COSMO-CLM^2 : Current status and further plans

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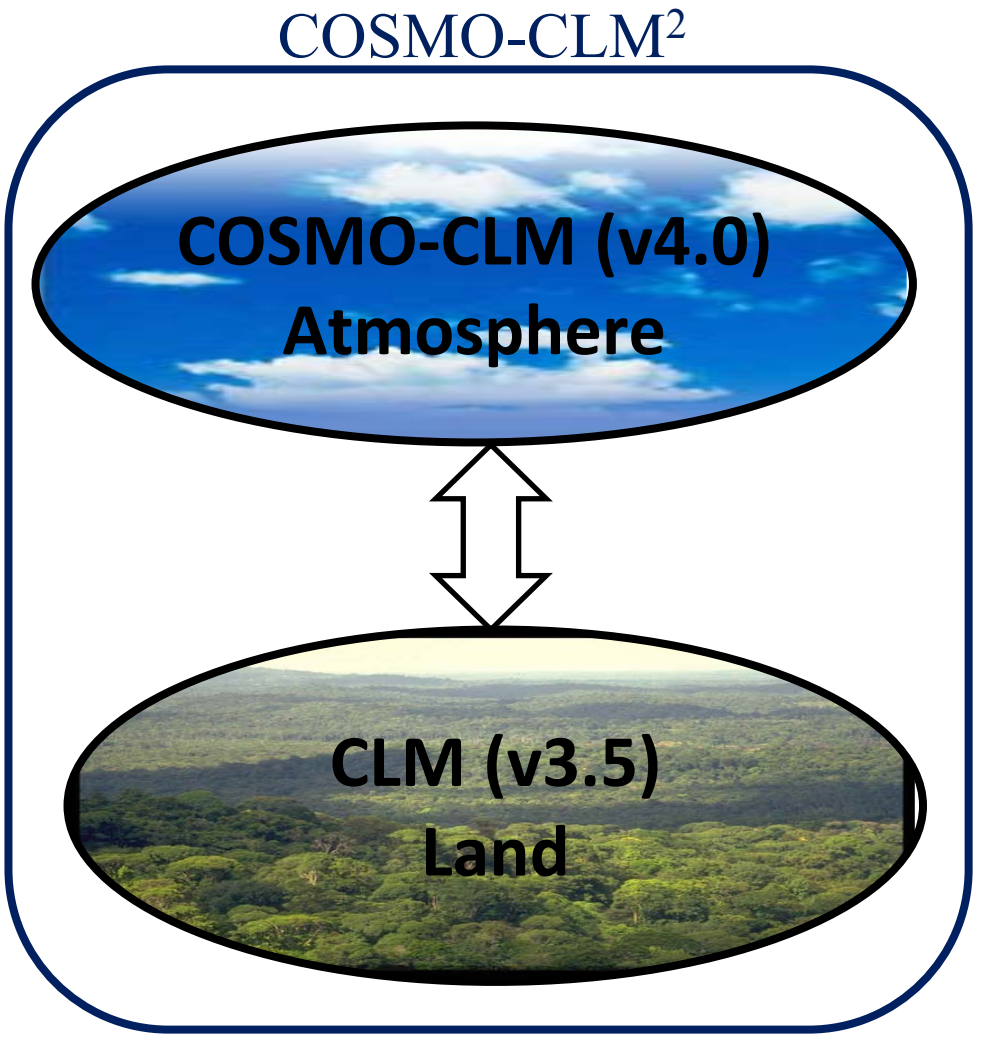
The coupled COSMO-CLM^2

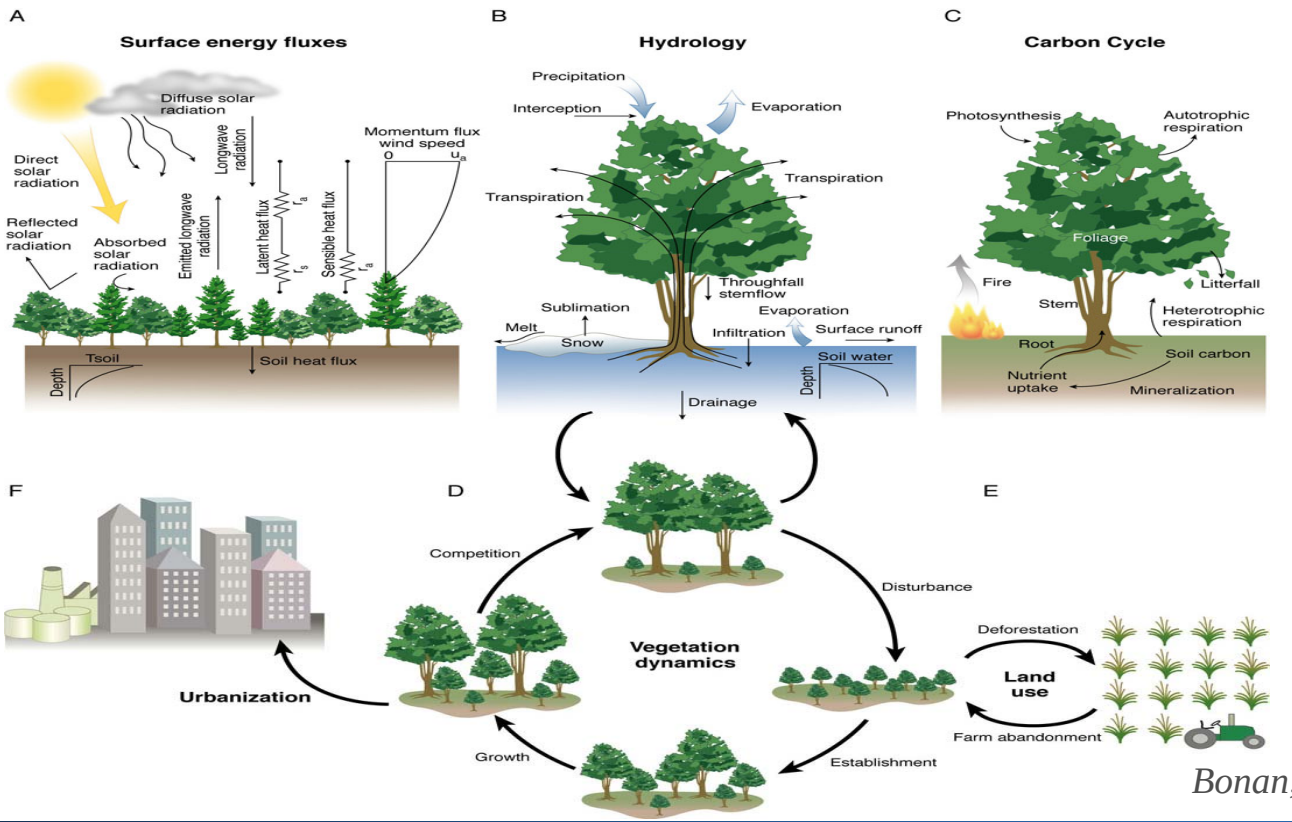
- COSMO-CLM: Regional Climate Model jointly developed by the COSMO consortium and the CLM-community (Climate Limited-area Modelling-community)

- CLM (Community Land Model): Land surface model developed at NCAR



Why CLM3.5?

