1660.5-1668.4 MHz

1. Band Introduction

The 1660.5-1668.4 MHz band is a shared band allocated to the Federal Government for the radio astronomy service and the space research (passive) service on a primary basis. Radio astronomy observations of the hydroxyl radical spectral lines are performed for research of stellar and expansion velocities, validation theories of the origins, and evolution of the universe. The National Aeronautics and Space Administration also operates the Deep Space Network system 70-meter diameter antenna and associated receivers in this band at their facility in Goldstone, CA.

2. Allocations

2a. Allocation Table

"The frequency allocation table shown below is extracted from NTIA's Manual of Regulations & Procedures for Federal Radio Frequency Management, Chapter 4 – Allocations, Allotments and Plans."

Table of Frequency Allocations

United States Table

Federal Table	Non-Federal Table	FCC Rule Part(s)
1660.5-1668.4 RADIO ASTRONOMY US74 SPACE RESEARCH (passive) 5.341 US246		

2b. Additional Allocation Table Information

5.341 In the bands 1 400-1 727 MHz, 101-120 GHz and 197-220 GHz, passive research is being conducted by some countries in a programme for the search for intentional emissions of extraterrestrial origin.

US246 No station shall be authorized to transmit in the following bands:

73-74.6 MHz,
608-614 MHz, except for medical telemetry equipment,[1]
1400-1427 MHz,
1660.5-1668.4 MHz,
2690-2700 MHz,
4990-5000 MHz,
10.68-10.7 GHz,
15.35-15.4 GHz,
23.6-24 GHz,
31.3-31.8 GHz,
50.2-50.4 GHz,
52.6-54.25 GHz,
86-92 GHz,
100-102 GHz,
109.5-111.8 GHz,
114.25-116 GHz,
148.5-151.5 GHz,
164-167 GHz,
182-185 GHz,
190-191.8 GHz,
200-209 GHz,
226-231.5 GHz,
250-252 GHz.

[1] Medical telemetry equipment shall not cause harmful interference to radio astronomy operations in the band 608-614 MHz and shall be coordinated under the requirements found in 47 CFR. 95.1119.

3. Federal Agency Use:

3a. Federal Agency Frequency Assignments Table:

The following table identifies the frequency band, types of allocations, types of applications, and the number of frequency assignments by agency.

Federal Frequency Assignment Table

There are no federal frequency assignments in this band.

3b. Percentage of Frequency Assignments Chart

There are no federal frequency assignments in this band.

4. Frequency Band Analysis By Application

4a. Radio Astronomy Service

Radio astronomy is defined as astronomy based on the reception of radio waves of cosmic origin.[1] The service is unique in that it involves only passive systems. Since the signals received emanate from natural sources, radio astronomers have no control over the power, the frequency, or other characteristics of the emissions. The spectrum used is based on physical phenomena rather than expected growth, as is the case for most other radio services. Using terrestrial radio telescopes, radio astronomers can observe cosmic phenomena at frequencies ranging from 15 MHz to over 800 GHz. To meet the needs of radio astronomy, frequencies at regular intervals across this range must be protected from interference in the vicinity of the radio astronomy observatories. The basic plan of spectrum management for radio astronomy is to protect small bands across the range for continuum observations, while choosing those bands so they contain the spectral lines of greatest scientific interest.[2] Radio astronomy has contributed much to the science of astronomy and has produced numerous technical innovations that have benefitted radiocommunications and humankind in general. It has provided information on the

[1] NTIA Manual §6.1.1 at 6-12.

[2] The preferred frequency bands for continuum and spectral line observations are specified in International Telecommunication Union-Radiocommunication Sector Recommendation RA.314-10.

atmospheric absorption of radio waves, important in the area of telecommunications and communications technology.[3]

The 1660.5-1668.4 MHz band is part of the larger 1660-1670 MHz band that is used for both hydroxyl spectral line and continuum measurements. The hydroxyl spectral lines have been observed both in emission and absorption from several hundred different regions in our Galaxy. The study of these spectral lines provides insight into the initial stages of star formation that can be used in studies related to the origin and evolution of the universe. The spectral line observations of the hydroxyl radical at frequencies of 1612.2 MHz, 1665.4 MHz, 1667.4 MHz and 1720.5 MHz are performed simultaneously to study the emitting radio source. In the 1660.5-1668.4 MHz band, the measurements from radio astronomy telescopes in the United States are combined with those in Europe to maximize the collecting area and the angular resolution that can be achieved for Very Long Baseline Interferometry measurements.

