Climate Monitoring Comments
Central Alaska Network Inventory and Monitoring Program

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Overall Process

We felt that the process followed by the CAKN group was well matched to the circumstances within which they operate. In light of the logistical and maintenance difficulties, the sparsity of existing observations, the extreme demands imposed by the climate itself, the importance of the information to a host of users, and the demands on time and resources, the approach taken was logical and well thought out, and we'd recommend it continue to be followed.

The report "Climate Monitoring Site Evaluation 2004" was well written, easy to follow, logical in its sequencing, and covered the necessary bases. This documentation was also very helpful in making further assessments of the various potential sites, and we especially would encourage this precedent be followed elsewhere in Alaska.

Station Design

It is quite obvious that climate conditions in Alaska are extreme, and frequently tax the survivability of both living organisms and of instruments set out to record those conditions. Equipment must be designed to not just survive but also to record the worst conditions it is expected to encounter. The most frequent cause of weather data failure is the weather we wish to record, and it is often the extremes that are of the greatest interest to save for posterity. Therefore, as much care as possible should be taken that the instruments can function during whatever conditions the climate system will produce.

Further, to record climate, the observational circumstances need to remain fixed: local artificial (hopefully none) and natural influences on the measured climate elements, methodological procedures, instrument characteristics, and in fact most aspects of the site, to ensure that the resulting record faithfully tracks environmental variations through time.

It is also well worth remembering that the best quality control consists of not producing bad data to begin with. A corollary to this is that acquisition and deployment costs are a small fraction of the lifetime costs that include maintenance, quality control and data handling. All automated systems require human oversight and continued attention.

With sufficient attention to maintenance, the suite of instrumentation acquired for the proposed climate monitoring network is adequate to meet the objectives of conducting long-term monitoring in the extreme climates characteristic of Alaska. Given the high price of travel and maintenance and of missed data, equipment with known track records and proven reliability in hostile environments should be given priority. Reliance on vendors who subject instrumentation to extreme conditions prior to shipping gives added confidence that the instruments will function properly in the field. The selected data loggers and measurement systems did meet these criteria.

It is also worth noting that the accurate determination of precipitation occurring in frozen form still remains the most difficult and important measurement problem, even after decades of effort. Heated systems require considerable electrical power, more than can be generated by renewable local resources. All precipitation gages under-catch, especially in snow, and this problem is greatly compounded in windy locations. The Snotel precipitation gages used by the Natural Resources Conservation Service, though slightly less resolution, are a good compromise, and have about 15,000 station-years of experience to make such an assessment. In some cases, dual systems may be worth considering: the more coarse (0.10 inch) but accurate Snotel fluid-based systems in winter, and the higher resolution (0.01") rain gages for liquid precipitation in the summer.

The best sites for one element many not be the best sites for others. Temperature is best measured away from local influences, such as nearby trees and vertical rock walls, but wind shielding of trees and shrubs, at appropriate distances (close enough to slow the wind, far enough to not act as snow fences), is friendly to better precipitation measurements. Wind is the biggest enemy to accurate precipitation measurements, and especially as snow, when undercatch can easily exceed 50 percent. Open sites are good for temperature and wind; closed sites are better for precipitation.

Recommendations

The severity of conditions that must be endured can vary greatly in short distances, and thus need to be evaluated individually for each site. Especially in regions of high topographic relief, but even in seemingly simpler situations, it is often better to think of stations as providing "index" values, rather than values of the "true" climate, which vary continuously and on fine scales, even to a few meters. The question of what a "representative" site actually represents seldom has a simple and straightforward answer. Since these sites are multi-purpose, with many applications not yet known, they should strive to constitute good compromises between competing influences. In deciding on the sensor complement, it is worthwhile to remember that salary and transportation costs can greatly exceed incremental equipment costs.

