Attribution of GHG cycle change: intercomparison projects and model developments

ORCHIDEE Meeting
January 8th

D. Solyga, B. Guenet, V. Yue, M. Saito S. Hantson B. Poulter, T. Kato, G. Berthier

Understand the role of different drivers to the change in GHG

- Participation to several intercomparison projects: Trendy, Mstmip, ISI-MIP **(G. Berthier for Mstmip)**
- Attribution of N. H carbon sink (focus on forest) **(B. Poulter)**
- Specific role of extreme events **(T. Kato)**

Based on several model improvements

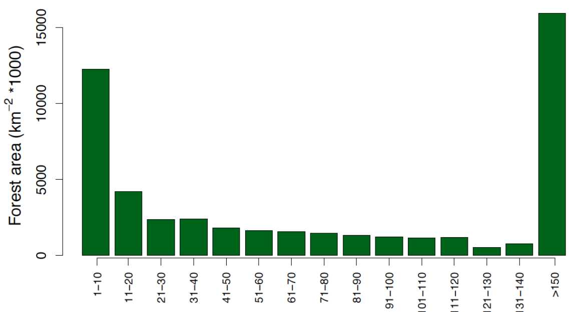
- Parameters externalization and analytical spinup **(D. Solyga)**
- Improvement of soil parameterization **(B. Guenet)**
- Forest growth **(B. Poulter)**
- Fire representation **(cf. P. Cadule)**
- Nitrogen **cycle (B. Guenet, B. Poulter, S. Luyssaert, N. Viovy)**

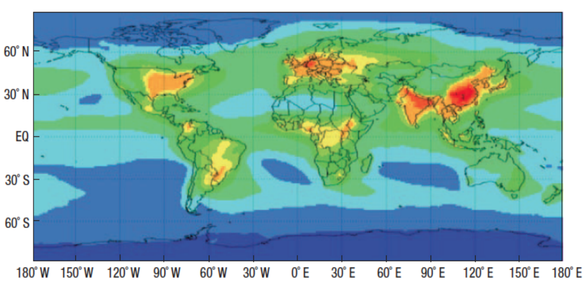
Ben Poulter

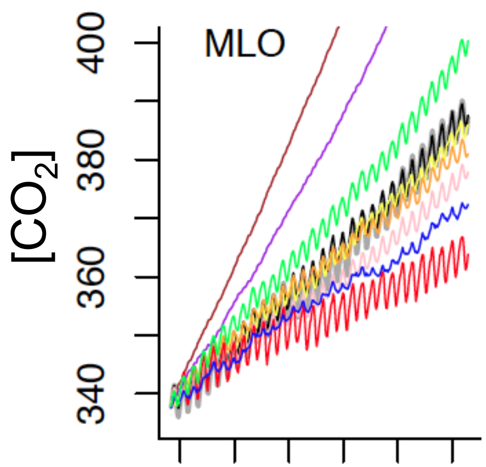
Research: Spatial and temporal dynamics of the terrestrial carbon sink

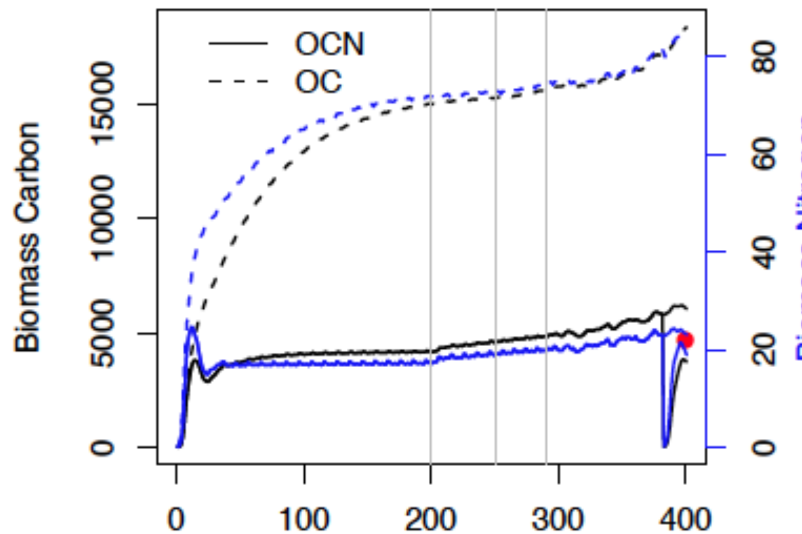
- *Spatial distribution and magnitude of the land carbon sink*
- *Mechanisms sustaining increasing carbon sequestration*
- *Resiliency of carbon sequestration and stocks to disturbance*
- *Management options to maintain or increase carbon storage*

