Forstliche Versuchs- und Forschungsanstalt Baden-Württemberg

The water budget of forests – the big unknown outside of our intensive monitoring plots?

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Background & Aims

- Increasing drought damages in forests
- Need for recommendations for forest conversion & reforestation
- Estimation of the water balance and future forecasts as a basis for silvicultural decisions

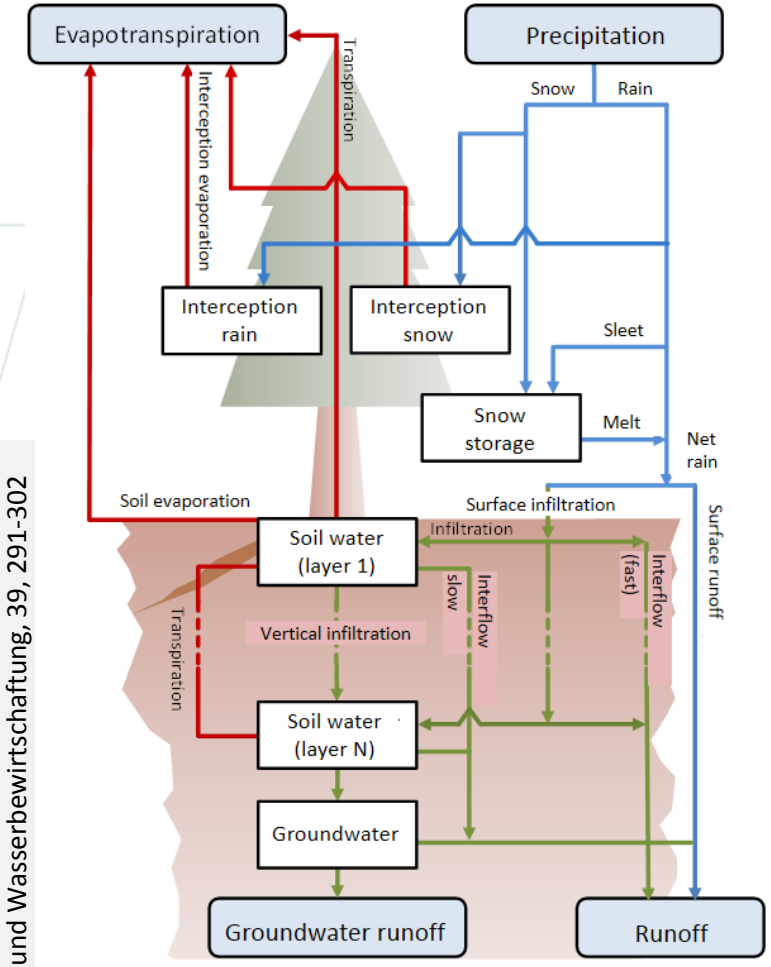
Can we estimate the water balance sufficiently reliably outside intensively monitored areas?

Project objectives:

- Calibrate LWF-Brook90 on Level II plots
- Derive rules for the parameterisation of LWF-Brook90 for modelling at forest sites without measured data
- Assess model uncertainties

Methods

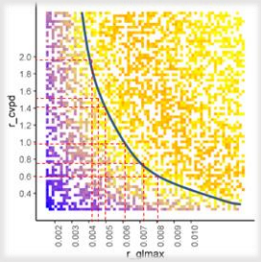
Water budget model LWF-Brook90



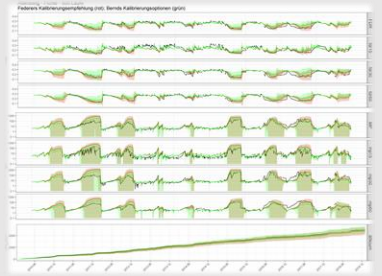
Hallas et al. 2018. Forum für Hydrologie und Wasserbewirtschaftung, 39, 291-302

ICP Forest Level II sites

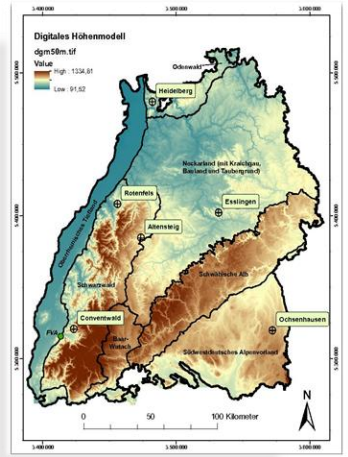
Sensitivity analysis
- important model parameters
- irrelevant model parameters
- sensible value ranges



