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On the need for a soil moisture observation network to support flow forecasting in Quebec

Richard Turcotte
Chef de la division de l'hydrométéorologie
Centre d'expertise hydrique du Québec

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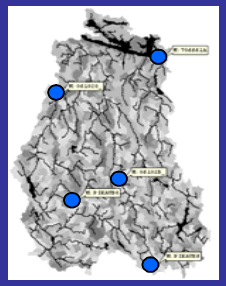
Outline

- Soil moisture estimate used to define initial conditions in operational hydrological models
  - obtained by optimizing prediction of past streamflow
- Representation of soil moisture in operational hydrological models remains conceptual
- It is therefore difficult to link prognostic soil moisture to actual measurements

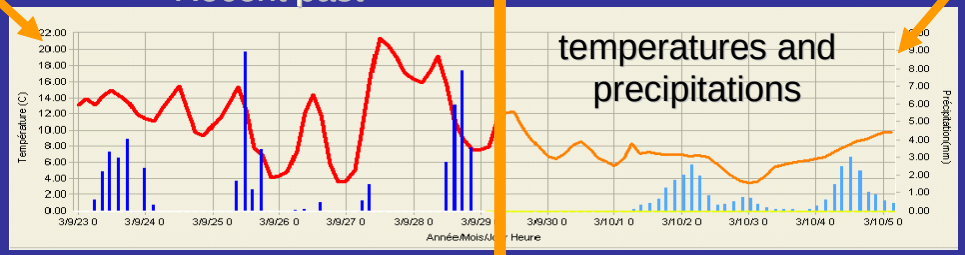
Soil moisture estimate used to define initial conditions in operational hydrological models

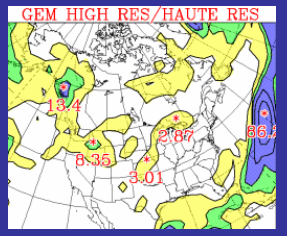
Inflow forecasting



Meteorological network

Meteorological forcing

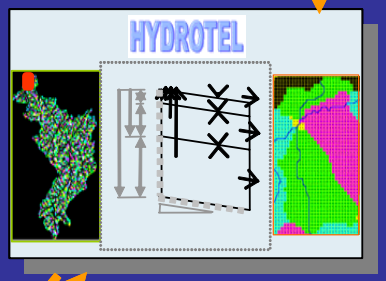


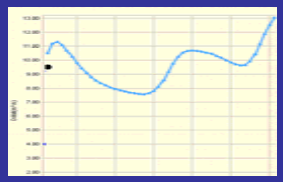


Weather forecast including value added from ECan/Quebec

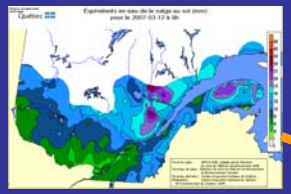
Initial conditions for soil moisture are provided by the past state of the hydrological model and can be manually adjusted by the forecaster

