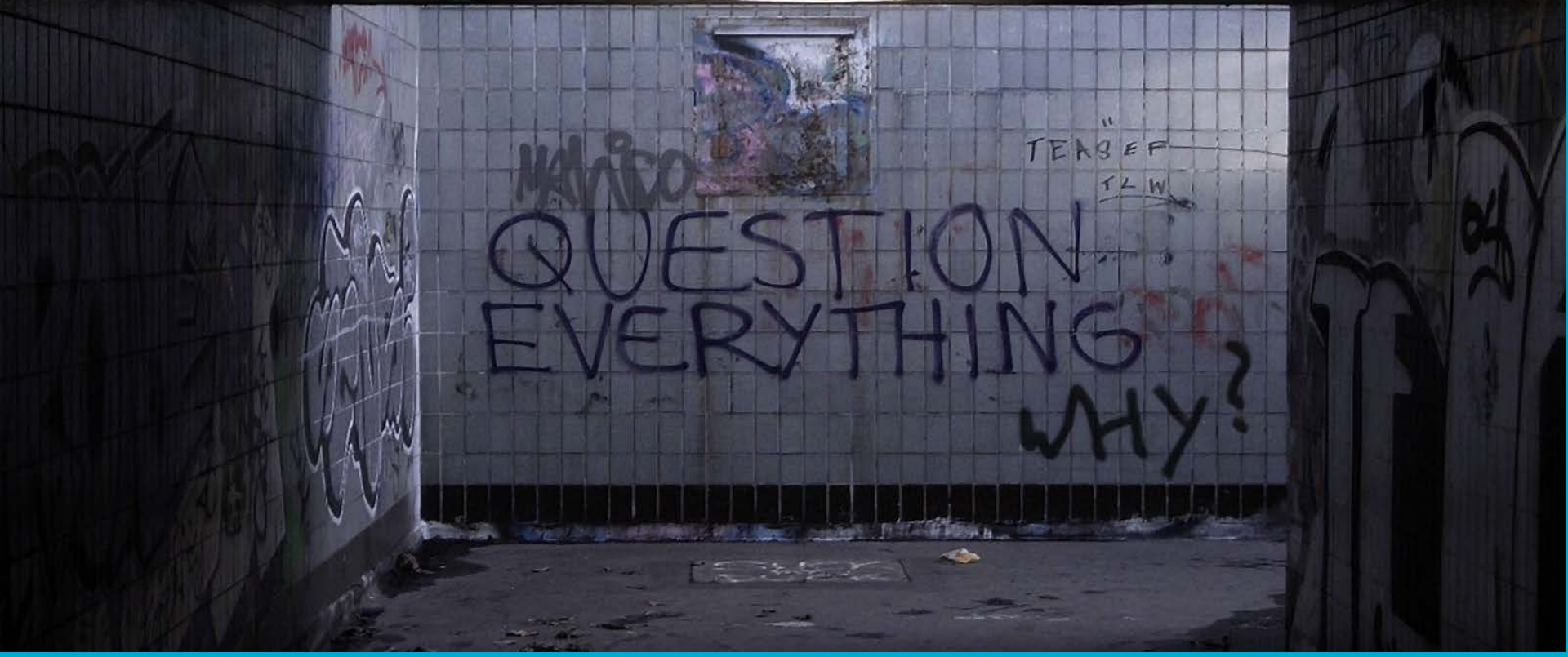

Qualitative uncertainty analysis: addressing the ‘so what?’ question

Luk Peeters

20 May 2016

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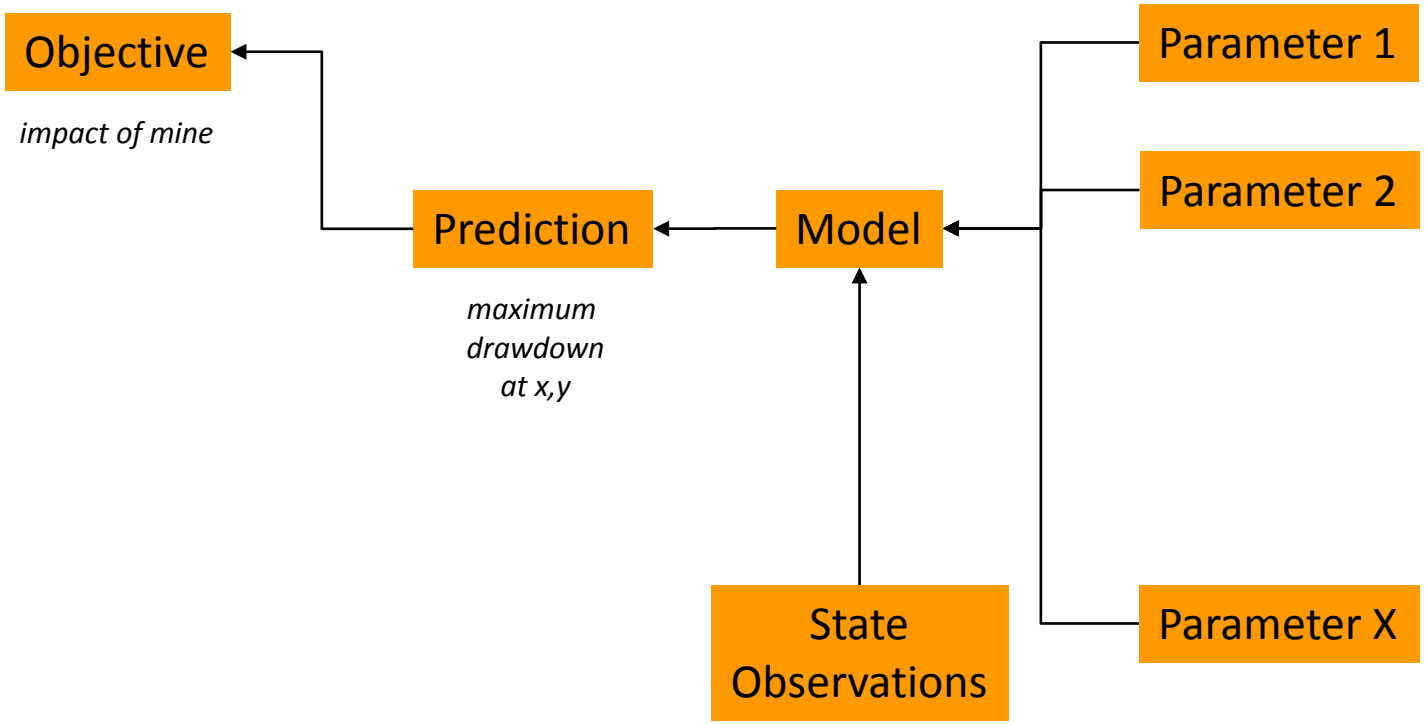
https://www.flickr.com/photos/dullhunk/202872717/

Uncertainty analysis is simple



Qualitative uncertainty analysis

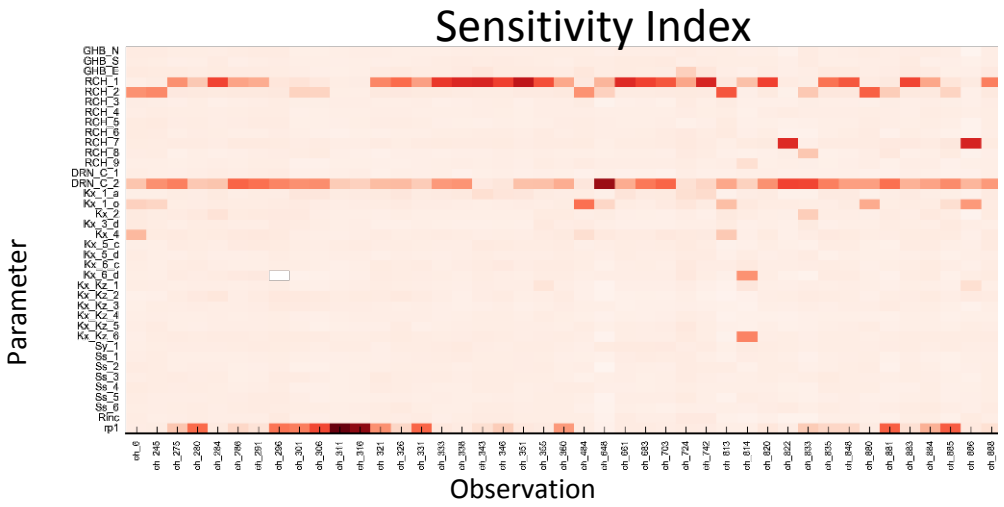
- formal, structured discussion of all assumptions and model choices
- scoring (lo-med-hi) of 4 attributes:
  - data
    - Would this choice change if I had more data?
  - resources
    - Would this choice change if I had more time and money?
  - technical
    - Would this choice change if I had a better model?
  - effect on predictions
    - So what?

