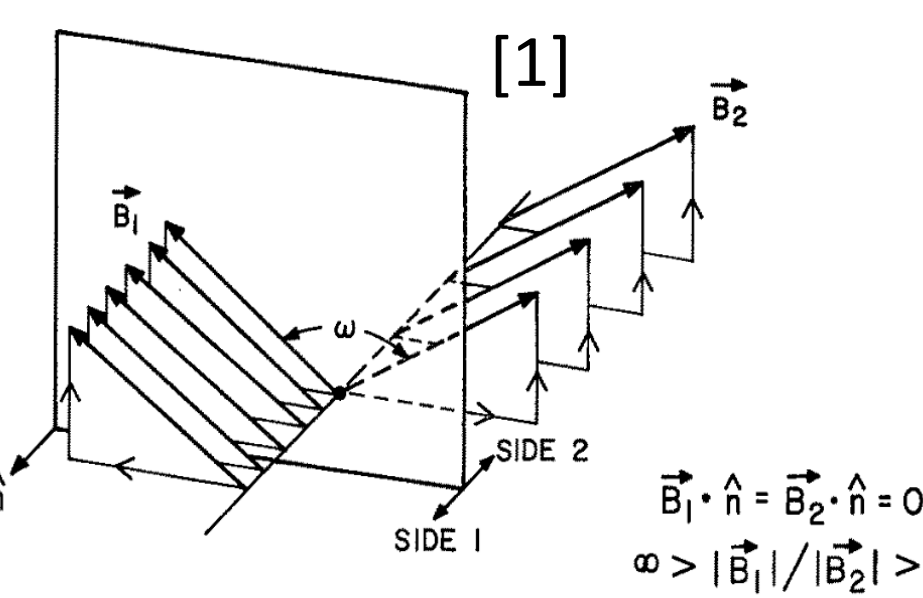


Introduction

Tangential discontinuities (TDs) in solar wind are the most commonly observed type of interplanetary or directional discontinuity. These discontinuities exhibit an abrupt alteration in the direction of the solar wind's magnetic field, accompanied by simultaneous changes in the plasma parameters. Importantly, there is no mass flow or magnetic flux crossing the surfaces of these discontinuities. However, tangential field component can vary in both direction and magnitude across the discontinuity. They are highly abundant in solar wind and can occur with a frequency ranging from several minutes to several hours. It is important to note that any tangential discontinuity must interact with **Earth's Bow Shock (BS)** before reaching the magnetosphere, *giving rise to intriguing consequences and effects.*



