Surface Nuclear Magnetic Resonance for non-invasive observation of the vadose zone

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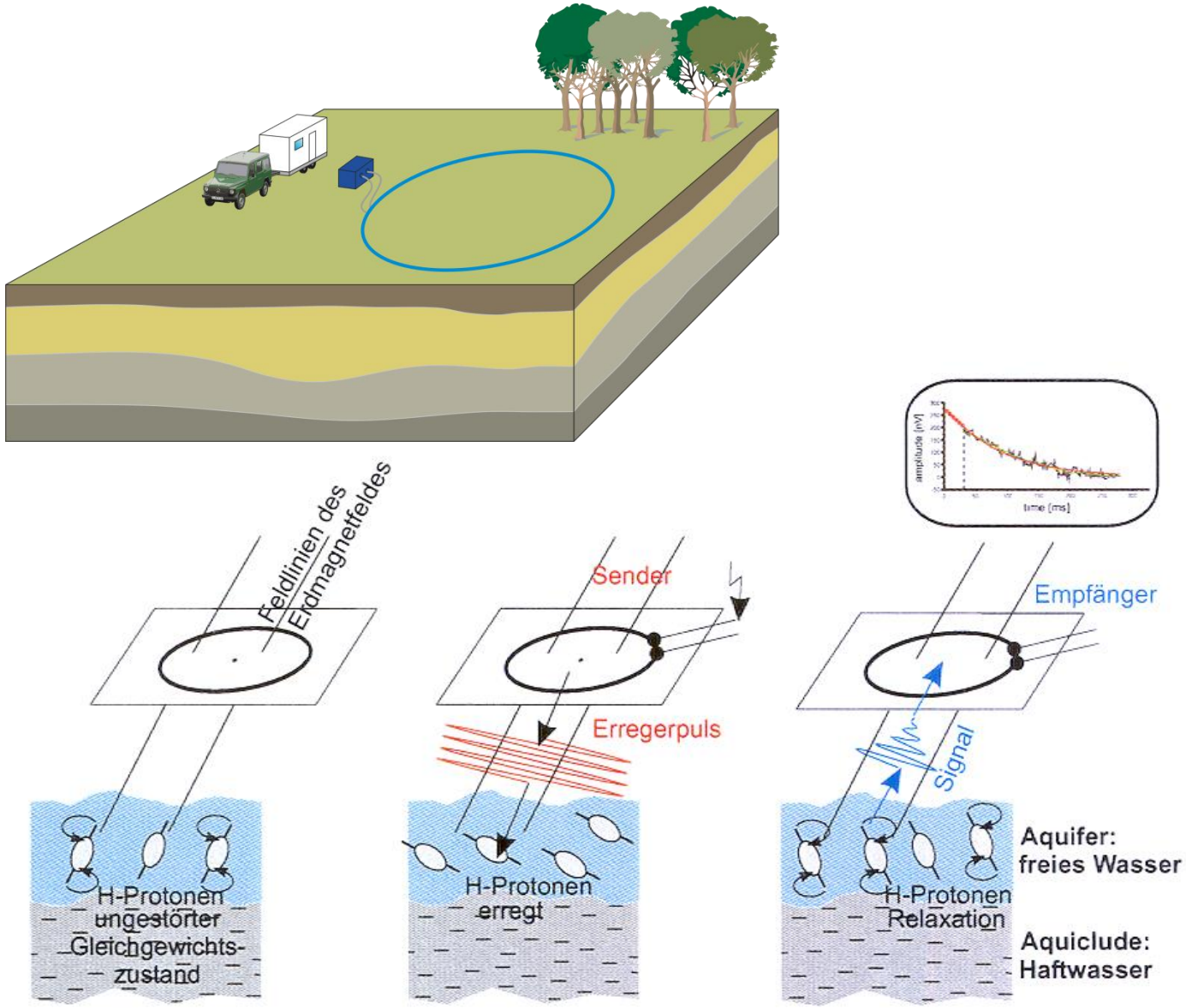
Surface nuclear magnetic resonance (SNMR)



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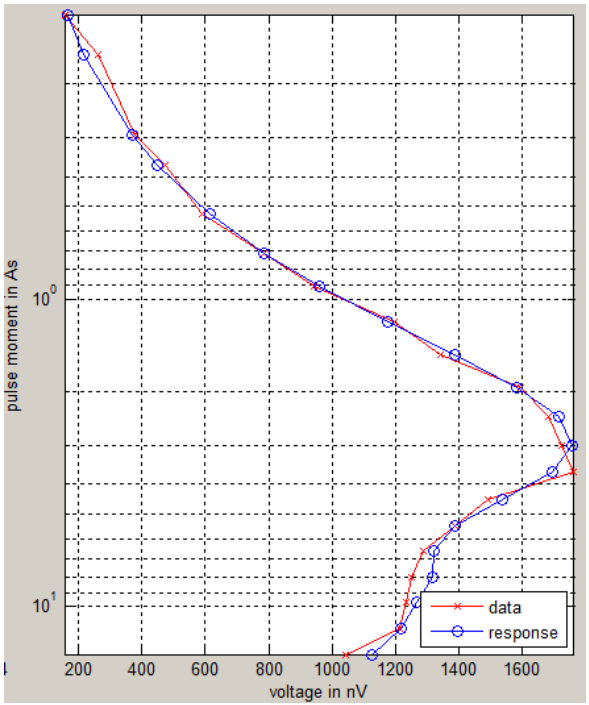
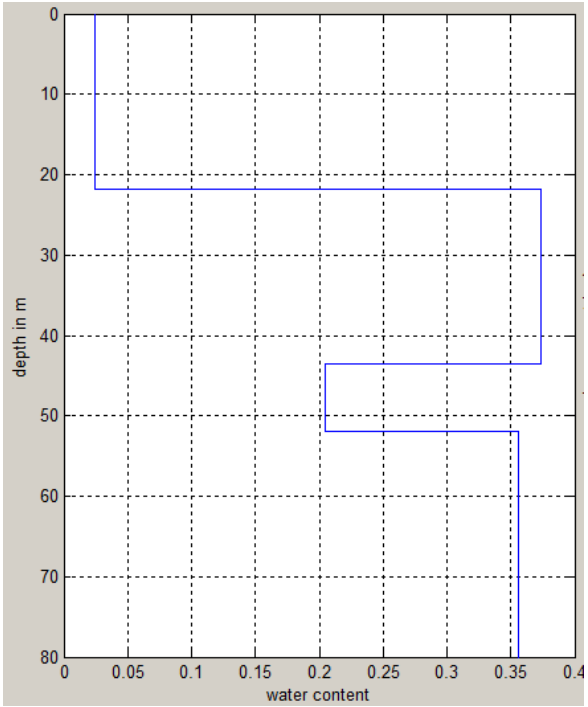
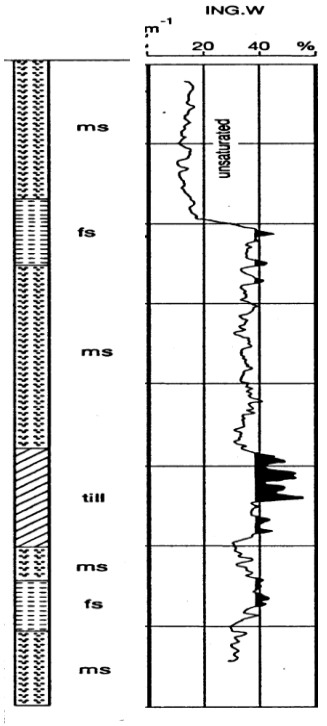
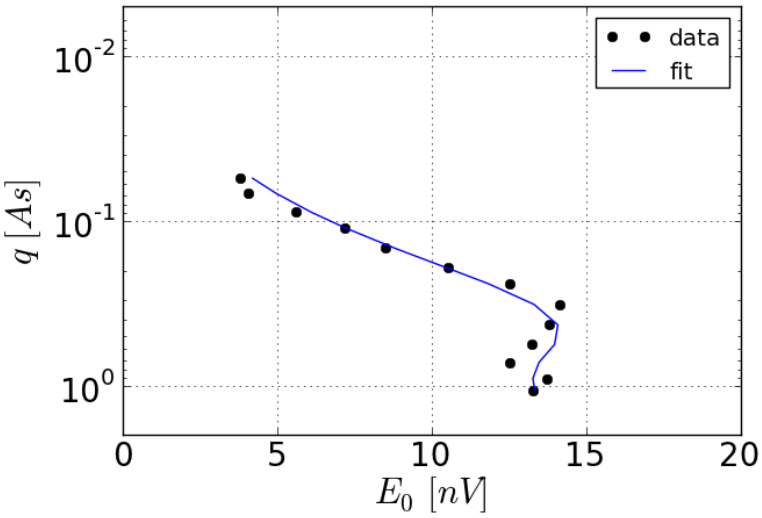


