Greenhouse Gas Observation
& Climate-Smart Agriculture

Filling the gap: assessment and design of an observational infrastructure for the long-term monitoring of GHGs and the carbon cycle in Africa.

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Trinity College Dublin · SASSCAL · cmcc · WITS University · ILRI · ICOS · THÜNEN

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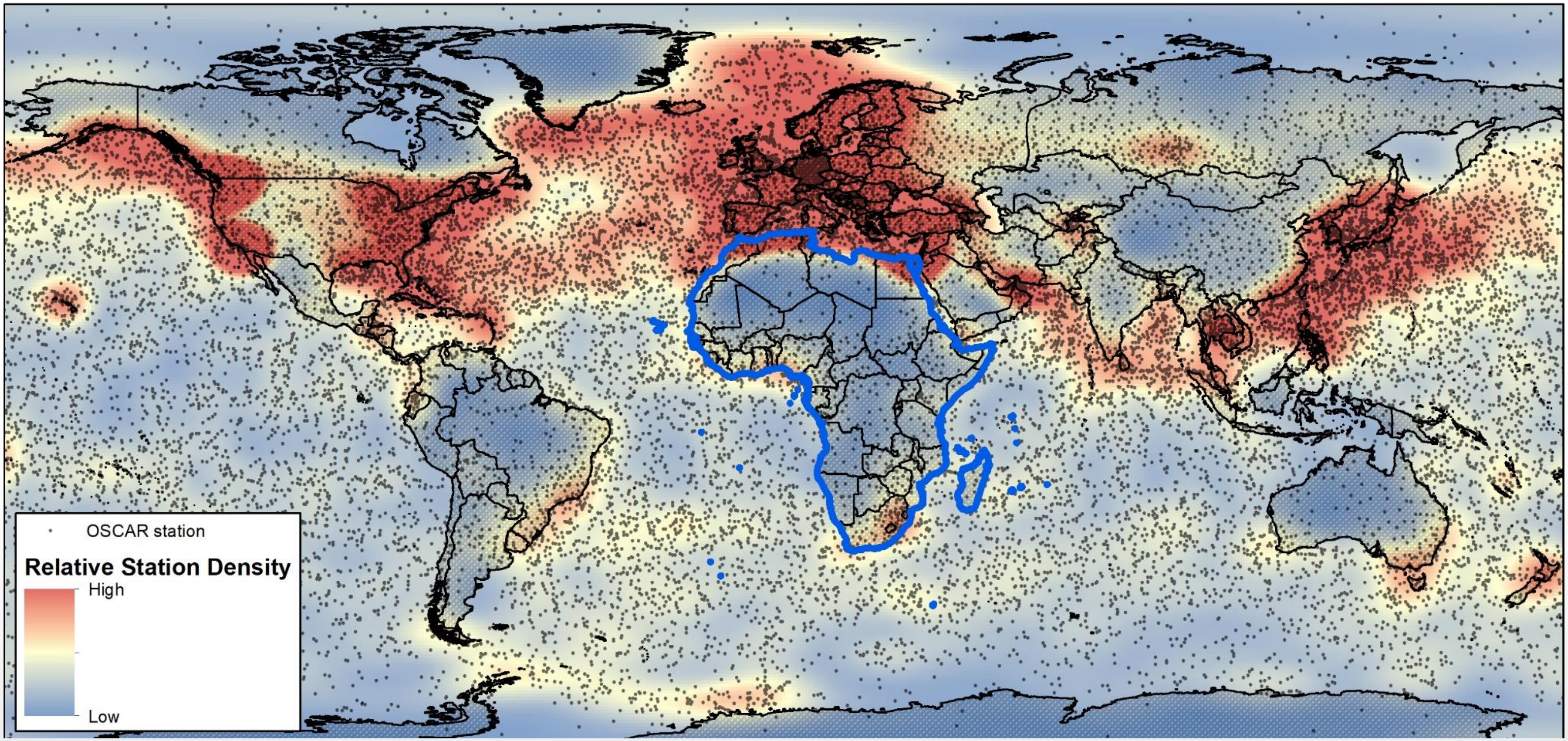
Environmental research infrastructures

- Utility of these networks:
  - Knowledge to assess drivers, impacts and feedback loops of climate change
  - Validate atmospheric inversions, satellite data and models
  - Enable the harmonisation of data products
  - Evaluate both vulnerabilities and the suitability of climate adaptation and mitigation strategies

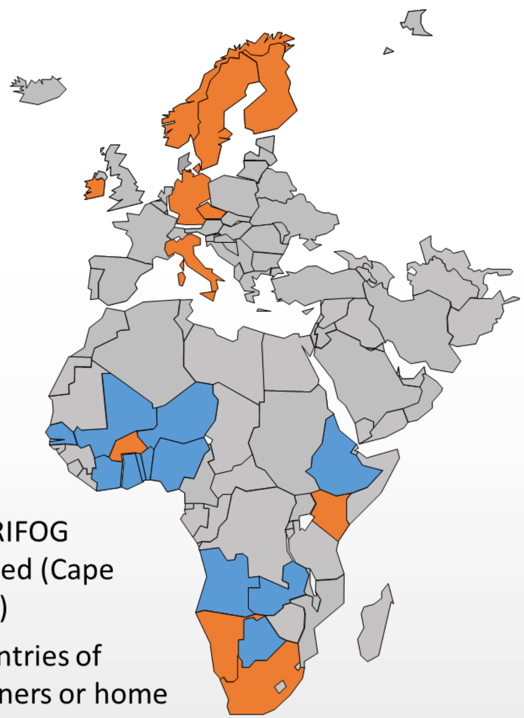
Why is an observational network for Africa important?



