Conductivity and Water Temperature Data from Lake Superior Tributaries, Initial Quality Control

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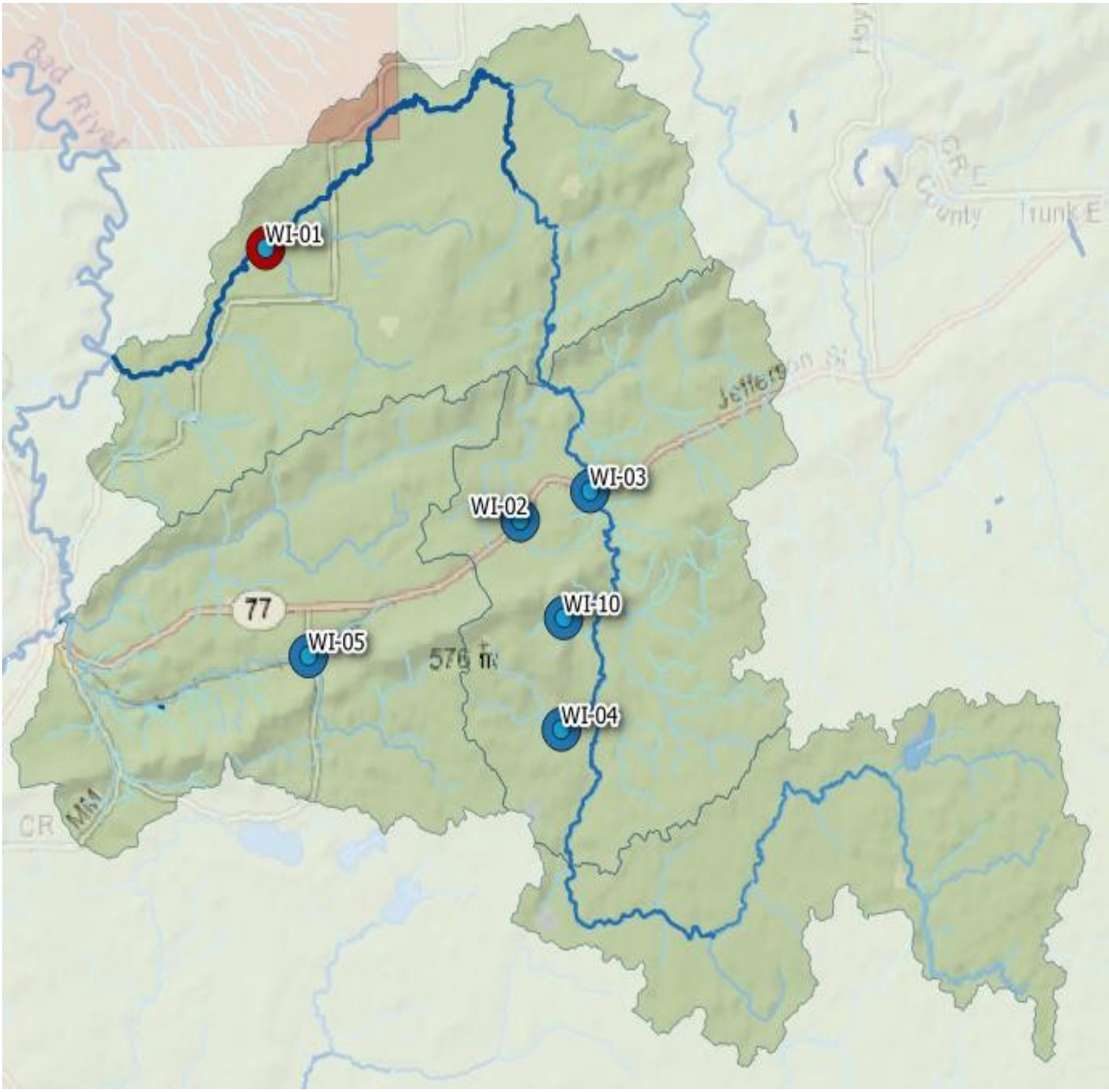

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Introduction

In 2011, GLIFWC Environmental Section staff began collecting water quality data in three watersheds in the Chippewa Ceded Territory. Those focus ares were:

1. the **Upper St. Louis watershed** in Minnesota which may see an increase in mining from the development of sulfide mineral deposits recently under exploration and permitting;
2. the **Tyler Forks watershed** in Wisconsin which has been the subject of much speculation due to the presence of a large taconite deposit with known sulfide components;
3. the **Presque Isle watershed** in Michigan which may see an increase in mining from the development of metal sulfide, iron and uranium deposits recently under exploration.

These three areas (Map 1) were selected because they are relatively un-impacted by human activity, in particular hardrock mining, yet are areas of recent exploration for minerals. The goal of the project was to establish baseline water quality in those watersheds prior to impact from mining or other landscape scale disturbances. The rationale for selecting individual monitoring sites within each of these three watersheds was to establish one site on the main stem of the river as in the Presque Isle watershed (Map 2) and establish 3-4 contributing sites (e.g. Map 2, blue points) on tributaries upstream of the main-stem site. Not all watersheds had significant branching in the stream network and were more linear in nature, such as the Upper St. Louis (Map 3). In one focus area, 6 sites were established, 5 sites within the Tyler Forks watershed and one site in an adjacent watershed (WI05) to provide contrast with a road salt impacted stream (Map 4).

Methods

Field

Data loggers from Onset Computing (model #U24) using Hoboware software were deployed as described in the project SOP and consisted of:

- Selection of sites in tributaries to Lake Superior that may be or are impacted by mining (Figure 1).
- Placement of loggers in 50 micron domestic water system filter bags to exclude sediment.
- Inclusion of foam flotation in the filter bag to keep the bag/logger combination in the water column and prevent it from becoming embedded in stream sediments.
- Deployment of the loggers by attachment of the bag containing the logger to the stream bed in a channel of flow.
- Downloading and re-launching data loggers once or twice per year.
- Archiving each downloaded logger data file in Hoboware file format using the site id, period of record and logger serial number as filenames (e.g. WI10_2019-08-14_2020-06-30_20100499.hobo).

Study sites and logging frequency

Monitoring began in 2011 as part of a larger study that includes grab sampling and USGS stream gages and has been conducted through 2021. Loggers were set to record water temperature and conductivity ever 30 minutes. In recent years, in an attempt to extend battery life of the loggers, logging intervals have been lengthened to 1 hour. A description and coordinates of loggers was recorded as specified in the logging SOP and is reproduced in Table 1.

Table 1. Logger site ID, location, water body type, and pairing with USGS gaging for each site in this report.

Site ID	Location	Latitude	Longitude	Type	USGS gage
MN-01	St. Louis River at CR 346 (Moose Line Rd.) (FR130)	47.472603	-92.121252	River	No
MN-02	St. Louis River at Highway 110 (stream gage location)	47.481121	-92.03985	River	Yes
MN-03	St. Louis River and Skibo Mill landing at FR795	47.4676	-91.93831	River	No
MN-04	St. Louis River at railroad near river mile 194	47.491488	-91.845856	River	No
WI-01	Tyler Forks at Stricker Rd. [stream gage location], north shore	46.394597	-90.590024	River	Yes
WI-02	Javorski Cr. at railroad grade	46.340885	-90.516924	Stream	No
WI-03	Tyler Forks at Highway 77	46.347234	-90.494316	River	No
WI-04	Bull Gus Cr. at County Forest Rd.	46.303023	-90.504947	Stream	No
WI-05	Devil's Creek at Lake Rd.	46.318347	-90.580478	Stream	No
WI-10	Stream13 at Cedar Falls	46.32378	-90.5033	Stream	No
MI-01	Presque Isle & M28 [stream gage location]	46.546727	-89.777243	River	Yes
MI-02	Little Presque Isle 1.5 miles NW of Wolf Mtn.	46.462213	-89.786601	River	No
MI-03	Presque Isle & Copps Rd. north of Theilers	46.478664	-89.721304	River	No
MI-04	Presque Isle east off Old Michigan 64 near State Line Trail	46.361915	-89.6971	River	No

Data files downloaded from the onset loggers during each site visit were identified by site and period of coverage and stored on hard drives for later analysis. Logger battery failure was a fairly frequent occurrence but in most cases a partial record of the logging period could be recovered by replacement

of logger batteries. In a few cases logger failure caused gaps in the data record. Logger downloads from 2011 to 2021 resulted in 10-20 data files per monitoring site. In all, over 2.1 million records were collected at the sites. Each record consisted of a date stamp and water temperature and electrical conductivity.

Data Processing

Data files from each of the 4-6 sites in each of the three focus areas were exported from the proprietary Onset Computer Corporation ".hobo" format to ASCI comma delimited (.csv) files using the bulk export routine of the Onset HoboWare software. Data were reported with a CST time offset (GMT-6) but a flaw in the Onset software resulted in an error of up to 1 hour in the timestamp for some records due to incorrect correction for time-zone offset. Onset Computing is working on a software fix and this report and processed data will be updated when that fix is released. Using the R statistical and data management software, individual download files in .csv format were compiled into composite files covering the period of record for each of the 14 sites. Data record time stamps were standardized to Central Standard Time (GMT-6) and column headers were standardized. During record processing, all data records were retained but empty or non-data columns were eliminated.

Variables initially retained from the ".hobo" data files were :

- **"rec"** : a numeric value indicating the data record number within each downloaded onset dataset. e.g. 1
- "**datetime"** : the date and time in Central Standard Time (tz="Etc/GMT+6") when the data was recorded. e.g. "2011-09-09 10:00:00 -0600"
- "**cond"** : the electrical conductivity of the water. e.g. 3.4
- **"C"** : the water temperature in degrees C. e.g. 30.56
- "**source"** : the source file for the record, referencing back to the original downloaded onset logger file. e.g. "MI01_2011-09-09_2011-11-10_9944499.csv"
- **"site"** : the site id of the logger, derived from the downloaded data filename. e.g "MI01"

An example of a retained data record is:
1,"2011-09-09 10:00:00 -0600",3.4,30.56,"MI01_2011-09-09_2011-11-10_9944499.csv","MI01"

Light processing was conducted to flag obvious erroneous data, create derived variables and correct data for logger specific temperature offsets. All original data records were retained, regardless of Quality Control (QC) tagging or missing values. QC tags, derived variables and corrected temperatures were simply added as additional collumns.

Calculation of Specific Conductance

Specific Conductance (conductivity corrected for temperature at 25deg.C) was calculated from raw Conductivity and Temperature with the formula:

Specific Conductance = raw conductivity/(1+(0.019*(degreesC-25)))

This is the same default formula used in field YSI meters.

Quality Control Tagging

Data records were tagged with Quality Control (QC) codes based on observed and detected problems with the data records.

Codes were:
- "P" for Pass, indicating that the data record passed the QC check
- "F" for Fail, indicating that the data record failed the QC check
- "S" for suspect, indicating that the data record looks suspicious.

Initially all data was assumed to be of adequate quality and marked with a QC tag "P".

New variables based on data quality criteria were assigned to each record as new columns. Initially all new variables of all records were assigned to "P" (Pass) and then flipped to "F" (Fail) according to the following rules:

Periods of known logger failure.-
a new column "BP" (Bad Period) was recorded as:
- "F" if the temperature or conductivity sensor failed or was know to be non-functional over an extended period of time.

In order to identify these known periods, failure periods were recorded by date in manually created files named "Site_ID_Bad-Periods.csv" and matched by R routines with logger data records based on Site ID and dates.

Comparison of Specific Conductance (SC) to expected values.- was conducted as follows:
a new column "SC_SPK" (a data SPiKe) was recorded as:
- "S" if SC reading was more than 5 uS/cm above or below the mean of the adjacent 2 readings on either side (i.e. a 4 readings average)
- "F" if SC reading was more than 10 uS/cm above or below the mean of the adjacent 2 readings on either side (i.e. a 4 readings average)

a new column "SC_OOR" (data Out Of Range) was recorded as:
- "F" if SC reading was less than 20 uS/cm

a new column "SC_ROC" (unusual Rate Of Change) was recorded as:
- "F" if SC reading was more than 20 uS/cm above or below the previous or next reading.

Comparison of Temperature degrees (C) to expected values.- was conducted as follows:
a new column"C_SPK" (a data SPiKe) was recorded as:
- "S" if C reading was more than 1 deg.C above or below the mean of the adjacent 2 readings on either side (i.e. a 4 readings average)
- "F" if C reading was more than 2 deg.C above or below the mean of the adjacent 2 readings on either side (i.e. a 4 readings average)

a new column "C_OOR" (data Out Of Range) was recorded as:
- "S" if C reading was more than 30 deg.C
- "F" if C reading was more than 35 deg.C
- "S" if C reading was less than -1 deg.C

a new column "C_ROC" (unusual Rate Of Change) was recorded as:
- "F" if C reading was more than 2 deg.C above or below the previous or next reading.

Overall data record quality.- was conducted as follows:
a new column "QC" was recorded as:
- "P" if all of the above tags were recorded as "P" (record Passed)
- "F" if any of the above tags were recorded as "F" (record failed)
- "S" if any of the above tags were recorded as "S" (record is suspect)

Presence of missing values.- was conducted as follows:
a new column "MISS" (MISSing data) was recorded as:

- "P" if neither conductivity nor C readings were missing for a sample date
- "F" if either conductivity or C readings were missing for a sample date

Logger Temperature Correction

Observations in the field indicated that temperature sensors of the loggers were as much as 2 deg.C different from the surrounding water. Deviation for actual water temperature varied between loggers but was more consistent for each logger. Since over the life of the project different loggers were used at each site, each logger's temperature readings had to be corrected.

Initially, logger temperature correction to readings taken with a YSI meter at time of logger deployment and logger retrieval was attempted. Despite the manufacturer recommending this approach, it was observed that YSI vs logger temperature readings differed greatly and depended on the exact placement of the YSI temperature sensor in the water column. In addition water temperature in some small streams varied by 1 or 2 degrees over short time periods (60 min or less) during some months of the year. And finally, the logger manufacturer's software error that introduced an time error of up to 1 hour made matching exactly the time of YSI readings and logger records impossible given the large number of records. These factors made it extremely difficult to dependably match YSI meter readings with loggers readings at deployment and retrieval.

Because of the difficulty in using YSI readings to correct logger temperatures, an alternative temperature calibration approach was taken. This was based on the observation that YSI and logger temperature reading taken in mid-winter (weeks 3-6 of the year), ice covered streams generally remained between 0 and 1 deg.C. Therefore, temperature data was corrected by comparing the median logger late January - early February temperature readings to 0.5 deg.C. for each logger. This provided a logger specific temperature correction factor. Using that correction factor, data was adjusted so that the median of each logger's mid-winter readings was 0.5 deg.C. If, as occurred for a few loggers, there were no data records over late January to Early February, no correction was applied. If temperature correction was applied, data records were tagged with a flag T_Corr as either "Y"(yes) or "N"(no). A table of the temperature correction factors used for each logger was recorded in a table labeled:
"site_begin-date_end-date_T_corr.crv"
e.g. "WI-01_2011-09-08_2021-05-01_T_corr.csv"

After correction of data record temperatures, a corrected Specific Conductance was re-calculated based on the corrected temperature using the default YSI specific conductance correction formula.

Temperature corrections based on comparison of mid-winter water temperature records to 0.5 deg.C ranged from 0.00 to 2.7 (median=0.27) degrees centigrade. The correction values for individual loggers can be found listed by logger serial number in the T_corr.csv files. Both the corrected and uncorrected temperatures were included in the final data file.