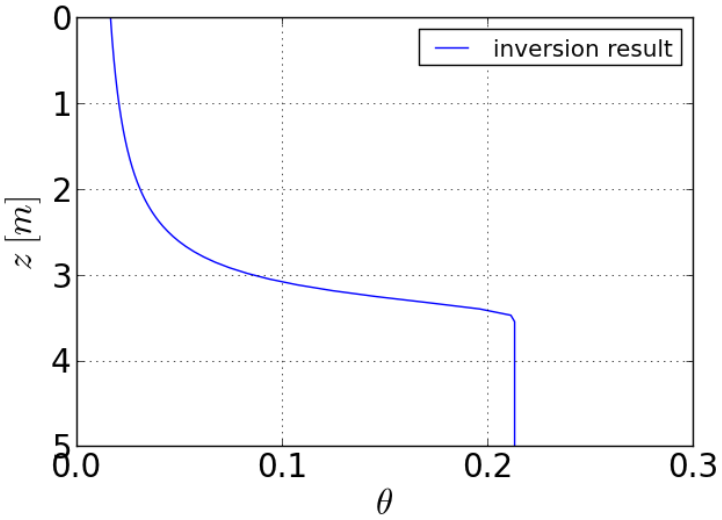




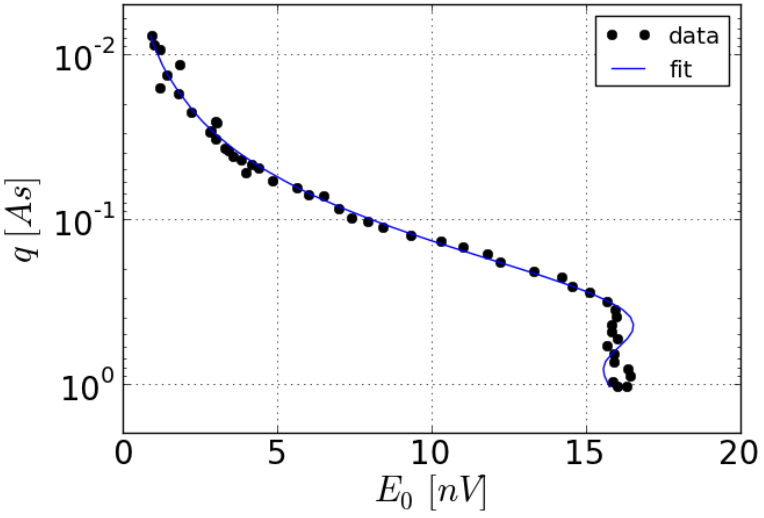
Small scale investigation with SNMR

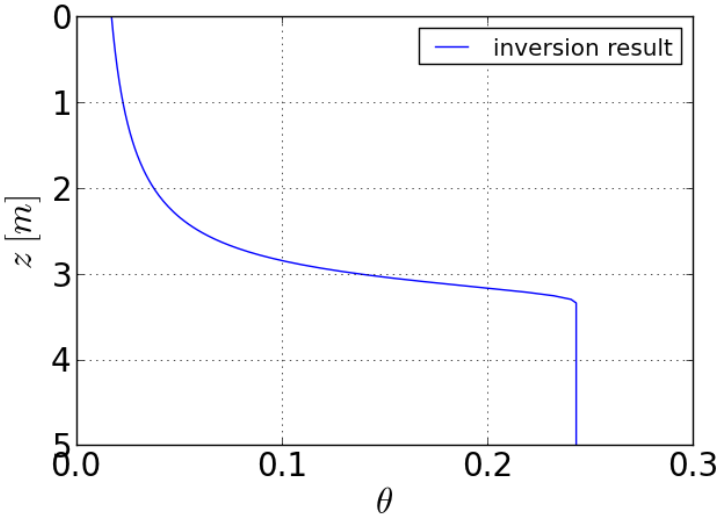
June 2011





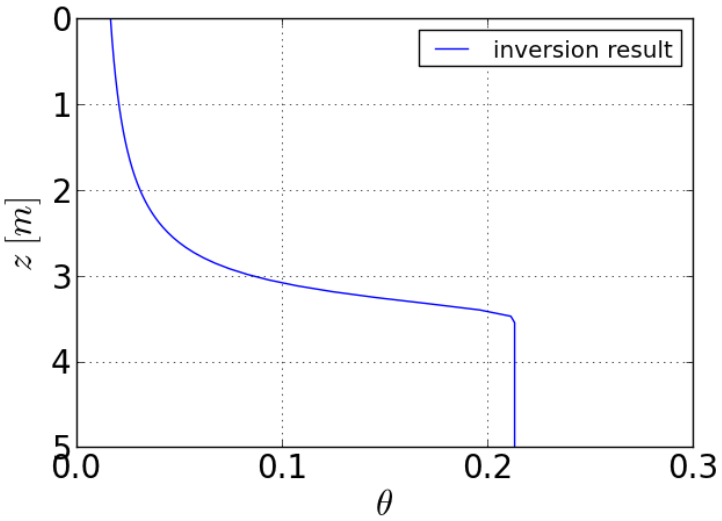
March 2012

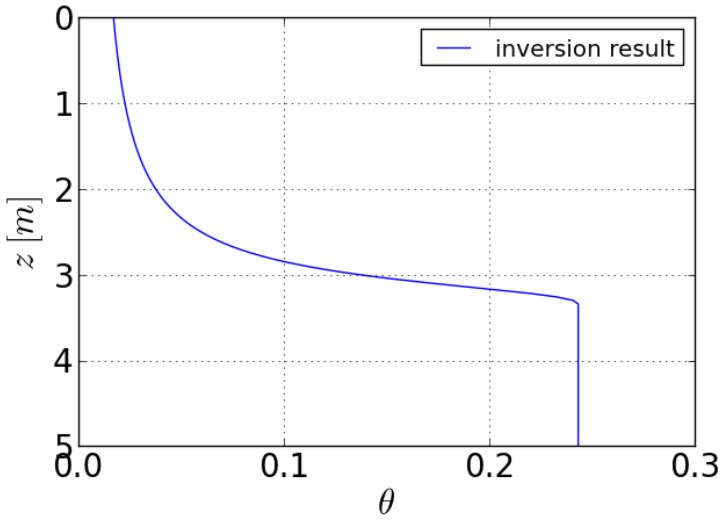




Small scale investigation with SNMR

Van Genuchten	June 2011	March 2012	Samples
Θ_S [%]	21.3 ± 0.5	24.3 ± 0.2	38
Θ_R [%]	0.8 ± 6.6	0.7 ± 1.3	0.7
n	2.2 ± 2.0	2.2 ± 0.4	2.8
z_{table} [m]	3.5 ± 0.4	3.3 ± 0.1	?
α [1/cm]	0.04	0.04	0.04

