"Reverse modeling": a simple and robust method for modeling and forecasting the piezometric level/discharge of a pumping well A case study in a Hard Rock Aquifer

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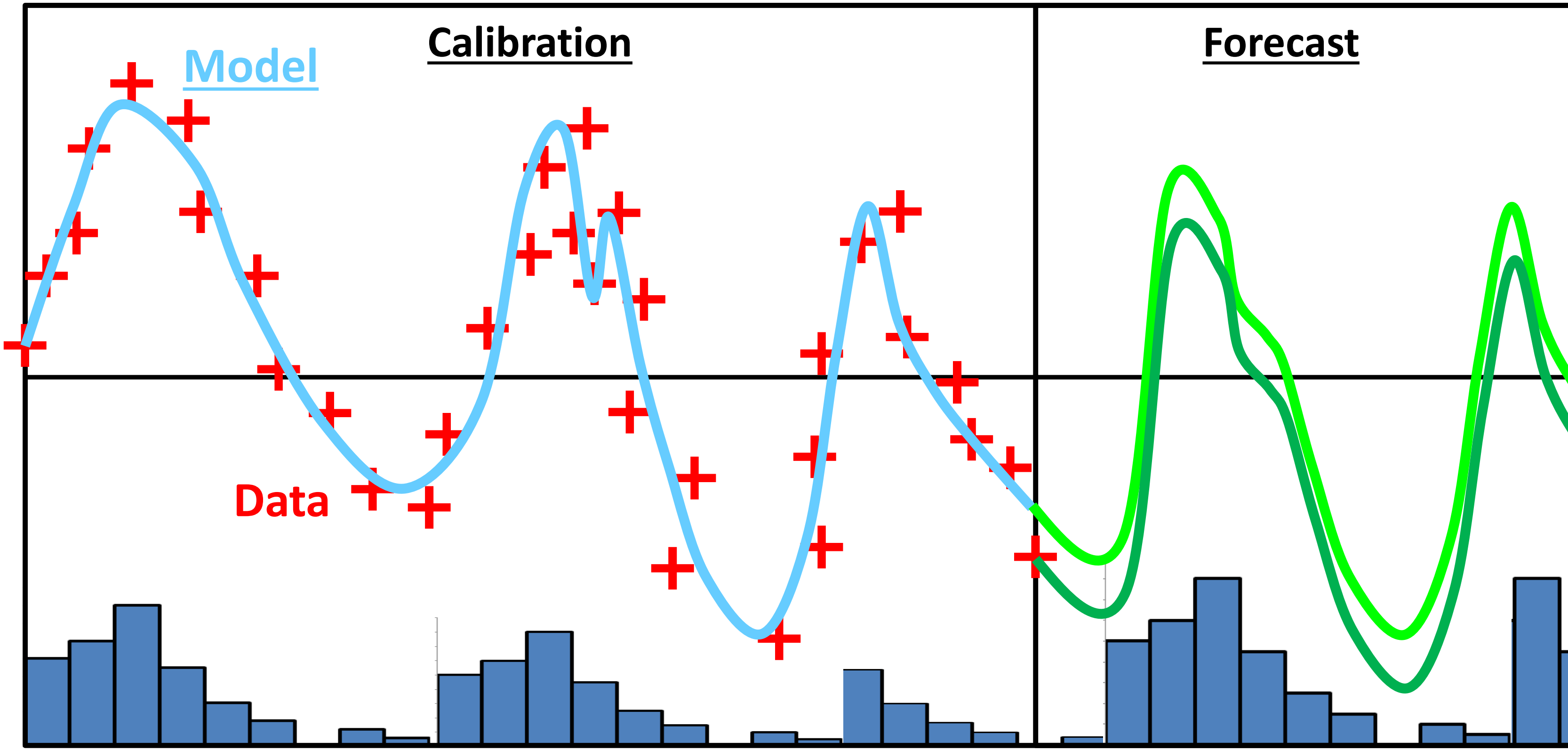
25-29th September 2016
Montpellier, France
CORUM CONFERENCE CENTER
43rd IAH congress

1. « Reverse modeling »

