

Auxiliary Material: 2008GL035074

Observational Evidence for Asymmetric Changes in Tropospheric Heights over Antarctica on
Decadal Time Scales

W. Neff, J. Perlwitz, & M. Hoerling

Station	Lat	Long	Start	End	Major Gaps	Missing Months (exclusive of major gaps)
"West" Antarctic Coastal Stations						
Halley (HAL)	75.5S	26.4 W	Apr-57	Dec-07	None	16
McMurdo (MCM)	77.9S	166.7E	May-56	Dec-07	None	11
High Plateau Stations						
South Pole (SP : 2835 m ASL)	90.0S	0.0E	Aug-57	Dec-07	None	5
Vostok (VOS : 3490 m ASL)	78.5S	106.9E	Jan-58	Dec-91	2/1962-4/1963; 5/1982-3/1983	0 (Note: data prior to 1964 suspect)
"East" Antarctic Coastal Stations						
Merged: (MCC)						
Casey	66.3S	110.5E	Apr-57	Dec-07	None	3
Mirny	66.5S	93.0E	Feb-56	Dec-07	None	5
Davis	68.6S	78.0E	Apr-59	Dec-07	11/1964-03/1969	9
Mawson	67.6S	62.9E	Apr-57	Dec-07	None	10
Merged: (MS)						
Molodeznaja	67.7S	45.9E	Jun-64	Jan-98	1/1962-5/1964	6
Syowa	69.0S	39.6E	Apr-59	Dec-07		
Merged: (NNS)						
Novolazarevskya	70.8S	11.8E	Jan-61	Dec-07	None	0
SANAE	70.3S	2.4W	Jan-57	Nov-92		
Neumayer	70.7S	8.4W	Feb-83	Dec-07		

Table S1. Summary of 500 hPa monthly geopotential heights (GPH) available for this study. Data from stations within reasonable proximity of each other have been merged as noted by the shaded sections in the above table. Data developed using READER project data, Climate Data Volumes, and reprocessing of raw sounding data where possible. In the case of McMurdo records, there were 24 missing monthly averages at 500 hPa from April 1956 to December 1961, 22 of these were filled using Climate Data Volume data and two months filled using reprocessing with a constraint of ten soundings/month. After 1961, there were 47 missing monthly averages: 36 of these were filled with reprocessing using a minimum of ten soundings/month. This left 11 missing months out of a total of 621 for McMurdo. In the case of South Pole records, Climate Data Volume records were used to fill 36 monthly averages out of the 41 missing months from August 1957 through December 1960. Of the 23 missing months in the READER data set, 22 were replaced through reprocessing of raw soundings with a constraint of a minimum of 15 soundings/month. One was replaced from the Climate Data Volumes.

Linear Regression Between Stations (R^2 /Difference in GPH)					
<i>Station</i>	<i>Long.</i>	<i>March</i>	<i>June</i>	<i>September</i>	<i>December</i>
<i>Mawson (67.6°S)</i>	<i>62.9°E</i>	-	-	-	-
<i>Davis (68.6°S)</i>	<i>78.0°E</i>	0.70/-20m	0.83/-6m	0.87/+2m	0.91/+6m
<i>Mirny (66.5°S)</i>	<i>93.0°E</i>	0.50/+11m	0.58/+26m	0.66/+23m	0.74/+18m
<i>Casey (66.3°S)</i>	<i>110.5°E</i>	0.43/+8m	0.47/+40m	0.49/+23m	0.69/+20m
<i>South Pole (90°S)</i>	-	-	-	-	-
<i>Halley (75.5°S)</i>	<i>26.4°W</i>	0.50/+56m	0.40/+20m	0.52/+38m	0.67/+14m
<i>South Pole (90°S)</i>	-	-	-	-	-
<i>McMurdo (77.9°S)</i>	<i>166.7°E</i>	0.37/-17m	0.40/-35m	0.44/-34m	0.82/-10m

Table S2. Regression analysis of monthly 500 hPa GPHs between stations for March, June, September, and December. Difference in monthly averaged GPH is reference from the initial station listed in each grouping.

	September	December	May
MCC (62.9°-110.5°E)	R ² = 0.10 B = +0.34 Sig = 0.025	R ² = 0.31 B = -0.75 Sig = 0.000	R ² = 0.45 B = -1.13 Sig = 0.000
MS (39.6° – 45.9°E)	R ² = 0.06 B = +0.27 Sig = 0.096	R ² = 0.05 B = -0.40 Sig = 0.127	R ² = 0.66 B = -1.35 Sig = 0.000
NNS (2.4°W – 11.8°E)	R ² = 0.43 B = +1.03 Sig = 0.000	R ² = 0.04 B = -0.24 Sig = 0.138	R ² = 0.28 B = -0.81 Sig = 0.000
HAL (26.4°W)	R ² = 0.29 B = +0.84 Sig = 0.000	R ² = 0.01 B = +0.12 Sig = 0.561	R ² = 0.09 B = -0.30 Sig = 0.025
SP (90°S)	R ² = 0.86 B = +1.76 Sig = 0.000	R ² = 0.19 B = +0.66 Sig = 0.002	R ² = 0.01 B = 0.13 Sig = 0.56
MCM (166.7°E)	R ² = 0.71 B = +1.95 Sig = 0.000	R ² = 0.13 B = +0.58 Sig = 0.012	R ² = 0.01 B = -0.17 Sig = 0.48

