

PANHANDLE AMATEUR RADIO CLUB · TECHNICAL TRAINING

Radio Wave Propagation

How your signal travels — and how to work the bands when conditions change

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What we'll cover



The basics

1

Ground wave, sky wave & line of sight



The ionosphere

2

D, E and F layers — our mirror in the sky



The Sun's role

3

Sunspots, solar flux & the 11-year cycle



Disturbances

4

Flares, geomagnetic storms, A & K index



Band by band

5

Where each HF band shines, day vs night



Putting it to use

6

Tools, gray line & practical operating

Three ways a signal travels



Ground wave

Hugs the Earth's surface, following its curve. Strong on the low bands (160 / 80 m) and the backbone of local AM. Range: tens of km, more at lower frequencies.



Sky wave

Refracted back to Earth by the ionosphere. The workhorse of HF DX — a single skip can span thousands of km, and multiple hops can circle the globe.



Line of sight

Direct path, like light. Dominates VHF / UHF (2 m, 70 cm). Range is set by antenna height and the horizon — hence “height is might.”

The ionosphere

Sunlight ionizes the upper atmosphere into layers that bend HF signals back to Earth. Their height and density change constantly — that's why the bands “open” and “close.”



Remember: the D layer is the enemy of daytime low-band work; the F2 layer is the friend of HF DX.

F2

250–400 km

Highest & most important. Carries long-haul HF DX day and night.

F1

150–250 km

Daytime only; merges with F2 after dark.

E

90–150 km

Daytime; supports shorter HF hops. Sporadic-E opens VHF.

D

60–90 km

Daytime absorber — soaks up low-band signals, then vanishes at night.

Day versus night



Daytime

- D layer present — absorbs 160 / 80 / 40 m, killing low-band DX
- E and F1 active; F2 strongly ionized
- Higher bands (20 / 17 / 15 / 10 m) open up for DX
- Higher MUF — the upper bands carry the traffic



Nighttime

- D layer vanishes — the low bands come alive
- 160 / 80 / 40 m become the DX bands
- F layers thin and lower; the MUF drops
- Upper bands (15 / 10 m) usually close after dark

MUF, LUF & the skip zone

MUF

Highest frequency the ionosphere will reflect on a given path. Work just below it for the best DX.

LUF

Below this, D-layer absorption swallows the signal. Your window sits between LUF and MUF.

Skip zone

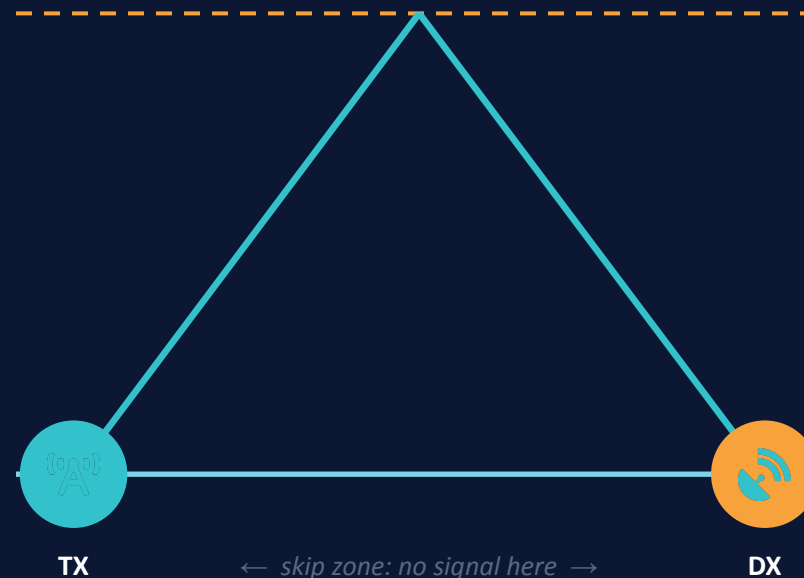
Past ground-wave range but short of where the first hop lands — stations there can't hear you.

Critical angle

Steeper angles need lower frequencies to reflect; too high and the signal punches through to space.

ONE HOP

Ionosphere



The Sun runs the show

Solar radiation creates the ionosphere, so HF conditions rise and fall with solar activity — minute to minute and across the 11-year cycle.



Sunspots (SSN)

More spots → more ionization → higher MUF. High counts light up 15, 12 and 10 m.



Solar Flux (SFI)

10.7 cm radio flux. ~70 = quiet; 150+ and the upper HF bands come alive.



The 11-year cycle

Activity swings from a quiet minimum to an active maximum — we're near the Cycle 25 peak.

Solar disturbances & the indices



Solar flares

A burst of X-rays floods the D layer, causing a sudden ionospheric disturbance (SID) — a daytime HF blackout lasting minutes to hours.



CMEs & geomagnetic storms

Clouds of plasma hit Earth's field 1–3 days later, disturbing the F layer, depressing the MUF and sparking auroras.

READING THE INDICES

K-index 0–9 scale, updated every 3 hours — a quick pulse of geomagnetic activity.

A-index 0–400 daily average — the bigger picture of the day's stability.

K 0-2

Quiet — go!

K 3-4

Unsettled

K 5+

Storm — HF hit

Band by band

Band	Best time	Character & typical use
160 / 80 m	Night	Regional ragchew & NVIS; daytime D-layer absorption kills DX.
40 m	Night / dusk	Reliable all-rounder — local by day, solid DX after dark.
20 m	Day	The premier DX band; often open dawn-to-dusk and beyond.
17 / 15 m	Day	Excellent DX when solar flux is high; follows the Sun.
12 / 10 m	Day, high SFI	Spectacular near solar max — worldwide on low power.
6 m	Seasonal	“The Magic Band” — sporadic-E & tropo surprises in summer.

VHF / UHF propagation modes



Tropospheric ducting

Weather inversions trap signals near the ground, extending 2 m / 70 cm hundreds of km — best at dawn and over water.



Sporadic E (Es)

Patches of intense E-layer ionization mirror 6 m and even 2 m worldwide. Peaks in early summer.



Meteor scatter

Brief reflections off ionized meteor trails — quick pings used for digital MSK144 contacts.



Auroral propagation

During geomagnetic storms the aurora reflects VHF with a distinctive raspy, watery tone.

Gray line & the tools to read it



Gray line propagation

Along the twilight band circling the Earth at dawn and dusk, the D layer has faded but the F layer is still charged. For 30–60 minutes the low bands offer enhanced, often spectacular long-haul DX. Aim along the terminator for the best results.

USEFUL TOOLS



PSK Reporter / DX cluster

See in real time which bands are open and where you're being heard.



WSPR

Low-power beacons map live propagation paths across the globe.



VOACAP

Predicts the best band & time for any path from solar data.



Solar dashboards

SFI, SSN, A & K at a glance (e.g. hamqsl.com, NOAA SWPC).

KEY TAKEAWAYS

Five things to carry to the radio

- 1 Low bands by night, high bands by day — the D layer is the switch.
- 2 Watch the Sun: high SFI / SSN opens the upper HF bands.
- 3 Check the K-index before you call CQ — K 5+ means HF is hurting.
- 4 Work the gray line for enhanced low-band DX at dawn and dusk.
- 5 Let the tools confirm it — PSK Reporter shows what's open right now.

Questions? Let's hit the bands. 73!