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Evaluation of the Suitability of the Land Surface Model JULES for Environmental Change Studies in Belgium

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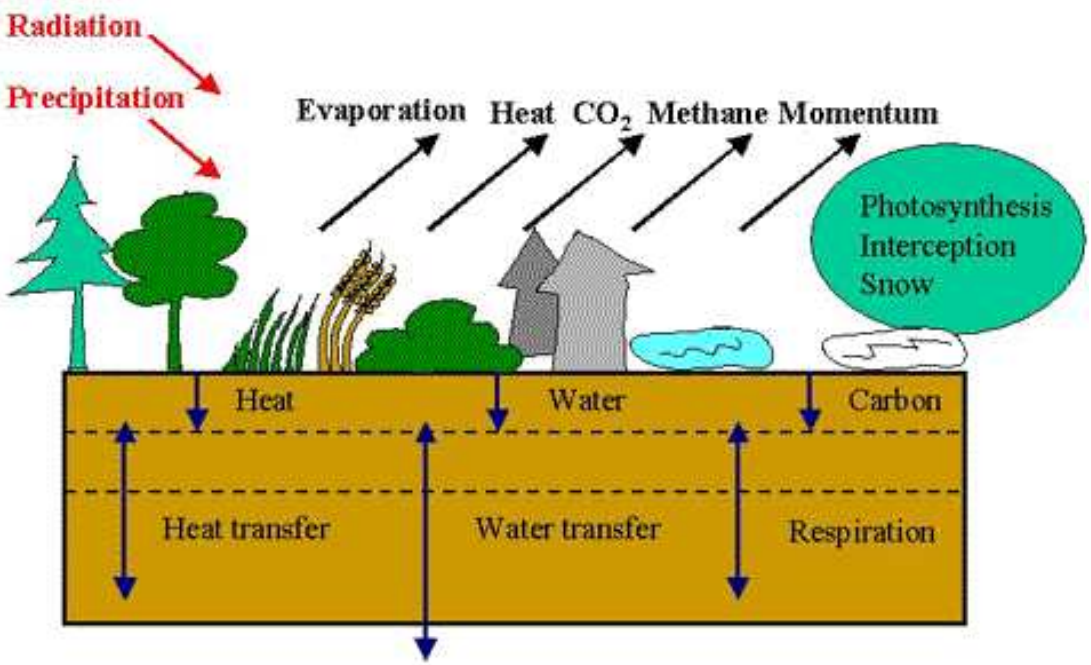
The Joint UK Land Environment Simulator (JULES)

JULES (*Cox, 1999*) was originally designed to represent the land surface in UK meteorological and climate models. Its scheme includes the full hydrological cycle and vegetation effects on energy, water and carbon fluxes. It is a so called "third generation" land surface model (*Sellers, 1997*).



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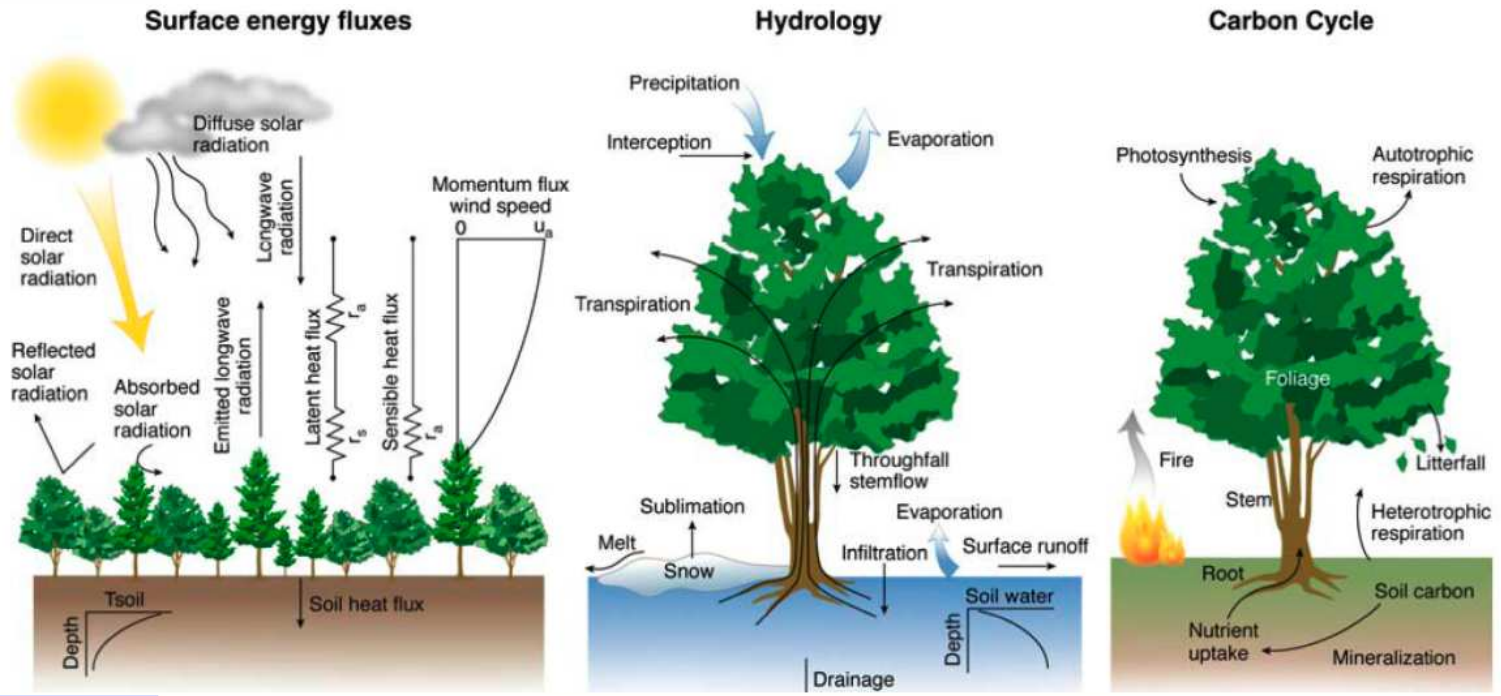
Fluxes of Energy, Water and Carbon on the Land Surface



(*Bonan, 2008*)

- Energy balance: $S\downarrow + L\downarrow = S\uparrow + L\uparrow + \lambda E + H + G$
- Water balance: $P = E_S + E_T + E_C + R_{Surf} + R_{Subsurf} + \Delta SM/\Delta t$
- Carbon balance: $NEP = NPP - R_h = (GPP - R_a) - R_h = [(\Delta C_f + \Delta C_s + \Delta C_r)/\Delta t] - R_h$