Composite data record files

Finally, data records for each site for the entire period of record were written to a composite data file in .csv format. All original data records were retained, regardless of Quality Control tagging or missing values. QC tags, corrected temperature and corrected specific conductance were simply added as

additional record columns. The composite data files were named based on the site id and the period of record. The 19 variable in the final composite files were:

"rec" : a numeric value indicating the data record number within each downloaded onset dataset. e.g. 1
"datetime" : time in Central Standard Time (GMT-6) when the data was recorded. e.g. "2011-09-09 10:00:00 -0600"
"cond" : the electrical conductivity of the water. e.g. 3.4
"C" : the water temperature in centigrade . e.g. 30.56
"source" : the file source for the record, referencing back to the original downloaded onset logger file.
"site" : the site id of the logger, derived from the downloaded data filename and referencing the watershed site. e.g. "WI02"
"sp.c" : Specific Conductance in uS/cm calculated from the water conductivity and temperature. e.g. 54.5
"BP" : "F" or "P" if a record is/is-not during an identified "bad period" listed in the file "Site_Bad_Periods01.csv".
"SC_SPK" : If a record passes "P" or fails "F" the SPiKe Specific Conductance test
"SC_OOR" : If a record passes "P" or fails "F" the Out Of Range Specific Conductance test
"SC_ROC" : If a record passes "P" or fails "F" the Rate Of Change Specific Conductance test
"C_SPK" : If a record passes "P" or fails "F" the SPiKe temperature C test
"C_OOR" : If a record passes "P" or fails "F" the Out Of Range temperature C test
"C_ROC" : If a record passes "P" or fails "F" the Rate Of Change temperature C test
"MISS" : If a record has both temperature and conductivity values "P" or does not "F"
"QC" : If a record passes "P", is suspect "S", or fails "F" for any of the quality control tests
"T_corr" : If temperature correction was applied "Y" or not "N"
"C2" : Temperature in deg. C corrected by comparison of mid-winter water temp. to 0.5 deg.C
"sp.c2" : Specific Conductance in uS/cm calculated from the water conductance and corrected temperature. e.g. 55.6

The header of the composite data file for each site is:

"rec","datetime","cond","C","source","site","sp.c","BP","SC_SPK","SC_OOR","SC_ROC","C_SPK","C_OOR","C_ROC","MISS","QC","T_corr","C2","sp.c2"

Example data records are:

1,2011-09-07 09:00:00,24.5,15.76,"MN-01_2011-09-07_2011-11-08_9944494.csv","MN-01",29.72,"F","P","P","P","P","P","F","P","F","Y",15.52,29.88
and
3,"2011-09-10 12:30:00 -0600",109.5,12.37,"STE-24-01_2011-09-10_2011-11-11_9792833.csv","STE-24-01",144.07,"F","F","P","P","S","P","P","P","F","Y",11.92,145.71

Three data files were created for each site:

1. The composite data record covering the complete period of record and including the QC tags, the corrected temperature and the corrected specific conductance. e.g. MN-02_2011-09-07_2020-06-28_combo.csv
2. Records of periods of know bad data for each site. e.g. MN-02_Bad_Periods01.csv
3. Table of the logger SNs, the median temperature recorded during the 3-6th week of the year, the target temperature for mid-winter water, and the correction that was applied to temperature data to calculate corrected temperature. e.g. MN-02_2011-09-07_2020-06-28_T_corr.csv

In additiona a single data file of YSI meter field readings collected during all site visits was created. i.e. YSI_Sampling_Events_2005-2020_3ws.csv . It contains the Site_ID, date of the visit, water temperature and specific conductance measured during the visit. It can be to compared to the temperature and specific conductance values collected by the data loggers.

"Site" : The site ID
"DateTime" : The date and time that the site visit started
"DO_YSI" : Dissolved oxygen in mg/L
"pH_YSI" : pH
"Water_C" : Water temperature in deg.C
"Sp.Co_YSI" : Specific conductance in uS/cm (water conductivity corrected to 25deg.C, using YSI standard formula of: Specific conductance = raw conductivity/(1+(0.0191*(degreesC-25))))
"Cond_YSI" : Conductivity in uS/cm (conductivity of the water un-corrected for temperature)

The header of the YSI field readings file is:

"Site","DateTime","DO_YSI","pH_YSI","Water_C","Sp.Co_YSI","Cond_YSI"

Example data record:
"MI-01",2019-08-15 11:00:00,8.5,7.4,18.6,164,144

Visualization of Quality Control and Data Correction.

The temperature and specific conductance for each site was plotted by date to show the contrast between data that passed the overall Quality Control test (i.e. QC="P") and had its temperature corrected (in blue "cleaned") versus the unflagged original data (in yellow uncleaned). The 28 Plots are organized by focus area and monitoring site. Across all sites 92.5% of data passed QC checks. Overall failure rates from all causes ranging from 0.1 to 12.1% at individual sites (Table 1). The primary cause for failure of QC check was due to know equipment failures or poor initial deployment. Those were the bad data periods identified in the "Site_ID_Bad-Periods.csv" file for each site. At all sites the data collected prior to May 8, 2012 was flagged as failing the Bad-Period QC check because deployment methods in filter bags to prevent fouling was still being developed. Other periods of known equipment failure such as battery degradation were also flagged as "Bad-periods". Further, site specific, data cleaning should be conducted after examination of the uncleaned and cleaned data for each site.

Failure of QC checks for reasons other than those identified as "Bad Periods", was between 0.0 and 1.8% of the data collected at each site and failures exceeded 1% at only 1 of the 14 sites, (Table 1). Those other failures were due to causes such as data being out of reasonable range (most often when records were recorded while logger was out of the water for download) or short-term data spikes caused by brief fouling.

Table 1: Percent of data records that failed one or more Quality Control checks

Site	Overall Percent Failure Rate	Failure Rate Due to Known Equip. Error	Failure Rate Due to Other Causes
MN-01	10.3	10.3	0
MN-02	12.1	12	0.1
MN-03	9.6	9.5	0.1
MN-04	6.7	6.7	0
WI-01	5.8	5.8	0
WI-02	8.1	7.1	1
WI-03	7.5	7.5	0
WI-04	7.7	7.7	0
WI-05	0.1	0	0.1
WI-10	1.8	0	1.8
MI-01	11.1	11	0.1
MI-02	7.5	7.4	0.1
MI-03	7.2	7.2	0
MI-04	9.1	9	0.1
average	7.5	7.2	0.2

Data Availability

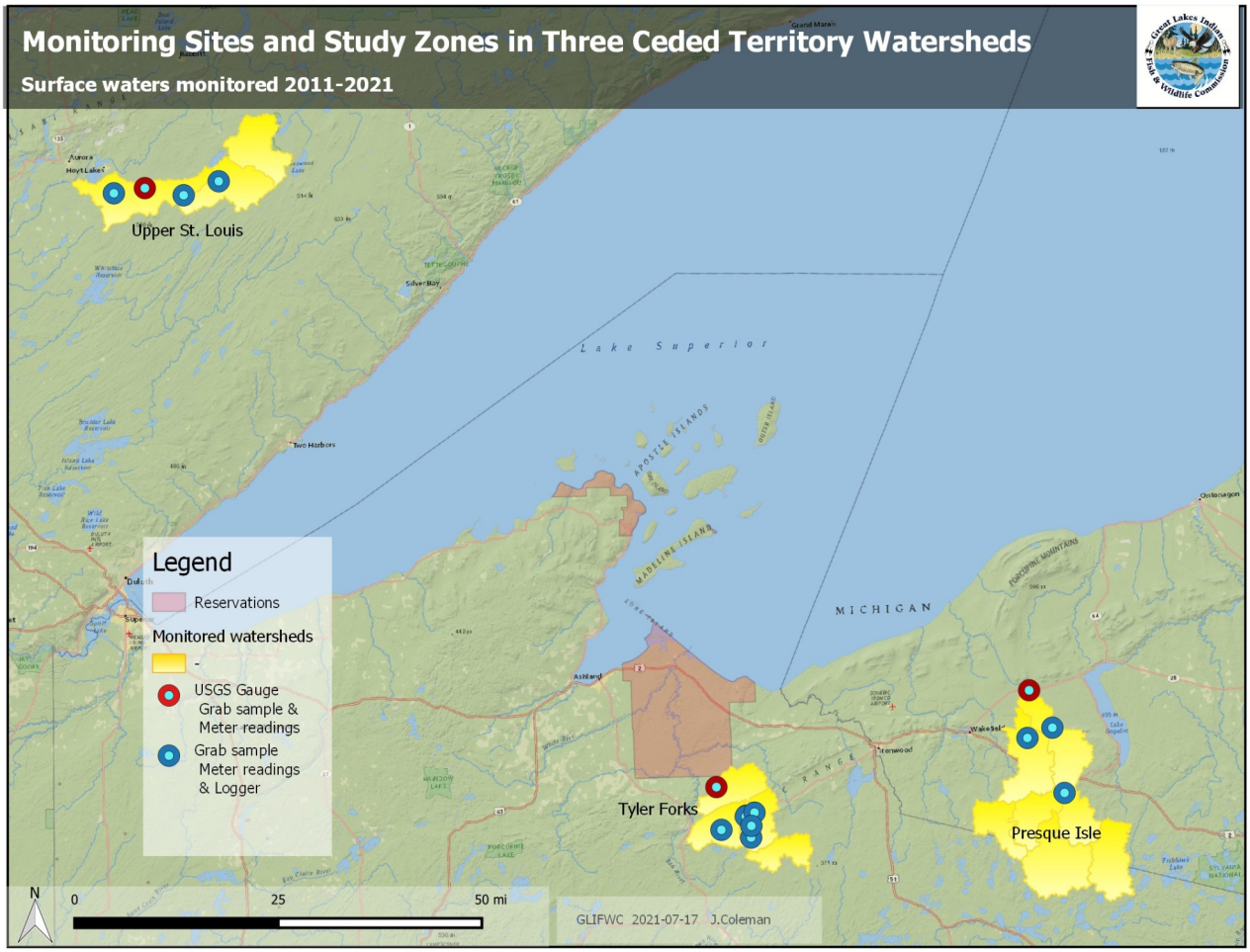
The quality controlled data and supplemental files are available from the author at <jcoleman@glifwc.org>.

Data Patterns Derived from tributary data.

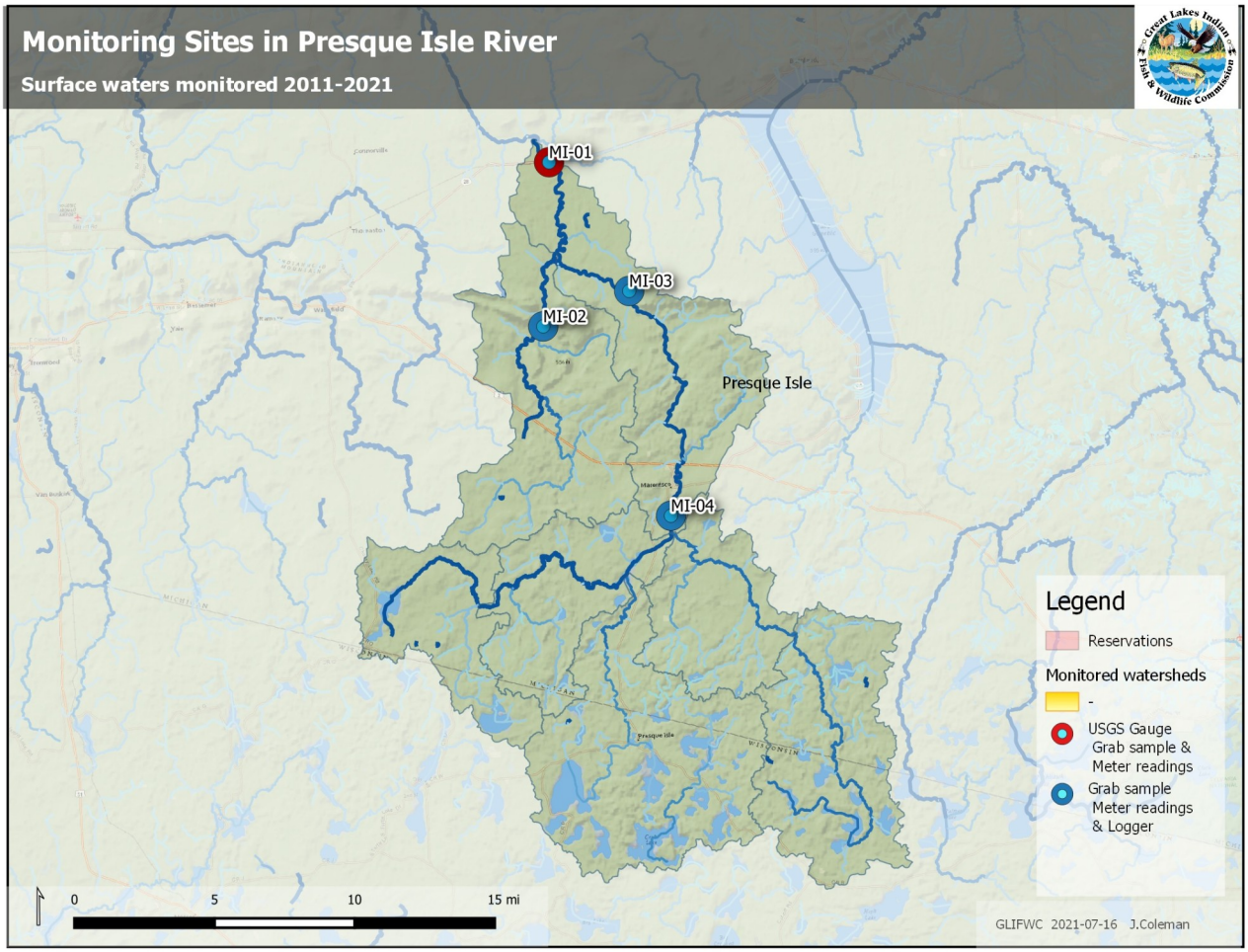
The data records for temperature and specific conductance were summarized by site and season to show patterns over the year. Time series decomposition was also conducted to extract seasonal and long term patterns in the data. That analysis is compiled and reported in a, soon to be released, Administrative Report supplemental to this document. Examples of graphical representations of that analysis can be seen in Figures 1 and 2 at the end of this document. Contact the author for information on availability of the supplemental Administrative Report.

