Amateur Radio License

Propagation and Antennas

Todays Topics

- Propagation

- Antennas

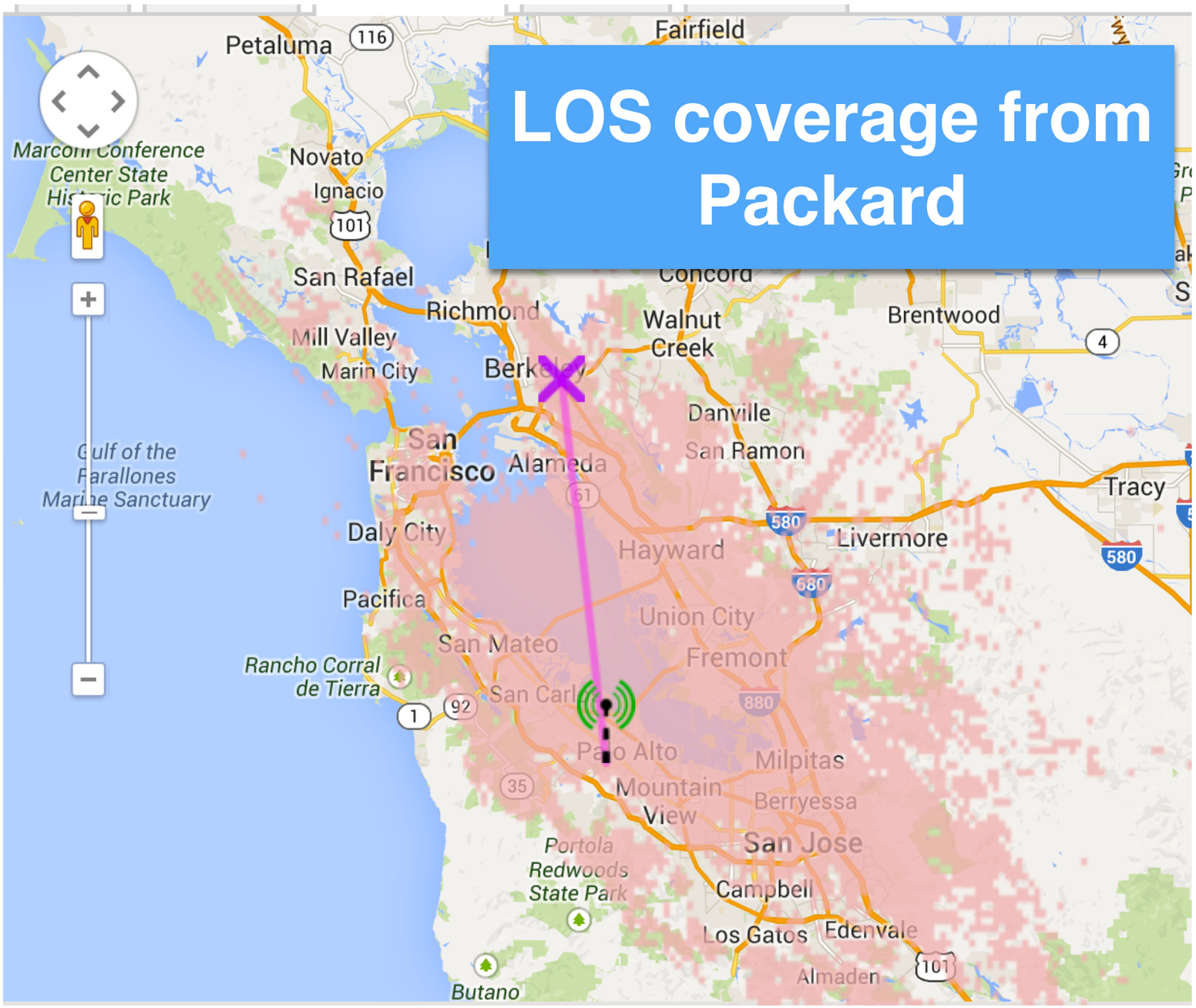
Propagation Modes

- Ground wave
  - Low HF and below, ground acts as waveguide
  - AM radio
- Line-of-Sight (LOS)
  - VHF and above, radio waves only slightly refracted or reflected by the atmosphere
  - FM Radio
- Sky wave
  - For HF, and sometimes VHF, the upper atmosphere acts as a reflector, bouncing radio waves back to earth far from the source
  - Short wave radio

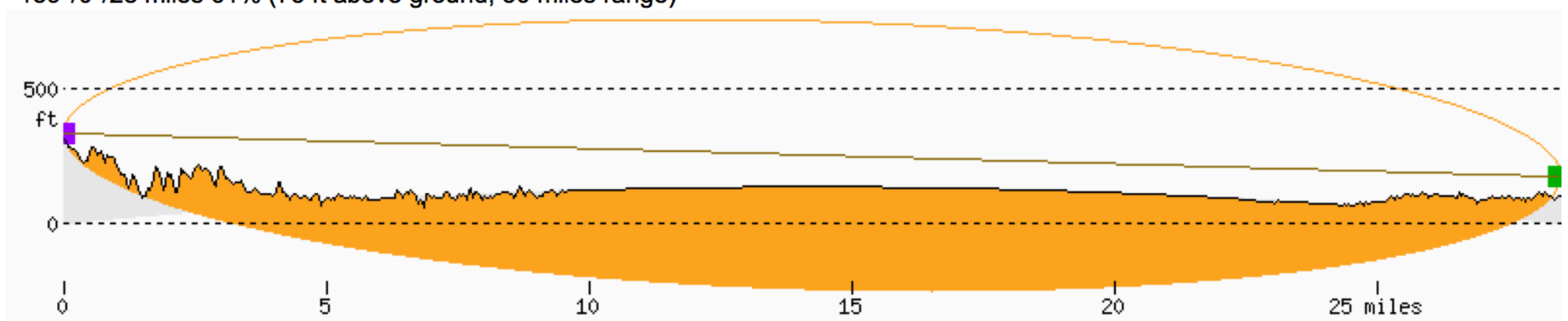
Line-of-Sight

- At VHF and UHF radio waves effectively travel in straight lines
- Limited by radio horizon
- Slightly refracted by the atmosphere
  - Effective earth radius 4/3 the true radius
  - From a radio perspective, the earth is slightly flatter

Packard EE
to
Cory Hall, UCB



Packard EE
159°/0°/28 miles 61% (75 ft above ground, 50 miles range)



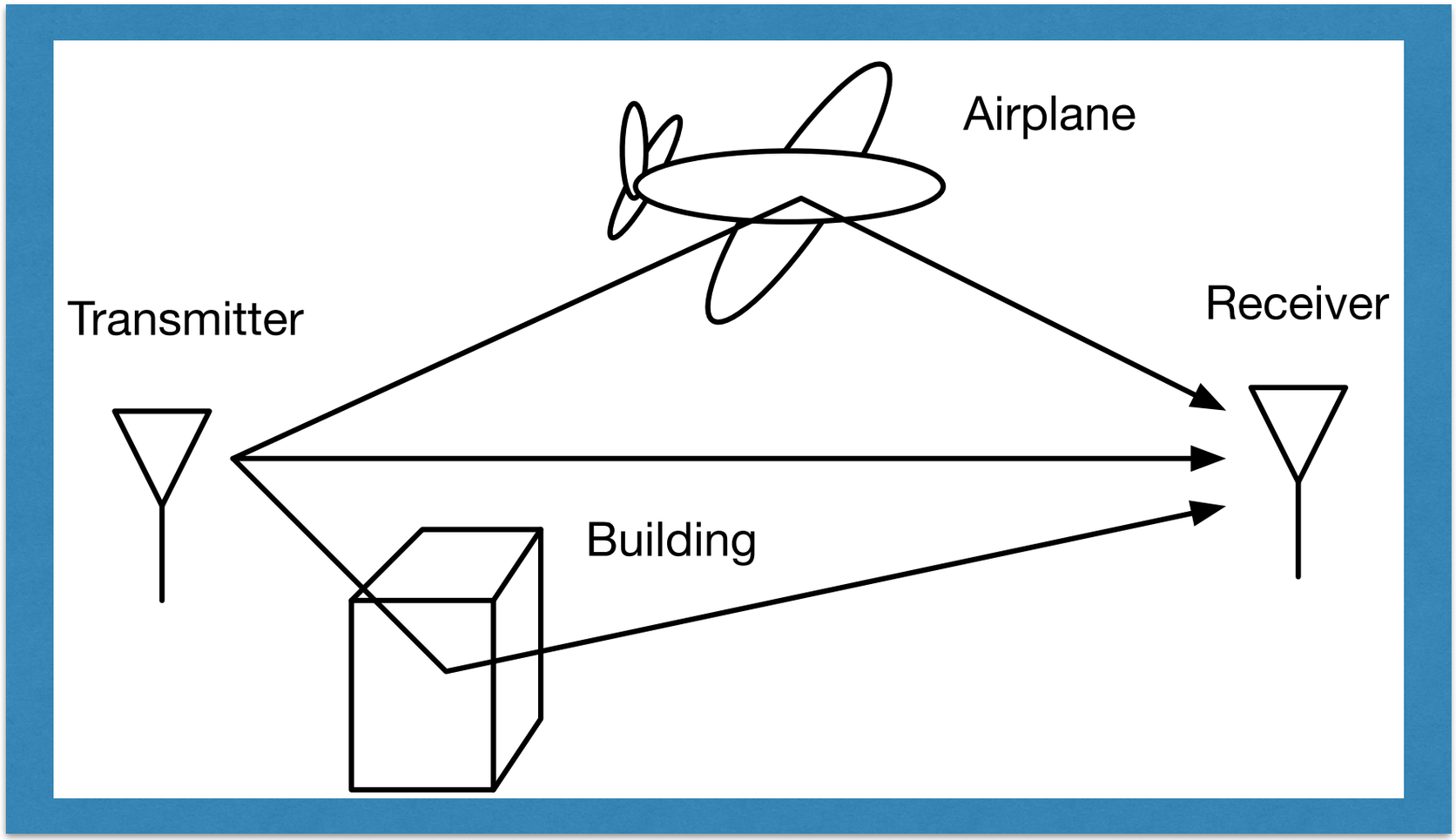
Cory Hall

Packard EE

Propagation Path

Multipath

- Radio waves often travel by multiple paths, which can constructively or destructively interfere

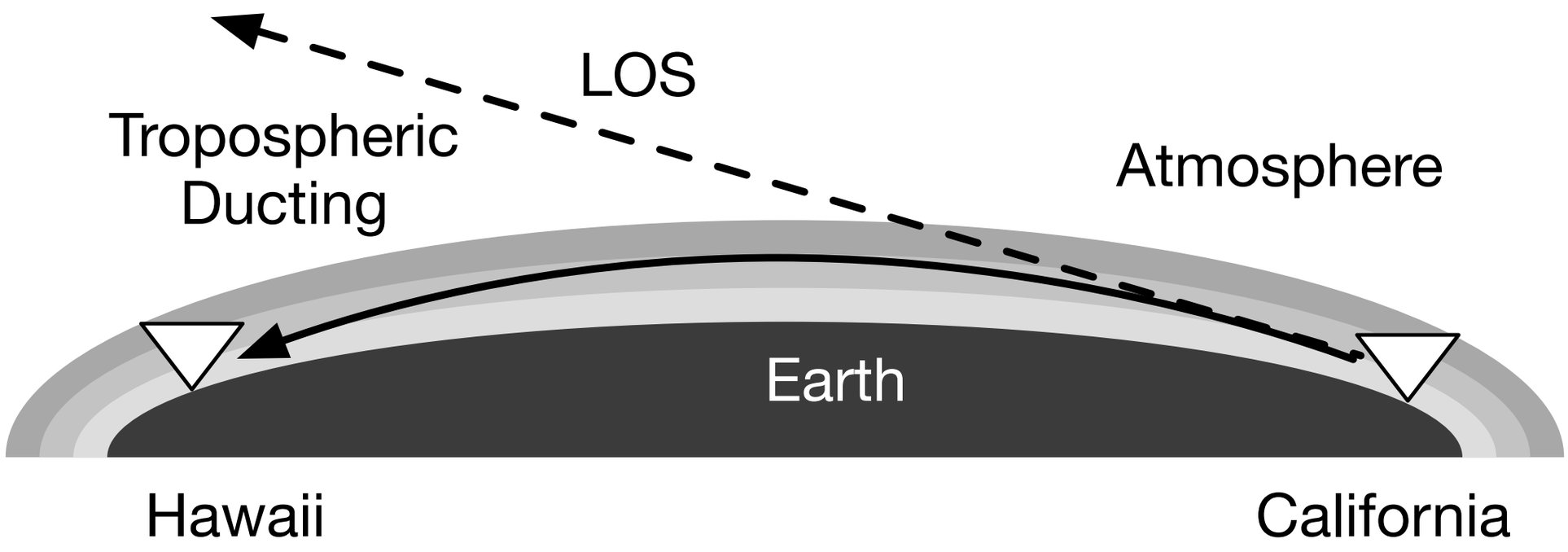


- Small changes in location can result in large changes in signal: “picket fencing”

