HNRAO Observing Log
40.673181 N – 80.437885 W
EN90sq

Date: December 2016

Object: Ionospheric and Shortwave Broadcast Stations

Observatory equipment:

1. FSX-8S
    a. Connected to the TFD/RCP array
    b. HNRAO Multicoupler #2, Port #1 – TFD/RCP
        i. Port 1 having 10 dB of gain, all other ports on Multicoupler have approximately 3 dB gain.
2. RSP2, SDRplay receiver.
    a. Connected to the LWA array, LCP polarization directly.
    b. SDRuno software
3. HP Noise source
4. KAY attenuator

HF broadcast stations have been an issue at HNRAO with some stations so strong as to saturate the FSX-8S spectrograph and affecting the entire span of the observed frequency range (Figure 4).

We are particularly interested in stations that affect our radio observatories which typically observe in the range of 15-30 MHz. Because the stations only affect the HNRAO spectrograph during the daytime hours, typically between 1200 UT and 0000 UT, it's also necessary to factor in the ionosphere and how it affects different frequencies at different times. There are more detailed explanations on this subject[1] than this paper will present, but a look at Figure 1 is self-explanatory without going into great detail.

In an attempt to locate the prominent transmitters, the FSX-8S connected to the TFD array was adjusted below our normal scanning frequencies. Figure 3 shows the RSS chart for the FSX-8S adjusted to scan from 11-18 MHz in an attempt to see what transmitter below 15 MHz might be causing some of the overload. (Figure 4)

Table 1 lists the shortwave stations I could identify hoping to identify the transmitting stations prominent on the spectrograph display during daylight hour as well as identify the transmission source or sources that were overdriving the FSX-8S spectrograph at HNRAO. Using the RSS display gave an approximate frequency of the strongest broadcast. The exact frequency was identified using the RSP2 receiver. Going to a website on the internet and entering the frequency, a list of stations using that frequency and at what hour of the day is given. (https://www.shortwaveschedule.com/). Matching the frequency and the time of day told me who and where each of the transmitters were as well as their reported transmitter power.

While many of these transmitters are very strong, it's clear that the strongest interference sources for my spectrograph are the stations from Havana Cuba. These are Government owned and operated propaganda transmitters. They operate on a rotating broadcast and frequency schedule. When one transmitter goes off the air, on one frequency, another picks up the broadcast on another frequency. This is no doubt to take advantage of the changing ionospheric conditions.

In Figure 5, the time span is from 1200 UT through 1345 UT. This is 7:00 am to 8:45 am EST. It's easy to follow the change in ionospheric conditions as the stations begin to become visible on the spectrograph. In 1.5 hours, the signal at 17.730 MHz and or 17.780 MHz grow so strong in signal strength as to saturate the front end of the receiver, causing it to become overdriven and creating the "smearing" across the entire spectrograph display. Figure 6 shows the two stations in closer detail. Using the HP noise source and the KAY attenuator, I was able to estimate an equivalent antenna temperature of these two stations during this period at about 170 Mk.

It's also easy to see the two strong stations at 15.610 MHz and 15.770 MHz. The transmitter at 15.825 MHz may well be there as well. Other than the Cuban and Voice of America transmitters, the remaining transmitters are all Christian broadcasting stations.

Due to ionospheric conditions, a phenomenon called Skywave is responsible for these stations only affecting the spectrograph in the daytime hours. Skywave or skip refers to the propagation of radio waves reflected or refracted back toward Earth from the ionosphere.

When high frequency signals enter the ionosphere obliquely, they are back-scattered from the ionized layer as scatter waves. If the mid-layer ionization is strong enough compared to the signal frequency, a scatter wave can exit the bottom of the layer earthwards as if reflected from a mirror. Earth's surface (ground or water) then diffusely reflects the incoming wave back towards the ionosphere. Consequently, like a rock "skipping" across water, the signal may effectively "bounce" or "skip" between the earth and ionosphere two or more times (multi-hop propagation). Since at shallow incidence losses remain quite small, signals of only a few watts can sometimes be received many thousands of miles away as a result. With a single "hop," path distances up to 2200 miles may be reached.

Near vertical incidence skywave, or NVIS, is a skywave radio-wave propagation path that provides usable signals in the range between groundwave and conventional skywave distances—usually 30–400 miles. It is used for military and paramilitary communications, broadcasting, especially in the tropics, and by radio amateurs. The radio waves travel near-vertically upwards into the ionosphere, where they are refracted back down and can be received within a circular region up to 400 miles from the transmitter.

