P2.5 A REGIONAL COMPARISON OF GPS ATMOSPHERIC MOISTURE MEASUREMENTS AT PLYMOUTH AND BARTLETT, NEW HAMPSHIRE

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1. INTRODUCTION

GPS measurements of atmospheric water vapor in the form of integrated precipitable water (IPW) have proliferated worldwide. In the U.S., the National Oceanographic and Atmospheric Administration's (NOAA's) Forecast Systems Laboratory (FSL) has deployed an expanding, nationwide, demonstration network of GPS sensors that is fully operational and is being incorporated into the National Weather Service's suite of graphical products (Gutman, 2001). One of the FSL sites is located at Bartlett, NH (BARN) at a Mount Washington Observatory research facility. Dumont and Zabransky (2000) examined the first three months of IPW data from the Bartlett site comparing them to measurements from regionally surrounding radiosonde stations in the Northeast. In general the data compared very well with correlation coefficients for both 00Z and 12Z around 0.92. However, occasional significant departures of a mesoscale nature were evident in the GPS data.

Recently, the National Science Foundation funded the University NAVSTAR Consortium (UNAVCO), a network of colleges, universities and research institutions, to field the SuomiNet Program. The SuomiNet Program is designed to further spread the use of the GPS system in both geodetic positioning and atmospheric moisture measurements for both educational and research purposes (Ware, 2000). The combination of FSL and SuomiNet sites should provide a rather dense network of atmospheric moisture sampling around the country and particularly in the Northeast. Data generated by SuomiNet participants, however, should be viewed experimental in nature.

Plymouth State College (PSC) first committed to participating in the SuomiNet Program in 1999 and is now actively transmitting data to Boulder. PSC's installation is designed for atmospheric moisture measurements only.

2. SYSTEM INSTALLATION

SuomiNet is a cost sharing arrangement between individual participating institutions and the NSF. To that end PSC was responsible for installing a grounding system for the outdoor antenna mount and purchasing the meteorological package (metpack) which was obtained from Paroscientific, Inc. The metpack provides supportive pressure, temperature and relative humidity data in order to convert GPS measurements into IPW values. The NSF funded (through UNAVCO) the Trimble GPS antenna and receiver, a pre-configured computer as well as cabling. At PSC, the GPS and metpack were installed on a guyed mast atop the science building (Boyd Hall). Cabling was strung through a dormant ventilation duct to the receiver and computer in a room immediately below the rooftop where the computer was connected to the Internet. Installation was complete on July 10, 2001 when data transmission began.

3. DATA COLLECTION AND ANALYSIS

This study is limited to the initial seven-week period of data collection at Plymouth from 11 July to 31 August 2001. GPS data are sampled every 30 seconds and metpack data are sampled at five-minute intervals. The data are collected continuously and placed in binex form for hourly transmission to UNAVCO in Boulder. In Boulder the data undergo processing, including quality control, half-hourly averaging, conversion to netCDF format and insertion into the Local Data Management (LDM) queue on the SuomiNet server. The PSC LDM is programmed to scan the SuomiNet server periodically for any new files and downloads them.

The downloaded files, in netCDF format, are converted to a simple text format using a post-ingestion FORTRAN reader program developed at Unidata. This process allows the data to be saved in a spreadsheet for analysis.

Bartlett data are downloaded as half-hourly averages from the NOAA/FSL Ground-Based GPS-IPW Demonstration Network website using their Data Displays tab and PWV plot. These data, after being saved as unformatted text, are conveniently read by the spreadsheet program.

The spreadsheet was then used to create scatter plots, determine correlation coefficients and standard errors of estimate. The data were also separated into four-day intervals to conveniently view trends and allow for an easy comparison of Bartlett and Plymouth data during specific synoptic events.

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4. RESULTS

SuomiNet IPW values, shown in Figure 1 correlate well with FSL IPW from Bartlett. Some outliers can be identified as synoptic phenomena whereas others cannot be identified and may be associated with mesoscale or micro-scale phenomena. Even with these smaller scale situations, a correlation coefficient of 0.89 (Table 1) demonstrates that the experimental SuomiNet data compare quite favorably to the Bartlett data given the 56km separation in locations. In fact, Table 1 indicates that all of the variables used to calculate IPW at Plymouth correlate well with FSL data at Bartlett. Smaller differences of a few tenths of a centimeter may very well relate to differences in the way that orbital calculations are done by FSL and UNAVCO.

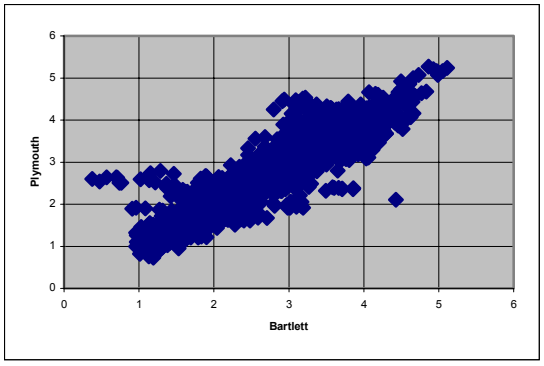

FIGURE 1. Scatter plot of GPS-derived IPW (cm) at Plymouth and Bartlett, NH (11 July to 31 August 2001).

