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Interactive comment on "Aircraft-based observations and high-resolution simulations of an Icelandic dust storm" *by* A.-M. Blechschmidt et al.

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Blechschmidt et al (in discussion – henceforth, B12) present the results of a research aircraft flight during which they serendipitously encountered an intense dust event along the south coast of Iceland. On the basis of the aircraft measurements, satellite data, and modeling they state that their results "document the transport of dust from Icelandic sand fields towards the ocean." These measurements are indeed unique. There has been very little research on high-latitude deserts as sources of dust aerosol. Such sources are expected to become increasingly important as temperatures increase and glaciers retreat. Especially lacking are aircraft studies of airborne

dust from such sources and the factors that affect their emission and transport. In this regard B12 makes a substantial contribution to the field.

However there are some concerns about some aspects of the paper. Throughout B12 they refer to previous work on Iceland, especially the work of Thorsteinsson et al. [2011, T11] and to an earlier version of the recently-published Prospero et al., [2012, P12] who report on six years of dust measurements made on the island. In doing so B12 implies that their results are consistent with those of T11 and P12. However, while there is general agreement that there is significant dust activity on Iceland and that large amounts of dust are transported over the ocean, the sources implied in B12 differ considerably from the conclusions of T11 and P12. These differences suggest either that the event reported in B12 is unusual with regard to sources or that the modeling and the interpretation of the limited aircraft aerosol data were incorrect.

The modeling studies in B12 as depicted in Figure 8 suggest that the highest dust concentrations are found inland over central Iceland in the extreme north of the modeling domain. In this regard it should be noted that Figure 8 covers a relatively small area of southeast Iceland. This implies that at the time of the modeling the dust was coming mainly from interior terrains, the terrains identified by Arnalds as cited in B12. However, given the limited domain shown in Figure 8 we cannot see the origin of these high dust values. I would suppose that a considerable fraction of the dust in the northern part of Figure 8 is advected from the North, not generated within the high-resolution grid box (1km, G3) but rather in the 5km grid box (G2). MODIS images on 26 and 28 February show large areas of bare ground outside the G3 box. It would be helpful if the coverage in Figure 8 extended further to the North although it is recognized that the high-resolution domain is restricted to the area in Figure 8. The results from this larger domain should be presented in the paper so that the reader has a better sense of the dust sources that feed into the G3 domain.

In any case, while those inland terrains are known sources of dust, they are not the ones that are normally associated with the large dust events cited in T11 or P12. T11 reports on two years of data on PM 10 measurements made in the Reykjavik area and at air quality stations on the southeast coast. Amongst other presentations, they show time series of PM10 measurements and winds during six major dust events in 2008 (which I assume were the six largest of the year). The dust concentrations were comparable to those reported in B12 and P12. However in T11, in all cases winds were from the east and southeast. Indeed, in their conclusions T12 specifically states, “Periods of high (>100 μg m3, 30-min values) levels of particulate matter pollution (PM10) in Reykjavík are directly related to aeolian sediment transport from the sandur [proglacial sand deposit] region at Landeyjasandur [west of Vatnajökull ice cap] some 100 km ESE of the capital city.” The jet (red area in B12 Figure 7) shows strong easterly flow which would could well serve to carry dust from the ice-cap-linked sandur sources to Reykyavik if, indeed, such sources had been activated in the model. (In this regard, were PM 10 measurements made in Reykjavik on the flight day? T11 shows measurements throughout this period.)

Similarly P12 reports on six years of quasi-daily dust measurements made on the island of Heimaey, situated off the southeast coast of Iceland. P12 shows that low dust concentrations are often present in the region. However on occasion intense dust events are observed. All major dust events are linked to the sandur deposits in the region of the MÃ¡rdalsjökull and Vatnajökull ice caps. Six of these major events were captured in MODIS and SeaWiFS satellite images which show large plumes emitted from these specific sources and carried far to the south and east of Iceland. The conclusions of P12 are in agreement with those stated in T11, “There is a long history of glacial outburst flood events that have affected large areas of the floodplain (40 - 50 km2) and deposit material that is susceptible to aeolian entrainment (Smith and Dugmore, 2006). Arnalds (2010) identified Landeyjasandur as a major dust plume source area in his recent review of Iceland dust sources and this is confirmed by the events analyzed in this [T11] paper. Satellite images show that sandur regions around the glaciers in Iceland are prone to aeolian sediment transport and that a significant amount of dust is transported to populated areas, like Reykjavík.” In contrast B12 in

