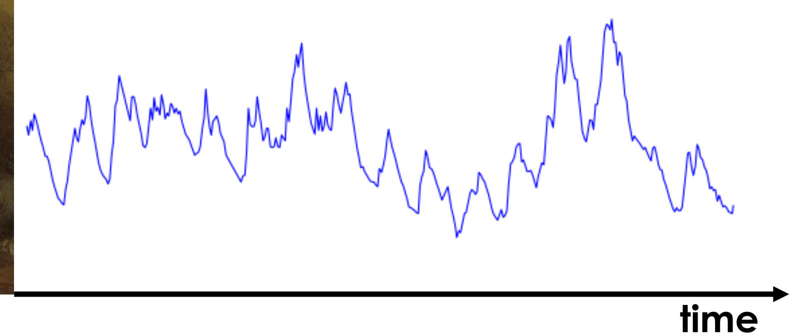
Complémentarité de l'analyse des séries temporelles et des modèles à base physique dans le traitement de signal hydrogéologique

Séminaire APRONA du 30-11-2021
Christophe Obergfell
Stantec Consulting



**‘A woman at a well,
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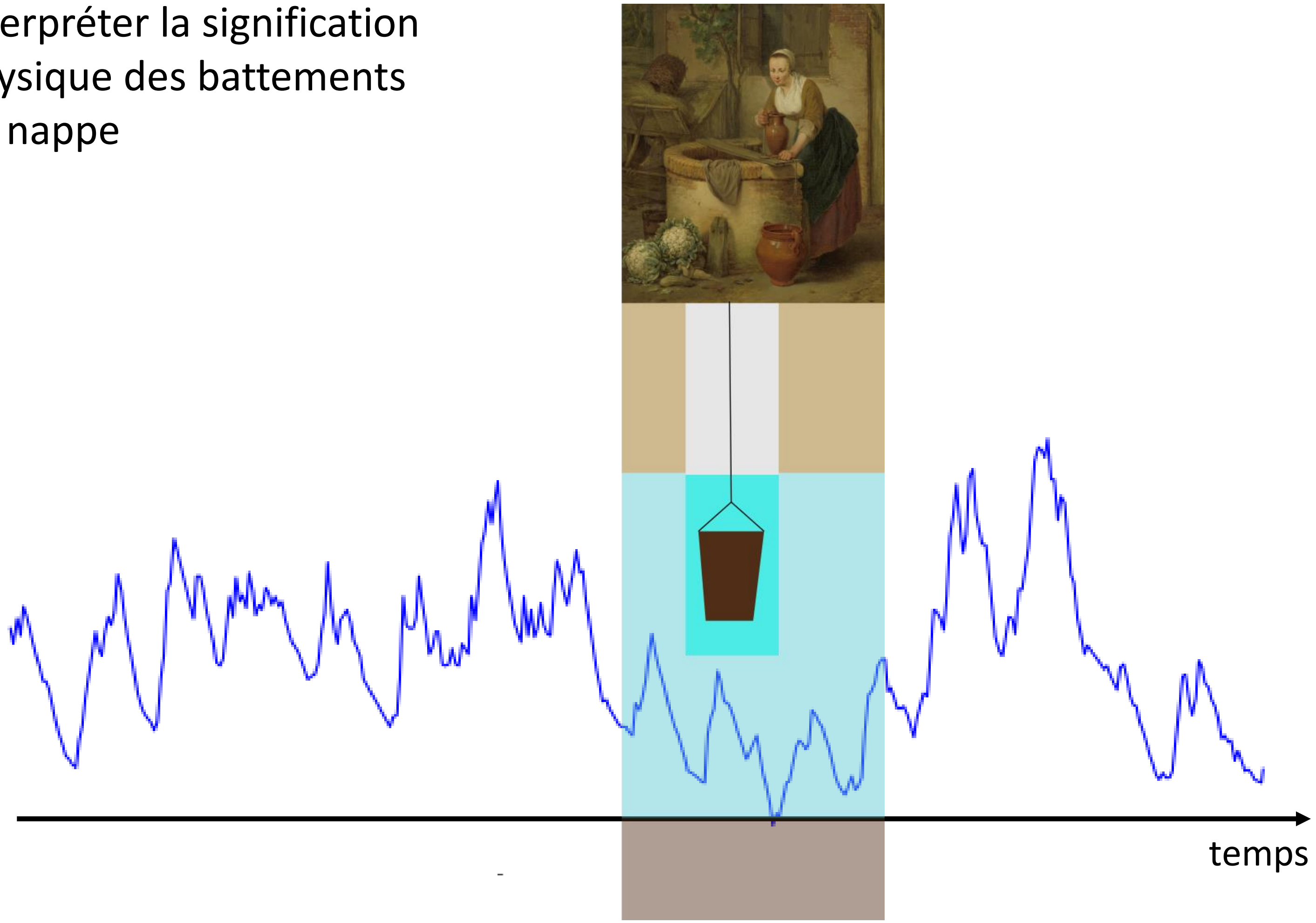
Fluctuations de niveau de nappe: le pouls d'un aquifère

