The University of Wisconsin Antarctic Automatic Weather Station Program 2013-2014 Field Season: Objectives, Accomplishments, and Impacts for Future Seasons

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Abstract: *The University of Wisconsin-Madison's Antarctic Automatic Weather Station (AWS) program completed its 34th year of operations during the 2013-2014 field season. This report highlights the plans for the field season, what was accomplished despite some unforeseen circumstances, and how this season's accomplishments will impact future field seasons. The majority of the fieldwork was completed in the Ross Island and Ross Ice Shelf regions. Additional fieldwork was completed by collaborating personnel in Terre Adelie Land in East Antarctica, Victoria Land, and the Antarctic Peninsula. Despite the relative degree of success in these regions, some key AWS installations and station visits in West Antarctica were thwarted due to the United States government shutdown. These plans have been pushed to the 2014-2015 field season. Also examined is the warm temperatures and resulting melting at Pegasus, which impacted AWS health and flight operations. The University of Wisconsin-Madison's AWS network supports various scientific studies regarding the climate of the Antarctic, certain meteorological phenomena, and other areas of research.*

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1. Introduction

The University of Wisconsin-Madison's (UW) Antarctic Automatic Weather Station (AWS) program has been operating since 1980 as part of the United States Antarctic Program (USAP) with funding support from the United States' National Science Foundation (NSF). With the unique location of Antarctica and its harsh climate, a fully functional AWS network is necessary in order to understand the surface meteorology and climatology of the continent (Lazzara *et al*., 2013; Lazzara *et al*., 2013 in review). For 34 years, field teams from UW, as well as other collaborating science groups such as the University of Colorado-Boulder (CU), have deployed to Antarctica to service and maintain the AWS network (Figure 1). This report highlights this 34th year of field work, the 2013-2014 field season, covering the field season plans, a station-by-station account of each AWS visited, which stations went unvisited and why, and how that will impact future field seasons.

2. 2013-2014 Field Season Objectives

Multiple regions of Antarctica were planned to be visited during this field season. David Mikolajczyk and Lee Welhouse, the UW personnel, would complete AWS servicing to 7 AWS sites in the Ross Island region and 11 AWS sites in the Ross Ice Shelf region. One such AWS on the Ross Ice Shelf, Alexander Tall Tower!, was to be visited twice: once by Lee and David, and once by John Cassano and Melissa Nigro from CU for a two-week stay. Accompanying John and Melissa would be Ben Jolly, a New Zealand scientist, and Susan Detweiler, a mountaineer. Ben would install several SNOW-WEB portable weather stations to gather data for the duration of their stay at Tall Tower! to compare with John and Melissa's work. Plans were also made for servicing to be done in West Antarctica. David and Lee would do field work out of the West Antarctic Ice Sheet (WAIS) field camp. Two new AWS were to be installed, as well as servicing to several others.

The remaining regions to be serviced were to be completed by international collaborating groups. In Victoria Land, one AWS site would be visited by the Italian group ENEA-CNR. In Terre Adelie Land in East Antarctica, the Institut polaire francais Paul Emile Victor (IPEV) would visit 5 AWS sites that are jointly managed by IPEV and UW-Madison, with 3 of them along their traverse from Cape Prudhomme, near Dumont D'Urville, to Concordia Station. With the Australasian Antarctic Expedition 2013-2014, Chris Turney, the leader of the expedition, and Chris Fogwill planned to service one AWS on the Adelie Coast. There were no planned collaborations with the Japanese

Antarctic Research Expedition (JARE) this field season. It is anticipated that in future field seasons activities will continue in that portion of the network.

3. Accomplishments

The majority of the field work this season was completed by UW and CU personnel. In the Ross Island region, servicing was expanded and additions completed to the FreeWave network. This included site check-ups as well as switching some of the AWS data relay from Argos satellite transmissions to FreeWave. Linda AWS, previously an Argos station, was reinstated into the AWS network and now transmits via FreeWave. Inspection of instrumentation was completed for several AWS sites in the region that are used as a part of a tropospheric ozone study project (Kalnajs *et al.*, 2013; Seefeldt *et al.*, 2013). In the Ross Ice Shelf region, servicing was completed for the Argos network, including restoring Lettau AWS into the network and visiting Margaret AWS, which had not been visited since its installation in 2008.

