Magnetic Variations of a Sol Observed over a Year on Mars with InSight

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InSight

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Intro: InSight landed on Mars in November 2018 [1]. The InSight FluxGate Magnetometer (IFG) is part of the Auxiliary Payload Sensor System (APSS) that monitors the environmental conditions around the lander [2]. However, the IFG is also the first magnetometer to operate on the martian surface, and it has enabled characterization of crustal and time varying magnetic fields [3,4].Here we focus on variations of the magnetic field within and among sols over one martian year and compare these observations with predictions for magnetic fields due to ionospheric currents.

DATA

A year of continuous 0.2 Hz IFG data reveals a diurnal pattern which shows seasonal variation

- Diurnal variations peak amplitudes of 20-40 nT in the early- to mid morning
- Median diurnal signal peaks at around 10 nT in all components with the largest variations in By
- Higher amplitudes observed around sol 100 and 550.

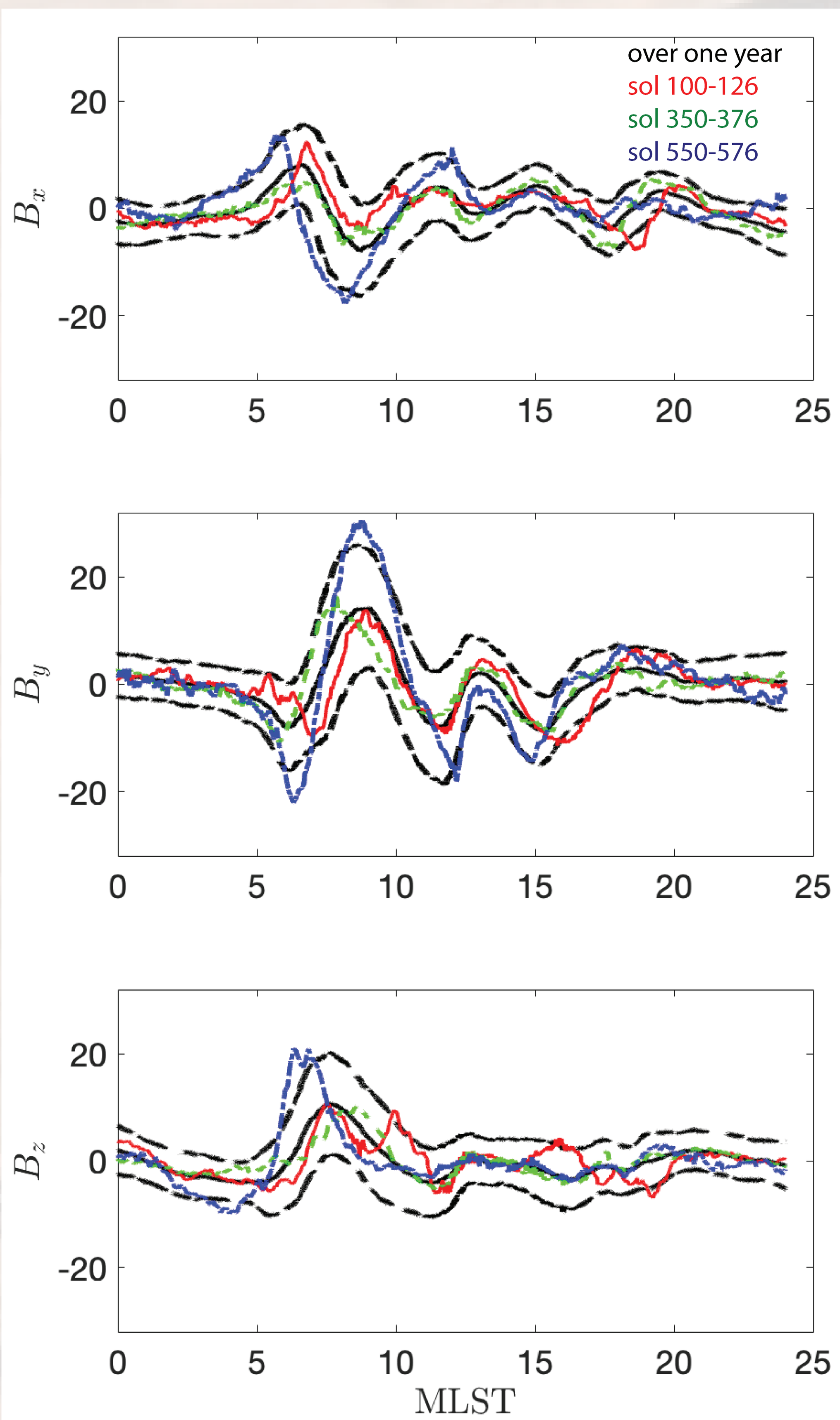


Figure 1: The median magnetic field components for a sol in mean local solar time (MLST) bins throughout a martian year (black solid) with standard deviation (black dashed), and for 26-sol median fields for different time frames.