- Open source
- Well documented (see *http://www.cgd.ucar.edu/tss/clm/distribution/clm3.5/index.html*)
- Extensively evaluated (e.g., *Oleson et al., 2008; Stöckli et al., 2008*)
- Modular structure
- Maintained by a large community
- State of the art, comprehensive LSM



Bonan, 2008

Experiments

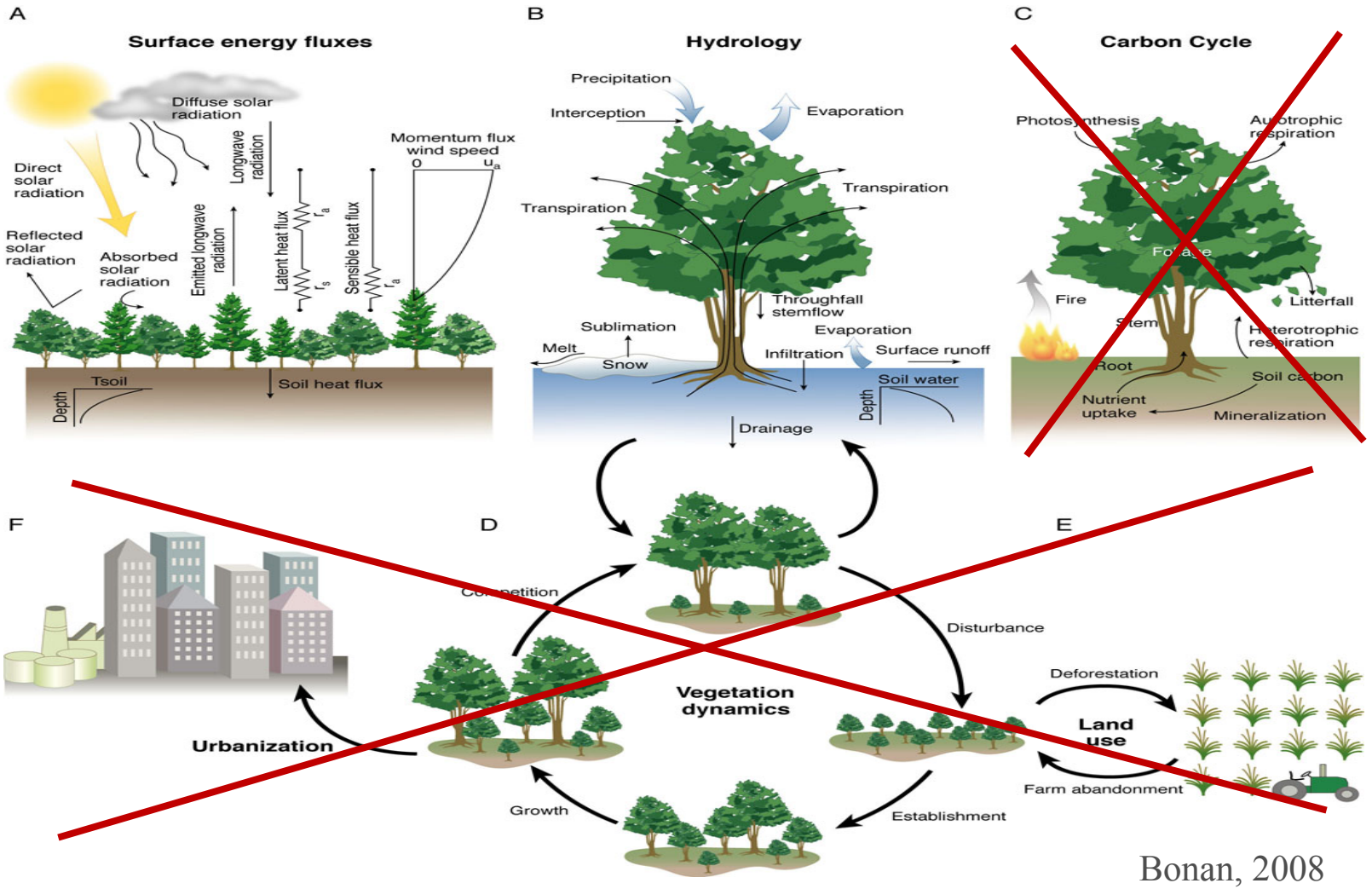
COSMO-CLM experiment with the standard COSMO-CLM

COSMO-CLM^2 experiment coupled with CLM

- COSMO-CLM version 4.0; CLM version 3.5
- Resolution: 50km
- Boundary conditions: ERA40 reanalysis
- Period: 1980-2006 (first 6 years used as spinup)

➢ Same atmospheric model, same setup, thus isolate the effect of having 2 different Land Surface Models (and associated parameters)

CLM configuration



Bonan, 2008

Validation datasets

- CRU TS 2.1 (*Mitchell and Jones, 2005*) → T2m, precip, clouds

- GSWP-2 (*Dirmeyer et al., 2006*) → surface fluxes
- FLUXNET (*baldocchi et al., 2001*)

- Focus only on summer season (JJA)

