How to reduce uncertainties in a coupled and spatialized water quality model using data assimilation?

Emilie Rouzies, Claire Lauvernet, Arthur Vidard

EGU General Assembly 2021

INRAE Inria

How to reduce uncertainties in a coupled and spatialized water quality model using data assimilation?

Rouzies Emilie[1], Lauvernet Claire[1], Vidard Arthur[2]

[1]INRAE, UR RiverLy, F-69625, Villeurbanne, France , [2]INRIA, LJK, F-38000 Grenoble, France

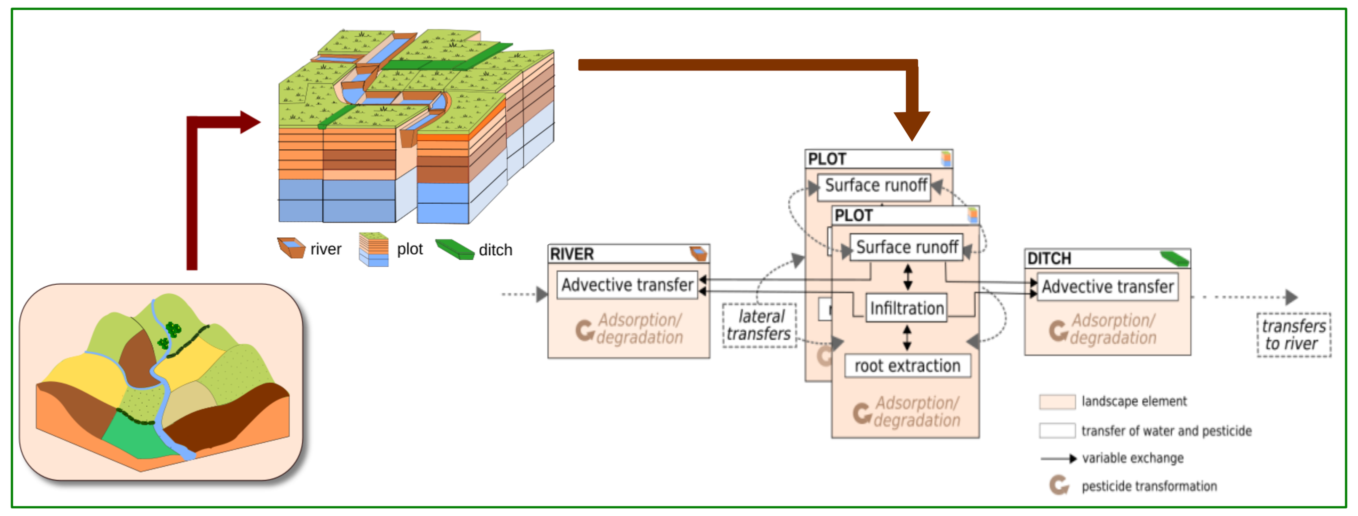
Contact : emilie.rouzies@inrae.fr

Uncertainty quantification and reduction is necessary before considering operationnal use of any pesticide transfer model. In this study, we developed a framework for joint variable-parameter assimilation of satellite surface moisture images in the PESHMELBA model. A fairly simple virtual hillslope inspired from a realistic catchment is set up and data assimilation is performed on twin experiments.

1. The PESHMELBA model (Rouzies et al., 2019)

The PESHMELBA model simulates pesticide transfers and fate on small agricultural catchments.