(1 and 2) Multi-factor attribution experiment: age, nitrogen, climate, CO_2



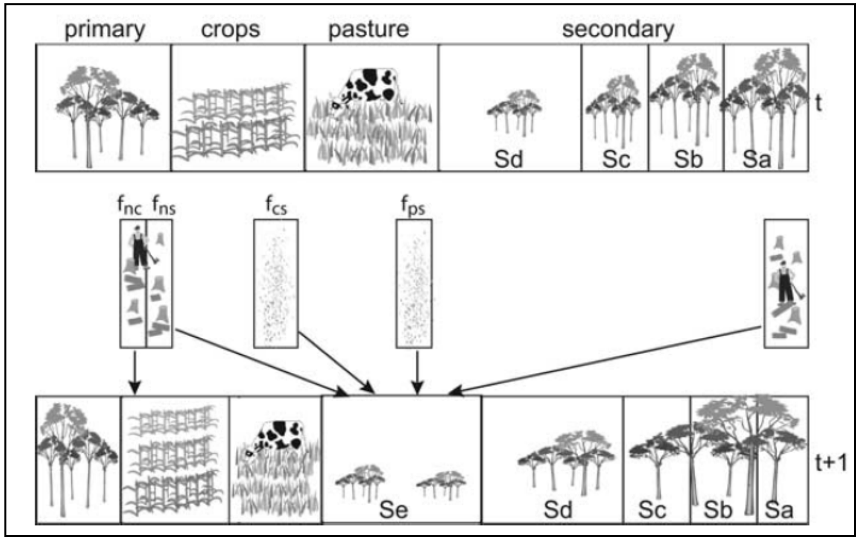




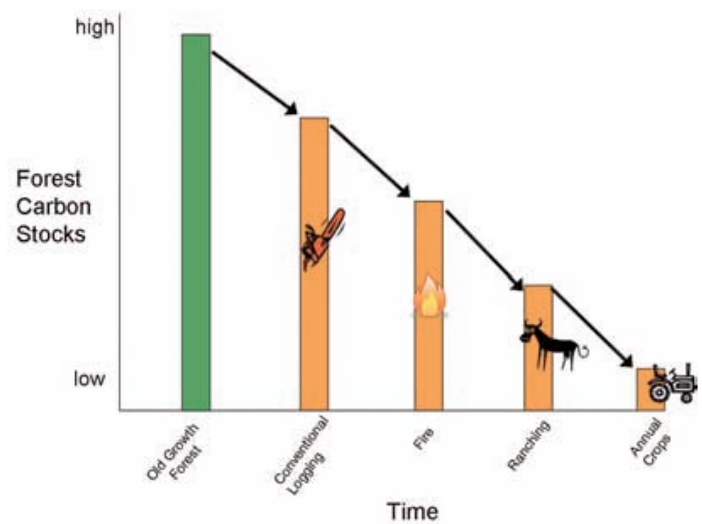


(3 & 4) Resiliency of carbon stocks and response to management and fire

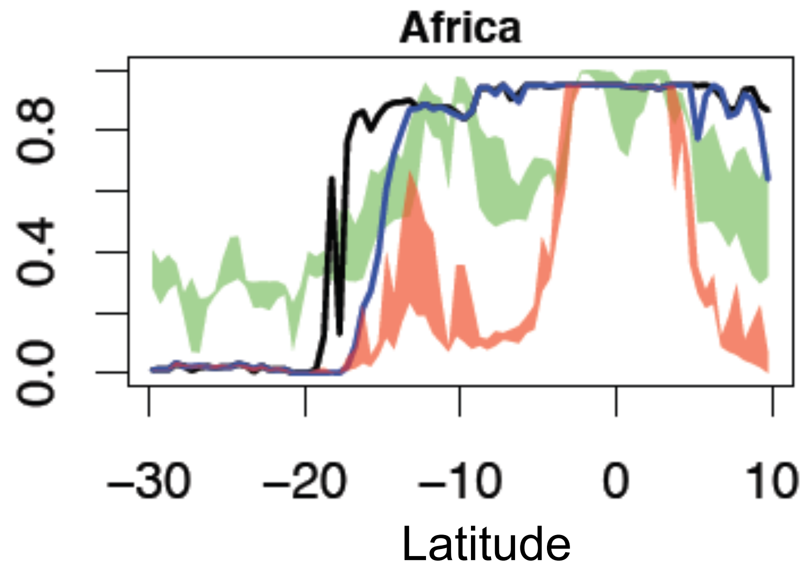
Sub-grid cell tiling scheme
(w. Daniel McInerney)



Tropical forest degradation
(UCL N Nadjowksi)



Fire frequency and tree cover



Vulnerability of ecosystem productivity over Europe under past and future climate extremes

Tomomichi Kato
(supervised by Nicolas Viovy, Nicoals Vuichard, Philippe Ciais)

LSCE, IPSL, CEA-CNRS-UVSQ

What are Vulnerability and Risk?

By Dr. O. Marcel (CEH)’s proposal under CarboExtreme WP6

Vulnerability = *E*(sys|env non-hazardous) – *E*(sys|env hazardous)

NPP, Rh, Carbon storage, etc.

Drought, heat wave, cold winter, etc.

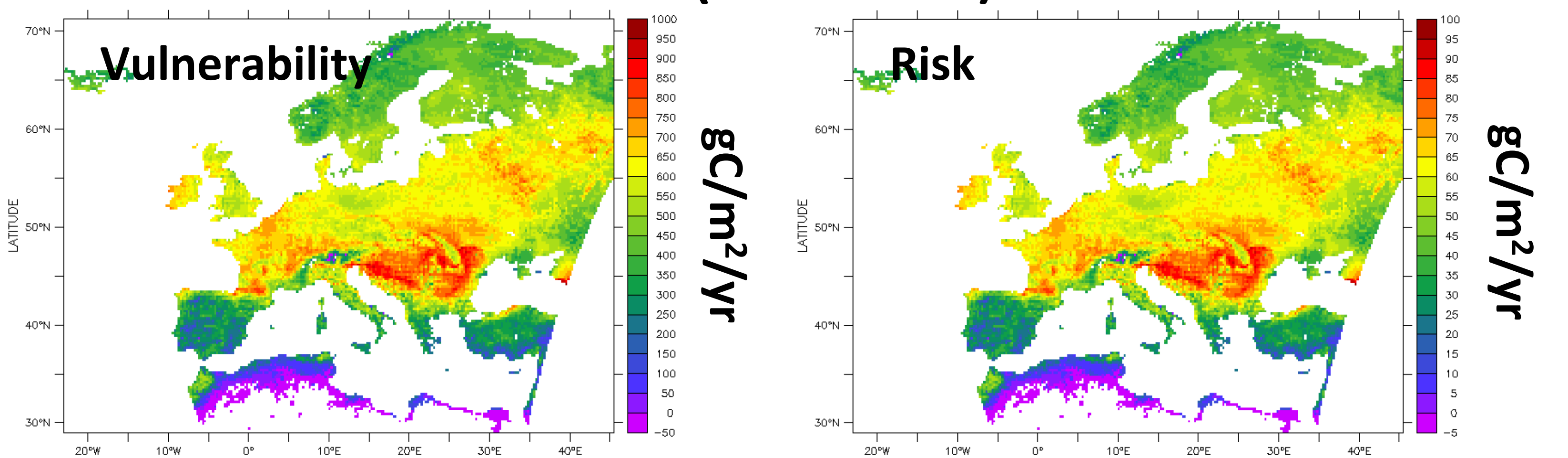
Risk = *P*(env hazardous) x Vulnerability

Vulnerability and risk by extreme drought on NPP

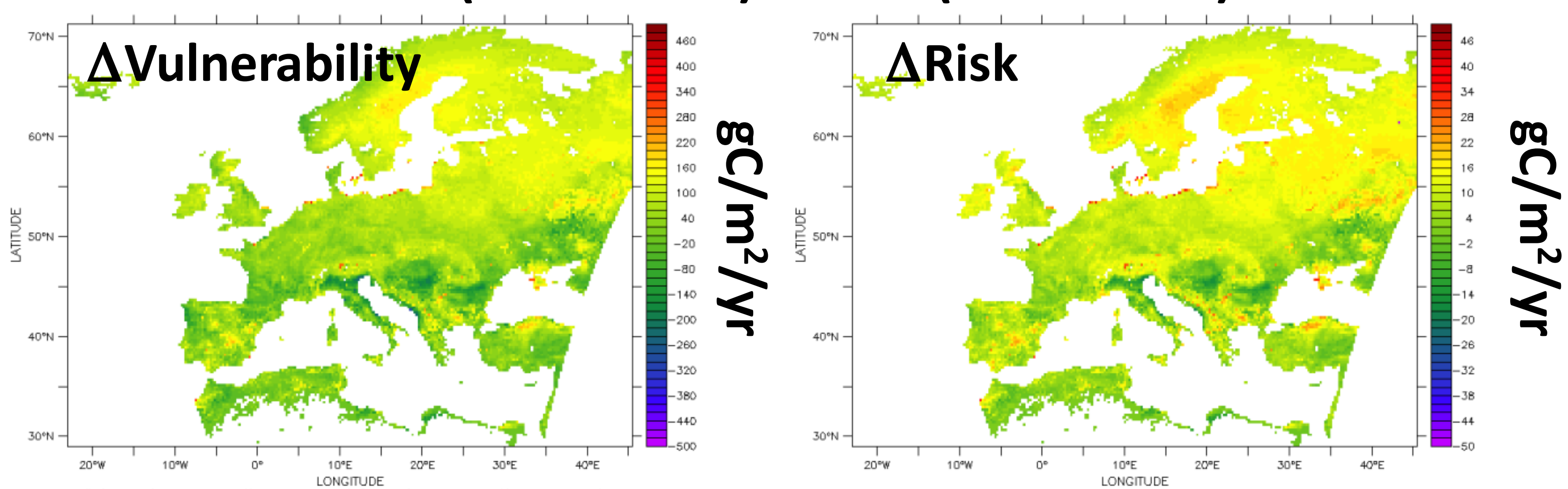
Vulnerability = E(NPP|Rain >= 10%ile) - E(NPP|Rain < 10%ile)