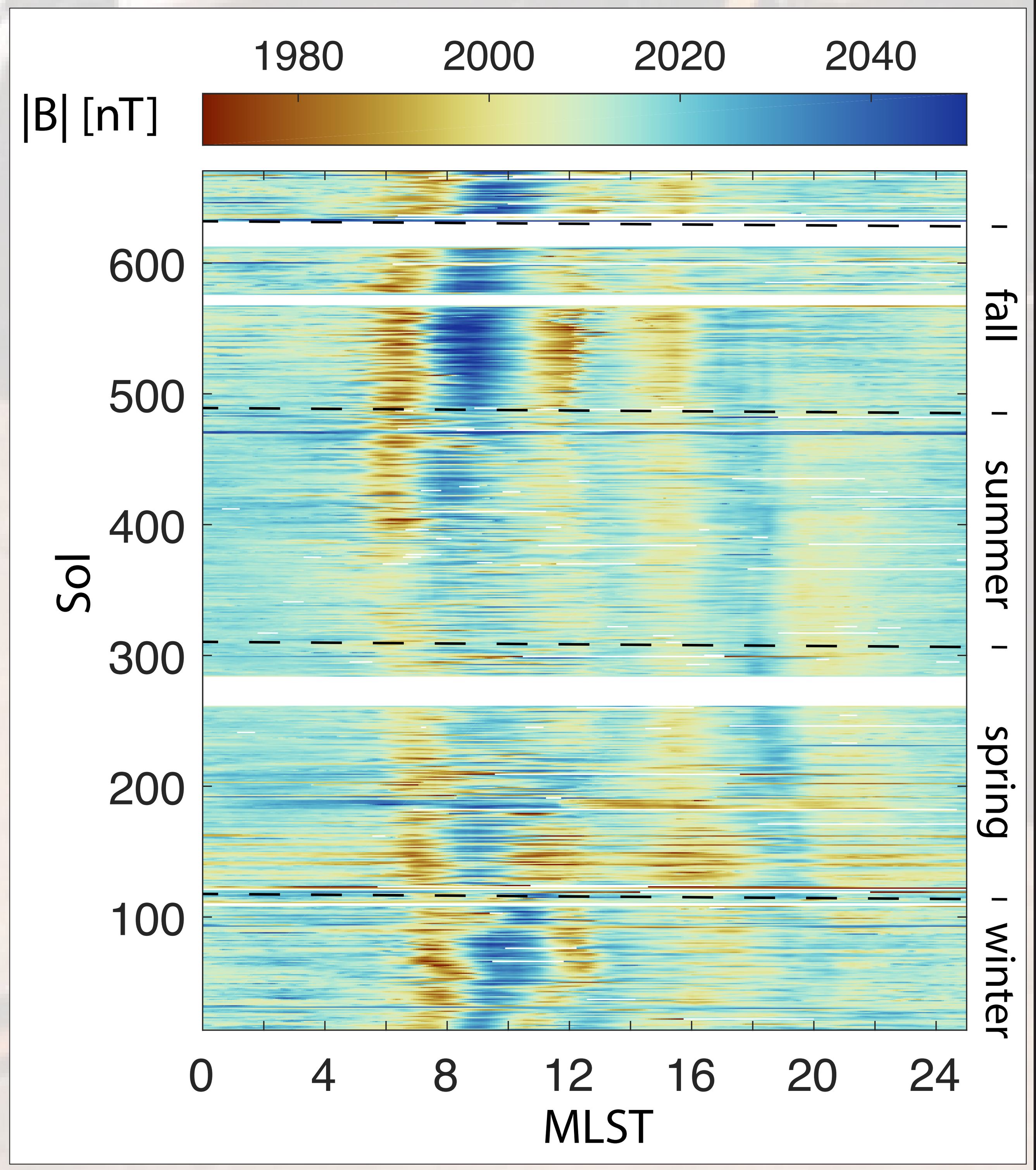


Figure 2: The magnetic field amplitude, |B|, versus local time over the first martian year of InSight operations. Dashed lines indicate solstices and equinoxes in the northern hemisphere.

