

# The two-layer conceptual model of hard-rock aquifers: validation with a deterministic hydrogeological model

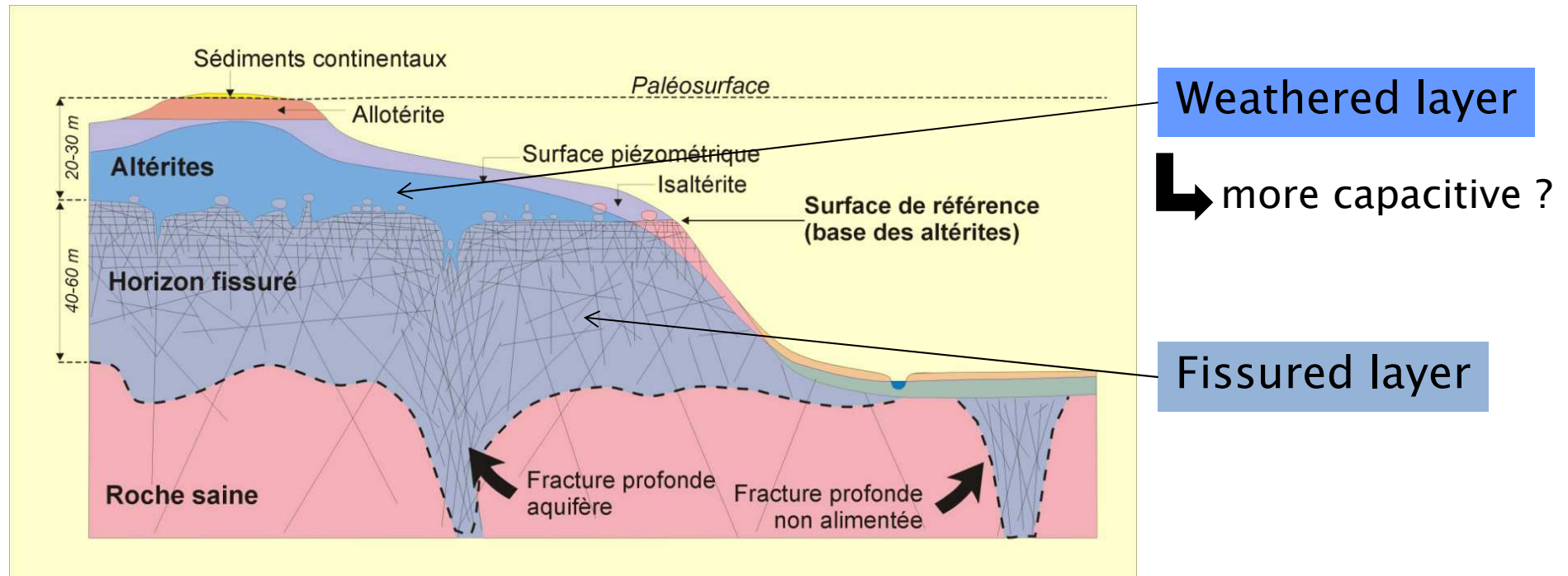
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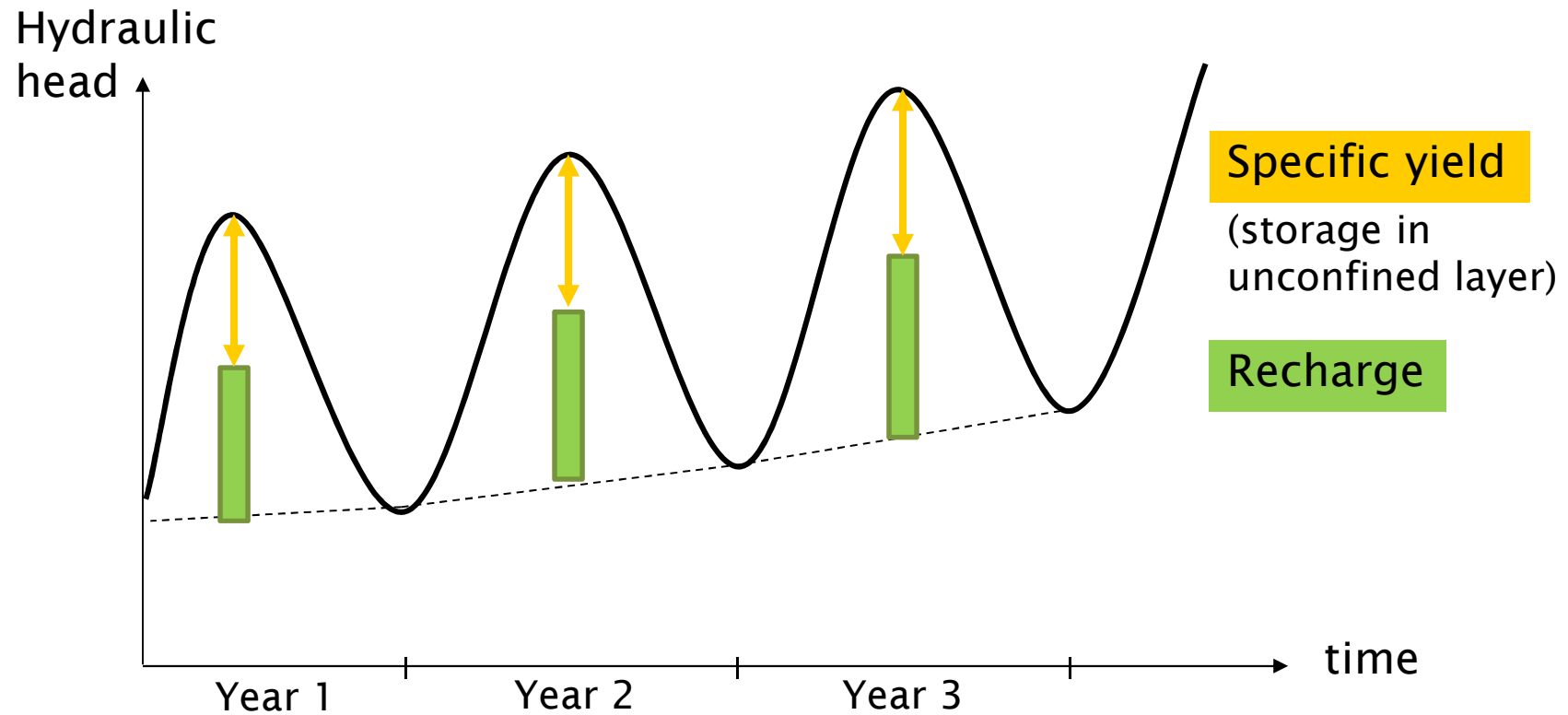
## Two-layer conceptual model



Wyns et al. (2004)

Is it possible to distinct the storage layer properties with a deterministic hydrogeological model ?

