User's Guide for Data from a Soil Moisture Network in the ShanDian River basin (SMN-SDR)

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1. Introduction

This data set contains in-situ measurements of soil moisture, soil temperature, and precipitation at 34 stations from a wireless Soil Moisture Network within the ShanDian River basin (referred to as the SMN-SDR hereafter). The coverage of the entire network is about 10,000 km^2 (115.5-116.5°E, 41.5-42.5°N). The topography of the SMN-SDR is relatively flat, and land surfaces are typically dominated by grasslands and croplands. A total of 34 stations are set up in the network with three sampling scales including 100 km (large scale), 50 km (medium scale), and 10 km (small scale). The soil moisture sensors used are Decagon 5TM with five measuring depths (3, 5, 10, 20, and 50 cm) installed for each station. Of the 34 stations, there are 20 stations equipped with HOBO rain gauges. Undisturbed soil samples at each layer of soil for each station were taken to analyze the gravimetric/volumetric water content, bulk density, and soil texture for further specific calibration. The power supply is provided by solar panels and all data can be transmitted wirelessly to a server. The sampling interval of the data recording time is 10 (before June 2019) or 15 minutes (after June 2019).

This network can improve the comprehensive observation capabilities of key water cycle parameters in the ShanDian River basin and provide long-term ground reference data for satellite- and model-based soil moisture products.

2. Network configuration

The SMN-SDR was established during the Soil Moisture Experiment in the Luan River (SMELR, Zhao et al., 2020), from July 18, 2018 to September 28, 2018.

There are three sampling scales including 100 km (large scale), 50 km (medium scale), and 10 km (small scale). These were initially designed to match different scales

of land surface modeling and various satellite products (SMAP, SMOS, AMSR2, and downscaled soil moisture products).

The layout of the large-scale soil moisture sites basically follows the M-shaped transect. The medium-scale sites are deployed as plum-shaped. The small-scale sites, which are exactly within a SMAP 9-km grid, are further nested and distributed as uniformly as possible according to realistic feasibility, as shown in Figure 1.

Moreover, Table 1 (see the last two pages) summarizes the detailed information of each station in SMN-SDR, including station ID, geographic location, setup time, elevation, land use type, and soil texture.

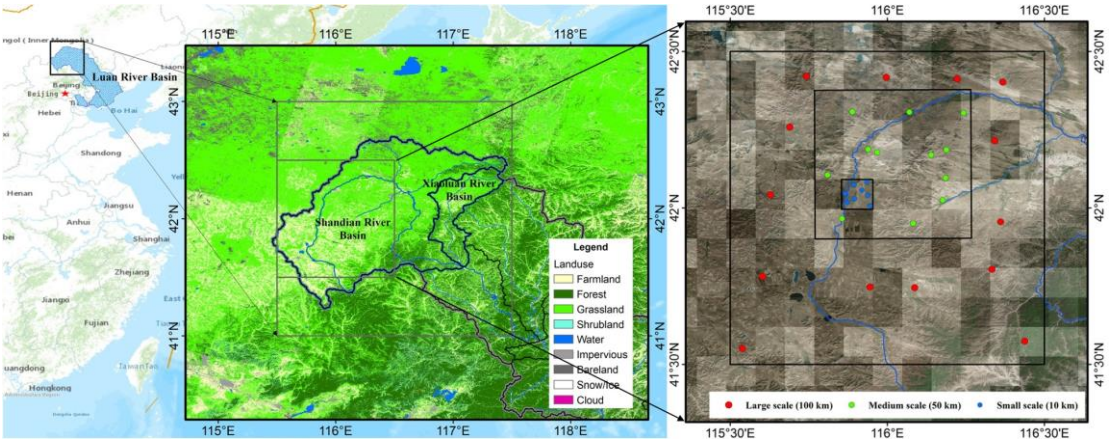

Figure 1. Experimental areas of the SMELR (Left) and the layout of the SMN-SDR (Right, Shandian river basin with transparent gray grids indicating SMAP 9-km grids).

