AIIM

Association for Information and Image Management

1100 Wayne Avenue, Suite 1100
Silver Spring, Maryland 20910

301/587-8202

Centimeter

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 mm

1 2 3 4 5

Inches

1.0 1.1 1.25 1.4 1.6 1.8 2.0 2.2 2.5 2.8 3.2 3.6 4.0 4.5 5.0 5.6 6.3

MANUFACTURED TO AIIM STANDARDS
BY APPLIED IMAGE, INC.

Conf-9407124--1

LA-UR- 94-2951

Title: RESULTS FROM THE NORTHERN NEW MEXICO SATELLITE-BEACON RADIO INTERFEROMETER

Author(s): Robert Carlos
Abram Jacobson
Robert Massey
Guanghui Wu

Submitted to: International Beacon Satellite Symposium 1994
Aberystwyth, Wales

MASTER

Los Alamos
NATIONAL LABORATORY

RESULTS FROM THE NORTHERN NEW MEXICO SATELLITE-BEACON RADIO INTERFEROMETER

Robert Carlos, Abram Jacobson, Robert Massey, and Guanghui Wu
Los Alamos National Laboratory (MS D466, 87545) (rcarlos@lanl.gov)

INTRODUCTION

An interferometer described in the Boston, 1992, meeting of the Beacon Satellite Symposium has been in full operation for over a year now. It consists of four autonomous stations; three are in a triangle 70 km on a side and one is in the center. The stations receive the VHF beacons from two geosynchronous satellites, GOES-2 and ATS-3. The phases of the beacons are tracked at each station by referring them to an extremely stable rubidium oscillator. The studies of the two satellites are virtually separate experiments.

The received phase of the beacon is retarded by the increased Total-Electron-Content of the dense regions of waves in the ionosphere. By comparing the phase history at four spatially separated stations, we can determine the two-dimensional propagation vector of the waves. This array is optimal for wavelengths of 70-300 km (periods of 300-3000 seconds). Since the measurement is of the phase of the signal rather than the difference between the O-mode and X-mode phases, and since the beacons are in the VHF rather than in the L-band of GPS beacons, the array is very sensitive. It has a noise level of 10^{13} electrons/m^2, or 10^{-4} of the normal daytime TEC. This has been verified by operating two stations in the same location, so that they saw the same ionosphere.

The stations operate nearly continuously under the control of their local computers. (The computers are generic pc-clones, 486/50 with 4 Mbytes RAM and 340 Mbyte disks.) The audio-frequency output of the radio receiver is digitized by an A/D card at 200 samples/s/channel and stored on disk. This sample rate is necessary because the bandpass of the radio is almost 100 Hz; this bandpass is necessary because the satellites we watch have doppler and thermal frequency shifts of this magnitude. This sample rate, though, makes a file of 34 megabytes per day, and we are really interested only in a 30 milli-hertz portion of the spectrum at any given time. This problem is solved by opening another window, reading the raw data, analyzing it with a narrow tracking filter, and re-writing the data to disk at 10 second intervals. These filtered files require only 80 kilobytes per day, a quantity that can easily be downloaded over a telephone line to a central site for analysis with the data from all the sites.

The large, raw files are available for analysis, but they must be copied from the computer by tape by an operator who is present. This is done when there is an incident of particular note; but if there is a problem on an otherwise normal day, in practice the day is just given up.

In addition to sampling, analyzing, and reporting the data, the computer is able to upload control instructions and change the receivers, delete the oldest raw files on the disk so that there is space for new data, keep track of time-of-day through an internal GPs or WVV radio card, and answer stupid questions when an operator is present.

Since each station operates autonomously, and needs no more facilities than standard wall-plug electricity and a telephone, they are very mobile and can be set up wherever there is going to be an interesting target.

RESULTS

The first interesting result from a year's study is that we do not see the same TID's when looking at the two satellites. The horizontal separation of the lines-of-sight in the ionosphere depends on the altitude of the active regions; for every 100 km altitude the separation is about 100 km. The same types of TID's are seen in both data sets; i.e. both data sets have the same direction, velocity, time history, etc. However, when a wave is seen on the line-of-sight to one satellite, a wave is not seen on the other, more often than a random distribution would cause. It may be that the waves mutate within a hundred kilometers or so, so that they are not recognizable.