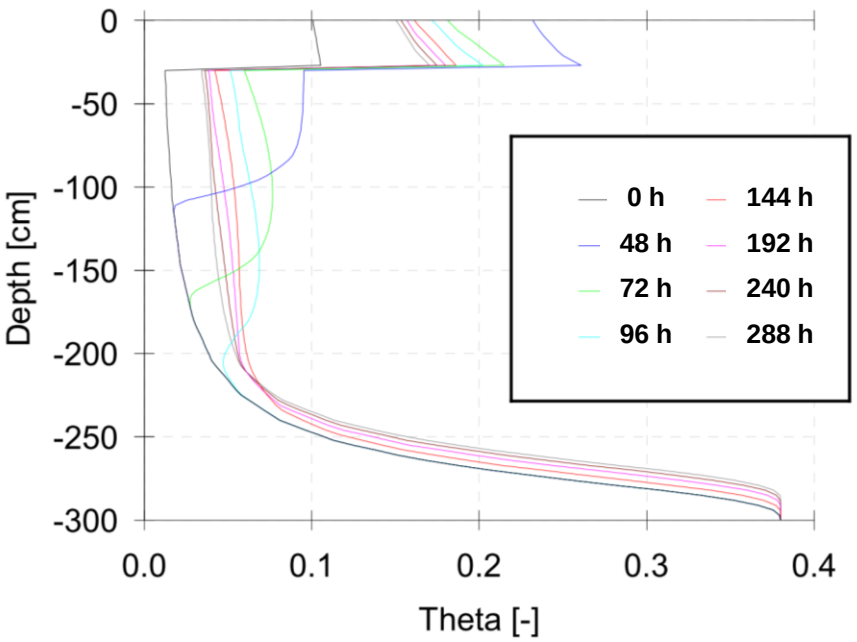




SNMR forward modeling: Simulation of monitoring scenarios

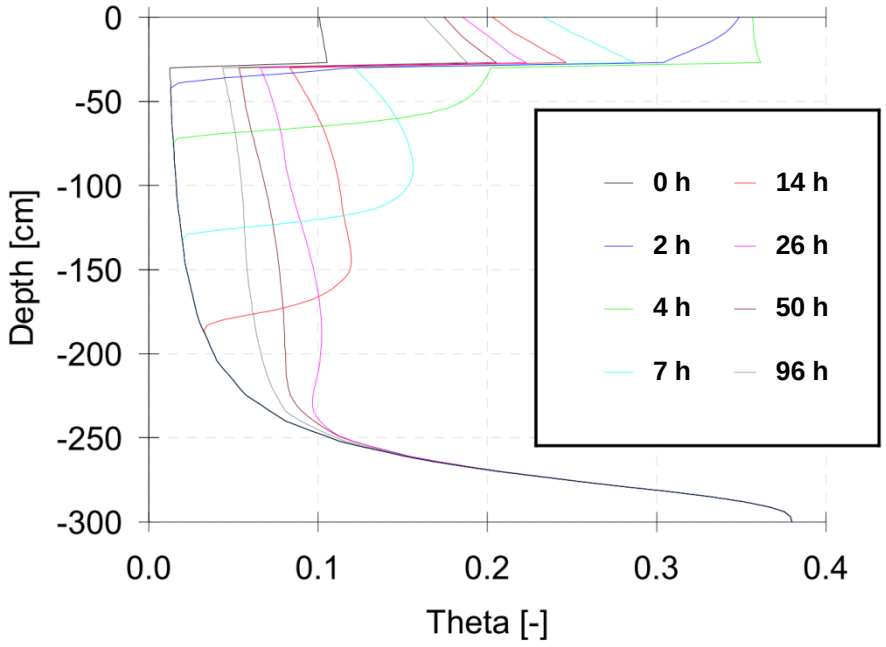
➢**Rainfall event:**

•duration: 48 h
•Precipitation: 2 mm/h
•total infiltrated water amount: 96 mm
•Bottom boundary condition: zero water flux



➢**Irrigation experiment:**

•duration: 4 h
•Irrigation: 37 mm/h
•Bottom boundary condition: zero pressure head



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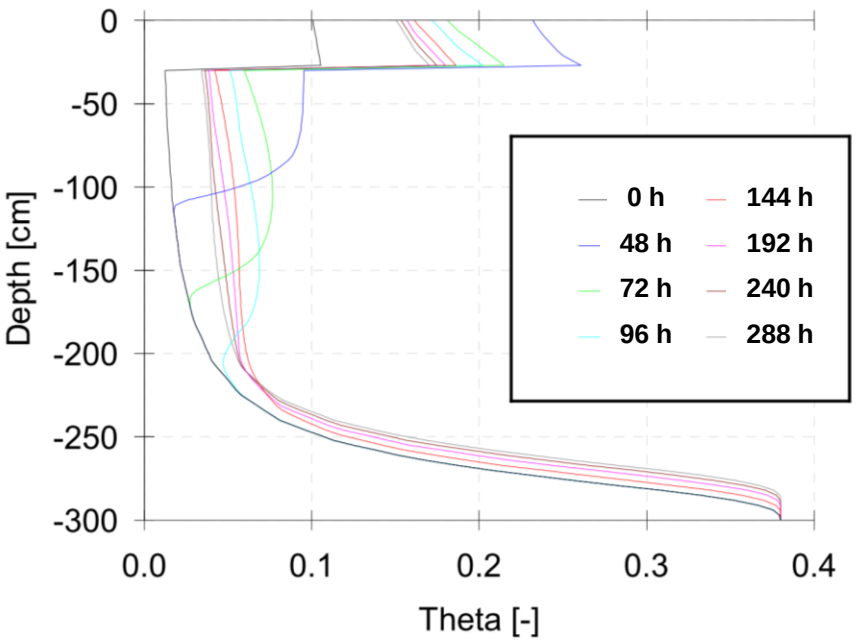

➢**SNMR measurements:**
•Standard measurement layout
(1 to 3 h per sounding)
• high data quality > high spatial resolution
•Inversion on water content changes

➢**Irrigation experiment:**

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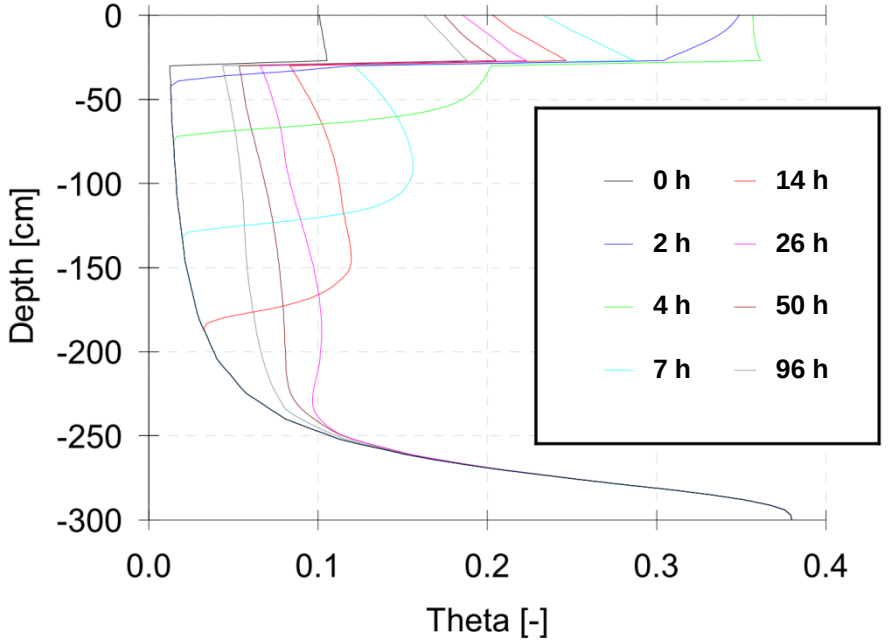