Interpréter la signification physique des battements de nappe



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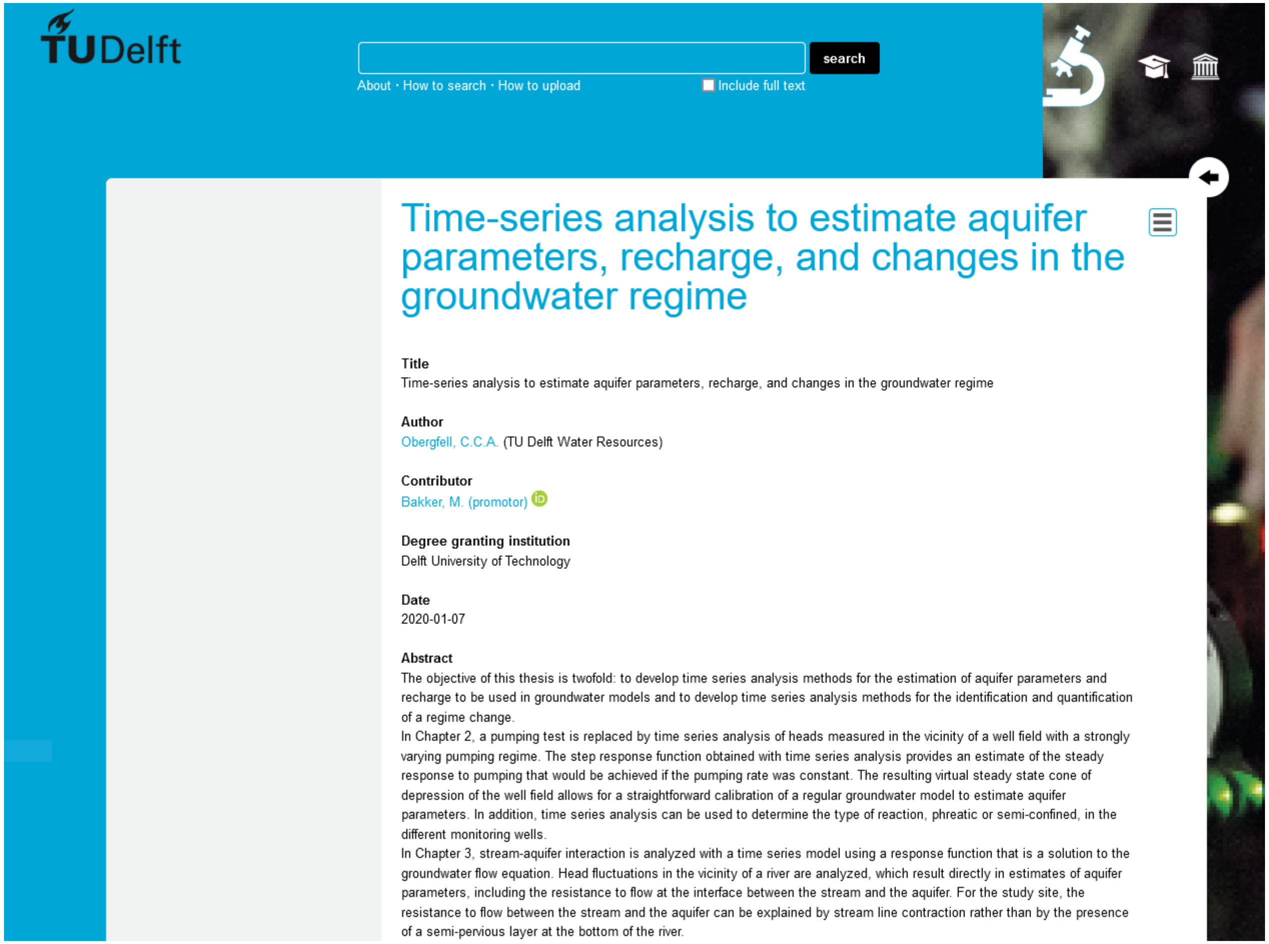

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Time-series analysis to estimate aquifer parameters, recharge, and changes in the groundwater regime

Title
Time-series analysis to estimate aquifer parameters, recharge, and changes in the groundwater regime

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Degree granting institution
Delft University of Technology

Date
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Abstract
The objective of this thesis is twofold: to develop time series analysis methods for the estimation of aquifer parameters and recharge to be used in groundwater models and to develop time series analysis methods for the identification and quantification of a regime change.
In Chapter 2, a pumping test is replaced by time series analysis of heads measured in the vicinity of a well field with a strongly varying pumping regime. The step response function obtained with time series analysis provides an estimate of the steady response to pumping that would be achieved if the pumping rate was constant. The resulting virtual steady state cone of depression of the well field allows for a straightforward calibration of a regular groundwater model to estimate aquifer parameters. In addition, time series analysis can be used to determine the type of reaction, phreatic or semi-confined, in the different monitoring wells.
In Chapter 3, stream-aquifer interaction is analyzed with a time series model using a response function that is a solution to the groundwater flow equation. Head fluctuations in the vicinity of a river are analyzed, which result directly in estimates of aquifer parameters, including the resistance to flow at the interface between the stream and the aquifer. For the study site, the resistance to flow between the stream and the aquifer can be explained by stream line contraction rather than by the presence of a semi-pervious layer at the bottom of the river.

Obergfell, C., Time-series analysis to estimate aquifer parameters, recharge, and changes in the groundwater regime, Doctoral Thesis,TU Delft repository,
https://doi.org/10.4233/uuid:40454512-e67c-41c5-963b-5862a1b94ac3

