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

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European Commission

Explain changing conditions of the biosphere

- **Are the measured ECVs accurate enough to explain changes of the biosphere (for example, species composition, biodiversity, etc.)?**

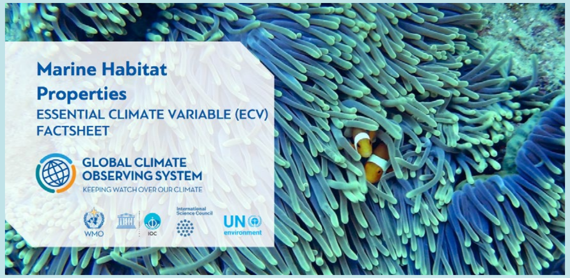
- **How are the biosphere ECVs linked to species composition, biodiversity, etc.?**

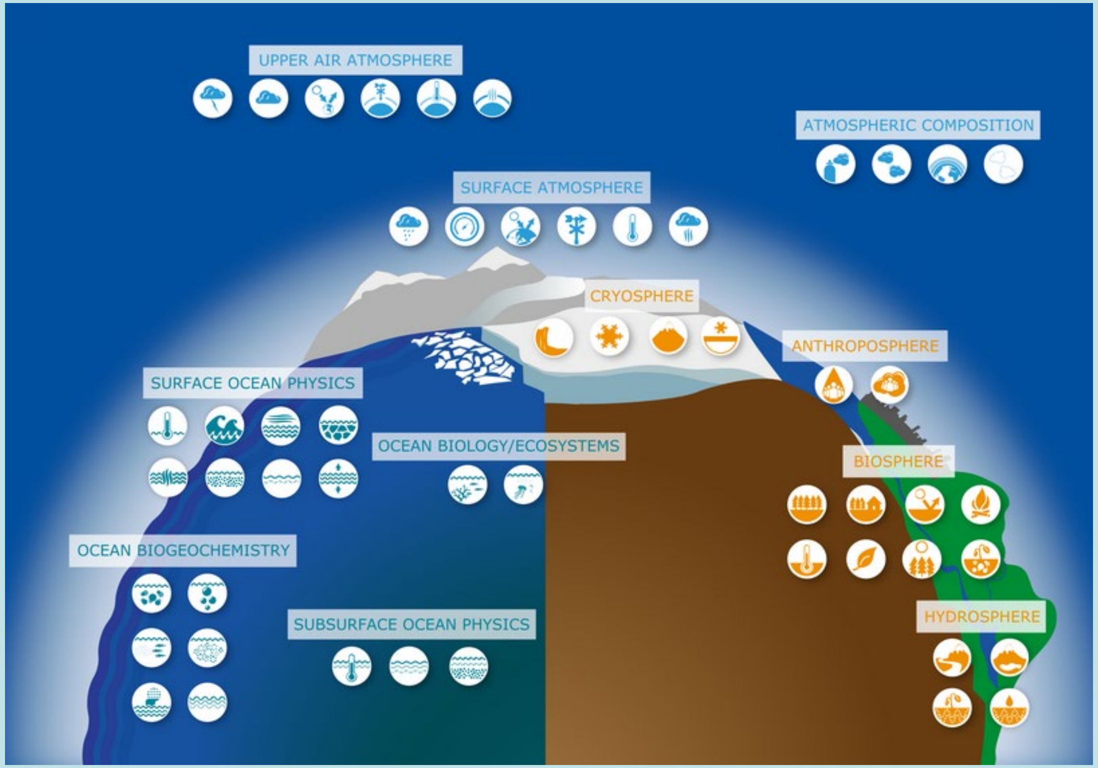
- **Are the biosphere ECVs sufficient to measure biological contributions to the carbon and climate cycles?**

Biosphere GCOS ECVs

Biological/ecosystems

- Marine habitat properties
- Plankton





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

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

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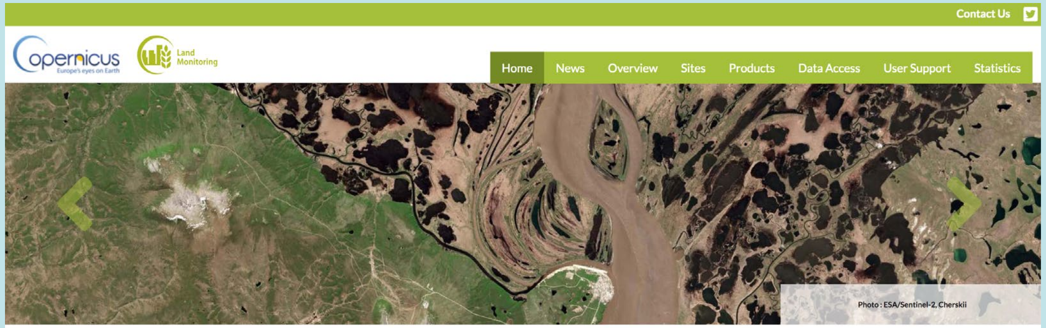
Ground-based Network (Land)

