Psychrometric Analysis for New NuMI Evaporator Weather Station

FERMILAB-POSTER-23-157-STUDENT

Chase Alvarado-Anderson[1] I Stanford University; 2023 GEM Fellow
Chris Greer[2] I Fermi National Accelerator Laboratory

Introduction

Tritium (H-3) is a weakly radioactive isotope of hydrogen and is a byproduct of accelerator operations at Fermi National Accelerator Laboratory (Fermilab). The Neutrinos at the Main Injector (NuMI) target produced tritiated condensate exhausted via the MI-65 building evaporators. Re-condensation of tritium evaporate was observed on the MI-65 rooftop, on nearby buildings, and on the surrounding grounds due to inefficiency of the existing evaporator system. A new evaporator system is being designed to eliminate re-condensation, and psychrometric data (temperature, humidity and dew point) plays a vital role in determining the location of a weather station to control the new evaporator system.

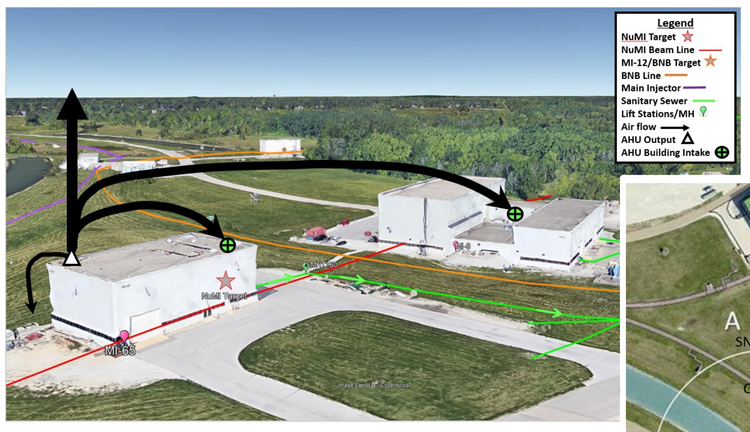

Figure 1(L): Google Earth graphic illustrating evaporate discharge pathways from the MI-65 stacks.

Figure 2 (R): Overhead graphic with alphabetically labeled potential placements for the evaporator weather station control and deployed temperature/humidity loggers relative to the MI Pond H sprayer.

Methods

Psychrometric data was collected from four data loggers placed in the MI-65 complex area during 2022. Python scripts were developed to analyze the available weather parameters over time provided by the data loggers. We then take this data and contrast it with the general meteorological data obtained from the Fermilab meteorologic station. Wind direction was added as an analysis parameter to determine which timeframes show when the MI Pond H sprayer can potentially impact the dew point readings and to what extent the weather station controlling the MI-65 evaporator may be susceptible to sprayer conditions.

