This supplementary material has 3 sections:

S1. Additional results of field studies for validation

S2. Selection and validation of average hydrological condition “Ave”

S3. Additional results of soil crop experiments to analyse the role of upward flow

S1. Additional results of field studies for validation

See the text of the article for an explanation of the references to the cases

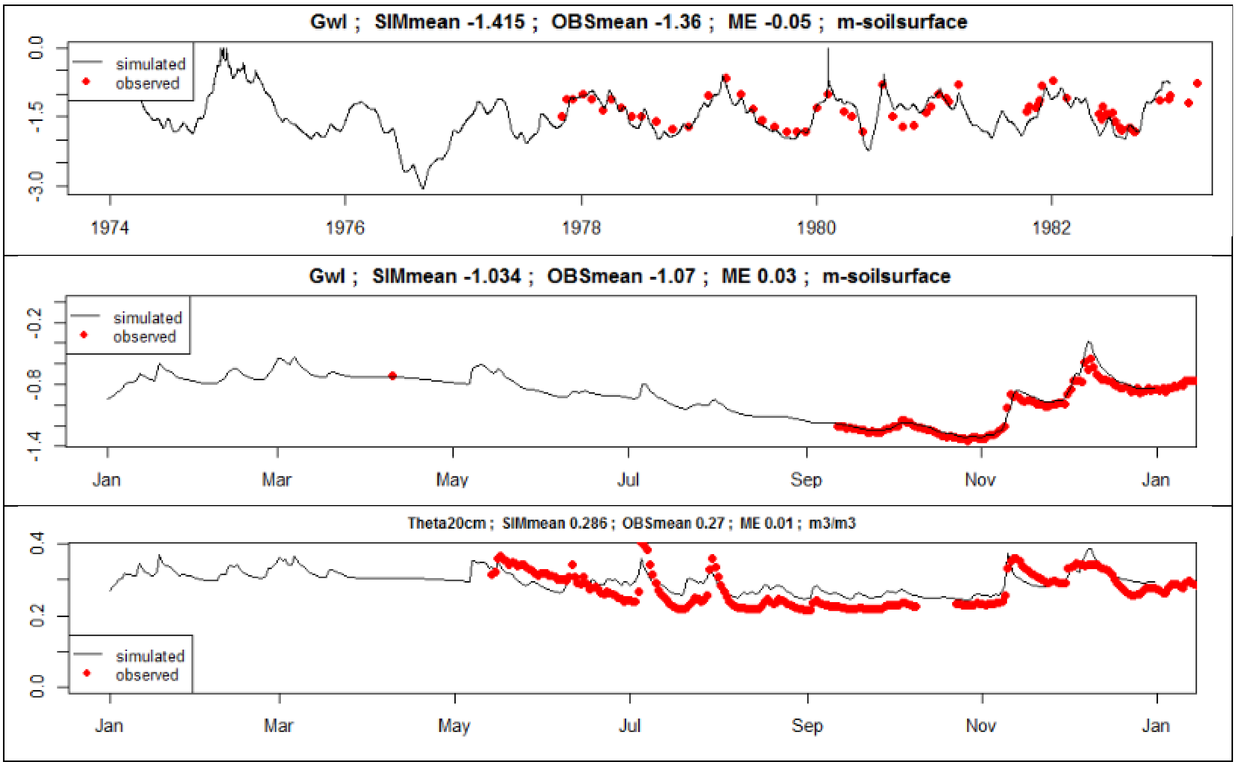

Figure S1. Results of case studies for silage maize:

- *top figure = groundwater levels (Gwl in m-soil surface) case C-Maize;*
- *middle figure = groundwater levels (Gwl in m-soil surface) case D-Maize;*
- *bottom figure = theta (Theta20cm in $m^3.m^{-3}$) at a depth of 20 cm-soil surface case D-Maize.*

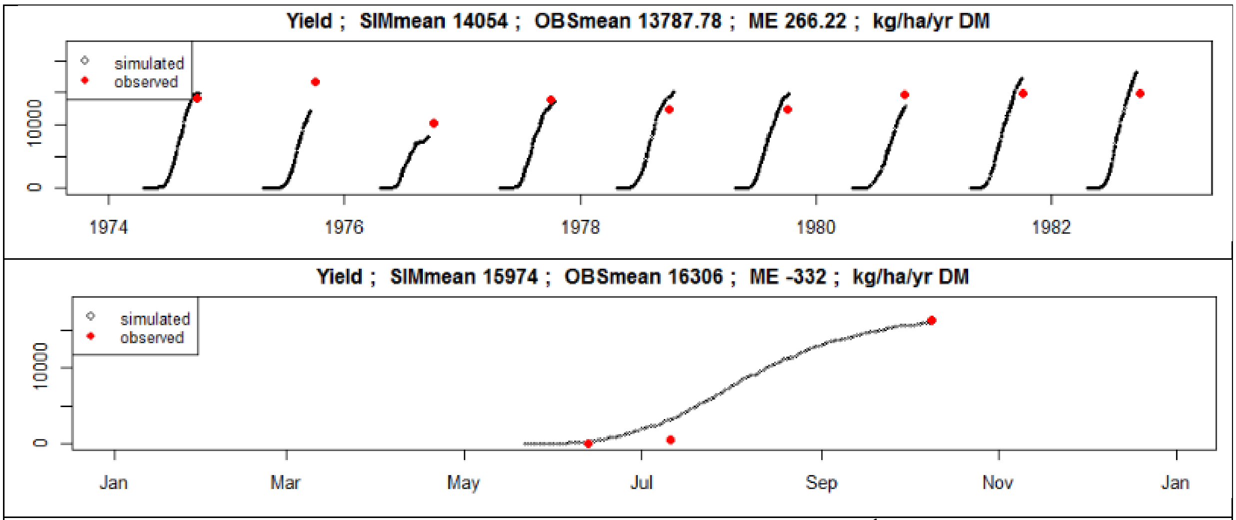

Figure S2. Results of case studies for silage maize: Yields (kg.ha^{-1}DM) Observed as red dots and Simulated above ground biomass as black dots.