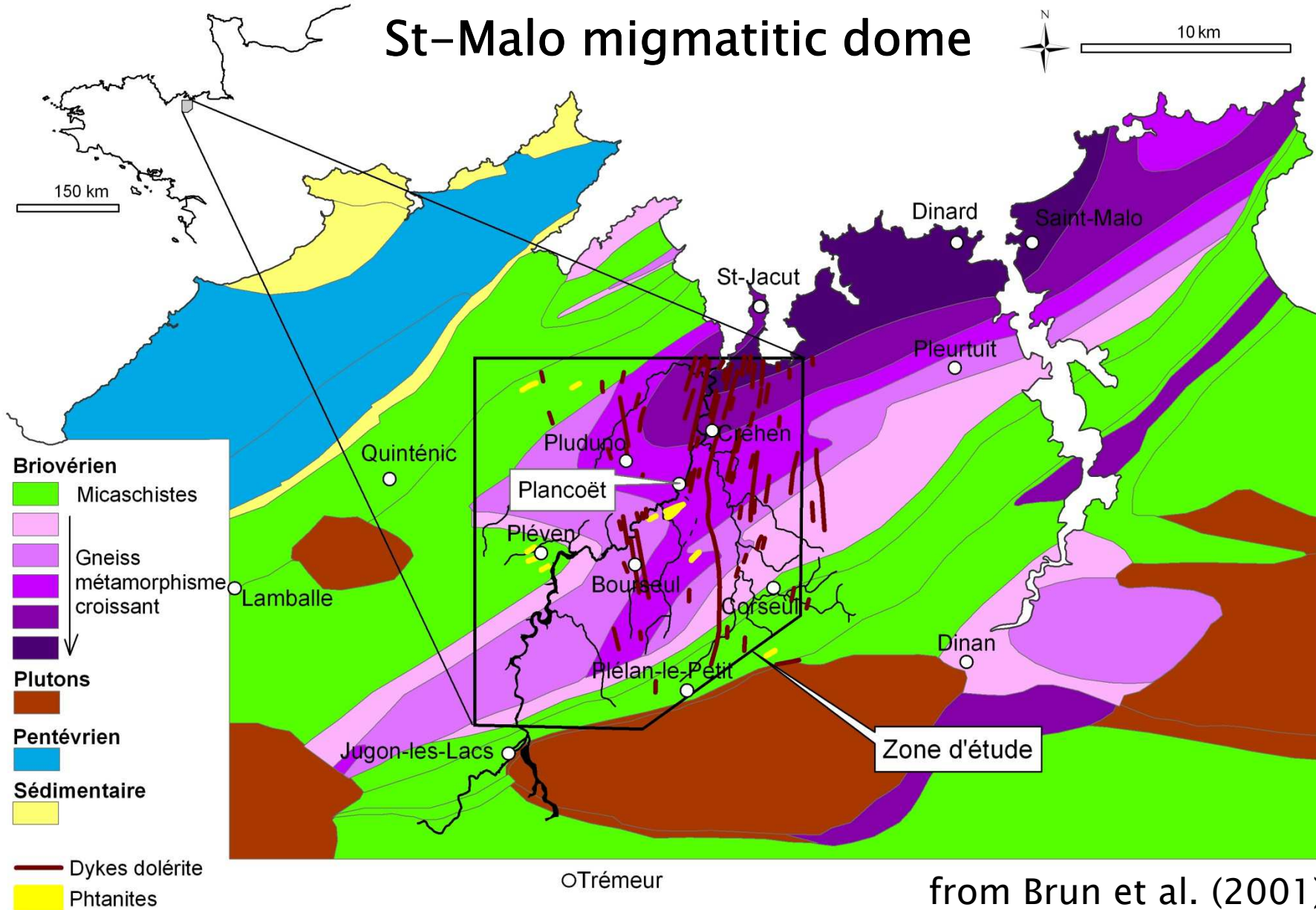
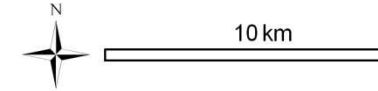
## Storage and piezometric variations