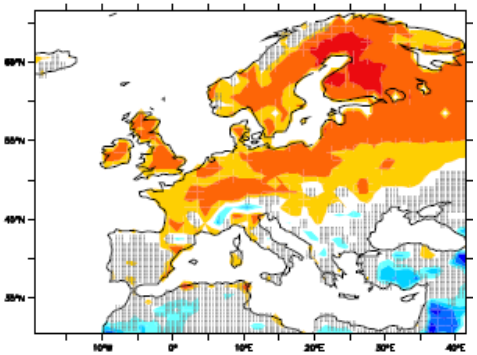
Surface radiation

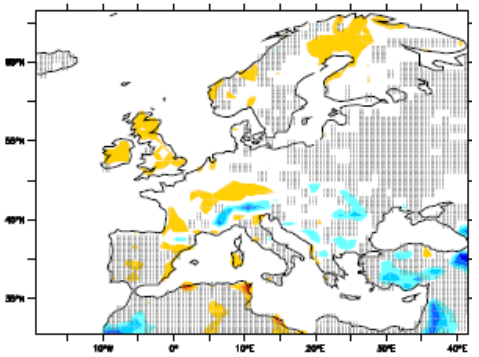
Model minus GSWP-2

COSMO-CLM

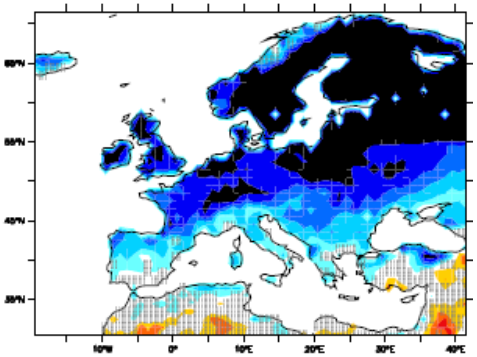
COSMO-CLM^2

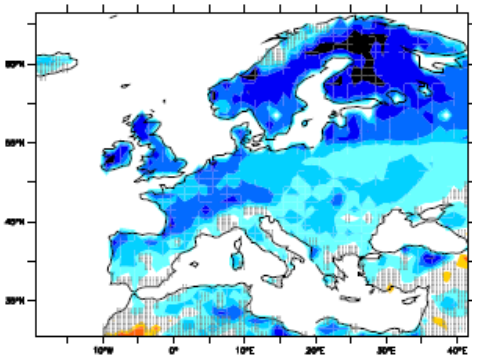
Net longwave



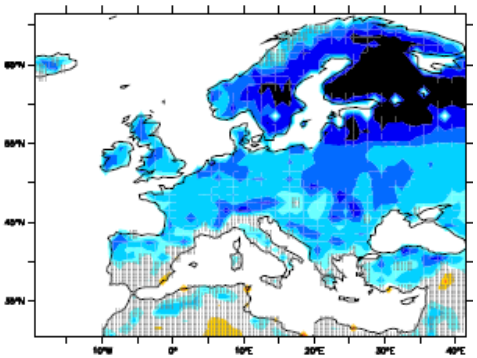


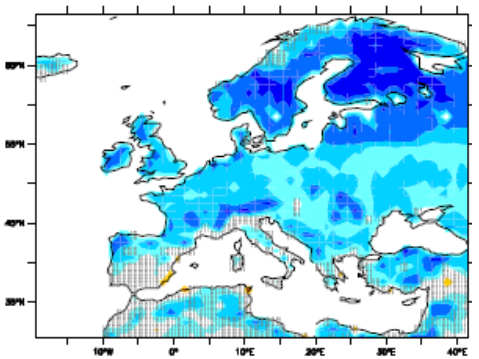
Net shortwave

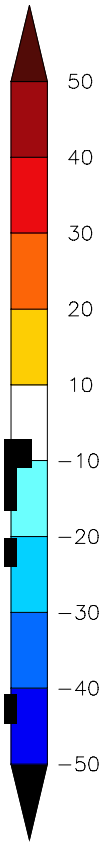




Net radiation





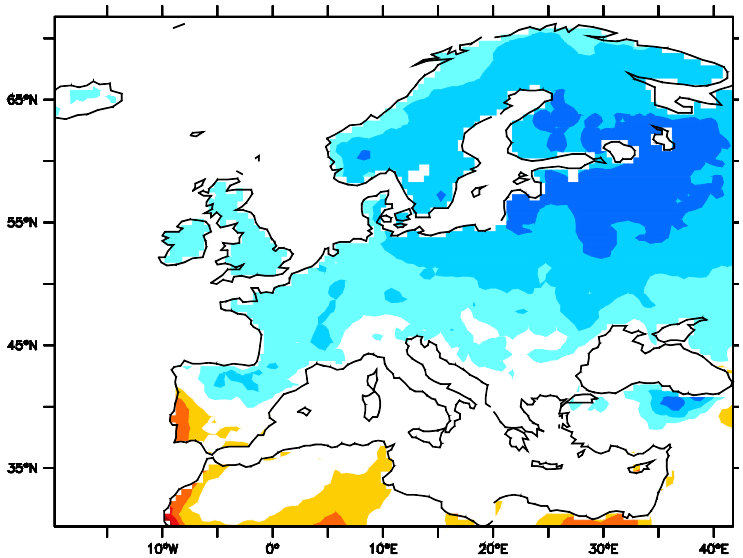


W/m^2

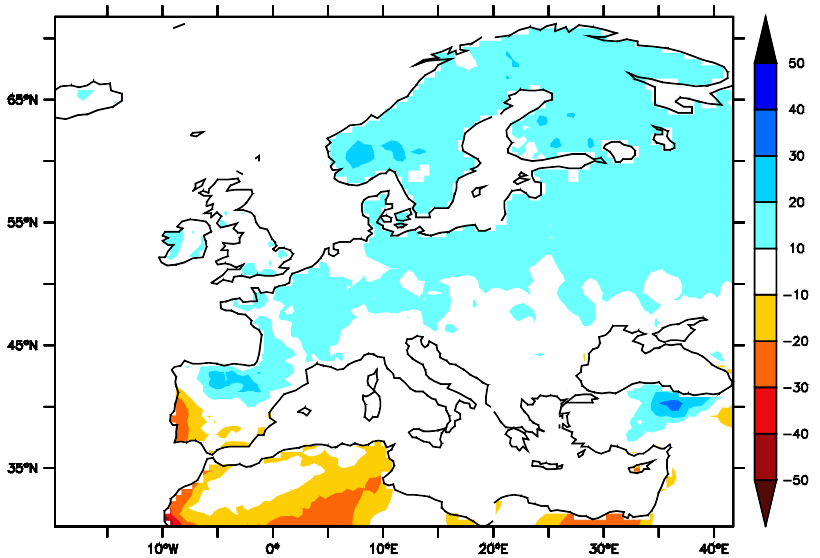
Cloud cover

Model minus CRU

COSMO-CLM



COSMO-CLM^2

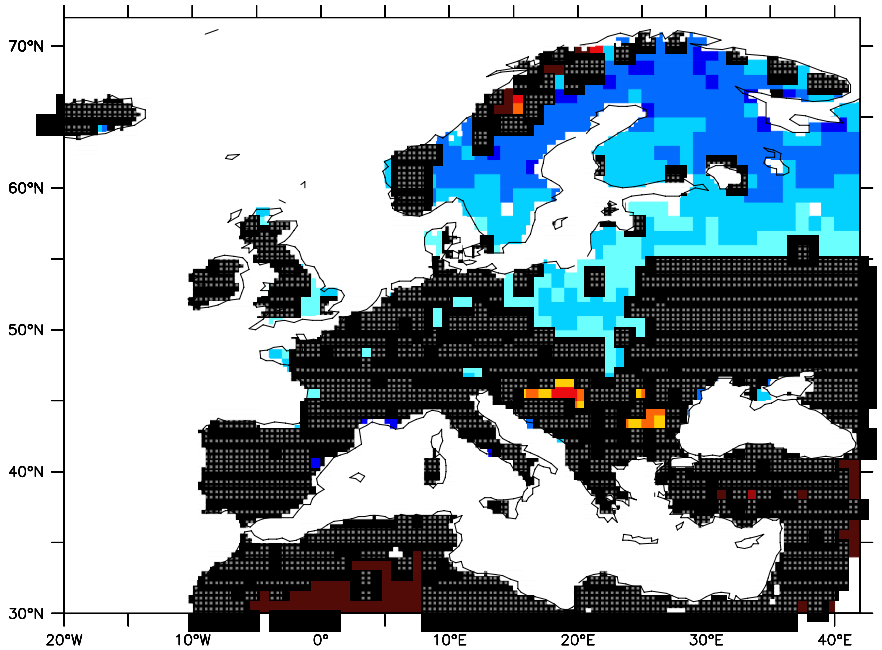


Reduction in cloud cover in COSMO-CLM^2 exclusively affects low level clouds

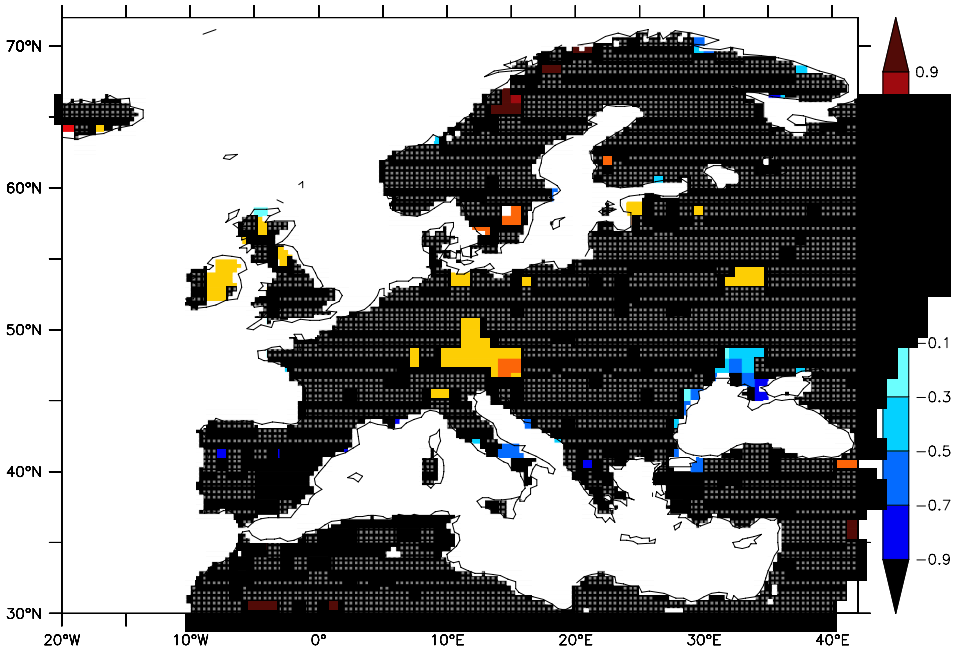
Bowen ratio

Model minus GSWP-2 (JJA)

COSMO-CLM



COSMO-CLM^2



Comparison against FLUXNET measurements:

