8.7 PROGRESS TOWARDS DRIZZLE DETECTION ON ASOS

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1. INTRODUCTION

ASOS stations currently do not report drizzle unless a human augments the observation. This is due primarily to the fact that when the National Weather Service (NWS) procured the LEDWI precipitation identification sensor, the specification required only that the sensor be able to distinguish between rain and snow at precipitation rates greater than .254 mm/hr (0.01 inch/hr). Drizzle generally occurs at precipitation rates less than 0.01 inch/hr. Thus, there was no requirement that LEDWI be able to detect drizzle, or to distinguish between drizzle and rain at rates greater than 0.01 in/hr. Furthermore, it was generally believed that the LEDWI sensor would have difficulty detecting precipitation particles that had diameters smaller than about 1 mm, since this is the height of the horizontal slit aperture in the receiving lens. Drizzle particles are defined as having diameters of 0.5 mm or smaller. As a result, the NWS is currently seeking a means to upgrade the ASOS stations so that they are able to detect and report drizzle when it occurs.

Recent papers by Wade (2000a) and (2000b) have shown that when drizzle is occurring that there is, in fact, useful information in the LEDWI 1-minute raw channel data that can be used to distinguish drizzle from rain and snow. The problem is that these signals are relatively weak, and that they look similar to signals produced by clear-air (index of refraction) turbulence. To distinguish the drizzle signal from these other signals it is necessary to combine the LEDWI data with output from other ASOS sensors.

During the past year an algorithm was developed that uses the LEDWI 1-minute channel data, in combination with data from other ASOS sensors, to detect when drizzle is occurring. This algorithm is currently being tested on LEDWI sensors at the NWS Research and Development site at Sterling, VA (SRD). The purpose of this paper is to describe the algorithm and to show how it performed during a drizzle event that occurred at the SRD site on 21 May 2001.

2. CLIMATOLOGY OF DRIZZLE CONDITIONS

A study of drizzle conditions was conducted on a 30-year data set (1961-1990) obtained from NCDC. Observations from 277 stations were analyzed for this period. The results show that 95% of all drizzle events (including freezing drizzle) occurred with ceilings below 2000 feet, and that 80% occurred with ceilings below 1000 feet. Similarly, 90% of all drizzle cases occurred with temperature-dew point spreads of less than 4 degrees Fahrenheit, and 70% occurred with a spread of less than or equal to 2 F. Visibility was also reduced to less than or equal to 3 statute miles in 70% of the observed drizzle cases. This information is useful in developing an algorithm to distinguish drizzle from clear-air signals observed by LEDWI.

3. THE DRIZZLE ALGORITHM

There are two parts to the drizzle algorithm. The first part looks at the weather being reported from other ASOS sensors to see if drizzle conditions are present. The current algorithm being tested at the NWS SRD site includes a requirement that ceilings be overcast below 2000 feet, and that temperature-dew point spreads be less than or equal to 4 F. This a somewhat loose requirement and could be tightened in the future to require that ceilings be overcast below 1000 feet and that temperature-dew point spreads be less than 3 F. Also, a requirement could be added that visibility be less than 6 SM. It is not uncommon to see very light rain being incorrectly reported as drizzle by some observers, and these tighter requirements might be necessary to reduce the chances of this happening.

If these conditions are met, the drizzle algorithm then examines the raw 1-minute data from the LEDWI sensor. LEDWI has three channels that are used in precipitation detection: the Low, Particle and High channels. Typically the Particle channel, which provides an estimate of particle size, is the first channel to show an elevated signal when precipitation begins to fall. If the Particle channel determines that precipitation may be occurring, LEDWI software then examines the difference between the High and Low channels to determine if the precipitation is rain or snow. If the precipitation is very light the LEDWI software may be unable to determine precipitation type. In this event LEDWI reports UP (Undetermined Precipitation).

LEDWI maintains a running 20-minute average of the value in each of the 3 channels, and these values are recorded in a set of 3 reference or baseline channels. When the difference between the current value in the Particle channel and the value in its reference channel exceeds 56, the channel is locked "on", meaning that precipitation is likely occurring. From this point forward the reference channel is locked to its most recent value and is not allowed to change until the difference between the two channels

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decreases to less than 28. If the difference decreases to less than 28, the Particle channel is turned “off” and the value in the reference channel is then allowed to float as a function of the previous 20 minutes of data.

The distinction between the Particle channel being “on” or “off” is very important. When it is “on” the software is essentially saying that ‘I think precipitation may be occurring, let’s look at the values in the High and Low channels to see if it is rain or snow’. Thus, the Particle channel can be thought of as a “yes” or “no” indicator for when precipitation may be occurring. In the algorithm being tested, if the Particle channel is “on”, the algorithm proceeds; if it is “off” the algorithm stops.

