WMO Evaluation of Two Extreme High Temperatures Occurring in February 2020 for the Antarctic Peninsula Region

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Abstract. Two reports of Antarctic Region potential new record high temperature observations (18.3°C, 6 February 2020 at Esperanza station and 20.8°C, 9 February 2020 at a Brazilian automated permafrost monitoring station on Seymour Island) were evaluated by a World Meteorological Organization (WMO) panel of atmospheric scientists. The latter figure was reported as 20.75°C in the media. The panel considered the synoptic situation and instrumental setups. It determined that a large high-pressure system over the area created föhn conditions and resulted in local warming for both situations. Examination of the data and metadata of the Esperanza station observation revealed no major concerns. However, analysis of data and metadata of the Seymour Island permafrost monitoring station indicated that an improvised radiation shield led to a demonstrable thermal bias error for the temperature sensor. Consequently, the WMO has accepted the 18.3° C value for 12 noon (LST) 6 February 2020 [1500 UTC 6 February 2020] at the Argentine Esperanza station as the new "Antarctic Region [continental, including mainland and surrounding islands] highest temperature recorded observation" but rejected the 20.8° C observation at the Brazilian automated Seymour Island permafrost monitoring station as biased. The committee strongly emphasizes the permafrost monitoring station was not badly designed for its purpose, but the project investigators were forced to improvise a non-optimal radiation shield after losing the original covering. Secondly, with regard to media dissemination of this type of information, the committee urges increased caution in early announcements as many media outlets often tend to sensationalize and mischaracterize potential records.

1. Introduction

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In early February 2020, a large high-pressure system was located in the Antarctic Peninsula region capable of producing pronounced subsidence, föhn winds and subsequent high temperatures. The sites of interest are located near the tip of Graham Land on the Antarctic Peninsula. On 6 February 2020, an observation of 18.3°C (some initial reports indicated this value as 18.4°C) was recorded at Esperanza station (a research station operated by Argentina, 63°24'S, 57°00'W, 25 meters elevation). Subsequently on 9 February 2020, an automated permafrost monitoring station on nearby Seymour Island (64°16'S, 56°45'W, 51 meters elevation) which was a part of a network operated by a Brazilian research team reported an observation of 20.8°C. The locations of these stations are shown in Figure 1.

As part of its ongoing mission to adjudicate and record global, hemispheric and regional extremes, the World Meteorological Organization's Archive of Weather and Climate Extremes (https://wmo.asu.edu/) assembled an international team of polar scientists to examine these two observations. This follows similar such recent investigations of Arctic and Antarctic temperatures (e.g., Weidner et al 2020; Skansi et al 2017). If verified, these two observations would be the highest temperatures recorded for the Antarctic region (continental, including the continent and surrounding islands) and, if confirmed, the 20.8°C observation would be the highest temperature recorded for all of the Antarctic Region (all land/ice south of 60°S) exceeding the 19.8 °C value recorded on 30 January 1982 at the Signy station (UK) [60°43' S, 45°36' W] (King et al. 2017).

In this evaluation, we examine first the overlying synoptic conditions of the area and examine next the specifics of each of the two extreme reports. This is followed by a more detailed discussion of the metadata and data of the two extreme observations.

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2. Synoptic Background

The synoptic situation was assessed through use of observational data and ERA5 (Hersbach et al. 2020). ERA5 is the most recent climate reanalysis produced by the European Centre for Medium-Range Weather Forecasts, providing hourly data on many atmospheric, land-surface and sea-state parameters together with estimates of uncertainty. ERA5 data are available on regular latitude-longitude grids at 0.25° x 0.25° resolution, with atmospheric parameters on 37 pressure levels.

Observational data were used to create meteorograms of the two locations. Meteorograms (Figure 2A) indicate the high temperature observation at Esperanza station on 6 February 2020 was associated with increased wind speeds and decreased atmospheric humidity ($T_d = -0.9$℃; RH = 27%). This strongly supports the occurrence of a föhn event over the station producing substantial surface warming. A lesser föhn event is also evident on 9 February 2020 at the Brazilian permafrost monitoring station on Seymour Island (Figure 2B).