Risk = P(Rain < 10%ile = 0.1) x Vulnerability

Ave: Past (1961-2010)



Diff: Future (2011-2060) – Past (1961-2010)



Carbon pools in ORCHIDEE? -Modifications from the STD version

Gwenaëlle Berthier

Postdoc fellow at LSCE

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Carbon pools in ORCHIDEE? -Modifications from the STD version

- **Project = MsTMIP** (Multi-Scale Systhesis and Terrestrial Model Intercomparison Project)
- **Overall goal** of providing feedback to the terrestrial biospheric modeling community to improve the diagnosis and attribution of **carbon sources and sinks** across regional and global scales
- Models = ORCHIDEE, LPJ, CLM, JULES, VISIT, ...
- Modifications to ORCHIDEE to respect the protocol: (No Fires, No nitrogen deposition, Vcmax/Vjmax modified)

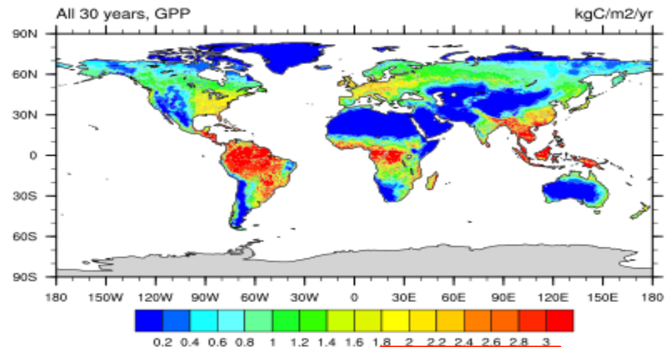
ORCHIDEE	STD	MsTMIP –Global run	MsTMIP –NA run
Land-use change	From Olson et al. 1983, 1985: 94 PFTs to 13 PFTs	From Harmonized Hurtt's and SYNMAP (Jung et al. 2006): 48 PFTs + 4 major crops + C3/C4 grassland to 13 PFTs	
Soil properties	Soil texture by Zobler 1986	Sand/clay/silt fractions from Harmonized World Soil Database (HWSD) and water holding capacity from Cosby et al. 1984	Sand/clay/silt fractions and water holding capacity from Saxton et al. 2006
Soil depth	2 m	Variable (from HWSD)	Variable (from HWSD + N.A. and Can. datasets)

Gwenaëlle Berthier, Shushi Peng, Ben Poulter, Fabienne Maignan, Nicolas Viovy, Philippe

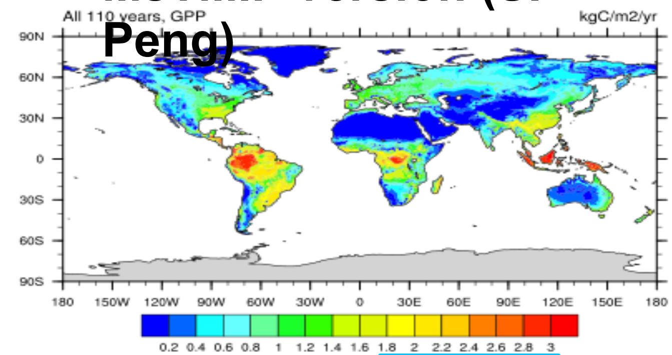
Carbon pools in ORCHIDEE? -Results versus STD version

