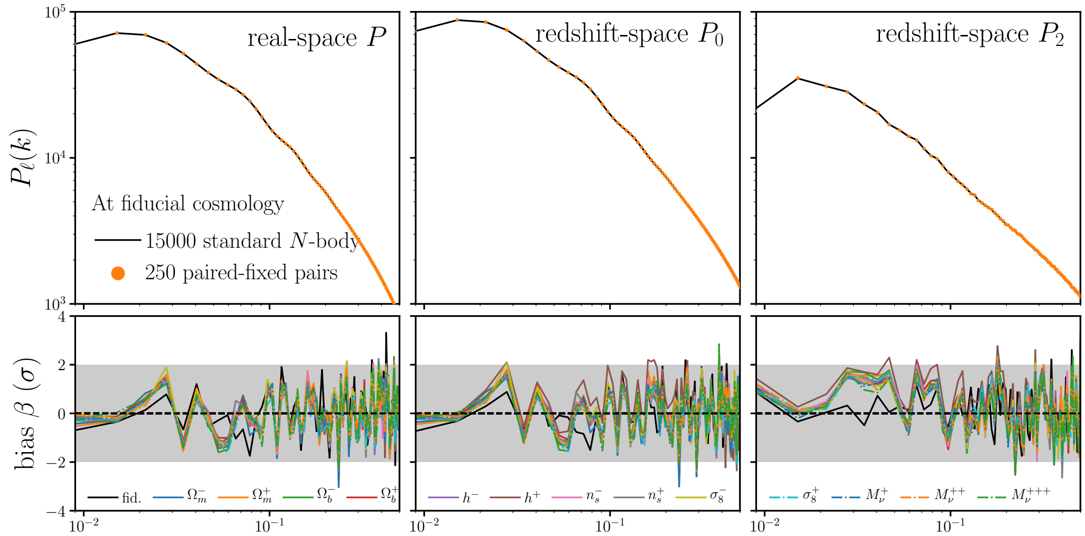

Figure 1. Comparison of the power spectra of standard N-body simulations and paired-fixed simulations. We compare the real-space power spectrum, redshift-space power spectrum monopole, and quadrupole in the left, center, and right columns, respectively. In the top panels, we compare the average power spectra of the standard simulations (black line) to the paired-fixed simulations (orange scatter) at the fiducial cosmology. In the bottom panels, we compare the bias, β of the paired-fixed simulations for the power spectra for all 14 cosmologies (Table 1). We mark bias within $\pm 2\sigma$ within the shaded region. At the fiducial cosmology we use 15,000 standard N-body and 250 pairs of paired-fixed simulations. For the other cosmologies, we use 500 standard N-body and 250 pairs of paired-fixed simulations. Consistent with previous results, *we find no significant bias in the real and redshift-space power spectra of paired-fixed simulations.*

We're using Paco's Quijote suite (Table 1) to determine whether using paired-fixed simulations instead of standard N-body simulations can bias clustering analyses with the redshift-space power spectrum and bispectrum. More specifically, the context we have in mind is to see whether an emulator constructed using paired-fixed would bias parameter constraints. We quantify the bias for some observable X as

$$\beta_X = \frac{\overline{X}_{\rm std} - \overline{X}_{\rm pf}}{\sqrt{\sigma^2_{\rm std} + \sigma^2_{\rm pf}}} \tag{1}$$

where $\overline{X}_{\rm std} = \frac{1}{N_{\rm std}} \sum\limits_{i=1}^{N_{\rm std}} X_{{\rm std},i}$ and $\overline{X}_{\rm pf} = \frac{1}{N_{\rm pf}} \sum\limits_{i=1}^{N_{\rm pf}} X_{{\rm pf},i}$. $X_{{\rm pf},i}$ is the mean observable for a pair of paired-fixed simulations: $X_{{\rm pf},i} = \frac{1}{2}\left[X^{(1)}_{{\rm pf},i} + X^{(2)}_{{\rm pf},i}\right]$. For the most part $N_{\rm std} = 500$ and $N_{\rm pf} = 250$.

We first look at the amplitudes of the power spectrum and bispectrum in Figures 1 and 2. There's some noticable discrepancies for the bispectrum at the h^+ and M_ν^{+++} cosmologies, but nothing statistically significant. Next we look at the derivatives of the power spectrum and bispectrum with respect to $\Omega_{\rm m}$, $\Omega_{\rm b}$, h, n_s, σ_8, and $\sum m_\nu$. Here we find more significant biases in the derivatives with respect to h and σ_8.

