# Alternative Formalism for Computing Likelihood of Scintillation Effect from Inferred Vertical Drift in the Absence of Direct Measurements

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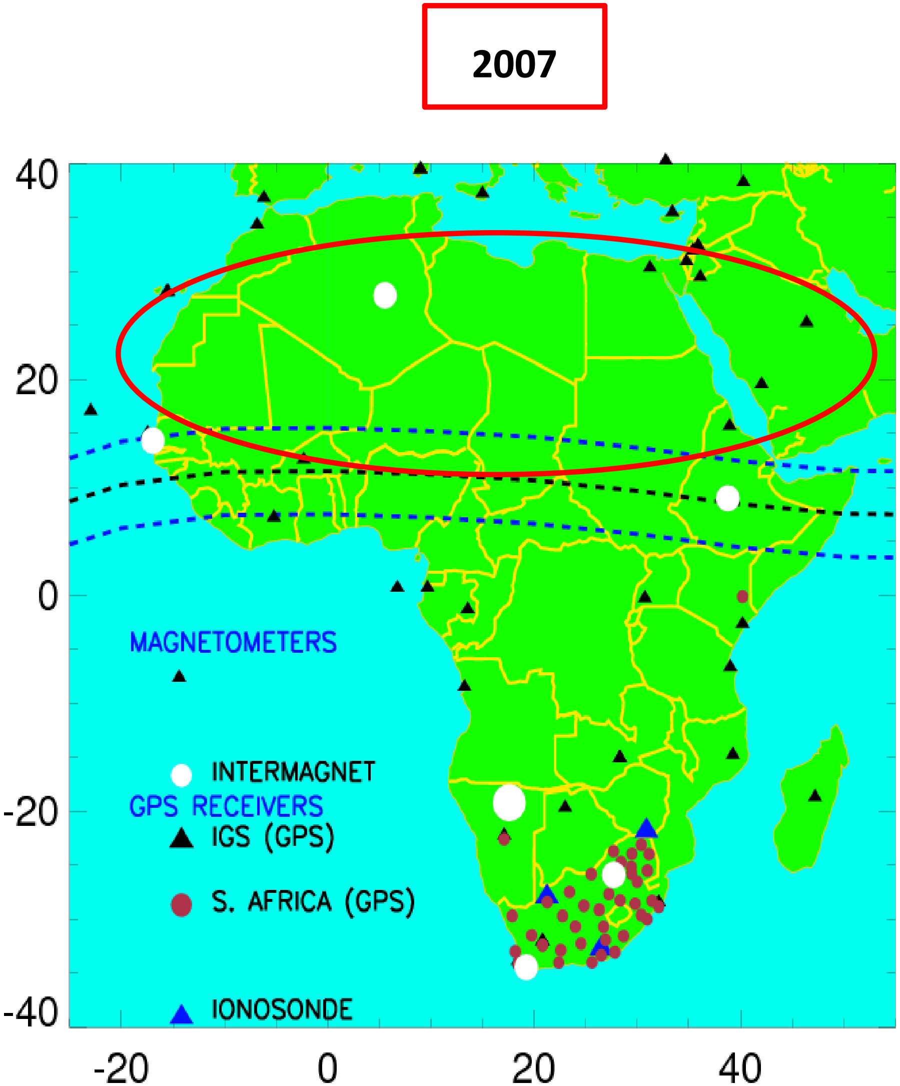
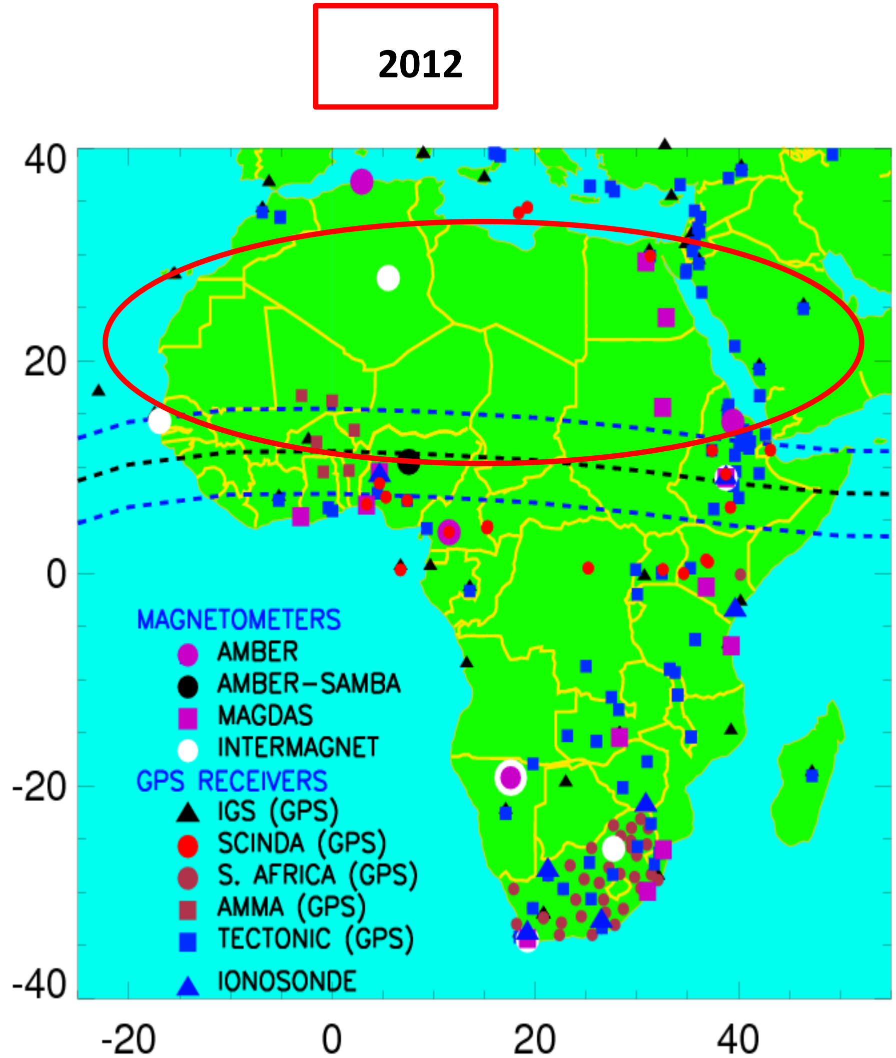
# MOTIVATION

