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Southern African Science Service Centre for Climate Change and Adaptive Land Management

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Winter School on
Eddy Covariance Flux Measurements

10 June 2019, Vuwani, South Africa

GHG Observations in Africa
From the perspective of the SEACRIFOG Project

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Outline

- Why bother?
- African GHG budget: What do we know?
- Introduction to the SEACRIFOG Project
- An African Climate Observation Network
- Essential Variables to be Observed

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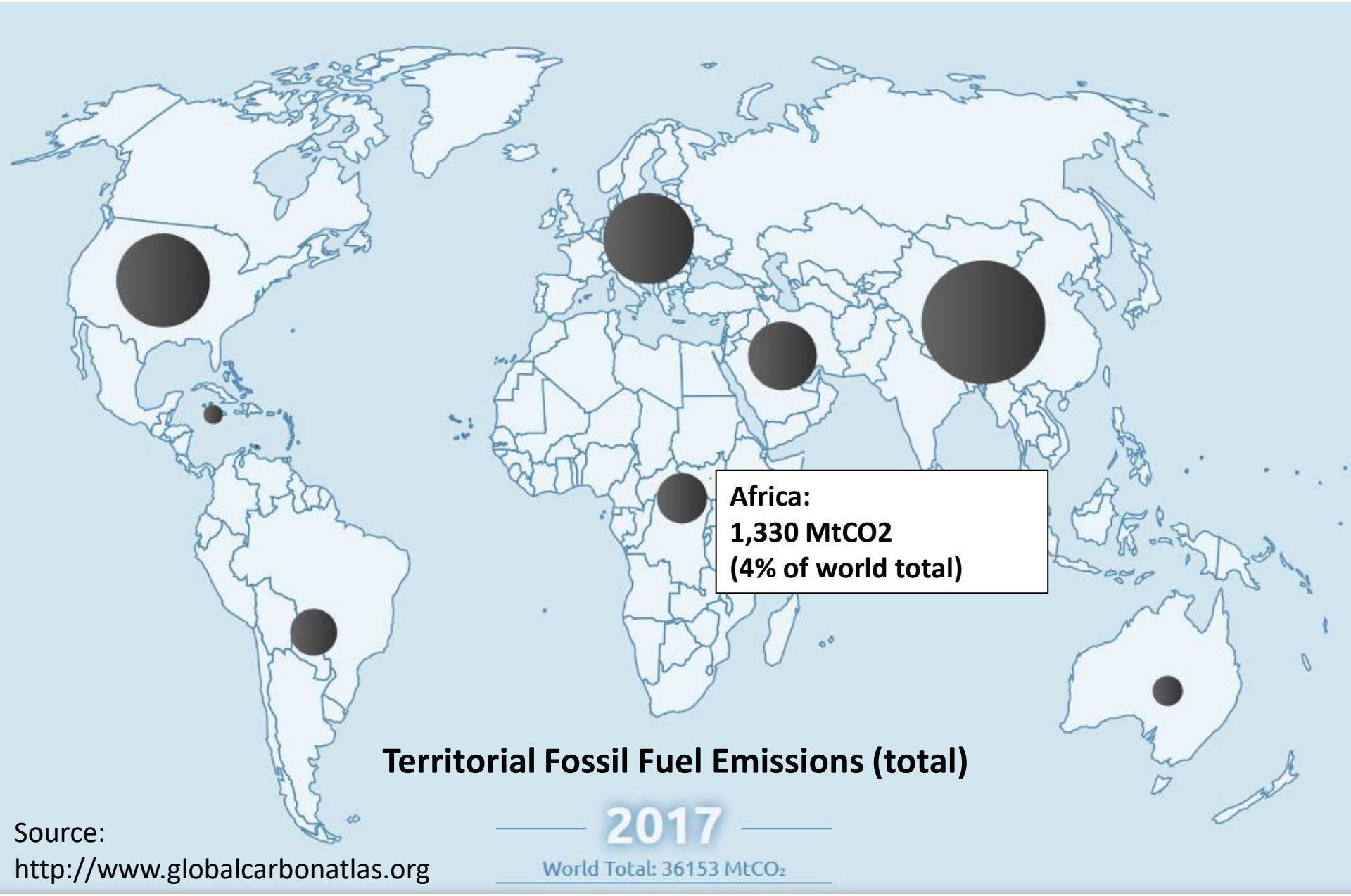
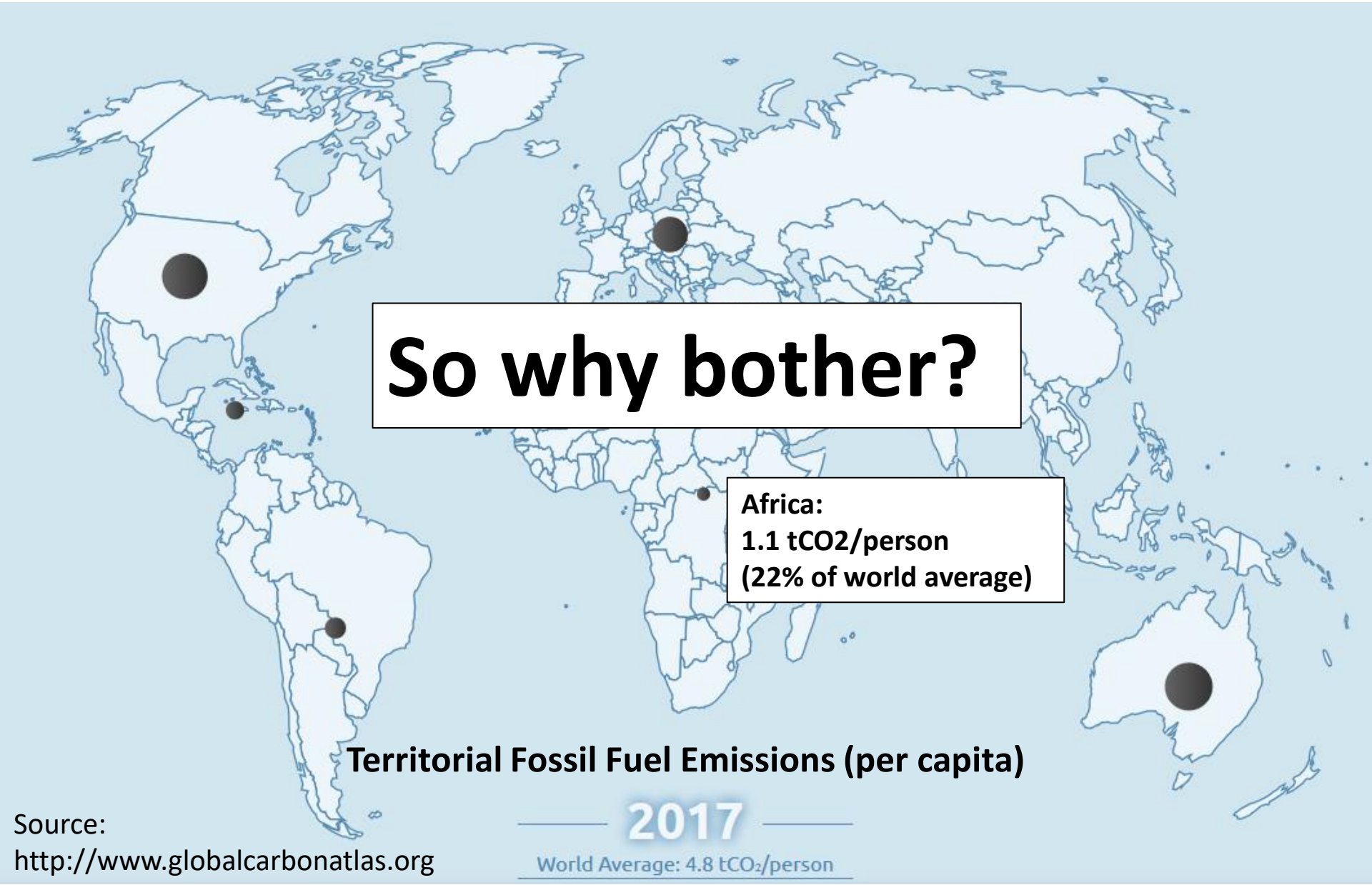
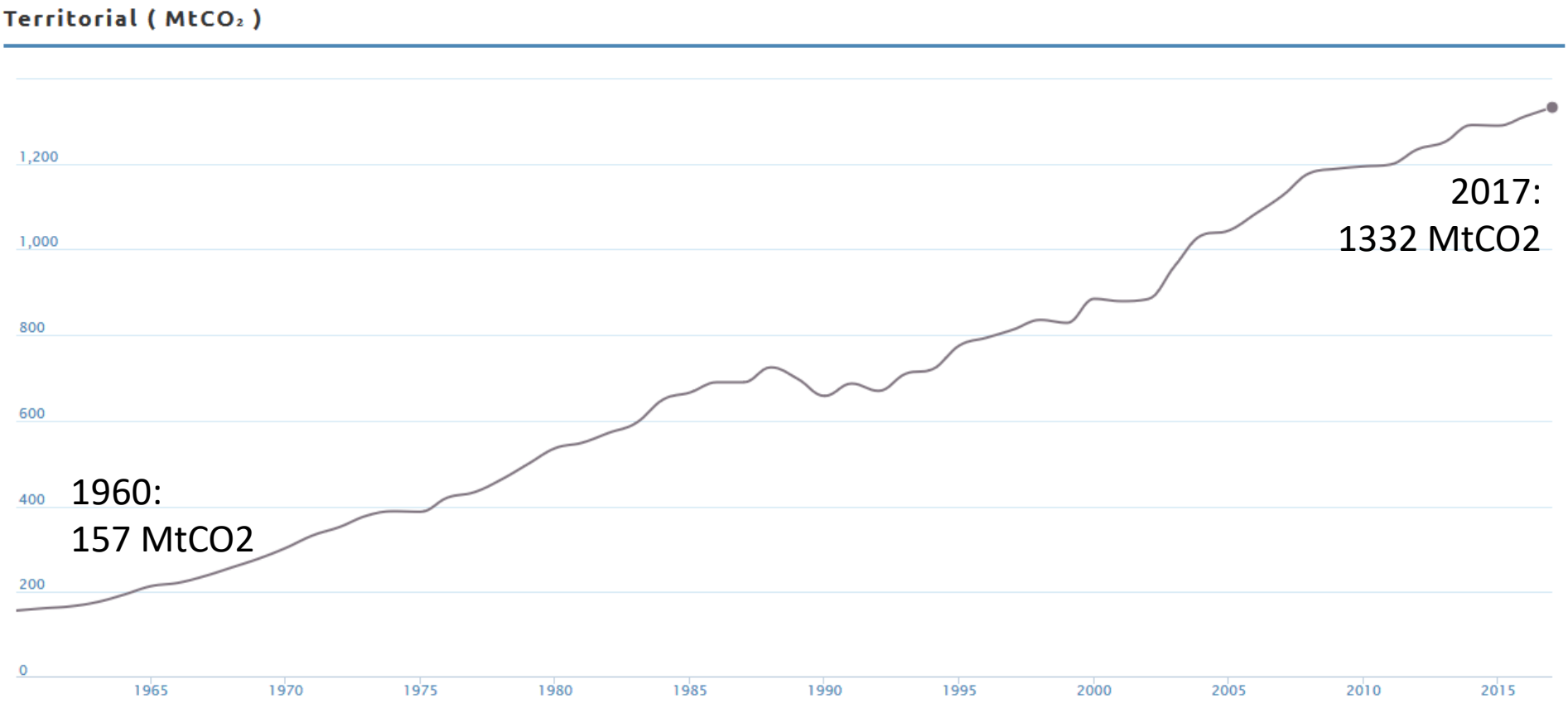


