National Park Service
U.S. Department of the Interior

Natural Resource Stewardship and Science

High Elevation National Parks

2010 Climate Summary Report

Natural Resource Data Series NPS/GRYN/NRDS—2011/203

ON THE COVER
Cooperative Observer Program weather station at Mammoth Hot Springs in Yellowstone National Park.
Photograph courtesy of Yellowstone National Park.

High Elevation National Parks

2010 Climate Summary Report

Natural Resource Data Series NPS/GRYN/NRDS—2011/203

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The National Park Service, Natural Resource Stewardship and Science office in Fort Collins, Colorado publishes a range of reports that address natural resource topics of interest and applicability to a broad audience in the National Park Service and others in natural resource management, including scientists, conservation and environmental constituencies, and the public.

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Executive Summary

This climate data summary report is a descriptive summary and analysis of climate data in 2010 for 13 national park units located in Colorado, Idaho, Montana, and Wyoming. This report describes park-level climate at both a local (single weather station) and regional setting (gridded climate maps) using standard data summary and analysis tools described in the *Rocky Mountain Climate Protocol* prepared by the Greater Yellowstone and Rocky Mountain Inventory and Monitoring Networks. The impetus for this combined report is the multi-network strategy for enhanced monitoring to better address rapid climate change in high-elevation parks located in the Greater Yellowstone Network, Rocky Mountain Network, and Upper Columbia Basin Network.

Total monthly and annual accumulated precipitation and mean monthly minimum and maximum temperatures and departures from an established baseline are the primary metrics for annual climate status reporting. The 30-year climatological reference or "normal" period (currently 1971-2000), is the primary baseline period used to determine average conditions in this report. The results from this analysis are presented for each park or reporting area (group of parks) and summarized under the heading "2010 climate at a glance".

On the whole, calendar year 2010 was characterized by near average (vs. 1971–2000) precipitation across the reporting area. Over this twelve-month period the southern and middle Rockies tended toward relative dryness, while the northern Rockies and Snake River Plain region saw near average to slightly wetter-than-average conditions. Based on the water year (October 2009 through September 2010), the greater Yellowstone region and parts of the southern Rockies were notably dry over the reporting period (roughly 75% of 30-year averages). Temperatures in winter 2010 were generally warmer-than-average in the northern Rockies and the upper Columbia basin, with near-average to slightly cooler-than-average conditions prevailing in the southern Rockies. Late winter and early spring was average to slightly cooler-than-average for almost all of the reporting area. Summer was warmer-than-average in the southern Rockies, and was cool to very cool in the northern Rockies. Summer in the upper Columbia basin was generally cool, though not appreciably different than average. Broadly speaking, the reporting area experienced a warm late summer and fall (September through November). The northern Rockies and eastern Montana experienced relative cooling in December, but the remainder of the reporting area experienced continued warmer-than-average temperatures.

Snow water equivalent was below average at nearly every location during the 2010 water year. Melt out dates were earlier than average by 1 to 4 weeks at most locations, however melt out dates were near average at a few places in the middle and northern Rockies.

The year 2010 began with areas in the reporting area designated as abnormally dry to experiencing moderate drought by the U.S. Drought Monitor. As winter progressed, the area having abnormally dry to drought conditions expanded to include northwestern portions the Rockies. Conditions tended to improve over the summer months, though dryness lingered in the greater Yellowstone region. Fall brought a southward shift in the areas experiencing dryness or drought conditions and the southern ROMN would continue to experience drought throughout the remainder of 2010.

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Comments from Kristin Legg, Mike Britten and Tom Rodhouse greatly improved this document.

List of Acronyms

AGDD	Accumulated Growing Degree Days
BICA	Bighorn Canyon National Recreation Area
BIHO	Big Hole National Battlefield
CIRO	City of Rocks National Reserve
COOP	Cooperative Observer Program
CRMO	Craters of the Moon National Monument and Preserve
FLFO	Florissant Fossil Beds National Monument
GLAC	Glacier National Park
GRSA	Great Sand Dunes National Park and Preserve
GRTE	Grand Teton National Park
GRYN	Greater Yellowstone Network
I&M	Inventory & Monitoring
JODR	John D. Rockefeller Jr. Memorial Parkway
LIBI	Little Bighorn Battle National Monument
NCDC	National Climatic Data Center
NEPE	Nez Perce National Historical Park
NOAA	National Oceanic and Atmospheric Administration
NPS	National Park Service
NRCS	Natural Resources Conservation Service
NWS	National Weather Service
PRISM	Parameter-Elevation Regressions on Independent Slopes Model
RAWS	Remote Automated Weather Station
ROMN	Rocky Mountain Network
ROMO	Rocky Mountain National Park
SNOTEL	Snowpack Telemetry
SWE	Snow water equivalent
UCBN	Upper Columbia Basin Network
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
WRCC	Western Region Climate Center
YELL	Yellowstone National Park

Introduction

This report is a descriptive summary analysis of climate data in 2010 for 13 national park units located in Idaho, Montana, Wyoming, and Colorado (fig. 1; table 1). The impetus for this combined report is the multi-network strategy for enhanced monitoring to better address rapid climate change in high-elevation parks located in the Greater Yellowstone Network (GRYN), Rocky Mountain Network (ROMN), and Upper Columbia Basin Network (UCBN) (Bingham et al. 2011). This report focuses on key climate metrics: temperature, precipitation, snowpack, drought, and streamflow. It reports on the 2010 calendar year (January–December) for precipitation, temperature, and drought, and the previous water year (October 2009–September 2010) for streamflow and snowpack.

The monitoring objectives for climate are described in the *Rocky Mountain Climate Protocol* (RMCWG 2010). These objectives, as they relate to annual status reports, are to determine the status in the following:

- Minimum, maximum, and mean monthly temperatures and departures from "normal" or average
- Number of growing degree days per year, timing of first and last frosts, number of frost-free days per year, and number of days per year above or below critical temperature thresholds
- Total accumulated precipitation and departures from average
- Frequency and duration of drought based on established thresholds
- Amount and timing of peak snowpack measured as snow water equivalent
- Number of days with snow cover and timing of snowmelt
- Timing and intensity of peak and average streamflow and departures from average and other seasonal shifts in stream hydrographs.

The condition of park unit natural resources is linked, directly and indirectly, to the climate of a region. The status and dynamics of plant associations, migratory or resident mammal and bird populations, insect outbreaks, and hydrological resources are tied to climate (Kittel 2008). The summaries in this report comparing 2010 data to a climatic reference period provide information park managers can use to help understand climatic conditions and effects relating to park planning and operations. For instance, changes in the timing of first and last snows can help determine the schedule of road closures and openings. Indications of drought and a subsequent increase in fire danger may lead park managers to close areas or change policies regarding fires within the park. Climate influences animal behavior, nutrient cycling and productivity, the spread of exotic species, the structure of vegetation communities, and water quality and quantity. By understanding and isolating the effect of climate it becomes possible to discern the effects of other, possibly anthropogenic, drivers of change (RMCWG 2010).

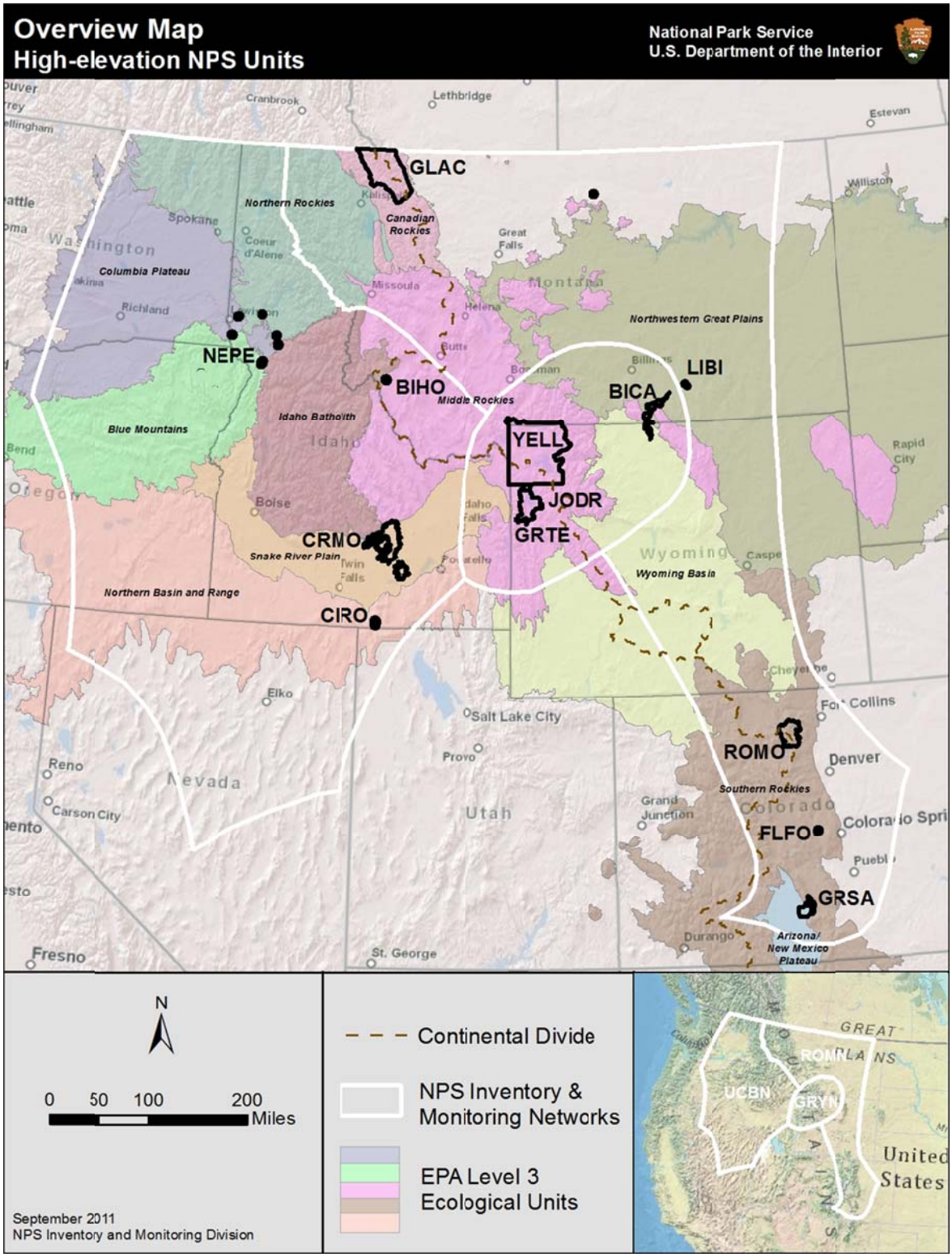


Figure 1. Map showing the National Park Service (NPS) Greater Yellowstone (GRYN), Upper Columbia Basin (UCBN), and Rocky Mountain (ROMN) Inventory and Monitoring Networks, and the park units addressed in this report. Map background shows the Environmental Protection Agency (EPA) Level 3 ecological unit boundaries.

A key concept in physical geography is that climate is organized spatially into regimes, each with characteristic conditions and a consistent set of processes operating across a region underlies this similarity (Kittel 2008). The Environmental Protection Agency (EPA) ecoregions shown in figure 1 provide a framework for a multi-network overview (Kittel 2008). The parks included in the multi-network strategy for enhanced monitoring are located in the northern Rockies, Columbia Basin, and Snake River Plains ecoregions in Idaho; the Canadian Rockies, middle Rockies, northwestern Great Plains, and Wyoming Basin in Montana; the southern Rockies and Arizona–New Mexico Plateau in Colorado (fig. 1) (Chapman et al. 2004, 2006; McGrath et al. 2002; Woods et al. 2002).

Table 1. National park units included in the multi-network strategy for enhanced monitoring to address climate change. The park four-letter code is included.

Park name	Park code
Big Hole National Battlefield	BIHO
Bighorn Canyon National Recreation Area	BICA
City of Rocks National Reserve	CIRO
Craters of the Moon National Monument and Preserve	CRMO
Florissant Fossil Beds National Monument	FLFO
Glacier National Park	GLAC
Grand Teton National Park	GRTE
Great Sand Dunes National Park and Preserve	GRSA
John D. Rockefeller Jr. Memorial Parkway	JODR
Little Bighorn Battle National Monument	LIBI
Nez Perce National Historical Park	NEPE
Rocky Mountain National Park	ROMO
Yellowstone National Park	YELL

Methods

The *Rocky Mountain Climate Protocol* prepared by the Greater Yellowstone and Rocky Mountain Networks outlines the procedures for station selection and the methods to acquire, quality control, archive, and process climate data used in this report (RMCWG 2010; fig. 2). It is critical to select stations with consistent, long-term, and high-quality data, and also include stations that provide adequate spatial representation for the reporting area (Kittel 2010). Although specific criteria were used to determine most reportable stations, it was necessary to relax or adjust standard criteria in order to provide some information for parks that have few stations within or nearby the park boundary. For example, seasonal data (rather than year round) are reported for some stations, and some summary tables and figures include only 2010 data because the period of record for these stations does not support comparisons to data averaged over an adequate reference period.

Data from selected stations were obtained from established meteorological and surface water monitoring programs (table 2) in order to summarize, report, and interpret 2010 calendar year and water year observations in the context of longer-term climate at the park scale. Primary data providers are the National Weather Service (NWS) Cooperative Observer Program (COOP), the U.S. Department of Agriculture Natural Resources Conservation Service (NRCS) Snowpack Telemetry (SNOTEL) network, and the U.S. Geological Survey (USGS) stream gauging network. Data for stations selected from these providers were obtained by the National Park Service (NPS) Inventory and Monitoring Division at the request of the GRYN, ROMN, and UCBN, and stored in a Microsoft SQL Server climate database housed at the NPS Natural Resource Stewardship and Science office in Fort Collins, Colorado. A timing issue with acquiring COOP and SNOTEL data for the NPS Inventory and Monitoring Division climate database required separately downloading or infilling December 2010 temperature values for most selected COOP stations and locally acquiring SNOTEL temperature data through December 31, 2010. USGS gauge data acquired by the NPS Inventory and Monitoring Division were complete and directly usable for most stations, and in a few cases missing data were subsequently available directly from the USGS. Lessons learned from these data completeness and acquisition timing issues will enable users and administrators of the NPS Inventory and Monitoring Division climate database to improve documentation and procedures to help streamline data acquisition and processing for future reporting cycles. In some parks data from Remote Automated Weather Station (RAWS), the Colorado Division of Water Resources, or Environment Canada are reported to provide limited information from areas that lack data from one of the three main U.S. providers. Data from these providers were not acquired by the NPS Inventory and Monitoring Division for the climate database because they are not within the scope of data acquisition for the NPS Inventory and Monitoring Division climate database. However, data downloaded locally for processing and reporting from these providers are included in the complete data package accompanying this report.

Table 2. National and state climate monitoring programs used in the 2010 climate report

Program	Measures and metrics of interest	Spatial scale	Temporal scale
National Weather Service Cooperative Observer Program	Temperature, precipitation	Local stations	Daily
U.S. Department of Agriculture Natural Resource Conservation Service Snowpack Telemetry	Precipitation, SWE, snow depth, temperature*	Local stations	Hourly
U.S. Geological Survey Stream Gauging Network	Streamflow	Local stations	Hourly
Remote Automated Weather Stations	Temperature, precipitation	Local stations	Hourly
Oregon State University PRISM Climate Group	Temperature, precipitation	4 km grid	Monthly
U.S. Drought Monitor	Drought	National; State, Region	Weekly
Colorado Division of Water Resources Stream Gauging Network	Streamflow	Local stations	Hourly
Environment Canada Water Survey of Canada	Streamflow	Local stations	Hourly
Environment Canada National Climate Data Information Access	Temperature, precipitation	Local stations	Daily

Note: SWE = snow water equivalent; PRISM = Parameter-elevation Regression on Independent Slopes Model.
*SNOTEL temperature data were used to describe current year in places where there are few COOP stations reporting temperature.

The role of the gridded climate map is to give a wall-to-wall representation of climate status across a park and put park climate variability in perspective of the surrounding regions' climate (Kittel et al. 2010). These maps also add spatial details for important management areas. Regional gridded monthly climate datasets were obtained from Oregon State University Parameter-elevation Regression on Independent Slopes Model (PRISM; http://www.prism.oregonstate.edu/) group to produce maps showing departures from average conditions at a regional scale. These datasets are generated via a statistical modeling technique that interpolates precipitation and temperature values between actual climate observation stations while also accounting for the effects of aspect and elevation. PRISM's level of quality control permits off-the-shelf use of the gridded data, that is, without additional network in-house quality checking.

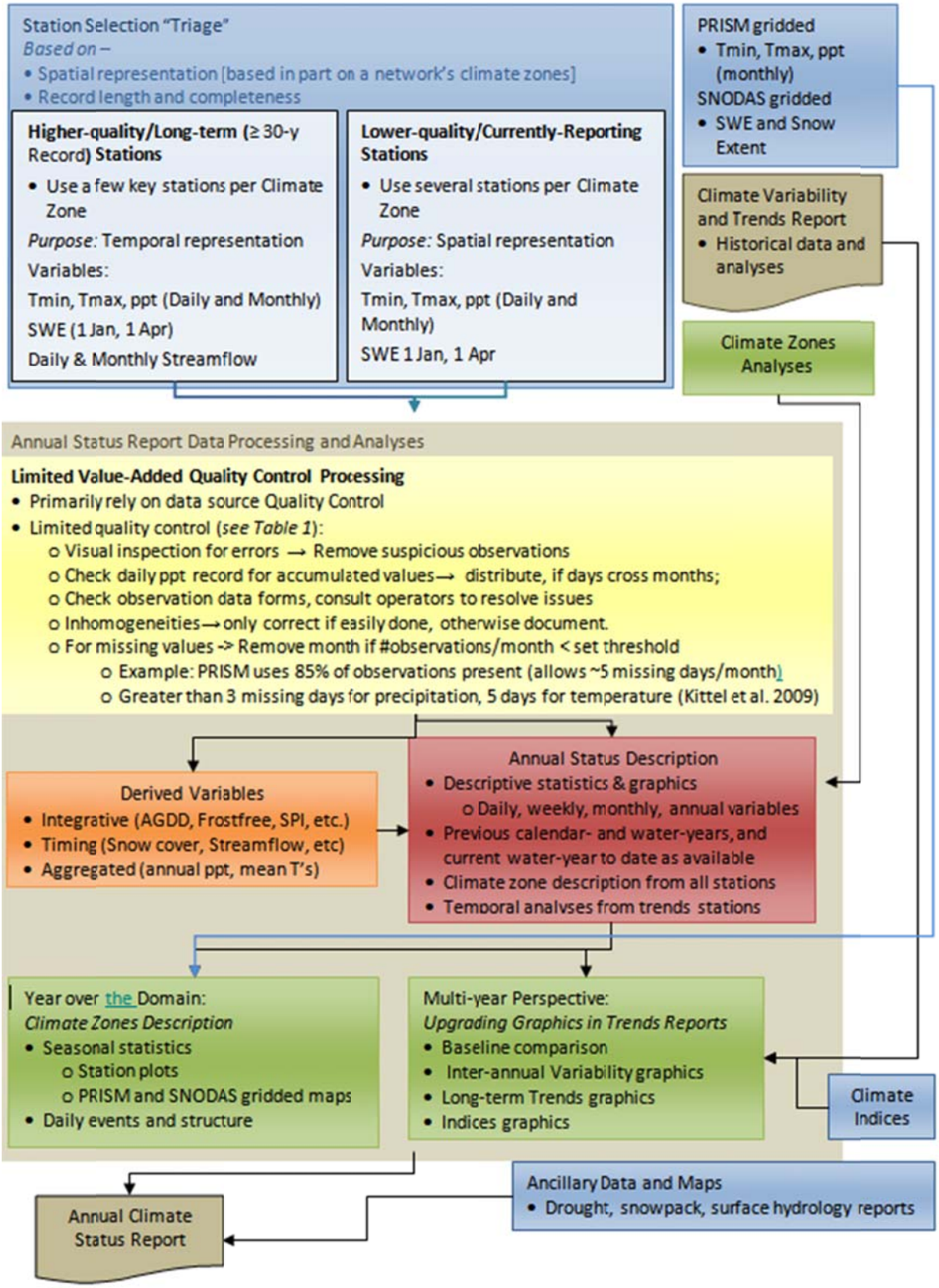


Figure 2. Overview of processing for climate status reports (after Kittel et al. 2010).

Quality control and availability of provider data

Basic data quality control by the NOAA, NRCS, and USGS prevents obvious errors and provides flags for known issues such as estimated versus actual values in original data. Additional investigation is necessary to identify and address certain data continuity and quality requirements for annual climate status reporting, such as missing data from the electronic record that can be added by referring to hard copy data recording sheets from COOP stations. GRYN personnel inspected time-series graphs of 2010 data from each COOP and SNOTEL station, compared 2010 data with historical data from the same station and with data from surrounding stations, and validated logical consistency (e.g., confirmed that minimum daily temperatures were lower than the daily maximum temperatures). Much of the quality control process is facilitated using the *Climate Data Screener and Summarizer version 3.2* (Tercek 2011), to generate a series of diagnostic plots that allow the user to visually inspect data for outliers and logical inconsistencies. The program also reads National Climatic Data Center data quality flags and provides alerts about data utility issues such as accumulated precipitation values at the beginning of the month and precipitation values estimated as "0"(zero) when the precipitation was unreported by the observer so they can be investigated and resolved if necessary. For many COOP stations, the National Weather Service records of climatological observations (Form B-91) were obtained to check and correct data values or to fill missing data.

All changes and additions to data values from original station data files obtained from providers are stored in a copy of the original file, described in a master list of reported stations, and bundled for distribution and archival with this report in the NPS Data Store. The quality-controlled station data files used for 2010 reporting are not uploaded to the NPS Inventory and Monitoring Division climate database because they are formatted for use in the Climate Data Summarizer and would require reformatting and preparation and submission of 97 separate Microsoft Excel files according to current upload procedures. Because quality control for status reporting is considered "mid-level" rather than exhaustive, all data reported here are subject to revision if subsequent data releases with corrected values become available from an original provider. Therefore, it is recommended to retrieve and perform comprehensive quality control on data directly from the original providers for efforts such as in-depth trend reporting, modeling, and intensive analysis.

Averages used for statistical comparisons

The reference period for comparing 2010 precipitation and temperature observations from COOP stations with historic climate data is "1971–2000 normals"[1] ("averages") published by the NOAA National Climatic Data Center. Averages for the first and last freeze and frost dates,

[1] "In the strictest sense, a 'normal' of a particular variable (e.g., temperature) is defined as the 30-year average. For example, the minimum temperature normal in January for a station in Chicago, Illinois, would be computed by taking the average of the 30 January values of monthly-averaged minimum temperatures from 1981 to 2010. Each of the 30 monthly values was in turn derived from averaging the daily observations of minimum temperature for the station. In practice, however, much more goes into [National Climatic Data Center]'s Normals product than simple 30-year averages. Procedures are put in place to deal with missing and suspect data values. In addition, Normals include quantities other than averages such as degree days, probabilities, standard deviations, etc. Normals are a large suite of data products that provide users with many tools to understand typical climate conditions for thousands of locations across the United States." (Source: http://www.ncdc.noaa.gov/oa/climate/normals/usnormals.html, September 15, 2011)

accumulated growing degree days and the number of days exceeding certain thresholds were obtained from the Western Regional Climate Center General Climate Summary Tables for COOP climate stations. The reference periods for these variables are the period of record and will vary by station. The reference period for each COOP station is listed in appendix A and table A1.

The NRCS provided reference period values for precipitation and snow water equivalent (SWE) at SNOTEL stations. The reference period for these average conditions is the standard 1971–2000 period; for stations where these were unavailable, averages were computed locally using monthly historical precipitation data obtained from the NRCS. Only precipitation averages from the NRCS are used because SNOTEL temperature data can be of poor quality or have missing values that make it impossible to calculate accurate 1971–2000 averages.

Normals for USGS gauging stations are two-fold: averages used to determine the percent of average annual runoff are published by the USGS in their 2010 Water-Data Reports and are based on the period of record (e.g., consistent uninterrupted record). Averages used to determine the historical discharge at gauge stations are based on the standard 30-year period (1971–2000) when possible. However, exceptions are reported when the period of record for a station does not cover the standard reference period.

Published climate averages are not available and, thus, are not reported for Remote Automated Weather Stations or stations operated by the Colorado Division of Water Resources and Environment Canada. For a complete list of reference period values used in this report see appendix A.

Data analysis methods and criteria

Most of the summary analysis for this report was completed using the *Climate Data Screener and Summarizer version 3.2* (Tercek 2011) written to automate the production of annual climate status reports using criteria from Kittel et al. (2010) and the *Rocky Mountain Climate Protocol* (RMCWG 2010). The summarizer is a stand-alone program with a simple user interface to read and process data from COOP, SNOTEL, and USGS stream gauges. Data from RAWS stations were transformed into the SNOTEL format for use in the summarizer. The summarizer program outputs tables for monthly totals and their departure from 30-year averages, accumulated growing degree days (AGDD), first and last dates of freeze and frost, and the number of days above or below the threshold temperatures 0°F, 32°F, 80°F, and 90°F.

The summarizer uses a set of decision rules recommended by climatologists to determine whether enough data of sufficient quality is available by month and by year to reliably compute summary statistics. For example, if more than three days of precipitation data are missing for a particular month, a monthly total is not calculated, and the entire month is reported “missing.” If more than five days of mean daily maximum temperature (Tmax) or mean daily minimum temperature (Tmin) are missing then monthly average temperatures are not calculated or reported.

Climate zones used as reporting units

Climate zones were used sparingly in this report to color code figures in the large parks by their assigned zone. Climate zones are formally defined by weather station data and they consist of

groups of weather stations having consistent seasonal and temporal dynamics according to a 2009 analysis. The delineation of distinct, internally-consistent climate zones have been derived statistically from long-term temperature and precipitation records for parks within the GRYN and ROMN (Tercek et al., in review; Tercek 2010a, 2010b). A detailed description of the entire process of identifying climate zones can be found in Tercek et al. (in review), and additional information is provided by Kittel et al. (2010).

Multi-network Climate Overview

Precipitation

On the whole, calendar year 2010 was characterized by near average (vs. 1971–2000) precipitation across the reporting area. Over this twelve-month period the southern and middle Rockies tended toward relative dryness, while the northern Rockies and Snake River Plain region saw near average to slightly wetter-than-average conditions. Based on the water year (October 2009 through September 2010), the Greater Yellowstone region and parts of the southern Rockies were notably dry over the reporting period (roughly 75% of 30-year averages).

In terms of seasonal moisture variability, January through March was relatively dry across much of the reporting region, with a few exceptions near the southern boundary of ROMN. March through May was dryer in portions of ROMN in the southern Colorado park units and in the network's far north. Spring and summer precipitation (June through August) was highly variable across the reporting area. For example, the southern half of the Snake River Plain experienced notable dryness over this period, while parts of the Idaho Panhandle in the northern Rockies received 150–200% of average precipitation. Fall (September through November) was marked by very dry conditions in parts of the GRYN, as well as in the Colorado portions of ROMN. December 2010 brought above normal amounts of moisture to parts of the Snake River Plain (>200% of average), but southern ROMN and parts of GRYN and ROMN in southern Montana missed the majority of this precipitation. Snow water equivalent was below average at nearly every location during the 2010 water year. Melt out dates were earlier than average by 1 to 4 weeks at most locations, however melt out dates were near average at a few locations in the middle and northern Rockies.

Temperature

Temperatures in winter 2010 (January through March) were generally warmer-than-average in the northern Rockies and the UCBN, with near-average to slightly cooler-than-average conditions prevailing in the southern ROMN. Late winter and early spring (March through May) was average to slightly cooler-than-average for almost all of the reporting area. Summer (June through August) was warmer-than-average in the southern ROMN, and was cool to very cool in the northern end of ROMN. Summer in the UCBN was generally cool, though not appreciably different than average. Broadly speaking, the reporting area experienced a warm late summer and fall (September through November). The northern Rockies and eastern Montana portion of the ROMN experienced relative cooling in December, but the remainder of the reporting area experienced continued warmer-than-average temperatures.

Drought

Drought is an extended period of time where an area has a deficiency of precipitation. The U.S. Drought Monitor is designed to provide a "broad brush," regional perspective on drought, and therefore offers an ideal tool for tracking generalized drought conditions throughout the western states. The year 2010 began with areas along the border between the UCBN and GRYN designated as abnormally dry to experiencing moderate drought by the U.S. Drought Monitor (fig. 3). As winter progressed, the area having abnormally dry to drought conditions expanded to include northwestern portions of the ROMN and the Idaho Panhandle. Conditions tended to improve over the summer months, though dryness lingered in the GRYN. Fall brought a southward shift in the areas experiencing dryness or drought conditions and the southern ROMN would continue to experience drought throughout the remainder of 2010.

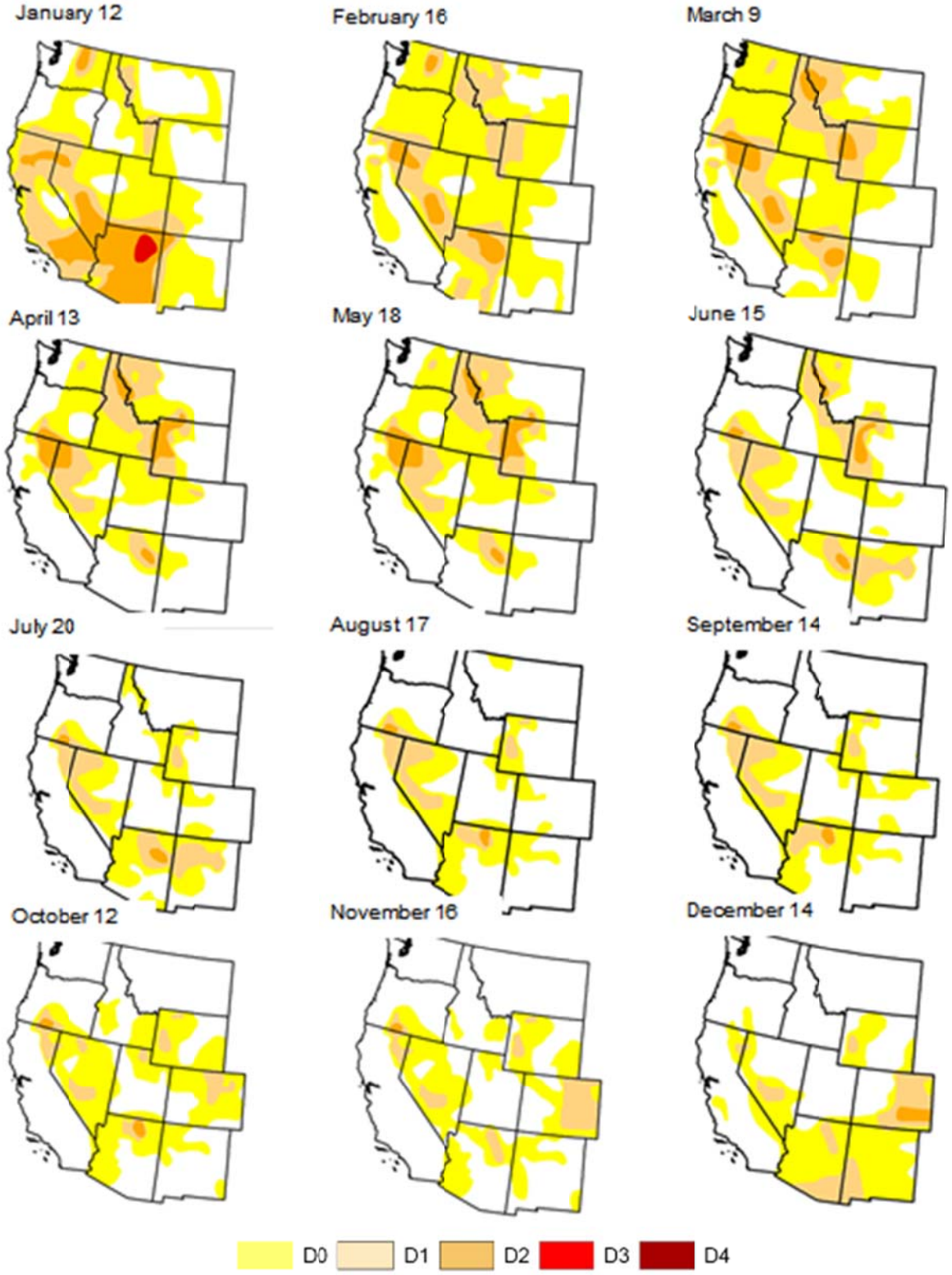


Figure 3. Monthly U.S. Drought Monitor maps for the western states over the course of calendar year 2010. Drought classifications range from "abnormally dry" (D0) to "exceptional drought" (D4). Maps courtesy of the U.S. Drought Monitor.

John D. Rockefeller Jr. Memorial Parkway and Grand Teton and Yellowstone National Parks

2010 climate at a glance

- Total annual precipitation at Moose was 128% of average; total annual precipitation at Yellowstone Park Mammoth was 104% of average.
- Average annual maximum daily temperatures at Moose and Yellowstone Park Mammoth were near average.
- Average annual minimum daily temperatures were near average at Moose and 2.85°F warmer than average at Yellowstone Park Mammoth.
- The on-set of spring and fall at Moose was 2–9 days earlier than average; the on-set of spring at Yellowstone Park Mammoth was near average while the on-set of fall was 22 days later than average.
- Snow water equivalent was below average during the 2010 water year. The timing of maximum SWE was near normal and was reached between April and June, depending on station. Melt out dates were earlier than average by 2 to 3 weeks.
- Above average precipitation in June and rapid snowmelt lead to higher than average peak flows in June and July.
- Total annual runoff measured at the gauge on the Snake River at Moose was 77% of average; total annual runoff measured at the gauge on the Yellowstone River at Corwin Springs was 96% of average.

2010 climate data summary

This climate data summary report describes park-level climate at both a local (single weather station) and regional setting (gridded climate maps) using standard data summary and analysis tools described in the *Rocky Mountain Climate Protocol* (RMCWG 2010). Climate data that describe precipitation, temperature, streamflow, and snowpack were gathered from key climate stations in or John D. Rockefeller Jr. Memorial Parkway (JODR), Grand Teton National Park (GRTE), and Yellowstone National Park (YELL), and summarized for this report. The climate stations cited in this report are shown in figure 4; station metadata are available in appendix A.

Total accumulated precipitation and minimum, maximum, and mean monthly temperatures and departures from an established baseline are summarized in figures and tables below. We consider recent events in a historical context, based primarily on a standard 30-year climatological reference or "normal" period (currently 1971–2000) which we refer to as an "average." The baseline period used to determine average conditions in this report for each climate station is included in the station metadata in appendix A.

A section on streamflow and snowpack are included as they integrate the combined effects of temperature and precipitation. Variables indicating the timing or length of a seasonal process (e.g., accumulated growing degree days, frosts, snowpack duration, and peak unregulated streamflow) are noted throughout the data summary report.

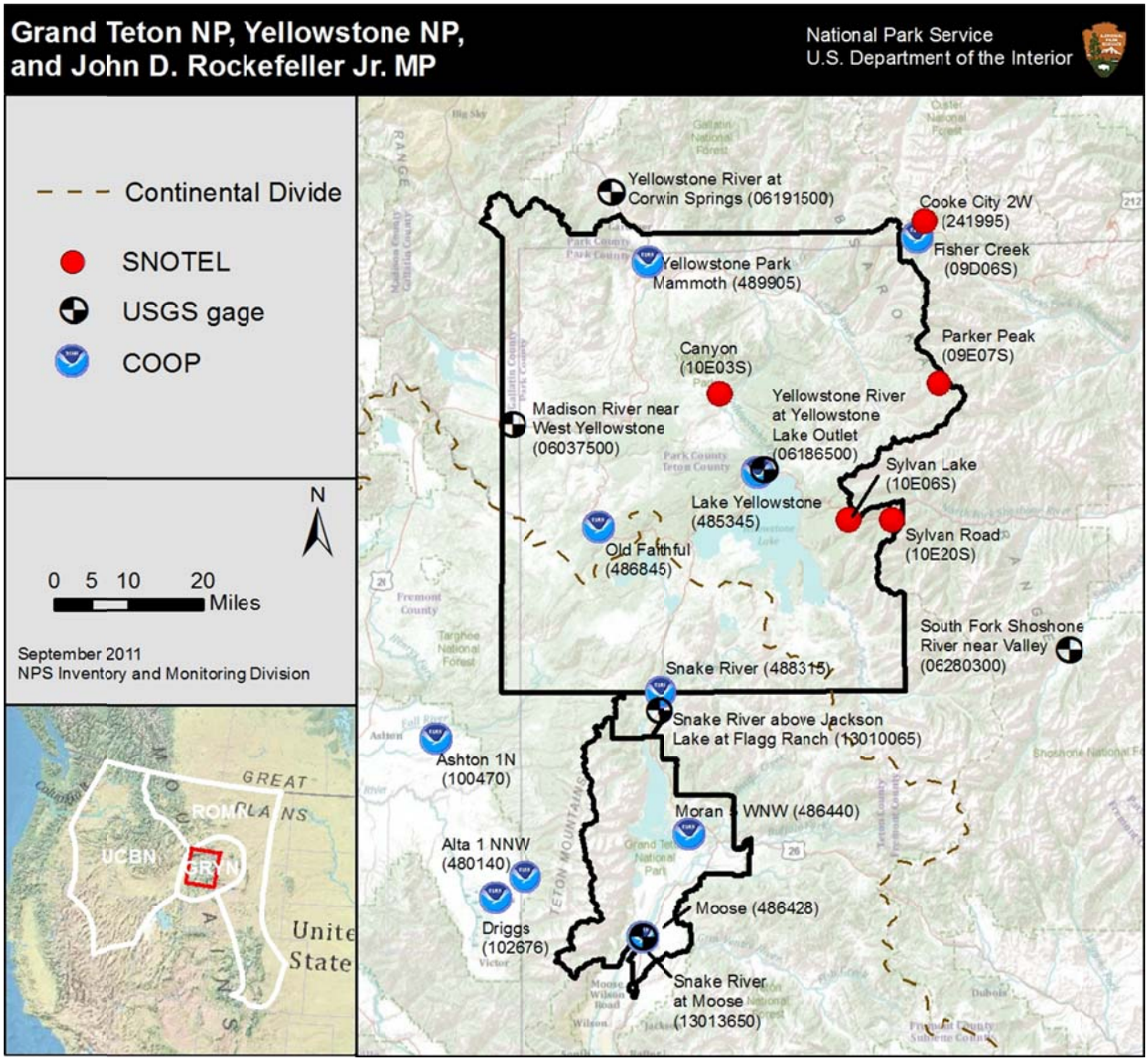


Figure 4. Map showing key climate and stream gauge stations in or near Yellowstone and Grand Teton National Parks and John D. Rockefeller, Jr. Memorial Parkway in northwestern Wyoming, southern Montana, and Eastern Idaho.

Climate zones

The figures presented in this report are colored coded into four climate zones (Tercek et al., in review) described by the authors as:

> *Zone 1 weather stations that are located in or near the northern range of Yellowstone National Park, which is recognized as an ecological unit containing distinct vegetation, as well as being the winter home of Yellowstone's northern elk herd (National Research Council 2002). This part of Yellowstone experiences its highest precipitation during late spring and early summer months (May and June). Zone 1a weather stations have patterns of seasonal and long-term variability similar to zone 1, but they are located primarily southwest of Yellowstone and Grand Teton. Zone 2 weather stations are located on Yellowstone's central plateau and in Grand Teton, and have highest precipitation during*

winter months. Zone 2a stations are located in high elevation areas in eastern Yellowstone differs from other parts of the GRYN because it had long-term climatic patterns, during the period 1895–2008, that were similar to zone 1 during the summer and to zone 2 during the winter.

Gridded climate maps

Given the relatively sparse network of climate stations and complex topography of the Greater Yellowstone area, regional color maps (figs. 5–7) showing month-to-month departure from average conditions for precipitation and temperature using PRISM data provide a visual overview of the climate in 2010. PRISM interpolates precipitation values between actual observation stations, and corrects these interpolated estimates for changes in topography across the region. For more information, see http://www.prism.oregonstate.edu/.

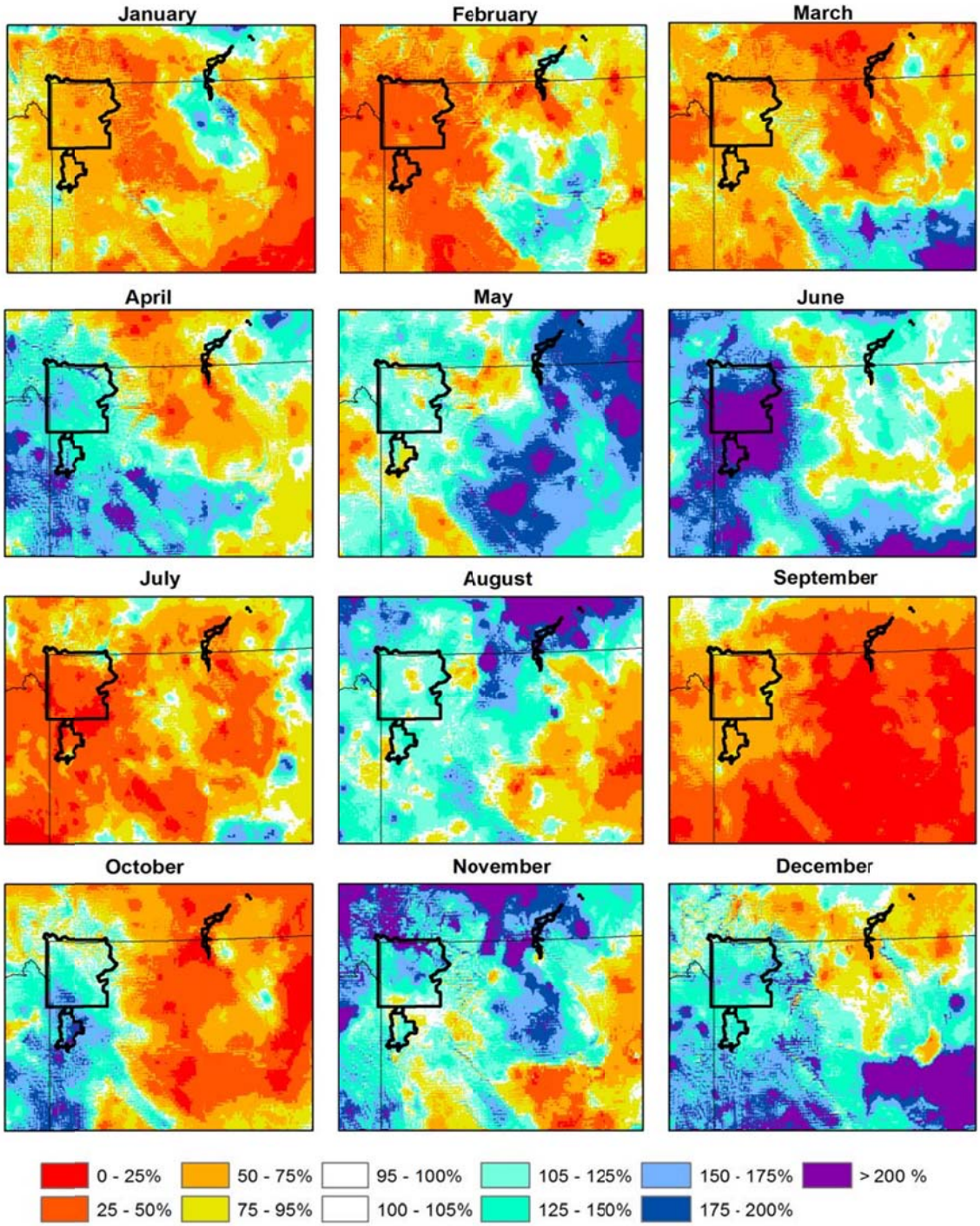


Figure 5. Maps showing percent of average precipitation versus 1971–2000 for each month in calendar year 2010 in the area surrounding Bighorn Canyon National Recreation Area (northeast unit in Montana and Wyoming), Little Bighorn Battlefield National Monument (northeast park unit), Yellowstone and Grand Teton National Parks (western park units). Colors show estimates from the Parameter-elevation Regressions on Independent Slopes Model (PRISM).

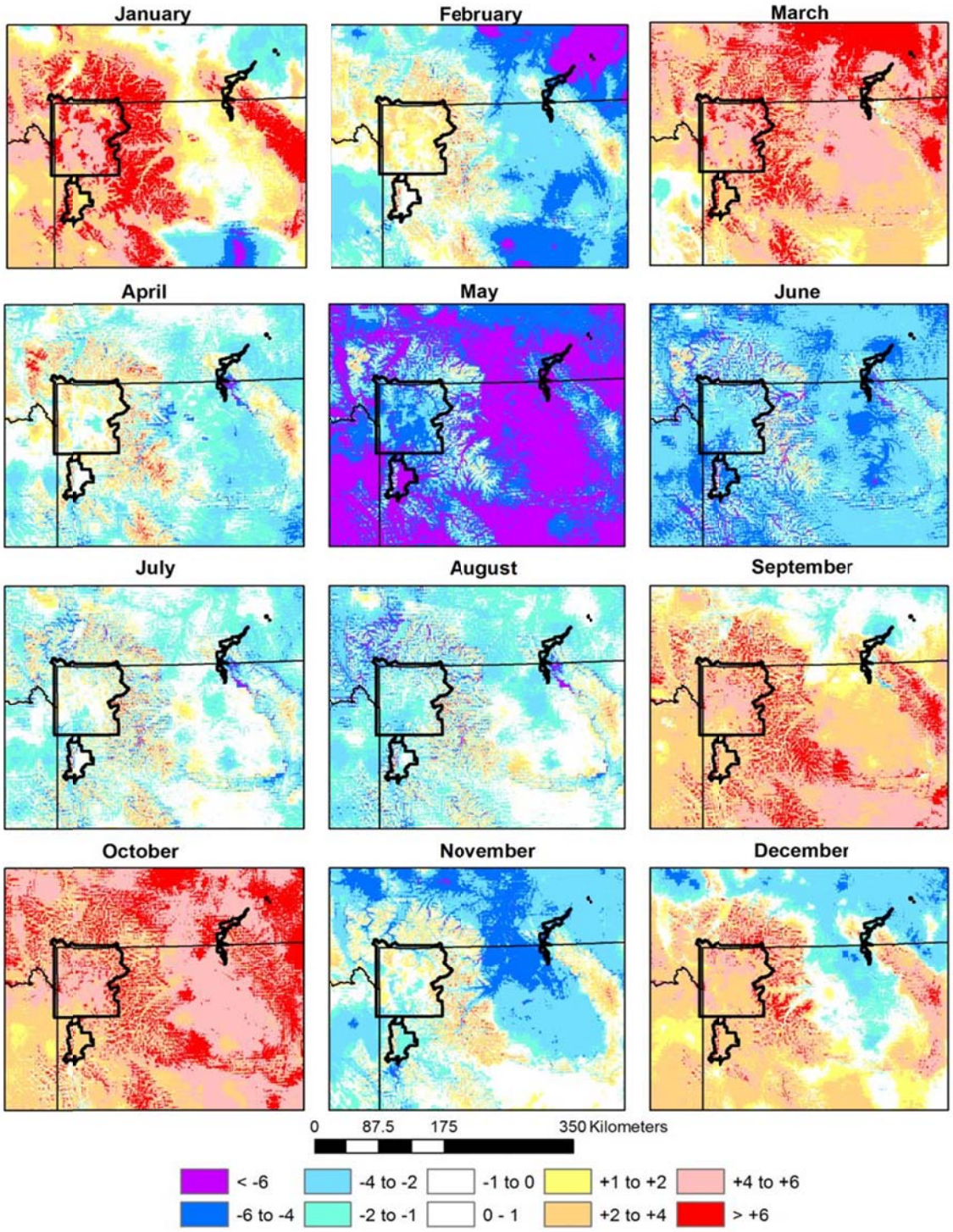


Figure 6. Maps showing departures from average maximum daily temperatures for each month in calendar year 2010 versus 1971–2000 in the area surrounding Bighorn Canyon National Recreation Area (northeast unit in Montana and Wyoming), Little Bighorn Battlefield National Monument (northeast park unit), Yellowstone and Grand Teton National Parks (western park units). Departure values are reported in degrees Fahrenheit. Maps were created using estimates from the Parameter-elevation Regressions on Independent Slopes Model (PRISM).

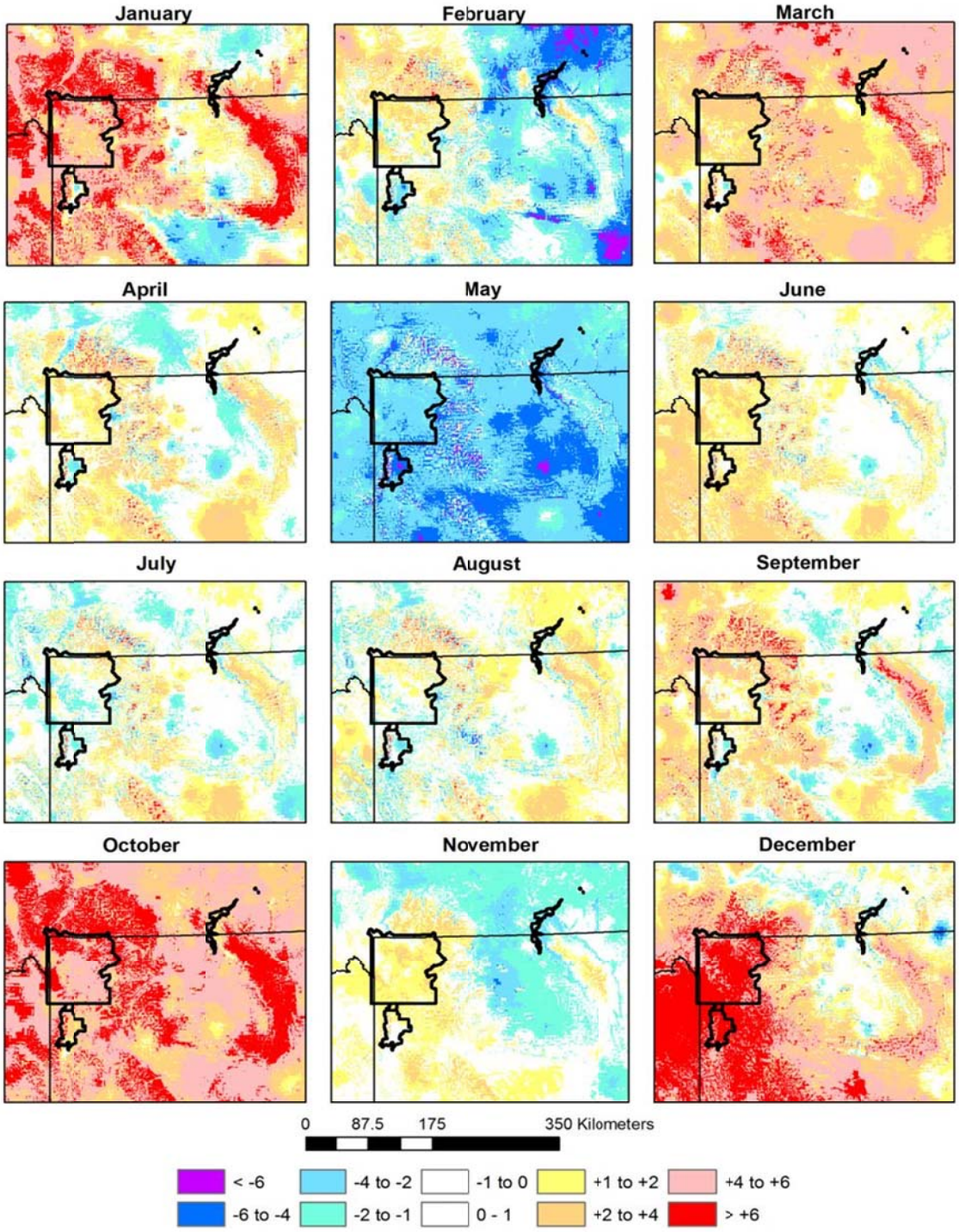


Figure 7. Maps showing departures from average minimum daily temperatures for each month in calendar year 2010 versus 1971–2000 year 2010 in the area surrounding Bighorn Canyon National Recreation Area (northeast unit in Montana and Wyoming), Little Bighorn Battlefield National Monument (northeast park unit), Yellowstone and Grand Teton National Parks (western park units). Departure values are reported in degrees Fahrenheit. Maps were created using estimates from the Parameter-elevation Regressions on Independent Slopes Model (PRISM).

Precipitation

Total annual precipitation

During 2010, individual weather stations in the Greater Yellowstone area reported total annual precipitation ranging from 157% of average at Driggs to 90% of average at Snake River. Total monthly and annual precipitation and departures from average, expressed as a percentage, are shown in figure 8 and table 4.

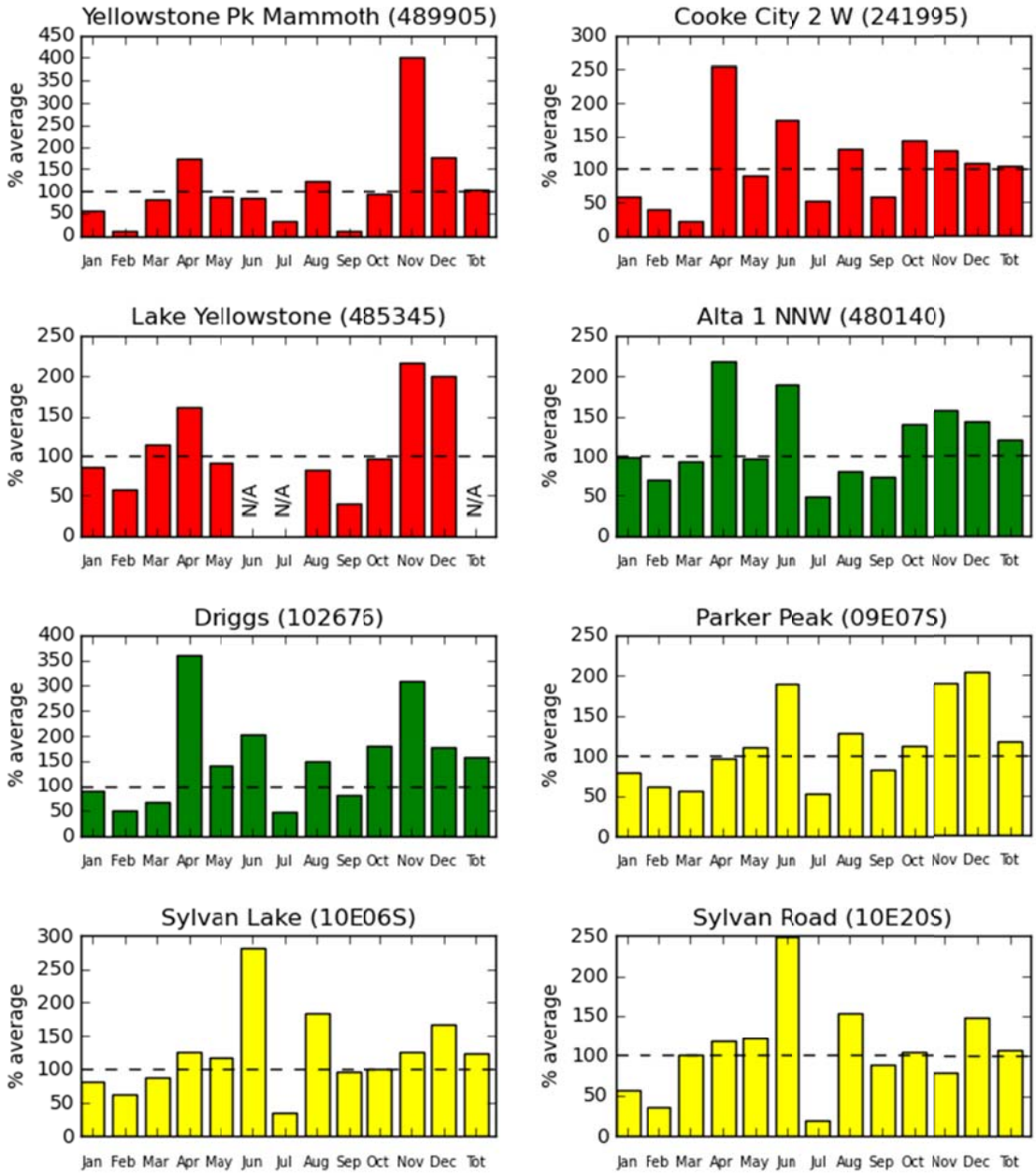


Figure 8. Departure of 2010 precipitation from 1971–2000 average at key climate stations in and near Yellowstone and Grand Teton National Parks. Colors indicate the climate zone for each station. Red = zone 1, Yellow = zone 2a. Cody (black) is an outlying station located between Yellowstone and Bighorn Canyon. Missing bars (NA) indicate months in which there were insufficient data to calculate a total.

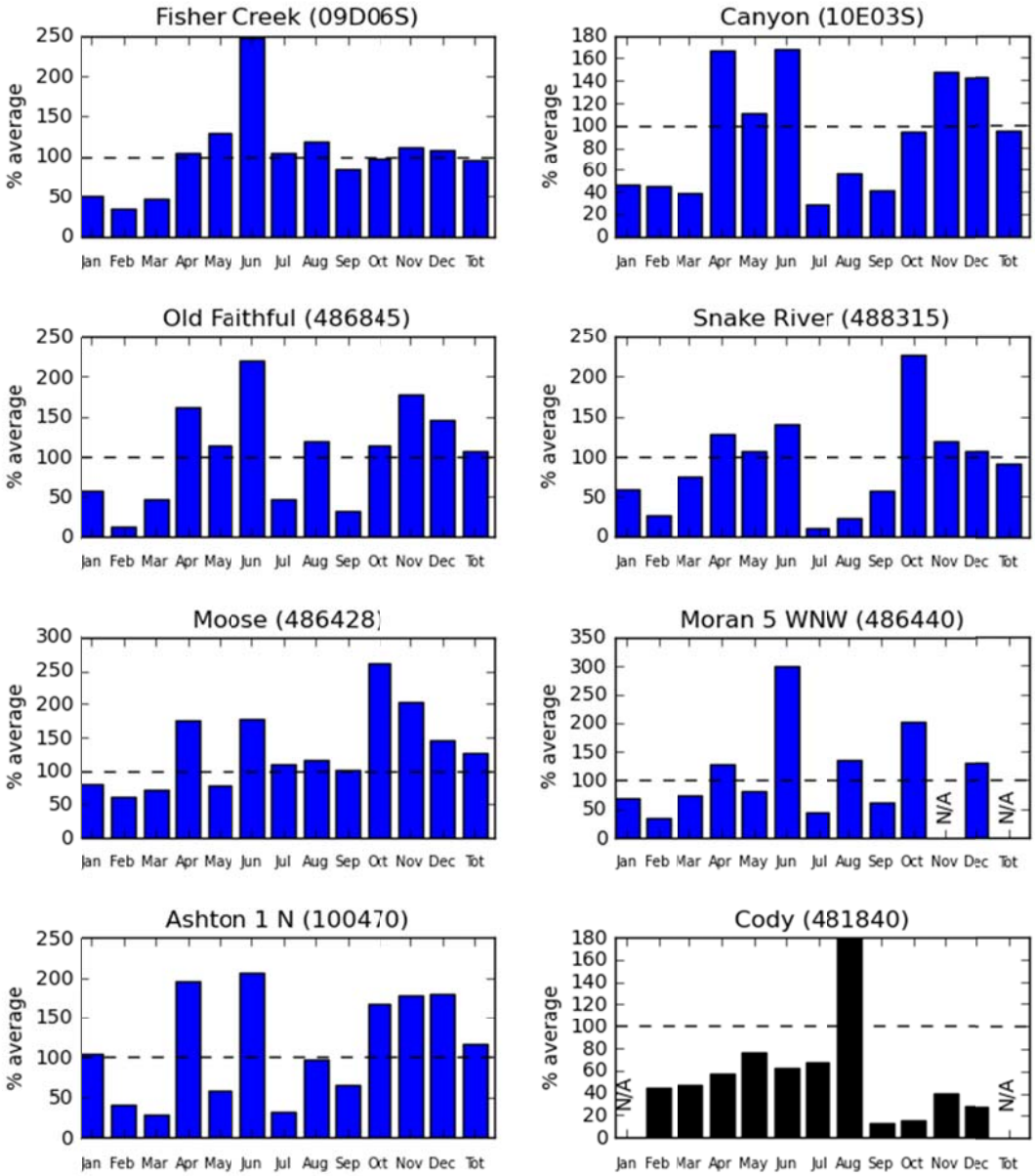


Figure 8. Continued.

