

Abstract: This study investigates correlation between Equatorial Plasma Bubbles (EPBs) and Interhemispheric Asymmetries (IHAs) in nighttime Equatorial Ionization Anomalies (EIAs) over American/Atlantic sector using 2019–2026 GOLD mission data. While the Bubble Index (BI) and Asymmetry Index (Asyl) correlates positively with solar flux, their correlation polarity alternates annually with the sign of Asyl. As denser EIAs favors EPBs initial growth, high Asyl effectively predicts the BI onset. Additionally, observations highlight an anomalous Southern Hemisphere-dominant Asyl during the 2020–2021 boreal winter. We hypothesize this deviation is driven by quasi-16-day planetary waves, linking the anomaly to Sudden Stratospheric Warming (SSW).

Introduction and Motivations

- EPBs cause significant ionospheric scintillations, and their formation is modulated by background conditions [Aa+ 2023]
- Growth, $\gamma = \frac{\Sigma_p^F}{\Sigma_p^F + \Sigma_p^R} \left(v_{E \times B} + \frac{g}{v_{eff}} \right) \left(\frac{1}{N_e} \frac{\partial N_e}{\partial h} \right) - R$
- IHA is often caused by EIA plasma redistribution
 - Interhemispheric Plasma Transport (IHPT)
 - Recombination rate at different altitudes
 - Asymmetric lower atmospheric forcing

- GOAL 1:** To establish a long-term correlation between BI and Asyl
- GOAL 2:** Investigate underlying mechanism driving anomalous SH EIA dominance during the 2020-2021 boreal winter

Data and Methodology

Data

- Daily nighttime GOLD “Level 1C” OI 135.6 nm emissions (R) around **23:55 UT**
- Resolution:** 0.15° GLAT x 0.15° GLON, 0.04nm radiance. **SZA:** < 95°
- Coordinate Transform:** Geographic → Apex Geomagnetic (0.5° x 0.5°)
- Region:** QDLat ±25°, QDLon (**5°–45°E**)

Bubble Index (BI, Aa+ 2023)

- BI** = $\sigma(\Delta R_N)$, where $\Delta R_N = (R_{sum} - R_{fit})/R_{fit}$ and $R_{sum}(QDLon)$ is latitudinal sum of radiances (R) between ±8 QDLat
- BI** ≥ 0.12 is threshold to see bubbles

Asymmetry Index (Asyl, Khadka+ 2018)

- Asyl** = $\frac{2 \cdot (R_{NH} - R_{SH})}{R_{NH} + R_{SH}}$, where R_{NH} , R_{SH} are longitudinally averaged EIA crest radiances