It's possible then to believe that the broadcast stations between HNRAO and approximately 400 miles are NVIS signals (Figure 2). These would be the Voice of America transmitters (17.655 MHz & 15.580 MHz) in Greenville, NC, WCB (17.640 MHz) in Franklin, TN, and WWCR (15.825 MHz) in Nashville, TN.

The broadcast stations in Cuba and Okeechobee, FL are most likely a single hop propagation.

While I've identified the stations causing all the problems, there isn't a lot that can be done about it. It's not practical to try to notch out those specific frequencies.

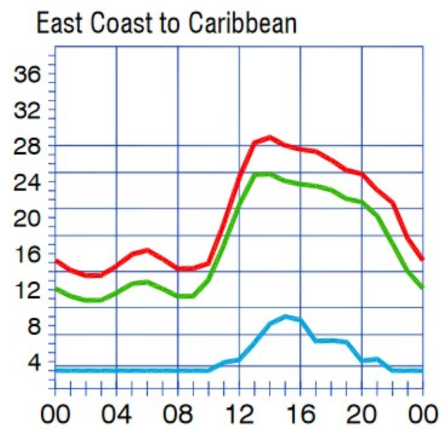


Figure 1

The current propagation chart for the East Coast to the Caribbean (which would include the Eastern Seaboard shows the observed sharp rise in the maximum useable frequency (MUF) climbing from about 16 MHz to 29 MHz (Fig 5) then descending through the remainder of the day until sunset.

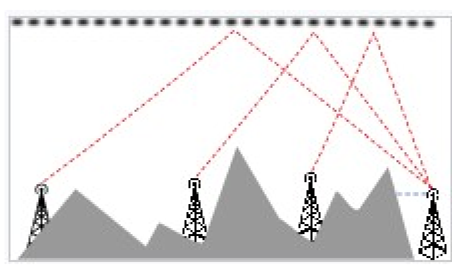


Figure 2

NVIS radiation pattern While the groundwave (blue) cannot propagate, the refracted skywaves (red) achieve HF coverage within the common first hop (~300 miles).