Tropospheric Ducting

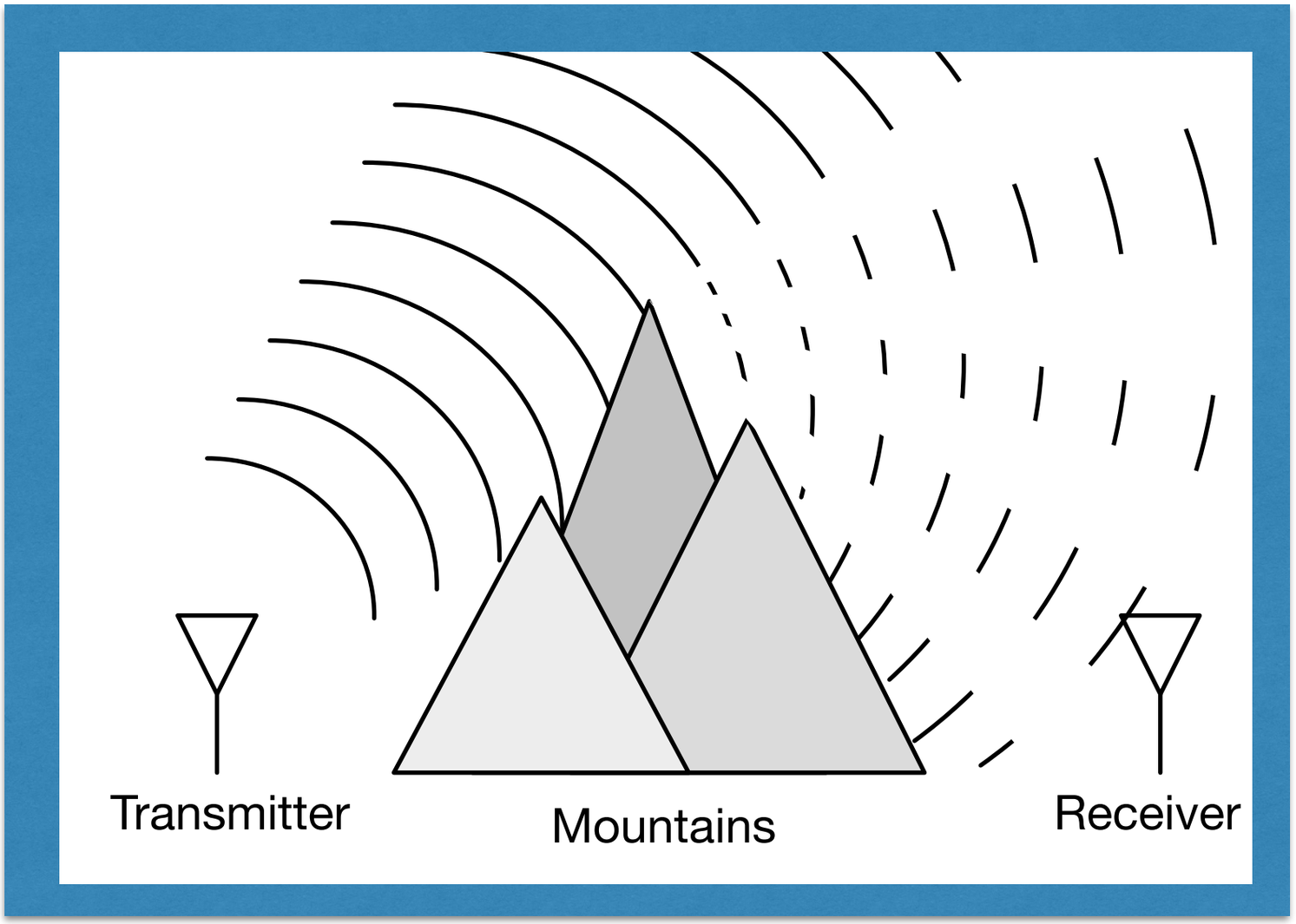
- Temperature and humidity inversions can cause the atmosphere to act as a wave guide

- Frequently in August VHF is ducted from California as far as Hawaii



Knife-Edge Diffraction

- Radio waves will diffract from sharp edges, some power will be delivered behind the obstruction

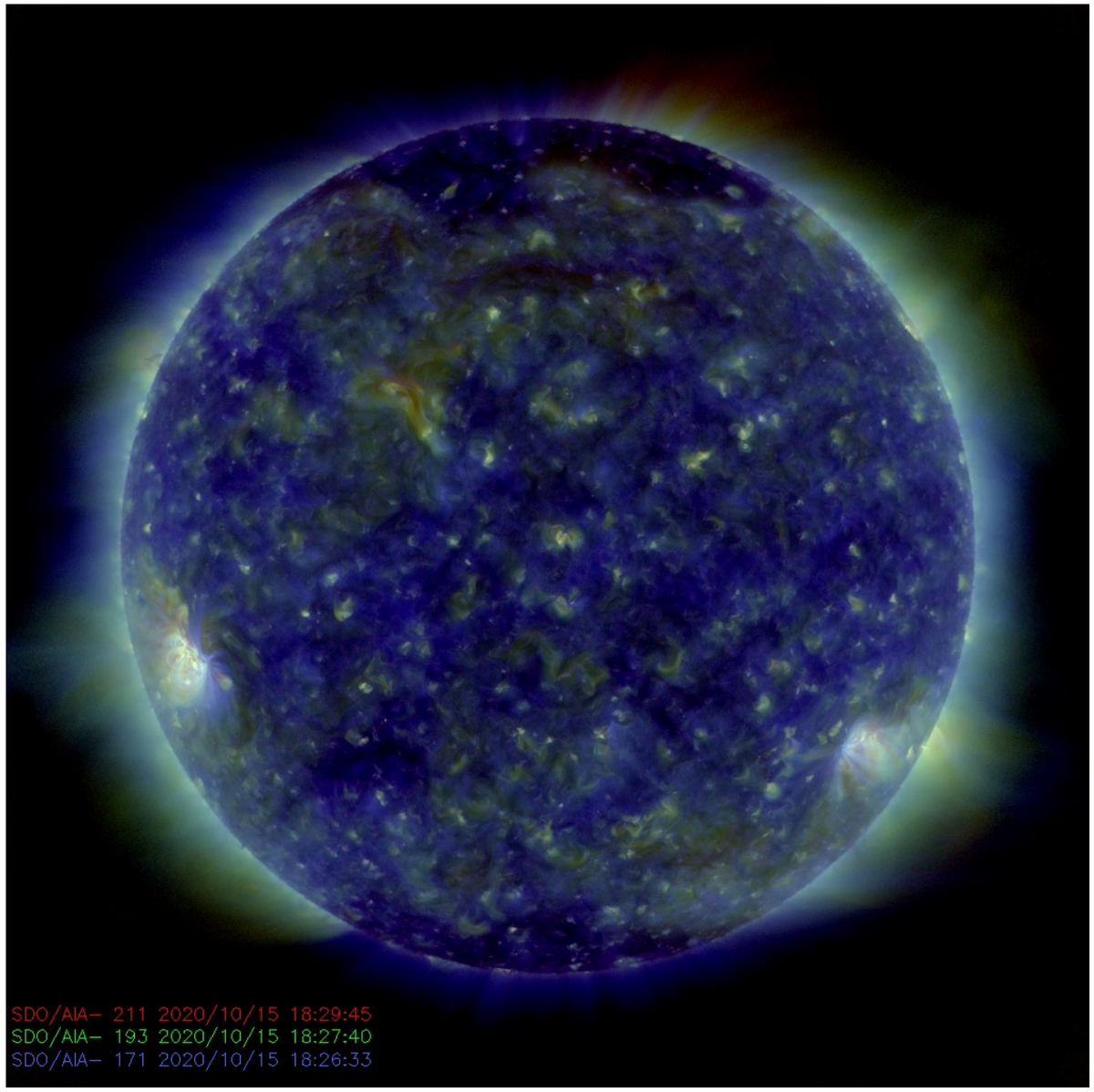


Diffraction Lobes

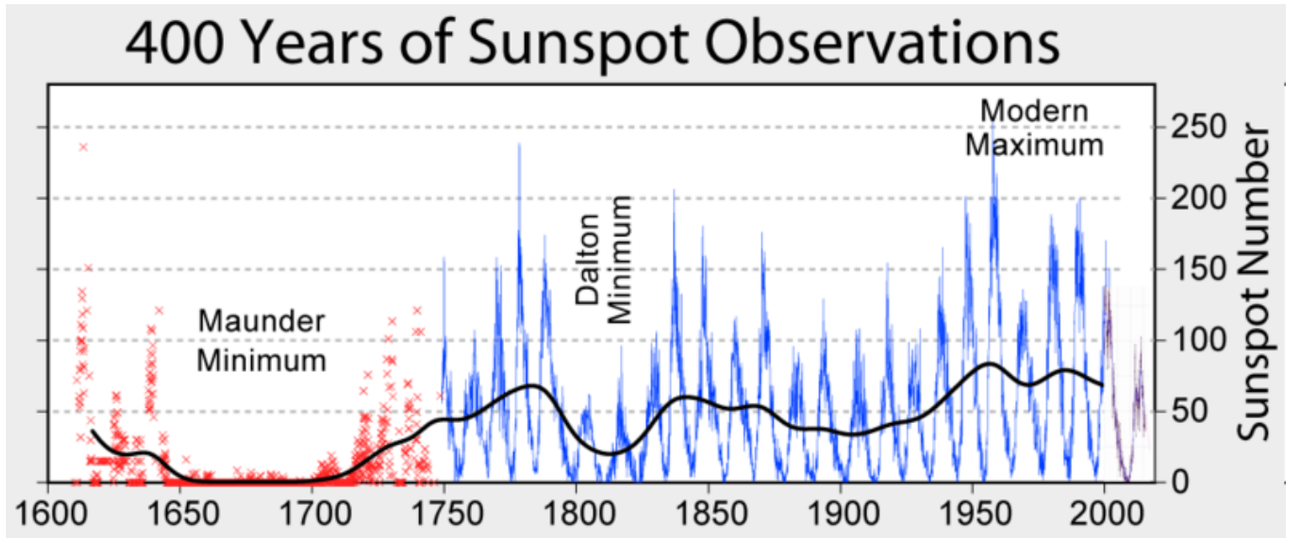
Ionospheric Propagation

- Sun ionizes the upper levels of the atmosphere
- Some layers attenuate, others reflect radio waves
- Varies day to night
- Driven by solar activity, number of sunspots (space weather), which varies periodically over a 11 (or 22) year cycle
- Sun has been extraordinarily inactive this past cycle, we are just starting the next