3. Instruments

Each station of the SMN-SDR is equipped with 5TM sensors. The 5TM uses capacitance/frequency domain technology to determine volumetric water content (VWC) by measuring the dielectric constant of the soil. Besides, the 5TM sensor is equipped with an onboard thermistor to accurately measure soil temperature. For more detailed technical specifications of the 5TM sensor, readers are referred to: https://metos.at/portfolio/decagon-5tm-soil-moisture-sensor/.

There are 20 stations in the SMN-SDR equipped with the HOBO rain gauges, which can record up to 160 in. of rainfall at rates up to 12.7 cm (5 in.) per hour. More detailed information about the HOBO rain gauge data logger can be found at: https://www.onsetcomp.com/products/data-loggers/rg3/.

Figure 2 shows the installation of the in-situ measurement station. All stations were equipped with solar panels and IoT links to realize remote wireless access to all the ground measurements (see c in Figure 2). At each station, five Decagon 5TM sensors were installed at different depths (3, 5, 10, 20, and 50 cm below the surface) to measure

soil moisture and soil temperature (see b in Figure 2). To maintain the normal operation of the stations, fences were installed around the station (see a in Figure 2).

Figure 2. Installation of the in-situ measurement station, including a real photograph of the S2 station (a), a soil profile view when the 5TM sensor is inserted (b), and installation of above-ground instruments (c).

4. Data specification

4.1 File naming

The in-situ measurement data set of the SMN-SDR is stored in CSV format, and the file name is:

"ShandianRiver_XY_5TM/HOBO_SM/TS/PP_xxcm_YYYY-MM-DD_YYYY-MM-DD.csv"

where, X represents the sampling scales, usually “L” (100km) or “M” (50km), or “S” (10km); Y stands for site number; 5TM/HOBO stands for sensor type, for example, the sensor for soil moisture and soil temperature data is 5TM, and the sensor for precipitation observation is HOBO; SM/TS/PP represents the type of in-situ data, SM is soil moisture, TS is soil temperature, and PP is precipitation; xxcm represents the detection depth, usually "03cm", "05cm", "10cm", "20cm", "50cm". Note that when the measurement data is precipitation, xxcm does not display. YYYY-MM-DD_YYYY-MM-DD represents the start and end time of the in-situ data.

4.2 Data reading method

The data set can be directly opened with a text program (such as notepad or excel).

4.3 File content

Each CSV file consists of two parts, measurement time and in-situ measurement data.

Kindly note that all times mentioned in the data file (including the start and end times in the file name) are local times. The middle time of the 8th Time Zone (east) is

adopted in China.

Unit description of in-situ measurement data:

(1) soil moisture: 'Soil_VWC'; '% vol';

(2) soil temperature: 'Soil_TEM'; '°C';

(3) precipitation: 'PP'; 'mm'.

The missing data are replaced with filled values (9999).

4.4 Raw sensor data (soil moisture) calibration

This data set only stores the raw data recorded from the sensor (5TM or HOBO). Before being used, the soil moisture data from the 5TM sensor could be calibrated by one of the following formulas:

$$SMC_v = 1.0458 * SMC_{5TM} - 0.0022 \quad (1)$$

$$SMC_v = 1.0350 * SMC_{5TM} \quad (2)$$

where SMC_v is the calibrated soil moisture (% vol/vol), and SMC_{5TM} is the original soil moisture recorded by the 5TM sensor (% vol/vol).

The calibration formula is obtained by using soil samples results from the oven drying (thermogravimetric) method. For more detailed information, please refer to Zhao et al., 2020 (https://doi.org/10.1016/j.rse.2020.111680) and the comparison shown in Figure 3 between Frequency Domain Reflectometry (FDR) measurements and thermogravimetric values.

