List of ABSTRACTS

The CarboAfrica Project

The CarboAfrica Project: first results

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This presentation is a summary overview of the results from the first 2 years of the CarboAfrica project. According to these preliminary estimates from field data and model estimates the overall carbon balance of Sub-Saharan Africa is a net sink, probably overestimated. The carbon uptakes by forests and savannas are the main components of the sink effect, while emissions are dominated by fires, deforestation and forest degradation. It is very important to note that the impact of forest degradation can even be higher than deforestation in Sub Saharan Africa. Furthermore, it seems that the rather large sink of carbon in Sub-Saharan Africa is dominated by the net ecosystem productivity of savannas, which appears to be only partially counterbalanced by fires. These first results show that Africa plays a key role in the global climate system and probably could have a higher potential for carbon sequestration than expected. Further investigations are needed and the current CarboAfrica network of carbon measurements could provide a future unique data sets for better estimating the African carbon balance.

Keywords: CarboAfrica Project; African Carbon Balance; Savannas; Fires; Deforestation

Key note speeches on Africa and Global Carbon Cycle

Dynamics of the African carbon cycle

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The African continent as a whole was close to carbon-neutral in the 1990s. With a few notable exceptions, such as South Africa, Nigeria and Egypt, the industrial emissions of fossil-fuel derived CO2 are small, but growing. The emissions from land use change (especially tropical deforestation in the Congo Basin) are uncertain, but known to be substantial. Therefore the overall near-neutrality can only be because the relatively untransformed ecosystems of Africa constitute a net sink of carbon at the present time. In general, the carbon budgets of least-developed African countries are mostly controlled by the land use, land use change and forestry (LULUCF) components. The role of savannas is of particular interest. When an open savanna becomes a densely wooded savanna, the amount of carbon stored on the land surface approximately doubles over a period of about three decades. This process dominates the carbon budgets of some lightly-industrialised African countries.

The reverse process – the clearing of woodlands for agriculture and fuel wood – dominates in other countries. There are clear differences between tropical and temperate or boreal systems in the degree to which water constraints rather than temperature constraints determine carbon flux seasonality. All of Africa outside of the evergreen rainforest core is highly seasonal, and most of that seasonality is imposed by a 4 to 7 month long dry period each year. Furthermore, there is a very high interannual variation in the amount of rainfall in the wet season, largely linked to global climatic processes. A second important difference is the predominance of fire as a key flux-mediating process. Fires in Africa are predominantly in the savannas. The above characteristics are shared by the carbon cycles of other tropical continents, such as Australia, South America, and the southern part of Asia.

Greenhouse gas inventories in Africa: constraints and perspectives

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Greenhouse gas inventories in Africa: constraints and perspectives (M. Khouma, UNDP) Summary Most of African people rely on natural resources for food, fiber, medicines and housing material. These resources are seriously threatened by climate change impacts which main driver is greenhouse gas concentration in the atmosphere deriving from human activities. The sectors of agriculture, land Use land Use change and Forestry are the main sources of emission of African countries. Inventories of these greenhouse gas emissions besides its mandatory aspect resulting from the United Nations Framework Convention on Climate Change allow a better integration of climate change issues in the development planning process by generating quantified data on most emitting sources of greenhouse gas in order to better allocate financial resources devoted to mitigation and adaptation. The paper focused on key findings from the regional Project (14 countries) on quality improvement of greenhouse gas inventories in West and Central Africa and data gaps still needed to be filled in terms of activities and emission factors for the sake of quality improvement of these inventories.

Terrestrial Carbon Observations in Africa and Ecosystem fluxes

Vegetation heterogenity, does it matter?

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Soil respiration as the major part of ecosystem respiration is very challenging to explain on the temporal as well as on the spatial scale. Therefore we carried out soil respiration measurements during 2 intensive field campaigns in Mongu, Zambia. During the campaigns we had a closer look on ecosystem heterogeneity, using various classifications of ground cover and measured the corresponding effluxes of CO2, instead of measuring randomly within the ecosystem. Thereafter we tried to compare our findings with flux measurements received by the Eddy covariance tower.

Estimation of Net Ecosystem Exchange at the Skukuza Flux Site, Kruger National Park, South Africa

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Annual estimates of primary production (GPP) and ecosystem respiration (Re) were obtained for the Skukuza flux site, Kruger Park, South Africa, based on the eddy covariance flux data at this site. New methods of extrapolating night-time respiration to the entire day and filling gaps in eddy-covariance data in semi-arid systems were developed. Net ecosystem exchange (NEE) in these systems occurs as pulses driven by rainfall events, which cannot be accounted for by current standard gap-filling procedures developed primarily for temperate flux sites. They furthermore do not take into account the decrease in respiration at high soil temperatures. An artificial neural network (ANN) model was used to model GPP and Re by incorporating fractional interception of photosynthetically active radiation (fAPAR), the timing and magnitude of rainfall events, and temperature in the model. These features predicted measured fluxes accurately (MAE 0.42 gC/m2/day), and were able to represent the seasonal patterns of photosynthesis and respiration at the site. The annual integral of the filled NEE data was found to range from -138 to +155 g C/m2/y over the 5 year eddy covariance measurement period.

Effect of burning on soil-atmosphere greenhouse gas exchange in African grassland savanna in Congo Brazzaville

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African savannas are mostly characterized by grasslands with scattered trees and shrubs supporting high biodiversity, which occur in areas with a clear dry season, followed by a rainy season. In grassland and steppes, burning is a widely recognized and utilized ecological factor. These type of grasslands are generally characterized by a quite tight C and N cycle. Fire can uncouple these two phenomena bringing to an alteration of the overall balance of greenhouse gases in the ecosystem. In the present study a grassland savanna (Brazzaville, Congo) was investigated to evaluate the short term effect of fire on soil-atmosphere gas exchange of CO2, N2O, NO and CH4. Gas (CO2, N2O, and CH4) measurement campaigns (closed chambers coupled with GC analyses or IR analyzer) were done in the dry season (2007), immediately following the fire event and in the next wet season (2008). Subplots were treated to simulate the effect of isolated rain events of gas emissions. Laboratory experiments were carried out to evaluate the potential N2O/NO emissions at different soil water potentials (10% and 50% water saturation) and the relationship of N2O and CO2 emissions with soil water content and temperature.Results indicate that the savanna soils have a strong potential to emit NO, especially at low water content, whereas N2O emissions are very low and increase at significant levels only above 50-60% of soil water filled pore space, with temperature having a much less influent effect on gas emissions. Given the quite sandy nature of the soil, these conditions were hardly reached in the study site even in the wet season, so that N2O fluxes were overall quite low. Also CO2 emissions were quite low although a more significant increase was observed in the wet season (wetter and warmer soil).

Semi-arid afforestation and its effect on land-atmosphere interactions

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Climatic models predict that deserts feed-back upon themselves and changes in land use can affect both the local and global climate conditions. We present results of 8 years of extensive measurements of energy, water, and CO2 fluxes of a semi-arid forest which suggest that a large scale afforestation feedback could ease the climatic conditions in dry-land areas. Semi-arid terrain covers ~10% of Africa's surface that is largely free of forests; less than 10% of this land. Most semi-arid areas are exposed to high solar radiation and are considered carbon neutral. Our study is conducted at the timberline for forest growth (Yatir forest, AF-0.18, 300 t/ha) where the forest is annually exposed to seasonal soil and atmospheric water stress that closely resemble conditions at the edges of African deserts. The annual average net carbon uptake (NEE) by the Yatir forest was ~220 gCm-2; ~50 gCm-2 lower than the global forest NEE average. The forest, as carbon absorber, mitigates the increase of CO2 concentration in the atmosphere. Consequently, afforestation activities involving even a small fraction of Africa semi-arid lands could play a meaningful role in sequestering large amount of carbon from the atmosphere, for over a century. Forests usually have lower albedo than their surroundings, absorbing greater amount of solar radiation (a source of atmospheric heating). Depending on local conditions, the change from being net atmosphere heater to a cooler may take a few decades (~40 years at Yatir). Conversely, a forest canopy found to dissipate heat with a high efficiency; in dry conditions this is mainly in form of sensible heat; values over 800 Wm-2 were measured at Yatir. Such strong air lifting, if coming from a large enough area, should enhance the local and regional circulation, creating a positive feedback effect that assists in cloud formation and eases climatic conditions.

