

Climatic variability in a regional climate simulation for Europe for the period 1645–2000 AD

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Project PRIME [Precipitation in the past Millennium] carried out in the framework of
INTERDYANIK [Integrated Analysis of Interglacial Climate Dynamics]
funded by the German Research Foundation



Motivation

_1 Quantify uncertainties in regional hydrological reconstructions

_2 Comparing model simulations with proxy reconstructions

_3 Investigate underlying physical mechanisms

_4 Assess impact of changes in external forcing parameters:

→ Natural (orbital, solar, volcanic) and anthropogenic (CO₂, land use changes)

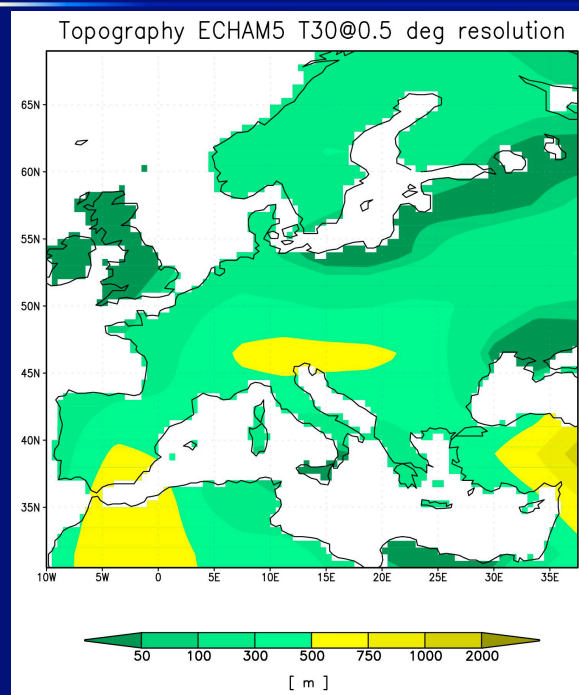
→ Regional structure of climatic response

_5 Compare temporal and spatial variability between ESM and RCM:

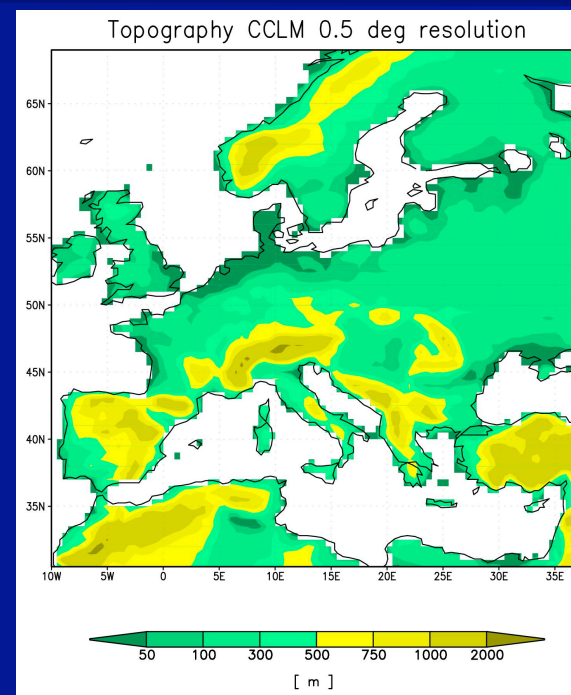
→ Target variables for paleoclimate: Temperature and Precipitation

