Investigating Differences in Upwind and Downwind Influences Surrounding Lake Kegonsa

ATM OCN 404: Meteorological Measurements

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Abstract

Lakes are sources of naturally occuring heat and gas fluxes capable of affecting the surrounding local environment. Here, we attempt to observe differences in the upwind and downwind components of Lake Kegonsa by comparing dynamic variables and aerosol/greenhouse gas concentrations. The experiment was conducted from March 2nd - April 1st, 2020 at four different sites surrounding Lake Kegonsa with one site in each directional quadrant (North, South, East, and West). Dynamic variables were measured daily with HOBO weather tripods taking measurements in pressure, temperature, relative humidity, and wind speed and direction. Methane and CO_2 were measured using Picarro GasScouter for 5 minutes at each site four times, while $PM_{2.5}$ was measured by DustTrak at the western station. Some dynamic variables such as temperature and wind speed do have noticeable differences on the downwind side of the lake. However, other variables such as pressure and relative humidity do not have any noticeable differences. The lake reduced CO_2 downwind but increased CH_4, indicating different processes affecting the two gases.

1.1 Introduction

Lakes have been shown to influence the exchange of heat, gas fluxes, and evaporation due to temperature gradients between lake water surfaces and the air above (Woolway et al. 2017; Long et al. 2007). These fluxes can cause significant differences between the upwind and downwind shores. Therefore, we wanted to determine whether Lake Kegonsa in Dane County, WI exerts a measurable influence on the surrounding environment. Lake Kegonsa covers 3,209 acres (12.99 km^2) and is more than 30 feet (9 meters) deep (WI DNR 2020). To determine if Lake Kegonsa influenced the surrounding environment, we measured temperature, pressure, humidity, wind speed and wind direction on all sides of the lake. We measured the concentrations of methane (CH_4) and carbon dioxide (CO_2) at the same locations that dynamic variables were measured, while the concentration of particulate matter smaller than 2.5 microns in diameter ($PM_{2.5}$) was measured at one site.

1.1 Background

Lakes have a profound effect on their surrounding environment. In the American Midwest, states like Michigan, Illinois, Minnesota, and Indiana can experience multiple feet of lake-effect snow a year (Kunkel et al. 2000). In the spring and summer months, lakes act as energy sinks, absorbing solar radiation. Through mixing, the water is able to transport the heat downward into the lake and hold onto this energy. This process overall has a net cooling effect on the surrounding environment (Long et al. 2007). However, the atmospheric effects of lakes on the surrounding environment are most likely to be found downwind (Scott et al. 1996). A study of lakes in the Himalayas concluded that lakes can affect an area three times their size. As the wind flows across open water it will interact with the lake and collect moisture. This increase in moisture leads to an increase in precipitation in downwind regions (Wen et al. 2015). However, mountain lakes are subject to different environmental conditions than those closer to sea level, such as increased solar flux, colder temperatures, and lower surface pressures.

Lakes are also heavily involved in the local and global carbon and methane cycle. Decay and animal respiration lead to large amounts of carbon being dissolved in lake water. Carbon concentrations are correlated with the size of the lake with smaller lakes having a larger concentration of dissolved carbon (Hanson et al. 2007). Ice coverage during winter months prevents lakes from releasing stored carbon and methane, resulting in a concentration spike once the ice thaws in the spring. The amount and duration of this carbon spike is dependent on the depth of the lake, while the methane spike correlates with the ecosystem that surrounds the vegetation (Karlson et al. 2013) and the size of the lake itself (Michmerhuizen et al. 1996). Lake Kegonsa is a small and shallow lake that is not in a mountainous environment. Thus, we wanted to evaluate how its influence on the local environment may be similar to or different from previous lake studies.

1.2 Hypotheses and Questions

i. Dynamics

We hypothesize that the stations on the downwind side of the lake would experience cooler temperatures, higher wind speeds, and higher relative humidity, but no change in pressure. We expect cooler temperatures because in a springtime scenario, the lake water temperature is cooler than the surrounding air temperature. Higher wind speeds are expected because over the length of fetch of the lake, winds will be able to travel in a layer that has significantly less friction than the land, increasing the magnitude of the wind speed. Humidity is predicted to increase because the warmer air above the lake will increase evaporation as an air mass passes over Lake Kegonsa. Pressure is not expected to see major differences as we don't believe the spatial difference between stations is large enough.

ii. Greenhouse Gases (GHG)

We predict that there will be measurable reduction of carbon dioxide, methane, and particulate matter ($PM_{2.5}$) concentrations downwind of the lake when the lake is ice-free. Once lake ice has broken up and melted, the surface of the lake will be open to interaction with the atmosphere above it, thus allowing for exchange. If the lake is ice covered, we expect no concentration exchanges downwind.

2. Methods and Instrumentation

2.1 Site Locations

To best examine patterns in the variables monitored, four stations were set up along the perimeter of the lake in each of the cardinal directions, allowing for the investigation of across-lake patterns and influences. Figure 1 depicts all station locations. Fish Camp County Park was the northmost station, coordinates 42.9831, -89.26258 (Station A); the University of Wisconsin - Madison, Physical Sciences Lab was the western station, coordinates 42.96102, -89.28999 (Station E); Quam Park was the southmost station with coordinates 42.94775, -89.24579 (Station D); and LaFollette Park was the eastern station at coordinates 42.96613, -89.22168 (Station B). Relatively flat and open areas were chosen for instrument deployment, although Station B was more sheltered than the other stations. Stations A and B were directly on the shoreline, while stations D and E were slightly inland.

2.2 Dynamics Instrumentation

Four HOBO Weather Stations continually recorded wind speed (mph) and direction, relative humidity (%), temperature (˚C), and pressure (hPa) every five minutes from the time of deployment to the time of takedown on April 1st. The weather stations at Fish Camp County Park (Station A), Quam Park (Station D), and the Physical Sciences Lab (Station E) began recording data on March 2nd, while LaFollette County Park (Station B) data beginning on March 9th. This provided us with three contemporaneous weeks of dynamic variable data from the four stations.

The weather station instruments were calibrated a week before deployment to ensure a consistent baseline between sites.

2.3 Greenhouse Gas and Aerosol Instrumentation

To track patterns in aerosol variation, a TSI DustTrak Aerosol Monitor model 8520 was deployed at the Physical Sciences Lab (Station E). A second DustTrak was intended to be deployed at LaFollette Park. However, power supply difficulties prevented deployment. The DustTrak was running from the time of deployment (March 2nd) to the time of takedown (April 1st), measuring $PM_{2.5}$ concentration (mg/m^3) at 15 minute intervals. A Picarro G4301 GasScouter was used to track CO_2 and CH_4 concentrations (ppm), and was run for roughly five minutes at each of the four stations. Greenhouse gas concentrations were collected roughly once a week rather than continuously, for a total of four weeks of data. Concentrations during the sample interval were averaged to provide one data point per gas per day.

3. Results

3.1 Wind Speed and Direction

Each weather station presents a unique temporal trend during the period of deployment. Figure 2 shows a wind meteogram for each of the four stations; it is important to note that the x-axis timestamps are not the same for all stations since Station B was deployed a week later than the other three weather tripods. The fastest winds at Station A (Fish Camp) are associated with east/southeast winds and south winds. Station B (LaFollette Park) has the strongest winds when they are from a southeast direction. The direction of fastest wind for Station D (Quam Park) is from the southwest, and for Station E (PSL) it is from an east/southeast direction. For most of the stations other than Station B, this is the direction of longest fetch for each location.

Figure 3 shows wind roses for the length of data collection for each tripod. These windroses show wind speed and wind direction for the period of deployment. The length of each “spoke” relates to the frequency of that wind from that direction. For Station A the dominant wind was from the southeast; for Station D and E, the prevailing wind was from the southeast; and for Station B the dominant wind was from the northeast but not at a strong wind speed. Winds are generally lighter and more variable at Station B than the other stations. For a predominantly southerly wind during the deployment period, this puts the upwind site at Station D at Quam Park, with the downwind site at Station A at Fish Camp.

