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A RICH HARVEST OF CLIMATE INFORMATION FROM THE NATIONAL WEATHER SERVICE COOPERATIVE OBSERVER PROGRAM

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1. A BRIEF INTRODUCTION TO CLIMATOLOGICAL DATA

Data – numerical and descriptive narrative reports of weather conditions from known locations recorded at specific time increments (hourly, daily, etc.) provide the foundation for the field of applied climatology. Through our nation's history, there have been many excellent sources of weather data that have, over time, become useful, if not essential, for climate description, research and application (Table 1).

Table 1.
Examples of government sponsored long-term weather station networks and observing systems.

Forts	18th Century
U.S. Signal Service telegraphic stations	1871 – 1890
First Order surface weather stations (major cities)	~1880s – recent
Aviation Weather Stations	1930s – present
Military bases	1940s – present
Radar	late 1950s – present
Satellite	1960s – present
Upper Air	1940s – present

In addition to these traditional sources of weather data, a myriad of special programs have provided other special data such as solar radiation, precipitation chemistry, soil temperatures and soil moisture. Together, these networks have all produced and many continue to produce data of considerable worth for applied climatology while also meeting a variety of immediate needs such as weather forecasting and other special purposes for which they were designed and operated

In addition to these government-supported primary data sources, there is a long U.S. tradition of volunteer weather observing. This dates back to the original Smithsonian Network of the early 1800s. Later, with the encouragement of the U.S. Signal Services, State Weather Services were established in the 1870s and 1880s. These networks pioneered the concept of utilizing volunteers on a state and local level to collect simple but very useful data systematically, uniformly and at a low cost to help document local differences in climate. With the creation of the U.S. Weather Bureau in 1890, these state networks all came under the jurisdiction of one federal program which launched one of the most successful long-term low cost programs in the history of the U.S. (this author's opinion). This network of "Substations" is now known as the National Weather Observer Cooperative Observer Network. With thousand of stations nationally some of them with over 110 years of data from the same locations, this network became a great favorite of climatologists studying and describing spatial patterns and temporal variations in climate. We have reaped the benefits of this network for many years (National Research Council, 1998).

2. EXTRACTING VALUABLE INFORMATION FROM SIMPLE DATA

Fascinating articles on many aspects of U.S. climate can be found back into the late 1800s, many of them based on data from the early Cooperative Network. A series of climate atlases and special U.S. Weather Bureau reports were assembled and published early in the 1900s when data records first reached sufficient length to provide a stable representation of spatial and temporal differences in climatic conditions across the U.S. Many articles in *Monthly Weather Review* published from the late 1800s through the mid 1900s used data from the Cooperative Program. This work eventually led to the landmark publication, "Climate and Man" (USDA, 1941) which summarized in about 1250 pages much of what had been learned about our climate during the period of history where we were predominantly an agrarian society. This publication also marked the end of the 50-year era

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where weather and climate data collection, analysis and forecasting were the responsibilities of the U.S. Dept. of Agriculture. The transition to the Dept. of Commerce around 1941 marked a significant turning point for our country and a change for climatology and climate applications as well. Priorities for weather and climate information shifted increasingly to technology, transportation and commerce although agriculture continued to hold an important place. Users needed data faster and needed a variety of climate information beyond basic temperature and precipitation. Still through this major transition, the workhorse volunteer network of the National Weather Service held its place as a source of basic but valuable data on temperature and precipitation with sufficient local detail to capture many of the local climate features that are so important.

Along the way, there have been several climatologists who have been particularly successful and creative in harvesting valuable information from this network of cooperative stations. The career contributions of Stanley A. Changnon (see picture below) at the Illinois State Water Survey have demonstrated clearly just how much information can be gleaned from a simple but high spatial density volunteer network.

Picture of Stan Changnon taken from http://mrcc.sws.uiuc.edu/html/bio/StanleyChangnon.htm

3. STAN CHANGNON'S CONTRIBUTIONS

Stan Changnon's experiences as a data analyst at the Illinois State Water Survey back in the 1950s, helped shape and motivate an entire career. His first major projects as a young scientist involved processing and digitizing the older (pre-1948) "Substation Reports" for Illinois, in collaboration with what is now known as the NOAA National Climatic Data Center. He saw first hand the care and commitment that so many volunteers had made to provide quality long-term observations of the climatic elements affecting their lives and livelihoods. Through these experiences, he came to appreciate the vast resource of climate information contained in those humble records. Many other climatologists, myself included, whose first work experiences in climatology involved working with "Substation Reports," have also gained this same deep respect for the Cooperative Program. Not only are the numerical data important, but the comments made and recorded by hundreds of volunteers over the course of many decades have brought out both the physical side of climatology and also its social and economic implications.