Table S3. Summary from linear-regression-analysis of the time series of GPH derived from the stations listed in Table S1. R² = the fraction of variance accounted for by a linear relationship; B = trend in m/yr; and Sig = probability of the null hypothesis being true (we have taken 0.05 as the limit for significance here with significant trends indicated by the bold typeface. (MCC: Mawson, Davis, Mirny, Casey composite; MS: Molodeznaja, Syowa composite; NNS: Neumayer, Novolazarevskya, SANAE composite; HAL: Halley Bay; SP: Amundsen-Scott South Pole; MCM: Mcmurdo)

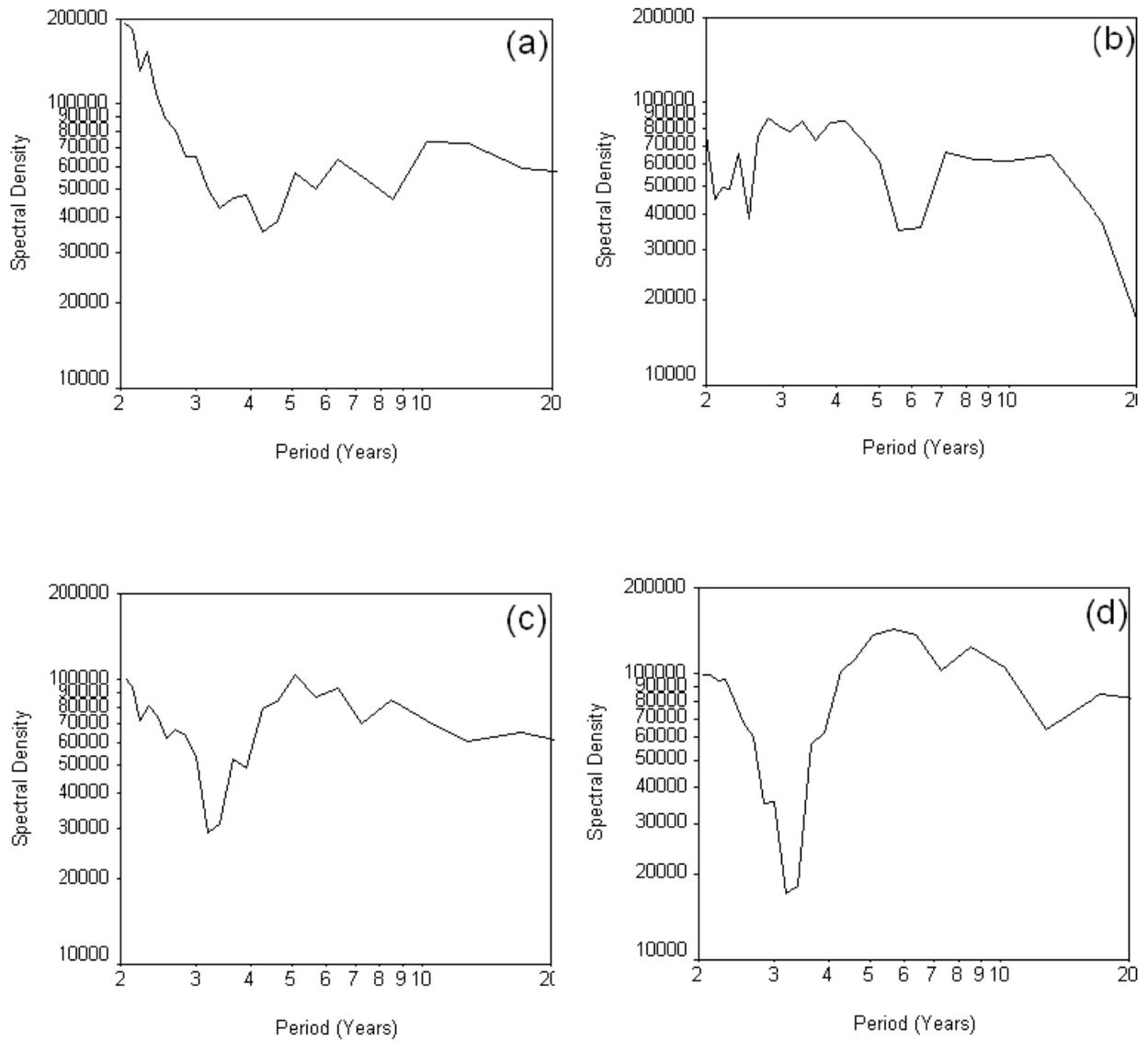


Figure S1: Power spectral density: (a) May – MCC, (b) September – SP, (c) December – MCC, (d) December – SP.

