Inferring Impacts of Volcanic Eruptions on Baffin Island Climate Using a Regional Climate Model

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Motivation

Geological evidence collected from Northern Baffin Island, Canada, suggests a sudden expansion of ice caps began soon after a succession of several large eruptions in the 13th century, and they did not start to melt until roughly a century ago (Anderson et al., 2008; Geirsdottir et al., 2008). How did these ice sheets persist for so long after the short-term volcanic forcings disappeared?

Figure 1. Recently isolated lobe of Serpens Ice Cap, Northern Baffin Island. Courtesy of G.H. Miller

We present results from three unique 6-month long simulations which test if the snow line elevation will change based on imposed temperature perturbations to the initial and lateral boundary conditions.

Methods

We ran the Weather Research and Forecasting (WRF) Model over Baffin Island from **April-Sept 2005** and compared results to National Climatic Data Center (NCDC) Interactive Multisensor Snow and Ice Mapping System (IMS) and ground station data.

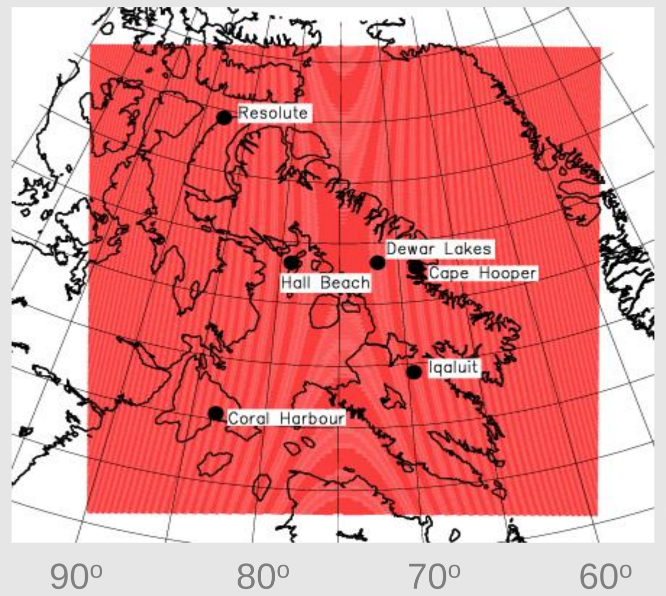

Figure 2. Inner WRF domain over Baffin Island and available weather stations.

The WRF control run specifications are described in **Table 1**. Two additional experiments were run, one with +3 K (**WRF +3 K**) added to the initial and lateral boundary conditions (applied every 6 hours of simulation time) and the second with -3 K added (**WRF -3 K**). All other details of these runs remained identical to those of the control run.

Table 1. Simulation details for WRFcontrol run.

	Resol'n	Input Data	LSM	Surface Layer	Cumulus	Micro-physics	SW Rad'n	LW Rad'n	PBL
WRF Control Run	Outer Domain: 30 km Inner Domain: 10 km	Global Forecast System Final Analysis (GFS- FNL) (1°x1°)	Noah	Monin-Obhukov	Kain Fritsch (new Eta) scheme	WRF Single Moment 5-class microphysics	Goddard shortwave scheme	Rapid Radiative Transfer Model (RRTM) scheme	Yonsei University (YSU) planetary boundary layer

