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Can the Convective Temperature from the 12UTC Sounding be a Good Predictor for the Maximum Temperature, During the Summer Months?

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ABSTRACT

Several forecasting techniques use soundings to get the value of the variable being forecasted. This study examines the validity of a using the convective temperature to forecast for the maximum temperature, while comparing it to other forecasting techniques that use soundings. These include adding 13 degrees to 850mb temperature and using the forecasted high that is included in the sounding analysis. This study also examined where the convective temperature matches the observed high temperature. To do this, most of the information was obtained from the Iowa State University Meteorology Archive and National Weather Service's archived data. Days were chosen to include at least one day a week for the last week of May and the first week of September. The data points included the convective temperature from the 12UTC, the 850mb temperature, the forecasted high, cloud cover, and the month, region and latitude that the sounding was taken in. The difference was taken between the variable temperatures and the observed maximum temperature. The average was taken of these differences and were taken against each other and against the other variables: latitude, region, month, and cloud cover. Statically analysis was performed to determine how well the variables are correlated and their statistical significance Region and latitude showed the at least some correlation, with latitude being the best. Lower latitudes had the smallest average temperature difference. An additional 20 cases were added to determine how well this proposed convective temperature forecasting method performs in the lower latitudes.

1. Introduction

Weather forecasting has come a long way in recent decades. From creation of the numerical weather prediction models in the late 1950s [Shuman 1989], to the establishment of Model Output Statistics or MOS. Still, the need for accuracy is as prevalent as it was then as it is today. In both the private and public sector, there are companies and organizations striving to create the most accurate forecasts. Even with the advancement with modern forecasting techniques, there are still several quick and simple forecasting methods that do not require using massive supercomputers. One of these methods includes taking the 850 mb temperature from a radiosonde sounding, then following the dry adiabat line (or moist adiabat if it is cloudy) down to the surface. If the station is at or above 850 mb, then the 700 mb temperature is used. This method is laid out in the Weather Forecasting Red Book, a book used by professionals in operational forecasting and students a like. It can be further simplified by just adding 13^o C to the 850 mb temperature. [Vasquez 2009] A radiosonde is a package that carries several instruments that measures atmospheric parameters. It is typically carried up through the atmosphere via a large weather balloon. As the radiosonde rises through the atmosphere, it transmits the data back down into a ground receiver. Many of The National Weather Service forecast offices sends at least two of these radiosondes per day: at 12z and 00z. [NWS 2017] These soundings are used to help provide a idea of what the vertical structure of the atmosphere is at that time. They also may have some use in short term forecasting. The goal of this project is to determine whether or not the convective temperature from the 12 UTC sounding is a good predictor of the maximum temperature in the summer months, given limited large-scale forcing. This could give forecasts another "low tech" way forecasting for certain parameters. Convective temperature is the minimum surface temperature needed for convection to take place with no mechanical lifting., and can be found on a sounding by finding the Convective Condensation Level (CCL) and following the dry adiabat line down to the surface. [NCAR 2017] The convective temperature is usually reached in the late afternoon. Mechanisms like fronts and other boundaries provide lift and lower the convective temperature as well as influence the maximum surface temperature. It is because of this fact that only soundings from the summer months will be used. Outside of the summer months, there is normally insufficient surface heating for the convective temperature to even exist. The surface heated by incoming solar radiation. All things emit radiation, and when the surface is heated, it begins to radiate more longwave radiation into the surrounding air, warming it, in a process called diabatic heating. This process continues throughout the day until the near surface air hits its maximum. The convective temperature and the maximum temperature result from diabatic surface heating and are reached during the late afternoon. An additional goal of the is project will include comparing the proposed convective temperature forecasting method to the other sounding methods mentioned above as well as determining where and when each of these methods perform the best.