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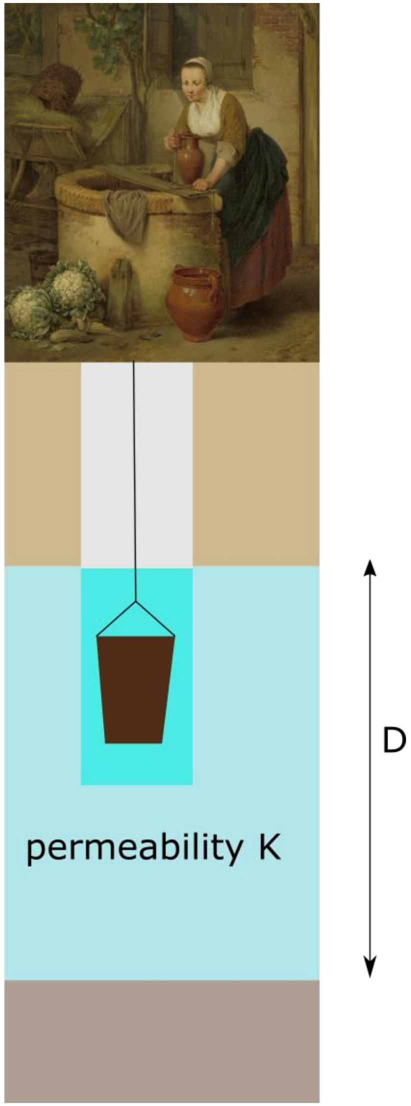
Modèles physiques des aquifères

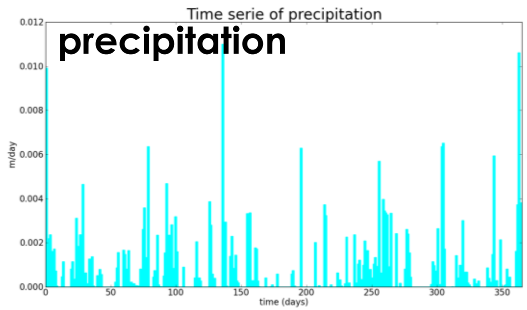


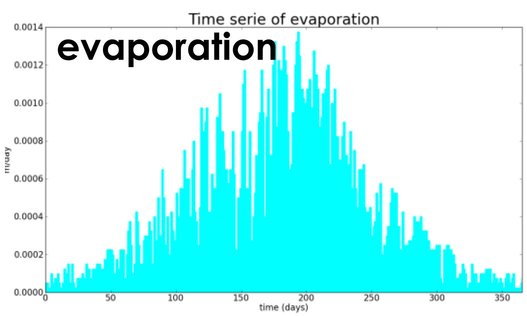
Représentation physique des aquifères et de leur conditions aux limites

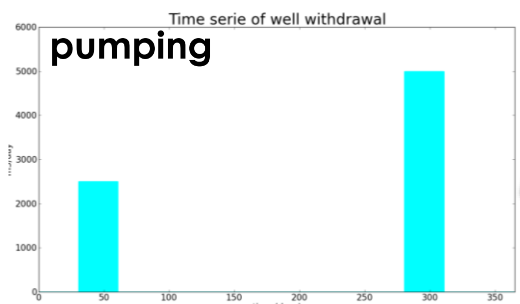
Principale difficulté: trouver le juste milieu entre simplicité et complexité de complexité

-

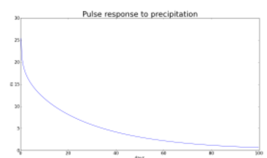
Analyse de séries temporelles par la méthode des fonctions prédéfinies





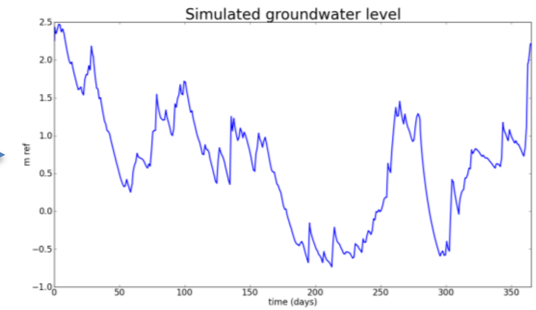


Modélisation de la contribution de chaque facteur de fluctuation



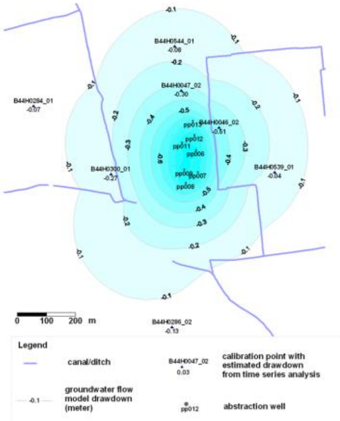
$$\int_0^t N_{PREC}(\tau)\theta_{PREC}(t-\tau)d\tau$$

convolution

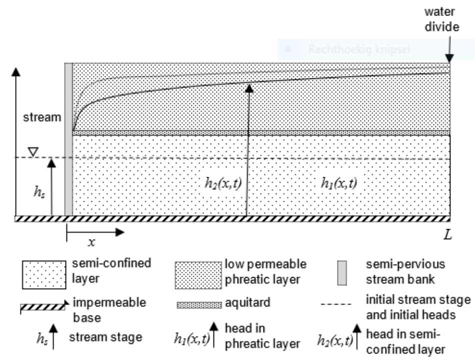


Moyenne pondérée de données météo, débits de pompage et niveaux de rivières

Ce qu’on peut faire en combinant modèles physiques et analyse de séries temporelles