Source:
http://www.globalcarbonatlas.org

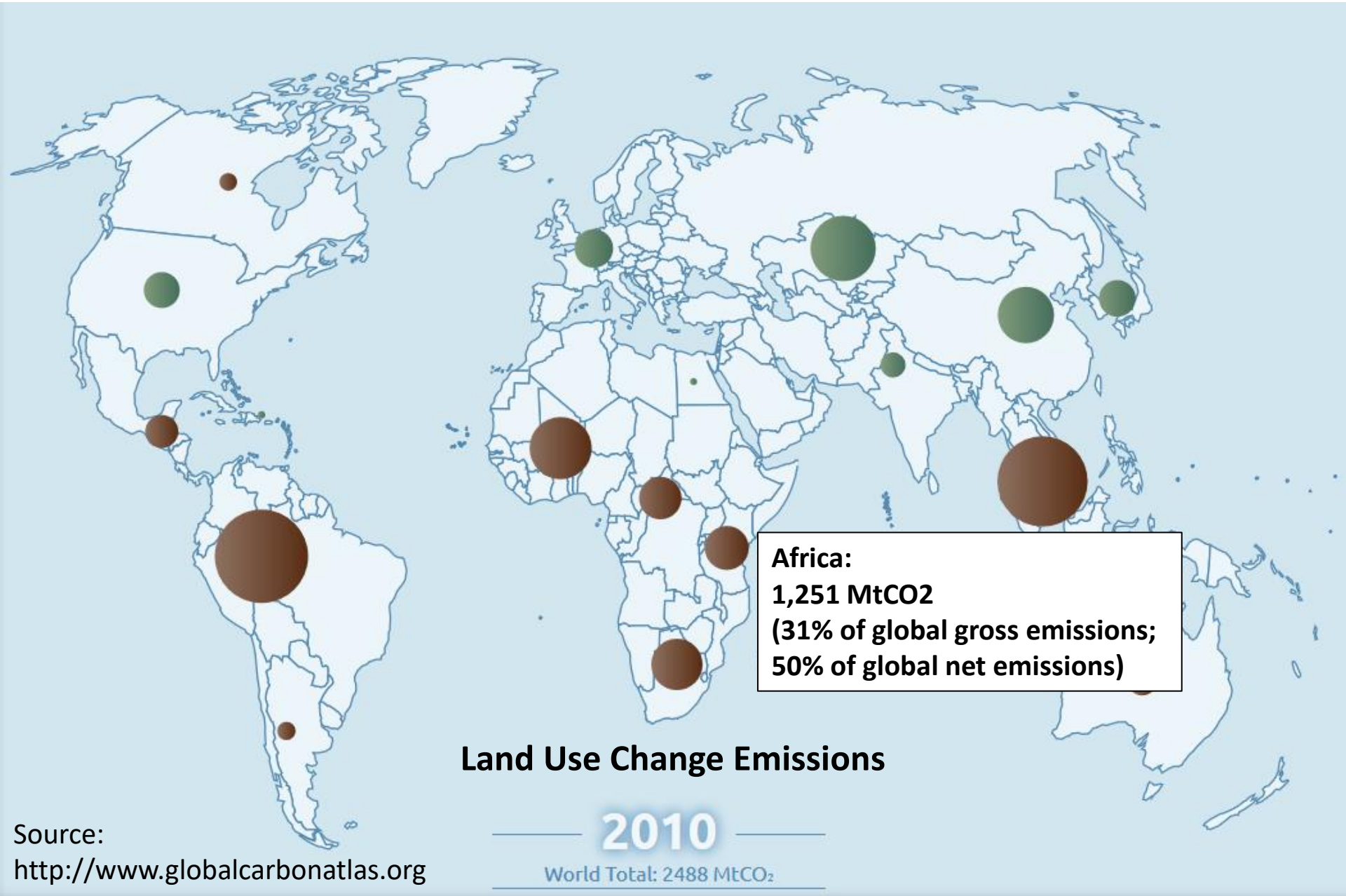


Source:
http://www.globalcarbonatlas.org



Source: http://www.globalcarbonatlas.org

African fossil fuel emissions over time



Source:
http://www.globalcarbonatlas.org

Major dynamics and drivers

- Population growth: Projected doubling of population within next 30 years (from currently 1.3 billion to 2.7 billion in 2050) – more than half of projected global growth for that period
- Development agenda envisages economic growth throughout

→ increasing needs for resources and energy

→ further land use change (currently LUCF responsible for 1/3 of Africa‘s anthropogenic emissions (global average: 14%), on the same order as fossil fuels)

→ increasing role in global carbon cycle and GHG budget

→ quantification of stocks and fluxes

→ need for appropriate mitigation and adaptation strategies

→ understand processes, role and responses of biosphere

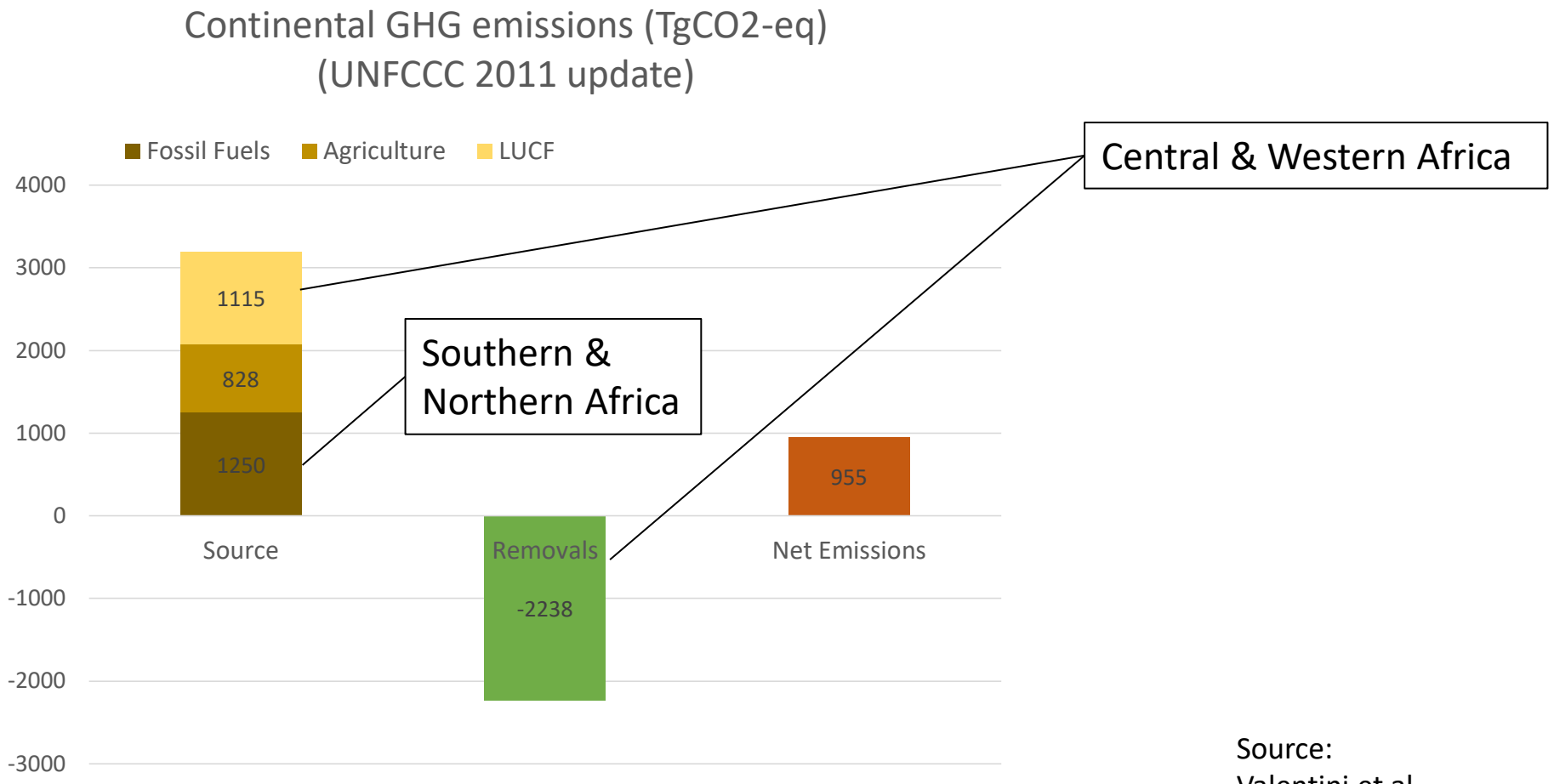
WHAT DO WE KNOW ABOUT THE AFRICAN GHG BUDGET?

Review of estimates, based on different contributing sources/methodologies:

- Inventories
- Flux measurements
- Models (DGVMs)
- Atmospheric inversions

2011 UNFCCC nat. communications

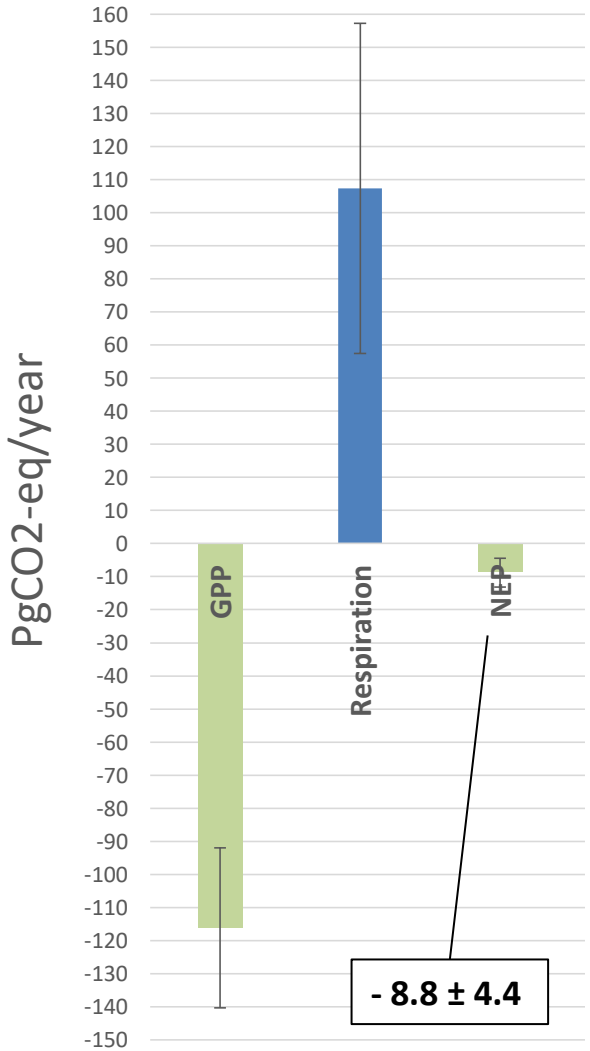
Sum of emissions as estimated and reported by countries