Need of

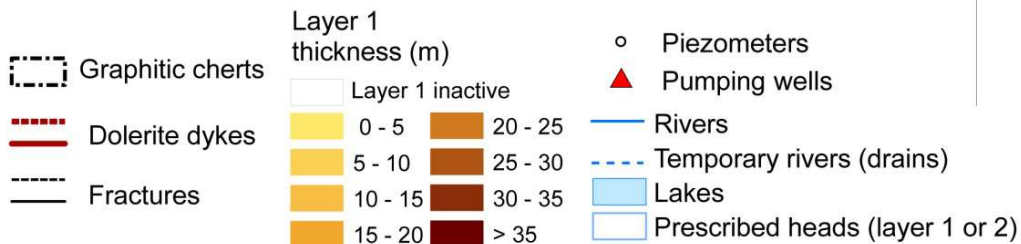
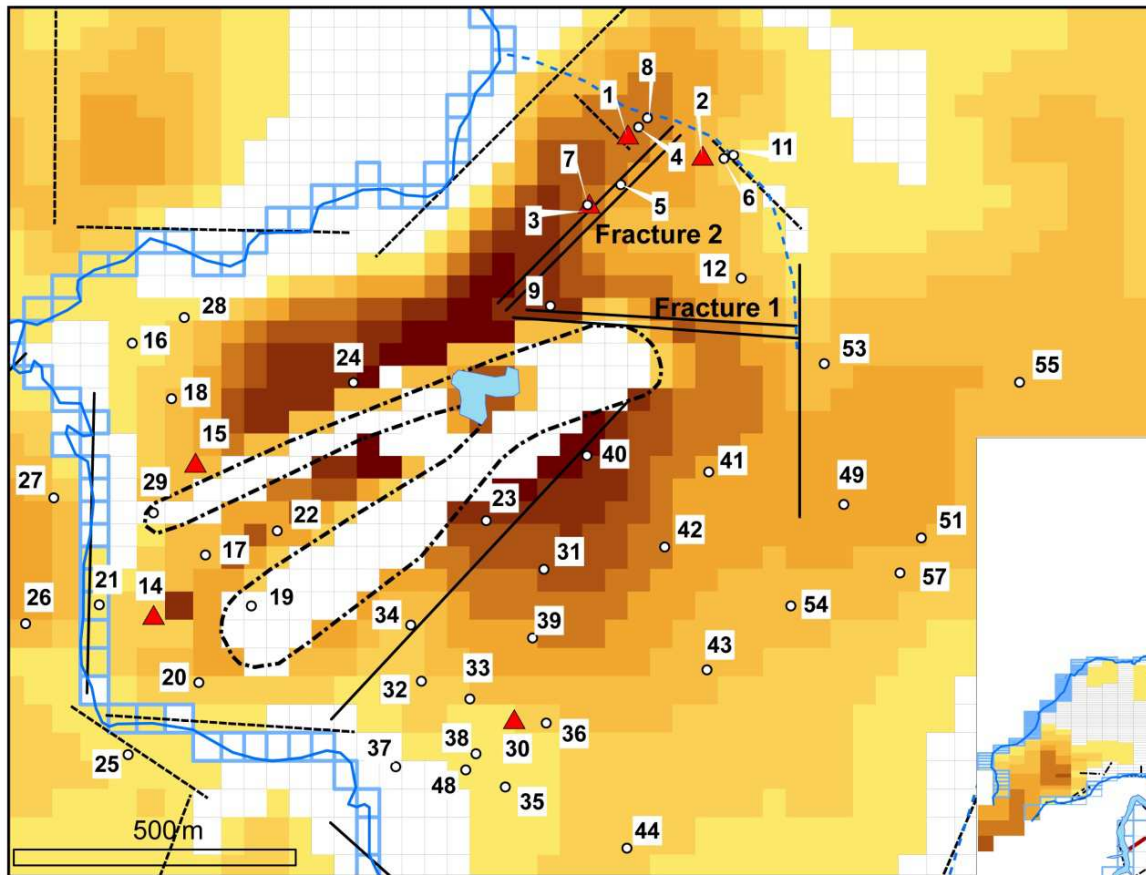
- recharge estimation (coupled problem)
- transient field data for the two layers

# St-Malo migmatitic dome



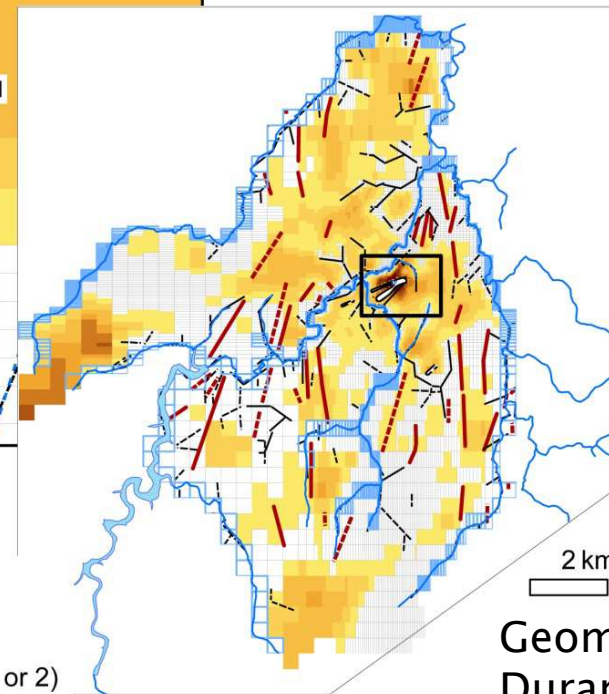
from Brun et al. (2001)