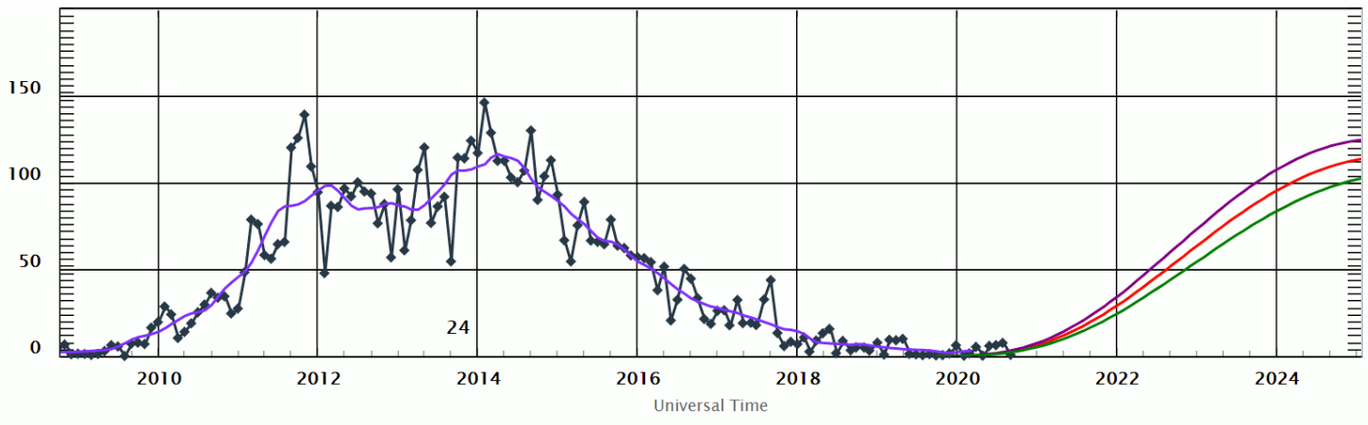
Solar Activity



Recent Solar Activity
DSO, Three Wavelength



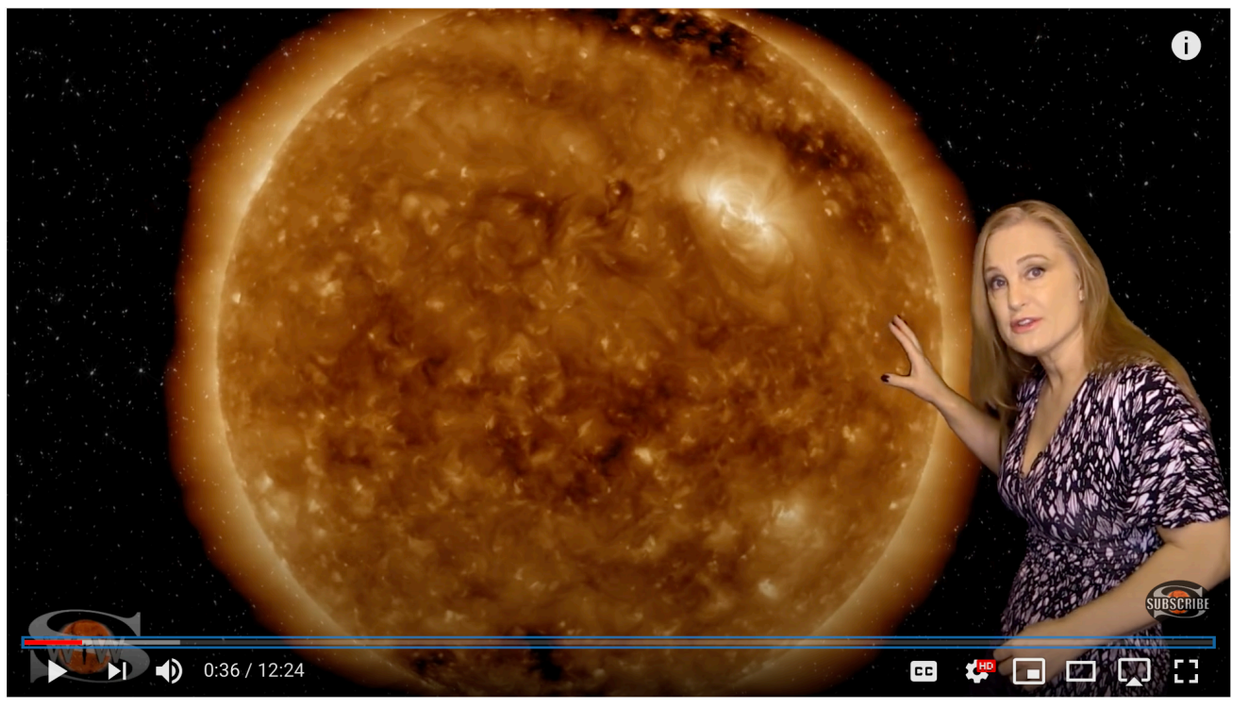
History of Sun Spot Number

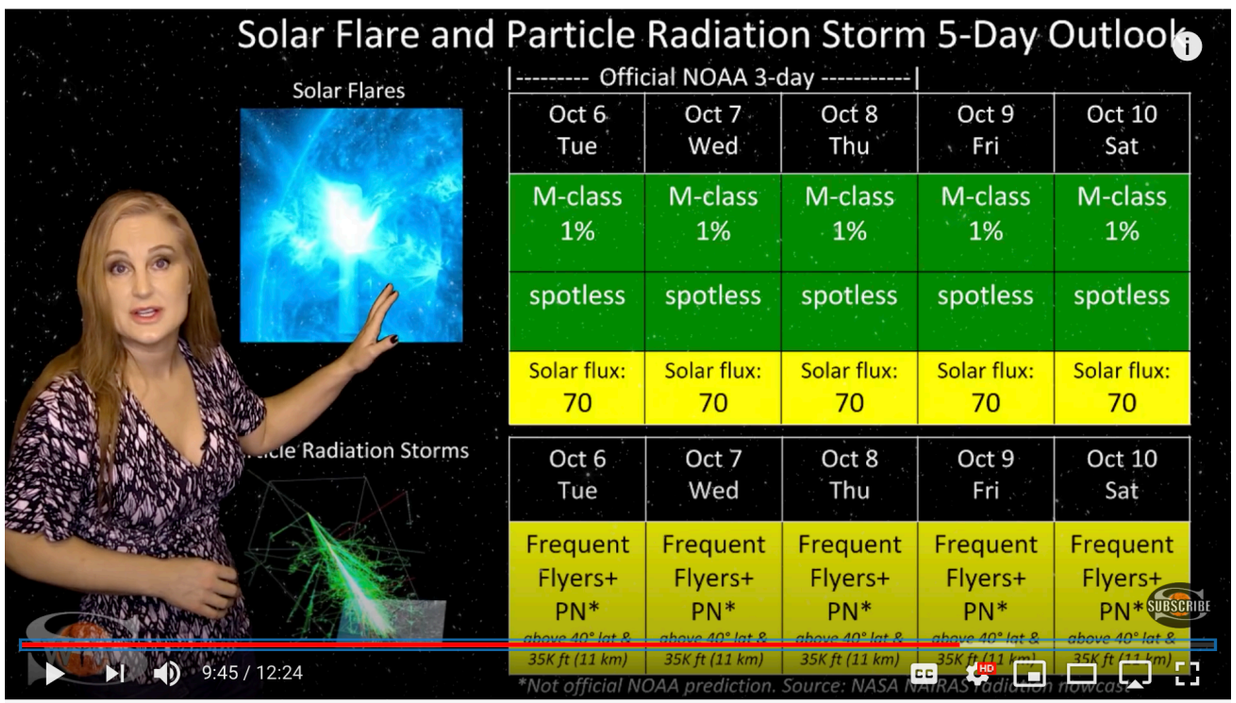


Solar Cycle 24

Solar Weather Report

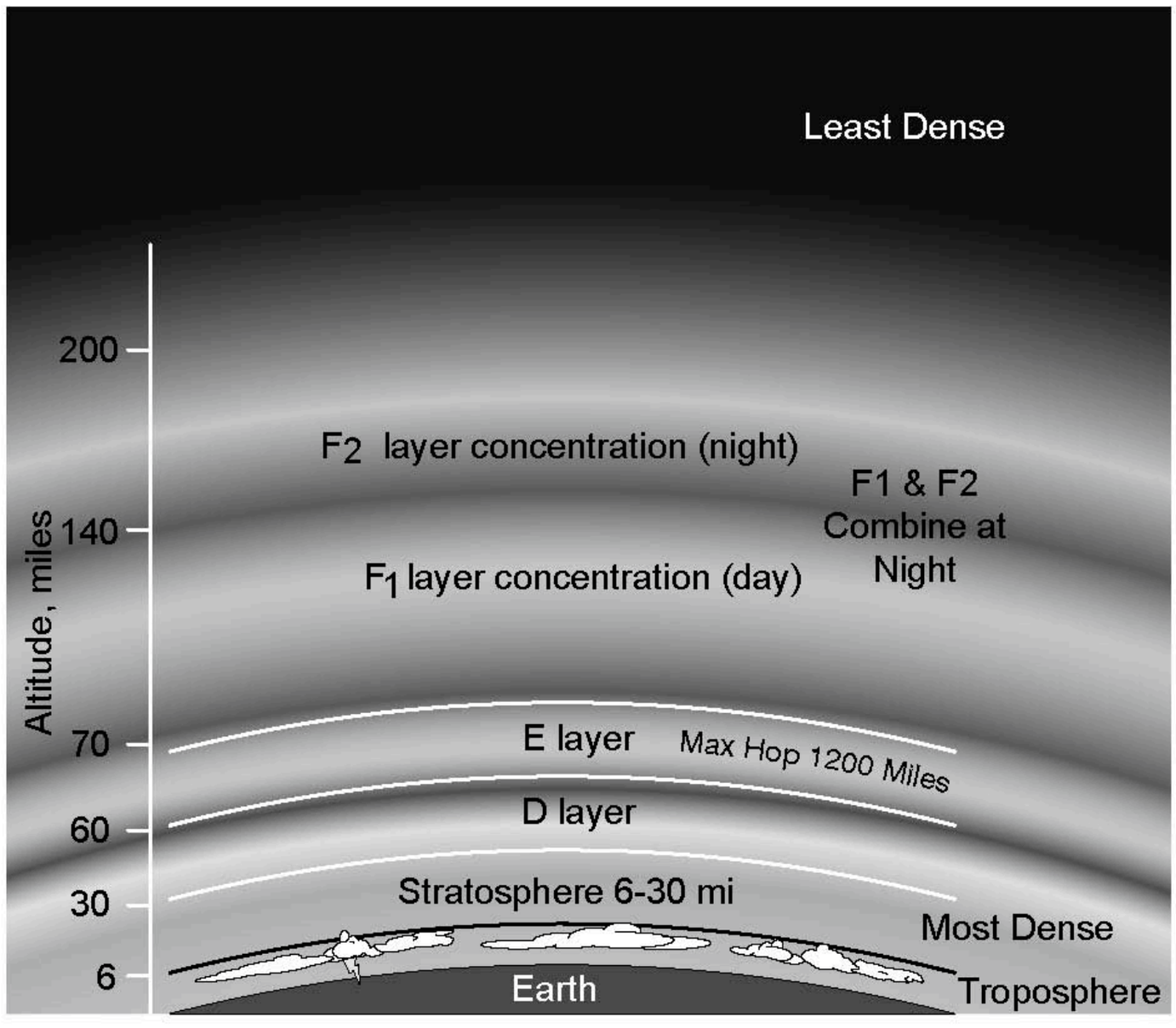
- Tamitha Skov on YouTube
- Updated weekly
- Highly recommended





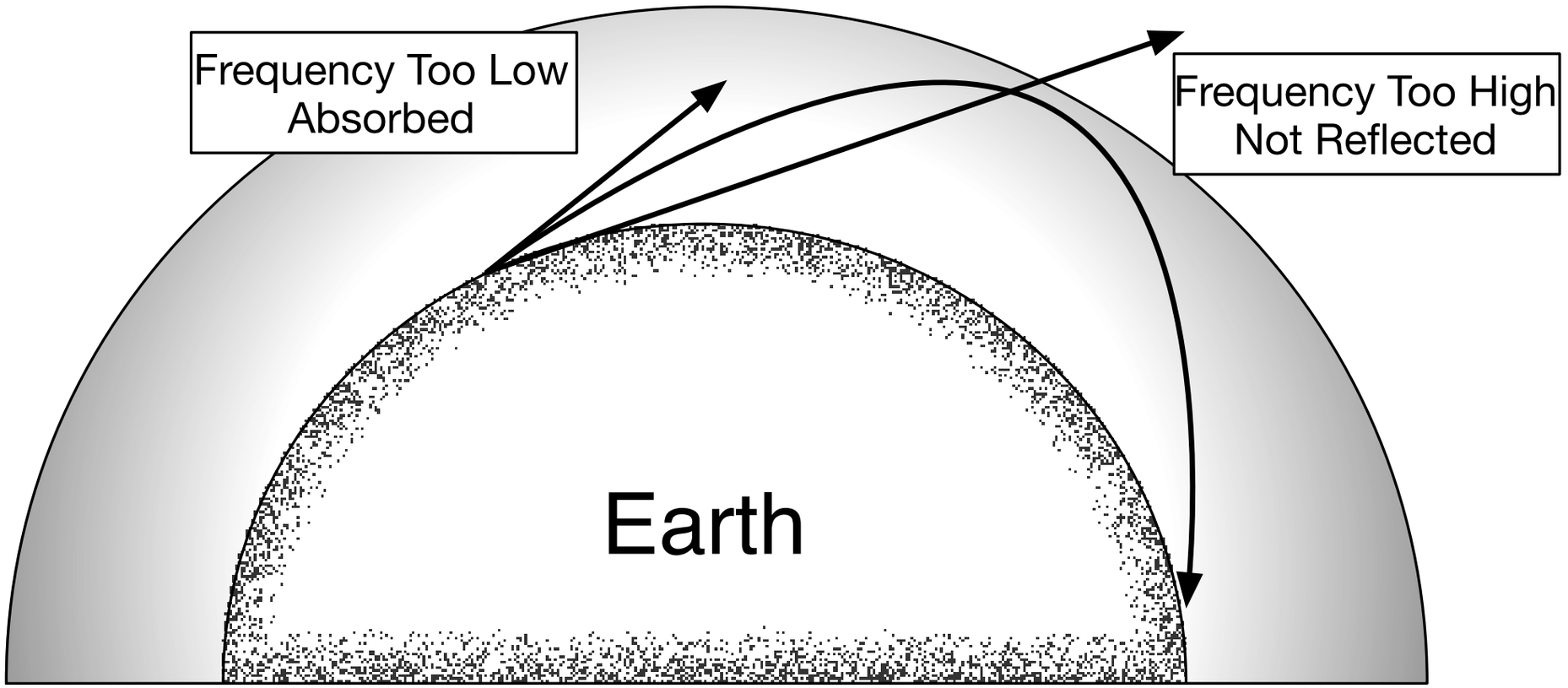
Ionosphere

- Sun ionizes atmosphere during daytime
- Layers dissipate and combine at night
- Some layers reflect (E, F), some layers absorb (D)



Usable Frequencies

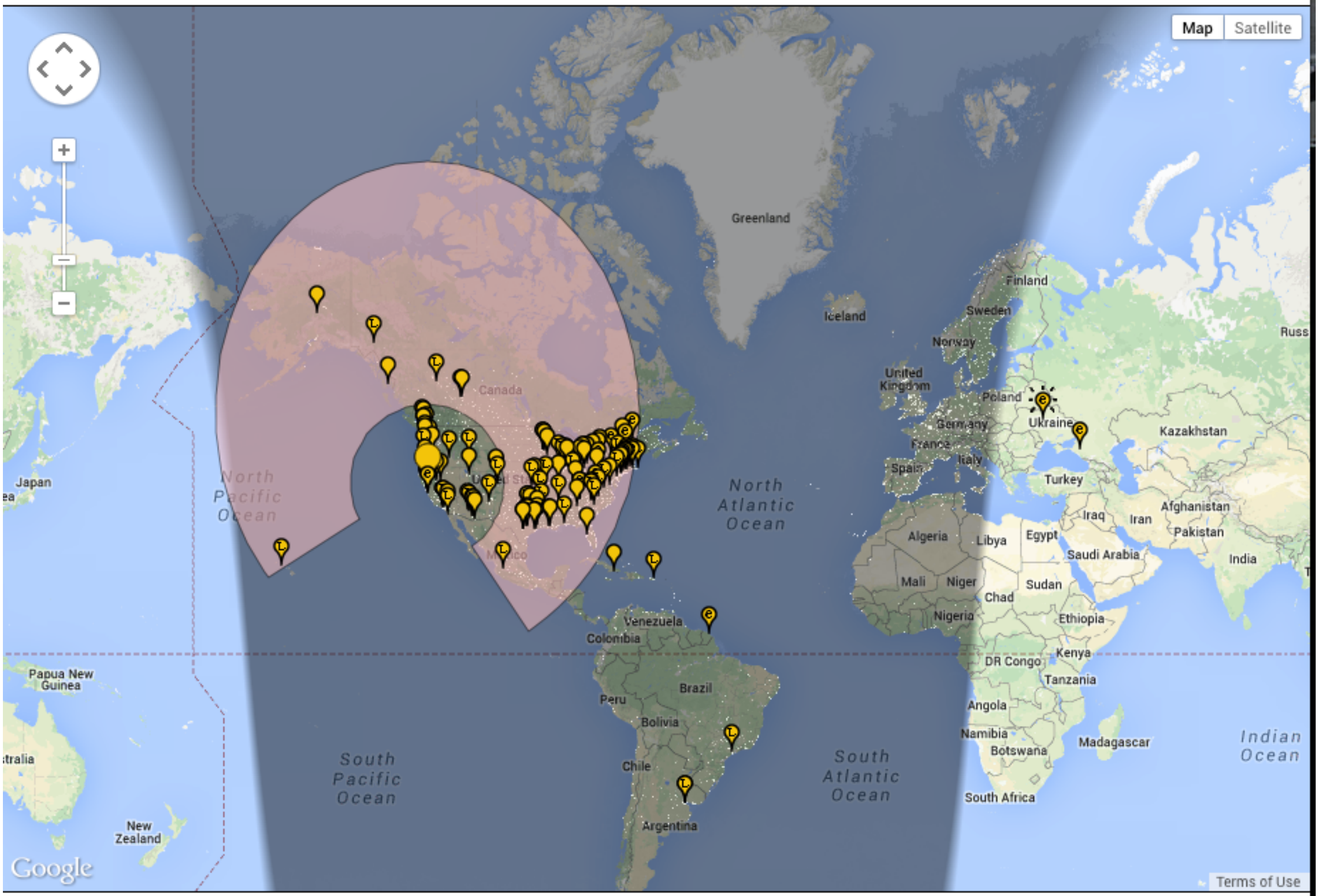
- Lowest usable frequency (LUF): absorption
- Maximum usable frequency (MUF): no reflection
- Web sites calculate these for you for any day or time



On 20m , show signals rcvd by the callsign ag6wh using all modes over the last 6 hours Go! Display options Permalink

Automatic refresh in 3 minutes. Small markers are the 124 transmitters (show logbook) heard (distance chart) at AG6WH (292 reports, 22 countries last 24 hours; 629 reports, 28 countries last week).

