Colorado Water

March/April 2019

Data-Driven
Water Management

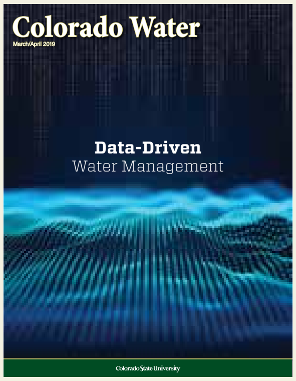
Colorado State University

Table of CONTENTS

Features—Data-Driven Water Management

From our Cooperators

In Every Issue



On the cover—New and emerging technologies increasingly allow water managers to collect and analyze large volumes of data, which may in turn improve the quality and quantity of our water resources in Colorado and beyond. Illustrations © iStock.com

References can be found in the online version of this newsletter at http://cwi.colostate.edu/newsletters.asp

Cooperators include the Colorado State Forest Service, the Colorado Climate Center, and CSU's Water Resources Archive.

COLORADO **WATER**

Volume 36, Issue 2

Colorado Water is a publication of the Colorado Water Center. The newsletter is devoted to highlighting water research and activities at CSU and throughout Colorado.

Published by
Colorado Water Center
Reagan Waskom, Director

Editor
Catie Boehmer

Design
R. Emmett Jordan

Production Director
Nancy Grice

Supported by
This publication is financed in part by the U.S. Department of the Interior Geological Survey, through the Colorado Water Center; College of Agriculture, Warner College of Natural Resources, Agricultural Experiment Station, and Colorado State University Extension.

COLORADO WATER CENTER
COLORADO STATE UNIVERSITY
watercenter.colostate.edu
cwi.colostate.edu

Where and When does river flow originate?

Stephanie Kampf, John Hammond, Abby Eurich, and Kira Puntenney-Desmond,
Ecosystem Science and Sustainability, Colorado State University

▼ SYNOPSIS

Snowmelt is incredibly important to Colorado's water supply, and monitoring stations track snow levels in the high mountains throughout the state. Less attention is paid to snow at lower elevations, despite it being an important source of river flow in some years. To better understand where and when river flows originate—information that is critical to meeting water demands as Colorado's population grows and future water supplies are increasingly uncertain—geospatial technology has been combined with crowdsourced stream data to paint a more comprehensive picture of how the state's watersheds function.

Colorado contains the headwaters of four major rivers, each beginning as small mountain streams fed by melting snow. Because of the importance of snow to our water supply, an extensive network of National Resources Conservation Service snow telemetry (SNOTEL) stations monitors snow in the high mountains throughout the state (Figure 1). The focus on high mountain snow has sometimes led researchers and water managers to pay less attention to lower elevations. Lower elevations do not have as much snow in the winter, but they cover much larger areas than the high mountain peaks and can be important sources of river flow in some years. As the state plans for growing population and uncertain future water supplies, a better understanding of where and when river flow originates can help managers protect critical water supply source areas. Geospatial technology provides many useful tools for examining rivers and their source watersheds. Here we highlight two examples: (1) using snow cover images from the MODIS (or Moderate Resolution Imaging Spectroradiometer) satellite sensor to map snow patterns and water yield and (2) using crowdsourced observations of headwater streams to identify which parts of watersheds contribute water to large rivers at different times of year.

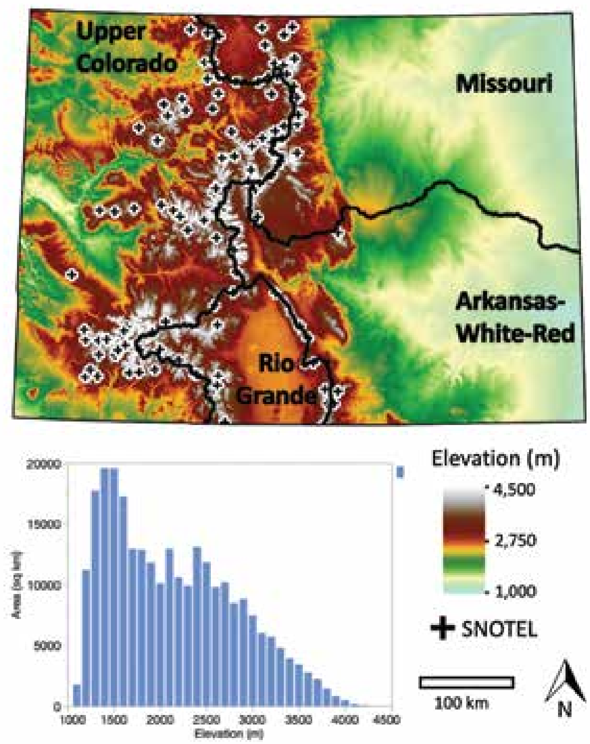


Figure 1. Colorado includes elevations as low as 3315 feet (1010 m) in its eastern plains, up to 14,440 feet (4400 m) at the top of Mt. Elbert. Most snow monitoring (SNOTEL) sites are at high elevations (>9,000 ft, >2,700 m), which cover smaller land areas than lower elevations.

