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The Cryosphere Discussions
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Interactive comment on "Annual and interannual variability and trends of albedo for Icelandic glaciers" *by* Andri Gunnarsson et al.

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The authors provide well-written detailed study on albedo changes of all Icelandic major glaciers using a comparison of MODIS snow albedo products and in situ measurements. This study could also serve as a comprehensive review of rapidly changing glaciers in Iceland with focus on impacts on their changing albedo. It brings insights into albedo analysis in problematic cloud-obscured region while providing novel findings on linear albedo gradients and dust plume shape patterns on snow and ice. Direct impacts of explosive volcanic eruptions as well as severe and moderate dust storms on the glaciers are evaluated. Additionally, possible indirect impacts of effusive eruptions such as Holuhraun 2014-2015 are suggested. It is clear that the authors know perfectly the local environment and its past. The data from the MODIS products were

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carefully screened during extensive manual quality control and results were evaluated with valuable data from in situ ICE-GAWS network. The greatest contribution of this study is that the data set does not only include major explosive eruptions and cold years, but it includes extremely rare year 2019, dry and dusty in the southern part of Iceland. This allows the authors to compare the impacts of volcanic ash and general volcanic/glacial dust on the albedo at the same level. There are minor errors in references that should be stated in ascending order and several references could be added. I would recommend publication after minor revisions.

Specific comments:

L18-95 – Introduction

Consider to add studies on snow albedo reductions due to volcanic dust, eg. Meinander et al., 2014, Peltoniemi et al., 2015, Dagsson-Waldhauserova et al., 2015, Zubko et al., 2019).

Kylling et al., 2018 calculated the instantaneous radiative forcing of the bottom of the atmosphere due to mineral dust deposited on snow as 0.135 W m-2.

Kylling A., Groot Zwaaftink, C. D., Stohl, A., 2018. Mineral dust instantaneous radiative forcing in the Arctic. Geophysical Research Letters, 45. doi: 10.1029/2018GL077346.

Peltoniemi, J. I., Gritsevich, M., Hakala, T., Dagsson-Waldhauserová, P., Arnalds, Ó., Anttila, K., Hannula, H.-R., Kivekäs, N., Lihavainen, H., Meinander, O., Svensson, J., Virkkula, A., de Leeuw, G., 2015. Soot on snow experiment: bidirectional reflectance factor measurements of contaminated snow. The Cryosphere 9, 3075-3111.

Dagsson-Waldhauserova, P., Arnalds, O., Olafsson, H., Hladil, J., Skala, R., Navratil, T., Chadimova, L., Meinander, O., 2015. Snow-dust storm A case study from Iceland, March 7th 2013. Aeolian Research 16, 69–74.

Meinander, O., Kontu, A., Virkkula, A., Arola, A., Backman, L., Dagsson-Waldhauserová, P., Järvinen, O., Manninen, T., Svensson, J., de Leeuw, G., and Lep-

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päranta, M., 2014. Brief Communication: Light-absorbing impurities can reduce the density of melting snow. The Cryosphere 8, 991-995.

Zubko, N., Muñoz, O., Zubko, E., Gritsevich, M., Escobar-Cerezo, J., and Berg, J., 2019. Light scattering from volcanic-sand particles in deposited and aerosol form. Atmos. Env. 215, 116813. doi: 10.1016/j.atmosenv.2019.06.051

L40 and L85 – remove ‘a’ in Wittmann et al., 2017a. Consider to add Gascoin at al., 2017 here.

L40-41 – ’surface albedo IS the dominating factors’ - change ARE->IS, FACTORS->FACTOR

L44-45 – ..but it IS limited. . .

L47 – Stroeve et al. 2001? As in reference, not 2002.

L70-72 – Can you please rephrase the sentence or cut into two sentences. It is difficult to understand.

L144 – Van Den Broeke et al., 2004 a,b?

L164 – Table 1 – What do you mean by ’average location’?

L192-193 – opening brackets are missing

L229-230 – Do you mean annual melt rates here?

L230 – Sand particles have certain size resolution, maybe ‘dust’ is better here. Or ‘sand and dust’.

L253– Small scale spatial variability of albedo could be also discussed here. See Hartl et al., 2020.

Hartl, L., Felbauer, L., Schwaizer, G., and Fischer, A.: Small scale spatial variability of bare-ice albedo at Jamtalferner, Austria, The Cryosphere Discuss., https://doi.org/10.5194/tc-2020-92, in review, 2020.

L289-308 – Linear albedo gradients are really important and well discussed here. However, the role of local impurities should be also mentioned here. General lower albedo values at certain parts of Hofsjökull, Langjökull and Myrdalsjökull coincides well with location of dust source areas described in Arnalds et al., 2016, and classified as severe or extremely severe erosion areas. This should be also included here in the discussion. There is also work from Antarctica showing the vertical gradient of local dust impurities on glacier that could be discussed here. See Kavan et al., 2020.

Kavan, J., Nyvlt, D., Láska, K., Engel, Z., and Knazková, M. (2020) High latitude dust deposition in snow on the glaciers of James Ross Island, Antarctica. Earth Surf. Process. Landforms, https://doi.org/10.1002/esp.4831

L319-321 – General trends in annual albedo (lowest values vs. highest values) correspond to the long-term dust storm frequency studies in Iceland. For evaluation, consider these three studies:

Nakashima, M. and Dagsson-Waldhauserová, P., 2019. A 60 Year Examination of Dust Day Activity and Its Contributing Factors From Ten Icelandic Weather Stations From 1950 to 2009. Frontiers in Earth Science 6, 245-252. DOI:10.3389/feart.2018.00245

Butwin, M.K., von Löwis, S., Pfeffer, M., and Thorsteinsson, Th., 2019. The Effects of Volcanic Eruptions on the Frequency of Particulate Matter Suspension Events in Iceland. Journal of Aerosol Science 128, 99-113.

