coverage or the development of new proxies. This mutually satisfying data-model relationship continues and promises to expand.

As an example, a Pliocene Model Intercomparison Project planning workshop was held in June 2008 at the NASA Goddard Institute for Space Studies, in New York. There, paleoclimatologists and climate modelers discussed the logistics of cooperatively using the PRISM data sets to initialize modeling runs on a diverse array of models. As the model intercomparisons begin, scientists from across the globe are preparing to meet next summer to discuss their results of all aspects of mid-Pliocene climate. The data-model relationship will continue as preliminary model results will be presented and compared, and future research will be defined.

Collaborations between paleoclimatologists and climate modelers provide a better understanding of mid-Pliocene climate dynamics as well as improved model capabilities through the comparison of model results. Results from these initial comparisons will highlight the importance of continuing the iterative process of data synthesis and model simulation, and will further our understanding of the mid-Pliocene and also of future warm climates and their impacts.

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Examining Arctic Ice Shelves Prior to the 2008 Breakup

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The last time researchers stood on the surface of the Serson Ice Shelf, at the northern end of Ellesmere Island, Canada, it was a chilly –26ºC April day in 2008. On a relatively warm 8ºC day 3 months later, the ice shelf began to break apart and within 3 weeks lost 122 square kilometers (60%) of its area. This past summer, Ellesmere's 50-square-kilometer Markham Ice Shelf also broke away, and there was major fracturing throughout the eastern half and well into the western half of the Ward Hunt Ice Shelf, which is the largest remaining ice shelf in the Northern Hemisphere.

Together, all of the Canadian ice shelves lost a total of 23% of their area during summer 2008, leaving only 720 square kilometers behind. Some fjords along northern Ellesmere Island are now ice free for the first time in 3000–5500 years, according to radiocarbon dating of ancient driftwood deposits [*England et al.,* 2008]. These losses have imperiled unique ecosystems containing cold-tolerant microbial mats on the surface of the ice shelves and freshwater aquatic organisms in ice-dammed lakes to the landward side of the ice shelves, which rely on the ice shelves for their physical structure [*Mueller et al.,* 2006; *Veillette et al.,* 2008].

Ice shelf collapse is often considered an indicator of climate change, although other factors such as variations in sea ice conditions may play a role. To further investigate the relationship between climate, Arctic ice shelves, and their associated ecosystems, a team of International Polar Year (IPY) scientists accompanied a Canadian Rangers sovereignty patrol along the northern coast of Ellesmere Island in April 2008 (see http://www.madzu.com/ellesmere). The Rangers are military reservists who live in the north and patrol this remote region. While scientists traveling with the Rangers learned how to travel by snowmobile, camp in frigid temperatures, and tow a wooden cargo sled known as a qamutiik over 1600 kilometers of sea and shelf ice, the Rangers learned about ice shelves and assisted in data collection, making the venture a successful cross-cultural experience.

Research Objectives

A principal goal of the research was to examine, with ground-penetrating radar, the extent and thickness of ice shelves and multiyear landfast sea ice along the northern coast of Ellesmere Island. An automated climate station was set up near the Serson Ice Shelf, and surface ablation measurements were made on the Ward Hunt Ice Shelf (Figure 1a). The network of ablation stakes was also extended to three other ice shelves along Ellesmere Island (Milne, Petersen, and Serson) to provide a baseline for future studies (Figure 1a). These measurements will contribute to the IPY-endorsed State and Fate of the Polar Cryosphere project.

Fieldwork for another IPY-endorsed project, MERGE (Microbiological and Ecological Responses to Global Environmental Change in the polar regions), focused on the diversity and composition of microbial communities that exist in several ice-dammed lakes formed by the impoundment of freshwater between thick ice and the coast. Researchers sampled these communities at several locations along the northern coast of Ellesmere Island for microbial DNA and determined the thickness of the freshwater habitats through conductivity-temperature-depth (CTD) profiling (Figure 1a). Oceanographic profiles and soundings were conducted at each of the sampling locations, and these profiles provided updates to measurements carried out four decades ago by Harold Serson, for whom the Serson Ice Shelf is named.

The unique partnership between researchers and the Canadian Rangers echoes past military interest in ice shelves. Canada's Defence Research Board and the U.S. Air Force first investigated them in the 1950s as the source of large "ice islands" floating in the Arctic Ocean. Since then, several ice islands have been used as scientific drift stations, including Arctic Research Laboratory Ice Station II, known as ARLIS-II, which formed when the Serson Ice Shelf last calved in 1955 [*Jeffries,* 1992].