➢**SNMR measurements:**
•Alternative measurement layout
(5 to 10 min per measurement)
• fast repetition: high temporal resolution
•Observation of apparent water content

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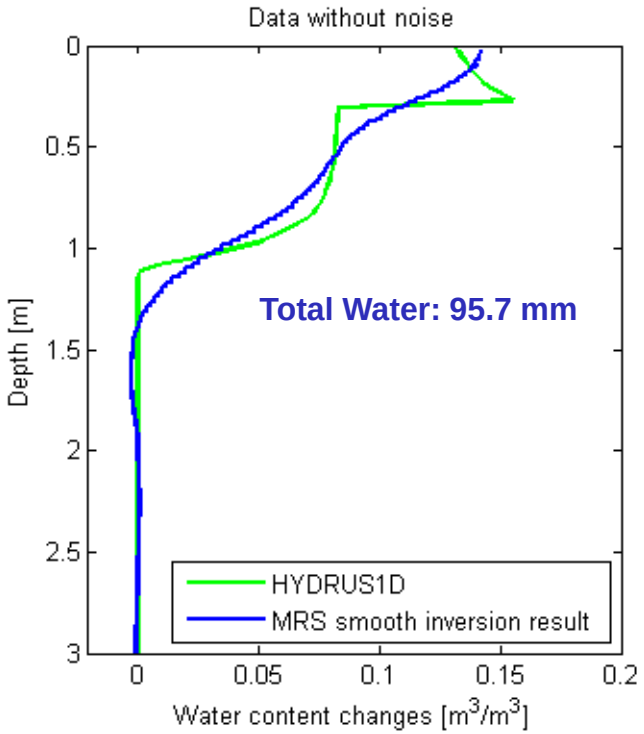
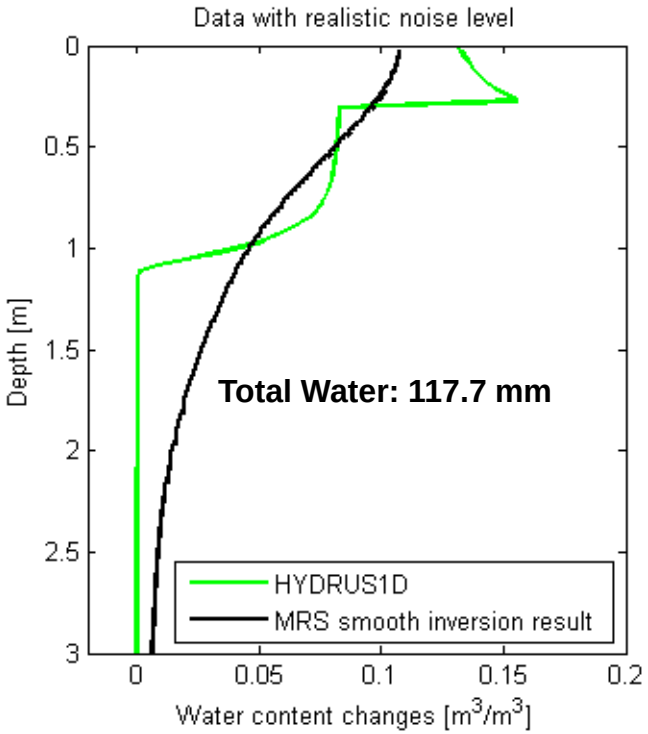
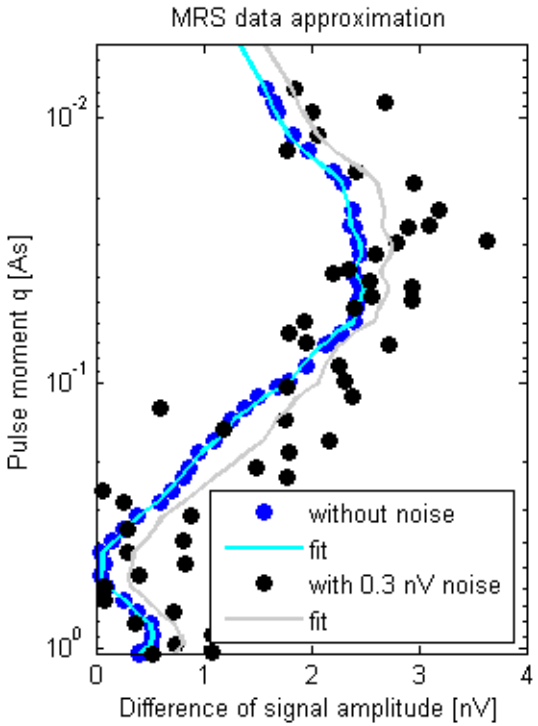
⇒**Scenario: observation of actual groundwater recharge**







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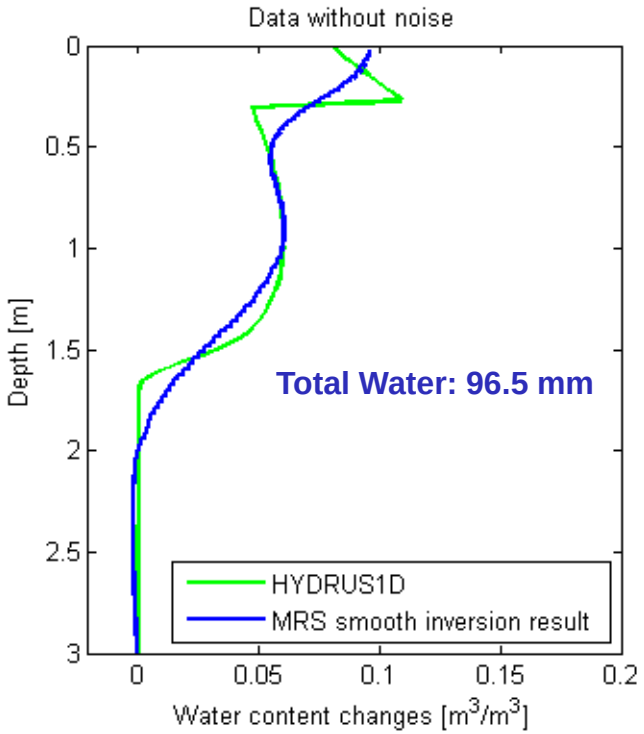

