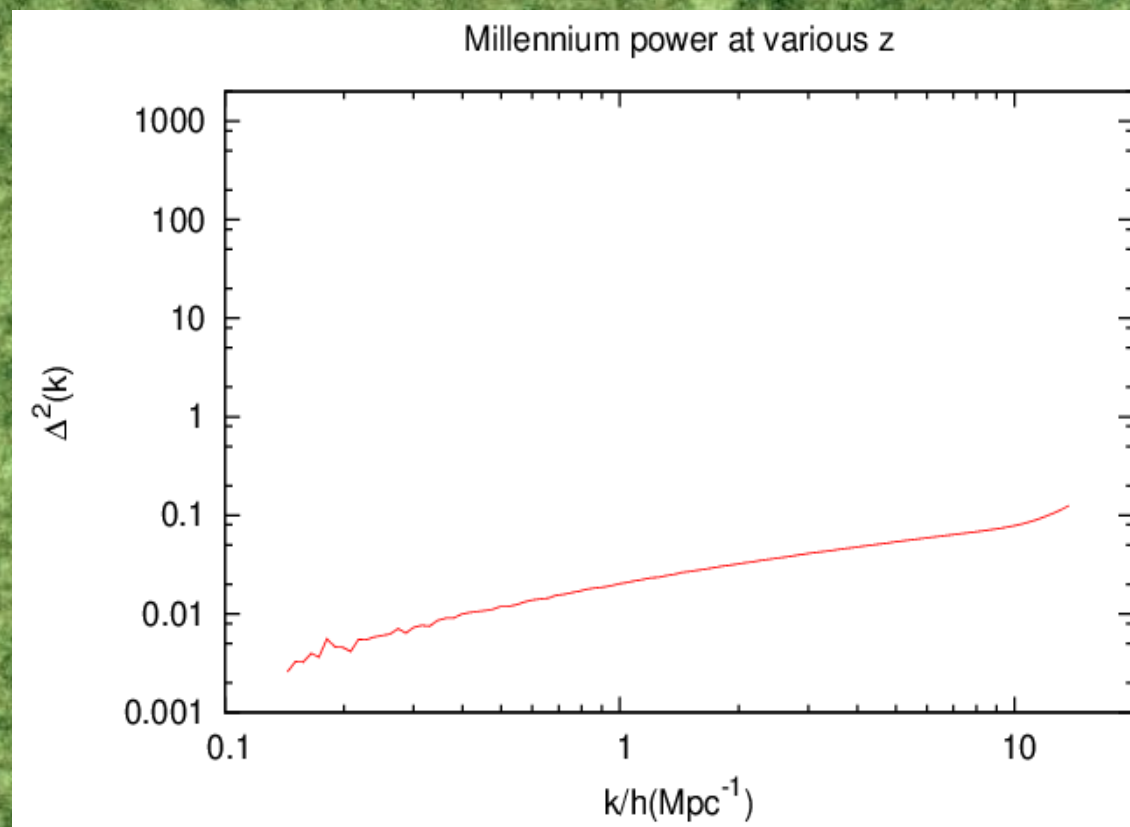


# HALOFIT revisited

Alexander Mead  
IfA Edinburgh

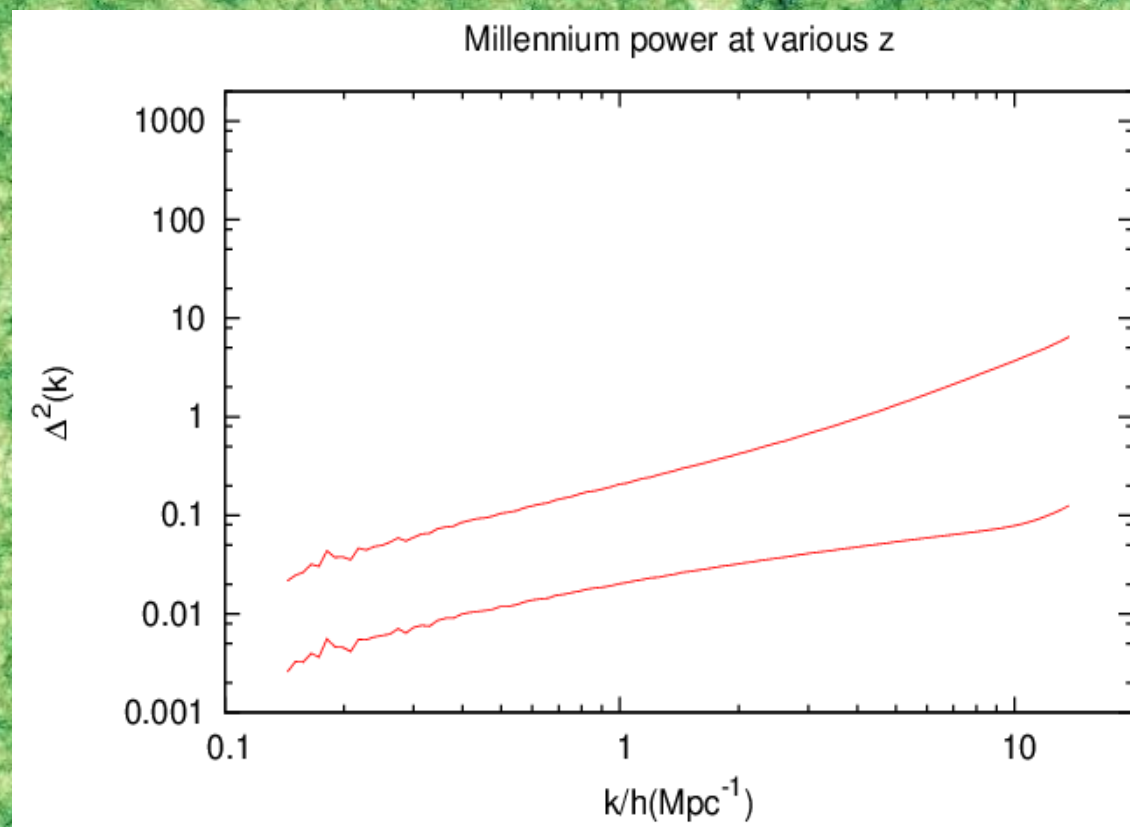


$z=18$



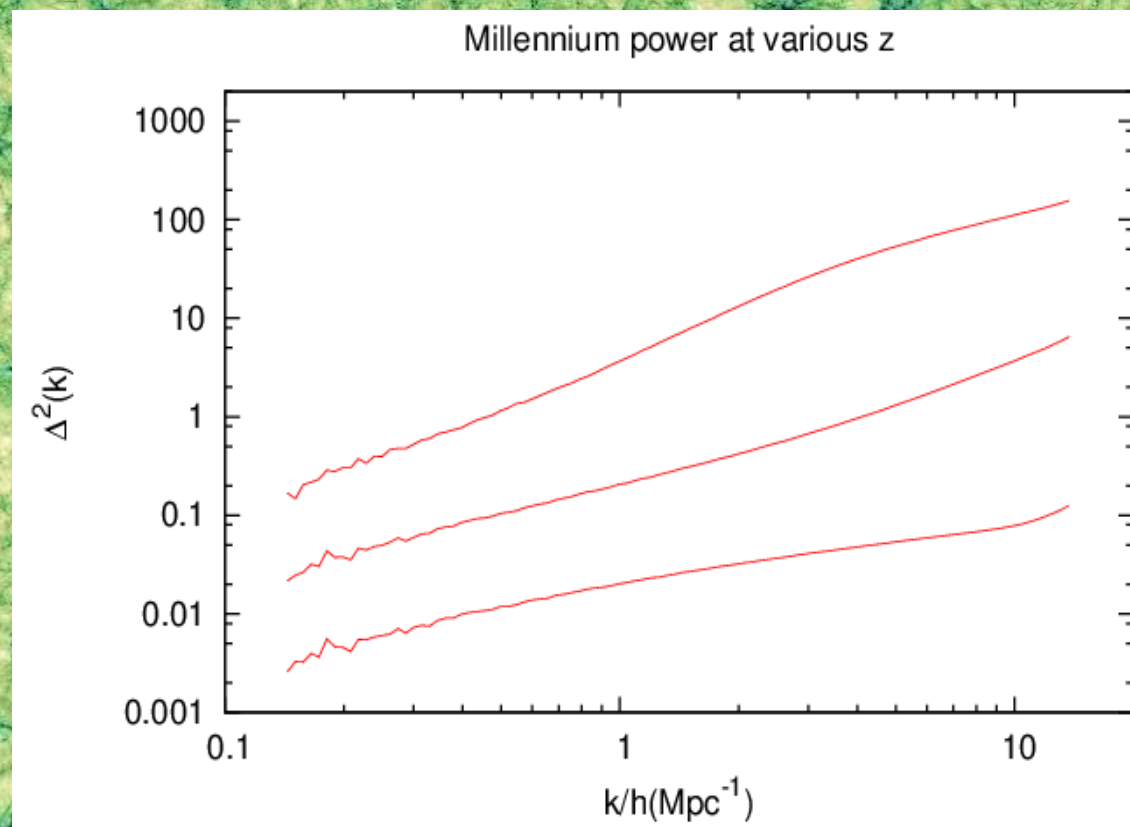


$z=6$

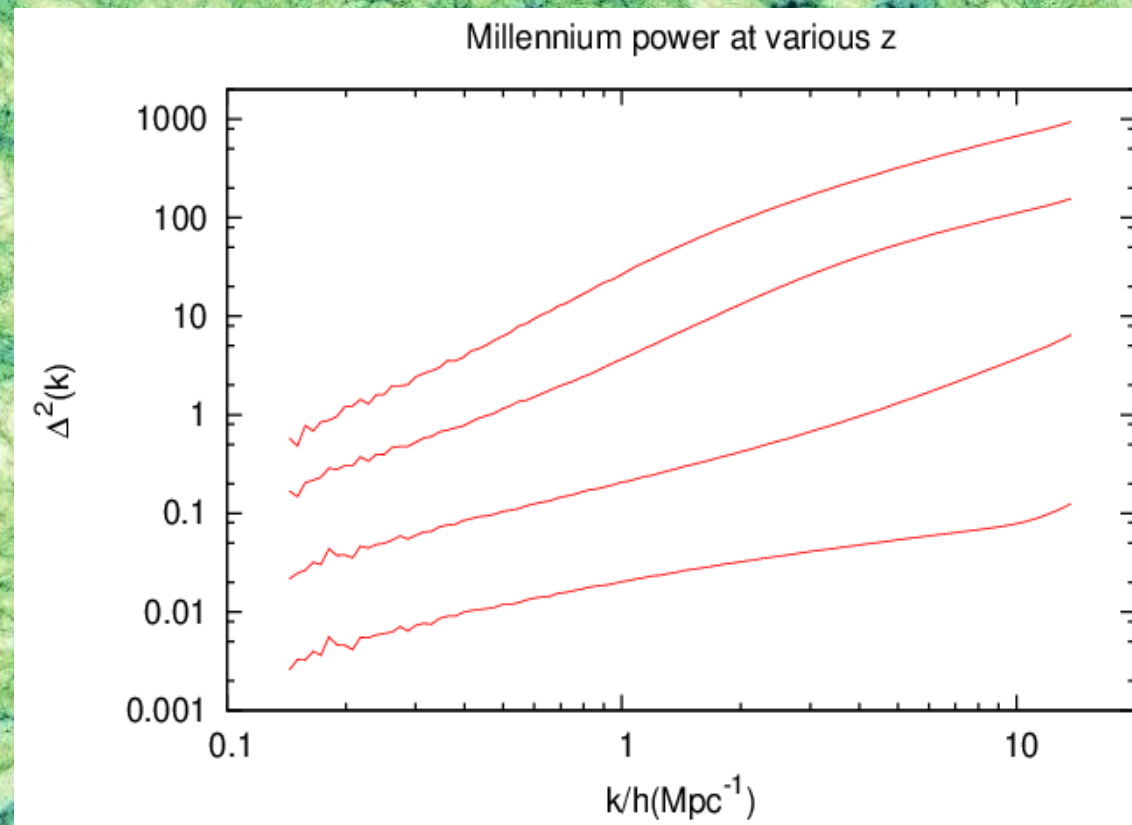
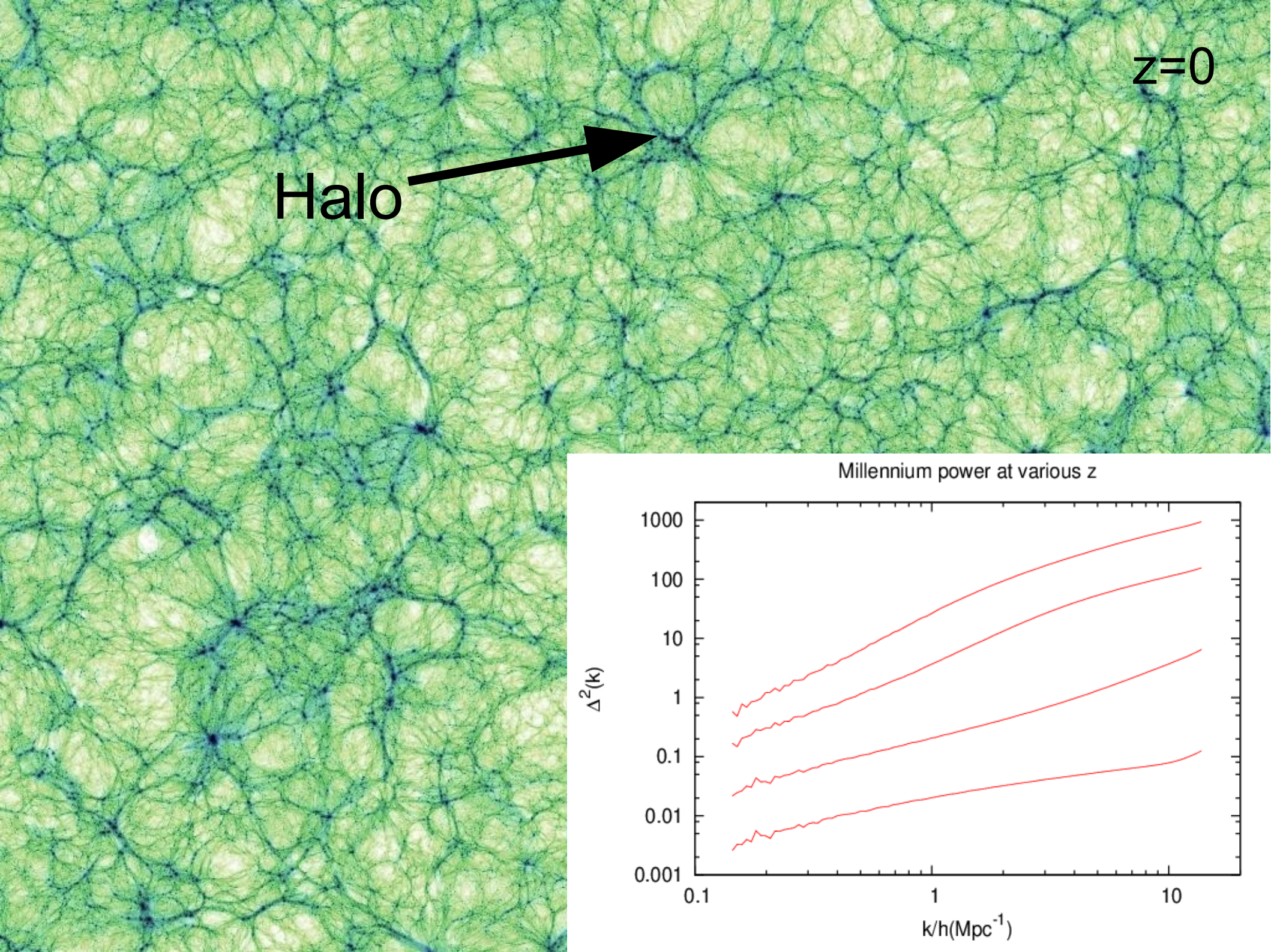




