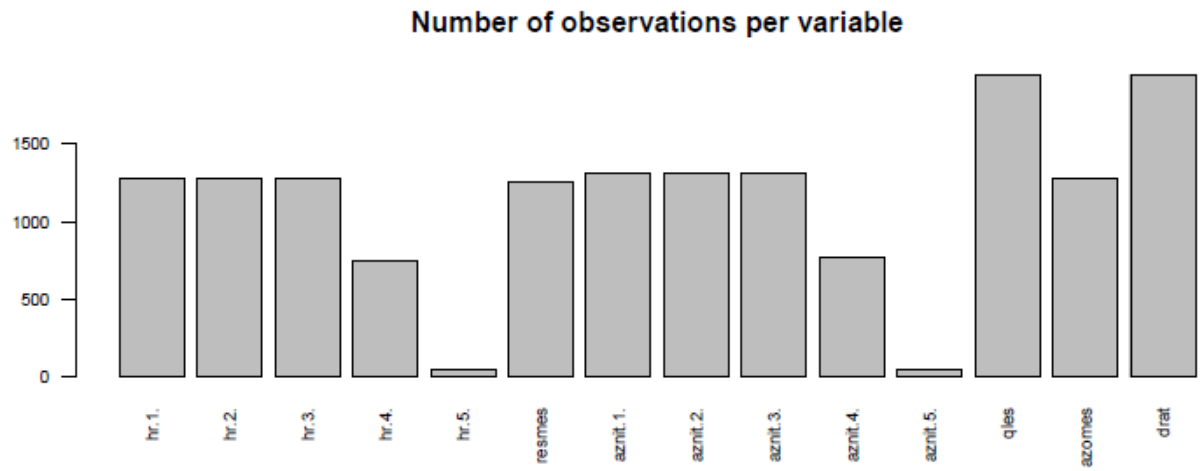
STICS Performance Evaluation Report: Bare Soil

Authors: J. Léonard, N. Beaudoin, P. Bertuzzi, F. Levavasseur, B. Mary, S. Buis

JavaSTICS version: 1.41
STICS version: 9.0
IdeSTICS version: r1220
Number of USMs: 566



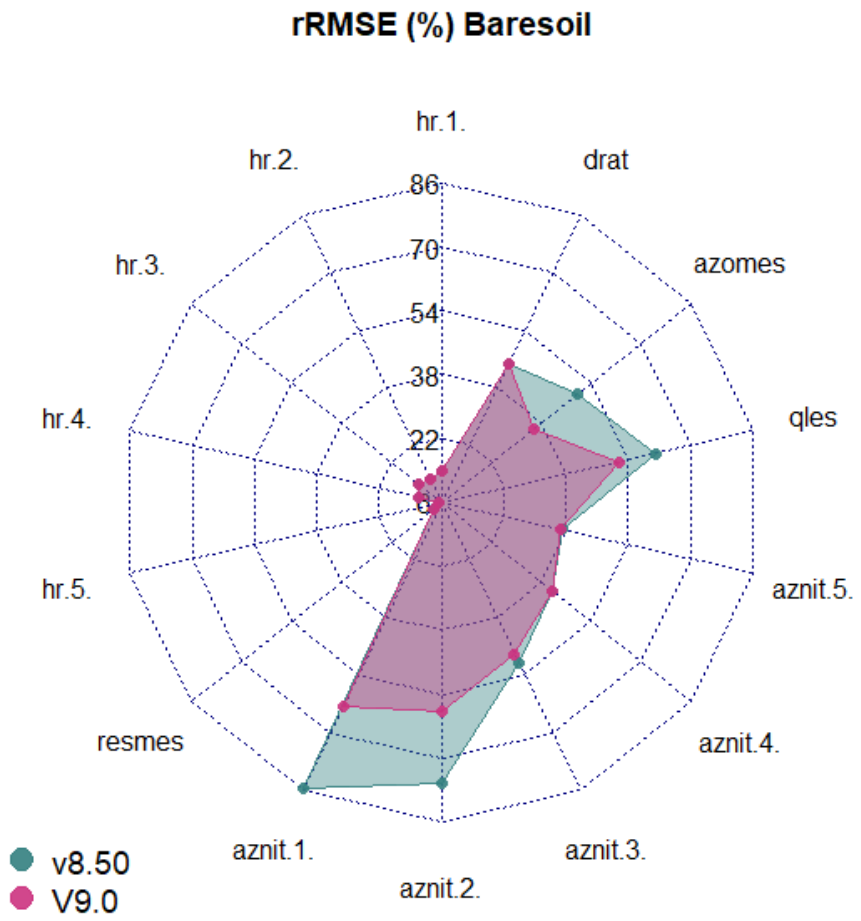
For that evaluation, we have chosen to keep the 131 usms that have been recently used to calibrate one parameter of the mineralization process (*gmin1*, see Clivot et al., 2017). Removing these usms would have considerably reduced the range of the explored situations while this parameter only affects the mineralization process. Performances of soil nitrogen variables simulations obtained with and without these usms will however be discussed.

