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Supplement of

Analysis of soil hydraulic and thermal properties for land surface modeling over the Tibetan Plateau

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Supplement

Table S1 Information of the exiting soil datasets

Name	Soil property	Spatial resolution	Profile information	Data source	Reference	Released Date
FAO-UNESCO	Soil texture fractions, SOC	5km	2 layers 0-30cm, 30-100cm	1:5 million soil map of world 1:1 million soil map of China;	FAO-UNESCO Digital Soil Map of the World, 2007	2007
HWSD	Soil texture fractions, SOC	1km	2 layers 0-30cm, 30-100cm	1:5 million soil map of world; 7292 profiles in China	FAO/IIASA/ISRIC/ISSCAS/JRC, 2012. Harmonized World Soil Database (version 1.2). FAO, Rome, Italy and IIASA, Laxenburg, Austria.	2012
BNU	Soil texture fractions, SOC, BD, GGF, Porosity	1km	8 layers 0-4.5cm, 4.5-9.1cm 9.1-16.6cm, 16.6-28.9cm 28.9-49.3cm, 49.3-82.9cm 82.9-138.3cm, 138.3-229.6cm	1:1 million soil map of China; 8979 profiles in China Chinese soil profile database (Shangguan et al. 2013)	Shangguan et al. (2012, 2013)	2012
SoilGrid1km	Soil texture fractions, SOC, BD, GGF	1km	7 layer 0, 5, 15, 30, 60, 100 and 200cm.	Covariables: MODIS images, SRTM DEM etc. Chinese soil profile database (Shangguan et al. 2013)	Hengl et al. (2014)	2014
SoilGrid250m	Soil texture fractions, SOC, BD, GGF	250m	7 layer 0, 5, 15, 30, 60, 100 and 200cm.	Covariables: MODIS images,	Hengl et al. (2017)	2017

				SRTM DEM etc.		
HPSS	Parameters in the van Genuchten and Mualem model	25km	7 layer 0, 5, 15, 30, 60, 100 and 200cm.	SoilGrid1km	Montzka et al. (2017)	2017

Table S2 Means and standard deviations of soil properties at different depths in the Ngari area

Parameter	5 cm	10 cm	20 cm	40 cm
Sand (%)	84.54±8.28	86.19±8.63	77.21±17.55	78.81±17.93
Clay (%)	3.05± 1.99	2.73± 2.03	3.83± 2.67	3.27± 2.71
Silt (%)	12.42± 6.54	11.08± 6.93	18.96± 14.98	17.93± 15.41
GGF (%)	11.26± 10.76	11.77± 15.71	23.17± 25.05	18.75± 20.17
SOC (%)	1.02± 0.67	0.7± 0.49	0.73± 0.49	0.79± 0.67
Porosity (%)	33.49± 2.78	35.8± 6.76	31.4± 7.2	33.8± 9.47
GD (mm)	5.02± 2.92	5.23± 2.47	7.56± 5.07	4.96± 1.7
FD (mm)	0.22± 0.1	0.2± 0.08	0.23± 0.19	0.19± 0.09
BD (g/cm^3)	1.56± 0.13	1.63± 0.26	1.6± 0.26	1.56± 0.18
$LogK_s$ (m/s)		-4.57± 0.24	-4.94± 0.47	-4.68± 0.30

Table S3 Means and standard deviations of soil properties at different depths in the Naqu area