Maps

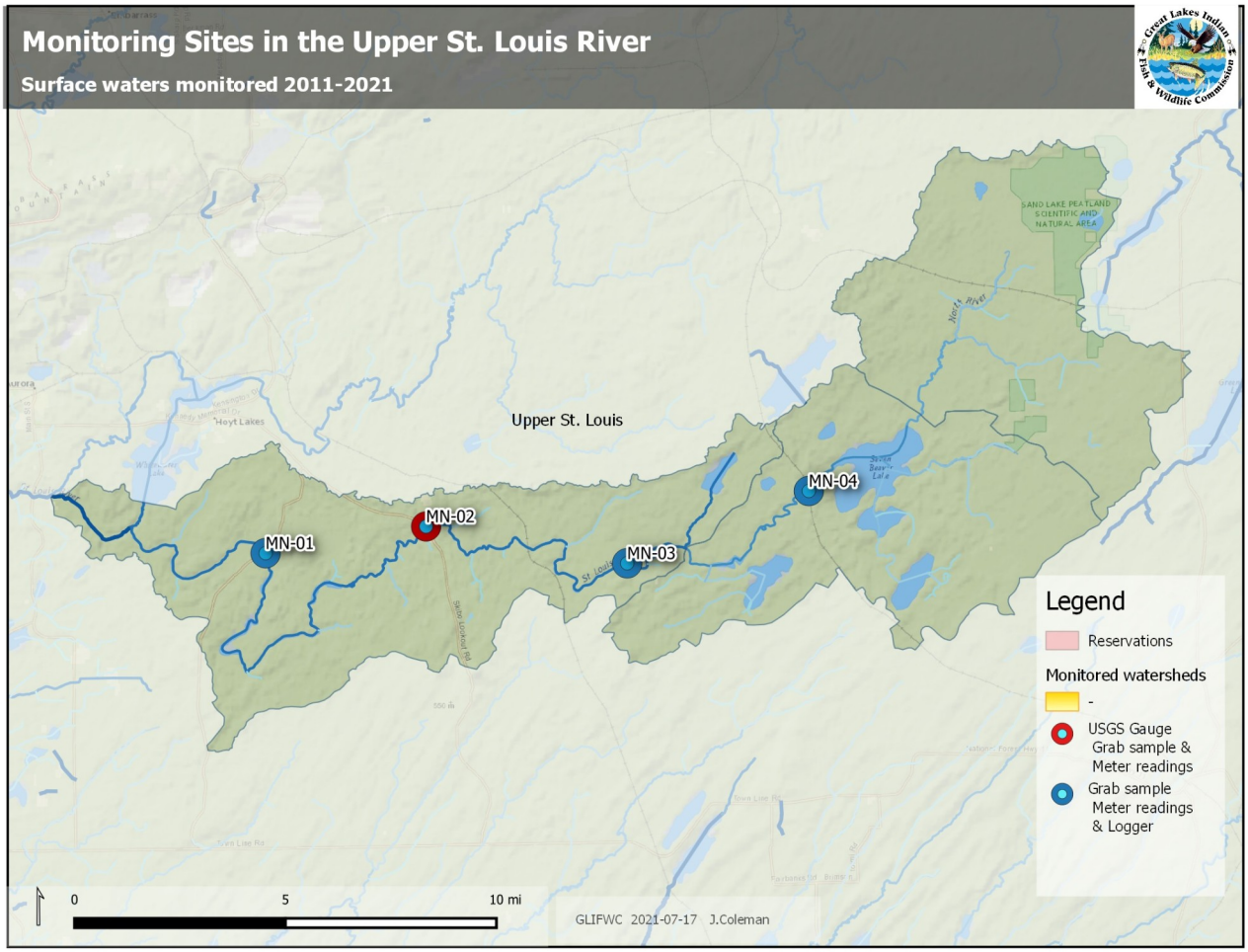
Site Maps



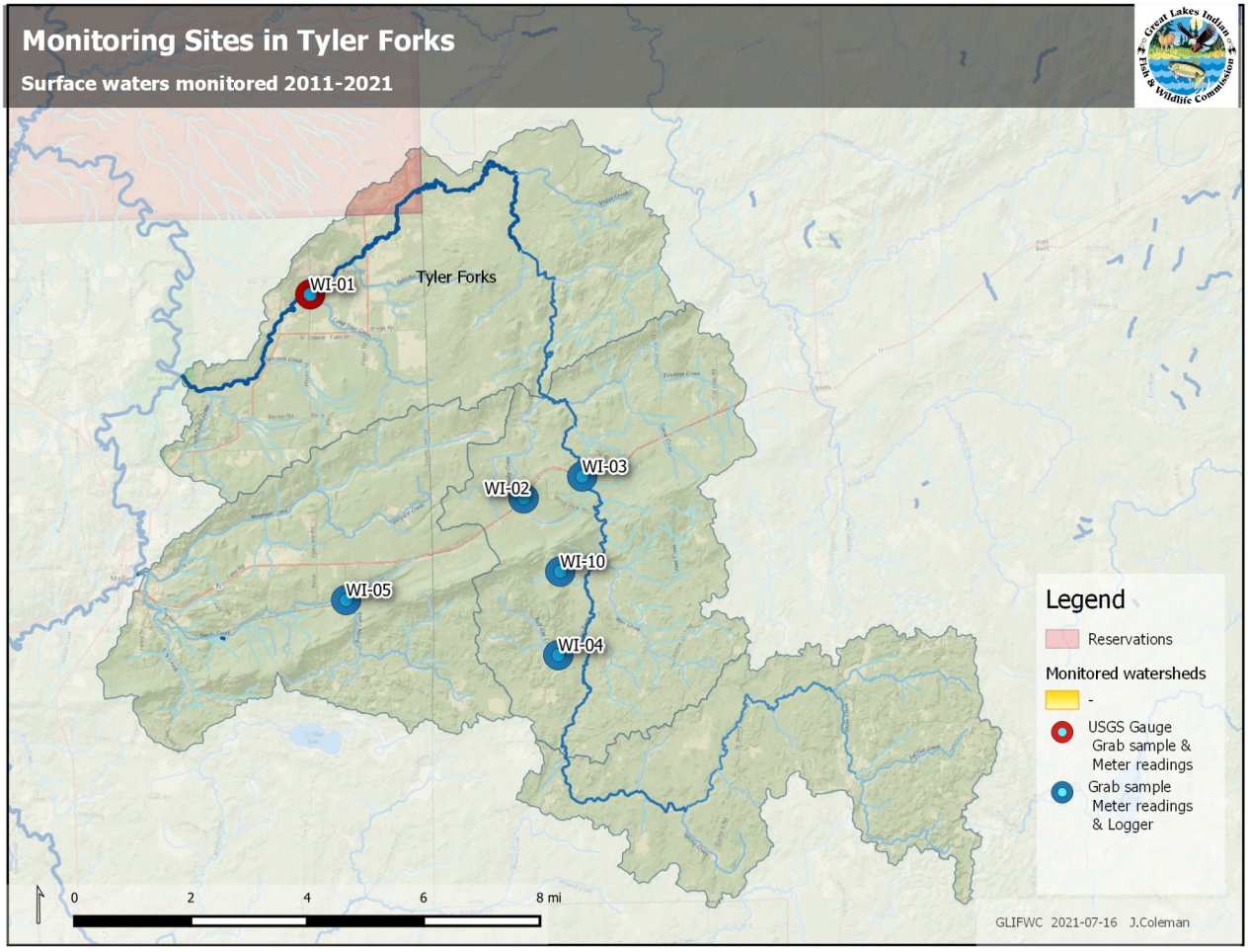
Map 1: Fourteen sites in three watersheds in Minnesota, Wisconsin and Michigan.



Map 2: Sites on the Presque Isle River, Michigan.



Map 3: Sites on the Upper St. Louis River, Minnesota.



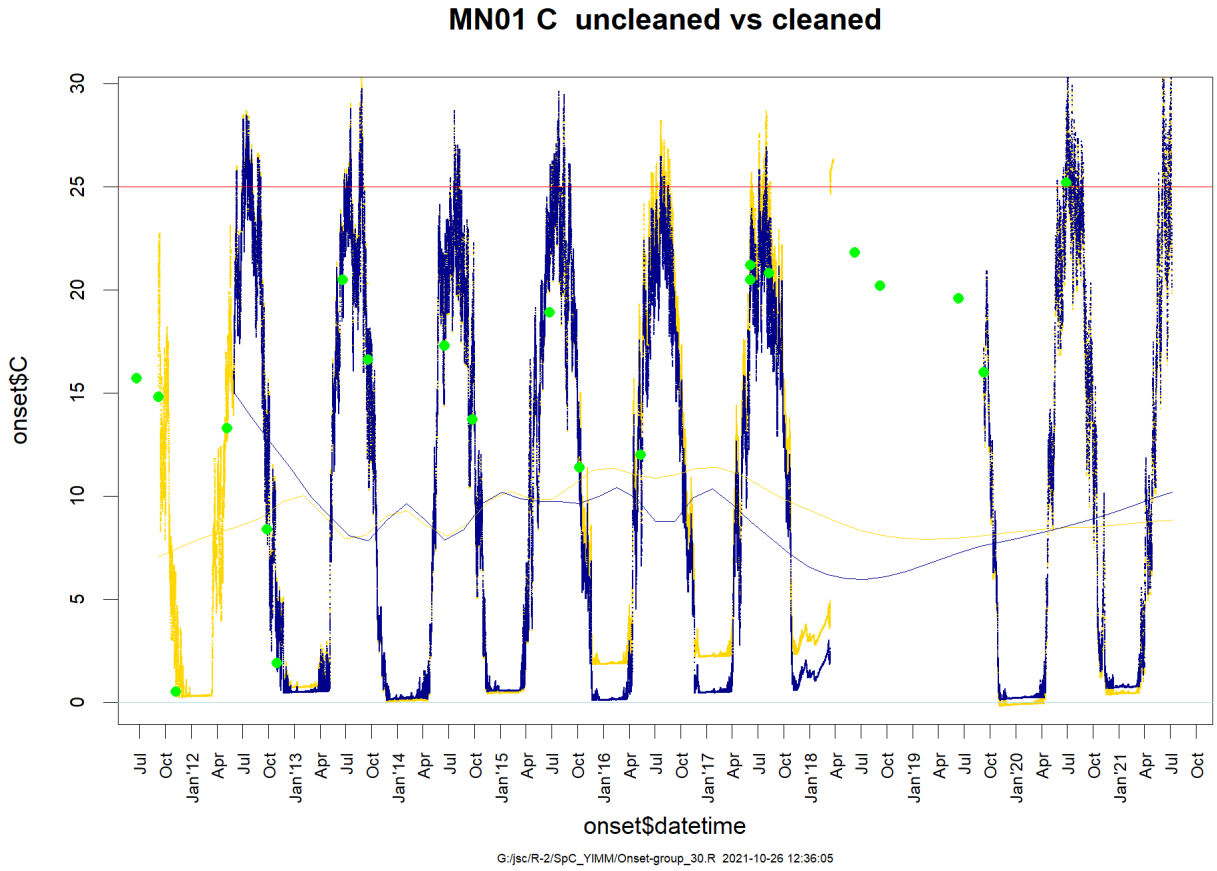
Map 4: Sites on the Tyler Forks River, Wisconsin.

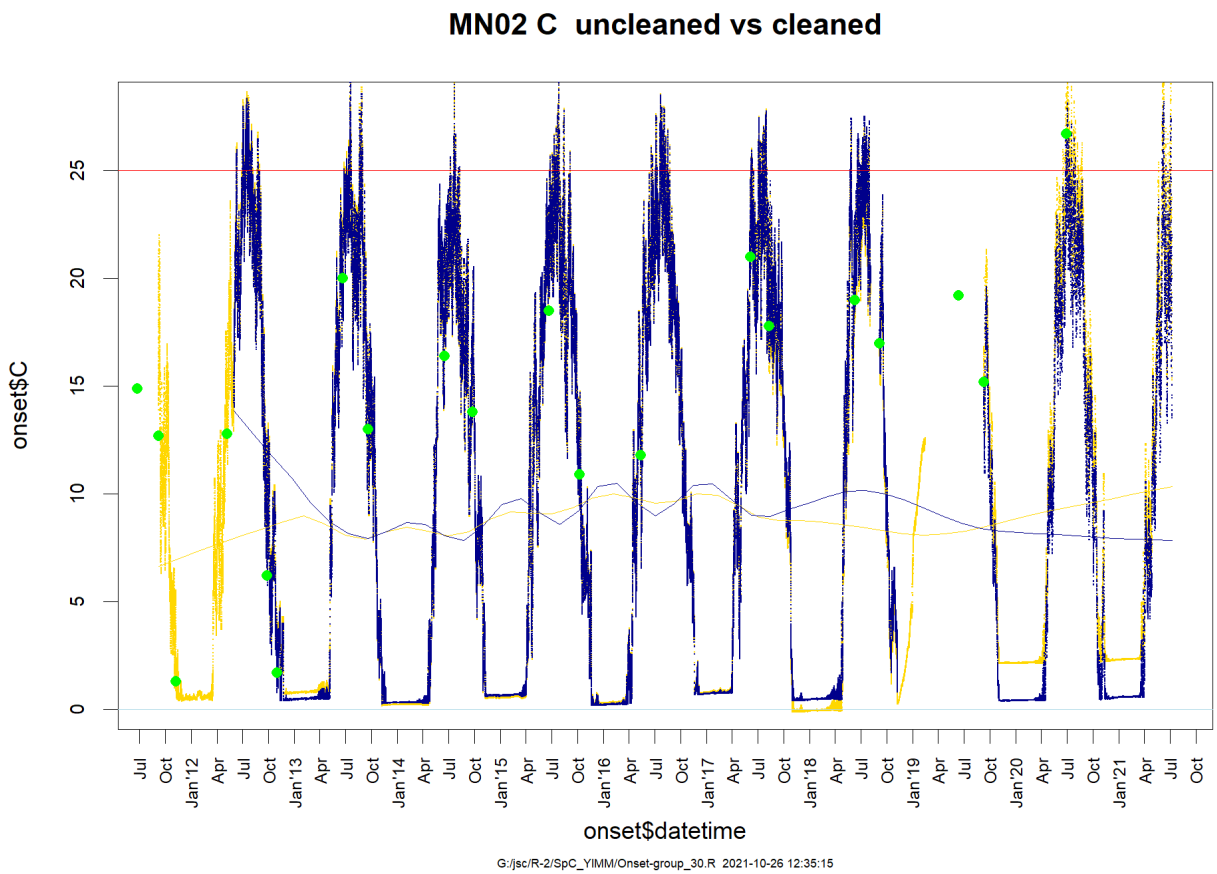
Data Plots

Temperature and Specific Conductance during 10 years

St. Louis River, Minnesota Water Temperature and Specific Conductance

Temperature (°C) with uncleaned(yellow) and cleaned(blue) data, showing trend lines and YSI meter readings (green points).