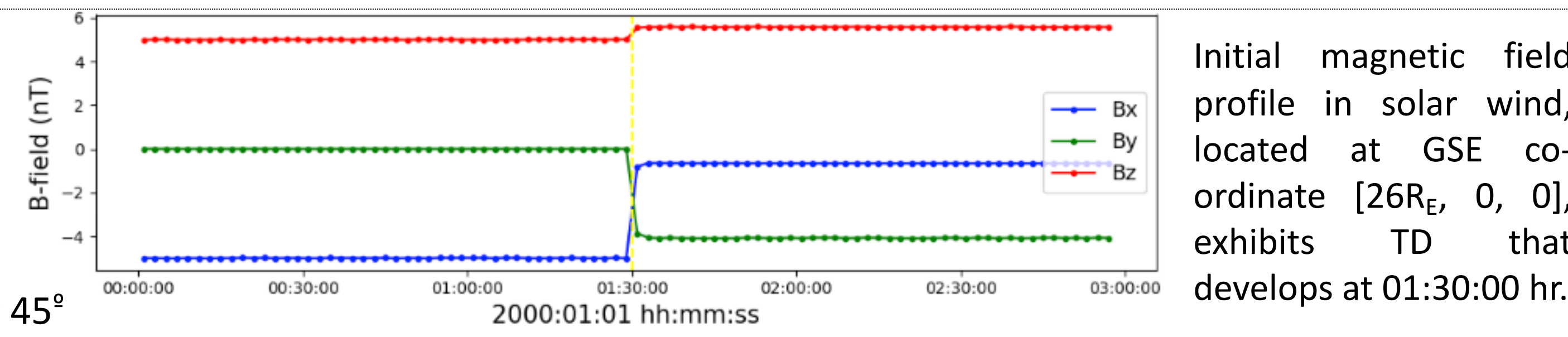
Numerical Model

In this study, our objective is to simulate interaction between two synthetically generated tangential discontinuity (not a real recorded solar wind data) and Earth's Bow Shock using a global magnetohydrodynamics (MHD) simulation model known as **Open Geospace Circulation Model (OpenGGCM)**. OpenGGCM is comprehensive global model of Earth's geospace environment, encompassing the solar wind, interplanetary magnetic field, upper atmosphere, and ionosphere. It employs semi-conservative formulation of MHD equations to simulate motion of single-fluid plasma within a 3-D, stretched cartesian grid, allowing us to use very high resolution in area of interest.

OpenGGCM Simulation Results

Case Study I

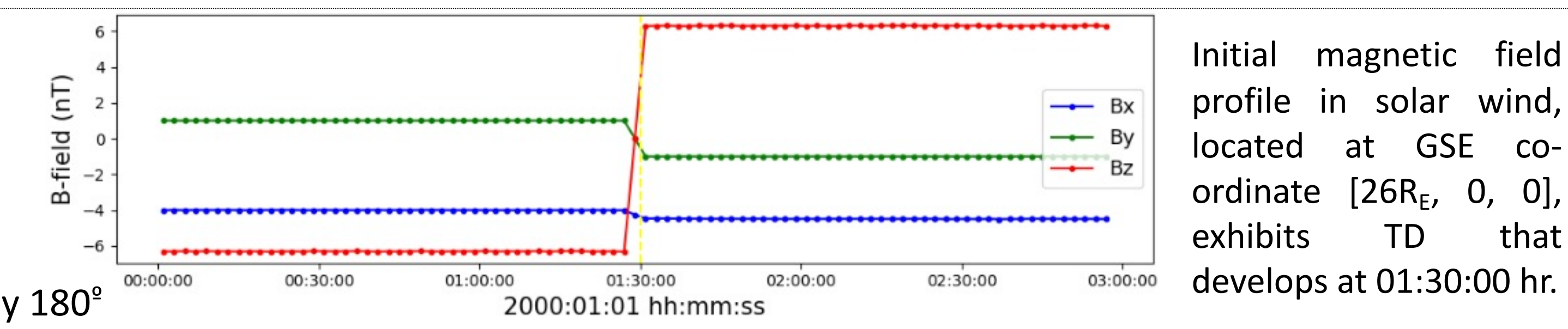
Input Solar Wind TD : $M_A = 8$
Velocity (V_{sw}) = -450 Km/s (anti-sunward)
Density (rr) = 6 /cc
Temperature = 8.6 eV
Tangential magnetic field component is rotated by 45°