- ✓ Being able to predict the likelihood of scintillation effect in a station where direct measurement is not available (using observations from ionosonde)

- ✓ The first of such investigation in the African equatorial latitude




# Distribution of Ground-based measuring equipment in the African sector

(Source: Yizengaw et al., 2012)

# DATA AND METHODOLOGY

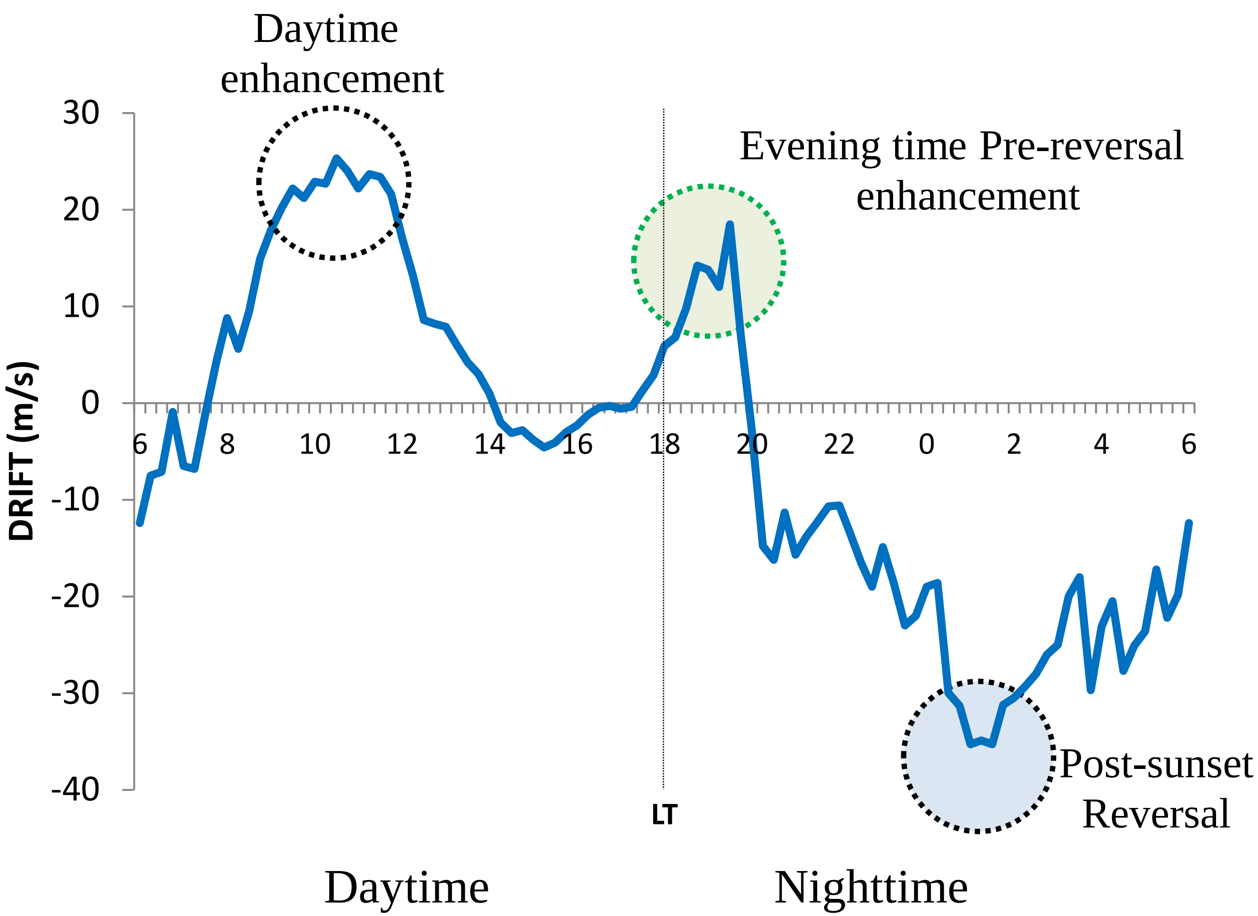
- ✓ Data spans 1966 – 1998
- ✓ Covering 3 Sunspot cycles
- ✓ Large database only available at Ouagadougou (in the African sector)
- ✓ Observation spans 16-06 LT
- ✓ During PRE max. and Reversal max.

Table showing classification of solar activity

| Solar cycle phase | Minimum (Rz < 20) | Maximum (Rz > 100) | Descending (100 ≥ Rz ≥ 20) | Ascending (20 ≤ Rz ≤ 100) |
|---|---|---|---|---|
| 20 | ** | 1968 – 1970 | 1971 – 1976 | 1966 – 1967 |
| 21 | 1976 | 1979 – 1981 | 1983 – 1986 | 1976 – 1978 |
| 22 | 1986 | 1989 – 1991 | 1992 – 1996 | 1986 – 1988 |
| **SC 20 minimum phase year (1964) is not covered by data | | | | |

Classification similar to Quattara et al., [2009] Ann. Geophys, 27.

# Basic features of Equatorial vertical plasma drift




Typical direct measured vertical drift using ISR observations for Jicamarca for equinox in 2010.

# DATA DEVELOPMENT

(i) Monthly mean value is the arithmetic hourly daily mean value for a month.

(ii) Annual mean value is the arithmetic hourly monthly mean value for a year.

