



Protocol Implementation Plan for Monitoring Climate in the Southeast Alaska Network

Natural Resource Report NPS/SEAN/NRR—2017/1572



ON THE COVER

Queen Inlet weather station at Glacier Bay National Park and Preserve (NPS)

Protocol Implementation Plan for Monitoring Climate in the Southeast Alaska Network

Natural Resource Report NPS/SEAN/NRR—2017/1572

Michael R. Bower¹, Pamela J. Sousanes², William F. Johnson¹, Ken R. Hill², and Scott D. Miller³

¹ National Park Service

Inventory and Monitoring Program, Southeast Alaska Network

3100 National Park Road

Juneau, AK 99801

² National Park Service

Inventory and Monitoring Program, Arctic and Central Alaska Networks

4175 Geist Rd.

Fairbanks, AK 99709

³ National Park Service

Inventory and Monitoring Program, Arctic and Central Alaska Networks

2800 Lake Shore Dr. E

Ashland, WI 54806

December 2017

U.S. Department of the Interior

National Park Service

Natural Resource Stewardship and Science

Fort Collins, Colorado

The National Park Service, Natural Resource Stewardship and Science office in Fort Collins, Colorado, publishes a range of reports that address natural resource topics. These reports are 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.

The Natural Resource Report Series is used to disseminate comprehensive information and analysis about natural resources and related topics concerning lands managed by the National Park Service. The series supports the advancement of science, informed decision-making, and the achievement of the National Park Service mission. The series also provides a forum for presenting more lengthy results that may not be accepted by publications with page limitations.

All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner.

Peer review of this document was completed in accordance with Inventory and Monitoring Division guidance of 6 July 2015 for development of protocol implementation plans based on published source protocols. Limited independent review was conducted to evaluate the utility of the proposed protocol to meet monitoring objectives and the effects of proposed modifications that have been made to adapt procedures.

Views, statements, findings, conclusions, recommendations, and data in this report do not necessarily reflect views and policies of the National Park Service, U.S. Department of the Interior. Mention of trade names or commercial products does not constitute endorsement or recommendation for use by the U.S. Government.

This report is available in digital format from the [Southeast Alaska Network website](#) and the [Natural Resource Publications Management website](#). To receive this report in a format optimized for screen readers, please email irma@nps.gov.

Please cite this publication as:

Bower, M. R., P. J. Sousanes, W. F. Johnson, K. R. Hill, and S. D. Miller. 2017. Protocol implementation plan for monitoring climate in the Southeast Alaska Network. Natural Resource Report NPS/SEAN/NRR—2017/1572. National Park Service, Fort Collins, Colorado.

Contents

	Page
Figures.....	v
Tables.....	v
Executive Summary	vii
Introduction.....	1
Conceptual Framework for Monitoring	3
Measurable Objectives.....	3
Methods.....	3
Sampling Design and Monitoring Schedule	5
Site selection in KLGO	5
Site Selection in GLBA	5
Site Selection in SITK	7
Monitoring Schedule	7
Data Management, Analysis, and Reporting	9
Data Processing and Workflow	13
Defined Data Levels	13
Level 0 – RAWs Station Download	13
Level 1b – RAWs Corrected Data	13
Level 2 – Value Added Data	13
Budget.....	17
Safety	17
Risks Inherent in Climate Monitoring in the Southeast Alaska Parks	18
Standard Operating Procedures.....	19
Literature Cited	25

Figures

	Page
Figure 1. Approximate location of sites selected for KLGO and GLBA RAWS. Final coordinates of active stations will be documented as deliverable WC_B.	6
Figure 2. Flow chart of the RAWS station download (Level 0) comprising the WC_F annual deliverable.	14
Figure 3. Flow chart for the RAWS corrected data (Level 1b) comprising the WC_G annual deliverable.	15

Tables

	Page
Table 1. Stations identified for monitoring climate in the Southeast Alaska parks (KLGO and GLBA). Additional locational details can be found in SOP 2.	6
Table 2. Data processing and certification matrix for the SEAN climate monitoring protocol.	10
Table 3. Estimated annual operating cost (based on FY2017 dollars) for implementation of the SEAN Weather and Climate Vital Sign.	17
Table 4. Narrative documents and standard operating procedures for the SEAN weather and climate monitoring vital sign.	19

Executive Summary

Weather and climate were selected as high priorities during development of the Southeast Alaska Network's (SEAN's) Vital Sign Monitoring Plan given their fundamental role in driving the physical and biological processes that define ecosystem form and function. Given the generally sparse density of existing weather stations in Alaska, and in particular in the backcountry of Alaska's national parks, the focus of the SEAN weather and climate monitoring program is collection, storage, and dissemination of climate data representing the diverse geographies of the SEAN parks. This is accomplished through operation of a series of 12 Remote Automated Weather Stations (RAWS) in Glacier Bay National Park and Preserve (n = 9) and Klondike Gold Rush National Historical Park (n = 3). No stations are being operated in Sitka National Historical Park given proximity to several stations run by cooperating agencies.

Weather stations record air temperature, soil temperature at three depths (10-, 20-, and 50-cm), relative humidity, wind speed and direction, solar radiation, precipitation (as rainfall), and snow depth. Stations are visited at least annually to institute sensor calibration schedules based on manufacturer recommendations and to download station data. Downloaded data are subjected to rigorous quality control procedures to ensure reliability. Program deliverables include:

- raw and corrected tabular data products
- weather station maps
- station maintenance visit worksheets
- datalogger programs
- site photographs
- sensor calibration records

Program deliverables are published along with complete metadata to the [SEAN Weather and Climate Vital Sign Project](#) in the [National Park Service's online Data Store](#).

Stations also transmit provisional hourly observations via satellite telemetry to the Wildland Fire Management Information portal (WFMI). Provisional data are subsequently ingested by a number of repositories and other outlets where they can be viewed in near real-time for a variety of purposes (e.g. weather forecasting, backcountry travel planning).

This protocol implementation plan adopts the climate monitoring protocol used by the Central Alaska Network (CAKN) with minor adaptations to meet site-specific conditions. Specific standard operating procedures for implementation of the CAKN protocol were revised in 2017 to standardize methods for adoption at the regional scale. The CAKN, SEAN, and Arctic Networks are now implementing consistent methods for greater regional consistency and to facilitate the sharing of knowledge and monitoring assets for improved program sustainability.