All the usms were simulated independently. In almost all these usms, specific options such as nitrification, denitrification, macroporosity, shrinkage, capillary rise, draining were not used. Activating nitrification and denitrification will probably become the default in future version, to better allow for N_2O emission simulation, and results will then be proposed with these options activated. Preliminary tests already indicate that it does not result in big changes for most variables, altho ugh nitrate simulation is slightly improved. Other options should be used with care.

The range of key soil variables or parameters in the dataset used is quite large:

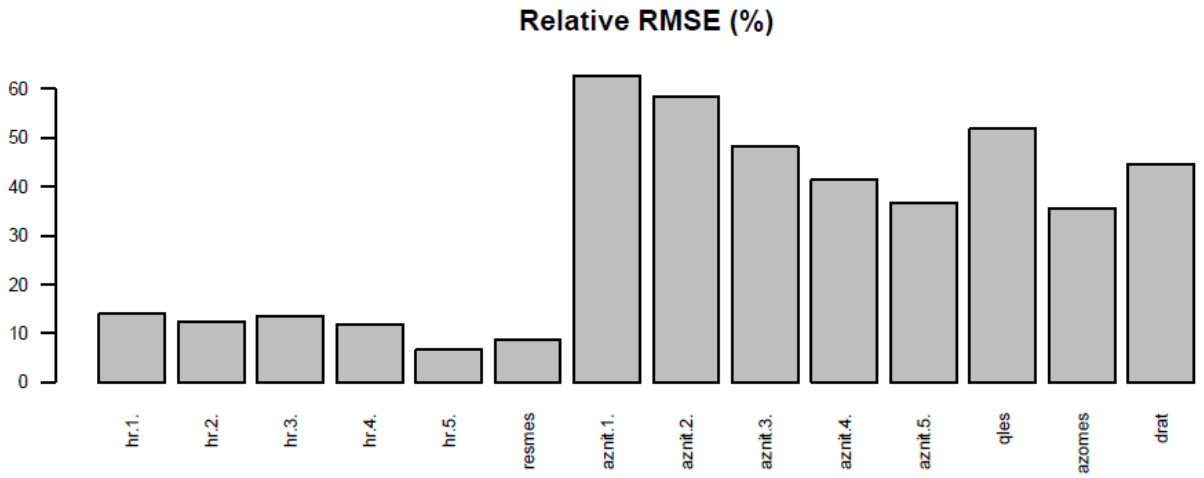
- 20 to 30 cm for the surface soil layer,
- 80 to 150 cm for soil depth,
- 0.07 to 0.42 for *Norg*,
- 0 to 85% for *CaCO3*,
- 5.6 to 8.4 for *pH*,
- 1 to 1.69 for bulk density,
- 2.4 to 39.6 % for clay content,
- 0.15 to 0.31 for *albedo*,
- 3 to 11 mm for *q0*,
- 12-36 % for *hcc*, 5-17 % for *hpf*.

