Sensitivity of soil moisture initialization for decadal predictions under different regional climatic conditions in Europe

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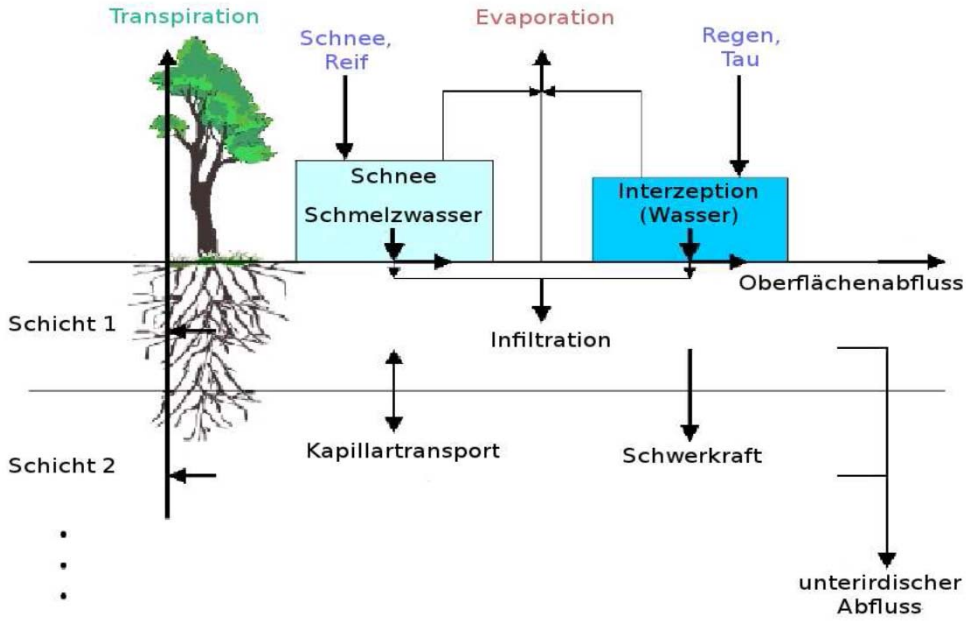


TERENO International Conferenece 2014, Bonn, Germany

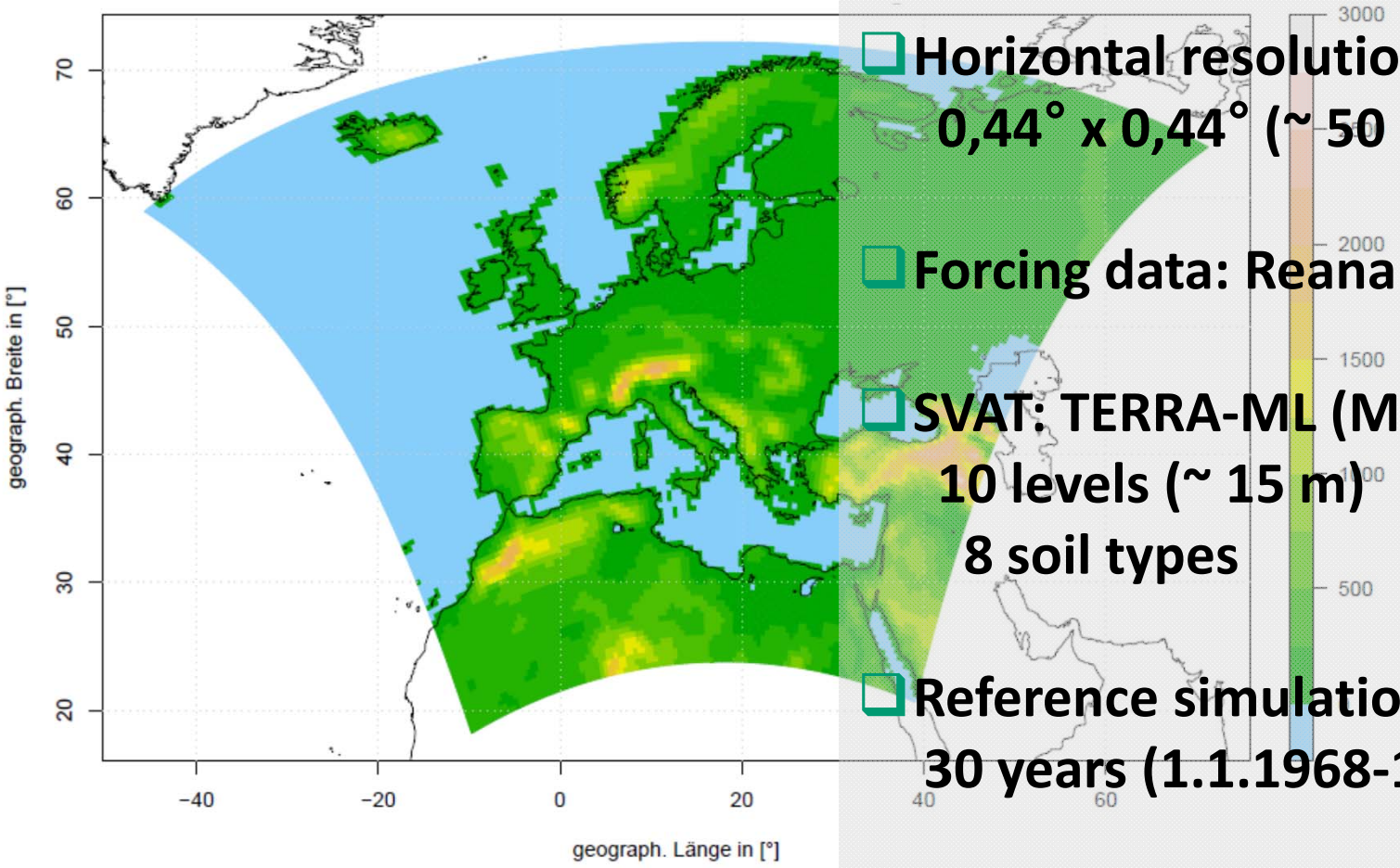
Motivation

- **Uncertainties** related to:
  a) Initial condition uncertainties
  b) Soil-atmosphere feedbacks

- **Progress** expected from a better initialization of the **slow components** in the climate system

- ***We explore the issue as to whether soil moisture initialization is relevant for decadal predictions with focus on extreme periods which has not been attempted in this time scale up to date.***

