COSMO-CLM Soil and Vegetation Working Group:

Report on recent activities

Summary

I. Implementation of the European Soil DataBase (JRC) in COSMO-CLM

II. Coupling COSMO-CLM with the Community Land Model.

Implementation of the European Soil DataBase (JRC) in COSMO-CLM

Master thesis of Christine Kündig
(advisor Sonia Seneviratne; co-advisor Edouard Davin)

Motivations

- Replace the standard Soil Map of the World (FAO) by the more recent and better resolved (1km) European Soil DataBase (JRC).
- What is the sensitivity of the simulated climate to the soil type distribution? (Anders & Rockel, 2008)

implementation

- The JRC raw dataset was converted into a form suitable for the PEP pre-processor.
- The PEP was used to produce an external parameter file containing the JRC dataset (done by G. Smiatek).
- The new external parameter file can be used as input for int2lm to create the laf boundary files.

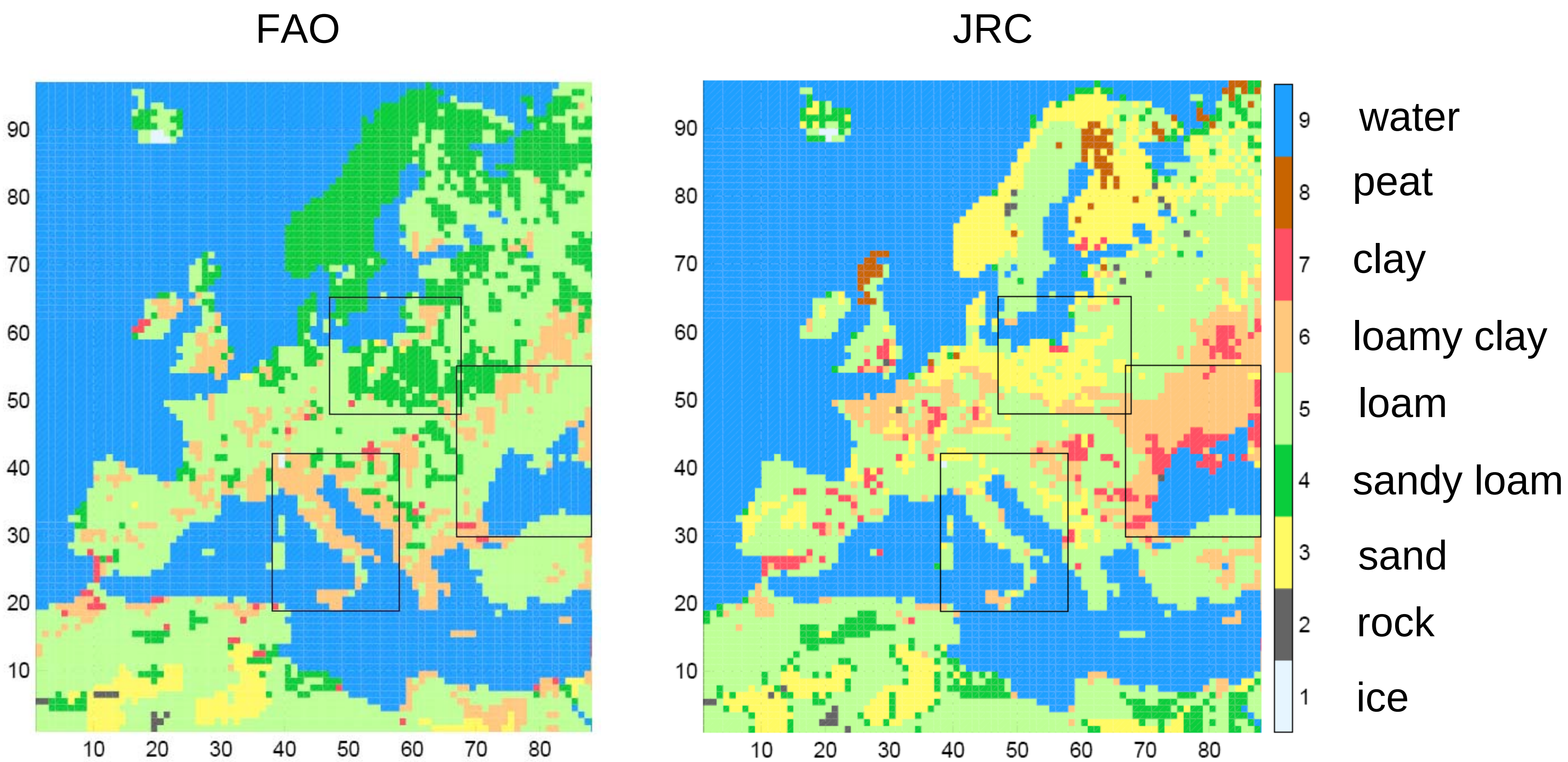
Experiments

CTL: FAO soil map

EXP: JRC soil map

- Version: 2.4.11
- Resolution: 50km
- Boundary fields: ERA40 reanalysis
- Initialyzed with the same soil moisture state
- Period: 1992-2006 (last 10 years are analysed)

Soil maps

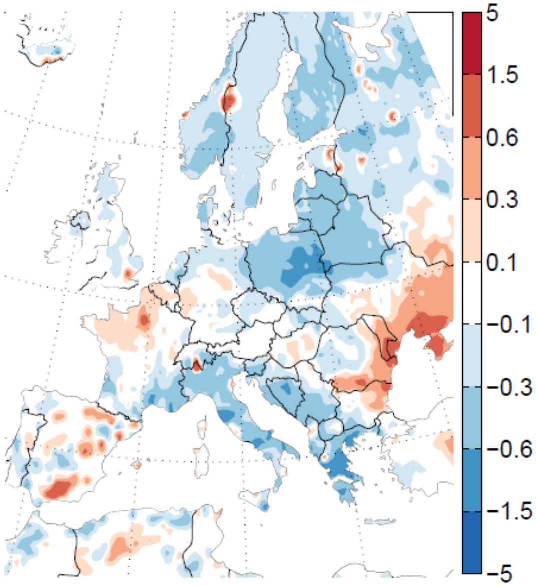

FAO
JRC
90
80
70
60
50
40
30
20
10
10 20 30 40 50 60 70 80
9 water
8 peat
7 clay
6 loamy clay
5 loam
4 sandy loam
3 sand
2 rock
1 ice