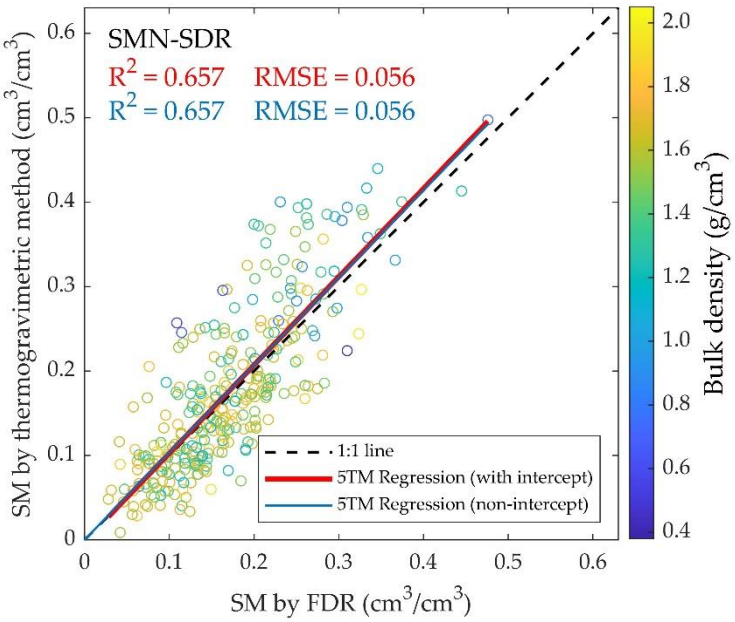

Figure 3. Comparison of thermogravimetric and FDR soil moisture measurements (5TM: hollow circle) within the SMN-SDR.

4.5 Station number with precipitation observation

A total of 20 sites were installed with rain gauges offered to observe precipitation information, mainly concentrated in the small and medium scales.

The numbers of these sites are listed below: L11, L13, M1, M2, M3, M4, M5, M6, M7, M8, M9, M11, M12, S1, S2, S3, S4, S5, S7, S8.

5. Data Acknowledgement

Upon using this data please cite as follows:

Zhao, T.J., Shi, J.C., Lv, L.Q., Xu, H.X., Chen, D.Q., Cui, Q., Jackson, T.J., Yan, G.J., Jia, L., Chen, L.F., Zhao, K., Zheng, X.M., Zhao, L.M., Zheng, C.L., Ji, D.B., Xiong, C., Wang, T.X., Li, R., Pan, J.M., Wen, J.G., Yu, C., Zheng, Y.M., Jiang, L.M., Chai, L.N., Lu, H., Yao, P.P., Ma, J.W., Lv, H.S., Wu, J.J., Zhao, W., Yang, N., Guo, P., Li, Y.X., Hu, L., Geng, D.Y., & Zhang, Z.Q. (2020). Soil moisture experiment in the Luan River supporting new satellite mission opportunities. Remote Sensing of Environment, 240. https://doi.org/10.1016/j.rse.2020.111680.

Zheng, J., Zhao, T., Lü, H., Shi, J., Cosh, M.H., Ji, D., Jiang, L., Cui, Q., Lu, H., Yang, K., Wigneron, J.-P., Li, X., Zhu, Y., Hu, L., Peng, Z., Zeng, Y., Wang, X., Kang, C.S., 2022. Assessment of 24 soil moisture datasets using a new in situ network in the Shandian River Basin of China. Remote Sensing of Environment 271, 112891. https://doi.org/https://doi.org/10.1016/j.rse.2022.112891.

6. Disclaimer

(1) Although we strictly control the quality of in-situ measurement data in the SMN-SDR by maintaining the network, calibrating sensors, and carefully processing data, unexpected errors may still occur. The data provider shall not be liable for any direct, indirect, special, incidental, or consequential losses caused by the use (or inability to use) of this data.

(2) The in-situ measurements of the SMN-SDR are only for users for academic research purposes and are prohibited for other purposes such as commercial use. The data is not allowed to be transferred to any third party, and all consequences arising therefrom shall be borne by the data user.

(3) Users are encouraged to communicate directly with data producers for problems or questions that arise during data usage.

