USING GPS TECHNOLOGY TO PROBE THE ATMOSPHERE

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ABSTRACT

The following documents the processing and analysis of Global Positioning System (GPS) precipitable water vapor data in various locations in the Mainland US and Hawaii. This idea of using GPS signals to measure an important aspect of the Earth's atmosphere, water vapor, is cutting edge. The hassle of sending up radiosondes twice a day in only a fraction of the world cannot compare to having updated data every few minutes in all parts of the world including oceans.

INTRODUCTION

The Global Positioning System consists of a constellation of satellites that transmit radio signals to large numbers of users engaged in navigation, precise timing and relative positioning. Geophysicists and almost all earth scientists utilize the capabilities of GPS technology. In recent times there has been a surge of interest in the usage of GPS technology as a tool for remote sensing for remote sensing of the atmosphere. This emerging field is called GPS meteorology.

Water vapor interacts strongly with signals that the GPS satellite emits. There is a lack in information of the highly variable water vapor available, thus the popularity of GPS measurements is growing.

When signals from the GPS satellites are sent to the earth-based receivers, the signal experiences certain delays and from those delays the precipitable water values are calculated.

Similar levels of accuracy are obtained with GPS when compared to radiosondes and fine-tuned water vapor radiometers. The number of GPS receivers, whether for navigation or study, are steadily growing and may prove to be of value to future studies of the atmosphere.

METHODS

The data first had to be obtained from a File Transfer Protocol (FTP) site of the University of Hawaii Meteorology Department. CuteFTP is a program that allows one to connect via a modem/internet connection and transfer files from such a site very little effort. At the time, only 1997 and partial 1998 GPS data were available. Mainland and local data files were downloaded and stored on 100mb Zip disks because of their enormous size. Measurements of precipitable water in the atmosphere were taken every

thirty minutes and logged with the corresponding time value either in julian format or twenty-four-hour fashion in two separate columns.

It was decided that it would be best that the data be handled in Microsoft Excel because this program allowed for easy manipulation of data. All files were to be thoroughly examined for missing values and invalid entries (e.g. negative numbers) which would cause discrepancies when part of calculations. Having the time values in twenty-four-hour format was desired so the files with julian time values had to be converted. The precipitable water data was sometimes in inches or centimeters and required conversion to millimeters. Upon the calculation of each mean, the standard deviation from the mean was to also be obtained for testing the quality of the data.

The results would then be saved and visual representations of the data would be created using a very complex program, Matlab and Excel (see Fig. 2). Unlike Excel, Matlab is able to graph each point with its own error bar value (see Fig. 3).

Finally, processed data was compared to specific severe weather cases and rainfall measurements as seen in Figure 1.

DISCUSSION

Files containing the data were so large that it was difficult to pinpoint problems in the measurements. Any missing time values or invalid data would result in the corruption of the results, so the file had to be checked line by line and because each data set spanned over 18,000 rows in an Excel spreadsheet this step in the project took a lot of time. Time had also been taken to learn basic statistical analysis in order to calculate standard deviation from the mean. A previous copy of Excel had been corrupted so reliance on other programs was inevitable. The use of Matlab was unexpected because of the assumption that Excel could handle the set tasks.

CONCLUSION

An archive of analyzed GPS precipitable water data for the mainland US and Hawaii has been established and will continue to grow as more data is made available. General problems with the data have been found to be missing data, obscure values, time-format disagreements and extreme variance in overall structure of the raw data. The belief that large spikes in precipitable water data correspond to rain, severe weather, etc. has been validated further through this study.

ACKNOWLEDGMENTS

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FIGURES

Figure 1. Comparison of rainfall data and PW data.