There are 251 active monitors on 20m. Show all on all bands. Legend



System statistics. Comments, problems etc to Philip Gladstone. Online discussion of problems/issues. Last modified: August 11, 2014 at 7:21:28 PM PDT

Reception records: 531,278,187 g+1 301

PSKREPORTER.INFO

10 m, 28 MHz : Day

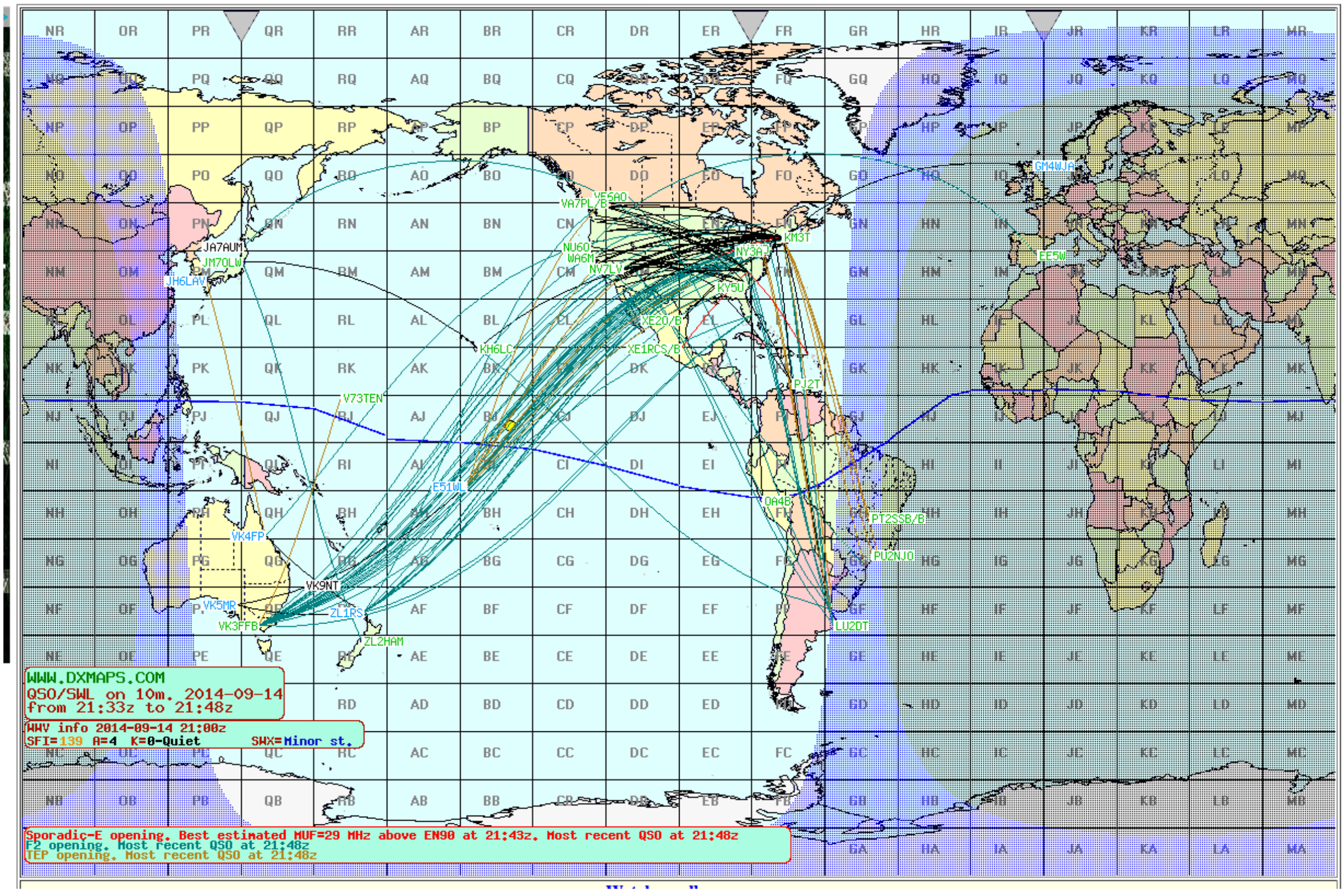
DXMAPS 2.6 - QSO/SWL real time maps

Europe | Africa | North America | South America | Asia | Oceania | **World**

2200 m | 600 m | 160 m | 80 m | 60 m | 40 m | 30 m | 20 m | 17 m | 15 m | 12 m | **10 m** | All bands

☑ Grey line

☐ Only DX-Cluster



20 m, 14 MHz : Grayline

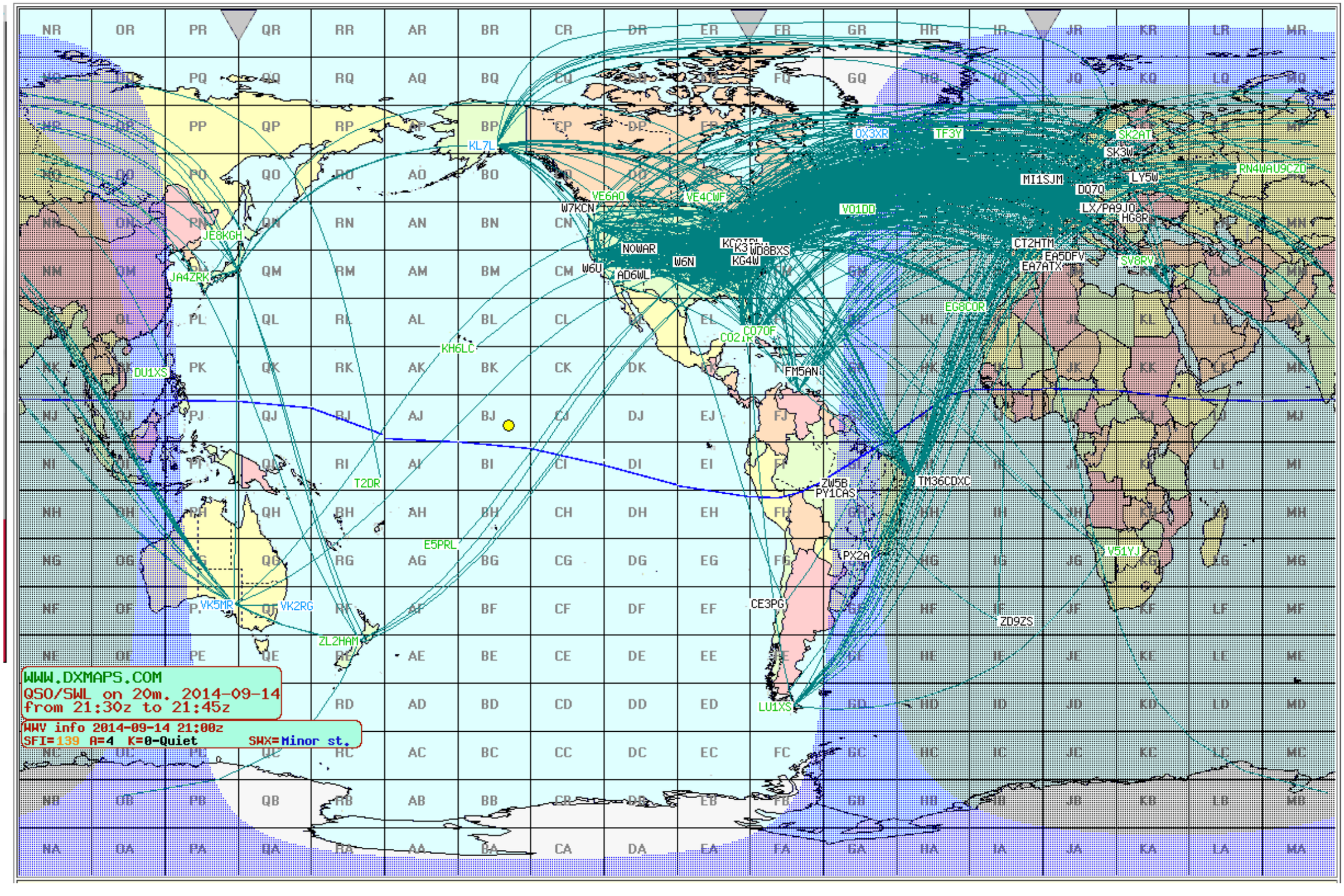
DXMAPS 2.6 - QSO/SWL real time maps

Europe | Africa | North America | South America | Asia | Oceania | **World**

2200 m | 600 m | 160 m | 80 m | 60 m | 40 m | 30 m | **20 m** | 17 m | 15 m | 12 m | 10 m | All bands

☑ **Grey line**

☐ Only DX-Cluster



40 m, 7 MHz : Night

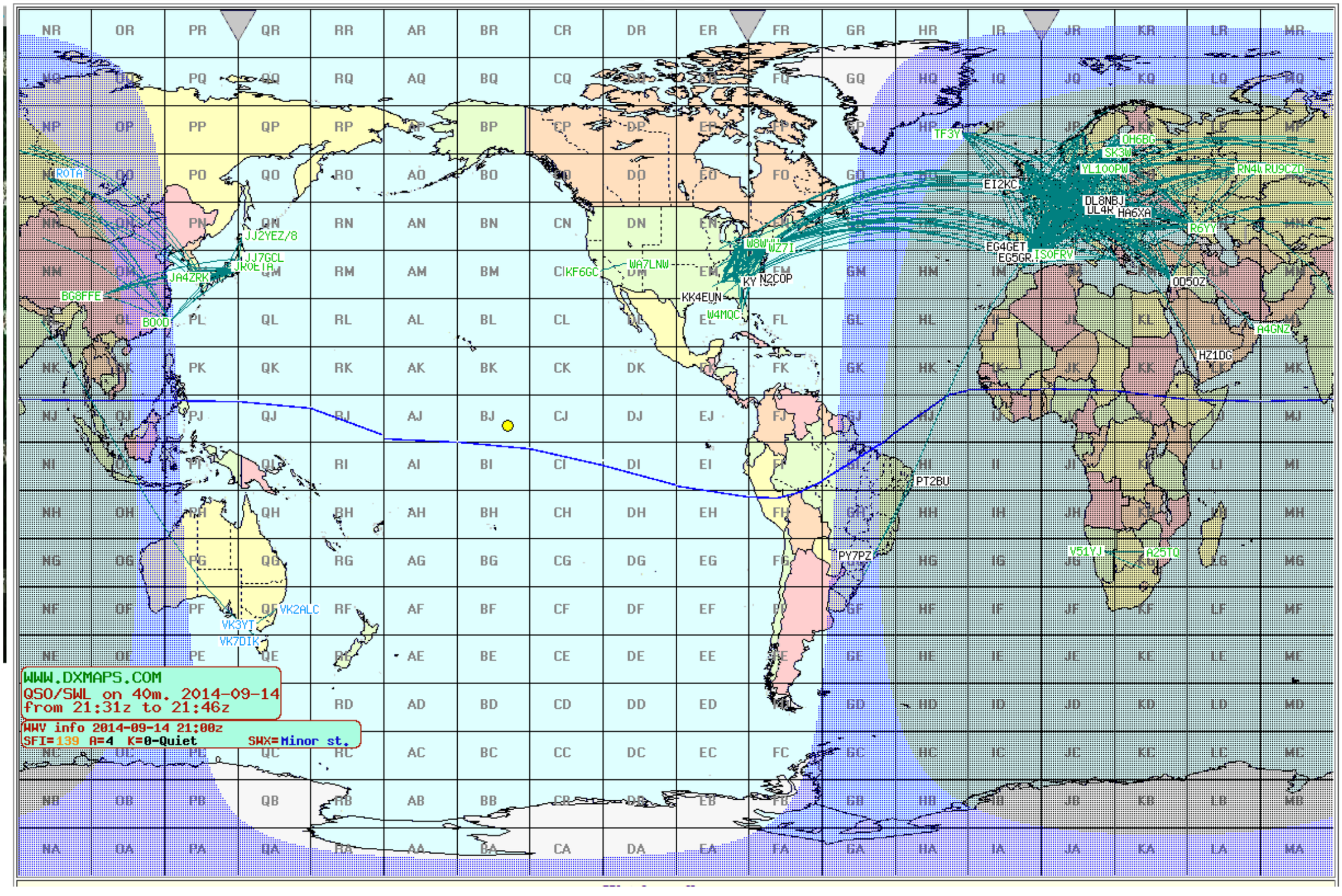
DXMAPS 2.6 - QSO/SWL real time maps

Europe | Africa | North America | South America | Asia | Oceania | **World**

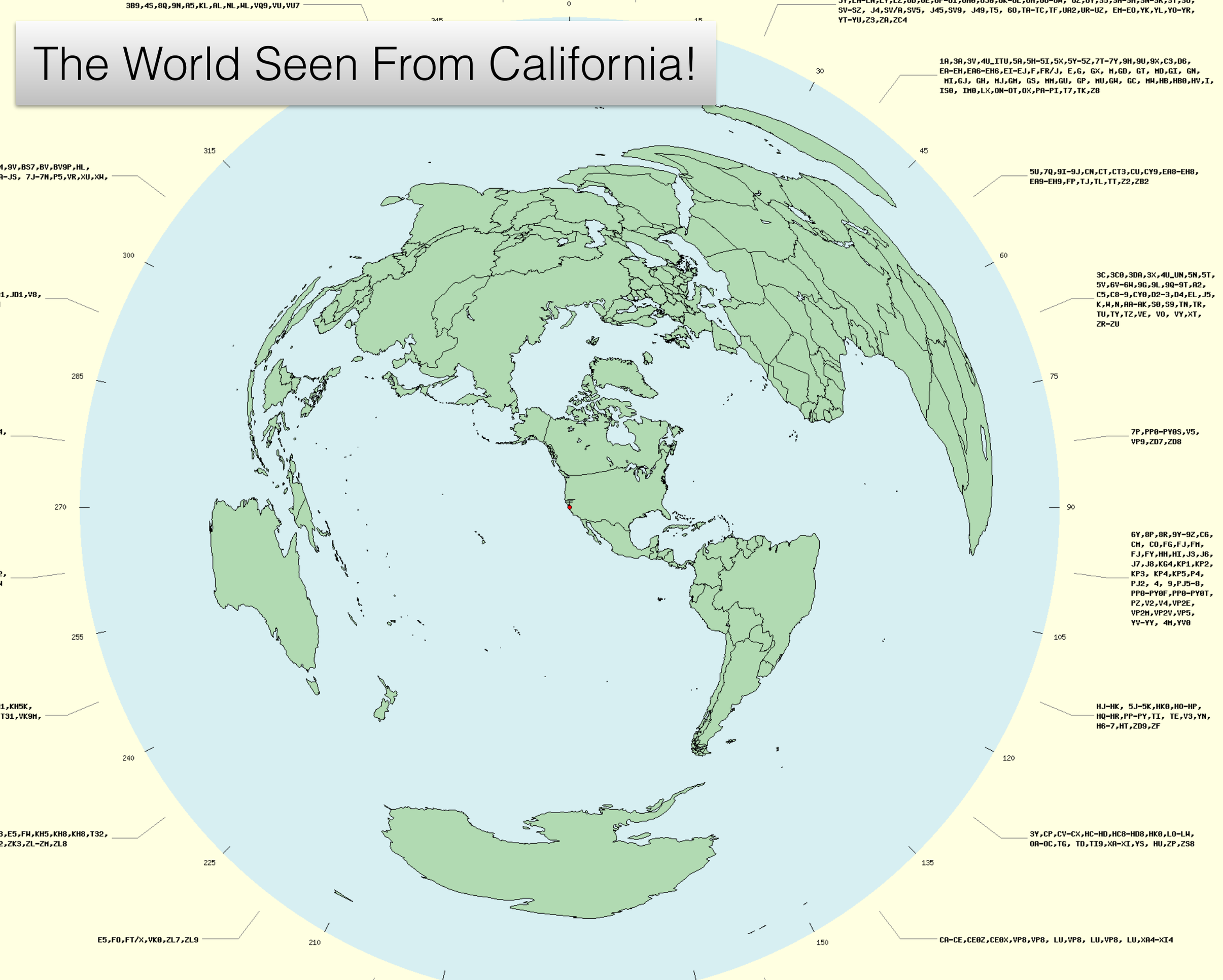
2200 m | 600 m | 160 m | 80 m | 60 m | **40 m** | 30 m | 20 m | 17 m | 15 m | 12 m | 10 m | All bands

☑ **Grey line**

☐ Only DX-Cluster



The World Seen From California!



