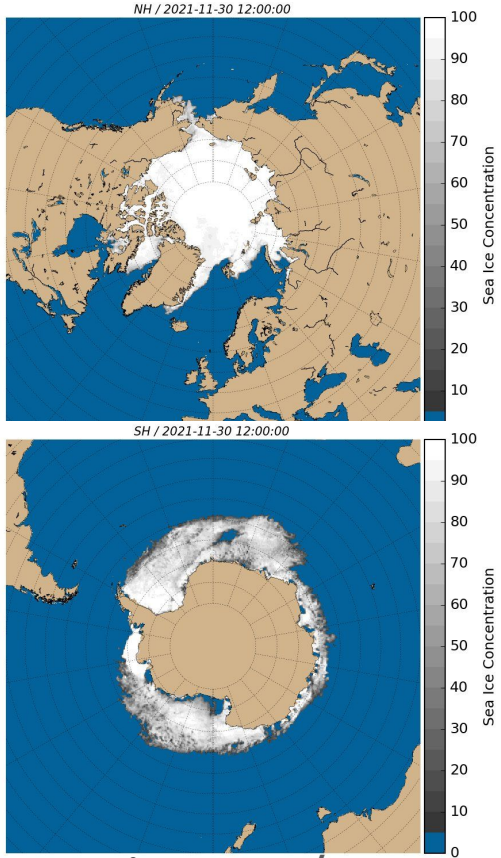
Sea ice is a key element of the climate system

Sea ice forms from sea water as a blanket between the ocean and atmosphere.

It covers between 16 and 28 million km^2 globally year-round.

In winter, it isolates the ocean against cooling by the atmosphere. In summer, it reduces the amount of solar radiation available for heating the ocean.

Its formation and melt play a key role for vertical exchange of salt and heat within the upper ocean, stratification, and for the global thermohaline circulation.



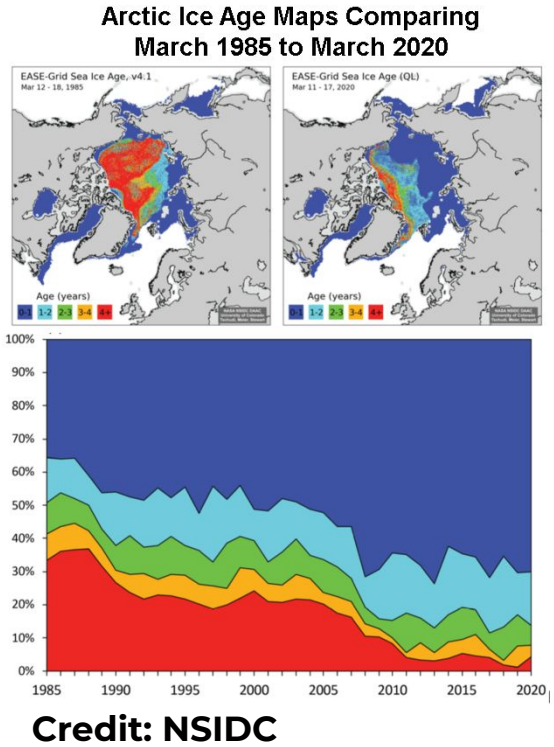
Credit: OSI SAF / CCI

Sea ice undergoes unprecedented changes (Arctic)

The Arctic warms three times as fast as the global average (AMAP, 2021).

Arctic sea ice shrinks in area and in thickness. It moves faster, and multiyear ice disappears (IPCC SROCC).

This as profound impacts. On the climate system, but also on biosphere (e.g. light availability and habitat), human populations and economic activity (e.g. landfast sea-ice, coastal permafrost erosion, polar navigation, etc...).