- *top figure = case C-Maize;*
- *bottom figure = case D-Maize.*

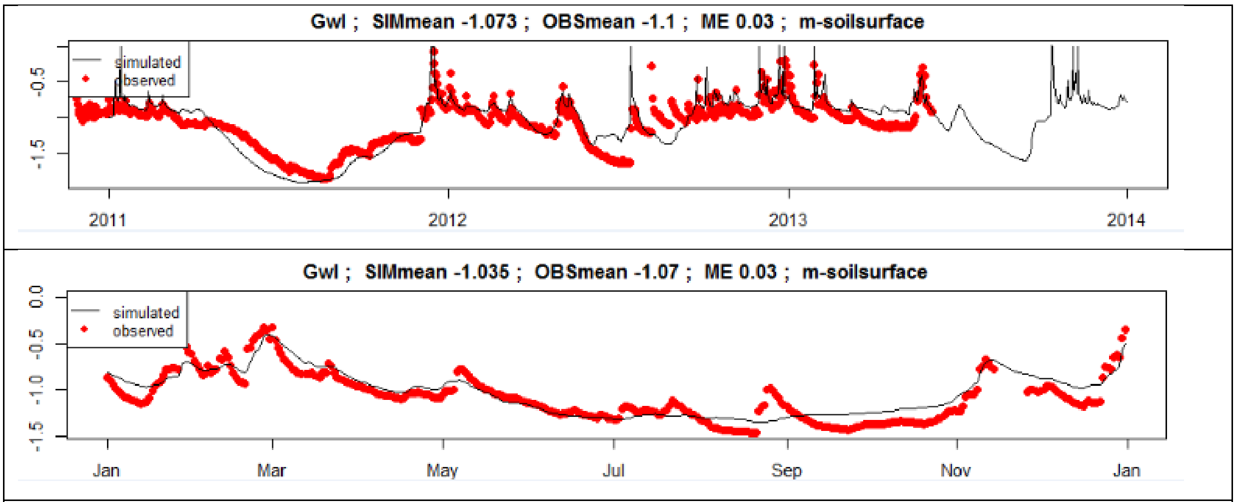

Figure S3. Results of case studies for potato:

- *top figure = groundwater levels (Gwl in m-soil surface) case R-potato;*
- *bottom figure = groundwater levels (Gwl in m-soil surface) case V-Potato.*

S2. Selection and validation of average hydrological condition "Ave"

This section describes how we found the average hydrological condition "Ave".

We selected units from the National Study (Van Bakel et al., 2008) which has 3 types of land use (grassland, arable crops (potatoes) and forage maize) distributed over 12 groundwater classes (Gt in Table S1). From these groundwater classes the class IV may be regarded as an average class. From this average class IV we selected boundary conditions from large plot numbers 2245, 3859 and 621 for grassland, maize and potatoes (Table S2), which are units with sizes of respectively 1806, 794 and 5812 ha.

Resulting groundwater levels were verified for grassland (Figure S4), forage maize (Figure S5) and potatoes (Figure S6).

Table S1. Groundwater classes (Gt) on the national soil map 1:50.000 of The Netherlands with their mean highest (GHG) and mean lowest (GLG) groundwater levels (in cm below the soil surface) and their agricultural land areas (1000 ha) according to the soil map and the model system applied by Van Bakel, 2008).

Groundwater class			Agricultural land area (1000 ha)			
Gt	GHG (cm)	GLG (cm)	Grassland	Maize	Arable	Total
I	-	<50	52	0	1	54
II	-	50-80	155	6	7	168
III	<40	80-120	125	16	15	157
IV	>40	80-120	66	18	74	157
V	<40	>120	117	18	14	150
VI	40-80	>121	286	72	275	633
VII	>80	>122	183	91	360	635
Total			984	221	746	1952

Table S2 Calculation units of which boundary conditions for the average situation were taken from the national study (Van Bakel et al., 2008).

Gt	landuse	plot nrs	area (ha)	soiltype
IV	grassland	2245	1806	sand
IV	silage maize	3859	794	sand
IV	potato	621	5812	sand

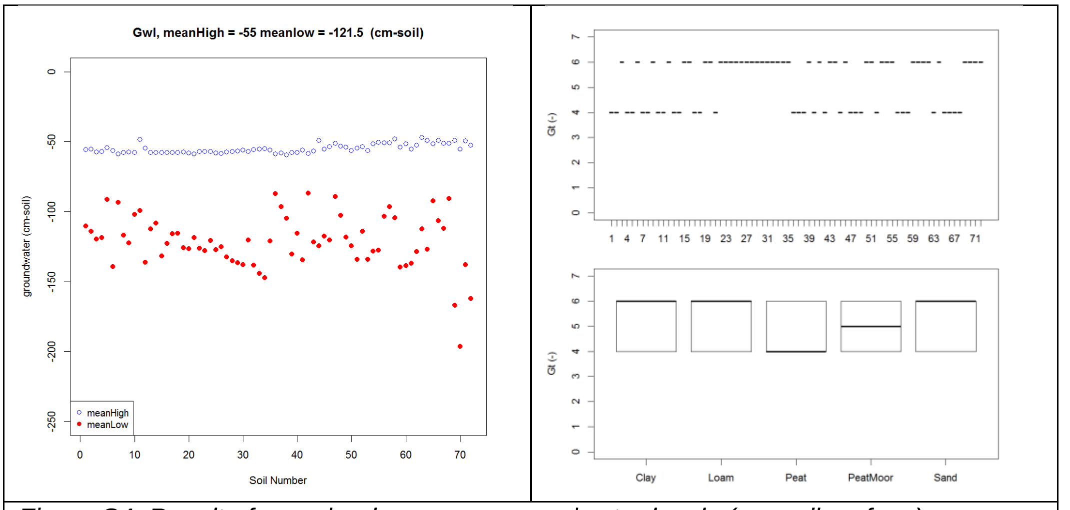

Figure S4. Result of grassland: average groundwater levels (cm-soil surface) characterized for each soil unit by mean highest and lowest groundwater levels(left) and by groundwater class (right).