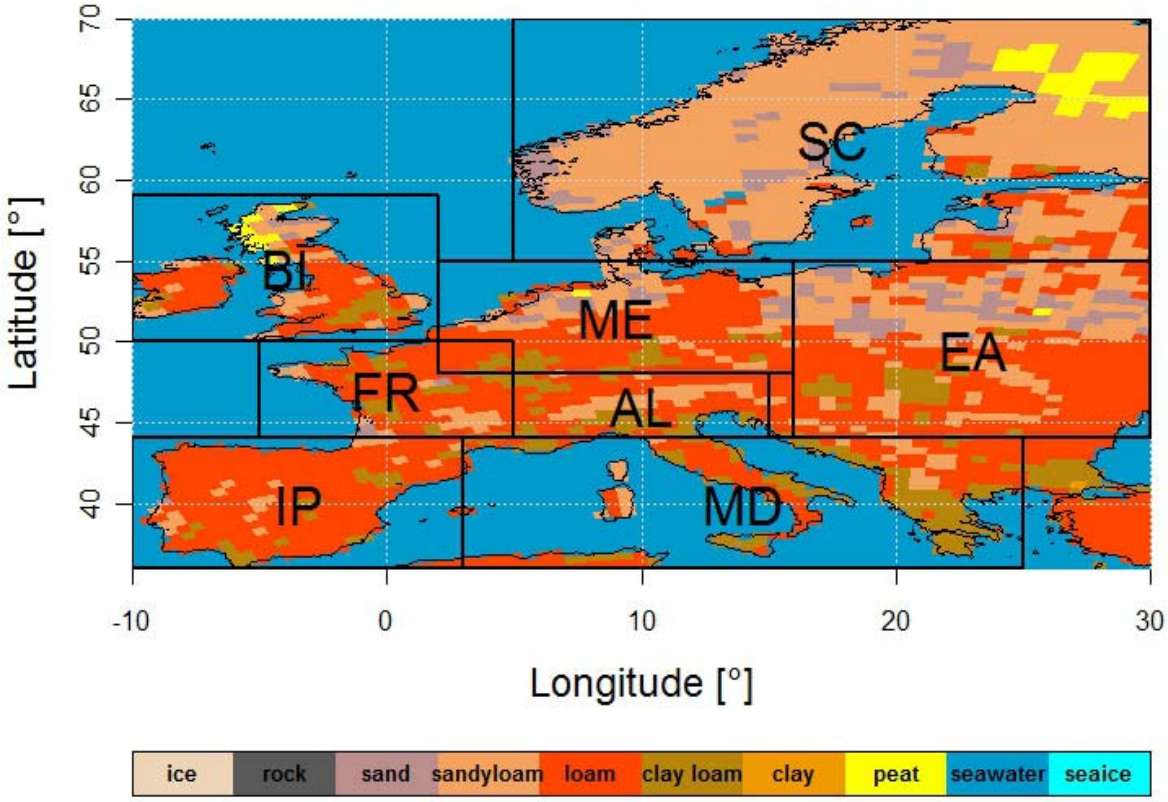
COSMO-CLM model



- Regional Climate model
- Horizontal resolution:
  0,44° x 0,44° (~ 50 km)
- Forcing data: Reanalysis ERA-40
- SVAT: TERRA-ML (Multi Layer)
  10 levels (~ 15 m)
  8 soil types
- Reference simulation:
  30 years (1.1.1968-1.1.2000)
- 5 Sensitivity experiments

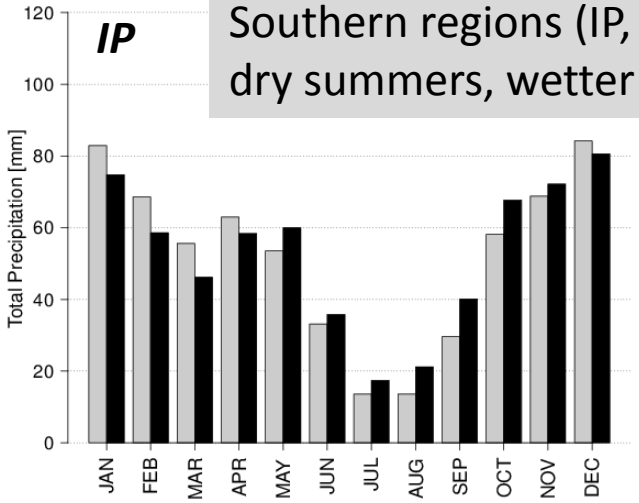
Investigation area

- The European model domain is divided in **8 regions**.
- Loam is the dominant soil type: Iberian Peninsula (**IP**, 81%), France (**FR**, 68%), Mid Europe (**ME**, 62%), the Alps (**AL**, 56%), the Mediterranean Region (**MD**, 55%), Eastern-Europe (**EA**, 54%). Scandinavia (**SC**, 74% Sandy loam).

