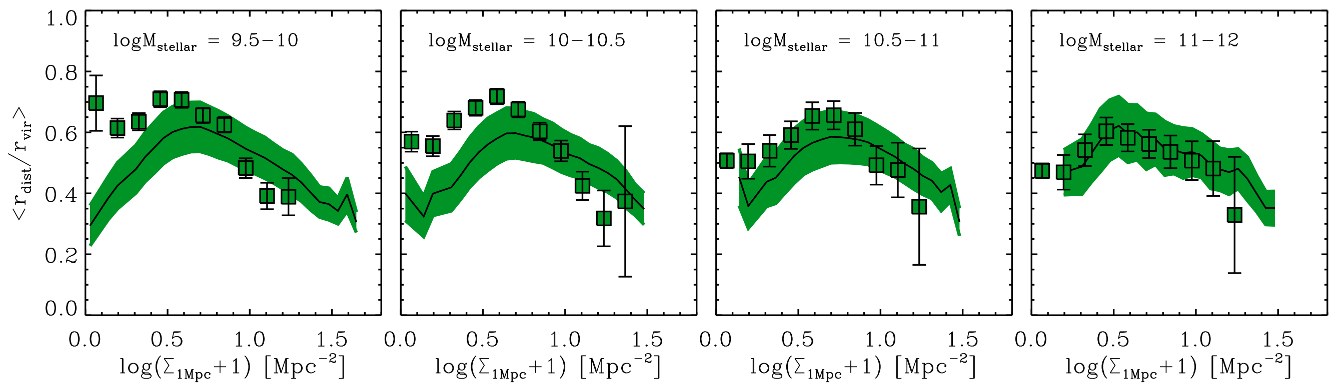

Figure 10. Mean radial distance versus the 1 Mpc density for satellites in different stellar mass bins (different panels) in observations (symbols) and models (lines with shaded areas). Density and radial distance are strongly correlated for densities above $\log(\Sigma_{1\mathrm{Mpc}}+1) > 0.5$.

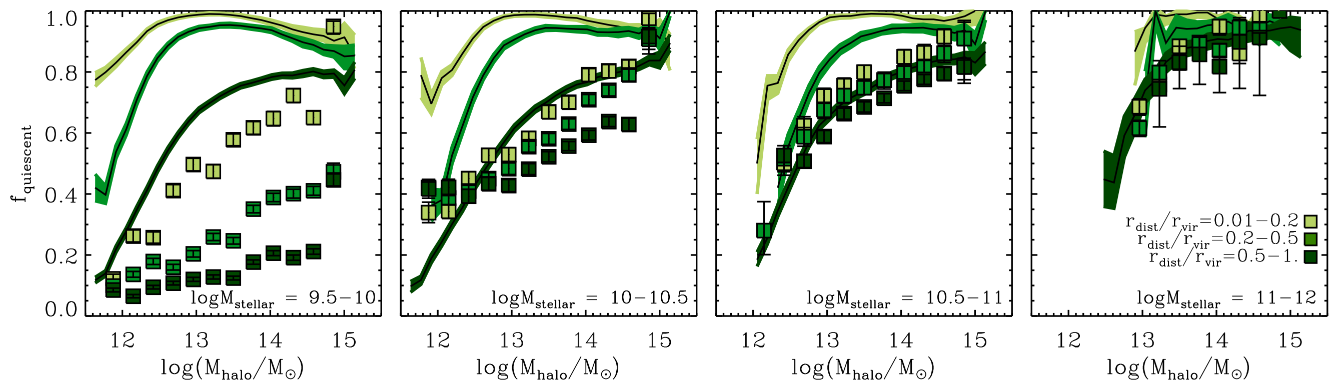

Figure 11. Quiescent fractions of satellite galaxies divided into bins of their radial distance to the halo centre (different colours as indicated in the legend) are plotted versus the parent halo mass for observations (symbols) and the Guo model (lines with shaded areas). Different panels correspond to different stellar mass bins. Interestingly, observations mainly reveal a dependence on the radial distance for lower mass satellites.

We have verified (not shown here) that at fixed density and stellar mass, there is hardly any residual dependence on parent halo mass or on radial distance. This means that the increasing fraction of quenched satellites as a function of density is fully explained by the trend as a function of the parent halo mass and radial distance. Equivalently, the halo mass and radial trends can be viewed as components of the trend with density.

In contrast to the observations, model satellites show a significant residual dependence on the radial distance on top of the host halo mass up to large stellar masses of $\log(M_{\mathrm{stellar}}/M_{\odot}) = 11$. In addition, models extremely overestimate the quiescent satellite fractions at a given halo mass and radial distance, particularly in the innermost parts of their parent haloes. Low-mass model satellites in low-mass host haloes have a strong dependence on the radial distance, while most of the satellites residing in massive host haloes are already quenched irrespectively of the radial distance. In contrast, observations reveal just the opposite trends.

Overall, these results confirm and strengthen our earlier conclusion that model satellites, particularly the low mass ones, suffer from too strong environmental effects leading to too short quenching time-scales. Moreover, these strong environmental effects predict excessive residual dependence on the radial distance for $\log(M_{\mathrm{stellar}}/M_{\odot}) > 10$ which is not displayed by observations.

5 CONSTRAINING QUENCHING TIME SCALES FOR SATELLITES

In this section, we estimate which time scales for quenching star formation in satellite galaxies *should* be predicted by the models so that their quiescent fractions would be consistent with observations. For that, we take advantage of our knowledge of the environmental history of model galaxies and correlate it with observational estimates for the total fraction of satellites that became quiescent after being accreted. These fractions will be referred to as "transition fractions" and are defined in Section 5.2 below.

To constrain quenching time-scales we make the simple assumption that galaxies are quenched after having spent a given amount of time in a halo more massive than some critical threshold. Comparing the theoretical estimates with the observed transition fractions allows us to constrain both the typical time-scale for quenching and the typical environment (halo mass) where satellite galaxies get quenched.

The fraction of satellites that became quiescent *only after* the infall into their host halo is *not* a directly observable quantity. Indeed, the observed quiescent satellite fraction results from a *superposition of environmental and internal quenching processes* (some of the quiescent satellites have already been quenched whilst they are still centrals due to internal processes like e.g. supernovae or AGN feedback).