The National Aeronautics and Space Administration operates the Deep Space Network system 70-meter diameter antenna and associated receivers in Goldstone, CA for radio astronomy research observations of the hydroxyl radical spectral lines for research of stellar and expansion velocities, validation theories of the origins, and evolution of the universe.

Federal and university radio astronomy research activities are interrelated and complementary and in many cases involve collaborative efforts with other countries. A list of the radio astronomy facilities that perform observations in the 1660.5-1668.4 MHz band are provided in Table 1.

Table 1.

Facility	Latitude	Longitude
Arecibo, PR	18-20-38 N	66-45-09 W
Socorro, NM	34-04-43 N	107-37-04 W
Green Bank, WV	38-25-59 N	79-50-23 W
Pie Town, NM	34-18-00 N	108-07-00 W
Kitt Peak, AZ	31-57-00 N	111-37-00 W
Los Alamos, NM	35-47-00 N	106-15-00 W
Fort Davis, TX	30-38-00 N	103-57-00 W
North Liberty, IA	41-46-00 N	91-34-00 W
Brewster, WA	48-08-00 N	119-41-00 W
Owens Valley, CA	37-14-00 N	118-17-00 W

[3] An overview of applications of astronomical techniques and devices that benefit the public is contained in National Telecommunications and Information Administration, NTIA Report 99-35, *Radio Astronomy Spectrum Planning Options* (April 1998) at Appendix B.

Saint Croix, VI	17-46-00 N	64-35-00 W
Mauna Kea, HI	19-49-00 N	155-28-00 W
Hancock, NH	42-56-00 N	71-59-00 W
NASA Deep Space Network, CA	35-25-33 N	116-53-23 W

Radio astronomers employ radio telescopes, highly sensitive receivers with large, high-gain antennas, to detect the weak signals from space. Because the desired signals are so weak and the receivers are so sensitive, radio telescopes are highly susceptible to interference.[4] A typical radio astronomy telescope receives only about one-trillionth of a watt even from the strongest cosmic source. Radio astronomers can only control the electromagnetic signal environment at the receiver and this creates a potential incompatibility with other spectrum users. Radio observatories are usually built in remote locations with surrounding terrain that provides natural shielding from interference sources. Nonetheless, effective spectrum management is critical to protect the radio telescopes from harmful interference. Sources of potential interference are spurious, harmonic, and adjacent band emissions from satellite and airborne transmitters, and aggregate interference from licensed and unlicensed ground-based transmitters. Spectrum contours for the facilities shown in Table 1 can be computed based on the maximum permissible interference level necessary to protect radio astronomy service receivers. The maximum permissible interference level necessary to protect radio astronomy service and DSN receivers are specified in International Telecommunication Union recommendations.[5] The spectrum contours are computed using a 0 dBi gain for the radio astronomy receive antenna[6]; a maximum allowable equivalent isotropically radiated power level of 10 dBW/MHz for a ground-based transmitter[7] and a terrain

[4] The receivers used by radio astronomers can detect signals that are typically 60 dB below thermal noise, whereas the signal levels for normal radiocommunication systems are typically 20 dB above thermal noise.

[5] Recommendation ITU-R RA.769-1, *Protection Criteria Used For Radioastronomical Measurements* (1995); Recommendation ITU-R SA.1157, *Protection Criteria for Deep Space Research* (1995).

[6] Recommendation ITU-R RA.1031-1, *Protection of the Radioastronomy Service in Frequency Bands Shared with Other Services*.

