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Effects of High-Altitude Nuclear Explosions on Radio Noise

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High-altitude nuclear explosions over Johnston Island in August 1958 appear to have had a rather pronounced effect on the radio noise recorded at Kekaha, Hawaii. Graphs are presented showing the hour-to-hour variation of the noise during August at eight frequencies from 13 kc to 20 Mc. All frequencies seem to have been affected, and the drop in received noise power amounted to as much as 32 db in the hour following the first explosion. The period of time over which abnormal noise conditions were observed suggests that high-altitude nuclear explosions may have a rather persistent effect on radio communications at certain frequencies.

1. Introduction

Atmospheric radio noise originates primarily in thunderstorms, and the amount of noise received at a given location is influenced not only by storms in the immediate vicinity, but also by storms a few hundred to several thousand miles distant. Since the noise from these distant storms is propagated by the ionosphere, a record of the radio noise will give an indication of changes in the ionosphere, particularly if there is little or no obscuring effect from storms close enough for groundwave propagation.

Noise records obtained in Hawaii during August of 1958 indicate an abnormal condition in the ionosphere which apparently persisted for most of the month, and which seems to be related to high altitude nuclear explosions over Johnston Island.

2. Observations

The system of noise recording used in the National Bureau of Standards network [1] [1] obtains a 15-min sample of the average noise power each hour on eight frequencies ranging from 13 kc to 20 Mc.[2] A median value of all observations made during a month at each hour of the day is determined at the end of each calendar month and is referred to as the "month-hour" median value of the noise. Necessary calibration factors are applied to convert to "db above ktb," this converted value being referred to as "F_a," or the effective antenna noise figure.

The Kekaha recording station is located on the island of Kauai, Hawaii. The nearest areas with high thunderstorm activity are on or near the major continental land masses several thousand miles distant. Records of weather stations on the islands of Kauai, Hawaii, and Oahu indicate a mean annual number of days with thunderstorms of less than ten, and no thunderstorms were observed at any of these stations during July or August 1958 [2]. It may be assumed, therefore, that the noise recorded at Kekaha in August was mainly noise originating at considerable distances from the station, and that most of it was propagated by the ionosphere.

From April through July of 1958, the median noise levels recorded at Kekaha indicated a remarkably constant pattern of noise: both the shape of the diurnal noise curve and the median observed levels of the noise power (for a particular time of day) showed only minor variations from month to month. The median levels for August, however, indicated some marked changes had occurred: from 51 kc to 2.5 Mc, the median nighttime levels were 5 to 15 db lower than previously, while the daytime levels at 51 kc and 160 kc were from 5 to 10 db higher than in previous months. The median diurnal range at 160 kc amounted to only 23 db in August, compared to 42 db in July; but in September the noise was once again very close to the July levels (fig. 1).

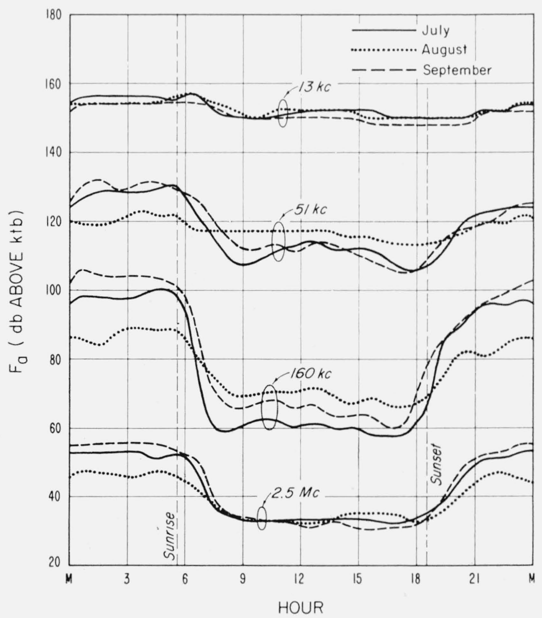

FIGURE 1. *Month-hour median values of radio noise at Kekaha.*

[1] Figures in brackets indicate the literature references at the end of this paper.
[2] Note: A 500-sec time constant is used in the averaging circuits.