Changnon's extraordinary career in applied climatology has come about not so much by employing new measurements and new technologies (although there has been plenty of that, too), but more so by harvesting the information that many might otherwise have overlooked. The information stored in old government data documents and hidden in remarks and supplemental data on aging paper forms recorded by citizens from all walks of live, some living and some long deceased – that is where Stan first struck gold some 50 years ago. He, and all of the rest of us with common interests in climatology, have been enjoying a rich harvest of climate information ever since.

Stan's accomplishments and contributions to applied climatology go far beyond just data. His lifelong connection to the land and people of Illinois, his personal fascination with and appreciation for the weather and climate of the Midwest, his full awareness of how climate affects so much of what we do, his hard work, his contagious enthusiasm for what he does, and his gifted abilities to extract useful relevant information from stacks of seemingly senseless numbers have worked together to build a remarkable career. His findings have always interested people in many walks of life and not just other climatologists. He routinely published his findings in local newspapers as well as professional scientific journals. His personal skill in helping politicians, planners, policymakers, and those who lead the direction of science and policy through the distribution of research funding, to somehow "see the light" of the importance and relevance of applied climatology, has helped our entire field. Persistence has had its benefits, too. Decades of analyzing data and decades of educating the people of Illinois and the policy makers in Washington DC, have worked together to raise applied climatology to a proud and prominent place.

4. SUMMARY OF CHANGNON'S USE OF NWS "SUBSTATION DATA"

The following is an inventory of some of Stan Changnon's prominent work that utilized data from the National Weather Service Cooperative Observer Network. The studies of convective storms, water resources, drought, severe and hazardous weather (hail, heavy rains and floods, high winds, snow, and ice), planned and inadvertent weather modification and the effects of urbanization on local and regional climate have all advanced due substantially to the data resources from the Cooperative Network. Basic climate description and the documentation of long-term variations, trends and extremes on a local county and community scale, have only been possible due to the continued existence and operation of the Cooperative Program.

1957–Thunderstorm-precipitation relations in Illinois. SWS Report Investigation 34.

1958–Climate conditions, water resources and climate, Section 1 of Atlas of Illinois Resources.

1959--Hail climatology of Illinois. SWS Report of Investigation. 38 (Huff co-author).

1962–Areal frequencies of hail and thunderstorms in Illinois. Mon Wea Rev #90

1963–Drought Climatology of Illinois. SWS Bulletin 46 (Huff co-author)

1964–Relation between precipitation deficits and low streamflows. Geophys Res. #59.

1966–Effect of Lake Michigan on severe weather. J Great Lakes Res. #15

1967–Method of evaluating substation records of hail and thunderstorms. Mon Wea Rev #15

1968–The LaPorte anomaly–fact or fiction? Bull Amer Meteor Soc #49.

1969–A climatological-technological method for estimating irrigation water requirements to maximize yields. J Soil & Water Cons #24.

1973–Precipitation modification by major urban areas. Bull Amer Meteor Soc #54.

1975–Precipitation increases in the hills of southern Illinois. Mon Wea Rev #103.

1977–Scales of hail. J Appl Meteor. #16.

1978–Winter storms and record breaking winter in Illinois. Weatherwise #31.

1980–Review of Illinois summer rainfall conditions. SWS Bulletin 64.

1980–Climatology of high damaging winds in Illinois. SWS Rept. Invest #95.

1981–Evaluation of Illinois' weather modification projects. SWS Circular 148.

1981–Midwestern cloud, sunshine and temperature trends since 1901: possible evidence of jet contrail effects. J Appl Meteor #20.

1983–Record dust storms in Illinois: Causes and implications. J. Soil & Water Cons #38.

1983–Trends in floods and related conditions in Illinois. Climate Change #5.

1984–Climate fluctuations in Illinois. SWS Bull #68.

