National Weather Service Training Center

ASOS Algorithm Tutorial

Pressure Algorithms

Even though Automated Surface Observing System (ASOS) observations look similar to those produced by human observers, ASOS uses automated sensors and logical processes that differ from the human senses. It is important for ASOS users to know how ASOS arrives at its observation values. This and other ASOS algorithm lessons will assist you in understanding these processes.

Lesson Objectives

Upon completion of this lesson you will be able to:

- Describe how ASOS processes pressure sensor data and determines pressure data at the observation site.
- Describe how ASOS uses the pressure data at the observation site to produce each of the following special pressure data:
  - Field Pressure
  - Station Pressure
  - Sea Level Pressure
  - Pressure Altitude
  - Density Altitude
  - Altimeter Setting
- Describe how ASOS produces pressure sensor remarks using pressure data determined at the observation site
- Describe how ASOS produces pressure change and tendency data using pressure data determined at the observation site
- Describe how ASOS produces pressure data for the monthly summary

Lesson Overview

Use these links to move to various sections of this module.

Tutorial Instructions

This tutorial is structured so that you can progress through the primary tutorial material to achieve a basic understanding of how the ASOS pressure algorithm works. At various points throughout the tutorial, review questions are placed to test your understanding of the material. In addition, links are embedded within the tutorial text to provide additional information on specific topics.

Introduction

This is a tutorial on the pressure algorithms used by the Automated Surface Observing System (ASOS). The purpose of this tutorial is to help you better understand what ASOS does in determining pressure and related parameters.

There are three reasons why you need to understand how ASOS obtains atmospheric data and processes this information into reportable values. First, a knowledge of the ASOS algorithms will allow you to better judge data quality and to more effectively conduct on-station quality control of ASOS observations. When ASOS is operating properly, it reports what it senses. Sometimes, however, you might ask: *What is it sensing?* An understanding of how ASOS works will help answer this infrequent question.

The second reason why you need to know how ASOS processes information deals with the system response to rapidly changing conditions. Because ASOS algorithms typically use a time average rather than a spacial average (per the human process), a lag can exist in the ASOS response to rapidly changing weather conditions. You need to know when to expect this type of response from ASOS.

Lastly, ASOS users must realize that ASOS sensors and algorithms have certain limitations built into them. Although ASOS senses basically the same thing as the human observer, there are differences. These differences affect what is transmitted in an ASOS observation. You, as an ASOS user, need to be aware of these events in the background.

Sensor Operation and Output

Once every ten seconds the two digital barometers (Class I system) or three digital barometers (Class II system) provide pressure readings for the observing site. The barometers are very accurate quartz barometers which are regularly checked for tolerance. These are located in the Acquisition Control Unit (ACU) usually inside a building. These units are vented to the outside to ensure observation of ambient pressure.

If you have a Class I system with two barometers, the six readings taken every minute are sent to algorithms for processing and comparison. If you have a Class III system with three barometers, the same process occurs but here you have three readings to compare.

If one or more of the 6 pressure values obtained during a one-minute period are missing, the sensor is automatically logged as "inoperative". It can only be returned to "operational status" by a maintenance technician.

Once the sensor data has been determined, the further processing by the pressure algorithms takes place so as to provide additional pressure parameter information which is especially useful for those in the aviation community.

Algorithm Processing and Output

The sensor, the aneroid barometer, senses pressure data once every ten seconds. This sensor is found as a black box inside the cabinet of ACU in the forecast office. There are six pressure samples every minute. These six samples are then linearly averaged to come up with a 1-minute average pressure value. Then depending on whether you have 2 barometers or 3 barometers, these 1-minute averaged pressure values are compared to determine which of those values will be reported in the observation that is transmitted. Then additional pressure parameters are computed.

The following steps are completed by the processing associated with the ASOS pressure algorithms.

Step 1*: Determine the observed pressure value.*

The *pressure algorithm uses the 6 ten-second pressure samples from the previous minute to calculate the 1-minute averaged pressure value*. If less than 6 of those 10-second samples are available for a sensor, the output value will be reported as missing and the sensor logged as "inoperative".

Step 2*: Compare the 1-minute pressure values and calculate the output.*

The output for the pressure algorithm is calculated by comparing the 1-minute average values of the sensors.

