An Overview of the US Climate Reference Network Station Design and Power Systems Used for Remote Stations in Alaska

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Climate Reference Network

The U.S. Climate Reference Network (USCRN) is a network currently comprised of 116 broadcasting climate stations throughout the continental United States, 13 stations in Alaska, 2 stations in Hawaii, and an experimental site in Canada.

The vision of the USCRN program is to maintain a sustainable high-quality climate observation network that 50 years from now can with the highest degree of confidence answer the question: How has the climate of the nation changed over the past 50 years?

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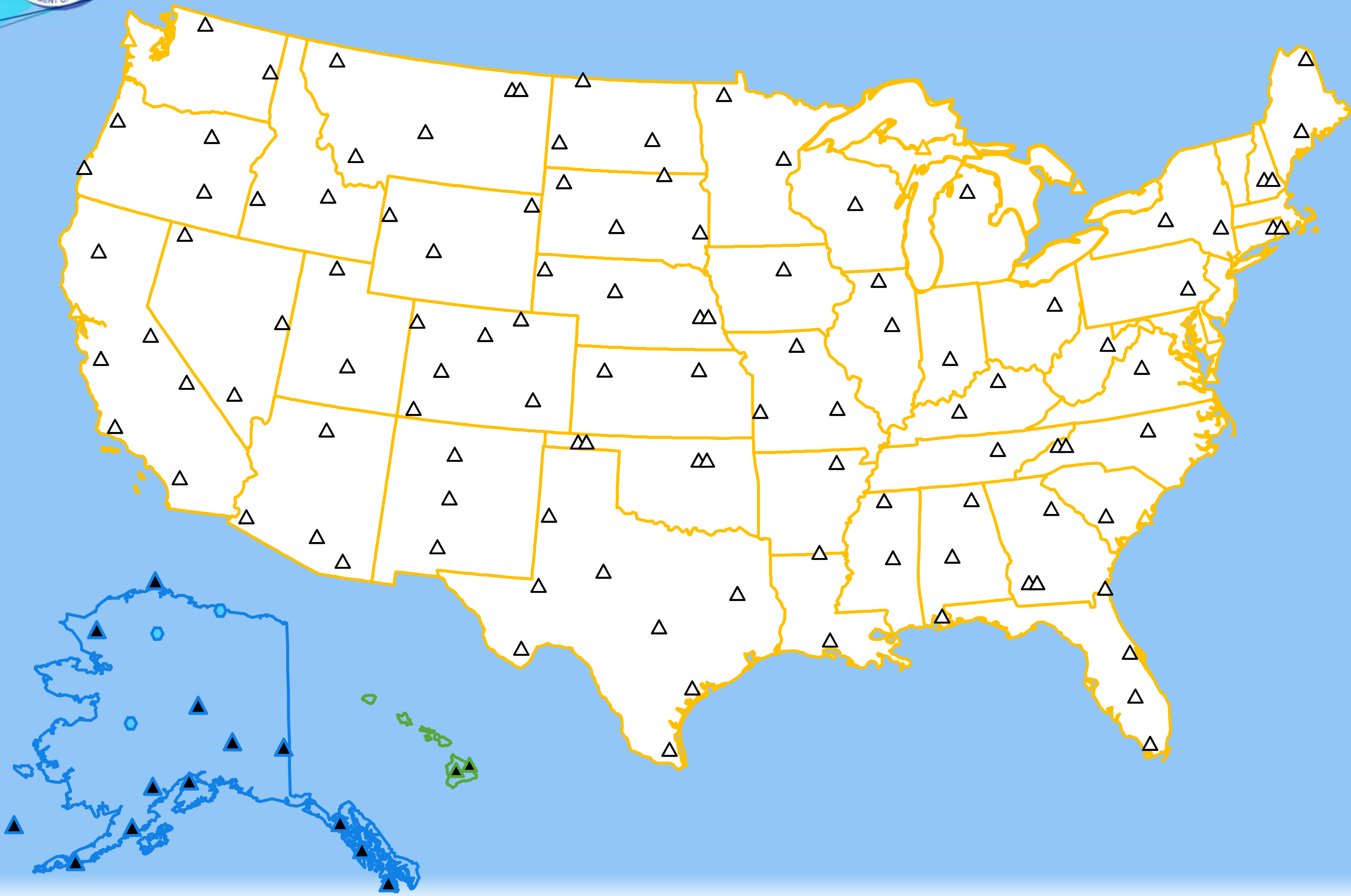
The CRN networks infrastructure, sensors and data collection and transmission equipment are installed and maintained by a team of 13 technicians and engineers.

Between 2010 and 2013, our team logged, on average, 700 man-days per year in the field performing scheduled and unscheduled maintenance as well as performing site installations and surveys for future stations.

