Towards a feasible and representative pan-African RI for GHG observations

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RIs and the Paris Agreement on Climate
Brussels, 20-21 Nov 2018

Greenhouse Gas Observation & Climate-Smart Agriculture

Trinity College Dublin
Coláiste na Tríonóide, Baile Átha Cliath
The University of Dublin

SASSCAL

cmcc

WITS UNIVERSITY

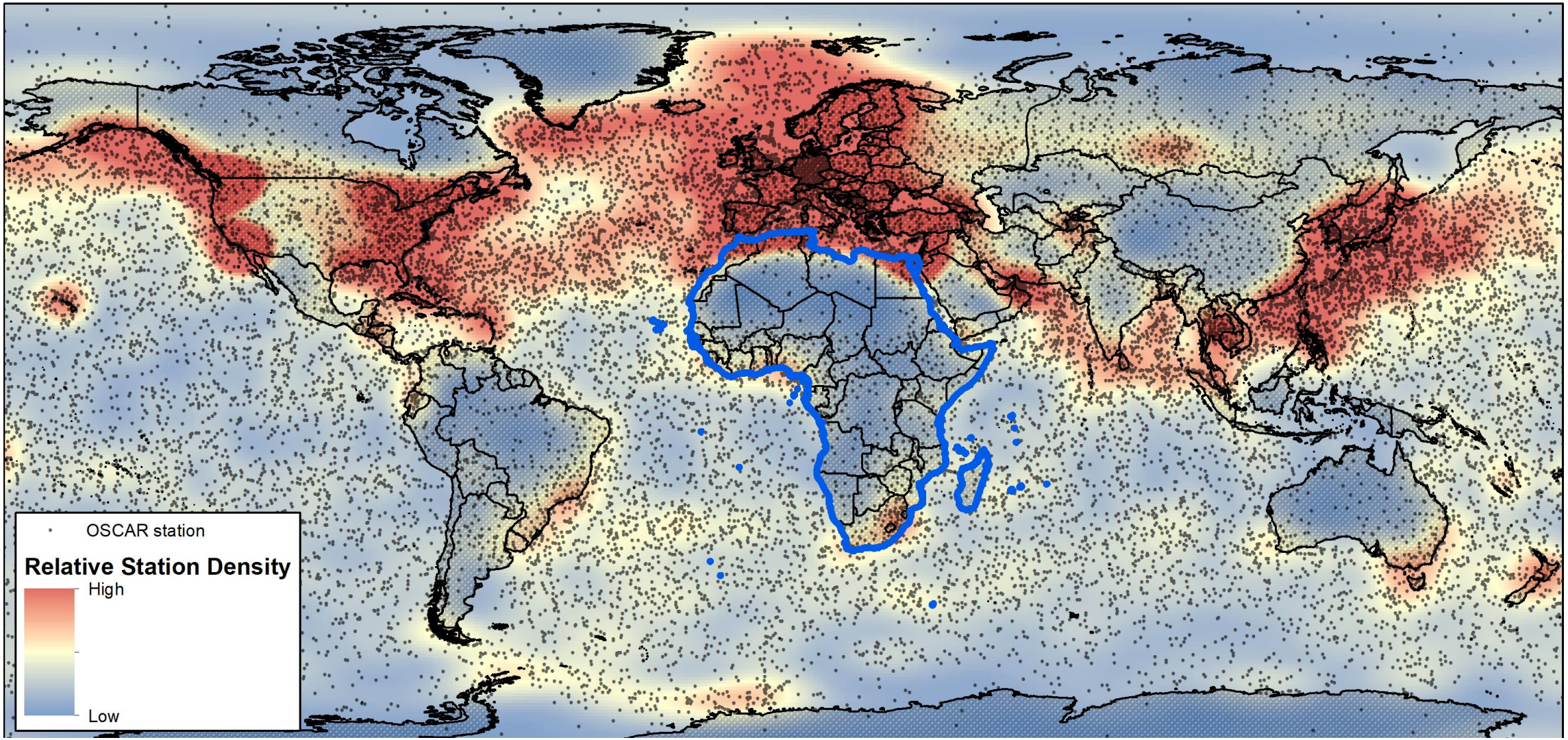
ICOS INTEGRATED CARBON OBSERVATION SYSTEM

THÜNEN

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730995

WHY?

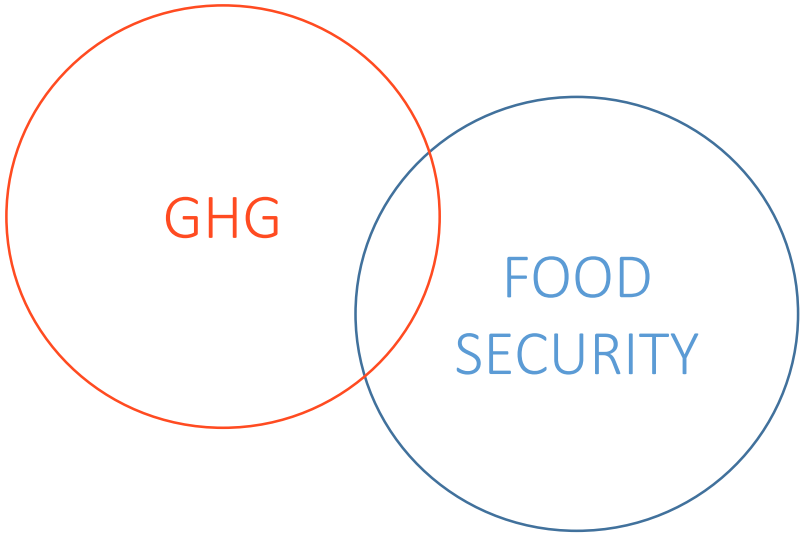
López-Ballesteros et al 2018 *Environ. Res. Lett.*



López-Ballesteros et al 2018 *Environ. Res. Lett.*

SEACRIFOG

Supporting EU-African Cooperation on Research Infrastructures for Food Security and Greenhouse Gas Observations



SEACRIFOG – The project

- European Commission
- 3 years
- Consortium:
  - 7 European countries & 14 African countries
  - 16 institutions

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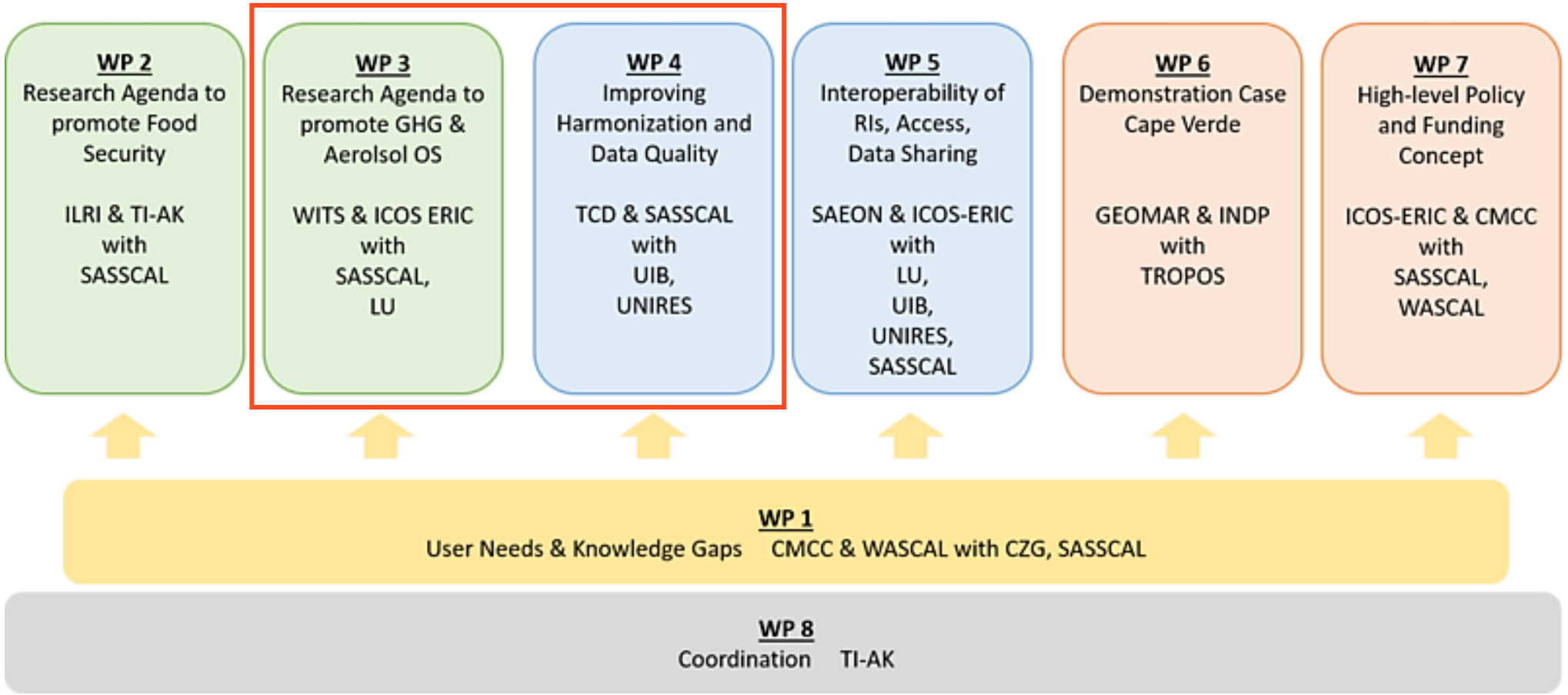
seacrifog.eu

SEACRIFOG – The project

To develop a concept for a pan-African observation system for GHG observations, taking into account:

- Atmosphere-land-ocean continuum
- Natural vs disturbed ecosystems (land use change)
- Data access and interoperability
- **Harmonization:** cross-domain, international & flexible