Introduction

Climate has been selected as a high priority for long-term monitoring by the Southeast Alaska Network (SEAN) parks given its fundamental role in driving the physical and biological processes that define ecosystem form and function. The SEAN parks include Glacier Bay National Park and Preserve, Klondike Gold Rush National Historical Park, and Sitka National Historical Park. The goal of the SEAN Weather and Climate Vital Sign monitoring program is to monitor and record weather conditions at representative locations in order to quantify one of the drivers in Alaskan ecosystems, identify long and short-term trends, provide reliable climate data to other researchers, and to participate in larger scale climate monitoring and modeling efforts.

This plan outlines the means by which monitoring data will be collected, managed, and reported for the Weather and Climate Vital Sign as described in the approved SEAN Vital Sign Monitoring Plan (Moynahan et al. 2008). The SEAN will implement the peer-reviewed and approved protocol in use by the Central Alaska Network (CAKN; Sousanes 2006), including current standard operating procedures (SOPs), with minor modifications to the methods presented therein that describe its precise implementation in SEAN parks.

Implementation of the CAKN climate protocol in SEAN parks will occur with the following modifications:

- 1) Twelve additional weather stations will be operated in GLBA (9) and KLGO (3). This brings the total number of stations managed by the CAKN, Arctic Network (ARCN), and SEAN climate monitoring programs to 42. The climate stations are referred to as SEAN Remote Automated Weather Stations (RAWS).
- 2) Several of the SEAN RAWS have non-standard installation configurations to facilitate incorporation into existing infrastructure. These include the following:
 - a) Chilkoot Pass (KLGO) –taller and more robust tower (17') and battery enclosure installed in 2016 to help protect the station from over-winter damage. With the taller tower, the heights of several sensors exceed the standard range.
 - b) Sheep Camp (KLGO) – powered by the Sheep Camp Ranger Station battery array and solar charging system.
 - c) Dyea (formerly Taiya River; KLGO) – mounting pole and sensor crossarm integrated into an existing stream gage hut adjacent to the Taiya River. Custom snow depth target installed on hut. Power shared with USGS stream gage.
 - d) Lituya Bay (GLBA) – instrumentation integrated into USCG range mark to minimize the environmental footprint of this wilderness installation.
 - e) Deception Hills (GLBA) –agreement being pursued for sharing power with the USCG Deception Hills Rescue 21 installation.
 - f) GLBA Fuel Dock – originally installed and operated by the National Weather Service. The SEAN assumed operation in the fall of 2015. Station is located at the end of the

GLBA fuel dock and integrated into the dock infrastructure. Primary power is supplied by the park's electrical grid. The station lacks snow depth and solar radiation sensors.

- g) Lone Island (GLBA) – visibility minimized by using low-profile mounting options, sensors, and power supplies.
- 3) In several cases, the specific equipment models cited by the CAKN protocol have been replaced by newer versions. A major revision of the CAKN climate protocol SOPs was undertaken in 2017 to account for these changes and to generalize procedures for adoption at a broader regional scale (Sousanes et al. 2017). Future technological advancements or changes will be accounted for in subsequent SOP revisions.
- 4) The SEAN will utilize a different staffing solution than described by the CAKN protocol. A combination of permanent SEAN staff, shared park staff, and regional collaborations will be used to implement the program with existing personnel. The SEAN Program Manager currently serves as the Project Lead for the Weather and Climate Vital Sign. The SEAN Data Manager collaborates on the preparation and publication of project deliverables. Shared staff in KLGO and GLBA assist with station installation and annual maintenance. The ARCN Physical Scientist assists with annual data processing, quality control, and reporting functions.
- 5) The SEAN will streamline reporting operations as necessary to prioritize timely access to climate data given staffing constraints. A narrative summary of annual operations at each station will be incorporated into the field visit sheet to serve as a long-term record of station operations in the event that a formal operations report is not compiled for a given year. Climate summary reports will be considered dependent on staffing levels and the availability of tools to streamline analysis and reporting functions such as the toolkit being developed by the Central Office of the Inventory and Monitoring Division.

Conceptual Framework for Monitoring

Weather and climate are key physical drivers of ecosystem structure and function. In the SEAN parks, anticipated future climate changes including increasing temperatures, increasing total precipitation and the proportion as rain, are expected to bring a suite of new stresses to Southeast Alaska ecosystems (Shanley et al. 2015).

Within the context of the SEAN monitoring program, long-term climate records are critically important for understanding responses of vital signs selected as important indicators of resource condition in the Southeast Alaska parks. Precipitation and air temperature drive stream discharge (Streamflow Vital Sign) which directly affects water quality conditions (Freshwater Water Quality Vital Sign). Precipitation and temperature are also important drivers of contaminant deposition and persistence (Airborne, Freshwater, and Marine Contaminants Vital Signs). Weather patterns strongly influence patterns of marine productivity, marine food web dynamics, and the survival and recruitment dynamics of predator and prey populations (Oceanography, Kittlitz's Murrelet, and Sea Otter Vital Signs).

Measurable Objectives

The main objective for the SEAN climate monitoring program is to monitor and record weather conditions at representative locations in the Southeast Alaska parks in order to quantify one of the drivers in Alaskan ecosystems, identify long and short-term trends, provide reliable climate data to other researchers, and to participate in larger scale climate monitoring and modeling efforts.

Specifically we have the following monitoring objectives:

- 1) Determine long and short term trends in climate by recording weather parameters at sites that capture the primary climate gradients within the Southeast Alaska parks.
- 2) Using all relevant climate data, analyze, summarize and report on climatic averages and extremes in the Southeast Alaska region.

Methods

The SEAN, ARCN, and CAKN have committed to the use of standardized procedures for climate monitoring to promote regional consistency and efficiency. Each network will be utilizing the most recent SOP versions associated with the original CAKN climate monitoring protocol of Sousanes (2006) to implement their respective climate monitoring programs. To facilitate this shared approach, SOPs were recently revised to standardize methods to the extent practical and incorporate network-specific implementation details where necessary (Sousanes et al. 2017). Sousanes et al. (In press), provide additional details regarding program data quality standards that can be used to help interpret results.