Such surface conditions can be linked to the upper atmosphere. ERA5 reanalysis indicates a strong ridge at 500 hPa built over the Drake Passage, extending from the southern tip of South America towards the west coast of the Antarctic Peninsula, with heights at 2020-02-06 15UTC (near the time of 18.3℃ observation by the Argentine Esperanza station) of 5529 gpm (Figure 3). These values are approximately 300m above the February average (1971-2000) for the northern end of the Peninsula, thereby indicating the air column was unusually warm. The ridge remained in place through 2020-02-09, 15UTC (near the time of the 20.8℃ observation by the Brazilian automated weather station) with a height of 5480 gpm. During this event, there was a sharp shift in wind direction at 500 hPa from the northwest to the southwest, which can also reflect the domination of high pressure centered over the Drake Passage.

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The large geopotential height gradient around the southern edge of the ridge drove a strong westerly to southwesterly geostrophic wind across the mountainous crest of the Antarctic Peninsula, which has an elevation of between 500 and 1000 masl in the region under consideration. Under such synoptic conditions, strong, warm and dry föhn winds can develop on the downwind (eastern) side of the Peninsula (Elvidge et al. 2015, Cape et al. 2015). ERA5 reanalysis of mean sea level pressures at the times of the two respective events indicates föhn conditions were present for both cases (Figure 4A&B). It is not surprising that the ERA5 reanalysis regional two-meter temperatures for the events are as warm as 10°C (Figure 4C&D)

3. 18.3 °C Observation [6 February 2020 at Esperanza station]

Temperature observations at Esperanza station were initiated in January 1953 and have continued since that time at that location. A past WMO evaluation committee evaluated the historical record of this station as part of another Antarctic Region high temperature extreme investigation (17.5° C on 24 March 2015) and found no concerns about instrumentation or procedures used for temperature measurement at the station (Skansi et al 2017). For the 2020 observation, the manual meteorological log for the station indicates proper recording of the observation while the instrumentation consisted of a common (mercury in glass) maximum/minimum thermometer that was installed on 3 December 2005 located within a pagoda-style naturally-vented meteorological shelter. For this investigation, the committee considered photographs of the station (Figure 5) and the thermograph as well as the raw data.

In the consensus opinion of the committee, the high temperature extreme observation was made under conditions associated with a föhn event, e.g., supporting measurements show increased wind speed and decreased atmospheric humidity ($T_d = -0.9$℃; RH = 27%). Given

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that the wind speed was 14 kts [7.2 ms^{-1}] (with gusts to 32 kts [16.5 ms^{-1}]), it is likely that solar radiation-related biases would be small. Photographs of the station and sensors indicate that measurements were made under ventilated conditions with no obstructions or visible station attributes leading to potential bias. Consequently, the committee recommended acceptance of the 18.3℃ value for 12 noon (LST) 6 February 2020 [1500 UTC 6 February 2020] at the Argentine Esperanza station.

4. **20.8°C Observation [9 February 2020 by Brazilian permafrost monitoring site on Seymour Island]**

Temperature measurements were first monitored at the Brazilian permafrost monitoring site on Seymour Island from 03/2011 to 04/2016, then restarted in January 2020. The station, which is one of 28 sites in the SCAR-ANTPAS network (https://www.scar.org/science/antpas/about/), is supported by the Brazilian Antarctic Program. The specific emphasis for this station was, and remains, directed towards pedoclimatic research. Therefore, it is important to note that this station's installation was not specifically intended for accurate air temperature measurements. After the station's initial installation in 2011, the station was disabled in 2016 due to lack of maintenance.

However, in January 2020 this site was reactivated and a satellite transmission system was installed. It has been fully operational and consistent since 5 January 2020. The station consists of Campbell Scientific equipment, with the sensors connected to a CR1000 model datalogger, which is powered by battery connected to solar panels. The datalogger is connected to a modem that transmits data via satellite. A Campbell 107E temperature sensor was located 1.65 meters above the ground over exposed soil, without vegetation cover.

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As the committee examined data and photographs of the station, several concerns were noted. First, at the time of the extreme, the nearby Marambio (Argentina) station (7.2 km from the permafrost monitoring station, which is 145 m lower, see Figure 1) reported a temperature of 15.5℃, i.e. 5.3°C lower than that recorded at the permafrost station. This difference is suspiciously large for two stations so close together and in similar environments. Second, photographs (Figure 6) indicated that the air temperature sensor was installed within an improvised radiation shield. Accurate temperature measurements require free circulation of air around the instrument as well as shielding from direct solar heating, among other factors. Concerns were expressed that the temperature sensor would not be adequately ventilated, leading to radiation errors under conditions of high insolation. This information suggests that a thermal bias of the temperature sensor is very likely.