STD version (B. Poulter) | **MsTMIP version (S. Peng)**

GPP

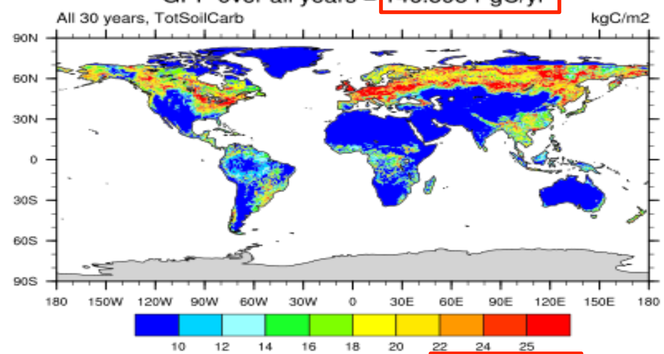


GPP over all years = 146.898 PgC/yr

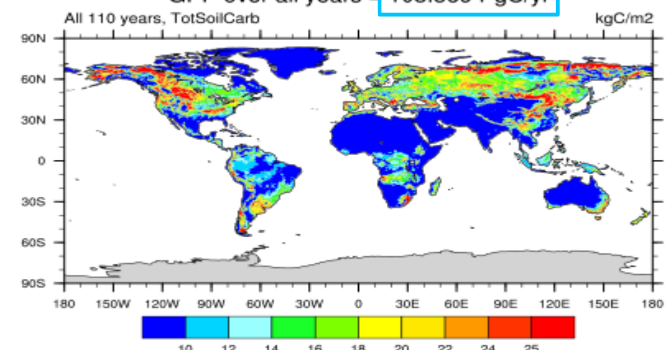


GPP over all years = 103.569 PgC/yr

Total Soil Carbon

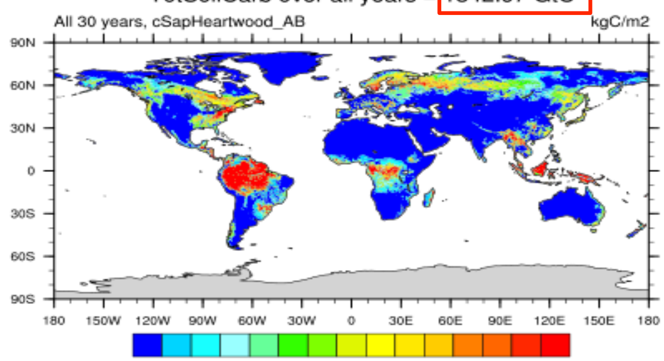


TotSoilCarb over all years = 1342.97 GtC

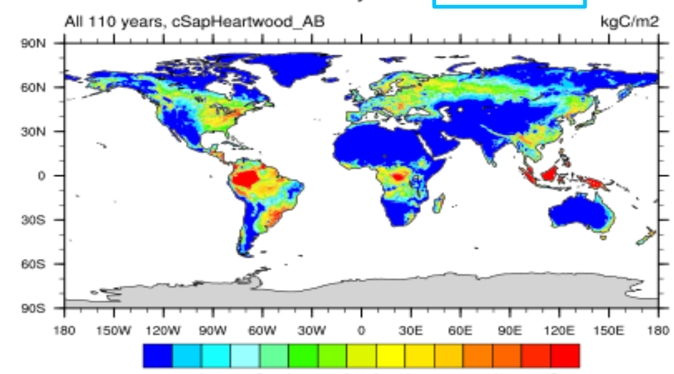


TotSoilCarb over all years = 1304.35 GtC

Above Ground Wood



cSapHeartwood_AB over all years = 450.968 GtC



cSapHeartwood_AB over all years = 499.873 GtC

Gwenaëlle Berthier, Shushi Peng, Ben Poulter, Fabienne Maignan, Nicolas Viovy, Philippe

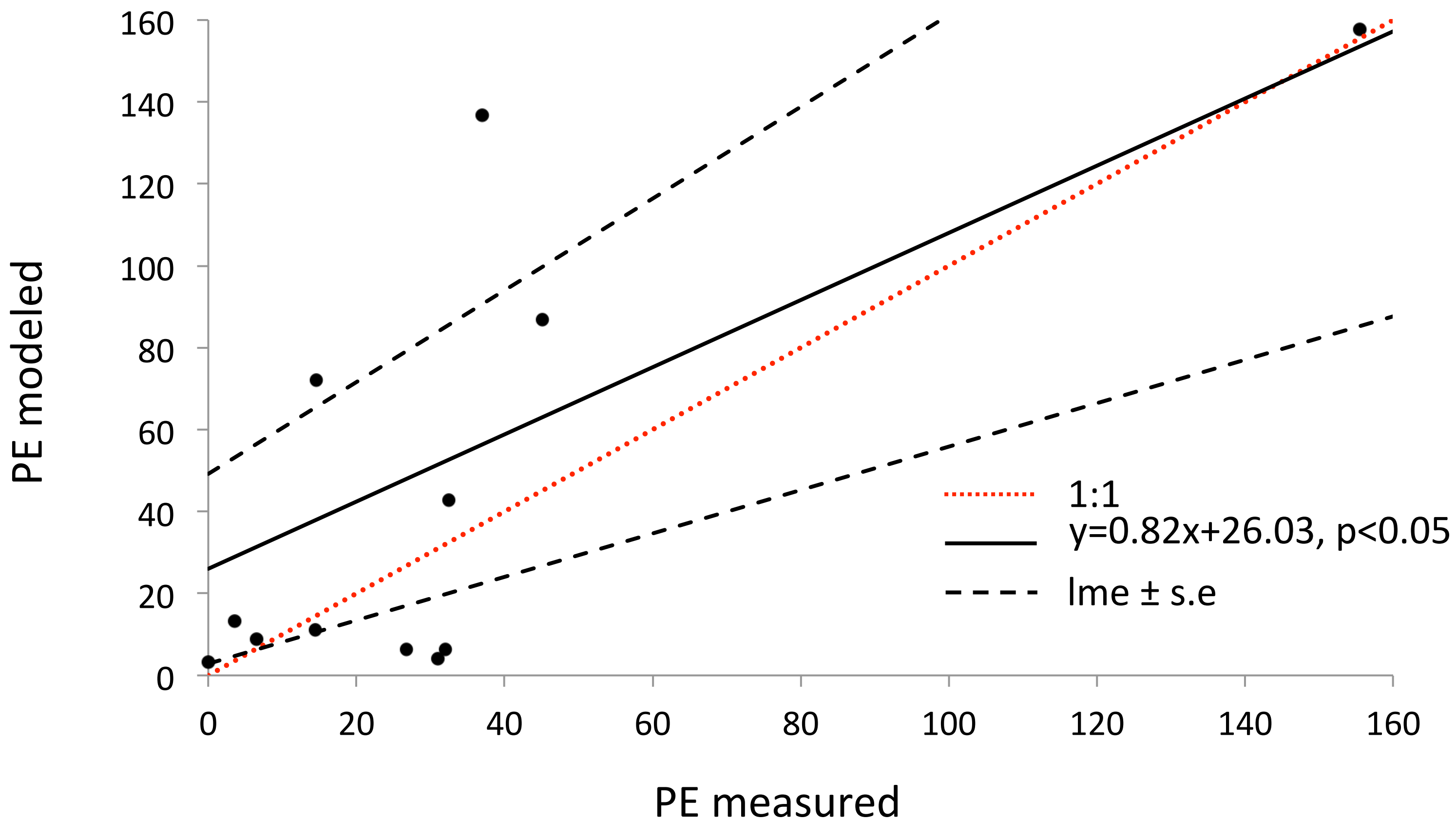
ORCHIDEE-FOM-DEP

- New formulation for soil carbon mineralization (Guenet et al., 2012, BGD)

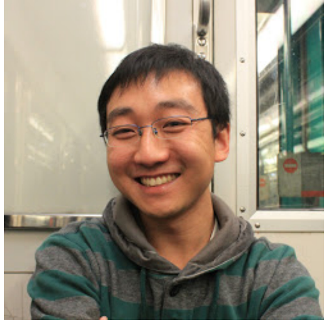
$$\mathbf{dSOC/dt = Input - k \times SOC \times (1 - exp(-c \times litter))}$$

- Parameters optimized to obtain the same equilibrium state between ORCHIDEE and ORCHIDEE-FOM-DEP.
- This new formulation is able to reproduce the Priming Effect (PE) which is the impact of the litter input on the SOC decomposition.
- PE may substantially accelerate the SOM decomposition (Kuzyakov et al. 2000).
- Evaluated against five litter manipulation experiments (no litter, control, litter doubled).

ORCHIDEE-FOM-DEP



The model reproduces the order of magnitude **BUT** the set of parameters must be improved to better reproduce the data.