- Explicitly considers the effect of discontinuities (hedges, ditches, rivers, filter zones) and the spatial organisation of the landscape
- Characterized by a modular structure that makes it possible to test different scenarios of agricultural/landscape management practices
- Process-oriented, fully spatialized model.
- One module ≡ one process or ensemble of processes on a landscape element + coupling within the OpenPALM coupler (Buis et al., 2006)

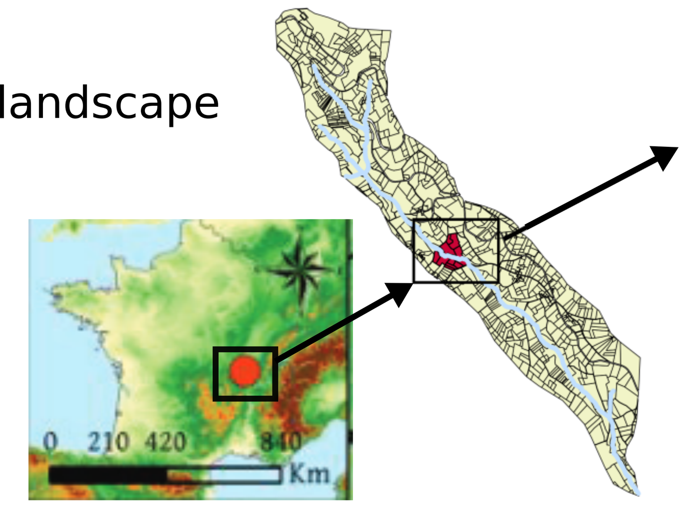


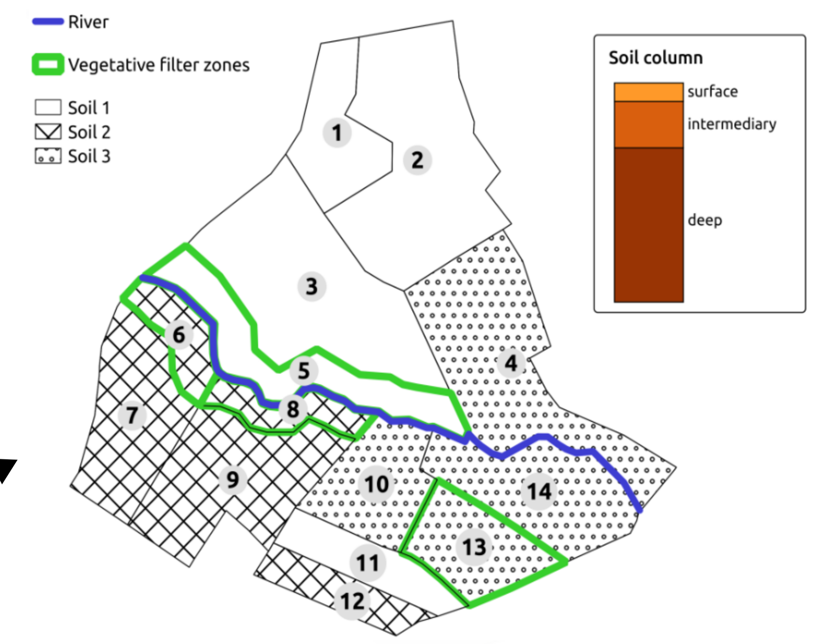
Overview of a PESHMELBA simulation workflow

How to use data assimilation to quantify and reduce uncertainty in this spatialized, highly coupled model ?