The WMO committee is extremely appreciative to note that Brazilian researchers were both responsive and prompt in addressing this issue. Following the cancellation of all research activities for the upcoming season (2020/21) due to the global Covid-19 pandemic, they made a formal arrangement with the Brazilian Navy for military personnel to install a monitoring system that will have both conventional and improvised (e.g., the Seymour Island permafrost station type) Campbell 107 sensor protection shields. Such a system allows remote transmission of comparative data. In addition, they also installed a similar double system at one of their mountainous terrain (650 m.s.l.) sites in Brazil to conduct a test for discrepancies.

In September 2020, data from that test were made available to the committee (Figure 7), the plot of the dual values indicate that the improvised radiation shield did produce radiation errors of up to +5℃ in daytime temperatures during the intercomparison period. There is a marked over-reading of the temperature when there are high solar radiation values. As the Brazilian

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researchers noted, this is likely the result of ventilation limitation. Over the course of the entire test period, the average difference between the improvised and conventional shields was +1.49 ℃.

From this evidence, the committee determined that the improvised radiation shield likely created a thermal bias on the associated temperature measurements at this station. Therefore, the committee consequently recommended that the 20.8℃ observation on 9 February 2020 for the Brazilian Seymour Island permafrost monitoring site be rejected as a new Antarctic Region extreme.

Following the recommendations by the committee, the WMO Rapporteur of Weather and Climate Extremes has accepted the 18.3℃ value for 12 noon (LST) 6 February 2020 [1500 UTC 6 February 2020] at the Argentine Esperanza station as the new "Antarctic Region [continental, including mainland and surrounding islands] highest temperature recorded observation." However, with the rejection of the 20.8℃ Seymour Island permafrost monitoring station observation, the "Antarctic Region [all land/ice south of 60°S] highest temperature recorded observation" remains the 19.8 °C value measured on 30 January 1982 at Signy station (UK) [60°43' S, 45°36' W] (King et al. 2017).

5. Final Discussion Points

The committee deemed that two additional points are noteworthy with regard to this evaluation. First, the committee strongly emphasizes that the Brazilian Seymour Island permafrost monitoring station was not badly designed. The project investigators were forced to improvise a non-optimal radiation shield due to the correct shield being missing from the shipment. In addition, the Brazilian Field team responsible for the setting of this improvised

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radiation shield only informed the Project coordinators of that unusual situation a few days after the press had already disseminated the record. The shielding problem was a logistics issue limited to this station. The committee also stresses that the system was intended for permafrost research and was not designed for accurate air temperature measurements, particularly of extremes.

Consequently, the committee believes this is an important 'teachable moment,' particularly with regard to media dissemination of this type of information. When news of this observation became known, global media quickly disseminated it. The examples presented here illustrate why media should be cautious in reporting temperature extremes: to achieve the level of absolute accuracy needed for robust temperature measurements requires a great deal of attention to screening and radiation shielding, among other factors—factors that are often not appreciated by the media and the public. Fortunately, many news organizations urged caution. For example, the *Washington Post* reported the observation but noted that the WMO "is looking into the new report, too, but urged caution about the higher reading [the Seymour Island permafrost monitoring station 20.8℃ observation]" (Freedman, 2020), as indicated by the Brazilian scientist during the interview.

Unfortunately, many other media outlets did not. For example, the *Guardian* news site reported, "The Antarctic has registered a temperature of more than 20°C (68°F) for the first time on record, prompting fears of climate instability in the world's greatest repository of ice." (Watts, 2020). However, the reporter did note in a subsequent update to the initial report, "these records will need to be confirmed by the World Meteorological Organization …"

Additionally, a myriad of values for both observations were reported by media. Values of 18.3° C (the accepted temperature) and 18.4° C were reported for the Argentine Esperanza

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station while most media reported a value of 20.75º C for the Seymour Island permafrost monitoring station (contrary to normal temperature reporting only to the nearest tenth of a degree Celsius). All of this misinformation, in turn, resulted in the problematic observation being reported as a 'truth' in many sites such as one of the most widely viewed sites in the world (one reviewer informed us that Wikipedia has, for months after the observation, misreported the observation as a world record).