SEACRIFOG – The project structure



SEACRIFOG – Diagnosis & Harmonization

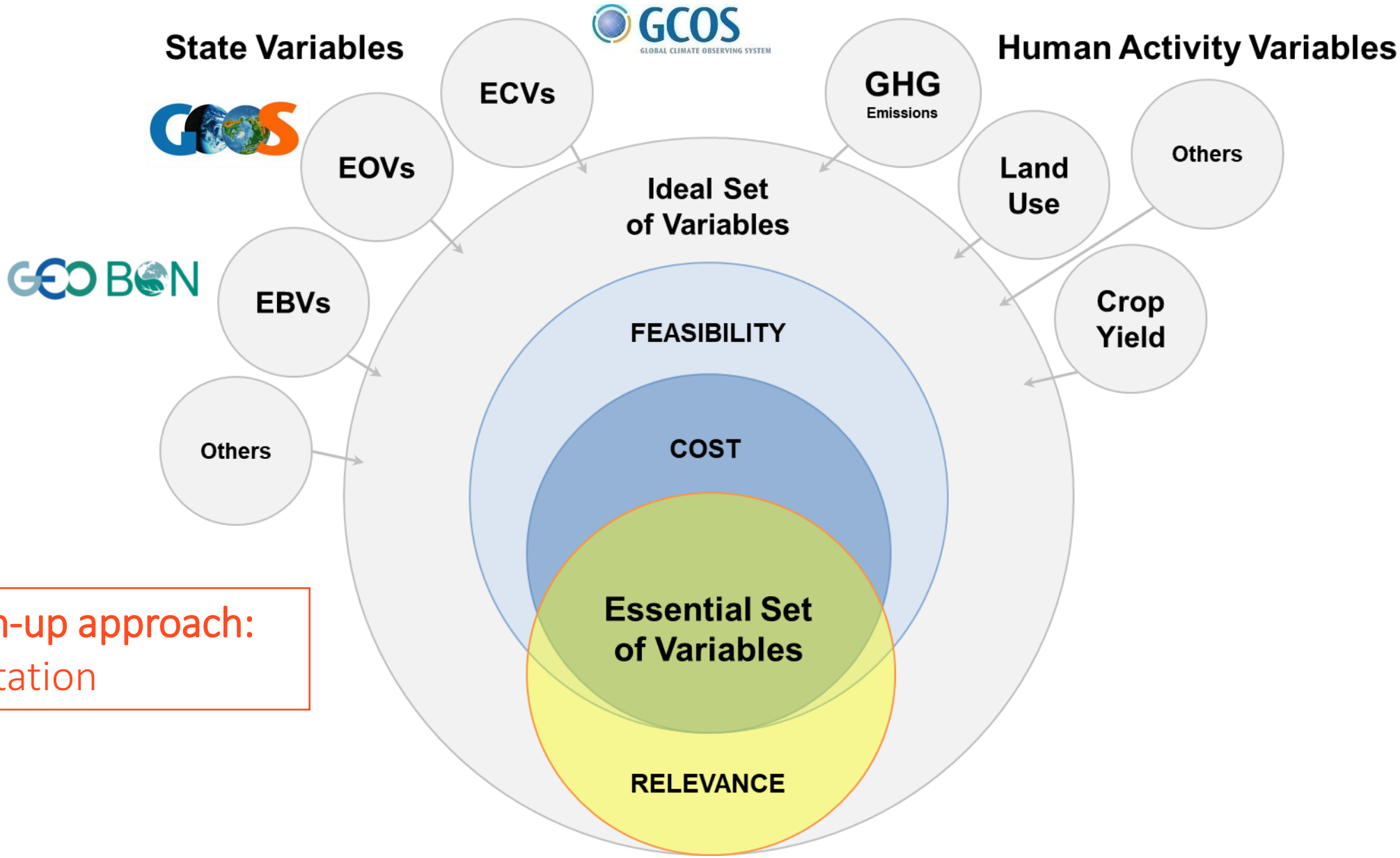
- **What needs to and can be observed across the African continent?**
  Selection of minimum Essential Variables

- What are the gaps and needs regarding infrastructure?

- What are existing relevant methodological protocols?

- What are the gaps and needs regarding data?

SEACRIFOG – Essential variables



Bottom-up approach:
consultation

SEACRIFOG – Essential variables

D3.1

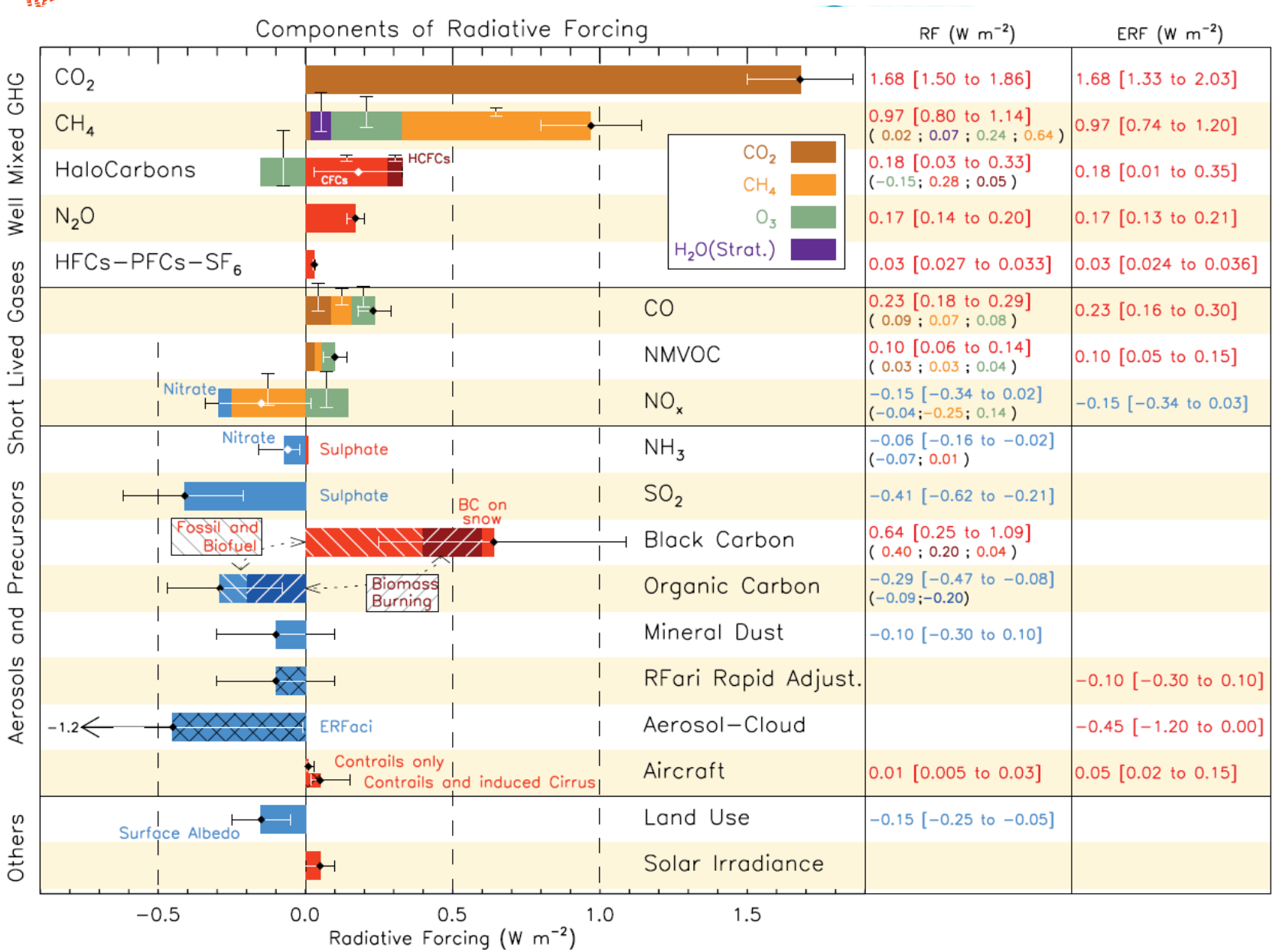


Figure from IPCC Fifth Assessment Report, WGI, Chapter 8 (2013)

Top-down approach: Anthropogenic radiative forcing

SEACRIFOG – Essential variables

López-Ballesteros et al 2018 *Environ. Res. Lett.*

D4.1

Essential Biodiversity Variables

- Plant Species Traits
- Land Cover
- Ecosystem Function -Net Primary Production

Essential Ocean Variables

- Sea Surface T
- Sea Surface Salinity
- Stable C Isotopes
- Inorganic Carbon
- Nitrous Oxide
- Nutrients
- Ocean Color
- Oxygen

Essential Climate Variables

- Above-ground biomass
- Litter
- Albedo
- Fire
- FAPAR
- Inland water extent
- Land surface T
- River Discharge
- Soil Organic Carbon
- Soil Moisture
- Precipitation (surface)
- Pressure (surface)
- Surface wind speed and direction
- Atmospheric temperature at surface
- Water vapor (surface)
- Aerosols properties
- CO_2, CH_4 & N_2O tropospheric mixing ratio
- Cloud cover fraction
- Precursors (NMVOCs, CO, NO_x, SO_2)

Anthropic Factors

- LULUC
- Human population
- Economic development
- Livestock population
- Reported Anthropogenic GHG emissions

- Agricultural management
  - Area of Ploughed Land
  - Manure Management
  - Fertilizer Application
  - Irrigation
- Crop yield by type

Ancillary / Other Variables

- Atmospheric Boundary Layer
- Below-ground biomass
- Biosphere-Atmosphere CO_2, CH_4 & N_2O fluxes

- Net radiation (SW/LW) at surface
- Dimethyl Sulfide (Oceanic)
- Surface roughness
- Soil type
- Infiltration & Runoff
- Evapotranspiration
- Wild herbivores

