Report for 2004CA92B: Feasibility of Snowpack Characterization Using Remote Sensing and Advanced Data Assimilation Techniques

- Other Publications:
  - 1. Articles in Refereed Scientific Journals Durand, Michael, and Margulis, Steven, 2005: Feasibility test of multi-frequency radiometric data assimilation to estimate snow water equivalent, Journal of Hydrometeorology, accepted. 6. Other Publications Durand, M. and S.A. Margulis, 2005: Large-scale SWE Estimation: Optimal Use of Remote Sensing and Snow Modeling, Southwest Hydrology, 4(2), 20-21,32.

Report Follows

RESEARCH PROGRAM:

Many semi-arid regions of the world, including California, depend on annual snowmelt for the majority of their water supply. However the primary method for estimating the amount of water stored in the snow pack (snow water equivalent, SWE) is still done by field snow surveys. This approach is extremely limited because the survey data are sparse point estimates and because they rely upon regression and comparison to historical measurements.

New methods for estimation of SWE have been developed recently. For the past several decades, inversion of remote sensing data and application of snow models have been used to estimate SWE. However SWE estimates based solely on either remote sensing inversion or snowpack modeling techniques are contain large uncertainty. For retrieval methods, the uncertainty lies primarily in the relationship between the snow states and the remote sensing observations. For modeling, errors occur primarily as a result of the propagation of uncertainty in model inputs (e.g., precipitation) to the SWE estimates. It is this uncertainty that motivates the development of the data assimilation approach used in this project.

Data assimilation methods, such as the Ensemble Kalman Filter (EnKF) are used to merge remote sensing observations into a hydrologic model to produce spatially distributed estimates of SWE over the entire basin. The EnKF weighs the relative uncertainty of the model and of the observations and provides an estimate of the state variable as well as an estimate of its uncertainty. This project constitutes a feasibility study for estimating SWE through the incorporation of remote sensing observations in the microwave, visible, and thermal infrared parts of the spectrum into a physically-based snow model.

The first phase of our work focused on the selection and development of the required snow and remote sensing models needed in the data assimilation approach. We have chosen two widely accepted models as the foundation of the data assimilation framework. During the preliminary testing phase we have incorporated more realistic models for the snow grain diameter evolution and snow albedo (reflectivity) which were found to be extremely important parameters in the radiative transfer model. These model refinements should ultimately significantly improve the SWE estimates. We have applied the model to data in the Mammoth Mountain region in the Sierra Nevada. These models have been embedded in a data assimilation framework (EnKF) to the ability to estimate SWE from remotely sensed microwave radiobrightness observations.

As a first step, synthetic experiments at the point-scale were performed to test the feasibility of the approach. In these tests, synthetic realizations of the remotely sensed observations were used in the assimilation scheme to test whether the true snowpack characteristics could be recovered under conditions of uncertain initial conditions and precipitation. The methodology was shown to outperform commonly used retrieval methods and overcome significant biases often seen in precipitation in mountainous regions. This part of the study has been recently accepted for publication (see reference below). Our future work will extend the method to a spatially distributed basin-scale application.

INFORMATION TRANSFER PROGRAM:

No information transfer activities to report.

STUDENT SUPPORT:

Michael Durand, graduate, Ph.D.; Civil and Environmental Engineering, UC Los Angeles

NOTABLE ACHIEVEMENTS AND AWARDS:

The preliminary work started in this project was helpful in obtaining a NASA New Investigator Program (NIP) award. This supplemental funding will allow for extension to the work after completion of the project.

PUBLICATIONS:

1. Articles in Refereed Scientific Journals
Durand, Michael, and Margulis, Steven, 2005: Feasibility test of multi-frequency radiometric data assimilation to estimate snow water equivalent, Journal of Hydrometeorology, accepted.
2. Book Chapter
None.
3. Dissertations
None.
4. Water Resources Research Institute Reports
None.
5. Conference Proceedings
None.
6. Other Publications
Durand, M. and S.A. Margulis, 2005: Large-scale SWE Estimation: Optimal Use of Remote Sensing and Snow Modeling, Southwest Hydrology, 4(2), 20-21,32.