Stochastic analysis of soil hydraulic property uncertainty propagation in predictions by the SWAP model

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cena 1966 2016 50 anos

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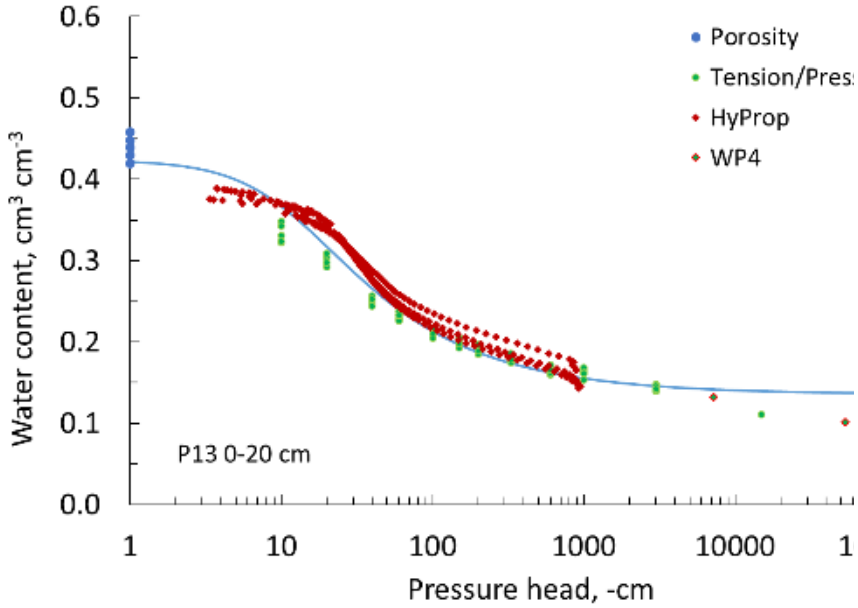
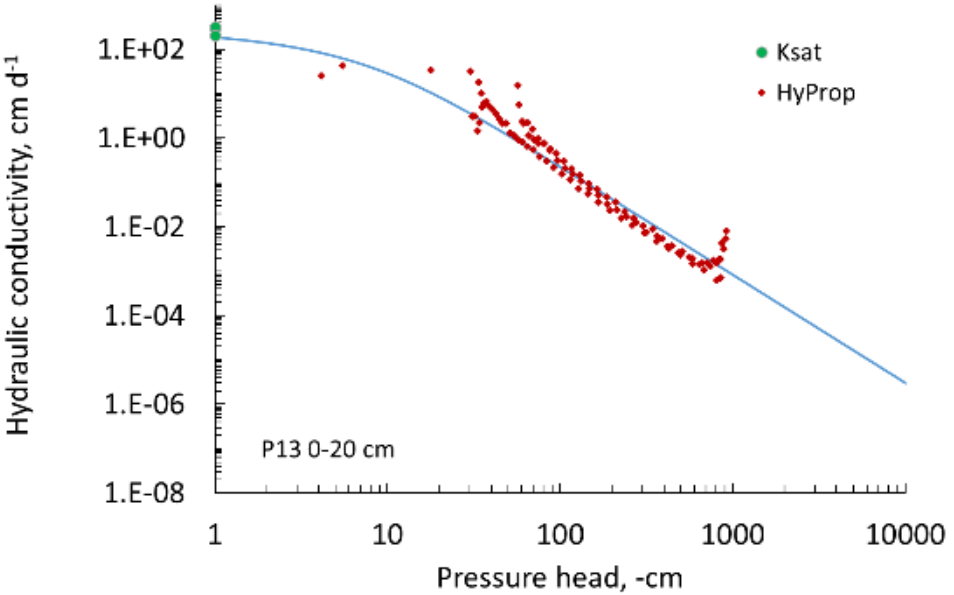
SWAP

Focusing on the uncertainties resulting from *hydraulic parameterization* of the SWAP model

Retention h-θ



Conductivity K-h



The SWAP model employs VGM hydraulic parameters

Nonlinear least-squares analysis: final results

Variable	Value	S.E.Coeff.	T-Value	95% Confidence limits Lower	Upper
ThetaR	.14030	.00872	16.10	.1206	.1600
ThetaS	.39627	.00877	45.19	.3764	.4161
Alpha	1.78168	.04780	37.27	1.6736	1.8898
n	3.07096	.26583	11.55	2.4696	3.6723
Ks	.03504	.00041	84.56	.0341	.0360