Chao

Makoto

Patricia

The contribution of fires in climate change and their interactions

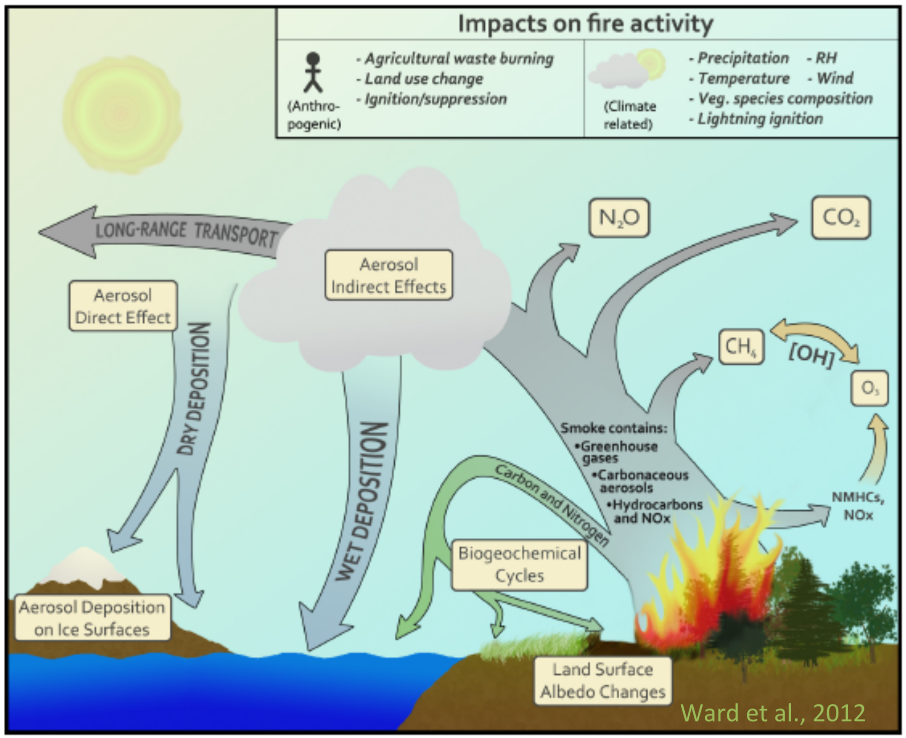
ORCHIDEE Meeting

January the ~~8th~~ 29th, 2013

Patricia Cadule, Chao Yue, Makoto Saito

On the importance of fires

Fires: a global phenomenon impacting the Earth System at various temporal and spatial scales



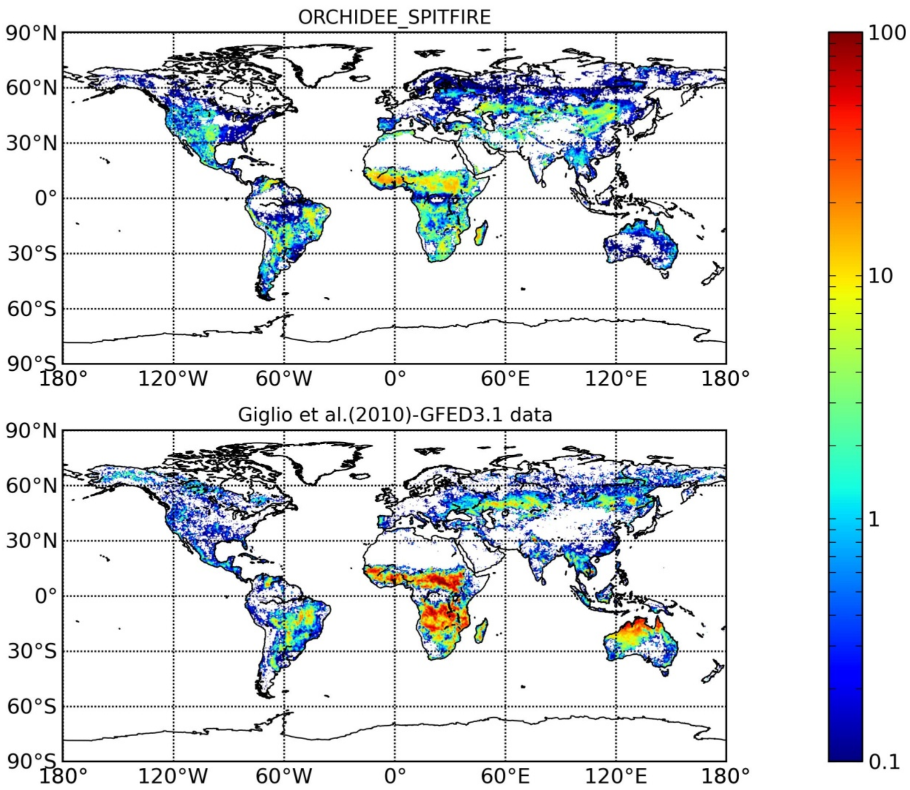
Fires produce

- Greenhouse gases (CO_2, CH_4, N_2O, …) with well known effects on climate
- Also CO, non-methane hydrocarbons, and NO_x altering the oxidation capacity of the atmosphere
- Aerosols (OC, BC) having an impact on the radiation budget

Climate and anthropogenic activity also impact fires.

Need for modelling and better understanding of fire impacts

Ongoing research at the LSCE

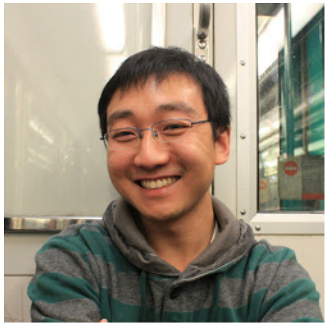


Mean annual fire burned fraction between 1997-2009

- Modelling CO_2 emissions through boreal forest fires and their sensitivity to climate change. **Chao**
- How fire regimes and climate change regulate above ground biomass in an African savanna? **Makoto**
- Fire ignition in the Mediterranean Region. **Stijn**
- Interactions between fires and the climate system. **Patricia**