→ Evolution of different climate variables on longer time scales

Comparison between GCM and RCM horizontal resolution

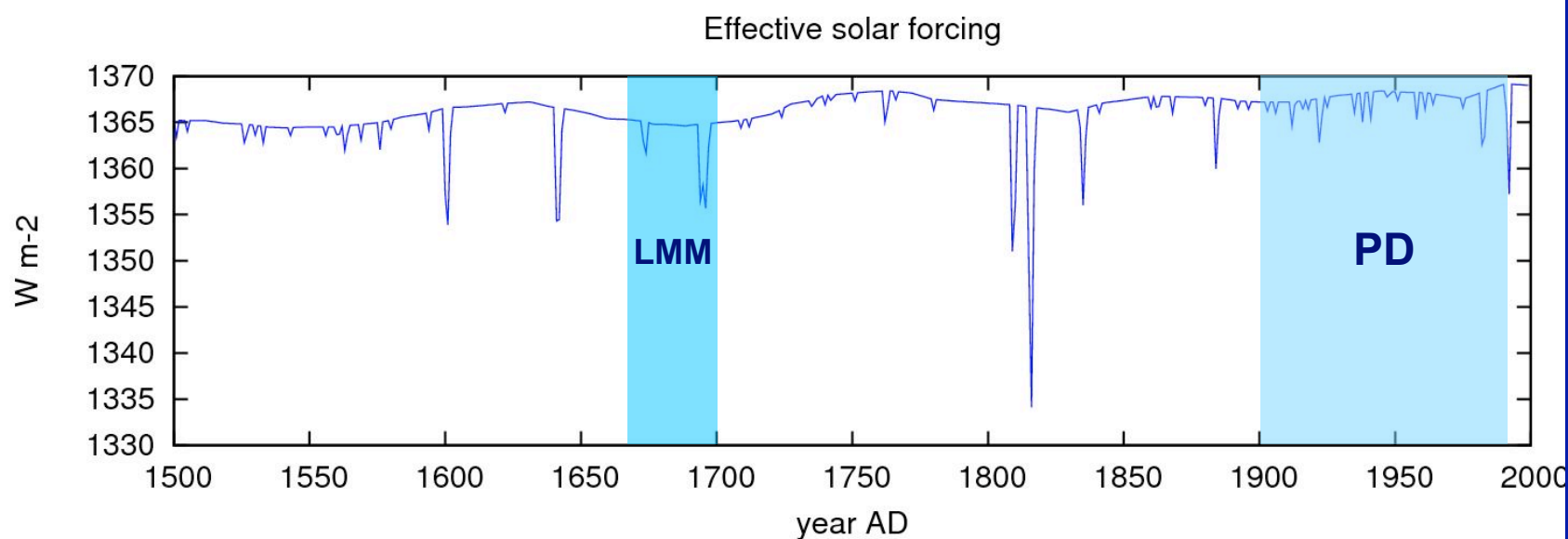


Earth System Model [MPI-ESM]:
Max-Planck-Institute of Meteorology,
Hamburg
ECHAM5-JSBACH/MPIOM-HAMOCC
3.75° x 3.75° corresp. ~350 x 350 km



Regional Climate model [RCM]:
COSMO-CCLM model
0.44° x 0.44° corresp. ~50 x 50 km

_ Combined solar and volcanic forcing



Transient regional climate simulation with forced with MPI-ESM for the period 1650–1990 including solar, volcanic, interactive carbon and land use changes

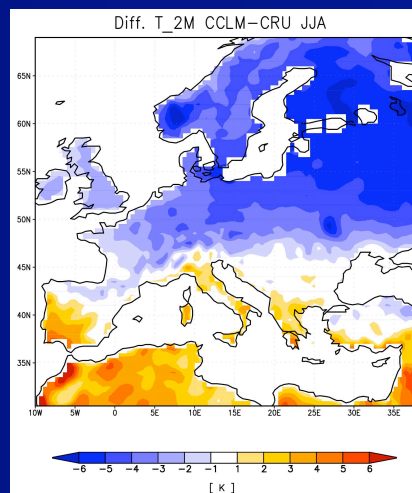
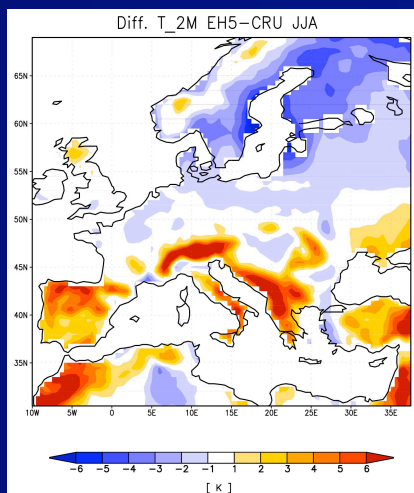
(Jungclaus et al., 2010, *Climate of the Past*, 6, 723–737)

Comparison of ESM and RCM results with observations [CRU] for **summer** for 2nd half of the 20th century:

ESM minus OBS

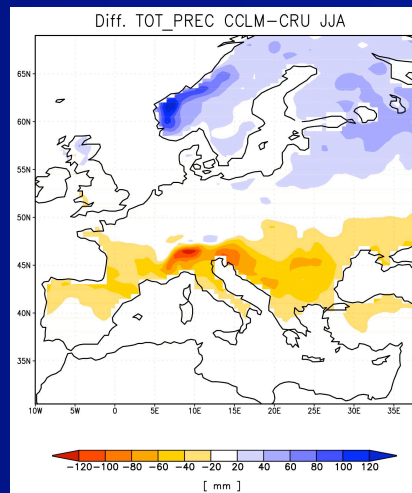
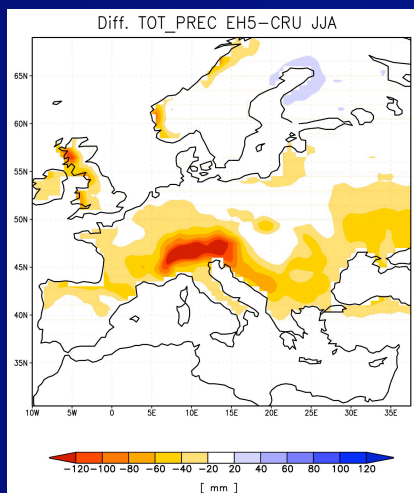
RCM minus OBS

T2m



- ESM and RCM show dipole pattern between northern and southern Europe
- larger temperature biases over complex terrain in ESM

Precip



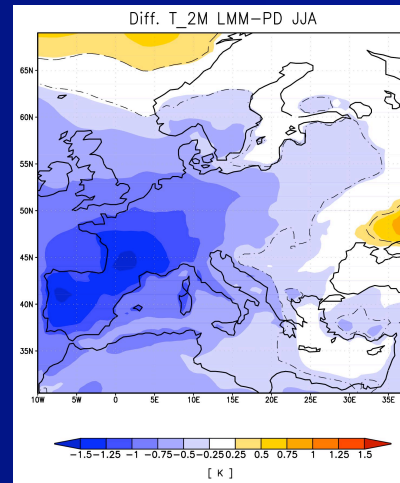
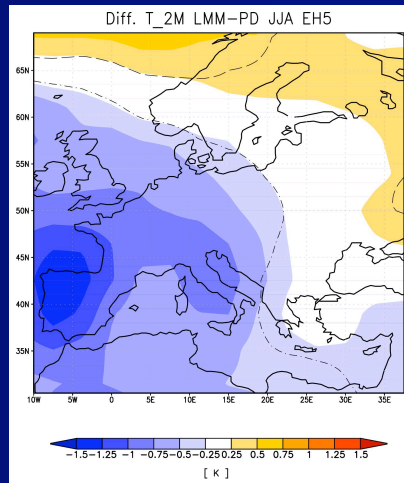
- Negative precipitation bias over central and eastern Europe in ESM
- Dipole pattern with positive bias over northern Europe and negative bias over southern Europe in RCM

Climatic changes between Late Maunder Minimum [1675 – 1700 AD] and 20th century [1900 – 1990 AD] for **summer**:

ESM

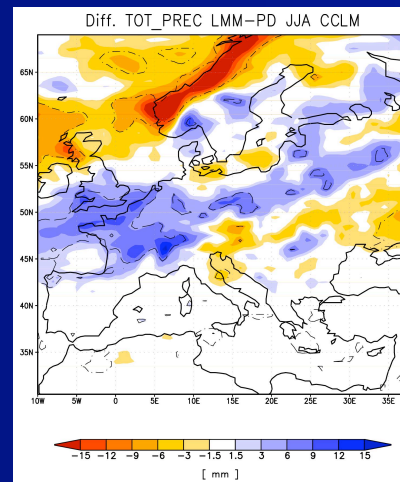
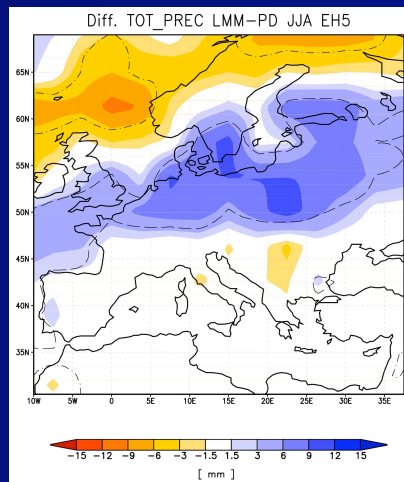
RCM