$z=1$

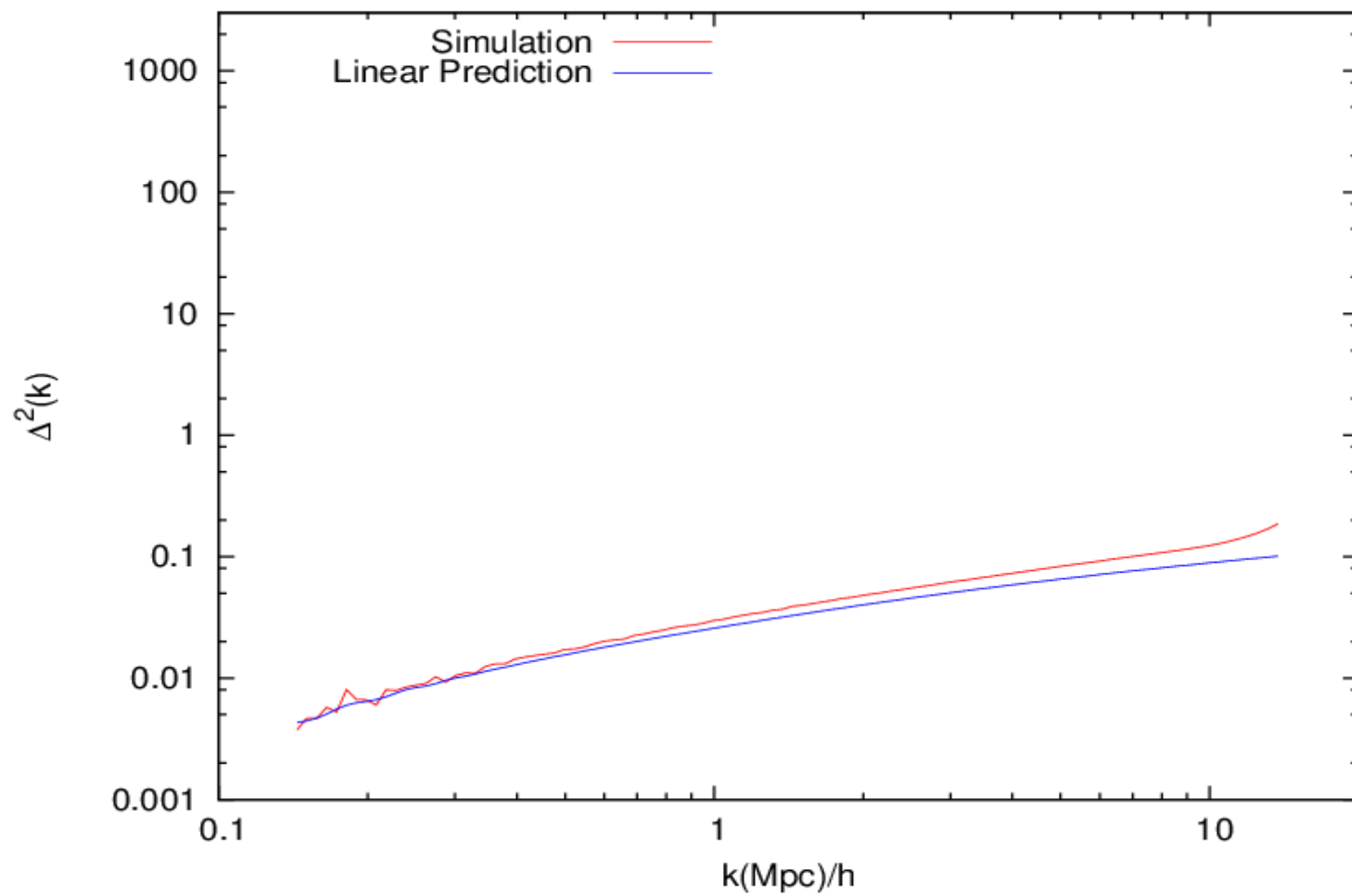




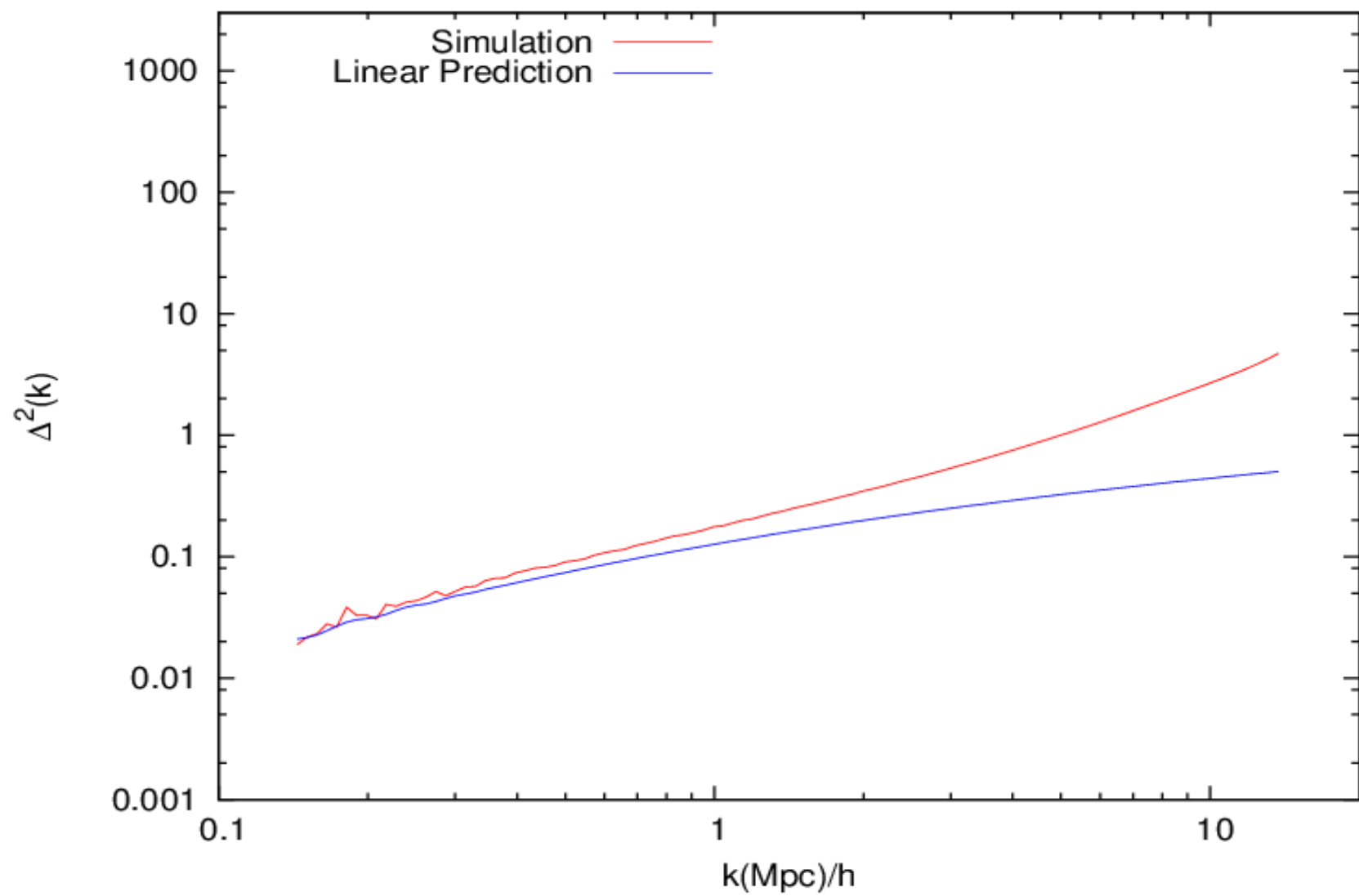




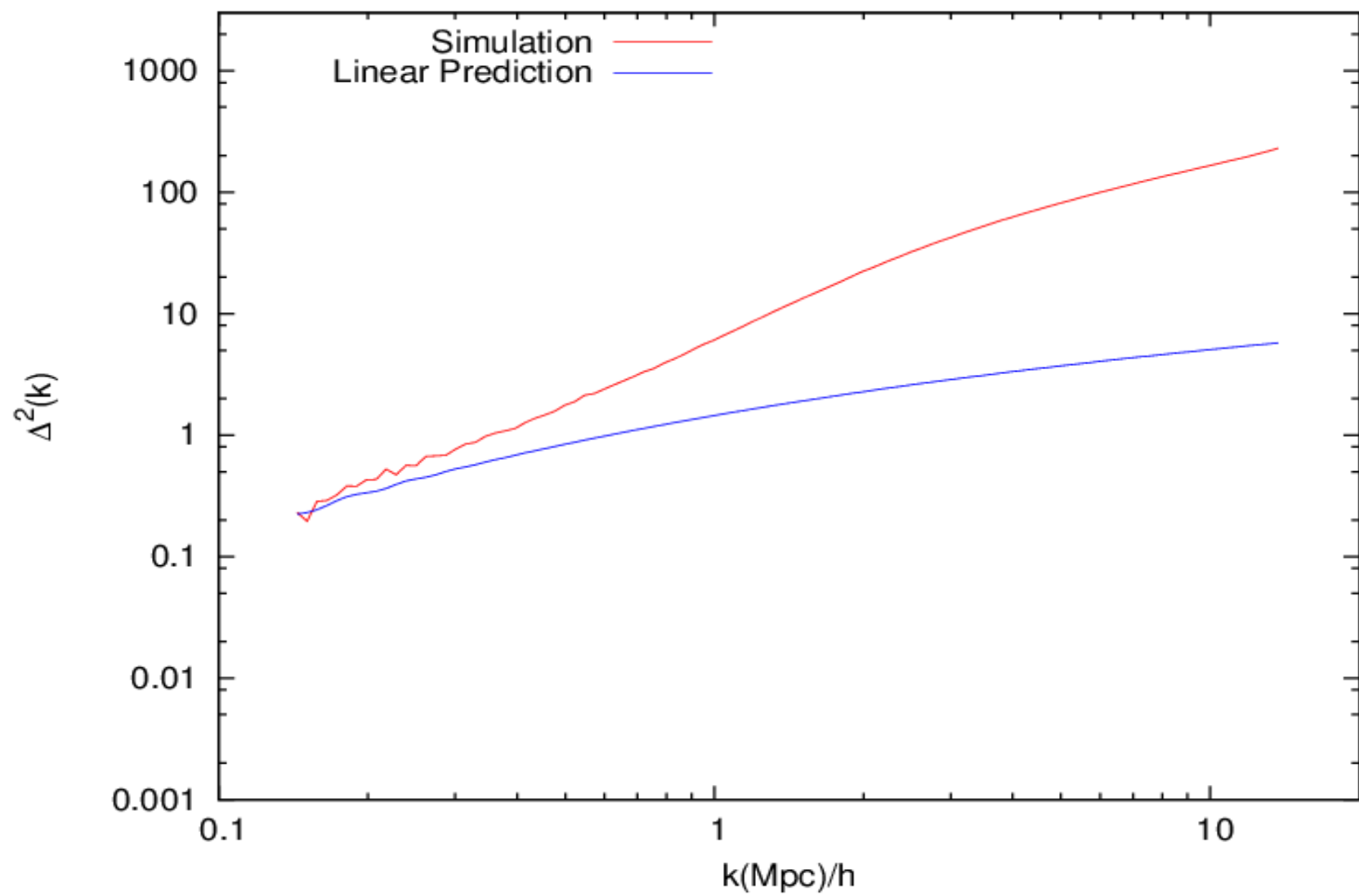
# $z=18$



$z=6$

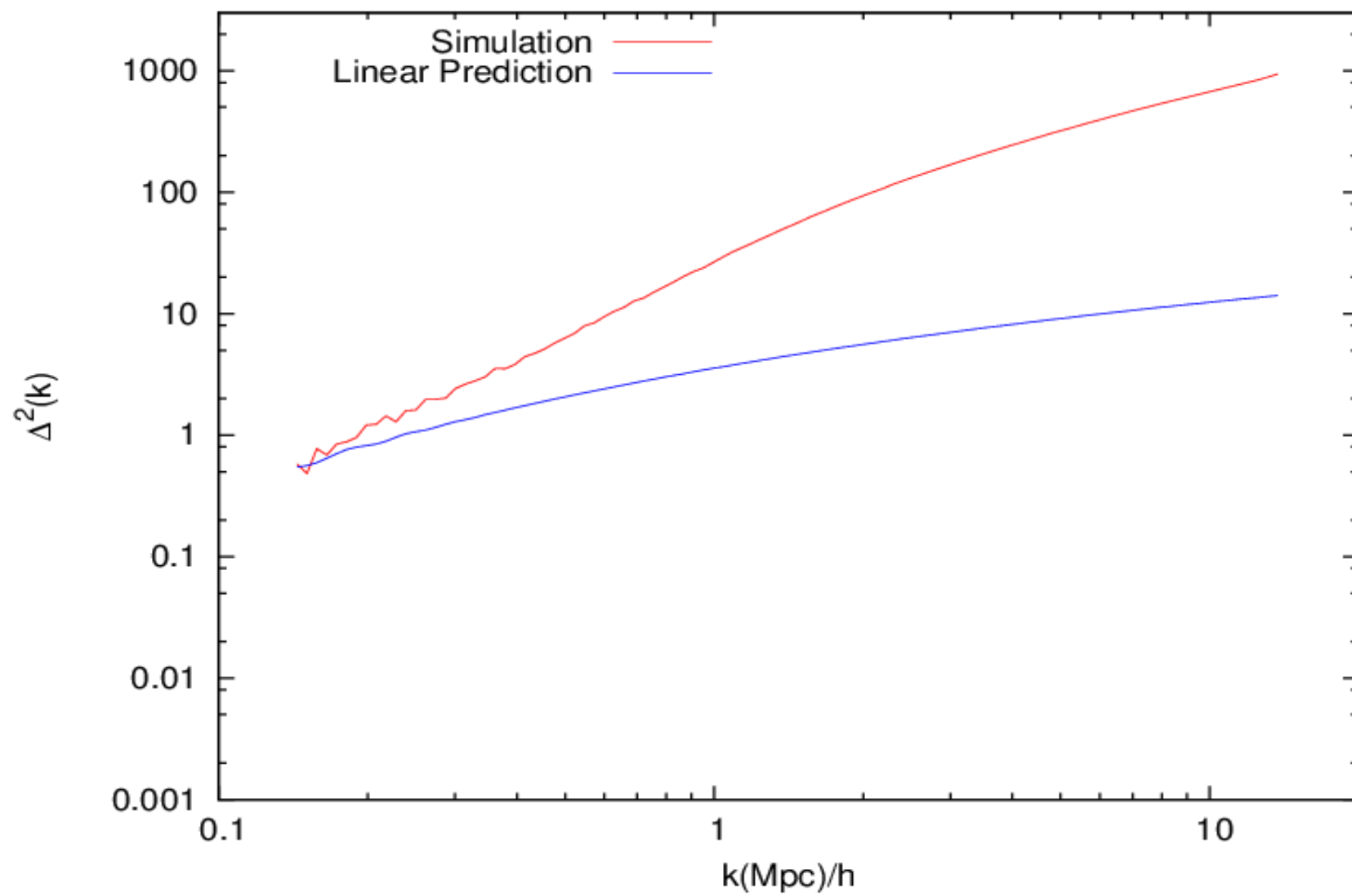


$z=1$





$z=0$





# Aim

- To have an accurate model of the full matter power spectrum.
- Important for weak lensing (EUCLID needs 1% accuracy to  $k = 20h \text{ Mpc}^{-1}$ ).
- One approach – simulations and interpolate
- Coyote Universe
- Constrained by parameter space



# HALOFIT

- HALOFIT is an analytic formula which is tuned to simulations
- It is important to note that HALOFIT is not the halo model directly.
- It is a clever fitting formula which is based on the halo model and is tuned to simulations via free parameters (quite a number).
- HALOFIT was released in 2003 and it has been shown to systematically under predict power on small scales.