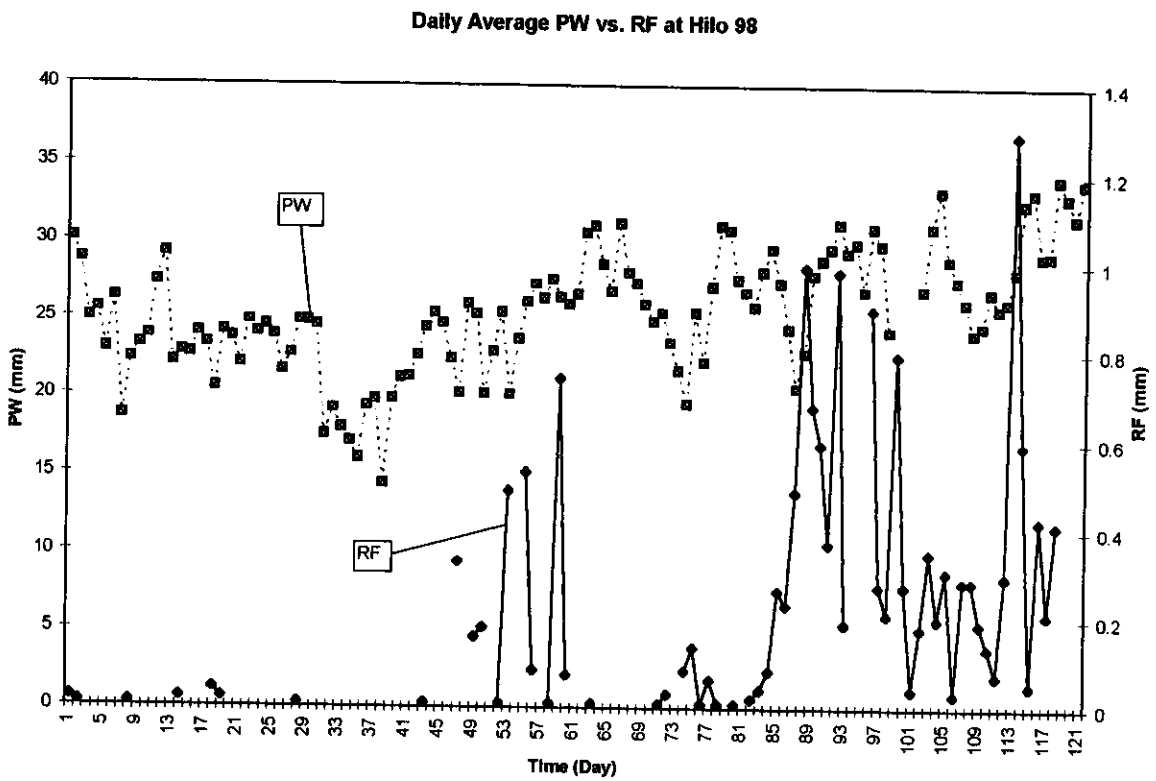


Figure 2. One full year of quality controlled data..

