ANNEX

Operation of Automated Surface Observing Systems in Harsh Climatological Environments

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1. Introduction

There is a growing trend whereby manual observations of weather parameters are being replaced by the introduction of automated weather observing systems. Mature automated weather observing systems are capable of producing accurate results when operating under relatively benign climatological conditions. However, when designing and operating these systems for use in harsh climatological conditions, many challenges must be addressed.

This paper will summarize the experience gained by the United States, Canada, and Norway in developing and operating automated weather observing systems under extremely harsh climatological regimes ranging from tropical to arctic. Aspects of automated systems considered include effects on sensors, systems design, installation, maintenance, and robustness. It is hoped that lessons learned from these experiences will provide guidance to those operating in similar environments. These lessons learned may also provide insight into future directions to assist investigations addressing some of these issues.

2. Climatic Regimes

2.1 Mountain/Arctic Climate

Some of the most challenging problems are encountered when designing, installing, and operating automatic weather stations in mountain and arctic climatic regimes. In order to survive the environment and produce accurate output, these stations must be designed to withstand extremely cold temperatures, heavy snowfall, extreme snow depths, and excessive stresses caused by wet snow accretion and heavy icing.

During mild winter weather, the electronics components usually give off enough heat to maintain an acceptable operating temperature inside the electronics enclosures. However, in colder arctic environments, additional heaters must be provided in order to keep internal temperatures of electronics enclosures at an operational level. In the harshest of extreme arctic/mountain environments, special equipment shelters have to be installed to ensure proper operation of the electronic equipment and provide maintenance technicians with protection from the elements (see Figure 1).

Figure 1. Haines, Alaska ASOS

To prevent blockage of the lenses and windows of optical sensors by snow and ice, lens heaters or window conditioners have to be employed. These may be contact heaters applied directly to the surface of the lens or in the form of an external heat source. Some protection from lens blockage can be provided by the use of heated lens hoods. However, wind-driven wet snow has been shown to block the lenses of some instruments in spite of the added protection (see Figure 2). A recent EUMETNET project reported similar impacts to operations caused by ice and wet snow blocking sensors and instrument shelters [EUMETNET, 1999].

Special considerations have to be made when installing and maintaining stations in mountain and arctic climates. This is especially true when the sites are located on or near permafrost. For those stations, great care must be taken not to disturb the terrain. The installation at Haines, Alaska (see Figure 1) is an example of the steps taken to prevent damage to the underlying permafrost. The transmission of heat energy is minimized by thick layers of gravel and insulation both at the sensor suite and the access road.

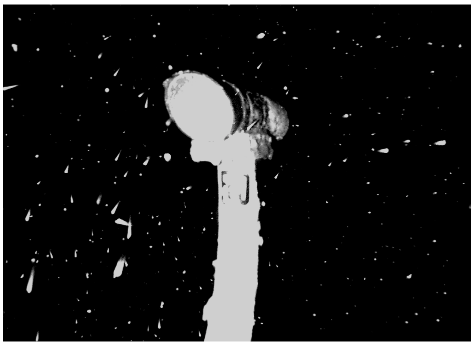

Figure 2. Lens Blockage

At some mountain/arctic sites, such as the Haines, Alaska site, the addition of a strong fence is required to prevent damage to the automatic weather station by large wildlife species such as bears and moose. In the Svalbard region of Norway, where fences are not permitted, all exposed cables must be protected with sturdy stainless steel tubing to avoid damage caused by polar bears.

At selected automatic weather stations, extreme snow depths may be encountered. In order to prevent deep snow from covering the sensor suite, some stations in the United States have been installed on elevated platforms. At Mullan Pass, Idaho, the sensor suite is mounted atop a fourteen-foot (4.3 meter) high platform (see Figure 3).

Figure 3. Mullan Pass, Idaho

2.2 Maritime Climate

Operation of automatic weather stations in coastal environments also presents many challenges. Installations along the coast are usually subjected to the effects of sea spray. The residual salt from the spray can coat the lenses of optical sensors, reducing sensor functionality while increasing the maintenance workload required to clean the lenses.

Sea spray can also contribute to a more rapid deterioration of materials used in the automatic weather station. At a minimum, the corrosion caused by salt air and sea spray increases the maintenance workload needed to prevent early failure of materials. Left unchecked, severe corrosion can cause weakened components to fail suddenly, resulting in a loss of support structures and sensors (see Figure 4).

Figure 4. Extensive Corrosion

Salt corrosion is an incessant problem at maritime coastal stations, causing premature component failure. For example, metal junction boxes exposed to salt spray experience complete corrosion after 4 to 5 years of service. Figure 5 shows a typical case of such corrosion after less than 5 years service on Sable Island, Nova Scotia. Aluminum boxes fare somewhat better, lasting 8 to 9 years before replacement is necessary. Open wiring is usually clear coated where boxes are not completely sealed. Boxes, even if completely sealed, will have a small hole bored to ensure moisture drainage in the event of moisture formation. Desiccants are used in all Canadian applications. The service technicians are currently experimenting with various new rust inhibitors to further extend the life of these systems.