[7] This equivalent isotropically radiated power level is consistent with levels permitted for mobile systems used in the Advanced Wireless Systems service, Personal Communications Service, and Cellular service. These calculations are limited to ground-based transmitters and it is noted that emissions from airborne stations can be particularly serious sources of interference to the radio astronomy service (*see* ITU *Radio Regulations* at Nos. 4.5, 4.6, 5.376A and Article 29 and US342).

dependent propagation model.[8] The statistical and environmental parameters used with the terrain profile in calculating the propagation loss are shown in Table 2.

Table 2.

Parameter	**Value**
Refractivity	301 N-units
Conductivity	0.005 S/M
Permittivity	15
Humidity	10
Reliability	50 percent
Confidence	50 percent
Radio Climate	Continental Temperate
Antenna Polarization	Vertical
Transmit Antenna Height	3 meters
Receive Antenna Height	Extracted from Terrain Database

The radio astronomy facility latitude and longitude in Table 1 represents the center point for the contour.

The spectrum contours for the radio astronomy facilities performing observations in the 1660.5-1668.4 MHz band are shown in Figures 1 through 9.

[8] The propagation loss for the spectrum usage contours is computed using the Irregular Terrain Model in the point-to-point mode and three second U.S. Geological Survey topographic data. A detailed description of the Irregular Terrain Model is available at http://flattop.its.bldrdoc.gov/itm.html.

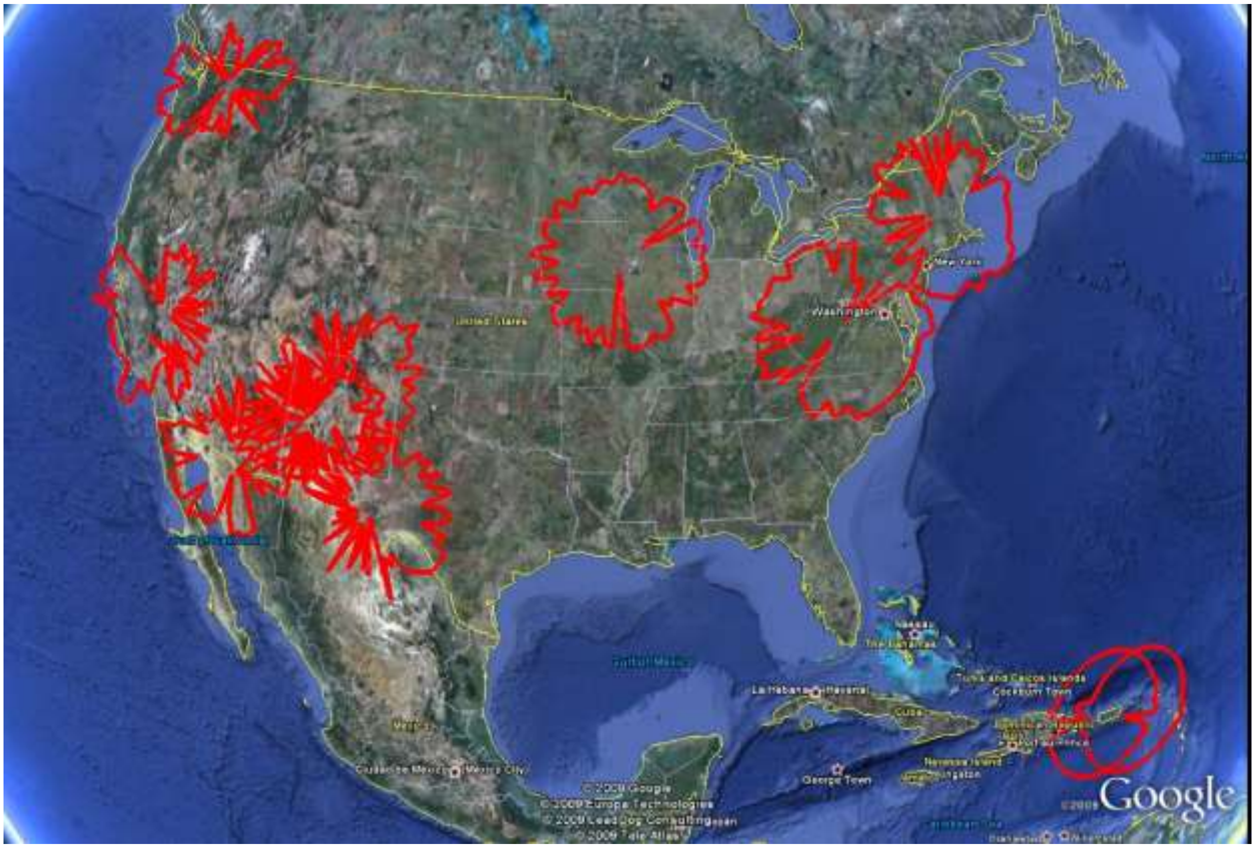


Figure 1.

