Correlation Between Air and Surface Temperature and Wind Speed

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Abstract

In order to improve meteorological understanding, the relationship between air temperature, surface temperature, and wind speed. These results would have varied applications, including agriculture, meteorology, environmental science, and agriculture. Increased wind speeds decrease air and surface temperature in an inverse relationship. The surface temperature is determined with an infrared handheld thermometer in different but very near locations. The air temperature is determined with a weather station that records current air temperature. The wind speed is determined with a weather station that records wind speed and direction. All data sets are collected on non-equally spaced data collection days; one set of data points is collected per day. Our results disprove our original supposition, as all variables had a direct relationship, rising and falling in sync, unlike the expected inverse relationship. Thus, higher wind speeds may herald warmer temperatures, especially in winter months. All three variables were shown to be a cause of changes in the others, indicating not only a correlation, but also a causation.

Introduction

The temperature plays a crucial role in life on this earth. As it goes up, the plants thrive (till they reach a limit), the air is humid, and the sun shines. As the temperature declines, plants crumble, the skies are grey, and the air is bitter and dry. What brings about these changes on the planet? The amount of sunlight is vital, yet the sun can shine one day and the temperature is -25ºC, and the next the sky is blanketed in clouds and the temperature is 20º degrees warmer. The answer to this can assist in predicting future temperatures and wind speeds and determining optimal locations for events, structures, etc. As the sun warms the atmosphere, electrons are excited, and the hotter air rises, as it is less dense. The denser, cooler air sinks to the ground. Due to obstructions such as clouds, mountains, etc., the heating of the earth is uneven, leading to the formation of hot and cold pockets of air. Intuitively, it would be assumed that a higher temperature of the air molecules would lead to a higher pressure, but as less dense hot air rises, it leaves a lower pressure area. This is where concentration gradients become important. The higher-pressure air diffuses into the regions of lower temperature; through convection heat transfer, hotter air warms colder air. This transfer of heat and pressure gradient causes the air to move. The greater the temperature or pressure difference, the faster the air moves. Wind. This moving air can come from areas of high or low temperatures, meaning it can warm the air on its path or cool it, depending on where the wind comes from(SciJinks.gov (Anonymous, y)). The info collected by Utah State indicated that air temp is higher than surface temp, though the disparity lessens during daylight hours (Utah State University (Anonymous, y)). However, according to Koenigsberger, this is the case only in winter, and reverses during the summer, as the ground absorbs more solar radiation.   To determine the quantitative effect of wind speed on air and surface temp, one must have sufficient data. According to Weather Underground data from January 2025, the wind speed seemed to warm the air, increasing temperature(Weather Underground(Anonymous, n.d.).

Wind Chill Chart

Wind (mph) \ Temperature (°F)	40	35	30	25	20	15	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45
5	36	31	25	19	13	7	1	-5	-11	-16	-22	-28	-34	-40	-46	-52	-57	-63
10	34	27	21	15	9	3	-4	-10	-16	-22	-28	-35	-41	-47	-53	-59	-66	-72
15	32	25	19	13	6	0	-7	-13	-19	-26	-32	-39	-45	-51	-58	-64	-71	-77
20	30	24	17	11	4	-2	-9	-15	-22	-29	-35	-42	-48	-55	-61	-68	-74	-81
25	29	23	16	9	3	-4	-11	-17	-24	-31	-37	-44	-51	-58	-64	-71	-78	-84
30	28	22	15	8	1	-5	-12	-19	-26	-33	-39	-46	-53	-60	-67	-73	-80	-87
35	28	21	14	7	0	-7	-14	-21	-27	-34	-41	-48	-55	-62	-69	-76	-82	-89
40	27	20	13	6	-1	-8	-15	-22	-29	-36	-43	-50	-57	-64	-71	-78	-84	-91
45	26	29	12	5	-2	-9	-16	-23	-30	-37	-44	-51	-58	-65	-72	-79	-86	-93
50	26	19	12	4	-3	-10	-17	-24	-31	-38	-45	-52	-60	-67	-74	-81	-88	-95
55	25	18	11	4	-3	-11	-18	-25	-32	-39	-46	-54	-61	-68	-75	-82	-89	-97
60	25	17	10	3	-4	-11	-19	-26	-33	-40	-48	-55	-62	-69	-76	-84	-91	-98

Frostbite Times: 30 minutes, 10 minutes, 5 minutes

$$\text{Wind Chill (°F)} = 35.74 + 0.6215T - 35.75(V^{0.16}) + 0.4275T(V^{0.16})$$

Where, T= Air Temperature (°F) V= Wind Speed (mph)

Effective 11/01/01

Figure 1

However, according to the National Weather Service, increased wind speed(at least at temperatures(< 36)) directly decreased the temperature(National Weather Service (Anonymous, y)). This is because wind moving quickly captures heat and distributes it, lowering the air temperature. and consequently the surface temperature. Due to the effects of wind in distributing heat, a higher wind speed will result in a lower surface and air temperature, especially in the winter months. This in turn will increase temperature shifts that create wind.

