Weather Pattern

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Goal

We aim to prove that there is a correlation between MEI index and temperature and a correlation between MEI index and rainfall, if we do so we can say that global weather patterns predictably affect local weather.

Discussion

Summary of our data

We have data from a local weather station (Dinse) that spans from October 2008 to Oct 2012. The data includes the following statistics for each day: High temp, Low temp, Average temp, High humidity, Low humidity, Average humidity, Rainfall, High pressure, Low pressure, and Average pressure.

For this project we are only using the average temperature values per month and the total rainfall per month.

In addition, we found ENSO data going back 60 years here on the NOAA website (Wolter). We are using the normalized values as given.

Definitions

The following terms throughout this report:

ENSO: El Niño/Southern Oscillation - a global weather pattern

MEI: Multivariate ENSO Index (MEI) - a standardized measurement of ENSO.

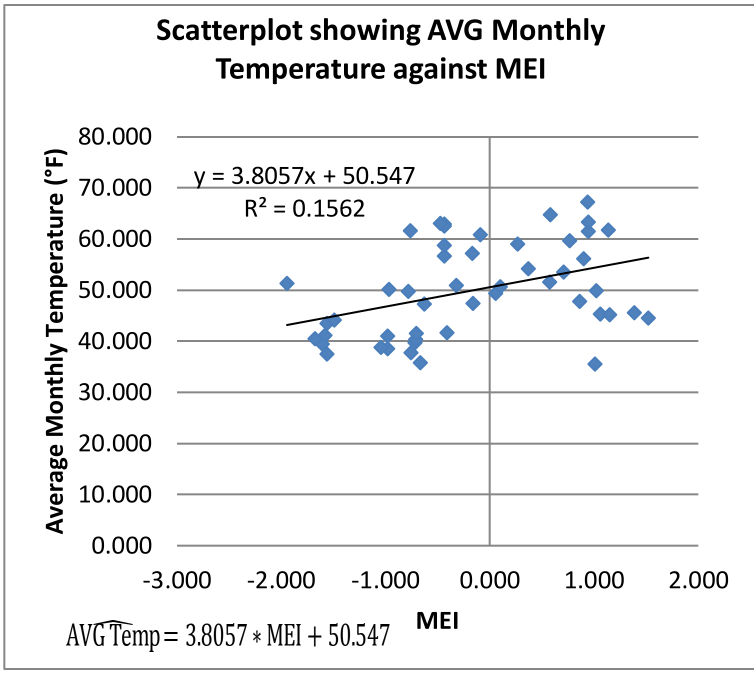
Hypotheses & statistical techniques

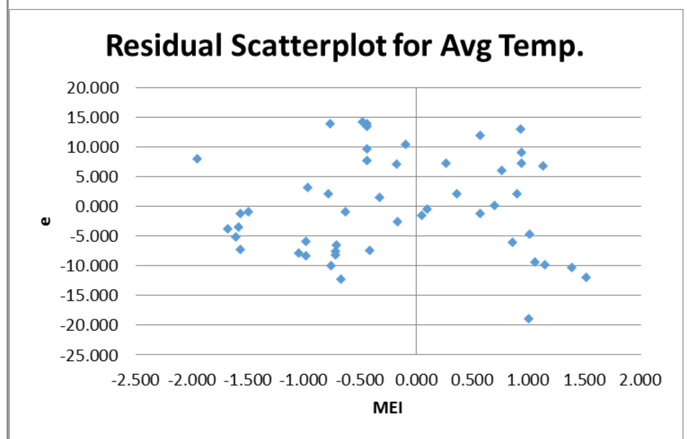
To prove that there is a correlation between MEI index and our observed rain and temperatures, we first hypothesize that there is no correlation, and then we will try to disprove it with 95% confidence.

MEI vs. Avg Temperature

- Assumptions and Conditions:

1. Linearity Assumption: Here is our scatterplot and the residual plot. It is fairly linear with no pattern in the residuals