1660.5-1668.4 MHz Radio Astronomy Spectrum Contours

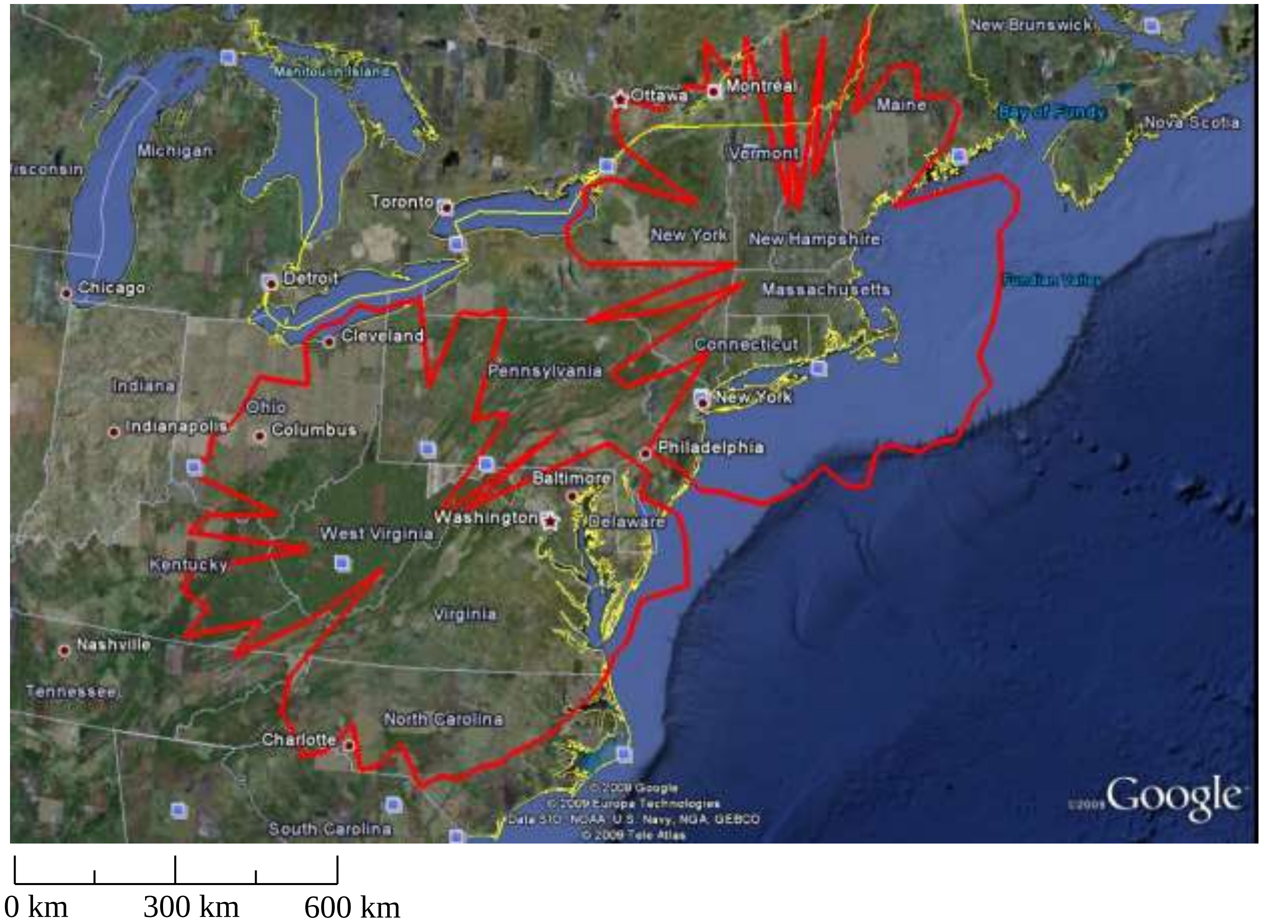


Figure 2.

