

Baltex 2008: Utility of Regional Climate Models

# Accounting for terrestrial ecosystem feedbacks in a regional climate model

Ben Smith

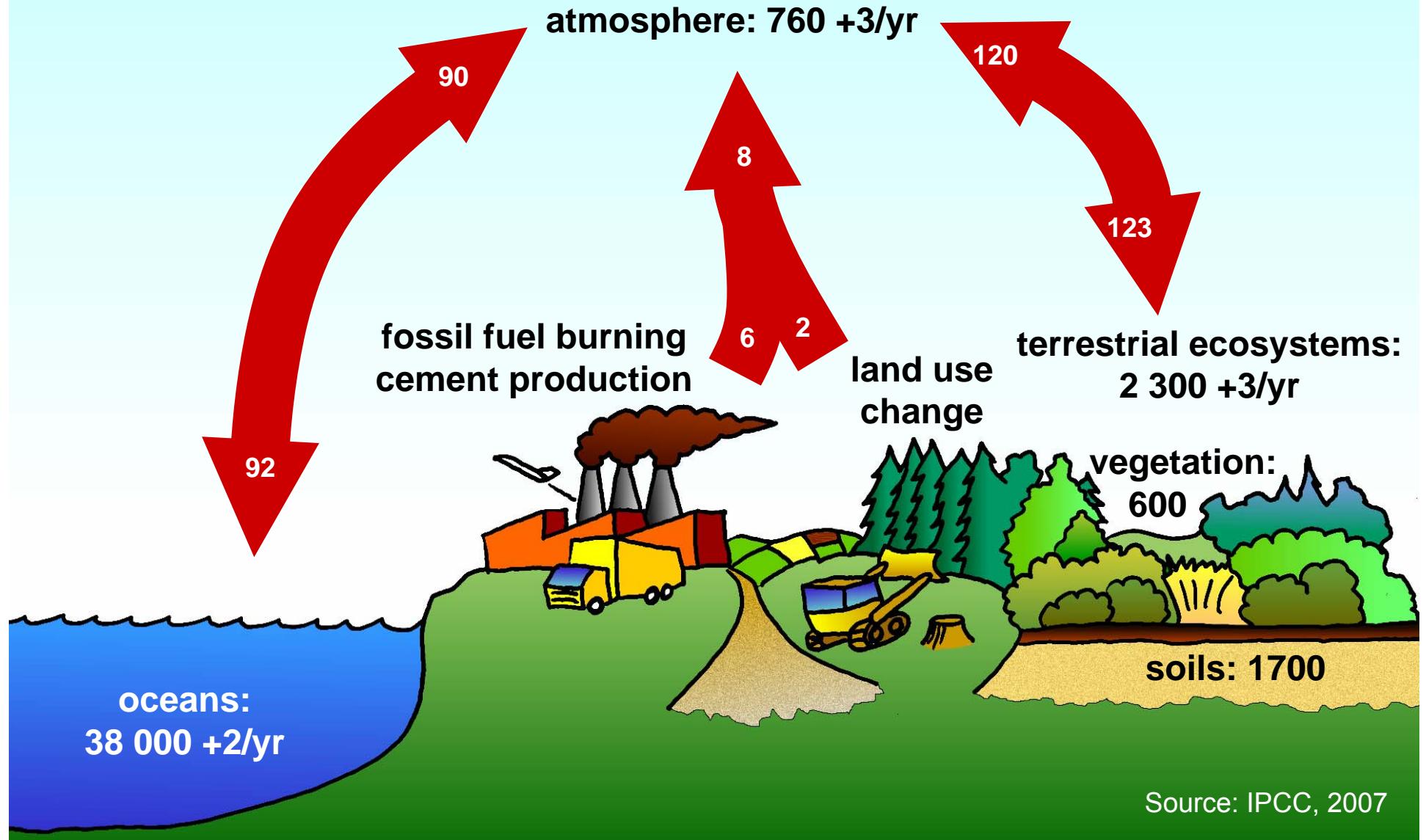
Geobiosphere Science Centre,  
Lund University, Sweden