Table 1. The QUIJOTE suite includes 15,000 standard N-body simulations at the fiducial cosmology to accurately estimate the covariance matrices. It also includes sets of 500 simulations at 13 different cosmologies, where only one parameter is varied from the fiducial value (underlined), to estimate derivatives of observables along the cosmological parameters. At every cosmology, the QUIJOTE suite also includes 250 pairs of paired-fixed simulations.

Name	$\sum m_\nu$	Ω_m	Ω_b	h	n_s	σ_8	ICs	standard realizations	paired-fixed pairs
Fiducial	0.0	0.3175	0.049	0.6711	0.9624	0.834	2LPT	15,000	250
Fiducial ZA	0.0	0.3175	0.049	0.6711	0.9624	0.834	Zel'dovich	500	250
$\sum m_\nu^+$	$\underline{0.1}$ eV	0.3175	0.049	0.6711	0.9624	0.834	Zel'dovich	500	250
$\sum m_\nu^{++}$	$\underline{0.2}$ eV	0.3175	0.049	0.6711	0.9624	0.834	Zel'dovich	500	250
$\sum m_\nu^{+++}$	$\underline{0.4}$ eV	0.3175	0.049	0.6711	0.9624	0.834	Zel'dovich	500	250
Ω_m^+	0.0	$\underline{0.3275}$	0.049	0.6711	0.9624	0.834	2LPT	500	250
Ω_m^-	0.0	$\underline{0.3075}$	0.049	0.6711	0.9624	0.834	2LPT	500	250
Ω_b^+	0.0	0.3175	$\underline{0.051}$	0.6711	0.9624	0.834	2LPT	500	250
Ω_b^-	0.0	0.3175	$\underline{0.047}$	0.6711	0.9624	0.834	2LPT	500	250
h^+	0.0	0.3175	0.049	$\underline{0.6911}$	0.9624	0.834	2LPT	500	250
h^-	0.0	0.3175	0.049	$\underline{0.6511}$	0.9624	0.834	2LPT	500	250
n_s^+	0.0	0.3175	0.049	0.6711	$\underline{0.9824}$	0.834	2LPT	500	250
n_s^-	0.0	0.3175	0.049	0.6711	$\underline{0.9424}$	0.834	2LPT	500	250
σ_8^+	0.0	0.3175	0.049	0.6711	0.9624	$\underline{0.849}$	2LPT	500	250
σ_8^-	0.0	0.3175	0.049	0.6711	0.9624	$\underline{0.819}$	2LPT	500	250