Source:
Valentini et al.,
Biogeosciences (2014)

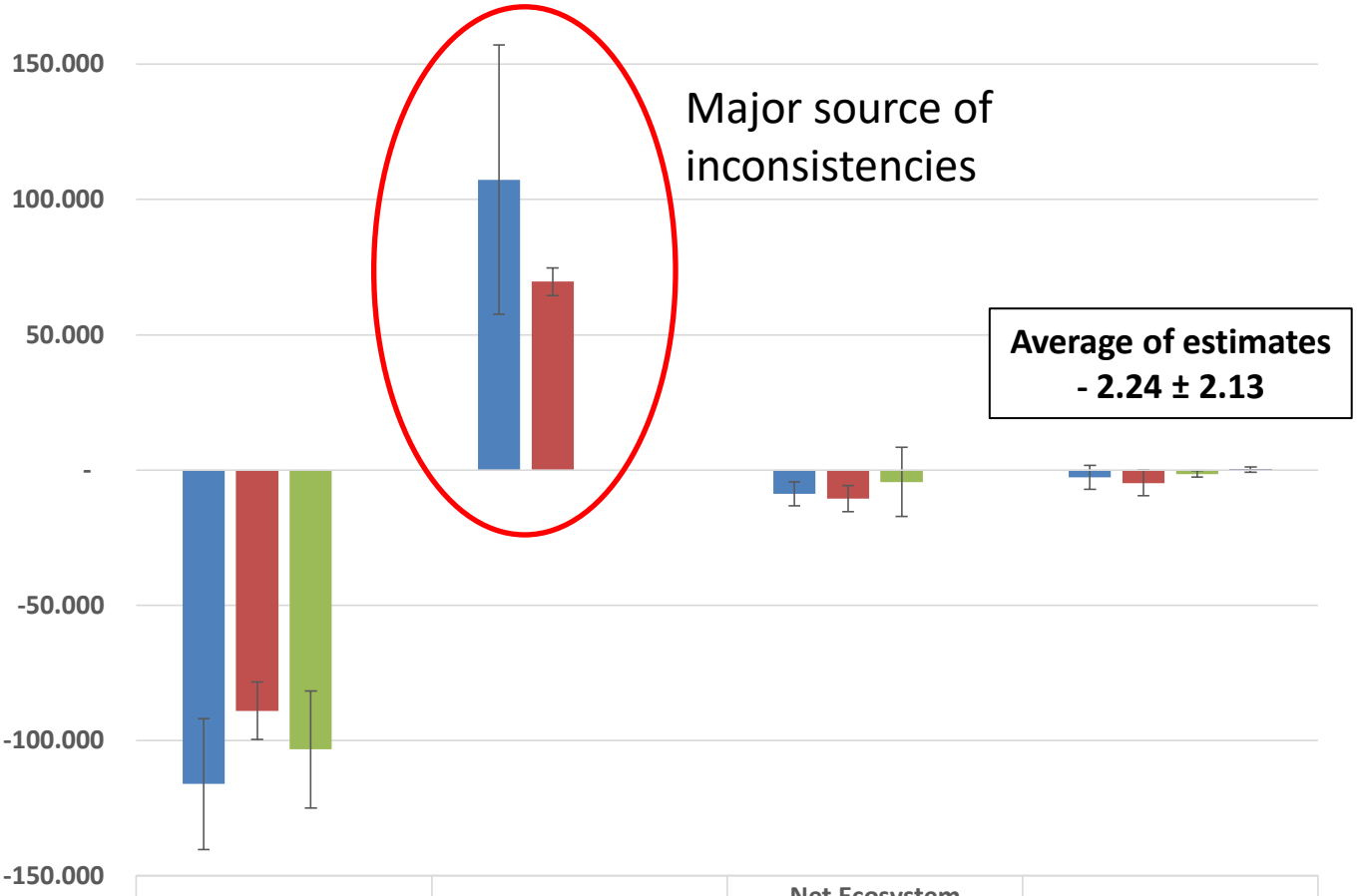
Synthesis of Estimates

Synthesis of recent inventory estimates of continental GHG fluxes



Source:
Valentini et al.,
Biogeosciences (2014)

Synthesis of Estimates



	GPP	Respiration	Net Ecosystem Production	Net Biome Production
Inventory	-116.149	107.355	-8.794	-2.711
Ecosystem Fluxes	(89.04)	69.62	(10.63)	(4.82)
Models (DGVM)	(103.32)		(4.40)	(1.48)
Atm. Inversions				0.18

Ref. periods

- Flux: 1982-2008
- Models: 1990-2010
- Inversion: 1996-2004

Source: Valentini et al., Biogeosciences (2014)

So what do we know?

- Uncertain whether Africa is a carbon source or sink
- Taking into account other GHGs, the continent is probably a net GHG source, but non-CO2 GHGs not well studied
- High interannual variability: One quarter of global year-to-year variation in global land-atmosphere CO2 exchange attributed to African continent

→ **African continent currently one of the weakest links when it comes to constraining the global GHG budget**