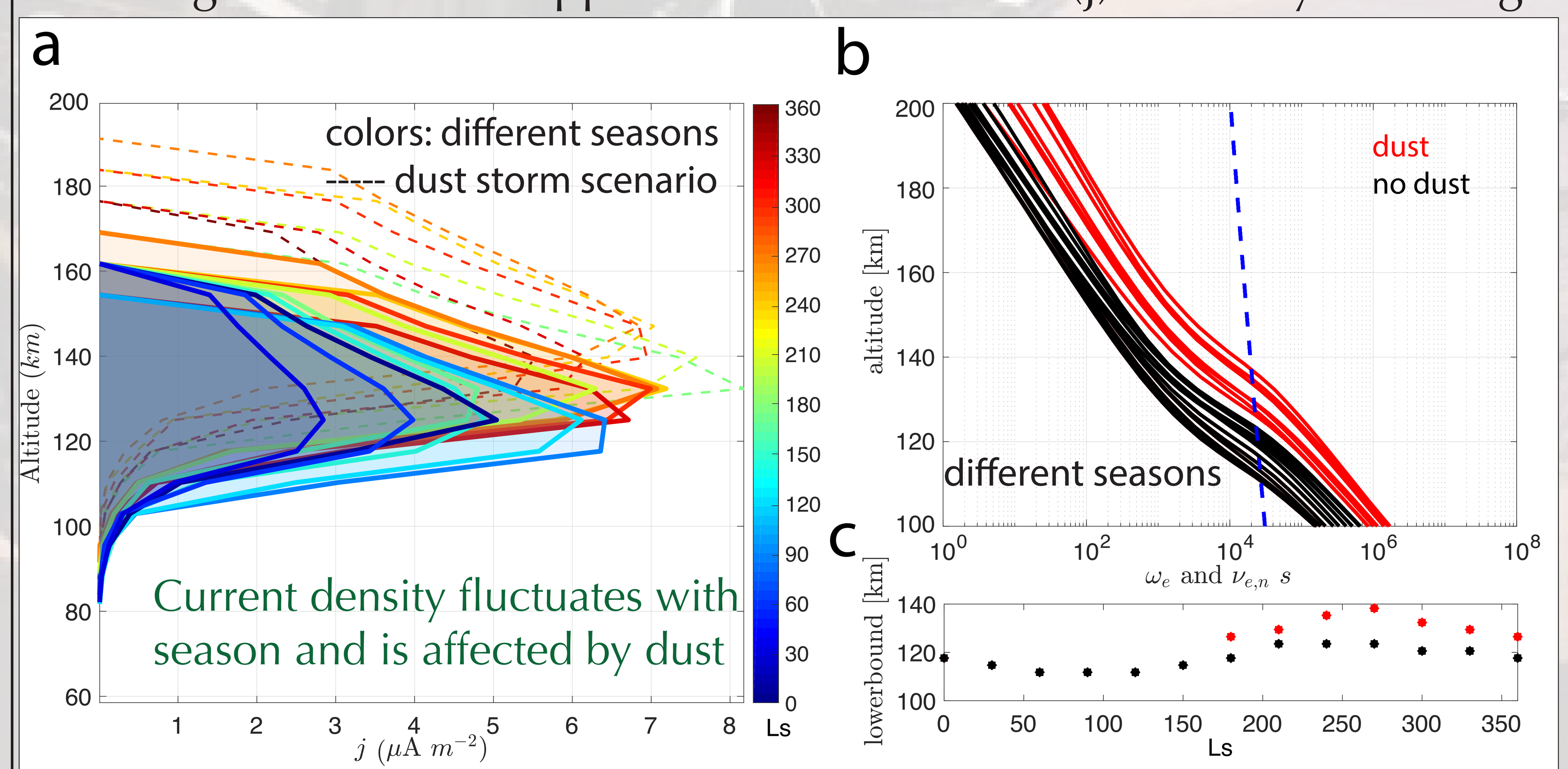
References: [1] Banerdt, W.B. et al. (2020) Nature Geo., 13, 183. [2] Banfield D. et al. (2018) Space Sci. Rev., 214, 109. [3] Johnson, C.L. et al. (2020) Nature Geo., 13, 199. Poster based on: [4] Mittelholz et al., (2020) JGR Planets, 125.

DISCUSSION

Could observed variability originate in the ionosphere?

Dynamo Region: Ions are collisionally coupled to the atmosphere and will move in direction of neutral winds

→ Using a MGCM we approximate the current (j) in the dynamo region



For different solar longitudes (ls) and with and without dust scenario:

a Calculate current $j = n_e q(v_i - v_e)$
Approximate v_i with horizontal wind velocity