Figure 8 suggests that the major sources lie to the north of the MÃ¡rdalsjökull and Vatnajökull source regions. It is notable that B12 Figure 2 shows very high winds between the MÃ¡rdalsjökull and Vatnajökull ice caps. One would expect sources in this region to be activated under such conditions. MODIS shows that these source areas were snow-free on 26 and 28 February.

I am not a modeler and, thus, I cannot comment in depth on the modeling schemes. In B12 the authors discuss how they adapted their model to the unique conditions on Iceland with regard to vegetation cover and other terrain characteristics. However, in the absence of knowledge about dust source terrain responses, they found it necessary to use test values of "α" (the erodible soil fraction). In this manner they arrived at values of α that yielded the best fit to their measurement data. Given that major dust events as reported in T11 and P12 are derived from sandur deposits and given the unusual nature of these soils, it is not clear how these soils might respond relative to the conventional soil classifications and test values of α used in the model. In this regard, it should be noted that the satellite images cited in P12 (and the one in T11) show that the sandur dust sources were typically seen as clearly-defined localized "point" sources, i.e., dust “hot spots”. Because of the small-scale and unique character of these hot-spot sources, the modeling scheme might not be capable of capturing their activity. These factors could explain why B12 sees so little dust coming from the sandur deposit region in southeastern Iceland.

Regarding the aerosol measurements themselves, I recognize that the flight was not intended to study aerosols and consequently the instrumentation was limited. However I have a concern about the measurements made by the Passive Cavity Aerosol Spectrometer Probe (PCASP), “. . .an optical particle counter which counts and sizes aerosols in 15 channels between 0.1 μm and 3.0 μm diameter. The instrument measures the intensity of light backscattered by particles that pass a laser beam.” In our experience, the dust color is a gray-to-black which is consistent with the dust being derived from the sandur deposits. Indeed one can see in Google Earth that the most active source areas around the ice caps are quite dark. Consequently one might expect that size measurements (and count response) based on light scatter (i.e., the PCASP) will be affected. Was any consideration give to that aspect? In any event, there is a large gap between the PCASP with an upper limit of 3 μm diameter and the cloud particle instruments which have a lower limit of 25 μm diameter. This gap is important from the standpoint of long range transport which would mostly consist of particles under 25 μm diameter with a large fraction of the mass falling between 3 μm and 10 μm diameter.

The authors comment on a peak in particle number concentrations observed at 18.9W. They suggest that “It could be due to volcanic emissions or sulfate produced from DMS not included in the model set up.” It seems unlikely that the DMS source could be significant in February when primary productivity is extremely low. Thus DMS emissions are expected to be quite low. Prospero et al. [1995] in their Heimaey aerosol measurements found an extremely strong seasonal cycle in methanesulfonic acid (MSA) concentrations with values close to zero in winter and early spring. Also the long-distance transport of pollutants cannot be completely excluded. Prospero et al.[1995] show that on occasion pollution events can be transported from across the polar regions; I do not know if the CO measurements would be useful in identifying such events. Some insights on this issue could be provided by the PCASP aerosol size data. Although the size range measured by the PCAS is limited (0.1 to 3.0 um diameter), these data might present some insights on the hypothesized contribution from sulfate relative to dust and sea salt. It would be interesting and informative to have a figure that shows changes in relative size distribution (say below 0.5 or 1.0 um and that in the larger size range). Indeed, it would be very helpful to see PCASP data over the entire flight track of the island. If the sources are indeed located over the central part of Iceland, you should see strong changes along the northwestern leg of the flight triangle; data along the southeast leg would also provide "background" aerosol data that could be extremely useful in the context of the general source identification problem. This data would also help to resolve the conflict with the CALIPSO results (Section 5) which suggested that

there was dust over the northwestern areas of Iceland.

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