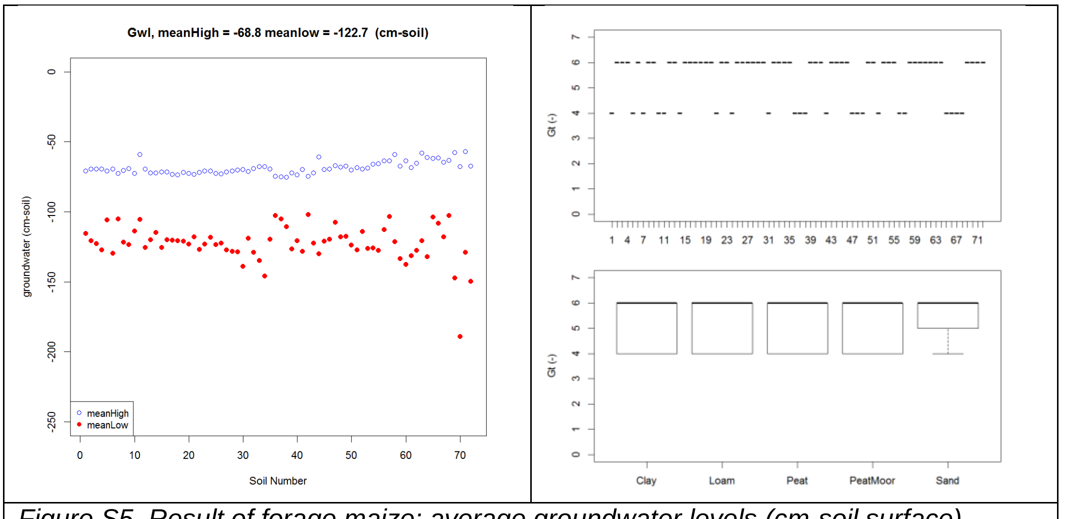

Figure S5. Result of forage maize: average groundwater levels (cm-soil surface) characterized for each soil unit by mean highest and lowest groundwater levels(left) and by groundwater class (right).

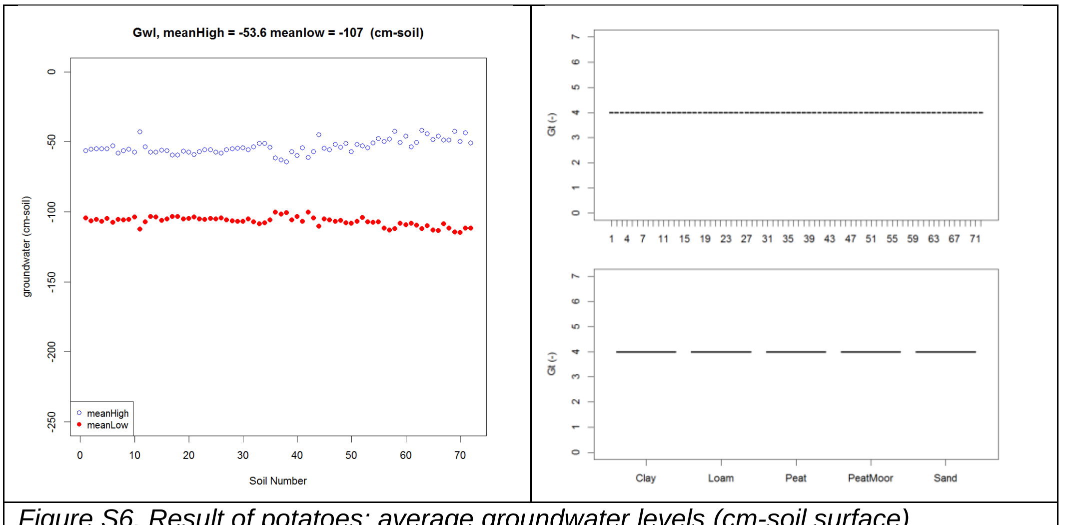

Figure S6. Result of potatoes: average groundwater levels (cm-soil surface) characterized for each soil unit by mean highest and lowest groundwater levels(left) and by groundwater class (right).

S3. Additional results of soil crop experiments to analyse the role of upward flow

This section presents results of the 3 hydrological conditions:

- FD_{nc}: Free Drainage without recirculation across bottom of rootzone
- FD_{rc}: Free Drainage with recirculation across bottom of rootzone
- Ave: Average fluctuating groundwater level

The capillary rise presented in Figures S7-S12 is always the upward flux across the bottom of the rootzone. For the condition FD_{rc} this upward flux is the recirculation flux caused by root extraction that moves percolating water upward. See the main text and figures for an explanation of hydrological conditions and corresponding fluxes.