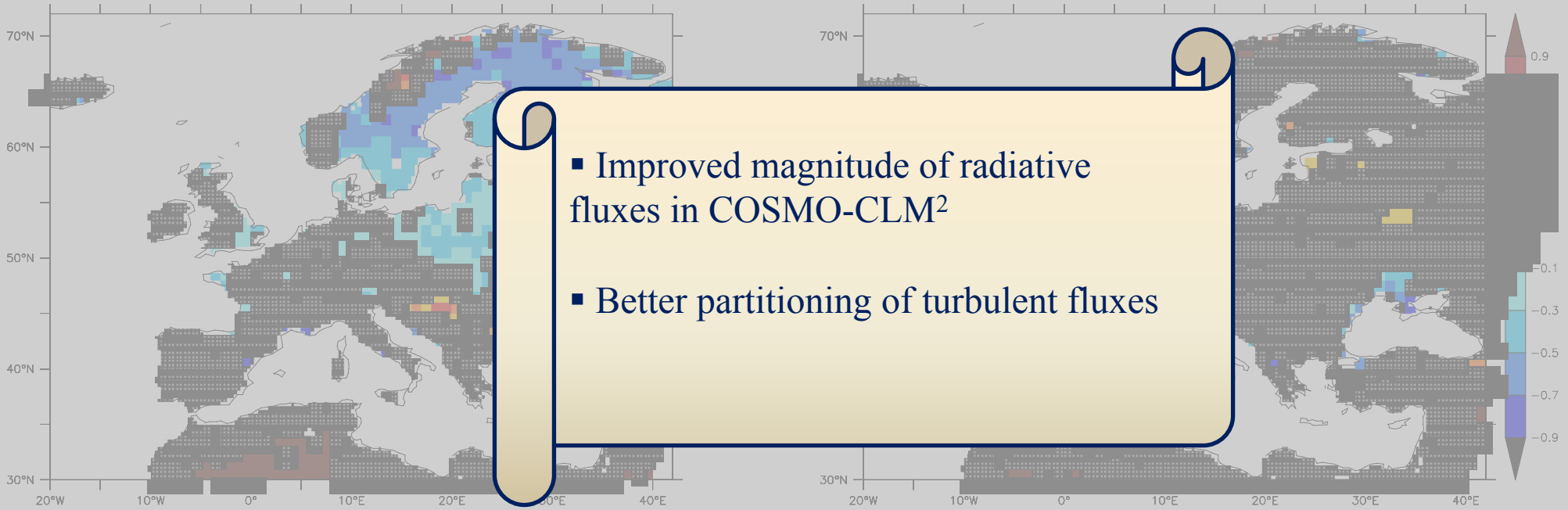
- Out of 10 sites, 8 sites show that the Bowen ratio in COSMO-CLM^2 is closer to observations
- 2 sites show similar performances for the 2 model versions

Bowen ratio

Model minus GSWP-2 (JJA)

COSMO-CLM

COSMO-CLM²



- Improved magnitude of radiative fluxes in COSMO-CLM²
- Better partitioning of turbulent fluxes

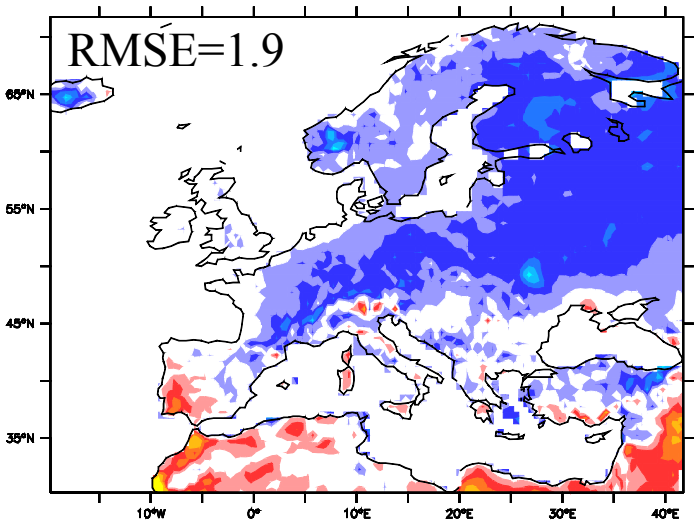
Comparison against FLUXNET measurements:

- Out of 10 sites, 8 sites show that the Bowen ratio in COSMO-CLM² is closer to observations
- 2 sites show similar performances for the 2 model versions

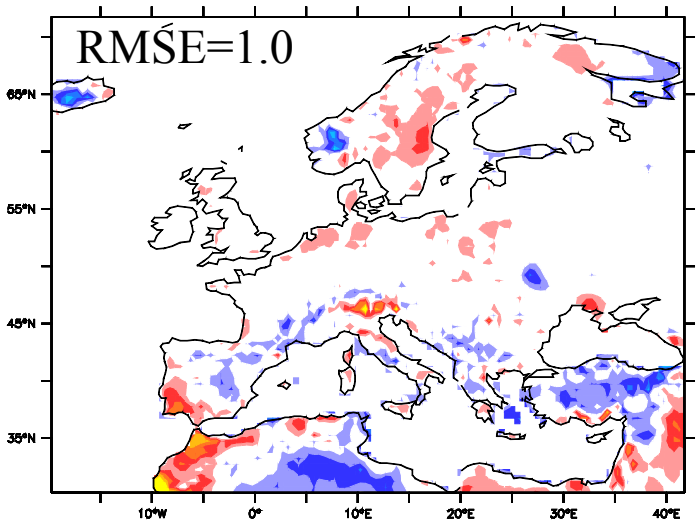
Temperature and precipitation

2-meter temperature (model – CRU)

COSMO-CLM

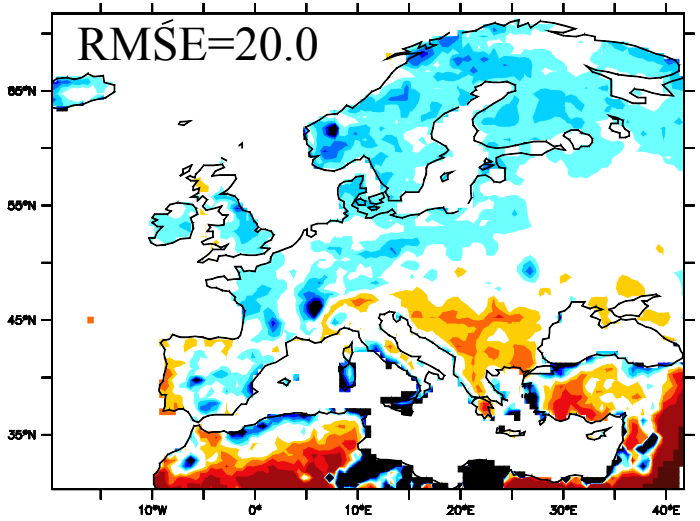


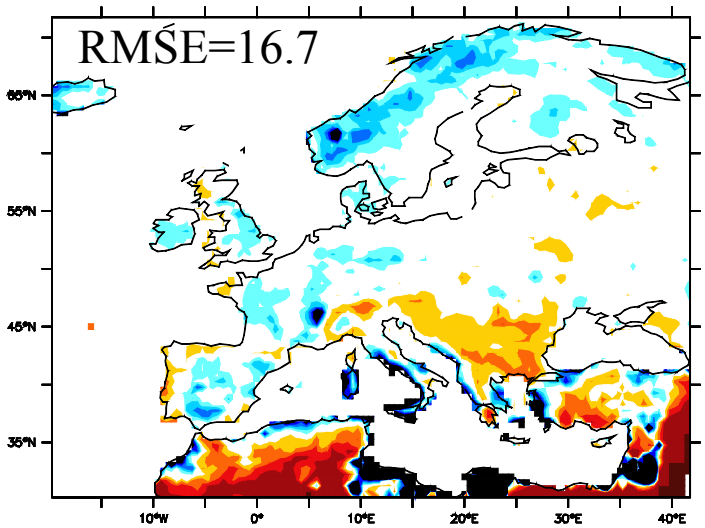
COSMO-CLM²

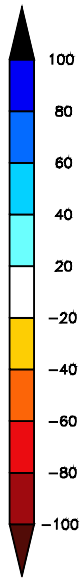


K

Precipitation (model – CRU)