The day-to-day and hour-to-hour variations in recorded noise power at Kekaha for the period July 25 to September 4, 1958, are shown in figures 2, 3, and 4. The period July 25 to 31 is indicative of normal conditions at Kekaha: the noise tends to reach its highest levels between 2200 and 0400 H.s.t. (Hawaiian standard time) with a fairly rapid fall starting at or shortly after local sunrise (about 0530 H.s.t. in late July) and reaching a minimum between 0800 to 1200 H.s.t. At 13 kc, however, the minimum value usually occurs in late afternoon; while at 51, 160, and 545 kc (and occasionally at higher frequencies) there are two minimums: about 0800 to 1000 and 1600 to 1800, with midday levels at these frequencies commonly 4 to 10 db above the minimum level.

Two nuclear devices were set off over Johnston Island (about 700 miles southwest of Kekaha) in August: one at an altitude of greater than 60 km on August 1 at 1050 G.c.t. (0050 H.s.t.), and a second at around 30 km on August 12 at 1030 G.c.t. (0030 H.s.t.) as announced by the AEC [3].

Referring to figure 2, note the abrupt drop in the received noise which occurred shortly after midnight on August 1, at a time of day when the noise is normally steady or rising.[3] The original recorder charts show that the drop in noise level was practically simultaneous with the explosion; the average noise power on the low frequency channel recording at the time (545 kc) began dropping rapidly at about 0050 H.s.t. and fell 18 db in 10 min. Because of the averaging time delay of the equipment, the actual decrease of the noise power during this interval was probably much greater, as indicated by the value obtained on 545 kc 1 hr later which was 32 db below the reading at 0050 H.s.t.

After the initial decrease in the noise, a partial recovery began 1 or 2 hr after the explosion, and it appears to have been nearly complete within a few hours at 5, 10, and 20 Mc as well as at 13 kc. However, at 51, 160, and 545 kc and at 2.5 Mc the nighttime levels were 10 to 30 db lower (than the preblast averages) for about six days, and conditions did not appear to be completely normal when the second explosion occurred on August 12.

Coincident with the second blast, the received noise level at Kekaha again dropped sharply, but the immediate effect of the explosion seemed to be somewhat smaller than after the August 1st blast. The long-term effects seem to have been somewhat greater, however, with a very slow rate of recovery at 51 kc to 2.5 Mc for 10 to 12 days afterward and a disturbed condition prevailing for about another 10 days. After about September 1, the recorded noise again seemed to be near normal (pre-August levels).

[3] Note: The apparent premidnight drop at 545 kc is attributable to the method of sampling used in the ARN–2 recorder. The value for the "00" hour is recorded at any time between 0000 and 0100 l.s.t., depending on the frequency; in this case, the values plotted at "00" for 545 kc and 20 Mc were actually recorded about 10 min after the blast, while the values plotted at "00" for all other frequencies were recorded before the blast.

FIGURE 2. *Radio noise power recorded at Kekaha, Hawaii: July 25 to August 7, 1958.*

Time of explosion indicated by arrows.

FIGURE 3. *Radio noise power recorded at Kekaha, Hawaii: August 8 to August 21, 1958.*
Time of explosion indicated by arrows.