In general, the signal from ATS-3 is rather weak. At its best it has a signal-to-noise ratio of better than 30 db, but it sometimes drops below 15 db and we cannot track its phase accurately. For this reason, we have used it mainly as a check on our GOES data, and we present only the GOES data.

Figure 1 shows the number of events as a function of intensity and time-of-day, divided into four periods centered around the solstices and equinoxes. The intense events—some up to 5×10^{15} /m^2 at midday in winter and spring—have weakened by a factor of 10 in summer and autumn; but at those seasons the activity around sunset has increased. There is little activity from midnight to dawn at any time of year.

Figure 1

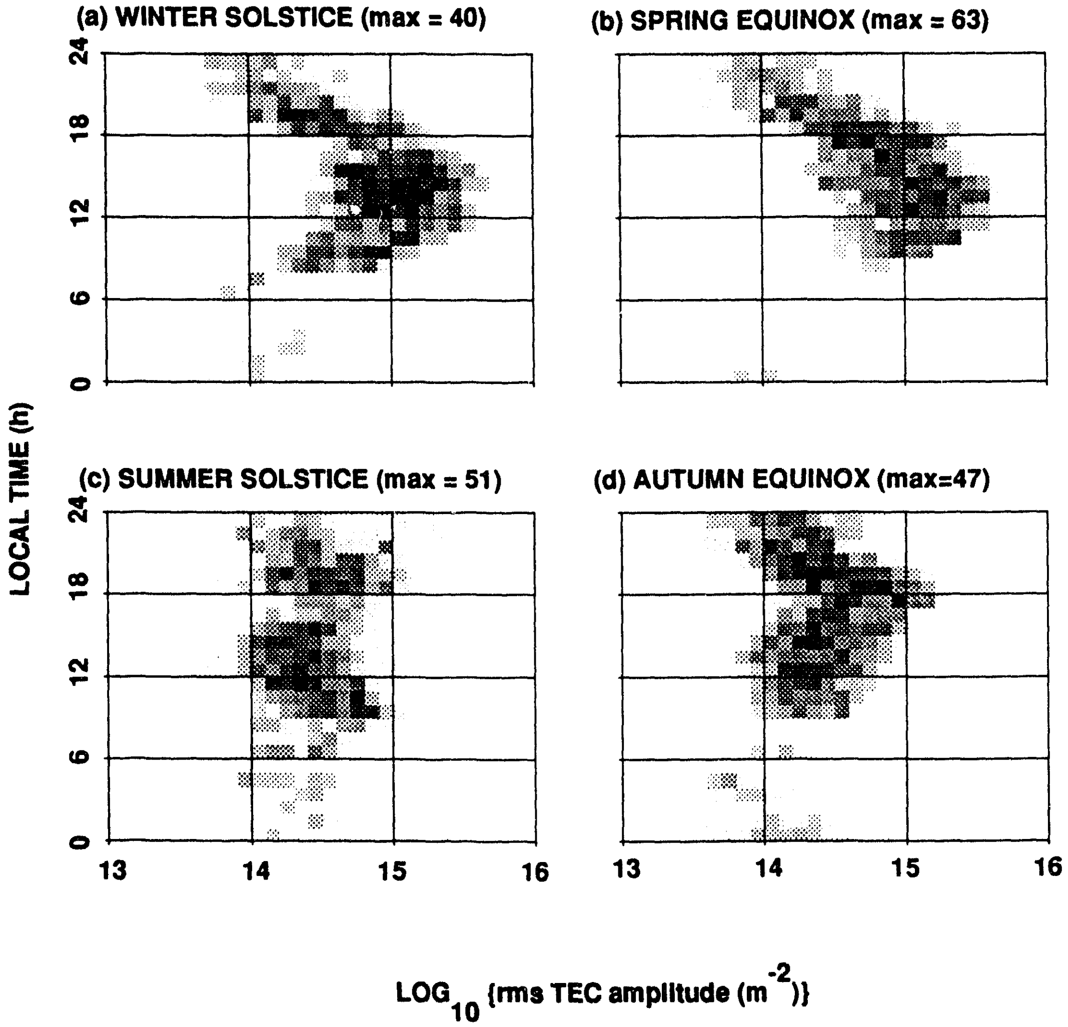


Figure 2 shows the number of events as a function of the time-of-day and the azimuth-of-propagation. There are two distinct sets of TID's. The midday events, throughout the year, propagate southward; the sunset events, which are most prominent at summer and autumn but can be seen developing in spring, are directed to the west-northwest.

