



# Tracking Sporadic E with the LWA Radio Telescopes

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# The Bottom Side Ionosphere

- Bottom side ionosphere is somewhat predictable
- The electron density profile is monitored for both scientific and space weather situational awareness
- Can display highly dynamic behavior on a range of size/time scales
- One type of disturbance is sporadic E
  - E region of ionosphere (90 – 130 km)
  - Ions interact with wind and geomagnetic field to produce extremely dense, thin structures
  - Structures are highly reflective at HF and VHF frequencies having a severe impact on radio propagation

Lowell DIGISONDE

foF2	N/A
foF1	N/A
foF1p	N/A
foE	2.58
foEp	2.48
fxI	N/A
foEs	7.40
fmin	2.24

MUF(D)	N/A
M(D)	N/A
D	N/A

h`F	N/A
h`F2	N/A
h`E	105.0
h`Es	100.0

hmF2	N/A
hmF1	N/A
hmE	97.3
yF2	N/A
yF1	N/A
yE	7.2
B0	N/A
B1	N/A

C-level	22
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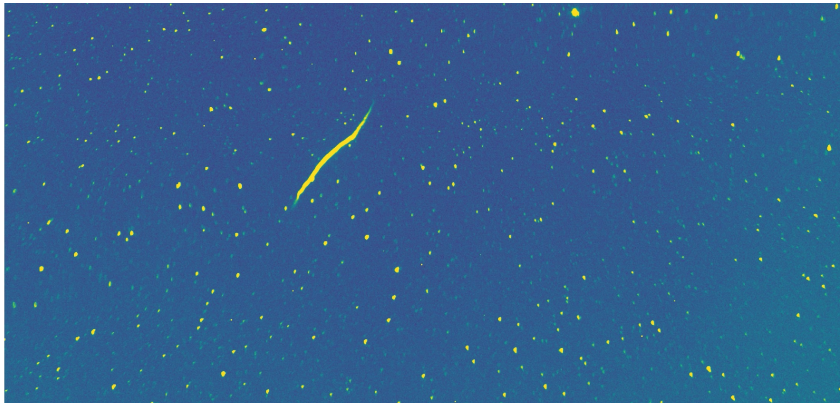
Auto:  
Artist5  
500200

Station YYYY DAY DDD HMMSS P1 FFS S AXN PPS IGA PS  
Kirtland 2018 Jul21 202 002829 RSF 1 713 200 03+ 85

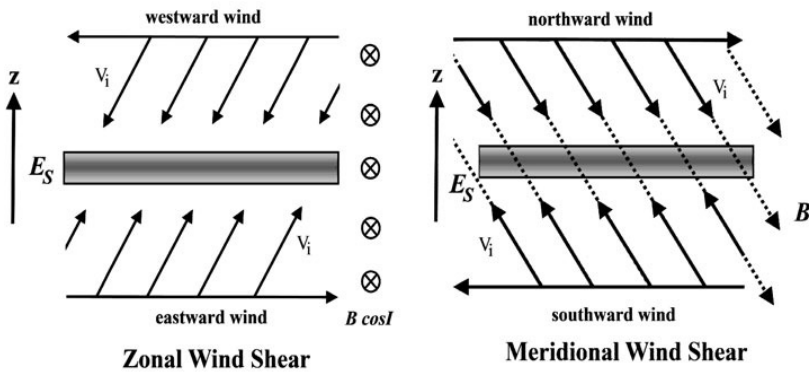


D 100 200 400 600 800 1000 1500 3000 [km]  
MUF 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 [MHz]  
KR835\_2018202002829.RSF / 565fx256h 20 kHz 2.5 km / DPS-4D KR835 991 / 35.0 N 253.5 E Ion2Png 1.3.20

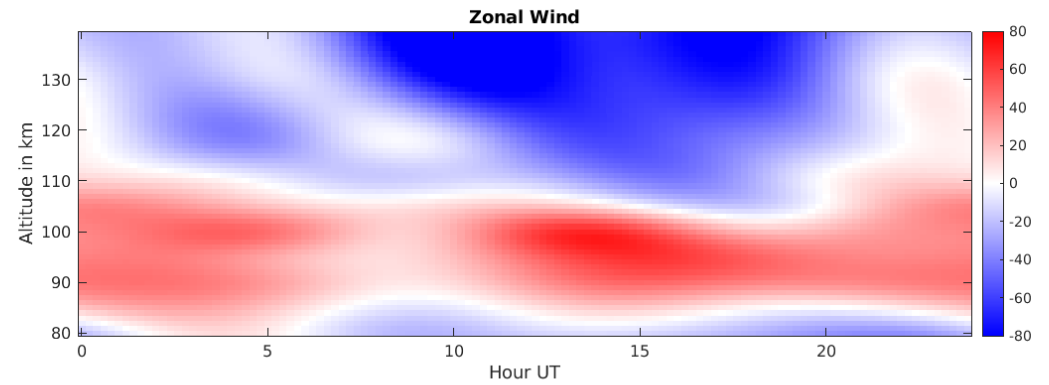
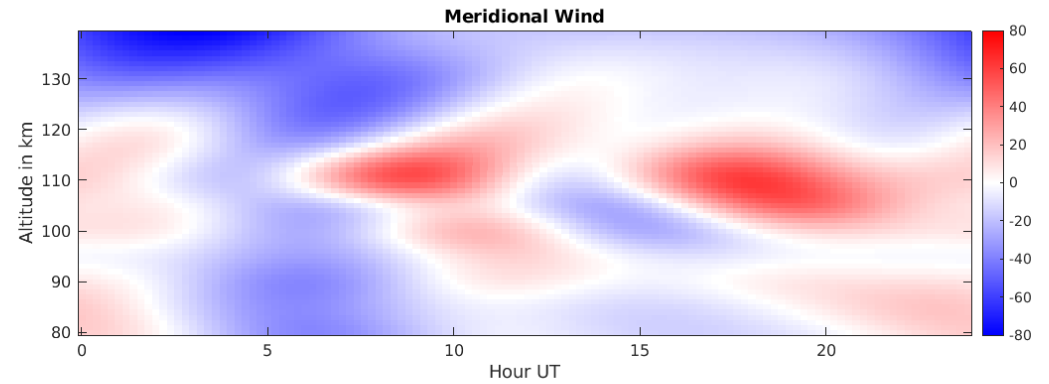
# Sporadic E Formation



