Investigating the impact of soil moisture on European summer climate in ensemble numerical experiments

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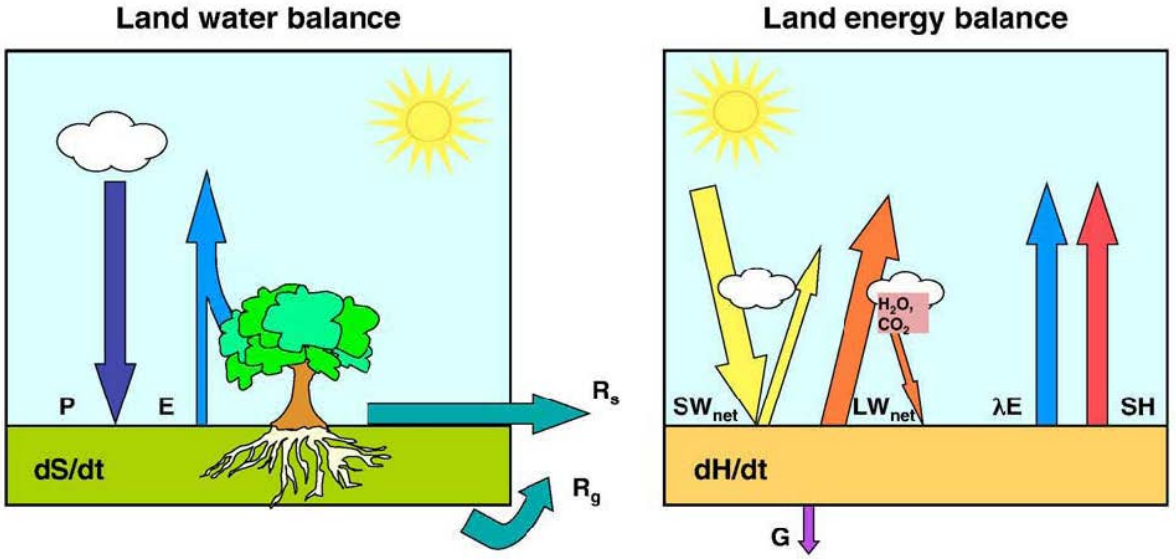
Introduction (1/2)

- Dynamical forecast systems are poorly skilled in predicting the summer temperature and precipitation in Europe and the Mediterranean

- Empirical relationship found between spring soil moisture (SM) and summer temperature anomalies

- Many studies have spotted regions where **summer climate is influenced by SM anomalies**, as a result from intense land-atmosphere coupling (e.g. Seneviratne et al., 2006; Dirmeyer, 2011, Koster et al. 2011)



(Seneviratne et al., 2010)

Introduction (2/2)

- **Improved SM initialization → improved seasonal forecasts?**

  Only partly confirmed for Europe, and mainly for T_{2m} (e.g. Van den Hurk et al. 2012, Prodhomme et al. 2016, Ardilouze et al. 2017, Bunzel et al., 2018)

- **Could we expect more from SM**?

  Is the role of SM as a driver of predictability overstated?

- Here, we assess the role played by **SM as a boundary condition** for the European summer climate

- Comparison of 2 sets of 4-month (MJJA) ensemble simulations over a 20-year period, in which SM is:
  - Initialized (= re-forecast)
  - Initialized and daily prescribed to pseudo-observations

- Simulations performed with 2 distinct RCMs

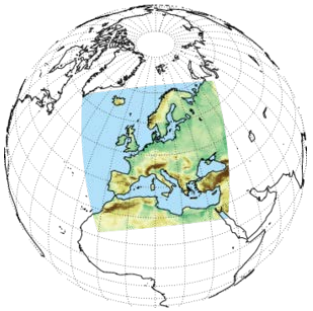
Experimental design

RCM

GCM

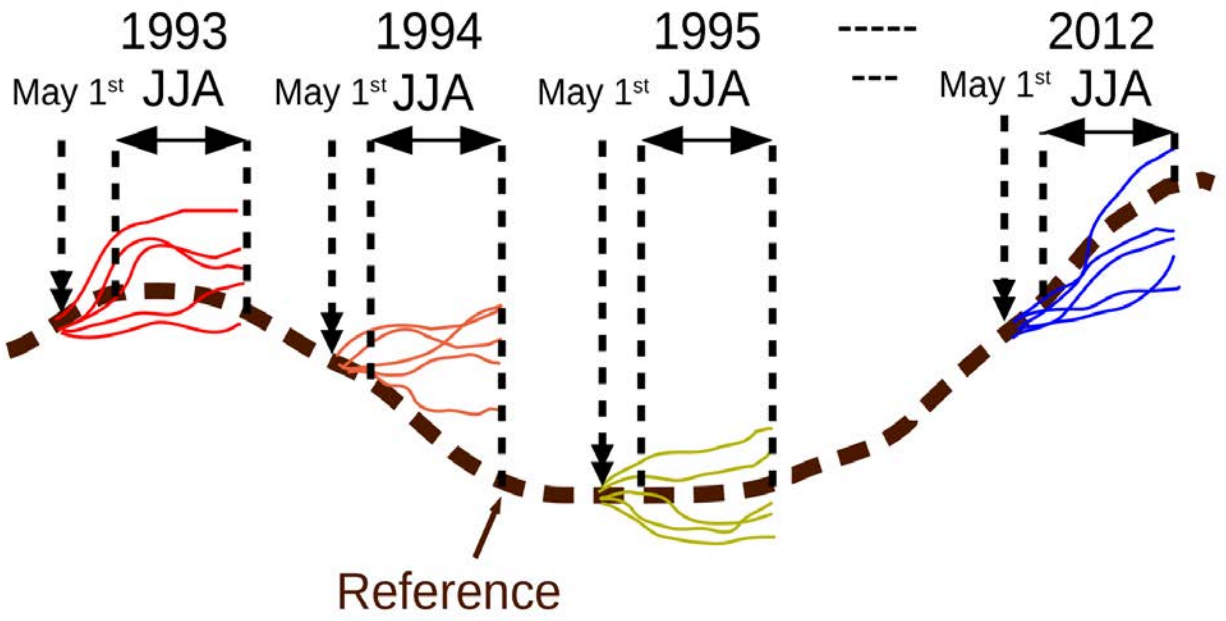
15-member re-forecast

15 LBC



15-member ensemble
(Free-running SM)