Primary operational elements of the network climate monitoring programs include:

- 1) **Field Data Collection:** A series of weather stations will be installed and operated at locations representative of the climatic gradients present in Alaska parks. Research-grade meteorological instrumentation will be used to collect weather data. The standard array includes the following sensors: air temperature sensor (rated to -60°C), air temperature + relative humidity sensor, rain gauge for summer rainfall, distance sensor for snow depth, pyranometer for solar radiation, anemometer for wind speed and direction, and three soil temperature probes (10, 20, and 50 cm depths). A fourth soil sensor may be added at some sites (100 cm depth). Data are continuously recorded on an hourly interval and stored within the datalogger on site and transmitted via satellite in near real-time.
- 2) **Annual site maintenance visits** will occur at each climate station. The site visits include annual data download, sensor swaps or calibration, programming/equipment upgrades or updates (if needed), photo documentation, basic maintenance of the site (tighten bolts, repairs, brushing, etc.), and completion of a site visit worksheet.
- 3) **Data management:** The continuous time series data that are generated by the climate vital sign will be managed using Aquarius software. Final data are provided to the Western Regional Climate Center for incorporation into the Applied Climate Information System (ACIS) archive and published to the Integrated Resources Management Application (IRMA) Data Store.
- 4) **Reporting:** Annual operations reports, annual climate summary reports, seasonal summary reports, and long-term trend reports will be completed as time and staffing allow. The reports will be published under the Natural Resource Publication Management guidelines and published in the Integrated Resource Management Applications (IRMA).

Sampling Design and Monitoring Schedule

A comprehensive inventory of existing weather and climate monitoring programs and associated weather stations was completed by Davey et al. (2007) to identify gaps in monitoring coverage and inform the development of the SEAN weather and climate vital sign monitoring program. While a large number of weather stations existed across Southeast Alaska at the time, most stations were located outside of park boundaries at or near sea level, oftentimes near population centers. In particular, the authors cite broad geographic coverage gaps and the lack of high elevation representation among existing stations as major limitations for monitoring future climate trends in the SEAN parks. To overcome these limitations, installation of new stations representing the coastal zone, the interior zone, higher elevations closer to the location of what is now quasi-permanent ice, and transition regions such as drainage divides was recommended (Davey et al. 2007). These suggestions, along with additional considerations such as site access and wilderness restrictions were balanced during identification of the final suite of weather monitoring sites for the SEAN parks.

Site selection in KLGO

An Environmental Assessment and FONSI for the installation of four weather stations and additional communications infrastructure was completed in 2010 (Figure 1, Table 1). Three stations along the Chilkoot Trail were identified to represent the coastal-interior and elevational gradients of the park, as recommended by the SEAN climate monitoring inventory of Davey et al. (2007). These included the Chilkoot Pass (high elevation), Sheep Camp (mid elevation), and Dyea (formerly Taiya River; low elevation) stations. An additional high-elevation station at Goat Lake on USFS property was also identified for monitoring conditions in the KLGO White Pass Unit, but this station has since been decommissioned due to poor satellite visibility and the subsequent installation of a nearby cooperator station. Combined with the stations operated by other agencies, the sites cover the two river drainages in the park and span the transition from marine to alpine ecosystems.

Site Selection in GLBA

The SEAN undertook an interdisciplinary scoping process to identify and review candidate weather station sites for GLBA, aiming to follow the specific recommendations of Davey et al. (2007) to the extent practical in light of wilderness area constraints and logistical considerations (Figure 1, Table 1). A primary goal was to establish a representative suite of stations across the park's geographic scope and elevational gradients. More specifically, the team sought representation across the park's west to east (or coastal to interior) and north-south (or more to less glaciated) geographies and high to low elevations. The work of this team informed the development of a final Environmental Assessment and FONSI, signed in 2015, authorizing the installation of eight new weather stations. One additional weather station, originally installed by the National Weather Service (Glacier Bay Fuel Dock), has since been incorporated into the program to improve data compatibility and continuity. While existing stations adequately covered the southern border of the park, new sites were needed to represent the Outer Coast, West Arm, East Arm and Brady Icefield regions.

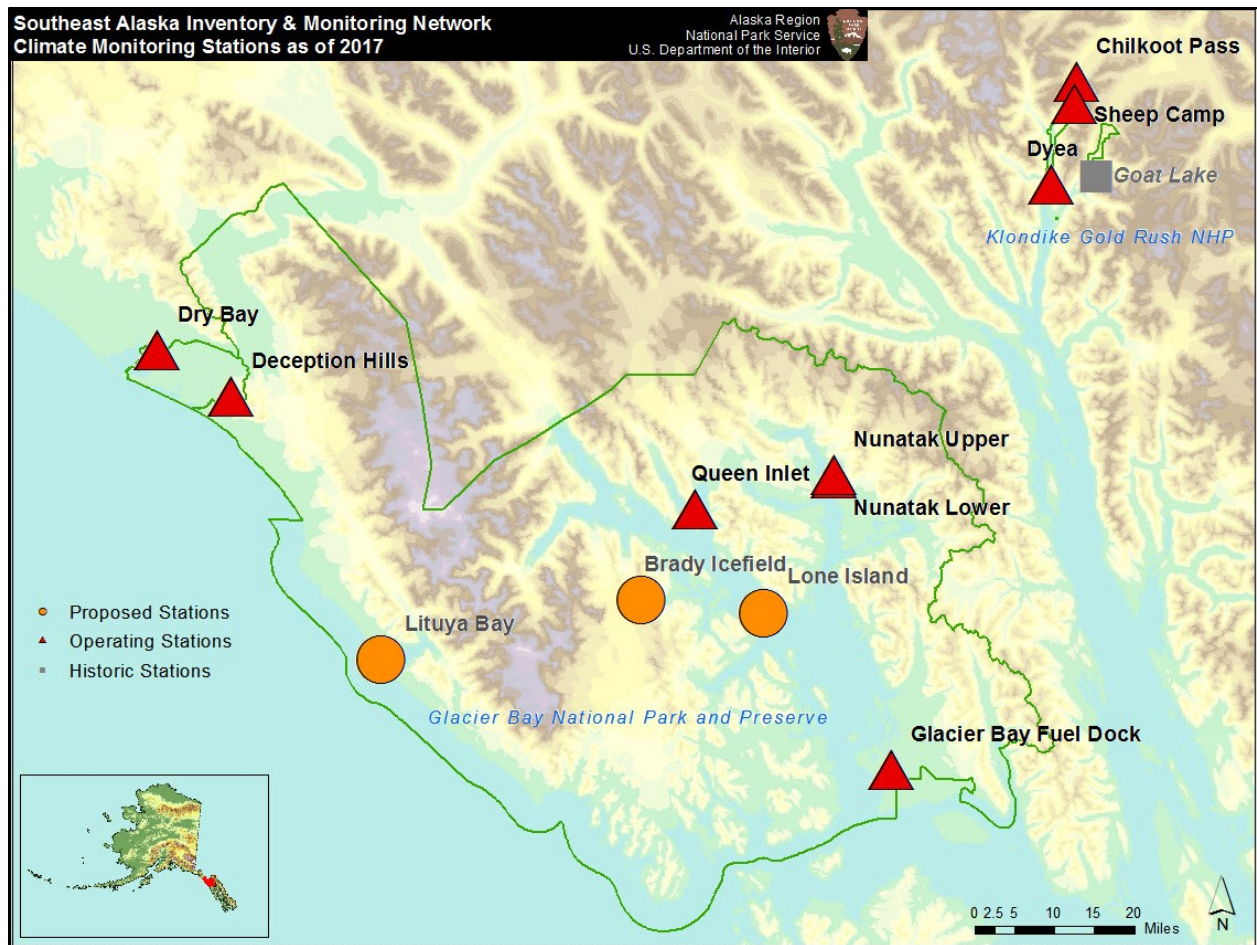


Figure 1. Approximate location of sites selected for KLGO and GLBA RAWs. Final coordinates of active stations will be documented as deliverable WC_B.

