Climate Monitoring in
Glacier Bay National Park and Preserve:
Capturing Climate Change Indicators

2007 Annual Report

Studies Conducted As Part of Research Project:
Long-term tidewater and terrestrial glacier dynamics, glacier hydrology, and Holocene and historic glacier activity and climate change in Glacier Bay National Park and Preserve

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Executive Summary
Climate is the primary driver of the physical, hydrological and biological processes of Glacier Bay's diverse ecosystems. Because few data on the climate of the Park existed and no systematic monitoring of the climate had been performed previously, we initiated a long-term monitoring of contemporary climate in Glacier Bay in cooperation with the National Park Service (NPS) in 1999. Our climate monitoring is providing data necessary to understand the effects of global changes in climate on Glacier Bay and to calibrate Global Climate Models (GCM's) for southeast Alaska, thus enabling them to be used to predict how future global changes in climate will impact the environment and ecosystems of Glacier Bay. Knowledge of such likely responses in the short- and long-term will be important considerations to management for utilizing and protecting Park resources while accommodating visitors in the future.

Currently, twenty-four climate sites measuring air temperature and precipitation, including snow water equivalent gauges at three of the sites, are active. In addition, we are upgrading near real-time GOES satellite systems for the hourly dissemination of weather data from two sites based on previous field tests, with the goal of establishing multiple remote sites that can be monitored by park staff and researchers via a World Wide Web site established and maintained by CRREL. We also collaborated with the Park and National Weather Service to establish a new climate site on the fuel dock at Bartlett Cove, providing instrumentation and GOES satellite equipment for that site. We are also now testing new systems using Iridium satellite phones for transmitting data and images, again with the idea to install such systems which have potentially lower visual impact and yet provide greater data transmission capabilities in remote areas.

In addition to monitoring climate, we have established the climate sites to foster research, supporting our studies as well as that of other researchers in the park and eventually providing near real time data to the Park Rangers and interpretive staff. All but one of our climate sites is located near sea level in elevation and therefore allows us a direct comparison of the measurements necessary to define the source of variability from site-to-site, a key factor in attempting to understand where and how weather may vary

between inlets and the lower bay for example. The data also provide the basis for calibrating tree-ring records and interpreting the paleoclimatic indices of interstadial wood sites for our ongoing research on the climate of the past 10,000 years (Lawson et al 2007). Combined with other measurements such as ablation and accumulation rates, these data are critical to understanding how glaciers and other physical systems are responding to regional and global changes in climate. We are collaborating with other researchers in examining fresh water flux to the fjord systems which has significant impacts on oceanographic properties and marine ecosystems. Comparing modern data to historical records from long-term meteorological sites outside Glacier Bay will indicate whether those longer records are representative of past climatic trends within the bay.

The current length of record remains too short to evaluate the source and significance of longer trends in the variability at annual and decadal scales, but it is approaching that needed to analyzing seasonal trends over the period of record and thus assessing sub-regional changes within the Glacier Bay watershed. In addition to acquiring the data for the 2006 – 2007 year, we spent considerable time quality checking and processing the data on temperature for the entire period of 2001 to 2007 and examining basic information within the database. In 2007, we also completed processing of the temperature data for the entire period of record (2000 – 2007).. This was a formidable effort and we are just now beginning to examine and analyze relationships in the data. Spatial trends suggest a strong connection between the lower bay sites and the East Arm site, with a significant difference from the West Arm sites. Temporally over the period of record, mean annual temperatures gradually increased from 2001 to 2005, but have decreased over the last two years. In addition there is an intriguing relationship between winter and summer temperatures: as summer mean temperatures rise, winter temperatures decrease and conversely, which we do not yet understand but are investigating possible causes. Precipitation records continue to exhibit no consistent pattern temporally by site nor spatially by area; amounts in some summers are greatest within the mid-bay area south of the mouths of the East and West Arms, but in other years are greatest near the heads of inlets occupied by glaciers.

In assessing the trends in temperature in last year's annual report, we observed an interesting trend in the air temperature record for the period of 1999 to 2006 that suggested an overall warming of the climate by as much as 1.5 °C. However now that we have additional data, it appears that the warming actually took place for the period of 2001 to 2005 and that cooling has characterized the last two years. This observation points out the need for much longer records to be able to assess trends in climate and attempt to assign causes for such trends. Caution is clearly needed in interpreting the short records of climate we have been able to assemble for the period of 2000 to 2007.

We continue to maintain the climate systems and propose to expand the capabilities in terms of parameters measured and methods of data storage and transmission so that the climate database will provide a unique and extremely valuable resource on the climate of Glacier Bay. Long-term monitoring is essential to understanding the current and future trends in climate of the Park. Expansion of the network to the outer coast and higher elevation sites would provide a more complete record and fill the critical data gap that exists on the climate of the upper accumulation areas of the glacial systems. As global climate continues to warm, the monitoring will provide a glimpse into how the Glacier Bay watershed is being impacted and provide the data needed by researchers investigating biological and physical system adjustments to such changes. The database will be important to calibrating Global Climate Models for the Glacier Bay and southeast Alaska region, so that improved predictions of future changes in climate can be made. Such knowledge may be important to management in determining strategies for a park under the stress of climate change.

Gully eroded by a significant rain event in November of 2005; precipitation totals across the park varied but averaged 20 to 28 inches in a 24 hour period.

Introduction

Over the last 16 years, CRREL has conducted long-term, integrated monitoring and site-specific multidisciplinary studies of glacial, marine and terrestrial environments to improve our understanding of the physical processes and their interactions with regional and global systems. Understanding climatic change and the resulting environmental and ecosystem responses are critical to the Park’s adaptive management scheme for utilizing and protecting its resources and accommodating visitors in the future. Our research investigates the processes that control physical conditions and ultimately ecosystem biodiversity along marine and terrestrial glacier margins. Sedimentologic, climatic, oceanographic and glaciohydraulic studies of glacier dynamics improve the state of knowledge of tidewater and terrestrial glacier systems. Although sediment dynamics appear to control glacier margins in fjords over the short-term, climate affects longer-term trends in tidewater glacier activity but data to investigate the role of climate in tidewater glacier dynamics have been lacking.

Thus, climatic data are a critical component in most of our research, as well as in numerous other investigations of the marine, terrestrial and freshwater environments and ecosystems within the Park. Having a detailed, high resolution record of the air temperature and precipitation is necessary to define the daily, seasonal, annual and decadal controls on the biological and physical processes operating within each ecosystem. An important aspect of the monitoring is to provide the baseline climatic data to which future changes in climate can be compared, and ultimately applied to understanding ecosystem and other changes in the Park. CRREL climate sites are distributed across the Glacier Bay watershed such that regional trends can be identified and compared and correlated with temporal variations. These data will allow us to analyze storm patterns in the Park, assess differences in weather between the East and West Arms, and evaluate impacts of short-term climatic changes. For our paleoclimate investigations, we are using these data to calibrate tree-ring records, and as the record lengthens, examine the spatial and seasonal variability that may affect how the tree-ring record is interpreted (Lawson et al. 2007).

Project History

We began establishing test sites for monitoring climate within Glacier Bay in 1999. We identified the lack of any climatic data within Glacier Bay as a significant gap in knowledge about a very important and basic driver of the physical and biological systems within the Park. This sentiment was echoed by many Park staff and researchers alike. Although specific funding for climate monitoring could not be secured, it was an obvious data gap that we have tried to fill by establishing the current network of climate sites to meet our requirements for studies of the glacial and hydrologic systems and to meet the apparent needs of other Park and independent researchers. The sequence of events in developing the current deployment of 25 stations is detailed in last year's annual report (Lawson et al 2006a) to which the reader is referred..

We are continuing to improve and upgrade the climate sites. Our goal is to develop systems that have low power usage, a remote near real time capability for data transmission, minimal maintenance requirements and multiple sensors to monitor the full suite of meteorological parameters. We have identified barometric pressure, solar radiation and wind speed and direction sensors to meet these requirements and are continuing to evaluate satellite systems for data transmission. In addition to increasing the suite of parameters measured, it is critical to establish higher elevation sites at several or more locations across the Glacier Bay watershed. Such sites were not initially established due to requirements for remote access and unknown reliability of instrumentation for long-term deployment of battery power systems. The use of GOES, meteor burst, satellite phones and other technologies as well as various wind generators for power may be viable, particularly at existing radio repeater sites where access may be possible during annual maintenance.