Deterministic

Stochastic, *Monte Carlo*

Correlation matrix

	ThetaR 1	ThetaS 2	Alpha 3	n 4	Ks 5
1	1.0000				
2	-.0821	1.0000			
3	.3888	.2096	1.0000		
4	.4684	.1400	.7016	1.0000	
5	-.0218	.0154	.0654	-.0768	1.0000

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Nonlinear least-squares analysis:
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ThetaS	.39627	.00877
Alpha	1.78168	.04780
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Correlation matrix
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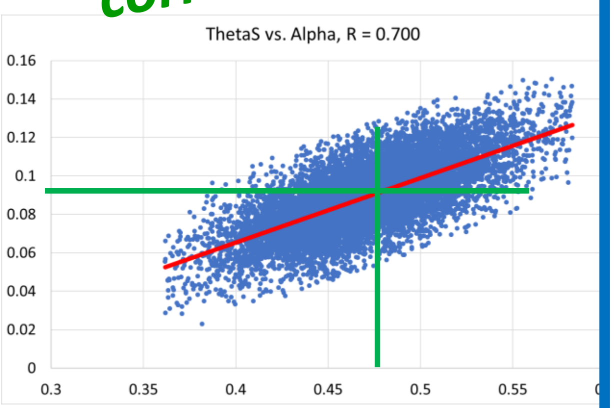
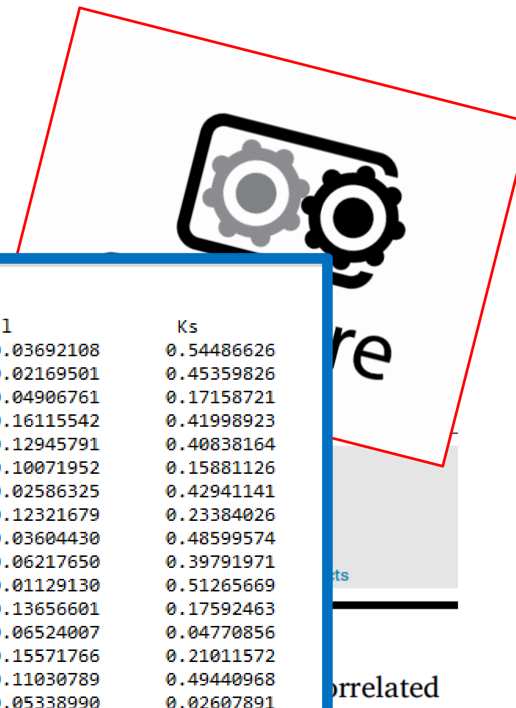
Generate (many) ***STOCHASTIC REALIZATIONS*** using Cholesky decomposition

dispersion correlation





```
*  StochHyProp v. 2.02
* SAMPLE 1
```

* Tr	Ts	alpha	n	l	Ks
-0.00079520	0.69951260	0.21734463	1.52117932	0.03692108	0.54486626
-0.00115651	0.68776667	0.21443641	1.95608008	0.02169501	0.45359826
-0.00261618	0.61810911	0.14713705	2.01655555	-0.04906761	0.17158721
0.00169656	0.68162876	0.19899122	1.76946473	0.16115542	0.41998923
-0.00306452	0.65312523	0.20790803	1.86205351	-0.12945791	0.40838164
-0.00157755	0.58375096	0.15299240	1.89184654	-0.10071952	0.15881126
0.00205356	0.64643294	0.19132270	1.68927026	-0.02586325	0.42941141
0.00388708	0.62379289	0.12976496	1.73450232	0.12321679	0.23384026
0.00157530	0.66412598	0.21049795	1.82528758	-0.03604430	0.48599574
0.00067051	0.64971173	0.18419911	2.00232983	-0.06217650	0.39791971
0.00054247	0.66998225	0.21904631	1.65202427	-0.01129130	0.51265669
-0.00341600	0.62594718	0.14953178	2.15735340	-0.13656601	0.17592463
0.00433187	0.60033679	0.10410007	2.53562474	0.06524007	0.04770856
0.00334529	0.64384621	0.13999063	2.15565705	0.15571766	0.21011572
-0.00184498	0.66463816	0.20704147	1.61253810	-0.11030789	0.49440968
0.00377259	0.59475356	0.09962637	2.44901013	0.05338990	0.02607891
-0.00008015	0.65110618	0.16144577	1.98151088	0.01193557	0.30161369
0.00066236	0.64234793	0.15373656	1.49666595	-0.00074687	0.33739102
0.00192962	0.65054232	0.15361685	2.21762109	0.00964811	0.27613640
0.00246992	0.60920292	0.08470164	2.40272999	0.10532485	-0.00575402
0.00180155	0.66474342	0.22006433	1.80445659	-0.03959258	0.52509111