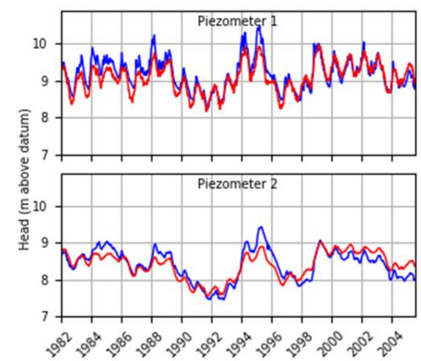


Simplifier un modèle de champs de captage



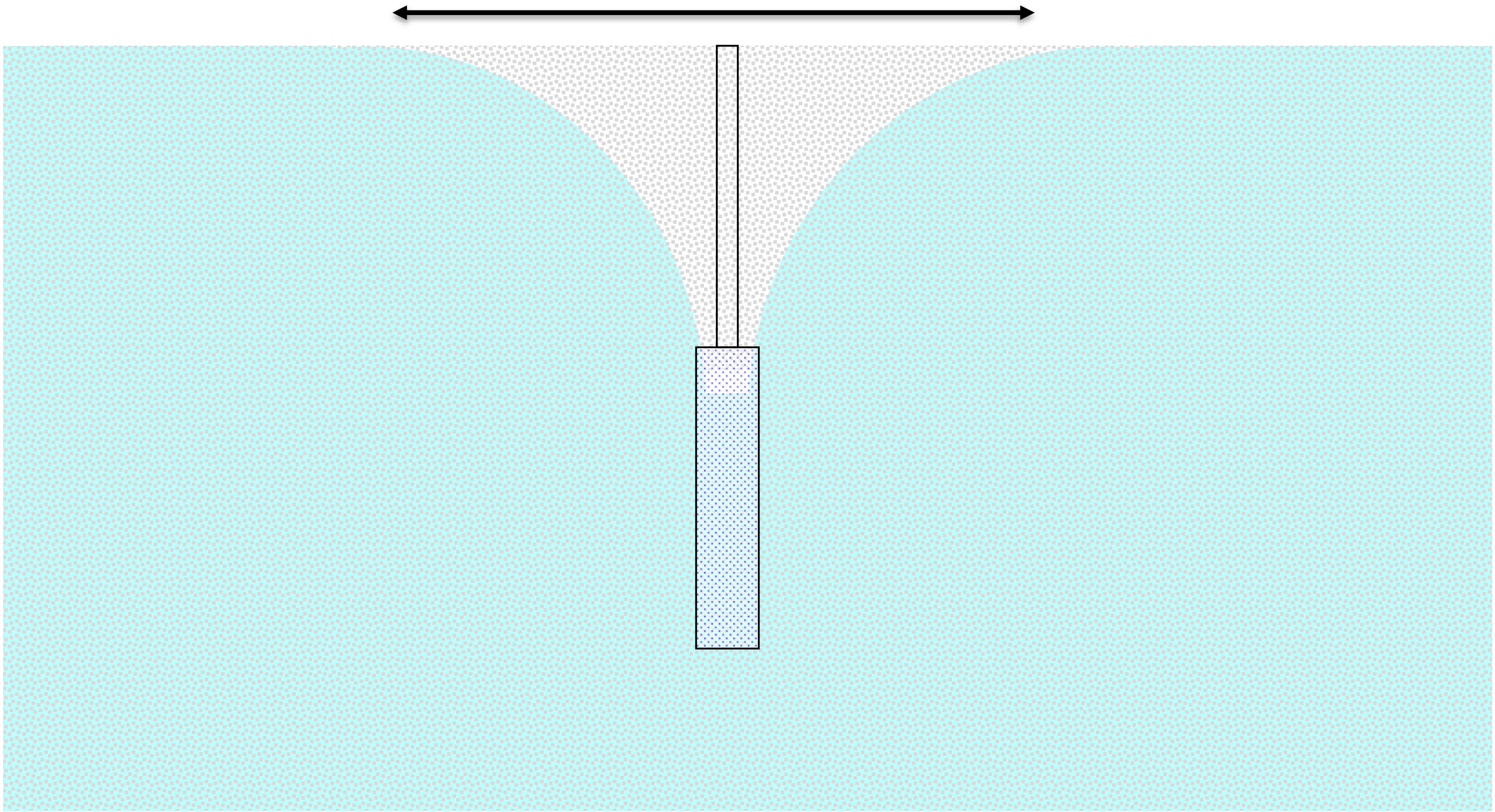
Quantifier l’échange rivière/aquifère

Estimer le taux de recharge d’aquifères peu profonds



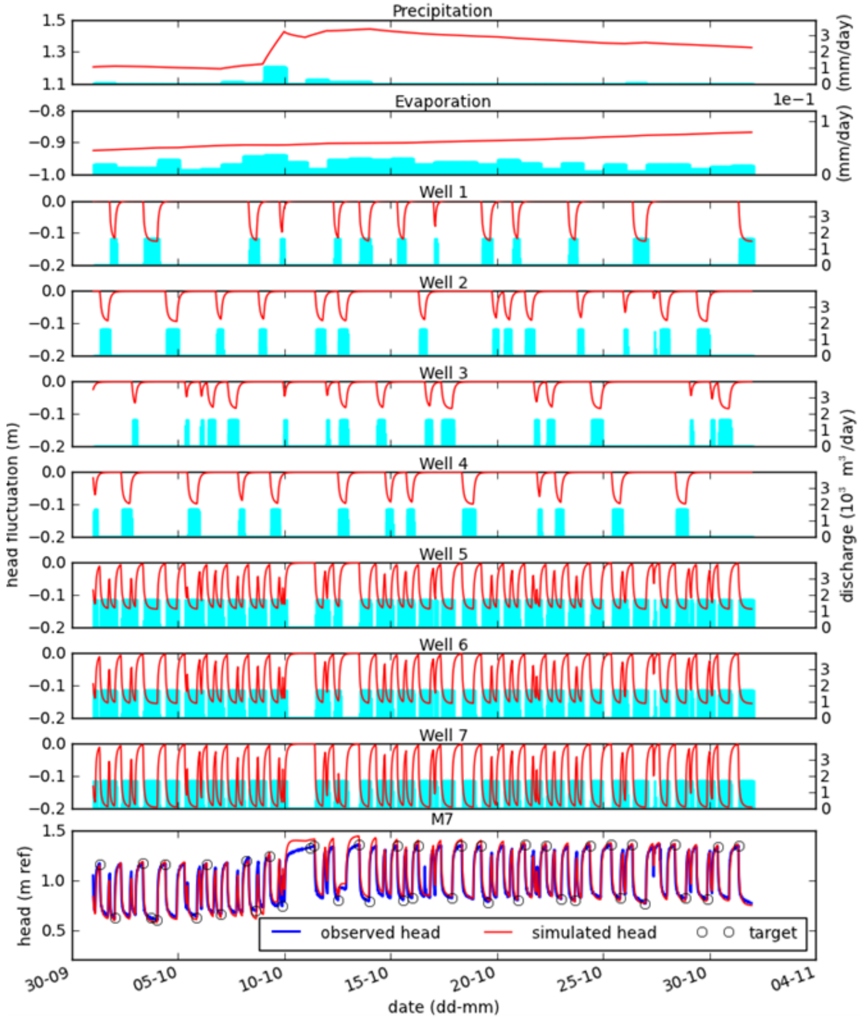
Identifier les altérations de regimes de battement de nappe

