Study of drought processes in Spain by means of offline Land-Surface Model simulations. Evaluation of model sensitivity to the meteorological forcing dataset

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1. Introduction

- Drought is a hazard impacting all climates and regions of the world. In Spain, its societal impacts may be especially severe, creating water resources related tensions.
- Drought affects different aspects of the continental water cycle, from precipitation, to soil moisture, streamflow, lake volume and piezometric levels.
- The spatial and temporal scales of drought, together with its propagation through the system must be well understood.
- Land-Surface Models (LSM) physically simulate the continental water cycle and, thus, are appropriate tools to quantify soil moisture and other relevant variables and processes.

2. Objectives

1. Are LSMs correctly reproducing how drought propagates through the system?
2. Which are the main sources of uncertainty? Meteorological forcing, model structure, … ?

3. Datasets and models

- Meteorological forcing datasets:
  - SAFRAN (Quintana-Seguí et al 2016, 2017) is a 5 km resolution meteorological forcing dataset.
  - The FP7 earth2Observe project has produced a 0.25° resolution global forcing dataset, based on ERA-Interim and observations.
- Land-Surface Models (LSMs):
  - SASER (SAfran-Surfex-Eaudysée-Rapid) is a LSM developed by Météo-France. We use the ISBA scheme for natural surfaces in two versions: a simple 3 layered force-restore method (3L) and a multilayer diffusion method (DIF).
  - The RAPID river routing scheme is used within the Eaudysée framework.
  - SASER does not simulate underground water processes.
  - LEAFHYDRO (Míguez-Macho et al., 2007), land-surface model which is able to simulate groundwater processes.

4. Area of study and study period

- The area of this study is mainland Spain for the period 1980-2013.

5. Methods

- Drought is assessed by means of standardized indices: SPI (for precipitation), SSMI (for soil moisture), SSI (for streamflow).
- Drought propagation is studied by correlating one month SSMI or SSI with n month SPI for n in (1, …, 24).

6. Precipitation

- SAFRAN reproduces relief related effects better than E2O, due to the higher resolution and the high number of observation stations used to prepare the dataset.
- E2O and SAFRAN SPI indices correlated well on the west part of the Iberian Peninsula but correlations are lower in the Mediterranean area and in the North.
- Both products simulate similar SPI time series, but they do not present the same trends.

7. Soil Moisture

- Maps: n of maximum correlation between SPI-n and root zone SSMI-1.
  - Number in the lower right corner: same value but for the aggregated time series.

8. Streamflow

- The spatial patterns are very different between models (SURFEX is very homogeneous).
- SURFEX’s soil moisture is more reactive to precipitation than LEAFHYDRO’s due to the lack of groundwater processes.
- The forcing doesn’t change the spatial pattern but it does change the temporal dynamics: On average, E2O introduces a 1 month delay compared to SAFRAN.

9. Conclusions and perspectives

- Model structure plays a very important role in determining how drought propagates within the system.
- The dynamics and spatial patterns of soil moisture are different between models.
- The same applies for streamflow, where large differences are due to model structure.
- SAFRAN (SURFEX) lacks groundwater processes, LEAFHYDRO could be exaggerating the impact of groundwater on streamflow.
- The forcing dataset also plays a role. The low resolution forcing dataset delays the propagation of drought (+1 month for root zone soil moisture).
- Also, the low resolution land dataset is not able to reproduce smaller scale drought patterns.
- This study will be extended by including more forcing datasets and an improved methodology.

Simulations used in this study

<table>
<thead>
<tr>
<th>Forcing datasets</th>
<th>Land-Surface Models</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAFRAN (5 km)</td>
<td>SURFEX (ISBA-3L)</td>
</tr>
<tr>
<td>E2O (0.25°)</td>
<td>SURFEX (ISBA-DIF)</td>
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<td>LEAFHYDRO</td>
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