1987–Temporal changes in design rainfall frequencies in Illinois. Climate Change #10.

1988–Relations between precipitation and shallow groundwater in Illinois. J Climate #1 (Huff and Hsu, co-authors).

1989–Measuring drought impacts: the Illinois case. Water Res Bull #25 (Easterling, co-author).

1990–Use of climatological data in weather insurance. J Climate #3 (Joyce Changnon, co-author).

1991–Potential effects of changed climate on rainfall frequencies in the Midwest. Water Res Bull #27 (Huff co-author).

1993–Temporal and spatial characteristics of heavy precipitation events in Midwest. Mon Wea Rev #75.

1994–Climatic aspects of the 1993 Mississippi River basin flood. Bull Amer Meteor Soc #75.

1996–Detection of changes in streamflows and floods resulting from climate fluctuations and land use changes. Climate Change #32.

1997–An investigation of historical temperature and precipitation data at climate benchmark stations in Illinois. SWS Circular 184 (Kunkel and Winstanley, co-authors).

1999–Data and approaches for determining hail risk in the United States. J Appl Meteor #38.

2000–Longterm fluctuations in hail incidences in the U.S. J Climate #13 (D.Changnon, co-author).

2001–Long-term fluctuations in thunderstorm activity in the U.S. Climate Change #50 (D.Changnon, co-author).

2001–Thunderstorm rainfall in the conterminous U.S. Bull Amer Meteor Soc #82.

2001–Thunderstorms across the nation: An atlas of storms, hail, and their damages. Climatologist Pub. (Changnon, co-author).

2003–Temporal and spatial variations in freezing rain in the U.S. J Appl Meteor #42 (Karl, co-author).

2003–Urban modification of freezing rain events. J Appl Meteor. #42 .

2003 or 2004—Climate atlas of Illinois. SWS publication (in press).

5. OTHER IMPORTANT CONTRIBUTIONS RESULTING FROM THE COOPERATIVE OBSERVER NETWORK.

While Changnon has been a moving force in applied climatology, many others have also been utilizing the data resources of the Cooperative Observer Program to make huge contributions applied climatology. More than ever, business and commerce, construction and engineering, agriculture and energy, planning and resource management and many other activities are relying on climate information to guide their operations and planning.

The following list is only a small sample of the types of research and climate information that have been derived from data from the Cooperative Network by other climatologists during the period of time spanning the career of Stan Changnon.

–Rainfall Frequency Analysis (NWS Technical Paper 40 and the NOAA Precipitation Frequency Atlas for the Western U.S. as well as more recent updates)

–Design Temperatures for American Society of Heating Refrigerating and Air-Conditioning Engineers (ASHRAE).

–Climate Atlases

- Climate Atlas of the U.S. (1968)
- NCDC Digital Climate Atlas, 1961-1990 (2002)

–Growing season and plant hardiness zone maps.

–Snow and ice applications

- Snowfall and snow cover maps and probabilities
- Snow Load maps
- Icing probabilities and ice loads

–State and national drought monitoring.

–Decision tools for agriculture and natural resources (daily and monthly means, extremes and probabilities).

–Trends, variations and extremes in assorted elements of U.S. climate.

While all very important, these are just a few important examples of the uses of climate information derived from simple data collected over long periods of time. No one could have known 100 years ago how valuable cooperative data would become, but we should all be thankful that the system of basic climate observations was preserved.

6. THE FUTURE OF THE COOPERATIVE PROGRAM

The future of the NWS Cooperative Program is in doubt. While few who know the network challenge its importance, the reality is that federal support has been declining. As the lowest tech component of a high-tech modernized and downsized National Weather Service, the program seems to be one of the lowest priorities of the NWS. Fortunately, the program continues to function, data continue to flow and demand for quality data continues to grow. Although somewhat smaller than in it's heyday in the 1950s–1970s, there are still thousands of cooperative stations nationally monitoring the climate of the U.S. This precious resource for applied climatology has not yet fallen prey to budget cuts and reorganizations. In fact, due to gradual improvements in timely data communication, the utilization of Cooperative Network data is at an all-time high.

Competition for resources will continue to stiffen, so it is our obligation as climatologists and citizens to point out the importance of the Cooperative Network. Stan had lead the way in the past and we must continue to do so now.

