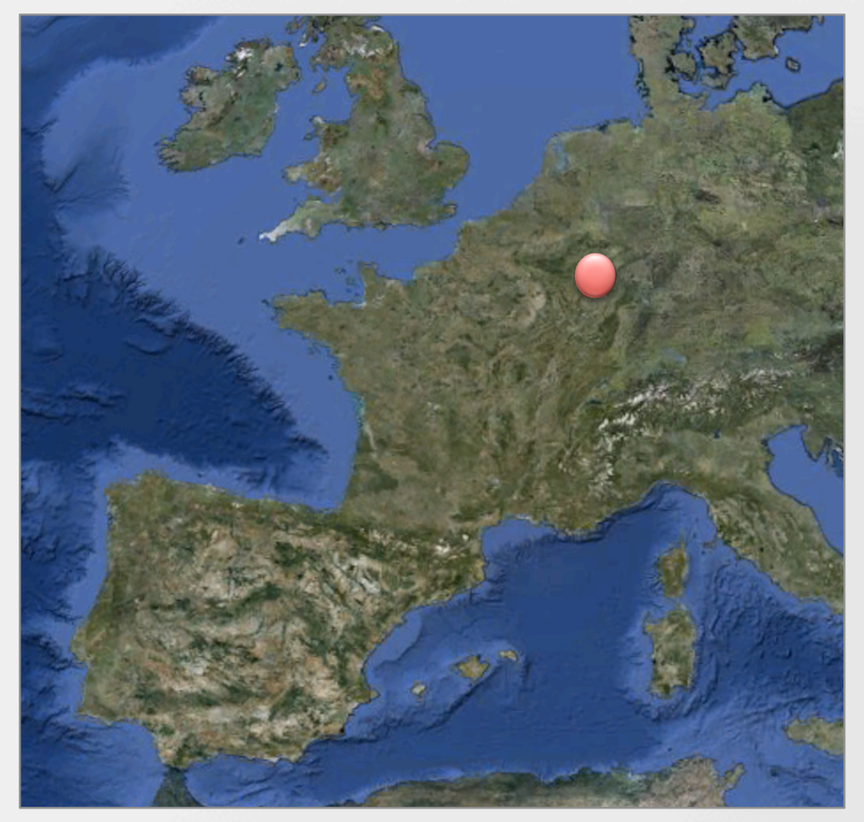

Figure 3: Western Europe, Metz shown in red.

Trees and the weather: correlating local historic climate data from Metz, France to tree ring analysis and precipitation data (1465-1502)

Introduction

That tree rings preserve some memory of past years may not surprise anybody, but the precision of this inanimate memory is stunning, at least when it comes to the weather.