15-member ensemble
(Daily prescribed SM)



Experimental design

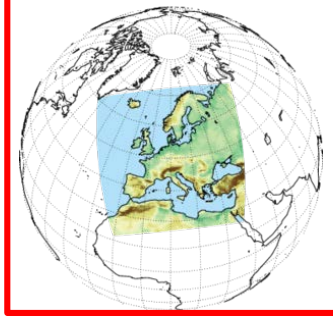
EC-Earth 3.1 T255

15 LBC

RACMO RCM

R-CTRL

(Free-running SM)



R-SOIL

(Daily prescribed SM)

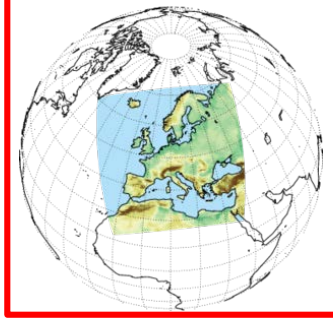
CNRM-CM T255

15 LBC

ALADIN RCM

A-CTRL

(Free-running SM)



A-SOIL

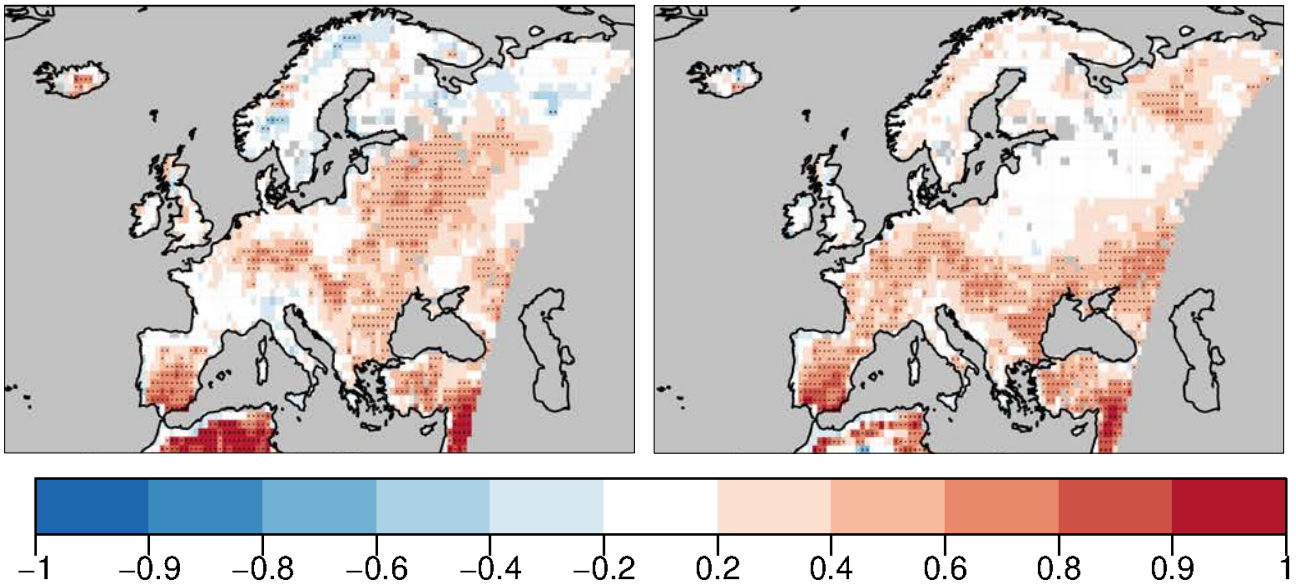
(Daily prescribed SM)