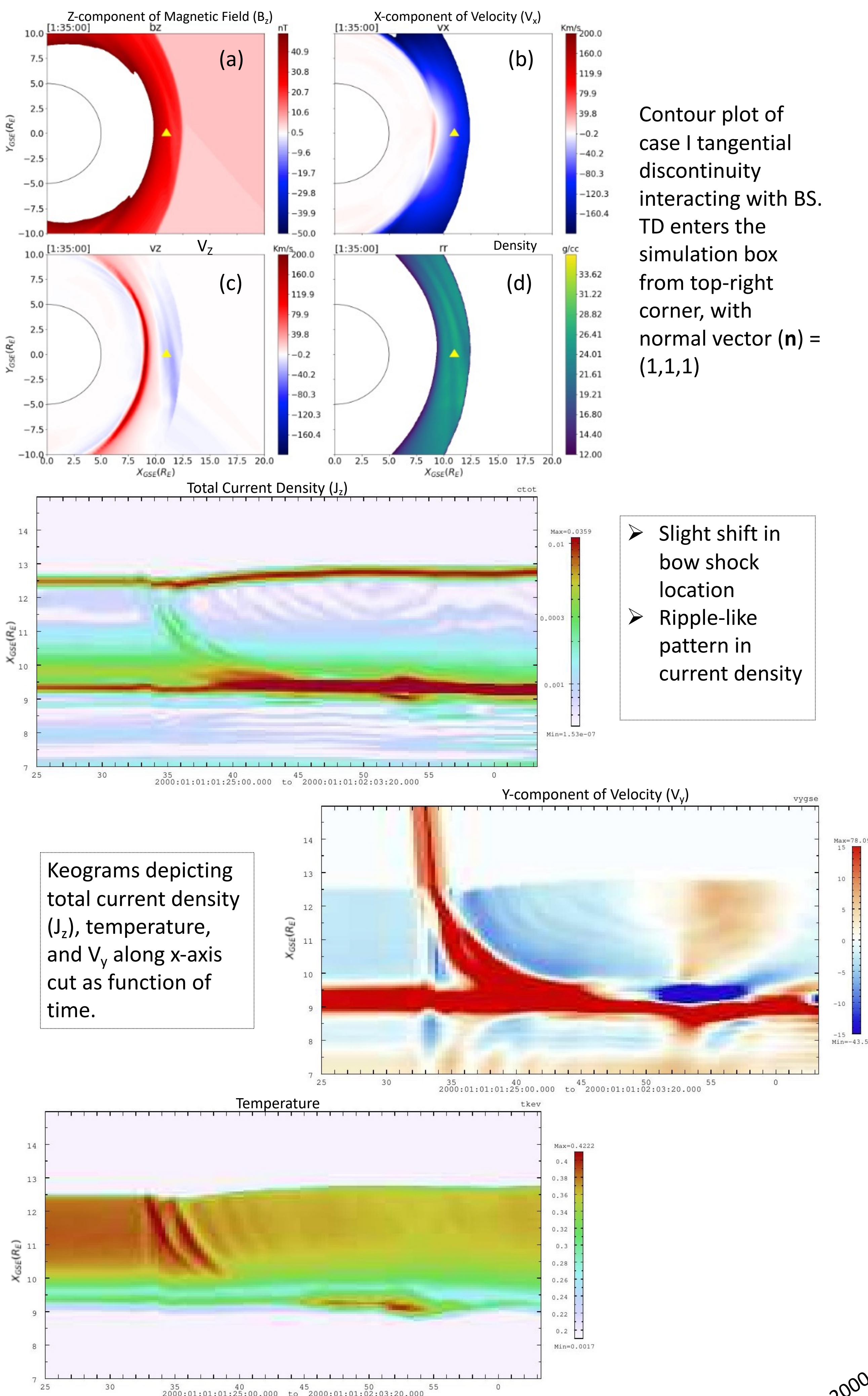
Initial magnetic field profile in solar wind, located at GSE coordinate $[26R_E, 0, 0]$, exhibits TD that develops at 01:30:00 hr.

Case Study II

Input Solar Wind TD : $M_A = 8$
Velocity (V_{sw}) = -450 Km/s (anti-sunward)
Density (rr) = 6 /cc
Temperature = 8.6 eV
Tangential magnetic field component is rotated by 180°