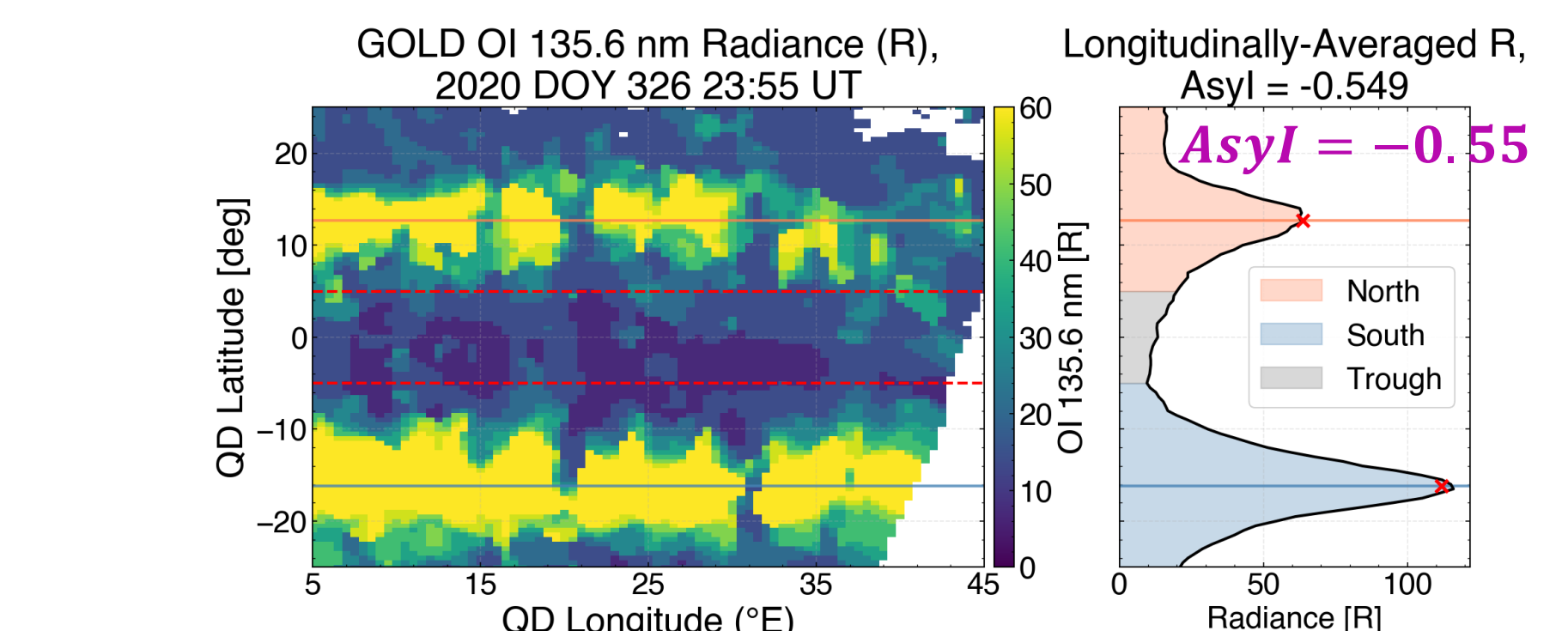


Fig. 1: (Left) GOLD OI 135.6 nm radiance and (Right) Longitudinally averaged R on DOY 326 of 2020.

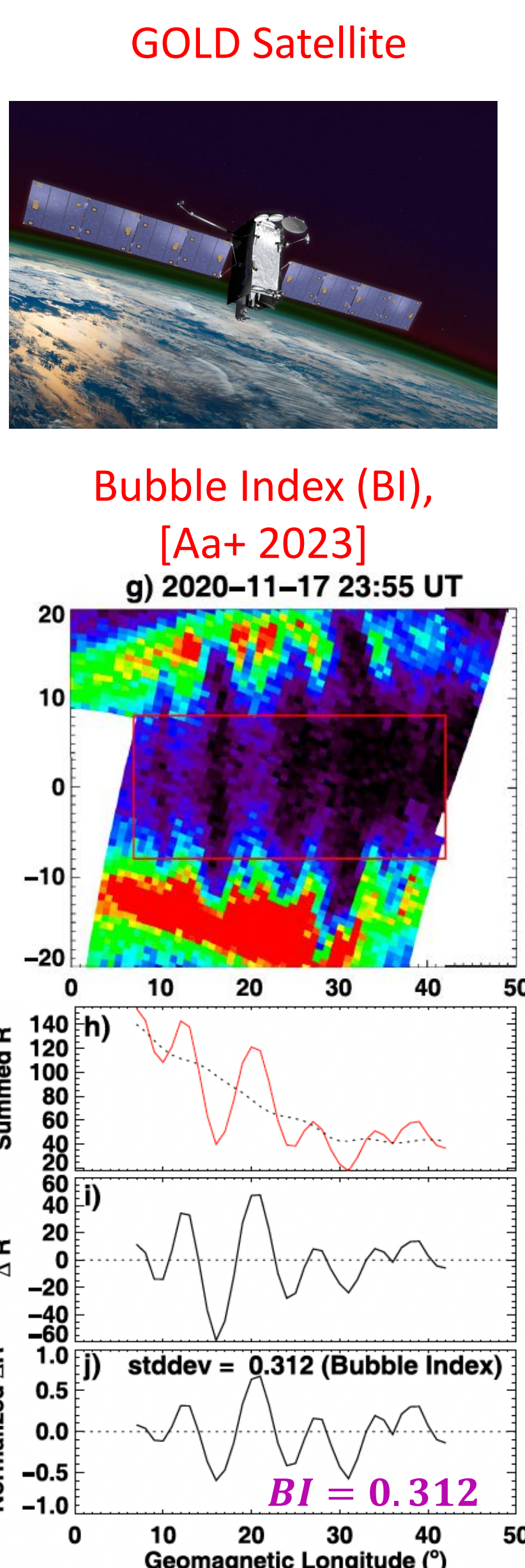


Fig. 2: Method for calculating BI taken from [Aa+ 2023]

