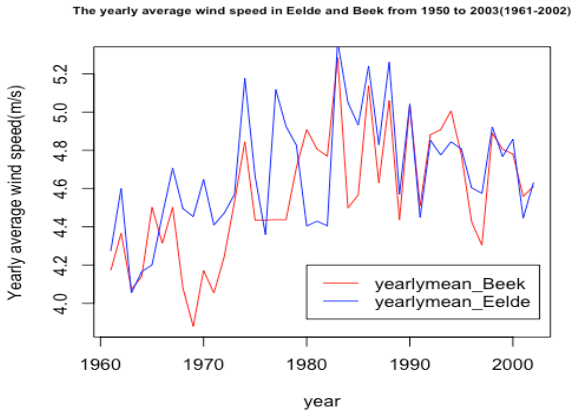
STAT1006, 2018: report on Dutch wind

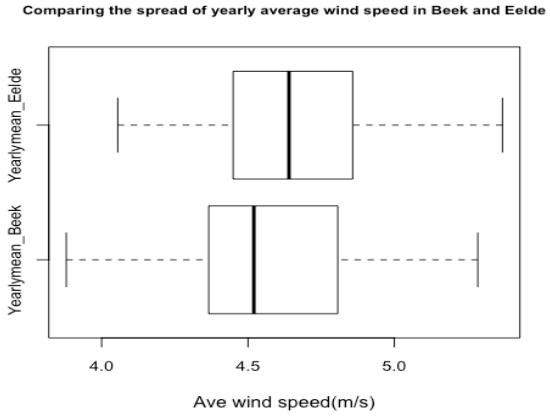
1. Description of data

The dataset records the monthly wind speed readings from two weather stations, Beek and Eelde, for the period 1950-2003. Yearly average wind speeds are recorded by calculating the average of monthly wind speeds, unrepresentative values with less than 3 monthly wind speed observations were removed. 2 data sets were created for each location, Beek and Eelde. 3 key observations from this data is described as follows:

Firstly, the yearly average wind speed during earlier years is less than that in later years. Figure 2 shows an upward trend in the yearly average wind speed in both stations over the entire period. Between 1959-1976 the yearly average wind speed fluctuated between 3.92 m/s to 5.20 m/s for both locations. However, between 1977-2003 the yearly average wind speed fluctuated between 4.32 m/s to 5.40 m/s, an upward shift between periods.

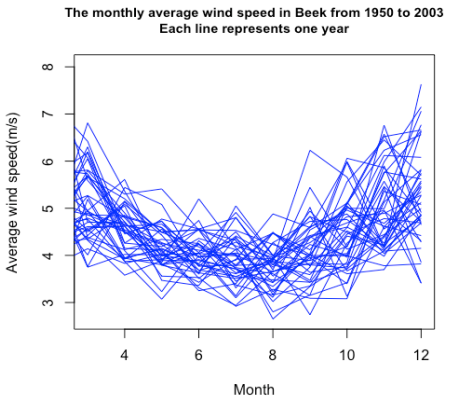


(figure1)

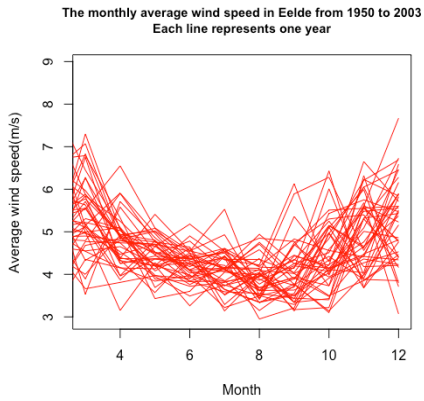


(figure2)

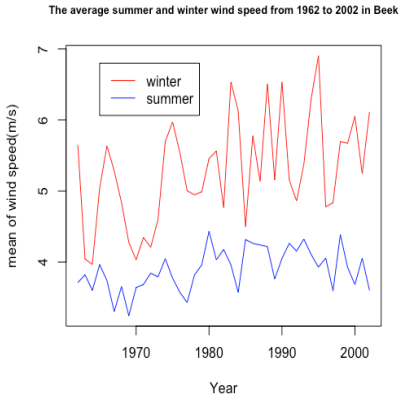
Secondly, the yearly average wind speed in Eelde is slightly higher than that in Beek. According to Figure 1, the median of yearly average wind speeds at Eelde is 4.64 m/s, while the median average wind speed is 4.52 m/s at Beek. The spread of data between Beek and Eelde is similar, evidenced by the interquartile range of 0.43 m/s and 0.41 m/s at Beek and Eelde, respectively.



