Indian Journal of Radio & Space Physics
Vol. 7, August 1978, pp. 205-209

Prediction of Atmospheric Radio Noise Field Strengths for the Indian Subcontinent*

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Received 15 *June* 1977; *accepted* 5 *August* 1978

An attempt has been made to predict atmospheric radio noise field strengths (ARN-FS) for frequencies up to 30 MHz, for different time blocks and seasons at any place in the Indian subcontinent. These are in the form of contour diagrams at 5 MHz for 1 kHz bandwidth. A relation has been given to predict ARN-FS values for any given frequency for any given location using these contour diagrams.

1. Introduction

The Consultative Committee on International Radio (CCIR) in its report Nos. 65 (1957) (Ref. 1) and 322 (1964) (Ref. 2) predicted atmospheric radio noise-field strengths (ARN-FS) on world-wide basis. When these predicted values are compared with the measured values at Delhi and Gauhati[3,4] large differences are found. Such observed differences in the values of ARN-FS are also found in the tropical region by other workers.[5-7] Also these CCIR reports do not show much latitudinal and longitudinal changes for the Indian subcontinent.

Therefore, an attempt has been made in this paper to predict ARN-FS values at any time, any season and any place in the Indian subcontinent. Measured values[4,8] of ARN-FS are available for Delhi and Gauhati representing northern and eastern regions, respectively, and for Vizag and Trivandrum representing southern region at seven frequencies around 2·5, 3·4, 5·0, 6·0, 7·0 and 9·5 MHz. A semi-empirical relation was developed[4] for estimation of ARN-FS values for other frequencies up to 30 MHz utilizing these measured values. These measured values are in μV/m for 6 kHz bandwidth for different time blocks and seasons. They are then converted in dB above 1μV/m for 1 kHz bandwidth. Ghosh *et al.*[9] have also estimated ARN-FS values for corresponding frequencies in this range for Poona and Nagpur representing Western and Central regions, respectively, by considering a relation associating ARN-FS values and thunderstorm activities in these regions. These estimated values are found to be comparable with the limited measured ARN-FS values by other workers.[10] These measured and estimated ARN-FS values have been used to draw contour diagrams on the Indian subcontinent.

*Paper presented at the Symposium on Ionosphere and Magnetosphere held at the Andhra University, Waltair, during 7-9, Jan. 1976.

2. Data

The geographic coordinates of the stations for which measured and estimated ARN-FS values have been considered in this analysis are given in Table 1.

3. Analysis

3.1 Variation of ARN-FS with Frequency

The variation of ARN-FS in dB above 1μV/m for 1 kHz bandwidth with frequency (in logarithmic scale) for various time blocks during summer months (June-Aug.) and for different locations is shown in Fig. 1. While measured ARN-FS values for Delhi, Gauhati, Vizag and Trivandrum are given in Fig. 1, for Poona and Nagpur estimated values have been used. In all these places except Trivandrum there is more or less a smooth linear decrease

Table 1 — Details of Stations the Data for which are used in the Present Analysis

Station	Geographical Cordinates: Latitude	Longitude
Delhi	28°38′N	77°13′E
Gauhati	26°10′N	91°40′E
Nagpur	21°05′N	79°0′E
Poona	18°19′N	73°33′E
Vizag	17°41′N	83°18′E
Trivandrum	08°29′N	76°57′E

in ARN-FS values with logarithmic frequency. In an analysis like this, some spread of points are expected. So care has been taken to accommodate as many points on the line showing the variations as far as possible and to see that equal number of those points which lie outside of it is as much equidistant from it as possible. An examination of Fig.1 will reveal that out of 24 lines, this is almost the case for at least 19 lines, i.e. for about 79% cases. In addition most of the straight lines showing the variations are parallel with almost a constant gradient of about −12. Similar variations are found for other seasons with almost same gradient and therefore, are not shown here. At Trivandrum there are enhancements in ARN-FS values around 3·0 and 7·0 MHz and these are considered due to propagation of atmospheric radio noise via sporadic-E layers.[8,11] Ignoring these enhancements, a gradient of around −12 is also found at Trivandrum.