2. Data and Methodology

The data comes, in large part, from the Meteorology Archive at Iowa State. The archive includes Gempak files that served as the main data source for this study.

a. Case Selection

Days were chosen at random to include one day of each week between the last week of May and the first week of September, over the years of 2014-2017. This simulates the use of this method during any given day. The convective temperature only exists because of diabatic surface heating and only the summer months provide sufficient surface heating for the convective temperature to exist, so only the summer months were included. For stations that are near or above the 850 mb level, the 700 mb temperature was used. Locations were chosen at random as well, in order to give an even spread of different regions and latitudes across the continental United States. In the cases of a bad sounding, where the radiosonde did not record properly through the atmosphere, a different location was selected. An additional 25 cases were taken from between 28^{o} and 24^{o} latitude and were analyzed separately.

b. Data

The regions were classified using a number systems according the regions in Figure 1. Topography and regional climate could play a role on what the convective temperature would end up being and how well it matches up with the maximum temperature. Information was downloaded from the archive for each day and was included in the upper air data. The upper air file served as the source of the convective temperature, the 850mb temperature, and the forecasted high temperature. The upper air file was run through a sounding analysis software that produced these datasets from

Figure 1: United States Geographical Regions. 1 is assigned to the Southwest, 2 to the Northwest, 3 to the South-Central Plains, 4 to the North-Central Plains, 5 to the Southeast, and 6 to the Northeast Image Source: Storm Prediction Center

the 12 UTC soundings that are released everyday by the National Weather Service offices. The 12 UTC sounding is being used because the surface temperature around this time is the temperature the surface has before there has been sufficient surface heating. For the continental United States, 12 UTC is early morning. This proposed method will be compared to other techniques including the adding 13 degrees to the 850 mb temperature and as well as the forecasted maximum temperature, that is generated from the sounding analysis. The station's location and latitude are being recorded to determine if the location has any effect on whether or not the convective temperature is a good predictor of the maximum temperature. The observed maximum temperature from the METAR stations corresponding to the NWS offices was obtained from the National Centers for Environmental Information, through the Daily Summaries Climate Data. Cloud cover was also recorded via a numbering system. Zero was assigned to clear skies, after that, one through four was assigned to the corresponding number of octas that are filled in the station plot. This data is provided by

NOAA's Weather Prediction Center surface analysis archive and is averaged through the day. Recording cloud cover is used to determine whether cloud cover has any effect on the relationship between the convective temperature and the high temperature. The month that the sounding was taken into also taken into account, to determines its role in this process.

c. Methodology

Once all the data was recorded, the differences between the temperatures and the observed maximum temperature (i.e. convective temperature – observed temperature, etc.) were taken, then the mean of those differences were taken across all data points. The mean differences were compared to each other and the region, latitude, and month that they were taken. If the convective temperature is not a good predictor of the maximum temperature, this study will examine how well the other methods are at predicting the maximum temperature. When and where do each of these methods perform the best. To properly analyze the data, correlation statistics, regression and significance testing were performed. Correlation statistical testing explains how much of the variance in the data can be explained by the variables involved. Significance testing determines if the variance is caused by chance or human error, and regression testing determines how well the data fits a linear model. The additional 25 cases mentioned above were analyzed separately to determine how well the convective temperature matches the maximum temperature in the lower latitudes.

3. Results

a. Temperature Differences

The mean temperature differences between the variable temperatures and the observed maximum temperature were

Table 1: The Mean Temperature Difference between the Convective, 850+13, and forecasted high and the observed maximum temperature.

Mean Temperature Differences	
Convective Difference	-9.483
850+13 Difference	-1.784
Forecasted Max Difference	-0.957

recorded in Table 1. The difference between the convective temperature and the observed maximum is significantly more than the other temperatures. This is likely due to the fact that most of the continental United States does not have barotropic conditions were the convective temperature is normally higher. The forecasted high that is included in the sounding analysis provided in most analytical software such as NSHARP or SHARPy. The 850mb temperature method is also promising. The month that the sounding was taken shows little variation of the means across the different months. Cloud cover also showed little variation. The spread of the convective/maximum temperature difference across each of the coverage categories was too much to observe any significant correlation. The region however shows some correlation between the convective/maximum difference. Through correlation testing, two factors show at least a small relationship between them and the

