General: This is potentially an interesting an important paper dealing with the use of ground based X-band and C-band polarization radar and SSM-I microwave observations from space to characterize the size and total columnar concentration mass of the ash from the Grimsvotn volcanic eruption, Iceland, May 21, 2011. However, closer inspection of the paper raises fundamental questions as to the accuracy of the radar retrievals and the reliability of the inferences claimed in the paper.

Specific.
The derivations of ash properties from the dual-polarization X-band radar (DPX) situated 70km from the volcano are as follows. Fig 4 is a PPI displaying the maximum value of reflectivity (Z) from four PPIs at different elevation angles and the polarisation parameters associated with the max Z; Fig 5 has the values of the radar parameters at an azimuth of 21degs at the four elevations with the actual values as a function of range in fig 6, finally fig 8 shows an RHI (vertical slice) with the derived the derived ash mass concentration and ash type/size. The data reported are for just one single time of 0712 on May 22, 2011, although the radar appears to have been scanning for many hours.

The following questions arise:

1.The ash type/size derived in fig 8 follow the values of Z in fig 5a very closely, so that high Z is where we have large (10mm) ash and low Z with small (10um) ash, but, surprisingly, the large ash is associated with the lowest low mass concentrations of <1g/m^3, and the highest mass concentration (red – 10g/m^3) is where the ash size is only 10 and 100um (volume one million times less). How does this unphysical result, that the high Z plume above the volcano vent has the biggest particles but by far the lowest ash mass concentration, arise?

2. The coefficients, a and b, for computing the ash mass concentration, Ca. are given in Table 2 where Ca = a Z^b, and b is about 0.4, but more importantly depending upon the categorisation into Fine Ash, Coarse Ash, Large and Small Lapilli (sizes, 10mm, 1mm, 100um and 10um) the value of 'a' varies from 4.37, to 0.78, to 0.0837, to 0.00193. Consequently a value of Z =40dBZ (Z=10,000) which is the value deemed to define the plume (Section 3.1, first para) leads, by definitin to a Ca of 0.15, 1.68, 13.9, and 244 g/m^3. Clearly, the classification scheme into the four categories of different sized ash is crucial in the derivation of the ash mass concentration. This classification scheme is referred to in section 4 first para. It depends upon values of Z, KDP, and phhv, but apart from a reference to Marzano paper on 'synthetic signatures of volcanic ash' there is no information as to how this classification method works or to its the reliability or to any validation. As commented above, visual inspection of Fig 8 reveals that the classification scheme depends only on the value of Z and the effect of the (very noisy values -see point 3) of KDP and phohv is minimal.

3. The discussion and interpretation of the noisy values of KDP and phohv is superficial, quantitative and subjective.

a) The polarimetric radar observables are discussed in section 2.1.1, but only in terms of hydrometeors (water drops and ice particles); there is no quantitative discussion in the paper of how values of ZDR, KDP and phohv, might be interpreted for ash.

b) We do learn in the last two paragraphs of section 2.1.2 that a filter of width 7km smoothed the KDP estimate, and 5km for ZDR data. Would this not affect the inferences made from plots with higher range resolution? In the last sentence, after all the discussion on ZDR, we are told that it was not used quantitatively, so why was it mentioned in the first place.

c) Section 3.1 on radar data interpretation has vague and unsubstantiated statements. On line 6 we learn that i) the signature of the volcanic plume is 40dBZ, then on line 12 ii) that a strong depression of phovh values seems to be an important volcanic plume signature, in para 2, than within the plume Z and phov are well correlated with values larger than 25dBZ corresponding to low values of phohv, and iii) in the same area KDP shows positive values of about 0.5deg/km. Let's examine these statements in terms of figures 5 and 6. First of all – is the plume defined by 40dBZ or 25dBZ? It looks more like 40dBZ. It is clear from fig 5 that phohv is lowered behind the plume due to the well known effect of incomplete beam filling. The profiles in fig 6 confirm this – in three of the four profiles phohv is a minimum in the low values of Z behind the main plume. The authors never mention the problem of X-band attenuation and differential attenuation with these high values of Z, so that behind the high Z plume, one half of the beam has different ratios of H and V illumination from the other half, so phohv is lowered. The authors should produce a scatter plot of the values of phohv and Z to see if their assertion of correlation is correct. Then they should also plot the values of phohv with the distance ahead of, within and behind the max in Z and see if these are correlated. Finally the statement about KDP being high within the plume – again a rigorous statistic analysis is needed to justify this, but examination of fig 6 suggests that values of KDP (blue stars) are noisy and there is little correlation with the high Z (solid blue line). It should also be mentioned that the 7km filtering length of KDP would smooth most features associated with the sharp maximum in Z.

4) The C-band radar. In the abstract we learn that this is at a range of 260km from the radar, without mentioning that this implies a beam width of almost 5km. The only results from the C-band seem to be in Fig 9, where the total columnar content of ice is plotted and compared with SSMI and X-band radar. The reliability of the mass concentration derived from the X-band has already been questioned above, but the problems will be far worse at C-band with a 5km beamwidth. There is no discussion of how the ash mass is retrieved at C-band or of how beam filling problems might affect the undefined algorithm.

5) Only one PPI series at 0712 hours is analysed in the paper. This is justified (Section 3 – last line) because this was the only time the X and C band data were jointly available. Since the C-band data contribution to the paper is negligible, this raises the question as to why the many hours of X-band data were not analysed. It would be interesting to see if the ash retrievals showed any consistency as they evolved from scan to scan.