Applied Sciences Program
NASA Earth Science

Incorporating remote sensing and snow energy balance modeling into runoff forecasting in the Colorado River Basin

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Project Overview

The Colorado River, fed primarily from snow melting out of the Rocky Mountains, is referred to as the 'lifeblood' of the Western US because it supplies water to seven western US states and Mexico. With increasing regional populations and shifting snowmelt patterns, it is more critical than ever to accurately forecast the timing and amount of snowmelt from the Colorado River headwaters. This project will develop an operational framework that incorporates remote sensing products into a process-based snowmelt model to support operational decision making at the Colorado River Basin Forecast Center (CBRFC).

The Colorado River. The headwaters are the snow covered peaks of Colorado, Wyoming, and Utah. (Source: American Rivers)

Expected Benefits

In the Western US, where surface water patterns are governed by the timing and magnitude of snowmelt runoff, downstream decision making regarding water allocation, reservoir storage and release, and hydropower is dependent on snowmelt forecasting. Confidence in the amount of water held as snow, and when that water will be available, directly translates into water, and thereby economic, security for agricultural, urban, and recreational communities. The sustainable incorporation of process based snow energy balance modeling, informed by remote sensing, into the CBRFC decision making process will provide a more physically-complete description of the factors that regionally and seasonally influence snow net radiation, energy balance, and melt rates. This project will improve water forecasts from the Colorado River Basin headwaters, which benefits CBRFC stakeholders including the Bureau of Reclamation, Army Corps of Engineers, and various power, conservation, and irrigation districts.

Motivation

Current operational snowmelt runoff forecasts, including those from the CBRFC, rely on temperature index models that use calibrated relationships between air temperature and snowmelt. This approach is simple, and computationally efficient, but can result in forecasting errors when snow conditions are outside the calibration range. This is because

Project Highlights

- Develop CBRFC capacity to run a process based, spatially distributed, snow-melt model that assimilates publicly available data from NASA and NOAA
- Produce accurate maps of snow covered area, snow water equivalent, and streamflow
- Improve water forecasts from the snow dominated headwaters of the Colorado River
- Support decision making and water security for agricultural, urban, and recreational communities in the Colorado River Basin

Dust on snow deposition in the San Juan Mountains of Colorado, headwaters of the Colorado River. The darker surface absorbs more sunlight, which accelerates snowmelt.

temperature index models do not represent the physical processes that drive snowmelt, primarily the balance between solar and terrestrial radiation, which are dependent on snow cover extent, surface reflectivity, and atmospheric conditions. For example, in the headwaters of the Colorado River, forecasting errors have been directly related to surface darkening following episodic dust on snow events. Widespread dust deposition, the frequency and intensity of which has been related to land use change and surface disturbance, shifts snowmelt timing and magnitude by dramatically accelerating snowmelt. This process cannot be directly represented in the current CBRFC modeling framework.

Objectives

This project will address the limitations of operational temperature index modeling in the Colorado River Basin by supplementing current methods with ouputs from a spatially distributed process based snow energy balance model. The ability to run a spatially distributed model over the snow dominated headwaters of the Colorado River is currently limited by the availability of local and relevant snow energy and mass balance information from sparse observation networks. This project addresses the data limitation by supplementing traditional data sources with remote sensing imagery and weather forecasting ouputs. Snow cover information from MODIS (NASA), and cloud cover information from GOES (NOAA), will be used to inform net radiation, and an atmospheric model outputs from the High Resolution Rapid Refresh model (NOAA) will be used to inform meteorological variables. The model will be validated over well instrumented snow study basins. At the completion of the project there will be successful technology transfer to the Colorado Basin River Forecast Center.

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For more information, please contact:

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