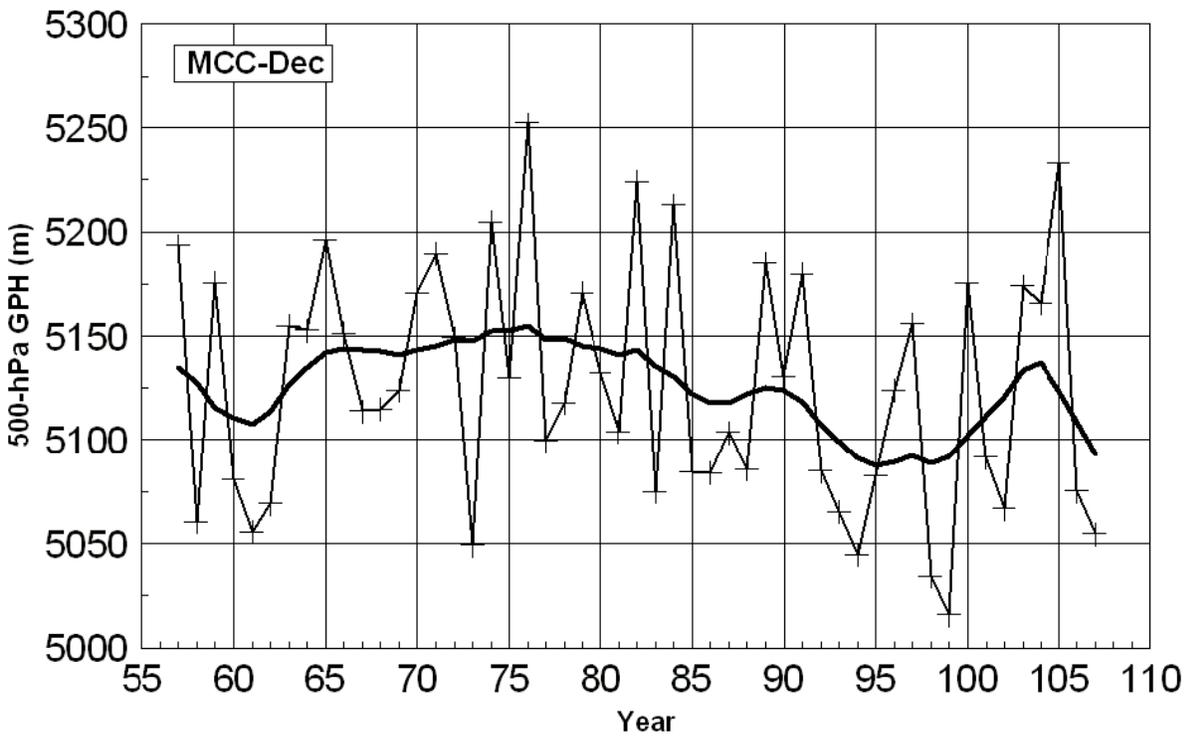
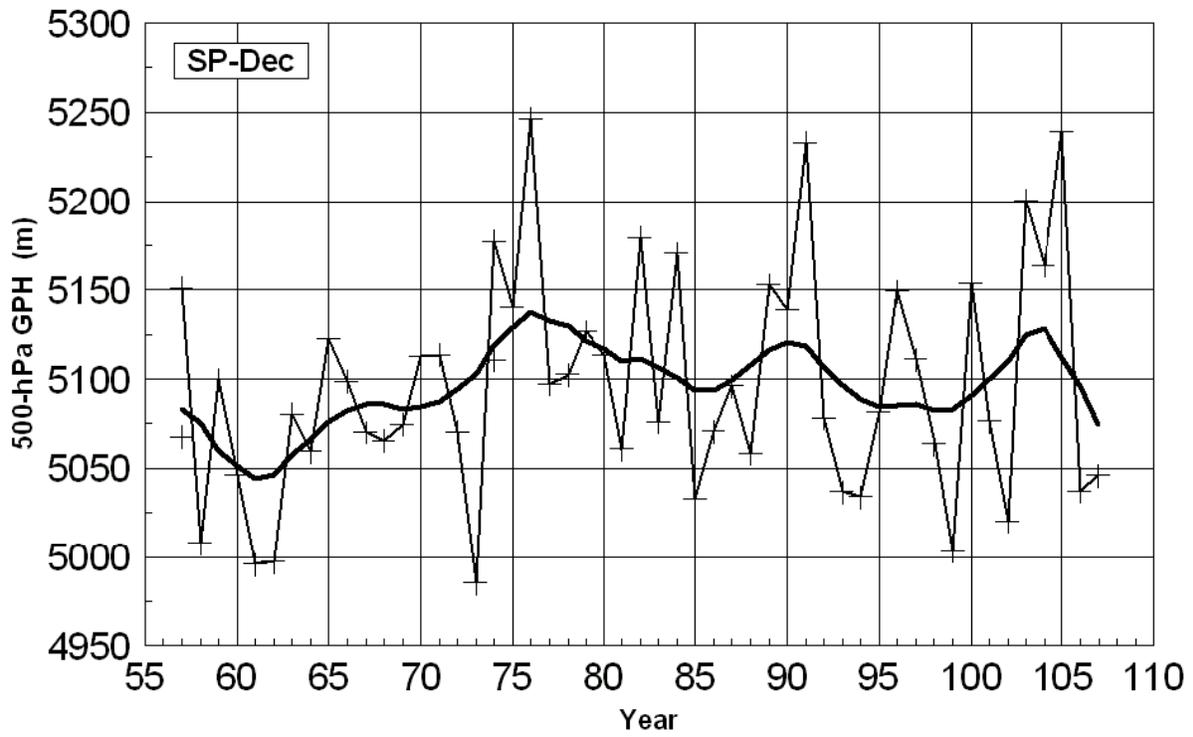


