A Climatology of Lake Breezes at O'Hare International Airport

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Abstract

Lake breezes pose a significant challenge to forecasters and can have widespread effects on airports such as Chicago O'Hare International (ORD) and Chicago Midway International Airport (MDW). Since airplane pilots prefer to land and take off into the wind, the sudden change in wind direction that lake breezes induce can pose a problem to this process. As a result, lake breezes often cause ORD to shift its operations from west flow to east flow if they reach or surpass a threshold of 10 knots. West flow is preferred and refers to the arrival/departure configuration. Under west flow, airplanes land from the east and take off to the west. If the lake breeze is well forecasted, this shift can be made during an off-peak time, allowing for minimal delays. To aide in the forecasting of these events and their impacts to the airports, a climatology of lake breezes was constructed for ORD and MDW over 20 years from 1996-2016 during the months of April-October. To identify a lake breeze, a wind shift from offshore to onshore had to occur during the daylight hours. To distinguish a synoptic event from a true lake breeze event, days exhibiting this shift were compared to Rockford International Airport (RFD), located 105km inland. This yielded 791 and 716 lake breeze events at MDW and ORD, respectively. On average, the lake breeze arrived at MDW an hour before ORD with the greatest frequency of arrival time between 18 and 20Z.

Objectives

Forecasting lake breezes is a challenging task, and this task is only more difficult when forecasting for ORD. An accurate forecast for the lake breeze can be the difference between minor delays and widespread delays. By developing a climatology for the airport, we're hoping to confirm the rules of thumb used by the forecasters at the National Weather Service (NWS) Chicago and improve lake breeze forecasts for the airport.

Background

To start building the climatology, three key assumptions had to be made. The first is that a lake breeze is classified as an easterly wind between 10° and 160°. The second assumption that was made is that a three-hour wind average is representative of the morning and afternoon conditions. The final assumption is that the lake breeze would not be able to reach Rockford International Airport at 105km from the lakeshore. Another important aspect to understand before building the

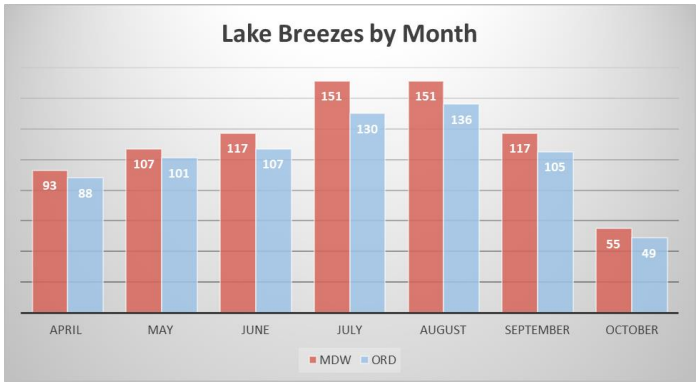
climatology is the configuration of ORD. The configuration that the airport chooses is dependent on both the speed and the direction of the wind. ORD is primarily an east-west airport as most of its runways are in these directions. Therefore, the airport will either be running west flow, normal operations, or switch to east flow. Under west flow, airplanes land from the east and takeoff to the west. East flow is the opposite of this. Although both configurations can land 114 planes per hour, switching to east flow requires another air traffic control tower to be staffed and also takes time. If a lake breeze is not well forecasted, this shift could take an hour or more. During this time, a ground stop is in effect while the airport flips. With the airport landing, on average, 90 planes per hour, this shift could be catastrophic if occurring during one of their busy hours when they are pushing the 114 capacity. The speed of the lake breeze is also crucial. If the lake breeze is forecasted to be over 10 knots, the airport has to switch to east flow as many pilots will refuse to land with a tailwind 10 knots or greater. As a result, the speed of the lake breeze and the time of arrival at the airport are the most important factors to the airport.