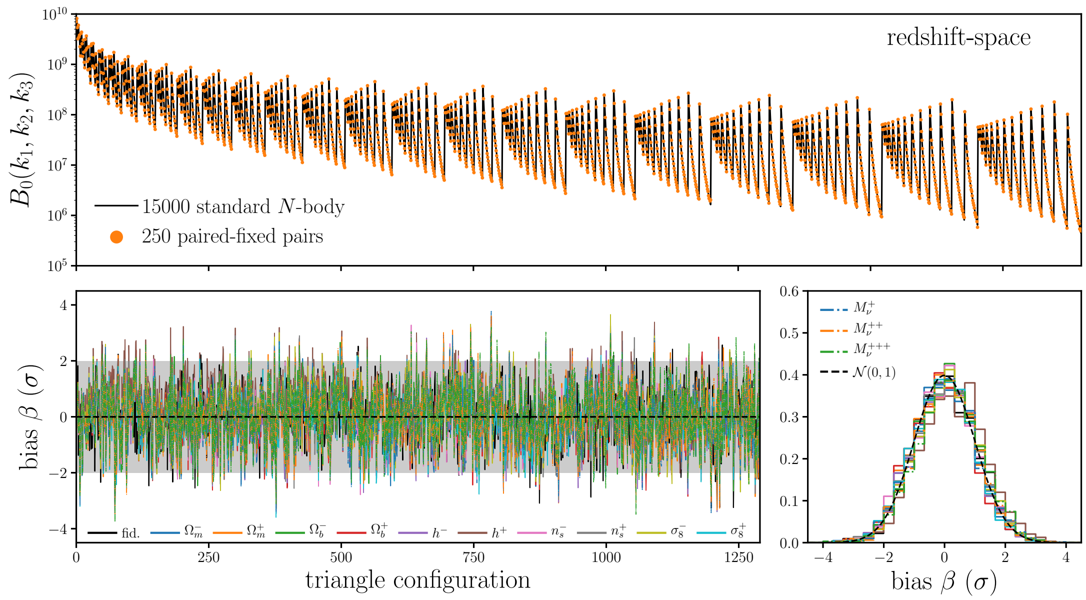

Figure 2. Comparison of the redshift-space bispectrum of standard N-body and paired-fixed simulations. In the top panel, we compare the average bispectrum of the standard simulations (black line) to the paired-fixed simulations (orange scatter) at the fiducial cosmology. We include all 1898 triangles out to $k_{\max} = 0.5$. In the bottom panels, we compare the bias, β of the paired-fixed simulations for the bispectrum for all 14 cosmologies, as a function of triangle configuration (left) and their distribution (right). The β distributions of the different cosmologies are mostly in good agreement with $\mathcal{N}(0, 1)$ (lower right panel). A few cosmologies, h^+, M_ν^{+++}, have noticable discrepancies; however, these discrepancies are within 1σ. *Hence, we also find no significant bias in the redshift-space bispectrum of paired-fixed simulations.*

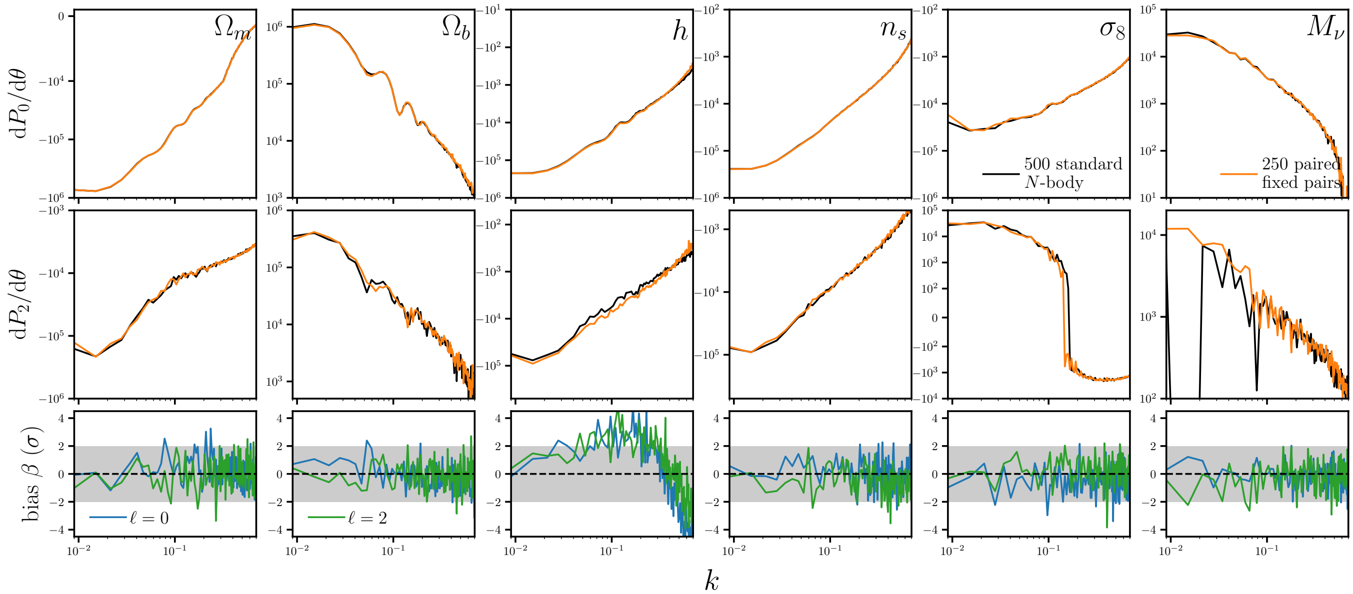

Figure 3. Comparison of the redshift-space power spectrum monopole (top panels) and quadrupole (center panels) derivatives with respect to Ω_m, Ω_b, h, n_s, σ_8, and M_ν derived from standard N-body versus paired-fixed simulations. In the top panels, we compare the derivatives from the standard simulations (black) to the paired-fixed simulations (orange). In the bottom panels, we compare the bias, β of each P_ℓ derivative. We find significant biases for the derivatives with respect to h, σ_8 and M_ν. The bias for both $\mathrm{d}P_0/\mathrm{d}h$ and $\mathrm{d}P_2/\mathrm{d}h$ exceed 2σ in the range $k > 0.04\ h/\mathrm{Mpc}$.