## Two-layer finite difference model



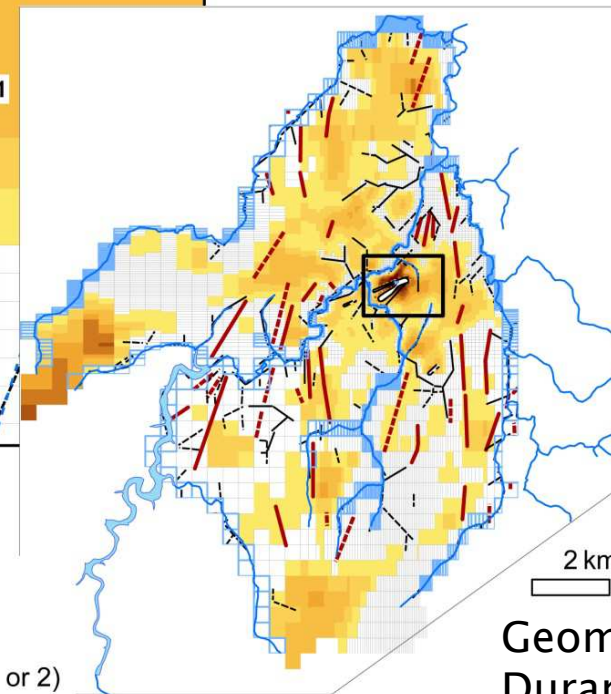
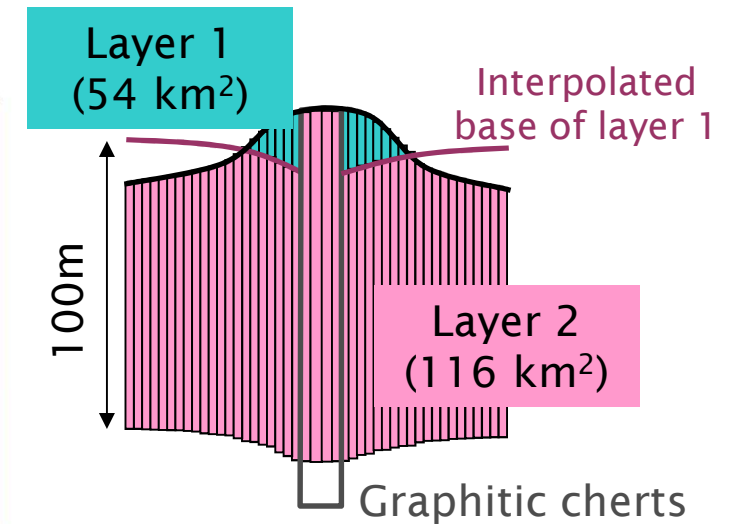
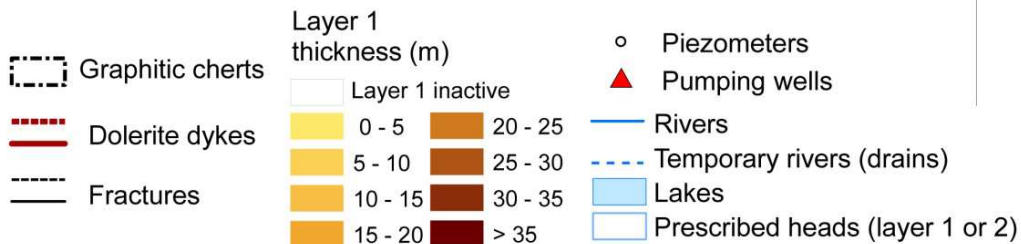
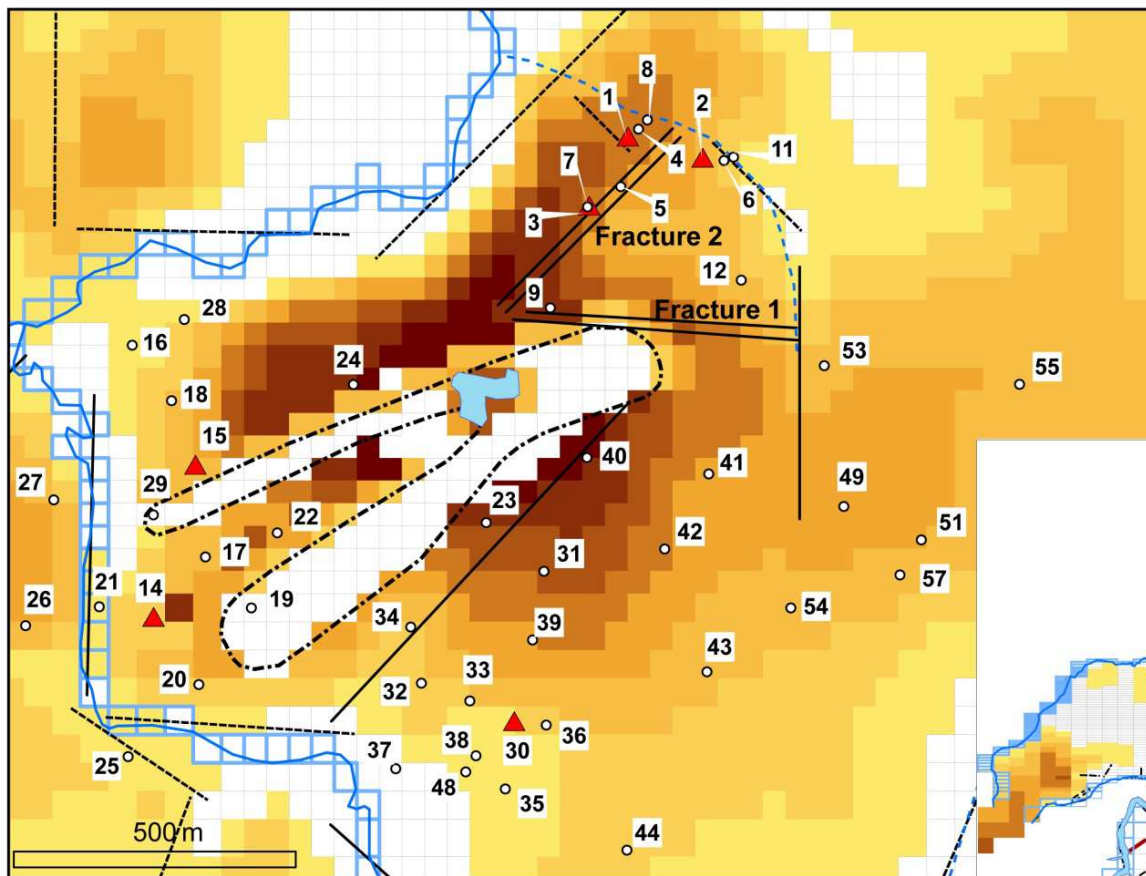
Nestlé Waters :

- 6 pumping wells
- 40 boreholes
- 8 years data, 15d time step



Geometry from  
Durand et al. (2006)

