Global Observations of the "Biosphere" (land and marine)

Background Paper for the GCOS - All Panel meeting, 18-22 March 2019.

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Targets from the GCOS IP: **Measured ECVs that are accurate enough to explain changes of the biosphere (for example, species composition, biodiversity, etc.)**

1. Background

GCOS [1] highlighted the need for coordination with respect to biodiversity-related observations, mainly with Group on Earth Observations (GEO) and Group On Earth Observations Biodiversity Observation Network (GEOBON). Its mission is "to improve the acquisition, coordination and delivery of ***biodiversity observations*** and related services to users, including decision-makers and the scientific community" and with the vision of "a global observing network of biodiversity that contributes to effective management policies for global biodiversity. and ecosystem services".

a. Terrestrial domain

The terrestrial biosphere Essential Climate Variables (ECVs) and their GCOS target requirements were mainly defined for climate change analysis purposes rather than studying ecosystems, species composition or biodiversity, per se. Beyond the preliminary application, ECVs can however be used for assessing some Essential Biodiversity Variables (EBVs) that are being defined by [2] such as the phenology, the net primary productivity (NPP), habitat structure, ecosystem extent and fragmentation etc. … The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) (https://www.ipbes.net/), an intergovernmental body, assesses the state of biodiversity and of the ecosystem services it provides to society was established in 2012 by more than 100 governments. Its membership has continued to grow as IPBES' impact has increased. The list of indicators is provided in the annex.

The EBVs and ECVs 'relations' start to be defined but further analyses are certainly needed to assess if the current ECVs measurements are good enough for terrestrial biodiversity purposes. As example, they include the FAPAR, LAI that are directly linked to vegetation canopies but concern mainly the Land Cover/Land Cover Change ones.

Updated terrestrial ECVs requirements are discussed via the TOPC Forum (https://board.geo.tuwien.ac.at/topc/index.php?p=/categories/action-plan). Note that the goal of these new requirements is mainly developed for climate change studies but also for climate adaptation purposes.

Several terrestrial monitoring networks exist for ground-based measurements, such as FLUXNET [2], long-term ecological research (LTER), terrestrial ecosystems research network (TERN), National Ecological Observatory Network (NEON) and the World Radiation Monitoring Center (WRMC) Baseline Surface Radiation Network (BSRN). For example, the LTER network information system data portal contains ecological datasets from past and present LTER sites whereas TERN measurements address biodiversity, carbon and water and soils. At the level of space Earth Observation (EO), new (pre-)operational products using past or new instruments (e.g. Copernicus Sentinels) are systematically delivered providing longer-term series and higher spatial resolution, respectively.

b. Ocean domain

The primary requirement for the design of the ocean observing system for climate is to resolve ocean variability at timescales from sub-seasonal to longer. The ocean observing system is also used to improve numerical weather prediction and operational ocean forecasting and is frequently leveraged for short-term, high-density process studies which then feed advanced understanding back into the sustained observing system design. To this end, OOPC and its sibling GOOS panels work with research groups such as the WCRP CLIVAR programme and GOOS development projects.

The Global Ocean Observing System is organized by the user-driven requirements for ECV observations for:

(a) Monitoring the climate system;

(b) Detecting and attributing climate change;

(c) Assessing impacts of, and supporting adaptation to, climate variability and change;

(d) Application to national economic development;

(e) Research to improve understanding, modelling and prediction of the climate system.

The ECV observational requirements can be satisfied in a number of different ways using a variety of sensors and observational platforms. To meet the ECV requirement and to provide the greatest resilience of the observing system, the ocean observing system is coordinated through global networks which are organized around a particular platform or observing approach (Constellations, Argo Profiling Floats, OceanSITES time-series sites, etc.) and with defined missions and implementation targets.

The composite observing networks monitor ocean ECVs globally, but do this at different temporal and spatial scales, depending on requirements and feasibility. Sustaining observations of ECVs relies on the existence of a range of different platforms and sensors, based on feasibility, building on the long-term existence of in situ and satellite components. The global ocean observing system put in place for climate also supports global weather and seasonal prediction, global and coastal ocean prediction and marine environmental monitoring. This multi-purpose aspect of the design contributes to its sustainability.

