State of the art - modeling evergreen tropical forests with ORCHIDEE

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OPTIMIZATION

Verbeeck et al., JGR-Biogeosciences 2011

optimized 22 key parameters of ORCHIDEE using eddy covariance data

Goal: identify the driving factors of the seasonal variations in CO₂ flux of tropical forests

parameter values retrieved for Tapajós, performance tested at the Guyaflux and Jaru site
OPTIMIZATION

Verbeeck et al., JGR-Biogeosciences 2011

Tapajos site: maintained transpiration and GPP during dry season

soil depth (10 m) and root profile (0.1) are essential parameters

indications for leaf flush: phenology in ORCHIDEE needs to be improved

evaluation of different respiration components is needed for LBA sites
MORTALITY

N. Delbart et al., Biogeosciences 2010

mortality rate is as important as NPP and allocation

ORCHIDEE: $\text{NPP}_{\text{AGW}}$ was overestimated by 63%
biomass lost through mortality 85% was too high

new formulation of mortality based on field inventory data introduced

Black triangles: above ground woody biomass (Malhi et al., 2006). Green dots: $\text{NPP}_{\text{AGW}}$ (Malhi et al., 2004). Red diamonds: allocation fractions (Aragão et al., 2009). Blue squares: leaf and fruit allocation (Chave et al., 2010)
MORTALITY

N. Delbart et al., Biogeosciences 2010

high productivity: higher mortality rate

t_{\text{residence}} = 217 \times (\text{NPP}_{\text{AGW}})^{1.32}

improved modeling of spatial variation above ground biomass:
AMAZALERT

Raising the alert about critical feedbacks between climate and long-term land use change in the Amazon

• EU FP7 project  3 years - starts mid 2011
• Budget: 4.4 Mio €
• Coordination: Bart Kruijt
• Modeling project, with groups from EU and South-America

• Partners:  ALTERRA Netherlands, INPE Brazil, MetOffice UK, CNRS/IPSL France , VU Netherlands, EMBRAPA Brazil, UGENT Belgium, JOANNEUM RESEARCH Austria, UEDIN UK, FAN Bolivia, PIK Germany, UNIVLEEDS UK, USP Brazil, UNAL Colombia
DGVM’s + earth system models

- INLAND + BMGCS
- LPJml
- ORCHIDEE + CNRS/IPSL-CM5
- JULES-ED + HadGEM2-ES

- Intercomparison of these DGVMs is included in WP2, this links nicely with LBA-DMIP
Hans Verbeeck, ... (other participants are welcome!)

Goals:

- compare model parameter values (between/within: models, sites, PFTs)
- Compare responses based on drivers and model outputs (e.g. light response), link this to parameters
- link with model performance

Similar analysis will be done for NACP site synthesis
Status:

-list of 10 selected parameters (Vcmax, SLA, ...) is ready to be send to modelling groups

-This will be send with second model questionnaire of NACP (Kevin Schaefer)

-For each site modellers have to give the PFT used + the parameter values used for each selected parameter
VEGECLIM PROJECT

- Quantitative estimates of central African carbon balance, annual and inter annual fluxes
- Evolution of central African carbon stock: different climate change and land-use change
- Combine ORCHIDEE model results
- 10 years of SPOT satellite data
- African rainforest system – highly productive region but smaller area than Amazon
- Little ground data: remote sensing data will be assimilated
- Optimized ORCHIDEE model coupled to cellular-automata land-cover change model
model adaptations focusing on canopy greenness leaf seasonality to be included in ORCHIDEE

canopy greenness can be linked to satellite data + field inventory data on seasonal litterfall are available

hypothesis:

- canopy properties of tropical evergreen forest change by season
- seasonally changing leaf properties affect GPP and NEE
- by including seasonal leaf litterfall and canopy greenness, we can improve ORCHIDEE model results
clear correspondence with radiation

- relate to SWdown and/or SWdown history or water availability?
- there is a time shift of ±1 month between radiation and litter peaks

LittSeas – LITTERFALL SEASONALITY

K67

Guyaflux

Rainfall (mm month⁻¹)

0 200 400 600 8000

jan-02 jul-02 jan-03 jul-03 jan-04 jul-04

Rainfall (mm month⁻¹)

