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Near real time snow data assimilation for streamflow forecasting using MODIS snow data products

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❶ Summary

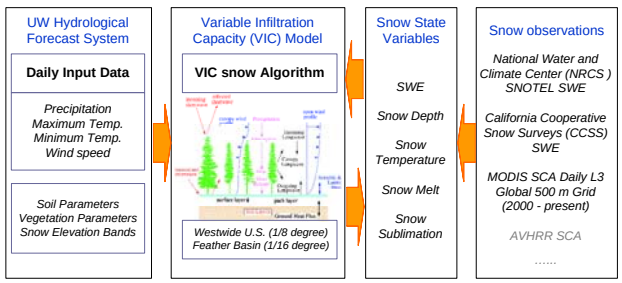
Snow plays a major role in streamflow generation in the western United States, hence estimates of snow water storage during winter are a key predictor of water availability in the spring and summer. In an effort to improve the estimation of snow cover, snow water storage, and consequently forecasts of seasonal streamflow, we have implemented an experimental approach for using MODIS snow cover imagery to reduce errors in snow states simulated by the Variable Infiltration Capacity (VIC) macro-scale hydrology model. We have implemented the approach in both retrospective and real-time contexts.

Our approach involves a composite insertion of MODIS/Terra Snow Cover Data, NRCS SNOTEL and California Cooperative Snow Surveys snow point observations of SWE into the VIC model. For the Feather River of California, our findings to date show good results for snow simulation and mixed results for streamflow prediction.

❷ Objective

The objective of this study is to evaluate the strategies for assimilating point SWE observations from the National Water and climate Center (NRCS) SNOTEL and California Cooperative Snow Surveys (CCSS) ground snow observation network, and the standard SCA derived from the MODIS instrument, both in terms of their influence on the model-based SWE estimates, and on runoff forecasts.

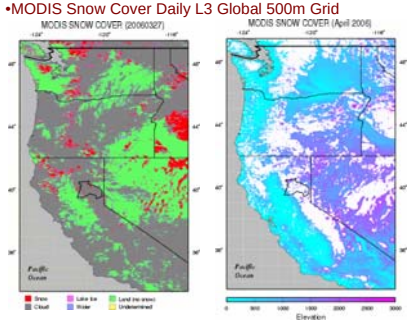
UW Snow Data Assimilation System (UWSDAS)



❸ Snow Information

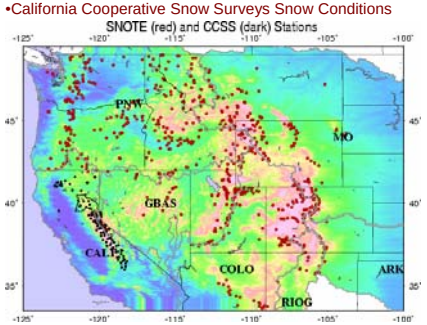
Satellite Observations

•MODIS Snow Cover Daily L3 Global 500m Grid



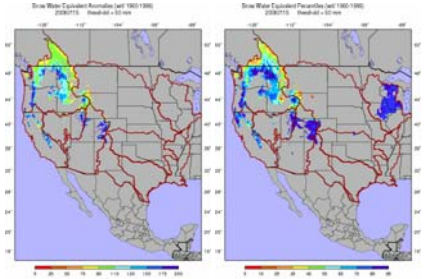
Ground Observations

•NRCS National Water and Climate Center, SNOTEL Data
•California Cooperative Snow Surveys Snow Conditions



VIC model simulation

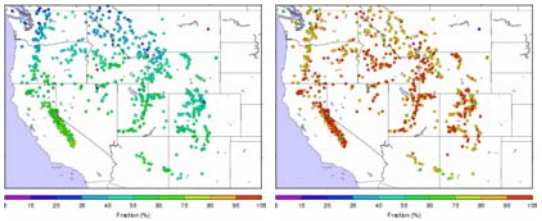
•University of Washington, Westwide Seasonal Hydrological Forecast System (Wood & Lettenmaier, 2006).



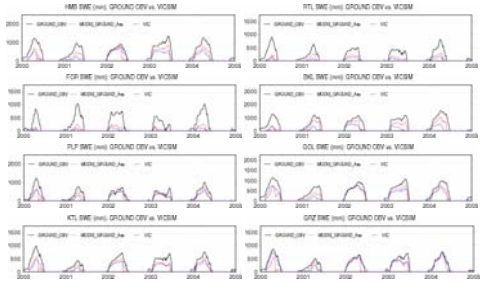
❹ Implementation and Evaluation

Our study area is the western United States. However, the evaluations of the system are done in the Feather River Basin, CA.