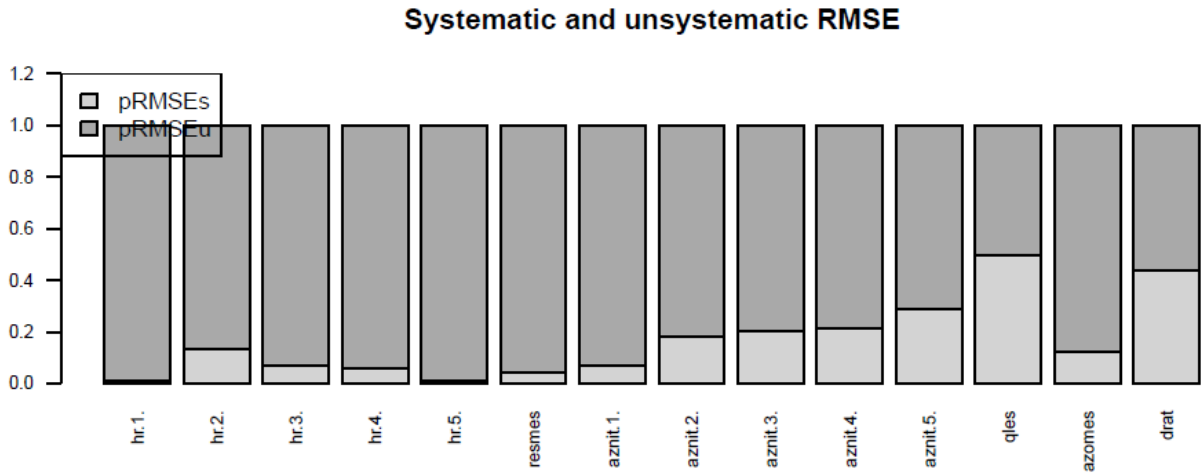
Evolution of performances with respect to former version 8.50



rRMSE are largely improved with the new version 9.0 compared to those obtained with the former version V8.50 for near-surface soil nitrogen content variables *aznit1-2*, for total soil nitrogen content *azomes* and for cumulative leached-nitrogen *qles*. This is due to the improvement of the mineralization formalism in the new version 9.0. Performances obtained for the other observed variables are similar for both versions.

Global analysis





As generally expected, the model performs much better for predicting soil water content, both at soil layer scale (*hr.x*) and whole profile scale (*resmes*), than for predicting soil nitrogen content (*aznit.x*, *azomes*) and flux related variables (*drat*, *qles*). This is for part related to the higher difficulty of measuring nitrogen and fluxes variables, and also to the fact that these variables result from the interaction of numerous processes which are to be simulated accurately.

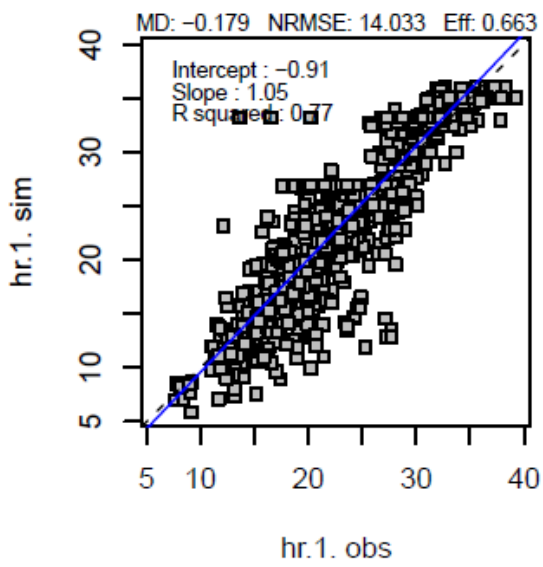
The systematic part of the error (pRMSEs) is globally much lower than the random part (pRMSEu), which indicates that bias is little present compared to dispersion error in the simulations of all variables except for *qles* and *drat*.

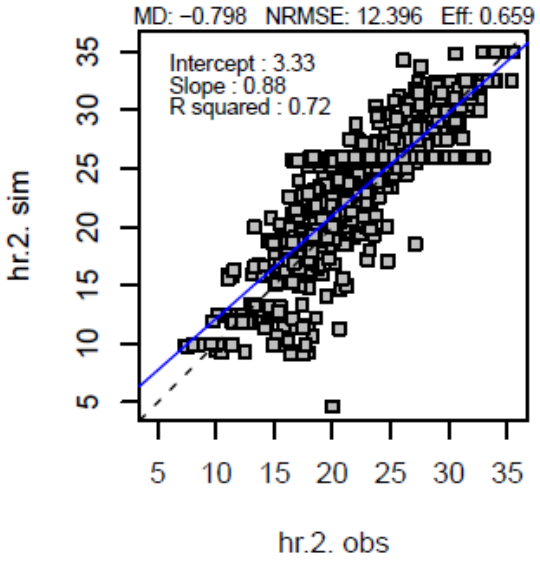
Soil Water Content (% ponderal; mm)