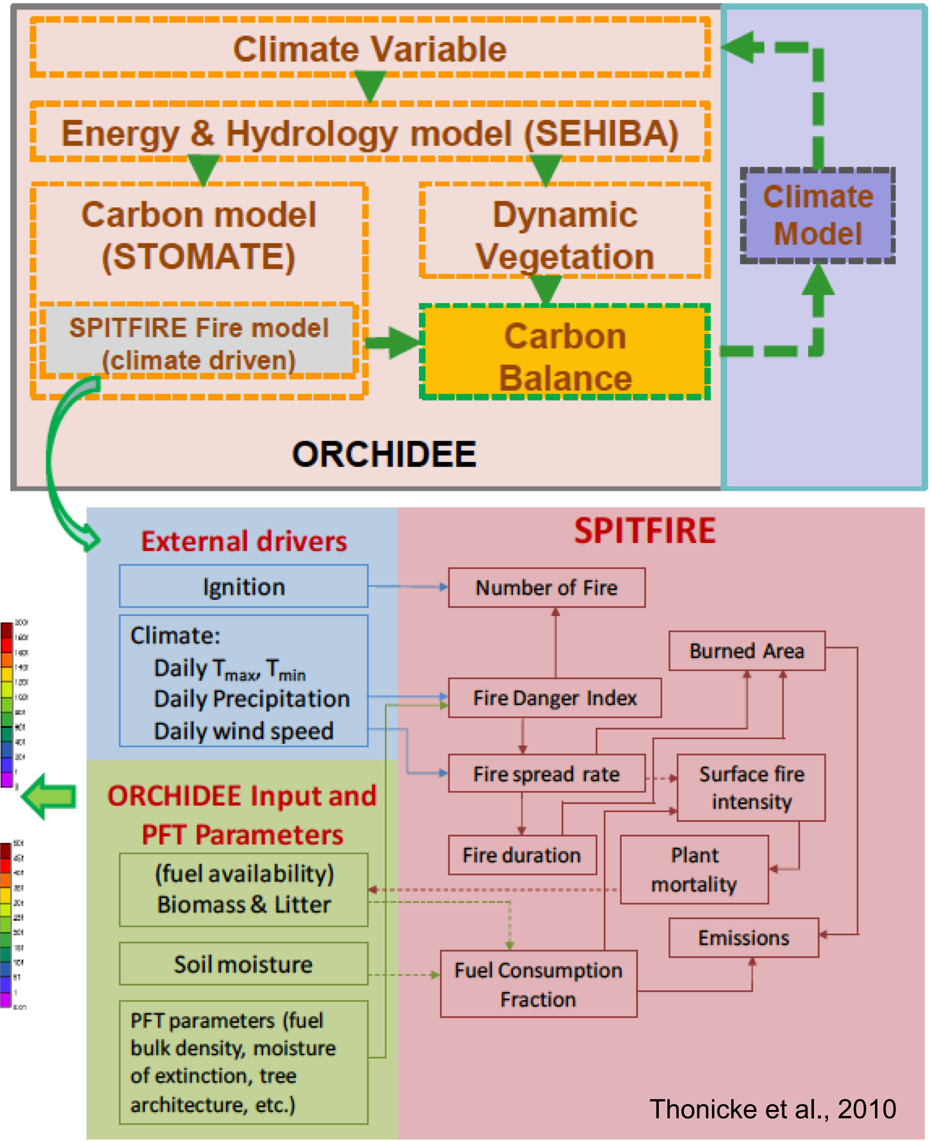
Modelling CO_2 emissions through boreal forest fires and their sensitivity to climate change

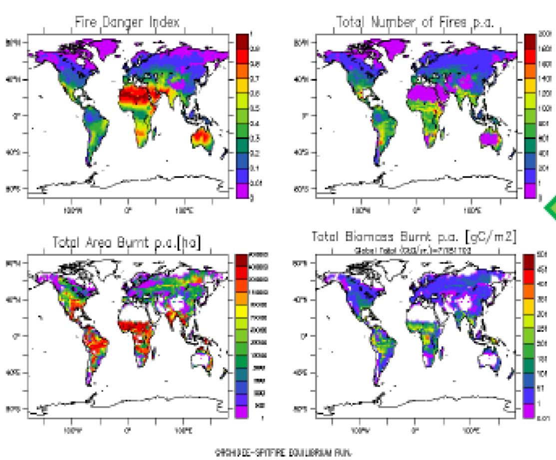
Chao Yue



Spitfire: A fire model

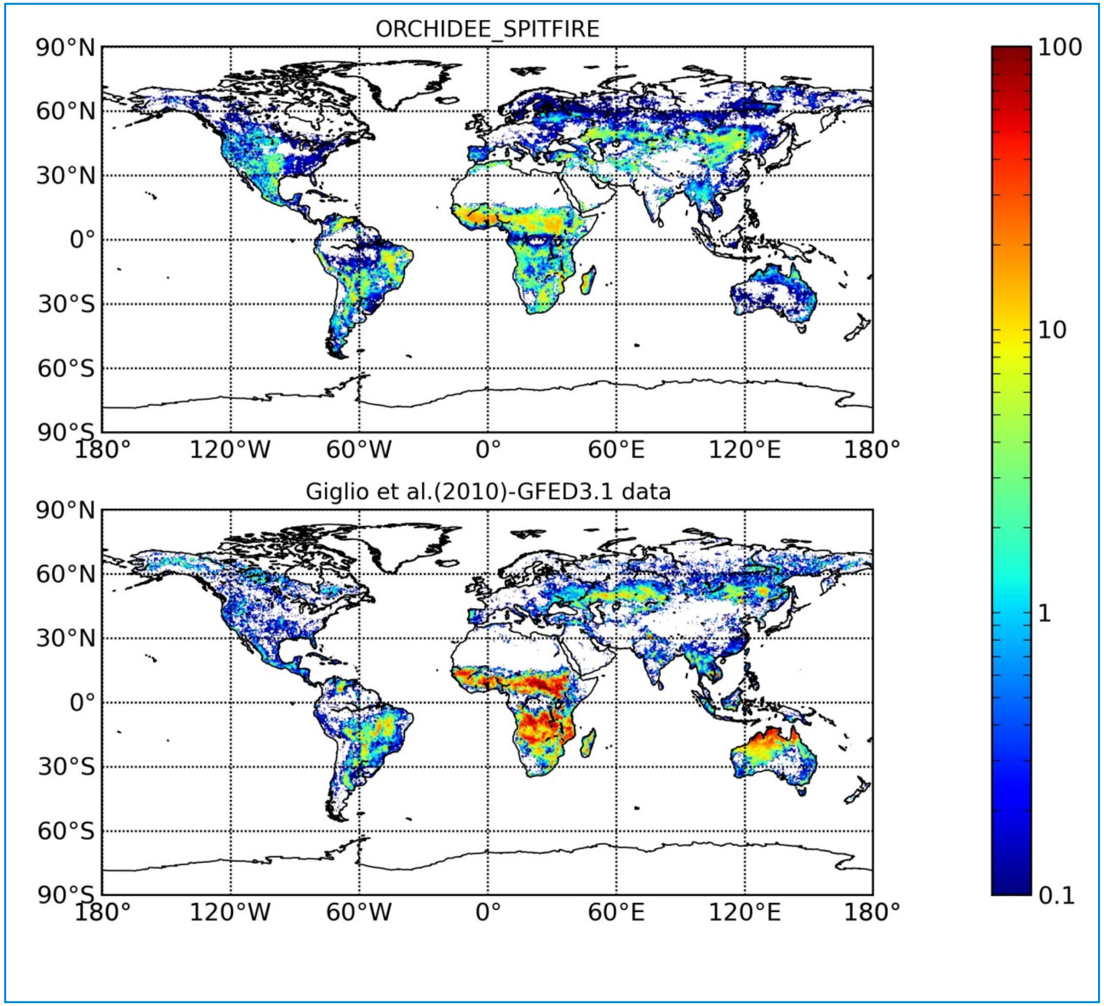
Use the ORCHIDEE-SPITFIRE model coupled with IPSL climate model to simulate future vegetation, fire and climate interactions.