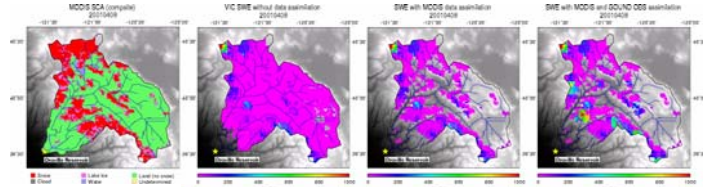
MODIS composite SCA data, which may show better agreement with ground snow observations, are used for the snow data assimilation in UWSDAS. Composite data significantly reduce the cloud and no-decision situation of MODIS data. In the below figure, the percentage means the probability when the MODIS data agrees with Ground Obs.



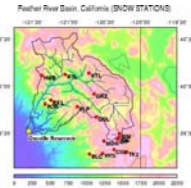
MODIS (left) and MODIS composite data (right) vs Ground Obs (02/2000-12/2006).



Ground snow observation, MODIS + Ground snow observation assimilation, and VIC simulation SWE at the stations



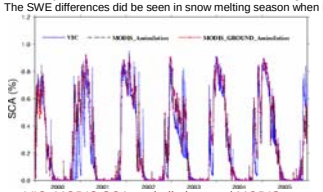
MODIS SCA (composite), VIC SWE without data assimilation, MODIS assimilation, MODIS + Ground data assimilation



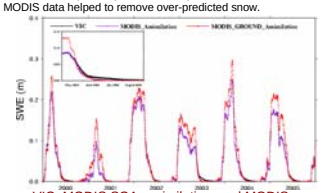
The Feather River Basin, CA

The Feather river is an important source of water and power for the northern California. Lake Oroville, at the outlet of the basin, plays an important role in flood management, water quality, and the health of fisheries of the region. There are 9 snow ground observation stations from CCSS in the Feather River Basin, CA. The predicted streamflow is compared with the natural flow at the Oroville Dam (OROVI).

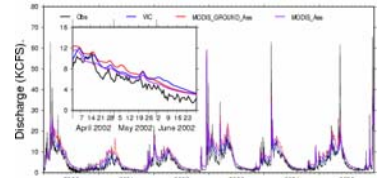
MODIS areal extent of snow cover are assimilated into VIC model. Ground-based snow water equivalent observations are then assimilated into the model by correcting the subgrid SWE where is determined covered by snow. The MODIS assimilation did not make big difference in SWE probably because the places where MODIS data does not agree with the model prediction are places where there isn't much SWE. The SWE differences did be seen in snow melting season when MODIS data helped to remove over-predicted snow.



VIC, MODIS SCA assimilation, and MODIS + Ground obsassimilation SCA, Feather basin Avg.



VIC, MODIS SCA assimilation, and MODIS + Ground obs assimilation SWE , Feather basin Avg.



VIC, VIC with MODIS and + Ground snow observation assimialtion, and observed Streamflow at OROVI.

❺ Conclusions

The University of Washington Snow Data Assimilation (UWSDAS) is a data assimilation and model system to provide the best possible estimations of snow cover, snow water storage, associated snow variables and consequently forecasts of seasonal streamflow.

UWSDAS provides a near real time framework for integrating the wide variety of snow information which is available from satellite and ground observations with various locations and time scales.

Our findings in the Feather River Basin show that the snow simulations are improved with data assimilation and there are mixed results for streamflow prediction.

http://www.hydro.washington.edu/forecast/rsda/

Welcome to

UWSDAS

Homepage

With
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❻ References

Hall, D. K., G. A. Riggs, and V. V. Salomonson. 2006, updated daily. MODIS/Terra snow cover daily L3 global 500m grid V005, [2000-2006]. Boulder, Colorado USA: National Snow and Ice Data Center. Digital media. McGuire, M; Wood, AW; Hamlet, AF; Lettenmaier, DP. 2006, Use of Satellite Data for Streamflow and Reservoir Storage Forecasts in the Snake River Basin. J. Water Resour. Plann. Manage. Vol. 132, no. 2, pp. 97-110. Andreadis, K. M.; Lettenmaier, D. P. 2006. Assimilating remotely sensed snow observations into a macroscale hydrology model, Advances in Water Resources, v. 29, iss. 6, p. 872-886. California Data Exchange Center (CDEC)' http://cdec.water.ca.gov/. Wood, A.W., and D.P. Lettenmaier, 2006: A Test Bed for New Seasonal Hydrologic Forecasting Approaches in the Western United States, Bull. Amer. Meteor. Soc., 87, 1699–1712.