FZ-J WWTP ATS: Preliminary Data

Dean Calahan

20 November, 2018

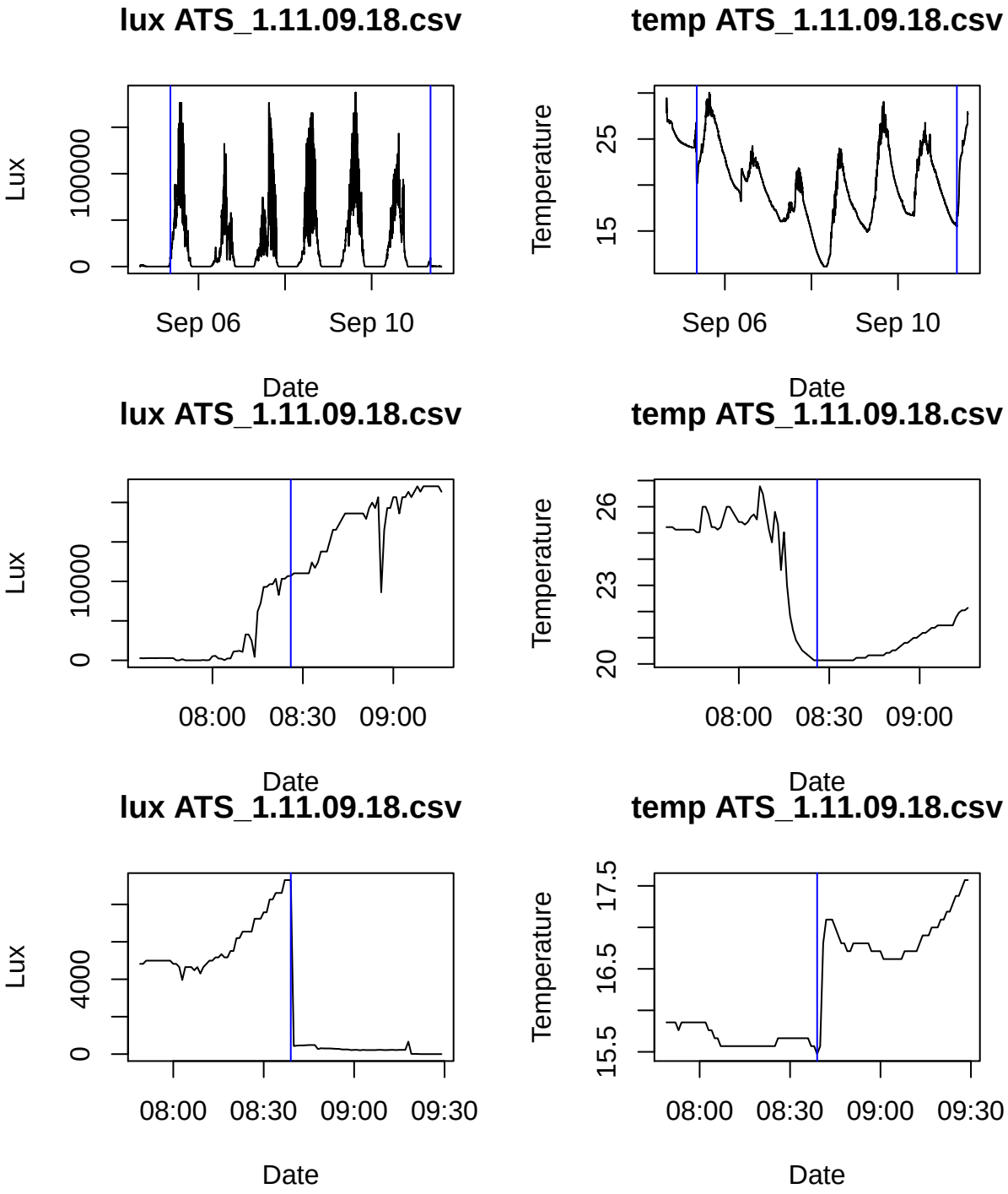
Introduction

Forshungzentrum-Jülich's (FZ-J) IBG-2 Alternative Biomass group installed a pilot algal turf scrubber (ATS) at its campus wastewater treatment plant (WWTP) in mid-August of 2018. This facility comprised a dump bucket and floway with approximately $1m^2$ algal growth area, and recirculated 500 L of secondary treated sewage for periods of 24 hr (Monday through Thursday) and 96 hr (Thursday through Sunday). Beginning in early September, the facility was harvested weekly, and elementary water chemistry, illumination, temperature, and biomass productivity data were collected. The facility was removed from the WWTP at the end of September. This document describes the data collection for this pilot project and summarizes the results.

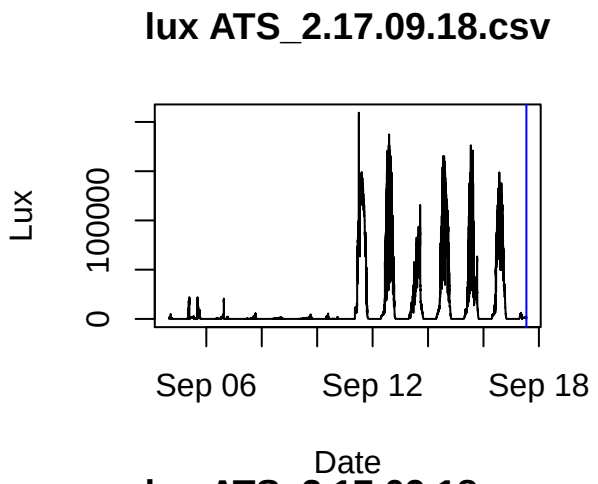
Cleaning of Illumination and Temperature Data

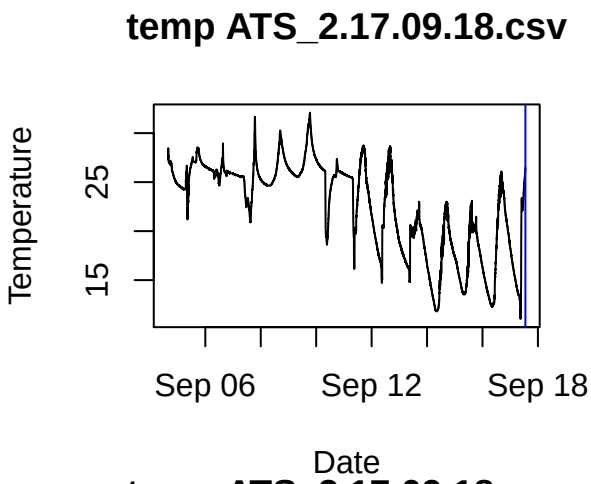
Two HOBO data loggers (ATS_1 and ATS_2) were used to gather temperature and illumination data, with one observation recorded per minute. The loggers were exchanged each week. Here we read the individual HOBO csv files and clean the data. To clean the data we need to trim away observations that were not taken while the data logger was actually installed in the floway. We open each file in order and determine which observations need to be removed by visual inspection. The following sections plot each complete data set, with blue vertical lines enclosing the window of valid observations. Each complete plot is followed my magnifications of each cutoff region.