Seasonal precipitation highlights

Throughout the winter (January–March) months, the Greater Yellowstone area experienced mostly below average precipitation. The lowest during this period was 12% of average reported at Old Faithful in February. Spring precipitation (April–June) varied by station, however most stations reported above average precipitation in April and June but not May. At Driggs precipitation was 362% of average in April. Summer precipitation (July–September) was mostly below average in zone 1 (e.g., northern range of YELL) but above average elsewhere except in July which was below average throughout the region. Fall precipitation (October–December) varied by station, however most stations reported above average precipitation. At Yellowstone Park Mammoth, precipitation was 400% of average in November. The station in Cody stands out as an anomaly with precipitation below average during all months of the year except August.

Temperature

During 2010, annual average minimum and maximum daily temperatures were average or near average at most stations except at Yellowstone Park Mammoth and Cooke City 2W which reported annual average minimum daily temperatures that were nearly 3°F above average. Monthly average maximum and average minimum daily temperatures were much more variable and highlight the differences and similarities at each weather station (fig. 9; tables 5 and 6) in the area. Of note is that all stations reported cooler than average maximum temperatures in May and June and warmer than average minimum temperatures in December. At Lake Yellowstone the average minimum temperature was nearly 10°F above average in December.

Box plots of average maximum and average minimum daily temperatures that that display data frequency distribution such as median, quartiles and outliers are shown in figure 10.

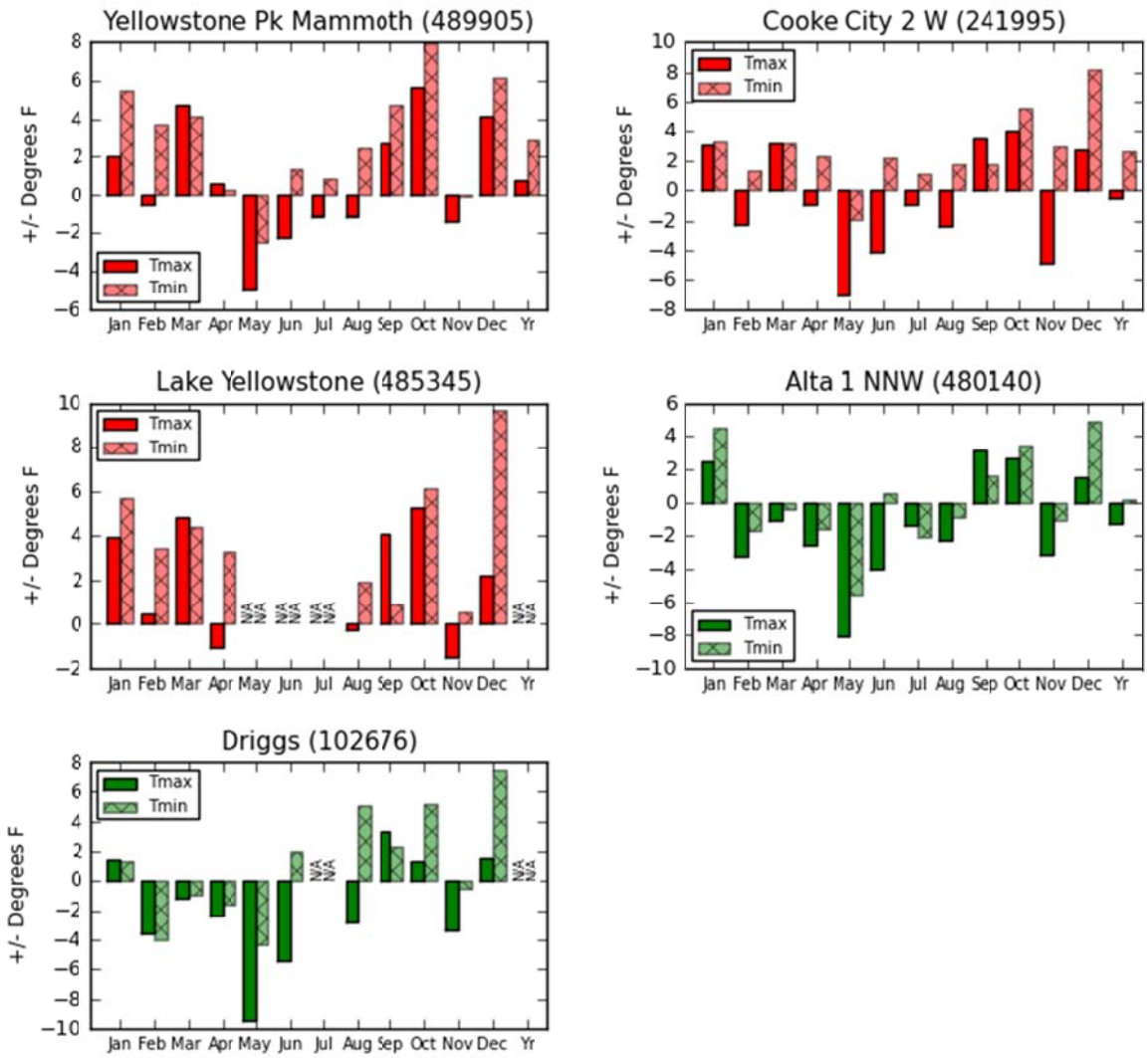


Figure 9. Departure of 2010 average minimum (Tmin) and average maximum (Tmax) daily temperatures from 1971–2000 average at key climate stations in an near Yellowstone and Grand Teton national parks. Colors indicate the climate zone for each station. Red = zone 1, Green = zone 1a, Blue = zone 2; Black = no zone assignment. Missing bars (NA) indicate months in which there were insufficient data to calculate an average.

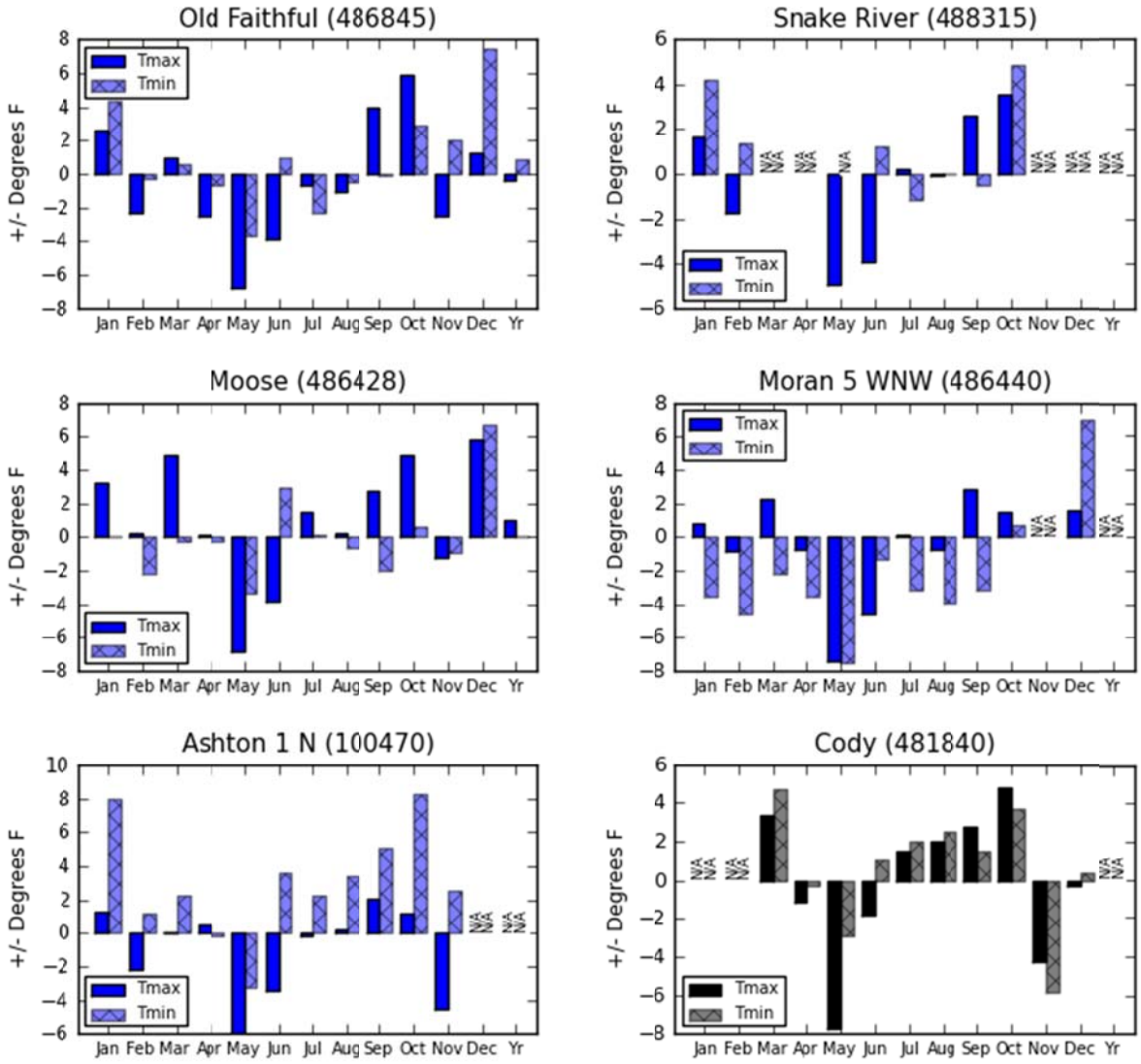


Figure 9. Continued.

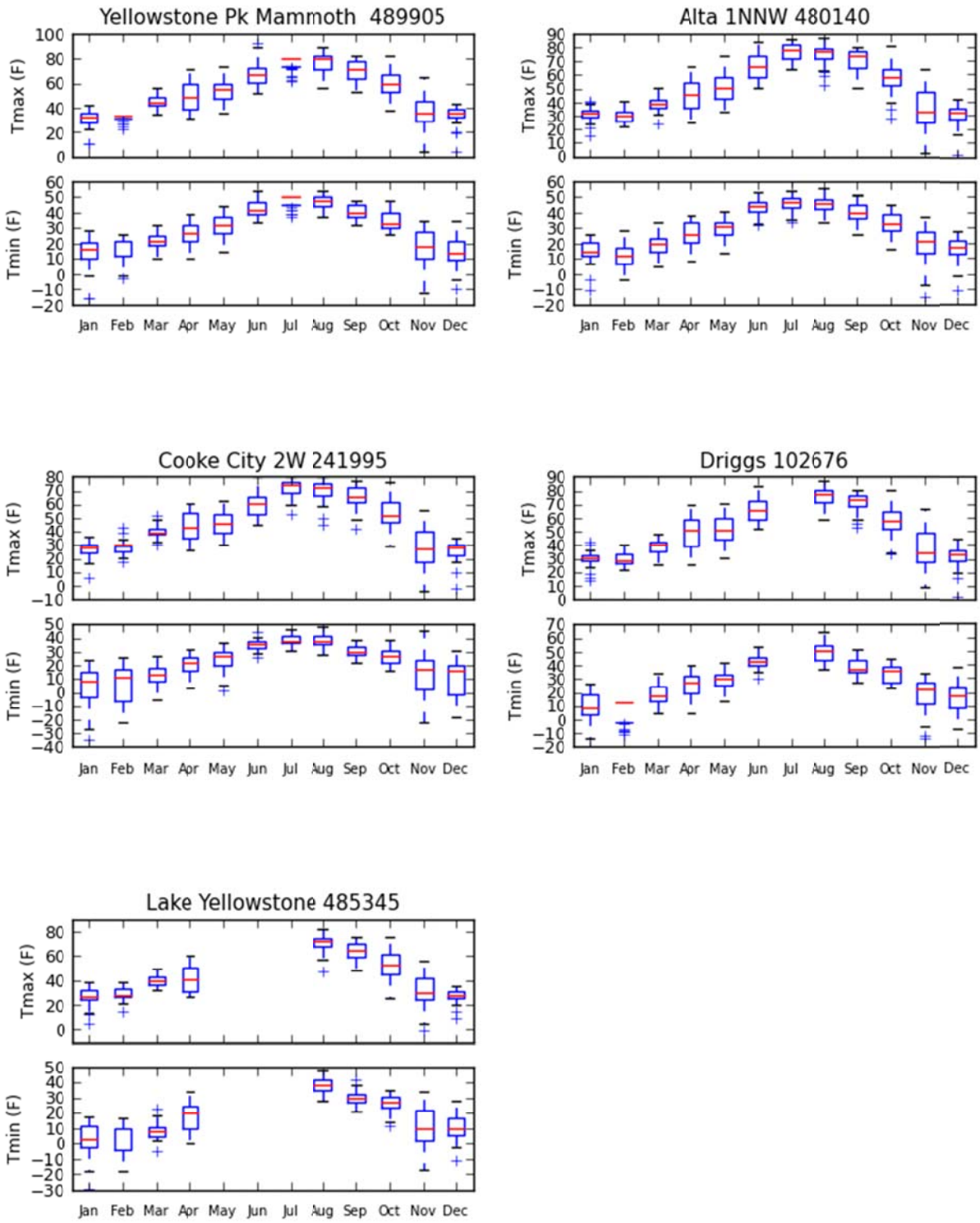


Figure 10. Box plots of average maximum and average minimum daily temperatures at key climate stations in and near Grand Teton and Yellowstone National Parks and John D. Rockefeller Jr. Memorial Parkway during 2010. Horizontal lines indicate the median value. Boxes indicate the 25th and 75th percentiles. Whiskers extend 1.5 times the interquartile Range (IQR). Crosses indicate values exceeding 1.5 times the IQR.

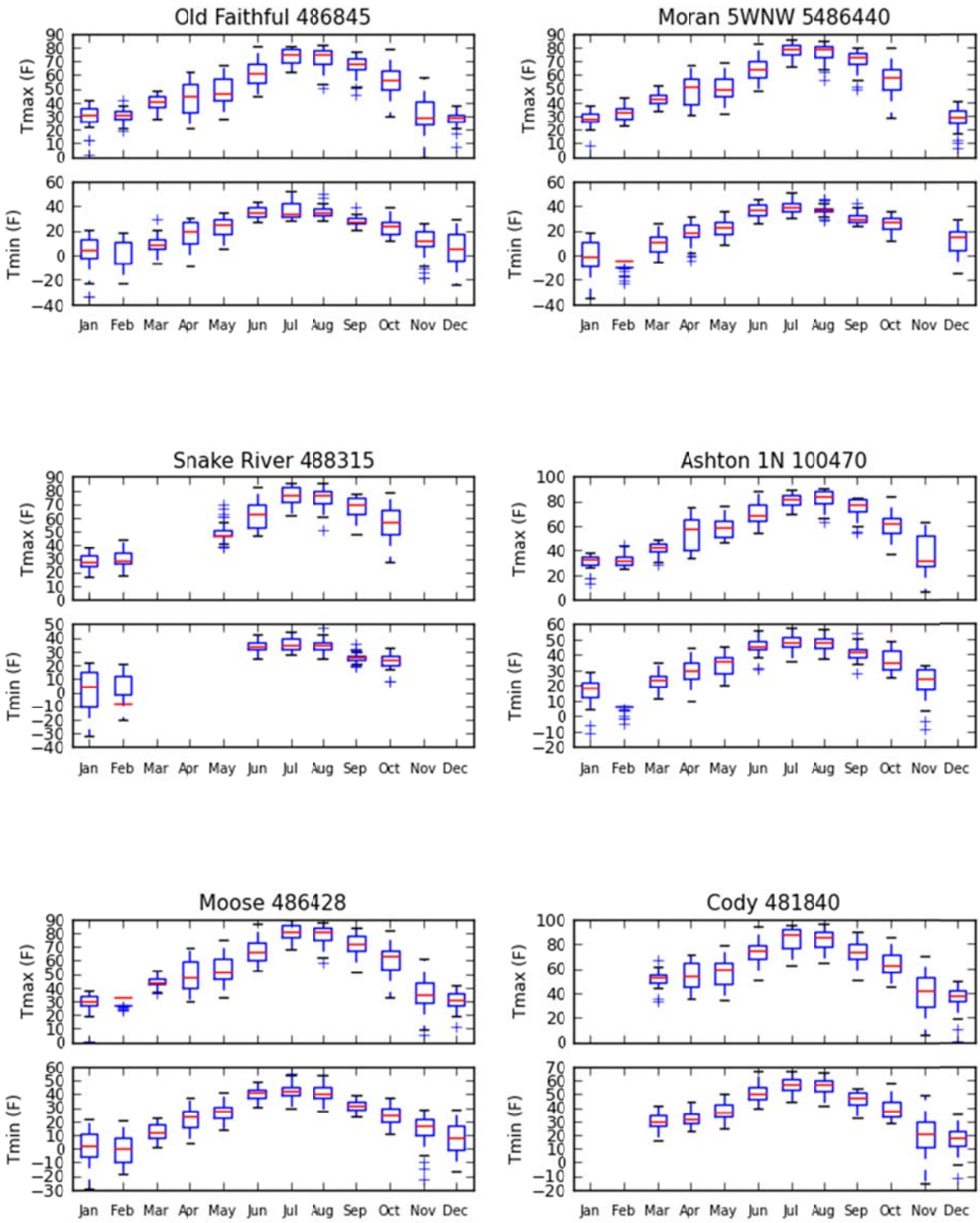


Figure 10. Continued.

Temperature thresholds

The onset of spring, defined as the last day when the minimum temperature dropped below 28°F, was earlier in 2010 by 1 to 12 days from average, depending on station. The first day of fall, defined as the first day when minimum temperatures drop below 28°F, was earlier in 2010 by

one to two weeks from average, depending on station. The stations Snake River and Yellowstone Park Mammoth are exceptions; at these locations the onset of spring and fall were later rather than earlier than average.

The number of hot days, defined as days where the maximum daily temperatures ≥ 90°F, were fewer than average. The number of frosty nights, defined as nights where the minimum temperatures ≤ 32°F, were fewer than average except at Moose which was close to average. First and last freeze and frost dates, accumulated growing degree days, and days above or below critical temperature thresholds for key stations in reporting area are show in table 7.

The Western Regional Climate Center (WRCC) reported daily and monthly temperature records that were exceeded in 2010 in the Greater Yellowstone area. At Moran 5 WNW and Driggs, the lowest monthly average minimum daily temperatures recorded for May were reported at 37°F and 40.8°F, respectively. Also at Moran 5 WNW, the highest maximum daily temperature recorded in October was reported on October 2 at 80°F, whereas at Yellowstone Park Mammoth, Lake Yellowstone, and at Cooke City 2W, the highest maximum daily temperature recorded in October was recorded on October 3 and measured 82°F, 76°F, and 73°F, respectively. At Cooke City 2W, the highest maximum daily temperature recorded in October was reported on October 3 at 73°F and the lowest minimum daily temperature recorded in July was reported on July 7 at 1°F. At Moose, the lowest minimum daily temperature recorded in November was reported on November 25 at -22°F.

Streamflow

The USGS monitors streamflow at numerous locations throughout the Greater Yellowstone area. Key aspects of the areas hydrology are represented by a subset of these gauging stations (table 3; appendix A). Total annual runoff was 77–98% of average as measured by the USGS gauge stations on the Madison, Yellowstone, and Snake Rivers. Figure 11 and table 3 summarize the 2010 water year, which runs from October 2009 to September 2010.

Table 3. Total annual runoff in acre feet and percentage of average for select USGS Gauge Stations in or near Grand Teton and Yellowstone National Parks and John D. Rockefeller Jr. Memorial Parkway during 2010 (Data source: USGS Water Data Reports for 2010).

Station Name	Total annual runoff (ac-ft) 2010	Total annual runoff (ac-ft) average	Percent of average
Madison River	320,500	358,400	89%
Yellowstone River at Corwin Springs	2,153,000	2,251,000	96%
Yellowstone River at Yellowstone Lake Outlet	944,300	963,000	98%
Snake River at Moose	1,606,000	2,079,000	77%
Snake River above Jackson Lake	553,100	637,600	87%

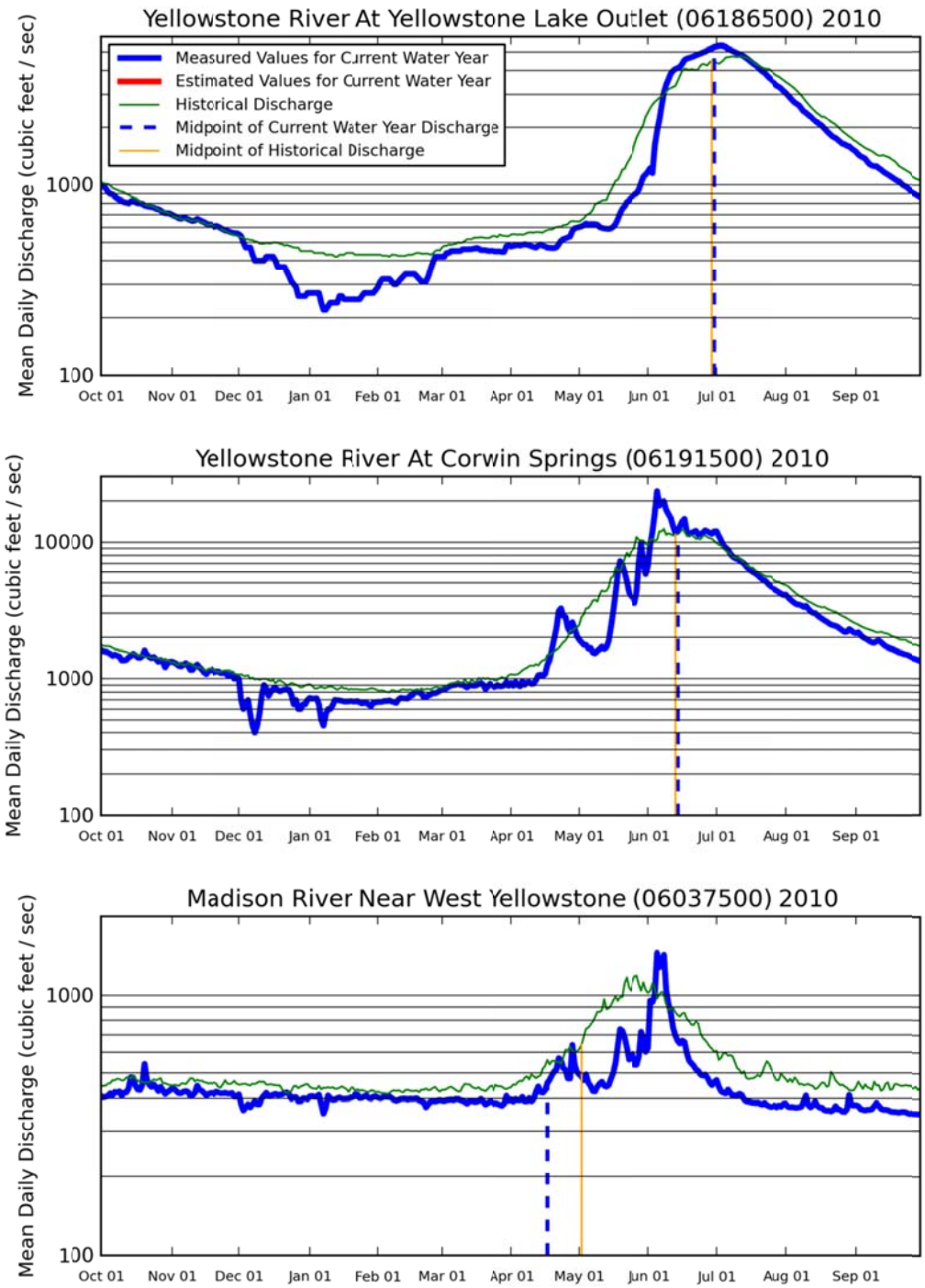
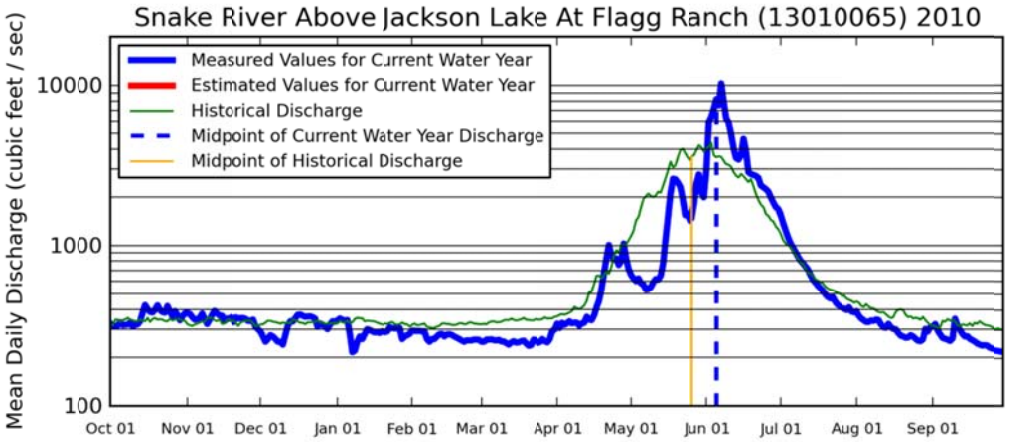
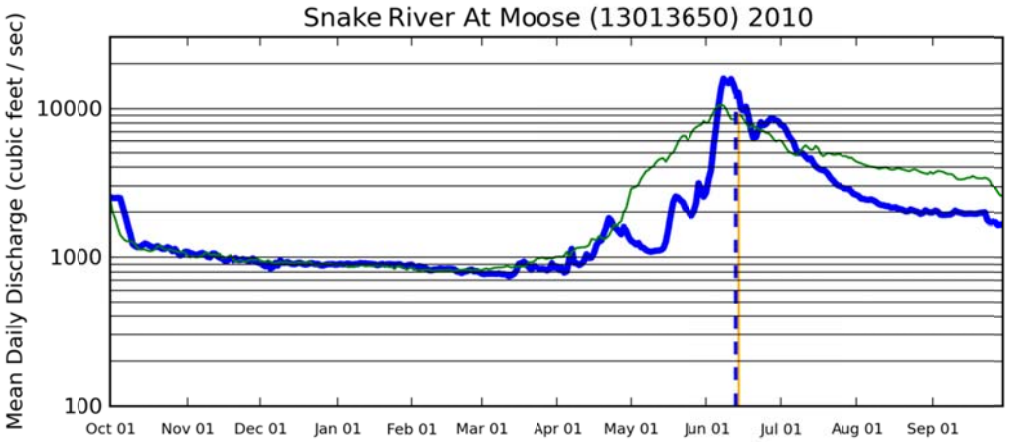


Figure 11. Streamflows from representative gauges in or near Grand Teton and Yellowstone National Parks and John D. Rockefeller Jr. Memorial Parkway for the 2010 water year (October 2009 through September 2010) are shown versus median daily flows for the reference period. Data courtesy of the U.S. Geological Survey.





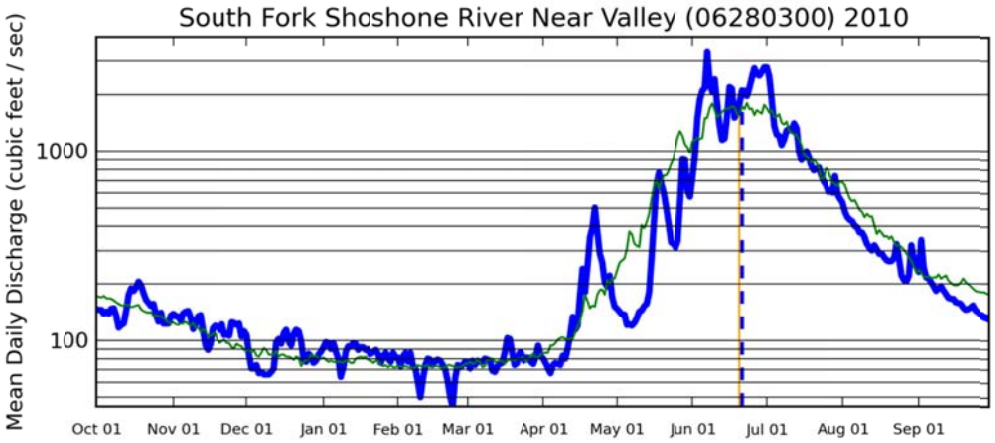


Figure 11. Continued.

Winter snowpack

The NRCS operates automated snow measurement (SNOTEL) stations throughout the western United States. These stations offer the best available means for tracking the accumulation and loss of snowpack. As measured in terms of SWE—the amount of liquid water held in a given volume of snow—snowpack measured at SNOTEL stations reported in figure 12, was below average during the 2010 water year. The timing of maximum SWE was near normal and was reached between April and June. Melt out dates were earlier than average by 2 to 3 weeks. Above average precipitation in June and rapid snowmelt lead to higher than average peak flows in June and July (fig. 12).

At Canyon, the maximum SWE for a given year is most often in April and in 2010 was reached on April 7. Compared to other years, SWE on April 1 measured 8.0″ or 58% of the 1971–2000 average. At Fisher Creek, the maximum SWE for a given year is most often in May and in 2010 was reached on June 5. Compared to other years, SWE on May 1 measured 24.8″ or 66% of the 1971–2000 average. At Parker Peak, the maximum SWE for a given year is most often in May and in 2010 was reached on May 14. Compared to other years, SWE on May 1 measured 19.10″ or 78% of the 1971–2000 average. At Sylvan Lake, the maximum SWE for a given year is most often in May and in 2010 was reached on April 14. Compared to other years, SWE on May 1 measured 12.5″ or 53% of the 1971–2000 average. At Sylvan Road, the maximum SWE for a given year is most often in April and in 2010 was reached on April 4. Compared to other years, SWE on April1 measured 7.0″ or 54% of the 1971–2000 average.

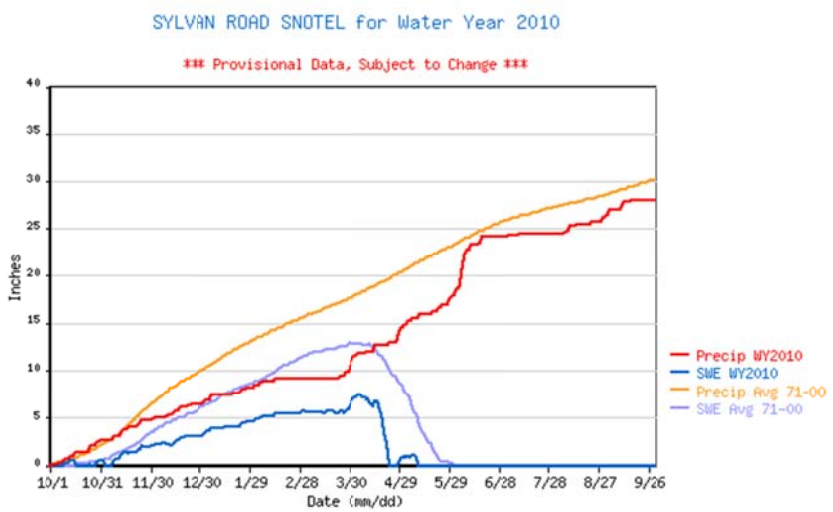


Figure 12. Daily measurements of snow water equivalent (SWE) and precipitation from representative SNOTEL stations in or near Grand Teton and Yellowstone National Parks and John D. Rockefeller Jr. Memorial Parkway from October 2009 to September 2010. Values are compared to averages from the 1971–2000 period. Data courtesy of the Natural Resource Conservation Service. These provisional data are subject to change.

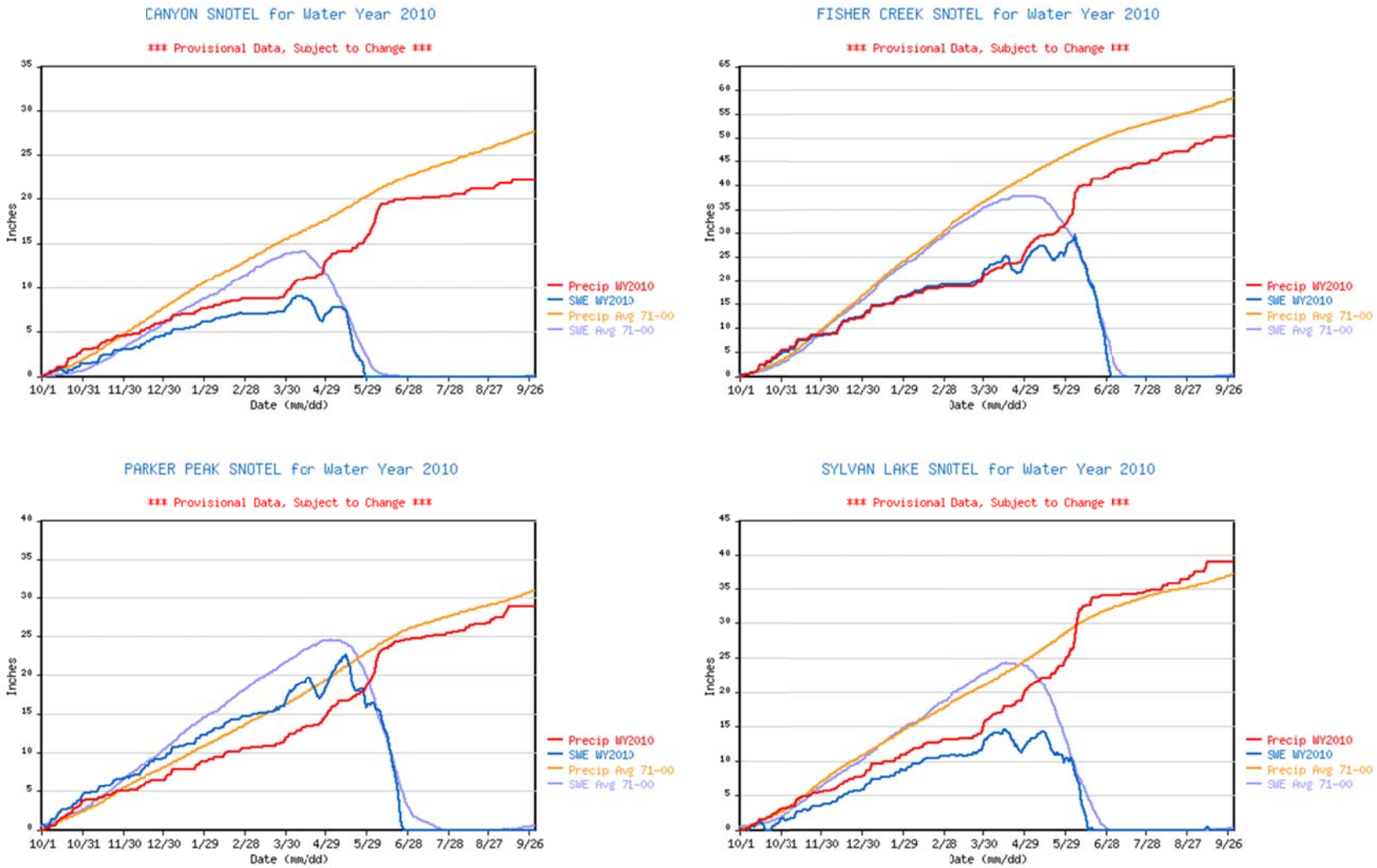


Figure 12. Continued.

Table 4. Total monthly precipitation in inches and percentage of average monthly precipitation versus 1971–2000 averages for select climate stations in or near Yellowstone and Grand Teton National Parks during 2010

Station Name (ID)		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Total
Alta 1 NNW (480140)		2.32	1.26	1.84	4.62	3.41	4.03	0.87	1.25	1.28	2.89	3.3	2.97	30.04
	% of 30-yr avg.	99	70	93	218	97	190	48	81	74	141	156	143	119
Ashton 1 N (100470)		2.36	0.67	0.45	2.87	1.38	3.37	0.35	1.05	0.77	2.36	3.6	4.04	23.27
	% of 30-yr avg.	105	40	28	195	58	205	31	97	65	167	177	180	116
Canyon (10E03S)		1.4	1	1	3.5	3.1	3.7	0.5	0.9	0.7	1.8	4.3	4.3	26.2
	% of 30-yr avg.	47	45	38	167	111	168	29	56	41	95	148	143	95
Cody (481840)		(-)	0.12	0.24	0.65	1.5	0.98	0.81	1.62	0.14	0.14	0.19	0.09	(-)
	% of 30-yr avg.	(-)	44	47.	58	77	62	67	180	12	16	40	28	(-)
Cooke City 2 W (241995)		1.35	0.72	0.44	4.54	2.41	4.95	1.12	2.7	1.14	2.26	2.63	2.46	26.72
	% of 30-yr avg.	59	40	22	255	90	174	52	130	58	142	128	110	105
Driggs (102676)		1.18	0.52	0.85	4.81	3.04	2.64	0.63	1.56	0.95	2.21	3.78	2.56	24.73
	% of 30-yr avg.	91	50	68	362	142	203	49	150	83	180	310	177	157
Fisher Creek (09D06S)		3.8	2.1	2.6	5.4	6.3	9.5	2.8	2.8	2.3	3.3	7.2	7.9	56
	% of 30-yr avg.	51	35	47	106	130	248	105	119	84	98	113	108	97
Moose (486428)		2.05	1.28	1.18	2.51	1.58	3.01	1.56	1.66	1.35	3.31	4.5	3.57	27.56
	% of 30-yr avg.	80	61	72	176	78	177	111	116	102	263	204	145	128
Moran 5 WNW (486440)		2.2	0.84	1.64	2.58	1.88	4.61	0.61	1.71	0.86	3.23	(-)	3.92	(-)
	% of 30-yr avg.	68	35	73	129	81	301	45	135	61	203	(-)	131	(-)
Lake Yellowstone (485345)		1.65	0.86	1.99	2.38	1.88	(-)	(-)	1.38	0.63	1.28	3.7	3.36	(-)
	% of 30-yr avg.	86	58	115	161	91	(-)	(-)	82	40	97	216	200	(-)
Old Faithful (486845)		1.32	0.25	1.02	3.28	2.77	4.7	0.78	1.65	0.5	1.93	4.16	3.76	26.12
	% of 30-yr avg.	57	12	48	162	114	220	47	119	32	114	177	145	107

Table 4. Continued.

Station Name (ID)		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Total
Parker Peak (09E07S)		2.3	1.6	1.5	3	4.1	5.5	0.9	1.8	1.5	2.7	5.9	5.5	36.3
	% of 30-yr avg.	79	62	56	97	111	190	53	129	83	113	190	204	117
Snake River (488315)		2.31	0.8	2.02	2.89	2.93	3.23	0.17	0.39	1.03	4.46	4.03	4.36	28.62
	% of 30-yr avg.	59	26	75	128	107	140	10	23	58	228	119	108	91
Sylvan Lake (10E06S)		3.1	1.9	2.8	4.5	5	8.7	0.7	2.4	1.8	2.7	5.5	6.5	45.6
	% of 30-yr avg.	82	61	88	125	116	281	35	185	95	100	125	167	122
Sylvan Road (10E20S)		1.8	0.8	2.2	3.2	3.4	6.2	0.3	2	1.5	2.3	3.5	5.2	32.4
	% of 30-yr avg.	56	35	100	119	121	248	20	154	88	105	80	149	107
Yellowstone Pk Mammoth (489905)		0.49	0.07	0.88	1.89	1.79	1.61	0.52	1.75	0.15	0.89	3.78	1.39	15.21
	% of 30-yr avg.	56	11	81	173	89	83	33	122	12	94	402	176	104

Note: Percentages of average monthly precipitation versus 1971–2000 averages are given in the second line of data for each station. Station IDs are from NWS Cooperative Observer Program (COOP) stations and NRCS Snowpack Telemetry (SNOTEL) stations. Monthly statistics are not reported if more than three days of data are missing. Individual months are not used for calculating annual statistics if more than five days of data are missing.

(-) Indicates missing data.

Table 5. Average daily maximum temperatures (degrees Fahrenheit) and departure from 30-year averages (+/- degrees Fahrenheit) in or near Grand Teton and Yellowstone National Parks and John D. Rockefeller Jr. Memorial Parkway

Station Name (ID)		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Alta 1 NNW (480140)		31.45	30.61	38.9	45.9	51.52	65.8	76.84	75.1	71.07	57.71	34.97	30.9	50.9
	Departure (+/- F)	2.45	-3.19	-1.1	-2.6	-8.08	-4	-1.36	-2.3	3.17	2.71	-3.13	1.5	-1.33
Ashton 1 N (100470)		30.77	32.18	41.94	53.8	58.45	70.13	81.39	82.19	74.93	61.74	37.27	(-)	(-)
	Departure (+/- F)	1.27	-2.22	0.04	0.5	-5.95	-3.47	-0.21	0.19	2.03	1.14	-4.53	(-)	(-)
Cody (481840)		(-)	(-)	51.84	55.57	57.77	73.77	84.42	83.39	73.8	64.32	39.63	36.23	(-)
	Departure (+/- F)	(-)	(-)	3.34	-1.13	-7.73	-1.83	1.52	1.99	2.8	4.82	-4.27	-0.27	(-)
Cooke City 2 W (241995)		26.71	28.14	39.97	43.3	46.68	60.17	72.03	69.65	65.07	52.97	26.67	25.81	46.43
	Departure (+/- F)	3.11	-2.26	3.17	-1	-7.02	-4.13	-0.97	-2.35	3.47	4.07	-4.93	2.71	-0.51
Driggs (102676)		30.13	29.57	39.03	48.67	52.19	65.77	(-)	75.42	72.1	57.97	36.33	31.35	(-)
	Departure (+/- F)	1.43	-3.53	-1.17	-2.33	-9.41	-5.43	(-)	-2.78	3.3	1.37	-3.37	1.55	(-)
Lake Yellowstone (485345)		26.77	28.79	40	41.13	(-)	(-)	(-)	70.16	64.4	53.42	31.63	27.03	(-)
	Departure (+/- F)	3.97	0.49	4.8	-1.07	(-)	(-)	(-)	-0.24	4.1	5.22	-1.47	2.23	(-)
Moose (486428)		28.58	31.14	44.42	49.3	53.74	66.93	80.58	78.48	71.3	60.03	35.83	31.3	52.64
	Departure (+/- F)	3.18	0.24	4.82	0.1	-6.86	-3.87	1.48	0.18	2.7	4.83	-1.27	5.8	0.95
Moran 5 WNW (486440)		27.45	31.96	42.81	48.07	51.06	64.57	78	76.58	70.4	56.13	(-)	28.42	(-)
	Departure (+/- F)	0.75	-0.84	2.21	-0.73	-7.44	-4.63	0.1	-0.72	2.8	1.43	(-)	1.62	(-)

Table 5. Continued.

Station Name (ID)		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Old Faithful (486845)		29.65	30.21	40.61	43.28	48.26	61.6	73.81	72.39	66.6	55.81	32	27.9	48.51
	Departure (+/- F)	2.65	-2.29	1.01	-2.52	-6.74	-3.9	-0.69	-1.11	4	5.91	-2.5	1.3	-0.41
Snake River (488315)		27.35	29.54	(-)	(-)	50.73	62.7	75.68	74.9	67.83	55.77	(-)	(-)	(-)
	Departure (+/- F)	1.65	-1.76	(-)	(-)	-4.97	-3.9	0.18	-0.1	2.63	3.57	(-)	(-)	(-)
Yellowstone Pk Mammoth (489905)		31.23	33.54	45.16	49.47	53.94	67.1	77.5	76.74	69.53	59.42	35.9	33.29	52.73
	Departure (+/- F)	2.03	-0.56	4.76	0.57	-4.96	-2.2	-1.1	-1.16	2.73	5.62	-1.4	4.09	0.7

Note: Monthly average maximum daily temperature departures from 1971–2000 averages are given in the second line of data for each station in degrees Fahrenheit. Station IDs are from National Weather Service Cooperative Observer stations. Monthly statistics are not reported if more than five days of data are missing. Individual months are not used for calculating annual statistics if more than five days of data are missing.

(-) Indicates missing data.

Table 6. Average minimum daily temperatures in degrees Fahrenheit for select climate stations in or near Grand Teton and Yellowstone National Parks and John D. Rockefeller Jr. Memorial Parkway during 2010. Departures from 1971–2000 averages are given in the second line of data for each station expressed as +/- degrees F.

Station Name (ID)		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Alta 1 NNW (480140)		15.29	11.89	19.19	25.13	29.61	43.23	46.29	45.58	40.37	33.55	18	15.81	28.66
	Departure (+/- F)	4.49	-1.71	-0.41	-1.57	-5.59	0.53	-2.11	-0.92	1.57	3.45	-1.1	4.91	0.13
Ashton 1 N (100470)		16.48	14.57	23.32	29.17	33.68	45.87	48.48	47.74	41.53	36.55	21.47	(-)	(-)
	Departure (+/- F)	7.98	1.17	2.22	-0.13	-3.22	3.57	2.28	3.44	5.03	8.25	2.57	(-)	(-)
Cody (481840)		(-)	(-)	30.45	32.23	37.97	50.07	56.81	56.35	46.4	39.61	18.87	17.1	(-)
	Departure (+/- F)	(-)	(-)	4.75	-0.27	-2.93	1.07	2.01	2.55	1.5	3.71	-5.83	0.4	(-)
Cooke City 2 W (241995)		5.42	5.54	13.29	19.9	24.61	35.13	38.74	38.29	30.67	27.16	13.47	10.52	21.89
	Departure (+/- F)	3.32	1.34	3.19	2.3	-1.89	2.23	1.14	1.79	1.77	5.56	2.97	8.22	2.66
Driggs (102676)		9.65	7.36	18.19	24.93	29.48	42.8	(-)	49.81	38.97	33	17.93	16.19	(-)
	Departure (+/- F)	1.35	-4.04	-0.91	-1.57	-4.32	2	(-)	5.01	2.37	5.2	-0.47	7.39	(-)
Moose (486428)		0.94	0.61	12.1	21.5	27.65	40.33	42.16	40.48	31.5	25.1	13.27	8.7	22.03
	Departure (+/- F)	0.04	-2.19	-0.3	-0.3	-3.35	2.93	0.16	-0.62	-2	0.6	-0.93	6.7	0.06
Moran 5 WNW (486440)		-1.23	-0.32	10.29	17.87	22.94	36.27	39.29	37.35	30.53	26.29	(-)	11.61	(-)
	Departure (+/- F)	-3.53	-4.62	-2.21	-3.53	-7.56	-1.33	-3.21	-3.95	-3.17	0.69	(-)	7.01	(-)
Lake Yellowstone (485345)		2.61	1.93	8.65	17.87	(-)	(-)	(-)	38.42	29.53	27	10.53	10.77	(-)
	Departure (+/- F)	5.71	3.43	4.35	3.27	(-)	(-)	(-)	1.92	0.93	6.1	0.53	9.67	(-)

Table 6. Continued.

Station Name (ID)		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Old Faithful (486845)		2.87	0.71	9.1	16.59	23.65	35.3	36.42	36.03	28.2	23.29	10.23	5.87	19.02
	Departure (+/- F)	4.37	-0.29	0.6	-0.71	-3.65	1	-2.28	-0.47	-0.1	2.89	2.03	7.47	0.9
Snake River (488315)		2.3	1.39	(-)	(-)	(-)	34.43	35.9	35.1	25.9	23.35	(-)	(-)	(-)
	Departure (+/- F)	4.2	1.39	(-)	(-)	(-)	1.23	-1.2	0	-0.5	4.85	(-)	(-)	(-)
Yellowstone Pk Mammoth (489905)		14.1	15.18	21.84	25.6	31.42	42.4	47.19	47.52	40.5	35	16.8	14.9	29.37
	Departure (+/- F)	5.5	3.68	4.14	0.2	-2.48	1.3	0.79	2.42	4.7	7.9	-0.1	6.2	2.85

Note: Monthly average minimum daily temperature departures from 1971–2000 averages are given in the second line of data for each station in degrees Fahrenheit. Station IDs are from National Weather Service Cooperative Observer stations. Monthly statistics are not reported if more than five days of data are missing. Individual months are not used for calculating annual statistics if more than five days of data are missing.

(-) Indicates missing data.

Table 7. First and last freeze and frost dates, accumulated growing degree days, and days above or below critical temperature thresholds for key stations in or near Grand Teton and Yellowstone National Parks and John D. Rockefeller Jr. Memorial Parkway during 2010. Values for 2010 are shown in the first line for each station and averages on the second line. Averages are published by the Western Region Climate Center in General Climate Summary Tables and reference period may differ from 1971–2000.

Station Name (ID)		AGDD40	AGDD50	Last date in spring <= 28F	Earliest date in fall <=28	Last date in spring <=32	Earliest date in fall <=32	# of days Tmax		# of days Tmin	
								>= 80 F	>= 90 F	<= 0 F	<= 32 F
Alta 1 NNW (480140)		2631	1093.5	23-May	6-Sep	17-Jun	2-Sep	28	0	12	207
	avg..	2656	1150	30-May	12-Sep	28-Jun	2-Sep	(-)	2.2	23.7	217.3
Ashton 1 N (100470)		3357	1589.5	21-May	6-Sep	18-Jun	6-Sep	63	6	8	172
	avg.	3096	1421	18-May	19-Sep	14-Jun	8-Sep	(-)	7.4	23.1	206.3
Cody (481840)		(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)
	avg.	4046	2108	5-May	1-Oct	17-May	20-Sep	(-)	18	18.3	168.5
Cooke City 2 W (241995)		1544.5	395.5	14-Jun	24-Aug	7-Jul	24-Aug	3	0	38	263
	avg.	1650	471	26-Jun	30-Aug	12-Jul	9-Aug	(-)	0.1	46.6	275
Driggs (102676)		(-)	(-)	23-May	6-Sep	18-Jun	6-Sep	31	0	22	210
	avg.	2754	1194	31-May	11-Sep	27-Jun	1-Sep	(-)	2.8	34	221.3
Lake Yellowstone (485345)		(-)	(-)	20-Jul	24-Aug	20-Jul	14-Aug	3	0	35	264
	avg.	1424	388	29-Jun	24-Aug	21-Jul	9-Aug	(-)	0	61.9	280.1
Moose (486428)		2335.5	919.5	31-May	31-Aug	15-Jul	24-Aug	51	2	43	250
	avg.	2340	926	9-Jun	2-Sep	29-Jun	24-Aug	(-)	2.7	53.7	249
Moran 5 WNW (486440)		(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)
	avg.	1970	674	17-Jun	2-Sep	9-Jul	15-Aug	(-)	0.5	60	265.3
Old Faithful (486845)		1533.5	397.5	8-Jul	24-Aug	24-Jul	15-Aug	15	0	51	293
	avg.	1715	540	27-Jun	24-Aug	18-Jul	5-Aug	(-)	0.5	57.1	276.6
Snake River (488315)		(-)	(-)	15-Jul	24-Aug	25-Jul	6-Aug	22	0	49	249
	avg.	1775	568	5-Jul	12-Aug	22-Jul	4-Aug	(-)	0.8	58.7	284.6
Yellowstone Pk Mammoth (489905)		2678.5	1130	23-May	12-Oct	26-May	6-Sep	38	2	14	203
	avg.	2732	1201	22-May	15-Sep	14-Jun	9-Sep	(-)	3.2	20.2	208.5

Note: AGDD = Accumulated Growing Degree Days

(-) Indicates missing data

Bighorn Canyon National Recreation Area and Little Bighorn Battlefield National Monument

2010 climate at a glance

- Total annual precipitation at Hardin was 141% of average whereas Lovell was 81% of average.
- Average annual maximum daily temperatures at Hardin were 1°F cooler than average whereas Yellowtail Dam was 5°F cooler than average. Average annual minimum daily temperatures were near average.
- The onset of spring and fall was one to three weeks later than average, depending on station.
- Snow water equivalent was below average at both Bald Mountain and Shell Creek. The timing of maximum SWE was near normal and was reached in June. Melt out dates were near normal.
- Above average precipitation in May and June and rapid snowmelt lead to higher than average peak flows in June.
- Total annual runoff on the Little Bighorn River near Hardin MT was 96% of average; annual runoff on the Bighorn River near St. Xavier and Kane was 113% and 115% of average.

2010 climate data summary

This climate data summary report describes park-level climate at both a local (single weather station) and regional setting (gridded climate maps) using standard data summary and analysis tools described in the *Rocky Mountain Climate Protocol* (RMCWG 2010). Climate data that describe precipitation, temperature, streamflow, and snowpack were gathered from key climate stations in or near Bighorn Canyon National Recreation Area (BICA) and Little Bighorn Battlefield National Monument (LIBI) and summarized for this report. The climate stations cited in this report are shown in figure 13; station metadata are available in appendix A.

Total accumulated precipitation and minimum, maximum, and mean monthly temperatures and departures from an established baseline are summarized in figures and tables below. We consider recent events in a historical context, based primarily on a standard 30-year climatological reference or "normal" period (currently 1971–2000) which we refer to as an "average." The baseline period used to determine average conditions in this report for each climate station is included in the station metadata in appendix A.

Streamflow and snowpack are included as they integrate the combined effects of temperature and precipitation. Variables indicating the timing or length of a seasonal process (e.g., accumulated growing degree days, frosts, snowpack duration, and peak unregulated streamflow) are noted throughout the data summary report.

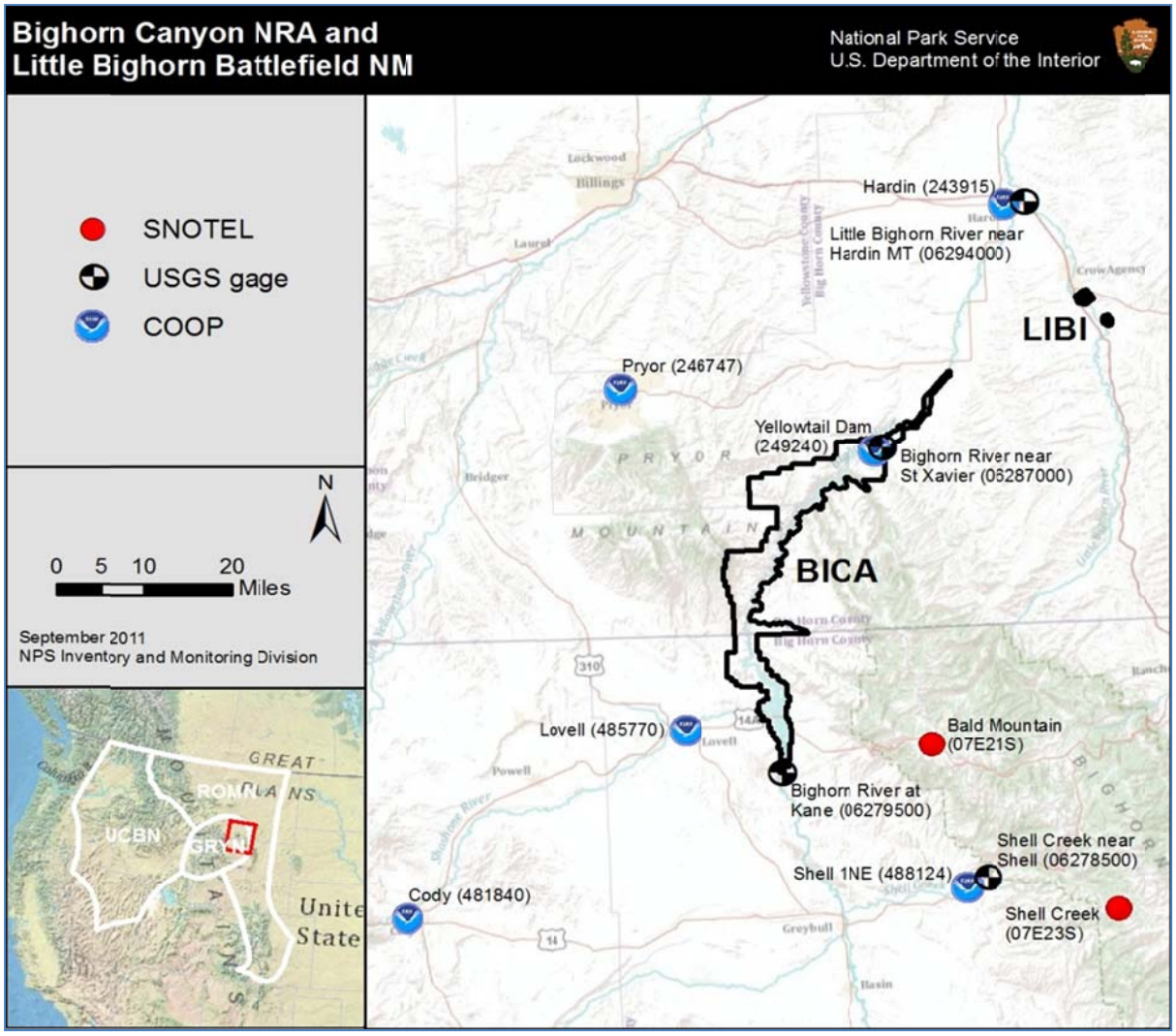


Figure 13. Map showing key climate and stream gauge stations in and near Bighorn Canyon National Recreation Area and Little Bighorn Battlefield National Monument in southeastern Montana and north-central Wyoming. Climate data from Cody is included in the Yellowstone National Park summary.

Gridded climate maps

Given the relatively sparse network of climate stations and complex topography of the area, regional color maps (figs. 5–7) showing month-to-month departure from average conditions for precipitation and maximum and minimum temperatures using PRISM data provide a visual overview of the climate in 2010. PRISM interpolates precipitation values between actual observation stations, and corrects these interpolated estimates for changes in topography across the region. For more information, see http://www.prism.oregonstate.edu/. Refer to the John D. Rockefeller Jr. Memorial Parkway and Grand Teton and Yellowstone National Parks section for region-wide PRISM maps.

Precipitation

Total annual precipitation

During 2010, individual weather stations in the Bighorn Basin reported total annual precipitation that was near average to below average whereas weather stations in the northwestern Great

Plains at Pryor and Hardin reported above average precipitation when totaled across the year. Total monthly precipitation is shown in figure 14 and table 9.

Yellowtail Dam, located on the edge of the northwestern Great Plains in Montana, normally receives 2.5 times the annual precipitation compared to Lovell, which is located in the Bighorn Basin. In 2010 Yellowtail Dam reported over 3.5 times the annul precipitation as Lovell. Also, in 2010 these locations differed in the amount of accumulated annual precipitation compared to average. Lovell reported only 81% of annual precipitation whereas Yellowtail Dam reported 108% of annual precipitation. Springtime is peak precipitation months in both places and the months of April–June accounted for 57% of the annual precipitation at Lovell and 60% of the annual precipitation at Yellowtail Dam.

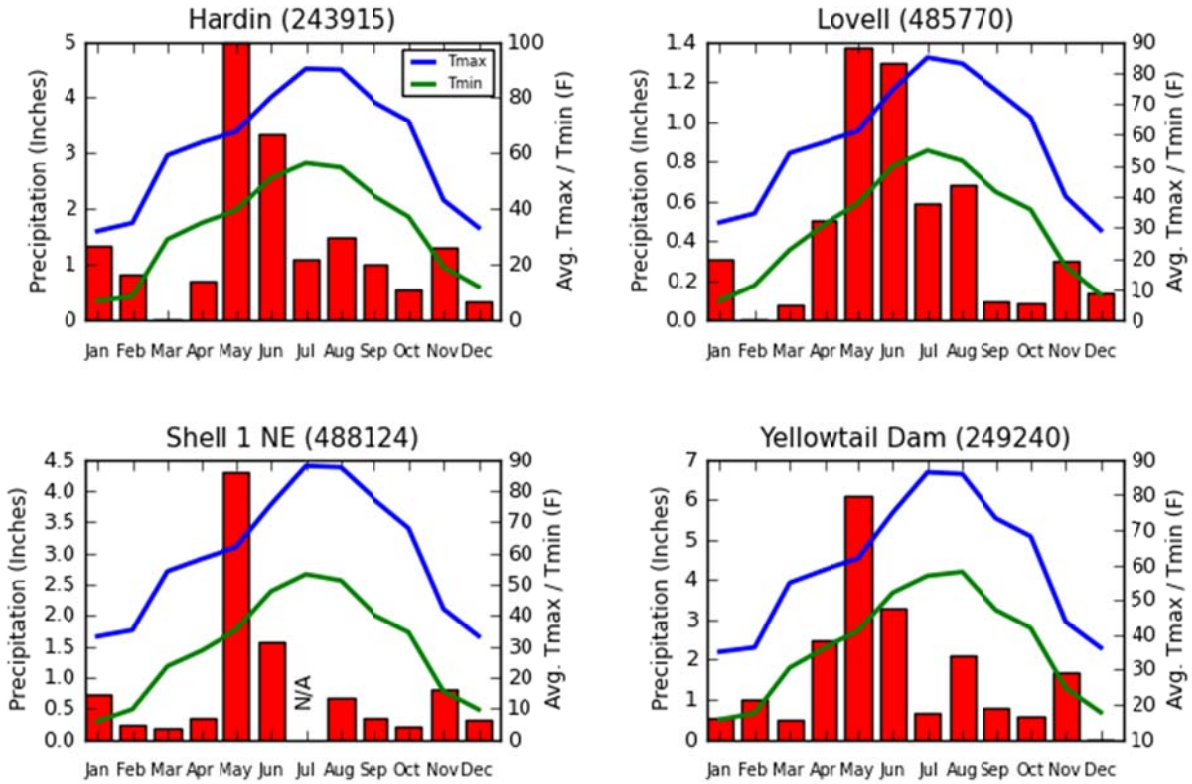


Figure 14. Monthly precipitation and average daily maximum temperature (Tmax) and average daily minimum temperatures (Tmin) during 2010 at key stations in and near Bighorn Canyon National Recreation Area and Little Bighorn Battlefield National Monument. The red bars show precipitation measured in inches. Missing bars (NA) indicate months in which there were insufficient data to calculate accumulated precipitation.