Methods and Site Instrumentation

Climate sites are located along fiord margins, generally at or near sea level (Figure 1). Each site has a minimum of two rain gauges (for redundancy), a dual temperature sensor, and a bulk precipitation collector for heavy isotope analysis (Lawson *et al* 2004;

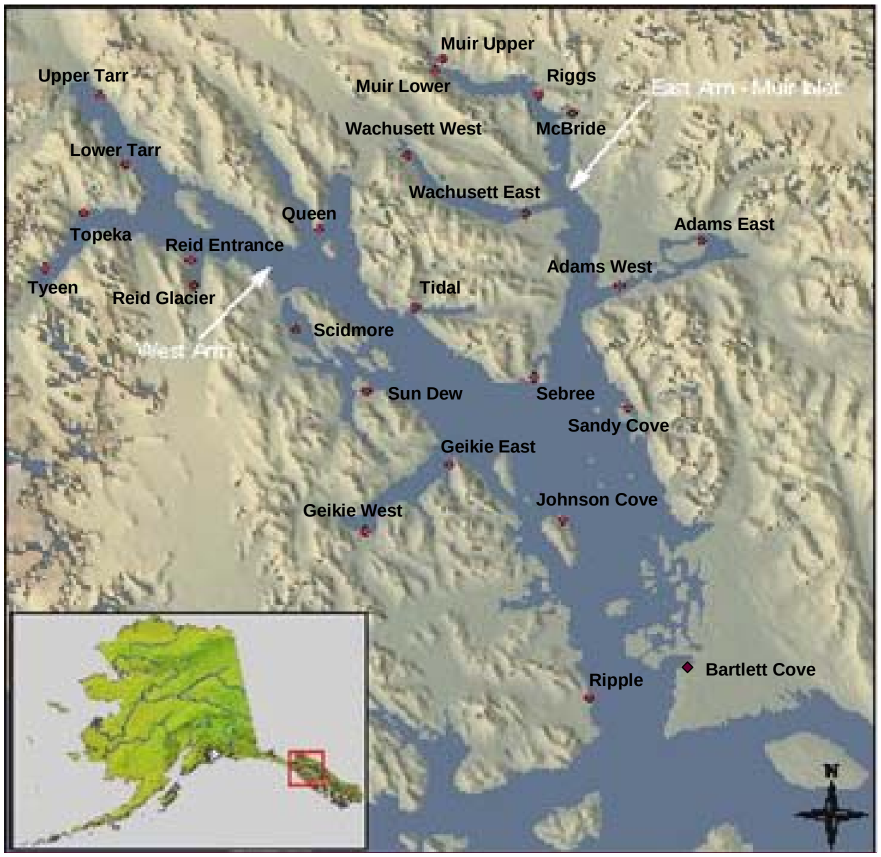


Figure 1. CRREL climate monitoring sites located within the Glacier Bay watershed. Bartlett Cove is a new site established on the NPS dock in December of 2007 by NWS, NPS and CRREL.

Finnegan *et al* 2007). The rain gauges (Onset RG-2 Tipping Bucket; Peet Electronic) record rainfall to Hobo event data loggers in 0.01 inch increments (Figure 2). Temperature is measured to 0.1 ° C accuracy at a 20 minute interval using two separate thermistors that are housed within a solar radiation shield (Figure 2). Snow gauges

Figure 2. Typical climate sites. Upper left photo shows white solar radiation shield housing temperature sensors and a tipping bucket rain gauge installed on 1-meter tall post at Muir Glacier. Photo on lower right shows the tipping bucket and electronic rain gauges in steel housings as mounted on the ground at the Riggs site. A post can only be used where animals are unlikely to damage rain gauges, but preferred to reduce snow cover effects early in the winter season.

previously used at three sites are being repaired and upgraded and will be returned to active use in 2008. Appendix A in Lawson et al (2006) provides detailed information on each site.

We have two sites (Queen Inlet, Tyeen) utilizing GOES (Geostationary Operational Environmental Satellite) transmitters for year-round, near-real time data transmission including precipitation, temperature, solar radiation and wind measurements (Figure 3). By using the GOES transmission system, data are collected at regularly timed intervals

(15 minutes) and transmitted via the GOES system for processing hourly. Once the data are transmitted, the information is decoded at a central receiving station located at the New England District Corp of Engineers Reservoir Control Center in Concord, MA. These data are quality checked and then pushed to a central database server at CRREL where the information is disseminated via the World Wide Web. The site address is: https://rsgis.crrel.usace.army.mil/ltir/GBweb.GBindex.

We plan additional satellite transmitters as funds allow, reducing the need for costly site visits especially in areas where access may be limited by vessel restrictions and providing data in near real time for park managers, staff and researchers. We are currently developing and testing new systems for transmitting larger amounts of data, possibly including digital images. The remote monitoring systems are ultimately expandable to include new instruments as research needs arise, and allows for collaboration with other researchers who likewise may benefit from near real-time data transmission.

Figure 3. GOES test site in Queen Inlet. GOES satellite transmission system transmits hourly data on precipitation and air temperature, while also storing these data as a backup on Campbell data logger located within the grey box.

Each climate site is routinely maintained during late spring or early summer and again in late summer or early fall. Typically we require 5 days to complete servicing, download, repair and maintenance of all 24 sites. We record the condition of the site in a field book upon arriving, sometimes photographing more serious problems such as animal or natural destruction of instruments and mounting equipment. The levelness of the rain gauges is measured and any deviation noted as this affects the volume recorded. The data loggers of each instrument are then downloaded to portable recorders, and batteries and desiccant are replaced while clearing the memory of older data and reinitializing loggers to begin a new data collection cycle.

Any problems with data loggers or instruments are noted in our field books, and we replace problematic loggers and broken instruments in the field with spares that we carry with us to minimize the time required to service each site and insure that we have fully operational equipment for the next period of monitoring. Simple repairs or download issues are addressed on board the vessel used to access the site or back in the office or lodging that night. More serious problems are repaired back at the CRREL Hanover laboratory. Details of each instrument recorded in the field book include condition and operation of the data loggers and any problems noted that may have affected the operation and recording of data (for example leaves or spiders in the rain gauge orifice). If data loggers or entire instruments must be replaced, the new serial numbers and time of start up are recorded. Bulk water samples are collected in 60 ml, air-tight Nalgene bottles and assigned sample numbers recorded in the notes for the particular site. On-board the vessel, we download all data files to a folder on a portable laptop computer and back-up these data on a data key.

Data files are archived on the CRREL server and its back up in Hanover, as well as on our office computers for processing and analyses. Prior to analysis of the temperature and precipitation records, we evaluate the data record from each individual instrument to ascertain if any problems exist. Such things as gaps in data or spurious data points must be identified and removed from the data set. In addition, any situation or problems in the field that were noted in our field books must be taken into account. Such things as clogged intakes on the rain gauges or sensors knocked from their mounts to the ground will either cause records to be incomplete or result in partly correct records with certain sections that must be deleted. In the case of rain gauges, we have two gauges and we can use the two records to delineate the latter problem. This is commonly a tedious and lengthy job for the over 96 instrument records taken during each download period. Once problems in the data sets are corrected, records are combined to develop a continuous time-series from which annual as well as monthly and daily information can be extracted and analyzed using standard statistical methods.

Current Monitoring and Results

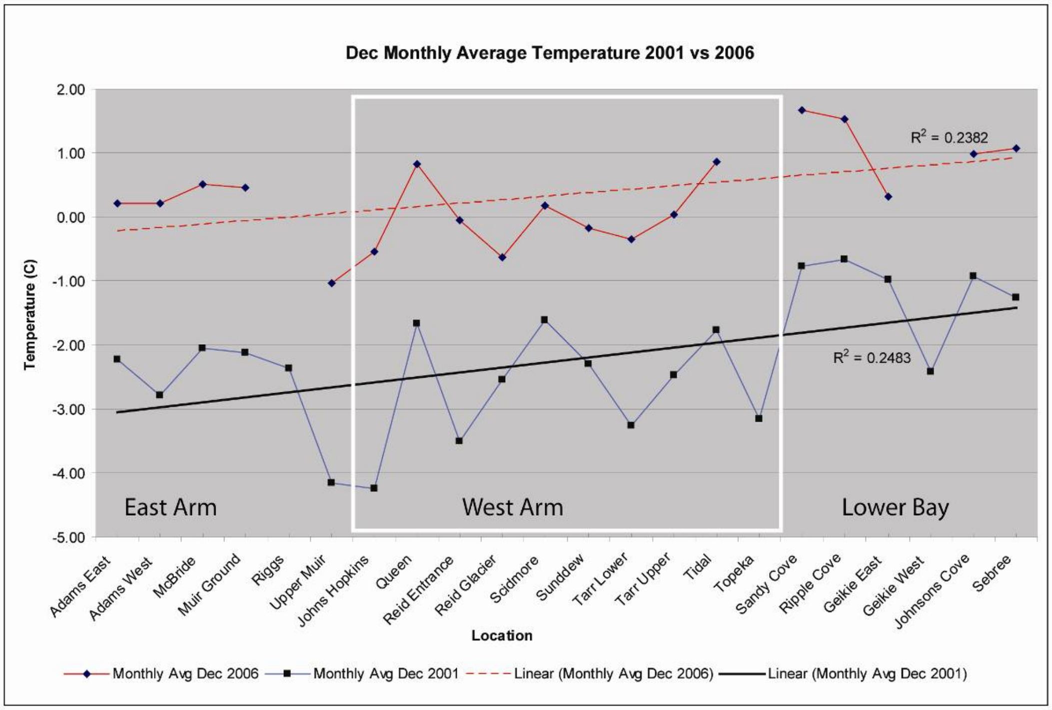
In 2007, we continued to service and acquire data from all sites across the park and have spent considerable effort in processing and analyzing the climate database, particularly the temperature record. Although we now have approximately six years data from most of the twenty-four sites, the length of record remains too short to permit analysis of the trends in seasonal and annual variability in climate and attempting to interpret its significance. The data from the climate sites do provide some preliminary indication of sub-regional variability within the Glacier Bay watershed and observations on the range in values for air temperature and precipitation over the course of a year. The entire database for all sites for the period is posted at the web site listed earlier and updated annually to Bill Eichenlaub by DVD for archiving on the Glacier Bay server.