Parameter	5 cm	10 cm	20 cm	40 cm	50 cm
Sand (%)	78.79± 6.86	81.48± 13.49	75.13± 14.67	75.93± 10.64	70.15± 20.28
Clay (%)	4.41± 1.63	4.02± 3.04	5.84± 3.87	6.43± 4.17	7.29± 6.39
Silt (%)	16.8± 5.79	14.5± 10.46	19.03± 10.85	17.64± 7.09	22.56± 14.14
GGF (%)	12.69± 13.11	19.3± 15.91	34± 25.97	53.29± 24.05	57.43± 22.43
SOC (%)	9.18± 3.55	8.17± 3.95	2.25± 1.11	1.61± 0.93	2.68± 3.24
Porosity (%)	58.5± 21.49	45.67± 6.81	39.75± 5.8	29.5± 6.61	24.5± 5.92
GD (mm)	4.55± 1.78	3.96± 1.2	7.28± 4.57	7.75± 4.99	6.18± 2.6
FD (mm)	0.19± 0.04	0.21± 0.07	0.19± 0.08	0.22± 0.05	0.19± 0.12
BD (g/cm^3)	1.01± 0.48	1.42± 0.08	1.64± 0.17	1.87± 0.21	2.11± 0.18
$LogK_s$ (m/s)		-5.20± 0.25	-5.09± 0.50	-5.20± 0.77	-6.12± 0.99

Table S4 Means and standard deviations of soil properties at different depths in the Maqu area

Parameter	5 cm	10 cm	20 cm	40 cm	80 cm
Sand (%)	26.95± 10.55	29.03± 13.08	29.21± 12.61	31.6± 12.47	34.83± 17.06
Clay (%)	9.86± 0.89	9.95± 0.91	10.15± 0.61	10.43± 0.89	9.35± 2.68
Silt (%)	63.19± 10.08	61.02± 12.52	60.65± 12.48	57.97± 12.18	55.82± 14.95
SOC (%)	17.88± 9.05	12.16± 6.23	8.05± 5.05	4.13± 3.14	2.87± 2.89
Porosity (%)	72.92± 7.55	65.57± 7.57	59.21± 6.22	50.96± 7.5	47.06± 6.5

FD (mm)	0.03± 0.01	0.03± 0.01	0.03± 0.01	0.03± 0.01	0.04± 0.02
BD (g/cm^3)	0.76± 0.22	0.95± 0.25	1.23± 0.19	1.4± 0.12	1.49± 0.18
$LogK_s$ (m/s)		-5.5± 0.32	-5.55± 0.44	-6.52± 0.3	-5.65± 0.97

10 Table S5 Absolute bias of estimated SWRCs from PTFs combined without BD scheme, with the measurements at 5 cm under three climate zones.

PTFs	Ngari (arid)	Naqu (semi-arid)	Maqu (sub-humid)
	Absolute Bias (cm3 cm-3)	Absolute Bias (cm3 cm-3)	Absolute Bias (cm3 cm-3)
Cosby et al., 1984	0.03	0.09	0.23
Cosby et al., 1984	0.03	0.09	0.20
Saxton et al., 1986	0.09	0.08	0.21
Campbell and Shiosawa, 1992	0.06	0.11	0.17
Saxton et al., 2006	0.05	0.07	0.07
Rawls and Brakenssiek 1985	0.06	0.16	0.30
Wösten et al., (Class PTF)	0.05	0.05	0.36
Vereecken et al., 1989	0.02	0.11	0.36
Wösten et al., 1999	0.05	0.07	0.25
Rosetta1-H3	0.05	0.14	0.26
Rosetta3-H3	0.04	0.12	0.40
Weynants et al. 2009	0.05	0.07	0.23