Figure S2. Raw and smoothed time series of GPH for September and December for the South Pole.

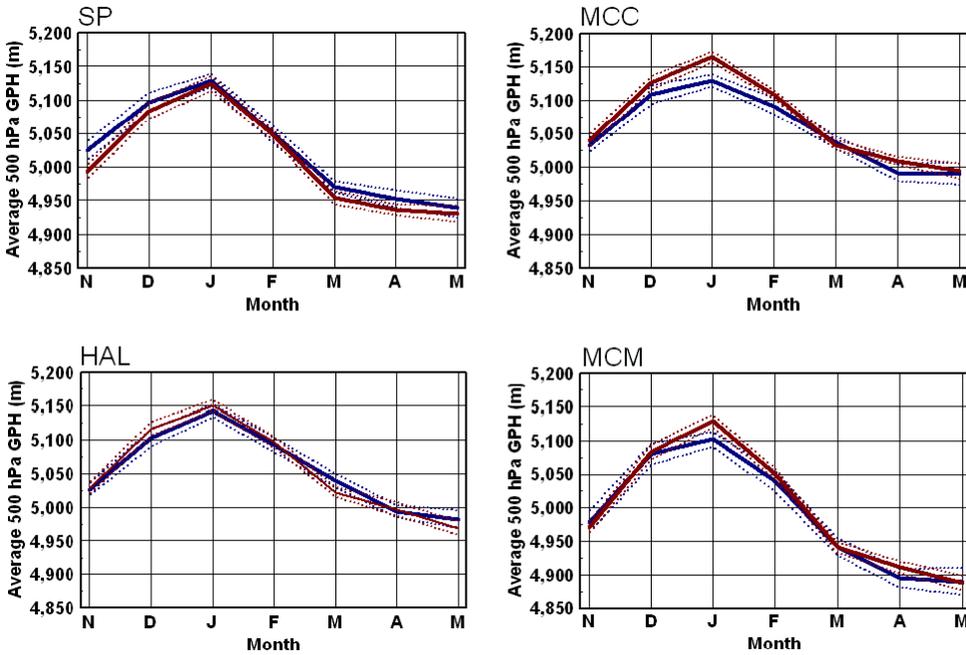


Figure S3. Average GPH in low (<253 DU) and high (>300) TOC Novembers for the South Pole (SP), the Mawson to Casey composite (MCC), Halley Station (HAL), and McMurdo Station (MCM). Dotted lines indicate standard error of estimate.