T2m



- ESM and RCM show similar large-scale pattern reduced temperature over western and southern Europe
- RCM shows some more regional details e.g. land-ocean boundary

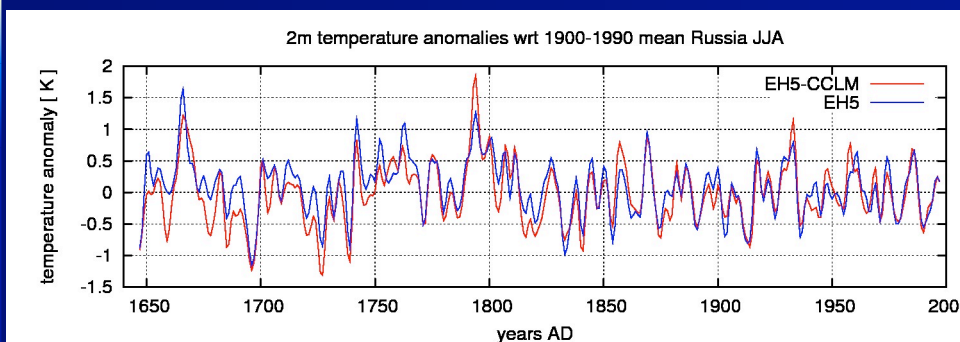
Precip



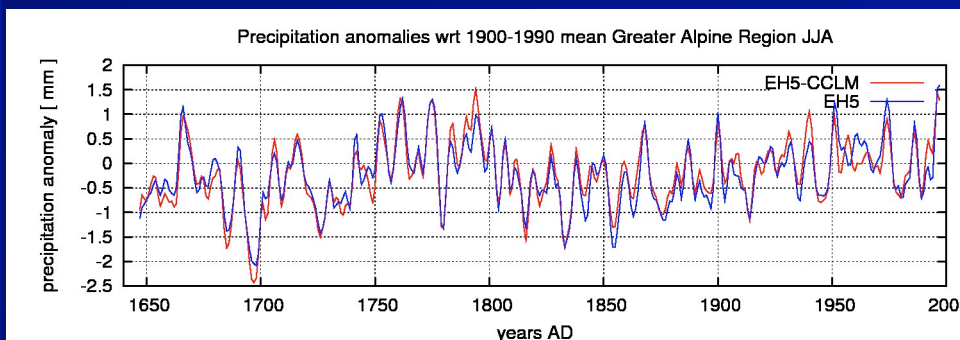
- Dipole pattern over North Atlantic and western and central Europe in ESM
- In RCM more regional fine-scale structures, e.g. increased precipitation over Norway coast

Comparison of the temporal evolution of *2m temperature* between ESM and RCM for different European regions

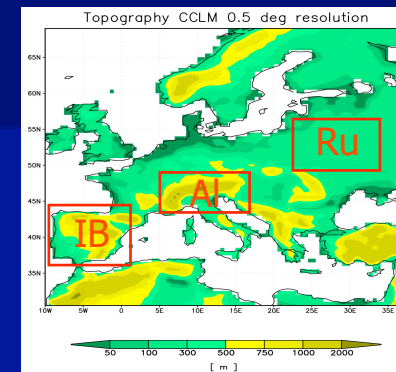
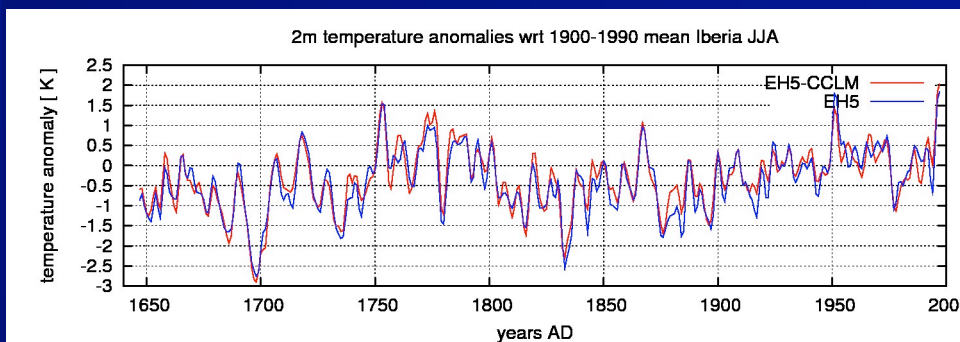
Russia