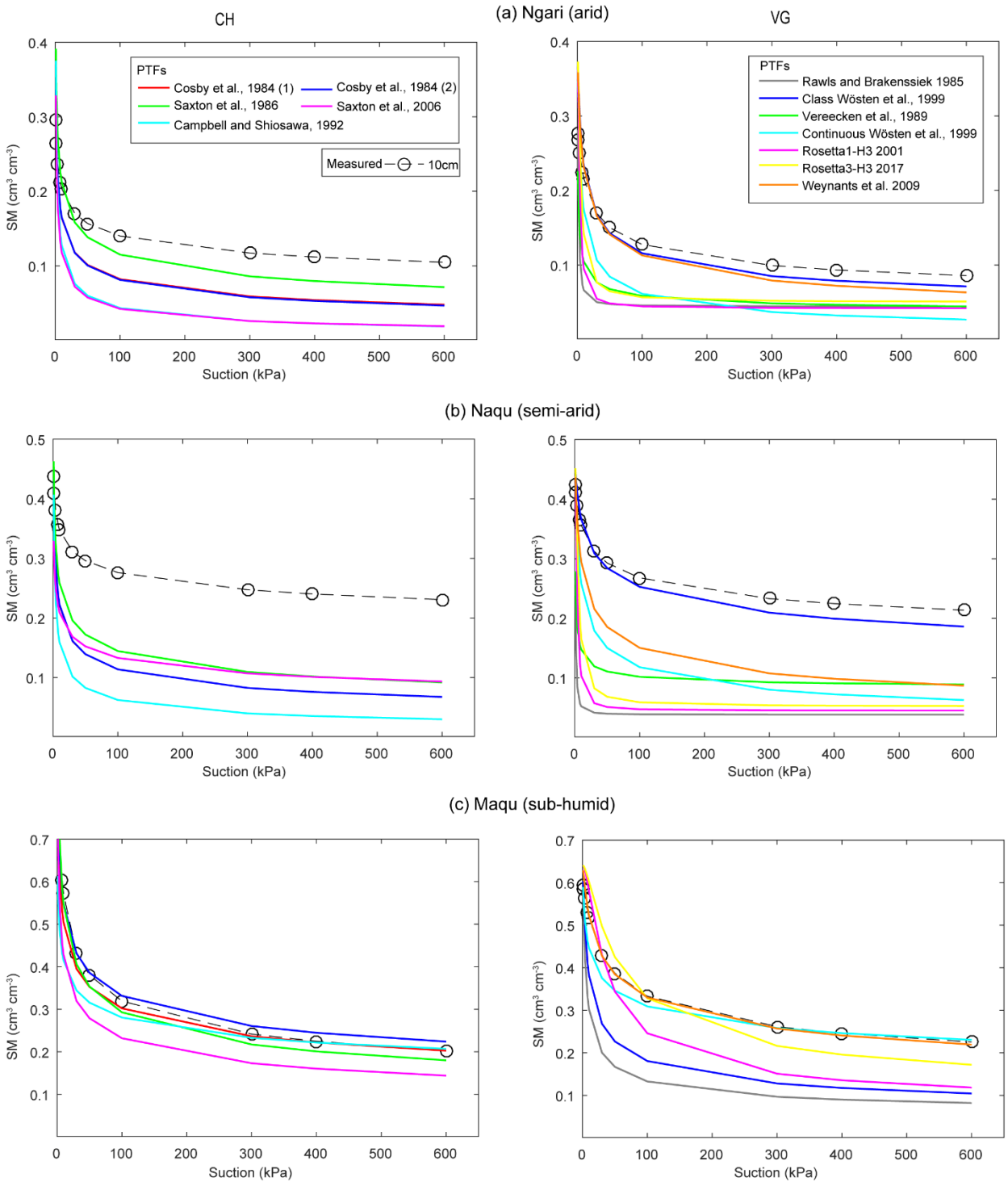


Figure S1-1 Comparisons between estimated SWRCs from PTFs combined with the BD scheme, and the measurement determined SWRCs at 10 cm for three climate zones. It is to note that the SWRC estimated from Vereecken et al. (1989) PTFs was out of range over the sub-humid zone and was removed (right figure in Fig. S1-1C).