Table 1. Stations identified for monitoring climate in the Southeast Alaska parks (KLGO and GLBA). Additional locational details can be found in SOP 2.

Park Unit	Station	Approximate Elevation (ft)	Location Description
Klondike Gold Rush National Historic Park (KLGO)	Chilkoot Pass	4,200	High-elevation site collocated with existing park radio repeater a mile from the Chilkoot Trail.
	Dyea (formerly Taiya River)	50	Collocated with USGS stream gage and SEAN water quality monitoring site on the Taiya River at the U.S. trailhead for the Chilkoot Trail.
	Sheep Camp	920	Collocated with Sheep Camp Ranger Station at mid-elevation along the Chilkoot Trail.
Glacier Bay National Park and Preserve (GLBA)	Brady Icefield	3,000	High-elevation station located on an exposed nunatak atop the Brady Icefield.
	Deception Hills	2,200	Mid-high-elevation site collocated with U.S. Coast Guard Rescue 21 installation.

Table 1 (continued). Stations identified for monitoring climate in the Southeast Alaska parks (KLGO and GLBA). Additional locational details can be found in SOP 2.

Park Unit	Station	Approximate Elevation (ft)	Location Description
Glacier Bay National Park and Preserve (GLBA) (continued)	Dry Bay	30	Located near the Dry Bay Ranger Station adjacent to the Alsek River.
	Glacier Bay Fuel Dock	30	Former NWS station located on the fuel dock in Bartlett Cove. Provides important real-time conditions for park staff, visitors, and marine weather forecasters.
	Lituya Bay	15	Exposed coastal station, collocated with a U.S. Coast Guard range marker along the outer coast of GLBA.
	Lone Island	30	Located on a small, mid-bay island, site has excellent marine exposure in Glacier Bay.
	Nunatak Lower	15	Protected coastal site in the East Arm of Glacier Bay at the head of Nunatak Cove.
	Nunatak Upper	940	Mid-elevation site adjacent to Nunatak Lower station.
	Queen Inlet	1,050	Mid-elevation site in the West Arm of Glacier Bay.

Site Selection in SITK

The SEAN weather and climate inventory recommended no additional RAWS installations in SITK, noting that while no stations currently record within park boundaries, there are many near-real-time weather stations and longer term climate records in and near the city of Sitka (Davey et al. 2007).

Monitoring Schedule

Standard SEAN climate stations will be operated year-round to record and transmit hourly values for average air temperature, minimum air temperature, maximum air temperature, relative humidity, total rainfall, average wind speed, average wind direction, peak wind gust and direction of gust, average solar radiation, average soil temperature at three depths, and snow depth.

Data Management, Analysis, and Reporting

The outcome of the network's climate monitoring vital sign takes the form of ten formal deliverable products listed in Table 2. These include data products, detailed metadata products required so users may properly interpret the data, and associated NPS reports.

The authoritative repository used by all these deliverables is the NPS Integrated Resource Management Applications (IRMA) Data Store. Permanent archiving, disaster recovery, and public accessibility of the deliverables are accomplished through the enterprise facilities built into the Data Store.

IRMA is the only authoritative repository for mission critical inventory and monitoring products. Data from the NPS weather stations are available in near real-time from various weather and climate web portals. These sources have disclaimers that state that data are provisional and subject to further review and editing.

Table 2. Data processing and certification matrix for the SEAN climate monitoring protocol.

Deliverable Title	Description	Provided to Customers as	Frequency Produced	Responsibilities		
				Builder	Validator	Acceptor
WC_A: Protocol-QAP-DQS-PIP-SOPs	The detailed document set defining this weather and climate monitoring program throughout its history and published as NRR reports in the NPS Data Store.	PDF files.	New documents as needed, but always prior to the field season they operate on.	Project Leader	Peer Review Manager	Regional I&M Coordinator
WC_B: Site map	Map documenting location of stations participating in network's climate monitoring.	ESRI layer, JPEG, and KMZ files	As needed to accommodate new sites.	Project Staff	Project Leader	Project Leader
WC_C: Site visit worksheets	One worksheet per site visit documenting in a standard form the condition of the site, actions taken, and final configuration. Packaged as a cumulative set of all worksheets for all stations in a particular field season zipped into one file.	Windows files in XLSX format, wrapped into a single ZIP file.	One zip file per year created after completion of all field work.	Project Staff	Project Leader	Project Leader
WC_D: Datalogger program code	The program source code installed into dataloggers for all stations over a field season. They authoritatively document the exact nature of parameters collected.	A ZIP of text files containing all versions of programs used by stations in a field season.	One zip file per year created after completion of all field work.	Project Staff	Project Leader	Project Leader
WC_E: Site photo sets	One set of photos per site per field season used to document physical conditions.	Windows JPEG data files wrapped into a single ZIP file for each site/year.	One ZIP file per site per year created after completion of all field work.	Project Staff	Project Leader	Project Leader

Table 2 (continued). Data processing and certification matrix for the SEAN climate monitoring protocol.