In an attempt to reduce this type of potential misinformation, the WMO Archive of Weather & Climate Extremes recently instituted a "fast response team" approach. In this approach, the Rapporteur of Weather & Climate Extremes quickly assembles a small team of international atmospheric scientists familiar with the type of extreme recorded within hours or days of the claim. Using the best *available* data, the team then makes a preliminary (and immediate) recommendation as to whether or not the extreme is valid. Following that recommendation, the WMO then issues a global press release normally containing the proviso "pending full investigation." Subsequently, a full WMO extreme evaluation team is created and assembled (such as the one for these two Antarctic extremes). That full evaluation team then conducts a full and comprehensive evaluation of the given extreme (including photographs, raw data and metadata of the observation equipment).

Secondly, given the strong relationship between föhn events and recent record temperature extremes, members of the committee would urge researchers to continue to examine long-term trends in warm advection, föhn and extremes. While a few studies of this type have been carried out for the Antarctic Peninsula and other Antarctic and subantarctic regions (e.g. Cape et al, 2015; Spiers et al, 2013, Bannister and King, 2020, Kazutoshi et al., 2021), questions still remain as to whether or not föhn events are getting warmer and generating new temperature extremes.

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We would also suggest that more research is also warranted to determine at which degree the föhn type contributes or interferes with the record temperature extremes.

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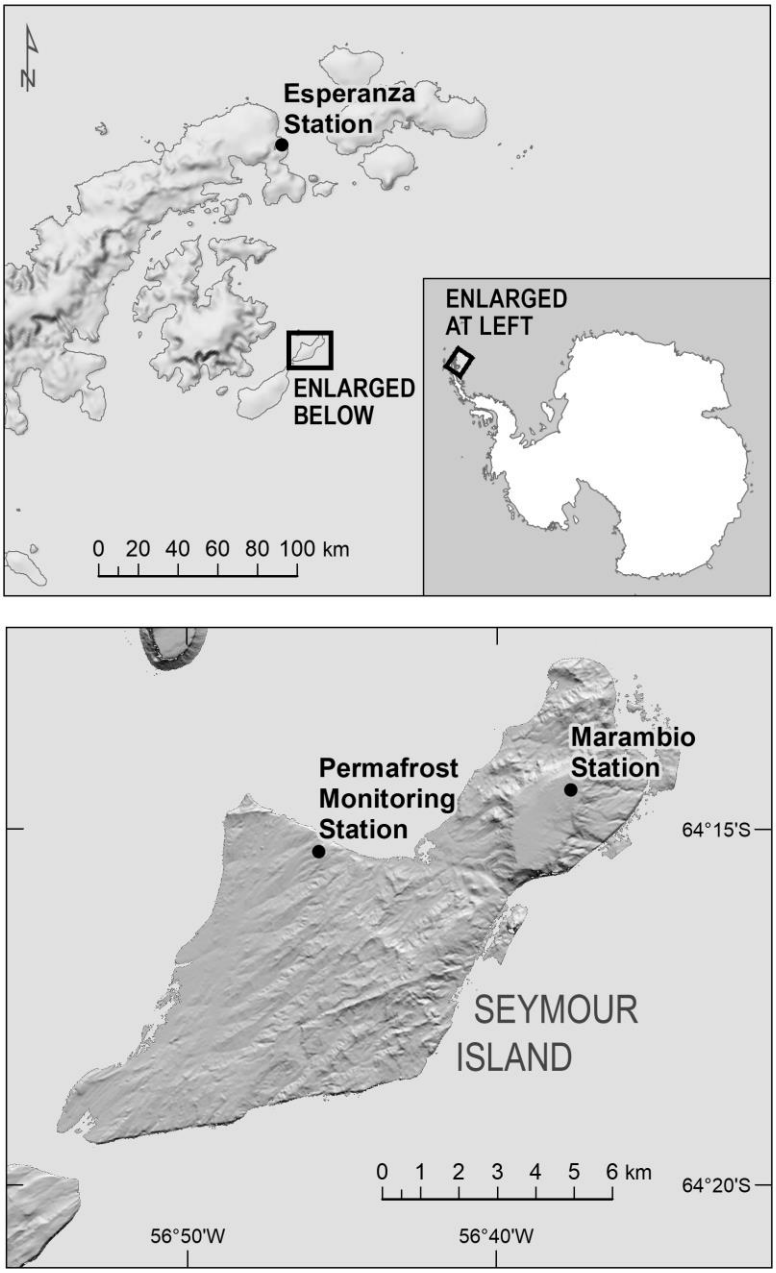
297 **Figures**



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299 **Figure 1.** Locator image displaying Esperanza station (Argentina) situated in the Antarctic
300 Peninsula region, and Seymour Island (with the permafrost monitoring station (Brazil) and
301 Marambio station (Argentina) indicated. Topography (top map) from the National Snow &
302 Ice Data Center at 1 km resolution (Liu et al., 2015). Topography (bottom map) from the

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University of Minnesota's Polar Geospatial Center with 8 meter resolution (Howat et al., 2019).