This allows upgrading from deterministic to stochastic interpretation of model outputs


```
*  StochHyProp v. 2.02
* SAMPLE 1
*      Tr              Ts              alpha           n               l               Ks
     -0.00079520     0.69951260      0.21734463      1.52117932      0.03692108      0.54486626
     -0.00115651     0.68776667      0.21443641      1.95608008      0.02169501      0.45359826
     -0.00261618     0.61810911      0.14713705      2.01655555     -0.04906761      0.17158721
      0.00169656     0.68162876      0.19899122      1.76946473      0.16115542      0.41998923
     -0.00306452     0.65312523      0.20790803      1.86205351     -0.12945791      0.40838164
     -0.00157755     0.58375096      0.15299240      1.89184654     -0.10071952      0.15881126
      0.00205356     0.64643294      0.19132270      1.68927026     -0.02586325      0.42941141
      0.00388708     0.62379289      0.12976496      1.73450232      0.12321679      0.23384026
      0.00157530     0.66412598      0.21049795      1.82528758     -0.03604430      0.48599574
      0.00067051     0.64971173      0.18419911      2.00232983     -0.06217650      0.39791971
      0.00054247     0.66998225      0.21904631      1.65202427     -0.01129130      0.51265669
     -0.00341600     0.62594718      0.14953178      2.15735340     -0.13656601      0.17592463
      0.00433187     0.60033679      0.10410007      2.53562474      0.06524007      0.04770856
      0.00334529     0.64384621      0.13999063      2.15565705      0.15571766      0.21011572
     -0.00184498     0.66463816      0.20704147      1.61253810     -0.11030789      0.49440968