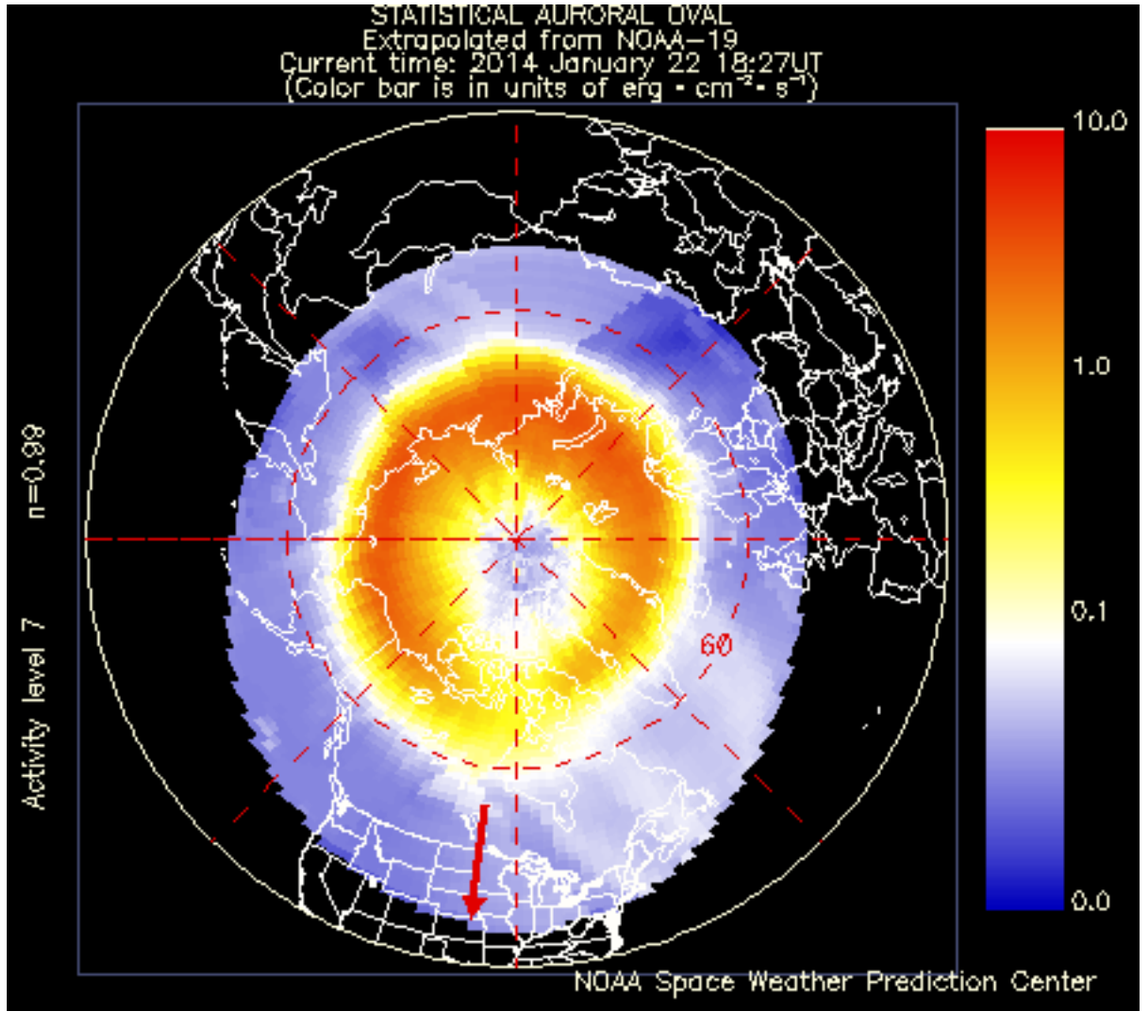
Other Radio Reflectors

- Meteor trails
- Aurora
- Satellites
- Moon

Aurora

- Aurora is due to charged particles from the sun following the earth's magnetic field lines

- These reflect radio waves over thousands of miles



Antennas

Antenna

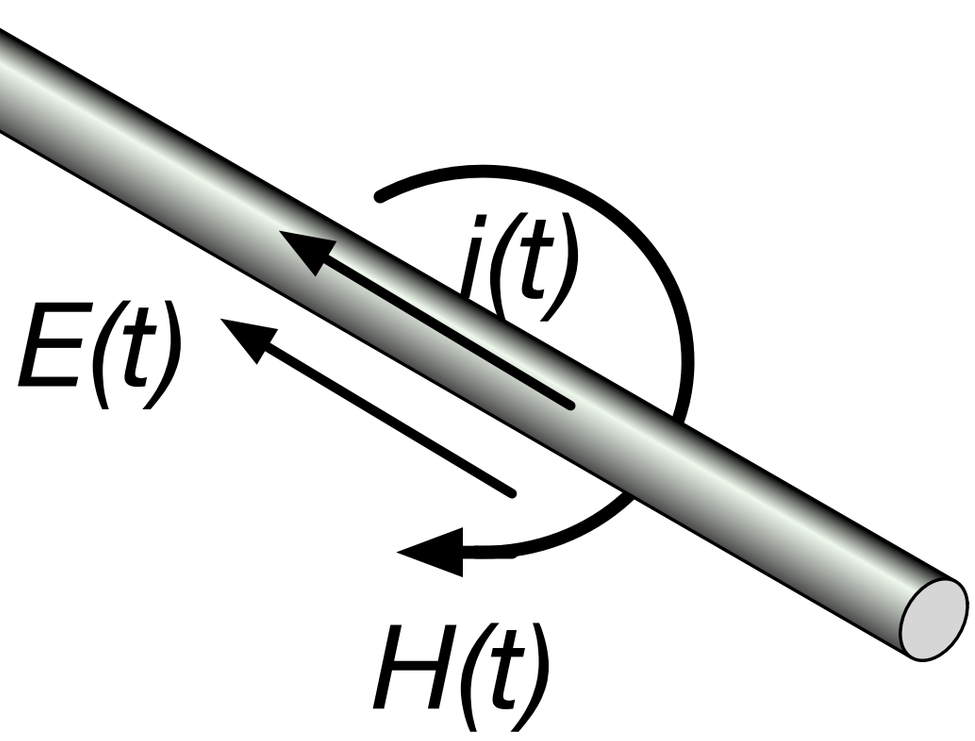
- Couples amplifier to propagating waves
- Currents on the antenna elements produce electric and magnetic fields in space
- Antenna dimensions matched to dimensions of the electromagnetic wave you want to generate

Types of Antennas

- Omni-directional: no direction preference
- Directional beam: Focuses energy in one direction
- Gain: How much the signal is enhanced in one direction, compared to a reference antenna. Measured in dB, i.e. 10 $\log_{10}(P/P_r)$
  - dBi : compared to an ideal isotropic antenna
  - dBd : compared to a dipole antenna

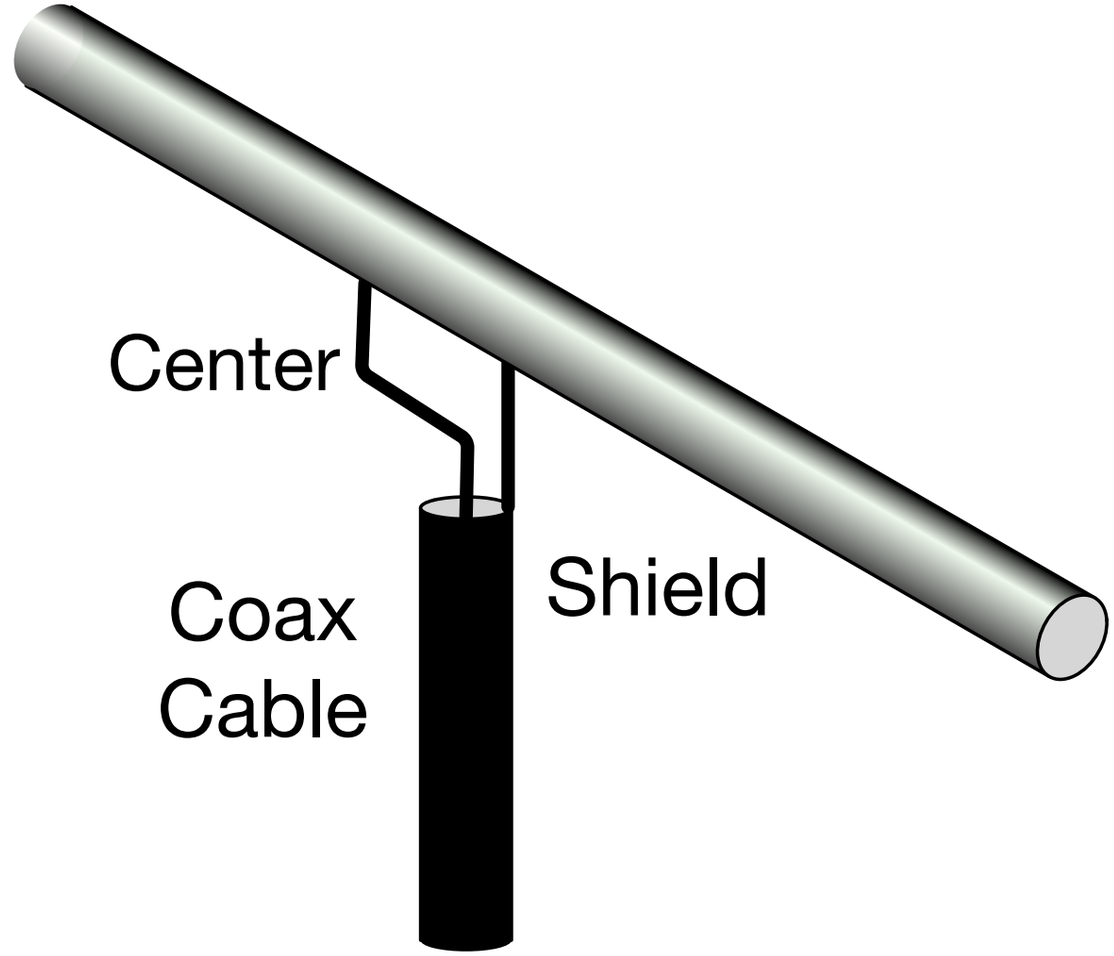
Current in a Conductor

- Current flows along conductor
- Electric fields parallel
- Magnetic fields perpendicular



