Article:

Fogt, R. L., Jones, M. E., Solomon, S. et al. (2 more authors) (2017) An Exceptional Summer during the South Pole Race of 1911-1912. Bulletin of the American Meteorological Society, 98 (10). pp. 2189-2200. ISSN 0003-0007

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Figure S1 demonstrates that along the sledging journeys, despite only a few observations per day, the same general story emerges whether daily means or maximum or minimum temperatures are used. Since the sign of temperature anomalies switched during the journey, with temperatures above average for much of December, but notably below average for January as well as late February / early March for Scott, we use daily averages rather than a combination of daily maximum and daily minimum temperatures.

Figure S2 shows the mean climatological cycle of 2 m temperature over the Ross Ice Shelf region from ERA-Int. The values are in close agreement with Costanza et al. (2016), including the colder air near Roosevelt Island that extends westward toward the Transantarctic mountains in all months, and the warmer air descending down the major glacial valleys in the Transantarctic mountains, most marked in October- November and February – March.

The model elevations for the 0.75°x0.75° resolution ERA-Int data under-represent the complex and steep terrain in the vicinity of the Transantarctic mountains (compare Fig. 1 from main paper with Fig. S3). Using a standard environmental lapse rate of 6.5°C per km, the 2m temperatures in ERA-Int were adjusted to the correct elevations along the sledging journeys for both Amundsen and Scott. Despite the differences in regions of steep terrain and the glacial valleys, the elevation-corrected climatological temperature data agrees well with the conditions experienced by both polar parties (Fig. S4); most sledging observations fall within the 30-year temperature variability and absolute range provided from the elevation-corrected ERA-Int data.

The pressure reconstruction at Amundsen-Scott (Fig. S5) from Fogt et. al (2016a,b), like at McMurdo, shows that the summer of 1911/1912 is one of the highest points for the entire reconstruction and observation period. The reconstruction value is slightly above 692 hPa, and although the reconstructed values have pressure this high multiple times, the observations only have a similar value two times during 1957-2013. The Amundsen-Scott pressure reconstruction is similarly reliable, with a calibration correlation value of r=0.859. When considering this with the McMurdo pressure reconstruction, and the same large positive spike during this season, we are more confident in the exceptional nature of this season, especially along the routes of both Amundsen and Scott. All available early gridded pressure datasets indicate this was a season of very high pressure across the entire Antarctic continent, reflecting a negative phase of the Southern Annular Mode (Fig. S6).

One of the common assumptions made in this paper is that pressure values from McMurdo, Cape Evans, and Framheim are comparable to conditions across the Ross Ice Shelf (Barrier). Figure S7 shows the relationships between different regions of Antarctica compared to McMurdo, with Fig. S7a illustrating correlations of r=0.99 across much of the Ross Ice Shelf. Fig. S7b shows the root mean squared error (RMSE), with the lowest values in this same region (primarily along Scott's route on the Barrier) when comparing both plots. In the original paper, Fig. 2a is a comparison of pressure on the barrier between the sledging parties and the two bases, with the McMurdo 1981-2010 climatological mean and +/- 2 standard deviations. The barrier is defined as any observations taken at elevations below 100 m, and the sledging parties' observations match up very well with the data from Cape Evans and Framheim. Fig S7 demonstrates that these are fair comparisons, since the pressure correlation between the Ross Ice Shelf and the Ross Island area is near unity. Although a bit weaker, the correlations are still high and the RMSE is still low from the Transantarctic Mountains southward to the South Pole with those at the Ross Island area, allowing for comparison with notable skill of the pressures at Cape Evans / Framheim all the way to the South Pole in summer.

Figure S8 demonstrates that while there is a significant relationship using seasonal mean data between the SAM index and temperature across Antarctica (Marshall 2007), the relationship using monthly data is primarily insignificant across the Ross Ice Shelf, except in November and February. Therefore the higher pressures observed by the field parties and at Cape Evans and Framheim may not necessarily have a corresponding strong temperature anomaly associated with them, especially when on the Ross Ice Shelf. During much of January when pressures were lower, it is not surprising also to see weaker temperature anomalies by both parties, as well as the lack of simultaneous strong temperature anomalies as noted in early December 1911.

The warm temperatures Amundsen experienced in early December are compared to the 10-minute quality controlled temperatures from the closest automatic weather station, Henry AWS (-89.0°S, -0.39W) using daily maximum temperatures in Fig. S9. The values on December 5-6 recorded by Amundsen stand out as very warm conditions, which have only been recorded at Henry AWS later in the month.

Figure S10 demonstrates the sensitivity to the length and duration of the time windows chosen to contrast the warm temperatures in early February 1912 to the cold temperatures in late February / early March 1912, and is based on the original data (similar structure as in the main manuscript is observed when using anomaly data). We used differing lengths for the number of days included for both the early and late time periods (from as little as 4 consecutive days to as long as 15 consecutive days, termed the 'windows') over which temperatures were averaged. We then took the difference of all these averages, and generated a histogram. The time windows for the early period encompass all or portions of February 9-15 for the earlier period, and February 27 – March 5 for the later period. For window lengths over the original 7 days length, the windows were generated such that they extended evenly outside the original 7-day periods, and as such for even length day windows above 6, two subsets were created: one that had an extra day at the beginning of each time period, and one that had an extra day at the end of each time period. The histograms there have larger counts for all the differences for even numbered windows >6, and for smaller windows <7. The red vertical line shows the average temperature difference experienced by Scott during the same periods. Regardless of how the time windows are chosen, it is seen that the temperature change experienced by Scott during this time was in the top <3% of the data distribution based on ERA-Int data, highlighting its uniqueness.