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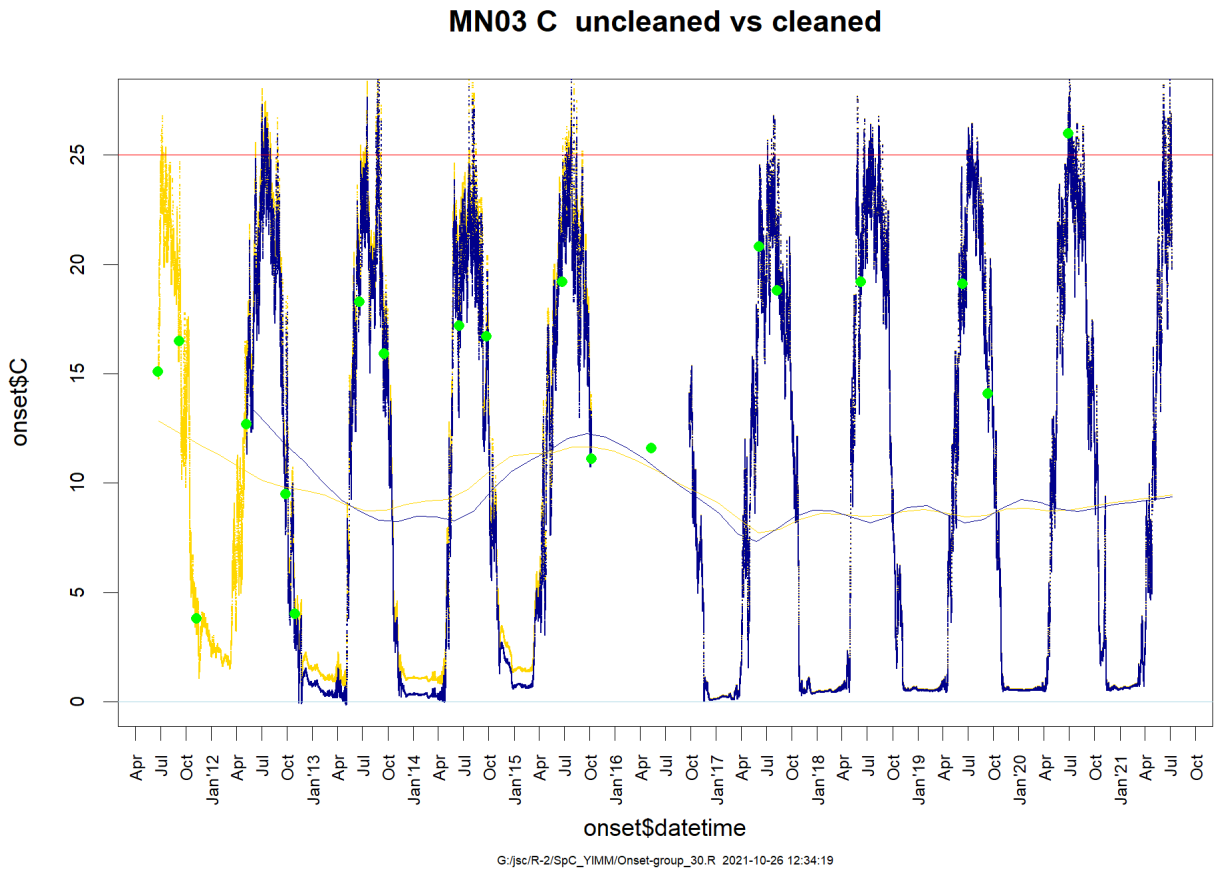
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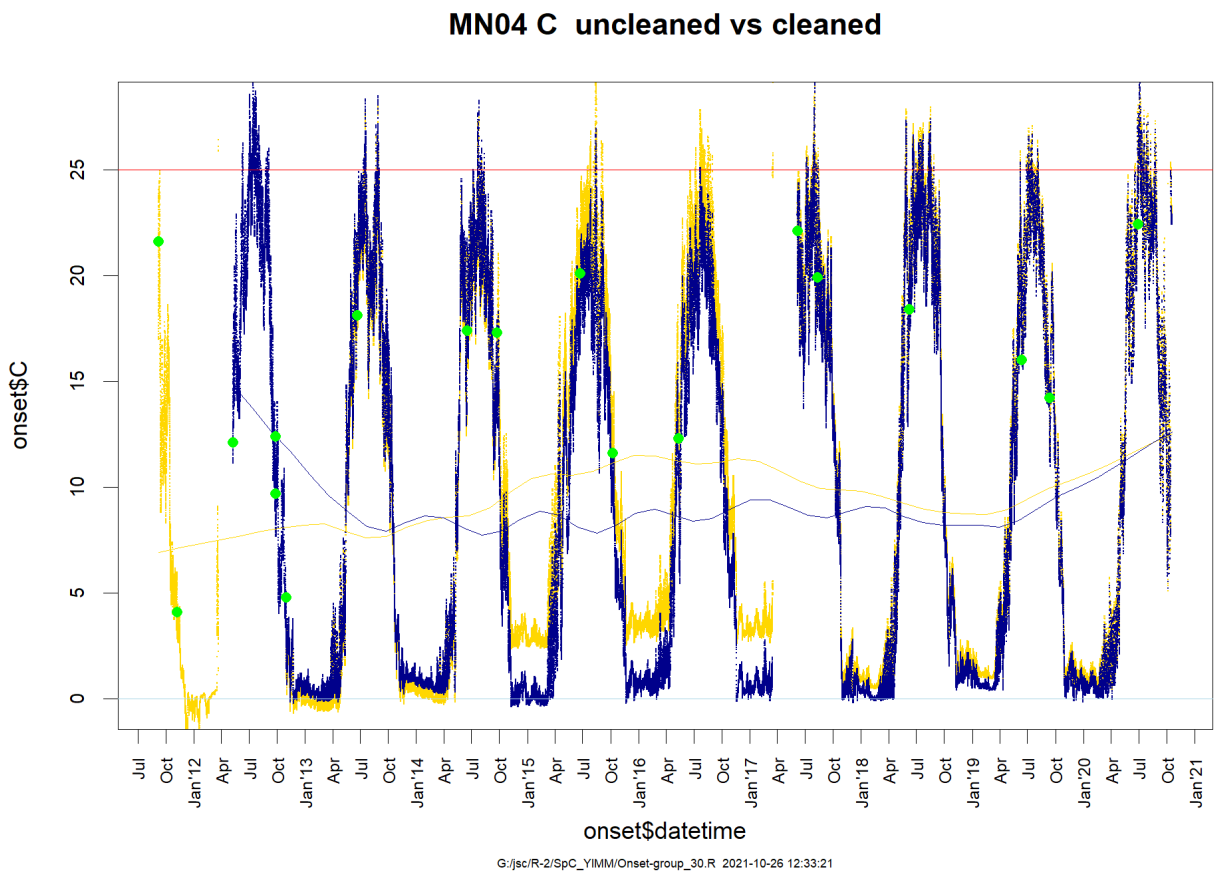
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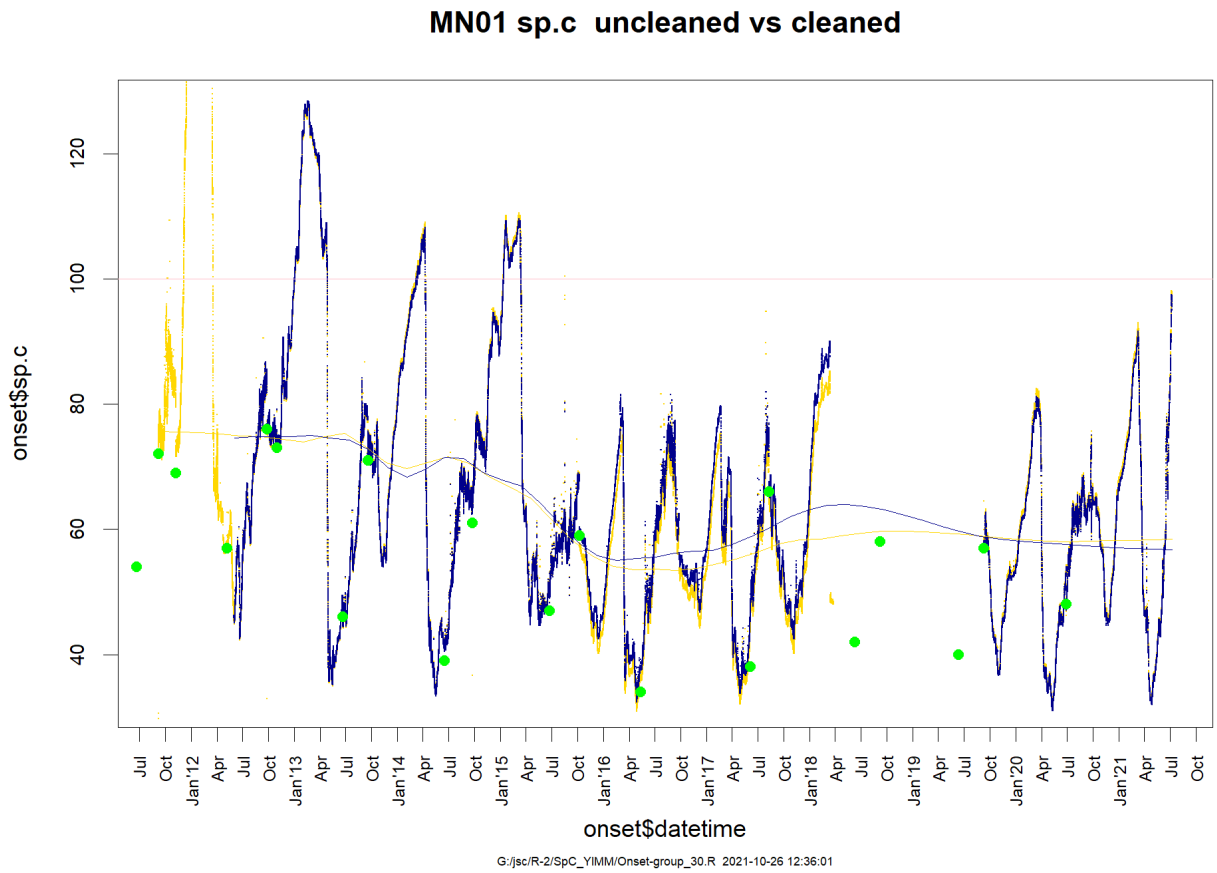
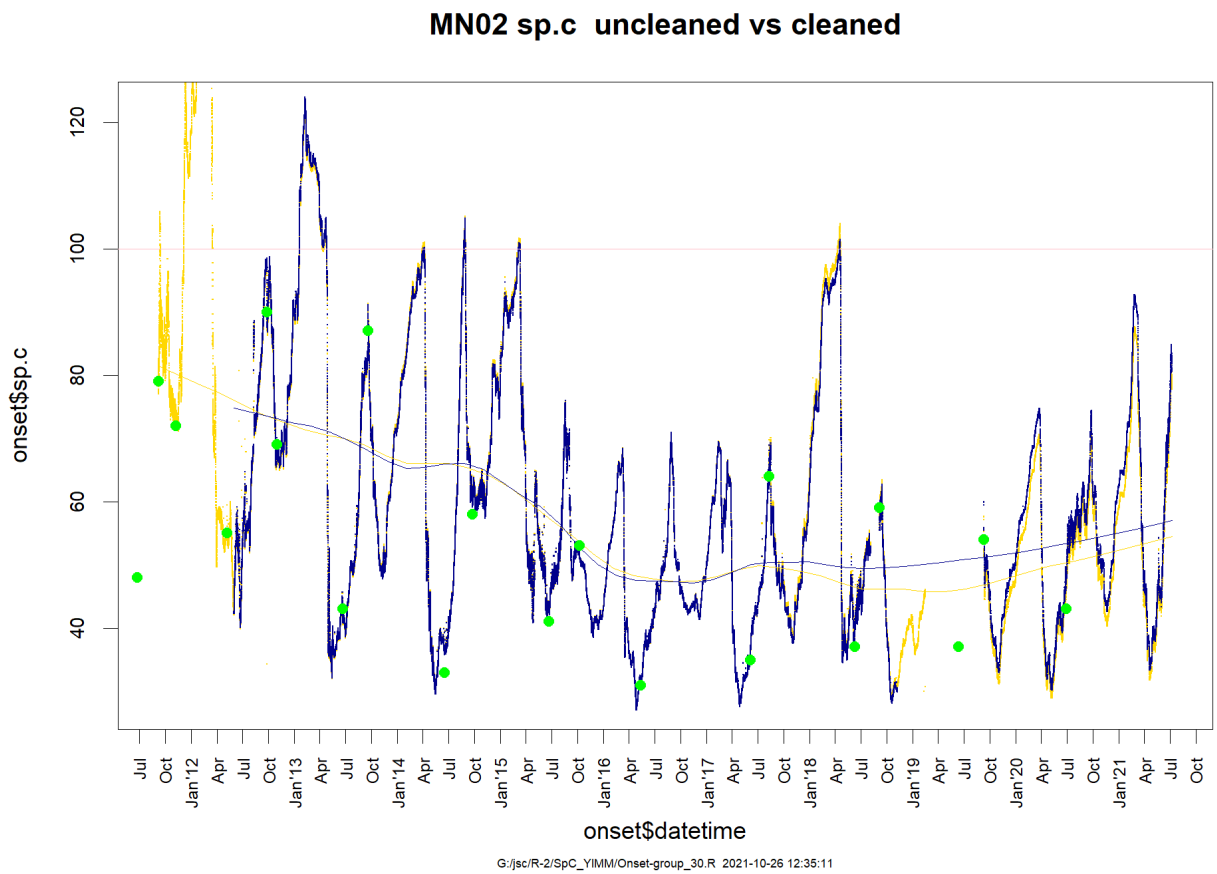
Specific Conductance with uncleaned(yellow) and cleaned(blue) data, showing trend lines and YSI meter readings (green points).

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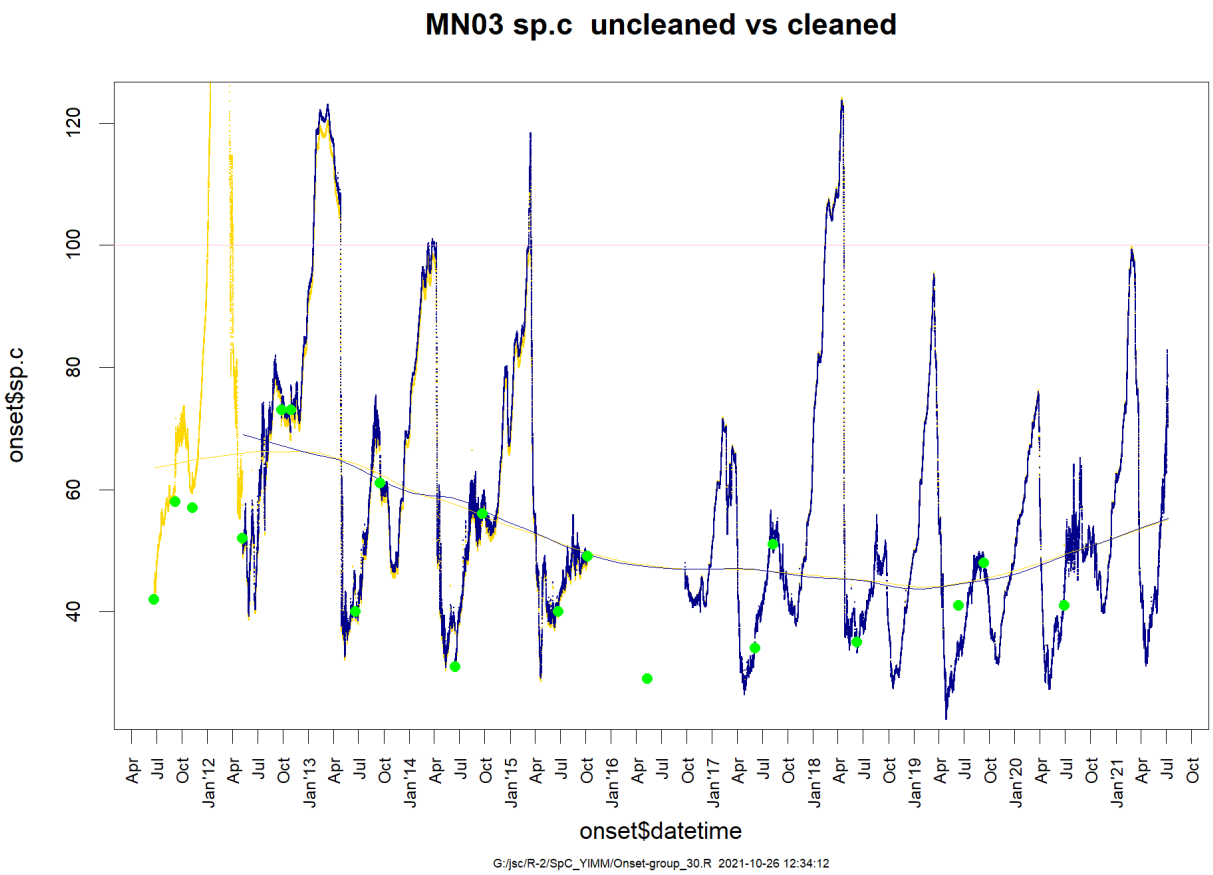
G:/jsc/R-2/SpC_YIMM/Onset-group_30.R 2021-10-26 12:35:11


MN03 sp.c uncleaned vs cleaned
onset$sp.c
40
60
80
100
120
Apr
Jul
Oct
Jan'12
Apr
Jul
Oct
Jan'13
Apr
Jul
Oct
Jan'14
Apr
Jul
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Jan'15
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Jan'16
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Jan'19
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Jan'20
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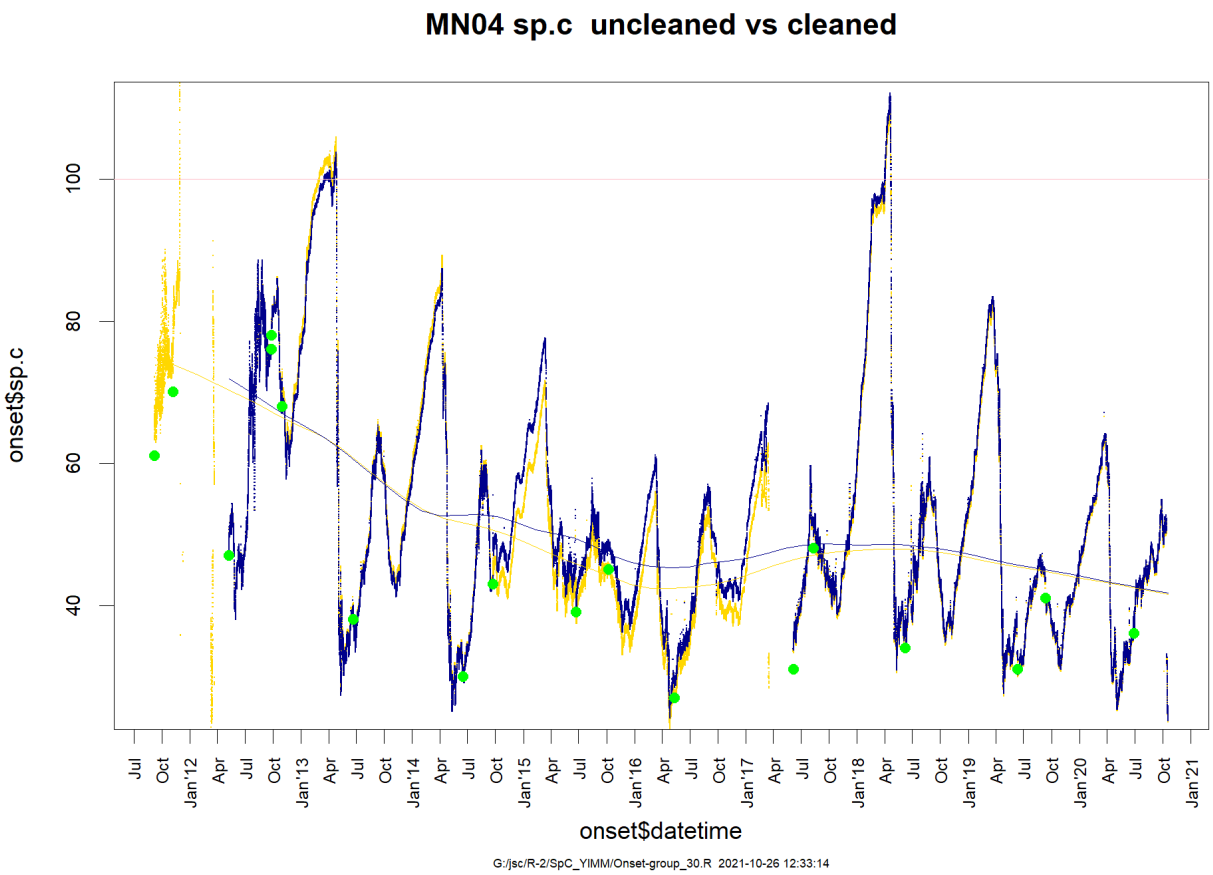
Jul
Oct
Jan'21
Apr
Jul
Oct
onset$datetime
G:/jsc/R-2/SpC_YIMM/Onset-group_30.R 2021-10-26 12:34:12