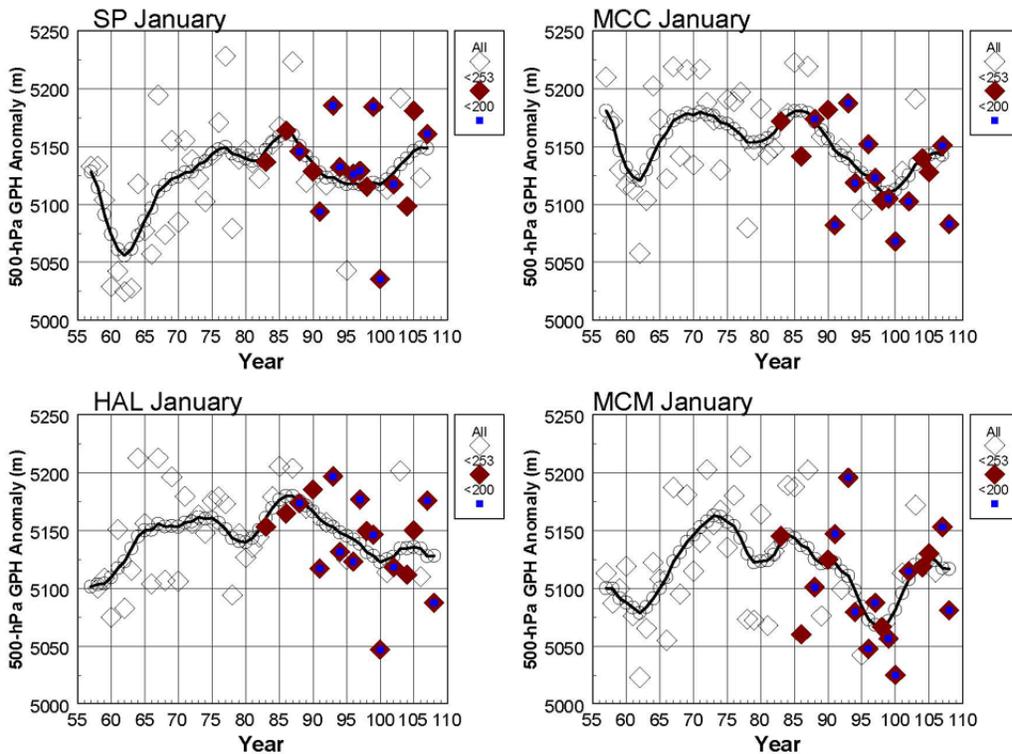


Figure S4. Individual data for the January averages shown in Figure A3. Blue Diamonds correspond to November TOC <200 DU; red diamonds are the additional points added using TOC < 253 DU. Smoothed data is shown with a solid line and open circles.