Naturally occurring turbulence and index of refraction variations affect the values of the LEDWI channels and sometimes result in the false reporting of precipitation when none is occurring. To minimize these occurrences the thresholds for setting the channels to their “on” position are set relatively high. Although this reduces the number of false reports of precipitation, it sometimes has the opposite effect of preventing very light precipitation from being detected when it is occurring. Drizzle falls into this category of very light precipitation, and the problem of getting the Particle channel to turn “on” when the drizzle intensity increases very gradually is one of the problems associated with detecting it with the LEDWI sensor.

Once the Particle channel is turned “on” the drizzle algorithm checks the intensity of precipitation that is being reported by LEDWI. If the precipitation intensity is moderate or heavy the algorithm accepts these and terminates for the current minute. If the intensity is light or the precipitation type is unknown, the algorithm computes the following function based on values typically observed in the Low and Particle channels:

$$F1 = Low - (0.25*Particle) + 60 \qquad (1)$$

(For Particle channel values less than or equal to 300)

Generally if F1 is positive the precipitation particles are sufficiently small that they may be considered to be of drizzle size, and the algorithm would report drizzle. If F1 is negative the particles are larger and are likely rain or snow. In this event the algorithm would report the precipitation type detected in the original LEDWI algorithm. This relationship between the Low channel and the Particle channel will be more obvious in the example shown in the next section.

4. CASE STUDY: 21 MAY 2001

On 21 May 2001 a rain and drizzle event occurred at the SRD site near Dulles airport. Figure 1 shows the LEDWI Particle channel data plotted as a function of the Low channel data, for a 24-hour period starting at local midnight, excluding those times when the Particle channel was “off”. The diagram shows that there was a considerable range in Particle channel values for a given value of the Low channel. For example, for a Low channel value of zero, the Particle channel ranged from about 140 to slightly over 400. Since the Particle channel values are correlated with particle size, the data suggest that there was a considerable range in particle sizes that occurred on this day. The larger rain drop-sized particles appear near the right side of the diagram, and the smaller drizzle drop-sized particles appear near the left side of the diagram.

The F1 function was developed in an attempt to divide the points on the diagram into a drizzle region and a rain region. Since the LEDWI has not been calibrated against known particle sizes, the placement of the line separating these two precipitation types is somewhat arbitrary. However, after examining LEDWI data from numerous rain and drizzle cases, it was decided to place the F1=0 line in the position shown in Fig. 1. A linear function was used for F1, although a higher-order polynomial certainly could be used in the future if warranted.

Data points lying to the upper left of the F1=0 line have F1 values greater than zero and are considered to be drizzle. Those lying to the lower right of the F1=0 line have F1 values less than zero and are considered to be rain. The fact that the points are distributed more or less continuously across the diagram suggests that the precipitation on this day may have been rain, drizzle, and rain mixed with drizzle. However, at this point we are only concerned with demonstrating that the points having a positive F1 value are well correlated with periods when drizzle was occurring (as determined by a human observer).

Figure 2 shows a time series of the Particle channel and the F1 function for this event. The types of precipitation recorded by the observer are also shown on the diagram using line segments with arrows on the ends. Just below that line is a line indicating times when the algorithm detected drizzle. The data show that positive F1 values and Particle channel values less than 300 are well correlated with observations of drizzle. Rain (and intermittent drizzle) occurred from 0000 until about 0600, followed by a period of all drizzle from 0600 until 1130. Rain started again at 1200 and lasted until 1400, and was followed 3 periods of intermittent rain and drizzle after 1400.

5. SUMMARY OF DRIZZLE ALGORITHM

The drizzle algorithm is summarized as follows:

If T-Td < 5F AND
If the cloud amount is OVC or VV AND
If the cloud height of VV is < 2000 AND
If LEDWI precipitation is NOT R, R+,S, S+ AND
If the Particle channel is “on”
THEN proceed to the calculation of the F1 function.
F1 = Low – 0.25*Particle + 60.
F1 > 0 means drizzle is likely occurring.
Drizzle intensity is based on the value of the High channel. High < 106 = Light drizzle; High >=106 and < 137 = Moderate drizzle; High > 137 = Heavy drizzle.
High = 106 roughly equals 0.01 in/hr; 137 = 0.02 in/hr.
If any of the checks fails, skip the F1 calculation and report precipitation type as determined by LEDWI

