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Abstract: Physically-based models represent detailed surface/subsurface transfer, but the required spatial information does not allow their operational use.

- In situ data on pesticides in a catchment are usually rare and not continuous in time and space.
- Satellite images well describe data in space, but only water related, and at limited time frequency.
- The ADIMAP project aims to exploit these 3 types of information (model, in situ data, images) with data assimilation methods adapted to image data, in order to improve pesticide fluxes simulation and estimates of hydrological parameters. This poster discusses the proposed methodology as well as the available study site data and modeling components.

CATHY-Pesticide Hydrological model
Coupled surface/subsurface flow and transport [1–7]
- Richards eq. for variably saturated porous media:
\[ S_m \frac{\partial h}{\partial t} + \frac{\partial q_m}{\partial x} = \nabla \cdot (K_s \nabla \psi) + q_w \]
- ID diffusive wave equation at surface:
\[ \frac{\partial Q}{\partial t} + \frac{\partial Q}{\partial x} = D_i \frac{\partial ^2 Q}{\partial x^2} + q_s(h, \psi) \]
- Advection – dispersion equation
\[ \frac{\partial C}{\partial t} = \nabla (D \nabla C) - \nabla (\vec{v} C) + R \]
- Linear adsorption and first order decay
\[ K_d = \frac{C_i}{\omega t_n} = -\lambda C \]

The Morcille study site (Beaujolais)
- Small watershed (8.8 km²)
- 70% of vineyard
- High risk of pesticide contamination
- Steep slopes > 25%
- Permeable sandy soils
- Continental climate with Mediterranean influence
- Research on pesticides since 1985
- River quality and flow monitored between 2006 and 2011.

Reactive solute transport on a short event
- Dynamics are reproduced, but significant delay
- Sensitivity Analysis showed high influence of hydrodynamic characteristics on solute transfer outputs [see Gatell pres. on Wednesday Session 43!]
- Need to reduce uncertainty
- Need to better parameterize CATHY spatialized hydrodynamic characteristics

DA for pesticide transfer modeling
Modeling pesticide transfer in a watershed is particularly complex:
- Very high heterogeneity of the system
- Many processes in interaction
- Few information on physico-chemical interactions of molecules
- Lack of data deep in the soil
- Research focuses on development of modeling in function of chosen processes to describe
- DA would improve input parameters characterisation and pesticide transfer understanding.

Hypothèse:
Assimilating hydrological variables will improve the pesticide fluxes simulations and the input parameters estimates.
⇒ Coupled Data Assimilation

Model setup on a simplified hillslope

Parameter unit Zone 1 Zone 2
\( K_s \)  \( m \cdot s^{-1} \) (1.819 (0.164) 1.952 (0.263)
\( v_s \)  \( m \cdot s^{-1} \) (0.540 (0.064) 0.420 (0.044)
\( n \)  \( m^{-1} \)  (1.46 (0.146) 1.52 (0.152)
\( m \)  cm  (0.0032 (0.0069) 0.01 (0.033)
\( K_{Do} \) \( m^2 \cdot s^{-1} \)  (27.5 (4.51) 5.1 (1.2)
\( K \)  \( m^2 \cdot s^{-1} \)  (45.1 (3.0) 1.48 (1.43)
\( K_{inflow} \) \( m \)  (30) 20
\( P_{inflow} \)  \( m \)  (0.0025 (0.0015)

Assimilation of images
- Usually, remote sensing data and sequences are under-used, though their content in information is very high (shapes evolution, correlations, . . .)
- HR Images would also help to identify the landscape elements (grass strips, hedges, . . .)
- In classical approaches: uncorrelated noise, diagonal error covariance matrices
- How to provide observation error covariance matrices adapted to spatially correlated errors? [2]
- Focusing on the observations operator description, and distances definition in the DA scheme

4DVar
\[ J(x) = \frac{1}{2} \|x - x_0\|^2 + \frac{1}{2} \sum_i \|H(M_{in}x_i) - y^{i}_{obs}\|^2 \]
with B and R background and observation error covariance matrices
- would allow testing more situations to help estimate the input parameters for the hydrological part of CATHY
- would reduce uncertainty for the pesticides transfer part
- no need for expensive MC estimation, as long as the adjoint model codes.