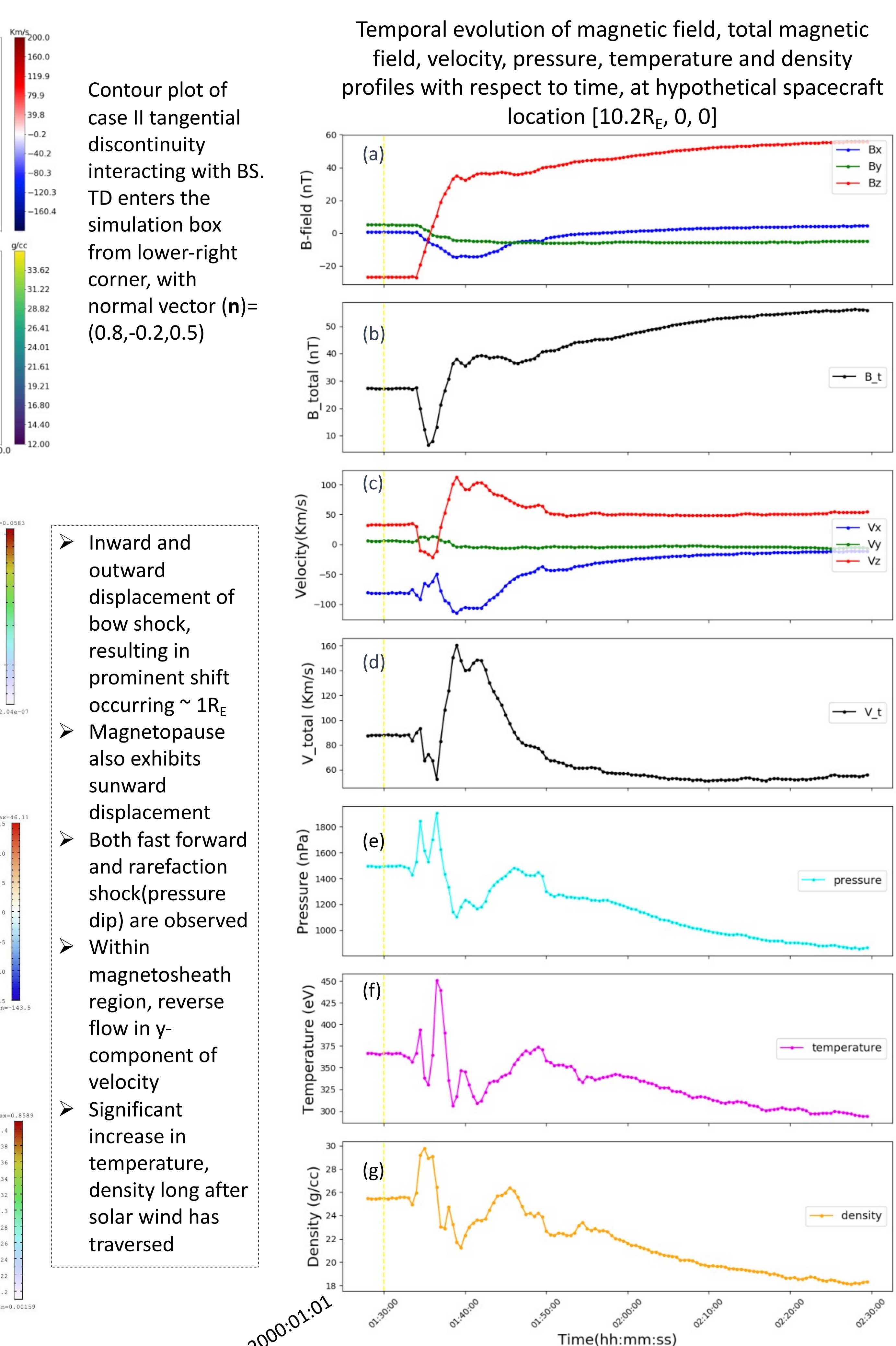
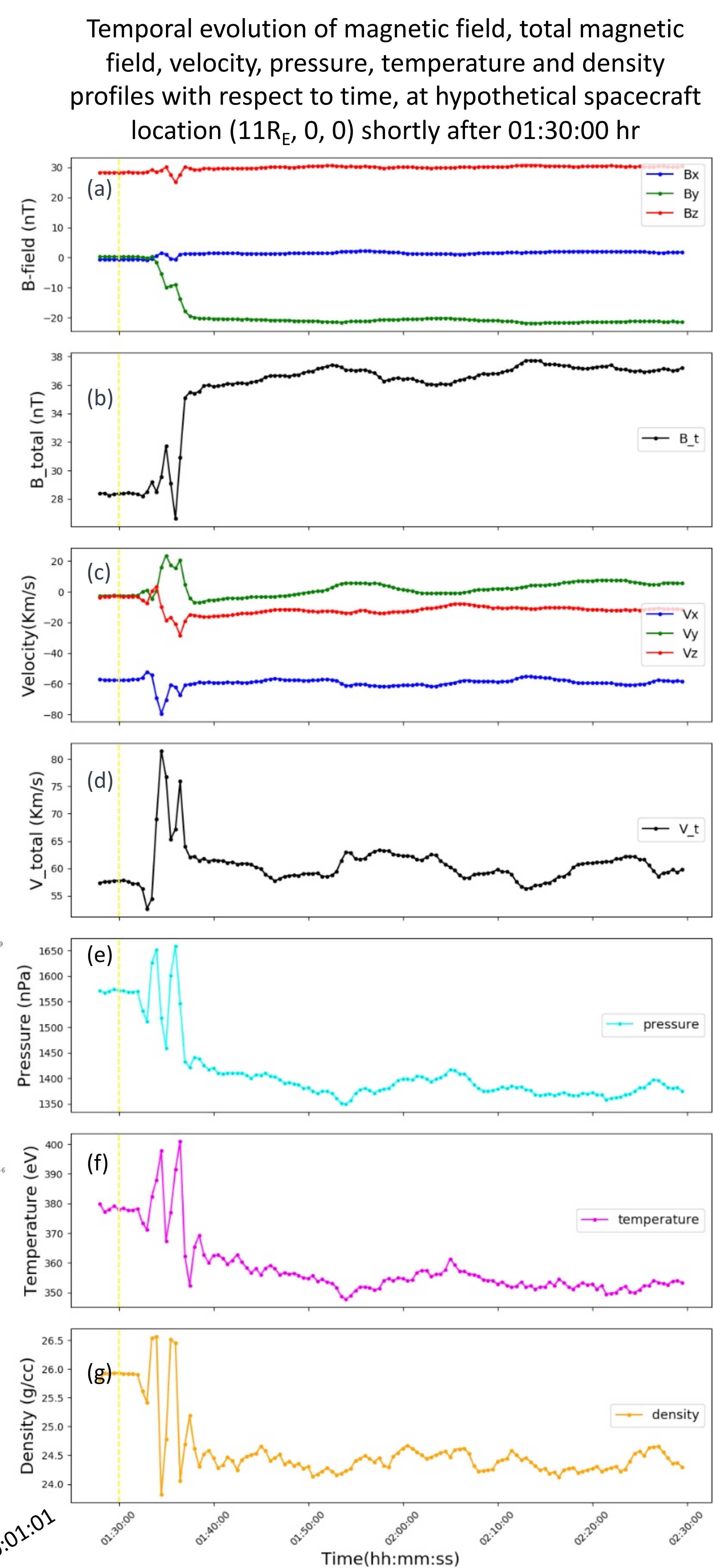
Initial magnetic field profile in solar wind, located at GSE coordinate $[26R_E, 0, 0]$, exhibits TD that develops at 01:30:00 hr.