Methods and Materials

To begin wind speed collection, a weather station was used to collect the average wind speed, actual wind speed, gust speed, and direction in MPH. 4 data points. The weather station was again used to gather the current air temperature(in ºC); eight data points were collected. To collect ground temp, an infrared thermometer was used to collect temp (in ºC). The thermometer was held away from the body and pointed downward to ensure maximum accuracy with minimum interference, collecting 8 data points in different locations on 4 separate occasions. The information has been collected in a spreadsheet and will be graphed on a line graph, highlighting correlations and potential causations. The time and date in UTC were collected from every data point. The information was collected in the parking lot and courtyard near the Ottawa Hills High School field. No immediate health or safety concerns, bar exposure to cold air and high winds, but this was minimal and not a concern.

Presentation of Data and Results

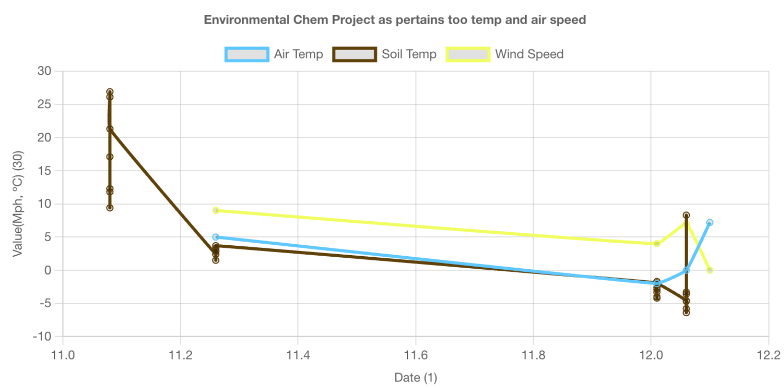

Figure 2

A combined graph of the values of wind speed, air temp, and soil temp yield an unexpected result. For all three variables, the general shape is a downward trend resulting in a sharp spike at the end of collection. This indicates at least heavy correlation, if not causation between the variables. Note the soil temperature varies more than the others at a single line on the y axis, as soil temp varies based on the location of the reading, while the others are fairly stable in short distances.

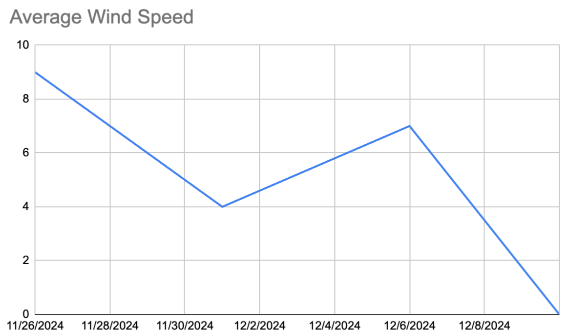

Figure 3

A graph of the wind speeds shows a downward trend interrupted by a spike in the middle that falls quickly.This demonstrates the wind at its highest point at the first datapoint collected, falling as temp falls, and rising again almost to the beginning point.

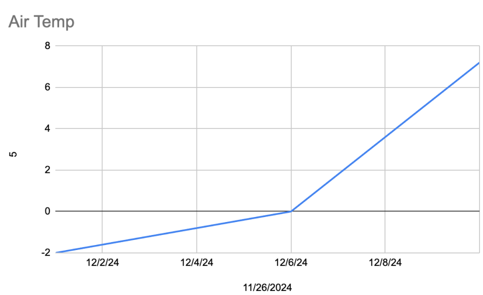

Figure 4

Unlike the others, air temperature strictly grew as the seasons change and the temperature steadily increases. Had the sample range been longer, many dips and spikes would have been recorded due to the unpredictable nature of the weather.

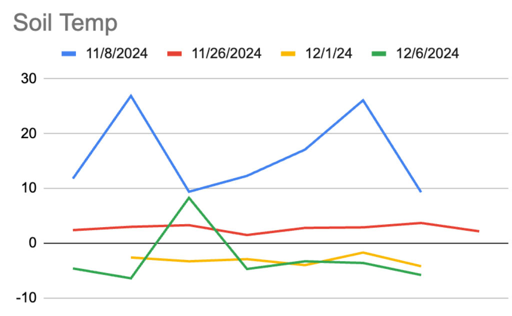

Figure 5

This graph of soil temp shows that on any given day, the temperature of the soil varied depending on snow cover, light, shade, dirt, rocks, plants, etc. However, the general trend shows a decrease in soil temperature, which is interesting as the air temperature increases.