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

The SEACRIFOG Project

- **S**upporting **E**U-**A**frican **C**ooperation on **R**esearch **I**nfrastructures for **Fo**od Security and **G**reenhouse Gas Observations.
  - 7 EU and 14 African partners



Countries SEACRIFOG partners are based (Cape Verde is missing)

Consortium countries of SEACRIFOG partners or home of third linked party

The SEACRIFOG Project - Objectives

- To design a continental network of joint EU-African research infrastructures (RI) to monitor climatic and environmental change on the African continent linked to GHG emissions and food security
  - Identify essential parameters to develop science-based strategies to improve food/nutritional security including warning systems to mitigate climate change
  - Develop a roadmap towards an interoperable and accessible RI in agricultural and climate research that aligns with stakeholder needs
  - Contribute towards capacity development in Africa

The SEACRIFOG Project - Concept

- To develop a pan-African GHG observation system that considers:
    - A cross-domain approach – Atmosphere-Land-Ocean continuum
    - The impacts of land use change – natural/disturbed/urban systems
    - Enhance data access and interoperability
    - Ensure harmonisation and integration with existing networks
    - Build capacity – training networks

The SEACRIFOG Project - Structure

WP 2
Research Agenda to promote Food Security

ILRI & TI-AK
with
SASSCAL

WP 3
Research Agenda to promote GHG & Aerolsol OS

WITS & ICOS ERIC
with
SASSCAL,
LU

WP 4
Improving Harmonization and Data Quality

TCD & SASSCAL
with
UIB,
UNIRES

