1.5 BEWARE OF STITCHING TOGETHER A MESONET

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1. INTRODUCTION

The Pennsylvania State Climate office in cooperation with several state and federal agencies has constructed a network of hourly weather reporting sites across Pennsylvania. These sites include 32 Automated Surface Observing Systems (ASOS) maintained by the FAA plus a handful of new AWOS (Automated Weather Observing System) sites, 82 Roadway Weather Information Systems (RWIS) operated by the Pennsylvania Department of Transportation (PennDOT) and 47 Commonwealth of Pennsylvania Air Monitoring System (COPAMS) sites, which are maintained by the Pennsylvania Department of Environmental Protection (DEP). All reporting stations measure hourly temperature and wind direction and speed. In addition, the office is incorporating the state's approximately 200 hourly precipitation gauges of the Integrated Flood Observing and Warning Systems (I-FLOWS) in the network (see Figure 1). When the National Weather Service's cooperative weather stations, which submit their data daily (about 125 sites) are included with their reports of maximum temperature, minimum temperature and 24-hour precipitation, well over 300 daily observations can be determined for the Commonwealth.

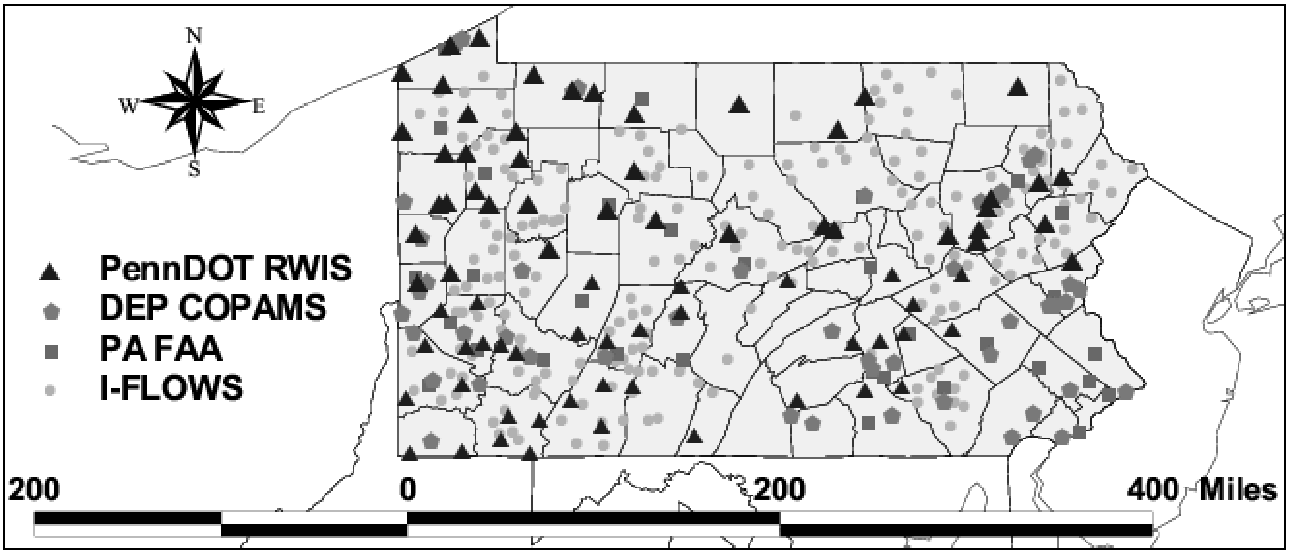

Figure 1: **Stations included in the Pennsylvania Mesonet**

These reports are being stored in a MYSQL database and are being processed each hour for real-time display (http://pasc2.met.psu.edu/hourly) of weather derived parameters including wind streamlines, temperature and dewpoint contours (see Figure 2) and time series displays from each site. The streamlines are being overlaid on a topographic map to discern channeling and air motions over the complex mountain-valley system of the state.

