Global S4 Index Max in the Ionosphere Observed by FORMOSAT-3/COSMIC

Tiger J.Y. Liu$^1,2$, S.P. Chen$^2$, G.S. Chang$^1$, C.H. Lin$^3$, T. Y. Liu$^1$

$^1$National Space Organization, TAIWAN
$^2$Institute of Space Science, National Central University, TAIWAN
$^3$Department of Earth Sciences, Cheng Kung University, TAIWAN
Content

- Ionospheric Scintillation
- F3/C 3-D S4 index max
- F3/C S4 index max in the E-region
- F3/C S4 index max in the F-region
- Summary
GPS Radio Occultation

Wavelength and amplitude of in the vertical direction

Global 3D structure
The disturbances observed at 06:08 UT and 1581 km from the epicenter result from the Rayleigh waves of the 2011 M9.0 Tohoku earthquake.
The 4 June 2011 Puyehue-Cordón Caulle Volcano
Fig. 1. Schematic of the global morphology of scintillations at L-band frequencies during the solar maximum (left panel) and solar minimum (right panel) conditions. Reproduced from S. Basu and K.M. Groves, Specification and forecasting of outages on satellite communication and navigation systems, Space Weather, Geophysical Monograph 125, 424–430, 2001. Published 2001 by the American Geophysical Union. Reproduced/modified by permission of American Geophysical Union.
Distribution of occultation events observed by FORMOSAT-3
F3/C S4 index sounding
F3/C S4 sounding weighting

Graph showing the relationship between altitude (h, km) and segment length (2ΔS, km) for different altitudes: 90km, 200km, 300km, 400km, 500km, 600km, and 700km.
F3/C S4 max monthly altitude distribution
F3/C S4max Daily Observation

(a) F-Region (150-350 km)

(b) E-Region (80-130 km)
Diurnal Variations of the S4 Max Alt vs. Mlat in M-month
Diurnal Variations of the S4 Max Alt vs. Mlat in J-month
Diurnal Variations of the S4 Max Alt vs. Mlat in S-month
Diurnal Variations of the S4 Max Alt vs. Mlat in D-month
Fig. 1. Schematic of the global morphology of scintillations at L-band frequencies during the solar maximum (left panel) and solar minimum (right panel) conditions. Reproduced from S. Basu and K.M. Groves, Specification and forecasting of outages on satellite communication and navigation systems, Space Weather, Geophysical Monograph 125, 424–430, 2001. Published 2001 by the American Geophysical Union. Reproduced/modified by permission of American Geophysical Union.
S4 max median in the 4 months
S4 max maximum in the 4 months
“Worst Case”
“Worst Case” in F-region S4 Found by F3/C
Nighttime “Worst Case” Found by F3/C S4
“Worst Case” in E-region S4 Found by F3/C
Daytime "Worst Case" Found by F3/C S4
F3/C S4 max in the E-region
E region S4 max LT vs. month in various Lats

- E region S4 at Lat. 70°
- E region S4 at Lat. 60°
- E region S4 at Lat. 50°
- E region S4 at Lat. 40°
- E region S4 at Lat. 30°
- E region S4 at Lat. 20°
- E region S4 at Lat. 10°
- E region S4 at Lat. 0°
- E region S4 at Lat. -10°
- E region S4 at Lat. -20°
- E region S4 at Lat. -30°
- E region S4 at Lat. -40°
- E region S4 at Lat. -50°
- E region S4 at Lat. -60°
- E region S4 at Lat. -70°
E region S4 max MLT vs. month in various MLats
S4 max in the E-region during 2007-2011

2007

2008

2009

2010

2011
Global Distribution of E-region S4 max
F3/C S4 max vs Es
F3/C S4 max in the F-region
F region S4 max MLT vs. month in various MLats
S4 max in the F-region during 2007-2011
Global Distribution of F-region S4 max

M-month

J-month

S-month

D-month
Summary (I)

• The most prominent signatures of the F3/C S4 max in the E- (F-)region are in middle (equatorial-low) latitudes of the Summer J-month (equinox) months.

• The F3/C S4 max in the E-region becomes prominent in middle latitudes during the morning and evening period.

• The F3/C S4 max in the E-region yields the strongest in the summer months (especially J-month), 2nd in the equinox months, and weakest in the winter months.

• The F3/C S4 max in the E-region can be observed in the polar regions during 2007-2011.

• The F3/C S4 max in the E-region is mainly contributed by the Es (sporadic-E) layer. Neutral wind is essential!
The F3/C S4 max in the F-region lies between 20N and 20S and expends to higher latitudes in the equinox and D months. *ExB plasma fountain is essential!*

The F3/C S4 max in the F-region becomes prominent in equatorial/low latitudes from the post sunset to the post midnight period.

The F3/C S4 max in the F-region becomes more intense and reaches higher altitude in the equinox and D months.

The F3/C S4 max in the F-region yields the greatest value in the American sector. *Geomagnetic control!*

The F3/C S4 max in the F-region in the polar region seems to be insignificant during 2007-2011.

The F3/C RO provides global 3-D S4 index observations.
Thank you!!!
Ionospheric Scintillation

SOLAR MAXIMUM

SOLAR MINIMUM

L-BAND
- 20 dB
- 15 dB
- 10 dB
- 5 dB
- 2 dB
- 1 dB

NOON

MIDNIGHT

18