HERCULES DOME: METEOROLOGY & CLIMATE FOR THE NEXT DEEP ICE CORE SITE

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ABSTRACT

We discuss preliminary results from analysis of WRF-based weather records for a region centered on Hercules Dome (86 °S, 105 °W). We focus on summer months (December, January) over six seasons (2013/14 to 2018/19) using runs from the Antarctic Mesoscale Prediction System (AMPS) archive at NCAR.

1. INTRODUCTION

Hercules Dome (Figure 1) is an ice divide at the edge of the East Antarctic ice sheet, south of the Transantarctic Mountains at 86 °S, 105 °W, with optimal glaciological conditions for the recovery of a long, well-dated ice core. An ice core from Hercules Dome provides a research opportunity for ice-core analysts and others to make progress on a number of research priorities, including the climate of the last interglacial period, the history of greenhouses gases and aerosols, and the magnitude and timing of changes in temperature and snow accumulation. The geographic setting of Hercules Dome also makes it well-situated to investigate the response of the West Antarctic ice sheet to changes in climate, including the possibility of ice sheet collapse during the last interglacial period, which is a central question in Antarctic glaciology. Together with the network of ice cores obtained by U.S. and international researchers over the last few decades, results from Hercules Dome will further advance understanding of global climate variability and yield improved estimates of the boundary conditions necessary for the implementation and validation of ice-sheet models critical to the projection of future Antarctic ice-sheet change.

On-site experiences (Steig) during geophysical site surveys in the 2018-19 field season suggest that this site may also have weather that will be particularly well-suited for field operations (drilling and air support). This work attempts to quantitatively test the subjective field impressions by judicious use of the AMPS archive to look at weather characteristics most relevant to field activity. Two variables of particular interest are near surface winds and metrics for “storminess”.

2. DATA

2.1 *AMPS*

At this time, data analysis has focused strictly on what is available from the AMPS archive. Specifically, we have been looking at archived WRF runs from a six-year period: Dec/Jan 2013/14 to Dec/Jan 2018/19 (12 months in total).

To use AMPS for analysis over an extended time period is to accept compromises. Because of its operational emphasis, the WRF configuration (in particular, the grid resolution) and version have changed multiple times over the years. That means that the AMPS archive is not, strictly speaking, suitable for “climate studies”. So we compromise in hope of extracting something useful. During our six-year study period the WRF grid resolution changed once (from 30 km to 24 km in the outer domain) and the WRF version changed twice (3.3.1 to 3.7.1 to 3.9.1.1). Note that this period starts just after both another grid change (to 45 km) and version change (3.2.1) occurred.

2.2 *ERA Reanalyses (Future)*

To get a longer term perspective (and to avoid the “nonconformities” in the AMPS archive), we will need to apply reanalysis data. Specifically, we will start with the well-established ERA Interim to develop longer climatologies. We will also consider the new ERA5 reanalysis as it becomes available.

3. PRELIMINARY RESULTS

Figure 2 shows basic statistics for two variables, near-surface temperature (tas) and 500 hPa geopotential height (Z500), over the 12-month period. Overall, these statistics reflect the site’s intermediate geographic and topographic location.

3.1 *Average conditions*

Temperature at the site is midway between the colder high plateau temperatures and warmer, lower elevation temperatures of the Ross and Weddell embayments. 500 hPa geopotential height shows a similar pattern with lower heights in the embayments and higher values on the plateau.

3.2 *Variability*

Here we use standard deviation as a proxy for variability. Temperature variability in the region of the site, similar to that seen over a broad region, is intermediate between the lower ocean and higher plateau values.

As a loose proxy for “storminess”, variability in 500 hPa geopotential height suggests that this area may be relatively calm compared to most of the rest of the AMPS domain.

4. FUTURE WORK

As noted in the abstract, this project is at an early stage of development. Additonal variables and analyses are still needed to fully characterize recent climate. One area of keen interest is to examine variability through the use of self organizing maps (SOMs). The generalized patterns produced by SOMs help to show dominant patterns in the variables being analyzed. Patterns can also be used to study temporal behaviors such as pattern frequency and transitions over time.

This preliminary work is also intended to support more in-depth studies in the future with potential for dedicated WRF runs. One possible area is to make use of the recent Reference Elevation Model of Antarctica (REMA) DEM. This dataset shows that the Dome actually has multiple “summits” not previously seen in DEMs of the area. New WRF runs with REMA topography might give improved answers versus those based on older data.

For a longer perspective than reanalyses can provide, and to assist interpretation of paleoproxies from the deep ice core, CMIP GCMs will be needed.

Our preliminary work has focused on December and January, the months most likely relevant to field operations at the site. We intend to expand the project to the full calendar year so as to gain a complete picture of site conditions.

