

With the modern galaxy surveys containing millions of galaxies, we are in the era of Precision Cosmology and accurate theoretical predictions are necessary for efficient use of data. However, the structures observed today are highly nonlinear due to gravitational and fluid forces moving particles over billions of years. Hence an alternative approach is to study these structures in initial conditions where linear theory is valid. This boils down to the problem of constructing accurate estimates of initial conditions corresponding to present day observations. Due to huge parameter space of tens of millions at the very least, this optimization problem is computationally very hard. However, since we have accurate forward models for this non-linear evolution, we can in principle use optimization algorithms such as L-BFGS/conjugate gradients which are assisted with knowledge of analytic derivatives. In this study, we begin with the observation that perturbation theory at second order agrees well with full N-body evolution and thus use a hybrid model wherein we use the exact N-body evolution as forward model and perturbation theory to calculate derivatives. We show that this is incompatible in general. We then present results using perturbative models at different orders as the forward models and show that this on the other hand gives accurate estimates of initial conditions for large scales.