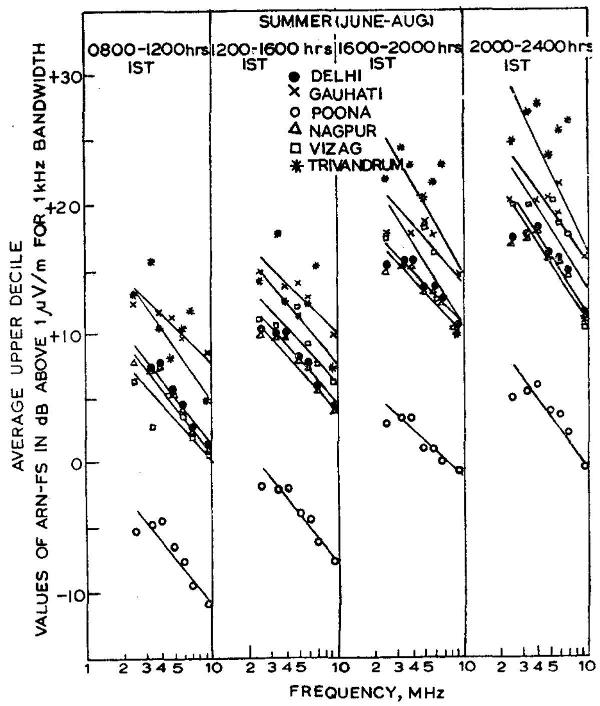


Fig. 1 — Variation of atmospheric radio noise field strength (ARN-FS) with frequency

Thus considering linear variations, if N is ARN-FS in dB above 1 μV/m at frequency f, then from Fig.1

$$N = A + B \log f \qquad ...(1)$$

where A is intercept and B is the gradient of the straight line.

If N_1 and N_2 are ARN-FS values at frequencies f_1 and f_2 then we have :

