Data analysis and optimization of WISCO-DISCO 2022 Unmanned Aerial System observations of ozone and meteorology in southeastern Wisconsin.

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Intro

Ozone, although beneficial at high altitudes specifically in the stratosphere, is very harmful when at or near ground level. Ozone has been linked to inflammation of the respiratory system, coughing, irritation, exacerbation of asthma symptoms, and long-term exposure can lead to more severe health problems including infections. This is a large problem around shoreline communities, in this case around Lake Michigan, due to the lake breeze effects on local air mixing. Ozone is created as a byproduct of the reactions of NOx compounds and volatile organic compound with sunlight. The WiscoDISCO-22 field campaign was conducted in June 2022 to capture lake breeze and high ozone events at a shoreline location in SE Wisconsin. The field campaign involved flying unmanned aerial systems mounted with devices to measure ozone and meteorological variables over water and over land in the Chiwaukee Prairie State Natural Area, outside of Kenosha Wisconsin. The Prairie site allowed the ability to run simultaneous flights of both overland and overwater atmospheric measurements showing comparison in local air mixing, inversion points (OL vs. OW), and sea breeze effects on ozone concentrations at and around these shoreline communities. Data analysis from the field campaign will be presented in how to best capture vertical profiles and remove surface effects from the observations.

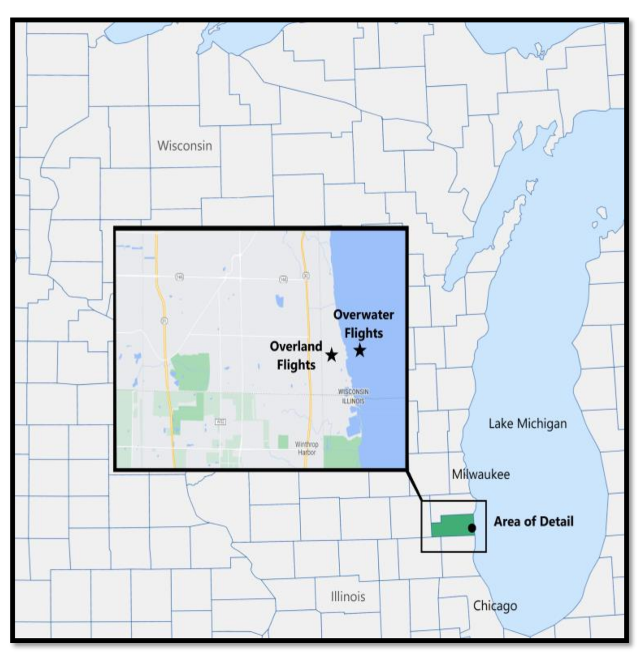
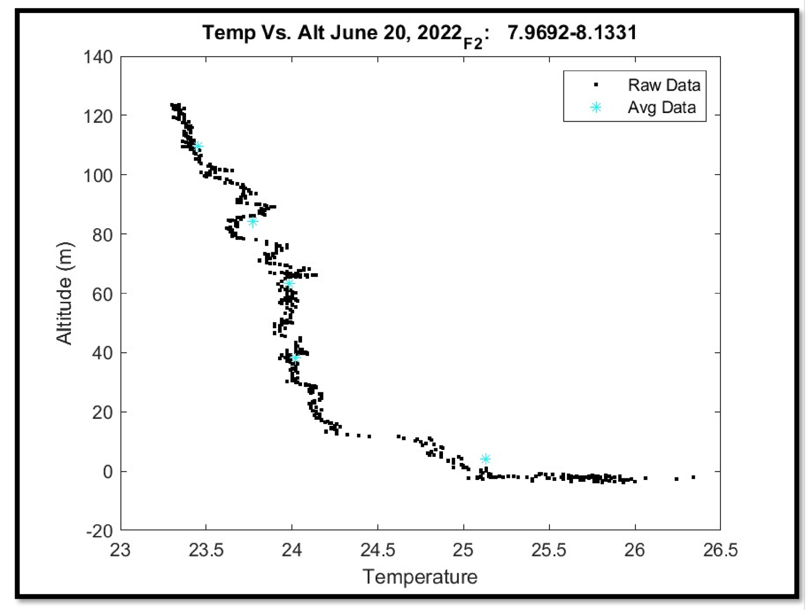