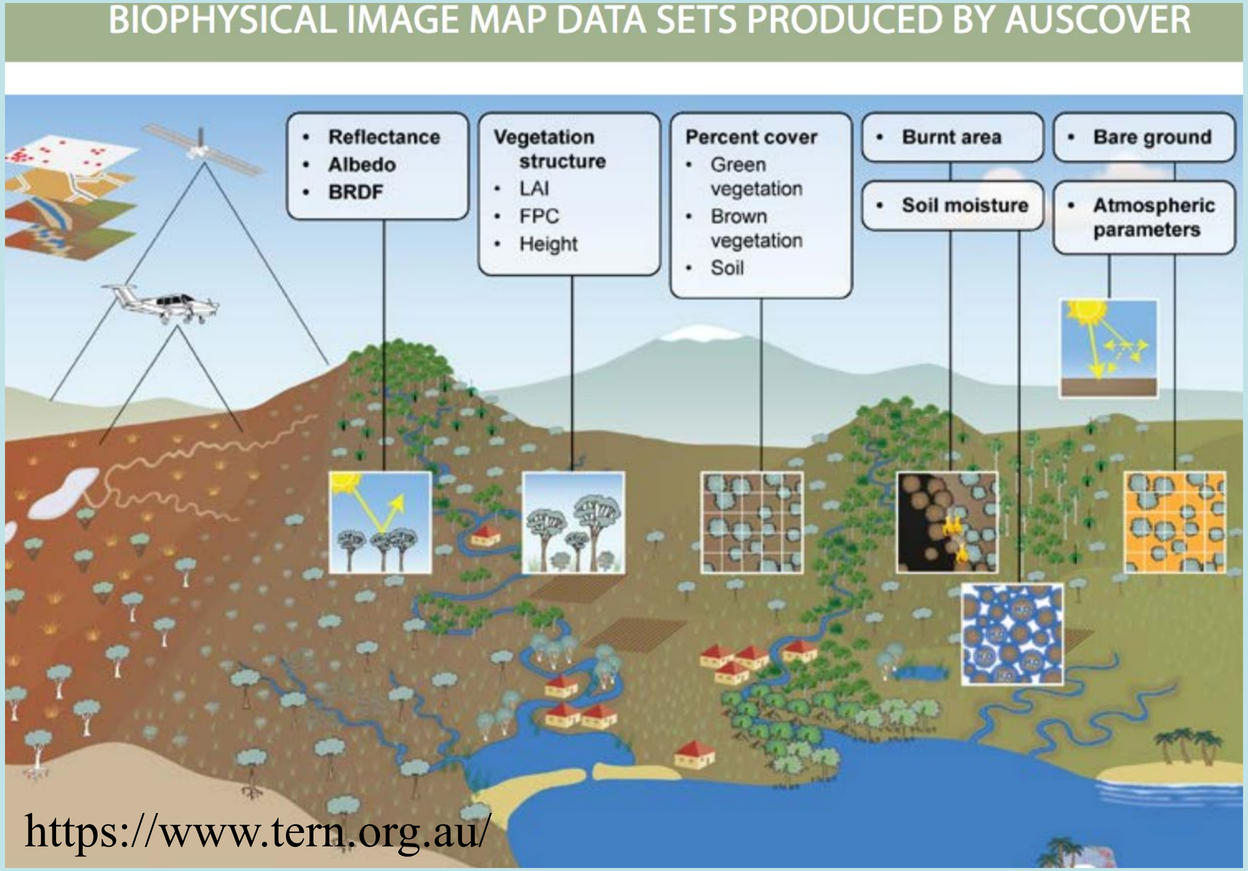
Multi-year of ground-based observations are collected over a series of selected sites organized through regional or international research networks, such as

SurfRad, FluxNet, NEON, ARM, BSRN, LTER, TERN, OZFlux, USRCN …



Ground-Based Observations for Validation (GBOV) of Copernicus Global Land Products

https://land.copernicus.eu/global/gbov



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

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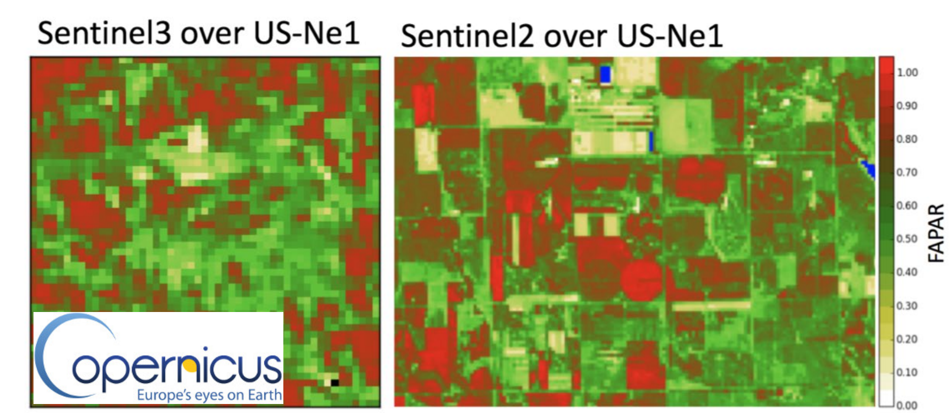
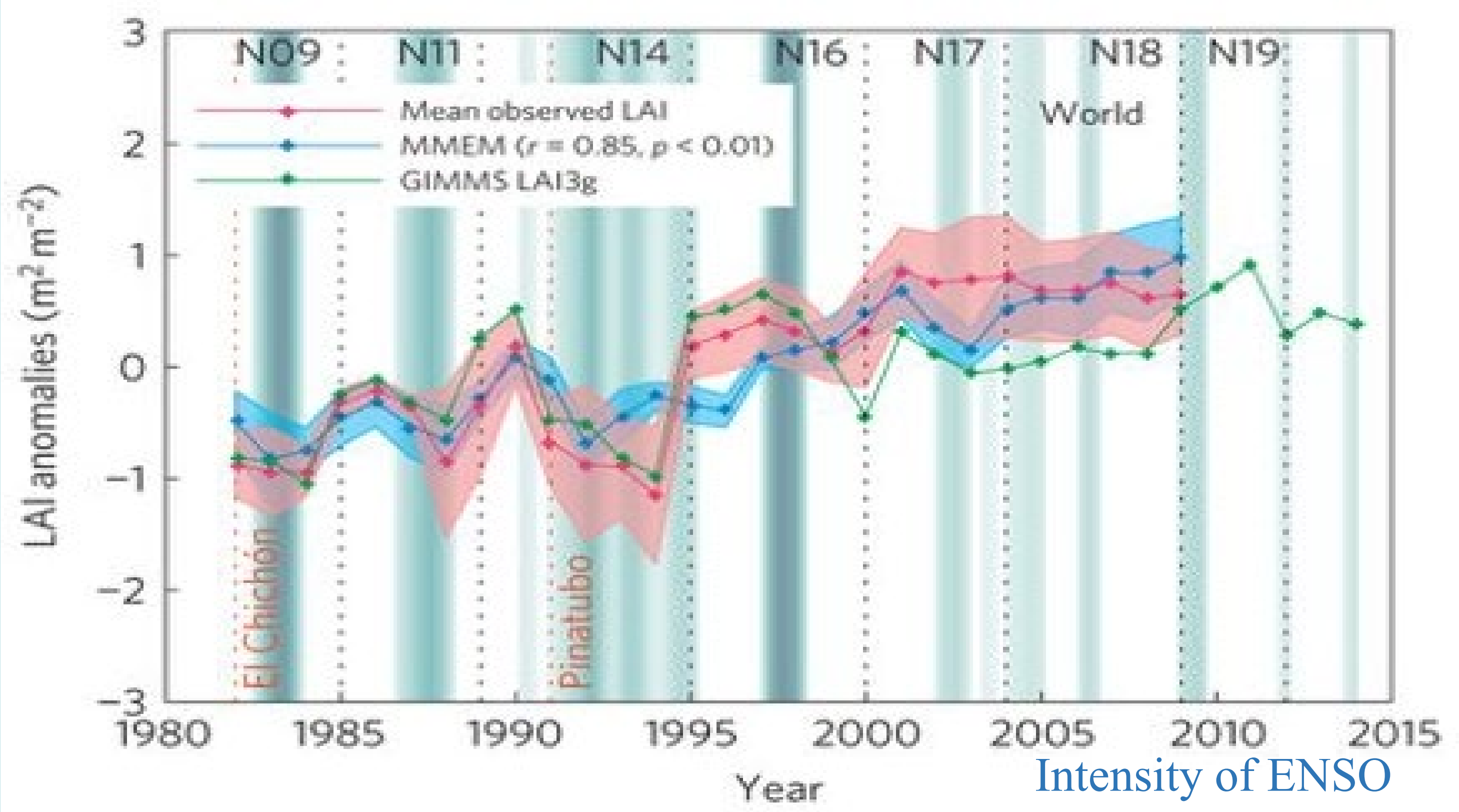
Space Earth Observation (Land)

New (pre-)operational products (such as NOAA CDR or C3S) using past or new sensors are now systematically delivered providing longer-time series and higher spatial resolution, respectively.





