Impact of soil moisture initialization on subseasonal and seasonal forecast skill of temperature over Europe in ECearth 2.3

Chloé Prodhomme[1], Francisco Doblas-Reyes[1,2]

[1] Catalan Institute of Climate Sciences (IC3), Barcelona, Spain

[2] Catalan Institute for Research and Advanced Studies (ICREA), Barcelona, Spain

1. Introduction

The forecast of surface temperature over Europe seems especially sensitive to soil moisture initialization. Douville (2009) and Quesada et al. (2012) have also shown that soil moisture pre-conditioning plays an important role on the extreme warm summer in Europe. Thus, taking into account our difficulties to predict this kind of extreme warm events, it appears essential to assess the impact of a proper soil moisture initialization on the forecast skill of surface temperature, including extreme events, over Europe.

With 2 set of hindcasts, carried out with EC-Earth 2.3 and with different soil moisture initializations methods, we analyse this role of soil moisture for Europe temperature forecast, especially in case of extreme events, as summer 2010.

2. Model and data

In order to discuss the impact of a realistic land-surface initialization on sub-seasonal and seasonal forecasts. We compare the forecast quality of a set of 10 members four-month long hindcasts performed over 1981-2010 with the EC-earth 2.3 forecast system where the land-surface is initialized either with the best observational estimates or with climatology. The land-surface data are extracted from the ERA-Land experiment, while the ocean, sea-ice and atmospheric components are initialized with ORAS4, the IC3 sea-ice analysis and ERA-Interim, respectively.

Data ERA-Interim: 2m-temperature, sea level pressure, geopotential height
GPCP: precipitation

3. Method for computing extreme

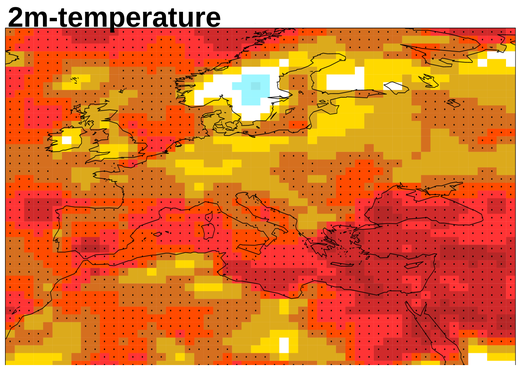
The monthly 90th (10th) percentile is computed both for reanalysis and model for 6 hourly data. We first compute the daily maximum (minimum) temperature, Tx (Tn). Then, we calculate the monthly 90th (10th) percentile of the daily Tx (Tn).

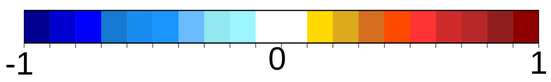
The climatological 90th (10th) percentile are estimated from all years and all members. We then calculate the number of days in a month over this threshold.

4. Increase of temperature forecast skill

Climatological soil moisture ini

2m-temperature



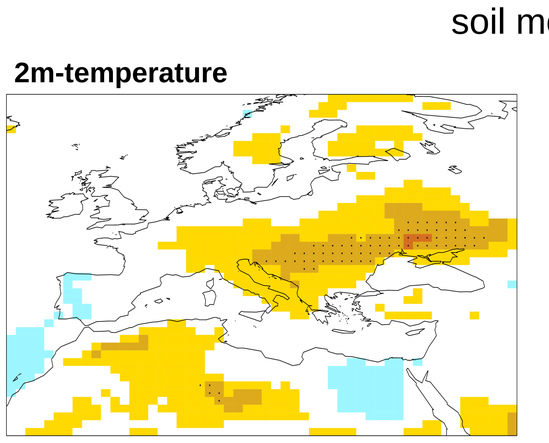


- A Global and significant skill improvement of summer temperature mean and 90th percentile forecast is found when the soil moisture is initialized realistically, especially over eastern Europe.

