

### **Greenhouse Gas Observation** & Climate-Smart Agriculture



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# Gaps, needs and options – A design study for long-term greenhouse gas observation in Africa



V. Jorch<sup>1</sup>, M. Acosta<sup>2</sup>, J. Beck<sup>3</sup>, A. Bombelli<sup>4</sup>, C. Brümmer<sup>1</sup>, K. Butterbach-Bahl<sup>5</sup>, B. Fiedler<sup>6</sup>, E. Grieco<sup>4</sup>, J. Helmschrot<sup>3</sup>, W. Hugo<sup>7</sup>, T. Johannessen<sup>8</sup>, A. Körtzinger<sup>6</sup>, W. Kutsch<sup>9</sup>, A. López-Ballesteros<sup>10</sup>, L. Merbold<sup>11</sup>, E. Salmon<sup>9</sup>, M. Saunders<sup>10</sup>, B. Schöles<sup>12</sup>

1 Thünen Institute of Climate Smart Agriculture, 2 Global Change Research Institute, CAS (CZG), 3 Southern African Science Service Centre for Climate Change and Adaptive Land Management (SASSCAL), 4 Foundation Euro-Mediterranean Centre on Climate Change (CMCC), 5 Karlsruhe Institute of Technology, 6 Geomar Helmholtz Centre for Ocean Research Kiel (GEOMAR), 7 South African Environmental Observation Network (SAEON), 8 University of Bergen, Integrated Carbon Observation System (ICOS ERIC), 10 Trinity College of Dublin (TCD), 11 International Livestock Research Institute (ILRI), 12 University of the Witwatersrand Johannesburg (WITS)

#### Background

Climate change is threatening ecosystems and societies in Africa. At the same time, population growth causing a higher food demand and land-use change, increased energy demand and the development of industry and transport infrastructure contributes to increasing greenhouse gas (GHG) emissions.

In global comparison carbon (C) emissions of Africa from fossil fuel and cement production are still very low (3.6% in 2014; Boden et al 2017). Regarding the African continent emissions from land use change and forestry account for more than one third of the total emissions (Valentini et al 2014).

For scientific analysis and advice, sufficient qualitative and quantitative data about GHG sources and sinks are essential.

# The essential Set of Variables to be monitored

For the design of an efficient observation system for Africa the interoperability with other networks we identified the essential set of variables which need to be monitored in Africa. The set of variables, including all climatic, oceanic and biodiversity. 210 experts were consulted to rate the variables on their 'relevance', 'feasibility' and 'costs', in the African context. 42 variables were identified as 'essential'. Apparent variables connected to land-use change and agriculture are prominent underneath those.

Figure 1-3 taken from Lopéz-Ballesteros et al (2018)

