



On the Relation between Sporadic-E and ENSO

Observed by FORMOSAT-3/COSMIC



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Abstract

In recent years, many studies have shown evidence for several types of atmosphere-ionosphere coupling. In this study, we show the possible relation between Sporadic-E (Es) and ENSO by using the FORMOSAT-3/COSMIC S4 scintillation index and tropopause height from 2007 to 2016. The long-term variation of the monthly midlatitudes median extreme/mean S4 index in the E-region shows similar trend and periods in wavelet spectrum to ENSO. These results indicate that ENSO signatures may be transmitted to Es formation mechanisms, potentially through modulation of vertically propagating atmospheric tides that alter lower thermospheric wind shears.

Introduction

- Sporadic E (Es)
 - The dense region where metallic ions are converged by the wind shear in the E layer of the ionosphere between about 95-120km
 - Has a pronounced summer maximum of the seasonal variation

Scintillation

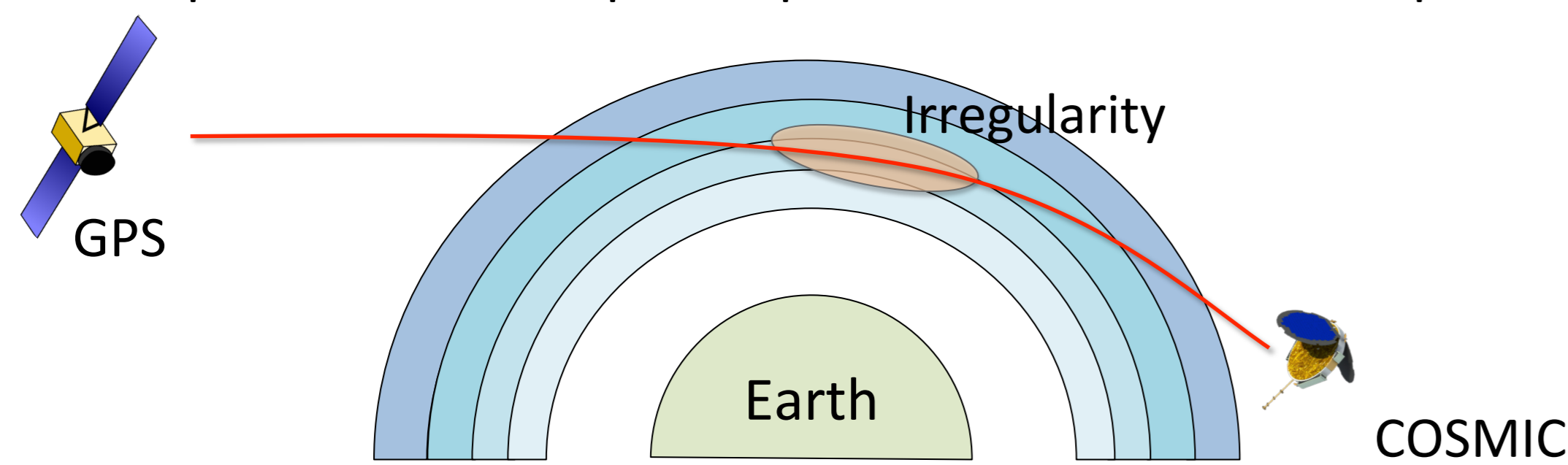
- A rapid fluctuation of radio signal phase and amplitude when propagating through irregular structure or highly varied media
- May cause GPS and satellite communications disruptions
- S4 index

Signal-to-noise intensity fluctuations of GPS 50-Hz L1 amplitude

$$S_4 = \frac{\sqrt{\langle (I - \langle I \rangle)^2 \rangle}}{\langle I \rangle}$$

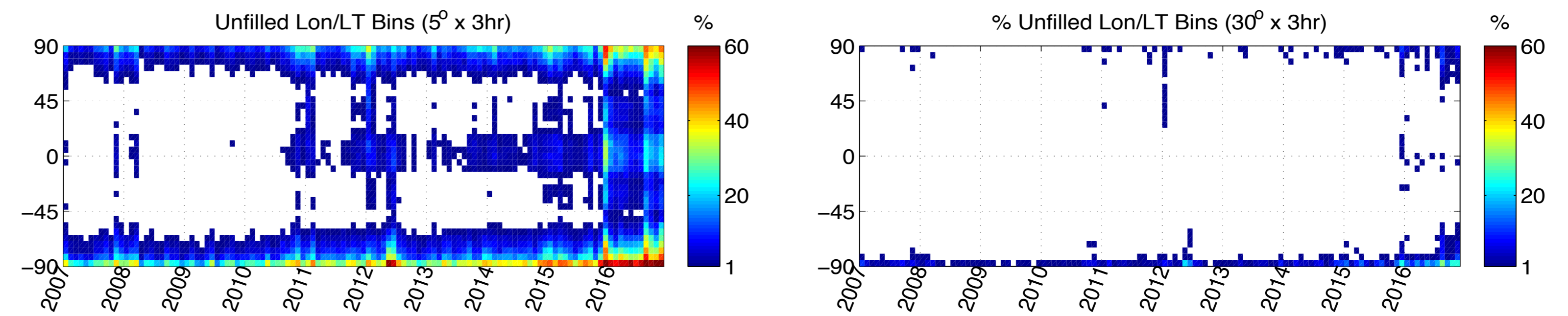
Radio Occultation (RO)

