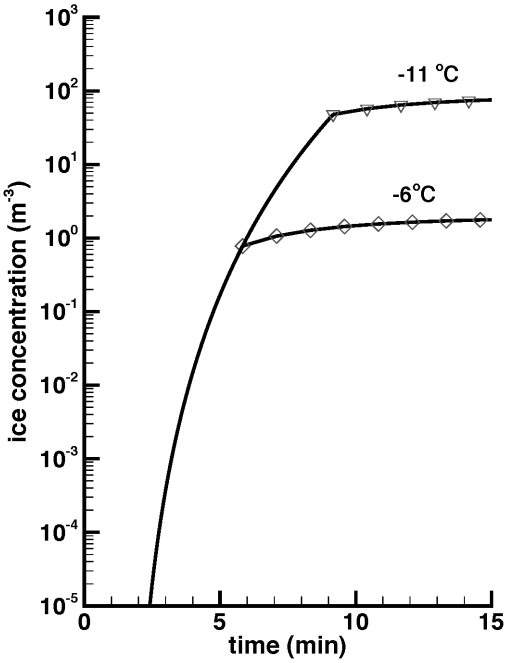
Reply to a comment by Anonymous Referee #1

The reviewer points to an overemphasis in the paper of the importance of temperature over that of time for ice nucleation in a cloud parcel. Since this is a key issue, some additional comments are warranted.

The reviewer contrasts the cases of active convection with significant updraft velocities and cooling rates versus clouds with slow development and long lifetime. Clearly, the latter type of cloud has the potential to have more ice form via immersion freezing as time goes on even without further cooling. However, the main determinant for how much ice forms is the temperature to which that cloud has cooled. An estimate of the relative magnitudes involved is shown in the figure below, based on the Time-dependent Freezing Rate (TDFR) parcel model (Vali and Snider, 2013). Details of the model and the assumed abundance of freezing nuclei are described in the reference.



The plot shows ice development in a parcel of raising with 4 m s^{-1} updraft velocity and then stopping at -6ºC in one case and at -11ºC in another. Line segments with symbols show the increase in ice concentration after the parcel ceased to rise. While far from negligible, the additional ice formation is smaller than what additional cooling produces.

While this example, and other similar calculations, confirm that temperature is the principal factor to consider, the reviewer's comments indicate that more precision will need to be sought in stating that fact when the paper is revised. Along with other suggestions of the reviewer, the final manuscript will include appropriate revisions.

Reference:

Vali, G. and J. R. Snider, 2013: Time and temperature dependence of freezing nucleation in a cloud parcel model. Nucleation and Atmospheric Aerosols, 19th International Conference, Ed. P.J.DeMott and C.D.O'Dowd, AIP Publishing, Melville, New York, pp. 914-917