Modélisation d'un champ captant



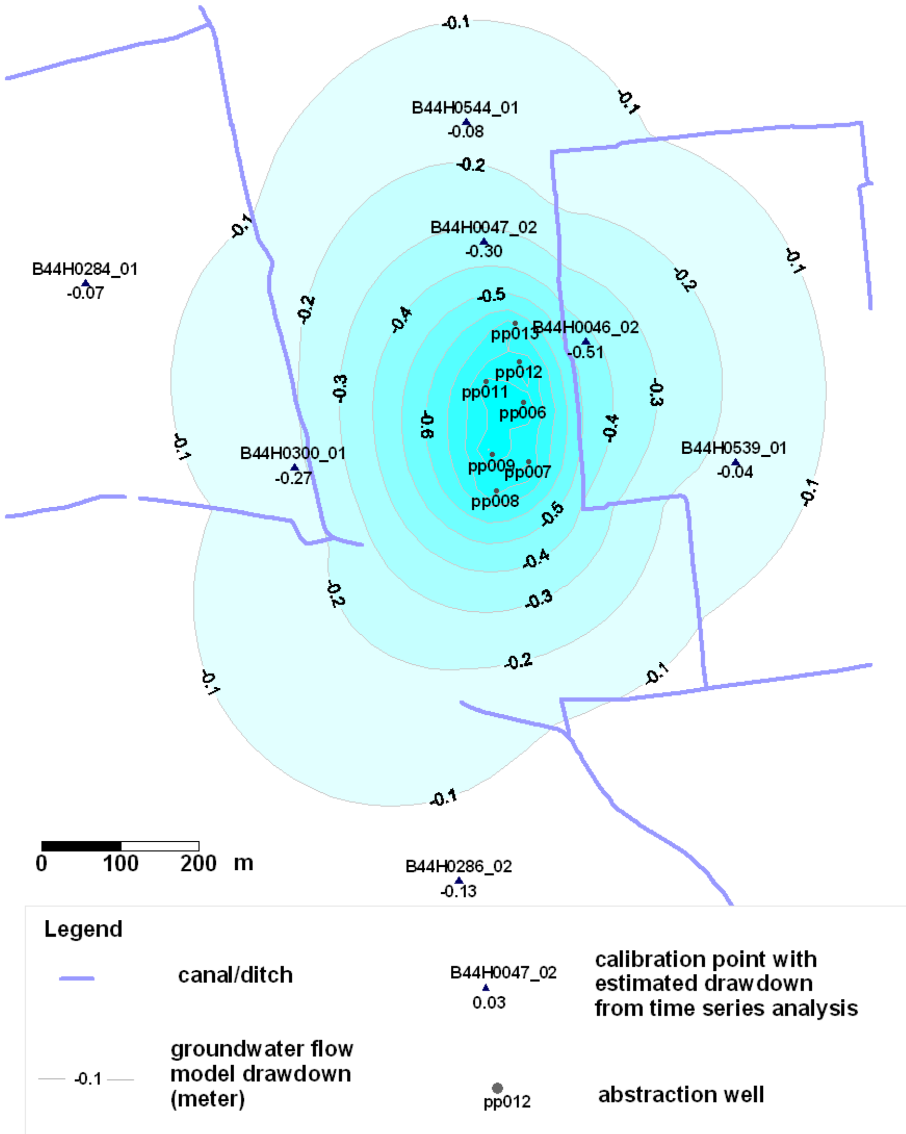
Dimension du cône rabattement?

Démêler le signal hydrogéologique



- Isoler l'influence de chaque puits du champs captant
- Estimer le rabatement par unite de debit de pompage

Résultats de l'analyse entrées dans le modèle physique du champ captant



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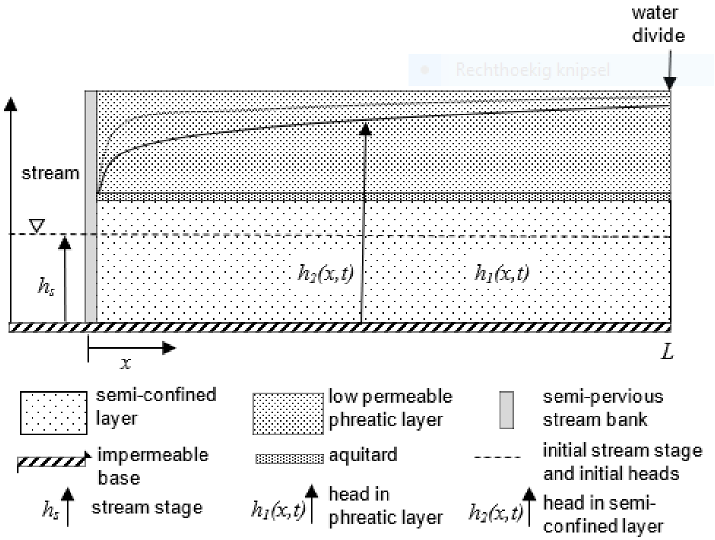
Echange rivière-aquifère