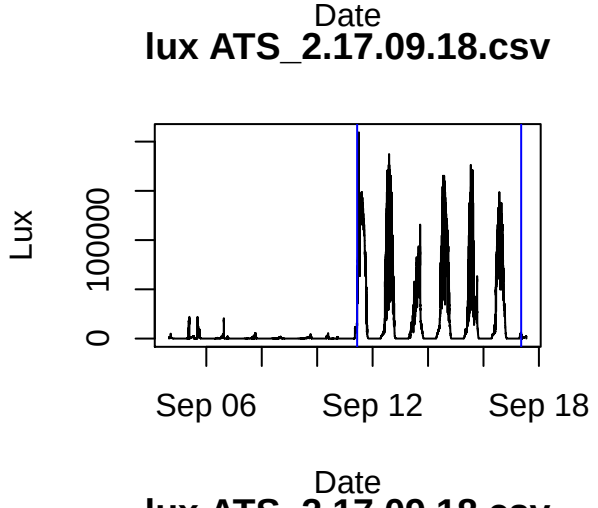
Week 1 (ATS_1)

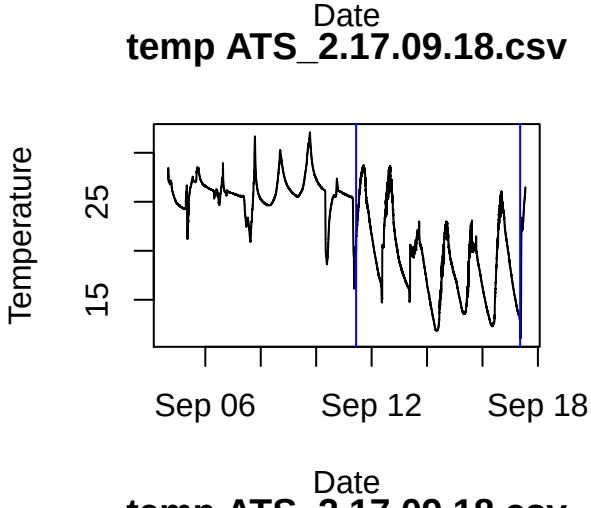


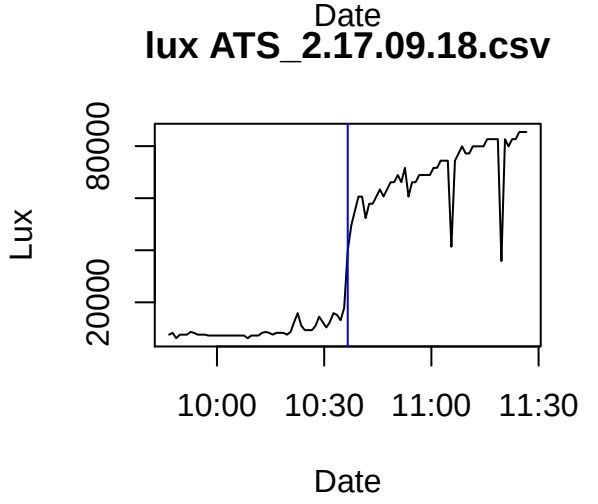
For this first file, both data loggers were initialized in the afternoon, and then ATS_1 was installed the next morning. We first glimpse the whole file. We see six complete days worth of observations and the beginning of a sixth day. Illumination ranges from 0 lux (darkness) to well above 150.000 lux (full sunlight), whereas temperature shows an expected rise and fall each day. As there are 10.028 observations total, The first 1.500 or so observations must contain the time at which the logger was installed.

