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Atmospheric Measurement Techniques Discussions

Interactive comment on "Pore structure 3-D imaging by synchrotron micro-tomography of graupel grains" *by* F. Enzmann et al.

Anonymous Referee #1

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The paper by Enzmann et al shows the use of synchrotron micro-tomography to image ice particles at nearly sub-micrometer resolution. To investigate ice structures at this resolution is clearly important for atmospheric science. The paper in its current form is however poorly written. The evaluation of the data is described unclear and insufficient to reproduce the procedure. At the focus of the journal chosen is "Techniques", this part must be substantially enhanced, as detailed in the point-by-point comments. For example, I would expect to find at least one unsegmented image, to make my mind how good the quality of the data is. The visualization of the graupel grains in the accompanying figures leaves a lot of room for improvement, considering that the authors have access to Avizo. I expect here high-quality images, showing the features of grapple with highest detail. I suggest a major revision, a clear focus on measurement

technique, and a check of the use of English.

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Detailed comments (number at the begin of sentence correspond to page/line number)

General comment on units used: the authors use a hard to understand logic in using different units: g, cm, m with varying pre-exponents. I suggest to us SI units with SI-recommended prefixes (a volume of 10-4 cmˆ3, density in g cm-3 etc)

4763/27 employing -> using ../28 no comma before that

4764/1 "the porosity of hydrometeors can be eventually be considered to affect ...." a bit a far-fetched statement.

.../3 this is a surprisingly wide definition. Densities above 0.6 Mg/mˆ3 have probably little open porosity?

...15 Tradition 2-D imaging .... : this statement is not correct. The authors seem not to be aware of the science of stereology, and I recommend to look into the corresponding literature (Stereology for statisticians Adrian Baddeley, Eva B. Vedel Jensen Chapman & Hall/CRC, 2005). Porosity, specific surface area, pore size distribution can be precisely measured by this technique. Clearly, optical microscopy wll still be difficult with rapidly metamorphosing ice. I suggest to completely rewrite the paragraph.

. . . / 23 The term "metamorphosis" is used in biology. The geoscience community (including geology) uses "metamorphism", synonymous for "recrystallization". "Annealing" is a specific form to induce metamorphism, and typically used if a metastable crystal form is generated by a rapid temperature change. Please consider to use consistently "metamorphism", as in other parts of the manuscript.

4765/4 I think the manuscript is here not up-to-date with the SEM imaging done by Si Chen et al. (eg The Evolution of Individual Snowflakes during Metamorphism, S. Chen and I. Baker, Journal of Geophysical Research 115, D21114, DOI:

10.1029/2010JD014132. Structural Evolution during Ice Sphere Sintering , S. Chen and I. Baker, 2010, Hydrological Processes 24, DOI: 10.1002/hyp.7787. Observation of the Morphology and Sublimation-induced Changes in Uncoated Snow using Scanning Electron Microscopy, S. Chen and I. Baker, 2010, Hydrological Processes 24, DOI: 10.1002/hyp.7689. SEM sublimation and imaging could be a useful technique for grapple.

.../23 The temperature history of the different samples is scattered and difficult to follow. If this is important in this paper (I don't think so for most of the paper), then clarify. Otherwise, shorten the story, and just write that for a quantitative analysis _continuous_ storage at LN temperature is necessary to conserve sub-micrometer features.

4766/7 evapourated -> evaporated (use spell-checker for the entire manuscript)

.../27 what is the importance o tris-poly-ethyl. . ... in this context? . . . again, the temperature history is confusing

4767/23 Sometimes "cyclohexane" sometimes "cycloheptane" is used for solidifying. What is _really_ used? I also expect a substantial difference in contrast between ice embedded in cyclo-xxx and ice-air. Please report on this.

4769/3 What do you mean by "shape metamorphism"? Metamorphism is always about shape, literally metamorphism means "change in form"

. . ./11 "isolating" means "to set apart" -> insulating

.../23 ff Very wordy sentence and explanation for something trivial. Shorten.

4770/18 "automatic gradient thresholding for segmentation": which technique do you refer to? Please add a reference. In my opinion, the whole part on data and image processing (section 2.3 and 2.4) was written with little experience in these techniques, and sounds like a poorly rewritten tutorial from Avizo. I recommend to involve a specialist in data and tomographic image processing for the revision.

A common and highly useful technique for low contrast image segmentation is anisotropic diffusion filtering.

4771 /ff I think the camera at PSI has at least 12-bit recording, and either float or 16-bit integers after reconstruction (by the way, what kind of reconstruction algorithm was used?) - to process the tomograms with just 8-bit data is not state of the art.

4772/ff What is resolution expressed as the modulation transfer function (MTF) of the used system?

.../3 a triangulated surface is _not_ a finite-element representation

.../14 ff Which code was used for the burning algorithm? Provide a reference. Was the procedure applied to a volume or to a (plane) image?

4773/10 The description provided is not clear. Please use a formula. I also found it unusual to use the volume to surface ratio, and not the more common specific surface area.

4774/16 What do you mean by "could ultimately not be determined. . ."? There is _no_ contrast between ice crystals (I suppose you infer that there should be some contrast because of the grain boundary) - but then the resolution must be a few nanometer !

4775/16 "the induced _isothermal_ metamorphism" why isothermal? there is a lot of temperature gradient during the described procedure. Simply, this test shows that metamorphism is extremely fast at this scale and temperatures.

4776/19 "a smoothing of the ice surface" : this is only the case for isothermal metamorphism, but not during temperature gradient (kinetic) metamorphism.

4777/15 lower -> smaller

4778/21 The sentence starting with "if to compare . . ." can't be understood by the reviewer.

4779/26 What do you mean by "a just affordable but flexible base" - I think synchrotron tomography is very expensive and also not very flexible . . ..

Caption of Fig. 4. What do you mean by "frames width 0.7 mm"? Has image 4b (after "annealing") the same size? The visualization is very poor, use an anaglyph image to present these data.

Interactive comment on Atmos. Meas. Tech. Discuss., 3, 4761, 2010.