Figure 1: All WiscoDISCO-22 associated measurements used In data interpretation and analysis were recorded over Chiwaukee Prairie and just offshore of the nearby shore of Lake Michigan.

Figure 2: Over summer graphical analysis of the drone flights showed that there was consistent skewing of data near ground level. This was determined to be caused by prolonged hovering before time of official ascent **(Temp vs Altitude data from Flight 2 overland, June 20th, 2022)**



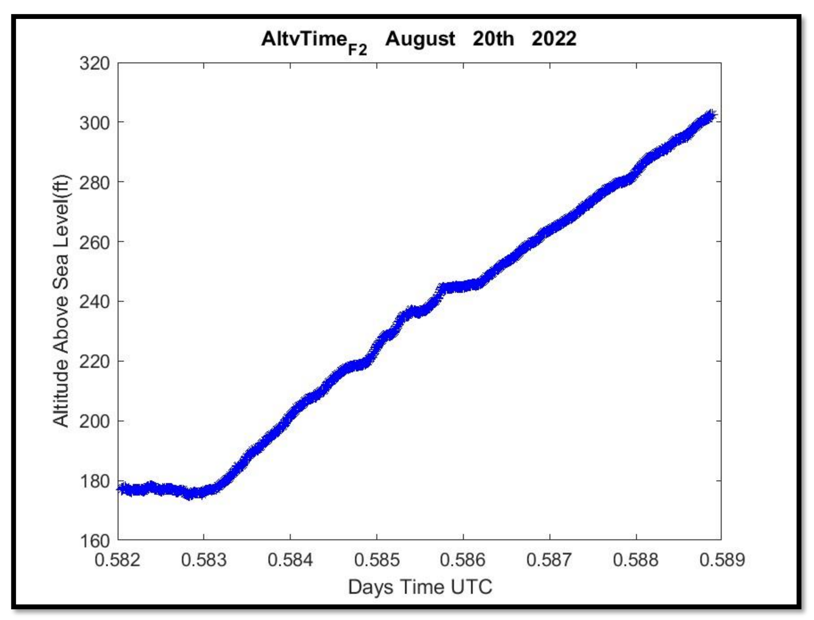


Figure 3: Altitude vs. Time data from Flight 2 overland, August 6th, 2022 (Uncropped).

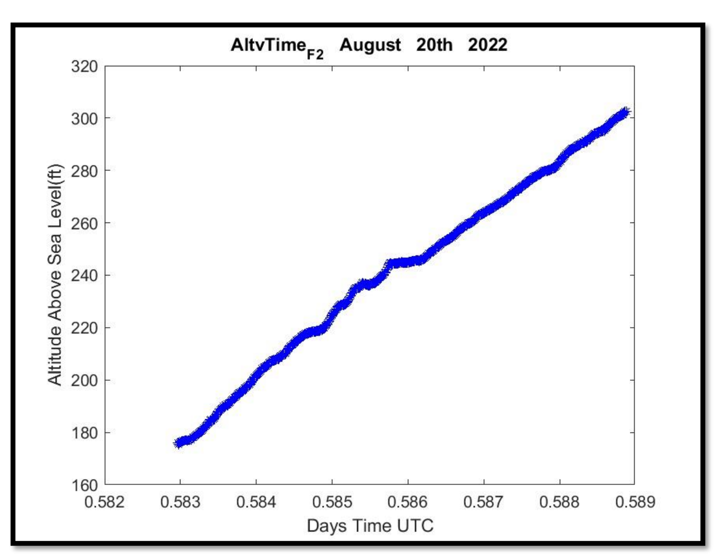


Figure 4: Using ascent times recorded in field notebooks the flight data was cropped to give a better indication of events occurring during the flight. **(Altitude vs. Time data from Flight 2 overland, August 6th, 2022 (Cropped))**