3.2 Temperature

Figure 4 shows recorded temperatures from all four HOBO Weather Stations during the deployment period. Temperatures were recorded to the thousandth of a degree Celcius, allowing for very accurate depictions of temperature at each station. All four stations followed similar diurnal patterns of temperature rise and fall, with the only significant deviation in temperature across the four stations occurring on March 9th, where the Fish Camp weather station (Station A) recorded temperatures 0.5-2 °C less than the temperatures at the other three stations.

We predicted that there would be a cooling effect on the downwind side of Lake Kegonsa. Figure 5 shows a calculated difference of temperatures between our defined upwind station, Quam Park, and the downwind station at Fish Camp. While much of the plotted difference is close to 0 ˚C, there is an almost daily increase in temperature difference that can be seen. These temperature spikes are generally between 0-2 ˚C, although there is a more noticeable difference between March 8 and March 16. During this time period, roughly half of the diurnal temperature spikes at Quam Park are warmer than Fish Camp by 0.5-4 ˚C. This comparison is highlighted in Figure 6, where the March 8 to March 18 time period is isolated to better analyze any downwind cooling effects, and in Figure 7 where the temperature differences between upwind and downwind stations are plotted in a histogram. Most of the temperature variations between Fish Camp and Quam Park are within a positive half degree. This means we are more likely to see variations in which Quam Park is warmer than Fish Camp, thus indicating a small cooling effect downwind.

3.3 Relative Humidity

During the study period, we expected to see an increase in relative humidity on the downwind side of the lake. Relative humidity on all sides of the lake followed similar diurnal patterns, as seen in Figure 8. The exception to this is at Station B on March 9th; during the delayed deployment the station recorded relative humidity no more than 10% less than than the other stations. This difference at Station B was the largest difference in relative humidity measured during the sampling period. Figure 9 shows the relationship between the upwind (Station D) and downwind (Station A) stations. The stations show no more than a 0-5% difference through the reading period. A scatter plot between the upwind (Station D) and downwind (station A) shows a correlation coefficient of 0.97 in Figure 10.

3.4 Pressure

Dynamical pressure was hypothesised to remain relatively unchanged with little variation between stations, especially between upwind and downwind sites. All four stations show similar pressure measurements and trends (Figure 11). Due to Station E (PSL) being on top of a hill, the hydrostatic equation was used in order to give a more accurate measurement in comparison to the other stations; however, pressure at this station is still consistently lower than at the other three stations. The upwind and downwind comparison between Station A (Fish Camp) and Station D (Quam Park) show extremely similar readings which can be seen in Figure 12. This station comparison has a strong correlation coefficient of 1.00 (Figure 13). However, the consistent difference between Station E and the other three stations may indicate that the barometer at Station E was not calibrated properly.

3.5 Greenhouse Gases

Measurements of CO_2 and CH_4 concentrations at each site were taken four times during the study period. Because of complications with accessing the sites, measurements were not able to be made at a consistent time or day each week. Despite this limitation, data was collected while the lake was completely iced over (Mar 2), during ice break-up (Mar 13), and after the lake was completely open (Mar 24, Apr 1). For all dates, the difference in upwind and downwind concentration averages proved to be statistically significant at a 95% confidence level (α=0.05) - with one exception for CO_2 on March 13 - utilizing a two sample t-test assuming unequal variance (Table 1). The mean difference grew in magnitude post ice breakup versus pre-breakup. On March 2, pre-breakup, the station average differences between upwind and downwind were -0.33% and 1.36% for CH_4 and CO_2, respectively, and on March 24 after breakup they were -1.27% and 2.75%. The upwind site, Station D, had higher CO_2 levels than downwind site, Station A, during most of the sampling period (Figure 14). Outside of a Mar 24 spike from ice thaw and its subsequent release of carbon, the lake seemed to act as a carbon sink, as concentrations were lower downwind.

At all four sites, both CO_2 and CH_4 concentrations demonstrate an increase during the March 24th sampling period compared to the local minima concentrations on March 13th (Figures 14 and 15). The CO_2 levels fluctuate much less at stations A and E than the levels at stations B and D. Since Station E was located the furthest from the lake (Figure 1); it is the least likely to see short-term fluctuations in concentration that may occur directly along the shore. However, the Station D site was also far from the waterfront, yet it did experience large fluctuations in CO_2 between the start and the end of the study period.

Although a similar temporal trend is seen with CH_4 concentration at all sites, the variability in concentration at the sites is different than with CO_2. Whereas Station D had the highest CO_2 concentrations, it had the lowest CH_4 concentrations. In general, CH_4 levels were lower upwind before and after ice break-up (Figure 15).The highest concentrations of CH_4 were measured on March 24 while the lowest were measured on March 13. Station A saw the greatest fluctuations in CH_4 concentration, while stations B and D had much smaller fluctuations in concentration. This may indicate that Station A was influenced by a local methane source, such as marshes along the lake, that were upwind of the sampling location. The lake's role as a carbon sink and a methane source is supported by calculated fluxes for the timeframe (Figure 16).

3.6 Aerosol

Because of data logging problems, $PM_{2.5}$ measurements were only made for a fraction of the deployment period at Station E, from March 16 to March 27. The DustTrak data at the Physical Sciences Lab does not correlate with a diurnal cycle or with temperature during the time when both DustTrak and HOBO instruments were in operation (Figure 17). We calculated a Pearson's coefficient of correlation for $PM_{2.5}$ concentration with each meteorological variable measured at Physical Sciences Lab during the time period that the DustTrak was fully operational. Based on the low R^2, there was no statistically significant correlation between $PM_{2.5}$ and temperature (R^2=0.01, p=0.05), relative humidity (R^2=0.03, p=2.5e-6), pressure (R^2=0.03, p=3.7e-7), or wind speed (R^2=0.04, p=9.8e-8). However, when wind speed and direction are considered together, there is a moderate correlation between aerosol concentration and wind.

Figure 18 shows the wind direction and speed at Station E during the time period that both meteorological and aerosol measurements were occuring. The periods of highest $PM_{2.5}$ concentration occurred when wind speeds were lowest and air was coming off the lake. When faster winds were from the northwest, aerosol concentration was generally low. The highest concentration of $PM_{2.5}$ occurred when winds were from the east-northeast and below 8 mph. Since the lake was east of the sampling location, the high $PM_{2.5}$ levels seen when winds were blowing off the lake may indicate that the lake increased ambient particle levels.

4. Discussion

Wind speed, wind direction, temperature, and relative humidity are affected differently by Lake Kegonsa. We hypothesized that there would be higher wind speeds on the downwind side of the lake because the wind will experience less drag over the lake than the land. Wind is mostly coming from the south during the deployment of the weather stations. Station B did record the most counts of light winds from the northeast, but this is an outlier amongst the other stations, potentially because it was the most sheltered site. We then denoted Station D at Quam Park as the upwind side of the lake, and Station A at Fish Camp the downwind side of the lake since Station A is on average at the end of the fetch across the lake for the deployment period. Station A had the highest wind speed peaks and Station D had much lower wind speed. This supports our hypothesis that the wind speeds would be higher on the downwind side of Lake Kegonsa.

We hypothesized there would be cooler temperatures downwind due to the heat exchange between air and cool lake water. Station D shows higher temperatures on days where winds are coming out of the south. Analysis of temperature difference between upwind and downwind sites indicates that Station D is more likely to have a higher temperature during the sampling period, indicating Lake Kegonsa tends to have a cooling effect on the downwind side of the lake. In contrast to this marked influence on temperature, relative humidity seems unaffected by the lake. We hypothesized that there would be noticeable differences in humidity across the lake because when the air travels across the water, the air mixes and picks up water vapor from the lake. Our results, on average, show that there is no significant difference in relative humidity between the upwind and downwind sites. It may be that Lake Kegonsa is not large enough to produce differences in humidity across the lake.