Soil moisture prediction skill in CTRL experiments

$$SWI_{1m} = \frac{\theta - \theta_w}{\theta_f - \theta_w}$$

θ = Soil water content
θ_w = Wilting point
θ_f = Field capacity

A-CTRL R-CTRL

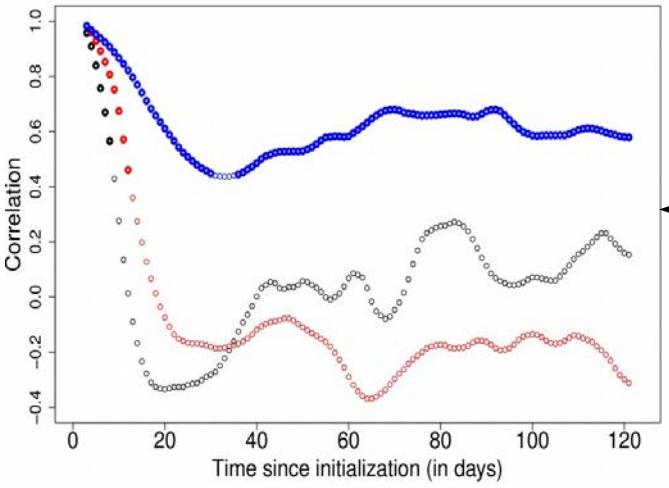


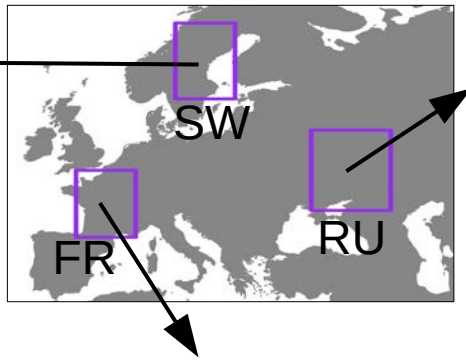
SWI JJA Correlation against ERA-Land

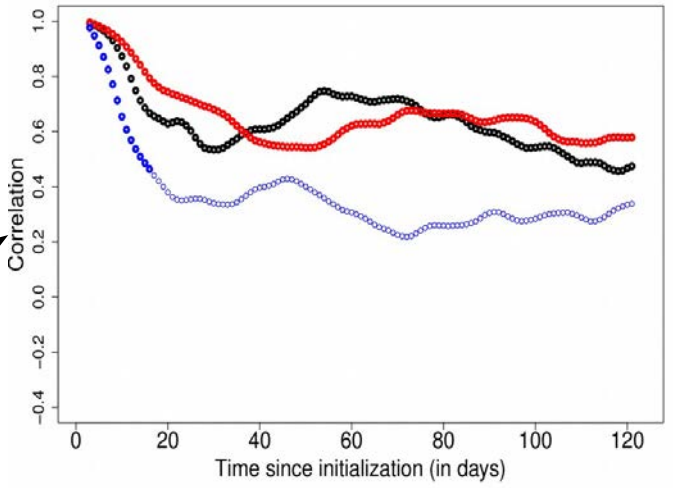
- SM is predictable to a certain extent
- Differences in predictability patterns → value of a multi-model approach

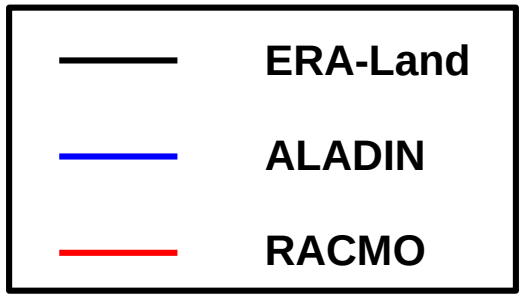
Soil moisture memory in CTRL experiments

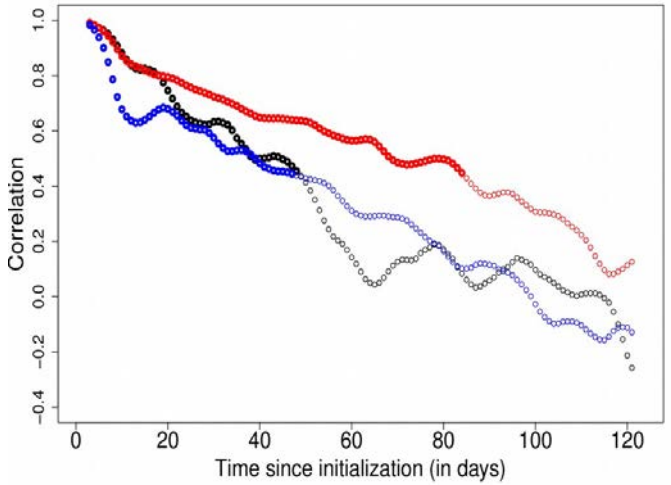
- Lagged correlations of initial SWI against 5-day running mean SWI











- Large uncertainties remain in terms of SM memory

JJA Tmax correlation (ref. EOBS)