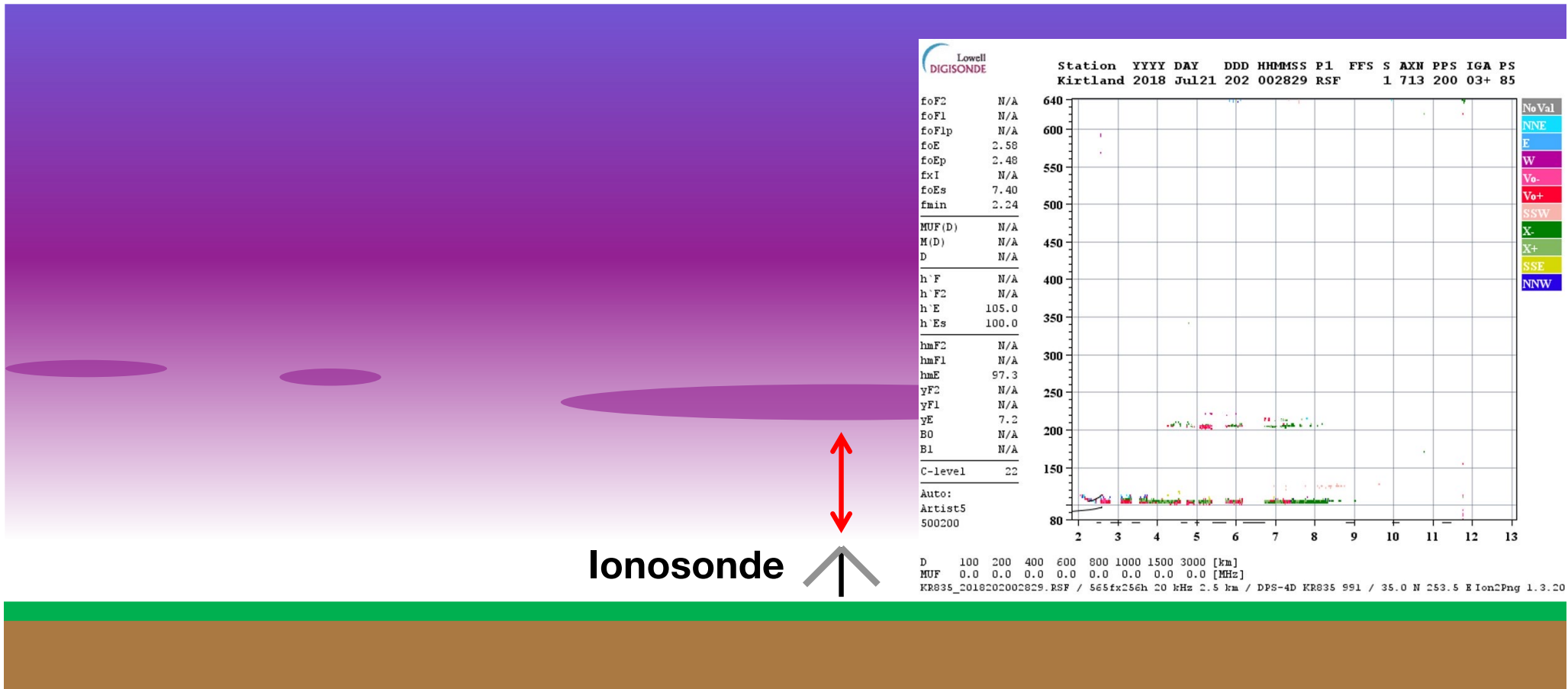
Windshear mechanisms of Sporadic E layer formation



(a) Haldoupis, C. (2012) (b)