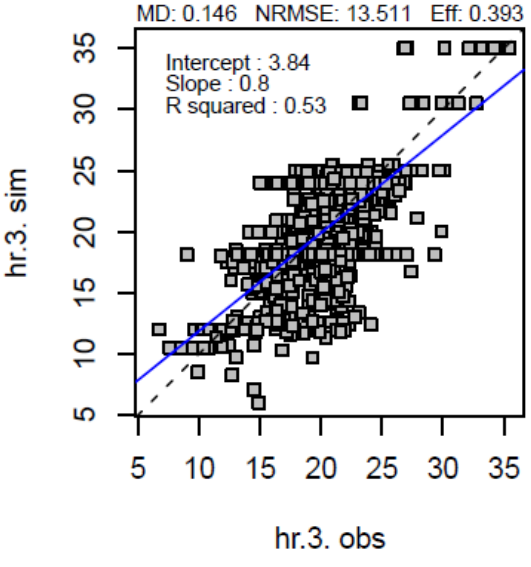
	hr.1.	hr.2.	hr.3.	hr.4.	hr.5.	resmes
number-of-usm	335	335	335	233	9	328
number-of-observations	1282	1282	1282	747	54	1250
Mean-of-measurement	22.57	21.39	20.21	21.36	19.92	295.34
CV-measurements	24	21	17	17	13	22
CV-simulations	29	21	19	19	15	22
RMSE	3.17	2.65	2.73	2.53	1.32	25.79
rRMSE (%)	14.03	12.40	13.51	11.84	6.61	8.73
pRMSEs	0.01	0.13	0.07	0.06	0.01	0.05
pRMSEu	0.99	0.87	0.93	0.94	0.99	0.96
Mean-difference (M)	-0.18	-0.80	0.15	0.41	-0.11	-1.66
Relative error (%)	-0.47	-4.36	0.02	1.57	-0.47	-1.02

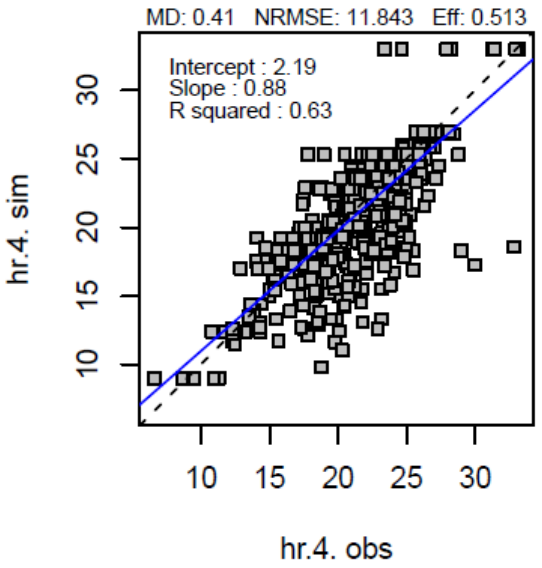
Comments:

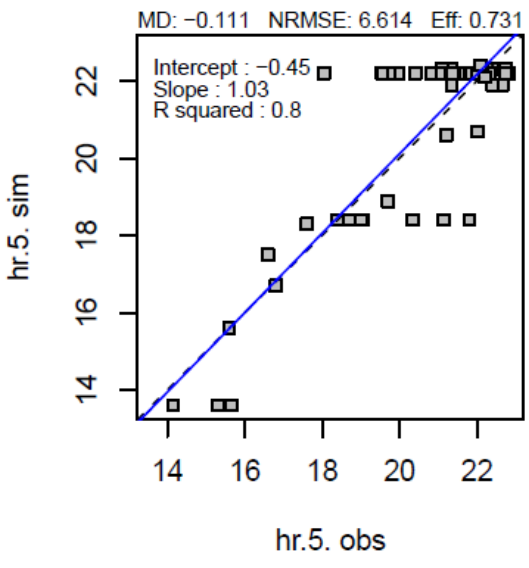
- Scatter plots, R^2 and efficiency values show slightly better performances for near surface layers than for deep layers (although RMSE and rRMSE and slightly larger).
- The presence of groups of distinct observed values with the same simulated value is related to the nature of the model: as soil water content cannot exceed field capacity, observations above field capacity are represented by the same constant value (equal to field capacity of the layer).
- Globally, simulated variability in soil water content is similar to observed variability.

