Understanding the 2003 and 2010 heat waves

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1. Introduction

Both 2003 and 2010 heat waves had dramatic consequences on the surrounding populations and none of those extreme events has been predicted in advance. Moreover, results of attribution studies seem to suggest that this kind of heat waves are more likely to occur in the future due to climate change. Thus, to be able to adapt and mitigate the effect of such heat waves, decision makers need a reliable and anticipated prediction of this kind of events.

In the present study, we demonstrate that those heat waves were predictable up to 4 months in advance. This allows us to investigate the mechanisms underlying the occurrence of the heat waves and especially the role of dry soil moisture initial conditions, which has been suggested to be a crucial factor for the occurrence of both heat waves.

2. Model and data

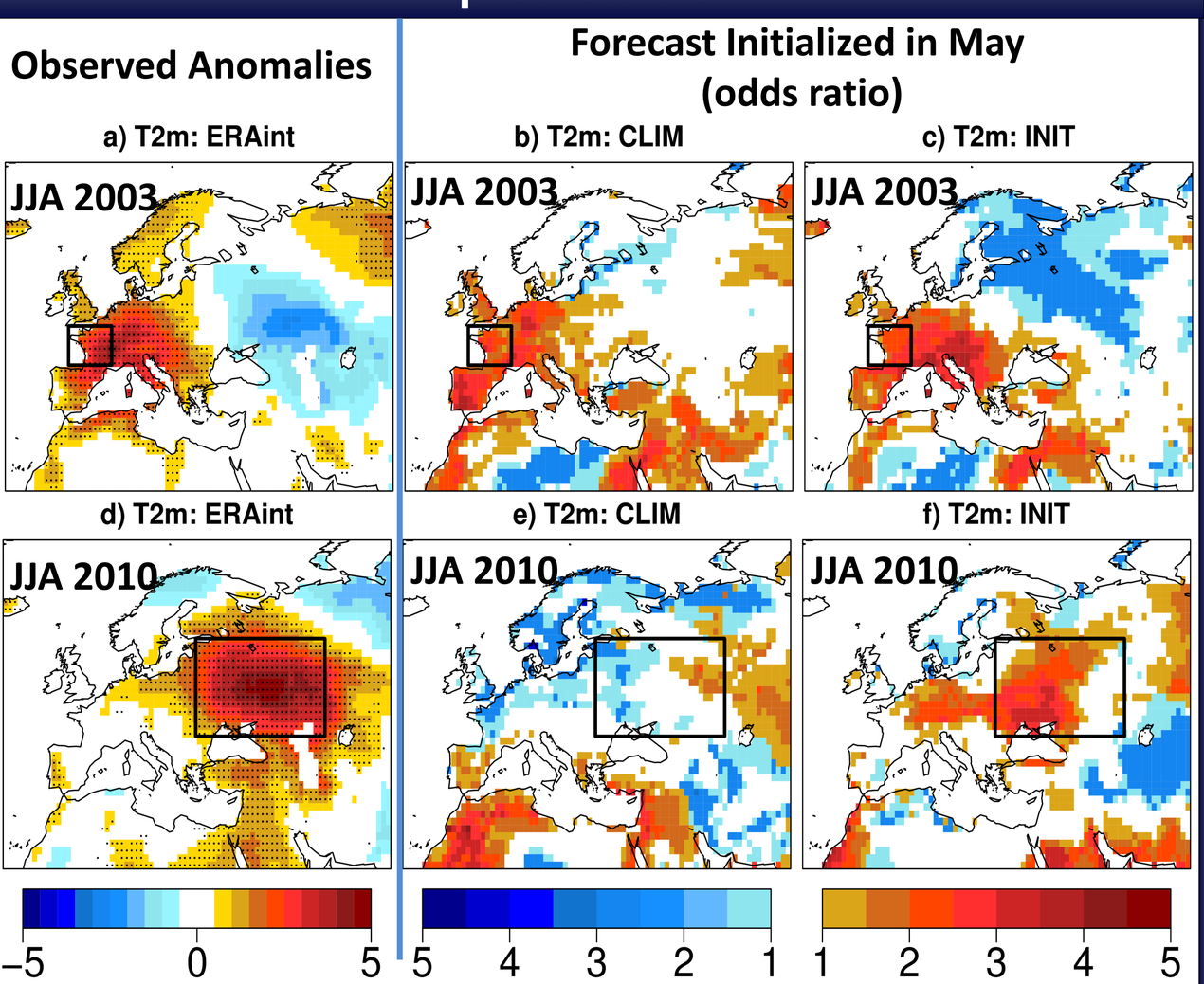
In order understand the role of soil moisture in initial condition in 2003 and 2010 heat wave we compare two sets of hindcasts:

model	Period	Start dates	Land IC	Atm IC	Oce/Ice IC
EC-Earth 2.3 (T106-ORCA1)	1981-2010	May, June, July, August	**ERA-Land**	ERA-Interim	ORA-S4

Realistic → **INIT**; Climatology → **CLIM**

We use **ERA-interim** to validate 2m-temperature (T2m) and soil moisture.