Deliverable Title	Description	Provided to Customers as	Frequency Produced	Responsibilities		
				Builder	Validator	Acceptor
WC_F: Station downloads	The cumulative collection of RAWS station observations in Campbell Scientific .DAT format. It is extracted from the station datalogger during each visit to each site. Multiple years are stored in a ring buffer in the station and the entire buffer is captured on each visit. No data corrections are directly applied to this Processing Level 0 product.	Windows data files of datalogger output in .DAT format wrapped into a single ZIP file for each field season.	One ZIP file per field season containing typically one downloaded file from each station visited that year.	Project Staff	Project Leader	Project Leader
WC_G: RAWS corrected data	The collection of RAWS output for all stations in ASCII CSV format at Processing Level 1B having duplicate readings removed, standard formatting applied, measurement units made consistent, and quality flags plus selected metadata added. This contains all network station data for all years and all stations.	A single Windows ASCII CSV data file.	Annually, after the WC_F station downloads and WC_C site visit worksheets are accepted.	Project Staff	Project Leader	Project Leader
WC_H: Annual operations report	Annual report summarizing operations and data in the form of an NPS NRR or NRDS publication. Deliverable WC_D is a prerequisite.	One PDF file.	One PDF file per year created after completion of all field work	Project Leader	Peer Review Manager	Network Program Manager

Table 2 (continued). Data processing and certification matrix for the SEAN climate monitoring protocol.

Deliverable Title	Description	Provided to Customers as	Frequency Produced	Responsibilities		
				Builder	Validator	Acceptor
WC_I: Calibration certificate images	Scanned images of sensor calibration records provided by instrument vendor/servicer having printed dates that are in one calendar year.	One PDF file covering all instruments in the year.	One PDF file per calendar year following receipt of the year's last calibrated instrument.	Project Staff	Project Leader	Project Leader
WC_J: Periodic report	Multi-year climate analysis based in the parameters collected by stations, written in the form of an NPS NRR publication.	One PDF file.	Once every ten years.	Project Leader	Peer Review Manager	Regional I&M Coordinator

Data Processing and Workflow

- 1) Field data and supporting metadata are collected from each climate station on an annual basis. After field data collection the data are first manually checked by network staff. The RAWS station data (Level 0) data is then formatted and run through the Aquarius tools developed for the climate vital sign (SOP 11) for processing. The Level 1B RAWS corrected data files are the core data files. The other deliverables in Table 1 support the process of collecting, processing and disseminating these data.
- 2) Certification and publication of data sets will occur annually after the field season.
- 3) Climate data analysis, visualization, and dissemination continues to evolve at a rapid pace; the core datasets will remain the same but the path to value-added Level 2 type data products will likely change.
- 4) Data from other sites (NWS COOP, FAA AWOS, SNOTEL, fire RAWS, etc.) used for statistics and analysis will be acquired through the Applied Climate Information System data portal.

Defined Data Levels

Level 0 – RAWS Station Download

- Data products are unprocessed (raw) hourly weather data files from the climate station datalogger, downloaded annually during site visit (format .dat). See Figure 2.
- This is deliverable WC_F in the SEAN climate vital sign product matrix.

Level 1b – RAWS Corrected Data

- The RAWS corrected data WC_G is the collection of all RAWS output for all stations in ASCII CSV format at Processing Level 1B having duplicate readings removed, standard formatting applied, consistent measurement units enforced, and quality flags plus selected metadata added (details in SOP 11).
- This provides researchers and data aggregators Level 1B containing the monitoring program's best corrected data in a single file.
- This is deliverable WC_G in the climate vital sign product matrix. See Figure 3.

Level 2 – Value Added Data

- Data products are derived climate variables from the Level 1B source data and may include: 1) calculation of climate statistics on variety of time scales hourly to decadal (mean, totals, median), 2) calculation of climate trends and anomalies, and 3) calculation of derived climate variables (i.e. thaw degree days, P > 1 inch, T > freezing).

Weather and Climate
 Deliverable WC_F: Station download
Must be performed after end of field season