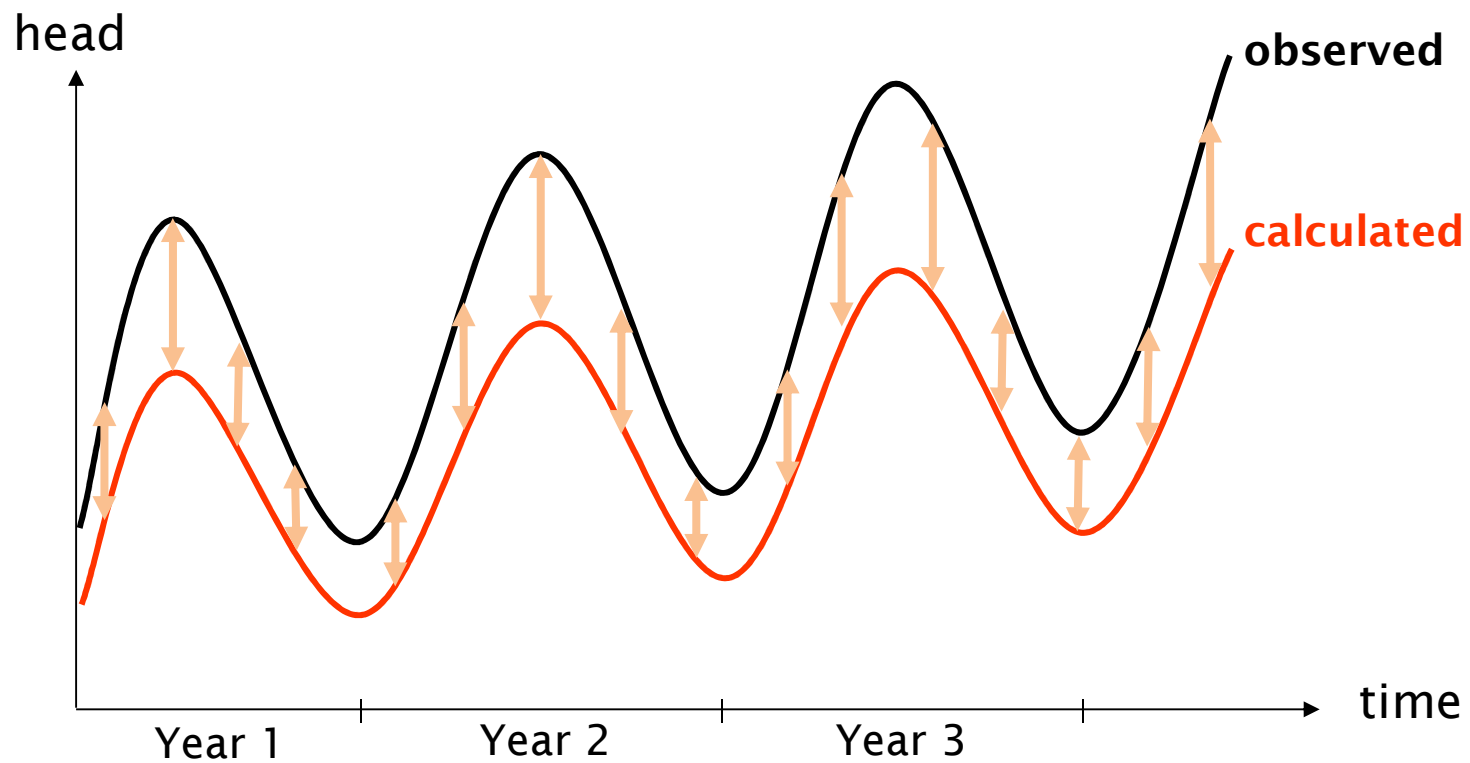
## Two-layer finite difference model



Geometry from  
Durand et al. (2006)