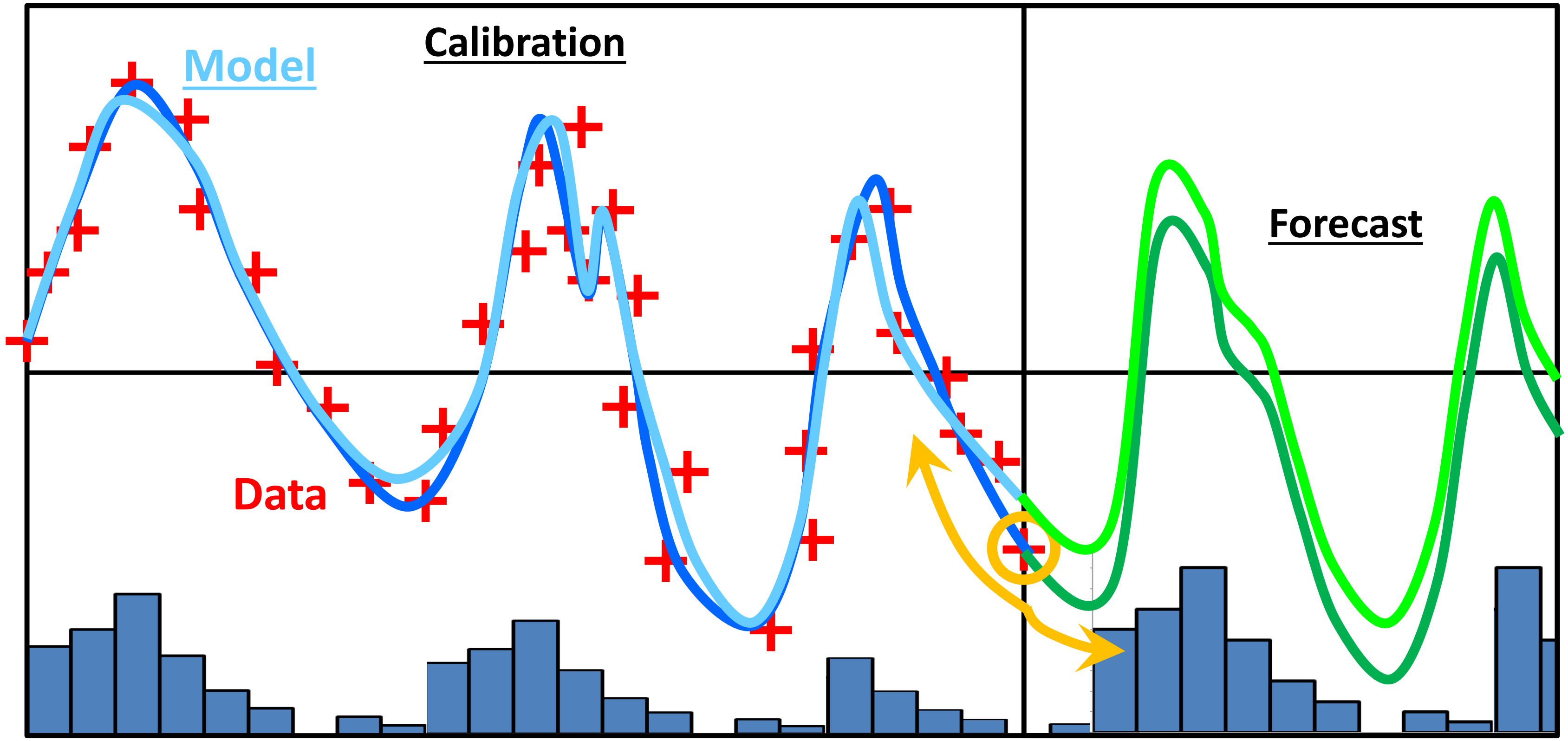
- « Normal » modeling



➔ Even if the calibration is rather good, there might be a (systematic) bias in the forecast

1. « Reverse modeling »

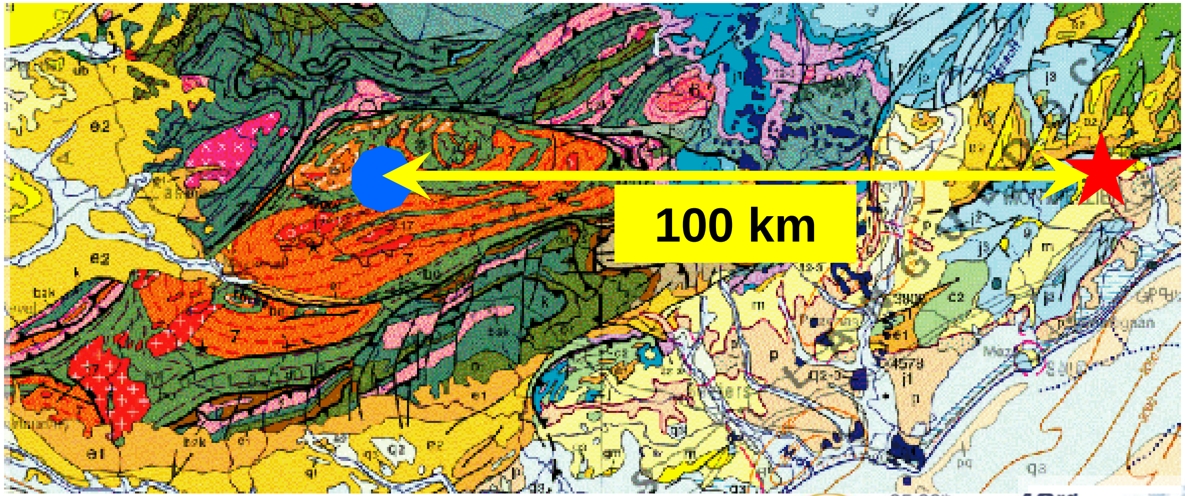
- « Reverse » modeling



1. To perform the calibration from the last data (if reliable) to the oldest
2. To begin the forecast from this last data

