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A non-equilibrium model for soil heating and moisture transport during extreme surface heating

William Massman
RMRS, US Forest Service, Fort Collinns, United States (wmassman@fs.fed.us)

The increasing use of prescribed fire by land managers and increasing likelihood of wildfires due to climate change requires an improved modeling capability of extreme heating of soils during fires. This study describes a new model of soil evaporation and transport of heat, soil moisture, and water vapor, for use during fires. The model is based on conservation equations of energy and mass and its performance is evaluated against dynamic soil temperature and moisture observations obtained during laboratory experiments on soil samples exposed to surface heat fluxes ranging between 10,000 and 50,000 Wm2. In general, the model simulates the observed temperature dynamics quite well, but is less precise (but still good) at capturing the moisture dynamics. The model emulates the observed increase in soil moisture ahead of the drying front and the hiatus in the soil temperature rise during the strongly evaporative stage of drying. It also captures the observed rapid evaporation of soil moisture that occurs at relatively low temperatures (50-90 C), and can provide quite accurate predictions of the total amount of soil moisture evaporated during the laboratory experiments. Overall, this new model provides a much more physically realistic simulation over all previous models developed for the same purpose.