LAMTO, Ivory Coast: A new station for monitoring CO2 and CH4 in the atmosphere

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Atmospheric inverse methods are used to infer sources and sinks of greenhouse gases from global to regional scale, using atmospheric transport modelling and atmospheric measurements. The status of the monitoring network is very heterogeneous, with a relatively high density of stations in North America and Europe, and almost none stations over large parts of the world like South America and Africa. As part of CARBOAFRICA, we have set up a new monitoring station at the Station de Géophysique de LAMTO, Ivory Coast. The site is located about 150km North/West from Abidjan in an ecological reserve. Air is sampled at the top of a 50m telecommunication tower. The instrument, developed at PICARRO Inc., is based on cavity ring down spectroscopy (CRDS) technology. In addition to CO2, the high precision analyzer is also monitoring CH4 and H2O. The instrument is linked to the WMO international reference scale by using 4 calibration tanks calibrated at LSCE. The full system has been installed at LAMTO in August 2008, and the first results will be presented.

Ground-based remote sensing of atmospheric trace gases in the tropics

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The tropics play a central role in global climate. Emissions within the tropics, especially from biomass burning and from plants, contribute substantially to the global budgets of many

important trace gases. Currently large uncertainties in the budgets of many trace gases in the tropics exist mainly due to a lack of measurements in the tropics. We are operating the first FTIR-spectrometer for solar absorption measurements in the inner tropics at Paramaribo, Suriname. About 20 different trace gases could be retrieved from the spectra. The importance of these measurements is best illustrated using the examples CH4 and CO (Petersen et al, 2008). In cooperation with the Kwame Nkrumah University of Science and Technology (KNUST) in Ghana, we plan to perform solar absorption measurements in Kumasi, Ghana. The location is well suited to study the composition of biomass burning emissions and the impact of biomass burning to the upper troposphere. With the start of high precision measurements of greenhouse gases from space the solar absorption measurements are becoming increasingly important for the validation of the spaceborne measurements. Solar absorption FTIR-spectrometry is the only ground-based remote sensing technique for the validation of these satellite measurements. Currently we prepare the instrument at the IUP in Bremen, Germany. A comparison with the NDACC spectrometer in Bremen will be presented.

Soil and Vegetation: Carbon and GHG emissions in Africa

Seasonal and inter-annual variations of LAI in a sahelian environment (Gourma, Mali)

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LAI is a key variable that controls energy interception, carbon and water fluxes at the leaf and canopy level. Hence, a realistic description of its seasonal and inter-annual variations is required to correctly simulate carbon assimilation and maintenance respiration along the year. Mainly due to the difficulties associated to field measurements in an arid environment like the Sahel, little is known about the temporal dynamics of the LAI for the main components (grasses and trees) of a sahelian pastoral landscape. The study was conducted within the AMMA super-site (15.3°N, 1.5°W) in the Gourma region of Mali during the 2005-2008 period. We will present the observed seasonal and inter-annual LAI dynamics for the 3 main surfaces, namely a grassland on sandy soils, an erosion rocky surface and an open forest on clay soil, that can be encountered within the super-site. For each type of surface, a specific field sampling strategy was developed associated to the use of hemispherical pictures and high resolution satellite images to up-scale local LAI observations to the landscape scale. Firstly, we present the methodology based on the use of hemispherical pictures to estimate the LAI of the grass cover and trees at a plot scale. Second, the up-scaling procedure with relies on the specific the field sampling strategy combined with the use of high resolution satellite images (SPOT and FORMOSAT) is described. Third, the derived seasonal and inter-annual LAI variations are given for the 3 typical surfaces. Finally, a comparison between time series of LAI derived field measurements and LAI satellite (MODIS) derived products will be shown at 1 km scale.

West Africa´s savannahs under change: a holistic synthesis of positive and negative effects of agriculture and land cover changes on carbon cycling and trace gas emission

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The WASAC project (West Africa´s savannahs under change) has been funded from 2002 to 2005 with the purpose of locating and analyzing data on carbon balance and carbon sequestration in the savannah region of West Africa. The project has focused on carbon and nitrogen pools in the savannah zone, aggregating data on plant cover, on primary production, on soil carbon, on CO_2 fluxes and gas emission from soils. Emissions from fires are included and the fire effects on productivity as well as the use and effects of fallows. Results from the cultivation of common crops are considered with reference to different fertilization patterns.
The WASAC project has created a comprehensive database as tool for the analyses of carbon storage in different natural and cultivated ecosystems of the savannah zone.
In the analyses of the results collected it has been the aim to identify relationships that may cause variations in the carbon pools and their turnover under changing environmental conditions and different types of management.
Some interesting relations are:

- NPP correlates with precipitation and with other environmental variables;
- there are rather high amounts of carbon in deeper soil layers;
- the emissions of N_2O from the savannah region have been found lower than the figures listed by IPCC.

Model analysis by use of the CENTURY models shows predictions of a moderate loss of soil carbon in different Global Change scenarios like increasing temperatures but also selective sensitivity to changes in moisture by photosynthesis and respiration. Many *of the* existing results from Africa have been published by few active groups and from campaigns in projects while a more substantial and systematic data collection seems to *be* missing. It is therefore the recommendation to establish:

- baseline studies to survey carbon cycle better for sinks and sources;
- long periods of observation – 5-10 years – to allow calibration of useful modeling of SOM and other carbon and nitrogen pools and fluxes;
- analysis of integrated management for food production and carbon sequestration;
- increased awareness of the connectivity between climate, environment, and land-use for food production;
- implementation of large scale projects to facilitate shareholders in the region to enter into the carbon trade system under the clean development mechanism.

Understanding soil carbon dynamics for sustainable land management

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Quantitative information about the amount and stability of organic carbon in different soil organic matter (SOM) fractions is needed to improve our understanding of organic matter sequestration in soils. Currently there is a knowledge gap regarding how land management strategies employed on different soils are likely to affect soil organic carbon (SOC) in the

future. In this paper, we summarized results performed on two different arable soils under continuous maize cultivation to identify: a) the storage of organic carbon in different soil organic matter fractions, b) the functions of these fractions with respect to soil organic carbon stabilization as assessed by isotope analyses. The fractionation procedure was based on density fractionation. The main inputs of organic carbon were plant litter and cattle manure. Total SOC to a depth of 120 cm was 150 t C ha^{-1} in the sandy loamy soil and 137 t C ha^{-1} in the loam soil. In general, the turnover times of the SOM fractions were shorter than the bulk soils. The major part of SOC was associated with the mineral fraction. The decline in C/N ratio through microbial transformation in the SOM pools was of the order Free light fraction (FRLF) > Intra-aggregate light fraction (IALF) > organo-mineral (OM). The isotopic signature suggests an efficient recycling of organic carbon derived from C_4 substrate. Mineral-bound organic matter represented highly stable organic carbon pools in both soils. Results further highlight the potential use of the IALF as a diagnostic indicator to test whether or not the SOM content of soil at a particular site is at an equilibrium level or is in the process of an increase or decrease. Through the appropriate management of soil organic carbon (SOC), countries can move closer to meeting the objectives of their national action plans on Climate Change relating to sustainable land management, reduction of land degradation, desertification and greenhouse gases (GHG) emissions.

Seasonal dynamics of soil carbon dioxide efflux in a restored young mangrove plantation at Gazi Bay Kenya

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Soil CO2 efflux is an integrated measure of root and microbial respiration and is an important source of atmospheric CO2. This study measured seasonal variation in soil CO2 efflux and the influence of species richness, temperature and soil moisture content in young replanted mangrove stands at Gazi bay Kenya. Soil CO2 efflux was measured approximately every fortnight from Sept 2005 to January 2007 in thirty two plots with different mixes of mangrove species as well as controls using the soda-lime technique. Periodic measurements using an infrared gas analysis method were also carried out. Results indicate significant effects of tidal period and soil temperature on soil CO2 efflux. Other factors, i.e., species richness, soil moisture and year did not significantly affect soil CO2 efflux. Soil CO2 efflux exhibited a seasonal pattern which was clearly related to soil temperature pattern. Mean daily CO2 efflux ranged from a low of 18.71 (±3.64) g m-2 d-1 to a high of 45.81 (±14.39) g m-2 d-1. Higher soil CO2 efflux was also found immediately after spring tides compared to the middle of neap tide. Given the observed pattern of increasing fluxes with time, we anticipate that both contributions from root respiration of planted trees as well as from microbial biomass (arising from gradual changes in sediment micro-climate caused by replanting) will increase over time.

