


Observations to explain climate-induced changes in the global biosphere

The Essential Climate Variables (ECVs) have been defined in the context of the climate system by the Global Climate Observing System (GCOS) since 2004. One ECV is a physical, chemical or biological variable or a group of linked variables that critically contributes to the characterization of Earth's climate. They were identified based on their relevance, feasibility and cost effectiveness.


Ocean Biological/ecosystems

- Marine habitat properties
- Plankton



Terrestrial Biosphere

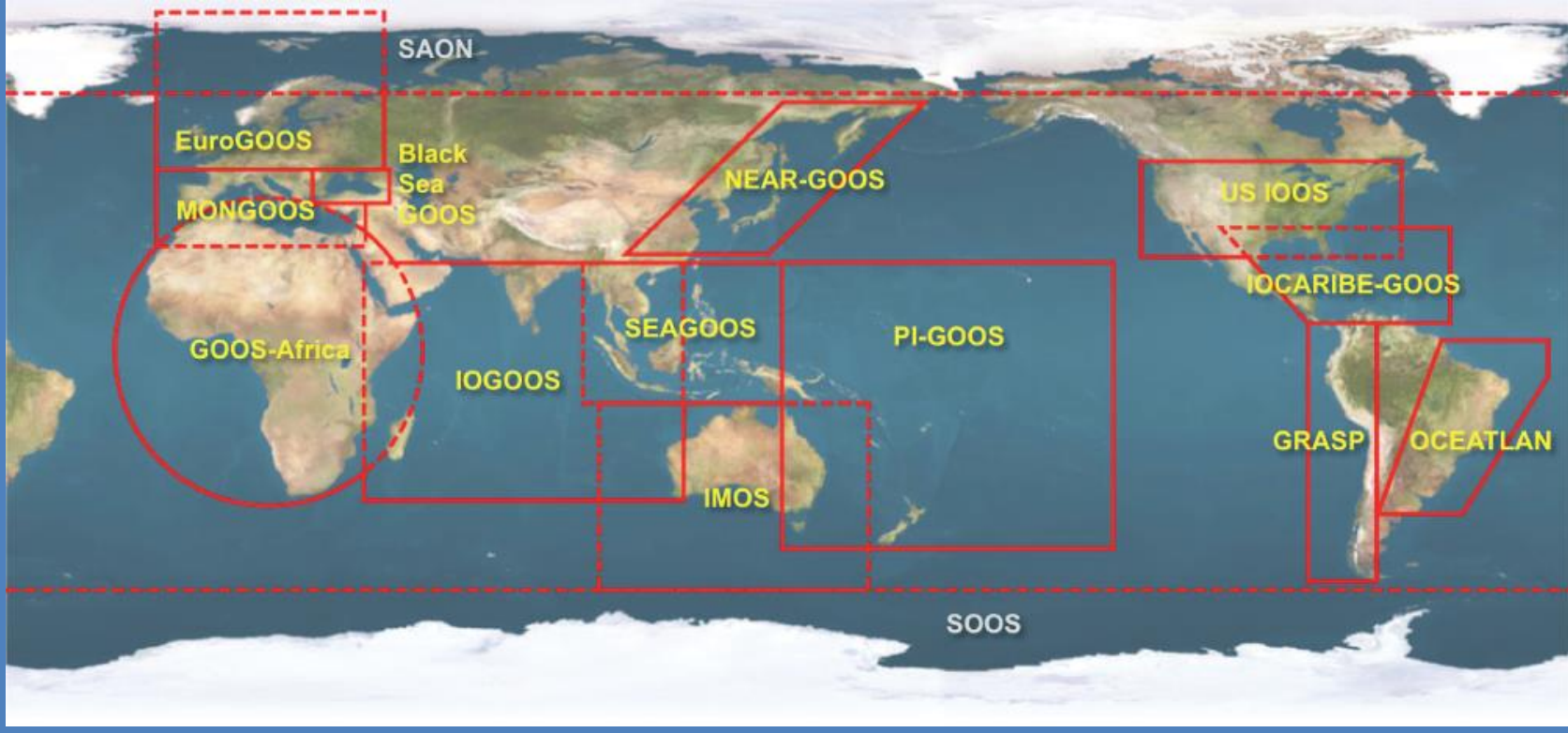
- Above-ground biomass
- Albedo
- Evaporation from land
- Fire
- Fraction of absorbed photosynthetically active radiation (FAPAR)
- Land cover
- Land surface temperature
- Leaf area index
- Soil carbon
- Soil moisture