Model calibration
- structural model problems
- best fitting parameter values



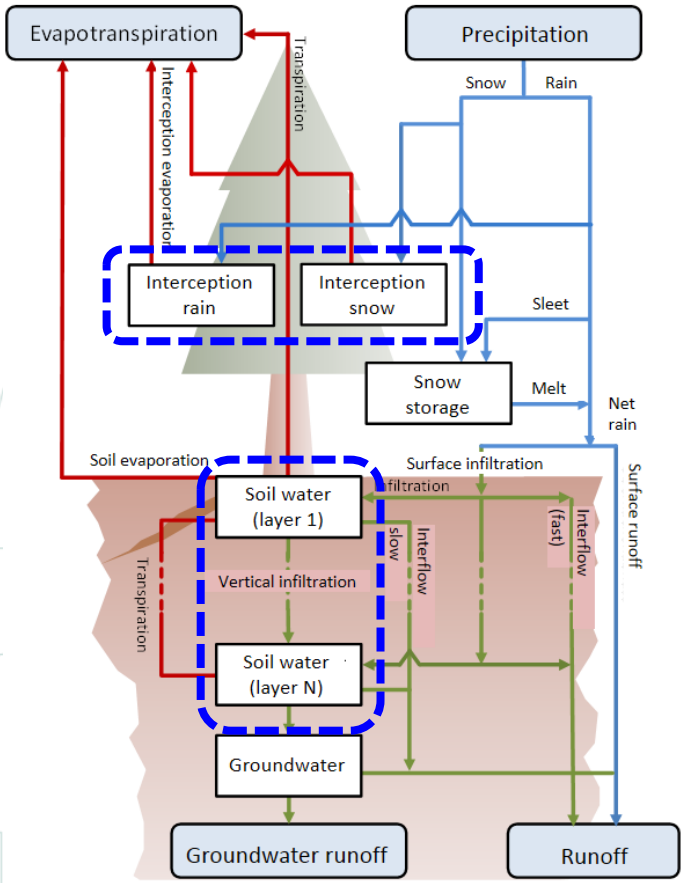
Uncertainty analysis
- sites/time periods with high/ low prediction uncertainty



Test regions

Transfer to unobserved sites
- uncertainty of model parameters and transfer function
- error propagation to drought indices

Methods: Sensitivity analyses after Hornberger, Spear & Young (HSY)



min/max ranges from literature
20‘000 parameter combinations

Uniform Random Sampling (URS)

modelled vs. observed **daily** soil water contents/tensions, throughfall

Use samples to calculate model response

Nash Sutcliffe efficiency, R^2, RMSE, ME,… for year and seasons

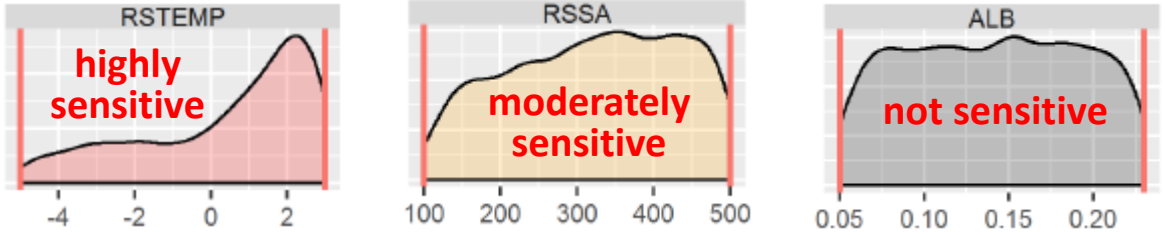
Evaluate response and split population

Model calibration

Behavioral population

Model uncertainty

Nonbehavioral population



Results: Sensitive model parameters

Tab.: Number of sensitive objective functions per site

	Altensteig - Fichte			Conventwald - Buche			Conventwald - Fichte			Heidelberg - Buche			Heidelberg - Fichte			hoch sensitiv
	FULL	VEG	WIN	FULL	VEG	WIN	FULL	VEG	WIN	FULL	VEG	WIN	FULL	VEG	WIN	
DURATN	0	0	2	2	2	0	3	3	2	2	2	0	3	3	0	24
R5	0	0	1	0	0	0	2	2	2	2	0	2	2	2	2	17
GLMAX	0	0	1	0	0	0	2	2	2	0	0	0	2	2	2	13
GLMIN	0	0	1	0	0	0	2	2	2	0	0	0	2	2	2	13
RSTEMP	2	0	2	0	0	1	2	0	3	0	0	0	0	0	2	12
FRINTL	1	1	1	0	0	0	2	2	2	0	0	0	0	0	0	9
CINTRL	0	0	0	0	0	0	2	2	2	0	0	0	0	0	0	6
CVPD	0	0	0	0	0	0	0	1	0	0	0	0	2	2	0	5
CZR	0	0	0	0	0	0	2	1	2	0	0	0	0	0	0	5
LWIDTH	0	0	0	0	0	2	0	0	0	0	0	2	0	0	0	4
FRINTS	0	0	1	0	0	0	0	0	2	0	0	0	0	0	0	3
WNDRAT	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	2
RSSA	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
ALB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ALBSN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CCFAC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CINTRS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CINTSL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CINTSS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CZS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FETCH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FSINTL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FSINTS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FXYLEM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GRDMLT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