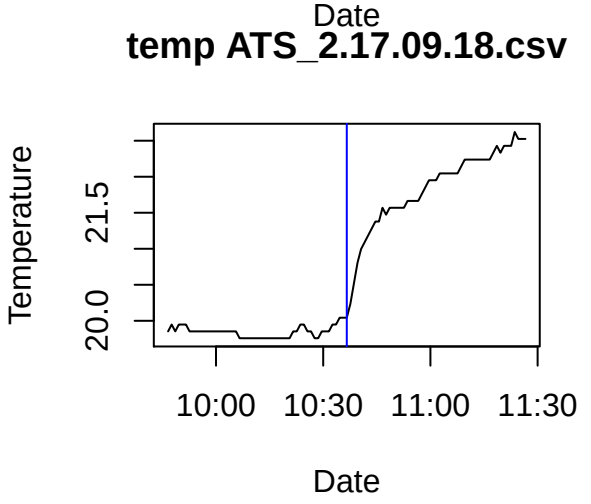

lux ATS_2.17.09.18.csv
Lux
0
100000
Sep 06
Sep 12
Sep 18
Date

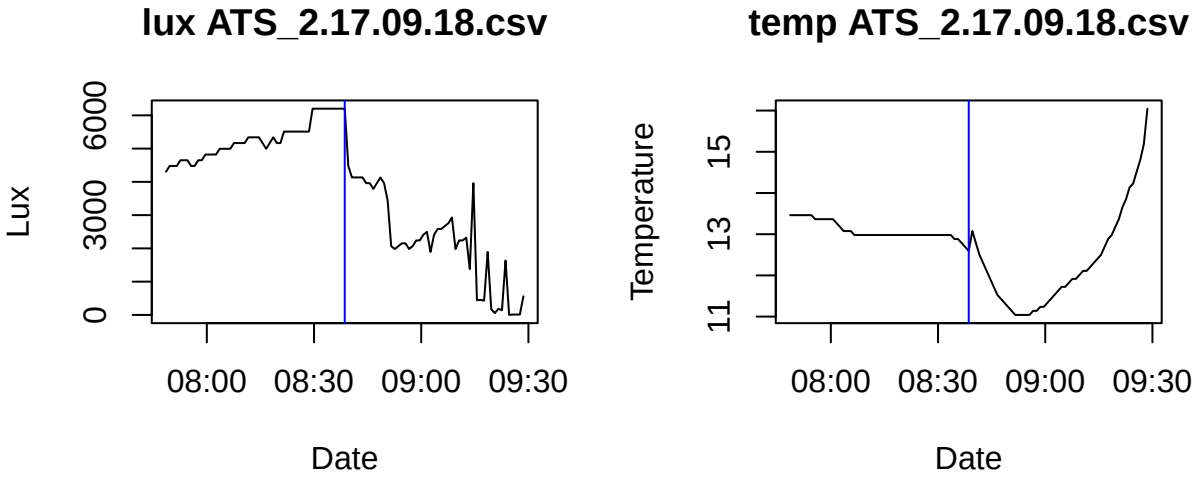

temp ATS_2.17.09.18.csv
Temperature
15
25
Sep 06
Sep 12
Sep 18
Date


lux ATS_2.17.09.18.csv
Lux
0
100000
Sep 06
Sep 12
Sep 18
Date

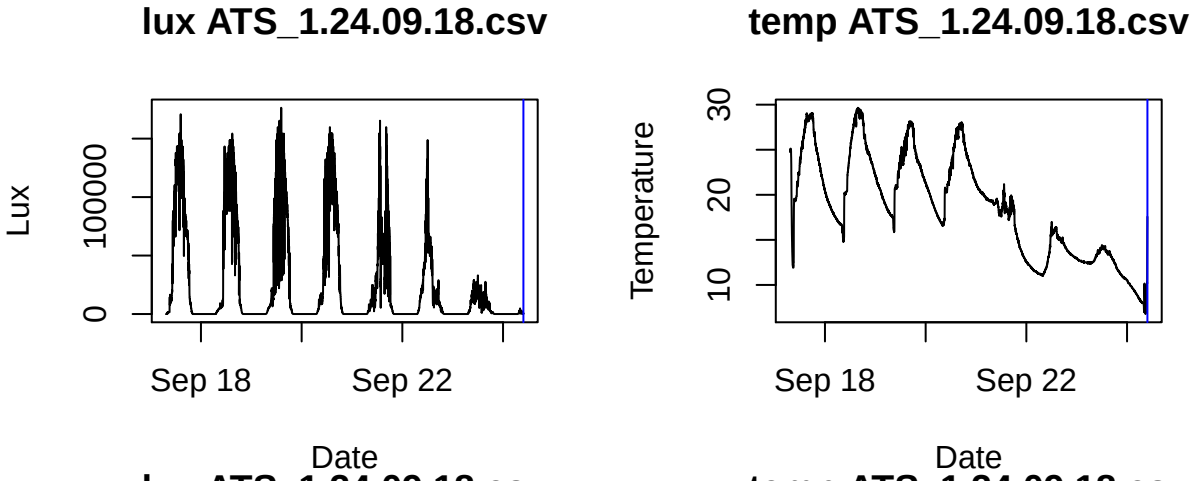

temp ATS_2.17.09.18.csv
Temperature
15
25
Sep 06
Sep 12
Sep 18
Date

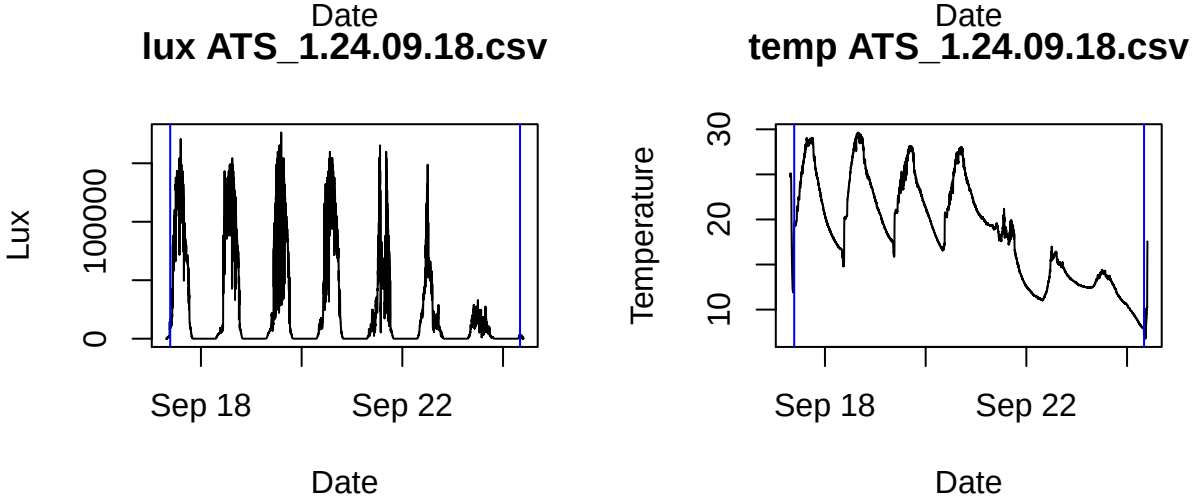

lux ATS_2.17.09.18.csv
Lux
20000
80000
10:00
10:30
11:00
11:30
Date

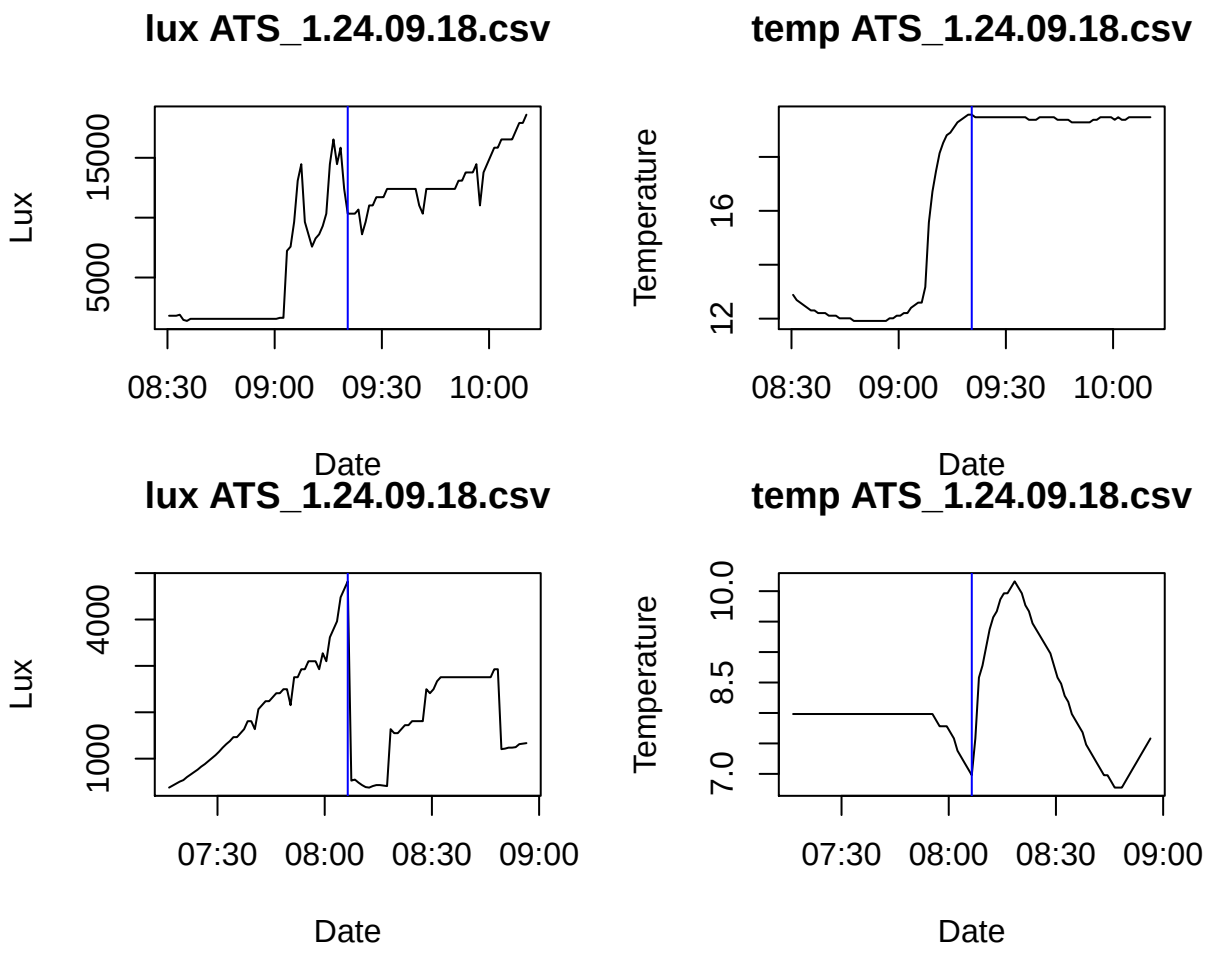

temp ATS_2.17.09.18.csv