## Credits:

Patrick Samuelsson, Ulf Hansson, Rossby Centre SMHI

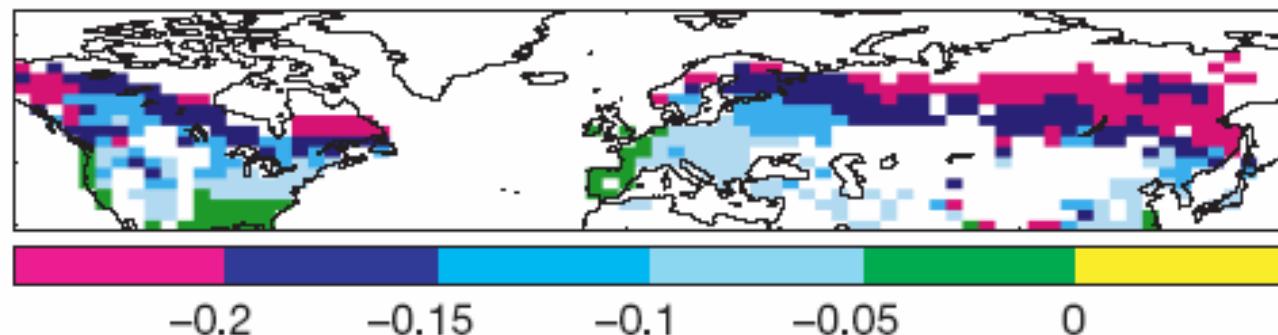
Anna Wramneby, Lund University

## Global carbon cycle mean stocks and fluxes for 1990s (Gt C)

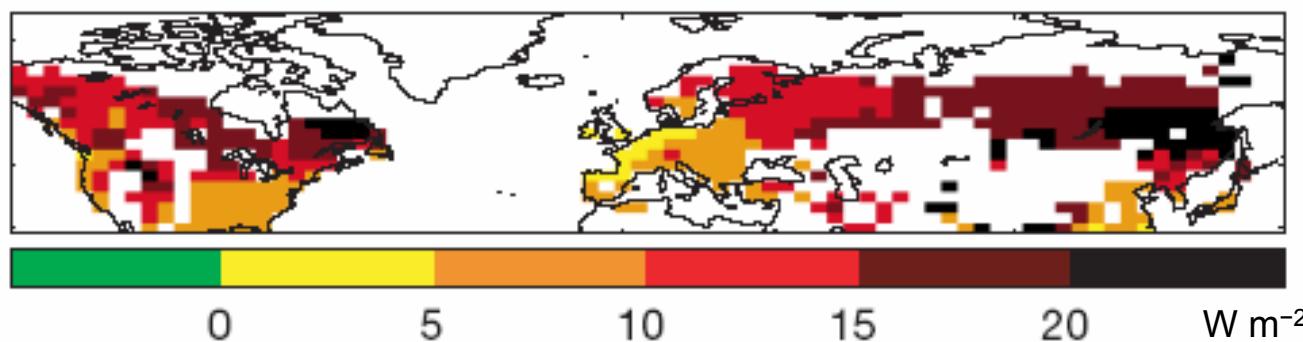


## Albedo change could offset carbon sequestration as forests expand at high northern latitudes\*

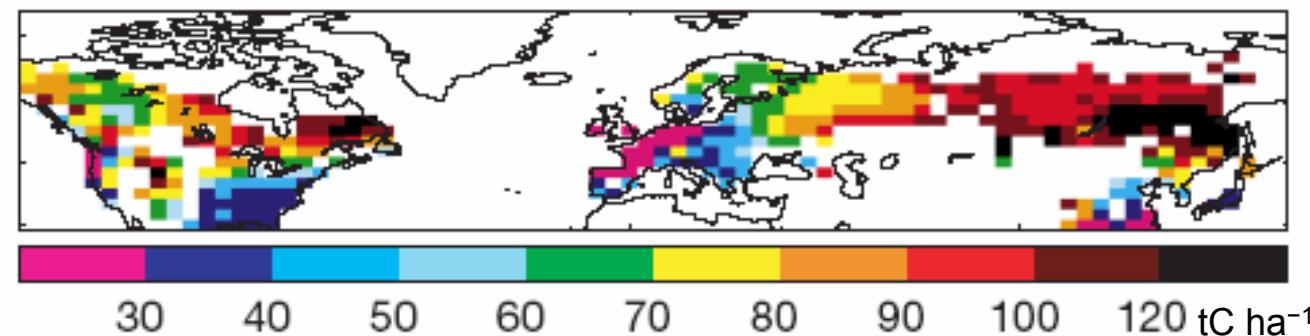
Albedo change



Radiation forcing due to albedo change

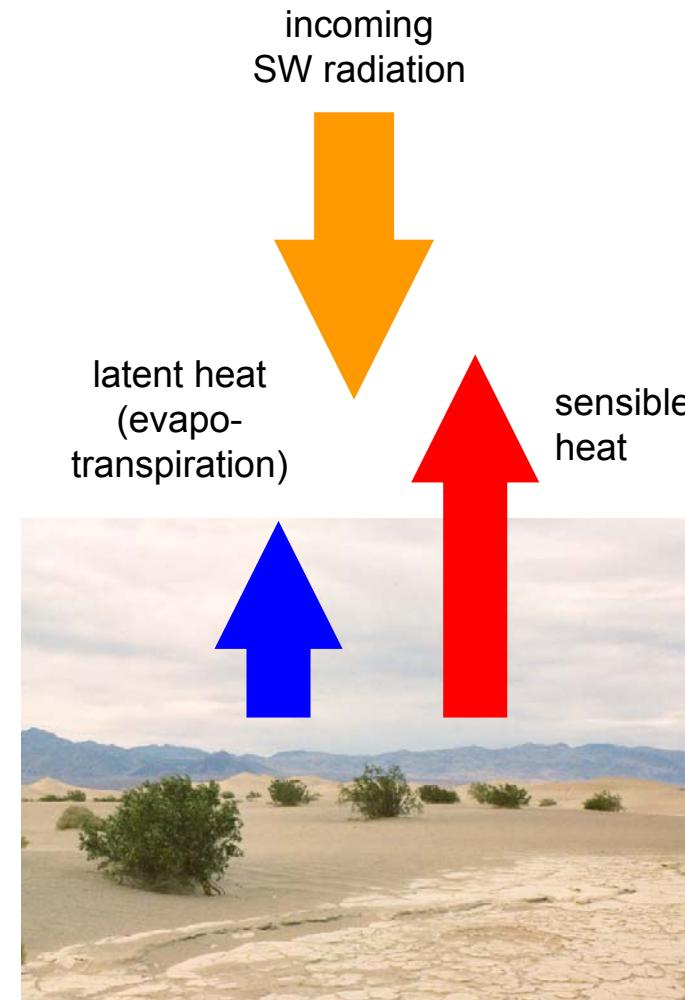
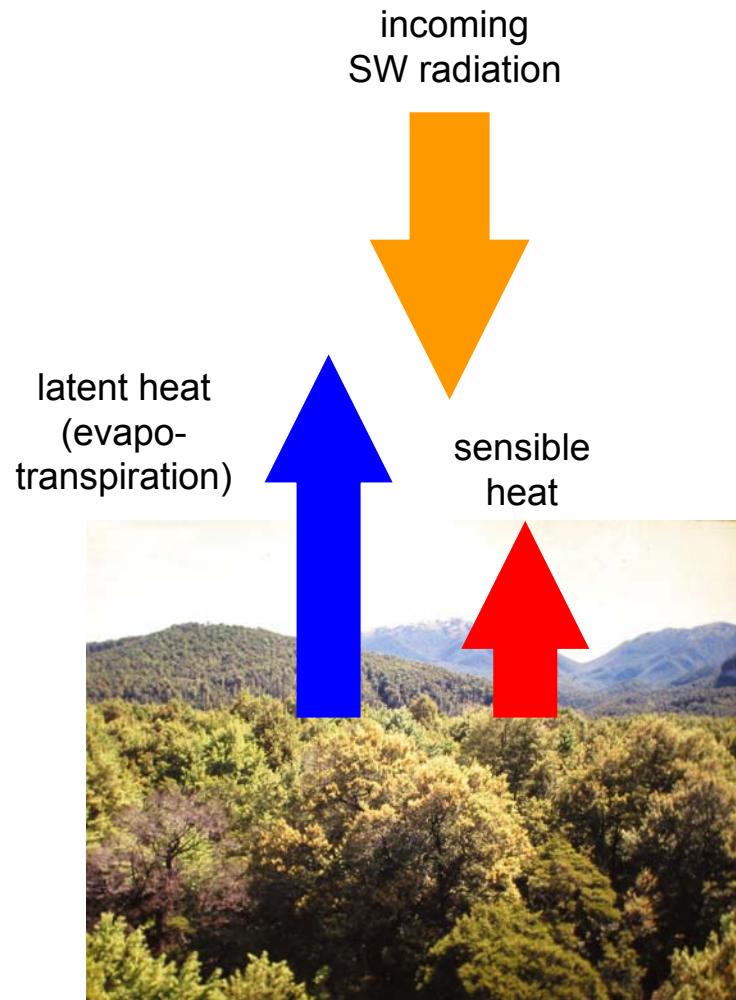


