Satellite Earth Surface Temperature: Averaging Process and Validation

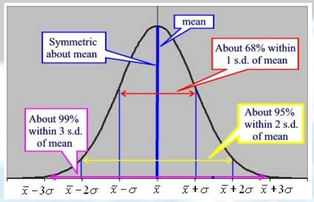
Krzysztof Wasilewski (LaGuardia), Sejal Jain (Bergen County Academies)
Angelo Angeles (Educator, The School for Legal Studies)
Mentors: Dr. Yasser Hassebo and Dr. Reginald Eze

Introduction

Measuring and monitoring Earth's accelerated climate change is vital in order to visualize and anticipate potential environmental issues. NASA, along with many other international space agencies, measures this change through satellite remote sensing installed on satellite platforms orbiting the Earth. Satellite remote sensing is the science of obtaining information about the Earth's surface without being in physical contact with it. For this research project, 248 data files were provided by NASA for surface temperature over the course of the month July in 2004. As with any data collection, there were errors in the readings. MATLAB®, a high-level language and interactive environment for numerical computation, visualization, and programming, was used to correct the data through an averaging and validation process. It was hypothesized that the surface temperature of the Earth would follow a Gaussian distribution pattern. Ultimately, the goal of this research is to develop a model of the climate over any given period using single files which give the weather at a particular points in time. This will provide a valuable tool in predicting changes in climate, weather, oceans, and coasts.

Methods/Approach

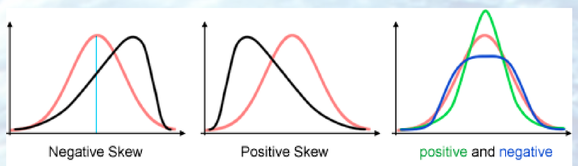
The surface temperature data was received from NASA for July 2004 in 72x144 matrices, each element corresponding to a 2.5°x2.5° patch on the earth's coordinate surface.



http://www.regentsprep.org/Regents/math/algtrig/ATS2/NormalLesson.htm

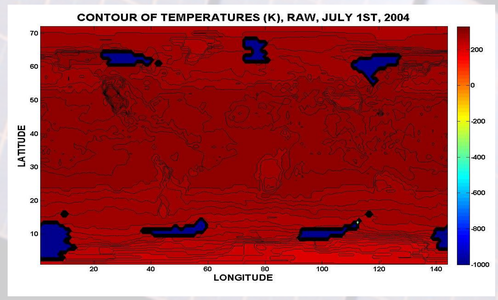
This data was imported into MATLAB, and outliers were removed in order to achieve the official NASA data values and a Gaussian distribution as close as possible. Ideally, 50% of the data should be to the right of the peak, and 50% to the left, and the mean, median, and mode should be equal and located at the peak of the curve. Several properties were calculated in order to analyze the data after various changes to the outliers.

Mean – the average of all the data elements
Standard Deviation (SD) – quantifies how tightly the data is clustered around the mean
Outlier – any element outside 3 SDs from the mean
Skewness – quantifies how symmetric the data distribution is; skewness for a perfect normal distribution is 0
Kurtosis – measures how peaked the data distribution is; the kurtosis value for a normal distribution is 3

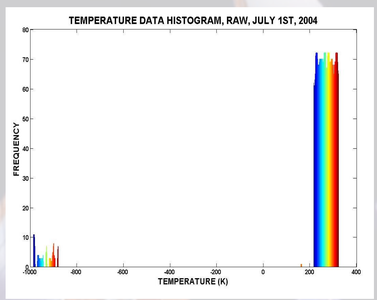


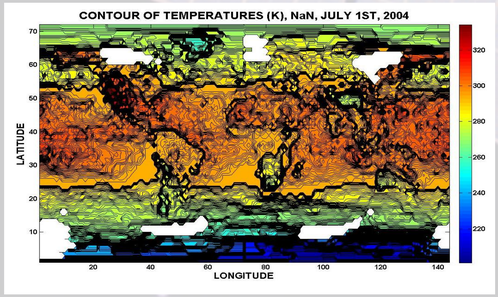
http://www.scratchapixel.com/assets/Uploads/Lesson016/l016-skew.png?

Results

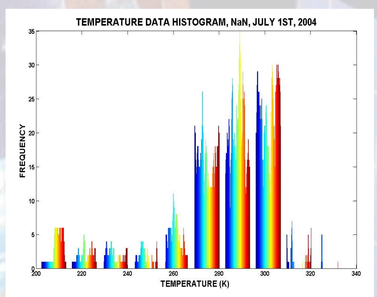


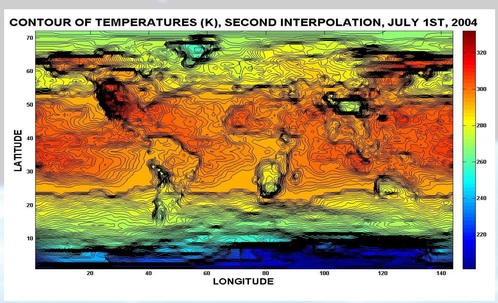
Raw Data, 1 file
- provided by NASA with outliers marked as -1000K.
- July 1, 2004