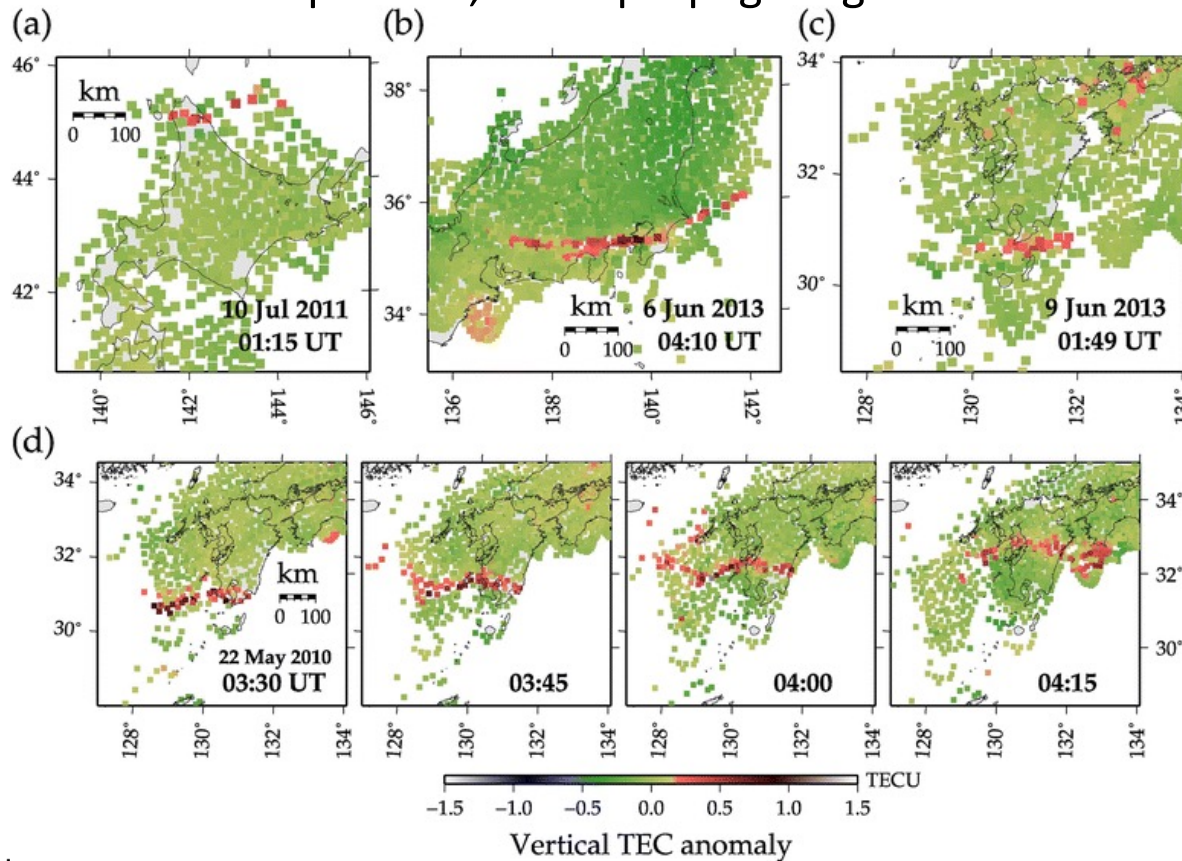
# Ionosondes are used for vertical observations, miss structure entirely



**Ionosonde**

# Horizontal Structure

Sporadic E forms in discrete patches, often propagating fronts.



