A multi-sourced assessment of the spatio-temporal dynamic of soil saturation in the MARINE flash flood model

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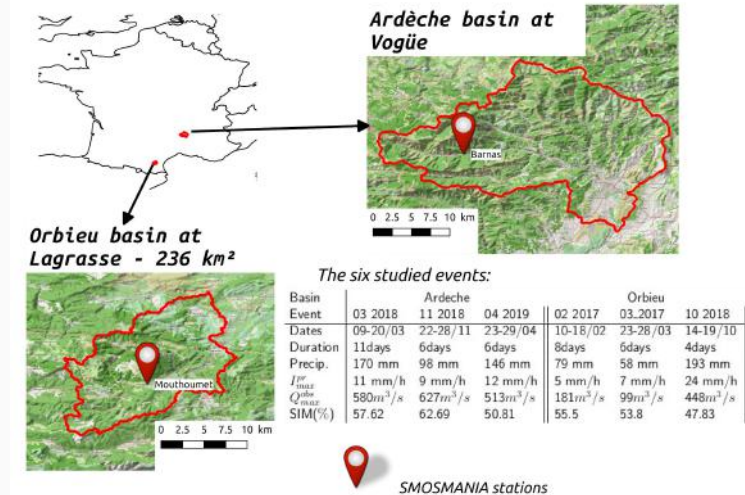
Introduction

The MARINE hydrological model (Roux et al., 2011) is a distributed model dedicated to flash flood simulation. Recent developments of the MARINE model are presented by Douniot et al., 2016 : on the one hand, the transfers through the subsurface take place in a homogeneous soil column based on the volumetric soil water content θ instead of the water height h (**SSF model**). On the other hand, the soil column is divided into two layers, which represent respectively the upper soil layer and the deep weathered rocks (**SSF-DWF model**). The aim of this work is to assess the performances of these new representations for the simulation of soil saturation during flash flood events.
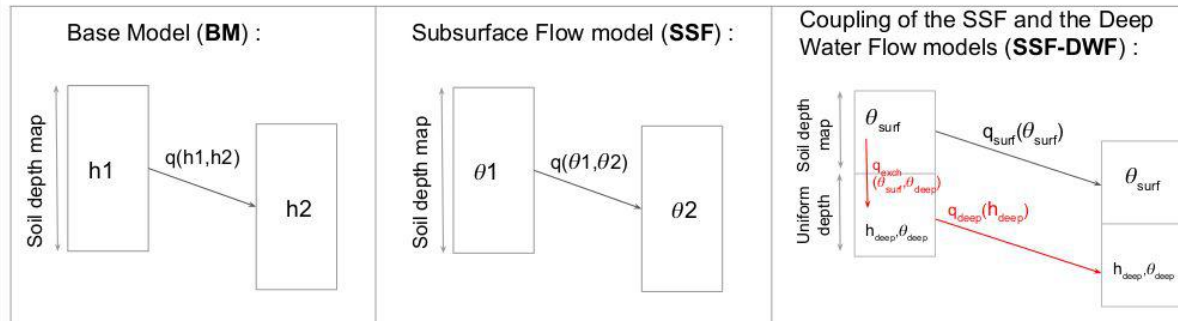
Data and methods

The performances of the model are estimated with respect to several soil moisture products, either at the local scale or spatially extended:

1. The gridded soil moisture product provided by the operational modeling chain **SAFRAN-ISBA-MODCOU (SIM)** (Habets et al., 2008) at the daily time step and at the 8-km resolution.
2. The gridded soil moisture product provided by the **LDAS-Monde assimilation chain** (Albergel et al., 2017), based on the ISBA-a-gs land surface model and assimilating high resolution spatial remote sensing data. LDAS- Monde is available at the hourly time step and at the 2.5-km resolution.
3. The upper soil moisture hourly measurements taken from the **SMOSMANIA observation** network (Calvet et al., 2007);
4. The **Soil Water Index (SWI)** provided by the Copernicus Global Land Service (CGLS), derived from Sentinel1/C-band SAR and ASCAT satellite data, at the daily time step and at the 1-km resolution.

Ardèche basin at Vogüe

Barnas

0 2.5 5 7.5 10 km

Orbieu basin at Lagrasse - 236 km²

Mouthoumet

0 2.5 5 7.5 10 km

SMOSMANIA stations

The six studied events:

Basin	Ardeche			Orbieu		
Event	03 2018	11 2018	04 2019	02 2017	03.2017	10 2018
Dates	09-20/03	22-28/11	23-29/04	10-18/02	23-28/03	14-19/10
Duration	11days	6days	6days	8days	6days	4days
Precip.	170 mm	98 mm	146 mm	79 mm	58 mm	193 mm
I_{max}^{pr}	11 mm/h	9 mm/h	12 mm/h	5 mm/h	7 mm/h	24 mm/h
Q_{max}^{obs}	$580m^3/s$	$627m^3/s$	$513m^3/s$	$181m^3/s$	$99m^3/s$	$448m^3/s$
SIM(%)	57.62	62.69	50.81	55.5	53.8	47.83

The case study is led over two french Mediterranean basins impacted by flash flood events over the 2017-2019 period and where one SMOSMANIA station is available. The ANTILOPE QPE (Laurantin, 2008), a fusion between radar data and pluviometric measurements, is used for the model precipitation input. The calibrations of MARINE proposed by Garambois et al., 2015 and Douinot et al., 2016 are used. Soil moisture is initialized with the SIM data.