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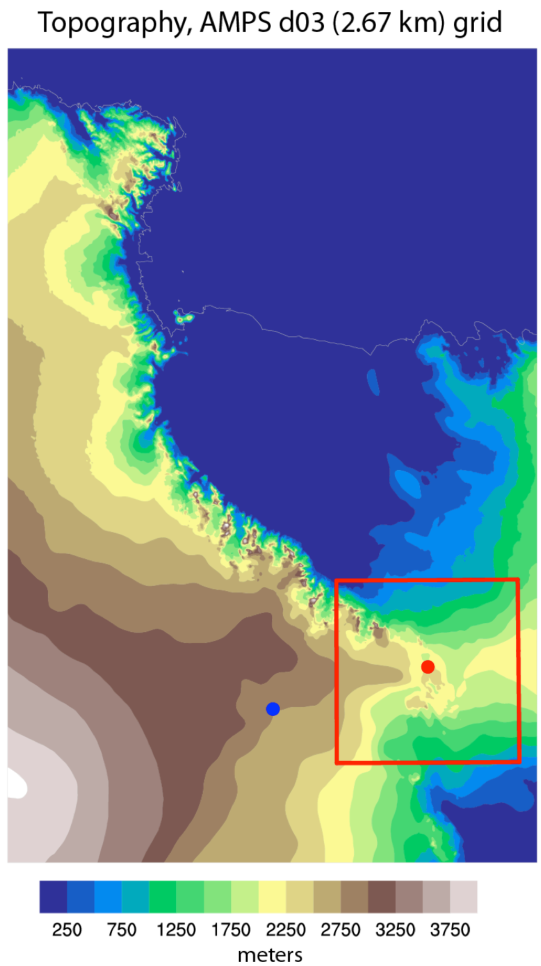

Figure 1. Elevation (m) on the AMPS d03 domain (grid is 675 x 1035). Red and blue dots show the geographic feature called Hercules Dome and South Pole, respectively. The red box indicates the study area centered on Hercules Dome (grid is 231 x 231 or ~614 km on a side).

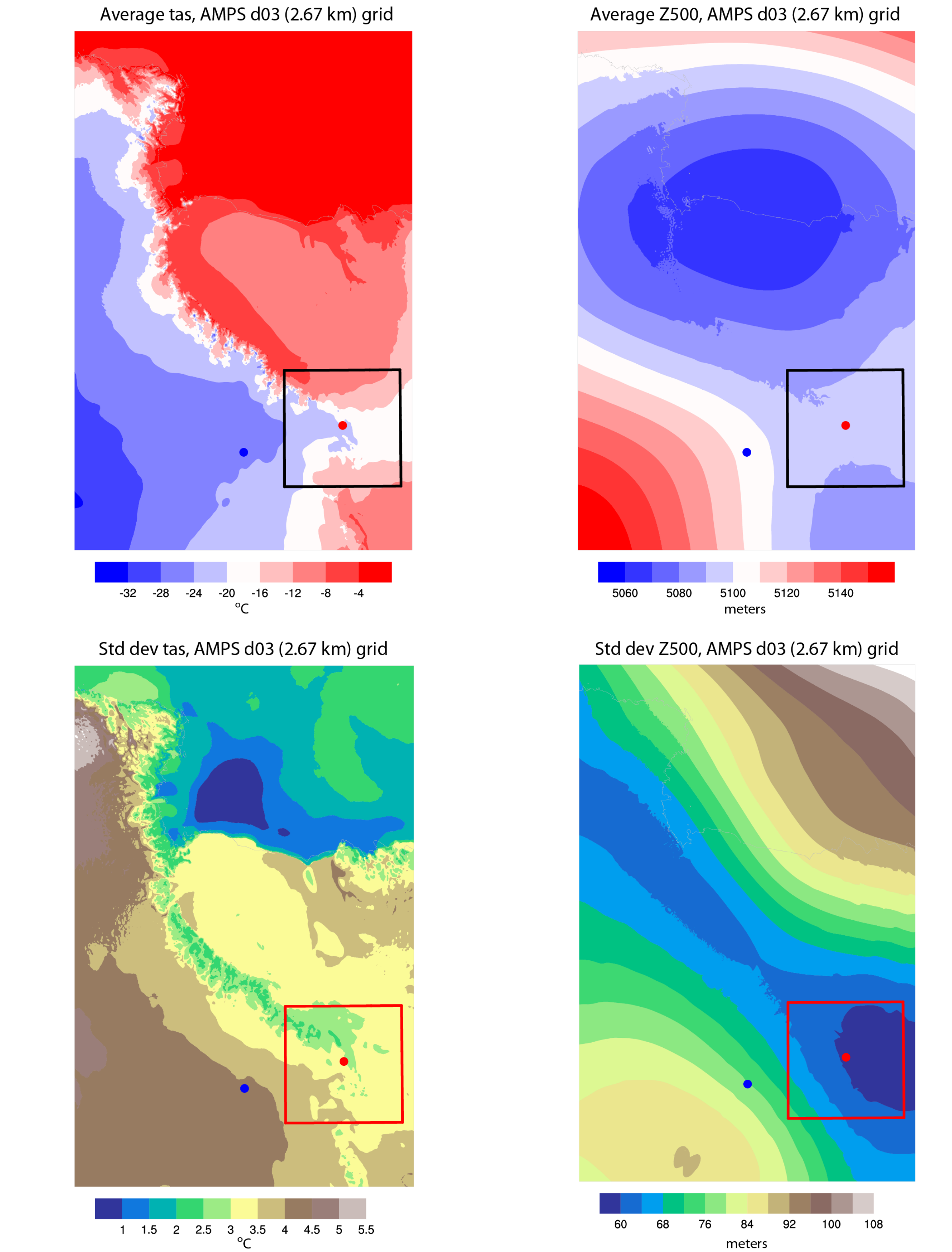

Figure 2. Averages and standard deviations for near-surface temperature (tas) and 500 hPa geopotential height (Z500). Red/blue dots and black/red boxes as in Figure 1.