SEACRIFOG – Diagnosis & Harmonization

- **What needs to and can be observed across the African continent?**
  Essential variables

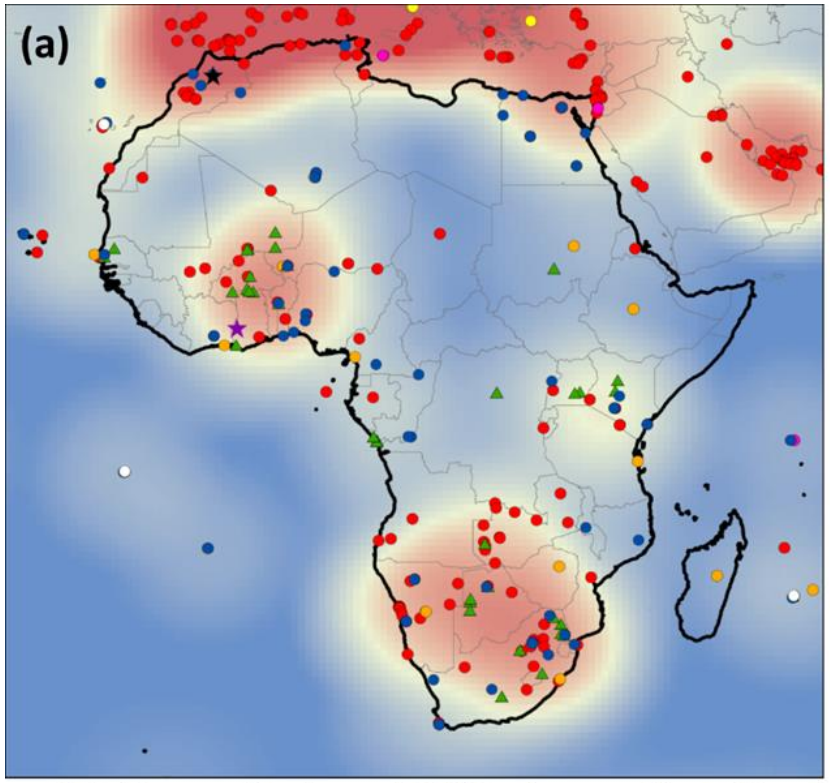
- **What are the gaps and needs regarding infrastructure?**
  Monitoring networks mapping

- What are existing relevant methodological protocols?

- What are the gaps and needs regarding data?

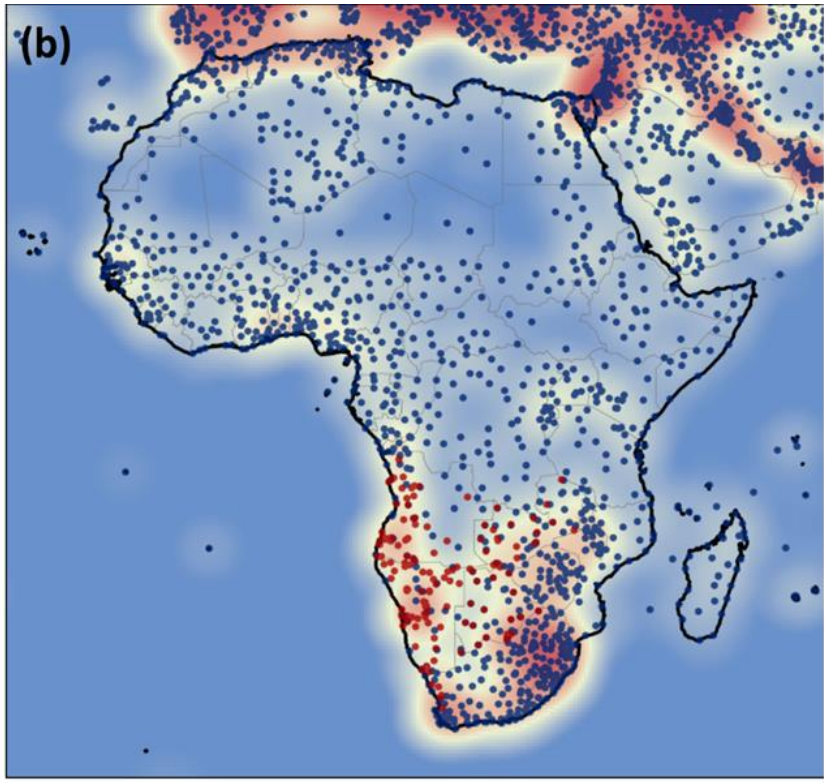
SEACRIFOG – Networks mapping

López-Ballesteros et al 2018 *Environ. Res. Lett.*



(a) Atmospheric and GHG observation sites

- Global Atmosphere Watch
- Eddy Covariance Flux Stations
- Total Carbon Column Observing Network
- Cooperative Air Sampling Network
- GCOS Reference Upper-Air Network
- GCOS Upper-Air Network
- Aerosol Robotic Network
- ★ Atlas Mohammed V (project)
- ★ Carbon-Ghana (project)

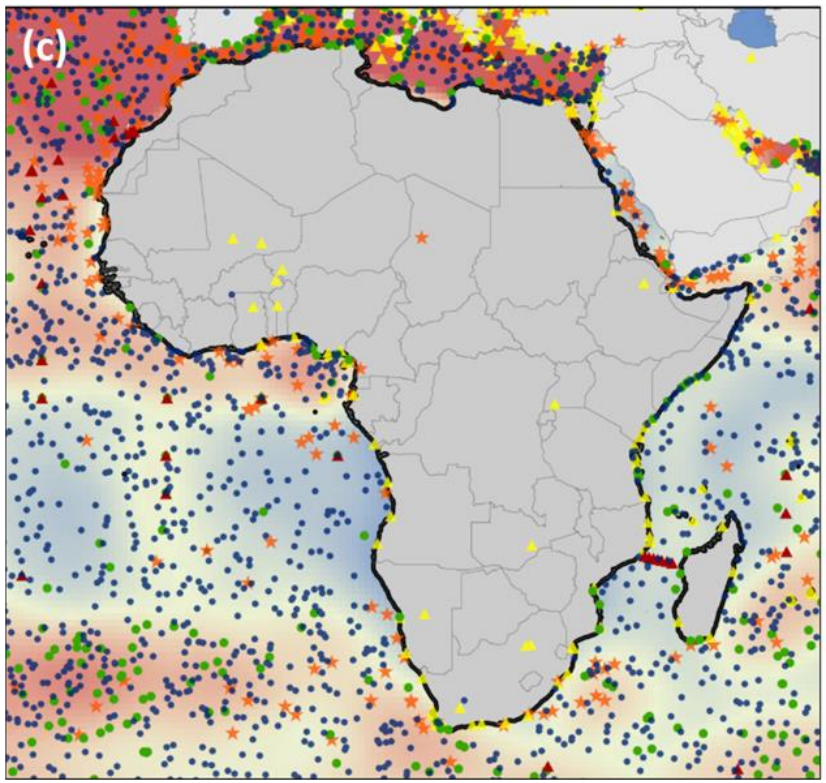


(b) Weather observation sites in Africa

- WMO Global Observing System (land-based)
- SASSCAL WeatherNet

Relative Station Density

High **Low**



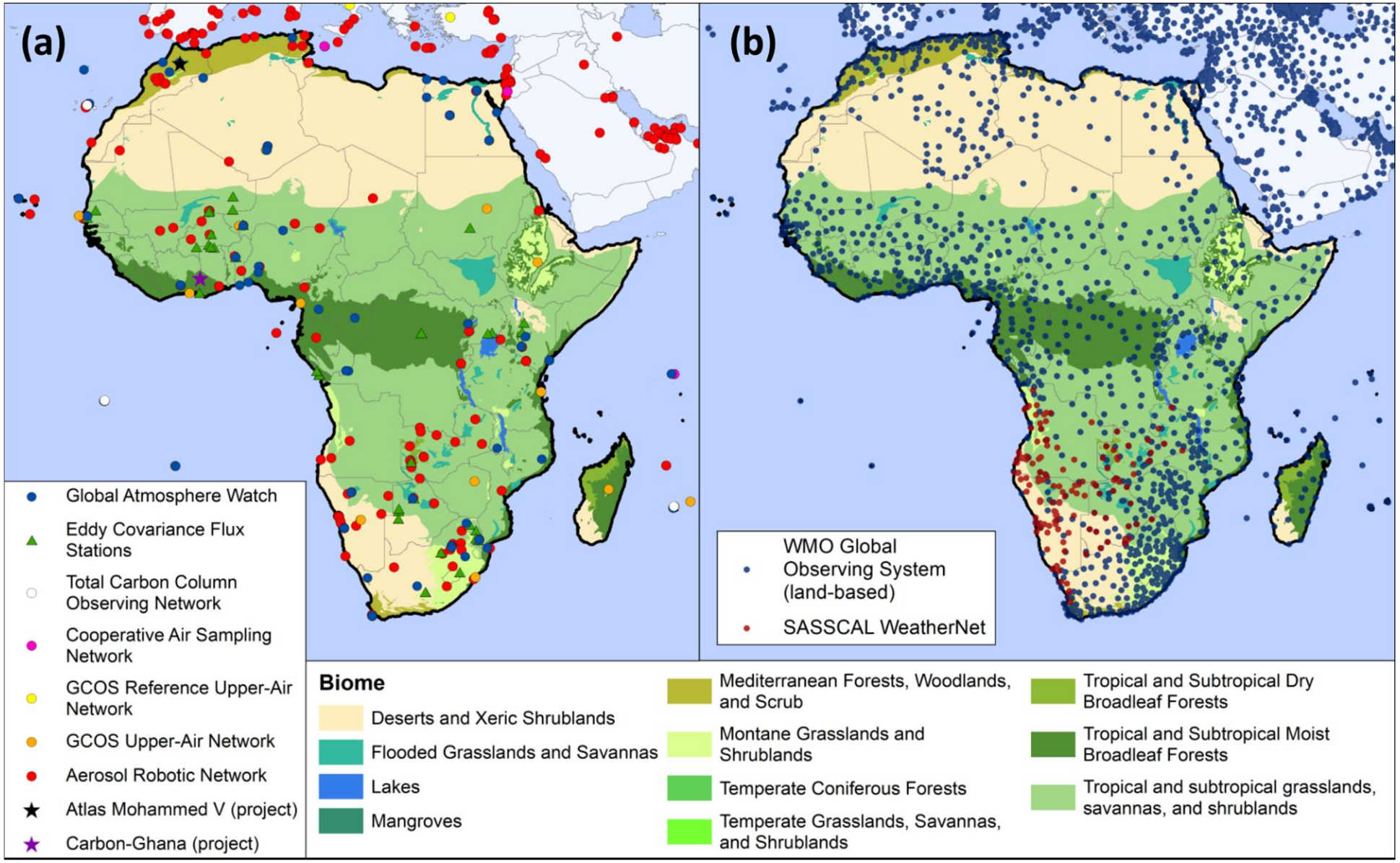
(c) Oceanic observation sites around

- Argo
- OceanSITES
- Data Buoy Cooperation Panel
- Sea Level Station Monitoring Facility
- ★ Ship Observations Team