WP 5
Interoperability of RIs, Access, Data Sharing

SAEON & ICOS-ERIC
with
LU,
UIB,
UNIRES,
SASSCAL

WP 6
Demonstration Case Cape Verde

GEOMAR & INDP
with
TROPOS

WP 7
High-level Policy and Funding Concept

ICOS-ERIC & CMCC
with
SASSCAL,
WASCAL

Supporting Information

Supporting Information

WP 1
User Needs & Knowledge Gaps   CMCC & WASCAL with CZG, SASSCAL

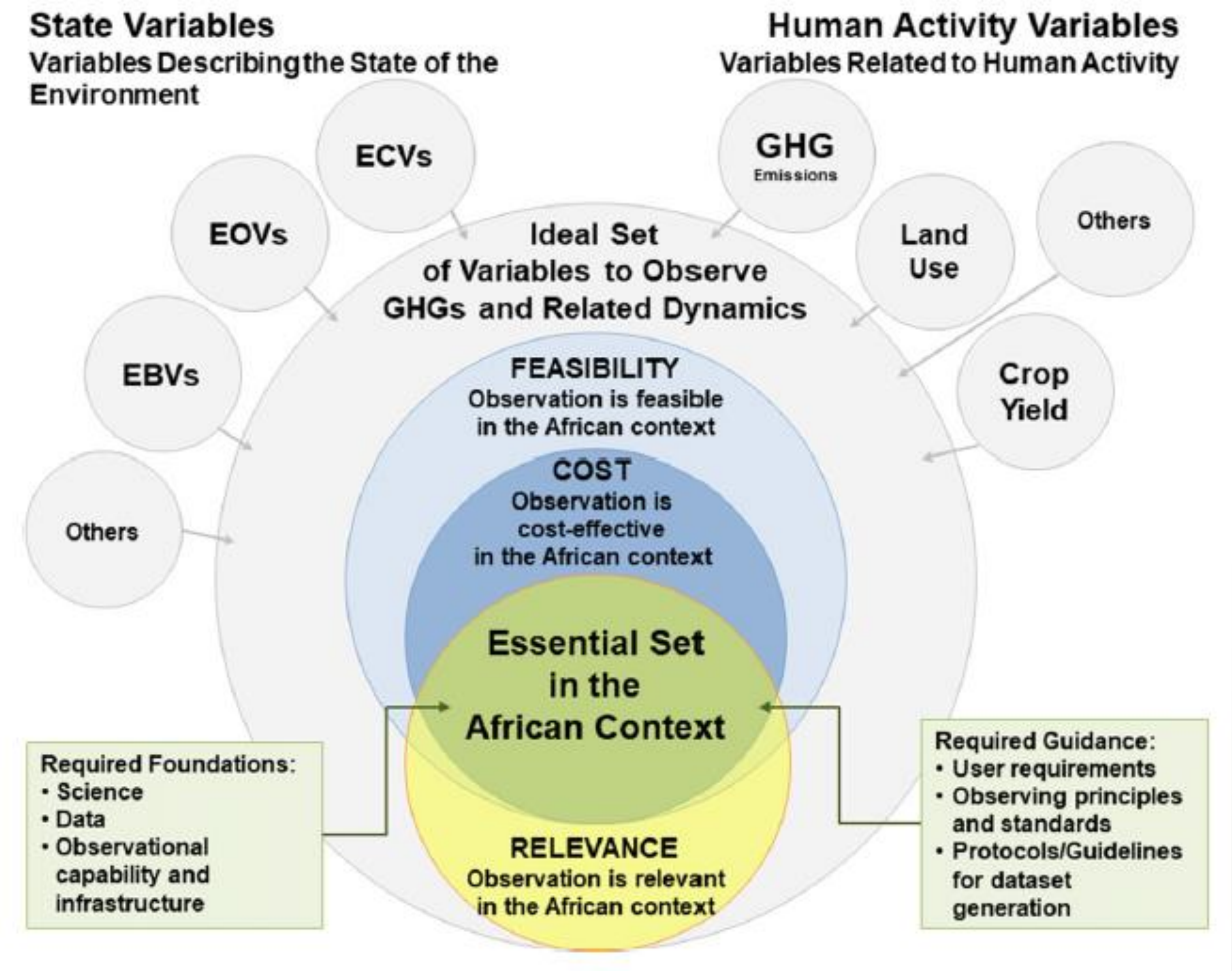
WP 8
Coordination   TI-AK

SEACRIFOG RI development – Knowledge gaps

- To assess the current status of observational networks across Africa
  - What observations do we need and are currently made?
  - Are there gaps in our knowledge and what infrastructure is required to address this?
  - Are there relevant methodological protocols available and are they fit for purpose?
  - How do the data products need to be compiled, managed and harmonised?




Identification of essential variables

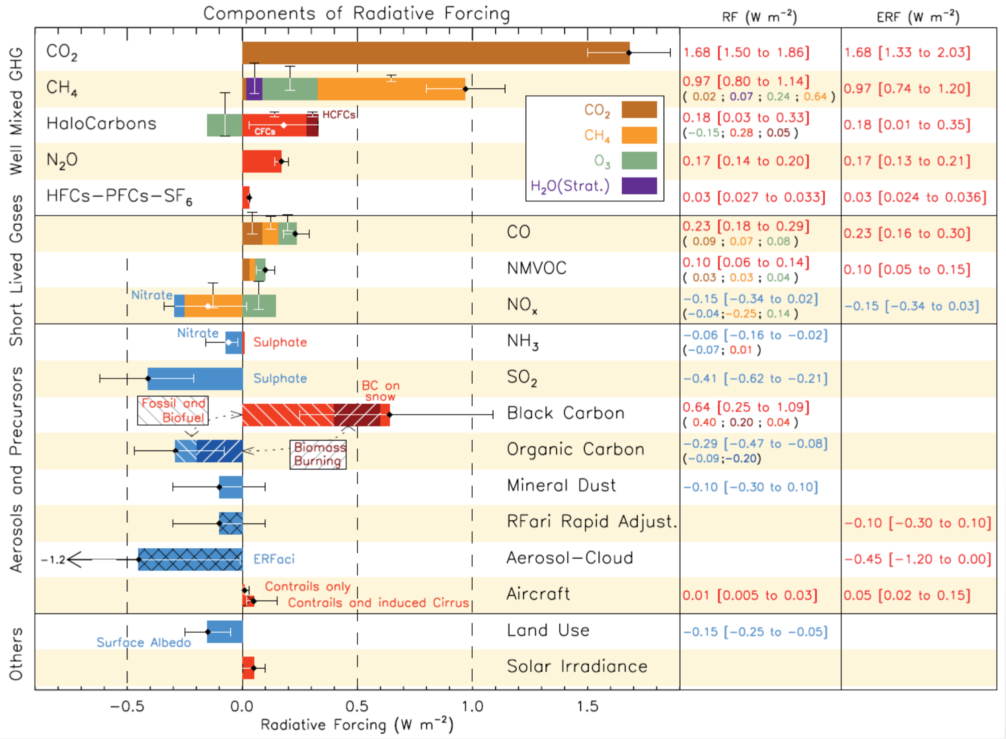


Prioritisation of essential variables

- Bottom-up approach - project partner and expert consultation
  - **Relevance** of variable in African context
  - **Feasibility** to measure variable in the long-term
  - **Cost** associated with measurement variable
- Development of online web-tool: https://seacrifog-tool.sasscal.org

Prioritisation of essential variables

- Top-down approach
  - Consideration of the variables required to quantify the main components of anthropogenic radiative forcing



Deliverable 3.1

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

Greenhouse Gas Observation & Climate-Smart Agriculture

Essential variables

- A minimum set of 58 essential variables were identified.