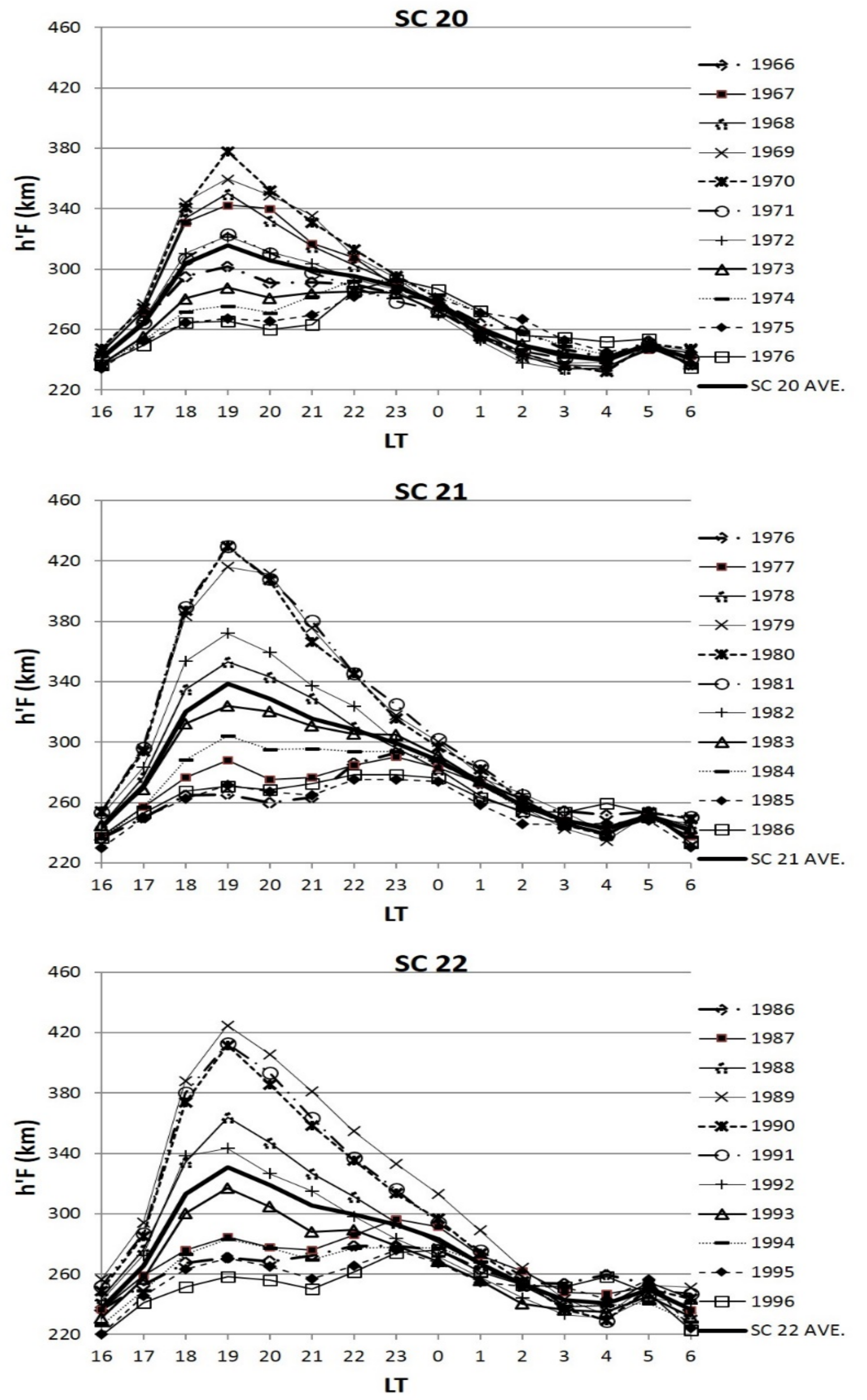
(iii) Sunspot cycle seasonal mean value is the arithmetic hourly monthly mean values for months constituting a particular season covering the entire years (11 years) that made up the sunspot cycle.

(iv) The 11-year cycle monthly PRE/minimum reversal peak mean values is the arithmetic hourly monthly mean value for similar months present in all 11-years that constitute a SC during the PRE/minimum reversal periods.