Contour plot of case I tangential discontinuity interacting with BS. TD enters the simulation box from top-right corner, with normal vector $(n) = (1,1,1)$

Slight shift in bow shock location
Ripple-like pattern in current density

Keograms depicting total current density (J_z), temperature, and V_y along x-axis cut as function of time.



Contour plot of case II tangential discontinuity interacting with BS. TD enters the simulation box from lower-right corner, with normal vector $(n) = (0.8, -0.2, 0.5)$

Inward and outward displacement of bow shock, resulting in prominent shift occurring $\sim 1R_E$
Magnetopause also exhibits sunward displacement
Both fast forward and rarefaction shock (pressure dip) are observed
Within magnetosheath region, reverse flow in y-component of velocity
Significant increase in temperature, density long after solar wind has traversed

Summary

- Interaction of tangential discontinuity with Bow shock yields several interesting results,
- Shift in location of bow shock, indicating bow shock influences the dynamics of bow shock region.
 - Variations in plasma current sheet reveals forward and reverse wave primary in case II study, and ripple-like patterns in case I study, indicating occurrence of complex interactions between tangential discontinuity and bow shock.
 - Subsequent increase in temperature long after the solar wind had traversed magnetopause, suggests the influence persists leading to delayed changes in plasma parameters.

Future Work

Our aim is to investigate and gain a deeper understanding of these intriguing processes by examining various cases of TDs, as well as other directional discontinuity. Ultimately, we intend to utilize authentic solar wind data from spacecraft located either upstream or downstream of the bow shock as an input for the model. That will enable us to conduct comprehensive study and analysis.

References

[1] Burlaga, L. F., N. F. Ness, Tangential discontinuities in the solar wind, *Sol. Phys.*, **9**, 467– 477, 1969.