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# Surface energy and water balance for snow covered areas: formulation and validation of a four-layer model.

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For the accurate prediction of floods in mountain environment, reliable estimations of the dynamics at the soil surface of snow melt/accumulation processes is fundamental.
Percentage of snow covered area, snow water equivalent at catchment scale impact the runoff volume during flood events in Alpine regions trough snowmelt. The latter is strongly influenced by the energy balance at the snow surface. For this reason it is necessary a reliable formulation of the physics of the coupled mass/energy exchange processes between soil-snowpack and atmosphere.
Here we present a model of water and energy balance over snow characterized by a four-layer scheme, with two layers of snow and two layers of soil. The eight state variables of the model are: average temperatures of layers, driving the energy balance represented by the Force Restore Equation, modified for snow; snow density and snow water equivalent, driving the mass balance equations evaluated for each snow layer.
In model formulation it was necessary to consider two layers of snow in order to take into account the different behavior of fresh and packed snow (e.g. different albedo density and grain size). On the other side two soil layers were considered due to the application of Force Restore Equation: this simplified representation of heat equation requires deep soil temperature constant at daily scale and this hypothesis is fulfilled in soil layers in which fluxes are not characterized by intermittency of snow presence. Furtthermore the two-layer formulation provides more stability of system solutions than the one-layer formulation.
Innovative contribution of this formulation is represented by cross-layer fluxes: in snow water equivalent and density equations are introduced two terms that mimic dynamic boundary between the two layers.
The chosen model formulation allows to consider the complexity of snow dynamics, but in a quite simple way, not heavy computationally, and gives the possibility to assimilate satellite data, such as Land Surface Temperature or snow cover maps.
In this study we present the calibration and validation of the model at punctual scale using data from 45 ground stations in the Valle d'Aosta region (Italy).