Lake Kegonsa is also perhaps too small for there to be noticeable pressure differences at the four stations. From March 2nd to April 1st, there is not a significant difference in pressure across the lake. There is not a large difference in height at each site around Lake Kegonsa, as the surrounding area is generally flat. There is also not a large enough distance between sites that low- or high-pressure systems would cause local differences in pressure between sites.

Greenhouse gas concentrations were affected by the presence of the lake: higher concentrations of CH_4 and lower concentrations of CO_2 occurred on the downwind side. We hypothesized that there would be no statistically significant effect on GHG concentration from the iced over lake, but that the ice-free lake would reduce GHG concentrations downwind. The magnitude of mean differences in CH_4 and CO_2 increased from March 2 (ice-covered lake) to March 24 (ice-free lake). A larger increase in CH_4 was seen downwind (Station A), but a smaller increase in CO_2 was observed at the same location. Thus, CH_4 increased downwind with ice breakup, refuting our initial hypothesis, but CO_2 decreased, supporting our hypothesis.

However, a minimum in sample concentration was measured for both gases at all four sites on March 13, when the lake still had some ice cover but the coverage was not complete. During this ice break-up period, Station A had lower CH_4 levels than Station D, showing that downwind of the lake may have been experiencing a reduction in CH_4 as a result of ice breakup. This ice breakup coincided with a period of falling average temperature (Figure 5). Methanogenesis by anaerobic bacteria is a temperature-dependent process, and different methanogenic bacteria dominate in different temperature regimes, so falling temperatures may have reduced CH_4 production from one lakeshore bacteria type (Liu et al. 2019). It is important to note that CH_4 fluxes from lakes do change seasonally; however, a small lake in Switzerland experienced the largest fluxes in CH_4 during autumn, almost an order of magnitude higher than fluxes in spring (Schilder et al. 2016).

Due to limitations in aerosol instrument deployment, no conclusions regarding differences between upwind and downwind concentrations or the effects of ice break-up can be made. Based on our results, we determined that wind speed and direction are predictors of aerosol concentration, but that temperature, humidity, and pressure did not affect $PM_{2.5}$ during the study period. Analysis of wind direction indicates that aerosol concentration is highest at Station E when wind is coming from the south or southeast. As Station E is to the west of Lake Kegonsa, the lake may be contributing to some of the increase in $PM_{2.5}$. The city of Stoughton is south east of the sampling location; vehicle or industrial emissions from Stoughton may be contributing to $PM_{2.5}$ levels. In addition to direction, aerosol concentration seems to be influenced by wind speed, where lower wind speeds contribute to higher concentrations. Lower wind speeds increase the time available for reaction of primary pollutants to form secondary organic aerosols. We did not collect composition data of the $PM_{2.5}$, so it is difficult to determine if the particles are primary emissions or secondary organic aerosols. Overall, our hypothesis that the lake would reduce $PM_{2.5}$ levels was not supported by the data.

5. Conclusions

From analysis of dynamic variables and greenhouse gas concentrations, it is clear that Lake Kegonsa has some effect on the surrounding environment. This effect can be seen on the downwind side of the lake for some of the variables measured, namely temperature, CO_2 concentrations, and CH_4 concentration. The openness of the lake also affected wind speed. However, relative humidity did not appear to be significantly affected by the lake during our study period. Pressure, which was not expected to be affected, was similar along all sides of the lake. From previous records we had expected the winds to be primarily westerly, and it was an interesting result that for the month of March this year we had dominantly southern flow.

We had expected both methane and carbon dioxide to be reduced on the downwind side of the lake when the water was open. However, we found that only CO_2 was reduced and that CH_4 increased downwind of the lake after the lake was ice-free. The break-up of the ice cover did seem to affect both GHG concentrations, but it is interesting that the lowest concentrations were measured while there was some open water, not during the period of complete ice coverage. Although particle measurements were not taken on multiple sides of the lake, contemporaneous wind measurements indicate that the lake may have had some effect on $PM_{2.5}$ concentration during the study period. Highest concentrations occurred when wind was coming from either the lake or from the city of Stoughton, although exact sourcing was not possible.

To improve our analysis of upwind and downwind effects, greenhouse gas measurements could have been taken more frequently and at more regular intervals. Water samples could also provide information on carbon fluxes in the water, perhaps correlating with air fluxes. Particle concentrations should have been measured on both upwind and downwind sides of the lake, and it would have been beneficial to determine these locations prior to DustTrak deployment. Further analysis concerning the effects of the lake on temperature and relative humidity versus specific humidity could provide more information on the lack of change in relative humidity seen during the study period.

6. Acknowledgments

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Quam Park: Alex Mesdjian, alex.mesdjian@pleasantsprings.org

LaFollette and Fish Camp Park: Darren Marsh, marsh@countyofdane.com

Physical Sciences Laboratory: Gary Anderson, granders@wisc.edu

Figures:

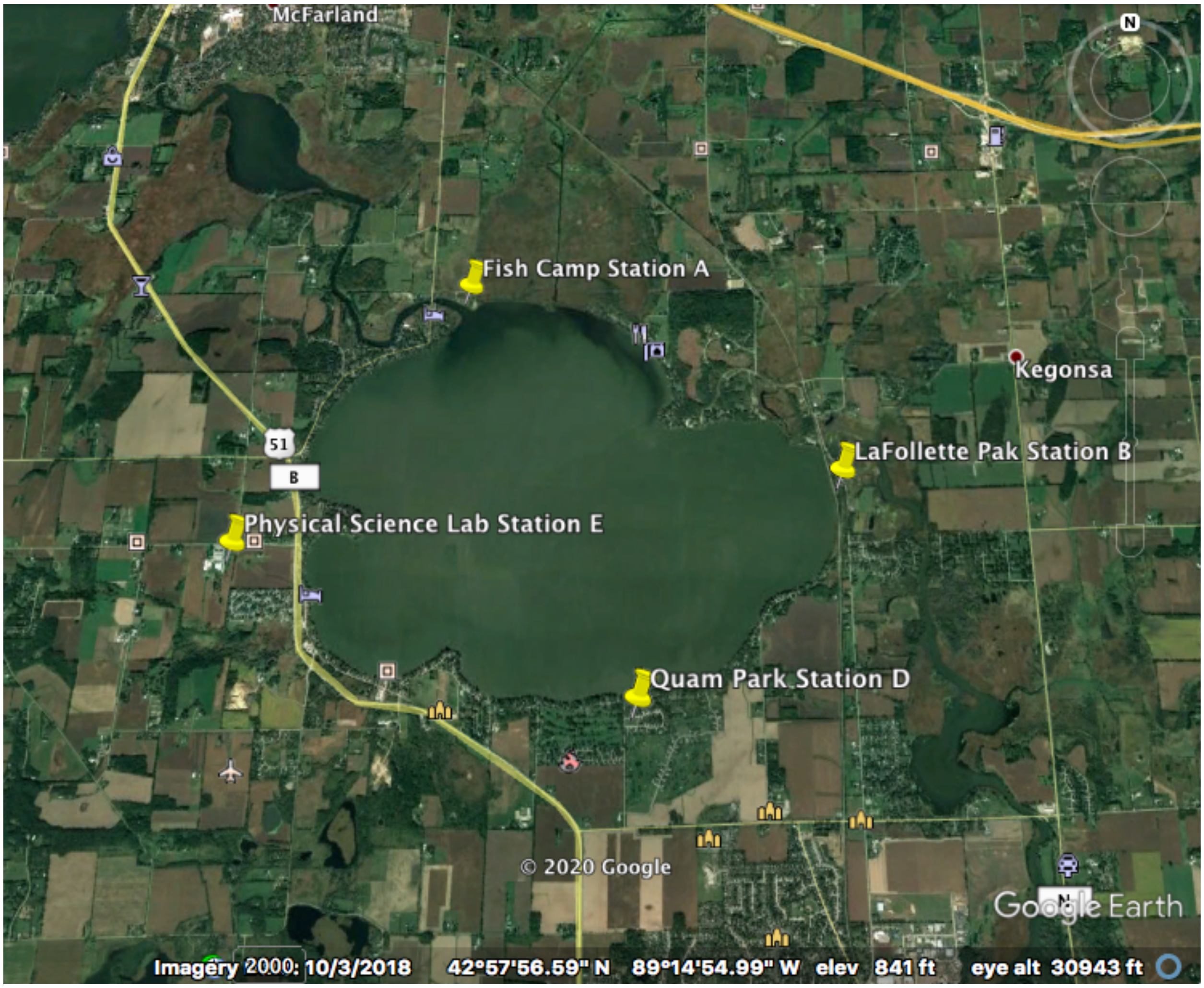
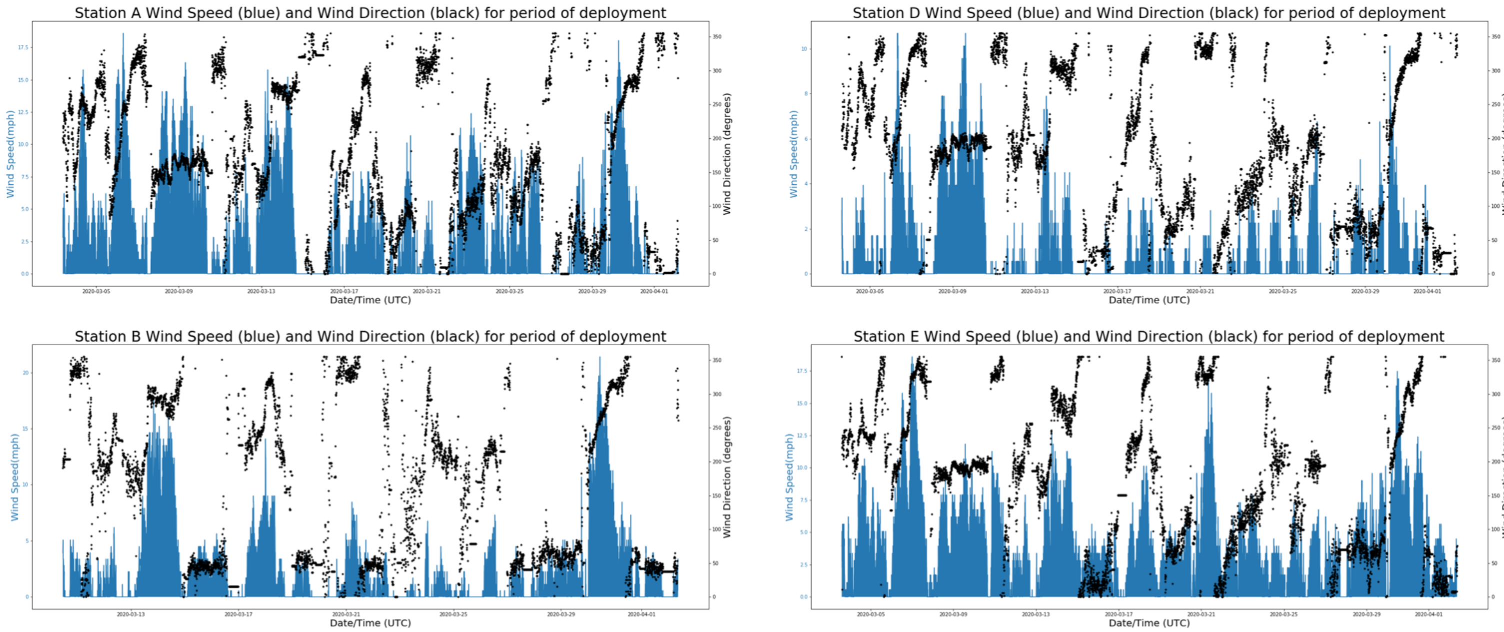


Figure 1. Site Locations around Lake Kegonsa. Sites were chosen so that each cardinal direction of the lake was monitored and so that differences across the lake would be measured.

Figure 2. Wind meteogram for each station's deployment, plotting wind speed in miles per hour (blue, filled) and wind direction in degrees (black dots). It is important to note that Station B was



deployed a week later than the other stations. Wind speeds at Station B are generally lower.

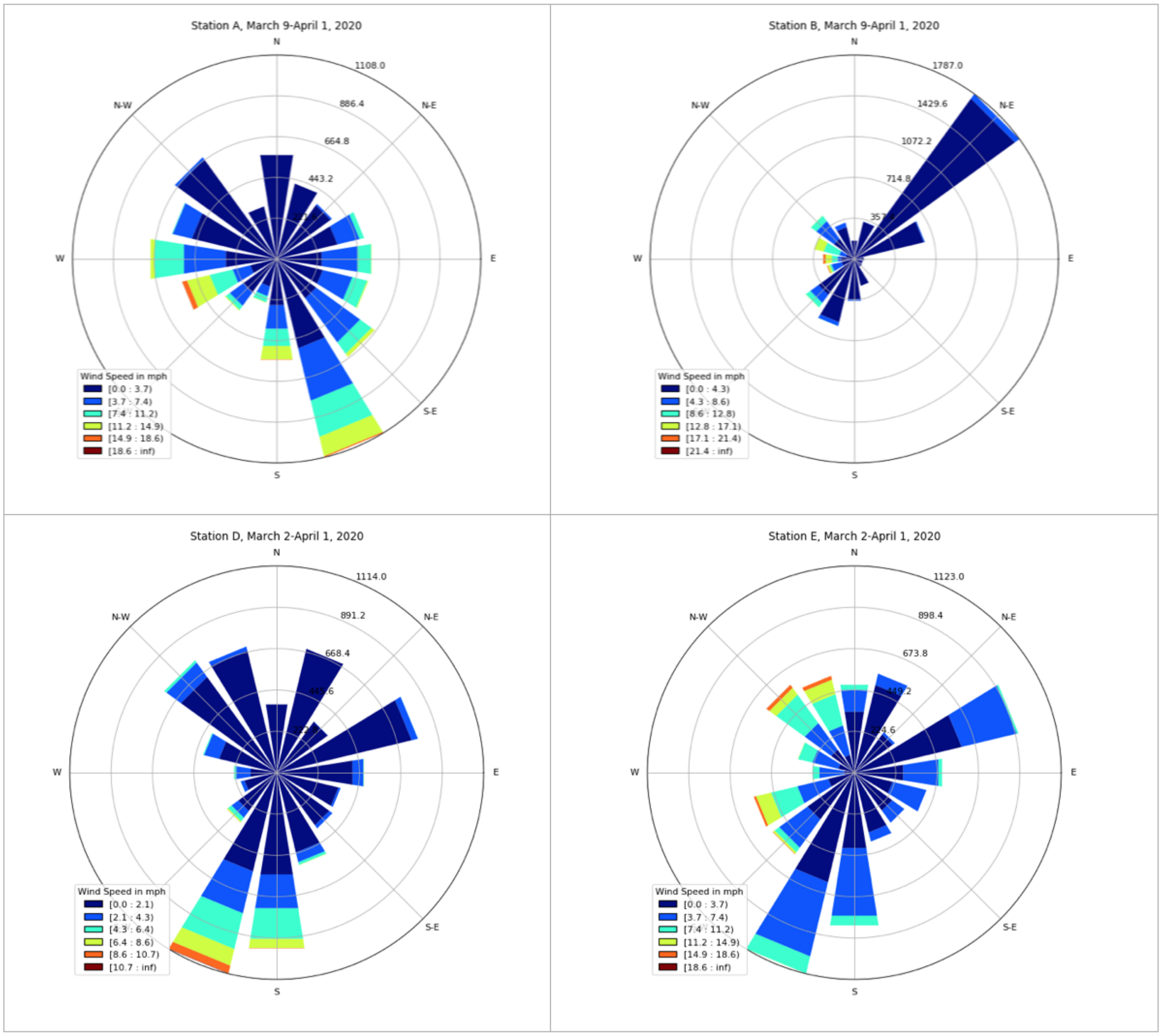


Figure 3. Plot of wind roses for each station for the length of deployment in miles per hour. Cool to warm colors signify increasing wind speed. Stations A, D, and E showed that most often the wind came from the south or southeast, although at Station B the wind most often came from the northeast. Wind speeds were mostly low, although the highest wind speeds occurred at Station A.

