IDENTIFICATION OF POTENTIAL NEW OBSERVATIONS SITES

Excerpts from: ***Climate Monitoring for Southwester Alaska National Parks: Network Design and Site Selection***

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Considerations:

There are several criteria we would like to utilize in deciding where to deploy new stations:

• Where are the existing stations?
• Where have data been gathered in the past (discontinued locations)?
• Where would a new station fill a gap about the basic long-term climatic averages for an area of interest?
• Where would a new station fill a gap in how climate behaves in time?
• As a special case of behavior in time, what locations might be expected to show a more sensitive response to climate change?
• How do the answers to the above questions depend on the climate element? Are the answers the same for precipitation, temperature, wind, snowfall, humidity, etc.?
• What unique information is provided? "Redundancy is bad."
• Because observing systems always have gaps and lose data, what nearby info is available to estimate for missing observations? "Redundancy is good."
• How would logistics and maintenance affect these choices?

Two main purposes for climate observations are to establish the long-term averages for given locations, and to track the variations in climate. Broadly speaking, these address topics of absolute and relative climate behavior. Once the former have been "established" (a job that is never really finished, because the long-term averages continue to vary in time), the temporal variability quickly becomes the item of most interest.

In popular usage, we often encounter the notion that a site is "representative" of another site if it receives the same annual precipitation, or has the same annual temperature, or if some other element-specific long-term average has a similar value. This notion of what is "representative" of another place does have a certain limited validity, but there are other aspects of "representativeness" that need to be considered.

A good monitoring site can also be said to be "representative" if the climate records from that site show sufficiently strong temporal correlation measures, such as the Pearson correlation coefficient, r, with a large number of locations over a sufficiently large area. If station A receives 20 cm a year, and station B receives 200 cm a year, these are obviously quite different precipitation climates. However, if their monthly, seasonal, or annual correlations are high (say, 0.80 or higher for a particular time scale) one can be used as a surrogate to estimate the values at the other if a particular month, season, or year is missing. That is, a wet or dry month at one site is also a wet or dry month (relative to its own mean) at the comparison station. Note that high correlations on one time scale do not automatically imply good correlations on other time scales.

Likewise, two stations with similar mean climates (for example, similar annual precipitation) might not co-vary in close synchrony (for example, coastal versus interior.) This might be looked at as a matter of climate "affiliation" of a particular location.

Thus, the "representativeness" of a site can refer either to the basic climatic averages for a given duration (or time window within the annual cycle), or to the extent to which it co-varies in time with respect to all surrounding locations. One site can be representative of another in the first sense but not the second, or vice versa, or neither, or both – all combinations are possible.

If two sites are perfectly correlated (r = 1.00) then in a sense they are redundant. However, redundancy has value, because all sites will experience missing data, especially with automated equipment in rugged environments and harsh climates, where outages and other problems can be nearly guaranteed. In many cases those outages are caused by the weather, particularly by unusual weather, the very conditions we most wish to learn about. Methods to fill in those values will need nearby proxy information from this or other networks. Thus, redundancy is a virtue rather than a vice.

Factors to consider in site selection:

Equipment and exposure factors

A. The measurement suite. All sites should measure temperature, humidity, wind, solar radiation, and snow depth. Precipitation is much more difficult, but probably should be attempted, with the understanding that in winter the measurements may be of limited or no value unless an all-weather gage has been installed. Even if an all-weather gage has been installed, it is a good idea to have a second gage present that operates on a different principle. For example, a fluid-based system like the one that Snotel uses, in concert with a higher resolution tipping bucket gage for summertime. Without heating, a tipping bucket gage is usually of use only when temperature is above freezing, and further, when temperature has not been below freezing for some time, so that accumulated ice and snow is not melting and being recorded as present precipitation. Gage undercatch is a significant issue in snowy climates, so shielding should be considered for all gages designed to work over the winter months. It is very important to note the presence or absence of shielding, and the type of shielding, and the dates of installation or removal.

B. Overall exposure. The ideal general all-purpose site has gentle slopes, is open to the sun and the wind, has a natural vegetative cover (whatever pertains to the area in consideration), avoids strong local (5-200 meter) influences, and represents a reasonable compromise among all climate elements. The best temperature sites are not the best precipitation sites, and the same is true for other elements. Steep topography in the immediate vicinity should be avoided, unless settings where precipitation is affected by steep topography are being deliberately sought, or a mountaintop or ridge line is the desired location. The potential for disturbance should be considered: fire and flood risk, earth movement, wind borne debris, volcanic deposits or lahars, vandalism, animal tampering, and general human encroachment are all factors.

C. Elevation. Mountain climates do not vary in time in exactly the same manner as adjoining valley climates do. This is more true the greater the degree to which temperature inversions are present, and to which winds during precipitation rise up the slopes at the same angle. There is considerable concern that mountain climates will be (or already are) changing, and perhaps changing differently than lowland climates. This has direct and indirect consequences for plant and animal life in the more extreme zones. Glacier behavior is an important indicator of climate variability, but glaciers can be quite sensitive to subtle and small shifts in climate. For these reasons, each park with significant mountain and frozen water presence should try to have one or two stations at higher elevations. Elevations of special significance are those that are near the mean rain/snow line for winter, near the tree line, and near the mean annual freezing level (these may not all be quite the same). Because the lapse rate in heavy precipitation climates during their main precipitation seasons will often be near moist adiabatic, measurements at one elevation may be extrapolated to nearby elevations. In drier climates, and in the low-sun seasons, temperature and to a lesser extent wind, will show a variety of elevation profiles.

D. Transects. The concept of observing transects that span climatic gradients is a good one. Transects need not, and by dint of topographic constraints probably cannot, be straight lines, but the closer that a line can be approximated the better. The main point is to systematically sample the key points of a behavioral transition without deviating too radically from linearity.

E. Other topographic considerations. Local topography can influence wind (channeling, glacier winds, upslope/downslope, etc), precipitation (orographic enhancement, downslope evaporation, catch efficiency, etc), and temperature (frost pockets, hilltops, aspect, mixing or decoupling from the overlying atmosphere, bowls, radiative effects, etc), to different degrees at different scales. In general, for measurements to be areally representative, it is better to avoid these local effects, to the extent that they can be identified before station deployment (once deployed, it's a good idea not to move a station). The primary purpose of a climate monitoring network should be to serve as an infrastructure in the form of a set of benchmark stations, to which other stations can be compared. Sometimes, however, it is just these very local phenomena that we want to capture. Living organisms, especially plants, are affected by their immediate environment, whether it is representative of some larger setting or not. Specific measurements of limited scope and duration made for these purposes can then be tied to the main benchmarks. This experience is useful also in guiding how complex the benchmark monitoring needs to be, in order to capture which phenomena at which space and time scales.

Sites that drain (cold air) well are generally better than sites that allow cold air to pool. Slightly sloped (1 degree is fine) planes or small benches, from tens to hundreds of feet above streams, are often good locations. Furthermore these often tend to be out of the path of hazards (like floods), and to have rocky outcroppings where vegetation management will not be a major concern. Benches or wide spots on the rise between two forks of a river system are often the only flat areas, and sometimes jut out to give good exposure for winds from more azimuths.