Precipitation during the period of record of 2001 to 2007 show inconsistent spatial trends in values within the watershed, with rainfall amounts generally low during the months of May through August, and highest in the months of October to December. Rainfall has actually dominated over snowfall during these latter months, with snowfall usually prevalent only in the months of January and February, and less often in March. A large rain event occurred in late November, 2005, with average rainfall amounts across the watershed of 20 to 28 inches in a 24 hour period. This event caused extreme erosion within gullies of steep slopes of fjord walls and erosion of stream banks and alluvial fans across the park. Significant changes in course as well as nature of the channels took place, with woody debris removed from many up-valley parts of the channels. We are currently collaborating with Sandy Milner in investigating the effects of this storm on salmon populations of streams within the park. Precipitation values exhibit the orographic effect of the Fairweather Range, with lowest values within Johns Hopkins Inlet in particular, and Tarr Inlet, in contrast to mid-bay and the East Arm where precipitation totals are nearly twice as high on average.

In general, annual rainfall (excluding snowfall amounts) generally exceeds 70 inches to over 100 inches. Snowfall adds significantly to the amounts of precipitation with between 60 and 80 inches water equivalent measured at the Johns Hopkins, Muir and Geikie sites. We are continuing to process the precipitation data and extrapolate trends in precipitation, with 2006 to 2007 data now being processed. Inconsistent data acquisition during the early years of our monitoring (Appendix B, Lawson et al 2006a) continues to complicate interpreting this record. More recently, the instrumentation has been more reliable and with less disturbance by wildlife that has resulted in more complete records for the last 3 years.

In 2007, we completed processing of the temperature data for the entire period of record. This was a formidable effort and we are just now beginning to examine and analyze relationships in the data. The data were first analyzed to examine daily, seasonal and annual averages. *Appendix A* tabulates the average monthly air temperatures by site for each year of record. *Appendix B* lists the average annual temperatures, as well as the maximum and minimum air temperature for the year for all 24 sites. We could not include the daily average air temperatures in this report which we have also calculated for each site and each year of record due to page size limitations; we are including these data in tabular form in the archival DVD sent to Bill Eichenlaub.

We are now working to try to understand what the data indicate in terms of their temporal and spatial differences on a site-by-site basis. An example of the types of analyses that are possible for the records of temperature on an annual basis is exhibited in Figure 4 which shows how winter (December) and summer (July) average temperatures varied by site for the years 2001 and 2006. We chose these years because of the difference in annual temperatures, 2001 being on average for the year colder at the majority of sites within Glacier Bay than in 2006 (Appendix B). The graphs suggest that this difference



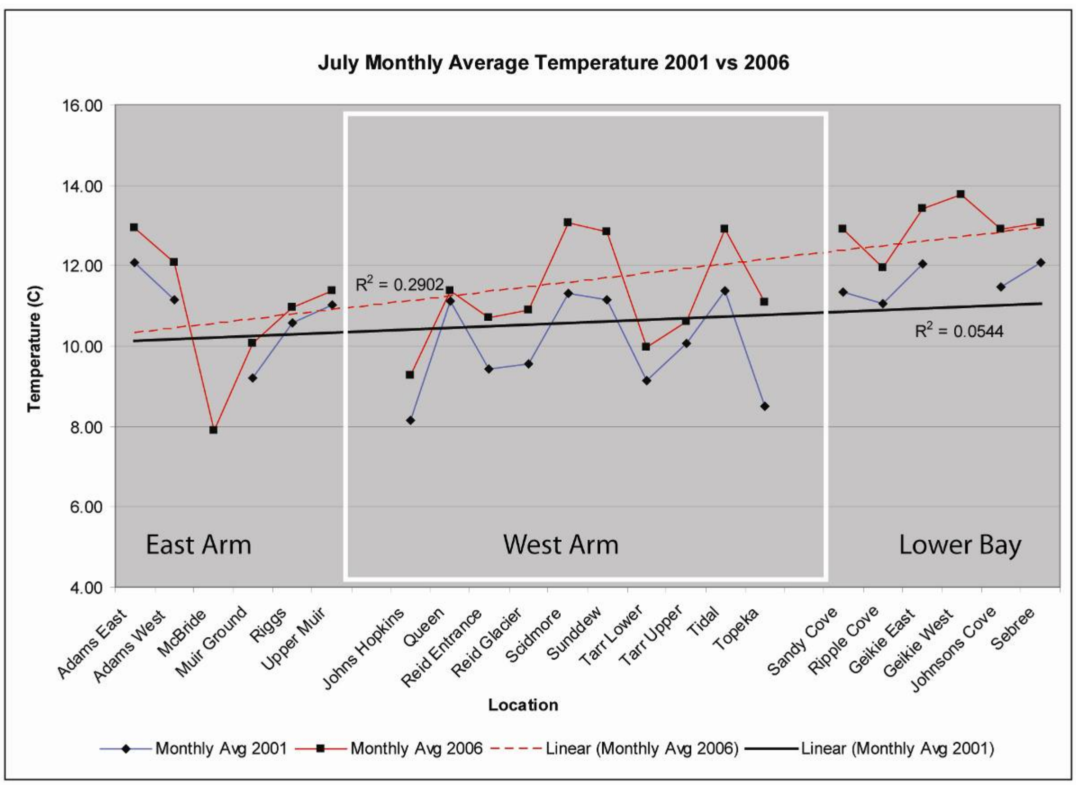


Figure 4. Graphs of the monthly average temperatures by site across the Glacier Bay watershed. The upper plot is of average December or winter temperatures by site, comparing the years of 2001 and 2006. The lower plot shows the mean July or summer temperatures by site for the years 2001 and 2006.

is due to colder winter temperatures, with summer temperatures nearly equal each year at each site. The temperature spread during winter of 2001 vs. 2006 was about 3 degrees C, whereas in summer it was about 1 degree C. these plots also show the regional variability with the lower bay sites tending to be warmer winter and summer than the East and West Arms. Looking at specific sites, the coldest sites in the East and West Arms are located nearer the active glacier margins at the heads of fjords.

We also compared the monthly average temperatures by site for the years 2001 and 2006 in Figure 5a, b. These comparisons suggest that the winter in 2006 was characterized by having only two months (December, March) that had average temperatures 4 to 5 degrees

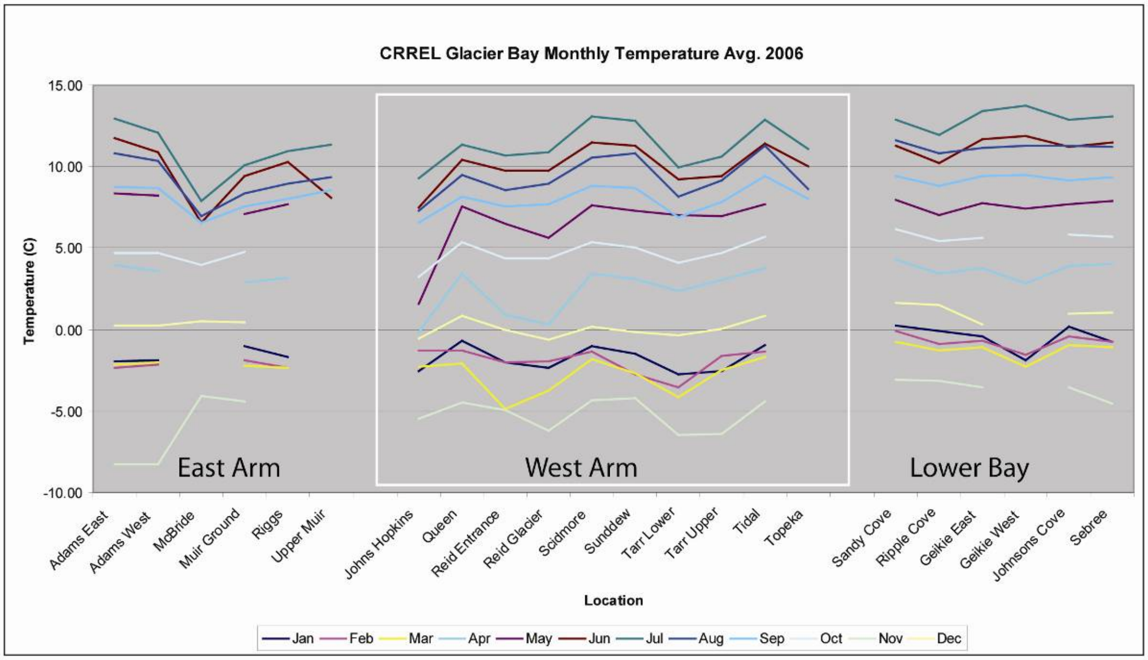


Figure 5a. Monthly average temperatures at each site during 2006

below zero, while the remaining months averaged within 1 to 2 degrees below zero. In contrast most winter months in 2001 were generally colder on average by 1 or 2 degrees. The range in temperature differences site to site during a particular month is well illustrated. Typically the data suggest that a 2 to 3 degree spread in summer and somewhat less in winter.