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Table 1. The station ID, geographic location, setup time, elevation, land use type, and soil texture at each station of the SMN-SDR.

Station ID	Longitude	Latitude	Setup time (local time)	Elevation (m)	Land use type	SAND (%)	SILT (%)	CLAY (%)
S1	115.945717	42.006639	2018/7/19 12:53	1368	farmland (carrots)	83.80	7.70	8.50
S2	115.937800	42.040172	2018/7/19 15:00	1363	grassland	83.75	7.71	8.54
S3	115.919400	42.057144	2018/7/18 18:40	1343	grassland	75.71	14.25	10.04
S4	115.935069	42.082669	2018/9/4 10:17	1357	grassland	82.69	10.18	7.12
S5	115.894050	42.073939	2018/7/18 15:30	1327	grassland	34.59	55.91	9.50
S6	115.865733	42.045544	2018/9/28 11:04	1331	grassland	72.18	22.27	5.55
S7	115.896111	42.029722	2018/8/14 09:08	1332	grassland	58.95	24.80	16.25
S8	115.873056	42.017500	2018/8/14 18:36	1334	grassland	29.32	46.25	24.43
M1	115.855928	41.965572	2018/9/4 11:56	1343	grassland	52.50	31.35	16.15
M2	115.809444	42.105278	2018/8/14 11:30	1451	grassland	89.77	6.84	3.39
M3	116.082500	41.949722	2018/8/14 15:41	1466	farmland (Avena nuda)	60.75	29.39	9.87
M4	116.185508	42.095956	2018/7/21 09:51	1394	grassland	86.39	7.74	5.87
M5	116.188236	42.185553	2018/7/20 14:30	1433	grassland	85.50	7.36	7.14
M6	115.938742	42.186800	2018/9/4 09:02	1308	grassland	69.83	18.05	12.12
M7	115.968181	42.176983	2018/7/18 12:30	1330	grassland	67.95	16.08	15.96
M8	115.888611	42.306389	2018/8/13 10:50	1363	grassland	58.68	24.56	16.76
M9	116.070372	42.305539	2018/8/13 14:13	1280	grassland	60.36	24.17	15.47
M10	116.242753	42.302567	2018/8/13 17:22	1327	woodland	72.40	12.80	14.80

M11	116.139483	42.168933	2018/7/20 16:35	1470	grassland	94.52	1.98	3.50
M12	116.176603	42.025097	2018/7/21 08:18	1354	grassland	54.53	43.85	1.63
L1	115.538853	41.550761	2018/9/1 11:12	1433	grassland	68.63	17.81	13.56
L2	115.603142	41.780069	2018/9/1 13:40	1401	grassland	60.64	35.42	3.95
L3	115.628383	42.042175	2018/9/1 17:30	1452	grassland	76.68	13.39	9.93
L4	115.689708	42.257611	2018/9/2 11:54	1338	grassland	76.93	12.81	10.26
L5	115.742808	42.419742	2018/9/2 09:49	1427	grassland	61.89	22.51	15.61
L6	116.333303	41.802947	2018/9/5 14:27	1369	grassland	57.12	27.79	15.09
L7	116.342378	42.214089	2018/9/3 13:51	1364	woodland (Pinus sylvestris)	89.91	5.83	4.26
L8	116.361031	41.955311	2018/9/3 11:15	1435	grassland	63.52	23.26	13.22
L9	116.087342	41.744736	2018/9/4 15:42	1443	grassland	83.91	11.11	4.98
L10	115.945078	41.746911	2018/9/4 13:53	1410	grassland	57.25	37.86	4.89
L11	116.222711	42.411972	2018/9/2 14:19	1280	grassland	64.46	24.13	11.41
L12	116.367775	42.401206	2018/9/2 16:07	1315	grassland	86.24	8.64	5.12
L13	115.996558	42.416431	2018/9/3 17:24	1329	grassland	85.31	8.77	5.92
L14	116.437414	41.574433	2018/9/5 11:19	1383	grassland	46.09	40.70	13.22