In a Class I System, if both average pressure values of the two sensors agree within 0.04 inch of each other, the lower of the two values will be output in the next observation. If the two sensors do not agree within 0.04 inch of each other, then this value is marked as missing.

In a Class II System, if all three sensors agree within 0.04 inch of each other, the lowest of the three values will be output. If only two out of the three sensors agree within 0.04 inch of each other, again the lower value will be output and the third sensor is logged as "inoperative".

Step 3*: Compute the Field Pressure value for output.*

By definition, the **field pressure** is the atmospheric pressure computed for a specific field elevation.

Using the 1-minute averaged pressure value (P) and 5-minute average temperature in degrees Rankine, field pressure (P_a) is calculated using the following formula:

$$P_a = P \times 10^{(0.00813 \times H_{Za}/TR)}$$

where H_{Za} = Pressure Sensor Elevation minus Field Elevation
and *TR* = Average ambient temperature in degrees Rankine

Step 4*: Compute the Station Pressure value for output.*

By definition, the **station pressure** is the atmospheric pressure computed for a specific station and location.

Using the 1-minute averaged pressure value, the system calculates station pressure first by computing the difference between sensor elevation (H_Z) and station elevation (H_P) using the equation:

$$H_{ZP} = (H_Z - H_P)$$

The system then obtains the current average 5-minute temperature in degrees Rankine (*TR*) and the current pressure (P) and calculates station pressure using the following formula:

$$P_S = P \times 10^{(0.00813 \times H_{ZP}/TR)}$$

If *TR* is marked missing and the absolute value of H_{ZP} is less than or equal to 100 feet, station pressure is calculated using the following equation:

$$P_S = [AS^{0.1903} - (1.313 \times 10^{-5}) \times H_p]^{5.255}$$

where: "AS" is the altimeter setting

Step 5*: Compute the Sea Level Pressure value for output.*

By definition, **sea level pressure** is the pressure value obtained by the theoretical reduction or increase of station pressure to sea level.

The system calculates sea level pressure by using 12-hour average ambient temperature to access the proper pressure reduction ratio value, then calculates sea level pressure using the following equation:

$$SLP = 33.864\ (mb/in) \times (P_s \times R \times C)$$

where P_s = Station Pressure
and R = Pressure Reduction Ratio
and C = Pressure Reduction Constant

Step 6: Compute the Pressure Altitude value for output.

By definition, **pressure altitude** is the altitude in the standard atmosphere at which a given pressure will be observed.

The system calculates pressure altitude (PA) using field pressure (P_a) and the following equation:

$$PA = 44331 \times [1 - (P_a / 29.92)^{0.1903}]$$

Step 7*: Compute the Density Altitude value for output.*

By definition, **density altitude** is the altitude in the standard atmosphere where air density is the equivalent to that at the airport.

The system calculates density altitude using the current 5-minute average temperature in degrees Rankine and current field pressure using the following equation:

$$DA = 145{,}366 \times (1 - [(17.326 \times P_a) / TR]^{0.235})$$

Step 8*: Compute the Altimeter value for output.*

By definition, the **altimeter setting** is the pressure value to which an aircraft altimeter scale is set, so it will indicate the altitude above mean sea level of the aircraft on the ground at the location for which the pressure value was determined.

It is calculated using the field pressure (P_a) and field elevation of the pressure sensor (H_a) using the following equation:

$$AS = [P_a^{0.1903} + (1.313 \times 10^{-5}) \times H_a]^{5.255}$$

If the field pressure is missing, average pressure (P) and elevation of the pressure sensor (H_z) are used.

$$AS = [P^{0.1903} + (1.313 \times 10^{-5}) \times H_z]^{5.255}$$

Step 9*: Compute the Pressure Remarks.*

The algorithms checks the remark criteria once each minute. Remarks are included in all observations, including the next hourly. Only the most current remark is included in the observation.

Remarks generated include PRESRR (Pressure Rising Rapidly), PRESFR(Pressure Falling Rapidly), and 3-hourly pressure change.

For rapid changes in pressure, the algorithm compares the current station pressure (P_s) with station pressure calculated 20 minutes (P_s 20) ago. The criteria the algorithm uses to create the rapidly rising and rapidly falling remarks are as follows:

- If [P_s - (P_s 20)] is greater than 0.025 inch, PRESRR remark is generated.
- If [P_s - (P_s 20)] is less than -0.025 inch, PRESFR remark is generated.

