



Supplement of

The value of ASCAT soil moisture and MODIS snow cover data for calibrating a conceptual hydrologic model

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Supplementary

	0 _Q	O _{SM}	0 _{sc}								
А	-0.11 0.16 0.18 0.15 0.22 0.22 0.21 0.20 0.21 0.19 0.21	-0.11 -0.17 -0.17 -0.18 -0.19 -0.22 -0.21 -0.21 -0.20 -0.19 -0.22	0.11 0.12 0.15 0.19 0.19 0.20 0.20 0.20 0.20 0.20 0.21								
MELE	0.06 -0.13 0.20 0.35 0.48 0.55 0.59 0.59 0.64 0.64 0.65	-0.60 -0.63 -0.65 -0.66 -0.67 -0.62 -0.66 -0.64 -0.65 -0.69 -0.73	-0.89 -0.86 -0.81 -0.79 -0.79 -0.79 -0.80 -0.79 -0.80 -0.81 -0.81								
MiELE	0.07 -0.19 0.11 0.26 0.37 0.42 0.47 0.47 0.49 0.51 0.51	-0.46 -0.46 -0.48 -0.49 -0.49 -0.42 -0.48 -0.44 -0.46 -0.50 -0.54	-0.86 -0.82 -0.79 -0.79 -0.79 -0.79 -0.80 -0.78 -0.79 -0.79 -0.80								
MxELE	0.02 -0.08 0.21 0.34 0.46 0.53 0.57 0.57 0.61 0.60 0.61	-0.69 -0.73 -0.75 -0.75 -0.77 -0.75 -0.77 -0.76 -0.76 -0.80 -0.83	-0.76 -0.73 -0.67 -0.64 -0.63 -0.64 -0.64 -0.64 -0.65 -0.66 -0.67								
ER	-0.01 -0.02 0.21 0.30 0.42 0.48 0.50 0.50 0.55 0.53 0.54	-0.66 -0.71 -0.72 -0.72 -0.75 -0.74 -0.75 -0.75 -0.75 -0.77 -0.80	-0.58 -0.57 -0.50 -0.47 -0.45 -0.46 -0.46 -0.46 -0.48 -0.49 -0.49								
RI	0.07 -0.18 0.14 0.29 0.41 0.46 0.51 0.49 0.55 0.55 0.55	-0.72 -0.73 -0.74 -0.74 -0.75 -0.73 -0.74 -0.75 -0.75 -0.79 -0.82	-0.82 -0.81 -0.78 -0.76 -0.76 -0.76 -0.76 -0.76 -0.77 -0.77 -0.78								
SL	0.09 -0.12 0.16 0.26 0.32 0.34 0.32 0.34 0.35 0.38 0.38	-0.10 -0.10 -0.12 -0.13 -0.12 -0.08 -0.09 -0.09 -0.11 -0.12 -0.17	-0.54 -0.52 -0.56 -0.55 -0.56 -0.56 -0.56 -0.55 -0.55 -0.55 -0.55								
MGR	-0.21 0.12 0.25 0.29 0.27 0.27 0.26 0.28 0.26 0.27 0.26	-0.17 -0.21 -0.23 -0.26 -0.25 -0.23 -0.24 -0.23 -0.22 -0.22 -0.20	-0.13 -0.08 -0.03 -0.02 0.00 -0.01 -0.02 0.00 -0.01 -0.02 -0.03								
SDGR	0.05 -0.16 0.20 0.31 0.42 0.46 0.51 0.50 0.54 0.53 0.54	-0.74 -0.74 -0.75 -0.75 -0.75 -0.73 -0.75 -0.75 -0.74 -0.78 -0.80	-0.73 -0.71 -0.70 -0.67 -0.67 -0.67 -0.66 -0.66 -0.67 -0.67 -0.68								
FP	-0.13 -0.18 -0.13 -0.05 -0.09 -0.14 -0.13 -0.17 -0.16 -0.18 -0.21	-0.49 -0.47 -0.43 -0.43 -0.40 -0.44 -0.42 -0.44 -0.43 -0.38 -0.35	0.18 0.18 0.12 0.10 0.10 0.11 0.12 0.12 0.11 0.10 0.10								
AP	0.01 0.24 -0.06 -0.21 -0.28 -0.30 -0.36 -0.33 -0.38 -0.37 -0.37	0.79 0.79 0.77 0.77 0.77 0.75 0.76 0.76 0.77 0.78 0.81	0.67 0.67 0.68 0.66 0.66 0.66 0.66 0.66 0.67 0.67 0.68								
MNDVI	-0.15 0.10 -0.14 -0.22 -0.36 -0.43 -0.47 -0.47 -0.51 -0.52 -0.54	0.29 0.30 0.33 0.33 0.34 0.26 0.32 0.28 0.31 0.35 0.41	0.84 0.81 0.77 0.76 0.76 0.77 0.78 0.78 0.77 0.77 0.77								
SDNDVI	-0.02 -0.04 0.14 0.20 0.34 0.42 0.46 0.47 0.52 0.52 0.55	-0.51 -0.54 -0.57 -0.57 -0.60 -0.56 -0.58 -0.58 -0.60 -0.64 -0.69	-0.66 -0.65 -0.57 -0.55 -0.54 -0.56 -0.56 -0.56 -0.57 -0.58 -0.58								