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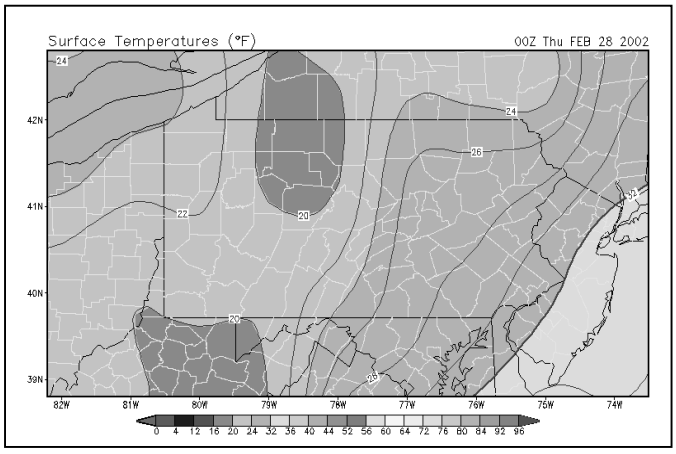

Figure 2: Temperature analysis based on mesonet data

2. NETWORK KNITTING

Utilizing data from a range of institutions to serve the function of a meteorological mesonet has presented challenges regarding data formats due to the priority of the meteorological parameters measured within each network. These factors are related to the primary purpose of the stations within each network. The FAA's ASOS stations serve the purpose of monitoring surface meteorological parameters in real time. Each ASOS reports in a standardized format (METAR) that has been designed for easy interpretation as it is used by the FAA and National Weather Service to make important aviation and weather forecasting decisions. The I-FLOWS network only reports hourly precipitation, however, measuring this parameter is the sole purpose of these stations. This network is similar to the ASOS in that the data is reported in real-time and in a standardized format that the River Forecasting Center can quickly process to make decisions regarding flooding risks.

Pennsylvania's Department of Transportation (PennDOT) installed 82 RWIS stations along various highways across the state. In an effort to maximize the benefit of the competitors in the RWIS market, PennDOT selected three different manufacturers (Nu-Metrics, SSI and Boschung) to provide, install and maintain units across various regions of the Commonwealth. All three types of the systems (RWIS) serve the primary objective to monitor the conditions of the roadway surfaces and secondarily to monitor the atmospheric conditions. A majority of the sensors that are used on an ASOS are also present on the RWIS stations. However, variables vital to a surface weather observation mesonet, such as air pressure and rainfall accumulation, are not available from these 82 hourly stations. Nonetheless, the absence of these two parameters is compensated by an abundance of roadway surface, and subsurface parameters, such as temperature, condition of ground (snow cover, icy, wet) and average speed of vehicles. This data can be applied to conduct research on the effects of adverse weather on public transportation. This large volume of information obtained from each RWIS observation in conjunction with the proprietary nature of the output by each manufacturer of RWIS, such as number of highway lanes at each station, units of visibility, wind variables and methods of reporting weather phenomena, has lead to three varying formats of data output within this single network.

The final member of the network includes data from the Pennsylvania DEP's COPAMSs. As with the RWIS network, these sites record meteorological data secondarily, since the primary function of the stations is to monitor the air quality across the state. Quantities such as sulfur dioxide, ozone, carbon monoxide, nitrogen oxides and others outnumber the standard surface weather parameters of temperature, wind speed and direction and solar radiation. Meteorological parameters do play a vital role with the DEP, however, the transport of pollution through the air is monitored with a very high degree of interest.

3. QUALITY CONTROL

After deciphering the unique formats from each data source, PERL scripts were written to transfer the data from a flat file into a MYSQL relational database on a hourly and even half-hourly basis. One issue that arose here was the determination of which parameters to collect from the different networks. First, it was necessary to confirm the routine collection of the parameter by all of the instruments within a network. This allowed for an adequate spatial representation of the data across Pennsylvania and provided enough of a database to perform quality control using neighboring sites within the network. For a parameter to be chosen, it needed to augment general surface observations, climatology, forecast verification, modeling, or the welfare of the general public. Nineteen parameters met this criteria (see Table 1) and are collected in the database as frequently as available to the State Climate Office.