The overall systems-based design and evaluation of the observing system is overseen by OOPC in consultation with the sibling GOOS panels for biogeochemistry and biology.

2. How well do we meet the targets for biosphere (ecosystem, biodiversity…)?

a. Terrestrial domain

The uncertainties of terrestrial ECVs have been improved since the 2000s and should reach the targets in a few years. However, past raw data (from 1980 to 2000) still pose stability problems (mainly due to instrument drift and intercalibration). The biases between the different sensors can be corrected, but the uncertainties of these past data will never reach the recent ECV products ones.

One can notice that the uncertainties associated with one specific ECV from various sources, and between different ECVs, are either missing or not comparable because they do not define the same mathematical quantities. In the TOPC forum we suggest to use the same uncertainties variables to satisfy different communities.

Despite that most of the terrestrial ECVs uncertainties are not yet at the expected target levels, they can be nevertheless used through climate or land model assimilation technique as they provide information on the dynamics changes of biosphere.

b. Ocean domain

Despite recent progress in sustained observations of ECVs and in building ocean observing networks and analysis systems, these are not yet adequate to meet the specific needs of the UNFCCC. Spatial and temporal sampling requirements are not met for most ECVs and in most regions, particularly the southern hemisphere. Table 1 outlines how the ECVs have evolved since the previous Plan, which, in part, reflects the establishment of GOOS panels for biogeochemistry and biology and developments in both understanding of requirements and observing technology.

There is a pressing need to expand the monitoring capabilities as specified by the OceanObs'09 Conference by obtaining global coverage using proven technologies and to continue to develop novel observing technologies, to establish communications and data management infrastructure and to enhance ocean analysis and reanalysis capacity. Attaining and sustaining global coverage is the most significant challenge for the oceanic climate observing system. This challenge will be met only through national commitments to the global implementation and maintenance effort and with international coordination provided by GOOS, the Joint WMO-IOC Technical Commission for Oceanography and Marine Meteorology (JCOMM) and other relevant bodies.

2010 ECVs	2016 ECVs	Comments
Physical		
Temperature	Temperature	
Sea-surface temperature	Sea-surface temperature	
Salinity	Salinity	
Sea-surface salinity	Sea-surface salinity	
Current	Current	
Surface current	Surface current	
Sea level	Sea level	
Sea state	Sea state	
Sea ice	Sea ice	
	Ocean surface stress	A new ECV to capture the wind-driven component of ocean circulation and processes
	Ocean surface heat flux	A new ECV for comprehensive observations of all components of the surface heat flux
Biogeochemical		
Carbon dioxide partial pressure (surface)	Inorganic carbon	Reframed to accurately reflect current observing requirements to characterize the carbonate system; depending on the platform, a choice of ideally at least 2 variables of dissolved inorganic carbon, total alkalinity, CO_2 partial pressure (pCO_2) or pH to be observed
Carbon dioxide partial pressure (subsurface)		

Ocean acidity (surface)		
Ocean acidity (subsurface)		
Nutrients	Nutrients	Includes: nitrate, phosphate, silicate.
Oxygen	Oxygen	
Tracers	Transient tracers	Includes: sulphur hexafluoride (SF6), CFCs, C-14, tritium, helium-3.
	Nitrous oxide	A new ECV to reflect the ocean's role for nitrogen dioxide cycling
Ocean colour	Ocean colour	
Biological/ecosystems		
Phytoplankton	Plankton	Includes phytoplankton and zooplankton.
	Marine habitat properties	Includes coral cover, mangroves, sea grasses, macroalgae.

Table 1: Evolution of ocean ECVs since 2010

3. EBVs versus ECVs

GCOS IP (200) suggested the following actions:

"Review various needs (ECV, EBV, etc.) to check for overlap and try to agree common observational requirements";

"Ensure there are no temporal gaps between systems providing the same variable and that data from different observing systems (e.g. climate and biodiversity) are consistent";

and

"Promote the need for global coordination of terrestrial observations";

Recently, [5] summarized relations between EBVs and Essential Ocean Variables (EOVs) by illustrated the conceptual relationship between EOVs and EBVs with simple examples (Figure 1). EOVs (listed on the left-hand side) are broadly taxonomically focused around productivity at the base of the food chain (microbes, phytoplankton and zooplankton), higher trophic levels (benthic invertebrates; fish; TBM: marine turtles, birds, and mammals), and habitat forming species (macroalgae, seagrass, mangrove, coral). In contrast, example EBVs (listed on the left-hand column) evaluate taxa across scales of spatial and temporal diversity within species (allelic diversity, species distribution, population abundance, population structure by age/size class, phenology), across species (taxonomic diversity), and in terms of ecological context (primary productivity, secondary productivity, habitat structure, ecosystem extent / fragmentation, ecosystem composition / functional type).