      0.00377259     0.59475356      0.09962637      2.44901013      0.05338990      0.02607891
     -0.00008015     0.65110618      0.16144577      1.98151088      0.01193557      0.30161369
      0.00066236     0.64234793      0.15373656      1.49666595     -0.00074687      0.33739102
      0.00192962     0.65054232      0.15361685      2.21762109      0.00964811      0.27613640
      0.00246992     0.60920292      0.08470164      2.40272999      0.10532485     -0.00575402
      0.00180155     0.66474342      0.22006433      1.80445659     -0.03959258      0.52509111
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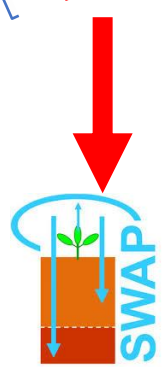
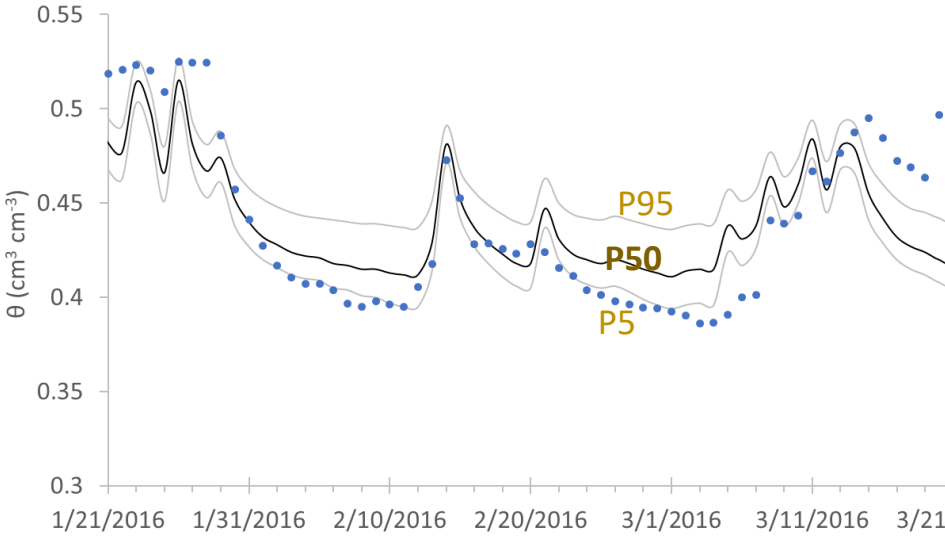


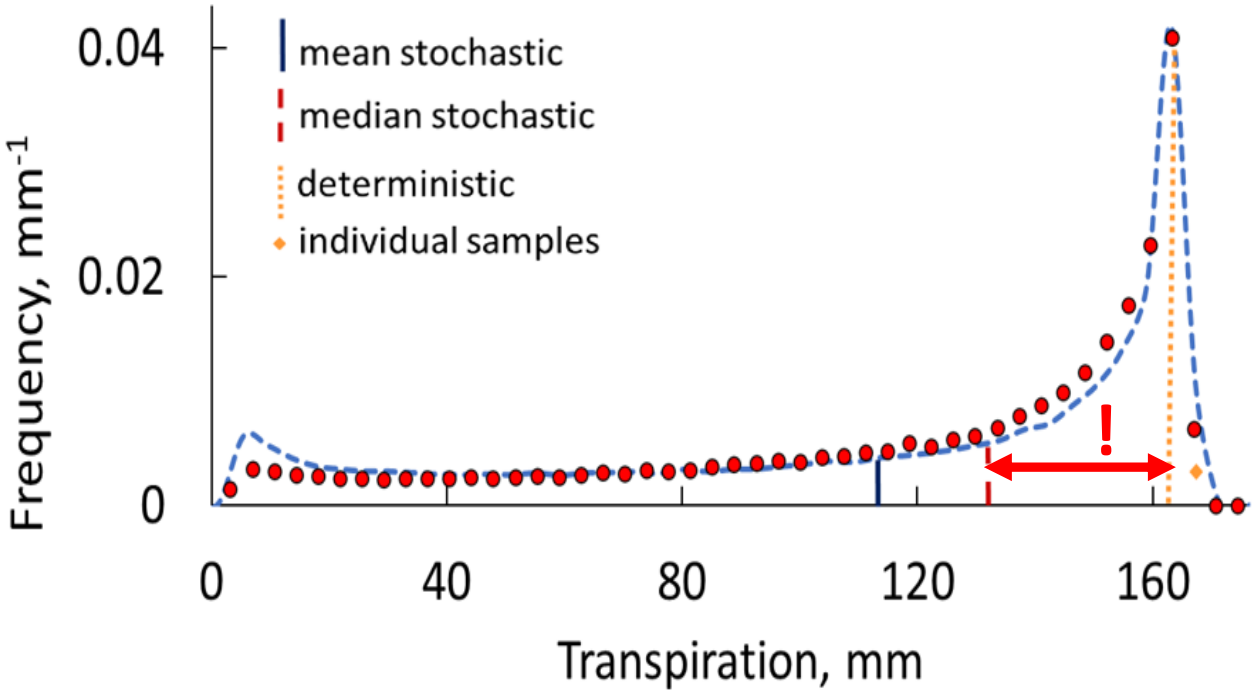
1. Runs the SWAP model for each stochastic parameter realization;
2. Extracts the required (user-defined) information from the SWAP output files;