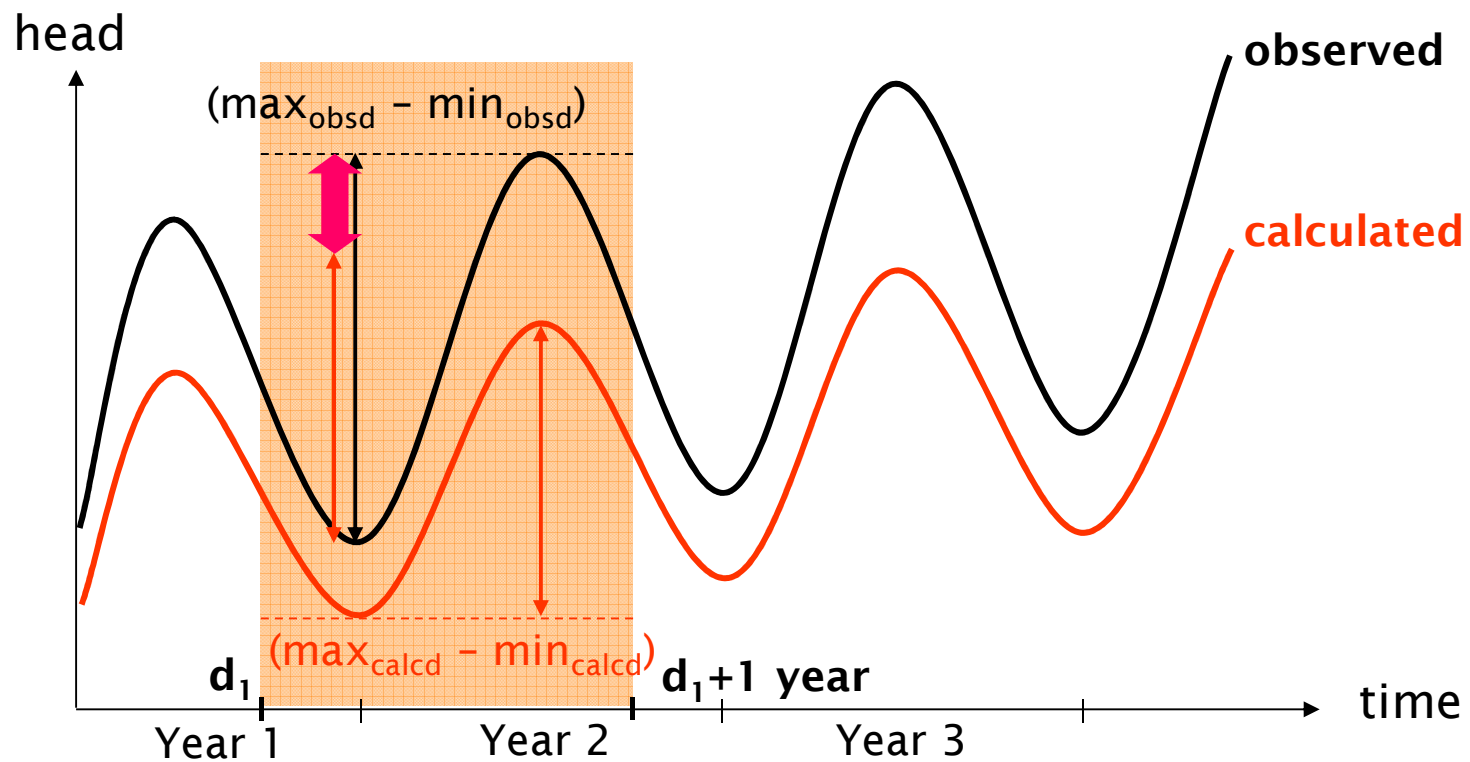
## Variance criterion

$$\text{Var} = \frac{\sum_{i=1}^n (\text{calc}_i - \text{obs}_i)^2}{n}$$



## New Advar criterion

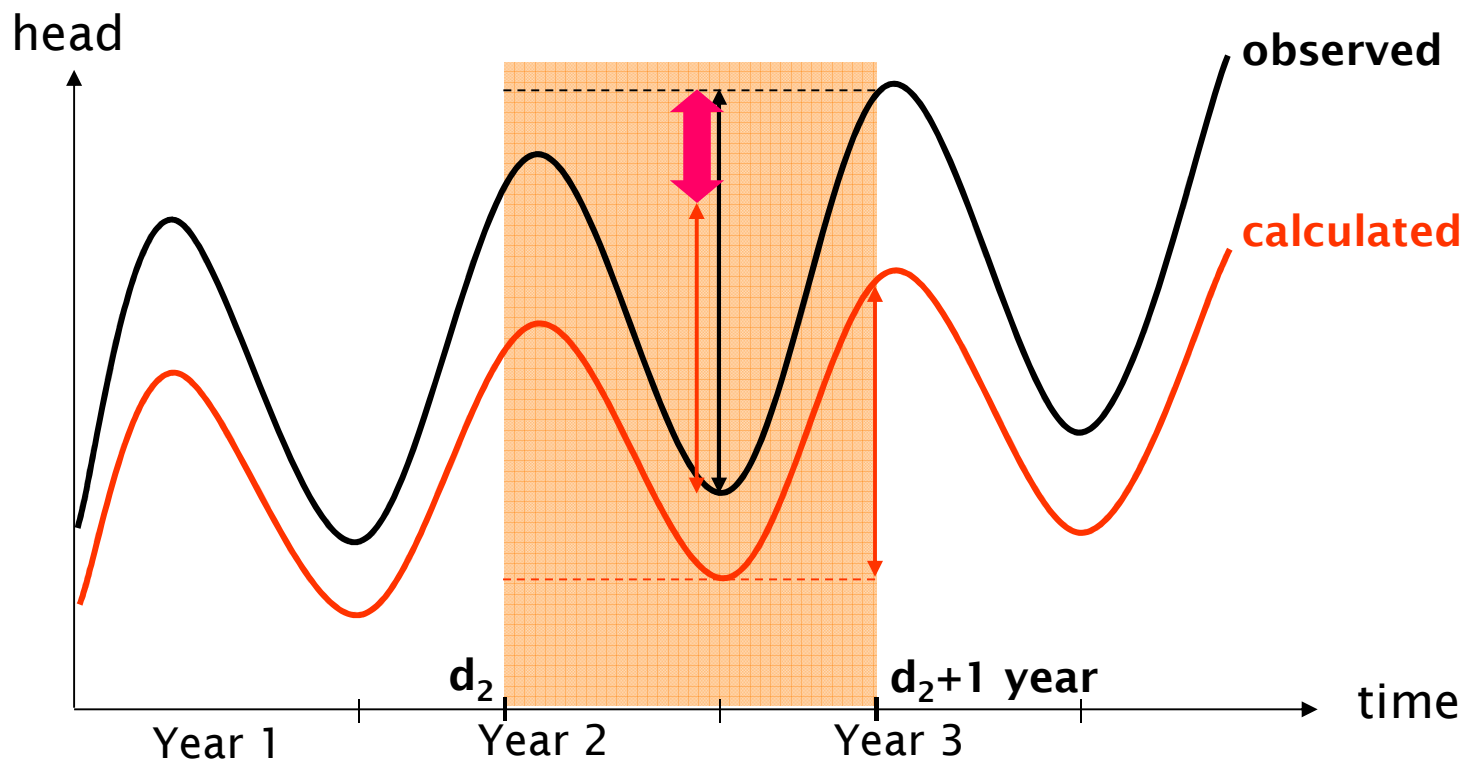
$$\text{Advar} = \frac{\sum_{d=1}^{n_{\text{year}}} \left[ (\max_{\text{calc}_d} - \min_{\text{calc}_d}) - (\max_{\text{obs}_d} - \min_{\text{obs}_d}) \right]^2}{n_{\text{day}}}$$