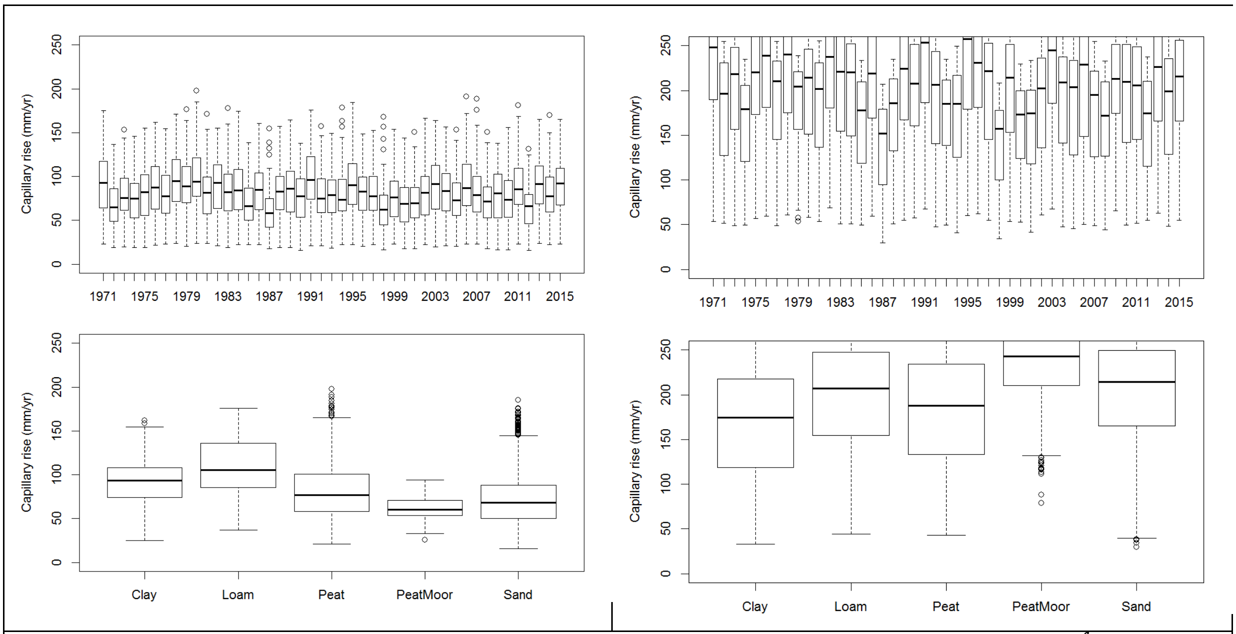

*Figure S7 . Results of soil-crop experiment for **grassland: Upward flux** (mm.crop season^{-1}) for conditions FD_{rc} (left) and Ave (right);*
Upper figures: results for all 72 soils for the period 1971-2015;
Lower figures: results as boxplots for clustered soil types.

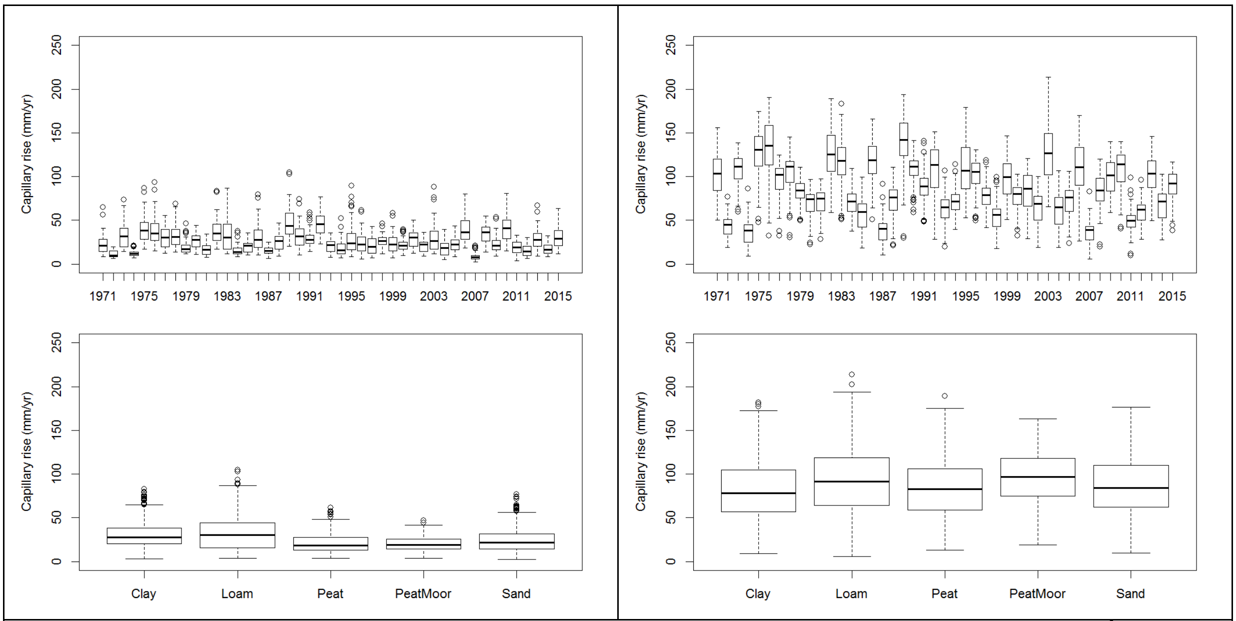

*Figure S8. Results of soil-crop experiment for **silage maize: Upward flux** (mm.crop season^{-1}) for conditions FD_{rc} (left) and Ave (right); Upper figures: results for all 72 soils for the period 1971-2015.*
Lower figures: results as boxplots for clustered soil types