Zhu et. al., 2016, Nature Climate Change

Terrestrial Biosphere ECVs Uncertainties

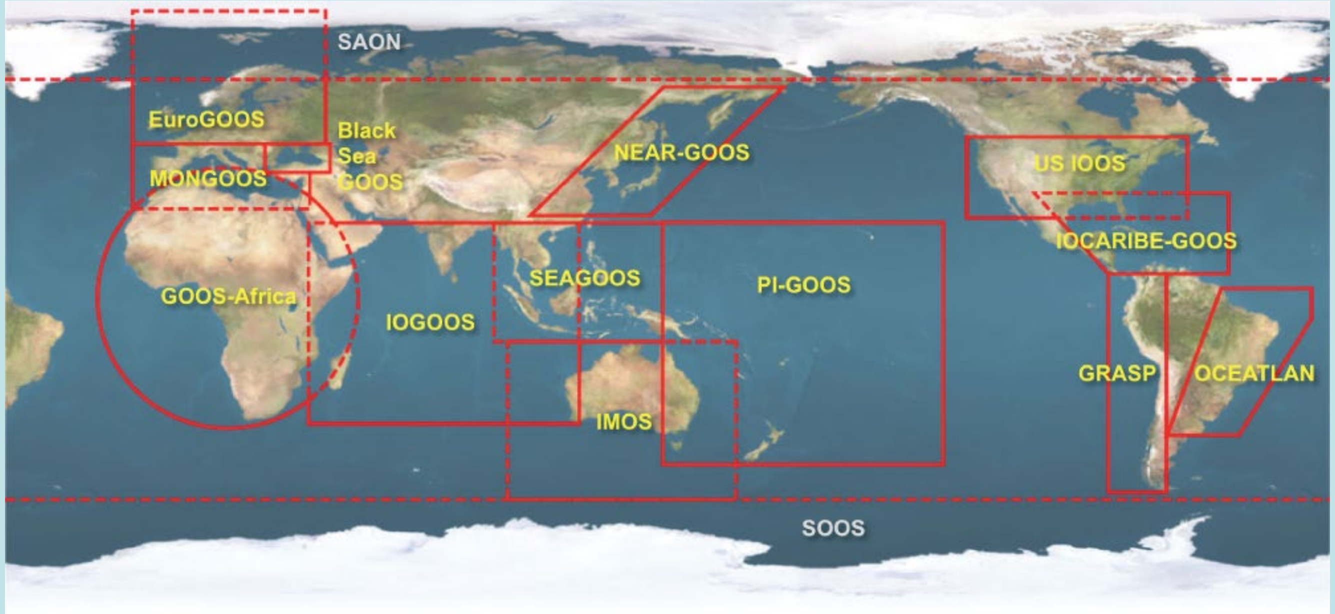
- **The accuracy of measured terrestrial ECVs has been improved (better sensors, calibration & retrieval algorithms) and is expected to reach the targets in few years.**

- **However, past raw data (from ~ 1980 to 2000) still pose stability problems for biophysical parameters (mainly due to instrument drift and inter-calibration).**

- **The biases between different sensor products can be corrected but the accuracy will never reach the best recent ECVs products.**

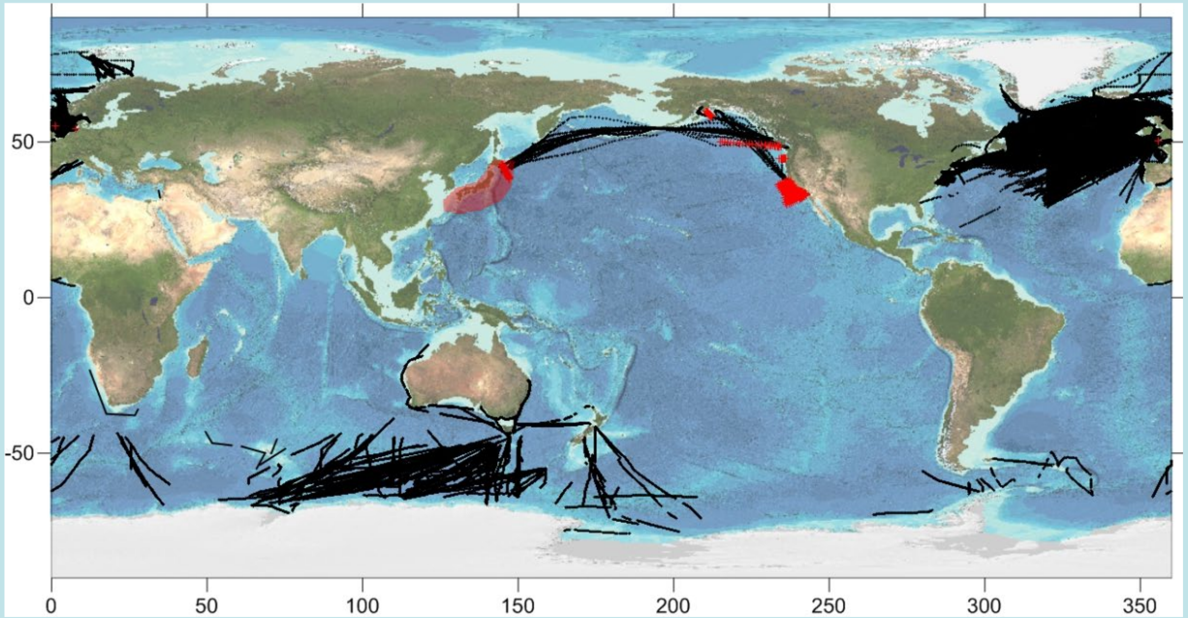
Network and Space (Ocean)

Monitoring networks are regional and variable



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

Observations are often lacking from low latitudes



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)

Ocean Biosphere ECVs Uncertainties

- **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 low latitudes and the southern hemisphere.**

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	
	Surface Stress	
	Ocean Surface Heat Flux (Emerging)	
	Biogeochemical	
Carbon dioxide partial pressure (surface)	Inorganic Carbon	Reframed to accurately reflect current observing requirements to characterise the carbonate system. Depending on platform a choice of ideally at least 2 variables of DIC, Total Alkalinity, 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: SF6, CFCs, C-14, Tritium, Helium-3.
	Nitrous Oxide	A new ECV to reflect the ocean's role for N2O cycling
Ocean Colour	Ocean colour	Ocean colour
	Biological/Ecosystems	
Phytoplankton	Plankton	Phytoplankton, Zooplankton
	Marine Habitat Properties	Includes Coral Cover, Mangroves, Sea Grasses, Macro Algae

Biodiversity and Ecosystem

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.

