COSMO-CLM^2 : A summary of its development and evaluation

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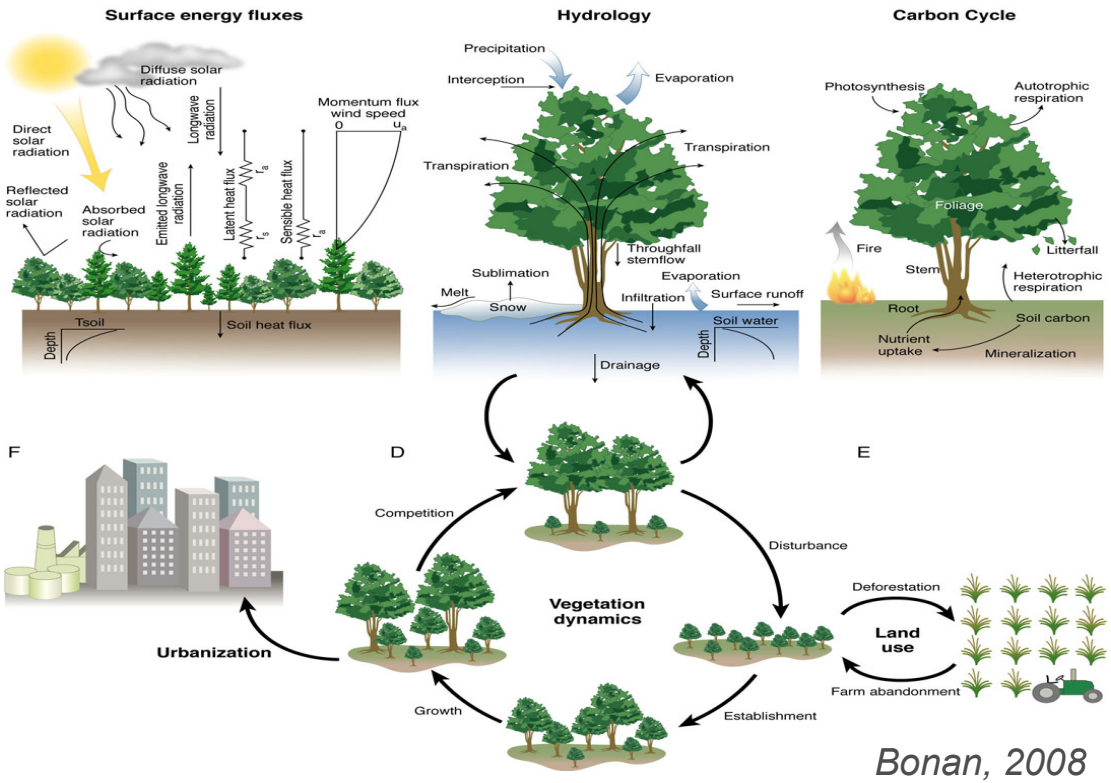
Community Land Model

- Open source
- Extensively documented and evaluated
- State of the art (3rd generation) Land Surface Model representing the links between energy, water and nutrient cycles within the terrestrial biosphere

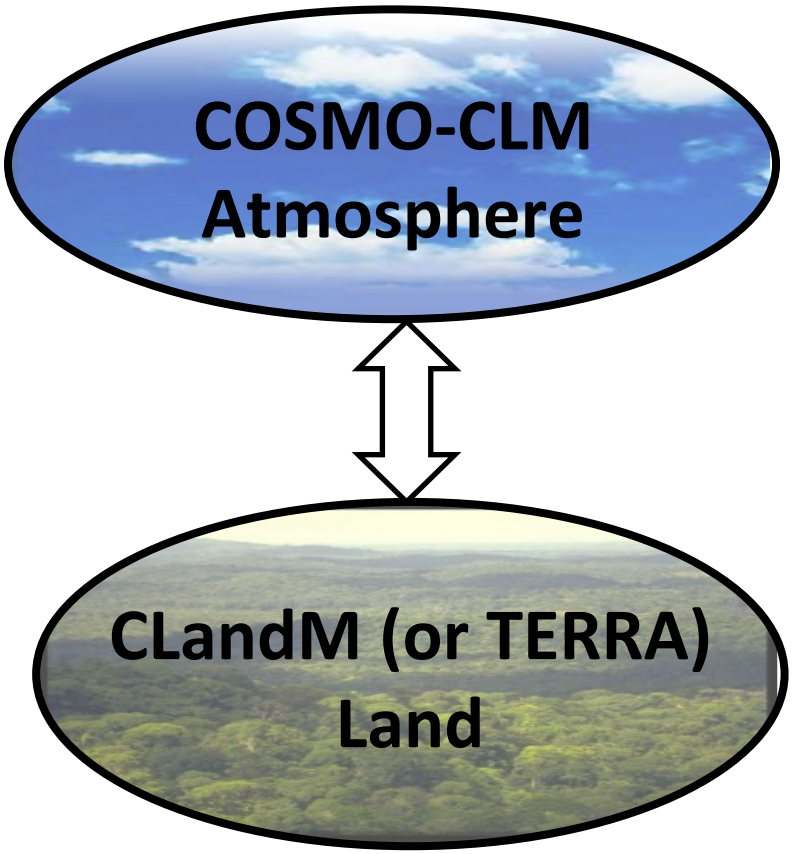


Bonan, 2008

COSMO-CLM^2

First version:

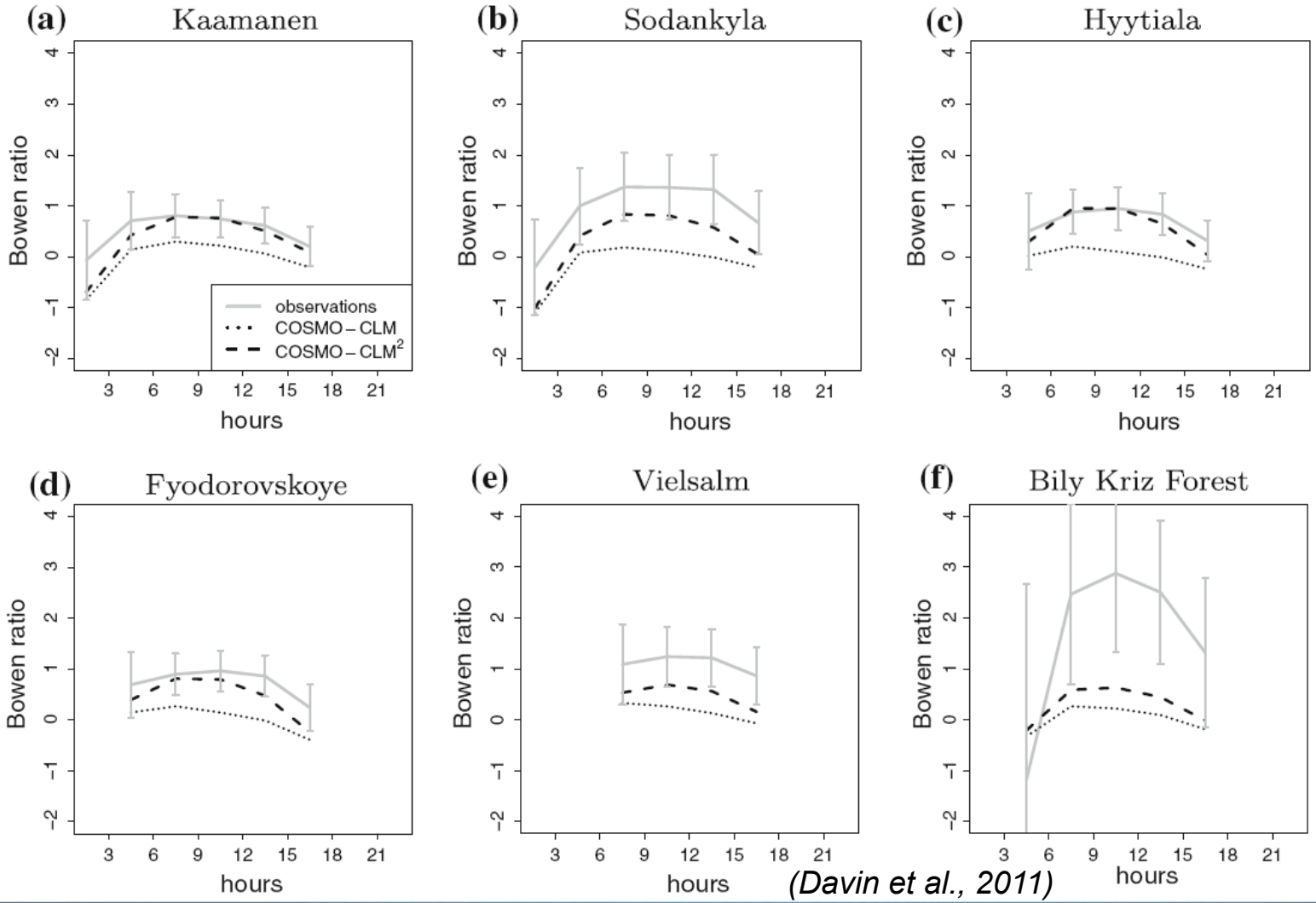
- Implementation finished in 2009
- COSMO-CLM version 4.0
- CLandM version 3.5