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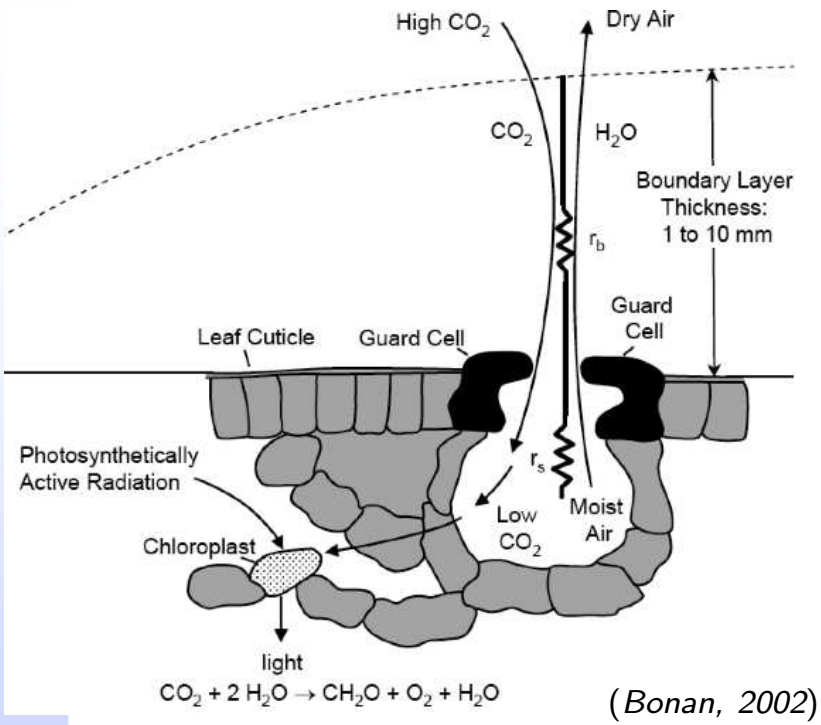
Third Generation Models (*Sellers, 1996*)



(*Bonan, 2002*)

Stomata close (smaller pore opening):

- Low light levels
- Dry leaf
- Cold temperature
- Dry air
- High CO_2
- Low leaf nitrogen

- The scheme uses quasi-mechanistic parameterisation of
  - photosynthesis (*Farquhar, 1980; 1989*)
  - stomatal conductance (*Collatz, 1991; 1992*)
- The water and carbon fluxes are fully coupled via the stomata.

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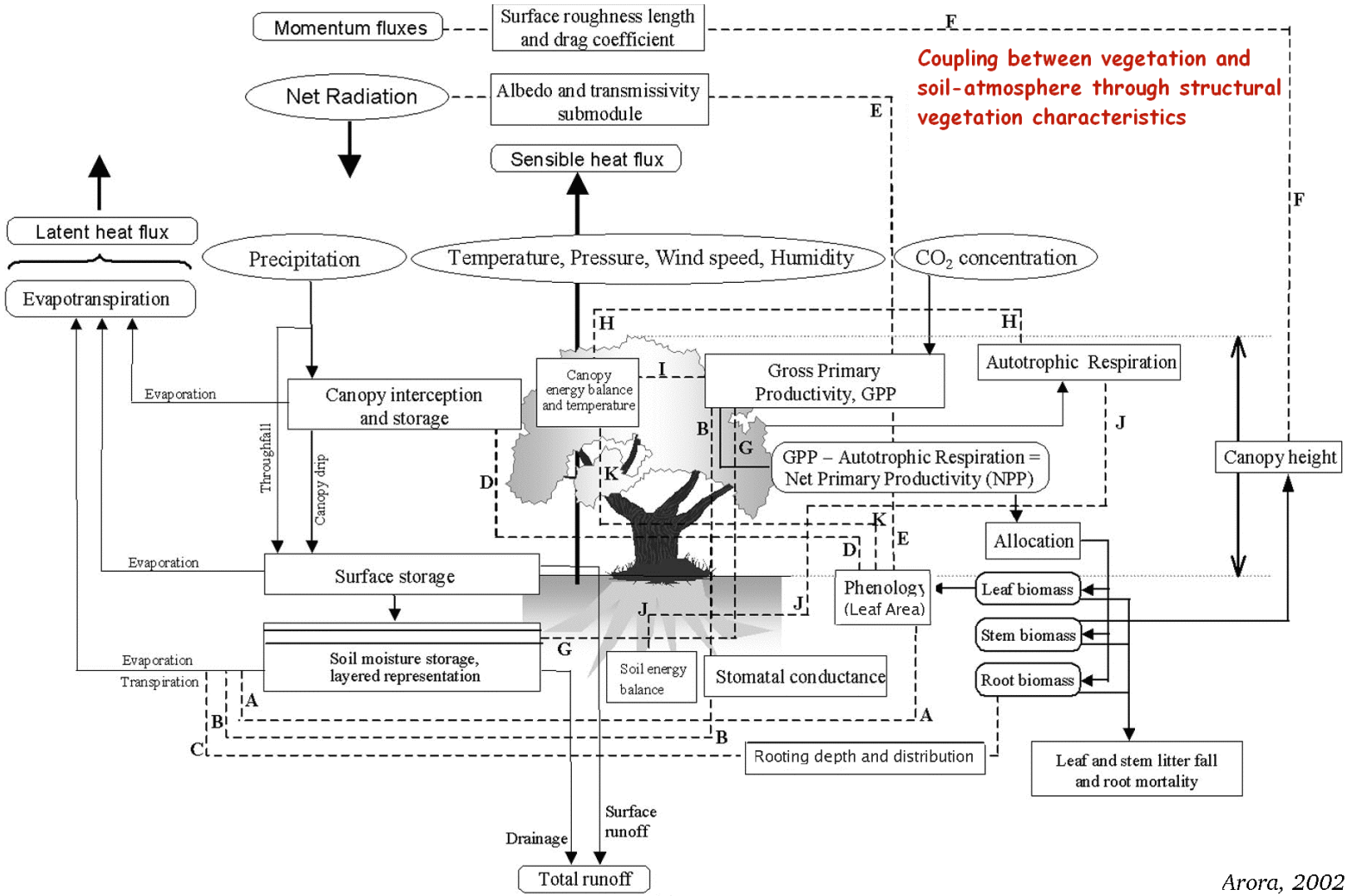
Soil-Vegetation-Atmosphere Transfer Scheme



Arora, 2002

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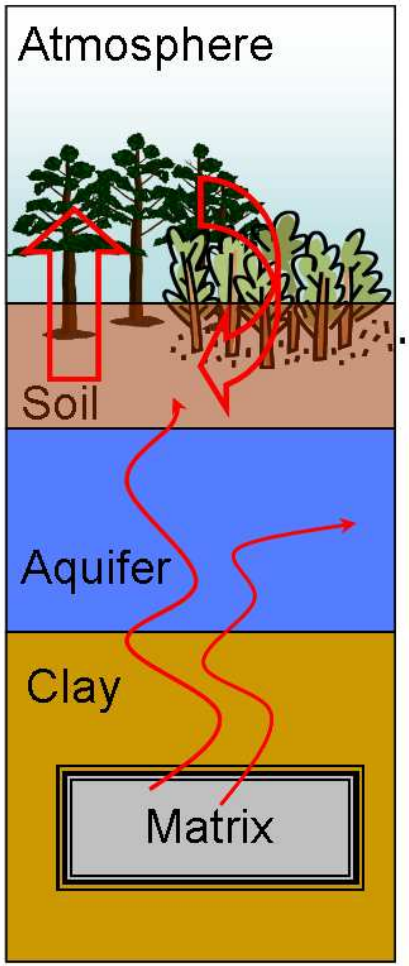
JULES as Tool for Long Term Safety Assessments



A land surface model is a valuable tool to link together the biosphere and the geosphere. In this study, we want to use it for long term safety assessments of nuclear disposal.