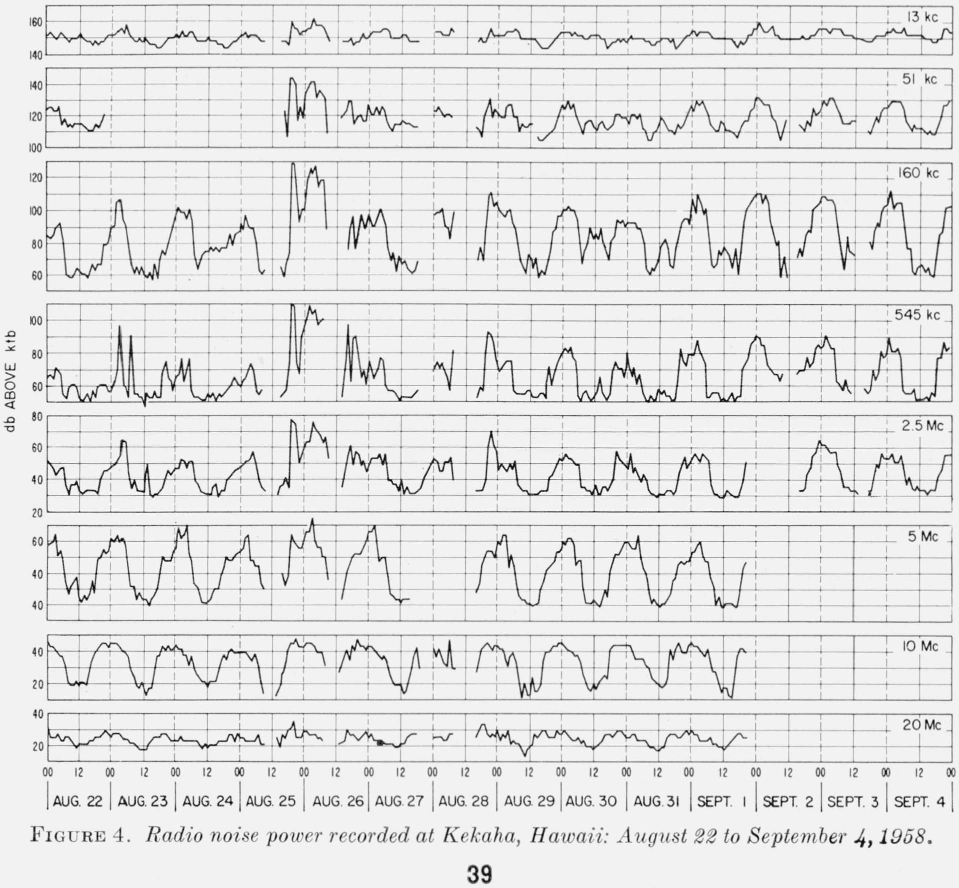

FIGURE 4. *Radio noise power recorded at Kekaha, Hawaii: August 22 to September 4, 1958.*

The unusually high levels recorded from 13 kc to 5 Mc on August 25 and 26 (fig. 4) may have been related to some local electrical phenomena on Kauai, since the station engineer reported a heavy overcast in the vicinity of Kekaha both days. However, no lightning or thunder were observed and no rainfall was recorded on either day in the southwest part of the island [4]. It seems more likely that some unusual ionospheric condition was responsible for the high noise levels recorded on these days.

As shown in figure 1, the median noise during the daytime at 51 kc and 160 kc was higher than normal during August. At 51 kc in particular, there was a "leveling out" of the received noise pattern in the daytime; the usual morning and afternoon minimums were much less pronounced or did not appear at all, and the overall daytime levels for several days after each explosion were close to the midday levels recorded during the pre-August period (fig. 2 and 3).

3. Conclusions

The records of the Kekaha noise station during August provide evidence of sudden and large magnitude changes in the ionosphere following the nuclear tests at Johnston Island. The main source of atmospheric noise at the time of day when the explosions occurred was probably in southeast Asia or Indonesia, resulting in a propagation path through or very near to the blast area. Apparently the region in which each explosion took place became very highly ionized, resulting in greatly increased absorption of signals normally propagated from levels of the ionosphere above that region.

Since an omnidirectional antenna is employed in the noise measurements, the horizontal extent of the abnormal ionization must have been rather large to produce changes in noise level of the degree observed at Kekaha. Some indication of the spread of ionization may be obtained from observations of signal strengths in a San Francisco, California to Hiraiso, Japan path at 13.75 Mc, which show a large loss of signal coinciding closely with the time of the first explosion [5]. Since this path is some 3600-km north of Johnston Island, a very rapid spread of ionization must have occurred to the north of Johnston. On August 12, however, when the explosion occurred at a much lower altitude, no significant effects were noticed on this circuit, although paths nearer Johnston were affected.

Because of the relatively short recombination time in the region where the explosions are thought to have occurred, the increase in absorption should have been of short duration. However, the Kekaha noise records indicate either a continued high level of absorption or a decrease in transmitted noise. The major sources of the noise received at Kekaha are believed to be several thousand miles distant, and it is extremely unlikely that overall thunderstorm activity in these regions could have been affected by the explosions to a sufficient degree to account for the changes in noise level which were observed. Therefore, it would seem that some mechanism in the ionosphere was acting to cause absorption of noise at night for an extended period at the frequencies from 51 kc to 2.5 Mc, while at the same time some improvement in daytime propagation may have occurred at 51 kc and 160 kc. Regardless of the exact mechanism involved, the Kekaha noise records provide evidence that high-altitude nuclear explosions may have a rather persistent effect on radio communications, particularly in the frequency range of 51 kc to 2.5 Mc.

Preliminary investigations of noise records from other stations in the NBS network have disclosed anomalies which may be related to the Johnston tests, but because of the more complicated nature of the received noise at these locations (compared to Kekaha), no conclusions can be reached until more thorough studies of the records can be made.

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4. References

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[5] T. Obayashi, S. C. Coroniti, and E. T. Pierce, Geophysical effects of high-altitude nuclear explosions, Nature, 183, 1476 (1959).

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