$$N_1 - N_2 = B \log (f_1/f_2) \qquad ...(2)$$

As B is constant, i.e. −12 for all the conditions, we may have

$$N_1 - N_2 = -12 \log (f_1/f_2) \qquad ...(3)$$

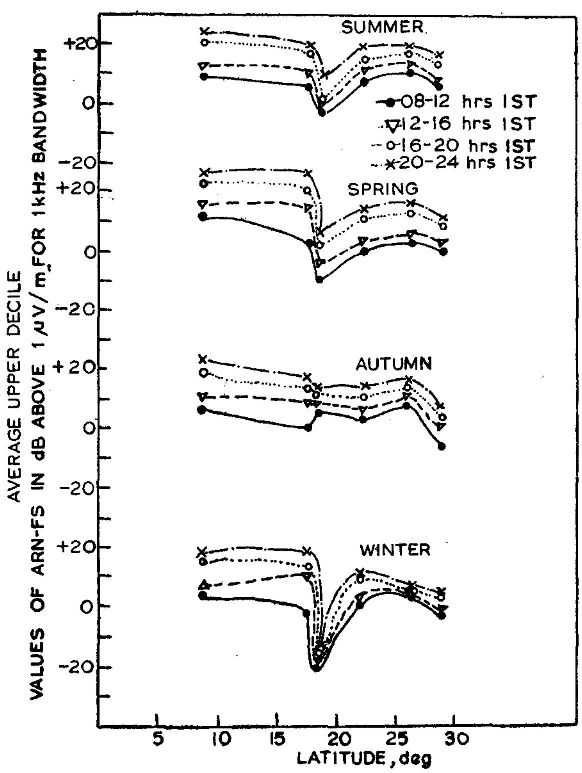


Fig. 2 — Latitudinal variation of ARN-FS at 5 MHz

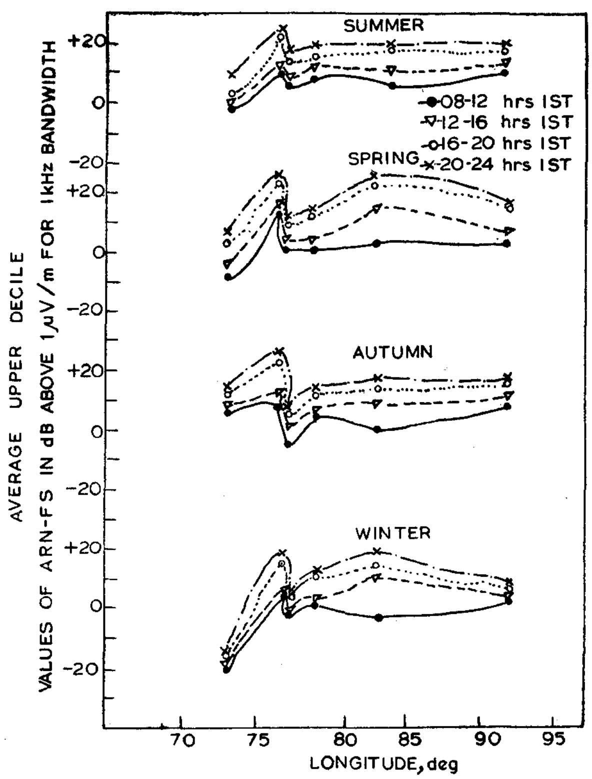


Fig. 3 — Longitudinal variation of ARN-FS at 5 MHz

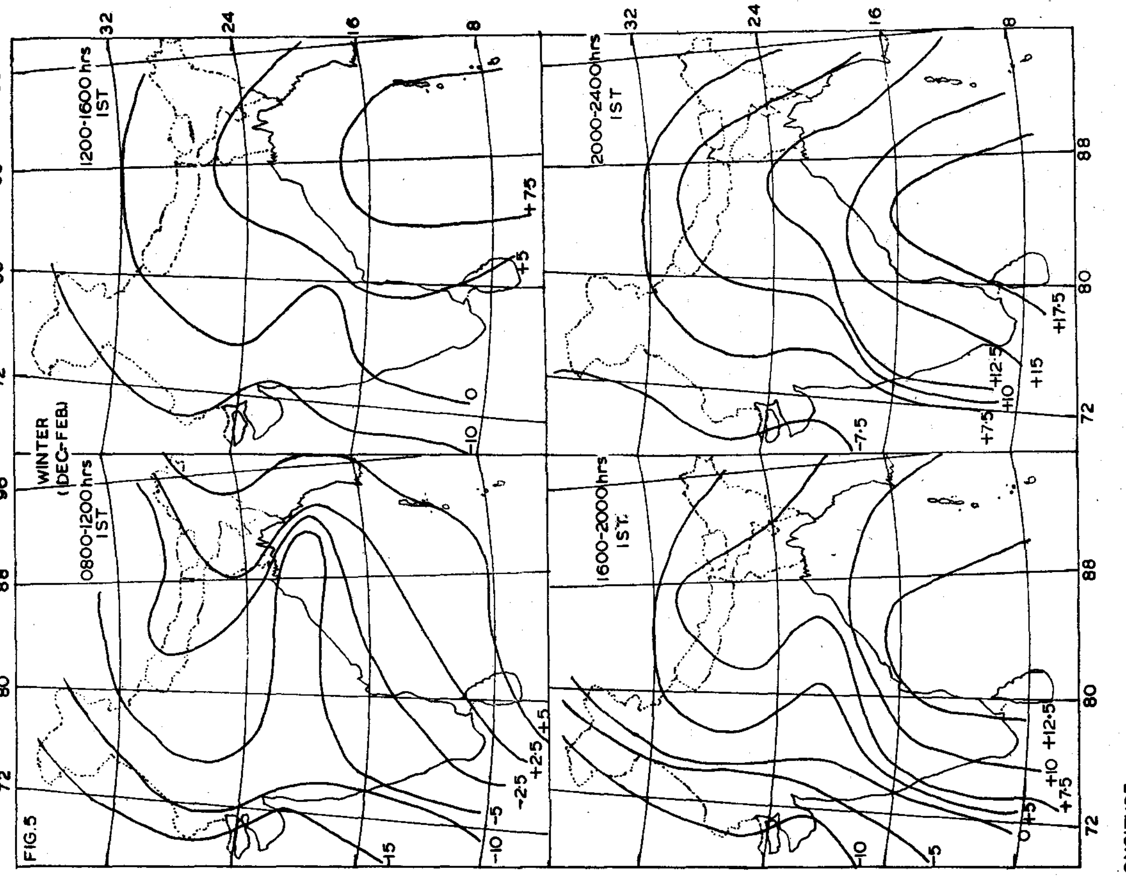


Fig. 5 — Contour lines representing average upper decile values of ARN-FS at 5 MHz (in dB above 1 μV/m for 1 kHz bandwidth) during winter