SEACRIFOG – Networks mapping

López-Ballesteros et al 2018 *Environ. Res. Lett.*

Olson et al 2001 *BioScience*



López-Ballesteros et al 2018 *Environ. Res. Lett.*

Olson et al 2001 *BioScience*

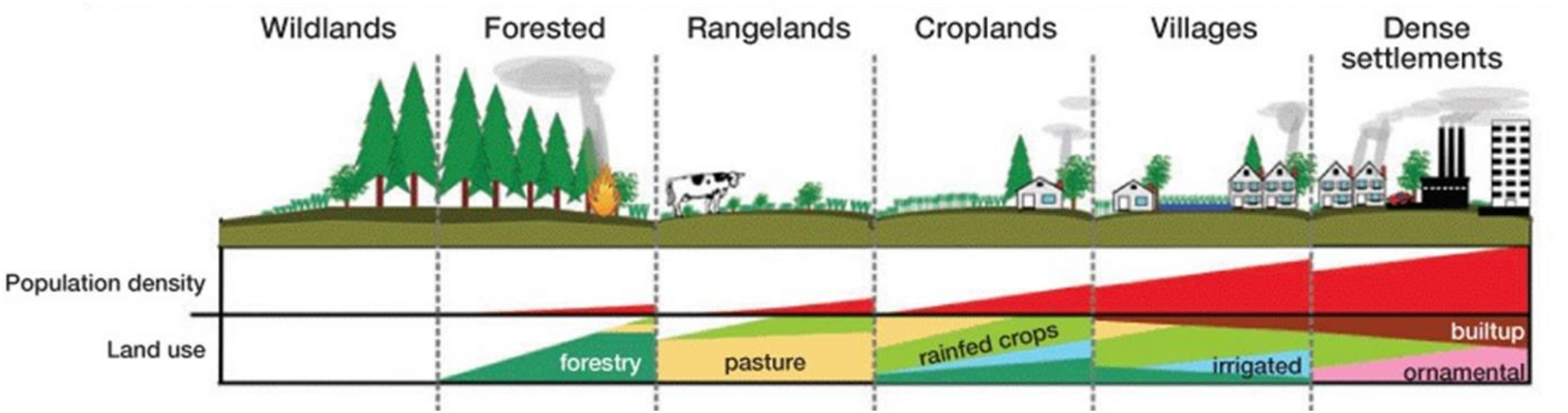
Table 2. Number of stations and station density (per 10 000 km^2) per biome on the African continent for the networks considered in figures 5(a) and (b). Corresponding figures were obtained by cross-tabulating the spatial intersection between biomes and stations using ArcGIS.

Biome	Area (km^2)	N. GHG and aerosol stations	GHG and aerosol station density	N. Weather stations	Weather station density
Temperate coniferous forests	21 764	2	0.919	5	2.297
Montane grasslands and shrublands	857 684	19	0.222	110	1.283
Flooded grasslands and savannas	553 912	10	0.181	42	0.758
Mediterranean forests, woodlands, and scrub	842 758	14	0.166	145	1.721
Mangroves	66 626	1	0.150	14	2.101
Tropical and subtropical dry broadleaf forests	191 222	2	0.105	10	0.523
Tropical and subtropical moist broadleaf forests	3455 531	26	0.075	168	0.486
Tropical and subtropical grasslands, savannas, and shrublands	13 948 474	96	0.069	560	0.401
Lakes	154 730	1	0.065		—
Deserts and xeric shrublands	9780 796	44	0.045	274	0.280
Totals	29 873 496	215		1328	

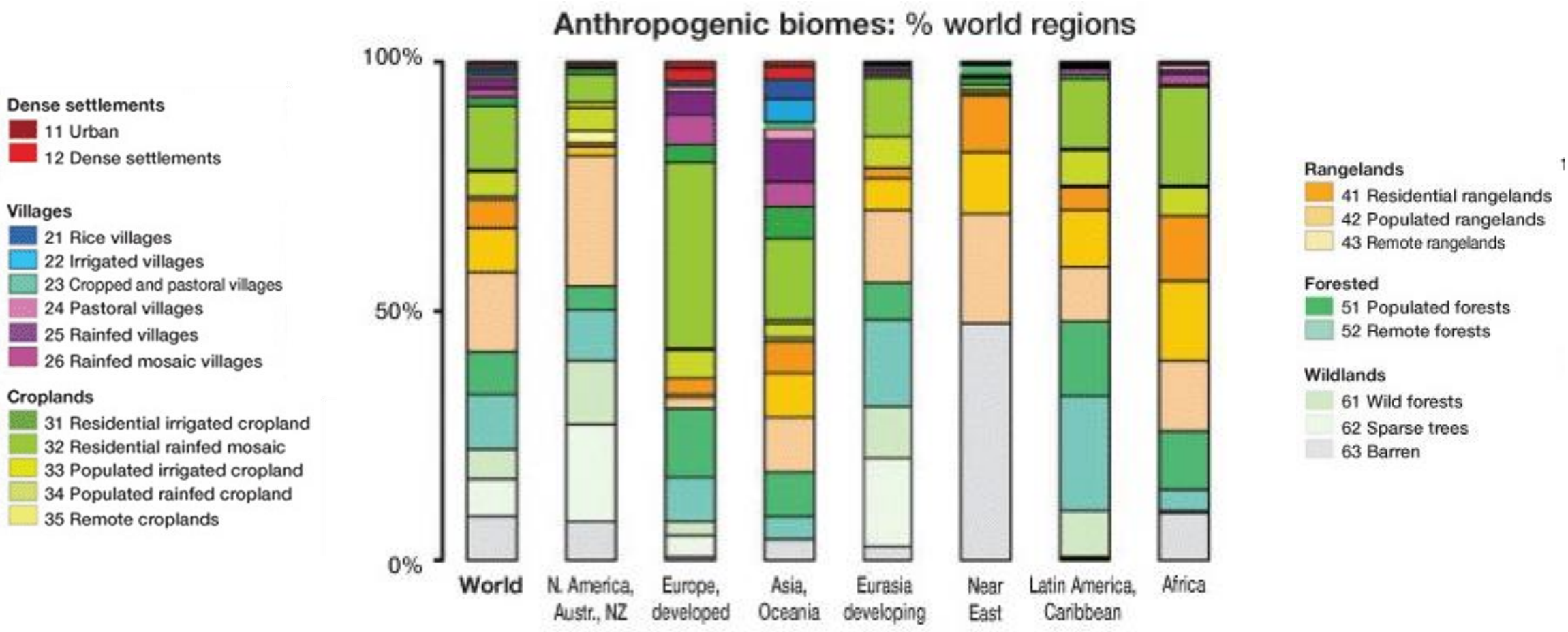
Ellis & Ramankutty 2008 *Front.Ecol.Envir.*

Anthromes

Anthropogenic biomes are spatial units used to categorize terrestrial land by considering the human disturbance level.