<https://gcos.wmo.int/en/essential-climate-variables/ecv-factsheets>

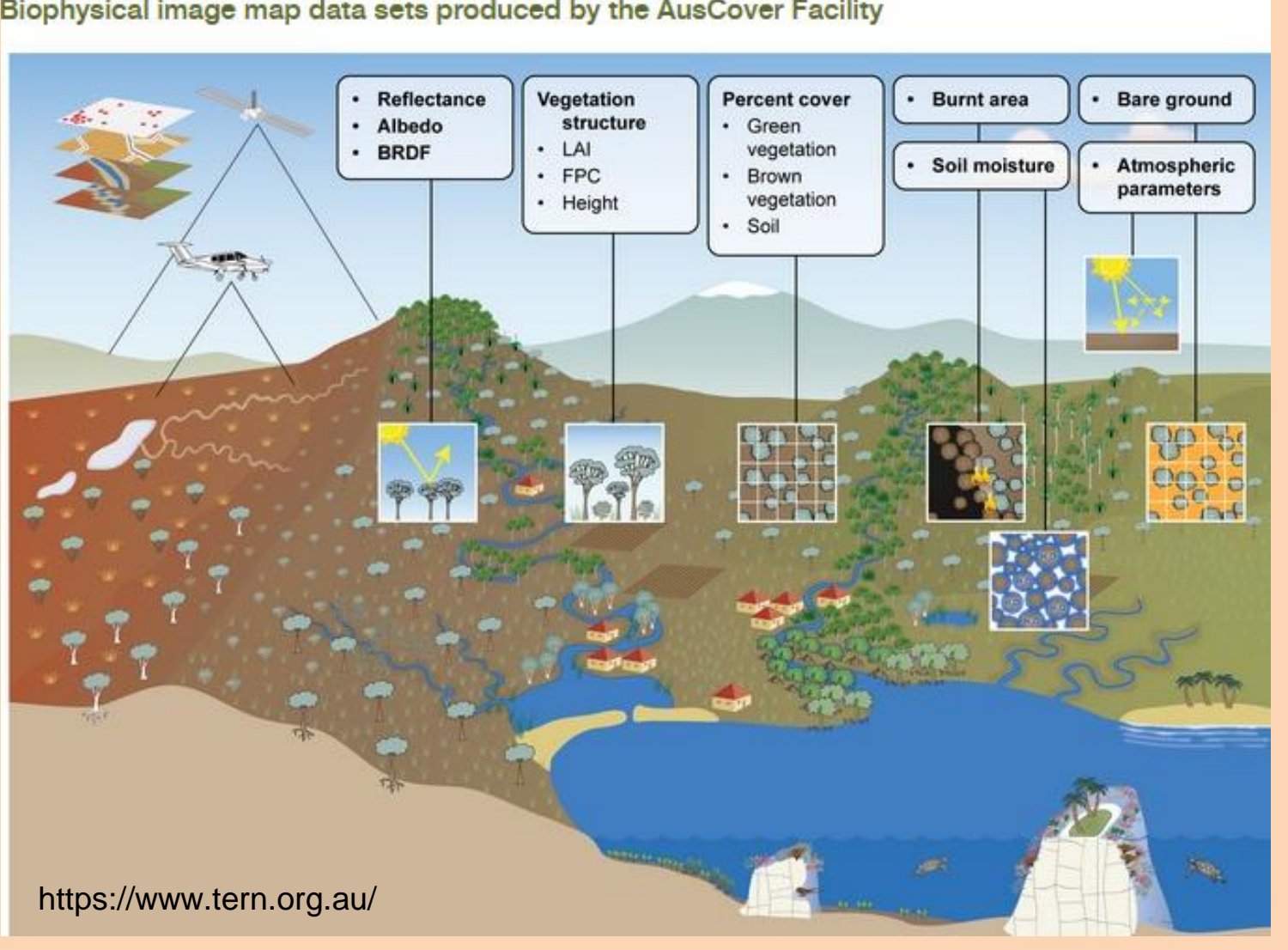
Ground-based network

Monitoring networks are regional and variable



The GOOS regional alliances formed in 1994 under Intergovernmental Oceanographic Commission of UNESCO, meet every 2 years but are of highly variable capacity and interest and omit large parts of ocean basins.