Estimates of CO_2 Emissions from Soil Organic Carbon for different land uses

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The study was carried out on acid soils (Ferralsols) at Ainyinasi in the High Rain Forest Agro-ecological Zone of Ghana in 1997. Samples were taken from the 0 – 15 cm depth in a Virgin, one-year old cassava farm, recent maize farm, a fully established rubber plantation

and a fallowed secondary forest. The organic carbon content of the soils was determined on air- dried samples sieved through 2 mm mesh using the wet oxidation method (Walkley and Black, 1934). Using the average bulk density of 1.4 Mg m-3 and soil depth of 0.15 m, the soil organic carbon was converted to kg ha-1 and the soil organic carbon (SOC) sequestered by the different land use types was converted to CO2 by multiplying by 3.67 (Molar ratio of 44/12).
The study showed that SOC sequestered was highest in the virgin forest soil, followed by one year old cassava farm, recent maize farm (slash and burnt), rubber plantation and fallowed secondary forest, in that decreasing order. Using the virgin forest as the standard of comparison, the one-year old cassava had emitted 1,386 kg ha-1 CO2, the recent maize farm (Slash and burnt) had emitted 7,777 kg ha-1 CO2, the fully established rubber plantation had emitted 8,855 kg ha-1 CO2, while the fallowed secondary forest had emitted 9,471 kg ha-1 CO2.
The study confirms that whenever the virgin forest is intact, the potential to sequester organic carbon is always high. Once the forest is converted to different land uses through vegetation removal decarboxylation processes set in to reduce soil organic carbon with accompanying CO2 emissions..

Soil respiration in a semi-arid ecosystem (Mali)

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During maximal plant growing period (August), intensive measurements of CO2 fluxes from soil have been performed throughout dune-interdune line using a closed dynamic systems. The objectives were: - To study temporal and spatial variations of soil respiration (soil functioning) - To study partition between root and microbes respirations in SR (mineralisation rate) - To quantify soil CO2 efflux in net carbon exchange (testing models).

The effect of cattle manure and nitrogen fertilizer amended wetland vegetable cropping on nitrous oxide emissions into the atmosphere

Masaka Johnson - Midlans State University, Zimbabwe

A two-season field experiment is being conducted to determine the effect of cattle manure and mineral N fertilizer application rate, cattle manure quality and methods of application on gaseous N2O emission at Dufuya Wetlands (19°17¢ S; 29°21¢ E) in Chief Sogwala area of Lower Gweru Communal Lands, about 42 km west of Gweru, Zimbabwe. Rape (Brassica napus L) and tomato (Lycopersicon esculentum, Mill) are the test crops. Three manure application rates of 0, 15 and 30t ha-1 and three N fertilizer rates of 0, 100 and 200 kg ha-1 as ammonium nitrate (per cropping) applied in combination were used in order to determine the effect N fertilizer and cattle manure application rates on gaseous emission of N2O on wetland soil. The effect of cattle manure quality (composition) and their rates of application on gaseous emission of N2O to the atmosphere was determined by using two cattle manure types separately in rates of 0, 15 and 30 t ha-1 in a Randomised Complete Block Design with four replications. Cattle manure collected from surrounding communal area constituted one type of manure while manure collected from adjacent commercial farming area constituted the other type.

Biogeochemical Modelling

The CA model intercomparison - review and outlooks

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Regional to continental scale estimates of the carbon balance from site observations is restricted by large spatiotemporal variations of ecosystem processes. Aiming for an improved representation of multi-scale CO2 balance estimates over the sub-Saharan African region a complex modelling framework is incorporated to generalize and upscale ecosystem level observations by integrating local and spatial data into data- and process-oriented models together with landsurface schemes of different complexity. To state baseline estimates for the African carbon balance a model intercomparison study (CAMIC) comparing the terrestrial ecosystem models ORCHIDEE, LPJ-DGVM, LPJ-Guess and JULES has been performed. Robust patterns of interannual variability among the models carbon fluxes have been found to be large in southern and eastern Africa, regions which are primarily covered by herbaceous vegetation. The interannual variability of the net carbon balance appears to be more strongly influenced by GPP than TER. Applying a principal component analysis indicates that moisture is the main driving factor of interannual GPP variability for those regions. Contrary two models suggest large parts of the inner tropics being limited by radiation. Future activities are planned to concentrate on semi-empirical models incorporating remote sensing vegetation properties to estimate fluxes at high resolution. Based on different input data model outputs will be investigated using flux data from various sites across Africa and possibly direct airborne measurements from Carbo Africa Regional Experiment (CARE) in order to quantify spatially relevant estimate ranges and uncertainties. The models will hereafter be parameterized with flux site data, and run at site level as well as on regional to continental scale. Results will be used to evaluate the performance of process model results (CAMIC) and lead to an improved process model parameterization resulting in better carbon balance representation. Additional process model runs on longer timescales enable analysis of interdecadal variability.

African Carbon Exchange II: A systems approach

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African Carbon Exchange II: A systems approach for diagnosis and prediction of carbon, vegetation and disturbance dynamics Africa has a large and growing role in the global carbon cycle, with important climate change implications. However, sparse observations in and around Africa makes it one of the weakest links in our understanding. Recent work by this team suggests Africa has a near zero decade-scale carbon balance, but that climate fluctuations induce sizeable variability in ecosystem productivity and savanna fires, greatly enhancing the inter-annual variability in global atmospheric [CO2]. With increasing populations and economic development Africa is poised for agricultural intensification and conversion to cropland and managed rangeland this century. Furthermore, complex

interactions among climate change and ecosystem processes (primary production, tree-grass interactions, grazers, browsers, fire and nitrogen) challenge our ability to predict future carbon stocks in Africa and other tropical regions. Perhaps more important, future provision of vital ecosystem services to Africa's people remains difficult to predict. We report an integrated approach to modeling carbon dynamics that builds on our understanding of African ecology and assimilates data from field measurements, remote sensing and atmospheric measurements. Our modeling system will be unique in allowing dynamic simulation of major disturbance factors for prediction of ecosystem processes and vegetation structure, or their proscription using measurements from field data and remote sensing. The integrated modeling system will provide a tool for carbon cycle diagnosis in tropical systems using remotely sensed and other datasets. However, the modeling system in prognostic mode will provide dynamic simulation of climate change and disturbance impacts and enable prediction of ecosystem dynamics, long-term carbon balance, and future productivity and sustainability in Africa's crucial grassland, savanna and forest ecosystems.

Towards an African carbon budget from data-oriented modelling

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The CarboAfrica Model Intercomparison (CAMIC) study by Weber et al (2008) identified consistent spatial patterns of large interannual variability of the carbon balance. However, the participating models showed large discrepancies regarding the simulated carbon flux magnitudes hampering the construction of a reliable carbon budget from process-oriented models alone. Our study aims at estimating the African carbon balance (net ecosystem exchange (NEE)) and its constituent gross fluxes (gross primary production (GPP), terrestrial ecosystem respiration (TER)) from data oriented modelling. Statistical models for NEE, GPP, and TER are produced based on remotely sensed estimates of FAPAR, and FLUXNET data. Given the sparsity of eddy-covariance measurements in Africa, the models are trained with flux data from all over the world and thus represent generic models applicable also to the globe. Preliminary results of the spatio-temporal fields of carbon fluxes retrieved from the upscaling are compared with CAMIC simulations and atmospheric inversion studies. Our results present an independent bottom-up estimate allowing to better constrain the African carbon budget from multiple methodologies and data sources.