Hydrological model





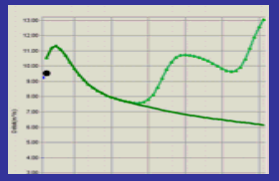
Main flow forecast



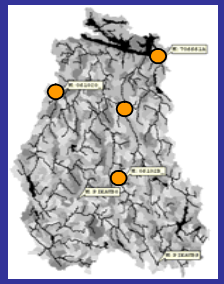
Snow analysis

Initial conditions

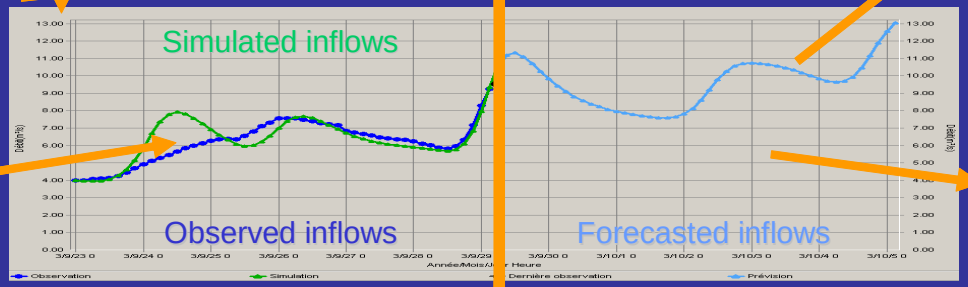
Updating of state variables



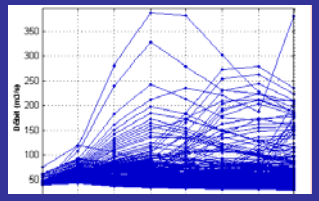
