Modelling of Forest Processes for Climate Change Impact Studies

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1. Introduction:

Purpose of Forest Growth Models

Environment

↓

Model

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Biosphere Change & Indicators for Management
1. Introduction:

Purpose of Land-Surface-Models (LSM's) - 1D! -
1. Introduction:

Purpose of Land-Surface-Models (LSM’s)

- Reflected radiation
- Longwave radiation
- Latent Heat flux (Evapotranspiration)
- Sensible Heat flux
- Runoff
- Drainage
- Momentum Wind Speed
- J F M A M J J A S O N D
- Conductivity
- Root Depth
- Albedo
- Height
- LAI
2. Objective: Improvement of common LSM’s

AIMS

1) Improve seasonal dynamics of LAI and ALBEDO
2) Improve initialization and long-term dynamics of HEIGHT
   → Increased spatial resolution (regional climate models)
   → Increased length of simulation runs
3) Include carbon cycle (seasonal $CO_2$ (and $CH_4$) dynamics)
   → Greenhouse effect (global climate models)
4) Include nitrogen cycle ($N_2O$ and $NOx$ emission)
   → Ozone formation (regional air chemistry models)
   → Greenhouse effect (global climate models)
5) Include emission of other reactive trace gases (VOC)
   → Ozone formation (regional air chemistry models)
2. Objective: Improvement of common LSM's

BIOSPHERE PROCESS GROUPS

- Veg. Physiology
- Microclimate
- Water Balance
- Veg. Structure
- Soil Processes
- Canopy Air Chemistry

Water Balance
Air Chemistry
Physiol. Microclimate

Vegetation Structure
Gas Exchange
C/N Soil
3. Method: MoBiLE FRAMEWORK
(possibly used later on as a LSM)

- Daily weather data
- Generated sub-daily weather
- Sub-daily input
- Sub-daily output
- Daily sums or means
- Daily output
- Annual output

Initials

Subdaily Loop

- Air Chemistry
- Micro Climate
- Physiology
- Water Cycle
- Soil Chemistry
- Vegetation structure
3. Method: MoBiLE FRAMEWORK

Air Chemistry
- acCACHE

Micro Climate
- mcECM
- mcCANAOK
- mcDNDC
- mcOSU

Physiology
- phFARQUHAR
- phGUENTHER
- phNIINEMETS
- phBIM

Water Cycle
- wcCANAOK
- wcOSU
- wcDNDC

Soil Chemistry
- scDNDC2
- scMICNIT

Veg. structure

Sub-Daily

Daily
- phPSIM
- phMYCOPHON
- phPNET
- phDNDC
- wcDNDC
- wcBROOK90
- wcQUERCUS
- scDNDC
- scSAFE
- vsTREEDYN

Grote et al., EMS, submitted
3. Method: MoBiLE FRAMEWORK

ADVANTAGES

• Flexible selection of biosphere process-groups according to aims

• Flexible selection of models within each process group

• Simple introduction of new models or model versions (distributed workload)

• Simulations with different model combinations based on the same boundary conditions (model comparison)
4. Simulation Examples

A) Spruce Forest (Höglwald, South Germany)

- Initialization of height and DBH from inventory and soil survey
- Input is daily climate from 1982-2004
- Generation of hourly climate data

- Micrometeorology: ECM (empirical distribution of temperature and radiation in the canopy)
- Physiology: Farquhar + PSIM (process-based photosynthesis, allocation, and seneszence)
- Soil Chemistry: DNDC (process-based mineralization, nitrification and denitrification)
- Watercycle: DNDC (sophisticated bucket approach)
4. Simulation Examples

A) Spruce Forest (Höglwald, South Germany)
4. Simulation Examples

A) Spruce Forest (Höglwald, South Germany)

- With additional vegetation structure model: modified TREEDYN
4. Simulation Examples

B) Holm oak forest (Puechabon, South France)

- Initialization of height and DBH from inventory and soil survey
- Input is daily climate from 1983-2005
- Generation of hourly climate data
4. Simulation Examples

B) Holm oak forest (Puechabon, South France)

![Graph showing monoterpene emission over time with labels for LAI, RootDepth, DroughtStress, and Climate Variation.](image)
4. Simulation Examples

B) Holm oak forest (Puechabon, South France)

• With additional vegetation structure model: modified TREEDYN

![Graph showing number and diameter changes over time for Holm oak forest](image)
4. Simulation Examples

C) Eucalypt plantation (Victoria, South Australia)

- Initialization with standard seedling dimensions
- Input is daily climate from 1997-2005

- Micrometeorology: ECM (empirical distribution of temperature and radiation in the canopy)
- Physiology: PNET (process-based photosynthesis, allocation, and senescence)
- Water cycle: DNDC (sophisticated bucket approach)
- Soil chemistry: DNDC (process-based C- and N balance)
4. Simulation Examples

C) Eucalypt plantation (Victoria, South Australia)

**Evaporation**

- transp
- evacep
- evasoil

+ LAI
+ Drought Stress
+ Nutrient Stress
+ RootDepth

Climate Variation

Day (1997-2005)
4. Simulation Examples

C) Eucalypt plantation (Victoria, South Australia)

- With additional vegetation structure model: modified TREEDYN

![Graphs showing various data points and trends related to the Eucalypt plantation.]

Miehle et al., EJFR, submitted
5. Outlook

Evolving from 1D to regional:

• Ongoing biosphere evaluation (various ecosystems)
• Species specific regional application (inventories)
• Coupling with regional air chemistry models (e.g. air quality)