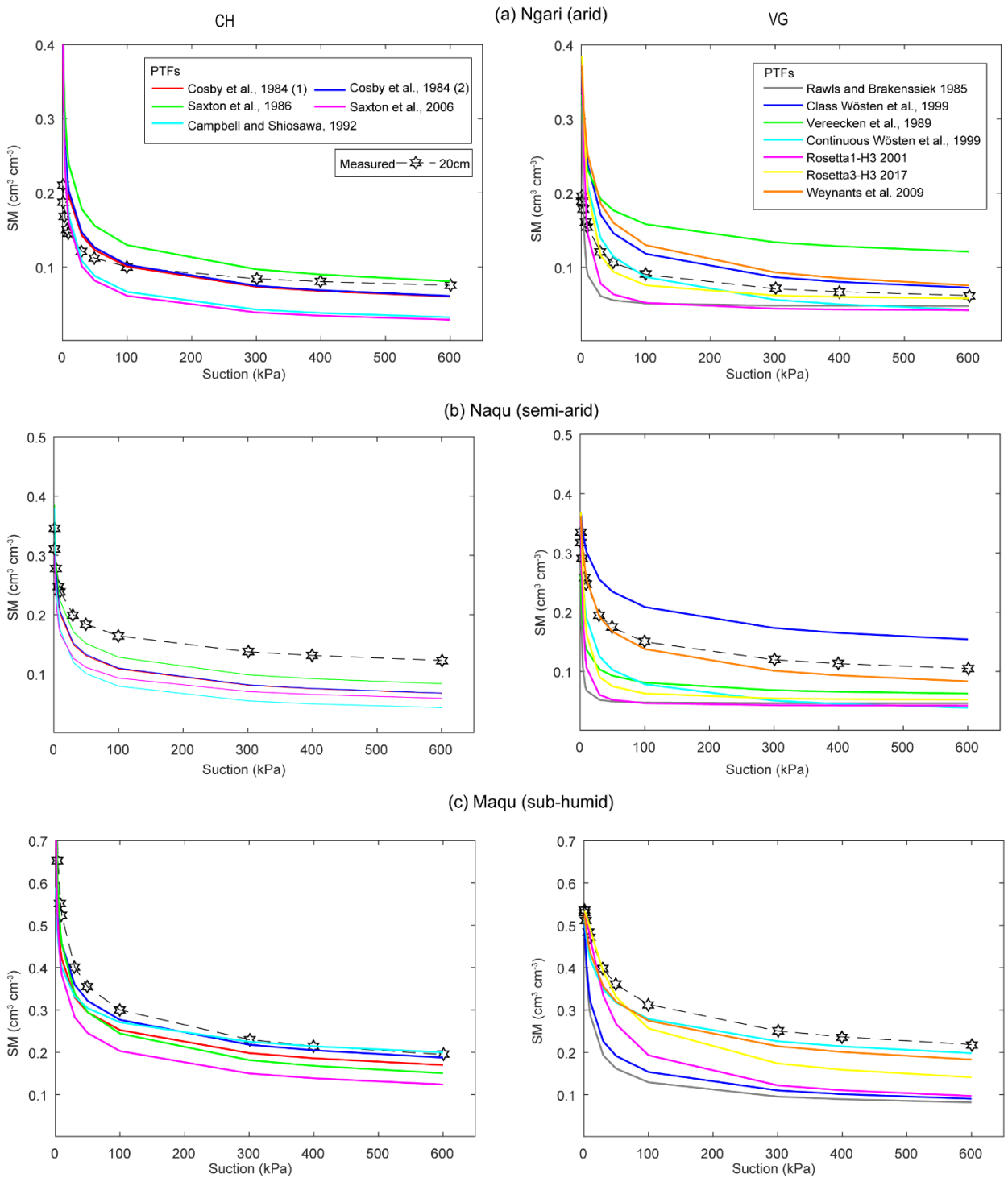