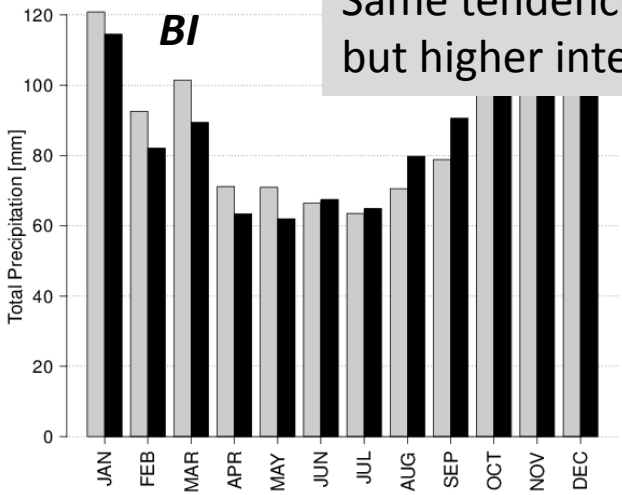


Precipitation climatology

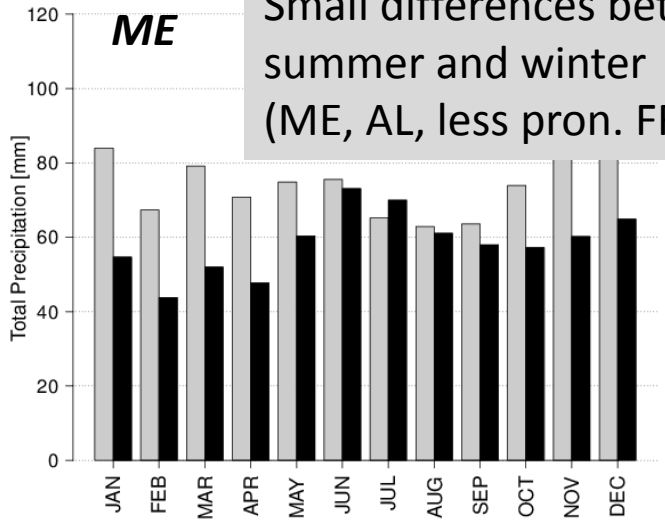
COSMO-CLM E-OBS



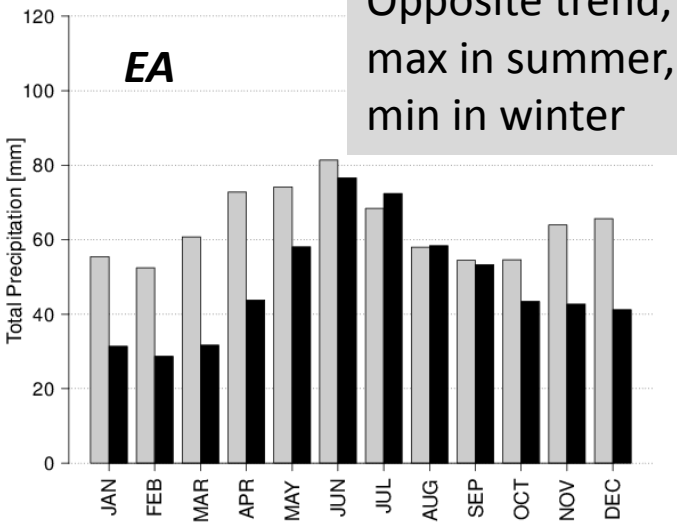
Southern regions (IP, MD): dry summers, wetter winters



Same tendency, but higher intensity



Small differences between summer and winter (ME, AL, less pron. FR)



Opposite trend, max in summer, min in winter

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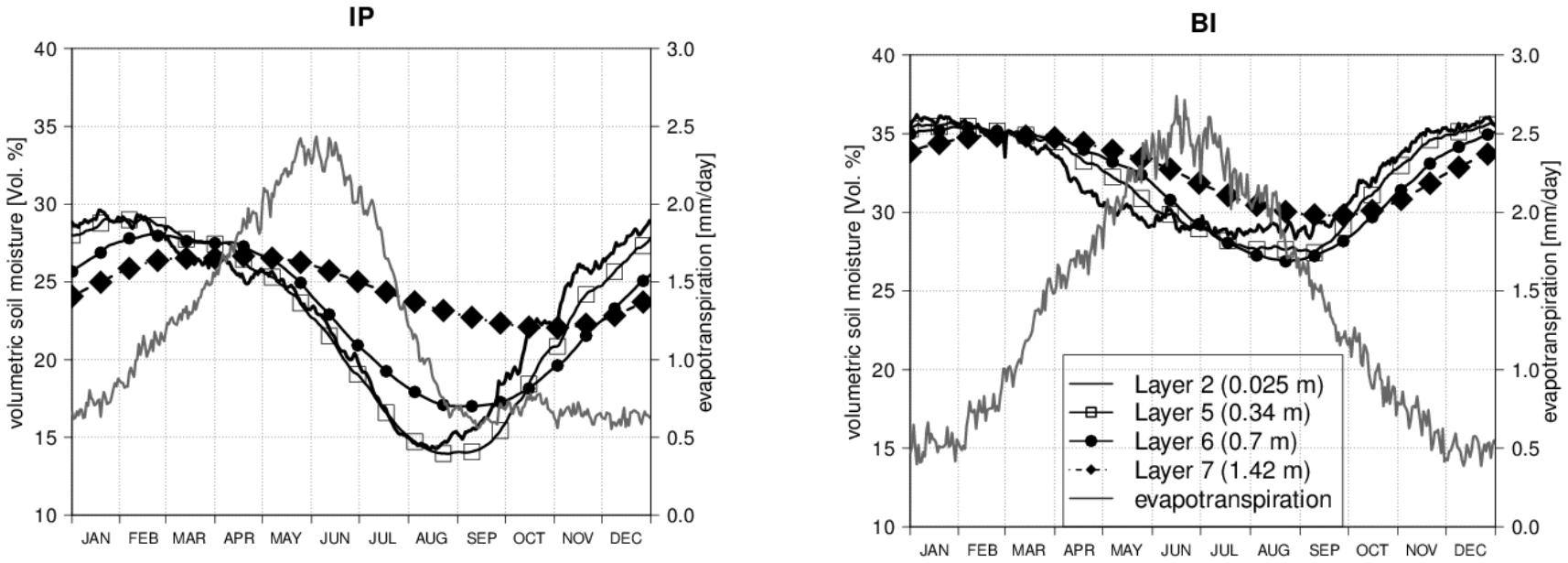
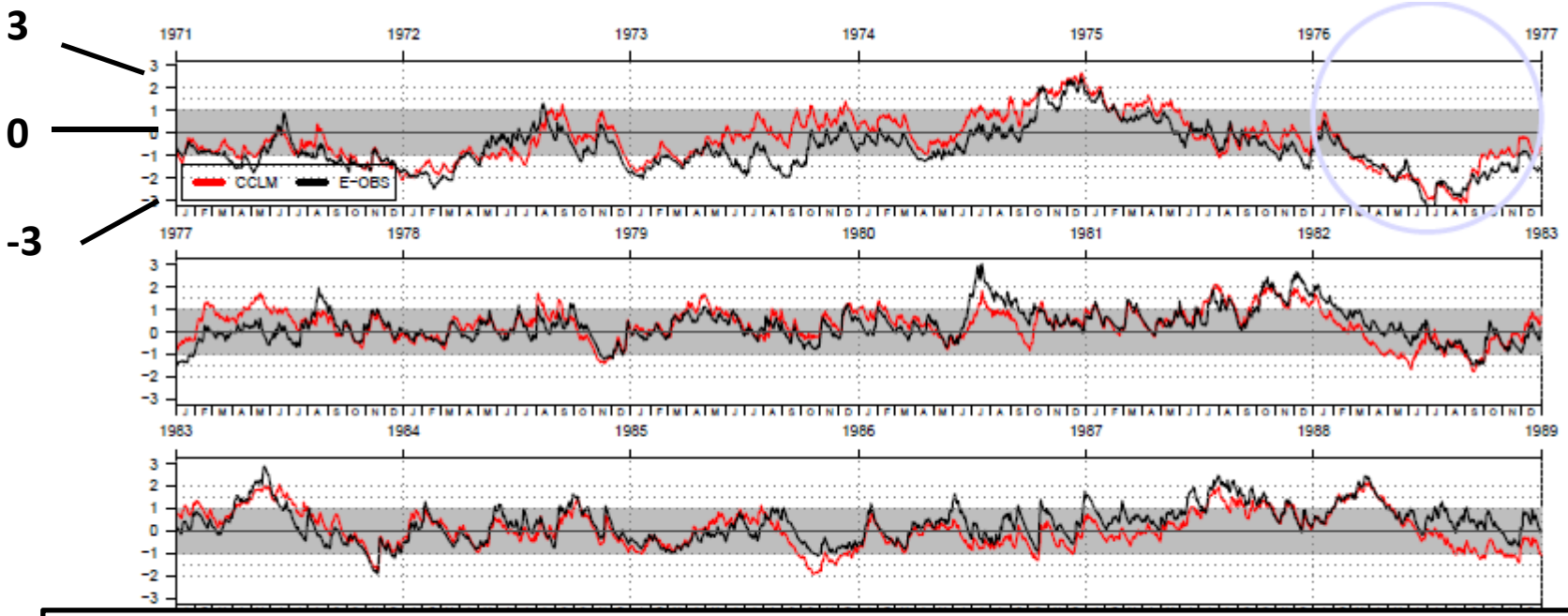
Vol. soil water content and evapotranspiration



