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THE EFFECTS OF MAGNETIC STORM PHASES ON F-LAYER IRREGULARITIES FROM AURORAL TO EQUATORIAL LATITUDES

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In October 1990 at an AGARD Symposium in Crete, Aarons gave a paper communicating to both researchers and users of propagation data, a summary of the results of the high and equatorial latitude studies. The AGARD Symposium was on " The Use or Reduction of Propagation and Noise Effects in Distributed Military Systems". It was the first paper of the symposium and there was considerable interest in the results.

In previous quarterly reports an outline of the developing pattern of irregularity penetration in the high latitude region and occurrence in the equatorial latitudes was given. The studies were done over a long period of time and a summary of early results was given at the Ionospheric Effects Symposium.

For the special issue of Radio Science devoted to papers from the Ionospheric Effects Symposium, two papers have been submitted and reviewed. The reviewers had many suggestions involving titles, concepts, details of the writing, and reconstruction of the diagrams. Therefore a good percentage of time in this quarter has been put into rewriting the papers. However we feel that the concepts advanced in the papers are definite advances in thinking about the physical mechanisms involved in forecasting whether or not irregularities will occur in the equatorial, auroral and sub-auroral regions. The revised papers are to be returned in January. Abstracts of the two papers plus the paper submitted to Annales Geophysicae are given below.

Radio Science Paper 1. Aarons, J. and A.S. Rodger The effects of electric field and ring current energy increases on F-layer irregularities at auroral and sub-auroral latitudes.

ABSTRACT: A model of the dynamics of magnetic storms is proposed which describes the effects of magnetospheric activity on irregularities at F-layer heights for auroral and sub-auroral latitudes. For high latitudes the initial phase of the storm dynamics first affects auroral latitudes and then the effects descend to what were sub-auroral and middle latitudes. The effects weaken as the convective electric field boundary moves equatorward. In the second stage of the storm i.e. the recovery period, the ring current plays a leading role at sub-auroral latitudes. The ring current, which has acted as a sink for ionospheric and solar wind ions, decays. In this recovery phase, the sources of energy producing the irregularities at sub-auroral latitudes are the ions in the ring current. The study, revolving around a number of magnetic storms with observations ranging from December 1971 to March 1989, primarily in years of high solar flux, illustrates the two stages:

1. The initial descent and weakening of the effects of the electric field changes.

2. Ring current decay which produces the conditions for the generation of the irregularities at sub-auroral latitudes.

Radio Science Paper 2. Aarons, J. The role of the ring current in generating or inhibiting equatorial F-layer irregularities during magnetic storms.

ABSTRACT

For the equatorial ionosphere in years of high solar flux, the F-layer parameters are such that irregularities are produced almost every night in specific months. The question that has emerged is why are there nights in these months without irregularities. The hypothesis advanced is that for this period, one must look not for external seeding mechanisms but for inhibiting factors. The ring current during magnetic storms appears to play a leading role directly or indirectly in establishing the conditions necessary for equatorial F-layer irregularity generation and inhibition. The hypothesis advanced is that for a particular ionospheric propagation intersection, the local time when the peak excursion of the ring current occurs (its decay from maximum negative values), affects the equatorial electric field and therefore the changes in height of the F layer. Using data from a number of magnetic storms with dates ranging from December 1971 to November 1981, primarily in years of high solar flux, the following categories were found. If the maximum ring current energy as shown by Dst occurred during the midnight to post-midnight time period, irregularities were generated. If the maximum Dst, the period before recovery set in, occurred in the early afternoon, irregularities were inhibited. If the maximum occurred around sunset or shortly after sunset then there was no effect on the generation of irregularities that night. While the ideas on positive and negative correlation with magnetic indices have been shown in many early references, the importance of local time and its relationship with the maximum ring current energy have not been emphasized. The use of widely spaced equatorial data from Manila and Huancayo allowed for contrasting reactions for the same storm and for validation of the hypothesis for the months and solar conditions stated. For other periods when occurrence of irregularities is lower, the effect on layer height may be only one factor in setting conditions for the generation of irregularities.

Annales Geophysicae: Submitted Paper

Aarons, J. J.C. Foster, and A.S. Rodger Auroral and sub-auroral F-layer irregularities and high plasma convection during the magnetically active periods of September 17-24, 1984

Coauthors include J.C. Foster of the Atmospheric Sciences Group of the Haystack Observatory, MIT and A.S. Rodger of the British Antarctic Survey Cambridge UK. This paper has been reviewed and is being revised.

ABSTRACT

Using observations of F-layer irregularities by satellite scintillation and spread-F techniques, three magnetic storm periods were studied for their adherence to instability processes. The data on irregularities taken from auroral and sub-auroral locations were compared with electron temperature (Te), electron density (Ne), and ion convection using observations of the Millstone Hill incoherent scatter radar during the Equinox Transition Period of September 17-24, 1984. Periods of shear convection patterns were correlated with the irregularities but the most significant correlation was with high convection velocities. Gradients of Te and Ne were examined as a function of latitude and of time and the possible invocation of gradient drift and current convective instabilities assessed for particular periods. During the times of the Harang discontinuity, irregularity levels were a minimum; this corresponded to a dip in convection velocity at higher latitudes earlier noted by Foster et al (1986) during periods when Kp >4.

COSPAR Paper 4

An invited paper was presented XXVIII COSPAR, 1990, the Hague, the Netherlands in July 1990. While the field program was sponsored by NASA the data analysis is being done with partial support from the ONR contract.

Simultaneous All-Sky Optical Airglow Imaging Observations and San Marco Satellite Measurements in the Pacific Sector ,
M. Mendillo, J. Aarons and P. Sultan

Coordinated airglow imaging and San Marco in-situ observations were conducted during the period 1-15 August 1988 from sites on Wake island and the Kwajelein Atoll in the western Pacific. The goal of the campaign was to study the trans-equatorial and geometrically aligned nature of the 6300 A depletions and F-region plasma irregularities that occur during the post-sunset period. The case studies selected for detailed analysis include periods when well formed depletions drifted into view (7 Aug) , depletions that formed with only partial development in altitude/latitude (12 Aug) , cases when depletions failed to form (14 Aug) and cases when depletions formed suddently with no pre-event signatures (15 Aug).

FUTURE WORK ON OBSERVATIONS IN THE PACIFIC:

The results of this study indicated that the orbit of the SAN MARCO satellite was most often below the altitude of spread-F formation. Additional work will concentrate on the radio and optical data sets from Kwajelein and Wake. The observations made in Wake Island and Kwajelein have been expanded with the capability of using the Dst index (which had been unavailable until this fall). Mendillo is developing a new concept for the destabilization of the ionosphere in the equatorial region i.e. North-South gradients which are produced by neutral winds. Evidence for this appears in the optical data. Other data sets were be reviewed to validate this concept.

FUTURE WORK ON IRREGULARITY AT HIGH AND EQUATORIAL LATITUDES:

Future work will address the problem of irregularity development during months of low occurrence of irregularities during high sunspot number years. In addition studies are ongoing to determine the correlation of irregularities with SAR arc data taken at Millstone Hill. Data from the March 1989 great magnetic storm will be analyzed with optical and radio observations now available at both high and equatorial latitudes.