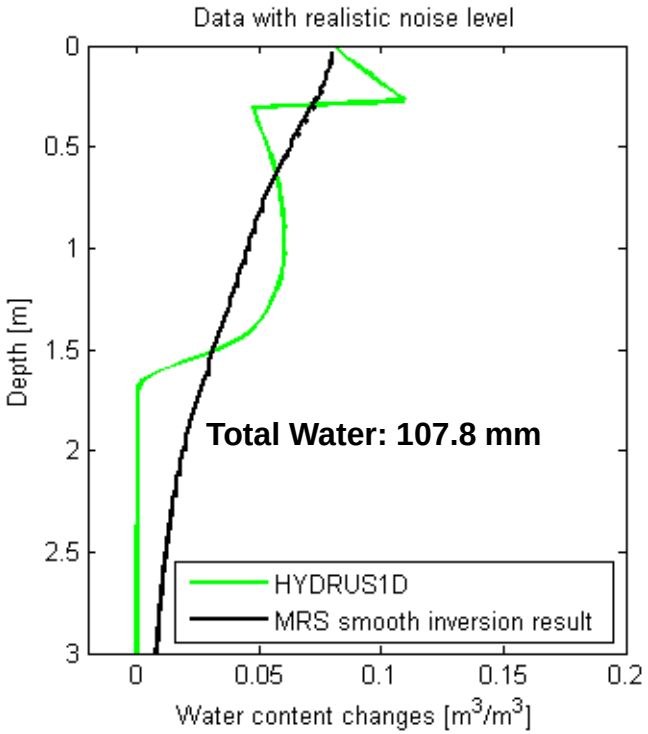

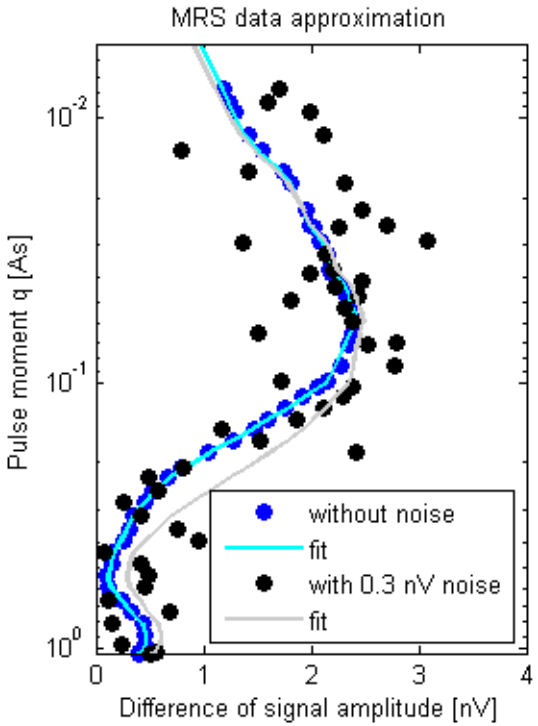

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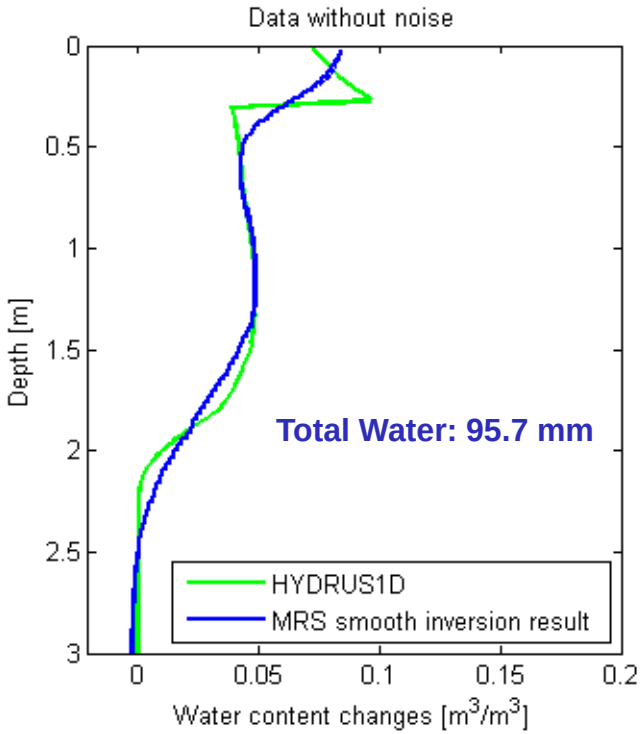

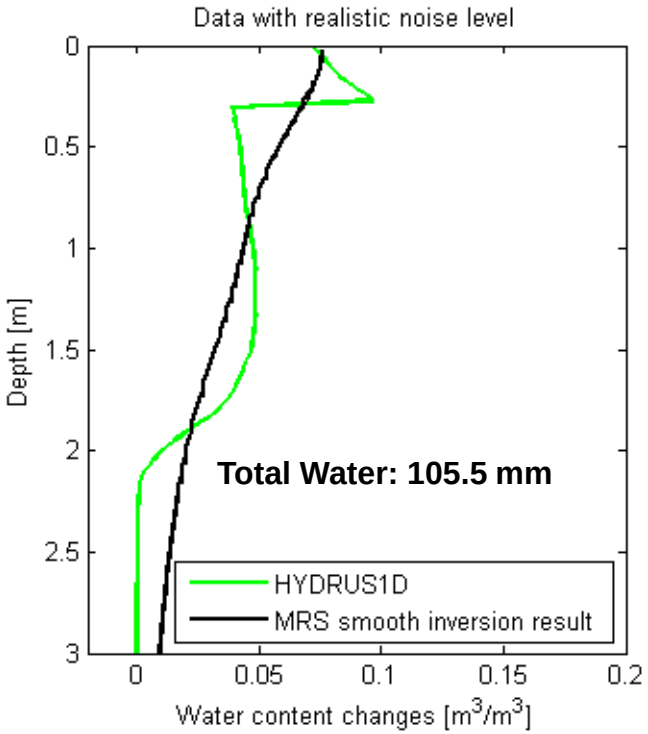

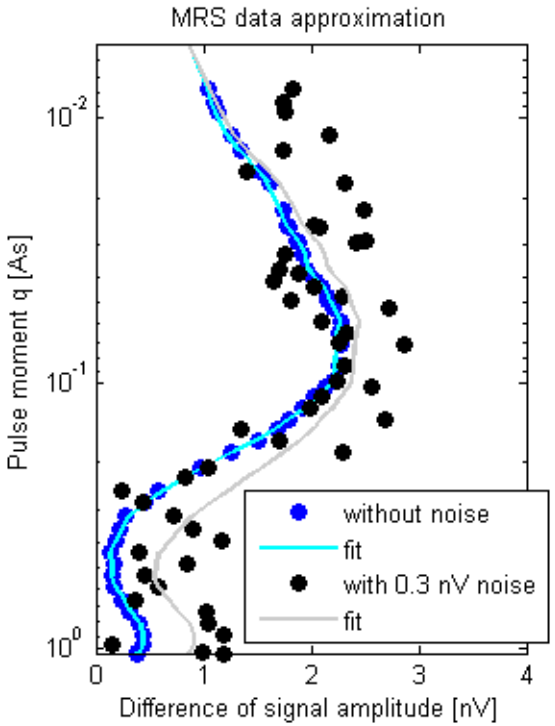

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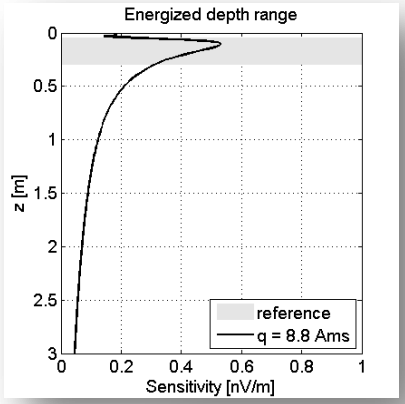