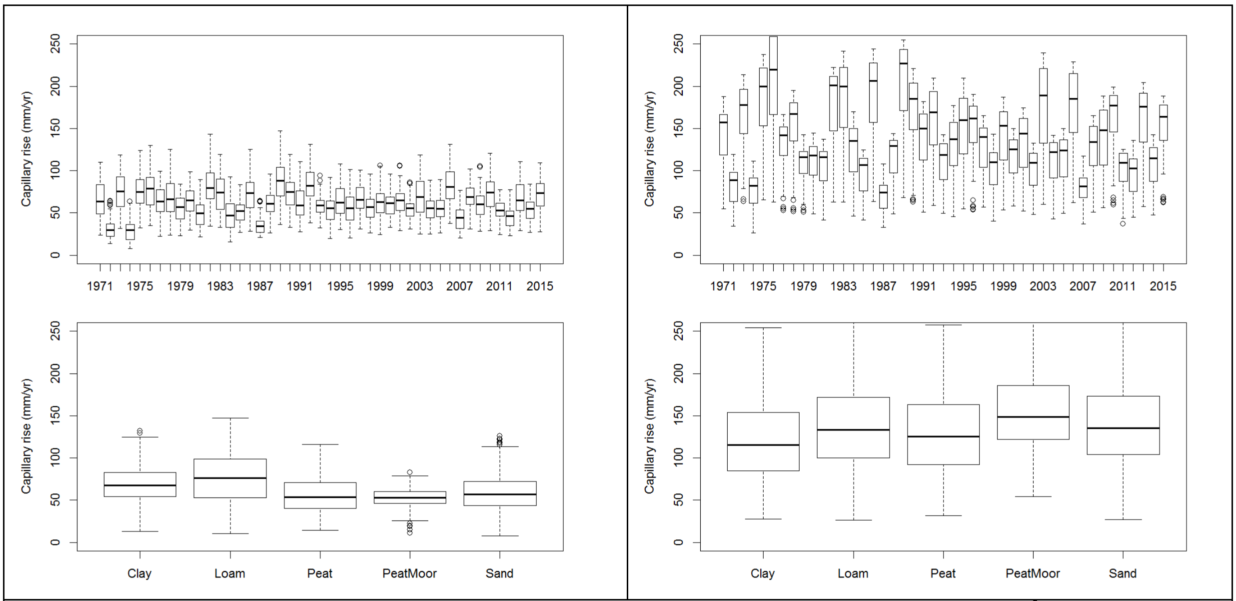

Figure S9. Results of soil-crop experiment for ***potato: Upward flux*** *(mm.crop season^{-1}) for conditions FD_{rc} (left) and Ave (right); Upper figures: results for all 72 soils for the period 1971-2015. Lower figures: results as boxplots for clustered soil types*

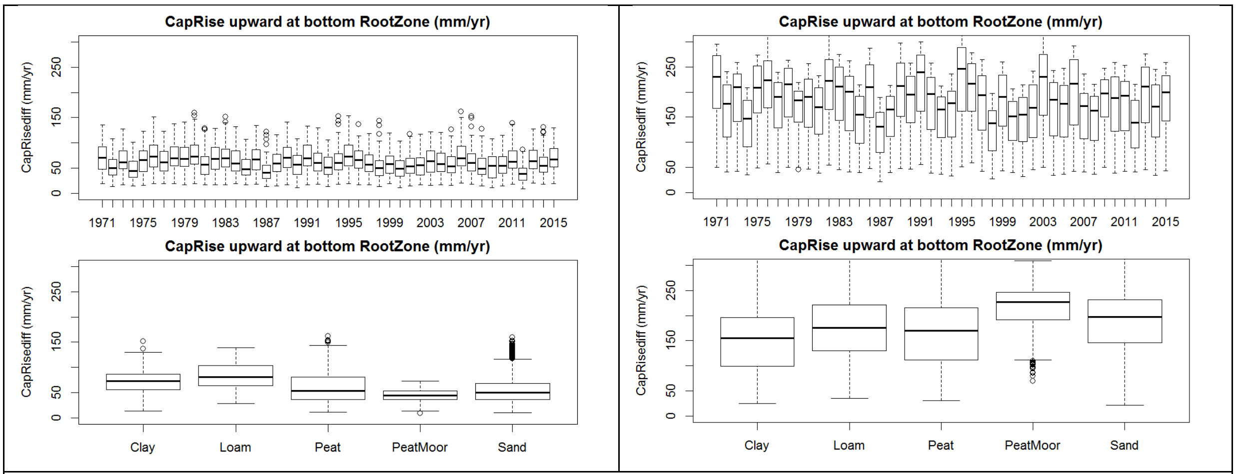

Figure S10. Results of soil-crop experiment for **grassland: difference in Upward flux** (mm.crop season[-1]) between conditions FD_{nc} and FD_{rc} (left) and between conditions FD_{nc} and Ave (right); Upper figures: results for all 72 soils for the period 1971-2015. Lower figures: results as boxplots for clustered soil types

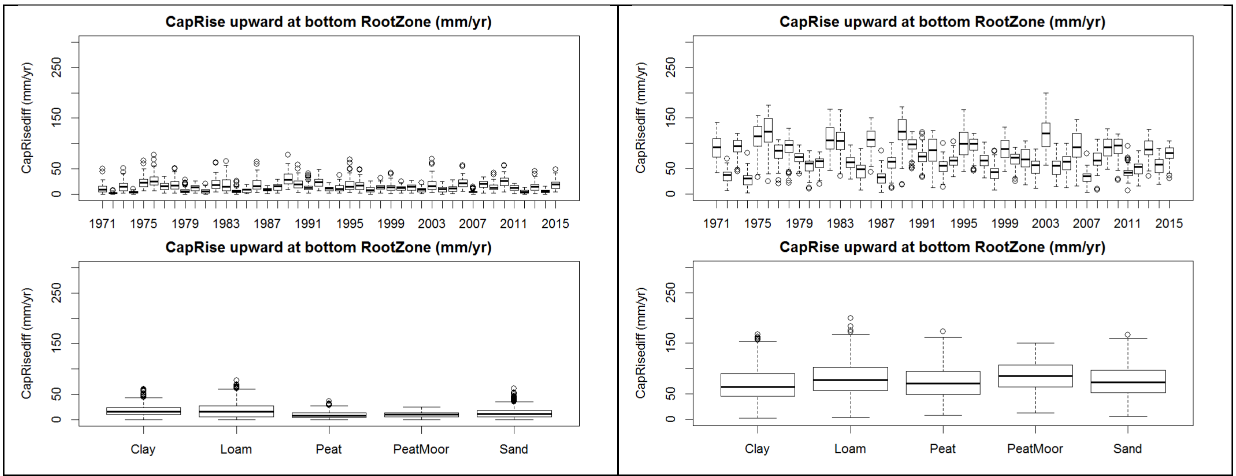

Figure S11. Results of soil-crop experiment for **silage maize: difference in Upward flux** (mm.crop season[-1]) between conditions FD_{nc} and FD_{rc} (left) and between conditions FD_{nc} and Ave (right); Upper figures: results for all 72 soils for the period 1971-2015. Lower figures: results as boxplots for clustered soil types