Soil parameters

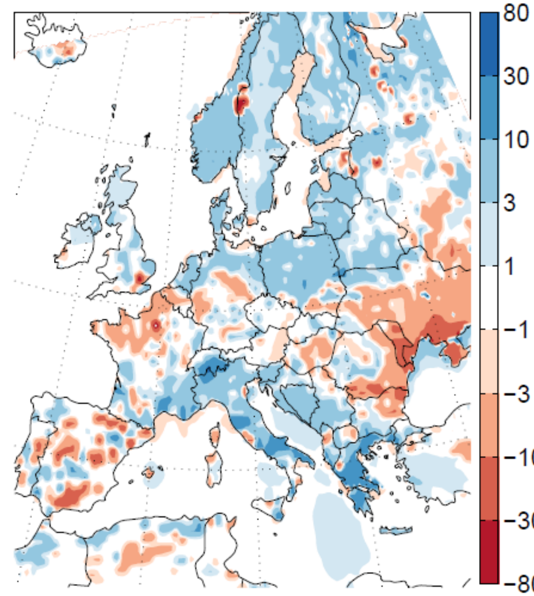
soil type	1 ice	2 rock	3 sand	4 sandy loam	5 loam	6 loamy clay	7 clay	8 peat
volume of voids w_{PV} [1]	-	-	0.364	0.445	0.455	0.475	0.507	0.863
field capacity w_{FC} [1]	-	-	0.196	0.260	0.340	0.370	0.463	0.763
permanent wilting point w_{PWP} [1]	-	-	0.042	0.100	0.110	0.185	0.257	0.265
air dryness point w_{ADP} [1]	-	-	0.012	0.030	0.035	0.060	0.065	0.098
minimum infiltration rate I_{K2} [kg/(m^2 s)]	-	-	0.0035	0.0023	0.0010	0.0006	0.0001	0.0002
hydraulic diffusivity parameter D_0 [10^{-9} m^2/s]	-	-	18400	3460	3570	1180	442	106
hydraulic diffusivity parameter D_1 [1]	-	-	-8.45	-9.47	-7.44	-7.76	-6.74	-5.97
hydraulic conductivity parameter K_0 [10^{-9} m/s]	-	-	47900	9430	5310	764	17	58
hydraulic conductivity parameter K_1 [1]	-	-	-19.27	-20.86	-19.66	-18.52	-16.32	-16.48
heat capacity $\rho_0 c_0$ [10^6 J/(m^3 K)]	1.92	2.10	1.28	1.35	1.42	1.50	1.63	0.58
heat conductivity								
λ_0 [W/(K m)]	2.26	2.41	0.30	0.28	0.25	0.21	0.18	0.06
$\Delta\lambda$ [W/(K m)]	0.0	0.0	2.40	2.40	1.58	1.55	1.50	0.50
exponent B [1]	1.0	1.0	3.5	4.8	6.1	8.6	10.0	9.0