No new precipitation flow forecast



Hydrometric network



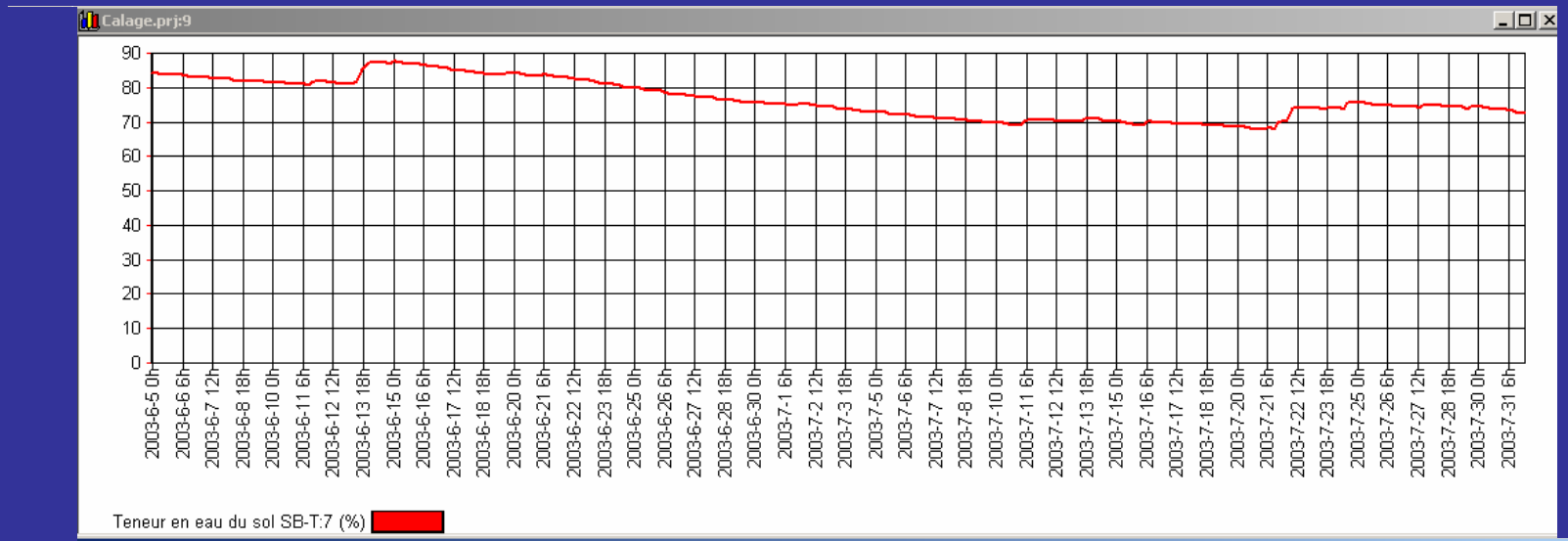
Simulated and forecasted inflows



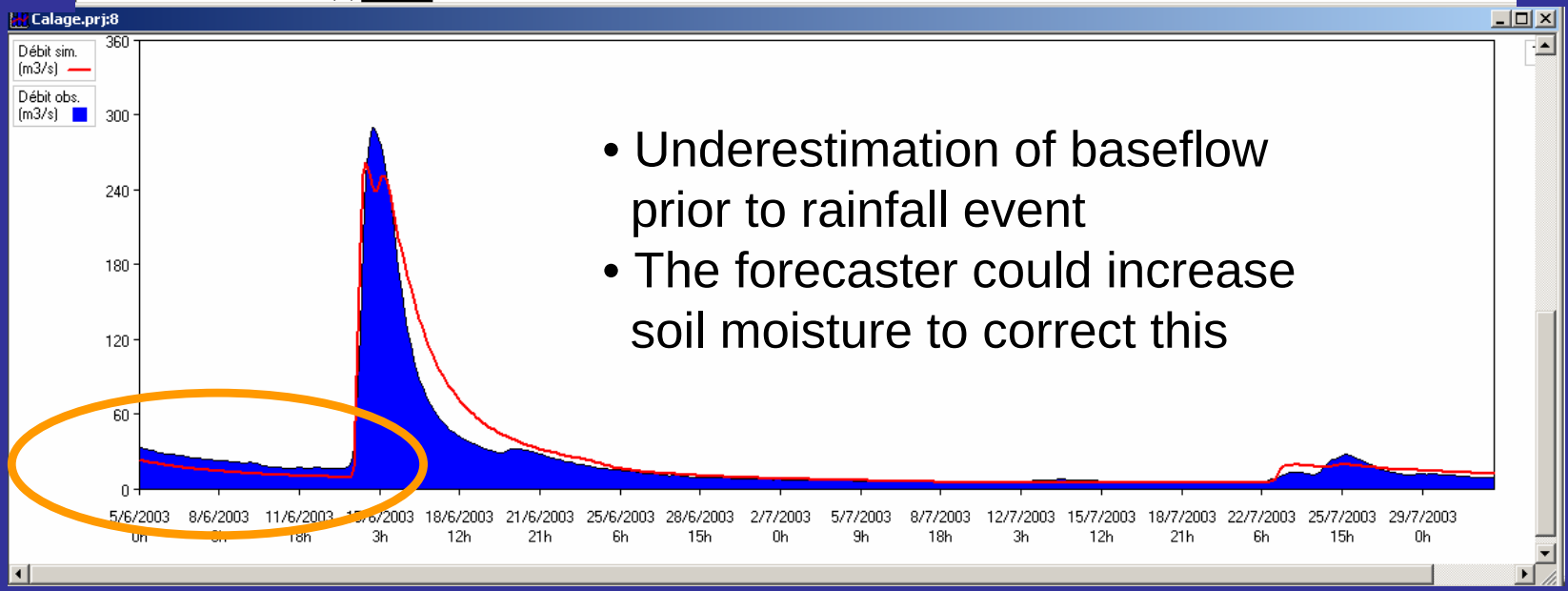
Flow forecast scenarios

Streamflow simulation at Châteauguay : June 2003

Mean soil moisture (layers 1, 2 and 3)