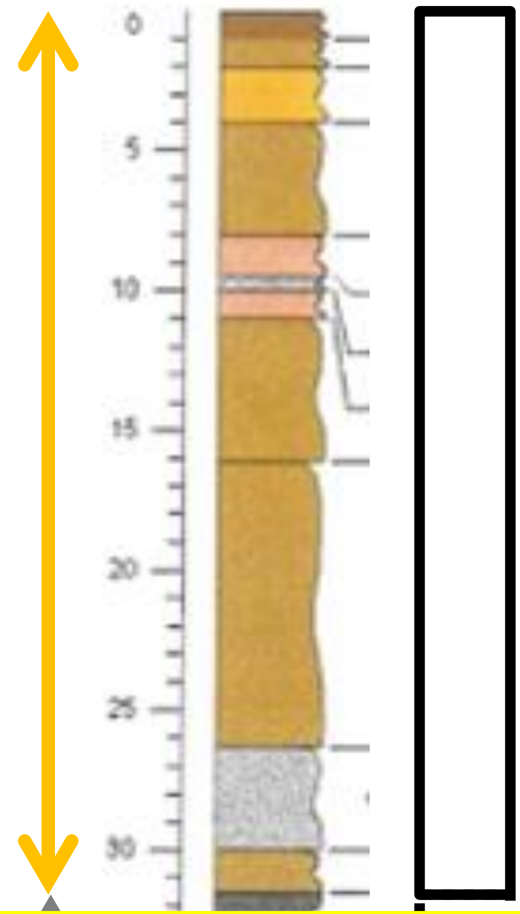
2. Testing « Reverse modeling » and application

- Calibrating the piezometric level of a pumping well vs well discharge and « recharge »
- Forecasting its sustainable yield and the admissible pumping rate for the coming months/year(s)
- Case study from a hard rock aquifer: fissured weathered metamorphic rocks (Southern France) – See also Oral paper from Belle et al., N°2063 (session 8.07)



2. Testing « Reverse modeling » and application

Saprolite



42 m deep well, open between 33 and 42 m, diam. casing: 193 mm

The "a few days" pumping tests seem to enable a quite high discharge (about 10 m^3/h), but pumping during several months at a 5-6 m^3/h discharge showed a continuous decline of the piezometric level (small closed system, low "recharge")
➔ It was then very important for the client to evaluate "the" sustainable yield of this well

2. Testing « Reverse modeling » and application

- A methodology in 3 steps:
  1. Interpretation of pumping tests and pumping time series to provide a « conceptual model » of the aquifer
  2. Development of a simple « water budget » model
  3. Calibration
- Then operational use of the model (forecast)

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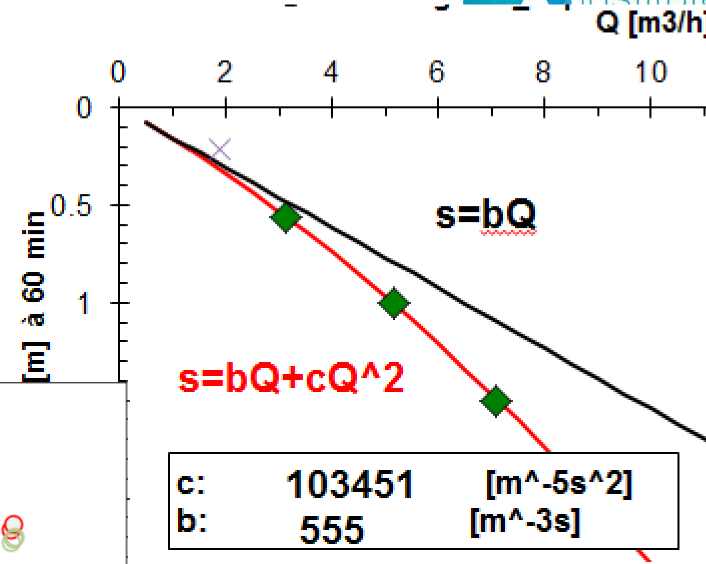
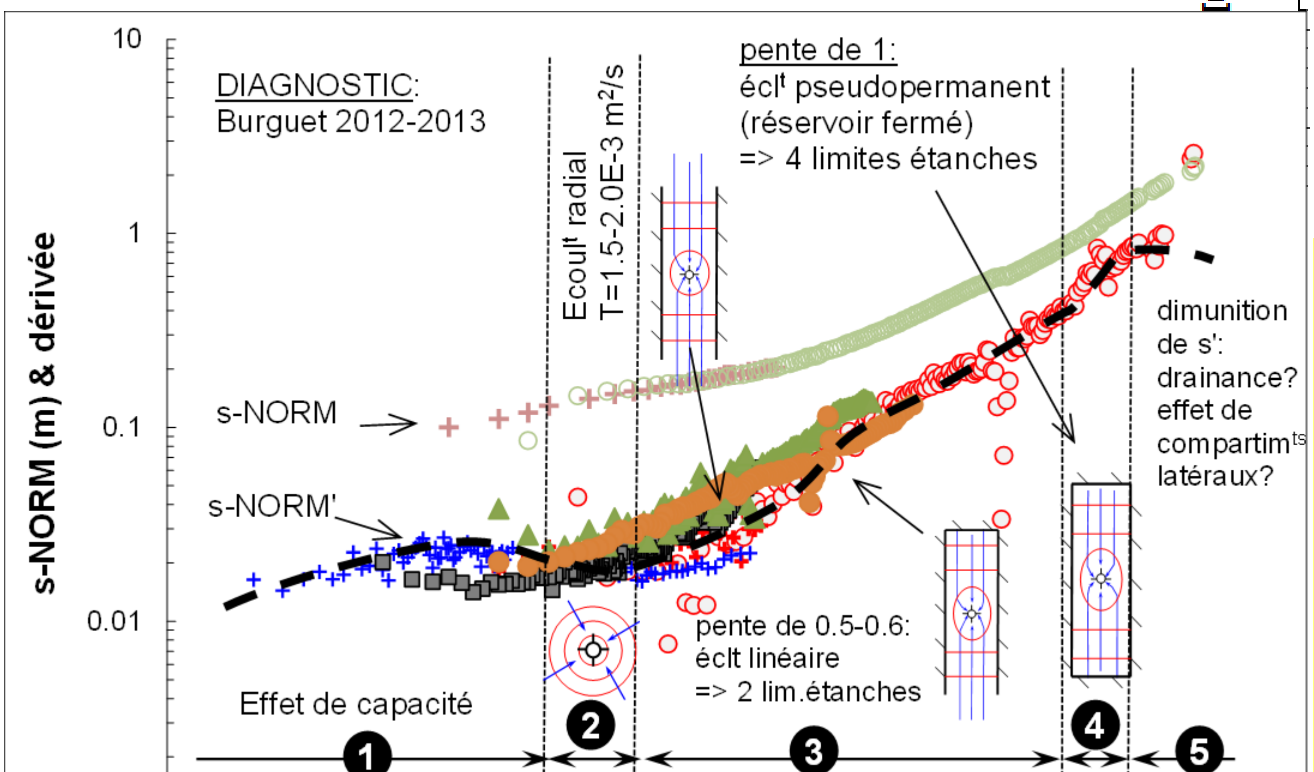
2.1 Interpretation of pumping tests