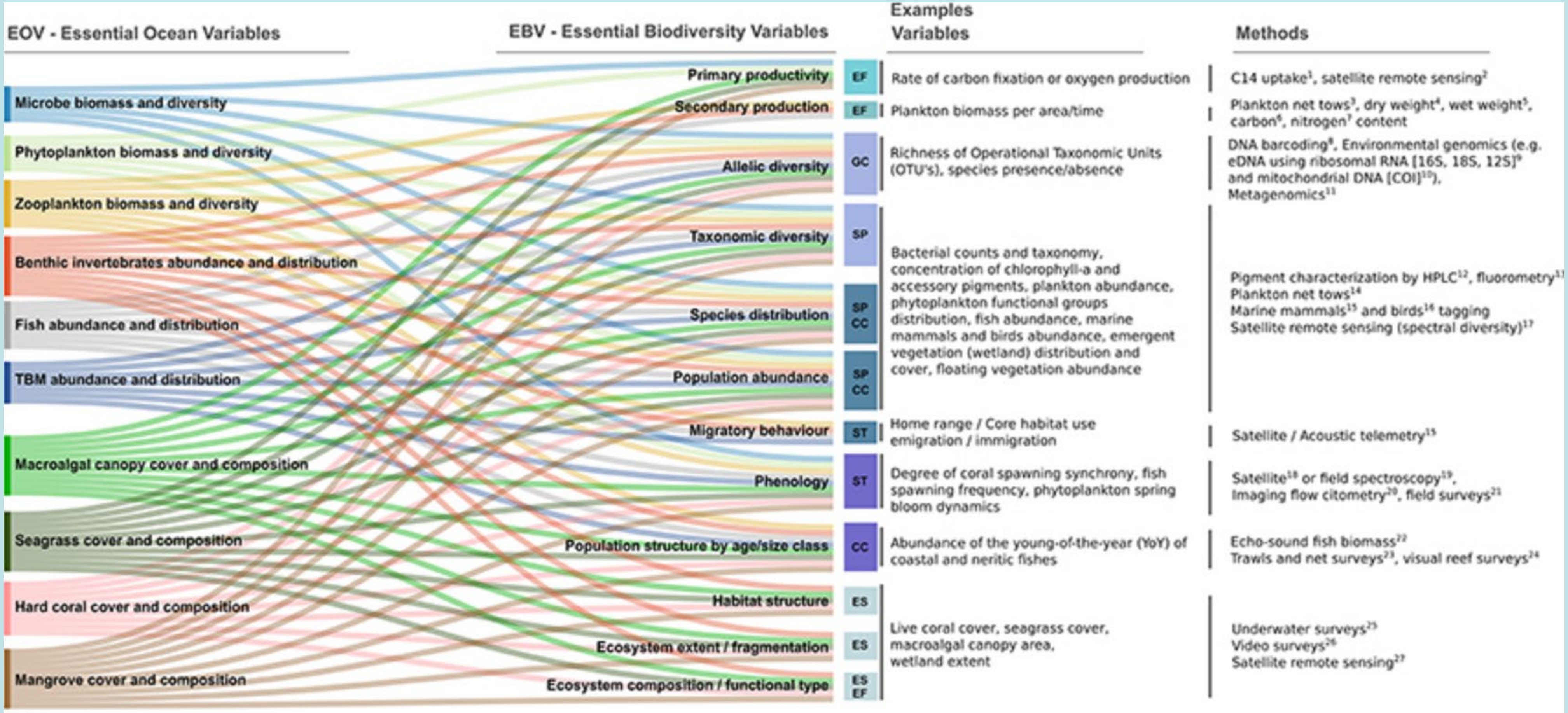
The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) assesses the state of biodiversity and of the ecosystem services it provides to society, in response to requests from decision makers.

It was established in 2012 by more than 100 governments (https://www.ipbes.net/)

ipbes Science and Policy for People and Nature

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

Relationship between EOVs and EBVs



Source: Muller-Karger et. al., 2018, Advancing Marine Biological Observations and Data Requirements of the Complementary Essential Ocean Variables (EOVs) and Essential Biodiversity Variables (EBVs)