Streamflow

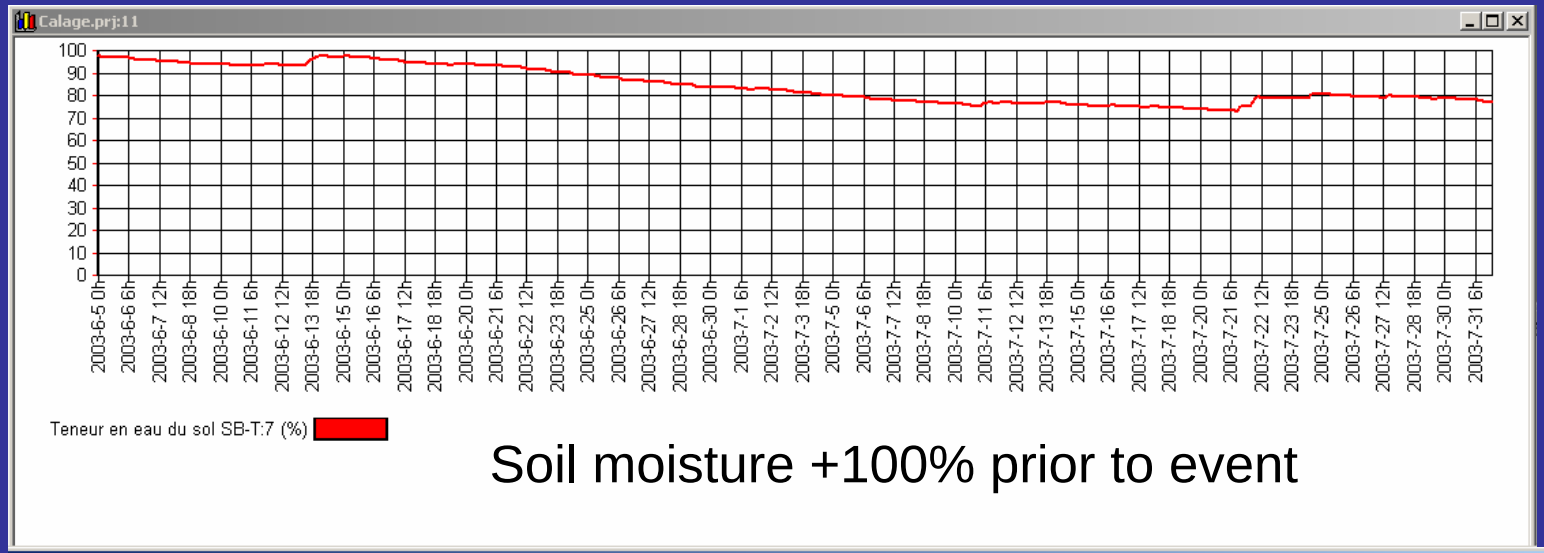


- Underestimation of baseflow prior to rainfall event
- The forecaster could increase soil moisture to correct this

Streamflow simulation at Châteauguay : June 2003

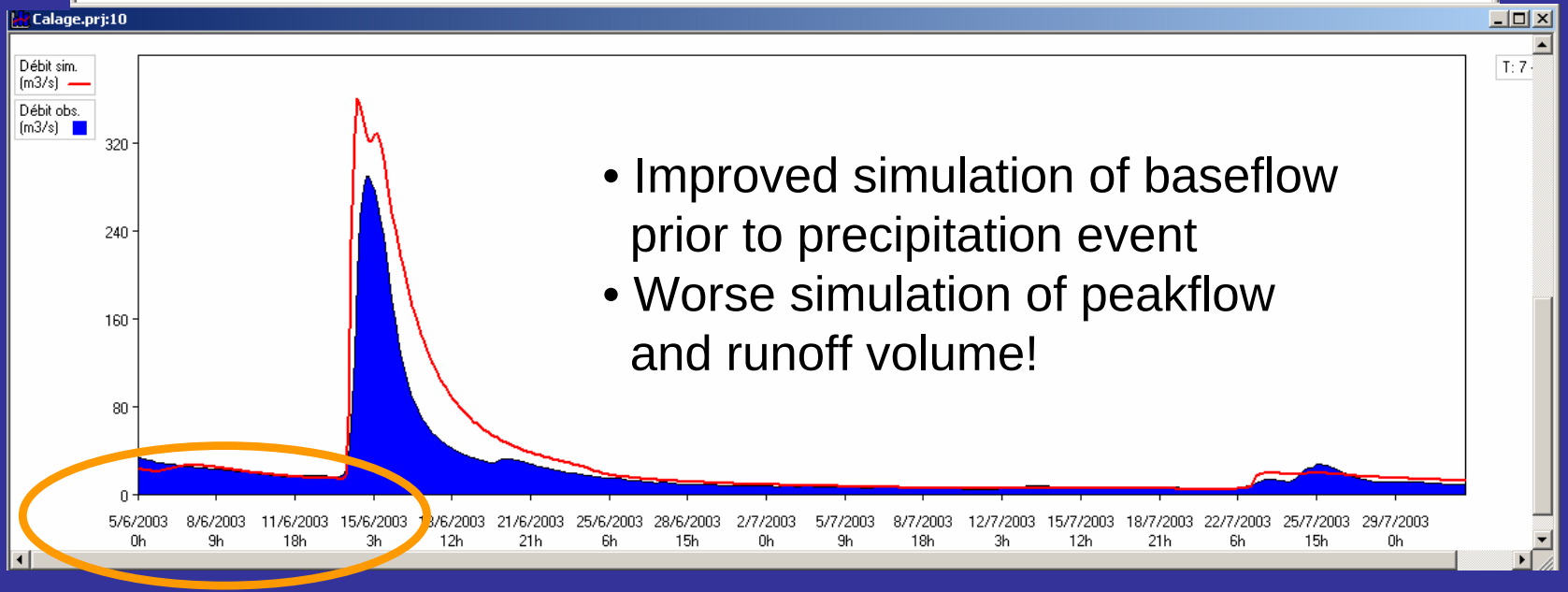
Sensitivity test : soil moisture increase interactively by a forecaster

