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Multi-sources data assimilation in a spatialized model of water and pesticide transfers

Emilie Rouzies⁽¹⁾, Claire Lauvernet⁽¹⁾, Arthur Vidard⁽²⁾



⁽¹⁾ Riverly, INRAE Lyon-Villeurbanne

⁽²⁾ AIRSEA, Inria Grenoble

Introduction

The PESHMELBA model

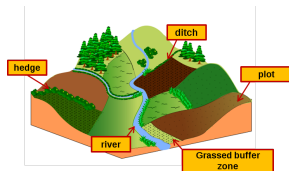
Development of the **PESHMELBA** model (Rouzies et al. 2019) to simulate pesticide transfers and fate on small agricultural catchments

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- ✓ Simulations of heterogeneous landscapes composed of plots, vegetative filter zones, hedges, ditches and rivers

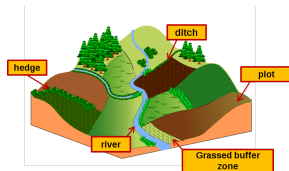


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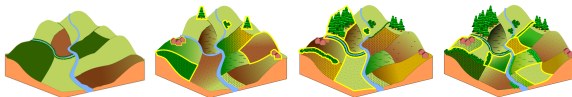
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- ✓ Modular structure to explore landscape management scenarios

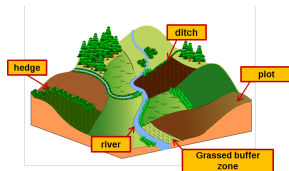


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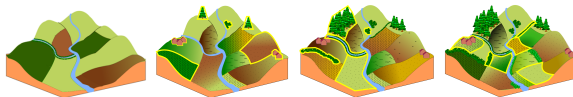
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- ✓ Simulations of heterogeneous landscapes composed of plots, vegetative filter zones, hedges, ditches and rivers



- ✓ Modular structure to explore landscape management scenarios



- ✓ Spatialized, process-oriented model : water transfers on surface and subsurface + pesticide advection, adsorption and degradation

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PhD Objectives



We have a dream that one day PESHMELBA will be used as a decision-making tool to set up management scenarios and to identify an optimal landscape configuration for pesticide transfer mitigation.

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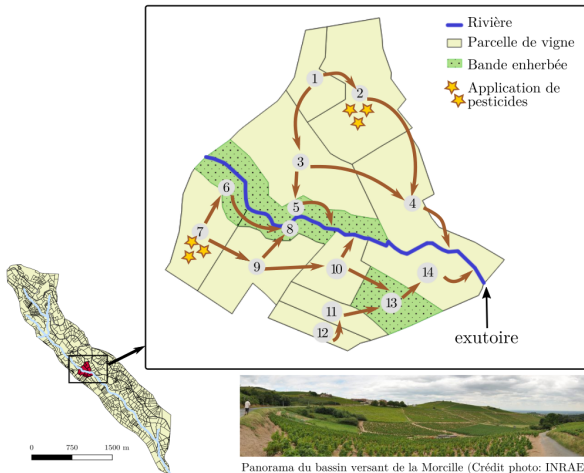
*This is our objective...but before, it is necessary to **quantify** and **reduce** the uncertainty associated to PESHMELBA output variables.*

PhD objectives

1. **Quantify**: performing an **uncertainty analysis** and a **sensitivity analysis** of the model
2. **Reduce**: performing **data assimilation** to integrate different sources of data: soil moisture images, ERT measurements and in-situ data of pesticide concentration

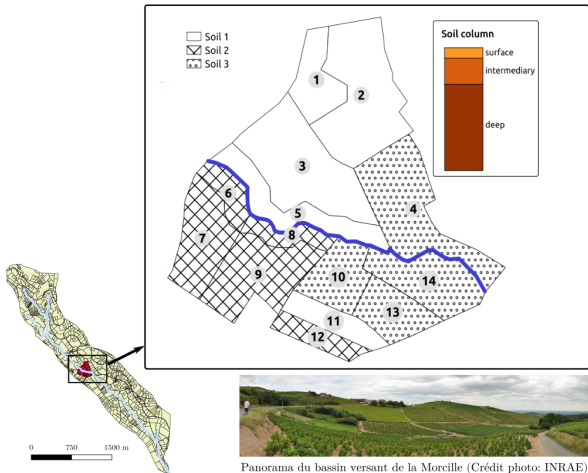
Case study

First attempt of DA in the PESHMELBA model: let's keep it simple...but realistic! (types of landscape elements, number of parameters, climate conditions...)