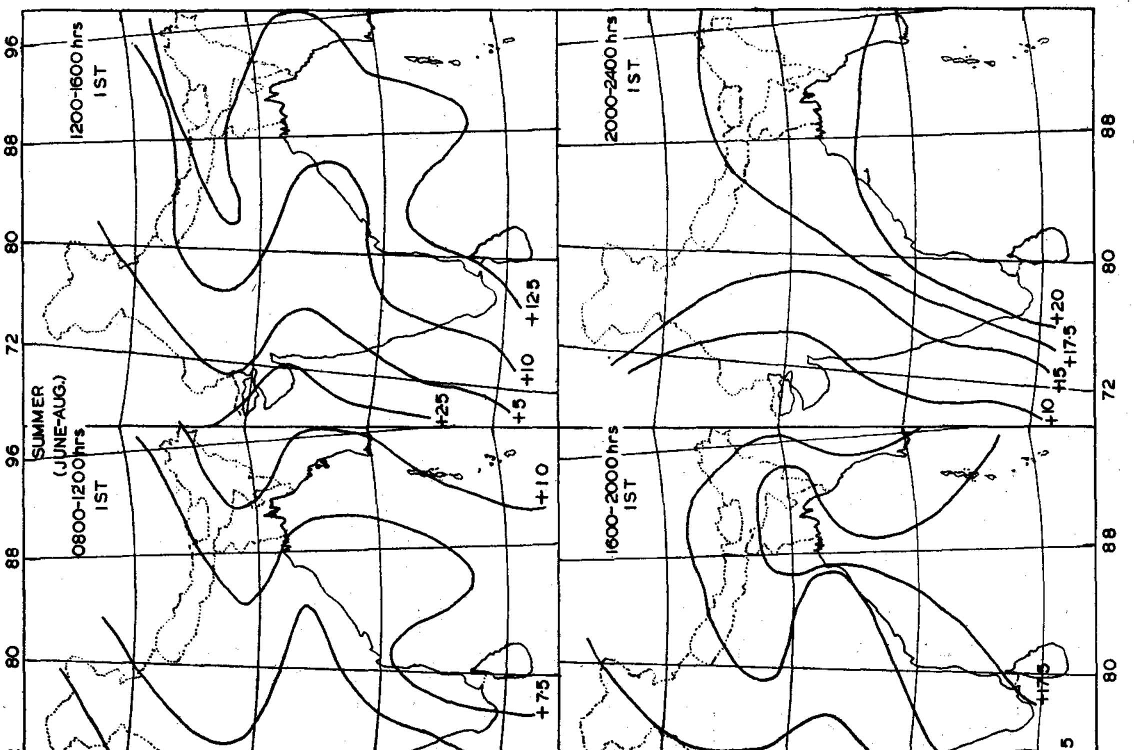
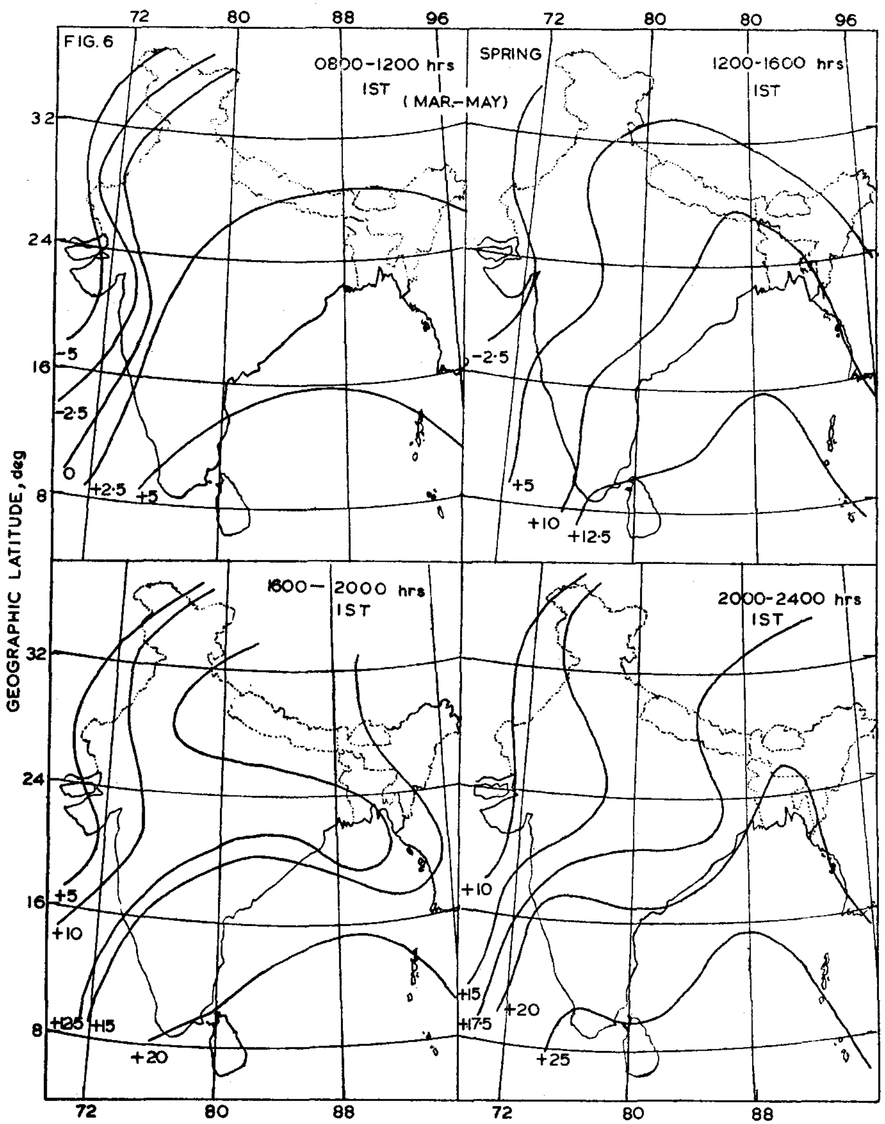