Kloprogge P, van der Sluijs J P and Petersen A C (2011) A method for the analysis of assumptions in model-based environmental assessments Environmental Modelling & Software, Thematic issue on the assessment and evaluation of environmental models and software, 26, 289-301

Peeters L, Pagendam D, Gao L, Hosack G, Jiang W and Henderson B (2016) Propagating uncertainty through models. Submethodology M09 from the Bioregional Assessment Technical Programme. *Department of the Environment, Bureau of Meteorology, CSIRO and Geoscience Australia, Australia.* http://data.bioregionalassessments.gov.au/submethodology/M09

Using groundwater head observations to constrain parameters

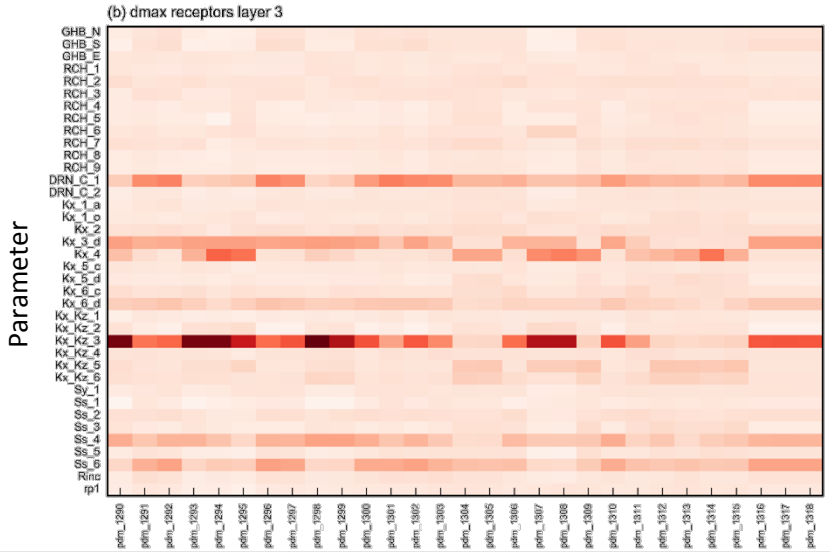
- data: H | resources: M | technical: L | predictions: L



Recharge

Evapotranspiration

River bed conductance



Pumping rate

Kh L3 & L4

Kh L6

Kh/Kz L3

Storage L5 & L6

Plischke E, Borgonovo E and Smith C L (2013) Global sensitivity measures from given data *European Journal of Operational Research, 226*, 536-550

Peeters L J M, Podger G M, Smith T, Pickett T, Bark R H and Cuddy S M (2014) Robust global sensitivity analysis of a river management model to assess nonlinear and interaction effects Hydrol. Earth Syst. Sci., 18, 3777-3785 http://www.hydrol-earth-syst-sci.net/18/3777/2014/