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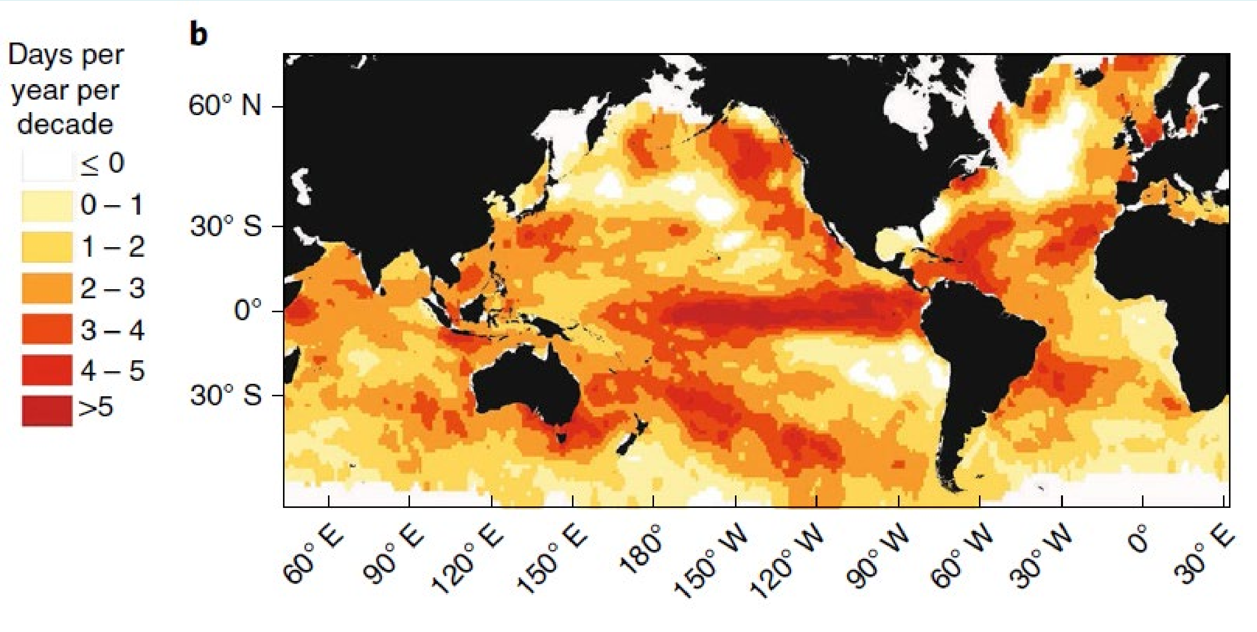
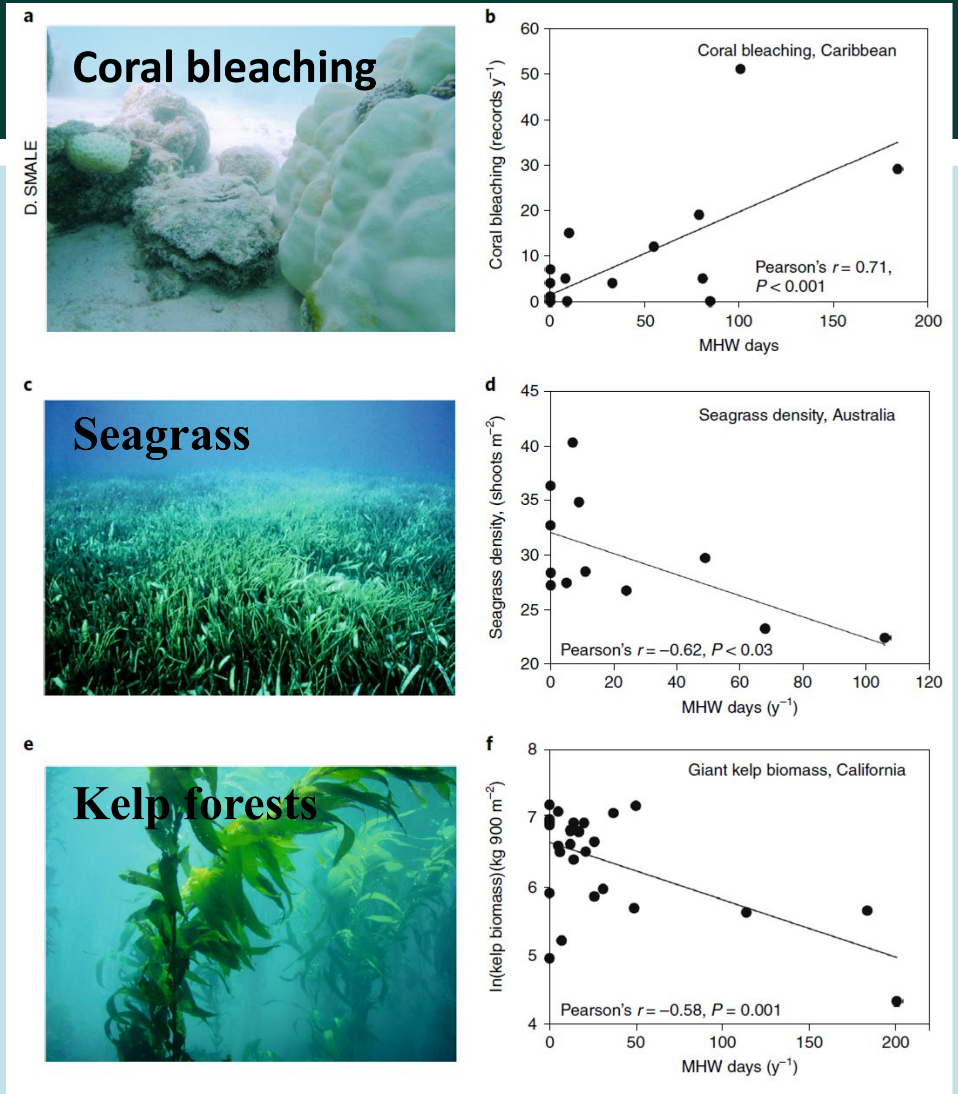
O1: Marine Heatwaves



Trend of annual number of marine heatwave (MHW)



Impact of marine heatwave days on marine habitat ECVs

Source: Smale, et al. 2019. Marine heatwaves threaten global biodiversity and the provision of ecosystem services. Nature Climate Change.