Some specific recommendations and considerations, not exhaustive, include the following:
- a spare deep cycle battery at each remote station;
- suitable anchoring systems for the meteorological tower or tripod;
- fencing around stations when appropriate and practical;
- utilization of specially constructed anemometers for mountain sites that have high wind speed and icing potential;
- heated precipitation gauges when practical;
- heated anemometers when icing is frequent;
- deployment of taller towers at locations with high snowfall potential;
- camouflaging towers and instrumentation (except temperature: always white) to minimize visual impact and vandalism potential (humans and animals);
- addition of sonic snow depth sensors at selected sites;
- sufficient data storage to hold at least one year, 4 megabyte modules on dataloggers.
- self diagnostic capabilities, such as battery ranges, solar panel charging rates, internal temperatures, and the like, are cheap and easy and very useful

Site Selection

According to the ***Climate Monitoring Site Evaluation 2004***, the main criteria in locating sites was 1) to get the best possible spatial coverage in the park, 2) to sample different ecoregions within each park, and 3) to get a good elevational gradient between sites. Furthermore, the issue of accessibility and routine maintenance was addressed.

Climate measurements must meet a higher standard than “weather” measurements. The most demanding of these is consistency through long periods of time. A time frame of 50-100 years should be envisioned, and a few decades at minimum. The process of choosing appropriate sites for long-term climate monitoring should take into account a variety of considerations: representativeness, accessibility, security, budgetary demands (personnel & maintenance), communications, stability of exposure characteristics, local hazards (flooding, avalanches, riming, etc). In some cases, successional processes may be at work, and the site supervisor is confronted with choices: an open site may become a closed site as a forest regrows, or as the climate changes and new vegetative forms replace old, or as a burn or disease opens up closed vegetation.

A system that seems to make sense is one of benchmark, reference stations, in locations relatively immune to local change, coupled with satellite stations, located in these more changeable environments, where those local departures from regional conditions are the main item of interest. These local departures may also be very long term: a cold pocket (frost hollow) a few tens of meters in diameter can remain so for centuries.

Especially in cold climates, and especially with snow on the ground, localized spatial temperature variations can be extreme. A movement of just a few meters can change the measured climate. Temperature inversions are a common occurrence (the rule, in most cases), particularly when the wind is blocked or disrupted, and especially when dark.

No site will be without local influences of some sort: on wind, on precipitation, on temperature, on humidity, on solar radiation, or on any other climate element. The best and only recourse is to thoroughly document the site, and to re-document periodically as the site changes with time. It is impossible to over-document. The rule of thumb is to preserve whatever information will be needed to properly interpret the each of the separate element records a generation or two hence, when today's site supervisor is no longer accessible or even in existence.

Comments on the specific sites

As a general comment, the series of specific sites were nicely described. And given that only two pictures are generally shown, those pictures conveyed quite a bit of useful information.

Wrangell St-Elias Park and Preserve

Clustering and transects

The idea of small clusters, which are themselves grouped in transects or other geometrical arrangements, such as that proposed for Wrangell-St Elias, seems like a very good one. It implicitly incorporates the notion that climate varies on a variety of spatial scales simultaneously, and that there are always local departures, sometimes very great, from the general regional climate properties. Furthermore, particular regions (boxes) highlighted seemed well chosen.

Another comment: with wind blasting, some sites might be considered for everything BUT precipitation. In other words, precipitation is sacrificed for the sake of other elements. Also, the kind of precip shields that might be needed at many of these sites would be more like the DFIR (double fenced intercomparison reference), which in effect have a 26 foot diameter (octagonal) vertical slat wooden fence, a 13 foot diameter similar fence, and regular Alter shield (vanes) surrounding the gage itself. Otherwise, there will be severe undercatch. These are work to put up, can be painted, and might represent weight for the helicopter (might weigh several hundred pounds).

McCarthy Area

Gates Peninsula. Good comments.