Seasonal precipitation highlights

January precipitation in Hardin and Pryor was 220–229% higher than average. Lovell recorded no precipitation in February and March was only 25% of average. Hardin recorded no precipitation in March. All stations reported above average precipitation in May with Shell 1NE reporting 270% of average and Yellowtail Dam reporting 200% of average. At Yellowtail Dam, precipitation was again over 200% of average in August. Precipitation picked up across the region in November; at Pryor it started raining around November 13 and continued through the

end of the month. The total monthly accumulation was 3.78″ which is 420% of average. Precipitation was notably absent at Yellowtail Dam in December. Departures from average, expressed as a percentage, are shown in figure 15 and table 9.

Temperature

During 2010, annual average minimum and maximum daily temperatures were average or within 1°F of average at Hardin, Lovell, and Shell 1 NE but cooler than average at Yellowtail Dam where the average maximum daily temperature was 5°F cooler than average when averaged across the year.

Monthly average maximum and average minimum daily temperatures highlight the differences and similarities at each weather station (fig. 16; tables 10 and 11) in the region. Of note is the cooler than average maximum temperatures recorded during spring and summer. Daily maximum temperatures started out warmer than average in March and then changed to cooler than average at most stations in April. By May, maximum daily temperatures were 5–11°F below average. Average maximum temperatures stayed below average at Yellowtail Dam, Hardin, and Lovell until September. October was unseasonably warm across the region with Lovell, Hardin, and Shell 1NE experiencing maximum daily temperatures 5–6°F warmer than average.

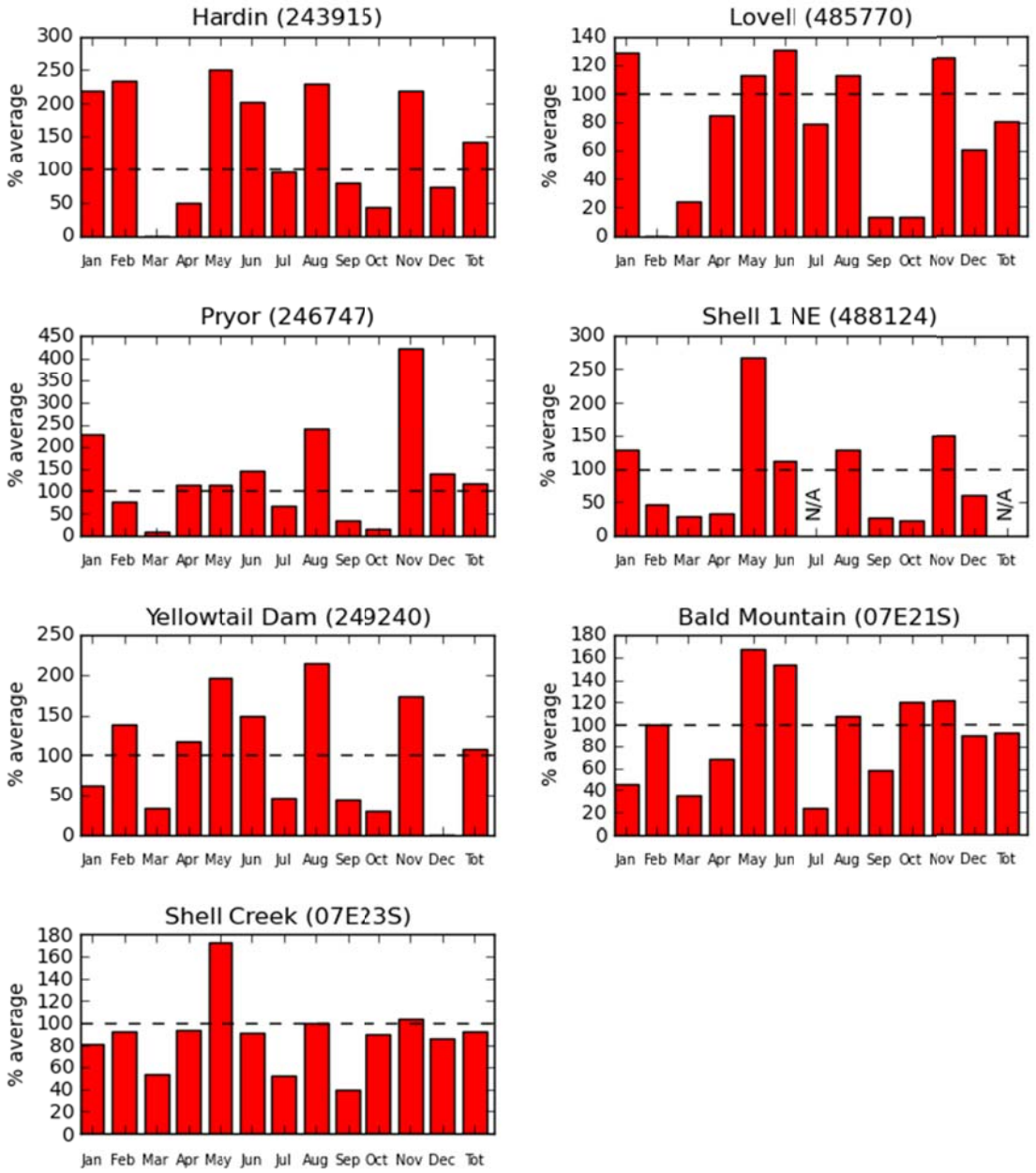


Figure 15. Departure of 2010 precipitation from 1971–2000 average at key climate stations in and near Bighorn Canyon National Recreation Area and Little Bighorn Battlefield National Monument. Missing bars (N/A) indicate months in which there were insufficient data to calculate accumulated precipitation.

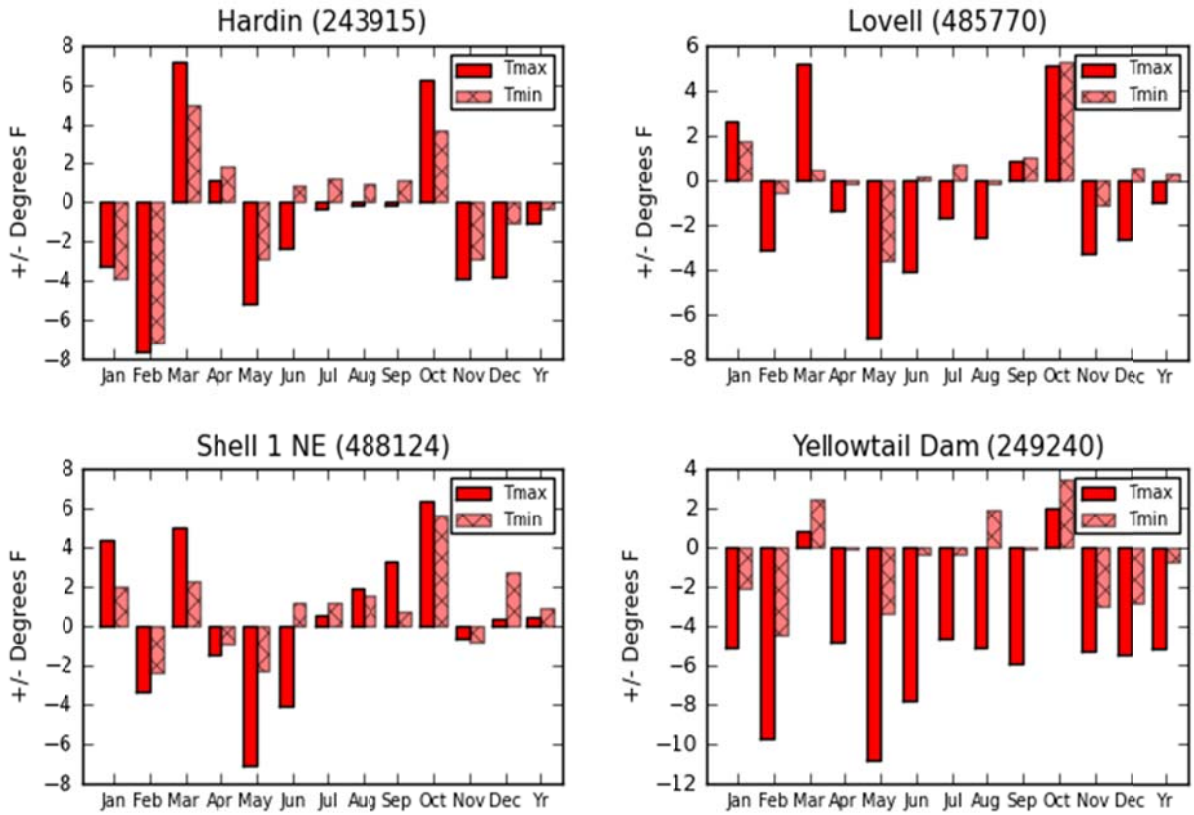


Figure 16. Departure of 2010 average maximum and average minimum daily temperatures from 1971–2000 average at key climate stations in and near Bighorn Canyon National Recreation Area and Little Bighorn Battlefield National Monument.

Box plots of average maximum and average minimum daily temperatures that display data frequency distribution such as median, quartiles, and outliers and are shown in figure 17.

Temperature thresholds

The onset of spring, defined as the last day when the minimum temperature dropped below 28°F, was later in 2010 by one to three weeks from average, depending on station. The first day of fall, defined as the first day when minimum temperatures drop below 28°F, was later in 2010 by two to three weeks from average, again depending on station.

The number of hot days, defined as days where the maximum daily temperatures ≥ 90°F, were fewer than average in Lovell and at Yellowtail Dam. Lovell had 16 fewer hot days and Yellowtail Dam had 18 fewer hot days than average. The number of frosty nights, defined as nights where the minimum temperatures ≤ 32°F, were near average except at Hardin which had 21 days fewer frosty nights than average.

Tables with first and last freeze and frost dates, accumulated growing degree days, and days above or below critical temperature thresholds for key stations in and near BICA and LIBI are shown in table 12.

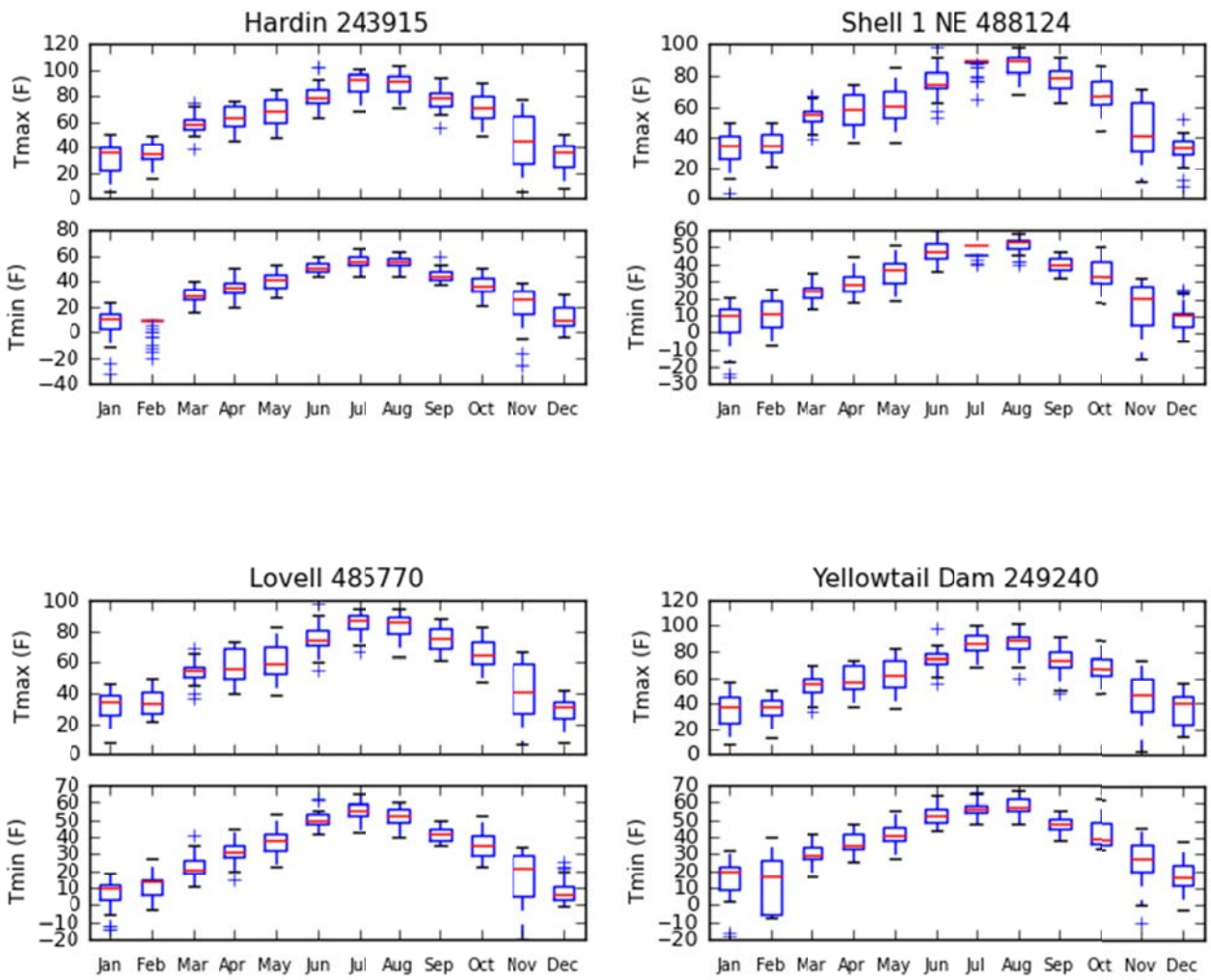


Figure 17. Box plots of average maximum and average minimum daily temperatures at key climate stations in and near Bighorn Canyon National Recreation Area and Little Bighorn Battlefield National Monument during 2010. Horizontal lines indicate the median value. Boxes indicate the 25th and 75th percentiles. Whiskers extend 1.5 times the interquartile Range (IQR). Crosses indicate values exceeding 1.5 times the IQR.

Streamflow

The USGS monitors streamflow at key locations along the Bighorn and Little Bighorn Rivers in Montana and Wyoming. Key aspects of area hydrology is represented by a subset of these gauging stations. Figure 18 and table 8 summarize the 2010 water year, which runs from October 2009 to September 2010.

Total annual runoff was 96% of average as measured by the USGS gauge on the Little Bighorn River at Hardin and was above average elsewhere. Total 2010 inflows to Bighorn Canyon and Bighorn Lake, as measured by the gauge on the Bighorn River at Kane were 115% of the 1930–2010 average. Total discharge on the Bighorn River near St. Xavier downstream from Bighorn Lake was 113% of the 1935–2010 average. The level of Bighorn Lake measured at Forebay by the Bureau of Reclamation stayed above the NPS recommended minimum lake level of 3620′ throughout the year.

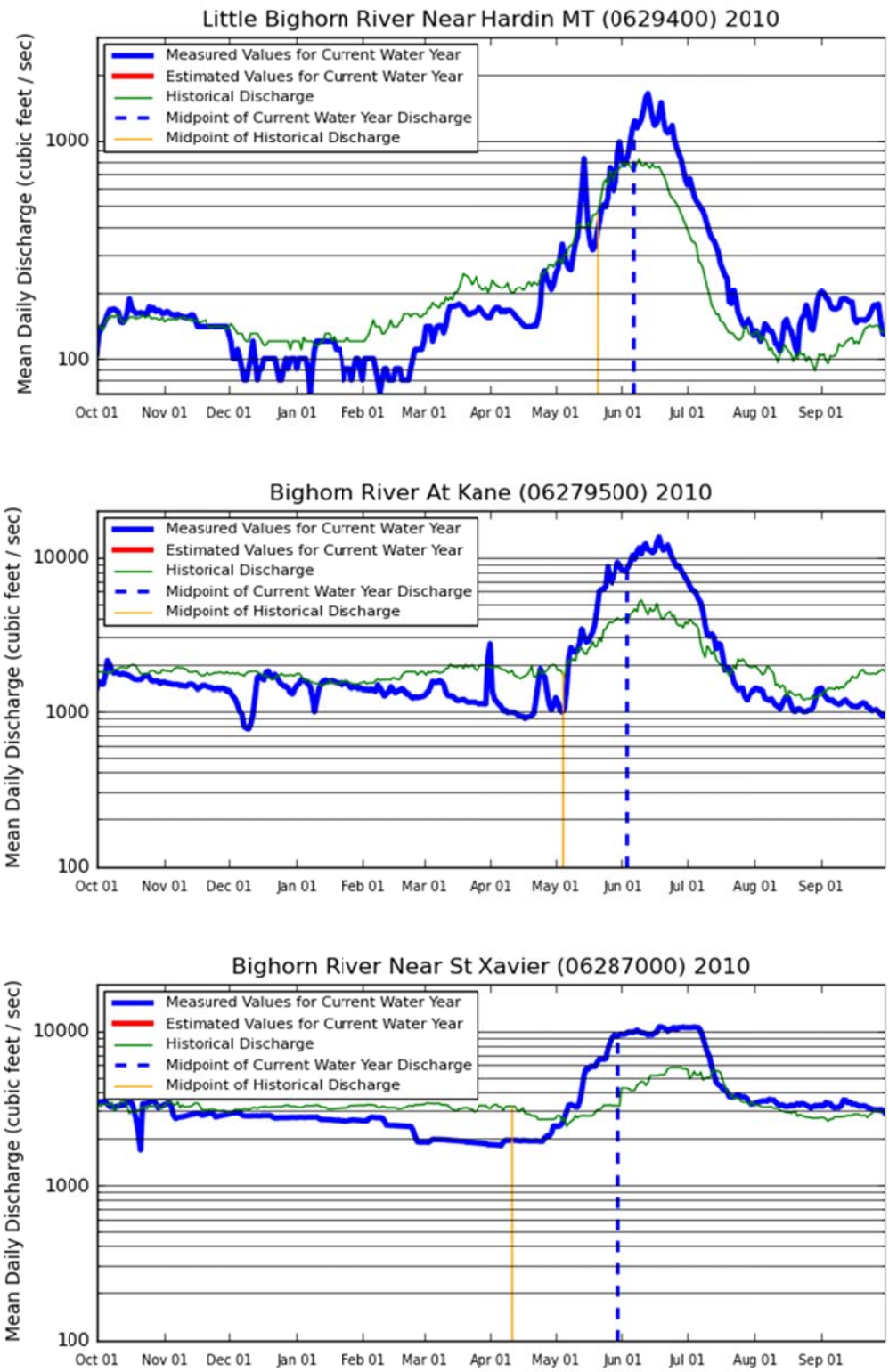


Figure 18. Streamflows from representative gauges in and near Bighorn Canyon Recreation Area and Little Bighorn National Battlefield National Monument for the 2010 water year (October 2009 through September 2010) are shown versus median daily flows for the reference period. Data courtesy of the U.S. Geological Survey.

Table 8. Total annual runoff in acre feet and percentage of average for USGS Gauge Stations near Bighorn Canyon National Recreation Area and Little Bighorn Battlefield National Monument (Data source: USGS Water Data Reports for 2010).

Station Name	Total annual runoff (ac-ft) 2010	Total annual runoff (ac-ft) average	Percent of average
Little Bighorn River near Hardin MT	189,200	196,900	96%
Bighorn River near St. Xavier	2,768,000	2,440,000	113%
Bighorn River at Kane	1,777,000	1,550,000	115%

Winter snowpack

The NRCS operates automated snow measurement (SNOTEL) stations throughout the western United States. These stations offer the best available means for tracking the accumulation and loss of snowpack. As measured in terms of snow water equivalent (SWE)—the amount of liquid water held in a given volume of snow—snowpack measured at Bald Mountain and Shell Creek (fig. 19), was below average during the 2010 water year. The timing of maximum SWE was near normal and was reached in June. Melt out dates were near normal. Above average precipitation in May and June and rapid snowmelt lead to higher than average peak flows in June (fig. 18).

At Shell Creek, the maximum SWE for a given year is most often in May and in 2010 was reached on May 27. Compared to other years, SWE on May 1 measured 15.16″ or 76% of the 1971–2000 average. At Bald Mountain, the maximum SWE for a given year is most often in June and in 2010 was reached on June 1. Compared to other years, SWE on June 1 measured 18.3″ or 78% of the 1971–2000 average.

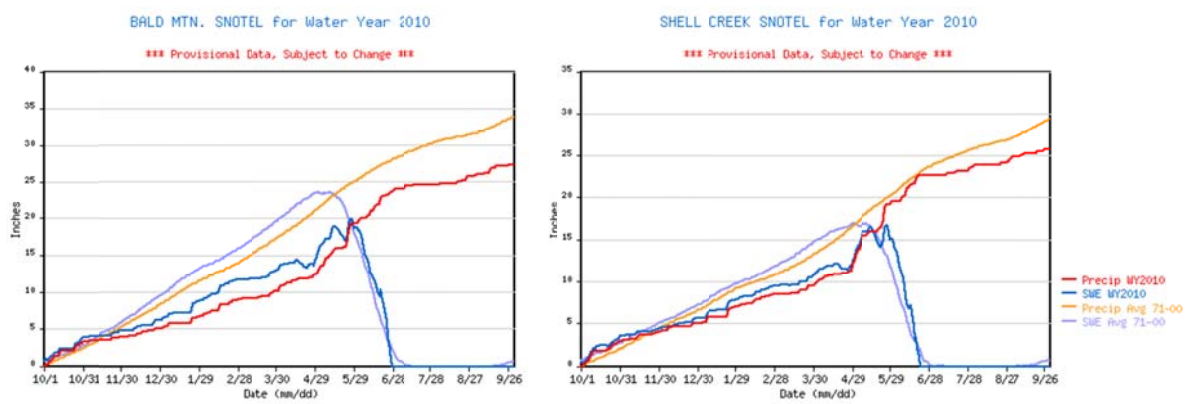


Figure 19. Daily measurements of snow water equivalent (SWE) and precipitation from representative sites near Bighorn Canyon National Recreation Area from October 2009 to September 2010. Values are compared to averages from the 1971–2000 period. Data courtesy of the Natural Resource Conservation Service. These provisional data are subject to change.

Table 9. Total monthly precipitation in inches and percentage of average monthly precipitation versus 1971–2000 averages for select climate stations in or near Bighorn Canyon National Recreation Area and Little Bighorn Battlefield National Monument during 2010

Station Name (ID)	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Total
Bald Mountain (07E21S)	1.5	2.3	1.2	2.6	6.7	4.6	0.5	1.3	1.4	3	3.4	2.9	31.4
	45	100	35	68	168	153	24	108	58	120	121	91	92
Hardin (243915)	1.34	0.82	0	0.7	4.97	3.35	1.11	1.49	1.01	0.57	1.32	0.34	17.02
	220	234	0	51	251	202	97	229	79	44	220	72	141
Lovell (485770)	0.31	0	0.08	0.5	1.37	1.29	0.59	0.68	0.1	0.09	0.3	0.14	5.45
	129	0	24	85	113	130	79	113	13	14	125	61	81
Pryor (246747)	1.51	0.44	0.1	2.1	3.61	3.03	0.95	2.37	0.55	0.24	3.78	0.78	19.46
	229	76	8	112	113	146	67	239	34	14	420	139	116
Shell 1 NE (488124)	0.73	0.22	0.17	0.33	4.29	1.57	(-)	0.67	0.34	0.2	0.81	0.31	(-)
	128	46	29	34	268	111	(-)	129	27	23	150	62	(-)
Shell Creek (07E23S)	2.1	1.4	1.4	3.2	6.4	3.1	1	1.3	0.9	1.9	2.5	1.9	27.1
	81	93	54	94	173	91	53	100	39	90	104	86	92
Yellowtail Dam (249240)	0.53	1	0.47	2.48	6.11	3.3	0.66	2.1	0.78	0.57	1.66	0	19.66
	62	139	34	118	198	149	46	214	44	30	175	0	108

Note: Percentages of average monthly precipitation versus 1971–2000 averages are given in the second line of data for each station. Station IDs are from NWS Cooperative Observer Program (COOP) stations and NRCS Snowpack Telemetry (SNOTEL) stations. Monthly statistics are not reported if more than three days of data are missing. Individual months are not used for calculating annual statistics if more than five days of data are missing.

(-) Indicates missing data

Table 10. Average maximum daily temperatures in degrees Fahrenheit for select climate stations in or near Bighorn Canyon National Recreation Area and Little Bighorn Battlefield National Monument during 2010. Departures from 1971–2000 averages are given in the second line of data for each station expressed as +/- degrees F.

Station Name (ID)		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Hardin (243915)		32.13	35.07	59.32	64.1	67.87	80.17	90.35	90.03	78.43	71.58	43.27	33.42	62.15
	Departure (+/- F)	-3.27	-7.63	7.12	1.1	-5.13	-2.33	-0.35	-0.17	-0.17	6.28	-3.93	-3.78	-1.05
Lovell (485770)		31.71	34.61	54.1	57.63	61.29	74.6	84.9	82.97	74.43	65.61	40.1	29.26	57.6
	Departure (+/- F)	2.61	-3.09	5.2	-1.37	-7.01	-4.1	-1.7	-2.53	0.83	5.11	-3.3	-2.64	-1
Shell 1 NE (488124)		33.23	35.29	54.19	58.23	61.97	75.6	88	87.55	77.27	68	42.1	33.33	59.56
	Departure (+/- F)	4.43	-3.41	4.99	-1.47	-7.13	-4.1	0.6	1.95	3.27	6.4	-0.6	0.33	0.43
Yellowtail Dam (249240)		35.1	36.36	54.87	58.57	61.84	74.87	86.39	85.9	73.27	68.13	43.77	36.29	59.61
	Departure (+/- F)	-5.1	-9.74	0.87	-4.83	-10.86	-7.83	-4.61	-5.1	-5.93	2.03	-5.23	-5.41	-5.15

Note: Monthly average maximum daily temperature departures from 1971–2000 averages are given in the second line of data for each station in degrees Fahrenheit.

Station IDs are from NWS Cooperative Observer Program (COOP) stations and NRCS Snowpack Telemetry (SNOTEL) stations. Monthly statistics are not reported if more than five days of data are missing. Individual months are not used for calculating annual statistics if more than five days of data are missing.

(-) Indicates missing data. SNOTEL temperatures are used to describe current year and not departure from average.

Table 11. Average minimum daily temperatures in degrees Fahrenheit for select climate stations in or near Bighorn Canyon National Recreation Area and Little Bighorn Battlefield National Monument during 2010. Departures from 1971–2000 averages are given in the second line of data for each station expressed as +/- degrees F.

Station Name (ID)		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Hardin (243915)		7	8.69	29.19	35.17	39.65	51.17	56.58	55.03	44.8	37.26	19.2	12.13	32.99
	Departure (+/- F)	-3.9	-7.21	4.99	1.87	-2.85	0.87	1.18	0.93	1.1	3.66	-2.9	-1.07	-0.31
Lovell (485770)		6.45	11.32	22.84	31.07	37.9	49.87	54.97	51.65	41.6	35.87	17.47	8.35	30.78
	Departure (+/- F)	1.75	-0.58	0.44	-0.13	-3.6	0.17	0.67	-0.15	1	5.27	-1.13	0.55	0.35
Shell 1 NE (488124)		5.81	9.68	23.58	28.73	35.39	47.77	53.23	51.23	40.13	34.58	15.47	9.63	29.6
	Departure (+/- F)	2.01	-2.32	2.28	-0.87	-2.31	1.17	1.23	1.53	0.73	5.68	-0.83	2.73	0.92
Yellowtail Dam (249240)		15.65	17.43	30.52	36.17	41.13	52.07	56.87	58	47.1	41.97	24.7	17.74	36.61
	Departure (+/- F)	-2.05	-4.47	2.52	-0.03	-3.37	-0.33	-0.33	1.9	-0.1	3.47	-3	-2.76	-0.72

Note: Monthly average minimum daily temperature departures from 1971–2000 averages are given in the second line of data for each station in degrees Fahrenheit. Station IDs are from NWS Cooperative Observer Program (COOP) stations and NRCS Snowpack Telemetry (SNOTEL) stations. Monthly statistics are not reported if more than five days of data are missing. Individual months are not used for calculating annual statistics if more than five days of data are missing.

(-) Indicates missing data. SNOTEL temperatures used to describe current year only and not departure from average

Table 12. First and last freeze and frost dates, accumulated growing degree days, and days above or below critical temperature thresholds for key stations in or near Bighorn Canyon National Recreation Area and Little Bighorn Battlefield National Monument during 2010. Values for 2010 are shown in the first line for each station and averages on the second line. Averages are published by the Western Regional Climate Center and the reference period may differ from 1971–2000.

Station Name		AGDD40	AGDD50	Last date in spring <= 28F	Earliest date in fall <=28	Last date in spring <=32	Earliest date in fall <=32	# of days Tmax		# of days Tmin	
								>= 80 F	>= 90 F	<= 0 F	<= 32 F
Hardin (243915)		4879	2709	9-May	18-Oct	9-May	12-Oct	93	48	19	153
	avg.	4593	2570	30-Apr	3-Oct	14-May	22-Sep	(-)	47.9	25	177
Lovell (485770)		3891	2012.5	8-May	20-Oct	23-May	13-Oct	68	17	17	187
	avg.	4079	2210	1-May	3-Oct	14-May	20-Sep	(-)	33.2	26.6	188.5
Shell 1 NE (488124)		3837.5	2013	8-May	14-Oct	26-May	8-Sep	75	35	25	198
	avg.	4086	2212	8-May	28-Sep	24-May	18-Sep	(-)	39.1	23.3	199.7
Yellowtail Dam (249240)		4610	2515	8-May	4-Nov	8-May	4-Nov	71	28	11	138
	avg.	5197	2938	18-Apr	15-Oct	6-May	5-Oct	(-)	46.4	14.7	130.7

Note: (-) temperature data or published averages are missing. SNOTEL temperatures used to describe current year only and not departure from average.

Rocky Mountain National Park

2010 climate at a glance

- Total annual precipitation at Grand Lake 1 NW was 86% of average; total annual precipitation at Lake Irene was 116% of average.
- Average annual maximum daily temperatures at Grand Lake 1 NW were near average.
- Average annual minimum daily temperatures at Grand Lake 1 NW were 1°F above average.
- The on-set of spring at Grand Lake 1 NW was nine days earlier than average; the on-set of fall eight days later than average.
- Maximum snow water equivalent was below average except at Wild Basin which reported above average snow water equivalent.
- The timing of maximum SWE was near normal and was reached in April and May. Melt out dates were earlier than average by 1 to 3 weeks.
- Rapid snowmelt lead to higher than average peak flows in June.
- Total annual runoff measured at the gauge on Joe Wright Creek above Joe Wright Reservoir was 92% of average; total annual runoff measured at the gauge on the Big Thompson River below Moraine Park near Estes Park and the Michigan River near Cameron Pass was 107% and 109% of average, respectively.

2010 climate data summary

This climate data summary report describes park-level climate at both a local (single weather station) and regional setting (gridded climate maps) using standard data summary and analysis tools described in the *Rocky Mountain Climate Protocol* (RMCWG 2010). Climate data that describe precipitation, temperature, streamflow, and snowpack were gathered from key climate stations in or near Rocky Mountain National Park (ROMO) and summarized for this report. The climate stations cited in this report are shown in figure 20; station metadata are available in appendix A.

Total accumulated precipitation and minimum, maximum, and mean monthly temperatures and departures from an established baseline are summarized in figures and tables below. We consider recent events in a historical context, based primarily on a standard 30-year climatological reference or "normal" period (currently 1971–2000) which we refer to as an "average." The baseline period used to determine average conditions in this report for each climate station is included in the station metadata in appendix A. Streamflow and snowpack are included as they integrate the combined effects of temperature and precipitation. Variables indicating the timing or length of a seasonal process (e.g., accumulated growing degree days, frosts, snowpack duration, and peak unregulated streamflow) are noted throughout the data summary report.

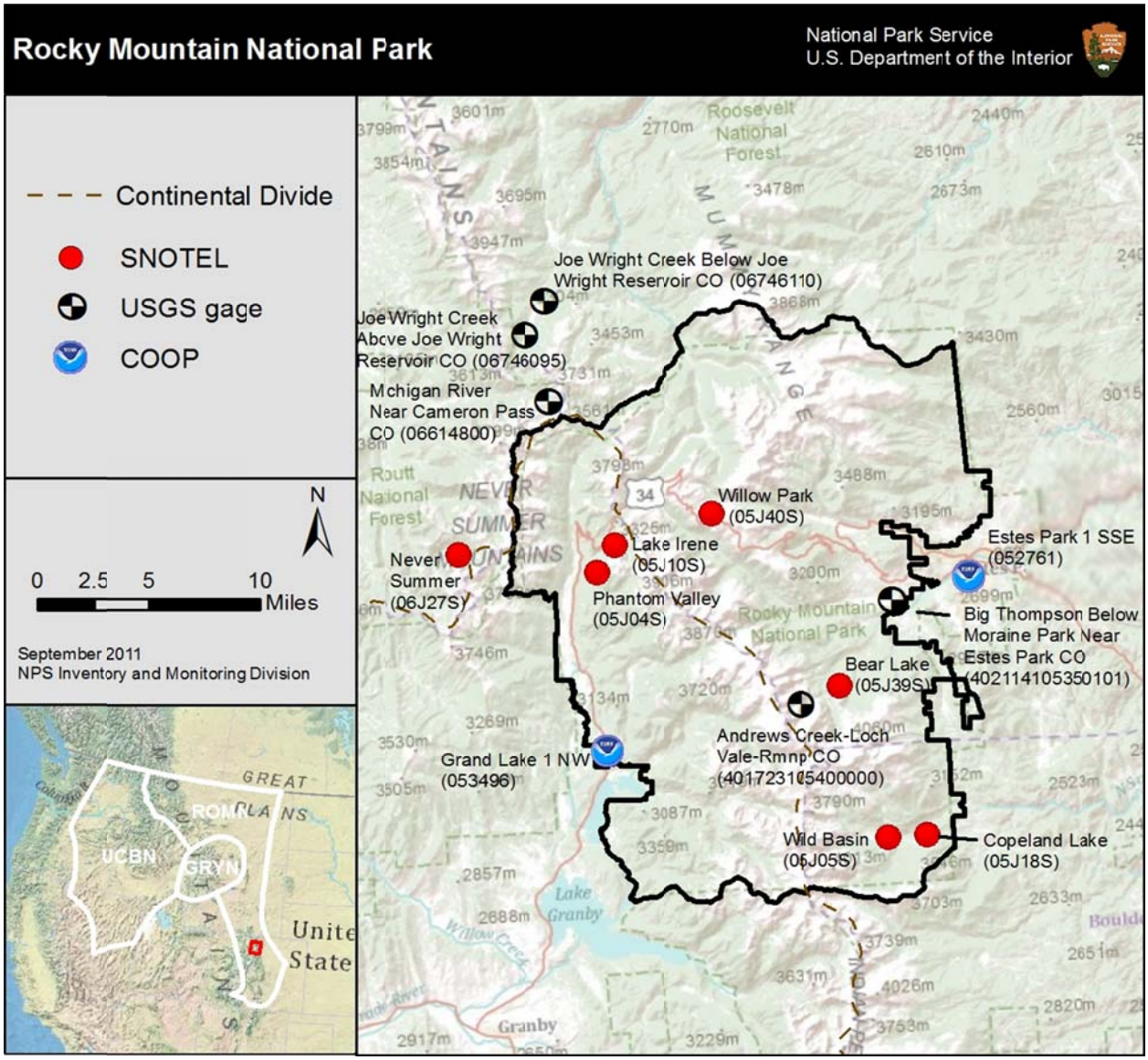


Figure 20. Map showing key climate and stream gauge stations in or near Rocky Mountain National Park in Colorado.

Gridded climate maps

Given the relatively sparse network of climate stations and complex topography of the area, regional color maps (figs. 21–23) showing month-to-month departure from average conditions for precipitation and maximum and minimum temperatures using PRISM data provide a visual overview of the climate in 2010. PRISM interpolates precipitation values between actual observation stations, and corrects these interpolated estimates for changes in topography across the region. For more information, see http://www.prism.oregonstate.edu/.

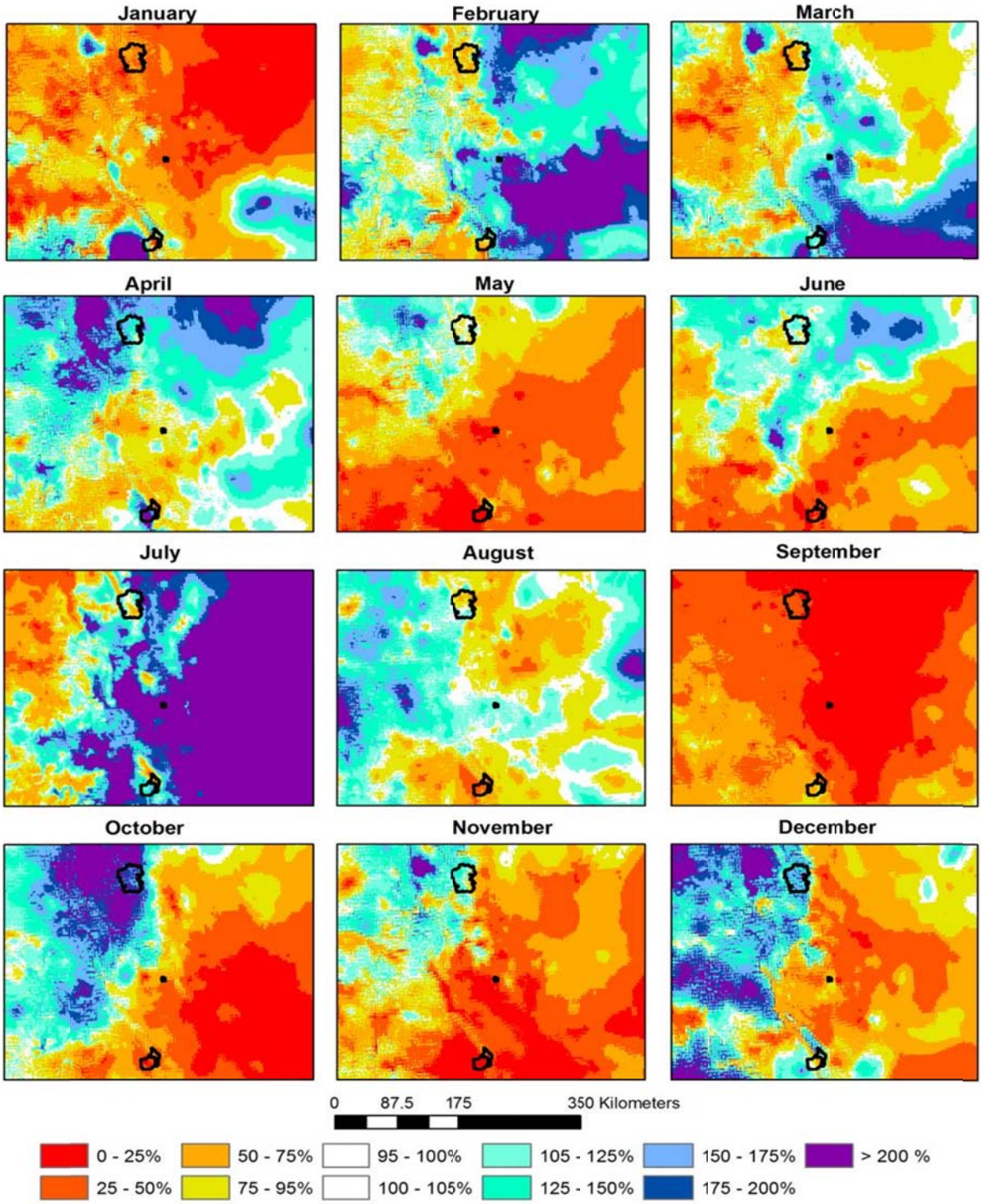


Figure 21. Maps showing percent of average precipitation versus 1971–2000 for each month in calendar year 2010 in the area surrounding Rocky Mountain National Park (northern park unit), Florissant Fossil Beds National Monument (middle park unit) and Great Sand Dunes National Park and Preserve (southern park unit) in Colorado. Colors show estimates from the Parameter-elevation Regressions on Independent Slopes Model (PRISM).

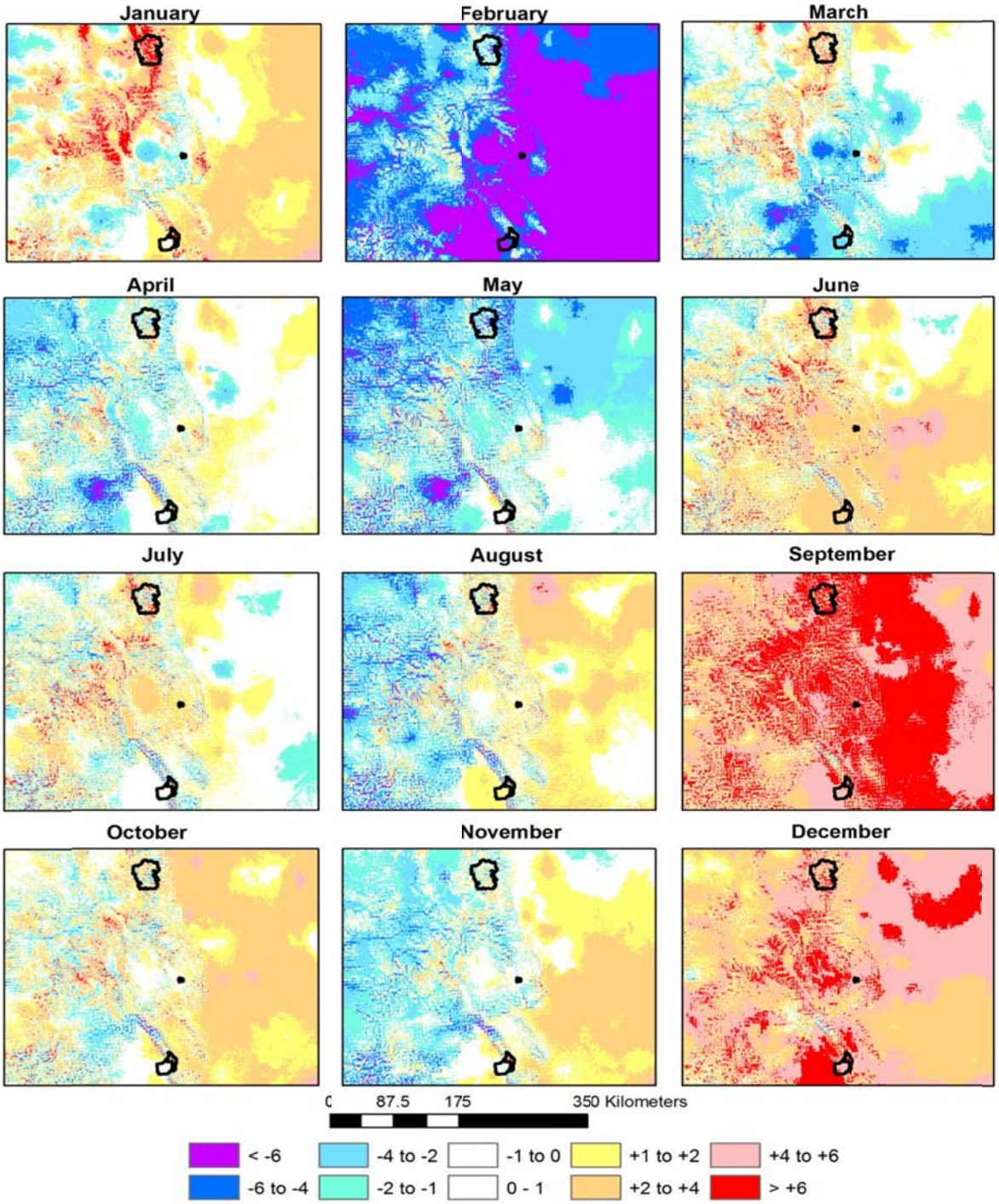


Figure 22. Maps showing departures from average maximum daily temperatures for each month in calendar year 2010 versus 1971–2000 in the area surrounding Rocky Mountain National Park (northern park unit), Florissant Fossil Beds National Monument (middle park unit) and Great Sand Dunes National Park and Preserve (southern park unit) in Colorado. Departure values are reported in degrees Fahrenheit. Maps were created using estimates from the Parameter-elevation Regressions on Independent Slopes Model (PRISM).

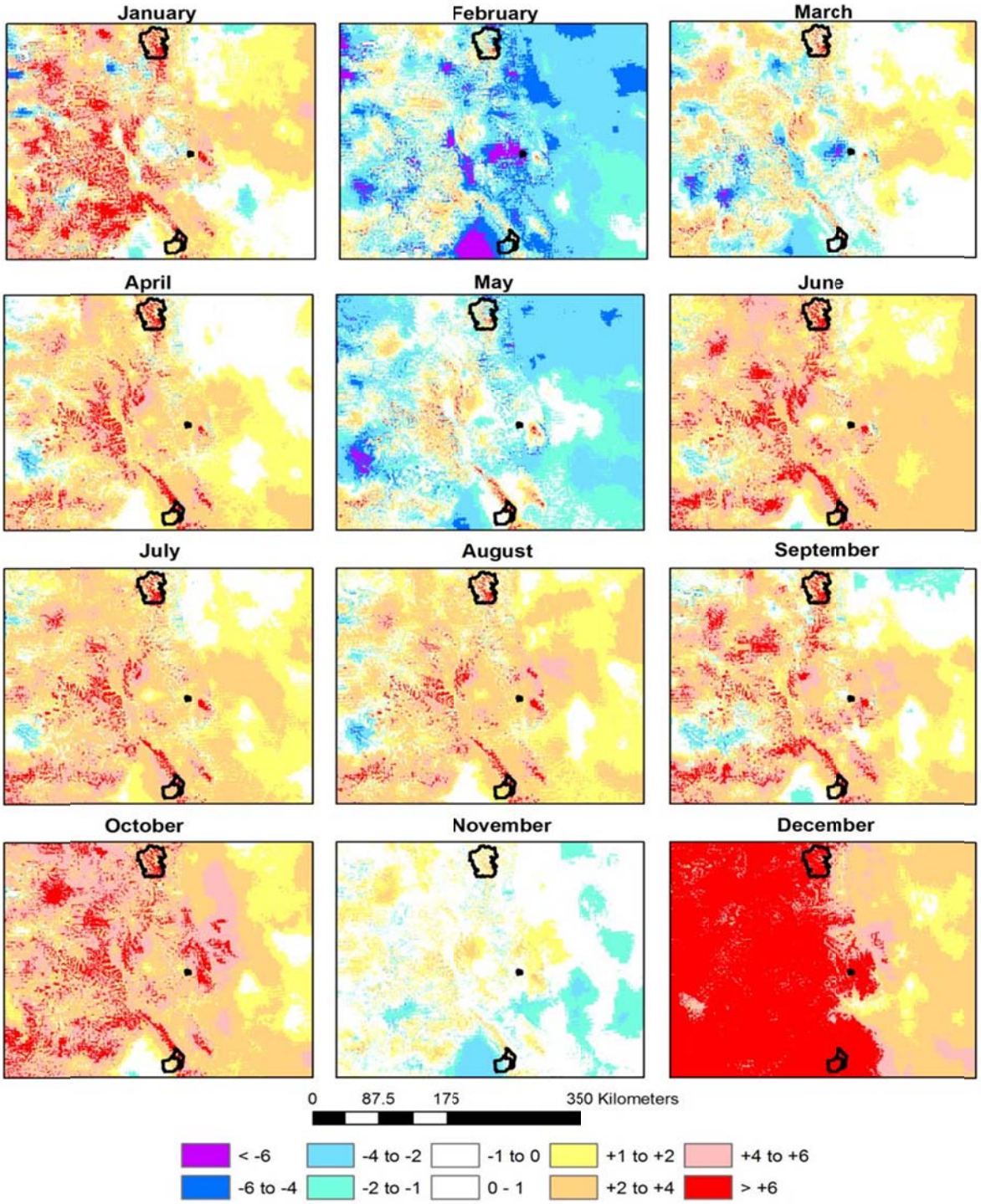


Figure 23. Maps showing departures from average minimum daily temperatures for each month in calendar year 2010 versus 1971–2000 in the area surrounding Rocky Mountain National Park (northern park unit), Florissant Fossil Beds National Monument (middle park unit) and Great Sand Dunes National Park and Preserve (southern park unit) in Colorado. Departure values are reported in degrees Fahrenheit. Maps were created using estimates from the Parameter-elevation Regressions on Independent Slopes Model (PRISM).

Precipitation

Total annual precipitation

During 2010, individual weather stations in or near ROMO reported total annual precipitation ranging from 86% of average at Grand Lake 1 NW to 116% of average at Lake Irene. Grand Lake 1 NW was the only station to report below average total annual precipitation while the other stations report near to above average annual precipitation. Total monthly precipitation is shown in figure 24 and table 14.

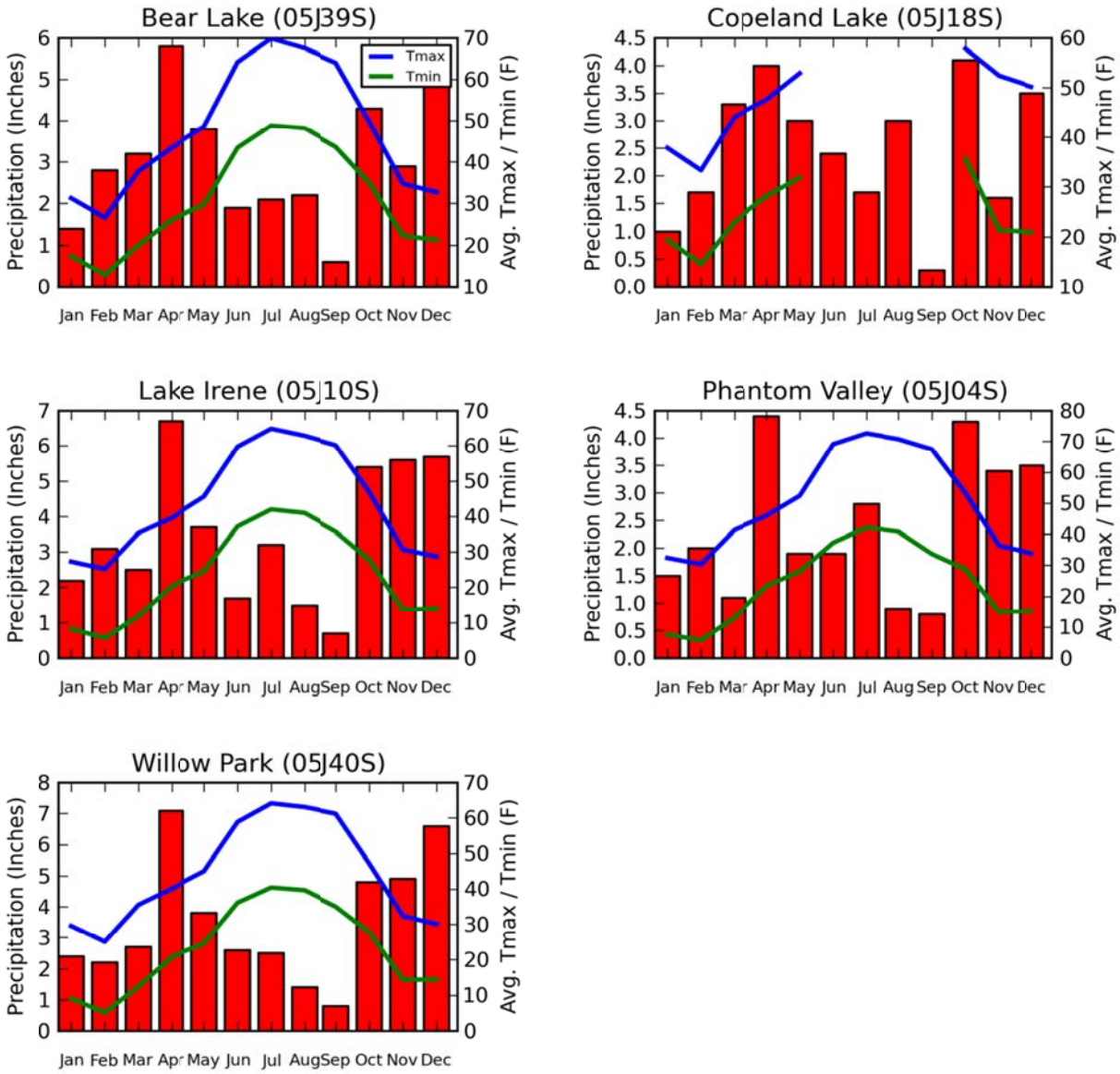


Figure 24. Monthly precipitation totals and average daily maximum temperature (Tmax) and average daily minimum temperatures (Tmin) during 2010 at key climate stations in or near Rocky Mountain National Park. The red bars show precipitation measured in inches.

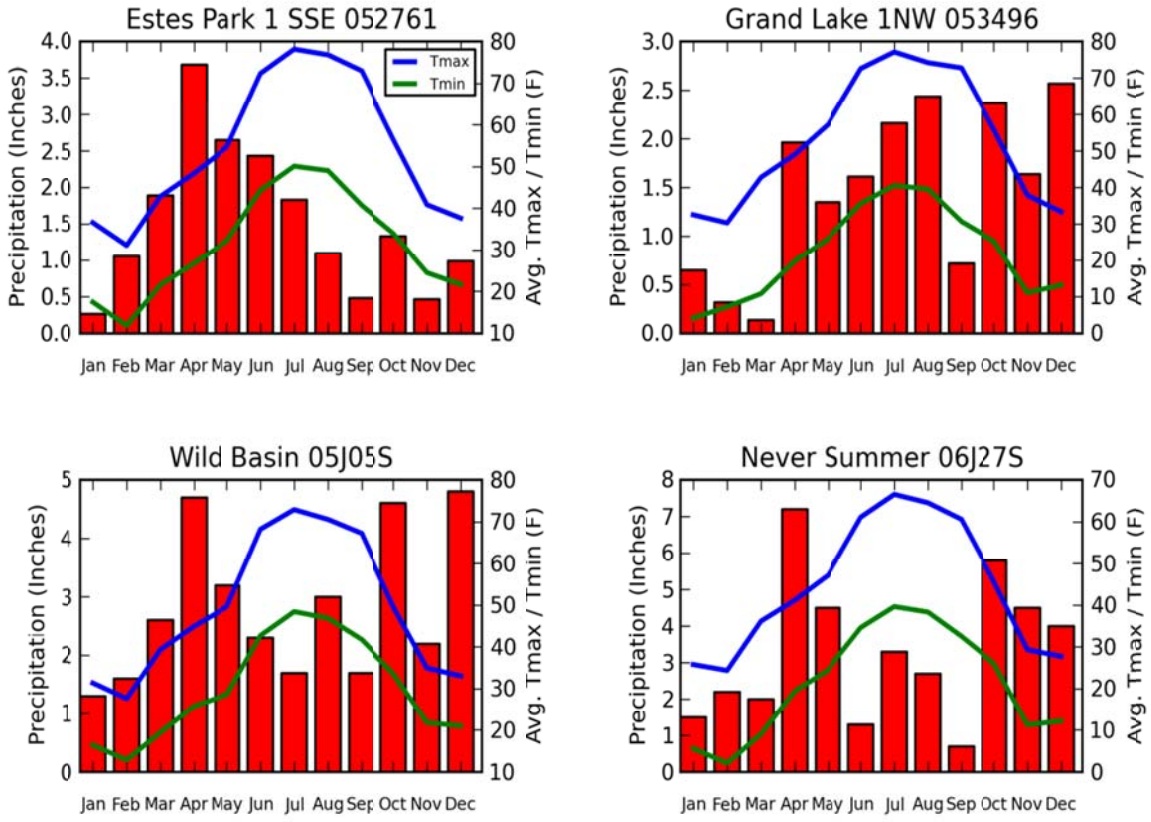


Figure 24. Continued.

Seasonal precipitation highlights

Throughout the winter (January–March) months, the area in and near ROMO experienced mostly below average precipitation. The lowest during this period was 9% of average reported at Grand Lake 1 NW in March. Spring precipitation (April–June) varied by station, however most stations reported near to above average precipitation in April and June but not May. Precipitation at Phantom Valley was 183% of average in April. Early summer precipitation (July–August) was mostly above average but precipitation in September was below average throughout the region. Most stations reported above average precipitation during the fall (October–December) months except at Bear Lake and Copeland Lake which reported below average precipitation in November. Departures from average, expressed as a percentage, are shown in figure 25 and table 14.

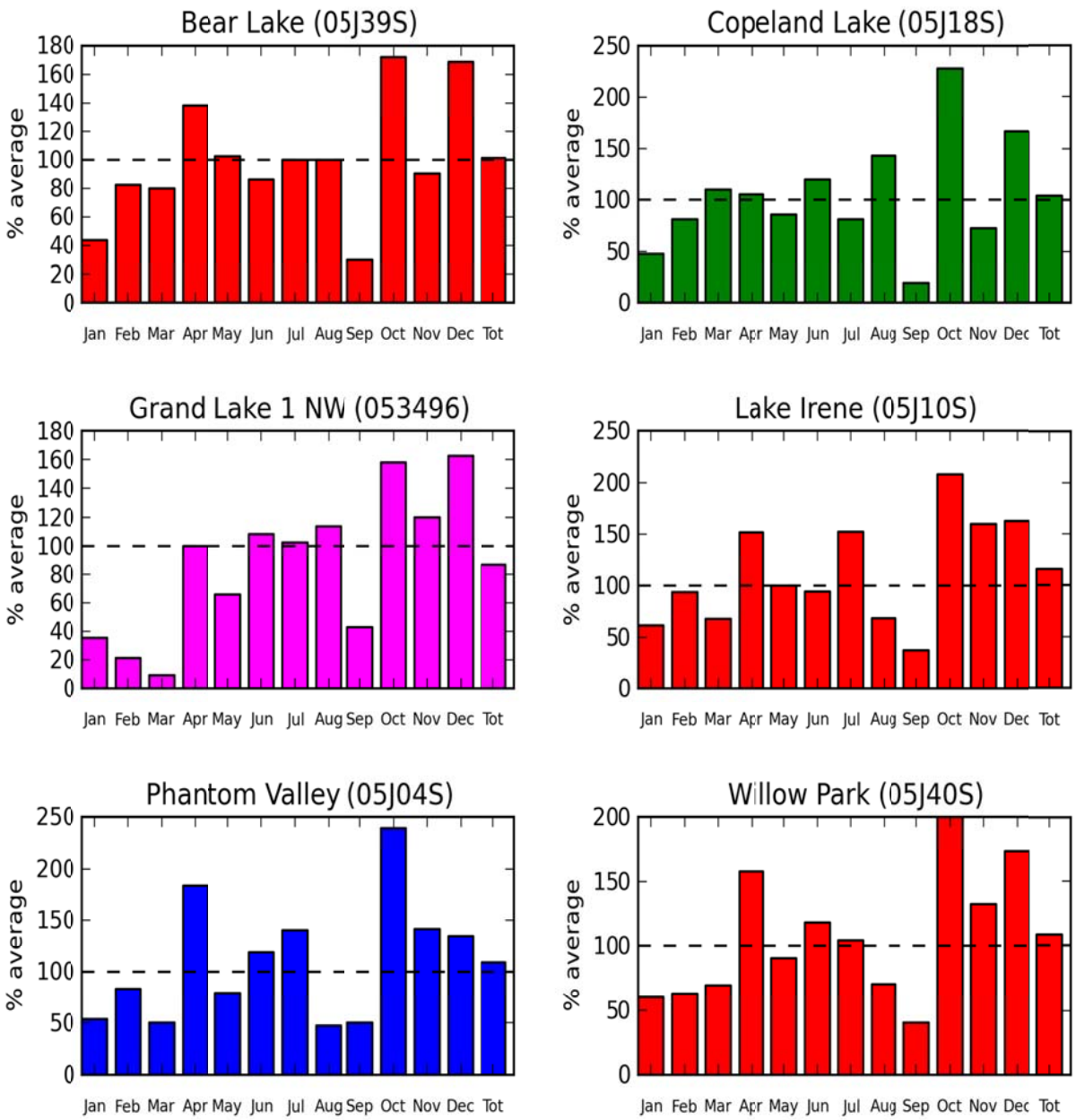


Figure 25. Departure of 2010 precipitation from 1971–2000 average at key climate stations in and near Rocky Mountain National Park. Colors indicate the climate zone for each station. Red = zone 1C, Green = zone 1A-A, Blue = zone 1A-B, Magenta = zone 2B-B.

Temperature

During 2010, the annual average maximum daily temperature was average and the annual average minimum daily temperature was 1°F above average at Grand Lake 1 NW, when averaged across the year.