- RO observations can provide global distribution of atmospheric and ionospheric parameters with vertical profile

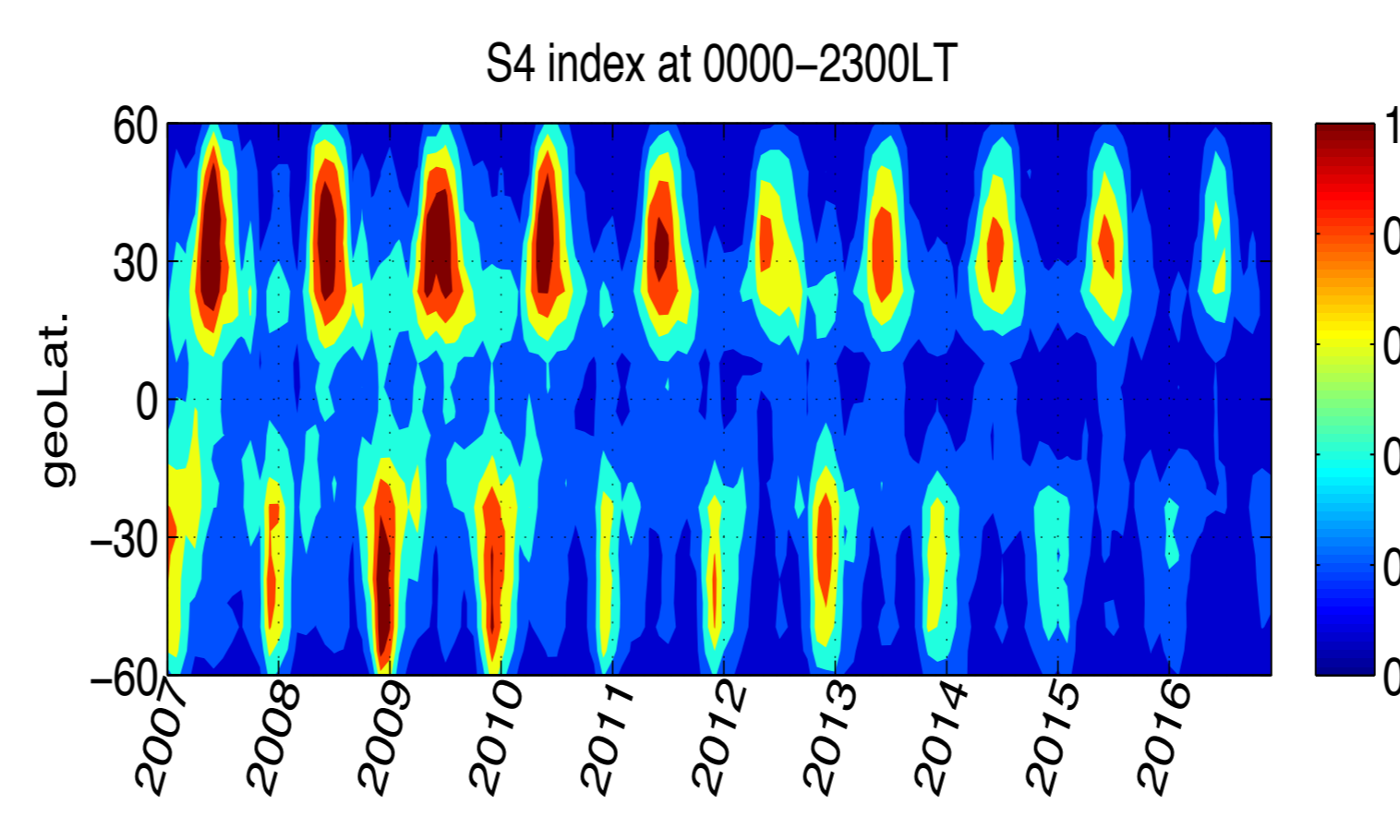


Methodology

- S4 index is binned into grid cells of 5° (magnetic latitude) × 5° (longitude) × 10 km (altitude) × 1-h (LT) resolution from 2007 to 2016
- We take the global median of extreme/mean S4 index in the E-region from 90-110km and compare with ENSO index and tropopause height