Kennicott Glacier. Good comments. The third picture here is the same as the third Gate Glacier picture.
Jumbo Trail. Good comments. One says in a semi-protected bowl, another says on a slight slope. Are these compatible statements? For the Climate Reference Network, we've given a small preference to slightly sloped terrain above drainage bottoms. The air is likely not to pond up during quiet or nighttime conditions. Slight slopes favor small movement all night via gravity drainage, so that effectively the sampled area increases.
Fireweed Mountain. Good comments. The note about glacier winds here and elsewhere is good. To the extent that glaciers partly *define* Wrangell St Elias, measurements that are biased by their presence are actually representative. If they recede, from climate change, the site climate might change for both large scale (regional climate change) and small scale (glacier packed up and left) reasons. These are both legitimate changes. One strategy is allow one site to be subject to both large scale and local influences, and another to be more insulated from local (glacier) influences.
Nikolai Mine. Good comments.
Nikolai Pass. Good comments.
Sourdough Ridge. Good comments.
Chititu. Good comments. Seemed like a pretty good site.

Summary of McCarthy area

We liked a Jumbo – Chititu combination. Not far behind, a Fireweed-Sourdough combination. Nicolai Pass is not that bad either. Chititu offers a nice south aspect for the big Aleutian storm winds. For glacial influence, Gates is probably a little better, but we thought that representing the whole area probably comes ahead of representing the glaciers. But among all the areas, it might be good to represent at least one glacier, hence we suggested a glacier site in the Tana River area.

Tana River Area

Iceberg Lake. Good comments. Rocky ground would mean warmer when sunny.
Iceberg Bench. Good comments.
Tana Glacier Seismic. Good comments. Possibly just forgo precip.
Ross Green Bench. Good comments. Nice site. With one-meter brush, this is halfway up to the thermometer. If cut back, would have to maintain this way indefinitely, probably cut 1-2 times a year.
Twelvemile Creek. Good comments.
West Fork Tana Knob. Good comments. Mtns in one direction, but seems open enough in all other directions. "At treeline": a nice sensitive elevation. If climate changes treeline would also probably change. Good to be right at that special elevation.

Tana River Airstrip. Good comments. Take heed of the flood comments. We've paid close attention to this at all CRN sites, where major river rechannelization could change valley microclimates. A warmer climate could also change the flood regime.

Summary of Tana River area

We liked Tana River Airstrip paired with Tana Glacier Seismic (low versus high, protected versus open; vegetated versus glacial). Also, seismic locale gives more than one reason to visit. Another pair we liked was West Fork Tana Knob paired with Ross Green Bench. Twelvemile Creek also looked good as a Ross Green substitute. Iceberg Lake and Bench we were a little less enthused about, being kind of rocky, not too sure of their precip characteristics.

Chisana area

Euchre Mountain. Good comments. Hobos: ok for local studies, but wouldn't consider them for one moment for a long term climate record.
Chicken Airstrip. Good comments.
Gold Hill. Good comments. Nice location. A bit high, but as pointed out, could pair well.
California Creek. Good comments. What a great spot.
Beaver Lake. Good comments. Also nice exposure.
Chisana area summary

The Chicken Airstrip seemed like a decent site, and it's an airstrip, nearly certain to get visitors and attention, mostly of the good kind. This could be paired with California
Creek (slight preference for this) or with Gold Hill.
Nothing that wrong with Beaver Creek, however, either.
Euchre Mountain, of all these sites, seemed a little high, and maybe just a bit too much exposure.

Upper Chitna Glacier

Chitina Glacier Seismic. Good comments. Nice site. Maybe consider no precip gage.
Notch Airstrip. Good comments. Flooding potential there, but was downplayed.
Huberts Cabin. Good comments. A lot of trees of varied size close by. As long as they were cleared, ok.
Bernard Glacier. Good comments. Bison??? They like to scratch themselves. Might put up a sturdy rail fence.

Upper Chitna Glacier area summary

For a lower site, slight preference for Barnard Glacier location, then not far behind, Notch Airstrip.

For a higher site, Chitna Seismic seemed like a good choice. Of all the upper Chitna sites, this had slightly better vibrations. Plus, seismic sites have more than one reason to be visited and to receive attention, and most geologists can probably be trusted to identify obvious weather station problems if they glance that direction.

Tebay area.

