Towards an innovative modelling framework to assess environmental change impact on the water cycle at the catchment scale

S5.1 Interaction between aquifers, rivers, lakes and estuaries: Flow and Transport

K. Beerten, B. Leterme, E. Laloy, M. Gedeon, B. Rogiers, K. Vandersteen, D. Jacques

Belgian Nuclear Research Centre, Institute Environment-Health-Safety, Mol, Belgium

Objective of modelling framework = reduce uncertainties

In-depth understanding of the current state

Material property characterization
State variable observations
Coupled process modelling
Uncertainty quantification of models

Past changes
Future changes

Past
Future
1850
2015

Characterization of the past behaviour of the catchment
Subjecting the model to drastic boundary condition changes

Copyright © 2015 - SCK•CEN - This presentation contains preliminary data for dedicated use ONLY and may not be cited without the explicit permission of the author.
Nete catchment has been subject of hydro(geo)logical research in context of radwaste storage

\[ T = 11^\circ C \]
\[ P = 800-900 \text{ mm/y} \]
Sandy soils
(Podzols, Arenosols, Cambisols, Anthrosols)

Model boundaries, land use, hydrography

Copyright © 2015 - SCK•CEN - This presentation contains preliminary data for dedicated use ONLY and may not be cited without the explicit permission of the author.
Hydrogeology

Material property characterisation: hydraulic conductivity

- Hydraulic conductivity conditioned on borehole, CPT and DP-data

Rogiers et al. 2013, 2014; Rogiers 2013
Uncertainty quantification

- Development and applications of probabilistic inversion methods
- $K$-fields

![Image of $K$-fields](Development: Laloy et al., 2013; Application: Rogiers et al., GeoEnv-poster, 2014)

Plume evolution based on random walk particle tracking

![Image of plume evolution](Rogiers et al., GeoEnv-poster, 2014)
Heat as a groundwater tracer

- Simulated temperatures, ca. 25 m depth

**Thermal conduction + advection (gw flow)**

**Thermal conduction only**

Rogiers et al., 2015

---

Redistribution of heat by advection (groundwater flow)

Rogiers et al., 2015
Heat as a groundwater tracer

Rogiers et al., 2015

Coupled process modelling: capturing surface-subsurface interactions

- HYDRUS-MODFLOW
  - Unsaturated flow
  - Groundwater flow

- Spatially variable gw recharge
  (PhD starting in Oct.)

- Nete catchment combinations of
  - land use
  - gw depth
  - soil type
Example: maize field, shallow groundwater, podzol soil

Reconstructing catchment parameters, state variables and boundary conditions for the last few 100 years

Leterme et al., 2013

Beerten and Leterme, 2015
How do we integrate all these aspects?

- Example: model-data comparison for historical periods, taking into account information on past soils, land use, climate etc...

Conclusions

- More state variable observations are needed, other than GW head and temperature, in order to reduce uncertainty
- Uncertainty can be quantified using advanced techniques
- Towards full understanding of drivers and consequences of hydrological changes in the Nete catchment, NE Belgium
- Advanced model verification tools help building confidence in model output for future scenarios
- Extending temporal and spatial scope of historical model-data comparison
Acknowledgements

Several datasets on which the models rely are provided by NIRAS/ONDRAF, the Belgian Agency for radioactive Waste and Fissile Materials, as part of the programme on surface disposal of low-level/short-lived radioactive waste that is carried out by ONDRAF/NIRAS. The views expressed in the presentation do not necessarily correspond to those of ONDRAF/NIRAS.