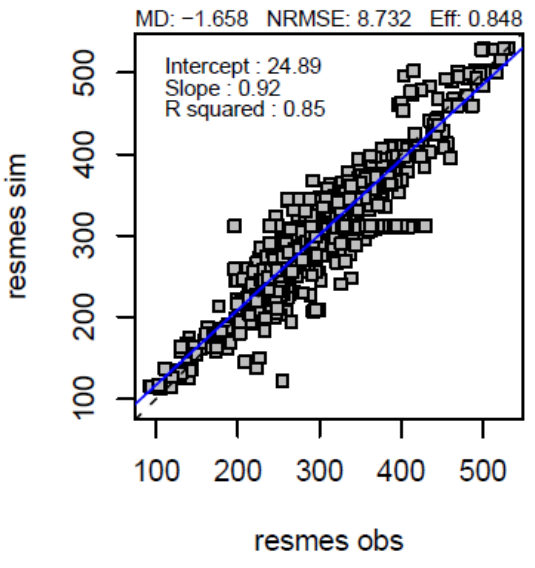

MD: −0.179 NRMSE: 14.033 Eff: 0.663
Intercept : −0.91
Slope : 1.05
R squared : 0.77
hr.1. sim
hr.1. obs


MD: −0.798 NRMSE: 12.396 Eff: 0.659
Intercept : 3.33
Slope : 0.88
R squared : 0.72
hr.2. sim
hr.2. obs


MD: 0.146 NRMSE: 13.511 Eff: 0.393
Intercept : 3.84
Slope : 0.8
R squared : 0.53
hr.3. sim
hr.3. obs


MD: 0.41 NRMSE: 11.843 Eff: 0.513
Intercept : 2.19
Slope : 0.88
R squared : 0.63
hr.4. sim
hr.4. obs


MD: −0.111 NRMSE: 6.614 Eff: 0.731
Intercept : −0.45
Slope : 1.03
R squared : 0.8
hr.5. sim
hr.5. obs


MD: −1.658 NRMSE: 8.732 Eff: 0.848
Intercept : 24.89
Slope : 0.92
R squared : 0.85
resmes sim
resmes obs

Soil Mineral Nitrogen (kgN/Ha)

	aznit.1.	aznit.2.	aznit.3.	aznit.4.	aznit.5.	azomes
number-of-usm	347	347	347	244	9	340
number-of-observations	1312	1312	1312	776	54	1280
Mean-of-measurement	32.79	25.25	21.52	19.44	19.81	89.53
CV-measurements	85	72	77	72	71	59
CV-simulations	85	70	77	67	75	56
RMSE	20.57	14.72	10.35	8.04	7.26	31.87
rRMSE (%)	62.72	58.29	48.12	41.38	36.63	35.60
pRMSEs	0.07	0.18	0.20	0.22	0.29	0.12
pRMSEu	0.93	0.82	0.80	0.79	0.71	0.88
Mean-difference (M)	-3.46	-0.58	1.70	0.69	2.69	-1.73
Relative error (%)	-35.93	-30.09	-10.48	-9.01	-45.61	-15.38

Comments:

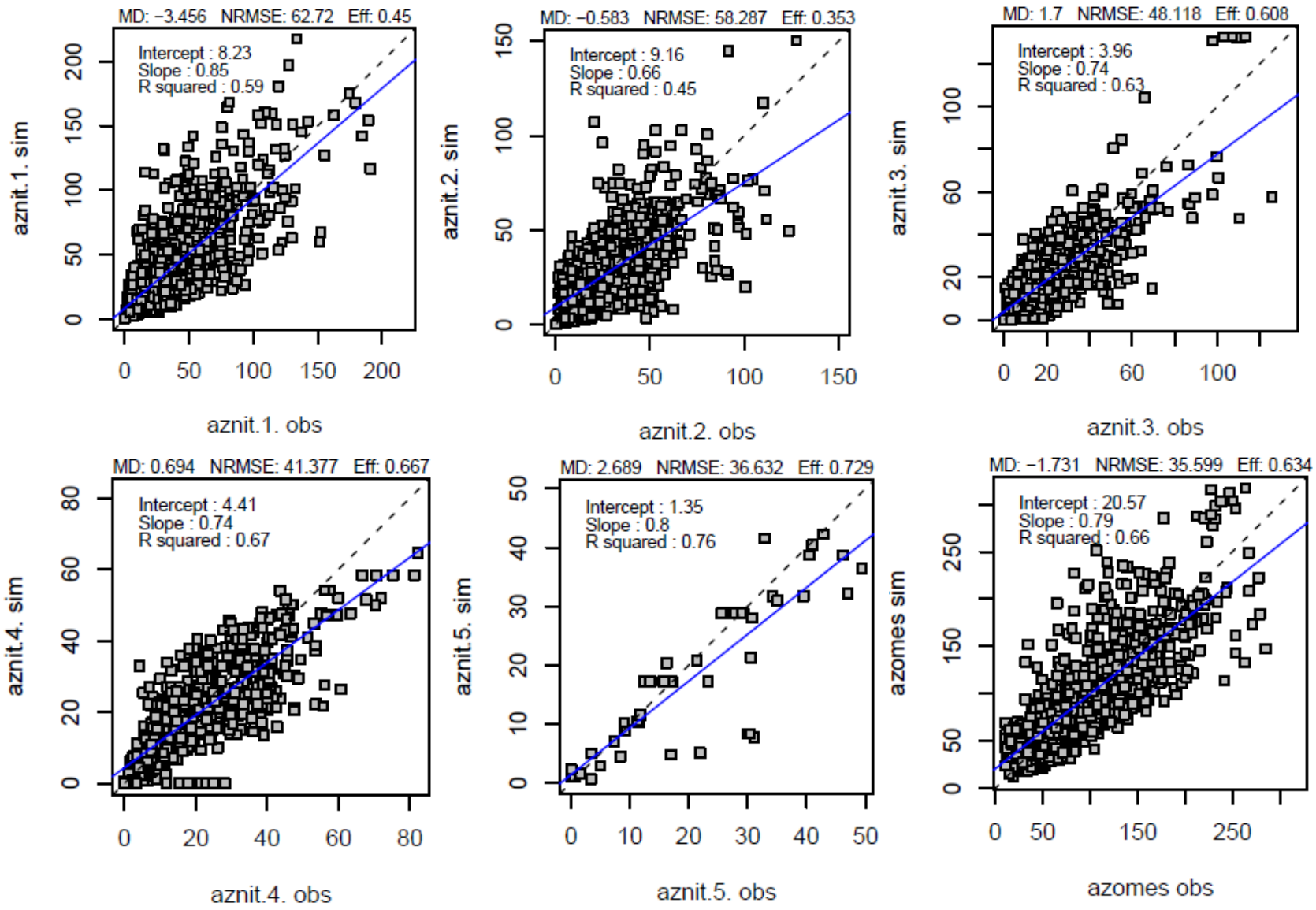
In addition to the general comments:

- Performances are better for deep layers than for near surface layers.
- Total variability of observed values is well simulated.
- Simulated values are globally underestimated (cf. relative errors and scatter plots).

Performances obtained when excluding the 131 usms used for *gmin1* calibration are globally comparable to the ones obtained with the full dataset:

	aznit.1.	aznit.2.	aznit.3.	aznit.4.	aznit.5.	azomes
RMSE	15.10	14.21	7.95	4.52	2.09	22.79
rRMSE (%)	71.24	80.66	63.66	51.79	37.57	43.17

RMSEs are even lower but relative RMSEs are higher since the mean of measurements significantly decreased. These differences however reflect more the change in the structure and range of the dataset than a difference between calibration and evaluation performances. Indeed, the 131 usms used for mineralization calibration were specifically chosen on the basis of being longer than 100 days and having numerous measurements per variable (>8), and they include the large majority of observations.