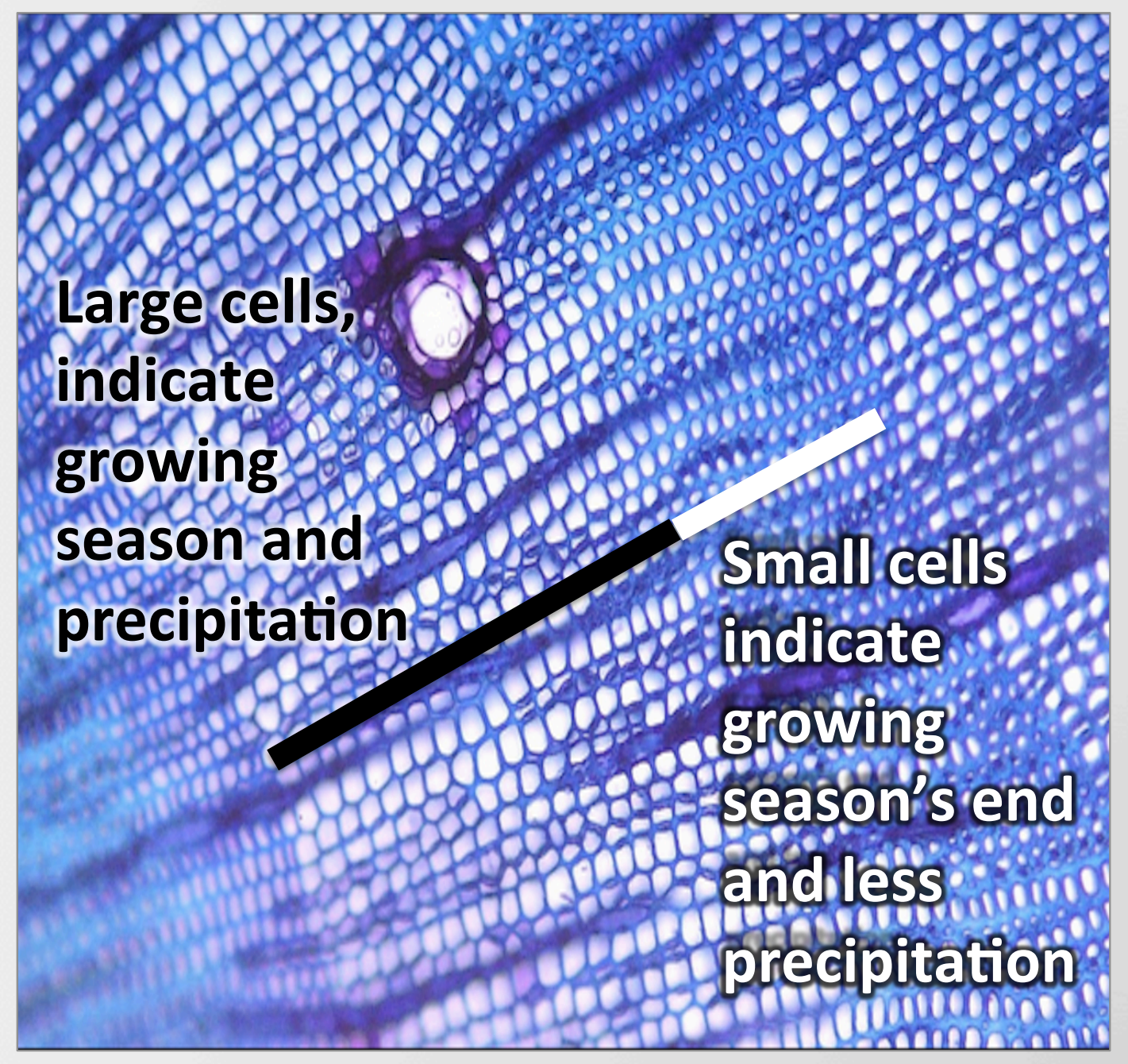

Figure 1: Tree cross section close up, one year's growth (original image by Scott St. George). Ring thickness and cell types provide information about yearly precipitation.

The recent push to compare climate data from dendrochronology, or tree ring analysis, to historical records has found the two resoundingly consistent (Büntgen et al. 2011). But while broader regional inquiries have predominated in the past, this study offers a local weather analysis from one city in Northeastern France over a thirty-year period. The apparent consistency between written records and tree rings in such a localized study has broad implications for future use of dendrochronology to understand historical climates.

Methods

This project used three data sets: a precipitation proxy from oaks in Northeastern France and a precipitation reconstruction from that data (Büntgen et al.), and written records from the Journal of Jean Aubrion from Metz (1465-1512).

To address the arbitrariness of turning written records into empirically malleable data, this study's classification system for historical climate events attempts, not to reconstruct climate, but to detect unusual years by accounting for an event's duration and strength. Yearly averages were then calculated from the individual event's "wetness levels."