Reference:

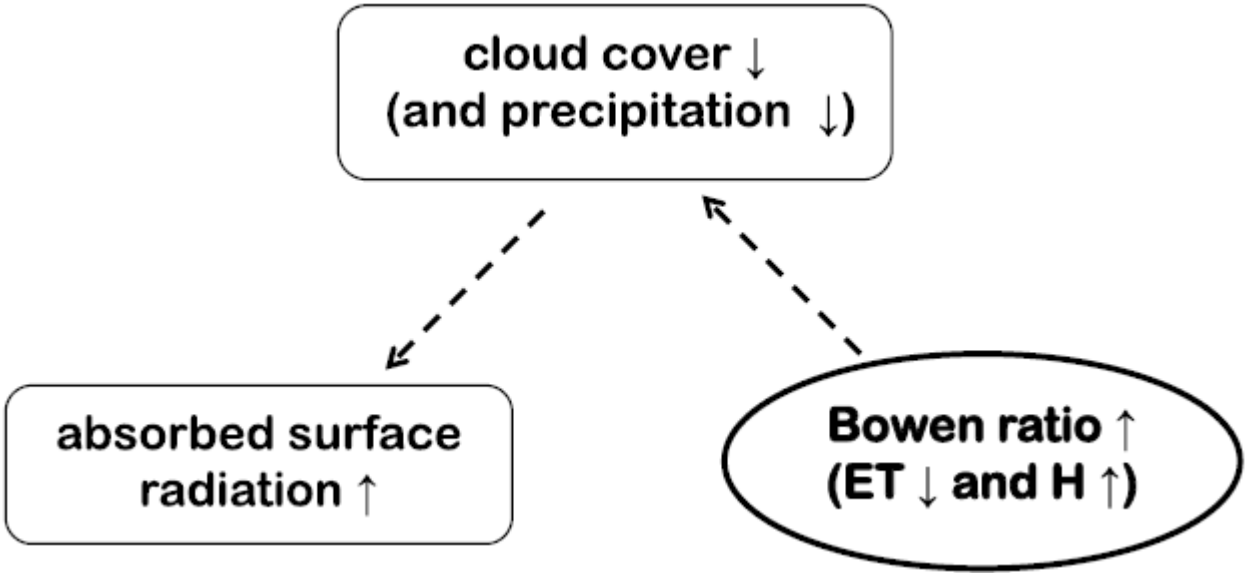
Davin, E. L., R. Stoeckli, E. B. Jaeger, S. Levis and S.I. Seneviratne (2011), COSMO-CLM^2: A new version of the COSMO-CLM model coupled to the Community Land Model, *Clim. Dyn., published online.*

Evaluation at FLUXNET sites



(Davin et al., 2011)

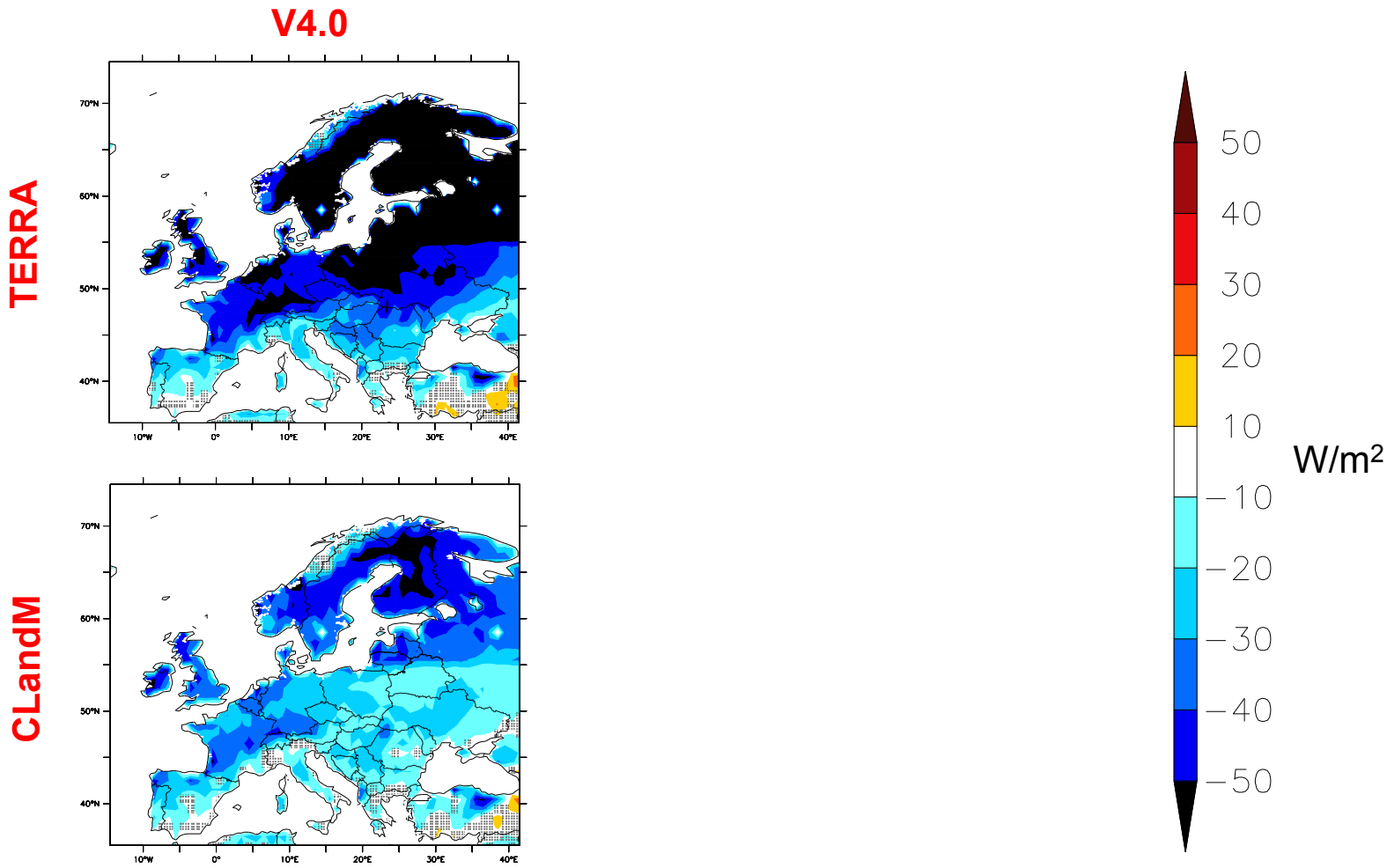
Indirect mechanism via cloud cover



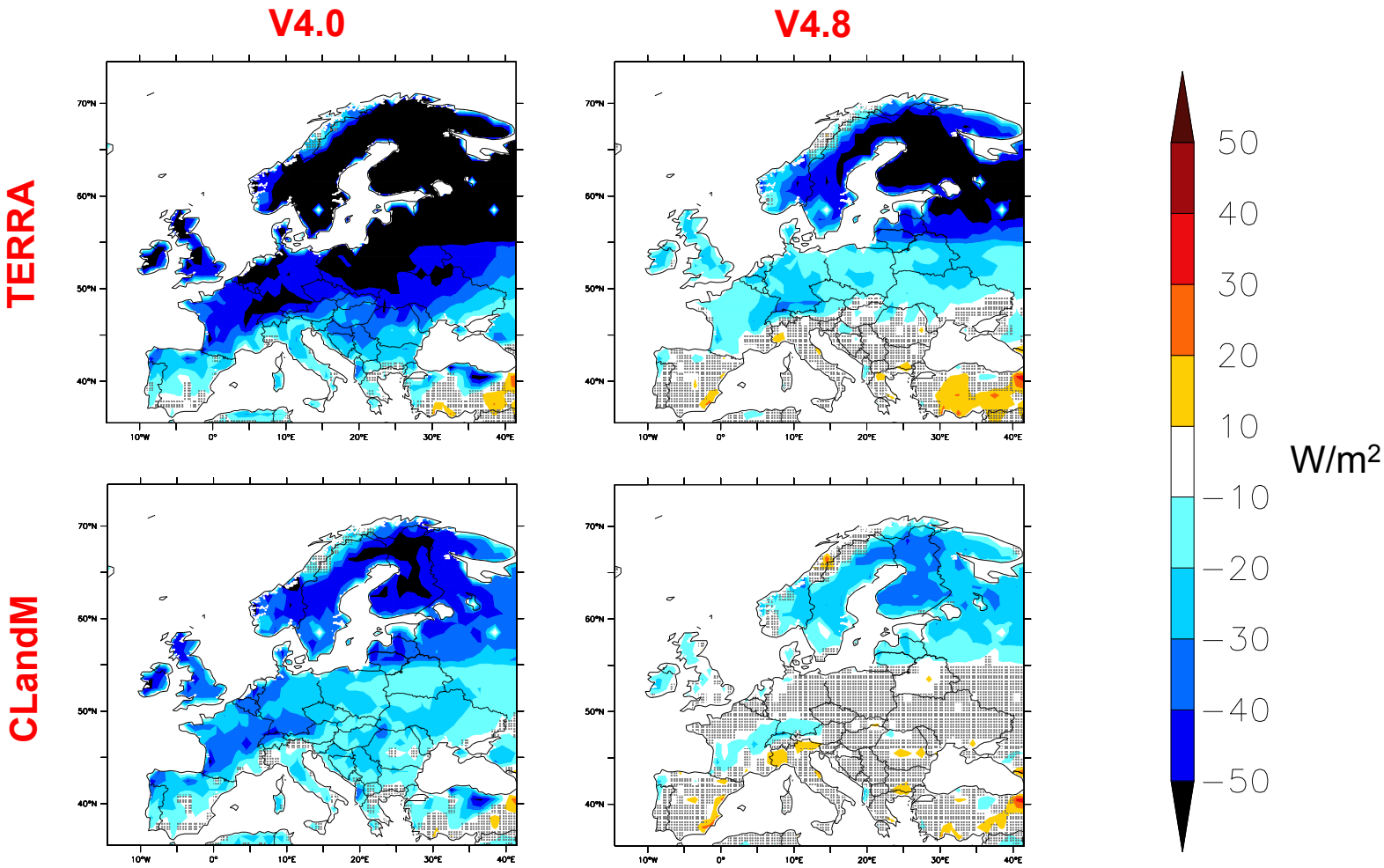
Sensitivity tests with COSMO-CLM (artificial tuning of bowen ratio) support this mechanism