Monthly average maximum and average minimum daily temperatures at Grand Lake 1 NW and departures from average varied throughout the year. Figure 26 (see also tables 15 and 16) highlight months where either average maximum or average minimum temperatures were average or not. Of interest is that the average daily maximum temperatures were 5.8°F below average in February and 5.1°F above average in September and the average daily minimum daily temperature was 8.7°F above average in December. Box plots of average maximum and average minimum daily temperatures that display data frequency distribution such as median, quartiles, and outliers are shown in figure 27.

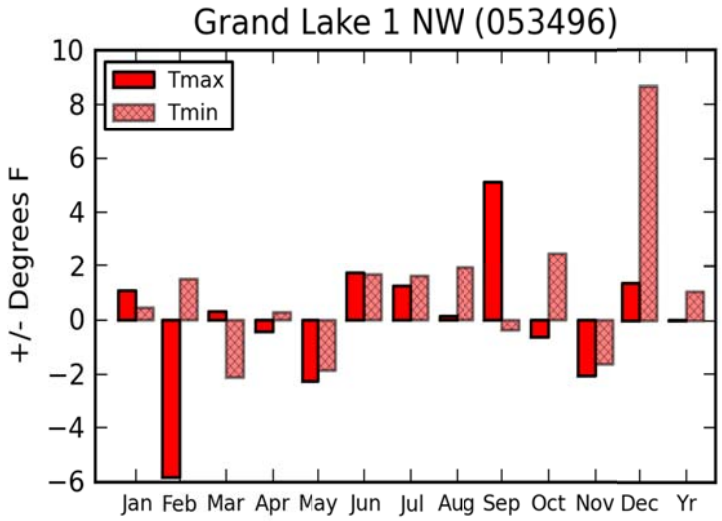


Figure 26. Departure of 2010 average minimum (Tmin) and average maximum (Tmax) daily temperatures from 1971–2000 average at Grand Lake 1 NW in Rocky Mountain National Park.

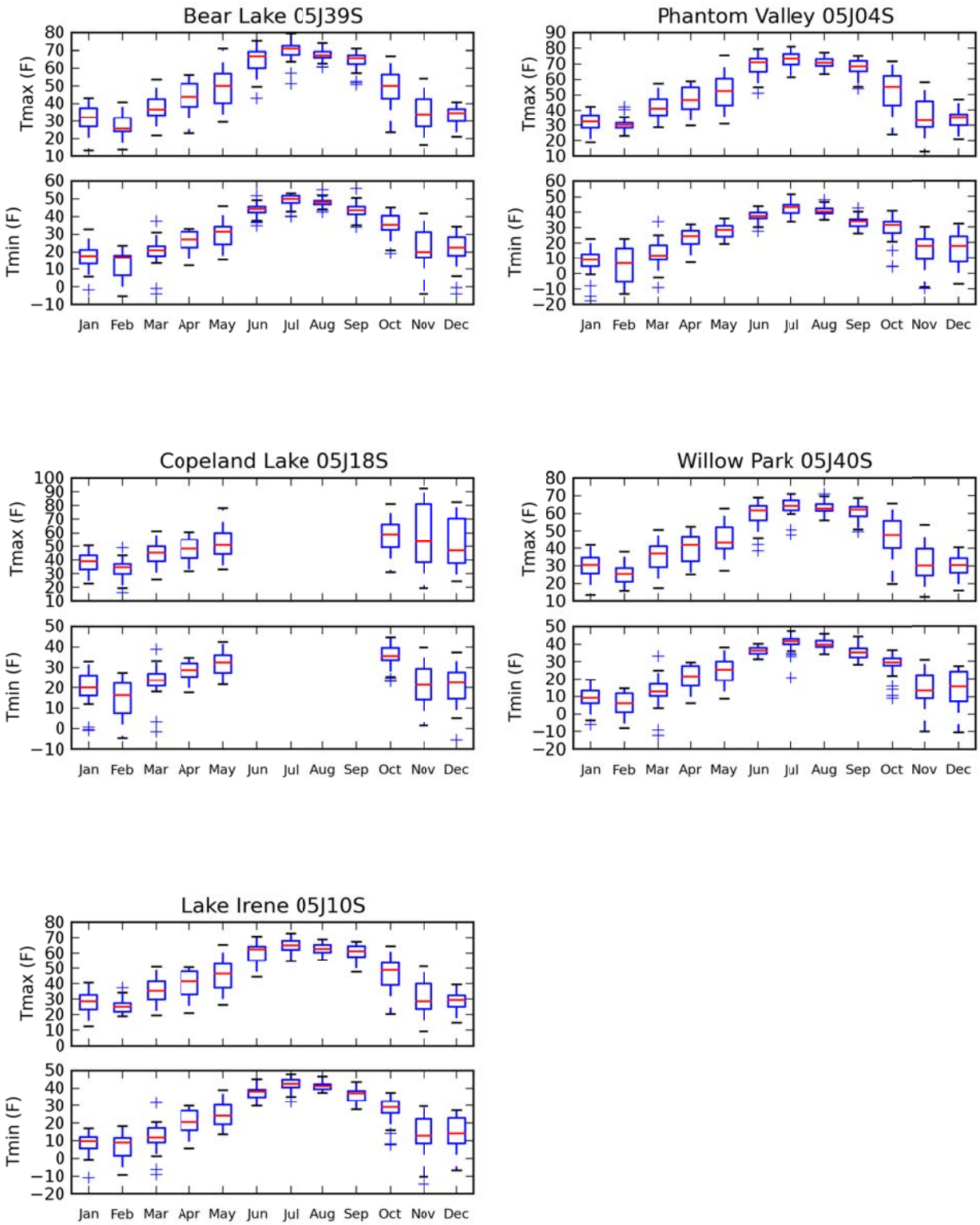


Figure 27. Box plots of average maximum and average minimum daily temperatures at key climate stations in and near Rocky Mountain National Park during 2010. Horizontal lines indicate the median value. Boxes indicate the 25th and 75th percentiles. Whiskers extend 1.5 times the interquartile Range (IQR). Crosses indicate values exceeding 1.5 times the IQR.

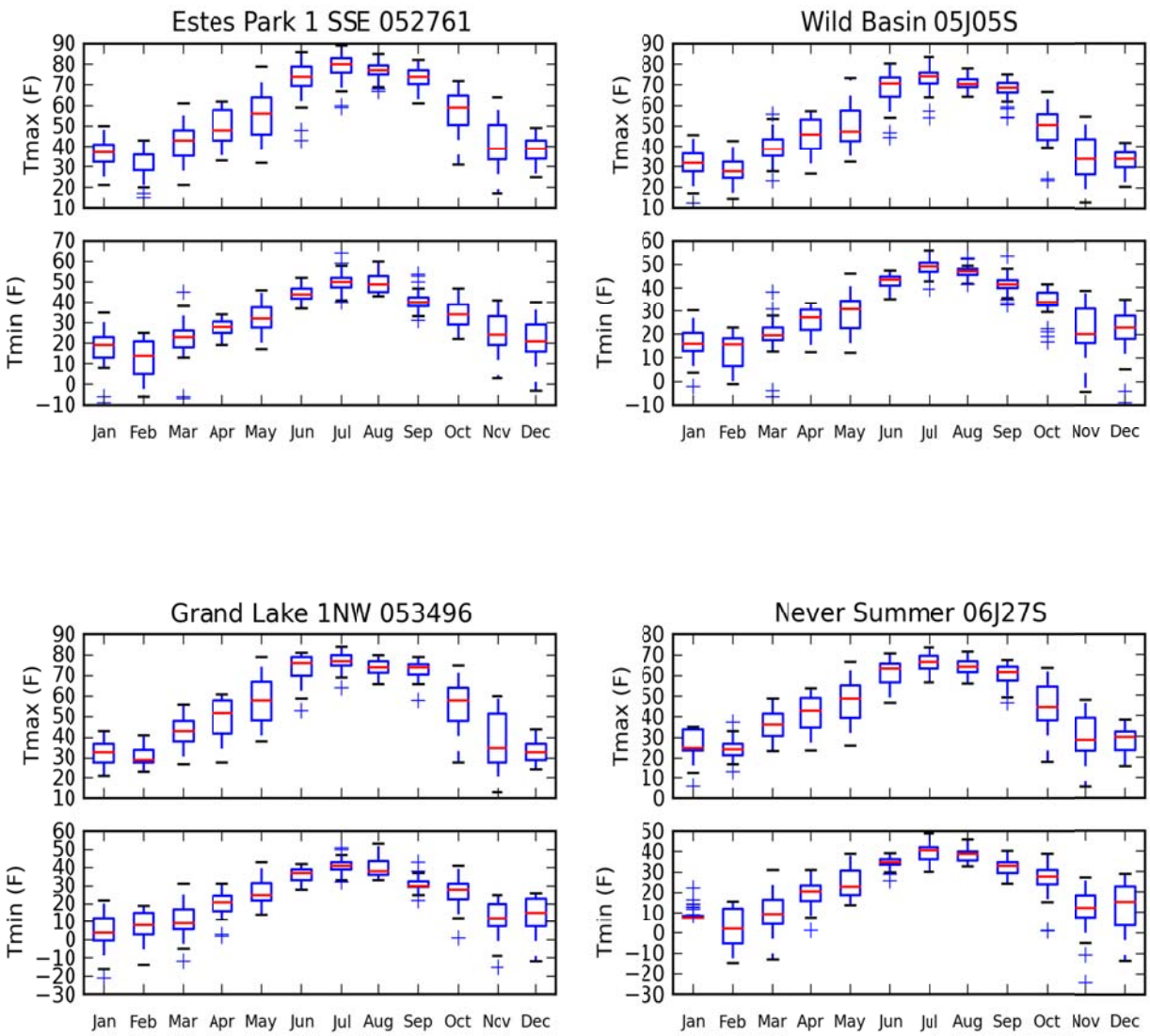


Figure 27. Continued.

Temperature thresholds

The onset of spring, defined as the last day when the minimum temperature dropped below 28°F, was earlier in 2010 by nine days from average at Grand Lake 1 NW and was near average at Estes Park 1 SSE. The first day of fall, defined as the first day when minimum temperatures drop below 28°F, was later in 2010 by eight days from average at Estes Park 1 SSE and average at Grand Lake 1 NW.

The number of hot days, defined as days where the maximum daily temperatures ≥ 90°F, were fewer than average. Neither station reported temperatures ≥ 90°F in 2010. The number of frosty nights, defined as nights where the minimum temperatures ≤ 32°F, were 5 days greater than average at Estes Park 1 SSE and 11 days greater than average at Grand Lake 1 NW. Tables with first and last freeze and frost dates, accumulated growing degree days, and days above or below critical temperature thresholds for key stations in reporting area are shown in table 17.

The Western Regional Climate Center reported daily and monthly records that were exceeded in 2010 (WRCC 2010) at Estes Park 1 SSE. The reference period for these records is from 2001 to 2010.

- The lowest monthly average minimum daily temperatures recorded for the month of February at 21.5°F and the month of May at 43.5°F.
- The highest monthly average maximum daily temperatures recorded in the month of September at 56.9°F.
- The lowest minimum daily temperature recorded in July was reported on May 13 at 17°F.

Streamflow

The USGS monitors streamflow at numerous locations in the area of ROMO. Key aspects of the areas hydrology are represented by a subset of these gauging stations (table 13; fig. 28). Total annual runoff ranged from 88% of average to 109% of average depending on gauge location. Figure 28 and table 13 summarize the 2010 water year (October 2009 to September 2010).

Table 13. Total annual runoff in acre feet and percentage of average for select USGS Gauge Stations near Rocky Mountain National Park during 2010 (Data source: USGS Water Data Reports for 2010).

Station Name	Total annual runoff (ac-ft) 2010	Total annual runoff (ac-ft) average	Percent of average
Joe Wright Creek above Joe Wright Reservoir, CO	6,620	7,210	92%
Joe Wright Creek below Joe Wright Reservoir, CO	9830	11230	88%
Big Thompson River bl Moraine Park near Estes Park, CO	39,050	36,510	107%
Michigan River near Cameron Pass, CO	2,370	2,180	109%
Andrews Creek-Loch Vale-Rmnp, CO	(-)	(-)	(-)

Note: (-) = No USGS Water Data Report available for 2010.

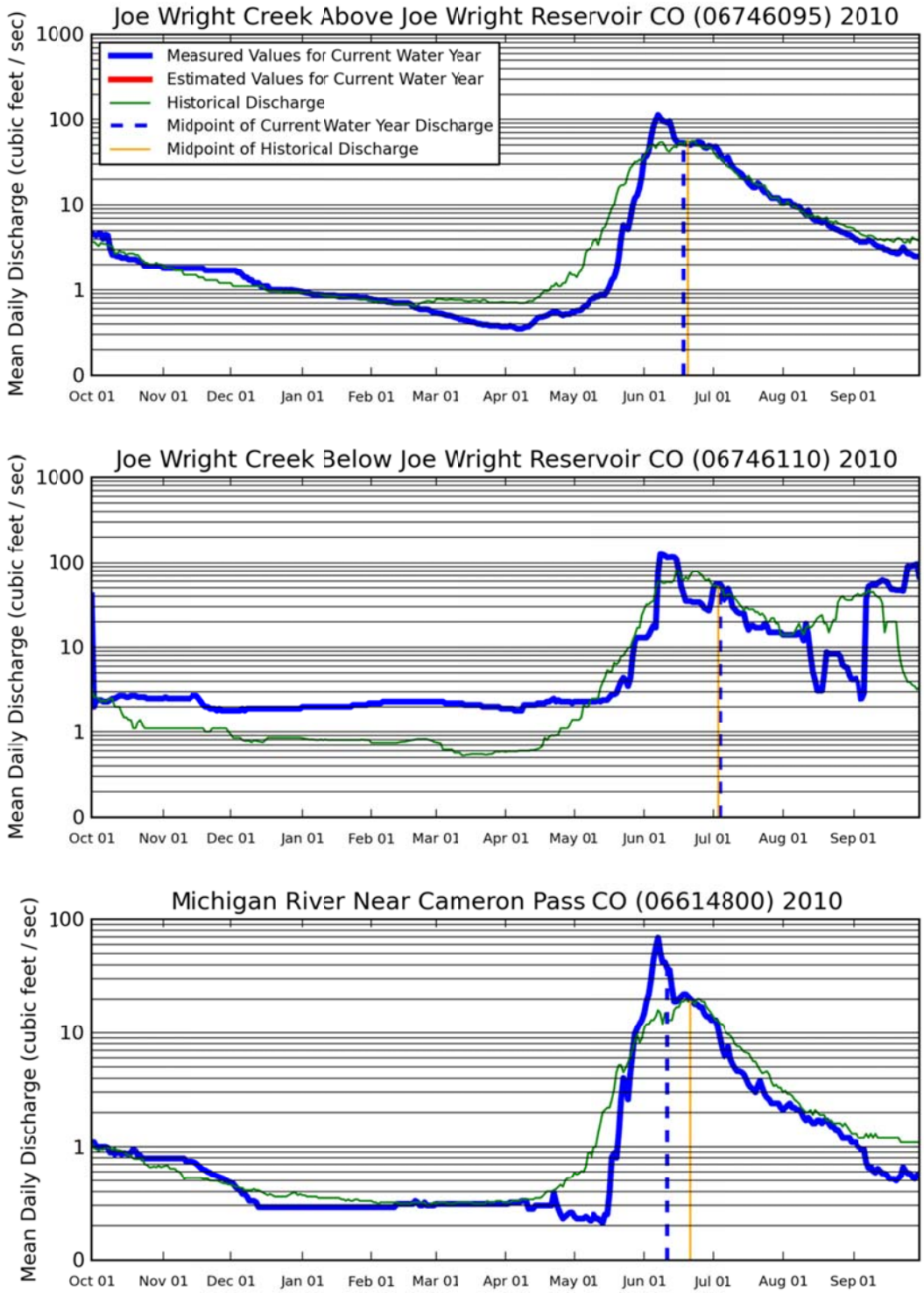


Figure 28. Streamflows from representative gauges in and near Rocky Mountain National Park for the 2010 water year (October 2009 through September 2010) are shown versus median daily flows for the period of record. Data courtesy the U.S. Geological Survey.

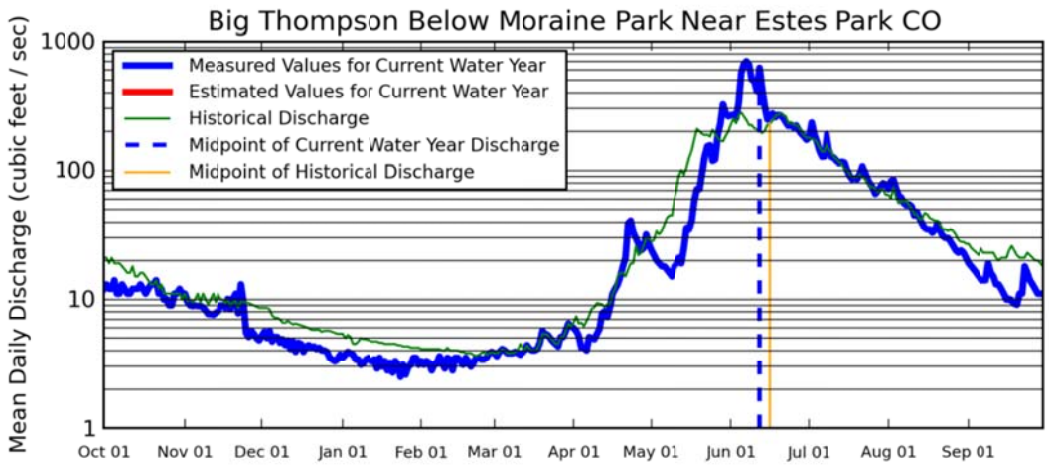


Figure 28. Continued.

Winter snowpack

The NRCS operates automated snow measurement (SNOTEL) stations throughout the western United States. These stations offer the best available means for tracking the accumulation and loss of snowpack. As measured in terms of SWE—the amount of liquid water held in a given volume of snow—snowpack was below average during the 2010 water year except for Wild Basin which reported above average SWE in 2010. The timing of maximum SWE was near normal and was reached in April and May. Melt out dates were earlier than average by 1 to 3 weeks. Rapid snowmelt lead to higher than average peak flows in June (fig. 28). Daily measurements of SWE and precipitation from representative sites in or near ROMO are shown in figure 29.

Snow water equivalent

Amounts of SWE at key times of year such as the month of maximum snowpack help determine if snowpack is decreasing and if runoff is earlier than average.

- Maximum SWE (8.4″) at Phantom Valley was reached earlier than average on March 13, 2010. Snow water equivalent (12.1″) on April 1 measured 73% of the 1971–2000 average.
- Maximum SWE (4.9″) at Copeland Lake was reached on March 9 which is average timing for this station. Snow water equivalent (4.6″) on April 1 measured 102% of the 1971–2000 average.
- At Bear Lake, maximum SWE (16.8″) was reached on May16 which is average timing for this station. Snow water equivalent (14.2″) on May 1 measured 72% of the 1971–2000 average.
- At Lake Irene, maximum SWE (23.7″) was reached on May 16 which is average timing for this station. Snow water equivalent (21.9″) on May 1 measured 78% of the 1971–2000 average.
- At Willow Park, maximum SWE (20.4″) was reached on May 16 which is average timing for this station. Snow water equivalent (17.2″) on May 1 measured 76% of the 1971–2000 average.

- At Wild Basin, maximum SWE (15.1″) was reached May 15 which is average timing for this station. Snow water equivalent (14.1″) on May 1 measured 75% of the 1971–2000 average.
- At Never Summer, maximum SWE (24.2″) was reached May 20 which is average timing for this station. Snow water equivalent (20.4″) on May 1 measured 86% of the 1971–2000 average.

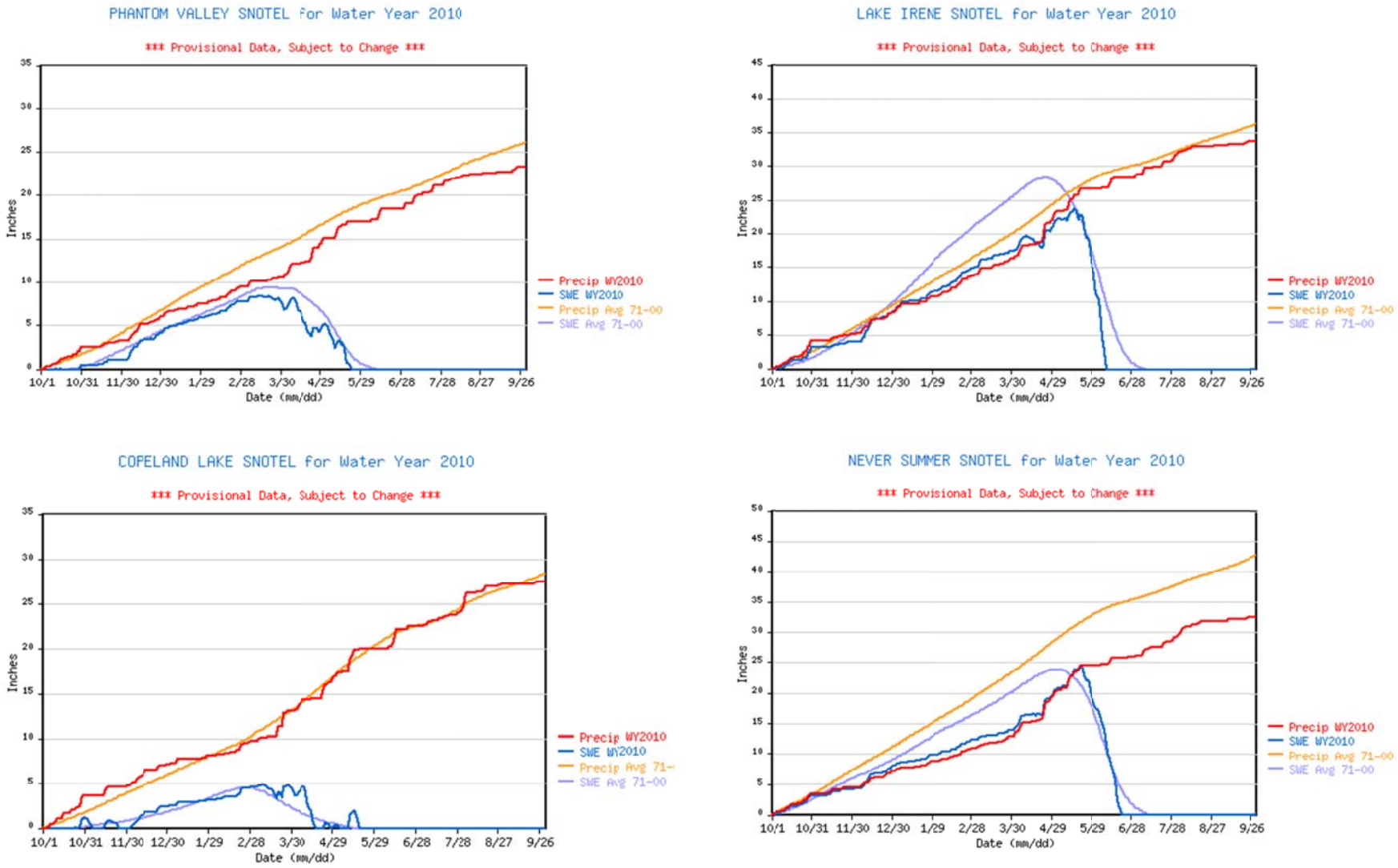
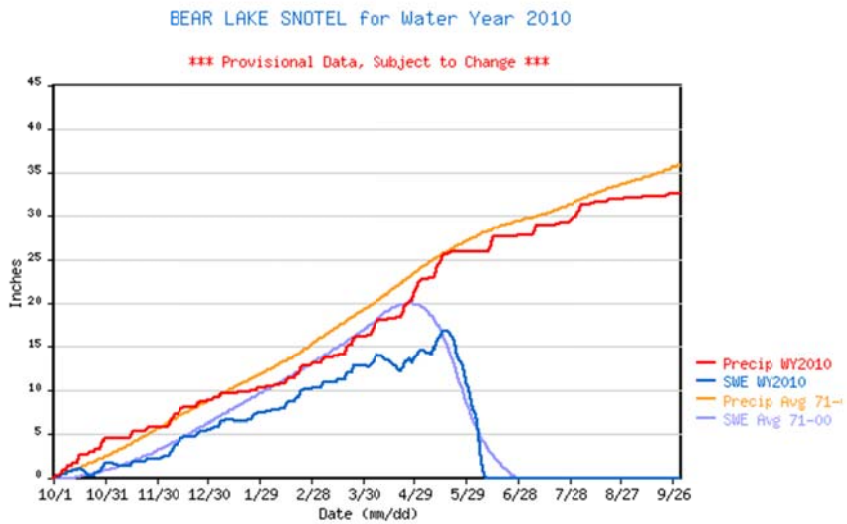
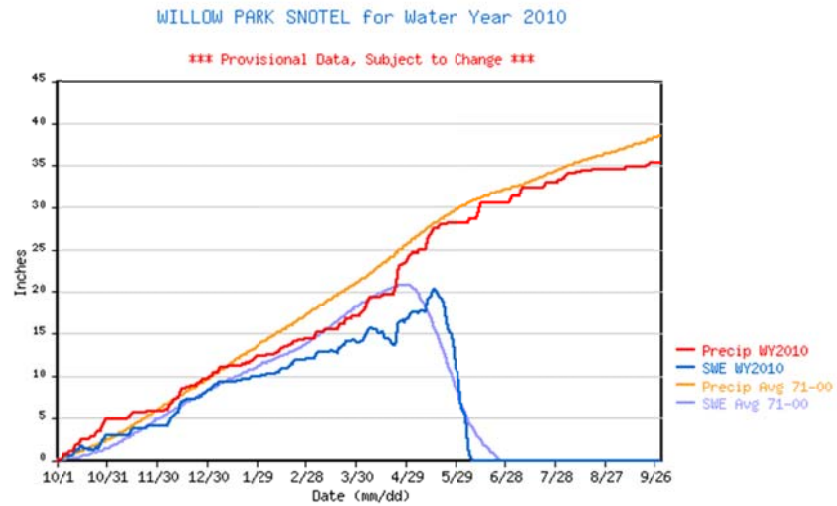


Figure 29. Daily measurements of snow water equivalent (SWE) and precipitation from representative sites in the Rocky Mountain National Park from October 2009 to September 2010. Values are compared to averages from the 1971–2000 period. Data courtesy of the Natural Resource Conservation Service. These provisional data are subject to change.





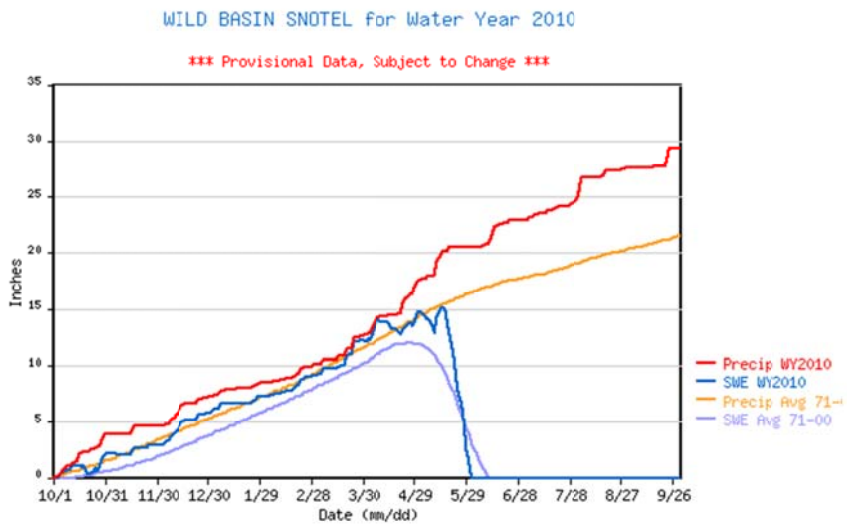


Figure 29. Continued.

Table 14. Total monthly precipitation in inches and percentage of average monthly precipitation versus 1971–2000 averages for select climate stations in or near Rocky Mountain National Park during 2010

Station Name (ID)		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Total
Bear Lake (05J39S)		1.4	2.8	3.2	5.8	3.8	1.9	2.1	2.2	0.6	4.3	2.9	5.4	36.4
	% of 30-yr avg.	44	82	80	138	103	86	100	100	30	172	91	169	101
Copeland Lake (05J18S)		1	1.7	3.3	4	3	2.4	1.7	3	0.3	4.1	1.6	3.5	29.6
	% of 30-yr avg.	48	81	110	105	86	120	81	143	19	228	73	167	104
Estes Park 1 SSE (052761)		0.27	1.06	1.89	3.68	2.65	2.43	1.83	1.1	0.48	1.33	0.47	0.99	18.18
	na	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)
Grand Lake 1 NW (053496)		0.65	0.32	0.14	1.96	1.35	1.61	2.16	2.44	0.72	2.37	1.64	2.57	17.93
	% of 30-yr avg.	36	21	9	100	66	108	102	113	43	158	120	163	86
Lake Irene (05J10S)		2.2	3.1	2.5	6.7	3.7	1.7	3.2	1.5	0.7	5.4	5.6	5.7	42
	% of 30-yr avg.	61	94	68	152	100	94	152	68	37	208	160	163	116
Never Summer (06J27S)		1.5	2.2	2	7.2	4.5	1.3	3.3	2.7	0.7	5.8	4.5	4	39.7
	na	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)
Phantom Valley (05J04S)		1.5	2	1.1	4.4	1.9	1.9	2.8	0.9	0.8	4.3	3.4	3.5	28.5
	% of 30-yr avg.	54	83	50	183	79	119	140	47	50	239	142	135	109
Wild Basin (05J05S)		1.3	1.6	2.6	4.7	3.2	2.3	1.7	3	1.7	4.6	2.2	4.8	33.7
	na	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)
Willow Park (05J40S)		2.4	2.2	2.7	7.1	3.8	2.6	2.5	1.4	0.8	4.8	4.9	6.6	41.8
	% of 30-yr avg.	60	63	69	158	90	118	104	70	40	200	132	174	108

Note: Percentages of average monthly precipitation versus 1971–2000 averages are given in the second line of data for each station. Station IDs are from NWS Cooperative Observer Program (COOP) and NRCS Snowpack Telemetry (SNOTEL) stations. Monthly statistics are not reported if more than three days of data are missing. Individual months are not used for calculating annual statistics if more than five days of data are missing.

(-) Indicates missing data or missing averages.

Table 15. Average maximum daily temperatures in degrees Fahrenheit for select climate stations in or near Rocky Mountain National during 2010. Departures from 1971–2000 averages are given in the second line of data for each station expressed as +/- degrees F.

Station Name (ID)		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Bear Lake (05J39S		31.29	26.67	37.8	43.49	48.62	64.21	69.93	67.57	64.02	49.69	34.78	32.7	47.56
	Departure (+/- F)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)
Copeland Lake (05J18S)		37.85	33.35	44.14	47.62	52.96	(-)	(-)	(-)	(-)	57.86	52.45	50.21	(-)
	na	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)
Estes Park 1 SSE (052761)		36.65	31.14	42.94	48.47	54.74	72.37	78.16	76.81	73	56.58	40.93	37.71	54.12
	na	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)
Grand Lake 1 NW (053496)		32.58	30.36	42.81	49.07	57.35	72.63	77.13	74.23	72.8	55.97	37.93	33.39	53.02
	na	1.08	-5.84	0.31	-0.43	-2.25	1.73	1.23	0.13	5.1	-0.63	-2.07	1.39	0.02
Lake Irene (05J10S)		27.35	25.29	35.37	39.68	45.65	59.8	64.92	62.91	60.21	46.88	30.77	28.77	43.97
	na	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)
Never Summer (06J27S)		25.84	24.41	36.21	41.22	47.26	61.12	66.54	64.55	60.61	45.74	29.38	27.78	44.22
	na	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)
Phantom Valley (05J04S)		32.46	30.42	41.44	46.02	52.44	69.18	72.69	70.8	67.51	53.22	36.38	33.88	50.54
	na	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)
Wild Basin (05J05S)		31.43	27.67	39.45	45.02	49.69	68.24	72.92	70.59	67.27	49.7	35	33.1	49.17
	na	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)
Willow Park (05J40S		29.61	25.12	35.61	40.19	45.11	58.92	64.18	63.14	61.25	47.25	32.43	30.15	44.41
	na	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)

Note: Monthly average maximum daily temperature departures from 1971–2000 averages are given in the second line of data for each station in degrees Fahrenheit.

Station IDs are from NWS Cooperative Observer Program (COOP) stations and NRCS Snowpack Telemetry (SNOTEL) stations. Monthly statistics are not reported if more than five days of data are missing. Individual months are not used for calculating annual statistics if more than five days of data are missing.

(-) Indicates missing data. SNOTEL temperatures are used to describe current year and not departure from average.

Table 16. Average minimum daily temperatures in degrees Fahrenheit for select climate stations in or near Rocky Mountain National Park during 2010. Departures from 1971–2000 averages are given in the second line of data for each station expressed as +/- degrees F.

Station Name (ID)		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Bear Lake (05J39S		17.45	12.93	20.09	26.23	29.72	43.46	48.84	48.21	43.65	34.96	22.35	21.32	30.77
	Departure (+/- F)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)
Copeland Lake (05J18S)		19.46	14.6	23.06	28.16	31.87	(-)	(-)	(-)	(-)	35.63	21.44	21.03	(-)
	na	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)
Estes Park 1 SSE (052761)		17.52	11.89	21.68	26.87	32.26	44.37	50.13	49.06	40.77	34.06	24.57	21.74	31.24
	na	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)
Grand Lake 1 NW (053496)		4.23	7.29	10.87	19.87	26.03	35.67	40.61	39.61	30.73	25.35	11.17	13.26	22.06
	na	0.43	1.49	-2.13	0.27	-1.87	1.67	1.61	1.91	-0.37	2.45	-1.63	8.66	1.06
Lake Irene (05J10S)		8.3	5.71	11.92	20.52	24.68	37.24	42.05	41.04	35.73	27.85	13.74	14.07	23.57
	na	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)
Never Summer (06J27S)		5.64	2.11	9.12	19.46	24.54	34.66	39.69	38.38	32.58	26.1	11.28	12.28	21.32
	na	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)
Phantom Valley (05J04S)		7.62	5.84	13.1	23.41	28.11	37.33	42.24	40.87	33.72	28.77	14.89	15.28	24.27
	na	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)
Wild Basin (05J05S)		16.46	12.88	19.52	25.87	28.65	42.74	48.48	46.91	41.81	33.64	21.87	21.04	29.99
	na	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)
Willow Park (05J40S		9.12	5.19	12.52	20.88	24.65	36.21	40.5	39.75	35.08	27.81	14.47	14.44	23.39
	na	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)

Note: Monthly average minimum daily temperature departures from 1971–2000 averages are given in the second line of data for each station in degrees Fahrenheit. Station IDs are from NWS Cooperative Observer Program (COOP) stations and NRCS Snowpack Telemetry (SNOTEL) stations. Monthly statistics are not reported if more than five days of data are missing. Individual months are not used for calculating annual statistics if more than five days of data are missing.

(-) Indicates missing data. SNOTEL temperatures are used to describe current year and not departure from average.

Table 17. First and last freeze and frost dates, accumulated growing degree days, and days above or below critical temperature thresholds for key stations in or near Rocky Mountain National Park during 2010. Values for 2010 are shown in the first line for each station and averages on the second line. Averages are published by the Western Regional Climate Center and the reference period may differ from 1971–2000.

Station Name (ID)		AGDD40	AGDD50	Last date in spring <= 28F	Earliest date in fall <=28	Last date in spring <=32	Earliest date in fall <=32	# of days Tmax		# of days Tmin	
								>= 80 F	>= 90 F	<= 0 F	<= 32 F
Bear Lake		2274.5	847.35	25-May	26-Oct	26-May	14-Oct	0	0	8	193
(05J39S)	na	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)
Copeland Lake		(-)	(-)	15-May	26-Oct	1-Jun	8-Sep	8	3	5	185
(05J18S)	na	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)
Estes Park 1 SSE		3038	1392	15-May	14-Oct	25-May	7-Sep	31	0	9	192
(052761)	avg.	3089	1394	13-May	6-Oct	28-May	14-Sep	na	2.5	7.5	186.6
Grand Lake 1 NW		2157	737	15-Jun	3-Sep	6-Jul	1-Sep	12	0	29	269
(053496)	avg.	1879	547	24-Jun	3-Sep	12-Jul	11-Aug	na	0.1	45.8	280.5
Lake Irene		1399.51	242.37	31-May	12-Sep	16-Jun	4-Sep	0	0	19	241
(05J10S)	na	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)
Never Summer		1305.14	192.24	1-Jun	4-Sep	6-Jul	3-Sep	0	0	28	245
(06J27S)	na	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)
Phantom Valley		1983.29	613.17	1-Jun	8-Sep	16-Jun	4-Sep	2	0	23	233
(05J04S)	na	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)
Wild Basin		2403.48	965.79	25-May	26-Oct	26-May	13-Oct	3	0	9	196
(05J05S)	na	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)
Willow Park		1313.39	193.23	10-Jul	13-Oct	10-Jul	3-Sep	0	0	17	240
(05J40S)	na	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)

Note: (-) temperature data or published averages are missing. SNOTEL temperatures used to describe current year only and not departure from average.

Florissant Fossil Beds National Monument

2010 climate at a glance

- Total annual precipitation at Florissant Fossil Bed was 88% of average.
- Average annual maximum daily temperatures were near average and average annual minimum daily temperatures were 1.4°F warmer than average.
- The onset of spring and fall occurred 1 week earlier than average.
- Snow water equivalent measured on April 1 was 138% of average.
- Rapid snowmelt lead to higher than average peak flows in late April – early May
- Total annual runoff measured at the gauge on Four Mile Creek was 116% of average.

2010 climate data summary

This climate data summary report describes park-level climate at both a local (single weather station) and regional setting (gridded climate maps) using standard data summary and analysis tools described in the *Rocky Mountain Climate Protocol* (RMCWG 2010). Climate data that describe precipitation, temperature, streamflow and snowpack were gathered from key climate stations in or near Florissant Fossil Beds National Monument (FLFO) and summarized for this report. The climate stations cited in this report are shown in figure 30; station metadata are available in appendix A.

Total accumulated precipitation and minimum, maximum, and mean monthly temperatures and departures from an established baseline are summarized in figures and tables below. We consider recent events in a historical context, based primarily on a standard 30-year climatological reference or "normal" period (currently 1971–2000) which we refer to as an "average." The baseline period used to determine average conditions in this report for each climate station is included in the station metadata in appendix A.

A section on streamflow is included as streamflow integrates the combined effects of temperature and precipitation. Variables indicating the timing or length of a seasonal process (e.g., accumulated growing degree days, frosts, snowpack duration, and peak unregulated streamflow) are noted throughout the data summary report.

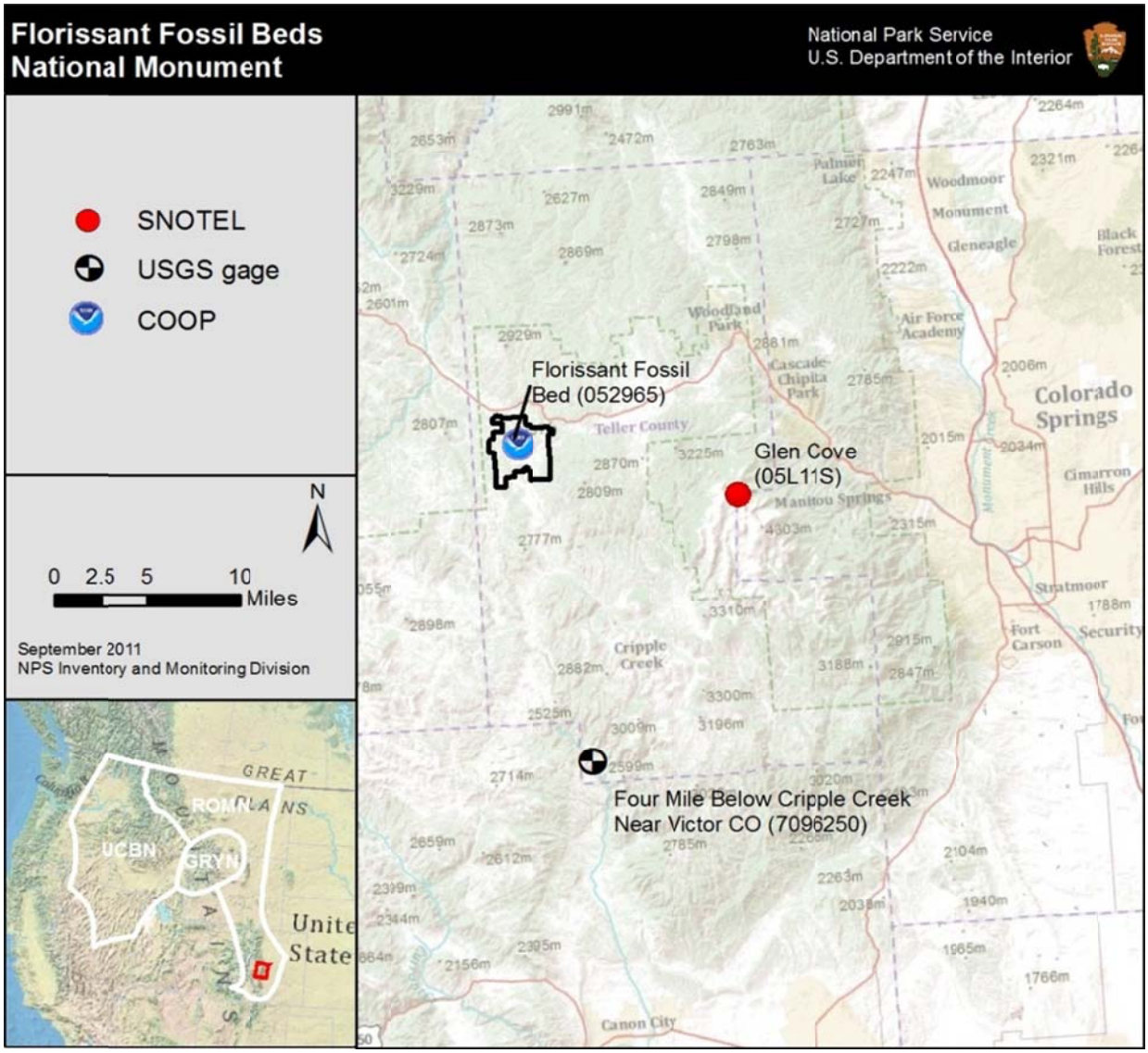


Figure 30. Map showing key climate and stream gauge stations in or near Florissant Fossil Beds National Monument in south central Colorado.

Gridded climate maps

Given the relatively sparse network of climate stations and complex topography of the area surround FLFO, regional color maps (figs. 21–23) showing month-to-month departure from average conditions for precipitation and temperature using PRISM data provide a visual overview of the climate in 2010. PRISM interpolates precipitation values between actual observation stations, and corrects these interpolated estimates for changes in topography across the region. For more information, see http://www.prism.oregonstate.edu/. Refer to the ROMN section for region-wide PRISM maps.

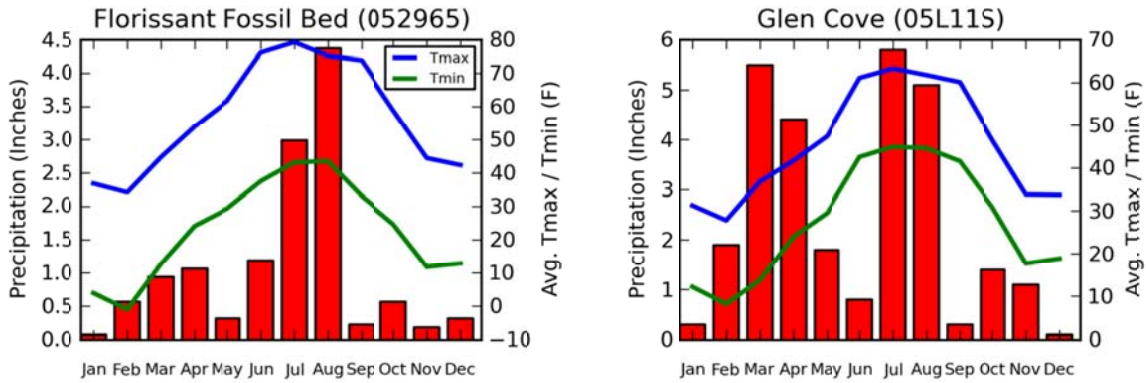


Figure 31. Monthly precipitation totals and average daily maximum temperature and average daily minimum temperatures during 2010 at key climate stations in or near Florissant Fossil Beds National Monument. The red bars show precipitation measured in inches.

Precipitation

Total annual precipitation

During 2010 the total annual accumulated precipitation at Florissant Fossil Bed was 88% of average. Total monthly precipitation values are shown in figure 31 and table 20.

Seasonal precipitation highlights

Winter precipitation started out below average in January and changed to above average conditions in February and March. Total monthly precipitation measured 0.52″ in February and was 187% of average. Based on average conditions, most of the annual precipitation in Florissant Fossil Bed comes during the spring (April–June) and summer (July–September) months. Spring precipitation started out below average with as little as 0.31″ measured in May (19% of average) and changed to above average conditions in July and August. A total of 34% of the annual precipitation came in August (4.37″) which is 145% of the monthly average. Monthly precipitation fell below average from September through November and increased to slightly above average in December. Departures from average, expressed as a percentage, are shown in figure 32 and table 20.

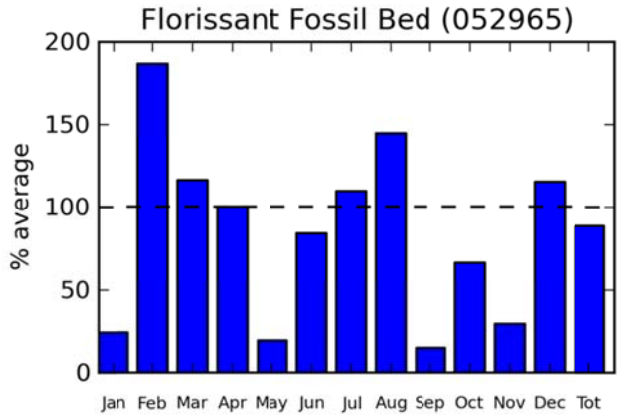


Figure 32. Departure of 2010 precipitation from 1971–2000 average at Florissant Fossil Bed Cooperative Observer Program (COOP) station in Florissant Fossil Beds National Monument.

Temperature

During 2010 average maximum daily temperatures were near average and average minimum daily temperatures were 1.4°F above average when averaged across the year (fig. 33; tables 21 and 22). Monthly average maximum and average minimum daily temperatures were mostly below average during the winter (January–March) and above average throughout spring (April–June) and summer (July and September). Temperatures during the fall (October–December) started out with below average maximum daily temperatures and turned to above average temperatures in December. Both the average minimum and maximum daily temperatures in February were >7°F below average, making February a cold month, whereas the average minimum daily temperatures the following December were > 9°F above average.

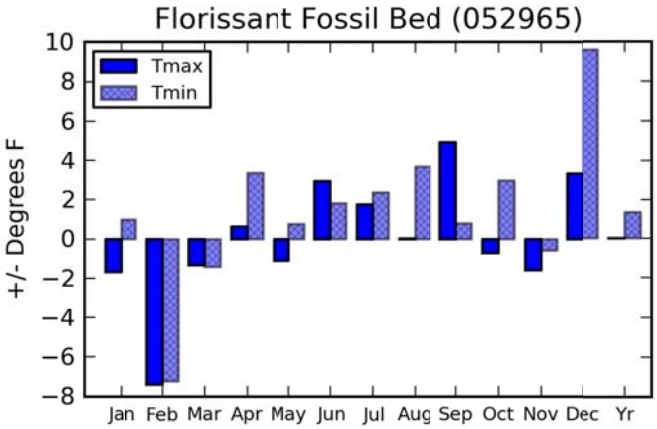


Figure 33. Departure of 2010 average minimum (Tmin) and average maximum (Tmax) daily temperatures from 1971–2000 average at Florissant Fossil Bed weather station in Florissant Fossil Beds National Monument.

Box plots of average maximum and average minimum daily temperatures that display data frequency distribution such as median, quartiles and outliers and are shown in figure 34.

Temperature thresholds

The onset of spring, defined as the last day when the minimum temperatures dropped below 28°F, was seven days earlier than average at Florissant Fossil Bed COOP station. The first day of fall, defined as the first day when minimum temperatures drop below 28°F, was six days earlier than average.

The number of hot days, defined as days where the maximum daily temperatures ≥ 90°F, were near average (+ 0.2°F) and the Florissant Fossil Bed COOP station reported no days ≥ 90°F in 2010. The number of frosty nights, defined as nights where the minimum temperatures ≤ 32°F, were within one day of average.

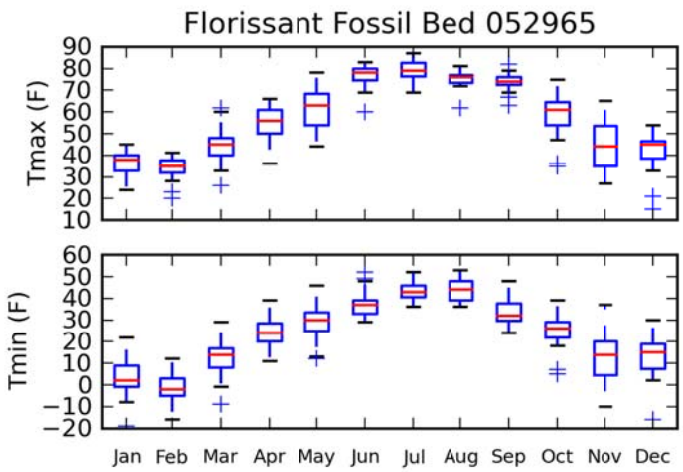


Figure 34. Box plots of average maximum and average minimum daily temperatures at Florissant Fossil Bed weather station in Florissant Fossil Beds National Monument during 2010. Horizontal lines indicate the median value. Boxes indicate the 25th and 75th percentiles. Whiskers extend 1.5 times the interquartile Range (IQR). Crosses indicate values exceeding 1.5 times the IQR.

The Western Regional Climate Center reported monthly records that were exceeded in 2010 (WRCC 2010) at Florissant Fossil Bed.

- The lowest monthly average minimum daily temperatures recorded in February 2010 at 16.6°F.
- The highest monthly average maximum daily temperature recorded in December 2010 at 27.6°F.

Tables with first and last freeze and frost dates, accumulated growing degree days, and days above or below critical temperature thresholds for key stations are shown in table 23.

Streamflow

The USGS monitors streamflow on Four Mile Creek south of FLFO. Total annual runoff in 2010 was 116% of average. Figure 35 and table 18 summarize the 2010 water year, which runs from October 2009 to September 2010.

Table 18. Total annual runoff in acre feet and percentage of average for a USGS Gauge Station near Florissant Fossil Bed National Monument (Data source: USGS Water Data Reports for 2010).

Station Name	Total annual runoff (ac-ft) 2010	Total annual runoff (ac-ft) average	Percent of average
Four Mile Creek below Cripple Creek near Victor, CO	16,470	14,200	116%

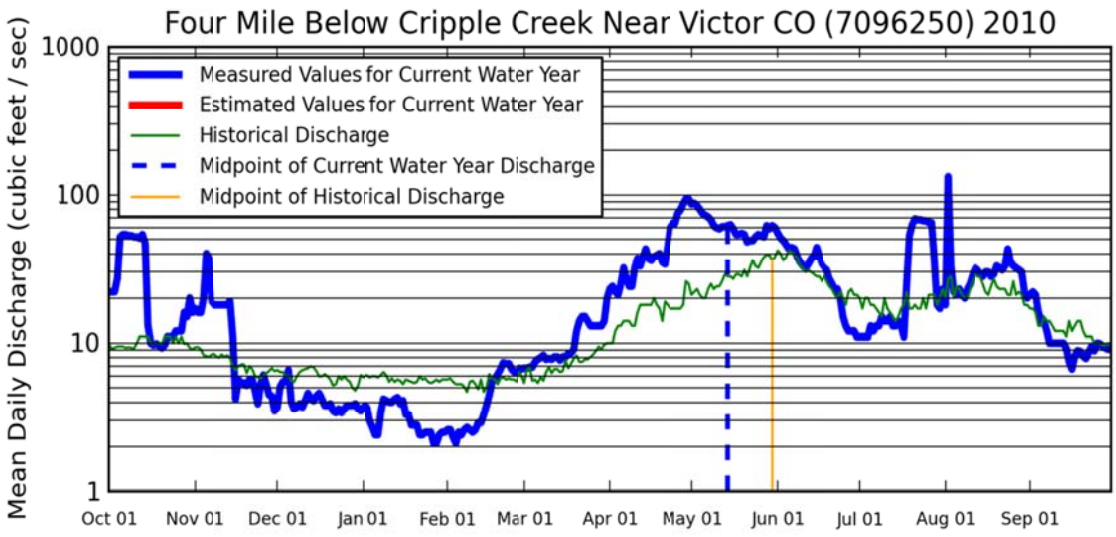


Figure 35. Streamflow from Four Mile Below Cripple Creek Near Victor CO gauge south of Florissant Fossil Bed National Monument for the 2010 water year (October 2009 through September 2010) is shown versus median daily flows for the period 1992–2010. Data courtesy of the U.S. Geological Survey.

Winter snowpack

The NRCS operates automated snow measurement (SNOTEL) stations throughout the western United States. These stations offer the best available means for tracking the accumulation and loss of snowpack. As measured in terms of SWE—the amount of liquid water held in a given volume of snow— snowpack was 138% average on April 1 Rapid snowmelt lead to higher than average peak flows in late April – early May (fig. 35).

The first day of the average month of maximum SWE is a key time of year for tracking if snowpack is decreasing and if runoff is earlier or later than average. At the SNOTEL station at Glen Cove, maximum SWE (11.1″) was reached on May 5. Daily measurements of SWE from Glen Cove are shown in figure 36.

Table 19. Snow water equivalent (SWE) (inches) on April 1 and maximum SWE measured at the Snowpack Telemetry station Glen Cove near Florissant Fossil Bed National Monument and percentages of average. Data courtesy of the Natural Resource Conservation Service. These provisional data are subject to change.

Snowpack Telemetry (SNOTEL)	SWE on April 1, 2010	% of April 1 average	2010 max SWE	Date of 2010 max SWE
Glen Cove	10.8	138%	11.1	5-May

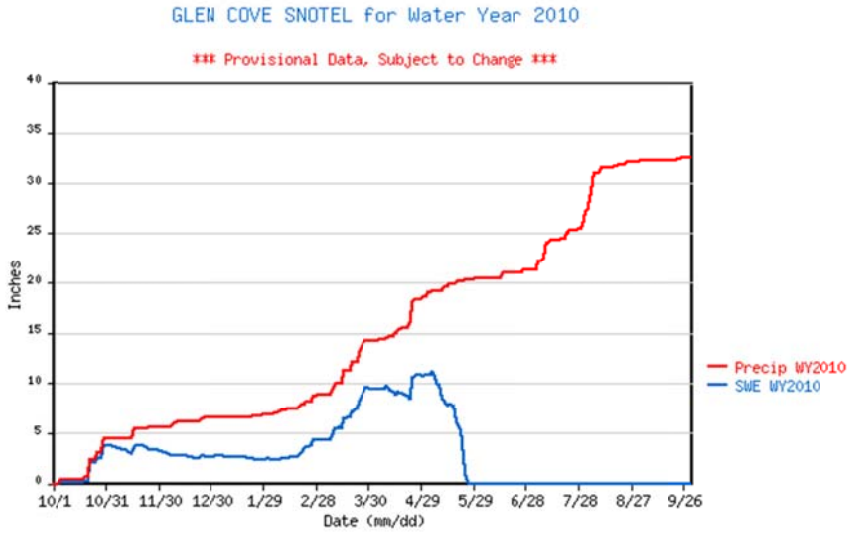


Figure 36. Daily measurements of snow water equivalent (SWE) and precipitation from Glen Cove (SNOTEL) near Florissant Fossil Bed National Monument from October 2009 to September 2010. NRCS averages were unavailable for this station. Data courtesy of the Natural Resource Conservation Service. These provisional data are subject to change.

Table 20. Total monthly precipitation in inches and percentage of average monthly precipitation versus 1971–2000 averages for select climate stations in or near Florissant Fossil Beds National Monument during 2010

Station Name (ID)		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Total
Florissant Fossil Bed (52965)		0.07	0.56	0.94	1.06	0.31	1.19	2.99	4.37	0.22	0.56	0.18	0.31	12.76
	% of 30-yr avg.	24	187	116	100	19	84	110	145	15	67	30	115	88
Glen Cove (05L11S)		0.3	1.9	5.5	4.4	1.8	0.8	5.8	5.1	0.3	1.4	1.1	0.1	28.5
	na	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)

Note: Percentages of average monthly precipitation versus 1971–2000 averages are given in the second line of data for each station. Station IDs are from NWS Cooperative Observer Program (COOP) stations and NRCS Snowpack Telemetry (SNOTEL) stations. Monthly statistics are not reported if more than three days of data are missing. Individual months are not used for calculating annual statistics if more than five days of data are missing.

(-) Indicates missing data.

Table 21. Average maximum daily temperatures in degrees Fahrenheit for select climate stations in or near Florissant Fossil Beds National Monument during 2010. Departures from 1971–2000 averages are given in the second line of data for each station expressed as +/- degrees F.

Station Name (ID)		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Florissant Fossil Bed (52965)		36.81	34.18	44.68	53.93	61.71	76.13	79.26	75.13	73.83	58.87	44.43	42.32	56.77
	Departure (+/- F)	-1.69	-7.42	-1.32	0.63	-1.09	2.93	1.76	0.03	4.93	-0.73	-1.57	3.32	-0.03
Glen Cove (05L11S)		31.32	27.85	36.88	41.74	47.47	61.11	63.32	61.79	60.13	46.61	33.89	33.77	45.49
	Departure (+/- F)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)

Note: Monthly average maximum daily temperature departures from 1971–2000 averages are given in the second line of data for each station in degrees Fahrenheit.

Station IDs are from NWS Cooperative Observer Program (COOP) stations and NRCS Snowpack Telemetry (SNOTEL) stations. Monthly statistics are not reported if more than five days of data are missing. Individual months are not used for calculating annual statistics if more than five days of data are missing.

(-) Indicates missing data. SNOTEL temperatures are used to describe current year and not departure from average.

Table 22. Average minimum daily temperatures in degrees Fahrenheit for select climate stations in or near Florissant Fossil Beds National Monument during 2010. Departures from 1971–2000 averages are given in the second line of data for each station expressed as +/- degrees F.

Station Name (ID)		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Florissant Fossil Bed (052965)		3.87	-1.04	12.68	24.13	29.35	37.5	43.16	43.48	33.1	24.65	11.8	12.87	22.96
	Departure (+/- F)	0.97	-7.24	-1.42	3.33	0.75	1.8	2.36	3.68	0.8	2.95	-0.6	9.57	1.36
Glen Cove (05L11S)		12.25	8.25	13.86	24.07	29.57	42.57	44.98	44.63	41.61	30.97	17.76	18.91	27.45
	na	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)

Note: Monthly average minimum daily temperature departures from 1971–2000 averages are given in the second line of data for each station in degrees Fahrenheit. Station IDs are from NWS Cooperative Observer Program (COOP) stations and NRCS Snowpack Telemetry (SNOTEL) stations. Monthly statistics are not reported if more than five days of data are missing. Individual months are not used for calculating annual statistics if more than five days of data are missing.

(-) Indicates missing data. SNOTEL temperatures used to describe current year only and not departure from average.

Table 23. First and last freeze and frost dates, accumulated growing degree days, and days above or below critical temperature thresholds for key stations in or near Florissant Fossil Beds National Monument during 2010. Values for 2010 are shown in the first line for each station. 1988-2010 averages appear in the second line for the NWS COOP station.

Station Name (ID)		AGDD40	AGDD50	Last date in spring <= 28F	Earliest date in fall <=28	Last date in spring <=32	Earliest date in fall <=32	# of days Tmax		# of days Tmin	
								>= 80 F	>= 90 F	<= 0 F	<= 32 F
Florissant Fossil Bed (052965)		2566.5	1005.5	25-May	7-Sep	23-Jun	2-Sep	22	0	39	251
	11-yr avg.	2363	831	3-Jun	13-Sep	23-Jun	2-Sep	(-)	0.2	34.9	249.7
Glen Cove (05L11S)		1683.6	401.4	17-May	14-Oct	16-Jun	9-Oct	0	0	13	210
	na	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)

Note: (-) temperature data or published averages are missing. SNOTEL temperatures used to describe current year only and not departure from average.

Great Sand Dunes National Park and Preserve

2010 climate at a glance

- Total annual precipitation was 85% of average at Great Sand Dunes NM and 69% to 74% of average at all other stations.
- Average annual maximum daily temperatures were near average at Great Sand Dunes NM.
- Average annual minimum daily temperatures were 2.61°F warmer than average at Great Sand Dunes NM.
- The on-set of spring was near average at Great Sand Dunes NM whereas the on-set of fall was 19 days later than average.
- Maximum snow water equivalent was above average at all stations.
- The timing of maximum SWE was earlier than average at Ute Creek and near or later than average at South Colony and Medano Pass.
- Melt out dates were earlier than average by 1 to 3 weeks.