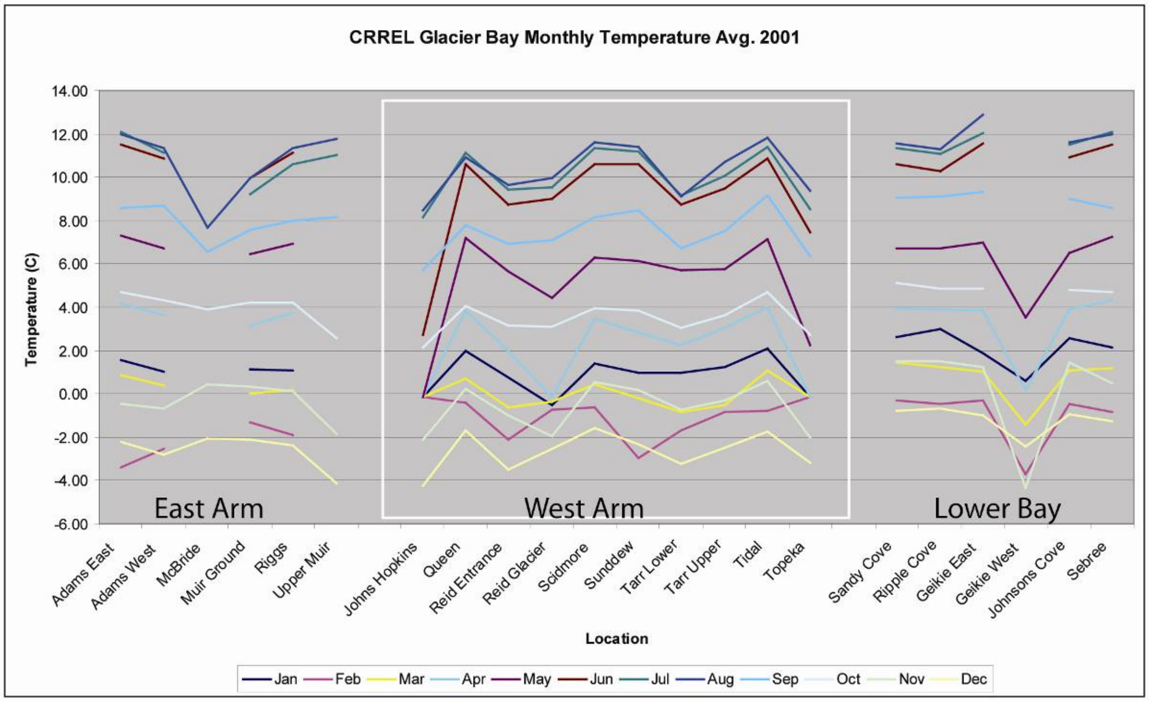


Figure 5b. Monthly average temperatures by site for 2001.

We will continue to analyze the temperature data during 2008, with the intention of trying to better understand the regional or site-to-site variability by month, season and year. This particular difference may have bearing on interpreting the paleotemperature records from interstadial wood which is of the same age, but from different locations within the Glacier Bay watershed. We will also be interested in understanding if there are trends in the data in an annual basis. In last year's report, we suggested that the data in trends in the mean annual temperature suggested a warming of 1 to 2 degrees and possible implications for regional or global climatic effects. The data we now have in hand however suggests that there was indeed a period of overall warming from 2001 to 2005 but that since that time, cooling has occurred (Appendix B).

Continuing Work and Products

We plan to visit each climate site over two, 5-day periods in the spring and fall of 2008, and each year thereafter until systems are fully automated. These visits are necessary to insure that a complete record of the air temperature and precipitation from each site is acquired, barring any problems over which we have no control. Continued processing and analysis of the precipitation data database will be done during 2008. We will also be testing new systems using Iridium satellite phone technology for possible test deployment at the Johns Hopkins site. If successful this would include obtaining daily digital images of the glacier terminus that would be transmitted and displayed on the CRREL Glacier Bay web site. We will be updating the archival database for the 2006 – 2007 data by DVD to Bill Eichenlaub for archiving on the NPS Glacier Bay server. The climate data are available for other researchers and park staff, but we ask that requests be made directly to us to insure no duplication of effort and that the most up-to-date and quality checked processed data are utilized. In addition we will update the CRREL Glacier Bay web site to include all data as well as tabulated statistical data including the temperature averages calculated this past year.

Existing data from the climate monitoring effort will continue to be processed and analyzed through winter of 2008. As new records are acquired, we will produce continuous records for precipitation at monthly and annual intervals. As measurements continue to be acquired annually, the length of record necessary to discern and analyze long-term trends versus short-term variability inherent in natural systems will lengthen and enable such analyses. The temperature trends expressed in the statistically based graphs of this report may represent decadal events and cycles (e.g. El Nino and the longer Pacific Decadal and Arctic Oscillations) that are known to influence the North Pacific region climate, but our record remains too short for evaluating such trends and processes.

Collaborators and Synergistic Activities

We collaborated with Justin Smith (NPS) and Tom Ainsworth (NWS) to provide a climate station at Bartlett Cove that includes satellite transmission to an NWS web site and local transmission to the Visitor Center. CRREL provided a GOES system, precipitation gauge and solar radiometer, while the Weather Service provided the temperature gauge, barometric pressure gauge and related equipment for local weather download. The Park provided the mounting on the dock and electrical power. This climate station provide current weather conditions for the Park staff at the Visitor Center, while the GOES transmission provide the Weather Service and CRREL data hourly via the web. The climate site now provides new climate coverage for the lower, eastern side of the bay, supplementing the existing CRREL sites. Additional sensors may be added, including a tide gauge, if funding can be acquired. We are also planning to provide direct access to the NWS for our up-bay sites with satellite coverage.

We are collaborating with Dave Hill (Penn State) to enhance his oceanographic model to include the freshwater flux based on the precipitation data across the park. In addition we have submitted a collaborative proposal with John Piatt, Lead PI (USGS), which applies the climate site database to examining ecosystem changes resulting from global warming. Our field work during the summer of 2007 relied in part on undergraduate students from The College of Wooster and Dartmouth College, high school students from Vermont and significant assistance from Park volunteers in the downloading of data loggers and servicing of the instruments. We are also collaborating with Sandy Milner to examine the effects of the November storm on salmon streams within the park, attempting to understand what the short and long term effects may be.

Management Implications and Significance

Climate change is one of the most important things affecting the world today and in the future. The long-term climatic data that we are now collecting will be essential to understanding how global and regional changes in climate are affecting Glacier Bay and in predicting how such changes will impact the Park's ecosystems. Such changes may cause significant change sin marine, terrestrial and freshwater ecosystems in the park, significant impacts that Park management may need to consider and address. Climate is the essential driver controlling physical and biological processes and environments and the feedbacks among them. The CRREL climate network is a first step toward meeting the goal of long-term monitoring and will feed directly into the SEAN Inventory and Monitoring Program. By upgrading the existing sites for additional sensors for wind, solar and barometric pressure and for satellite transmission with web access to the data, a full suite of climatic data will be available in near real time for use by park management, rangers, naturalists and interpreters as well as researchers. Our extremely limited understanding of the climate in the Park and such basic knowledge as storm tracks and prevailing winds will be met by our climate sites and the associated studies of stable isotopes and other aspects of the hydrologic cycle. Emergency situations such as accidents involving cruise ships would benefit from having real time information on local meteorological conditions.

Acknowledgements
This project has been funded in part by the US Army Cold Regions Research and Engineering Lab, the National Science Foundation, Rockefeller Center for Public Policy and Social Sciences and the Institute of Arctic Studies at Dartmouth College, and private donations. We are extremely grateful to the current and past staff and management of Glacier Bay National Park and Preserve for their logistical support, assistance and encouragement. We particularly would like to thank Tomie Lee, Former Superintendent, Susan Boudreau, Former Chief Resource Management, and Lewis Sharman, Ecologist, for their permission and encouragement to conduct the research, and in providing the continuing support of their staff and vessels, housing, office space and other facilities.