References

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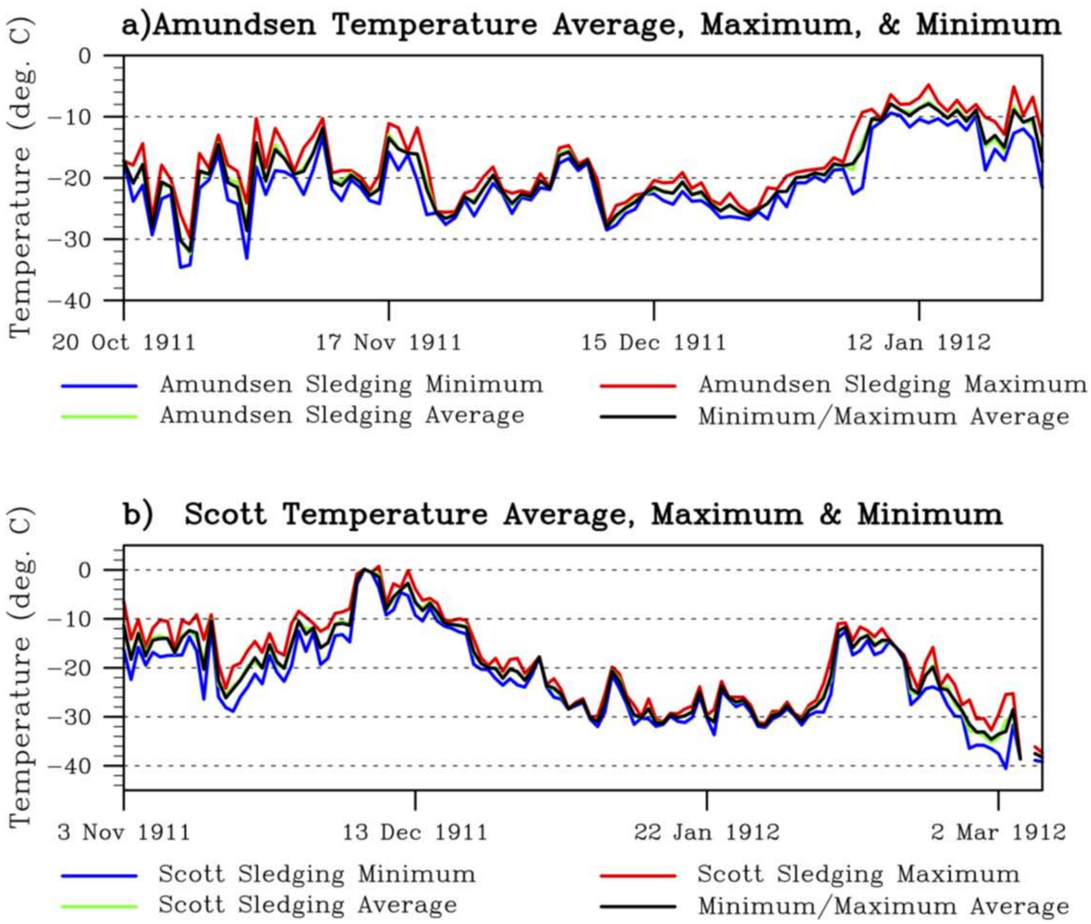

Figure S1. Time series of daily mean, maximum, and minimum temperatures along the sledging journey for a) Amundsen and b) Scott. Also shown is the average of the daily maximum and minimum (black line), which agrees closely with the average of all observations (green), further providing support that using the daily mean of the limited number of observations does not bias the interpretation of the temperature variability during the sledging journeys.

