A magnetic field model for substorm growth phase

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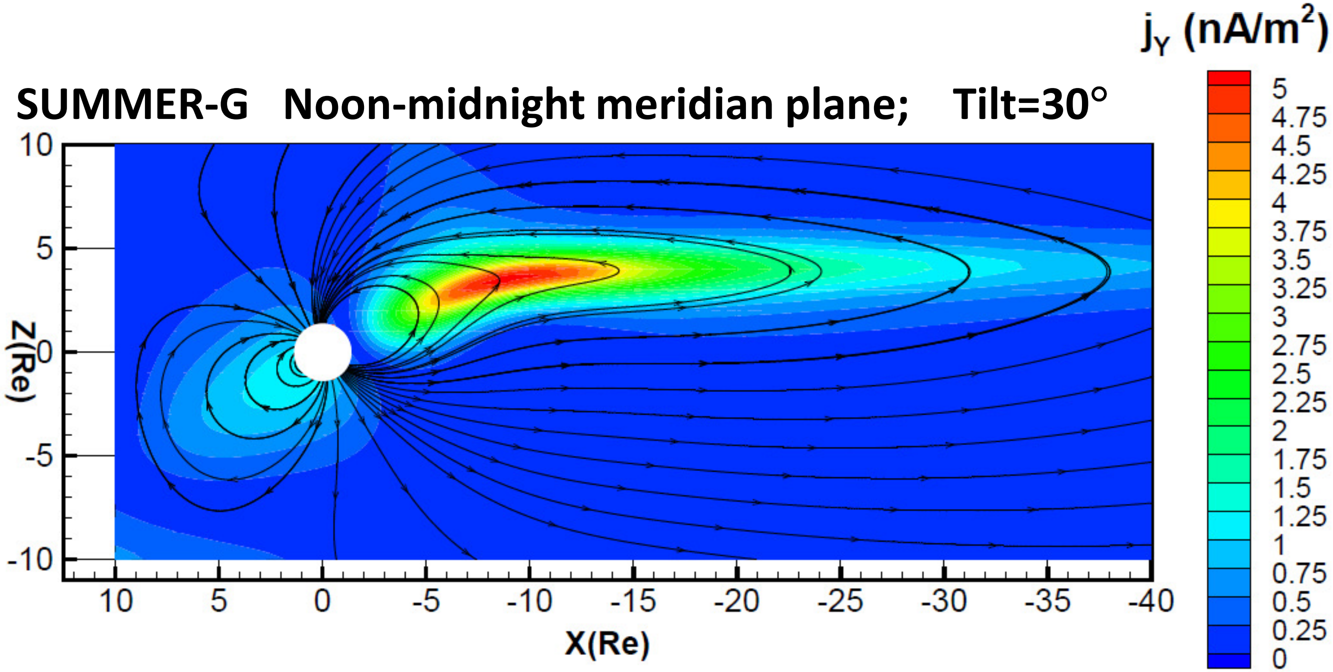
SUMMER (SUMMER-G, SUMMER-E):

SUbstorm-time Magnetic-field Model based on the Equilibrium version of the RCM

- Goal: construct an analytic and easy-to-use magnetic field model for substorm growth phase
- Approach: fit RCM-E results to a T89-like model (the same mathematical form of current sheet module as in T89 but different coefficients)
- Key features: intensified cross-tail current system as a function of solar wind history



SUMMER (SUMMER-G, SUMMER-E):

SUbstorm-time Magnetic-field Model based on the Equilibrium version of the RCM

	Nsw (cm^{-3})	Vsw (km/s)	IMF-Bz (nT)	
Solar wind Inputs for driven RCM-E	{ 2.5, 5.0, 7.5 }	{ 300, 400, 500, 600 }	{ 0, -2, -4, -6 }	48 runs

Least-squares fitting in the near-Earth plasma sheet
X[-6, -18], Y[-8,8], Z[0,3.5]