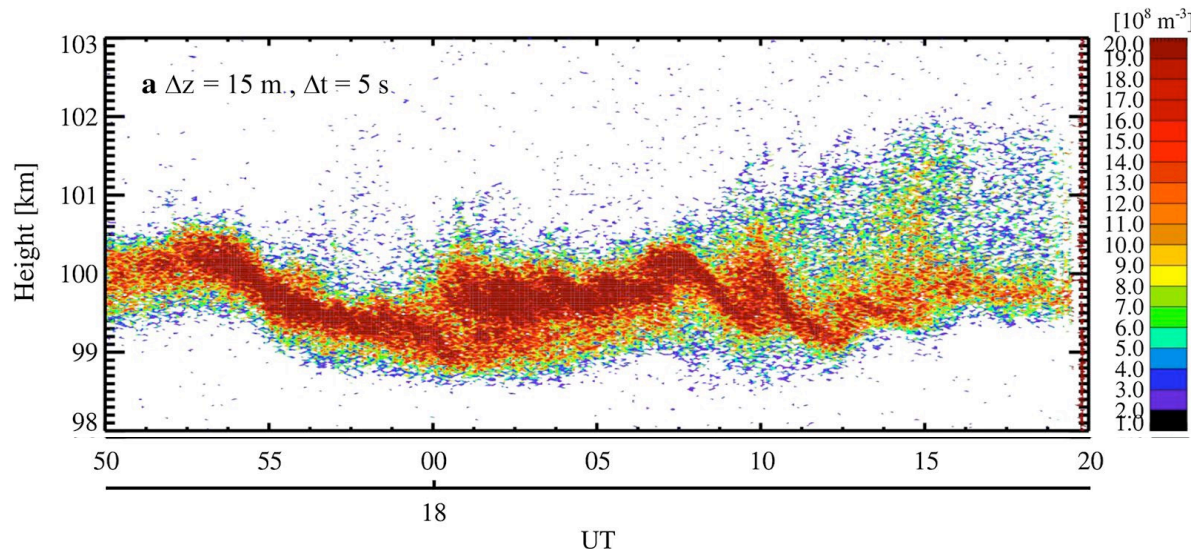
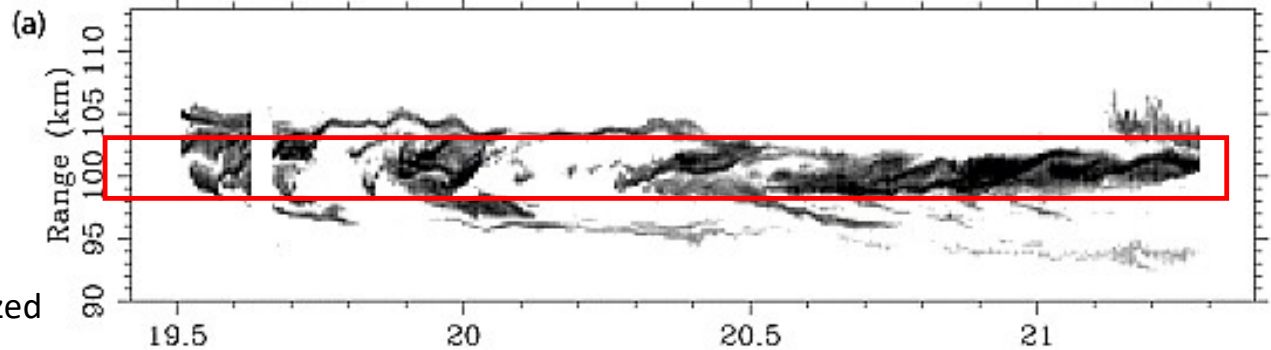
Maeda and Heki 2015

# Vertical Structure

Not all irregularities are field aligned!

At 100 km electrons are not fully magnetized

In coherent scatter radar over Puerto Rico - Hysell et al. 2009



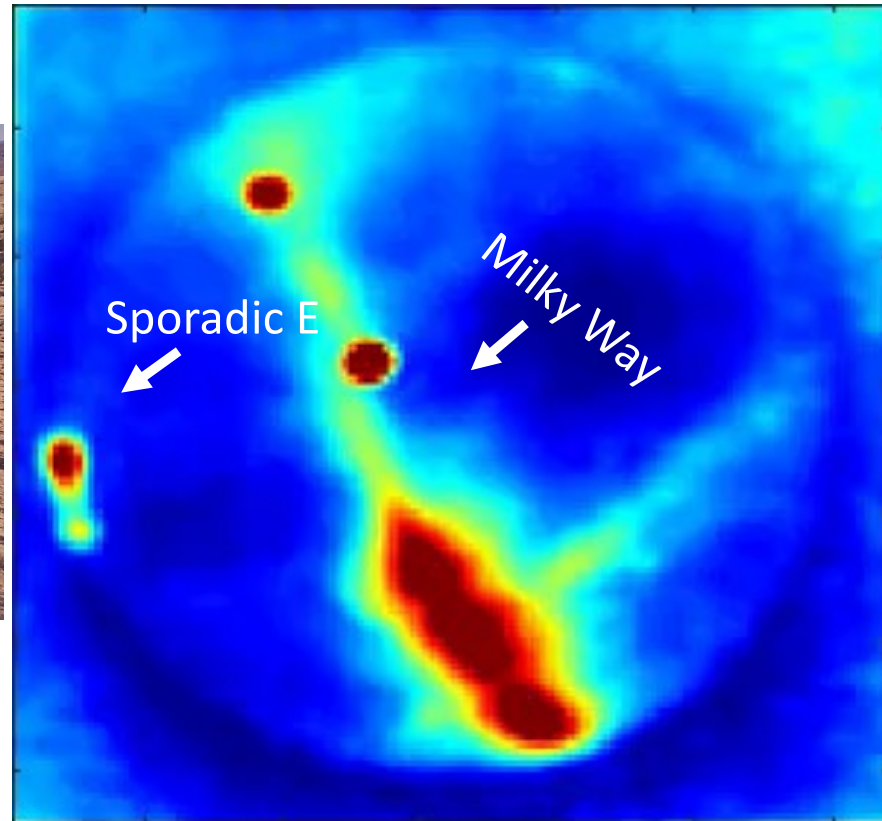
Ca<sup>+</sup> Lidar measurements over Tachikawa - Ejiri et al. 2019