Temperature
20.0
21.5
10:00
10:30
11:00
11:30
Date



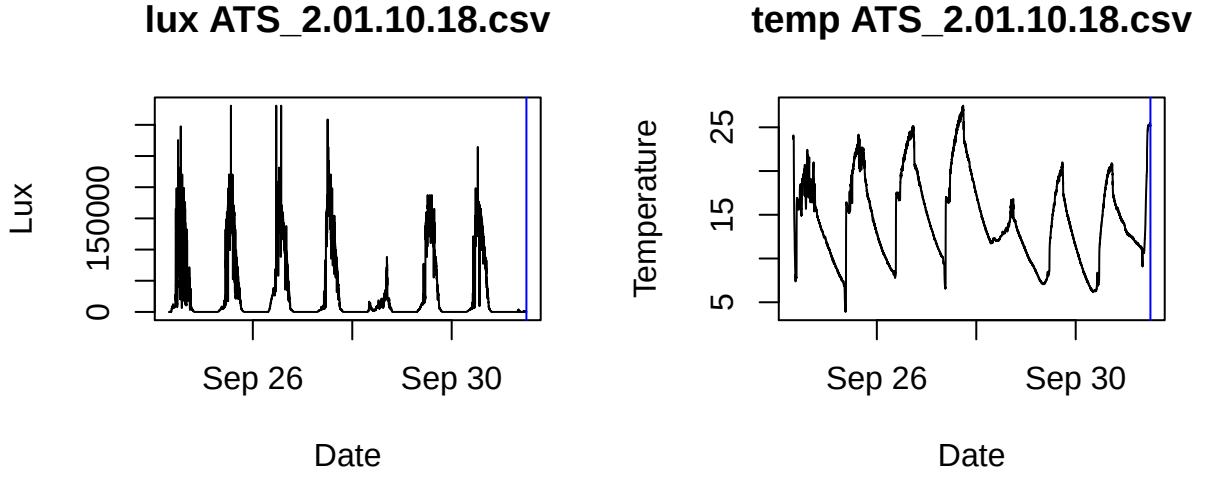
Here we zoom in to the first 1.500 observations. To the left of the illumination observations are low peaks representing light levels inside Dean's office, followed by a period of darkness, then a series of peaks representing dawn and Dean taking ATS_1 out to the floway. The temperature profile is more revealing, with a high afternoon temperature falling off smoothly over the night, dawn bringing in some heat, followed by placing the HOBO into the cool water of the floway.