	Variables	Above-ground biomass (82)     Albedo (66)			
Essential Biodiversity Variables • Genetic Composition (10) • Species Populations (47) • Species Traits (36) • Community Composition (41)	<ul> <li>Land Cover (81)</li> <li>Ecosystem Function (48)</li> <li>Ecosystem Structure (45)</li> </ul>	<ul> <li>Fire (79)</li> <li>FAPAR (67)</li> <li>Glaciers (32)</li> <li>Groundwater (56)</li> <li>Ice sheets and ice shelves (41)</li> <li>Lakes (69)</li> <li>Land surface temperature (72)</li> <li>Latent and sensible heat fluxes (45)</li> <li>Leaf Area Index (74)</li> <li>Permafrost (15)</li> <li>River Discharge (55)</li> <li>Snow (46)</li> </ul>	<ul> <li>Anthropogenic GHG emissions (55)</li> <li>Anthropogenic water use (54)</li> </ul>	Anthropic Factors <ul> <li>Land use/land use <ul> <li>change (84)</li> </ul> </li> <li>Human population (93)</li> <li>Economic development <ul> <li>(81)</li> </ul> </li> <li>Livestock population <ul> <li>(73)</li> <li>Ecosystem/agricultural <ul> <li>management (58)</li> </ul> </li> </ul></li></ul>	
Essential Ocean Variables • Particulate Matter (38) • Stable Carbon Isotopes (25) • Dissolved Organic Carbon (39) • Fish Abundance and Distribution (53) • Zoo- (44) and Phytoplankton (48) Biomass and Diversity • Marine turtle, bird and mammal abundance (47)	<ul> <li>Ocean Surface Heat Flux (50)</li> <li>Sea Level (84)</li> <li>Sea Surface Temperature (85)</li> <li>Sea State (55)</li> <li>Sea Surface Salinity (66)</li> <li>Sea lce (49)</li> <li>Subsurface Currents (32)</li> <li>Subsurface Salinity (52)</li> <li>Subsurface Salinity (52)</li> <li>Subsurface Temperature (57)</li> <li>Surface Stress (47)</li> <li>Inorganic Carbon (54)</li> <li>Nitrous Oxide (45)</li> <li>Nutrients (56)</li> <li>Ocean Color (65)</li> <li>Oxygen (68)</li> <li>Transient Tracers (18)</li> <li>Marine Habitat Properties (57)</li> <li>Plankton (50)</li> </ul>	<ul> <li>Soil Carbon (56)</li> <li>Soil Moisture (65)</li> <li>Precipitation (surface) (84)</li> <li>Pressure (surface) (67)</li> <li>Surface wind speed and direction (72)</li> <li>Atmospheric temperature at surface (88)</li> <li>Water vapor (surface) (71)</li> <li>Earth radiation budget (upper air) (54)</li> <li>Lightning (36)</li> <li>Temperature (upper air) (44)</li> <li>Water vapor (upper air) (49)</li> <li>Wind speed and direction (upper air) (42)</li> <li>Aerosols properties (50)</li> <li>Carbon dioxide, methane and other GHGs (63)</li> <li>Ozone (47)</li> <li>Precursors (supporting the Aerosol and Ozone ECVs) (33)</li> </ul>	<ul> <li>Net radiation (SW/LW) at surface (73)</li> <li>Below-ground biomass (44)</li> <li>Natural GHG flux <ul> <li>CO<sub>2</sub> (55)</li> <li>N<sub>2</sub>O (48)</li> <li>CH<sub>4</sub> (51)</li> </ul> </li> </ul>	Other Variables • Topography (84) • Surface roughness (60) • Crop yield (78) • Ground/soil heat flux (48) • Soil type (75) • Soil quality/health (58) • Dissolved organic (30) and inorganic (26) carbon (terrestrial) • Atmospheric /Planetary Boundary Layer (21) • Atmospheric nitrogen deposition (39) • Infiltration (hydrology) (45) • Runoff (hydrology) (54)	<b>Figu</b> vari sco con pre higl

Figure 1: Indicative list of all candidate variables proposed and their assessment score (in parentheses) resulting from the consultative rating process. The preliminary set of 'essential variables' is highlighted in bold font.





veronika.jorch@thuenen.de

www.seacrifog.eu

@SEACRIFOG

Email

Web

(a) Atmospheric and GHG observation sites in Africa
 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)
 Karbon-Ghana (project)

(b) Weather observation sites in AfricaWMO Global Observing System (land-based)

## **Inventory of RIs across Africa**

compiled of the We inventory an environmental observation stations, measuring any of the identified variables, through literature search and consulting relevant projects and experts. 47 observation infrastructures were identified. The density of stations is relatively high in parts of Northern, Western and Southern Africa, but still does not reach the level of other continents. We show that smaller biomes, such as mangroves



**Figure 3:** Observing stations of selected networks for (a) GHG and aerosols and (b) weather observation against the major biomes (Olson et al 2001) of the African continent.

SASSCAL WeatherNet
 (c) Oceanic observation sites around Africa

Argo

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

Figure 2: Observation stations and density of selected networks.

Contact Veronika Jorch (Coordinator), Thünen Institute of Climate-Smart Agriculture,

Bundesallee 68, 38116 Braunschweig, Germany

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are underrepresented. Moreover a significant weat correlation of population and station density

was found.

Literature:

Boden T A, Marland G and Andres R J 2017 Global, Regional, and National Fossil-Fuel CO2 Emissions (Carbon Dioxide Information Analysis Centre (CDIAC), Oak Ridge National Laboratory, US Department of Energy, Oak Ridge, Tenn., USA) (http://cdiac.ess-dive.lbl.gov/trends/emis/meth\_reg.html)(Accessed: 28th August 2018) Lopéz-Ballesteros et al 2018 Towards a feasible and representative pan-African research infrastructure network for GHG observations Environmental Research Letters 13 8 Olson D M et al 2001 Terrestrial ecoregions of the world: a new map of life on Earth Valentini R et al 2014 A full greenhouse gases budget of Africa: synthesis, uncertainties, and vulnerabilities Biogeosciences 11 381–407