During the summer of 2023 work was done on the graphical comparisons between flight sets of the 2022 data gathered at Chiwaukee Prairie. Through this analysis it was found that surface effects altered the data point placements for averaging data before analysis (Figure 2). When the data sets for Ozone concentration and temperature are compared to the altitude vs time data (Figure 3) the cause of the skew in averaging points is evident. This semester's work has been primarily focused on developing an accurate method in cleaning up the low altitude noise.

Conclusions

From graphical analysis over the summer of 2023, it can be concluded that the previously developed method for binning standard points for accuracy, reduction in data noise and use in comparison is valid and effective (Figure 7). This is true with the exception of data sets that include long term hovering (>10m). In which case the average points become skewed and less effectively show the actual atmospheric events occurring during the flights.

Utilizing the times of ascent recorded in the field notebook has so far been semi-effective where-in some ascents, the recorded time aligns directly with the transition from low ground hovering, directly to vertical ascent. While in other flights there is still a window between hovering duration, and vertical climb where the gathered data is still influenced by low level hovering. Combining the use of recorded time stamps in conjunction with using GPS measurements, and altitude data seems to be the best approach to optimize each data set and remove inconsistencies.

Further Work

To further develop the methods of analysis for data set optimization and organization more comparisons will have to be done. That is, in order to isolate a consistent flight pattern recognition that can be applied to the start of ascents. If it is possible, from what graphs are currently made the point of low altitude hovering is difficult to distinguish numerically Some possible solutions that could be explored include:

-Utilizing the already made method for determining change in velocity over a given interval to measure 3-point (rapid changes in velocity)
-Using an averaging system on the velocity, where noise could be excluded while any drastic changes, such as hovering to ascending would be more prominent.
-Setting a rough time limit for the program to search up to, so only matching values found in the lower half of the ascent are picked out.