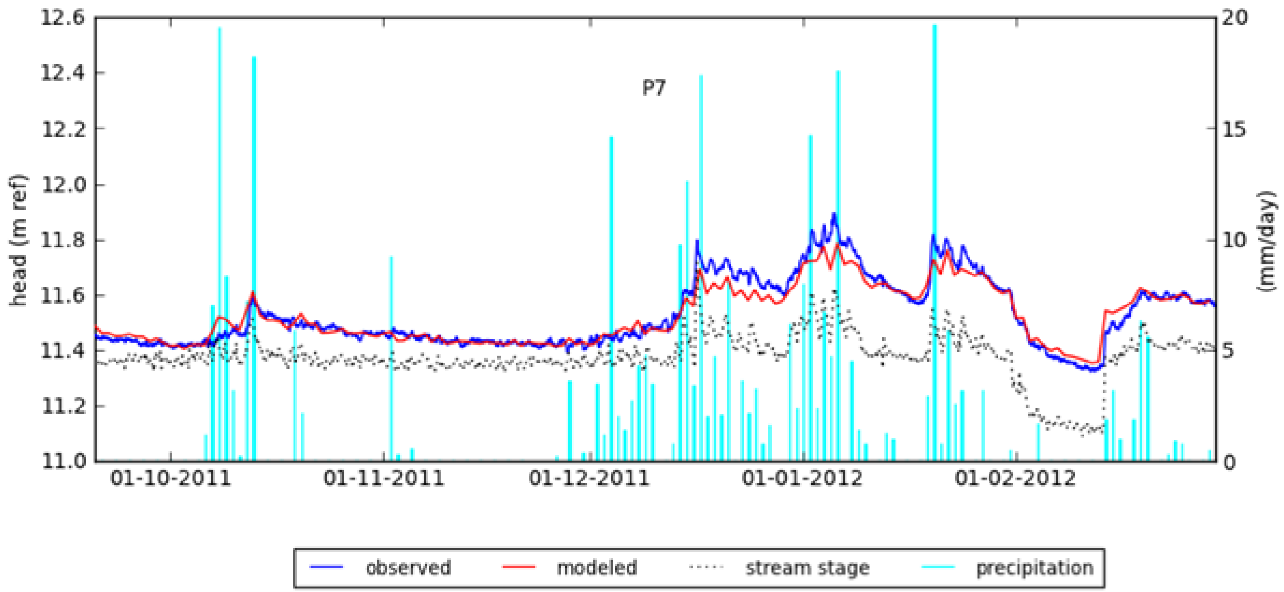
Rivère l'Aa, Pays-Bas



Modèle en coupe transverse

Le modèle physique est utilisé comme fonction réponse du modèle d'analyse de séries temporelle

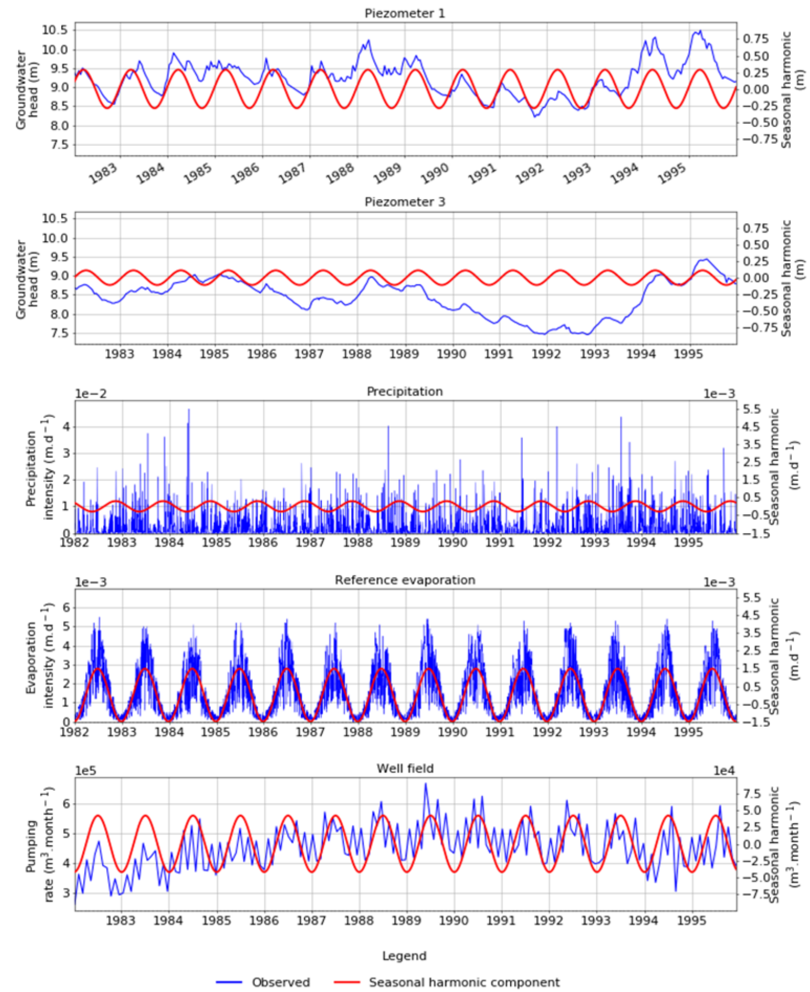
Paramètres hydrogéologiques évalués à partir du modèle de série temporelle



