LBA-DMIP meeting Tucson, AZ 18-20 April 2011

#### State of the art - modeling evergreen tropical forests with ORCHIDEE

De Weirdt Marjolein UGent, LSCE

# 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  $CO_2$  flux of tropical forests

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





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: NPP<sub>AGW</sub> 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:  $NPP_{AGW}$  (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

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

# MODEL PARAMETER COMPARISON

- 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 landcover change model

## PHENOLOGY TROPICAL FOREST

- 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

## LittSeas – LITTERFALL SEASONALITY

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 neaks



#### LittSeas – LITTERFALL SEASONALITY



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 \*: lineair relation with SW<sub>down</sub>, 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)?

**D** ...







- : radiation threshold above which leaf litterfall can peak (210 W.m<sup>-2</sup> for Guyaflux)
- : first order derivative of SW<sub>down</sub>
- , : radiation sum above which leaf litter can peak (210 W.m<sup>-2</sup> for Guyaflux)



 $t_{max}$  : 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



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

 $LL[dec] = LL\min + (LL\max - LL\min)(\frac{SWdown, avg[dec + 3] - SWdown, \min}{SWdown, \max - SWdown, \min})$ 



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

#### LittSeas

- leaf litter inventory data are reported in literature for various locations (Brasil, Ivory Coast, French-Guyana, Venezuela, Peru, DRC)
- ORCHIDEE: vcmax changes with leaf age relative leaf efficiency e<sub>rel</sub> versus relative leaf age a<sub>rel</sub>



# MODEL VALIDATION – GPP

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)?



#### SEASONAL PATTERNS



#### SEASONAL PATTERNS



#### LittSeas – litter model

3rd order relationship between cumulative leaf litterfall and cumulative Sw<sub>down</sub> by decad (Guyaflux):



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

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