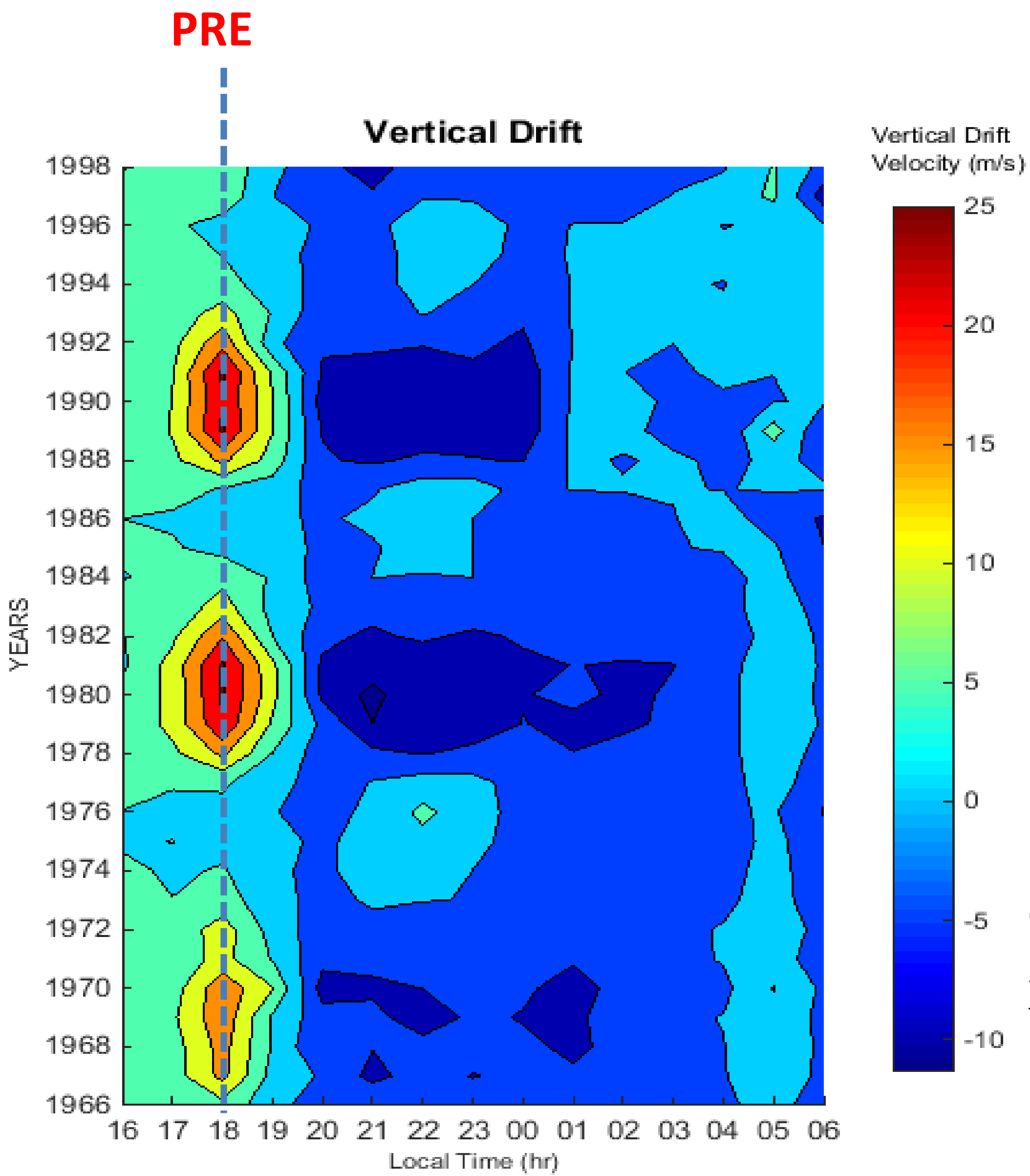
(v) The sunspot cycle phase mean value is the arithmetic hourly mean values of the years that constitute a particular cycle phase per sunspot cycle event.

# RESULTS

Nighttime hourly annual profile of *h'F* over Ouagadougou ionosphere for sunspot cycles 20-22