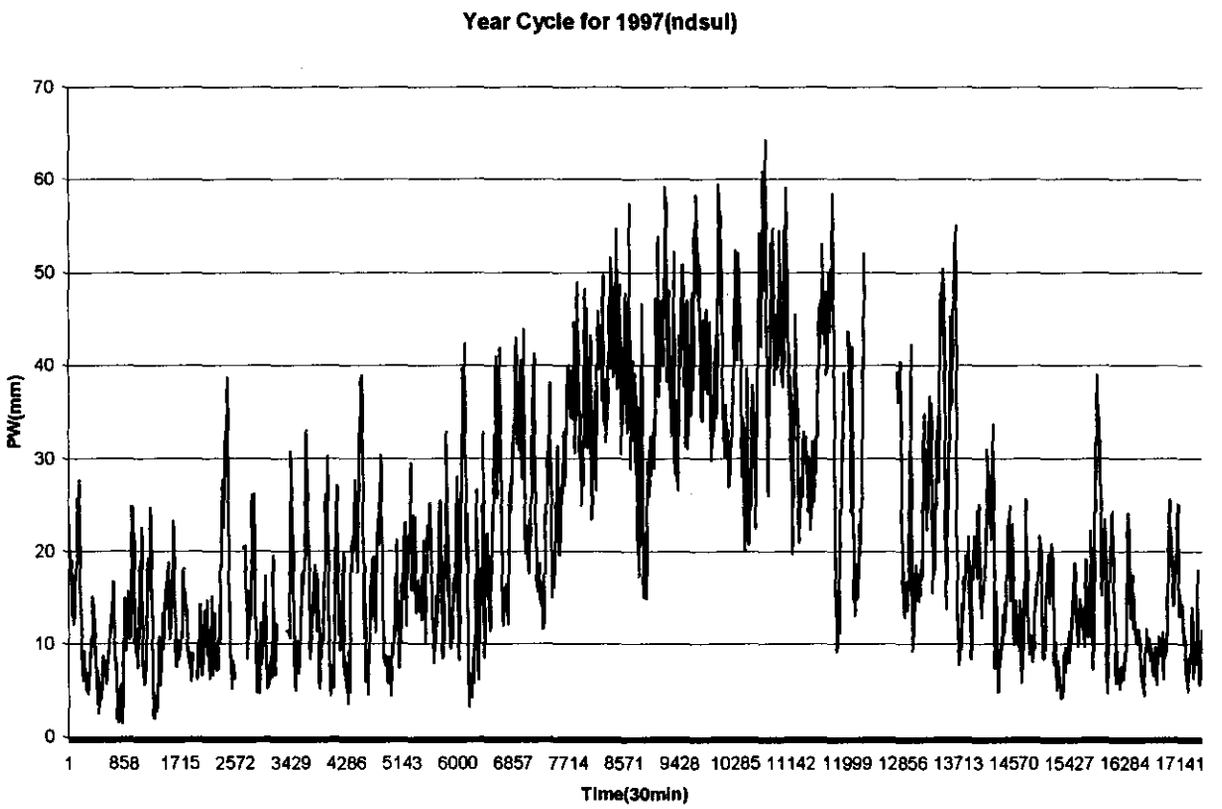
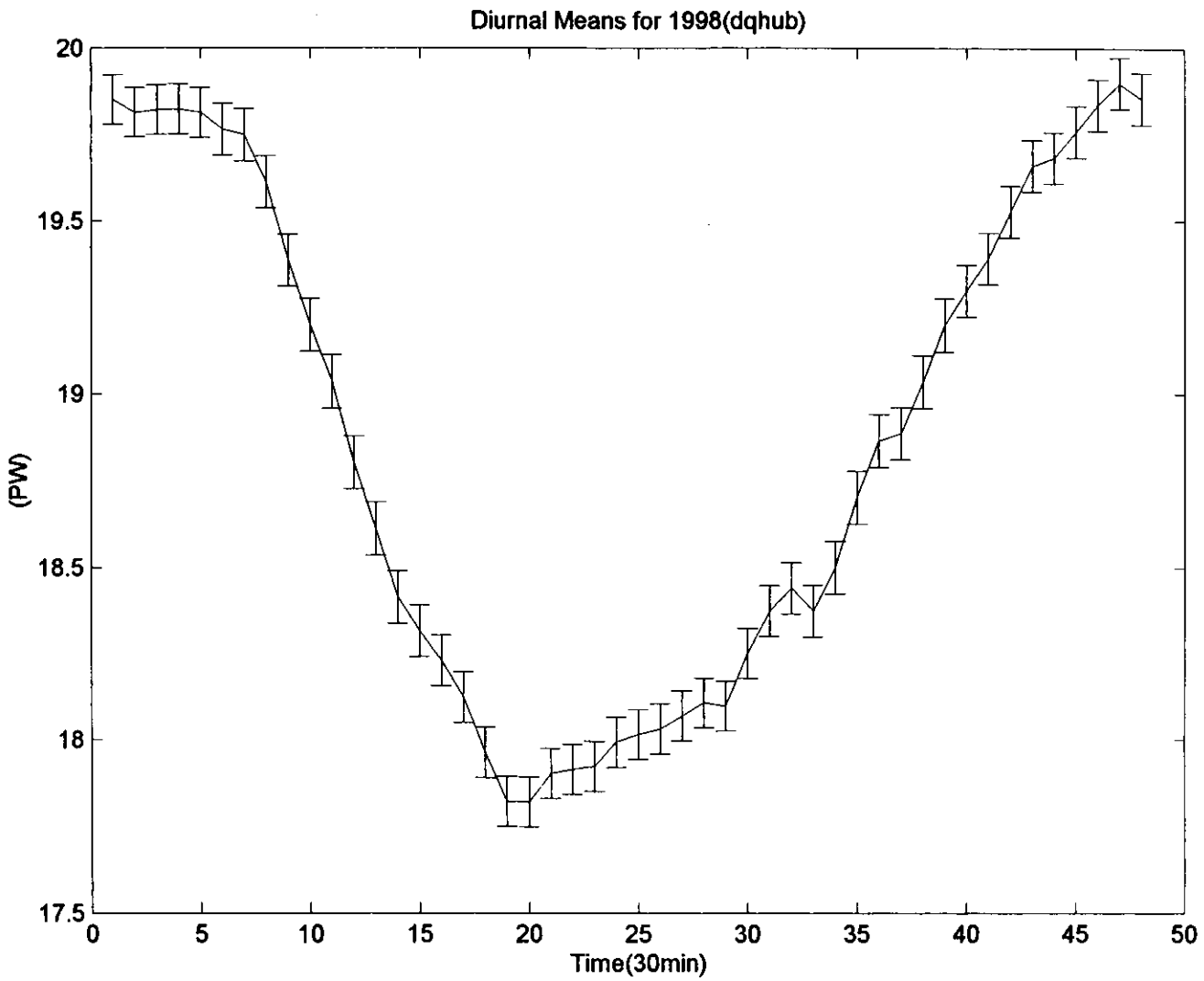


Figure 3. Diurnal means with SDM using Matlab (on next page).


Diurnal Means for 1998(dqhub)
20
19.5
19
18.5
18
17.5
(PW)
0
5
10
15
20
25
30
35
40
45
50
Time(30min)