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AN ALGORITHM TO ELIMINATE PRECIPITATION REPORTS CAUSED BY SURFACE CONDENSATION IN AEV-ASOS DATA

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1. INTRODUCTION

Quality control of forecasts and verifying observations is part of the normal processing of the AFOS-era verification (AEV) data. Ideally, data are checked for errors at the local National Weather Service Forecast Office (NWSFO) prior to being transmitted to the central collection site at the National Centers for Environmental Prediction (NCEP) in Camp Springs, Maryland. To ensure that a variety of problems have not caused contamination of the data, automated quality control is also administered by the Techniques Development Laboratory (TDL) at the central site prior to generating verification scores. These checks of the data are done with the concurrence of the verification program manager in the Office of Meteorology.

At times, close monitoring and special processing of the data have been necessary. Specifically with regard to precipitation amount, observations collected by the Automated Surface Observing System (ASOS) have not been reliable under certain circumstances. For example, ASOS sometimes reports the occurrence of measurable precipitation when dew forms on the tipping bucket rain gauge. In order to eliminate such erroneous precipitation amount observations from the AEV database, manual editing of the data at the local NWSFO has been particularly important. To provide additional assurance that the central AEV data archive contains accurate data, TDL's automated quality control system checks and eliminates certain observations. In the past, this was done by setting entire blocks of precipitation amount observations to missing for specific stations and/or time periods. As a long-term solution, this approach was undesirable because many good observations were eliminated in order to remove a small number of spurious reports. In addition, the central quality control software had to be told, a priori, the stations and time periods for which data should be set to missing in order to quality control the observations in this manner.

Concerns voiced by NWS forecasters about the quality of verification results led us to devise a new algorithm to eliminate false reports of 0.01 inches of precipitation at AEV ASOS sites. Beginning with the 1996 warm season, an additional step was added to our AEV quality control procedure to automatically check all reports of 0.01 inches of precipitation collected by ASOS on a case-by-base basis. This check was designed to identify suspicious observations and to modify the values based on the results of the algorithm.

2. DESCRIPTION OF ALGORITHM

The precipitation check algorithm examines the observed meteorological data at the AEV ASOS station in order to evaluate whether a precipitation report of 0.01 inches in the AEV database is spurious. TDL's archive of hourly surface observations is used to supply the input for the algorithm. In addition, we decided that observations from a nearby site would be helpful in determining whether the reported precipitation at the AEV site was accurate. We identified for each AEV ASOS station a nearby "companion" site whose hourly observations would be used to corroborate the ASOS site's precipitation reports.

This companion station was preferably one where manual observations were still collected. Often, the companion station was a military site located in the same city or in close proximity to the ASOS station. If a suitable site could not be found, we accepted as a companion site any "nearby" manual station. Because some regions of the country were void of manual stations for a radius of several hundred miles, another ASOS station was occasionally chosen as the companion. In the worst cases, the selected companion sites were also ASOS stations and were located farther away than we considered ideal. For AEV sites where manual observations were still available, we did not check the precipitation amount observations.

For all AEV ASOS sites, we extracted from the AEV database the 12-h precipitation amount observations. From TDL's hourly observation database, we extracted for these same sites the two 6-h precipitation amount reports that should sum to the 12-h precipitation amount. We also collected the present weather, temperature, and dew point observed every hour during the 12-h period. Finally, the 6-h precipitation amount observations and the hourly present weather for the companion sites were obtained.

The precipitation check algorithm performs three tests on the data from the AEV ASOS stations. The algorithm begins by identifying cases where the 12-h AEV precipitation observation is equal to 0.01 inches. When such a report is found, the companion site's precipitation report is also checked for the same time period. If the companion station reports precipitation, then the AEV report of 0.01 inches of precipitation is kept and the quality control procedure ends. If, however, the companion does not report precipitation, a second test is performed.

During the second test of the algorithm, the two 6-h precipitation reports that comprise the 12-h observation are used to specify the 6-h period in which the precipitation event occurred. These two 6-h precipitation reports are checked to ensure that they sum to 0.01 inches. If they do not, we set the AEV 12-h precipitation report to missing, and the algorithm ends. If the two 6-h reports do sum to 0.01 inches, we examine all of the hourly present weather observations for both the station in question and the companion station during the 6-h period encompassing the precipitation report. If precipitation (for example, a rain shower) is observed at any hour for either station, then the AEV precipitation report of 0.01 inches is kept, and the quality control procedure ends. If neither station reported weather during the 6-h period, a final test is performed.