Hancock, NH and Green Bank, WV
1660.5-1668.4 MHz
Radio Astronomy Spectrum Contours

Figure 3.

North Liberty, IA
1660.5-1668.4 MHz
Radio Astronomy Spectrum Contour

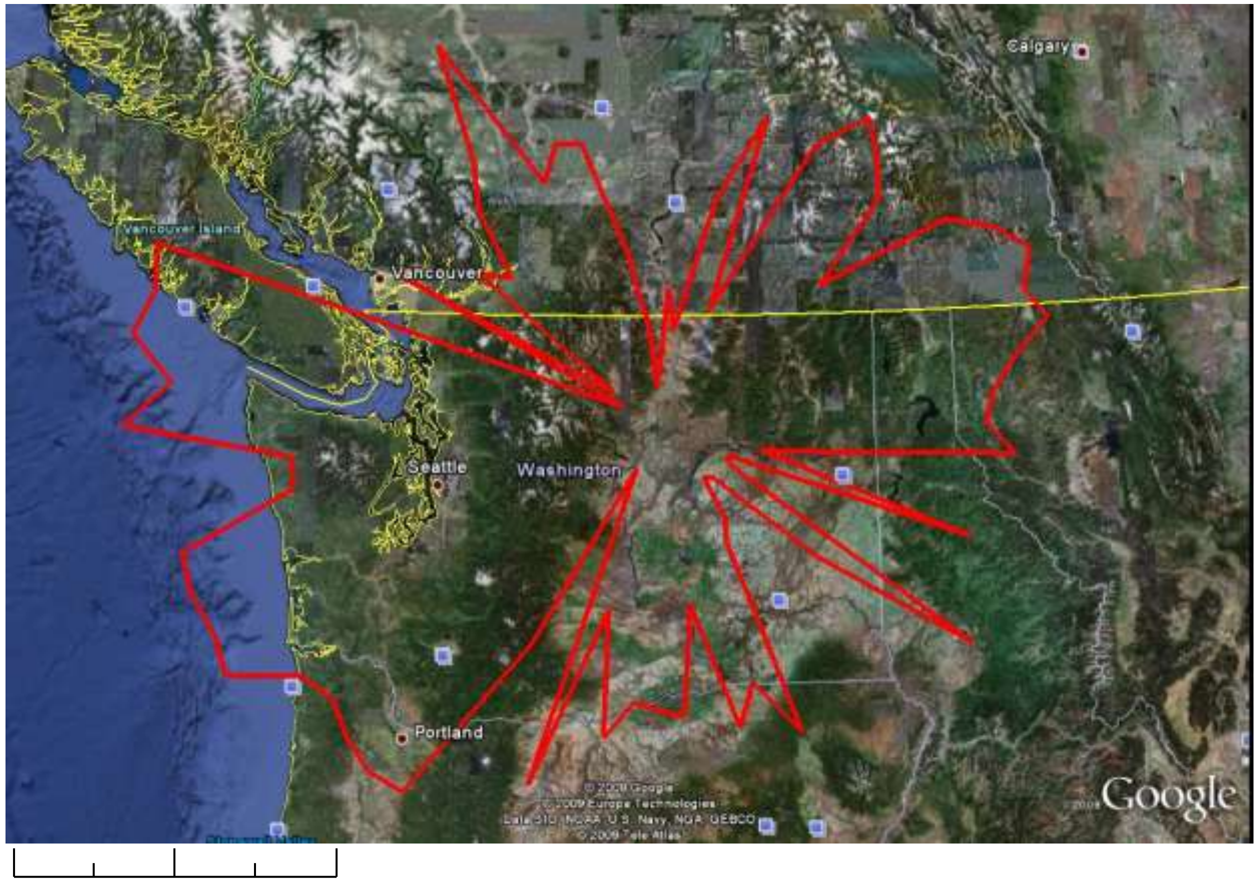


Figure 4.