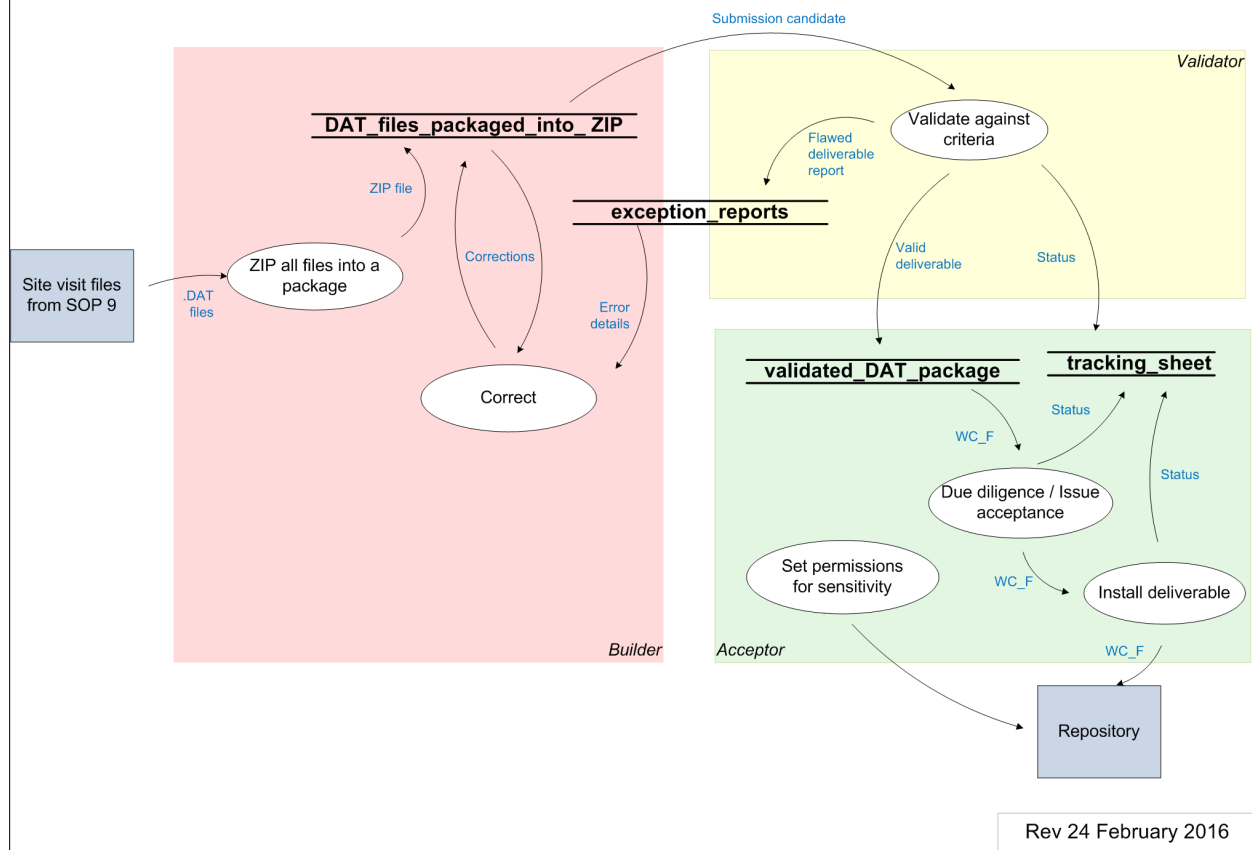
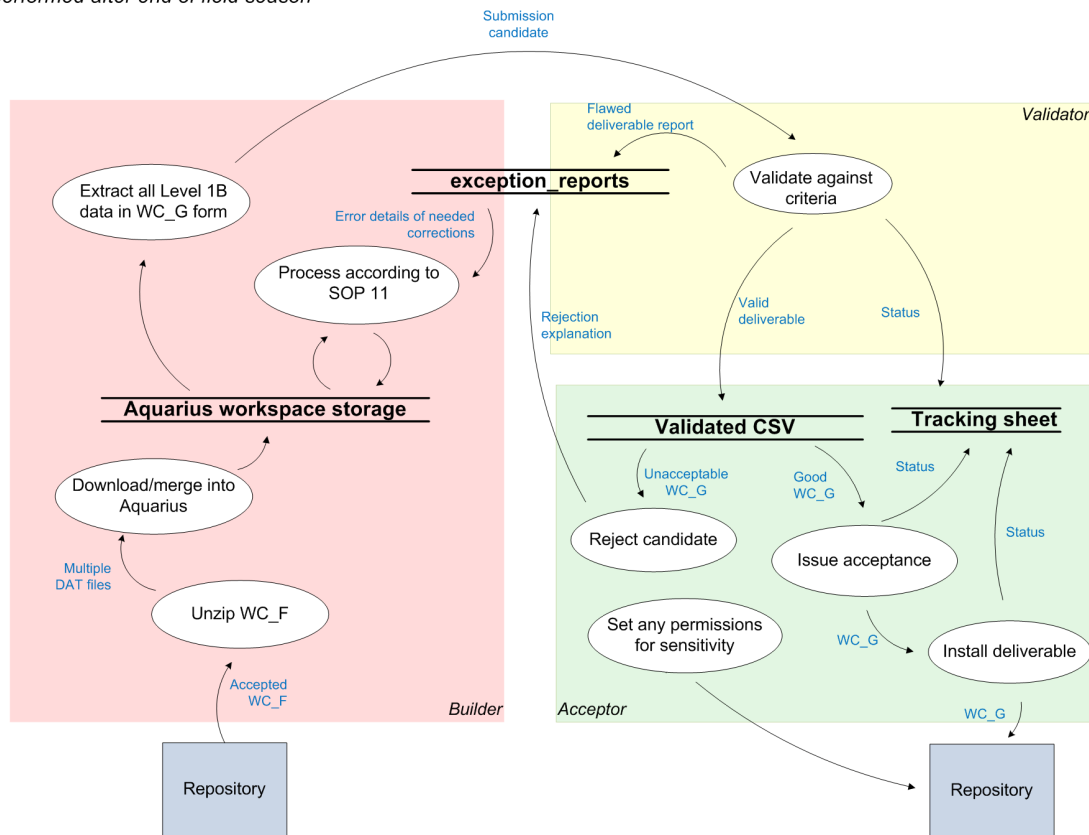


Figure 2. Flow chart of the RAWS station download (Level 0) comprising the WC_F annual deliverable.

Weather and Climate
 Deliverable WC_G: RAWS corrected data
Must be performed after end of field season



Rev 3 March 2016

Figure 3. Flow chart for the RAWS corrected data (Level 1b) comprising the WC_G annual deliverable.

Budget

Estimated operating costs are shown in Table 3.

Table 3. Estimated annual operating cost (based on FY2017 dollars) for implementation of the SEAN Weather and Climate Vital Sign.

Category	Item	Estimated Cost (FY 2017)
Personnel	Sean Program Manager (GS-13, 6 pay periods)	34,348
	Sean Data Manager (GS-11, 4 pay periods)	19,785
	GLBA Park Lead (GS-09, 2 pay periods)	5,814
	KLGO Park Lead (WG-07, 2 pay periods)	5,929
	ARCN Physical Scientist (GS-09, 1 pay period)	3,502
Aviation	Chilkoot Pass, Sheep Camp helo charter	2,000
	Lituya Bay float plane charter	2,125
	Dry Bay fixed-wing charter	800
	Deception Hills and Brady Icefield helo charter	9,000
Travel	Station maintenance (Glacier Bay proper)	1,658
	Station maintenance (Dry Bay)	452
	Station maintenance (Lituya Bay)	702
	Station maintenance (KLGO)	1,425
Equipment and supplies	Routine sensor and logger service	7,000
	Equipment repair/replacement	2,640
	Field supplies, shipping	1,500
	Total program costs	98,680

Safety

A primary goal of the SEAN is to ensure the safety of its staff and partners while conducting inventory and monitoring activities in parks. Encountering hazardous situations is inherent in outdoor monitoring activities, and all staff persons need to be aware and are committed to ensuring that all monitoring staff receive adequate training on safety procedures, incident reporting, and emergency response prior to field work.

There are four different levels of training and safety related policies that need to be followed in order to conduct a safe and successful climate monitoring program: 1) National/NPS level policy, 2) SEAN or Inventory and Monitoring (I&M) policy, 3) Regional policy, 4) Park level policy.

For Alaska based field work, the Alaska Region Communication Center (ARCC) staff are available to answer radio or satellite phone calls 24 hours a day 7 days a week throughout the field season.

Flight, float, or backcountry plans are filed with the ARCC prior to the field mission, which include established check-in times.

Risks Inherent in Climate Monitoring in the Southeast Alaska Parks

The parks in Southeast Alaska are remote and rugged with challenging weather extremes. Protection against sun, rain, wind, and snow is critical. Extra food and survival gear is a must. Protection from mosquitos is absolutely necessary. The climate sites are remote and could involve commercial airline flights, long drives on remote roads, long boat rides, strenuous hikes, fixed-wing flights to remote airstrips, and helicopter flights to the climate sites. The cumulative stress of multiple forms of transportation and a long field day is an inherent risk for field staff. *Standard Operating Procedure (SOP) 3 - Safety* addresses specific concerns for monitoring climate in the Alaska parks with links to park safety requirements.