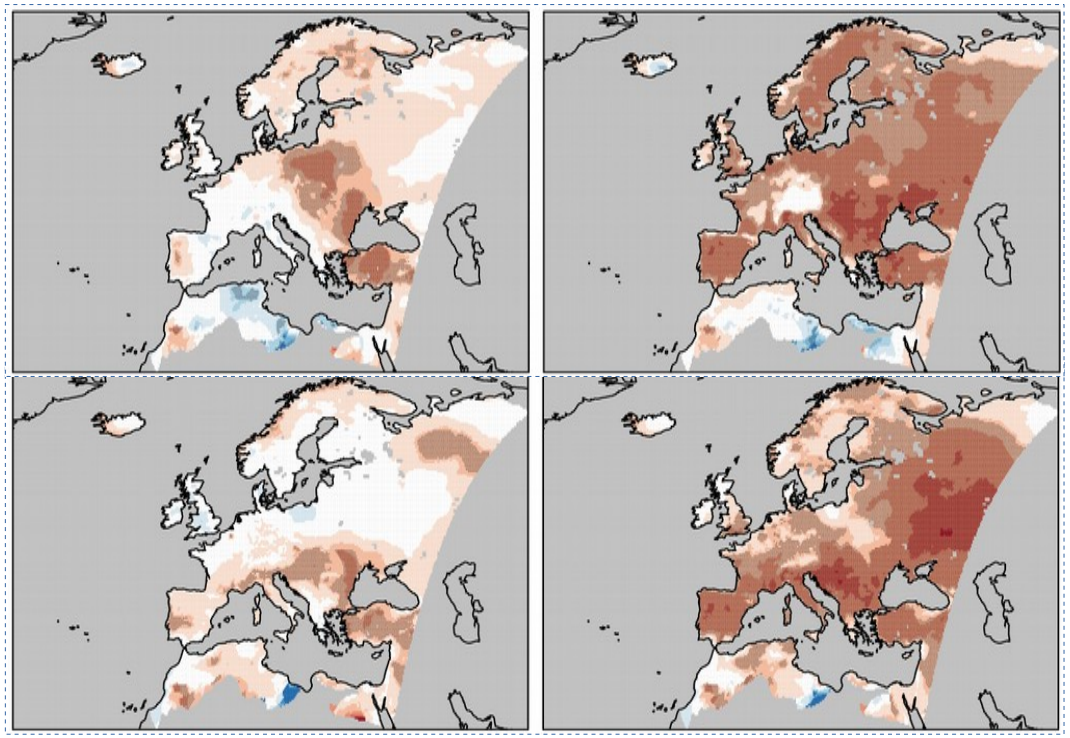
CTRL

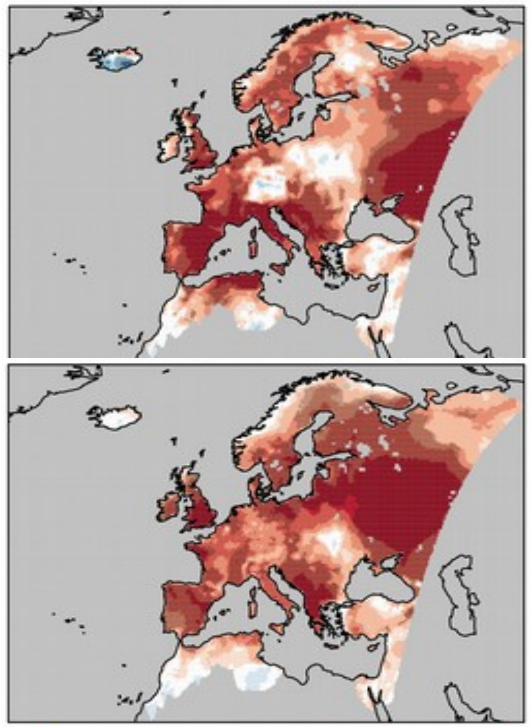
SOIL

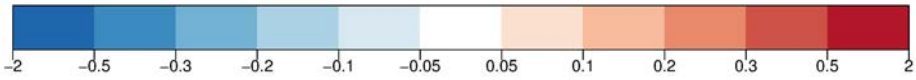
SOIL minus CTRL

ALADIN

RACMO







JJA Precipitation Correlation (ref. EOBS)