The objective is to evaluate the impact of environmental change on the energy, water and carbon fluxes in Belgian ecosystems.

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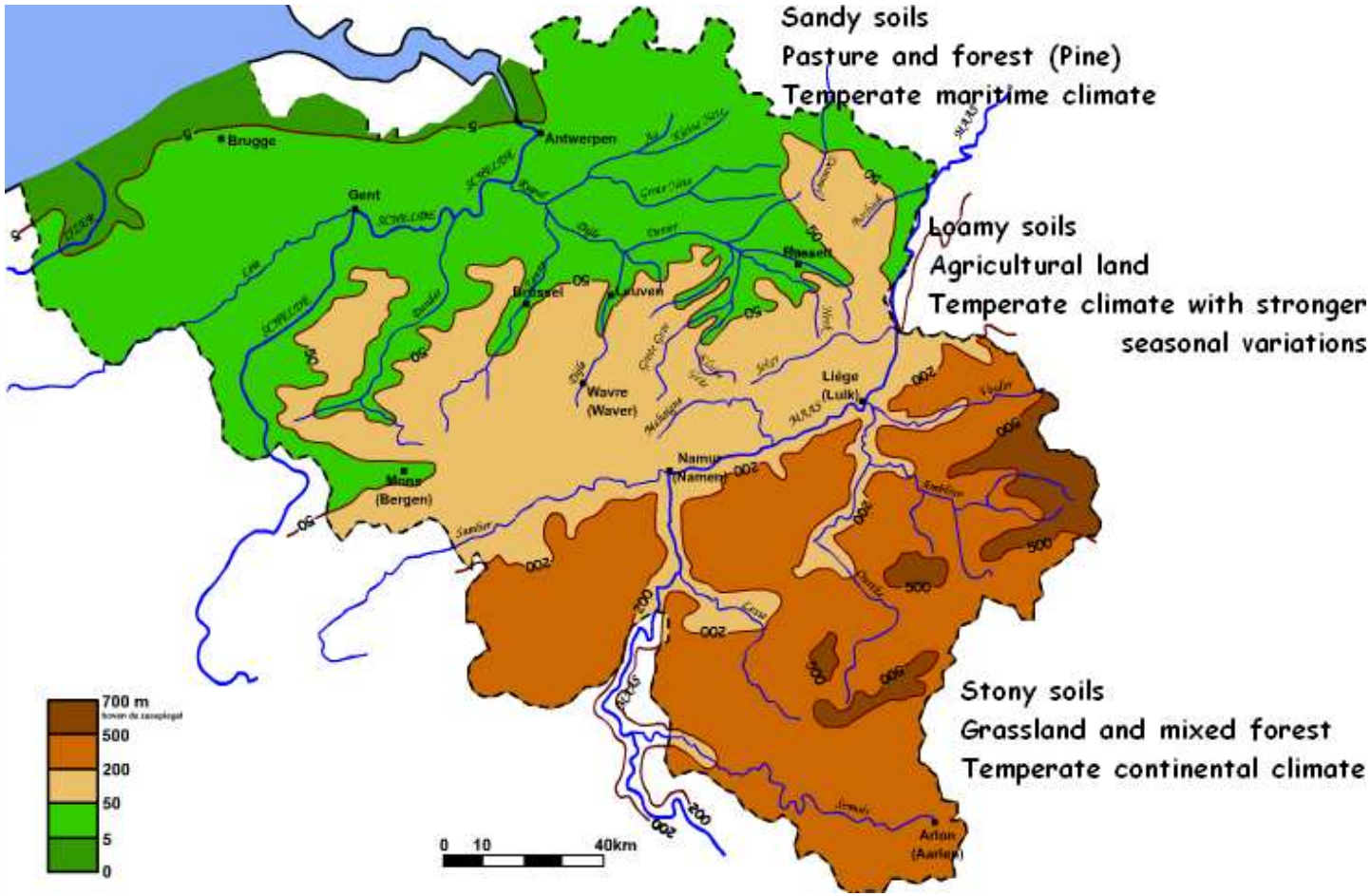
Soil, Vegetation and Climate types in Belgium



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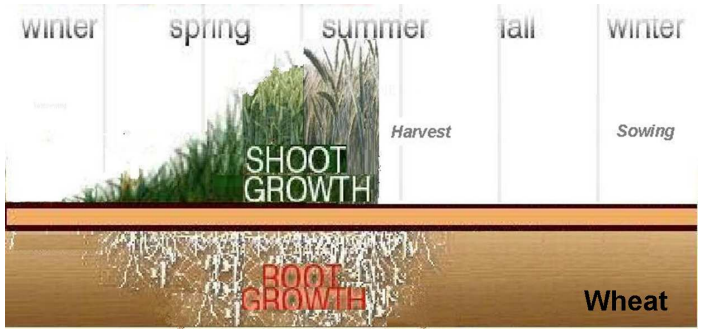
General Issues for the Use of JULES in Belgium: Scale and Cropland

- JULES has shown to improve the simulation of global surface climate when included in a climate model, but has been scarcely tested at field site and regional scales in temperate regions.
- JULES was originally developed for natural vegetation only. C3 grass is often use as proxy for annual crops.



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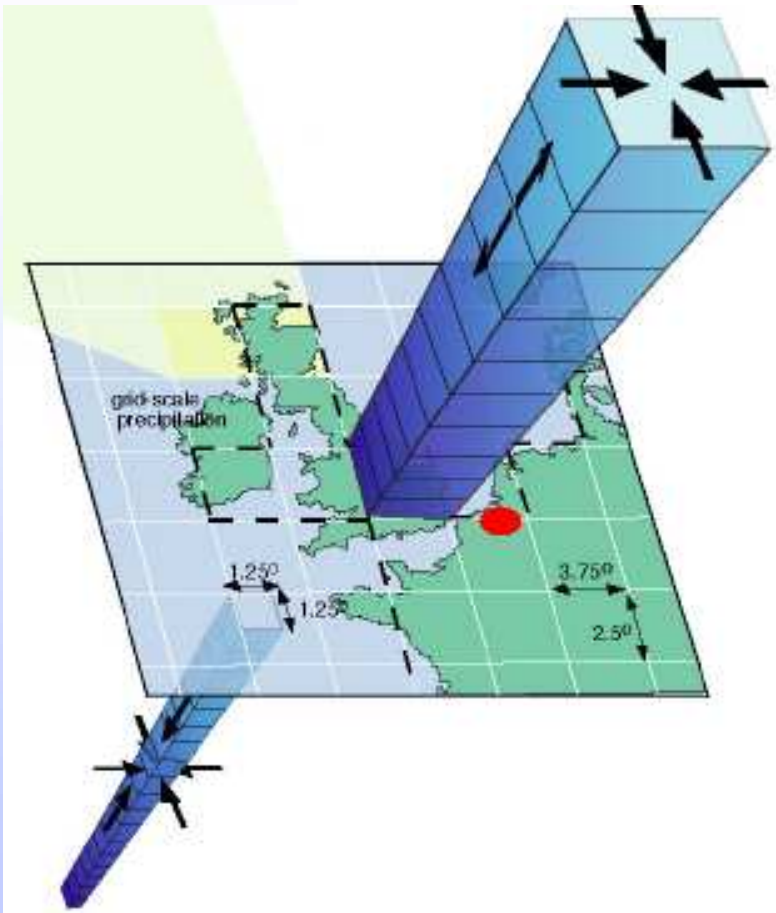
Evaluation of JULES at Belgian Regional Scale