$\text{CO}_2$ -emission yielding same radiation forcing

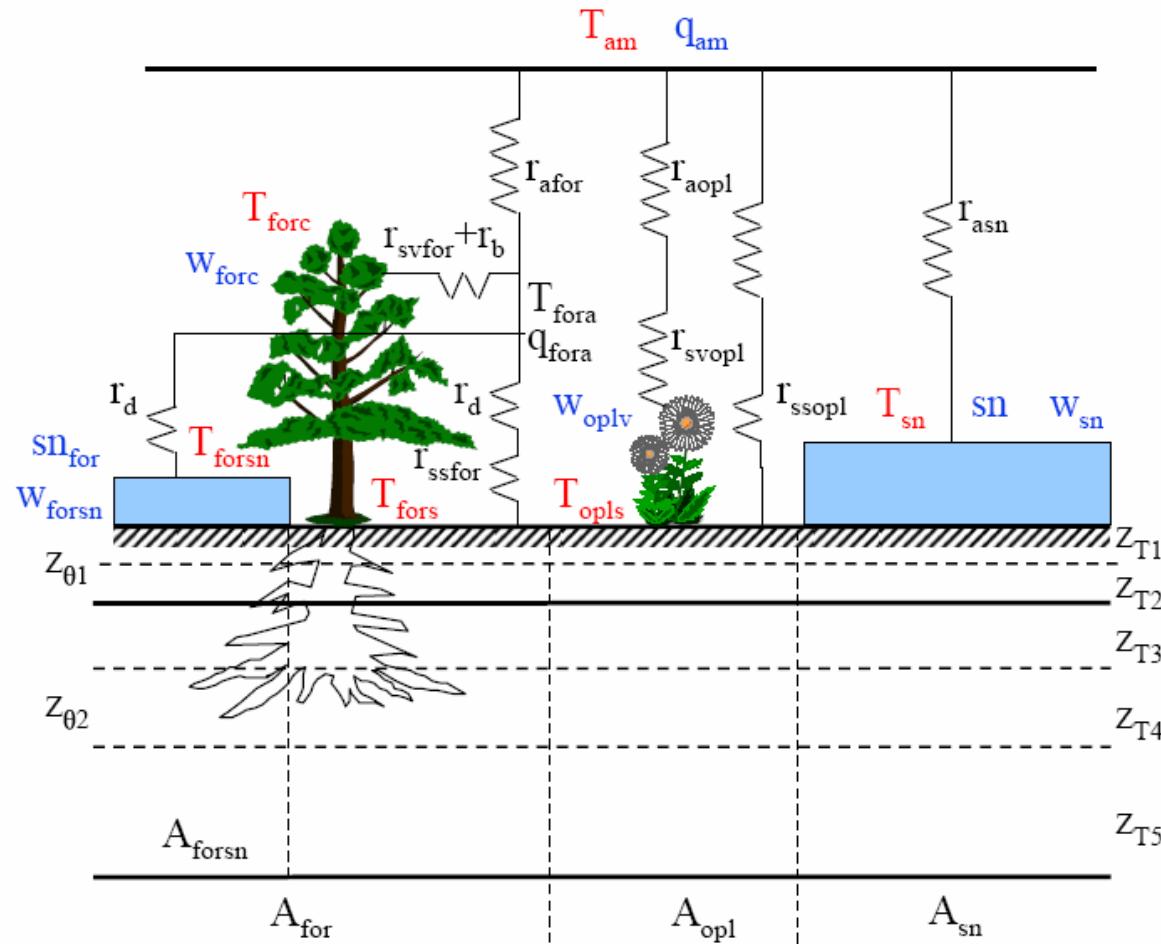


\*Betts 2000  
*Nature* 408: 187

## Partitioning of land surface-atmosphere energy fluxes depends on vegetation type and cover



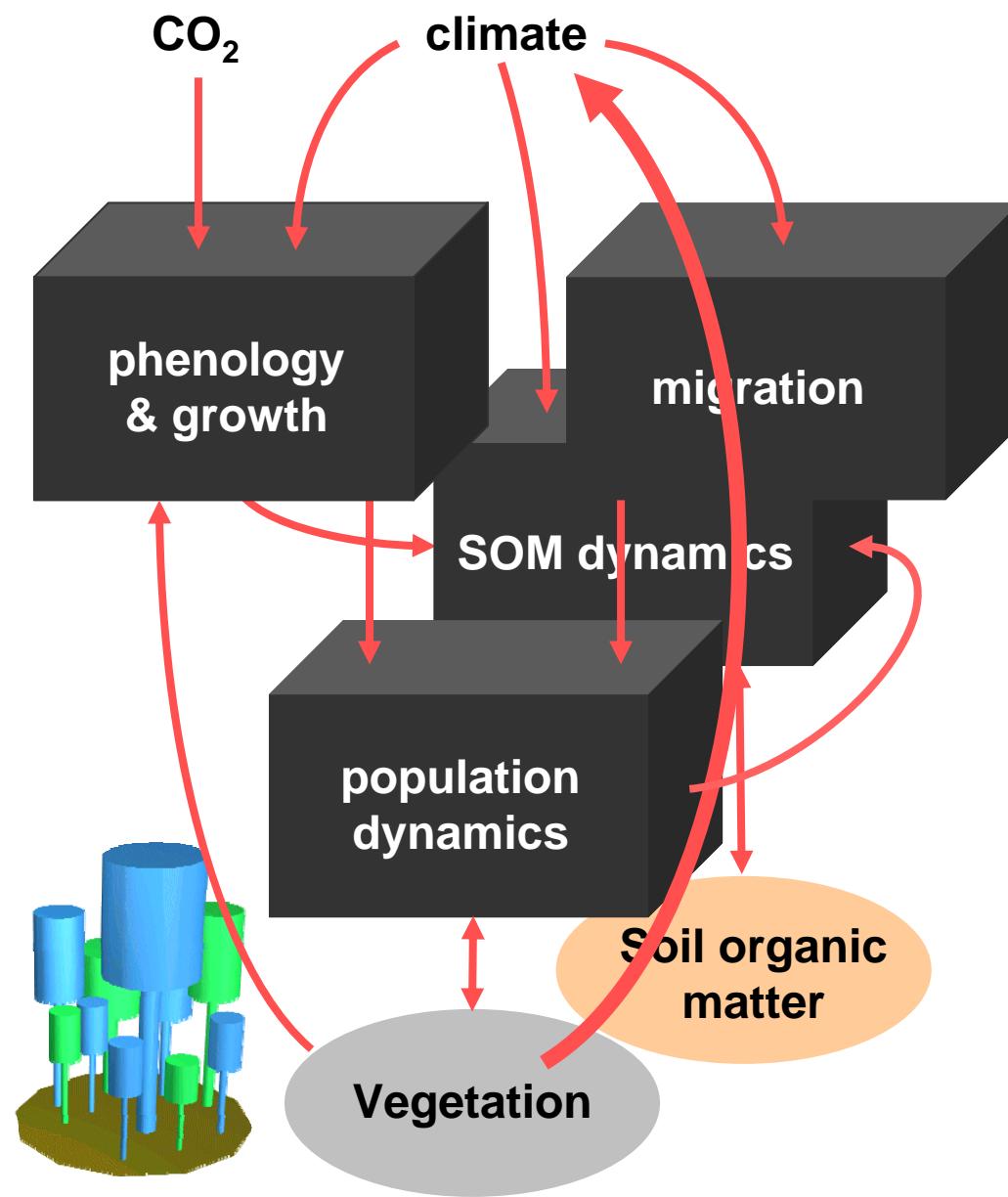
## Land surface scheme of RCA3\*



- forest, open land, bare ground, snow
- conifer, broadleaved forest (prescribed fractions)
- leaf phenology (prescribed)
- leaf area index (scaled to soil T)