- The regional **annual cycles** are **well represented** in the model
- In **agreement with precipitation distributions**, higher prec→ wetter soils
- **Largest soil moisture** amplitudes where more **prec pronounced annual cycles**
- **Low SM availability** in summer reflects in **low evapotranspiration** in S regions

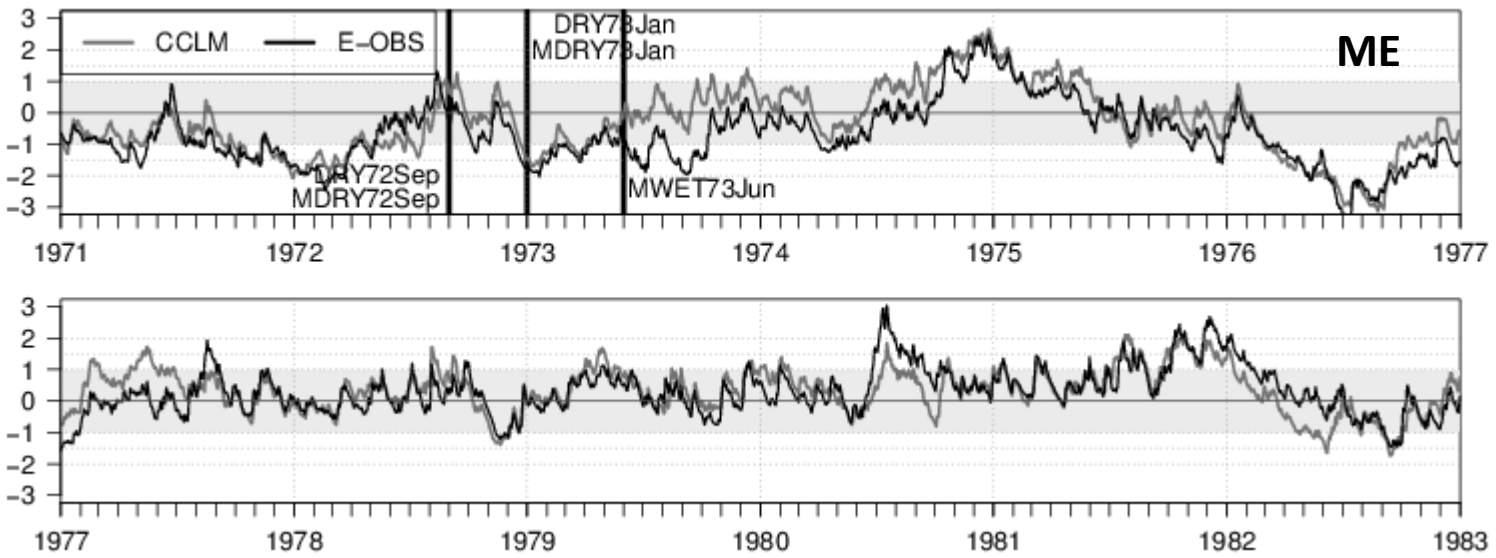
Effective Drought Index (EDI)

Mid Europe (ME) 1971-2000



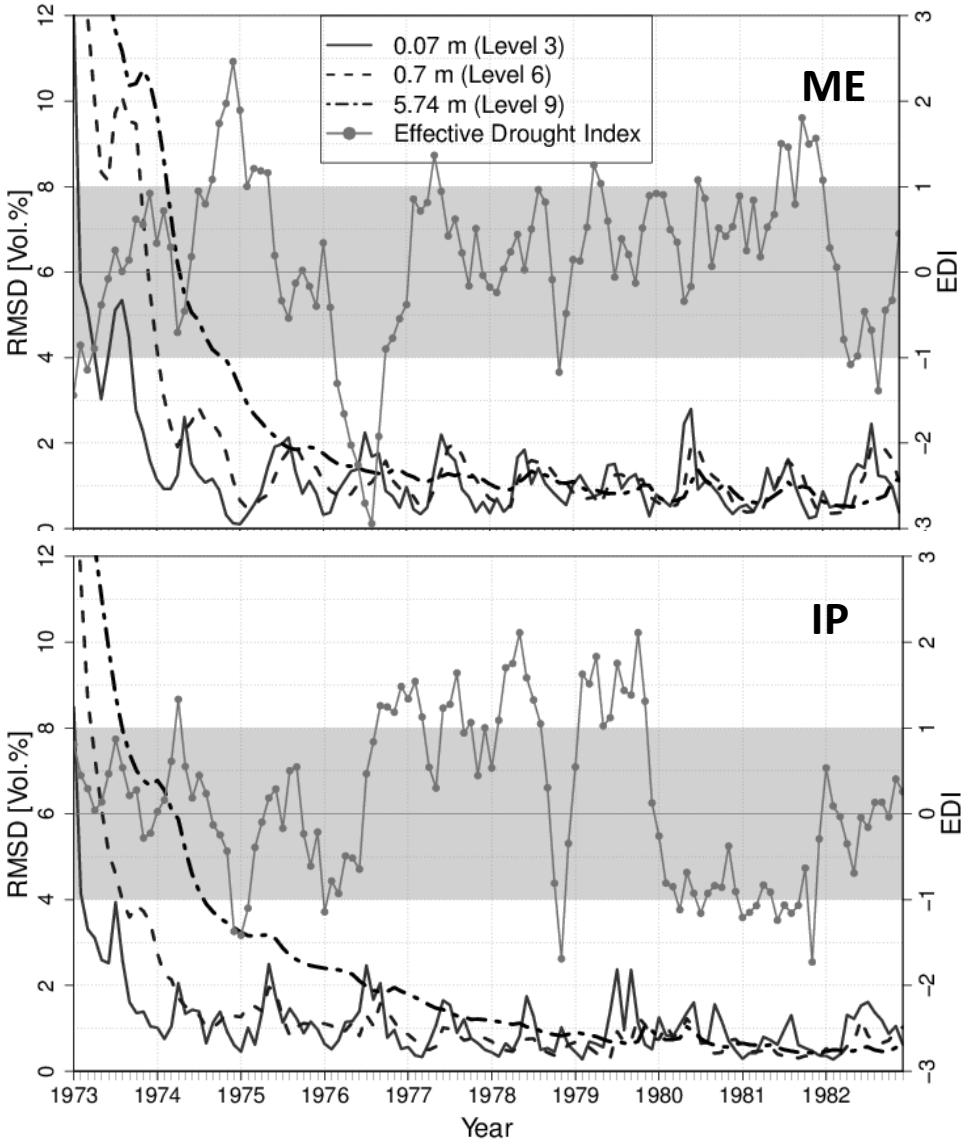
- The OBS and the model do not show any contrary behaviour, **regional/seasonal trends**, **extreme dry and wet periods** are **well simulated**.
- **High correlation between simulations and observations**, model offers a good base for investigating extreme climatic periods and the potential impact of soil initialization on decadal predictions.