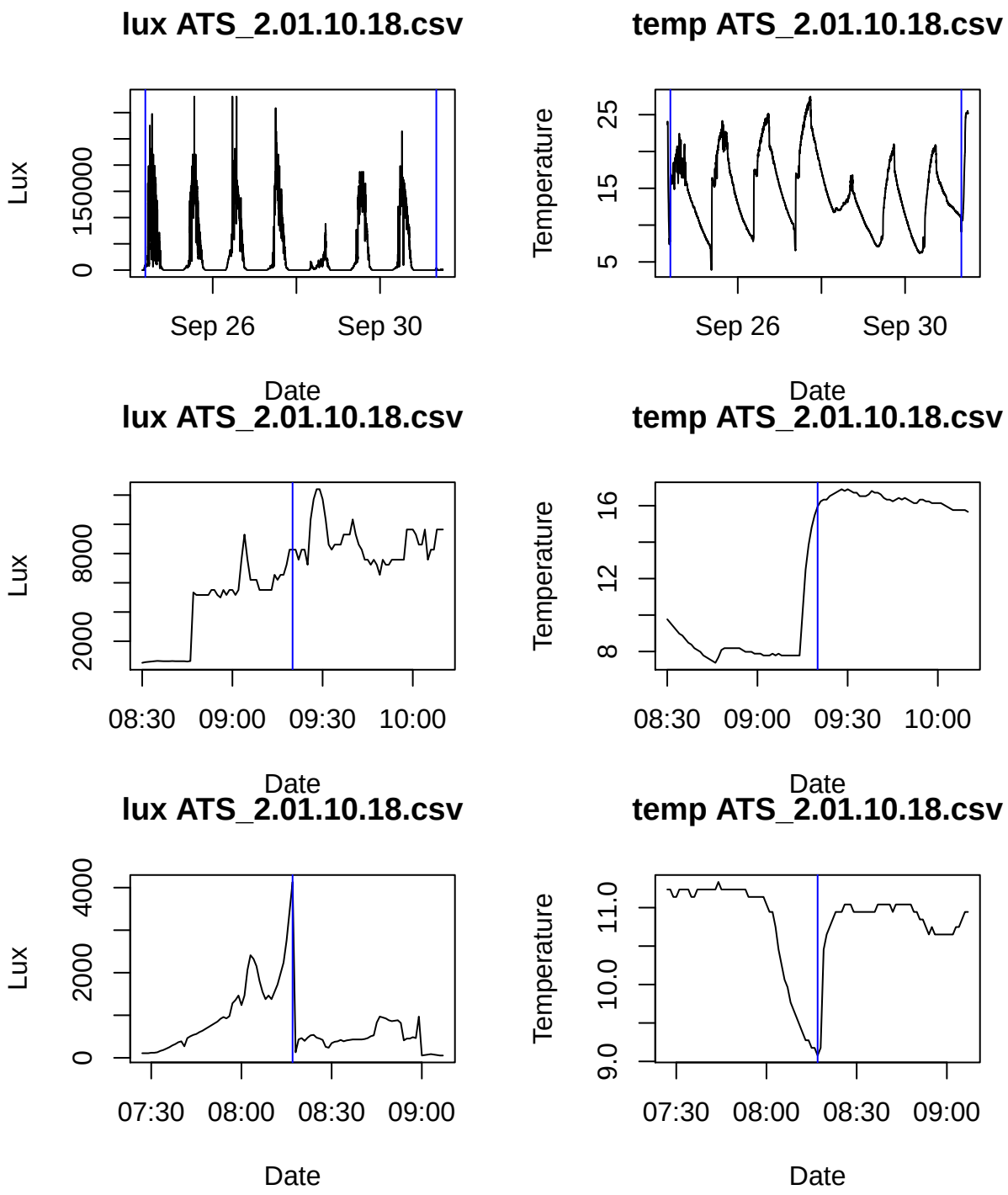






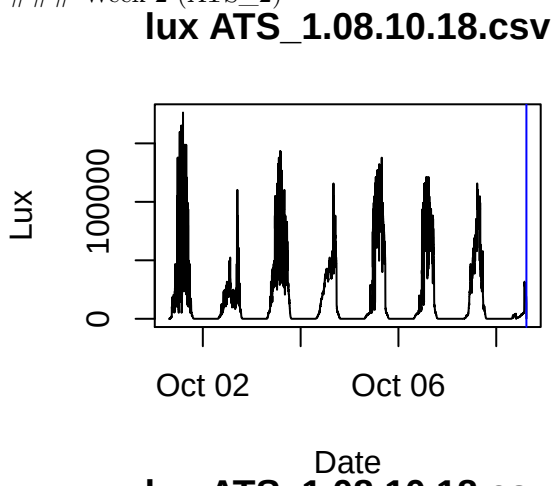
Here we zoom in to where the temperature really drops off around 8:30, representing placing the HOBO into the water, then zoom in further to deterimine the precise initial observation, which is #1009. Thus we know to trim observations from 1:1008 in this file, with the first relevant observation at 2018-09-05 08:26:59.

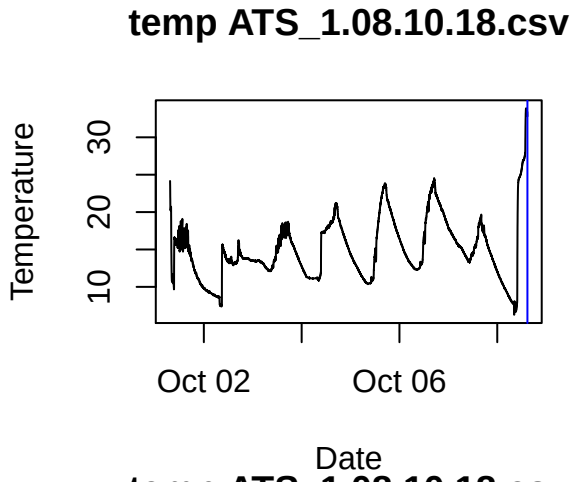


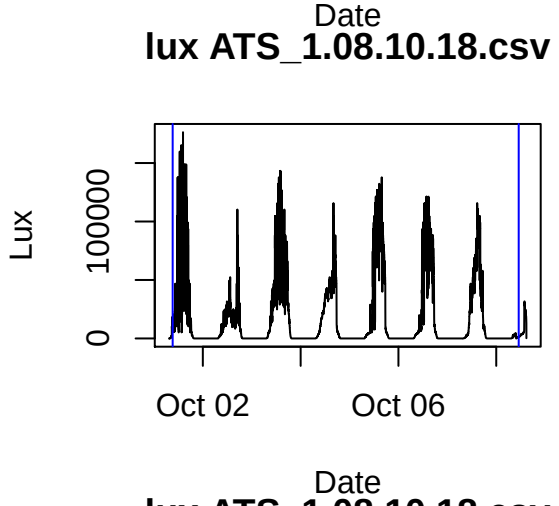


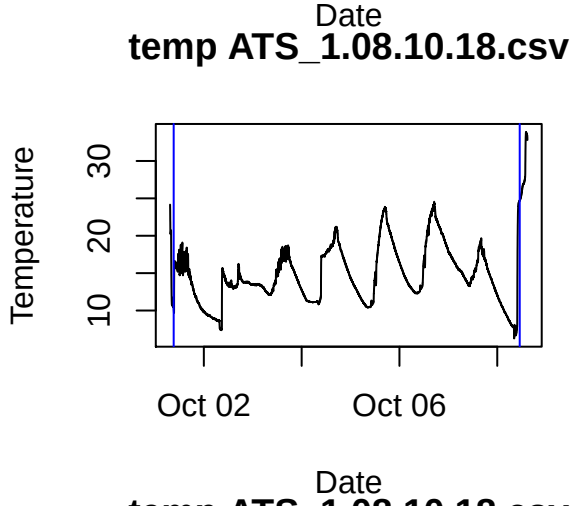
Here we wish to determine the end of the Week 1 recording period for HOBO ATS_1. Here we zoom in on the last 1.500 observations and observe that on Tuesday morning illumination starts to rise but then drops off sharply as ATS_1 is removed from the floway and stowed. Zooming in further reveals that observation #9663 is the one after which the Lux declines, thus we know to select observations 1009:9663 for the cleaned Week 1 data.