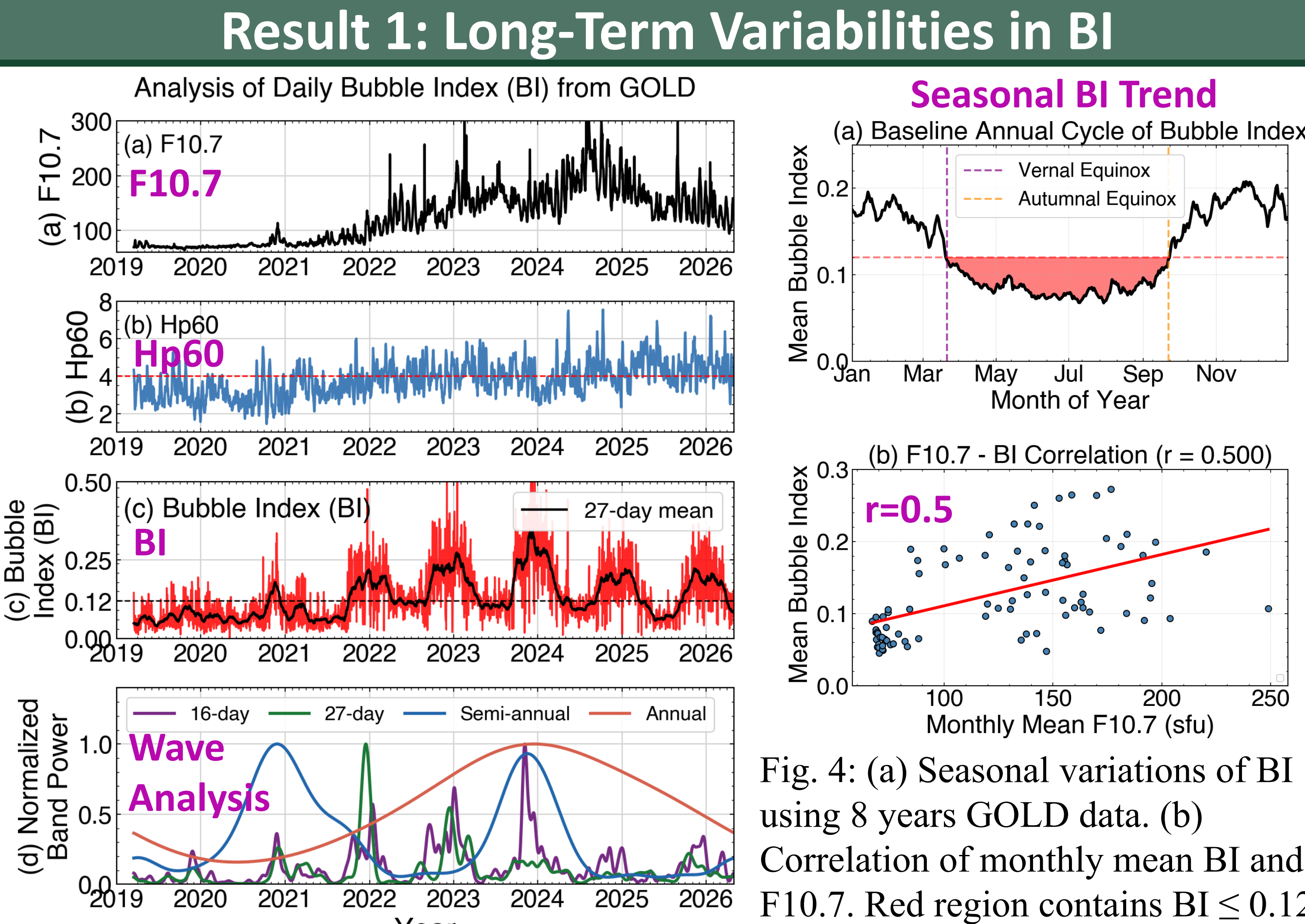


Fig. 3: Daily (a) F10.7, (b) Hp60, and (c) BI during ascending phase of solar cycle 25. (d) Normalized powers of major waves in Morlet Wavelet Transform of daily BI.

