Modeling Fire on the African continent

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Objectives (amongst others):

Understand quantify and predict the GHG budget of Sub-Saharan Africa and its associated spatial and temporal variability LPJ Guess reproduces tree/grass mixtures badly Fire is suggested to be one of the main actor in maintaining vegetation structure in areas like savannas

Approach:
Integrated, considering flux measurements together with specific models

Results:
Will provide the knowledge elements necessary for reducing uncertainty and bias in GHG budget estimates
Aims: of implementing SPITFIRE fire module

(I) Vegetation modeling:
   LPJ Guess reproduces tree/grass mixtures badly
   Fire is suggested to be one of the main actor in maintaining vegetation structure in areas like savannas

(II) Fluxes:
   Wild fires as well as fires for agricultural clearance produce fluxes of CO$_2$, CO, NOx, VOC, methan....
   while re-growth utilizes CO$_2$, hence there is only a limited long effect to be expected, other gas species depend strongly on the fire frequency, timing, fuel availability and combustion
LPJ vs LPJ GUESS: Population mode vs. Cohort mode

**LPJ**
- Each PFT is represented by a single 'individual'
- No stochastic processes, no age structure (establishment)
- In some respects comparable with TRIFFID.

**LPJ GUESS**
- Each tree PFT can have several individuals growing, which represents an age-cohort.
- To average out effects of establishment and include disturbances, several realizations (patches) are calculated and averaged.
- In some ways comparable ED but all tiles have equal size.
Aims using SPITFIRE in the Cohort mode

Fire affects young (small) cohorts stronger-size related mortality -> could maintain tree grass mixture as hypothesized by several authors
SPITFIRE: SPread and InTensity of Fire

SPITFIRE

LPJ GUESS

Ignition

Propagation

Fire effects

Modeling

results

Outlook

SPITFIRE simulates fires depending on:

- above ground fuel load
- climatic conditions / litter moisture
- human ignition pattern

SPITFIRE Fires cause in LPJ GUESS

- Post fire plant mortality
- Biomass reduction due to burning
SPITFIRE

Spitfire Natural Ignition: Lightning

Satellite based climatology of lightning

From OTD/LS; correction ratio by Price (1999)

Ignition

Propagation

HRMC 0.5 degree monthly climatology [flashes per km² and day]

July

January

SPITFIRE in LPJ - GUESS
Fire spread depends on fuel availability:
calculated by LPJ GUESS (litter)
litter subdivided into fuel size classes according
to fixed ratio per PFT fuel size classes 1hr 10hr 100hr 1000hr
also influenced by fuel moisture (soil moisture)
and wind speed
fuel bulk density (PFT specific)
Fire is assumed to form an elliptical shape
Human influence on fire regime

99% of all fires are anthropogenic

Human caused fires can be directly prescribed to calculate recent emissions and vegetation

be scaled to human population density, land use and climatic conditions to simulate scenarios
Fire effects:

- Fire intensity depends on fuel availability and environmental conditions.
- Leads to crown scorching and cambial damage and hence to post fire mortality.
Results: Total burned area spatial and variation: prescribed and nat. fire

SPITFIRE

LPJ GUESS

Ignition

Propagation

Fire effects

Modeling results

Outlook

km² burned area per 0.5 degree cell (3080 km² total)

Southern Hemisphere A.:
total burned area:

Guess presc fire  1.83*10⁶ km²
Guess nat. fire only 0.90*10⁶ km²

Ito et al. (2007)  2.3*10⁶ km²
Gigliio et al. (2006) 0.81*10⁶ km²
Scholes et al. (1996) 1.68*10⁶ km²

A slightly changed Giglio et al. (2006) alg. was used for the prescribed fire.

Burned area natural ignition
Results: emissions: prescribed and nat. fire

Southern Hemisphere A.: CO emissions

- Guess prescr. fire: 70 Tg
- Guess nat. fire only: 38 Tg
- Ito et al. (2007): 60 Tg

SPITFIRE in LPJ - GUESS

Exeter 06/29/2007
Perspective Milestones

Flux calculation CO₂ & trace gases:
Site (7 local CarboAfrica flux stations) with site climate and continental runs

Incorporation of fire intensity related versus PFT specific emission factors

Calculation of projected emissions and vegetation according to IPCC scenarios