- 60 target functions:

  5 Level II sites
  x 2 measures (soil water content, throughfall)
  x 2 goodnes-of-fit measures (RMSE, wRsq)
  x 3 aggregations (year, growing/dormant season)

- 56 free model parameters; soil water retention function and water conductivity were fixed

- 43 model parameters influenced the model output only marginally

- most sensitive parameters were those that control
  - stomata function & canopy conductance
  - interception capacity & dynamics

Results: Transfer to test regions

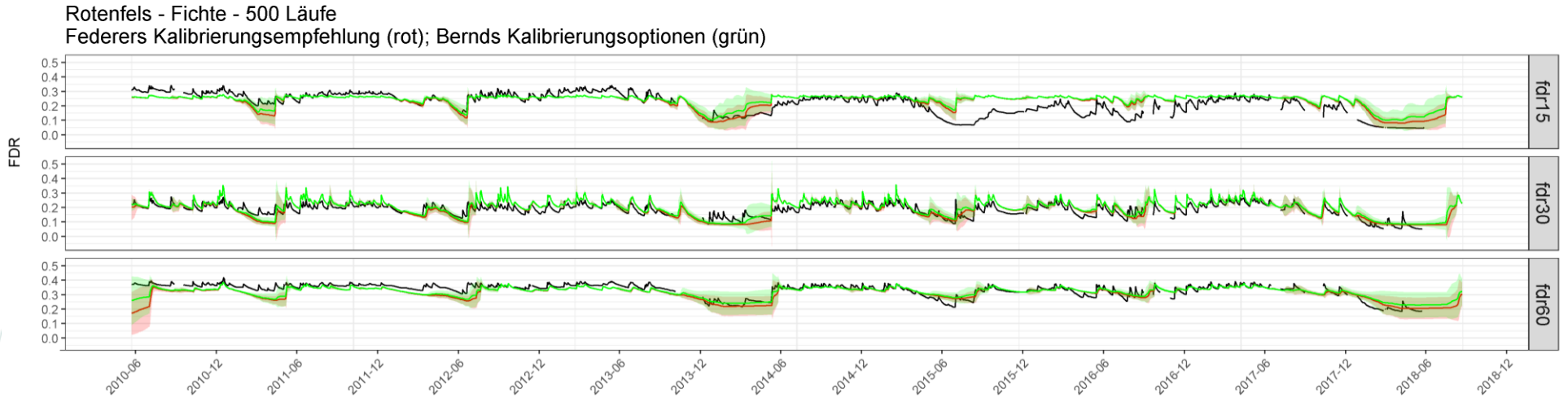
based on sensitivity and uncertainty analyses:

- insensitive parameters: fixed at standard value
- sensitive parameters:
  - transfer functions based on data evaluation from Level II (and other) plots, e.g. DURATN (disaggregation of daily rainfall to hourly data),
  - calibrated on 59 German Level II plots, e.g. GLMAX (stomata conductance)
  - correlated sensitive parameters: parameters fixed for which measurements exist, others calibrated, e.g. interception parameters (LWIDTH fixed (leaf size), FRINTL calibrated)

- project output: recipe for LWF-Brook90 parameterisation

Coming soon ;)

Preliminary results: Uncertainty analysis



- comparatively larger uncertainty in
  - resaturation periods in autumn
  - less severe drought events
- comparatively smaller uncertainty in
  - begin of vegetation period
  - extreme droughts

To Dos:

- Uncertainty assessment on more Level II plots
- Ranking of drought indices according to related model uncertainty

Conclusions

- Forest management needs decision support for climate adaptation, regardless of whether we have a blurred (model) view of the future.
- No matter how hard we try, process-based modeling will always be associated with uncertainty.
- On-site measurements such as ICP-Forest Level II are essential for model calibration and development of transfer functions/rules for unobserved sites.

- The LWF-Brook90 parameterization “recipe book” helps reduce model bias and sharpen our drought predictions.
- Model predictions seem to be less uncertain for extreme droughts than for moderate droughts.
- After completion, uncertainty analyses will help identify time periods and water budget/drought indices will large/small prediction uncertainty.

FVA Forstliche Versuchs- und Forschungsanstalt Baden-Württemberg

LFV Landes Forst Verwaltung BW

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