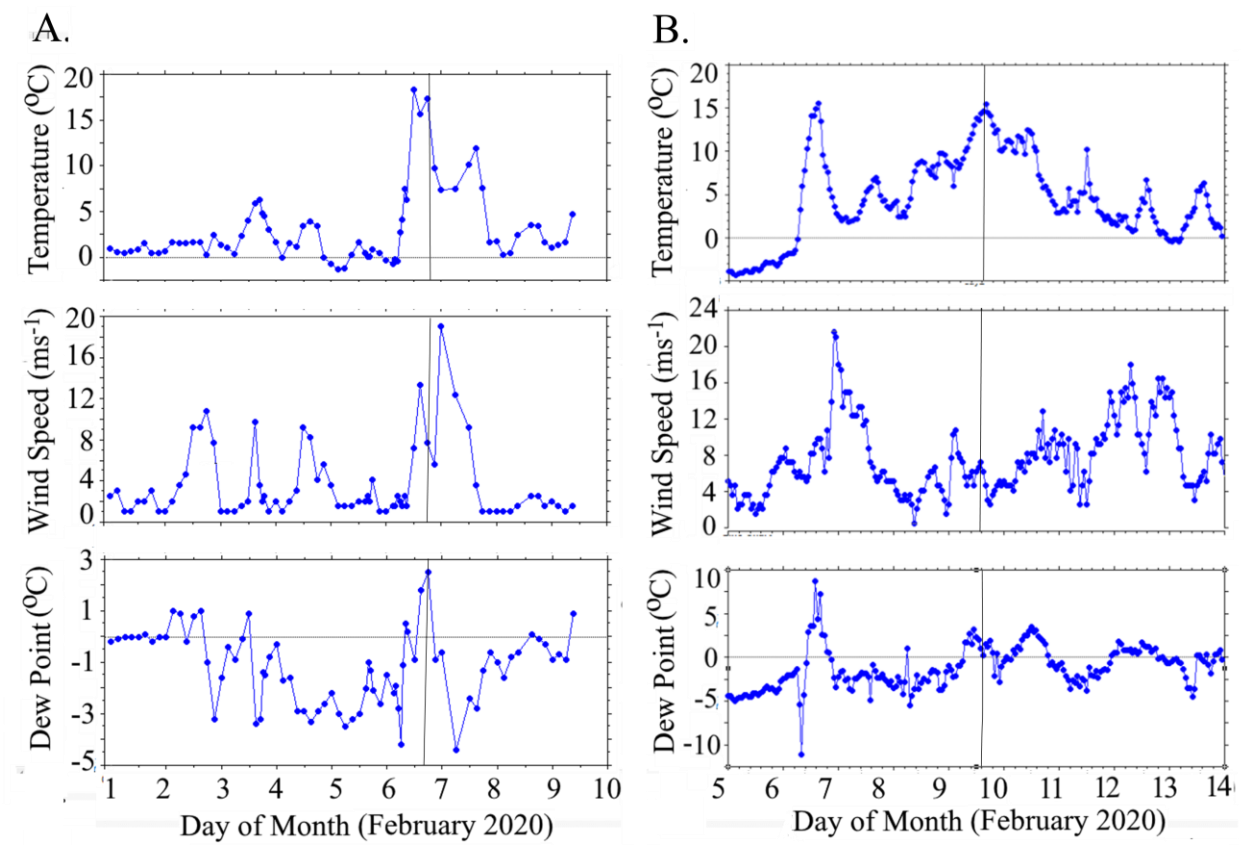

Figure 2. Meteorograms of Temperatures (top in ° C), Wind Speeds (middle in ms^{-1}) and Dew Points (bottom in ° C) for A. Esperanza station (Argentina) and B. Marambio station (Argentina) on Seymour Island (located near the Brazilian permafrost monitoring station, see Figure 1) for selected days in February 2020. A and B are constructed so they are each centered about the specific days under investigation (6 Feb, Esperanza; 9 Feb, Seymour Island). The thin black lines at 15 UTC (1200 LST) 6 Feb 2020 (A) and 15 UTC (1200 LST) 9 Feb 2020 (B) indicate times of the specific observations under investigation.