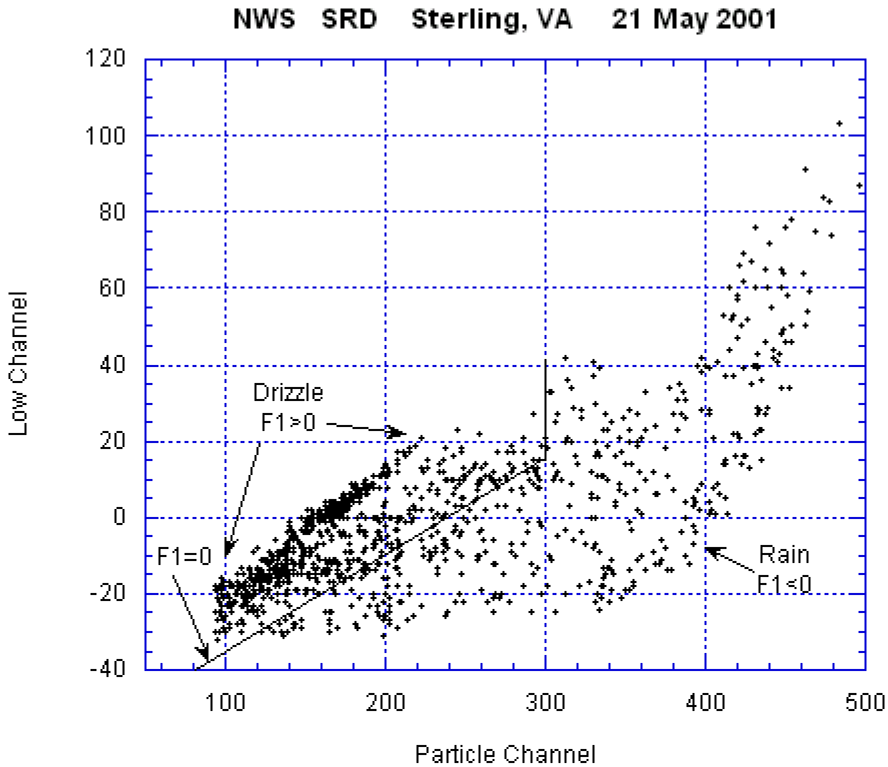

Figure 1. Diagram showing the Particle channel data plotted versus the Low channel data for all minutes when the Particle channel was locked "on". The lines separating the rain and drizzle regions (function F1= Low-0.25*Particle+60=0 and Particle =300) are shown.

6. CONCLUSIONS

The purpose of this paper was to describe an algorithm that was designed to detect drizzle on ASOS stations using information that is already available on the stations. The algorithm uses ceiling height and temperature-dew point information to determine if drizzle conditions may be present (and to minimize those times when turbulence-induced signals may be present). The algorithm then computes a function based on the LEDWI 1-minute data that is designed to detect when small precipitation particles are occurring. If the algorithm detects drizzle it then computes drizzle intensity based on the value of the High channel data.

7. REFERENCES

Wade, C. G., 2000a: A Technique for Improving the Detection of Drizzle and Freezing Drizzle on ASOS Automated Weather Observing Stations. Preprints *9th Conference on Aviation, Range and Aerospace Meteorology*. AMS, Boston, MA. pp 543-546.

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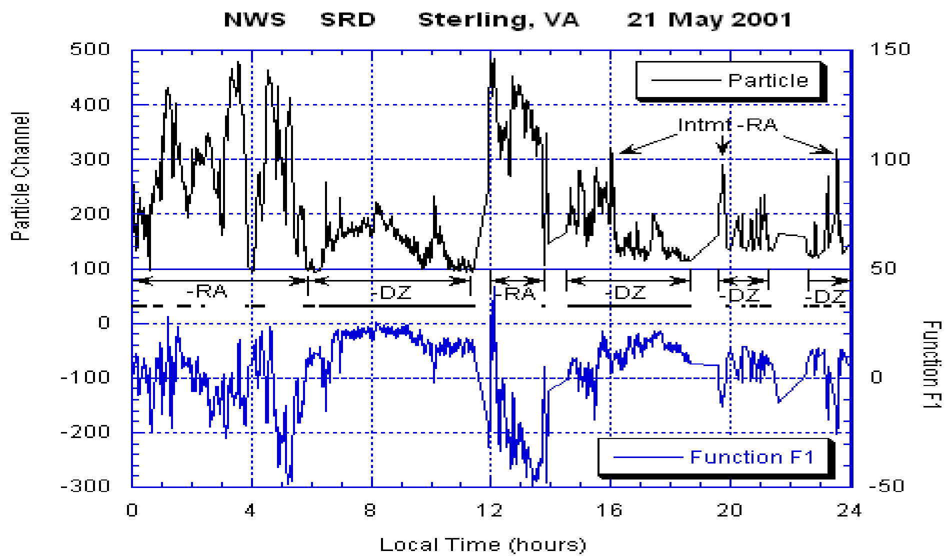

Figure 2. Time series showing the Particle channel and the derived F1 function for SRD LEDWI #614 for 21 May 2001. Periods when rain and drizzle were observed by a human observer are shown with lines using arrows. Periods when drizzle was detected by the drizzle algorithm are shown just below the observer's notes.