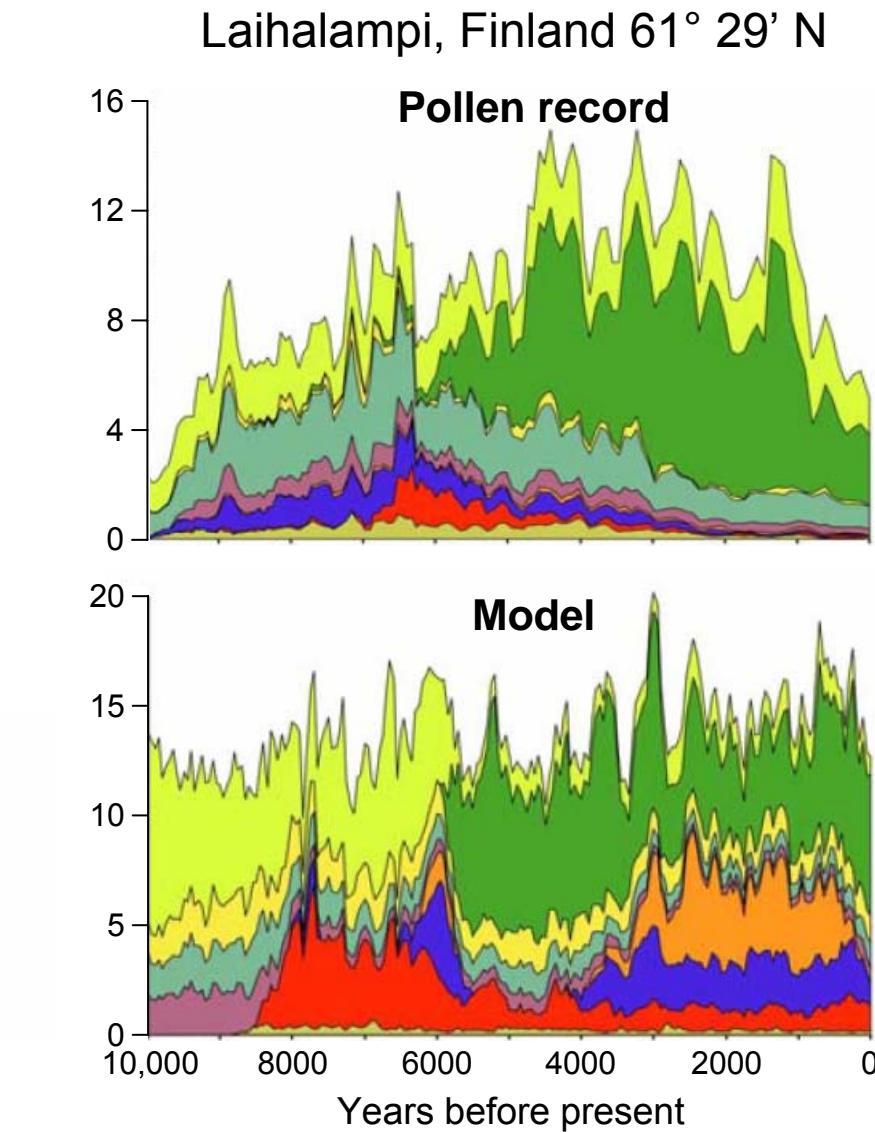
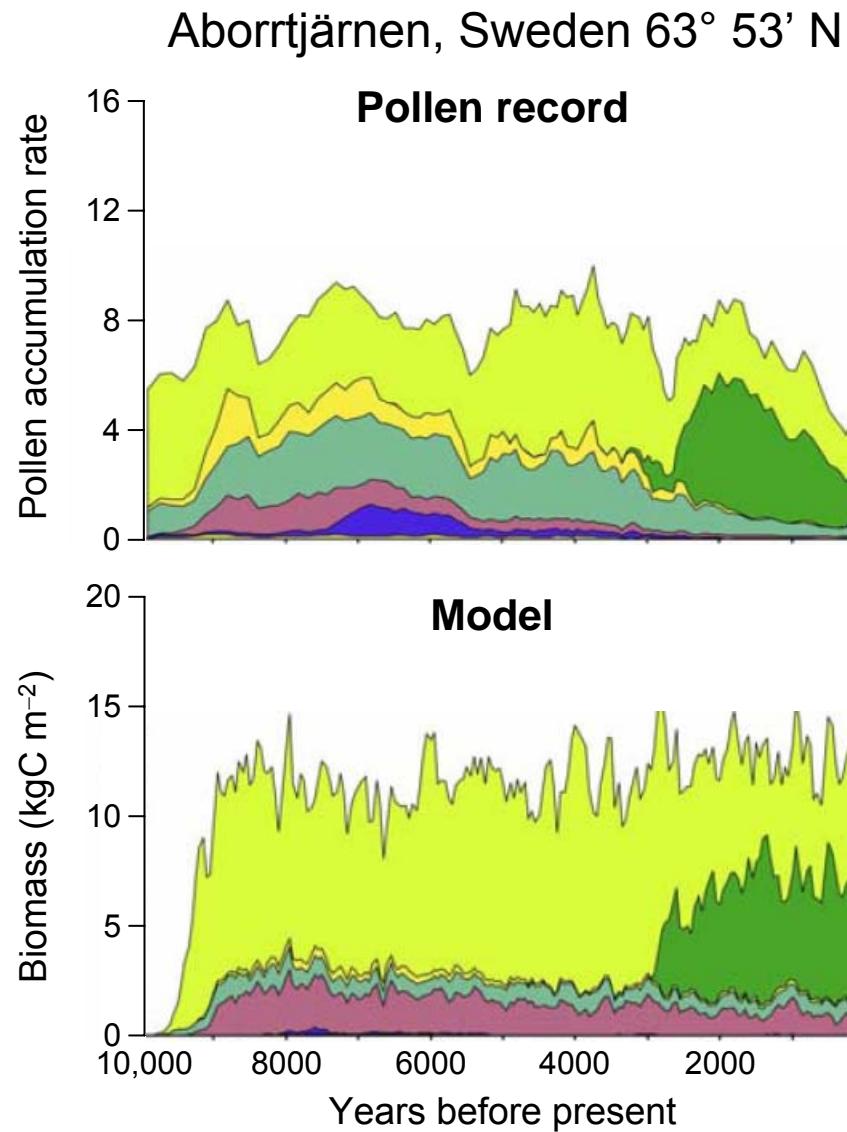
\*Samuelsson et al. 2006  
*Nature* 408: 187

## LPJ-GUESS – a process-based ecosystem modelling framework\*



\*Smith et al. 2001  
*Global Ecology and Biogeography* 10: 621

## Modelling Holocene vegetation history in Fennoscandia\*

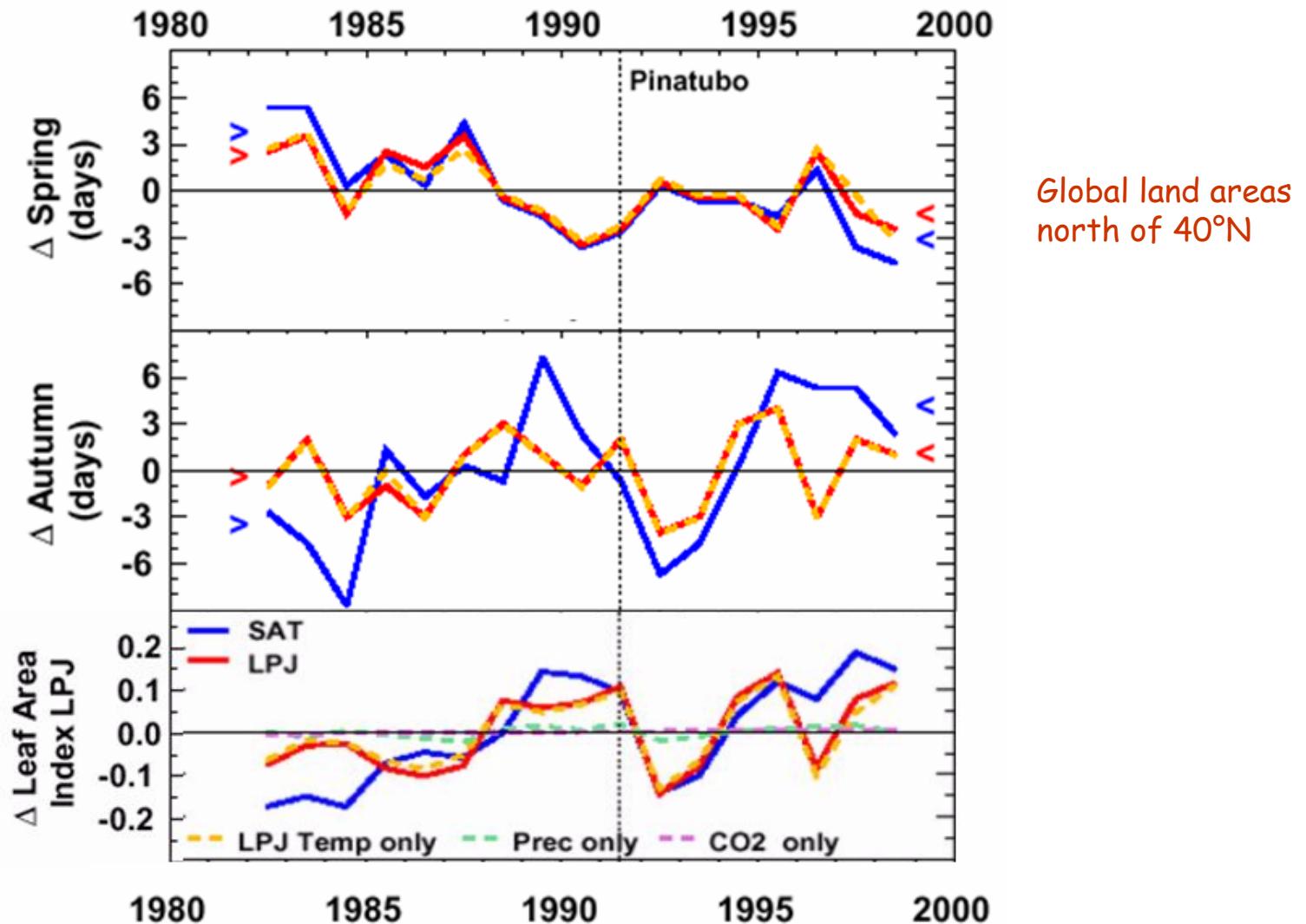


■ *Pinus sylvestris* ■ *Betula* spp.  
■ *Picea abies* ■ *Aldus incana*  
■ *Populus tremula* ■ *Ulmus glabra*