Land Cover Change, Biogeochemical Modeling of Carbon Stocks, and Climate Change in the Sahel/West Africa

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The carbon in ecosystems exists in dynamic soil and vegetation pools which vary in amounts and cycle with the global atmosphere at varying rates. These stocks and fluxes play important roles in global carbon regulation and in the maintenance of goods and services. Changes in land cover or ecosystems result in increased or decreased fluxes to the atmosphere and play a major role in climate regulation. Carbon in soil is closely coupled to soil nitrogen, and the continued mining of soil for crops or fuel without replenishment of nutrients results in decreased productivity and impacts food security. The assessment of these processes across large areas, although difficult, is aided by the integration of simulation modeling (biogeochemical and ecosystem) and remote sensing. We distributed satellite imagery for four

periods from 1960s to 2000s, trained environmental scientists in 14 countries, and now report systematic analyses of land cover changes in select countries of the Sahel and quantify potential impacts of climate change and management in specific sites. Statistical changes and maps of land cover are documented for most countries. Senegal, for example illustrates a 57% loss in dense forests between 1975 and 2000 with an even greater loss rate in the preceding 10 years; bare soil increased 16.6%, often related to unproductive "badland" formation; settlements increased 45.6%, and reforestation replaced bare sandy areas along the coast. In some countries (Senegal and Ghana) the impact of these conversions and changes in land management and future projections have been incorporated in biogeochemical models which quantify carbon losses and project future carbon and crop scenarios. We present current assessments of carbon fluxes and the availability of data for these Sahel/West Africa countries.

Assimilation of land-surface temperature in the land surface model JULES over Africa

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Despite the importance of Africa in the global carbon cycle, climate scenarios for the continent are highly uncertain; and it is even unknown whether Africa is a net source or sink of CO2 (Williams et al., 2007). These uncertainties can only be reduced by the incorporation of representations of the most relevant processes into models, and constraining the model uncertainty with observations. The simulation of realistic fire disturbance regimes with biophysical and biogeochemical models is a prerequisite for reducing the uncertainty of the African carbon cycle. A critical variable for vegetation fires is land-surface temperature (LST), which is the radiative skin temperature of the land. It is derived from solar radiation and the exchange of heat flux between the land-surface and the atmosphere, and is useful in applications such as vegetation water stress monitoring, and surface energy balance assessment (Pinheiro et al., 2006). Furthermore, LST has an important relationship to the fire regime. It has been argued in previous studies (Sandholt et al., 2002; Snyder et al., 2006) that the ratio between the Normalised Difference Vegetation Index (NDVI) and LST can be expressed as a surface dryness index representing live fuel moisture content (FMC), which is a critical variable in the prediction of fire occurrence and propagation. However, despite the importance to fire modelling, and the fact that LST is more closely related to the physiological activities of leaves than air temperature (Sims et al., 2008); it is air temperature that is more commonly employed in land-surface models. The aim of this study is to constrain the simulation of surface energy fluxes, and furthermore the prediction of FMC, through the assimilation of remotely sensed LST into the land-surface model JULES (Joint-UK-Land Environment Simulator). The first step is to ascertain the most appropriate spatial and temporal satellite product for incorporation into a regionalised model of JULES for Africa. A multi-temporal analysis is carried between the JULES derived LST, and MODIS, AATSR, and SEVIRI products, with the preliminary results presented here.

Evaluation and improvement of the representation of sahelian savannah in the vegetation model ORCHIDEE

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It is necessary to better understand and quantify surface processes that impact on carbon, sensible and latent heat fluxes over sahelian savannah and steppes landscapes. An approach using the process-based vegetation model ORCHIDEE and site level measurements build up a preliminary for a spatialised analysis of CO2, H2O and energy fluxes at different scales. A calibration of phenological, and key physiological parameters and a preliminary local validation have been conducted at Agoufou, Mali, a site established in the framework of the AMMA project. At this site, leaf area index assessments, biomass samplings, energy fluxes, soil water and temperature profiles were available. One notable achievement of this study was that it gave us the opportunity to validate for the first time a new physically-based distributed soil hydrology scheme whilst the dynamic phenology module of ORCHIDEE was activated. It also enables us to identify some of the deficiencies of the modeling approach employed.

Impact of vegetation fires on African GHG budget

Remote sensing methods for monitoring fire related biophysical parameters

Balzter H. - University of Leicester, UK

With the advent of the Global Earth Observation System of Systems (GEOSS) an unprecedented continuity of environmental remote sensing satellites is now being planned by the major space agencies. Some of the observation requirements have been defined based on the Global Climate Observing System's (GCOS) Essential Climate Variables, which include fire disturbance. This talk gives an overview of what satellite and airborne remote sensing methods can deliver to support fire monitoring and assessment. It will discuss Synthetic Aperture Radar (SAR) for vegetation biomass estimation, optical/near-infrared remote sensing for mapping burned areas and estimating fuel load and moisture, thermal remote sensing of active fires and briefly touch on fire radiative energy.

Analysis of satellite imagery to map burned areas in Sub-Saharan Africa

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Satellite images acquired by the AATSR sensor (Advanced Along-Track Scanning Radiometer) onboard the ENVISAT platform (European Space Agency) were used in this study. We tested the feasibility of Top of the Atmosphere (TOA) reflectances for mapping the burned areas in Sub-Saharan Africa. The AATSR sensor carries optical and thermal instruments and it acquires near-simultaneous multi-angle information of the same area at a dual view (nadir and forward). As a consequence the spectral differences in two consecutive images are mainly due to the different atmospheric path followed by the spectral signal. Since the atmospheric conditions and the presence of aerosols can affect the data quality and therefore the accuracy of the derived products, the dual-view observations provided by AATSR were used to derive the atmospheric properties over each scene and remove their effect from the TOA observations. The atmospheric correction was applied using the Atmospheric Aerosol Retrieval using the Dual-View Angle Reflectance Channels (AARDVARC) model, developed at Swansea University (Grey et al., 2006). The resulting

surface reflectances showed some missing data and artefacts when derived at the 1km resolution, whereas they were of higher quality at 10km. However it was possible to use the 1km-corrected reflectances to derive burned area maps over regions of interest and then compared them to the MODIS burned area product (MCD45) at 500m. The results showed that for burned area mapping purposes a higher spatial resolution is more relevant than the removal of the atmospheric effect. The MODIS product was therefore chosen to analyse the fire seasonality over Sub-Saharan Africa during the period 2002-2004.

Modeling tree - grass balance in savanna ecosystems: the importance of different factors

Lehsten V. - Lunds University, Sweden

The vegetation structure of the many different savannah systems worldwide is influenced by a large number of factors including grazing, climate, soil conditions and a variety of land use practices. Especially the balance between tree and grasses in savannah systems is of high interest in theoretical modeling as well as for dynamic global vegetation modeling. Despite the manifold influencing factors, a number of features are hypothesized to be able to prevent competitive dominance of either trees or grasses their by maintaining the vegetation structure. These are among others differences in the rooting and the phenological niche, or the demographic bottleneck imposed by climate, grazing or fire. In a simulation study applying the dynamic vegetation model LPJ-GUESS coupled with the fire module SPITFIRE, we investigated the effects of several of the suggested factors and examined their effect. The study is performed along a precipitation gradient and by varying each factor singly. The demographic bottleneck caused by fire is proven to be sufficient to maintain the mixture of grasses and trees at sites with sufficient vegetation to allow the fire to spread. At sites with lower precipitation tree dominance is effectively prevented by the climatic conditions.

An enhanced estimate of pyrogenic carbon emissions from Africa using a synthesis of polar orbiting and geostationary active fire products

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Inventories of trace gas and aerosol fluxes from terrestrial ecosystems have increasingly relied upon Earth observing satellites to identify active landscape fires. Though it has been suggested that a more accurate spatio-temporal representation of biomass burning could be achieved by combining polar orbiting and geostationary observations, the ability to enhance fire detection and characterization through a symbiotic synthesis of active fire products remains relatively unexplored. The following work specifically addresses this issue by assimilating active fire pixels detected by the Moderate Resolution Imaging Spectroradiometer (MODIS) and the Spinning Enhanced Visible and Infrared Imager (SEVIRI) across Africa between February 2004 and January 2005. An empirical database was populated with pairs of frequency density distributions of fire radiative power (FRP) measured by MODIS and SEVIRI, and a statistical matching technique was employed to correlate coincident observations of fire activity between these two sensors. Fire radiative power is currently garnering considerable attention within the wildland fire science community since this parameter has been found to be directly proportional to fuel consumption rate and thus carbon emission rate. The result is the first generation of a "virtual" fire product that exhibits the full continental coverage and high (15-minute)

temporal resolution of SEVIRI whilst quantifying FRP, and thus carbon emission rates, with accuracies approaching those from MODIS. This "virtual" fire product was then used to develop a relationship between the carbon emission rates measured up to four-times daily by MODIS and the total carbon emitted in intervals of one week. Results indicate a high degree of confidence in the prediction, and it is expected that the linear regression developed for this year-long study period can be retrospectively applied throughout the lifetime of the MODIS sensors to provide new information on the magnitude and inter-annual variability of pryogenic carbon emissions from the continent of Africa.