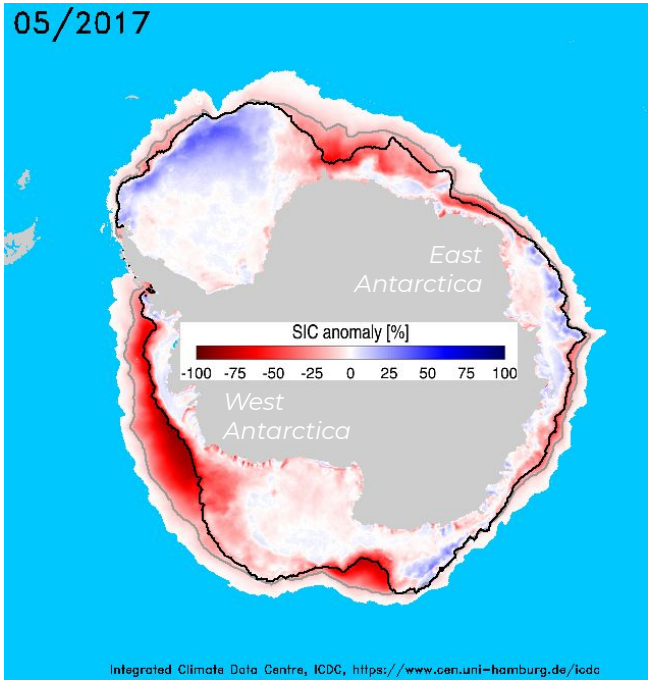
Credit: NSIDC

Sea ice undergoes unprecedented changes (Antarctic)

The overall sign of changes of the Antarctic sea-ice environment remains uncertain.

The sea-ice cover is highly variable temporally, with contrasted signals by regions.

There are documented impacts on the biosphere (e.g. primary production), deep sea formation, and stability of ice shelves and sheets (West Antarctica), thus on sea-level rise.



Credit: ICDC Hamburg

A set of seven core sea-ice variables

Sea ice is a complex environment with many geophysical variables and processes within sea ice, and with the rest of the climate system.

The sea-ice environment contributes to the climate cycles (carbon, water, enery) and biosphere, and is relevant for adaptation policies in the Arctic.

By focusing on three key processes (short-wave and long-wave radiation balance, and sea-ice mass transport), and after careful considerations -using notably proxy variables- our group concluded upon a core set of seven geophysical variables that are critical to monitor.

A set of seven core sea-ice variables

Sea ice variables			
Name and Acronym	Description	determined by	relevant for
Sea-ice concentration (SIC)	fraction of known ocean area covered by sea ice	ice formation & melt, [SID]	sea-ice area & extent, sea-ice mass
Sea-ice thickness (SIT)	vertical extent of the sea ice	thermodynamic growth & melt, [IST], dynamic processes, [SID]	sea-ice mass ISA, IST, SID
Snow depth (SND)	vertical extent of the snow on top of the sea ice	snow precipitation, accumulation ability, [SIC,SIT,AGE], metamorphism & melt [IST], aeolian redistribution [SIT,AGE]	sea-ice mass ISA, IST
Ice surface albedo (ISA)	ability to reflect solar short wave radiation	[SIT,SND,AGE]	net shortwave surface radiation balance sea-ice mass, area and extent
Ice surface temperature (IST)	ice or snow surface temperature	[SIT,SND,AGE]	net long-wave surface radiation balance physics of sea ice processes sea-ice mass, area and extent
Sea ice age (AGE)	lifetime of the sea ice since its formation	[SIT,SND,SID]	sea-ice mass ice-type fraction & distribution
Sea ice drift (SID)	lateral movement of the sea ice (transport and deformation)	[SIC,SIT], near-surface wind, ocean surface currents, surface & bottom topography,	SIT distribution, SIC, AGE surface & bottom topography

The sea ice ECV in GCOS IP-16 and its challenges

- GCOS IP-16 has one ECV, the sea ice ECV, to deal with all aspects of the sea-ice environment.
- This ECV has four ECV products:

Sea-ice concentration	Sea-ice thickness	Sea-ice extent/edge	Sea-ice drift

- Some critical variables are thus missing to adequately monitor the sea-ice environment.
- Unfortunately, the current single-ECV model has already challenges with these four variables.