- Monthly mean BI positively correlates with solar flux (r=0.50)
- Bubble activity stays below threshold between March to Sept equinoxes
- Annual oscillations in BI increases with F10.7, while semi-annual peaks in 2021 and 2024
- 27-day and 16-day waveforms peaks are also observed each year
- Quasi 16-day PWs modulating ExB drifts might indicate SSW event**

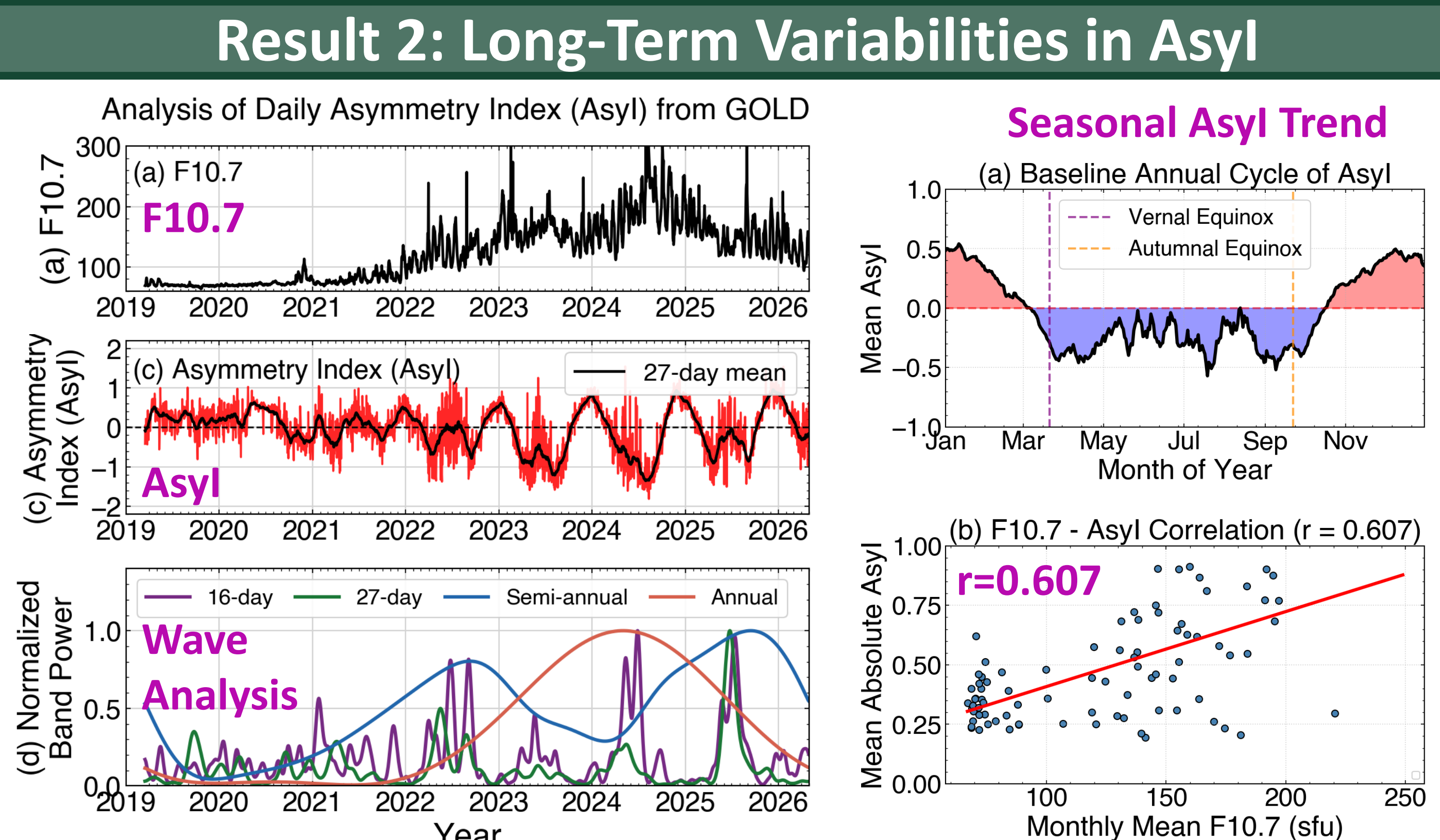


Fig. 5: Same as Fig. 3 but for Asyl

- Monthly mean Asyl positively correlates with solar flux (r=0.607)
- Asyl annual cycle shows reversal of polarity close to the equinoxes due to reversal of trans-equatorial winds (TEW)
- Hemispherical dominance of EIA crest occurs during local summer
- 16-day and 27-day power peaks near solar maxima
- All waveform characteristics are heavily suppressed before 2022
- Between Nov 2020-Jan 2021 Asyl is SH dominant which is anomalous**

