P 3.4 DYNAMIC CLIMATOLOGY – A TOOL FOR ASSESSING CLOUD SEEDING OPERATIONS IN WATER RESOURCE MANAGEMENT

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1. INTRODUCTION

Various government and private entities have been applying precipitation-enhancing (PE) weather modification techniques in the Colorado Rockies for a number of years with the primary purpose of augmentation of snowpack across various basins. The primary end-goal of such activities is typically to increase quantitative runoff into local streams and reservoirs with secondary benefits being the physical enhancement of the actual snowpack during the late-fall to early-spring period for recreational use (primarily downhill skiing) with additional benefits to quantitative spring/early summer runoff. Given the 5-year drought that has affected much of the Western U.S. in the 1999-2004 period, increased interest have arisen as to the role of PE techniques and projects in the realm of water management practices across the region. This particular study will be focused on a handful of basins in Colorado that are important surface water producing regions.

A basin-specific database of temperature, wind speed, wind direction and moisture at various levels will be examined for the October-April period where high-altitude snow pack typically accrues in Colorado. A potential benefit of generating this database is to perform a more temporally and spatially intense survey of favorable conditions in applying PE techniques in these basins in a uniform fashion. The goal of extracting this information is to examine how windows of potential weather modification and enhanced precipitation transport changes not only with time-of-year but, on a specific year-by-year basis with respect to a number of basins in Colorado.

2. METHODOLOGY

Many times, basin-specific studies of PE feasibility utilize data based on real-time, in-situ observations such as upper-air soundings and current fixed-level analyses to detect potentially favorable temperature-moisture structures and their frequency. Such observations and subsequent analyses may have some limitations in terms of the applicability of sparsely spaced upper-air sounding stations especially when they are applied to areas that can be some distance from actual basins of interest. However, in-situ observations, such as radiosondes, are very critical as these instruments observe detailed information regarding vertical moisture, temperature and wind structures. A primary question remains on how to resolve this information in between the 'sparsely' spaced upper-air observations and second, how to potentially improve on the temporal resolution of the upper-air soundings that are typically taken 12-hours apart.

An example of prior radiosonde-based PE studies has been performed by Holroyd (2000) in which a detailed examination of nearly 50-years of actual radiosonde information at three sites in/near the central Rockies including Denver, Co., Grand Junction, Co. and Riverton/Lander, Wy. were applied to a feasibility study of PE potential in the headwaters of the North Platte River basin in northern Colorado/southern Wyoming These results indicated how potentially interpolated conditions could help shape PE instrumentation deployment based on a combination of factors that include meteorological parameters, topography and land use considerations. An example from Holroyd (Figure 1) shows the distribution of potential PE conditions that are present with respect to the percent of soundings where potentially favorable PE conditions exist vs. time of year (x-axis) and by elevation above sea level (y-axis) for the Denver, Grand Junction, and Lander/Riverton sites.

However, Holroyd also recognized the limitations of the extension of the somewhat distant radiosonde observations to the basin given the local topographical effects and the potentially unknown 'true' nature of the actual meteorological conditions in the basin.