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Appendix A.

Monthly Temperature Averages (Celsius) – By site & year

Location	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adams East	2000							11.32	11.02	7.51	4.22	1.83	-1.28
Adams East	2001	1.54	-3.38	0.88	4.18	7.29	11.52	12.06	11.99	8.56	4.69	-0.44	-2.23
Adams East	2002	-1.57	-1.15	-2.15	1.91	8.45	11.53	11.87	11.49	8.49	5.50	3.48	-0.94
Adams East	2003	-1.12	-0.53	-0.43	5.69	8.44	11.61	13.43	11.80	8.33	5.28	-2.45	-0.83
Adams East	2004	-5.56	1.17	1.22	4.36	10.91	13.56	13.93	12.96	8.18	4.50	1.50	-0.96
Adams East	2005	-4.32	-1.88	2.43	6.32					7.84	4.67	0.38	-0.14
Adams East	2006	-1.94	-2.36	-2.13	3.98	8.38	11.73	12.93	10.82	8.77	4.67	-8.26	0.21
Adams East	2007	-2.22	-4.34	-2.15	3.25	7.12							
Adams West	2000								10.40	7.84	4.31	1.72	-1.16
Adams West	2001	1.02	-2.55	0.37	3.60	6.72	10.87	11.14	11.36	8.70	4.33	-0.70	-2.79
Adams West	2002	-1.90	-1.23	-2.35	1.48	7.34	10.57	11.01	11.13	8.27	5.73	3.59	-0.86
Adams West	2003	-0.97	-0.46	-0.68	5.06	7.88	10.87	12.36	11.14	8.31	5.58	-1.94	-1.20
Adams West	2004	-5.00	0.98	1.19	3.85	9.96	12.54	12.95	12.69	8.52	4.52	1.46	-0.73
Adams West	2005	-3.82	-1.66	2.16	6.01	6.64	12.87	12.37	11.66	8.94	4.55	0.37	-0.11
Adams West	2006	-1.86	-2.15	-2.00	3.54	8.22	10.85	12.06	10.35	8.67	4.67	-8.26	0.21
Adams West	2007	-2.22	-4.34	-2.15	3.25	7.12							
Geikie East	2000					8.05	10.60	11.66	11.54	8.64	5.42	2.57	0.61
Geikie East	2001	1.89	-0.31	1.01	3.82	6.96	11.54	12.04	12.87	9.34	4.86	1.21	-0.98
Geikie East	2002	-0.22	-0.41	-0.66	3.39	8.10	11.24	11.93	11.94	9.06	6.24	4.16	-0.96
Geikie East	2003	-0.94	-0.96	-0.90	4.27	8.49	11.88	13.74	12.56	9.08	6.84	0.06	0.51
Geikie East	2004	-2.32	1.96	1.83	4.55	10.36	13.77	14.37	14.63	9.80	5.61	1.74	0.86
Geikie East	2005	-1.61	-0.73	2.64	6.19	10.54			13.16	9.41	5.50	1.86	1.00
Geikie East	2006	-0.40	-0.68	-1.09	3.73	7.77	11.66	13.41	11.18	9.40	5.63	-3.55	0.31
Geikie East	2007	-0.88	-2.14	-2.01	2.72	7.54							

Location	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Geikie West	2000							11.26	10.76	7.58	4.10	1.11	-1.03
Geikie West	2001	0.59	-3.74	-1.44	0.18	3.51						-4.36	-2.41
Geikie West	2002	-0.98	-0.22	-0.16	0.07	5.58	10.37	11.51	11.30	8.30	5.56	4.23	
Geikie West	2003					9.47	11.34	13.44	11.77	8.31	5.75	-1.95	-1.73
Geikie West	2004	-1.58	-0.16	-0.16	-0.16			13.52	13.59	8.82	4.72	0.59	-0.40
Geikie West	2005	-3.82	-1.56	-0.05	3.25	10.00	12.71	12.81	12.28	8.83	4.37	-0.09	-0.74
Geikie West	2006	-1.92	-1.58	-2.32	2.84	7.43	11.85	13.76	11.28	9.49			
Johns Hopkins	2000											-0.07	-2.46
Johns Hopkins	2001	-0.16	-0.16	-0.16	-0.16	-0.16	2.74	8.14	8.47	5.71	2.15	-2.11	-4.24
Johns Hopkins	2002	-0.16	-0.16	-0.16	-0.05	0.32	6.04	8.47	7.75	6.11	3.62	1.71	-1.46
Johns Hopkins	2003	-1.45	-2.71	-3.76	0.92	5.38	7.78	9.19	8.67	6.06	4.18	-3.00	-1.08
Johns Hopkins	2004	-0.16	-0.16	-0.16	-0.16	-0.16	5.70	9.18	10.92	6.34	2.80	-0.71	-1.42
Johns Hopkins	2005	-2.22	-0.27	-0.16	-0.16	1.61	9.10	9.84	9.63	6.41	3.07	-1.16	-0.72
Johns Hopkins	2006	-2.53	-1.29	-2.32	-0.15	1.59	7.49	9.27	7.30	6.58	3.25	-5.45	-0.55
Johns Hopkins	2007	-0.16	-0.16	-0.16	-0.16	-0.16	0.70	7.77					
Johnsons Cove	2000								10.44	8.22	5.23	3.20	0.77
Johnsons Cove	2001	2.57	-0.47	1.06	3.87	6.48	10.91	11.48	11.63	9.02	4.82	1.45	-0.93
Johnsons Cove	2002	0.19	-0.46	-0.76	2.53	7.53	11.05	11.68	11.73	8.77	6.10	4.61	0.98
Johnsons Cove	2003	0.85	0.91	0.48	5.47	8.31	11.36	13.39	12.11	8.80	6.20	-0.04	0.80
Johnsons Cove	2004	-2.13	2.17	1.54	4.30	11.38	13.12	13.58	13.49	9.18	5.52	2.40	1.13
Johnsons Cove	2005	-1.32	-0.16	2.90	6.14	9.78	13.46	13.09	12.37	9.60	5.57	2.39	1.92
Johnsons Cove	2006	0.17	-0.44	-0.99	3.88	7.69	11.24	12.90	11.29	9.18	5.80	-3.57	0.98
Johnsons Cove	2007	-0.98	-2.61	-1.72	1.59	6.77							

Location	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
McBride	2001								7.65	6.58	3.87	0.43	-2.06
McBride	2002	-1.15	-1.66	-2.37	1.31	5.74	7.09	7.21	7.61	6.10	4.69	3.82	-0.84
McBride	2003	-0.55	-0.31	-0.51	4.51	6.20	7.02	8.00	7.81	6.51	5.08	-1.22	-0.37
McBride	2004	-3.29	1.03	0.97	3.61	6.69	8.58	8.38	9.44	7.07	4.04	1.52	0.28
McBride	2005	-2.05	-1.01	2.17	5.34	9.56							
McBride	2006						6.56	7.90	6.94	6.57	3.94	-4.10	0.50
McBride	2007	-1.84	-4.35	-3.07	1.25	4.89	6.32						
Muir Ground	2000					8.07	9.35	9.56	9.25	6.96	4.50	2.11	-0.01
Muir Ground	2001	1.14	-1.32	-0.01	3.17	6.44	9.94	9.21	9.96	7.57	4.23	0.32	-2.12
Muir Ground	2002	-1.46	-0.86	-3.02	0.11	7.17	9.36	9.61	9.51	7.20	4.72	4.27	-0.29
Muir Ground	2003	-0.22	-0.29	-0.52	5.49	7.98	9.19	10.54	9.96	7.67	5.95	-1.35	-0.72
Muir Ground	2004	-3.91	-0.58	-0.36	2.55	8.90	11.43	11.33	11.92	8.18	4.35	1.53	-0.06
Muir Ground	2005	-1.91	-1.12	2.00	6.14	8.48	11.87	10.25	10.27	7.36	4.87	0.63	0.19
Muir Ground	2006	-1.01	-1.89	-2.24	2.91	7.12	9.42	10.07	8.35	7.54	4.74	-4.41	0.46
Muir Ground	2007	-1.39	-3.03	-2.78	-0.12	4.36							
Queen	2000					8.56	10.23	10.36	9.92	7.73	4.89	2.40	0.62
Queen	2001	1.97	-0.39	0.72	3.86	7.18	10.60	11.13	10.94	7.78	4.06	0.20	-1.67
Queen	2002	-0.39	-0.77	-1.77	2.23	7.80	9.91	10.04	10.12	7.86	5.43	4.50	0.32
Queen	2003	0.64	0.24	-0.02	5.50	8.78	11.18	11.72	10.56	7.72	5.73	-0.65	0.27
Queen	2004	-3.43	1.82	1.46	4.33	9.75	11.73	11.20	11.21	8.42	4.82	1.56	0.51
Queen	2005	-1.47	-0.86	2.46	6.07	9.28			10.57	7.55	4.87	1.32	1.25
Queen	2006	-0.68	-1.27	-2.06	3.44	7.58	10.44	11.37	9.46	8.18	5.36	-4.51	0.83
Queen	2007	-1.18	-2.13	-2.71	0.05	6.47							