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Which observations are available ?

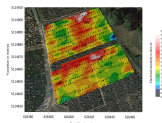
■ Surface moisture images

- ✓ Surface moisture images got from the synergic use of Sentinel-1 and Sentinel-2 data (El Hajj et al. 2017)
- ✓ One observation of mean moisture in the top 5 cm per landscape element per time step
- ✓ Freq. of observation: 144h, obs. error : assumed Gaussian, std $\sim 0.02 \text{ cm}^3\text{cm}^{-3}$ (⚠ may highly differ on vineyard!)



■ In-situ moisture profiles

- ✓ Moisture profiles from EMI measurements or probe.
- ✓ Assumption : 2m-moisture profile on some landscape elements, obs. error : assumed Gaussian, std $\sim 0.02 \text{ cm}^3\text{cm}^{-3}$

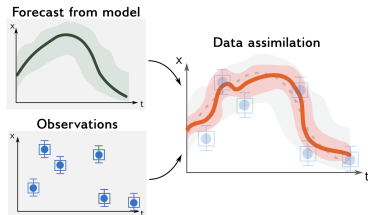


Data assimilation

Data Assimilation

“Approximation of the true state of a physical system at a given time by combining time-distributed observations with a dynamic model in an optimal way”

(Asch et al. 2016)

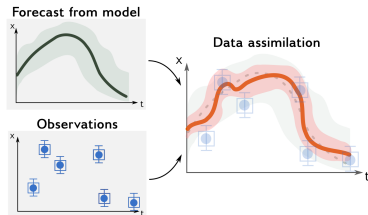


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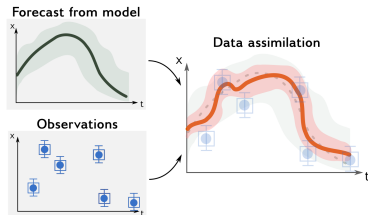
- ✓ Improve moisture dynamics modelling **both in surface and subsurface**
- ✓ Improve estimation of pesticide export at the outlet
- ✓ Estimate input parameters (θ_{sat}) that would be set for the exploration of landscape management scenarios

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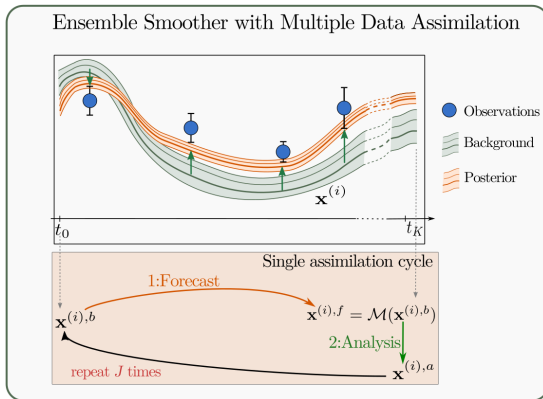
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⇒ **Joint-estimation** abilities are investigated

Ensemble Smoother with Multiple Data Assimilation (Emerick and Reynolds 2013)

- ✓ Ensemble method that inherits from Kalman Filter
- ✓ Iterative smoother well suited to parameter estimation problems in non linear contexts



Twin experiment

Obj 1: assimilate **satellite soil surface moisture images** to correct PESHMELBA moisture profile and input parameters.