Climate Reference Network



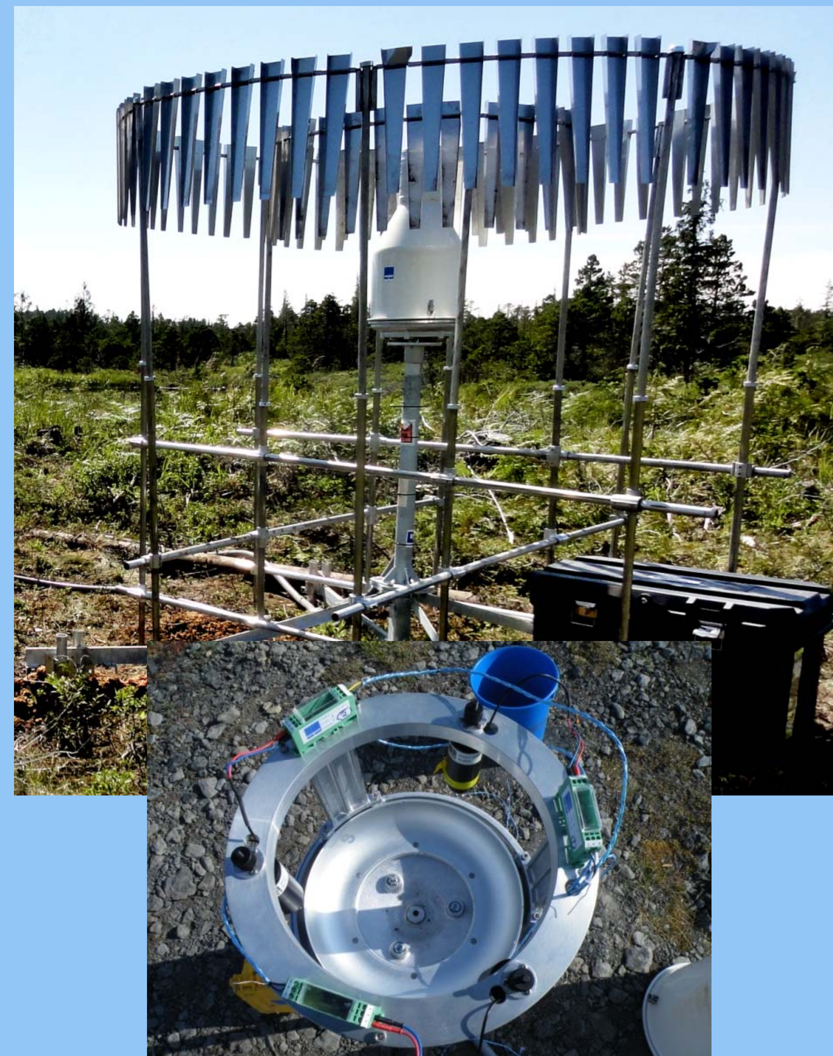
15 April 2014

Air Resources Laboratory

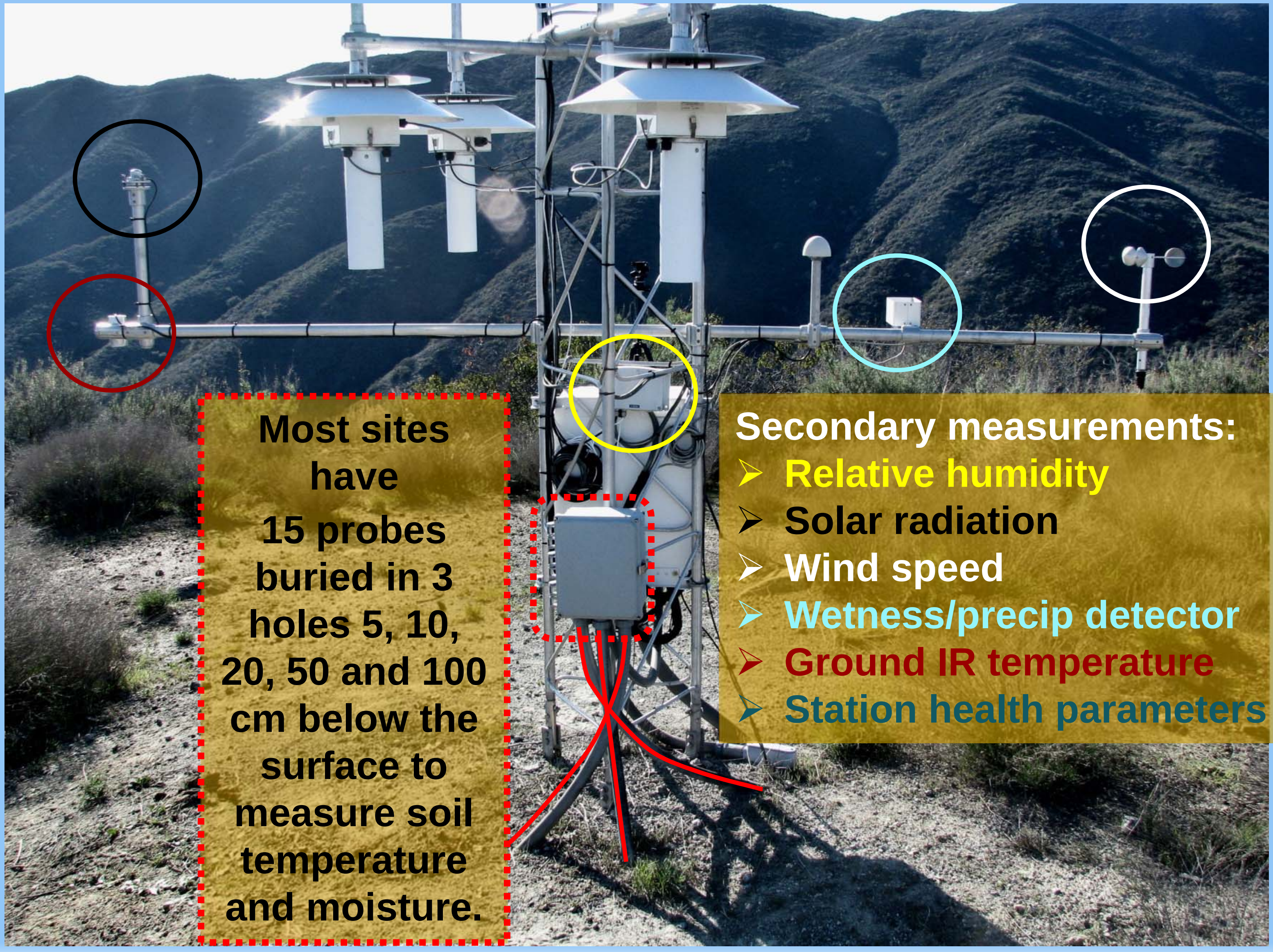
Climate Reference Network Sensors

Primary measurements:

- Aspirated temperature
  triple redundancy
- Precipitation sensor
  triple redundancy
- NIST traceable calibrations



Climate Reference Network Sensors



Most sites have