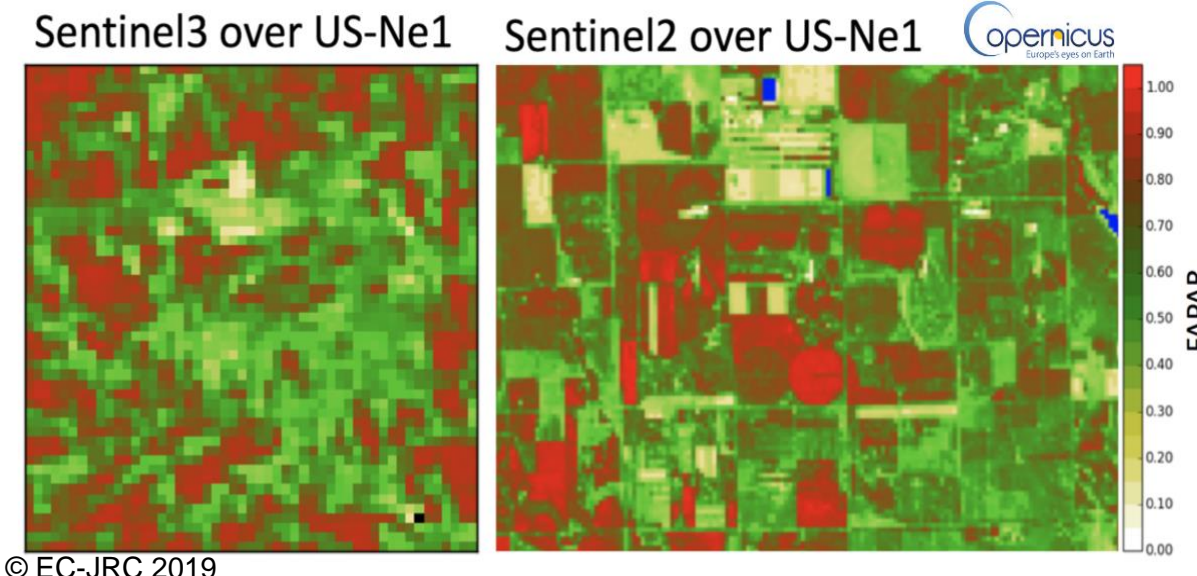
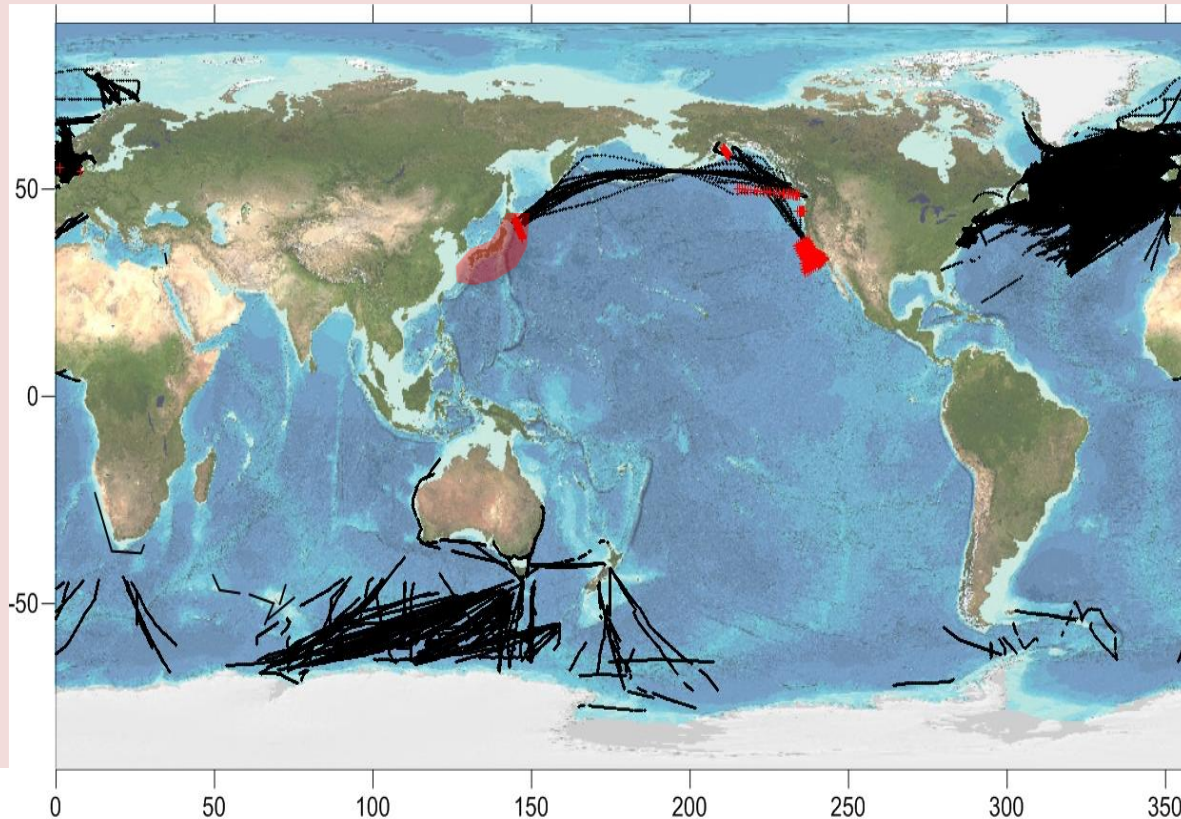
Multi-year ground-based observations are collected over a series of selected sites organized through regional or international research networks, such as SurfRad, FluxNet, NEON, ARM, BSRN, LTER, OZFlux, USRCNTERN ...