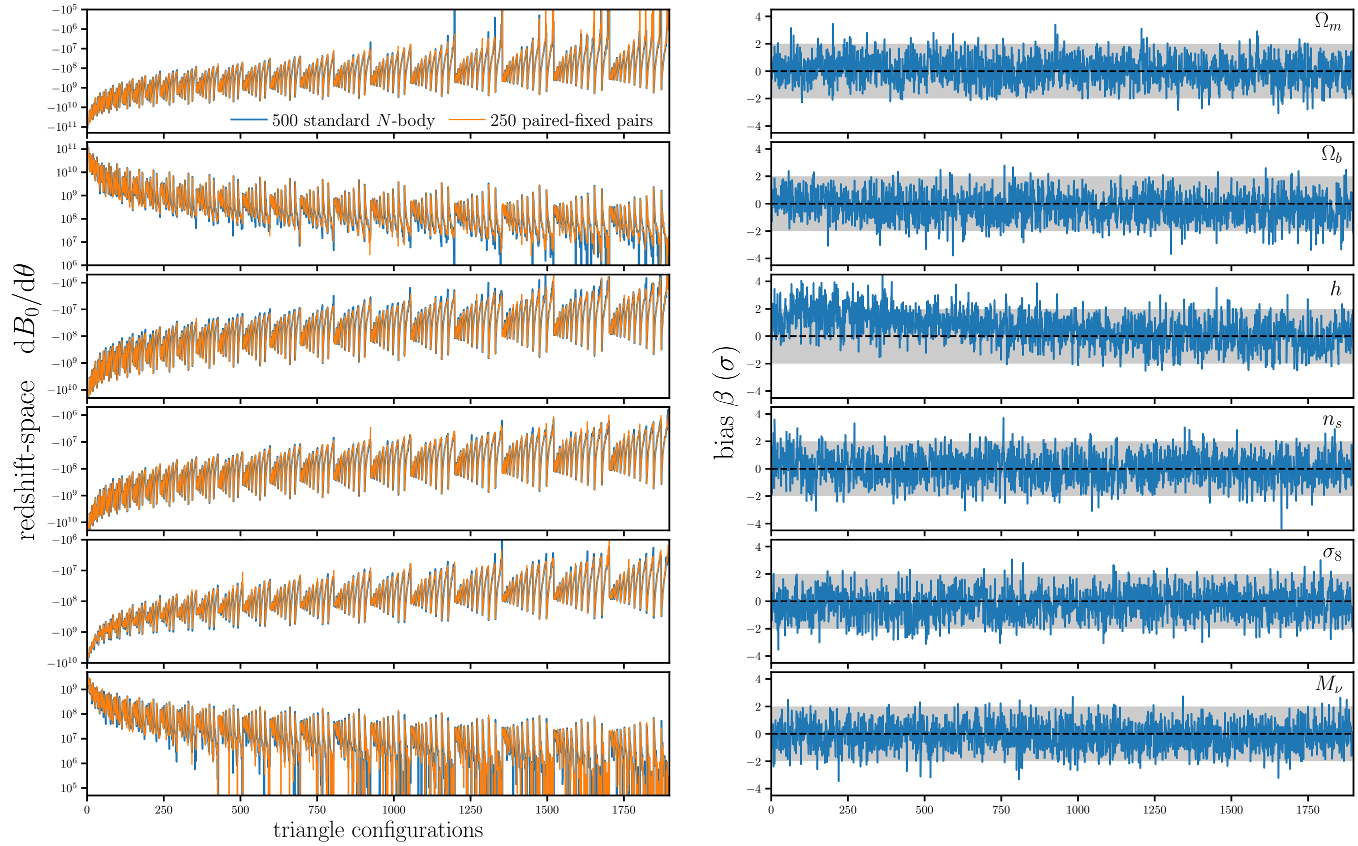

Figure 4. Comparison of the redshift-space bispectrum derivatives with respect to Ω_m, Ω_b, h, n_s, σ_8, and M_ν derived from standard N-body simulations versus paired-fixed simulations. In the left panels, we compare the derivatives from the standard simulations (black) to the paired-fixed simulations (orange). In the right panels, we compare the bias, β of the derivatives for each parameter. The bias for $\mathrm{d}B_0/\mathrm{d}h$ exceeds 2σ for triangle configurations with $0.1 \lesssim k_1, k_2, k_3 \lesssim 0.3$ h/Mpc.