(figure3)



(figure4)



(figure5)

Thirdly, Figures 3 & 4 suggests that the monthly average wind speed for each year follows a U-shaped pattern for both locations: Peak wind-speeds are recorded during winter (December, January and February), gradually declining during the summer period (June, July and August) and rising again as

winter approached. At Eelde, the max wind speed is 8.92 m/s observed in January (Winter, 1983), while the min wind speed is 2.95 m/s observed in August (Summer, 2002). This suggests that the wind speed in winter is higher than that in summer. This result is much more pronounced at Beek as shown in Figure 5, where the average wind speeds in winter are greater than that in summer. To illustrate, the monthly max wind speed is 8.04 m/s in February (Winter, 1990) and the monthly min wind speed is 2.65 m/s in August (Summer, 1977).

2. Tests

A. Is there a significant difference in average wind speed between the periods (1950-1976) and (1977-2003) at Eelde?

Let the mean average wind speed for the 1st period at Eelde be μ_1, and the mean average wind speed for the 2nd period at Eelde be μ_2. Independence between wind speeds is assumed, because wind speeds are measured at different time periods, and are therefore unlikely to be subject to the same weather or climate conditions. To determine if the average wind speeds is significantly different, a 2-tailed hypothesis test is constructed, where H_0 is the null hypothesis and H_1 is the alternative hypothesis. H_0 and H_1 are defined as follows. H_0: there is no difference between the periods 1950-1976 and 1977-2003 in Eelde(μ_1-μ_2=0). H_1: there is a difference between two periods in Eelde (μ_1-μ_2≠0). The 95% confidence interval of [-0.496, -0.150] is obtained from the 2-sample t-test. This means that if repeated samples are taken, there is a 95% probability that it contains the true value of μ_1-μ_2. Since 0 is not in this interval, the null is rejected. Since the confidence interval is negative, this implies that the average wind speed in the 1st period (1950-1976) is estimated to be less than the average wind speed in the 2nd period (1977-2003), at the significance level of 5%.

B. Is there a significant difference in the average wind speed in the winter (Dec, Jan, Feb) and summer Period (Jun, Jul, Aug) at Beek?

Let the mean average wind speed during the summer period be μ_S and the average wind speed during the winter be μ_W. The average wind speed in one season is likely to be dependent of the wind speed in another season in the same year. For example, a high wind speed in one season blows down trees at the location. In the next season, the wind speed would be higher than it would have been had the trees not blown down. Secondly, the wind speed is recorded in the same year, and is therefore likely to be affected by weather conditions existent during the year. Therefore, dependence is assumed. For every winter wind speed there is a corresponding summer wind speed, so data are paired. A 2-tailed, paired hypothesis test is constructed as follows. H_0: μ_S-μ_W=0, H1: μ_S-μ_W≠0. The 95% confidence interval of [-1.63, -1.17] is obtained from the 2-sample t-test. This means that if repeated samples are taken, there is a 95% probability that it contains the true value of μ_S-μ_W. Since 0 is not in the confidence interval, the null hypothesis is rejected. From the confidence interval μ_S-μ_W < 0, therefore the average wind speed in summer is estimated to be less than the average wind speed in winter.

C. Is there a significant difference in the average wind speed at Eelde and Beek?

Let the mean average wind speed at Eelde be μ_E, and the mean average wind speed at Beek be μ_B. Dependence between the average wind speed at Beek and Eelde is assumed, because data is obtained from the same period, meaning for every winter wind speed there is a corresponding summer wind speed. Secondly, Beek and Eelde are approximately 300 km apart, so they are close enough to be influenced by the same regional weather patterns. Thus, the 2-tailed hypothesis test is constructed, H_0: there is no difference in the mean average wind speed (μ_E-μ_B=0) and H1: there is a difference between the mean average wind speeds (μ_E-μ_B≠0). According to the test statistics given by the 2-sample t-test, the confidence interval is [0.0319, 0.193], which means that we are 95% sure that this interval contains the true value of μ_E-μ_B. Thus, the null is rejected, because μ_E-μ_B is estimated to be greater than 0 at the significance level of 5%. This means that the average wind speed at Eelde is estimated to be higher than that in Beek.