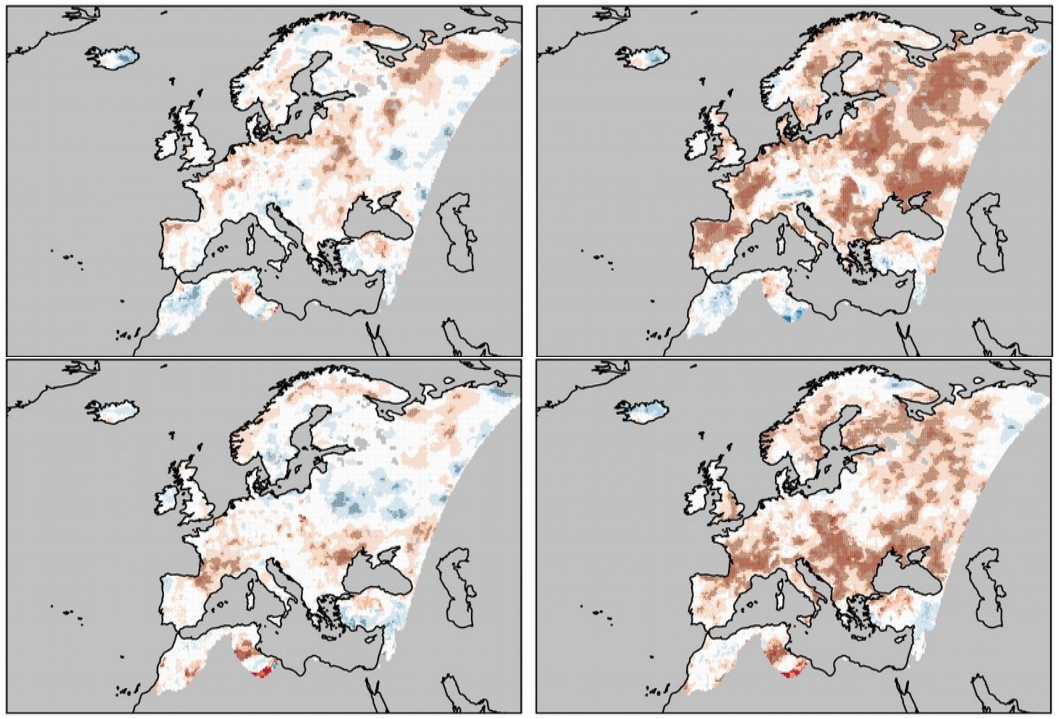
CTRL

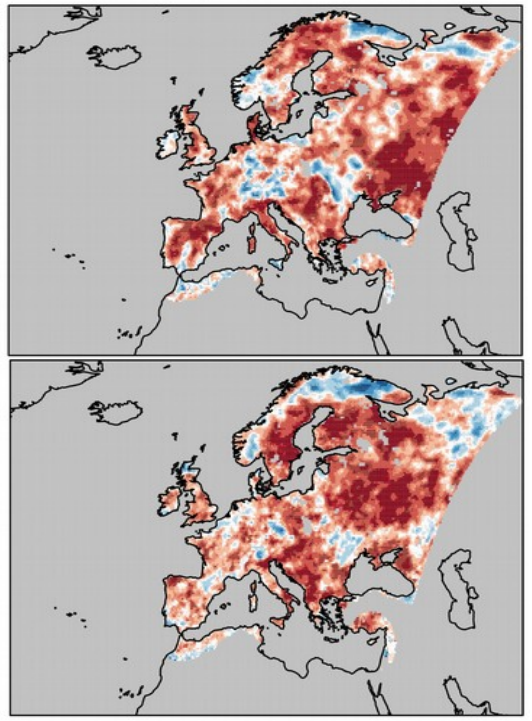
SOIL

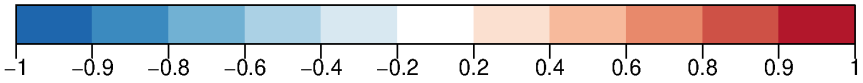
SOIL minus CTRL

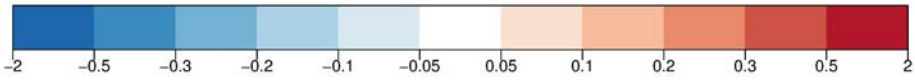
ALADIN

RACMO

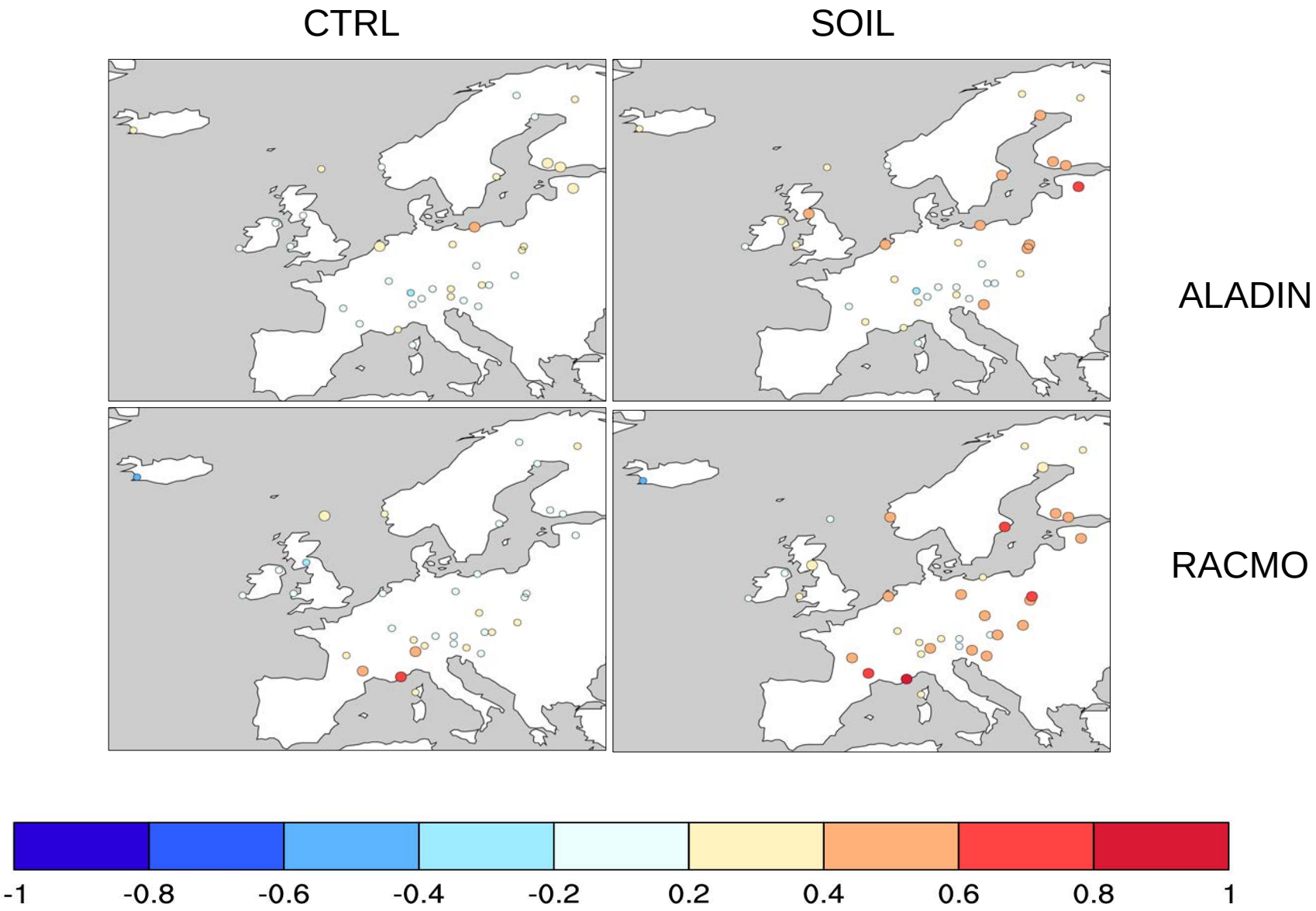






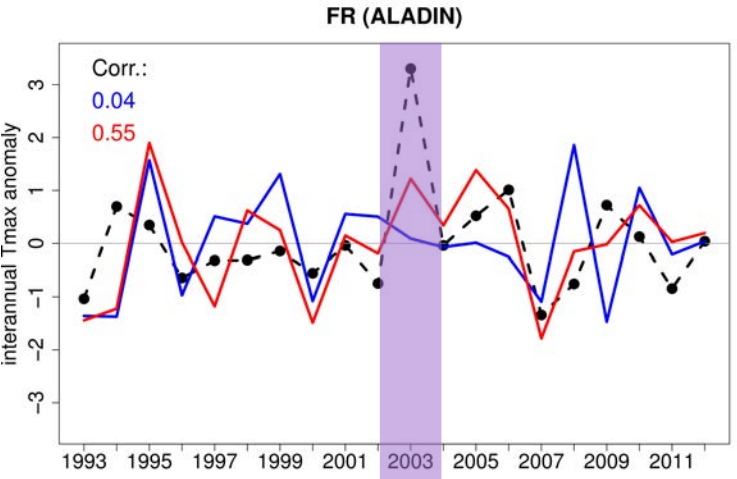