2010 climate data summary

This climate data summary report describes park-level climate at both a local (single weather station) and regional setting (gridded climate maps) using standard data summary and analysis tools described in the *Rocky Mountain Climate Protocol* (RMCWG 2010). Climate data that describe precipitation, temperature, streamflow, and snowpack were gathered from key climate stations in or near Great Sand Dunes National Park and Preserve (GRSA) and summarized for this report. Climate stations cited in this report are shown in figure 37; station metadata are available in appendix A.

Total accumulated precipitation and minimum, maximum, and mean monthly temperatures and departures from an established baseline are summarized in figures and tables below. We consider recent events in a historical context, based primarily on a standard 30-year climatological reference or "normal" period (currently 1971–2000) which we refer to as an "average." The baseline period used to determine average conditions in this report for each climate station is included in the station metadata in appendix A.

Monthly precipitation totals and average maximum and average minimum daily temperatures and their departures from average are summarized in figures and tables presented in the sections on precipitation and temperature. Sections on snowpack and streamflow are included as they integrate the combined effects of temperature and precipitation. Variables indicating the timing or length of a seasonal process (e.g., accumulated growing degree days, frosts, snowpack duration, and peak unregulated streamflow) are noted throughout the data summary report.

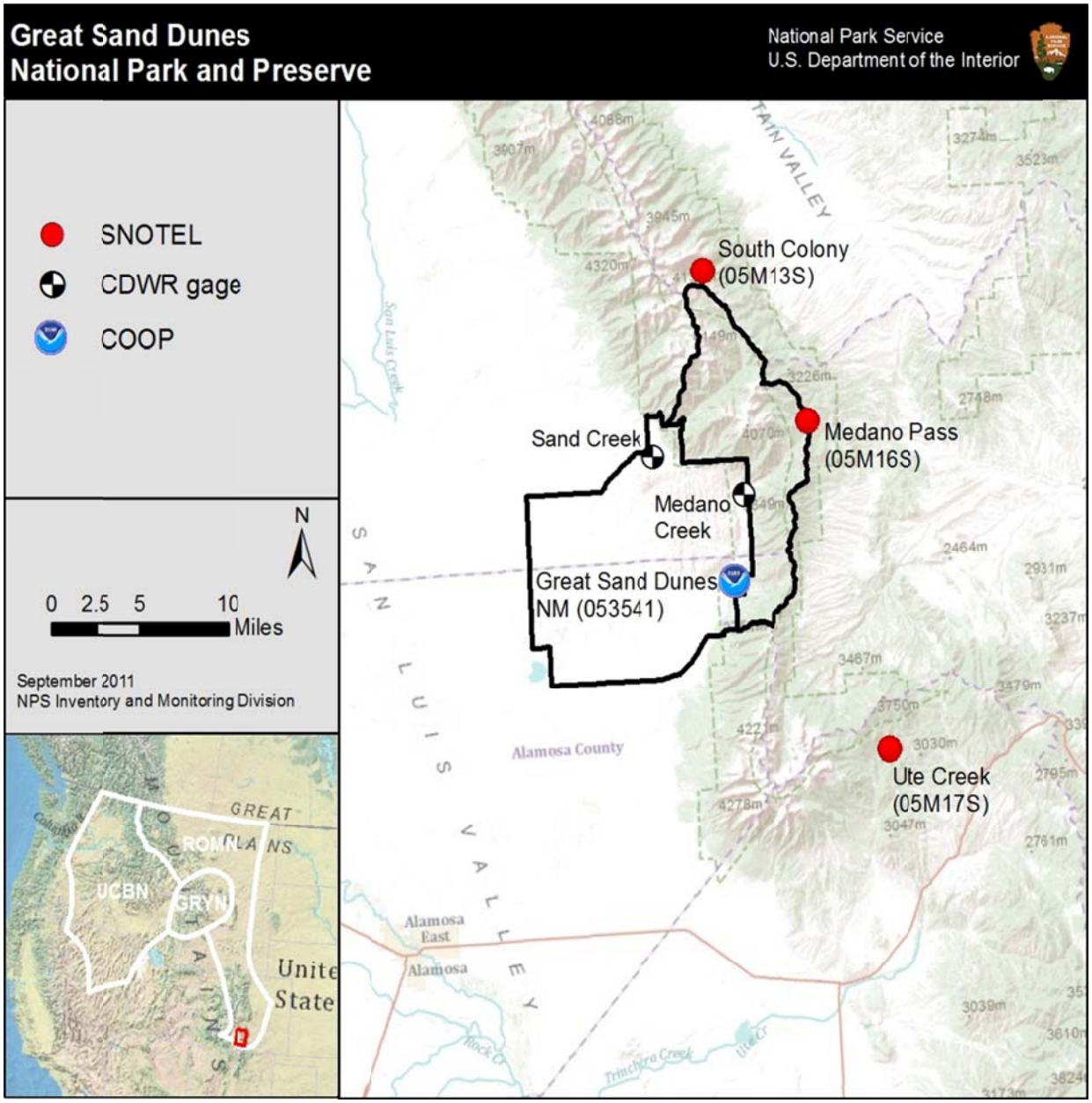


Figure 37. Map showing key climate and Colorado Division of Water Resources (CDWR) stream gauge stations in or near Great Sand Dunes National Park and Preserve in Colorado.

Gridded climate maps

Given the relatively sparse network of climate stations and complex topography of the area, regional color maps (figs. 21–23) showing month-to-month departure from average conditions for precipitation and average minimum and maximum temperatures using PRISM data provide a visual overview of the climate in 2010. PRISM interpolates precipitation values between actual observation stations, and corrects these interpolated estimates for changes in topography across the region. For more information, see http://www.prism.oregonstate.edu/. Refer to the ROMN section for region-wide PRISM maps.

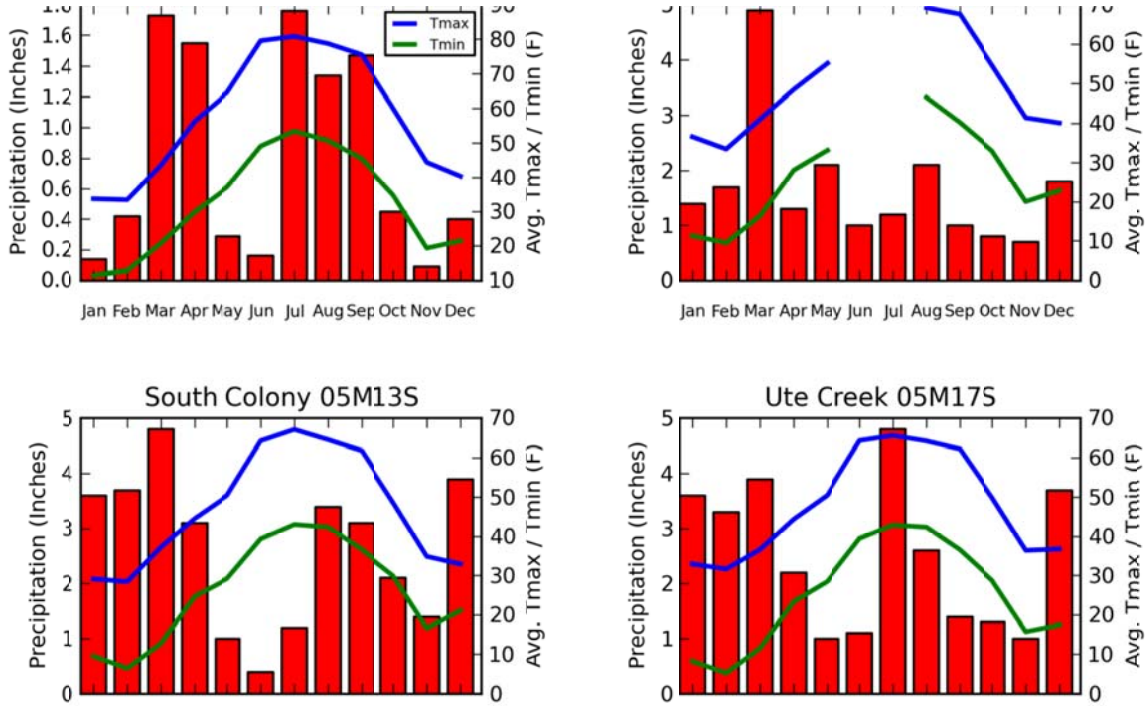


Figure 38. Monthly precipitation totals and average daily maximum and average daily minimum temperatures during 2010 at key climate stations in or near Great Sand Dunes National Park and Preserve. The red bars show precipitation measured in inches.

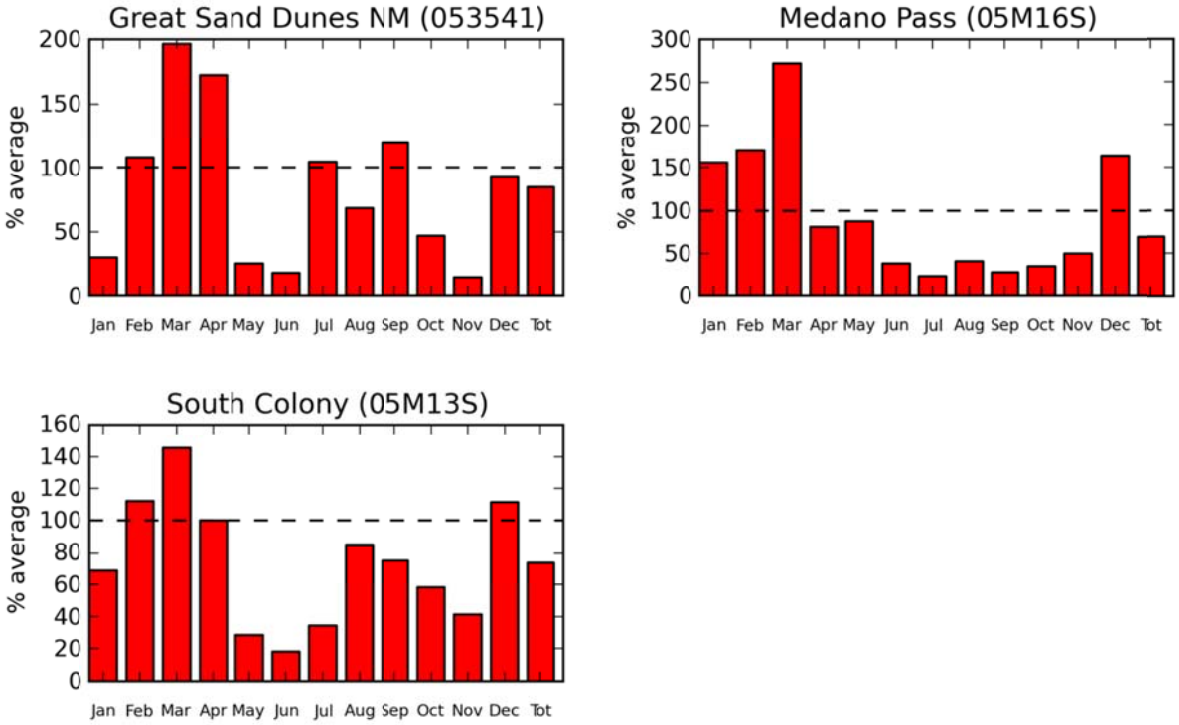


Figure 39. Departure of 2010 precipitation from 1971–2000 average at key climate stations in or near Great Sand Dunes National Park and Preserve.

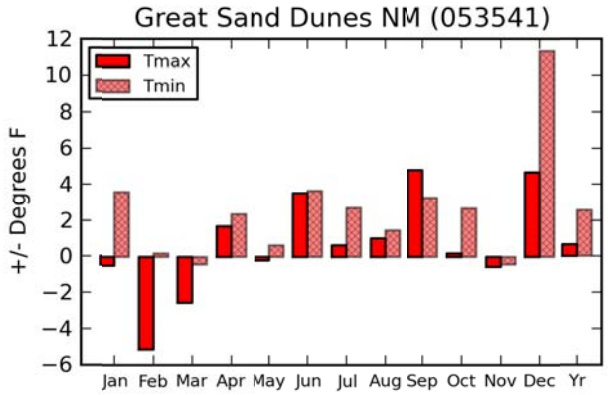


Figure 40. Departure of 2010 average minimum (Tmin) and average maximum (Tmax) daily temperatures from 1971–2000 average at Great Sand Dunes NM (053541) in Great Sand Dunes National Park and Preserve.

Precipitation

Total annual precipitation

During 2010 the climate station Great Sand Dunes NM in GRSA reported a total annual precipitation of 9.8″ which is 85% of average. Total monthly precipitation is shown in figure 38 and table 25.

Seasonal precipitation highlights

Winter started with below average precipitation in January and then switched to above average precipitation in February and March. Precipitation in the spring (April–June), summer (July–September) and early fall (October–November) was mostly below average with exceptions in GRSA where precipitation in April was 172% of average and in July 104% of average. Late fall (December) precipitation was below average at Great Sand Dunes NM and above average at the Medano Pass and South Colony SNOTEL stations. Departures from average, expressed as a percentage, are shown in figure 39 and table 25.

Temperature

During 2010, the average maximum daily temperature was near average, and the average minimum daily temperature was 2.56°F above average when averaged across the year (fig. 40 and tables 26 and 27). Monthly average maximum and average minimum daily temperatures were below average in the winter (January–March) and above average in the spring (April–June). The average maximum daily temperature in February was 5.16°F cooler than average. Both the average maximum and average minimum daily temperatures were above average during the summer (July–September) months and stayed above average thru October. Temperatures in November were near or slightly below average and in December temperatures were above average. The average minimum daily temperature in December was 11.32°F warmer than average.

Box plots of average maximum and average minimum daily temperatures that display data frequency distribution such as median, quartiles, and outliers are shown in figure 41.

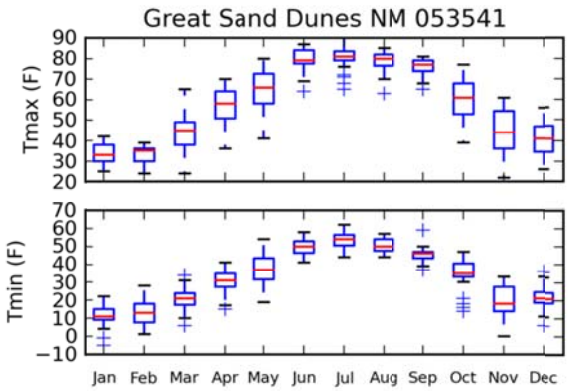


Figure 41. Box plots of average maximum and average minimum daily temperatures at Great Sand Dunes National Park and Preserve during 2010. Horizontal lines indicate the median value. Boxes indicate the 25th and 75th percentiles. Whiskers extend 1.5 times the interquartile Range (IQR). Crosses indicate values exceeding 1.5 times the IQR.

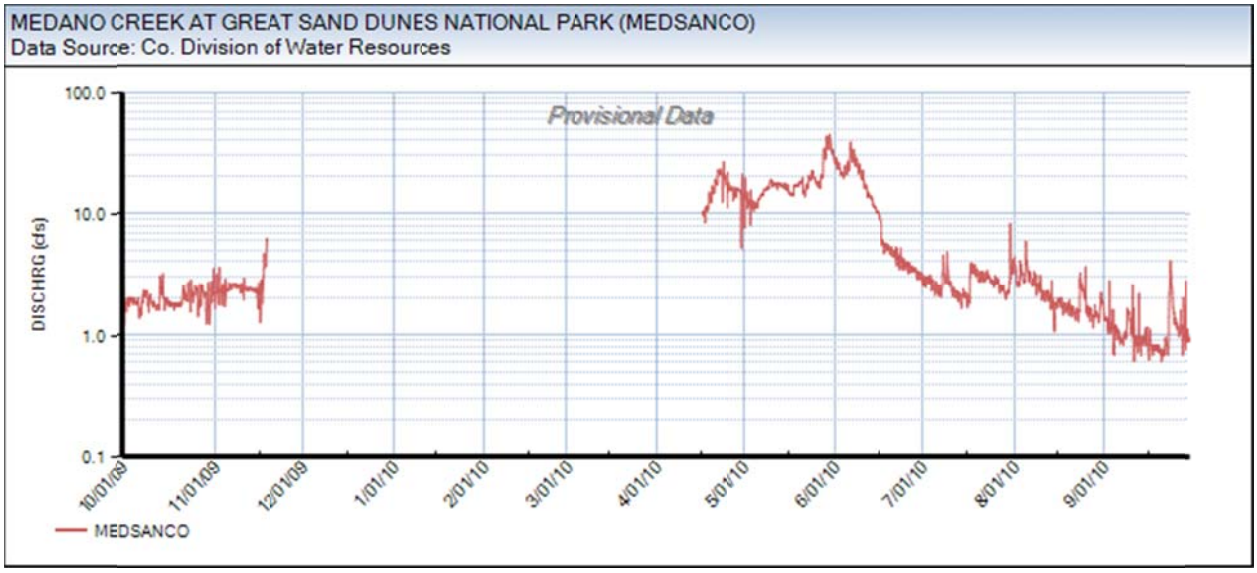
Temperature thresholds

The onset of spring, defined as the last day when the minimum temperature dropped below 28°F, was near average at Great Sand Dunes NM climate station. At the same location, the first day of fall, defined as the first day when minimum temperatures drop below 28°F, was later in 2010 by 19 days. The number of hot days, defined as days where the maximum daily temperatures ≥ 90°F, were near average. The number of frosty nights, defined as nights where the minimum temperatures were ≤ 32°F, was two weeks fewer than average. The first and last freeze and frost dates, accumulated growing degree days, and days above or below critical temperature thresholds for key stations in reporting area are show in table 28.

The Western Regional Climate Center reported that no daily or monthly records were exceeded in 2010 (WRCC 2010) at Great Sand Dunes NM.

Streamflow

The Colorado Division of Water Resources (CDWR) monitors streamflow from early spring to late fall at two locations in GRSA. Figure 42 shows the 2010 water year (October 2009 to September 2010) at Medano Creek and Sand Creek at GRSA



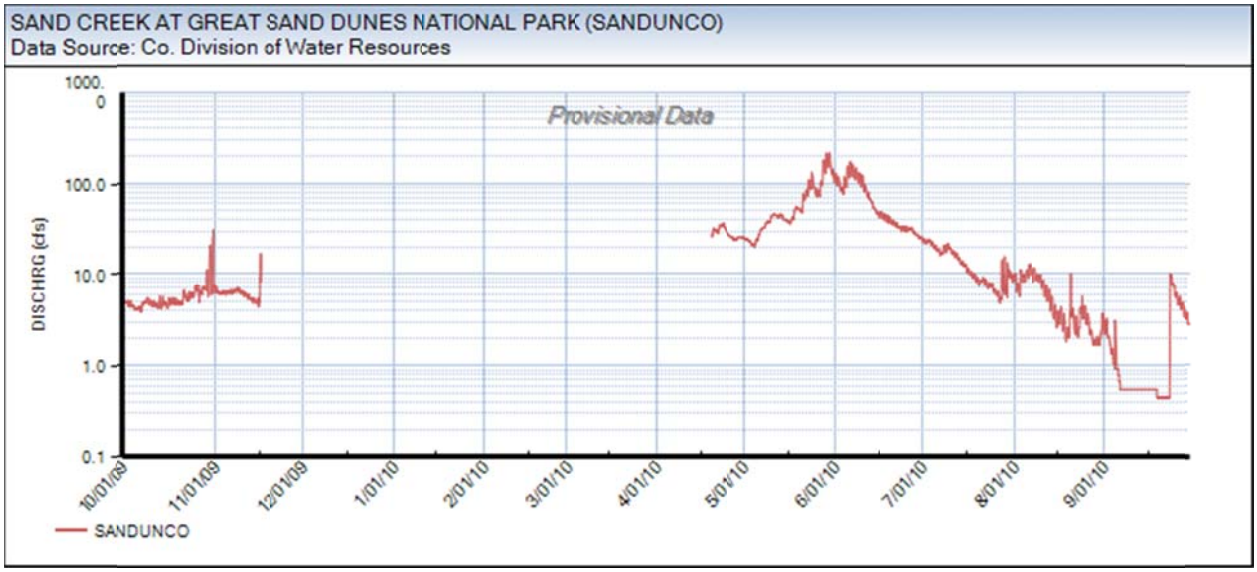


Figure 42. Seasonal streamflow from Medano and Sand Creek gauge stations in Great Sand Dunes National Park and Preserve for the 2010 water year (October 2009 through September 2010). Median daily flows were not available for these gauge stations. Graphs courtesy the Colorado Division of Water Resources (CDWR). Data from CDWR are provisional and subject to revision.

Winter snowpack

The NRCS operates automated snow measurement (SNOTEL) stations throughout the western United States. These stations offer the best available means for tracking the accumulation and loss of snowpack. As measured in terms of SWE—the amount of liquid water held in a given volume of snow—snowpack was above average during the 2010 water year (table 24; fig. 43). The timing of maximum SWE was earlier than average at Ute Creek and near or later than average at South Colony and Medano Pass. Melt out dates were earlier than average by 1 to 3 weeks. Daily measurements of SWE and precipitation from representative sites near GRSA are shown in figure 43.

Amounts of SWE at key times of year such as the first day of the month of maximum snowpack help determine if snowpack is decreasing and if runoff is earlier than average. Maximum SWE at Ute Creek and Medano Pass was reached March 29, 2010, which is earlier than average at Ute Creek and later than average at Medano Pass. Maximum SWE at South Colony was reached April 30 which is near average. Although SWE on March 1 was only 74% of average at Medano Pass, storms later in March added to the snowpack and maximum SWE was above average.

Table 24. Snow water equivalent (SWE) (inches) on March 1 and April 1 and maximum SWE from Snowpack Telemetry stations near Great Sand Dunes National Park and Preserve and percentages of average. Data courtesy of the Natural Resource Conservation Service. These provisional data are subject to change.

Snowpack Telemetry (SNOTEL)	SWE on April 1, 2010	% of April 1 average	2010 max SWE	Date of 2010 max SWE
South Colony	20.6	114%	21.6	30-Apr
Ute Creek	19	136%	19.4	29-Mar
	SWE on March 1, 2010	**% of March 1 average**	**2010 max SWE**	**Date of 2010 max SWE**
Medano Pass	4.3	74%	9.3	29-Mar

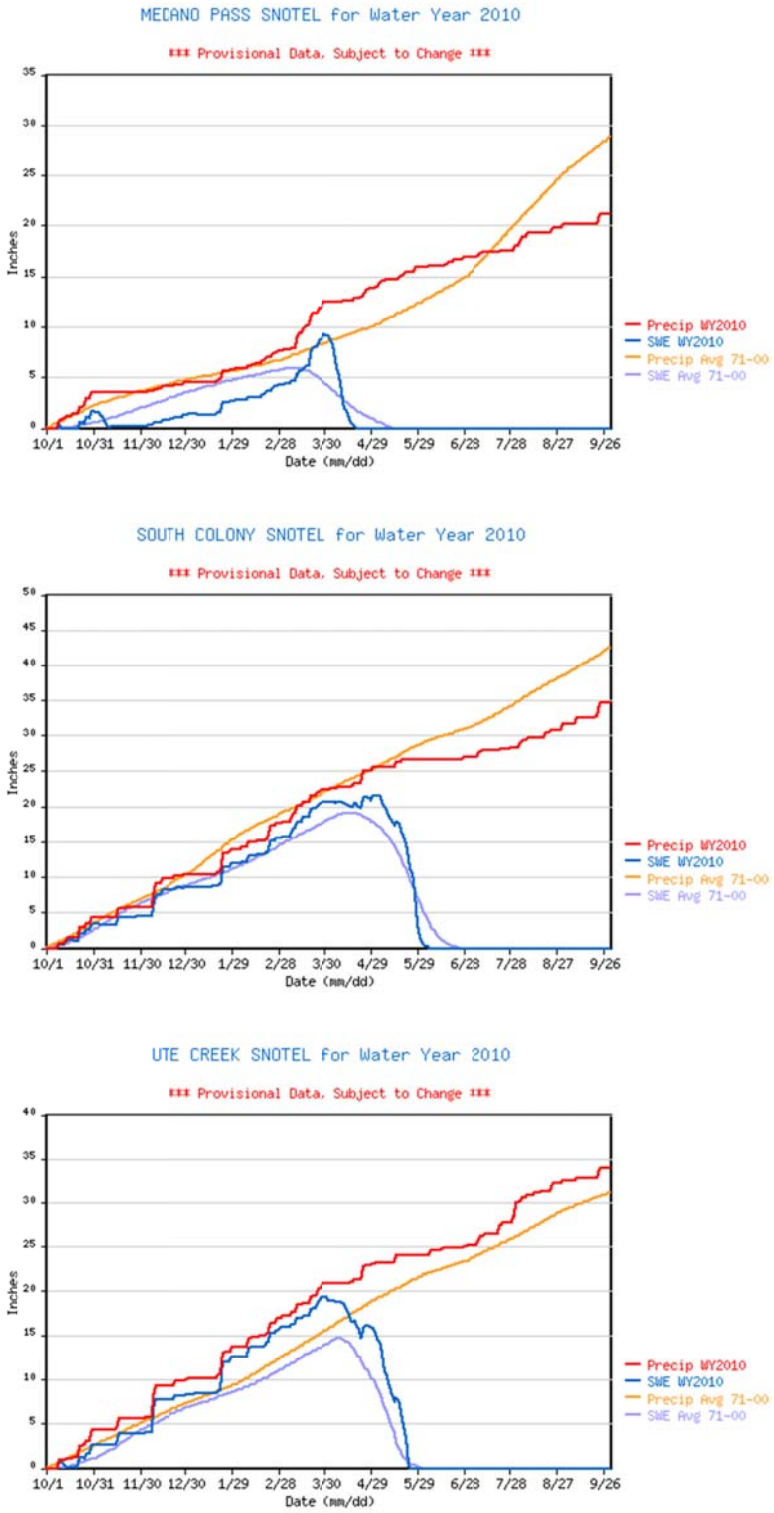


Figure 43. Daily measurements of snow water equivalent (SWE) and precipitation from representative sites near Great Sand Dunes National Park and Preserve from October 2009 to September 2010. Values are compared to averages from the 1971–2000 period. Data courtesy of the Natural Resource Conservation Service. These provisional data are subject to change.

Table 25. Total monthly precipitation in inches and percentage of average monthly precipitation versus 1971–2000 averages for select climate stations in or near Great Sand Dunes National Park and Preserve during 2010

Station Name (ID)		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Total
Great Sand Dunes NM (053541)		0.14	0.42	1.73	1.55	0.29	0.16	1.76	1.34	1.47	0.45	0.09	0.4	9.8
	% of 30-yr avg.	30	108	197	172	26	18	104	69	120	47	15	93	85
Medano Pass (05M16S)		1.4	1.7	4.9	1.3	2.1	1	1.2	2.1	1	0.8	0.7	1.8	20
	% of 30-yr avg.	156	170	272	81	88	38	24	41	28	35	50	164	69
South Colony (05M13S)		3.6	3.7	4.8	3.1	1	0.4	1.2	3.4	3.1	2.1	1.4	3.9	31.7
	% of 30-yr avg.	69	112	145	100	29	18	34	85	76	58	41	111	74
Ute Creek (05M17S)		3.6	3.3	3.9	2.2	1	1.1	4.8	2.6	1.4	1.3	1	3.7	29.9
	% of 30-yr avg.	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)

Note: Percentages of average monthly precipitation versus 1971–2000 averages are given in the second line of data for each station. Station IDs are from NWS Cooperative Observer Program (COOP) and NRCS Snowpack Telemetry (SNOTEL) stations. Monthly statistics are not reported if more than three days of data are missing. Individual months are not used for calculating annual statistics if more than five days of data are missing.

(-) Indicates missing data.

Table 26. Average maximum daily temperatures in degrees Fahrenheit for select climate stations in or Great Sand Dunes National Park and Preserve during 2010. Departures from 1971–2000 averages are given in the second line of data for each station expressed as +/- degrees F.

Station Name (ID)		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Great Sand Dunes NM (053541)		33.81	33.54	43.61	56.3	64.61	79.57	80.84	78.74	75.53	60.1	44.47	40.42	57.63
	Departure (+/- F)	-0.49	-5.16	-2.59	1.7	-0.19	3.47	0.64	1.04	4.73	0.2	-0.53	4.62	0.63
Medano Pass (05M16S)		36.65	33.52	41.03	48.55	55.19	(-)	(-)	69.23	67.63	54.66	41.43	40.13	(-)
	Departure (+/- F)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)
South Colony (05M13S)		29.18	28.5	37.31	44.62	50.52	64.3	67.15	64.57	61.8	48.68	34.93	32.98	47.04
	Departure (+/- F)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)
Ute Creek (05M17S)		32.99	31.72	36.67	44.45	50.56	64.35	65.64	64.24	62.23	49.94	36.49	36.8	48.01
	Departure (+/- F)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)

Note: Monthly average maximum daily temperature departures from 1971–2000 averages are given in the second line of data for each station in degrees Fahrenheit.

Station IDs are from NWS Cooperative Observer Program (COOP) stations and NRCS Snowpack Telemetry (SNOTEL) stations. Monthly statistics are not reported if more than five days of data are missing. Individual months are not used for calculating annual statistics if more than five days of data are missing.

(-) Indicates missing data. SNOTEL temperatures are used to describe current year and not departure from average.

Table 27. Average minimum daily temperatures in degrees Fahrenheit for select climate stations in or near Great Sand Dunes National Park and Preserve during 2010. Departures from 1971–2000 averages are given in the second line of data for each station expressed as +/- degrees F.

Station Name (ID)		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Great Sand Dunes NM (053541)		11.52	12.89	20.87	29.97	37.23	49.17	53.52	50.77	45.5	34.9	19.4	21.52	32.27
	Departure (+/- F)	3.52	0.19	-0.43	2.37	0.63	3.57	2.72	1.47	3.2	2.7	-0.4	11.32	2.57
Medano Pass (05M16S)		11.36	9.58	16.44	28.15	33.23	(-)	(-)	46.56	40.24	33.06	20.1	22.94	(-)
	Departure (+/- F)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)
South Colony (05M13S)		9.6	6.5	12.83	24.74	29.27	39.41	43.12	42.45	36.7	29.98	16.68	21.15	26.04
	Departure (+/- F)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)
Ute Creek (05M17S)		8.33	5.31	11.58	23.42	28.54	39.52	42.99	42.44	36.63	28.81	15.79	17.51	25.07
	Departure (+/- F)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)

Note: Monthly average minimum daily temperature departures from 1971–2000 averages are given in the second line of data for each station in degrees Fahrenheit. Station IDs are from NWS Cooperative Observer Program (COOP) stations and NRCS Snowpack Telemetry (SNOTEL) stations. Monthly statistics are not reported if more than five days of data are missing. Individual months are not used for calculating annual statistics if more than five days of data are missing.

(-) Indicates missing data. SNOTEL temperatures used to describe current year only and not departure from average.

Table 28. First and last freeze and frost dates, accumulated growing degree days, and days above or below critical temperature thresholds for key stations in or near Great Sand Dunes National Park and Preserve during 2010. Values for 2010 are shown in the first line for each station and averages on the second line. Averages are published by the Western Regional Climate Center and the reference period for Great Sand Dunes NM is 1950–2010.

Station Name (ID)		AGDD40	AGDD50	Last date in spring <= 28F	Earliest date in fall <=28	Last date in spring <=32	Earliest date in fall <=32	# of days Tmax		# of days Tmin	
								>= 80 F	>= 90 F	<= 0 F	<= 32 F
Great Sand Dunes NM (053541)		3781.5	1949	12-May	26-Oct	25-May	9-Oct	57	1	3	180
	avg.	3425	1610	13-May	7-Oct	26-May	23-Sep	(-)	0.8	12.8	195
Medano Pass (05M16S)		(-)	(-)	14-May	11-Oct	26-May	10-Oct	0	0	6	194
	avg.	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)
South Colony (05M13S)		1665.61	384.12	17-May	10-Oct	16-Jun	8-Sep	0	0	19	217
	avg.	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)
Ute Creek (05M17S)		1653.66	364.41	17-May	14-Oct	15-Jun	8-Sep	0	0	10	232
	avg.	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)

Note: (-) temperature data or published averages are missing. SNOTEL temperatures used to describe current year only and not departure from average.

Glacier National Park

2010 climate at a glance

- Total annual precipitation ranged from 77% of average at Badger Pass to 127% of average at Noisy Basin.
- Average annual maximum daily temperatures were below average at all stations and 7.7°F below average at St Mary.
- Average annual minimum daily temperatures were 1.5 to 2.2°F above average, depending on station.
- The on-set of spring was 6 days later than average at St. Mary, 13 days later than average at West Glacier and 10 days earlier than average at East Glacier.
- Maximum snow water equivalent was below average except at Stahl Peak which had above average snow water equivalent.
- Maximum SWE was reached near average to later than average in the spring. Melt out dates were near average to earlier than average by 1 to 4 weeks.
- Despite below average maximum temperatures in early summer, rapid snowmelt lead to higher than average peak flows during June and July.
- Total annual runoff measured at the gauge stations on the St Mary River, Swiftcurrent Creek and the NF and MF of the Flathead River were between 81% and 89% of average.

2010 climate data summary

This climate data summary report describes park-level climate at both a local (single weather station) and regional setting (gridded climate maps) using standard data summary and analysis tools described in the *Rocky Mountain Climate Protocol* (RMCWG 2010). Climate data that describe precipitation, temperature, streamflow, and snowpack were gathered from key climate stations in or near Glacier National Park (GLAC) and summarized for this report. The climate stations cited in this report are shown in figure 44; station metadata are available in appendix A.

Total accumulated precipitation and minimum, maximum, and mean monthly temperatures and departures from an established baseline are summarized in figures and tables below. We consider recent events in a historical context, based primarily on a standard 30-year climatological reference or "normal" period (currently 1971–2000) which we refer to as an "average." The baseline period used to determine average conditions in this report for each climate station is included in the station metadata in appendix A. Sections on snowpack and streamflow are included as they integrate the combined effects of temperature and precipitation. Variables indicating the timing or length of a seasonal process (e.g., accumulated growing degree days, frosts, snowpack duration, and peak unregulated streamflow) are noted throughout the data summary report.

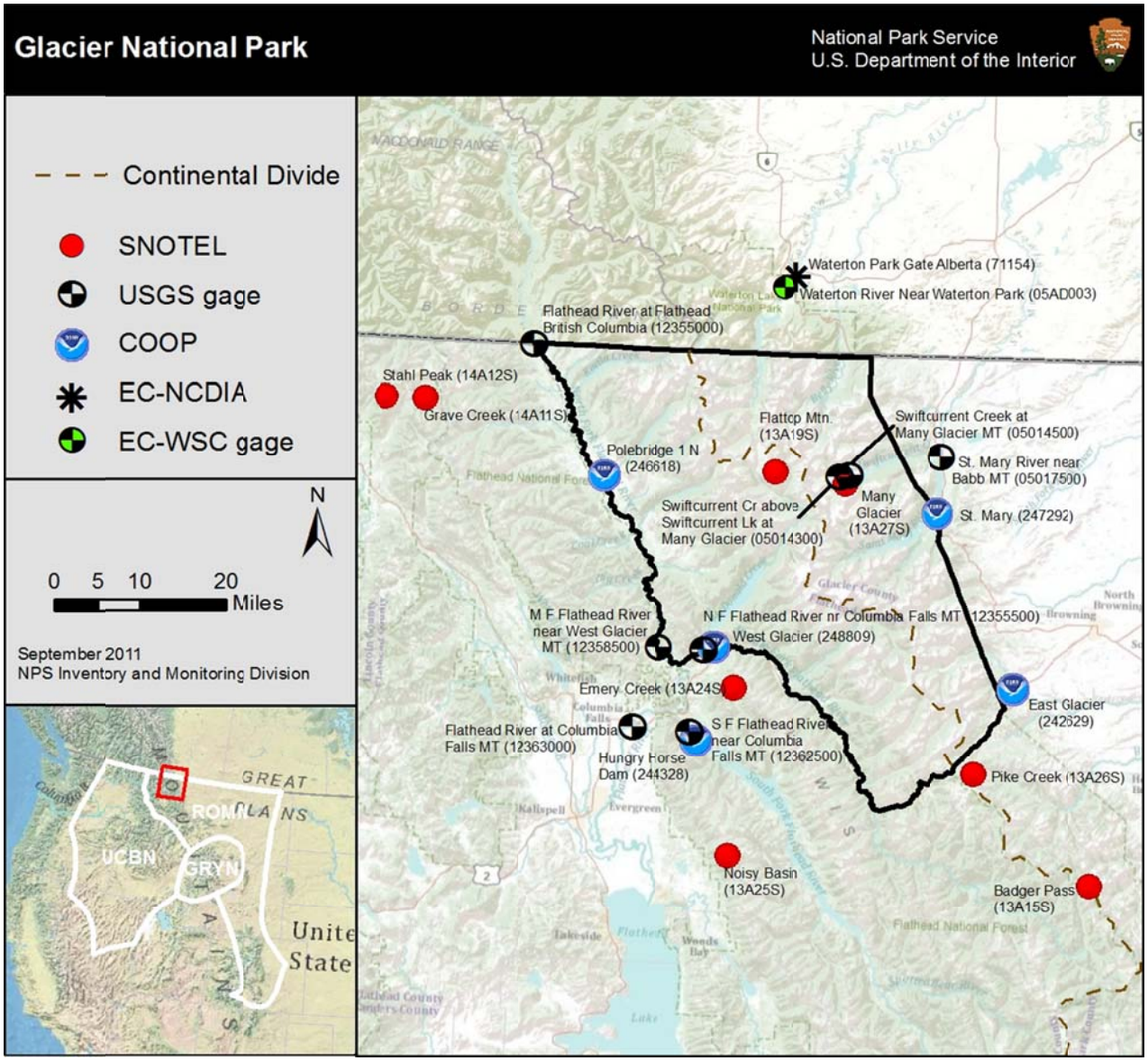


Figure 44. Map showing key climate and stream gauge stations in or near Glacier National Park, Montana.

Gridded climate maps

Given the relatively sparse network of climate stations and complex topography of the area surround GLAC, regional color maps (figs. 45–47) showing month-to-month departure from average conditions for precipitation and temperature using PRISM data provide a visual overview of the climate in 2010. PRISM interpolates precipitation values between actual observation stations, and corrects these interpolated estimates for changes in topography across the region. For more information, see http://www.prism.oregonstate.edu/.

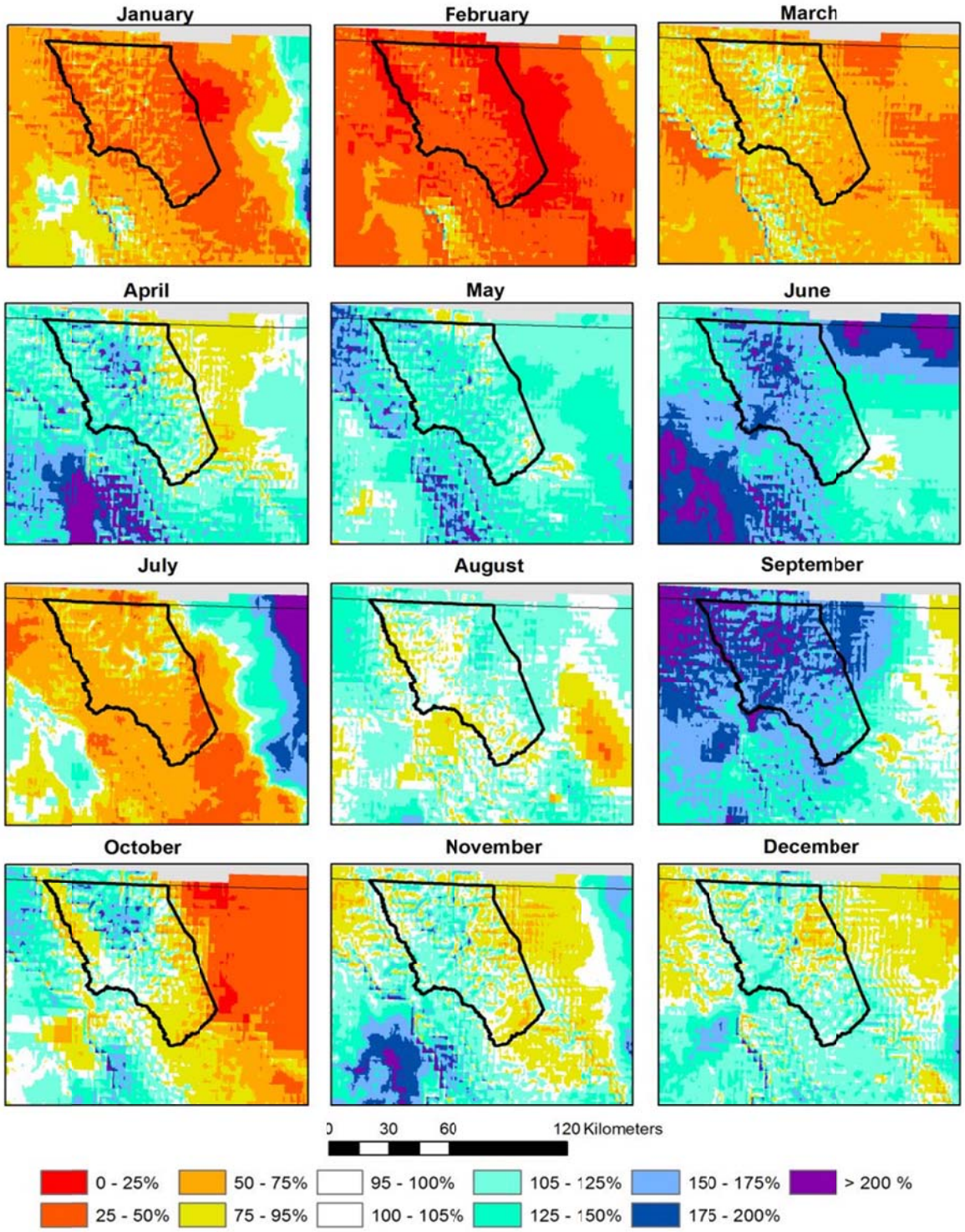


Figure 45. Maps showing percent of average precipitation versus 1971–2000 for each month in calendar year 2010 in the area surrounding Glacier National Park in northern Montana. Colors show estimates from the Parameter-elevation Regressions on Independent Slopes Model (PRISM).

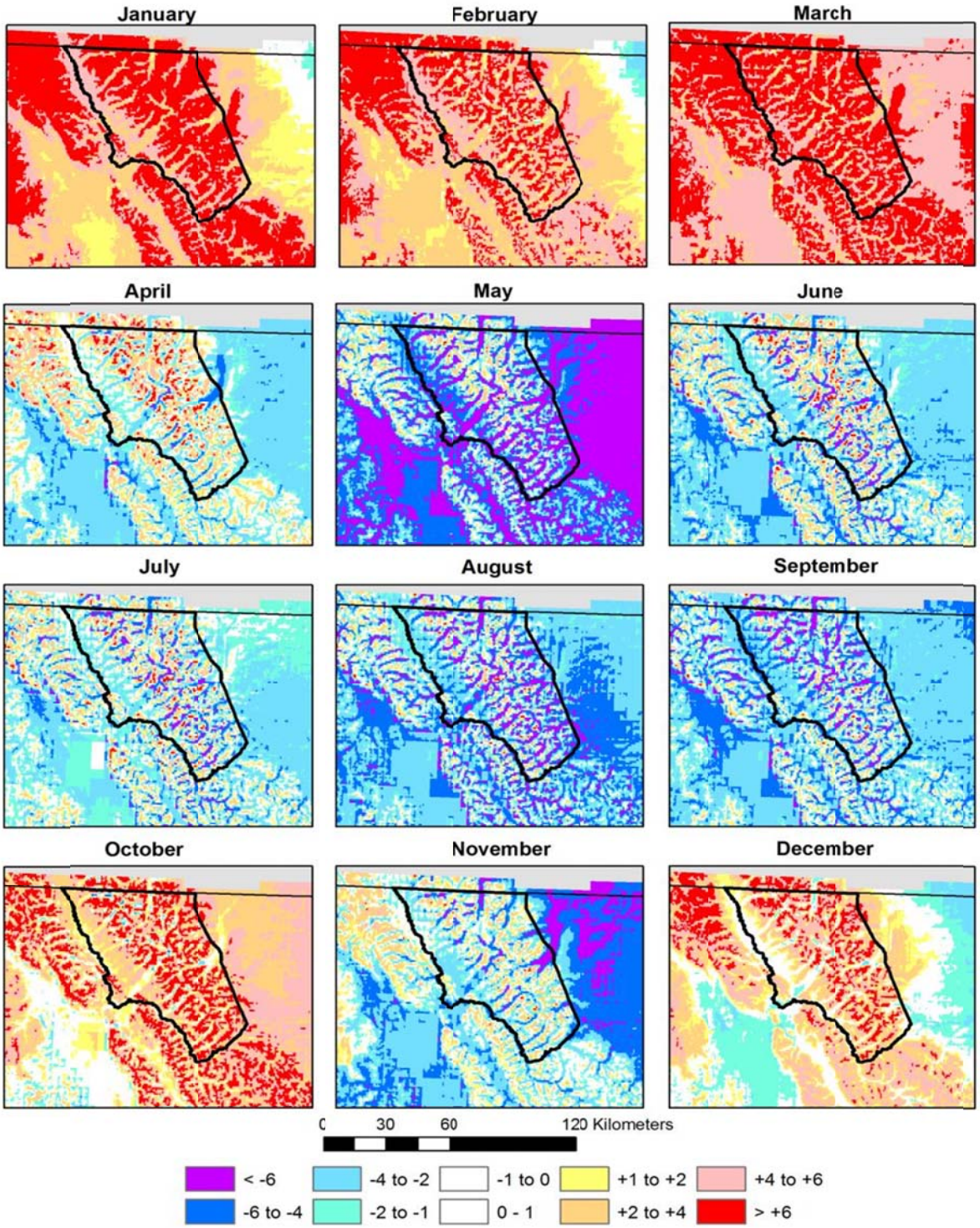


Figure 46. Maps showing departures from average maximum daily temperatures for each month in calendar year 2010 versus 1971–2000 in the area surrounding Glacier National Park in northern Montana. Departure values are reported in degrees Fahrenheit. Maps were created using estimates from the Parameter-elevation Regressions on Independent Slopes Model (PRISM).

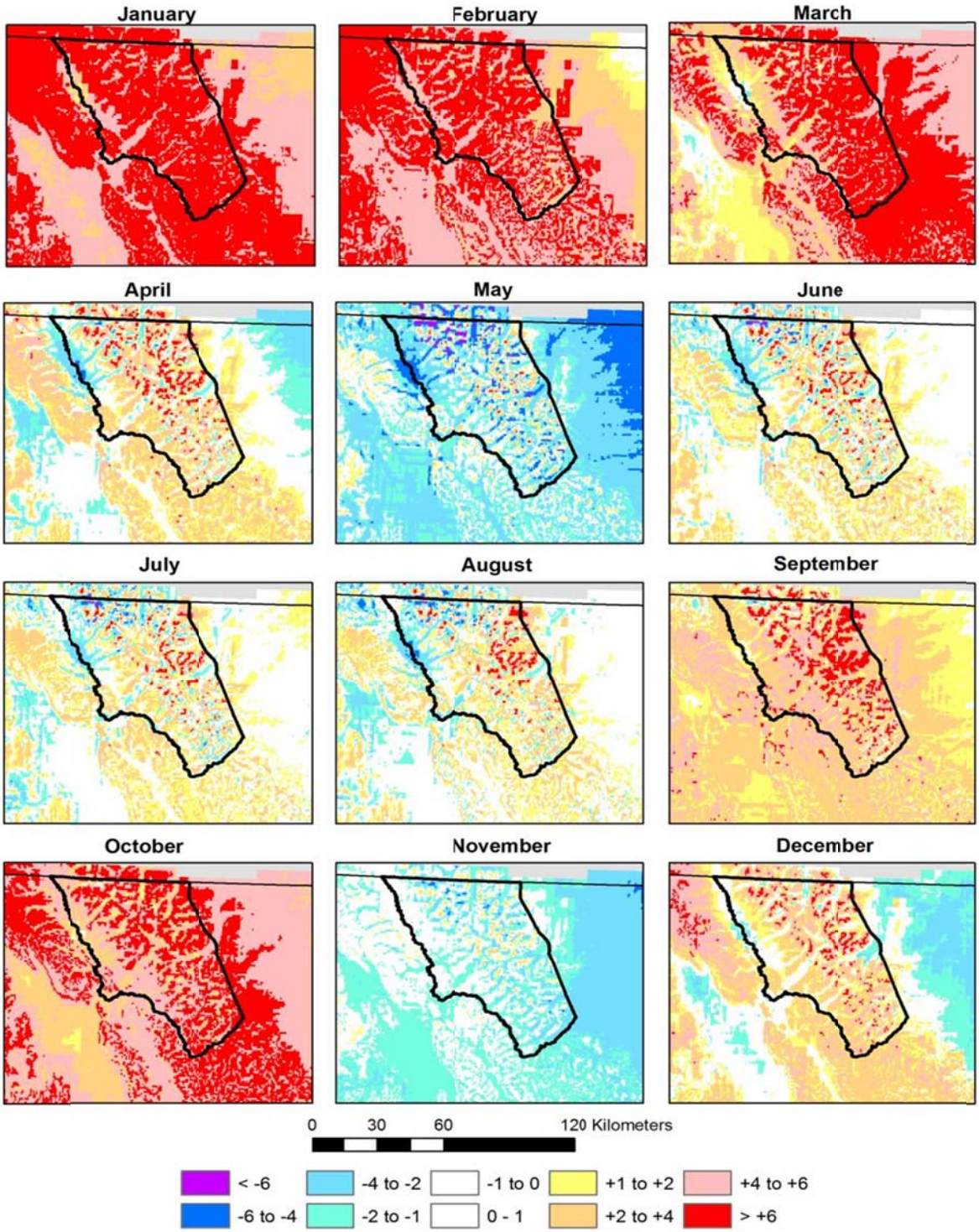


Figure 47. Maps showing departures from average minimum daily temperatures for each month in calendar year 2010 versus 1971–2000 in the area surrounding Glacier National Park in northern Montana. Departure values are reported in degrees Fahrenheit. Maps were created using estimates from the Parameter-elevation Regressions on Independent Slopes Model (PRISM).

Precipitation

Total annual precipitation

During 2010, individual weather stations in or near GLAC reported total annual precipitation ranging from 77% of average at Badger Pass to 127% of average at Noisy Basin. Total monthly precipitation is shown in figure 48 and table 31.

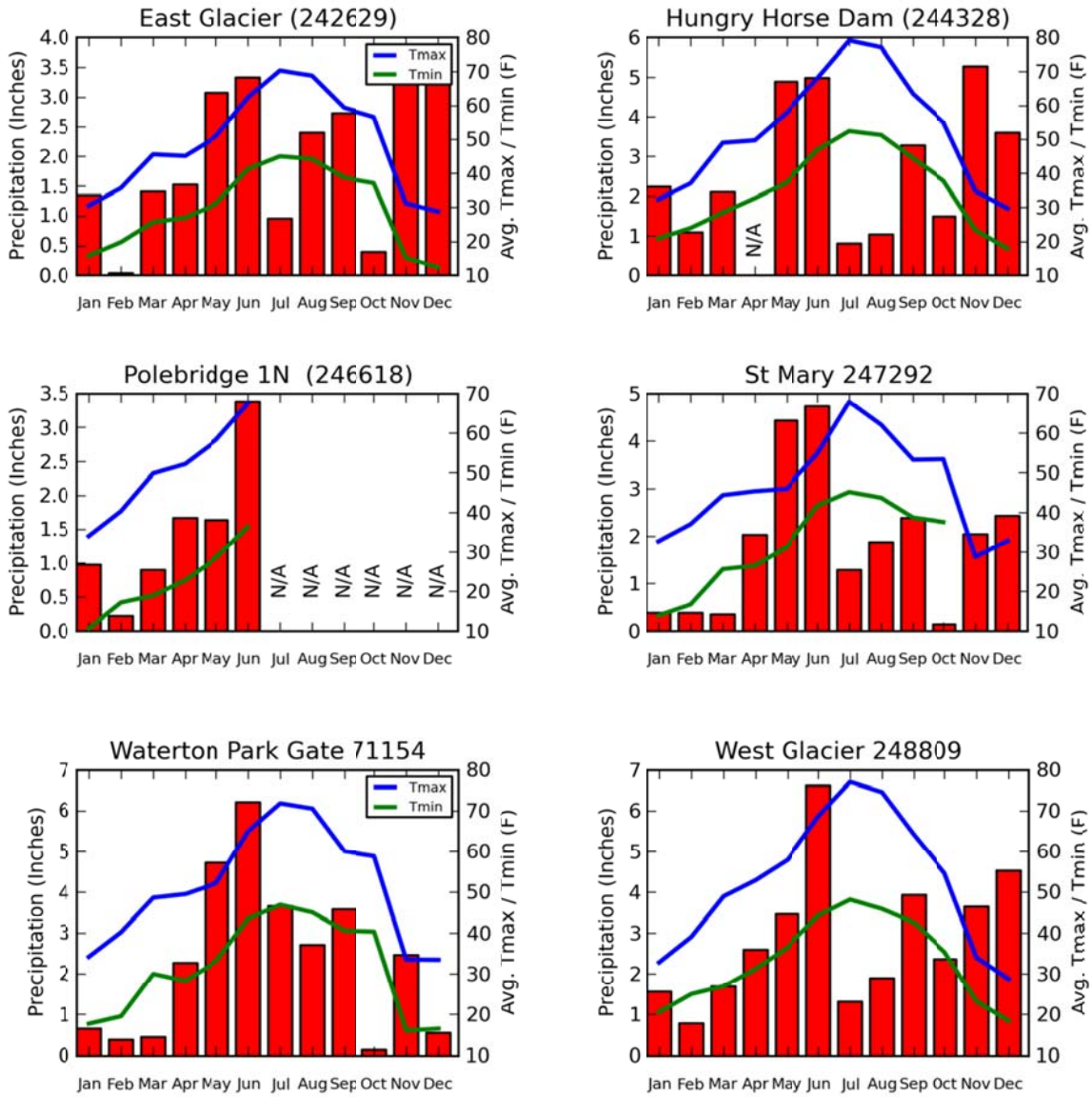


Figure 48. Monthly precipitation totals and average daily maximum temperature and average daily minimum temperatures during 2010 at key climate stations in or near Glacier National Park. The red bars show precipitation measured in inches. Missing bars (NA) indicate months in which there were insufficient data to calculate accumulated precipitation.

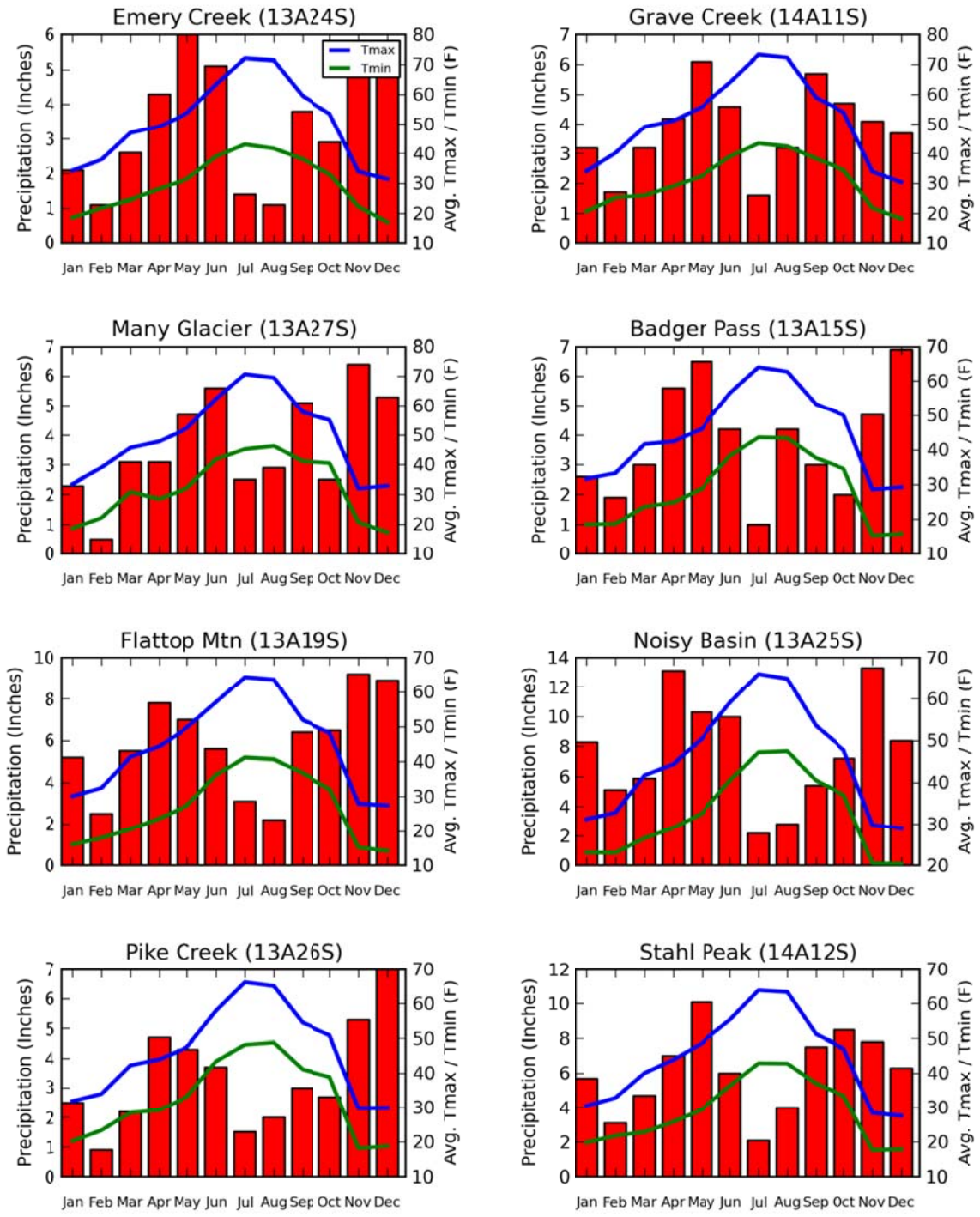


Figure 48. Continued.

Seasonal precipitation highlights

Throughout the winter (January–March) months, the area in and near GLAC experienced below average precipitation. The lowest during this period was 1.9% of average reported at East Glacier in February. Spring precipitation (April–June) was generally above average but varied by station location. On the east side of the continental divide, April precipitation was 85% of average at East Glacier whereas on the west side of the continental divide, April precipitation was 146% of average at West Glacier. Above average precipitation persisted at West Glacier and June precipitation was 206% of average. Early summer precipitation (July) started out below average, except at Many Glacier and then changed to above average and by September was above average at most places.

Fall (October–December) precipitation departures from average were variable from month-to-month. October started out below average at most places. St. Mary station reported 6.6% of average precipitation in October. November and December were mixed between above and below average precipitation. Departures from average, expressed as a percentage, are shown in figure 49 and table 31.

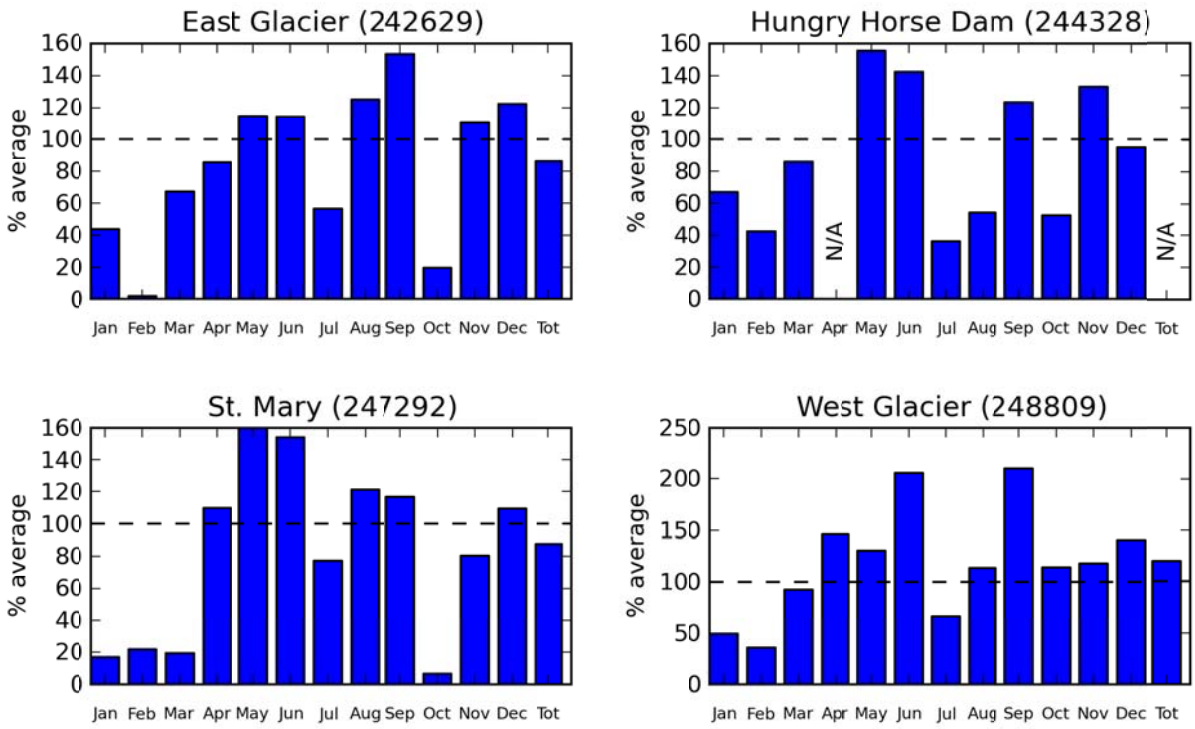


Figure 49. Departure of 2010 precipitation from 1971–2000 average at key climate stations in and near Glacier National Park. Missing bars (NA) indicate months in which there were insufficient data to calculate accumulated precipitation. Colors indicate the climate zone for each station. Blue = zone 1A, Black = zone 1B-A, Red = zone 1B-B.