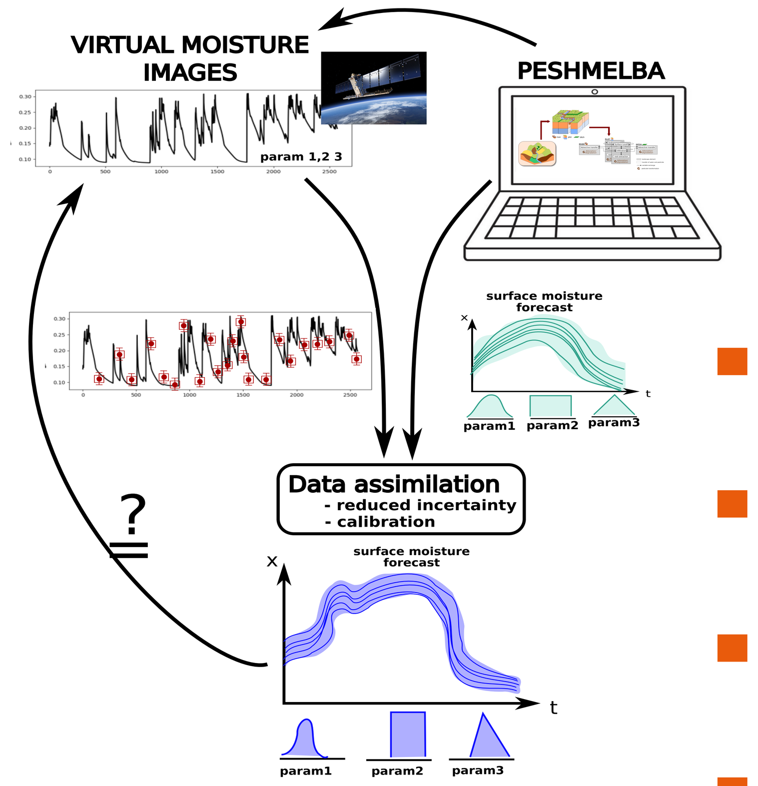
2. Data assimilation set-up (twin experiments)

- Available data : surface moisture images from Sentinel-2
  Frequency : 5 days
  Obs. error : ~5% (Baghdadi and Zribi, 2016)
- Let's start simple: virtual simplified hillslope derived from La Morcille real catchment (France)