International collaborating groups completed field work in other regions of the Antarctic. In Terre Adelie Land in East Antarctica, IPEV visited D-10 AWS and D-47 AWS. Australian collaborators visited Cape Denison AWS. The Italians completed a full instrument swap at Manuela AWS in the Victoria Land region. In the Antarctic Peninsula, Palmer Research Associate Glenn Grant performed maintenance on Bonaparte Point AWS.

4. Field Work

4.1. Ross Island Region

Pegasus North AWS (77.96°S, 166.52°E) was visited on multiple occasions throughout the field season, with the first visit on 30 December 2013 by Lee and the last visit on 31 January 2014 by both David and Lee. Previously transmitting via Argos, this station was switched over to FreeWave VHF transmissions. Multiple visits were required to insure a good line-of-sight connection could be made. Near the end of the field season, the power system for the station was replaced.

On 19 December 2013, Lee visited White Island AWS (78.08°S, 167.45°E) to install a new power system. Over the previous winter, there was a power system failure due to a battery failure; a cable from the power system installed the previous field season had broken, so it needed to be replaced. Due to vibrations, some connections began to back-thread. All of the connectors were taped to prevent further back-threading. On 14 January 2014, David and Lee revisited the station to do a station inspection. The wind monitor was tightened down to prevent backthreading. David and Lee also verified that the FreeWave transmissions were working correctly.

On 14 January 2014, Lee and David visited Minna Bluff (78.56°S, 166.69°E) for a station inspection. Due to the high wind speeds at this location, an annual station inspection is needed. No damage was found to the instrumentation, and the station seemed to be functioning nominally. The ozone equipment, collocated with the AWS, was also checked. Everything looked good there as well.

The last stations visited for inspection on 14 January 2014 were Marble Point and Marble Point II AWS. Marble Point AWS (77.44°S, 163.76°E) has been at that location for 34 years and utilizes Argos data transmission. Upon inspection of the station, it was noted that a small amount of damage to the solar panel had occurred.

Despite this damage, no issues with the station have been noticed. Marble Point II AWS (77.44°S, 163.76°E) is a FreeWave-transmitting station which was installed in 2011. No issues were found with the instrumentation on the station, nor the power system. Side-by-side testing between Marble Point and Marble Point II AWS remains ongoing.

Cape Bird AWS (77.22°S, 166.44°E) was visited on 15 January 2014 for a station inspection. The nose cone for the wind monitor was found to be knocked off and damaged. A replacement nose cone was installed, and the wind values are accurate. The radiation shield for the temperature sensor was damaged. A replacement shield was not readily available, so temperature measurements may be inaccurate during the summer. The collocated ozone station was relatively undamaged. A blade on one of the wind turbines was damaged, but the station still appeared to be functioning. The turbine was left in, as there was not another one available to replace it.

David and Lee visited Ferrell AWS (77.82°S, 170.82°E) on multiple occasions, the first of which was on 17 January 2014, to convert the station from Argos to FreeWave transmissions. The lower temperature sensor was buried, so this was dug out and raised on the station. On 27 January 2014, FreeWave transmissions were confirmed and Argos transmissions ceased. Due to inconsistent FreeWave connectivity, on the final visit to Ferrell AWS on 6 February 2014, David and Lee reinstalled the Argos antenna and transmitter, so Ferrell AWS is now a dual-transmitting Argos-FreeWave station. The Argos antenna and transmitter were reinstalled so data from Ferrell AWS could be quality-controlled on a monthly basis and CLIMAT messages could continue to be produced. The voltage output of the batteries at the station indicates there is sufficient power to support both types of transmission.

On 20 January 2014, David and Lee visited Linda AWS (78.44°S, 168.41°E) to raise the station and install the FreeWave transmitter (Figure 2). Linda AWS previously used Argos transmissions but stopped transmitting in May 2012. The instrumentation was upgraded on the station, including new temperature and relative humidity sensors, a new wind monitor, and a new power system. The station was also upgraded from an AWS2B system to a CR1000. In addition, an acoustic depth gauge (ADG) and an infrared temperature sensor were installed. The infrared sensor will act as the lower temperature sensor for the station.

