Response to Referee #3

I'd like to express my gratitude to the reviewer for providing thoughtful and insightful comments on this work, which have helped to improve the paper.

Specific comment:

The parameterisations of Franklin (2008) only consider the effects of turbulence on small collector cloud droplets with radii between 10 and 30 microns. This is different to the study of Ayala et al. (2008) (the work which the Wang-Ayala parameterisation is based on) who consider droplets up to 60 microns in radius. For the small droplets considered in Franklin (2008) it is the dissipation range turbulence that governs the droplet motion (e.g. Wang and Maxey 1993) and, therefore, the dissipation rate is the dominant flow property that determines the collision rate, with the Reynolds number effect of significantly less importance. This is clearly illustrated in Figure 4. of Ayala et al. (2008) who show that Reynolds number effects are only apparent for droplets of radius 40 microns and larger, which are larger than the size of droplets considered in Franklin (2008). This result is also described in Wyszogrodzki et al. (2013) who state that small drops with radius less than 30 microns are not affected by the root mean square velocity, or Re_λ. This is the reasoning behind the parameterisations of Franklin (2008) being a function of the dissipation rate only, where equation (4) of Franklin (2008) has been used to eliminate Re_λ. An additional discussion on why the dependence on dissipation rate only is an appropriate assumption is included in the revised paper.

The approach of relating the dissipation rate to Re_λ is also taken by Seifert et al. (2010), who use the Wang-Ayala parameterisation to generate an autoconversion scheme for their bulk model that includes the effects of turbulence. They take the same approach in the sense that the dissipation rate and Re_λ are functionally dependent in their calculation of the Reynolds number from the LES flow field, which means that turbulence is only characterized by one of these quantities, the dissipation rate. The advantage of the current approach is the wide range of dissipation rates used in the DNS, ranging up to 1500 cm^2s^{-3}, which is much larger than the rates considered by others. The kernel parameter in Seifert et al. (2010) includes a linear dependence on the dissipation rate, which is shown by Franklin et al. (2007) and Ayala et al. (2008) to be an incorrect assumption with the turbulent enhancement of the collision kernel showing a strong non-linear dependence, increasing as the dissipation rate increases, which is captured in the parameterisations used here.

It is also worth noting that in the work of Seifert et al. (2010) and Wyszogrodzki et al. (2013), the representation of the turbulent enhancement of the collision efficiency is a linear function of dissipation rate only, there is no dependence on Re_λ .

In addition, it is important to note here the reasons for the difference between the results of Ayala et al. (2008; which I think are the red circles in the figure provided in this comment) and Franklin et al. (2007): different schemes used to force the large-scale flow and different values of viscosity and density ratio between air and water. Ayala et al. (2008) noted the role that the different forcing schemes (stochastic in Ayala and deterministic in Franklin) may have in generating differences in the turbulent collision kernels in the two studies. Kunnen et al. (2013) use a different approach whereby turbulence is synthetically generated and they show good agreement with the results of Franklin et al. (2007). Kunnen et al. (2013) also used similar values of the momentum viscosity coefficient and density to Franklin et al. (2007), those that correspond to typical atmospheric warm cloud conditions.

As noted in the final summary section of the paper, there needs to be further work done to improve the existing parameterisations that include the effects of turbulence on cloud droplet collision rates. The work by Rosa et al. (2013) shown in this comment is an important step towards that goal.