Synchronizing Fire Emission Measurements with Land Use Patterns in Zambia

Mhango B. - Polytechnic of Namibia

Fire is climatically an earth system process not only as influenced by land use systems but also by its extensive influence on vegetation dynamics, atmospheric composition and biogeochemical cycling. Fire emission measurements can be synchronized with land use patterns in order to quantify emissions based on specific land use systems in Zambia. Key to this process is integration of crop calendars with relevant earth observing systems geophysical parameters intrinsically associated with emissions seasonal variability. A major practice in Zambia is the use of fires (slash-and-burn) in agricultural land use, and as a consequence biomass burning is an annual occurrence. A model using data sets of daily global imagery acquisition for burnt areas is here proposed in order to model fire emission scenarios in Zambia stratified into four temporal intra-annual emission measurements: (i). covering a six-months period (May to October) for Western Zambia, (ii) a shorter fire season covering four-months (July to October) for Eastern Zambia, a period covering two-months (July-August) for North-western Zambia, and a period covering two-months (May-June) for Northern Zambia. These data sets can then be evaluated and screened to match land use practices for the given temporal categories over a period ranging from 10 - 30 years in retrospect. Thus a robust time-series-based model is proposed to quantify fire emissions based on seasonality, land cover changes and land use systems.

Carbon sequestration and reduced emissions potentialities in Africa

REDD and CDM potentials for Ghana

Henry M., Tutu W., Kutsh W., Saint-André L.

Land use change is the major contributor of greenhouse gas emissions in Ghana. Most of Ghana's carbon stocks are contained in the forest zone. However, there is a large variation between different estimates of forest area. On the other hand there is still no reliable information on forest change at the national scale and on the impact of anthropic activities on carbon stocks. The aim of this presentation is to give estimates on the impact of anthropic activities on forest carbon stocks in terms of deforestation and degradation by selective logging and afforestation as wellas reforestation activities. The first part of the presentation will focus on recent estimates of land cover change using Landsat satellites images. The second part of the presentation will focus on the impact of selective logging on forest

degradation. The third part will focus on the potential for carbon sequestration through afforestation and reforestation activities. Finally, the potential implementation of REDD and CDM projects in Ghana will be discussed. A particular attention will be given to the constraints for project development (baseline, cost of implementation, land tenure, adaptation, feasibility, and acceptability).

Carbon stock under four land-use systems in three varied ecological zones in Ghana

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The study was undertaken to assess the trend in carbon stock under four different land-use systems namely, natural forest, teak plantation, cultivated land and fallow land. This was carried out in three varied ecological zones namely high forest, forest-savannah transition and savannah zones. Carbon accumulation in woody plants, herbaceous plants, litter and soil (up to 40 cm depth), was assessed. The biomass carbon stock in the various land-use systems in the high forest and transition zones was in the increasing order, cultivated land, fallow land, teak plantation and the natural forest. However for the savannah zone, the teak plantation accumulated more biomass carbon than the natural forest. Under each of the four land-use systems, the highest biomass carbon accumulation was exhibited by the high forest zone, followed in a decreasing order by the transition and the savannah ecological zones. The trend in the soil carbon stock under the various land-systems within each of the ecological zones was different among all the ecological zones. The least soil carbon stock in the high forest and the transition zones was in the cultivated land, whereas in the savannah zone it was in the teak plantation. The highest soil carbon stock was in the fallow land in both the transition and savannah zones, whereas the highest was in the natural forest land in the high forest zone. Total carbon stock (biomass plus soil) in the savannah zone was 39.51, 33.19, 63.63 and 68.21 Mg C ha-1, in the transition zone it was 64.06, 31.19, 228.00 and 93.34 Mg C ha-1, and in the high forest zone it was 95.43, 75.11, 347.18 and 154.95 Mg C ha-1, for fallow land, cultivated land, forest land and teak plantation land-use systems, respectively.

Carbon storage and the health of cocoa agroforestry ecosystems in Ghana

Asase A. - University of Ghana

Agriculture is one of the main drivers of the loss and degradation of humid forests in West Africa. Little economic incentive for small-holder farmers to protect agroforestry ecosystems and their associated services, resulting in the intensification of production methods for commodity crops such as cocoa. Agroforestry ecosystems store significant amounts of carbon. Diversifying rural livelihoods through carbon trading might change the economic incentive to farm intensively, thereby protecting ecosystem health and improving agricultural sustainability. The aim of our study is to estimate the magnitude of carbon stores in different cocoa agroforestry systems, and relate these to agricultural commodity production (cocoa) and measures of ecosystem health. We studied a gradient of increasing cocoa production intensity in the Eastern Region of Ghana. We quantified the cocoa standing crop, above and below ground carbon stores, soil nutrients and nutrient cycling and forest biodiversity along this gradient over a 3 year period (2005-2007). The above and below ground carbon stores declined significantly along the intensification gradient. Cocoa standing crop was

significantly greater on the unshaded farms, so there is a trade-off between cocoa productivity and carbon stores. Soil nutrient status and nutrient cycling deteriorated along the gradient, making intensive farming less sustainable. Forest biodiversity (the species richness of mammals, birds, butterflies and plants) showed a comparable pattern to carbon stores. Considering carbon stores and cocoa productivity in tandem could have important implications for land management strategies. Ecosystem health and biodiversity value are related to carbon stores, providing a potential economic mechanism for wider ecosystem protection if carbon stores could be traded. Comparable integrated studies within Ghana and across the entire West African region are needed to provide baseline data. Work to enable smallholder cocoa farmers to engage with the emerging carbon market is urgently needed.

Above-ground biomass in Gabon

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Much of our current understanding on tropical forest ecosystems is based on studies conducted in Central America, the Brazilian Amazon and South-East Asia. Scientifically, the central African rainforest is the least understood of the world's major tropical forest regions, in a period when its large cultural and biological diversity is buffeted by an increasingly complex array of economic and political factors. Until recently, the Congo Basin Forest (CBF) has received little attention in terms of climate change issues and the opportunity of tropical forest carbon trading. The aim of this study is to produce an above-ground biomass and carbon map of the CBF using Gabon as a case study. The data we are using includes ALOS-PALSAR data and a suite of other satellite imagery, permanent plots and forestry inventories. Wood density measurements and the development of allometric equations for the region will increase the accuracy of the biomass and carbon calculations. Currently, we have access to over 40 plots and transects and over 500,000 hectares of forest inventories scattered across the country. More data access to the Northeast and Southwest are will be available by the end of 2008. The outputs of this study will be to (1) produce a high-resolution map of above-ground biomass and carbon for Gabon and (2) extrapolate this to the regional level for the CBF using further satellite imagery, permanent plots, forestry inventories and ground-truthing. This is the first comprehensive dataset of its kind for Gabon and perhaps the Central African region where research institutions, NGOs and the logging sector are combining and sharing their data in a collaborative effort to inform both the scientific and policy debates around carbon stocks, threats and opportunities for the CBF.

Helping Small Scale Tree Farmers in Africa Participate in Carbon Trade

Kung'u J. - Kenyatta University, Kenya

On farm tree planting projects in Africa can lead to sustainable development and at the same time contribute to the global effort to stabilize Green House Gas (GAS) levels in the atmosphere. Trees can provide sinks of atmospheric carbon dioxide and the carbon credit accruing from such programs can be used to offset carbon emissions in industrialized countries whose emission levels have been capped. Many countries in Africa have met the requirements under the United Nations Framework Convention on Climate Change (UNFCCC) for hosting forestry projects under CDM. A study was carried out in Kenya to

assess whether the smallholder tree farmers are capable of participating in carbon-offset projects. The study established that opportunities exist for smallholder tree farmers to incorporate carbon offset as a tree product and participate in Clean Development Mechanism (CDM) and Voluntary Carbon Offset (VCO) markets. Currently farmers have been able to stock 2.08 tons of carbon per hectare with a market value of US$ 492. There exist networks in form of co-operatives and farmers groups which farmers can use to market their carbon stock.