0 200 400 600 8000

jan-04 jul-04 jan-05 jul-05 jan-06 jul-06
decadal incoming leaf litterfall versus shortwave incoming radiation for French-Guiana
(a) no shift, (b) 10 days, (c) 20 days, (d) 30 days, (e) 40 days, (f) 50 days
PROPOSED LITTER MODELS

model 1: step function - SWdown trigger based
model 2: step function – soil moisture stress trigger based?
model *: linear relation with $SW_{down}$, leaf litterfall (LL) by decad

Considerations for model:

- based on radiation or moisture stress? – physically based
- how about day length, solar angle?
- evaluate model performance: implementation in ORCHIDEE, timing, stability, response functions flux data, avoid meaningless empirical coefficients, ..
- include history of leaves already fallen (eg. larger peak in short dry season followed by smaller peak in long dry season at Guyaflux)?
- …
LittSeas – MODEL 1
LittSeas – MODEL 1

**Start annual litterfall peak:**

\[
\begin{align*}
\text{if } & \text{SW}_\text{down} > \text{SW}_\text{down,l} \\
\text{if } & \text{SW}_\text{down}’ > 0 \\
\text{if } & \text{SW}_\text{down,sum} > \text{SW}_\text{down,sum,l}
\end{align*}
\]

\( t = t_{\text{start}} \)

- **SW\(_{\text{down,l}}\):** radiation threshold above which leaf litterfall can peak (210 W.m\(^{-2}\) for Guyaflux)
- **SW\(_{\text{down}’}\):** first order derivative of **SW\(_{\text{down}}\)**
- **SW\(_{\text{down,sum,l}}\):** radiation sum above which leaf litter can peak (210 W.m\(^{-2}\) for Guyaflux)

**Stop annual litterfall peak:**

\[
\begin{align*}
\text{if } & \text{SW}_{\text{down}’} = \text{min} \\
\text{OR if } & t_{\text{peak}} > t_{\text{max}}
\end{align*}
\]

\( t = t_{\text{stop}} \)

- **t\(_{\text{max}}\):** maximum number of days of leaf litter peak
decadal leaf litterfall (top data and model 1) and shortwave incoming (bottom) radiation for Guyaflux 2004-2009
Start annual litterfall peak:

\[ t = t_{\text{start}} \]

if \[ |\text{WMS}'| = \text{max and WMS}' < 0 \]

OR if \[ t > t_{\text{max}} \]

...?
LittSeas –MODEL *

lineair relation with $SW_{down}$, leaf litterfall (LL) by decad:

$$LL[dec] = LL_{\text{min}} + (LL_{\text{max}} - LL_{\text{min}}) \left( \frac{SW_{down, \text{avg}[dec + 3]} - SW_{down, \text{min}}}{SW_{down, \text{max}} - SW_{down, \text{min}}} \right)$$

decadal leaf litterfall (top data and model 1) and shortwave incoming (bottom) radiation for Guyaflux 2004-2006

time shift modeling impossible – model 30/40 days in future
leaf litter inventory data are reported in literature for various locations (Brasil, Ivory Coast, French-Guyana, Venezuela, Peru, DRC)

- ORCHIDEE: $v_{cmax}$ changes with leaf age – relative leaf efficiency $e_{rel}$ versus relative leaf age $a_{rel}$
eddy flux derived GPP is estimated from NEE measurements

GPP Reichstein $u^*$ method ($GPP_f$) based on night-time fluxes
some difficulties:
- eddy flux only valid under turbulent atmospheric conditions
- temperature based formula – no soil moisture effect included
- tropics has small daily temperature amplitude

alternative: light use efficiency based estimates of GPP (HBLR)?
LittSeas – litter model

3rd order relationship between cumulative leaf litterfall and cumulative Sw_{\text{down}} by decad (Guyafux):

\begin{align*}
y &= -2 \times 10^{-9} x^3 + 1 \times 10^{-5} x^2 + 0.006 x + 0.532 \\
R^2 &= 0.9987
\end{align*}

Figure 1: 2004 GFG black=model; green=data

Figure 2: 2005 GFG black=model; green=data