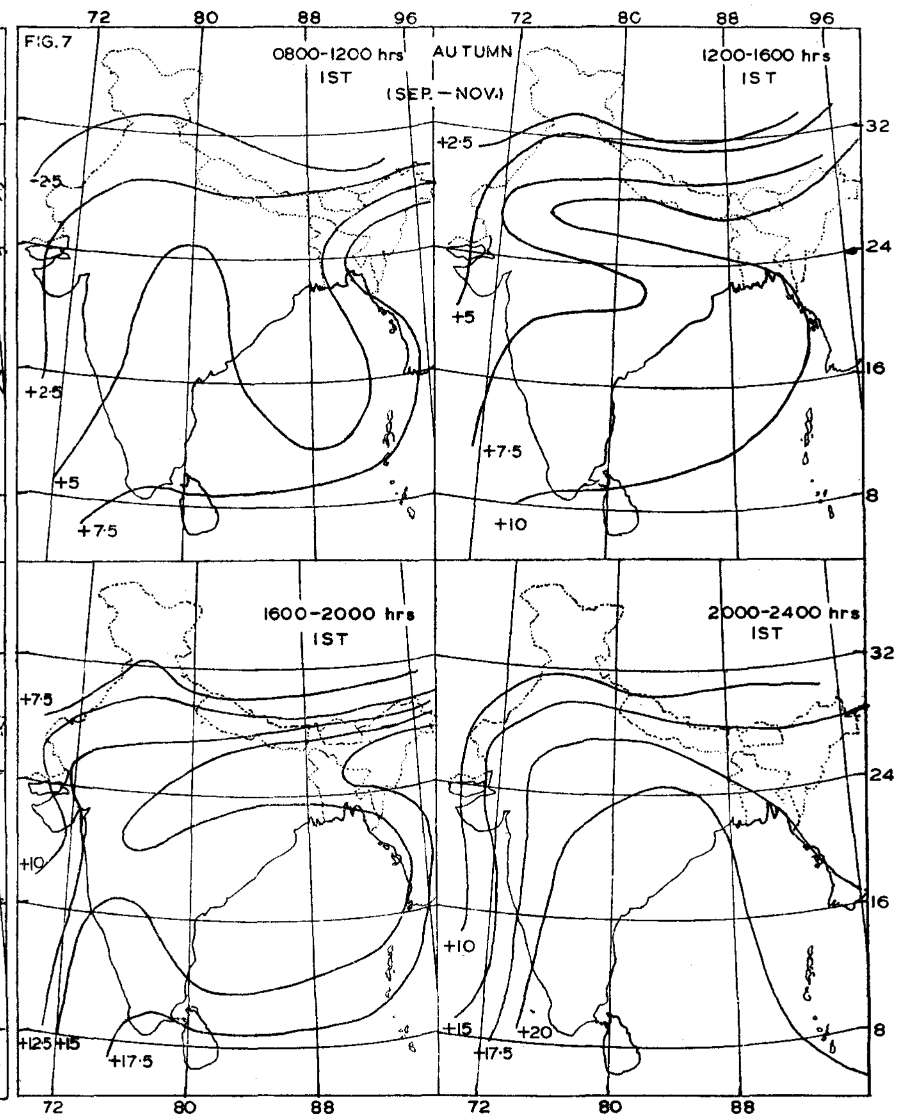