A station inspection of Lorne AWS (78.22°S, 170.02°E) was completed by David and Lee on 27 January 2014. No issues were noticed with the instrumentation on the AWS. It was determined that the collocated ozone station did not need servicing.

On 11 February 2014, David and Lee visited Willie Field AWS (77.87°S, 166.95°E). The pressure sensor was replaced, and issues were found with the previous pressure sensor's calibration. The data recorded by the previous pressure sensor is being corrected. The station is currently operating nominally.

David and Lee visited Windless Bight AWS (77.73°S, 167.69°E) on 11 February 2014 to raise the station. Due to the high amount of snow accumulation at this site, an annual visit is necessary. The station was successfully raised with a new tower section. The collocated ozone station instrumentation could not be raised, as David and Lee did not have the proper equipment to do so. The antenna cable for the ozone station had minor damage, but it was fixed and secured with electrical tape.

4.2. Ross Ice Shelf Region

Lee visited Schwerdtfeger AWS (79.84°S, 170.27°E) on 24 December 2014. The power system was replaced due to issues with installation in the prior field season. Lee inspected the AWS, and everything was functioning nominally.

On 22 January 2014, David and Lee visited Lettau AWS (82.48°S, 174.59°W) to restore the AWS into the Argos network. The electronics were unable to be installed the previous field season due to weather issues. This year, the electronics were successfully installed, and Argos data transmissions were verified. The lower temperature sensor was also raised. All other instrumentation appeared to be functioning properly.

Tom AWS (84.43°S, 171.48°W) was removed from the AWS network on 23 January 2014. It was intended to be moved to a new location, per studies on the Ross Ice Shelf air stream and associated dynamics (Nigro *et al*., 2012). Due to time constraints, the station could only be removed that day, with plans to reinstall it later in the field season. The tower sections and all instrumentation were removed successfully.

Alexander Tall Tower! AWS (79.03°S, 170.68°E) was first visited by John Cassano and Melissa Nigro from 14 January to 26 January 2014, as they set up a field camp to do field work studying the lower boundary layer. During their visit, they fixed the station error that kept the Iridium from properly transmitting data. On 28 January 2014, David and Lee visited the AWS, along with two riggers, to raise the lowest three levels of instrumentation and raise the power system. The instrumentation raises were successful. There was insufficient time to raise the power system.

On 29 January 2014, David and Lee visited Sabrina AWS (84.25°S, 170.07°W) after failing to land at the new location slated for Tom AWS, which was to be named

Emma AWS. Data indicated the wind monitor on Sabrina AWS was not working properly. Upon arrival, it was found that the nose cone and propeller were missing, with a crack found on the housing of the aerovane. A replacement nose cone and propeller were installed and secured with electrical tape.

Margaret AWS (80.00°S, 165.00°W) was visited for the first time since its installation in 2008. It was expected to need to be raised; however, there was less snow accumulation than anticipated. Additionally, David and Lee did not have enough extension cables for the batteries to raise the station, as there were three battery boxes instead of two. The station enclosure, lower temperature sensor, and ADG were raised.

4.3. Terre Adelie Land

On 24 January 2014, the IPEV visited D-10 AWS (66.71°S, 139.83°E). The station was raised with a new tower section. The instrumentation and electronics were updated on the station as well. The servicing initially appeared to be successful. As of the time of this writing, however, the station is failing to transmit data for unknown reasons.

D-47 AWS (67.40°S, 139.83°E) is along the traverse route for the IPEV, as they travel from Cape Prudhomme, near Dumont D'Urville station, to Concordia Station. On 08 January 2014, it was visited by IPEV to install FlowCapt instrumentation, designed to measure snow drifting around the station. No other work was completed on the station.

Cape Denison AWS (67.01°S, 142.66°E) was visited by an Australian research group in December 2013. The compact flash card was replaced, with the old one inspected by personnel at UW-Madison. It was found that there was only a few months'

worth of good data recorded on the card, with the last data recorded on 6 April 2011. As of the writing of this paper, the station is not transmitting out any data, so the status of the instrumentation is unknown.