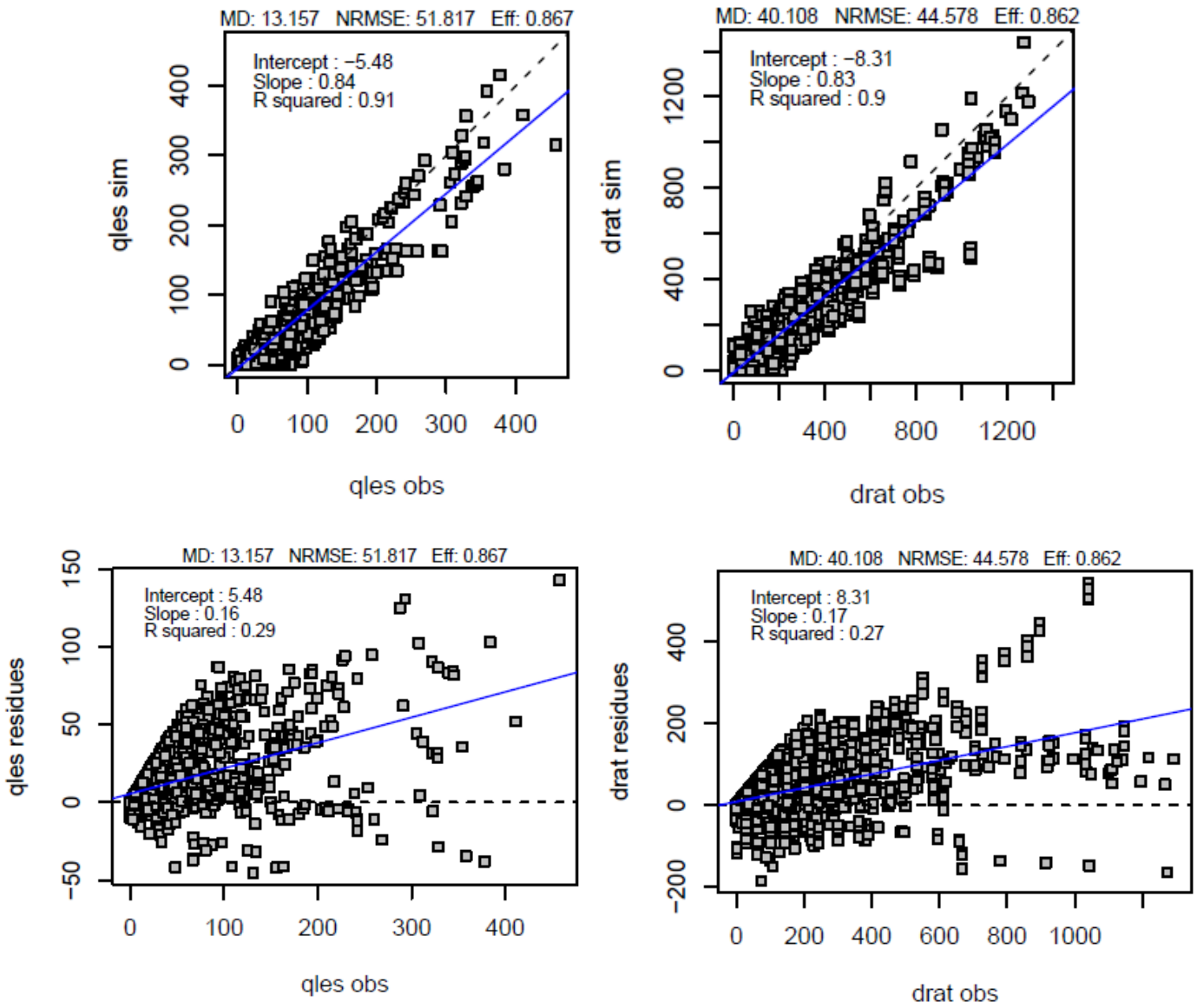

MD: −3.456 NRMSE: 62.72 Eff: 0.45
Intercept : 8.23
Slope : 0.85
R squared : 0.59
aznit.1. sim
aznit.1. obs
MD: −0.583 NRMSE: 58.287 Eff: 0.353
Intercept : 9.16
Slope : 0.66
R squared : 0.45
aznit.2. sim
aznit.2. obs
MD: 1.7 NRMSE: 48.118 Eff: 0.608
Intercept : 3.96
Slope : 0.74
R squared : 0.63
aznit.3. sim
aznit.3. obs
MD: 0.694 NRMSE: 41.377 Eff: 0.667
Intercept : 4.41
Slope : 0.74
R squared : 0.67
aznit.4. sim
aznit.4. obs
MD: 2.689 NRMSE: 36.632 Eff: 0.729
Intercept : 1.35
Slope : 0.8
R squared : 0.76
aznit.5. sim
aznit.5. obs
MD: −1.731 NRMSE: 35.599 Eff: 0.634
Intercept : 20.57
Slope : 0.79
R squared : 0.66
azomes sim
azomes obs