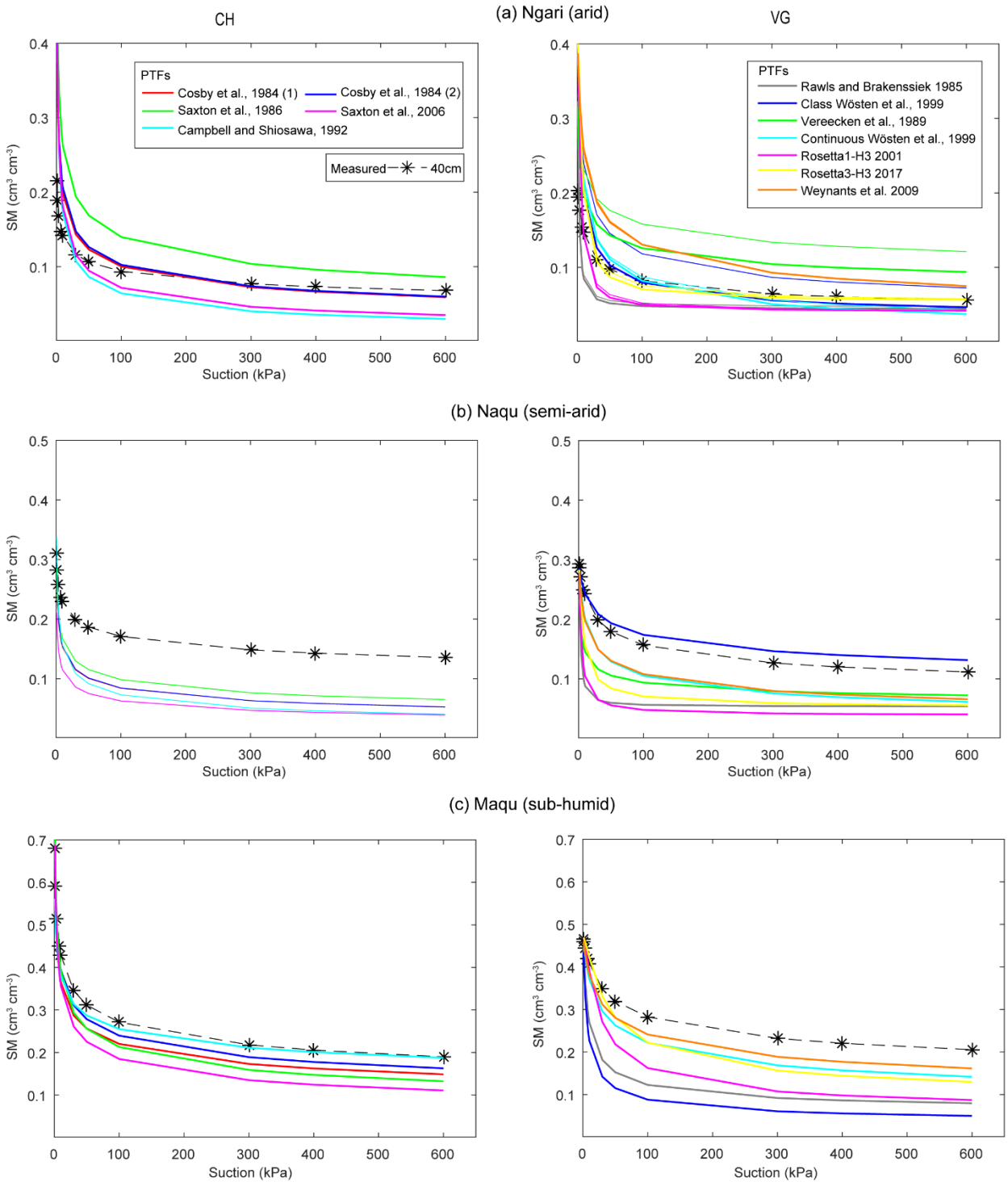