Results

The local comparison of the MARINE outputs with the SMOSMANIA measurements, as well as the comparison at the basin scale of the MARINE outputs with the gridded LDAS-Monde and CGLS data lead to the same conclusions: the dynamics as well as the amplitudes of the soil moisture simulated with the SSF and SSF-DWF models are better correlated with both the SMOSMANIA measurements and the LDAS-Monde data than the outputs of the base model. The emptying of the soil column in the base model is faster than in the SSF and SSF-DWF models. For the SSF-DWF model, the simulation of the deep layer moisture content strongly relies on the deep layer calibration. The two-layers model calibration could then be further investigated.

Figure 2: Local comparison of the MARINE simulated soil moisture with the SMOSMANIA measurements.
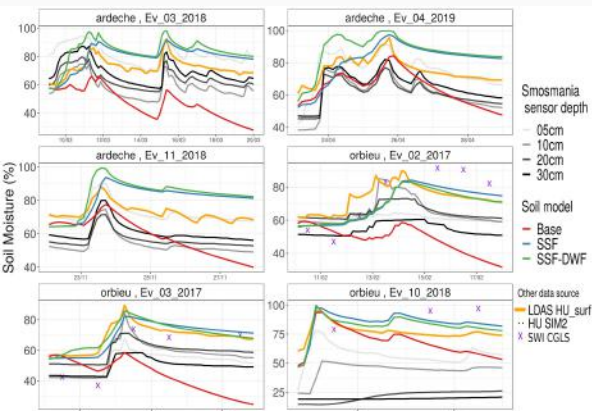
Figure 3: Comparison at the basin scale of the MARINE simulated soil moisture with LDAS- Monde and CGLS gridded products.
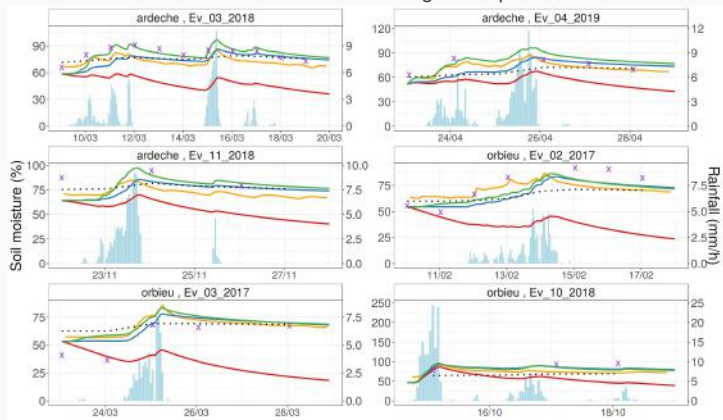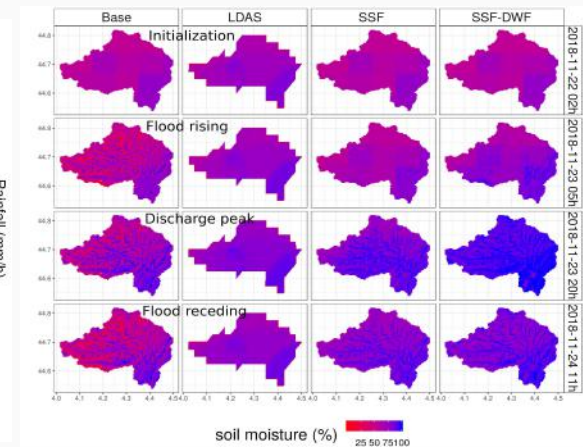
Figure 4: Soil moisture maps for all of the studied data sources. Case of the November,2018 event over the Ardeche basin.

Conclusions and forthcoming research

- The SSF and the SSF-DWF models allow to improve the soil moisture simulation for surface layers, at the local scale (comparison with Smosmania), as well as at the basin scale (comparison with gridded products: LDAS-Monde and CLGS data).

- Additional data about underground water would be necessary to validate the simulated moisture of the deep layer in the SSF-DWF model.

- The opportunity of improving the SSF-DWF model calibration for discharge simulation is investigated, in particular by considering the geomorphological characteristics of the basins.

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