Location	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Reid Entrance	2000								11.06	6.82	3.35	0.90	-0.99
Reid Entrance	2001	0.76	-2.12	-0.64	2.00	5.63	8.76	9.43	9.65	6.91	3.14	-0.99	-3.51
Reid Entrance	2002	-2.20	-0.30	-0.38	-0.39	3.97	9.02	9.44	9.32	7.05	4.64	2.94	-0.72
Reid Entrance	2003	-0.38	-1.07	-1.08	3.59	7.68	10.15	10.97	9.93	7.11	4.86	-1.97	-0.77
Reid Entrance	2004	-5.14	-1.19	-0.55	-0.01	9.15	11.29	11.18	11.50	7.47	3.90	0.49	-0.43
Reid Entrance	2005	-1.60	-1.83	1.45	5.17	8.47	10.65	10.73	10.18	7.11	3.81	-0.15	0.51
Reid Entrance	2006	-2.00	-1.99	-4.85	0.92	6.52	9.72	10.70	8.57	7.52	4.37	-4.97	-0.05
Reid Entrance	2007	-2.67	-3.30	-4.59	-0.25	0.56							
Reid Glacier	2000									6.87	3.31	0.94	-1.95
Reid Glacier	2001	-0.54	-0.75	-0.34	-0.13	4.42	9.02	9.55	9.97	7.09	3.09	-1.98	-2.55
Reid Glacier	2002	-0.16	-0.16	-0.16	-0.16	1.57	8.69	9.66	9.54	7.17	4.77	2.91	-0.85
Reid Glacier	2003	-0.67	-2.62	-3.87	-0.26	7.77	9.72	11.22	10.24	7.15	5.04	-2.49	-0.66
Reid Glacier	2004	-0.16	-0.16	-0.16	-0.16			14.31	11.62	6.78	2.91	-0.18	-0.71
Reid Glacier	2005	-1.72	-0.55	-0.16	-0.16	7.32	10.80	11.43	10.65	7.26	3.81	-0.52	0.46
Reid Glacier	2006	-2.36	-1.96	-3.77	0.29	5.62	9.75	10.90	8.93	7.68	4.37	-6.19	-0.63
Reid Glacier	2007	-0.16	-0.16	-0.16	-6.68	-17.10	-10.29	-17.56	-0.16	-0.16	-0.16	-0.16	-0.16
Riggs	2000							11.17	10.22	7.49	4.55	2.06	-0.50
Riggs	2001	1.10	-1.91	0.15	3.74	6.91	11.12	10.58	11.36	8.00	4.20	0.12	-2.38
Riggs	2002	-1.33	-0.70	-3.17	0.99	8.01	10.38	10.45	10.31	7.71	5.16	3.79	-0.87
Riggs	2003	-0.77	-0.43	-0.46	5.88	8.53	10.26	12.04	10.88	7.94	5.68	-2.16	-1.01
Riggs	2004	-4.28	0.21	0.25	3.32	9.97	12.84	12.63	12.76	7.96	4.28	1.22	-0.50
Riggs	2005	-2.51	-1.48	2.07	6.37	11.72	12.98	11.24	11.08	7.84	4.60	0.19	-0.22
Riggs	2006	-1.71	-2.36	-2.33	3.14	7.66	10.30	10.97	8.96	8.00			

Location	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Ripple Cove	2000					8.69	10.50	11.34	11.14	8.34	5.24	3.71	0.88
Ripple Cove	2001	2.97	-0.46	1.23	3.90	6.71	10.28	11.06	11.26	9.09	4.86	1.48	-0.66
Ripple Cove	2002	0.22	-0.41	-1.15	2.00	6.49	10.27	11.07	11.50	8.94	6.75	5.28	1.65
Ripple Cove	2003	1.43	1.31	0.70	4.84	7.72	10.71	12.59	11.63	8.86	6.62	0.03	1.33
Ripple Cove	2004	-1.70	2.60	1.68	4.42								
Ripple Cove	2005						12.11	12.33	11.69	9.52	5.44	2.32	2.05
Ripple Cove	2006	-0.08	-0.86	-1.27	3.41	7.00	10.21	11.95	10.80	8.81	5.45	-3.12	1.53
Ripple Cove	2007	-0.57	-1.95	-1.70	2.90	6.11	5.63						
Sandy Cove	2000							11.24	10.94	8.32	5.38	3.51	0.95
Sandy Cove	2001	2.63	-0.28	1.43	3.96	6.69	10.60	11.35	11.55	9.07	5.11	1.52	-0.77
Sandy Cove	2002	0.32	0.02	-0.66	2.43	7.63	10.76	11.55	11.84	9.04	6.49	4.92	1.10
Sandy Cove	2003	1.10	1.13	0.53	5.21	8.36	11.46	13.52	12.25	9.12	6.50	0.44	1.02
Sandy Cove	2004	-1.89	2.46	2.17	4.90	10.72	13.05	14.28	13.36	9.51	5.83	2.90	1.20
Sandy Cove	2005	-1.19	0.28	3.49	6.45		13.14	13.60	12.83	10.19	5.90	2.49	2.24
Sandy Cove	2006	0.25	-0.09	-0.74	4.29	7.92	11.29	12.90	11.59	9.42	6.17	-3.06	1.66
Sandy Cove	2007	-0.24	-1.72	-0.82	3.51	6.86							
Scidmore	2000											4.64	0.16
Scidmore	2001	1.41	-0.60	0.46	3.45	6.29	10.62	11.32	11.60	8.17	3.95	0.54	-1.61
Scidmore	2002	-0.53	-1.29	-1.84	1.81	7.43	10.58	11.12	11.20	8.09	5.35	3.93	0.05
Scidmore	2003	0.25	-0.25	-0.25	4.70	8.06	11.22	12.99	11.82	8.02	5.82	-1.24	-0.36
Scidmore	2004	-3.62	-0.31	-0.33	3.98	10.67	13.67	13.17	11.03	8.62	4.91	1.17	-0.10
Scidmore	2005	-1.73	-1.28	2.15	5.69	10.46	12.74	12.99	12.19	8.45	4.76	0.83	0.82
Scidmore	2006	-1.01	-1.35	-1.85	3.44	7.61	11.46	13.06	10.55	8.84	5.34	-4.37	0.17
Scidmore	2007	-0.16	-0.16	-0.16	-0.16	3.55							

Location	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sebree	2001	2.15	-0.84	1.18	4.33	7.25	11.52	12.06	11.99	8.56	4.69	0.49	-1.27
Sebree	2002	-0.34	-0.49	-0.85	2.59	8.31	11.07	11.66	11.82	9.08	6.17	4.40	0.39
Sebree	2003	0.55	0.60	0.25	5.85	9.80	11.42	13.35	12.42	9.10	6.60	-0.48	0.46
Sebree	2004	-2.80	2.32	1.83	4.71	10.81	13.25	13.76	13.89	9.16	5.49	2.35	0.63
Sebree	2005	-2.08	-0.34	3.19	6.52	10.13	13.90	13.52	12.77	9.61	5.42	1.60	1.24
Sebree	2006	-0.77	-0.76	-1.10	4.00	7.87	11.45	13.06	11.19	9.33	5.68	-4.55	1.06
Sebree	2007	-0.84	-2.48	-1.65	3.69	7.07							
Sundew	2000							11.19	10.48	7.73	4.33	1.55	-0.66
Sundew	2001	0.94	-2.94	-0.18	2.81	6.10	10.59	11.16	11.39	8.44	3.82	0.19	-2.31
Sundew	2002	-1.05	-0.81	-1.23	0.36	7.70	11.06	12.27	12.11	8.53	5.46	3.80	-0.60
Sundew	2003	-0.42	-0.40	-0.43	4.43	8.18	11.51	13.44	11.88	8.32	5.52	-1.83	-1.07
Sundew	2004	-1.99	-0.84	-0.35	2.19	9.81	13.77	13.96	13.92	8.47	4.77	0.79	-0.48
Sundew	2005	-2.32	-1.78	1.99	5.30	8.72			12.16	8.19	4.50	0.46	0.36
Sundew	2006	-1.46	-2.72	-2.69	3.08	7.28	11.29	12.83	10.79	8.70	5.05	-4.20	-0.18
Sundew	2007	-0.36	-0.80	-1.86	-0.22	4.53							
Tarr Lower	2000							8.79	8.77	6.48	3.31	0.88	-1.07
Tarr Lower	2001	0.98	-1.68	-0.82	2.26	5.71	8.75	9.14	9.13	6.73	3.06	-0.75	-3.26
Tarr Lower	2002	-1.98	-1.33	-1.78	-0.95	5.60	9.61	9.75	9.43	6.97	4.58	3.16	-0.83
Tarr Lower	2003	-0.56	-1.28	-1.11	4.11	7.85	10.09	10.71	9.52	6.80	4.73	-2.42	-1.85
Tarr Lower	2004	-2.60	-0.92	-0.36	0.70	9.09	10.82	10.51	10.42	6.67	3.58	-0.01	-1.07
Tarr Lower	2005	-2.60	-2.63	1.24	4.73	8.01	10.14	10.04	9.48	6.32	3.46	-0.65	0.15
Tarr Lower	2006	-2.72	-3.54	-4.12	2.35	7.03	9.23	9.96	8.15	6.90	4.07	-6.49	-0.34
Tarr Lower	2007	-0.16	-0.19	-0.40	-0.16	1.42							