Sensitivity experiments



Simulation	Modification	Start	End
MDRY72Sep	-15%	01.09.1972 00 UTC	01.01.1983 00:00 UTC
DRY72Sep	-50%	01.09.1972 00 UTC	01.01.1983 00:00 UTC
MWET73Jan	+15%	01.01.1973 00 UTC	01.01.1983 00:00 UTC
DRY73Jan	-50%	01.01.1973 00 UTC	01.01.1983 00:00 UTC
MWET73Jun	+15%	01.06.1973 00 UTC	01.01.1983 00:00 UTC

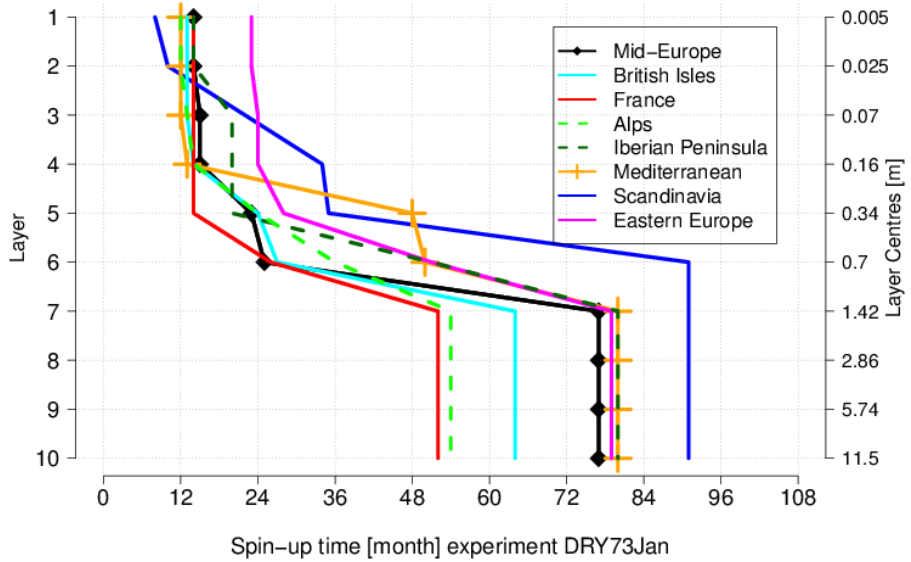
Soil moisture deviation

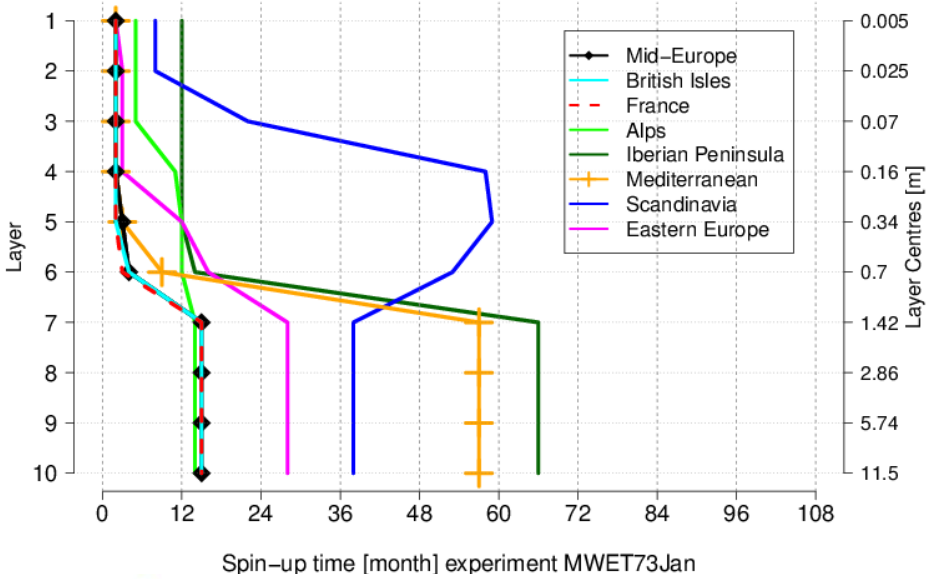


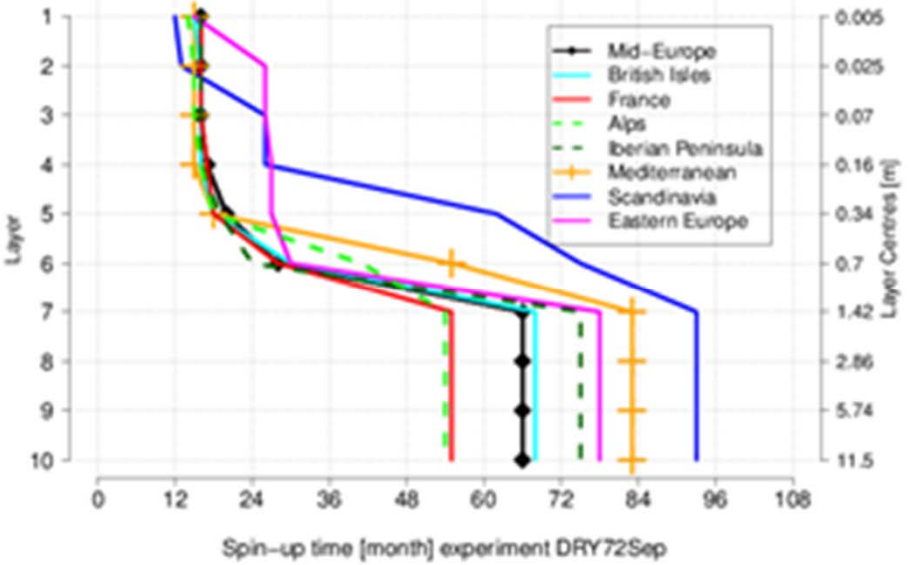
RMSD **DRY73Jan (-50%)** and REF SIM

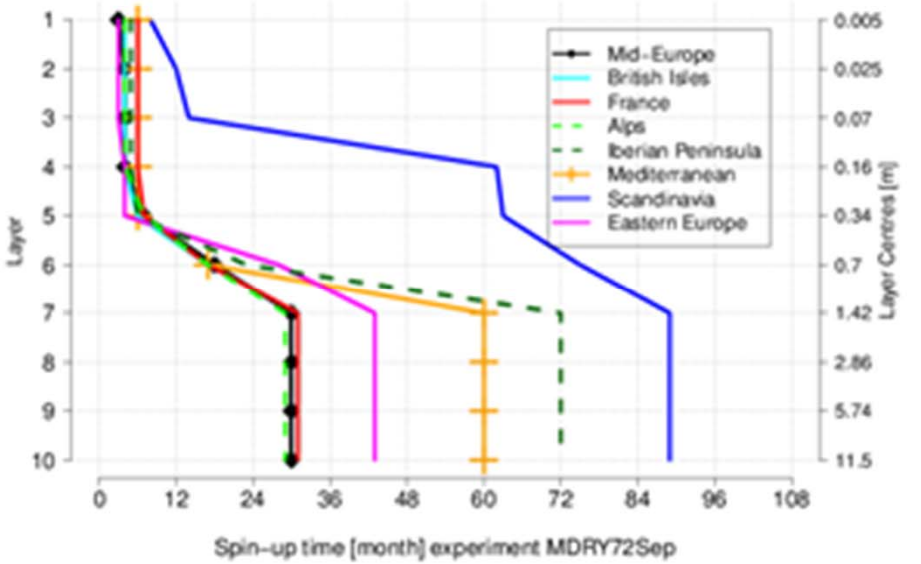