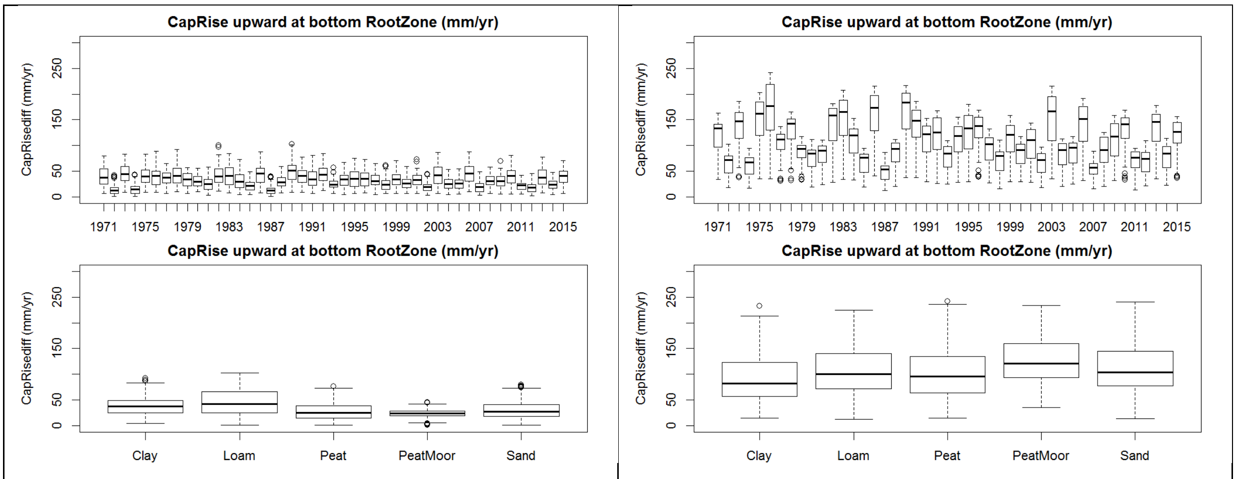

Figure S12. Results of soil-crop experiment for **potato: difference in Upward flux** (mm.crop season[-1]) between conditions FD_{nc} and FD_{rc} (left) and between conditions FD_{nc} and Ave (right); Upper figures: results for all 72 soils for the period 1971-2015. Lower figures: results as boxplots for clustered soil types

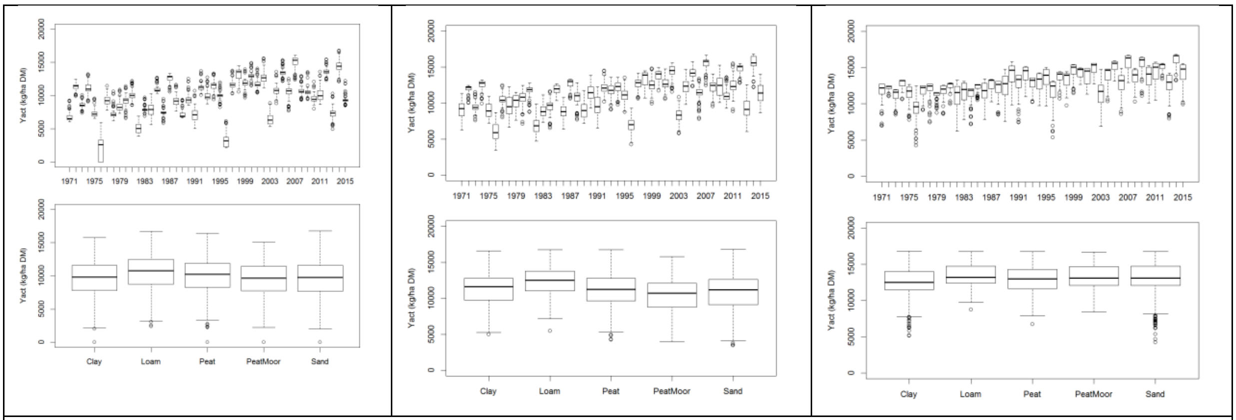

*Figure 13. Results of soil-crop experiment for **grassland: Yield** (kg/ha) for hydrological conditions FD_{nc} (left), FD_{rc} (center) and Ave (right);*
Upper figures: results for all 72 soils for the period 1971-2015;
Lower figures: results as boxplots for clustered soil types.