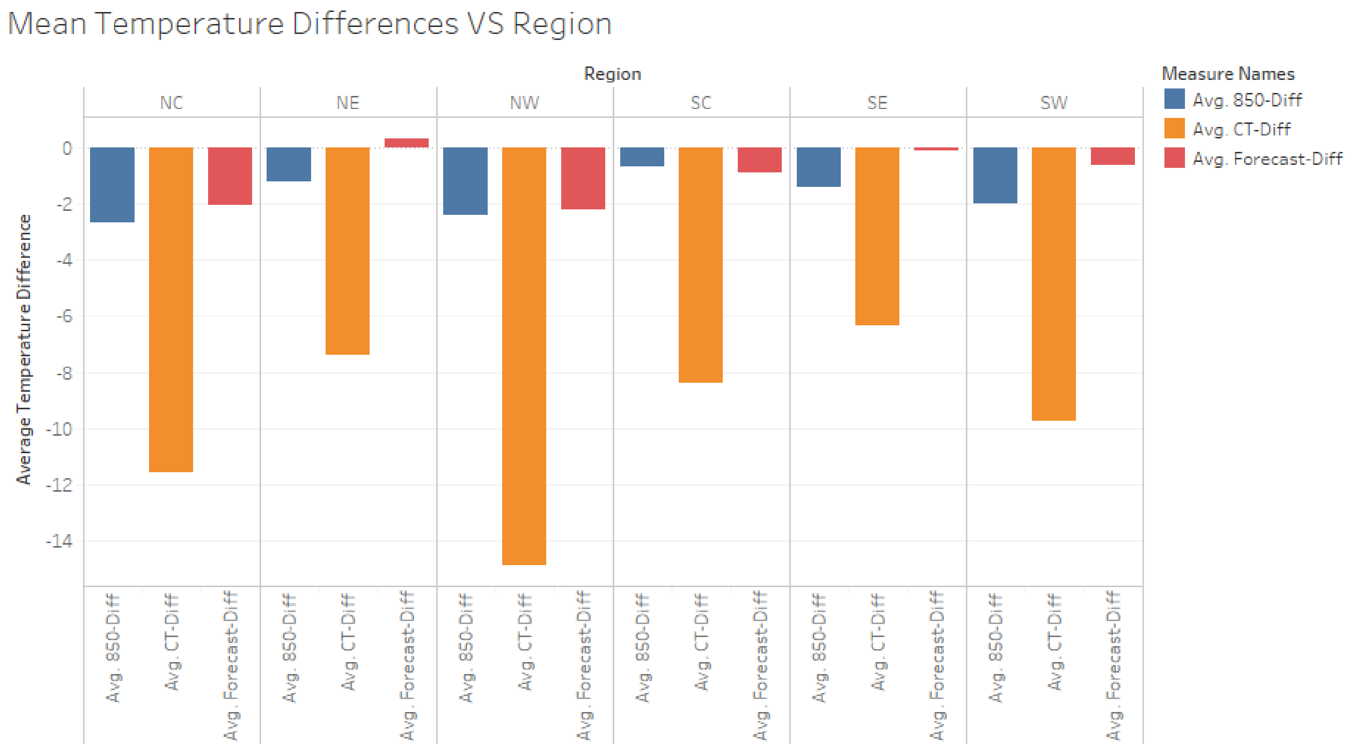


Figure 2. The mean temperature differences compared to the regions that they were taken. There were six regions, the southwest, northwest, south-central and north-central plains and the northeast and southeast. The convective/observed maximum difference is the smallest in the southeast. The blue bar represents the mean 850mb/Max temperature difference, the red bar is the mean forecasted max/observed max temperature difference, and the orange bar is the mean convective/maximum temperature difference.

convective/maximum difference. Through correlation testing, two factors show at least a small relationship between them and the convective/maximum difference. The region that the convective temperature was found in has some bearing on how close the convective temperature and the maximum temperature happened to be. It had an R value of 0.316, which is considered a slight positive relationship. This can be seen in Figure 2. The Northwest performed the worst and this is not surprising. Mechanical lift that accompanies synoptic systems that are prevalent in this region ranging from the low pressure systems that come in off the Washington coast, to the orographic lifting caused by the Rocky Mountains. These lower the convective temperature, increasing the temperature difference. Likely, other forcing mechanisms and advections are affecting the convective temperature in many of the regions in the United States. The elevation in the northwest and north-central plains also played a role on how accurate the 850mb+13 temperature was. The fact that many of these stations were at or near 850mb, so the 700mb temperature was used instead can be attributed to this. It made the 850mb+13 temperature a little cooler than it would be if the actually had been the temperature at