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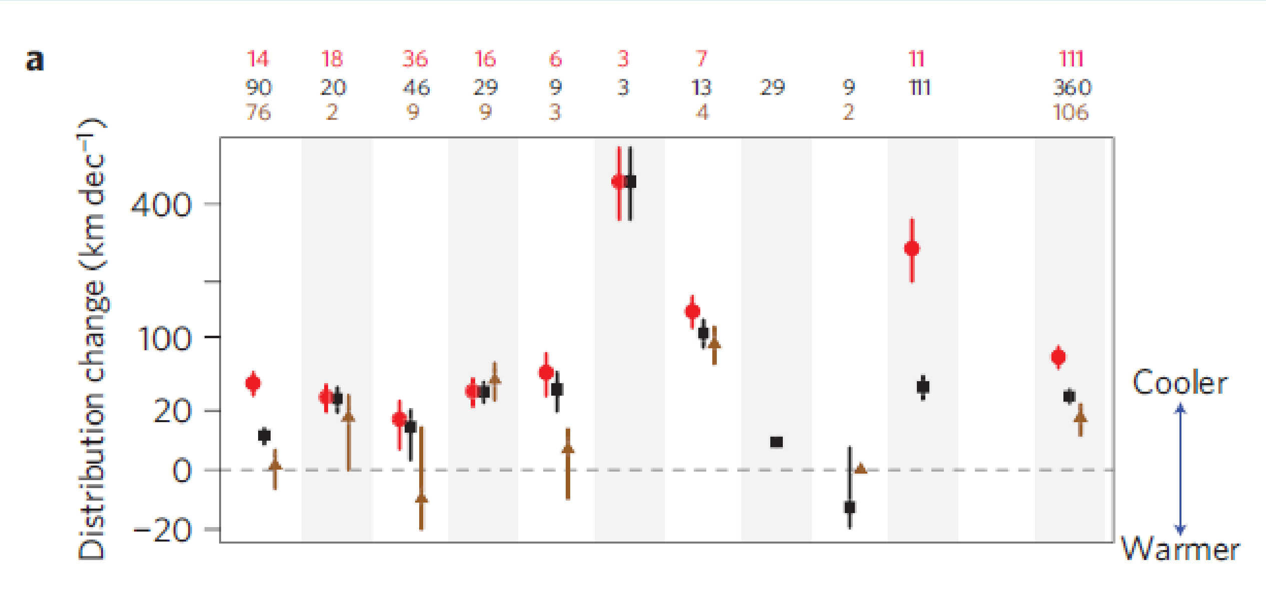
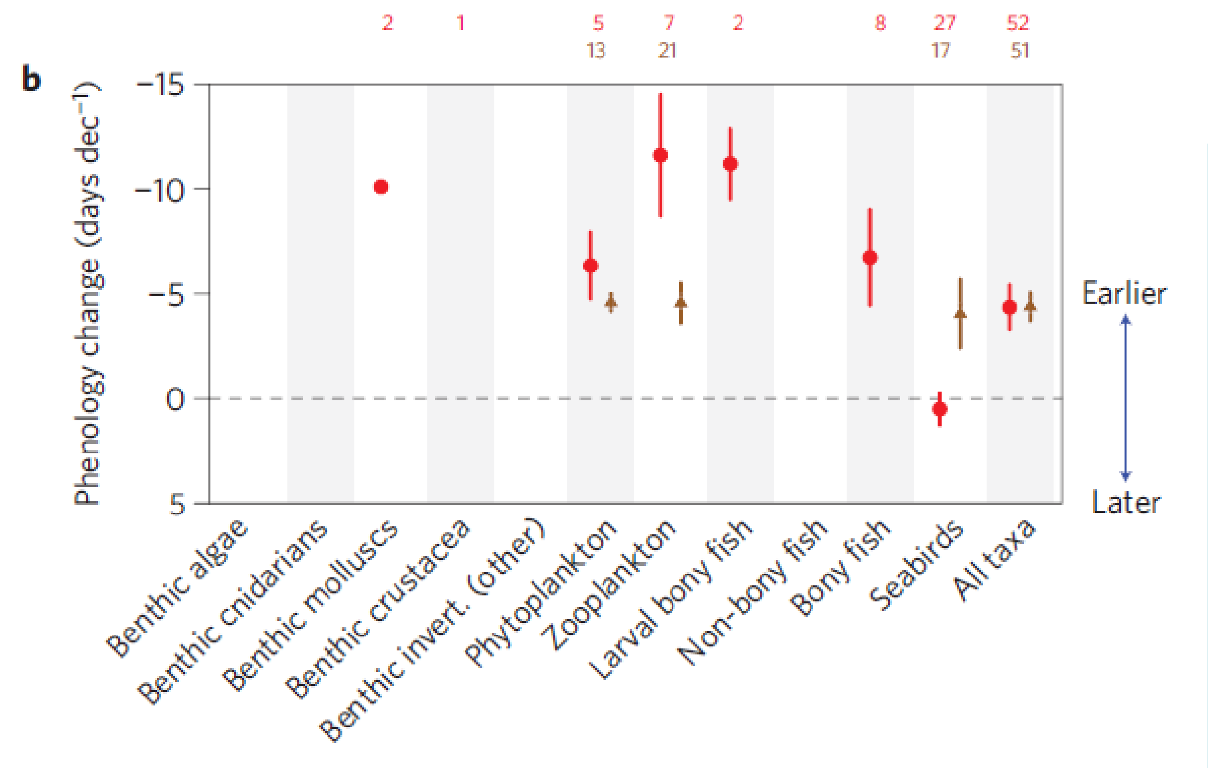
O2: Changes in distribution and phenology



Distributional shifts of up to 400km/decade



Changes in timing of key life history events of >10days/decade

Source: Poloczanska, E. et.al. 2013. Global imprint of climate change on marine life. Nature Climate Change.

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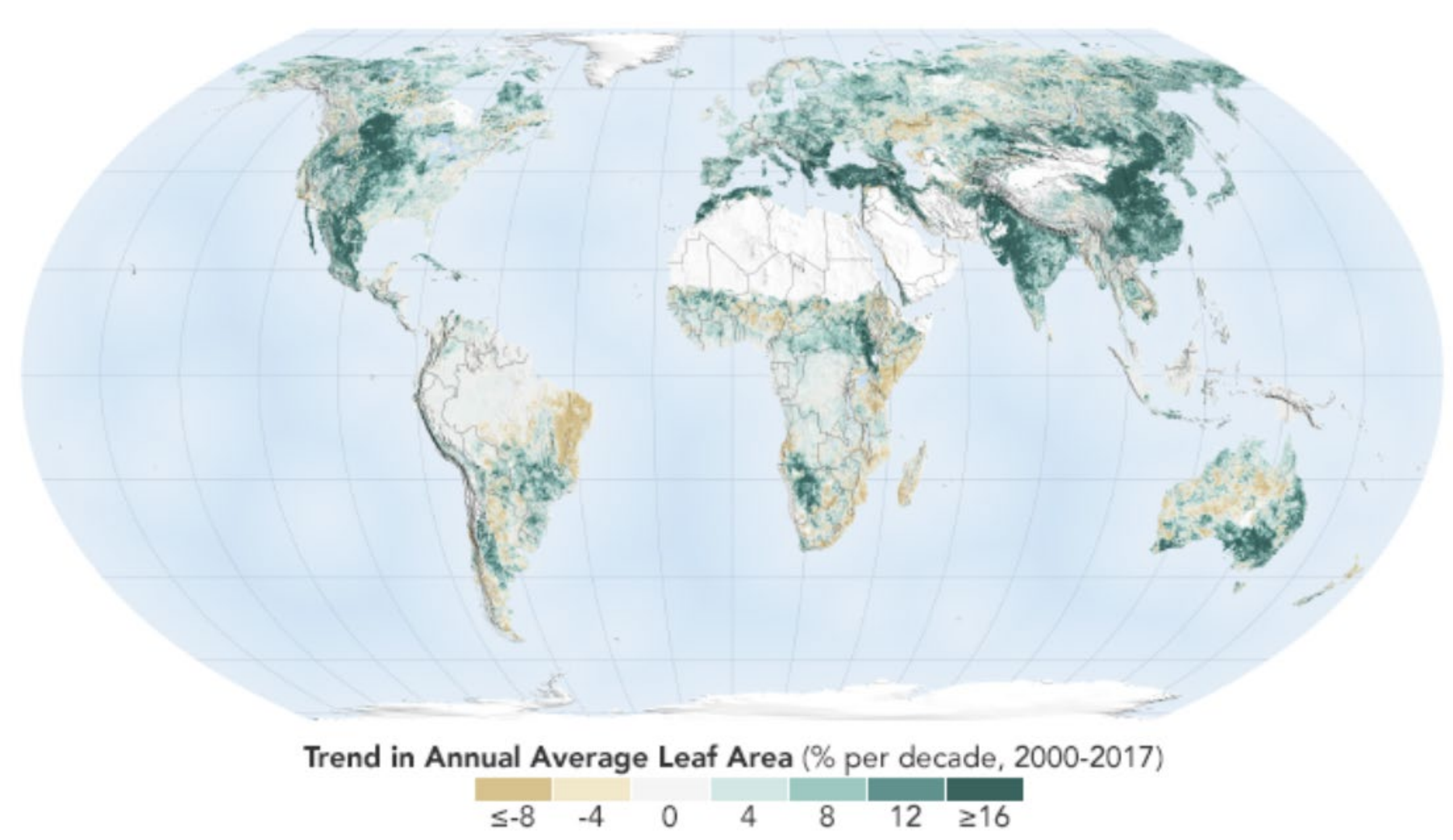
L1: Greening Earth (LAI)



1/3 of the global vegetated lands are becoming more 'productive' (intensive human use of land for crops and forests most in China and India.)