Mean soil moisture (layers 1, 2 and 3)



Soil moisture +100% prior to event

Streamflow

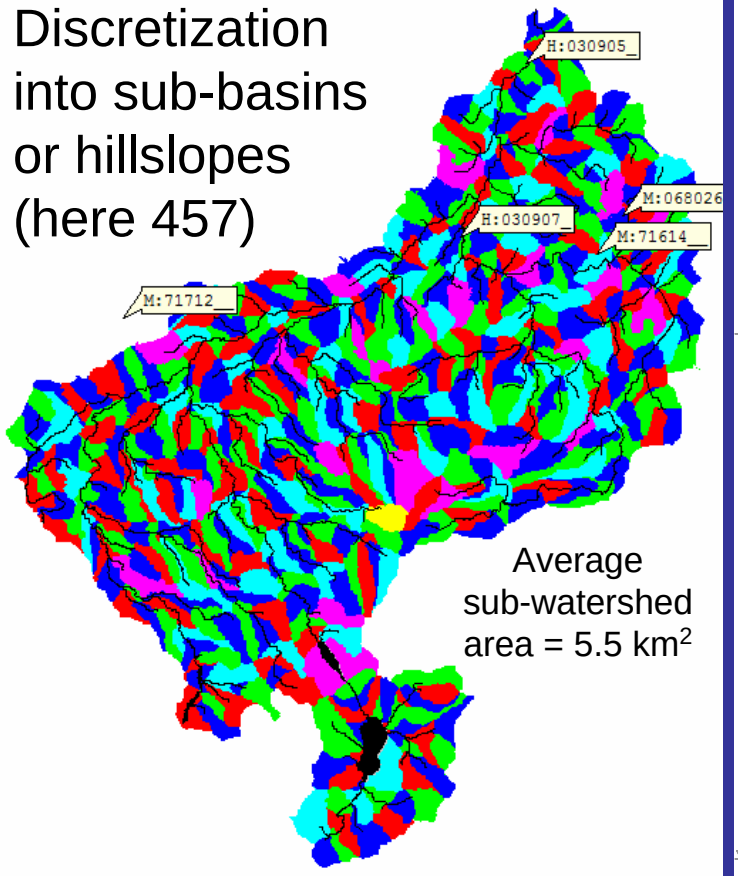


- Improved simulation of baseflow prior to precipitation event
- Worse simulation of peakflow and runoff volume!

Representation of soil moisture in operational hydrological models remains conceptual