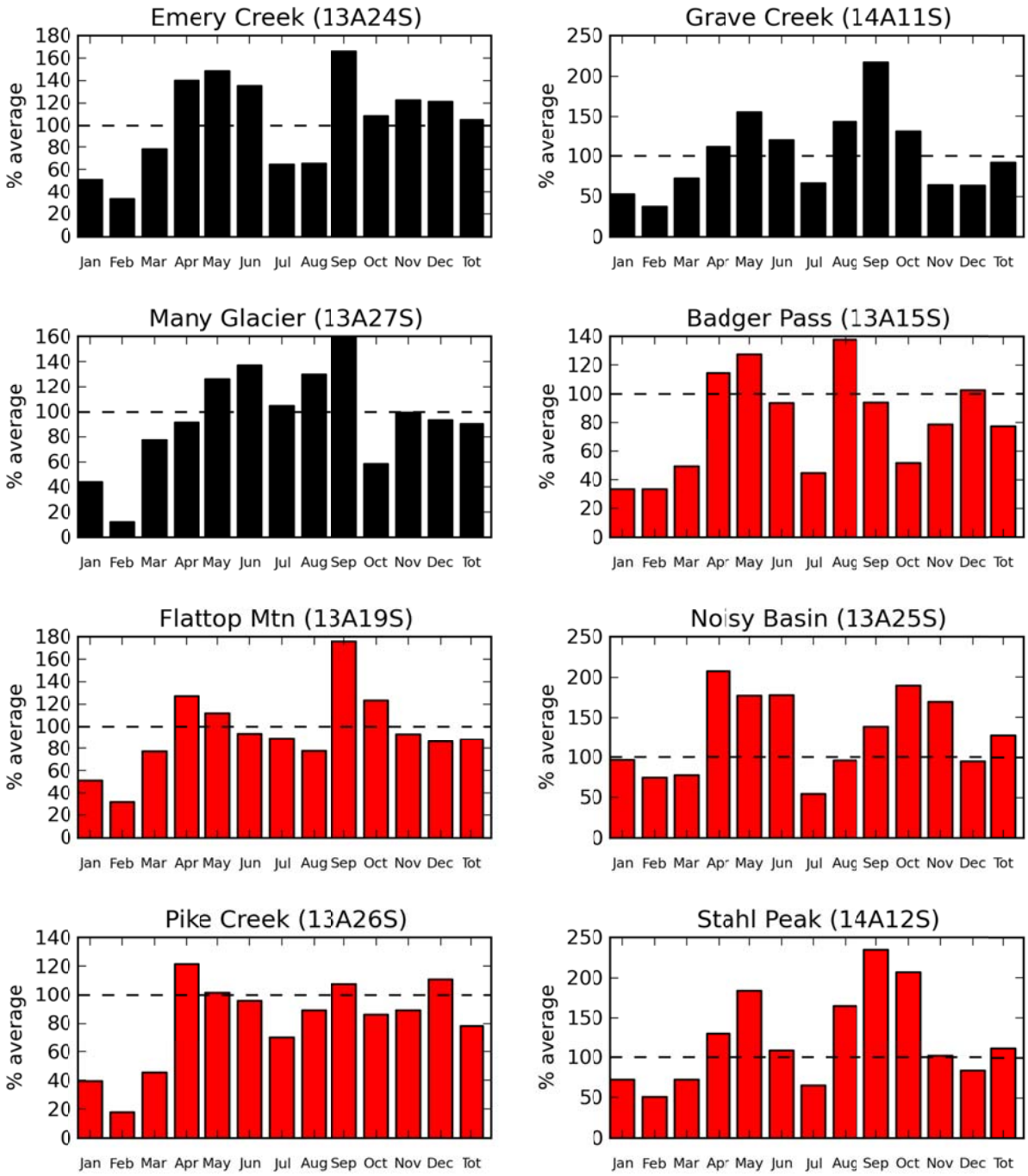


Figure 49. Continued.

Temperature

During 2010, the annual average maximum daily temperature was below average when averaged across the year (fig. 50). Monthly and seasonal average maximum and average minimum daily temperatures varied (tables 32 and 33). During the winter (January–March), both average maximum and average minimum daily temperatures were above average. During the spring (April–June) average minimum daily temperatures at St. Mary were below average all three months; elsewhere average minimum daily temperatures were above average except in May when they were above average. Average maximum daily temperatures during the spring were below average at all stations and stayed that way through the summer (July–August). The station at St. Mary reported average maximum daily temperatures in May and June that were 17°F and 16°F below average, respectively. Average minimum daily temperatures during July and August were near average and above average in September. Average minimum daily temperatures during fall (October–December) were above average in October, below average in November and near average in December except at St. Mary where average minimum daily temperatures were 4°F below average in December. Average maximum daily temperatures were above average in October (except at St. Mary's again) and below average in November. St. Mary reported average maximum daily temperatures that were 10°F below average in November. December average maximum daily temperatures were near average except at East Glacier which reported conditions 2°F below average.

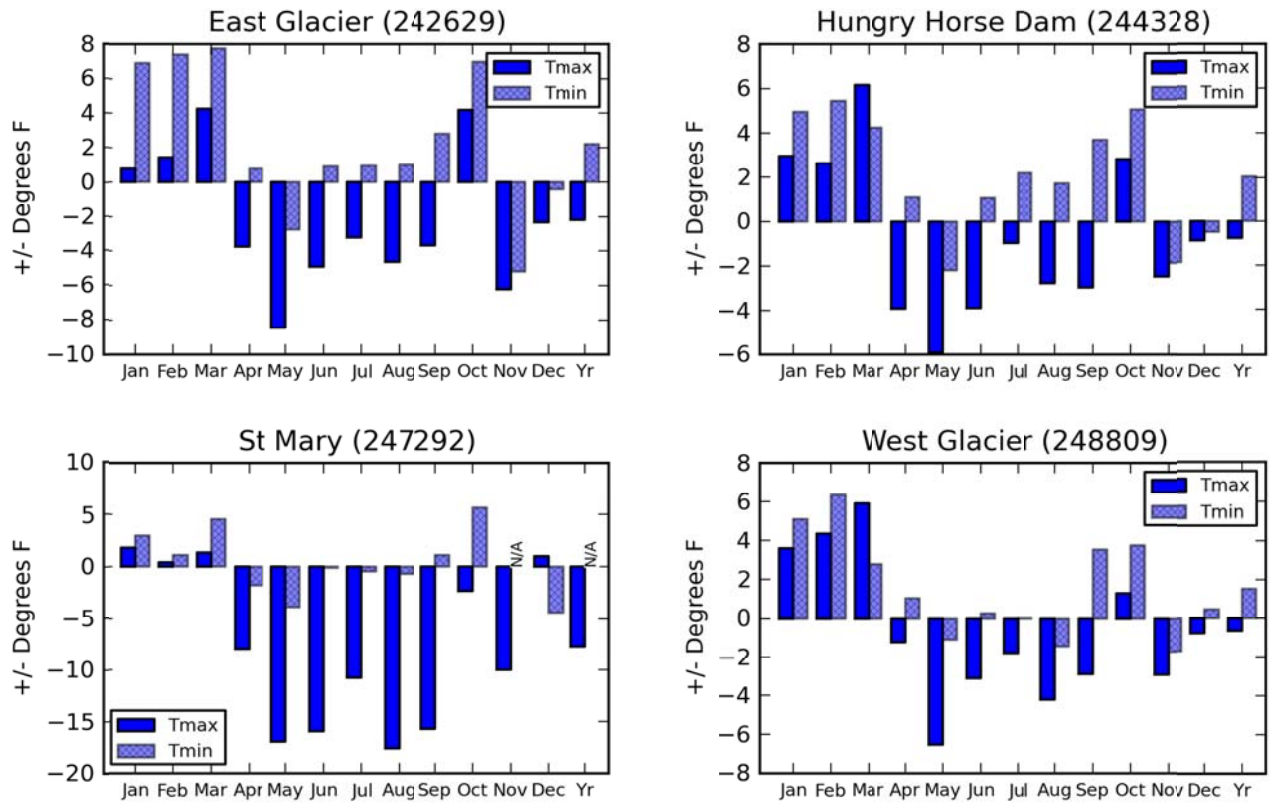


Figure 50. Departure of 2010 average minimum (Tmin) and average maximum (Tmax) daily temperatures from 1971–2000 average at key climate stations in or near Glacier National Park. Missing bars (NA) indicate months in which there were insufficient data to calculate average daily minimum and maximum temperatures.

Box plots of average maximum and average minimum daily temperatures that display data frequency distribution such as median, quartiles, and outliers are shown in figure 51.

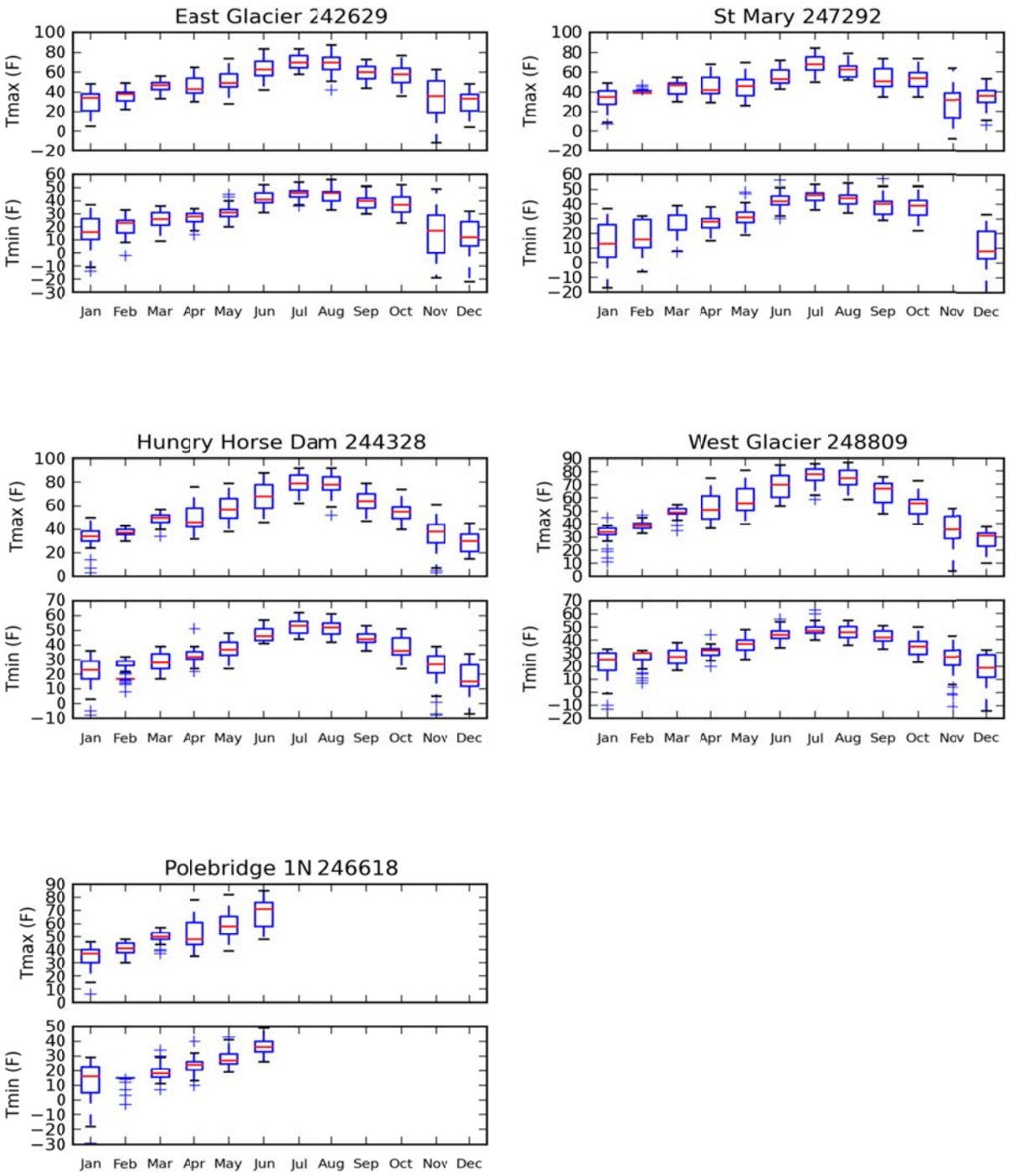


Figure 51. Box plots of average maximum and average minimum daily temperatures at key climate stations in and near Glacier National Park during 2010. Horizontal lines indicate the median value. Boxes indicate the 25th and 75th percentiles. Whiskers extend 1.5 times the interquartile Range (IQR). Crosses indicate values exceeding 1.5 times the IQR.

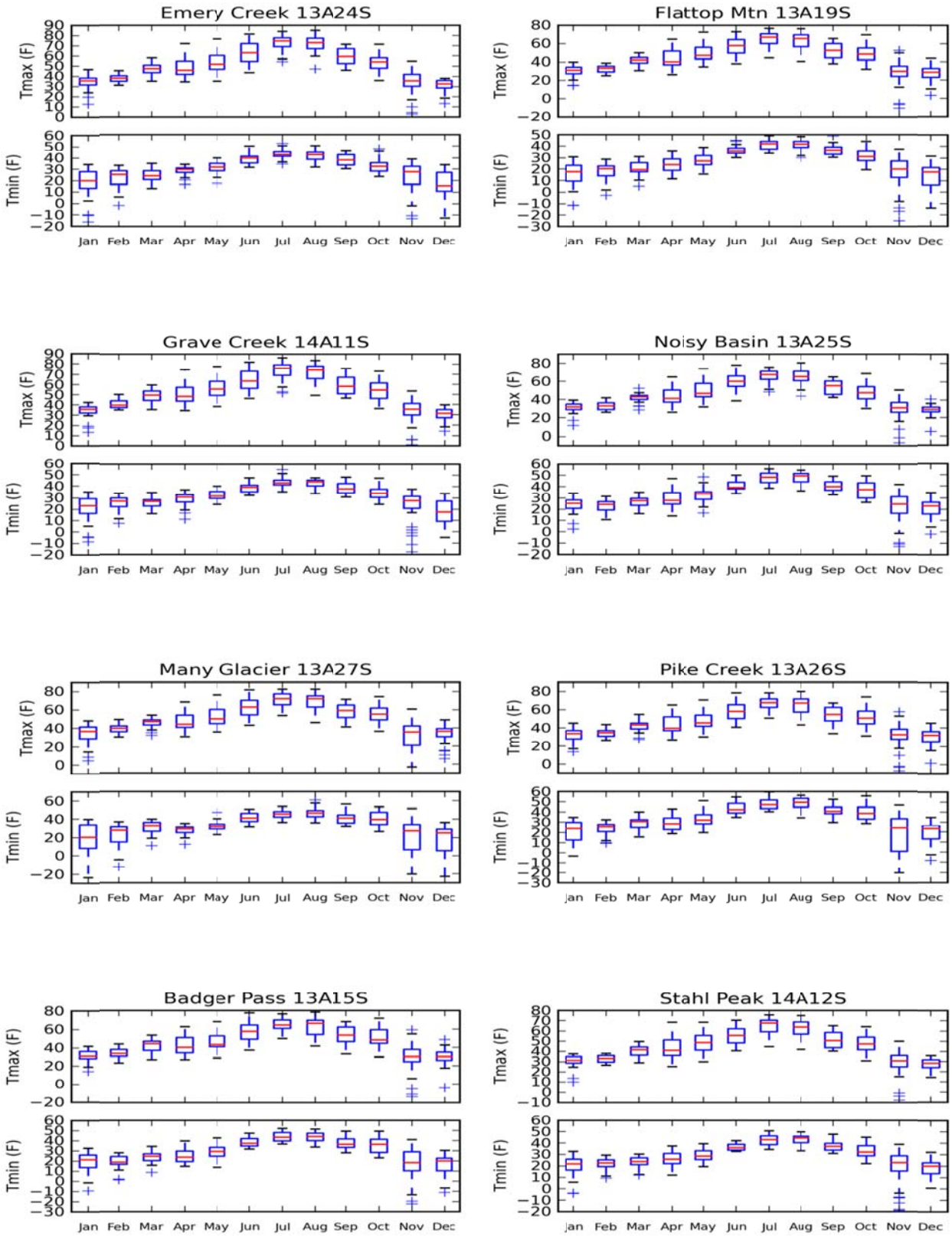


Figure 51. Continued.

Temperature thresholds

The onset of spring, defined as the last day when minimum temperatures dropped below 28°F, was six to seven days later at St. Mary and Hungry Horse and 10 days earlier at East Glacier. The onset of spring at West Glacier was near average. The first day of fall, defined as the first day when minimum temperatures drop below 28°F, was later in 2010 by as many as 27 days at East Glacier and 24 days at St. Mary.

The number of hot days, defined as days where the maximum daily temperatures ≥ 90°F, were fewer than average. The only station to report temperatures ≥ 90°F in 2010 was Hungry Horse where the maximum daily temperature was ≥ 90°F six times. The number of frosty nights, defined as nights where the minimum temperatures ≤ 32°F, were fewer than average. The number of frosty nights were more than two weeks few at St. Mary and West Glacier. Table 34 shows first and last freeze and frost dates, accumulated growing degree days, and days above or below critical temperature thresholds for key stations in reporting area.

The Western Regional Climate Center reported daily and monthly records that were exceeded in 2010 (WRCC 2010) at East Glacier and St. Mary stations.

- At East Glacier, the record for the highest monthly average maximum daily temperatures reported for October at 56.9°F and the lowest monthly average minimum daily temperatures reported for May at 41.0°F.
- At St. Mary, the lowest monthly average minimum daily temperatures reported for May, June, and August at 38.7°F, 48.3°F, and 53.0°F, respectively.

Streamflow

The USGS monitors streamflow at numerous locations in the area of GLAC. Key aspects of the areas hydrology are represented by a subset of these gauging stations (appendix A). At the gauge stations near GLAC, total annual runoff was below average and ranged from 81% to 89% of average depending on gauge location. Figures 52 and 53 and table 29 summarize the 2010 water year, (October 2009 to September 2010).

Table 29. Total annual runoff in acre feet and percentage of average for select USGS Gauge Stations near Glacier National Park during 2010 (Data source: USGS Water Data Reports for 2010).

Station Name	Total annual runoff (ac-ft) 2010	Total annual runoff (ac-ft) average	Percent of average
St. Mary River near Babb, MT	483,600	542,900	89%
MF Flathead River near West Glacier, MT	1,680,000	206,8000	81%
NF Flathead River Near Columbia Falls	1,749,000	2,150,000	81%
SF Flathead River near Columbia Falls, MT	2,092,000	(-)	(-)
Swiftcurrent Creek at Many Glacier, MT	90,360	101,000	89%

(-) indicates missing data

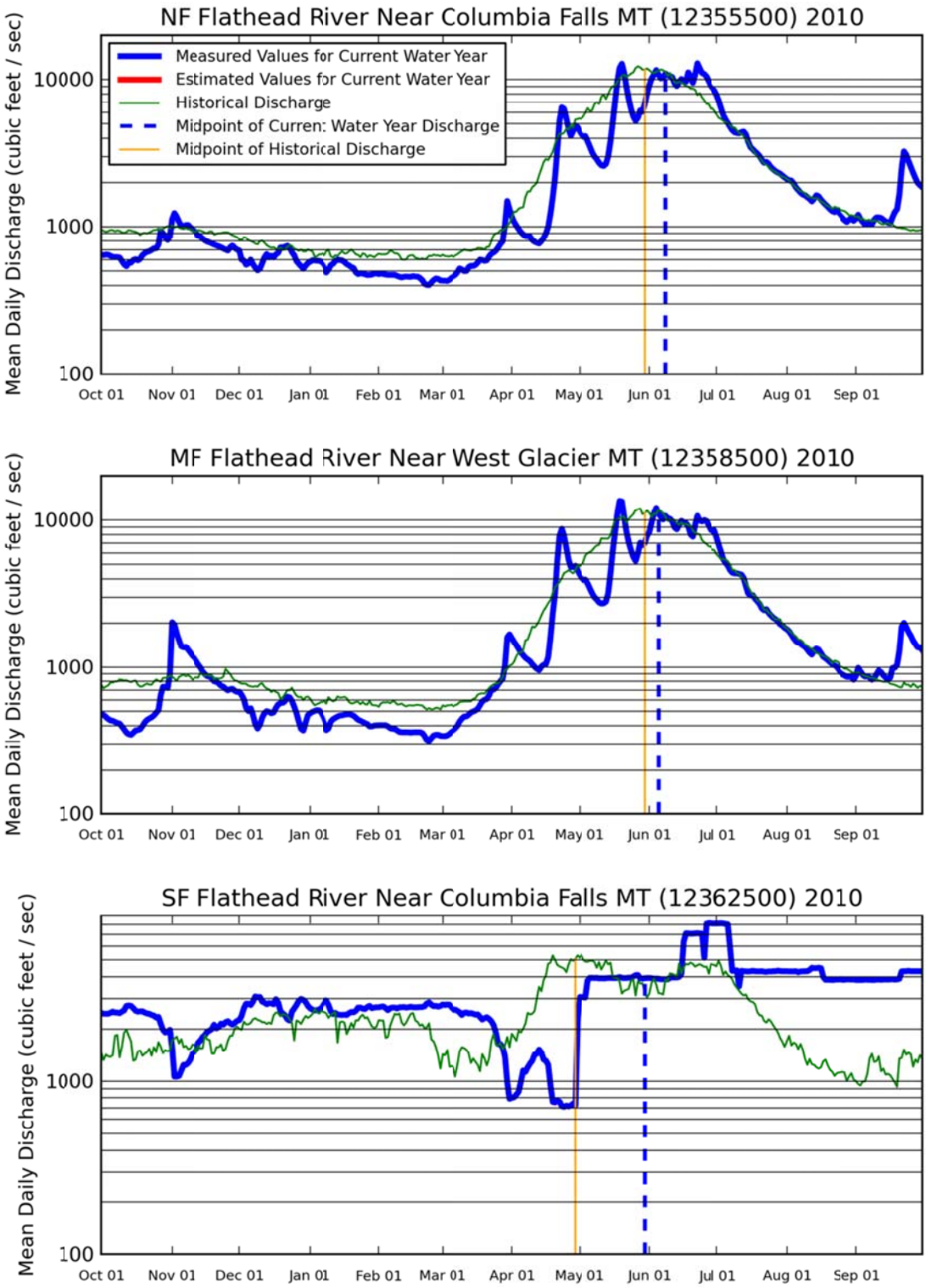


Figure 52. Streamflows from representative gauges in and near Glacier National Park for the 2010 water year (October 2009 through September 2010) are shown versus median daily flows for the reference period. Data courtesy the U.S. Geological Survey.

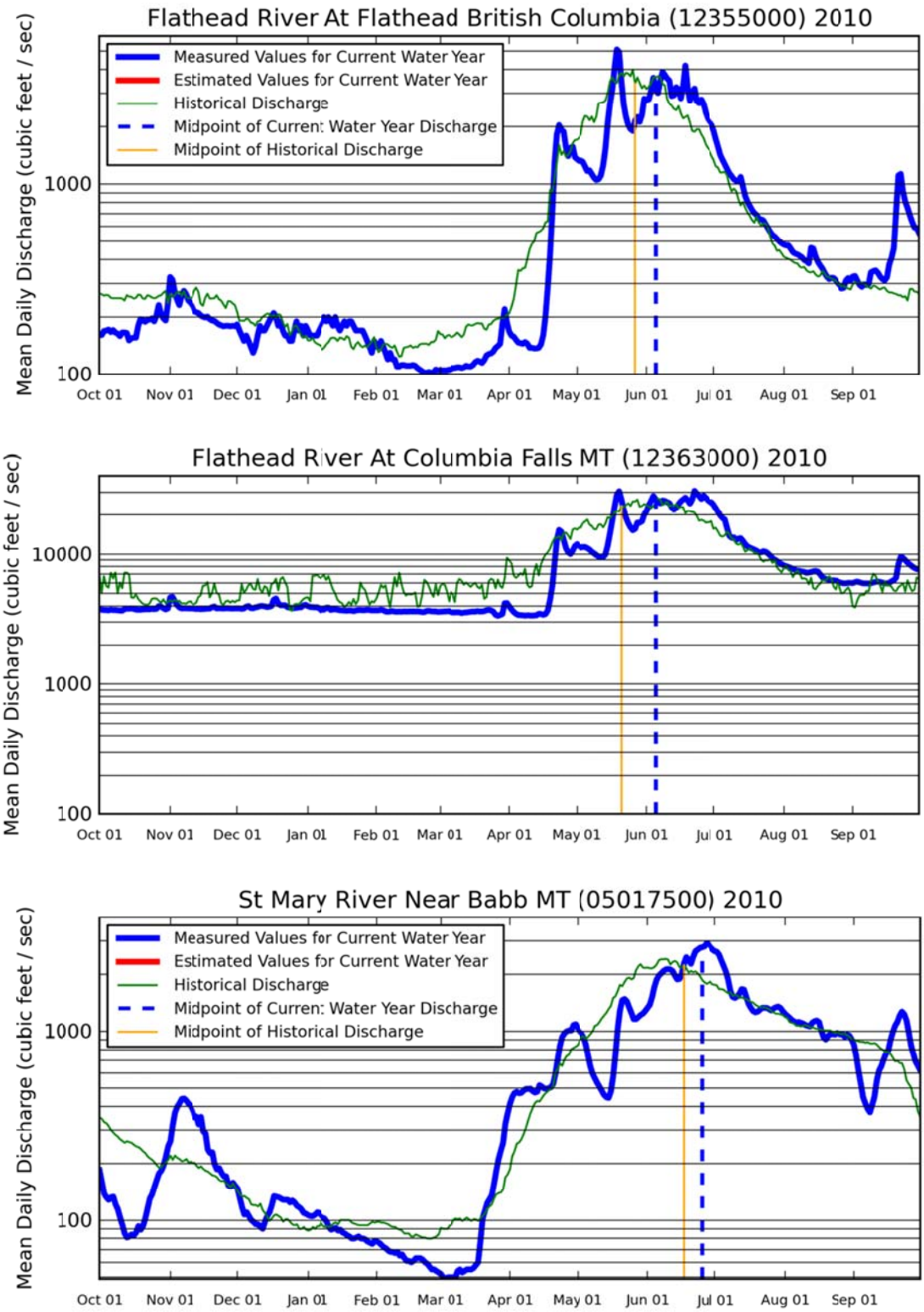


Figure 52. Continued.

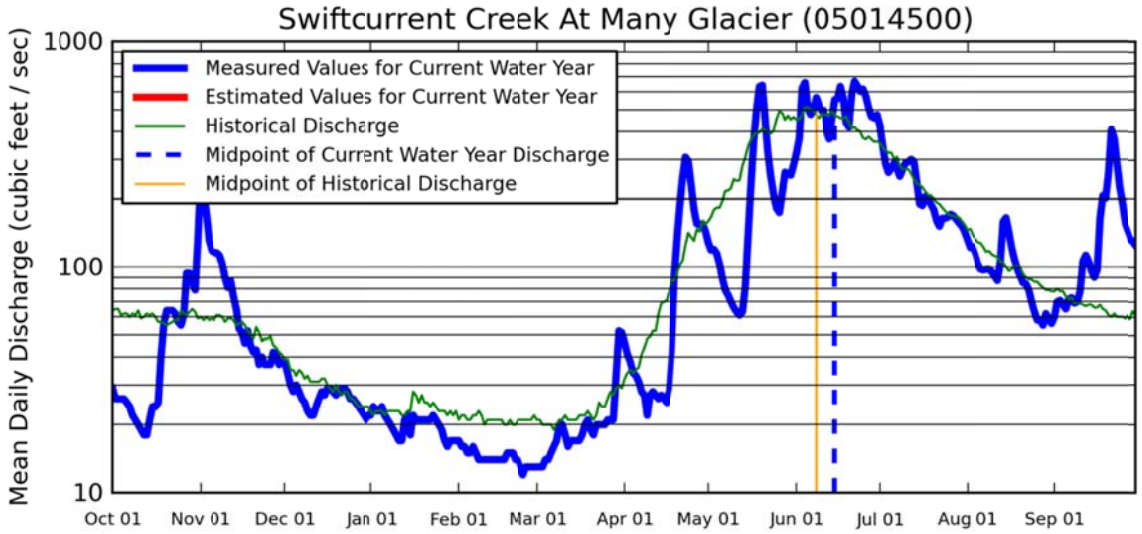


Figure 52. Continued.

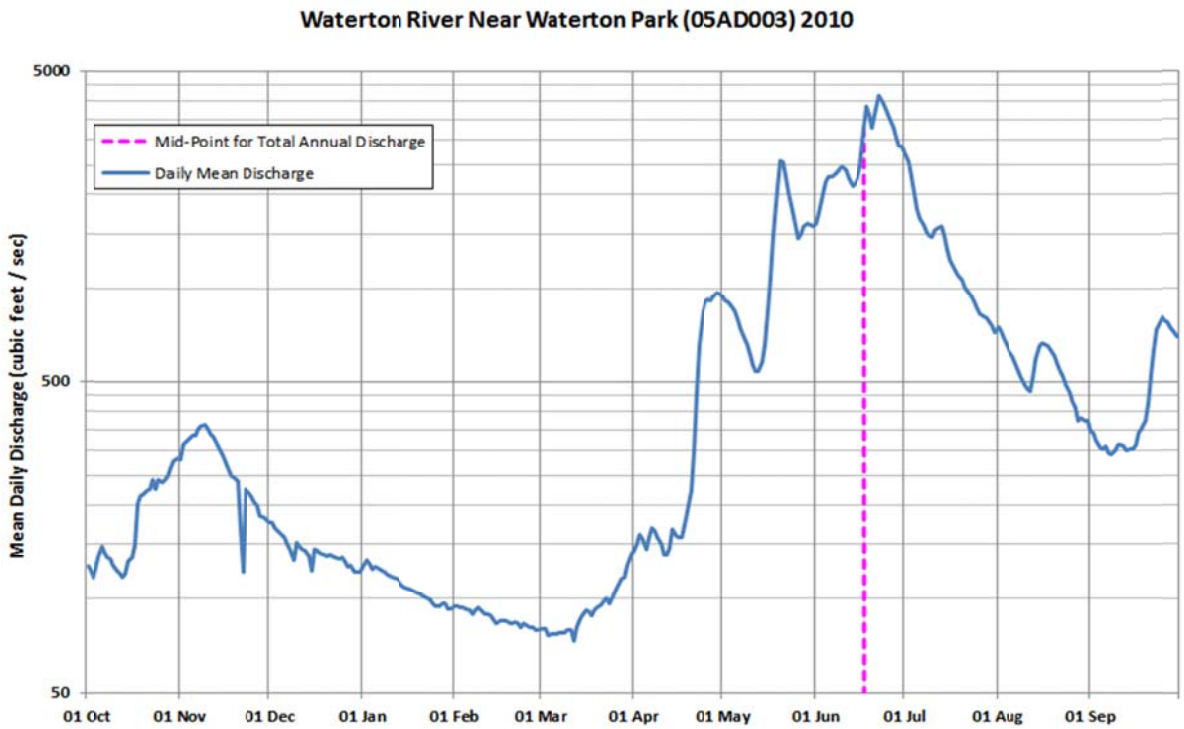


Figure 53. Streamflow from a representative gauge near Glacier National Park in Canada for the 2010 water year (October 2009 through September 2010). Median daily flows were not available for this gauge station. Data courtesy the Water Survey of Canada–Environmental Canada.

Winter snowpack

The NRCS operates automated snow measurement (SNOTEL) stations throughout the western United States. These stations offer the best available means for tracking the accumulation and loss of snowpack. As measured in terms of SWE—the amount of liquid water held in a given volume of snow—snowpack was below average during the 2010 water year except at Stahl Peak which had above average snow water equivalent (table 30; fig. 54). Maximum SWE was reached near average to later than average in the spring. Melt out dates were near average to earlier than average by 1 to 4 weeks. Despite below average maximum temperatures in June and July, rapid snowmelt lead to higher than average peak flows during these months (fig. 52). Daily measurements of SWE and precipitation from representative sites in or near Glacier National Park are shown in figure 54.

Amounts of SWE at key times of year such as the month of maximum snowpack help determine if snowpack is decreasing and if runoff is earlier than average. Maximum SWE was reached at most stations on either April 14–15 or May 9–10, 2010. Maximum SWE at Many Glacier (8.6″) was reached March 2, 2010 which is earlier than average. Maximum SWE at Badger Pass (29.5″) was reached May 10 which is later than average.

Table 30. Snow water equivalent (SWE) (inches) on May 1 and April 1 and maximum SWE from Snowpack Telemetry stations in and near Glacier National park and percentages of average. Data courtesy of the Natural Resource Conservation Service. These provisional data are subject to change.

Maximum Snow Water Equivalent (SWE) in April			
Snowpack Telemetry (SNOTEL)	**SWE on April 1, 2010**	**% of April 1 average**	**2010 Max SWE**
Grave Creek	10.7	69%	11.4
Many Glacier	7.1	46%	8.6
Badger Pass	24.7	66%	29.5
Emery Creek	9.1	59%	10
Pike Peak	8.9	32%	12.6
Maximum Snow Water Equivalent (SWE) in May			
	SWE on May 1, 2010	**% of May 1 average**	**2010 Max SWE**
Flat top Mtn	39.8	85%	43
Stahl Peak	34	92%	38.5
Noisy Basin	38.8	89%	42.2

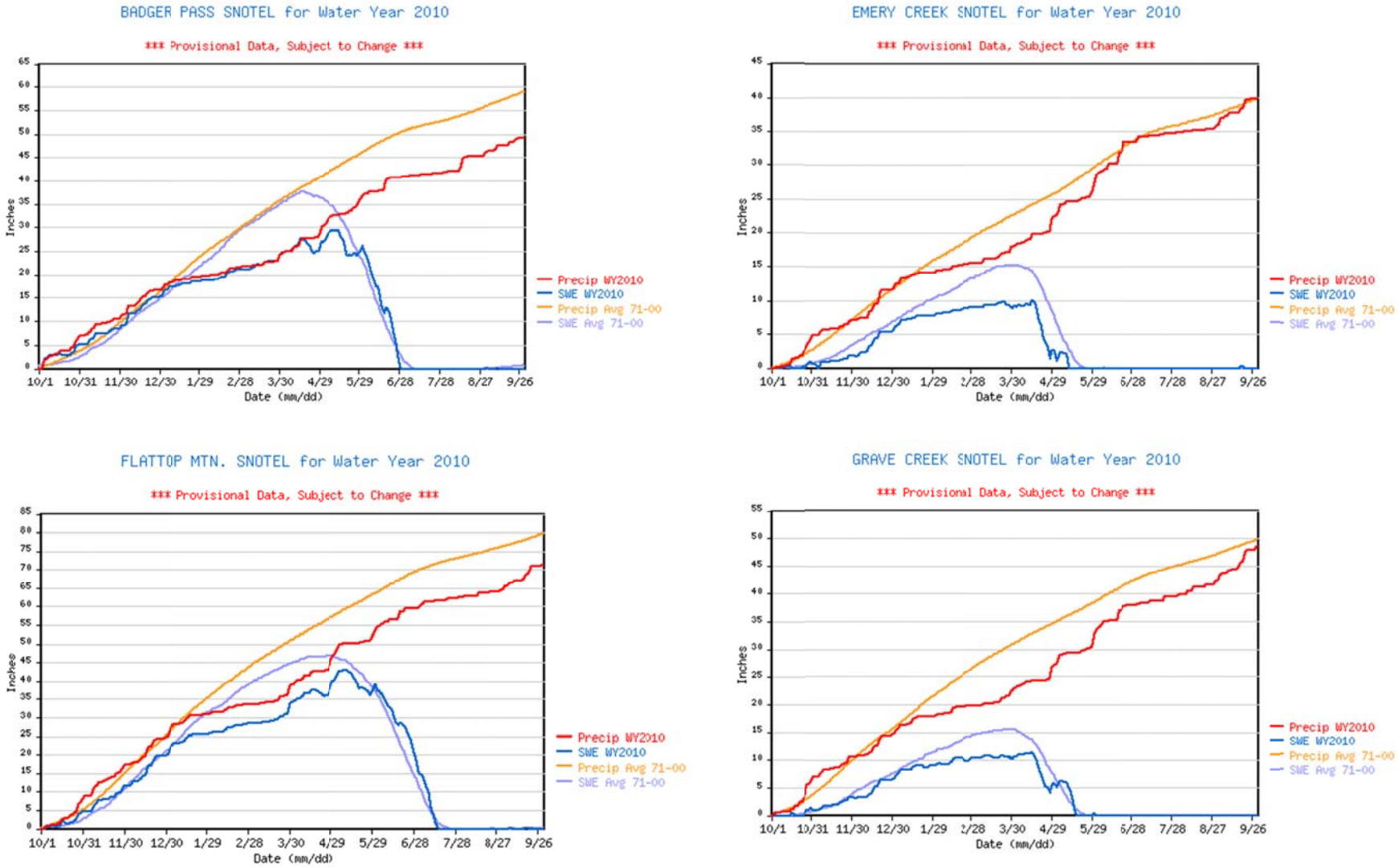
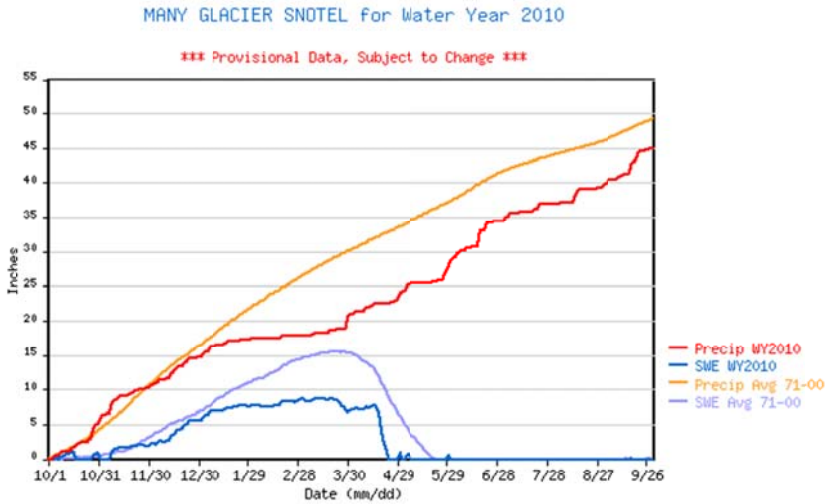
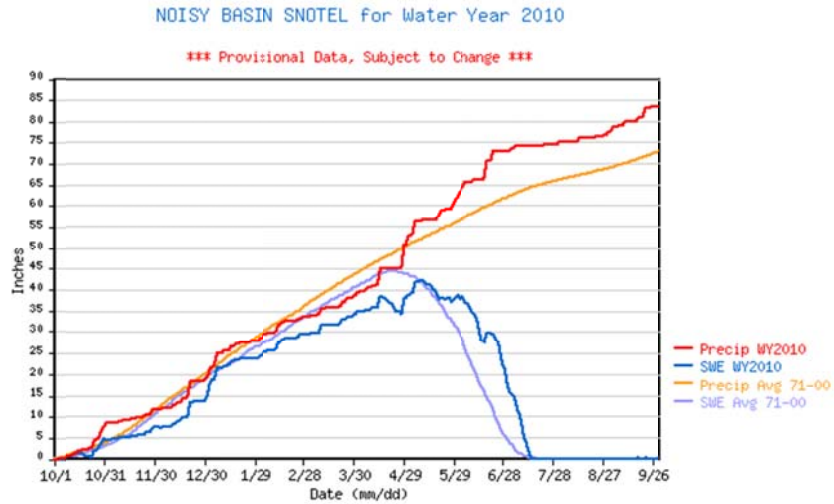
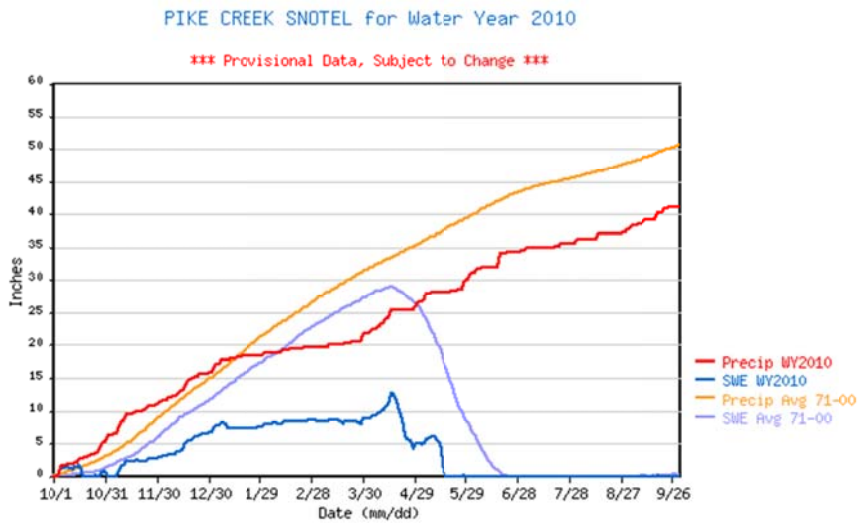


Figure 54. Daily measurements of snow water equivalent (SWE) and precipitation from representative sites in the Glacier National Park from October 2009 to September 2010. Values are compared to averages from the 1971–2000 period. Data courtesy of the Natural Resource Conservation Service. These provisional data are subject to change.







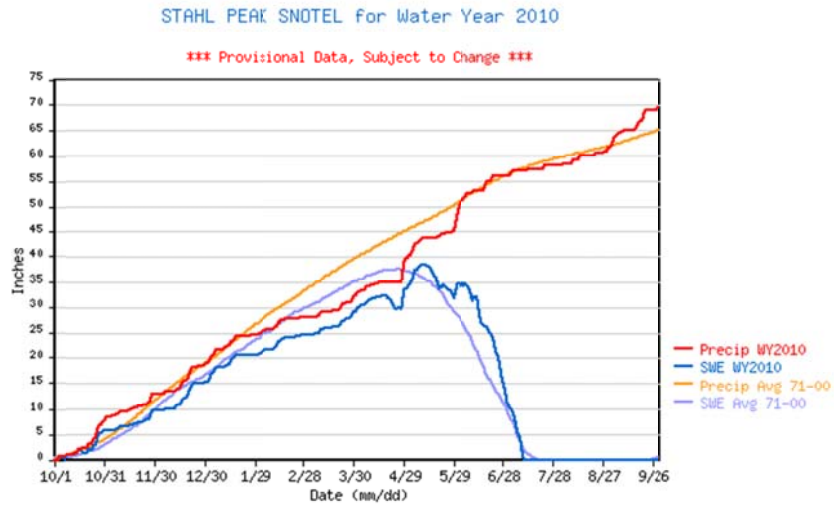


Figure 54. Continued.

Table 31. Total monthly precipitation in inches and percentage of average monthly precipitation versus 1971–2000 averages for select climate stations in or near Glacier National Park during 2010.

Station Name (ID)		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Total
Badger Pass (13A15S)		2.6	1.9	3	5.6	6.5	4.2	1	4.2	3	2	4.7	6.9	45.6
	% of 30-yr avg.	33	33	49	115	127	94	45	138	94	52	79	103	77
East Glacier (242629)		1.35	0.04	1.41	1.53	3.08	3.33	0.96	2.4	2.73	0.4	3.4	3.77	24.4
	% of 30-yr avg.	44	2	67	85	115	114	57	125	153	20	110	122	86
Emery Creek (13A24S)		2.1	1.1	2.6	4.3	6	5.1	1.4	1.1	3.8	2.9	5.4	5.6	41.4
	% of 30-yr avg.	50	33	78	140	149	136	64	65	166	109	122	121	105
Flattop Mtn (13A19S)		5.2	2.5	5.5	7.8	7	5.6	3.1	2.2	6.4	6.5	9.2	8.9	69.9
	% of 30-yr avg.	51	31	77	127	112	93	89	77	175	123	93	86	88
Grave Creek (14A11S)		3.2	1.7	3.2	4.2	6.1	4.6	1.6	3.2	5.7	4.7	4.1	3.7	46
	% of 30-yr avg.	52.37	36.88	72.07	111.11	155.61	119.79	65.84	143.5	216.73	131.28	63.47	63.25	92.18
Hungry Horse Dam (244328)		2.24	1.09	2.11	(-)	4.9	4.99	0.81	1.04	3.28	1.49	5.28	3.6	(-)
	% of 30-yr avg.	67	43	86	(-)	156	142	36	54	123	53	133	95	(-)
Many Glacier (13A27S)		2.3	0.5	3.1	3.1	4.7	5.6	2.5	2.9	5.1	2.5	6.4	5.3	44
	% of 30-yr avg.	44	12	78	91	126	137	105	130	159	58	99	93	90
Noisy Basin (13A25S)		8.3	5.1	5.9	13.1	10.3	10	2.2	2.8	5.4	7.2	13.3	8.4	92
	% of 30-yr avg.	96	74	78	208	177	178	54	96	138	190	170	95	127
Pike Creek (13A26S)		2.5	0.9	2.2	4.7	4.3	3.7	1.5	2	3	2.7	5.3	7	39.8
	% of 30-yr avg.	39	18	45	121	102	96	70	89	108	86	89	111	78

Table 31. Continued.

Station Name (ID)		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Total
Polebridge 1N (246618)		0.98	0.22	0.9	1.67	1.64	3.38	(-)	(-)	(-)	(-)	(-)	(-)	(-)
	% of 30-yr avg.	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)
St. Mary (247292)		0.38	0.38	0.35	2.03	4.43	4.73	1.29	1.88	2.39	0.14	2.05	2.43	22.48
	% of 30-yr avg.	17	22	19	110	160	154	77	121	117	7	80	109	88
Stahl Peak (14A12S)		5.7	3.1	4.7	7	10.1	6	2.1	4	7.5	8.5	7.8	6.3	72.8
	% of 30-yr avg.	72	51	72	130	184	108	65	165	234	207	102	83	112
Waterton Park Gate (71154)		0.65	0.38	0.45	2.27	4.72	6.21	3.66	2.71	3.59	0.13	2.47	0.55	27.79
	% of 30-yr avg.	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)
West Glacier (248809)		2	1	2	3	3	7	1	3	4	2	4	5	34
	% of 30-yr avg.	49	36	92	146	130	206	67	114	210	114	118	140	120

Note: Percentages of average monthly precipitation versus 1971–2000 averages are given in the second line of data for each station. Station IDs are from NWS Cooperative Observer Program (COOP) stations and NRCS Snowpack Telemetry (SNOTEL) stations. Monthly statistics are not reported if more than three days of data are missing. Individual months are not used for calculating annual statistics if more than five days of data are missing.

(-) Indicates missing data.

Table 32. Average maximum daily temperatures in degrees Fahrenheit for select climate stations in or near Glacier National Park during 2010. Departures from 1971–2000 averages are given in the second line of data for each station expressed as +/- degrees F.

Station Name (ID)		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
East Glacier (242629)		30.58	35.75	45.65	45.17	50.94	62.4	70.39	68.87	59.43	56.68	31.3	28.87	48.83
	Departure (+/- F)	0.78	1.45	4.25	-3.73	-8.46	-4.9	-3.21	-4.63	-3.67	4.18	-6.2	-2.33	-2.17
Hungry Horse Dam (244328)		32.45	37.14	49.06	49.77	57.97	68.1	79.13	77.13	63.53	55.03	34.83	29.81	52.83
	Departure (+/- F)	2.95	2.64	6.16	-3.93	-5.93	-3.9	-0.97	-2.77	-2.97	2.83	-2.47	-0.89	-0.77
Polebridge 1N (246618)		34.1	40.39	49.87	52.23	58.29	67.5	(-)	(-)	(-)	(-)	(-)	(-)	(-)
	Departure (+/- F)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)
St. Mary (247292)		32.77	37.11	44.43	45.43	46.03	54.87	67.94	62.13	53.3	53.45	28.8	32.9	46.6
	Departure (+/- F)	1.77	0.41	1.33	-7.97	-16.97	-15.93	-10.76	-17.57	-15.7	-2.35	-10	1	-7.7
West Glacier (248809)		32.9	39.14	49	52.97	57.97	68.7	77.1	74.58	64.2	54.68	34.07	28.81	52.84
	Departure (+/- F)	3.6	4.34	5.9	-1.23	-6.53	-3.1	-1.8	-4.22	-2.9	1.28	-2.93	-0.79	-0.66

Note: Monthly average maximum daily temperature departures from 1971–2000 averages are given in the second line of data for each station in degrees Fahrenheit.

Station IDs are from NWS Cooperative Observer Program (COOP) stations. Monthly statistics are not reported if more than five days of data are missing. Individual months are not used for calculating annual statistics if more than five days of data are missing.

(-) Indicates missing data.

Table 33. Average minimum daily temperatures in degrees Fahrenheit for select climate stations in or near during 2010. Departures from 1971–2000 averages are given in the second line of data for each station expressed as +/- degrees F.

Station Name (ID)		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
East Glacier (242629)		15.9	19.89	25.77	27.07	31.16	41.33	45.06	44.29	38.83	37.19	15.33	12.39	29.52
	Departure (+/- F)	6.9	7.39	7.77	0.77	-2.74	0.93	0.96	0.99	2.83	6.99	-5.17	-0.41	2.22
Hungry Horse Dam (244328)		20.97	24.04	28.55	32.8	37.39	46.97	52.48	51.32	44.5	37.87	23.43	18	34.86
	Departure (+/- F)	4.97	5.44	4.25	1.1	-2.21	1.07	2.18	1.72	3.7	5.07	-1.87	-0.5	2.06
Polebridge 1N (246618)		10.65	17.18	18.94	22.83	28.58	36.43	(-)	(-)	(-)	(-)	(-)	(-)	(-)
	Departure (+/- F)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)
St. Mary (247292)		13.87	16.68	25.68	26.57	31.32	41.77	45.23	43.77	38.77	37.65	(-)	10.23	(-)
	Departure (+/- F)	2.97	1.08	4.58	-1.83	-3.98	-0.13	-0.47	-0.73	1.07	5.65	(-)	-4.47	(-)
West Glacier (248809)		20.61	25.04	26.97	31.33	36.58	44.33	48.23	45.94	42.63	35.45	23.27	18.45	33.24
	Departure (+/- F)	5.11	6.34	2.77	1.03	-1.12	0.23	0.03	-1.46	3.53	3.75	-1.73	0.45	1.54

Note: Monthly average minimum daily temperature departures from 1971–2000 averages are given in the second line of data for each station in degrees Fahrenheit. Station IDs are from NWS Cooperative Observer Program (COOP) stations. Monthly statistics are not reported if more than five days of data are missing. Individual months are not used for calculating annual statistics if more than five days of data are missing.

(-) Indicates missing data.

Table 34. First and last freeze and frost dates, accumulated growing degree days, and days above or below critical temperature thresholds for key stations in or near Glacier National Park during 2010. Values for 2010 are shown in the first line for each station. Averages are published by the Western Region Climate Center in General Climate Summary Tables and reference period may differ from 1971–2000 average.

Station Name (ID)		AGDD40	AGDD50	Last date in spring <= 28F	Earliest date in fall <=28	Last date in spring <=32	Earliest date in fall <=32	# of days Tmax		# of days Tmin	
								>= 80 F	>= 90 F	<= 0 F	<= 32 F
East Glacier (242629)		2157.5	738.5	13-May	16-Oct	13-Jun	2-Sep	8	0	22	201
	30-yr avg.	2372	919	23-May	19-Sep	10-Jun	11-Sep	(-)	1.6	25.8	203.4
Hungry Horse Dam (244328)		3132.5	1459	6-May	17-Oct	12-May	14-Oct	35	6	5	161
	30-yr avg.	3182	1520	29-Apr	9-Oct	14-May	22-Sep	(-)	11.7	12.2	172.6
Polebridge 1N (246618)		(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)
	30-yr avg.	2270	896	11-Jun	30-Aug	13-Jul	10-Aug		0	27.9	89.9
St. Mary (247292)		1745.5	510	23-May	16-Oct	18-Jun	1-Sep	3	0	22	197
	30-yr avg.	2905	1260	17-May	22-Sep	8-Jun	12-Sep	(-)	7.9	22.4	182.6
West Glacier (248809)		2796	1157	10-May	14-Oct	24-May	12-Oct	28	0	7	174
	30-yr avg.	2920	1297	11-May	1-Oct	30-May	14-Sep	(-)	5.4	12	191.4

Note: (-) temperature data or published averages are missing

Nez Perce National Historical Park and Big Hole National Battlefield

2010 climate at a glance

- Total annual precipitation was 106% to 114% of average, depending on station.
- Average annual maximum daily temperatures at Grangeville were 1.8°F warmer than average and near average at Lewiston WSO AP and Pierce.
- Average annual minimum daily temperatures at Grangeville and Lewiston WSO AP were near average and 2.2°F warmer than average at Pierce.
- The on-set of spring was one to two weeks later than average; the on-set of fall was 25 days later than average at Pierce and 17 days later than average at Wisdom.
- Maximum snow water equivalent was below average at Calvert Creek.
- Maximum SWE was reached later than average and the primary melt out date was earlier than average by 4 weeks.
- Peak flows were higher than average. Total annual runoff measured at the gauge stations on Lapwai Creek near Lapwai and the Clearwater River at Spalding measured 65% and 74% of average, respectively.

2010 climate data summary

This climate data summary report describes park-level climate at both a local (single weather station) and regional setting (gridded climate maps) using standard data summary and analysis tools described in the *Rocky Mountain Climate Protocol* (RMCWG 2010). Climate data that describe precipitation, temperature, precipitation, streamflow and snowpack were gathered from key climate stations near Nez Perce National Historical Park (NEPE) and Big Hole National Battlefield (BIHO) and summarized for this report. The climate stations cited in this report are shown in figure 55; station metadata are available in appendix A.

Total accumulated precipitation and minimum, maximum, and mean monthly temperatures and departures from an established baseline are summarized in figures and tables below. We consider recent events in a historical context, based primarily on a standard 30-year climatological reference or "normal" period (currently 1971–2000) which we refer to as an "average." The baseline period used to determine average conditions in this report for each climate station is included in the station metadata in appendix A.

Sections on snowpack and streamflow are included as they integrate the combined effects of temperature and precipitation. Variables indicating the timing or length of a seasonal process (e.g., accumulated growing degree days, frosts, snowpack duration, and peak unregulated streamflow) are noted throughout the data summary report.

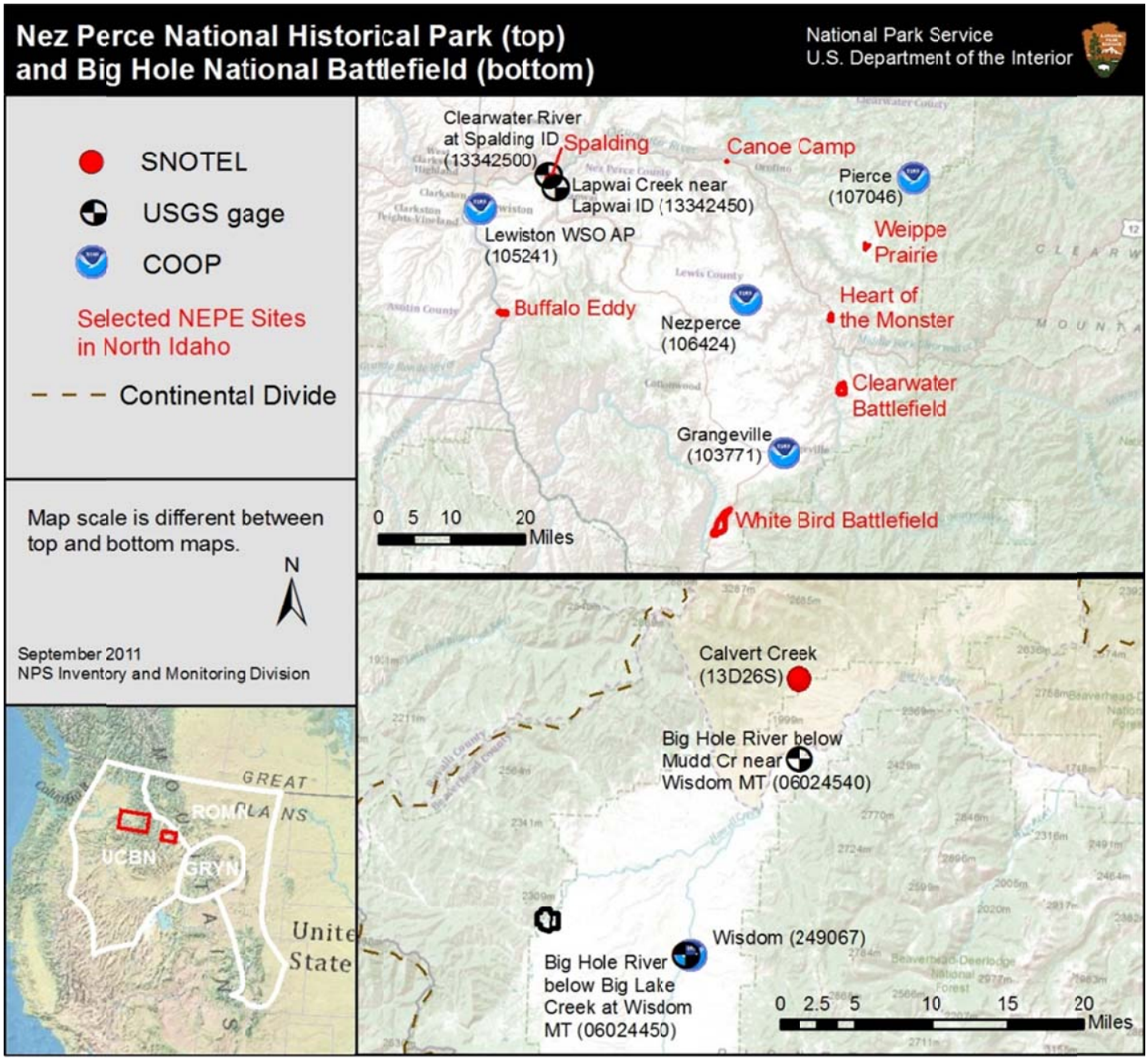


Figure 55. Map showing key climate and stream gauge stations near Nez Perce National Historical Park in Idaho (top) and Big Hole National Battlefield in Montana (bottom).

Gridded climate maps

Given the relatively sparse network of climate stations and complex topography in the area surrounding NEPE and BIHO, regional color maps (figs. 56–58) showing month-to-month departure from average conditions for precipitation and temperature using PRISM data provide a visual overview of the climate in 2010. PRISM interpolates precipitation values between actual observation stations, and corrects these interpolated estimates for changes in topography across the region. For more information, see http://www.prism.oregonstate.edu/.

Precipitation

Total annual precipitation

The 2010 precipitation records are incomplete at Wisdom near BIHO and therefore accumulated precipitation values are not given, however the SNOTEL station at Calvert Creek reported 110%

of average annual precipitation. Total annual precipitation near NEPE was above average and ranged from 106% at Pierce and Grangeville to 114% at Lewiston WSO AP. Total monthly precipitation is shown in figure 59 and table 37.

Seasonal precipitation highlights

The gridded climate map in figure 56 was used to describe seasonal precipitation patterns near BIHO due to missing monthly precipitation data at Wisdom. Near BIHO, winter (January–March) precipitation was below average at Wisdom and Calvert Creek. The lowest during this period was 32% of average reported at Calvert Creek in February. Spring precipitation (April–June) was above average at Calvert Creek and below average at Wisdom in April and above average in May and June. June precipitation was 194% of average at Wisdom and 200% of average at Calvert Creek. Early summer precipitation started out below average in July and changed to above average in August and September at Wisdom. Summer precipitation at Calvert Creek was below average in July and August and above average in September. Fall (October–December) precipitation was above average at both locations. December precipitation measured at Wisdom was 243% of average.