Carbon fluxes and deforestation

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The presentation shows recent examples of carbon fluxes associated to deforestation in Zambia and summarizes recent deforestation trends in Africa. An introduction of actual activities and potentials for REDD initiatives (Reduced Emissions from Deforestation and Land Degradation) is pointed to the demands of the REDD process regarding ecological science. REDD can be an attractive economic tool to avoid deforestation through the generation of carbon credits and can also foster biodiversity conservation and development. However, scientific questions have to be solved, particularly on the choice of baseline approach. Finally, the problem of deforestation is seen from an energy perspective and combined with development of regenerative power in African countries.

Potential for Carbon Sequestration in Terrestrial Forests of Zambia

Siampale A. - Ministry of Tourism, Environment and Natural Resources, Zambia

Scientific concerns regarding tropical deforestation and global climate change have motivated ongoing efforts to quantify the role of forests as terrestrial carbon stores in the global carbon cycle, and Zambia is no exception. In 2005, The Government of the Republic of Zambia in collaboration with FAO-UN, and the Finnish Government financed the implementation of the Integrated Land-use Assessment (ILUA) project. The purpose of ILUA was to assess forestry resources and land use practices, to provide new qualitative and quantitative information on the state, use, management and trends of these resources. Based on the ILUA results the potential for carbon sequestration in terrestrial ecosystems of Zambia is viewed from the four (4) main key results areas (KRAs) 1. Current status of forests in Zambia 2. Levels of human disturbance to the existing vegetation 3. The regeneration potential 4. Afforestation and reforestation.

Promoting carbon sequestration through participatory land use planning by poor resource farmers in arid communal areas of Zimbabwe: a case study

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Carbon sequestration has the potential to mitigate climate change. Soil is the largest terrestrial pool of carbon. Depending on management it can be a source or a sink. Participatory Rural Appraisal meetings and field assessments were employed to gather data on resource potential and key agricultural processes affecting soil carbon dynamics in Tagwira village, Mwenezi District. Results indicated that 14% of farmers in the village practice reduced tillage farming,

while (88%) practice residue mulching. Only 4% use cover crops while 24% have poorly maintained woodlots. Grazing land is adequate to meet the current livestock. No energy crops are grown in the village but almost 88% of the farmers practice crop rotation. Maps and action plans were produced indicating community plans for improved food security. Incidentally, all the action plans also contribute to carbon sequestration. It was proposed that there should be sustainable utilisation of existing resource base to promote carbon storage in soil. Land use planners have to play a key role in this regard through result documentation and field campaigns to promote technologies that would result in carbon sequestration and increased yield. This is the initial survey on carbon sequestration through proper land management. Financial support is required to analyse amount of carbon in the soil together with yields obtained under each land management technique to enable farmers to appreciate benefits derived. This will enable easier adoption of the technologies by other farmers.

Demonstration projects and developing capacities in Africa

Tropical Forests and Climate Change Adaptation

Nkem J. - CIFOR, Indonesia

There are several reasons why tropical forest management needs to be mainstreamed into climate change adaptation and the need to promote adaptation into national development agenda. The consequences of not incorporating climate change adaptation into the management of tropical forests risk diminishing their current potential to remove and store atmospheric carbon including the flow of natural resources for rural livelihoods with significant implications for poverty alleviation, food security, and the enhancement of the adaptive capacity of the community. Therefore, both natural and planted forests help to decrease the vulnerability of those whose livelihoods depend on forest goods and services. The objective of the presentation is to highlight the importance of tropical forests for climate change adaptation and the implications of tropical forest management for achieving both mitigation and adaptation to climate change.

SHARE: Soil Moisture for Hydrometeorologic applications in the SADC (Southern African Development Community) region

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Knowledge of spatial and temporal patterns of soil moisture is an essential prerequisite for assessing the carbon cycle. Together with temperature it controls the carbon storage capacity of the soil layer. Soil moisture plays also a role in forest fire occurrence. Apart from other climate-relevant parameters like air temperature or precipitation, there are no routine in-situ soil moisture measurements for the vast majority of the Earths surface. The installation and maintenance of a global soil moisture measurement network is not feasible. Here, remote sensing methods can fill the gap. For soil moisture measurements, microwave remote sensing is commonly regarded as the tool of choice. Within the SHARE project, a multi-temporal change detection approach for extracting relative surface soil moisture from ENVISAT

ASAR Global Mode (GM) data with a spatial resolution of 1 km for the South African Development Community (SADC) has been developed and implemented. The approach exploits comprehensive ASAR GM time-series data. A fully automatic pre-processing gives geocoded, resampled, radiometrically calibrated and local incidence angle normalized data. The surface soil moisture change detection approach is based two reference values indicating dry and wet surface soil moisture conditions. Actual backscatter measurements are scaled between these two extremes and give a relative measure for soil moisture. Validation for selected test sites proved the usability of the retrieved soil moisture data. Comparison to ground truth data showed, that the change detection algorithm is capable of mapping the temporal trends and spatial patterns of surface soil moisture. The remotely sensed soil moisture data already have been distributed to institutions in Europe, Africa and America. Surface soil moisture maps are updated every other week and are provided free of charge to interested users.

TerrAfrica partnership: potential for climate change adaptation and mitigation in Sub-Saharan Africa

Lamourdia T. - FAO-SFE, Ethiopia

TerrAfrica partnership: potential for climate change adaptation and mitigation in Sub-Saharan Africa L. Thiombiano, D. Lantieri FAO Abstract About 65 percent of Africa's population is affected by land degradation. This phenomenon cost over 3 percent of agricultural GDP, due to soil and nutrients including carbon stocks losses. Past experiences revealed that policy support and willingness, effective participatory approaches and substantive investments in land management were insufficient, in the efforts to reverse the resulted severe trend of land productivity decreasing, particularly in sub-Saharan Africa. In this context, TerrAfrica as a partnership Initiative provides a platform where countries, The World Bank, UN system (UNCCD Secretariat, the Global Environment Facility -GEF, FAO, UNEP, UNDP), AfDB and NEPAD, are joining efforts for the leverage of substantive investments to support the up-scaling of Sustainable Land Management (SLM) practices. Taking into consideration the linkage between land degradation and climate change, TerrAfrica partners are promoting SLM as part of adaptation and mitigation strategies. In this regard, adaptation and mitigation to climate change is an important component of Country Strategic Investment Frameworks (CSIF) for SLM.

Sustainable Production Intensification in Africa - a climate change perspective

Friedrich T. - FAO/AGST, Italy

Over the next few decades the production has to be doubled to respond to the food demand of a growing population. On the other side the natural resource base for agricultural production is showing increasing signs of. These problems are even more pronounced in Africa. In the past highly intensive agricultural production took a heavy toll on the environment, which was accepted as unavoidable collateral damage, while agriculture which was more respectful to the environment was less productive. The new paradigm of "sustainable production intensification" is recognizing the need for a highly productive agriculture which at the same time positively contributes to environmental services as an element of sustainability. With regard to climate change this refers to the reduction of the contributions of agricultural production to the release of green house gasses. Adequate agricultural production techniques,

based on minimum disturbance of soils (no-till) and enhancement of aerobic conditions in soils can reduce these emissions and eventually even lead to the sequestration of carbon in soils reaching 0.25-2.5 bill t/year. This reduction of GHG emissions results from a better efficiency and reduced losses of production inputs and carbon and is hence not sacrificing high production levels. Sustainable production intensification, based on concepts such as Conservation Agriculture, provide also opportunities for the adaptation to climate change. With these perspectives Conservation Agriculture has a particularly high potential to address the problems of African agriculture. Harnessing the potential of conservation agriculture for carbon sequestration and reduction of GHG emissions for the payment of environmental services to farmers would provide further incentives to farmers for changing to this new way of agriculture.