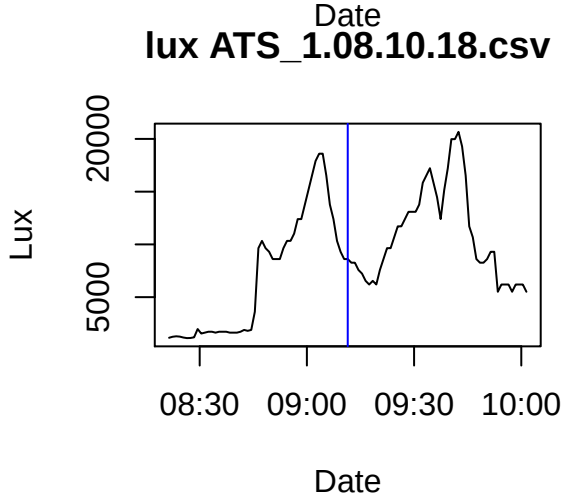
Week 2 (ATS_2)

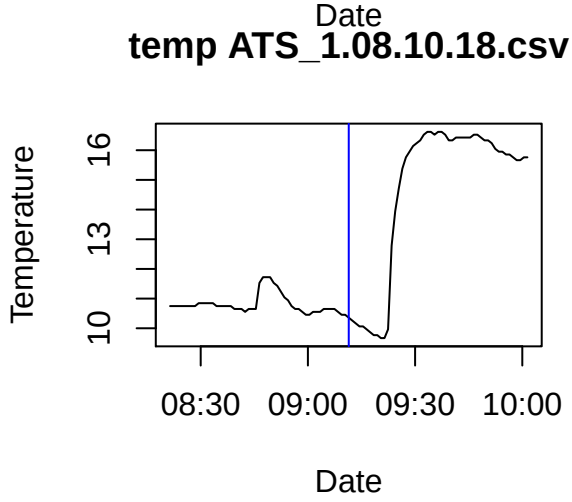

lux ATS_1.08.10.18.csv
Lux
0
100000
Oct 02
Oct 06
Date

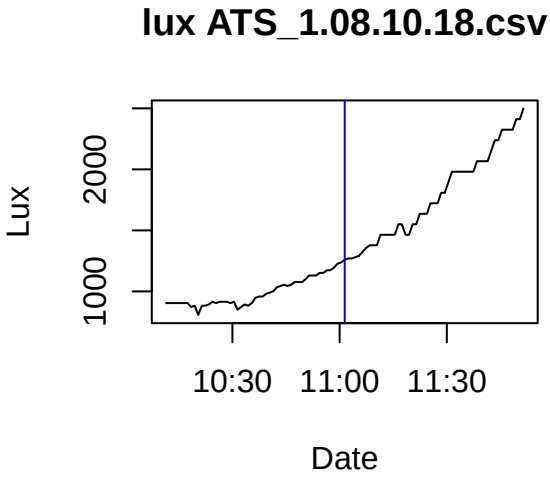

temp ATS_1.08.10.18.csv
Temperature
10
20
30
Oct 02
Oct 06
Date

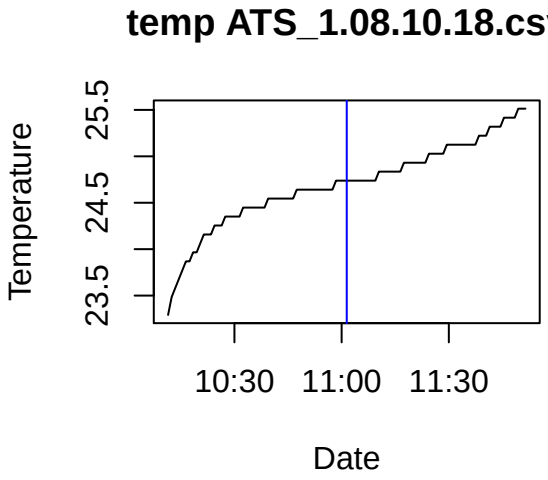

lux ATS_1.08.10.18.csv
Lux
0
100000
Oct 02
Oct 06
Date


temp ATS_1.08.10.18.csv
Temperature
10
20
30
Oct 02
Oct 06
Date

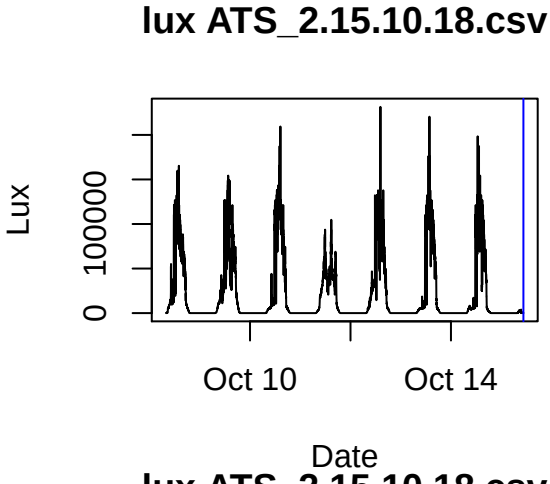

lux ATS_1.08.10.18.csv
Lux
5000
20000
08:30
09:00
09:30
10:00
Date

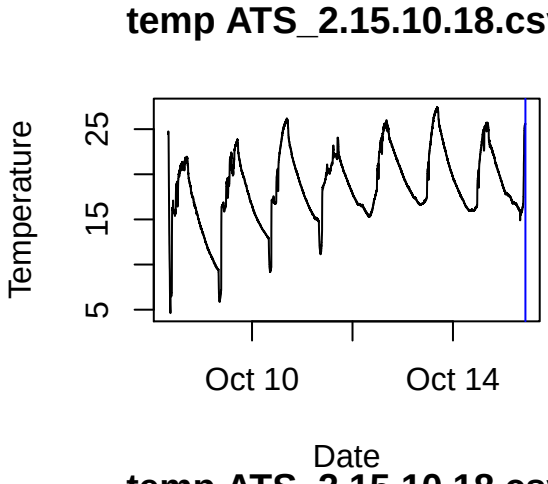

temp ATS_1.08.10.18.csv
Temperature
10
13
16
08:30
09:00
09:30
10:00
Date

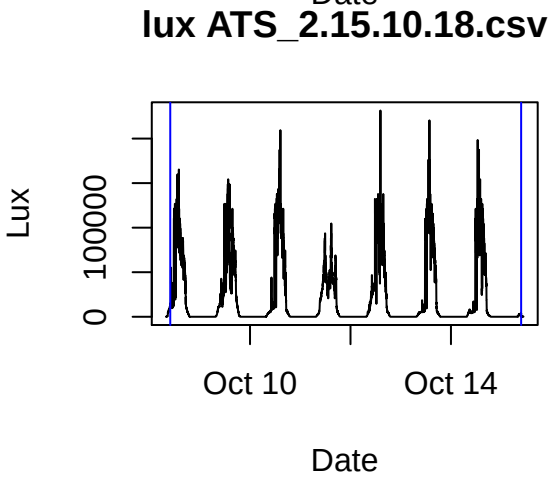


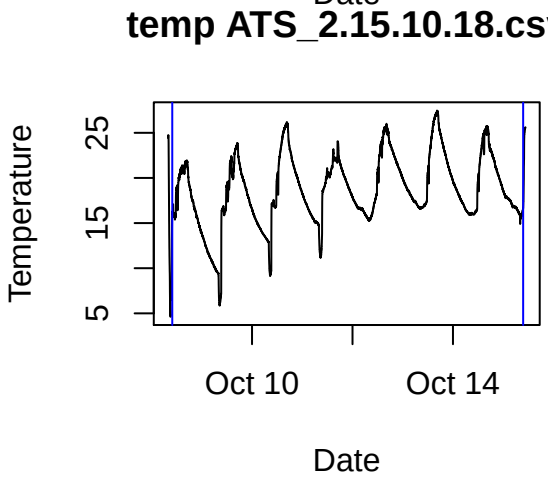


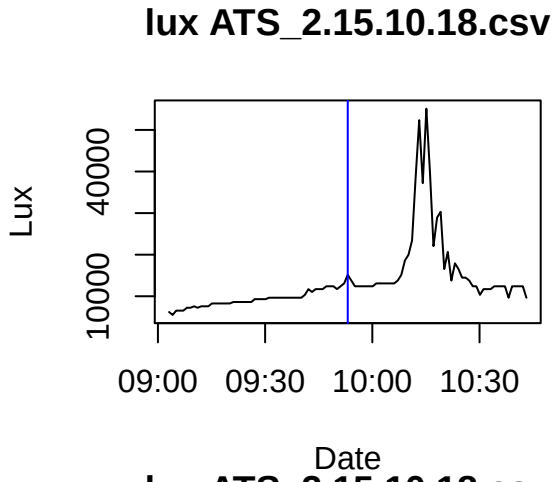
Here we see the total data for ATS_2, which was initiliazed at the same time as ATS_1, but left in Dean's office. We know when ATS_1 was removed from the floway; ATS_2 was installed probably no more than an hour after that.