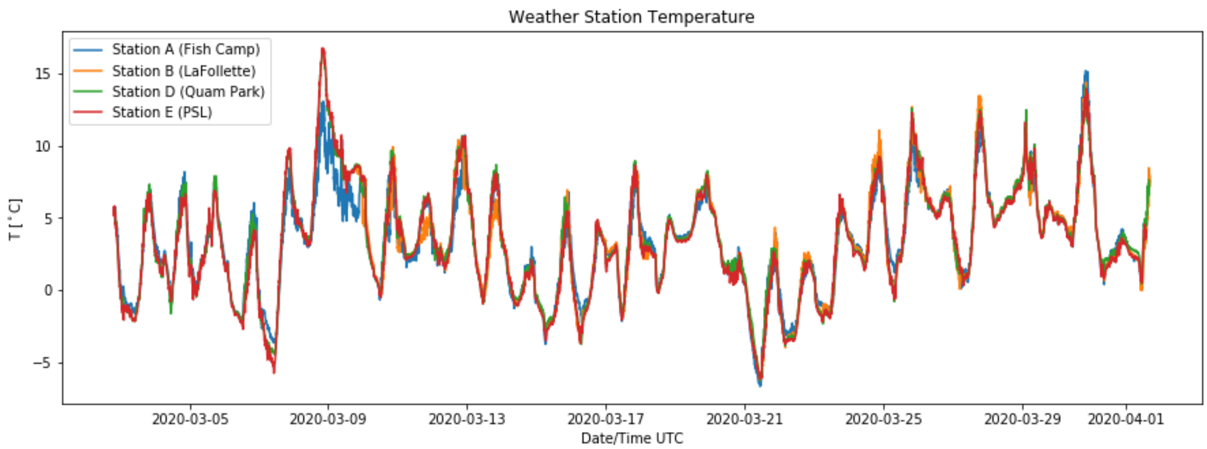


Figure 4. Recorded temperatures (˚C) from all four weather stations from March 2rd to April 1st. Temperatures follow a diurnal cycle, peaking during the day. A cold spell can be seen beginning around March 9.

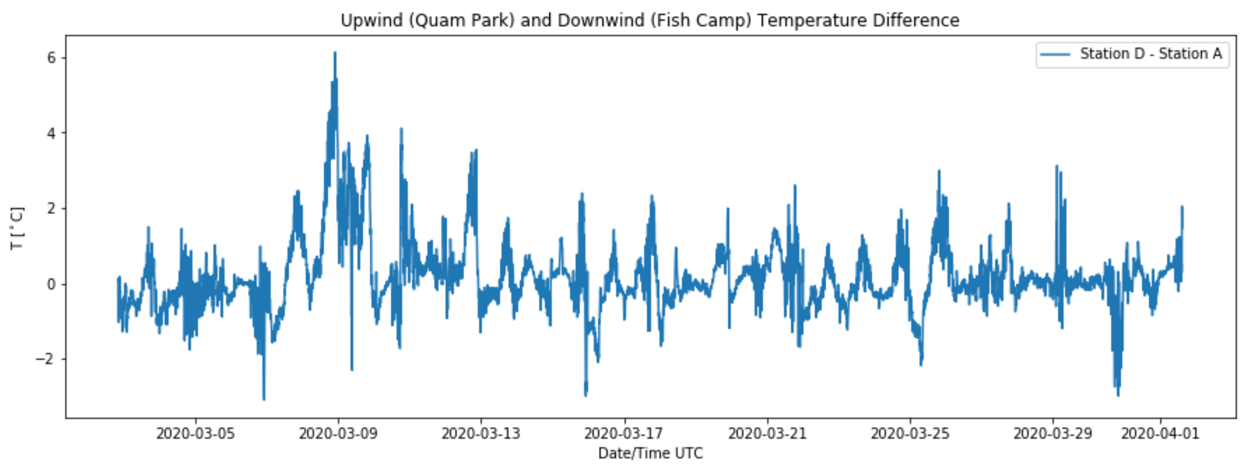


Figure 5. Calculated temperature difference between Station D (Quam Park) and Station A (Fish Camp) weather stations, which are our upwind and downwind locations respectively. The differences center around 0 ˚C, although there is a tendency for differences to be positive.

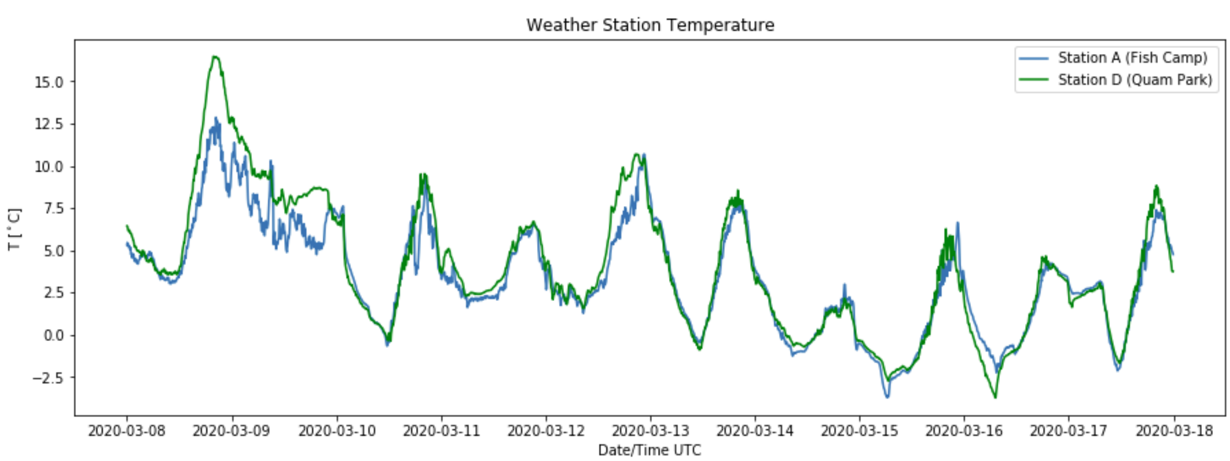


Figure 6. Temperature analysis from the Fish Camp (Station A) and Quam Park (Station D) weather stations from 08 March 2020 to 18 March 2020, during the cold spell. The differences in temperature peaks during this time was between 0.5-4 ˚C.

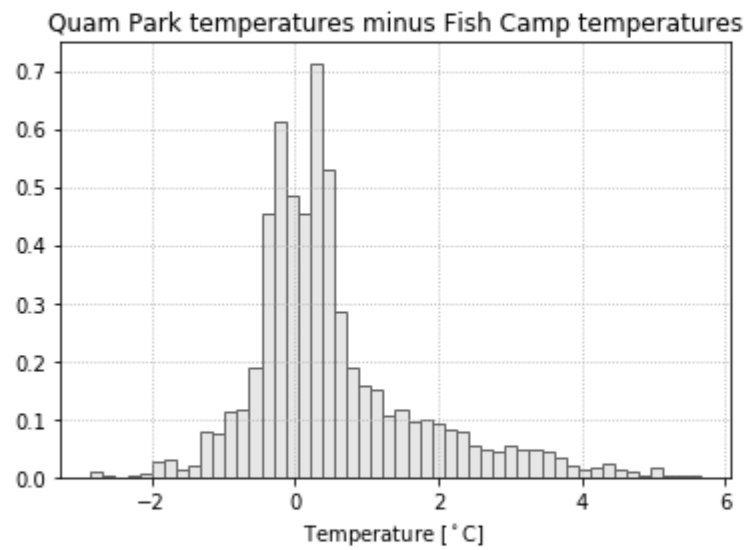


Figure 7. Histogram plot of temperatures taken at Station D (Quam Park) subtracted by recorded temperatures at Station A (Fish Camp). Although differences occur on either side of 0 ˚C, it is more likely that Station D will be warmer than Station A (positive temperature difference).