- **Artificial drift** with strong impact on the soil water contact during the **first phase**.
- **Deviations** larger than zero **until the end of the simulation**, summer months (1-3 Vol. %), in winter close to zero.
- IP vs ME: upper levels react similarly, **mid-soil depths** exhibit **lower deviations IP**, also less pronounced annual cycle.

Soil moisture spin-up time

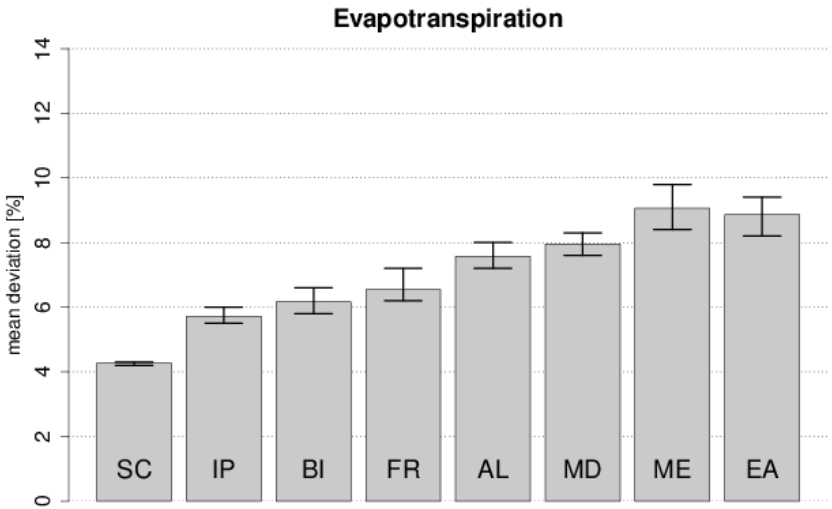


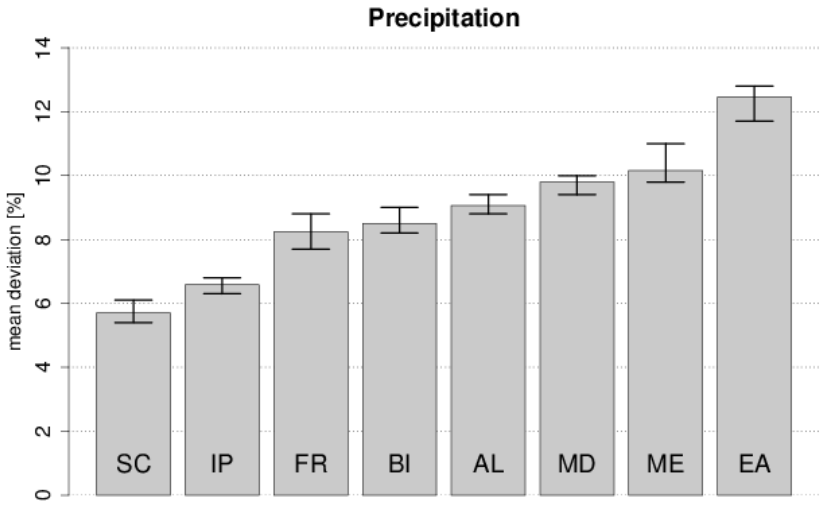






Mean deviation of the evapotranspiration and the precipitation for the investigated areas for all sensitivity runs