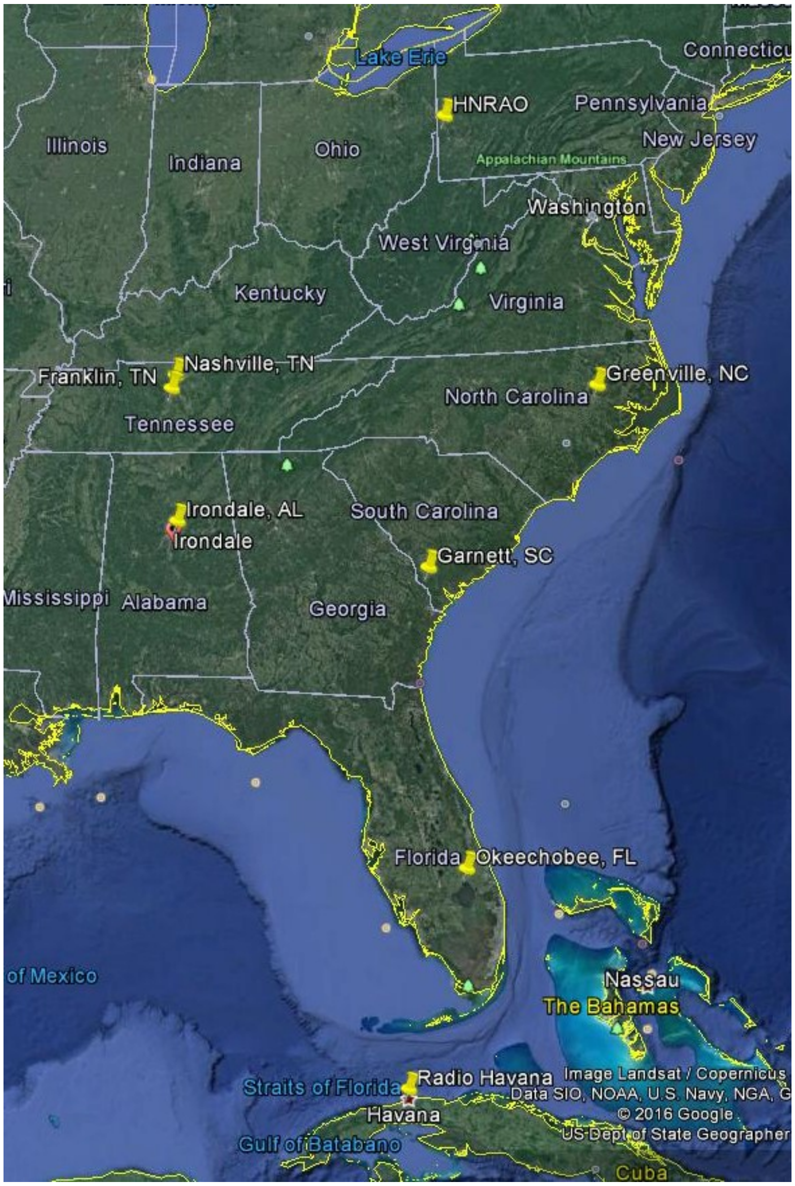
Source	Frequency MHz	Location	Station Description	Power KW	Distance Miles From HNRAO
WRMI*	21.675	Okeechobee, FL	Overcomer Ministries	100	932
WRMI*	21.610	Garnett, SC	Overcomer Ministries	250	554
WRMI*	17.790	Okeechobee, FL	Overcomer Ministries	100	932
Radio Havana Cuba	**17.730**	**Havana, Cuba**	**Radio Havana Cuban Government**	**100**	**1234**
VOA	17.655	Greenville, NC	Voice of America	250	389
WCB	17.640	Franklin, TN	African Pathways Radio	250	476
Radio Havana Cuba	**17.580**	**Havana, Cuba**	**Radio Havana Cuban Government**	**100**	**1234**
Sea conditions	**17.362**				
WLO - Data - Selcal 1090	**16.809**		**No location given since it is an automated transmitter. Location could either be Gulf of Mexico, SW N Atlantic or Caribbean**		
	16.180		**Digital data transmissions in Spanish**		
WWCR1	15.825	Nashville, TN	Religious broadcast	100	476
WRMI*	15.770	Okeechobee, FL	Overcomer Ministries	100	932
WEWN	15.610	Irondale, AL	**WEWN** is the shortwave radio outlet of the EWTN Global	250	596
WEWN	15.610	Irondale, AL	WEWN is the shortwave radio outlet of the EWTN Global Catholic Network	250	596
VOA	15.580	Greenville, NC	Voice of America	100	389
WRMI*	15.440	Okeechobee, FL	Overcomer Ministries	100	932
Radio Havana Cuba	**15.370**	**Havana, Cuba**	**Radio Havana Cuban Government**	**100**	**1234**
Radio Havana Cuba	**15.140**	**Havana Cuba**	**Radio Havana Cuban Government**	**100**	**1234**
WWV	15.000	Boulder, CO	NIST		
Radio Havana Cuba	**13.740**	**Havana, Cuba**	**Radio Havana Cuban Government**	**100**	**1234**
WRMI*	13.695	Okeechobee, FL	Overcomer Ministries	100	932
WRMI*	11.825	Okeechobee, FL	Overcomer Ministries	100	932

* WRMI broadcasts on over 25 SW frequencies. 24 hours a day.

Broadcast stations in **RED** indicate spectrograph front end overload.

