The manuscript “Theory of isotope fractionation on facetted ice crystals” by J. Nelson proposes a theoretical basis of taking into account the complexity of ice crystals formation on the water isotopic fractionation. If correct, this complexity adds a significant uncertainty into the often used paleo-thermometry of water isotope signals in snow and ice. I think the paper is clearly suited for readers of Atmospheric Chemistry and Physics and the possible consequences of this study are very relevant not only for the scientific community working on paleo-climatology but also for the widespread use of the water isotopes as an analytical tool for the global hydrological cycle. The manuscript is well presented and clear. The obvious “problem” with this study is that there are no experimental hints or evidences to actually corroborate the proposed impact of crystals shape and form on the water isotopes. This is hardly any problem in modern elemantary physics but in Earth Sciences it is quite unusual. However, as the author rightly observes, there are hardly any measurement on this issue in any case and not only specifically on the mechanisms proposed in this study. The call for future measurements made here in the manuscripts is therefore a central result of this study. I recommend publication of the manuscript and I would like to make some minor remarks and ask some questions that might help to improve the quality of the paper.

The only mayor question I have concerns again the obvious lack of direct evidence for the suggested relation between crystal shape and isotopic composition. For at least 30 years isotopic surface samples were taken along different transects in Antarctica. I point the author in particular to the recently published paper by Masson-Delmotte et al. (“A Review of Antarctic Surface Snow Isotopic Composition: Observations, Atmospheric Circulation, and Isotopic Modeling” in Journal of Climate, 2008 [see http://journals.ametsoc.org/doi/abs/10.1175/2007JCLI2139.1]). The transects took place between the Antarctic coast to the interior ending often at the different ice core drilling sites at more the 3500 meter height on the very dry and cold East Antarctic plateau. Fig. 6 in the same paper shows the relations between the isotopes and temperatures and between the isotopes and the deuterium excess. Shouldn’t we expect much more noise in these relationships if the influence of the crystal shape is as big as suggested here? In the dry interior nearly all precipitation falls as “diamond dust”, very small crystals formed near the extremely cold surface. To the contrary near the coast most of the precipitation is formed in typical extratropical storm systems and the corresponding snow/ice crystals are very large and of different form ans shape. How is it possible that still surface temperature seems to be such a dominating factor if such a variety of crystal shapes and formation history is such an important factor as suggested here in the paper? Might be it’s worth to speculate on this question in the conclusion/discussion part of the paper.

Some minor points

1) Introduction, first paragraph. It was shown that surface temperatures in Antarctica gave even better relationship with the isotopic composition than condensation temperatures. The reason for that is that in the “predictor” surface temperature there are more processes included than just the actual condensation processes (such as orography, wind strength, boundary layer stability and might be even typical ice crystal shape). So condensation temperature is not really the target of paleoclimatic reconstructions since we

know that there are processes involved in the isotopic fraction better linked to surface temperatures.

2) Introduction: Might be better to specify always the alpha. ${}^{18}\alpha$ and ${}^{D}\alpha$ for example.
3) 2.2 Crystal growth. I think it is helpful to mention here directly the dependencies of some of the introduced parameters, e.g. $\sigma$s depends on temperature and $\beta$ depends on the corresponding isotopes etc.
4) p17427 first paragraph: The mentioned values for Zv (between 7.5 and 3700) are measured or theoretical? Reference?
5) p17427 In my understanding $\chi$ is the instantaneous water isotopic relationship of some fraction of an ice crystal, not necessarily the entire crystal. To obtain the final composition of the entire crystal one needs to integrate over the entire process in small steps leading to a Rayleigh type distillation. This point is not relevant here but the distinction should be clear since the final composition depends on where in a cloud the crystal has been formed and where it continues growing during its travel through a cloud and below.
6) P 17429 “whenever d not equal 1/alpha_s”. I was a little surprised by this sentence. A priori this two quantities are independent from each other and never should be equal?
7) P 17430 formula 10: Is there a motivation for this formula? Reference?
8) P 17435 estimation of the possible impact of the crystal shape on the isotope temperature relationship: See Fig 6 b in the above mentioned Masson JoCl paper. Compare the mentioned 15°C uncertainty due to crystal shape with the real observed spread of the data.