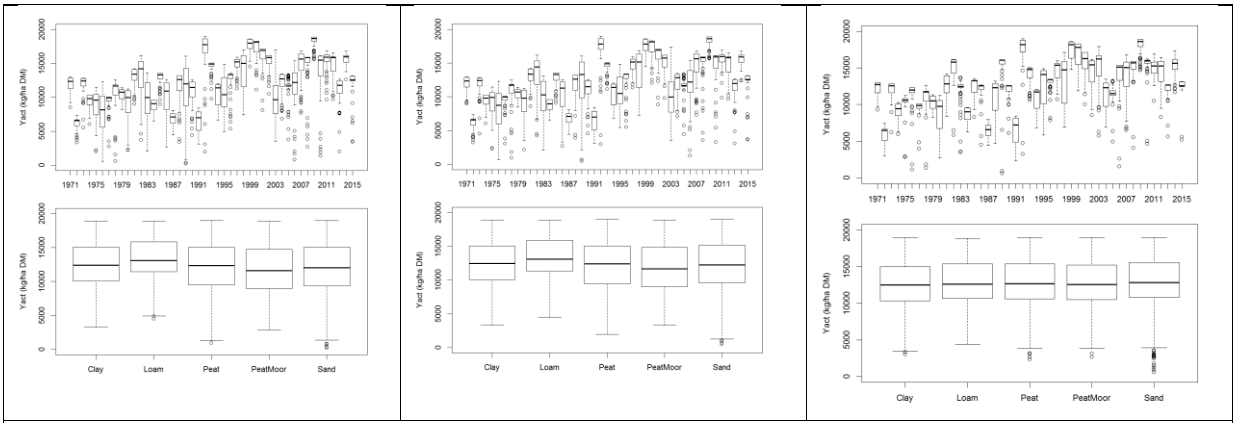

*Figure S14. Results of soil-crop experiment for **silage maize: Yield** (kg/ha) for hydrological conditions FD_{nc} (left), FD_{rc} (center) and Ave (right);*
Upper figures: results for all 72 soils for the period 1971-2015;
Lower figures: results as boxplots for clustered soil types.

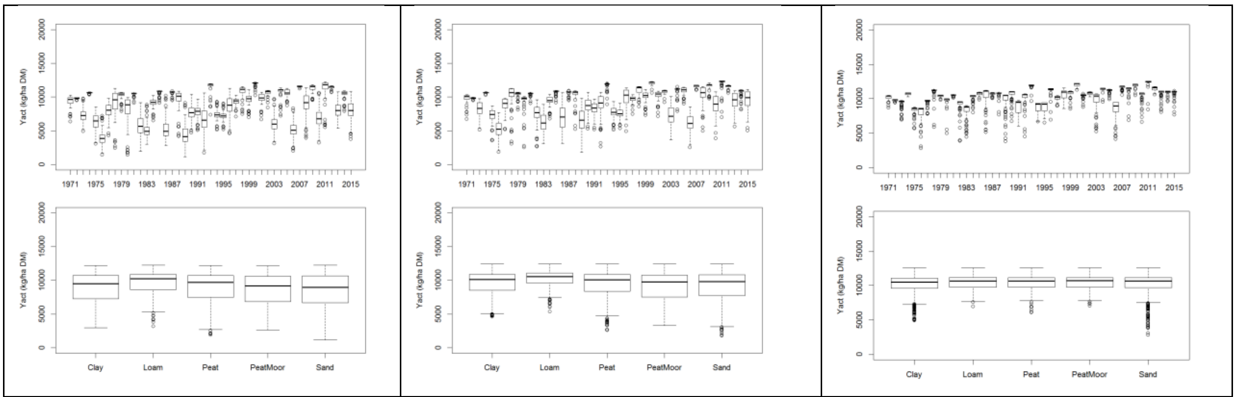

*Figure S15. Results of soil-crop experiment for **potato: Yield** (kg/ha) for hydrological conditions FD_{nc} (left), FD_{rc} (center) and Ave (right);*
Upper figures: results for all 72 soils for the period 1971-2015;
Lower figures: results as boxplots for clustered soil types.

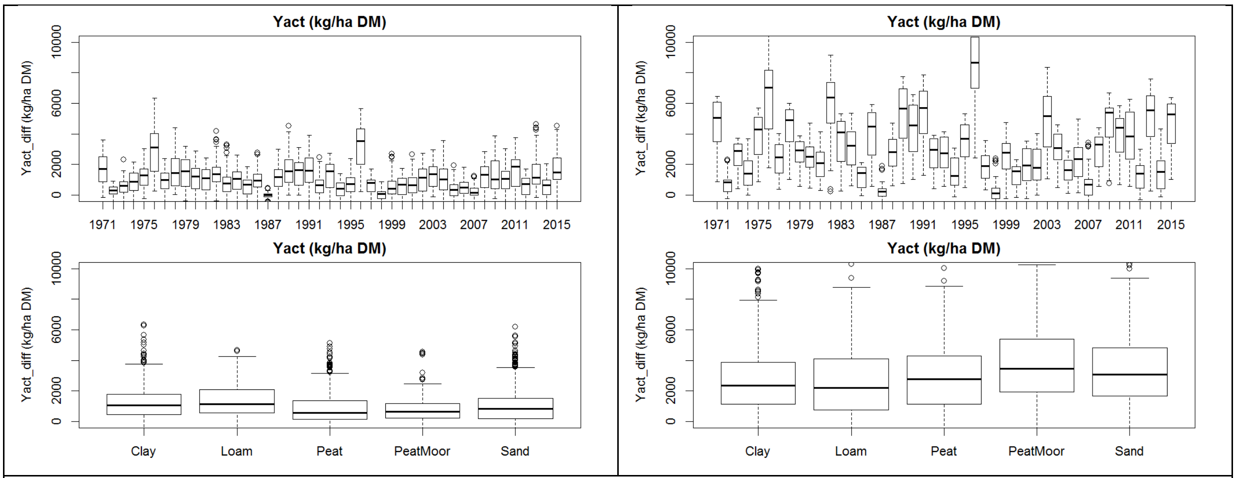

Figure S16. Results of soil-crop experiment for ***grassland: difference in Yield*** *(kg/ha) between conditions ($FD_{rc} – FD_{nc}$) (left) and conditions ($Ave – FD_{nc}$) (right);*
Upper figures: results for all 72 soils for the period 1971-2015;
Lower figures: results as boxplots for clustered soil types.