# LWA Sporadic E Tracking

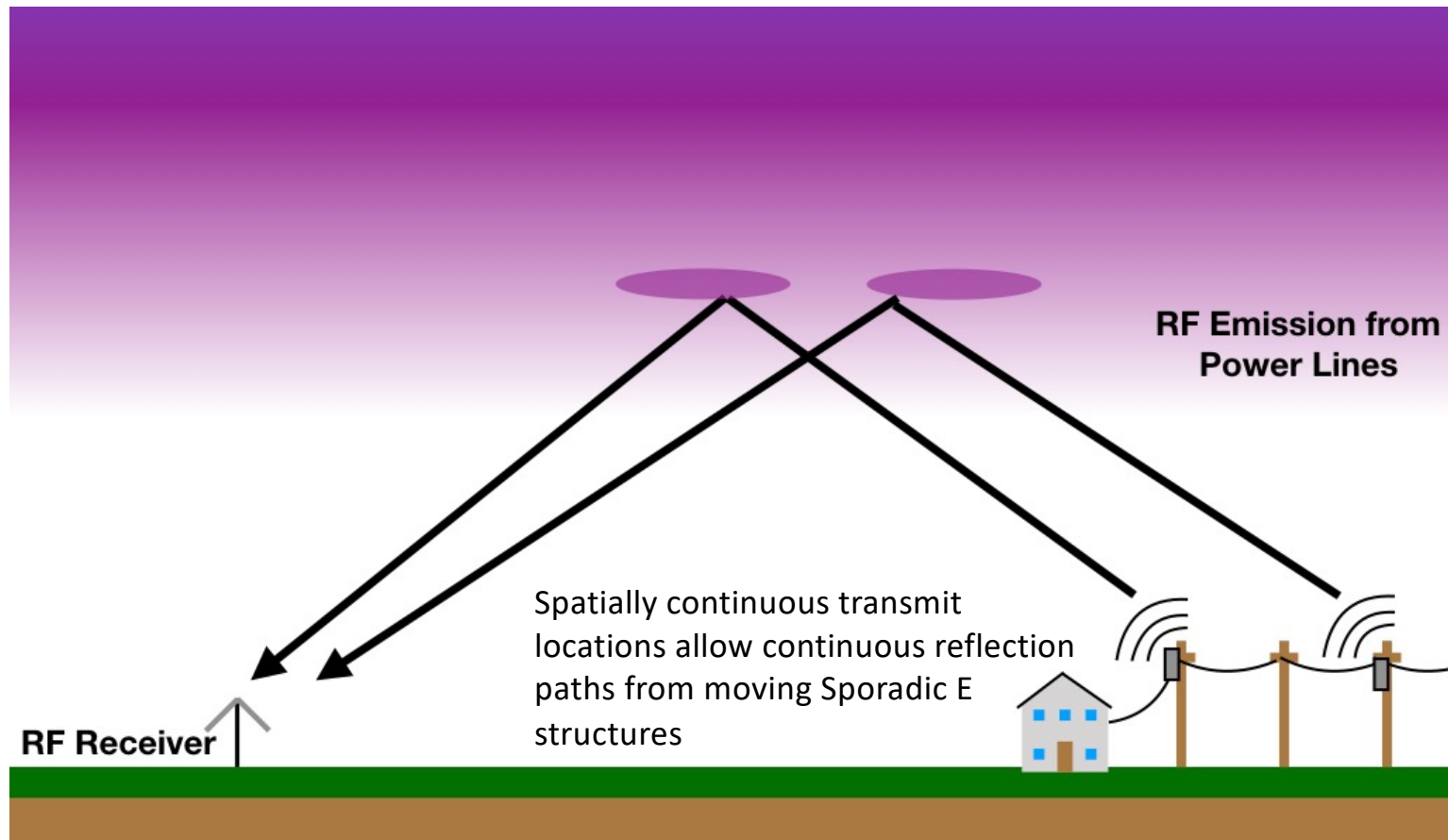


LWA-SV Station at Seville National Wildlife Refuge

LWA All-Sky Image at 38 MHz

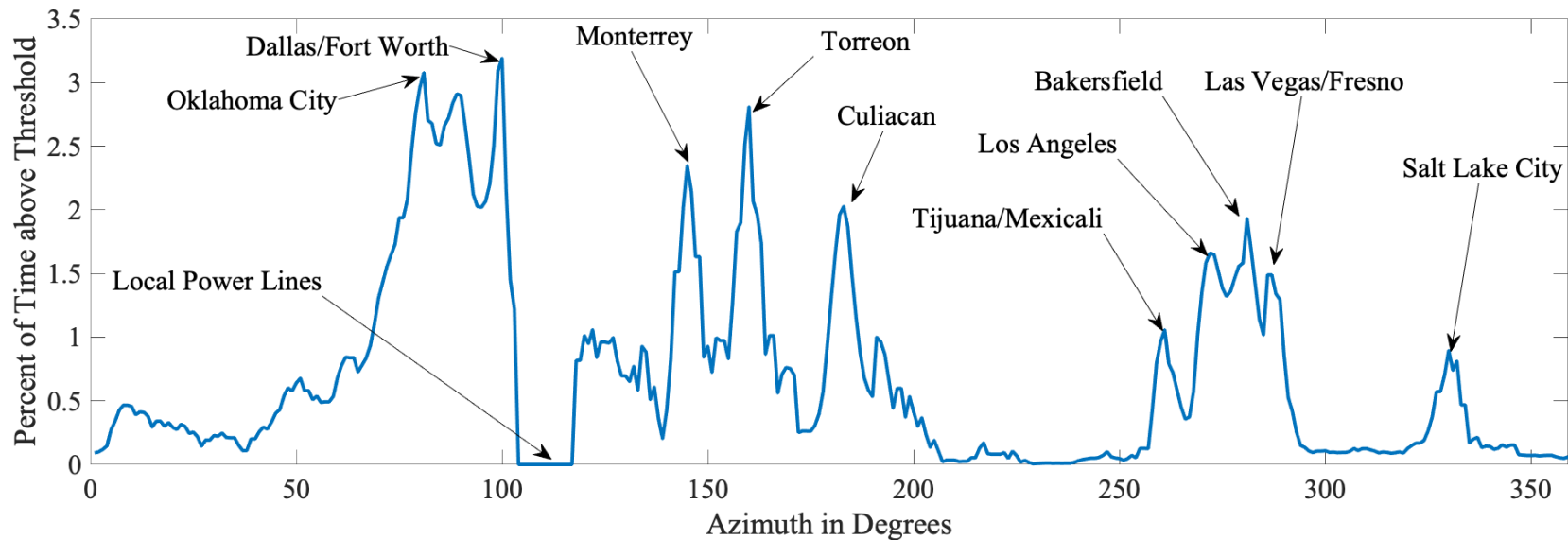