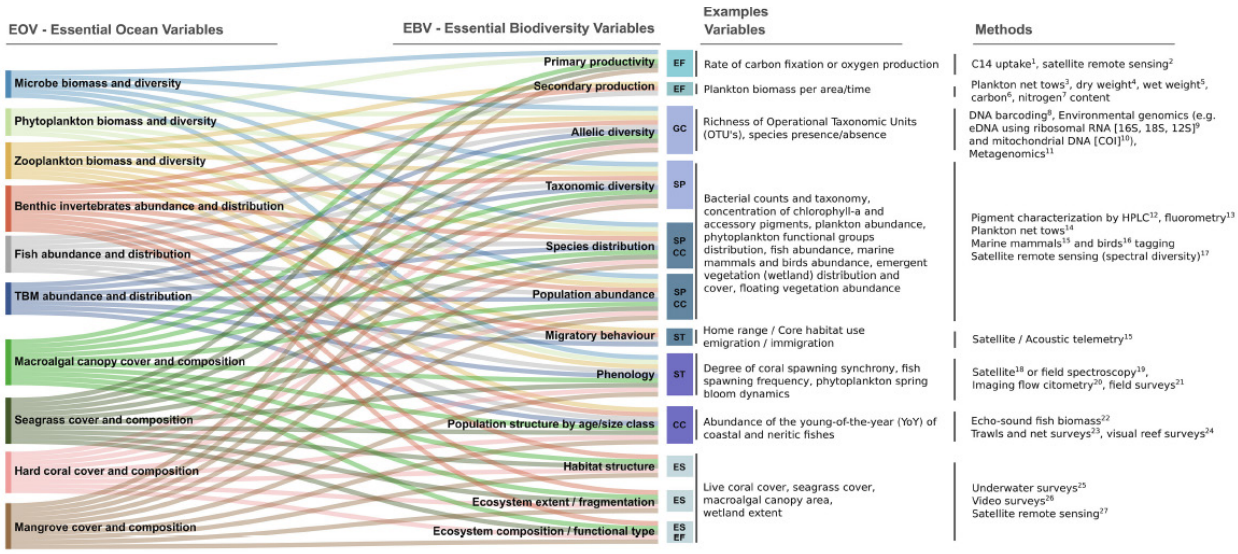

Figure 1: Ocean ECV and EBV overlap (Source: Muller-Karger et. al. 2018).

EOVs are described in [4] and EBV classes [2] shown as coloured boxes which aggregate different example EBVs, specifically: Genetic composition (GC); Species populations (SP); Species traits (ST); Community composition (CC); Ecosystem structure (ES); Ecosystem function (EF).

EBVs on primary/secondary production are directly associated with the microbe, phytoplankton, zooplankton, and fish EOVs. Other EBVs can be applied more broadly to the rest of the EOVs. References for the methods listed on the right-hand column of the diagram are given in annex at the end of this paper.

On the terrestrial domain side, several initiatives such as the Global Forest Biodiversity Initiative

https://www.gfbinitiative.org/ proposed to study and manage the world's largest tree-level forest inventory database. Thanks to the efforts of both the creation and validation within the Copernicus Global Land Service provide new biodiversity land cover maps [6].

4. Discussion and next steps (points for the meeting discussion)

There is a large gap between identifying biosphere indicators and having anything to measure against them to evaluate their quality. For most marine ECVs we simply do not have anything close to an integrated measurement system.

On the ocean side, the following steps are required:

a) Encourage existing systems to be part of a global network by adopting FAIR principles for their data

b) Develop standard operating practices so that data collected from different networks and platforms can be aggregated

c) Support cross-calibration studies so that data from networks and platforms can be analysed

d) Identify gaps (regional, technical, operational) and prioritise projects to fill them.