Methods

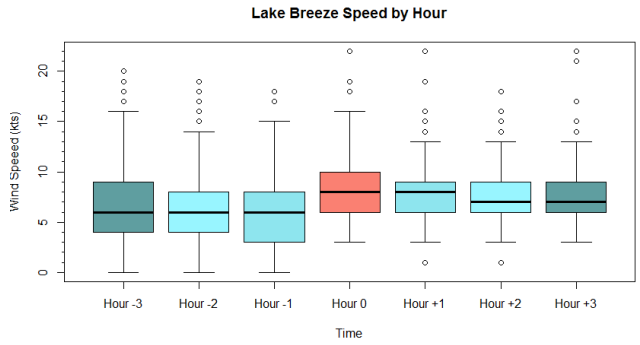
Using ASOS data from ORD, MDW, and RFD, a 20-year climatology was built from 1996-2016. I chose to begin in 1996 as this is where the previous study had ended. To determine a lake breeze, a wind shift from offshore/parallel to onshore (10°-160°) between the morning and afternoon was looked for. Days that showed this shift were compared to RFD to see if the shift was synoptic or a true lake breeze. Once a lake breeze was identified, 8 parameters were recorded: Onset Time, Wind Direction, Wind Speed, Maximum Temperature, Morning Cloud Cover, Afternoon Cloud Cover, and Afternoon Cloud Height. This yielded 791 lake breezes for MDW and 716 for ORD.

Results

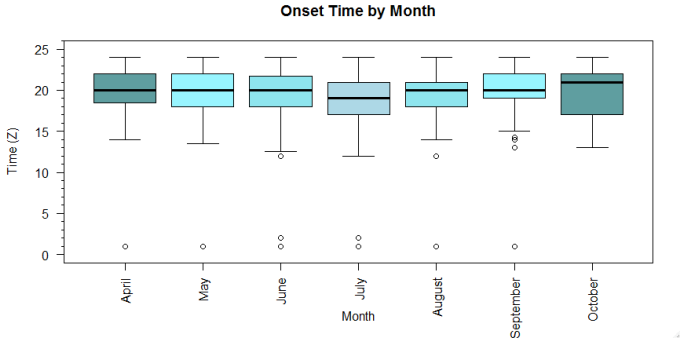
As expected, the greatest frequency of lake breezes is during the summer months and the lowest frequency is during the fall. We see an increasing number of lake breezes until August and then a decrease into the fall. Looking that the number of lake breezes per year, we see that the median value for MDW is higher than ORD at 39 and 35 respectively. Although there are some anomalous years, 2001 and 2005, the lake breeze is rather reliable with a small amount of variability from year to year.



Switching to the speed, we see that the median of the average speed of lake breezes is 8 knots. We can also see a decreasing trend from spring to fall with the median average lake breeze at 9 knots in April and 7 knots in October. The next step is to look at the speed by hour. To do this, the speed three hours before, at onset time, and 3 hours after the onset time was plotted using boxplots. Here, we see that the speed decreases until it suddenly jumps up at the time of onset. It then begins to taper off slowly.



The next important factor for the airport is the onset time of the lake breeze. Generally, lake breezes arrive at MDW and hour before they reach ORD with the median onset time being 19Z and 20Z, respectively. Looking just at ORD, we see that the greatest frequency for onset time is between 19 and 21Z. The next step is to look at the onset time by month, and unlike for speed, we do not see a statistically significant seasonality. Instead, we see that the onset time is roughly constant throughout the year with the median value at 20Z. Although not statistically significant, there is evidence that the onset time during the summer months is slightly earlier as the median for July and August is at 19Z.



Summary

As expected, lake breezes are most common during July and August and least common during October. They are also more common at midway with a median value of 39 a year as opposed to ORD's 35. In addition, the lake breeze arrives at MDW and hour before ORD. For both airports, the greatest frequency of onset times are between 18 and 20Z. Unlike frequency, the onset time of the lake breeze does not exhibit seasonality. On the other hand, the speed of the lake breeze also exhibits seasonality it decreases in speed from spring to fall with the median speed of all lake breezes at 8 knots and 48% of them reaching 10 knots during their duration.

Future Research

I plan to continue this research as my senior capstone project this upcoming semester. I would like to collect data from the Center Lake Buoy 45007 looking at the sea level pressure, air temperature, and water temperature. The next step would be to build a regression model to aide in the prediction of the speed of the lake breeze and the time of arrival of the lake breeze at O'Hare International.

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