Dipole Antenna

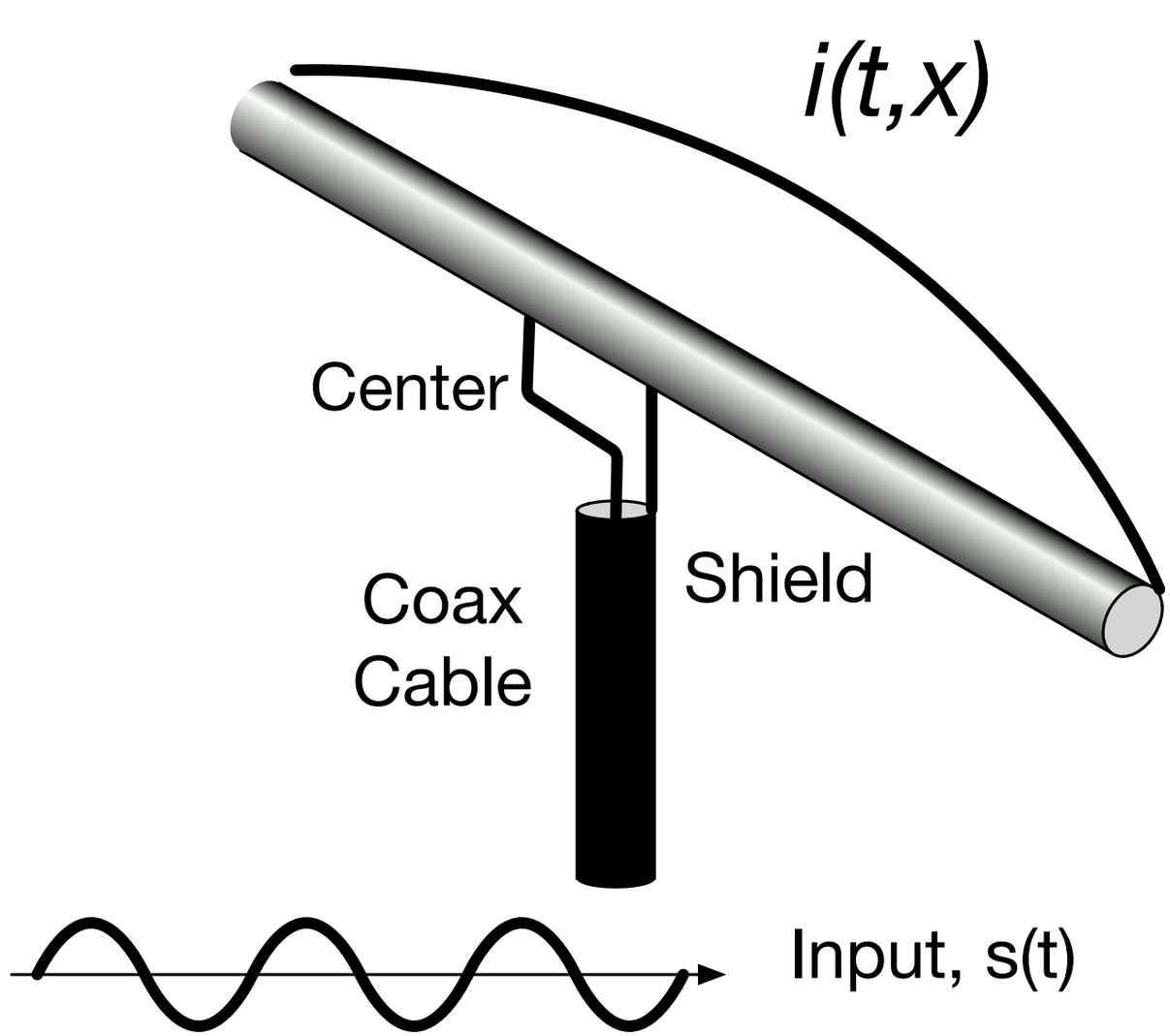
- Drive the antenna at center, offset
- Sets the input impedance



Dipole Antenna

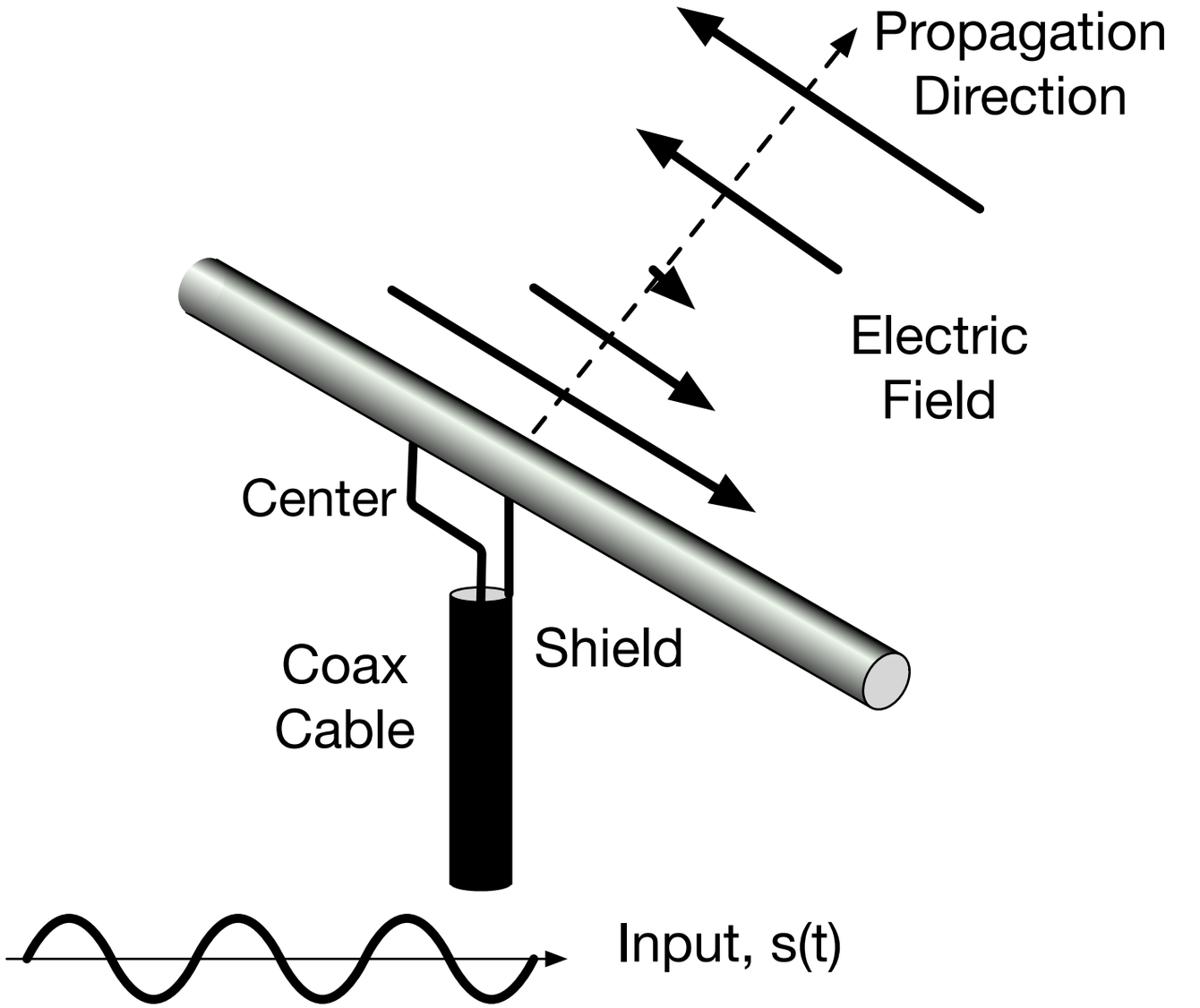
- Sinusoidal input sets up half cycle of current along antenna

- Length should be 1/2 wavelength for the frequency



Dipole Antenna

- Oscillating electric field propagates away from antenna



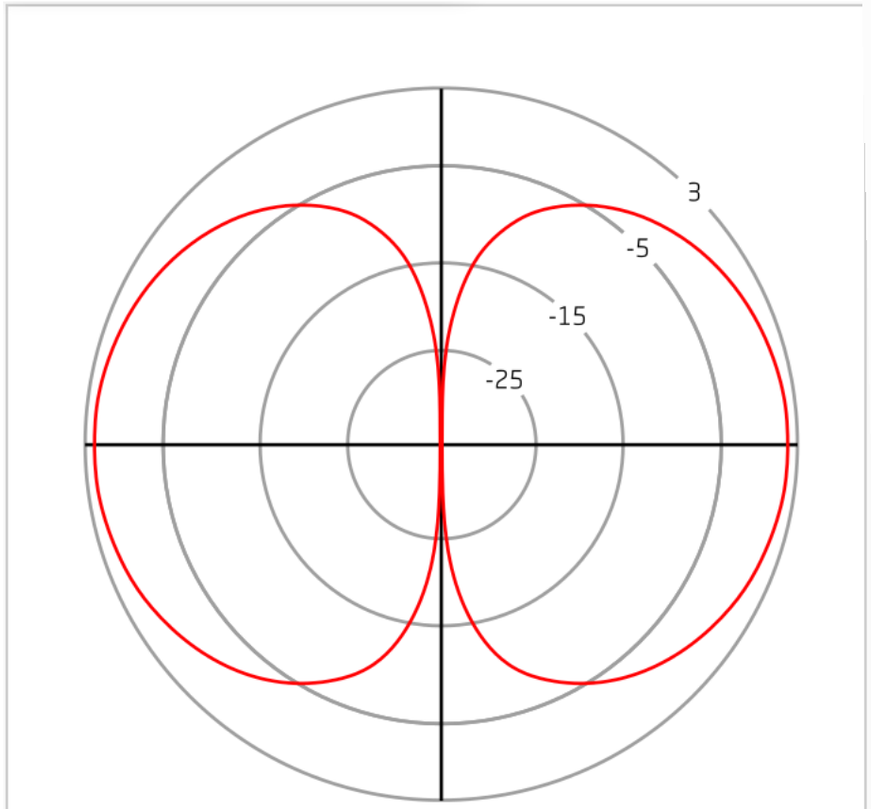
Dipole Antenna

- Length is 1/2 wavelength of the transmit carrier frequency

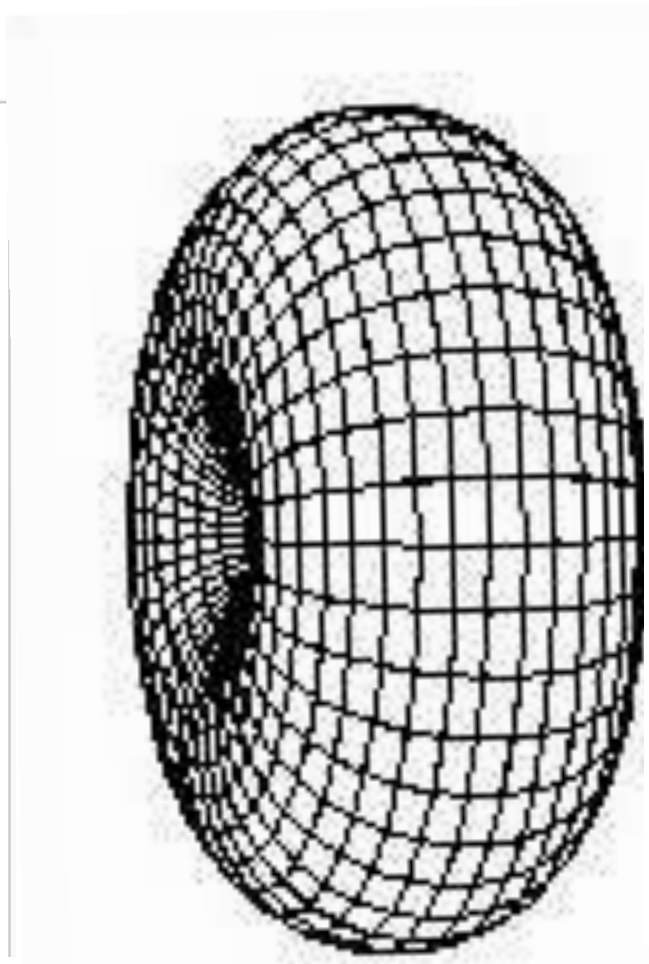
- For 150 MHz one wavelength is 2 m, and the antenna should be 1 m long

- For 450 MHz, one wavelength is 67 cm, and the antenna should be 33 cm long

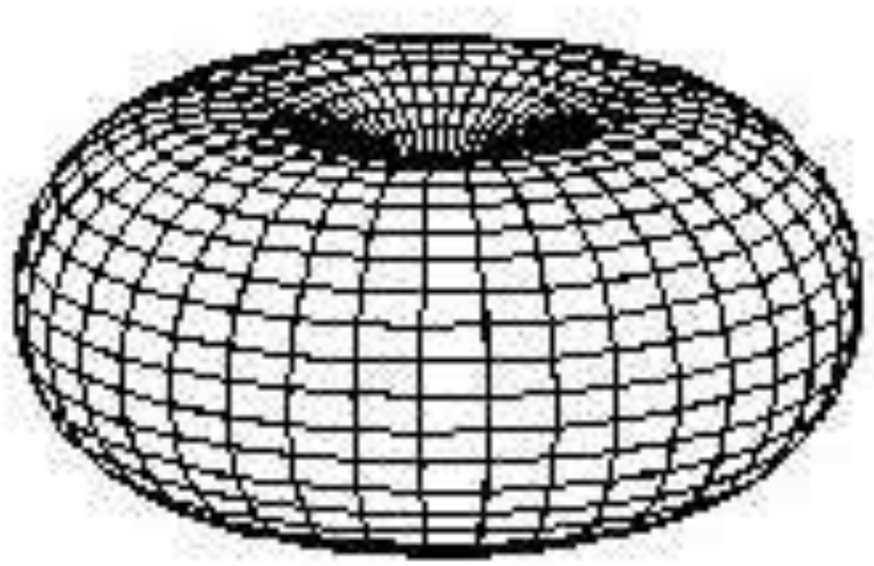
Dipole Radiation Pattern



Horizontal



Horizontal



Vertical

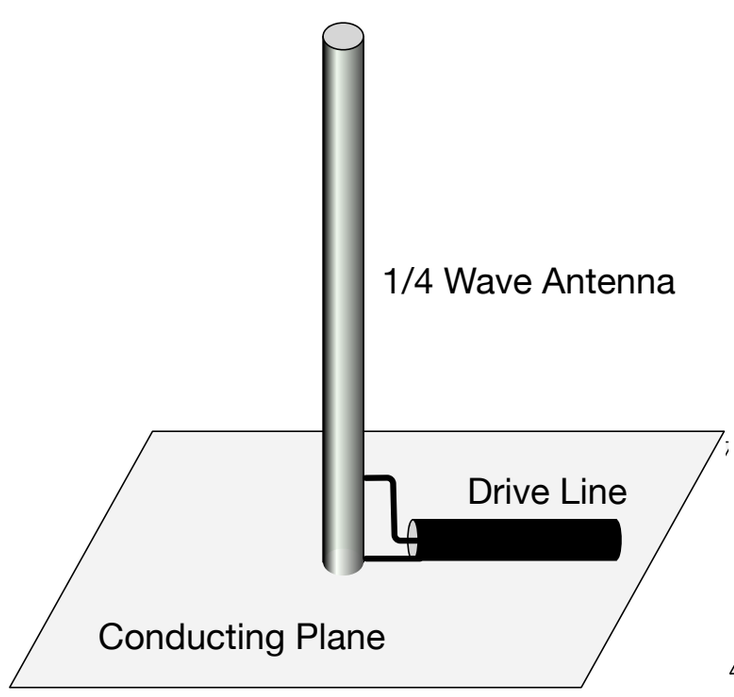
Polarization

- Polarization is the direction of the electric field (horizontal, vertical, circular)
- A horizontal dipole has a horizontal polarization
- A vertical dipole has a vertical polarization
- If the transmitting and receiving antennas have different polarizations, there can be a very large signal loss