MAP	0.22 -0.28 -0.07 0.05 0.09 0.08 0.14 0.11 0.16 0.15 0.15	-0.51 -0.48 -0.44 -0.42 -0.41 -0.38 -0.38 -0.40 -0.41 -0.45 -0.47	-0.55 -0.55 -0.62 -0.64 -0.65 -0.65 -0.65 -0.66 -0.66 -0.66 -0.66								
SDAP	0.05 0.00 0.16 0.17 0.23 0.27 0.30 0.29 0.33 0.28 0.31	-0.58 -0.58 -0.58 -0.57 -0.58 -0.60 -0.58 -0.59 -0.59 -0.61 -0.62	-0.33 -0.35 -0.31 -0.28 -0.27 -0.28 -0.27 -0.28 -0.28 -0.28 -0.28 -0.28								
MAT	-0.09 0.11 -0.21 -0.36 -0.50 -0.57 -0.61 -0.61 -0.66 -0.66 -0.67	0.55 0.58 0.62 0.62 0.64 0.57 0.61 0.59 0.61 0.64 0.68	0.90 0.87 0.81 0.80 0.79 0.80 0.81 0.80 0.81 0.81 0.82								
SDAT	0.03 -0.02 0.20 0.27 0.41 0.48 0.51 0.51 0.57 0.56 0.57	-0.60 -0.64 -0.66 -0.66 -0.68 -0.67 -0.67 -0.68 -0.69 -0.73 -0.76	-0.69 -0.67 -0.59 -0.56 -0.56 -0.57 -0.57 -0.57 -0.58 -0.60 -0.60								
MEPI	-0.07 0.11 -0.21 -0.37 -0.50 -0.57 -0.60 -0.61 -0.65 -0.66 -0.67	0.54 0.57 0.61 0.62 0.63 0.57 0.61 0.58 0.60 0.63 0.67	0.89 0.85 0.80 0.78 0.78 0.79 0.79 0.78 0.79 0.80 0.80								
SDEPI	0.05 -0.08 0.20 0.29 0.42 0.48 0.51 0.51 0.56 0.55 0.56	-0.64 -0.67 -0.68 -0.68 -0.70 -0.67 -0.69 -0.69 -0.69 -0.73 -0.77	-0.72 -0.71 -0.66 -0.64 -0.63 -0.64 -0.64 -0.64 -0.65 -0.66 -0.66								
CAI	-0.17 0.23 -0.09 -0.26 -0.33 -0.35 -0.41 -0.39 -0.44 -0.45 -0.43	0.66 0.66 0.64 0.64 0.63 0.59 0.61 0.61 0.62 0.66 0.68	0.78 0.76 0.77 0.78 0.78 0.79 0.78 0.79 0.80 0.80 0.80								
SDAI	- 0.16 0.10 0.15 0.11 0.17 0.23 0.23 0.24 0.26 0.23 0.27	-0.32 -0.36 -0.39 -0.40 -0.42 -0.43 -0.42 -0.42 -0.42 -0.43 -0.45	-0.12 -0.13 -0.05 -0.01 0.01 0.01 0.01 0.02 0.01 0.00 0.00								
MTL0	0.09 -0.08 0.21 0.34 0.49 0.57 0.60 0.60 0.65 0.66 0.67	-0.51 -0.54 -0.58 -0.59 -0.60 -0.54 -0.58 -0.55 -0.57 -0.60 -0.65	-0.89 -0.85 -0.78 -0.77 -0.77 -0.78 -0.79 -0.78 -0.78 -0.79 -0.79								
MFC	0.13 -0.23 -0.08 0.05 0.02 -0.01 0.03 0.00 0.02 0.01 -0.01	-0.57 -0.53 -0.49 -0.48 -0.44 -0.45 -0.45 -0.47 -0.46 -0.44 -0.45	-0.26 -0.26 -0.31 -0.33 -0.33 -0.33 -0.32 -0.34 -0.34 -0.33 -0.34								
SDFC	-0.03 0.14 0.04 -0.04 -0.05 -0.06 0.02 0.00 0.02 -0.02 0.01	-0.24 -0.25 -0.25 -0.23 -0.23 -0.21 -0.24 -0.23 -0.24 -0.25 -0.28	-0.03 -0.04 0.01 0.03 0.05 0.04 0.05 0.04 0.04 0.04 0.04								
MKS	-0.01 -0.14 0.22 0.39 0.48 0.53 0.57 0.56 0.60 0.61 0.60	-0.70 -0.72 -0.73 -0.73 -0.73 -0.70 -0.73 -0.73 -0.74 -0.76 -0.79	-0.80 -0.78 -0.76 -0.73 -0.73 -0.73 -0.73 -0.72 -0.74 -0.74 -0.75								
SDKS	-0.09 0.17 0.31 0.28 0.26 0.25 0.28 0.28 0.27 0.27 0.27	-0.36 -0.38 -0.36 -0.35 -0.33 -0.33 -0.34 -0.34 -0.35 -0.37 -0.40	-0.17 -0.15 -0.15 -0.10 -0.07 -0.08 -0.07 -0.07 -0.07 -0.08 -0.09								
	0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,	0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 10	00 01 03 03 04 02 06 03 04 08 10								
	W _Q (-)	W _Q (-)	W _Q (-)								
		Correlation									
		-1.00 -0.80 -0.60									