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)

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

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

Anthropic Factors

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

Ancillary / Other Variables

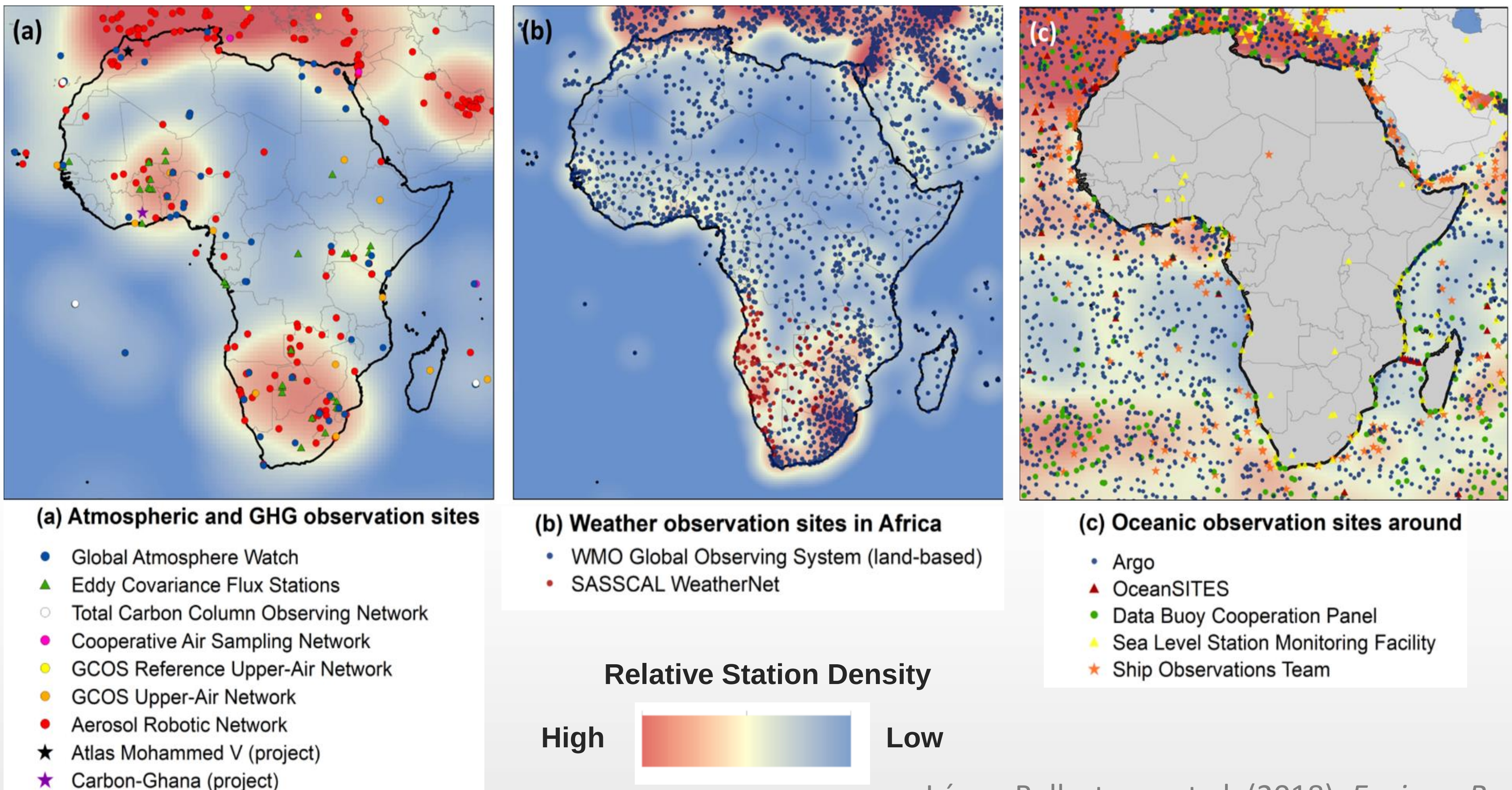
- Atmospheric Boundary Layer
- Below-ground biomass
- Biosphere-Atmosphere CO_2, CH_4 & N_2O fluxes
- Net radiation (SW/LW) at surface
- Dimethyl Sulfide (Oceanic)
- Surface roughness
- Soil type
- Infiltration & Runoff
- Evapotranspiration
- Wild herbivores