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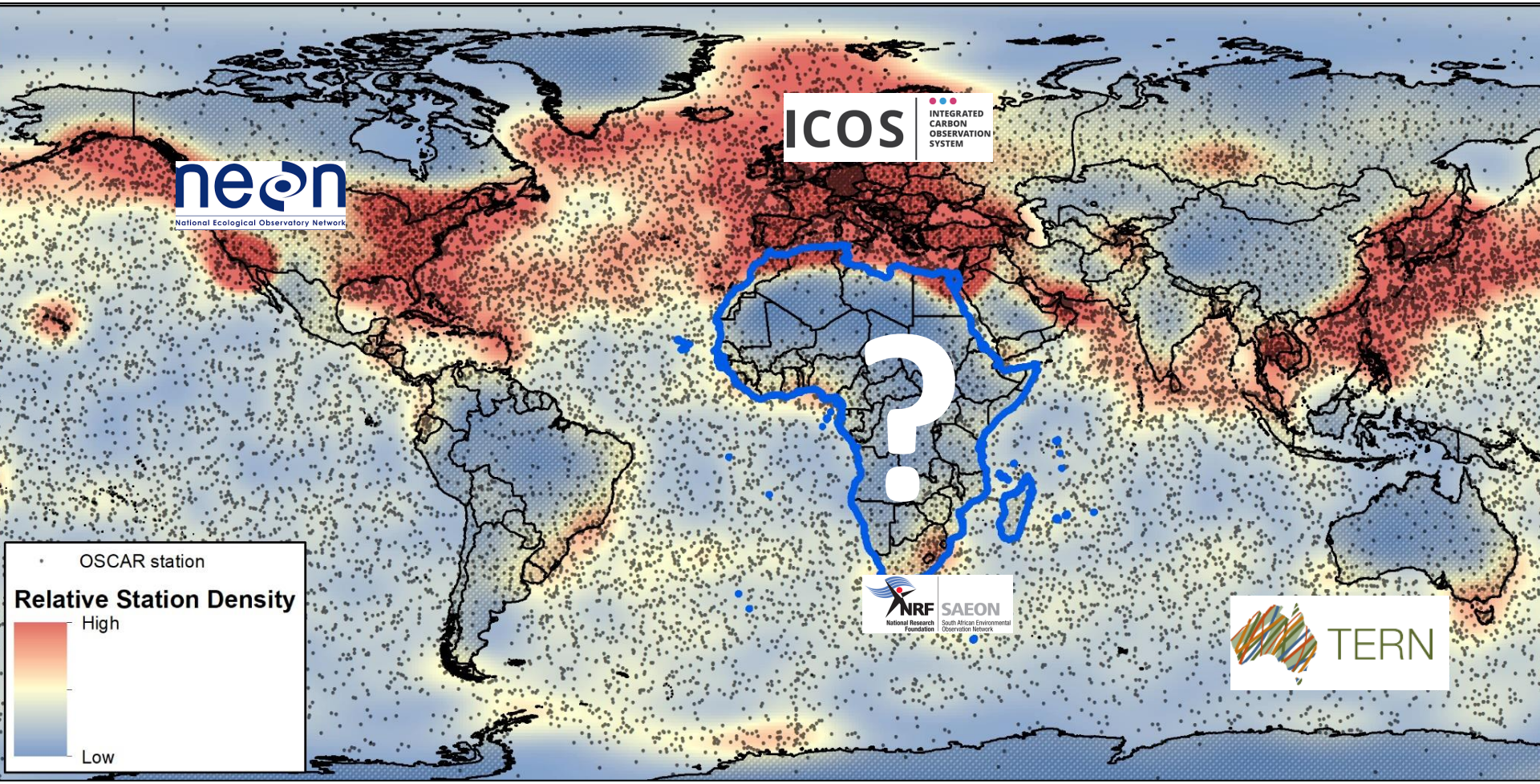


Source:
Lopez-Ballesteros et al.,
Environmental Research Letters (2018)

Greenhouse Gas Observation & Climate-Smart Agriculture

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

SASSCAL Southern African Science Service Centre for Climate Change and Adaptive Land Management

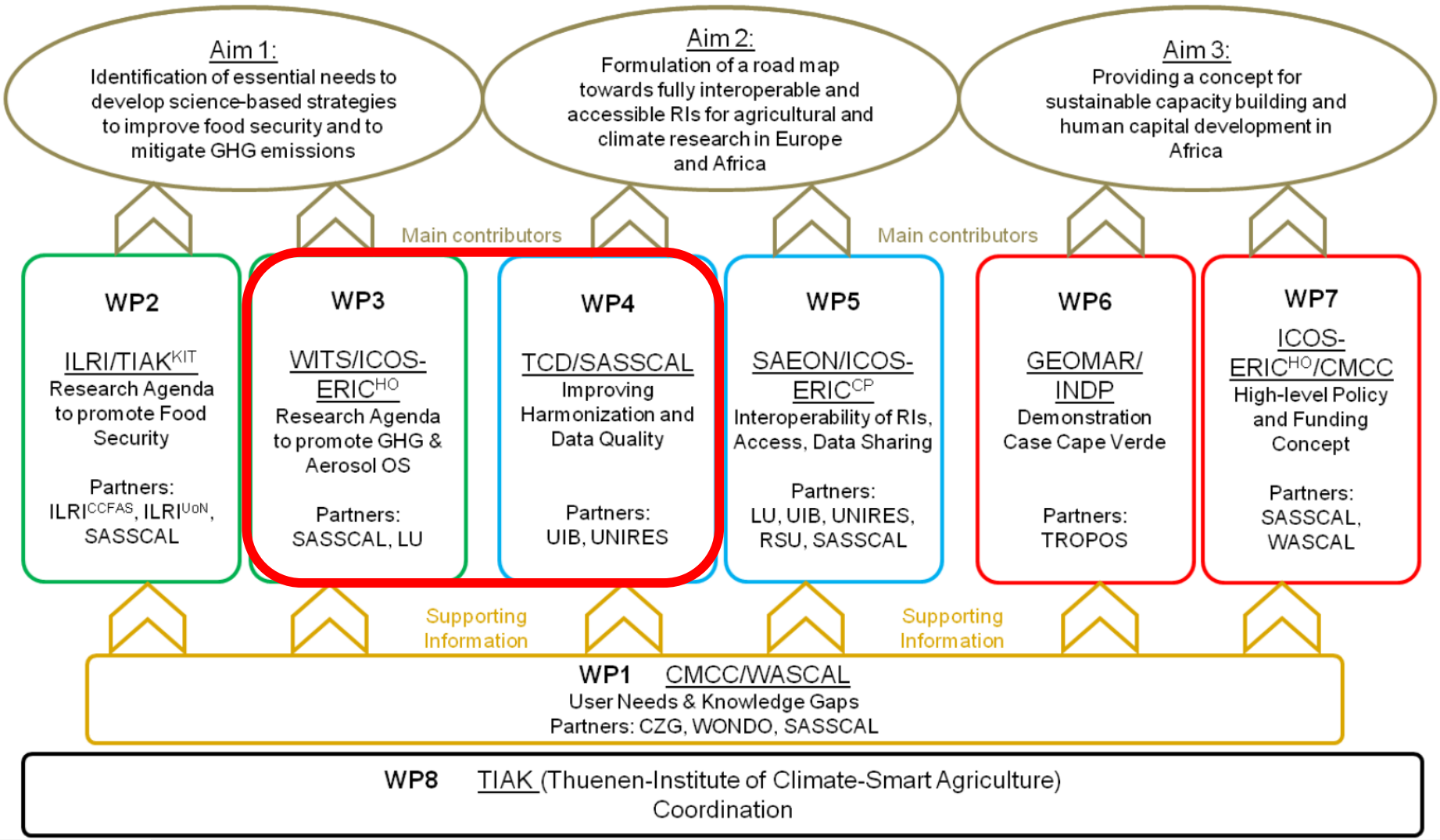
Supporting **E**U-**A**frican **C**ooperation on **R**esearch **I**nfrastructures for **Fo**od Security and **G**HG Observations (2017-2020)