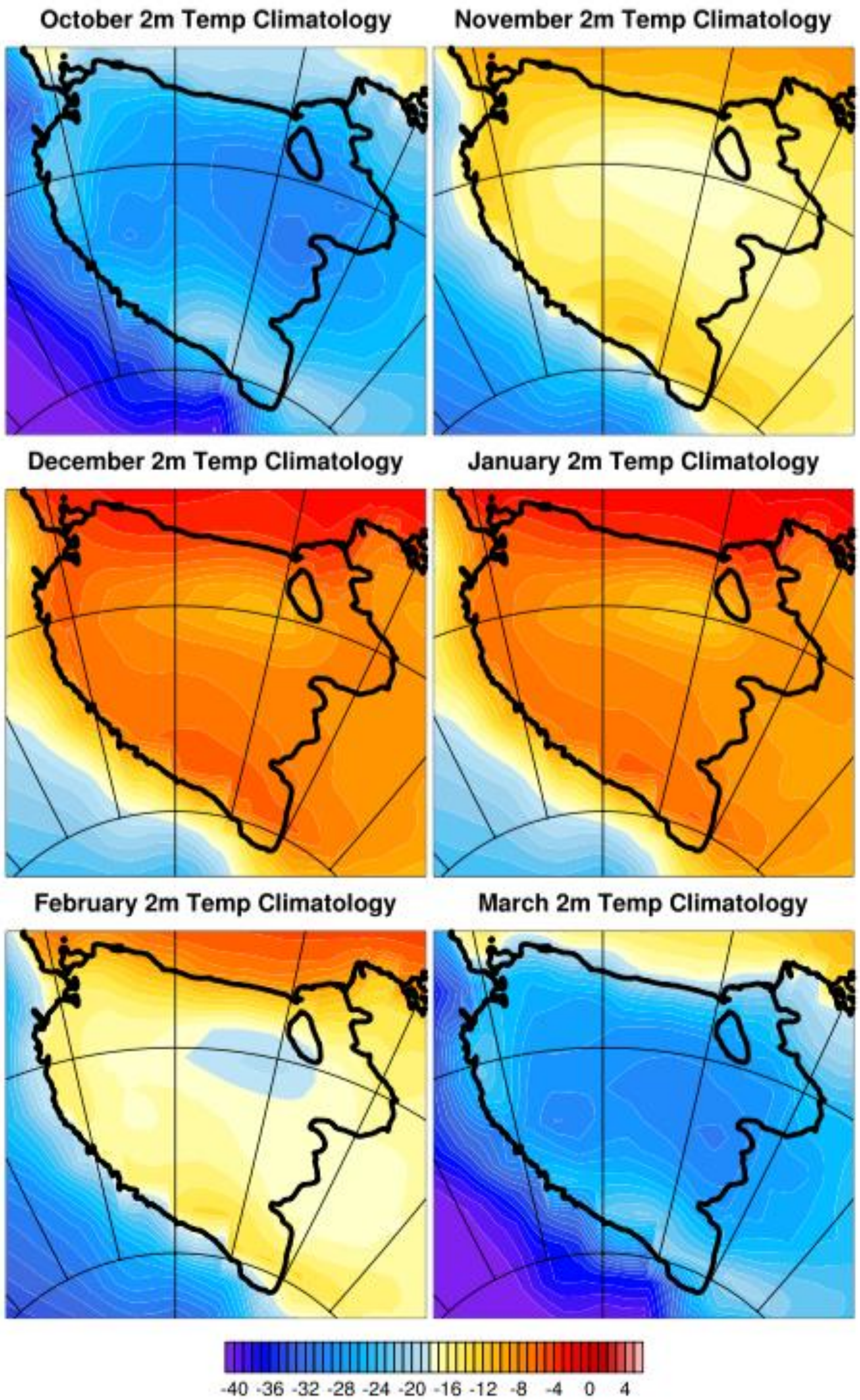

Figure S2. ERA-Int 2m temperature (in °C) climatology by month, October – March, averaged during 1981-2010.