Evaluation du taux de recharge moyen d'un aquifère sous une moraine glacière

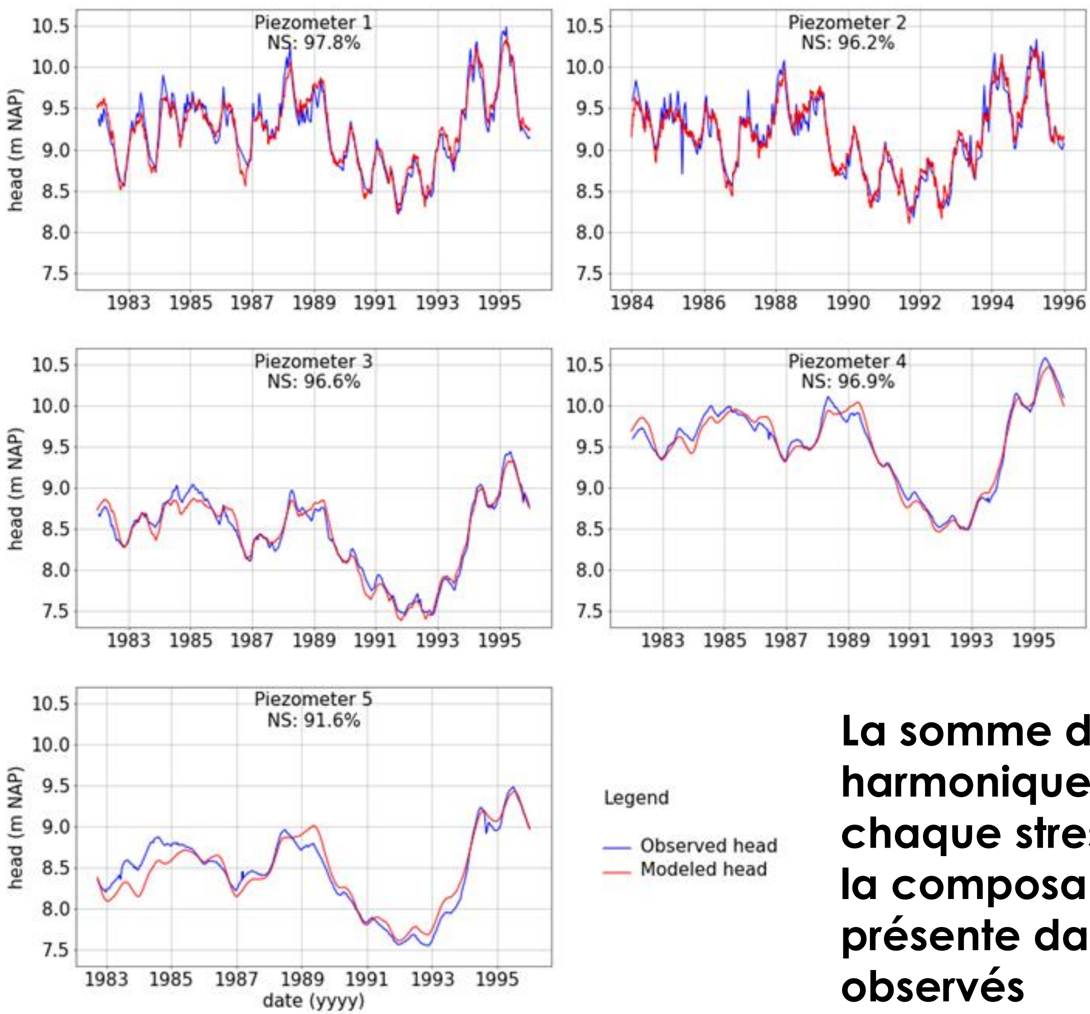
Source: Nationaal Park De Sallandse Heuvelrug

Méthode applicable pour des battements de nappe approximativement linéaires par rapport aux impulsions (précipitation, évaporation, pompage)



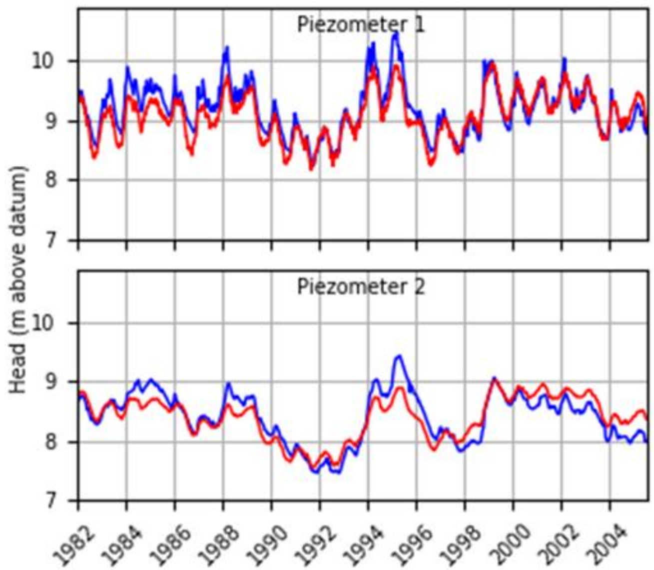
Composantes harmoniques dans une série temporelle