Level	Description	Durration
Wet Evetns		
1	one day weak event	
2	one day strong event	
3	several day weak event	2 to 7 days
4	several day strong event	
5	long weak event	> 7 days
6	long strong event	
Hot or Dry Events		
-1	one day weak event	
-2	one day strong event	
-3	weak mid-length event	2-14 days
-4	strong mid-length event	
-5	long weak event	> 14 days
-6	long strong event	

Figure 2: Wetness Key. "Strong events" associated in the written record with damage to crops, property, or persons. "Weak events not associated with any damage. Difference in duration definitions to account for generally milder descriptions of heat and dryness.

Tree rings store precipitation data during the months April, May, and June, so only years with spring precipitation or dryness in the historical record were analyzed, the rational being that we cannot assume a lack of written records implies an average year. Level 1 events were also ignored in yearly averages, assuming they would not affect tree growth.

Results

Yearly spring averages were correlated to both the tree ring growth precipitation proxy and Büntgen et al.'s precipitation reconstruction that models actual precipitation from each year.

The Pearson's Correlation Coefficient, or r value, for the correlation of historic data to the precipitation proxy is r = 0.351. This implies a weak to moderate correlation. We tend to see tree growth accompanied by an increase in recorded precipitation and visa versa, but the association is not very strong. This suggests that more variables than just precipitation affect tree growth, or that the data from the historical record is imperfectly analyzed. Alternatively, the historic data records some weather patterns so local that even Northeastern French trees do not pick them up. The probability that this correlation has arisen purely due to chance is p = 0.085 or 8.5%, making this result statistically significant at the 91.5% confidence level.

The three years highlighted in black are the most prominent points where the two data sets disagree. There were no obvious climate events in these years to explain their disrupted relationships. There was a volcanic event in 1483, two years before one disagreeing year, but the increased atmospheric aerosol concentration that volcanoes produce should have intensified the Earth's albedo, initiating cooler temperatures and decreased tree growth. What we actually observe is a decrease in recorded precipitation and an increase in tree growth in 1485, suggesting that this event is unrelated to the volcanic event of 1453. Future work on these sources should attempt to sort out these disagreements in the data.

The second correlation between historic data and the precipitation reconstruction has a Pearson's Coefficient value of r = 0.483, making this a moderate correlation. The increased correlation between these two experiments suggests that other variables besides precipitation also affect tree growth, and that the reconstruction has minimized the impact of these potentially confounding variables. The p value for this correlation is p = 0.014, meaning that the probability that this relationship has arisen randomly is only 1.4%. The results are therefore highly statistically significant to the 98.6% confidence level.