Location	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Tarr Upper	2000					7.90	9.36	9.70	10.01	7.05	3.68	1.20	-0.52
Tarr Upper	2001	1.23	-0.82	-0.53	3.04	5.78	9.50	10.07	10.71	7.53	3.64	-0.33	-2.46
Tarr Upper	2002	-1.14	-1.48	-2.27	1.90	7.23	9.60	10.23	9.58	7.47	5.13	3.63	-0.11
Tarr Upper	2003	-0.05	-1.09	-1.18	4.79	8.03	10.46	12.30	10.72				
Tarr Upper	2004					8.24	11.46	11.36	12.55	7.79	4.23	0.44	-0.79
Tarr Upper	2005	-2.42	-2.49	1.48	5.35	8.57	10.74	10.47	10.63	7.31	4.02	-0.25	0.55
Tarr Upper	2006	-2.54	-1.61	-2.51	3.05	6.96	9.43	10.60	9.13	7.83	4.72	-6.42	0.03
Tarr Upper	2007	-2.09	-4.43	-4.53	1.38	6.31							
Tidal	2000							11.38	11.24	8.42	5.19	2.68	0.11
Tidal	2001	2.10	-0.78	1.06	4.02	7.16	10.86	11.37	11.81	9.16	4.71	0.60	-1.76
Tidal	2002	-0.61	-0.99	-1.35	2.28	7.91	11.04	11.92	11.98	9.08	6.29	4.34	-0.13
Tidal	2003	0.22	0.31	0.03	5.43	9.01	11.66	13.54	12.61	9.28	6.40	-0.03	
Tidal	2004					10.36	12.86	13.43	13.42	9.29	5.51	1.89	0.42
Tidal	2005	-2.33	-1.03	2.92	6.16	9.30				8.00	5.25	1.20	1.19
Tidal	2006	-0.96	-1.35	-1.66	3.76	7.69	11.38	12.90	11.26	9.41	5.69	-4.40	0.85
Tidal	2007	-1.34	-2.82	-1.82	2.85	6.61							
Topeka	2000					6.21	7.80	9.10	9.33	6.53	2.92	0.53	-1.97
Topeka	2001	-0.16	-0.16	-0.16	-0.16	2.27	7.45	8.50	9.37	6.35	2.74	-1.99	-3.16
Topeka	2002	-0.16	-0.16	-0.16	-0.16	1.52	7.45	8.58	8.81	7.07	4.57	2.41	-1.09
Topeka	2003	-0.93	-1.51	-2.54	2.89	7.00	9.40	10.50	9.80	6.84	4.96	-1.85	-0.69
Topeka	2004	-0.16	-0.16	-0.16	-0.16	7.00	10.36	10.89	12.01	7.30	3.69	0.13	-1.43
Topeka	2005	-4.01	-1.02	-0.16	0.41	6.99	9.94	10.63	10.36	7.96			
Topeka	2006						9.99	11.08	8.60	8.01			

Location	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Upper Muir	2001							11.01	11.78	8.17	2.56	-1.87	-4.16
Upper Muir	2002	-2.80	-1.31	-1.97	-2.24	5.88	9.58	10.47	10.82	8.14	5.65	3.44	-0.60
Upper Muir	2003	-0.53	-1.79	-6.45		8.06	9.64	12.15	11.51	8.14	6.05	-2.22	-1.35
Upper Muir	2004	-1.14	-1.11	-0.16	-0.16				13.04	7.95	3.72	0.13	-1.88
Upper Muir	2005	-3.36	-3.40	-0.42	3.32	9.87	11.58	11.54	12.72	8.15	3.77	-1.79	
Upper Muir	2006						8.06	11.36	9.33	8.56	4.05	-7.20	-1.03
Upper Muir	2007	-2.24	-2.03	-4.20	-0.28	4.34	9.78	11.04					
Wachusett East	2000							9.00	8.96	6.68	4.02	0.88	-2.29
Wachusett East	2001	0.31	-6.08	-1.95	1.11	6.13	9.51	9.14	9.31	6.96	3.52	-1.01	-3.44
Wachusett East	2002	-3.16	-1.46	-2.50	-0.50	6.12	8.89	9.14	9.09	6.82	4.30	3.19	-1.81
Wachusett East	2003	-2.25	-2.21	-1.95	3.76	8.01	9.34	9.81	9.30	6.81	4.73	-3.55	-2.34
Wachusett East	2004	-2.80	-1.29	-0.20	-0.16	8.83	10.84	10.62	10.44	7.44	3.64	0.42	-1.37
Wachusett East	2005	-4.18	-2.97	1.12	5.05	9.05	11.14	9.77	9.45	6.88	4.07	-0.57	-1.04
Wachusett East	2006	-2.79	-5.09	-4.44	2.20	6.98	9.61	10.06	8.43	7.18	4.21	-6.46	-0.59
Wachusett East	2007	-0.31	-1.00	-3.20	-0.21	-0.11							
Wachusett West	2000					8.72	10.67	10.82	10.04	7.53	4.36	1.34	-1.87
Wachusett West	2001	0.71	-4.24	-0.18	2.55	6.77	10.84	10.54	10.54	8.03	4.15	-0.39	-2.99
Wachusett West	2002	-2.86	-1.06	-0.64	0.14	7.07	10.55	10.65	10.50	7.76	4.99	2.85	
Wachusett West	2003					9.23	11.20	11.90	10.83	7.81	5.14	-2.94	-0.98
Wachusett West	2004	-4.88	0.23	0.05	2.77	9.90	12.48	12.29	11.68	8.32	4.16	0.85	-0.64
Wachusett West	2005	-3.15	-1.81	1.98	5.78	7.29	12.61	11.79	11.04	8.13	4.21	-0.42	-0.80
Wachusett West	2006	-2.25	-3.36	-3.31	3.18	8.07	11.02	11.85	9.82	8.21	4.71	-5.60	-0.13
Wachusett West	2007	-0.46	-0.16	-0.63	-0.09	5.31							

Appendix B.

CRREL Climate Data - Yearly Temperature Averages (Celsius) By Site

Location	Year	Min Temp value	Max Temp value	Average Yearly Value
Adams East	2000	-13.49	22.09	5.49
Adams East	2001	-15.36	26.73	4.78
Adams East	2002	-20.24	26.34	4.79
Adams East	2003	-14.73	26.73	4.97
Adams East	2004	-20.24	29.50	5.11
Adams East	2005	-22.60	23.24	1.23
Adams East	2006	-20.24	25.17	3.95
Adams East	2007	-21.00	19.04	0.25
Adams West	2000	-11.70	22.86	3.83
Adams West	2001	-13.49	23.63	4.39
Adams West	2002	-16.68	24.79	4.43
Adams West	2003	-13.49	25.95	4.69
Adams West	2004	-18.05	29.90	4.92
Adams West	2005	-19.49	28.70	4.45
Adams West	2006	-20.24	28.31	3.74
Adams West	2007	-21.00	19.04	0.25
Geikie East	2000	-7.33	21.33	7.34
Geikie East	2001	-8.91	24.40	5.40
Geikie East	2002	-11.13	23.63	5.35
Geikie East	2003	-13.49	25.17	5.43
Geikie East	2004	-11.13	27.52	6.13
Geikie East	2005	-11.70	25.95	3.93
Geikie East	2006	-12.29	24.01	4.82
Geikie East	2007	-10.01	21.71	0.95

Location	Year	Min Temp value	Max Temp value	Average Yearly Value
Geikie West	2000	-11.13	20.57	5.27
Geikie West	2001	-14.73	17.14	-0.84
Geikie West	2002	-12.88	24.40	5.15
Geikie West	2003	-13.49	23.63	6.81
Geikie West	2004	-11.70	29.50	2.52
Geikie West	2005	-18.05	25.56	4.87
Geikie West	2006	-11.70	26.34	5.43
Johns Hopkins	2000	-10.56	4.57	-1.54
Johns Hopkins	2001	-15.36	19.04	1.68
Johns Hopkins	2002	-8.38	20.19	2.68
Johns Hopkins	2003	-14.73	19.04	2.55
Johns Hopkins	2004	-11.13	19.81	2.03
Johns Hopkins	2005	-11.13	21.33	2.93
Johns Hopkins	2006	-11.70	17.14	1.96
Johns Hopkins	2007	-0.16	15.62	0.88
Johnsons Cove	2000	-7.33	21.71	4.69
Johnsons Cove	2001	-8.38	22.09	5.19
Johnsons Cove	2002	-11.13	25.56	5.36
Johnsons Cove	2003	-11.70	25.56	5.75
Johnsons Cove	2004	-11.70	26.73	5.92
Johnsons Cove	2005	-11.13	23.63	5.65
Johnsons Cove	2006	-11.70	22.86	4.88
Johnsons Cove	2007	-10.56	17.52	0.53