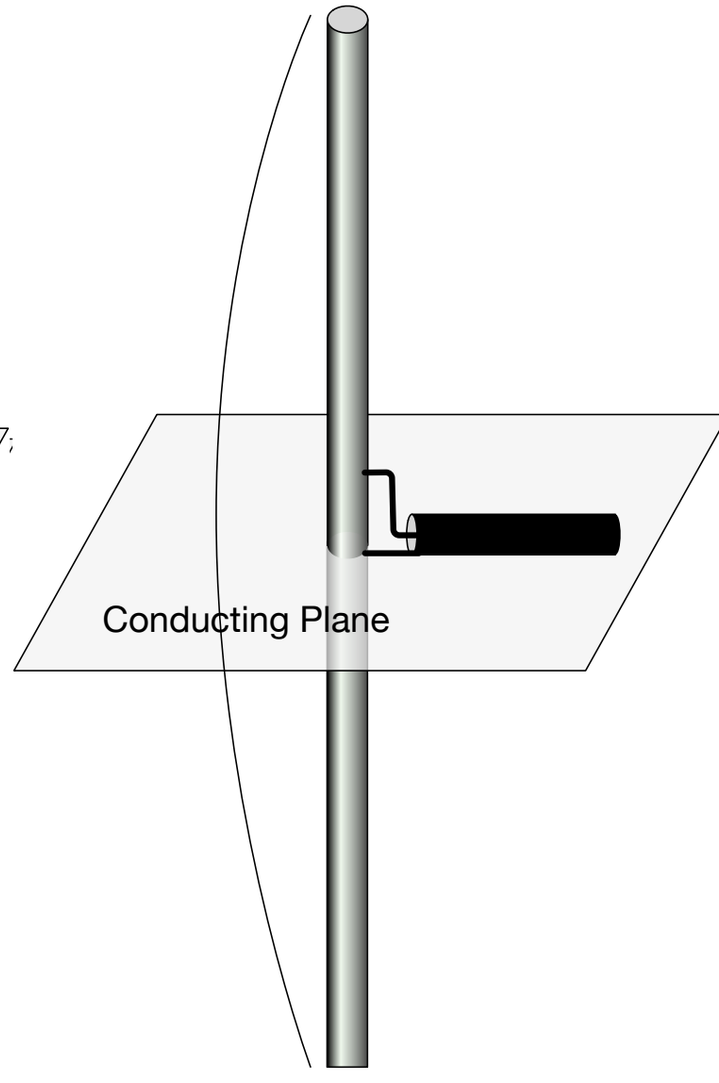
1/4 Wave Vertical Antennas

- Conducting surfaces (the earth, your car roof) act as current mirrors

- You get the second half of the antenna for free!