(Davin et al., 2011)

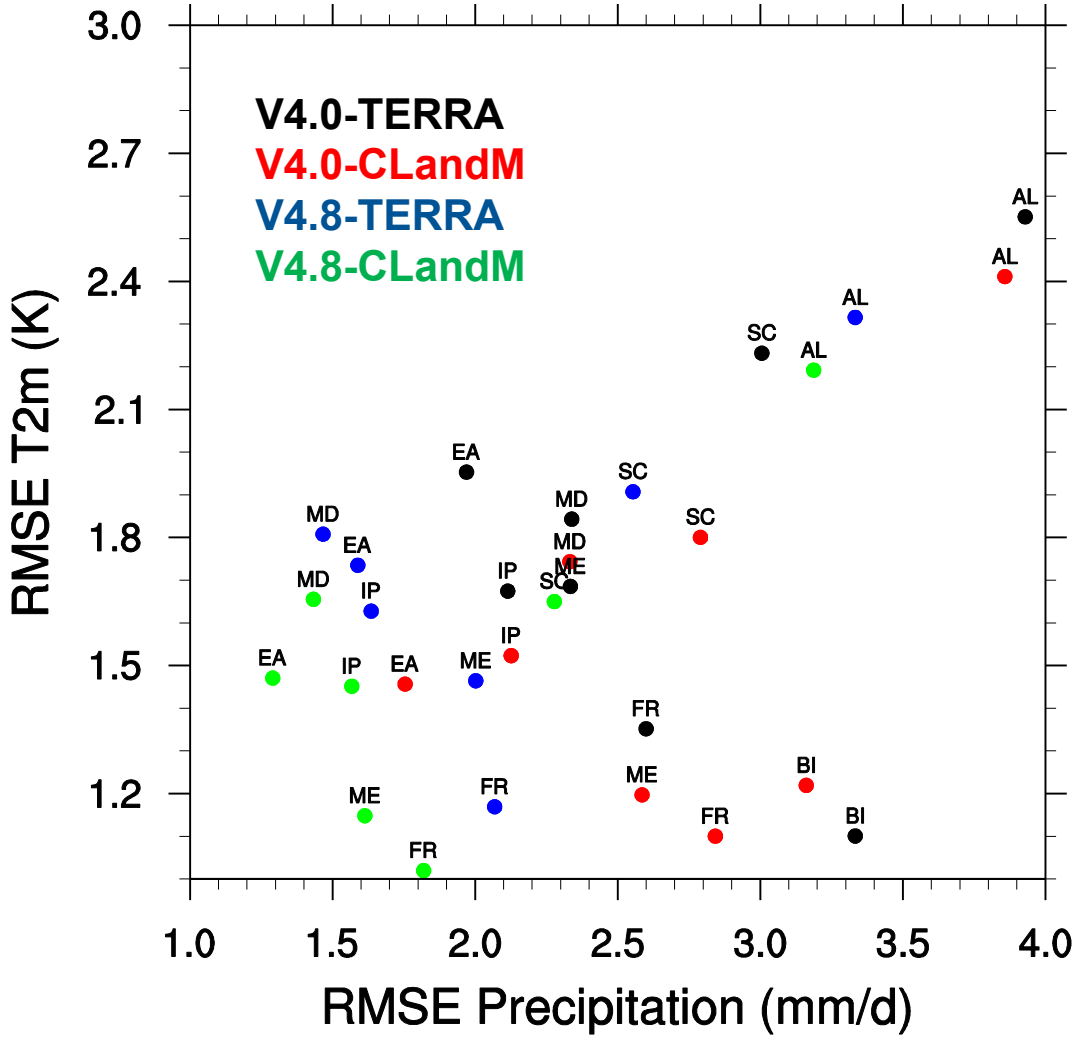
SW radiation bias (JJA) against GSWP-2



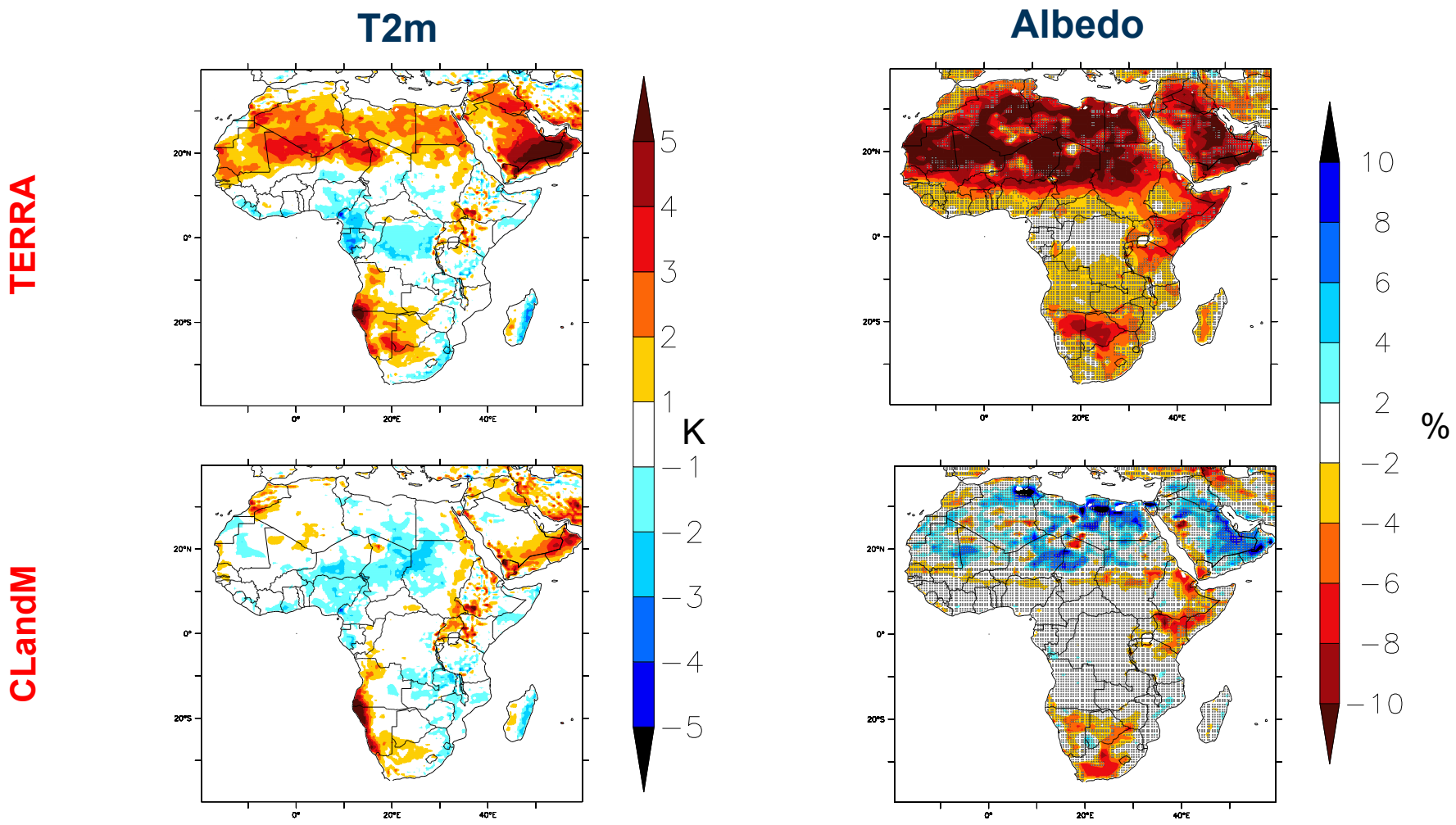
SW radiation bias (JJA) against GSWP-2



Scores for temperature and precipitation



Annual mean bias (IPCC/CORDEX setup)



