USGS

WATER RESOURCES RESEARCH GRANT PROPOSAL

Title: Compatibility Analyses of Various Snow Measurements/Data in Alaska

Focus Categories: CP, HYDROL

Keywords: 223, 208, 55

Duration: 1 March 2000 to 28 February 2001

FY 00 Federal Funding: $20,452

FY 00 Non-Federal Funding: $16,548

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Summary

Snow is one of the key components in cold region hydrology and climate systems. It is also the most important variable in global change analyses, as change of snow will have a major impact on hydrology, climate and ecosystem of the Earth. Snow data (such as snowfall, snow depth, snow course, snow survey) have been widely used in climatic and hydrologic applications in Alaska. Proper utilization of these data in Alaska is extremely important and largely depends on the user's knowledge of the observational methods and data processing and archiving procedures.

The proposed research will directly address the problems of biases of gauge snowfall measurements and the compatibility of various snow data in Alaska. Based on the extensive research experiments, this work will define and evaluate the accuracy of snowfall measurements and snowcover observations carried out by different government organizations and university research programs. It will implement the appropriate bias corrections to the NWS snowfall data and conduct various consistency analyses on all available snow data. The goal of the proposed project is to define the compatibility of various snow measurements and to develop an integrated snow data information system for Alaska. The results of this project will be useful for studies of Arctic water resources, climate, hydrology, and ecosystem.

This proposal addresses an important water related research issue in Alaska. The required funding will be mainly used to support a full-time graduate research assistant (thesis degree) for one-year period.

Importance of snow observations/data

Snow is one of the key components in cold region hydrology and climate systems. It is also the most important variable in global change analyses, as change of snow will have a major impact on hydrology, climate and ecosystem of the Earth.

Long-term snow (i.e. snowfall and snowcover) data have been collected at observational networks and research watersheds in Alaska. These data have been quality-controlled and archived by various organizations. Snow data have been widely used in climatic and hydrologic applications in Alaska. Proper utilization of these data in Alaska is extremely important and largely depends on the user's knowledge of the observational methods and data processing and archiving procedures.

In order to improve our understanding of snow data quality in Alaska, this study will compile various snow data and examine their compatibility. The goal of this research is to develop a methodology/system for integrating different snow information/data in Alaska. The results of this project will be useful to cold region hydrology, water resources and climate analyses.

Snow measurements and data quality

The available snow data collected by government agencies and university research programs in Alaska are listed below. Brief descriptions of the observation methods and error sources are also provided.

- NWS snowfall data

Snowfall water equivalent is measured by a standard precipitation gauge at the NWS network and is needed to determine daily, monthly, and yearly total precipitation. It can also be used to estimate snow depth on the ground. NWS precipitation gauge undercatch of snowfall by up to 50-70% at high wind speeds has been reported (Black, 1954; Benson, 1983; Yang et al., 1998a). Correction for this bias has been conducted at selected locations in Alaska and resulted in significant increase of snowfall amount in windy locations (Yang et al., 1998a).

- NWS snow depth measurements

A ruler is used to measure the depth of snow at the NWS station network. Snow depth value can be used to estimate snow water equivalent. Errors in ruler measurements of snowfall depth mainly originate from poor siting and observers. The type and magnitude of the errors vary from storm to storm, from observer to observer, and from station to

station. Errors in snowfall water equivalent estimations can also result by assuming a mean snow density of 100Kg/m3.

- Wyoming gauge snowfall data

The Wyoming snow gauge system has been used at an observation network (over 25 station in mid 1980's) in Alaska by the Natural Resources Conservation Survey (NRCS), USDA. Wyoming fence reduces wind speed at the gauge level and significantly improves gauge catch efficiency of snowfall. Benson (1983) reported that Wyoming gauge system measured snowfall amounts were much higher in comparison to the NWS snowfall data (measured by a standard precipitation gauge).

- Snow course and SnowTel data

The NRCS/USDA conducts snow depth, density and water equivalent measurements at extensive networks in Alaska, using both manual snow survey and snow telemetry system. These data are quality-controlled and archived by NRCS, and they are useful for generate regional snow cover maps.

- Basin-wide snow survey and automatic snow depth measurements at research sites.

Basin-wide snow survey was conducted by WERC/UAF research projects at Imnavait Creek watershed (North Slope), Caribou Poker Creeks Research Watershed (CPCRW, Interior Alaska) and other research sites in Seward Peninsula (West Alaska). Automatic snow depth sensors were also installed at the some locations in the watersheds to monitor 6-hourly or daily snow depth change over the winter and melt seasons. These data are needed to quantify the water and energy balances of the watersheds.