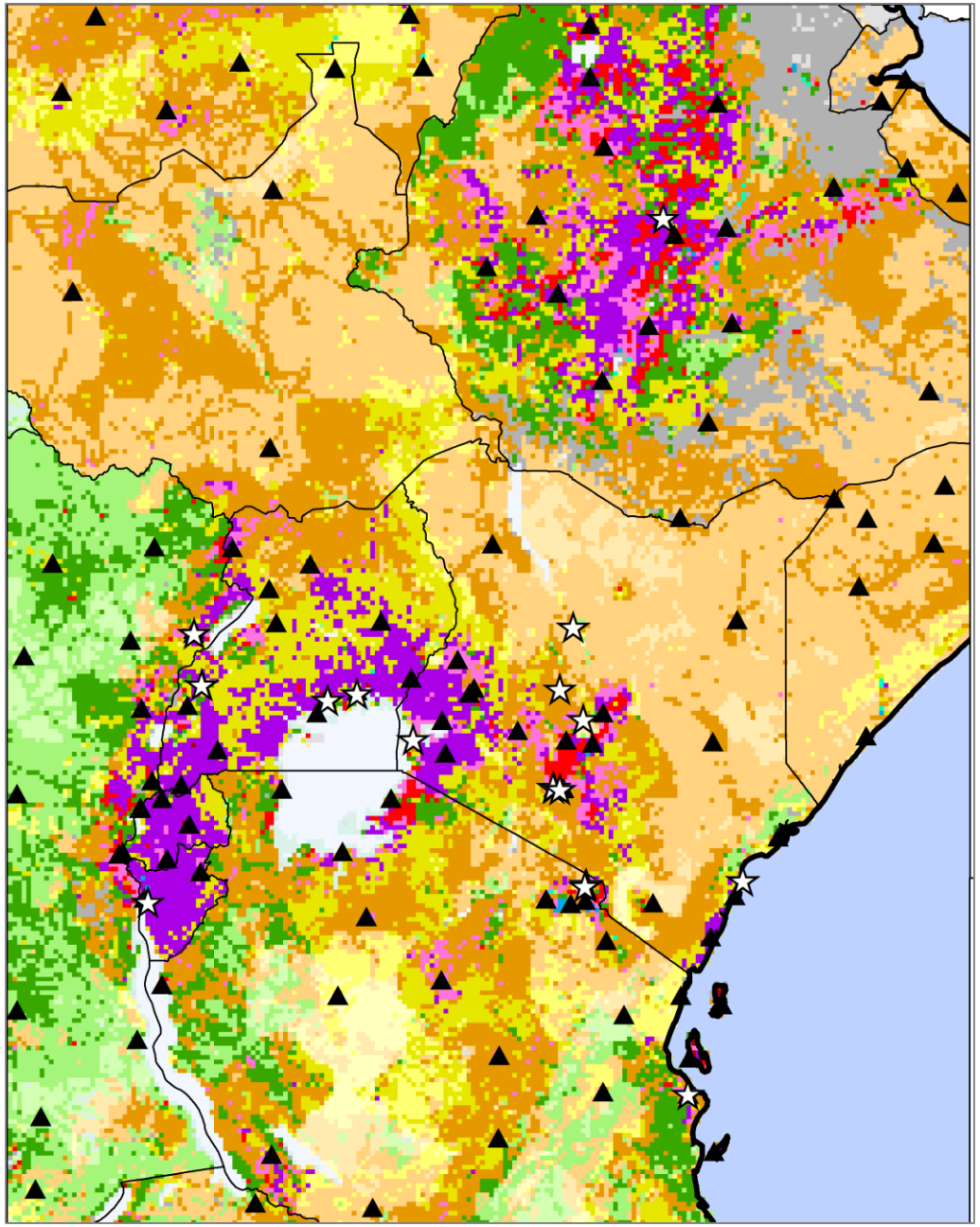


Ellis & Ramankutty 2008 *Front.Ecol.Envir.*



SEACRIFOG – Networks mapping

López-Ballesteros et al 2018 *Environ. Res. Lett.* 13 085003



▲ Weather Stations (115)

☆ Atmospheric and GHG stations (20)

Anthromes (V2)

Used

Dense Settlements
- Urban
- Mixed settlements

Villages
- Rice villages
- Irrigated villages
- Rainfed villages
- Pastoral villages

Croplands
- Residential irrigated croplands
- Residential rainfed croplands
- Populated croplands
- Remote croplands

Rangelands
- Residential rangelands
- Populated rangelands
- Remote rangelands

Ellis et al 2010 *Glob. Ecol. Biogeogr.*

Seminatural

Seminatural
- Residential woodlands
- Populated woodlands
- Remote woodlands
- Inhabited treeless & barren lands

Wild

Wildlands
- Wild woodlands
- Wild treeless & barren lands

SEACRIFOG – Diagnosis & Harmonization

- **What needs to and can be observed across the African continent?**
  Essential variables

- **What are the gaps and needs regarding infrastructure?**
  Monitoring networks mapping

- **What are existing relevant methodological protocols?** Work in progress
  Protocols inventory

- What are the gaps and needs regarding data?

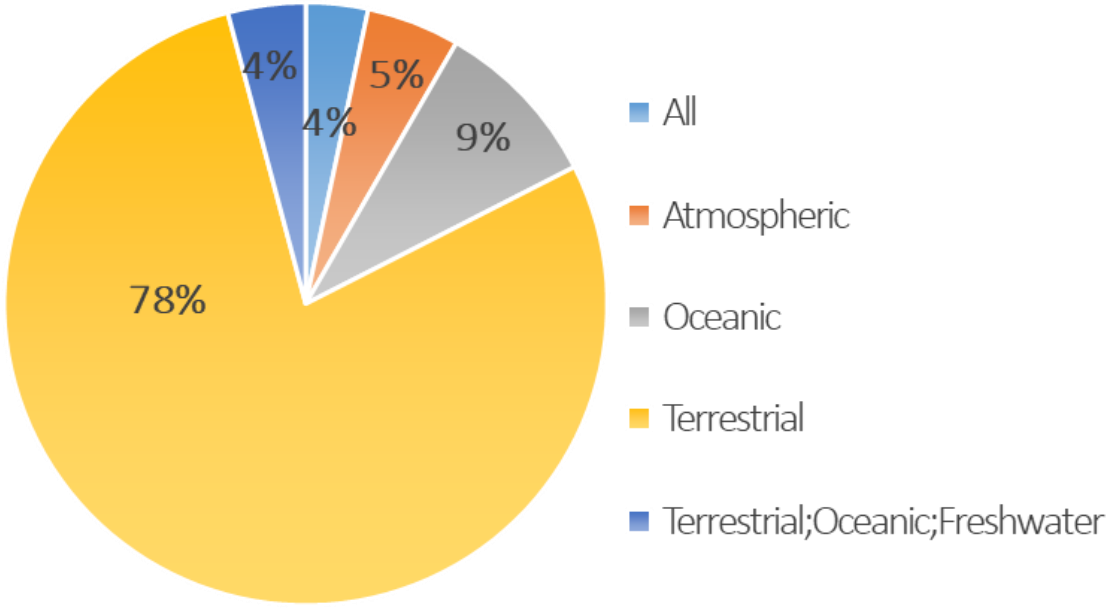
SEACRIFOG – Protocols

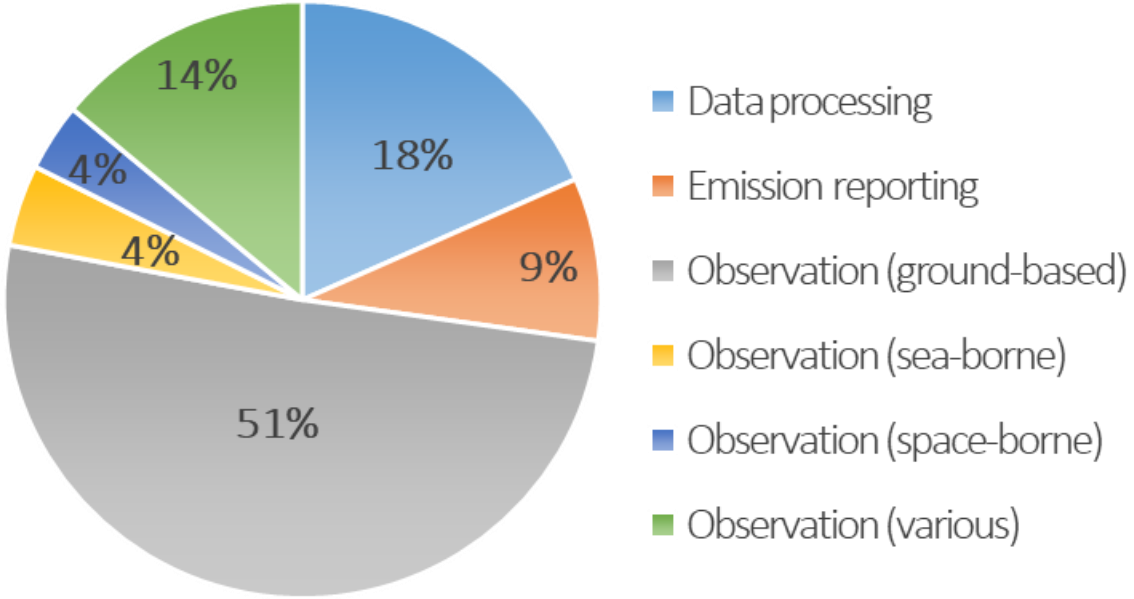
- N > 120 protocols
- Open-access
- Protocols metadata

  - **Citation metadata:** DOI, Author(s), Publisher, Title, Year of publication
  - **Discoverability:** spatial coverage (applicability, adoption) & temporal coverage (continuous vs discrete)
  - **Keywords:** variables, global change ontologies (CC, urban areas, land use, biodiversity), domain, purpose
  - **Re-usability:** abstract, language(s), sustainability, URL.

