$$
\begin{aligned}
&\delta\mathrm{Cov}[\Delta\Sigma(R_n, z_\mathrm{l}), \Delta\Sigma(R_{n'}, z_{\mathrm{l}'})] \\
&\quad = \frac{1}{\Omega_\mathrm{s}} \int \frac{l\mathrm{d}l}{2\pi} \hat{J}_2\left(l\frac{R_n}{\chi_\mathrm{l}}\right) \hat{J}_2\left(l\frac{R_{n'}}{\chi_{\mathrm{l}'}}\right) \Sigma_\mathrm{cr}(z_\mathrm{s}, z_\mathrm{l})\Sigma_\mathrm{cr}(z_\mathrm{s}, z_{\mathrm{l}'}) \\
&\qquad \times \left\{ \begin{array}{l}
2(\alpha_{l'}-1)C_{\mathrm{g}\kappa_\mathrm{s}}(l, z_\mathrm{l})C_{\kappa_\mathrm{l}\kappa_\mathrm{s}}(l, z_{\mathrm{l}'}) + 2(\alpha_\mathrm{l}-1)C_{\kappa_\mathrm{l}\kappa_\mathrm{l}}(l, z_\mathrm{l})C_{\mathrm{g}\kappa_s}(l, z_{\mathrm{l}'}) \\
+ \left(2(\alpha_{\mathrm{l}'}-1)C_{\mathrm{g}\kappa_\mathrm{l}}(l, z_\mathrm{l}, z_{\mathrm{l}'}) + 2(\alpha_\mathrm{l}-1)C_{\mathrm{g}\kappa_\mathrm{l}}(l, z_{\mathrm{l}'}, z_\mathrm{l})\right)\left(C_{\kappa_\mathrm{s}\kappa_\mathrm{s}}(l) + \frac{\sigma_\epsilon^2}{\bar{n}_\mathrm{s}^2}\right) \\
+4(\alpha_\mathrm{l}-1)(\alpha_{\mathrm{l}'}-1)\left[C_{\kappa_\mathrm{l}\kappa_\mathrm{l}}(l, z_\mathrm{l}, z_{\mathrm{l}'})\left(C_{\kappa_\mathrm{s}\kappa_\mathrm{s}}(l) + \frac{\sigma_\epsilon^2}{\bar{n}_\mathrm{s}}\right) + C_{\kappa_\mathrm{l}\kappa_\mathrm{s}}(l, z_\mathrm{l})C_{\kappa_\mathrm{l}\kappa_\mathrm{s}}(l, z_{\mathrm{l}'})\right]
\end{array} \right\},
\end{aligned} \tag{D8}
$$

where

$$C_{\mathrm{g}\kappa_\mathrm{s}}(l, z_\mathrm{l}) = \frac{W_\mathrm{s}(\chi_\mathrm{l})}{\chi_\mathrm{l}^2} P_\mathrm{gm}\left(\frac{l}{\chi_\mathrm{l}}, z_\mathrm{l}\right) \tag{D9}$$

$$C_{\kappa_\mathrm{l},\kappa_\mathrm{s}}(l, z_\mathrm{l}) = \int \mathrm{d}\chi \frac{W_\mathrm{s}(\chi)W_\mathrm{l}(\chi)}{\chi^2} P_\mathrm{mm}^\mathrm{NL}\left(\frac{l}{\chi}, z\right) \tag{D10}$$

$$C_{\mathrm{g}\kappa_\mathrm{l}}(l, z_\mathrm{l}, z_{\mathrm{l}'}) = \frac{W_{\mathrm{l}'}(\chi)}{\chi_\mathrm{l}^2} P_\mathrm{gm}\left(\frac{l}{\chi_\mathrm{l}}, z_\mathrm{l}\right)\Theta(z_{\mathrm{l}'} - z_\mathrm{l}) \tag{D11}$$

$$C_{\kappa_\mathrm{s}\kappa_\mathrm{s}}(l) = \int \mathrm{d}\chi \frac{W_\mathrm{s}(\chi)^2}{\chi^2} P_\mathrm{mm}^\mathrm{NL}\left(\frac{l}{\chi}, z_\mathrm{l}\right) \tag{D12}$$

$$C_{\kappa_\mathrm{l}\kappa_\mathrm{l}}(l, z_\mathrm{l}, z_{\mathrm{l}'}) = \int \mathrm{d}\chi \frac{W_\mathrm{l}(\chi)W_{\mathrm{l}'}(\chi)}{\chi^2} P_\mathrm{gm}^\mathrm{NL}\left(\frac{l}{\chi}, z\right). \tag{D13}$$

The Bessel function averaged over n-th radial bin range, $\{R_\mathrm{n,min}, R_\mathrm{n,max}\}$, is defined as

$$\hat{J}_2(kR_n) = \frac{2}{R_\mathrm{n,min}^2 - R_\mathrm{n,max}^2} \int_{R_\mathrm{n,min}}^{R_\mathrm{n,max}} R\mathrm{d}RJ_2(kR). \tag{D14}$$