15 probes buried in 3 holes 5, 10, 20, 50 and 100 cm below the surface to measure soil temperature and moisture.

Secondary measurements:

- Relative humidity
- Solar radiation
- Wind speed
- Wetness/precip detector
- Ground IR temperature
- Station health parameters

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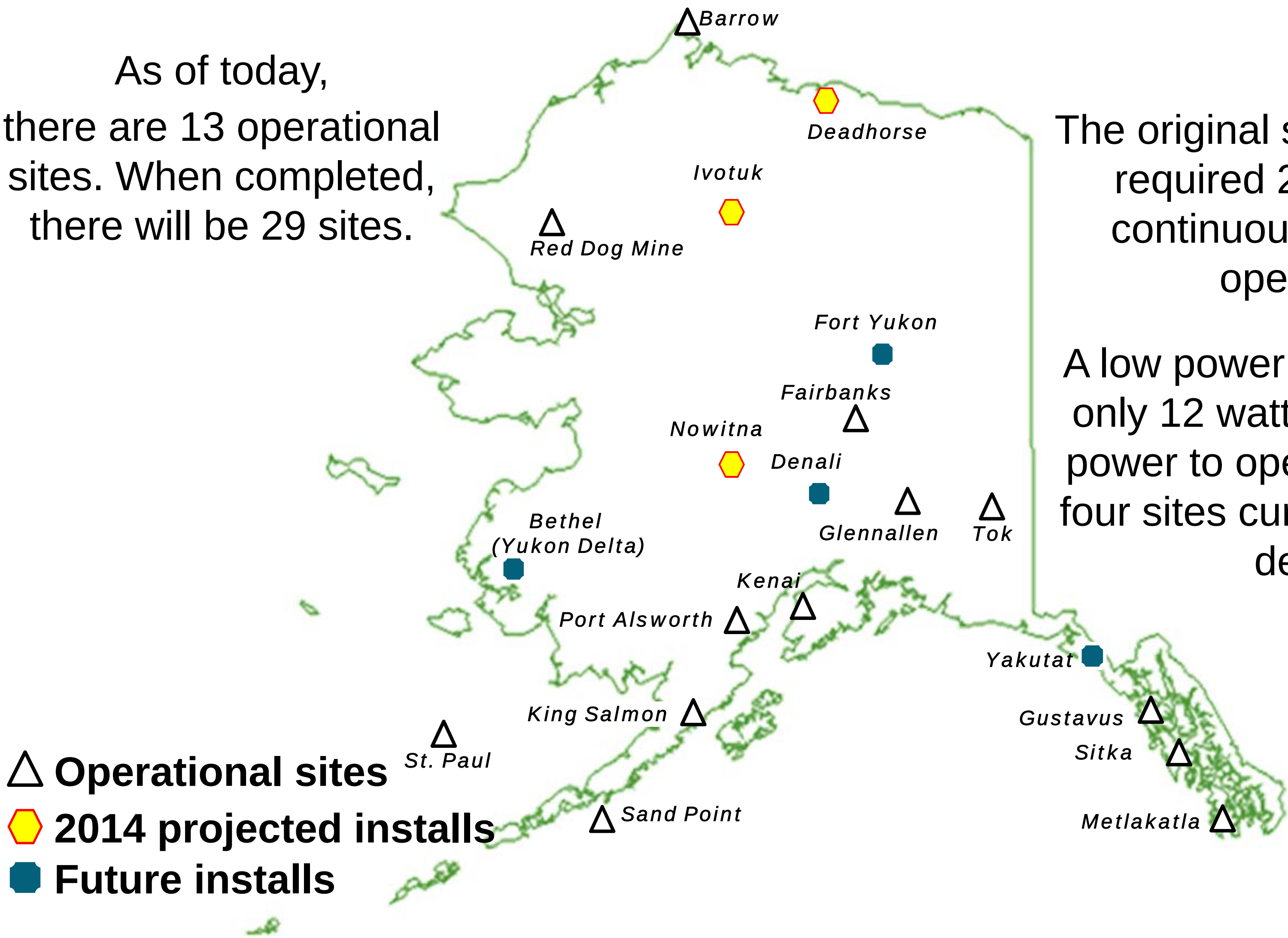
As of today,
there are 13 operational sites. When completed, there will be 29 sites.