Results for summer JJA

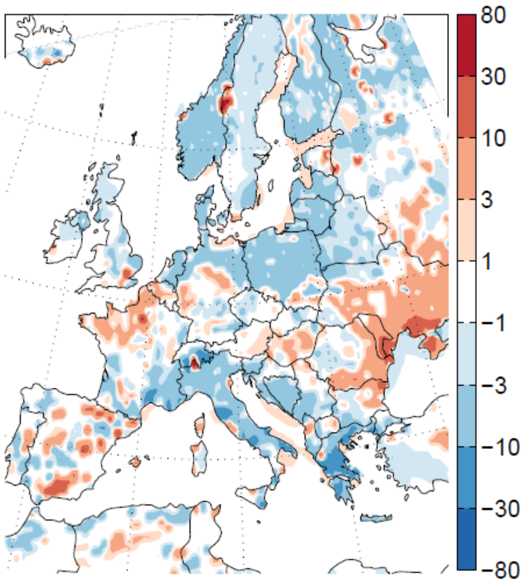
EXP - CTL



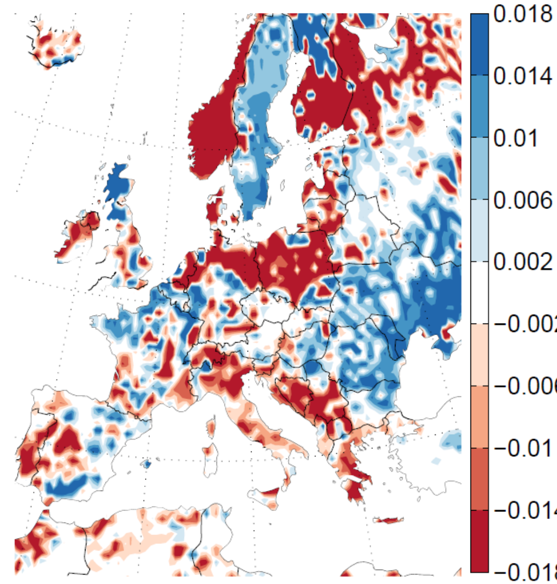
T2m



LH



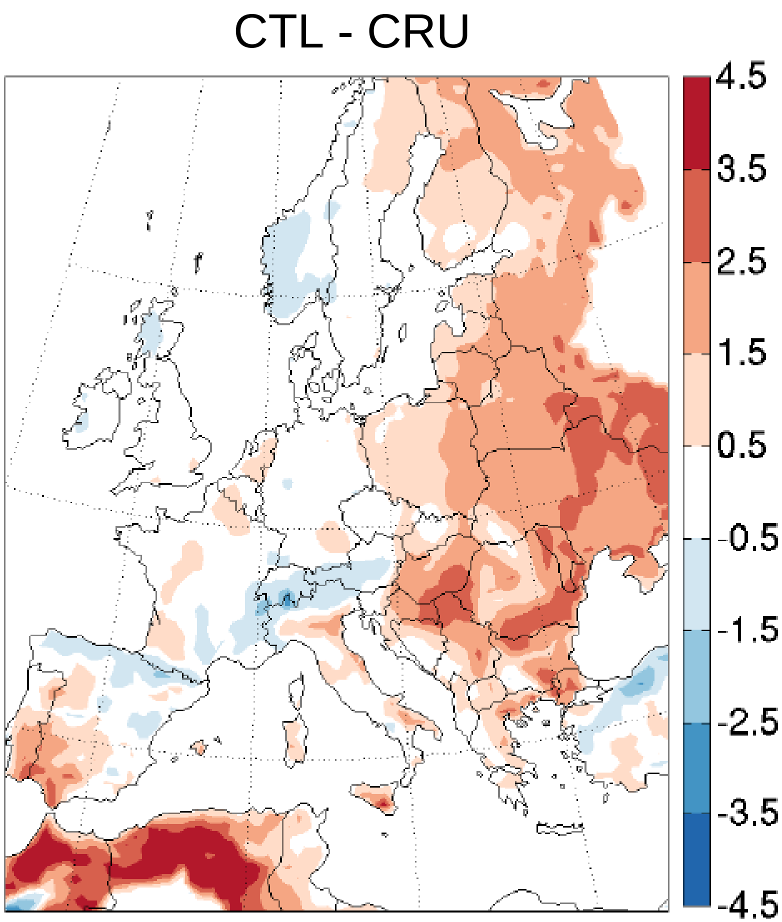
SH

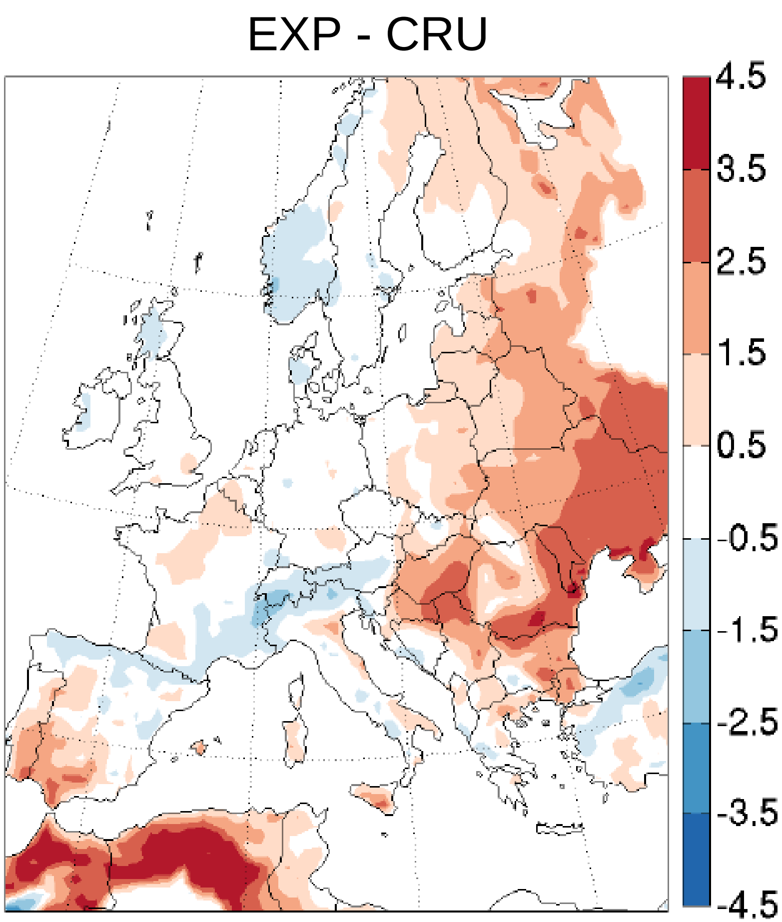


SM

Comparaison with observations

T2m JJA

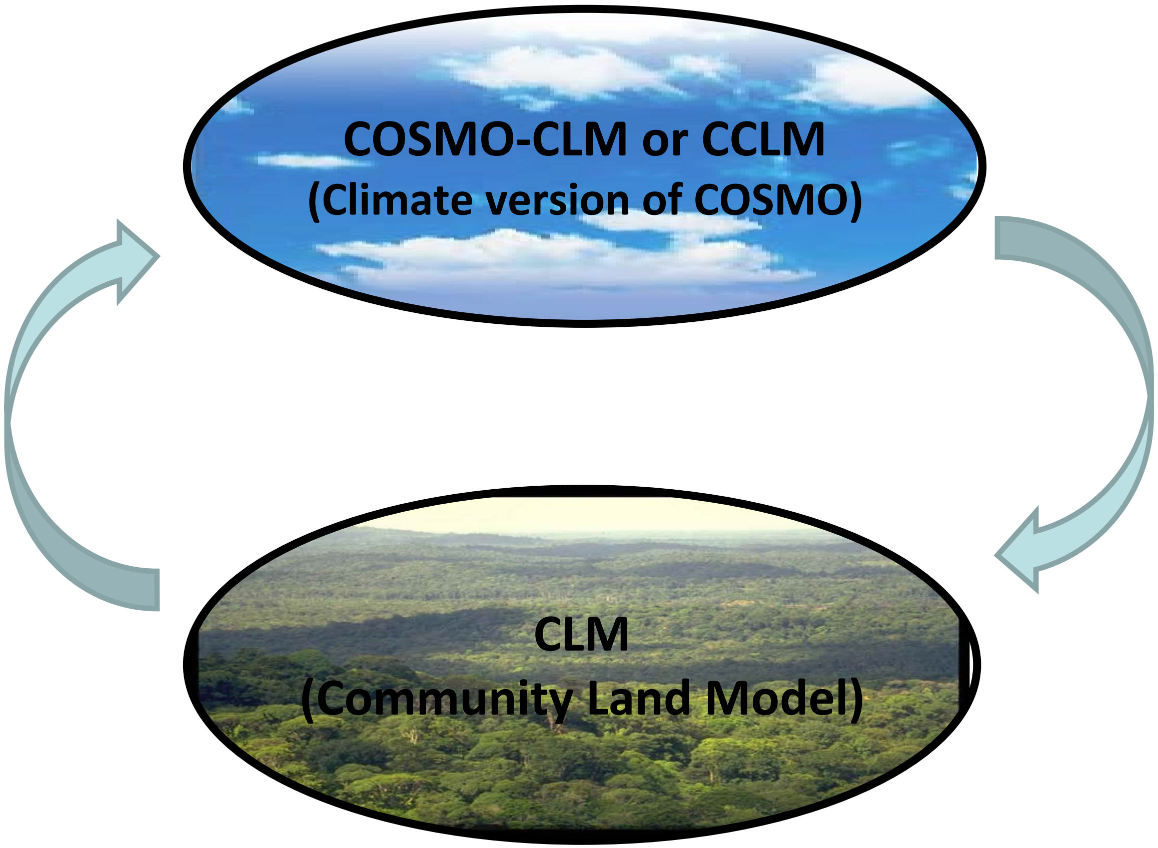




Coupling COSMO-CLM with the Community Land Model (CLM)

Persons directly involved: Edouard Davin, Reto Stockli, Sonia Seneviratne

CCLM-CLM


COSMO-CLM or CCLM
(Climate version of COSMO)
CLM
(Community Land Model)

Motivations

- Weather prediction and Climate simulations imply different needs in terms of land surface parameterization.