## Forward scatter of HF/VHF Noise?

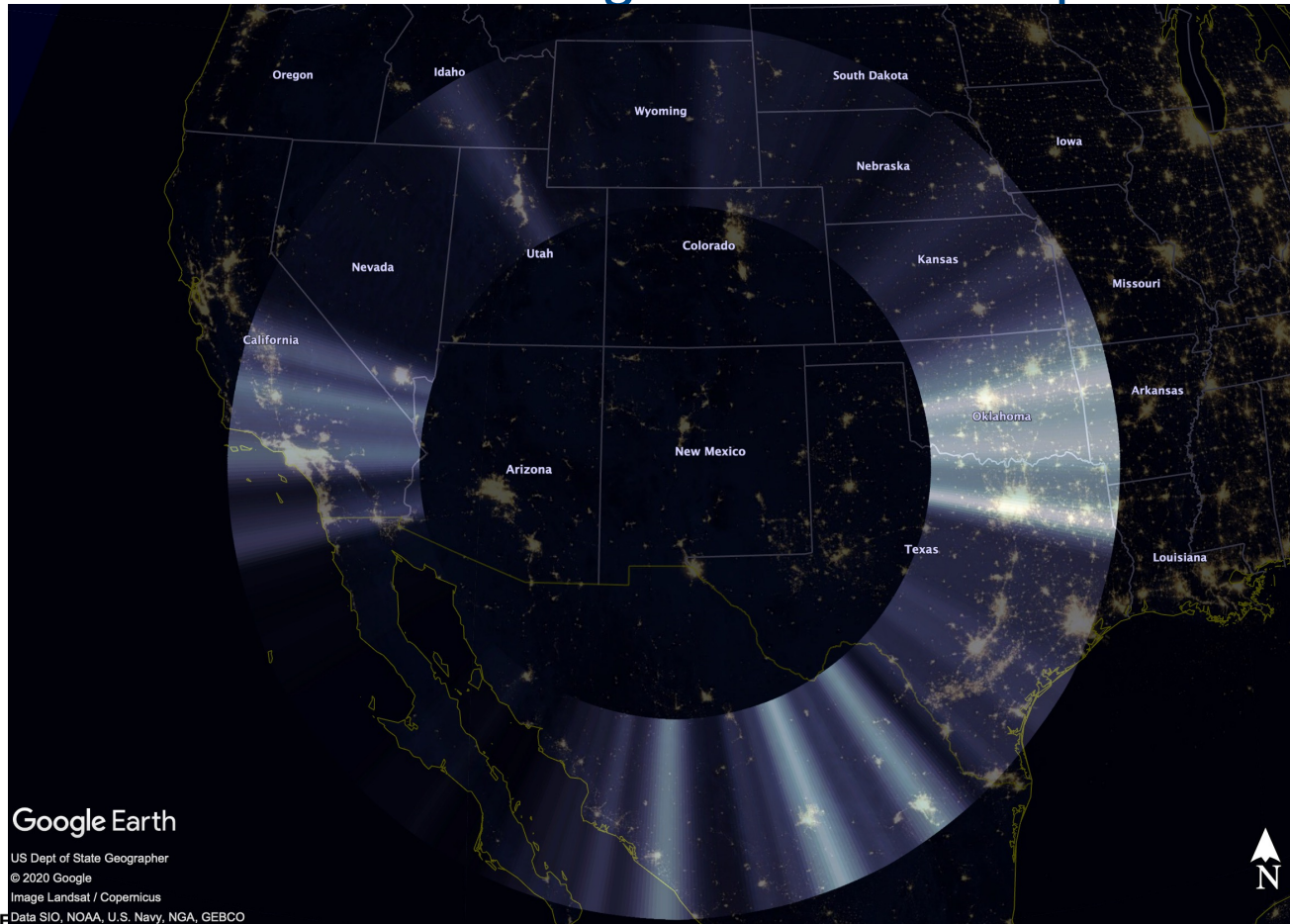




## Azimuthal Brightness Distribution Points towards cities

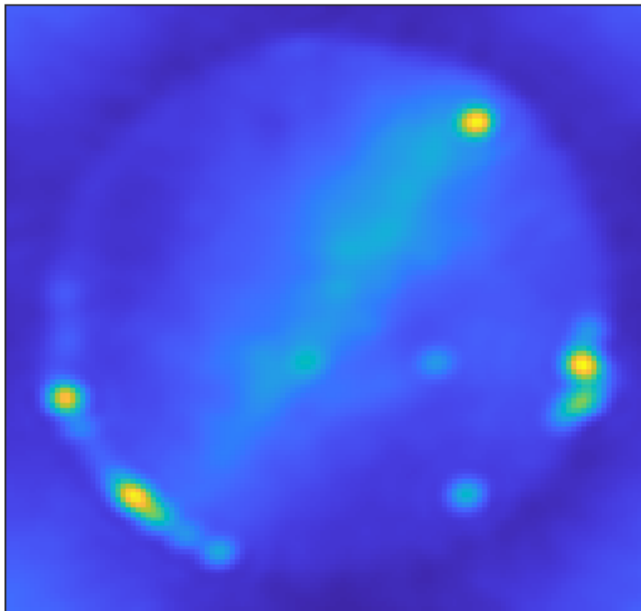