Alps



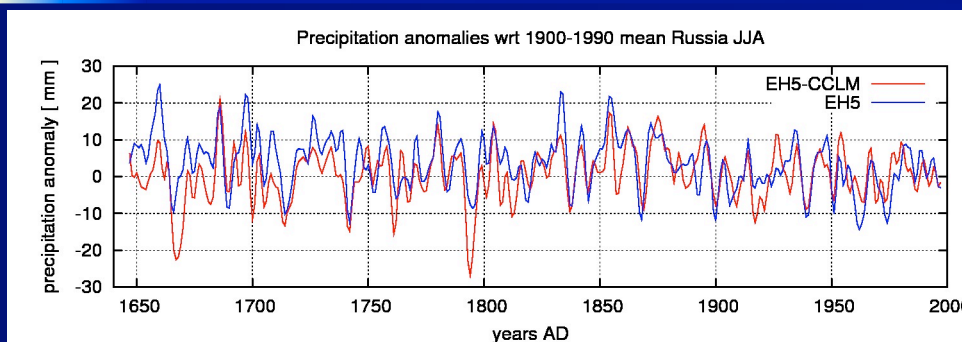
Iberia



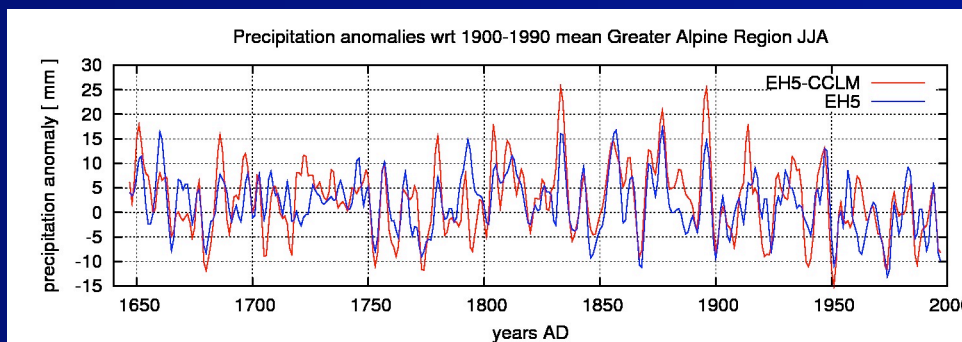
- High degree of similarity between ESM and RCM
- LMM evident with reduced T2m in all regions compared to 20th century
- Comparatively high T2m level in 2nd half of 18th century
- 20th century shows deviations in T2m evolution

Comparison of the temporal evolution of *precipitation* between ESM and RCM for different European regions

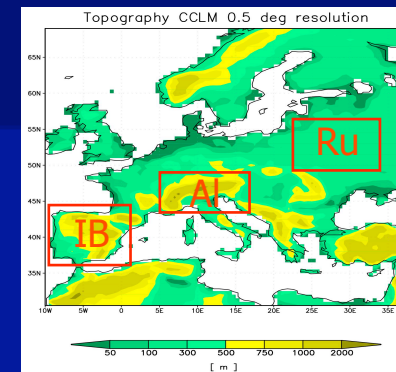
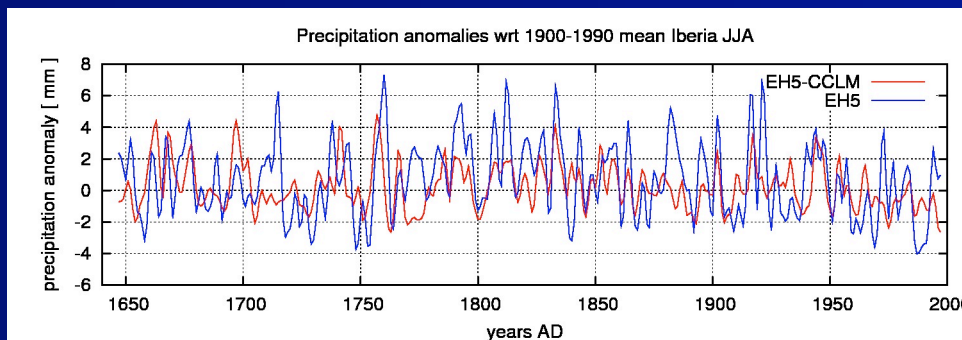
Russia