Figure S1: Correlation between catchment attributes (Table 1) and model performance, i.e. runoff (Eq. 2, left panel), soil moisture (Eq. 5, middle panel) and snow cover (Eq. 6, right panel), obtained from multiple objective calibration to satellite soil moisture (ASCAT), satellite snow cover (MODIS) and runoff (Var 3 of Table 4, SSM+SCM+runoff) in the calibration period 2000-2010. Cool and warm colors represent positive and negative correlations, respectively. Bold print indicates significance with p-value lower than 0.05.



-1.00 -0.80 -0.60 -0.40 -0.20 0.00 0.20 0.40 0.60 0.80 1.00

Figure S2: Correlation between catchment attributes (Table 1) and model performance, i.e. runoff (Eq. 2, left panel), soil moisture (Eq. 5, middle panel) and snow cover (Eq. 6, right panel), obtained from multiple objective calibration to satellite soil moisture (ASCAT), satellite snow cover (MODIS) and runoff (Var 3 of Table 5, SSM+SCM+runoff) in the validation period 2010-2014. Cool and warm colors represent positive and negative correlations, respectively. Bold print indicates significance with p-value lower than 0.05.



-1.00 -0.80 -0.60 -0.40 -0.20 0.00 0.20 0.40 0.60 0.80 1.00

Figure S3: Correlation between catchment attributes (Table 1) and model performance, i.e. runoff (Eq. 2, left panel), soil moisture (Eq. 5, middle panel) and snow cover (Eq. 6, right panel), obtained from multiple objective calibration to satellite soil moisture (ASCAT) and runoff (Var 1 of Table 4, SSM+runoff) in the calibration period 2000-2010. Cool and warm colors represent positive and negative correlations, respectively. Bold print indicates significance with p-value lower than 0.05.