- Quadratic head losses
- Aquifer parameters



➊ **Wellbore storage**

➋ **Radial flow**

(T = 2.10^{-3} m²/s - S = 10^{-3} from piezometer data)

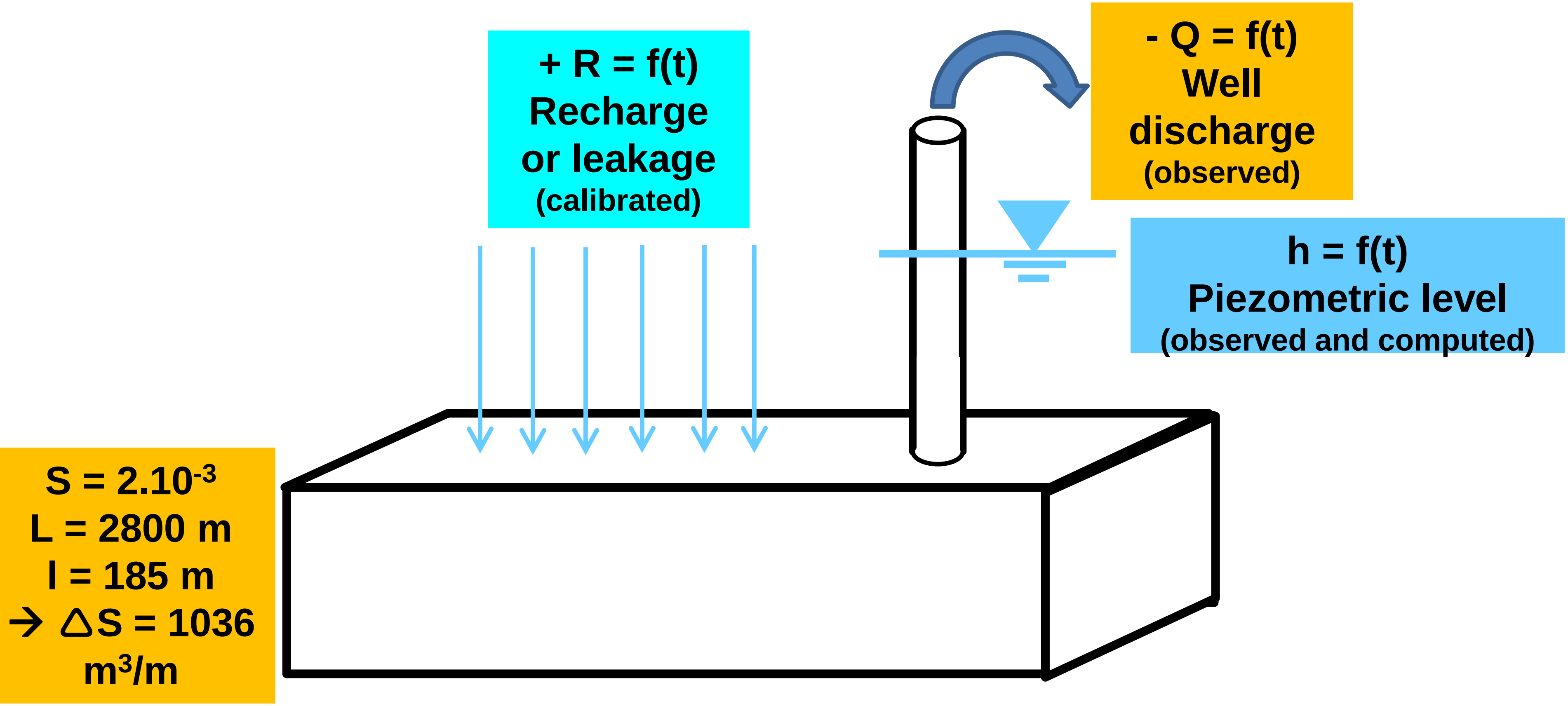
➌➍ **2, 3, 4 …**

No flow boundaries

➎ **Leakage or recharge?**

➔ But as the recharge/leakage in badly constrained, modelling the well long-term behavior is not accurate