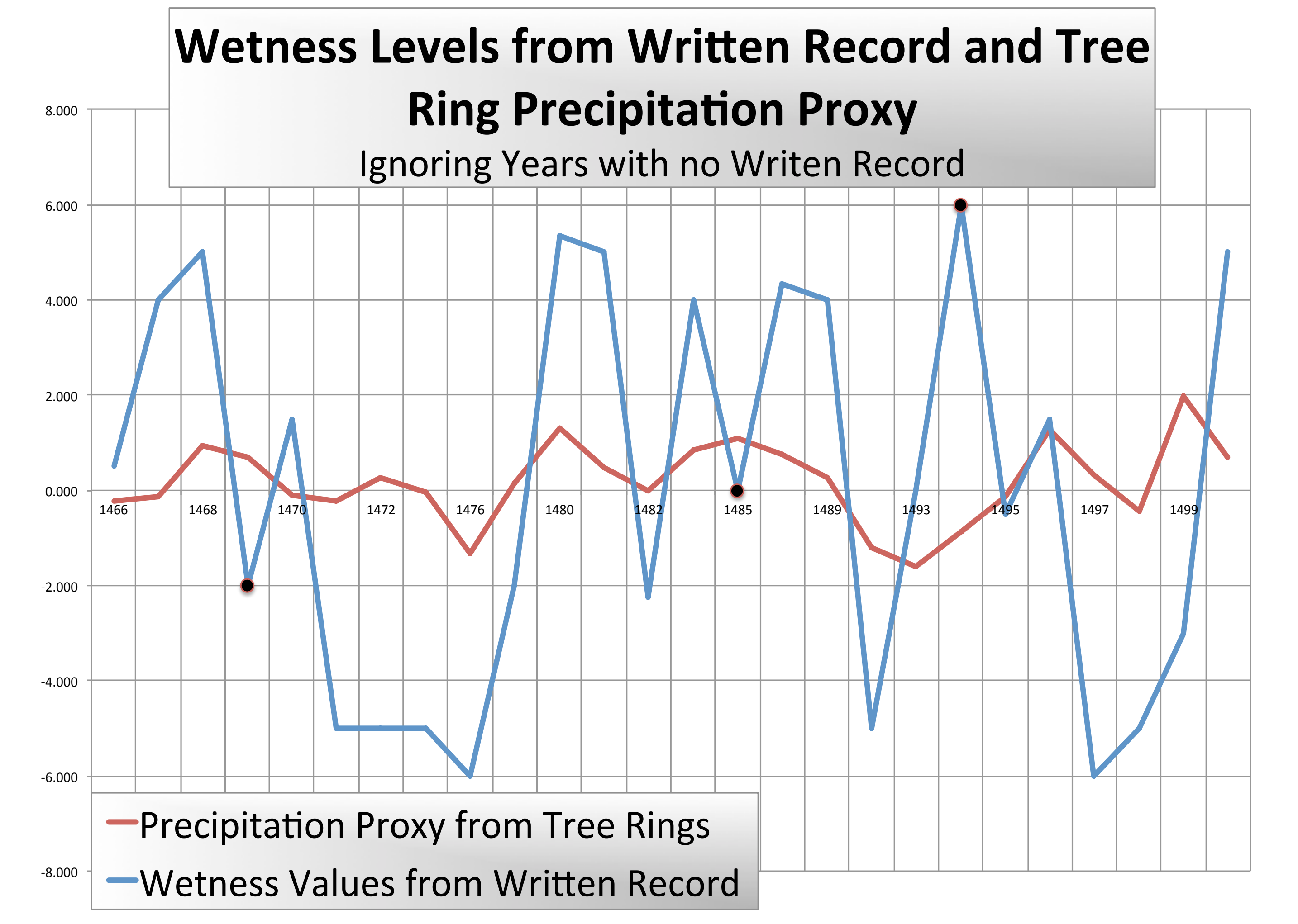

Figure 4: Shown here are wetness levels from the written record and the tree ring growth precipitation proxy. Correlating these two data sets we get an r value of 0.351 and a p value of 0.085 with a confidence level of 91.5%. Years highlighted in black are prominent years of disagreement between the two data sets.