Past and Future Arctic Ice Shelf Loss

Arctic ice shelf extent has declined by more than 90% in the past century, with much of this change occurring before 1950 [*Vincent et al.,* 2001]. Recent warming has surpassed temperatures the Arctic experienced from 1930 to 1950 [*Richter-Menge et al.,* 2006], and consequently thresholds of ice shelf stability are being exceeded

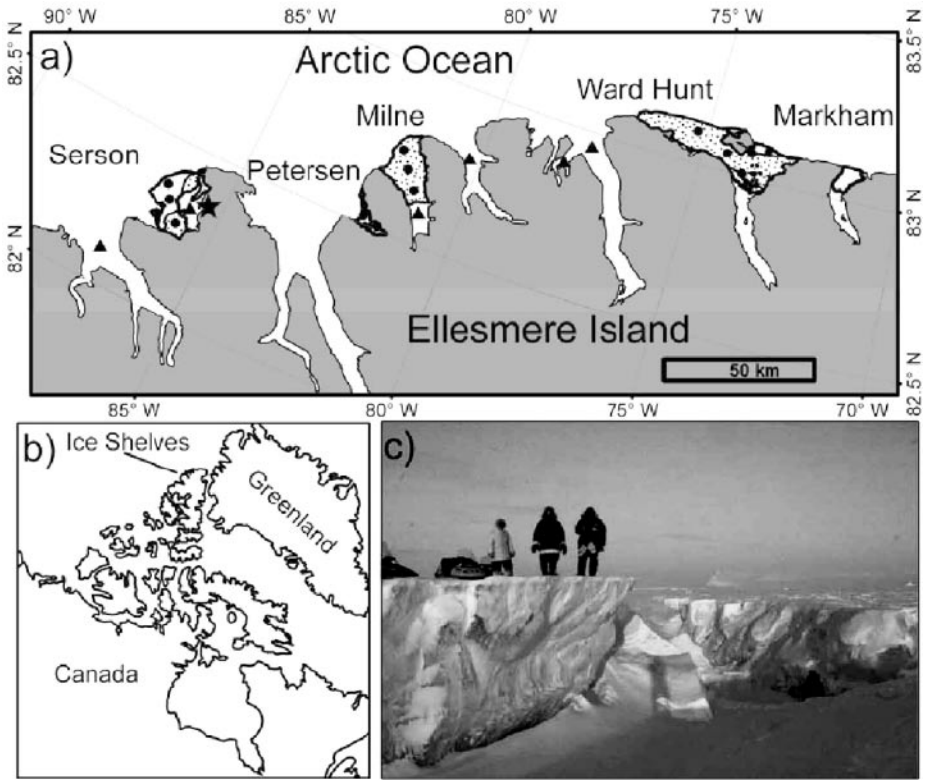

Fig. 1. (a) Field sites during the March–April 2008 Canadian Ranger patrols. Triangles indicate water sampling and profiles; circles indicate ablation stake measurements; and the star indicates the location of the automatic climate station. The current extent of the ice shelves (labeled) is indicated with stippling, and the extent during the expedition is outlined in black. (b) Location map. (c) Fissure found by Rangers on the Ward Hunt Ice Shelf in early April 2008 foreshadows the calving events in July 2008.

[*Copland et al.,* 2007]. In contrast to their Antarctic counterparts, Canadian ice shelves have little or no glacial input, and they primarily gain mass via sea ice and snow accumulation. Therefore, regeneration is only possible through the thickening of multiyear landfast sea ice. However, more than 1000 square kilometers of multiyear landfast ice, which had existed along the northern coast of Ellesmere Island since the 1950s and 1960s, has recently broken up, suggesting that ice shelves will not regrow given the present (and projected) climate.

Reductions in Arctic sea ice extent also do not bode well for the continued survival of Canadian ice shelves. Sea ice usually provides a semipermanent barrier along the seaward edge of these ice shelves, physically holding the ice shelves in place and protecting them from the influences of wind and waves [*Copland et al.,* 2007]. However, during recent summers there have been extended periods with no sea ice along the northern Ellesmere Island coastline, and all ice shelf breakup events since 2005 have occurred during these times. Research efforts during the current IPY are capturing dramatic climate-related changes in the Arctic region. Given future climate and sea ice projections, it is uncertain whether there will be any Canadian ice shelves left to study during the next IPY 50 years from now.

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