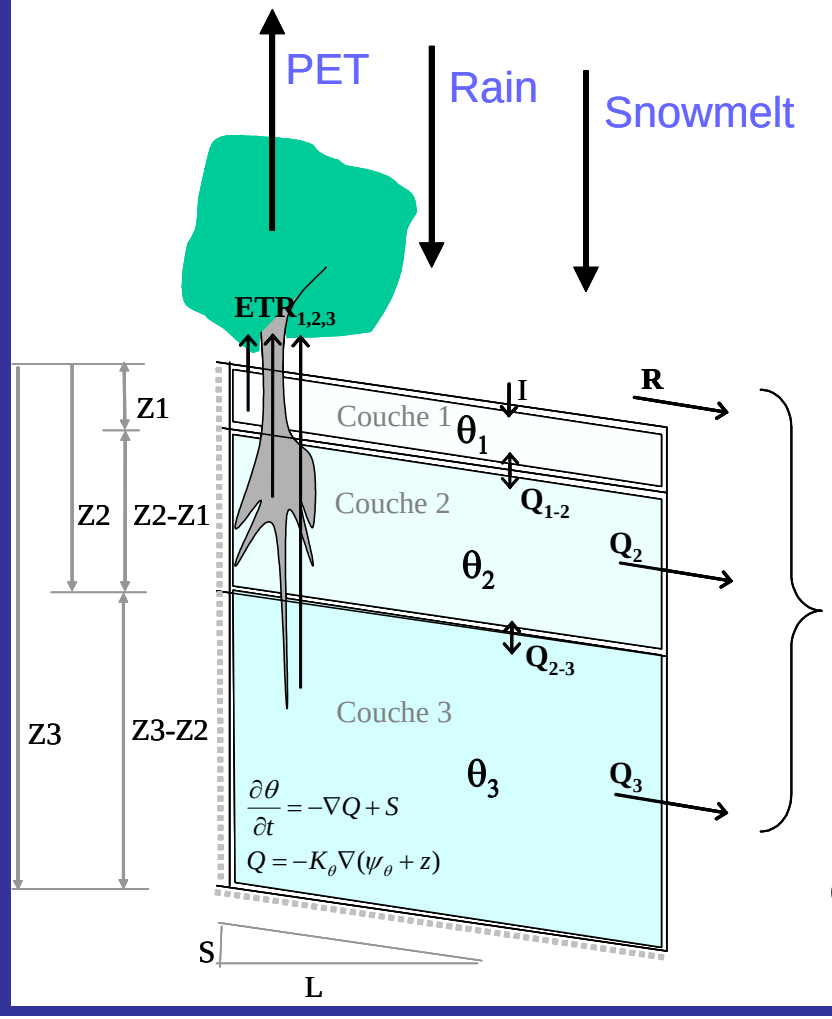
HYDROTEL hydrological model developed at INRS-ETE

Discretization into sub-basins or hillslopes (here 457)



Average sub-watershed area = 5.5 km^2

Vertical water balance model on each unit



BV3C:
Richard's equations in 1-D with 3 layers

Conductivity and matrix potential estimated from dominant soil type on each unit

Runoff produced on each subwatershed at each time step

↓

Kinematic or diffusive wave routing to the outlet

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Mean soil properties and prognostic variables at the scale of small sub-watersheds

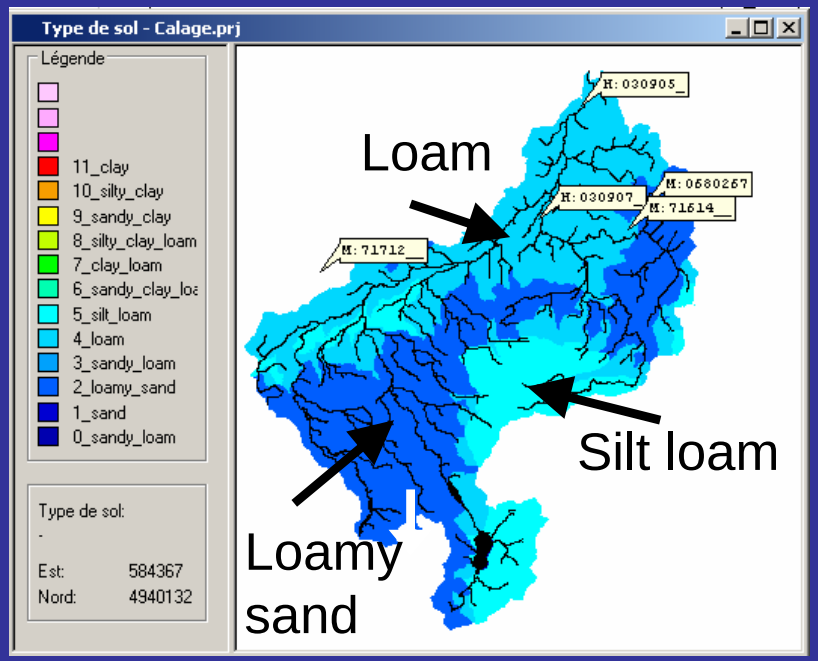
Percentage of sand and clay from AAFC and USDA