Temperature	Wind Speed	Accumulated Precipitation	Roadway Surface Temperature
Dewpoint	Wind Gust	Precipitation Rate	Roadway Surface Conditions
Relative Humidity	Visibility	Cloud Cover	Roadway Average Speed
Air Pressure	Ceiling	Weather	Solar Radiation
Wind Direction	Snow Depth	Subgrade (17") Temperature	

Table 1: Parameters collected on an hourly basis

The matter of data flow quality proved more challenging than expected. The primary factor was the means of communication of the data from the sensor to a central location. Information obtained from the automated I-FLOWS satellite system and the surface airway reporting system used by the ASOS

network regularly report on an hourly basis, in real time. The observations taken at the COPAMS's and RWIS's however, use external modems to communicate with their respective control centers. This has led to delays in the observations so that the COPAMS's reports arrive 90 minutes after the observation is taken while the RWIS's average a 30 minute to one hour delay depending on the time the 'call' out was made. This can hamper production of real-time products which are useful in nowcasting hazardous weather and highway conditions. A second drawback to using modems and traditional telephone lines is their lack of reliability in hazardous conditions when the observations are in highest demand. Another drawback of the RWIS network is that each of the three manufacturers transmits their data through a different method to a central computer at PennDOT. This adds another link between the observing station and the State Climate office database increasing the risk of communication failure. Table 2 shows the large difference in the number of observations taken by each RWIS station over a set time period.

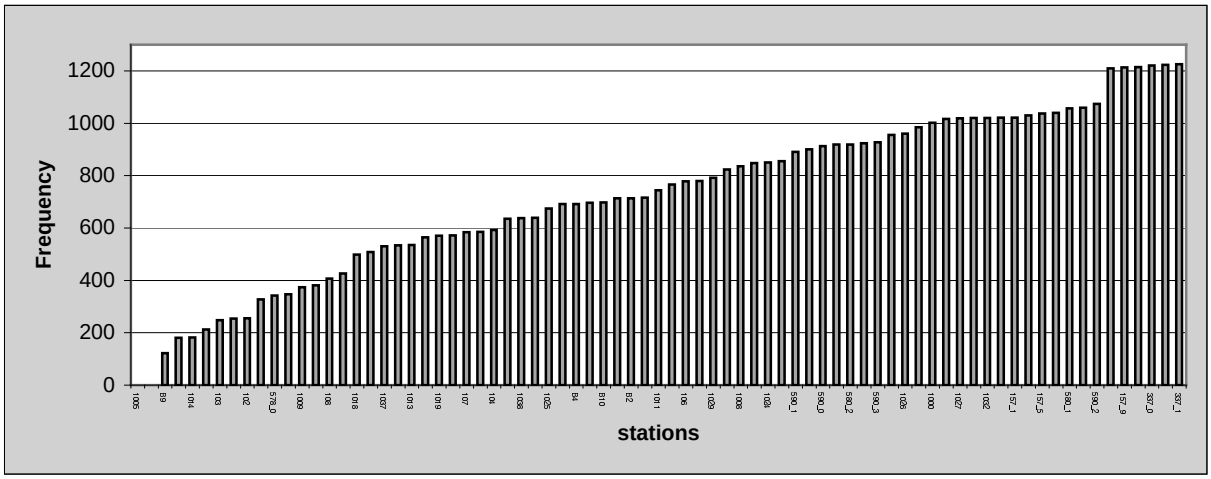

Table 2: Frequency of observations taken by RWIS network during 1 month

The final issue of data flow regards the RWIS stations' reliability during the seasons when the DOT is not in need of the observations. A gradual increase of reporting stations and frequency was noticed from the summer of 2001 through late winter 2002, at which time nearly 82 stations are regularly reporting data. If this number should decrease as the weather is less likely to affect DOT's activities then a large number of reporting sites could cease to report.

Besides these issues, there are still concerns of instrument siting and calibration which can add further errors to the quality control process.

Once the data quality is assured there is a goal to make it available for all involved parties. Early applications include thermal mapping and plotting critical isotherms for the Department of Transportation, wind streamlines for the Department of Environmental Protection to easily track airborne pollutants, development of a micro-climate database in the Office of the State Climatologist along with verification of warnings for the National Weather Service and more detailed mesoscale initial conditions for the forecasting community in Pennsylvania.