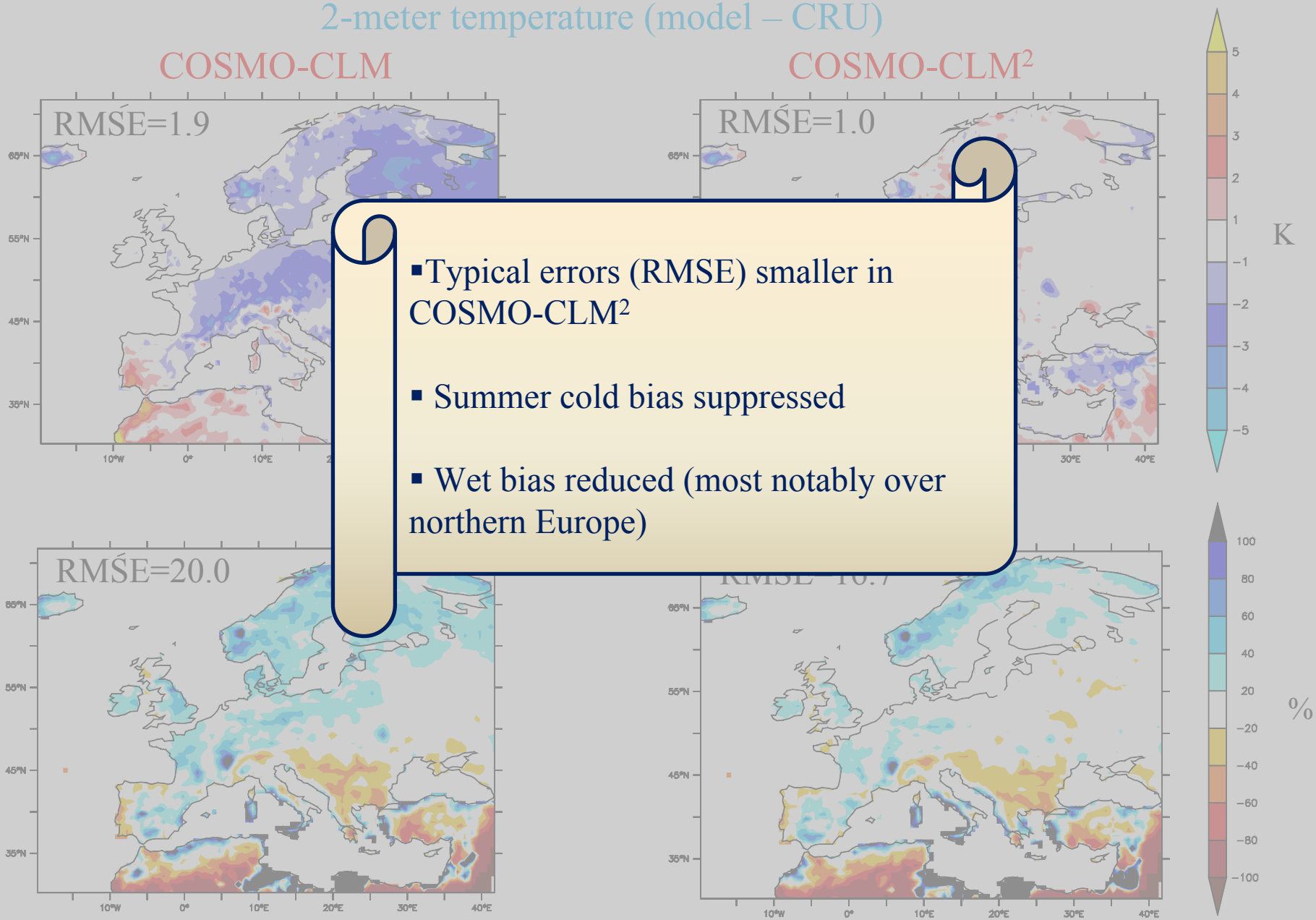
%

Temperature and precipitation

2-meter temperature (model – CRU)

COSMO-CLM

COSMO-CLM²



- Typical errors (RMSE) smaller in COSMO-CLM²
- Summer cold bias suppressed
- Wet bias reduced (most notably over northern Europe)

Interannual variability

Correlation between model and CRU observations
based on summer (JJA) temperature for the period 1986-2006

Domains	COSMO-CLM	COSMO-CLM^2
British Isles	0.97	**0.98**
Iberian Peninsula	0.89	**0.92**
France	0.86	**0.91**
Mid-Europe	0.92	**0.94**
Scandinavia	0.93	**0.94**
Alps	0.91	**0.92**
Mediterranean	0.75	**0.88**
Eastern Europe	0.67	**0.88**

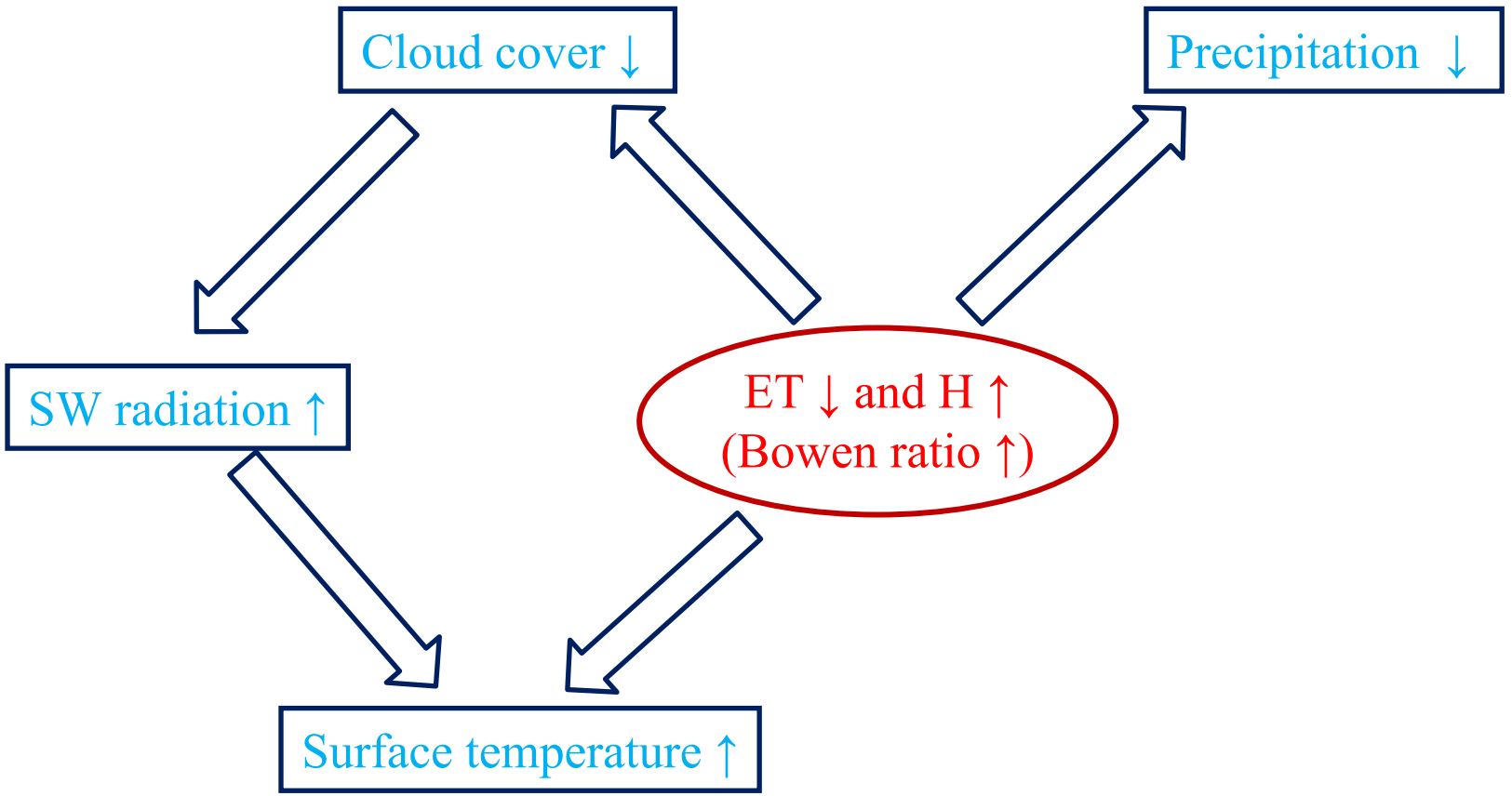
…but no improvements for precipitation…

- COSMO-CLM^2 leads to systematic improvements of several aspects of the simulated climate…

- … But what is the physical reason for these improvements?

