

# The ORCHIDEE land surface model.

## Inclusion of high-latitude processes and studies of the carbon cycle

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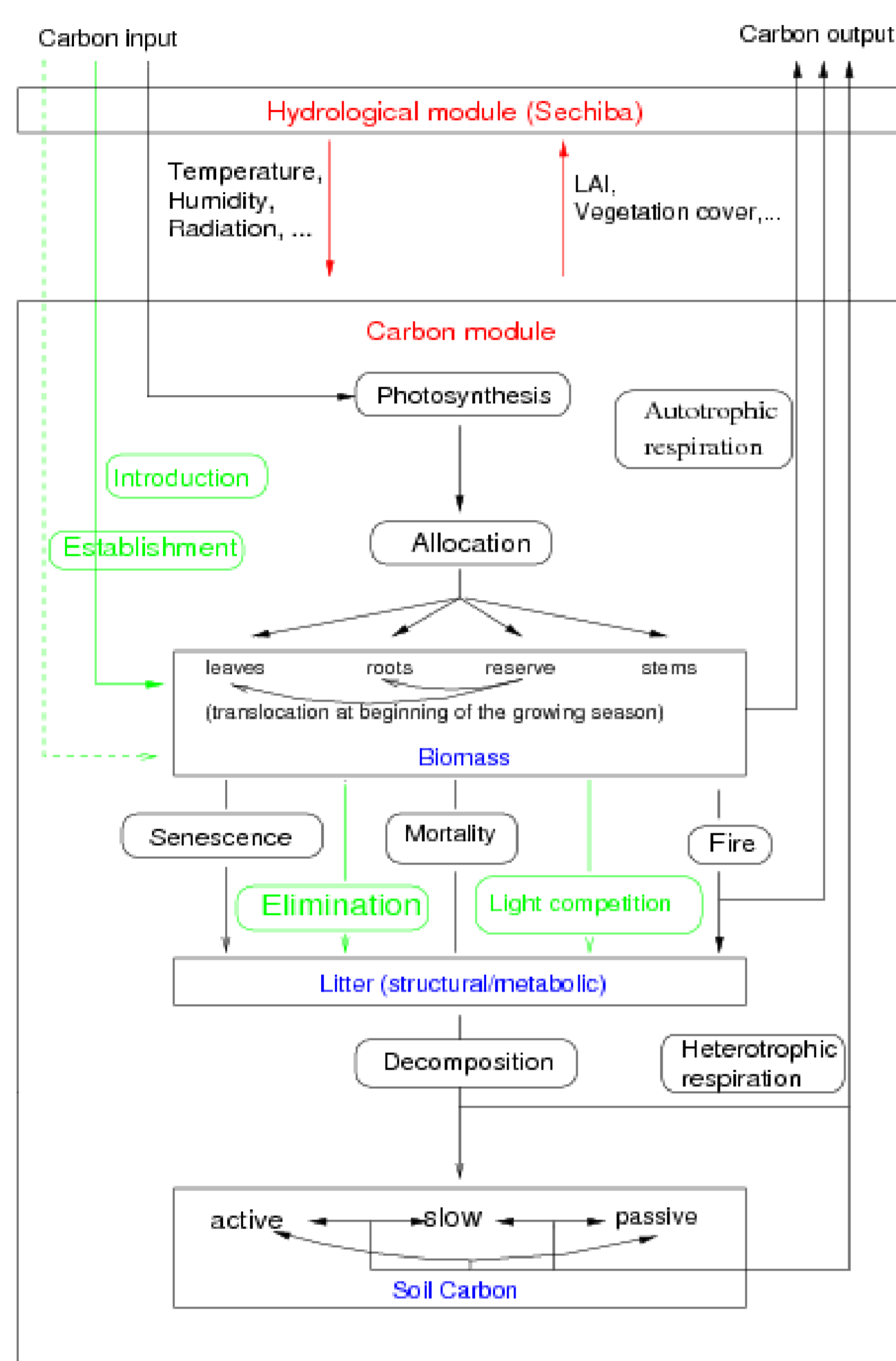
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