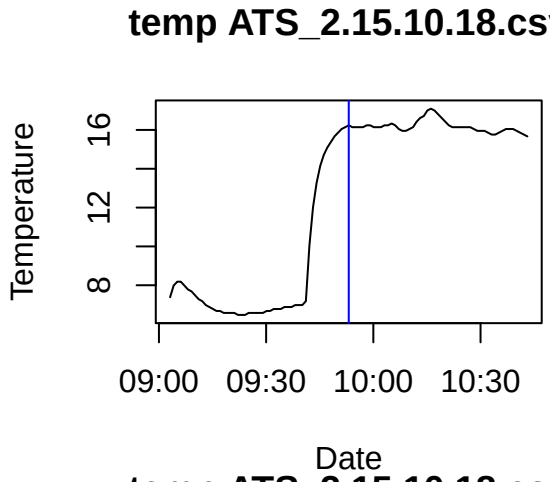


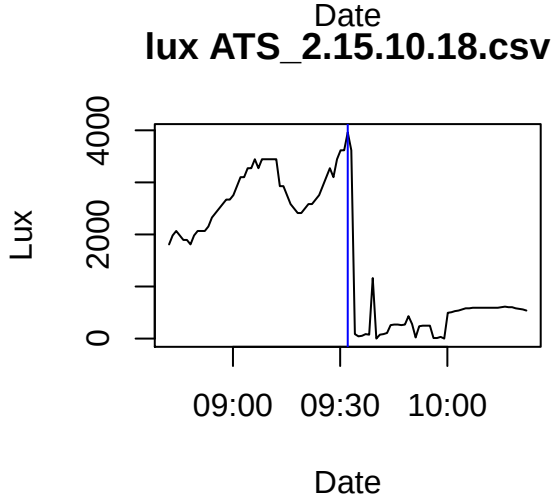


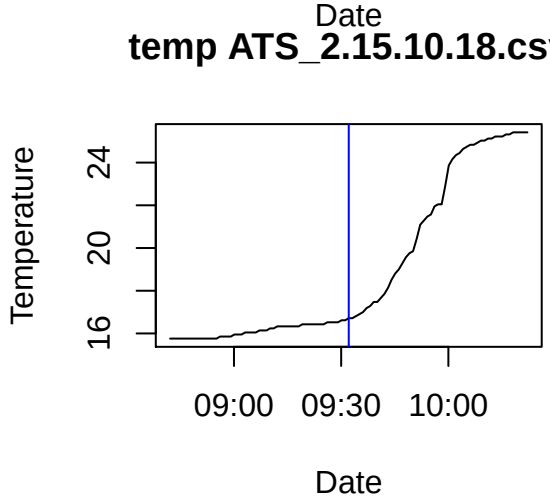




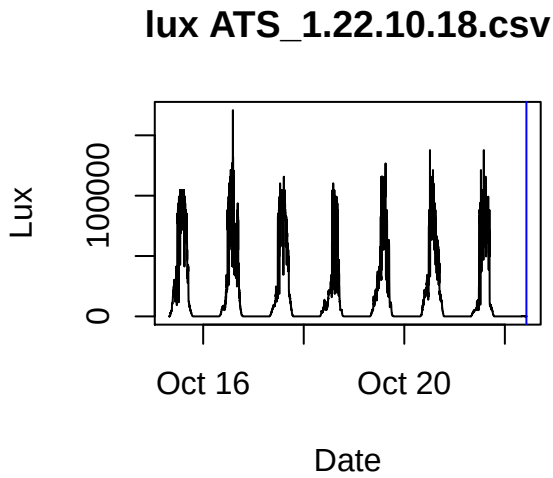


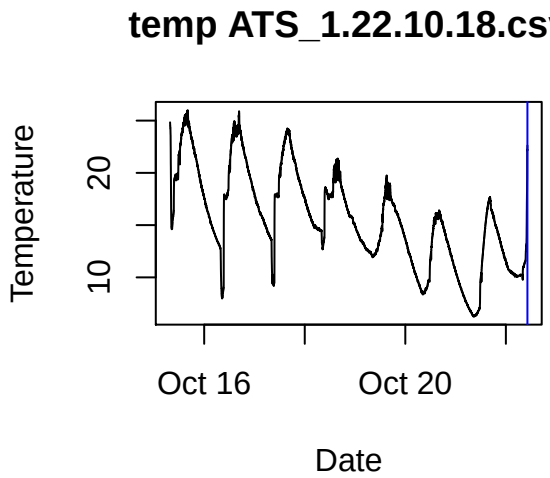


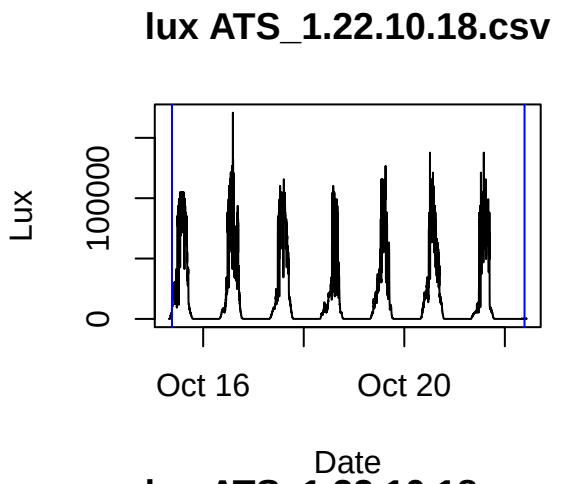


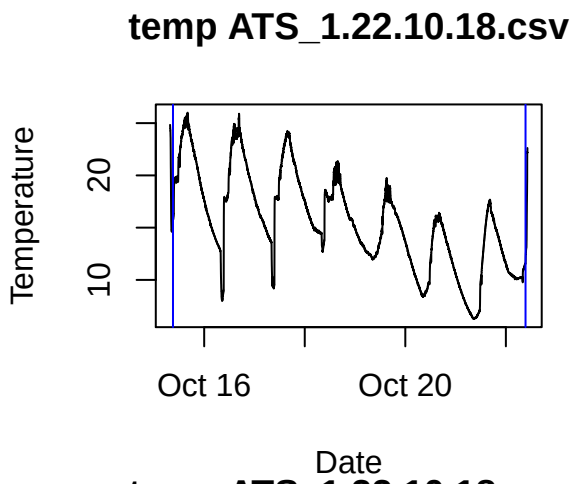


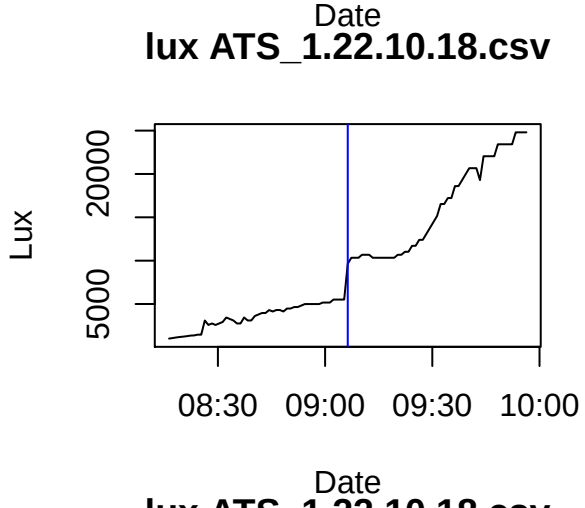
Here we determine the first observation from Week2 that is later than the last observation from the cleaned Week 1 data (#121, corresponding to 2018-09-11 12:36:36). We then zoom in on the 120 observations starting 10 minutes before that one. We observe a distinct rise in illumination that corresponds with a steep decline in temperature as ATS_2 is retrieved and placed in the water flow. We then zoom in closer to determine the exact observation corresponding to this event. Unsurprisingly, this