4.4. Victoria Land

On 16 December 2013, ENEA-CNR visited Manuela AWS (74.95^{o}S, 163.69^{o}E), located on Inexpressible Island, to do a full instrumentation upgrade. It was noticed that the wind monitor data was incorrect, so this instrument was swapped out. It was determined by personnel at UW that the connections were bad. The data collected during this time period (2012 through 2013) has been corrected to account for the bad connection. This instrumentation swap out was successful, as all data is being reported nominally.

4.5. Antarctic Peninsula

Glenn Grant, a Palmer Research Associate at Palmer Station, visited Bonaparte Point AWS (64.78^{o}S, 64.07^{o}W) on 13 January 2014 to replace a faulty Vaisala pressure sensor with a Paroscientific sensor. The Vaisala sensor was reporting pressure readings that were too high. Pressure readings now appear to be nominal. In early May 2014, personnel at Palmer Station noticed the wind monitor at Bonaparte Point AWS suffered severe damage. Graham Tilbury, a Palmer Research Associate, repaired the damaged wind monitor and reinstalled it. Wind values are currently reporting correctly, although a new wind monitor will be installed in the future to insure sustained, accurate measurements.

5. Setbacks and Impacts for Future Field Seasons

5.1. United States Government Shutdown

There were several circumstances that impacted the amount of field work that could be completed in this field season. At the beginning of October 2013, the United States government shutdown had a significant impact on operations in Antarctica, particularly because it coincided with the beginning of the 2013-2014 field season. The United States Antarctic Program was forced to delay sending personnel to Antarctica, leading to a delayed start to the field season. One consequence of this was that the WAIS field camp was unable to open. As a result, two new AWS installs were not completed, and three high-priority station visits were not done: Harry AWS, Elizabeth AWS, and Thurston Island AWS. Additionally, lower-priority visits to Theresa AWS, Siple Dome AWS, and Brianna AWS were not completed. These plans have been pushed back to the 2014-2015 field season.

5.2. Icebreakers

Another setback experienced this field season was caused by icebreakers, carrying the Australian and French science groups who were to service UW jointly-managed AWS, getting stuck in sea ice off the coast of Terre Adelie Land. The Australasian Antarctic Expedition 2013-2014, with Chris Turney and Chris Fogwill, was travelling on the Russian-owned Akademik Shokalskiy icebreaker when it became trapped in sea ice off the Adelie Coast on 24 December 2013. Chris Turney, a professor

at Sydney, Australia's University of New South Wales, was onboard and planned to service Cape Denison AWS. Turney's time at Cape Denison AWS was limited due to the delay caused by the trapped icebreaker, and he could only swap out the compact flash card. Due to a lack of transmissions from the station, as mentioned previously, a more in-depth station inspection will be necessary in future field seasons.

The French icebreaker, carrying members of the IPEV, was called upon to aid in freeing the Russian icebreaker from sea ice. Although the French icebreaker itself did not get stuck, the additional time spent to survey the conditions at the Russian icebreaker's location caused enough of a delay in their field season to impact the number of AWS their team could service along their traverse. They were unable to unload all of the AWS equipment from the ship onto land due to a lack of time. As such, servicing planned for D-85 and Port Martin was not completed. This work will be pushed back to future field seasons.

5.3. Poor snow conditions due to warmth at Pegasus

The poor conditions of the snow surface due to warm temperatures at Pegasus Airfield and Pegasus Road in the McMurdo area had an impact on operations. Pegasus North AWS is located at Pegasus Airfield and is subject to damage when the surface begins to melt (Figure 3). The AWS is located in an ablation zone, with no net accumulation of snow and ice throughout a year. During austral summer, the AWS can become loose and unstable if temperatures get warm enough and soften the surface layer of snow in which the chains and tower are secured. Figure 3 illustrates this point, as the AWS is seen to be tilted, with standing water at the base of the station.