↓

Dominant soil type for each subwatershed

→

Database resolution typically less than scale of subwatersheds



rawls.sol - Bloc-notes

Fichier Edition Format Affichage ?

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3
12      7
Soil hydraulic properties classified by soil texture
texture              thetas      thetacc     thetapf     ks          psis        lambda      alpha
0_sandy_loam           0.412       0.207       0.095       0.0259      0.3020      0.378       4.5
1_sand                 0.417       0.091       0.033       0.21        0.1598      0.694       10.0
2_loamy_sand           0.401       0.125       0.055       0.0611      0.2058      0.553       6.0
3_sandy_loam           0.412       0.207       0.095       0.0259      0.3020      0.378       4.5
4_loam                 0.434       0.270       0.117       0.0132      0.4012      0.252       3.5
5_silt_loam            0.486       0.330       0.133       0.0068      0.5087      0.234       3.0
6_sandy_clay_loam      0.330       0.255       0.148       0.0043      0.5941      0.319       3.5
7_clay_loam            0.390       0.318       0.197       0.0023      0.5643      0.242       2.0
8_silty_clay_loam      0.432       0.366       0.208       0.0015      0.7033      0.177       1.5
9_sandy_clay           0.321       0.339       0.239       0.0012      0.7948      0.223       1.0