The original station design required 24 watts of continuous power to operate.

A low power design requires only 12 watts of continuous power to operate. There are four sites currently using this design.

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Original site configuration examples

Barrow - 2002

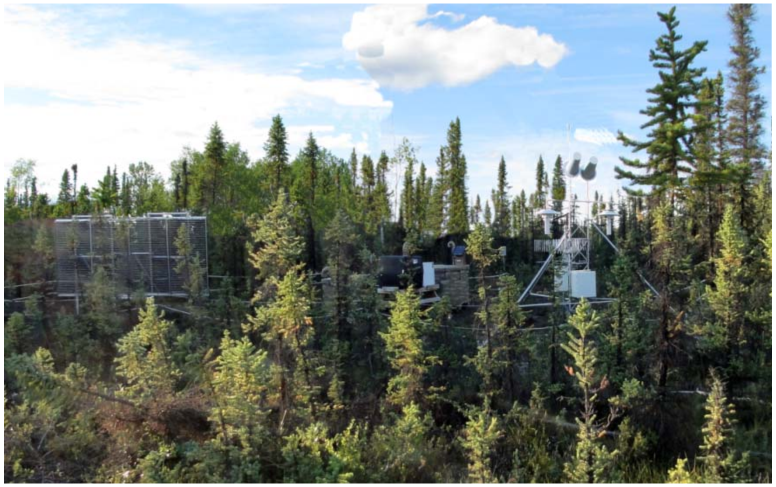
Sitka - 2005

Sand Point - 2009

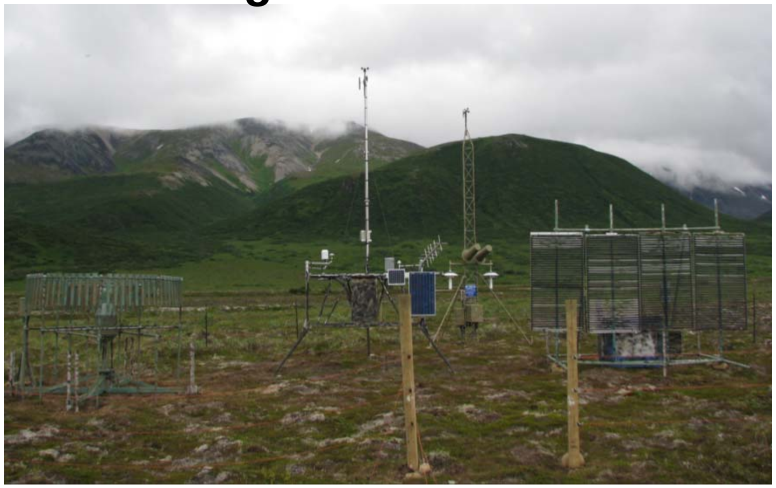
Port Alsworth - 2009

Low Power site configurations

Tok - 2011



King Salmon - 2012



Gustavus - 2012

Glennallen- 2013

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Redundancy of components and sensors

- Primary and secondary data logger and transmitter systems.
- Three temperature sensors with dual fans in one aspirated shield for each system.
- Dual infrared sensors.
- Dual wetness sensors.

Shared sensors

- Precipitation measuring sensor
- Wind speed
- Solar radiation
- Relative humidity

Station power

- The lower power requirements are primarily supplied by solar panels with a methanol fuel cell for backup.