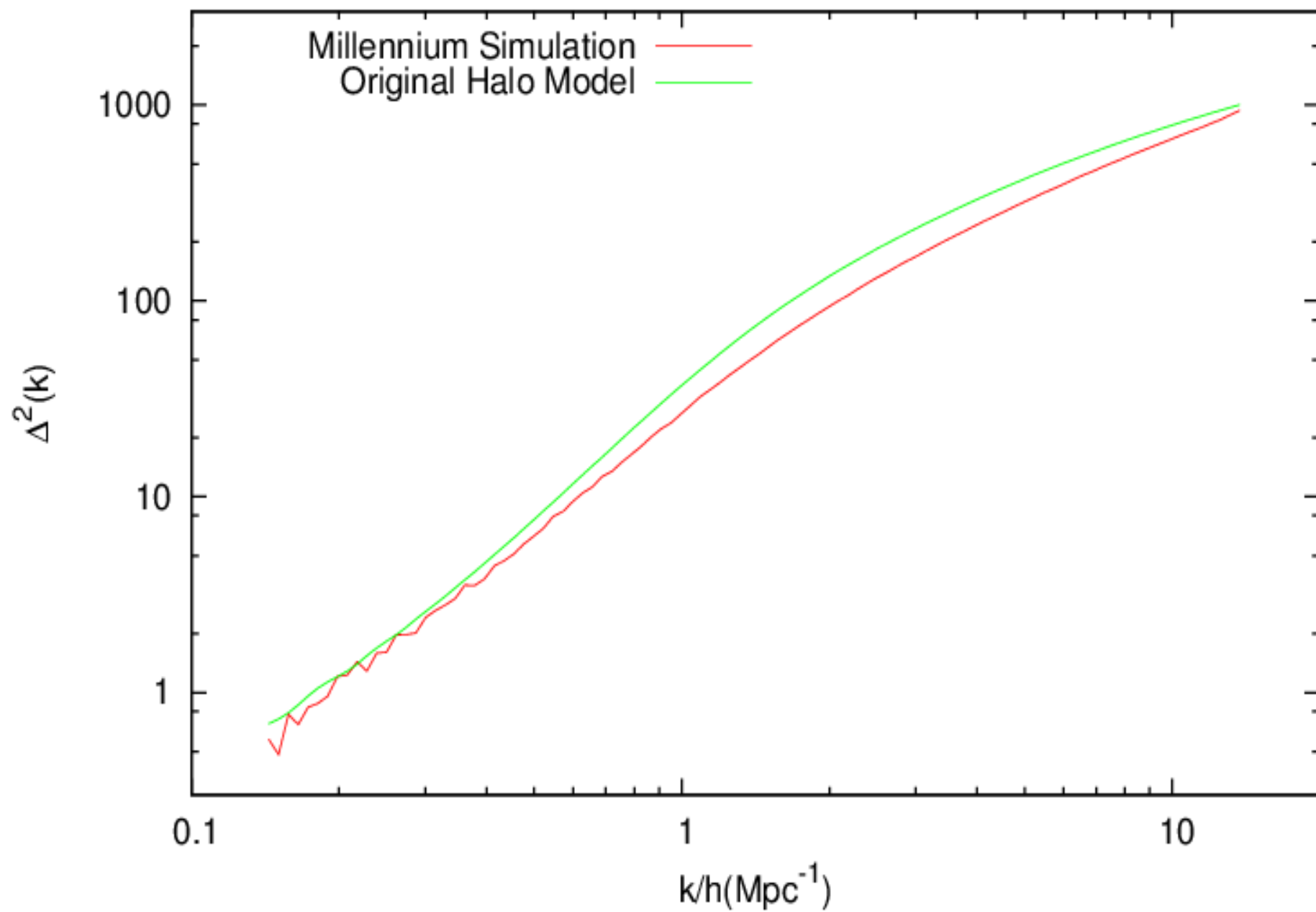
# The halo model

- Randomly distribute haloes
- Assign each a mass (from a mass distribution)
- Assign each a (mass dependent) density profile
- Fourier Transform
- Add linear power to account for large scale patterns

$$\Delta_{\text{halo}}^2(k) = 4\pi \left( \frac{k}{2\pi} \right)^3 \frac{1}{\bar{\rho}^2} \int M^2 W^2(k, M) f(M) dM.$$



