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Energy and mass balance for snow covered areas: formulation and validation of a four-layer model.

F. Martina (1), G. Boni (1,2), F. Castelli (3), S. Gabellani (1), and R. Rudari (1)
(1) CIMA Research Foundation, Savona, Italy , (2) DIST - University of Genoa, Italy, (3) DICEA, University of Florence, Italy

In mountain environment, to accurately predict floods, accurate estimations of the dynamics at the soil surface of snow melt/accumulation processes are fundamental.
The extension of snow covered area and the water equivalent of accumulated snow can influence the runoff volume during flood events in Alpine regions.
Especially snow melt 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.
Reliable coupling is necessary due to several feedback effects between mass and energy balances: e.g. in presence of snow, heat exchanges are mainly characterized by sublimation and melting, which are processes strongly dependent on the quantity of water present in the snow pack.
Here we present a model of mass 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: to use this simplification of heat equation it is necessary to have a deep constant temperature at daily scale, and to make valid this hypothesis it is necessary to have a soil layer in which fluxes are not characterized by intermittency of snow presence.
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 a micrometeorological FLUXNET station in the Valle d'Aosta region (Italy).