Maximum & Minimum Temperature Verification

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Overview

- Motivation
- Methodology
- Results
- Observations
- Future Work

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Motivation

- Temperature verification study of commercial vendors
- Temperature verification study of SPAWAR forecasters in 2008
- Comprehensive reference climatology

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Methodology

- Max and min temperature from SPAWAR forecasters compared against daily observations from Jan 2017 – Apr 2018
- Statistical analysis conducted:
  - Mean algebraic error (Bias)
  - Mean absolute error (MAE)
  - Root-mean-square error (RMSE)
  - Percentage of forecasts with error less than 1.7C
  - Maximum error
- Performance vs. climatology as a predictor
  - Daily temperature climatology constructed for both McMurdo and Palmer Stations

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Methodology

- Daily temperature data array and climatology spreadsheets constructed with data compiled from the following sources:

- Palmer Station (Apr 1989-Present)
  - Antarctic Meteorological Research Center (AMRC)
  - Scripps Institution of Oceanography (LTER Dataset)
  - National Climatic Data Center (NCDC)
  - OGIMET

- McMurdo Station (Mar 1958-Present)
  - NCDC
  - AMRC
  - SPAWAR Office of Polar Programs (SOPP)

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Methodology

Sunday, 8 April 2018
PALMER STATION WEATHER FORECAST INFORMATION

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REGIONAL WEATHER SUMMARY

Today will be gusty with northeasterly winds and cloudy skies. There is a low moving into the Drake's Passage that will be pushing a trough into the region causing a significant increase in the winds overnight and for tomorrow. Tomorrow afternoon the feature will be passing overhead causing severe winds and snowfall that is expected to reduce visibility.

Today 8 April	**Tonight**	**Tomorrow** 9 April
		
Sky: Cloudy	**Sky:** Cloudy becoming Mostly Cloudy	**Sky:** Mostly Cloudy
Visibility: Unrestricted w/ light snow flurries in the early morning	**Visibility:** Unrestricted	**Visibility:** Unrestricted becoming 1-3 in snow, blowing snow, and mist in the afternoon
Wind (kts): N-NE 15-20 gusting 30	**Wind (kts):** NE-E 20-25 gusting 35 becoming 35-40 gusting 50 in the early A.M.	**Wind (kts):** NE-E 35-40 gusting 50 w/ gusts to 65 in the afternoon
Max Temp: -1°C / 30°F	**Min Temp:** -2°C / 28°F	**Max Temp:** 0°C / 32°F
Min Wind Chill: -9°C / 16°F	**Min Wind Chill:** -10°C / 14°F	**Min Wind Chill:** -11°C / 12°F

ASTRONOMICAL DATA

Date	Sunrise	Sunset
08 April	8:13 a.m.	6:22 p.m.
09 April	8:16 a.m.	6:18 p.m.