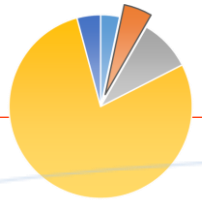
SEACRIFOG – Protocols

- N > 120 protocols
- Open-access
- Protocols metadata

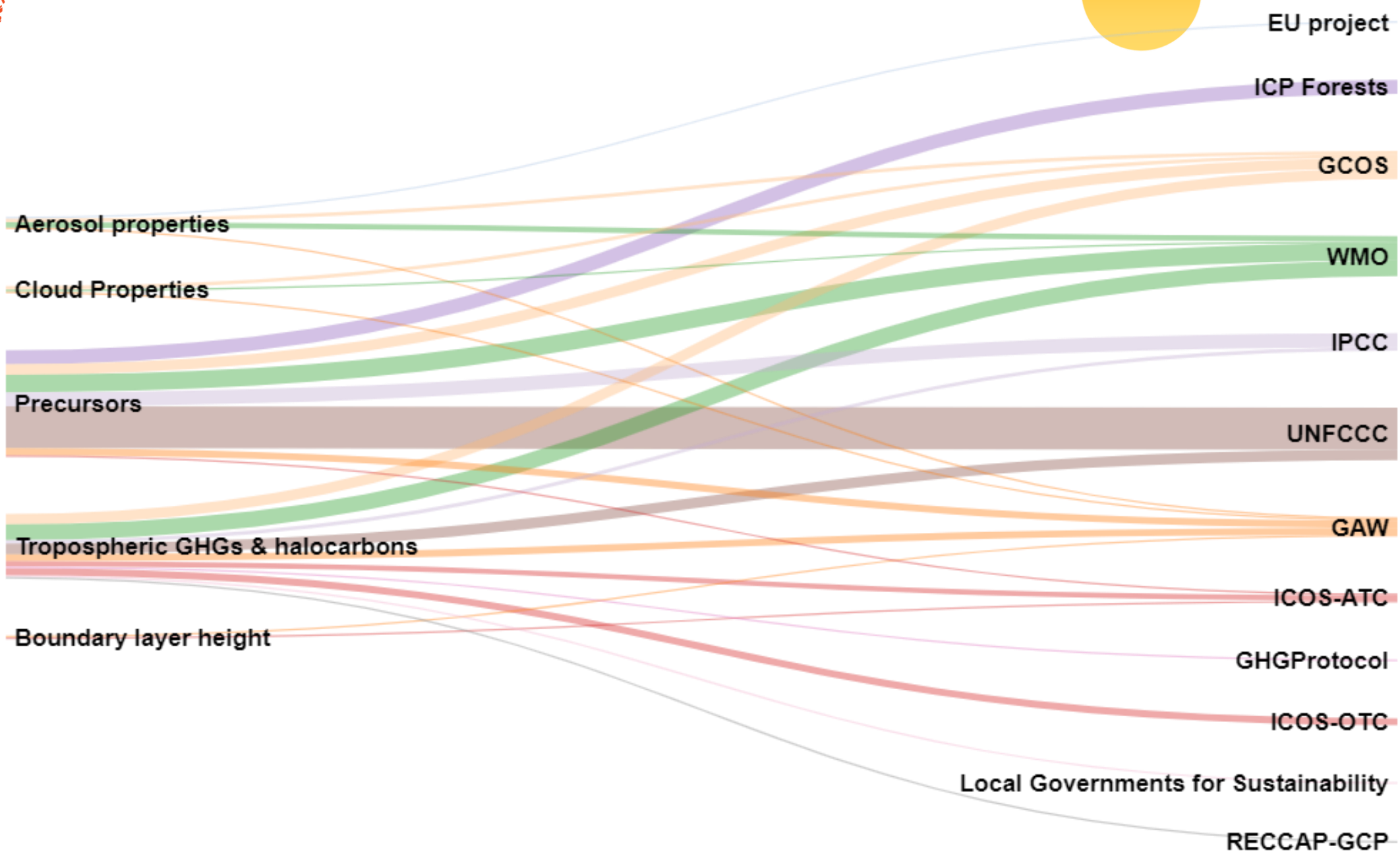




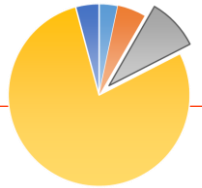
SEACRIFOG – Protocols



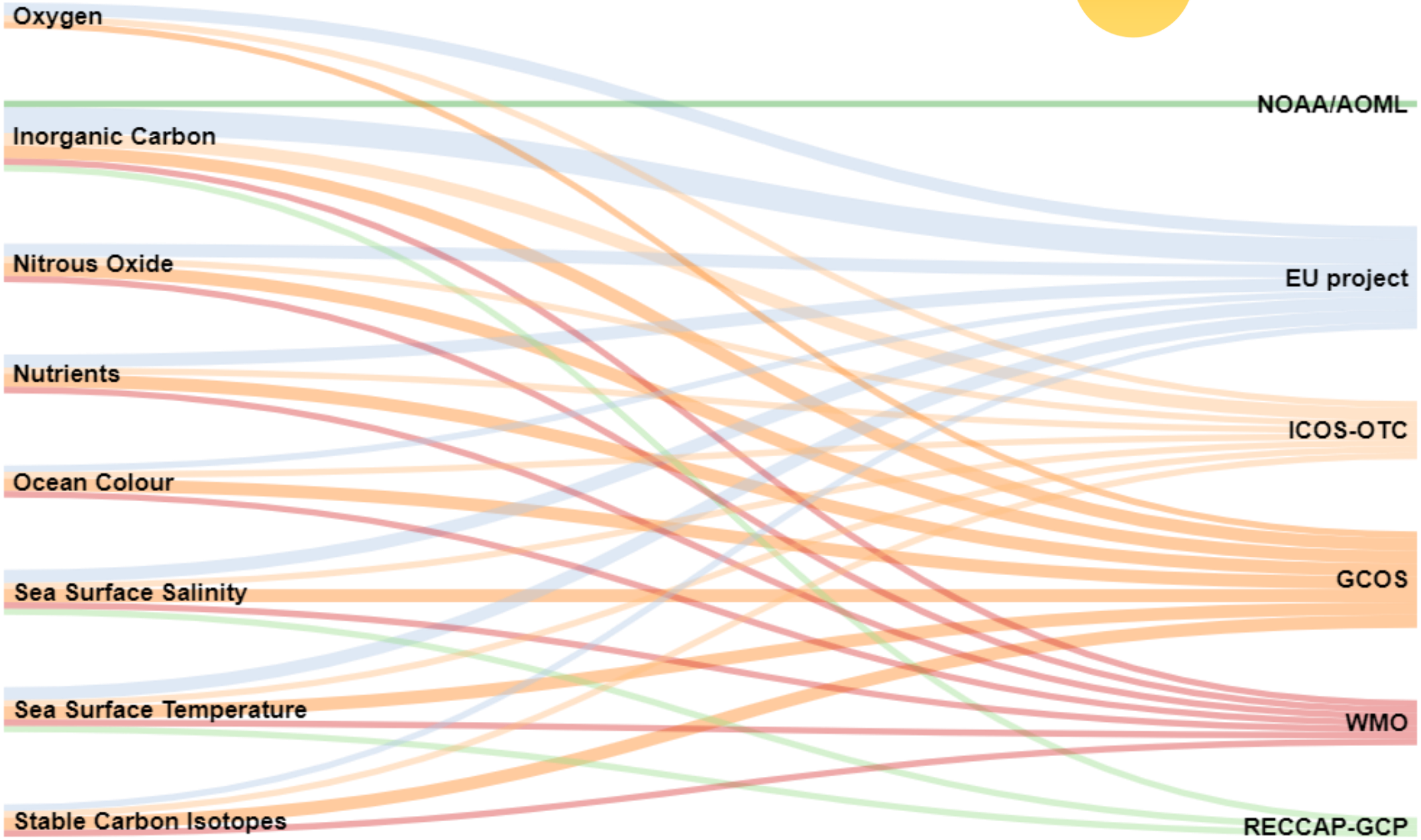
Atmospheric domain



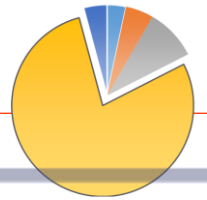
SEACRIFOG – Protocols



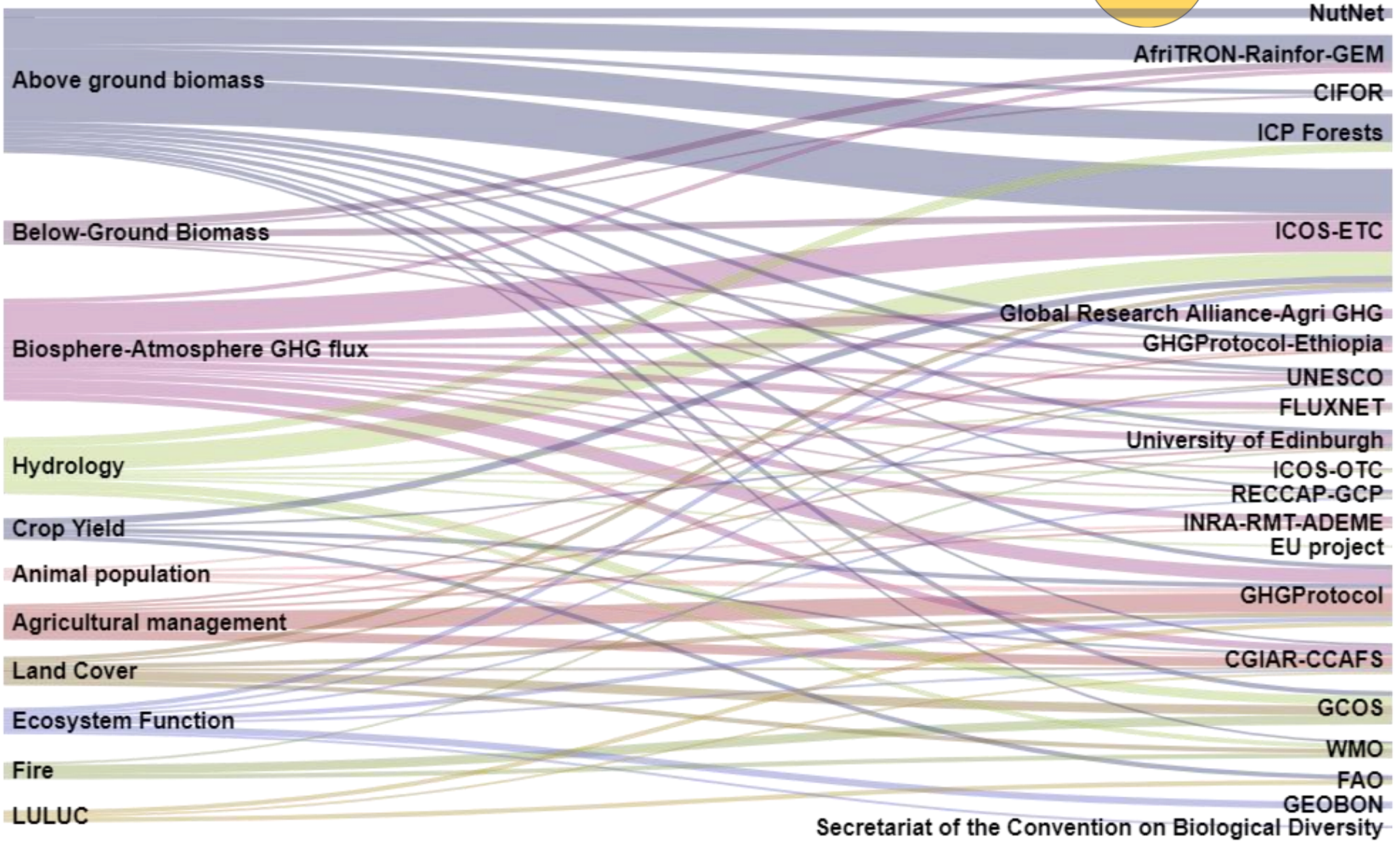
Oceanic domain



SEACRIFOG – Protocols



Terrestrial domain



SEACRIFOG – Diagnosis & Harmonization

- **What needs to and can be observed across the African continent?**
  Essential variables