Contraindre les paramètres à reproduire les composantes harmoniques

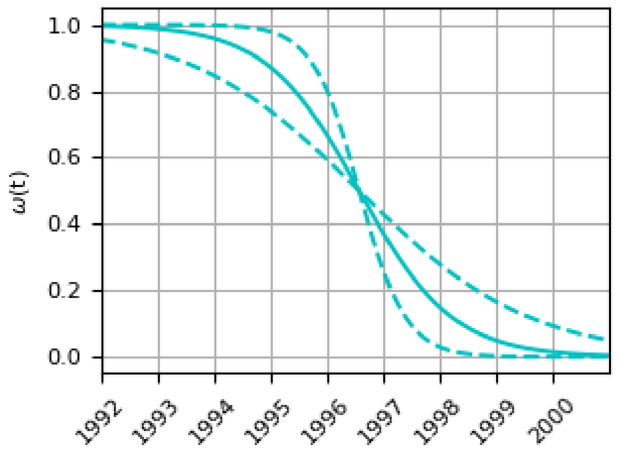


La somme des composantes harmoniques des réponse à chaque stress doit expliquer la composante harmonique présente dans les battements observés

Identifier des altérations de régime de battement de nappe

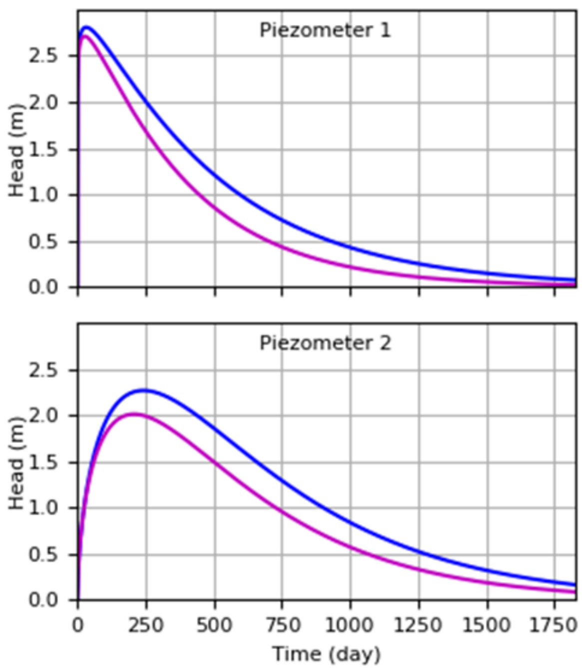


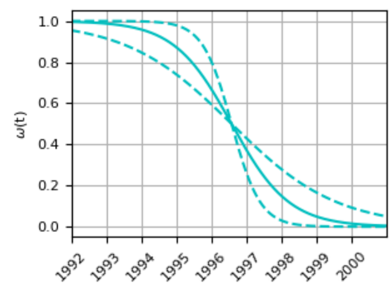
Analyse de séries temporelles indiquent une altération de régime

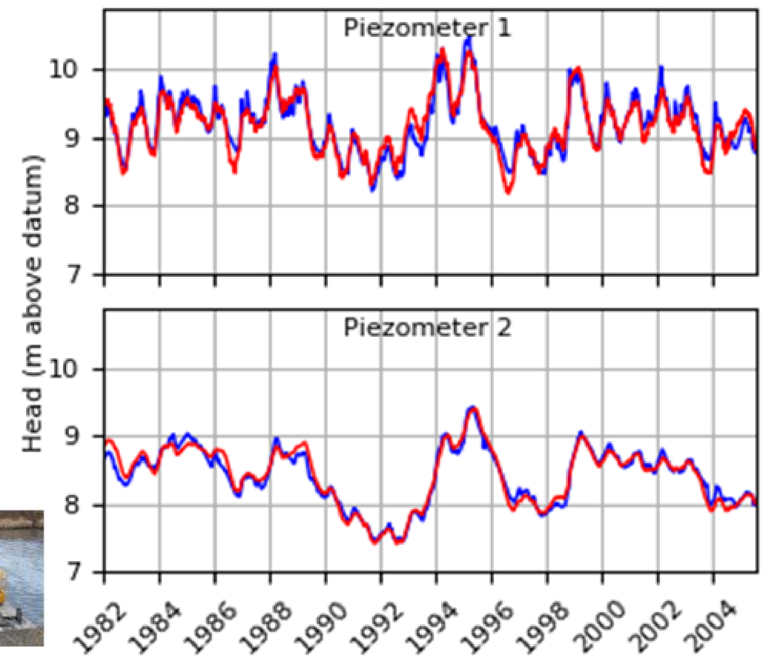


Modélisation des battements de nappe par superposition pondérées du régime initial et de régime final

Superposition pondérée de modèle de séries temporelles







Réduction de la magnitude de la réponse aux précipitations

La superposition pondérée des modèles reproduit bien les observations

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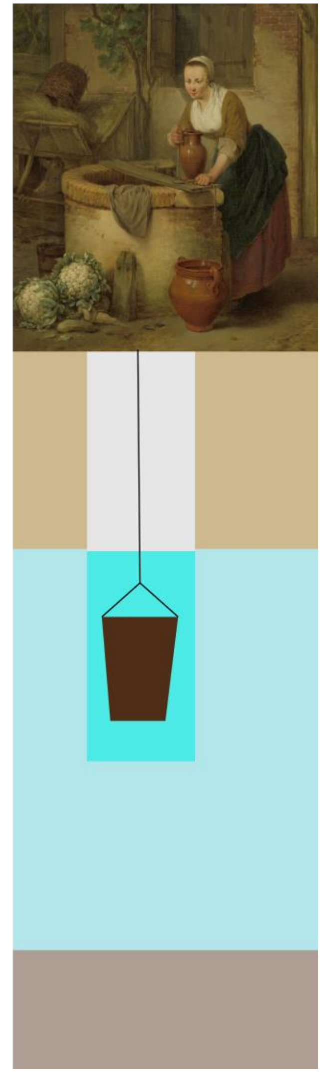
A retenir



Combiner modèles physiques et modèles de séries temporelles permet d'identifier et expliquer les processus sous jacents aux variation de niveaux de nappe

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