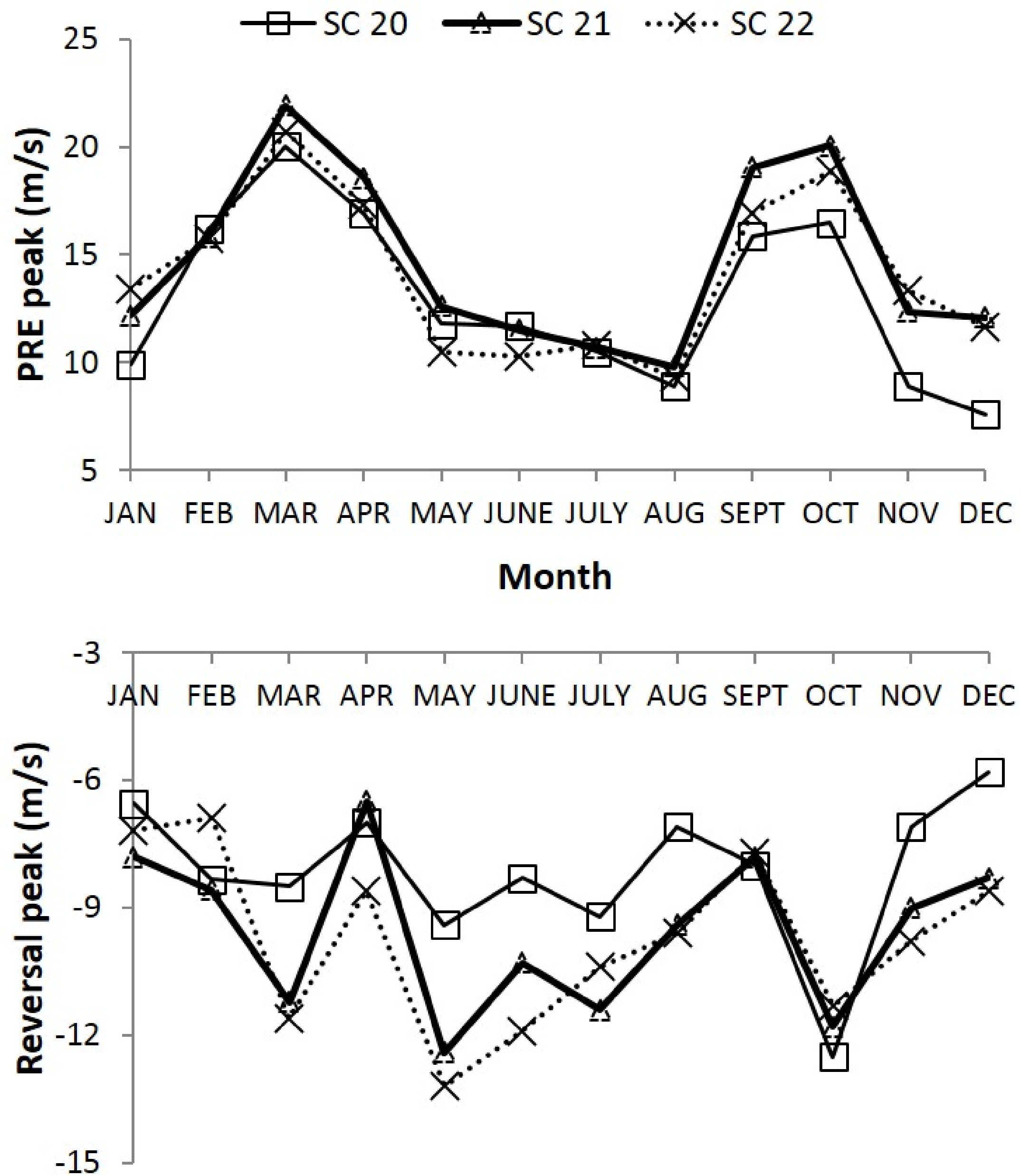
# RESULTS



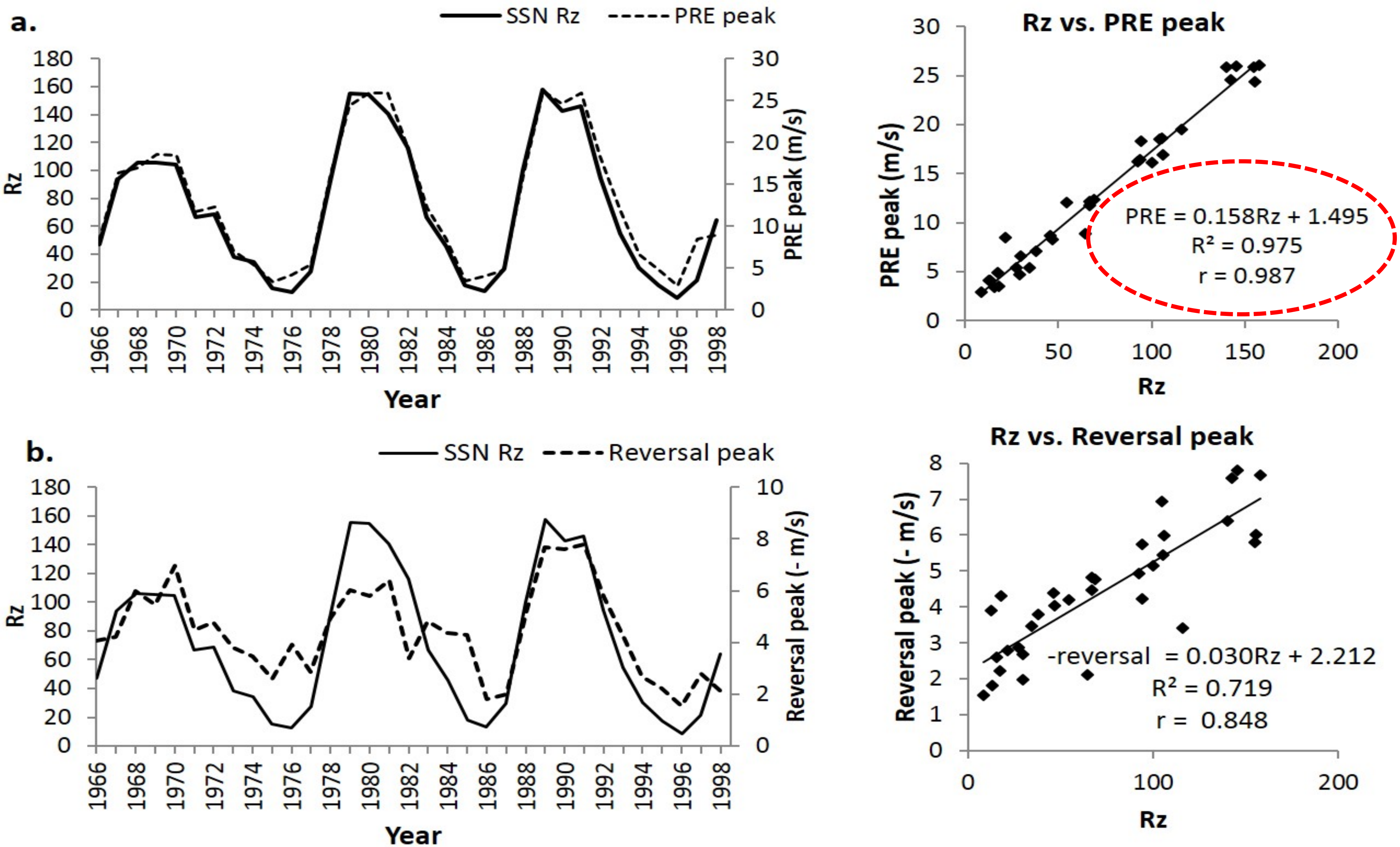

$$Drift\ Vd = \frac{d(h'F)}{dt}$$

Contour plot for the nighttime inferred vertical plasma drift

Average monthly variation of $\boldsymbol{V_d}$ for SCs 20-22 during maximum PRE (upper panel) and minimum reversal peak (lower panel) periods.