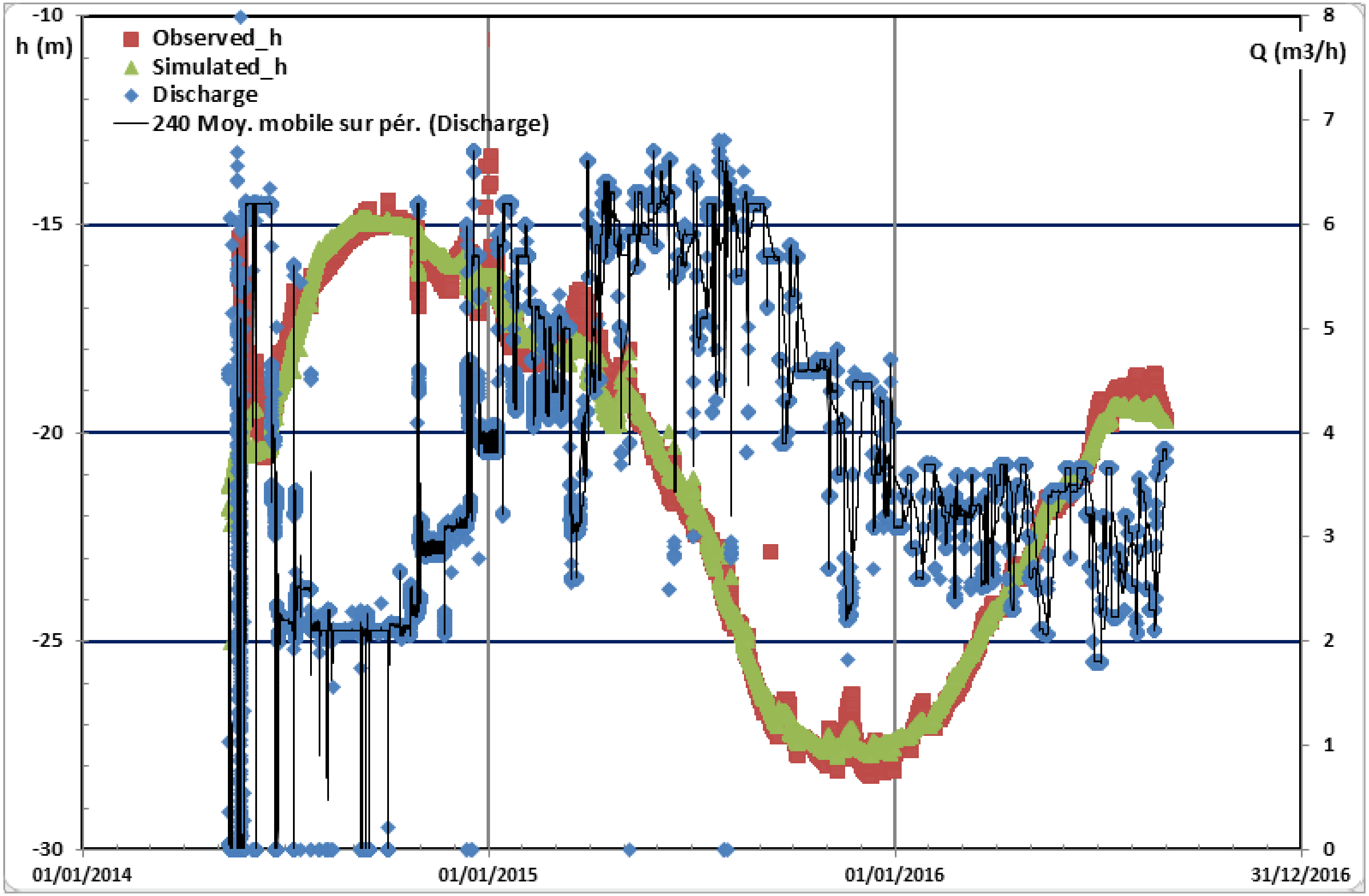
2.2 Development of a simple water budget model