Brewster, WA
1660.5-1668.4 MHz
Radio Astronomy Spectrum Contour

Figure 5.

Owens Valley, CA and NASA Deep Space Network, CA
1660.5-1668.4 MHz
Radio Astronomy Spectrum Contours

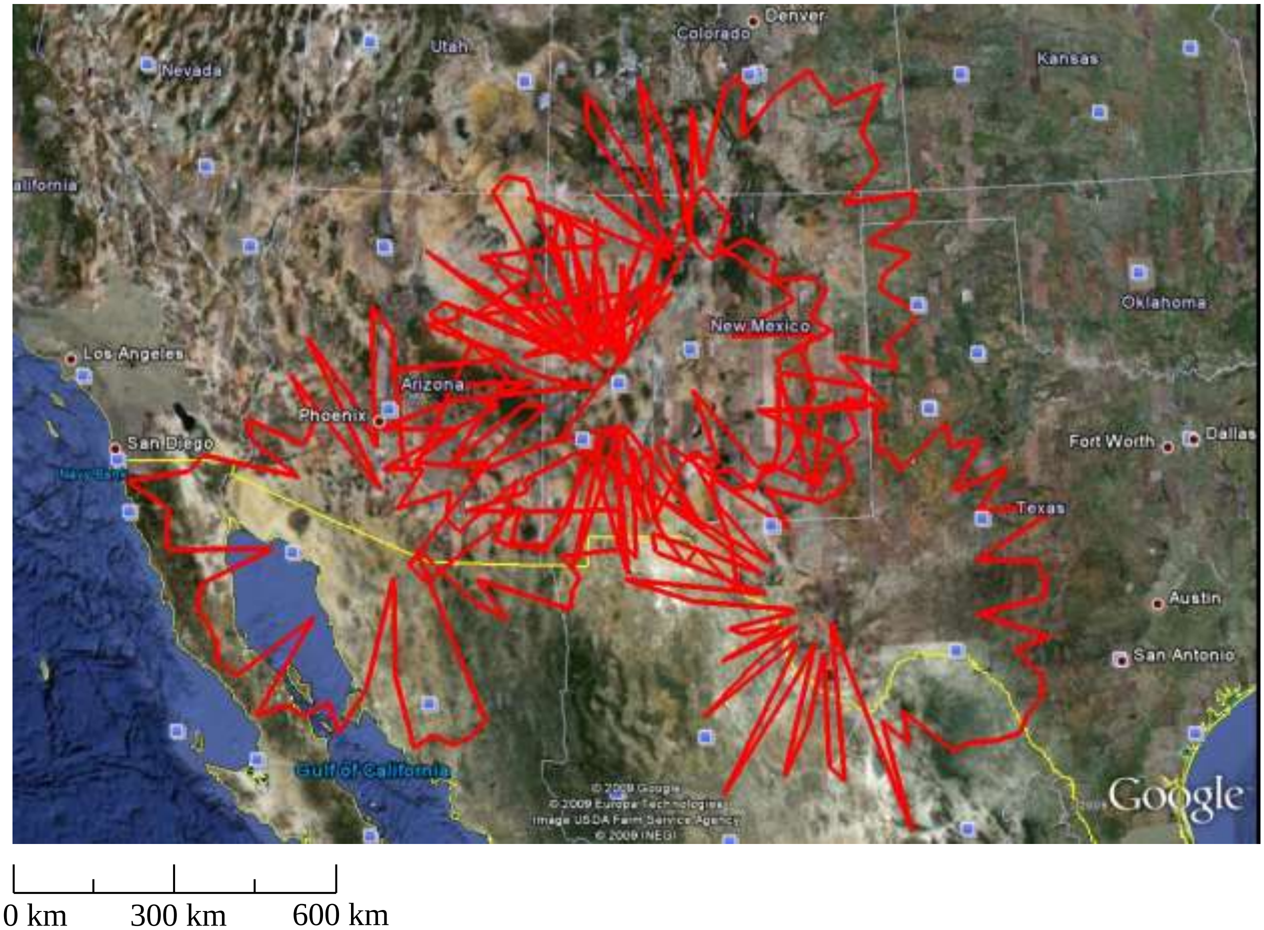
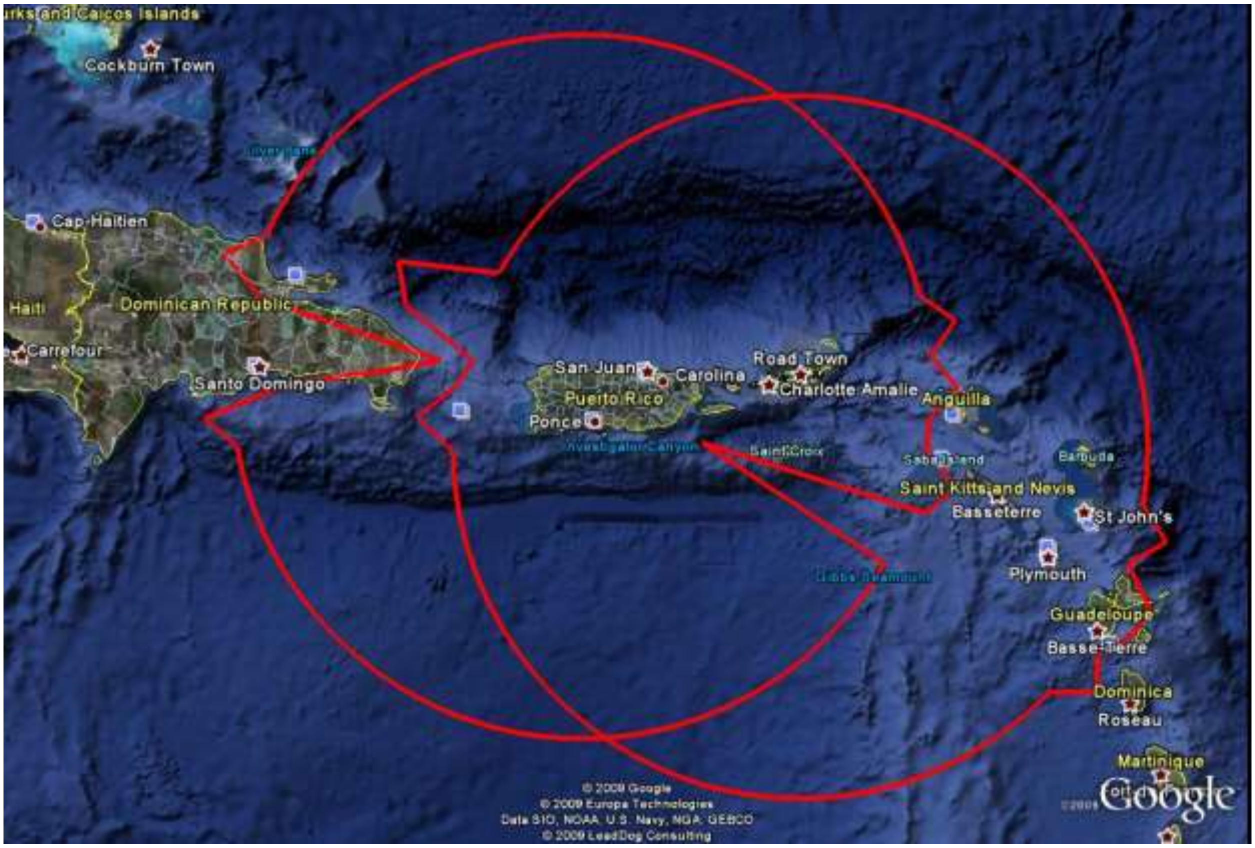