3. Compiles selected SWAP output in a resulting file.



Functional analysis using SWAP

Example 1: Predicted Transpiration during a crop season semi-arid (NE Brazil)

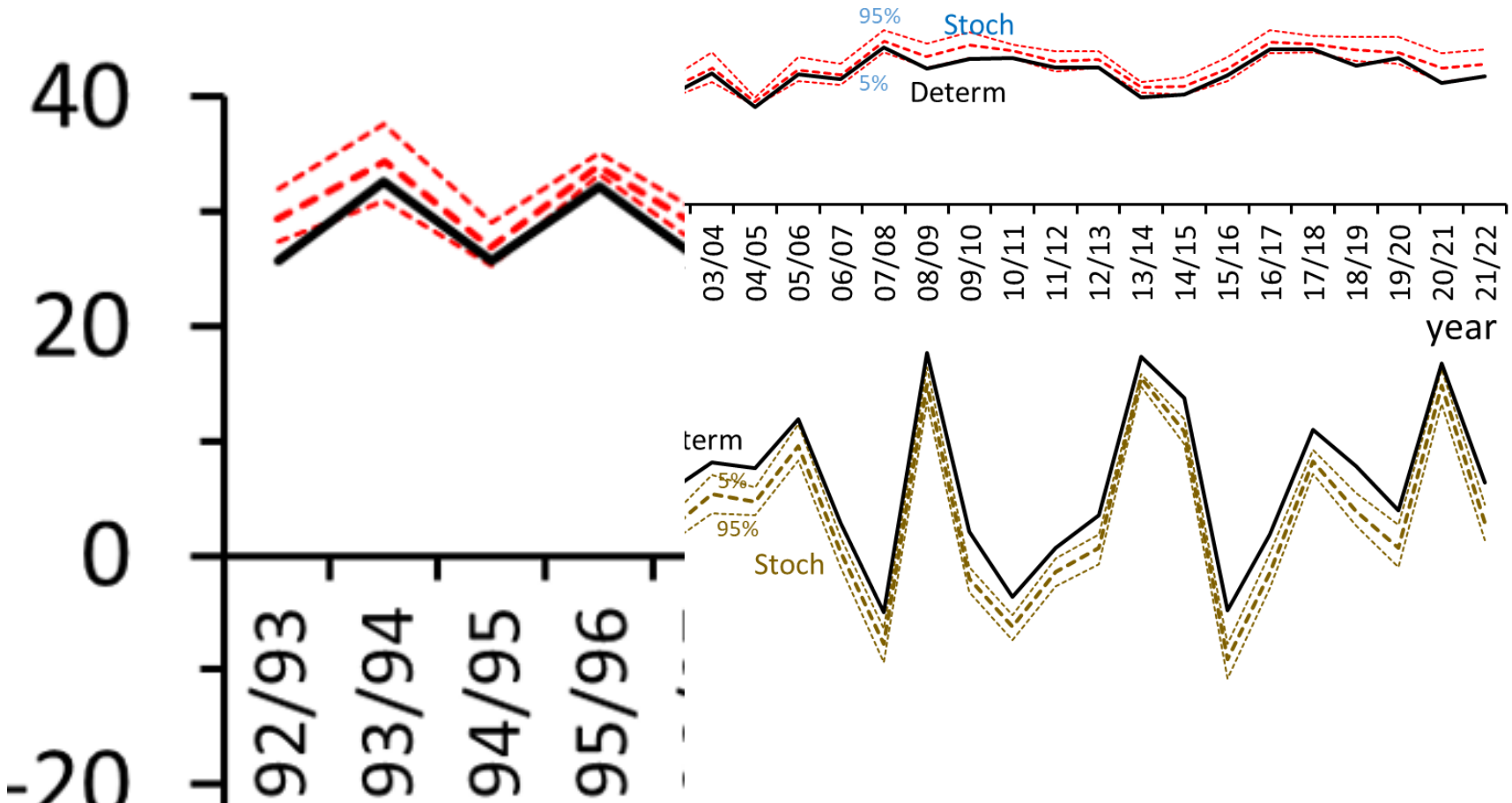
in this case: a significant difference between deterministic and median stochastic prediction



Functional analysis using SWAP

Example 2: Transpiration and Bottom Flux during 30 simulated years in a SE Brazilian soil

Stochastic analysis reveals uncertainties and results in a different prediction

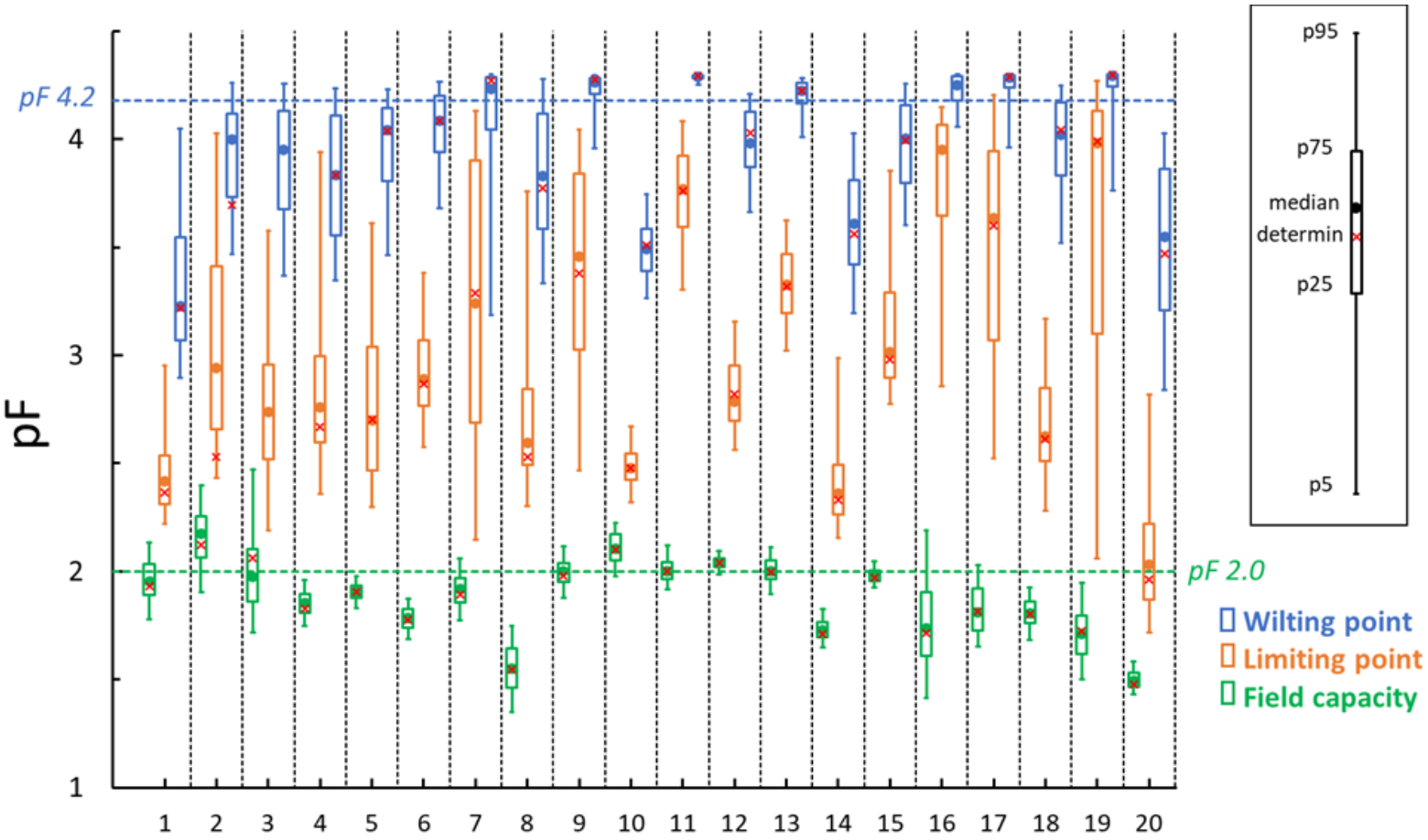


Functional analysis using SWAP

Example 3: Threshold pressure heads (flux-based FC, LP, WP) in 20 SE Brazilian soils

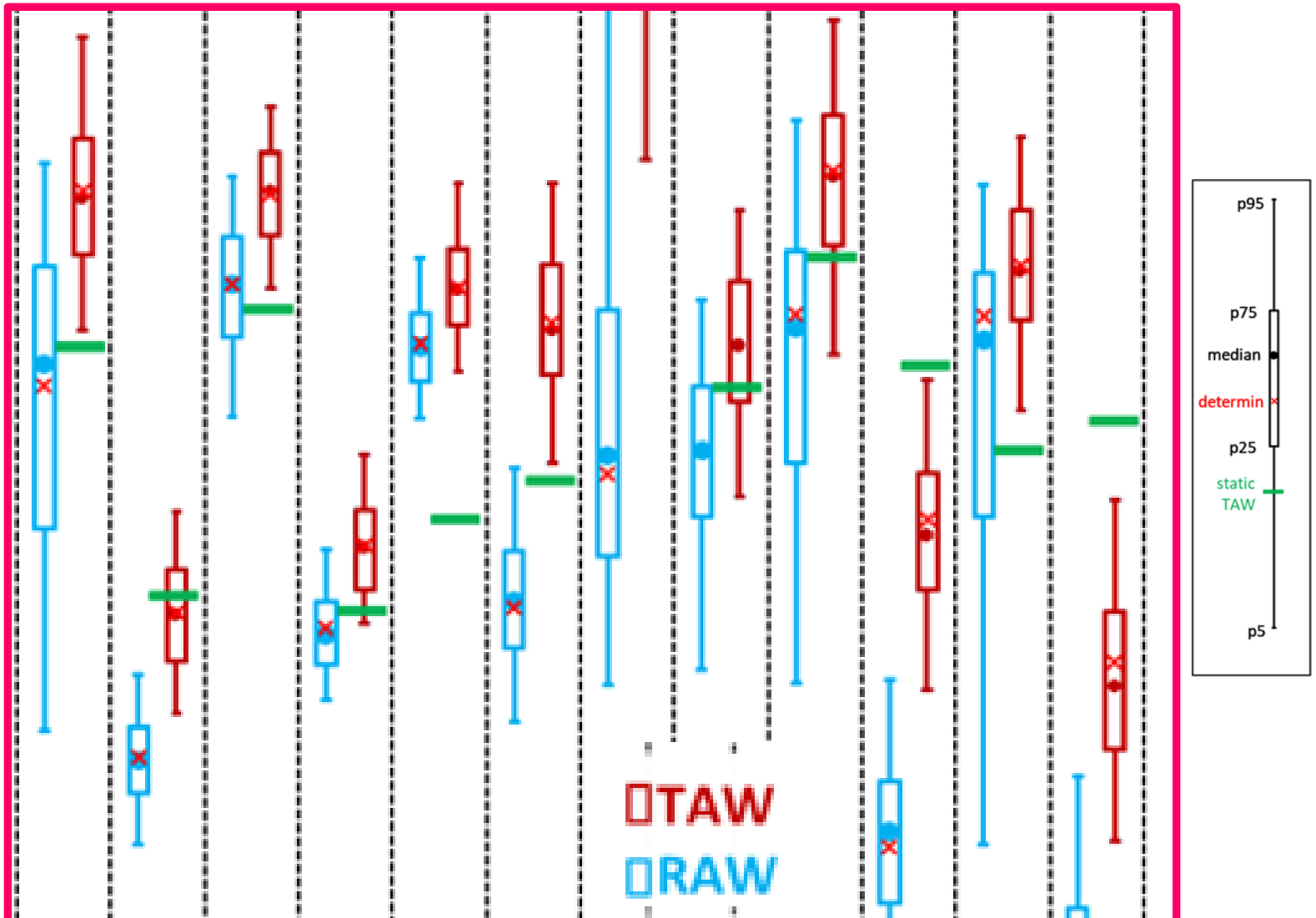
Stochastic Analysis allows insight in uncertainties

Some differences between deterministic and median stochastic prediction



Functional analysis using SWAP

Example 4: Plant available water (from flux-based FC, LP, WP) in 20 SE Brazilian soils



Conclusions

1. The impact of VGM parameter uncertainty on SWAP model predictions can be assessed using a stochastic approach with Cholesky decomposition to generate parameter realizations;

2. VGM parameters act together in the θ-h and K-h equations and do not have individual practical meaning – their functional analysis depends on a modelling framework, e.g. SWAP;

3. Deterministically predicted model outputs (e.g., water balance components) using mean hydraulic property parameter values may be substantially different than the median values of stochastic realizations.

Many thanks to former and current developers of the SWAP model!

Thanks for your attention.

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