www.seacrifog.eu

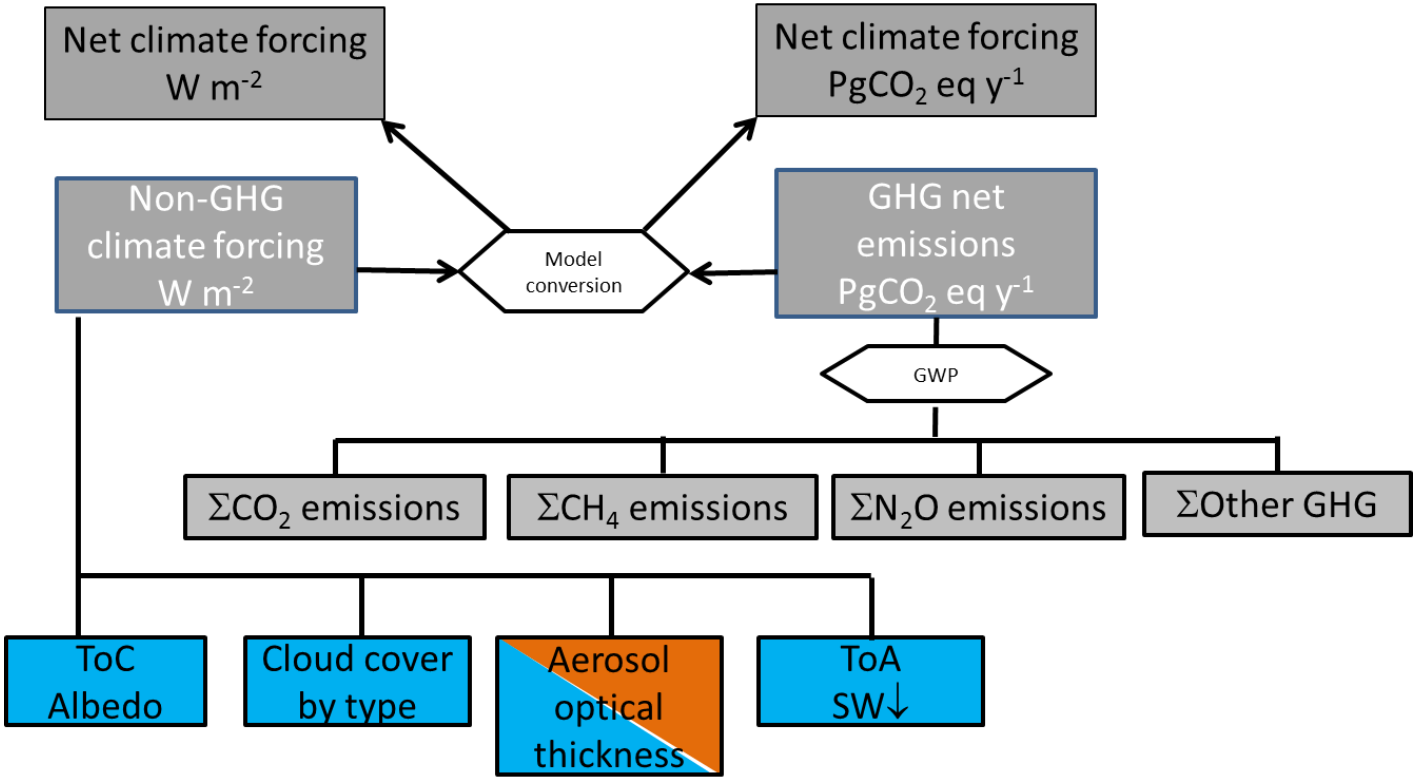
Main Objective: To develop a concept for a African continental observation system for GHGs (and climate forcing in general), taking into account:

- Terrestrial, atmospheric and oceanic domains
- Global uncertainty ranges
- Data access, harmonization and interoperability
- Africa-specific priorities, e.g. role of LULUCF and agriculture

SEACRIFOG


Aim 1:
Identification of essential needs to develop science-based strategies to improve food security and to mitigate GHG emissions
Aim 2:
Formulation of a road map towards fully interoperable and accessible RIs for agricultural and climate research in Europe and Africa
Aim 3:
Providing a concept for sustainable capacity building and human capital development in Africa
Main contributors
Main contributors
WP2
ILRI/TIAK KIT
Research Agenda to promote Food Security
Partners: ILRI CCFAS, ILRI UoN, SASSCAL
WP3
WITS/ICOS-ERIC HO
Research Agenda to promote GHG & Aerosol OS
Partners: SASSCAL, LU
WP4
TCD/SASSCAL
Improving Harmonization and Data Quality
Partners: UIB, UNIRES
WP5
SAEON/ICOS-ERIC CP
Interoperability of RIs, Access, Data Sharing
Partners: LU, UIB, UNIRES, RSU, SASSCAL
WP6
GEOMAR/ INDP
Demonstration Case Cape Verde
Partners: TROPOS
WP7
ICOS-ERIC HO/CMCC
High-level Policy and Funding Concept
Partners: SASSCAL, WASCAL
Supporting Information
Supporting Information
WP1 CMCC/WASCAL
User Needs & Knowledge Gaps
Partners: CZG, WONDO, SASSCAL
WP8 TIAK (Thuenen-Institute of Climate-Smart Agriculture)
Coordination

(African) CF Observation Network



Grey: Observationally constrained model products
Blue: Space-based obs
Brown: Land-based obs

Source:
Scholes et al.,
SEACRIFOG Deliverable 3.1 (2018)

bit.ly/network_concept

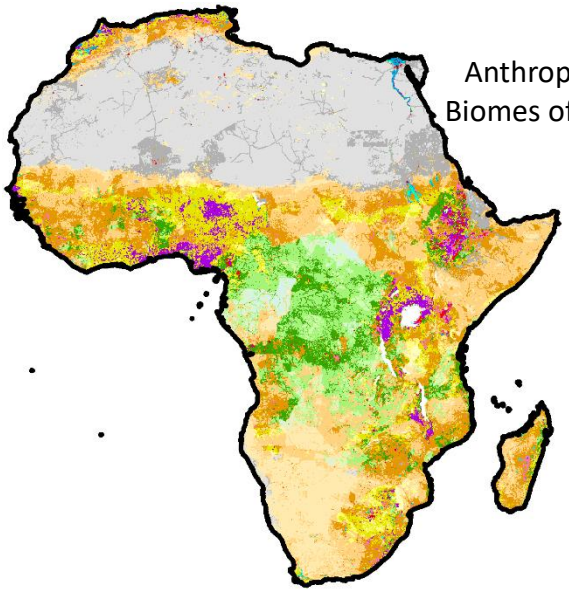
SEACRIFOG – Our work to date

What needs to and can be observed across the African continent?
→ 'Essential' set of observational variables

What are the gaps and needs regarding infrastructure?
→ Inventory of existing and planned infrastructures

What are the gaps and needs regarding data?
→ Assessment of available data (Spatial and temporal coverage, quality)

What are existing relevant methodological protocols?
→ Interoperability and harmonization → Define minimum requirements → Adopt existing protocols where possible, modify where necessary



Anthropogenic Biomes of Africa

SEACRIFOG Objective:
Design of continental observation network tailored to African requirements

Identification of 'Essential' Variables

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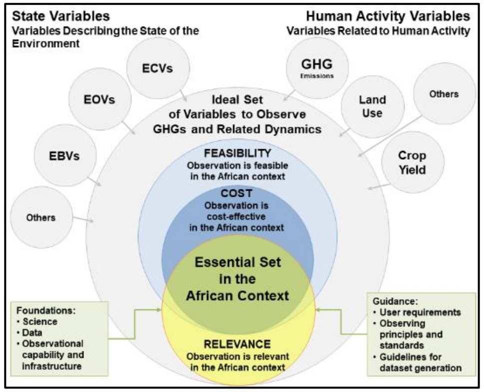
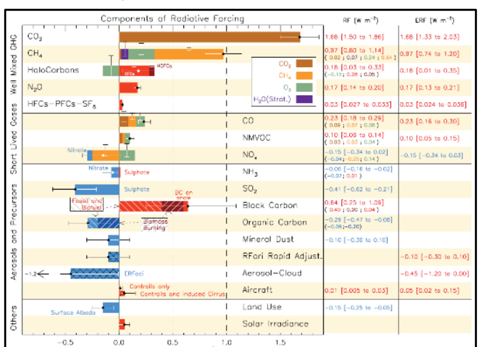
Possibly relevant: 110 variables
Essential (latest iteration): 58 variables



Bottom-up survey

Top-down radiative forcing



WGI, Chapter 8 (2013)
1449, 2014.