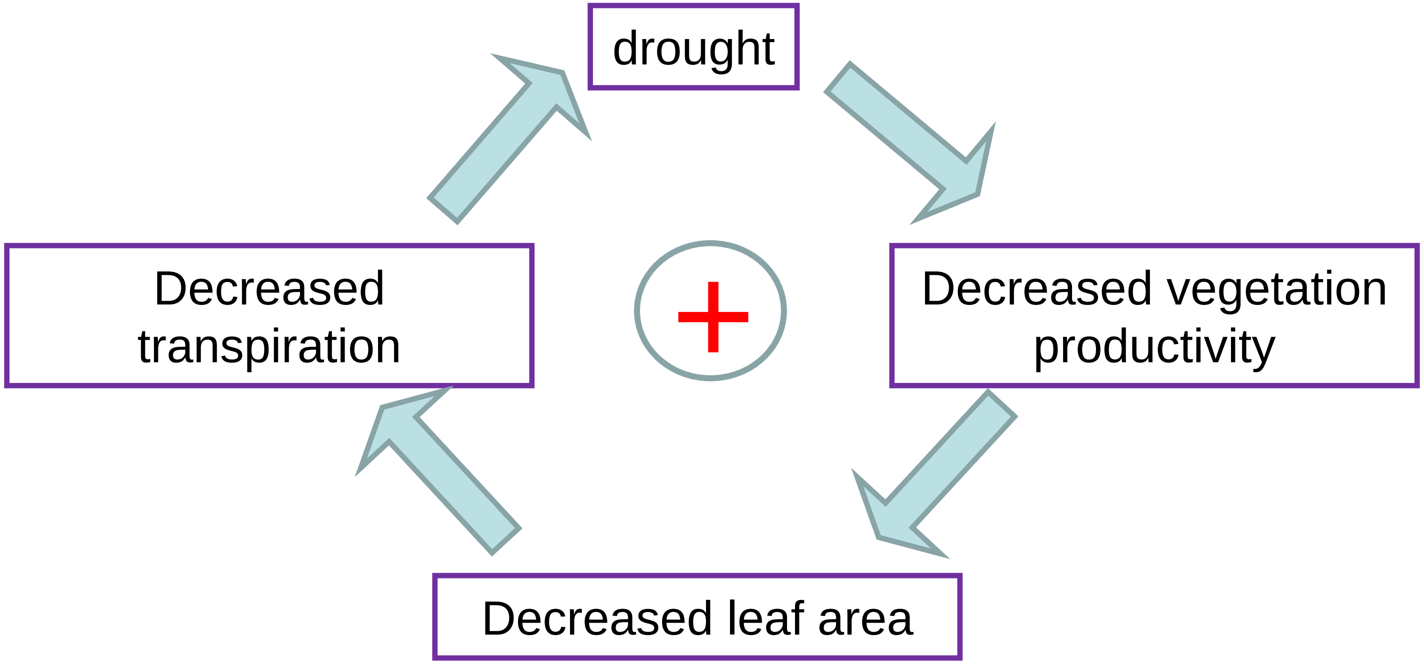
- At climate time scales, vegetation can not be considered as a “static system”. Some examples:
  - CO2 effect on vegetation.
  - Change in phenology.
  - Change in vegetation distribution (natural vegetation dynamics or land use change).

- The closure of water and energy budget at the surface is also an issue in climate mode.

Motivations

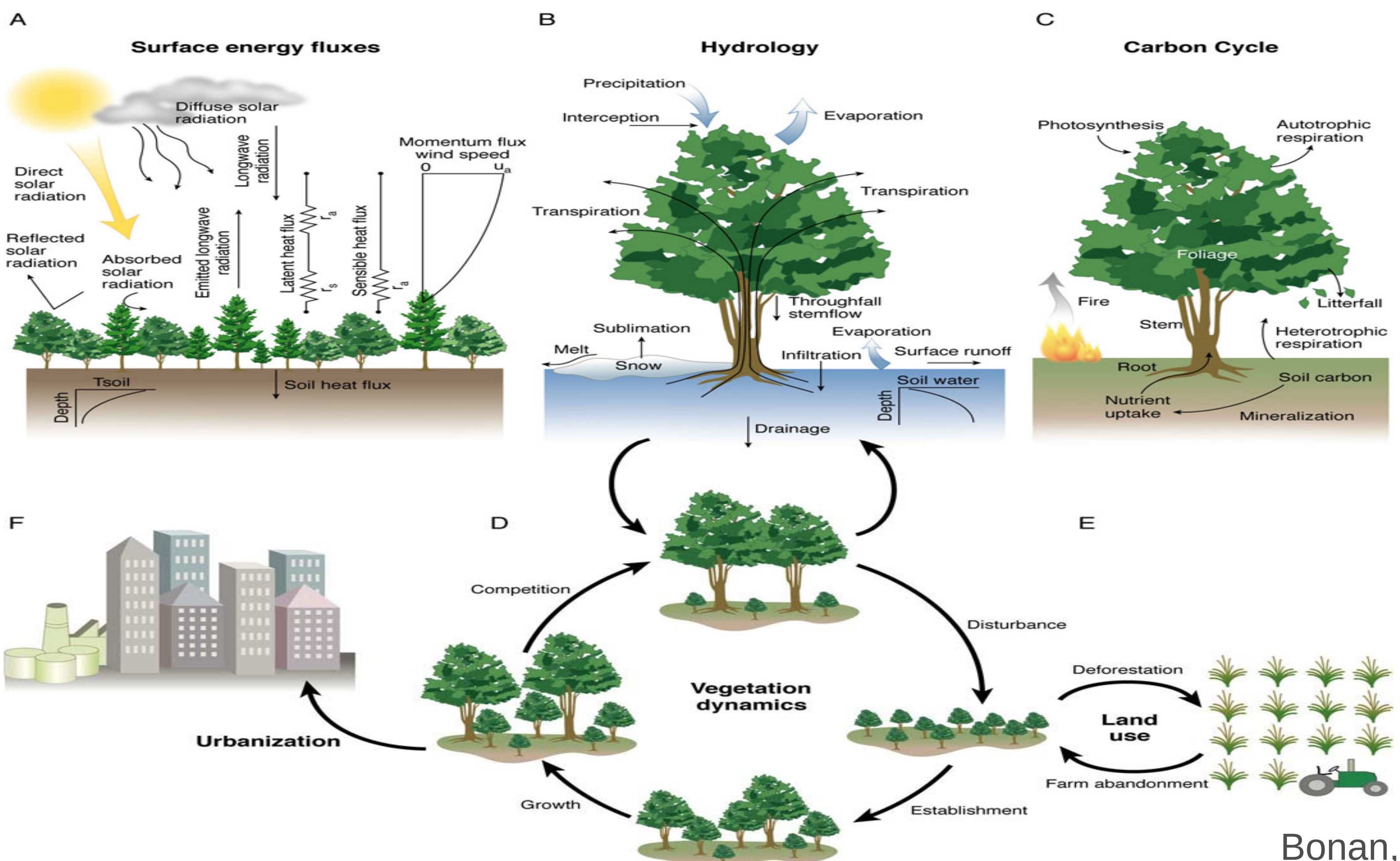
- Land surface processes provide feedbacks that may dampen or amplify climate variations.