The pressure change remark is retained through the next hourly.

The pressure tendency remark is also created for 3-hourly synoptic reports. Here, the algorithm compares the current station pressure to the station pressure recorded hourly for past three hours. If any of the pressures are missing, the remark created is 5////. The format for this element is 5appp where:

- a = The code for pressure tendency
- ppp = The code for pressure change

Reportable Values

Once every minute, the current 1-minute average from the algorithm is used to obtain the reportable sea level pressure values and altimeter setting for use in the coded METAR observation.

Examples

The examples given below show a series of Class I and Class II sites with the ten-second pressure samples used in determining the 1-minute pressure values available for output to the coded METAR observations.

Example 1

Computing the 1-minute pressure using the 6 consecutive ten-second samples to produce the next 1-minute average pressure output using a Class I site.

Date: 101597
Site: Farmville, IA

Time	Barometer A	Barometer B
1:45:10	30.153	30.151
1:45:20	30.153	30.152
1:45:30	30.154	30.153
1:45:40	30.154	30.153
1:45:50	30.155	30.154
1:45:60	30.155	30.155
Average	30.154	30.153

Comparing barometer A to barometer B:

A - B = 30.154 - 30.153 = 0.001

Since their difference is 0.001 which is less than 0.04 inch, both values are good. So the lowest of the two is taken as output pressure value for the next observation: 30.153 which is output as 30.15.

Example 2

Computing the 1-minute pressure using the 6 consecutive ten-second samples to produce the next 1-minute average pressure output using a Class II site.

Date: 101597
Site: Ranch City, SD

Time	Barometer A	Barometer B	Barometer C
1:45:10	30.150	30.151	30.152
1:45:20	30.151	30.152	30.152
1:45:30	30.152	30.152	30.152
1:45:40	30.153	30.154	30.153
1:45:50	30.154	30.157	30.156
1:45:60	30.154	30.158	30.157
Average	30.152	30.154	30.154

Comparing barometers A, B, and C:

A - B = 30.152 - 30.154 = -0.002
B - C = 30.154 - 30.154 = 0.000
A - C = 30.152 - 30.154 = -0.002

Since these differences are less than 0.040 inch, then all 3 samples are useable. So we take the lowest of the three samples to use as output which will be 30.152 output as 30.15.

Example 3

Computing the pressure from a Class II site with two barometers not in agreement with one another

Date: 101597
Site: River City, ND

Time	Barometer A	Barometer B	Barometer C
1:36:00	30.105	30.120	30.145
1:36:10	30.095	30.122	30.165
1:36:20	30.093	30.126	30.165
1:36:30	30.085	30.128	30.172
1:36:40	30.092	30.130	30.173
1:36:50	30.097	30.133	30.190
Average	30.095	30.127	30.168

Comparing these barometers:

A - B = 30.095 - 30.127 = 0.032
B - C = 30.127 - 30.168 = 0.041
A - C = 30.095 - 30.168 = 0.073

Since the differences between B - C and A - C were greater than 0.040 then the value for barometer C is not used. So the lowest pressure value from Barometers A and C is used, which is 30.095, which will be output as 30.10. Barometer C will be logged as "inoperative".

Conclusion

This tutorial discussed the various aspects of the ASOS pressure algorithms that provide the ASOS METAR observation with a value for sea level pressure and altimeter setting for related pressure parameters. It began with several reasons **why** you should know how ASOS algorithms work. It then briefly discussed the sensor and how, once every minute, the pressure algorithm computes a pressure reading by doing a linear average of the previous six 10-second samples. Also, it briefly discussed the pressure sensor and how it physically works. The steps used in the algorithm processing were then reviewed which included computing the following pressure parameters: (a) 1-minute pressure value; (b) field pressure; (c) station pressure;(d) sea level pressure; (e) pressure altitude; (f) density altitude; (g) altimeter setting; (h) pressure sensor remarks. The lesson concluded with three ***examples*** of ASOS pressure calculations. These provided a good review of how ASOS determines pressure values.

References

Chu, Roland, 1994: Algorithms for the Automated Surface Observing System (ASOS). ISL Office Note 94-4, NWS/OSD, 106pp.

Clark, P., 1994: "ASOS Trainer's Toolbox" series, various topics. Surface Observation Modernization Office, NWS.

Last updated 11/07/97