While Pegasus North AWS does not have a continuous temperature record for the months of December 2013 and January 2014, Willie Field does. Willie Field is located near Pegasus North AWS on the McMurdo Ice Shelf and along Pegasus Road. Figure 4 shows December 2013 temperatures recorded at Willie Field AWS, along with horizontal lines indicating the 1992-2009 December mean temperature (-5.2^{o} C) and December 2013 mean temperature (-5.3^{o} C). Figure 5 shows the same parameters for January 2014, with the 1993-2010 January mean temperature (-5.3^{o} C) and the January 2014 mean temperature (-4.7^{o} C). Figures 6 and 7 perhaps better illustrate the impacts of the warmth on the McMurdo Ice Shelf, with temperature departures from the monthly average plotted. Most of the month of December (Figure 6) shows a diurnal pattern in temperature, with the warmest part of one day above average and the coldest part of said day below average. For much of the first half of January (Figure 7), however, temperatures remain above the monthly average. This persistently warmer-than-average scenario has significant impacts on snow surface conditions in the region.

With warm temperatures, the snow on Pegasus Road becomes soft, rendering it difficult for vehicles to travel on it. This increases the amount of time it takes to travel from McMurdo Station to Pegasus Airfield, which leads to less time in the field to do field work, particularly when travelling by Twin Otter fixed wing aircraft. The snow conditions at Pegasus Airfield also impact the air travel to and from the continent. With soft snow, the larger, wheeled C-17 aircraft from the United States 109th New York Air National Guard cannot land; the smaller, skied LC-130 aircraft are used instead. With smaller aircraft, more flights are necessary to transport passengers and cargo to and from the continent, and that has the potential to slow operations. In the coming 2014-2015 field

season, airfield operations will be moved from Pegasus Airfield to Willie Field to help negate the impacts of poor snow road conditions on operations.

6. Conclusion

In order to service a large portion of the AWS network, it is necessary to visit Antarctica annually as well as collaborate with international science groups. A significant amount of field work was accomplished this field season. With the help of collaborating personnel from CU, IPEV, ENEA-CNR and the Australasian Antarctic Expedition 2013-2014, multiple regions of the Antarctic were serviced. Even when plans are made to visit certain AWS, however, unforeseen circumstances can impact how many AWS can be serviced. The United States government shutdown and the delay of the Russian and French icebreakers caused the greatest negative effect to this field season. For instance, field work out of West Antarctica will be moved to the 2014-2015 field season. In Terre Adelie Land, some field work will be moved to future field seasons.

The poor snow conditions due to warmth on Pegasus Road and at Pegasus Airfield in the McMurdo area had negative impacts on flight operations for UW and for USAP during this field season. Melting of the snow surface at Pegasus AWS caused the station to lean and the tower and chains to become loose. The snow conditions on Pegasus Road were poor due to warm temperatures. Vehicle travel was slowed, which decreased the amount of time UW personnel had to conduct field work when traveling to AWS in the Ross Ice Shelf region. In the 2014-2015 field season, operations will be moved from Pegasus Airfield to Willie Field, which is closer to McMurdo Base. Due to its

closer proximity, more time will be allowed for UW personnel to visit AWS throughout the Ross Ice Shelf.

