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Interactive comment on "A multi-layer physically-based snowpack model simulating direct and indirect radiative impacts of light-absorbing impurities in snow" *by* Francois Tuzet et al.

Anonymous Referee #1

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General comments:

This paper introduces the updated detailed snowpack model Crocus, which now calculates the deposition and the evolution of light-absorbing impurities (LAI) such as black carbon (BC) and dust in the snowpack. Although the previous version of Crocus that incorporated the TARTES radiative transfer model can consider effects of SSA (specific surface area of snow) and LAI on snow albedo explicitly, the present update allows

model users of Crocus to simulate more realistic energy exchanges between the atmosphere and the snowpack as well as temporal evolution of snow physical conditions.

Overall, this paper is well written and I found there is potential that the present study can provide deepened knowledges of snow modelling; however, model validation works are not sufficient to demonstrate effectiveness of the present update. Model performances in terms of snow depth and snow water equivalent are almost the same between the present updated version and the reference version that calculates snow albedo by a relatively simple empirical approach. Therefore, I think readers will find it difficult to assess whether the present update successfully worked or not. At least, I think the authors should present model performance in terms of shortwave (broadband) albedo at Col de Porte in the same manner as Table 2.

Specific comments:

P6 L30- P7 L2: Is there a reference paper for the description of "The parameterization implemented in Crocus considers that the dry deposition affects the near-surface with an exponential decay to take into account wind pumping which buries a fraction of the dry deposited particles by circulating air into the uppermost snow layers."? An observation-based evidence for this description would be needed.

P8 L14-16: The authors state that "In the present study, the default value of BC scavenging coefficient is set to 20% according to the values provided in Flanner et al. (2007) and assessed by Doherty et al. (2013) and Yang et al. (2015)."; however, BC scavenging ratios listed in Table 1 (note that scavenging ratios for BC and dust listed in the table are inverted) are set to 0 % for most of the settings. Please explain why.

P10 L4: Lateral boundary forcing of meteorological conditions of the ALADIN-Climate model is given from ERA-Interim. How about lateral boundary forcing for BC and dust? In case an emission inventory is used in the parent model (boundary forcing), it should be mentioned here as well.

P10-11 Sect. 3.3: The ALADIN-Climate-calculated LAI deposition fluxes were checked by referring to in-situ measurements obtained at Italian Alps. I think the authors should also check validity of the ALADIN-Climate-simulated precipitation rate at Col de Porte. This validation would reveal whether the ALADIN-Climate model could simulate wet deposition realistically or not.

P12 Sect. 4: Please add a subsection where validation results for shortwave albedo at Col de Porte are presented as mentioned above.

P14 L3-8: During the period when simulated near surface SSA are increased (new snow exists near the snow surface), observation data for SSA are not available as seen in the lower panel of Fig. 4. The authors should explain the reason.

P14 L21-22: When discussing radiative forcings due to direct and indirect impacts quantitatively, I think it is better to use C5 configuration as a control run rather than using C2 configuration. It is because C5 configuration gives more realistic LAI deposition fluxes, and values for radiative forcings would become more reliable and meaningful.

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Technical corrections:

P7 L7: When introducing zj and j, please explain the coordinate system considered by Crocus (e.g., positive direction).

P7 L21: “Mo” and “SWE)o” are typos.

Figure 1: Please explain definitions for red and black circles explicitly.

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