Multi-TeV cosmic rays (CRs) are trapped within the Milky Way and diffuse through the interstellar medium (ISM) for up to a hundred million years. This process creates a “sea” of particles around the Galactic plane, which is colloquially known as the TeV CR sea. CRs interact with the diffuse gas, radiation, and magnetic fields in the interstellar medium (ISM) to produce electromagnetic emissions that are a significant component of the all-sky flux across a broad wavelength range. These interactions result in a diffuse gamma-ray ($\gamma$-ray) emission along the Galactic plane.

The *Fermi* Large Area Telescope (LAT) has measured these $\gamma$-ray emissions at GeV energies with high statistics, and recent results from H.E.S.S., HAWC, LHAASO, and the Tibet Air-shower Array show that the diffuse $\gamma$-ray emission extends into the TeV and PeV energy regimes. The emissions observed at GeV and TeV energies are connected by the common origin of the CR particles injected by the sources, but the energy dependence and the CR sources themselves is not well understood.

In this contribution we use the 3D simulation software GALPROP to model the diffuse gamma-ray emission. We investigate predictions of the broadband emissions over a grid of steady-state 3D models that include variations over CR sources and other ISM target distributions. We compare the model predictions in the $\geq 100$ GeV $\gamma$-ray range with the H.E.S.S. Galactic plane survey (HGPS) after accounting for various observational uncertainties, and find that the GALPROP model predictions agree with lower estimates for the HGPS source-subtracted diffuse flux. We will also discuss the implications of the modelling results for interpretation of data from the next generation Cherenkov Telescope Array (CTA).

Finally, we performed time-dependent modelling of CR diffusion in the Galaxy and investigate the time-variability of the Galactic CR density and $\gamma$-ray flux along the Galactic plane. We discuss the origin and time-variability of the diffuse $\gamma$-ray emission and discuss the ability of future observations to constrain the Galactic distributions given the time-variability predicted by our models.