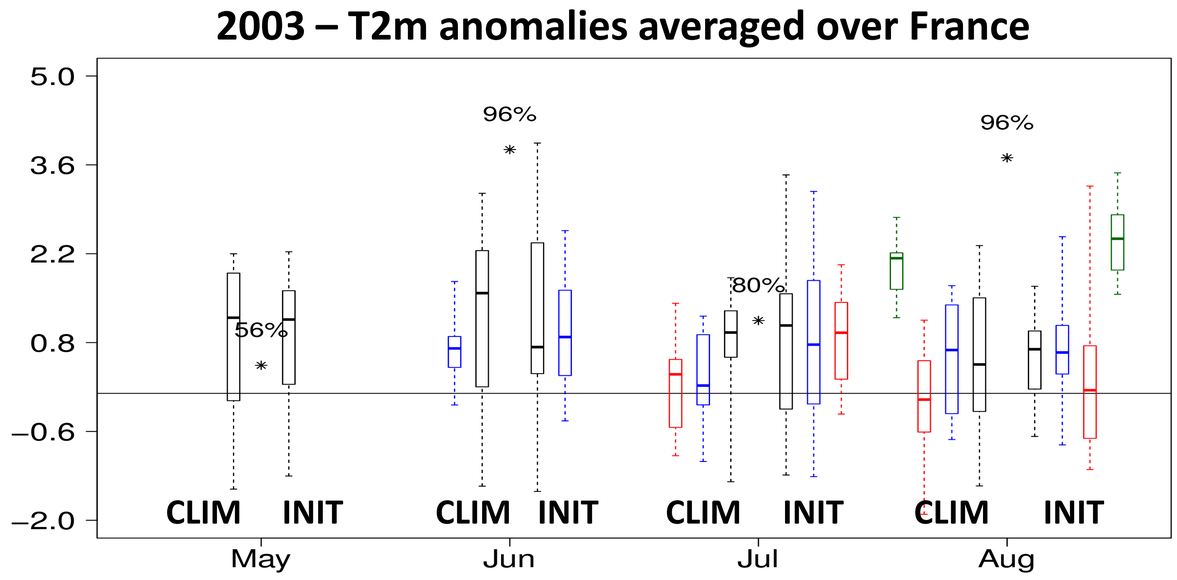
3. Were 2003 and 2010 heat waves predictable?