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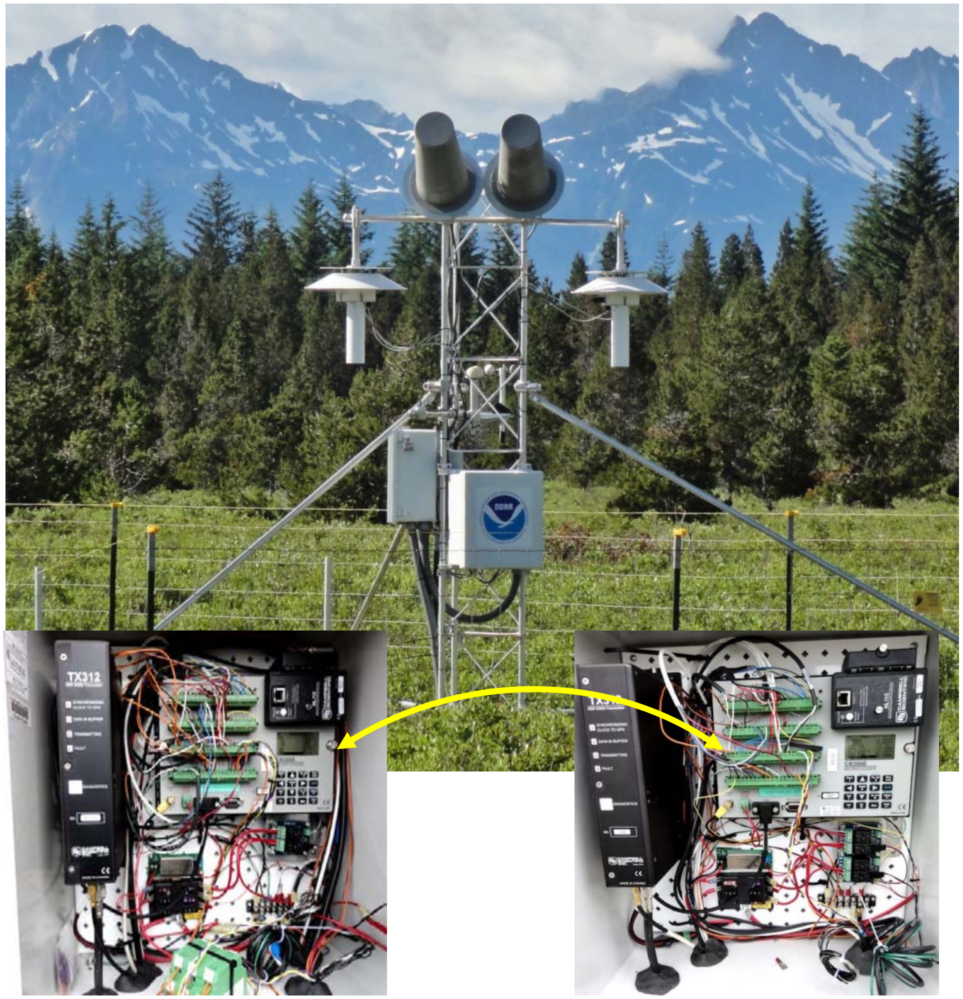
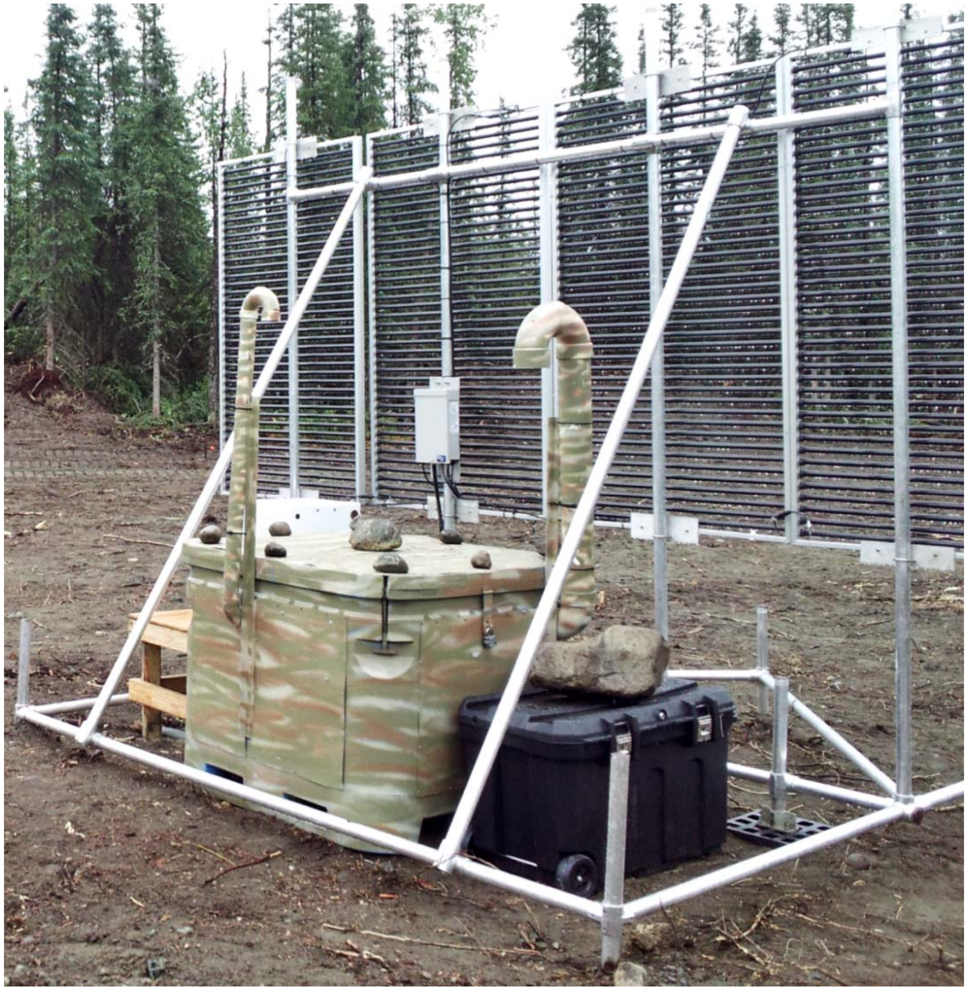
Dual data system operation