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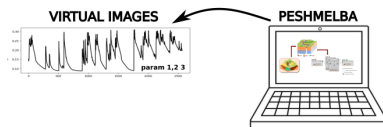
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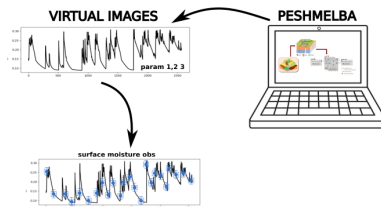


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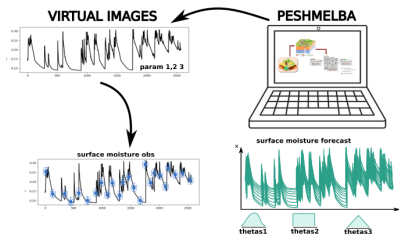


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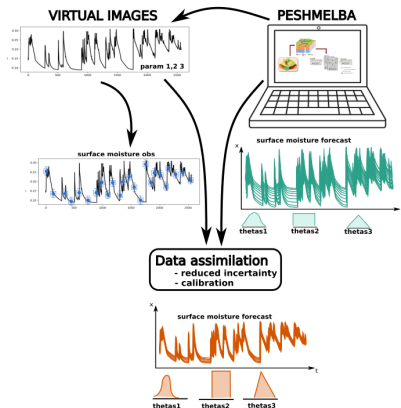


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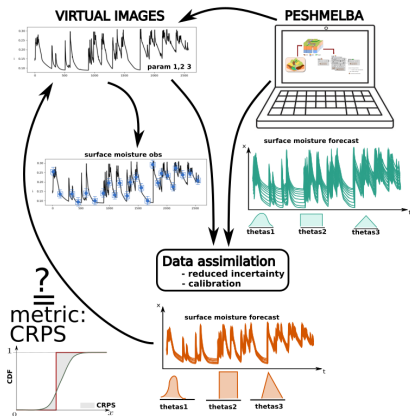


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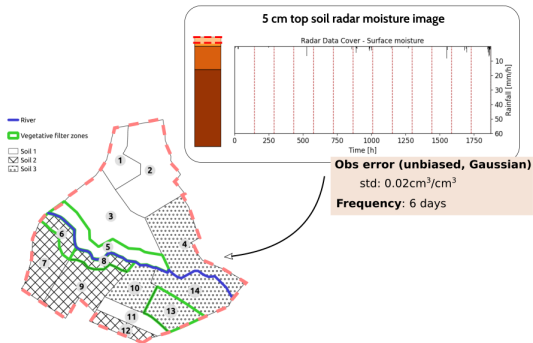
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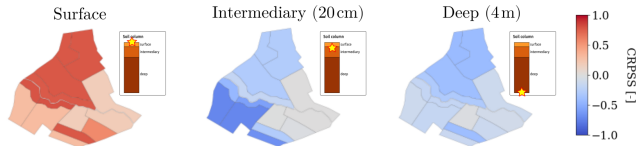


Results - Surface moisture images



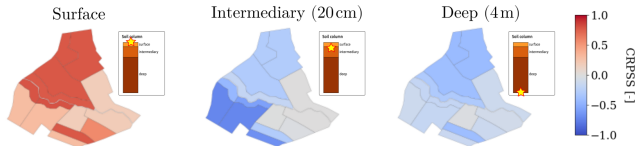
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■ Moisture estimation

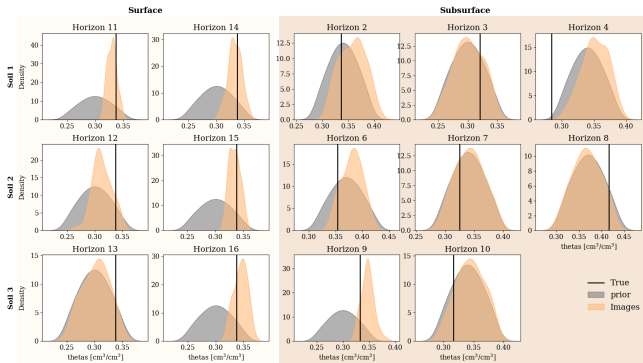


Results - Surface moisture images

Moisture estimation



Parameter estimation



Results - Surface moisture images

Observation: top 5cm moisture



Data assimilation of satellite moisture images

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- ✓ Good correction of surface moisture and surface parameters