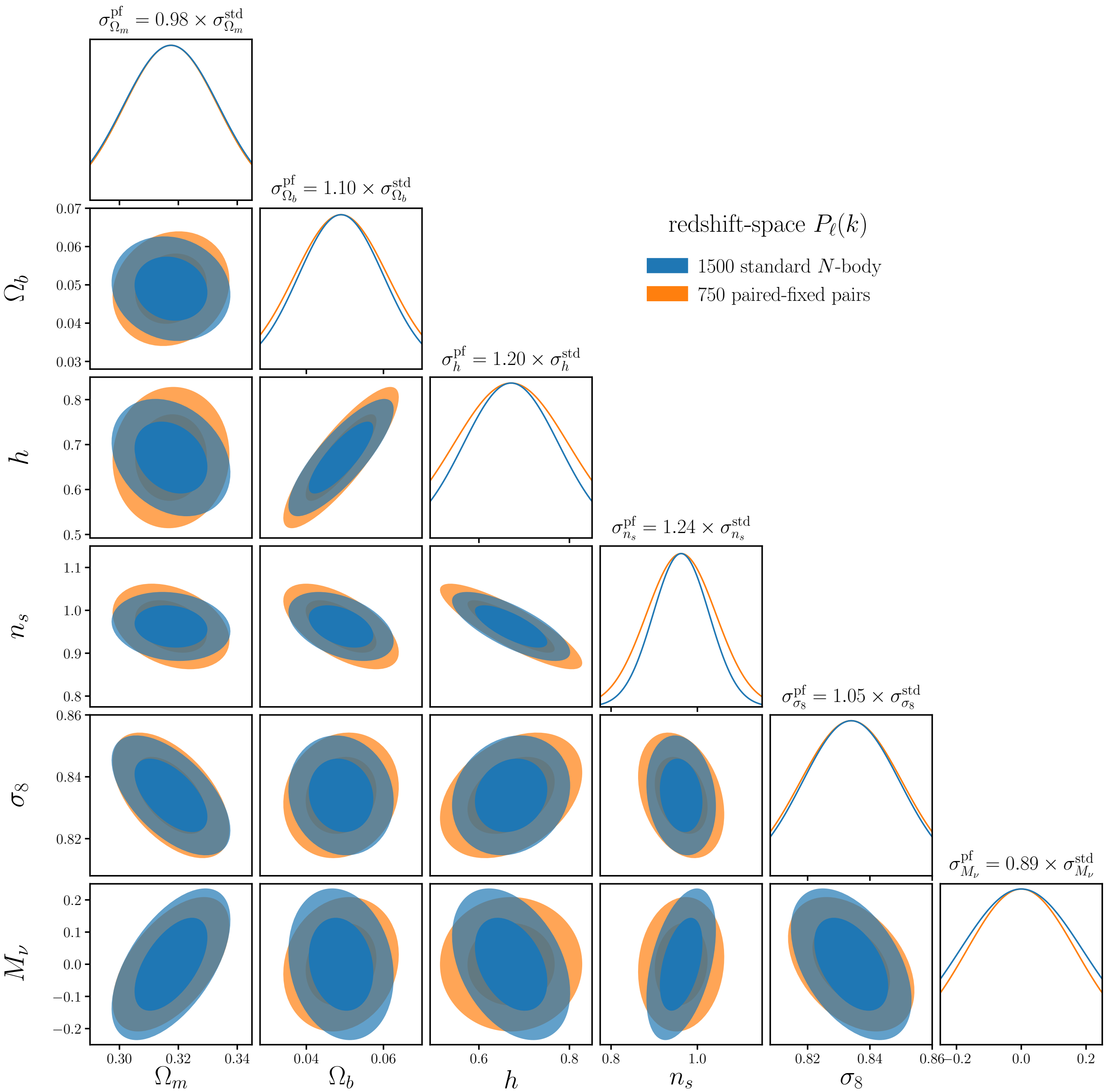

Figure 5. to be updated