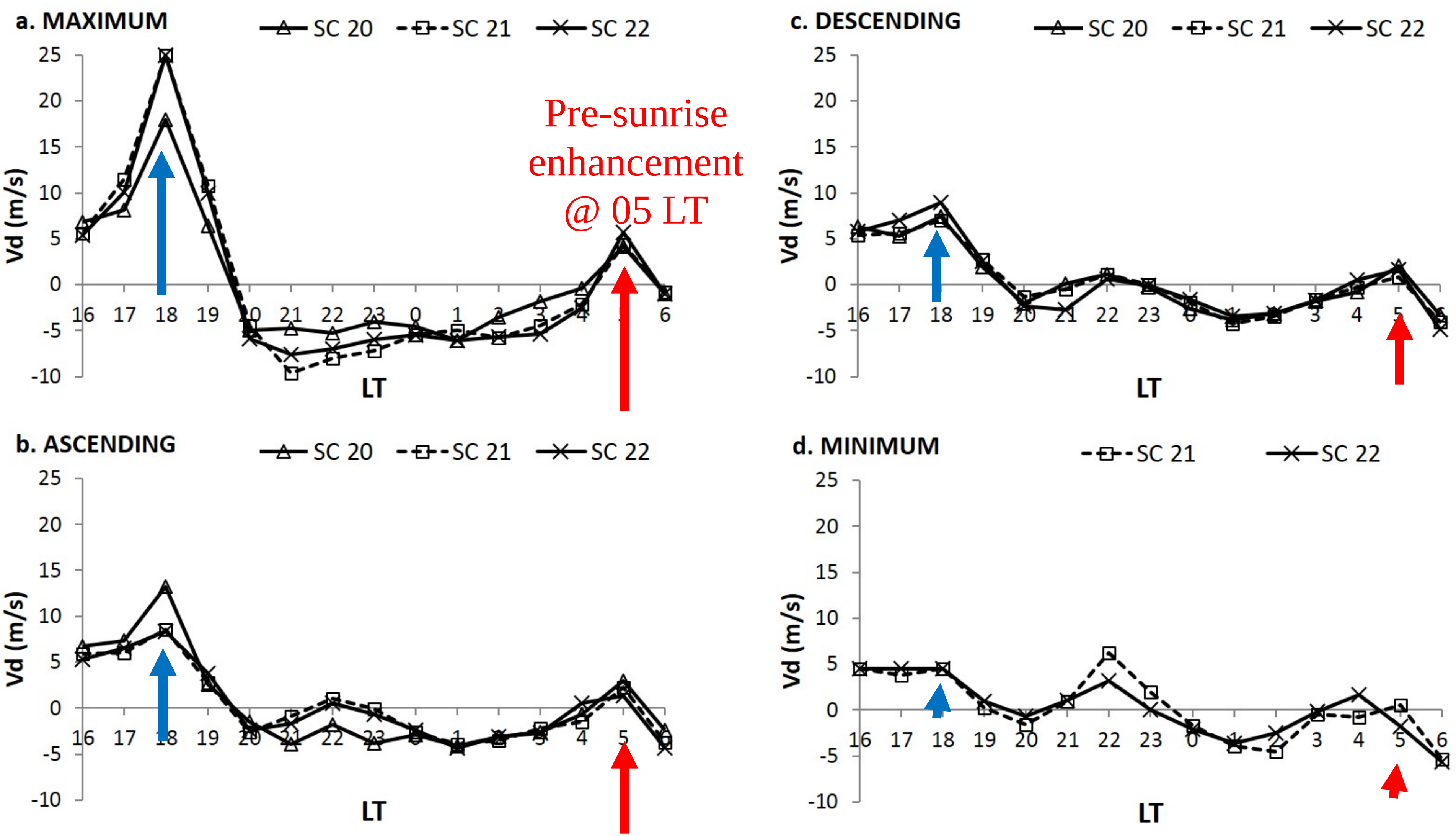


# VARIATION OF $V_d$ WITH SUNSPOT NUMBER (*Rz*)



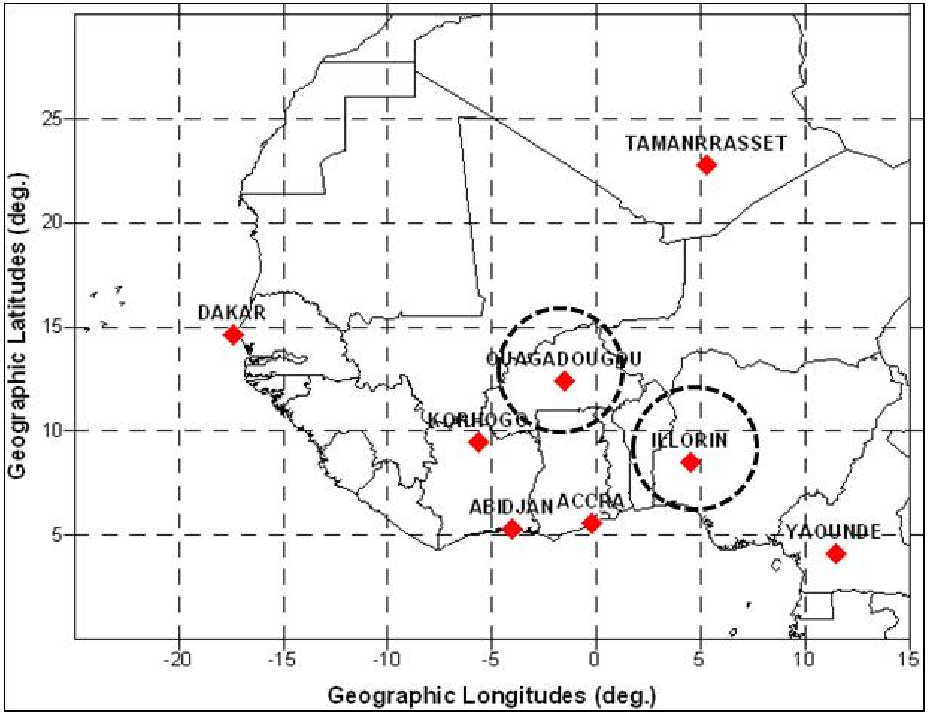

Annual variation of ***Rz*** (solid line) with $V_d$ for all SC cycles 20-22 during (a) peak PRE (dotted line), and (b) minimum peak reversal (dotted line) periods. The linear equations and ***r*** are shown on the RHS pane of each figure.

# VARIATION OF $V_d$ WITH PHASE OF SUNSPOT CYCLE




Hourly mean values of plasma drift during (a) maximum, (b) ascending, (c) descending, and (d) minimum phase periods of the SC 20-22.