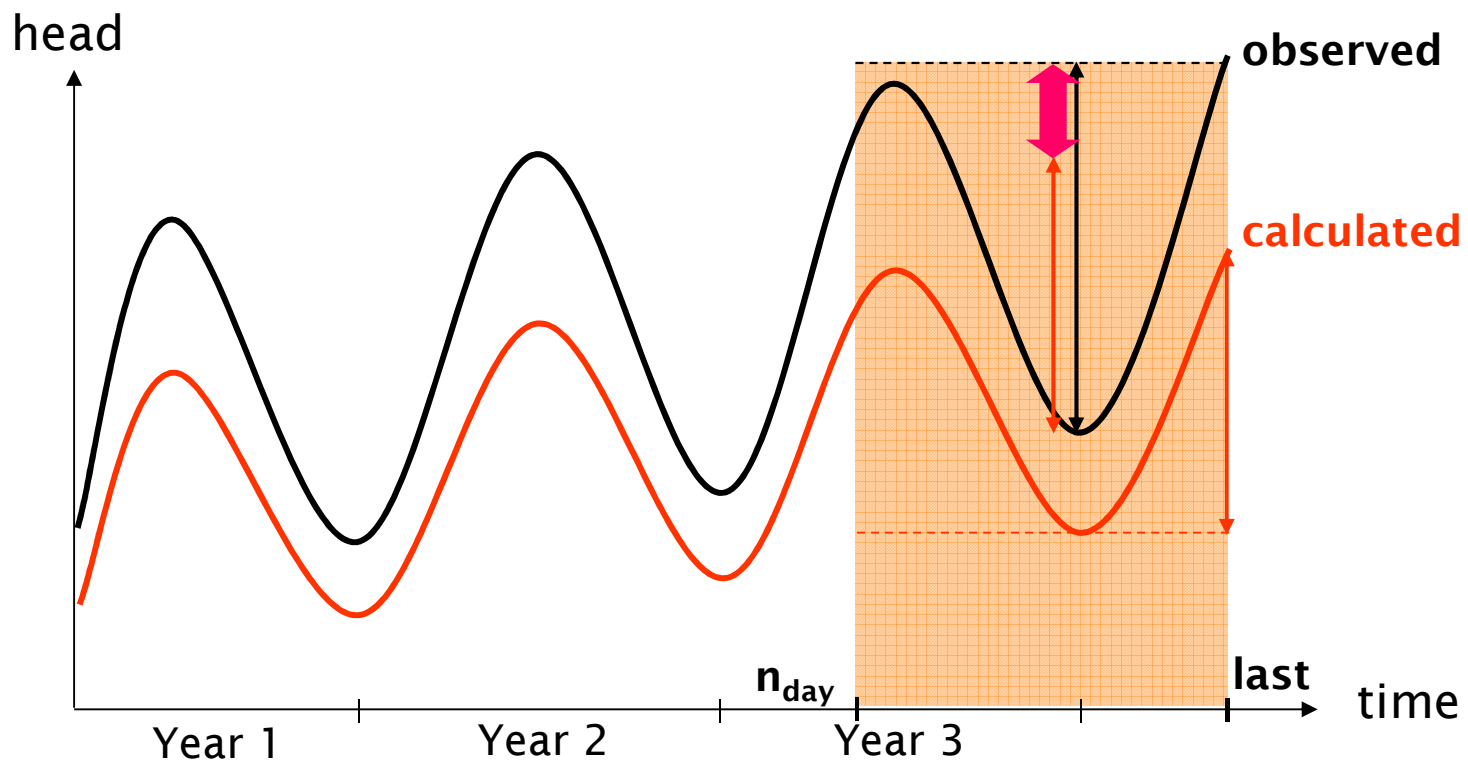
## New Advar criterion

$$\text{Advar} = \frac{\sum_{d=1}^{n_{\text{year}}} \left[ \left( \max_{\text{calc}_d} - \min_{\text{calc}_d} \right) - \left( \max_{\text{obs}_d} - \min_{\text{obs}_d} \right) \right]^2}{n_{\text{day}}}$$



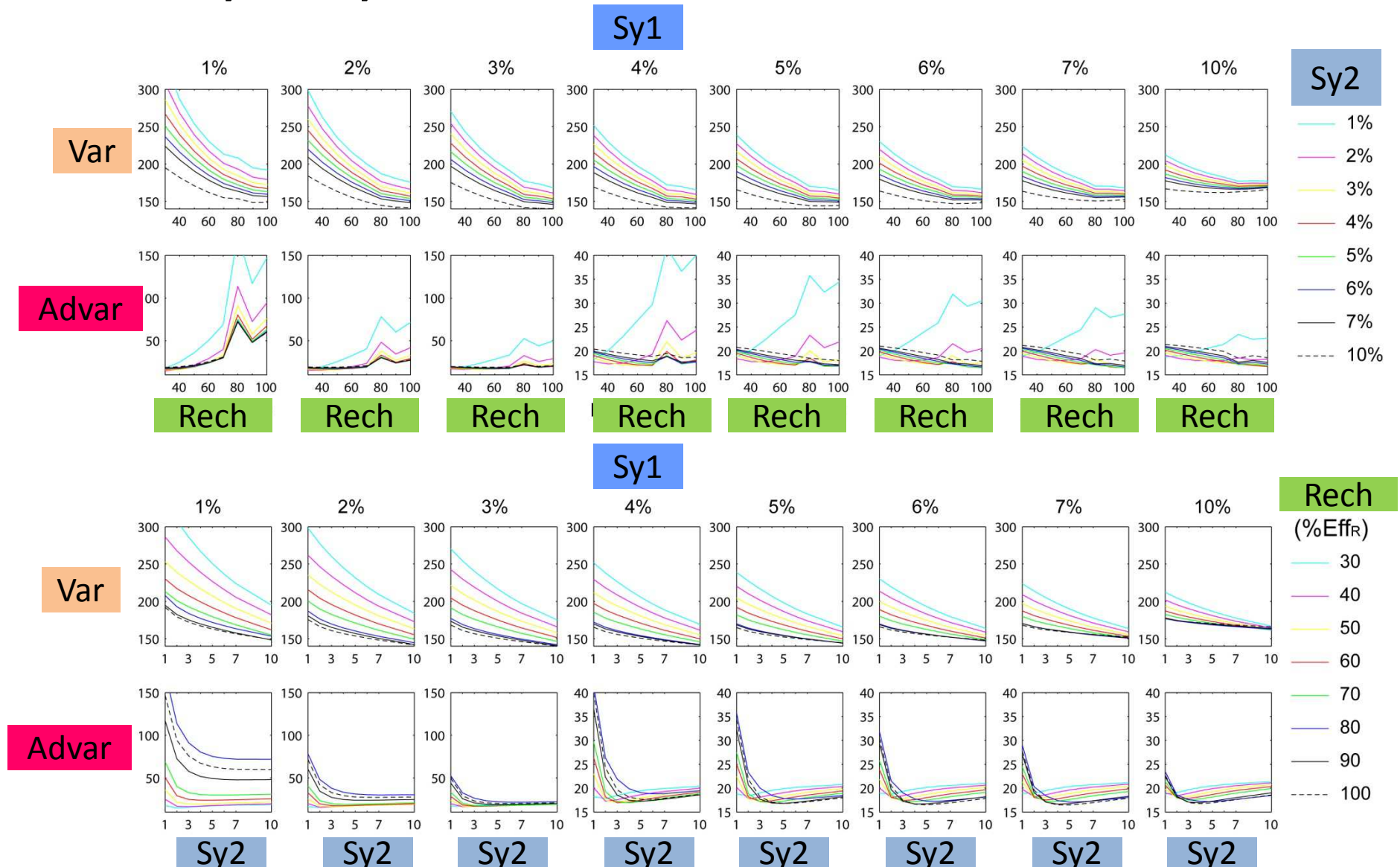
## New Advar criterion

$$\text{Advar} = \frac{\sum_{d=1}^{n_{\text{year}}} \left[ \left( \max_{\text{calc}_d} - \min_{\text{calc}_d} \right) - \left( \max_{\text{obs}_d} - \min_{\text{obs}_d} \right) \right]^2}{n_{\text{day}}}$$