<https://www.tern.org.au/>

Space Earth Observation

New (pre-)operational products (such as NOAA Climate Data Record or Copernicus Climate Change Service) using past or new sensors are now systematically delivered providing longer-time series and higher spatial resolution, respectively.

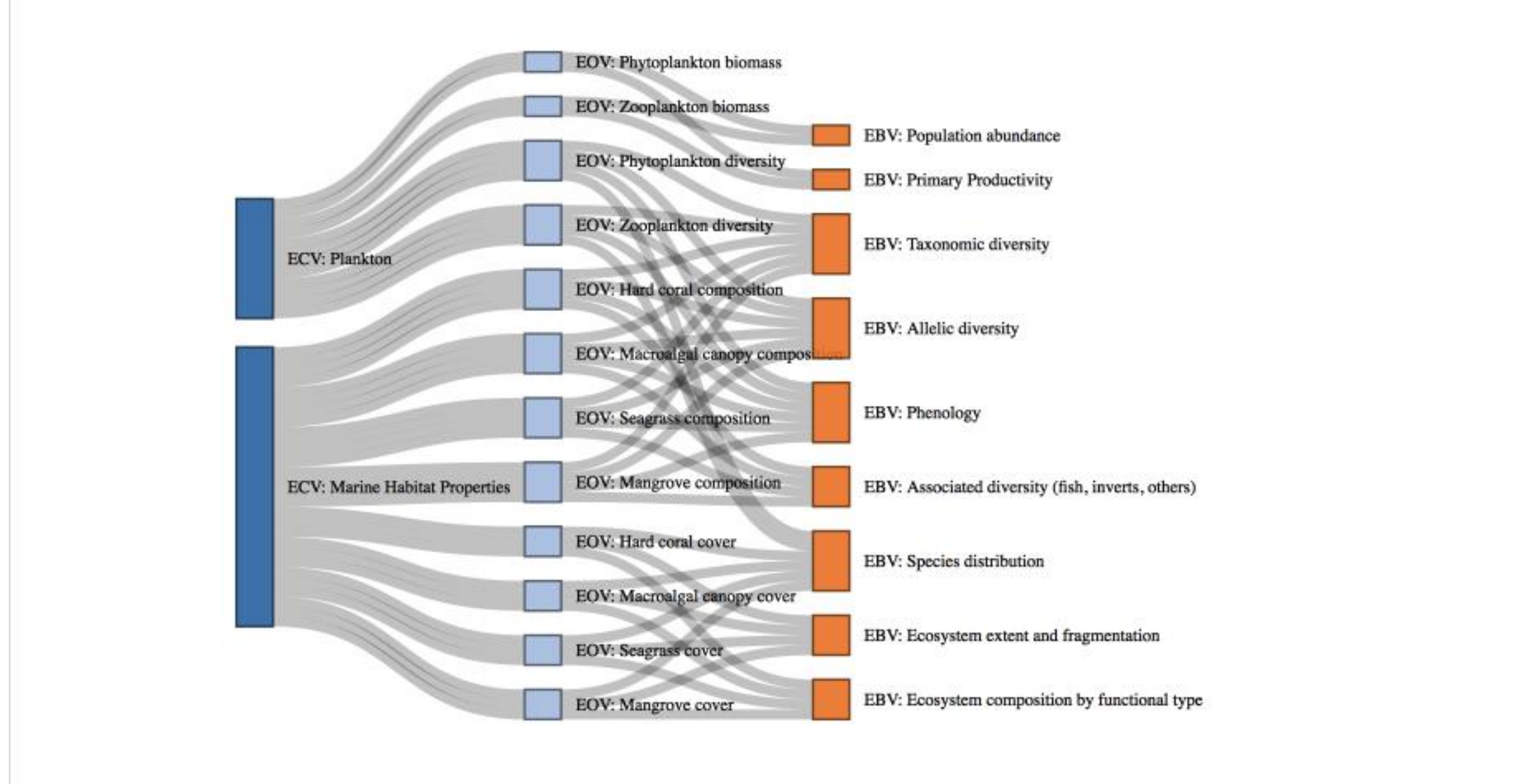
Zooplankton observations. Black points show continuous plankton recorder (CPR) samples, our longest time series (~80 years); red points indicate some of the long term zooplankton sampling stations (incomplete)