SUMMER-G

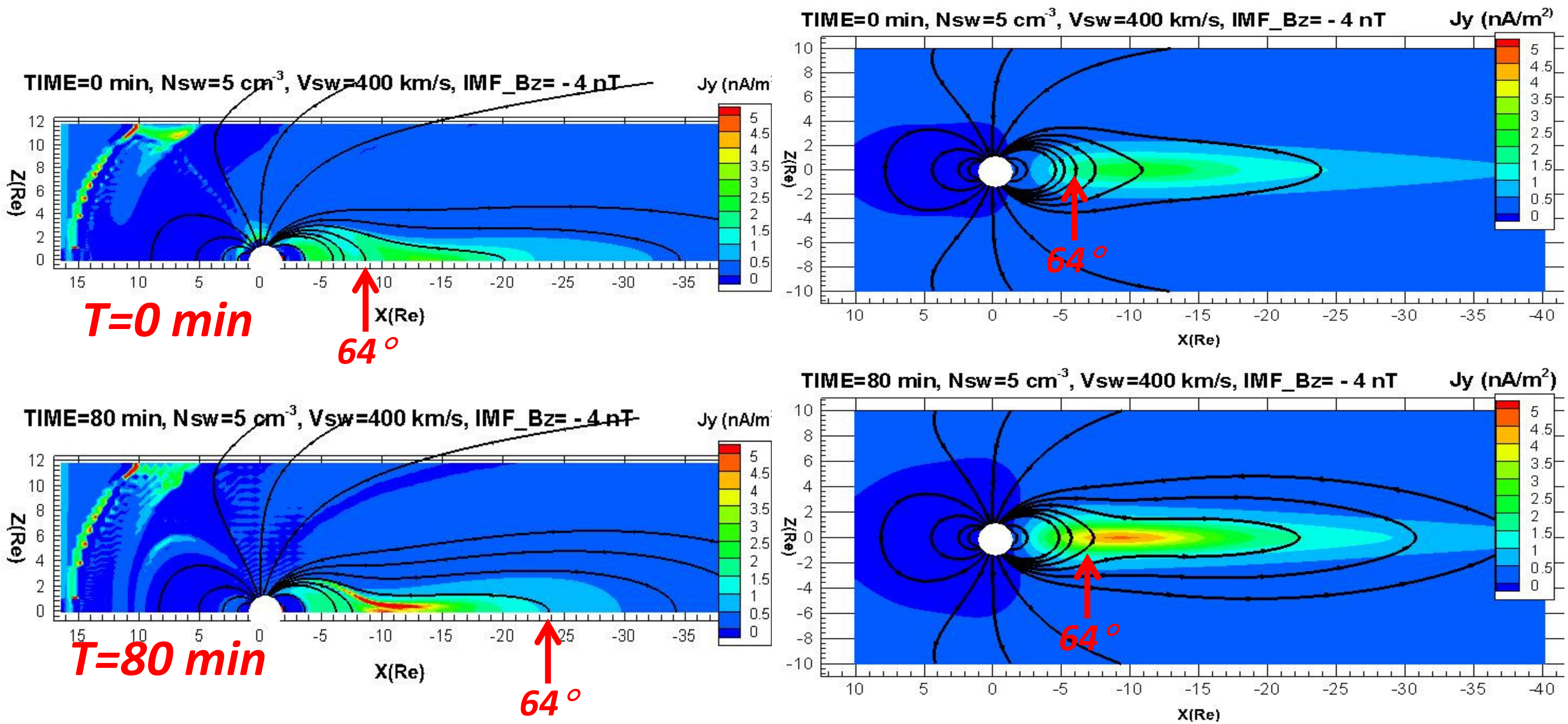
- A database of a set of coefficients $B_{Tail}(\alpha_1)+B_{SC}(\alpha_2)+B_{CF}$ binned by solar wind conditions and time in the growth phase
- Tilt effects are incorporated using an empirical CS shape model

Inputs: ① time since the start of growth phase $T-T_0$ (T_0 is the start of a growth phase, marked by the last IMF Bz southward turning)
② <IMF-*Bz*>,③ $<N_{SW}>$, ④ $<V_{SW}>$
⑤ Tilt angle Ψ
⑥ position ***X*** (GSM)

$$< N_{SW} > = \int_{T_0}^{T} N_{SW} dt / (T - T_0)$$

Outputs: external ***B*** (GSM)