# Azimuthal Distribution on Light Pollution Map

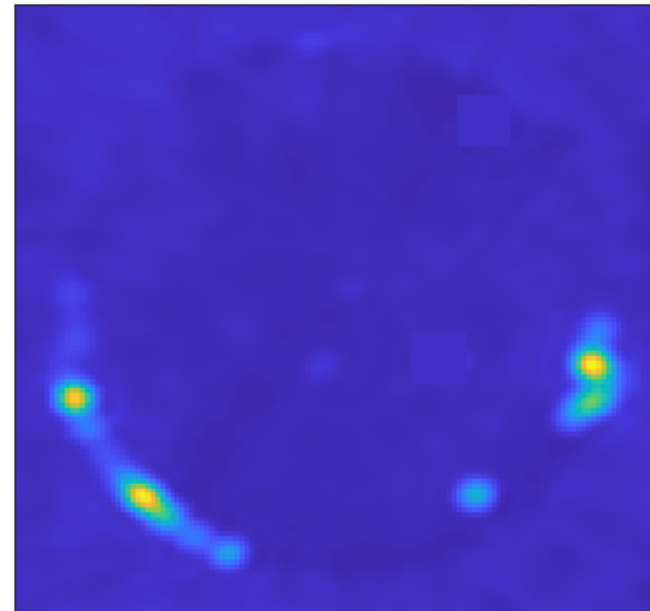


## LST Subtraction for Automatic Es Detection with LWA