Example of feedback: Phenology



Community Land Model (CLM)

- The CLM is the land surface component of the NCAR CCSM climate model.
- Latest generation of LSM representing biogeophysics, hydrology, C/N cycles and vegetation dynamics.



Bonan, 2008

TERRA-ML versus CLM

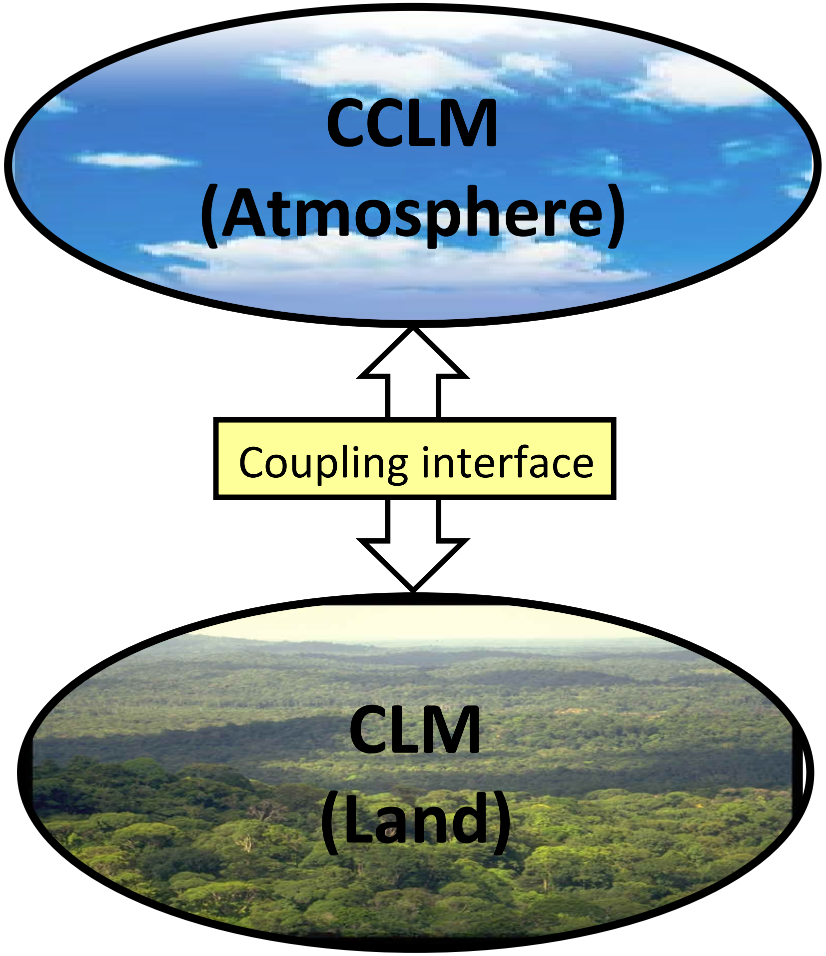
	TERRA-ML	CLM
Soil water	Multi-layer scheme	Multi-layer with prognostic ground water
Snow cover	1 layer	Multi-layer including compaction and melt-freeze cycle
Radiation	Not included	Radiative transfer within the canopy (SW, LW, direct, diffuse)
Transpiration	Does not account for CO_2 effect	Accounts for CO_2 effect
Vegetation phenology (LAI)	Prescribed	Prescribed or prognostic scheme
Biogeochemistry	Not included	Prognostic C/N cycle (optional)
Vegetation dynamic	Not included	Included (optional)

Coupling strategy

- The coupling strategy is meant to minimize changes made in both CCLM and CLM (facilitate version updates).

- A coupling interface enables the communication between CCLM and CLM.

- A switch controlling the use of TERRA versus CLM has been introduced in CCLM.



Coupling strategy

– TERRA-ML calculates the surface state (surface temperature, humidity…) not surface fluxes.
– Transfer coefficients for sensible and latent heat (C_h and C_q) and then surface fluxes are calculated as part of the boundary layer scheme.

$$H = C_h |v_h| (T_a – T_s)$$

$$LE = C_q |v_h| (q_a – q_s)$$

Problem...

– CLM provides directly surface fluxes to the atmosphere!

Solution:

1) Surface fluxes are first calculated by CLM.
2) Fluxes are passed to the coupling interface and are inverted to retrieve the transfer coefficients which are then passed to the atmospheric model.
3) Surface fluxes are finally recalculated in the atmospheric part (ideally the fluxes calculated in the atmospheric part should be similar to CLM fluxes).