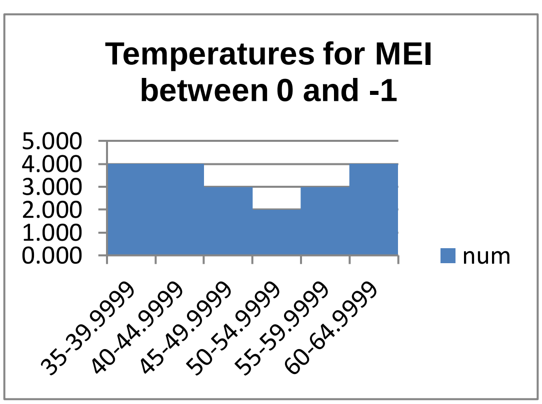


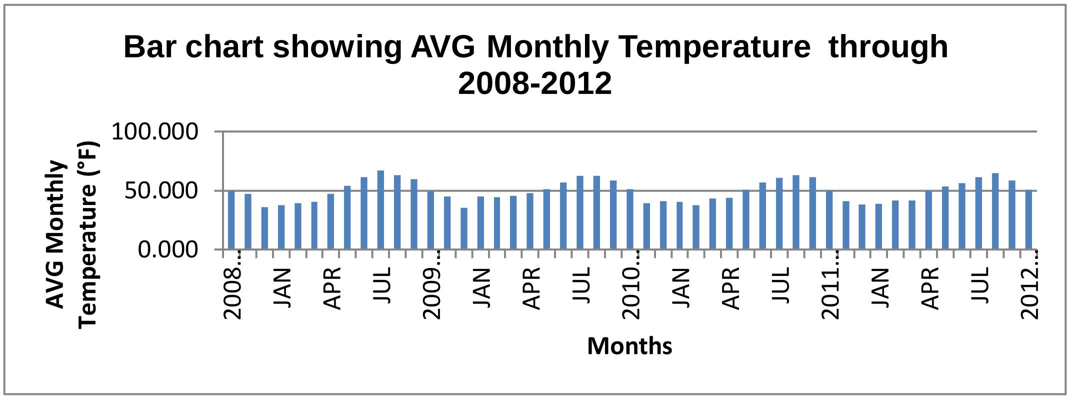


2. Independence Assumption: Weather is random.

3. Equal Variance Assumption: The residual scatterplot for temperatures shows equal variance.

4. Normal Population Assumption: A box plot of temperatures for MEI values between 0 and -1 and did not get a normal plot. However, when weather is looked at over time, it is normal within the cycles. So we are saying it passes the test.





Hypotheses for Temperature

Using standard slope intercept form: μy= β1 x +β0, our null hypothesis is that the slope is 0 (Ho: β1 = 0) and our alternate hypothesis is that the slope is not 0 (Ha: β1 ≠ 0) We are setting our alpha level at 5% (α = 0.05)

Calculation

Since this is a sample, we are using t values, with n = 49, degrees of freedom = 47. The mean slope is b_1 =3.8057, mean intercept is b_0 =50.547, with R^2= 15.6%,

The residual standard error is

$$s_e = \sqrt{\frac{\sum(y-\hat{y})^2}{n-2}} = 8.463$$

and the standard error of the slope is

$$SE(b_1) = \frac{s_e}{\sqrt{n-1}s_x} = 1.29.$$

The t value we get is

$$t = \frac{b_1-\beta_1}{SE(b_1)} = t(47) = 2.949$$

which when put into a t-value calculator gives us P-value = 0.004952 (danielsoper.com), which is much less than 0.05. Which allows us to reject the null hypothesis!

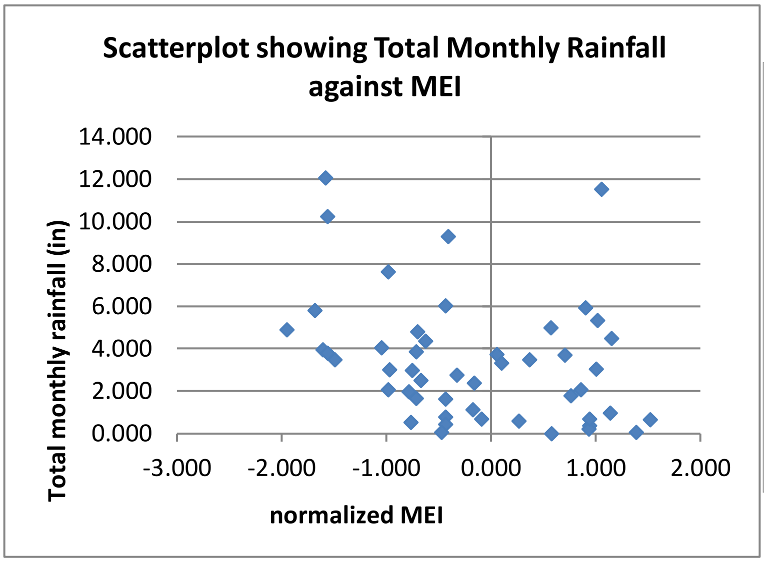
Now we can determine a confidence interval for the slope and intercept. Using Student's t value for 95% confidence and 47 degrees of freedom we get 95% t*(47) = 2.01174 (Soper). With SE(b1)= 1.29, b1= 3.80, t^*_{n-2} =2.01174 we calculate that C.I. of β1 = b1 ± t^*_{n-2} x SE(b1) =