Fostering shifts from existing fire behaviour patterns to more environmentally-friendly ones: challenges and approaches

Mammino L. - University of Venda, South Africa

Fostering changes in behaviour patterns is not easy, whether it refers to individuals or to communities. The difficulties are obviously greater for habits that are long-established, transmitted through generations and believed or proved to bring some benefits, as is the case of biomass burning in Sub-Saharan Africa. Attempts to foster changes require a delicate combination of approaches aimed at building conviction and active involvement of the communities concerned, so as to prevent the development of perceptions viewing the proposed changes as outsiders' interventions without links to the needs of the communities. This implies the design of approaches to illustrate the motivations for changing behaviour patterns, and to encourage the participation of the community in the search for alternative options that can be considered viable and can bring sufficient benefits to compensate or outweigh the ones that would be lost (e.g., short-term fertilization of the soil). The discussion is substantiated by the consideration of a number of comments from persons close to the type of community-life that would be the major target of change-fostering initiatives, and also the consideration of some of the difficulties encountered, in the past, by other types of initiatives requiring at least the consent of the communities in order to be successful. The presentation expands to include suggestions for a time-sequence identifying intermediate, more easily attainable objectives – e.g., ceasing the biomass burning utilised with the sole purpose of "cleaning" areas not devoted to agriculture may be pursued and achieved more easily and at a much earlier stage than the practice concerning areas devoted to subsistence agriculture, and bring about non-negligible reduction in greenhouse gases emissions.

Cooperative Community Carbon Offsetting with Biodiversity and Social Co-Benefits: a case study of trees for global benefits programme (Uganda)

Mwima P. - The Environmental Conservation Trust of Uganda

The Environmental Conservation Trust of Uganda (ECOTRUST) is implementing a cooperative community carbon offset scheme, the Trees for Global Benefit, as an incentive to small scale farmers to plant trees on their farms for carbon sequestration under the Plan Vivo system. This scheme has run for over 5 years and promotes Afforestation, Agroforestry, Biodiversity conservation through planting of native trees, and accrued incidental benefits that contribute to improved community livelihoods. The Plan Vivo system ensures supply of

verifiable emissions from rural communities in a way that promotes sustainable livelihoods. It targets voluntary carbon markets and the carbon buyers include Individuals and Companies. ECOTRUST is operating in 3 districts in Uganda namely Bushenyi, Masindi, and Hoima. Compliance is ensured through internal monitoring, and third party verifiers. Carbon payments to farmers are staggered (proportional payments), made only after farmers meeting required standards. The proportional payments are made up to the tenth year, which ensures capital for maintenance till tree establishments. The Trees for Global Benefit programme has exhibited both socio-economic and Environmental/Biodiversity conservation benefits. The beneficiaries include but are not limited to carbon producers or sellers, intermediaries, buyers, and service providers. To the sellers, there has been increased agricultural productivity, improved market access, reduced use of organic chemicals, reduced poverty, biodiversity conservation, reduced run-off, improved soil & water conservation, income diversification, robust vegetation, enhanced water flows To the buyers, corporate social responsibility, compliance with regulatory requirements, improved brand image, and enhance carbon sequestration. The intermediary agencies have benefited from environmental services such as water, increase in biodiversity, clean air, social benefits like improved working conditions and greater ecosystem supply.

Local strategies of adaptation to climate change: 6 case studies in Burkina Faso

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Les changements climatiques fragilisent les secteurs clés de développement des pays sahéliens comme le Burkina Faso. La bioénergie (charbon de bois, bois de feu, résidus de récolte, etc.) qui est la principale source d'énergie de cuisson en milieu rural est affecté par les changements climatiques. Pour planifier l'adaptation, nous avons évalué la perception et les stratégies endogènes d'adaptation aux changements climatiques qu'ont les populations rurales de six villages des régions du Centre, Est et Sahel du Burkina Faso. Nous avons utilisé des méthodes participatives (MARP). Les résultats montrent que les populations ont conscience des changements climatiques et développent des stratégies d'adaptation endogènes. En effet, dans les secteurs de la bioénergie, les critères de perceptions des changements varient par ordre d'importance d'un village à un autre. L'apparition de ces changements varie de 5 à 30 ans selon l'âge des interviewés. En effet, les critères de perception de ces changements en moyenne sont la hausse de la température, la pollution sous toutes ses formes, l'augmentation de la pauvreté et l'augmentation du prix du bois. Les raisons des changements évoqués par les populations sont surtout d'ordre anthropique. A court terme, les populations pratiquent l'accumulation du stock de réserve, la réduction du nombre de cuisson par jour et la diversification des sources d'énergie. Et dans le long terme, les populations pratiquent le reboisement, la réduction du nombre de cuisson par jour et le respect strict de la politique forestière.Ces méthodes d'adaptation sont des méthodes par planification même si l'intervention des moyens des autorités politiques est moindre. . Ces facteurs font que les populations sont vulnérables aux Changements climatiques, au double plan socioéconomique et écologique. Pour renforcer leurs stratégies d'adaptation, les populations ont des attentes techniques et économiques vis-à-vis des autorités pour renforcer pour renforcer les stratégies d'adaptation fragiles afin de leurs rendre durables.

Posters

Patterns of Variability and Climate Controls on African Photosynthesis

Hanan N. - Colorado State University, United States of America

African ecosystems are responsible for large net fluxes of carbon to and from the atmosphere mediated by photosynthetic uptake and respiratory releases. Although biotic carbon fluxes for Africa as a whole are near-neutral this occurs within the context of large spatial and temporal variability. In this paper we explore these patterns of variability focusing on photosynthetic uptake and explain their origin with respect to i) intra-seasonal and inter-annual variability in climate parameters, including rainfall, humidity and temperature; ii) variability in antecedent vegetation growth that impacts vegetation ability to respond to current favorable conditions, and iii) inter-annual and decadal-scale variability in synoptic weather conditions and relationship to ocean surface temperatures in the Pacific, Atlantic and Indian Oceans.

Site Characterization of the Malopeni Flux Site, Kruger Naional Park, South Africa

Kirton A. – CSIR, South Africa

This poster gives the site characterization for the newly established Malopeni flux site, located near Phalaborwa, South Africa, the second flux site in the Kruger National Park. This site is located at a latitude of -23.83254 and a longitude of 31.21436. This savanna site is dominated by Cholophospermum mopane and represents a hot, dry environment with an average daily temperature of 31 (deg. C) and an average annual rainfall of 480ml, which is concentrated in the Summer months. Other species at the site include Combretum apiculatum and Acacia nigrescens. The site occurs on shallow sandy loam luvisol soils, which are nutrient poor. The percentage nitrogen of the soil ranges between 1.00% and 11.00%, and the percentage carbon ranges between 36.00% and 50.00%. The bulk density of the soil is between 1.23 and 1.49 g/cm3.

Modelling the Carbon Budget at regional scale in West-Africa using remote sensing and ground observations

Machwitz M. - University of Wuerzburg, Germany

Global warming associated with climate change is one of the greatest environmental, social and economic challenges of today's world. Increasing emissions of the greenhouse gas CO2 are a major forcing to global warming. The biosphere is one of the most important components of the climate system. It influences atmospheric processes through drivers such as radiation budget, carbon exchange or water accessibility for evapotranspiration. Land cover, therefore, is important to know in order to determine the sources and sinks of CO2 and their changes. The Regional Biomass Model (RBM) Kaokoveld (Richters 2005) was developed to model the Net Primary Productivity (NPP) and is a biogeochemical model based on the physical-chemical principles of photosynthesis for areas of some hectares to several square kilometres. Consequently, the RBM Kaokoveld offers good prerequisites to calculate the NPP of the savanna vegetation in the Volta basin. To consider the fine scattered landscape

in West Africa the model is calculated on 250 m resolution in comparison to the original 1000 m. Therefore new input parameters with higher accuracies and resolution were generated instead of using the global standard product from e.g. MODIS etc. The most important parameters are a new land cover map and the percentage cover of woody and herbaceous vegetation and bare soil on 250 m MODIS data. Modelling the NPP on 250 m resolution gives consideration to the need of products in-between the local measurements for only few and small areas and the continental and global products on coarse scales. The medium scale can be the linkage between these products and is helpful for the validation of the wide ranging products in this area. For validation, ongoing field measurements of biosphere-atmosphere exchange in the semi-arid regions of Burkina Faso were used. These stations were established in joint cooperation between GLOWA Volta and BIOTA West.

