Soil organic carbon estimation and transfer framework in agricultural areas based on spatiotemporal constraint strategy combined with active and passive remote sensing

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Table S1 L-band quad-pol SAR and optical images used in the SMAPVEX12 dataset.

Data source	Imaging phase	Imaging time	Orbital direction	Imaging angle	Spatial resolution
UAVSAR	**06/17/2012** 06/19/2012 **06/22/2012** **06/23/2012** **06/25/2012** **06/27/2012** **06/29/2012** **07/03/2012** **07/05/2012** **07/08/2012** **07/13/2012** **07/14/2012** **07/17/2012**	18:00 UTC	—	20–65°	1.66×0.80 m ↓ 4×6 m ↓ 10–20 m
PLAS	**06/17/2012** **06/22/2012** **06/23/2012** **06/25/2012** **06/27/2012** **06/29/2012** **07/03/2012** **07/05/2012** **07/08/2012** **07/13/2012** **07/14/2012** **07/17/2012**			40°	650 m
SPOT-4/5	**04/28/2012** **06/15/2012** **06/23/2012** **06/28/2012** **07/05/2012** **07/14/2012** **07/19/2012**	17:40 UTC	—	—	10–20 m

Note: The bolded images are used for SOC modeling. The strip numbers of the UAVSAR used is 31606.

Table S2 C-band dual-pol SAR and optical images used in the SMAPVEX16-MB dataset.

Data source	Imaging phase	Imaging time	Orbital direction	Imaging angle	Spatial resolution
Sentinel-1A	**06/01/2016** **06/13/2016** **07/07/2016** **07/19/2016** **07/31/2016** **08/12/2016** **08/24/2016** **09/05/2016** **10/05/2016** **10/17/2016** **10/29/2016**	00:15 UTC	Ascending	30.9–33.2°	5×20 m ↓ 20 m
	05/13/2016 **05/25/2016** **06/06/2016** **06/30/2016** **07/24/2016** **08/05/2016** **08/17/2016** **08/29/2016** **09/10/2016** **09/22/2016** **09/28/2016** **10/10/2016** **10/22/2016**			40.3–42.2°	
	07/03/2016 **07/15/2016**	12:40 UTC	Descending	39.1–41.0°	
PLAS	**06/08/2016** **06/11/2016** **06/14/2016** **06/16/2016** **06/19/2016** **06/20/2016** **07/14/2016** **07/16/2016** **07/18/2016** **07/19/2016** **07/21/2016** **07/22/2016**	18:00 UTC	—	40°	450 m
Sentinel-2A	**05/04/2016** **05/21/2016** **06/10/2016** **06/13/2016** **06/20/2016** **06/23/2016** **07/30/2016** **08/02/2016**	17:30 UTC		—	10–20 m

Note: The bolded images are used for SOC modeling.

Table S3 Hyperparameter optimization range and optimal parameter setting.

Regression model	Optimizable hyperparameters	Optimization range	Optimal hyperparameters	
			SMAPVEX12	SMAPVEX16-MB
ETR	Max features	[1, n]	67	86
	Max depth	[1, 10]	7	8
	Min samples leaf (split)	[1, max (2,floor(n/2))]	1	1
	Min impurity decrease	[0.0, 1.0]	0.0	0.0
	Min weight fraction leaf	[0.0, 1.0]	0.0	0.0
XGBR	Subsample	[0.5, 1]	0.75	0.55
	Learning rate	[0.01, 0.2]	0.025493	0.008745
	Gamma value	[0.1, 10]	6.73	7.53
	Max depth	[1, 10]	6	8
	Min child weight	[1, 10]	2	3
	Alpha and Lambda	[0.1, 1]	0.5; 0.5	0.5; 0.5
SVR	Kernel function	Gaussian, Linear, Quadratic, and Cubic	Gaussian	Gaussian
	Box constraint	[0.001, 1000]	930.5244	13.3265
	Kernel scale	[0.001, 1000]	47.0487	47.2507
	Epsilon	[0.001, 100]*IQR(Y)/1.349	0.021124	0.14629
GPR	Basis function	Zero, Constant, and Linear	Zero	Zero
	Kernel function	Nonisotropic Rational Quadratic Isotropic Rational Quadratic Nonisotropic Squared Exponential Isotropic Squared Exponential Nonisotropic Matern 5/2 & 3/2 Isotropic Matern 5/2 & 3/2 Nonisotropic Exponential Isotropic Exponential	Isotropic Matern 5/2	Isotropic Exponential
	Kernel scale	[0.001, 1000]	837.9166	76.2304
	Sigma value	[0.0001, max (0.001,10*std(Y))]	0.017906	0.063931
DNNR	Initial learning rate	[0.001, 0.2]	Step decay (Adam)	Step decay (Adam)
	Regularization strength (Lambda)	[0.00001/n, 100000/n]	0.020781	0.039612
	Batch size	64, 128, 256, and 512	128	128
	Activation function	ReLU, Tanh, and Sigmoid	ReLU	ReLU
	Number of fully connected layers	[1, 3]	3	3
	Number of network layer	[1, 500]	76, 276, 41	48, 31, 68

Note: Input features include SAR features, TB features, and MS features. *n* represents input feature dimension. *Y* represents the measured SOC.