

Category I - Hydrology, Climatology & Hydraulics

Feasibility of Snowpack Characterization Using Remote Sensing and Advanced Data Assimilation Techniques

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Executive Summary:

Many semi-arid regions of the globe, and specifically California, rely on snowmelt and the resulting runoff from the winter snowpack in local or regional mountains for the majority of their water supply. As a result, the accurate characterization of accumulated winter snowpack is a critical task for water resource planners. Additionally, because of the seasonal time lag between snow accumulation and subsequent snowmelt, an accurate knowledge of the snowpack can provide important predictions of water shortage or abundance for the upcoming year. This task is becoming even more important as economic and political pressures related to the allocation of scarce water supplies continue to increase.

The task of snowpack characterization is made difficult by the remote locations and variability of conditions within the mountain basins that provide our water supply. In fact, most operational efforts to determine snowpack water supply still consist of snow surveys, where teams of people hike into the mountains, take snow cores at several specified points in a region, and manually determine the snow water equivalent (SWE) at those points. The data are then compared to historical records of past surveys or used in empirical relationships to determine whether the water supply is below, at, or above average. Planning for the upcoming year is based almost entirely on these point-scale estimates and empirical relationships that rely on the consistency of snow cover from year to year. Furthermore, these snow surveys can be costly, dangerous to the surveyors, and are subject to yield inaccurate results when extrapolated to the entire basin.

The goal of this research project is to test the feasibility of an innovative approach to the estimation of basin-wide snow water equivalent by optimally combining remote sensing observations with physically-based hydrologic models using an advanced “data assimilation” technique. Data assimilation is a framework that optimally merges information from (ground-based and remotely sensed) observations with physical models in order to obtain estimates of the spatially distributed states of interest. The use of remotely sensed satellite observations is attractive for snowpack characterization because they provide information over large spatial scales and in regions that may be inaccessible. This study will make a significant contribution by implementing an advanced integrated data assimilation system that will 1) use multiple satellite remote sensing observation types in conjunction with a physical snow model; 2) take into account model and measurement errors; 3) provide high-resolution estimates of snowpack characteristics from coarse remote sensing observations; 4) provide estimates of the uncertainty (error bounds) of the estimates, which are an essential piece of information for water resource planners; and 5) be sufficiently portable to be of benefit to water resource agencies and planners.

The potential benefits of the real-time estimation of basin-wide snow water equivalent from remote sensing observations are significant, and not only relevant to California water resources, but to many semi-arid regions of the globe. We believe that the feasibility study proposed here will provide a significant step toward the ultimate operational estimation of snowpack characteristics from space.