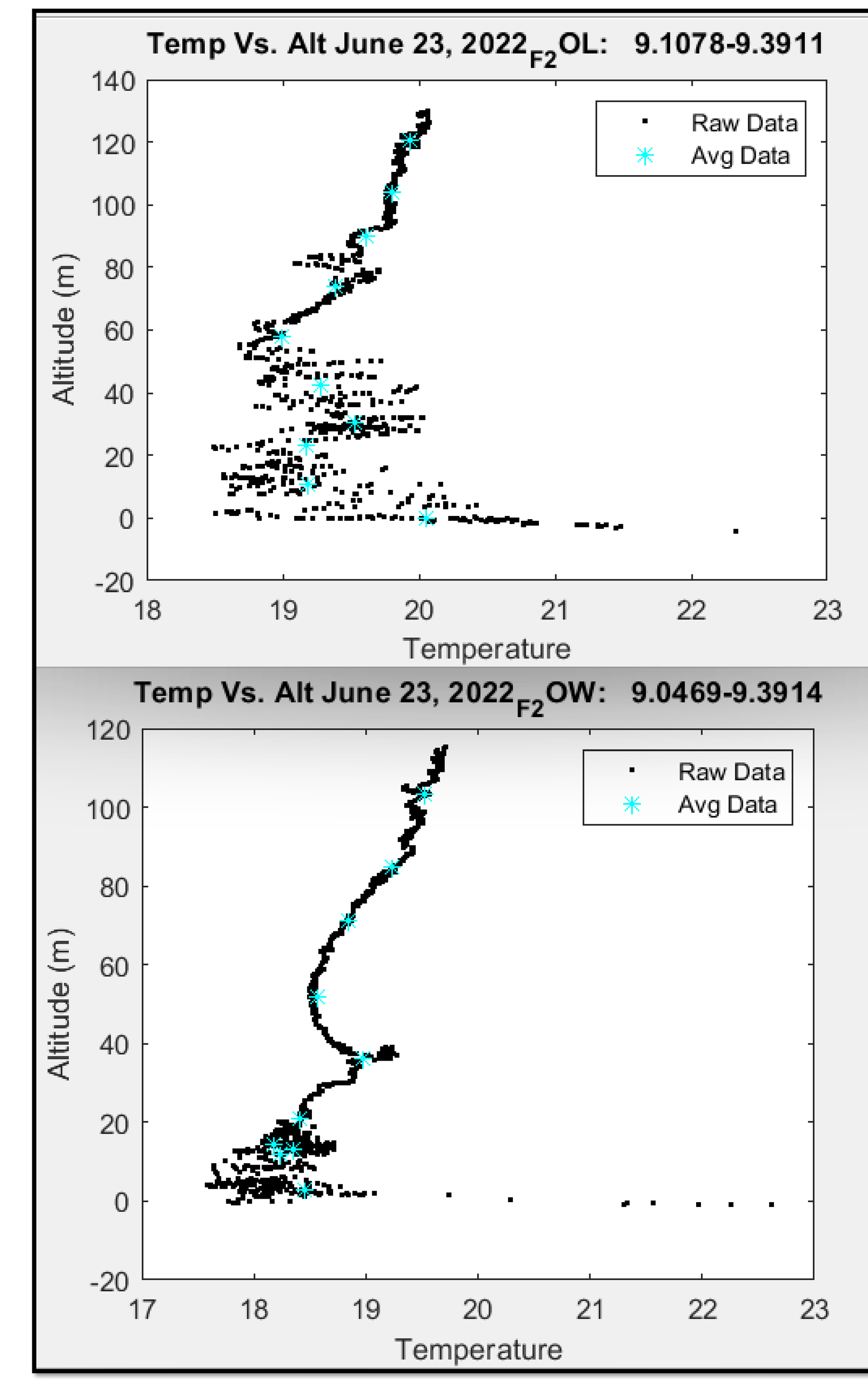


Figure 7: Graphical comparison shows that both instances of flight 2 contain scattered data below 10 meters that cause a deviation in the expected averaged values (Cyan Asterisks). Top: overland, Bottom: overwater. **Simultaneous flights OL and OW respectively, June 23rd, 2022.**

Methods

Figure 5: DJI M300 Drone equipped with a 3-d printed holder for attachment of POM device (Gray box, pictured with Blue/White filter inlet attached)

Field data was collected over the duration of the WiscoDISCO-22 field campaign from June 20th, 2022 to June 24th , 2022. To develop a full picture of the atmospheric events occurring near the shoreline of Lake Michigan; devices such as the POM (Personal Ozone Measurement devices) were used to read ozone concentrations (PPM) over each ascent, while iMet-XQ2 monitored the surrounding air temperature (⁰C), pressure (hPa), percent relative humidity, gps coordinates, and altitude (m AGL). All listed instruments were attached via mounts or Velcro connections to a DJI M300 drone (Figure 5).

To interpret the gathered data a series of processes including cropping, averaging and standardizing of data sets was done in order to minimize noise, instrument malfunctions and other instrument related inconsistencies. Using both the raw data files, and averaged data tables. Created by averaging and standardizing the collected data set to a consistent time scale. This process called binning, allows us to reduce noise in our measurements, as minor sporadic fluctuations in measurements lower the accuracy in which correct analysis of atmospheric trends can be drawn.

Graphically comparing the averaged data sets in instances such as temperature vs altitude (figure 6), showed that the effects of near ground hovering (>10m) skewed both averaged points, and attempts to determine confidence intervals in shown values.