Are the measured ECVs accurate enough to explain changes of the biosphere (for example, species composition and biodiversity) ? How are the biosphere ECVs linked to species composition, biodiversity, etc. ?

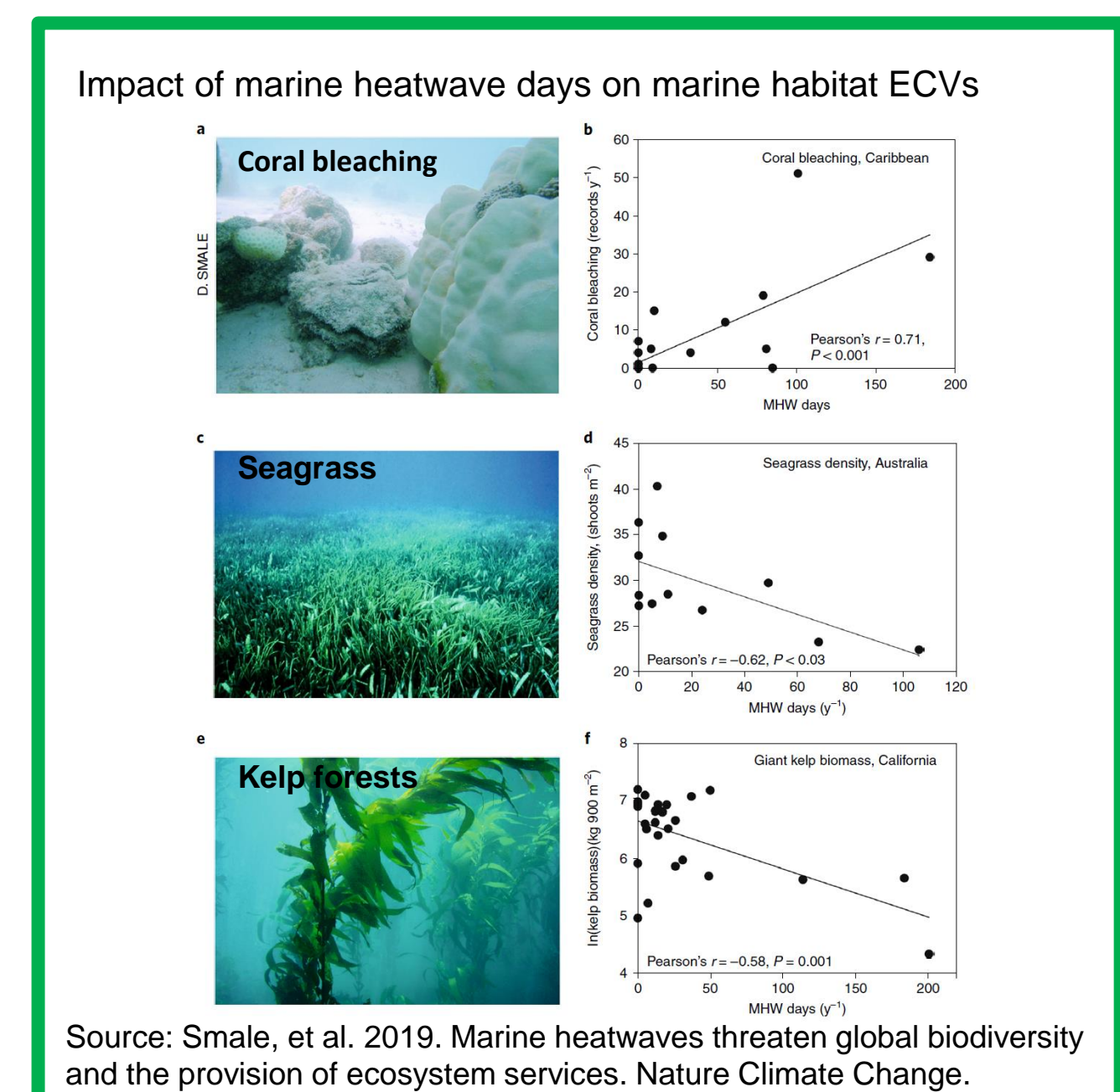
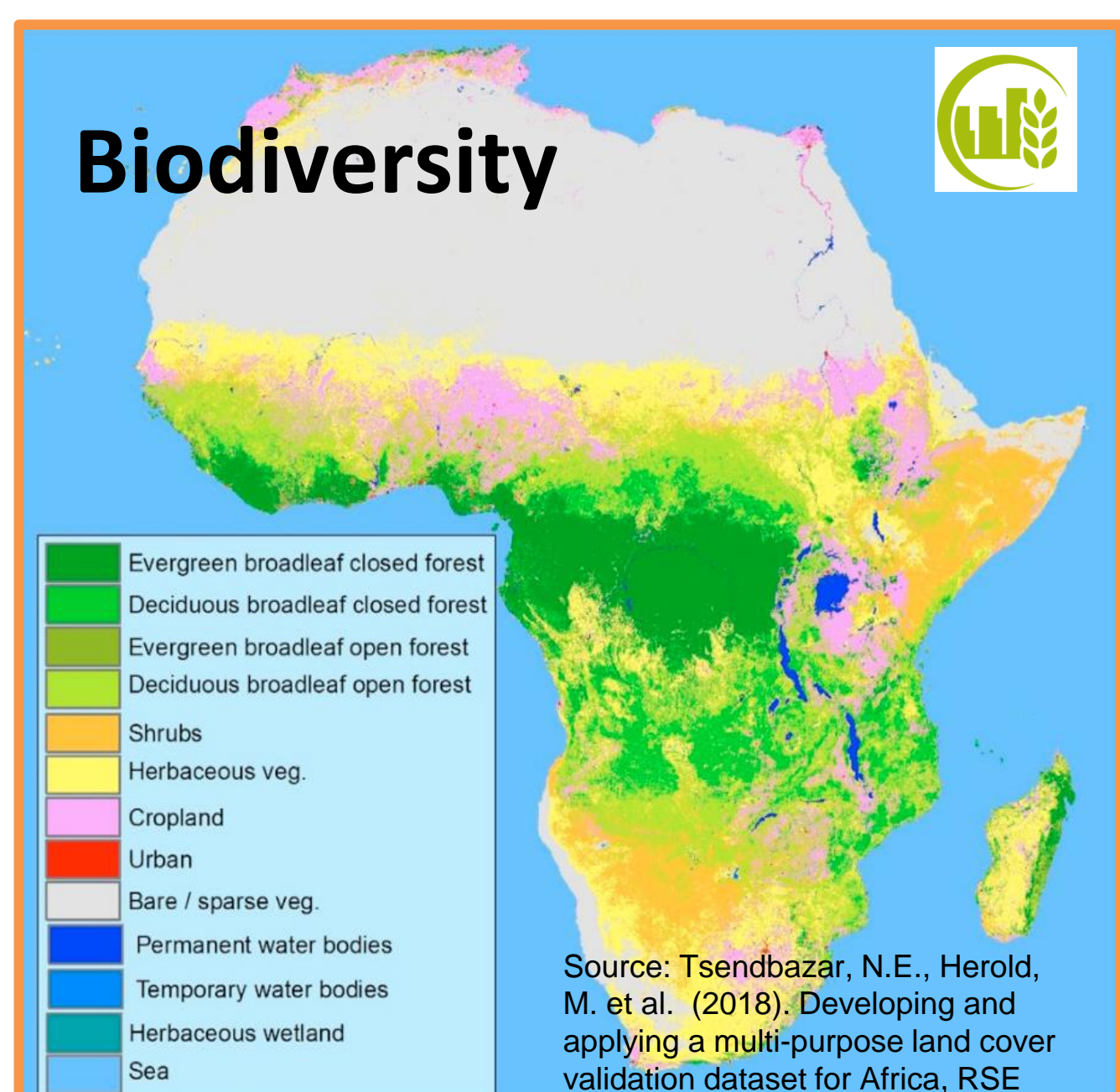
Are the biosphere ECVs sufficient to measure biological contributions to the carbon and climate cycles?