Possible mechanism

Changes in COSMO-CLM^2 compared to COSMO-CLM



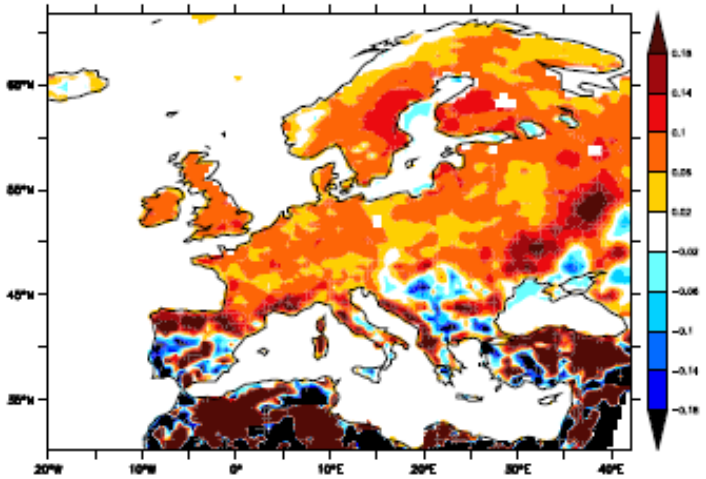
Sensitivity experiment

- Can we reproduce the results of COSMO-CLM^2 by tuning the Bowen ratio in COSMO-CLM?
- Additional simulation with COSMO-CLM where minimum stomatal resistance is increased from 150 to 300 s/m (COSMO-CLM_rs300)
- By increasing rsmin one expects an increase in Bowen ratio

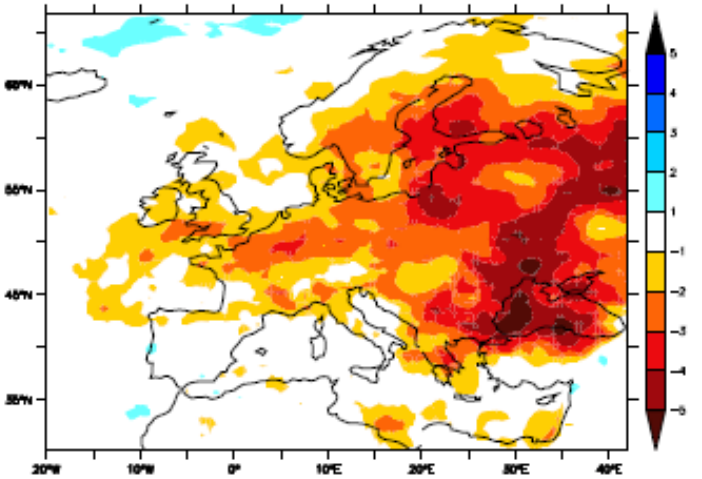
Sensitivity experiment

COSMO-CLM_rs300 minus COSMO-CLM

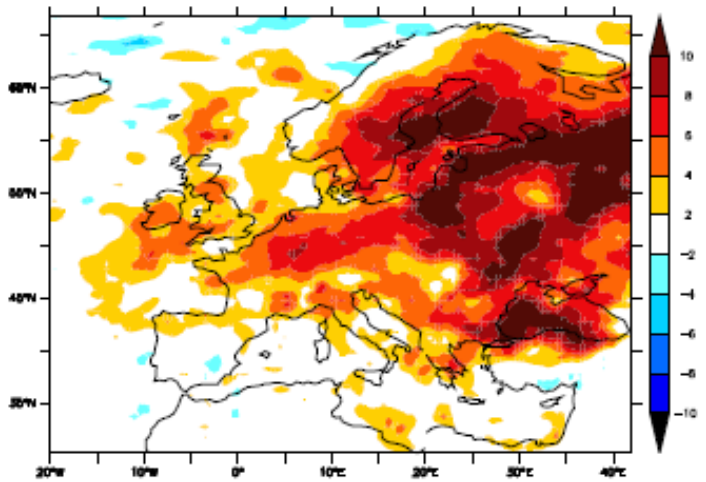
BR



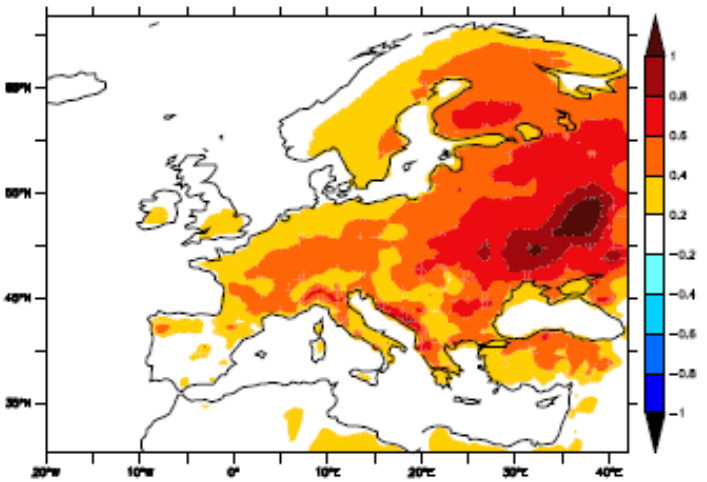
total cloud cover (%)



absorbed SW (W/m2)



2-meter temp (K)



Further plans

- Next milestone for COSMO-CLM^2 :
  - Upgrade to COSMO4.8-CLM11 (IPCC/CORDEX version)
  - Upgrade to CLM4.0
  - New evaluation round based on this version

  - Reimplementation of the coupling using OASIS coupler?

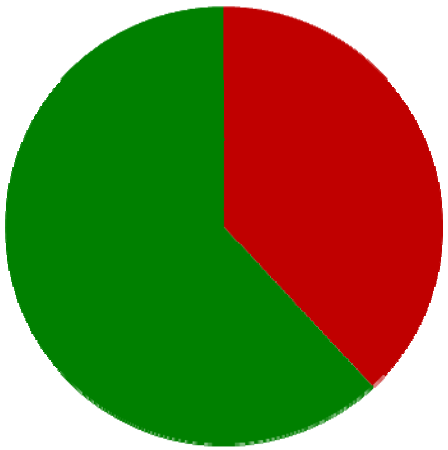
Community Land Model Meeting in Zurich 29/01/2010

- Several groups plan to use COSMO-CLM^2 :
  - JRC Ispra → model evaluation, carbon cycle
  - KU Leuven → vegetation dynamics, urban module
  - UFZ Leipzig → parameter optimization
  - Uni Bonn → mosaic approach within COSMO-CLM^2
  - EMPA Zurich → coupling with COSMO-ART
  - ETH Zurich → model evaluation, phenology, soil moisture, land use change…