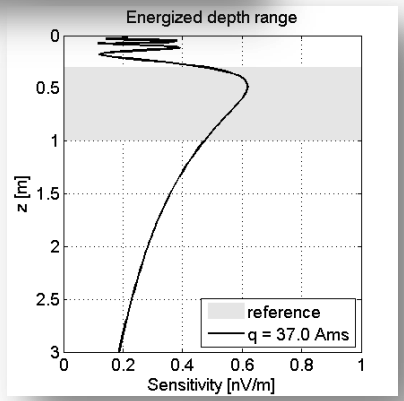

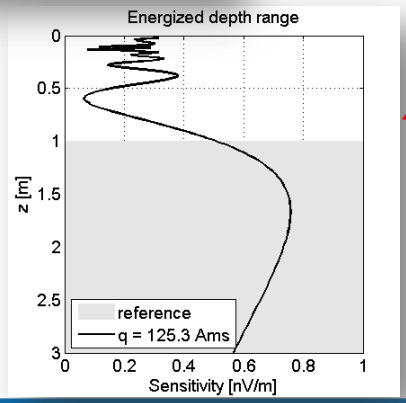

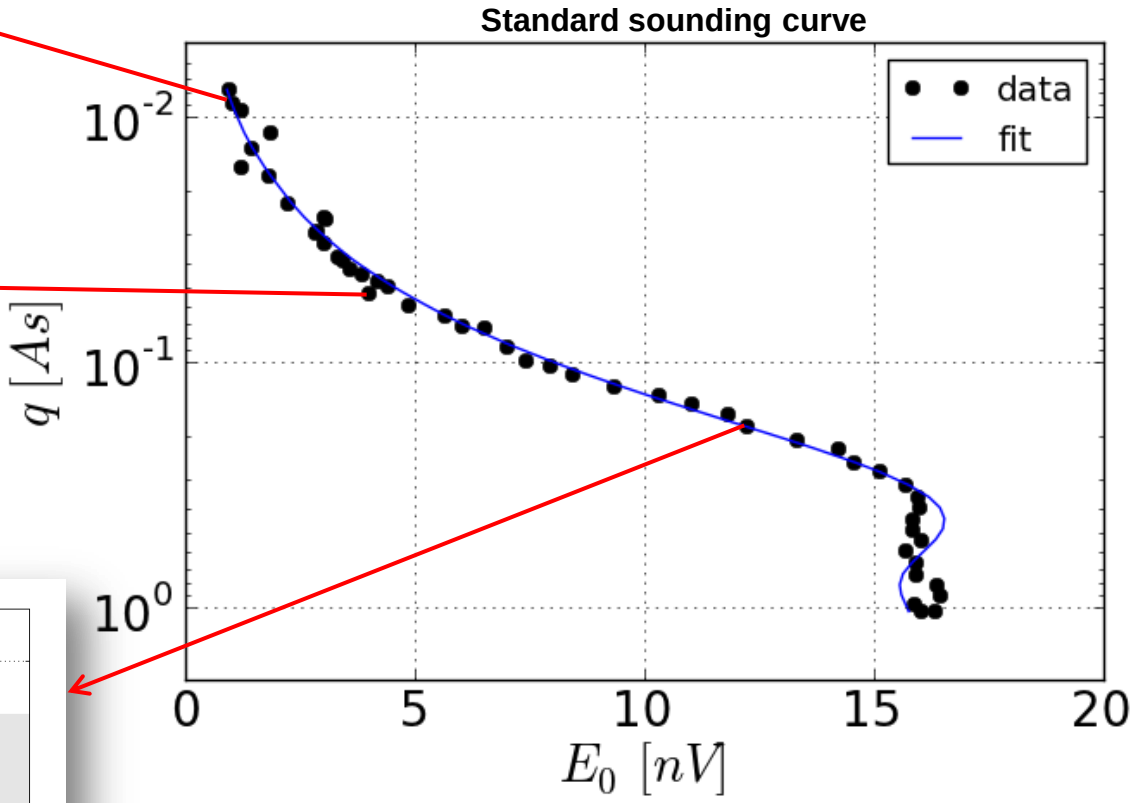

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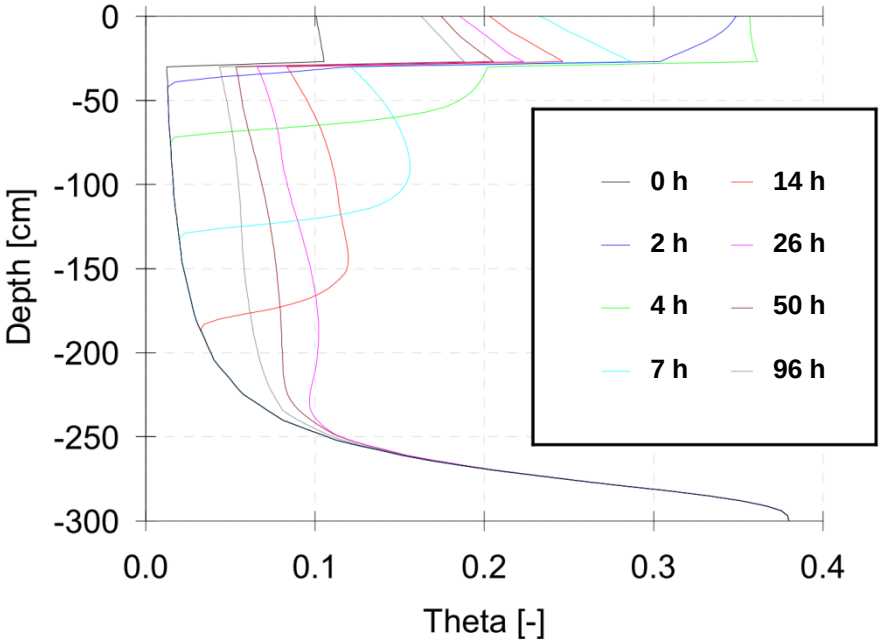

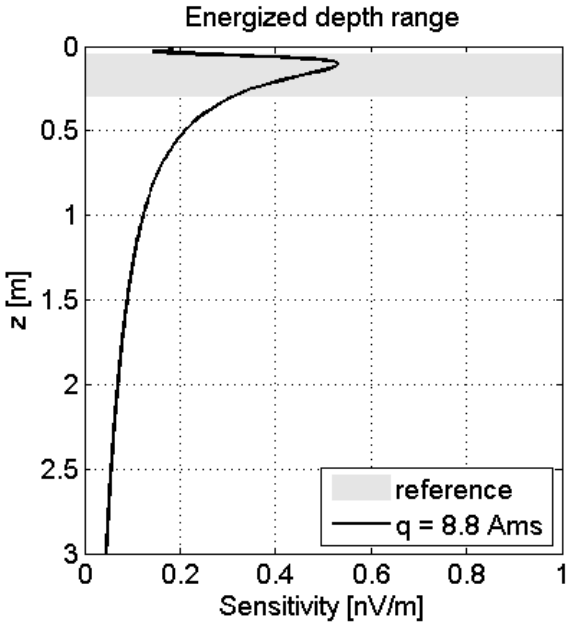

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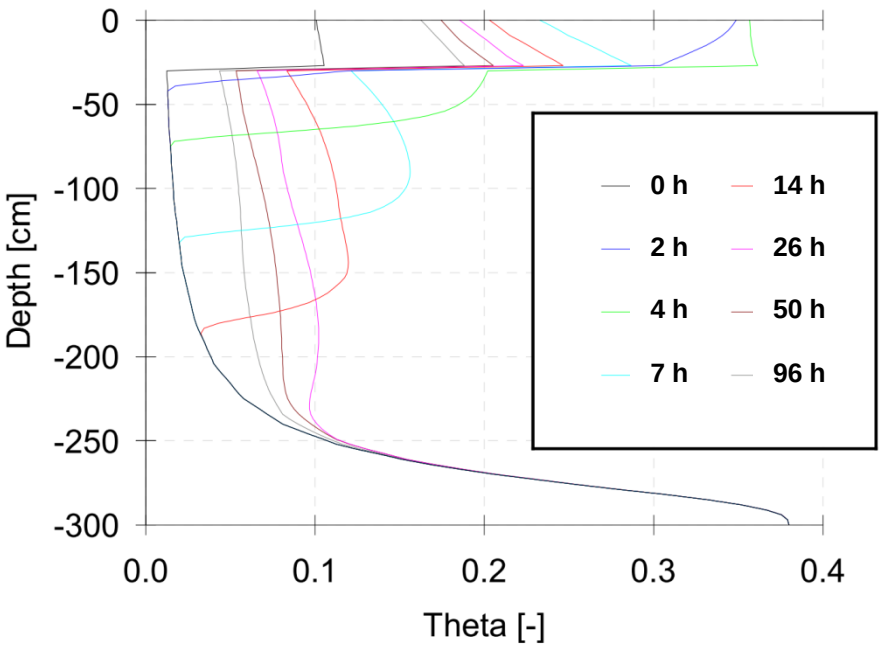