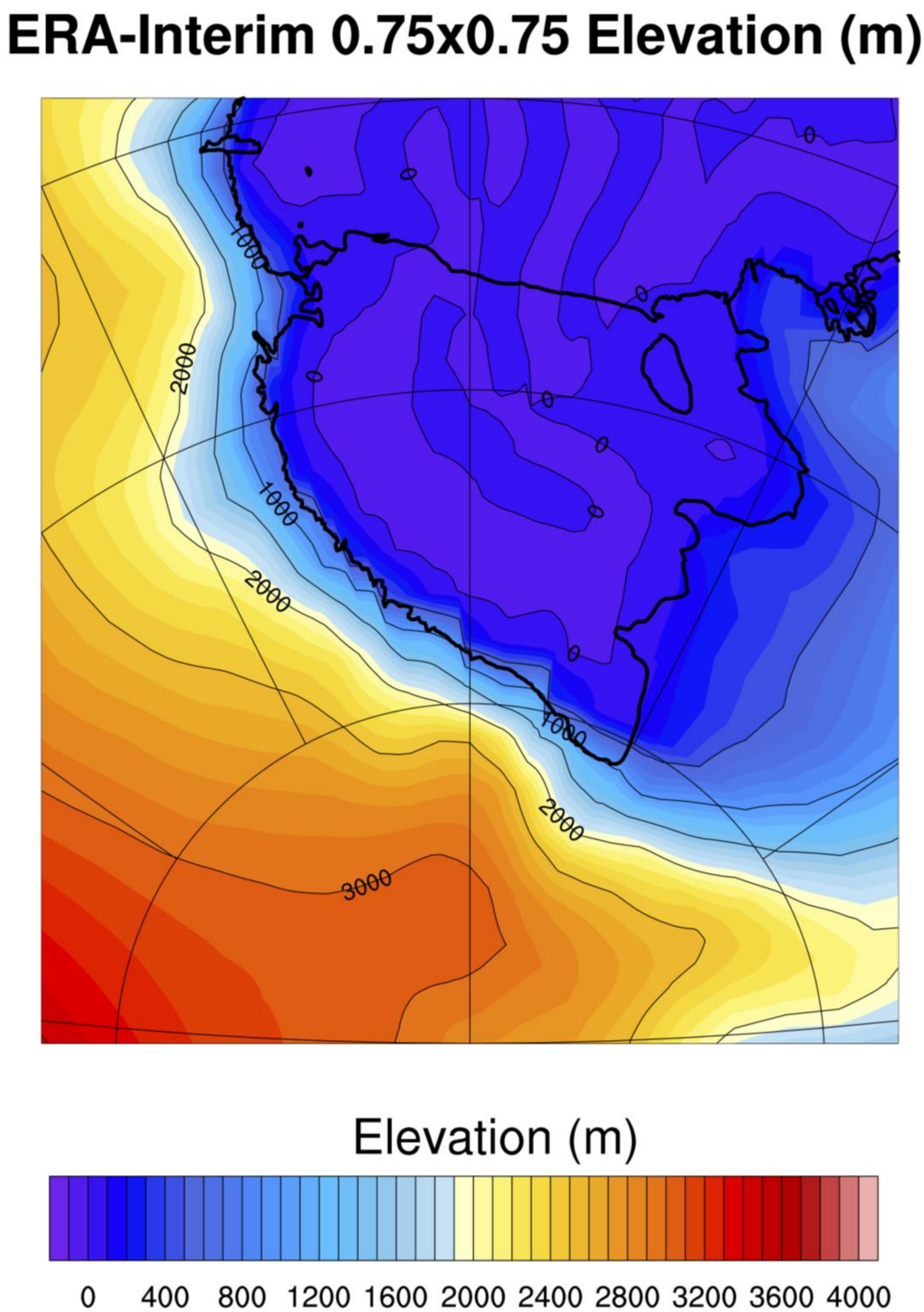

Figure S3. Model elevation for ERA-Int at the 0.75°x0.75° longitude-latitude resolution, based on the invariant variable geopotential. Along the Transantarctic mountains, elevations are greatly smoothed compared to the real world (Fig. 1 from main paper) and no glacier valleys exist. Therefore elevation corrections to temperature are required.

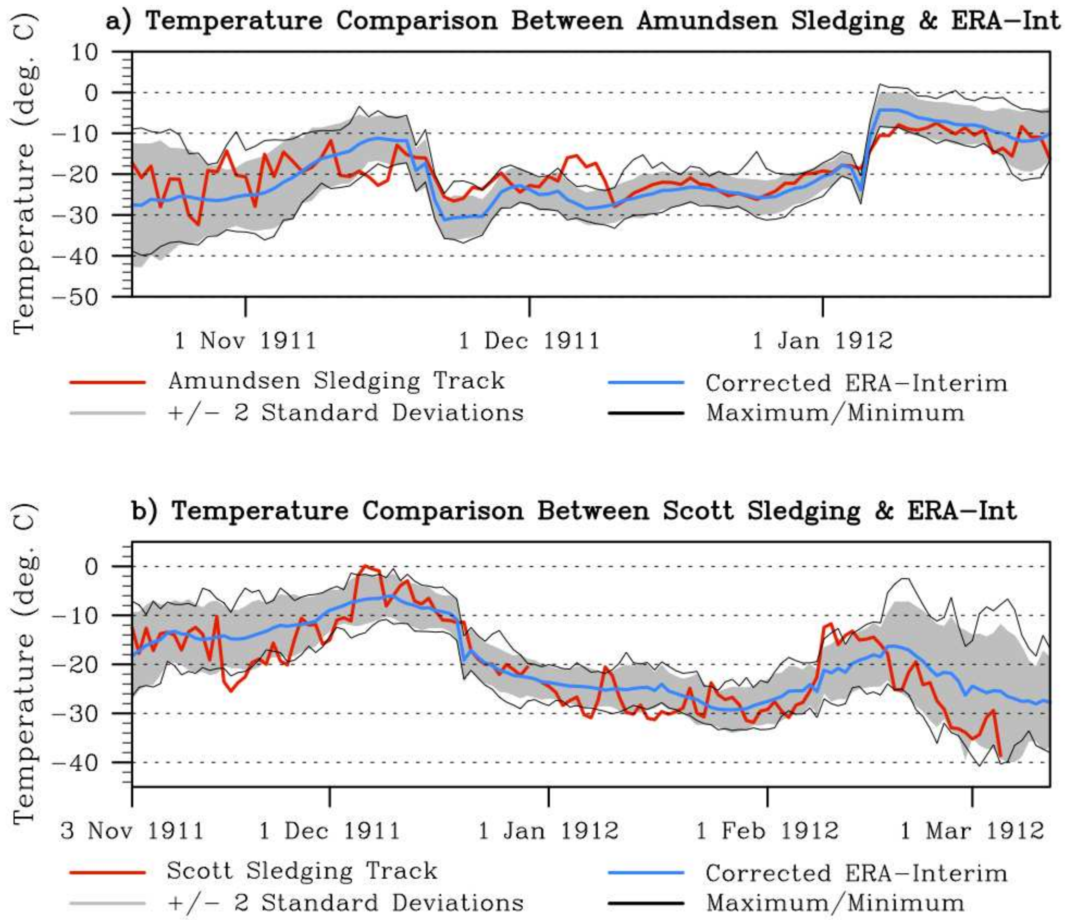

Figure S4. Comparison of temperature observations along the sledging journey for a) Amundsen and b) Scott along with the elevation-adjusted ERA-Int climatological daily mean temperature (blue line). The daily mean temperature variability is represented by the ± 2 standard deviation ERA-Int daily mean temperature envelope (gray shading) and the maximum / minimum ERA-Int daily mean temperature (think black lines).