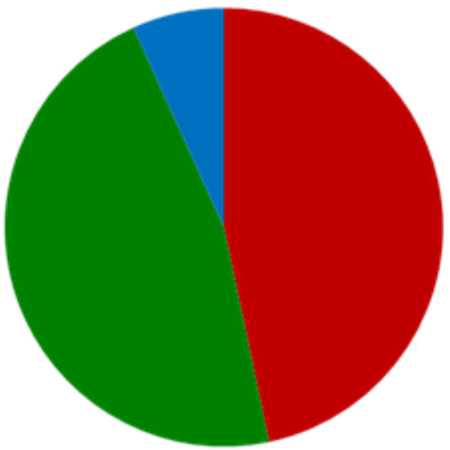
Backup slides

ET partitioning

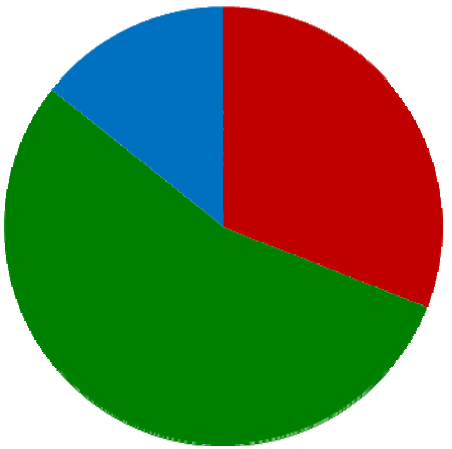
COSMO-CLM

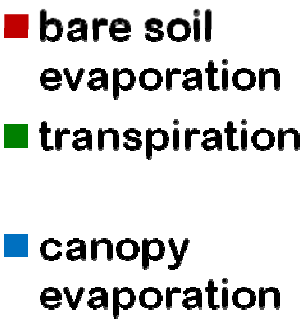


COSMO-CLM^2



GSWP-2





Motivations

- Historically, RCM development strongly based on pre-existing NWP systems. Need to include other components of the climate system (ocean, sea ice, glaciers, biosphere…).

- Include a more comprehensive representation of land surface processes for regional climate simulations

- Examples of processes not represented in the current generation of RCMs:
  - Photosynthesis-transpiration coupling
  - Prognostic phenology
  - Vegetation dynamics (both anthropogenic and natural vegetation)

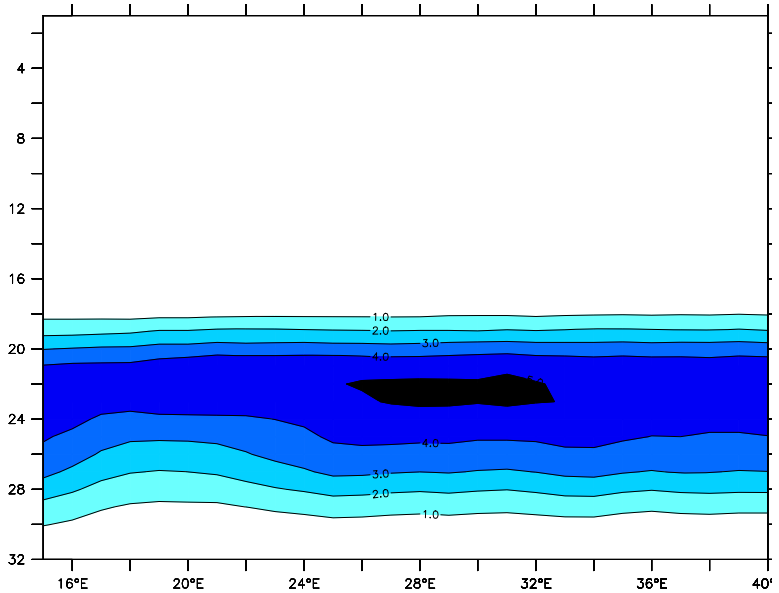
- Move from RCM to "RESM" (Regional Earth System Model)

Atmospheric profile

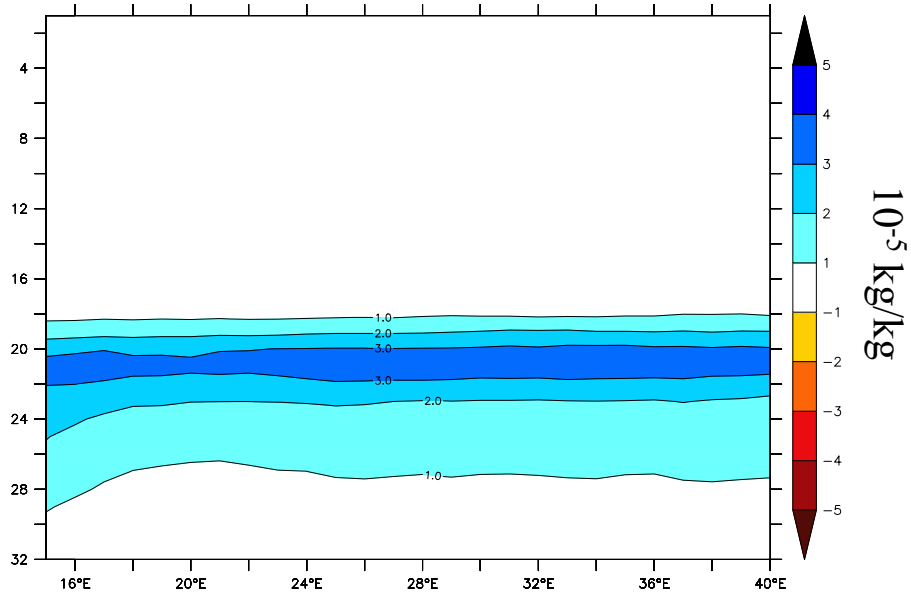
Model minus ERA40 (JJA)

Cloud liq. water content

COSMO-CLM



COSMO-CLM^2



Latent heat

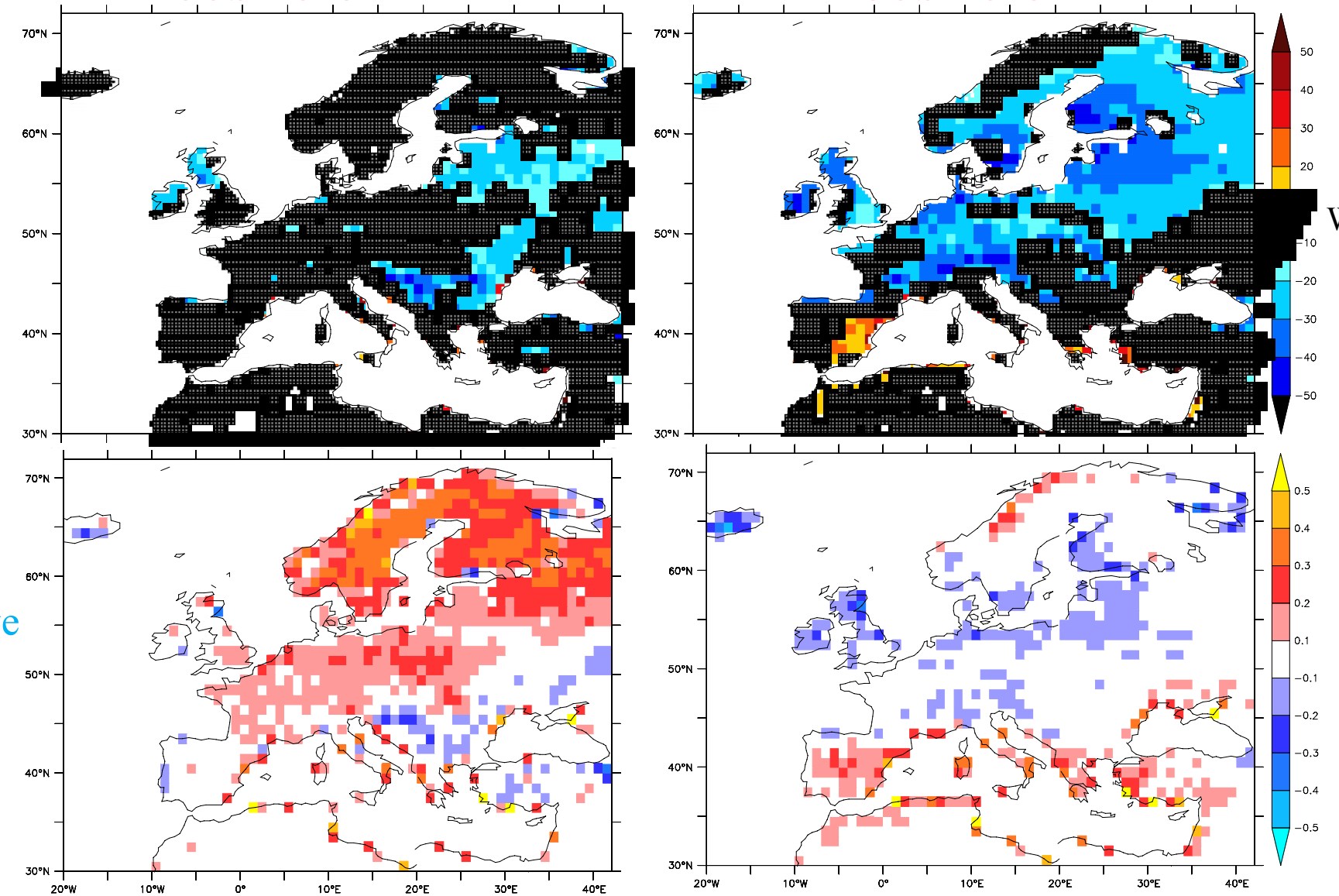
Model minus GSWP-2 (JJA)