# VALIDATING OUAGADOUGOU IONOSONDE DATA




**Ouag. (Lat. 12.4°N, long. 358.6°E)**
**Ilorin (Lat. 8.50°N, Long. 4.68 °E)**

$\text{Annual}_{\text{Ilorin}}$ PRE peak = **4.2 m/s** **(1)**

From the PRE peak/Rz equation for Ouagadougou,

**peak PRE = 0.158*Rz* + 1.495** (2)

In 2010, annual Rz is 16.5,

hence,

peak PRE = 0.158 (16.5) + 1.495 = **4.1 m/s** **(3)**

| Month | PRE peak (m/s) |
|---|---|
| March | 10.2 |
| April | 4.2 |
| May | -1.1 |
| June | 3.1 |
| July | -1.0 |
| August | 2.6 |
| September | 5.1 |
| October | 3.5 |
| November | 7.8 |
| December | 8.0 |

(Source: Adebesin et al., 2013 *ASR* 52(12),

Monthly mean PRE peak magnitude of ***Vd*** = *d(hmF2)/dt* obtained over Ilorin ionosphere for year 2010

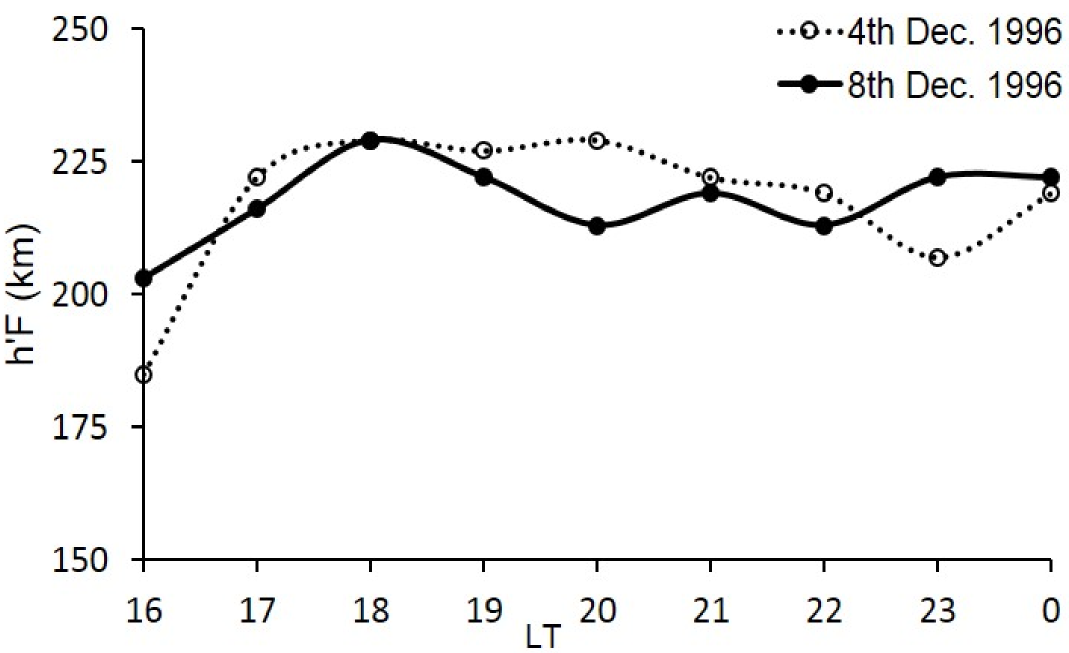
**(1) = (3)**

# MEASUREMENT OF SCINTILLATION INHIBITION FROM *h'F* AND PRE

The post-sunset increase/ decrease in *h'F* can be an indirect measure of the seeding/inhibiting characteristics to the existence of scintillation effect in the ionospheric region

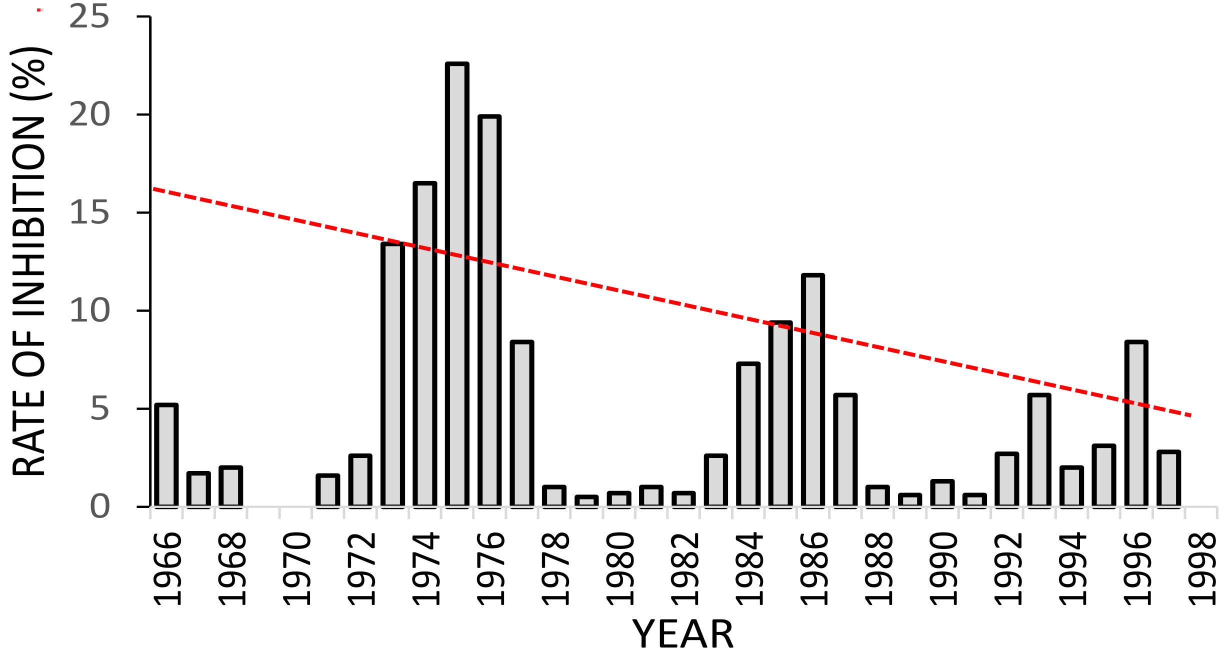
(Mazaudier et al., 1984, JGR, 89(A1))