Near NEPE, winter (January–March) precipitation was mostly near or below average, however precipitation in January at Lewiston WSO AP was 160% of average. Spring precipitation was near average in April and May and above average in June at all stations. Summer (July–September) precipitation was mostly below average; however precipitation in September at Pierce was 142% of average. The lowest during this period was 22% of average reported at Lewiston WSO AP in July. Fall (October–December) precipitation was generally above average however precipitation at Lewiston WSO AP and Pierce dropped to below average in November. Departures from average, expressed as a percentage, are shown in figure 60 and table 37.

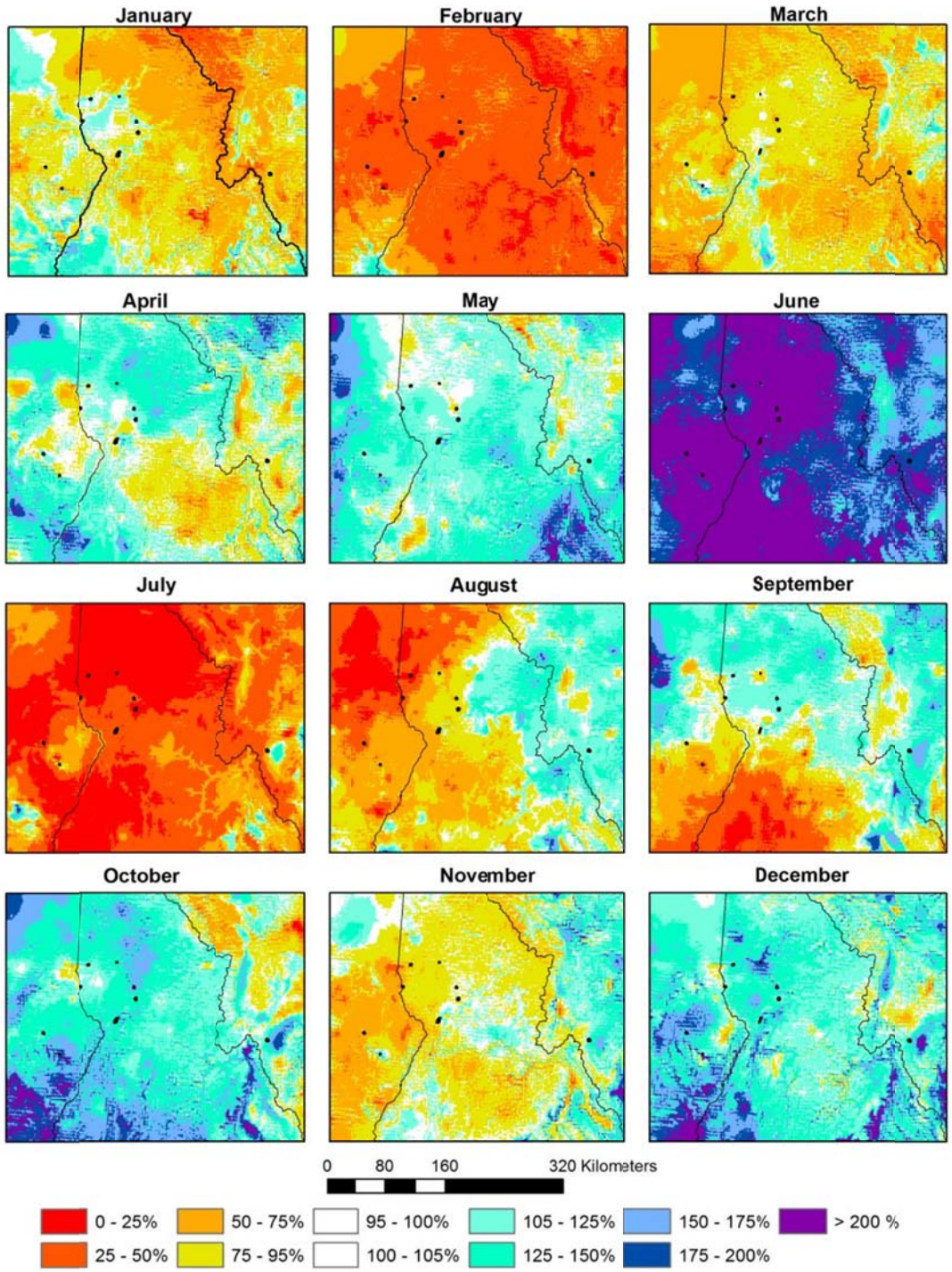


Figure 56. Maps showing percent of average precipitation versus 1971–2000 for each month in calendar year 2010 in the area surrounding Nez Perce National Historical (western park units in Oregon and Idaho) and Big Hole National Battlefield in Montana (eastern park unit in Montana). Colors show estimates from the Parameter-elevation Regressions on Independent Slopes Model (PRISM).

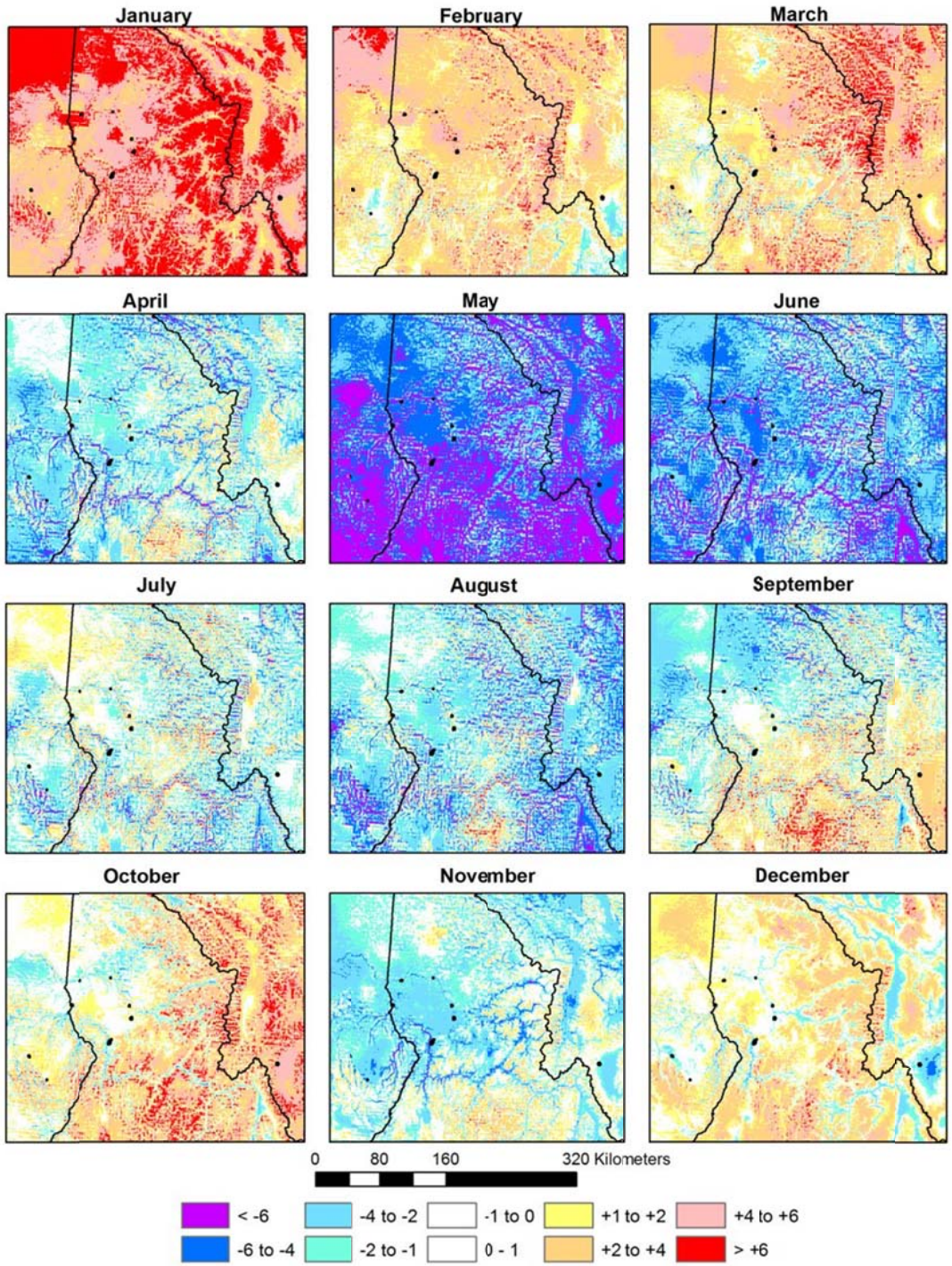


Figure 57. Maps showing departures from average maximum daily temperatures for each month in calendar year 2010 versus 1971–2000 in the area surrounding Historical (western park units in Oregon and Idaho) and Big Hole National Battlefield in Montana (eastern park unit in Montana). Departure values are reported in degrees Fahrenheit. Maps were created using estimates from the Parameter-elevation Regressions on Independent Slopes Model (PRISM).

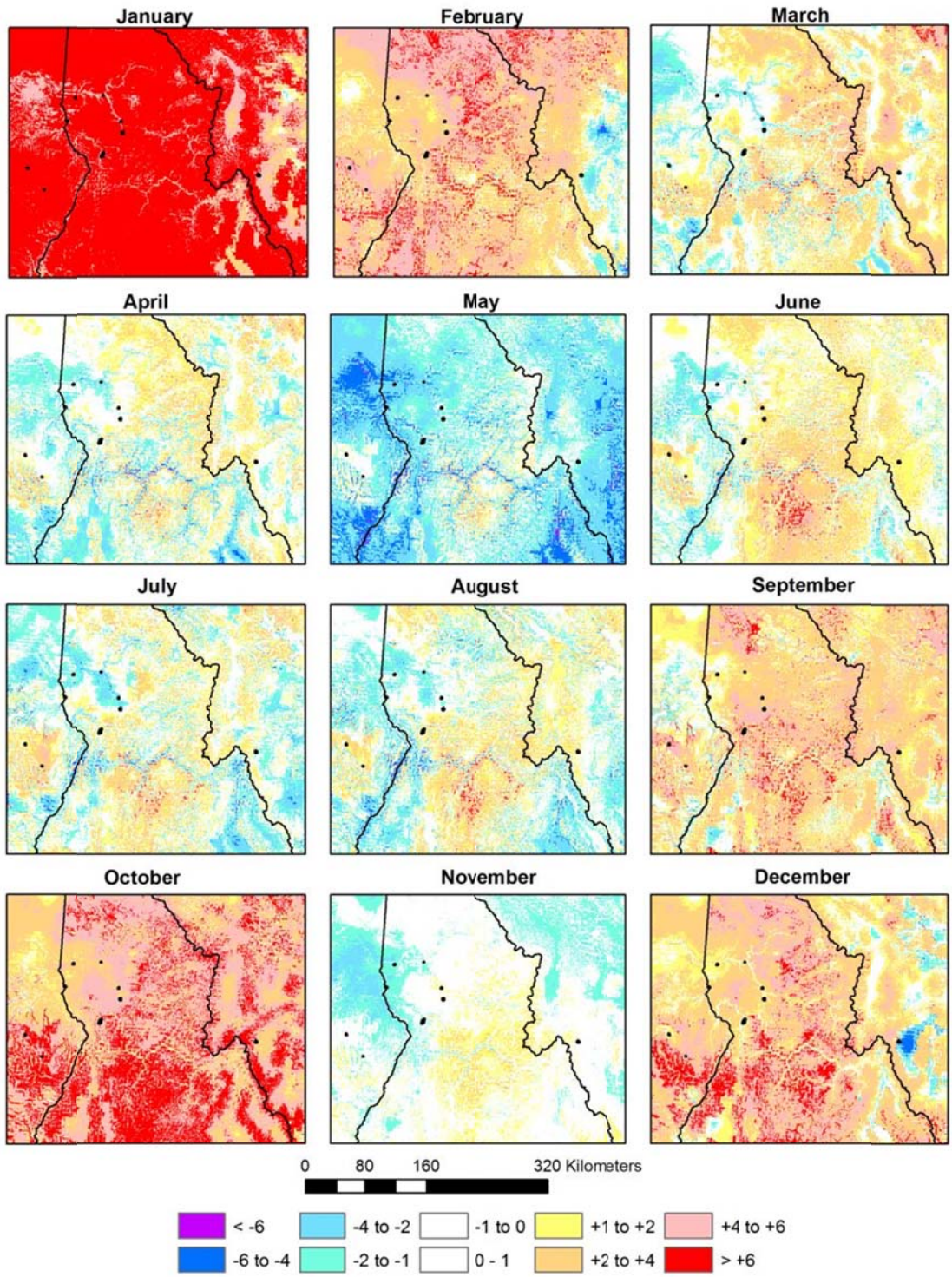


Figure 58. Maps showing departures from average minimum daily temperatures for each month in calendar year 2010 versus 1971–2000 in the area surrounding Historical (western park units in Oregon and Idaho) and Big Hole National Battlefield in Montana (eastern park unit in Montana). Departure values are reported in degrees Fahrenheit. Maps were created using estimates from the Parameter-elevation Regressions on Independent Slopes Model (PRISM).

Temperature

Near BIHO, temperature measurements are incomplete at Wisdom and SNOTEL temperature measurements are not used in this report to calculate departures from average so neither the annual average maximum or minimum daily temperature are given. The gridded climate map in figures 57 and 58 were used to describe maximum and minimum monthly temperatures near BIHO due to missing temperature data at Wisdom.

Near NEPE, the annual average maximum daily temperature in 2010 was near average at Lewiston WASO AP and Pierce and 1.82°F below average at Grangeville. The annual average minimum daily temperature was near average at Lewiston WASO AP and Grangeville and 2.23°F above average at Pierce.

Average monthly maximum and average minimum daily temperatures were above average in winter (January–March) and mostly below average during the spring (April–June) (fig. 61). Grangeville reported average maximum daily temperatures in May and June that were 7 and 5°F below average, respectively. Average monthly maximum daily temperatures stayed below average at most stations during the summer (July–September) while average monthly minimum daily temperatures were mostly above average. Fall temperatures were variable however, in general, average monthly maximum daily temperatures were above average in October, below average in November, and above average in December.

The station at Wisdom reported monthly maximum daily temperatures in December that were 7.86°F below average. Average monthly minimum daily temperatures during the fall were above average in October, near average in November and above average again in December.

Average maximum and average minimum daily temperatures and departures for average are show in tables 38 and 39.

Temperature thresholds

The onset of spring, defined as the last day when the minimum temperature dropped below 28°F, was later than average in 2010 by one to two weeks depending on location. The first day of fall, defined as the first day when minimum temperatures drop below 28°F, was also later in 2010 at all locations. The onset of fall occurred at Pierce 25 days later than average and at Wisdom, 17 days later than average.

The number of hot days, defined as days where the maximum daily temperatures ≥ 90°F, were fewer than average by 4 to 10 days. The station at Wisdom reported 0 days ≥ 90°F in 2010. The number of frosty nights, defined as nights where the minimum temperatures ≤ 32°F, were fewer than average. The numbers of frosty nights were fewer by 27 nights at Wisdom and 25 fewer nights at Grangeville.

Tables with first and last freeze and frost dates, accumulated growing degree days, and days above or below critical temperature thresholds for key stations in reporting area are shown in table 40.

The Western Regional Climate Center reported daily and monthly records that were exceeded in 2010 (WRCC 2010) at Wisdom COOP station where the highest maximum daily temperature recorded in October was reported on October 2, 2010, at 80°F.

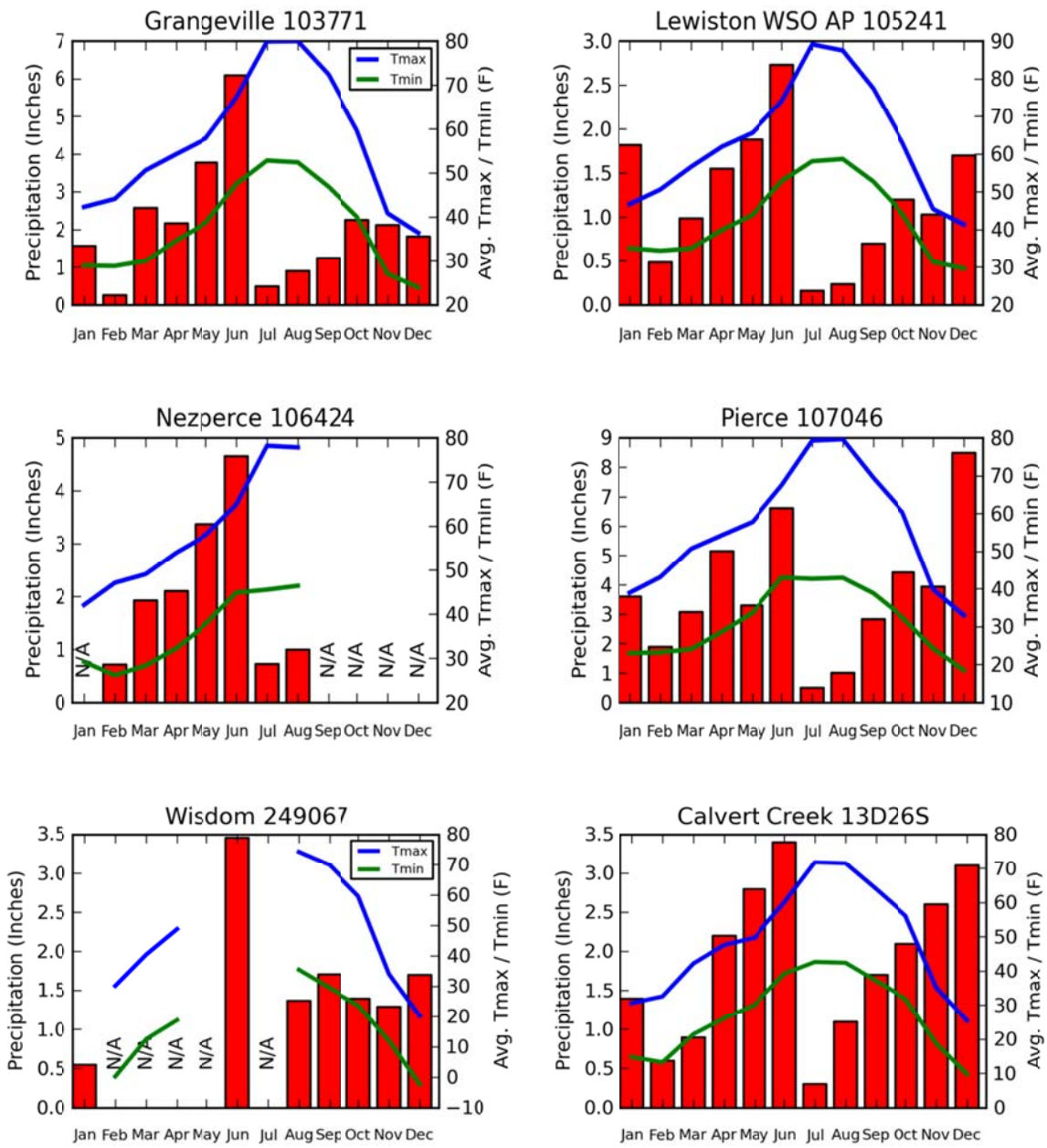


Figure 59. Monthly precipitation totals and average daily maximum temperatures (Tmax) and average daily minimum temperatures (Tmin) during 2010 at key climate stations near Nez Perce National Historical Park and Big Hole National Battlefield. The red bars show precipitation measured in inches. Missing bars (NA) indicate months in which there were insufficient data to calculate accumulated precipitation.

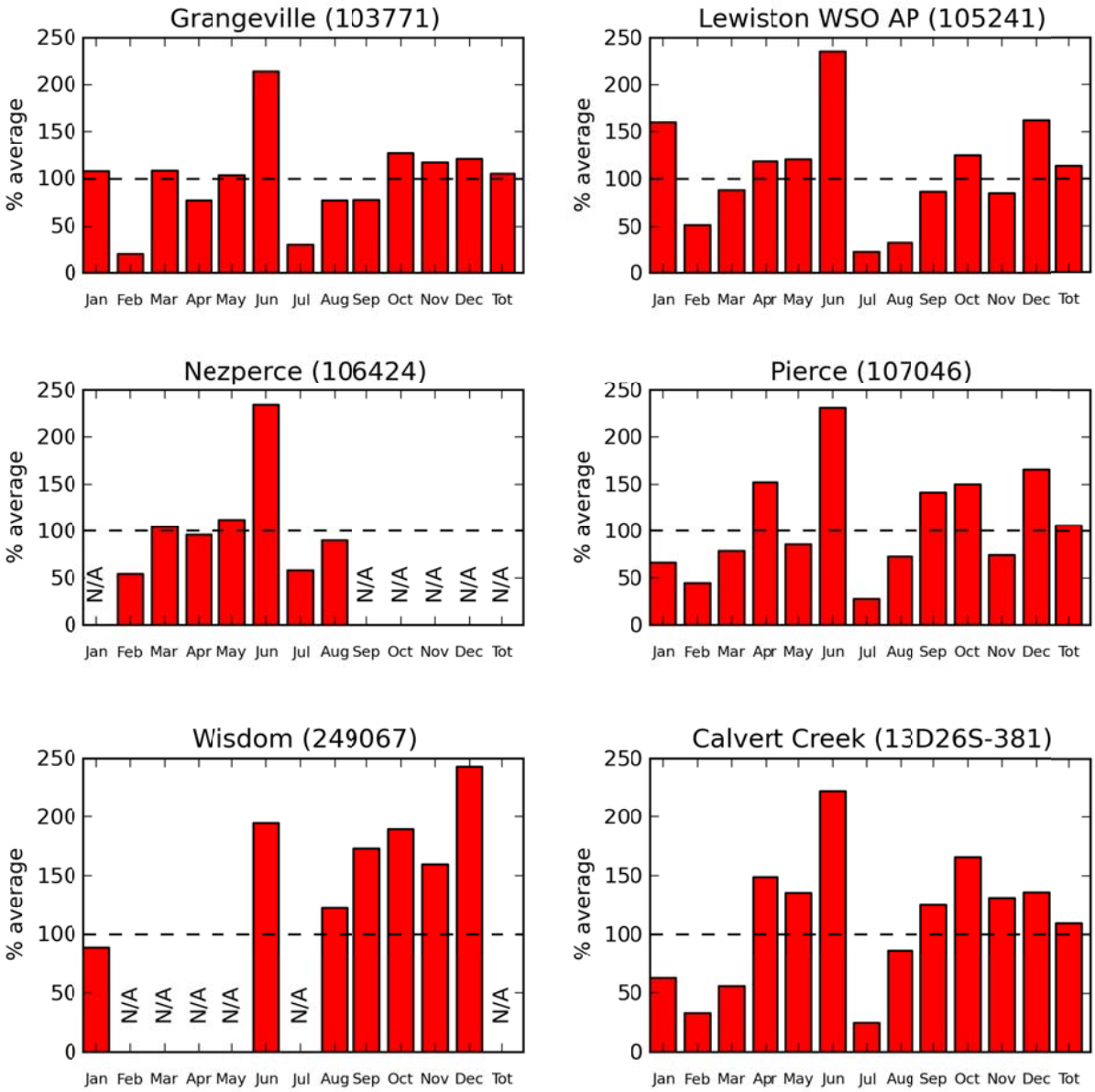


Figure 60. Departure of 2010 precipitation from 1971–2000 average at key climate stations near Nez Perce National Historical Park and Big Hole National Battlefield. Missing bars (NA) indicate months in which there were insufficient data to calculate accumulated precipitation.

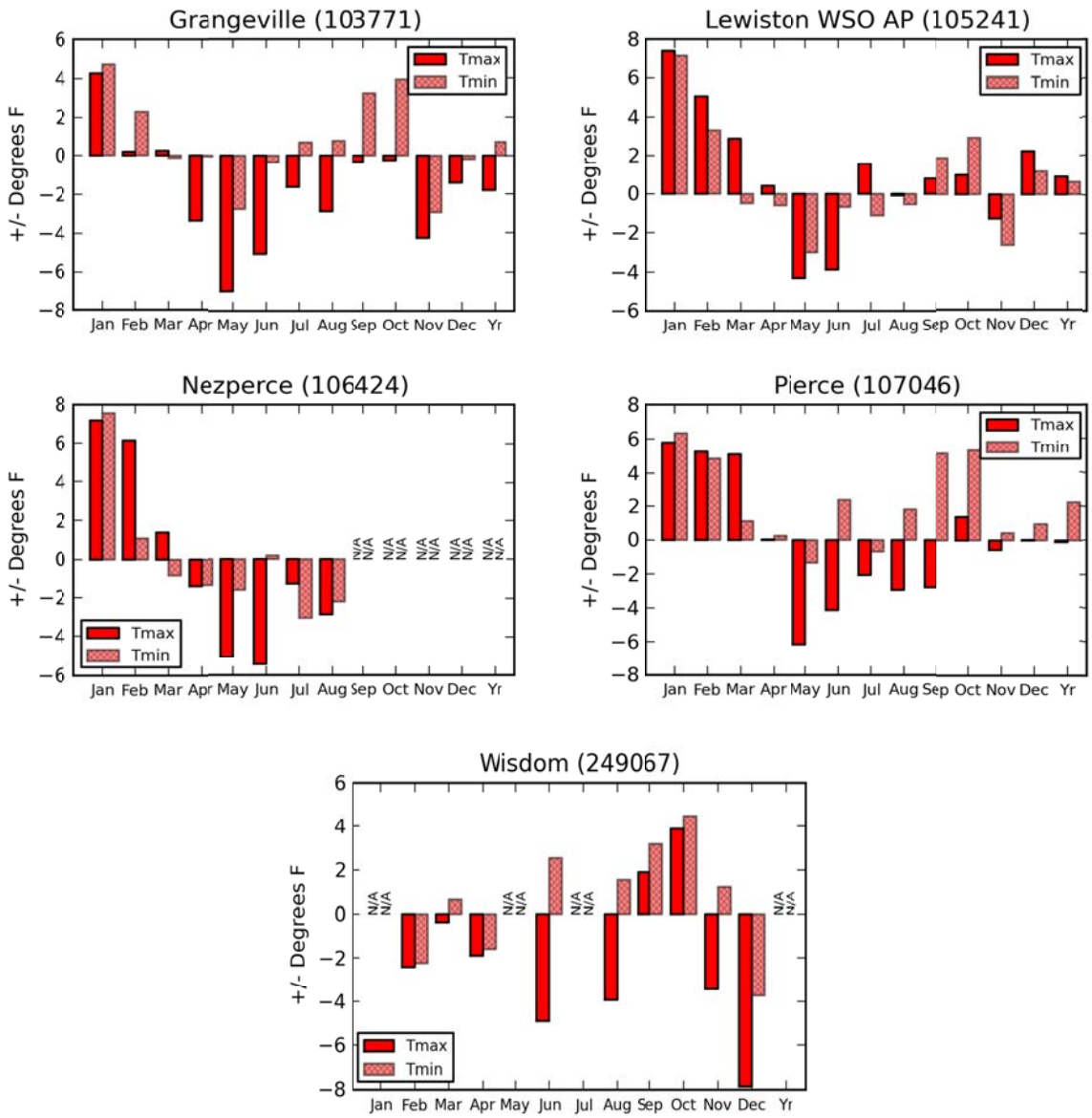


Figure 61. Departure of 2010 average minimum (Tmin) and average maximum (Tmax) daily temperatures from 1971–2000 average at key climate stations near Nez Perce National Historical Park and Big Hole National Battlefield. Missing bars (NA) indicate months in which there were insufficient data to calculate monthly average minimum and maximum temperatures.

Box plots of average maximum and average minimum daily temperatures that display data frequency distribution such as median, quartiles, and outliers and are shown in figure 62. Box plots are not presented for Wisdom due to missing data.

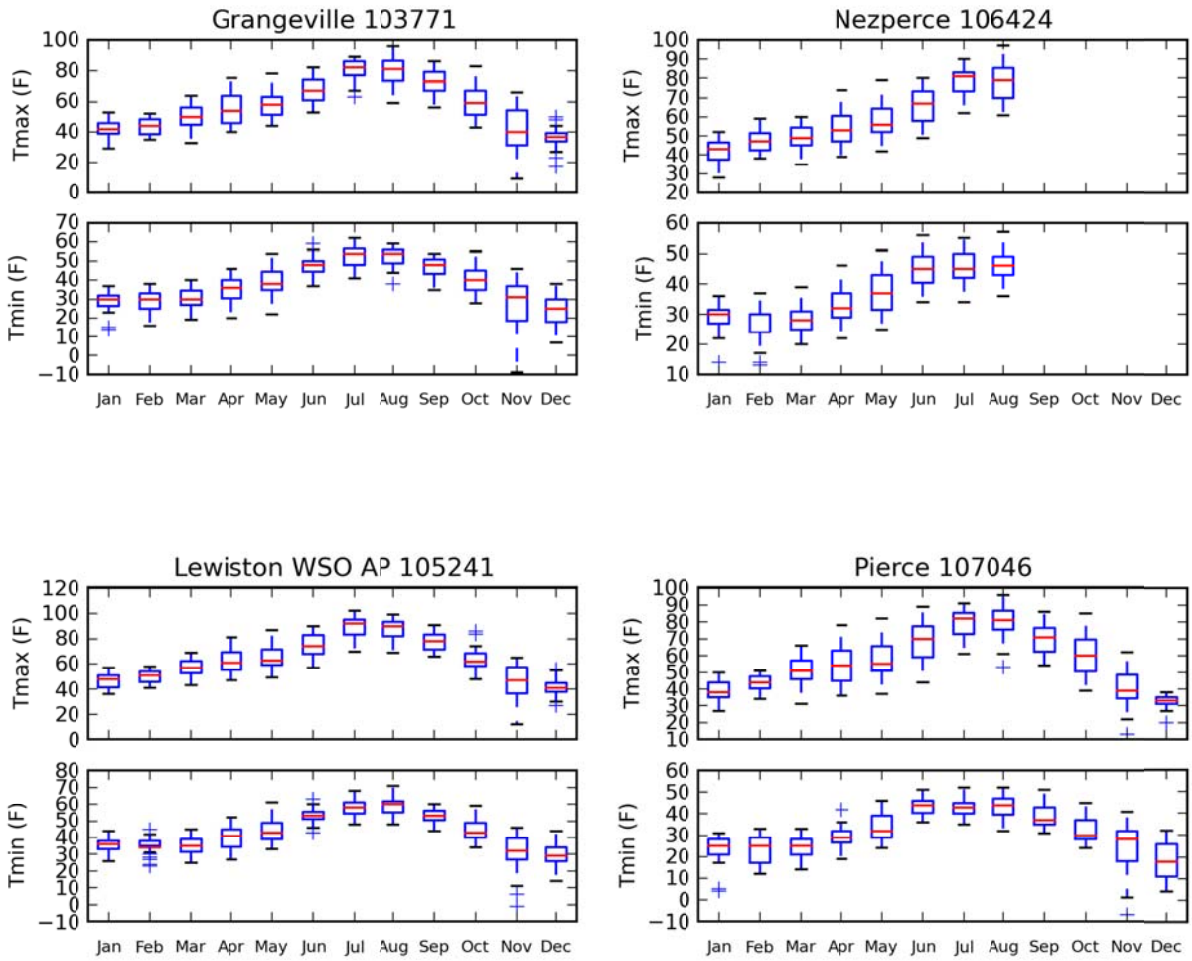


Figure 62. Box plots of average maximum and average minimum daily temperatures at key climate stations near Nez Perce National Historical Park during 2010. Horizontal lines indicate the median value. Boxes indicate the 25th and 75th percentiles. Whiskers extend 1.5 times the interquartile Range (IQR). Crosses indicate values exceeding 1.5 times the IQR.

Streamflow

The USGS monitors streamflow at locations on the Clearwater River and Lapwai Creek near NEPE in Idaho and on the Big Hole River near BIHO in Montana. Key aspects of the areas hydrology are represented by these gauging stations (table 35; appendix A). The stream gauge stations on the Big Hole River (fig. 64) measure seasonal flow only and total annual runoff cannot be calculated.

Table 35. Total annual runoff in acre feet and percentage of average for select USGS Gauge Stations near Nez Perce National Historical Park during 2010 (Data source: USGS Water Data Reports for 2010).

Station Name	Total annual runoff (ac-ft) 2010	Total annual runoff (ac-ft) average	Percent of average
Lapwai Creek nr Lapwai ID	35,580	55,000	65%
Clearwater River at Spalding ID	7,838,000	10,660,000	74%

At the gauge stations near NEPE, total annual runoff was below average on both the Clearwater River and Lapwai Creek in 2010. Figure 63 and table 35 summarize the 2010 water year (October 2009 to September 2010).

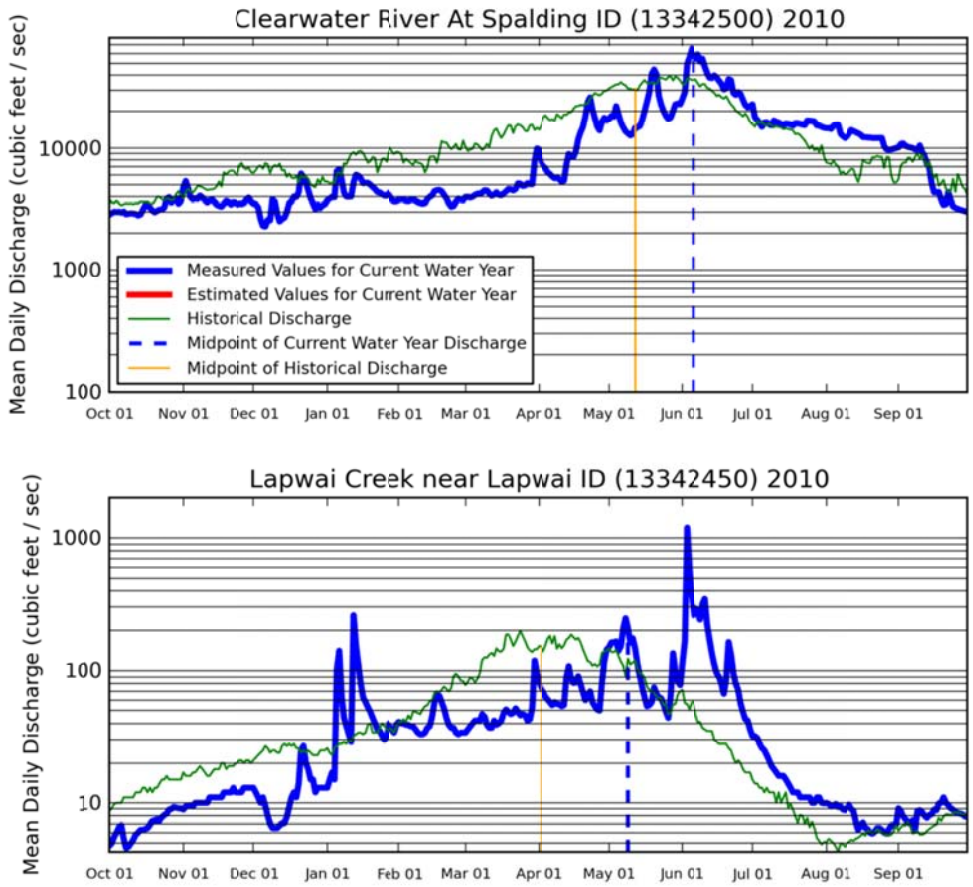


Figure 63. Streamflows from representative gauges near Nez Perce National Historical Park for the 2010 water year (October 2009 through September 2010) are shown versus median daily flow for the reference period. Data courtesy of the U.S. Geological Survey.

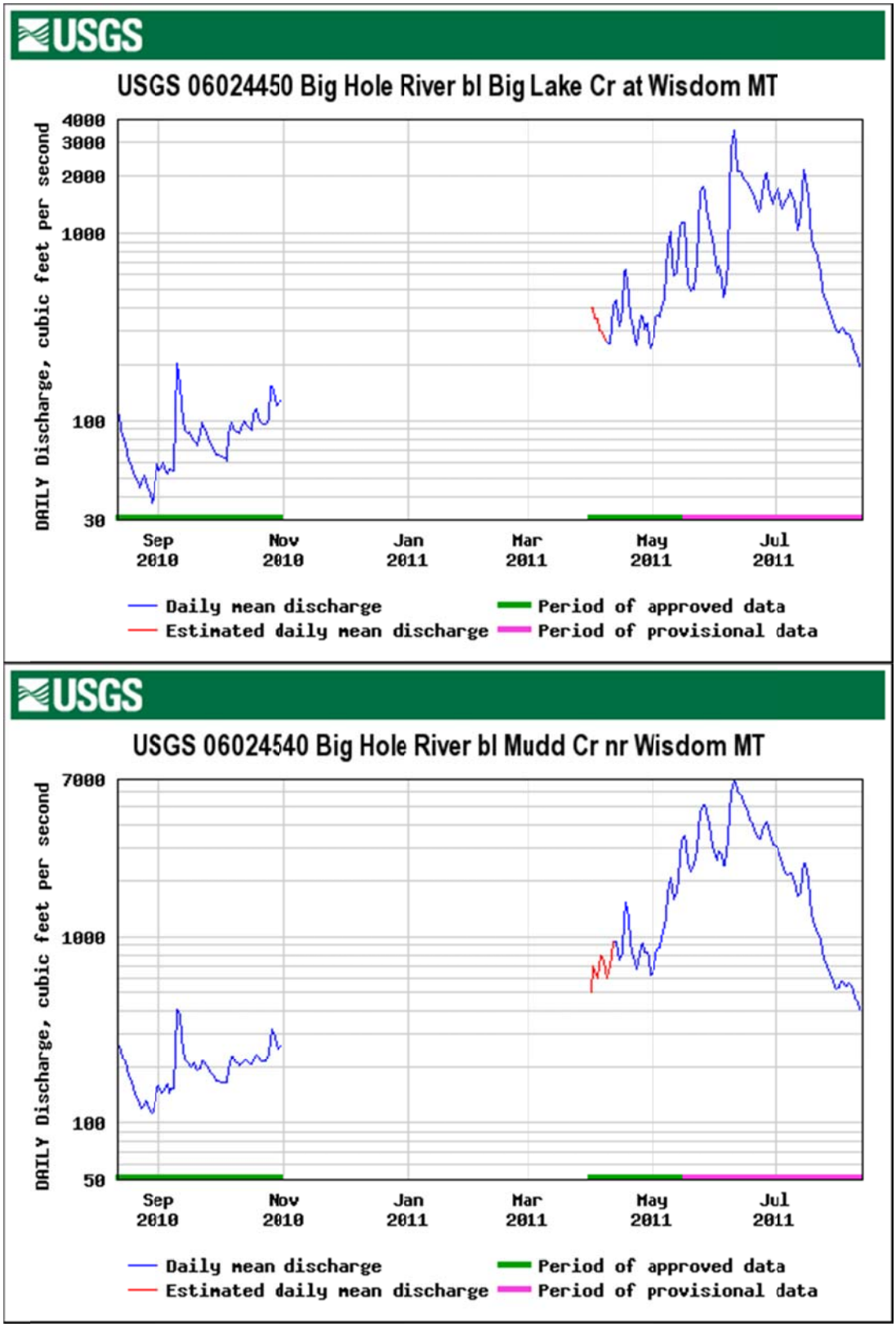


Figure 64. Streamflows from representative gauges near Big Hole National Battlefield for the 2010 water year (October 2009 through September 2010) are shown versus median daily flows for the period of record. Data and graphs courtesy of the U.S. Geological Survey.

Winter snowpack

The NRCS operates automated snow measurement (SNOTEL) stations throughout the western United States. These stations offer the best available means for tracking the accumulation and loss of snowpack. As measured in terms of SWE—the amount of liquid water held in a given volume of snow—snowpack was below average during the 2010 water year (table 36; fig. 65) at Calvert Creek near Wisdom MT. Maximum SWE was reached later than average and the primary melt out date was earlier than average by 4 weeks. Peak flows were higher than average. Daily measurements of SWE and precipitation from Calvert Creek station near Big Hole National Battlefield are shown in figure 65.

Table 36. Snow water equivalent (SWE) (inches) on April 1 and maximum SWE measured at the Snowpack Telemetry station Calvert Creek near Big Hole National Battlefield and percentages of average. Data courtesy of the Natural Resource Conservation Service. These provisional data are subject to change.

Snowpack Telemetry (SNOTEL)	SWE on April 1, 2010 (in)	% of April 1 average	2010 max SWE (in)	Date of 2010 max SWE
Calvert Creek	4.7	58%	5.8	14-Apr

Snow water equivalent at key times of year such as the first day of the month of maximum snowpack help determine if snowpack is decreasing and if runoff is earlier than average. Snow water equivalent on April 1 was 58% of average. Maximum SWE at Calvert Creek reached April 14, 2010, and measured 5.8″.

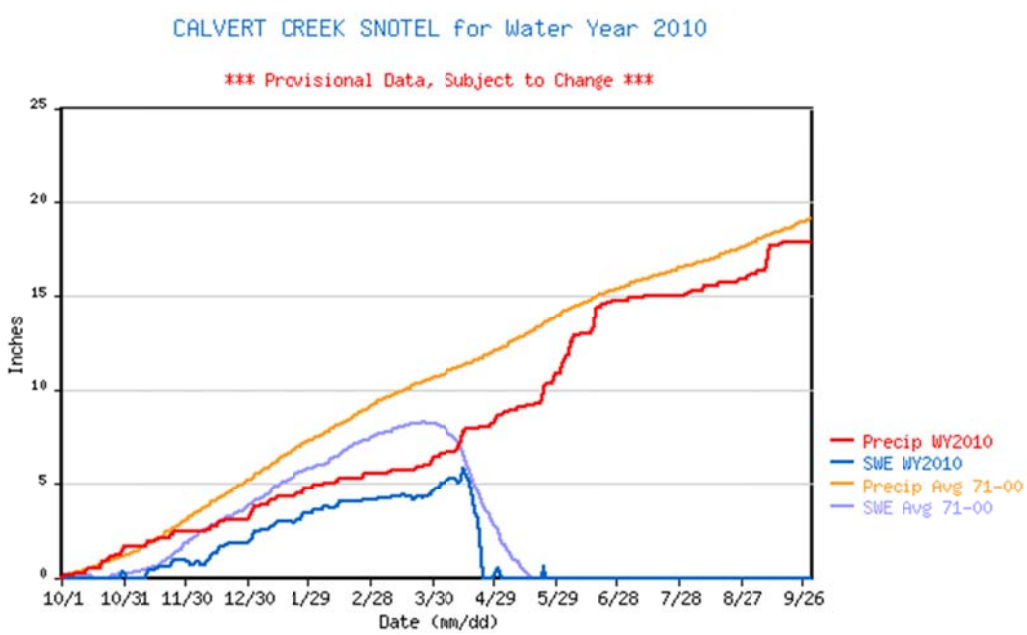


Figure 65. Daily measurements of snow water equivalent (SWE) and precipitation from Calvert Creek Snowpack Telemetry station near Big Hole National Battlefield from October 2009 to September 2010. Values are compared to averages from the 1971–2000 period. Data courtesy of the Natural Resource Conservation Service. These provisional data are subject to change.

Table 37. Total monthly precipitation in inches and percentage of average monthly precipitation versus 1971–2000 averages for select climate stations near Nez Perce National Historical Park and Big Hole National Battlefield during 2010.

Station Name (ID)		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Total
Calvert Creek* (13D26S-381)		1.4	0.6	0.9	2.2	2.8	3.4	0.3	1.1	1.7	2.1	2.6	3.1	22.2
	% of 30-yr avg.	62	32	56	149	135	222	24	86	125	165	131	135	111
Grangeville (103771)		1.57	0.26	2.58	2.18	3.77	6.09	0.49	0.9	1.26	2.26	2.13	1.82	25.31
	% of 30-yr avg.	108	20	109	77	104	214	30	76	78	127	118	121	106
Lewiston WSO AP (105241)		1.82	0.49	0.99	1.55	1.88	2.73	0.16	0.24	0.7	1.2	1.03	1.7	14.49
	% of 30-yr avg.	160	52	88	118	121	235	22	32	86	125	85	162	114
Nezperce (106424)		(-)	0.72	1.93	2.1	3.37	4.66	0.73	1	(-)	(-)	(-)	(-)	(-)
	% of 30-yr avg.	(-)	54	104	96	112	234	58	90	(-)	(-)	(-)	(-)	(-)
Pierce (107046)		3.6	1.9	3.07	5.16	3.3	6.61	0.5	1.01	2.83	4.42	3.93	8.5	44.83
	% of 30-yr avg.	66	44	78	152	85	231	28	73	142	150	74	166	106
Wisdom (249067)		0.55	(-)	(-)	(-)	(-)	3.46	(-)	1.37	1.71	1.4	1.29	1.7	(-)
	% of 30-yr avg.	89	(-)	(-)	(-)	(-)	194	(-)	122	173	189	159	243	(-)

Note: Percentages of average monthly precipitation versus 1971–2000 averages are given in the second line of data for each station. Station IDs are from NWS Cooperative Observer Program (COOP) stations and NRCS Snowpack Telemetry (SNOTEL) stations. Monthly statistics are not reported if more than three days of data are missing. Individual months are not used for calculating annual statistics if more than five days of data are missing.

* The reference period for average at Calvert Creek is 1975–2000.

(-) Indicates missing data.

Table 38. Average maximum daily temperatures in degrees Fahrenheit for select climate stations near Nez Perce National Historical Park and Big Hole National Battlefield during 2010. Departures from 1971–2000 averages are given in the second line of data for each station expressed as +/- degrees F.

Station Name (ID)		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Calvert Creek (13D26S-381)		30.65	32.6	42.22	47.66	49.78	60.03	71.82	71.52	63.96	56.16	35.22	25.43	48.92
	Departure (+/- F)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)
Grangeville (103771)		42.35	44.18	50.65	54.33	57.9	67.23	79.94	80	72.47	59.65	40.93	36.48	57.18
	Departure (+/- F)	4.25	0.18	0.25	-3.37	-7	-5.07	-1.66	-2.9	-0.33	-0.25	-4.27	-1.42	-1.82
Lewiston WSO AP (105241)		46.81	50.68	56.68	62	65.68	74.13	89.16	87.52	77.5	63	45.53	41.42	63.34
	Departure (+/- F)	7.41	5.08	2.88	0.4	-4.32	-3.87	1.56	-0.08	0.8	1	-1.27	2.22	0.94
Nezperce (106424)		42.1	47.14	49.1	54.03	58.06	64.97	78.26	77.87	(-)	(-)	(-)	(-)	(-)
	Departure (+/- F)	7.2	6.14	1.4	-1.37	-5.04	-5.43	-1.24	-2.83	(-)	(-)	(-)	(-)	(-)
Pierce (107046)		39	43.18	50.74	54.33	57.84	67.57	79.32	79.68	69.53	60.35	39.93	33.03	56.21
	Departure (+/- F)	5.8	5.28	5.14	0.03	-6.16	-4.13	-2.08	-2.92	-2.77	1.35	-0.57	0.03	-0.09
Wisdom (249067)		(-)	30.18	40.42	48.8	(-)	65	(-)	74.26	69.9	59.58	34.07	20.14	(-)
	Departure (+/- F)	(-)	-2.42	-0.38	-1.9	(-)	-4.9	(-)	-3.94	1.9	3.88	-3.43	-7.86	(-)

Note: Monthly average maximum daily temperature departures from 1971–2000 averages are given in the second line of data for each station in degrees Fahrenheit.

Station IDs are from NWS Cooperative Observer Program (COOP) stations and NRCS Snowpack Telemetry (SNOTEL) stations. Monthly statistics are not reported if more than five days of data are missing. Individual months are not used for calculating annual statistics if more than five days of data are missing.

(-) Indicates missing data. SNOTEL temperatures are used to describe current year and not departure from average.

Table 39. Average minimum daily temperatures in degrees Fahrenheit for select climate stations near Nez Perce National Historical Park and Big Hole National Battlefield during 2010. Departures from 1971–2000 averages are given in the second line of data for each station expressed as +/- degrees F.

Station Name (ID)		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Calvert Creek (13D26S-381)		14.82	13.27	21.48	26.17	30.13	39.24	42.67	42.43	37.14	31.83	18.79	9.83	27.32
	Departure (+/- F)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)
Grangeville (103771)		29	28.89	30.06	34.73	38.81	47.53	52.87	52.45	46.93	40.13	27.13	24	37.71
	Departure (+/- F)	4.7	2.29	-0.14	-0.07	-2.79	-0.37	0.67	0.75	3.23	3.93	-2.97	-0.2	0.71
Lewiston WSO AP (105241)		35.16	34.5	35.1	40	44	52.9	58.16	58.74	52.77	44.16	31.5	29.71	43.06
	Departure (+/- F)	7.16	3.3	-0.5	-0.6	-3	-0.7	-1.14	-0.56	1.87	2.96	-2.6	1.21	0.66
Nezperce (106424)		29.26	26.21	28.39	32.3	37.84	44.9	45.58	46.45	(-)	(-)	(-)	(-)	(-)
	Departure (+/- F)	7.56	1.11	-0.81	-1.3	-1.56	0.2	-3.02	-2.15	(-)	(-)	(-)	(-)	(-)
Pierce (107046)		23.06	23.29	24.13	28.73	33.74	43.07	42.71	43	38.9	32.48	24.33	18.55	31.33
	Departure (+/- F)	6.36	4.89	1.13	0.23	-1.36	2.37	-0.69	1.8	5.1	5.28	0.43	0.95	2.23
Wisdom (249067)		(-)	0.27	12.54	18.8	(-)	37.53	(-)	35.45	29.5	23.68	12.03	-2.34	(-)
	Departure (+/- F)	(-)	-2.23	0.64	-1.6	(-)	2.53	(-)	1.55	3.2	4.48	1.23	-3.74	(-)

Note: Monthly average minimum daily temperature departures from 1971–2000 averages are given in the second line of data for each station in degrees Fahrenheit. Station IDs are from NWS Cooperative Observer Program (COOP) stations and NRCS Snowpack Telemetry (SNOTEL) stations. Monthly statistics are not reported if more than five days of data are missing. Individual months are not used for calculating annual statistics if more than five days of data are missing.

(-) Indicates missing data. SNOTEL temperatures used to describe current year only and not departure from average.

Table 40. First and last freeze and frost dates, accumulated growing degree days, and days above or below critical temperature thresholds for key stations near Nez Perce National Historical Park and Big Hole National Battlefield in 2010. Values for 2010 are shown in the first line for each station and averages appear in the second line. Averages are published by the Western Regional Climate Center and the reference period may differ from 1971–2000.

Station Name (ID)		AGDD40	AGDD50	Last date in spring <= 28F	Earliest date in fall <=28	Last date in spring <=32	Earliest date in fall <=32	# of days Tmax		# of days Tmin	
								>= 80 F	>= 90 F	<= 0 F	<= 32 F
Calvert Creek (13D26S-381)		1991.73	637.56	14-May	13-Oct	14-Jun	8-Sep	7	0	15	213
	avg.	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)
Grangeville (103771)		3674	1754.5	7-May	18-Oct	21-May	12-Oct	49	4	1	131
	avg.	3632	1739	1-May	9-Oct	20-May	21-Sep	(-)	14	4.3	155.9
Lewiston WSO AP (105241)		5249.5	2763	10-Apr	19-Nov	10-Apr	9-Nov	76	37	1	66
	avg.	5250	2886	26-Mar	2-Nov	15-Apr	21-Oct	(-)	40.7	1.7	86.3
Nezperce (106424)		(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)
	avg.	3378	1554	4-May	2-Oct	13-May	19-Sep	(-)	10.8	3.9	158
Pierce (107046)		2801.5	1164.5	21-May	12-Oct	24-May	30-Aug	49	8	1	205
	avg.	2772	1209	14-May	17-Sep	23-Jun	29-Aug	(-)	13.2	8.6	223.1
Wisdom (249067)		(-)	(-)	14-Jul	14-Aug	20-Jul	14-Aug	27	0	45	246
	avg.	1922	679	27-Jun	18-Aug	21-Jul	4-Aug	(-)	2.9	49.7	272.7

Note: (-) temperature data or published averages are missing. SNOTEL temperatures used to describe current year only and not departure from average.

City of Rocks National Reserve and Craters of the Moon National Monument and Preserve

2010 climate at a glance

- Total annual precipitation was 115% to 124% of average, depending on station.
- Average annual maximum daily temperatures were near average except at Craters of the Moon which was 1.9°F cooler than average.
- Average annual minimum daily temperatures were near normal except at Craters of the Moon and Oakley which were 1°F and 1.7°F warmer than average.
- The on-set of spring was earlier than average at all stations except Richfield; the on-set of fall was later than average at all stations.
- Total annual runoff measured at the gauge station on the Raft River above Onemile Creek near Malta was 58% of average.

2010 climate data summary

This climate data summary report describes park-level climate at both a local (single weather station) and regional setting (gridded climate maps) using standard data summary and analysis tools described in the *Rocky Mountain Climate Protocol* (RMCWG 2010). Climate data that describe precipitation, temperature, and streamflow were gathered from key climate stations in or near City of Rocks National Reserve (CIRO) and the Craters of the Moon National Monument and Preserve (CRMO) and summarized for this report. The climate stations cited in this report are shown in figure 66; station metadata are available in appendix A.

Total accumulated precipitation and minimum, maximum, and mean monthly temperatures and departures from an established baseline are summarized in figures and tables below. We consider recent events in a historical context, based primarily on a standard 30-year climatological reference or "normal" period (currently 1971–2000) which we refer to as an "average." The baseline period used to determine average conditions in this report for each climate station is included in the station metadata in appendix A. Streamflow and snowpack are included as they integrate the combined effects of temperature and precipitation. Variables indicating the timing or length of a seasonal process are noted throughout the data summary report.

Gridded climate maps

Given the relatively sparse network of climate stations and complex topography surrounding the parks, color maps showing month-to-month departure from average conditions for precipitation and temperature using PRISM data provide a visual overview of the climate in 2010. PRISM interpolates precipitation values between actual observation stations, and corrects these interpolated estimates for changes in topography across the region. For more information, see http://www.prism.oregonstate.edu/. PRISM data were used to show precipitation (fig. 67), average maximum (fig. 68), and average minimum (fig. 69) daily temperatures.

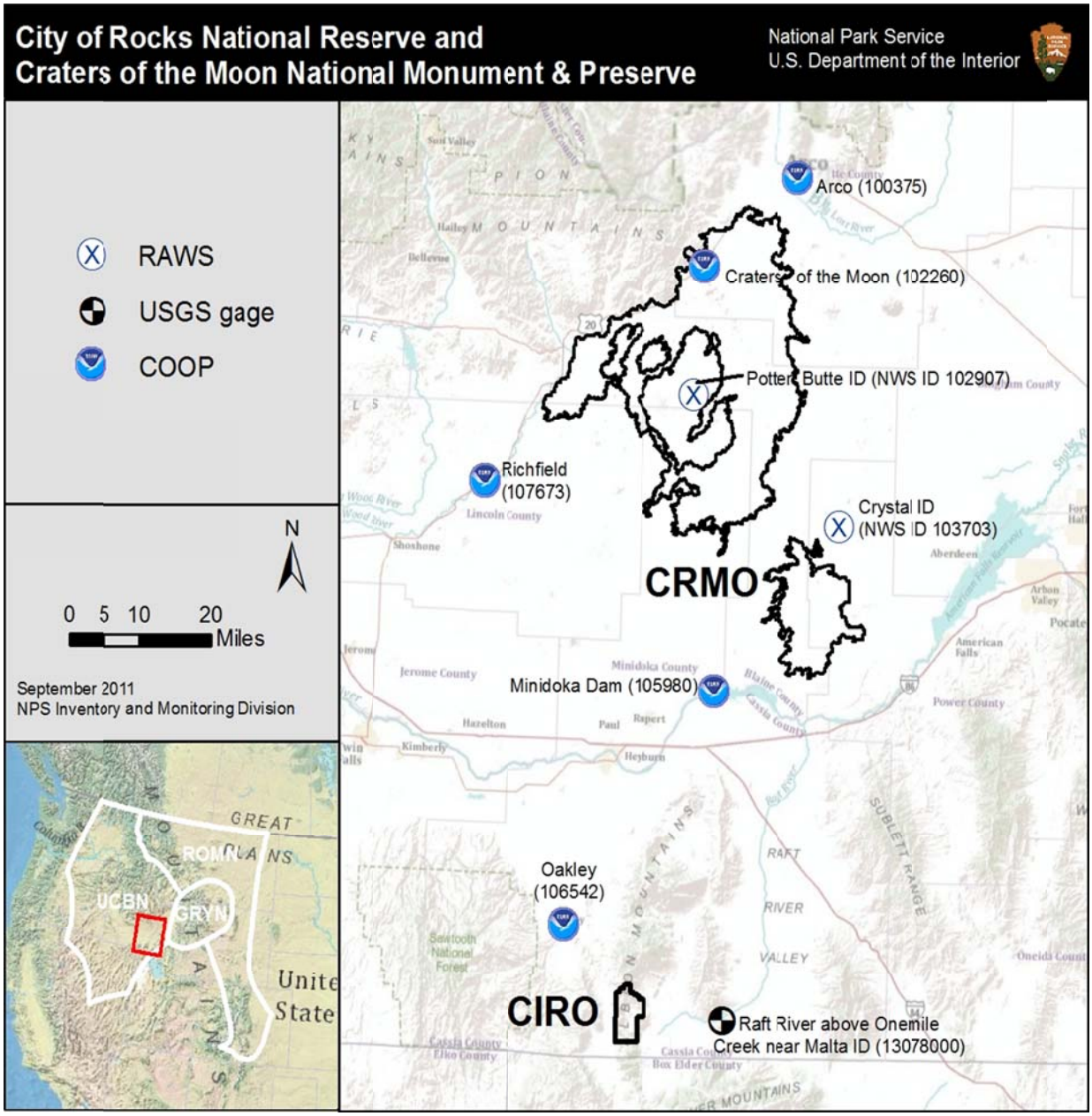


Figure 66. Map showing key climate and stream gauge stations in or near City of Rocks National Reserve and Craters of the Moon National Monument and Preserve in Idaho.

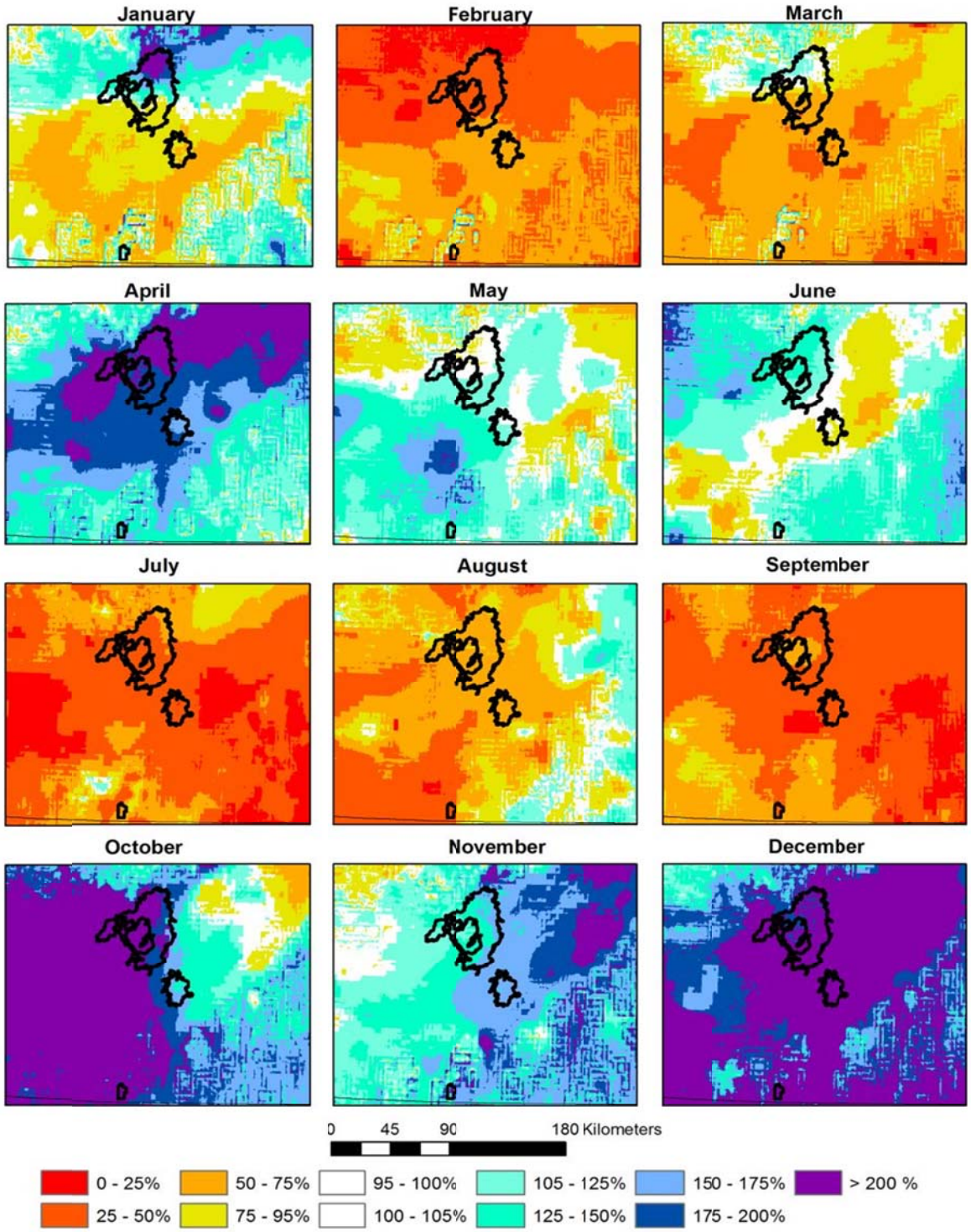


Figure 67. Maps showing percent of average precipitation versus 1971–2000 for each month in calendar year 2010 in the area surrounding City of Rocks National Reserve (northern park units) and Craters of the Moon National Monument and Preserve (southern park unit). Colors show estimates from the Parameter-elevation Regressions on Independent Slopes Model (PRISM).