The sea ice ECV in GCOS IP-2016 and its challenges

First challenge: reporting MATURITY of the observing system.

The maturity of the sea ice ECV is reported with a score of 3 in Status Report 21 (SR-21), but it is noted that the four ECV products have very different maturity levels. A single average score is not useful.

Second challenge: reporting PROGRESS on GCOS Actions.

For example “O35: Satellite sea ice” in SR-19 is reported with a score of 4 in the body of the report, but then with a long explanation in Appendix B noting that “*the score depends heavily on which ECV Product is considered*”.

The sea ice ECV in GCOS IP-2016 and its challenges

Third challenge: loosing traction in developing CDRs.

To develop the global observing system, implementation agencies take the list of GCOS ECVs (and their requirements) as aims for their funded activities.

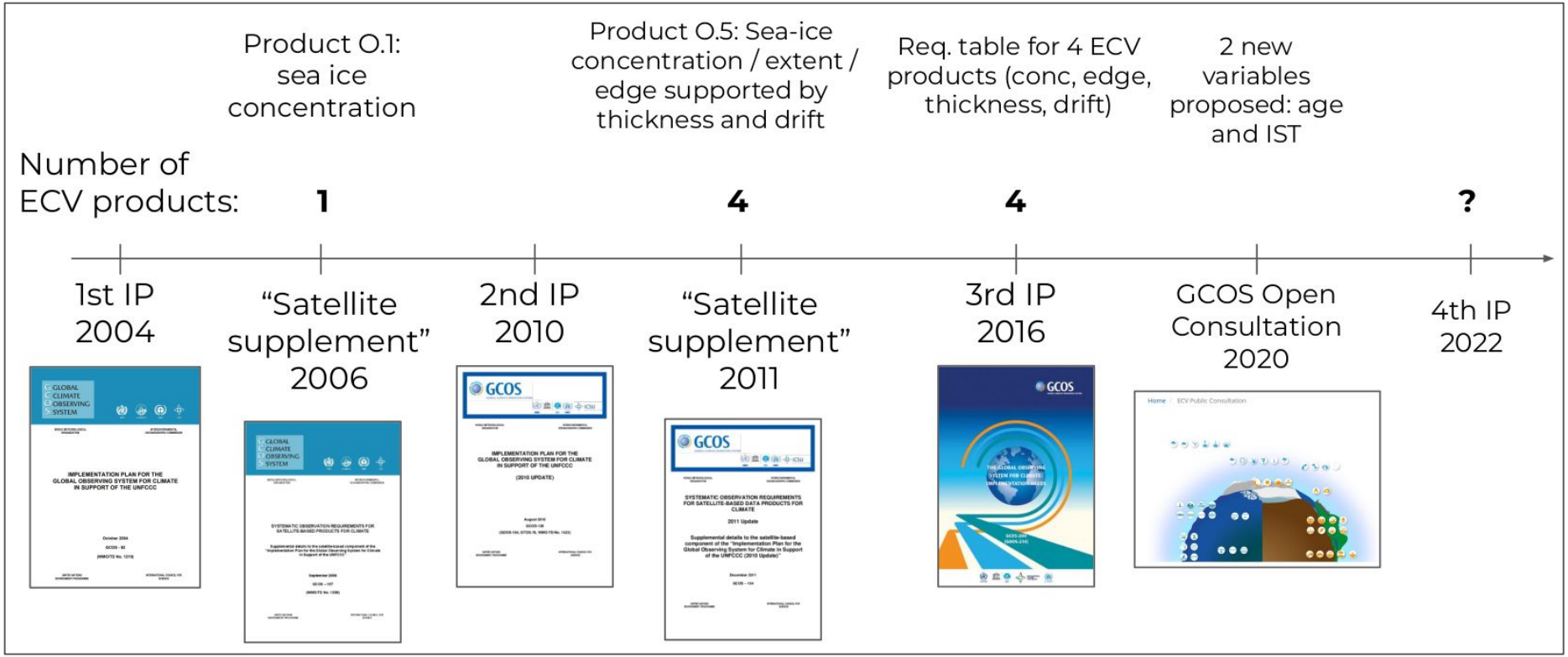
Because the funding agencies often use “one unit of funding per ECV”, ECVs with relatively many ECV products - like sea ice - loose traction, as they must cover more grounds than other ECVs.