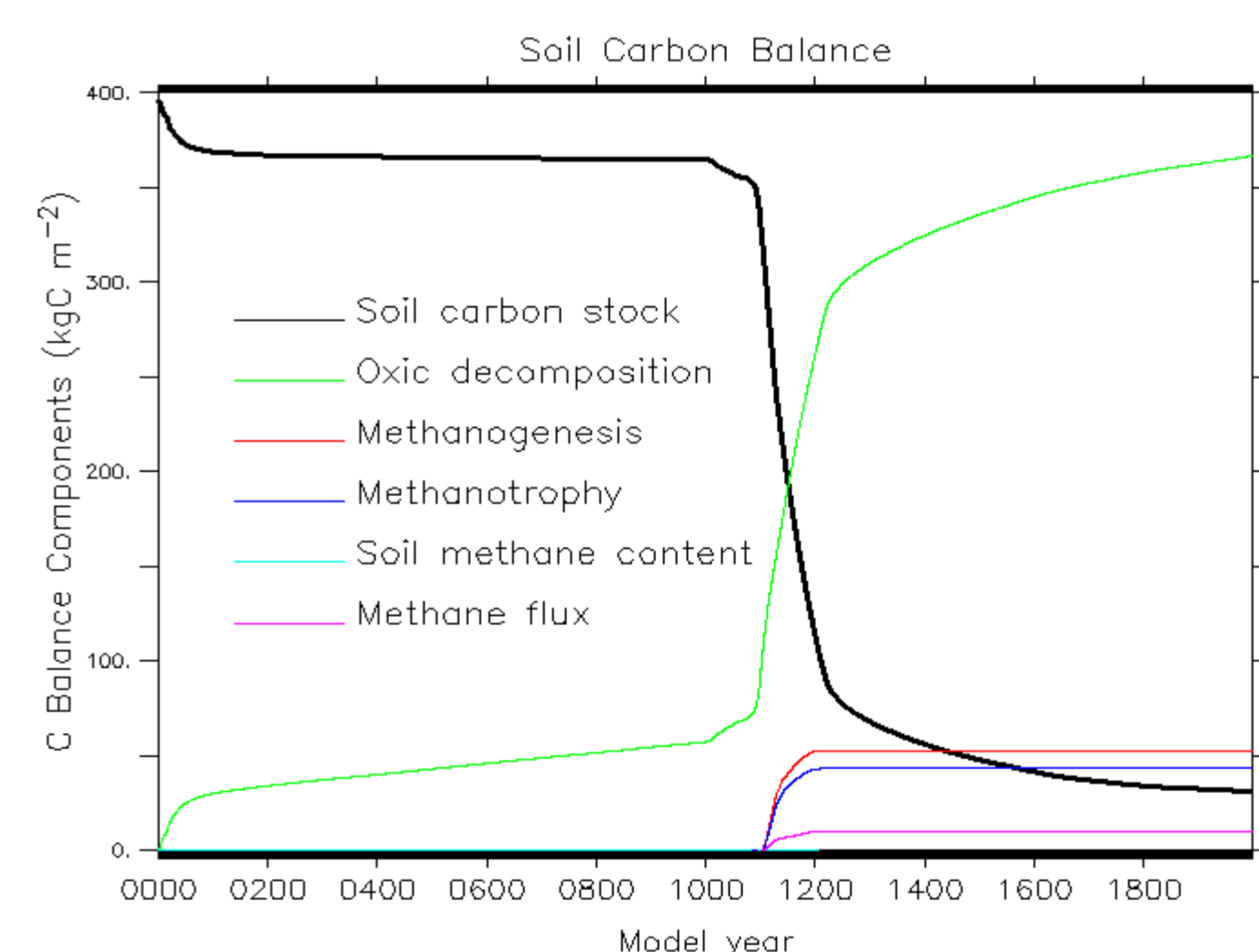
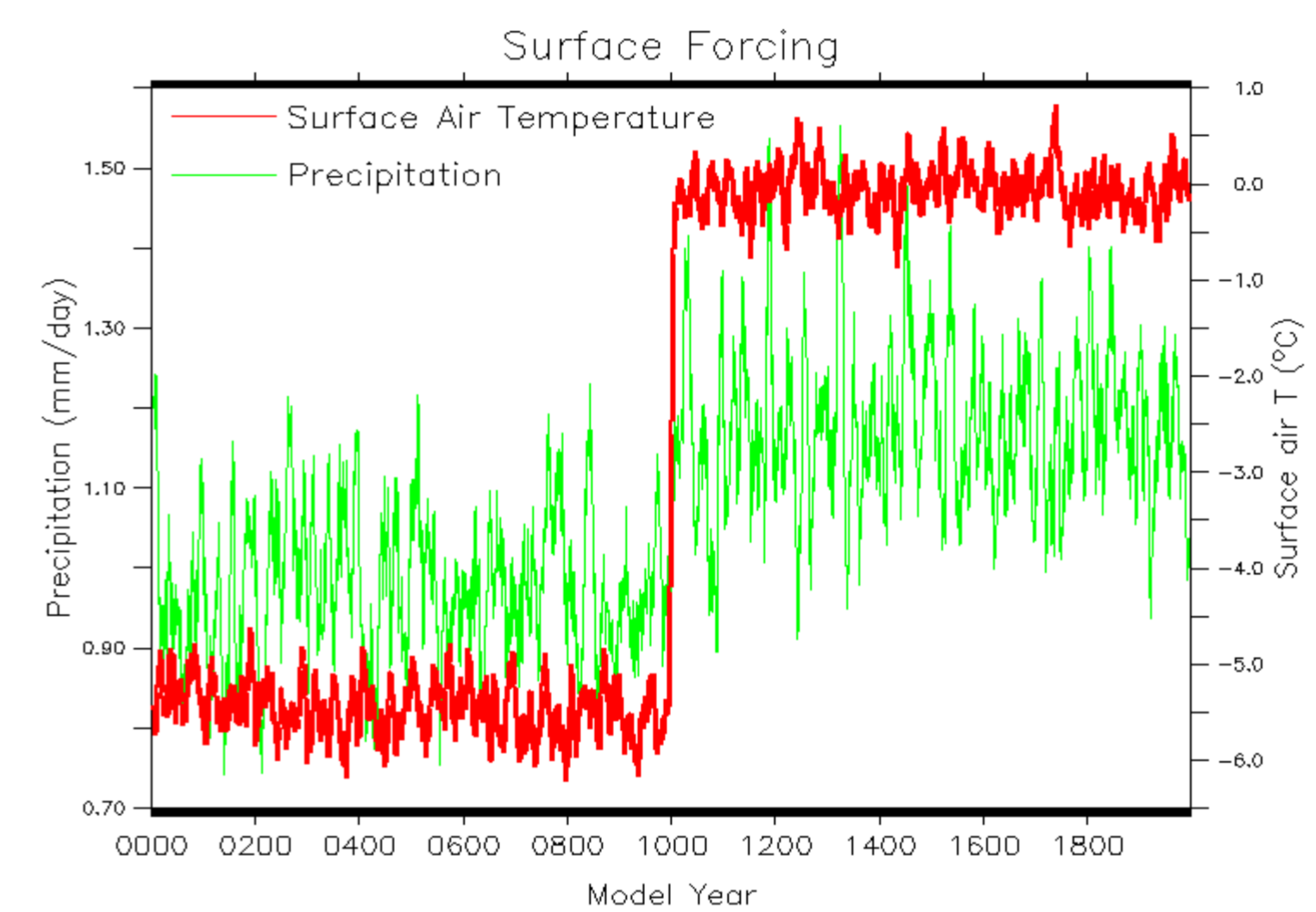
### The model

