A model for the magnetic field in the inner heliosphere

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- Creation of map of magnetic field in the inner heliosphere, with the irregularities in the field

Aim of research

- Creation of map of magnetic field in the inner heliosphere, with the irregularities in the field
- Comparison of the obtained model with the spacecrafts' data, such as ACE, Ulysses, Parker Solar Probe and others.

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    - $\vec{B}_{\text{aniso}}$ — Anisotropic component, collinear with $\vec{B}_{\text{reg}}$

Regular field

Regular field is given by Parker's model, which assumes, that the field lines are frozen inside the solar wind plasma.
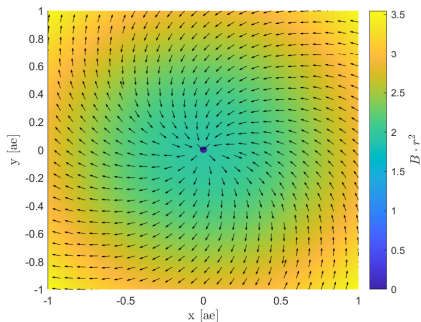
Parker's model

$$\vec{B}_{\text{reg}} = \pm B_0 \frac{r_0^2}{r^2} \left(\vec{e}_r - \frac{\Omega(r - r_s)}{V} \sin\theta \, \vec{e}_\varphi \right) H(\theta - \theta_{\text{CS}})$$
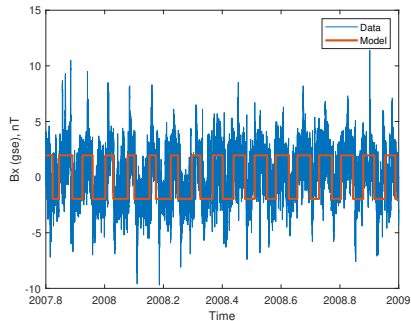
Here $H(\theta - \theta_{\text{CS}})$ takes into account the heliospheric current sheet (HCS) as follows:

$$H(\theta - \theta_{\text{CS}}) = \tanh\left(\frac{r(\theta_{\text{CS}} - \theta)}{L} \right)$$

The regular field at $z = 0$ slice.

The x component comparison in GSE coordinates across ACE spacecraft trajectory.

Noise Generation

A 4D random field $\vec{\mathcal{G}}_4$ is generated through Fourier transformation of the power spectrum $\sim k^{-\frac{5}{3}}$, such that $\langle \vec{\mathcal{G}}_4 \rangle = 0$ and $\langle \vec{\mathcal{G}}_4^2 \rangle = 1$. The first coordinate corresponds to the time dynamics of the random field, from the rest of them a spherical surface is sliced, which in its turn is corresponded with the source surface of the heliosphere. This procedure leads to a random field $\vec{\mathcal{G}}(t, \theta, \varphi)$ describing the irregularities on the source surface.

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The random field in the heliosphere

Given the law of the field lines $\varphi(r)$, one can transport $\vec{\mathcal{G}}$ into the inner regions of the heliosphere.

$$\vec{\mathcal{G}}_{\mathsf{H}}(t, r, \theta, \varphi) = \vec{\mathcal{G}}(t - \Delta t, \theta, \varphi(r_s) - \Omega \Delta t)$$

The random components of the magnetic field

Isotropic field

$$\vec{B}_{\mathsf{iso}} = \frac{\alpha}{r} \vec{G}_{\mathsf{H}}$$

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Anisotropic field

$$\vec{B}_{\mathsf{aniso}} = \beta\frac{\vec{B}_{\mathsf{reg}} \cdot \vec{G}_{\mathsf{H}}}{B_{\mathsf{reg}}}\vec{B}_{\mathsf{reg}}$$
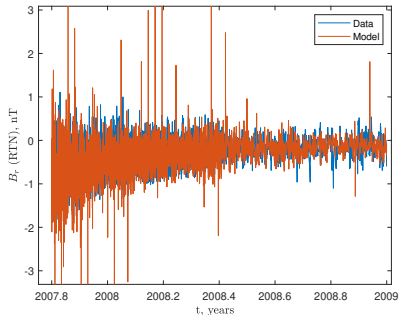
The total field
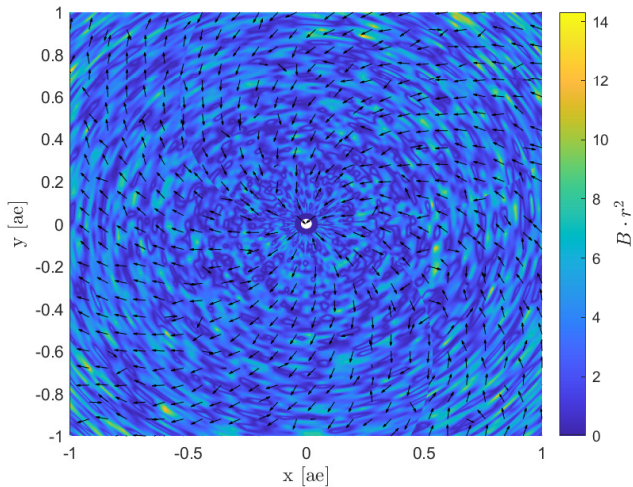
The total field at $z = 0$ slice.
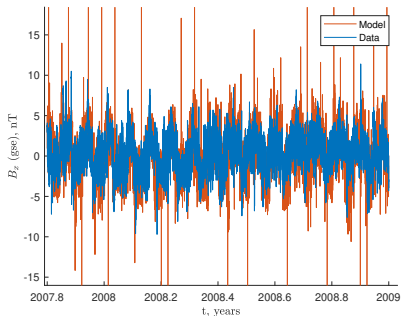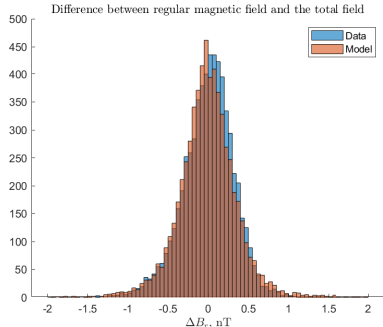
Comparing the model and observed field by ACE spaccarft
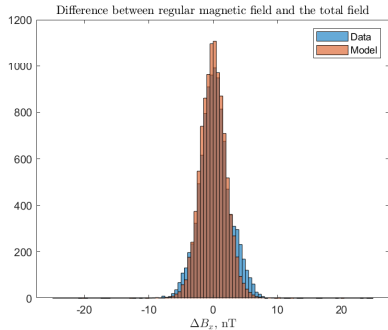
The random field histogram

Comparing the model and observed field by
Ulysses spacecraft

The random field histogram

- Compare the model with other spacecraft, such as Parker Solar Probe, Voyager, and others.

Future work

- Compare the model with other spacecraft, such as Parker Solar Probe, Voyager, and others.
- The power spectrum analysis of the obtained model

Thank you!