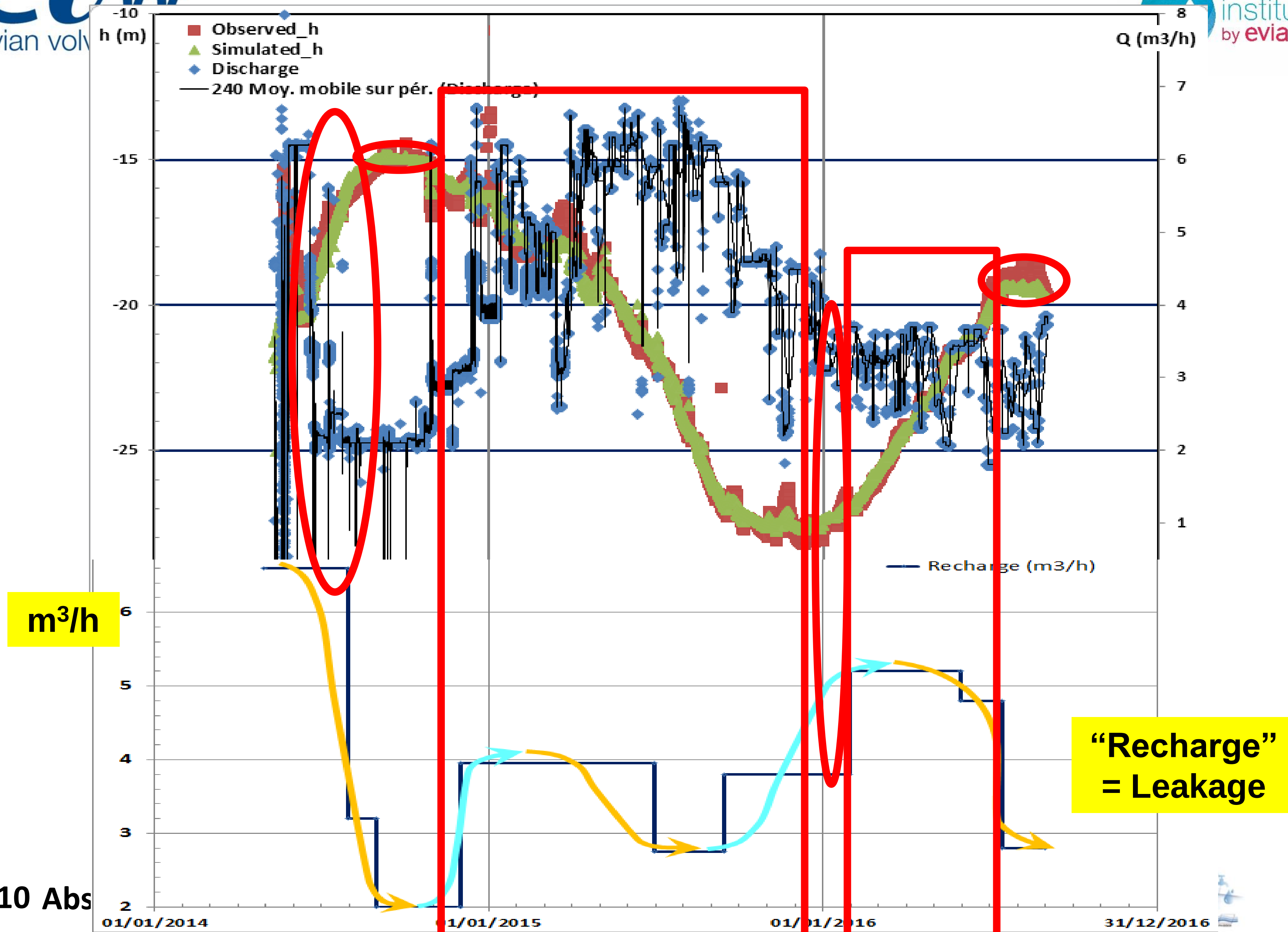
$$- Q(t) + R = \Delta S = h(t)$$

- MSExcel worksheet
- Time step = the one from the observed data (1 hour)