Snow and water yield

Since 2000, the MODIS satellite sensor has taken daily images across the globe that allow us to see where and when snow is on the ground. The persistence of snow on the ground, meaning how long it stays before melting, has a high correlation with annual total water yield in Colorado (Hammond et al. 2018), so we can use snow patterns to estimate how much streamflow is produced across the state. For example, during 2011, when most of the high mountains in Colorado had persistent snow that lasted until mid-May or later, some of the highest snow areas produced an estimated three feet of runoff, and statewide water yield was an estimated 30 million acre-feet (37 km^3) (Figure 2). In 2012, which was a low snow year, very few parts of the state had persistent snow, with most parts of the state snow-free in April or earlier (transitional and intermittent snow). This led to less than half the 2011 water yield across all elevations, with estimated statewide water yield around 12 million acre-feet (15 km^3).

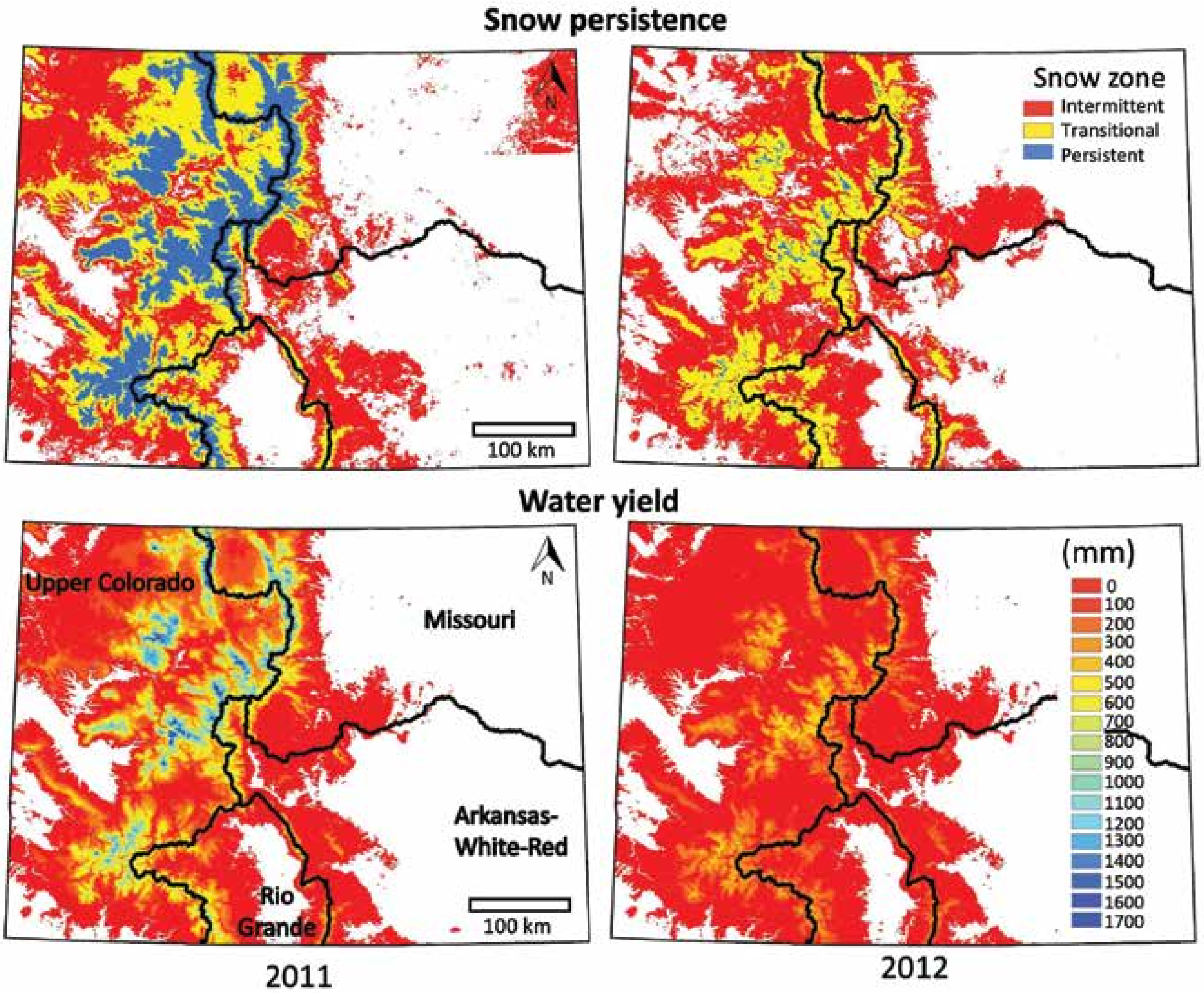


Figure 2. Snow persistence and water yield for a high snow year (2011) and a low snow year (2012). Snow persistence is from the MODIS satellite sensor and is shown as snow zones, where the persistent areas have snow that lasts until mid-May or later; transitional areas have snow that lasts until early April; and intermittent areas have snow that does not stay continuously on the ground through the winter. Water yield is predicted from snow persistence using relationships developed for stream gauging stations in Colorado (Eurich data, Kampf et al. 2018).