appears to be the one immediately following the one when ATS_1 was removed, or 122. We then zoom in on the end of the observations as with week 1 to determine the final relevant observation, focusing on the moment when both illumination and temperature begin to fall rapidly. This occurs at observation -206.

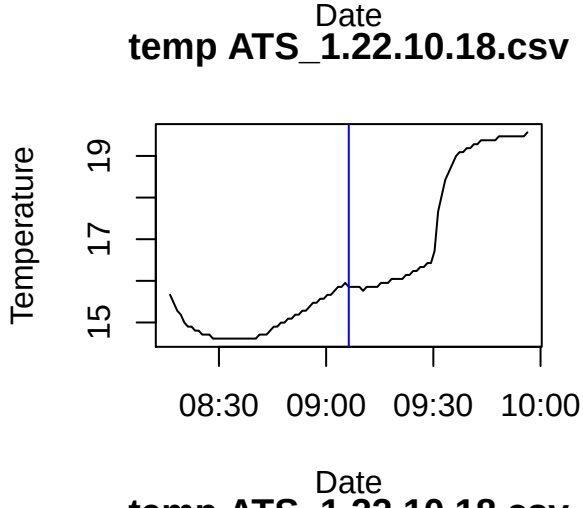


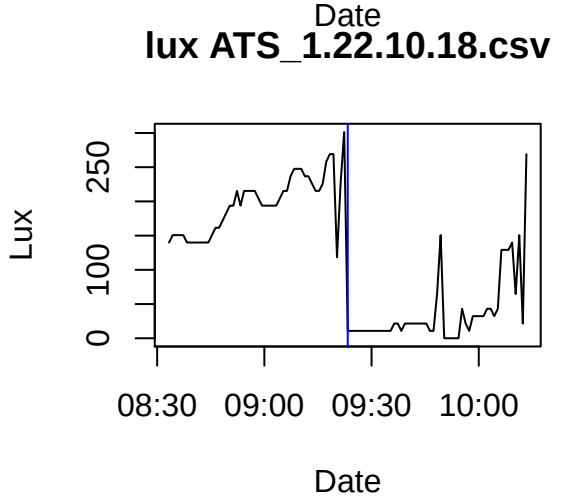


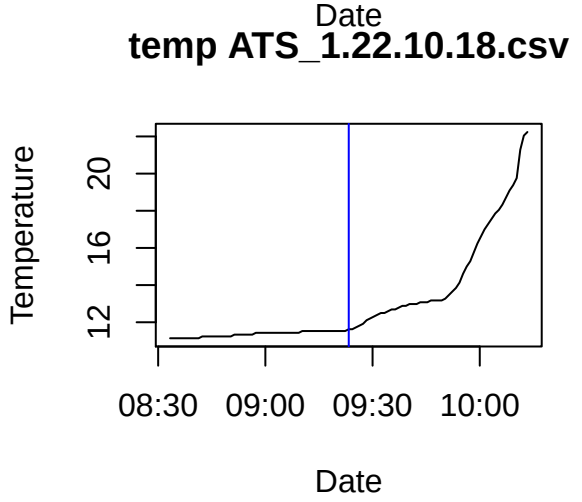

lux ATS_1.22.10.18.csv
Lux
0
100000
Oct 16
Oct 20
Date


temp ATS_1.22.10.18.csv
Temperature
10
20
Oct 16
Oct 20
Date


lux ATS_1.22.10.18.csv
Lux
5000
20000
08:30
09:00
09:30
10:00
Date


temp ATS_1.22.10.18.csv
Temperature
15
17
19
08:30
09:00
09:30
10:00
Date


lux ATS_1.22.10.18.csv
Lux
0
100
250
08:30
09:00
09:30
10:00
Date


temp ATS_1.22.10.18.csv
Temperature
12
16
20
08:30
09:00
09:30
10:00
Date