MN04 sp.c uncleaned vs cleaned
onset$sp.c
40
60
80
100
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Oct
Jan'12
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Jan'13
Apr
Jul
Oct
Jan'14
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Jan'15
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Jan'16
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Jan'20
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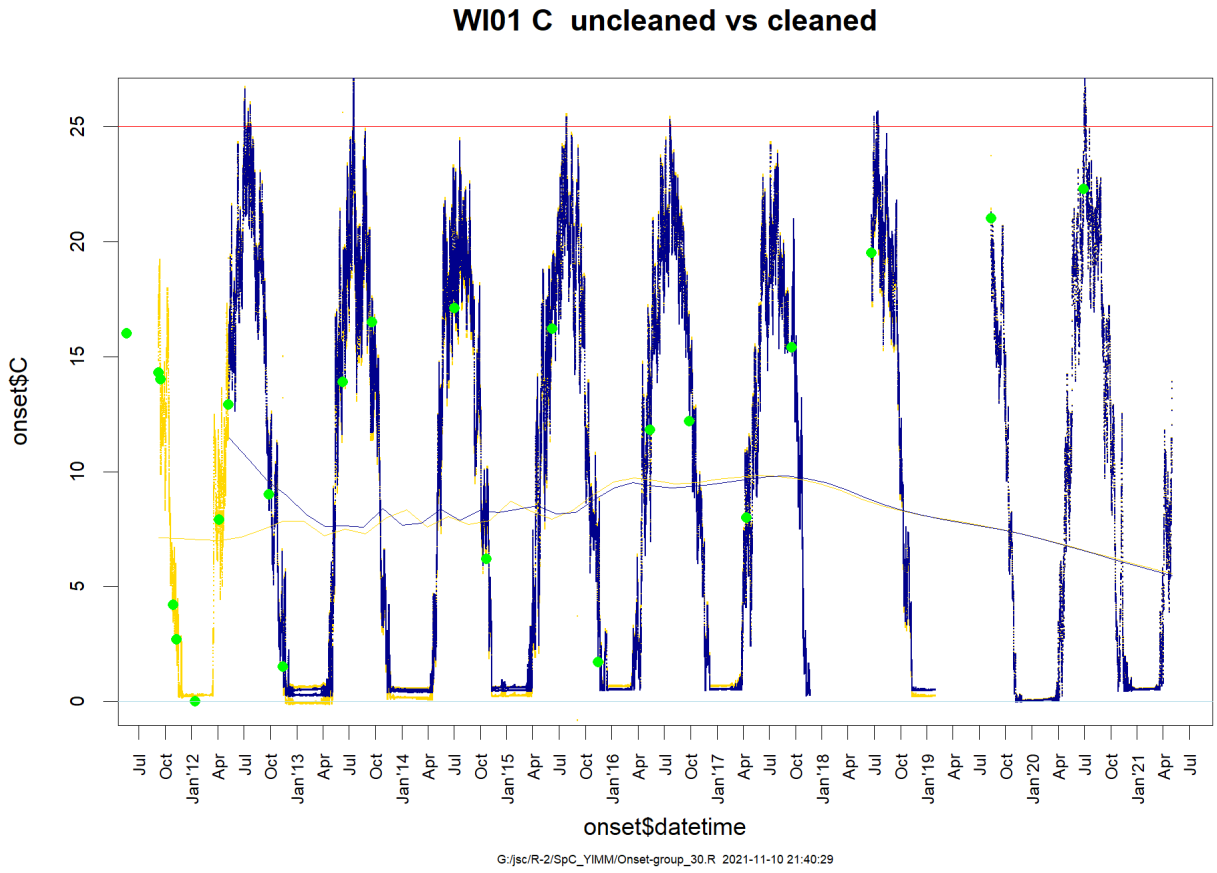
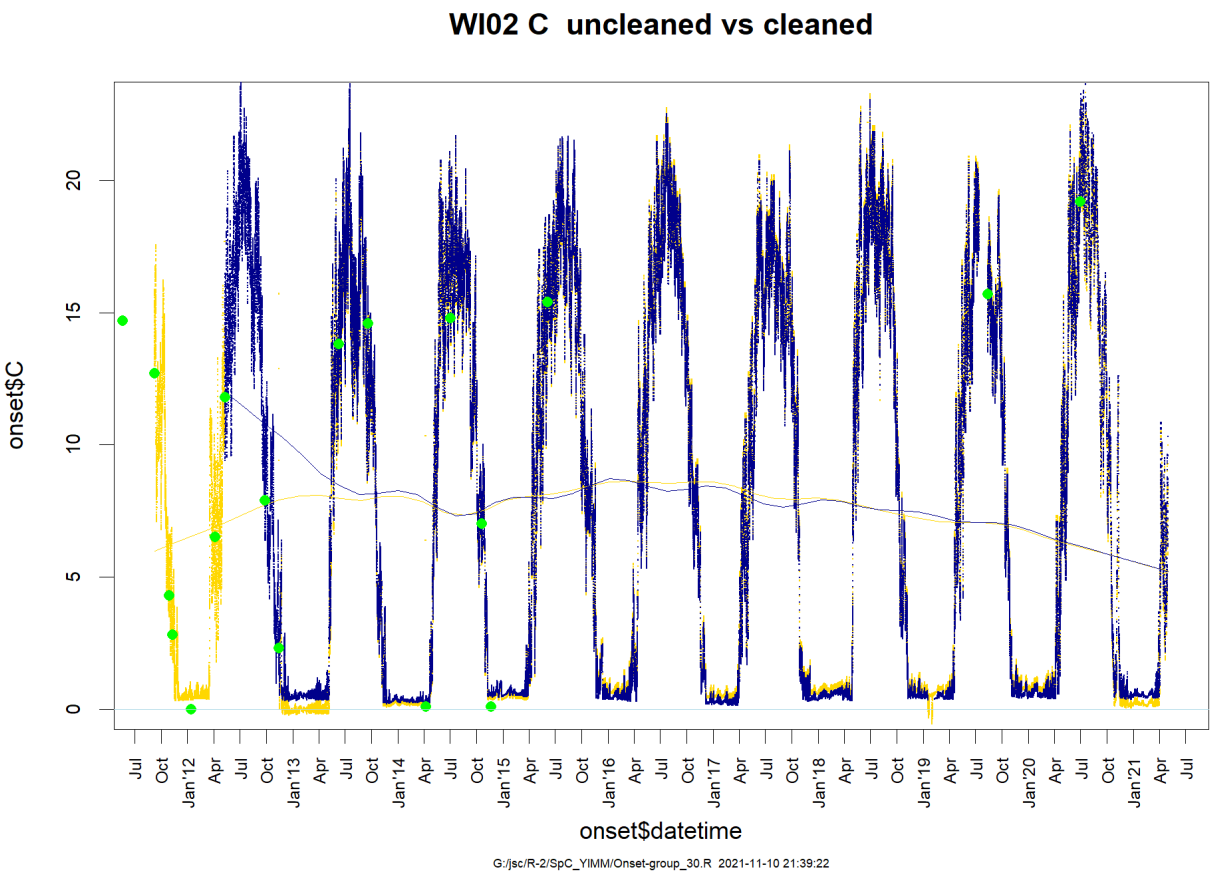
Jul
Oct
Jan'21
onset$datetime
G:/jsc/R-2/SpC_YIMM/Onset-group_30.R 2021-10-26 12:33:14

Tyler Forks, Wisconsin Water Temperature and Specific Conductance

Temperature (°C) with uncleaned(yellow) and cleaned(blue) data, showing trend lines and YSI meter readings (green points).




WI02 C uncleaned vs cleaned
onset$C
0
5
10
15
20
Jul
Oct
Jan'12
Apr
Jul
Oct
Jan'13
Apr
Jul
Oct
Jan'14
Apr
Jul
Oct
Jan'15
Apr
Jul
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Jan'16
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Jan'18
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Jan'20
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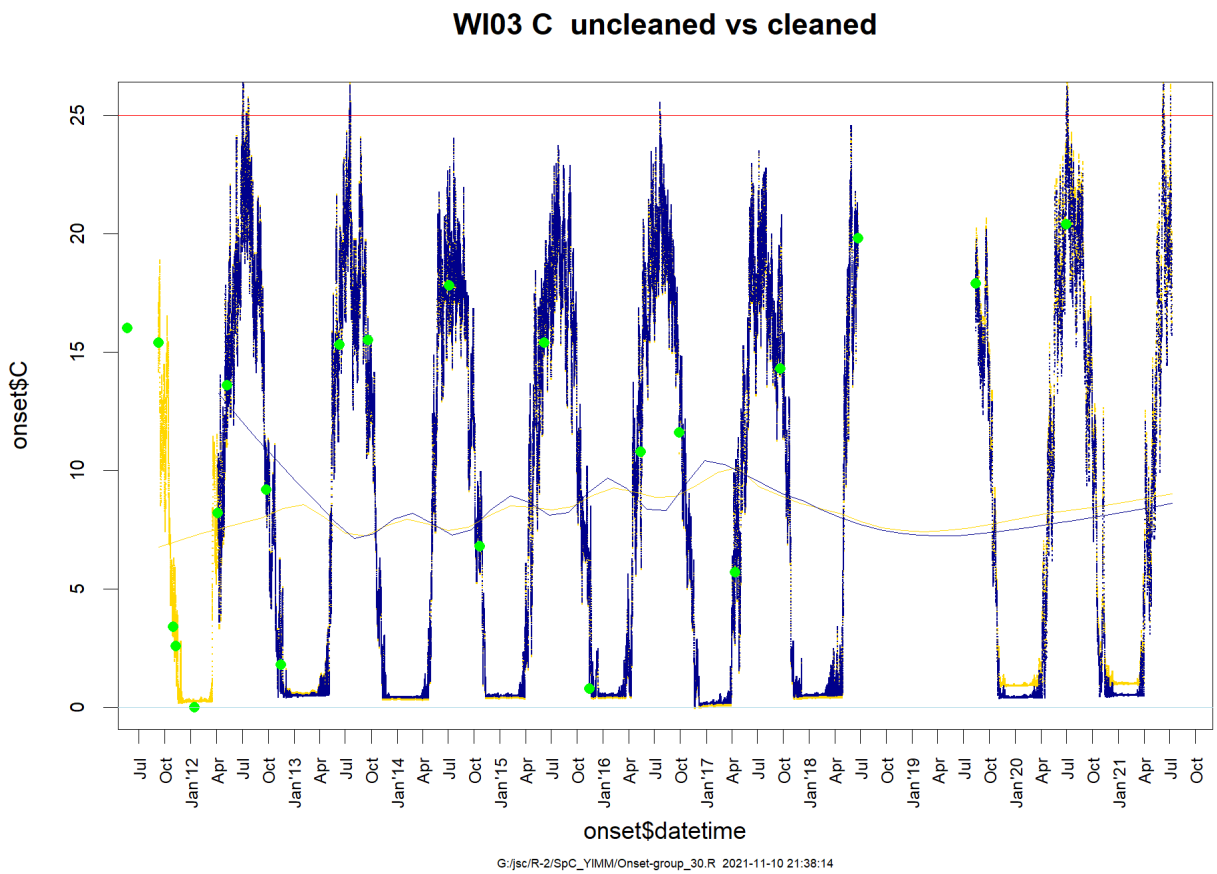
Oct
Jan'21
Apr
Jul
onset$datetime
G:/jsc/R-2/SpC_YIMM/Onset-group_30.R 2021-11-10 21:39:22


WI03 C uncleaned vs cleaned
onset$C
0
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Apr
Jul
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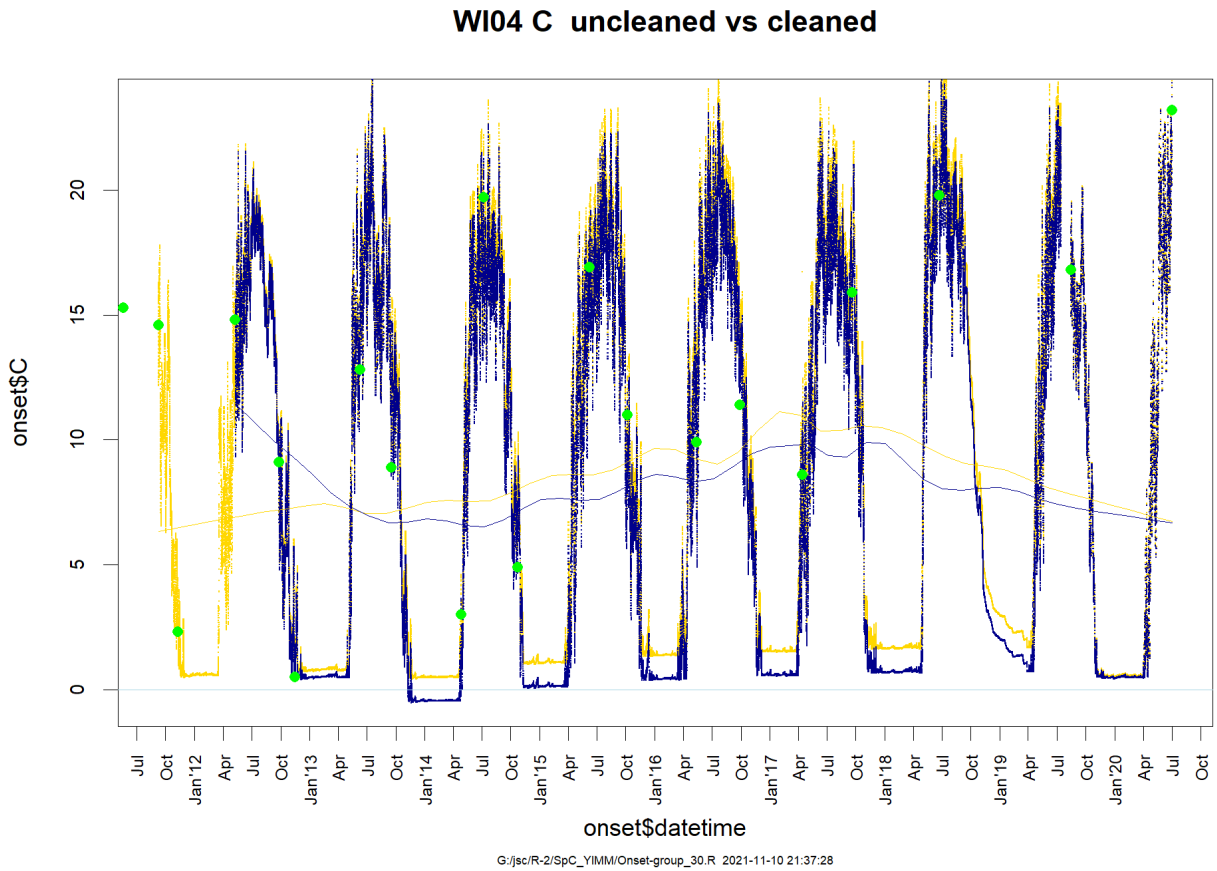
Jul
Oct
onset$datetime
G:/jsc/R-2/SpC_YIMM/Onset-group_30.R 2021-11-10 21:38:14