Role of diffuse/direct radiation partitioning

- The nature of light (diffuse or direct) and not only its quantity affects ecosystem functioning
- Relevant for the carbon cycle and also water and energy fluxes
- Opportunity to couple explicitly downward direct and diffuse radiation components in recent COSMO versions

Default procedure (CTL)

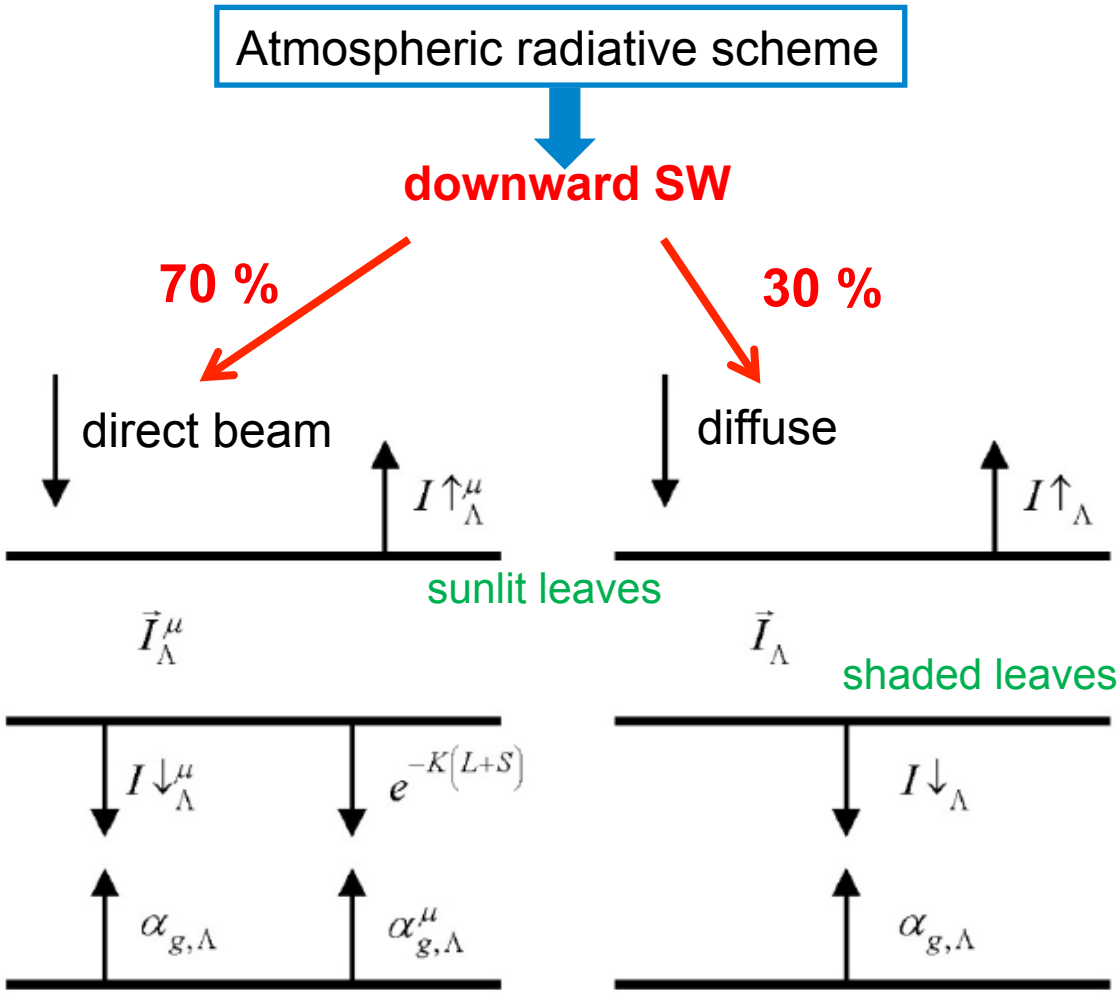


Figure from Oleson et al., 2004

New procedure (EXP)

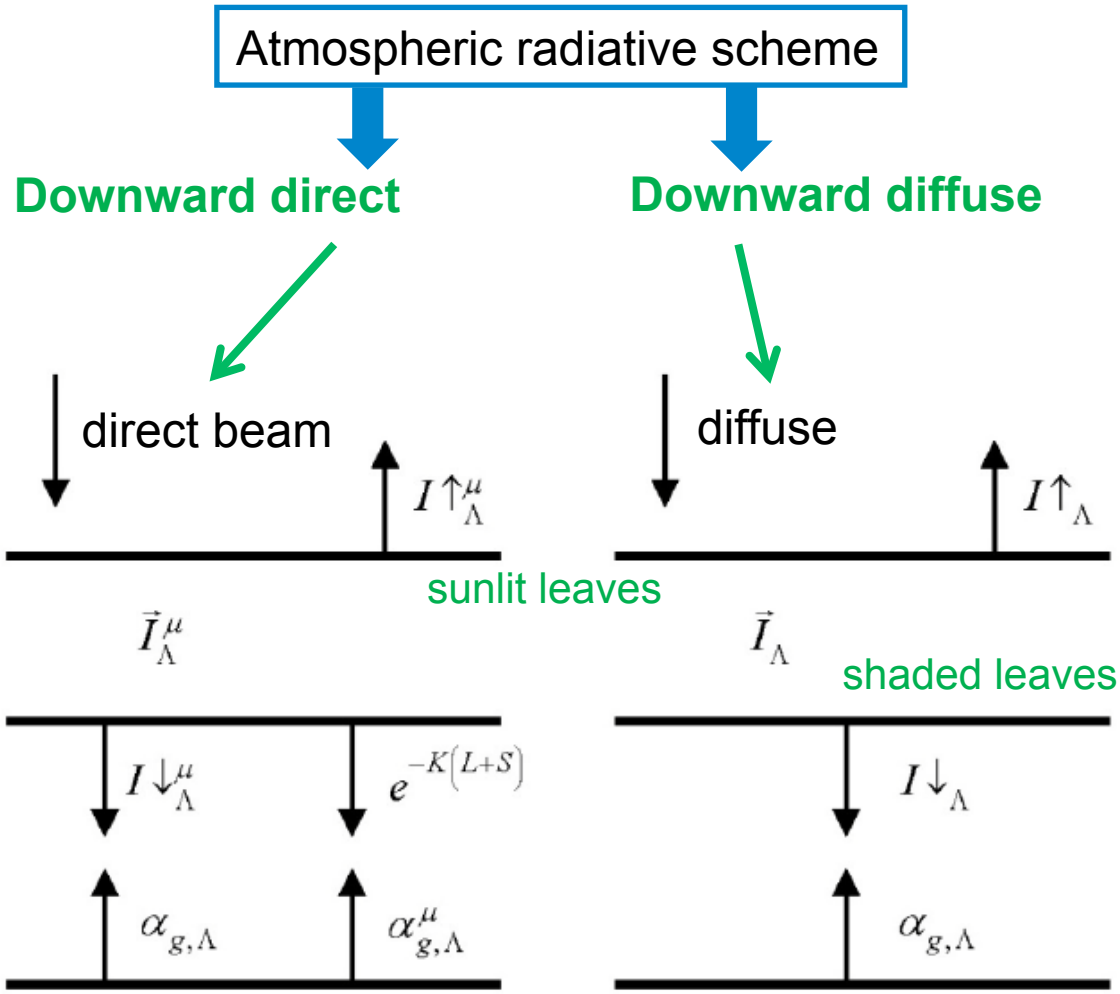
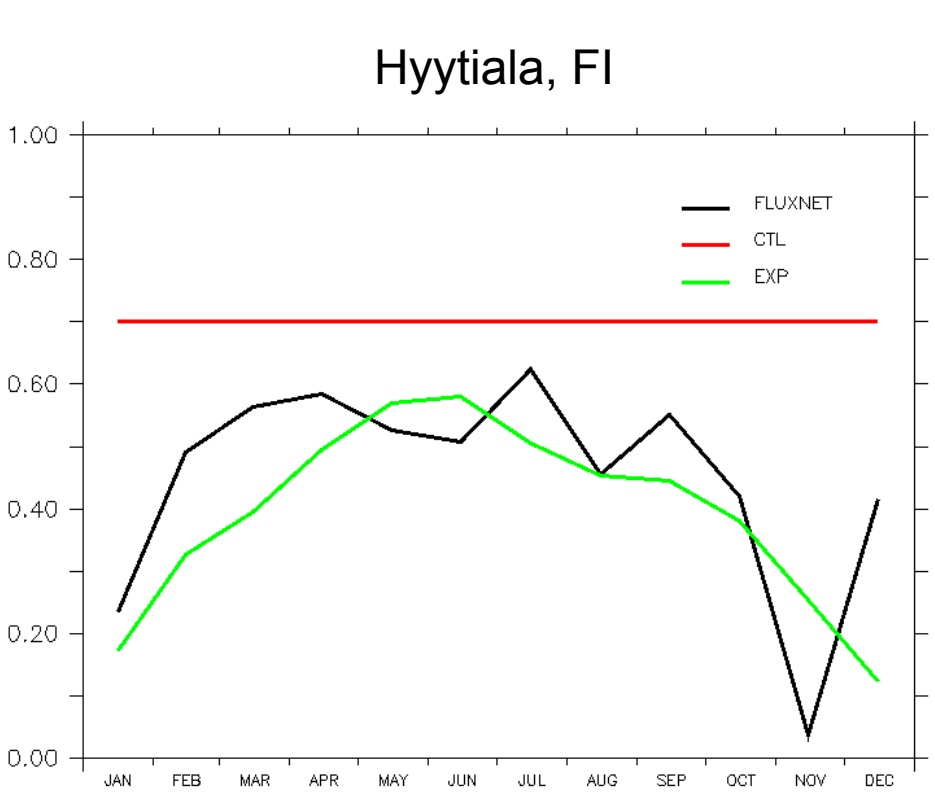
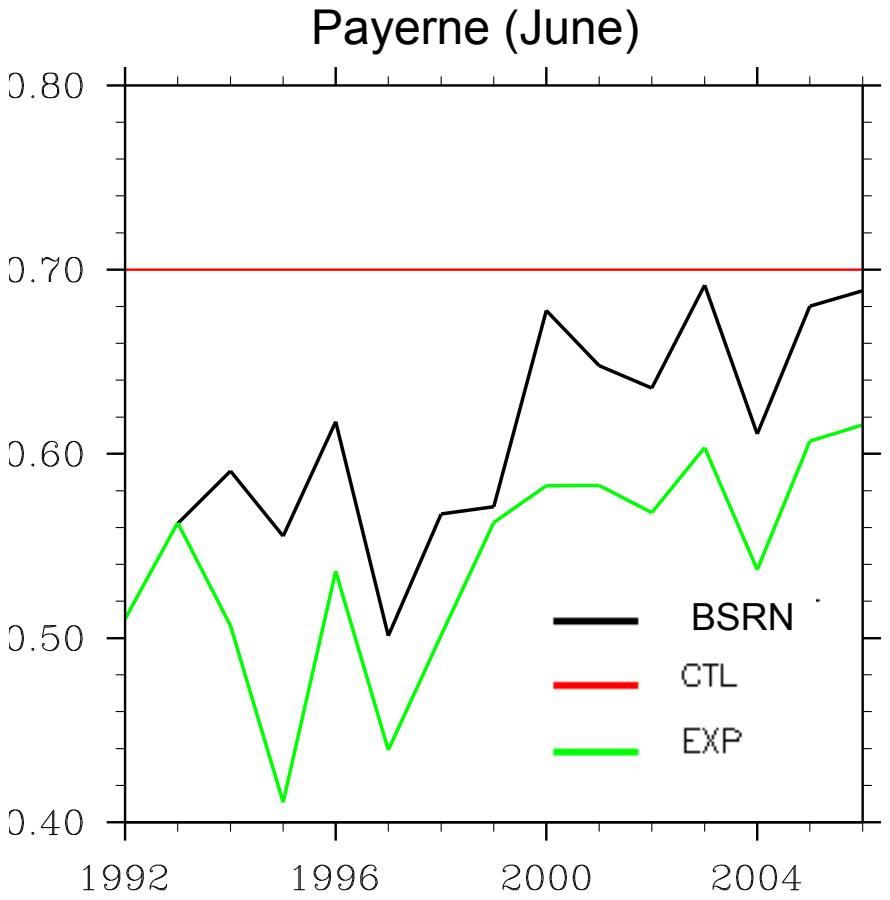