- General description and validation: Krinner et al., Glob Biogeochem Cyc 2005
- Part of the IPSL-CM4 Coupled Earth System Model (atmospheric and oceanic general circulation models), used for IPCC exercises
- Hydrology: Sechiba (Ducoudré-de Noblet et al., J Clim 1993, de Rosnay et al., J Geophys Res 2002)
- Includes LPJ (Sitch et al., Glob Ch Biol 2003) vegetation dynamics parameterizations
- Carbon dynamics and intermediate time scale processes (phenology, allocation, etc.): Krinner et al., Glob Biogeochem Cyc 2005



### Application 2. Studies of the boreal soil carbon stock

- 25% of the total world soil carbon pool (375 GtC) in the permafrost and the seasonally-thawed soil layer; estimate for upper meters only
- Probably much more. Example Yedoma Ice, Eastern Siberia: 400 GtC (Zimov et al., Science 1997)
- **Development of a soil model** including
  - Multi-level heat conduction and freezing/thawing
  - Hydrology
  - Soil respiration
  - Methanogenesis
  - Methanotrophy
  - Diffusion of O<sub>2</sub> and CH<sub>4</sub>
  - Transfer of gases due to pressure difference
  - Methane ebullition
- (Poutou et al., Clim Dyn 2003, Khvorostiyov et al., Tellus, submitted)
- **Idealized case study:** Step-wise warming in permafrost soil
- **Results** (Khvorostiyov et al., Tellus, submitted):
  - Positive feedback due to microbial heating
  - Methane processes important even when oxydation in the upper soil level occurs



### Application 1. Glacial dust deposition and ice sheet mass balances

#### Background

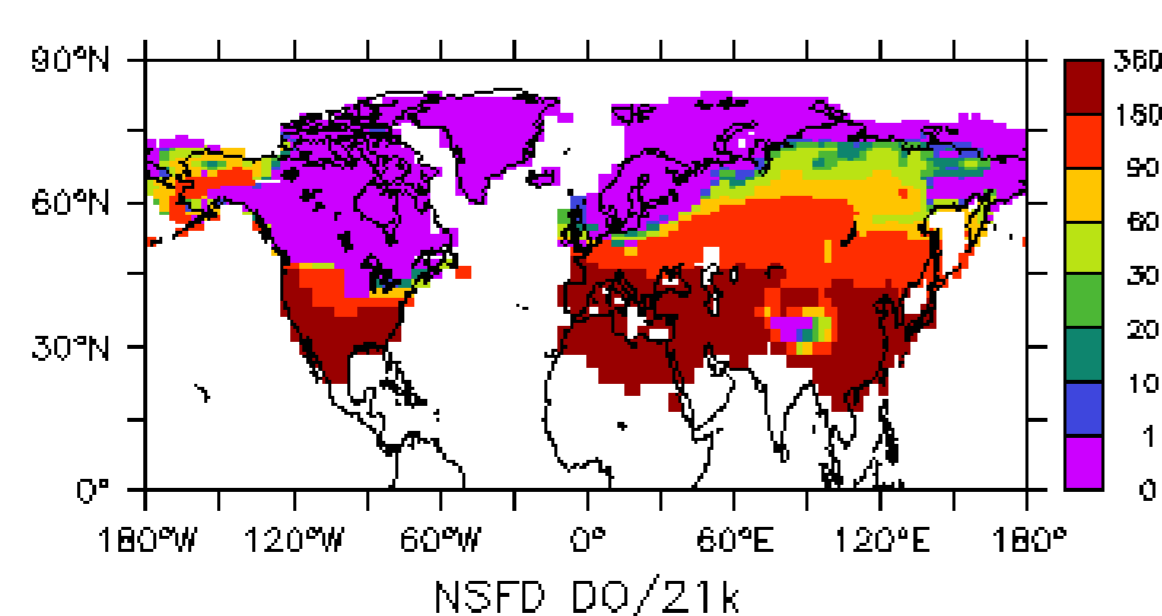
- Glacial dust deposition very high close to the major dust sources: Asian deserts
- No ice sheets present in Asia during the Last Glacial Maximum (21 kyr BP), while ice sheets existed in Europe and North America
- Possible link: dust deposition on snow decreases albedo, could increase summer melt and prevent ice sheets from growing