EXAMPLES OF CANDIDATE ESSENTIAL BIODIVERSITY VARIABLES					
EBV class	EBV examples	Measurement and scalability	Temporal sensitivity	Feasibility	Relevance for CBD targets and indicators (1,9)
Genetic composition	Allelic diversity	Genotypes of selected species (e.g., endangered, domesticated) at representative locations.	Generation time	Data available for many species and for several locations, but little global systematic sampling.	Targets: 12, 13. Indicators: Trends in genetic diversity of selected species and of domesticated animals and cultivated plants; RLI.
Species populations	Abundances and distributions	Counts or presence surveys for groups of species easy to monitor or important for ES, over an extensive network of sites, complemented with incidental data.	1 to >10 years	Standardized counts under way for some taxa but geographically restricted. Presence data collected for more taxa. Ongoing data integration efforts (Global Biodiversity Information Facility, Map of Life).	Targets: 4, 5, 6, 7, 8, 9, 10, 11, 12, 14, 15. Indicators: LPI; WBI; RLI; population and extinction risk trends of target species, forest specialists in forests under restoration, and species that provide ES; trends in invasive alien species; trends in climatic impacts on populations.
Species traits	Phenology	Timing of leaf coloration by RS, with in situ validation.	1 year	Several ongoing initiatives (Phenological Eyes Network, PhenoCam, etc.).	Targets: 10, 15. Indicators: Trends in extent and rate of shifts of boundaries of vulnerable ecosystems.
Community composition	Taxonomic diversity	Consistent multitaxa surveys and metagenomics at select locations.	5 to >10 years	Ongoing at intensive monitoring sites (opportunities for expansion). Metagenomics and hyperspectral RS emerging.	Targets: 8, 10, 14. Indicators: Trends in condition and vulnerability of ecosystems; trends in climatic impacts on community composition.
Ecosystem structure	Habitat structure	RS of cover (or biomass) by height (or depth) globally or regionally.	1 to 5 years	Global terrestrial maps available with RS (e.g., Light Detection and Ranging). Marine and freshwater habitats mapped by combining RS and in situ data.	Targets: 5, 11, 14, 15. Indicators: Extent of forest and forest types; mangrove extent; seagrass extent; extent of habitats that provide carbon storage.
Ecosystem function	Nutrient retention	Nutrient output/input ratios measured at select locations. Combine with RS to model regionally.	1 year	Intensive monitoring sites exist for N saturation in acid-deposition areas and P retention in affected rivers.	Targets: 5, 8, 14. Indicators: Trends in delivery of multiple ES; trends in condition and vulnerability of ecosystems.

Source: H. M. Pereira et al. 2013 *Science* 339 (6117), 277-278.



Ocean observing communities including GOOS and MBON are working together to develop a global ocean observing system for biology, linking ECVs, EOVs and EBVs that will deliver to the many societal needs including climate.



Increasingly rapid progress in both land and marine global observations of the biosphere; Several ECVs are sufficient to explain some biosphere changes; Connections between ECVs, EOVs and EBVs and collaborations between observing communities are growing, including linking the terrestrial Essential Variable systems.

Authors:
Nadine Gobron¹ and Nic Bax²
1 European Commission Joint Research Center, Ispra, Italy
2 CSIRO Oceans&Atmosphere, Hobart, Australia