An S-band Frequency-Modulated Continuous-Wave Radar: Observations During the 2017 California Oroville Dam Crisis

*Allen B. White[1], Paul E. Johnston[2,1], Daniel J. Gottas[1], Benjamin J. Moore[1]

1. NOAA/ESRL Physical Sciences Division, 2. Cooperative Institute for Research in Environmental Sciences

Scientists and electrical engineers in the United States (U.S.) National Oceanic and Atmospheric Administration (NOAA) Earth System Research Laboratory Physical Sciences Division and Cooperative Institute for Research in Environmental Sciences have developed a low cost, low power, easily transportable, frequency-modulated continuous-wave (FMCW), vertically pointing radar that operates at 2.835 GHz. The radar provides vertical profiles of radar reflectivity and Doppler vertical velocity with 40-m vertical resolution and ~40-sec temporal resolution (other resolutions are possible). Here we focus on the radar-derived measurements of the snow level, the level in the atmosphere where falling precipitation transitions from snow to rain. The snow level is based on an automated algorithm that uses profiles of radar reflectivity and Doppler vertical velocity in precipitation to detect the altitude of the radar bright band. During the boreal winter of 2016-17, California received highly anomalous precipitation that provided crucial water resources and ended a multi-year drought. However, a particularly intense and prolonged storm in early February caused damage to the flood-control spillway on Oroville Dam, the highest dam in the U.S. As a result, the dam’s emergency spillway had to be used for the first time in the dam’s existence. Erosion below the dam led to concerns for dam safety and the emergency evacuation of nearly 200,000 residents living downstream. Emergency response and repairs to the spillways cost $1.1 billion U.S. We use measurements from the snow-level sensing FMCW radar located at the base of Oroville Dam to illustrate how high snow levels associated with an anomalously warm air mass during the storm caused most of the precipitation across the Oroville watershed to fall as rain instead of snow. Snow-level forecasts from NOAA’s High Resolution Rapid Refresh weather forecast model are evaluated using a radar-based snow-level verification tool. Snow pillow measurements indicate how snowmelt contributed to runoff. The excessive runoff into Lake Oroville complicated dam operations, illustrating the challenging decisions water managers and dam operators in California and elsewhere may increasingly face under a warming climate.

Keywords: radar, snow level, Oroville Dam


Oroville Dam
Snow-level Radar
T, RH sensor
Rain gauge
GPS antenna for
integrated water vapor
Satellite comms.