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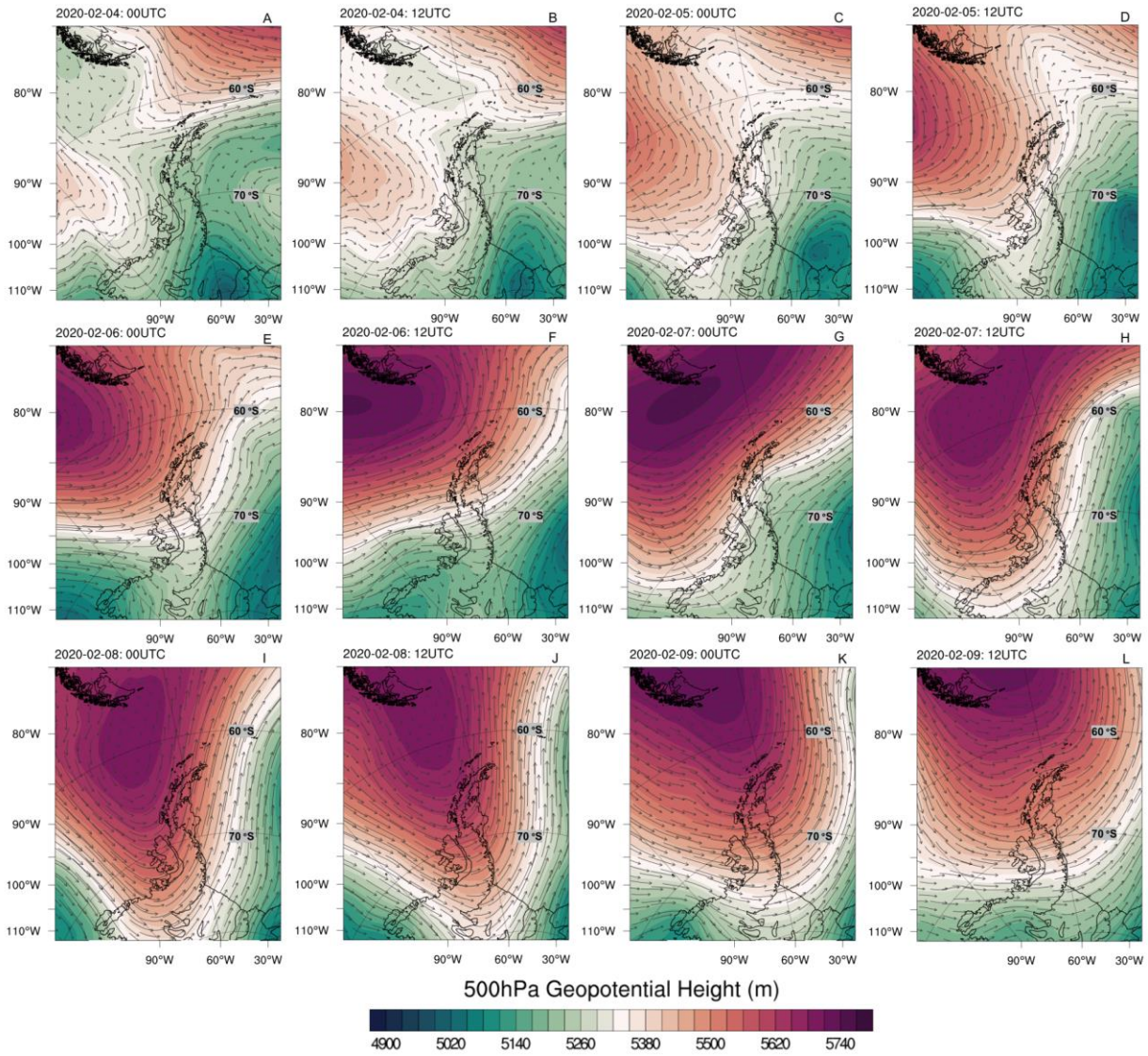

Figure 3. ERA5 reanalysis regional 500hPa heights (geopotential meters) together with 500 hPa vector winds for the Antarctic region for the period 2020-02-04 (00UTC, A) to 2020-02-09 (12 UTC, L). The Esperanza 18.3° C data point occurred at approximately 15UTC 6 Feb 2020. The Seymour Island permafrost monitoring site 20.8° C data point occurred at approximately 15 UTC 9 Feb 2020.