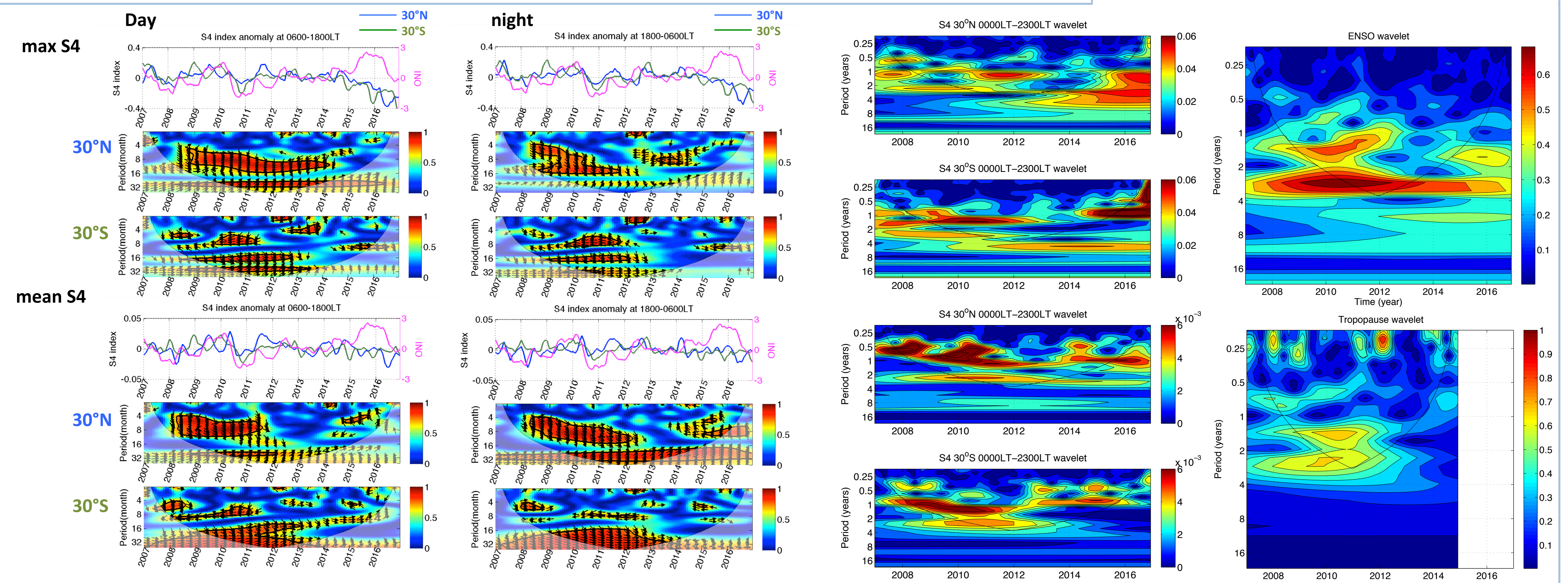
Time & Longitude median S4



Results

Cross-Correlation from 2007-2014

		Correlation Coefficient	Time Delay (months)
30°N S4 _{max}	ONI	0.52	2
30°S S4 _{max}	ONI	0.56	2
30°N S4 _{max}	Z _{tp}	0.49	0
30°S S4 _{max}	Z _{tp}	0.60	0
Z _{tp}	ONI	0.63	2



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Discussion and Summary

- The temporal and longitude midlatitude median extreme/mean S4 shows similar features with the known variation of Es, due to the structure of Es being easily detected by the radio occultation in horizontal direction.
- The global median S4 index in the E-region shows a prominent relationship to the variation of the Oceanic Niño Index (ONI) in the troposphere and tropopause height from 2007-2014 (significance level up to 99%), while the data in 2015 and 2016 may be affected by the decrease in data points.
- By calculating the cross correlation from 2007 to 2014, the S4 index lags the ONI index by 2 months.
- The wavelet analysis shows that the variation of the global median S4 index is dominated by periods of 1.5 and 2.5 years, which also have high wavelet coherence in the same periods with ONI.
- Most of the S4 and ONI are in phase (arrow point right), while parts of S4 leading ONI (arrow pointing up) so that the mechanism of how the ENSO affects the Es formation has to be explored more, and may be related to ENSO modulation of atmospheric tides controlling MLT wind shear.
- The result has not been previously reported, the data has to be double checked.