WI04 C uncleaned vs cleaned
onset$C
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Jan'14
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Jan'15
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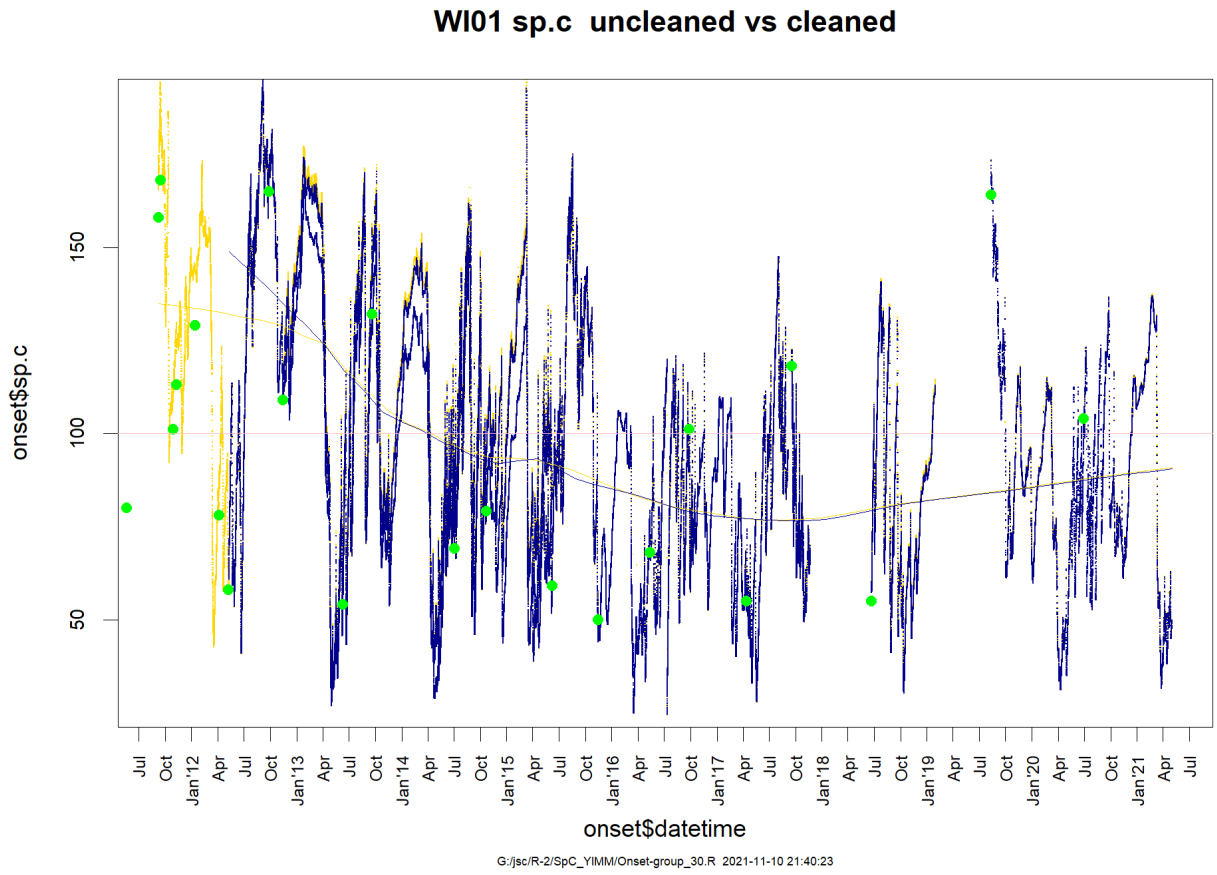
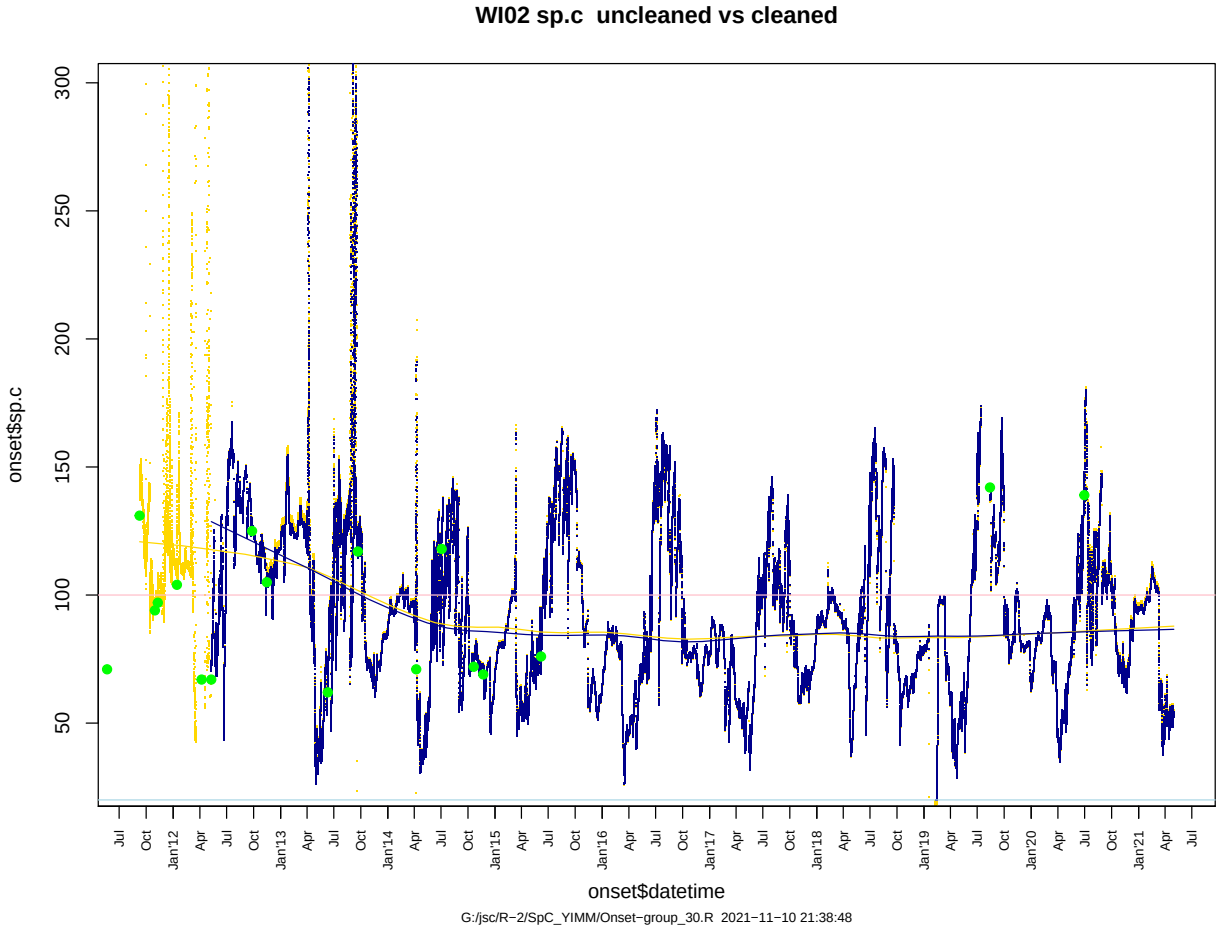
Jan'20
Apr
Jul
Oct
onset$datetime
G:/jsc/R-2/SpC_YIMM/Onset-group_30.R 2021-11-10 21:37:28

Specific Conductance with uncleaned(yellow) and cleaned(blue) data, showing trend lines and YSI meter readings (green points).




WI02 sp.c uncleaned vs cleaned
onset$sp.c
50
100
150
200
250
300
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Jan'13
Apr
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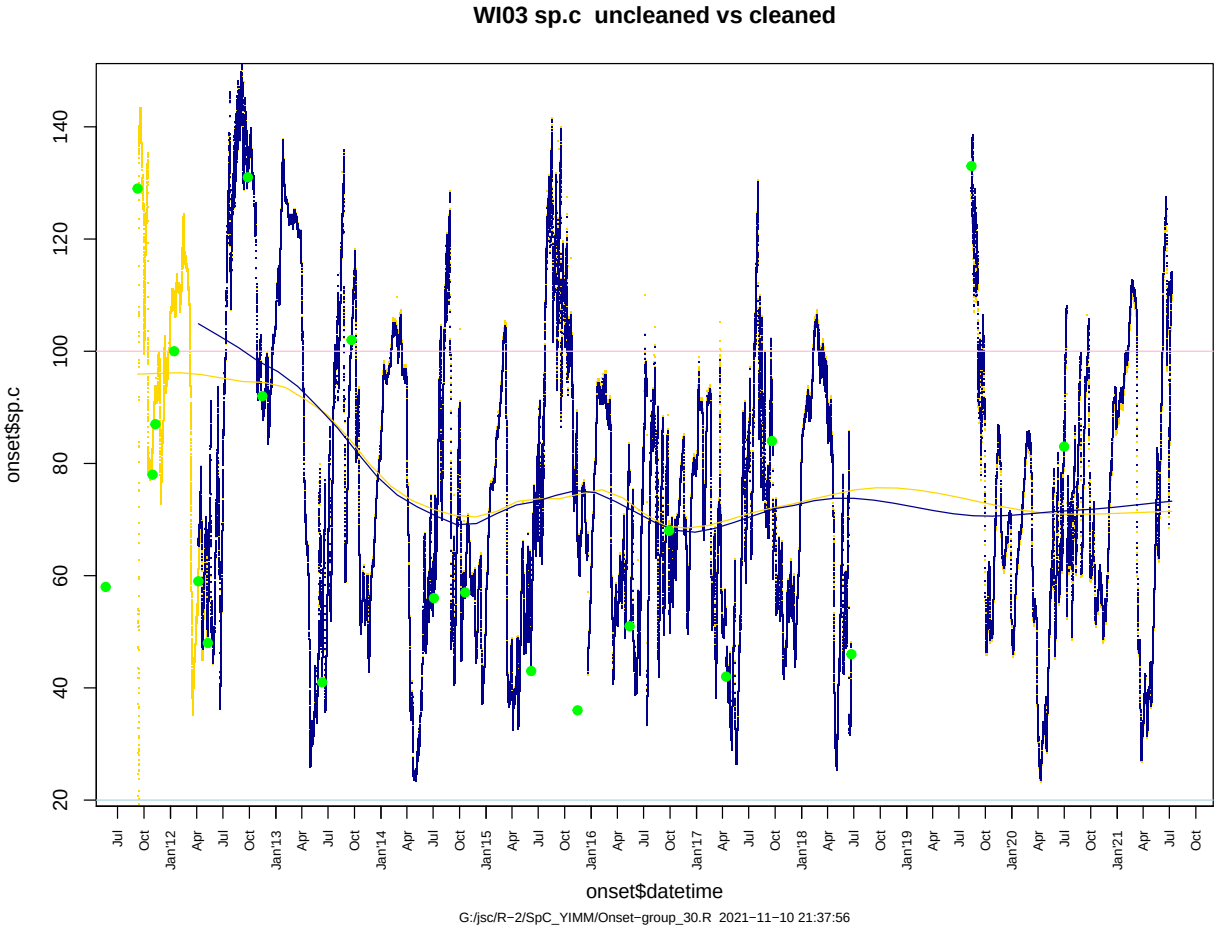
Jul
onset$datetime
G:/jsc/R−2/SpC_YIMM/Onset−group_30.R 2021−11−10 21:38:48


WI03 sp.c uncleaned vs cleaned
onset$sp.c
20
40
60
80
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120
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Oct
Jan'13
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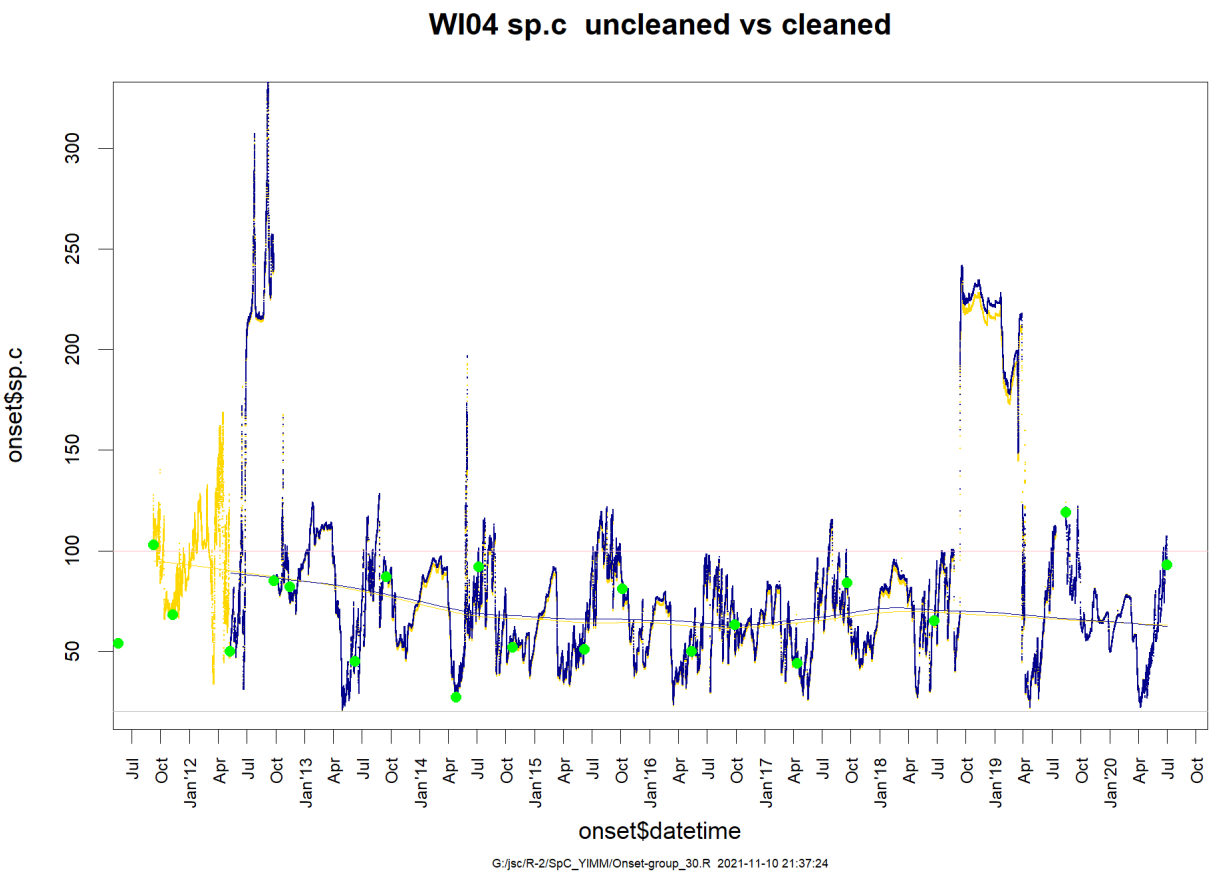
Oct
onset$datetime
G:/jsc/R−2/SpC_YIMM/Onset−group_30.R 2021−11−10 21:37:56