Figure 2

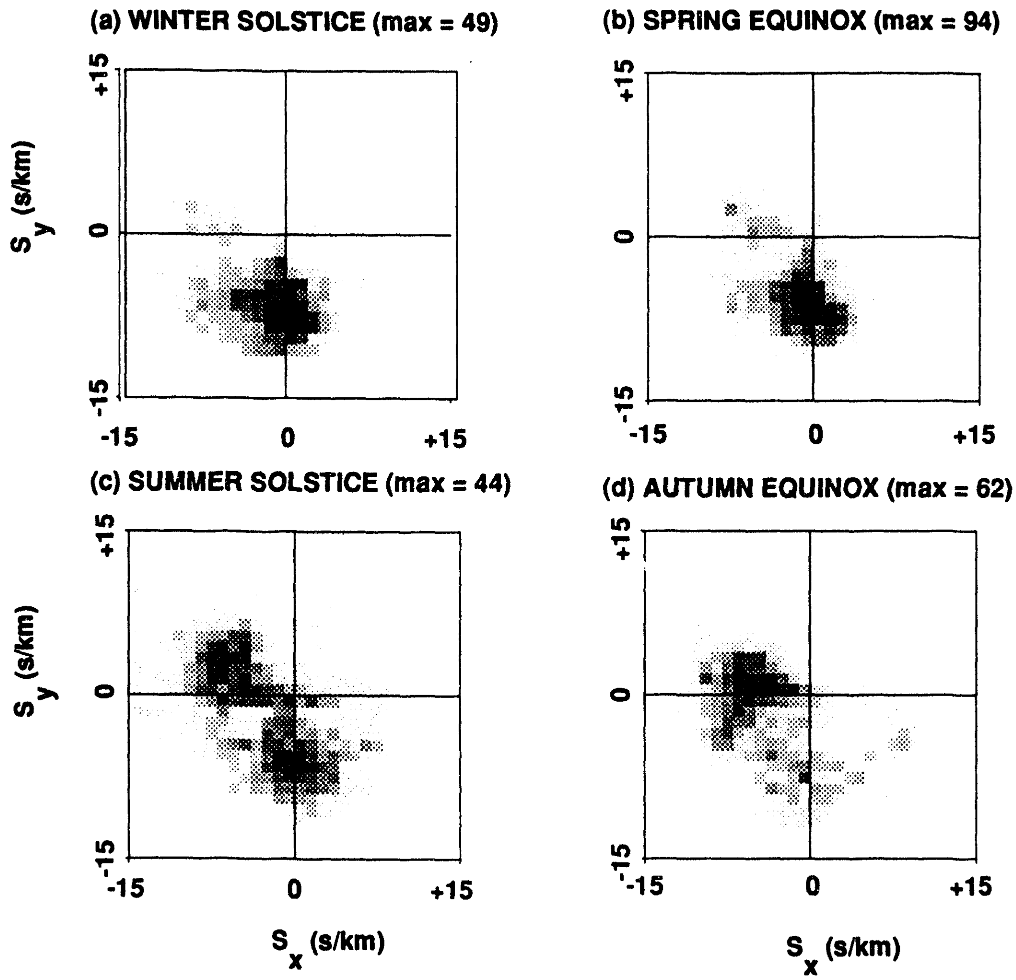
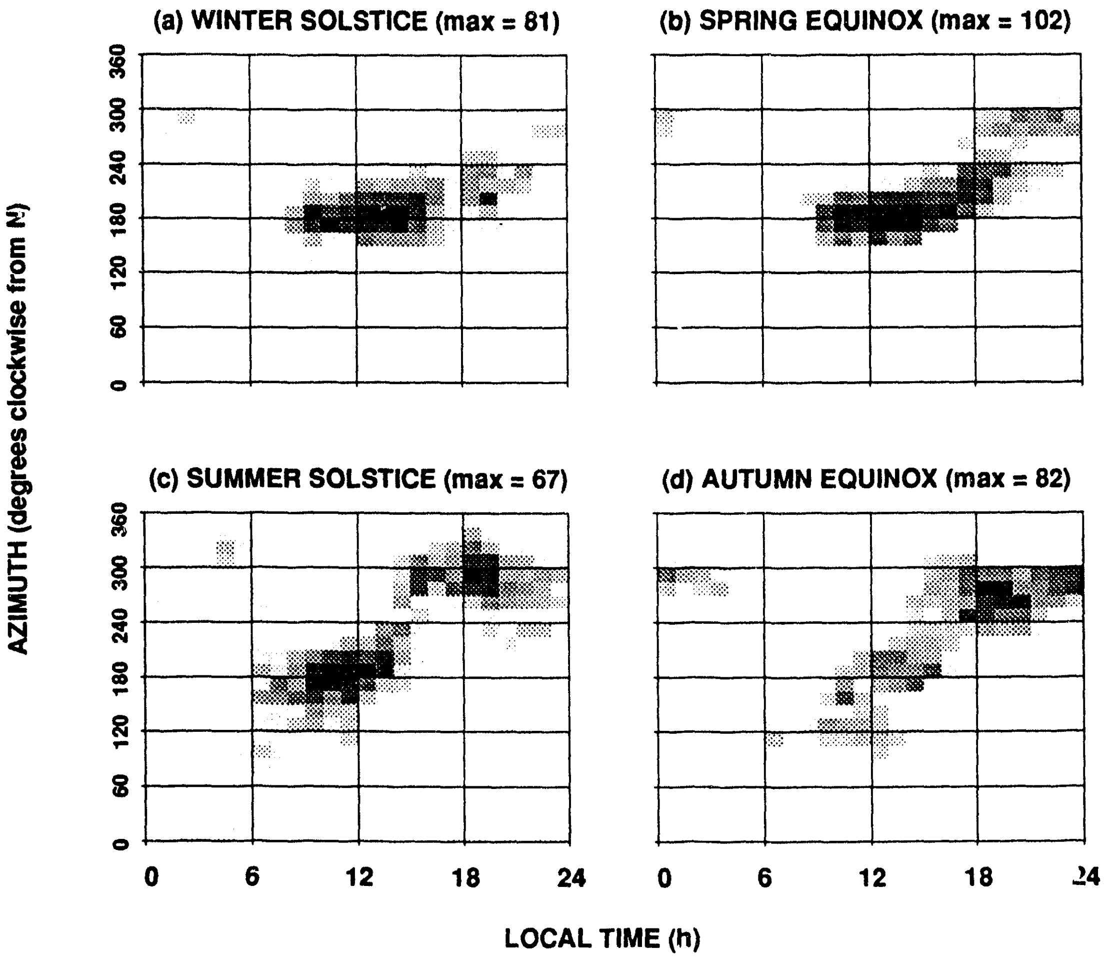


Figure 3 shows the number of events as a function of "slowness," which is the inverse of velocity. The apparent direction of the plots is the true direction; waves with a negative Sy and a zero Sx are moving southward, etc. The slowness of most of the waves shown here ranges from three seconds per kilometer to ten seconds per kilometer, i.e. the speed of sound and slower.

The same events are seen as in Fig. 2, propagating to the south at winter and to the west at autumnal equinox. The southward waves move at 5-8 seconds per kilometer; a fraction of the westward waves move more rapidly.

Figure 3



One conclusion we draw from our year's survey is that we do not see evidence of ionospheric winds. There are two sets of waves, southward from 0900 to 1500 local and westward at 1500 to 2100; but there are three arguments against their being evidence of wind filtering. 1) The two sets of waves occur at different times of year. 2) We divided each set into a faster half and a slower half, and found that the subsets move in the same direction. 3) Each set has a duration of about 6 hours, which is long enough to show a trend in the direction of propagation, if the waves were being affected by a wind that rotated diurnally.

DATE FILMED

10/20/94

END