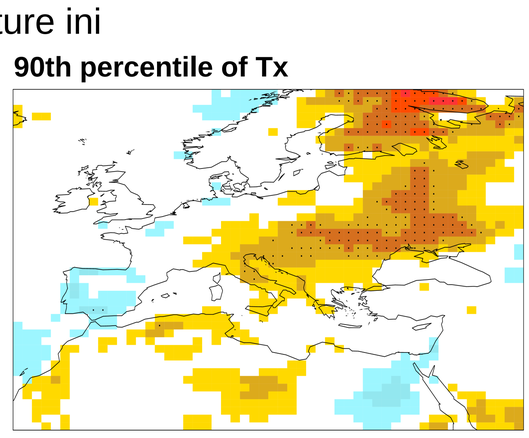
- Realistic soil moisture initialization seems crucial to forecast the extreme temperature.

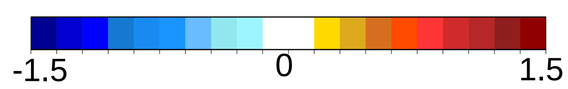
Realistic - Climatological soil moisture ini

2m-temperature



90th percentile of Tx

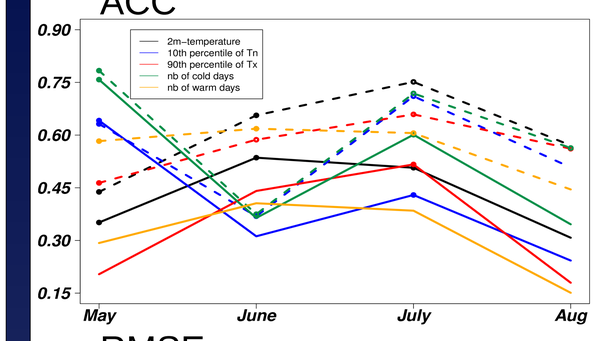




- Correlation of 2m-temperature in JJA in the experiments with a climatological initialization of the soil moisture (top). Difference of correlation of 2m-temperature (bottom left) and 90th percentile of Tx (bottom rigth) in JJA in the experiments with a realistic and with a climatological initialization of the soil moisture.
- The correlation is calculated between the ensemble mean and ERA-Interim 2m-temperature between 1981 and 2010.
- The dots mark the areas where the correlation (for left figure) or the difference of correlation (bottom figures) is 95% significant.

5. Sub-seasonal skill of mean and extreme temperature in Summer

ACC



RMSE

- Skill improvement is found all throughout the season for both correlation and RMSE skill.
- Realistic soil moisture initialization improves skill even on long time horizons (July-Aug)

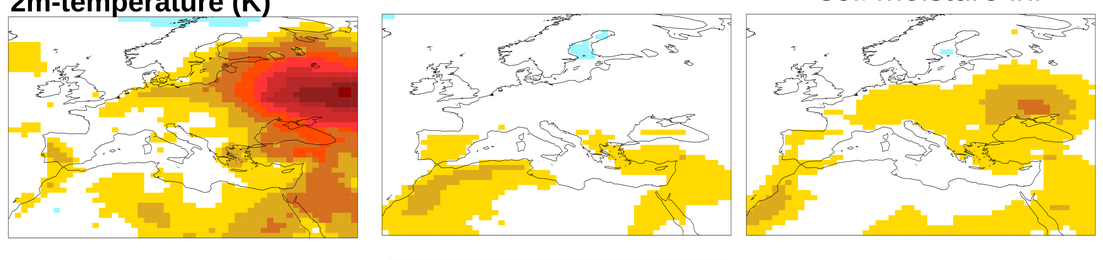
Climatological soil moisture ini
Realistic soil moisture ini

- Correlation (top) and RMSE (bottom) of JJA averaged over Europe (10ºW 40ºE – 35ºN 75ºN) in the experiments with a realistic (dotted lines) and a climatological initialization of the soil moisture (plain lines) for 2m-temperature monthly mean (black), 10th percentile of Tn (blue), 90th percentile of Tx (red).
- In the top figure yellow (green) lines represent the ACC for the number of days over (below) the 90th (10th) monthly climatological percentile.
- The correlation and RMSE are calculated between the ensemble mean and ERA-Interim 2m-temperature between 1981 and 2010.
- The dots marks the 95% significant correlation value, according to a Student t-test.