WI04 sp.c uncleaned vs cleaned
onset$sp.c
50
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150
200
250
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Jan'13
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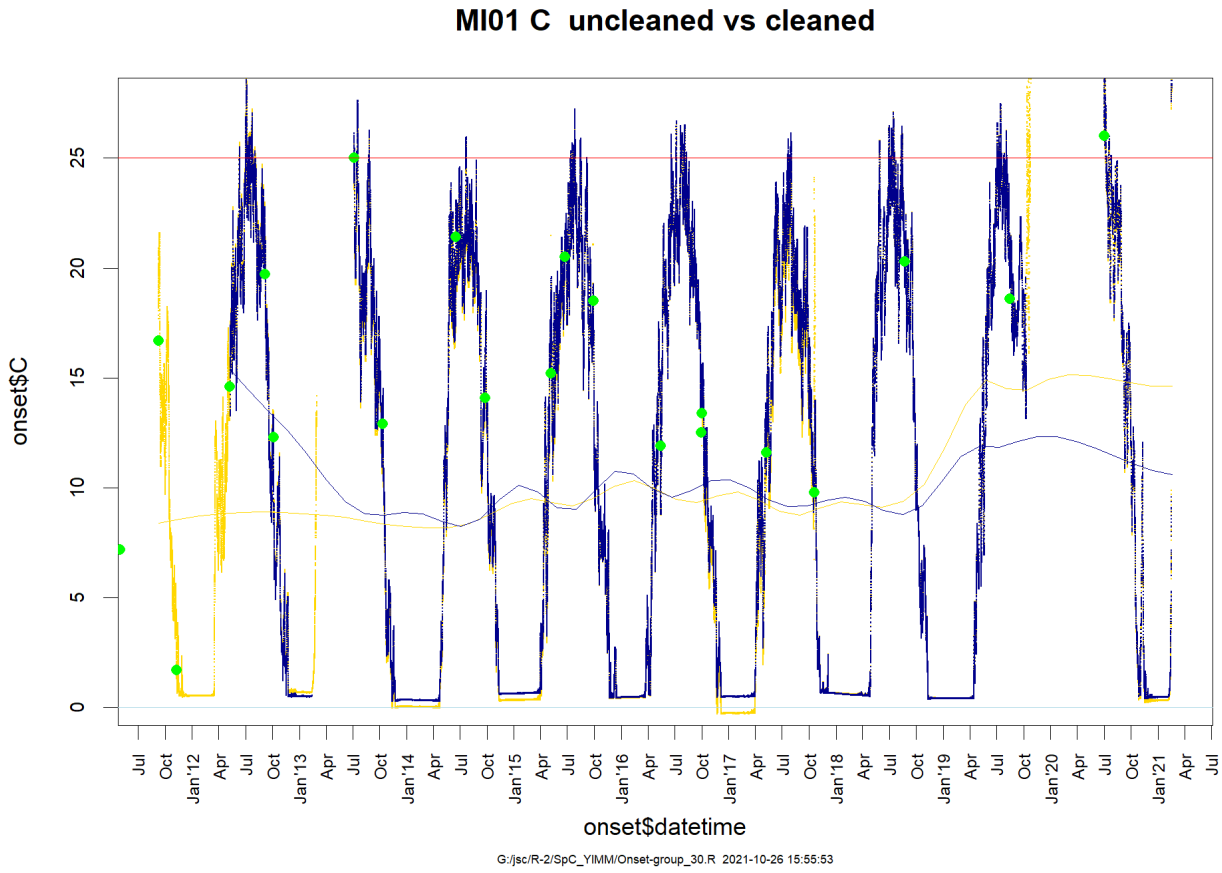
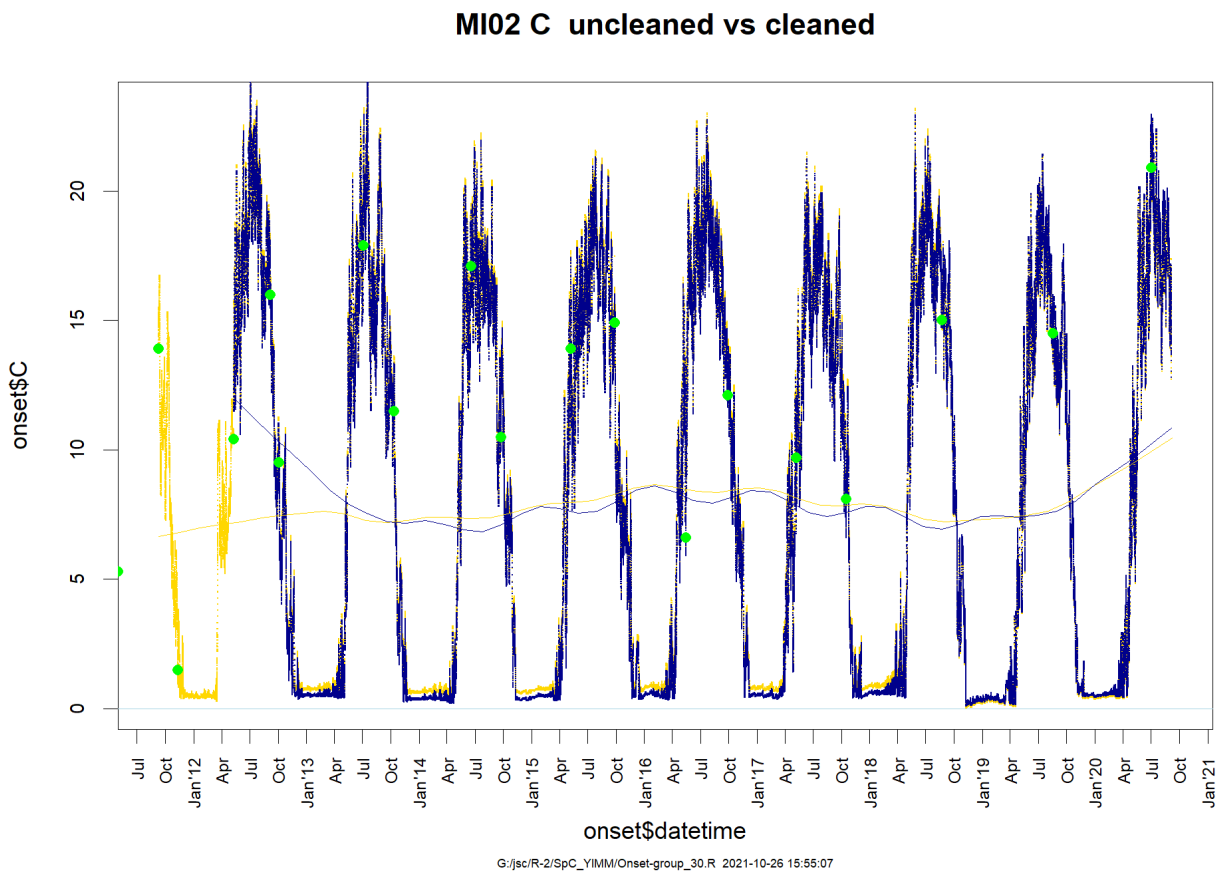
Jul
Oct
onset$datetime
G:/jsc/R-2/SpC_YIMM/Onset-group_30.R 2021-11-10 21:37:24

Presque Isle River, Michigan Water Temperature and Specific Conductance

Temperature (°C) with uncleaned(yellow) and cleaned(blue) data, showing trend lines and YSI meter readings (green points).




MI02 C uncleaned vs cleaned
onset$C
0
5
10
15
20
Jul
Oct
Jan'12
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Oct
Jan'13
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Jul
Oct
Jan'14
Apr
Jul
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Jan'15
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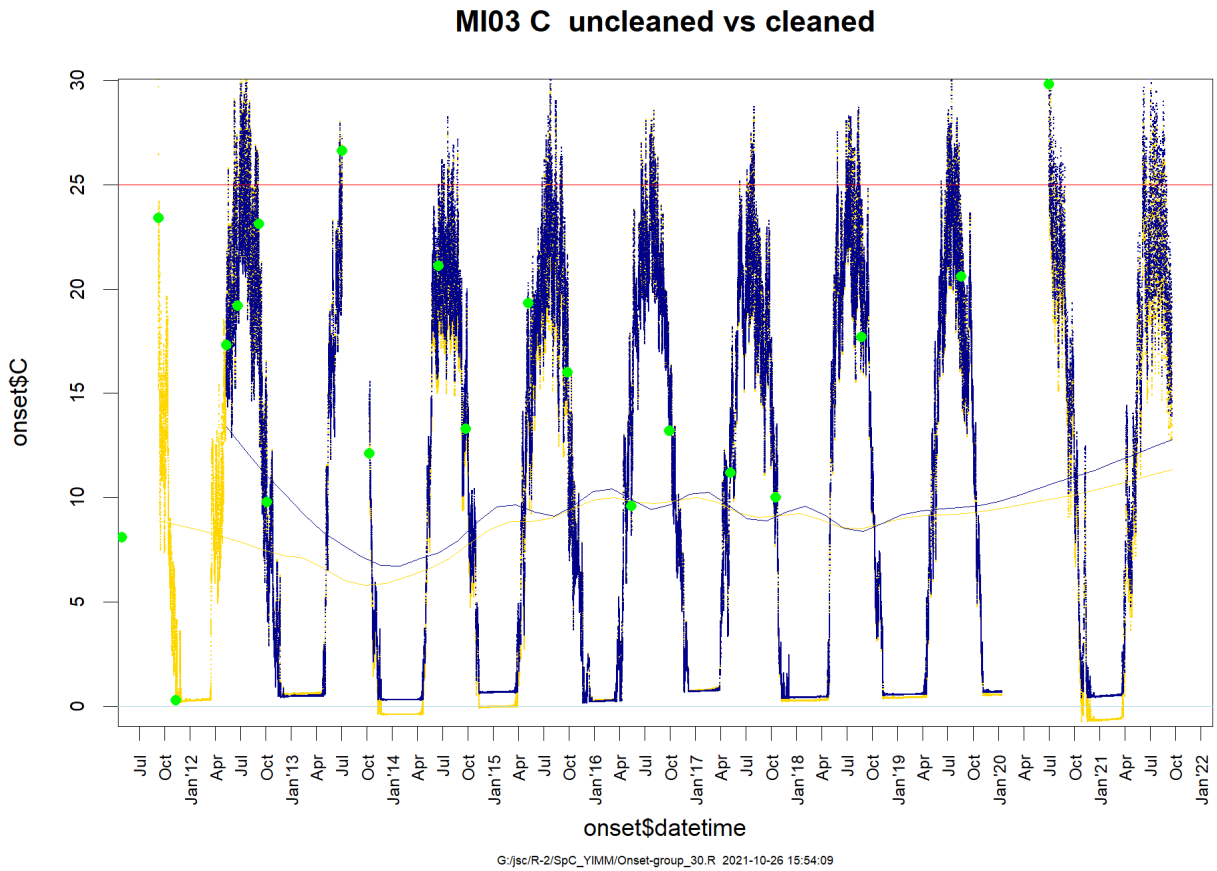
Jan'20
Apr
Jul
Oct
Jan'21
onset$datetime
G:/jsc/R-2/SpC_YIMM/Onset-group_30.R 2021-10-26 15:55:07


MI03 C uncleaned vs cleaned
onset$C
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Jan'13
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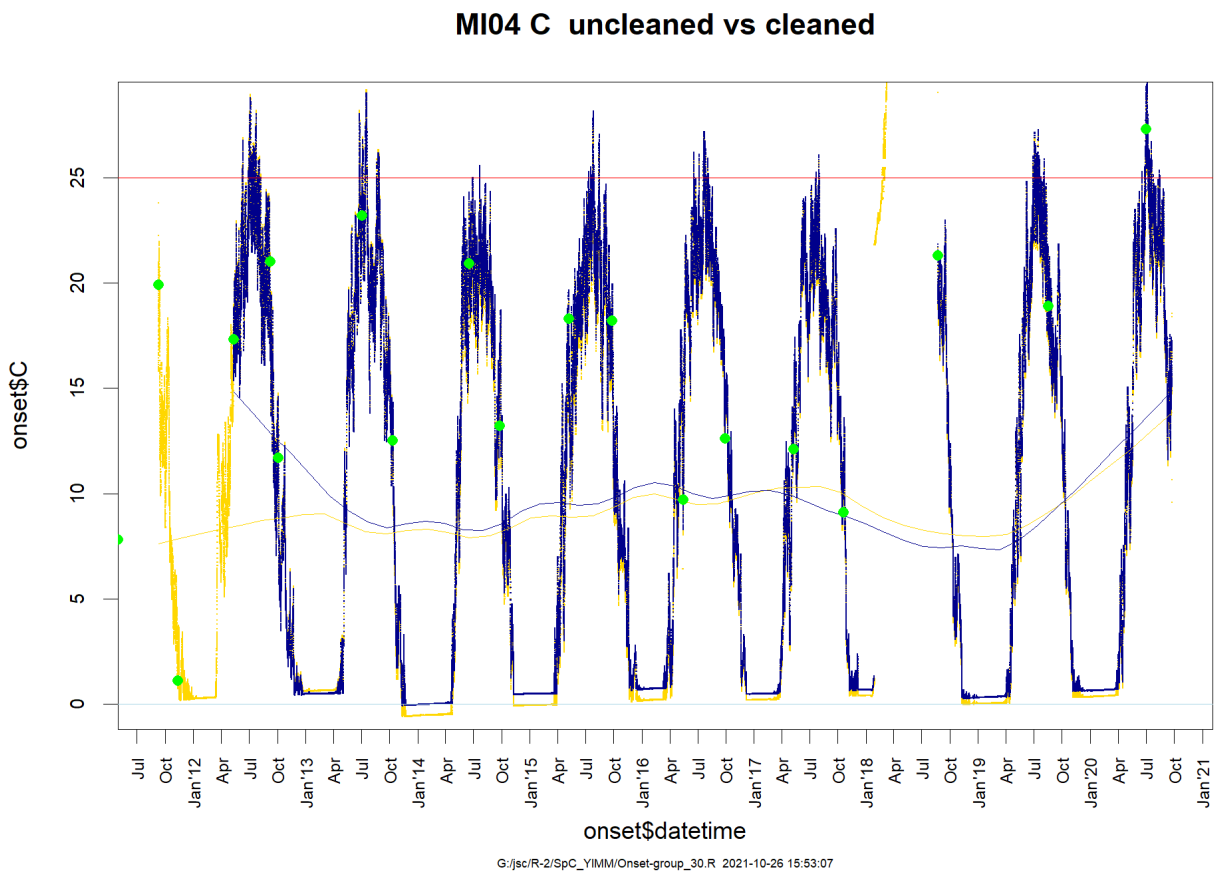
Jan'21
Apr
Jul
Oct
Jan'22
onset$datetime
G:/jsc/R-2/SpC_YIMM/Onset-group_30.R 2021-10-26 15:54:09


