We study $L^p(\mu) \to L^q(\nu)$ mapping properties of the convolution operator $T_\lambda f(x) = \lambda \ast (f \mu)(x)$, where $\lambda$ is a tempered distribution, and $\mu$ and $\nu$ are compactly supported measures satisfying the polynomial growth bounds $\mu(B(x, r)) \leq C r^{s_\mu}$ and $\nu(B(x, r)) \leq C r^{s_\nu}$. As a significant application of this work, we prove variants of the classical $L^p$-improving (Littman; Strichartz) and maximal (Stein) inequalities in a setting where the Plancherel formula is not available. Another particularly motivating application is to the study of geometric configurations in subsets of Euclidean space of a given Hausdorff dimension.