On the terrestrial side, there is an increase of the number of ground-based measurements data for the validation of biophysical ECVs (e.g. Copernicus GBOV service (https://land.copernicus.eu/global/gbov)) and the ESA FRM4VEG project (https://frm4veg.org/) aims at developing standards for the ground-based measurements.

Regarding the IPCC model outputs that are linked to ECVs, one should note there are some ECVs that are useful for biodiversity on their own (e.g. coral reef bleaching) and others that are of more value because they provide necessary input to climate models (e.g. carbon storage in estuarine habitats, surface albedo ...).

One question could be do we really know what is the IPCC ECVs outputs uncertainties?

Concerning the interpretation of long time series (back to 1981) of ECVs, we need to be cautious, but in many cases, we first need to identify suitable time series, if any, or make them up from overlapping but independent series .

One question is which action GCOS can take to improve these past ECVs quality? Creation of 'PastECVthlon'?

During the meeting, we should also discuss how/if both existing terrestrial and marine networks & space ECVs could play a relevant role in enhancing (monitoring?) changes of the biosphere (species composition, abundance and distribution, habitat cover and quality, timing of key ecological events, biodiversity) rather than if they are accurate enough. Suggested show cases are provide in the references list.

The questions are: which action GCOS can take to improve relations between biodiversity community and TOPC/ OOPC? How to enhance the use of ECVs by these communities? How to link ECV's uncertainties to EBV's ones?

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Show Cases (to be updated)

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Annex: Core indicators selected for use in IPBES regional assessments and global assessment (Source: https://www.ipbes.net/core-indicators)

AICHI TARGET	SPECIFIC INDICATOR	DPSIR[1]	CF[2]	GA CHAPTER	RA CHAPTER	LDRA CHAPTER	ORIGIN[3]	BIP[4]	SOURCE
4	ECOLOGICAL FOOTPRINT	P	DD	2,3,4	4	3	CBD	B	GLOBAL FOOTPRINT NETWORK
4	WATER FOOTPRINT (HUMAN APPROPRIATION OF FRESH WATER)	P	DD	2,3,4	4	3	CBD		WATER FOOTPRINT NETWORK
4	PERCENTAGE OF CATEGORY 1 NATIONS IN CITES	R	IGID	2,3,6	4,6		CBD	BP	CONVENTION ON INTERNATIONAL TRADE IN ENDANGERED SPECIES OF WILD FAUNA AND FLORA

									(CITES)
5	BIODIVERSITY HABITAT INDEX	S	DD, BEF	2,3,4	3,4	4	CBD		GEO BON - CSIRO
5, 12	SPECIES HABITAT INDEX	P,S	DD, BEF	2,3,4	3,4	4	CBD		GEO BON - MAP OF LIFE
5	FOREST AREA AS A PERCENTAGE OF TOTAL LAND AREA	S	DD, BEF	2,3,4	3,4	4	CBD	B	FAO
5	TRENDS IN FOREST EXTENT (TREE COVER)	S	DD, BEF	2,3,4	3,4	4	CBD		HANSEN ET AL., 2013
5, 7, 14	TOTAL WOOD REMOVALS	S,I	DD, NBP	2,3,4, 5,6	2,4, 5	5	FUTURE EARTH	BP	FAO

6	TRENDS IN FISHERIES CERTIFIED BY THE MARINE STEWARDSHIP COUNCIL	R	IGID	2,3,4	3,4		CBD		MARINE STEWARDSHIP COUNCIL
6	ESTIMATED FISHERIES CATCH AND FISHING EFFORT	P	DD, BEF	2,3,4	3,4		CBD		SEA AROUND US
6	PROPORTION OF FISH STOCKS WITHIN BIOLOGICALLY SUSTAINABLE LEVELS	S	BEF	2,3	3		CBD	B	FAO
6, 14	INLAND FISHERY PRODUCTION	S, I	BEF, NBP	2,3,4	2,4		FUTURE EARTH	BP	FAO
6	MARINE	S	DD,	2,3,4	3,4		FUTU	B	SEA AROUND