2.3 Calibration

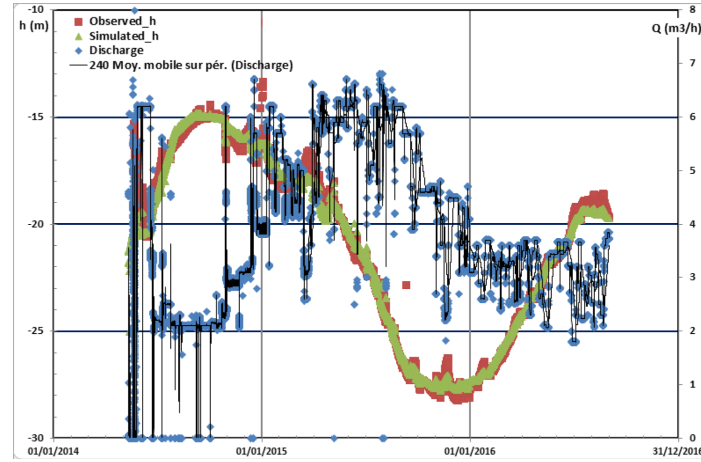


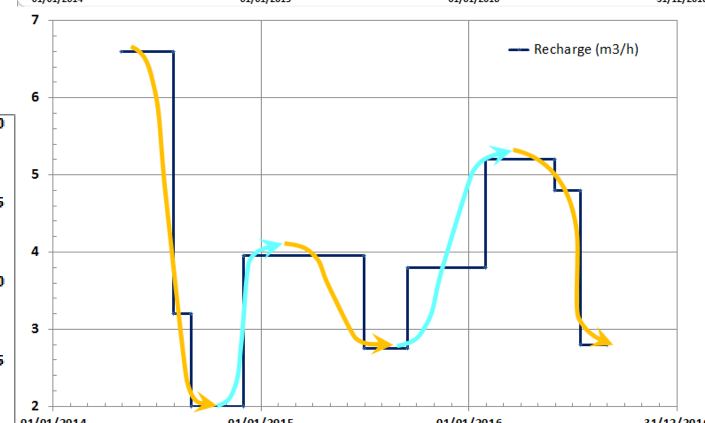
2.3 Calibration

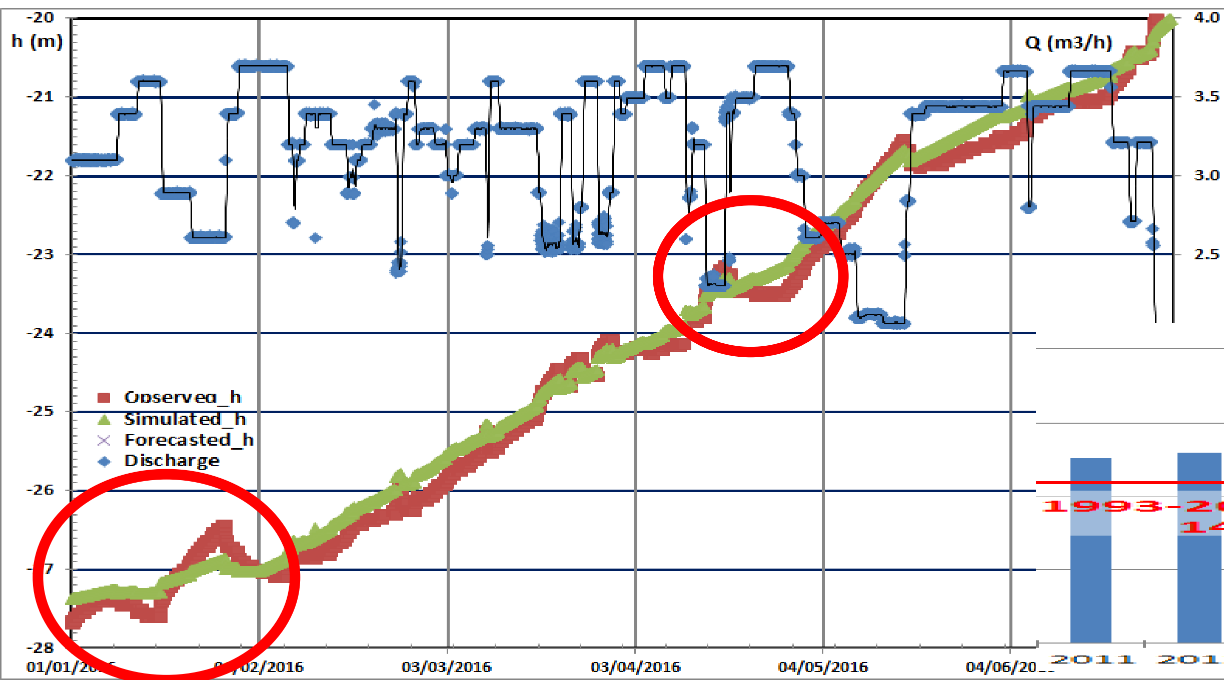


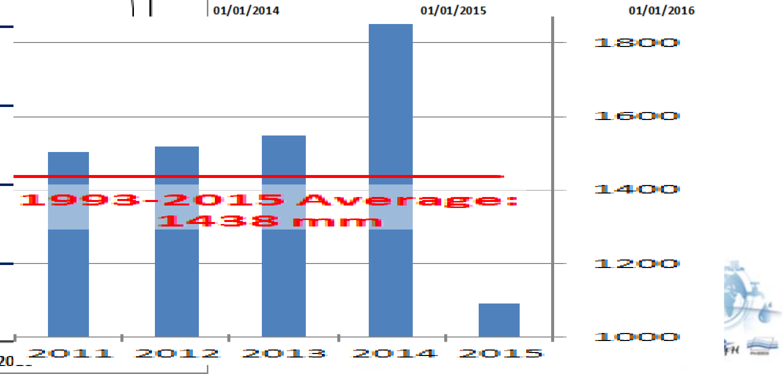
2.3 Calibration

- From a known « conceptual model », slight changes in « recharge » are quantifiable
- Such a « recharge » pattern is realistic (and works as no R=(h) relationships appears)
- Long term trends are well computed
- Medium term trends are badly simulated:
  - Theis « behaviour » is not implemented yet
- Very short term trends (quadratic head losses) are very well simulated