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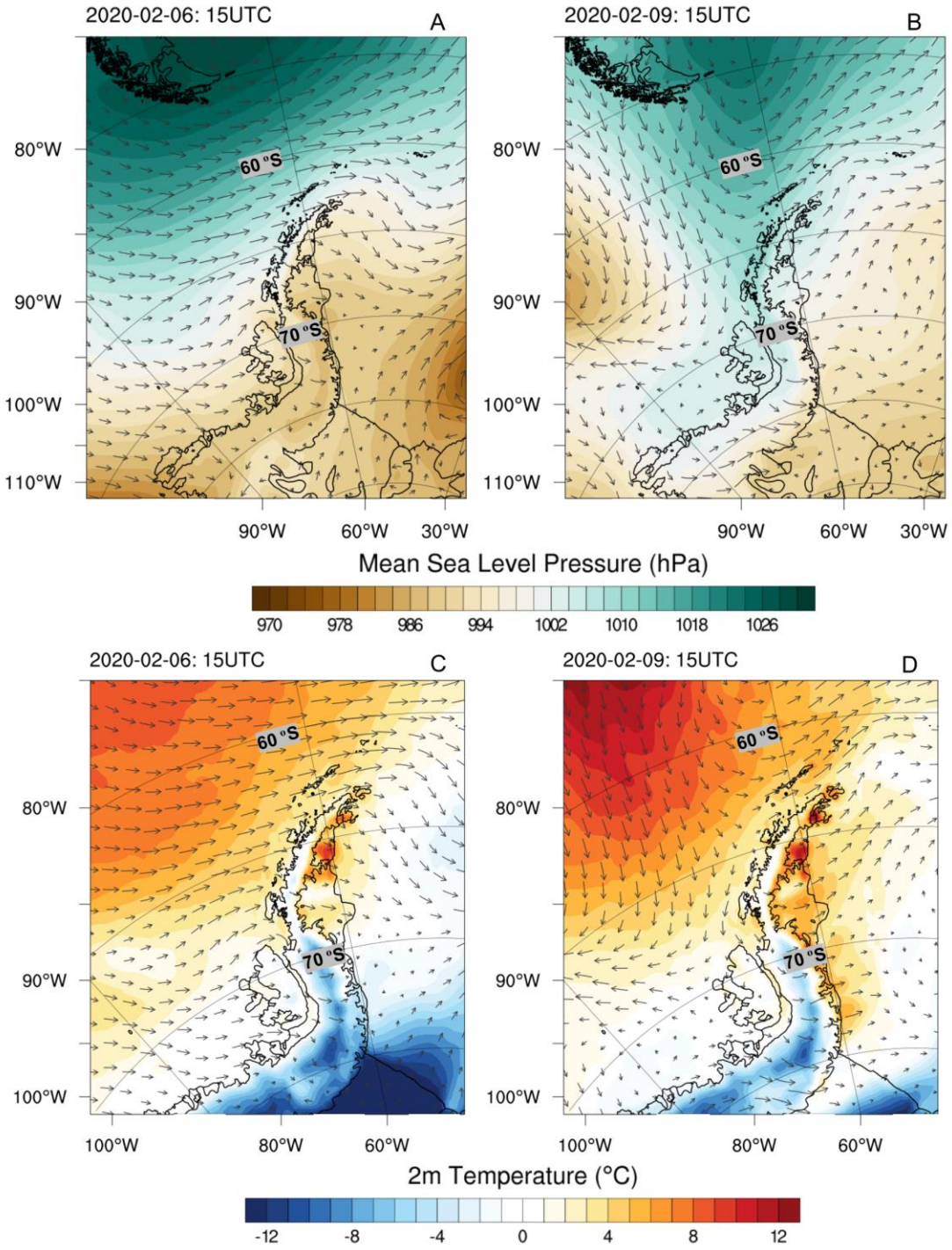

Figure 4. ERA5 reanalysis mean sea level pressure (hPa) with 10-m vector winds for the Esperanza 18.3° C (15UTC 6 Feb 2020, A) and the Seymour Island permafrost monitoring site 20.8° C (15 UTC 9 Feb 2020, B). ERA5 reanalysis of Antarctic Peninsula for 10-m

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vector winds and 2-m temperatures for the Esperanza event (C) and for the Seymour Island permafrost monitoring event (D).