RCM-E **SUMMER-G**



	RMSD of fitting	Eq. crossing of 62° (RCM-E/SUMMER-G)	Eq. crossing of 64° (RCM-E/SUMMER-G)	Eq. crossing of 66° (RCM-E/SUMMER-G)
T=00 min	1.0	-7/-5	-8.5/-6.5	-20/-8
T=40 min	1.1	-7.5/-6	-13/-7	-29/-10
T=80 min	1.8	-7.5/-6	-23/-8	-34/-22

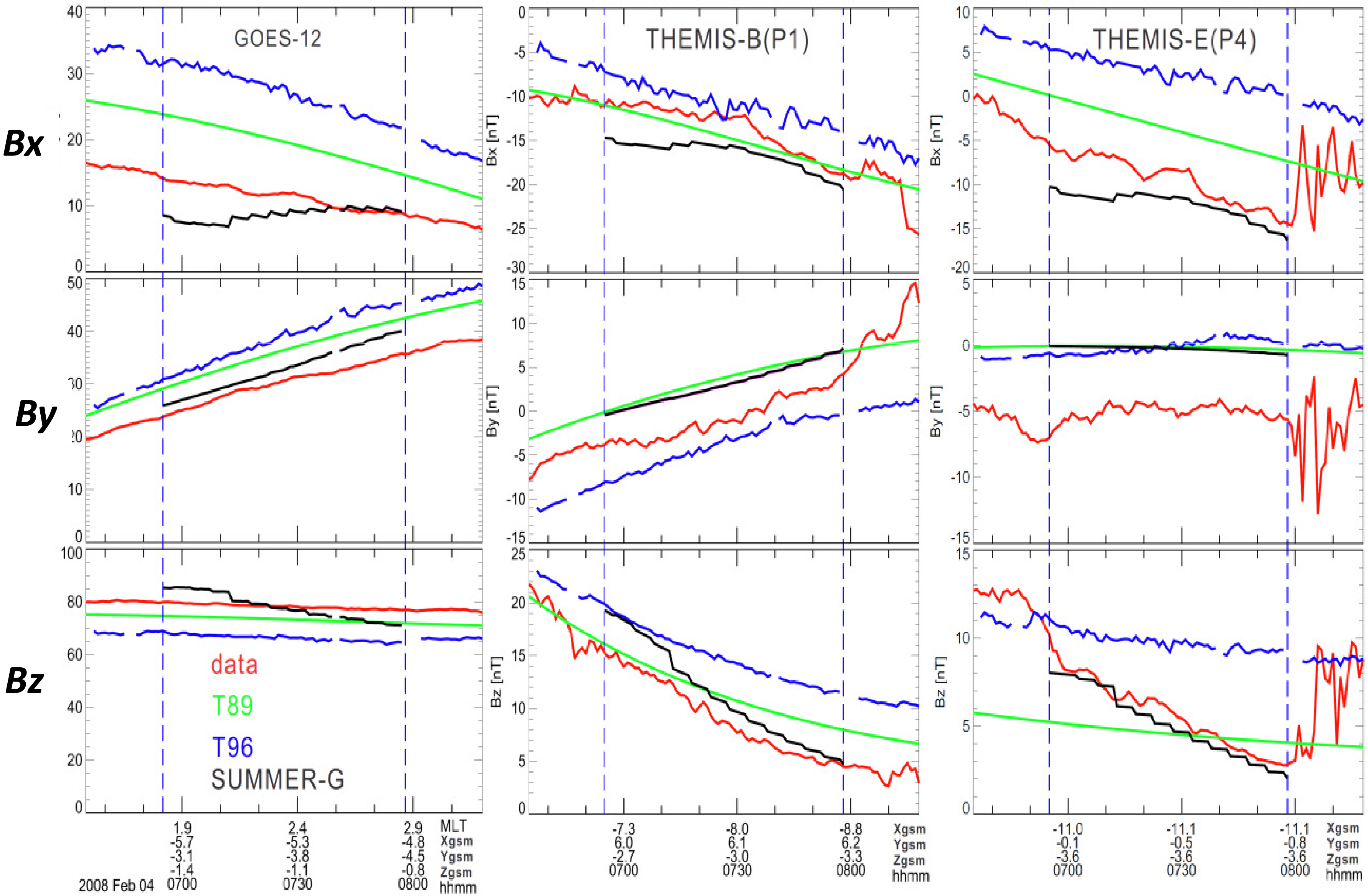
$$\sqrt{\sum (\Delta Bx^2 + \Delta By^2 + \Delta Bz^2)/3N}$$