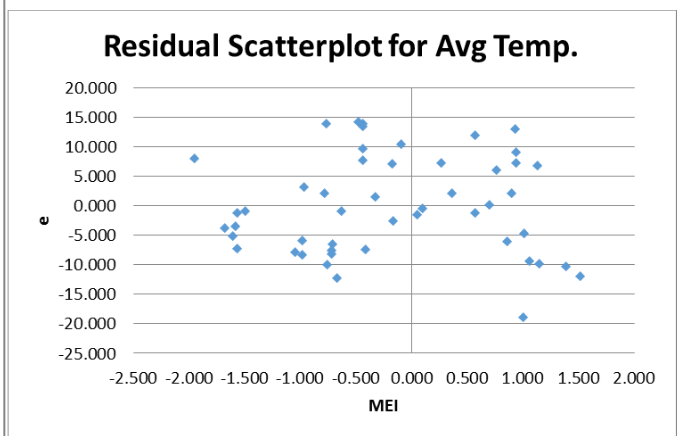
[1.21, 6.40]. Thus we are 95% confident there is an increase of temperature in Shoreline between 1.21 and 6.40° F as the MEI increase. The standard error for the [intercept, using the same techniques yields SE(b_0) = 1.088, and a confidence interval of [48.36, 52.74]

MEI vs. Total Monthly Rainfall

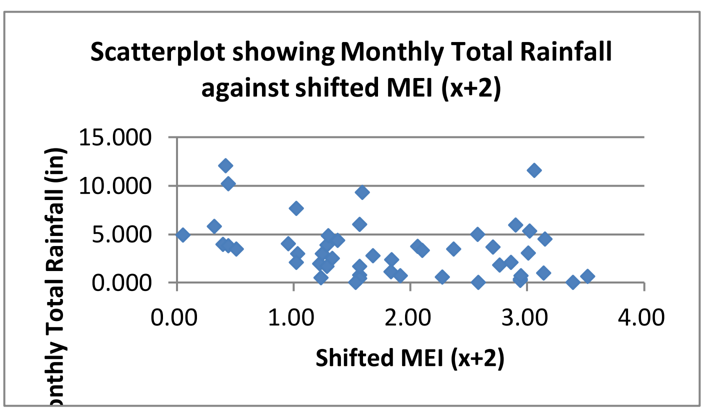
- Assumptions and Conditions:

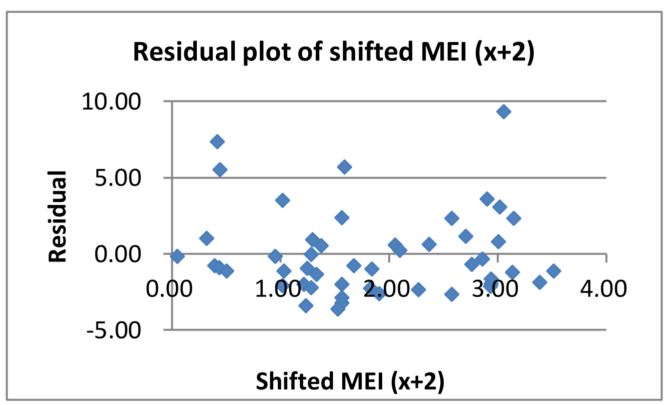
1. Linearity Assumption: Here is our scatterplot, along with a plot of the residuals. It is too curved to be linear