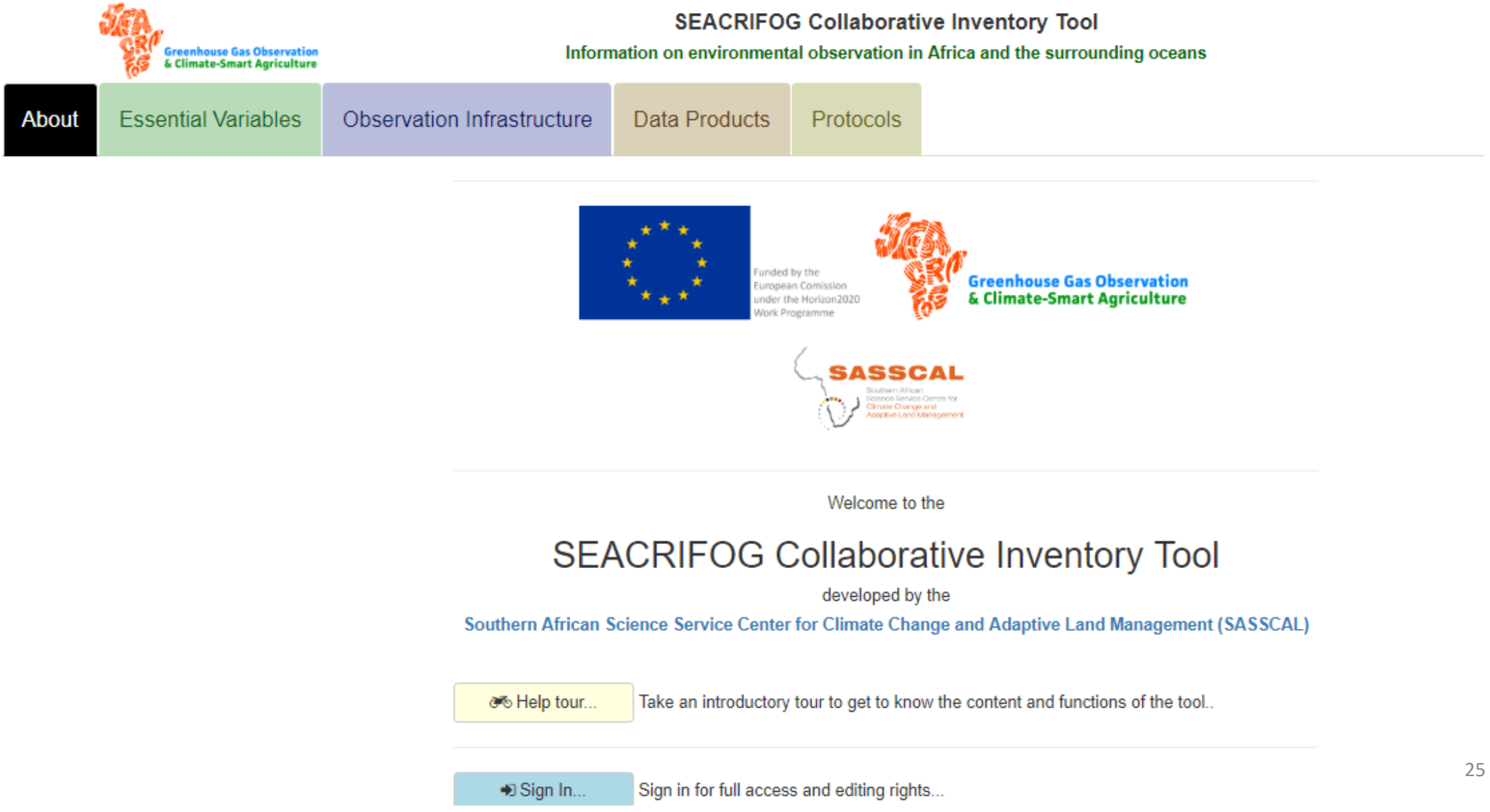
- **What are the gaps and needs regarding infrastructure?**
  Monitoring networks mapping

- **What are existing relevant methodological protocols?**
  Protocols inventory

- **What are the gaps and needs regarding data?** Work in progress
  Assessment of data products

SEACRIFOG – Collaborative Inventory Tool

https://seacrifog-tool.sasscal.org



SEACRIFOG – Collaborative Inventory Tool

https://seacrifog-tool.sasscal.org

About | **Essential Variables** | Observation Infrastructure | Data Products | Protocols

Search:

Variable Class	Variable Name	Variable Domain
Land Cover	Land Cover	Terrestrial
Land Use/Land Use Change	Land Use/Land Use Change	Terrestrial
Nitrous Oxide	Nitrous Oxide (Ocean)	Oceanic
Nutrients	Marine Nutrients	Oceanic
Ocean Colour	Ocean Colour	Oceanic
Oxygen	Oxygen	Oceanic
Plant Species Traits	Plant Species Traits	Terrestrial
Precursors	Carbon Monoxide (CO)	Atmospheric
Precursors	Dimethyl Sulfide	Oceanic
Precursors	Nitrogen Oxides (NOx)	Atmospheric
Precursors	Non-methane hydrocarbons	Atmospheric
Precursors	Sulfur Dioxide (SO2)	Atmospheric
Pressure (surface)	Pressure (surface)	Terrestrial
Radiation	Albedo	Terrestrial

Waiting for seacrifog-tool.sasscal.org...

Oxygen

Variable Class: Oxygen
Variable Domain: Oceanic
Variable Type: ECV
Further Information (URL): Click Here

Description:
O2 is essential for nearly all multicellular life. Future projections indicate that oceanic O2 levels will decrease substantially, in part because of ocean warming and increased stratification (a process often referred to as ocean deoxygenation), but also because of increased nutrient loadings in nearshore environments that lead to eutrophication. In a business-as-usual scenario, the ocean is projected to lose nearly 20% of its O2. This could have dramatic consequences for marine biogeochemistry and marine life, as the ocean's O2 minimum zones will expand substantially, and large swaths of ocean will appear that have O2 levels that are too low for fast-swimming fish to survive, and can potentially reduce the pool of bioavailable nitrogen due to reduction of nitrate.

Observation Methods:
NA

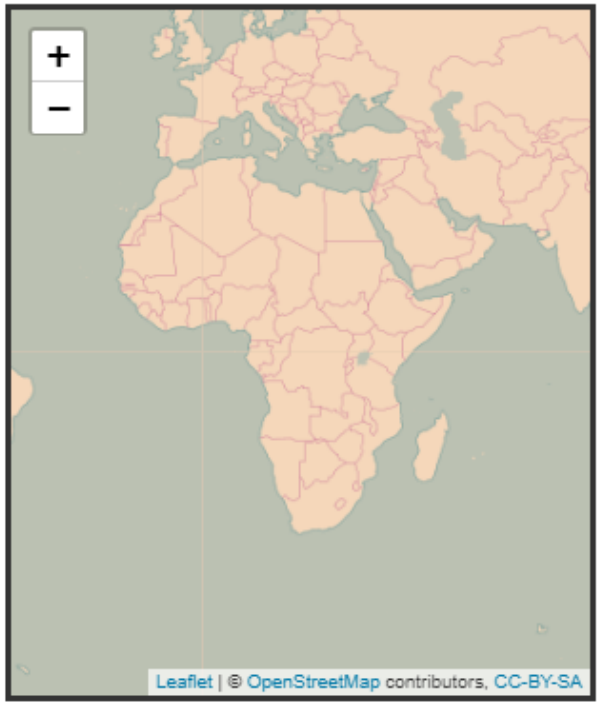
1 related data products available:

Data Product	T_start	T_end	Type	Link
GLODAP calibrated open ocean data product of inorganic and carbon-relevant variables	1972-01-01	2013-12-31	Geospatial - Raster	Click Here

5 related protocols available:

Protocol	Author/Institution	Year	Link
ECV-Ocean_requirements_IP2016	Global Observing System for Climate (GCOS)	2016	Click Here
The Global Observing System for Climate:	Global Observing System for Climate (GCOS)	2016	Click Here

Observation sites (points) and spatial coverage of data products (rectangles) related to this variable:



Role of variable in Radiative Forcing

Please note: Below figures are **simple aggregates** of **global** figures from the IPCC 5th Assessment Report and are only meant to provide a **very coarse guidance** with regards to sign and magnitude of uncertainty of the variable's contribution to radiative forcing on the African continent.