2008-02-04

Start of growth phase: 06:55UT

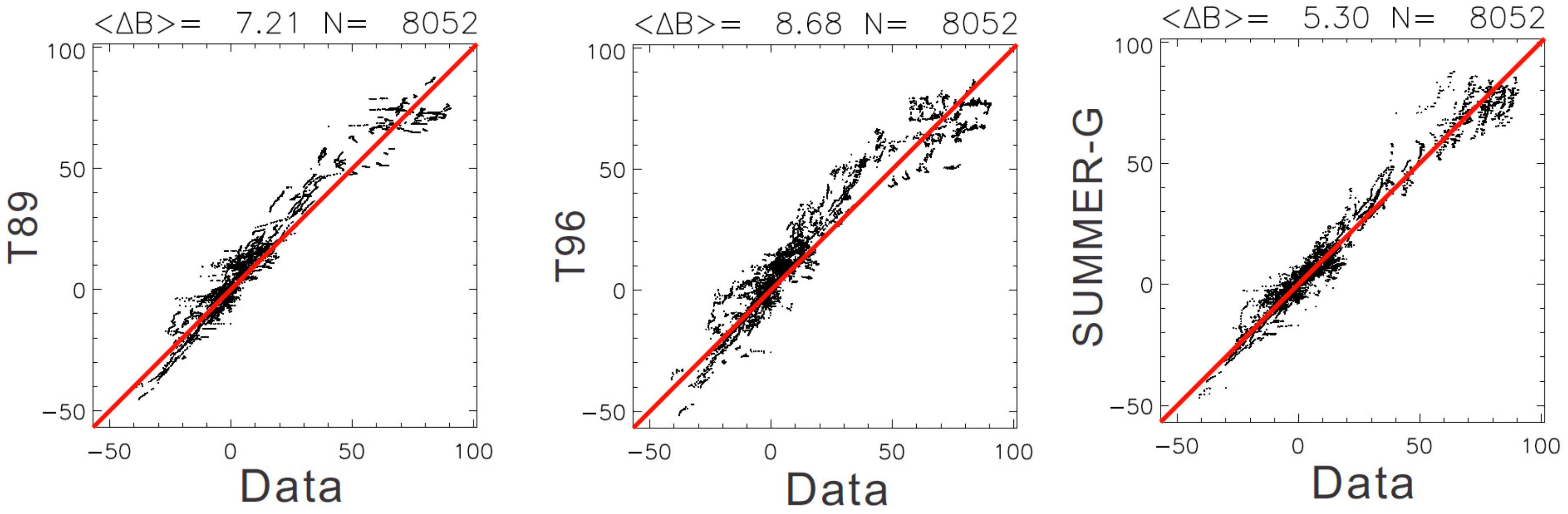
Substorm onset: 07:58UT

Nsw~1.5 cm^{-3} Vsw~600 km/s IMF Bz 0~-2.5 nT



Statistical results

- 24 events selected from *Nishimura et al*. [2010] list (~250 event)
  - IMF_Bz (1-min omni data) is continuously southward before “onset”.
  - Growth phase > 10 minutes
  - No major dipolarization during growth phase (visually identified)
  - Growth phase of isolated substorms
- Test again THEMIS and GOES data
  - Spacecraft must be in the region of X[-2, -30], Y[-18,18], Z[-10,10]
  - For THEMIS, plasma beta >1, Ti/Ni>5, Vi_x<50km/s



Summary

- ***SUMMER-G*** is an empirical analytic magnetic field model derived from RCM-E simulations of different substorm growth phases.
- ***Progress:***
  - ~25% and ~40% smaller RMSD against data than the T89 and T96
  - take the time history into account
- ***Challenge:*** Reliable mapping in the late growth phase still cannot be achieved.
  - Difference in equatorial crossing points can be large between SUMMER-G and RCM-E, even though RMSD of fitting is only 1~2 nT.
  - Warped current sheet shape cannot be accurately modeled.
  - Current sheet bifurcates.