Performances

- Since last September CCLM-CLM is running on the Cray XT cluster at the Swiss National Supercomputing Centre (CSCS).
- It is also currently tested on a NEC platform at ECMWF (A. Dossio).

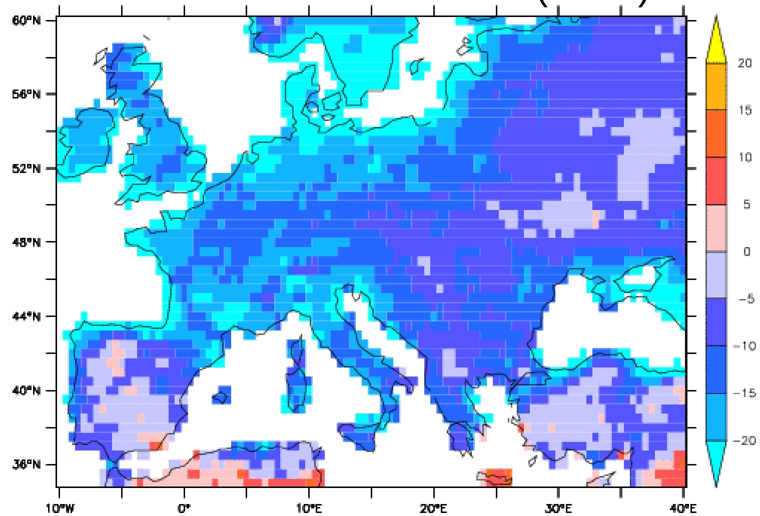
Performance on the Cray XT3 (palu.cscs)

	CCLM	CCLM-CLM
4 processors	486 s/day	561 s/day (+15%)

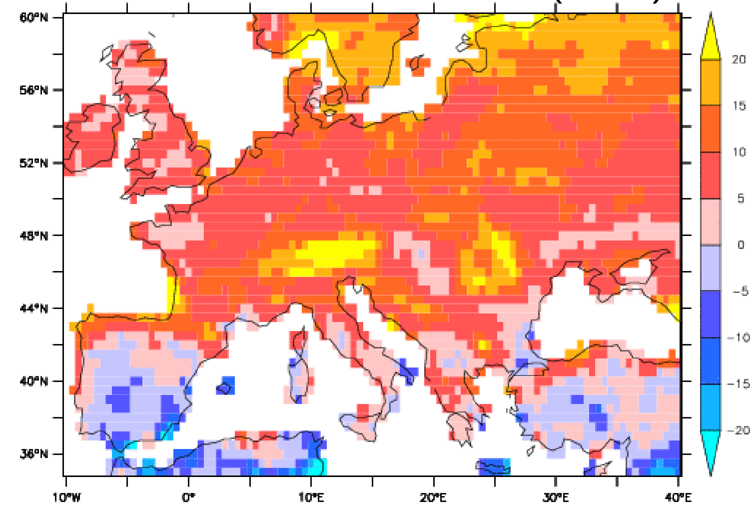
First test

Comparison of CCLM-CLM versus CCLM (1 year run without spinup)

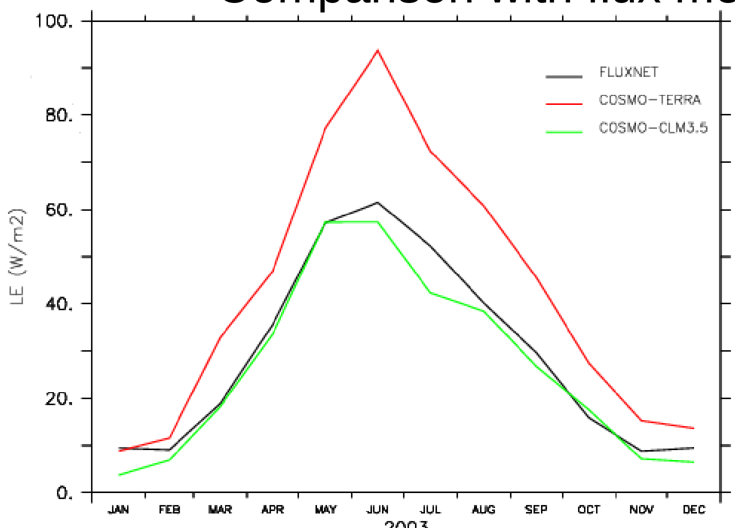
Annual mean latent heat (W/m²)

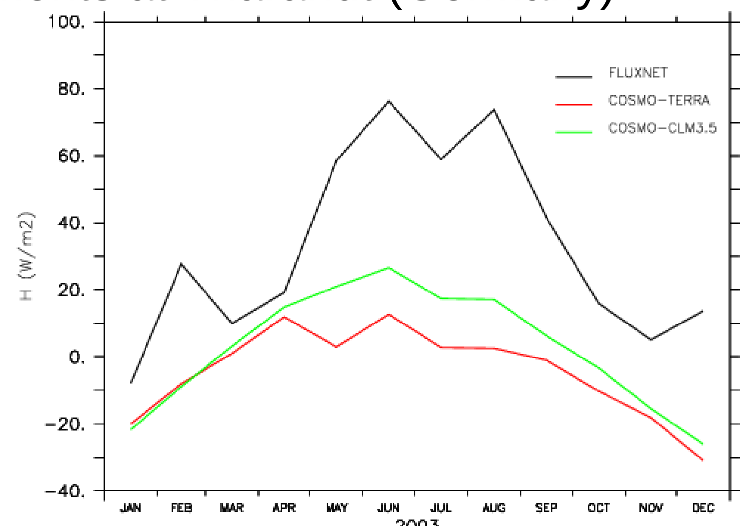


Annual mean sensible heat (W/m²)



Comparison with flux measurements at Tharandt (Germany)





Timeframe

- March 2009: First frozen version of CCLM-CLM.
- End of summer 2009: Evaluation of present day climate simulated by CCLM-CLM and comparison with standard CCLM.
- End 2009-2010: Simulations with CCLM-CLM over the 20th and 21st centuries (driven by GCM scenarios).

Portability/performances

The makefile is configured dynamically depending on OS/compiler which allows for portability on different platforms (OSX/Darwin, PC/Linux, Cray).