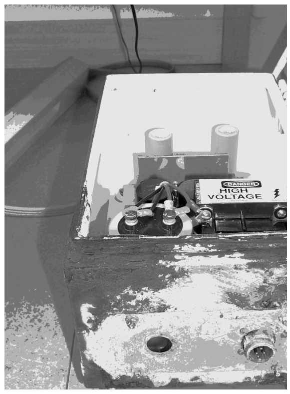
Figure 5. Corrosion

Sable Island also presents excellent examples of the deterioration caused by blowing sand and salt. The site is a small sand-covered island approximately 200 km east of Nova Scotia. Incidences of blowing sand result in a sandblasting effect, frosting over glass sensors such as the sunshine recorder. In addition, the sandblasting removes the anodized coating on aluminum surfaces, thus increasing the rate of salt corrosion.

Some coastal stations at high latitudes, such as St. John's, Newfoundland, are extremely susceptible to the problems caused by freezing precipitation and icing accompanied by high winds. These stations may experience ice accretion on the sensors rendering the output from the station unrepresentative. Figure 6 shows typical ice accretion on cup and vane wind equipment at St. John's.


Figure 6. Ice Accretion

At coastal sites, electrical connectors and junctions are often replaced with aluminum parts, although conversion to PVC is preferred. Silicone grease is applied liberally to inhibit corrosion. A new formulation is currently being tested. This substance has the consistency of petroleum jelly when applied, and thickens to a flexible finish as it dries. It can easily be scraped off and has good potential for protecting connectors and seals.

Some coastal sites require unusual precautions when the automatic weather station must be sited very close to the water. The sensor suite at Sitka, Alaska is installed at the top of an abandoned seaplane ramp very close to the bay. During periods of high winds, the swells on the bay would heave large rocks up the ramp at the sensor suite. Thus, a substantial seawall had to be constructed to prevent damage to the equipment. Coastal stations may also be affected by extreme wind speeds during the passage of hurricanes and severe cyclonic storms. Therefore, automatic weather station equipment at these sites must be capable of withstanding wind speeds up to 75 m/sec [WMO, 1996].


Figure 7. Sitka, Alaska

2.3 Desert Climate

Automatic weather stations installed in desert environments are subjected to a combination of extremely high ambient temperatures, low relative humidity, and blowing dust and sand. As mentioned earlier, blowing sand and dust can have a sandblasting effect on surfaces such as glass covers, sensor lenses, anodized aluminum, and painted surfaces. Certain adhesives can also be modified by constant exposure to high temperatures and blowing dust and sand.

Exposure to these conditions, plus the effects of extremely high ultraviolet radiation, can result in early failure of insulation on exposed wiring and more frequent maintenance actions to repaint metal surfaces.

2.4 Tropical and Sub-Tropical Climates

With the exception of hurricane-force winds mentioned earlier, excessive rainfall is the primary concern at stations installed in tropical and sub-tropical climates. Sudden torrential rainfall can easily submerge equipment that has been installed in low-lying areas as shown in Figure 8. To minimize damage to equipment that must be installed in flood-prone areas, the sensors and communications equipment can be mounted on the same type of platforms that are used in mountainous regions. During the massive flooding of the Mississippi River valley in 1993, the Jefferson City, Missouri ASOS was spared any significant damage through the use of such a platform (see Figure 9).

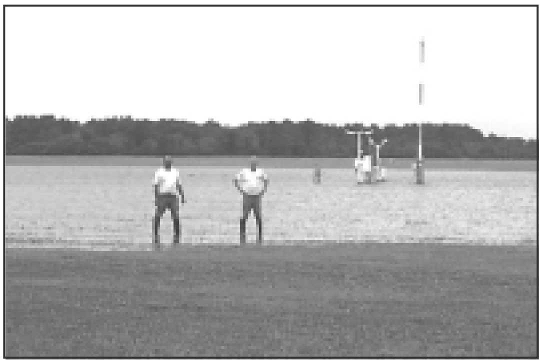

Figure 8. Flooded Sensor Suite

3. General Design Considerations

Power and communications are critical elements of all automatic weather stations, regardless of the severity of the environment. Some simple Norwegian stations - measuring temperature, humidity, pressure, and wind – have been designed to operate on battery power for up to two years. Such stations must necessarily have a very carefully calculated power budget without much need for heating. Remote sites are also prone to interruptions in commercial power. Therefore, these sites may be configured with uninterruptable power supplies to span the gaps in available AC power. Telecommunications may be unavailable or unreliable at some remote sites. In such cases, satellite communications or other backup means of communications needs to be provided in order to ensure a smooth flow of data.

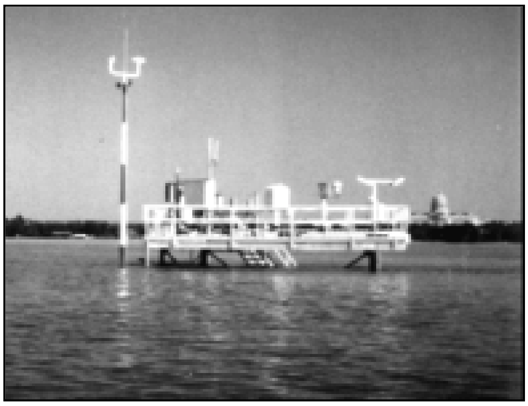

Figure 9. Jefferson City, Missouri

4. References

Tammelin, B., Joss, J., and Haapalainen, J., "Specification of Severe Weather Sensors," EUMETNET Contract EMN/C5 3/10/97

"Guide to Meteorological Instruments and Methods of Observation," World Meteorological Organization (WMO) No. 8, Geneva, Switzerland, 1996