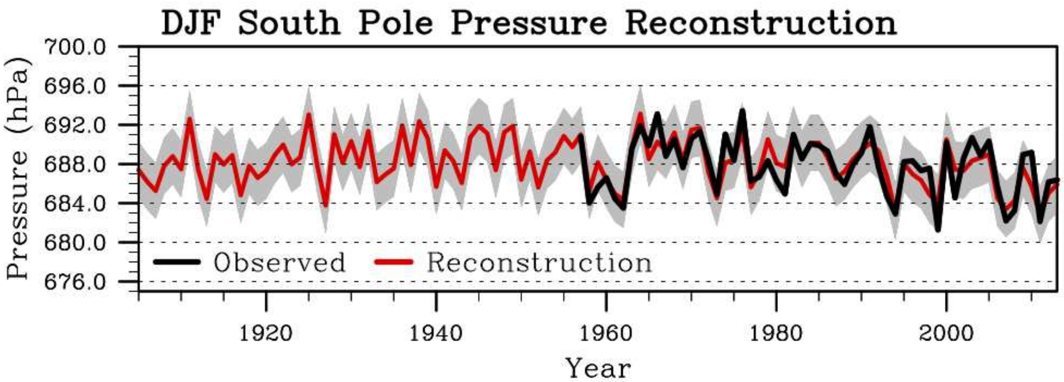

Figure S5. Summer (December-February) Amundsen-Scott South Pole station observed (black) and reconstructed (red) surface pressure. Also plotted is the 95% confidence interval for the reconstruction, which correlates with the observations at r=0.859.

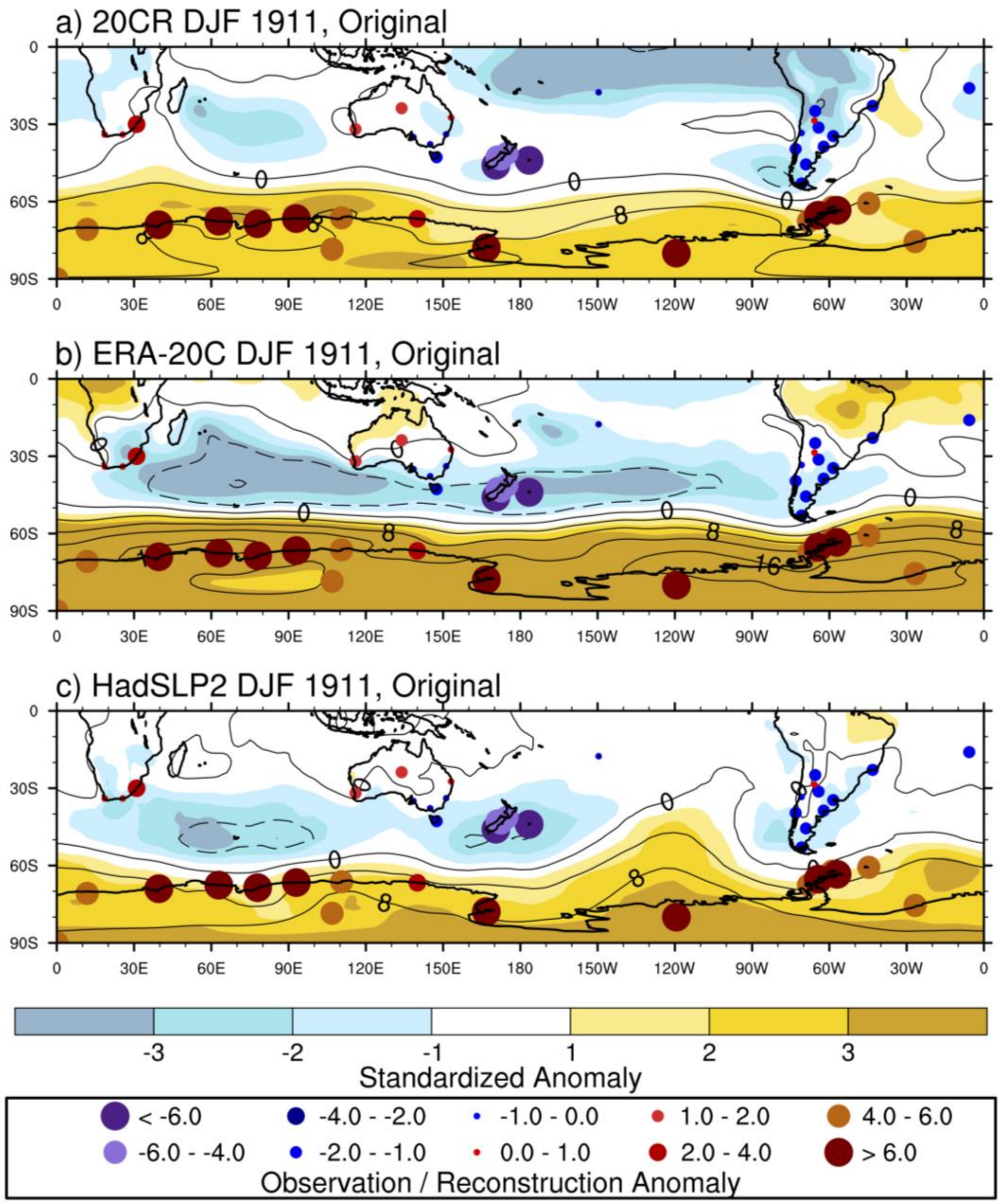

Figure S6. DJF 1911/12 pressure anomalies and standard deviations (contoured and shaded, respectively) from the 1981-2010 climatological mean for a) 20CR b) ERA-20C and c) HadSLP2, along with circles indicating observed midlatitude pressure anomalies (equatorward of 60°S) and Antarctic pressure reconstruction anomalies (poleward of 60°S), with anomaly magnitude given by the legend.