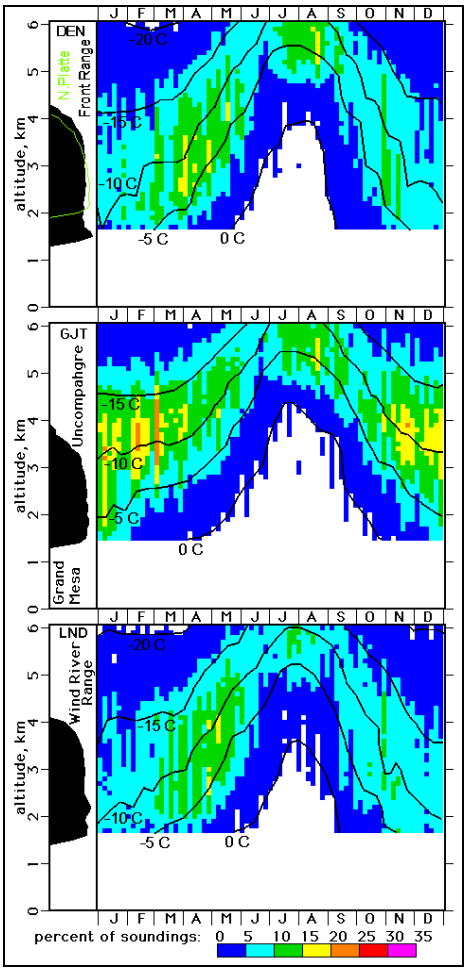

Figure 1. Frequency of 'cold cloud' conditions derived by Holroyd (2000) for Denver, Co., Grand Junction Co. and Lander/Riverton, Wy. for the period 1948-1996.

To potentially remedy these interpolation considerations this particular study, will use the North American Regional Reanalysis (NARR) (Mesinger et. al. 2004) that was recently completed by the National Centers for Environmental Prediction (NCEP-NOAA). This reanalysis is performed at a higher spatial and temporal resolution than prior reanalysis datasets that are currently available. The NARR utilized a 32-km resolution version of the ETA model forecast/analysis system with output produced every 3-hours from 1979 through 2003 (25 years). The first step is to extract vertical profiles of temperature, moisture and wind parameters for the actual upper-air sounding sites including the above mentioned sites in addition to Albuquerque, N.M and Flagstaff/Winslow, Az. and a limited set of high-elevation surface observation stations that are located at/near peak barriers across the state (AWOS) and data from the Storm Peak Laboratory (SPL) (Borys and Wetzel 1997) which is also located at the crest of a key barrier in northwestern Colorado (see Figure 2 for Colorado-based stations). Once the NARR and radiosonde/surface observations are compared for a given period of time, then potential bias corrections maybe applied to the extended period of the NARR dataset for specific basins.

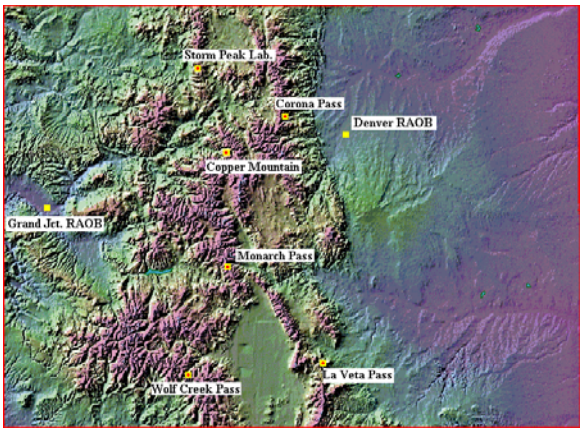

Figure 2. Topographic map of Colorado with both the radiosonde (RAOB) and high-elevation surface-based stations used in the analysis.

3. RESULTS

At the time of paper submittal, the project is still deriving the site-specific results. However, it can be stated that a prime objective of the project is to determine a year-by-year analysis of PE potential of various key basins in Colorado. During periods of extended drought, a question may remain as to the actual impact of PE activities given that the opportunities for conditions potentially favorable for weather modification may, in fact be also limited as well. The next question arises as to the potential role of weather modification in drought mitigation from a timing standpoint, should it be used before, during, or after meteorological drought conditions exist? Another potential benefit of the end results of this study would be to examine the potential impacts of different precipitation-enhancement techniques employed in different basins (i.e. AgI vs. propane vs. airborne seeding, ect). Other considerations include the potential modulation of PE opportunities with respect to the variability of climate indices (i.e. ENSO, Pacific North American Oscillation, ect.). Although there have been preliminary studies performed to link precipitation variability to these indices, are there notable modulations in the opportunities for PE under certain climate conditions? It is recognized that 25 years is a relatively short period of time for climate-scale analysis but, it is hoped that these results will provide some preliminary insight as to potential PE modification from a planning standpoint.

4. REFERENCES

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