Drainage (mm/usm) and N Leaching (kgN/ha/usm)

	qles	drat
number-of-usm	369	369
number-of-observations	1938	1938
Mean_of_measurement	46.91	188.25
CV-measurements	142	120
CV-simulations	173	134
RMSE	24.31	83.92
rRMSE (%)	51.82	44.58
pRMSEs	0.50	0.44
pRMSEu	0.51	0.56
Mean-difference (M)	13.16	40.11
Relative error (%)	-16.62	-77.62

Comments:

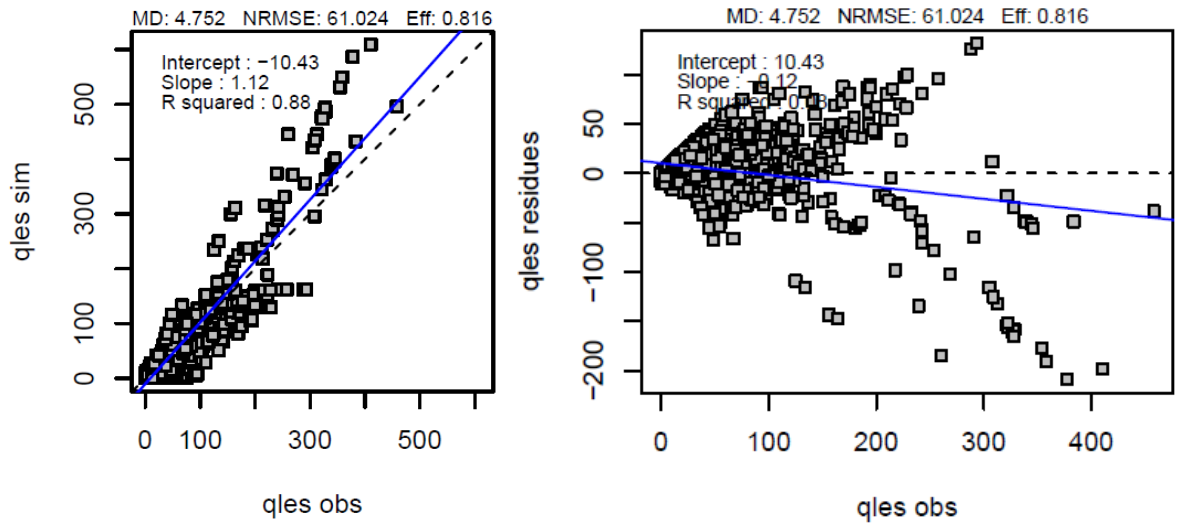
- The systematic part of error is about half of RMSE. The global tendency is an underestimation of observed values, which seems consistent with the tendency to underestimate mineral nitrogen content. Mean-differences and Relative errors show opposite signs, which may be due to a more pronounced underestimation for large values (> 200). Dependence of bias on drainage or leaching was however significantly improved with respect to previous STICS version 8.5.0, for which high values were systematically overestimated contrary to low values (cf. graph in annex).
- The total variability of observed values is correctly simulated although a bit underestimated for both variables.


MD: 13.157 NRMSE: 51.817 Eff: 0.867
Intercept : −5.48
Slope : 0.84
R squared : 0.91
qles sim
qles obs
MD: 40.108 NRMSE: 44.578 Eff: 0.862
Intercept : −8.31
Slope : 0.83
R squared : 0.9
drat sim
drat obs
MD: 13.157 NRMSE: 51.817 Eff: 0.867
Intercept : 5.48
Slope : 0.16
R squared : 0.29
qles residues
qles obs
MD: 40.108 NRMSE: 44.578 Eff: 0.862
Intercept : 8.31
Slope : 0.17
R squared : 0.27
drat residues
drat obs

Conclusion

When considering the whole dataset, the results are satisfactory both in term of performances and evolution compared to the previous STICS version. Next step will be to extend the analysis with activation of the nitrification and denitrification options which will be the default in the future.

Annex



Simulated values and residues versus observed values for variable *qles*, obtained with STICS version 8.50