-1.00 -0.80 -0.60 -0.40 -0.20 0.00 0.20 0.40 0.60 0.80 1.00

Figure S4: Correlation between catchment attributes (Table 1) and model performance, i.e. runoff (Eq. 2, left panel), soil moisture (Eq. 5, middle panel) and snow cover (Eq. 6, right panel), obtained from multiple objective calibration to satellite soil moisture (ASCAT) and runoff (Var 1 of Table 5, SSM+runoff) in the validation period 2010-2014. Cool and warm colors represent positive and negative correlations, respectively. Bold print indicates significance with p-value lower than 0.05.



-1.00 -0.80 -0.60 -0.40 -0.20 0.00 0.20 0.40 0.60 0.80 1.00

Figure S5: Correlation between catchment attributes (Table 1) and model performance, i.e. runoff (Eq. 2, left panel), soil moisture (Eq. 5, middle panel) and snow cover (Eq. 6, right panel), obtained from multiple objective calibration to satellite snow cover (MODIS) and runoff (Var 2 of Table 4, SCM+runoff) in the calibration period 2000-2010. Cool and warm colors represent positive and negative correlations, respectively. Bold print indicates significance with p-value lower than 0.05.



-1.00 -0.80 -0.60 -0.40 -0.20 0.00 0.20 0.40 0.60 0.80 1.00

Figure S6: Correlation between catchment attributes (Table 1) and model performance, i.e. runoff (Eq. 2, left panel), soil moisture (Eq. 5, middle panel) and snow cover (Eq. 6, right panel), obtained from multiple objective calibration to satellite snow cover (MODIS) and runoff (Var 2 of Table 5, SSM+SCM+runoff) in the validation period 2010-2014. Cool and warm colors represent positive and negative correlations, respectively. Bold print indicates significance with p-value lower than 0.05.



Figure S7: Distributions of mean catchment elevation (MELE) and percentage of arable land (AP) for the groups of catchments with (blue) and without (red) runoff model efficiency improvement in the validation period when including soil moisture and snow data in the calibration.



Figure S8: Distributions of mean catchment elevation (MELE) and percentage of arable land (AP) for the groups of catchments with (blue) and without (red) soil moisture model efficiency improvement in the validation period when including soil moisture and snow data in the calibration

Aqua		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
below	non-forest	0.36	0.34	0.36	0.67	0.98	0.97	0.89	0.96	0.84	0.67	0.43	0.41
900 m	coniferous forest	0.17	0.24	0.34	0.50	0.63	0.66	0.79	0.77	0.92	0.47	0.42	0.26
a.s.l.	other forest	0.32	0.29	0.29	0.82	0.70	0.78	0.75	0.89	0.90	0.80	0.47	0.30
over	non-forest	0.22	0.18	0.28	0.49	0.67	0.91	0.89	0.91	0.71	0.43	0.45	0.26
900 m	coniferous forest	0.20	0.14	0.29	0.49	0.74	0.86	0.82	0.87	0.82	0.49	0.43	0.25
a.s.l.	other forest	0.17	0.12	0.13	0.50	0.83	0.74	0.77	0.58	0.69	0.44	0.46	0.20
				•			•	•		•			
Terra		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
below	non-forest	0.32	0.30	0.37	0.57	0.74	0.78	0.82	0.85	0.82	0.52	0.41	0.36
900 m	coniferous forest	0.30	0.19	0.29	0.34	0.72	0.80	0.65	0.93	0.61	0.56	0.31	0.34
a.s.l.	other forest	0.22	0.19	0.29	0.86	0.78	0.64	0.78	0.74	0.65	0.65	0.40	0.31
over	non-forest	0.21	0.16	0.20	0.44	0.60	0.90	0.77	0.70	0.84	0.54	0.35	0.27
900 m	coniferous forest	0.16	0.12	0.22	0.40	0.65	0.78	0.80	0.76	0.78	0.47	0.37	0.20
a.s.1.	other forest	0.10	0.11	0.10	0.17	0.53	0.16	0.26	0.69	0.67	0.31	0.31	0.22

Table S1. Normalized Difference Snow Index (NDSI) threshold for snow cover mapping from Tong et al. (2020)