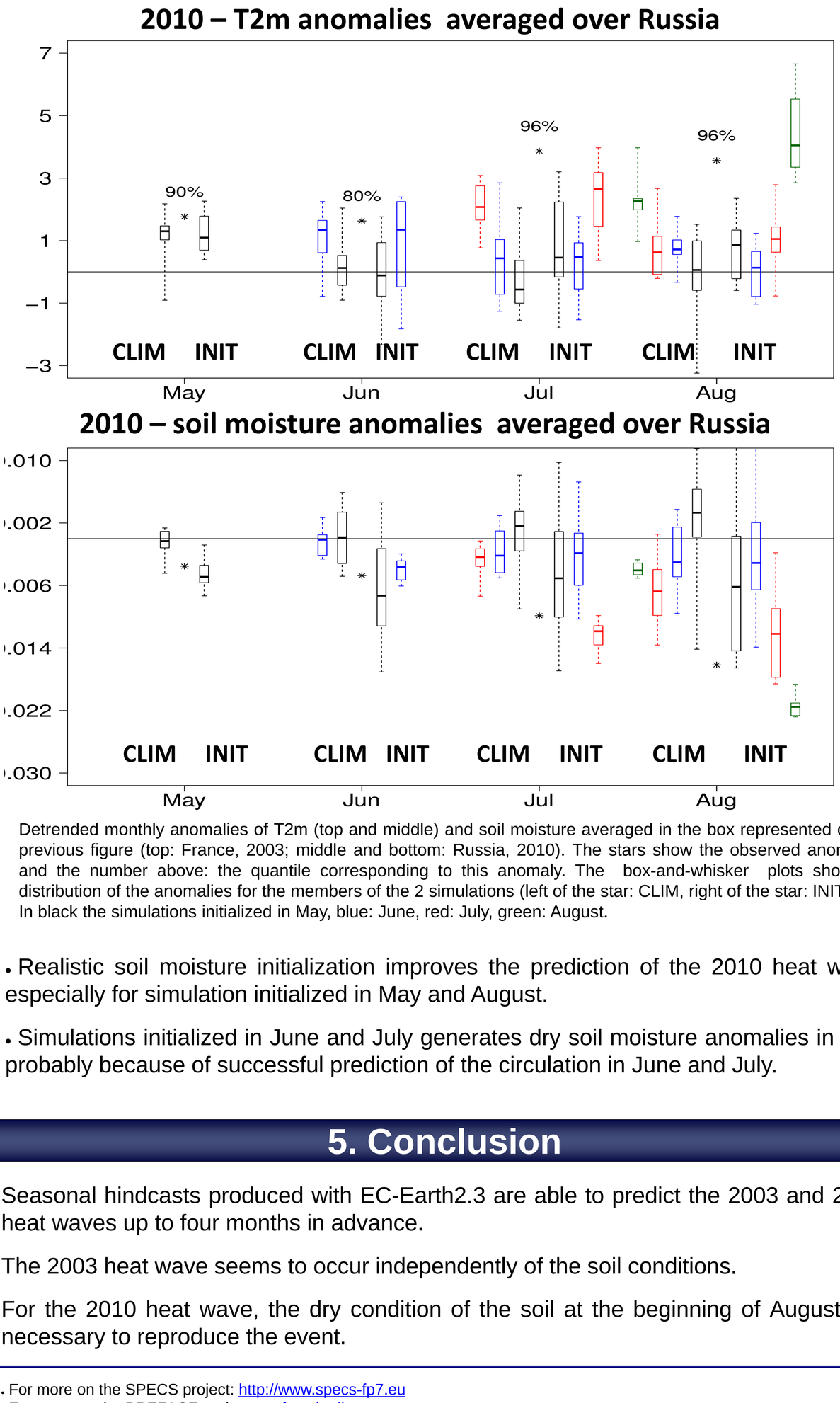
a) and d) Anomalies of detrended 2m-temperature in JJA 2003 (top) and 2010 (bottom). The dots indicate the area where the anomaly is in the upper quintile (estimated over 1981-2010). b)-c) and e)-f) Odds in CLIM (middle) and INIT (right) for T2m. The odds are the ratio between the probability for the anomalies to be in the upper quintile, the interquintile range or the lower quintile and with the climatological probability of these three categories (20%, 60% and 20%, respectively). Each point is attributed to the category corresponding to the highest odds ratio. If the point is attributed to the interquintile range or if there is no category assigned (the categories with two highest odds ratio have an equal value) the point is drawn in white. If the point is attributed to the lower/upper quintile category, the corresponding odds ratio is plotted with the left/right color scale.

- The 2003 heat wave seems to be predictable 4 months in advance **even without the realistic soil initialization.**
  - ⇒ The 2003 heat wave has been driven by the large-scale circulation, the dry soil moisture anomalies from the previous spring can not considered as the main “responsible” of the heat wave.
- Cold Anomalies in Eastern Europe in 2003 are predicted only when the soil is initialized.
- The 2010 heat wave is predicted by the model 4 months in advance **but only when the soil is properly initialized.**

4. How does the predictability evolve with the start date?



Land-surface initialization does not seem to affect the predictability of the 2003 heat wave (INIT~CLIM).



Detrended monthly anomalies of T2m (top and middle) and soil moisture averaged in the box represented on the previous figure (top: France, 2003; middle and bottom: Russia, 2010). The stars show the observed anomalies and the number above: the quantile corresponding to this anomaly. The box-and-whisker plots show the distribution of the anomalies for the members of the 2 simulations (left of the star: CLIM, right of the star: INIT). In black the simulations initialized in May, blue: June, red: July, green: August.

- Realistic soil moisture initialization improves the prediction of the 2010 heat wave, especially for simulation initialized in May and August.
- Simulations initialized in June and July generates dry soil moisture anomalies in July, probably because of successful prediction of the circulation in June and July.

5. Conclusion

Seasonal hindcasts produced with EC-Earth2.3 are able to predict the 2003 and 2010 heat waves up to four months in advance.

The 2003 heat wave seems to occur independently of the soil conditions.

For the 2010 heat wave, the dry condition of the soil at the beginning of August are necessary to reproduce the event.

. For more on the SPECS project: http://www.specs-fp7.eu
. For more on the PREFACE project preface.b.uib.no