- Even simple: 3 heterogeneous soil types + 3 landscape element types => 145 parameters !





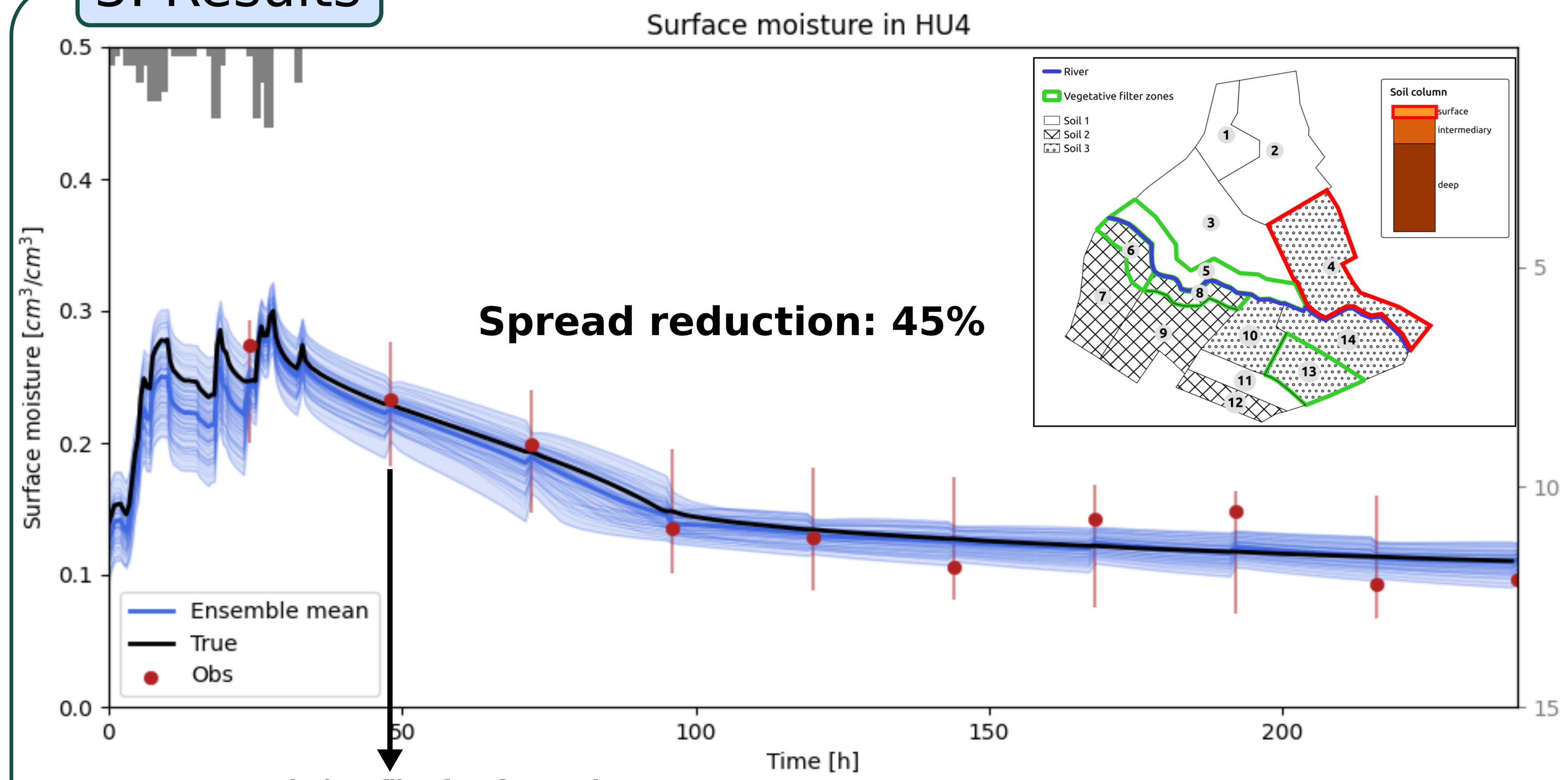
Virtual hillslope used to set up DA framework. It is composed of vineyard plots, vegetative filter zones and rivers.