#### Test

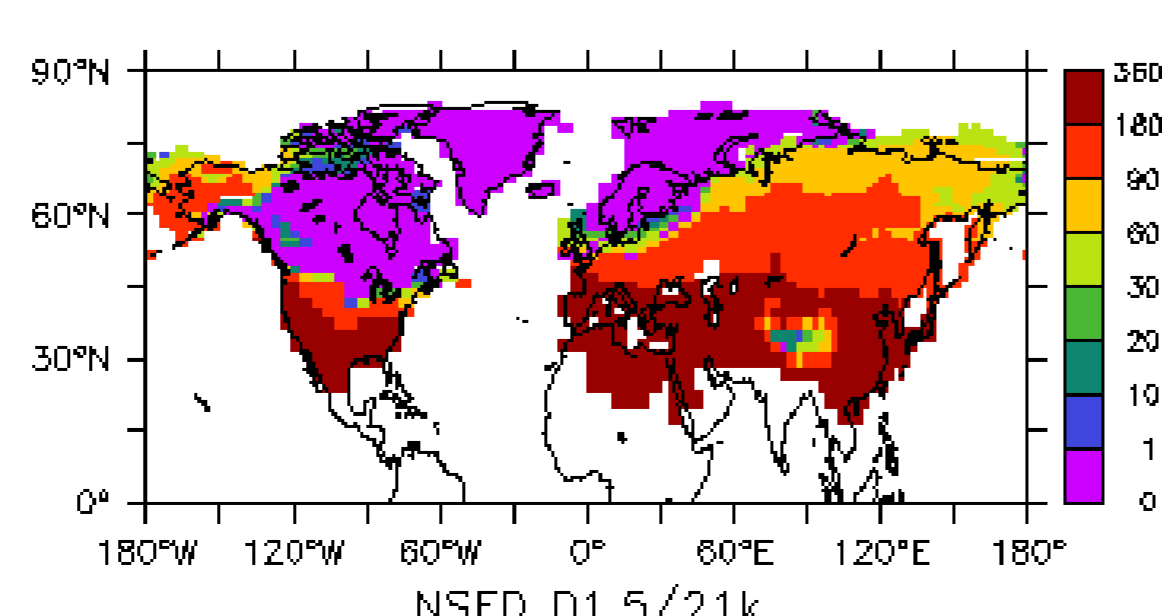
- Use IPSL atmospheric general circulation model coupled to ORCHIDEE; impact of dust on snow albedo taken into account in ORCHIDEE.
- Last Glacial Maximum simulations with and without prescribed dust deposition
- Assess impact on simulated permanent snow cover on (prescribed) ice-free regions

#### Results

- Dust deposition indeed increases summer melt at the LGM significantly and prevents ice sheets from growing in Northern Asia. Important rôle in glacial climate dynamics (Krinner et al., Clim Dyn, submitted).



Simulated number of snow-free days at the LGM without dust deposition on snow (above) and with snow deposition (below). Zero snow-free days means that ice sheet inception occurs. Without dust deposition on snow, the model simulates wide-spread ice sheet inception in glacial northern Asia, while no ice sheets were present in this region at that time.



### Future model developments

(French national programmes ACI MC<sup>2</sup> and C<sup>3</sup>, EC RTN Greencycles)

- Improved snow model
- Snow albedo including pollution and interactions with vegetation
- Soil freezing with impact on hydrology
- Lakes and wetlands (Krinner, J Geophys Res 2003; Krinner et al., Nature 2004)
- Introduction of specific high-latitude plant functional types (based on BIOME4 ?)
- Nitrogen Cycle

### Future studies of the boreal soil carbon stock

(French national programme ANR GOBAC)

- Realistic forcing for the 20<sup>th</sup> and 21<sup>st</sup> centuries (from IPSL-CM4 coupled climate model)
- Whole Eurasian region, or whole circumpolar area
- Glacial-Interglacial climate transitions
- Interactions with vegetation changes
- Wetland dynamics, CH<sub>4</sub> emissions