- Primary and secondary data loggers exchange data once each hour.
- Every hour, there are two transmissions with identical data.
- Secondary system monitors primary system operating status. In the event the primary system has a malfunction, the secondary system assumes the primary role.
- If battery voltage drops below 11.7 volts a low voltage disconnect turns off everything except the data loggers. Data continues to be collected and can be recovered at AMV.



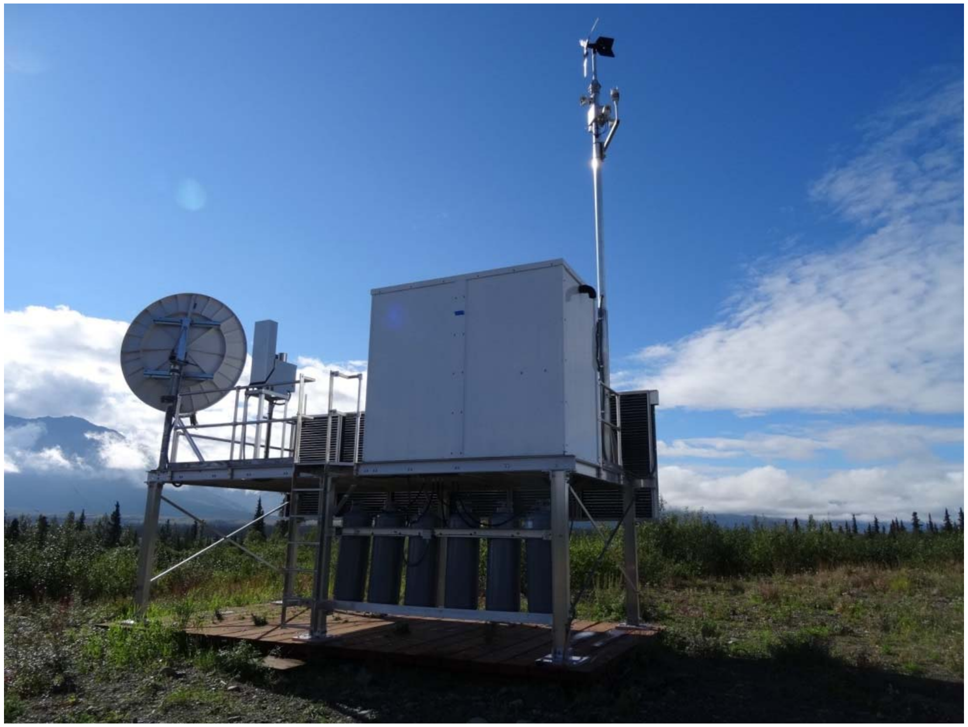
Station power

- Currently, the electrical requirements are primarily met with the use of four 182-watt Solyndra solar panels.
- A 1600-watt EFOY methanol fuel cell is the backup power supply.
- In addition to the 12 watts required for continuous operation, an additional 60 watts is needed when the precipitation gauge inlet heater is operating.