Why is the Cooperative Network so important? Let me tell you. The Cooperative Program is simply the best source of precipitation data nationally and the sole source of systematic observations of snowfall and snow depth. Other networks such as Automated Surface Observing System (ASOS), which report current weather conditions at hundreds of locations across the country in real time, do not currently have the capability to measure precipitation accurately over a range of weather conditions. At this time, there is no automated way of measuring snowfall employed at NWS stations, and the automation of precipitation has introduced significant problems and biases (McKee et al, 2000). Also, no other climate observing network has the history and data continuity that the Cooperative Program does.

Can the Cooperative Network be preserved into the future so that the next generation of applied climatologists can also enjoy a rich harvest of climate information? For at least ten years the National Weather Service has been seeking support to "Modernize" the program. Its traditional low-tech nature seems to continually doom it to a low priority. So far, modernization efforts have failed or only succeeded marginally, although some improvements in data communications and data availability have occurred.

As of late 2003, the NWS is finally taking a more aggressive approach to propel this remarkably long-lived network into the 21st Century. The currently proposed view of a modernized Cooperative Program, expressed in a recent NOAA draft modernization plan, describes a "National Cooperative Mesonet" patterned after the very successful Oklahoma Mesonet. This draft modernization plan currently being circulated for final review calls for upgrading many stations to real-time communications capabilities and operating in near total automated mode. The traditional cooperative station is not excluded however, and the overall goal is to improve quantity, accuracy and timeliness of the data.

This is an admirable plan that nearly all climatologist support in concept. But before we take this step it may be worthwhile to look again at what Changnon and others have seen, done and learned. Clearly the most important data from the Cooperative Network are the daily temperatures, precipitation, snowfall and the frequency of certain hazardous events such as hail and freezing rain. Full automation will, at a price, greatly improve the timeliness of data and is very likely to improve some of the long-nagging problems of the network such as time of observation biases and instrument exposure deficiencies. Improvements in these areas are much needed and will increase the user base and user confidence significantly. This is very important to be successful in getting broad-based support for the modernization.

But much of what Changnon and others have accomplished is due to accurate and consistent measurements of rainfall and snow, and useful information on the frequency of other events that are difficult to measure automatically such as hail and freezing rain. Automating the measurement of precipitation is not easy and not cheap. There is the potential for modernization to introduce biases or inaccuracies such as occurred with the deployment of ASOS in the 1990s. It has taken the NWS close to a decade to find a replacement gauge for the Heated Tipping Bucket gauge that is a part of the Automated Surface Observing System instrument set. This new all-weather precipitation should greatly improve the measurement of frozen precipitation in cold climates of the U.S., but it is expensive and may not be practical for thousands of Cooperative stations. Are there affordable options available that will allow the automation of precipitation data without loosing the reliability and consistency of daily, monthly and annual accumulation that we are so accustomed to?

The Cooperative Program has helped our nation address countless questions because it provides consistent year-round measurements of total accumulated precipitation. As we move to "***modernize***" the coop program, I simply ask that we proceed with wisdom knowing that what matters most when it comes to climatology is what lasts longest. We must make sure that we preserve the best quality and highest spatial resolution of precipitation data – the most difficult of the common climate elements to automate successfully. Also, we must keep the eyes and other senses of the human observer integrated into the observing system. Much of what Stan Changnon has gleaned from the co-op data were elements not so easily measured – frequency of significant events like thunder, hail, high winds, snowstorms and freezing rain. Some of these elements can and should be automated, but some cannot. It is worth making sure we don't inadvertently throw out precious things just so we can get something new.

7. SUMMARY AND CONCLUSION

Stan Changnon has had an impact on applied climatology that extends beyond his home state of Illinois and surpasses in significance his legendary publication record. Perhaps his most important accomplishment is the stream of younger climatologist that he has inspired and encouraged. Applied climatology – a topic once thought to be a limited if not totally boring career field – is now much esteemed. Furthermore, he has shown that humble and simple data, that which has been provided by the National Weather Service Cooperative Observer Network for nearly 115 years, is "really good stuff" well worth preserving and protecting for generations to come.

Climatology, as much as any science can be, is a science of the people to benefit and be enjoyed by all people. Stan Changnon has long recognized that fact and so should we.

8. REFERENCES

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