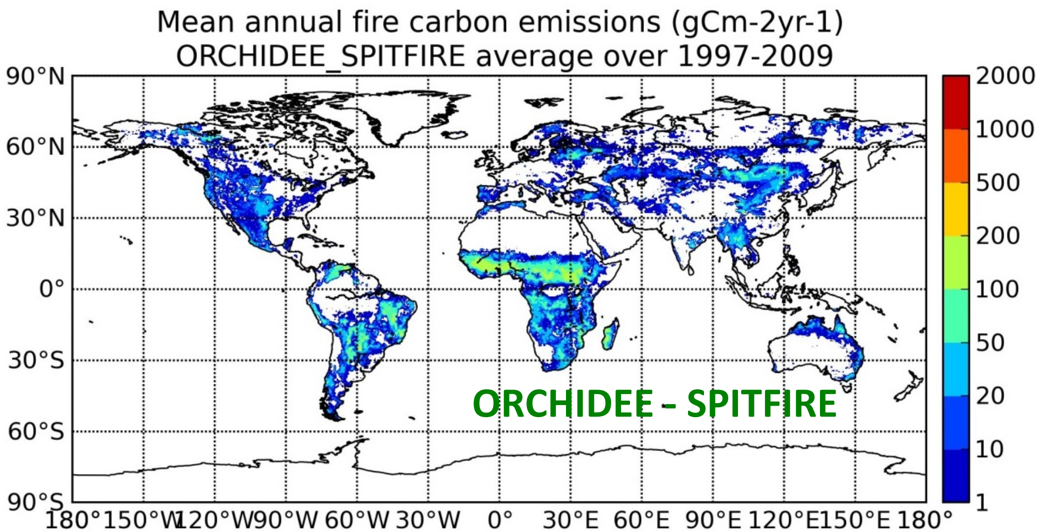


A better fire model in ORCHIDEE for everybody

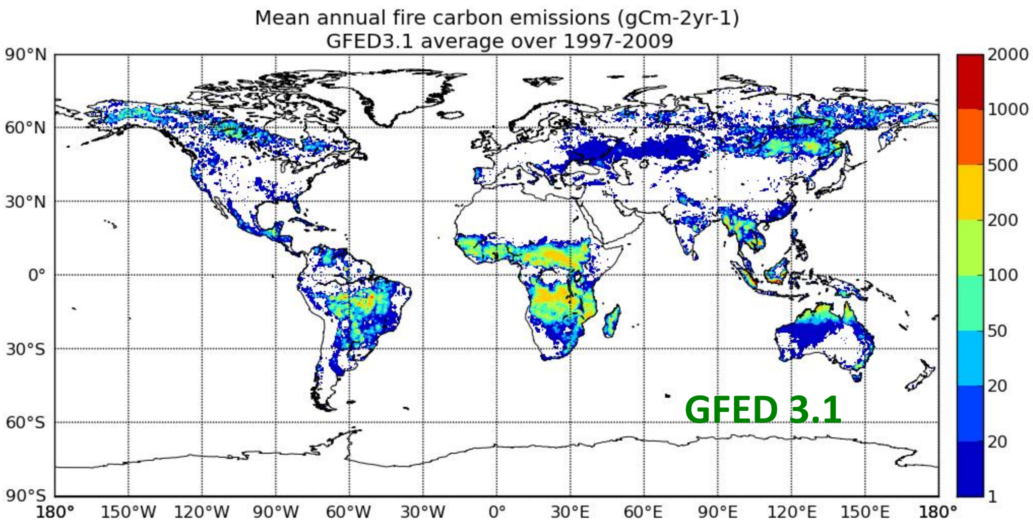
1. Fire simulated on explicit fire climate; 2. explicit ignition sources; 3. Tree mortality. 4. Easy flags to feed external BA and CF.



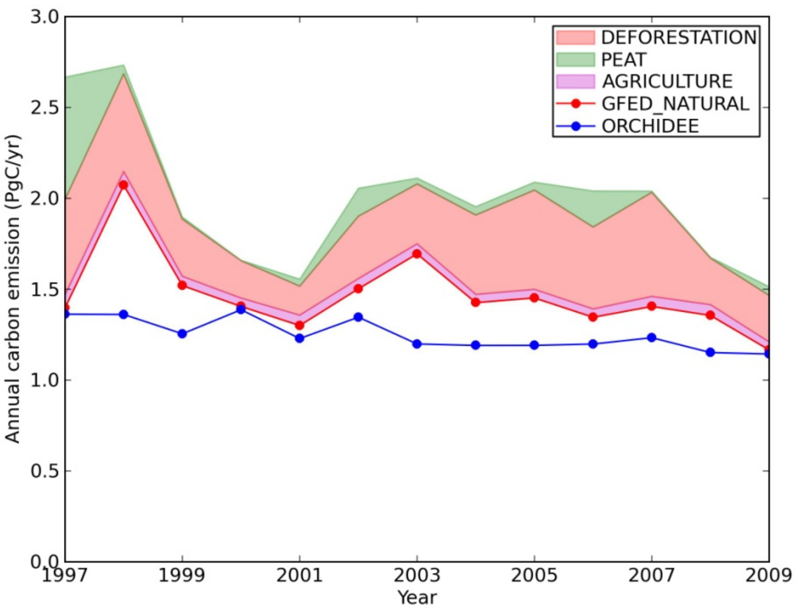
Mean annual fire burned fraction between 1997-2009



Fire carbon emission on grid area basis (gC/m2yr)