## Sensitivity analysis

$$K_1 = K_2 = 0.07 \text{ m/d}$$



## Comparison Var / Advar

Rech = 100 %

Var

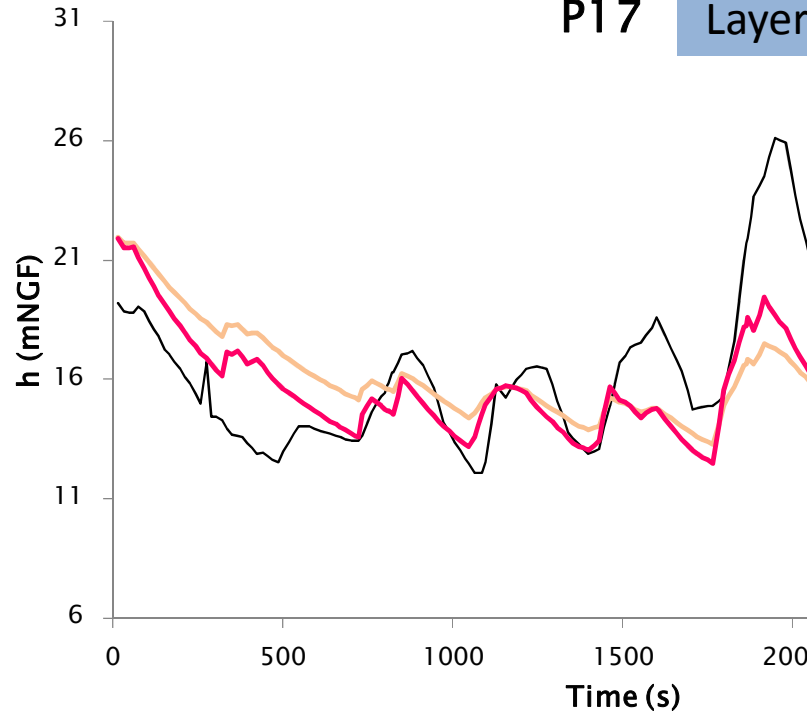
Advar

|     |     | Sy1 |     |     |     |     |     |     |     |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
|     |     | 1%  | 2%  | 3%  | 4%  | 5%  | 6%  | 7%  | 10% |
| Sy2 | 1%  | 192 | 176 | 168 | 165 | 165 | 166 | 168 | 177 |
|     | 2%  | 179 | 166 | 161 | 159 | 160 | 162 | 164 | 174 |
|     | 3%  | 172 | 161 | 157 | 156 | 157 | 159 | 162 | 173 |
|     | 4%  | 167 | 157 | 154 | 153 | 154 | 157 | 160 | 171 |
|     | 5%  | 163 | 154 | 151 | 151 | 152 | 155 | 159 | 170 |
|     | 6%  | 160 | 151 | 148 | 149 | 151 | 154 | 157 | 169 |
|     | 7%  | 157 | 148 | 146 | 147 | 149 | 152 | 156 | 168 |
|     | 10% | 149 | 142 | 140 | 142 | 144 | 148 | 152 | 166 |

|     |     | Sy1   |      |      |      |      |      |      |      |
|-----|-----|-------|------|------|------|------|------|------|------|
|     |     | 1%    | 2%   | 3%   | 4%   | 5%   | 6%   | 7%   | 10%  |
| Sy2 | 1%  | 146.7 | 71.4 | 49.7 | 40.0 | 34.4 | 30.4 | 27.7 | 22.7 |
|     | 2%  | 94.2  | 41.9 | 29.1 | 24.3 | 21.9 | 20.5 | 19.6 | 18.3 |
|     | 3%  | 75.7  | 32.7 | 23.0 | 19.6 | 18.2 | 17.5 | 17.1 | 16.9 |
|     | 4%  | 67.2  | 29.2 | 20.8 | 18.1 | 17.1 | 16.6 | 16.5 | 16.8 |
|     | 5%  | 63.0  | 27.7 | 20.1 | 17.7 | 16.8 | 16.5 | 16.5 | 16.9 |
|     | 6%  | 61.1  | 27.3 | 19.9 | 17.7 | 16.9 | 16.7 | 16.7 | 17.2 |
|     | 7%  | 60.2  | 27.2 | 20.1 | 17.9 | 17.1 | 16.9 | 17.0 | 17.6 |
|     | 10% | 59.7  | 27.7 | 20.8 | 18.7 | 18.0 | 17.8 | 17.9 | 18.6 |

P17 Layer 2

### Piezometers comparison



Observed

Best Var

Best Advar

Sy1

Sy2

3%

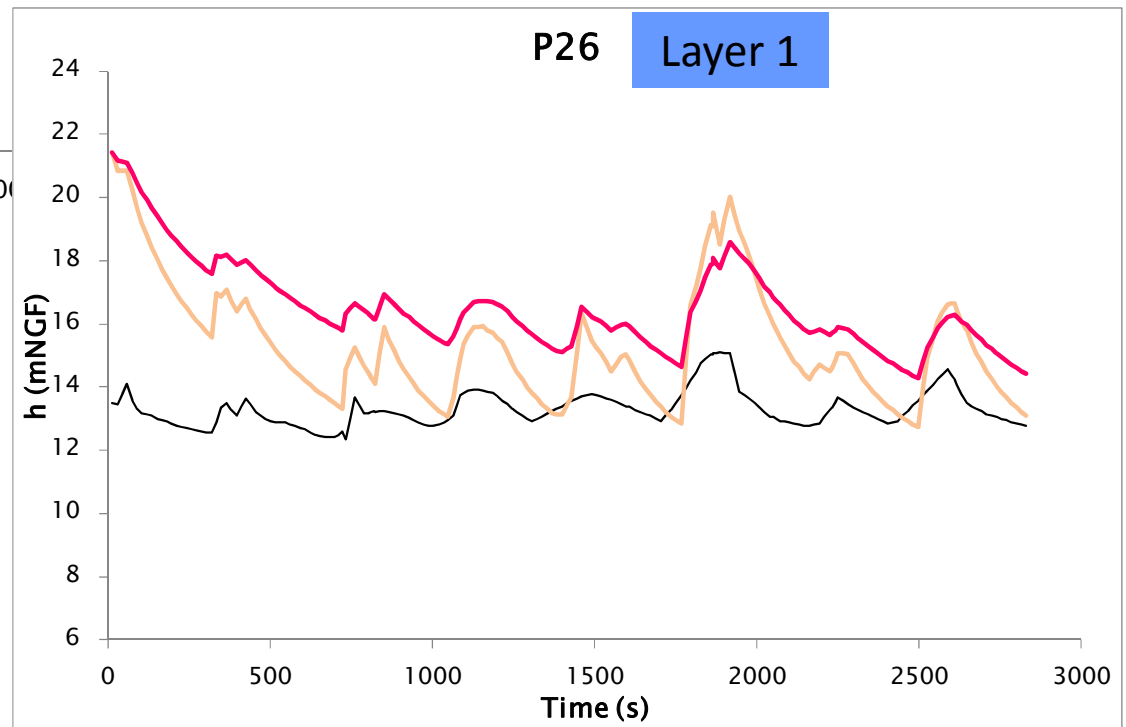
10%

7%

5%

Rech = 100 %

P26 Layer 1



## Main conclusions

### Recharge estimation

- No runoff

### Calibration methodology

- Advar criterion helps to calibrate the specific yield

### Two-layer model

- Weathered layer more capacitive than the fissured layer