Original Halo Model vs. Millennium Simulation at  $z=0$

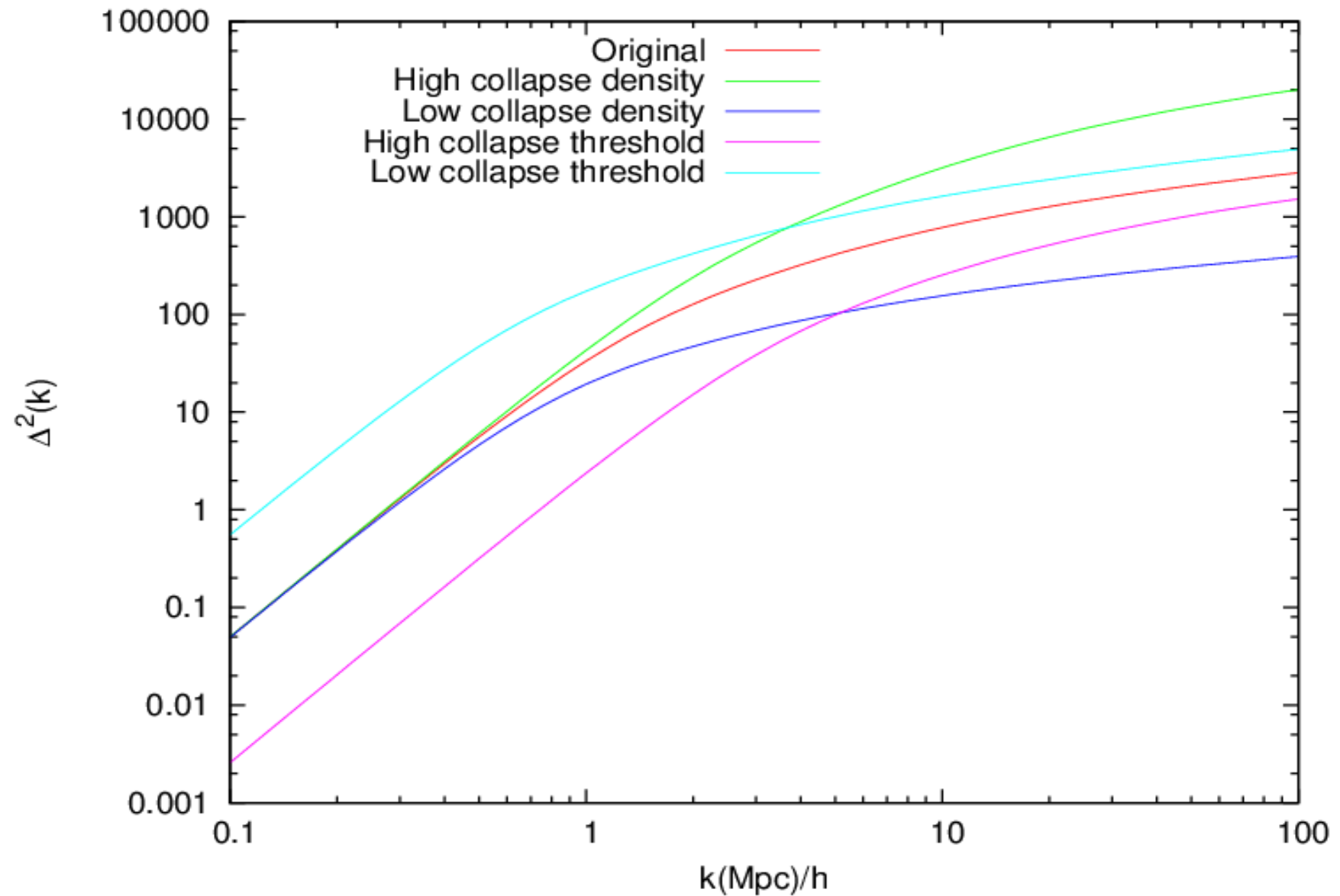


# Modifications

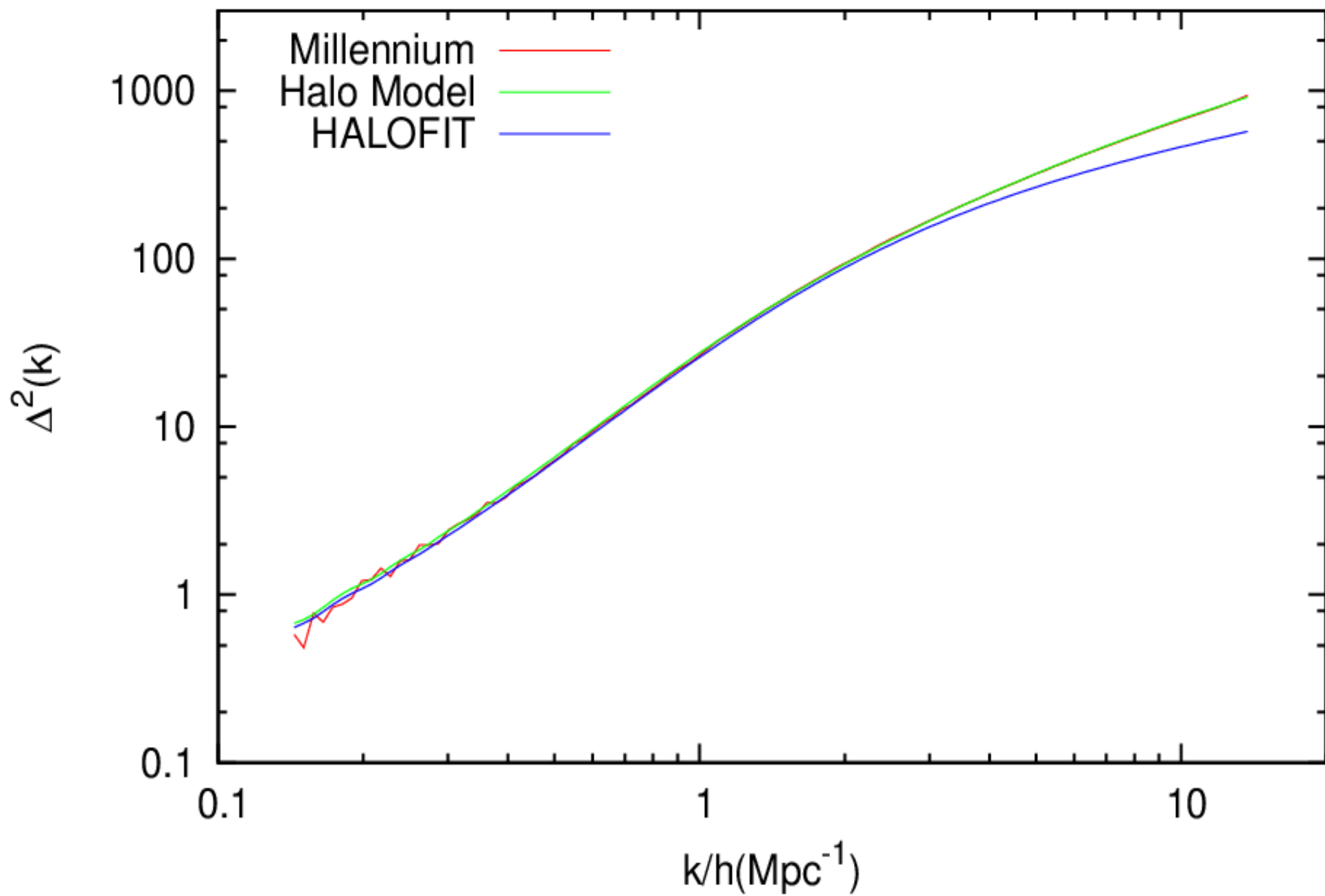
- The halo model has some exploitable freedoms.
  - Mass Function
    - Press-Schechter
    - Sheth-Tormen
    - Linear collapse threshold
  - Halo Profiles
    - NFW
    - Moore
    - Virialised over density
    - Effective haloes