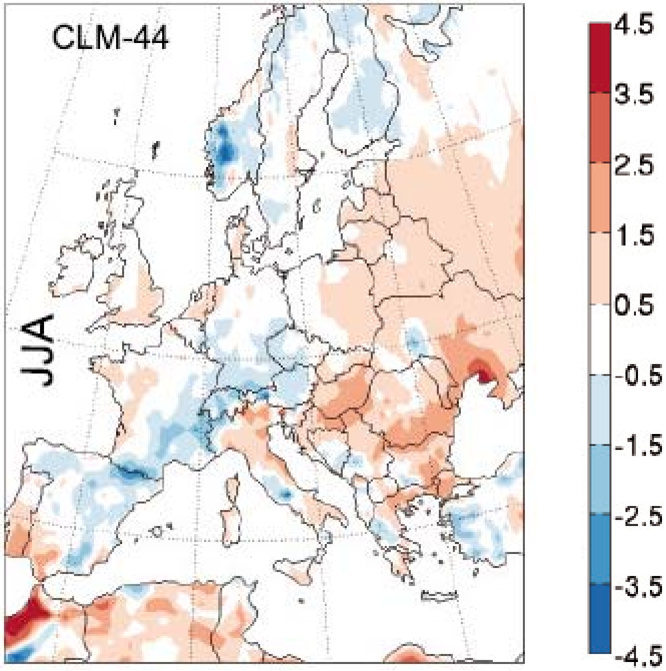
Performances on the Cray XT3 (palu.cscs)

	CCLM	CCLM-CLM
4 processors	486 s/day	561 s/day (+15%)

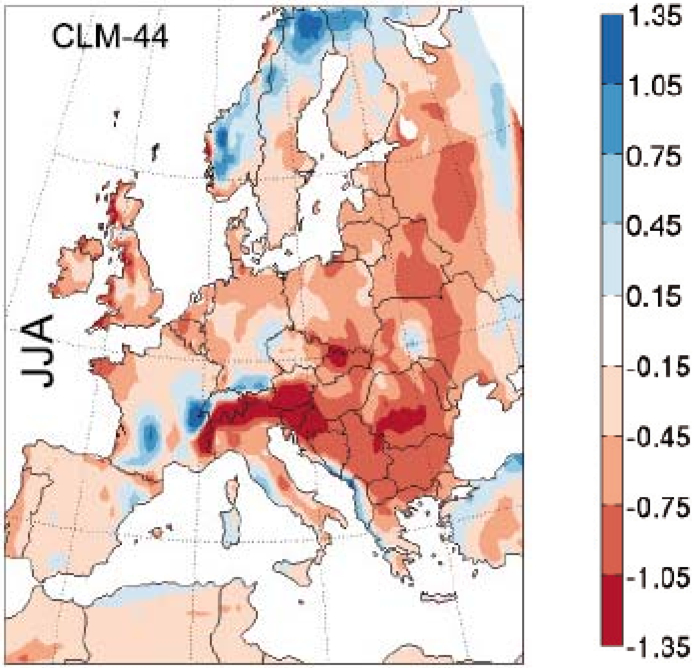
Motivations

- Land surface processes are influencing the climate mean state.
- Common biases in current RCMs are still due to the representation of land surface processes.