Results

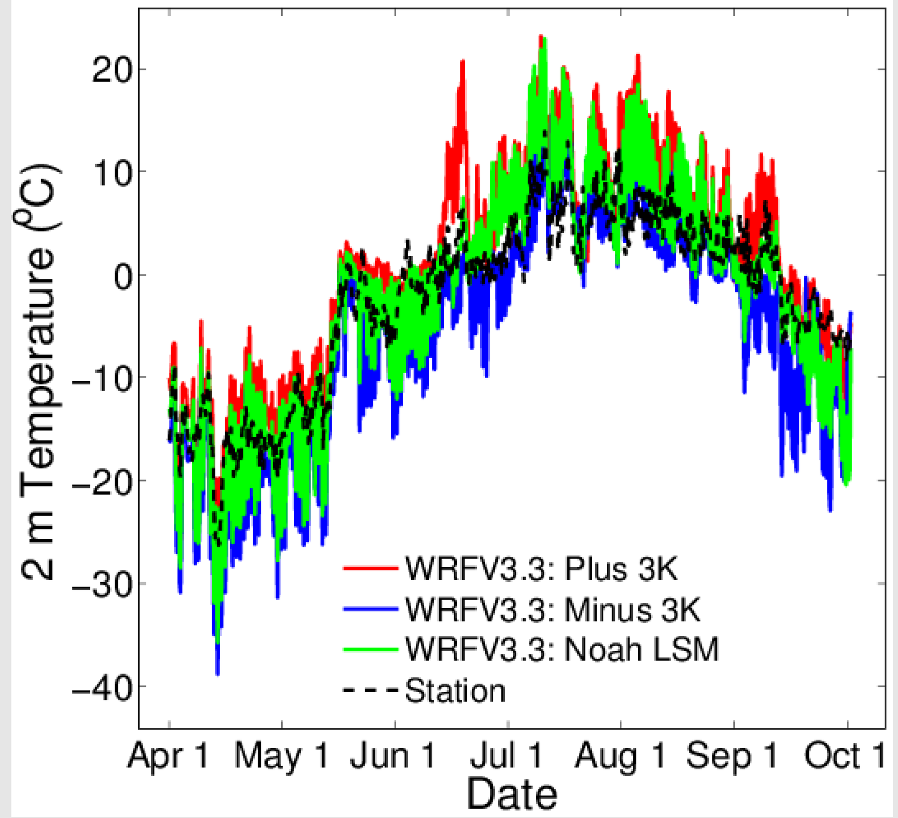

Figure 3. Dewar Lakes 2 m Temperature. The three WRF runs are shown along with the station data. It is clear that WRF does a reasonable job at capturing the seasonal cycle, however the diurnal cycle is exaggerated in all WRF runs.

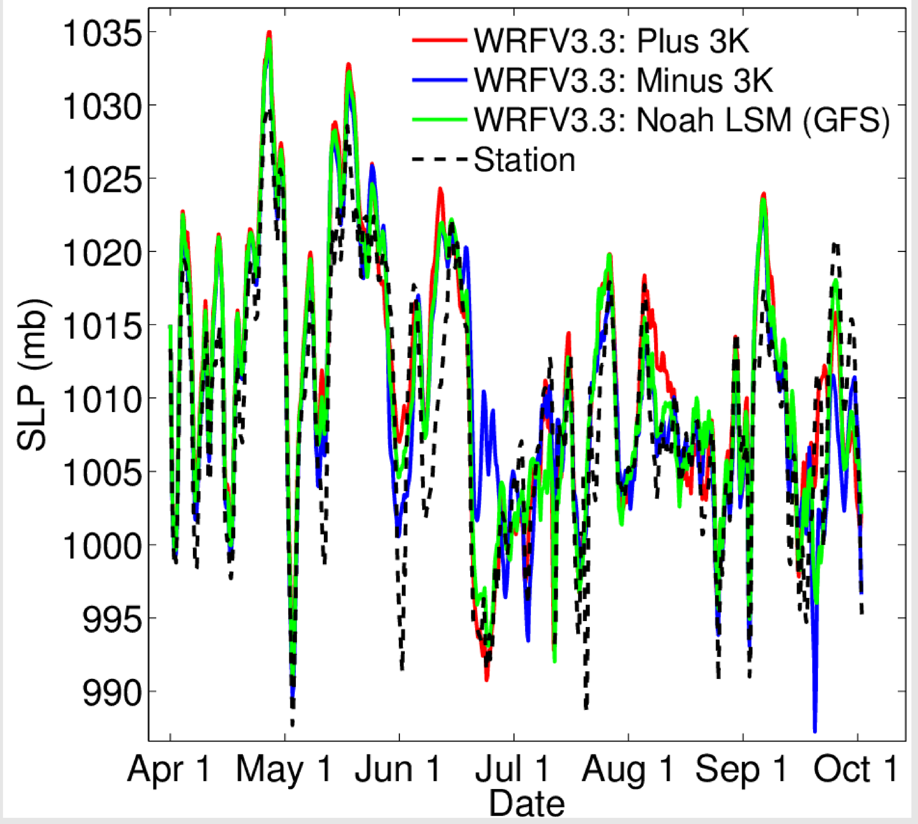

Figure 4. Dewar Lakes sea level pressure for WRF runs and station data. WRF, in general, does an excellent job of capturing the weather patterns during the 6 month runs.