COSMO-CLM

COSMO-CLM^2

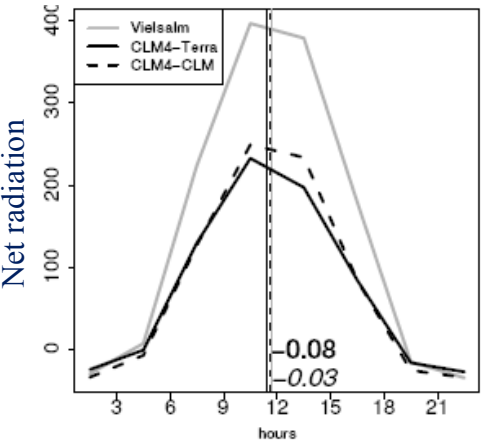
LH

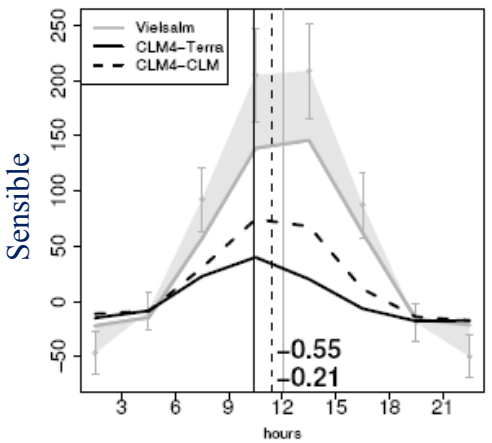
Evaporative fraction

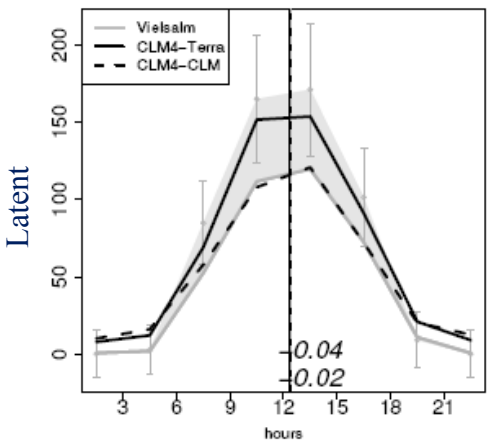


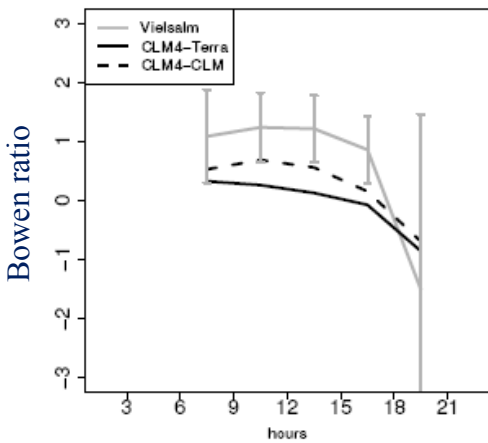
FLUXNET comparison

July mean diurnal cycle









FLUXNET comparison

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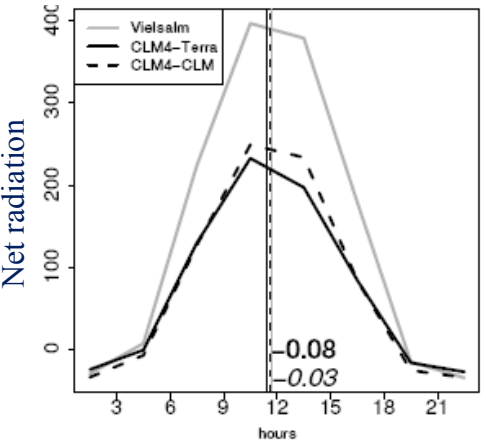

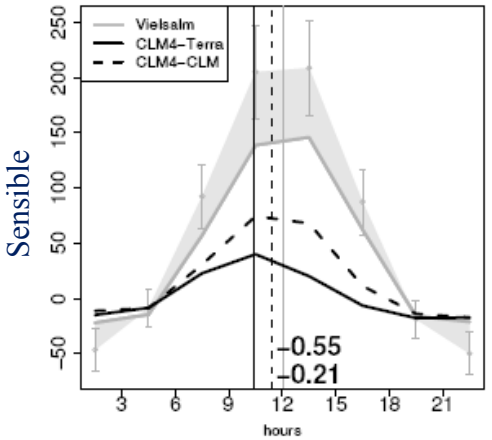

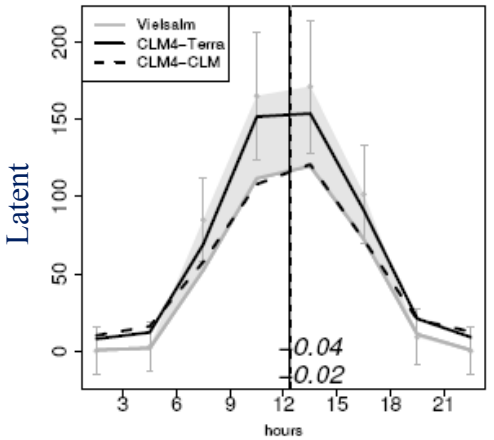

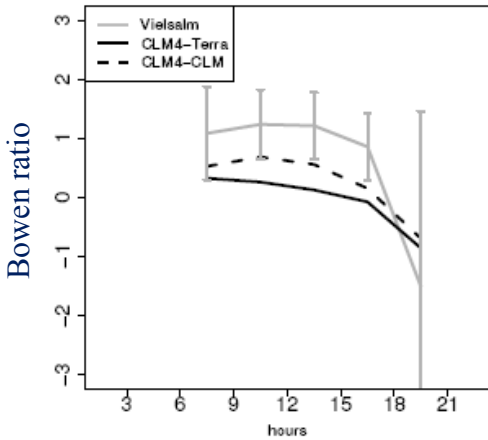

- Robust conclusions we could draw from evaluation against GSWP-2 and FLUXNET:
  - Surface net radiation underestimation alleviated in COSMO-CLM^2
  - Bowen ratio underestimation alleviated