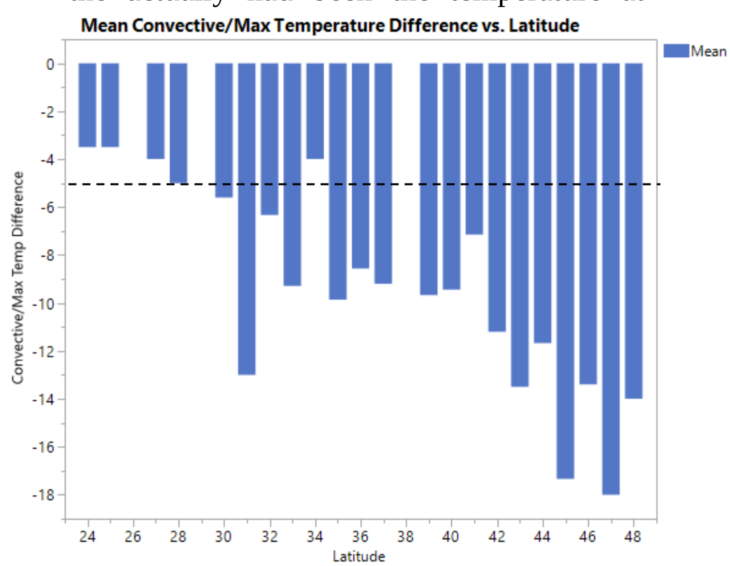


Figure 3: Mean convective/maximum temperature difference vs. Latitude. Latitudes below 30°perform the best, with a difference less than 5 degrees C. 5° line is denoted by the black dashed line.

850mb. Month did not have an effect on the how well the forecasted high temperature performed. The factor that had the most impact was the latitude of the stations. It had an R-value of -0.485, which is a near moderate negative correlation. Figure 3 shows how the latitude compares with the convective/maximum. There is a near linear relationship between the two. Linear regression testing in Figure 4 shows how well relationship fits into a linear model. It has an R^2 of 0.236 which means that about 25% of the variblity in the temperature difference can

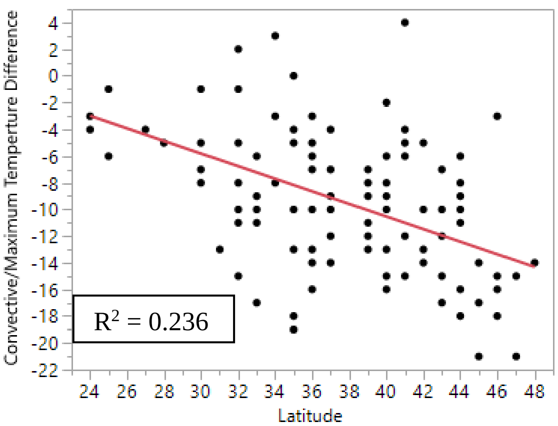


Figure 4: A Linear regression model of the relationship between the convective/maximum temperature difference and latitude. It has an R^2 of 0.236.

be explained by latitude. The lower latitudes performed the best. Latitudes between 24° and 38° had a mean difference of ~-5°C. This again is not surprising, the lower latitudes, espically tropical areas, have near barotropic conditions that allow for the convective temperature to be fully reached. And since the convective temperature and maximum temperature are achieved the same way during the same time of day, they should have very similar values. These results correspond to the relationship between region and the convective/maximum difference. Most of the southeast region lies in these latitudes. It is this reason that the additional cases were selected in this area; to see how well the convective tempearture forecasting method performs in this area compared to the methods.

b. Analysis of the Lower Latitudes

A second set of data points were collected in the latitudes between 28° and 24° where the mean difference was the least out of the other areas. There were five stations within the new study region: Brownsville, TX (KBRO) at 25° latitude, Corpus Christi, TX (KCRP) at 27° latitude, Key West, FL (KKEY) at 24° latitude, Maimi, FL (KMFL) at 25° latitude, and Tampa Bay, FL (KTBW) at 28° latitude. Figure 5 shows the average difference between the observed maximum temperature and the measured tempeatures.