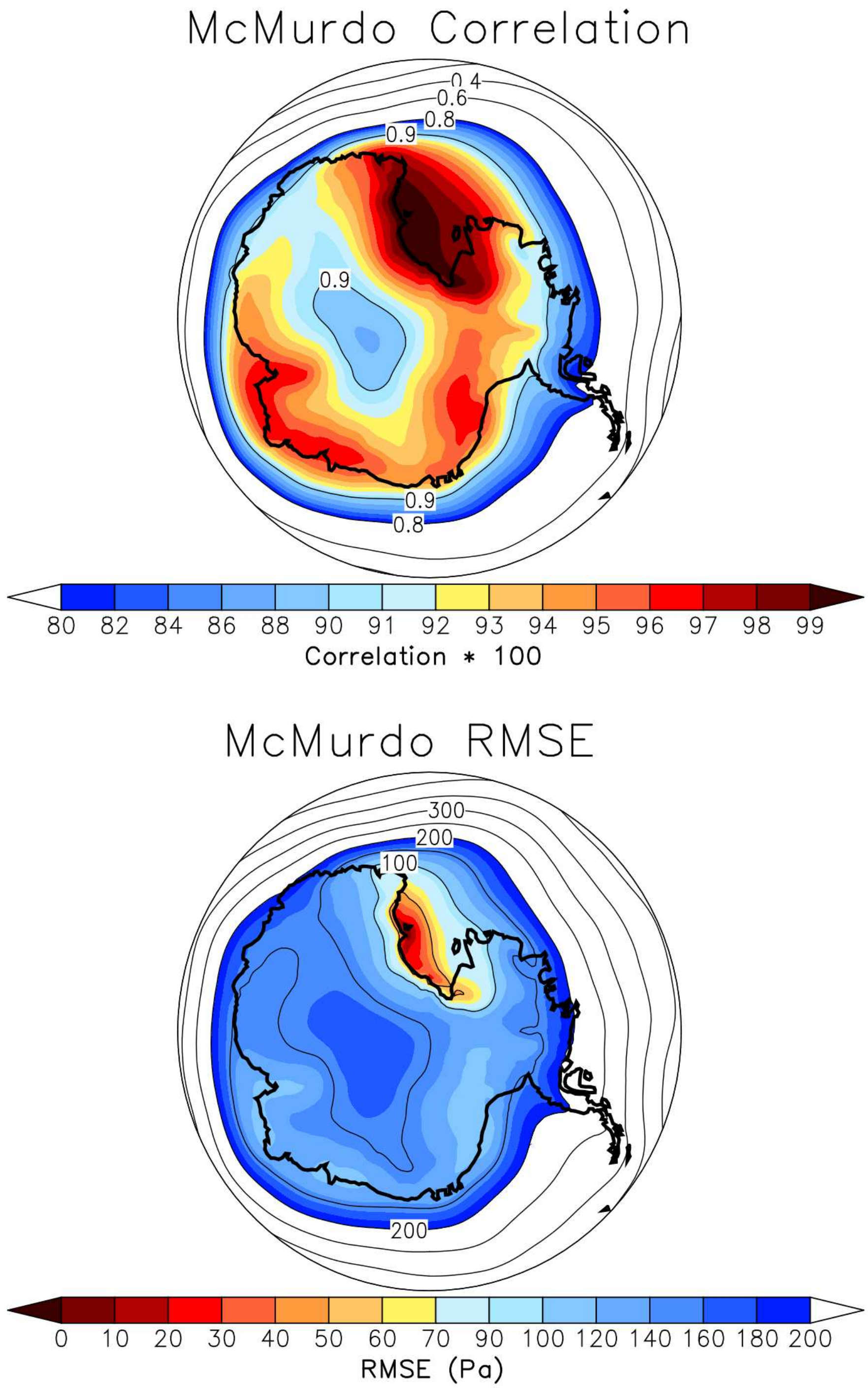

Figure S7. Top: Correlation of the pressure at McMurdo station with every other grid point of the ERA-Int surface pressure anomalies during DJF. Pressure correlations on the Ross Ice Shelf exceed 0.95 everywhere, and are above 0.99 for much of the western Ross Ice Shelf along Scott's route. Bottom: The root mean squared error (RMSE, in Pa) between McMurdo pressures and every other grid point of the ERA-Int surface pressure anomalies during DJF. Again, across the Ross Ice Shelf the mean error is less than 1 hPa, and less than 0.5 hPa in the western Ross Ice Shelf along Scott's route.