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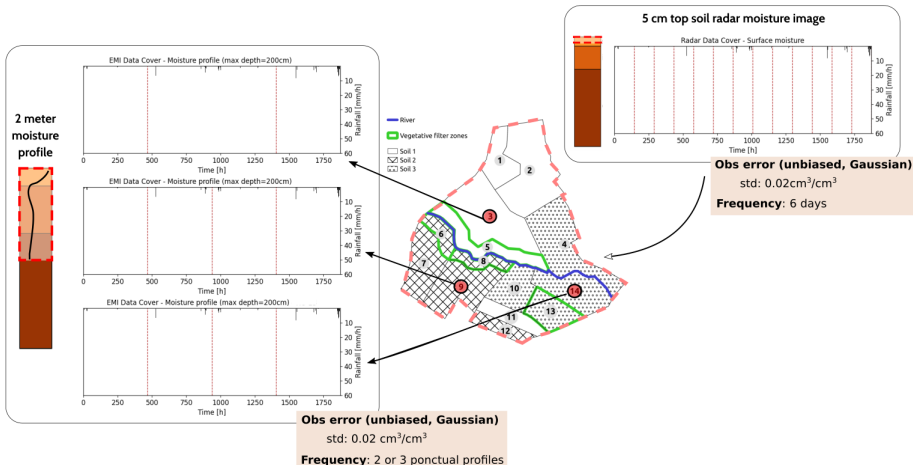
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⇒ Solution ? Integrate subsurface observations :
point vertical profiles of moisture

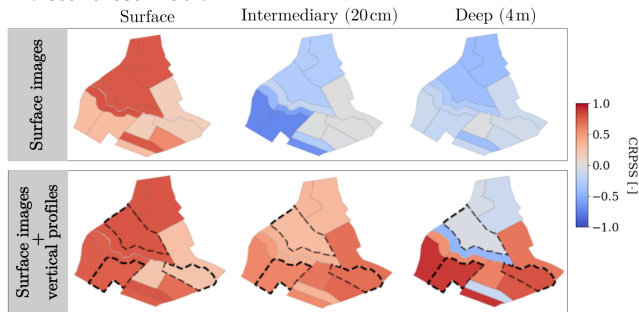


Results - Surface images + vertical profiles



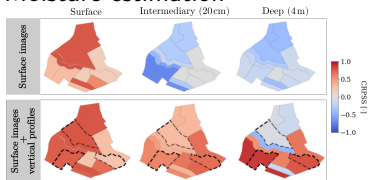
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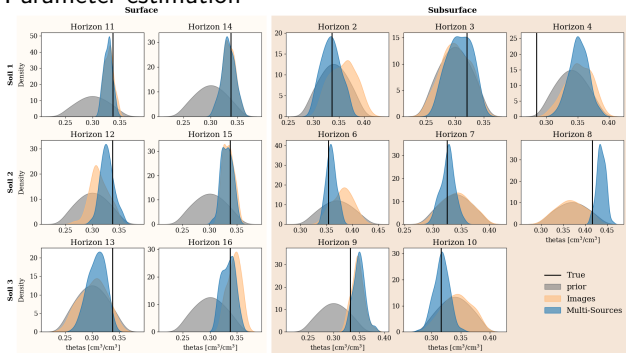


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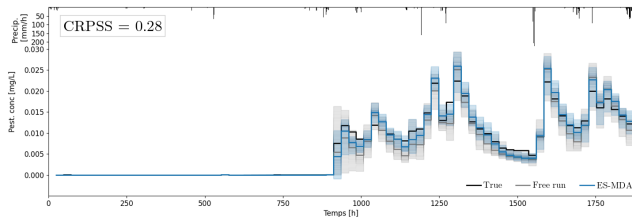


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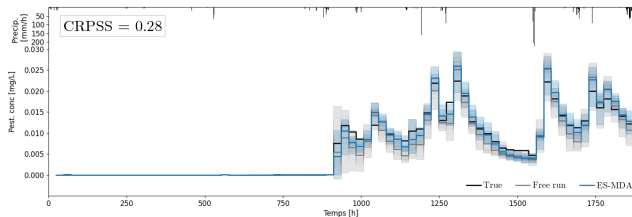
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■ Pesticide concentration at outlet



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■ Pesticide concentration at outlet



Strongly-coupled DA assimilation efficiently corrects pest. concentration.

- DA framework set for the first time in PESHMELBA
- Twin experiments provide answers to the question : *What can be estimated from which data ?*
- Next step : set a DA framework on a real catchment : many challenges ! (get data, characterize real observation errors, handle high computation cost...)