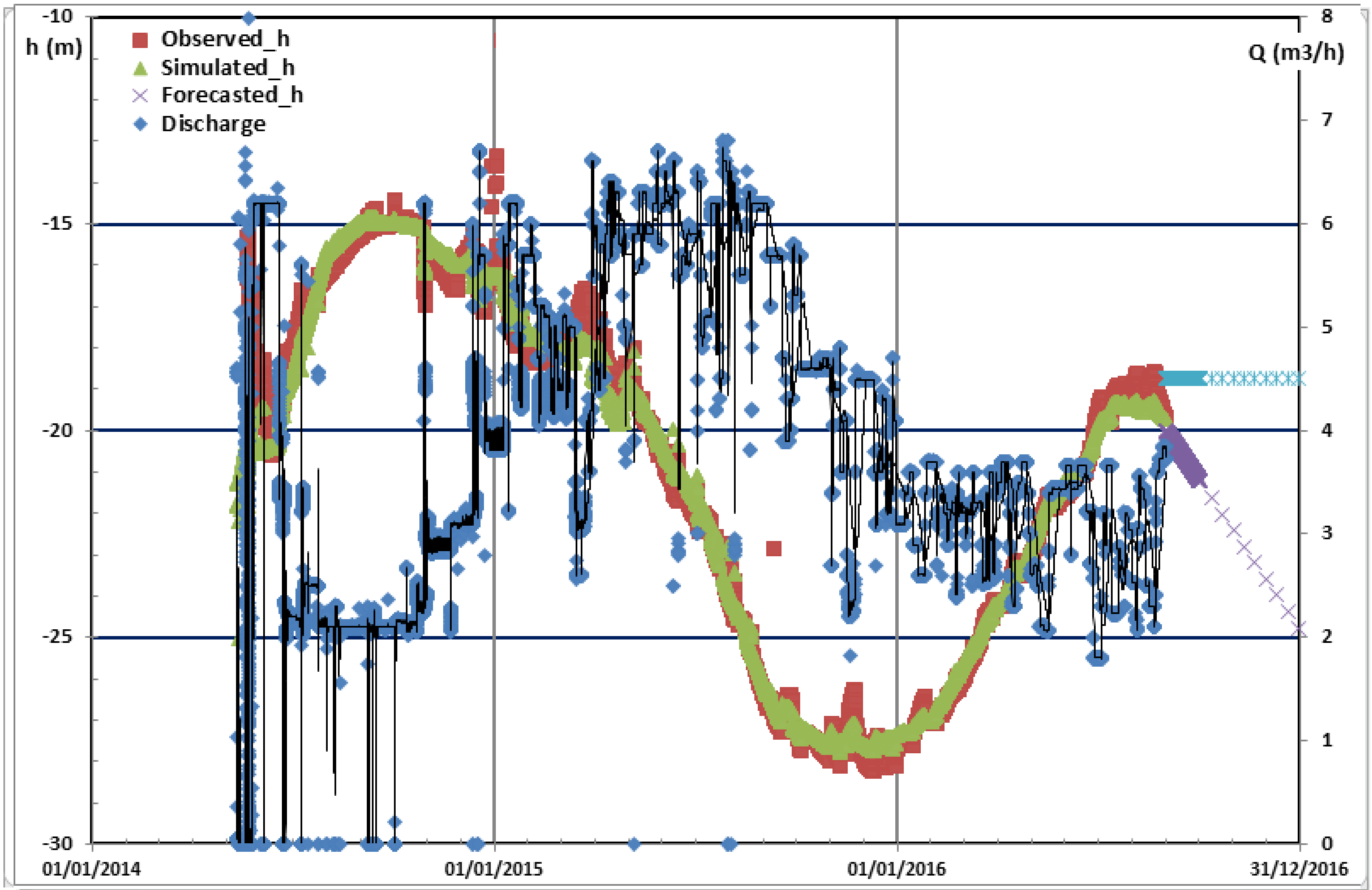








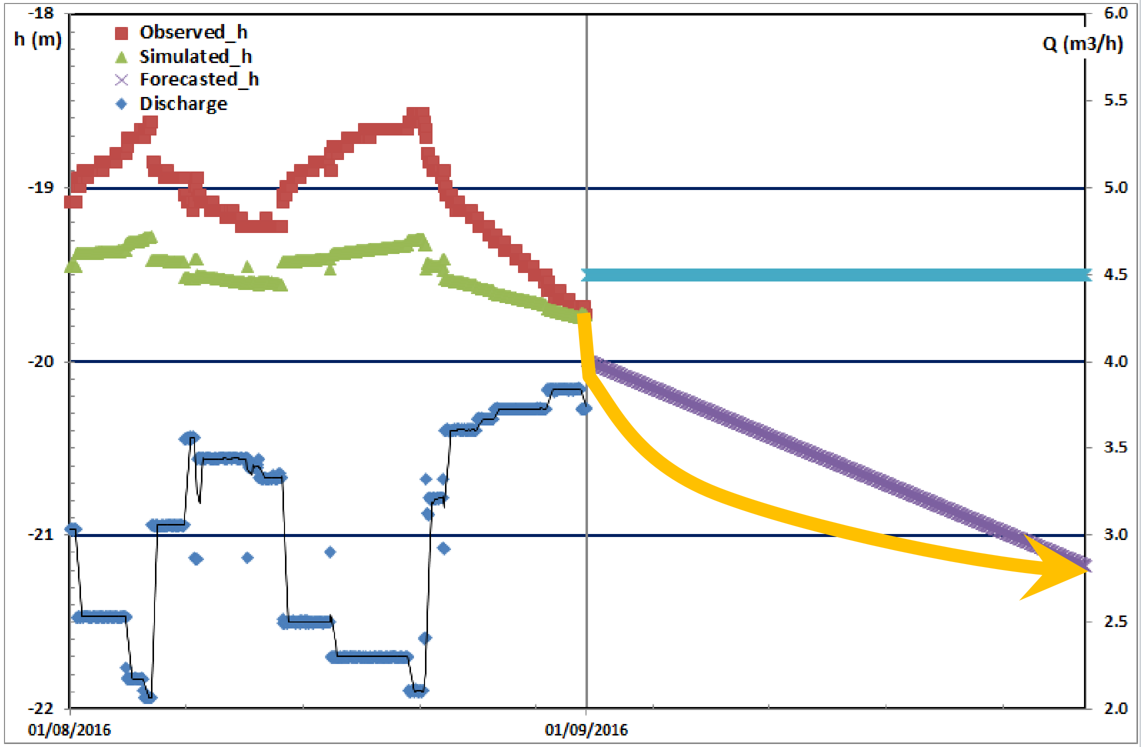
2.4 Forecast



For a given "Recharge" or recharge chronicle (2.8 m^3/h here)

3. Conclusion

- What works well:
  - The principle itself:
    - Calibration OK
    - In that case, no initialization required (particularly on the recharge)
  - Forecast very usefull particularly for long term trends (unsteady Theis effect is significant for about 1 month in the case study)



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  - Forecast very usefull particularly for long term trends (unsteady Theis effect is significant for about 1 month in the case study)
- What doesn't well work:
  - Medium term variations (= Theis) are badly simulated. Not really necessary at this time scale and could be (simply – Superposition method, reversely?) implemented
  - Scheme (reservoir model) well adapted to this kind of well with impervious limits
- Such « reverse modeling » principle could be used for other kind of models