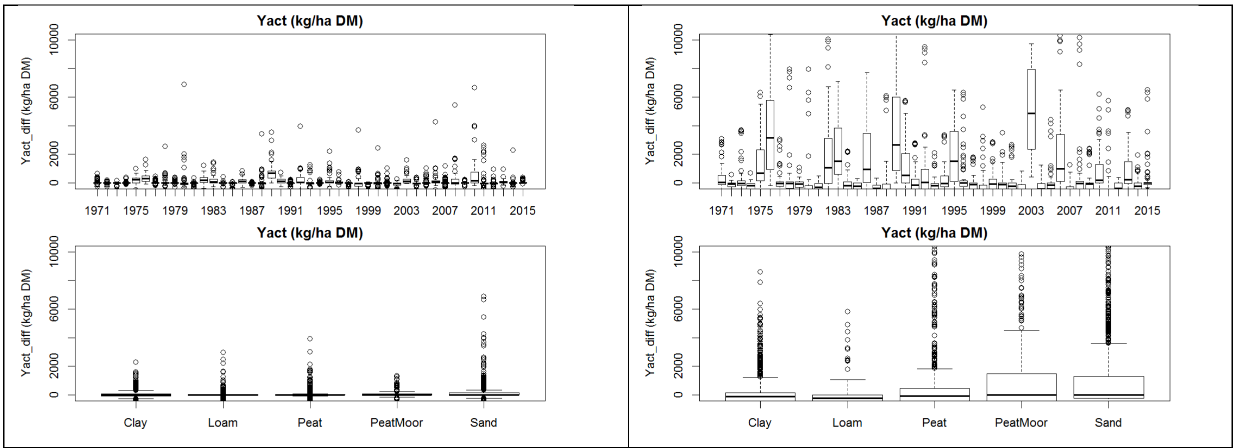

Figure S17. Results of soil-crop experiment for ***silage maize: difference in Yield*** *(kg/ha) between conditions b – a ($FD_{CR} – FD_{NC}$) (left) and conditions c – a ($Ave – FD_{NC}$) (right);*
Upper figures: results for all 72 soils for the period 1971-2015;
Lower figures: results as boxplots for clustered soil types.

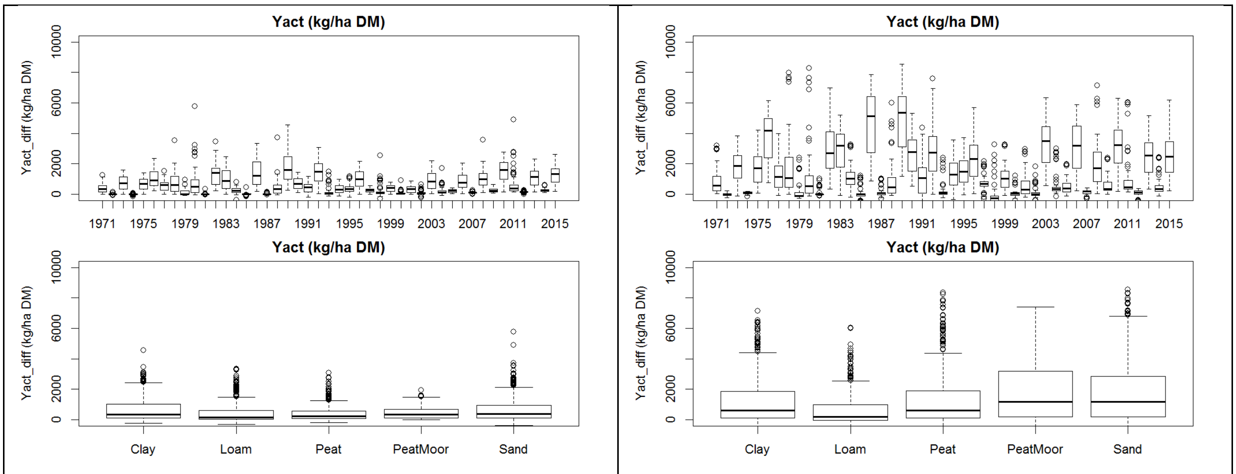

Figure S18. Results of soil-crop experiment for ***potato: difference in Yield*** *(kg/ha) between conditions b – a ($FD_{CR} – FD_{NC}$) (left) and conditions c – a ($Ave – FD_{NC}$) (right);*
Upper figures: results for all 72 soils for the period 1971-2015;
Lower figures: results as boxplots for clustered soil types.

The water balances of the soil profiles (0 - 5.5 meter) are given in table S3.

Table S3 The average water balances of the soil-crop-experiments for 3 different hydrological boundary conditions (hydrCond). Water balance terms in mm/year.

crop	hydrCond	Prec	q_inf	q_seep	Ta	Ei	Es	q_drain	q_leach	dstorage
grass	FDnc	815	0	0	342	39	131	0	302	1
	FDrc	815	0	0	389	41	126	0	259	1
	Ave	815	3	227	447	44	123	430	0	3
maize	FDnc	815	0	0	251	16	166	0	381	1
	FDrc	815	0	0	253	16	166	0	380	1
	Ave	815	0	155	259	16	167	526	0	2
potato	FDnc	815	0	0	234	22	134	0	423	2
	FDrc	815	0	0	251	24	132	0	407	1
	Ave	815	22	291	274	24	133	696	0	2

References

Van Bakel, P.J.T., Massop, H.Th.L., Kroes, J.G., Hoogewoud, J., Pastoors, R., Kroon, T., 2008. Actualisatie Hydrologie voor STONE 2.3; Aanpassing randvoorwaarden en parameters, koppeling tussen NAGROM en SWAP, en plausibiliteitstoets. (Eng: Updating the hydrology component in STONE 2.3; Adjusting boundary conditions and parameters, linking NAGROM and SWAP, and plausibility test). WOt-rapport 57. Wettelijke Onderzoekstaken Natuur & Milieu (MNP), Alterra, Wageningen, The Netherlands.