Analysis and Results

Our findings indicate that the steady decline in wind speed did in fact affect the air and surface temperature and air temperature. The air temperature, surface temperature, and wind speed all followed a similar trend, peaking together and falling together. All variables trended downwards as the months shifted from November to December, until an increase was marked in the last collected data point. Though a correlation was apparent, a causation is a different matter. The temperature is caused by the sun's uneven heating of earth causing cold and warm temperature pockets, while wind is caused by sun's uneven heating of earth causing cold and warm temperature pockets which by the temperature gradient, diffuses to even out temperatures, moving air and therefore creating wind varying in speed by the temperature difference. The causation of higher and lower temperatures and higher and lower wind speeds are the same, making it necessary for them to reflect each other. In this way, they both are a causation of the other. Higher temperature difference, higher winds. But also, the greater the wind speed, the greater the distribution of heat, which can increase or decrease the temperature significantly. For example, In Antarctica, on July 13, 2024, the temperature was -94º F, but with wind speeds of 8.7 mph, the temperature felt to a human body like -130ºF(timeanddate (Anonymous, 2024)). However, it is important to note that the objective temperature, like the reading on a thermometer, was still -94, but due to wind speeds taking heat from the body, it would have felt like -130. This is calculated by the equation: Wind chill(ºF) = $35.74 + 0.6215T - 35.75(V^{0.16}) + 0.4275T(V^{0.16})$, where T = Air Temp(ºF) and V = Wind Speed(mph)(National Weather Service (Anonymous, y)). To perform an example, a reasonable temperature of 50º and wind speed of 5 mph will be used. After variables are plugged in: Wind chill(ºF) = $35.74 + 0.6215(50) - 35.75(5^{0.16}) + 0.4275(70)(5^{0.16})$. Together, this would equal 48º, a wind chill dropping by two degrees. The wind speed and temperature could not be perfectly gauged, and the infrequent and irregular data points cloud the result slightly. Our original belief was confirmed to the extent that a limited experiment can, wind speed can correlate to air and surface temperature, and can causate through an interesting cycle. However, unlike our supposition, the wind can have a heating effect in warmer temperatures, however this was not observed in the fall/winter months in which testing occurred. Also, we originally supposed that the stronger wind in the winter would always correlate to lower temperatures, but this was not true in our data. For the majority of the data points collected, as wind decreased in speed, the temperature decreased. Of course, wind distributes heat, moving around cold or warm air. Although this was known, the expectation was for wind to bring colder air, lowering the temperature.

Conclusion

The question of temperature and wind, seemingly trivial and plain, can be explored at a much deeper level, as all sciences can. Data was gathered through in-the-field testing of temperature and wind speed, recorded on a data table, and graphed on a line graph to show correlations between temperature and wind speed peaks and troughs. The results were contrary to our original belief that wind speed lowered the air and surface temperature. The results showed a trend in which the data points of all 3 variables nearly perfectly correlated. However, the collection of the data points was done solely in cold, windy months, skewing the results. Theoretically, there might have been a similar correlation in the summer, where wind pulls warm air into a colder area. More probably, the result would be the opposite in the summer, with wind bringing colder air to warmer areas. The results, showing the lower the wind speed, the lower the temperature, were unexpected. Especially in cold, dry, wintry months, wind was expected to move cold air quickly, decreasing the temperature. Winter Underground records show that often, temperature decreases as wind increases in the summer months, but in the winter months, temperature decreases as wind decreases. Therefore, our expectations were disproven. Data was gathered in a semi-enclosed area with little sun and significant quantities of stone/brick/cement present, which retained cold temperatures and commonly held temperatures of -10º to -20º C. Thus, the wind was unlikely to carry colder air, as the are released heat and retained cold very easily. Wind was likely to bring warmer air, from places that receive more sun or retain more heat, such as the wooded area or the large field nearby. The fact that the last data point recorded an increase in wind speed and soil temp but a decrease in air temperature could be put down to uneven heating of the earth creating a nearby pocket of cold air, which was blown into the area, lowering air temp, but as more sun appeared, the soil temp increased. Another factor to take into consideration is the wind direction. The wind can only enter the sample area from one direction, around 150º SE. This wind speed and direction was only partially present on two data collection days, and these days showed a sudden spike in wind speed and temperature, indicating a warmer wind than the standing air. Discussion

Discussion

The project was executed in an imperfect manner. Many improvements could be made. If more data samples were recorded at more regular intervals, in a variety of locations, for the duration of a year, much more accurate results could have been obtained. However, Weather Underground keeps records of air temperatures and wind speeds going back decades, and records seem to align with the results of our experiment. The ascertained information has many unexpected real-world effects. For example, the data can be used to predict future weather patterns based on nearby meteorological conditions. Also, the data could be used in agriculture to prevent crop frost by using high power wind machines to move the right amount of war or cold air necessary to protect crops. The information could be used to place renewable energy sources such as wind turbines and solar panels in ideal conditions. Photovoltaic cells degrade over time, reducing output and efficiency, a process expedited by high temperatures. Knowing how wind blows in a certain region can aid in keeping solar cells functional for as long as possible. However, wind should be moderated, as too much exposure to oxygen or water the wind may bring will also accelerate degradation.

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