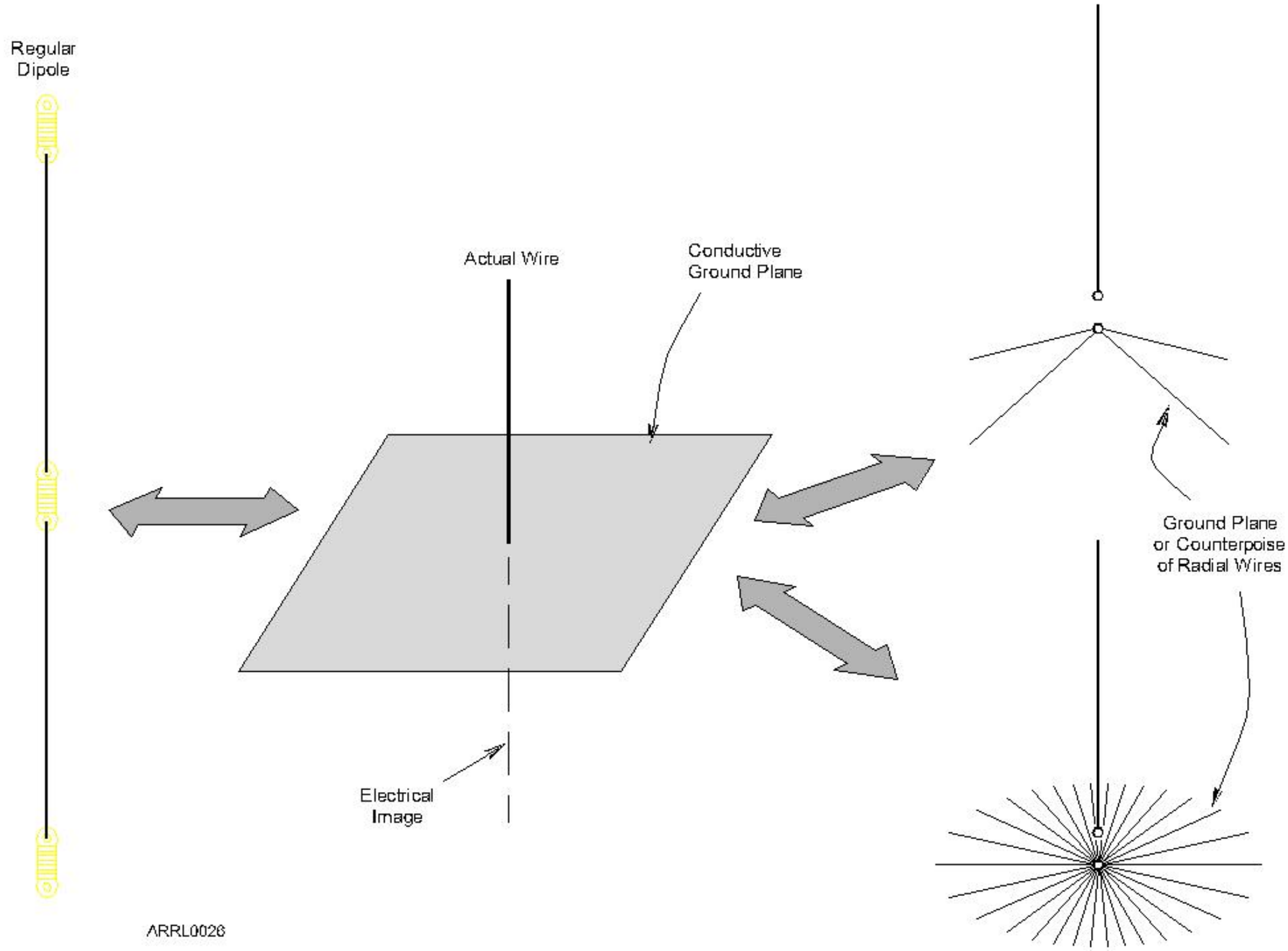


Antenna above Conducting Plane

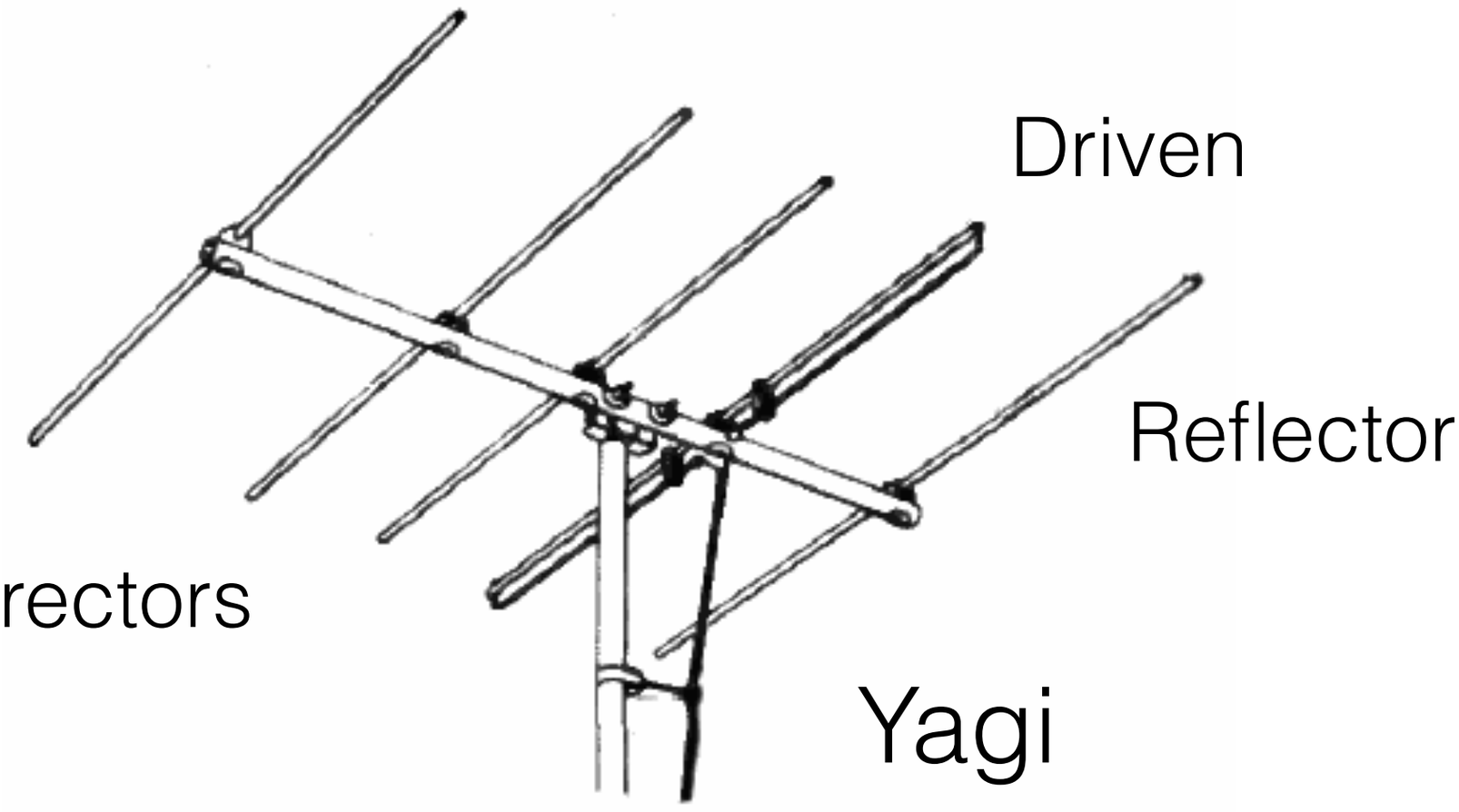


Effective Antenna

1/4 Wave Antennas

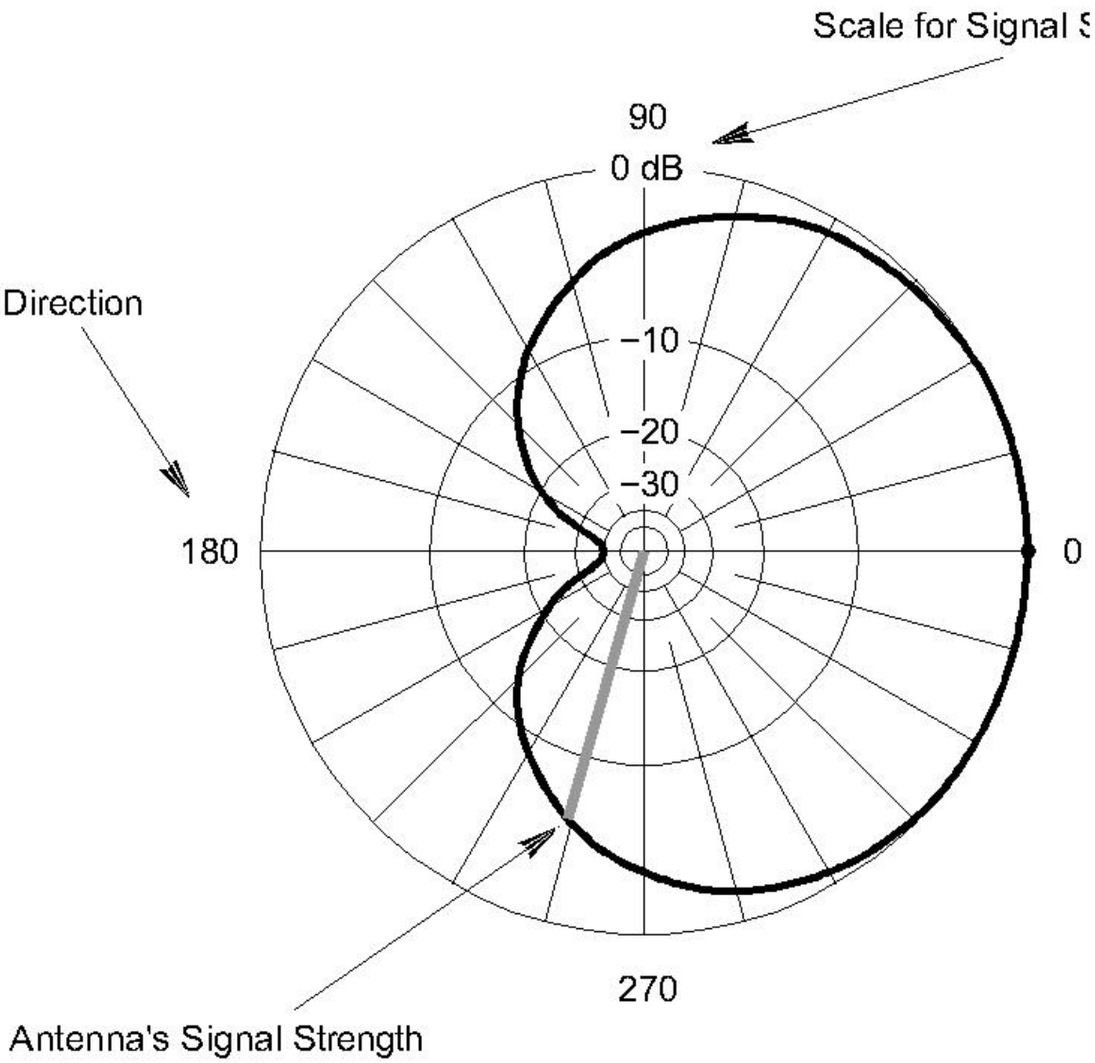


Beam Antennas



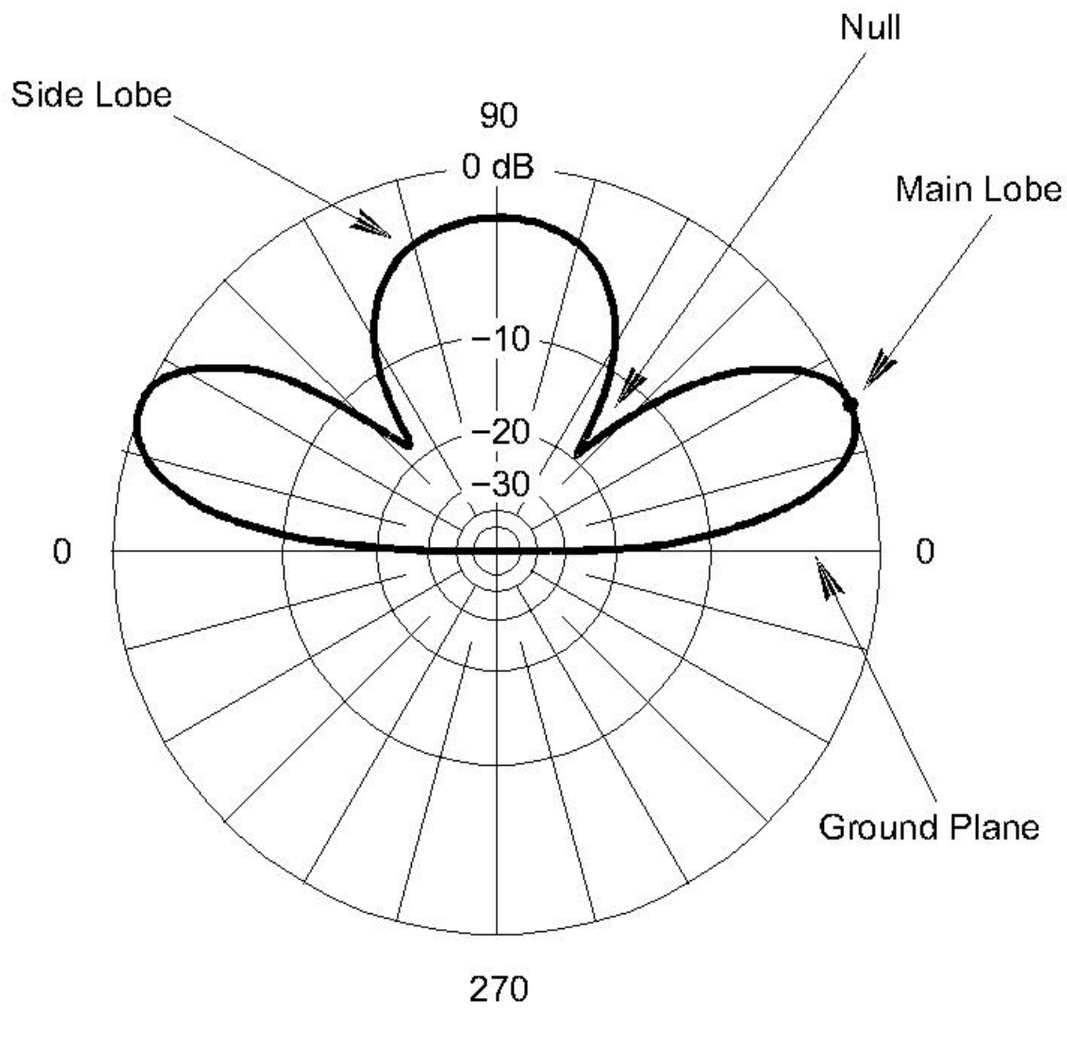
- Generally one driven element
- Directors to focus energy forward
- Reflectors to cancel out pattern to the rear

Radiation Patterns



Azimuthal Pattern

A



Elevation Pattern

ARRL0018

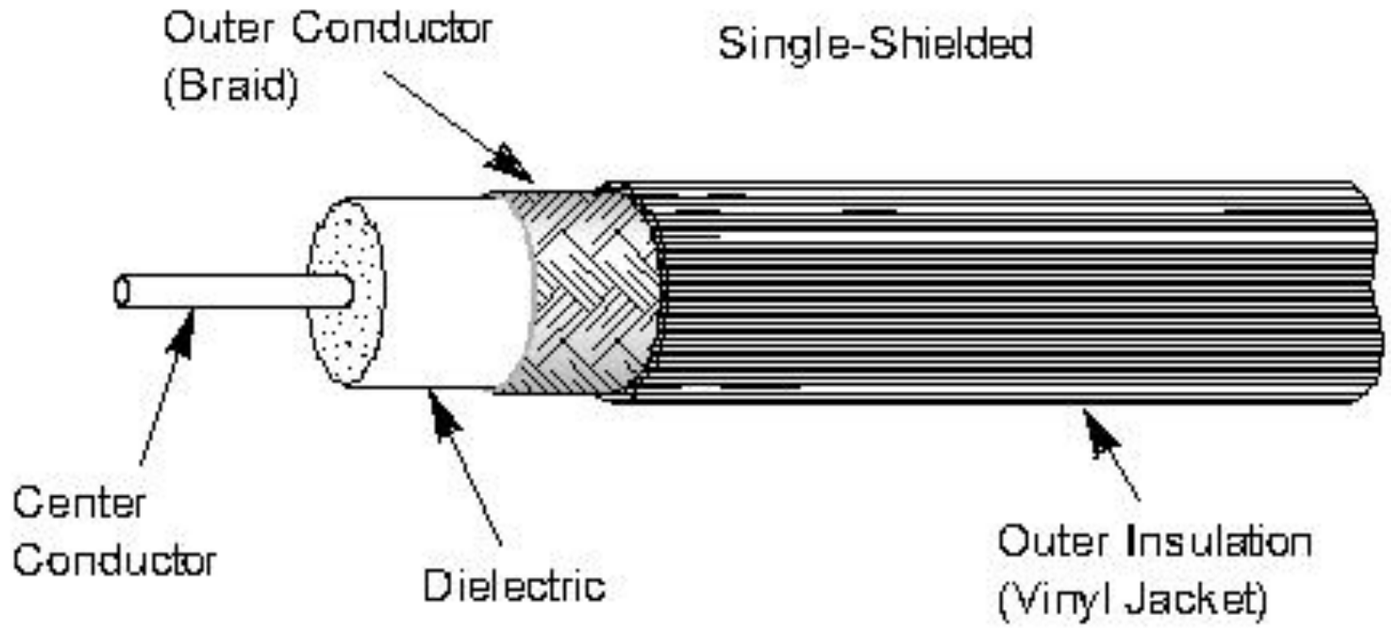
Feed Lines

- Balun
- Duplexer
- Antenna switch
- SWR meter
- Antenna analyzer
- Antenna tuner

Types of Coax

- RG-58 : most common
- RG-8 : low loss, large
- RG-8x : between RG-58 and RG-8 in size and loss
- RG-213 : low loss, large
- RG-174: micro coax, high loss
- Hardline : very low loss

Coax



- Most common feed lines
- Commonly 50 Ohm impedance (there are others)
- Loss depends on frequency (in dB/100 ft)

Coax Cable Loss

Type	Impedance	Loss @ 30 MHz (dB/100ft)	Loss @150 MHz (dB/100ft)
RG-8	50	1.1	2.5
RG-58	50	2.5	5.6
RG-174	50	4.6	10.3
RG-213	50	1.1	2.5

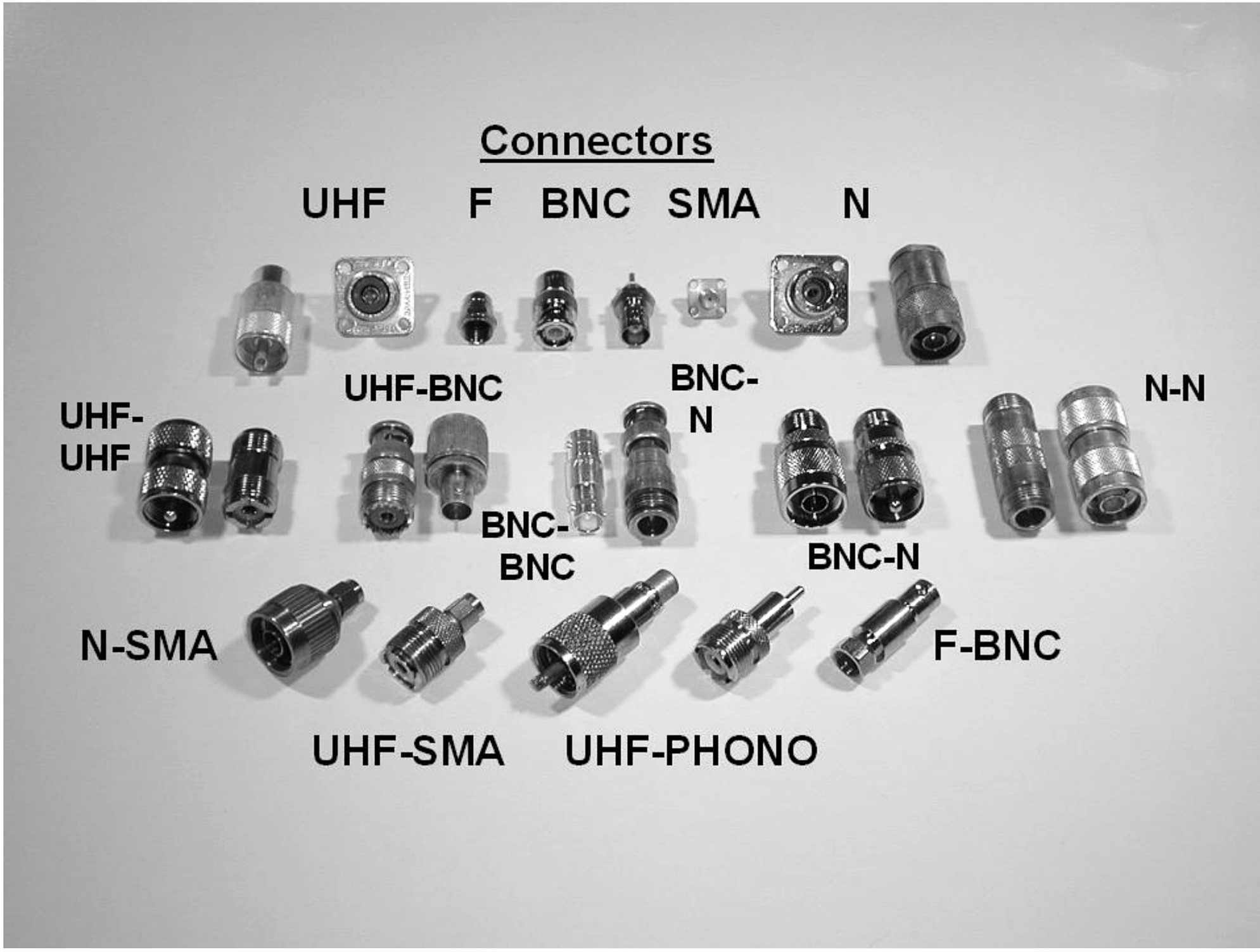
Connectors

- SO-259, UHF
  Common for HF
  Up to 450 MHz

- N
  Common
  above 400 MHz

- BNC
  up to GHz

- SMA
  GHz and above



Connectors

UHF
HF, low VHF

BNC
up to 1 GHz

BNC
1 GHz and up

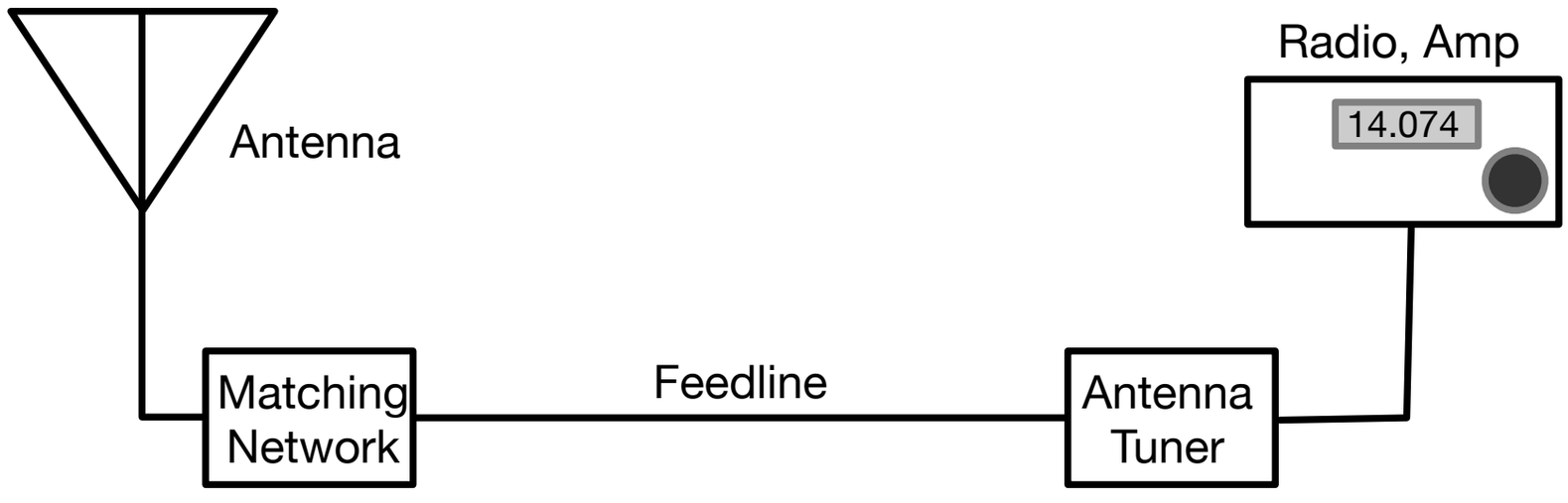
Connection to the Antenna

- Ideally, all the power from the feed line ends up in the antenna
- The feed line impedance and the antenna input impedance should be matched
- If the impedances are mismatched, some of the power is reflected back to the amplifier
  - Reduces transmit power
  - Increases line losses
  - Reduces amplifier output, can damage the amplifier

Standing Wave Ratio (SWR)

- Ratio of total to forward power
- Always in the for X:1, where X is greater than 1
- Perfect SWR is 1:1
- Semiconductor amps begin have trouble at SWR of 2:1

Antenna Matching



- Matching Network : part of the antenna
  - Makes sure the antenna can accept the power from the feed line
- Antenna Tuner : adjustable matching network
  - Doesn’t really tune the antenna
  - Makes the amplifier happy
  - You can still have a large standing wave on the feedline

Antenna Tuners

Measuring Antenna Matching

- Antenna Analyzer : measures the antenna input impedance, frequency response
- SWR Meter : measures SWR, forward and reflected power

Questions?