Emerging Technologies and Development of Automatic Weather Stations and National Networks

C. Bruce Baker
National Climatic Data Center
151 Patton Avenue
Asheville, NC 28801, USA
Bruce.Baker@noaa.gov

Abstract
There have been considerable advances in technology for the in-situ measurement of atmospheric parameters in the last 5 years. In addition, with the emphasis on understanding climate change at national and international levels some nations are choosing to use new technology. It is important to understand the methodologies that are needed to incorporate new technology into a new or existing network. For example; Is it possible to have high quality measurements and minimize the cost to make it affordable? There needs to be standardization of algorithms, QC/QA, testbed evaluation of the system, siting standards, a maintenance strategy, configuration management and a transition strategy for integrating the new systems with an exisiting network. All of these components are an integral part of the measurement system and network design. What is the best way to carry these concepts from the national to international?? This paper will provide an overview of these concepts and some examples.

1. INTRODUCTION

The first and foremost objective of a network should be to provide quality measurements free of time-dependent biases, provide traceable calibrations and minimize latency of the transmission time.

Any new program that is addressing a new network should have an initial design, testing, and evaluation phase for selecting instruments and an integrated measurement platform. It is essential to understand the performance of the sensors in field test programs and different climate regimes in order to meet the design criteria of the functional requirements, and also, where possible, to periodically compare the sensors with others that measure the same parameters. The analysis of these data will contribute to the final design and provide information on transfer functions between the new and legacy systems.

2. DEMAND FOR A NEW NETWORK

In most countries the organizations involved with or have the responsibility for in-situ observing systems continually have to address a number of issues.

1. What is the usefulness of the existing observing system or observations?
2. What is the Capacity and demand for the existing network and data?
3 Is there the potential for Dual use??
4. Can the current State of models efficiently use the new data both temporally and spatially??
5 What is the perceived impact of the resulting data??

Critical elements include having a continual dialogue between those who make observations and those who use them. These forums or discussions provide the framework for existing requirements and future requirements as the network evolves through time. There also needs to be a continuing assessment of the health of the observing system, including near-real time observing system. This assesment will determine the performance of the network and aid in determining long term mainteance costs.. The spatial distribution and temporal resolution can predetermine the usefulness for assessing local and regional climate change, synoptic weather events and extreme weather . The more basic question relies on an assessment of the existing network's utility in it's present state and can it be modified to meet future needs.

2. NETWORK DESIGN AND IMPLEMENTATION

Practical considerations that can impact the design of the system and network need to include:

1. What will be the cost to upgrade an existing network as opposed creating a new one with new technology??
2, What will the operating costs be in the out years??
3. Does the network design have well defined measurement principles??
4. Does the design of the network allow for extensibility of observing system with respect to later improvements??
5. What is the degree of expertise required to deliver observations??

These questions will develop the framework necessary to plan for assessing and testing new technology, costs of the network, and design of the system. The new technology includes a re-evaluation of communications, improvments in instrumentation, and new techniques in quality control. A real assessment of the costs of equipment, installation, metadata and maintenance are critical in the intial planning stages of any new network. The areas that are most frequently underestimated are the cost for gathering and maintaining metadata and long term maintenance.

There are other considerations in the design of the network that should be addressed in the implementation plan. These include:

1. The ability to adapt and assess new technologies and minmize the cost of adding new parameters.
2. Adequate support should be available for changes to instrumentation.
3. Contingency plans that address fluctuating funding cycles and personnel changes.
4. Ensuring that all observations are utilized in real time and operational products are developed to help in the assessment and quality control.

One aspect of a network program that is essential in the outyears is the flexibility of adding new instruments and assessing new technology. There is an investment in research and development in the life cycle of the program but that investment ensures that there is the potential for reduced costs over the lifetime of the network as new technology is developed. In addition, the research and development allows for engineering improvments to the existing instrumentation and provides for an understanding of the biases, if any, introduced with the substitution of instrumentation. The operational aspect of the program should include contingency plans for fluctuating funding and development of the ingest, QA/QC of the data and end user products.

3. STRATEGIC CRITERIA

The strategic criteria adresses practical considerations of system execution and performance. What kind of existing infrastructure is there to support data stewardship activities? What mechanisms are there in place to transition from research to operations? Are there opportunities for cost sharing and partnerships? What are the capacity building opportunities? What is the potential for synergistic use for multiple societal drivers? How will the network provide easy and convenient access to data? These questions are essential to a successful program and the answers or solutions will be unique to each national program.

4. APPLIED SCIENCE AND RESEARCH

Applied science and research should be an integral part of any national network program. One facet ensures the data quality, data homogeneity, and guides the spatial and temporal sampling strategies. Data quality and homgeneity is an ongoing effort that relies on the metadata and receipt of the data to qualify their usefulness, timeliness, and is the precurser to delivering products to the end user. Studies that examine the spatial and temporal sampling are driven by costs (How many stations will be in the network?), and the end user needs. The end user needs will drive the requirements and the design. For example, climate monitoring spatial and temporal needs will be much different than the needs for real time monitoring of the weather or extreme events. Support decisions regarding system design, verification, validation, and engineering are also an integral part of applied science and resaerch. The design, verification of calibrations, validation of the data and engineering documentation lays the foundation for data quality. This aspect of the program also ensures transfer functions between sensors measuring "like" parameters are developed and validated based on accepted scientific methods, and are made available to researchers in a timely manner. An ongoing reserach effort needs to address the routine and continuous evaluation of new (replacement) sensors and techniques in support of the timely replacement of sensors to meet the requirements of of the end user and long range plans of the network.

5. LONG RANGE OBJECTIVES OF APPLIED SCIENCE AND RESEARCH

It is important to have an ongoing applied science and resaerch program to collect, analyze, and provide intercomparison data and develop the transfer functions between sensors measuring same parameters. Long term intercomparison testing and evaluation of new instruments and techniques is necessary for the infusion of new technology The collection and evaluation of data and information on instrument performance will support decisions regarding system design, engineering, verification, and validation. The long term applied science and research will support initial suitability/feasibility/acceptability analyses regarding data quality, sensor uncertainty, sensor suitability, and bias errors. It also necessary to identify and support the evaluation of instruments that measure other parameters (i.e., soil temperature, soil moisture, etc.) that may become part of the network. Ultimately this part of the program should collect and provide data and information that contribute to programmatic budget and engineering design and test plans and objectives, such as sensor/equipment performance, sensor/equipment verification/validation, and maintenance costs, including an assessment of repair/replacement costs that will be incurred over the expected lifetime of various components of the system.

6. CONCLUSION

It is important that almost all planning is directed at the strategic criteria, demand criteria, and implementation criteria for new and existing networks. Figure 1 below illustrates the connections between the different program elements discussed above. This is only one model for the overall planning, design and implementation of a national observing network but can provide guidance on the important considerations needed to incorporate new and old observing systems into an integrated observing system. The most critical aspect is the initial funding phase for the network and the most difficult issue is the long term funding for IT infrastructure, program management, continual updating of the metadata and long term maintenance.

Figure 1. Schematic of the key components for a National network.