- Validation against surface flux data collected for several consecutive years at FLUXNET sites in Belgium.
- Sensitivity analysis to the environmental conditions; i.e. soil, vegetation and climate (incl. seasonal and inter-annual variability) found in major Belgian ecosystems.

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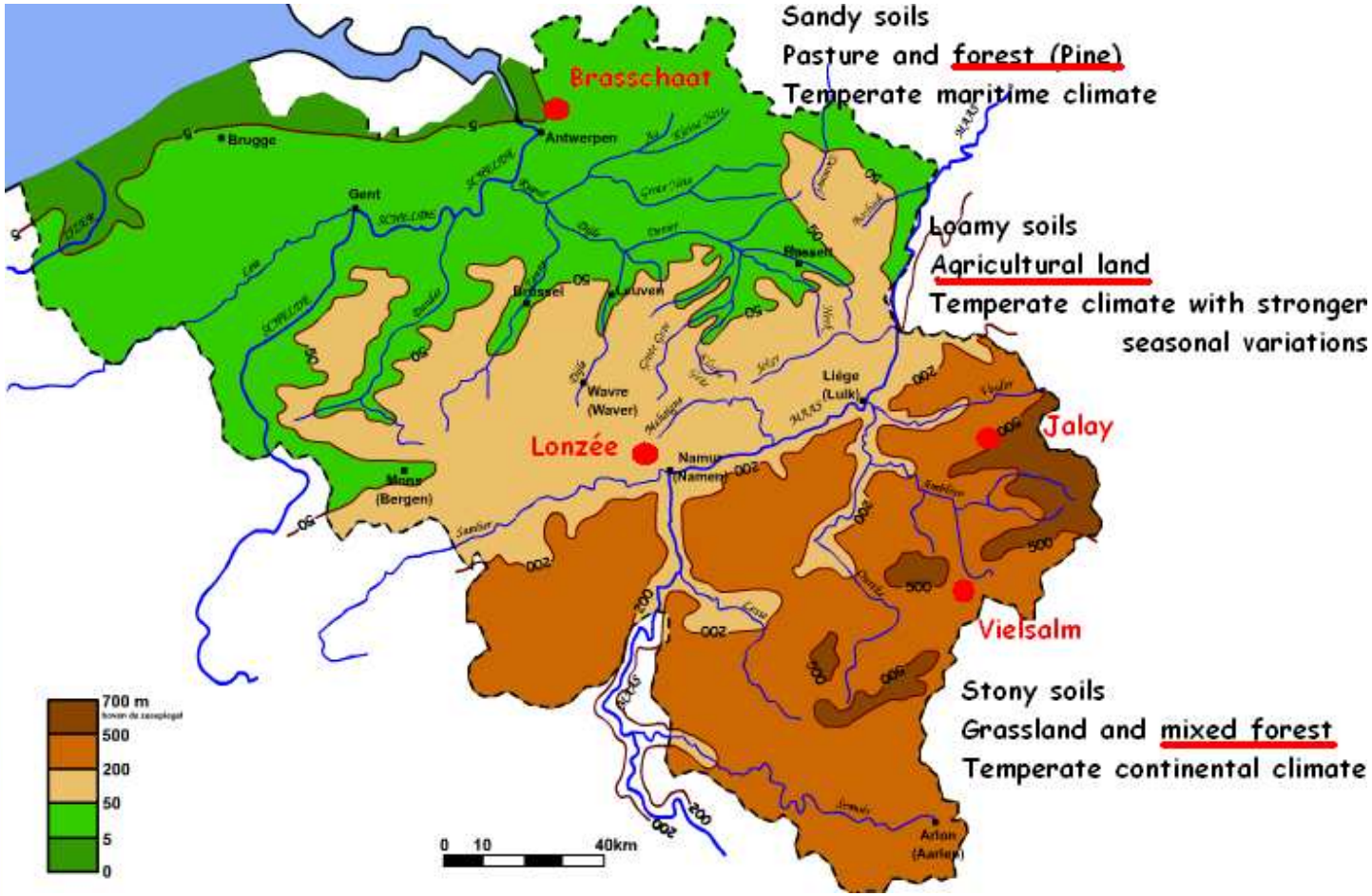
FLUXNET Sites in Belgium



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Data at FLUXNET Sites used for Model Simulations

- As model input:
  - Meteorological data (30 min): Rs, Rl, T, Precip, Ws, Pa, q
  - Vegetation and soil type, vegetation status (LAI,rooting depth, height)(*)
- For model output validation:
  - Carbon, water and energy fluxes
  - Other time varying environmental variables; e.g. soil moisture

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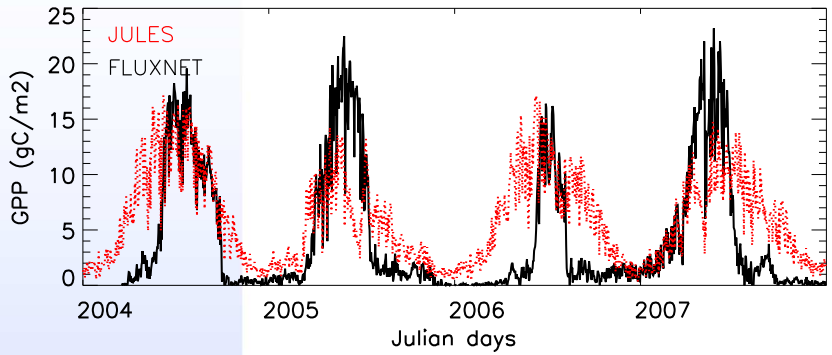
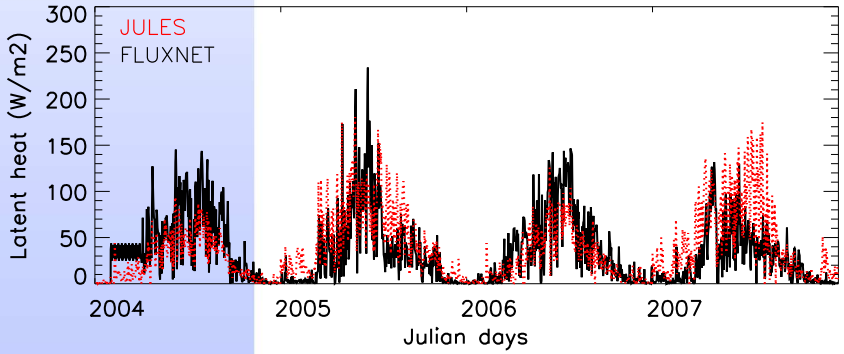
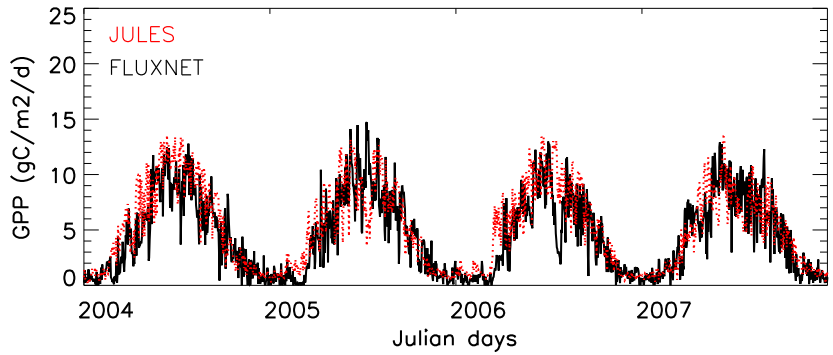
Model outputs for Lonzée and Vielsalm