Deliverable 4.1

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

Observational capacity in Africa

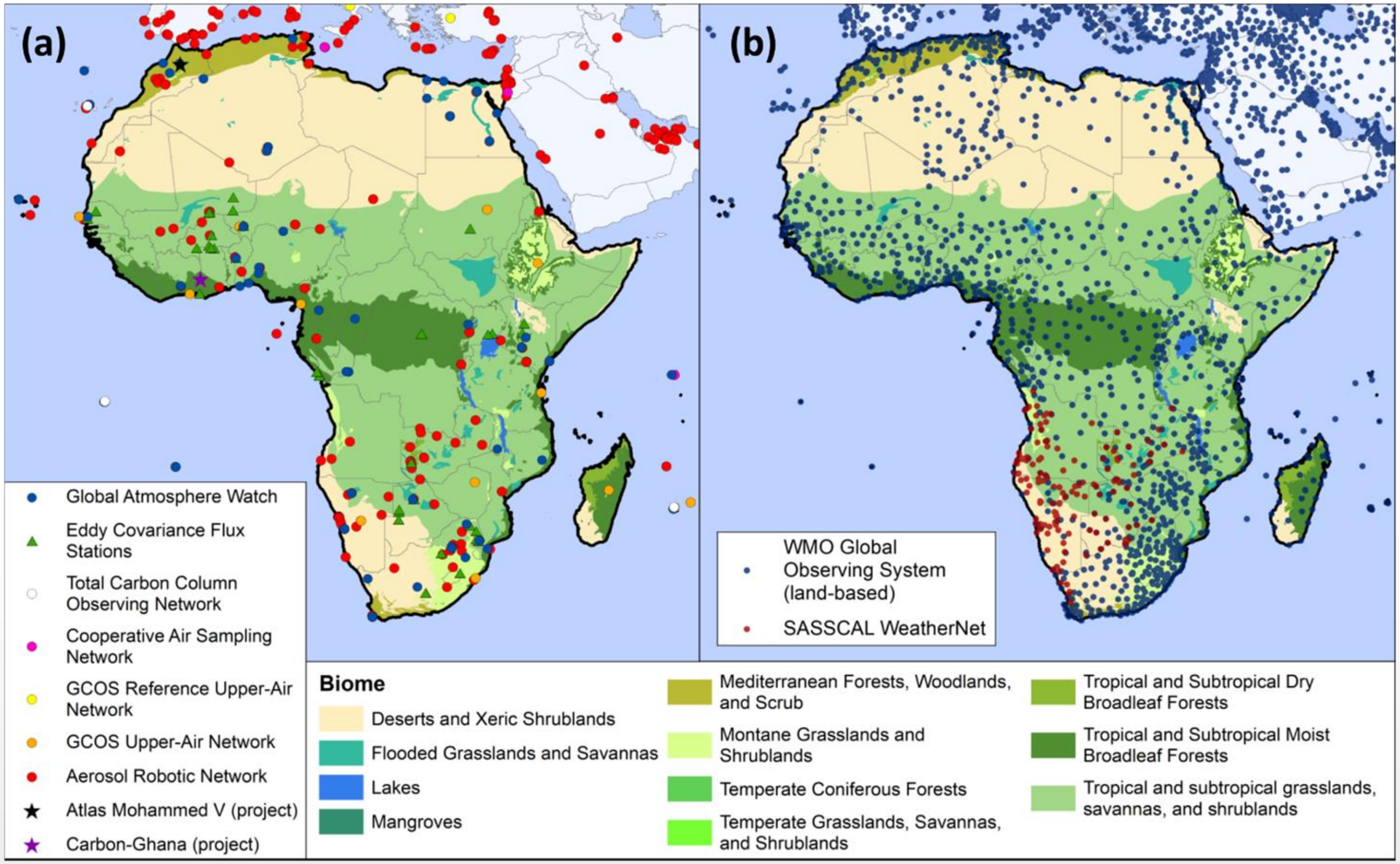
- Inventory of existing or planned networks – 47 in total



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

Observational capacity in Africa

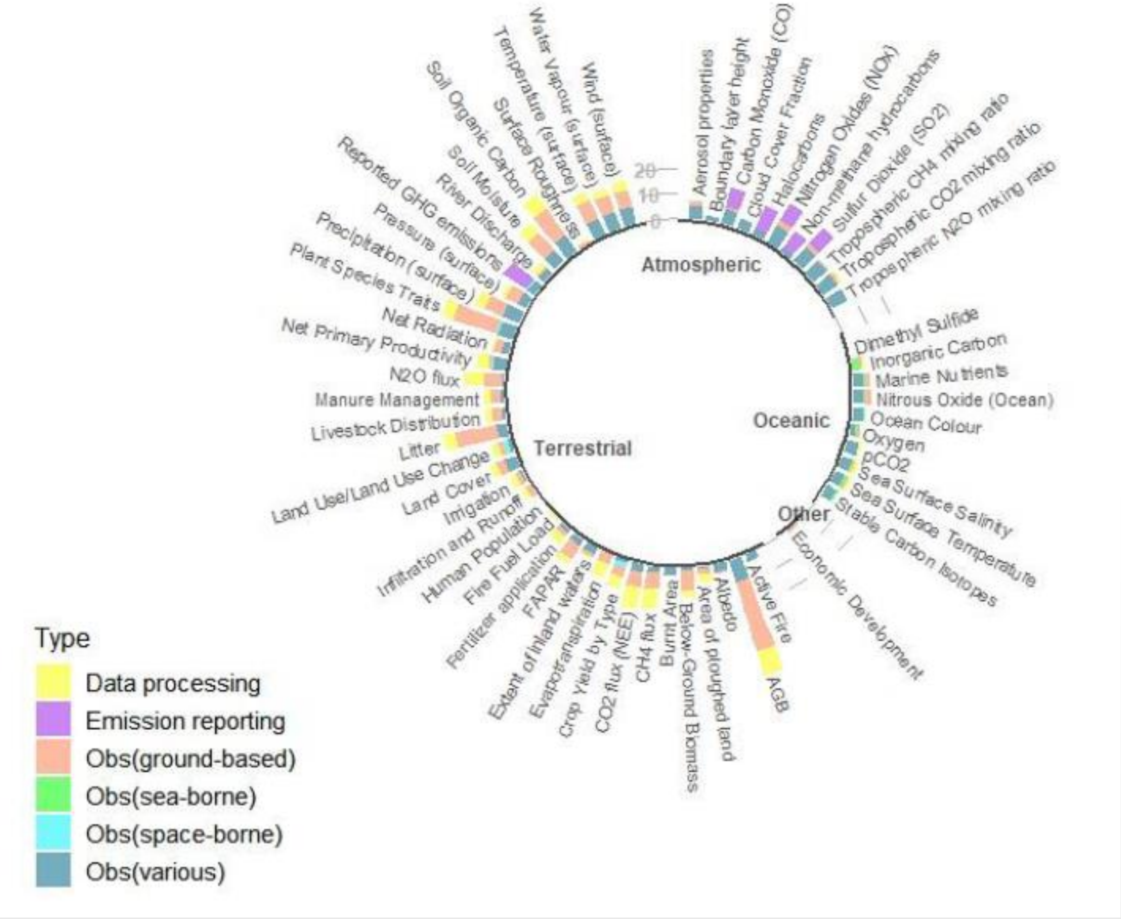
- Distribution of observational stations across biomes