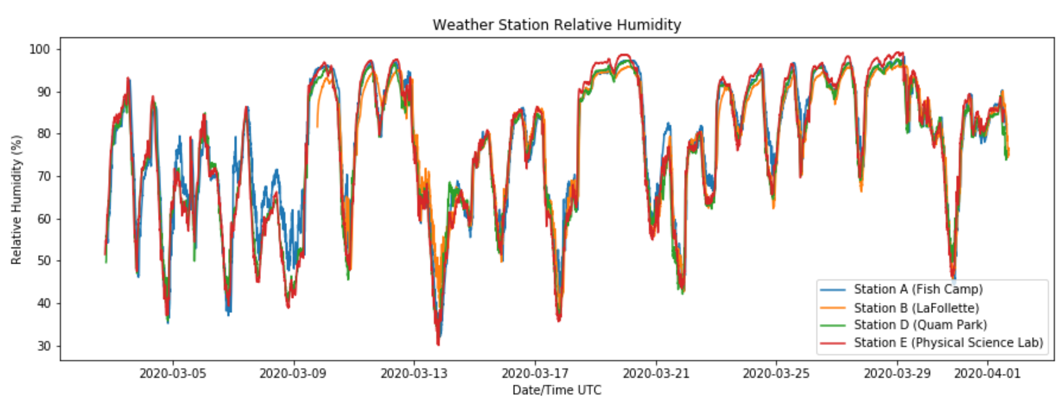


Figure 8. Relative Humidity (%) comparison between all stations.

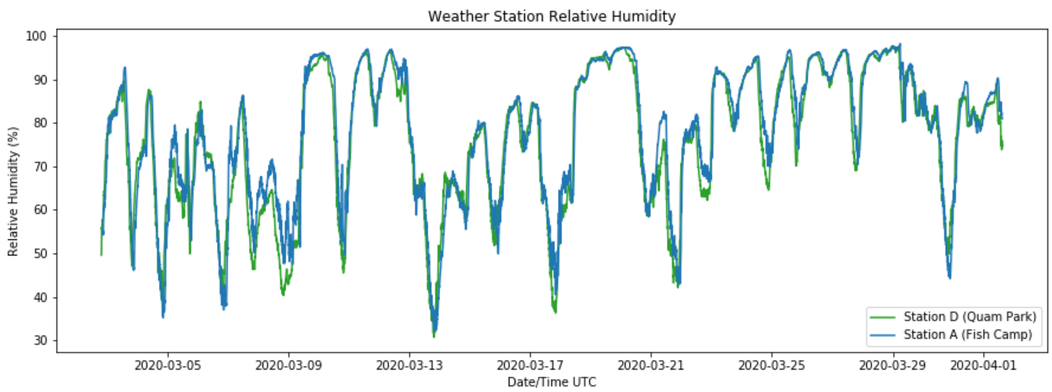


Figure 9. Relative Humidity (%) comparison between the upwind (Station D) and downwind (Station A) stations. The two stations trend together, following the same pattern of increases and decreases.

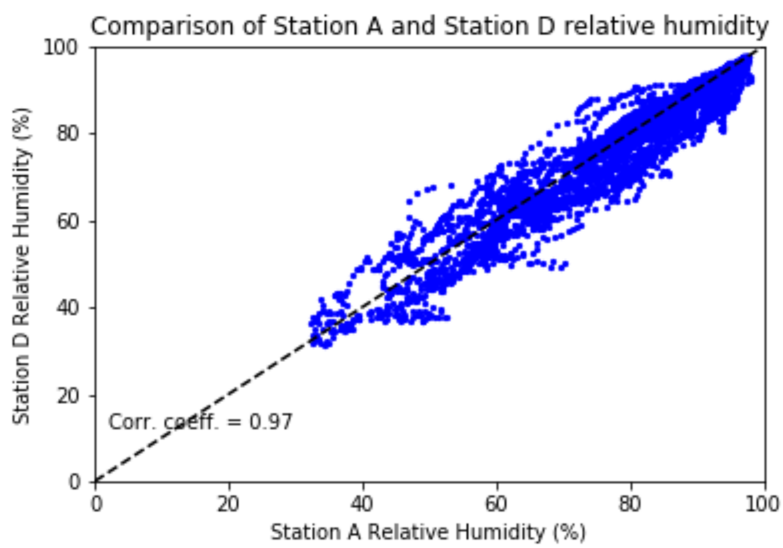


Figure 10. Scatter plot of relative humidity at the upwind (Station D) and downwind (Station A) locations. A correlation coefficient of 0.97 indicates that relative humidity at the two stations correlate strongly.

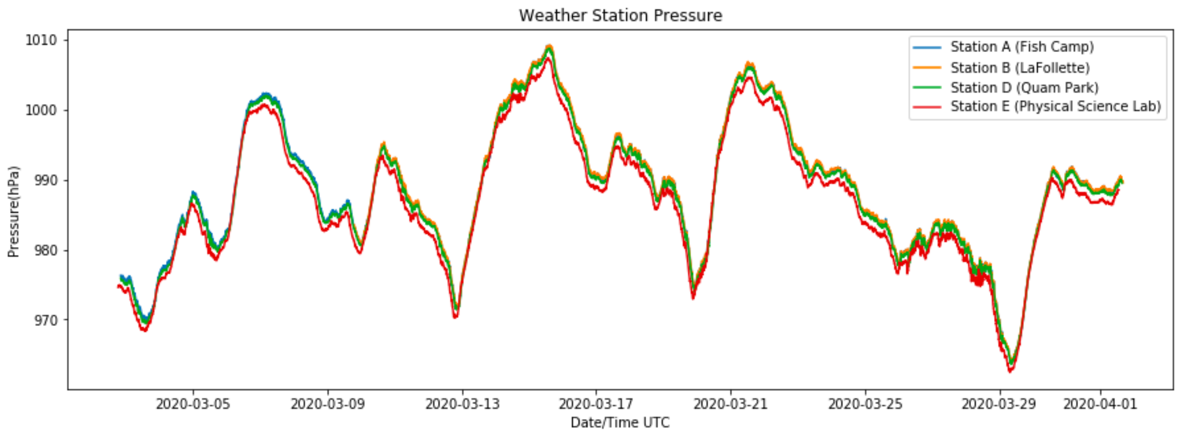


Figure 11. Pressure (hPa) measured at Station A, Station B, Station D, and Station E. Pressure does not follow a diurnal cycle, unlike temperature or relative humidity. All stations seem to trend together, although Station E is consistently below the pressure of the other stations.