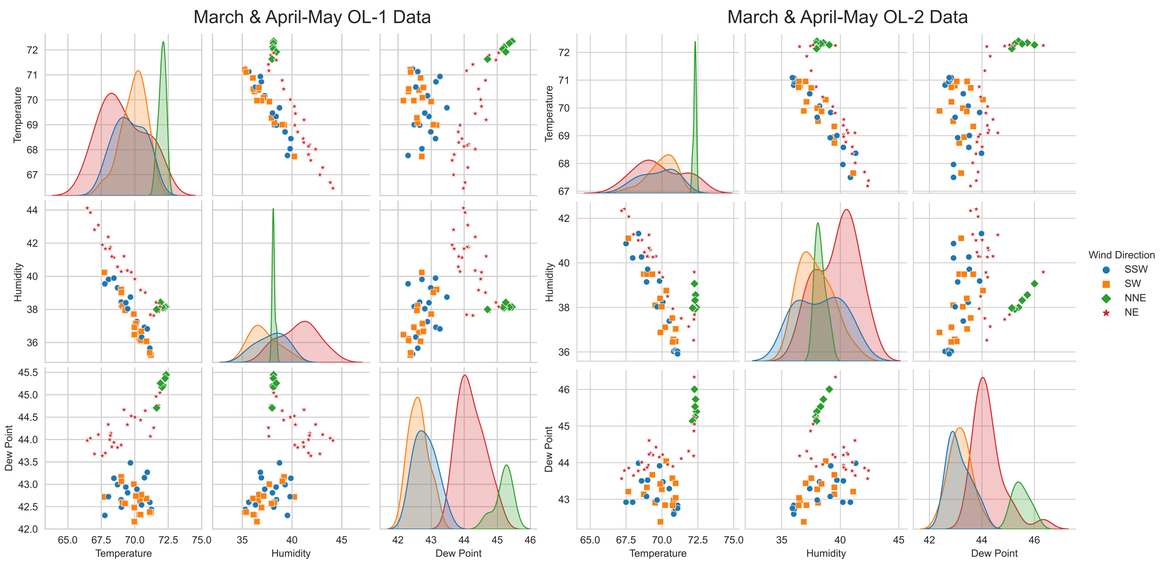

Figure 3: Temperature, humidity and dew point variable pair plots for OL-1 and OL-2 logger data for the March 16-18 and April 20-May 4, 2022 deployments. Data are limited to aligned wind directions (SSW and SW) from the sprayer to the logger and to non-aligned wind directions (NNE and NE) from the logger to the sprayer.

Results

The establishment of wind direction as a variable in the psychometric analyses allowed us to examine conditions when the sprayer release was directed by the wind toward or away from our data loggers. As shown by Figure 3, we observe a bivariate spread in dew point readings between the aligned and non-aligned wind direction points at farther distances (OL-1), while wind direction appears less significant, but non-negligible, at closer proximities to the sprayer (OL-2). We also observed that the data loggers closest (OL-2) and farthest (OL-1) had fewer differences than expected in their respective average dew point distribution over the experimental period. The similar distribution of dew points over a similar temperature range indicates that there would not be a significant impact to evaporator system control by a weather station located no closer to the sprayer than the OL-2 logger location (Figure 4).

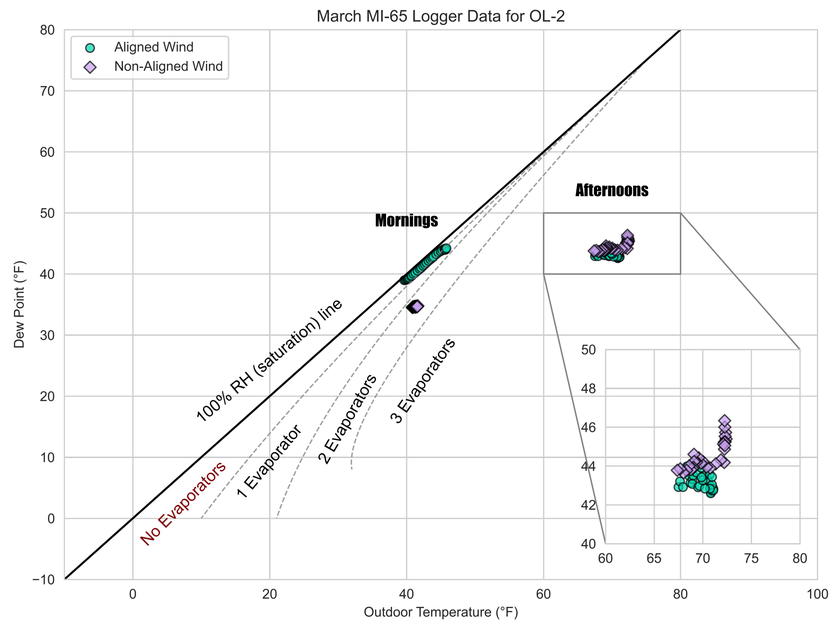

Figure 4 (R): Temperature vs. dew point data from the OL-2 logger for two 30-minute periods on successive days over a similar temperature range but with opposing aligned (S-SW) and non-aligned (N-NE) wind directions. The 100% RH Saturation line and approximate proposed evaporator system control boundaries (Jacobs, 2022) are included for reference.

Conclusion & Discussion

This work, along with similar psychrometric studies, will greatly aid in determining the proper location to install a weather station that can efficiently control the MI-65 evaporator system. The distribution of data during NE wind (non-aligned) resembles the aligned (SSW and SW) wind data for the logger closest to the sprayer (OL-2). This could be an indication that the logger was slightly impacted by the sprayer even during non-aligned winds. Since the wind speed is not considered as a variable in our modeling, calmer variable winds could allow an impact near the sprayer even with non-aligned wind directions. This indication of a slight possible impact would make the proposed A location for the weather station preferable to one closer to the sprayer. However, the results reinforce the conclusion that the newly proposed installation locations all satisfy the distance component required to effectively control the evaporator system.

Future Work

More accurate data on the exhaust system and an increase in the quantity of data loggers that record ambient weather conditions will inevitably help in quantifying annualized system capacity and highlight the dependency on operational constraints.

This manuscript has been authored by Fermi Research Alliance, LLC under Contract No. DE-AC02-07CH11359 with the U.S. Department of Energy, Office of Science, Office of High Energy Physics.