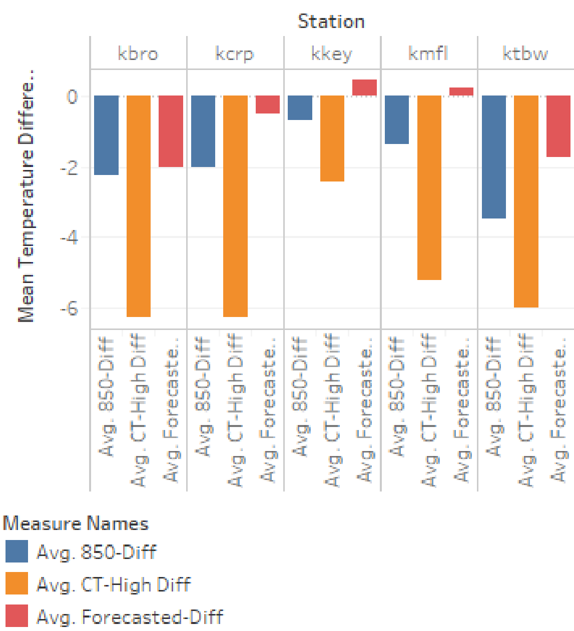


Figure 5: The Mean Convective/Maximum Temperature Difference verses the stations in the latitudes between 24 degrees and 27 degrees. The Key West station, located at 24 degrees latitude performed the best.

Again, the station in the lowest latitude performed the best. KKEY had the lowest mean difference between all of the measured temperatures and the observed maximum temperature compared to the other stations. The difference between the convective temperature and maximum temperature around 2^{o} C. The KKEY station would be considered most tropical station in the continental United States with the most consistent barotropic conditions, letting the convective temperature reach its full potential and be closer to that days maximum temperature.

4. Conclusion and Discussion

This study determined that convective temperature from the 12UTC sounding is not a good predictor of that days maximum temperature. Although, the convective temperature and maximum temperature are reached the same way and reach their max at the same time, the overall differences between the two across the study area were significant, often being over 10^{o} only factor that has any contribution to how close the convective temperature and maximum temperature was latitude and region to an extent. The R^2 value was 0.23, meaning that about twenty-five percent of the variability can be explained by latitude. This may seem low, but considering how variable the differences can be due other environmental factors, twenty-five percent is a fairly significant relationship. Other factors however, had little or no relationship. The amount of cloud cover and the month that the temperatures were recorded have little to no bearing on the how close the temperatures are. The other forecasting methods that use soundings are much better at predicting the maximum temperature than the convective temperature. The only area that this method would be viable would be in the lower latitudes. The lowest latitudes of the continental United States had the smallest difference between convective temperature and the maximum temperature, but the other methods still performed better in predicting the high temperature. It is no surprise that the Forecasted Maximum temperature worked the best. It was developed to do so. However, if an individual has only a standard Skew-T plot or raw radiosonde data, they can make a fairly accurate temperature forecast with this information using the 850mb forecasting technique, if the area being forecasted for is in a lower elevation. In higher elevations, the 850mb level was either very close to the surface or was nonexistent because it would be below the surface. In these cases, the 700mb temperature was used and this provided a larger difference between it and the observed maximum temperature since the mixing layer would vary based on location and elevation changes.

To conclude, if one is using an atmospheric sounding to forecast a high temperature, they should use the forecasted high that is provided in the sounding analysis. However, with only the standard skew-t plot, a forecaster could make a fairly accurate temperature prediction using the 850mb forecasting method. The only time the convective temperature would be a good predictor of the maximum temperature would be in low latitude areas – less than 25^{o} latitude – where there are more consistent barotropic conditions.

Shuman, F.G., 1989: History of Numerical Weather Prediction at the National Meteorological Center. *Wea. Forecasting*, **4**, 286–296, https://doi.org/10.1175/1520-0434(1989)004<0286:HONWPA>2.0.CO;2

Vasquez, T., 2009: Forecasting Temperature. *Weather Forecasting Red Book.* Weather Graphics Technologies, 131-138

Wallace, John M., Hobbs, Peter V., 2006: *Atmospheric Science: An Introductory Survey.* Elsevier Inc, 138-145

The National Weather Service Radiosonde Information, 2017: Radiosonde Factsheet. [Available online at: https://www.weather.gov/upperair/factsheet]

University Corporation for Atmospheric Research, 2017: MetEd Skew-T Mastery [Available at https://www.meted.ucar.edu/mesoprim/skewt/navmenu.php?tab=2&page=3.9.2&type=flash]