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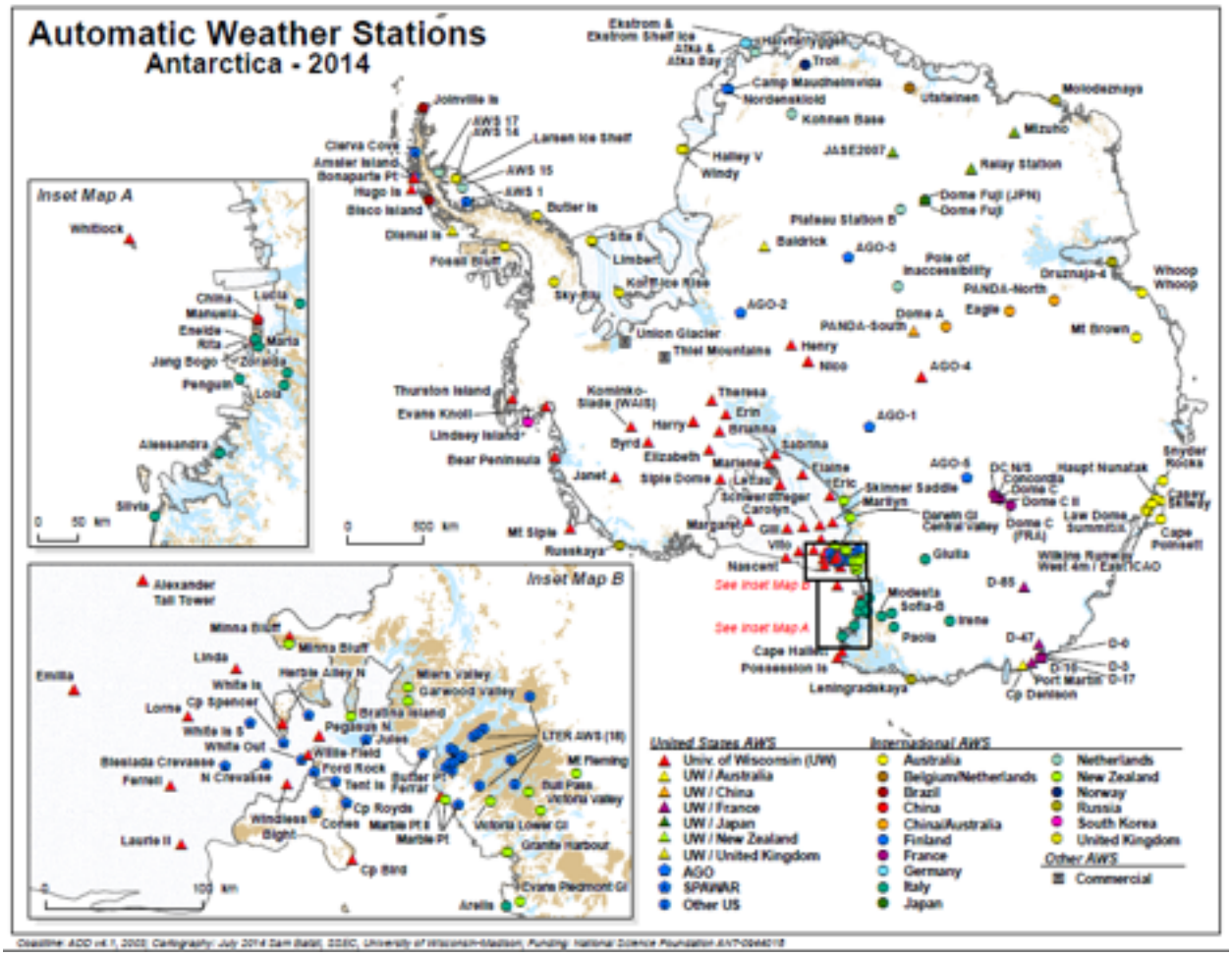
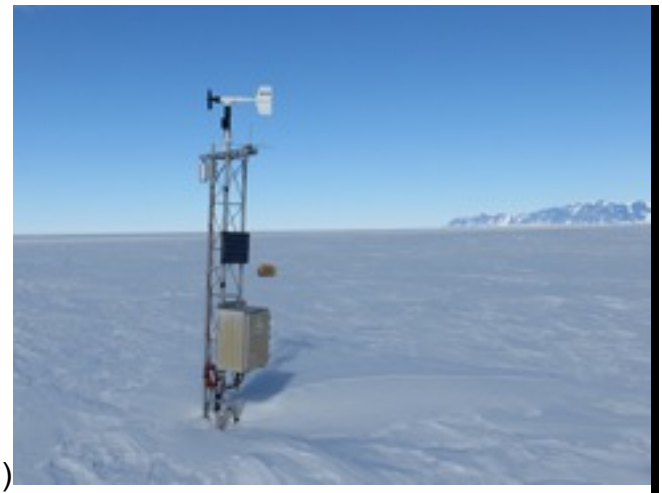


Fig. 1. Map of all known automatic weather stations on Antarctica, as of 2014. All AWS marked with a triangle are managed by the University of Wisconsin directly or with collaborating groups.