Figure from Oleson et al., 2004

Fraction of direct light

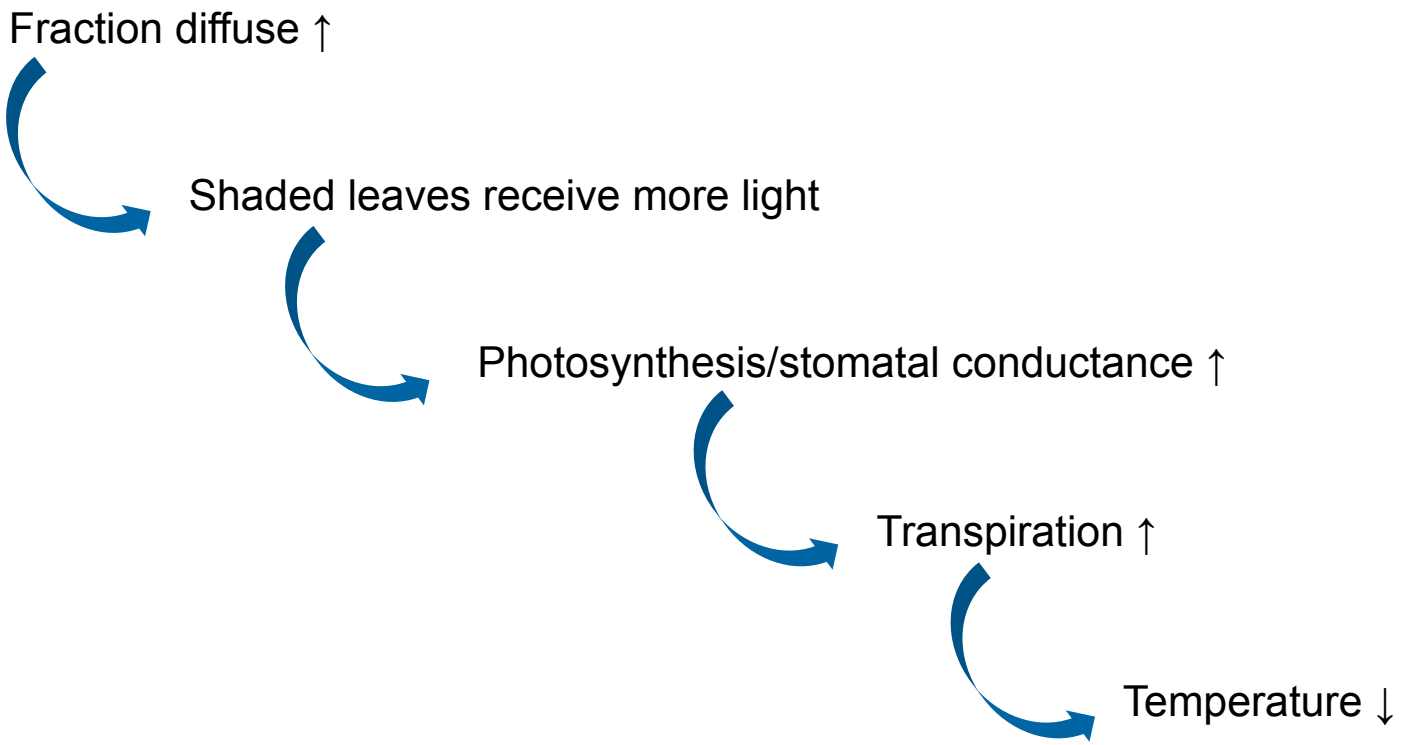




T2m: correlation with CRU (June; 1986-2006)

Regions	CTL	EXP
British Isles	0.88	**0.9**
Iberian Peninsula	0.95	**0.96**
France	0.93	**0.95**
Mid-Europe	**0.87**	0.86
Scandinavia	0.86	**0.91**
Alps	0.92	**0.95**
Mediterranean	0.9	**0.91**
Eastern Europe	0.61	**0.66**

Mechanism


Fraction diffuse ↑
Shaded leaves receive more light
Photosynthesis/stomatal conductance ↑
Transpiration ↑
Temperature ↓

Summary

- The CLandM has a positive effect on surface fluxes and surface climate (seems robust across different regions/COSMO versions)