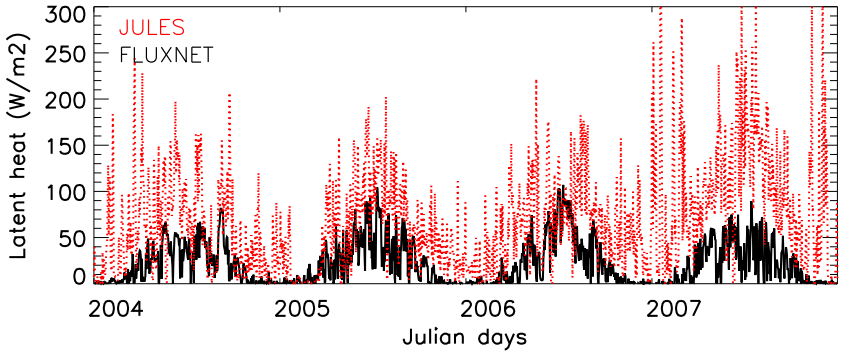
Lonzée (C3 grass as proxy for crop)





Vielsalm (mixed broadleaf/needleleaf)





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Correction for Bias in Evapotranspiration Rate

- Adaptations made to:
  - top soil conductance (*Sellers, 1996;...*)
  - canopy boundary layer conductance (*Choudoury, 1996; Verhoef, 1998*)
  - canopy water storage (*Sellers, 1996;...*)

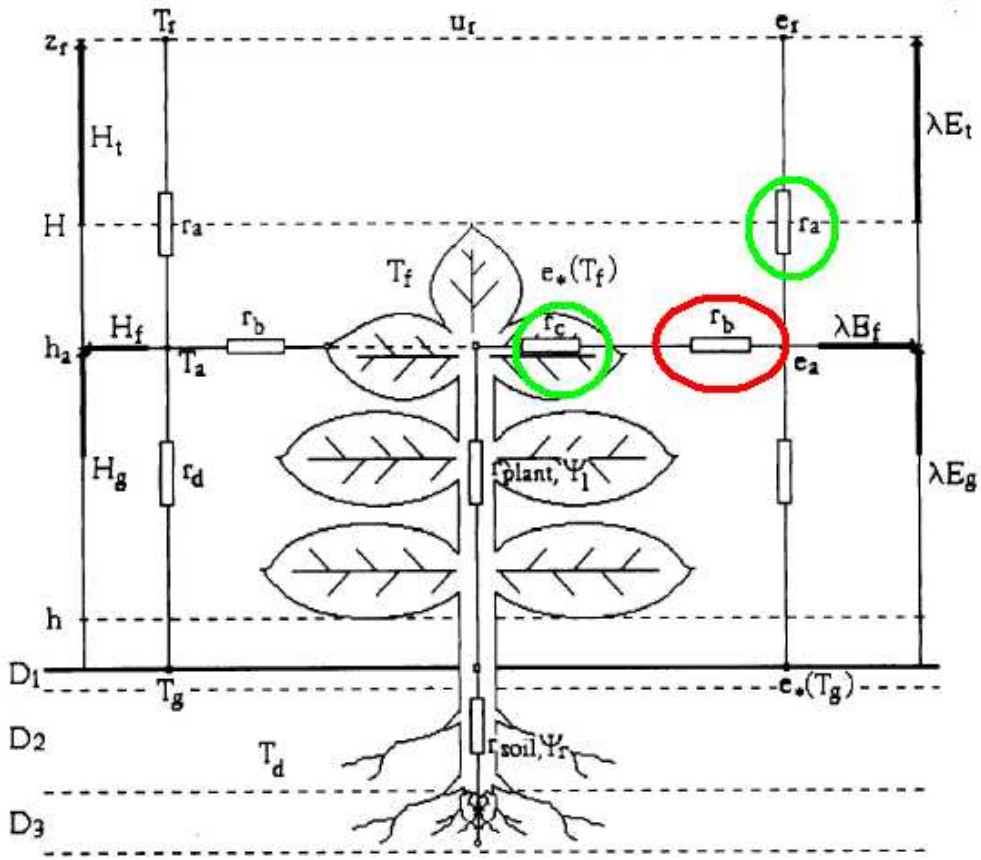

Figure 1. Schematic diagram of transfer pathways for latent and sensible heat fluxes.
(*Mihailovic, 1995*)