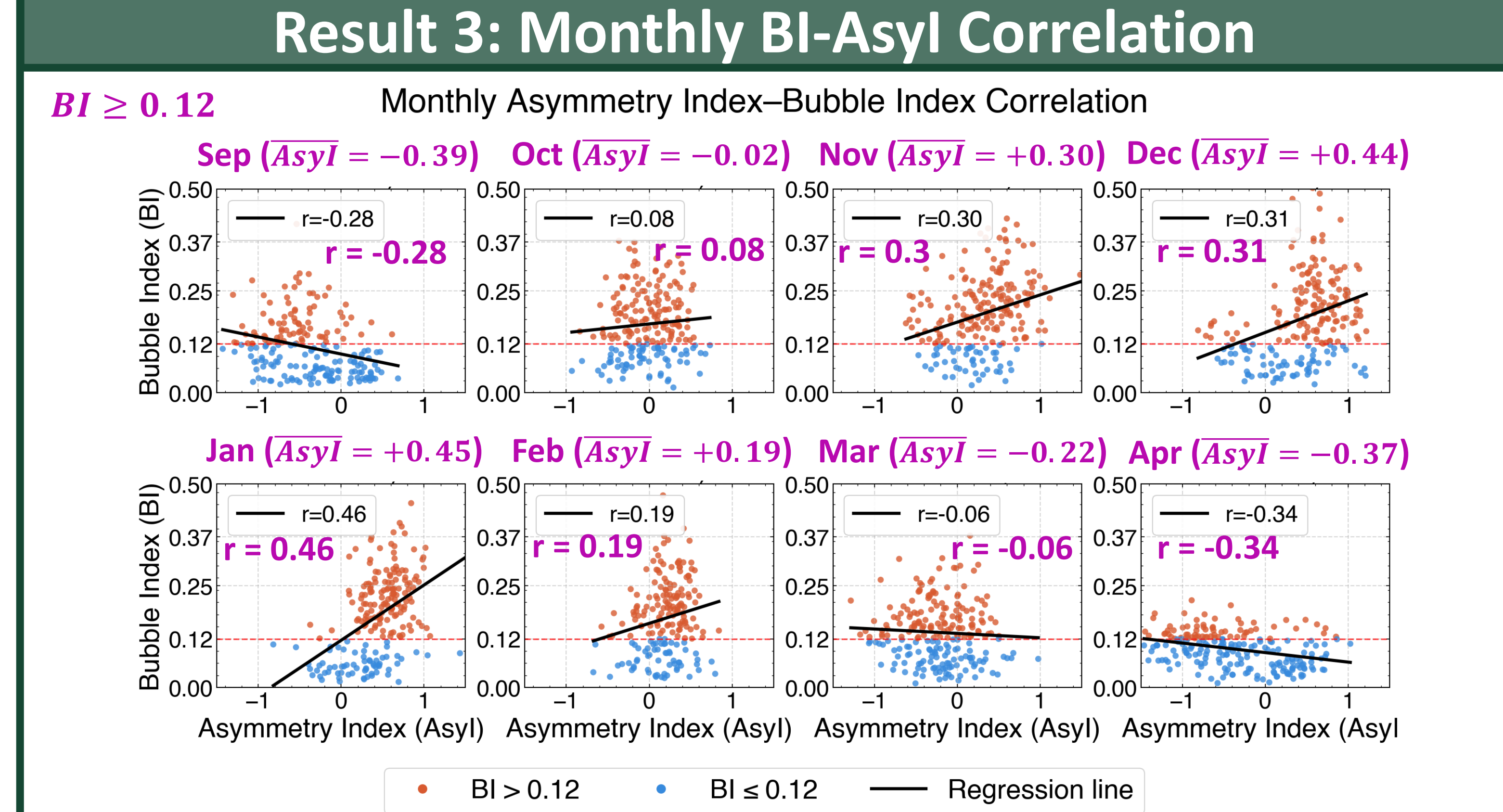
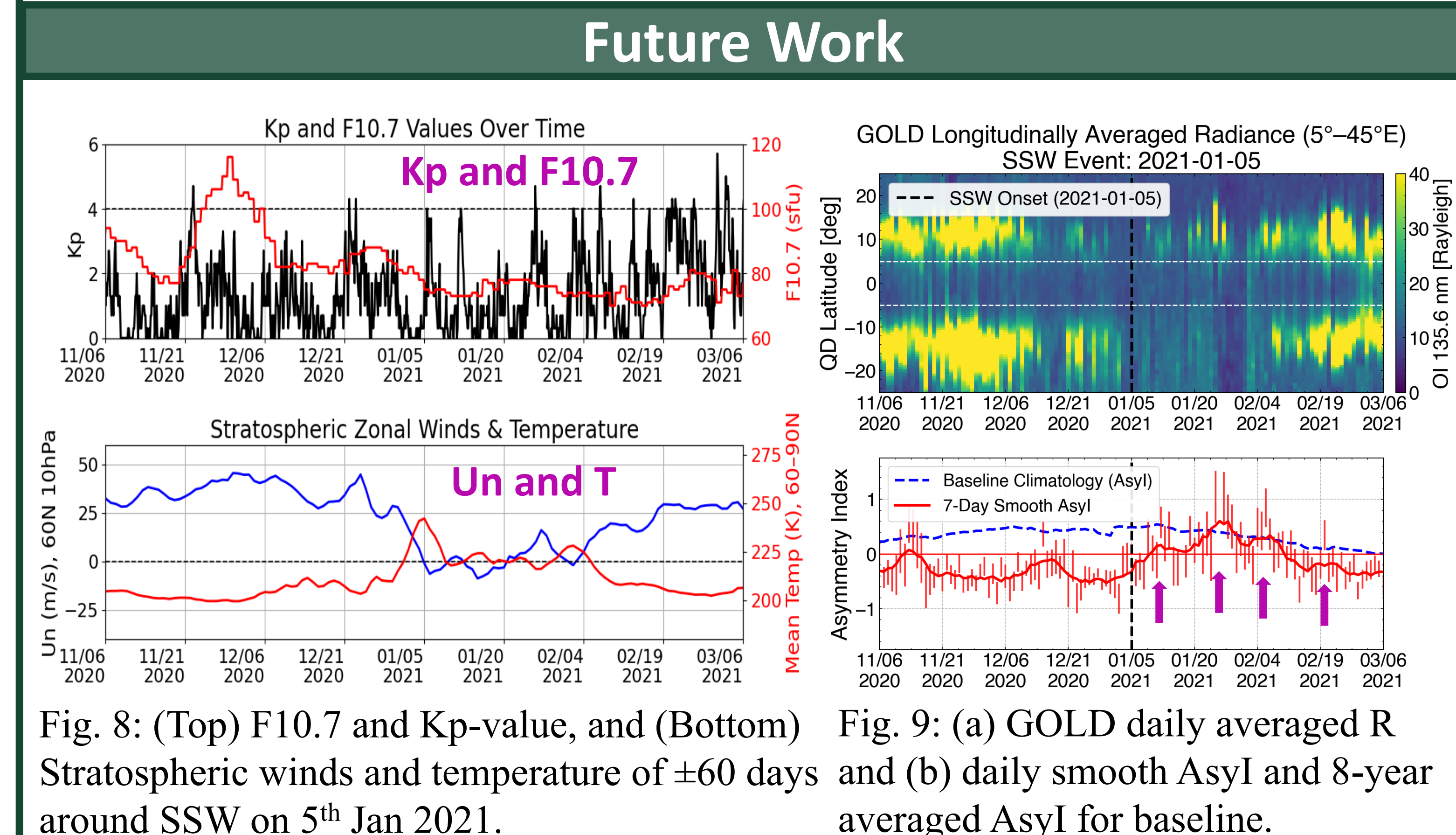


Fig. 7: Monthly correlation of daily Asyl and BI using 8 years GOLD data.

- January shows the strongest Asyl-BI (r=+0.46)
- Transition months of March and October show near-zero correlation
- Denser hemisphere preferentially drives EPB initiation**



- 2021 Asyl in boreal winter is SH-dominated**
- Include SSW case study and include more events for statistical confirmation
- Test whether quasi-16-day PWs reliably precede SSW onset
- Link SSW-driven changes in IHPT to EPB occurrence threshold shifts

- ## Main Takeaways
- Asyl and BI strengthens concurrently with solar flux (F10.7)
 - Asl-BI correlation sign flips seasonally, tracking the dominant hemisphere.
 - Asyl is a good predictor of BI onset (rather than strength), as denser hemisphere favors initial conditions required for bubble formation.

References:

- Aa+(2023), 10.1029/2023GL103510
- Khadka+(2018), 10.1029/2017RS006428
- Sultan+(1996) 10.1029/96JA00682
- Eastes+(2019) 10.1029/2019GL084199
- Aa+(2024) 10.3390/rs16081469

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