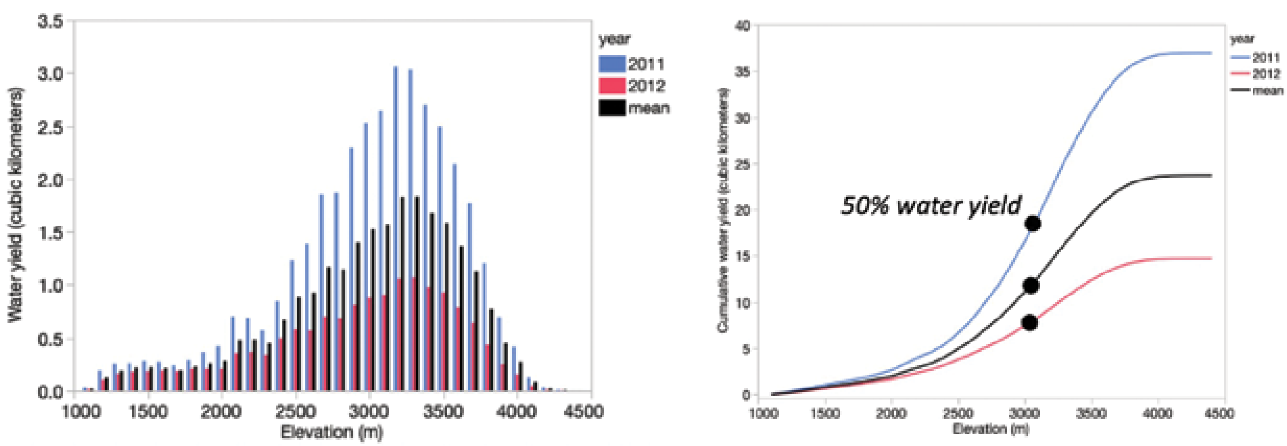


Figure 3. Estimated water yield produced by elevation across Colorado in water years 2011 and 2012 and the average water yield from 2001-2018. Elevations between 3,000-3,500 meters produce the highest water yield by volume (left), but lower elevations are also important contributors to water yield, with half of the statewide water yield coming from elevations less than around 3,000 meters (black circles, right).

Figure 4. Snapshot of Stream Tracker monitoring points on tributaries to the Cache la Poudre River. Red dots indicate tributaries that were dry in September 2017, and blue dots indicate tributaries that were flowing. These points are displayed on an ESRI webmap linked through streamtracker.org. Lower photos show one site, Hewlett Gulch, with high flow and turbid water after a summer thunderstorm, clear high flow during snowmelt, low flow before snowmelt, and a dry channel in September 2018. These photos and data are publicly accessible through the Stream Tracker project on CitSci.org.

High elevations are clearly important sources of streamflow across the state, with peak water yield generation at around 10,000-11,500 feet (3,000-3,500 m). However, about half of the estimated total water yield comes from lower elevations, particularly areas above 6,500 feet (2,000 m) (Figure 3). This means tracking snow conditions and streamflow in lower elevation areas is important for water supply planning, particularly because these areas may be most sensitive to warm winter temperatures. Even though SNOTEL stations are concentrated at high elevations, we can use geospatial technology to estimate streamflow contributions from lower elevations and identify priority areas for ground monitoring.

Crowdsourcing data on headwater streams

Snow does not tell the full story of where river flow originates. On the ground, each of the thousands of headwater streams in Colorado is unique, and we have little if any information on flow conditions in most of these streams. This monitoring challenge led to the Stream Tracker project (streamtracker.org), a community monitoring network that focuses on crowdsourcing information about whether or not headwater streams are flowing. Volunteers can navigate to streams using a GPS unit or a mapping application on their mobile phone (Figure 4), then enter stream data either on their mobile phone or on the project website. Observers record whether they see flowing water, standing water, or a dry channel and are able to document their observation with a photo. When these observations are entered frequently for headwater streams located throughout larger watersheds, they begin to reveal which parts of watersheds are supplying the water that reaches larger rivers. The expanding Stream Tracker network of over 470 volunteers now tracks more than 860 individual streams, 440 of which are in Colorado. This growing dataset of flow conditions can be used to improve maps, indicate where flow originates in headwater channels, and track how flow conditions vary between seasons and years.

Connecting the pieces

Geospatial technology allows us to connect satellite imagery with on-the-ground measurements of streams to build a comprehensive understanding of how watersheds function, from the scale of large river basins down to small headwater tributaries. Statewide analysis reveals broad patterns of where river water originates, while measurements on the ground document the small streams that deliver this water to larger rivers. Both statewide snow products and small stream data are publicly accessible, and anyone is welcome to join Stream Tracker and help document the conditions of Colorado's headwater streams.

Acknowledgements

The work presented here has been funded by the National Science Foundation, National Aeronautics and Space Administration, and Colorado Water Conservation Board.