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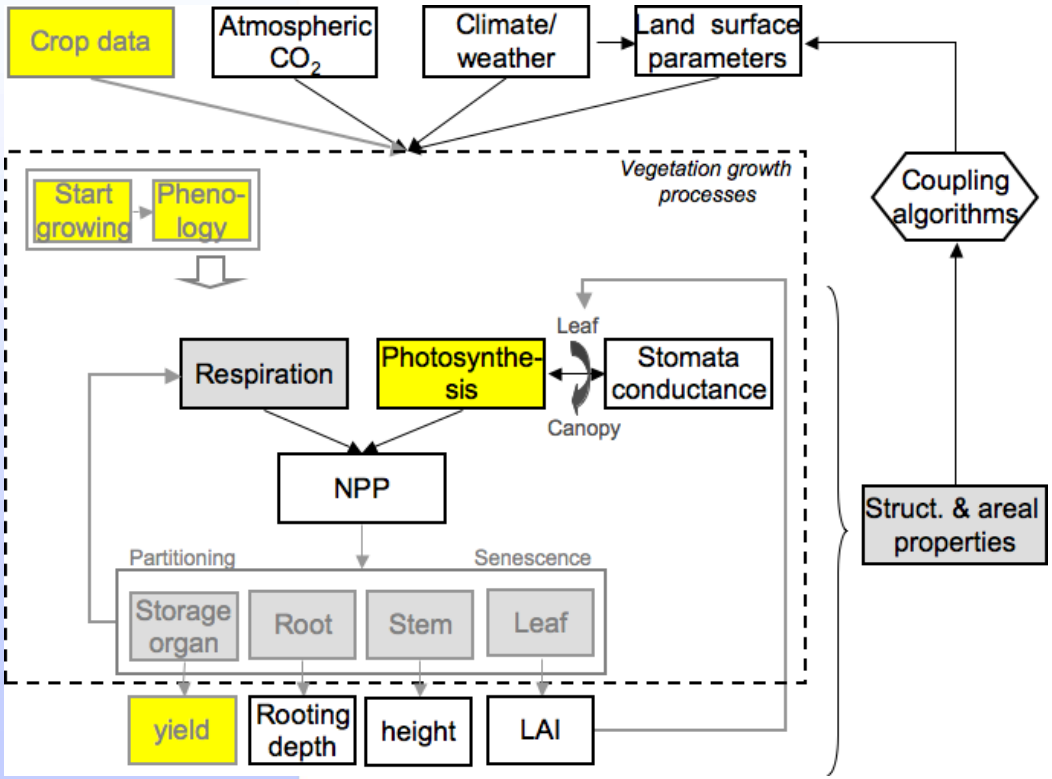
Accounting for Agro-ecosystems : JULES-SUCROS

An improved version of JULES has been developed for annual crops: JULES-SUCROS.



- **JULES**
- **Crop modules based on SUCROS**

  (Goudriaan and van Laar, 1994)
- **General model adaptations**

(*in collaboration with P.L. Vidale, Univ.of Reading*)

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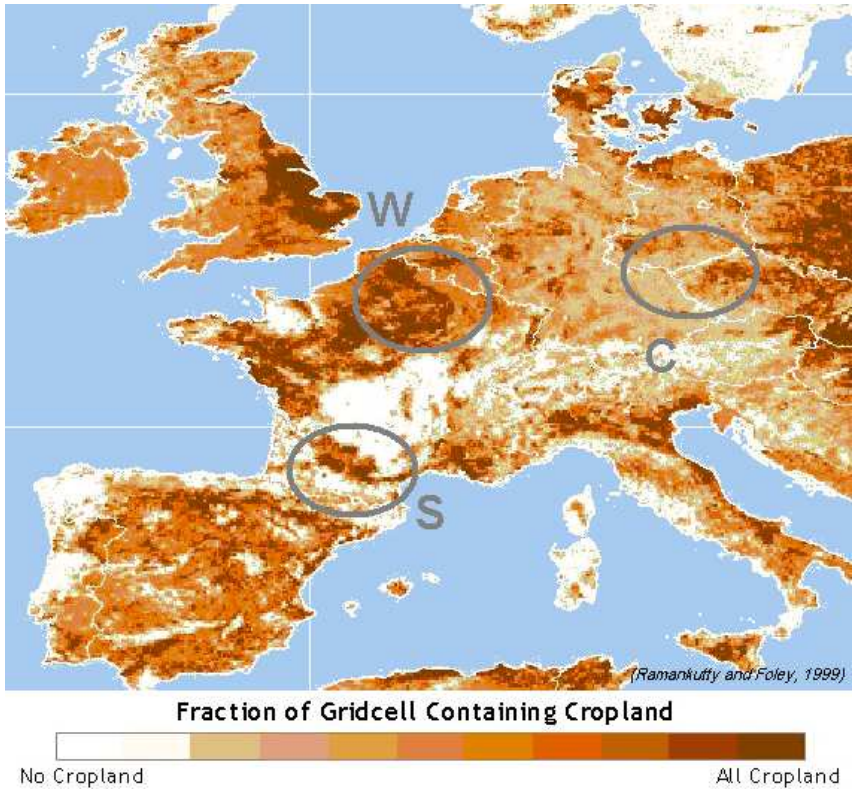
Validation of JULES-SUCROS over Europe

JULES-SUCROS has been validated against FLUXNET data in 3 geographically distinct regions in Europe with different growth conditions.

- Gebesee
- Klingenberg
- Lonzée
- Grignon
- Auradé
- Lamasquère



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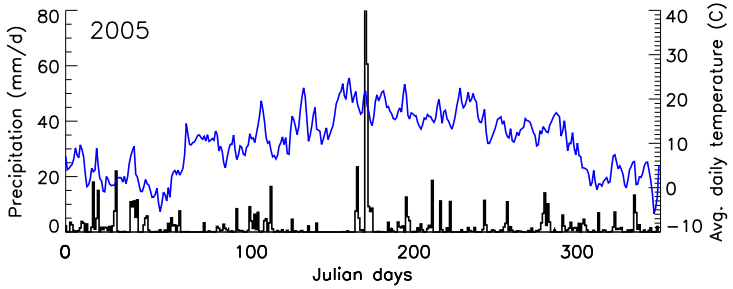
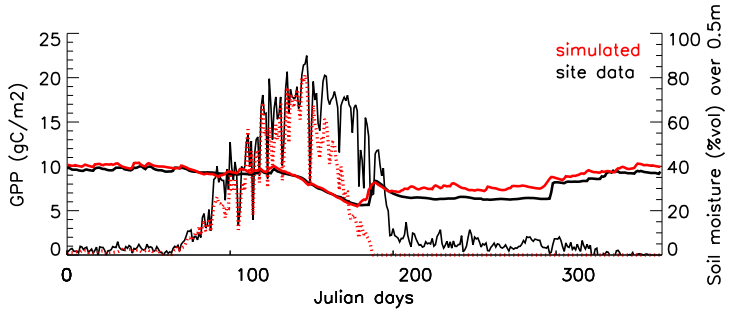
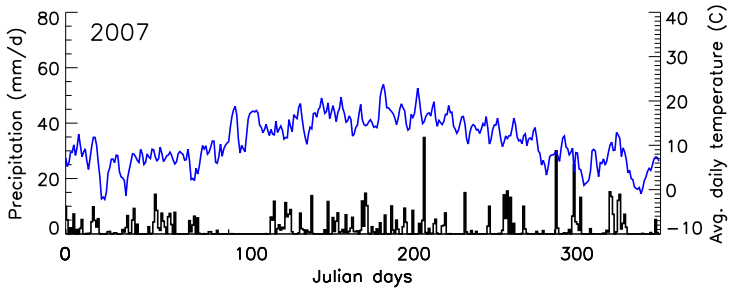
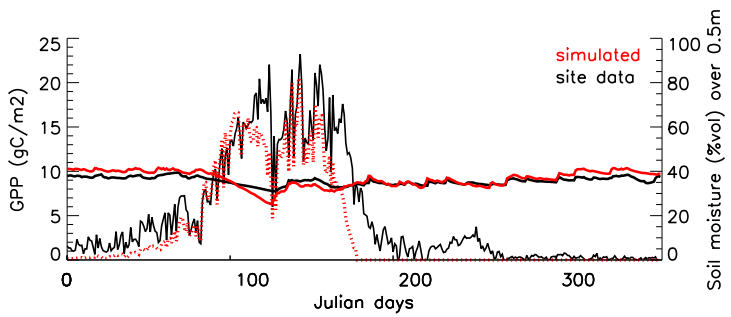
JULES-SUCROS captures both spatial and temporal variability