10_silty_clay          0.423       0.387       0.250       0.0009      0.7654      0.150       0.8
11_clay                0.385       0.396       0.272       0.0006      0.8560      0.165       0.5
```

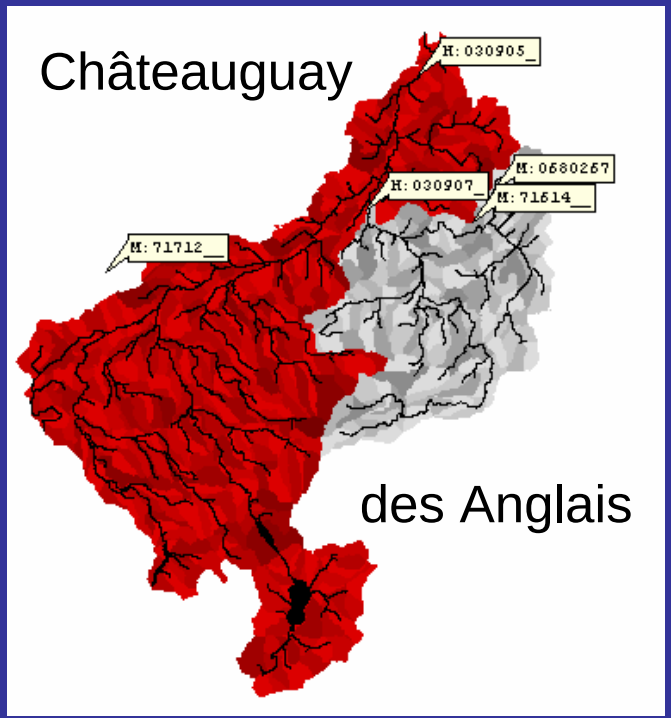
←

Lookup table to obtain soil parameters

It is difficult to link prognostic soil moisture values to actual measurements

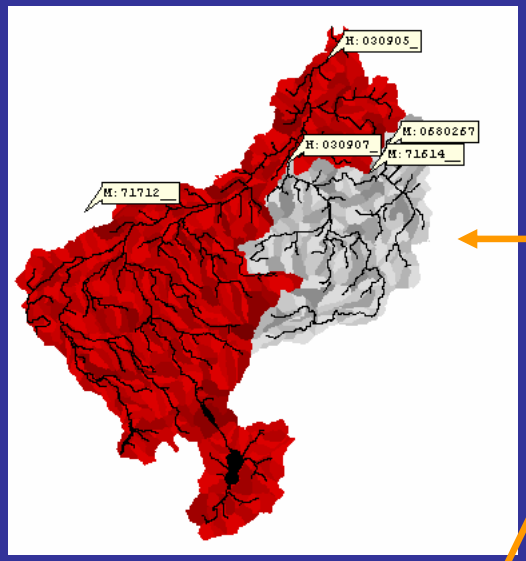
Calibration

- Many parameters are optimized against streamflow observations to minimize prediction error
  - e.g. depth of soil layers

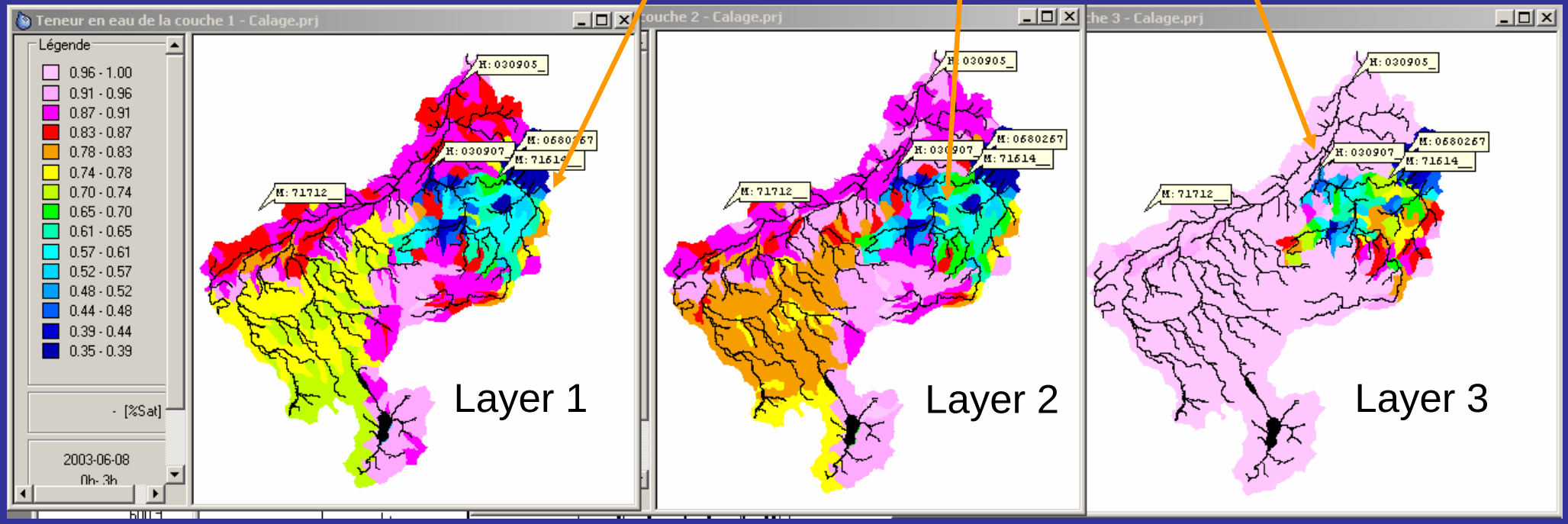


Layer	Châteauguay	Rivière des Anglais
1	11 cm	6 cm
2	69 cm	22 cm
3	2.51 m	1 m

Streamflow simulation at Châteauguay : June 2003



We can see the signature of the calibration in predicted soil moisture



Soil moisture on June 8th

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Recommendations

- Not straightforward to use soil moisture observations efficiently in our operational hydrological forecasting system
- Current models can make better use accurate streamflow observations at the outlet and for subwatersheds
  - the immediate value added by one hydrometric station is much higher than the value added by a single soil moisture measurement
- Soil moisture monitoring should be directed towards research purposes