Figure 6.

Kitt Peak, AZ, Socorro, NM, Pie Town, NM, Los Alamos, NM and Fort Davis, TX
1660.5-1668.4 MHz
Radio Astronomy Spectrum Contours



0 km 170 km 340 km

Figure 7.

Arecibo, PR and Saint Croix, VI
1660.5-1668.4 MHz
Radio Astronomy Spectrum Contours

1660.5 – 1668.4 MHz

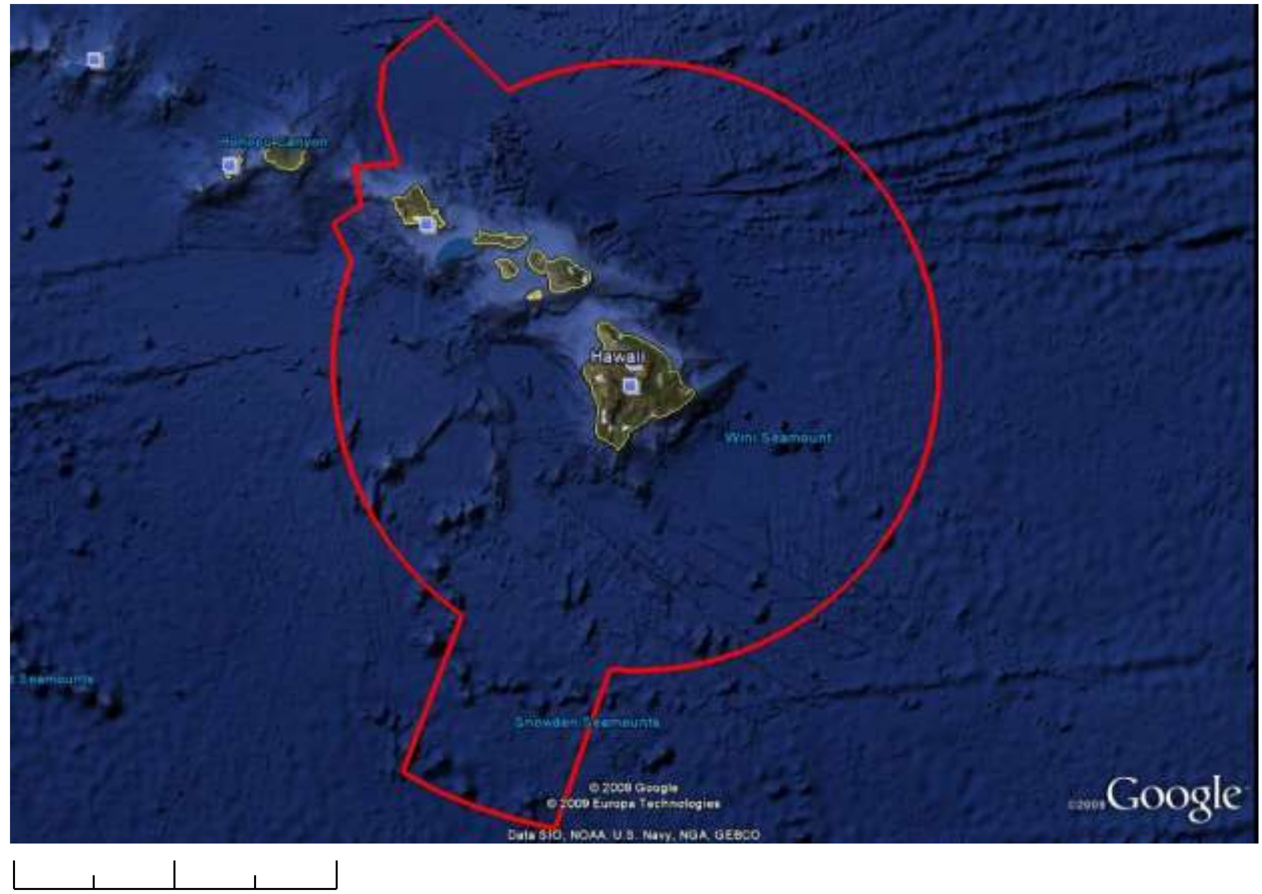


Figure 8.

Mauna Kea, HI
1660.5-1668.4 MHz
Radio Astronomy Spectrum Contours

4b. Space Research (Passive) Service

The Federal Government is not using the 1660.5-1668.4 MHz band for space research (passive) operations at this time.

5. Planned Use:

The radio astronomy observations performed in this band are expected to continue indefinitely.
There are currently no plans to use this band for space research (passive) operations at this time.