Location	Year	Min Temp value	Max Temp value	Average Yearly Value
McBride	2001	-10.56	14.85	2.94
McBride	2002	-12.88	22.48	3.15
McBride	2003	-13.49	20.95	3.54
McBride	2004	-14.73	21.71	3.83
McBride	2005	-14.10	15.62	1.17
McBride	2006	-10.56	17.52	3.79
McBride	2007	-16.02	9.82	-0.53
Muir Ground	2000	-8.38	19.04	6.06
Muir Ground	2001	-11.13	20.95	4.08
Muir Ground	2002	-11.70	26.34	3.88
Muir Ground	2003	-15.36	22.86	4.50
Muir Ground	2004	-16.68	24.79	4.31
Muir Ground	2005	-14.73	24.01	3.78
Muir Ground	2006	-14.10	19.04	3.46
Muir Ground	2007	-14.73	12.16	-0.59
Queen	2000	-7.85	19.81	6.69
Queen	2001	-10.56	25.95	4.74
Queen	2002	-11.13	22.09	4.64
Queen	2003	-14.73	24.79	5.17
Queen	2004	-14.73	23.63	4.94
Queen	2005	-14.10	22.86	3.31
Queen	2006	-13.49	21.71	4.05
Queen	2007	-11.13	14.85	0.13

Location	Year	Min Temp value	Max Temp value	Average Yearly Value
Reid Entrance	2000	-9.46	28.70	3.30
Reid Entrance	2001	-11.13	18.66	3.29
Reid Entrance	2002	-10.56	19.42	3.55
Reid Entrance	2003	-12.88	20.95	4.12
Reid Entrance	2004	-12.29	22.48	3.62
Reid Entrance	2005	-14.10	22.86	3.98
Reid Entrance	2006	-14.10	20.95	2.91
Reid Entrance	2007	-13.49	9.82	-2.04
Reid Glacier	2000	-12.88	14.85	2.21
Reid Glacier	2001	-14.10	19.42	3.10
Reid Glacier	2002	-7.33	18.66	3.58
Reid Glacier	2003	-14.73	21.71	3.22
Reid Glacier	2004	-5.81	22.48	2.02
Reid Glacier	2005	-10.01	23.63	4.09
Reid Glacier	2006	-12.88	20.19	2.76
Reid Glacier	2007	-69.16	24.79	-4.70
Riggs	2000	-10.56	22.86	5.65
Riggs	2001	-12.88	25.56	4.45
Riggs	2002	-14.10	24.40	4.25
Riggs	2003	-14.10	25.56	4.73
Riggs	2004	-16.68	28.31	4.72
Riggs	2005	-18.05	26.34	3.83
Riggs	2006	-15.36	23.63	4.58

Location	Year	Min Temp value	Max Temp value	Average Yearly Value
Ripple Cove	2000	-9.46	23.24	7.40
Ripple Cove	2001	-12.88	21.71	5.18
Ripple Cove	2002	-13.49	22.86	5.23
Ripple Cove	2003	-11.70	24.01	5.68
Ripple Cove	2004	-11.70	10.99	1.66
Ripple Cove	2005	-8.91	21.71	7.45
Ripple Cove	2006	-13.49	20.57	4.53
Ripple Cove	2007	-11.70	15.62	1.01
Sandy Cove	2000	-6.31	18.66	6.57
Sandy Cove	2001	-8.91	23.24	5.27
Sandy Cove	2002	-10.01	24.79	5.48
Sandy Cove	2003	-11.70	25.56	5.92
Sandy Cove	2004	-12.29	27.12	6.27
Sandy Cove	2005	-12.88	24.40	5.97
Sandy Cove	2006	-12.88	20.57	5.17
Sandy Cove	2007	-11.70	16.76	1.44
Scidmore	2000	-7.85	20.95	1.95
Scidmore	2001	-9.46	22.48	4.67
Scidmore	2002	-11.13	22.09	4.70
Scidmore	2003	-12.88	24.01	5.10
Scidmore	2004	-13.49	29.90	4.13
Scidmore	2005	-13.49	29.10	5.72
Scidmore	2006	-13.49	27.12	4.36
Scidmore	2007	-1.51	17.90	0.56

Location	Year	Min Temp value	Max Temp value	Average Yearly Value
Sebree	2000	-8.38	22.09	7.22
Sebree	2001	-11.13	26.73	5.22
Sebree	2002	-11.70	30.31	5.36
Sebree	2003	-13.49	1,613.70	5.86
Sebree	2004	-13.49	29.10	5.96
Sebree	2005	-14.73	27.12	5.00
Sebree	2006	-14.10	27.12	4.75
Sebree	2007	-12.88	21.33	1.07
Sundew	2000	-11.13	21.71	5.42
Sundew	2001	-14.10	24.79	4.21
Sundew	2002	-14.73	32.76	4.85
Sundew	2003	-12.29	30.31	4.96
Sundew	2004	-10.56	32.34	5.02
Sundew	2005	-18.05	28.31	2.93
Sundew	2006	-16.68	27.12	4.03
Sundew	2007	-5.31	18.28	0.21
Tarr Lower	2000	-11.70	19.04	4.25
Tarr Lower	2001	-13.49	19.42	3.30
Tarr Lower	2002	-16.02	22.48	3.55
Tarr Lower	2003	-14.73	22.48	3.92
Tarr Lower	2004	-12.29	23.24	3.54
Tarr Lower	2005	-16.68	20.95	3.24
Tarr Lower	2006	-17.36	19.04	2.30
Tarr Lower	2007	-1.06	11.38	0.10

Location	Year	Min Temp value	Max Temp value	Average Yearly Value
Tarr Upper	2000	-11.13	19.42	5.90
Tarr Upper	2001	-12.29	19.81	3.97
Tarr Upper	2002	-12.29	21.71	4.18
Tarr Upper	2003	-16.02	27.12	7.45
Tarr Upper	2004	-9.46	24.01	6.75
Tarr Upper	2005	-16.02	21.33	3.93
Tarr Upper	2006	-14.73	21.71	3.26
Tarr Upper	2007	-15.36	16.00	-0.63
Tidal	2000	-9.46	23.63	6.25
Tidal	2001	-13.49	25.95	5.07
Tidal	2002	-14.73	31.12	5.18
Tidal	2003	-14.10	31.52	6.77
Tidal	2004	-8.91	29.90	8.17
Tidal	2005	-16.68	22.86	2.17
Tidal	2006	-14.10	26.34	4.59
Tidal	2007	-15.36	17.90	0.66
Topeka	2000	-9.46	17.14	4.96
Topeka	2001	-13.49	18.28	2.59
Topeka	2002	-6.82	19.81	3.24
Topeka	2003	-13.49	22.48	3.69
Topeka	2004	-12.88	22.09	3.94
Topeka	2005	-12.88	22.09	3.61
Topeka	2006	3.31	22.09	9.63

Location	Year	Min Temp value	Max Temp value	Average Yearly Value
Upper Muir	2001	-14.73	22.09	3.96
Upper Muir	2002	-16.68	21.33	3.79
Upper Muir	2003	-18.05	23.63	4.34
Upper Muir	2004	-11.13	24.40	1.16
Upper Muir	2005	-18.05	24.40	5.06
Upper Muir	2006	-14.10	22.86	4.40
Upper Muir	2007	-14.10	20.19	2.15
Wachusett East	2000	-14.73	19.81	4.31
Wachusett East	2001	-18.05	22.86	2.86
Wachusett East	2002	-27.06	23.63	3.20
Wachusett East	2003	-18.05	1,617.90	3.32
Wachusett East	2004	-12.29	23.24	3.57
Wachusett East	2005	-18.76	21.71	3.13
Wachusett East	2006	-20.24	20.95	2.49
Wachusett East	2007	-7.33	0.70	-0.98
Wachusett West	2000	-13.49	19.81	6.23
Wachusett West	2001	-17.36	25.56	3.92
Wachusett West	2002	-21.00	25.56	4.73
Wachusett West	2003	-13.49	25.56	6.29
Wachusett West	2004	-16.02	24.01	4.42
Wachusett West	2005	-17.36	22.48	4.11
Wachusett West	2006	-16.02	23.24	3.57
Wachusett West	2007	-3.37	15.23	0.77