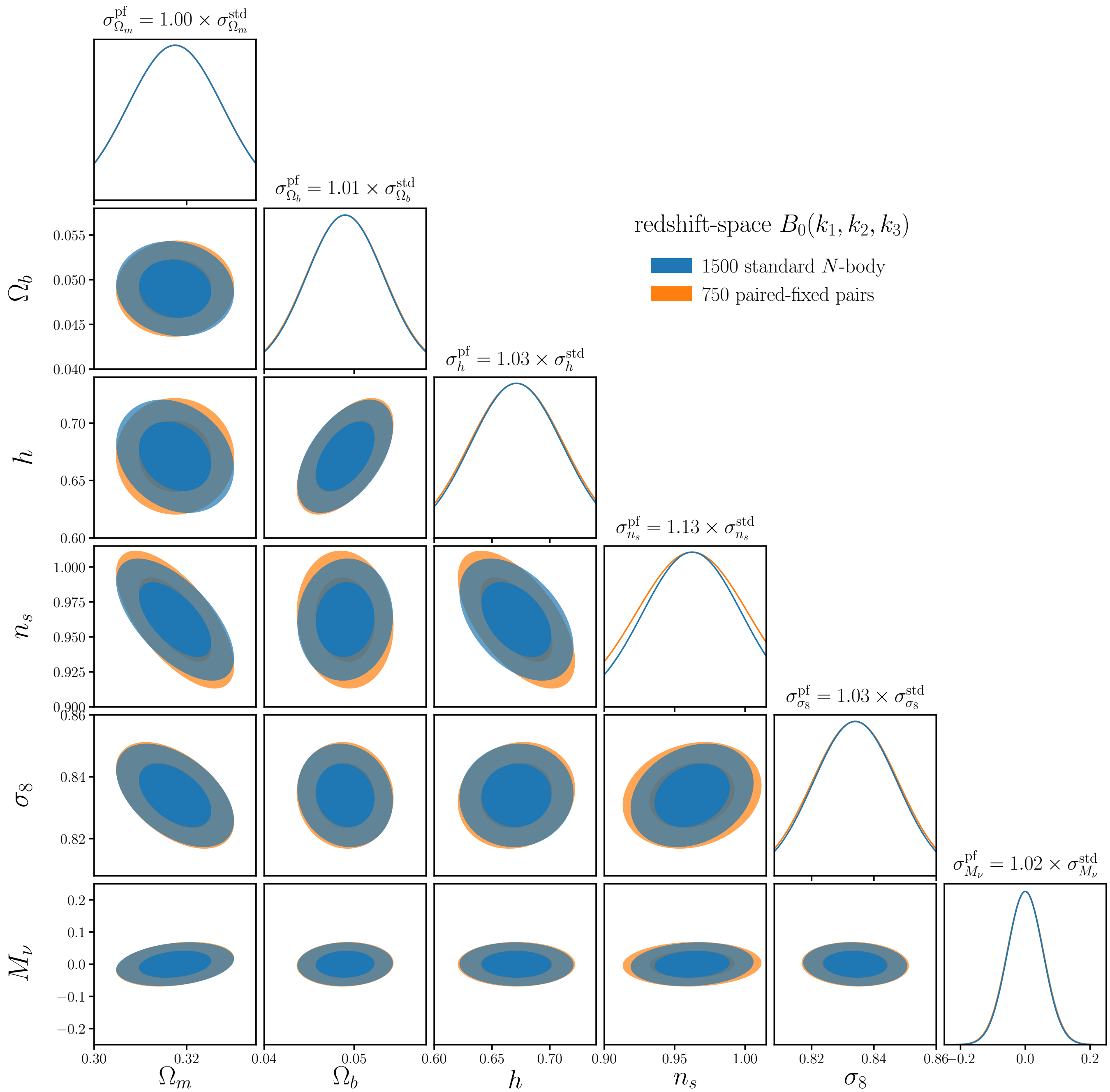

Figure 6. to be updated