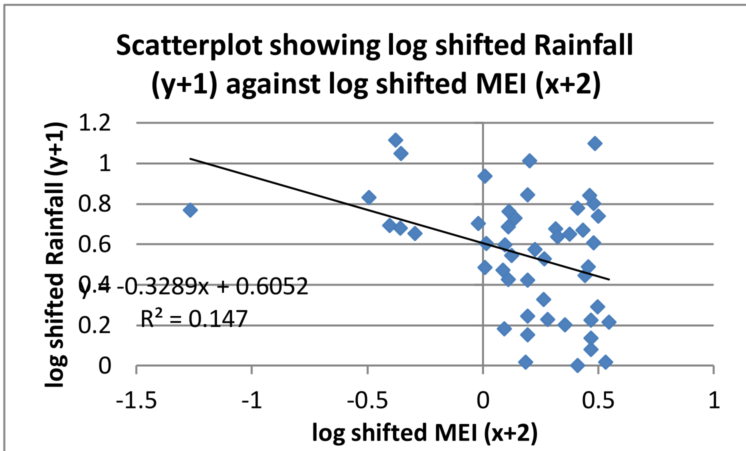




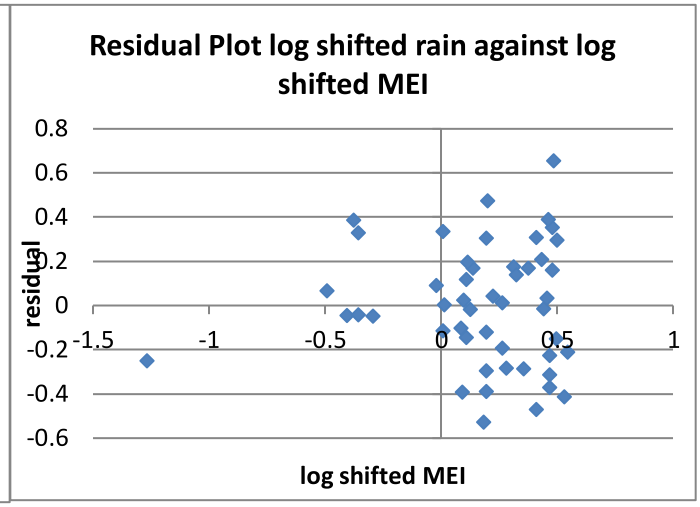
So we re-expressed it the following ways looking for a linear regression. First we shifted the data to eliminate negative values and zero. Then we took the log of both sides.



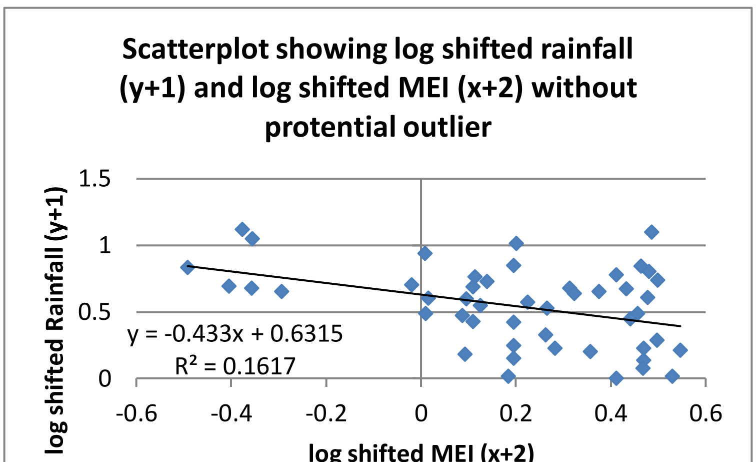




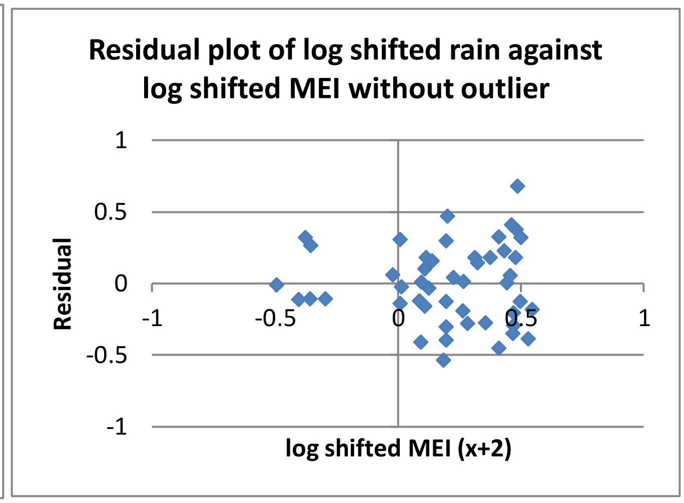
With outlier: $\log(\widehat{Rainfall}+1) = -0.3289 * \log(MEI+2) + 0.6052$