Broadcast stations in GREEN indicate extremely strong stations

Table 1



Shortwave station locations affecting HNRAO spectrograph

Figure 3

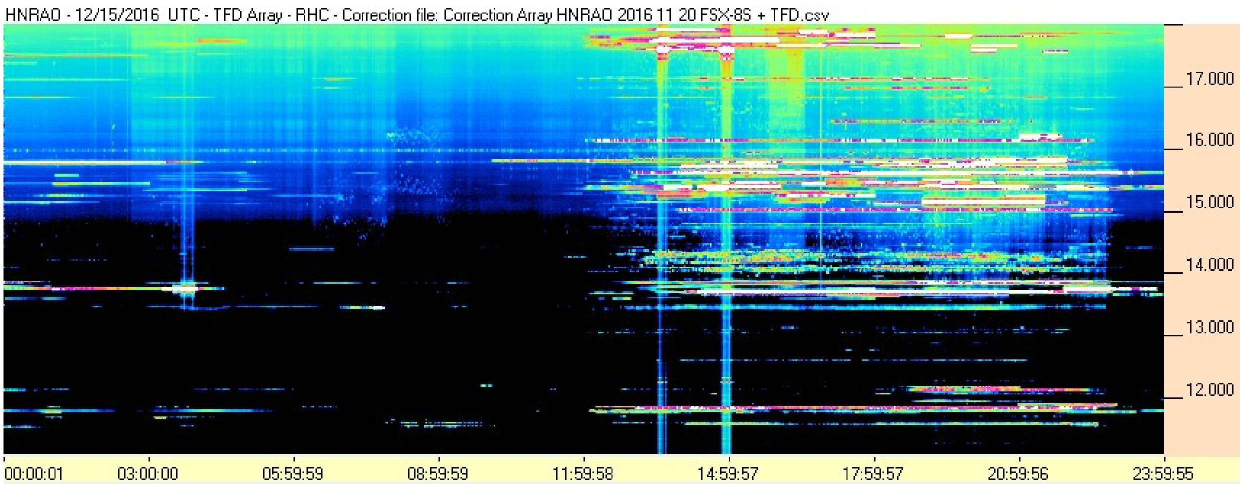


Figure 4

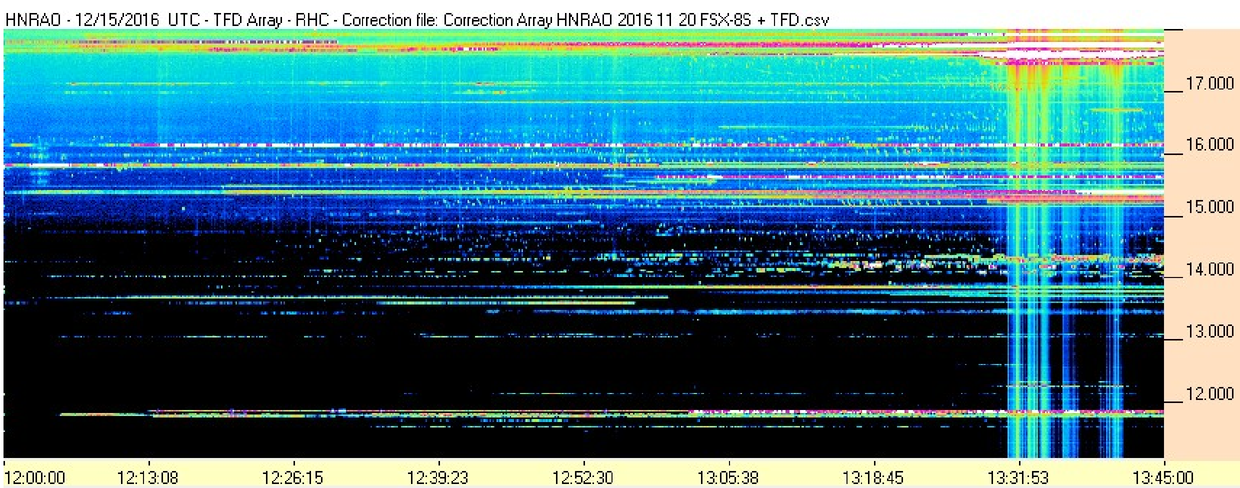


Figure 5

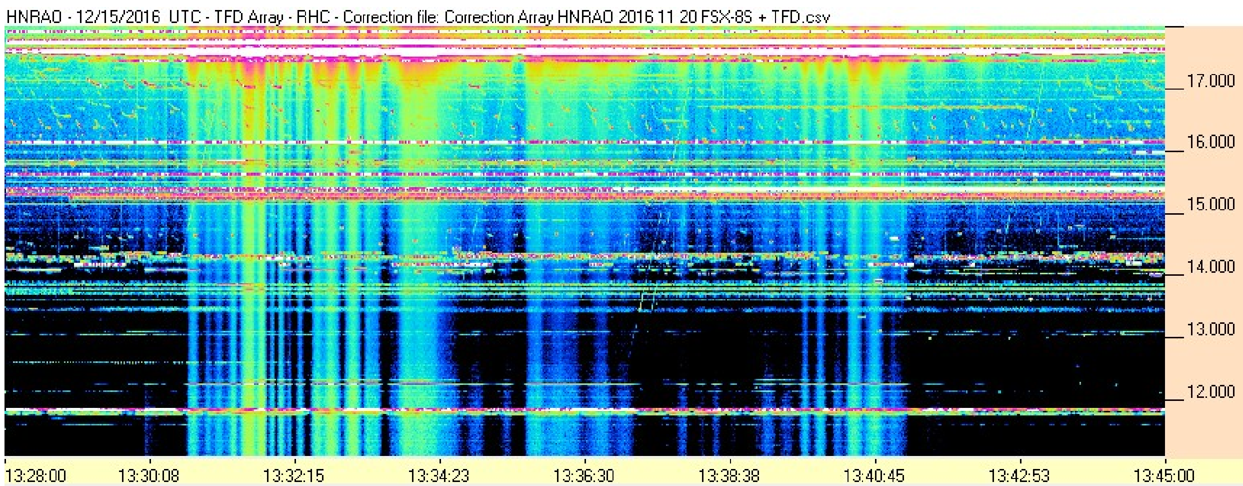


Figure 6

[1] More detailed information about the ionosphere and propagation of signals can be found here: http://www.arrl.org/propagation