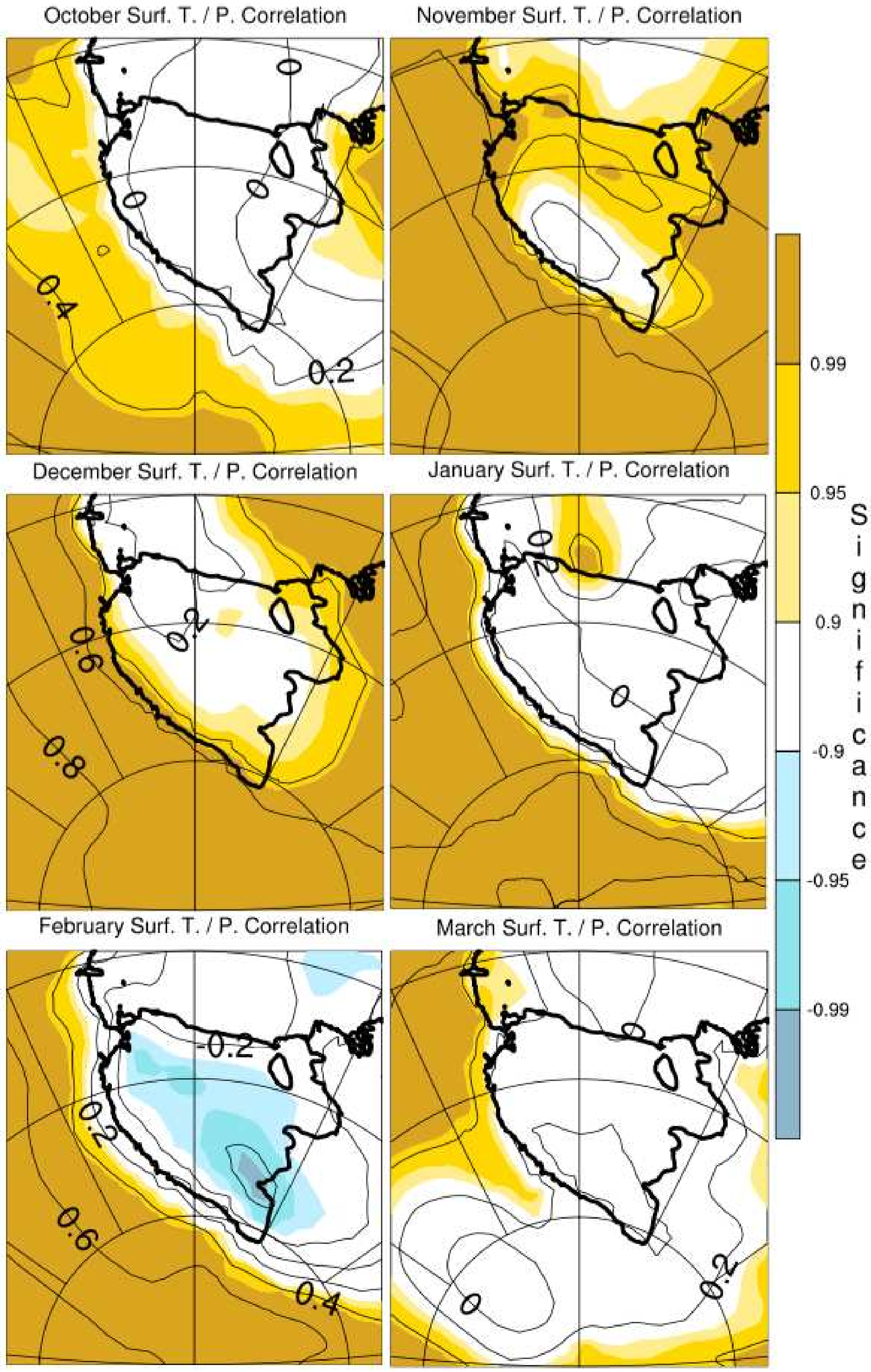

Figure S8. Monthly (October- March) surface pressure and temperature correlation maps during 1979-2015 at every gridpoint from ERA-Interim 0.75°x0.75° data. Shading represents the statistical significance of the monthly correlations, as given by the label bar on the right (1-*p*)*100, and negative for negative correlations; white areas indicate regions of $p>0.10$.

