Example of QAQC using North Carolina Econet data

The process of our quality control (QAQC) steps are showing in Fig.1.

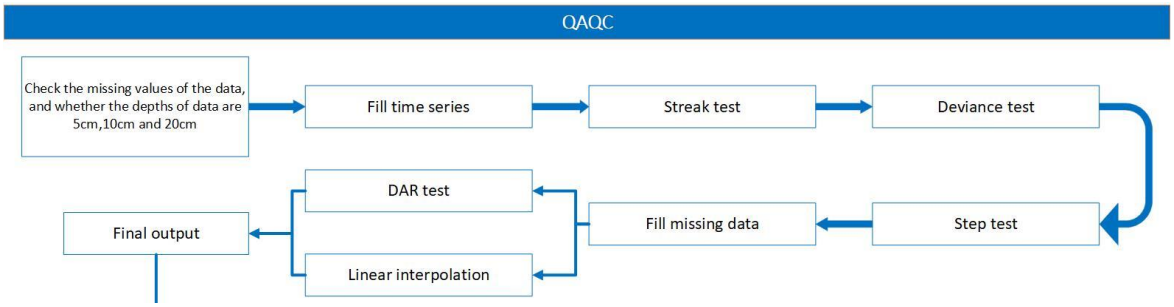

Figure 1 Flow chart of QAQC

The meaning of the flags are shown in Tab.1.

Table 1 QAQC flag description

Flag number	Operation	Explanation
1	filled as nan	flagged by FillTimeSeries
2	filled as nan	flagged by Streak test
3	filled as nan	flagged by Deviance test
4	filled as nan	flagged by Step test
10	filled by DAR	Original is nan, not flagged
11	filled by DAR	flagged by FillTimeSeries
12	filled by DAR	flagged by Streak test
13	filled by DAR	flagged by Deviance test
14	filled by DAR	flagged by Step test

Because the soil moisture is only measured at 20 cm, the flag_depth1 refers to the QAQC flag of soil moisture measured at 20cm. The flag in the percentile data is the same flag that applied in QAQC process.

Here, AURO station data is used as an example. Fig.1 shows the original data, and Fig.2 shows the data after QAQC. Data between 10/13 and 10/22, they are flagged as 13, which means they didn't pass the Deviance test, so the data is filled with NaN at first, then filled by daily average replacement (DAR) method using 10 days window (Ford and Quiring 2014). From 10/23 to 10/31, they are flagged as 3,

which means the data didn't pass the Deviance test, and due to the availability of data within 10 days, these data are not filled by DAR method. The data between 11/1/2001 to 11/9/2001 is missing. The missing data is filled with NaN, and flagged as 1.

FillTimeSeries fills the missing dates with NaN data. Deviance test assesses if the absolute magnitude of a soil moisture measurement is valid based on previous measurements during that period of time (Quiring et al. 2016). The streak test assesses soil moisture variability over time. Soil moisture observations are removed if the same value is recorded every day over a >10-day period. The step test assesses the change in magnitude between consecutive measurements. The procedure calculates the average and standard deviation of the difference between consecutive measurements for each site. Here, DAR method fills missing values with the average of the observation day before (n−5) and the day after (n+5), in other words, the window threshold is 10 days. More details of these methods can be found at Quiring et al., 2016.

1	Station ID	year	month	day	doy	sm_20cm	lat	lon
62	AURO	2001	10	7	280	0.309	35.36232	-76.7163
63	AURO	2001	10	8	281	0.313	35.36232	-76.7163
64	AURO	2001	10	9	282	0.326	35.36232	-76.7163
65	AURO	2001	10	10	283	0.336	35.36232	-76.7163
66	AURO	2001	10	11	284	0.4	35.36232	-76.7163
67	AURO	2001	10	12	285	0.5	35.36232	-76.7163
68	AURO	2001	10	13	286	0.652	35.36232	-76.7163
69	AURO	2001	10	14	287	0.878	35.36232	-76.7163
70	AURO	2001	10	15	288	0.722	35.36232	-76.7163
71	AURO	2001	10	16	289	0.608	35.36232	-76.7163
72	AURO	2001	10	17	290	0.743	35.36232	-76.7163
73	AURO	2001	10	18	291	0.948	35.36232	-76.7163
74	AURO	2001	10	19	292	1.231	35.36232	-76.7163
75	AURO	2001	10	20	293	1.623	35.36232	-76.7163
76	AURO	2001	10	21	294	2.087	35.36232	-76.7163
77	AURO	2001	10	22	295	2.857	35.36232	-76.7163
78	AURO	2001	10	23	296	4.156	35.36232	-76.7163
79	AURO	2001	10	24	297	6.468	35.36232	-76.7163
80	AURO	2001	10	25	298	9.98	35.36232	-76.7163
81	AURO	2001	10	26	299	9.98	35.36232	-76.7163
82	AURO	2001	10	27	300	9.98	35.36232	-76.7163
83	AURO	2001	10	28	301	9.98	35.36232	-76.7163
84	AURO	2001	10	29	302	9.98	35.36232	-76.7163
85	AURO	2001	10	30	303	9.98	35.36232	-76.7163
86	AURO	2001	10	31	304	9.98	35.36232	-76.7163
87	AURO	2001	11	10	314	9.98	35.36232	-76.7163
88	AURO	2001	11	19	323	9.98	35.36232	-76.7163
89	AURO	2001	11	20	324	9.98	35.36232	-76.7163
90	AURO	2001	11	21	325	9.98	35.36232	-76.7163
91	AURO	2001	11	22	326	9.98	35.36232	-76.7163
92	AURO	2001	11	23	327	9.98	35.36232	-76.7163