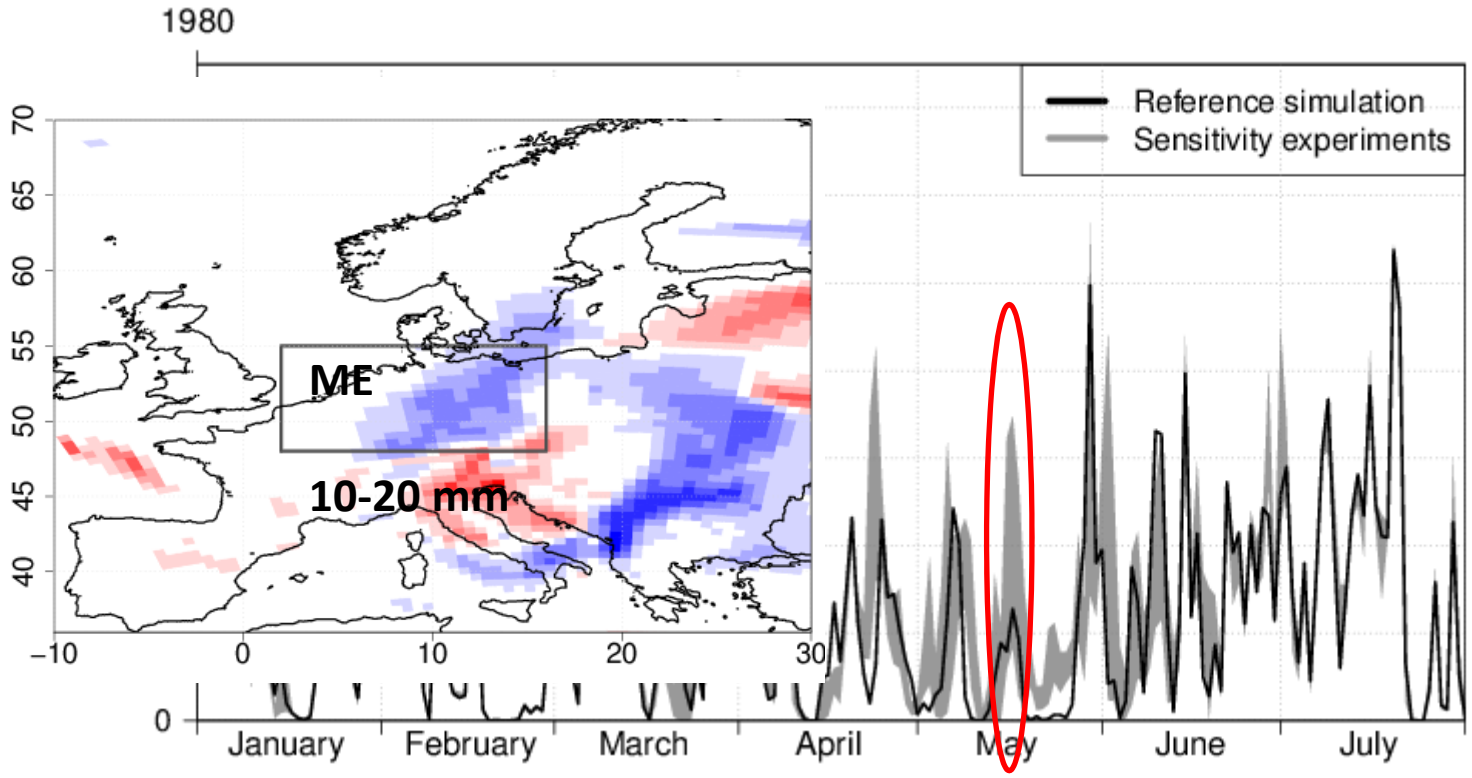




SC and IP (frozen and semi-arid soils) less moisture availability.

Sensitivity of atmospheric conditions to soil initialization: episodic investigation

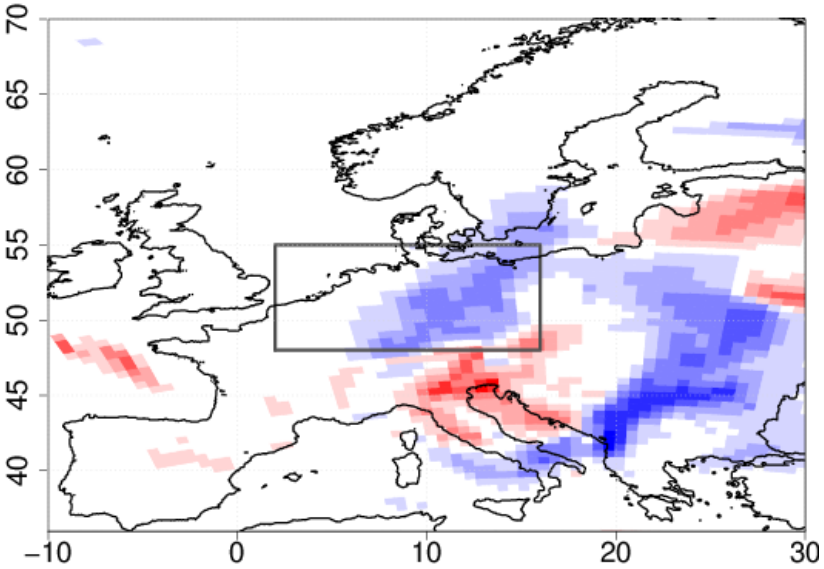
Precipitation deviations during the whole simulation



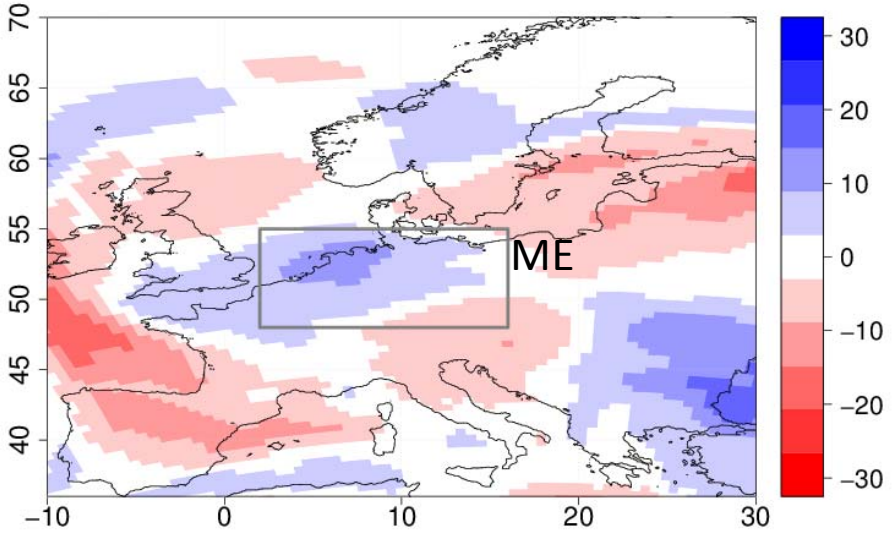
Precipitation deviation ~ 43% in the DRY73Jan