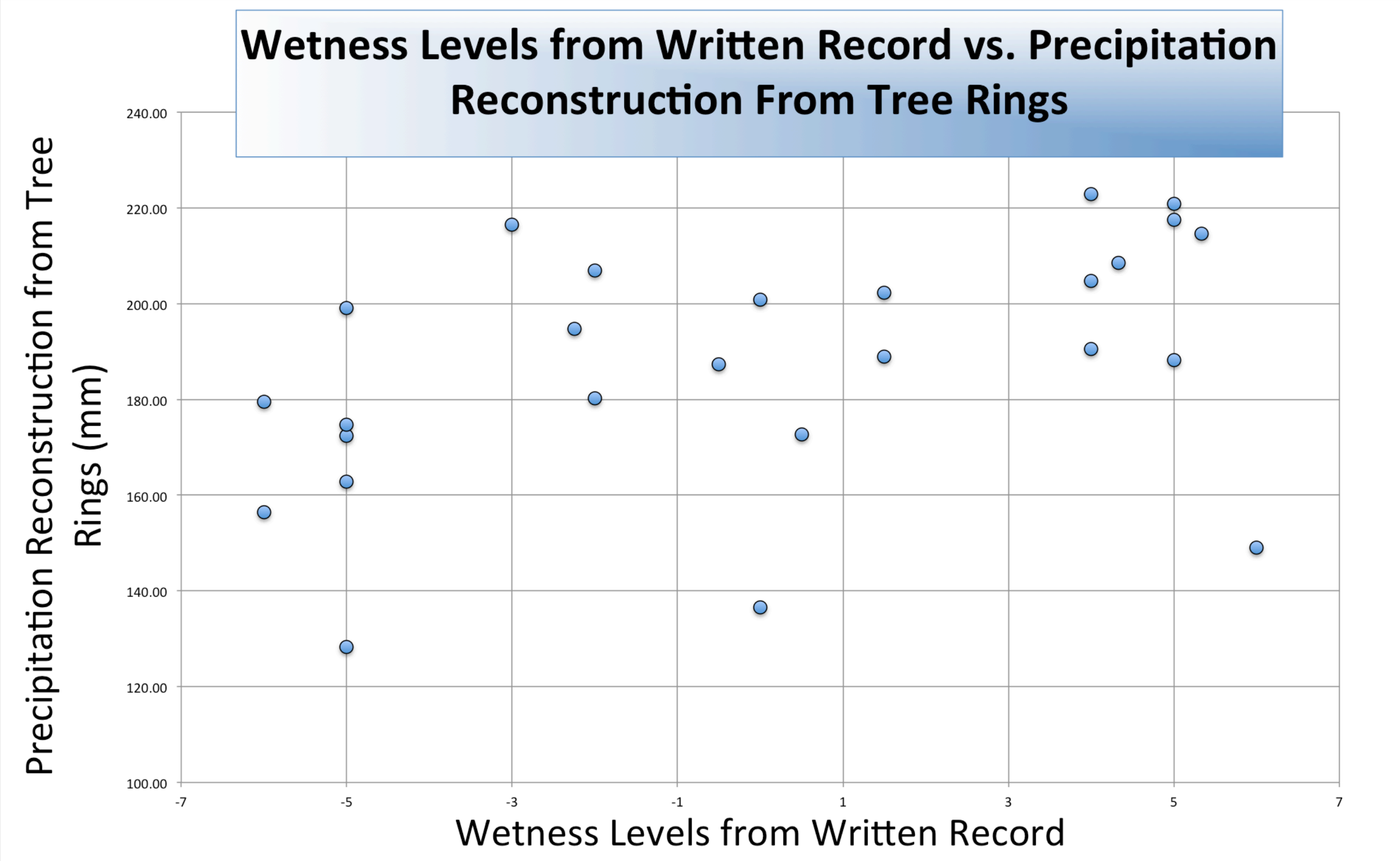

Figure 5: Shown here are wetness levels from the written record versus the actual precipitation reconstruction. Correlating these two variables we get an r value of 0.481 and a p value of 0.014 with a confidence level of 98.6%.

Conclusion

The observed correlation between historical records and tree ring data is significant for several reasons. First, confirming tree ring data by comparing it to other sources reinforces earlier studies' findings that dendrochronology provides accurate data on historic climates. Correlations in this study were moderate, but were still clearly visible and statistically significant.

Secondly, while previous studies tend to addressed extreme events over broader areas, this study suggests a methodology for addressing local and non-extreme variations in historic climates. By assigning every climate event in the written record a value based on strength and duration, and then taking yearly averages, spring precipitation in the written record could be empirically assessed. The local detail in this study was possible because of the richness of this particular historical source and will not be possible in all cases, but the methodological framework should still hold.

Jean Aubrion's stunningly detailed account of local weather in Metz is not the norm in the world's historical archives. Often we have little or no idea whether or not it rained on a specific day in April, 1458. But what this study and the work that it built on are beginning to bring to light is that we need not resign ourselves to ignorance in cases where the written record fails us. What this study and the correlation of local written records with tree ring data tells us is that tree rings can reflect certain aspects of people's everyday experiences seven hundred years ago. Not only can we use dendrochronology to detect the coldest winters or the largest droughts on record, but we can also use it to understand people and their everyday environments throughout history.

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