■ *Quercus robur*  
■ *Tilia cordata*  
■ *Corylus avellana*

\*Miller et al. 2008  
*Journal of Ecology*

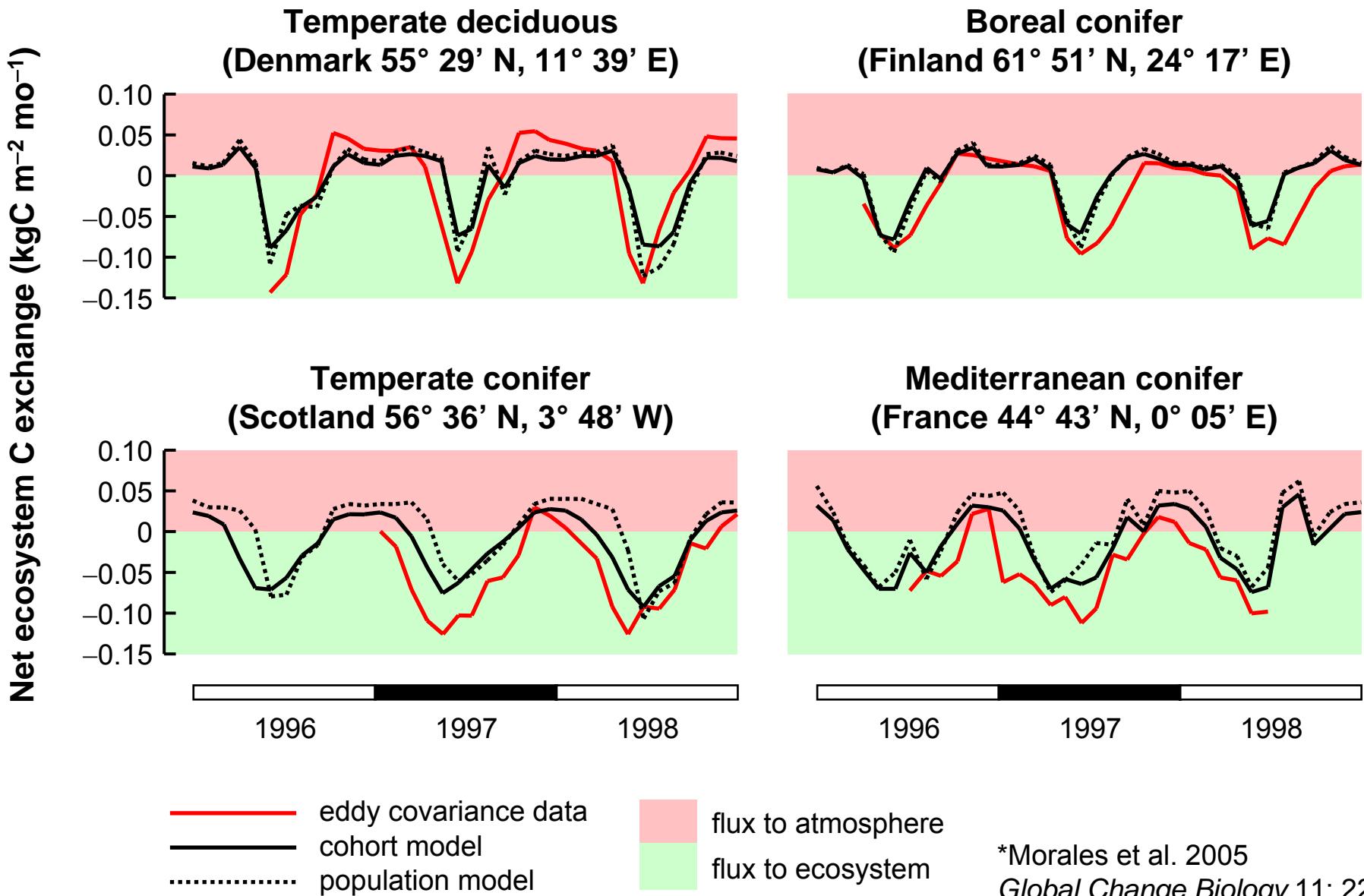
## Observed and modelled changes in leaf phenology and LAI\*



\*Lucht et al. 2002.