Forecaster: *J Spencer*

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McMurdo Station, Antarctica - January																	
Date	Mean High Temp (°C)	Mean Low Temp (°C)	Record High Max Temp (°C)	Year	Record Low Max Temp (°C)	Year	Record Low Min Temp (°C)	Year	Record High Min Temp (°C)	Year	Peak Wind (KT)	Peak Wind Dir	Year	Max 24-HR Liquid Equiv.	Year	Max 24-HR Snowfall	Year
1	0.5	-4.1	5.6	1987	-6.1	1978	-11.6	2016	-0.1	2013	41	340	1988	0.30	1970	3.0	1970
2	1.4	-4.4	8.3	1974	-5.6	2016	-11.1	1976	0.6	1974	40	160	2002	0.32	1996	3.2	1996
3	0.7	-4.4	6.7	1971, 1974	-6.4	2001	-9.4	1964	1.8	2014	49	160	2002	0.40	1970	4.0	1970
4	0.6	-4.4	5.8	2014	-6.2	2010	-11.1	1964	0.7	2014	51	180	1977	0.15	2017	0.7	2017
5	0.6	-4.5	8.3	1988	-7.8	1960	-11.1	1964	0.8	2014	43	190	2007	**1.60**	**2005**	8.0	1966
6	0.3	-4.8	5.8	2003	-7.8	1960	-12.8	1991	-0.2	1992	53	100	1974	0.20	2009	0.8	1995
7	0.9	-4.7	5.2	2003	-6.0	2001	-13.3	2001	-1.1	1971, 1987	50	170	1977	0.46	1961	4.6	1961
8	0.6	-4.3	6.7	1970	-9.1	2001	-11.0	2001	0.0	1971	38	190, 120	1977, 1981	1.12	1968	11.2	1968
9	0.6	-4.5	6.7	1988	-8.9	1978	-12.8	1978	0.0	1970	46	140	1974	0.55	1998	4.9	2012
10	0.6	-4.5	8.3	1993	-6.7	1978	-12.2	1980	0.3	2007	38	140	1974	1.00	1966	10.0	1966
11	0.4	-4.6	8.8	2007	-7.8	1984	-11.7	1980	1.9	2007	41	170	1976	0.20	1973, 1990	2.0	1973
12	0.7	-5.1	**10.1**	**2002**	-4.4	1964	-11.1	1960, 1978	2.1	2002	54	140	1965	0.17	1978	2.0	1978
13	0.8	-5.2	6.2	2002	-5.6	1964	-15.9	2004	0.9	2007	41	170	2017	0.08	1982	2.0	1995
14	0.6	-5.0	7.1	2002	-3.9	1991	-12.0	2000	0.6	1987	32	160	2011	0.12	1968	1.2	1968
15	0.3	-5.0	6.7	1987	-9.4	1978	-15.0	1978	1.1	1987	41	090	1978	0.37	1980	3.7	1980
16	0.4	-5.4	6.7	1987	-7.2	1978	-12.2	1978	2.2	1987	43	180	1982	1.47	1968	**14.7**	**1968**
17	0.5	-5.2	7.2	1987	-8.3	1978	-12.2	1960	2.2	1987	38	090	1960	0.40	1970	4.0	1970
18	0.6	-5.2	5.8	2007	-5.6	1959	-13.9	1960	1.1	1972	42	090	1960	0.15	2003	1.4	2010
19	-0.3	-5.6	6.1	1987	**-11.1**	**1960**	-15.6	1960	**2.8**	**1987**	46	090	1960	0.28	2013	4.3	2013
20	0.0	-5.4	4.4	2002	-10.6	1960	-13.9	1960	-0.6	1976, 1987	44	090	1960	0.20	1980	2.0	1980
21	-0.2	-6.0	6.1	1984	-7.9	2001	-14.0	2001	-1.1	1984	47	140	1960	1.30	1960	13.0	1960
22	-0.1	-5.9	5.7	2007	-7.0	2011	-10.5	2011	-0.6	1977	**60**	**240**	**1980**	0.27	1962	2.7	1962
23	-0.1	-5.8	7.6	2003	-7.2	1964	-13.3	1964	-0.5	2007, 2014	46	110	1960	0.27	1965	2.0	1965
24	-0.8	-6.2	5.1	2007	-7.8	1991	-12.2	1976, 1991	0.1	2007	41	090, 070	1965, 1976	0.08	1982, 1987	0.8	1982, 1987
25	-0.9	-6.7	4.6	2007	-8.4	2011	-13.6	2011	-2.2	MULTI*	54	180	1967	0.09	1982	0.9	1982
26	-1.2	-7.1	8.2	2007	-10.4	2011	-13.5	2011	-1.7	1967	43	140, 180	1967, 1971	0.19	1987	1.9	1987
27	-1.1	-6.7	6.7	2007	-7.8	1957	-13.4	2004	-1.1	1967	43	180	1985	0.17	1981	2.4	2013
28	-1.1	-7.4	7.1	2007	-8.3	1972	-13.9	1975	-1.9	2007	48	140	1965	0.25	1960	2.5	1960
29	-1.5	-7.1	5.9	2007	**-11.1**	**1972**	-13.3	1972	-1.7	1967	43	180	1958	0.39	1998	1.4	1974, 1981
30	-1.5	-7.3	4.0	2002	-8.9	1974	-15.0	1974	-1.1	1985	42	180	1958	0.04	1973, 2010	0.4	1973, 2010
31	-2.4	-7.8	2.2	MULTI*	-9.4	1983	**-17.2**	1989	-1.1	1971, 1996	54	180	1961	0.26	1964	2.9	1964
Mean	0.0	-5.5	Max Snowfall:		28.2 (1968)		Max Liquid Equiv:		2.82 (1968)			Mean Precip:		0.41	Mean Snow:	4.9	

Challenges

- Minimum temperature verification imprecise
  - May not occur during the overnight period
  - 24 hours minimum temperature from the following day was used in this study
- Gaps in climatology data