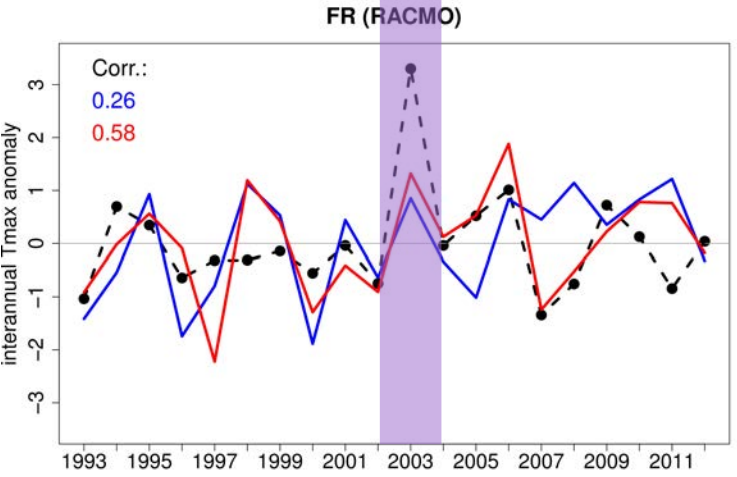
JJA Downward Surface SW radiation Correlation
(ref. : GEBA)

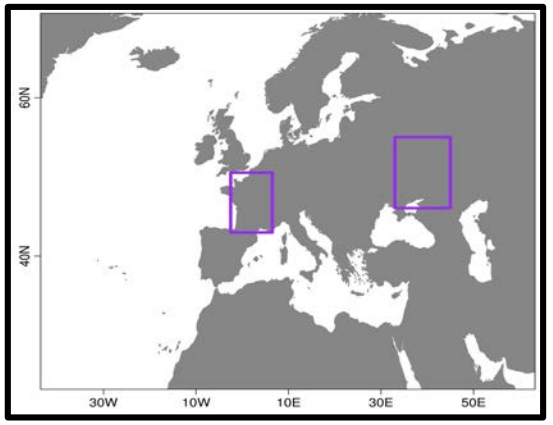


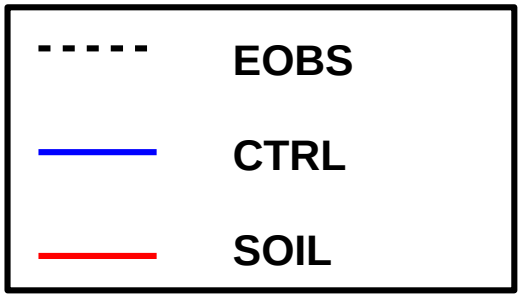
Extreme summers of 2003 and 2010 : Normalized JJA temperature anomalies

