Supplement

Table S1

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	FAO-UNESCO Digital Soil Map of the World, 2007	2007
HWSD	Soil texture fractions, SOC	1km	2 layers 0-30cm, 30-100cm	1:1 million soil map of China; 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

Table S2 Means and standard deviations of soil properties in the profile 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

Table S3 Means and standard deviations of soil properties in the profile 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 S3

Table S3 Means and standard deviations of soil properties in the profile 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

Figure S1

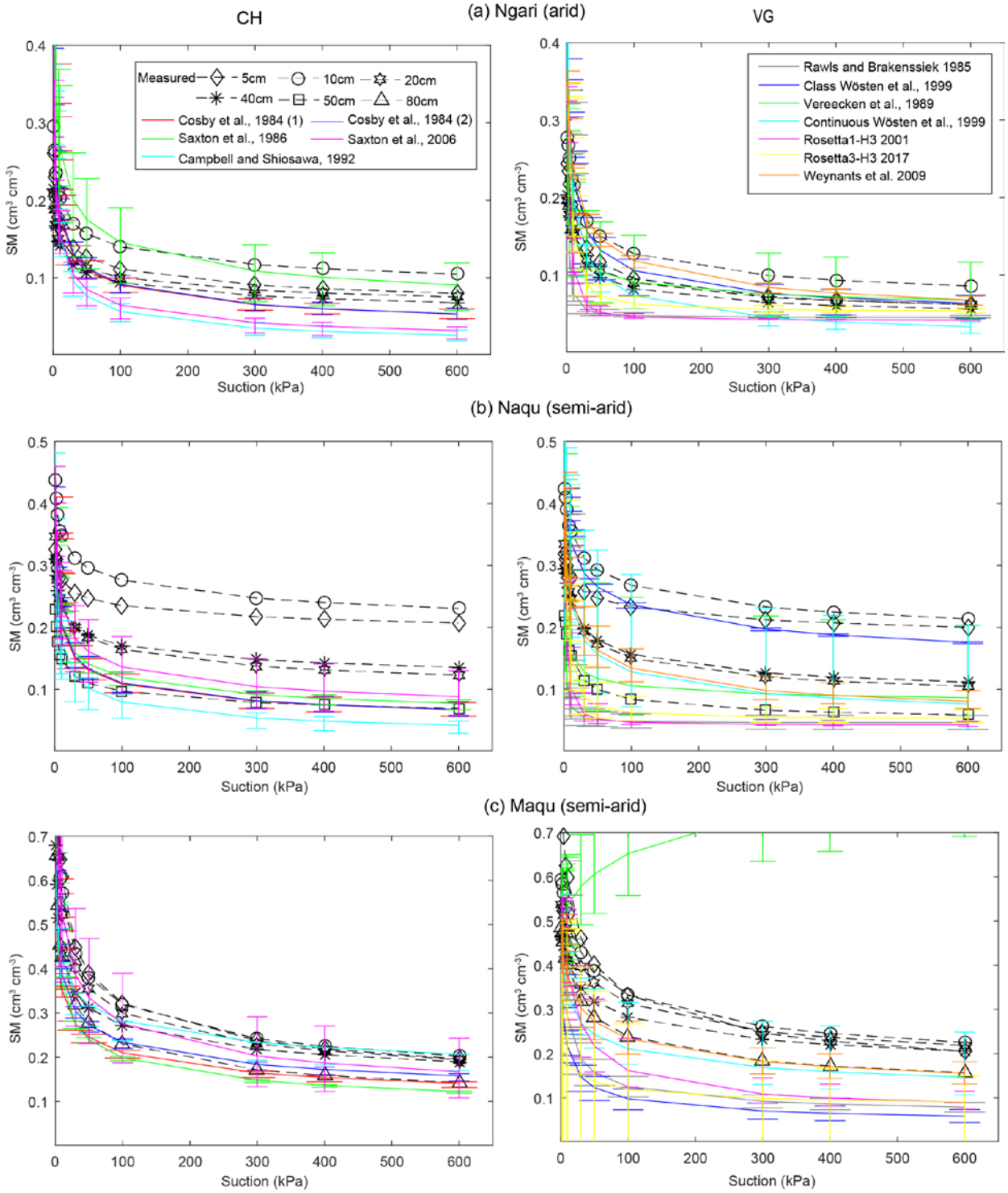

Figure S1 Comparisons of mean estimated SWRCs from PTFs combined without BD scheme with the measurements at three climate zones. The bar represents the lowest and highest values in the profile.