Lonzée

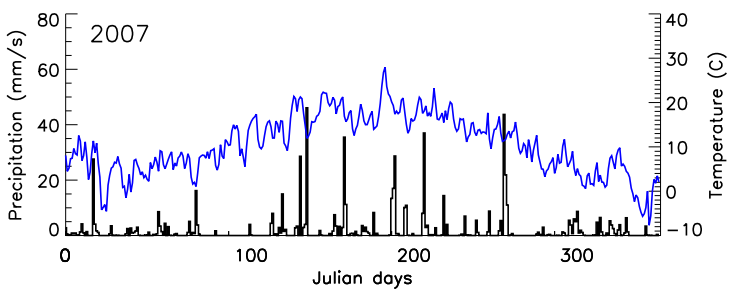


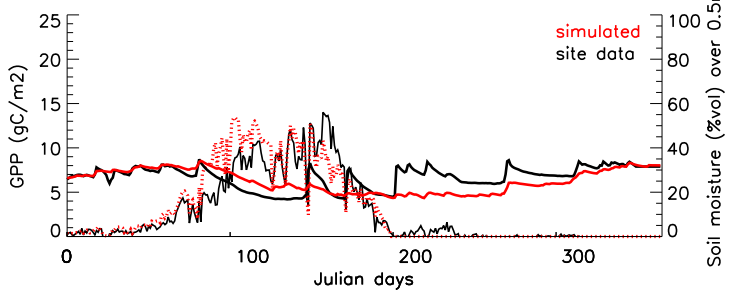






Gebesee





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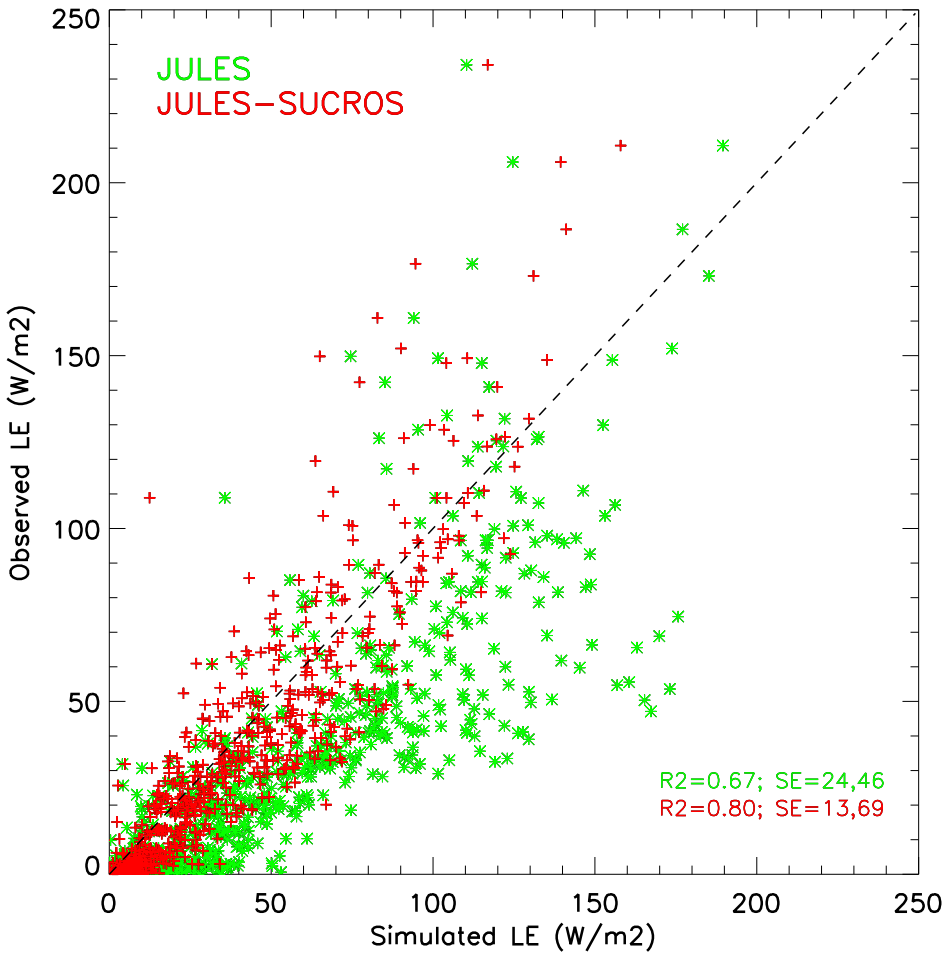
The simulation of fluxes are improved with JULES-SUCROS



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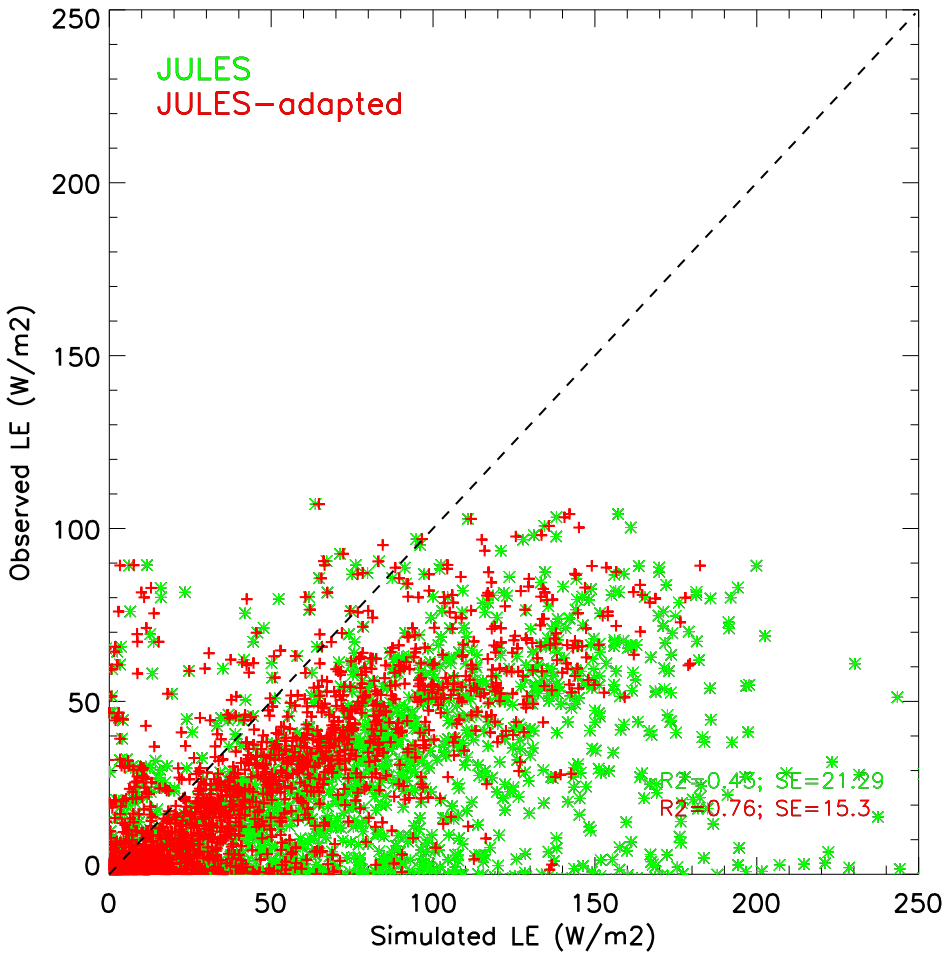
Some LE Bias Remains at Vielsalm