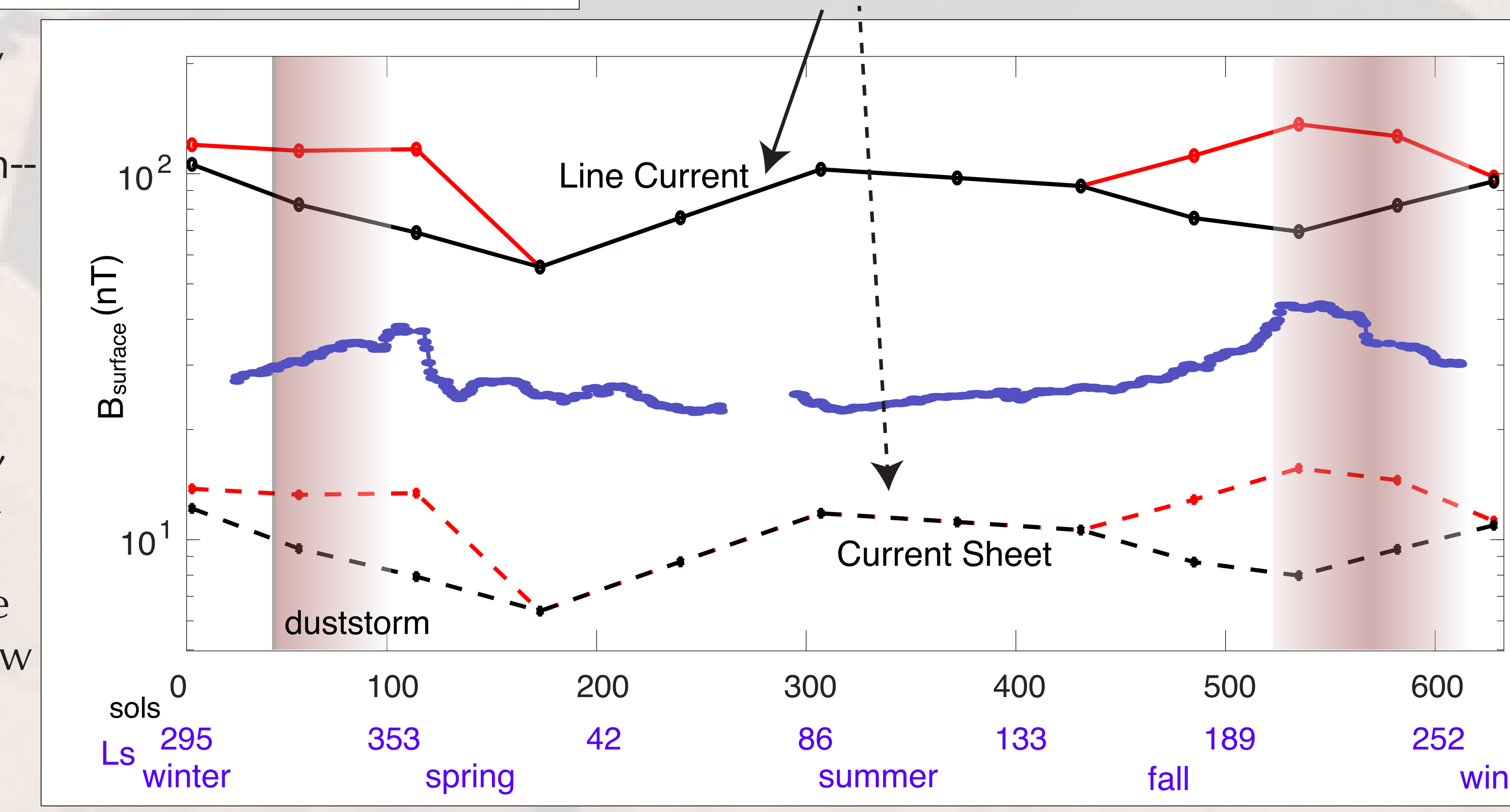
b Calculate ω_e and ν_e, to estimate **c**
ω_e: *Assume background crustal magnetic field*
ν_e: *Assume CO_2 is the dominant neutral constituent below 200 km*

c Lower bound of dynamo region where $\omega_e = \nu_e$

→ $B \sim \sum_{\text{lower,upper bound}} j(z)$

Figure 3: (a) Wind driven current densities, initially assuming currents are possible at any altitude. (b) Electron gyration frequency, ω_e (blue), and electron--neutral collision frequency, $\nu_{e,n}$. The lower dynamo boundary shown in (c) as a function of season for the dust-free and dust scenarios.

Figure 4: Wind driven magnetic field response, |B|, at the surface for an average scenario (black) and a dust storm scenario during dust season (red). The purple curve shows the maximum amplitude of the observed magnetic field in a 26-sol running window (examples shown in Figure 1).



Conclusions:

The **amplitude and seasonal variability of the surface magnetic fields** are generally **consistent** with those predicted from **wind-driven currents in the ionosphere**. Moreover, regional **dust storms** in the vicinity of the InSight landing site are **responsible for the higher magnetic field amplitudes** observed in the IFG data during dust season. InSight observations taken during the extended mission will provide further constraints on diurnal field variations and ionospheric currents.