Dagsson-Waldhauserova, P., Arnalds, O., Olafsson, H., 2014. Long-term variability of dust events in Iceland. Atmospheric Chemistry and Physics 14, 13411-13422. DOI:10.5194/acp-14-13411-2014.

L322-323 – Such unstable erosive surfaces are defined as ‘dust hot spots’ and it has been shown that dust events occur frequently in southern parts of Iceland in winter. Examples here:

Dagsson-Waldhauserova, P., Arnalds, O., Olafsson, H., 2014. Long-term variabil-

ity of dust events in Iceland. Atmospheric Chemistry and Physics 14, 13411-13422. DOI:10.5194/acp-14-13411-2014

Dagsson-Waldhauserova, P., Renard, J.-B., Olafsson, H., Vignelles, D., Berthet, G., Verdier, N., Duverger, V., 2019. Vertical distribution of aerosols in dust storms during the Arctic winter. Scientific Reports 6, 1-11.

Dagsson-Waldhauserova, P., Arnalds, O., Olafsson, H., Hladil, J., Skala, R., Navratil, T., Chadimova, L., Meinander, O., 2015. Snow-dust storm A case study from Iceland, March 7th 2013. Aeolian Research 16, 69–74.

L329 – delete ‘r’ in severer

L329-332 – Just to comment. There are few cases when Drangajökull and Westfjords receive dust from the dust hot spots in central and South Iceland. Such events were captured by satellite or by dust model frequently in 2019.

L353 – ‘>30%’ Did you mean <30%

L375 – Liu et al. (2014) do not really refer to volcanic ash from eruption, but dust event with maybe some relicts of ash. Their sample was collected in 2013 and they describe a dust event in 2013. I would suggest to remove this from the references here.

L380-381 – It was also induced by high dust storm activity in that area, see Möller et al., 2019. Volcanic ash is usually being removed fast from surfaces in Iceland, in < 1 year. See Butwin et al., 2019 or Arnalds et al., 2013.

Butwin, M.K., von Löwis, S., Pfeffer, M., and Thorsteinsson, Th., 2019. The Effects of Volcanic Eruptions on the Frequency of Particulate Matter Suspension Events in Iceland. Journal of Aerosol Science 128, 99-113.

Arnalds, O., Thorarinsdottir, E.F., Thorsson, J., Dagsson-Waldhauserova, P., Agustsdottir, A.M., 2013. An extreme wind erosion event of the fresh Eyjafjallajokull 2010 volcanic ash. Nature Scientific Reports 3, 1257.

L382 – Wittmann et al. (2017a). Why ‘a’?

Figure 8 – Correct the title – delete ‘for the’?

L400 – 1999 Hekla – Are you talking about 26th Feb 2000 Hekla eruption here?

L386-398 – When discussing dust influence on the albedos, you can also include that not only volcanic ash can be lifted to high altitudes and transported long distances. It is also Icelandic volcanic dust that can reach several km heights and travel long distances of thousands of km:

Dagsson-Waldhauserova, P., Renard, J.-B., Olafsson, H., Vignelles, D., Berthet, G., Verdier, N., Duverger, V., 2019. Vertical distribution of aerosols in dust storms during the Arctic winter. Scientific Reports 6, 1-11.

Djordjević D., Tošić I., Sakan S., Petrović S., ÄŘuričić-Milanković J., Finger D.C. and Dagsson-Waldhauserová P. 2019. Can Volcanic Dust Suspended From Surface Soil and Deserts of Iceland Be Transferred to Central Balkan Similarly to African Dust (Sahara)? Frontiers in Earth Sciences 7, 142-154.

Moroni B., Ólafur Arnalds, Pavla Dagsson Waldhauserová, Crocchianti, S., Vivani R., and Cappelletti, D. 2018. Mineralogical and chemical records of Icelandic dust sources upon Ny-Ålesund (Svalbard Islands). Frontiers in Earth Science 6, 187-219.

Beckett, F., Kylling, A., SigurÃřardóttir, G., von Löwis, S., and Witham, C., 2017. Quantifying the mass loading of particles in an ash cloud remobilized from tephra deposits on Iceland, Atmos. Chem. Phys., 17, 4401-4418.

Ovadnevaite J., Ceburnis D., Plauskaite-Sukiene K., Modini R., Dupuy R., Rimselyte I., Ramonet R., Kvietkus K., Ristovski Z., Berresheim H., O‘Dowd C.D., 2009. Volcanic sulphate and arctic dust plumes over the North Atlantic Ocean. Atmospheric Environment 43, 4968-4974

L405-417 – Can you explain better why Dyngjujökull shows positive albedo trend? Is it

after the Holuhraun eruption and reduction of dust events from Dyngjusandur towards the glacier?

L419-426 – Figure 11 and discussion. Doesn′t this show that warm, dry and dusty year as 2019 have similar impacts on albedo as volcanic eruption years?

L427 – Conclusions – It would be beneficial to conclude in one sentence also the difference in influence of tephra after eruption and dust during dusty year as 2019 on albedo.

L472- References should be ordered in ascending order (Palsson et al., Schmidt et al., Stroeve et al, need to be corrected).

L549-551 – Liu is not relevant reference in the text. They do not refer to volcanic ash from eruption, but general dust event. Consider to remove this from the reference list.

L554 – remove 'a' in Matlab, 2017a

L566 – Thorsteinsson et al., 2017 should be under T in the reference list, not under P.

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