Standard Operating Procedures

To ensure consistent implementation of this protocol over time, the following Standard Operating Procedures (SOPs) have been identified (Table 4.) SOPs are adopted from procedures approved and implemented programmatically through the CAKN climate monitoring program. The latest approved versions of operational SOPs are always available for download at the NPS Integrated Resource Management Applications portal at <http://irma.nps.gov>.

Table 4. Narrative documents and standard operating procedures for the SEAN weather and climate monitoring vital sign.

Subject	Topic	Citation	Notes	Links to Published/Document Record
Monitoring protocol	Original monitoring protocol guiding program design.	Sousanes, P. J. 2006. Climate monitoring protocol for the Central Alaska Network – Denali National Park and Preserve, Yukon-Charley River National Preserve, and Wrangell -St. Elias National Park and Preserve. National Park Service, Denali Park, Alaska.	General methods and the rationale for monitoring climate are described in the CAKN climate monitoring protocol narrative along with original standard operating procedures (SOPs).	Available online at https://irma.nps.gov/DataStore/Reference/Profile/2192457
SOPs	Overview of 2017 standard operating procedure updates	Sousanes, P.J., et al. 2017. Standard operating procedure updates 2017: Central Alaska Network (CAKN) climate monitoring protocol. Natural Resource Report NPS/CAKN/NRR—2017/1504. National Park Service, Fort Collins, Colorado.	In 2017 the ARCN, CAKN, and SEAN staff worked collectively to update the CAKN climate monitoring standard operating procedures (SOPs), which integrated programmatic aspects of the ARCN and SEAN networks. The updated SOPs now include information that apply to all three networks.	Available online at https://irma.nps.gov/DataStore/Reference/Profile/2243728

Table 4 (continued). Narrative documents and standard operating procedures for the SEAN weather and climate monitoring vital sign.

Subject	Topic	Citation	Notes	Links to Published/Document Record
SOPs	Deliverables	Sousanes, P., K. Hill, M. Bower, W. Johnson, and S. Miller. 2017. Standard Operating Procedure (SOP) 1: Annual Deliverable Schedule, Version 1.0. Weather and Climate Monitoring Protocol, Arctic (ARCN), Central Alaska (CAKN), and Southeast Alaska (SEAN) Inventory and Monitoring Networks. National Park Service, Fairbanks, Alaska.	Outlines typical annual work plan and product deliverable schedule.	Available online at https://irma.nps.gov/DataStore/Reference/Profile/2243685 .
SOPs	Compliance, Permitting, and Site Locations	Sousanes, P., K. Hill, M. Bower, W. Johnson, and S. Miller. 2017. Standard Operating Procedure (SOP) 2: Compliance, Permitting, and Updating Site Maps (WC_B), Version 2.0. Weather and Climate Monitoring Protocol, Arctic (ARCN), Central Alaska (CAKN), and Southeast Alaska (SEAN) Inventory and Monitoring Networks. National Park Service, Fairbanks, Alaska.	NEPA compliance and permitting requirements to conduct weather and climate monitoring in ARCN, CAKN, and SEAN	Available online at https://irma.nps.gov/DataStore/Reference/Profile/2243687
SOPs	Safety	Sousanes, P., K. Hill, M. Bower, W. Johnson, and S. Miller. 2017. Standard Operating Procedure (SOP) 3: Field Safety, Version 1.0. Weather and Climate Monitoring Protocol, Arctic (ARCN), Central Alaska (CAKN), and Southeast Alaska (SEAN) Inventory and Monitoring Networks. National Park Service, Fairbanks, Alaska.	Information on basic safety principles and risks inherent in remote fieldwork.	Available online at https://irma.nps.gov/DataStore/Reference/Profile/2243689

Table 4 (continued). Narrative documents and standard operating procedures for the SEAN weather and climate monitoring vital sign.

Subject	Topic	Citation	Notes	Links to Published/Document Record
SOPs	Climate Station Specifications	Sousanes, P., K. Hill, M. Bower, W. Johnson, and S. Miller. 2017. Standard Operating Procedure (SOP) 4: Climate Data Specifications, Sampling Frequency, and Measurement Intervals, Version 2.0. Weather and Climate Monitoring Protocol, Arctic (ARCN), Central Alaska (CAKN), and Southeast Alaska (SEAN) Inventory and Monitoring Networks. National Park Service, Fairbanks, Alaska.	Defines the data collection methods for the weather and climate monitoring vital sign using research grade automated weather station equipment.	Available online at https://irma.nps.gov/DataStore/Reference/Profile/2243690
SOPs	Field Laptop	Sousanes, P., K. Hill, M. Bower, W. Johnson, and S. Miller. 2017. Standard Operating Procedure (SOP) 5: Field Laptop Setup, Version 2.0. Weather and Climate Monitoring Protocol, Arctic (ARCN), Central Alaska (CAKN), and Southeast Alaska (SEAN) Inventory and Monitoring Networks. National Park Service, Fairbanks, Alaska.	Step-by-step procedures for preparing a field laptop to directly communicate with the weather station data loggers.	Available online at https://irma.nps.gov/DataStore/Reference/Profile/2243691
SOPs	Programming	Sousanes, P., K. Hill, M. Bower, W. Johnson, and S. Miller. 2017. Standard Operating Procedure (SOP) 6: Datalogger Programming, Version 2.0. Weather and Climate Monitoring Protocol, Arctic (ARCN), Central Alaska (CAKN), and Southeast Alaska (SEAN) Inventory and Monitoring Networks. National Park Service, Fairbanks, Alaska.	Describes the process for programming the weather station datalogger.	Available online at https://irma.nps.gov/DataStore/Reference/Profile/2243693

Table 4 (continued). Narrative documents and standard operating procedures for the SEAN weather and climate monitoring vital sign.