→ **Earth System Model** should have a better realistic representation of the spatio-temporal dynamics of key land-use practices (multiple cropping, irrigation and fertilizer use, fallowing and abandonment of land, afforestation, reforestation and deforestation.)

Source: Chen *et al.* (2019) China and India lead in greening of the world through land-use management. *Nature Sustainability*, (2) 122–129.

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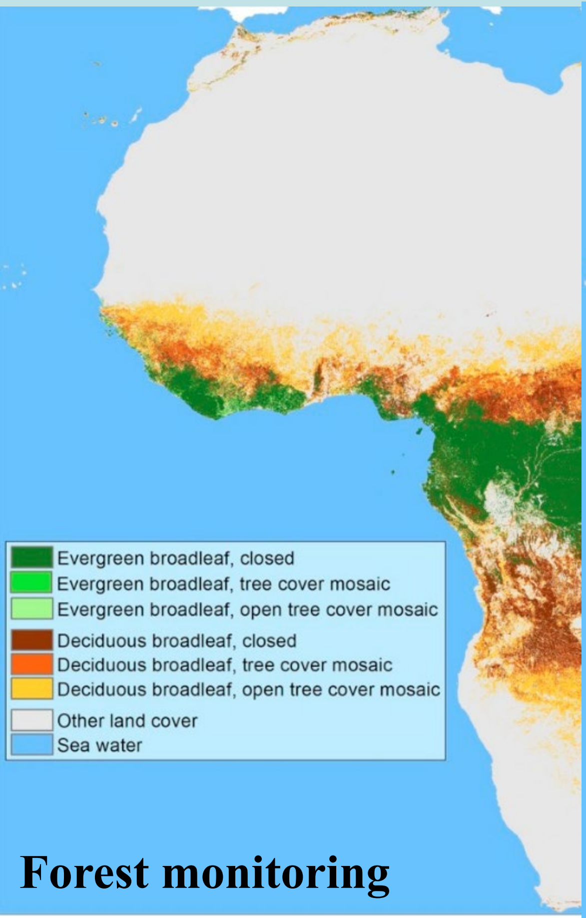
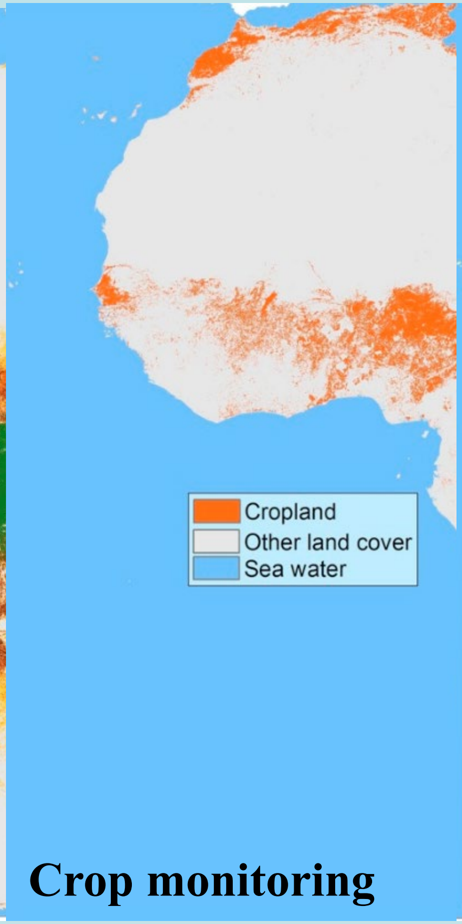
L2: Land Cover Map (Copernicus GLS 100m)



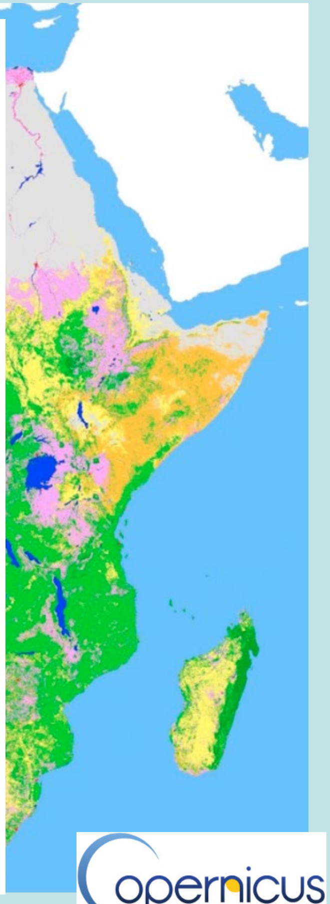
Forest monitoring



Crop monitoring

Table 6
A summary of the considered land cover classes and their accuracies for the users.

User groups	User specific maps and remarks	Overall accuracy (area adjusted)/estimate with 95% confidence intervals
General user (producer)	Discrete land cover map with 9 general classes	74.6% ± 2.1%
Forest monitoring	A map with 6 forest related classes (Fig. 4a)	81.3% ± 1.4%
Crop monitoring	Cropland and non-cropland mask (Fig. 4b)	93.5 ± 0.9% Cropland class: User's accuracy: 59.4 ± 6.5% Producer's accuracy: 66.3 ± 6.2%
Biodiversity	Discrete land cover map with 11 classes (Fig. 4c)	73.7% ± 2.1%
Climate modelling	Discrete land cover map with 9 classes (Fig. 4d) Fractional land cover maps for trees, shrubs, herbaceous vegetation and bare areas	77.3% ± 2.1% MAE: 9, 8.8, 16, and 6.5%, respectively RMSE: 16.7, 15, 24.8, and 14.8%, respectively



Source: Tsendbazar, N.E., Herold, M. et al. (2018). Developing and applying a multi-purpose land cover validation dataset for Africa, RSE