(a)



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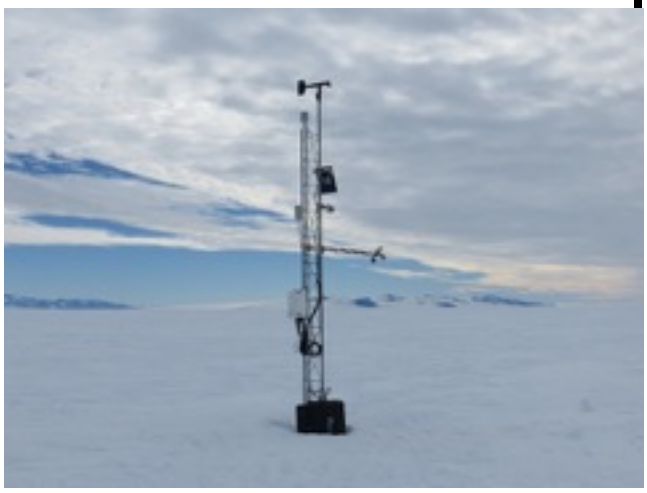

Fig. 2. Linda AWS before (a) and after (b) servicing on 20 January 2014.

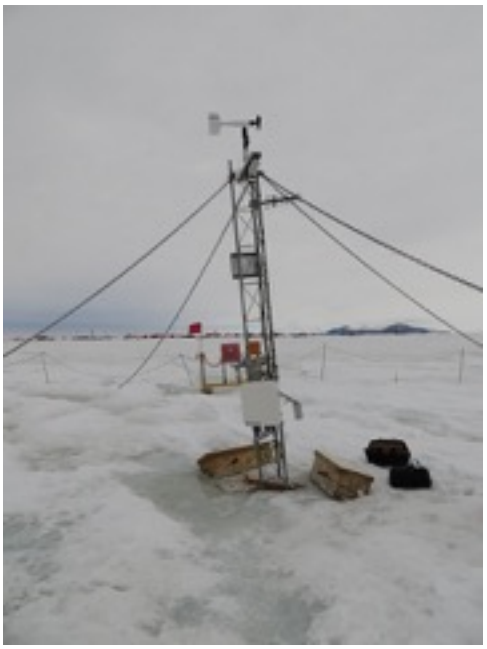

Fig. 3. Pegasus North AWS on 7 January 2014. Note the standing water on the left at the base of the station and the tilt of the station.

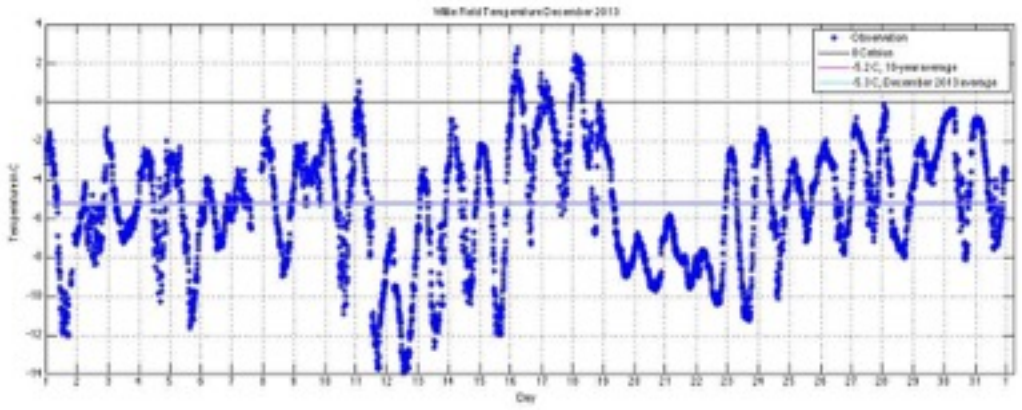

Fig. 4. Willie Field AWS temperature observations for December 2013.