López-Ballesteros et al. (2018). *Environ. Res. Lett;* Olson et al. (2001) *BioScience*

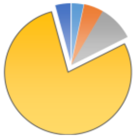
Measurement protocol inventory

- 140 protocols compiled from open-source material

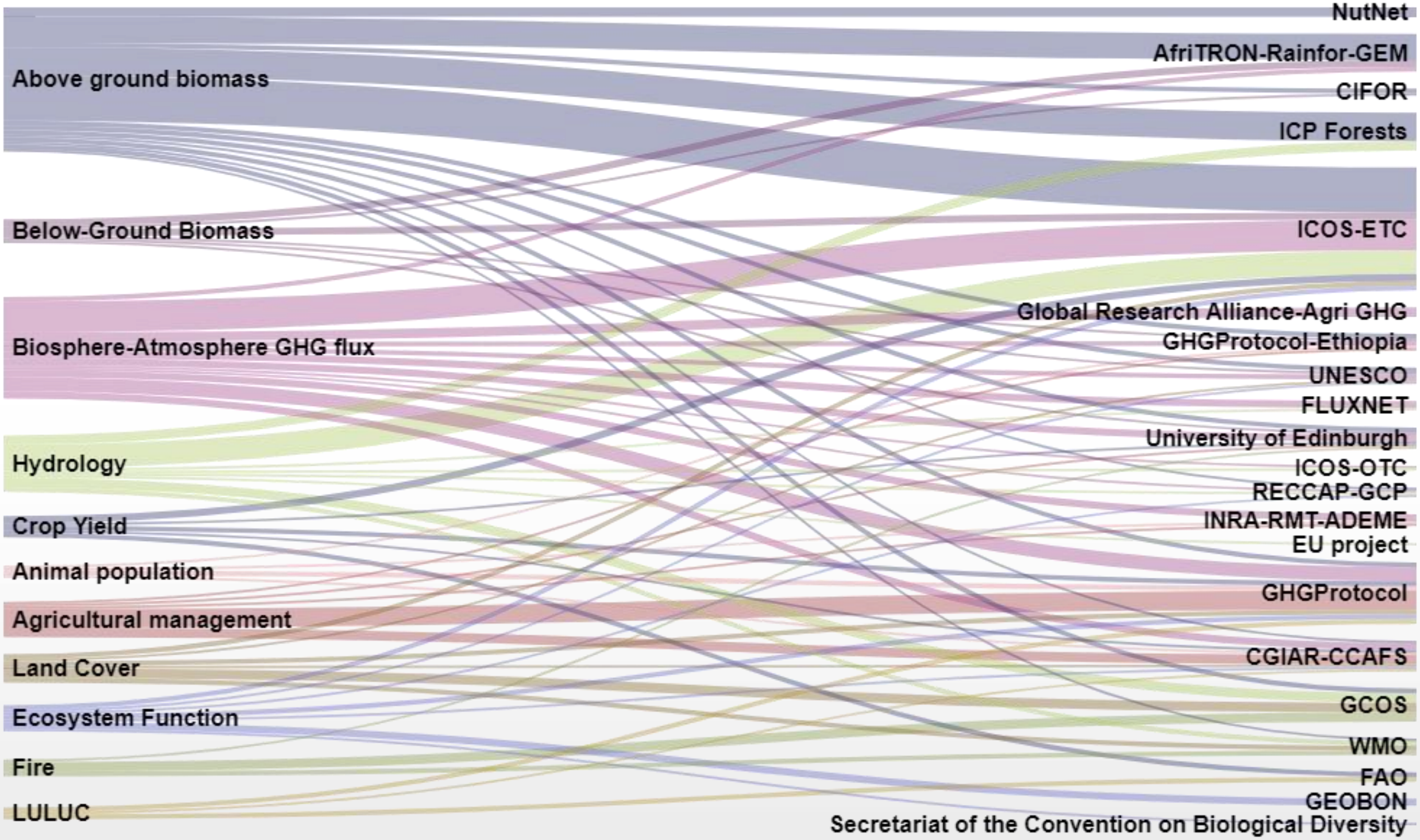


Deliverable 4.3

Measurement protocol inventory



Terrestrial domain



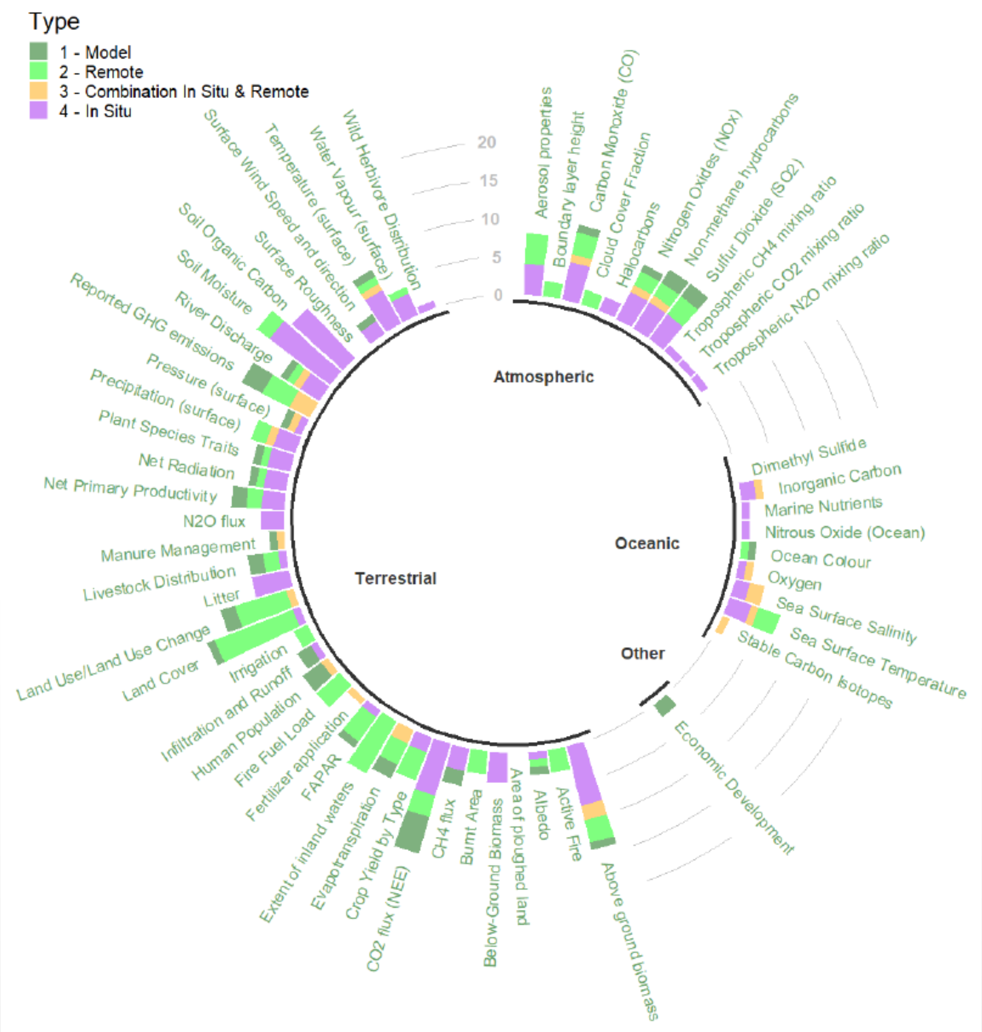
Deliverable 4.3

Measurement protocol feasibility assessment

ID	Title	Publisher	Variables	Domain	Equipment cost	Running cost	Installation effort	Maintenance effort	Knowledge needed	Measurement mode
6	Guide for Urban Integrated Hydro-Meteorological, Climate and Environmental Services	World Meteorological Organization (WMO)	Aerosol properties;Boundary layer height;Tropospheric CH_4 mixing ratio;Tropospheric CO_2 mixing ratio;Tropospheric N_2O mixing ratio;Cloud Cover Fraction;Carbon Monoxide (CO);Halocarbons;Nitrogen Oxides (NOx);Non-methane hydrocarbons;Sulfur Dioxide (SO_2)	All	€€€	€€€	L-H	H	L-H	AM
7	Low-cost sensors for the measurement of A composition: overview of topic and future applications	World Meteorological Organization (WMO)	Aerosol properties;Tropospheric CH4 mixing ratio;Tropospheric CO2 mixing ratio;Carbon Monoxide (CO);Nitrogen Oxides (NOx);Sulfur Dioxide (SO2)	A	€-€€	€	H	L	M-H	AM
9	Turbulent flux measurements of CO2, energy and momentum	ICOS-ETC	Biosphere-Atmosphere CO2 flux (NEE);Evapotranspiration;Water Vapour (surface);Surface Wind Speed and direction	T	€€€	€€	H	L	H	AM