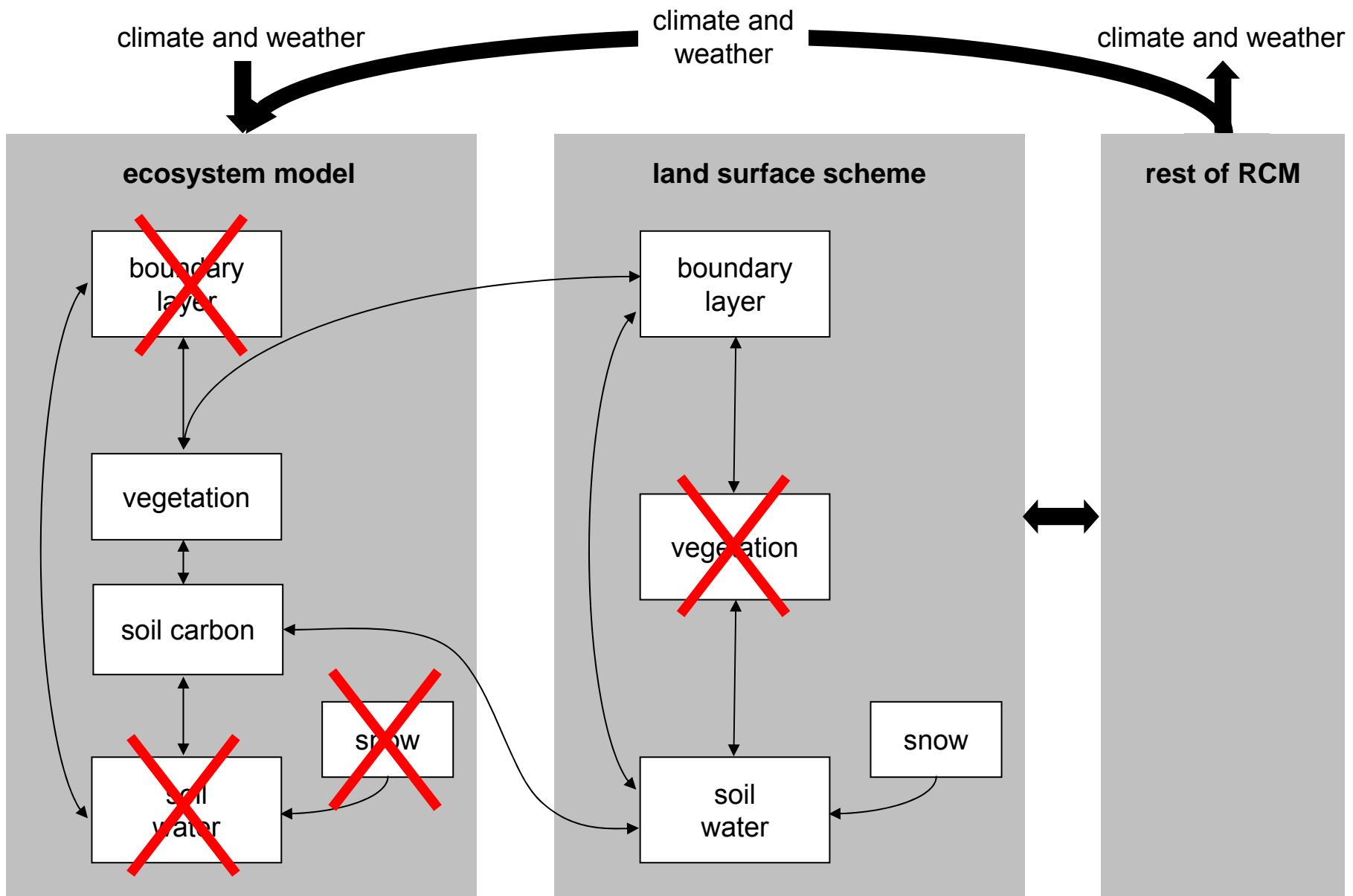
Science 296: 1687-1689

## Carbon exchange of European forest ecosystems\*



\*Morales et al. 2005  
*Global Change Biology* 11: 2211

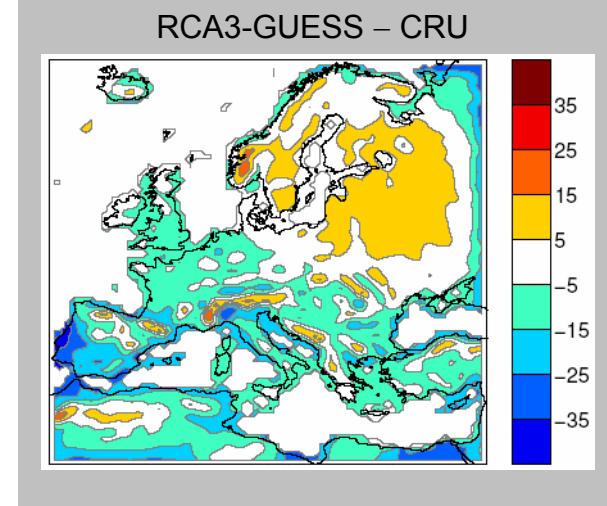
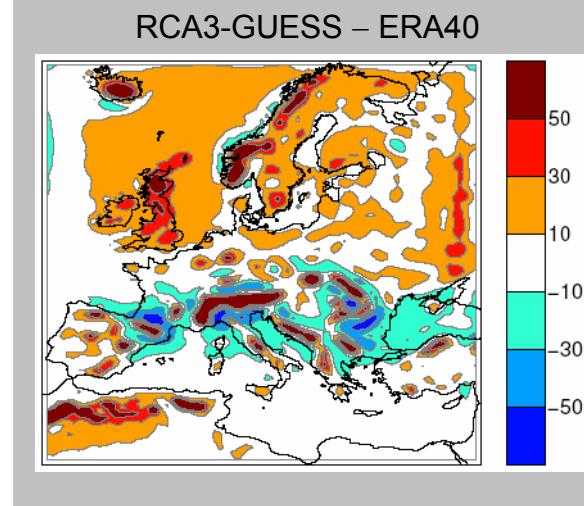
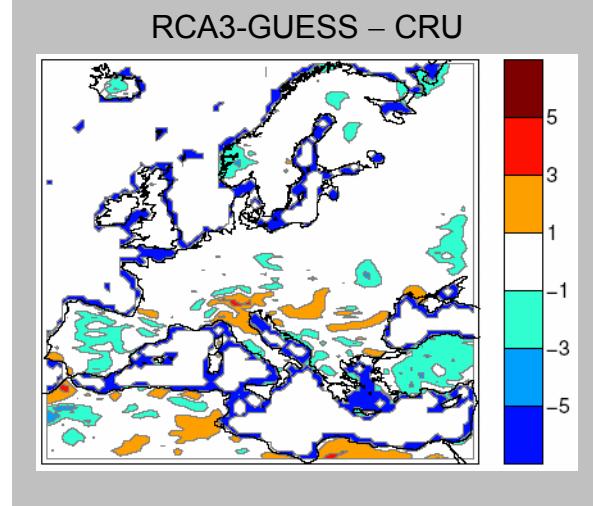
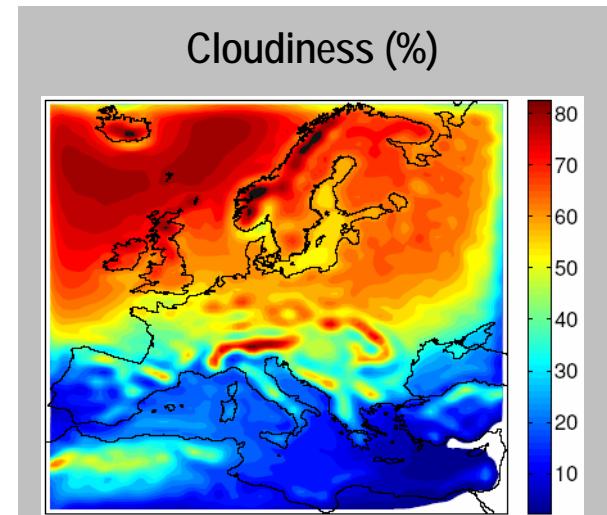
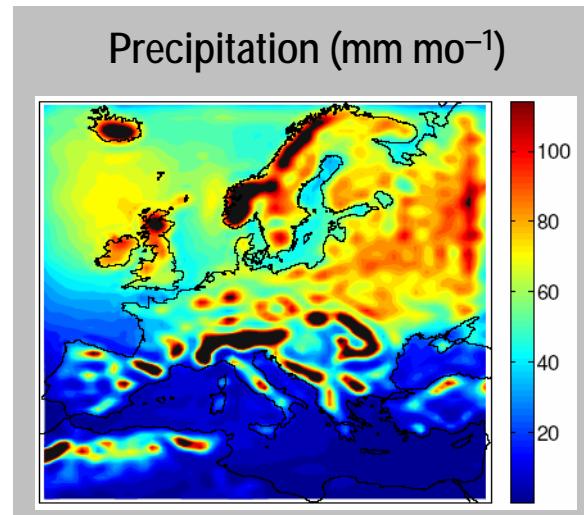
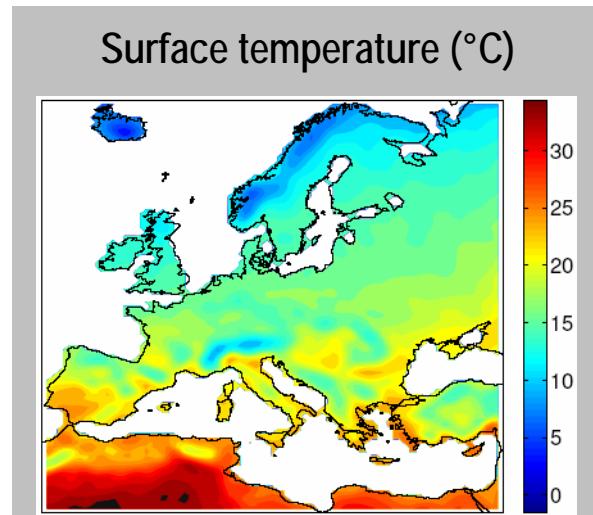
## RCA-GUESS: a coupled regional climate-terrestrial vegetation model



<b>GUESS tells RCA</b>	<b>Used by RCA for</b>	<b>RCA tells GUESS</b>	<b>Used by GUESS for</b>
<p>fraction of conifer, broadleaved forest, open land, bare ground</p> <p>leaf area index (LAI)</p>	<p>roughness, albedo, displacement height evaporation, transpiration</p> <p>interception, displacement height, radiation partitioning, transpiration</p>	<p>incoming SW radiation</p> <p>near-canopy temperature</p> <p>soil water</p> <p>soil temperature</p>	<p>photosynthesis, stomatal conductance</p> <p>respiration, photosynthesis, canopy conductance, fire</p> <p>stomatal conductance, soil respiration, fire</p> <p>respiration</p>