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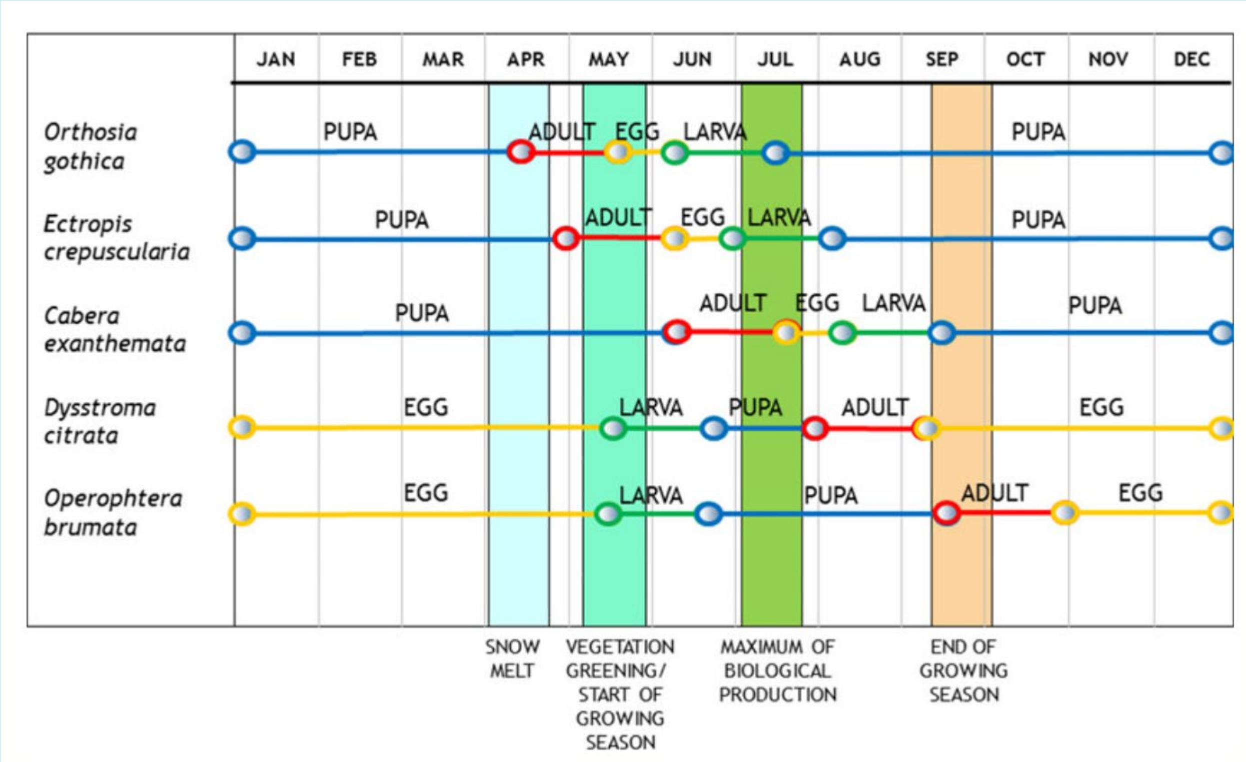
L3: Moos Phenology



Typical phenological sequence during an average year in the southern part of Finland. (5 moos species)

Each focal moth species were related to explanatory variables using linear mixed effect models (LMM)

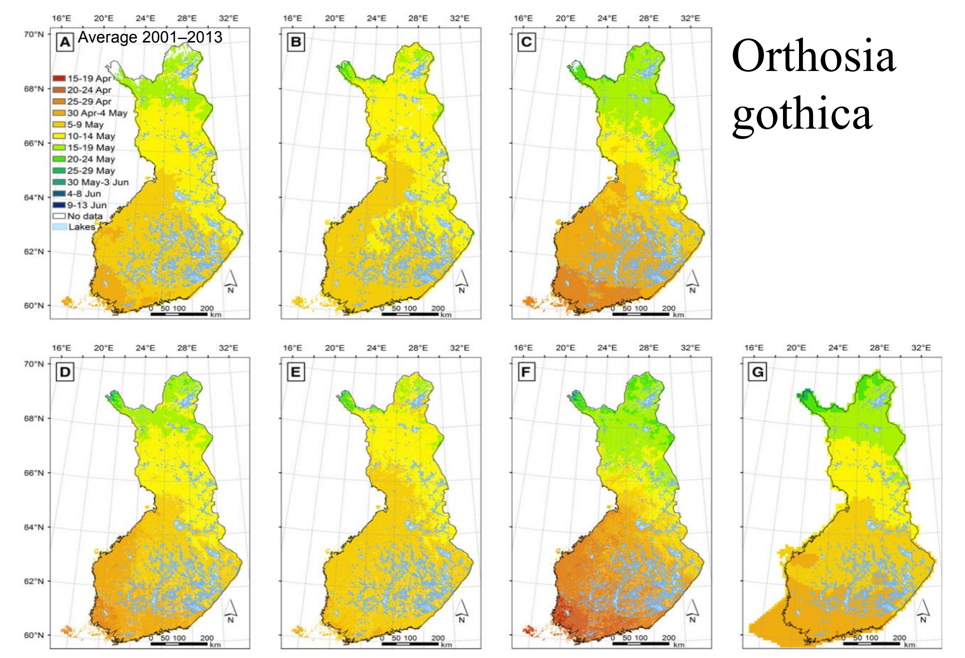


Figure 4. Maps of the peak flight periods for *Orthosia gothica*: predictions made on the basis of the total model including all variables for (A) an average period of 2001–2013, (B) a phenologically late year (2006), (C) a phenologically early year (2007); predictions made on the basis of snow melt-off date for (D) an average period of 2001–2013, (E) a phenologically late year (2006), (F) a phenologically early year (2007) and (G) an average prediction for 2001–2013 based on an alternative variable (weekly accumulating growing degree days). Model formulas are presented in Table S2. Data sources: Country borders © ESRI, Lakes © SYKE, Biogeographical provinces ©LUOMUS and SYKE.

Orthosia gothica

Pöyry J. et. al. (20118) Predictive power of remote sensing versus temperature-derived variables in modelling phenology of herbivorous insects. Remote Sensing in Ecology and Conservation

Summary

- **Progress in both land and marine global observations of the biosphere;**

- **Several ECVs are accurate enough to explain some changes of the biosphere;**

- **Relations (Equations?) between ECVs and EBVs still need R&D.**

Questions for discussion

- *How GCOS could improve relations between biodiversity community and TOPC/OOPC?*
- *How to support the development of accurate ECVs by these communities? and help to identify and reduce the uncertainties. Also for EBVs?*
- *What are the ground-based uncertainties?*
- *What level of in-situ calibration is required for eg. satellite data?*
- *Which action GCOS can take to improve the standardization of historic-ECVs?*
- *Others? Please come to the panel this afternoon !*

Any questions?

You can find me at nadine.gobron@ec.europa.eu