For the final test, the AEV ASOS station's dew point depression for each hour during the 6-h period is examined. If the dew point depression remains above 2°F, the AEV precipitation report of 0.01 inches is kept. We felt that this allowed us to retain the AEV ASOS precipitation report whenever possible. If, however, the dew point depression becomes less than or equal to 2°F during the 6-h period, the report of 0.01 inches is changed to 0.00 inches. At this point, we've concluded that precipitation has not occurred and that the AEV report is erroneous. This is not to say that precipitation does not occur with dew point depressions less than or equal to 2°F. But, as discussed in the next section, light precipitation usually occurs when dew point depressions are greater than 2°F. This result, along with the results from the first two tests of our algorithm, established our confidence in changing the data.

3. DEVELOPMENT OF ALGORITHM

In developing the quality control algorithm, we tested the procedure by examining other precipitation amount totals, such as 0.02 inches, 0.03 inches, and so on, but decided that the final algorithm should only consider observations equal to 0.01 inches as potentially erroneous. This means that precipitation reports of greater than 0.01 inches caused by dew or condensation on the gauge are neither checked nor modified by the quality control software. Traces of precipitation are not affected by the quality control procedure and are counted as no precipitation when verifying probability of precipitation (PoP) forecasts.

To determine the threshold for the dew point depression used in the algorithm, we examined hourly weather reports at 170 sites for April 1996 through January 1997. These sites included ASOS, military, and manual observing stations. Whenever a 12-h precipitation total exceeded 0.00 inches, we checked the present weather report at each of the 12 hours. If precipitation (for example, a rain shower) was observed at a specific hour, the dew point depression was noted. For events resulting in trace amounts of precipitation, 76.3% had dew point depressions greater than 2°F during the hour that precipitation was reported as the present weather. In addition, 62.8% of all precipitation observations resulting in precipitation amounts of 0.01 inches occurred with dew point depressions greater than 2°F. Therefore, we concluded that light precipitation events were usually characterized by dew point depressions greater than 2°F. In contrast, all dew theoretically occurs with dew point depressions of close to or equal to 0°F. In addition, we found that virtually all fog events investigated were characterized by dew point depressions of less than or equal to 2°F. Therefore, we felt confident that by using a 2°F dew point depression in the algorithm, we could differentiate between erroneous ASOS precipitation reports caused by fog or dew and true precipitation reports.

Other meteorological variables, such as cloud cover and obstruction to vision, were also tested for their value in our algorithm. Cloud cover was found to be ineffectual in determining the occurrence of precipitation due to its variable nature during a given 6-h period. The obstruction to vision value in the hourly meteorological observations was also found to be ineffective in the algorithm. Virtually all fog reports were accompanied by dew point depressions of 2°F or less, and therefore, this information was redundant to the information gathered from the dew point depression test.

In light of the above considerations, we acknowledge a specific scenario which could result in valid precipitation observations being identified as dew or condensation by the algorithm. Suppose that a precipitation event of 0.01 inches occurs between hourly reports (i.e., a rain shower starts after the top of the hour, but stops before the top of the next hour). Then suppose that the dew point depression falls to 2°F or less during one of the subsequent hours included in the 6-h time frame being investigated. The algorithm would falsely identify this precipitation as spurious, and would replace the report with 0.00 inches.

4. RESULTS

Using our new algorithm, we checked the AEV ASOS precipitation amount observations for the period April 1996 through December 1996. During this period, there were 1522 12-h precipitation reports of 0.01 inches (roughly 3.4% of the total sample of 12-h reports). More importantly, this subset of 1522 cases accounted for 16.6% of the 12-h reports in which measurable precipitation was reported. The algorithm identified 263 of these cases as reports caused by surface condensation and changed them to 0.00 inches. In addition, 39 reports were found to be indeterminate and were changed to missing. Of the 263 cases identified as erroneous, we randomly selected 10 cases and manually examined the appropriate hourly observations. We concluded that the AEV observations were indeed suspicious and were likely due to dew or fog.

