Interactive Comments on "Ice Nucleation Terminology" by Vali et al. (2014). Comments posted by Zamin Kanji are on behalf of the Lohmann Ice Nucleation Group at ETH – Zurich and do not reflect the sole opinion of the author.

General Comments:

We thank the authors for initiating the process of feedback and giving the chance to the general community to respond to this paper in form of the interactive discussion. This allows others to make a contribution to a paper that could be instrumental in shaping how the atmospheric science community will use ice nucleation terminology in future work.

The paper currently lacks sufficient introduction explaining why there is a need for publishing a new terminology paper. The previous terminology paper [*Vali*, 1985] defines many of the terms herein and has not been referred to in the current paper. We think it should be acknowledged. For definitions that are not different from that described in Vali [1985], it should be clarified and the paper should be cited. Most of the definitions proposed here - appear in Pruppacher and Klett [1997]. Why is this not referred to in the paper, and how are the current definitions different from what is suggested in P&K-97?

Explanations for certain definitions could be supplied in addition to stating the definition. In some cases, definitions increase ambiguity (for example the use of INxx, see specific comments below), while this has been acknowledged in the abstract, it does not help clarify the terms used.

Also, how are the contributions of the community going to be acknowledged in this paper? In Vali (1985), suggestions were put forth by the committee on Nucleation and Atmospheric Aerosols as well as the International Commission on Cloud Physics – why is this not the case this time around?

A large contingent of ice nucleation researchers, for example those involved in INUIT have not been involved prior to publishing the current version. Is there a plan to actively seek out the contributions from researchers who have been involved in ice nucleation work over the last decade in addition to the current author list? Would it make sense to have a spin-off meeting during a conference where people have the chance to make their contributions to this process?

In various places in the document, could it be specified whether the definitions are based on currently used experimental approaches or are meant to be fundamental. Authors do acknowledge phenomenological nature of the terms (however, in that case the definitions such as condensation freezing, and apparent nucleation rate need to be added and defined more clearly (see detailed comments below)).

Related to the above, perhaps the authors would consider adding a section that would define terms to describe current experimentally derived definitions such as condensation freezing/regime, apparent nucleation rate, $n_{s(geo)}$ (ice active surface density derived from geometric surface area), $n_{s(BET)}$ (ice active surface density derived from BET surface area) and so on.

The authors should consider specifying that the terminology is specific to the atmospheric science/cloud nucleation physics community rather than just ice nucleation in general which could extend to food preservation and molecular sciences.

Specific comments:

Deposition (page 22158, line 7): We think this should be specified as "Deposition Nucleation". The word deposition is too vague. It could mean many different things.

Freezing (page 22158, line 12): Can freezing of a solution droplet be included here? Why only freezing of water has been considered?

Why is there no definition for **condensation freezing?** Can the authors propose a definition for this for example: freezing immediately after CCN activation? i.e. CCN activation followed by freezing whereby both processes occur at the same temperature.

OR

water condensation immediately followed by freezing. Thus implying sub-zero temperature water condensation in order for freezing to occur at the same temperature as the condensation process.

Embryo (page 22157, line 5): should not be interchangeable with "germ". Embryo should refer to the subcritical ice cluster whereas germ refers to the stable cluster that is capable of growing into an ice crystal i.e. one that has overcome the critical size at a given T and RH or is in equilibrium with the metastable parent phase at a given set of T and RH conditions. An example is from P&K-97 (page 192, line 5-8) where it is explained that an embryo is subcritical (i-mer from the embryo population) and germ is critical size of an embryo that will be followed by ice formation.

Substrate (Page 22158, line 22): substrate is a generally used expression to denote the surface on which samples and particulates such as droplets, ice nuclei etc are deposited. A definition that relates it specifically to the ice nucleating surface would lead to confusion.