Summer temperatures compared to CRU



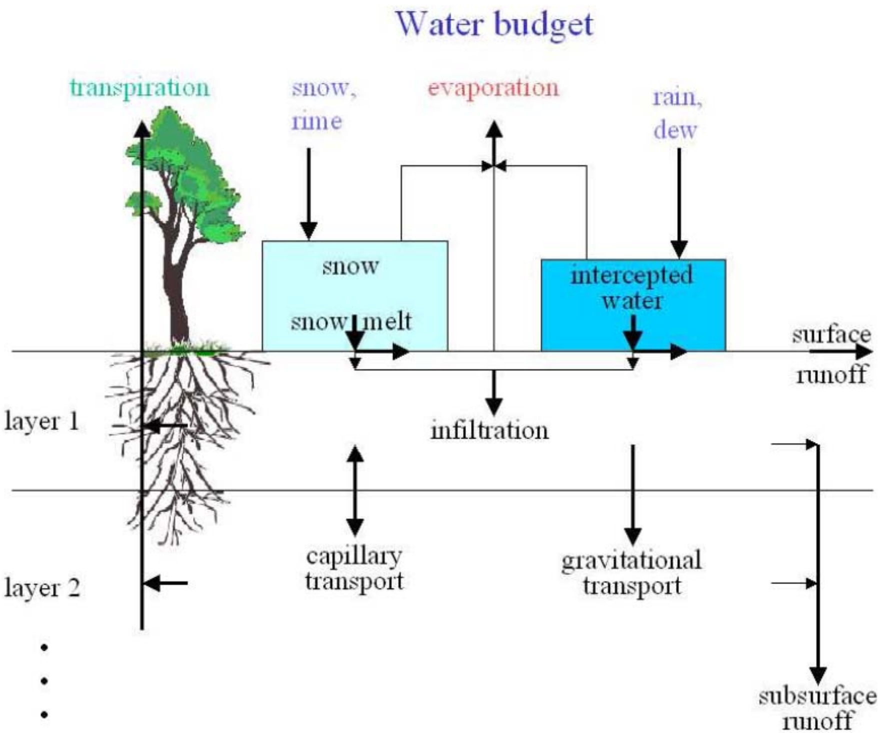
Summer precipitations compared to CRU

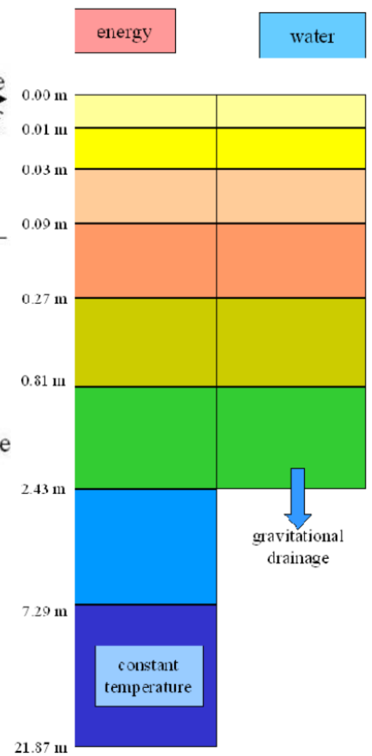


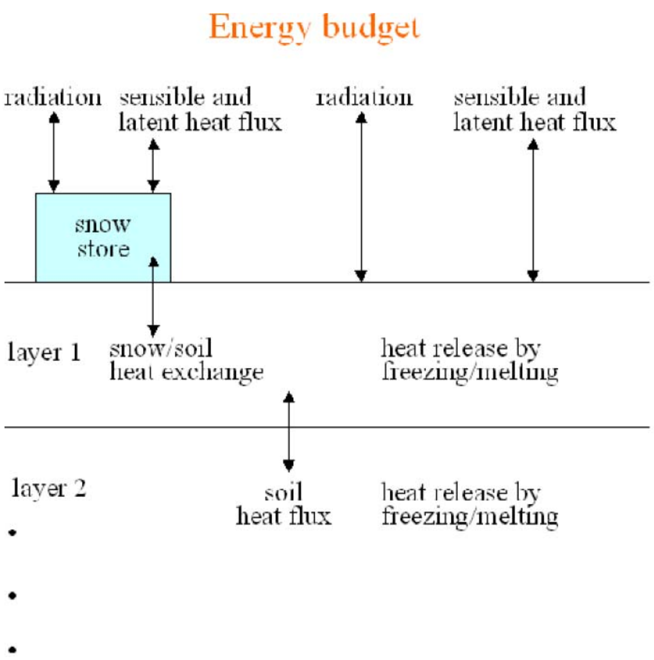
(Jaeger et al., 2008)

TERRA_ML

- TERRA_ML is the land surface component of CCLM.
- It is meant to represent hydrological and thermal processes.
- It provides the lower boundary conditions for the atmospheric part: i.e: the temperature and the specific humidity at the ground.

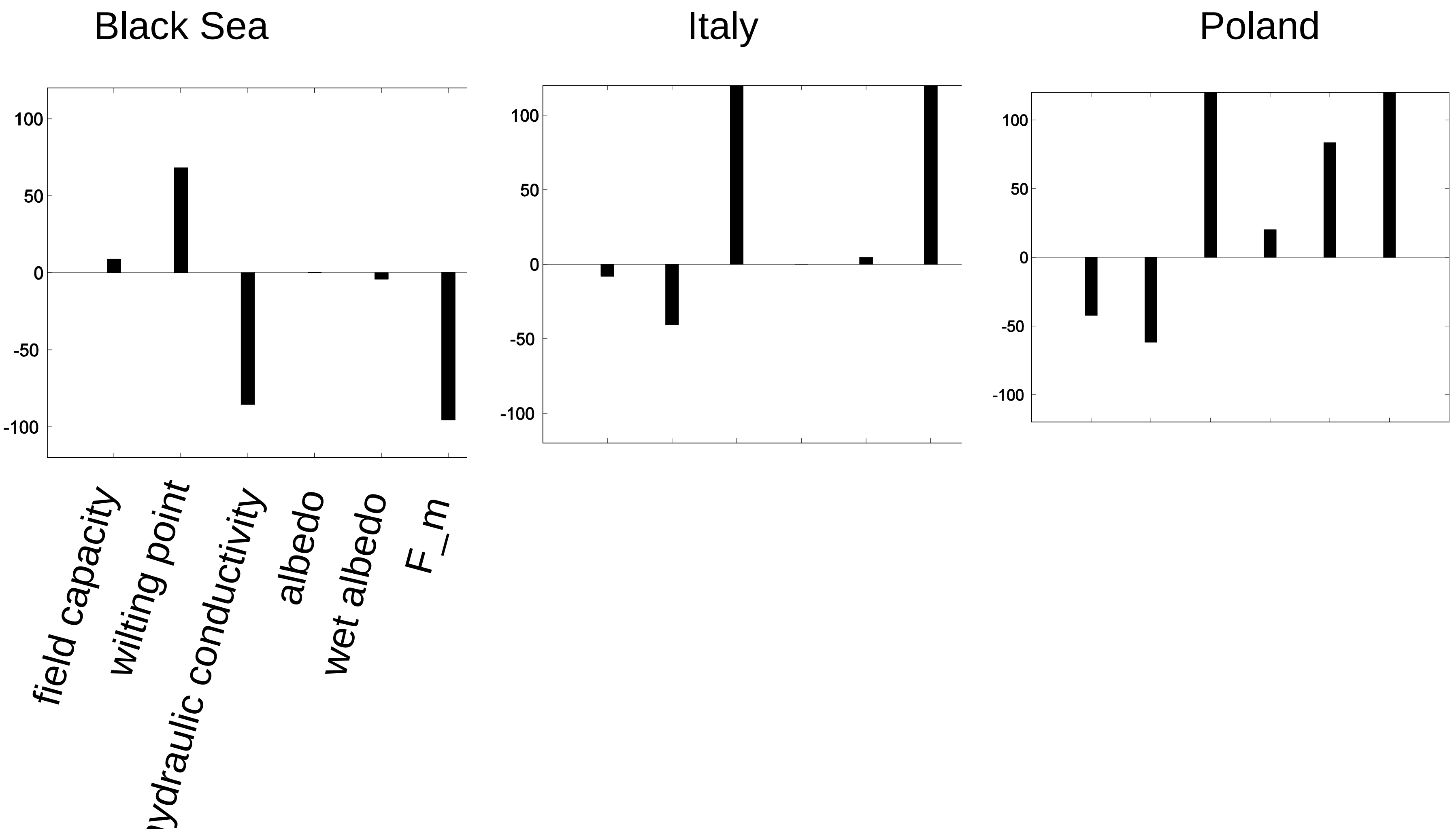






Limitations of TERRA_ML

- "Technical" limitations:
  - TERRA_ML provides only the surface state (temperature and humidity) and not surface fluxes to the atmosphere.
  - TERRA_ML is not a separate component from the atmospheric part, thus it can not be used in a stand-alone mode (i.e, uncoupled from the atmospheric part and forced with meteorological data).
  - ➢ Not possible to evaluate the land surface processes independently of the atmospheric model (e.g., comparison with FLUXNET data).


Black Sea
Italy
Poland
100
50
0
-50
-100
field capacity
wilting point
hydraulic conductivity
albedo
wet albedo
F_m