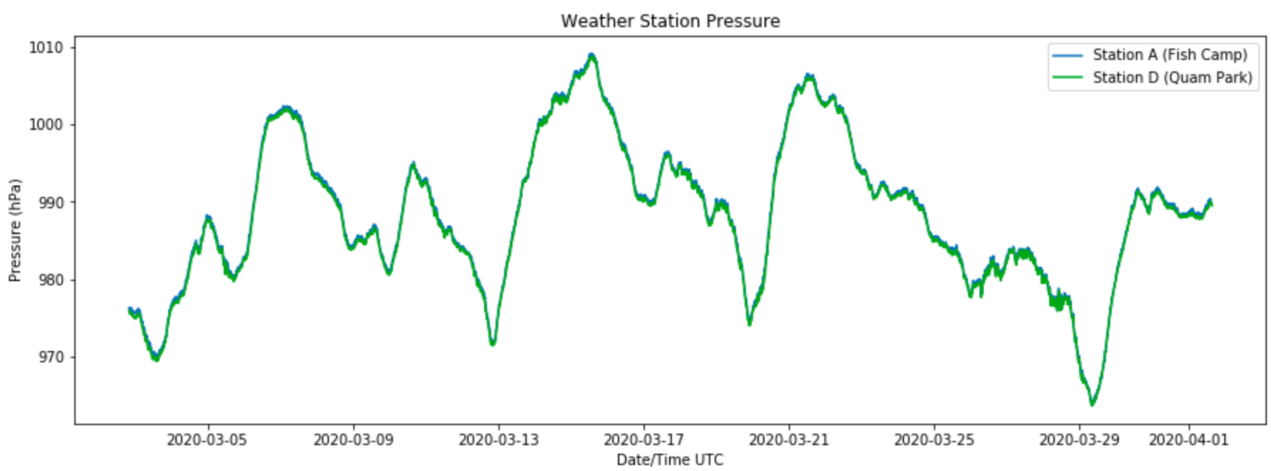


Figure 12. Pressure (hPa) comparison of upwind (Station D) and downwind (Station A). There is essentially no difference between the upwind and downwind measurements of pressure.

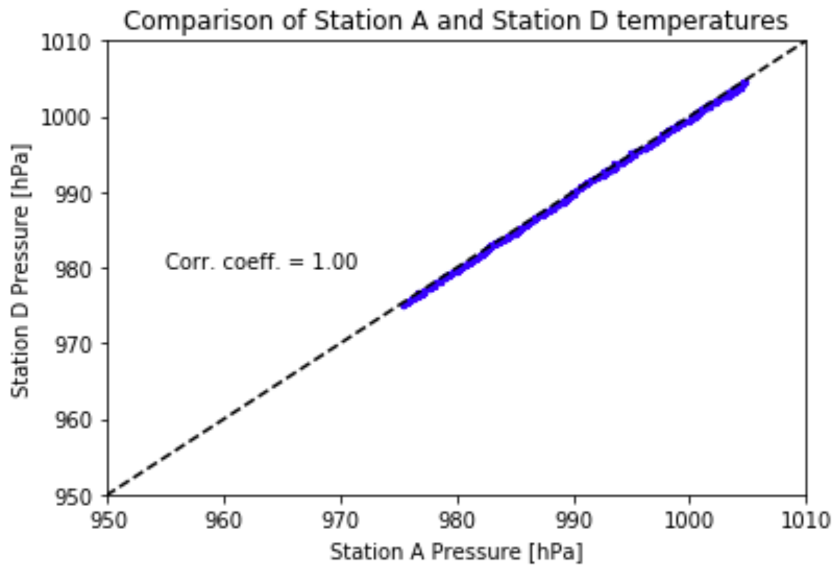
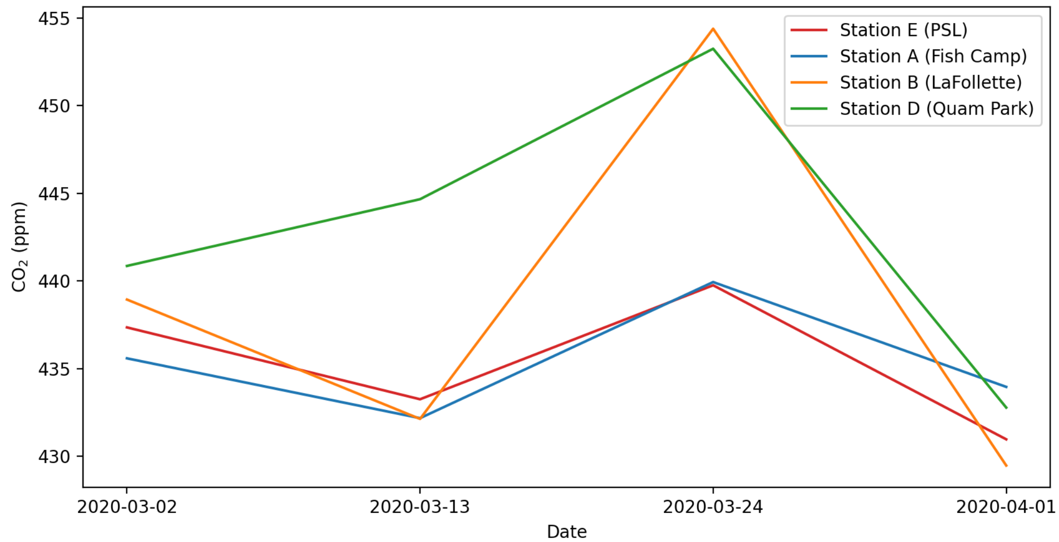


Figure 13. Scatter plot of Station D and Station A pressures. A correlation coefficient of 1.00 indicates that the two pressure measurements trend together exactly.

Table 1. Statistical significance of difference between upwind and downwind GHG samples.

	March 2	**March 13**	**March 24**	**April 1**
CO_2 *t*-value (*p*-value)	6.97 (< 0.0001)	-0.17 (0.87)	-12.48 (< 0.0001)	27.14 (< 0.0001)
CH_4 *t*-value (*p*-value)	-6.53 (< 0.0001)	2.23 (0.03)	126.18 (< 0.0001)	58.89 (< 0.0001)

Figure 14. Carbon dioxide concentration measured by Picarro GasScouter at each site. A local maximum in CO_2 is seen on March 24 at each site and a local minimum on March 13. The largest



fluctuations in CO_2 occur at Stations B and D.

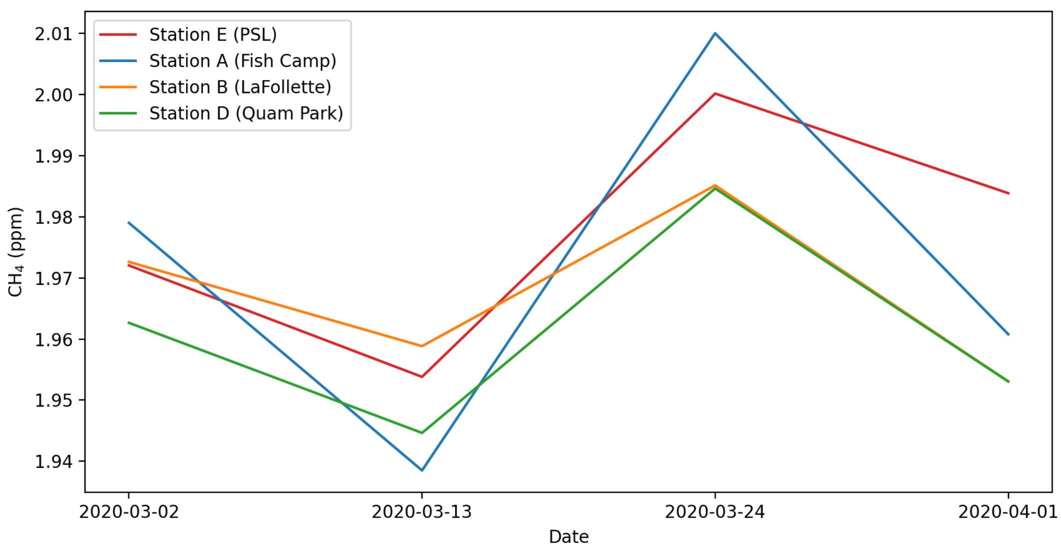


Figure 15. Methane concentration measured by Picarro GasScouter at each site. The highest CH_4 concentrations are seen on March 24, coinciding with the CO_2 maximum, and the lowest concentrations occur on March 13, coinciding with the CO_2 minimum.