Alps



Iberia

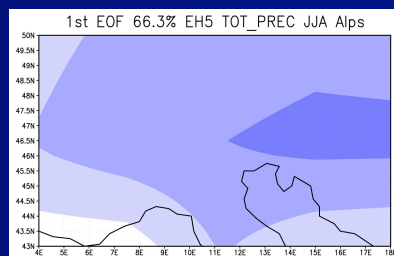


- Larger differences between ESM and RCM compared to T2m
- Relation to changes in external forcings less clear-cut
- Higher degree of variability over Russia and Alps
- Decreased degree of variability over Iberia

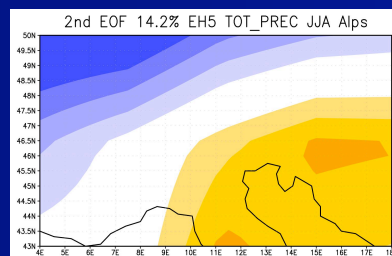
Comparison between centres of variability between ESM and RCM over the Greater Alpine Region

ESM

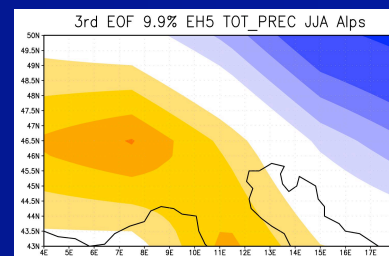
EOF1



EOF2

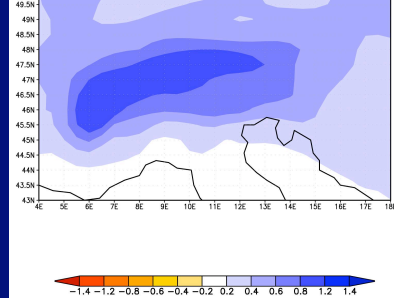


EOF3

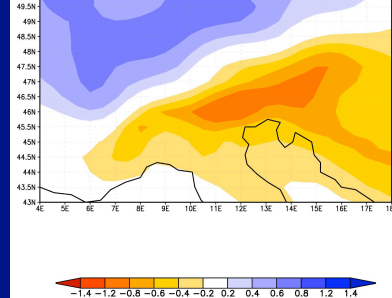


RCM

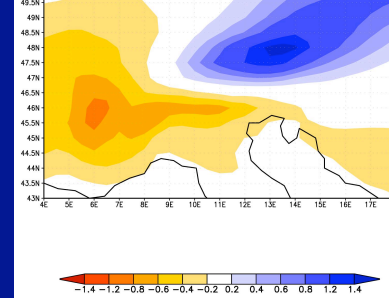
EOF1



EOF2



EOF3



- More fine-scale structures related to complex topography in RCM-EOFs
- Larger spatial gradients represented in RCM-EOFs
- Temporal evolution of PCs shows differences between ESM and RCM

Summary

- _ Regional climate simulations show greater regional details
- _ RCM inherits basic model biases from driving ESM
- _ Large-scale spatial patterns are similar to driving model
but: Precipitation variability different in regions with complex terrain
- _ Long-term temporal variability is similar to ESM
but: amplitude and precipitation variability is different in RCM

Conclusions for data-model comparisons:

- ESM-Temperature might be used for direct comparisons
- Precipitation averaged of larger areas might also be used for direct comparisons on longer time scales
but needs to be downscaled for proper comparisons over regions with *complex terrain* and *semi-arid regions*

Outlook

_Comparison with pseudo-proxy and proxy data

→ Using regional simulations as testbed for climate reconstructions

_Deeper Investigations of underlying physical mechanisms

→ Impact of regional to local scale features, e.g. of soil moisture on hydrological patterns

_Extension of simulations into the past (last 2000 years)

→ PRIME 2: Investigations of hydrological changes in the Mediterranean area during Roman times

Thank you for your attention