In addition, we were able to identify 60 cases during the period April through September 1996 in which the ASOS report of 0.01 inches of precipitation was changed to 0.00 inches during the NWSFO's manual quality control of the AEV data. Our automated quality control algorithm was in agreement with all but one change. In other words, if the manual quality control procedure had missed those suspicious observations, the automated precipitation check algorithm would have successfully changed the report in over 98% of the cases.

Additional evidence to support the use of the algorithm was found when we examined the local and NGM-based MOS PoP forecasts valid for the 12- to 24-h period for a sample of the events when the algorithm changed the observed 0.01 inches of precipitation to 0.00 inches. One station, namely, Fresno, California, stood out by virtue of the large number of suspicious precipitation observations. The precipitation-checking algorithm identified 16 events where a precipitation report of 0.01 inches should be changed to 0.00 inches at that station. Table 1 displays the results of this investigation. As indicated by the low PoPs on all occasions, we believe the algorithm was effective in removing the spurious observations.

As expected, there was also evidence of events where the precipitation reports appeared to be changed incorrectly. For instance, Table 2 shows the precipitation reports changed by the algorithm and the corresponding local and NGM-based MOS PoP forecasts for Charleston, South Carolina. Note that in 3 of the 8 cases, the local PoP forecast was 50% or greater. Therefore, it is likely that some of the ASOS reports of 0.01 inches were, in fact, accurate.

These results prompted us to investigate the forecast PoP's of 112 cases (of the original 263) where the algorithm changed the precipitation report to 0.00 inches. We found the following results: 86.6% of the cases had local PoP forecasts of less than 50%; and 65.2% of the cases had local PoP forecasts of less than or equal to 10%. If we assume that the algorithm correctly changed the precipitation amount from 0.01 inches to 0.00 inches only when the local PoP was less than or equal to 10%, the algorithm made the wrong decision about 35% of the time. We suspect the actual false alarm ratio is much less than 35%, but probably greater than 15%.

Table 1. MOS and NWSFO 12- to 24-h PoPs valid for Fresno, California, for events in which 0.01 inches of precipitation were reported in the AEV data but were set to 0.00 inches by TDL's quality control algorithm.

Date	24-hr MOS PoP %	24-hr Local PoP %
11/03/96	10	0
11/09/96	0	0
11/10/96	0	0
11/11/96	0	0
11/13/96	5	0
11/18/96	20	0
11/23/96	0	0
11/24/96	5	0
11/26/96	0	0
11/27/96	0	0
12/06/96	30	0
12/07/96	0	0
12/13/96	10	0
12/15/96	0	0
12/24/96	0	0
12/27/96	30	0

Table 2. Same as Table 1, except for Charleston, South Carolina.

Date	24-hr MOS PoP %	24-hr Local PoP %
4/22/96	10	10
5/08/96	10	20
6/16/96	20	30
8/01/96	60	60
8/03/96	40	50
8/07/96	40	50
9/12/96	5	0
9/25/96	10	0

5. CONCLUSIONS

In order to eliminate erroneous ASOS precipitation observations equal to 0.01 inches from the AEV database, we devised an algorithm to check the AEV ASOS precipitation observations equal to 0.01 inches and to set suspicious values to 0.00 or missing. Use of this algorithm allows us, on a case-by-case basis, to identify and eliminate many of the relatively small number of erroneous precipitation reports caused by ground condensation. While we acknowledge that the algorithm likely accepts some erroneous cases of precipitation equal to 0.01 inches and sets to 0.00 inches (or missing) some legitimate values of 0.01 inches, we think that, overall, the quality of the AEV precipitation verification is improved by the use of the algorithm.

6. FUTURE WORK

Reports of precipitation are used to develop the statistical equations required to predict the probability of precipitation and precipitation amount. Erroneous observations will likely lead to poor forecast equations. We are continuing efforts to develop quality control algorithms that will eliminate other problems in the ASOS reports, for example, false precipitation associated with melting snow. Eventually, we will do all of the quality control in the processing of our hourly observation data; at that point, the AEV reports will simply be checked against our archives of the hourly data and what we have deemed to be “truth.”