The propagation code USINE (Maurin et al., in preparation) provides the GCR fluxes in both the framework of the leaky-box model (LBM) and the diffusion model (DM). Associated with an efficient minimisation tool for finding the best-fit parameters of a model (w/wo convection, w/wo diffusive reacceleration), it allows these differences to be addressed thoroughly. We also investigate how sensitive these best-fit parameters are to various input ingredients/parameters.

The paper is organised as follows. In Sect. 2, the DM used is briefly recalled. In Sect. 3, the free parameters of the study, our methodology, and the input ingredients—the systematic effects of which are studied in this paper—are described. In Sect. 4, we discuss the consequences of varying the gas characteristics on the transport parameter determination. In Sect. 5, we focus on the effect of the source spectrum on the best-fit values for δ in models with or without convection/reacceleration. In Sect. 6, a similar analysis is carried out for the low-energy shape of the diffusion coefficient. We repeat again the analysis in Sect. 7, using various production cross-section sets. In a final step, we explore in Sect. 8 the effect of biasing B/C HEAO-3 data at high energy. We summarise, discuss our results, and conclude in Sect. 9.

2. Description of the diffusion model

The models and the equations are described in Paper II, to which we refer the reader for a complete discussion.

2.1. Diffusion equation

The differential density N^j of the nucleus j is a function of the total energy E and the position $\boldsymbol{r}$ in the Galaxy. Assuming steady-state, the transport equation can be written in a compact form as

$$\mathcal{L}^j N^j + \frac{\partial}{\partial E}\left(b^j N^j - c^j \frac{\partial N^j}{\partial E}\right) = \mathcal{S}^j \ . \qquad (1)$$

The operator $\mathcal{L}$ (we omit the superscript j) describes the diffusion $K(\boldsymbol{r}, E)$ and convection $\boldsymbol{V}(\boldsymbol{r})$ in the Galaxy, the decay rate $\Gamma_{\rm rad}(E) = 1/(\gamma\tau_0)$ for radioactive species, and the destruction rate $\Gamma_{\rm inel}(\boldsymbol{r}, E) = \sum_{ISM} n_{\rm ISM}(\boldsymbol{r}) v \sigma_{\rm inel}(E)$ on the interstellar matter (ISM):

$$\mathcal{L}(\boldsymbol{r}, E) = -\boldsymbol{\nabla}\cdot(K\boldsymbol{\nabla}) + \boldsymbol{\nabla}\cdot\boldsymbol{V} + \Gamma_{\rm rad} + \Gamma_{\rm inel}. \qquad (2)$$

The coefficients b and c are respectively first and second order gains/losses in energy, with

$$\begin{aligned} b\,(\boldsymbol{r}, E) \ &= \ \langle \frac{dE}{dt} \rangle_{\rm ion,\,coul.} - \frac{\boldsymbol{\nabla}.\boldsymbol{V}}{3} E_k \left(\frac{2m + E_k}{m + E_k}\right) \qquad (3) \\ &+ \ \frac{(1+\beta^2)}{E} \times K_{pp}, \\ c\,(\boldsymbol{r}, E) \ &= \ \beta^2 \times K_{pp}. \qquad (4) \end{aligned}$$

The coefficient K_{pp} is the diffusion coefficient in momentum space, and it can take several forms (see later).

2.2. Geometry of the Galaxy

The Galaxy is modelled to be a thin disc of half-thickness h, which contains the gas and the sources of CRs. This disc is embedded in a cylindrical diffusive halo of half-thickness L (where the gas density is assumed to be equal to 0). A constant wind $\boldsymbol{V}(\boldsymbol{r}) = {\rm sign}(z)\cdot V_c \times \boldsymbol{e}_z$, perpendicular to the Galactic plane, is assumed. In this framework, CRs diffuse in the disc and in the halo independently of their position. These assumptions allow for semi-analytical solutions of the transport equation, as the interactions (destruction, spallations, energy gain and losses) are restricted to the thin disc. Such semi-analytical models reproduce all salient features of full numerical approaches (e.g., Strong & Moskalenko 1998).

In this study, the disc half-height is set to $h = 100$ pc. It is not a physical parameter *per se* in the thin-disc approximation, but the phenomena occurring in the thin disc are related to it. The physical parameter is the surface density Σ: should a different h value be used, a rescaling always allows obtaining the same Σ.

Considering the radial extension R of the Galaxy to be infinite leads to the 1D version of the DM. This geometry, used in Jones et al. (2001) and in our Paper II, is also used in this analysis. The corresponding sets of equations and their solutions are presented in the Appendix of Paper II. They are not repeated here.

3. Methodology

As in Papers I and II, three different classes of diffusion models are considered. In addition, for completeness, we also treat the pure diffusion case:

- Model 0 = $\{K_0,\, \delta\}$, i.e. pure diffusion ($V_a = V_c = 0$);
- Model I = $\{K_0,\, \delta\ V_c\}$, i.e. no reacceleration ($V_a = 0$);
- Model II = $\{K_0,\, \delta,\, V_a\}$, i.e. no convection ($V_c = 0$);
- Model III = $\{K_0,\, \delta,\, V_c,\, V_a\}$.

The parameters K_0 and δ come from the standard form assumed for the diffusion coefficient, namely,

$$K(E) = \beta K_0 \mathcal{R}^\delta. \qquad (5)$$

3.1. Constrained parameters

At most, for Model III, four transport parameters need to be determined from CR data:

- K_0, the normalisation of the diffusion coefficient (in unit of kpc^2 Myr^{-1});
- δ, the slope of the diffusion coefficient;
- V_c, the constant convective wind perpendicular to the disc (km s^{-1});
- V_a, the Alfvénic speed (km s^{-1}) regulating the reacceleration strength [see Eq. (6)].

As in other studies, we use the B/C ratio to constrain these parameters. In DMs, the halo size of the Galaxy L is an extra free parameter. It cannot be determined solely from the B/C ratio because of the well-known degeneracy between K_0 and L. In this study, we choose to fix L. The value of the transport parameters for any other values of L can be obtained from simple scaling laws, as presented in Fig. 5 of Paper II (note that δ does not depend on L). To keep the discussion as simple as possible, this paper is based on B/C data alone, with four free parameters $\{K_0,\, \delta,\, V_c,\, V_a\}$ and the halo size set to $L = 4$ kpc.