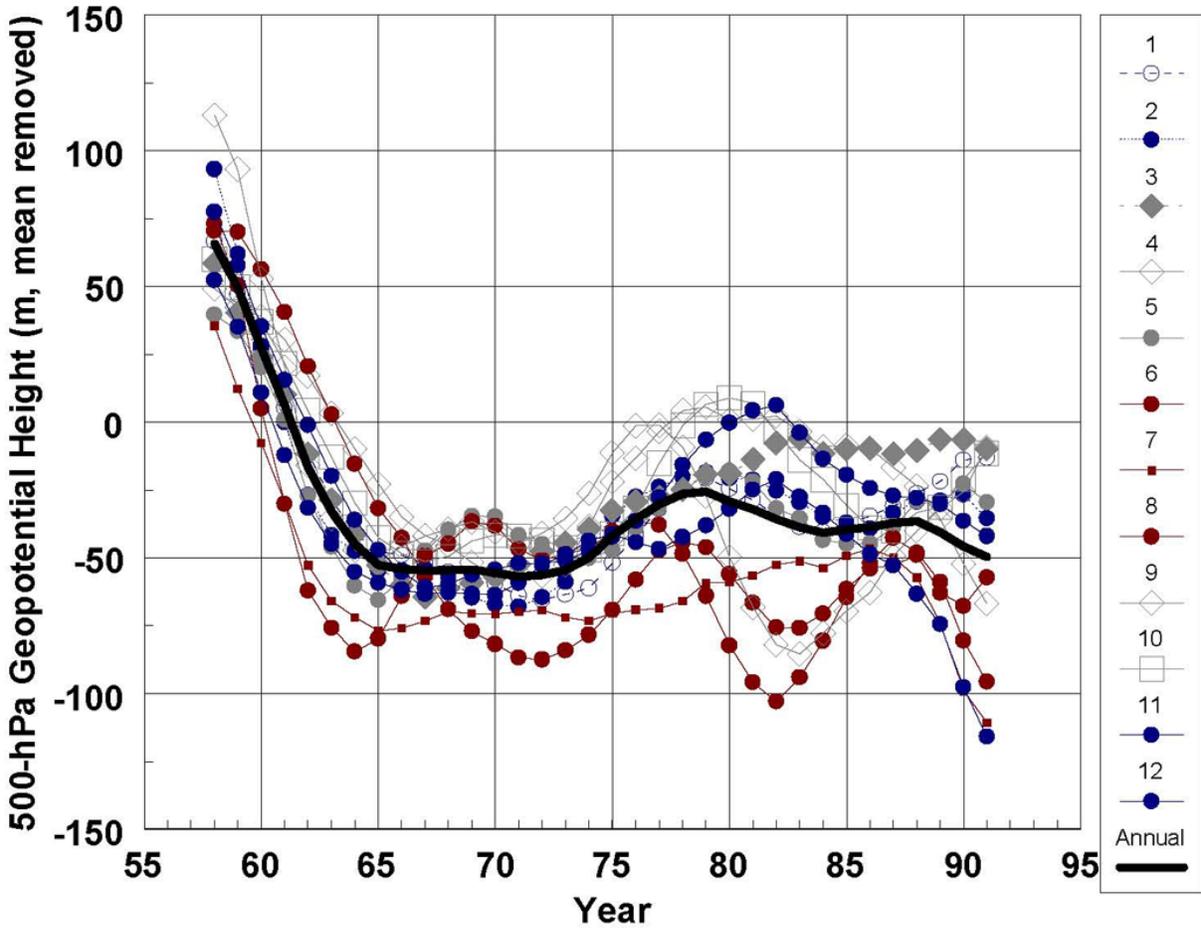


Figure S5. Smoothed difference in 500 hPa GPH between South Pole and Vostok: large differences exist prior to 1964 with consistent but smaller differences following, the latter in agreement with the comments of [Bromwich, et al., 2000]. Thus, we consider the Vostok data limited in their usefulness to the period 1964-1991.

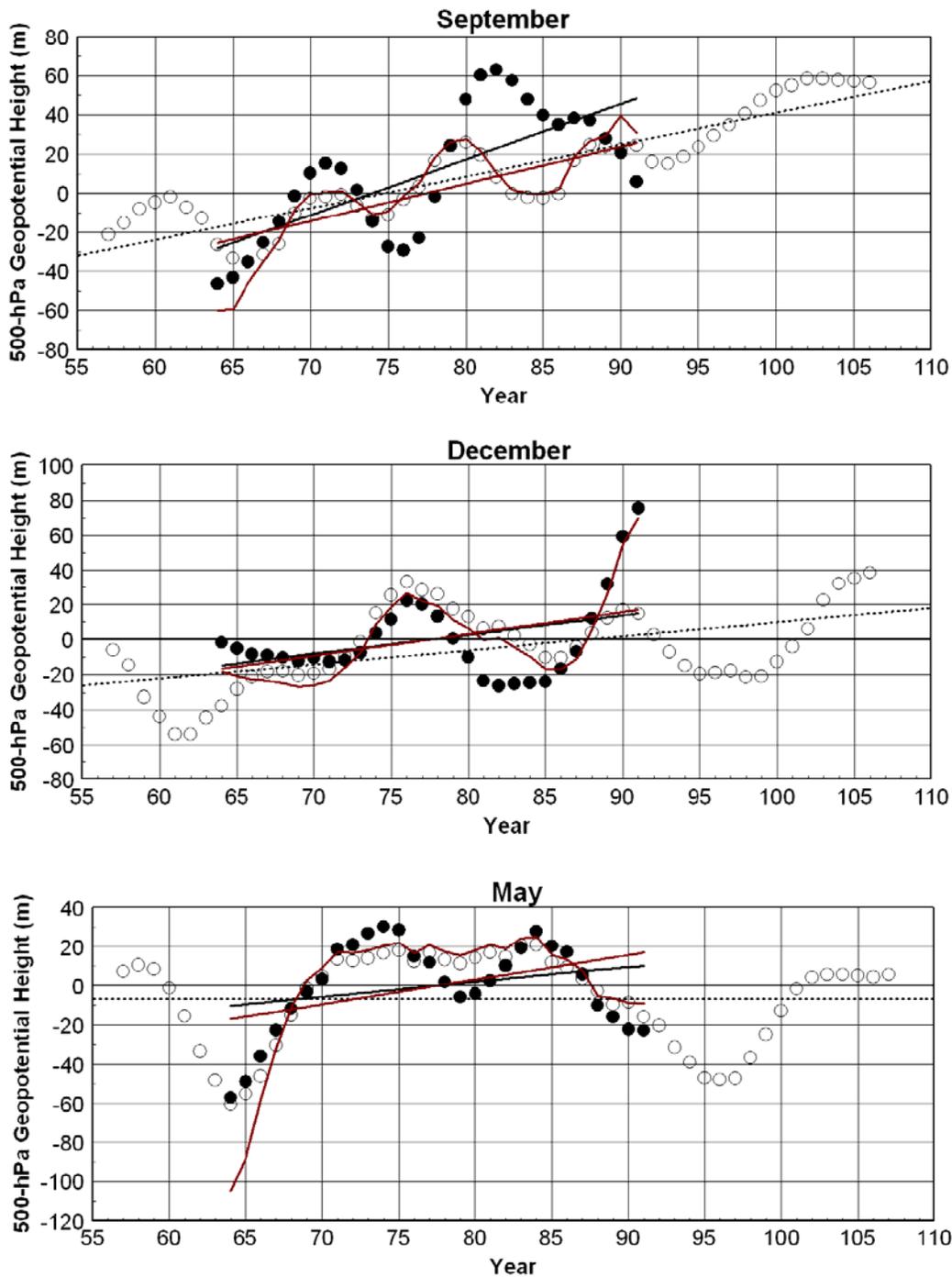
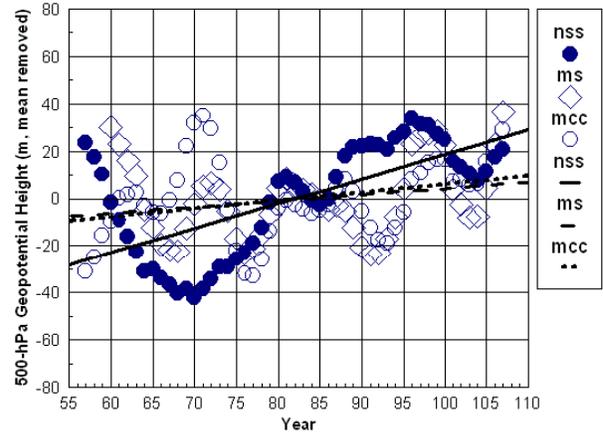
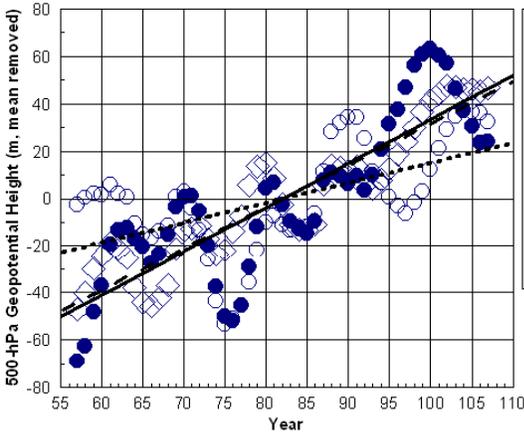
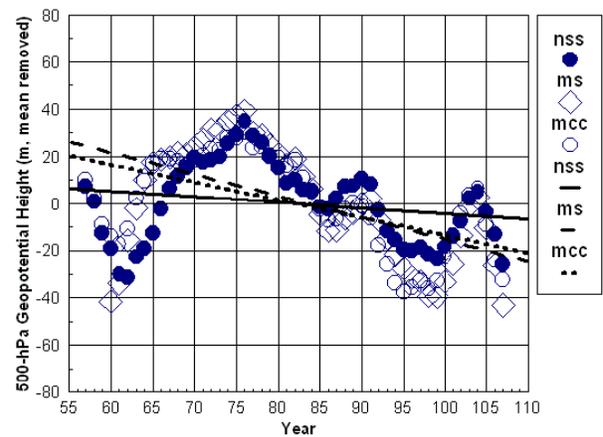
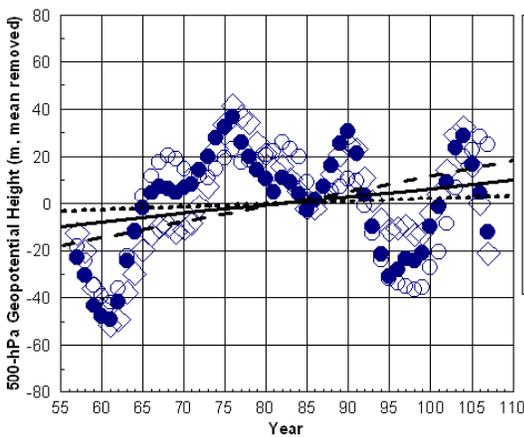