## Comparison of modelled to observed climate

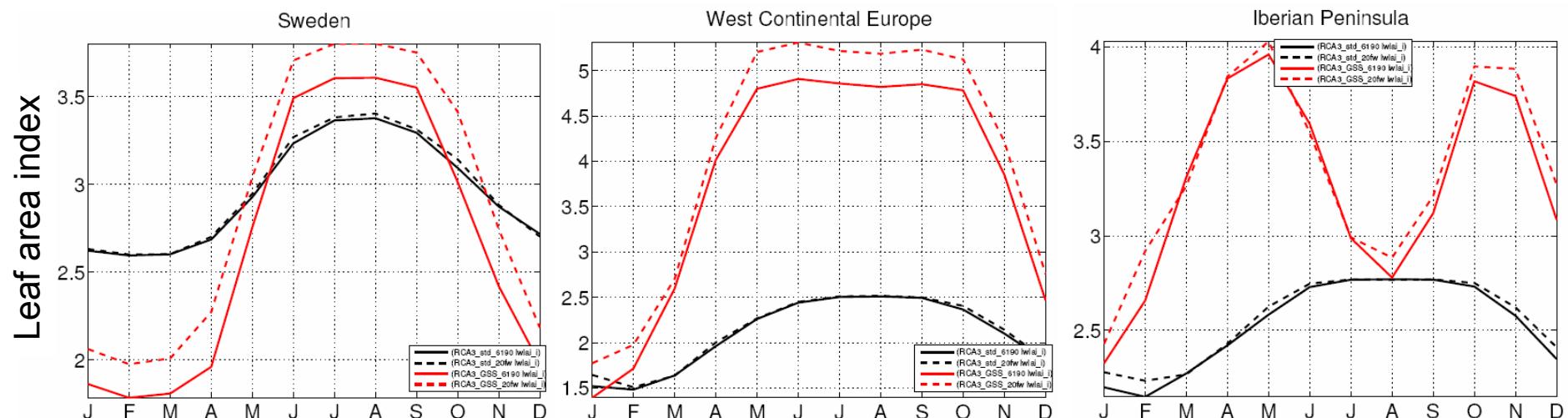
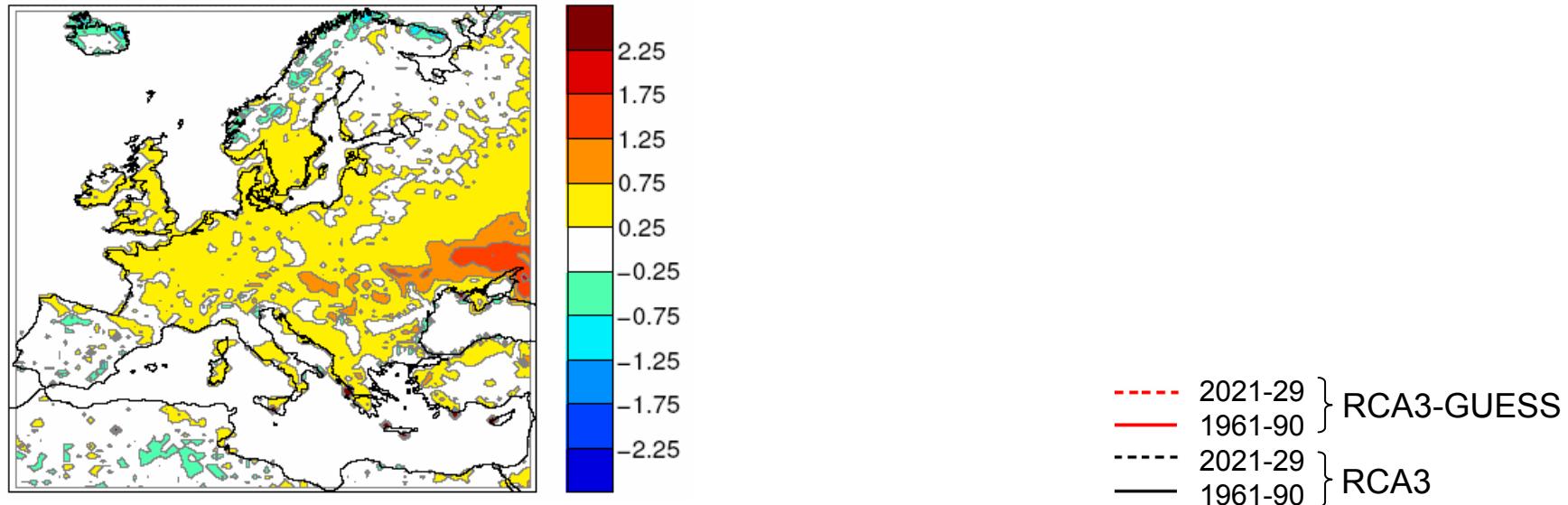
RCA3-GUESS ERA40 1961-1990 JJA



## Simulated changes in vegetation structure

Simulated change (2020-2029)–(1961-1990) RCA3-GUESS ECHAM5-A1B Transient

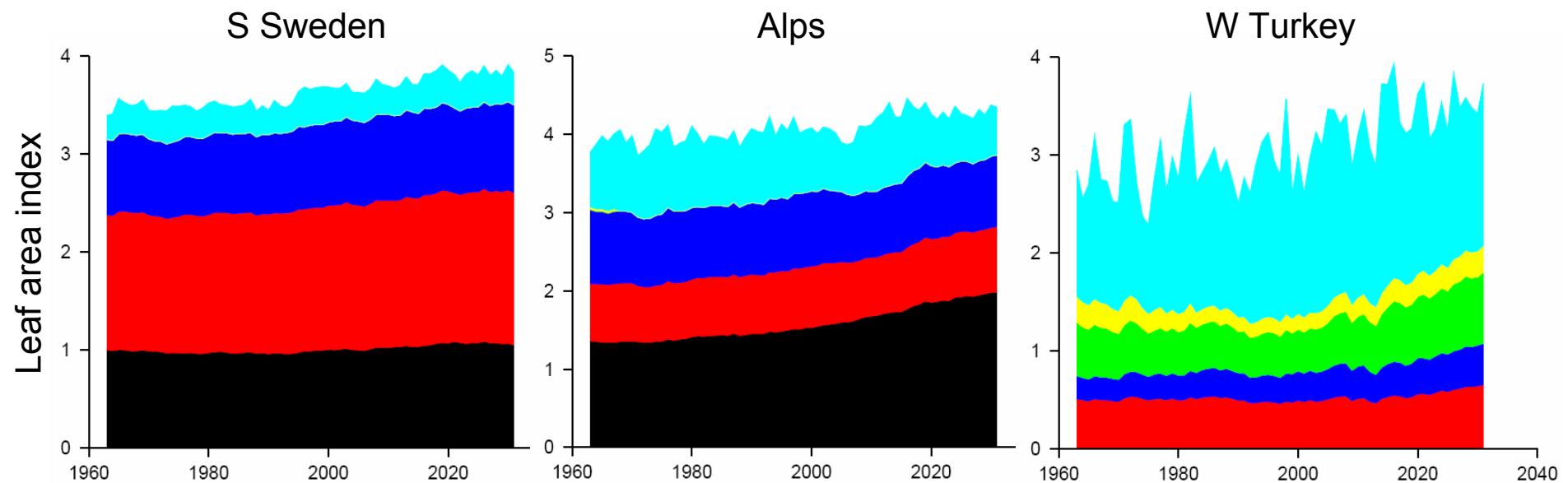
Change in JJA leaf area index  $\Delta LAI$



## Simulated changes in vegetation composition

RCA3-GUESS ECHAM5-A1B Transient 1964-2030

Forest tile



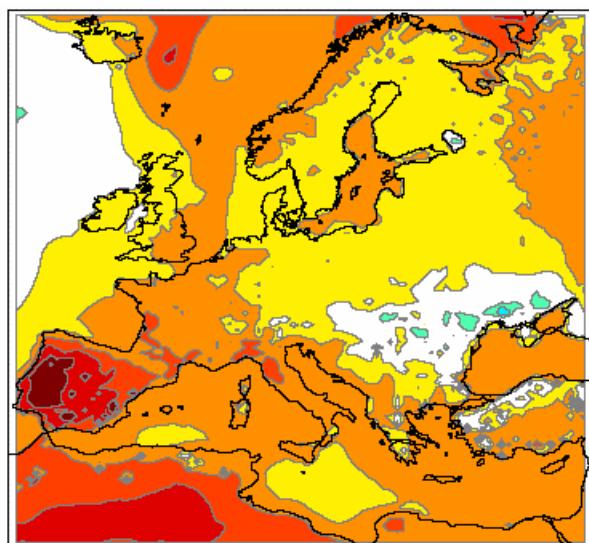
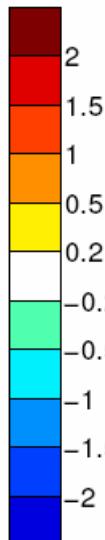
- [Black square] boreal/temperate needleleaved evergreen
  - [Red square] shade-tolerant broadleaved summergreen
  - [Blue square] shade-intolerant broadleaved summergreen
  - [Green square] broadleaved evergreen
  - [Yellow square] Mediterranean needleleaved summergreen
  - [Cyan square] grass/herbaceous vegetation
- } trees