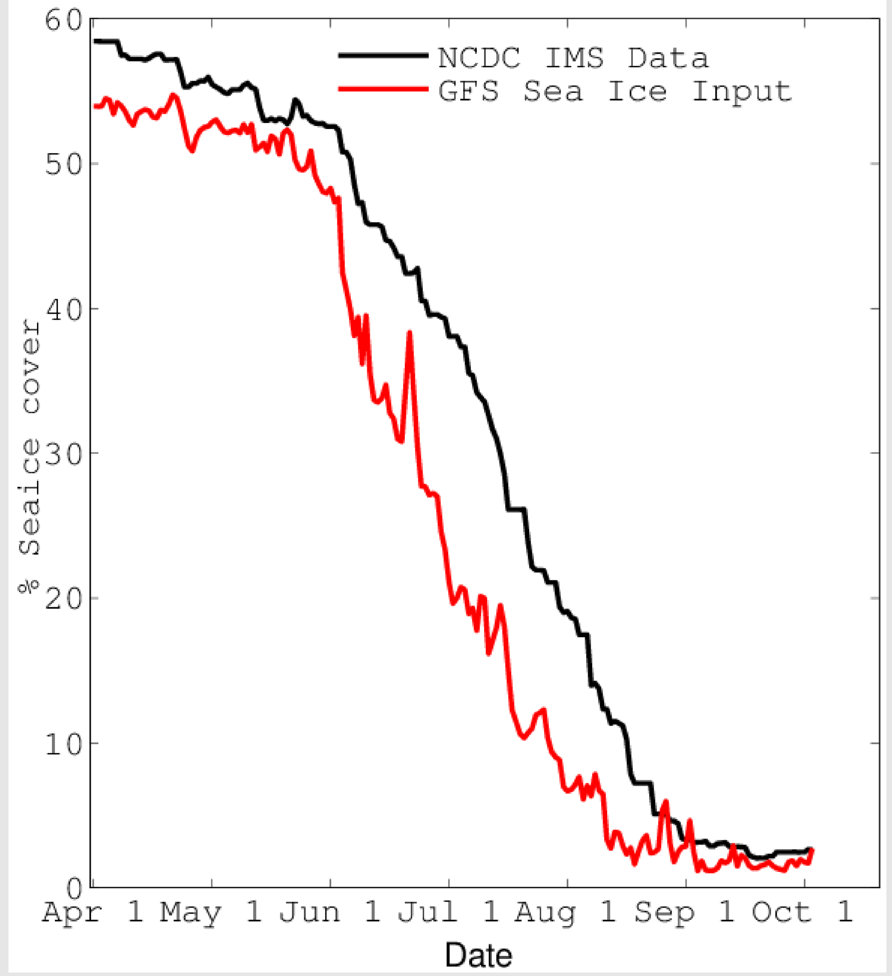

Figure 5. Six month time series of IMS sea ice extent observations (shown as percent cover of inner domain) and GFS sea ice boundary conditions read in by WRF every 6 hours of simulation time. There are not large differences between observed and prescribed sea ice extent.