Figure S6. Comparison of Vostok 500 hPa GPH (solid circles) with those from the SP (open circles) using five-point tapered filter. The red line is the filtered version of the SP time series reduced to the period 1964-1991 which captures the “noise” associated with the strong interannual variability in these time series. The extremes at the ends of some of the short time series occur because of consistently higher or lower GPH values that are not removed by the filter. The mean from 1964 to 1991 was removed from both time series. Least-squares fit lines are also shown (dashed: long term SP time series; solid black: short Vostok time series; solid red: short SP time series). This analysis of the Vostok data for the period 1964-1991 confirms the same upward trend as the SP for the period 1964-1991 within the uncertainties associated with the short time series and after removal of the means.

September



December



May

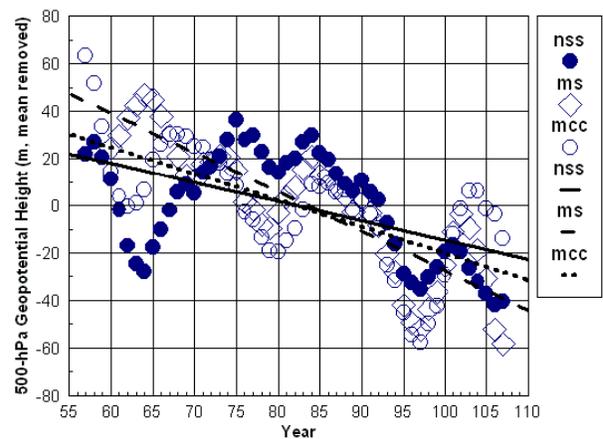
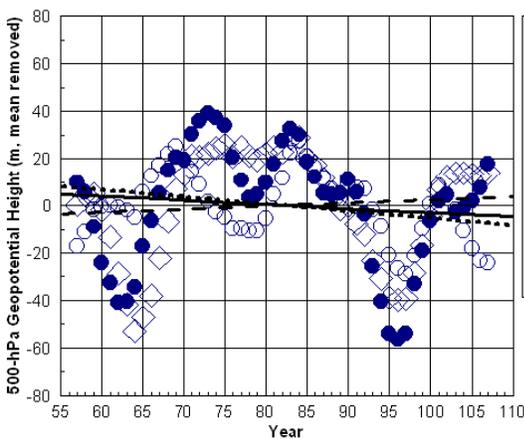