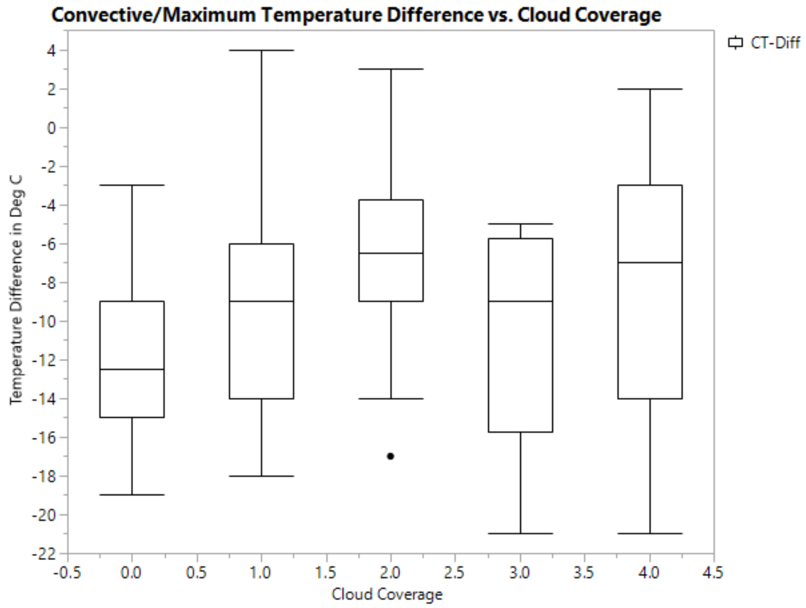
The National Weather Service Weather Prediction Center, 2017: Surface Analysis Archive. [Available online at: http://www.wpc.ncep.noaa.gov/archives/web_pages/sfc/sfc_archive.php]

National Centers for Enviromental Information, 2017: Daily Observation Summaries [Available online at: https://gis.ncdc.noaa.gov/maps/ncei/summaries/daily

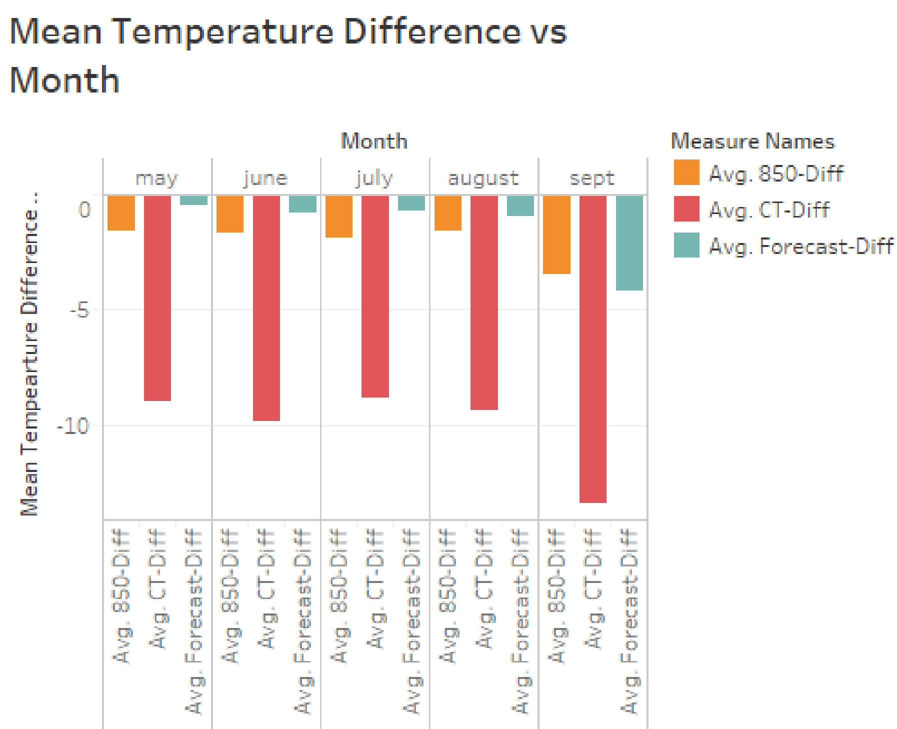
Iowa State Meteorology Archive, 2017: [Avaiable online at http://www. mtarchive.geol.iastate.edu]

National Weather Service Storm Prediction Center, 2017: Sounding Analysis Page [Available online at http://www.spc.noaa.gov/exper/soundings/

Appendix



Appendix A. *The convective/maximum temperature difference vs cloud coverage.*



Appendix B. The mean temperature difference vs month.

Appedix C. Correlation Statistics of the convective/maximum temperature difference and factors contributing to the variance.

Variable	R-value
Month	0.08
Region	0.31
Latitude	-0.48
Cloud Cover	0.12