Fig. 4 — Contour lines representing average upper decile values of ARN-FS at 5 MHz (in dB above 1 μV/m for 1 kHz bandwidth) during summer





GEOGRAPHIC LONGITUDE, deg

Fig. 6 — Contour lines representing average upper decile values of ARN-FS at 5 MHz (in dB above 1 μV/m for 1 kHz bandwidth) during spring

Fig. 7 — Contour lines representing average upper decile values of ARN-FS at 5 MHz (in dB above 1 μV/m for 1 kHz bandwidth) during autumn

If we know the ARN-FS values at one frequency, they can be calculated at any other frequency by using Eq. (3).

3.2 Latitudinal and Longitudinal Variation of ARN-FS

The near middle of seven frequencies around which measured values of ARN-FS are available is 5 MHz and it has been chosen for considering the latitudinal and longitudinal variations of ARN-FS. Data for this frequency from six stations, almost at equal latitudinal and longitudinal coordinates, have been considered quite adequate to indicate actual conditions covering geographical range of only 30° × 30°, almost the entire area of the Indian landmass. The variations so obtained are shown in Figs. 2 and 3 which are useful for the estimation of rate of decrease or increase in the levels of ARN-FS at a receiving location while going from north to south or from west to east and vice versa.

3.3 Variation of ARN-FS Represented by Contour Lines on the Indian Subcontinent

As described in Section 3.2 the ARN-FS values for any latitude or longitude can be assessed. The values of ARN-FS for various latitudes at an interval of 5° from 10° to 30° have been assessed from Fig.2 while for various longitudes at an interval of 5° from 70° to 95° have been assessed from Fig. 3. From these assessed values ARN-FS have been calculated for places represented at the crossings of constant latitude with varying longitudes by averaging the two values. Similarly, the same have been repeated for places at the crossings of constant longitude with varying latitudes. This method has given a number of ARN-FS values relating to a number of locations on the Indian subcontinent. Contour lines joining equal values of ARN-FS have been drawn. This has been done for various time blocks for summer (June-Aug.) and winter (Dec.-Feb.), spring (Mar.-May) and autumn (Sep.-Nov.). These are shown in Figs. 4-7.

The procedure adopted and as described above is amply justified as the values of ARN-FS read off from the contour lines give actually measured values for stations for which they are available.

From these diagrams knowing the ARN-FS values in dB above 1 μV/m for 1 kHz bandwidth for a particular place at 5 MHz, ARN-FS can be predicted for any other frequency using Eq. (3) for the same place, season and time blocks. For bandwidth other than 1 kHz, ARN-FS values can be converted as given in CCIR Report No. 322 (Ref. 2) :

$$N'_1 - N'_2 = 10 \log (B_1/B_2)$$

where N'_1 and N'_2 are the ARN-FS values in dB above 1 μV/m for bandwidth B_1 and B_2, respectively in hertz.

In predicting the ARN-FS values for equatorial region care must be taken at frequencies around 3·0 and 7·0 MHz as there are enhancements in the ARN-FS levels around these frequencies.

4. Conclusion

The formula to find out ARN-FS values at any frequency knowing its values at another frequency as given in Section 3.1 and contour lines given in Figs. 4-7 need to be tested against measured values before arriving at definite conclusion.

Acknowledgement

The authors are grateful to Dr A P Mitra for suggesting this problem and to Dr A K Saha for many useful suggestions and helpful disscussions in the preparation of this paper. They are also thankful to the referee for useful comments.

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