	TROPHIC INDEX		BEF				REEARTH		US
7	PROPORTION OF AREA OF FOREST PRODUCTION UNDER FSC AND PEFC CERTIFICATION	R	IGID, DD	2,3,4, 6	4,6	6	CBD	B	FOREST STEWARDSHIP COUNCIL (FSC), PROGRAMME FOR THE ENDORSEMENT OF FOREST CERTIFICATION (PEFC)
7	NITROGEN USE EFFICIENCY	P	DD	2,3,4	4	3	EPI		LASSALETTA ET AL., (2014) FROM ENVIRONMENTAL PERFORMANCE INDEX (EPI)
7	NITROGEN + PHOSPHATE FERTILIZERS (N+P205 TOTAL NUTRIENTS)	P	DD	2,3,4	4	3	FUTUREEARTH	BP	FAO

8	TRENDS IN PESTICIDE USE	P	DD	2,3,4	4		CBD	BP	FAO
8	TRENDS IN NITROGEN DEPOSITION	P	DD	2,3,4	4		CBD	B	INTERNATIONAL NITROGEN INITIATIVE
11	PERCENTAGE OF AREAS COVERED BY PROTECTED AREAS - MARINE, COASTAL, TERRESTRIAL, INLAND WATER	R	IGID	2,3,6	4,6		CBD	B	UNEP-WCMC, IUCN
5, 11, 12	PROTECTED AREA COVERAGE OF KEY BIODIVERSITY AREAS (INCLUDING IMPORTANT BIRD AND BIODIV	R	IGID, DD	2,3,4,6	4,6		CBD	BP	BIRDLIFE INTERNATIONAL, IUCN, ALLIANCE FOR ZERO EXTINCTION (AZE)

	ERSITY AREAS, ALLIANCE FOR ZERO EXTINCTION SITES)								
11	SPECIES PROTECTION INDEX	P, R	IGID, DD	2,3,4,6	4,6		CBD		GEO BON - MAP OF LIFE
11	PROTECTED AREA MANAGEMENT EFFECTIVENESS	R	IGID, DD, BEF	2,3,6	4,6		IPBES	BP	UNEP-WCMC
11	PROTECTED AREA CONNECTEDNESS INDEX	R	DD, IGID	2,3,4,6	4,6		CBD		GEO BON - CSIRO
12, 14	BIODIVERSITY INTACTNESS INDEX	P,S	DD, BEF	2,3,4,5	4,5	4	CBD		GEO BON - PREDICTS
12	RED LIST INDEX	S	BEF	2,3	3		CBD	B	IUCN, BIRDLIFE INTERNA

									TIONAL AND OTHER RED LIST PARTNERS
13	PROPORTION OF LOCAL BREEDS, CLASSIFIED AS BEING AT RISK, NOT-AT-RISK OR UNKNOWN LEVEL OF RISK OF EXTINCTION	S	BEF, NBP	2,3,4	2,3		CBD	B	FAO
14	PERCENTAGE OF UNDERNOURISHED PEOPLE	I	GQL	2,3,4	2	5	FUTURE EARTH	BP	FAO
17	NUMBER OF COUNTRIES WITH DEVELOPED OR	R	IGID	2,3,6	4,6		CBD	B	SECRETARIAT OF THE CONVENTION ON BIOLOGICAL DIVERSI

	REVISED NBSAPS								TY (CBD)
19	PROPORTION OF KNOWN SPECIES ASSESSED THROUGH THE IUCN RED LIST	R	IGID	2,3,6	4,6		CBD	BP	IUCN
19	SPECIES STATUS INFORMATION INDEX	R	IGID, BEF	2,3,6	4,6		CBD		GEO BON - MAP OF LIFE

[1] DPSIR - D: Drivers, P: Pressure, S: Status, I: Impact, R: Response

[2] CF (Conceptual Framework) - DD: direct driver, NBP: nature's benefit to people/ ecosystem goods and services, BEF: nature/biodiversity and ecosystem functions, IGID: institutions, governance and other indirect drivers, GQL: good quality of life/human well-being

[3] CBD: Convention of Biological Diversity SBSTTA 20 draft indicator list; Future Earth: recommended by Future Earth indicator group; EPI: used in the Yale Environmental Protection Index; IPBES: added by the IPBES Task Force for Data and Knowledge

[4] BIP (Biodiversity Indicator Partnership): B: indicators in BIP global suite, BP: data/indicator holder in BIP partnership