Tebay Falls Creek. Good comments. Lovely spot.
Tebay Cabin. Good comments. Nice spot for precip, a little less so for temp.

Tebay area summary

Some preference for Tebay Falls Creek site.

Cheshnina area

Cheshnina. Good comments. Agree about precip.
Long Glacier. Good comments. Same issues as other near-glacier settings. Nice exposure for everything but precip.

Cheshnina area summary

We both agreed on the Long Glacier site as being just a little more preferable.
Box Score:

Among the three alternate boxes, we favored the upper Chitna area. Reason was this box is farthest from existing or planned data sources, the most data sparse area, appeared to be nothing in Kluane. There are existing data sources within 10-20 miles of the Cooper River. As for the other two boxes, we decided that the Cheshnina area was more unlike the other five boxes (likely closest to Chisana) and was more of a “dry interior” type than the other sites. The Tebay box would be a good spot for a precip measurement, and the Coast range is not that well sampled and could always use more, but the Tana sites are also somewhat coastal. So we decided Chitna, Cheshnina, Tebay. The French judge gave the high score to the Canadian ice itself, and the Ukrainian judge liked the blueberries.

Yukon Charley Rivers National Preserve

Three Fingers. Good comments. Aufeis? Hunters (1 per hundred) like to practice on weather stations.

Crescent Creek. Good comments.
Gelvins Airstrip. Good comments. This site is down in the bottom, would have some locally variable effects, heavily treed, with openings, could burn. Suggest leave this site, let somebody else put up a cheap weather station for the floaters, and place more consideration on the other two sites.
Beverly Bench. Good comments. Like the exposure. Not much comment on how magic 144 degrees is. Not sure what is meant by a "good hobo datalogger site". For reference stations, I'd use high quality stuff exclusively. Hobos are ok as temporary supplements.
Coal Creek. Good comments. Kelly was not too enthused. Not a natural site. Cold pocket. Flooding could be an issue, historic district issues might necessitate relocation at a future date, need to keep well away from all artificial influences, probably best kept off cobble. This area could become popular at some point, though not quite Gatlinburg. Dave and Greg, on the other hand, liked the big open area, thought that the frequent visitation would help keep the station maintained, suggested a site off to the side of the open area, and thought this would be a good choice. The site could make a good contrast to the nearby RAWS site that is 1000 ft higher, during inversions.

Yukon Charley area summary

We seemed to like Beverly Bench a little more than the others. Nice spot, as well as not much other data around. Then, Three Fingers and/or close choice Crescent Creek. Then Coal Creek Airstrip. We all thought the Gelvins airstrip was not as good as the others, with local influences more of a possibility, flooding, wondering why those open patches were open, more susceptible to burning.

Denali Park and Preserve

West Fork Yentna. Good comments. No other stations in this area. Yes, it'd be more expensive. Needs a blueberry-cam.
Tokositna Valley. Good comments. High enough above floods. Year round snotel precip makes this attractive.
Eielson Visitor Center. Good comments. "Design includes climate monitoring station": does that mean a separate station from this one? If so, might put it elsewhere. The visitor center here deserves a really good high quality station. Lots of interest in this site. Keep well away from any possible expansion over the next 50 years, new parking lots, buildings, etc. For this one, I'd consider redundancy, especially in precip measurements. Really do not want any gaps in a visitor station record.
Kantishna. Good comments. Snow course upgrade to year round Snotel is attractive. Except for precip, any redundancy with the RAWS site at Wonder Lake? Most RAWS sites in cold climates are worthless for precipitation, except in summer when consistently above freezing. Redundancy can be good: quality

control, backup data, etc. Good mixed exposure. Would not want to accidentally promote the relocation of Wonder Lake RAWS either (because “too close”).

Denali area summary

No clear preferences, and we thought the Denali people probably already had ideas about what locations were important and what they might like to get from them, and figured they’d like to see them all funded. Just from a dot-on-a-map sense, the West Fork Yentna area seemed in greatest need of a data point.

Practical issue

No station installer has yet died from mosquitoes at a wind-blasted location.