Essential Climate Variables

- **Land Cover (81)**
- **Ecosystem Function - Net Primary Production (48)**
- Ecosystem Structure (45)
- **Above-ground biomass (82) incl. litter (36)**
- **Albedo (66)**
- **Fire (79)**
- **FAPAR (67)**
- Glaciers (32)
- Groundwater (56)
- Ice sheets and ice shelves (41)
- **Inland water extent (69)**
- **Land surface temperature (72)**
- Latent and sensible heat fluxes (45)
- Leaf Area Index (74)
- Permafrost (15)
- **River Discharge (55)**
- Snow (46)
- **Soil Organic Carbon (56)**
- **Soil Moisture (65)**
- **Precipitation (surface) (84)**
- **Pressure (surface) (67)**
- **Surface wind speed and direction (72)**
- **Atmospheric temperature at surface (88)**
- **Water vapor (surface) (71)**
- Earth radiation budget (upper air) (54)
- Lightning (36)
- Temperature (upper air) (44)
- Water vapor (upper air) (49)
- Wind speed and direction (upper air) (42)
- **Aerosols properties (50)**
- **Carbon dioxide, methane and nitrous oxide tropospheric mixing ratio (63)**
- **Cloud cover fraction (38)**
- Ozone (47)
- **Precursors (supporting the Aerosol and Ozone ECVs) (33)**

Essential Biodiversity Variables

- Genetic Composition (10)
- Species Populations (47)
- **Plant Species Traits (36)**
- Community Composition (41)

Essential Ocean Variables

- Particulate Matter (38)
- Dissolved Organic Carbon (39)
- Fish Abundance and Distribution (53)
- Zoo- (44) and Phytoplankton (48) Biomass and Diversity
- Marine turtle, bird and mammal abundance (47)
- Marine Habitat Properties (57)
- Ocean Surface Heat Flux (50)
- Sea Level (84)
- **Sea Surface Temperature (85)**
- Sea State (55)
- **Sea Surface Salinity (66)**
- Sea Ice (49)
- **Stable Carbon Isotopes (25)**
- Subsurface Currents (32)
- Subsurface Salinity (52)
- Subsurface Temperature (57)
- Surface Stress (47)
- **Inorganic Carbon (54)**
- **Nitrous Oxide (45)**
- **Nutrients (56)**
- **Ocean Color (65)**
- **Oxygen (68)**
- Transient Tracers (18)

Anthropic Factors

- **Reported Anthropogenic GHG emissions (55)**
- Anthropogenic water use (54)
- **Land use/land use change (84)**
- **Human population (93)**
- **Economic development (81)**
- **Livestock population (73)**
- **Crop yield (78) by type**
- **Agricultural management (58)**
  - **Area of Ploughed Land**
  - **Manure Management**
  - **Fertilizer Application**
  - **Irrigation**

Ancillary/Other Variables

- **Net radiation (SW/LW) at surface (73)**
- **Below-ground biomass (44)**
- **Dimethyl Sulfide (Oceanic)**
- **Atmospheric /Planetary Boundary Layer (21)**
- **Biosphere-Atmosphere GHG flux**
  - CO_2 (55) – Net Ecosystem Exchange
  - N_2O (48)
  - CH_4 (51)
- Topography (84)
- **Surface roughness (60)**
- Ground/soil heat flux (48)
- **Soil type (75)**
- Soil quality/health (58)
- Dissolved organic (30) and inorganic (26) carbon (terrestrial)
- Atmospheric nitrogen deposition (39)
- **Infiltration (45) and Runoff (54)**
- **Evapotranspiration**
- **Wild herbivores**

Radiative Forcing (W m⁻²)

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Essential Climate Variables

Essential Biodiversity Variables

- Plant Species Traits

- Land Cover
- Ecosystem Function (Net Primary Productivity)

Essential Ocean Variables

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

- Above-ground biomass incl. litter
- Albedo
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  - CH_4

- Reported Anthropogenic GHG emissions

Anthropic Factors

- Land use/land use change
- Human population
- Economic development
- Livestock population
- Crop yield by type
- Agricultural management
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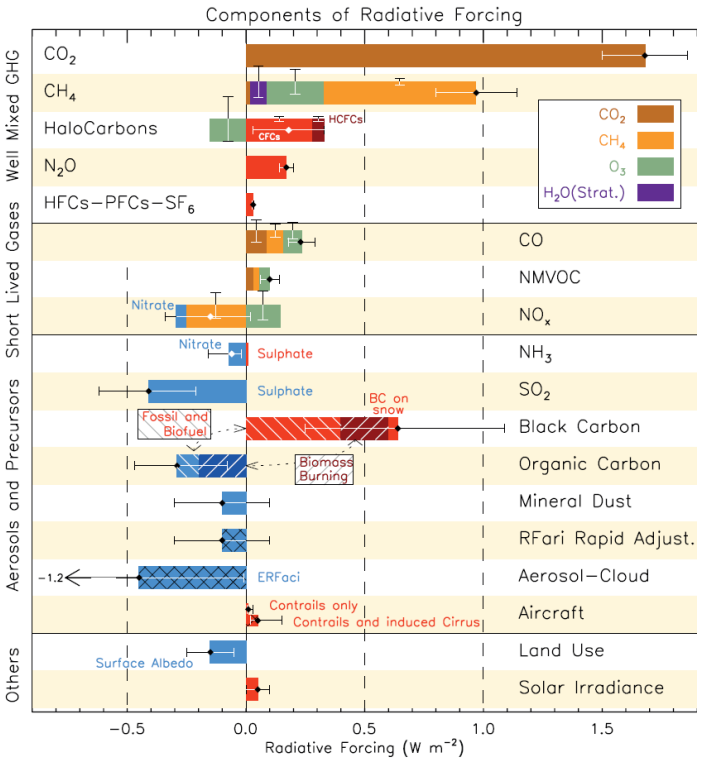
  - Fertilizer Application
  - Irrigation