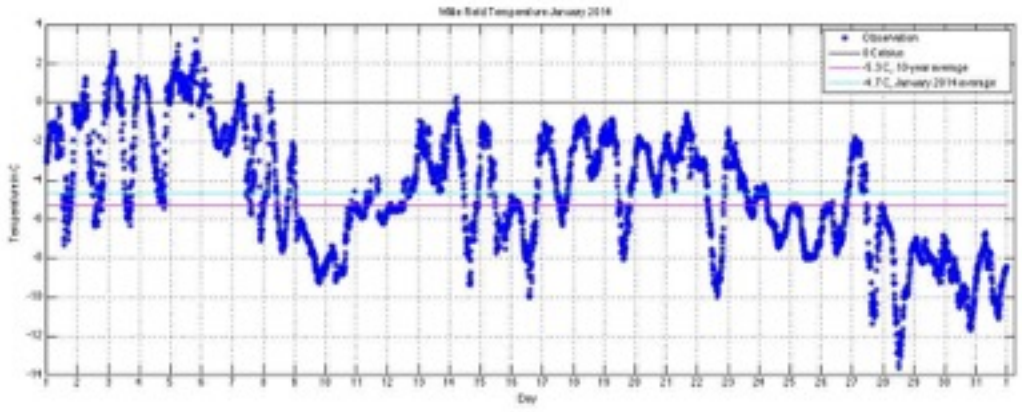

Fig. 5. Willie Field AWS temperature observations for January 2014.

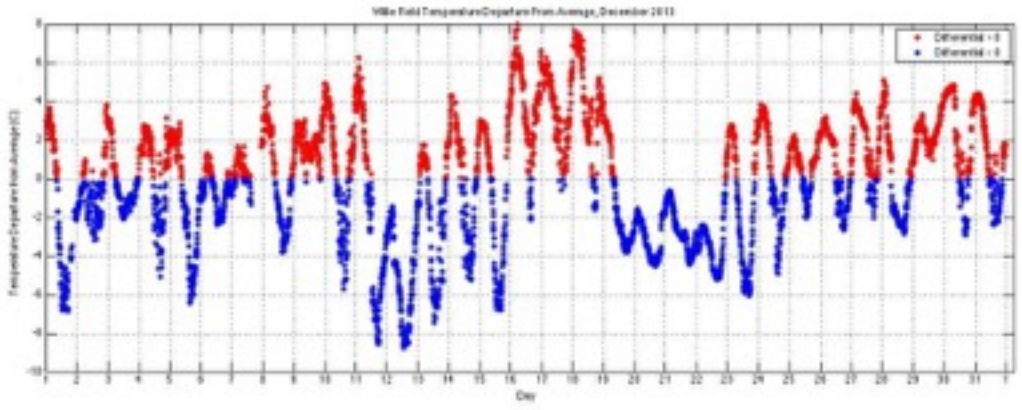

Fig. 6. Willie Field AWS temperature departures from average, December 2013.

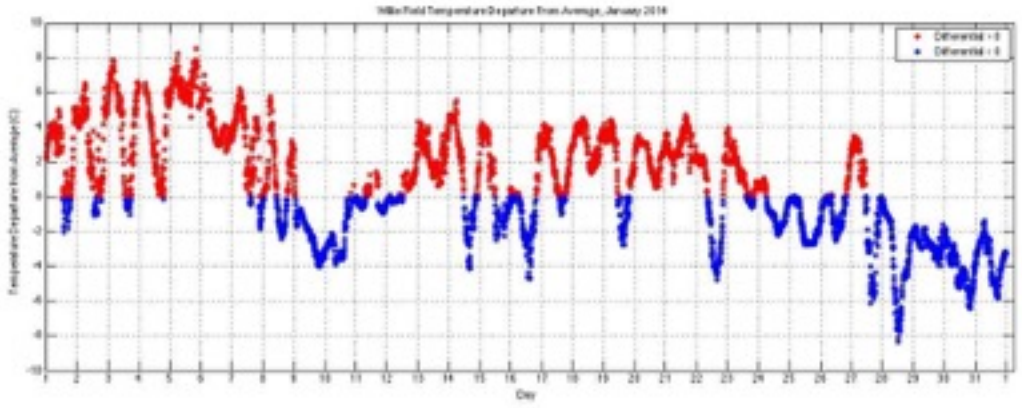

Fig. 7. Willie Field AWS temperature departures from average, January 2014.