MI04 C uncleaned vs cleaned
onset$C
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Apr
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Jan'19
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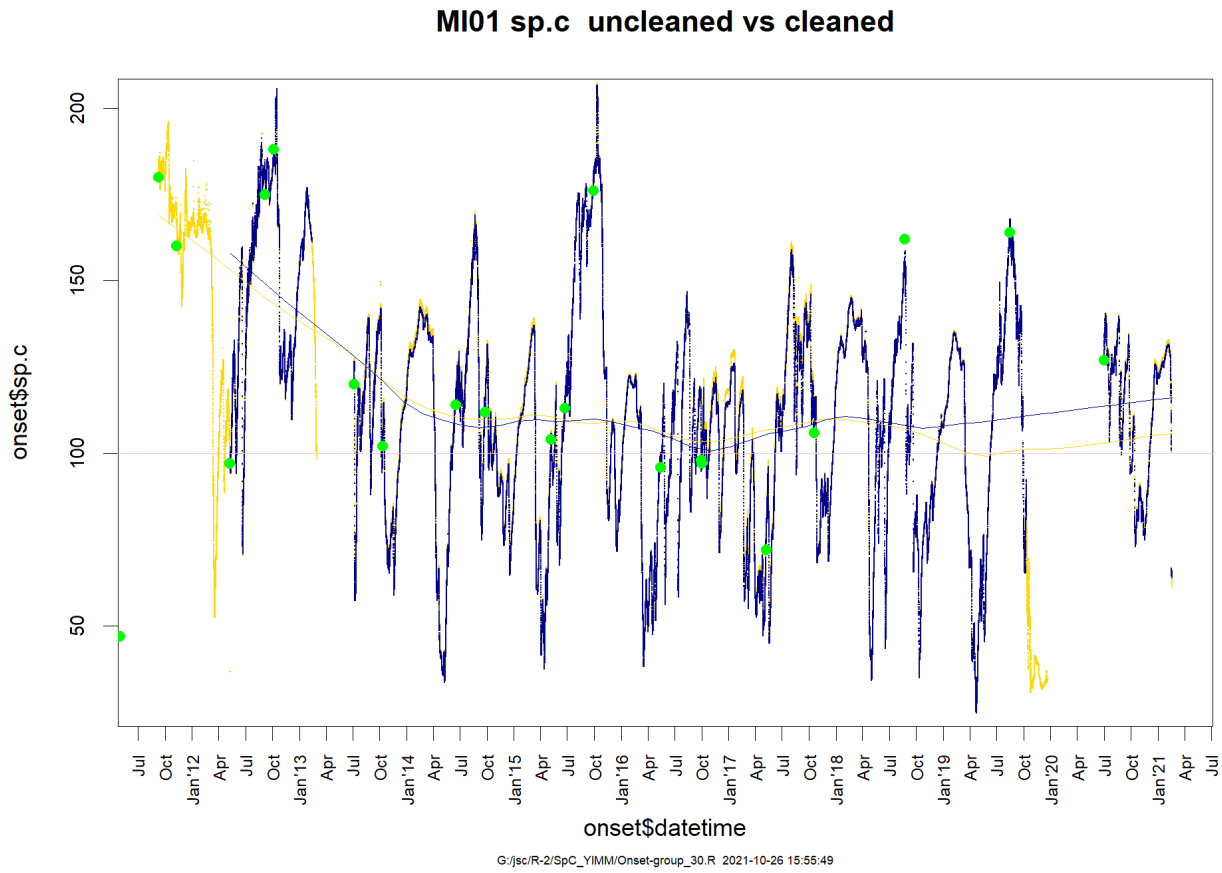
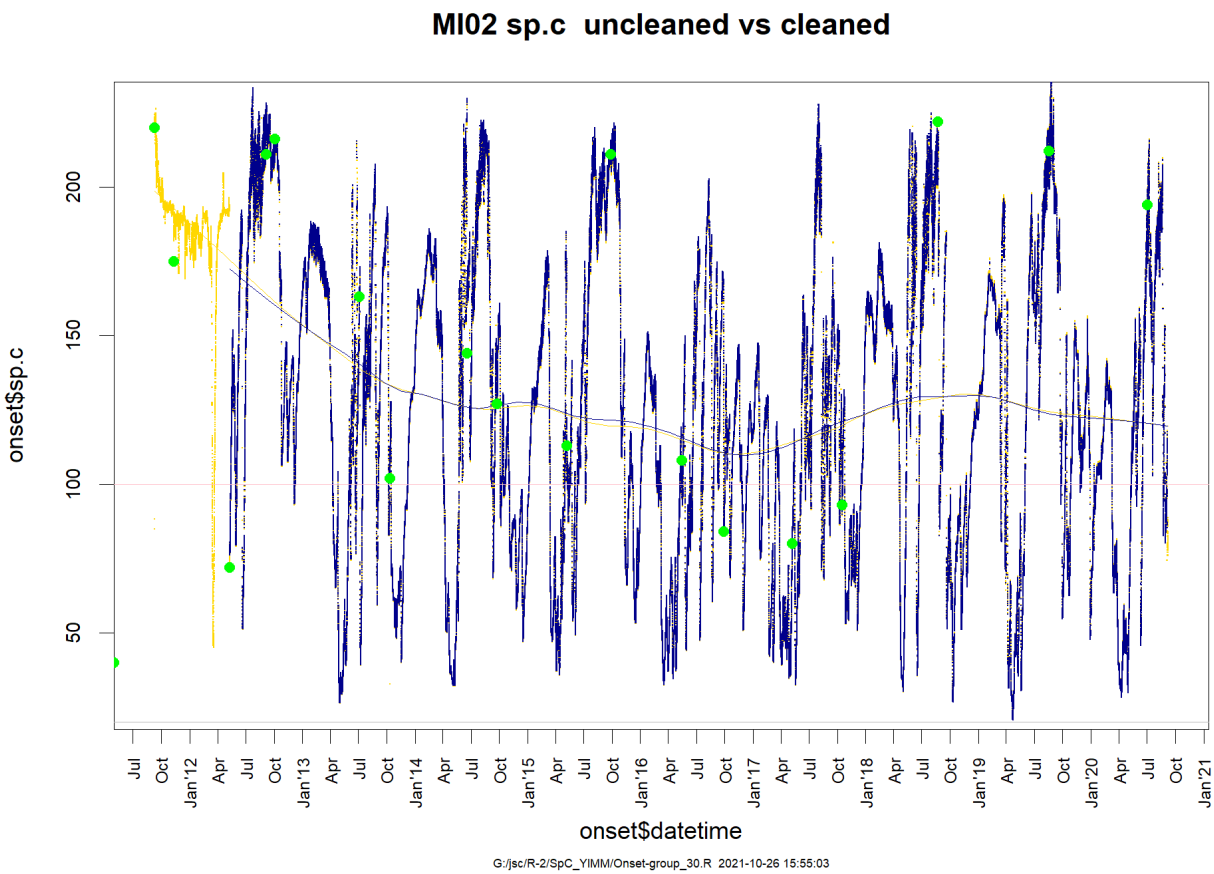
Jul
Oct
Jan'20
Apr
Jul
Oct
Jan'21
onset$datetime
G:/jsc/R-2/SpC_YIMM/Onset-group_30.R 2021-10-26 15:53:07

Specific Conductance with uncleaned(yellow) and cleaned(blue) data, showing trend lines and YSI meter readings (green points).




MI02 sp.c uncleaned vs cleaned
onset$sp.c
50
100
150
200
Jul
Oct
Jan'12
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Jul
Oct
Jan'13
Apr
Jul
Oct
Jan'14
Apr
Jul
Oct
Jan'15
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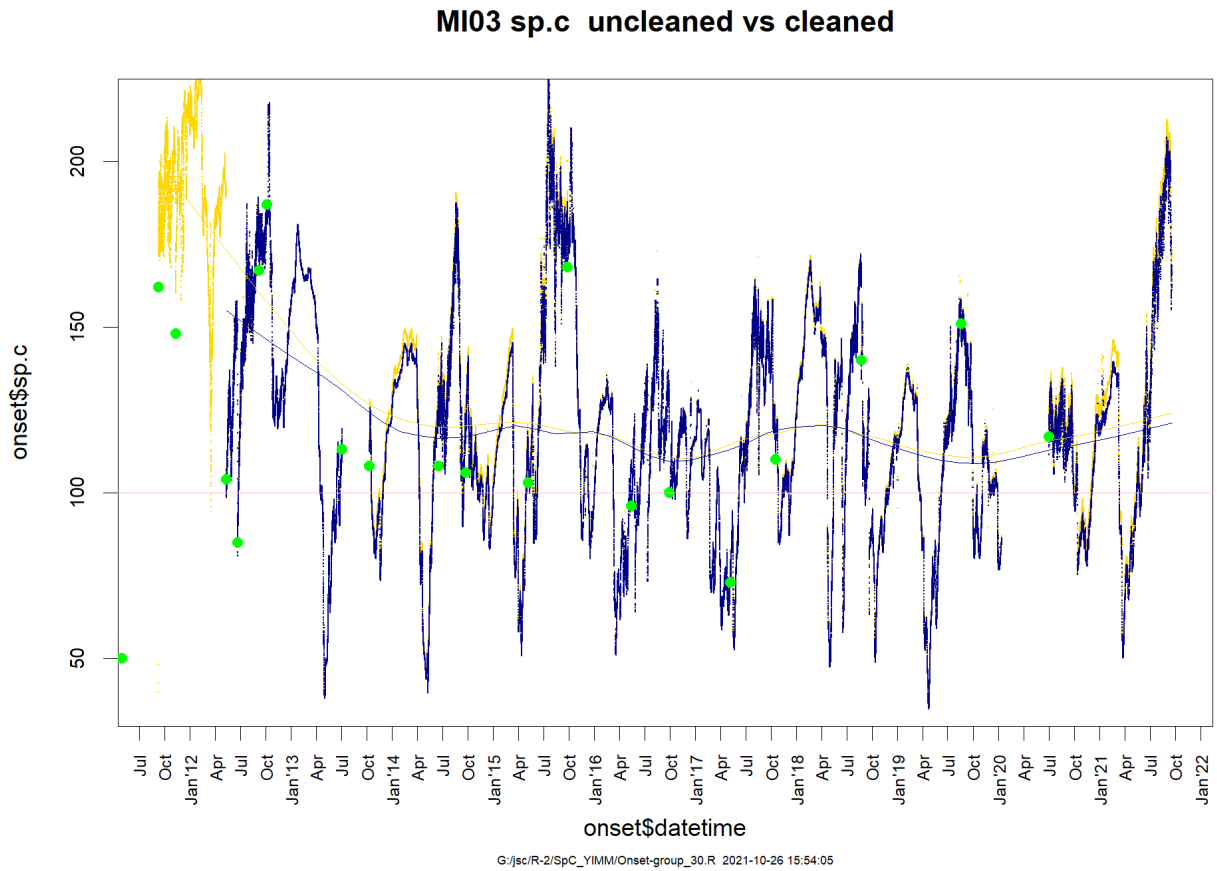
Jan'20
Apr
Jul
Oct
Jan'21
onset$datetime
G:/jsc/R-2/SpC_YIMM/Onset-group_30.R 2021-10-26 15:55:03


MI03 sp.c uncleaned vs cleaned
onset$sp.c
50
100
150
200
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Jan'12
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Jan'13
Apr
Jul
Oct
Jan'14
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Oct
Jan'15
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Jan'16
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Jan'19
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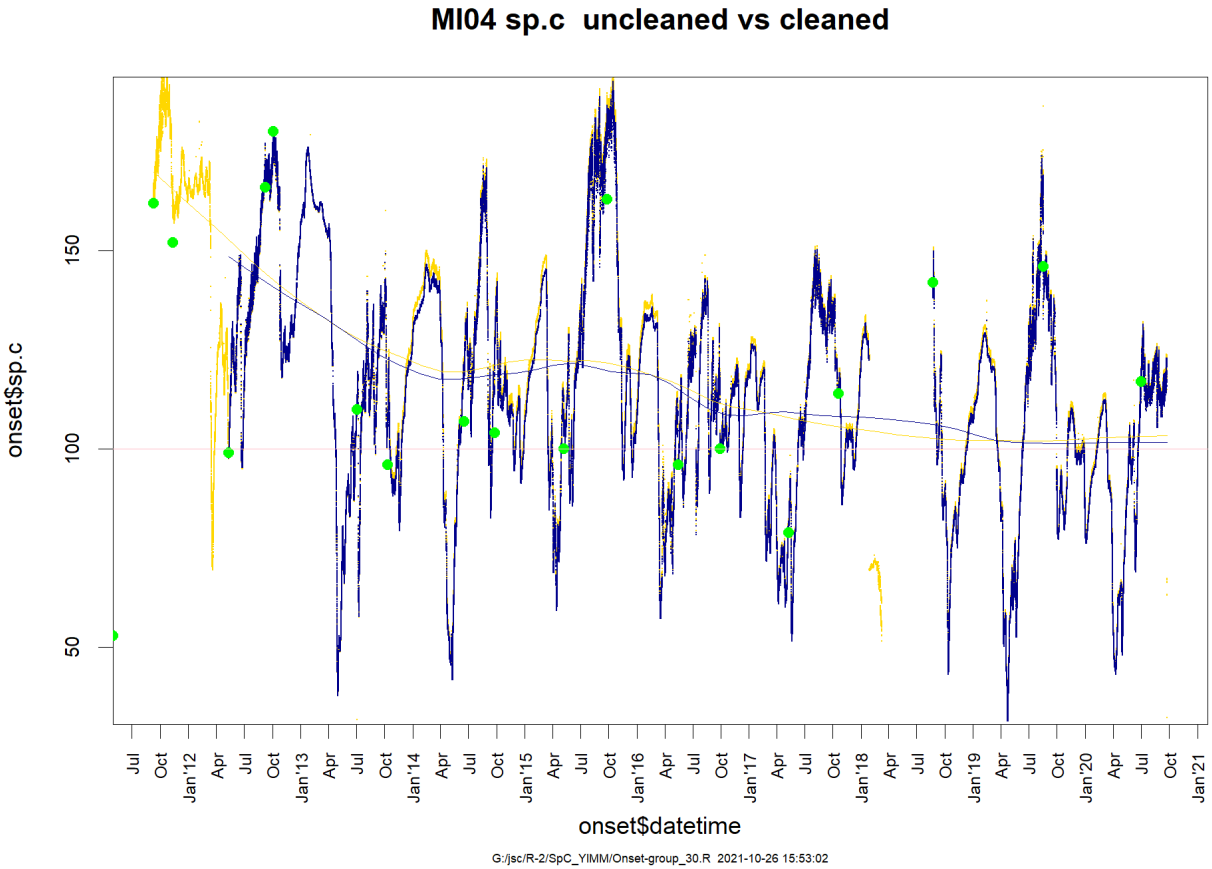
Oct
Jan'21
Apr
Jul
Oct
Jan'22
onset$datetime
G:/jsc/R-2/SpC_YIMM/Onset-group_30.R 2021-10-26 15:54:05


MI04 sp.c uncleaned vs cleaned
onset$sp.c
50
100
150
Jul
Oct
Jan'12
Apr
Jul
Oct
Jan'13
Apr
Jul
Oct
Jan'14
Apr
Jul
Oct
Jan'15
Apr
Jul
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Jan'16
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Jan'19
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Jul
Oct
Jan'20
Apr
Jul
Oct
Jan'21
onset$datetime
G:/jsc/R-2/SpC_YIMM/Onset-group_30.R 2021-10-26 15:53:02

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Figures showing example plots of annual pattern of temperature and specific conductance.

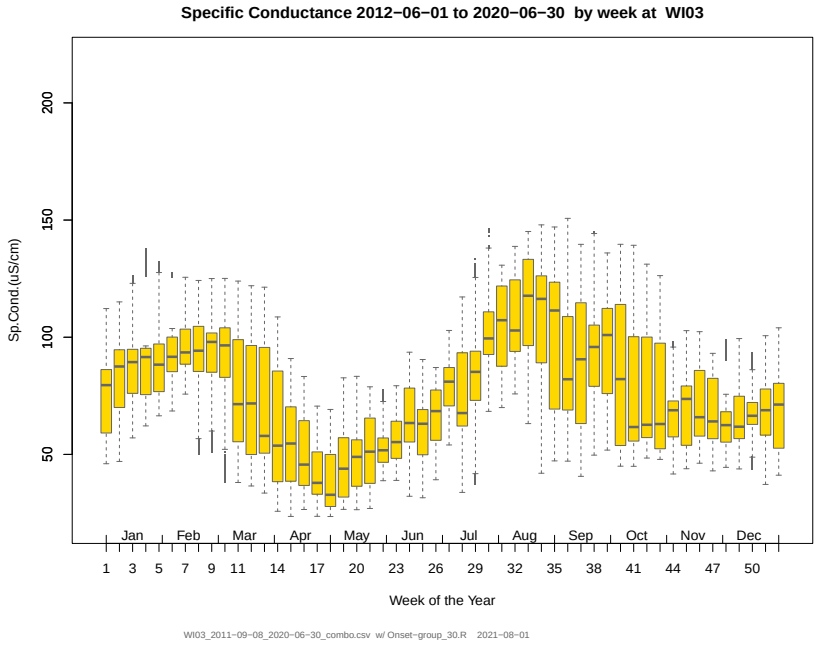

Figure 1: Weekly box plots of Specific Conductance (uS/cm @25C) for 10 years of data showing median and range of data for each week of the year.

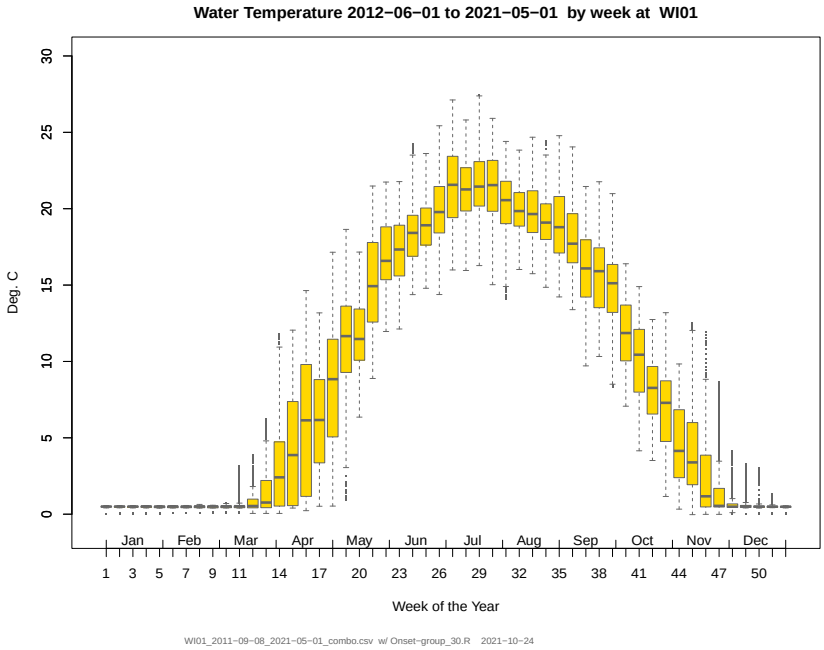

Figure 2: Weekly box plots of temperature (C) for 10 years of data showing median and range of data for each week of the year.