Spatially uniform parameters

- Data: H | Resources: M | Technical: M | Predictions: L

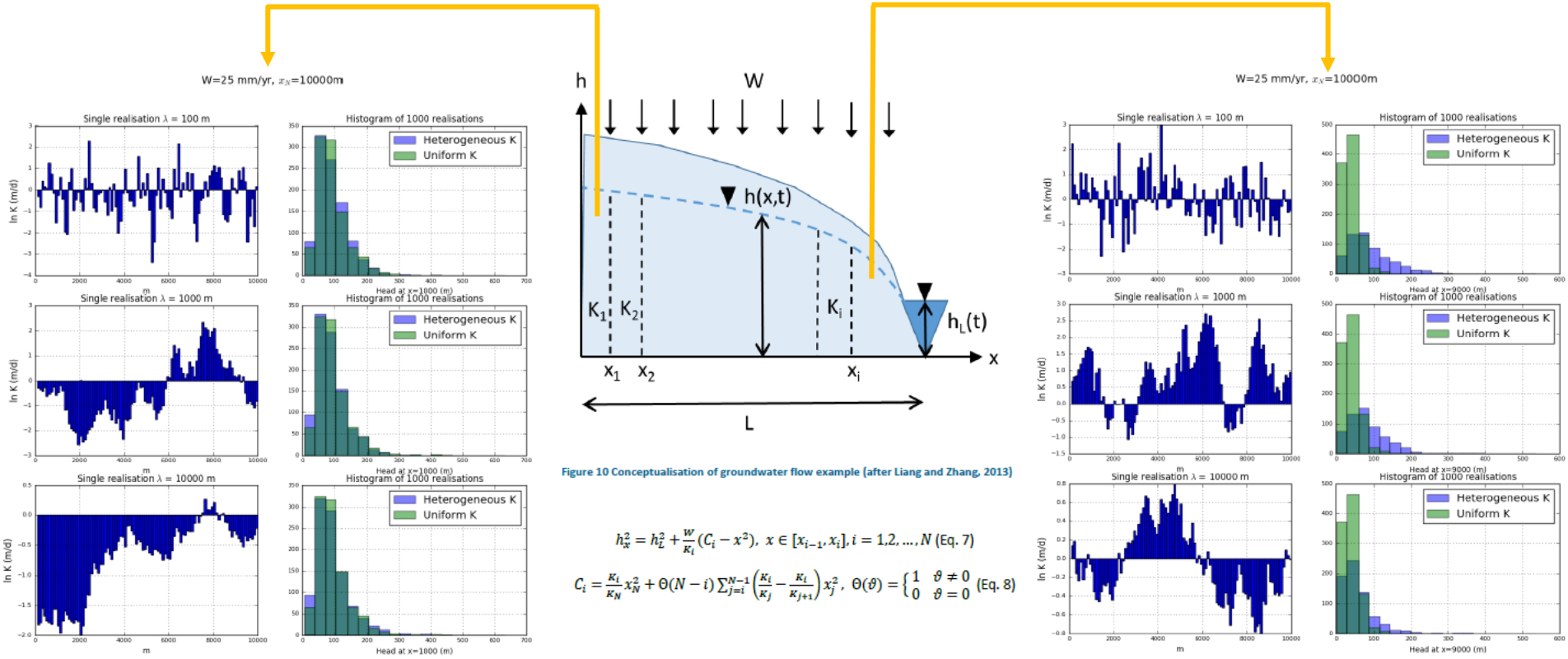


Figure 10 Conceptualisation of groundwater flow example (after Liang and Zhang, 2013)

$$h_x^2 = h_L^2 + \frac{W}{K_i}(C_i - x^2),\ x \in [x_{i-1}, x_i], i = 1,2,\ldots,N \text{ (Eq. 7)}$$

$$C_i = \frac{K_i}{K_N}x_N^2 + \Theta(N-i)\sum_{j=i}^{N-1}\left(\frac{K_i}{K_j} - \frac{K_i}{K_{j+1}}\right)x_j^2,\ \Theta(\vartheta) = \begin{cases} 1 & \vartheta \neq 0 \\ 0 & \vartheta = 0 \end{cases} \text{ (Eq. 8)}$$

Liang X and Zhang Y-K (2013) Analytic solutions to transient groundwater flow under time-dependent sources in a heterogeneous aquifer bounded by fluctuating river stage Advances in Water Resources , 58, 1 - 9 http://www.sciencedirect.com/science/article/pii/S030917081300050X

Crosbie R, Peeters L and Carey H (2016) Groundwater modelling. Submethodology M07 from the Bioregional Assessment Technical Programme
Department of the Environment, Bureau of Meteorology, CSIRO and Geoscience Australia, Australia, http://data.bioregionalassessments.gov.au/submethodology/M07.

Pumping rates of coal mines and CSG

- Data: H
  - CSG: number of wells, footprint, gas/water production
  - Mining: mine footprints, timing, depth of exploitation
- Resources: L
- Technical: H
  - Mining:
    - mine pumping rate controlled by local geology
    - resolution geological and groundwater model
  - CSG:
    - dual phase flow & local geology (Herckenrath et al. 2015)
    - resolution and processes
- Predictions: H
  - Change (almost) linearly related to stress (Reilly et al. 1987)

Herckenrath D, Doherty J and Panday S (2015) Incorporating the effect of gas in modelling the impact of CBM\ extraction on regional groundwater systems *Journal of Hydrology, 523*, 587 – 6

Reilly T E, Franke O L and Bennet G D (1987) The principle of superposition and its application in groundwater hydraulics *U.S. Geological Survey, Techniques of Water-Resources Investigations, Book 3, Chapter B6, U.S. Geological Survey, Techniques of Water-Resources Investigations, Book 3, Chapter B6,* http://pubs.usgs.gov/twri/twri3-b6/html/pdf.html

Conclusions

- Discuss impact on predictions via
  - formal sensitivity analysis of model
  - groundwater theory (analytical solutions)
  - literature & experience
- Guidance to non-technical reader
- Basis for review discussion and future work

- Experience so far
  - Groundwater and surface water models Bioregional Assessments (www.bioregionalassessments.gov.au)
  - Intense internal meetings – involve stakeholders / reviewers?
  - Brutally honest
  - Surprisingly difficult
  - Assumption hunting
    - *'find assumptions before they find you'*