Effect of land use systems on soil and vegetation carbon in the Nioro area (Senegal)

Bayala R. - CERAAS/CORAF, Senegal

Managing carbon stocks within landscapes is a key mid-term mitigation of atmospheric and climate change. Carbon stocks residing in vegetation and soils of an agro ecosystem (about 980 km²) were determined in different land use classification. Based on satellite images this study attempts to make explicit analysis, both temporally and spatially. It shows major land use classification in 8 types which are low lands, fallows, plantations, cultivated areas, timbered savannah, shrubby savannah strand ("tanne") and water plan. Soil carbon is most sequestered in low land with 3.55 C t ha-1 in the top of 20 cm which is rainfall and soil erosion concentration. Plantation areas, essentially eucalyptus and fruit trees cultivation, shrink 91 C t ha-1 in biomass. Between 1990 and 2001, common area of the both years is 460 km². This study carried out the lost 12% and 59% respectively shrubby savannah and timbered savannah areas which progressively leave the place to the cultivated area increasing with 15% in surface. Results could not suggest a projection model account of a lack of data on older years (e.g. 1960 or 1970) land use for this area.

Wood density variation in Central Africa using xylarium samples - implications for biomass calculations

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Wood density, together with diameter at breast height and height, is an important factor for biomass estimations. As approximately 50% of plant biomass is carbon, this has implications for carbon dioxide emissions from deforestation and degradation. Currently, there is little understanding on the wood densities - and how these vary - of dense tropical central African tree species. We have created a wood density database for 54 common species totalling 980 samples of wood based on measurements performed on historical samples at the xylarium of the Museum for Central Africa in Tervuren, Belgium. Due to the limitations of working with historical samples that must be preserved, we tested volume measurements by solid and liquid displacement. We found that both techniques have merit but that volume displacement is the most accurate. We assess inter and intra wood density based on geographical locations of the samples measured.

Estimation Des Facteurs D'émission Locaux De Methane (Ch4) Imputable À La Gestion Du Fumier Chez Les Ovins Au Benin

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La réalisation des inventaires de gaz à effet de serre (GES) dans les pays en développement et surtout au Bénin est basée sur l'utilisation des facteurs d'émission par défaut du Groupe Intergouvernemental d'Experts sur l'Evolution du Climat (GIEC). L'objectif visé par cette étude est de contribuer à la détermination des coefficients d'émission de GES spécifiques au Bénin. Cette évaluation a consisté à appliquer les Directives Techniques du GIEC (1996 et 2000) aux données sur la performance des différentes sous-catégories d'ovins. Sur cette base, les facteurs d'émission locaux du méthane imputable à la gestion du fumier chez les ovins ont été estimés en kilogrammes de méthane par tête de bétail et par an (kg CH4 TETE-1AN-1) comme suit: Agneaux et Agnelles (0,09), Antenais et Antenaises (0,16), Béliers (0,19), Brebis (0,21). Cette étude révèle, globalement, que les facteurs locaux d'émission de CH4 varient selon les sous-catégories d'ovins au Bénin. Pour les brebis et les béliers, ils sont de même ordre de grandeur que les valeurs par défaut du GIEC. Quant aux autres sous catégories d'ovins, les facteurs d'émission locaux de méthane obtenus sont différents de ceux du GIEC. Les facteurs d'émission locaux de CH4 imputable aux ovins obtenus au Bénin, pourraient éventuellement être adoptés par défaut par d'autres pays, notamment ceux du Golfe de Guinée, ayant une caractérisation similaire au Bénin en ce qui concerne ce cheptel.

Estimating the impact of selective logging on aboveground carbon stocks in Boi Tano Forest Reserve

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Reducing Emissions from Deforestation and forest Degradation (REDD) is recognized as a potential option to mitigate the greenhouse effect. The implementation of the REDD mechanism will require estimates on the impact of forest degradation and deforestation on carbon (C) stocks. The aim of this study is to provide (1) estimates of aboveground carbon stocks in a Wet evergreen Forest Reserve of Boi Tano and (2) an estimation of the impact of logging on aboveground carbon stocks. Sixteen plots of one hectare were randomly implemented within a 170 ha forest compartment, each of them centred on a selected tree to be felled. Three plots in different ecological zones were selected to analyse the spatial variability. All the plants of a diameter at breast height above 2 cm were inventoried, the DBH was measured and 55% of plant species were identified. Biomass contained into the different vegetation classes was estimated using different allometric regressions found into the litterature. After the logging, different ground damage types were identified: roads, logging bays, skid trails and felling gaps. The impact of logging was estimated assuming that all the aboveground biomass on the damaged area was removed. Average Aboveground C stocks was 154.2 (±16.2) Mg.ha-1. Using different root-shoot ratios, belowground C stocks ranged 52.6 – 114.1 Mg.ha-1. When considering the compartment scale, the impact of logging is about 10.01 Mg.ha-1 and represents 5% of the C stocks. Our estimate ranges 3.7-49.0 Mg.ha-1 at the compartment scale. When considering the 16 plots, in average, 170 and 160 Mg.ha-1 of C were stored in natural forests and after selective logging, respectively. A precision of 3% is needed to differenciate a natural forest from a logged forest, and at least 57 plots of one hectare have to be measured to identify significant C stocks between the forest types.

Ankasa flux tower: a new facility for the study of the carbon cycle of primary tropical forests in Africa

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A new station for the monitoring of CO_2 and energy fluxes over a primary tropical forest in Ghana is operative as part of the Carboafrica eddy covariance network. The facility, located in the Ankasa Conservation area (05° 16' 11.2''N; 02° 41' 41.55'' W), includes a 65 m tall steel tower equipped with a system enabling the measurements of fluxes at the top of the structure, of CO_2, air temperature and humidity along a vertical profile and of relevant physical parameters of the forest ecosystem.
The Ankasa flux tower is the first in the African continent collecting data on CO2 exchanges over a tropical primary forest, and from its activity a breakthrough in the understanding of the carbon cycling in this kind of environment is expected. Moreover the knowledge gained on the carbon balance of this primary forest can be used as a reference to thoroughly evaluate the impacts of deforestation, beyond the decrease of carbon stocks.
The analysis of preliminary data collected in the first week of August 2008 shows a daily uptake of 1.33±0.73 gC m^{-2} d^{-1} (mean±s.e.) and highlights the large magnitude of the storage of CO_2 within the canopy space causing a discrepancy between the CO_2 flux observed at the top of the tower (Fc) and the overall net ecosystem exchange (NEE). During night-time NEE reveals a respiration rate up to 4 times higher than Fc while in the first hours after dawn assimilation of CO_2 in the canopy space is sensed at the top level of measurement with about 3 hours of delay.

Soil carbon storage and nutrients in the primary rain forest of Ankasa, Ghana

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In this preliminary study, the soil of the primary rain forest of Ankasa (5° 16' 51.12'' N; 2° 41' 21.14'' O), located in the south-western corner of Ghana, was investigated in term of organic carbon amount and nutrients. The aim was to provide an overview of the basic characteristics of this tropical soil and a reliable estimate of its soil organic carbon (SOC) storage. In this purpose, forty soil samples for each horizon down to 1 m depth (A, Bt1, Bt2) and 20 samples of the organic layer were collected in an area of 200x200 m. The mineral soil was analysed for particle size distribution (pipette method) and pH in water (1:2.5 ratio soil-solution). The cation exchange capacity (CEC) was determined by atomic absorption spectroscopy, while total SOC and N were determined in the different genetic horizons and in the organic layer by dry combustion. The CEC shows averages values and the availability of nutrients in cationic forms is generally good. Total SOC to 1 m depth (14.6 kg m^{-2}) is not elevated for a primary rain forest suggesting, as observed by Sanchez and Logan (1992), a similarity with the SOC amount per unit area found in temperate forests. In any case, these results highlight the fast turnover of C occurring in this soil and the consequently low SOC amount possibly being stored for long time. Other measurements such as radiocarbon, currently in progress, can help elucidating the C dynamics of this forest soil.

Biodiversity and biomass in the primary rain forest of Ankasa, Ghana

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Associated to the tower site, a field campaign to estimate biomass and biodiversity was carried out. Two transects were demarcated for a total surface of 2 ha. Each transect measuring 1000 m x 10 m and intersect each other at the centre where is located the tower and it is divided into 10 subplots in which all the plants with diameter > 5 cm were measured. Standing and downed dead trees were measured without identification. A permanent plots was demarcated along each of the two transects for a total surface of 0,2 ha. Inside every permanent plot all plant individuals were identified and measured and the natural regeneration was counted. The LAI was calculated by hemispherical photo processing. All data are still being processed but the first analysis has already highlighted the high biodiversity that characterizes Ankasa forest.