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对自相似扩展(SSE)模型的改进和研究

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Modification and study of self-similar expansion (SSE) model

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摘要

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摘要

自相似扩展拟合法(Self-Similar Expansion,SSE)假设日冕物质抛射(CME)具有恒定角宽度、沿径向向外传播的、自相似扩展的球形前沿,由日心出发的、与这个球形前沿相切的圆锥的圆锥角就是通常所说的CME角宽度,半角宽度取值范围是 $[0^\circ, 90^\circ]$,固定 Φ 角拟合法(Fixed- Φ , $F\Phi$)和调和均值拟合法(Harmonic-mean, HM)分别对应SSE模型的半角宽度为 0° 和 90° 的特殊情况.本文中修改后的自相似扩展拟合法(MSSE)假设CME具有自相似扩展的半球形前沿,能够提取的CME参数包括由日心出发的、圆锥截面过球心的圆锥的半圆锥角和CME的主传播方向、传播速度,其中半圆锥角取值范围是 $[0^\circ, 90^\circ]$, $F\Phi$ 和HM分别对应MSSE模型的半圆锥角为 0° 和 45° 的特殊情况,半圆锥角为 90° 时,CME前沿是以日心为圆心的半圆.MSSE拟合法扩大了SSE模型对CME前沿形态的描述范围,将半圆锥角作为判断CME是否能够到达、何时到达某颗卫星的重要参数.基于单颗STEREO卫星日球层成像仪(Heliospheric Imager,HI)图像,结合STEREO和ACE卫星的太阳风实地观测数据,本文深入分析了2010年23个CME事件,结果发现:在用于预报CME事件是否能到达某颗卫星、何时到达时,MSSE拟合法相比 $F\Phi$ 、HM和SSE拟合法,不但可以更准确地拟合CME主传播方向和传播速度,也可以缩小预计到达时间和到达速度的误差.

关键词 CME, STEREO, HI, 角宽度

Abstract:

Self-Similar Expansion (SSE) fitting models the leading edge of the Coronal Mass Ejection (CME) as a self-similar expansion sphere with a fixed propagation direction and a fixed angular width. Cone angle of the heliocentric cone which is tangent to the sphere usually refers to the angular width of the CME, ranging from 0 to 90 degrees. Angular widths of Fixed- Φ ($F\Phi$) and Harmonic-mean (HM) fitting are defined, corresponding to 0 and 90 degrees of SSE model, respectively. Modified SSE (MSSE) fitting discussed in this paper models the leading edge of the CME as a self-similar expansion semi-sphere. It is able to extract CME parameters using MSSE fitting, including propagation direction, velocity and cone angle of the heliocentric cone, whose conic section is across the center of the semi-sphere, ranging from 0 to 90 degrees. Cone angles of $F\Phi$ and HM fitting are defined, corresponding to 0 and 45 degrees of MSSE model, respectively. Leading edge of the CME can be assumed as a heliocentric semi-sphere when cone angle is assumed to be 90 degrees. MSSE fitting expands the morphology of leading edge of the CME and considers cone model as a reference to determine whether and when the CME will reach a satellite. 23 CMEs were analyzed based on the observations by Heliospheric Imager (HI) from one spacecraft of STEREO, combined with in-situ observations of solar wind on STEREO and ACE. We found that the error of the CME propagation direction, arrival speed and theoretical arrival time analyzed by MSSE fitting decreased, compared to $F\Phi$, HM and SSE fitting.

Keywords CME, STEREO, HI, Angular width

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