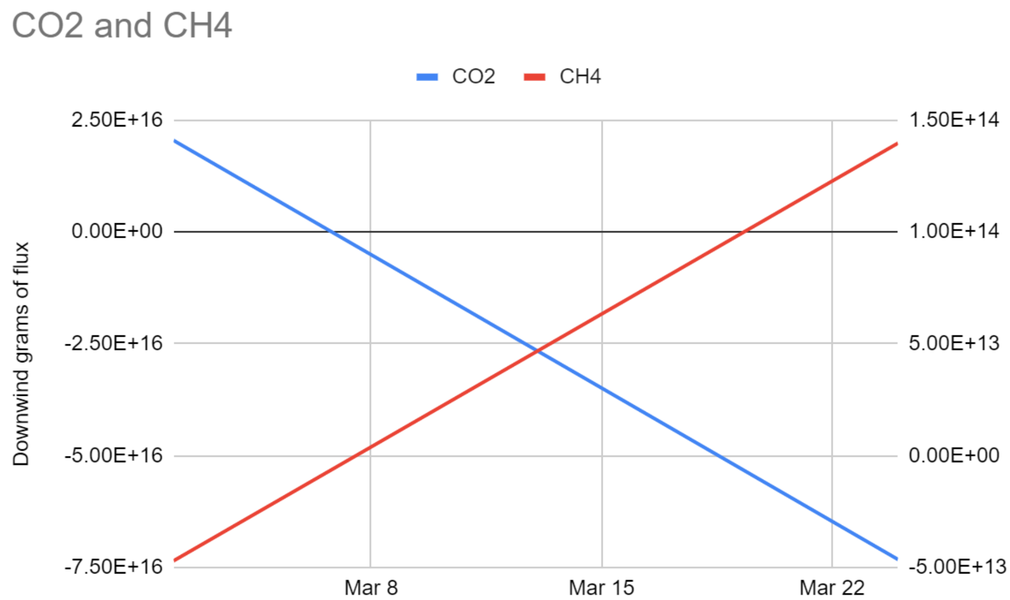


Figure 16. Shows the change in flux from pre and post ice breakup (subtracting upwind values from downwind using average wind direction and speed and calculating distance from upwind and downwind stations) and indicates a CO_2 sink and a CH_4 source.

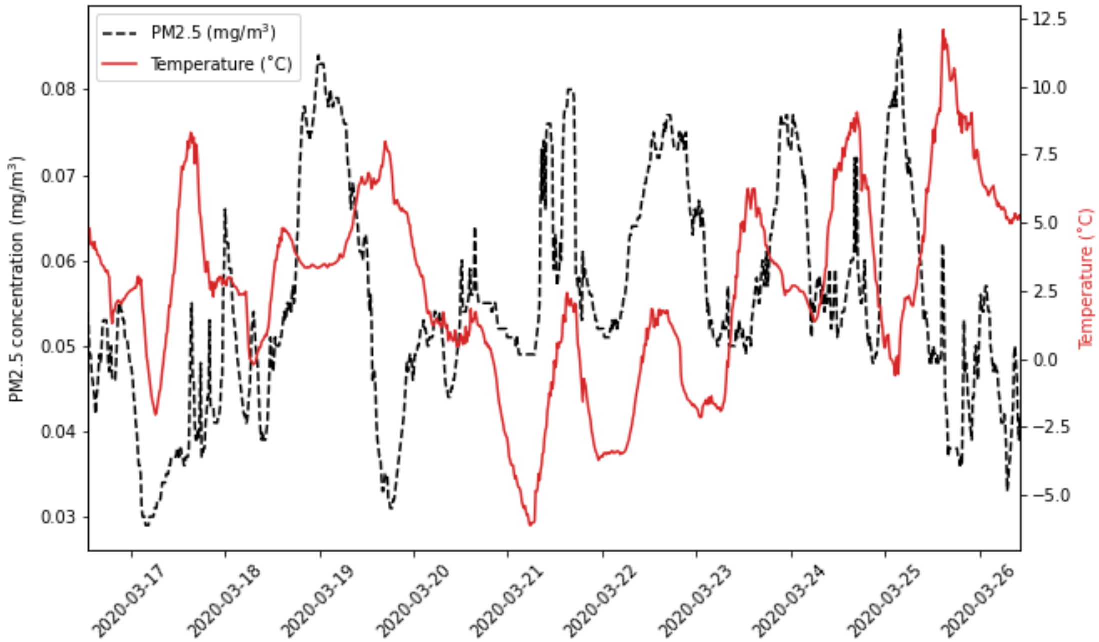


Figure 17. Aerosol concentration at Station E from March 17 to 27, when weather tripods were also deployed. $PM_{2.5}$ concentration (black dashed line) fluctuated between 0.03 and 0.08mg/m^3 during the sampling period. There is no apparent diurnal dependence of this fluctuation. Temperature (red solid line) does show a diurnal dependence, peaking during the day, but does not correlate with $PM_{2.5}$ concentration during the study period.

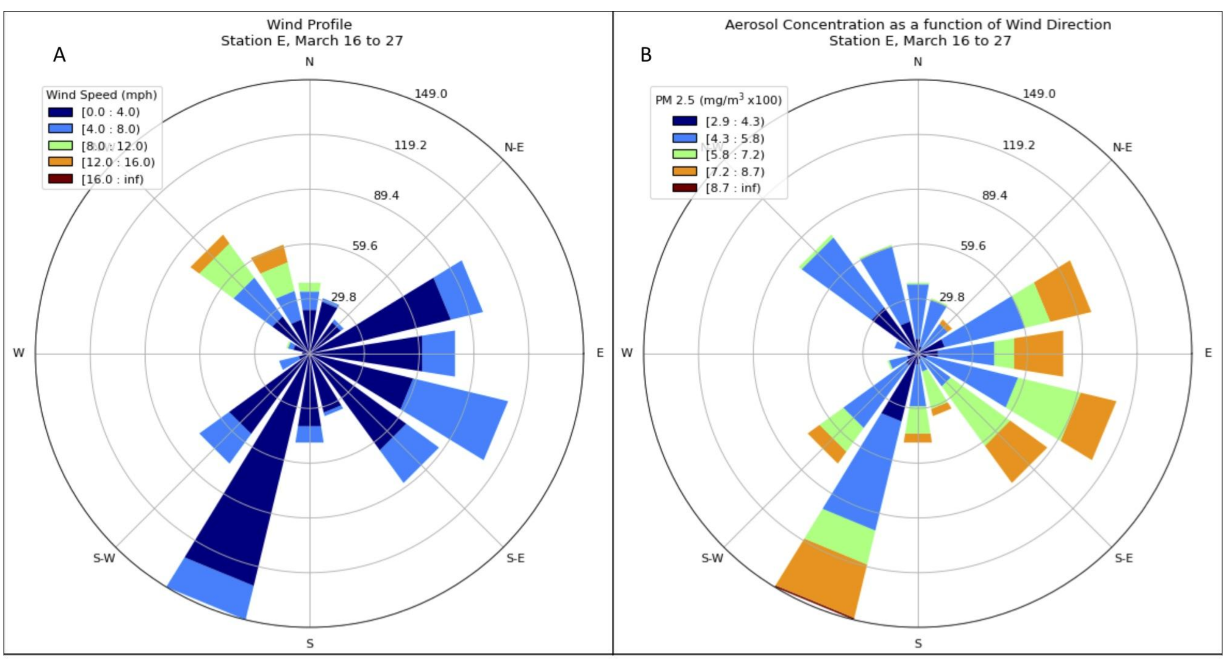


Figure 18. Wind roses showing the effect of wind speed and direction on aerosol concentration at Station E. Wind was generally from the south/southeast during the DustTrak deployment, though wind speeds were low from this direction (A). The highest aerosol concentrations occurred with these slow, southerly winds (B).

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