Absorbing aerosols affect the Earth's climate through direct radiative heating of the troposphere. This heating can have myriad effects on tropospheric properties with significant implications for radiative forcing and beyond. While there is large uncertainty in model simulation of absorbing aerosols’ tropospheric interactions, we argue that it is possible to gain valuable insight into the robustness of model responses using energy balance constraint of the troposphere. We analyse the tropospheric response to a globally uniform increase in absorbing aerosols simulated with an atmospheric general circulation model (AGCM) for robustness using this theoretical framework. We find that over the convective regions, heating in the free troposphere hinders the vertical development of deep cumulus clouds, resulting in detrainment of more cloudy air into the large-scale environment and stronger cloud reflection. A different mechanism operates over the subsidence regions, where heating near the boundary layer top causes a substantial reduction in low cloud amount thermodynamically by decreasing relative humidity and dynamically by lowering cloud top. These findings suggest that the main characteristics of the tropospheric adjustment may be robust regardless of model physics parameterisation. We show that this framework can be extended to the model’s simulation of the impact on global-mean precipitation or “hydrological forcing”. Comparison with coupled model runs demonstrates that a global-mean energy budget analysis can be used to create an expression for the hydrological impact of absorbing aerosols that can be readily evaluated with AGCM simulations alone. The implications for quantifying the climate perturbation posed by absorbing aerosols are discussed.