Estimating soil hydraulic parameters from lysimeter data: a Bayesian perspective

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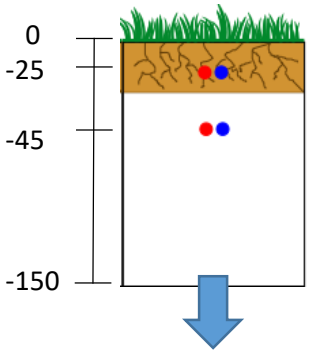
ÖAW ÖSTERREICHISCHE AKADEMIE DER WISSENSCHAFTEN

Background & aim of the study

- Simulation of soil water fluxes using a (physically based) numerical model requires the estimation of Soil Hydraulic Parameters (SHPs)
  - Question: Which measurements from a lysimeter experiment are most efficient for the inverse estimation of SHPs and for reducing uncertainty in seepage prediction?

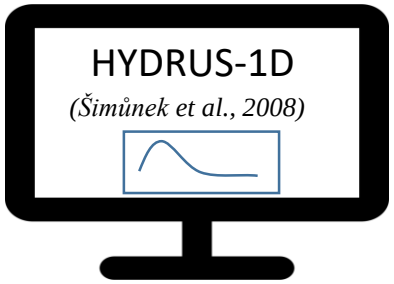
7 Data Scenarios



- Gravimetric monolith lysimeter
- TDR probes
- Tensiometers
- Time series (daily) March - October

1) Seepage (Q)
2) Vol. soil water content (SWC)
3) Matric potential (MP)
4) Seepage & matric potential (Q+MP)
5) Seepage & vol. soil water content (Q+SWC)
6) Matric potential & vol. soil water content (MP+SWC)
7) Seepage & matric potential & vol. soil water content (Q+MP+SWC)

Bayesian model framework



Bayesian inference

Posterior: $P(\theta \mid D, M)$ = Data likelihood: $P(D \mid M, \theta)$ Prior: $P(\theta \mid M)$ / $P(D \mid M)$

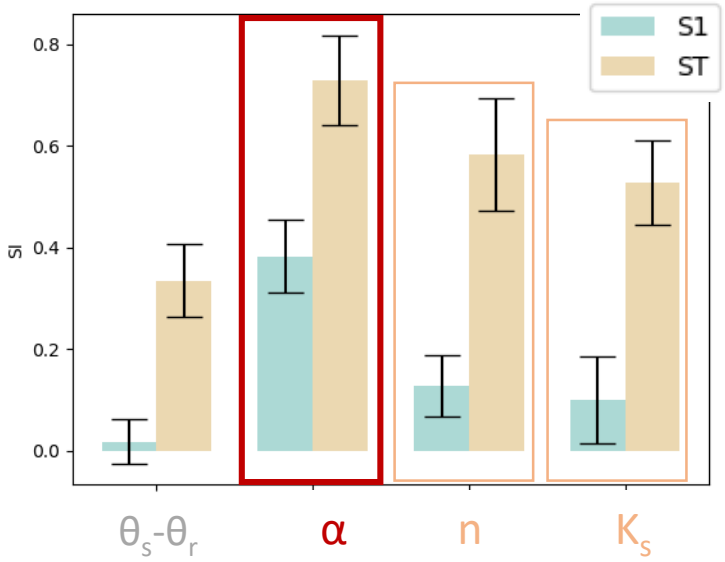
Quantification of gain in information: Kullback-Leibler divergence (KLD):

$$KLD\ (p(x) \parallel q(x) = \int p(x) \log\left(\frac{p(x)}{q(x)}\right)\ dx$$

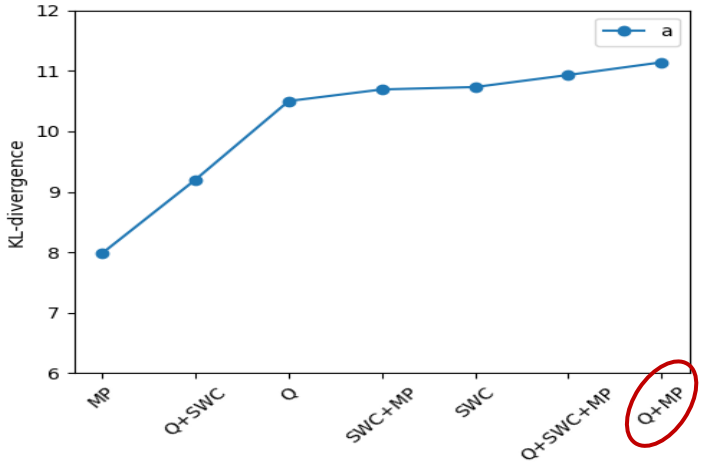
Parameter sensitivity and uncertainty

Global Sensitivity Analysis:

Sobol' Indices cumulative seepage

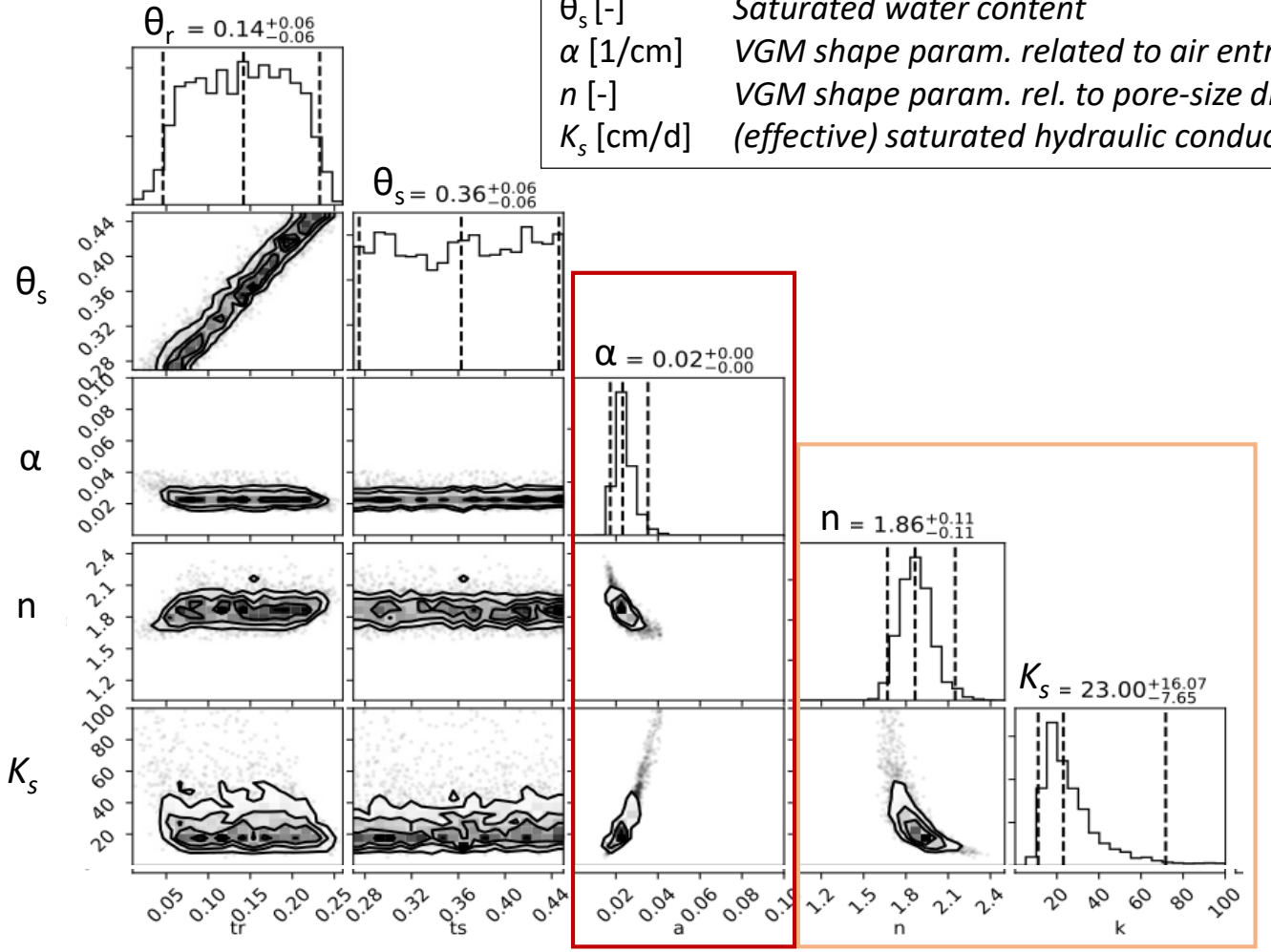


Kullback-Leibler divergences α:



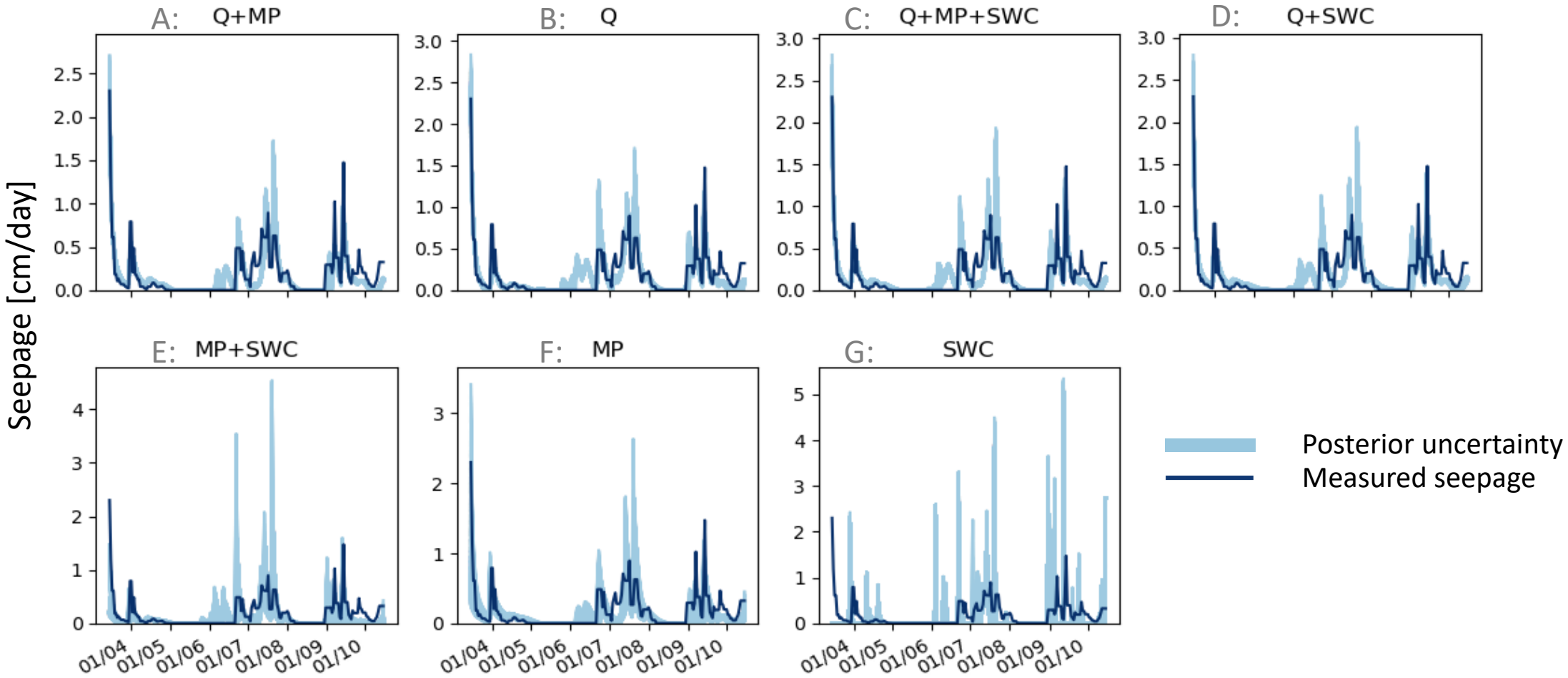
Marginal posterior distributions Scenario A **Seepage + Matric Potential**

θ_r [-]	*Residual water content*
θ_s [-]	*Saturated water content*
α [1/cm]	*VGM shape param. related to air entry*
n [-]	*VGM shape param. rel. to pore-size distribution*
K_s [cm/d]	*(effective) saturated hydraulic conductivity*



Uncertainty propagation to seepage flux

Data assimilation scenarios A-G (increasing uncertainty):



Summary and conclusions

- Bayesian assessment of data-worth for reducing uncertainty in SHP estimation and seepage prediction with real measurements from a lysimeter experiment
- Most efficient in reducing uncertainty in the prediction of the seepage flux:
  ➔ Simultaneous assimilation of daily seepage + matric potential measurements
- Higher uncertainty in seepage prediction in scenarios without assimilation of seepage measurements
- No general statement; comprehensive analysis with different soils and climates required