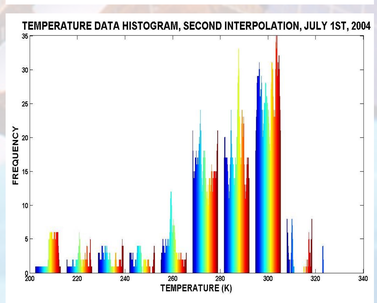


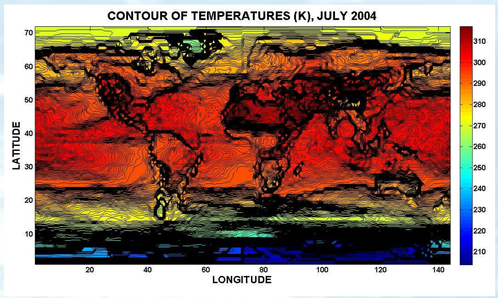
Outliers replaced with NaNs, 1 file (July 1, 2004)



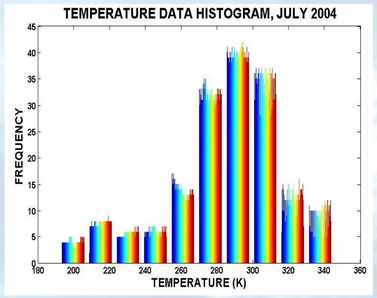


Outliers corrected through 2nd interpolation, 1 file (July 1, 2004)





2nd Interpolation of all data, 248 files (July 2004)



Statistical Data Analysis

	Mean (K)	Mean (°C)	Mean (°F)	Std. Deviation	Skewness	Kurtosis
Actual (NOAA)	289.56	16.56	61.808	-	0 (Ideal)	3 (Ideall)
Raw Data, 1 file	230.4414	-42.5586	-44.6055	250.4718	-4.6651	22.9795
Zero, 1 file	270.5826	-2.4174	27.6487	60.0707	-3.6740	16.7212
NaN, 1 file	281.0071	8.0071	46.4128	24.0574	-1.5364	4.9970
1st Interpolation, 1 file	281.0342	8.0342	46.4616	24.5711	-1.3761	4.6975
2nd Interpolation, 1 file	280.4427	7.4427	45.3969	23.9561	-1.4853	4.7952
2nd Interpolation (July 2004)	281.1152	8.1152	46.6074	24.3224	-1.4605	4.6350
Area Weights (July 2004)	290.4063	17.4063	63.3313	-	-	-

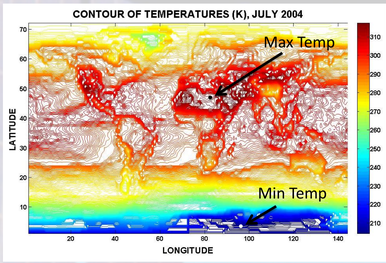
The table shows the numerical progression after various methods of validation were applied in MATLAB.

Discussion/Conclusion

Based on our results, the Earth's surface temperature seems to follow a Gaussian distribution trend. As more precise methods of outlier removal and correction were applied, the histogram for temperature distribution became increasingly similar to the normal distribution curve. The best results came after the interpolation method was used. Although the theoretical values for skewness and kurtosis were not achieved, their measurements were closely approximated, as shown in the table.

Visually, the improvement in correction can be seen through the contour plots. As more levels of correction were applied, the contours became clearer. Due to the difference between land and water temperature, coastlines are distinct and differentiable, creating a map of the world. From the contour of the raw data, the picture is very blurred as contours are not precise due to the large outliers. In contrast, the interpolation contour creates a picture where all the continents, as well as notable points on the Earth, are distinguishable.

As expected, the highest temperature is shown in North Africa while the lowest is in Antarctica.



Statistically speaking, after factoring in area weights for different positions on the Earth, a mean temperature of 290.41 K was calculated, which is within 0.3% error of the actual value, 289.56 K (NOAA).

This method of data validation can be extended to be applied to any period of time as well as various measurements in the form of matrices.

References

1. Jensen, John R. (2007) *Remote Sensing of the Environment: An Earth Resource Perspective*. Upper Saddle River: Prentice Hall.
2. NASA, Retrieved from: www.nasa.gov (July 25, 2014)
3. National Oceanic and Atmospheric Administration. Retrieved from: www.noaa.gov
4. (July 25, 2014)
5. MathWorks. Retrieved from: www.mathworks.com (July 25, 2014)

Acknowledgements

National Aeronautics and Space Administration (NASA)
NASA Goddard Space Flight Center (GSFC)
NASA Goddard Institute for Space Studies (GISS)
NASA New York City Research Initiative (NYCRI)
Dept. of Education – The Alliance for Continuous Learning Environments in STEM (CILES) grant # P031C110158
LaGuardia Community College (LAGCC)

Dr. William Rossow, Distinguished Professor, EE Dept, CCNY
Dr. Jorge Gonzalez, ME Professor, PI of CILES grant, CCNY
Dr. John R.E. Toland, Physics Professor, LAGCC

http://js.defencetalk.com/wp-content/uploads/2010/03/remote-sensing-satellite-system.jpg