Several dispersion relation-preserving (DRP) spatially central discretizations are considered as the base scheme in the framework of the Yee & Sjogreen (Yee & Sjogreen, ICOSAHOM09) low dissipative nonlinear filter approach. In addition, the nonlinear filter of Yee & Sjogreen with shock-capturing and long time integration capabilities is used to replace the standard DRP linear filter for both smooth flows and flows containing discontinuities. DRP schemes for computational aeroacoustics (CAA) focus on dispersion error consideration for long time linear wave propagation rather than the formal order of accuracy of the scheme. The resulting DRP schemes usually have wider grid stencils and increased CPU operations count compared with standard central schemes of the same formal order of accuracy. For discontinuous initial data and long time wave propagation of smooth acoustic waves, various space and time DRP linear filter are needed. For acoustic waves interacting with shocks and turbulence induced noise, DRP schemes with linear filters alone usually are not capable of simulating such flows. The investigation presented in this paper is focused on the possible gain in efficiency and accuracy by spatial DRP schemes over standard central schemes having the same grid stencil width for general direct numerical simulations (DNS) and large eddy simulations (LES) of compressible flows. Representative test cases for both smooth flows and problems containing discontinuities for 3D DNS of compressible gas dynamics are included.