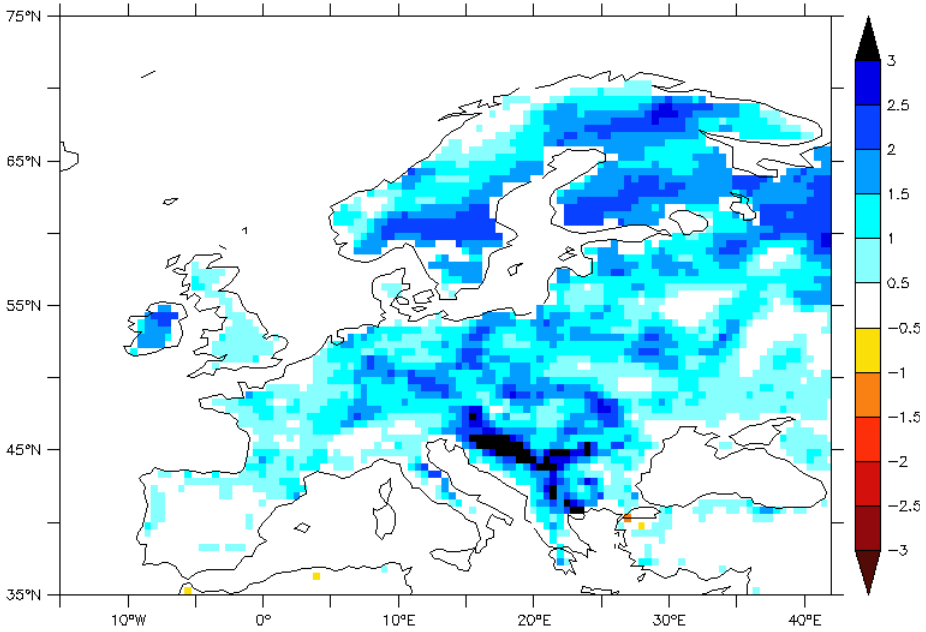
- More realistic diffuse/direct radiation treatment has a promising effect on water/energy fluxes (will become essential for biogeochemical cycles)

On-going and future steps

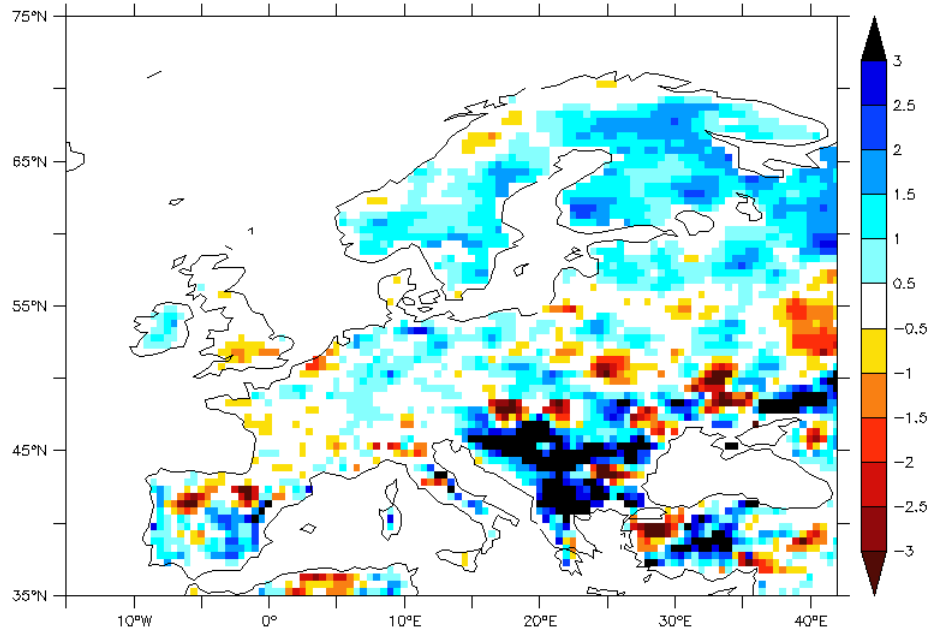
- Revision of the coupling procedure
  - Prototype version with OASIS4 has been implemented
- Consolidation of the interface
  - e.g., problem with momentum fluxes, adaptation to Runge-Kutta dynamics
- Switch to CLM4 (Lawrence et al. 2011)
  - To be done
- Evaluation with full Carbon-Nitrogen cycle and prognostic phenology

Effect at European scale (summer)

Transpiration (W/m^2) EXP - CTL



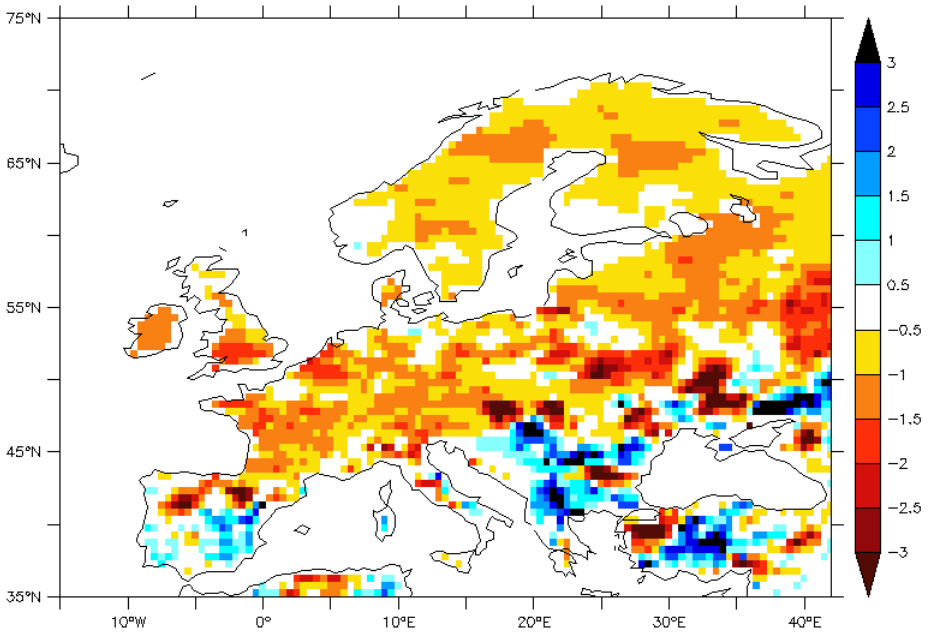
Evapotranspiration (W/m^2) EXP - CTL



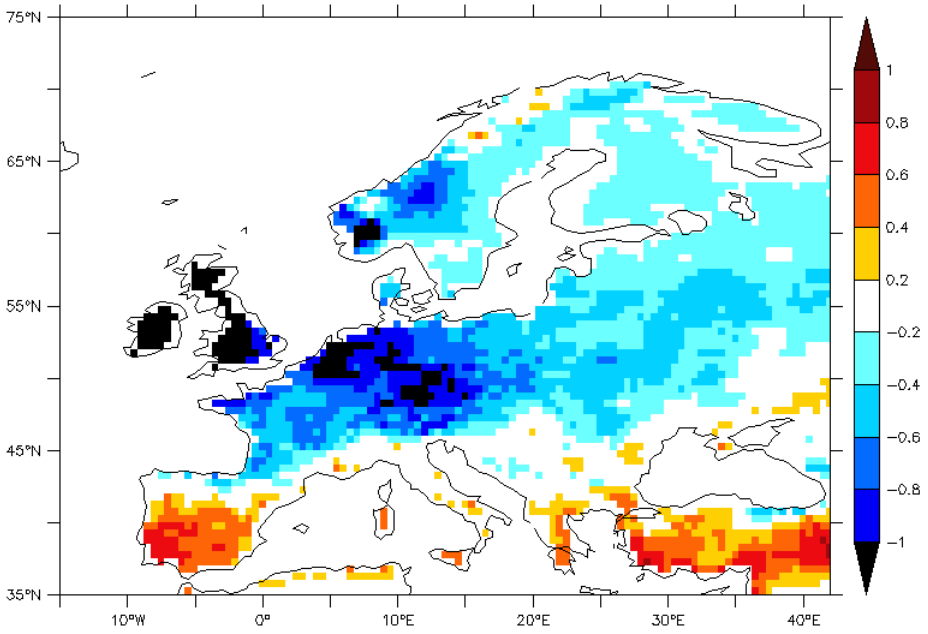
- More diffuse → more light for shaded leaves → enhanced photosynthesis and stomatal conductance → more transpiration
- Compensating effect limiting the change in ET: less light reaching the ground, thus less bare soil evaporation