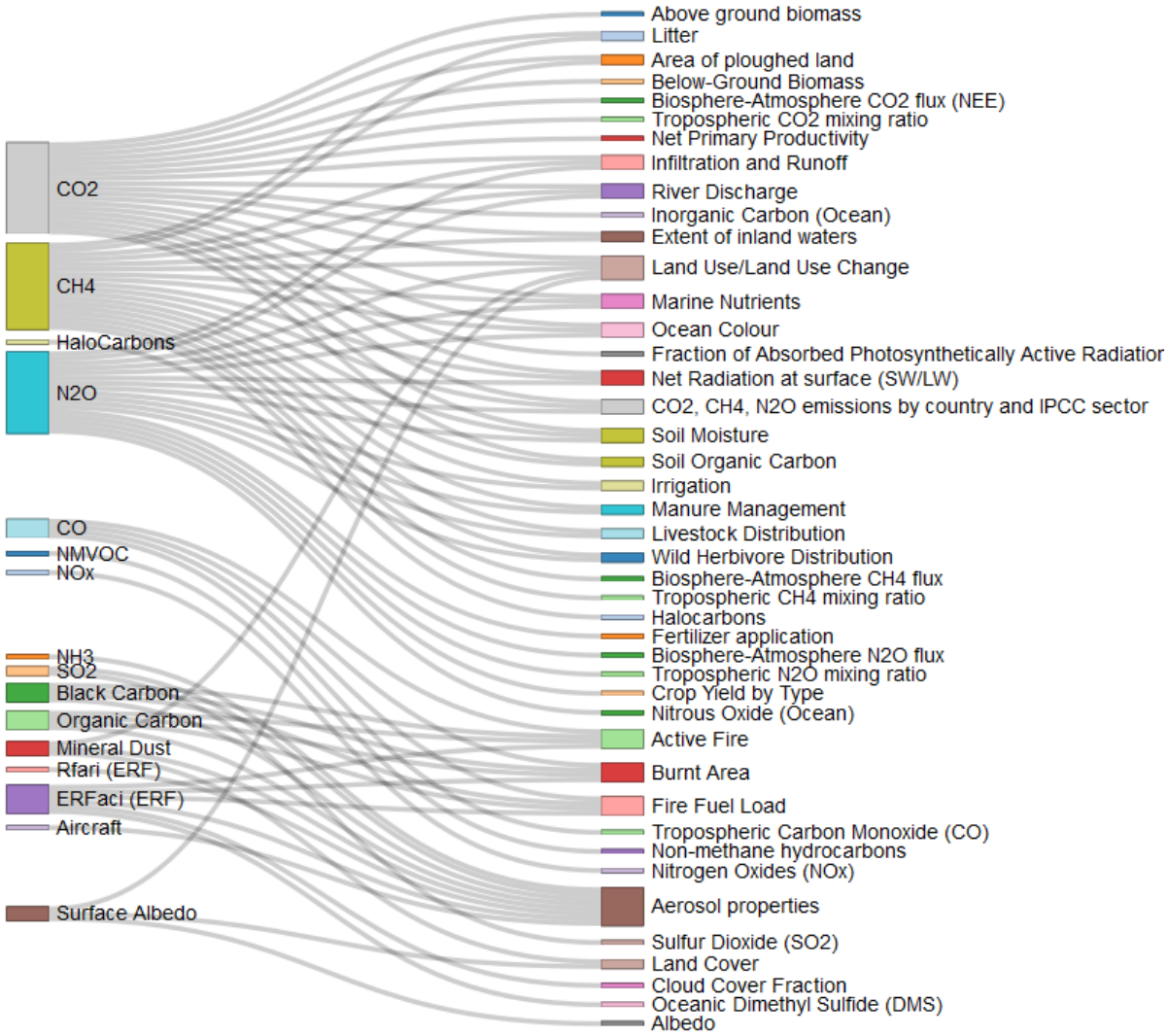
Ancillary/Other Variables

- Surface roughness
- Soil type
- Infiltration and Runoff
- Evapotranspiration
- Wild herbivores

LINK:
bit.ly/essential_variables

Resulting Set of Essential Variables





SEACRIFOG Tool

LINK:
bit.ly/SEACRIFOG_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:

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
Radiation	Fraction of Absorbed Photosynthetically Active Radiation (FAPAR)	Terrestrial
Radiation	Net Radiation at surface (SW/LW)	Terrestrial

Showing 33 to 48 of 58 entries Previous 1 2 3 4 Next

Net Radiation at surface (SW/LW)

Variable Class: Radiation
Variable Domain: Terrestrial
Variable Type: ECV
Further Information (URL): NA

Description:
Net radiation refers to the difference between the incoming and outgoing radiation related to the ground (terrestrial surface). It has four components: the incoming shortwave (SW) and longwave (LW) radiation and the outgoing SW and LW radiation, which can be aggregated as net SW and LW radiation. Net radiation is the fundamental driver of potential evaporation, a controller of soil moisture, which in turn controls many soil GHG emissions.

Observation Methods:
Net Radiation (SW+LW) is the fundamental driver of potential evaporation, a controller of soil moisture, which in turn controls many soil GHG emissions. It is measured at site with a net radiometer (Euro 1000) to an accuracy of +5%. It si is extrapolated spatially using satellite ,measures of its main componetnts-downwelling SW and LW, and upwelling SW (from albedo) and LW (from surface temperature).

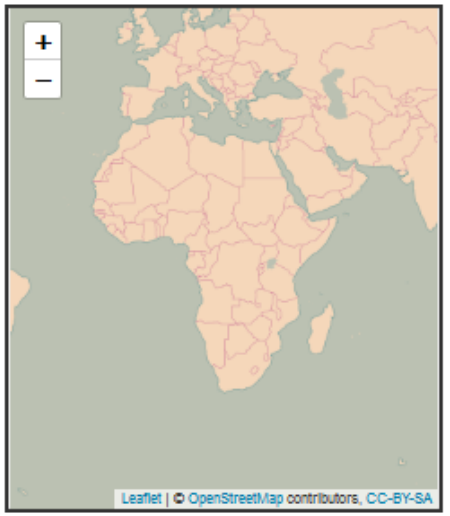
1 related data products available:

Data Product	T_start	T_end	Type	Link
MCD18A1: MODIS/Terra and Aqua Downward Shortwave Radiation Daily 3-Hourly L3 Global 5 km V006	2001-01-01	present	Geospatial - Raster	Click Here

7 related protocols available:

Protocol	Author/Institution	Year	Link
ECV-Land_requirements_IP2016	Global Observing System for Climate (GCOS)	2016	Click Here
Guide to the WMO Integrated Global Observing System	World Meteorological Organization (WMO)	2018	Click Here
The Global Observing System for Climate: Implementation Needs	Global Observing System for Climate (GCOS)	2016	Click Here
Radiations measurements. Short-wave	Integrated Carbon Observation System (ICOS) -		Click

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: ID

Related RF Components (global values):

Compound	Best Estimate (Wm-2)
CO2	1.68
CH4	0.97
N2O	0.17

Conclusion

- **Estimates of African GHG budget associated with high uncertainties**
- **Sparse observations compared to other continents**
- **SEACRIFOG: Design project to develop concept for African Climate Forcing Observation System**

SEACRIFOG Outcome (2020): Roadmap for the development of African climate forcing observation system, detailing

- Technical requirements, harmonized across the continent
- Capacity building requirements
- Investment/funding requirements
- Policy framework requirements

Ideally: Subsequent establishment of this network (with support from EU and other donors) over the following decades

Thank you for your attention!

www.seacrifog.eu

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