✓ **Daily nighttime hourly values are used**




Condition for determining the inhibition characteristics from the height profile (h'F)

% annual rate of inhibition = days with decrease in *h′F* around 19 LT through midnight hours in an entire year / Total number of days with *h′F* data availability for the same year

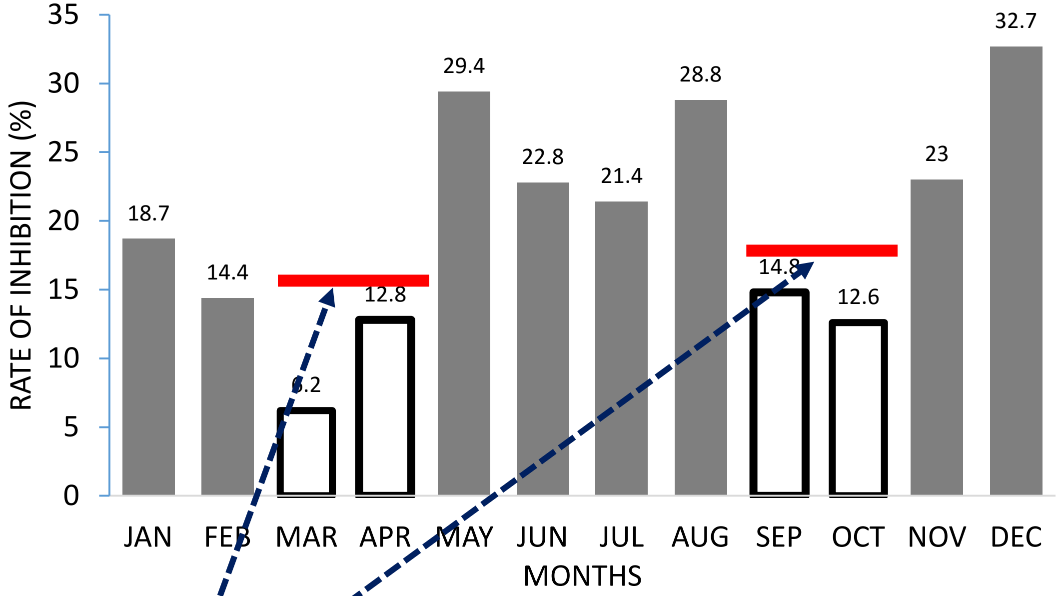



Annual rate of inhibition of scintillation effect. Dotted line indicates the trendline in the inhibition activity from SC 20 through 22.

| Solar cycle phase | Minimum ($Rz < 20$) | Maximum ($Rz > 100$) | Descending ($100 \geq Rz \geq 20$) | Ascending ($20 \leq Rz \leq 100$) |
|---|---|---|---|---|
| 20 | ** | 1968 – 1970 | 1971 – 1976 | 1966 – 1967 |
| 21 | 1976 | 1979 – 1981 | 1983 – 1986 | 1976 – 1978 |
| 22 | 1986 | 1989 – 1991 | 1992 – 1996 | 1986 – 1988 |

**The inhibition rate maximizes at sunspot minima, increases during sunspot descending phase, decreases during sunspot ascending phase, and minimizes during sunspot maxima for all SC conditions.**

$$\% \text{ monthly rate of inhibition} = \frac{\text{days with decrease in } h'F \text{ around 19 LT through the midnight hours in a month}}{\text{Total number of days with } h'F \text{ data availability for the same month}}$$




32-year average seasonal rate of inhibition of the likelihood of scintillation effect. The white/black bars are the equinox/ solstice seasons.

**Lowest during the equinoxes**

| Season | Rate of inhibition (%) | | |
|---|---|---|---|
| | SC 20 | SC 21 | SC 22 |
| March equinox | 4.70 | 3.35 | 1.45 |
| June solstice | 14.20 | 6.35 | 5.05 |
| September equinox | 5.20 | 5.10 | 3.40 |
| December solstice | 12.13 | 6.33 | 3.75 |

# SUMMARY

| Activity | plasma drift (m/s) | | |
|---|---|---|---|
| | Peak PRE | Maximum pre-sunrise | Minimum downward excursion |
| **Sunspot cycle** | | | |
| **SC 20** | 18.6 | 5.2 | -7.5 |
| **SC 21** | 25.9 | 5.0 | -11.4 |
| **SC 22** | 26.1 | 0.5 | -8.3 |
| | | | |
| **Solar activity phase** | | | |
| **Maximum/HSA** | 25.0 | 5.6 | -9.7 |
| **Ascending/MSA** | 13.3 | 3.0 | -4.3 |
| **Descending/MSA** | 9.0 | 2.1 | -4.3 |
| **Minimum/LSA** | 4.5 | 0.6 | -3.9 |
| | | | |
| **Seasonal activity** | | | |
| **March equinox** | 18.1 | 4.0 | -7.8 |
| **June solstice** | 12.0 | 1.4 | -10.9 |
| **September equinox** | 15.7 | 2.9 | -6.6 |
| **December solstice** | 12.8 | 3.8 | -8.5 |

Peak magnitudes of plasma drift for different activities and conditions


THANK
YOU
GRACIAS
DANKSCHEEN
TASHAKKUR ATU
VAQHANYELAY
SUKSAMA
EKHMET
ARIGATO
SHUKURIA
GOZAIMASHITA
EFCHARISTO
JUSPAXAR
KOMAPSUMNIDA
MAAKE
GRAZIE
MEHRBANI
PALDIES
BOLZÏN
MERCI
TINGKI
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