Project objectives

Several factors contribute uncertainties in snow measurements/data in Alaska. These include: 1) precipitation gauge undercatch of snowfall by up to 50-70% at high wind conditions (Black 1954, Beson, 1983; Yang et al., 1998a,b); 2) uncertainty of Wyoming gauge system performance, the mean catch efficiency of the system being reported between 50 to 90% (Recher 1975; Sturges, 1986); 3) poor spatial representativeness of point snow data (Benson, 1983; Woo et al., 1983; Yang and Woo, 1999); 4) lack of compatibility analysis of various observation methods and snow data (Woo et al., 1983). In order to better understand the limitation of various types of snow data and make a better use of them for climate, water resources and hydrology applications, research efforts to define and quantify the errors and uncertainties are necessary. The objectives of this research project are:

- Quantify the accuracy of the NWS gauge measured snowfall data.
- Evaluate the performance of Wyoming gauge system in Alaska.
- Define the compatibility of various snow measuremnts/data.
- Develop a methodology/system for integrating different snow data.

Methods of analysis

The following analyses will be carried out in this research project:

a) Bias correction of NWS gauge snowfall measurements

Bias correction of NWS gauge snowfall data will be based on the methodology derived from the WMO gauge intercomparison (Goodison et al., 1998). A correction procedure (Yang et al., 1998b) will be applied to selected NWS stations on a daily basis. Daily records of air temperature, wind speed, gauge measured precipitation are needed for this analysis. Long-term data in difference climate regimes in Alaska will be used for this study and reliable daily snowfall data will be generated. A comparison between the measured and bias-corrected daily snowfall data will also be conducted in order to assess the impact of bias-correction on climate change/variation analysis.

b) Compatibility analysis of bias-corrected gauge data vs. Wyoming gauge observations.

Recently Yang et al (1999c), using the WMO gauge intercomparison data, has reported that the Wyoming gauge system performed as well as the WMO reference (a Russian double fence system) and it can measure snowfall accurately in windy and cold conditions. To evaluate the bias-correction procedures and results, comparison of bias-corrected snowfall data with the Wyoming gauge measurements will be carried out at selected locations in Alaska, such as Imnavait Creek watershed and CPCRW. Both daily data and seasonal total snowfall will be compared. This will enhance our ongoing efforts to better quantify the water and energy balances in the research basins (Kane et al., 1999; Hinzman et al., 1998; Zhang et al., 1999).

c) Comparison of Wyoming gauge data to snowcover information/data

Yang et al (1999c) found Wyoming gauge measurements were generally compatible to snowpack water equivalent measurements at selected locations in northern Alaska. This project will examine the compatibility of Wyoming gauge data to snow survey/snow course data at more locations and for longer time periods. The differences of wind and snow conditions between years will be analyzed to explain the inter-annual variability of the relation between snowfall and snowcover data in the basins. This analysis will help us better define winter snowcover mass balance over these watersheds.

d) Compatibility of NWS snow depth observation with NRCS snow survey and SnowTel data.

Snow depth data can be used to estimate the SWE by assigning a snow density to the measured snowpack or new snowfall. Snow density exhibits wide temporal and spatial variations, mainly due to variations of upper air temperature, wind speed and direction near the surface, the elapsed time of measurement of snowfall after the beginning or end of the storm, the siting of the measurement station and the observer bias. It is difficult to apply universal corrections to daily snow depth data. However, comparison of these

measurements will crosscheck the data, quantify the systematic differences (if they exist) and hopefully lead to an establishment of a linkage (transfer function) between these data obtained and archived by different organizations.

e) Integration of different snow data/information

Based on the results of bias-corrections of gauge snowfall data and the comparative analysis of snowfall data with snowcover information, an integrated snow data information system will be created for Alaska. This information system will include all snow data available in Alaska and a detailed description of methods of observations and data processing procedures. It will present methods and results of bias-correction and compatibility analyses among various snow measurements. It will also include the presentation and validation of the derived transfer functions among different snow data.

Expected results

This research project will develop practical procedures for integrating various snow data and create an integrated snow data information system for Alaska. The methodologies and data information system will contribute to the ongoing efforts of development of a reliable, consistent snow data base for hydrologic and climatic investigations in the Arctic regions, such as Yang (1999), Yang et al. (1999b,c), and the Arctic Precipitation Data Archive (APDA) Project (WCRP/ACSYS, 1997).
This project will produce bias-corrected daily snowfall data for Alaska. These data sets will be an important basis for grid-scale analysis of distributed hydrological models and for meso-scale modeling. The integration of regional snowfall and snowcover data will create a valuable database, which will be used to develop improved baseline snow climatologies for Alaska. These climatologies will serve as an important benchmark for climate change/variation analyses in Alaska.
This study will also develop gridded snowfall and snowcover database and maps for selected regions and watersheds in Alaska. These products will be useful for studies of Arctic water balance, validation of atmospheric model simulations, and for calibration of remote sensing algorithms in the Arctic regions.

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