IN nomenclature/INP/INxx (Page 22159)

- ⇨ We find this section to be introducing confusion and making the terminology less clear than what is currently in use. We do not see a need to change the nomenclature as suggested here. In our community it is clear when to use the term 'ice nucleus' (this paper's definition of INP) and that in CNT the ice nucleus refers to the critical embryo/cluster (e.g. Strey et al., *The Problem of Measuring Homogeneous Nucleation Rates and the Molecular Contents of Nuclei: Progress in the From of Nucleation Pulse Measurements, J. Phys. Chem. 1994, 98, 7748-7758*).
- ⇨ Short forms like INprotein, INgene, INmaterial are grammatically incorrect because of mixing upper and lower cases in one word. These should rather be written as the whole word e.g. "Ice nucleating protein".
- ⇨ Using a subscript could be an alternate solution. For example IN_{gene}, $IN_{protein}$, this way we are still maintaining the use of IN but yet imparting more knowledge about its nature being a protein or gene etc.
- ⇨ Could the authors specify what ice nucleus/nuclei (IN) will mean? According to CNT, it should be the embryo that has reached the critical size so that energy is released upon further growth. In the atmospheric science community, IN generally refers to particles that induce heterogeneous ice nucleation. Do the authors agree with this? If so, this double use of nucleus should be clarified.

- ⇨ A suggestion could be why not retain the use of IN and define it as Ice Nucleator instead of changing to INP. This way, we would avoid making previous use of IN obsolete.
- ⇨ INP has been used in various publications to mean ice nucleating protein, so changing it to ice nucleating particles will introduce further confusion
- ⇨ This will introduce inconsistency with warm phase clouds. Cloud Condensation Nuclei (CCN) vs IN(P)?

Nucleation Rate/Freezing Rate (Page 22160 lines 8/15 respectively).

- ⇨ The units should be stated clearly in brackets that will depict nucleation/freezing rate is a function of certain variables, e.g. T, V or t (see point below).
- ⇨ Units are not correct. Nucleation rate/freezing rate are typically given per time. When using "per volume and time" or "per surface and time" it should be referred to as nucleation rate coefficient. Perhaps the authors would consider adding this as a separate definition. In this regard the distinction between freezing and nucleation rate maybe redundant.
- ⇨ Formulas that follow should be adjusted from $J_V(t)$ to $J(V,t)$, depending on nucleation rate terminology adapted because the function depends on both variables.
- ⇨ The wording that defines nucleation rate and freezing rate should be made clearer. This has been explained more clearly in Vali [2014]. The authors could consider referring to this paper here.
- ⇨ To derive nucleation rates in experimental work, we use residence times or cooling rates, not nucleation times. Therefore we should be specific that presented nucleation rates are lower limits. Without time dependent studies at all temperatures and investigated aerosol samples, which is not trivial, it may be better to use the phrase "apparent nucleation rate" (see last point below).
- ⇨ As mentioned in the general comments section, the authors may consider adding a section or re-defining the paper for terminology to better describe results obtained from experimental ice nucleation work.

Stochastic Nucleation (Page 22160, line 21): Do the authors mean "Stochastic Model"? "Stochastic nucleation" is redundant. Nucleation is fundamentally a stochastic process. Can P&K-97 not be referred to for this terminology?

Site (Page 22161, line 6): Why not use active site, like has been currently and previously used in published studies. We don't think just site is specific enough.

Site-Specific Nucleation (Page 22161, line 29): This should be replaced with site-specific model. Replace "unit of volume liquid" with "unit of surface of substrate" since the volume would not be a predicting variable for heterogeneous nucleation as long as it is a surface relevant process. Reference for V66 model is missing.

Apparent Nucleation Rate/ Lower Limit to Nucleation Rate: Given that most observation techniques use residence times (in cloud chambers) or observation times/cooling rates (for cold stage/substrate) studies to determine nucleation rates from ice formation experiments, it would be prudent to consider that neither of these methods can accurately report a nucleation time, rather just an observation time during which nucleation occurs. As such would it be more appropriate to refer to such derived

nucleation rates as “apparent nucleation rate” or specify reporting of “lower limit to nucleation rate”?

Pruppacher, H. R., and J. D. Klett (1997), *Microphysics of Clouds and Precipitation*, 2nd Edition ed., 976 pp., Kluwer, Dordrecht.

Vali, G. (1985), NUCLEATION TERMINOLOGY, *Bulletin of the American Meteorological Society*, *66*(11), 1426-1427.

Vali, G. (2014), Interpretation of freezing nucleation experiments: singular and stochastic; sites and surfaces, *Atmos. Chem. Phys. Discuss.*, *14*(2), 1711-1760, doi:10.5194/acpd-14-1711-2014.