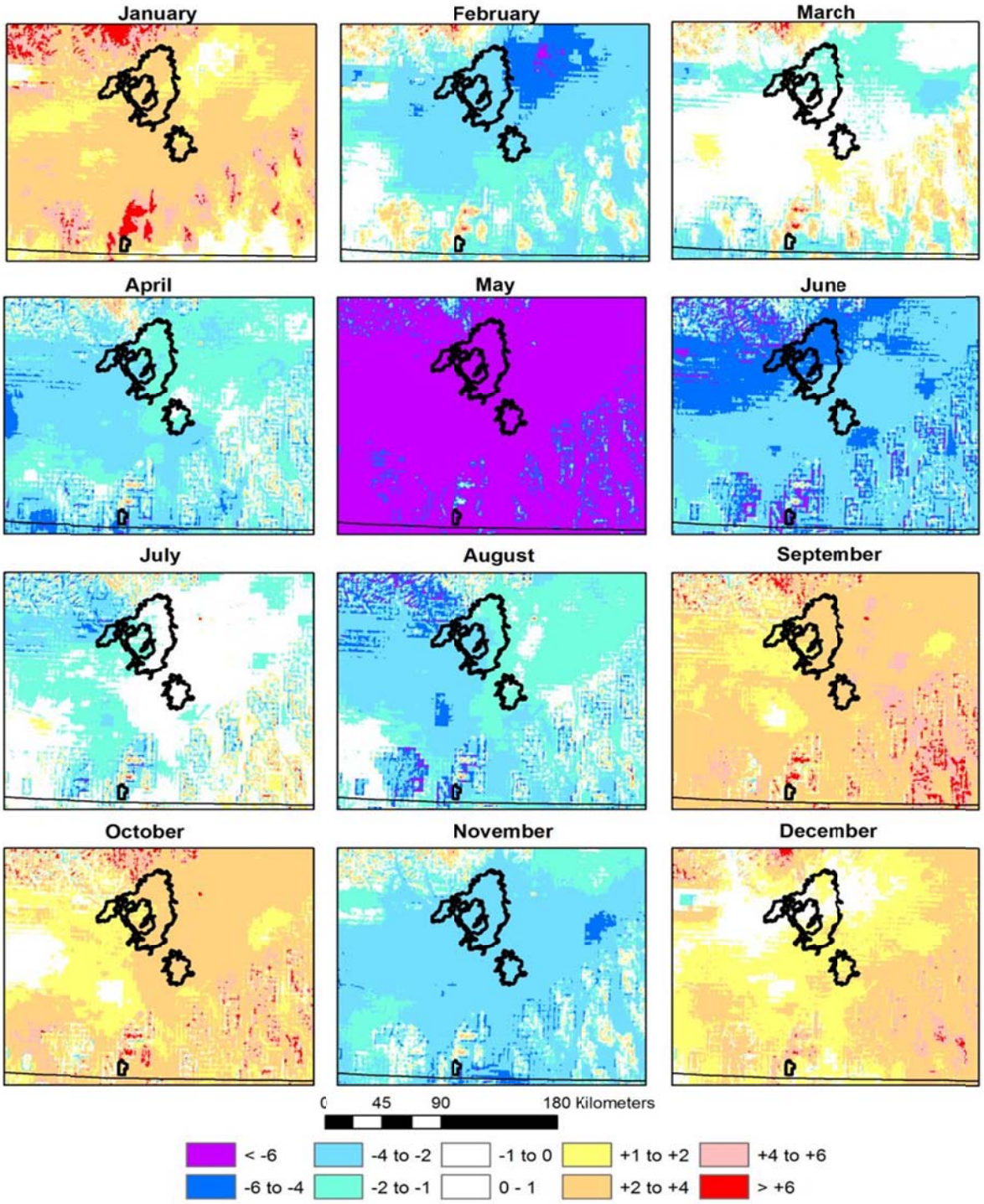


Figure 68. Maps showing departures from average maximum daily temperatures for each month in calendar year 2010 versus 1971–2000 in the area surrounding City of Rocks National Reserve (northern park units) and Craters of the Moon National Monument and Preserve (southern park unit). Departure values are reported in degrees Fahrenheit. Maps were created using estimates from the Parameter-elevation Regressions on Independent Slopes Model (PRISM).

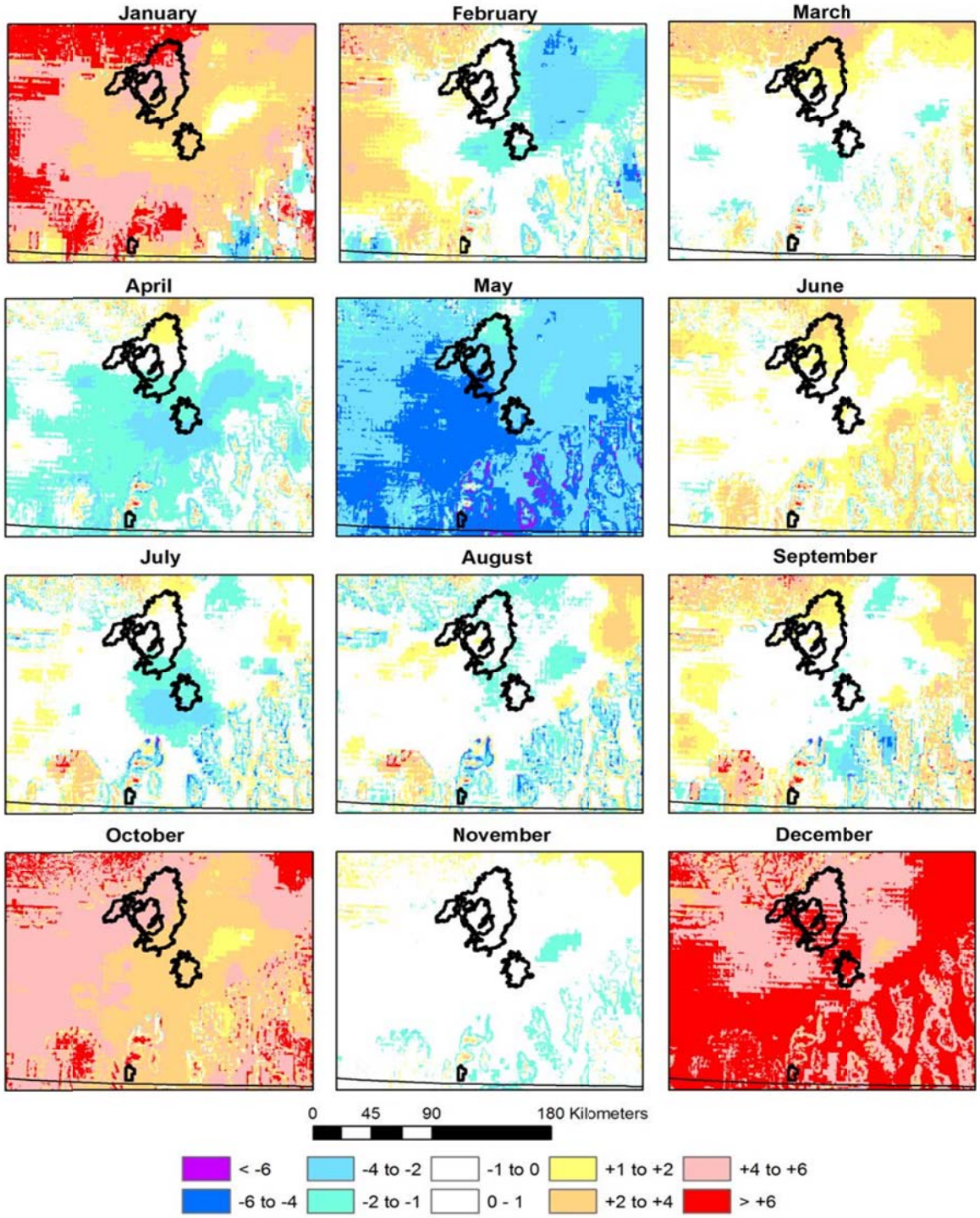


Figure 69. Maps showing departures from average minimum daily temperatures for each month in calendar year 2009 versus 1971–2000 in the area surrounding City of Rocks National Reserve (northern park units) and Craters of the Moon National Monument and Preserve (southern park unit). Departure values are reported in degrees Fahrenheit. Maps were created using estimates from the Parameter-elevation Regressions on Independent Slopes Model (PRISM).

Precipitation

Total annual precipitation

During 2010, individual weather stations in or near CIRO and CRMO reported total annual precipitation ranging from 115% to 134% of average (fig. 71). Total monthly precipitation values are shown in figure 70 and table 42.

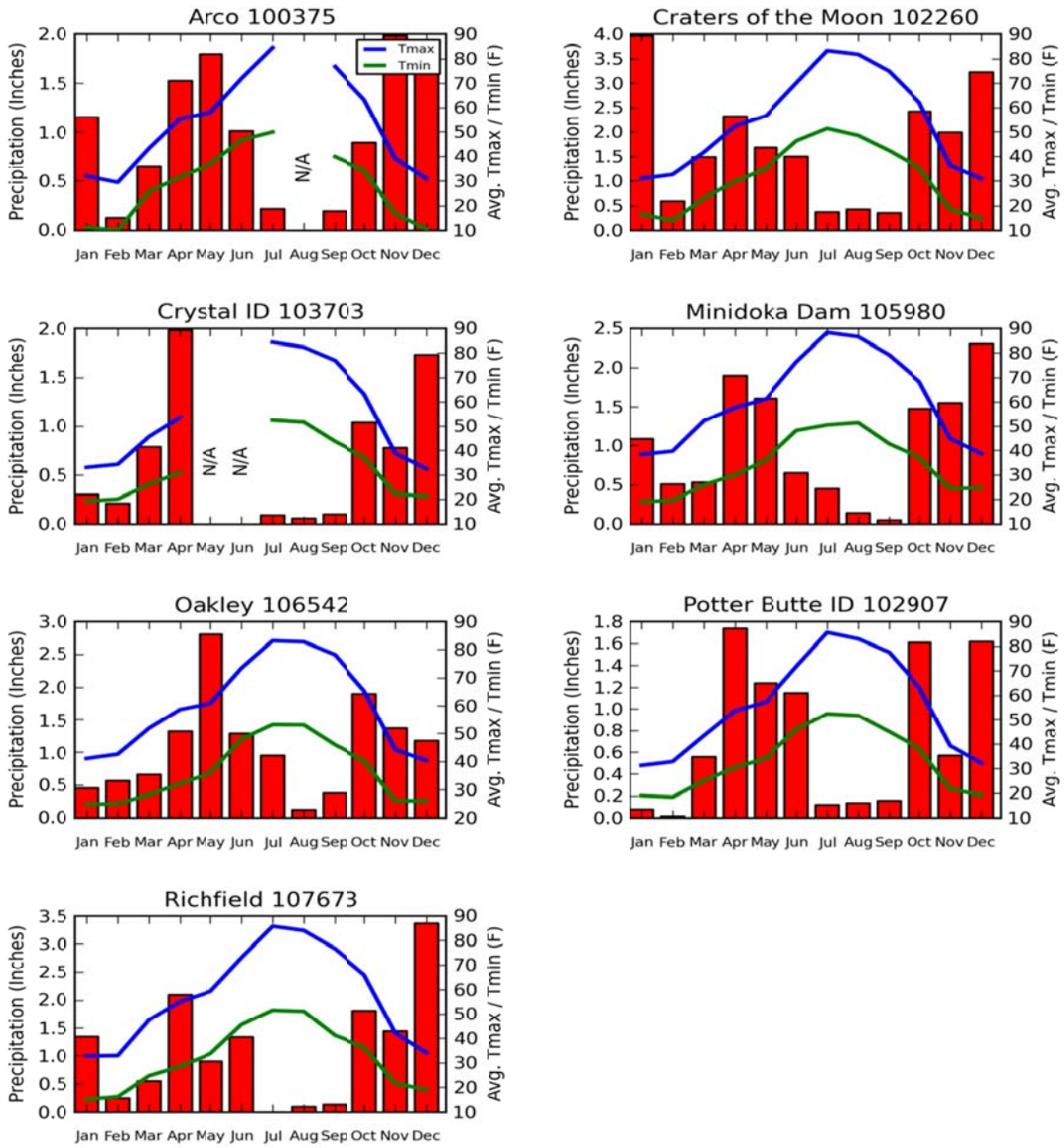


Figure 70. Monthly precipitation totals and average daily maximum temperature and average daily minimum temperatures during 2010 at key climate stations in or near City of Rocks National Reserve and Craters of the Moon National Monument and Preserve. The red bars show precipitation measured in inches. Missing bars (NA) indicate months in which there were insufficient data to calculate accumulated precipitation.

Seasonal precipitation highlights

Throughout the winter (January–March) months, the climate station near CIRO at Oakley reported below average precipitation. Climate stations in or near CRMO were mostly above average in January and then below average in February and March. The climate station Craters of the Moon reported 110% of average precipitation in March. Spring precipitation (April–June) started out above average in April and May and stayed above average in June at Arco, Craters of the Moon, Oakley and Richfield. June precipitation at Minidoka Dam was 77% of average. Summer precipitation (July–September) was below average except in July at Minidoka Dam and Oakley where precipitation was 122% and 141% of average, respectively. Precipitation was notably absent at Richfield in July. Precipitation was above average at all stations during the fall (October–December). Departures from average, expressed as a percentage, are shown in figure 71 and table 42.

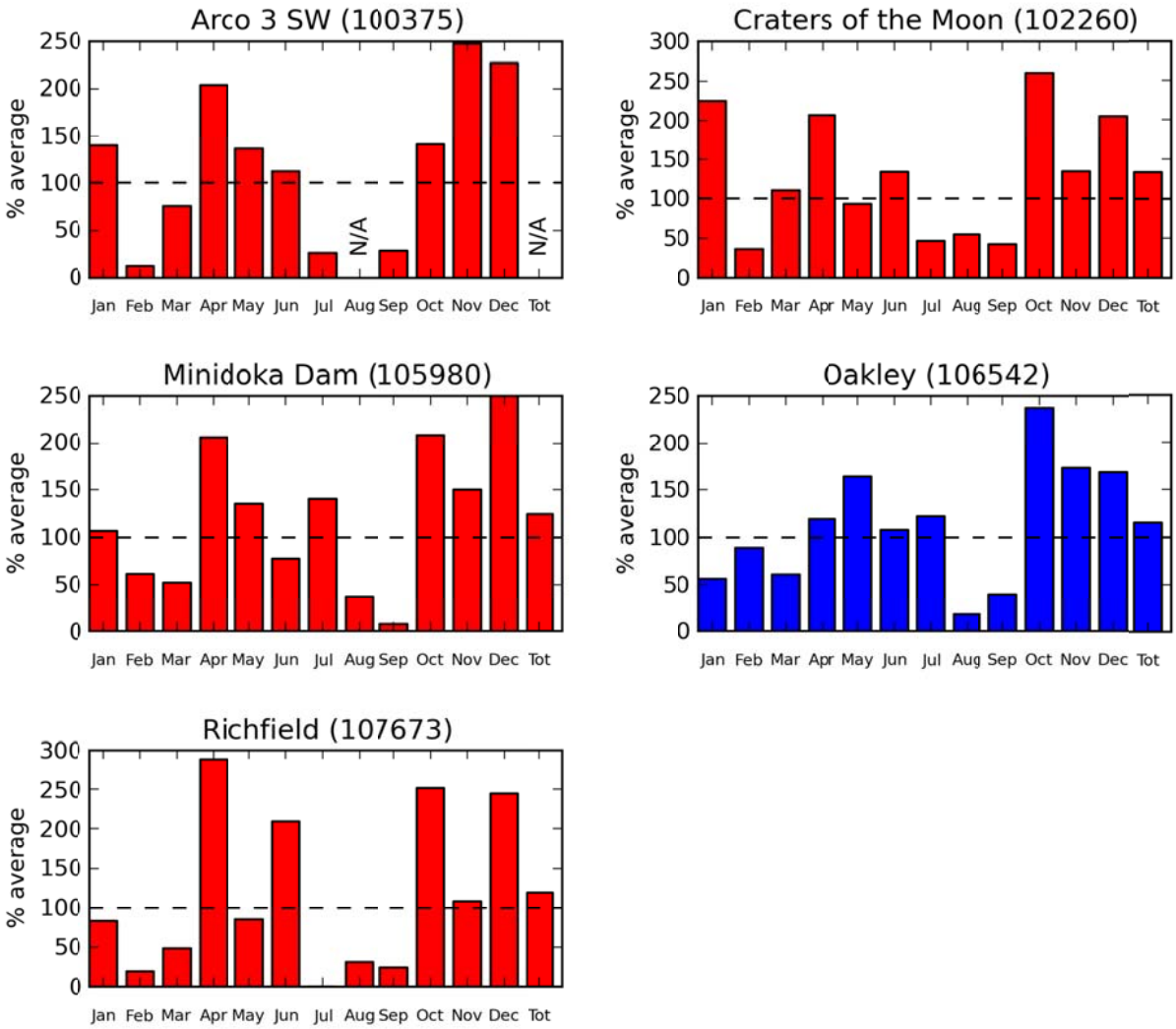


Figure 71. Departure of 2010 precipitation from 1971–2000 average at key climate stations in or near City of Rocks National Reserve and Craters of the Moon National Monument and Preserve. Missing bars (NA) indicate months in which there were insufficient data to calculate accumulated precipitation. Colors indicate the park unit. Red = Craters of the Moon National Monument, Blue = City of Rocks National Reserve.

Temperature

During 2010 average maximum daily temperatures were near average and annual average minimum daily temperatures were mostly near average when averaged across the year. Two exceptions include Craters of the Moon and Oakley which reported above average annual average minimum daily temperatures; Craters of the Moon was 1.09°F warmer than average and Oakley was 1.66°F warmer than average when averaged across the year.

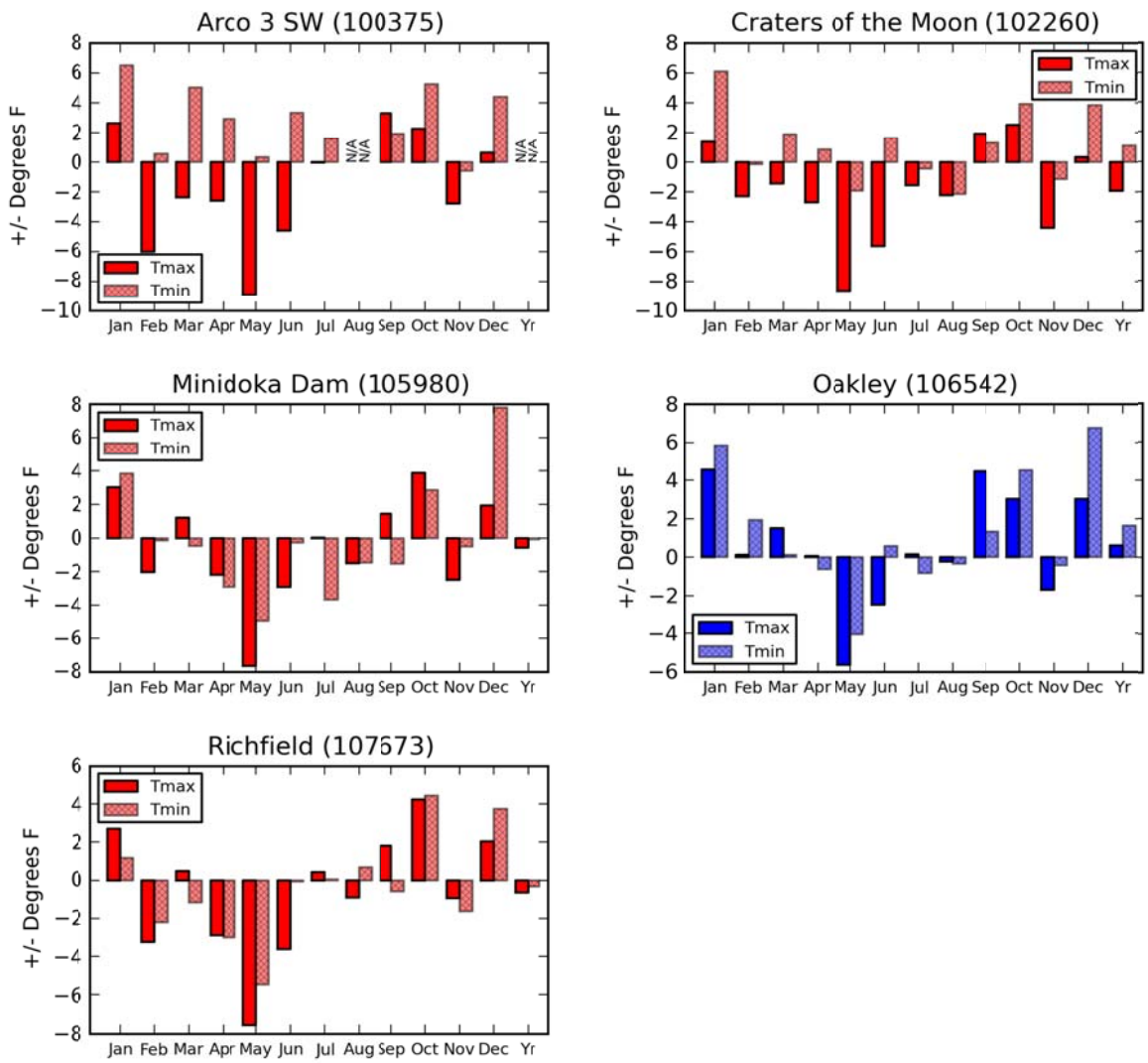


Figure 72. Departure of 2010 average minimum (Tmin) and average maximum (Tmax) daily temperatures from 1971–2000 average at key climate stations in or near the City of Rocks National Reserve and Craters of the Moon National Monument and Preserve. Missing bars (NA) indicate months in which there were insufficient data to calculate monthly minimum and maximum temperatures. Colors indicate the park unit. Red = Craters of the Moon National Monument, Blue = City of Rocks National Reserve.

Monthly average maximum and average minimum daily temperatures were much more variable and highlight the differences and similarities at each weather station (fig. 72; tables 43 and 44). The monthly average maximum daily temperatures at Craters of the Moon were cooler than average most months except in January, September, October, and December. All stations in the

area reported below average maximum daily temperatures in May and June. The average minimum daily temperatures at Craters of the Moon and Oakley were below average in May and above average in June. The monthly average maximum and average minimum daily temperatures were above average at all stations in October, November, and December.

Box plots of average maximum and average minimum daily temperatures that display data frequency distribution such as median, quartiles, and outliers are shown in figure 73.

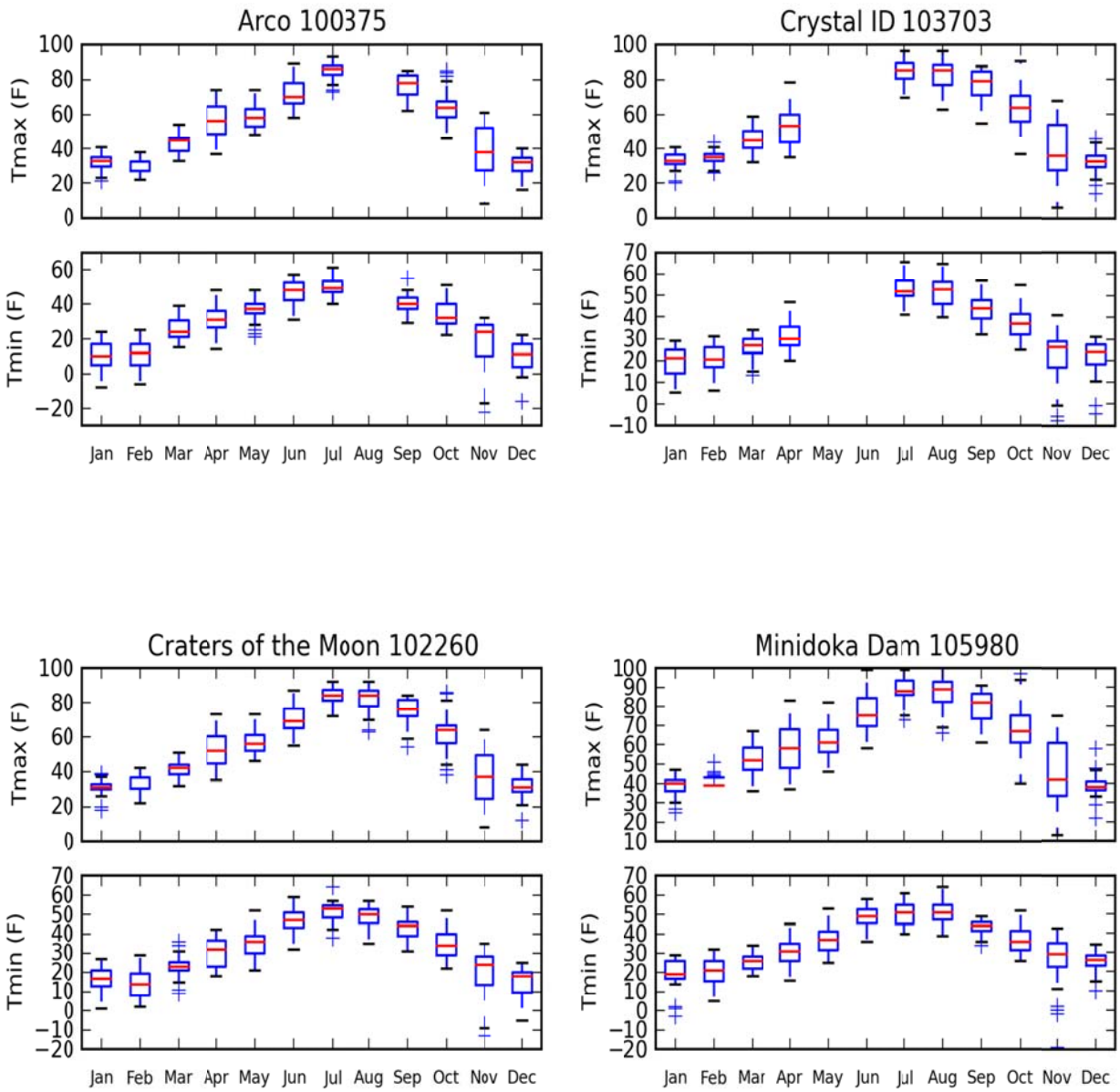


Figure 73. Box plots of average maximum and average minimum daily temperatures at key climate stations in and near City of Rocks National Reserve and Craters of the Moon National Monument and Preserve during 2010. Horizontal lines indicate the median value. Boxes indicate the 25th and 75th percentiles. Whiskers extend 1.5 times the interquartile Range (IQR). Crosses indicate values exceeding 1.5 times the IQR.

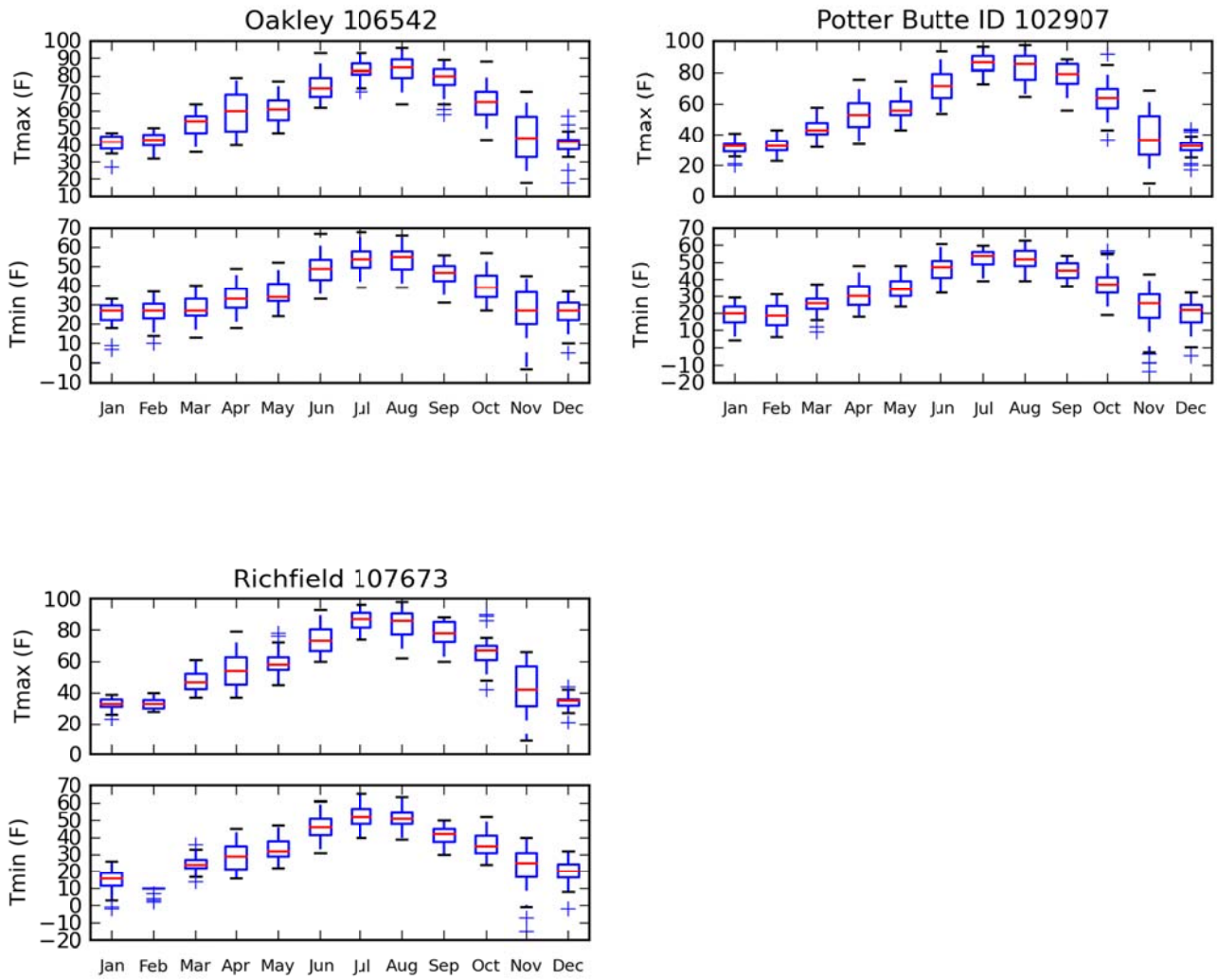


Figure 73. Continued.

Temperature thresholds

The onset of spring, defined as the last day when the minimum temperature dropped below 28°F, was earlier in 2010 at all locations except Richfield. The onset of spring occurred at Craters of the Moon five days earlier and at Oakley 18 days earlier than average. The on-set of fall, defined as the first day when minimum temperatures drop below 28°F, was later in 2010 at all locations. The onset of fall occurred at Craters of the Moon 16 days later than average and 22 days later than average at Oakley.

The number of hot days, defined as days where the maximum daily temperatures ≥ 90°F, were fewer than average at all stations but Minidoka Dam. Oakley reported 13 fewer hot days and Craters of the Moon reported eight fewer hot days. The number of frosty nights, defined as nights where the minimum temperatures ≤ 32°F, were fewer than average at Arco, Craters of the Moon, and Oakley and greater than average at the other stations.

The Western Regional Climate Center reported daily and monthly records that were broken in 2010 (WRCC 2010) at Arco, Richfield, Craters of the Moon, and Minidoka Dam.

At Arco,

- the lowest minimum daily temperature recorded in November was reported on November 25, 2010 at -22°F.

At Richfield,

- the lowest monthly average minimum daily temperatures was reported for the month of May at 46.6°F.

At Minidoka Dam,

- the highest maximum daily temperature recorded in October was reported on October 2, 2010 at 97°F.
- the lowest minimum daily temperature recorded in November was reported on November 25, 2010 at -19°F.
- the lowest monthly average minimum daily temperatures was reported for the month of May at 48.8°F.

At Craters of the Moon,

- the highest maximum daily temperature recorded in October was reported on October 2, 2010 at 86°F.
- the lowest minimum daily temperature recorded in November was reported on November 24, 2010 at -13°F.

Tables with first and last freeze and frost dates, accumulated growing degree days, and days above or below critical temperature thresholds for key stations in reporting area are show in table 45.

Streamflow

The USGS monitors streamflow on the Raft River above Onemile Creek near Malta ID, located near CIRO. Total annual runoff in 2010 was 58% of average. Figure 74 and table 41 summarize the 2010 water year (October 2009 to September 2010).

Table 41. Total annual runoff in acre feet and percentage of average for a select USGS Gauge Station near City of Rocks National Reserve (Data source: USGS Water Data Reports for 2010).

Station Name	Total annual runoff (ac-ft) 2010	Total annual runoff (ac-ft) average	Percent of average
Raft River above Onemile Creek near Malta, ID	7,550	12,990	58%

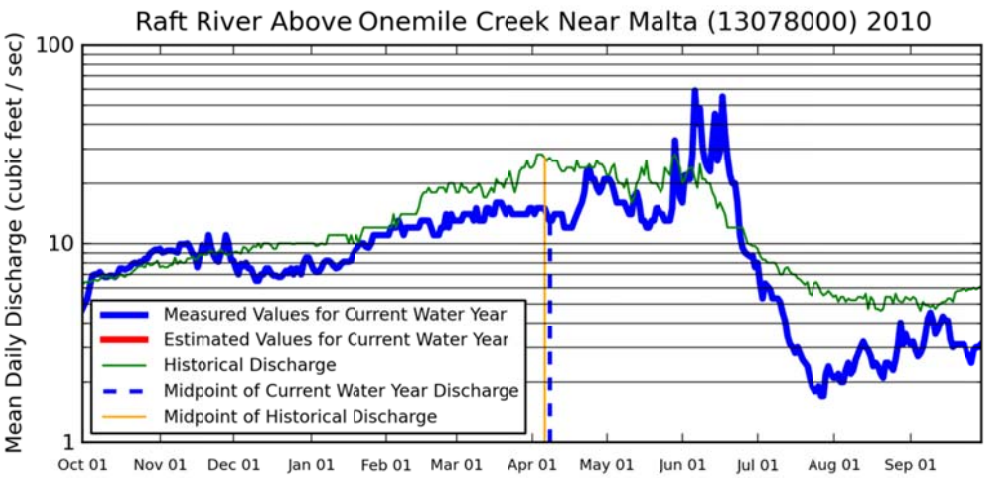


Figure 74. Streamflow from the gauge on the Raft River above Onemile Creek near City of Rocks National Reserve for the 2010 water year (October 2009 through September 2010) is shown versus median daily flows versus median daily flows for the reference period. Data courtesy of the U.S. Geological Survey

Table 42. Total monthly precipitation in inches and percentage of average monthly precipitation versus 1971–2000 averages for select climate stations in or near the City of Rocks National Reserve and Craters of the Moon National Monument and Preserve during 2010

Station Name (ID)		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Total
Arco 3 SW (100375)		1.15	0.13	0.65	1.53	1.8	1.01	0.22	(-)	0.2	0.89	1.98	1.84	(-)
	% of 30-yr avg.	140	12	76	204	136	112	27	(-)	29	141	248	227	(-)
Craters of the Moon (102260)		3.96	0.6	1.49	2.32	1.68	1.5	0.38	0.43	0.36	2.42	1.99	3.23	20.36
	% of 30-yr avg.	225	36	110	207	93	134	47	55	42	260	134	206	134
Crystal ID (103703)		0.3	0.21	0.79	1.98	(-)	(-)	0.09	0.06	0.1	1.04	0.78	1.73	(-)
	% of 30-yr avg.	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)
Minidoka Dam (105980)		1.09	0.51	0.53	1.9	1.61	0.65	0.45	0.14	0.05	1.48	1.55	2.3	12.26
	% of 30-yr avg.	107	61	52	207	135	77	141	37	7	208	150	250	124
Oakley (106542)		0.46	0.57	0.66	1.32	2.81	1.29	0.95	0.13	0.38	1.9	1.37	1.18	13.02
	% of 30-yr avg.	56	89	61	119	164	108	122	18	40	238	173	169	115
Potter Butte ID (102907)		0.08	0.02	0.56	1.74	1.24	1.15	0.12	0.14	0.16	1.61	0.57	1.62	9.01
	% of 30-yr avg.	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)
Richfield (107673)		1.35	0.25	0.55	2.1	0.91	1.34	0	0.1	0.14	1.81	1.44	3.37	13.36
	% of 30-yr avg.	83	20	48	288	85	209	0	31	24	251	109	244	120

Note: Percentages of average monthly precipitation versus 1971–2000 averages are given in the second line of data for each station. Station IDs are from NWS Cooperative Observer Program (COOP) stations and NRCS Snowpack Telemetry (SNOTEL) stations. Monthly statistics are not reported if more than three days of data are missing. Individual months are not used for calculating annual statistics if more than five days of data are missing.

(-) Indicates missing data.

Table 43. Average maximum daily temperatures in degrees Fahrenheit for select climate stations in or near the City of Rocks National Reserve and Craters of the Moon National Monument and Preserve during 2010. Departures from 1971–2000 averages are given in the second line of data for each station expressed as +/- degrees F.

Station Name (ID)		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Arco 3 SW (100375)		32.1	29.5	43.32	55.5	58.1	72	84.55	(-)	76.9	63.35	39.13	31.03	(-)
	Departure (+/- F)	2.6	-6	-2.38	-2.6	-8.9	-4.6	-0.05	(-)	3.3	2.25	-2.77	0.63	(-)
Craters of the Moon (102260)		31.06	32.71	41.74	52.5	56.77	70.17	83.35	81.87	75	62.29	36.37	30.94	54.56
	Departure (+/- F)	1.36	-2.29	-1.46	-2.7	-8.63	-5.63	-1.55	-2.23	1.9	2.49	-4.43	0.34	-1.94
Crystal ID (103703)		33.12	34.4	45.76	53.71	(-)	(-)	84.37	82.36	76.98	63.3	38.96	32.54	(-)
	Departure (+/- F)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)
Minidoka Dam (105980)		38.42	39.79	52.29	57.8	61.35	76.4	88.32	86.61	79.23	68.48	44.93	38.74	61.03
	Departure (+/- F)	3.02	-2.01	1.19	-2.2	-7.65	-2.9	0.02	-1.49	1.43	3.88	-2.47	1.94	-0.57
Oakley (106542)		41.16	42.71	52	58.77	60.97	73.53	83.26	82.87	78.27	65.42	44.3	40.42	60.31
	Departure (+/- F)	4.56	0.11	1.5	0.07	-5.63	-2.47	0.16	-0.23	4.47	3.02	-1.7	3.02	0.61
Potter Butte ID (102907)		31.36	32.92	43.5	53.78	57.42	71.83	85.68	83.06	77.61	63.33	39.39	32.32	56.02
	Departure (+/- F)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)
Richfield (107673)		32.9	33.04	47.68	55.27	59.45	73.07	85.81	84.1	76.7	66.13	42.27	34.13	57.54
	Departure (+/- F)	2.7	-3.26	0.48	-2.93	-7.55	-3.63	0.41	-0.9	1.8	4.23	-0.93	2.03	-0.66

Note: Monthly average maximum daily temperature departures from 1971–2000 averages are given in the second line of data for each station in degrees Fahrenheit.

Station IDs are from NWS Cooperative Observer Program (COOP) stations and NRCS Snowpack Telemetry (SNOTEL) stations. Monthly statistics are not reported if more than five days of data are missing. Individual months are not used for calculating annual statistics if more than five days of data are missing.

(-) Indicates missing data. SNOTEL temperatures are used to describe current year and not departure from average.

Table 44. Average minimum daily temperatures in degrees Fahrenheit for select climate stations in or near the City of Rocks National Reserve and Craters of the Moon National Monument and Preserve during 2010. Departures from 1971–2000 averages are given in the second line of data for each station expressed as +/- degrees F.

Station Name (ID)		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Arco 3 SW (100375)		11.29	10.14	25.74	31.73	36.94	46.73	49.97	(-)	39.9	34.26	17	10.58	(-)
	Departure (+/- F)	6.49	0.54	5.04	2.93	0.34	3.33	1.57	(-)	1.9	5.26	-0.6	4.38	(-)
Craters of the Moon (102260)		16.68	14.14	23.19	29.93	35.16	46.33	51.45	48.55	42.37	35.23	18.73	14.94	31.39
	Departure (+/- F)	6.08	-0.16	1.89	0.83	-1.94	1.63	-0.45	-2.15	1.27	3.93	-1.17	3.84	1.09
Crystal ID (103703)		19.39	20.19	26.28	31.08	(-)	(-)	52.5	51.74	43.75	37.21	22.33	21.33	(-)
	Departure (+/- F)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)
Minidoka Dam (105980)		19.23	19.64	26.03	30.1	36.23	48.23	50.52	51.45	42.77	37.13	24.5	24.71	34.21
	Departure (+/- F)	3.83	-0.16	-0.47	-2.9	-4.97	-0.27	-3.68	-1.45	-1.53	2.83	-0.5	7.81	-0.09
Oakley (106542)		24.94	25.14	28.32	32.27	36.06	48.07	53.26	53.16	46.03	40.32	26.17	26.16	36.66
	Departure (+/- F)	5.84	1.94	0.12	-0.63	-4.04	0.57	-0.84	-0.34	1.33	4.52	-0.43	6.76	1.66
Potter Butte ID (102907)		19.13	18.53	25.2	30.58	34.27	46.12	52.47	51.77	45.13	38.16	21.9	19.29	33.55
	Departure (+/- F)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)
Richfield (107673)		15.26	16.29	24.84	28.67	33.81	45.73	51.65	51.19	41.3	36.42	21.77	19.13	32.17
	Departure (+/- F)	1.16	-2.21	-1.16	-3.03	-5.49	-0.07	0.05	0.69	-0.6	4.42	-1.63	3.73	-0.33

Note: Monthly average minimum daily temperature departures from 1971–2000 averages are given in the second line of data for each station in degrees Fahrenheit. Station IDs are from NWS Cooperative Observer Program (COOP) stations and NRCS Snowpack Telemetry (SNOTEL) stations. Monthly statistics are not reported if more than five days of data are missing. Individual months are not used for calculating annual statistics if more than five days of data are missing.

(-) Indicates missing data. SNOTEL temperatures used to describe current year only and not departure from average.

Table 45. First and last freeze and frost dates, accumulated growing degree days, and days above or below critical temperature thresholds for key stations in or near City of Rocks National Reserve and Craters of the Moon National Monument and Preserve during 2010. Values for 2010 are shown in the first line for each station and averages appear in the second line. Averages are published by the Western Regional Climate Center and the reference period may differ from 1971–2000.

Station Name (ID)		AGDD40	AGDD50	Last date in spring <= 28F	Earliest date in fall <=28	Last date in spring <=32	Earliest date in fall <=32	# of days Tmax		# of days Tmin	
								>= 80 F	>= 90 F	<= 0 F	<= 32 F
Arco 3 SW (100375)	2010	(-)	(-)	22-May	12-Oct	18-Jun	7-Sep	50	5	13	191
	avg.	3492	1742	12-May	20-Sep	8-Jun	10-Sep	(-)	19.2	30.1	204.1
Craters of the Moon (102260)	2010	3407.5	1692	25-May	12-Oct	18-Jun	6-Sep	65	5	6	193
	avg.	3510	1820	20-May	26-Sep	9-Jun	13-Sep	(-)	13.3	13.6	198.6
Crystal ID (103703)	2010	(-)	(-)	23-May	12-Oct	24-May	6-Sep	63	13	6	185
	avg.	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)
Minidoka Dam (105980)	2010	4126.5	2188	25-May	20-Oct	25-May	12-Oct	88	34	4	181
	avg.	4386	2388	30-Apr	16-Oct	13-May	30-Sep	(-)	33.1	6.4	161.6
Oakley (106542)	2010	4097	2101	23-May	28-Oct	23-May	6-Sep	73	12	2	149
	avg.	4313	2261	5-May	6-Oct	28-May	22-Sep	(-)	24.7	4.6	155.5
Potter Butte ID (102907)	2010	3732.81	1962.405	25-May	26-Oct	17-Jun	12-Oct	69	23	6	183
	avg.	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)
Richfield (107673)	2010	3699.5	1887	9-May	13-Oct	18-Jun	6-Sep	72	27	7	195
	avg.	3900	2031	14-May	1-Oct	5-Jun	15-Sep	(-)	28.2	12.7	189.1

Note: (-) temperature data or published averages are missing. SNOTEL temperatures used to describe current year only and not departure from average

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Appendix A: Weather Stations 2010

Table A1. National Weather Service Cooperative Observer Program (COOP) stations and historic baseline period used to determine monthly average temperature (temp), precipitation (precip) and daily freeze & frost dates, Accumulated Growing Degree Days (AGDD) and extreme day dates in the 2010 Climate Summary Report

							Historic baseline period	
Park	**Station ID**	**Station**	**Latitude _deg**	**Longitude _deg**	**Elevation (ft)**	**State**	**Monthly average temp and precip values**	**Daily freeze & frost dates, AGDD and extreme day values**
BICA	481840	Cody	44.5219	-109.064	5082	WY	1971-2000	1915-2010
BICA	485770	Lovell	44.8375	-108.404	3837	WY	1971-2000	1897-2010
BICA	246747	Pryor	45.4328	-108.53	4068	MT	1971-2000	Unavailable
BICA	488124	Shell 1NE	44.5478	-107.763	7360	WY	1971-2000	1958-2010
BICA	249240	Yellowtail Dam	45.3128	-107.938	3305	MT	1971-2000	1948-2010
BIHO	249067	Wisdom	45.6178	-113.451	6060	MT	1971-2000	1923-2010
CIRO	106542	Oakley	42.2342	-113.898	4559	ID	1971-2000	1893-2010
CRMO	100375	Arco 3 SW	48.633	-113.3	5325	ID	1971-2000	1914-2010
CRMO	102260	Craters of the Moon NM	43.465	-113.558	5897	ID	1971-2000	1958-2010
CRMO	105980	Minidoka Dam	42.6767	-113.5	4164	ID	1971-2000	1947-2010
CRMO	107673	Richfield	43.0528	-114.158	4282	ID	1971-2000	1910-2010
FLFO	52965	Florissant Fossil Bed	38.917	-105.283	8379	CO	1971-2000	1988-2010
GLAC	242629	East Glacier	48.4469	-113.224	4806	MT	1971-2000	1953-2010
GLAC	244328	Hungry Horse Dam	48.3425	-114.022	3160	MT	1971-2000	1947-2010
GLAC	246618	Polebridge 1 N	48.783	114.283	3540	MT	Not available	2007-2010
GLAC	247292	St. Mary	48.7383	-113.429	4560	MT	1971-2000	1981-2010
GLAC	248809	West Glacier	48.5003	-113.985	3154	MT	1971-2000	1949-2010
GRSA	53541	Great Sand Dunes NM	37.733	-105.517	8183	CO	1971-2000	1950-2010
GRTE/YELL/JODR	480140	Alta 1 NNW	43.7728	-111.034	6437	WY	1971-2000	1909-2010
GRTE/YELL/JODR	100470	Ashton 1N	44.0425	-111.274	5212	ID	1971-2000	1897-2010
GRTE/YELL/JODR	241995	Cooke City 2W	45.0189	-109.955	7483	MT	1971-2000	1967-2010
GRTE/YELL/JODR	102676	Driggs	43.7306	-111.113	6120	ID	1971-2000	1904-2010
GRTE/YELL/JODR	485345	Lake Yellowstone	44.5619	-110.399	7870	WY	1971-2000	1904-2010
GRTE/YELL/JODR	486428	Moose	43.6536	-110.717	6444	WY	1971-2000	1958-2010

Table A1. Continued.

Park	Station ID	Station	Latitude _deg	Longitude _deg	Elevation (ft)	State	Historic baseline period	
							Monthly average temp and precip values	Daily freeze & frost dates, AGDD and extreme day values
GRTE/YELL/JODR	486440	Moran 5 WNW	43.8567	-110.589	6798	WY	1971-2000	1911-2010
GRTE/YELL/JODR	486845	Old Faithful	44.4569	-110.833	7360	WY	1971-2000	1904-2010
GRTE/YELL/JODR	488315	Snake River	44.1333	-110.666	6882	WY	1971-2000	1905-2010
GRTE/YELL/JODR	489905	Yellowstone Pk Mammoth	44.9767	-110.696	6230	WY	1971-2000	1897-2010
LIBI	243915	Hardin	45.7322	-107.608	2905	MT	1971-2000	1948-2010
NEPE	103771	Grangeville	45.9414	-116.117	3300	ID	1971-2000	1893-2010
NEPE	105241	Lewiston WSO AP	46.3747	-117.016	1436	ID	1971-2000	1948-2010
NEPE	106424	Nezperce	46.23333	-116.25	3240	ID	1971-2000	1901-2010
NEPE	107046	Pierce	46.4922	-115.801	3080	ID	1971-2000	1963-2010
ROMO	52761	Estes Park 1 SSE	40.366	-105.517	7785	CO	Not available	2001-2010
ROMO	53496	Grand Lake 1 NW	40.267	-105.833	8720	CO	1971-2000	1907-2010

Note: BICA = Bighorn Canyon National Recreation Area, BIHO = Big Hole National Battlefield, CIRO = City of Rocks National Reserve, CRMO = Craters of the Moon National Monument and Preserve, FLFO = Florissant Fossil Beds National Monument, GLAC = Glacier National Park, GRSA = Great Sand Dunes National Park and Preserve, GRTE = Grand Teton National Park, JODR = John D. Rockefeller Jr. Memorial Parkway, LIBI = Little Bighorn Battlefield National Monument, NEPE = Nez Perce National Historical Park, ROMO = Rocky Mountain National Park, YELL = Yellowstone National Park.

Table A2. Natural Resources Conservation Service Snowpack Telemetry (SNOTEL) stations and historic baseline period used to determine average values for precipitation (precip) and snow water equivalent (SWE) in the 2010 Climate Summary Report

Park	Station ID	Station	Latitude _deg	Longitude _deg	Elevation (ft)	State	Historic baseline period	
							Monthly historical precip	Daily historical SWE
BICA	07E21S	Bald Mountain	44.8	-107.833	9380	WY	1971-2000	1971-2000
BICA	07E23S	Shell Creek	44.5	-107.417	9581	WY	1971-2000	1971-2000
BIHO	13D26S	Calvert Creek	45.8833	-113.317	6431	MT	1975-2000*	1971-2000
FLFO	05L11S	Glen Cove	38.8667	-105.067	11461	CO	Not available	~5 yr avg
GLAC	13A15S	Badger Pass	48.1167	-113.017	6900	MT	1971-2000 *	1971-2000
GLAC	13A24S	Emery Creek	48.4333	-113.933	4351	MT	1976-2000*	1971-2000
GLAC	13A19S	Flattop Mtn.	48.8	-113.85	6300	MT	1975-2000*	1971-2000
GLAC	14A11S	Grave Creek	48.9	-114.75	4301	MT	1971-2000*	1971-2000
GLAC	13A27S	Many Glacier	48.7833	-113.667	4902	MT	1977-2000*	1971-2000
GLAC	13A25S	Noisy Basin	48.15	-113.933	6040	MT	1975-2000*	1971-2000
GLAC	13A26S	Pike Creek	48.3	-113.317	5929	MT	1971-2000*	~75 yr avg
GLAC	14A12S	Stahl Peak	48.9	-114.85	6030	MT	1971-2000*	1971-2000
GRSA	05M16S	Medano Pass	37.85	-105.433	9649	CO	1971-2000	1971-2000
GRSA	05M13S	South Colony	37.9667	-105.533	10801	CO	1971-2000	1971-2000
GRSA	05M17S	Ute Creek	37.6	-105.367	10650	CO	Not available	1971-2000
GRTE/YELL/JODR	10E03S	Canyon	44.7167	-110.5	7871	WY	1971-2000	1971-2000
GRTE/YELL/JODR	09D06S	Fisher Creek	45.05	-109.933	9101	MT	1971-2000	1971-2000
GRTE/YELL/JODR	09E07S	Parker Peak	44.7333	-109.9	9400	WY	1971-2000	1971-2000
GRTE/YELL/JODR	10E06S	Sylvan Lake	44.4667	-110.15	8419	WY	1971-2000	1971-2000
GRTE/YELL/JODR	10E20S	Sylvan Road	44.4667	-110.033	7120	WY	1971-2000	1971-2000
ROMO	05J39S	Bear Lake	40.3	-105.633	9502	CO	1971-2000	1971-2000
ROMO	05J18S	Copeland Lake	40.2	-105.567	8600	CO	1971-2000	1971-2000
ROMO	05J10S	Lake Irene	40.4	-105.817	10699	CO	1971-2000	1971-2000

Table A2. Continued.

Park	Station ID	Station	Latitude _deg	Longitude _deg	Elevation (ft)	State	Historic baseline period	
							Monthly historical precip	Daily historical SWE
ROMO	06J27S	Never Summer	40.4	-105.95	10279	CO	Not available	1971-2000
ROMO	05J04S	Phantom Valley	40.3833	-105.833	9029	CO	1971-2000	1971-2000
ROMO	05J05S	Wild Basin	40.2	-105.6	9561	CO	Not available	1971-2000
ROMO	05J40S	Willow Park	40.4167	-105.733	10699	CO	1971-2000	1971-2000

Note: BICA = Bighorn Canyon National Recreation Area, BIHO = Big Hole National Battlefield, FLFO = Florissant Fossil Beds National Monument, GLAC = Glacier National Park, GRSA = Great Sand Dunes National Park and Preserve, GRTE = Grand Teton National Park, JODR = John D. Rockefeller Jr. Memorial Parkway, ROMO = Rocky Mountain National Park, YELL = Yellowstone National Park. * indicates that average was calculated locally using NRCS monthly historical precipitation data.

Table A3. US Geological Survey stream gauging stations and historic baseline period used to determine average conditions used in this report (USGS gauge)

Park	Station ID	Station	Latitude _deg	Longitude _deg	Elevation (ft)	State	Historic baseline period	
							Median daily flows	Annual runoff
BICA	6279500	Bighorn River at Kane	44.7587	-108.182	3660	WY	1971-2000	1930-2010
BICA	6287000	Bighorn River near St Xavier	45.31696	-107.919	3158	MT	1971-2000	1935-2010
BICA	6278500	Shell Creek near Shell	44.56455	-107.713	4370	WY	1971-2000	Not available
BIHO	6024450	Big Hole River bl Big Lake Cr at Wisdom MT	45.61805	-113.457	6040	MT	Not available	Not available
BIHO	6024540	Big Hole River bl Mudd Cr nr Wisdom MT	45.80754	-113.313	5880	MT	Not available	Not available
CIRO	13078000	Raft River ab Onemile Creek nr Malta ID	42.06462	-113.452	4940	ID	1971-2000	1947-2010
FLFO	7096250	Four Mile Below Cripple Creek Near Victor CO	38.66406	-105.228	6870	CO	1992-2010	1993-2010
GLAC	12363000	Flathead River at Columbia Falls MT	48.36167	-114.184	2978	MT	1971-2000	Not available
GLAC	12355000	Flathead River at Flathead British Columbia	48.99995	-114.475	3965	MT	1971-2000	1929-2010
GLAC	12358500	M F Flathead River near West Glacier MT	48.49557	-114.01	3129	MT	1971-2000	1940-2010
GLAC	12355500	N F Flathead River nr Columbia Falls MT	48.49587	-114.127	3146	MT	1971-2000	1940-2010
GLAC	12362500	S F Flathead River nr Columbia Falls MT	48.35656	-114.038	3040	MT	1971-2000	Not available
GLAC	5017500	St. Mary River near Babb MT	48.8348	-113.422	4468	MT	1971-2000	1951-2010
GLAC	5014300	Swiftcurrent Cr ab Swiftcurrent Lk at Many Glacier	48.79542	-113.68	4920	MT	2004-2010	Not available
GLAC	5014500	Swiftcurrent Creek at Many Glacier MT	48.79884	-113.657	4877	MT	1971-2000	1912-2010

Table A3. Continued.

Park	Station ID	Station	Latitude _deg	Longitude _deg	Elevation (ft)	State	Historic baseline period	
							Median daily flows	Annual runoff
GRTE/ YELL/JODR	6037500	Madison River near West Yellowstone	44.65713	-111.068	6650	MT	1971-2000	1913-2010
GRTE/ YELL/JODR	13010065	Snake River above Jackson Lake at Flagg Ranch	44.09848	-110.667	6802	WY	1984-2009	1984-2010
GRTE/ YELL/JODR	13013650	Snake River at Moose	43.65379	-110.715	6431	WY	1996-2009	1995-2010
GRTE/ YELL/JODR	6280300	South Fork Shoshone River near Valley	44.20796	-109.555	6200	WY	1971-2000	1957-2010
GRTE/ YELL/JODR	6191500	Yellowstone River at Corwin Springs	45.11217	-110.794	5079	WY	1971-2000	1889-2010
GRTE/ YELL/JODR	6186500	Yellowstone River at Yellowstone Lake Outlet	44.56714	-110.38	7730	WY	1971-2000	1927-2010
LIBI	6294000	Little Bighorn River near Hardin MT	45.73581	-107.557	2882	MT	1971-2000	1954-2010
NEPE	13342500	Clearwater River at Spalding ID	46.44902	-116.828	770	ID	1971-2000	1972-2010
NEPE	13342450	Lapwai Creek nr Lapwai ID	46.42639	-116.806	865	ID	1981-2010	1975-2010
ROMO	4017231-05400000	Andrews Creek-Loch Vale-Rmnp CO	40.29	-105.667	10540	CO	Not available	Not available
ROMO	4021141-05350101	Big Thompson Below Moraine Park Near Estes Park CO	40.35387	-105.584	8005	CO	1995-2010	1996-2010
ROMO	6746095	Joe Wright Creek Above Joe Wright Reservoir CO	40.53998	-105.883	9990	CO	1981-2010	1979-2010
ROMO	6746110	Joe Wright Creek Below Joe Wright Reservoir CO	40.56193	-105.864	9710	CO	1981-2010	1979-2010
ROMO	6614800	Michigan River Near Cameron Pass CO	40.49609	-105.865	10390	CO	1981-2010	1974-2010

Note: BICA = Bighorn Canyon National Recreation Area, BIHO = Big Hole National Battlefield, CIRO = City of Rocks National Reserve, FLFO = Florissant Fossil Beds National Monument, GLAC = Glacier National Park, GRTE = Grand Teton National Park, JODR = John D. Rockefeller Jr. Memorial Parkway, LIBI = Little Bighorn Battlefield National Monument, NEPE = Nez Perce National Historical Park, ROMO = Rocky Mountain National Park, YELL = Yellowstone National Park.

Table A4. Remote Automated Weather Stations (RAWS) used in this report

Park	Station ID	Station	Latitude _deg	Longitude _deg	Elevation (ft)	State
CRMO	103703	Crystal ID	42.99	-113.16	5064	ID
CRMO	102907	Potter Butte ID	43.2261	-113.574	4930	ID

Note: CRMO = Craters of the Moon National Monument and Preserve.

Table A5. Environment Canada National Climate Data and Information Archive (EC-NCDIA) and Water Survey of Canada stream gauge (EC-WSC) stations used in this report

Park	Provider	Station ID	Station	Latitude _deg	Longitude _deg	Elevation (ft)	Province
GLAC	EC - NCDIA	71154	Waterton Park Gate Alberta	49.13	-113.81	4229	Alberta
GLAC	EC - WSC	05AD003	Waterton River Near Waterton Park	49.11361	-113.839	(-)	Alberta

Note: GLAC = Glacier National Park.

Table A6. Colorado Division of Water Resources (CDWR) stream gauge stations used in this report

Park	Station ID	Station	Latitude _deg	Longitude _deg	Elevation (ft)	State
GRSA	MEDSANCO	Medano Creek at Great Sand Dunes National Park	37.8	-105.5	8548	CO
GRSA	SANDUNCO	Sand Creek at Great Sand Dunes National Park	37.83	-105.59	7944	CO

Note: GRSA = Great Sand Dunes National Park and Preserve.

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

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National Park Service
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