How did we get there?

The sea ice ECV held a single, well defined variable (sea-ice concentration) in the 1st IP (2004). Now it holds four of them.

We are in today's sub-optimal situation because variables were added *into* the existing ECV (as ECV products) instead of *to the side* (initiating new ECVs).

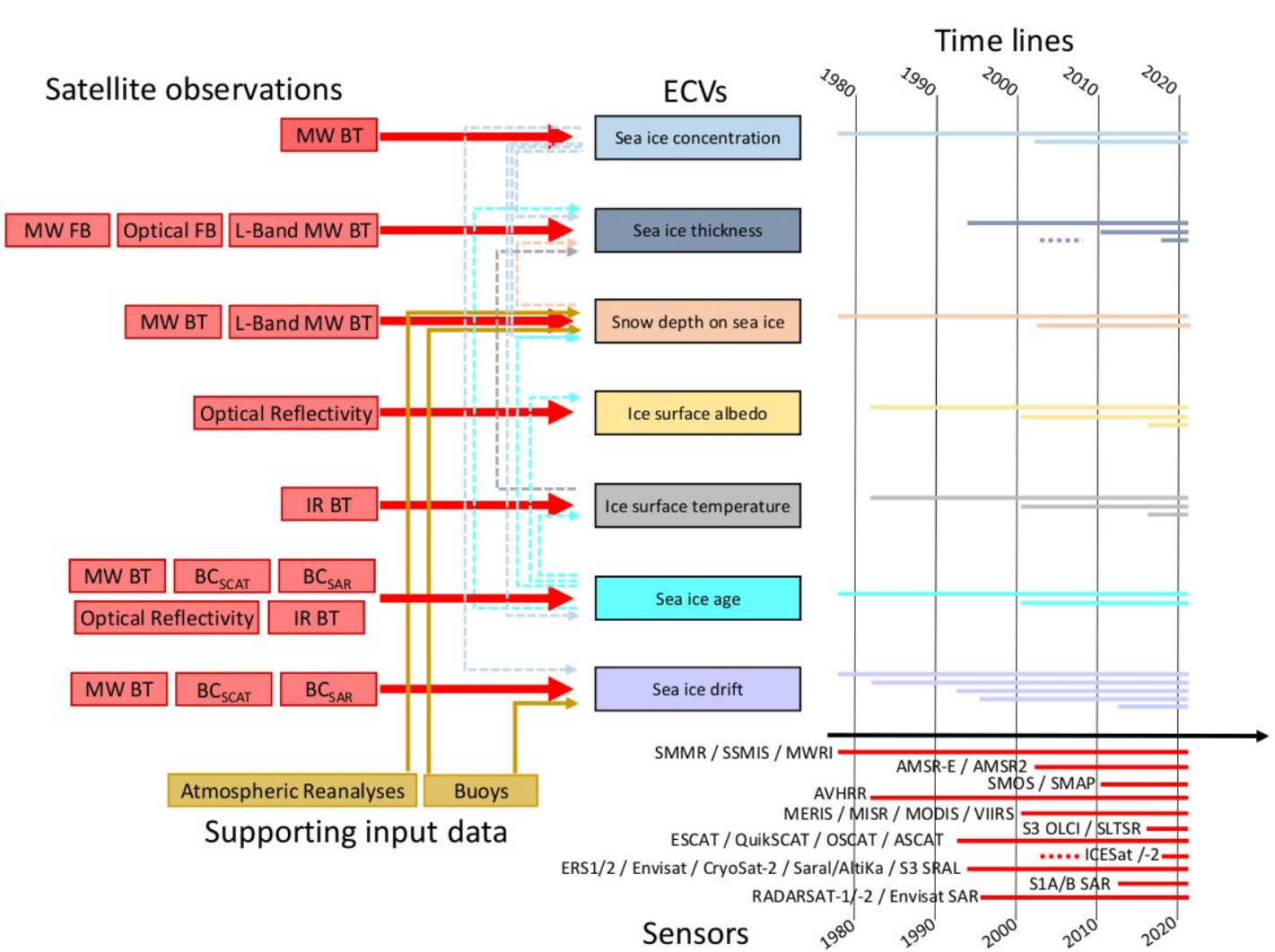
How did we get there?