Subject	Topic	Citation	Notes	Links to Published/Document Record
SOPs	Satellite Transmitter	Sousanes, P., K. Hill, M. Bower, W. Johnson, and S. Miller. 2017. Standard Operating Procedure (SOP) 7: Satellite Transmitter Programming (GOES) and Data Ingest System (WFMI), Version 2.0. Weather and Climate Monitoring Protocol, Arctic (ARCN), Central Alaska (CAKN), and Southeast Alaska (SEAN) Inventory and Monitoring Networks. National Park Service, Fairbanks, Alaska.	Outlines the process for setting up a remote weather station to transmit near real-time hourly weather data from the climate network.	Available online at https://irma.nps.gov/DataStore/Reference/Profile/2243694
SOPs	Climate Station Installation and Maintenance Equipment List	Sousanes, P., K. Hill, M. Bower, W. Johnson, and S. Miller. 2017. Standard Operating Procedure (SOP) 8: Site Installation and Maintenance Equipment Checklist, Version 2.0. Weather and Climate Monitoring Protocol, Arctic (ARCN), Central Alaska (CAKN), and Southeast Alaska (SEAN) Inventory and Monitoring Networks. National Park Service, Fairbanks, Alaska	Describes the individual components of a network weather station and the maintenance equipment that is required for every site visit.	Available online at https://irma.nps.gov/DataStore/Reference/Profile/2243696
SOPs	Annual Site Visit	Sousanes, P., K. Hill, M. Bower, W. Johnson, and S. Miller. 2017. Standard Operating Procedure (SOP) 9: Annual Site Visit, Version 2.0. Weather and Climate Monitoring Protocol, Arctic (ARCN), Central Alaska (CAKN), and Southeast Alaska (SEAN) Inventory and Monitoring Networks. National Park Service, Fairbanks, Alaska	Includes all the instructions necessary to conduct an annual site visit at a weather station.	Available online at https://irma.nps.gov/DataStore/Reference/Profile/2243697

Table 4 (continued). Narrative documents and standard operating procedures for the SEAN weather and climate monitoring vital sign.

Subject	Topic	Citation	Notes	Links to Published/Document Record
SOPs	Data management	Johnson, W., K. Hill, S. Miller, P. Sousanes, and M. Bower. 2017. Standard Operating Procedure (SOP) 10: Data Deliverable Creation, Validation, Acceptance, and Dissemination, Version 2.0. Weather and Climate Monitoring Protocol, Arctic (ARCN), Central Alaska (CAKN), and Southeast Alaska (SEAN) Inventory and Monitoring Networks. National Park Service, Fairbanks, Alaska.	Documents the technical specification of the ten formal deliverable products for the weather and climate monitoring program.	Available online at https://irma.nps.gov/DataStore/Reference/Profile/2243699
SOPs	Quality Control	Hill, K, W. Johnson, P. Sousanes, M. Bower, and S. Miller. 2017. Standard Operating Procedure (SOP) 11: Quality Control and Record Processing, Version 2.0. Weather and Climate Monitoring Protocol, Arctic (ARCN), Central Alaska (CAKN), and Southeast Alaska (SEAN) Inventory and Monitoring Networks. National Park Service, Fairbanks, Alaska.	Outlines quality control and quality assurance procedures for storing, processing, and exporting continuous weather and climate data.	Available online at https://irma.nps.gov/DataStore/Reference/Profile/2243700
SOPs	Reporting	Sousanes, P., K. Hill, M. Bower, W. Johnson, and S. Miller. 2017. Standard Operating Procedure (SOP) 12: Annual Reporting and Deliverable Publishing, Version 2.0. Weather and Climate Monitoring Protocol, Arctic (ARCN), Central Alaska (CAKN), and Southeast Alaska (SEAN) Inventory and Monitoring Networks. National Park Service, Fairbanks, Alaska.	Describes the method for reporting on the weather and climate monitoring protocol.	Available online at https://irma.nps.gov/DataStore/Reference/Profile/2243701

Table 4 (continued). Narrative documents and standard operating procedures for the SEAN weather and climate monitoring vital sign.

Subject	Topic	Citation	Notes	Links to Published/Document Record
SOPs	Protocol revisions	Sousanes, P., K. Hill, M. Bower, W. Johnson, and S. Miller. 2017. Standard Operating Procedure (SOP) 13: Revising the Protocol, Version 2.0. Weather and Climate Monitoring Protocol, Arctic (ARCN), Central Alaska (CAKN), and Southeast Alaska (SEAN) Inventory and Monitoring Networks. National Park Service, Fairbanks, Alaska.	This outlines how changes and revisions are made to the protocol or standard operating procedures.	Available online at https://irma.nps.gov/DataStore/Reference/Profile/2243704
Data Quality Standards	Quality control and quality assurance	Sousanes, P.J. et al (<i>In Press</i>). Data Quality Standards for Weather and Climate Monitoring in the Arctic, Central Alaska, and Southeast Alaska Networks. Natural Resource Report NPS/ARCN/NRR—2017/XXX. National Park Service, Fort Collins, Colorado.	Provides additional details regarding the standards used during collection, processing, storage, analysis, and publication of program data.	In Press, NPS NRR

Literature Cited

- Davey, C. A., K. T. Redmond, D. B. Simeral. 2007. Weather and Climate Inventory - National Park Service – Southeast Alaska Network. Natural Resource Technical Report NPS/SEAN/NRTR—2007/012.
- Johnson, W. F., and B. J. Moynahan. 2008. Data management plan: Southeast Alaska network. Natural Resource Report NPS/SEAN/NRR—2008/058. National Park Service, Fort Collins, Colorado.
- Moynahan, B. J., W. F. Johnson, D. W. Schirokauer, L. C. Sharman, G. Smith, and S. M. Gende. 2008. Vital sign monitoring plan: Southeast Alaska Network. Natural Resource Report NPS/SEAN/NRR—2008/059. National Park Service, Fort Collins, Colorado.
- Shanley, C. S., S. Pyare, M. I. Goldstein, P. B. Alaback, D. M. Albert, C. M. Beier, T. J. Brinkman, R. T. Edwards, E. Hood, A. MacKinnon, and M. V. McPhee. 2015. Climate change implications in the northern coastal temperate rainforest of North America. *Climatic Change* 130(2): 155-170.
- Sousanes, P. J. 2006. Climate monitoring protocol for the Central Alaska Network – Denali National Park and Preserve, Yukon-Charley River National Preserve, and Wrangell -St. Elias National Park and Preserve. National Park Service, Denali Park, Alaska.
- Sousanes, P. J., K. R. Hill, M. R. Bower, W. F. Johnson, and S. D. Miller. 2017. Standard operating procedure updates 2017: Central Alaska Network (CAKN) climate monitoring protocol. Natural Resource Report NPS/CAKN/NRR—2017/1504. National Park Service, Fort Collins, Colorado.
- Sousanes, P. J., K. R. Hill, M. R. Bower, W. F. Johnson, and S. D. Miller. *In Press*. Data quality standards for weather and climate monitoring in the Arctic, Central Alaska, and Southeast Alaska Networks. Natural Resource Report. National Park Service, Fort Collins, Colorado.

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.

NPS 953/141452, December 2017

National Park Service
U.S. Department of the Interior



Natural Resource Stewardship and Science

Natural Resource Stewardship and Science

1201 Oakridge Drive, Suite 150
Fort Collins, CO 80525

www.nature.nps.gov