Variable Type: A

Related RF Components (global values):

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About | Essential Variables | **Observation Infrastructure** | Data Products | Protocols

Search:

ID	Network Name	Status	Type
1	Global Climate Observing System	Existing	Ground-based; Sea-borne; Space-borne
2	SASSCAL ObservationNet	Existing	Ground-based
3	SASSCAL Weathernet	Existing	Ground-based
4	FLUXNET	Existing	Ground-based
5	Copernicus	Existing	Space-borne
6	Baseline Surface Radiation Network	Existing	Ground-based
7	China-Brazil Earth Resources Satellite Program for Africa	Planned	Space-borne
8	Global Atmosphere Watch	Existing	Ground-based
9	South African Weather Service	Existing	Ground-based
10	South African Environmental Observation Network	Existing	Ground-based

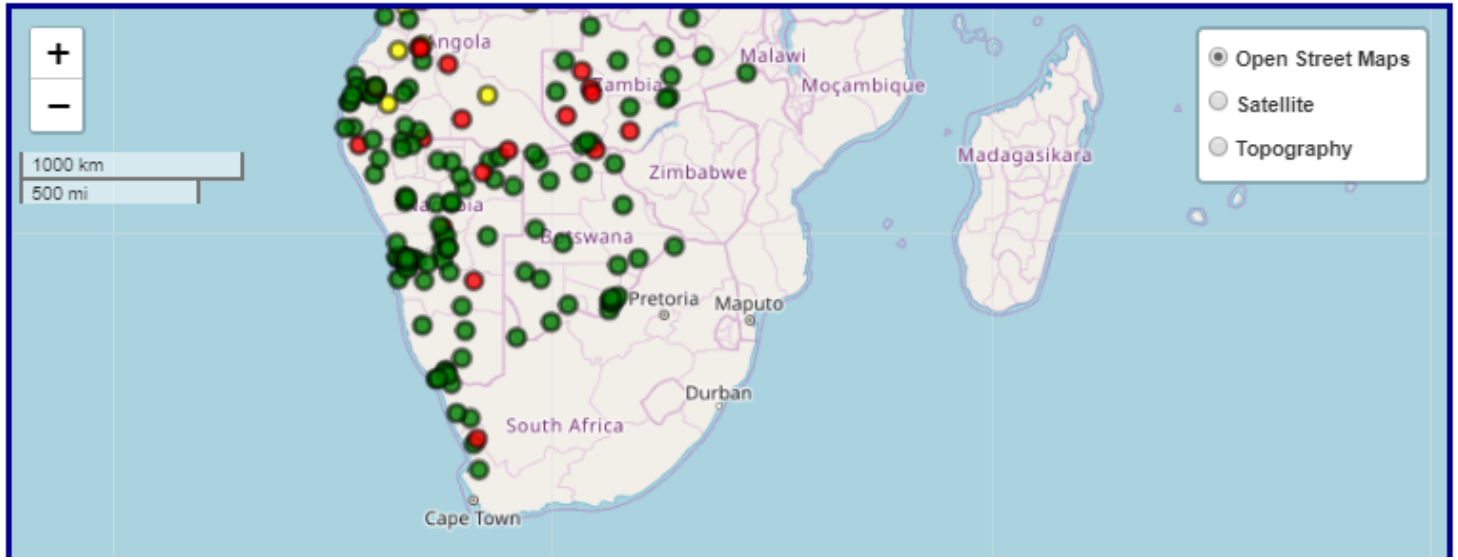
SASSCAL Weathernet (SASSCAL WN)

Parent Network (if applicable): NA
Network Type: Ground-based
Network Status: Existing
Network Start of Operation (Year): NA **(If applicable) Network End of Operation (Year):** NA

Network Description:
NA

Further Network Info (URL): Click Here
Network Data Access (URL): Click Here
Network Site Information (URL): Click Here

Map of Network Stations - Click a station marker for further station-specific information (Bounding box illustrates total coverage of network)



SEACRIFOG – Collaborative Inventory Tool

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About | Essential Variables | Observation Infrastructure | Data Products | **Protocols**

Search:

ID	Protocol	Author/Institution	Domain	Year
2	ECV-Atmosphere_requirements_IP2016	Global Observing System for Climate (GCOS)	Atmospheric	2016
3	ECV-Land_requirements_IP2016	Global Observing System for Climate (GCOS)	Terrestrial	2016
4	ECV-Ocean_requirements_IP2016	Global Observing System for Climate (GCOS)	Oceanic	2016
5	Guide to the WMO Integrated Global Observing System	World Meteorological Organization (WMO)	All	2018
6	The Global Observing System for Climate: Implementation Needs	Global Observing System for Climate (GCOS)	All	2016
7	Guide for Urban Integrated Hydro-Meteorological, Climate and Environmental Services	Global Atmospheric Watch (GAW)	All	2018
8	Low-cost sensors for the measurement of atmospheric composition: overview of topic and future applications	Lead authors: SC Candice Lung, Rod Jones, Christoph Zellweger, Ari Karppinen, Michele Penza, Tim Dye, Christoph Hueglin, Zhi Ning, Alastair C. Lewis, Erika von Schneidemesser, Richard E. Peltier, Roland Leigh, David Hagan, Olivier Laurent and Greg Carmichael	Atmospheric	2018
9	WMO Global Atmosphere Watch (GAW) Implementation Plan: 2016-2023	World Meteorological Organization (WMO)	Atmospheric	2017
10	Turbulent flux measurements of CO2, energy and momentum	Integrated Carbon Observation System (ICOS) - Ecosystem Thematic Center (ETC)	Terrestrial	2017

ECV-Atmosphere_requirements_IP2016

Author(s)/Institution: Global Observing System for Climate (GCOS)
Publisher: World Meteorological Organization (WMO)
Publication Year: 2016
DOI/ISBN/ISSN: --

Thematic category: Climate change
Domain: Atmospheric
Purpose: Observation (various)

Abstract:
Definitions, requirements, and network information of atmospheric Essential Climate Variables

Spatial applicability: Global
Spatial adoptability: Global
Temporal applicability: continuous
Intended Use / Level of Accuracy: NA
Protocol Sustainability: Long-term
Implementation Cost: Low

Format: Book
Version: --
License: Open-access
Language(s): English
File Access (URL): Click Here
Supplementary Information (URL): Click Here

Essential variables directly linked to this protocol:

Variable	Domain
Aerosol properties	Atmospheric
Carbon Monoxide (CO)	Atmospheric
Cloud Cover Fraction	Atmospheric

SEACRIFOG – Collaborative Inventory Tool

https://seacrifog-tool.sasscal.org

Greenhouse Gas Observation & Climate-Smart Agriculture

SEACRIFOG Collaborative Inventory Tool

Information on environmental observation in Africa and the surrounding oceans

SASSCAL

About | Essential Variables | Observation Infrastructure | **Data Products** | Protocols

Search:

ID	Data Product	Year	Provider
1	ESA CCI S2 Prototype Land Cover 20m Map of Africa 2016	2017	European Space Agency
2	Above-ground biomass and structure of 260 African tropical forests	2013	ForestPlots.net
3	Surface Ocean CO_2 Atlas (SOCAT) V6	2018	Bjerknes Climate Data Centre, ICOS Ocean Thematic Centre (Bergen, Norway)
4	River Discharge		Global Runoff Data Centre
5	Global 10-daily Directional Albedo 1km: Tiles	2018	Copernicus Global Land Sevice
	Land Surface		

Above-ground biomass and structure of 260 African tropical forests

Year of publication: 2013
Type of dataset: Cross-sectional Data
Type of observation: In Situ
Creator/Author: Simon L. Lewis et. al
Provider/Publisher: ForestPlots.net
Contact: NA

Description:
We report above-ground biomass (AGB), basal area, stem density and wood mass density estimates from 260 sample plots (mean size: 1.2 ha) in intact closed-canopy tropical forests across 12 African countries. Mean AGB is 395.7 Mg dry mass ha-1 (95% CI: 14.3), substantially higher than Amazonian values, with the Congo Basin and contiguous forest region attaining AGB values (429 Mg ha-1) similar to those of Bornean forests, and significantly greater than East or West African forests. AGB therefore appears generally higher in palaeo- compared with neotropical forests. However, mean stem density is low (426 ± 11 stems ha-1 greater than or equal to 100 mm diameter) compared with both Amazonian and Bornean forests (cf. approx. 600) and is the signature structural feature of African tropical forests. While spatial autocorrelation complicates analyses, AGB shows a positive relationship with rainfall in the driest nine months of the year, and an opposite association with the wettest three months of the year; a negative relationship with temperature; positive relationship with clay-rich soils; and negative relationships with C : N ratio (suggesting a positive soil phosphorus-AGB relationship), and soil fertility computed as the sum of base cations. The results indicate that AGB is mediated by both climate and soils, and suggest that the AGB of African closed-canopy tropical forests may be

Corresponding essential variable(s):

Variable	Domain
Above ground biomass	Terrestrial

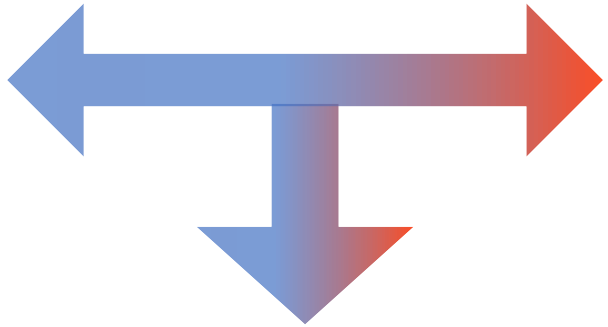
Spatial Coverage of Data Product

SEACRIFOG – Future steps

- Continue the inventory of data products (D4.2) and protocols (D4.3)
- Provide a set of methodological recommendations (D4.3)
- Optimal observation network design based on spatial optimization through inverse modelling (D3.2)
- Capacity building workshops (D4.4)

SEACRIFOG – How?

Scientific challenges



Societal challenges

Policy

International → National → Local

Paris Agreement	(I)NDCs	C40
2030 Agenda - SDGs		
HLDP-STI		

Thank you!

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https://seacrifog-tool.sasscal.org