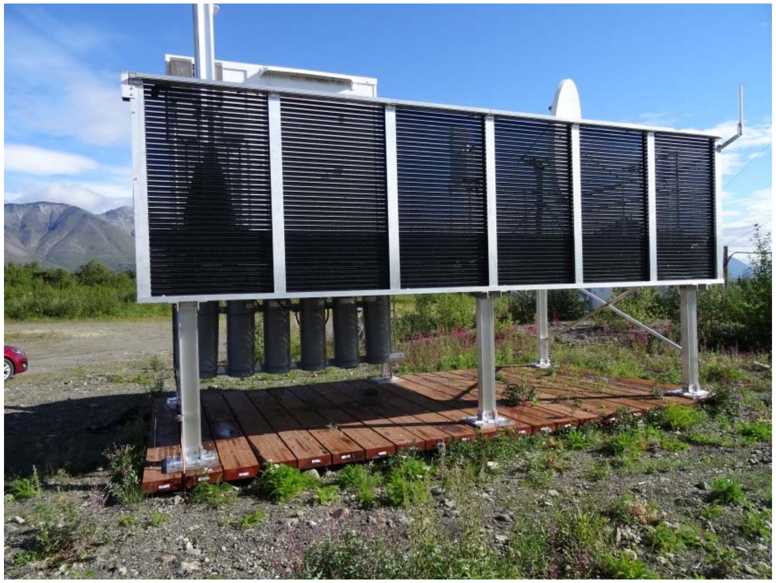


Why Solyndra panels?

- FAA recommended the use of Solyndra panels in remote locations.
- FAA uses 12 panels and a propane fuel cell at some of their remote camera sites.
- Reasons for recommendation:
  - Thin film design provides power even when the panel is partially shaded (i.e. snow cover).
  - Power production under overcast conditions is superior to other panels.



- FAA stacked Solyndra panels two layers deep and got almost double output in cloudy conditions.



Sunpreme Bifacial GxB 340

- Solyndra panels are no longer available.
- Evaluating Sunpreme bifacial GxB 340 panels for future installs.
- High Efficiency: 18% monofacial, and over 21% with 20% backside irradiance.
- Should have higher output than conventional panels in cloudy conditions.
- Bifacial design should increase output when ground is snow covered.
- Mounting vertically should reduce snow accumulation on surfaces and maximize bifacial design.

Methanol fuel cell configurations

The first MFC which was installed at Tok in 2011. The drawback to this configuration is it only had space for one fuel container in the manufacturer supplied enclosure.

The current configuration has room for four fuel containers.

- The EFOY unit at Tok performed well in 2011 but the need to switch fuel containers three times during the winter caused several logistical problems.
- Ambient temperatures dropped to -50 F twice.

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- In 2012 a new container was designed to house the EFOY Pro 1600 and two fuel cartridges controlled by a DuoCart switch and a waste water tank.
- This design was installed at Tok and Gustavus. Gustavus performed well.
- Tok had a fuel pump failure. A replacement fuel cell was shipped to the site but also had issues. Site was down until solar panels could supply power.

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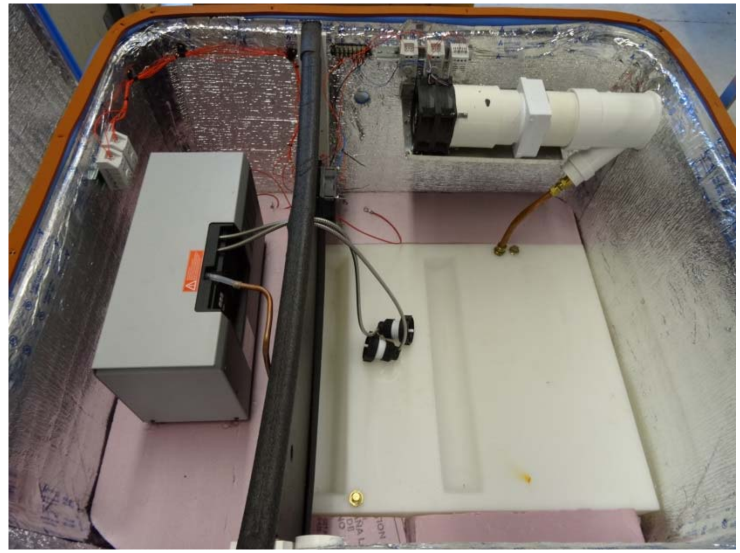
- King Salmon was installed in 2012 with an EFOY unit.
- In November, the unit ran warming cycles to keep itself warm but failed after running one charging cycle. The station was on and off in December and January until incoming solar was sufficient for operations.
- The housing was reworked summer of 2013.
- The EFOY unit was replaced at the AMV. In late August, it turned on unexpectedly for no apparent reason. A replacement unit was installed by NPS staff in September.
- This unit has run heating cycles during the winter but has never run a charging cycle.
- Station has run on solar power except for 22 days

Summary of current site configuration and performance

- King Salmon has had problems both winters of operation. This site is not extremely cold and the problems seem to be associated with the EFOY units.
- Gustavus has operated without issues for two winters. It has a smaller container that houses two fuel containers. It has consumed 1.5 fuel containers per winter.
- Glennallen has operated without issues this winter. It has the current container design with four fuel containers. It has consumed around 2 containers of fuel this winter.
- Tok has operated without issues this winter even with both the primary and secondary system fans running continuously. This would increase power demand to 18 watts. It has the current container design with four fuel containers. It has consumed around 3 containers of fuel this winter.