Spatial distribution of atmospheric water

16 May 1980 difference between the **DRY73Jan** and the **reference simulation**



Total precipitation (daily sum) in mm



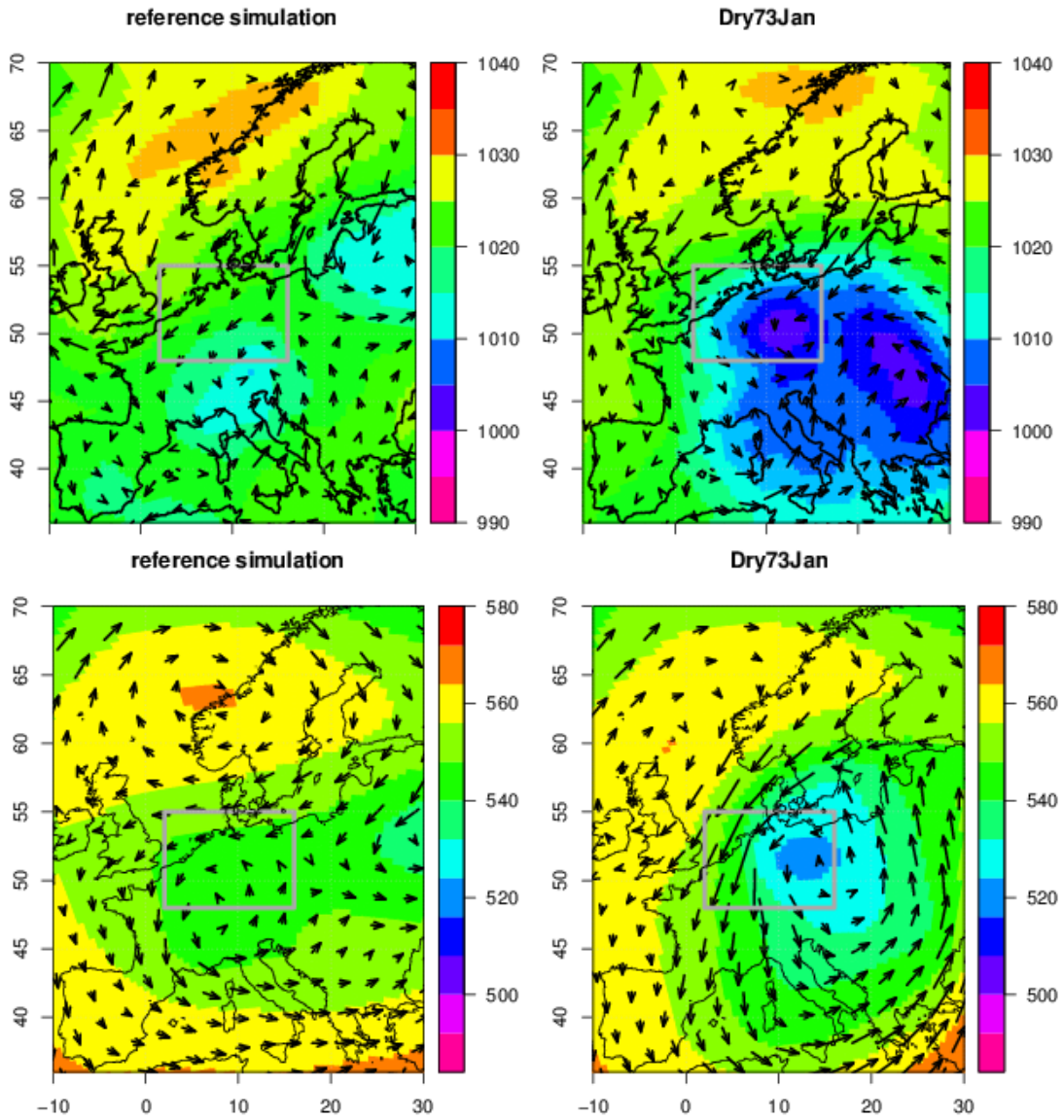
Integrated Water Vapour (IWV) in
(00 UTC; diff DRY73Jan)

Pressure and wind fields

16 May 1980 at 1200 UTC

Surface pressure and wind circulation at the corresponding level

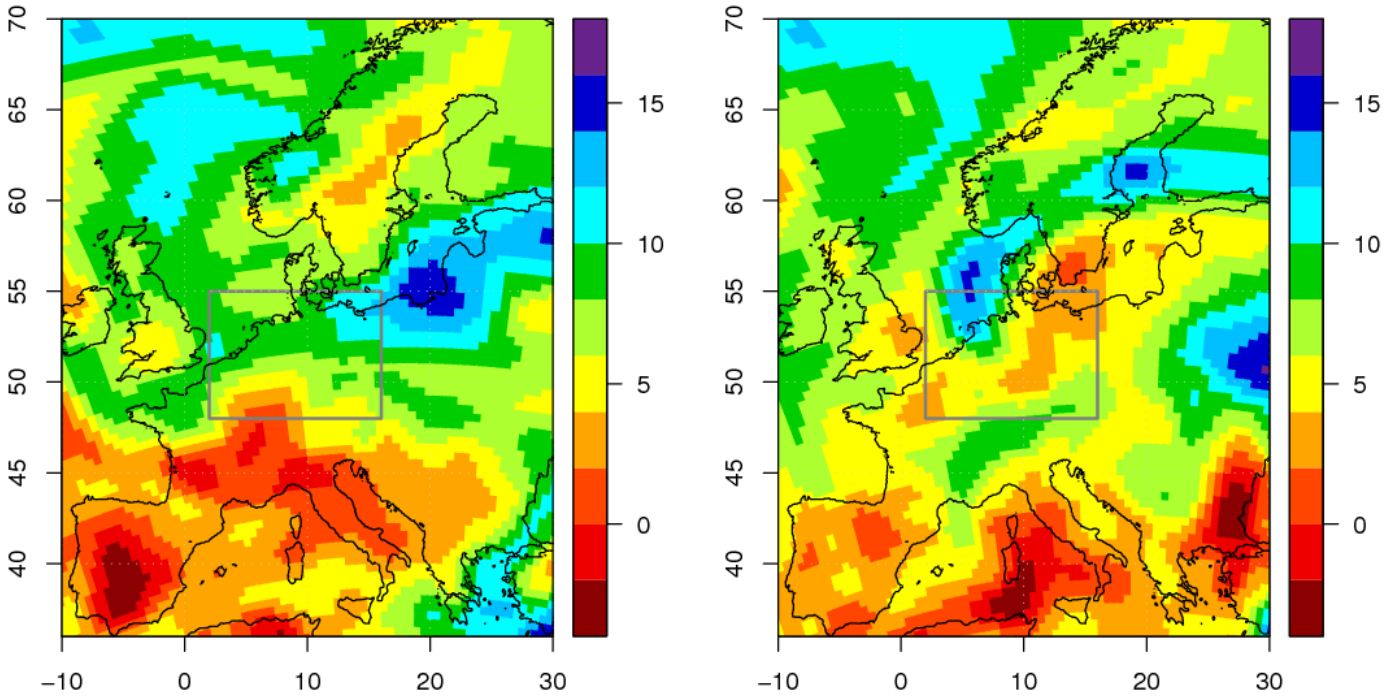
Geopotential height at 500 hPa and wind circulation at the corresponding level



Atmospheric instability conditions

16 May 1980 at 1200 UTC

Reference simulation | **DRY73Jan simulation**



KO-index in K (< 2 K, unstable atmosphere)

Conclusions

- The sensitivity studies prove the **soil as an element with long-term memory within the climate system**. Thus, insufficient knowledge of the soil moisture is prone to deteirorate predictions.
- **Regional characteristics** strongly impact response to **soil moisure initialization** also different soil levels react differently.
- **Humid areas**, and for all regions, a **humid initialization**, exhibit shorter spin-up times, also the soil reacts **less sensitive** when initialized during **wet periods**.
- **Reliable climatological observations are needed to characterize 3-D state of the soil.**

Thank you for your attention

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International Journal of Climatology
Article first published online: 16 JUL 2014
DOI: 10.1002/joc.4096

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