Soil evaporation compensating mechanism

Ground evaporation (W/m^2) EXP - CTL



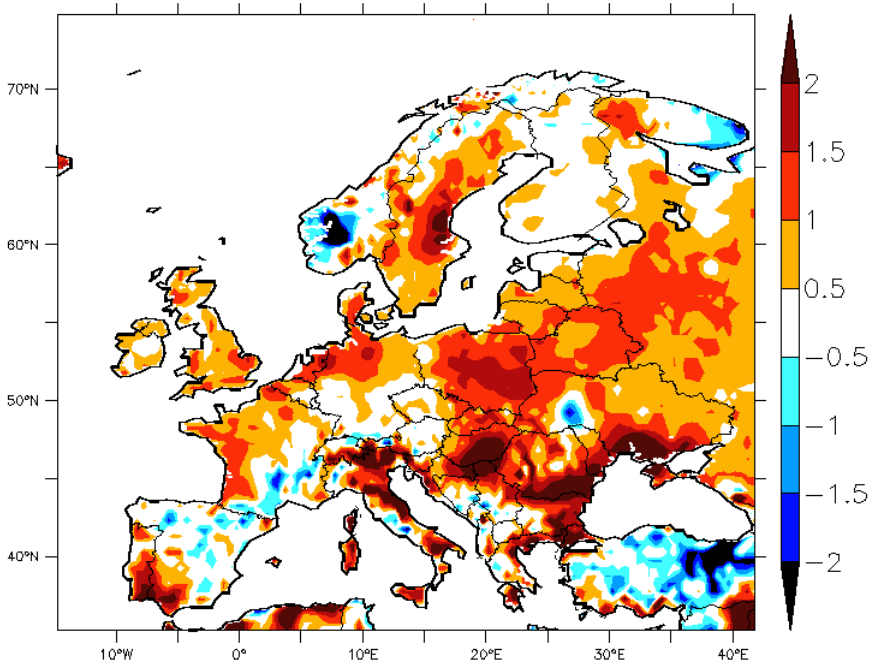
Light reaching ground (%) EXP - CTL



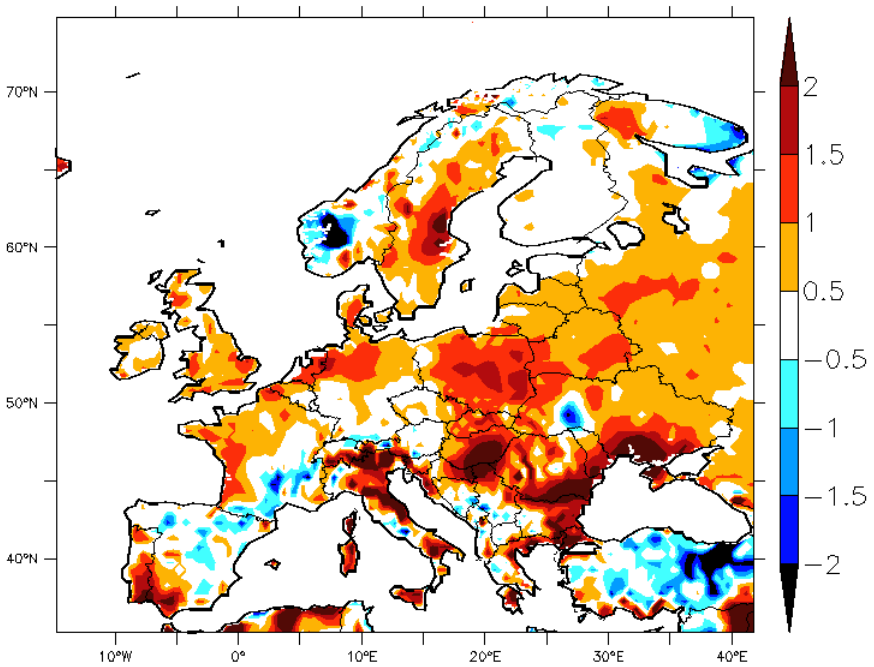
- Less light reaching the ground with increased diffuse
- Thus change in ground evaporation opposite of transpiration

Effect on temperature (summer)