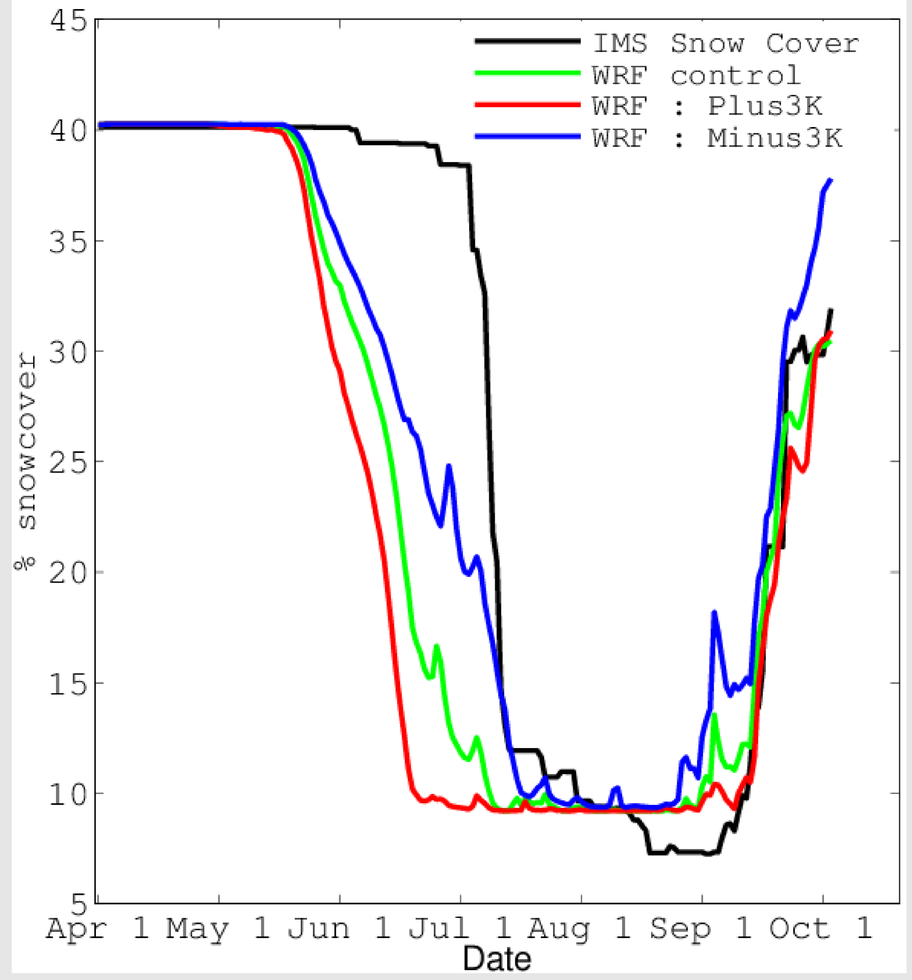

Figure 6. Six month time series of IMS snow cover extent observations and three simulation cases of WRF-modeled snow cover extent. Snow melts slower in the -3 K case, and faster in the +3 K case. All WRF runs begin losing snow cover about one month prior to IMS observations.

Results (continued)

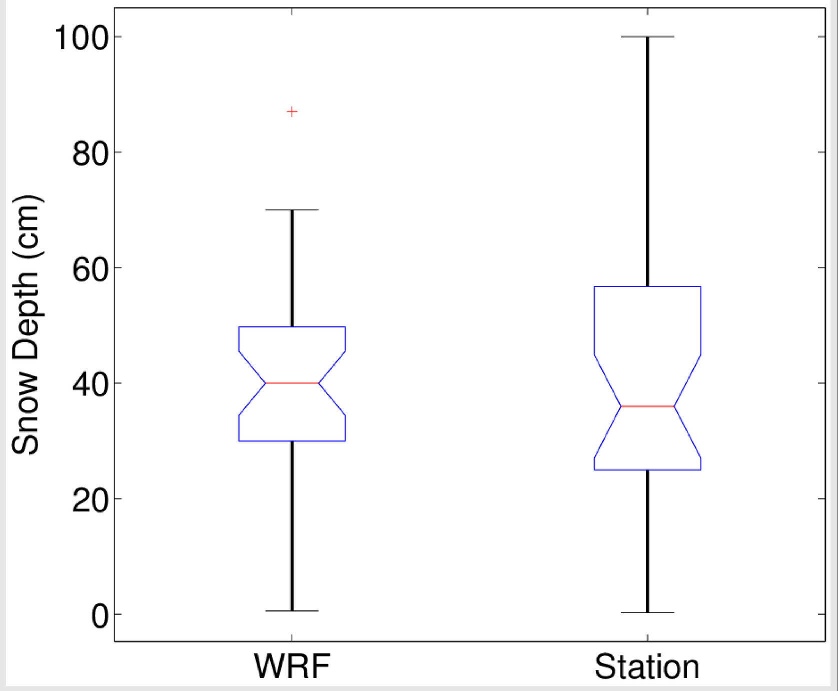

Figure 7. Whisker plot of WRF and station snow depths for all available stations in both domains on April 1, 2005. This rules out the notion that early onset melt was caused by insufficient initial snow cover over Baffin Island. Therefore, cloud cover during June could have obstructed IMS observations or WRF is melting or sublimating snow too fast due to the over-exaggerated diurnal cycle or unrealistically efficient turbulent mixing .

Conclusions and Future Work

1. All WRF runs begin to melt about a month earlier than the IMS data suggest. This could be a result of errors in observations (e.g., cloud cover) or a tendency for the model to sublimate or melt snow more readily than in the real world.
2. The +/- 3 K sensitivity test cases moderate the snow melt rate during spring, but all models reach the same minimum extent eventually. Thus, a -3 K perturbation to initial and lateral boundary conditions is not sufficient to maintain a lower snow line elevation through the melt season.
3. Further sensitivity tests which alter all ocean points to be either sea ice or open ocean for the entire model run are currently underway.
4. In the future, a reduction of the solar constant for the 6 month run will be tested to see if this has a greater impact on snow line evolution than the simple temperature tests did.

Acknowledgments and References

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