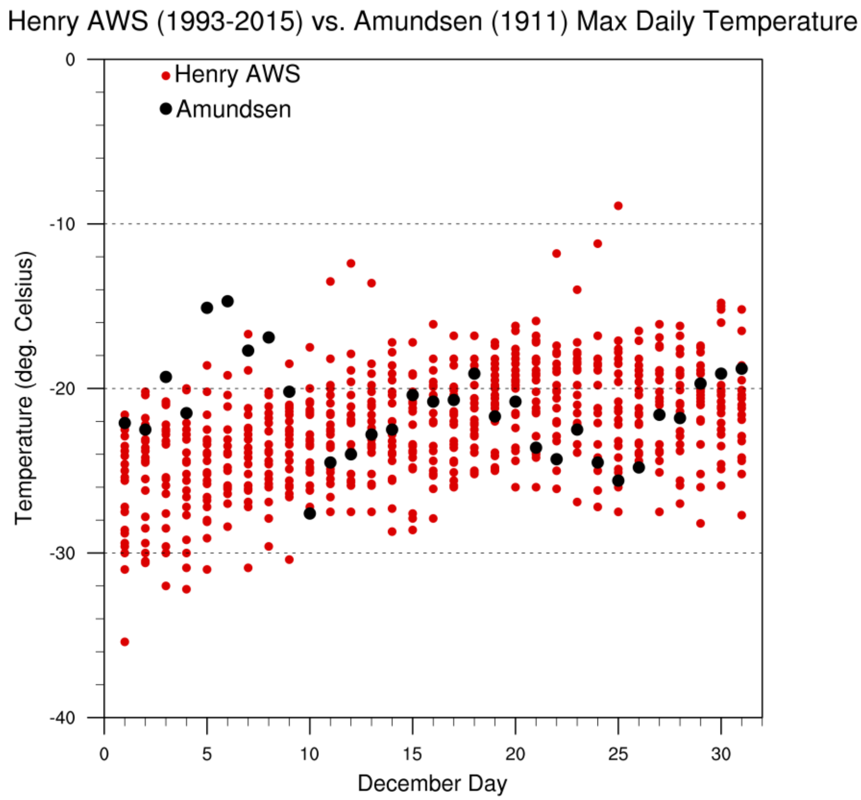

Figure S9. Daily maximum temperatures from the Henry automatic weather station (red) during 1993-2015, based on quality controlled 10-minute data, and the 1911 Amundsen daily maximum temperatures (black).

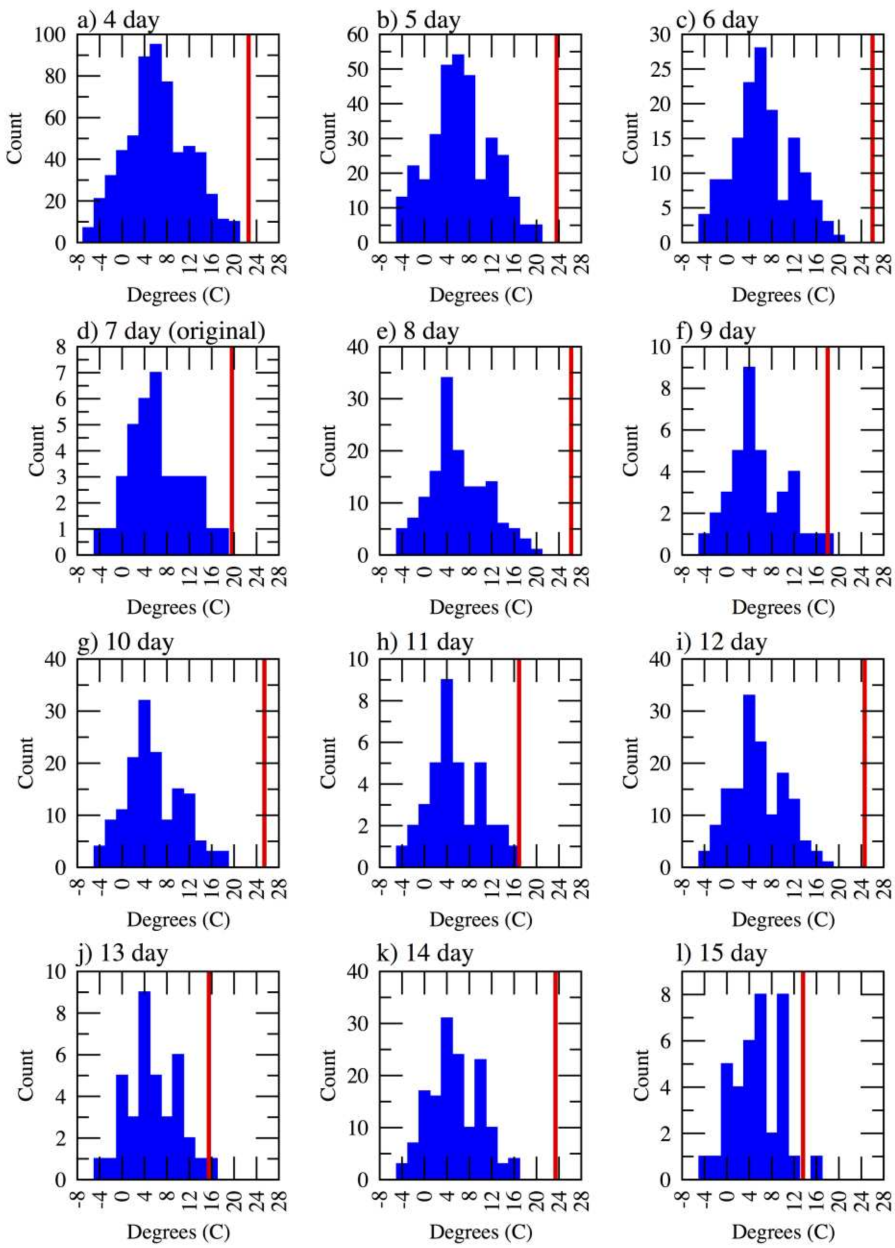

Figure S10. Histograms of absolute temperature difference from February 9-15 and February 27 – March 5, based on varying lengths of number of days for averaging in both the earlier and later periods (indicated by individual panel titles), from ERA-Interim daily temperature data during 1979-2015. The red vertical line indicates the mean temperature difference experienced by Scott in 1912.