FRANCE

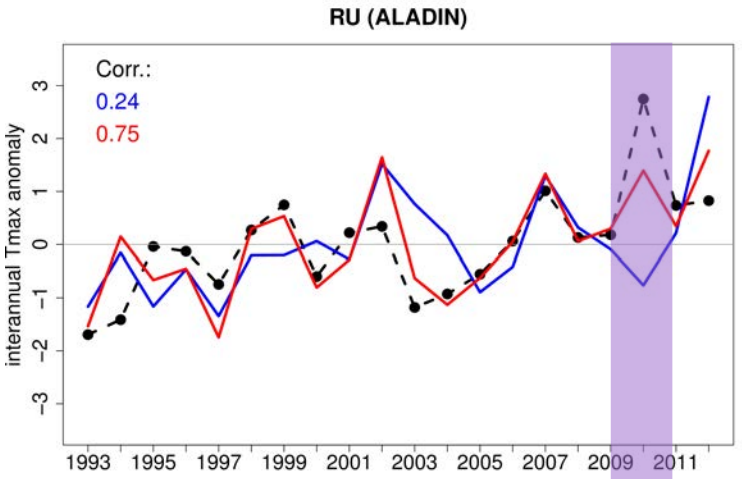


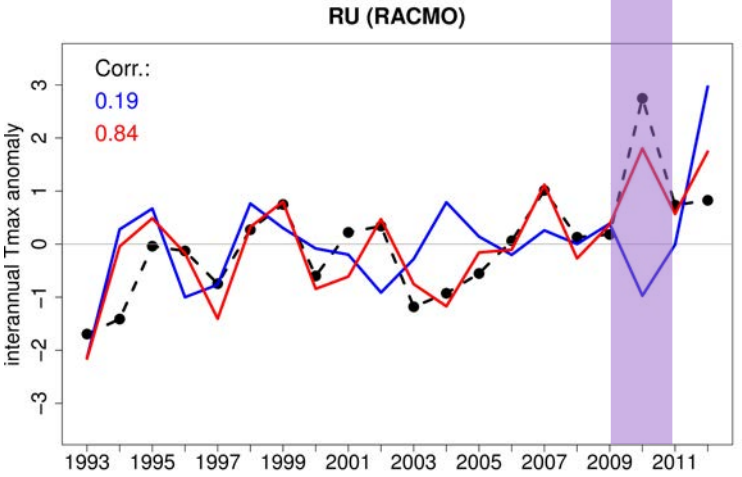




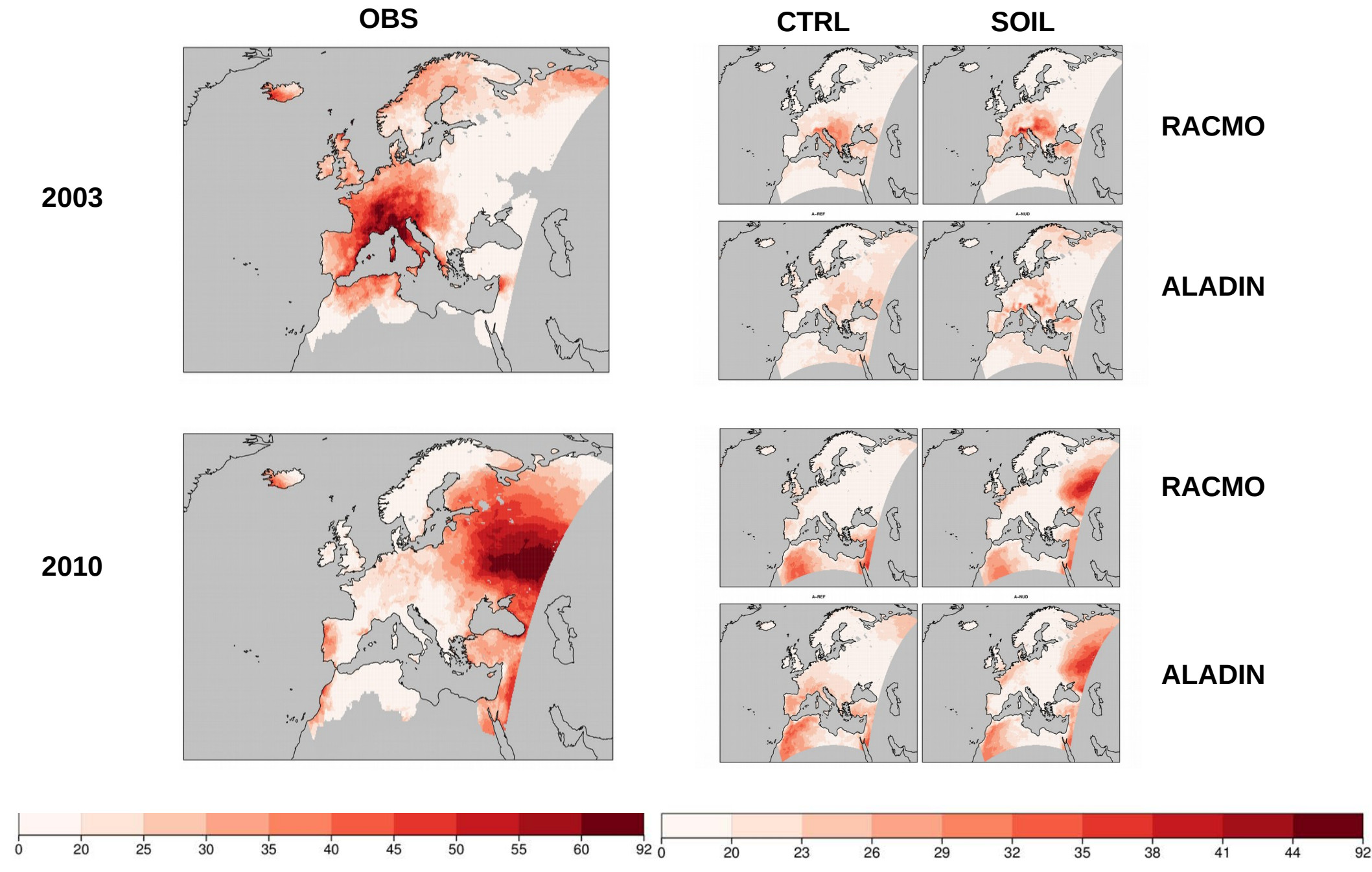


RUSSIA





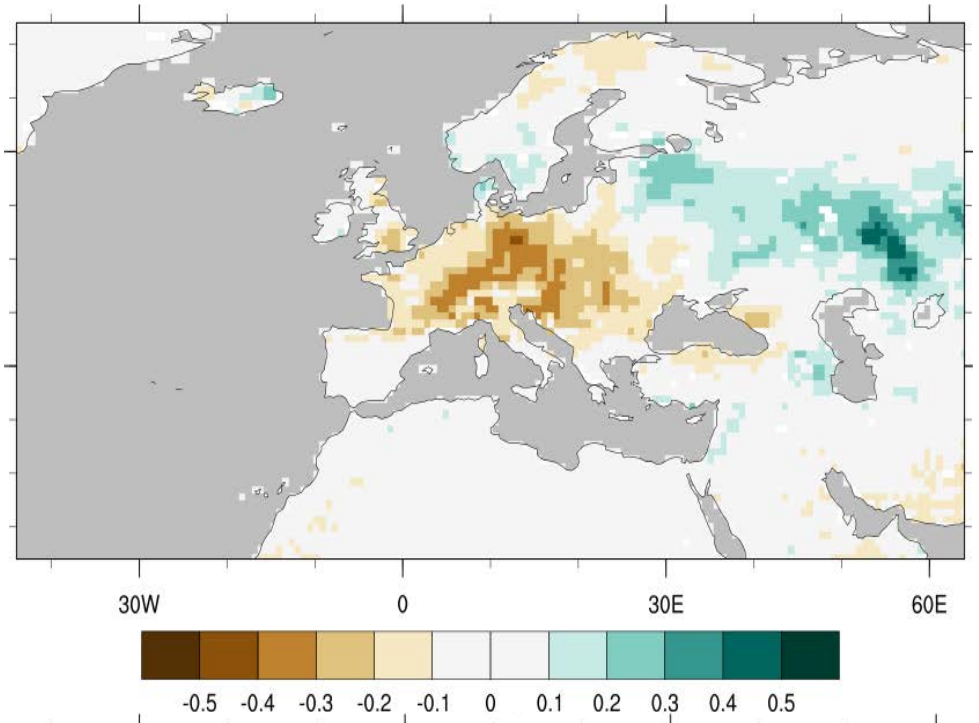
Number of days with Tmax > Q80

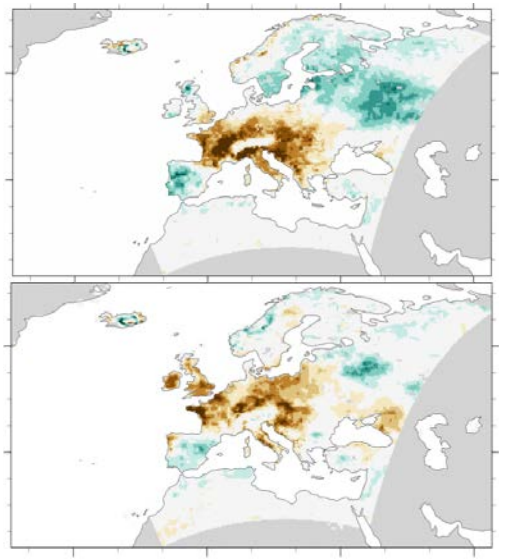


Extreme summers : JJA SWI anomalies

ERA-Land

2003

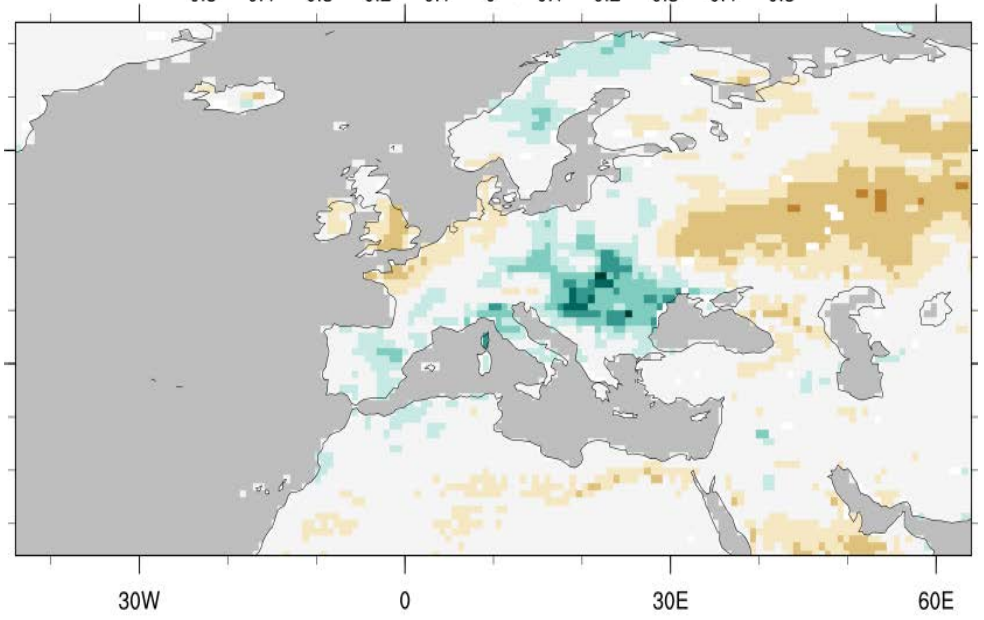


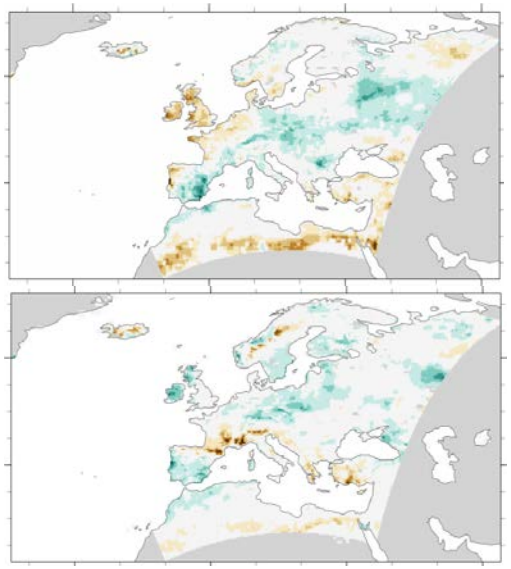


R-CTRL

A-CTRL

2010



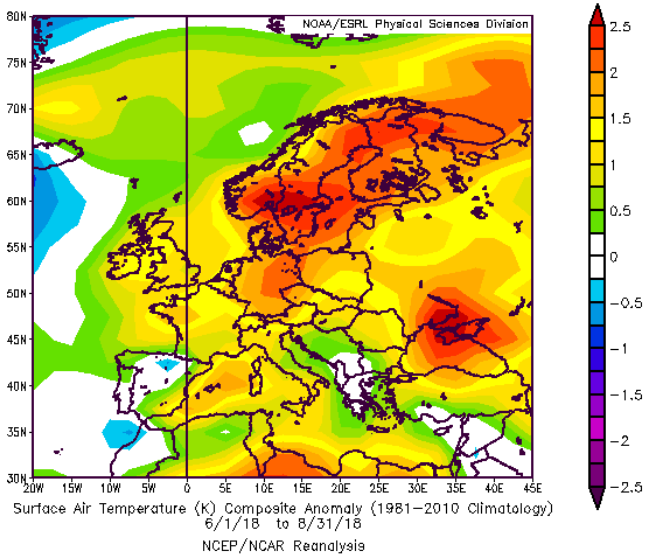


R-CTRL

A-CTRL

Conclusions

- Soil moisture is a key boundary condition for dynamical forecast systems. In our models, the European summer climate is **sensitive to SM even at high latitudes**.
- Applying the same setup to a GCM brings **similar conclusions for North America** (and Asia to a lesser extent)
- SM is a potentially **under-estimated driver of predictability**
- Result supported by *Bunzel et al. (2018)*: skillful summer forecasts achieved for Northern Europe with a refined land-surface component
- Future work : SM memory and contribution to the extreme 2018 summer in Scandinavia



More details in :

Ardilouze, C., *Batté, L., Déqué, M., van Meijgaard, E., van den Hurk, B. : Impact of soil moisture on European summer climate in numerical experiments. Clim Dyn (in press)*

doi:10.1007/s00382-018-4358-1

Thank you

Supplemental slide

JJA Precipitation correlation against GPCC (experiment with CNRM-CM5 GCM)