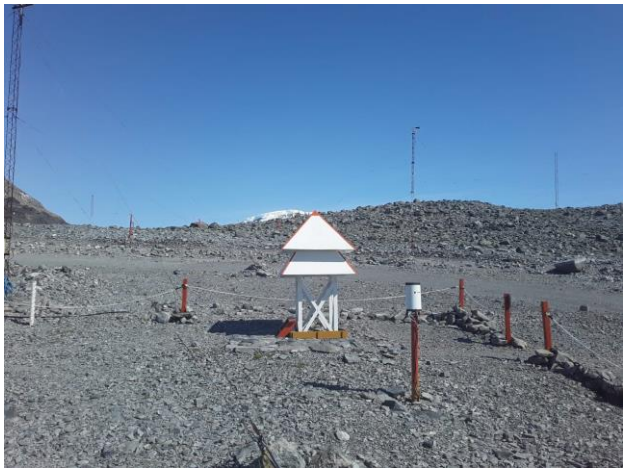

Figure 5. Site photograph of temperature sensor at Esperanza station, looking to the south-southwest. Photograph by Sergio Fabián Montoya, taken in February 2020.

Figure 6. Closeup photograph of the Brazilian permafrost monitoring station on Seymour Island with the improvised radiation shield circled in red. The Campbell 107E temperature sensor is inside this shield. Photo by personnel from Marambio station, taken in February 2020.

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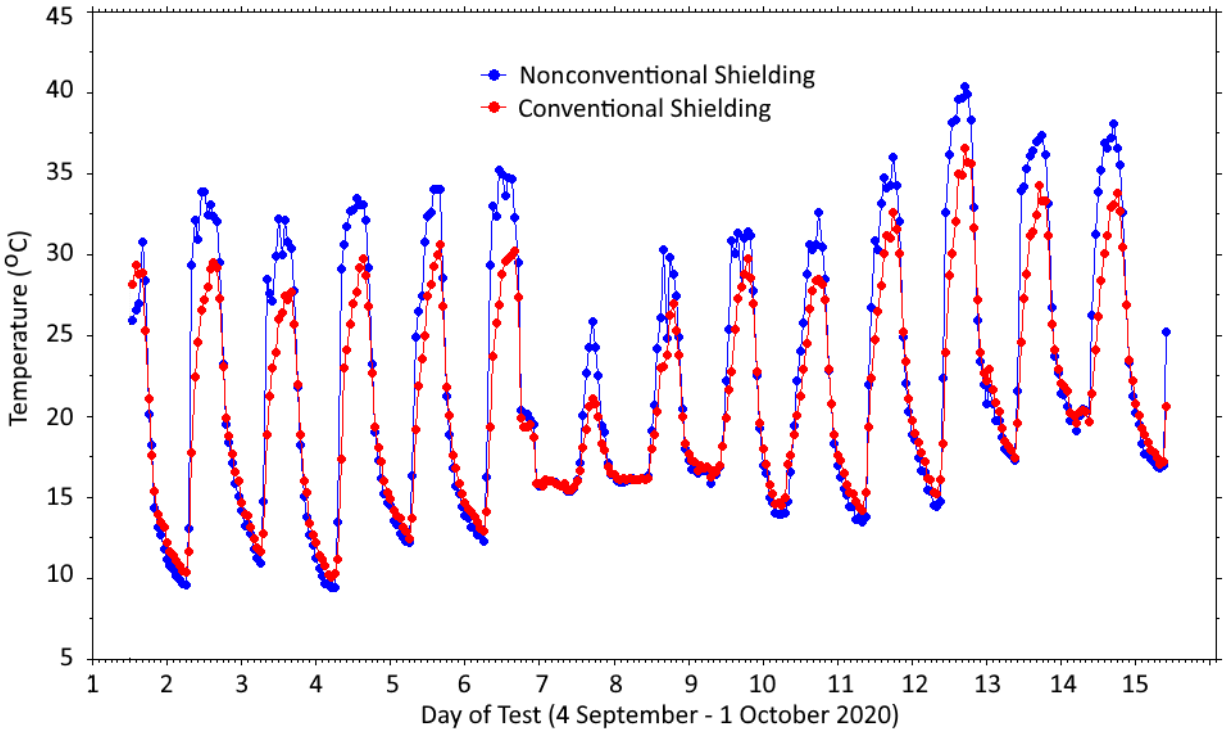

Figure 7. Brazilian mountain test site comparison of hourly temperatures (°C) between conventional and nonconventional (i.e., the Seymour Island permafrost monitoring station) Campbell 107 sensor protection shields. Test was conducted from 4 September to 1 October 2020, days 1-6 (4 September to 9 September), days 7-15 (22 September to 1 November).

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