# Effect of changes

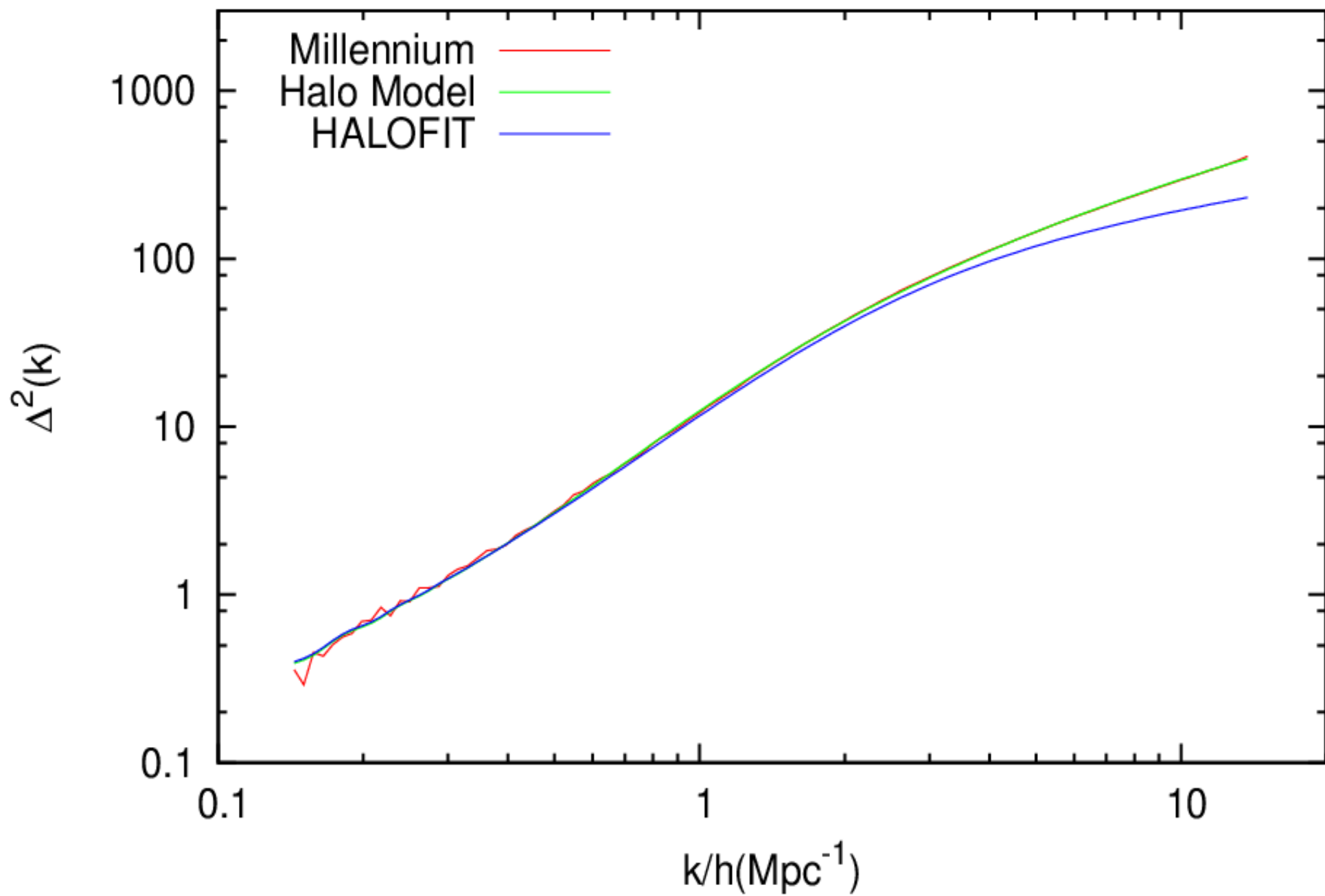


$z=0.0$

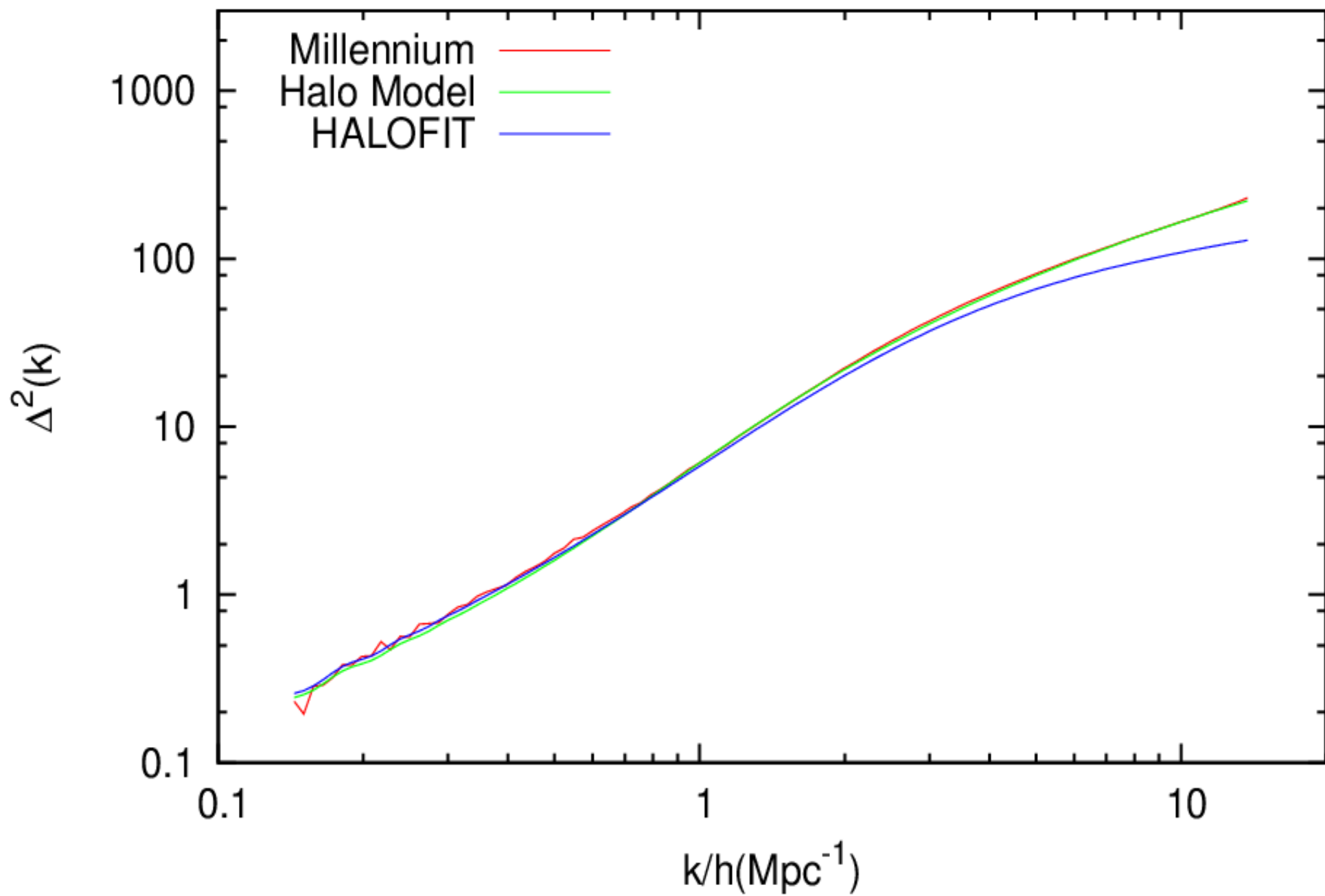




$z=0.5$

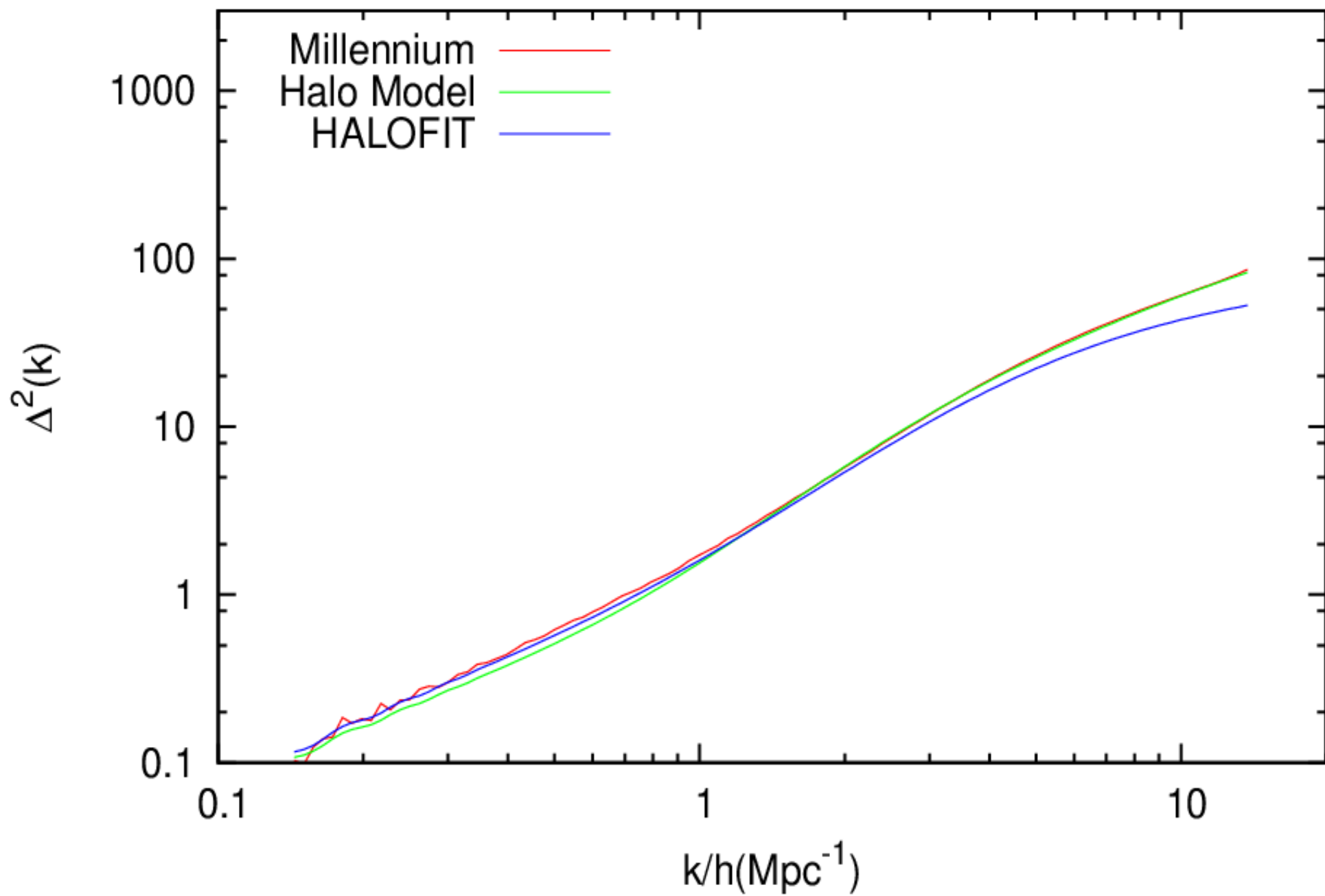


$z=1.0$

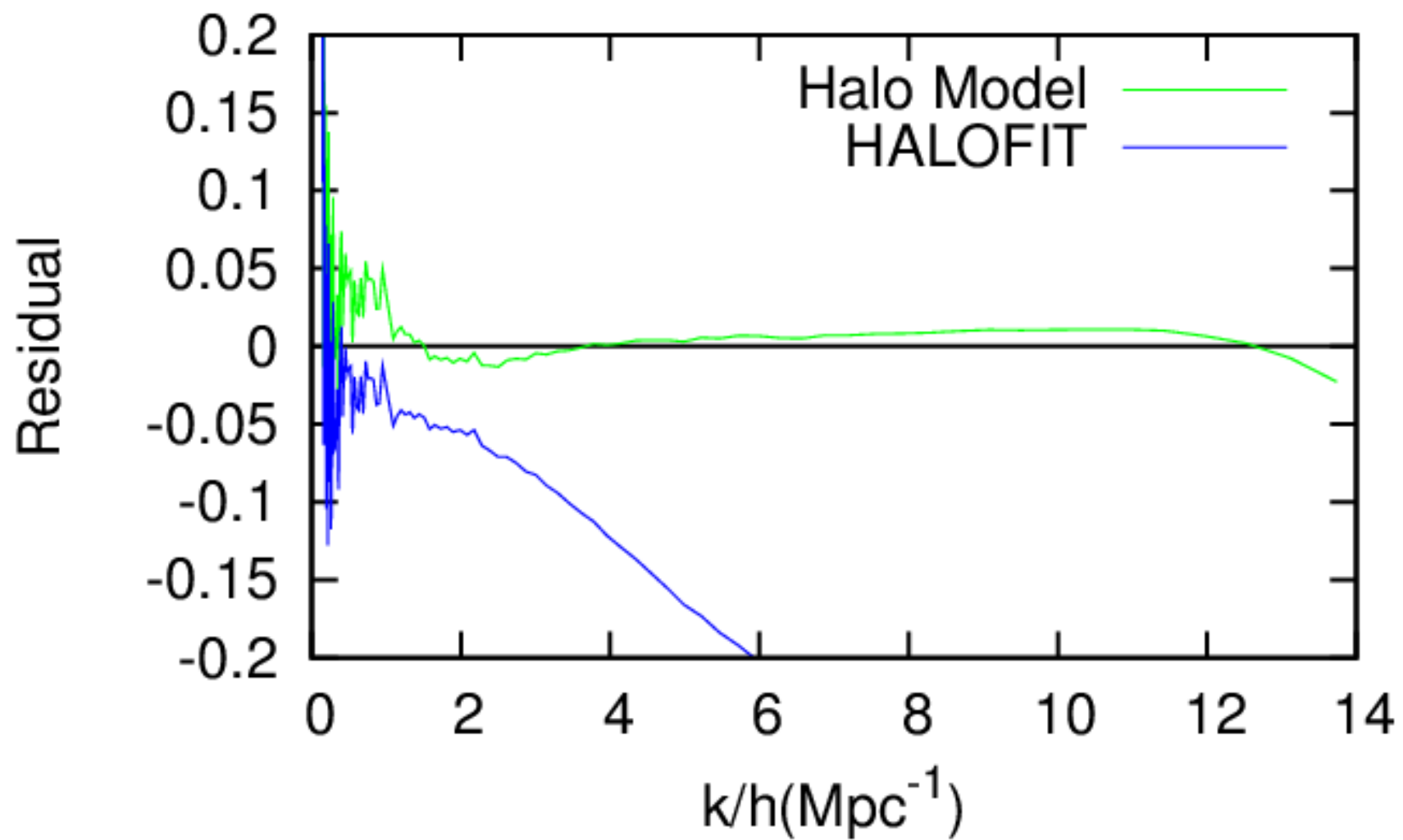




$z=2.0$

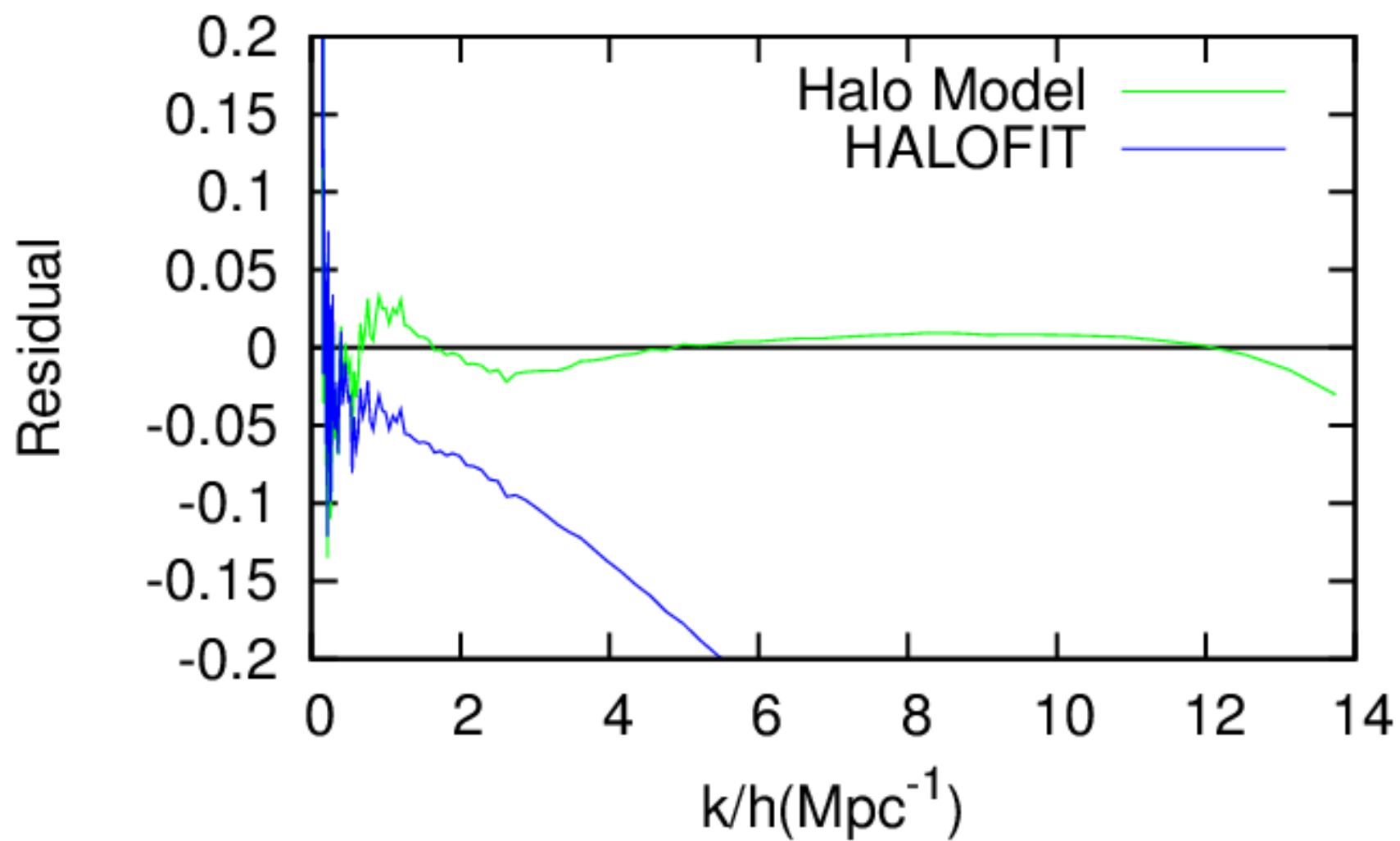


$z=0.0$