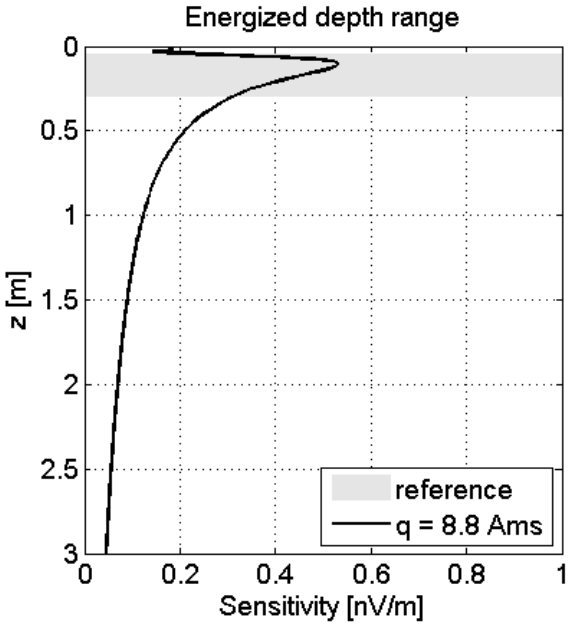

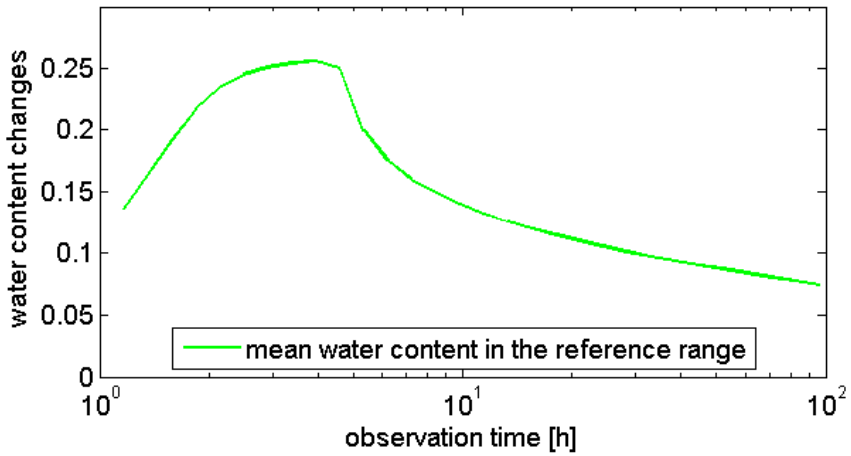

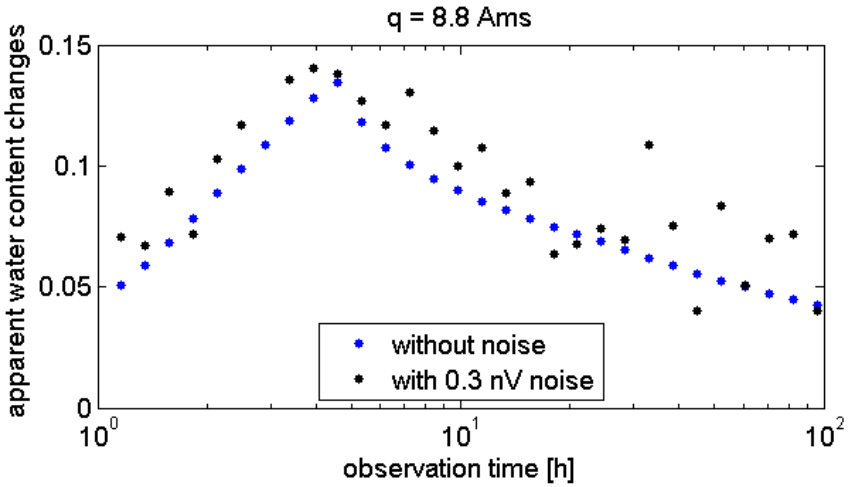

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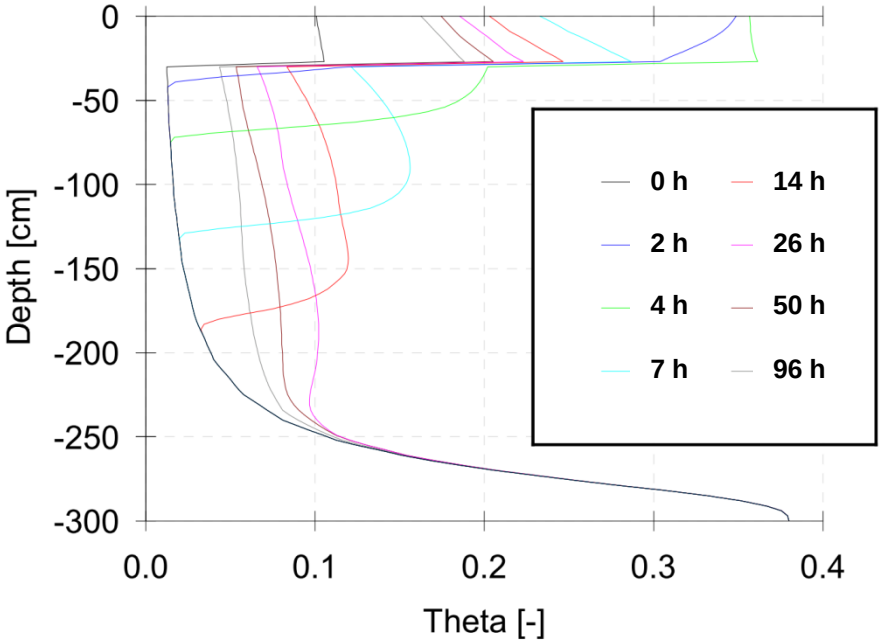