Earth Observation capabilities for the seven core variables.

- Given existing satellite Earth Observation missions, the seven core sea-ice variables are *feasible* and *cost-effective* to monitor.
- We identified algorithms as well as CDRs, for all seven variables, some more mature than others.
- Satellite EO data can extend back for up to four decades, and are supported by in-situ and reanalysis data.

EO capabilities for the seven core variables.



Proposal for a new structure for the sea ice ECVs in GCOS

- The seven core sea-ice variables are *relevant* (in fact *critical*), *feasible*, and *cost-effective*. They each qualify as ECVs.

- The single-ECV model is already sub-optimal with four variables, it cannot be expanded further.

- We thus call for dismantling today's ECV, and for initiating a set of seven ECVs (sea-ice concentration, thickness, snow-depth, surface temperature, surface albedo, age, and drift).

Proposal for a new structure for the sea ice ECVs in GCOS

- Our community is understood that this proposal will at first be commented as a jump with respect to today's single-ECV model.

- At the same time, seven variables represent less than a doubling with respect to the four ECV products defined in IP-16.

- This number has been unchanged since 2011, despite the needs for these variables and the many advances in satellite EO technologies.

Further discussion of the proposal

If the seven variables are made ECV products inside the sea ice ECV, it will be in stark contrast to what is practiced in other domains of GCOS.

Right: example with the ocean surface domain.

Concept	**Ocean surface**	**Sea Ice**
motion	currents	drift
surface temperature	SST	IST
vertical extent	sea level, sea state	thickness, snow-depth
short-wave solar radiation	ocean colour	albedo
Implementation by GCOS	**individual ECVs**	**ECV products**

Further discussion of the proposal

Also, the new sea ice ECVs close critical coverage gaps in GCOS monitoring:

- Temperature: IP-16 has five temperature ECVs, but none cover sea ice. This is although the Arctic warms three times as fast as the global average. The new sea-ice surface temperature will close this gap.

- Snow: IP-16 has the Snow ECV but only for snow on land. The new snow-depth on sea ice ECV will close this gap.

- Albedo: IP-16 has the Albedo ECV but only for land surfaces. The new sea-ice albedo ECV will close this gap. This new ECV is critical to progress on Action T38: "Improve quality of snow (ice and sea ice) albedo products".

Summary of the community proposal

- Out of a series of meetings organized by the GCW Project Office in 2021, the sea-ice community proposes *A New Structure for the Sea Ice Essential Climate Variables of the Global Climate Observing System*. (*in prep.* for BAMS).

- We call for dismantling today's sea ice ECV, and for initiating a set of seven ECVs (sea-ice concentration, thickness, snow-depth, surface temperature, surface albedo, age, and drift).

- The seven variables are *relevant* (in fact *critical*), *feasible*, and *cost-effective*. Today's sub-optimal single-ECV model cannot be expanded further.

- The new structure is a chance to gather the sea-ice community and funding agencies around renewed challenges to better monitor a key element of the climate system. We can start already at IP-22.