10	CO2, H2O, CH4 and N2O storage flux measurements	ICOS-ETC	Biosphere-Atmosphere CH4 flux;Biosphere-Atmosphere CO2 flux (NEE);Biosphere-Atmosphere N2O flux;Evapotranspiration	T	€€	€	M	L	M	AM
11	Meteorology. Air temperature, Air relative humidity, Air pressure, Wind speed, Wind direction, Backup meteo station	ICOS-ETC	Pressure (surface);Surface Wind Speed and direction;Temperature (surface);Water Vapour (surface)	T	€€	€	L	M	L	AM
12	Precipitations. Total precipitation, Snow depth	ICOS-ETC	Precipitation (surface)	T	€	€	L	L	L	AM
13	Radiations measurements. Short-wave radiations, Long-wave radiations, Photosynthetically active radiation	ICOS-ETC	Fraction of Absorbed Photosynthetically Active Radiation (FAPAR);Net Radiation at surface (SW/LW)	T	€€	€	M	M	M	AM
14	Soil-meteorological measurements. Soil Temperature; Soil Water Content; Soil Heat Flux Density	ICOS-ETC	Soil Moisture	T	€€	€	M	L	M	AM
15	Water Table Depth Measurements	ICOS-ETC	--	T	€€	€	M	L	L	AM
16	Station description. How to describe the station and history of the monitored ecosystem	ICOS-ETC	Biosphere-Atmosphere CO2 flux (NEE);Evapotranspiration;Water Vapour (surface);Surface Wind Speed and direction;Net Primary Productivity;Pressure (surface);Temperature (surface);Surface Roughness;Biosphere-Atmosphere CH4 flux;Biosphere-	T	N	N	N	L	L	MM

Deliverable 4.3

Data availability



Deliverable 4.2

Data availability – SEACRIFOG Inventory Tool

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

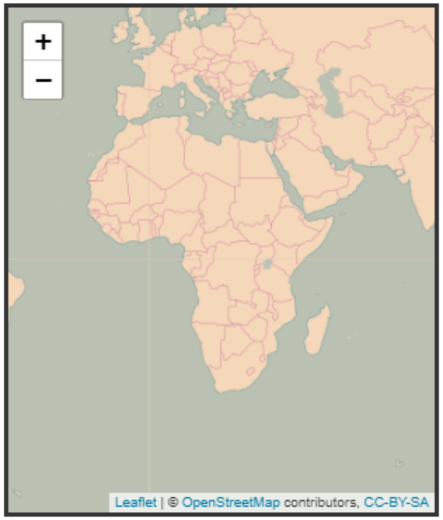