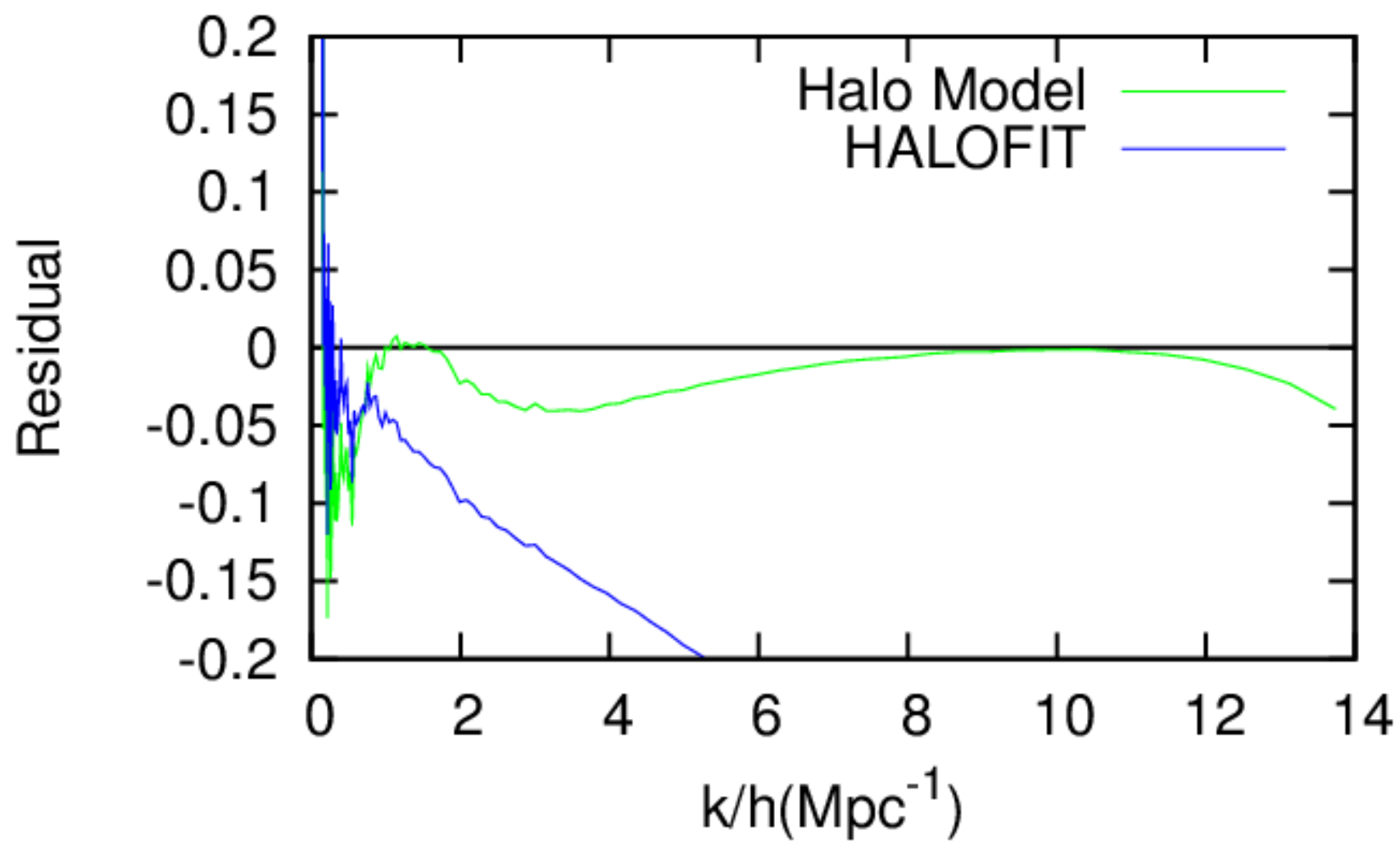




$z=0.5$

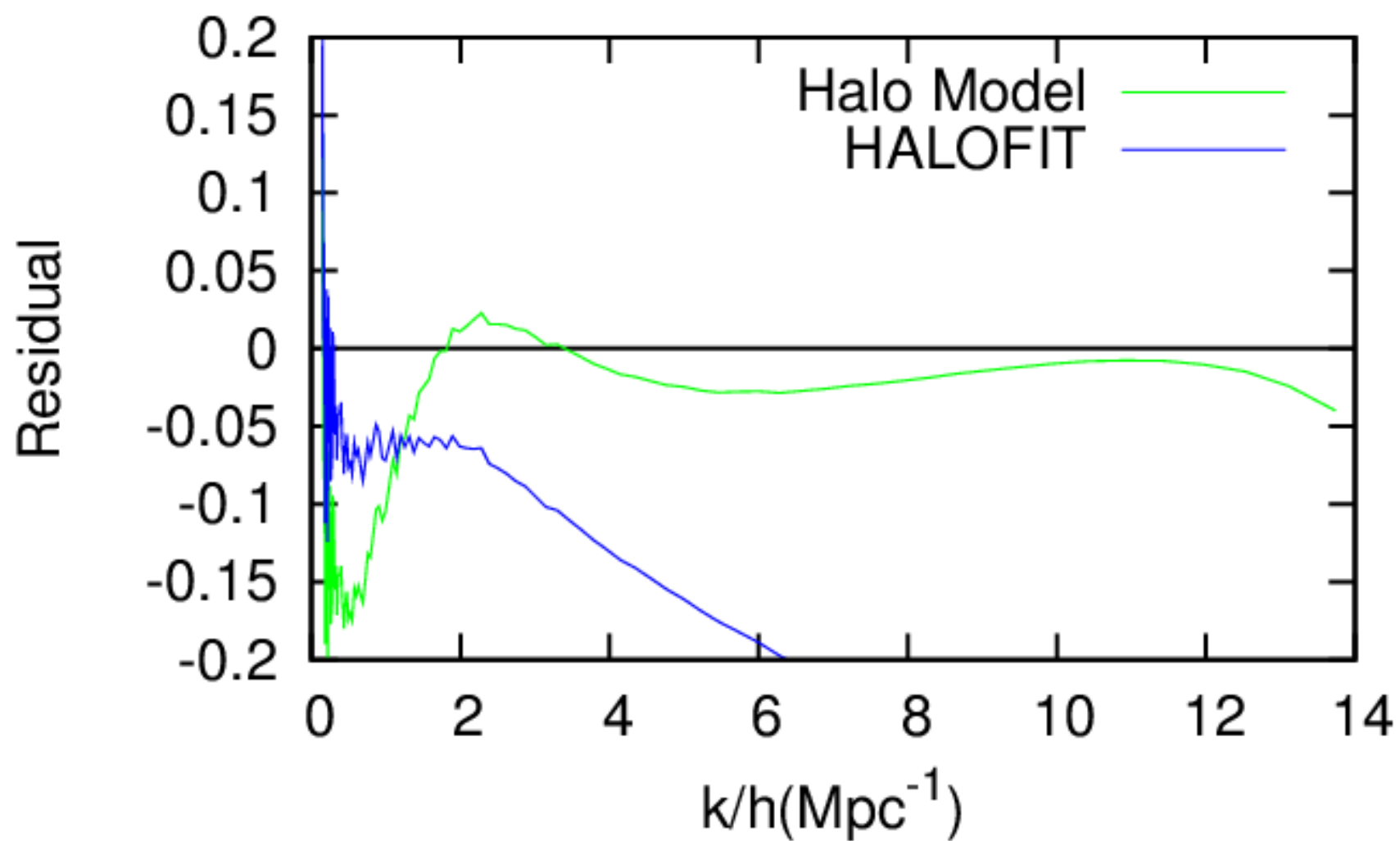


$z=1.0$



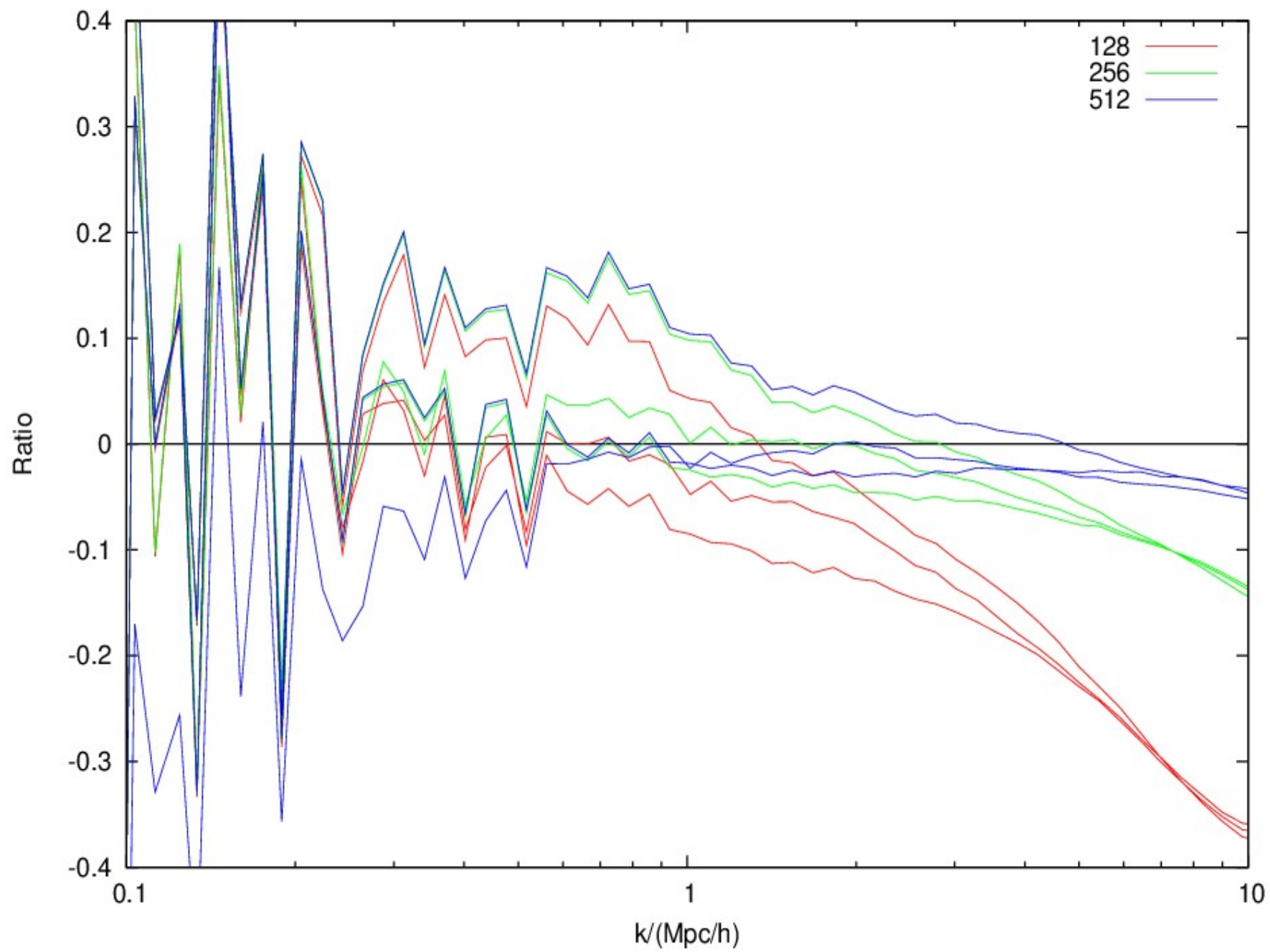


$z=2.0$

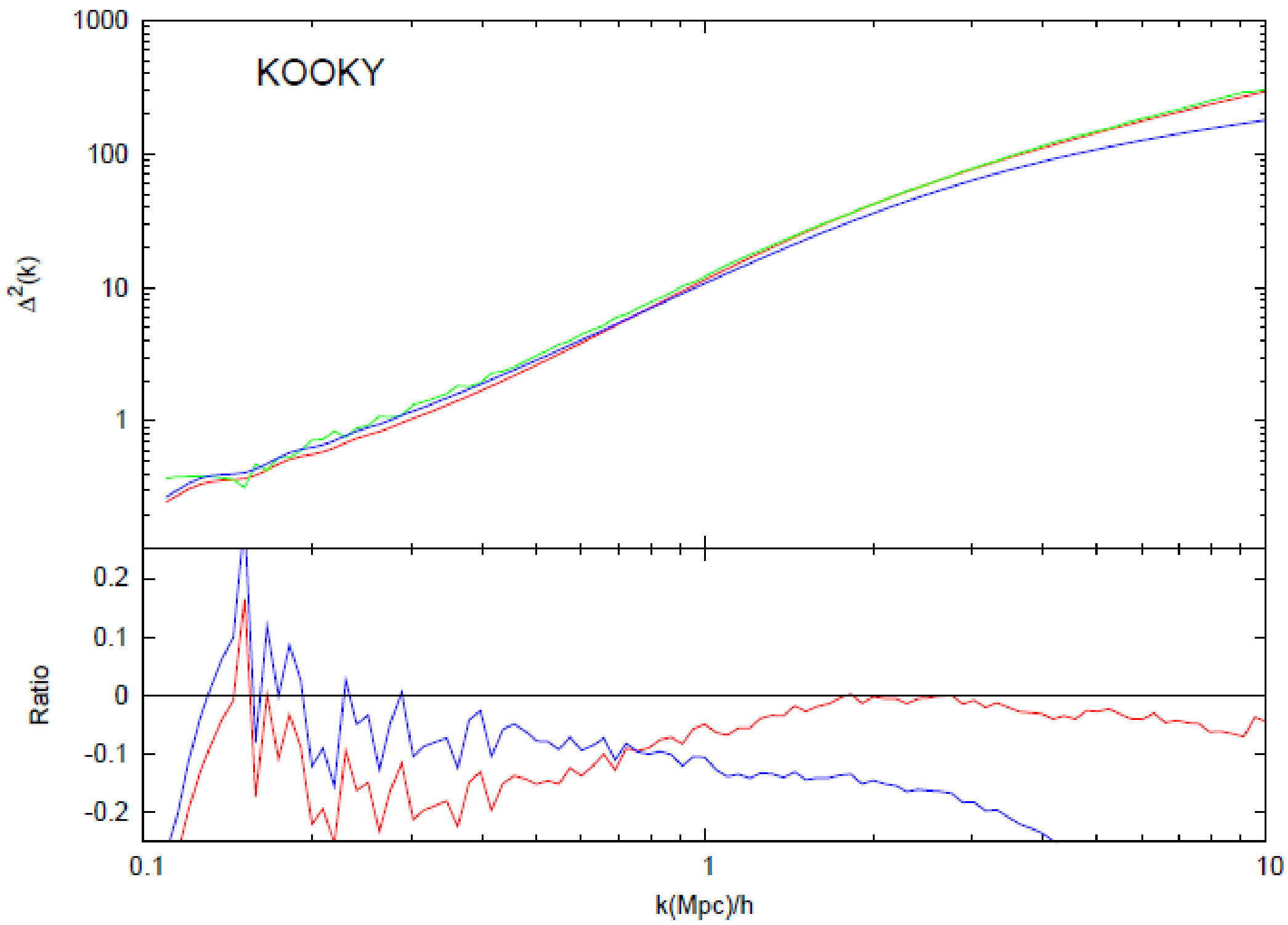


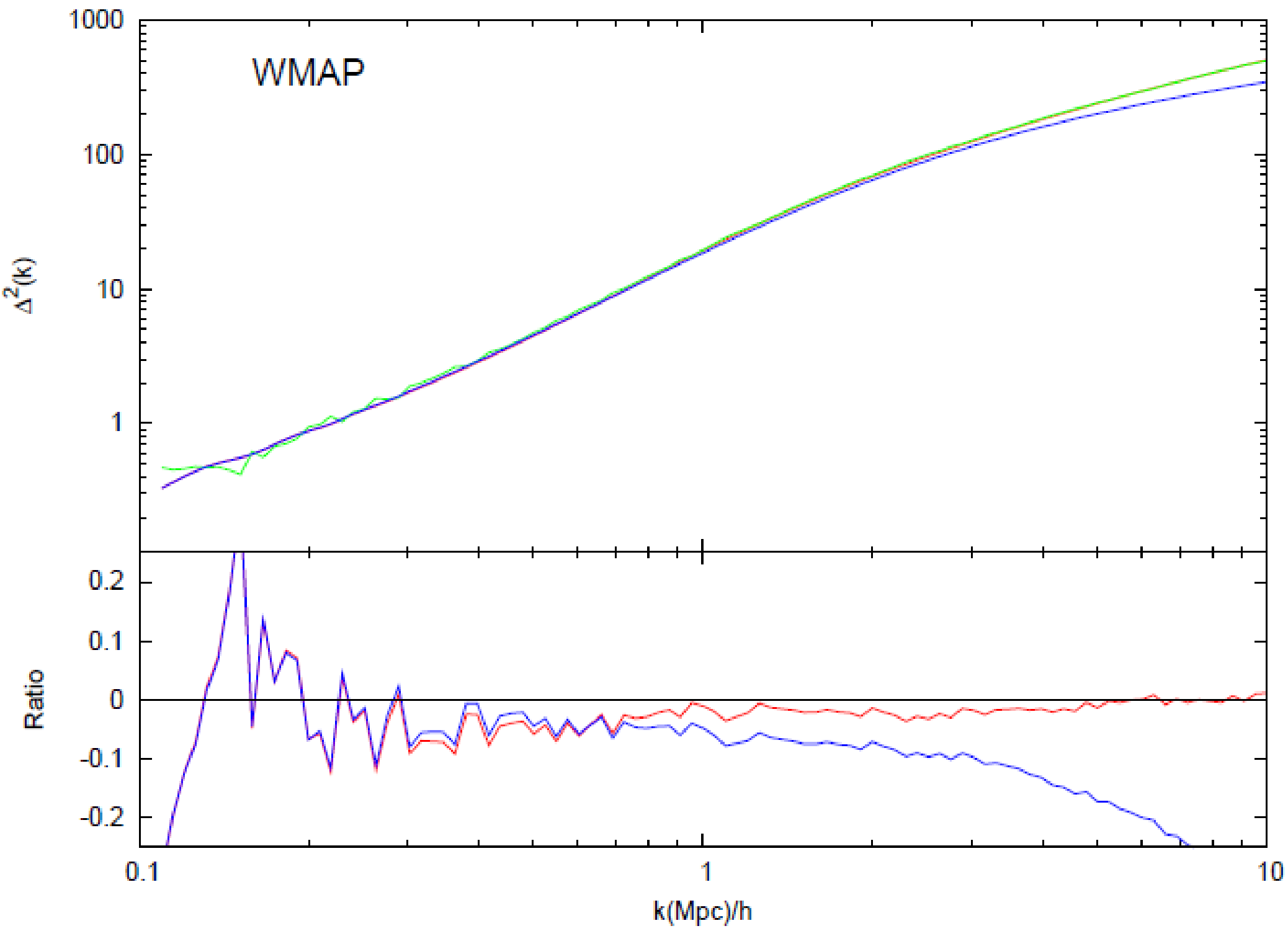
# Alternative cosmologies

- Next step – check against different cosmological models.
- Difficulty – simulations
- There are not many large simulations which probe small scales for different cosmological parameters (most/all are WMAP-esque)
- Other difficulty – when to trust a simulation









# Outlook

- Preliminary tests show that it certainly works well and outperforms HALOFIT.
- Need to get accurate power spectra for a variety of cosmological parameters out to  $k \sim 10h \text{ Mpc}^{-1}$
- Code to be released (including CAMB module and extension to COSMIC EMU)
- Future extensions:
  - modified gravity
  - dark energy
  - baryons