Current EFOY Enclosure Design

- 24 cu-ft insulated frozen food shipping container used for housing
- RV waste container to collect water byproduct
- EFOY unit housed in smaller compartment to conserve heat
- Each compartment has thermostatically controlled fans to exhaust waste heat if needed.
- RH sensor used to keep RH below 90%
- Three batteries gives 387 AH capacity
- Up to four M28 fuel containers
- Two DuoCart switches can be installed to give complete year capacity without service



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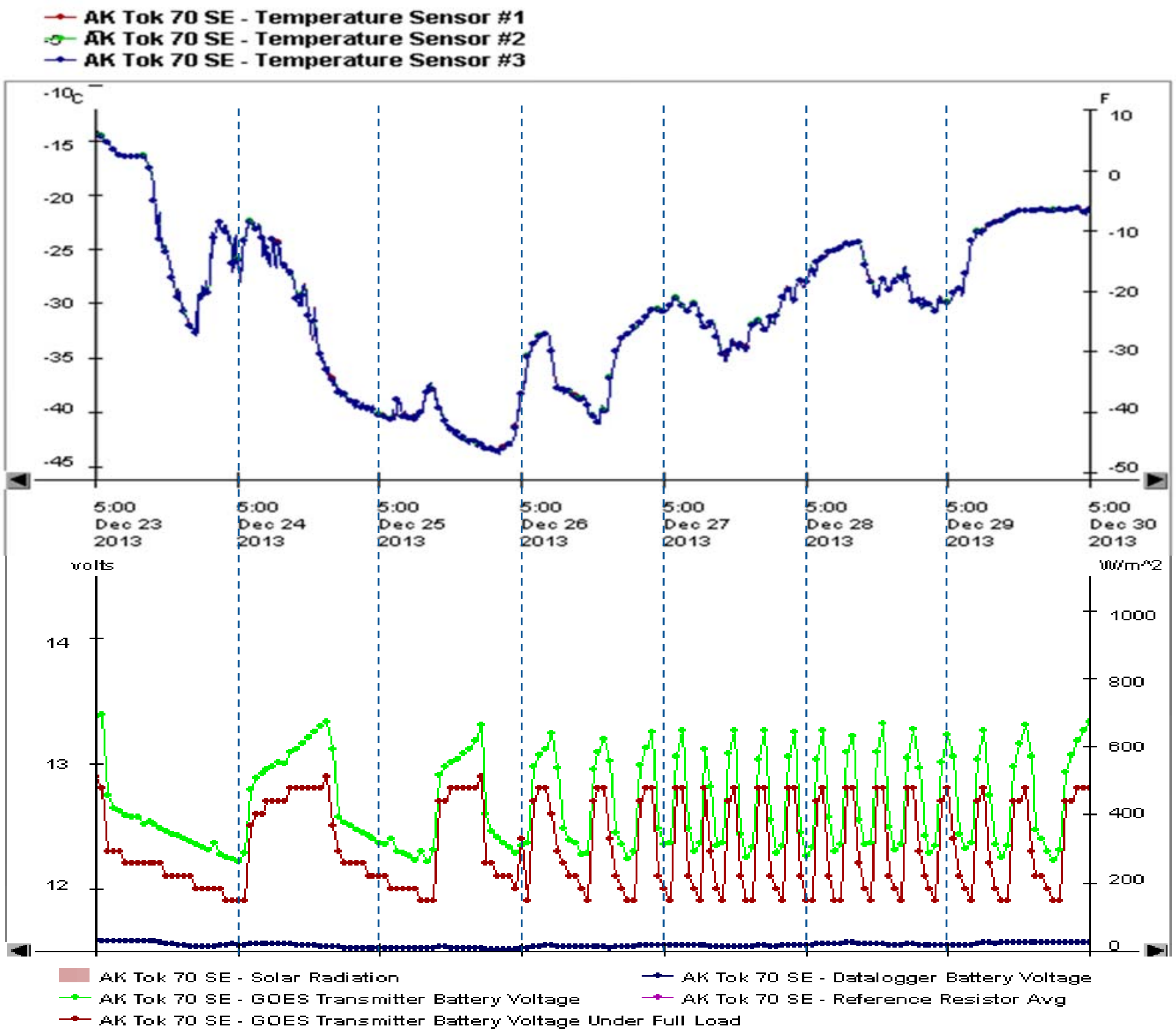

Data Recovery Rates for each site

Site Name	2011-12	2012-13	2013-14
Tok	100%	64.7%	100%
King Salmon		100%	88.1%*
Gustavus		100%	100%
Glennallen			98%*

* Remaining un-aspirated data will be recovered at AMV.

Plans for 2014-15

- Upgrade EFOY units at Tok, Glennallen to EFOY 2400 with two DuoCart switches.
- Install sites at Nowitna NWR and Deadhorse with this same configuration.
- Replace unit at King Salmon with a thoroughly tested 1600 unit.
- Install Sunpreme panels at Nowitna and Deadhorse sites.
- Install at Ivotuk using power generated by existing NSF generator/solar system.


Questions?