Figure S2

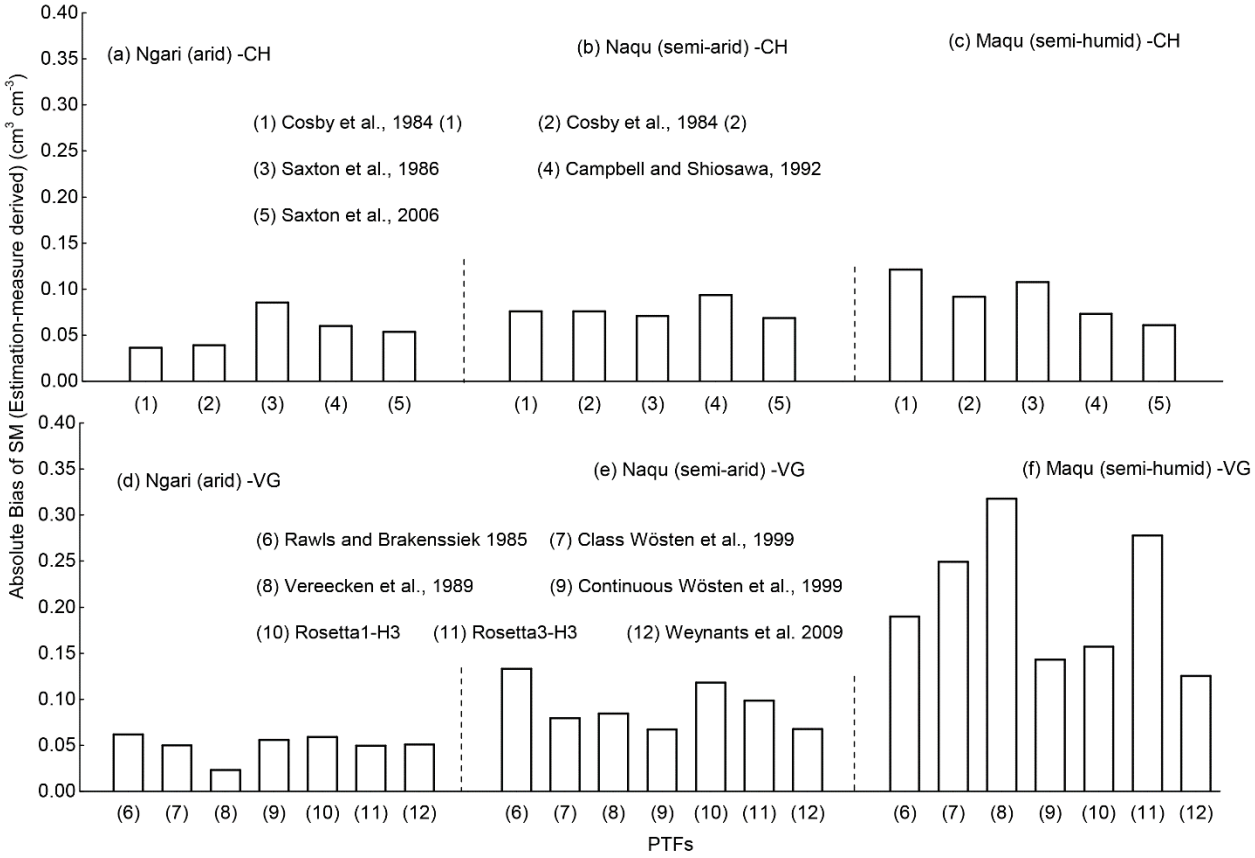

Figure S2 Absolute bias of estimated SWRCs from PTFs combined without BD scheme with the measurements at three climate zones.

Figure S3

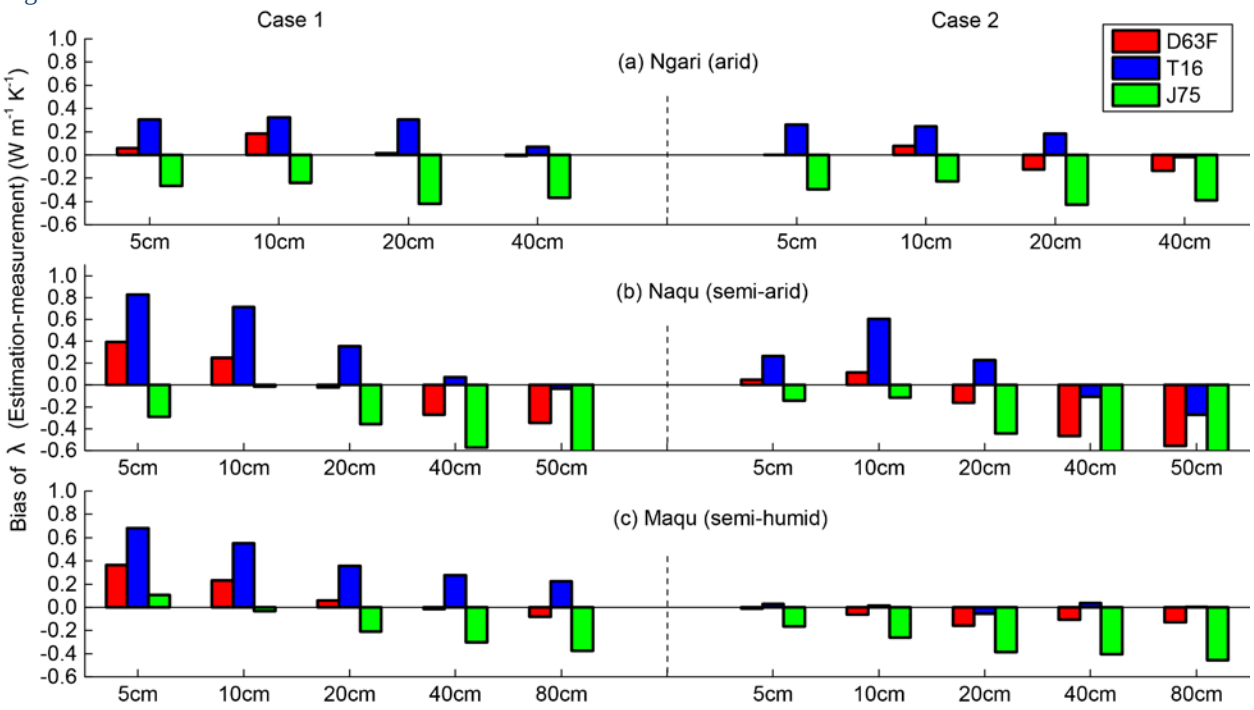

Figure S3 Biases of λ estimates based on D63F, T16 and J75 schemes combined with the Cosby-S scheme (Cosby PTFs) in the profile over the three climate zones with the measurements. Case 1 is the bias derived from schemes not considering gravel impact parameterization for the arid and semi-arid zone and 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