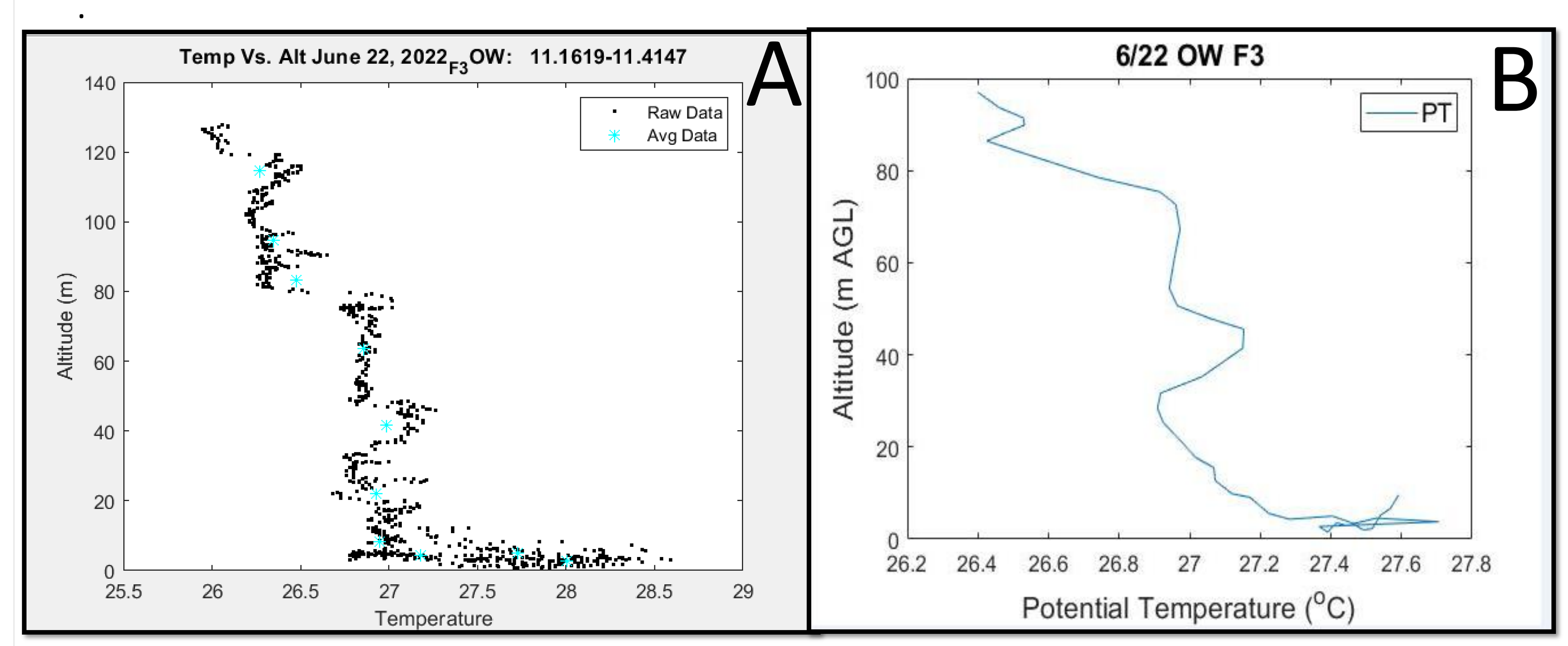


Figure 6: **(a)** shows the air temperature (⁰C) vs altitude during the 3rd OW ascent on June 22nd, 2022.
(b) shows the calculated Potential Temp. (⁰C) vs. Altitude for the same flight data. (*Potential Temp. is an important metric for determining inversion points in the atmosphere.)*

Acknowledgements

We would like to thank UWEC Office of Research, Sponsored Programs Facility/Student Research Collaboration Grants, and the National Science Foundation (#1918893) for funding this project.

We thank the Office of Research and Sponsored Programs for supporting this research, and Learning & Technology Services for printing this poster.