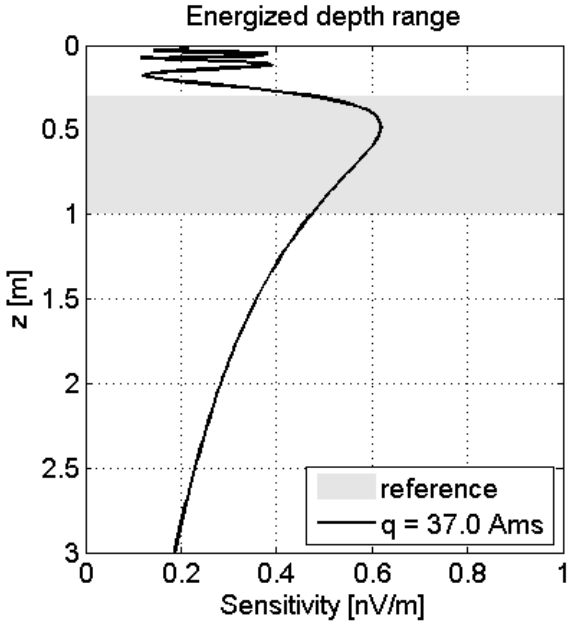

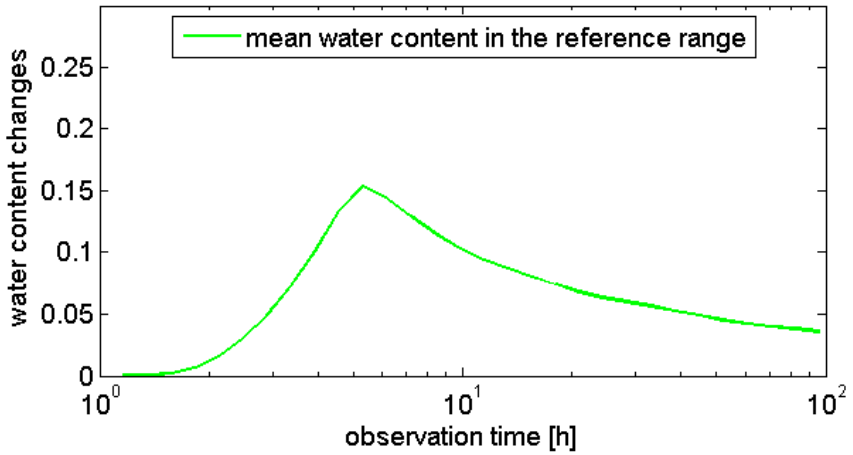

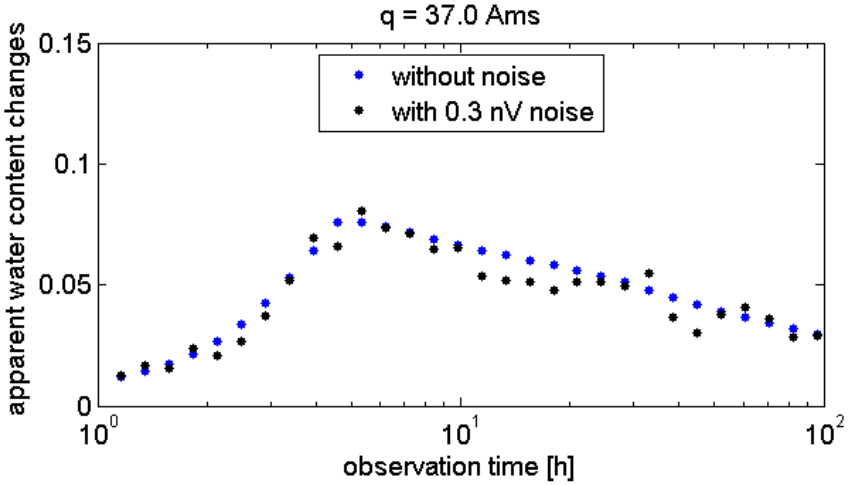

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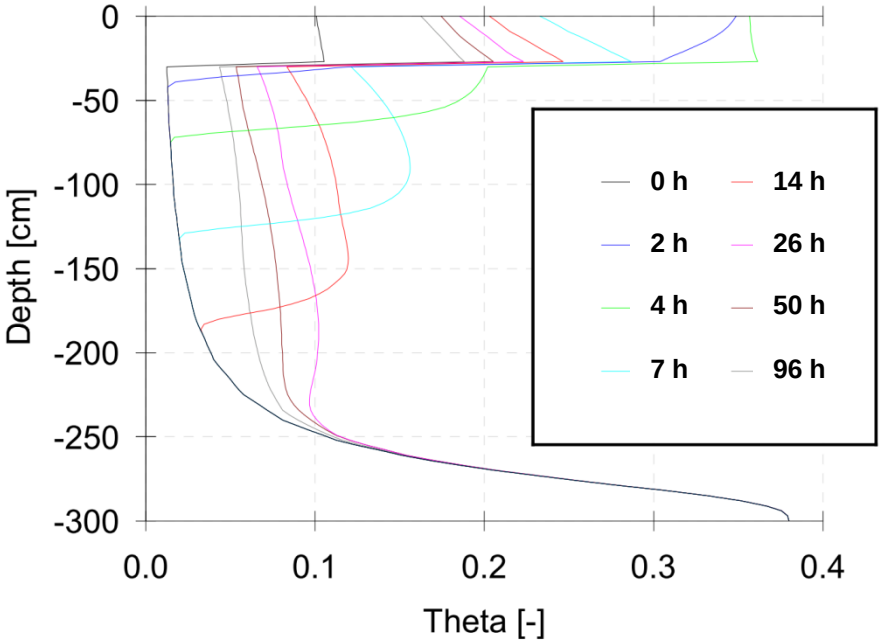

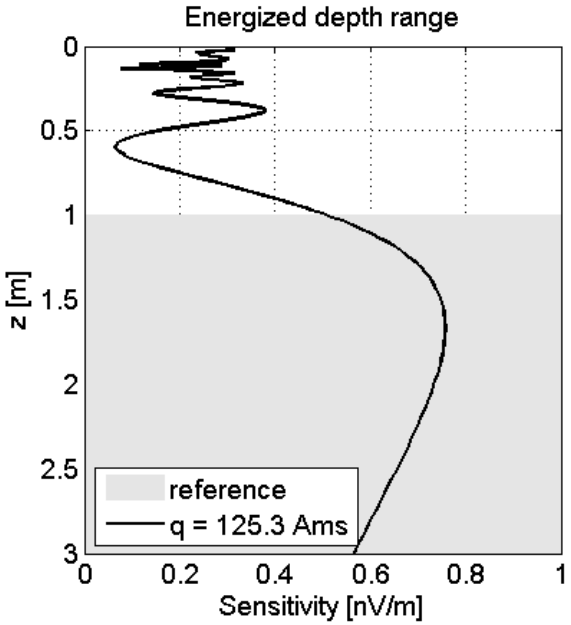

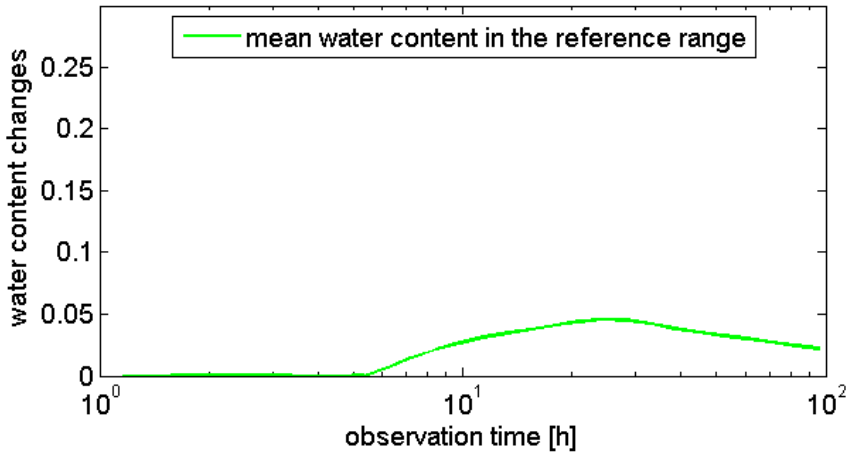

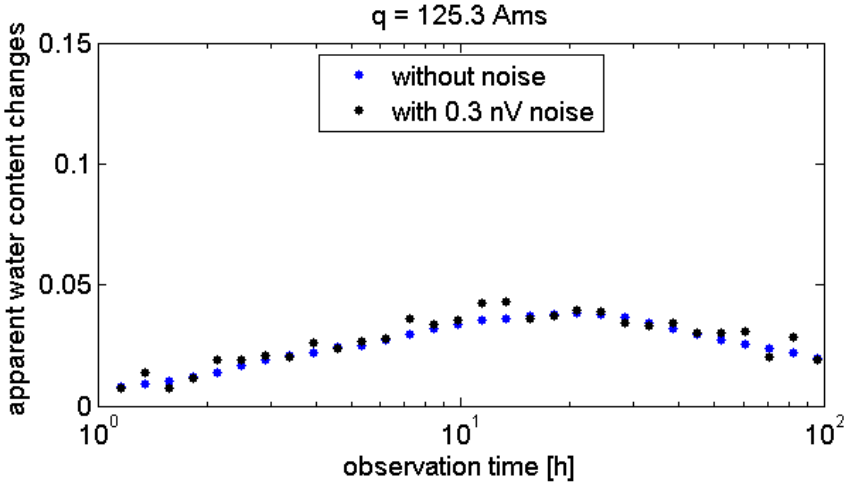

Conclusions

➢By parameterizing the capillary fringe, e.g. by using the van-Genuchten model, SNMR can:

- … non-invasively observe water table changes with time
- … estimate the relative hydraulic conductivity roughly from the slope of the capillary fringe

➢Observing the infltration front after a rainfall event seems not possible, spatial resolution under realistic noise conditions is not high enough!

- New inversion/interpretation aproaches are demanded that include a specific flow model

➢Outlook, Monitoring of irrigation experiments:

-fast repetitions of single SNMR measurements are possible
=> Observation of water content changes in specific depth ranges

➢Outlook: Combination with ERT measurements:

-Benefit of ERT: high spatial and temporal resolution
-Benefit of SNMR measurements: determination of water content changes with time in specific depth ranges (very low spatial resolution !)