## Quantifying feedback of vegetation structural change on climate

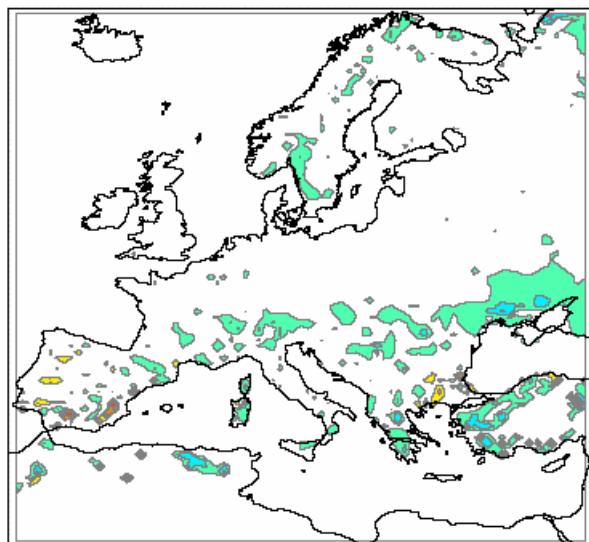
Simulated change (2020-2029)–(1961-1990) RCA3-GUESS ECHAM5-A1B Transient

Temperature change JJA  $\Delta T$

°C

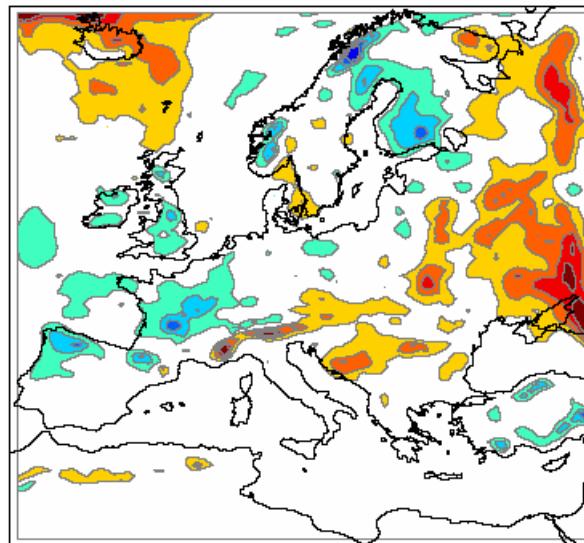
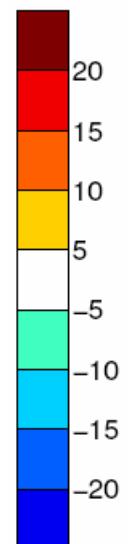


Feedback contribution  $\Delta T_{\text{RCAG}} - \Delta T_{\text{RCA}}$

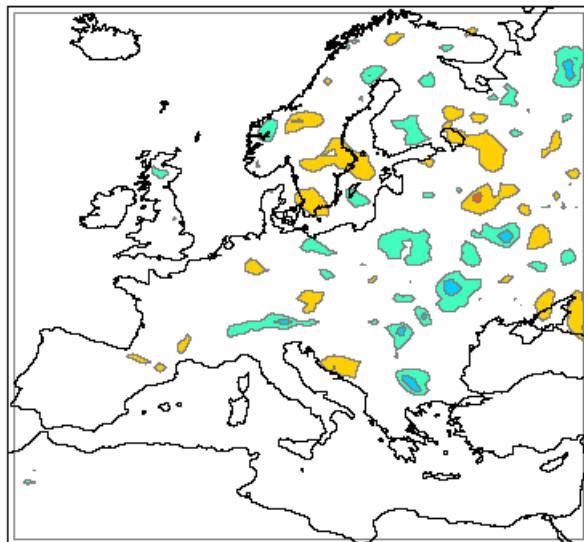


Precipitation change JJA  $\Delta P$

mm mo<sup>-1</sup>

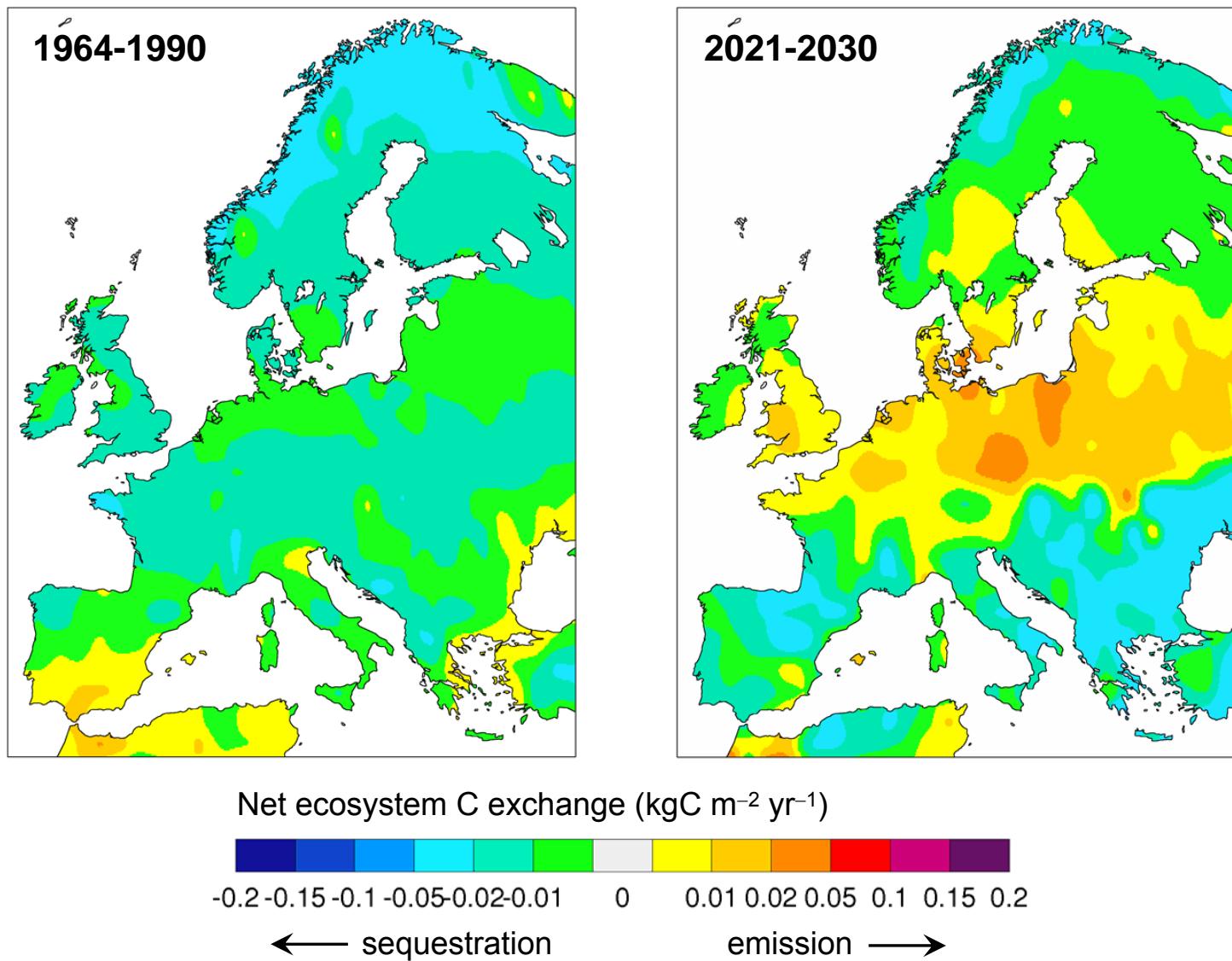


Feedback contribution  $\Delta P_{\text{RCAG}} - \Delta P_{\text{RCA}}$



## Simulated change in terrestrial ecosystem carbon balance

RCA3-GUESS ECHAM5-A1B Transient 1964-2030  
Open land tile



## Future prospects

- Centennial runs, stabilisation scenario, alternative emission pathways
- Land use change and management (forestry, agriculture)
- Peatlands, permafrost, non-CO<sub>2</sub> trace gases
- Integration with global studies using ESMs

## Thanks

Rossby Centre at SMHI

The Swedish Research Council for Environment, Agricultural Sciences  
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The Swedish Research Council