Space Weather and HF Propagation

Dr. Tamitha Skov
Physical Sciences Laboratory

22 February 2018
Why Does Space Weather Forecasting Matter?
What is Space Weather?

Essentially Space Weather is:

• A planet’s interaction with its host star and the surrounding space environment

• More generally, it occurs at planets, moons, comets, asteroids, and other celestial bodies in the universe

• We see aurora at planets
  - Jupiter, Saturn, Uranus, and Mars

• We see effects at Moons
  - Io, Europa, Ganymede, and Titan

• Main effects are **Sun-driven**

• Other sources of space weather
  - Cosmic rays
  - Micrometeoroids & interstellar dust
  - Space junk
Our Star

- Giant fusion reactor: Drives Space Weather
- Energy output in the form of:
  - Electromagnetic radiation
    (from X-rays through radio)
  - Solar wind plasma & magnetic fields
  - Flares
  - Solar Energetic Particles (SEPs)
    (aka solar radiation storms)
  - Coronal Mass Ejections (CMEs)

What do Space Telescopes See?

5700 °C → 6.3 Million °C
Four Basic Types of Solar Phenomena Affecting Earth

- **Solar Flares**
- **Solar Storms (a.k.a. CMEs)**
- **Solar Radiation Storms**
- **Coronal Holes (Fast Solar Wind)**
What is the Ionosphere?

- Ionosphere is a charged plasma layer above the atmosphere comprised of ions and electrons
- It would be neutral but it gets charged from exposure mainly to the Sun’s UV radiation
- This charged nature facilitates radio propagation
- Solar phenomena affect the ionosphere in dramatic ways
Space Weather Effects on Propagation

- **F Region**
- **E Region**
- **D Region**

- **signal reflection**
- **signal refraction**
- **currents in charged regions**
- **waves in neutral & charged regions**
- **signal scintillation**
- **signal amplitude & phase modulation (signal fading)**

- atmospheric heating instabilities
-TX

RX

RX
Space Weather Audible Interference

**Solar flare:** Solar radio bursts cause radio blackouts over a wide frequency range
https://www.wired.com/2013/02/radio-solar-outburst/

**Dawn Chorus:** Radio Waves due to energetic particles in the magnetosphere

**Sferics and Tweeks:** Radio waves caused by lightning nearby
http://www.spaceweather.com/glossary/inspire.html

**Whistlers:** Radio waves caused by lightning far away
http://www.spaceweather.com/glossary/inspire.html
3 Categories

- Geomagnetic Storms (CMEs)
- Solar Radiation Storms (Particle Events)
- Radio Blackouts (Solar Flares)

http://www.swpc.noaa.gov/noaa-scales-explanation
Ground & Space Communications Disruptions

X2 Solar Flare (27 Jan 2012)

Radiation Storm (23-25 Jan 2012)

GPS & Location-Based Service Disruptions

Reprinted courtesy of NOAA
FAA Radio Communications Center reported that the CEP (Central East Pacific) and CWP (Central West Pacific) regions were:

“impacted severely by solar activity between 1830Z and 1930Z on 27 Jan due to the R3 solar flare radio blackout. Thirteen requests were received from ATC for overdue position reports.”

Several polar flights altered due to S3 Radiation Storm (23-25 Jan)

Major airline report: “...some of our polar flights (but not all) have reported HF comm outages/issues over the past 3 nights.”

Reprinted courtesy of NOAA
Perfect Storm: Hurricane Harvey, Irma, & Region 2673

Battered Texas town may be without power for weeks

Explosive Growth of Region 2673

2 days ago    yesterday    today

complex magnetic mixing shown by red & blue colors ups the X-flare potential
Region 2673 launched in a single week (Sep 3 – Sep 10):

- 4 X-class flares  
  (R3 - R4 level radio blackout)
- 25 M-class flares  
  (R1 - R2 level radio blackout)
- 2 Solar Radiation storms (S2 - S3 level)
- 2 Geomagnetic storms (G4 level)

Reprinted courtesy of NOAA"
Perfect Storm: Hurricane Harvey, Irma, & Region 2673

Jack Reed @Jack WA7LNW · Sep 10
Repeating to @TamithaSkov
Amateur Radio, Reverse Beacon Network showing no CW signals in U.S. during 180 min.
radio blackout de WA7LNW
Space Weather Forecasting: A Return to the Sixties

**Space Weather Prediction Centers**
- Developed mainly as a response to super storms
- Models that predict solar fields, CME transit, magnetospheric responses → solar storm alerts
- Radio blackouts, solar radiation storms → FAA alerts
- Space & ground telescopes for 24/7 monitoring of Sun
- “Spaceship Earth” networks

~1960
Harry Volkman: Broadcast Meteorologist

Today
Tamitha Skov: Broadcast Space Meteorologist
Future of Space Weather Forecasting: “The Martian”

- Technology savvy Millennials are calling themselves “The Mars Generation”
- Curiosity is the first Martian colonist
- On March 7, 2013 (Martian Sol 207), NASA shut down Curiosity due to an approaching solar storm

This puts a whole new spin on the movie “The Martian”

How are over-the-horizon communications going to work on Mars?
Our Future Relies on Space

Reliance on Space is advancing

• Are we prepared?
• Space weather is like the weather in your own backyard just a little further up.

For more information visit:

• SpaceWeatherWoman.com
• YouTube for weekly forecast videos: http://www.youtube.com/user/SpWxfx
• @TamithaSkov on Twitter for daily forecasts and often hourly updates
• Space Weather Woman on Facebook
• SpaceWeatherWoman@gmail.com

All trademarks, trade names, and service marks are the property of their respective owners.