1 related data products available:

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):

https://seacrifog-tool.sasscal.org

Data availability – SEACRIFOG Inventory Tool

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

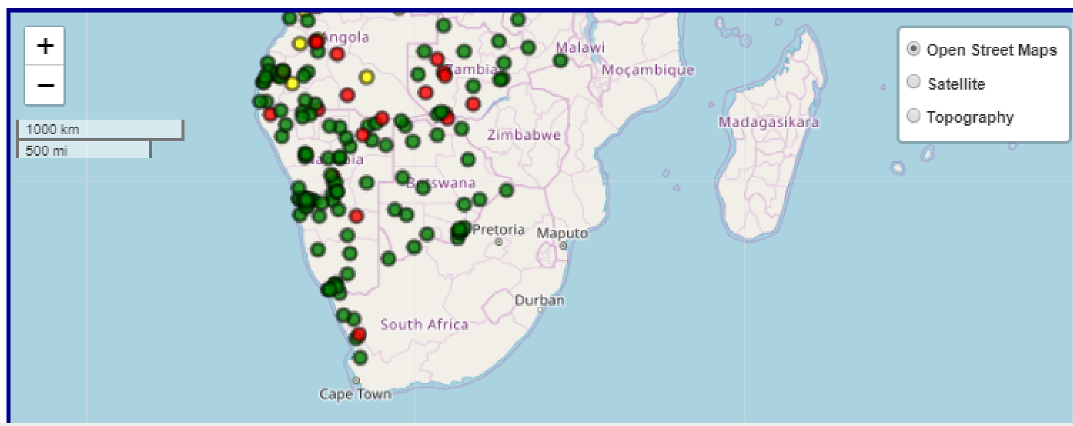
SASSCAL Weathernet (SASSCAL WN)

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)



https://seacrifog-tool.sasscal.org

Greenhouse Gas Observation & Climate-Smart Agriculture

Data availability – SEACRIFOG Inventory Tool

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

https://seacrifog-tool.sasscal.org

Data availability – SEACRIFOG Inventory Tool

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 Meteorogical 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

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https://seacrifog-tool.sasscal.org

SEACRIFOG – Next steps

- Continue updating inventory of data products, networks and protocols
- Develop a suite of recommended methodologies for measurement variables
- Assess the spatial optimisation of the observational network using inverse modelling techniques
- Build capacity through training workshops and online resources
- Develop high level policy and funding concept - investment

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Thank you for your attention!

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ICOS
INTEGRATED CARBON OBSERVATION SYSTEM

THÜNEN

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