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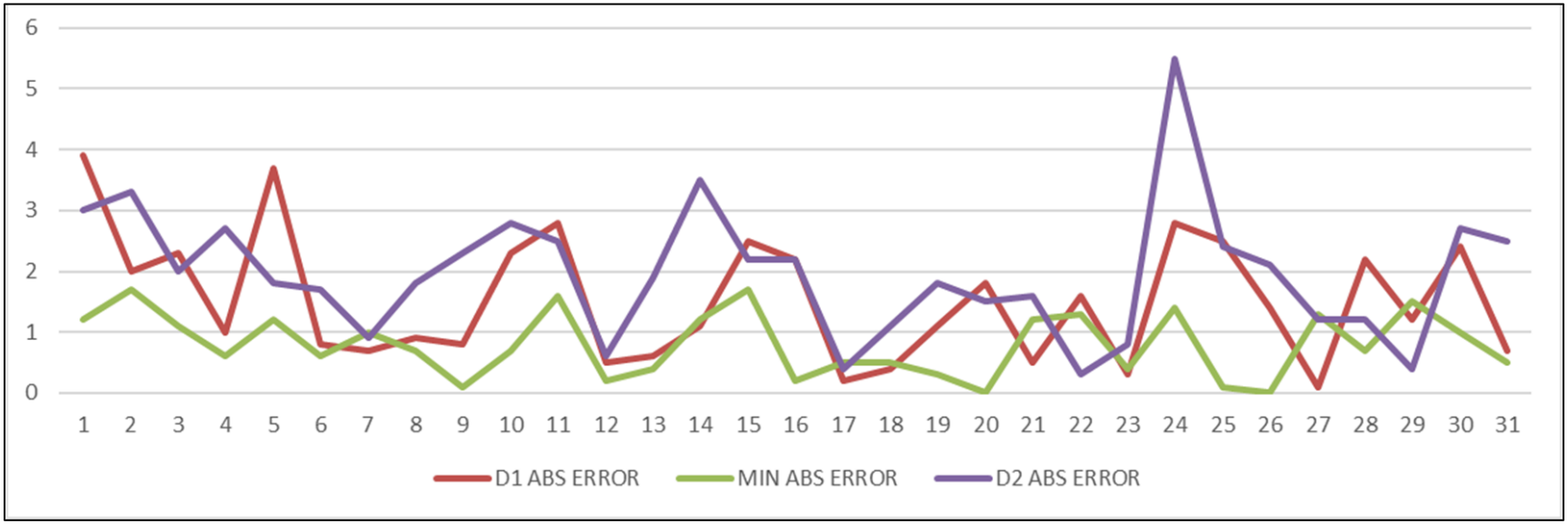
Results



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Palmer Station Max Temperature

SOURCE	BIAS	MAE	RMSE	% < 1.7C	Max Error
SPAWAR	-1.33°C	1.71°C	2.12°C	54	8.3°C
CLIMO	0.00	2.15°C	2.74°C	46	15.5°C

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Palmer Station Min Temperature

SOURCE	BIAS	MAE	RMSE	% < 1.7C	Max Error
SPAWAR	-0.09	1.55°C	2.19°C	63	13.2°C
CLIMO	-0.33	1.99°C	2.81°C	56	12.5°C

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McMurdo Station Max Temperature

SOURCE	BIAS	MAE	RMSE	% < 1.7C	Max Error
SPAWAR	-0.69°C	2.09°C	2.75°C	51	11.1°C
CLIMO	-0.67°C	3.50°C	4.47°C	35	11.6°C

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McMurdo Station Min Temperature

SOURCE	BIAS	MAE	RMSE	% < 1.7C	Max Error
SPAWAR	0.69°C	2.23°C	3.08°C	50	12.8°C
CLIMO	-0.54°C	3.57°C	4.63°C	32	16.2°C

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10 Year Comparison – Palmer Station

Asuma (2008 – 187 Days)

- Max T MAE: 1.77
- Max T RMSE: 2.36
- Min T MAE: 1.92
- Min T RMSE: 2.45

Tate (2018 – 484 Days)

- Max T MAE: **1.71**
- Max T RMSE: **2.12**
- Min T MAE: **1.55**
- Min T RMSE: **2.19**

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10 Year Comparison – McMurdo Station

Asuma (2008 – 164 Days)

- Max T MAE: **1.98**
- Max T RMSE: **2.50**
- Min T MAE: 2.83
- Min T RMSE: 3.72

Tate (2018 – 484 Days)

- Max T MAE: 2.09
- Max T RMSE: 2.75
- Min MAE: **2.23**
- Min RMSE: **3.08**

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Observations

- Forecasters had a low bias on maximum temperatures at both locations
  - Likely a reflection of model biases and timing errors
- Climatology performed slightly better than forecasters during January at Palmer Station, though tended to struggle during the winter months

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Future Work

- Reduce MAE at both locations to less than 1.7°
  - Insert station temperature climatology into quick-reference materials
  - Experimentation with blend of bias corrected temperatures
  - Random Forest regression or machine learning
  - Expansion of daily forecast verification processes
    - Wind speed
    - Minimum wind chill

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Acknowledgements

- SPAWAR Office of Polar Programs
- DIGITALiBiz
- AMRC
- NCDC
- Scripps Institution of Oceanography

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- Asuma, J., 2008: Forecast Verification Study for McMurdo and Palmer Stations: Preliminary Results, 3rd Workshop on Antarctic Meteorological Observation, Modeling, and Forecasting, Madison, WI, June 9-12

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Questions?

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