Global carbon emissions

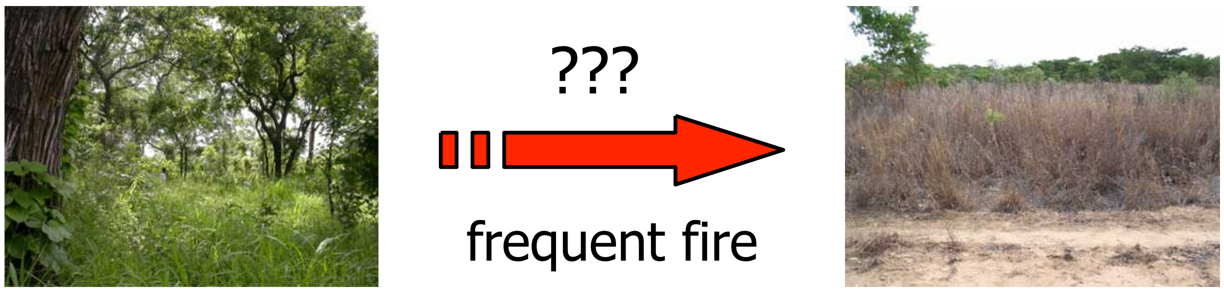


Fire in an African savanna

Makoto

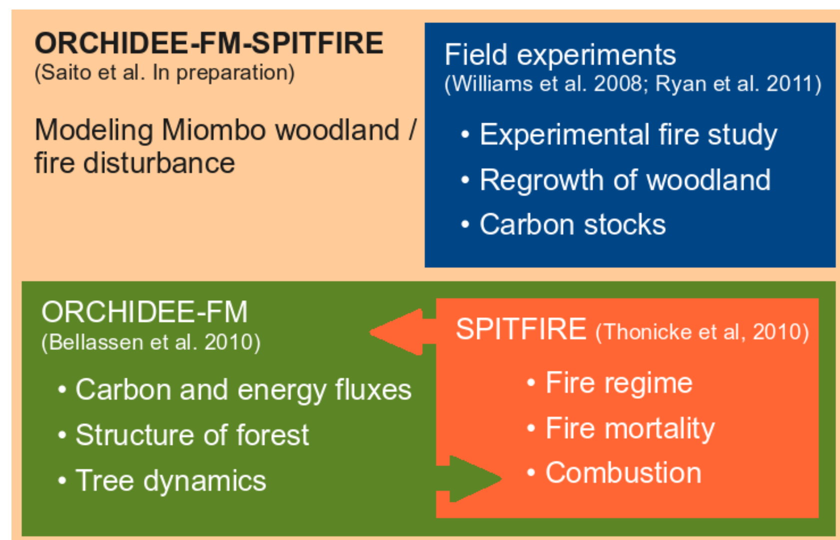
Subject: How fire regimes and climate change regulate above-ground woody biomass in an African savanna?

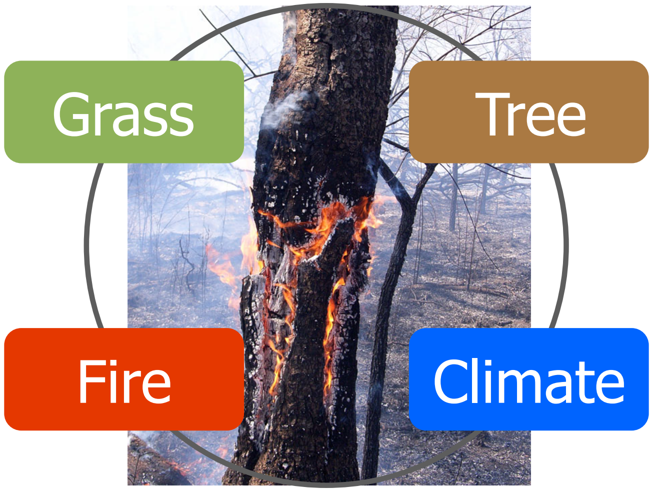
Background: Large part of African savanna has been burned annually or a few years interval for cultivation, deforestation, and fuel wood collection.



Model building:

This study coupled ORCHIDEE-FM and SPITFIRE fire regime model and modeled vegetation structure and fire mortality based on the field observations at miombo woodlands in Africa.





Key results:

- Significant effects of fire regime and climate change on above ground woody biomass.
- Demographic bottleneck in the growth of trees to mature stage.
- Less effective in fire disturbances on woody biomass in future climate.

Next steps:

Coupling with ORCHIDEE-DGVM

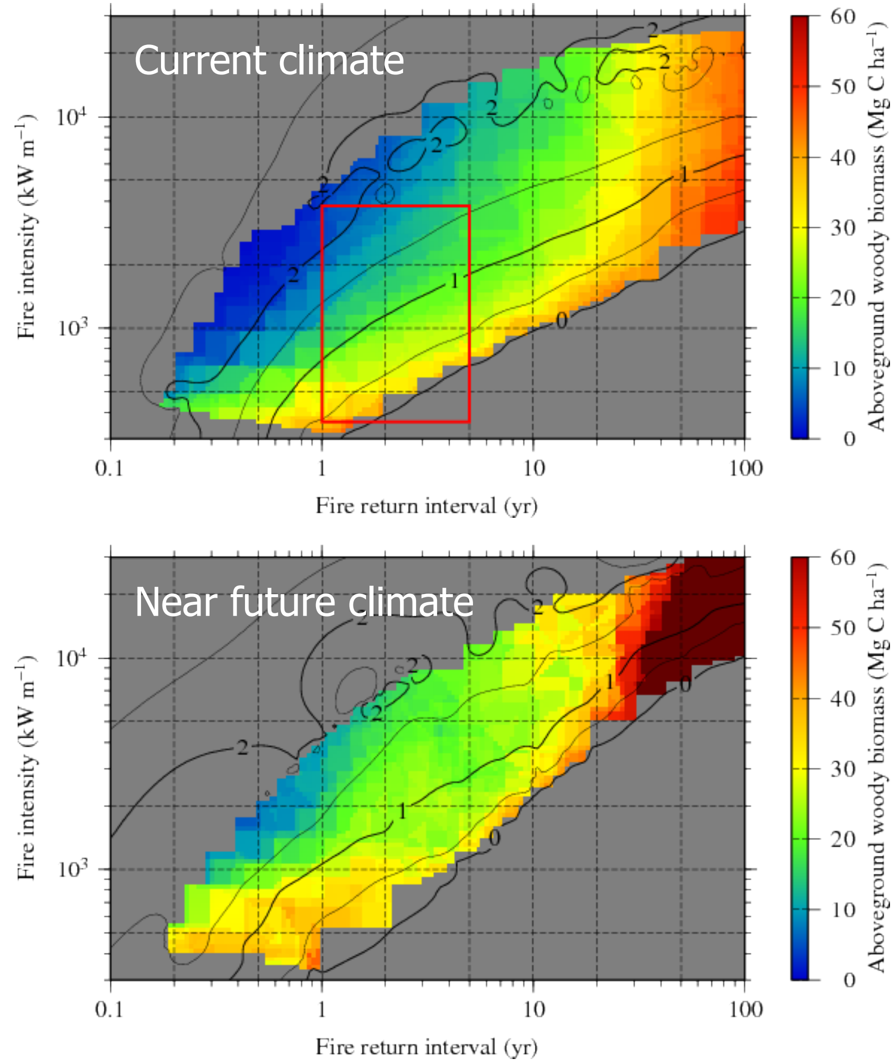


Fig. Relationships between mean fire return interval (yr) and mean fire intensity (kW m^{-1}) over 500-yr simulations under (top) current and (bottom) near future climate (2100) conditions. Mean above ground woody biomass (Mg C ha^{-1}) is shown by colors. Contours show mean annual aboveground grass biomass (Mg C ha^{-1}).