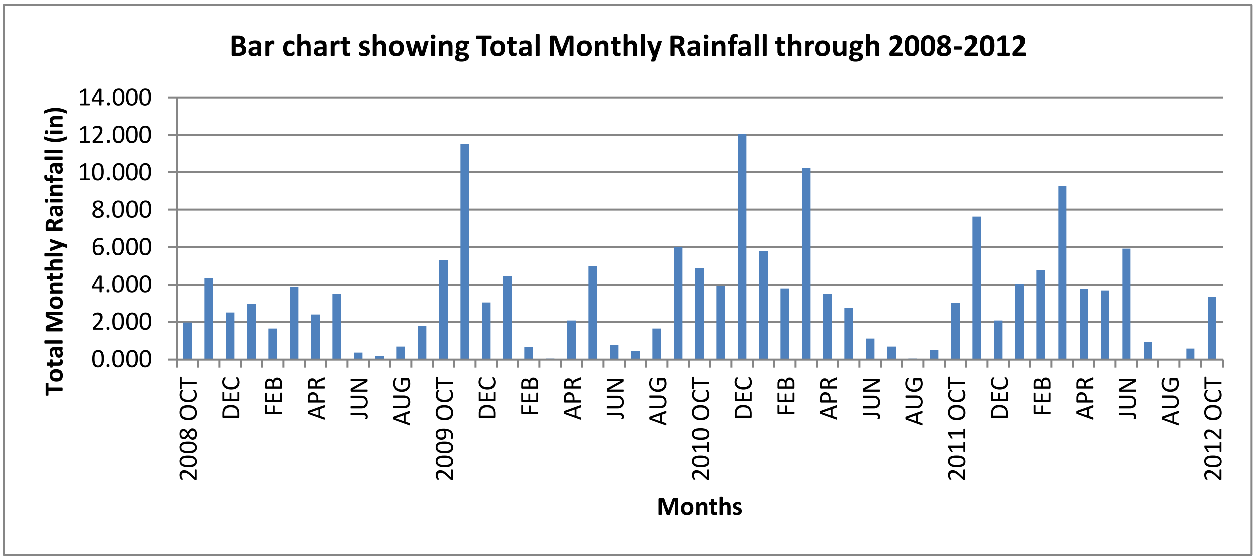
Note the outlier in the above plots. By removing that data point (October 2010) we got the following, which is much more linear:



Without outlier: $\log(\widehat{Rainfall}+1) = -0.433 * \log(MEI+2) + 0.6315$



2. Independence Assumption: Weather is random.
3. Equal Variance Assumption: The residual scatterplot for rain shows equal variance
4. Normal Population Assumption: this is assumed based on the following plot.



Hypotheses for Rainfall

Using the same statistical analysis we did before with the temperature, our null hypothesis is again that the slope is 0 (Ho: β1 = 0) and our alternate hypothesis is that the slope is not 0 (Ha: β1 ≠ 0) We are setting our alpha level at 5% (α = 0.05)

Calculation

Since this is a sample, we are using t values, with n = 48 (without the outlier), degrees of freedom = 46. The mean slope is b_1 =-0.433, mean intercept is b_0 =0.6315, with R^2= 16.2%, The residual standard error is the same,

$$s_e = \sqrt{\frac{\sum(y-\hat{y})^2}{n-2}} = 0.2742$$

and the standard error of the slope is

$$SE(b_1) = \frac{s_e}{\sqrt{n-1}s_x} = 0.145$$

The t value we get is

$$t = \frac{b_1-\beta_1}{SE(b_1)} = t(46) = -2.979$$

which when put into a t-value calculator gives us P-value = 0.004605 (Soper), which is much less than 0.05. Which allows us to again reject the null hypothesis!

Now we can determine a confidence interval for the slope and intercept. Using Student's t value for 95% confidence and 46 degrees of freedom we get 95% t*(46) = 2.0129 (Soper). With SE(b1)= 0.145, b1= -0.433, t^*_{n-2} = 2.0129 we calculate that C.I. of β1 = b1 ± t^*_{n-2} x SE(b1) = [-0.726, -0.140]. Thus we are 95% confident there is a decrease of rainfall in Shoreline between 0.19 inches (log(-.726)) and .72 inches (log(-.140) as MEI increases by 10 standard deviations (log(10) = 1).

In Conclusion

The increase in Temperature and decrease in Rainfall is unlikely to be coincidental. In addition There is a correlation between the change in local temperature and rainfall and the El Niño and La Niña phenomenon.

Reference:

Soper, Daniel. Statistics Calculators Version 3.0. Retrieved December 4, 2012 from http://www.danielsoper.com.

Dinse, Carl. (2012). Carl's Shoreline Weather Station. Retrieved November 12, 2012 from http://carlsshorelineweatherstation.com.

Wolter, Klaus. (2012). Multivariate ENSO Index (MEI). Earth Systems Research Laboratory. Retrieved November 18, 2012 from http://www.esrl.noaa.gov/psd/enso/mei/