Figure S1-2 Comparisons between estimated SWRCs from PTFs combined with the BD scheme, and the measurement determined SWRCs at 20 cm for three climate zones. It is to note that the SWRC estimated from Vereecken et al. (1989) PTFs was out of range over the sub-humid zone and was removed (right figure in Fig. S1-2C).



25 Figure S1-3 Comparisons between estimated SWRCs from PTFs combined with the BD scheme, and the measurement determined SWRCs at 40 cm for three climate zones. It is to note that the SWRC estimated from Vereecken et al. (1989) PTFs was out of range over the sub-humid zone and was removed (right figure in Fig. S1-

3C).

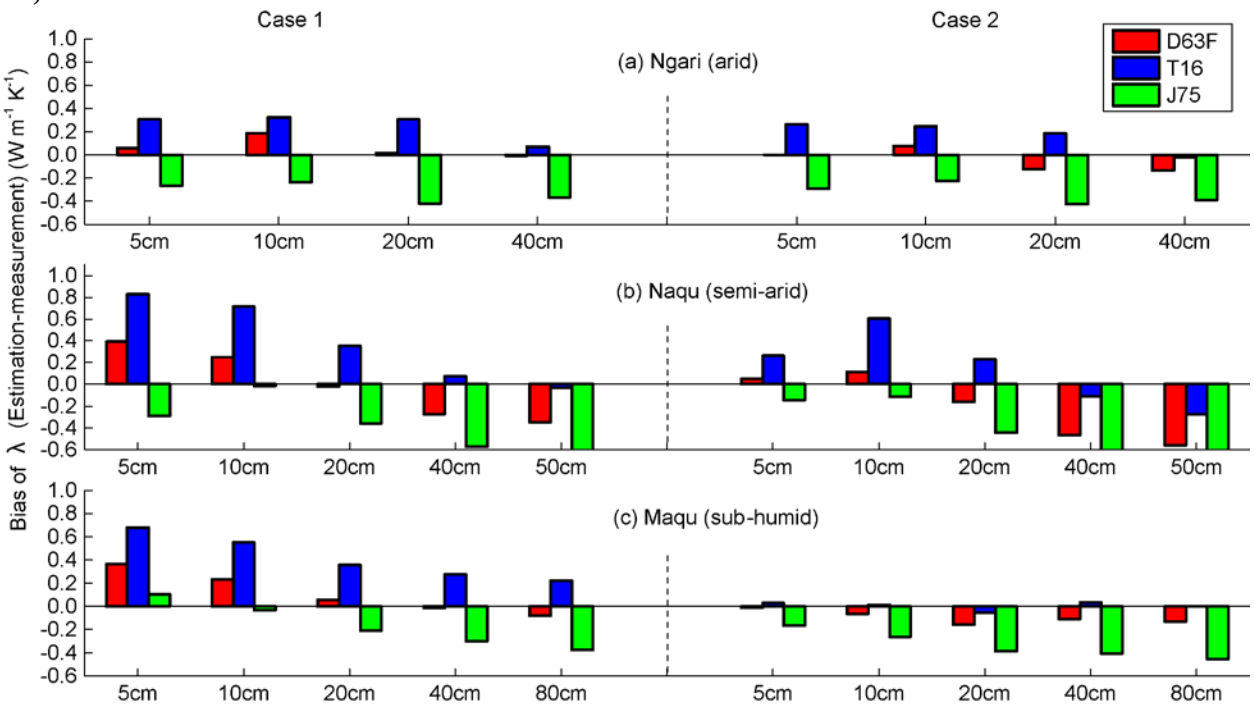


Figure S2 Biases of λ estimates based on D63F, T16 and J75 schemes combined with the Cosby-S scheme (Cosby PTFs) in the profile over the three climate zones with the measurements. Case 1 is the bias derived from schemes not considering gravel impact parameterization for the arid and semi-arid zone and SOC impact parameterization for the semi-humid zone. Case 2 is the bias with these parameterizations consideration.

List of Abbreviations:

SHP/STP	Soil hydraulic and thermal properties
LSM	Land surface model
TP	the Tibetan Plateau
SWRC	Soil Water Retention Curve
K_s	Saturated hydraulic conductivity
λ	Thermal conductivity
SM	Soil Moisture
ST	Soil temperature
Tibet-Obs	The Tibetan Plateau Observatory of plateau scale soil moisture and soil temperature
the CH model	The Clapp and Hornberger (1978) formulation
the VG model	The Van Genuchten (1980) formulation
PTFs	Pedotransfer functions
H-TESSEL	The Hydrology-Tiled European Centre for Medium-Range Weather Forecasts Scheme for Surface Exchanges over Land (H-TESSEL)
SOC	Soil organic matter content
BD	Bulk density
GGF	Gravimetric gravel fraction
USDA	The United States Department of Agriculture
FD	The mean particle diameter of fine component
GD	The mean particle diameter of gravels
BNU dataset	Soil dataset from Shangguan et al. (2013) released by Beijing Normal University
FC	Field Capacity
PWP	Permanent Wilting Point
D	Soil diffusivity
K	Soil conductivity