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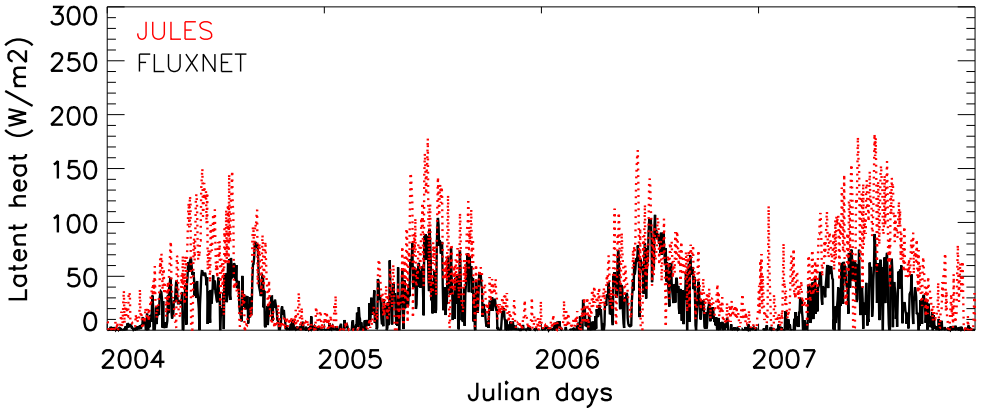
Small Sensitivity to Interannual Variability for Forest Ecosystem



- Forcing with VAI (=WAI+LAI), with constant seasonal cycle
- No interactive phenology and LAI for forest ecosystems
- Poor soil hydraulic parameterisation

Need to look at (*cfr. poster Rémy Soubie*):

- Contribution of transpiration, top canopy and soil evaporation
- Contribution of needle and broad leaf trees individually

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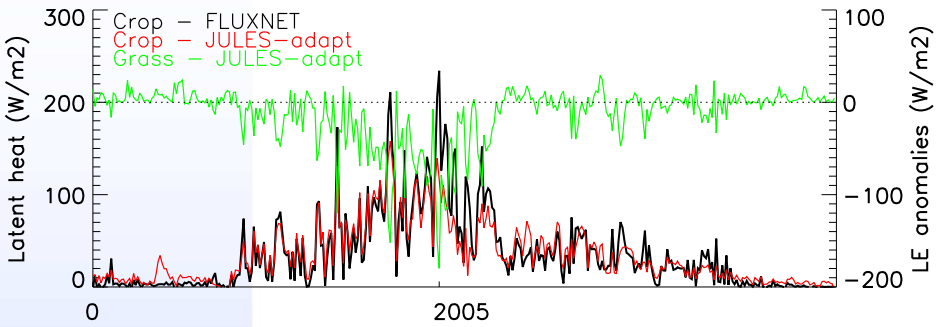
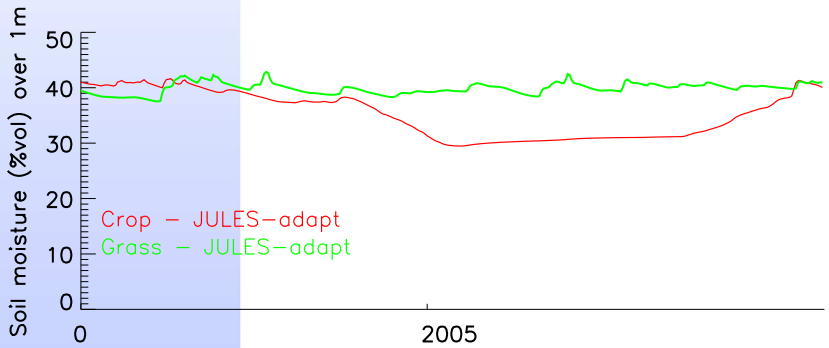
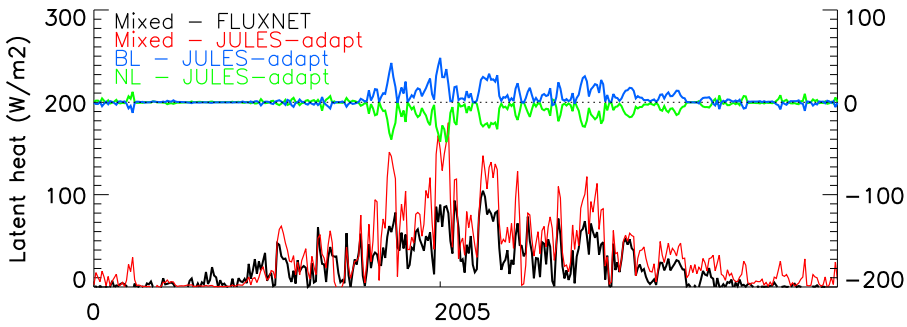
Sensitivity to Vegetation Type

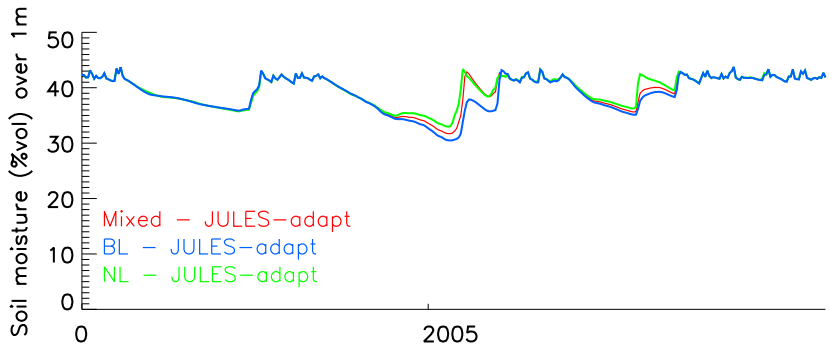
Lonzée (C3 grass vs. crop)





Vielsalm (mixed vs. BL vs. NL)





The model is rather sensitive to intra-annual varibility.

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Conclusion

- The adapted version of JULES for cropland, JULES-SUCROS, responds consistently to a variety of environmental forcings.
- Overall, the adapted model is sensitive to vegetation type and intra-annual variations.
- However, further investigations are required, in particular concerning forest ecosystems:
  - Better parameterisation and process representation (interactive LAI and phenology)
  - Validation at intermediate steps and at other sites (eg. Brasschaat)