TABLE 1. Correlation coefficients (**r**) from a comparison of IPW, pressure, temperature, and relative humidity at Plymouth and Bartlett, NH (11 July to 31 August 2001).

	IPW	Pressure	Temperature	R.H.
r	0.89	0 .99	0.97	0.92

Typical of the study period is the four-day trend of IPW shown in Figure 2 (20-23 August 2001) at both Bartlett and Plymouth. For the most part synoptic conditions were quite similar at both Plymouth and Bartlett. The small departures, beginning at approximately 0Z on August 23, may be representative of mesoscale differences between the two sites.

One of the aforementioned outliers in Figure 1 was identified as a synoptic difference between Bartlett and Plymouth. In this case, a weak, slow-moving cold front was stretched across north-central New Hampshire from August 3 to August 4, 2001. Cloudiness and scattered precipitation were evident in southern and central New Hampshire whereas mostly overcast conditions were reported at Mount Washington and in northern New Hampshire. Indicative of the frontal zone is a strong north-south dew point gradient at 21Z on August 3, 2001 (Figure 4) suggesting that the Bartlett site would be drier than Plymouth. This gradient is consistent with the IPW seen in Figure 3 after 12Z on August 3, 2001. This condition lasted until 15Z on 4 August when the front had passed to the New Hampshire coast.

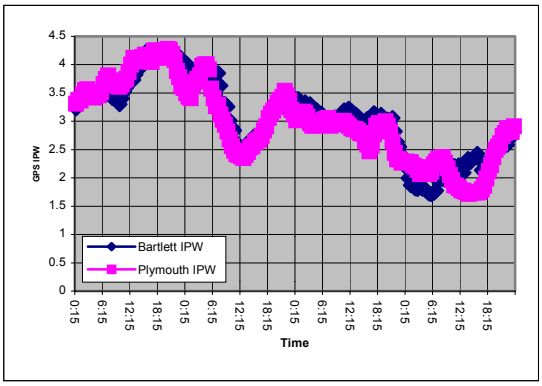

FIGURE 2. Four-day trends (20-23 August 2001) comparing IPW at Plymouth and Bartlett, NH. (Time in UTC)

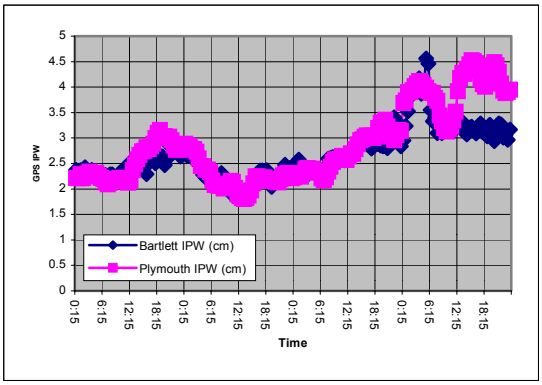

FIGURE 3. Four-day trends (31 July – 3 August 2001) comparing IPW at Plymouth and Bartlett, NH. (Time in UTC)

5. DISCUSSION

The SuomiNet GPS network is only now becoming deployed at the participant institutions. Full deployment may be a year off yet. IPW data from the network must be considered experimental and not formally available to use with operational forecast models by the National Weather Service. Nevertheless, given the proximity of Plymouth State College to the operational, NOAA, GPS site at Bartlett, NH, it was considered important to compare the initial data from Plymouth with the data at the Bartlett site.

The analysis showed that both the IPW and metpack data at Plymouth were very consistent with

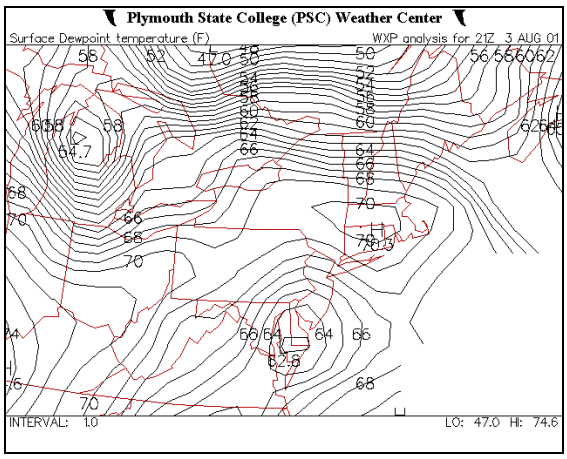

FIGURE 4. Surface dew point analysis (F) for the U.S. Northeast at 21Z on 3 August 2001.

the Bartlett datasets. While overall data trends were highly correlated, it was clear that occasional, short-term differences occurred that could be attributed to regional synoptic variations or mesoscale distinctions. On one occasion, a synoptic situation, involving a slow-moving cold front, was presented to account for significant differences in IPW values between the two sites.

If the early data from Plymouth State College is any indication of the data to be expected from the SuomiNet Program as a whole, the outlook may be very promising for combining, experimentally, SuomiNet and NOAA sites into an effective nationwide network of monitoring stations.

6. ACKNOWLEDGMENTS

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7. REFERENCES

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