Figure 2 Original data of AURO station

1	network	Station ID	year	month	day	doy	sm_20cm	lat	lon	flag_depth1
62	NCEconet	AURO_SoilM	2001	10	7	280	0.309	35.362	-76.716	0
63	NCEconet	AURO_SoilM	2001	10	8	281	0.313	35.362	-76.716	0
64	NCEconet	AURO_SoilM	2001	10	9	282	0.326	35.362	-76.716	0
65	NCEconet	AURO_SoilM	2001	10	10	283	0.336	35.362	-76.716	0
66	NCEconet	AURO_SoilM	2001	10	11	284	0.4	35.362	-76.716	0
67	NCEconet	AURO_SoilM	2001	10	12	285	0.5	35.362	-76.716	0
68	NCEconet	AURO_SoilM	2001	10	13	286	0.5	35.362	-76.716	13
69	NCEconet	AURO_SoilM	2001	10	14	287	0.5	35.362	-76.716	13
70	NCEconet	AURO_SoilM	2001	10	15	288	0.5	35.362	-76.716	13
71	NCEconet	AURO_SoilM	2001	10	16	289	0.5	35.362	-76.716	13
72	NCEconet	AURO_SoilM	2001	10	17	290	0.5	35.362	-76.716	13
73	NCEconet	AURO_SoilM	2001	10	18	291	0.5	35.362	-76.716	13
74	NCEconet	AURO_SoilM	2001	10	19	292	0.5	35.362	-76.716	13
75	NCEconet	AURO_SoilM	2001	10	20	293	0.5	35.362	-76.716	13
76	NCEconet	AURO_SoilM	2001	10	21	294	0.5	35.362	-76.716	13
77	NCEconet	AURO_SoilM	2001	10	22	295	0.5	35.362	-76.716	13
78	NCEconet	AURO_SoilM	2001	10	23	296	nan	35.362	-76.716	3
79	NCEconet	AURO_SoilM	2001	10	24	297	nan	35.362	-76.716	3
80	NCEconet	AURO_SoilM	2001	10	25	298	nan	35.362	-76.716	3
81	NCEconet	AURO_SoilM	2001	10	26	299	nan	35.362	-76.716	3
82	NCEconet	AURO_SoilM	2001	10	27	300	nan	35.362	-76.716	3
83	NCEconet	AURO_SoilM	2001	10	28	301	nan	35.362	-76.716	3
84	NCEconet	AURO_SoilM	2001	10	29	302	nan	35.362	-76.716	3
85	NCEconet	AURO_SoilM	2001	10	30	303	nan	35.362	-76.716	3
86	NCEconet	AURO_SoilM	2001	10	31	304	nan	35.362	-76.716	3
87	NCEconet	AURO_SoilM	2001	11	1	305	nan	35.362	-76.716	1
88	NCEconet	AURO_SoilM	2001	11	2	306	nan	35.362	-76.716	1
89	NCEconet	AURO_SoilM	2001	11	3	307	nan	35.362	-76.716	1
90	NCEconet	AURO_SoilM	2001	11	4	308	nan	35.362	-76.716	1
91	NCEconet	AURO_SoilM	2001	11	5	309	nan	35.362	-76.716	1
92	NCEconet	AURO_SoilM	2001	11	6	310	nan	35.362	-76.716	1

Figure 3 AURO soil moisture data after QAQC

Reference

Ford, T. W., and S. M. Quiring, 2014: Comparison and application of multiple methods for temporal interpolation of daily soil moisture. *International Journal of Climatology*, **34**, 2604–2621.

Quiring, S. M., T. W. Ford, J. K. Wang, A. Khong, E. Harris, T. Lindgren, D. W. Goldberg, and Z. Li, 2016: The North American soil moisture database: development and applications. *Bulletin of the American Meteorological Society*, **97**, 1441–1459.