Temp 2-meter (K) CTL - CRU

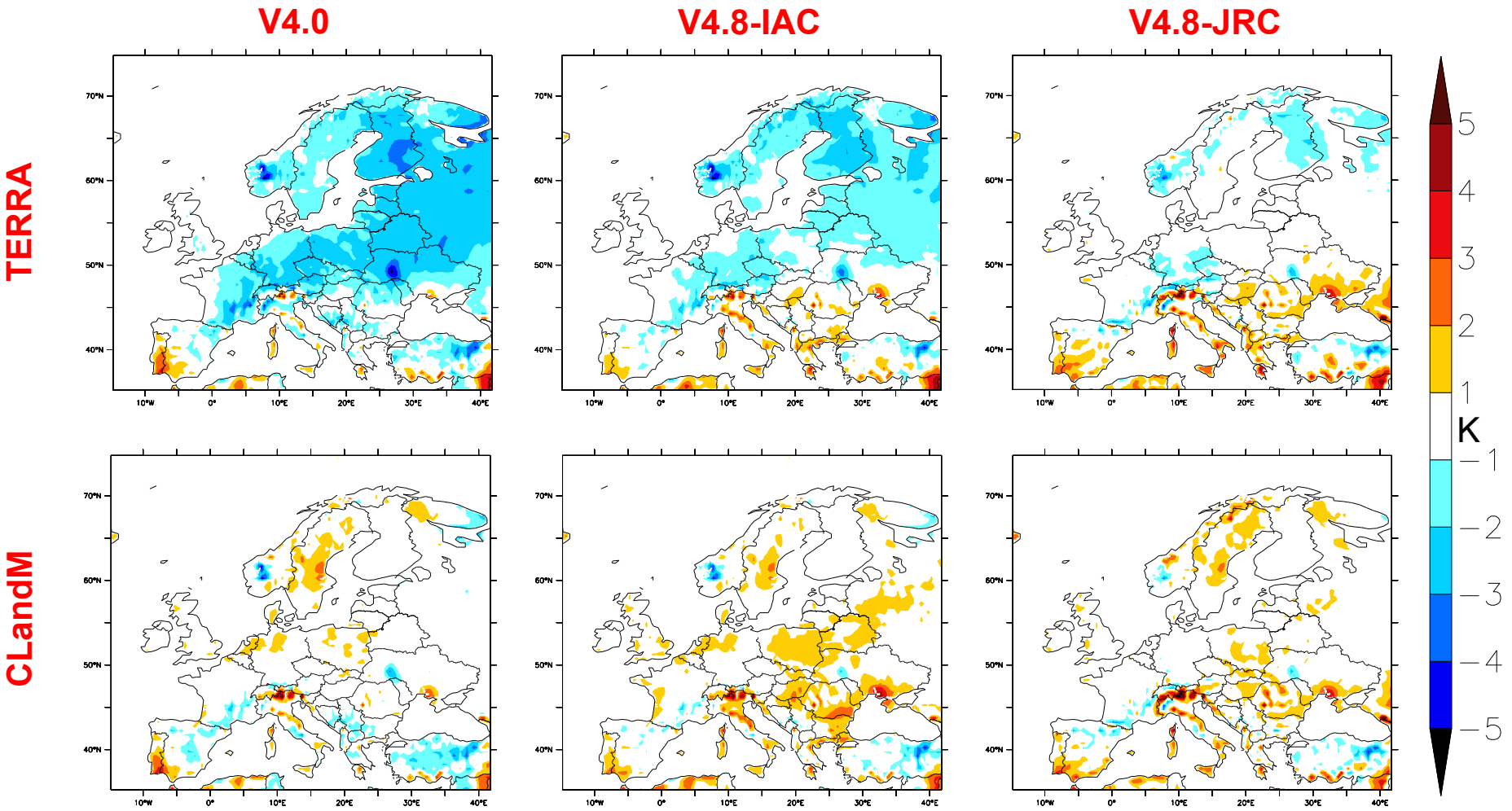


Temp 2-meter (K) EXP - CRU

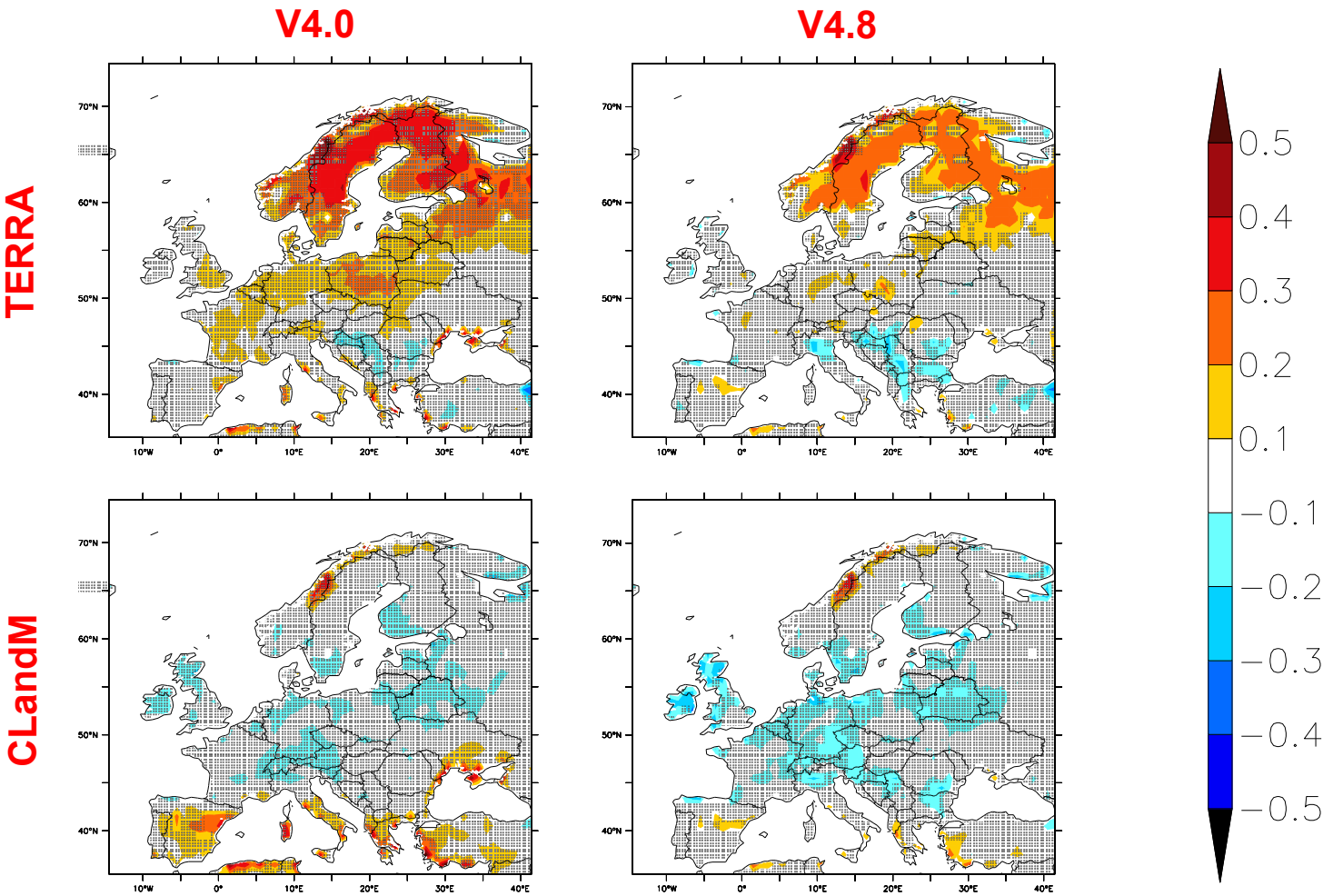


- Small cooling consistent with increased ET
- Slightly reduced bias

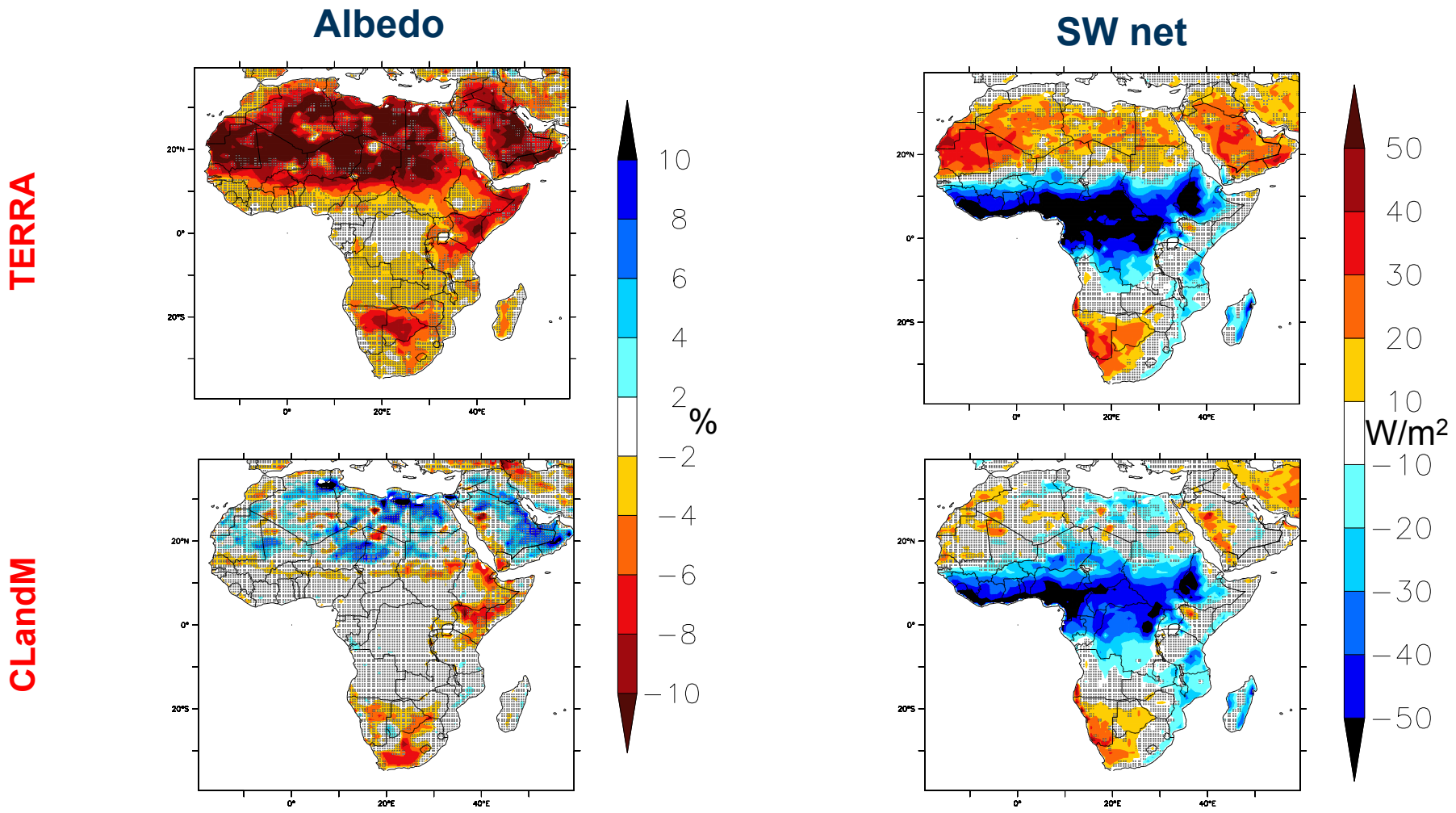
T2m bias (JJA)


V4.0
V4.8-IAC
V4.8-JRC
TERRA
CLandM
70°N
60°N
50°N
40°N
10°W
0°
10°E
20°E
30°E
40°E
5
4
3
2
1
K
−1
−2
−3
−4
−5

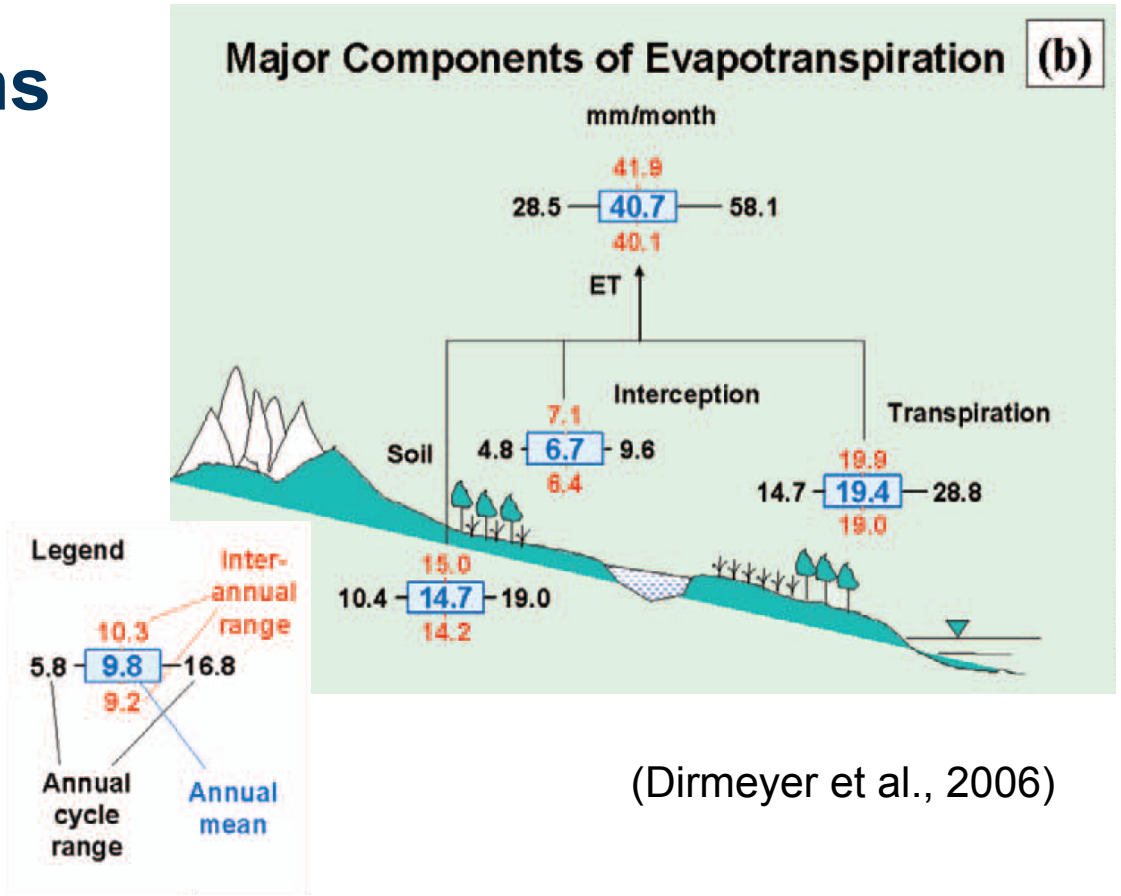
Evaporative fraction bias (JJA) against GSWP-2



Annual mean bias



Motivations



(Dirmeyer et al., 2006)

- Half of the evapotranspiration flux to the atmosphere is conveyed by plants

➢ Biological processes play a major role in shaping the terrestrial water cycle