Figure S7. Comparison of trends at the South Pole (sp) with those at McMurdo (mcm), Halley (hal), and composites from Molodeznaja/Syowa (ms), Neumayer/Novolazarevskya/ SANAE (nns) and the Mawson-Casey Composite (mcc). Figures on the left represent primarily “west” Antarctica while those on the right represent “east” Antarctica.

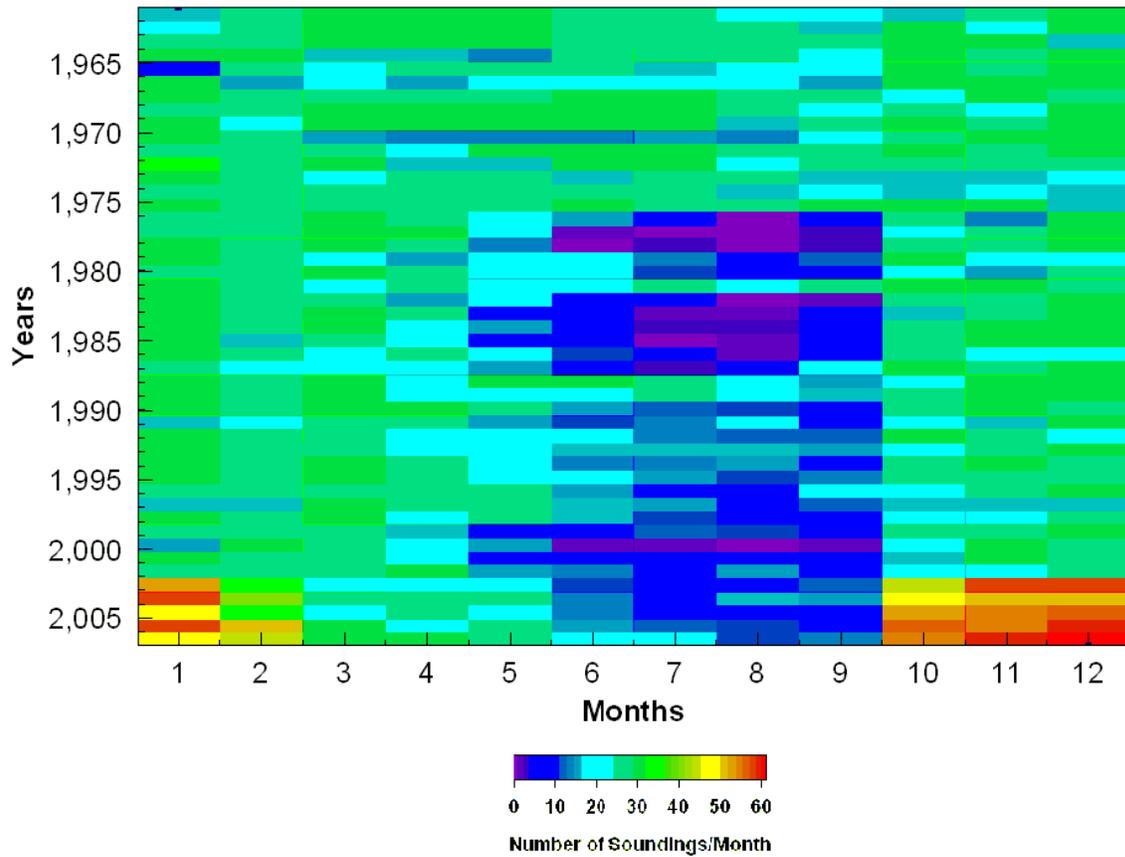


Figure S8. Distribution of McMurdo soundings by year and month at 100 hPa using 00Z and 12Z data. For calculations at 100 hPa, the READER data were used with 45 additional data points added (7% of total) using a relaxed constraint of between 5 and 9 observations per month obtained from the original sounding data. An additional twenty-two points were added from Climate Data Volumes. Note the reduced availability of data at 100 hPa after 1975 during the winter months.

Reference

Bromwich, D. H., et al. (2000), ECMWF analyses and reanalyses depiction of ENSO signal in antarctic precipitation, *J. Clim.*, 13, 1406-1420.