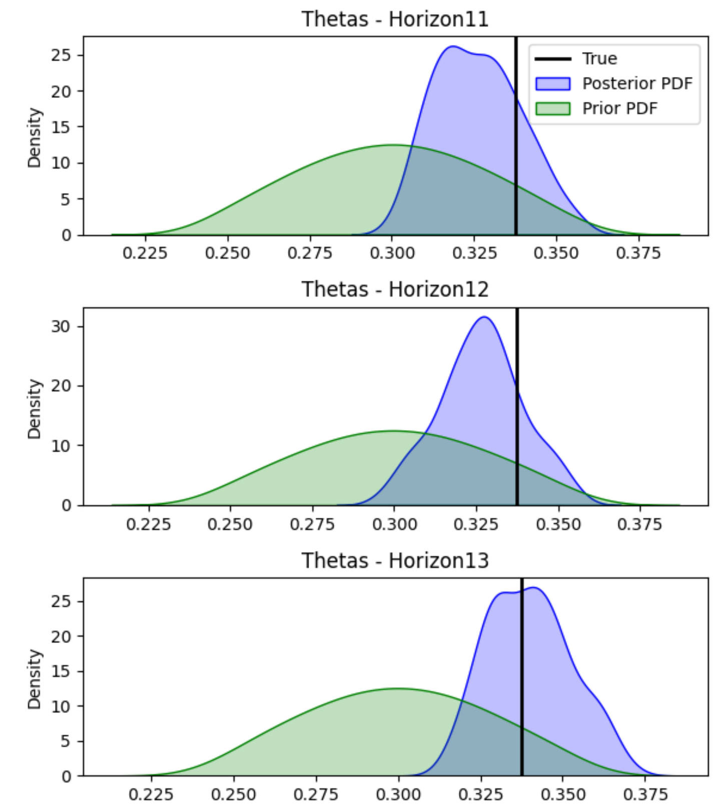


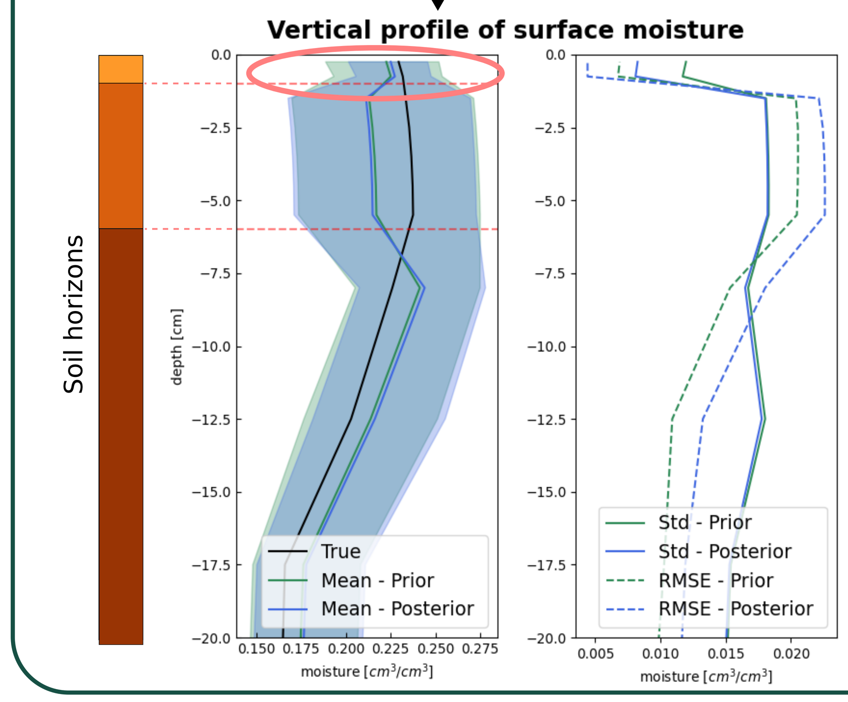
Twin experiments workflow for assimilating surface moisture images in PESHMELBA

- Twin experiments: virtual moisture images generated from a reference PESHMELBA simulation. First test : one obs. available at each 24h!
- DA method chosen to fit PESHMELBA specificities : Deterministic Ensemble Kalman Filter (DEnKF) (Evensen, 1994). Ensemble size = 100 members
- DA used both to correct moisture in vertical profile and to estimate some input parameters: saturated water content (θ_{sat}) on surface
- Initial ensemble: perturbation of 145 input parameters. Bounds and distributions are set from field measurements, litterature review or expert knowledge.

3. Results







DEnKF quickly decreases both ensemble spread and bias on surface moisture after 3 assimilation cycles (left panel on Figure above). There after, impact of analysis remains quite limited. Joint estimation also significantly improves estimation for surface θsat (horizon 11, 12 and 13, see right panels on Figure above).
However, correction is only significant in first soil horizon (~1 cm) and does not propagate towards deeper soil horizons (Left Figure). Assimilation of surface moisture images remains of no effect on subsurface.

Next challenge: how to better estimate water and pesticide variables in subsurface ?

4. Conclusion and next steps

- DEnKF potential to perform joint estimation in the PESHMELBA model is demonstrated using synthetic images. Uncertainty on both surface moisture variables and surface θsat parameters is reduced.
- But this setup does not allow for correcting other components of the model (subsurface moisture, pesticide concentration,...).

➡ Prospects for improving the process:

1. Smoothing approach instead of filtering approach to better catch the subsurface dynamics
2. Integratin EMI measurements that provide moisture on a vertical profile

References

[1] Rouzies et al., From agricultural catchment to management scenarios: A modular tool to assess effects of landscape features on water and pesticide behavior. Science of the Total Environment, Elsevier, 2019, 671, pp.1144-1160.

[2] Buis et al., PALM: a computational framework for assembling high-performance computing applications. Concurrency and Computation: Practice and Experience, John Wiley & Sons, Ltd., 2006, 18, 231-245

[3] Baghdadi and Zribi. Observation des surfaces continentales par télédétection micro-onde : techniques et méthodes. ISTE, pp.420, 2017

[4] Evensen, Sequential data assimilation with a nonlinear quasi-geostrophic model using Monte Carlo methods to forecast error statistics. Journal of Geophysical Research: Oceans, 1994, 99, 10143-10162