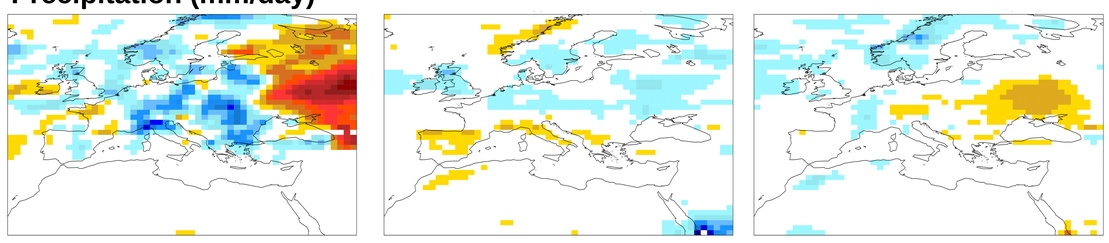
6. A case study: summer 2010

Observations | Climatological soil moisture ini | Realistic soil moisture ini

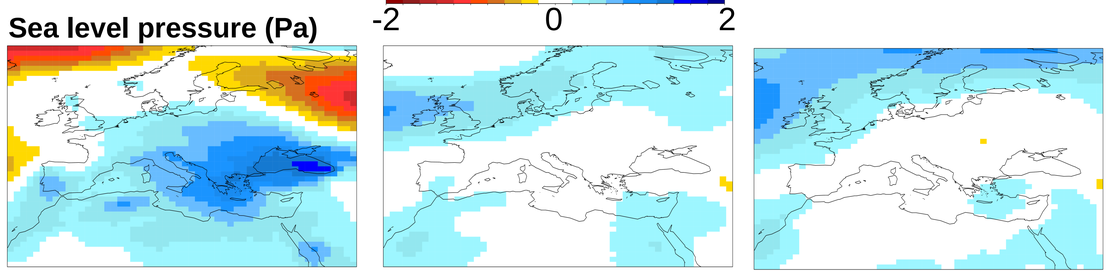
2m-temperature (K)

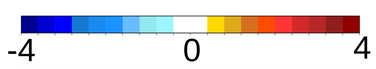


Precipitation (mm/day)

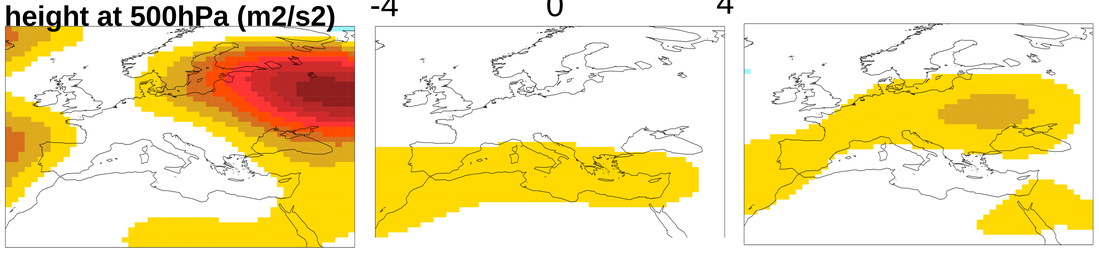


Sea level pressure (Pa)





Geopotential height at 500hPa (m2/s2)



Anomalies in JJA 2010, from top to bottom: 2m-temperature, precipitations, sea level pressure and geopotential height at 500hPa in, from left to right: in observations, in the experiment with a climatological initialization of the soil moisture and in the experiments with a realistic soil moisture initialization

7. Conclusion

- A realistic initialization of soil moisture increase skill to land surface temperature, including at long forecast time.

- The EC-Earth 2.3 forecast system predicts better both the frequency of daily extreme temperature and the extreme events (as summer 2010) with a realistic initialization of soil moisture.

- The land initialization does not only impact forecasts of 2m-temperature, but also of precipitations and atmospheric circulation.

- *Douville H., 2009, Relative contribution of soil moisture and snow mass to seasonal climate predictability: a pilot study, Climate Dynamics, 34, 797–818, DOI 10.1007/s00382-008-0508-1*
- *Quesada B., Vautard R., Yiou P., Hirschi M. and Seneviratne S.I., 2012, Asymmetric European summer heat predictability, from wet and dry southern winters and springs, Nature Climate Change 2, 736–741 , DOI: 10.1038/NCLIMATE15*
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