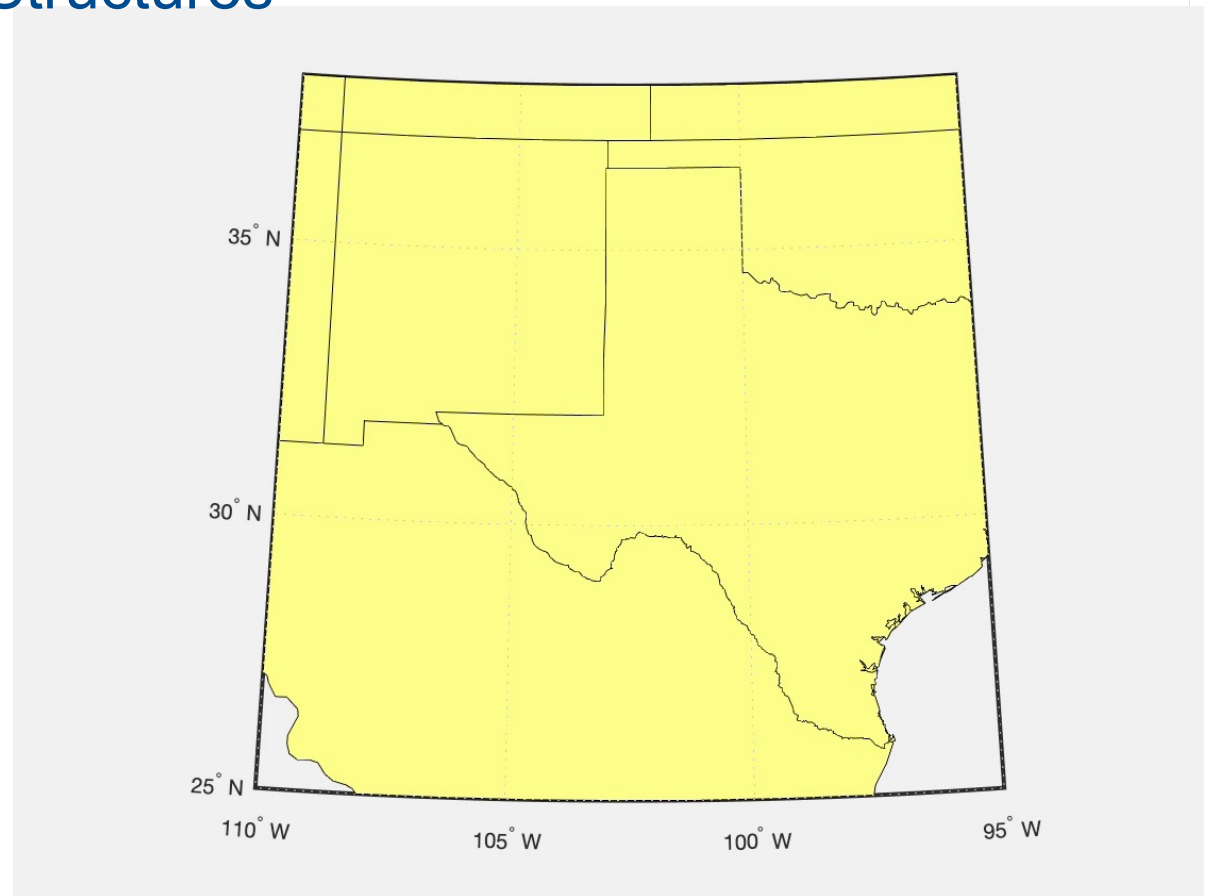
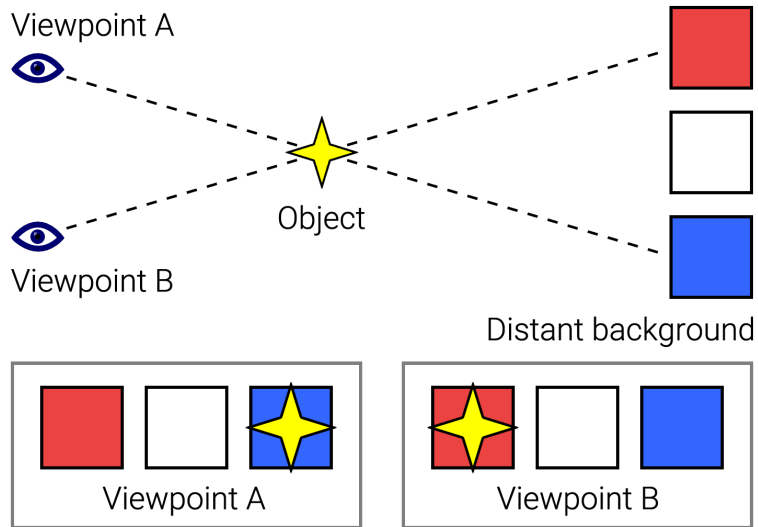
**Before**



**After**



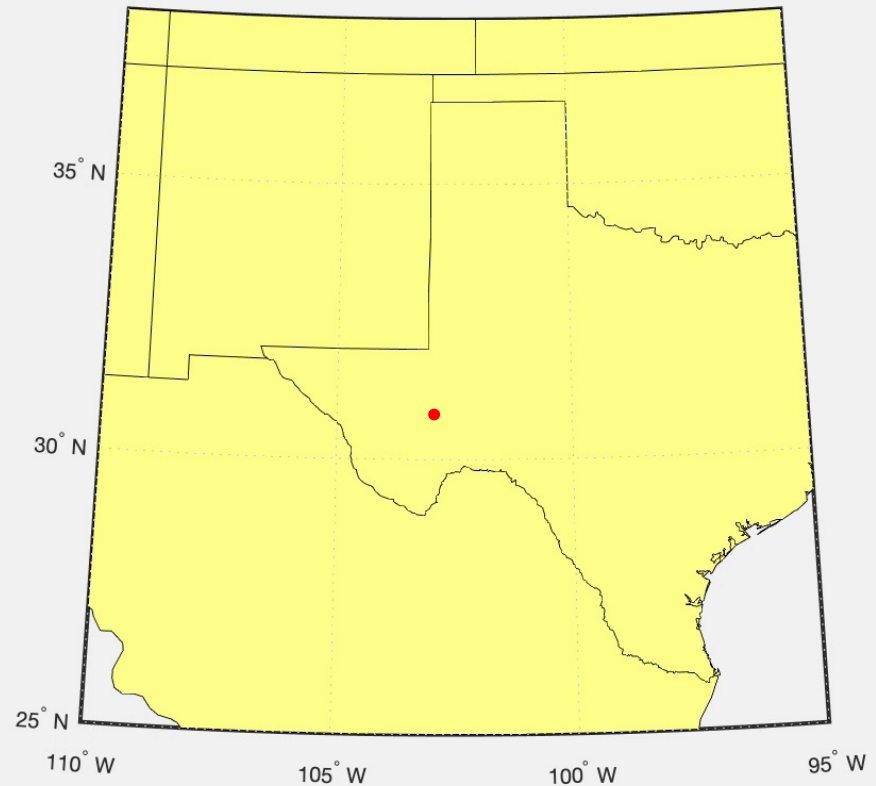
# Mapping and Tracking Structures



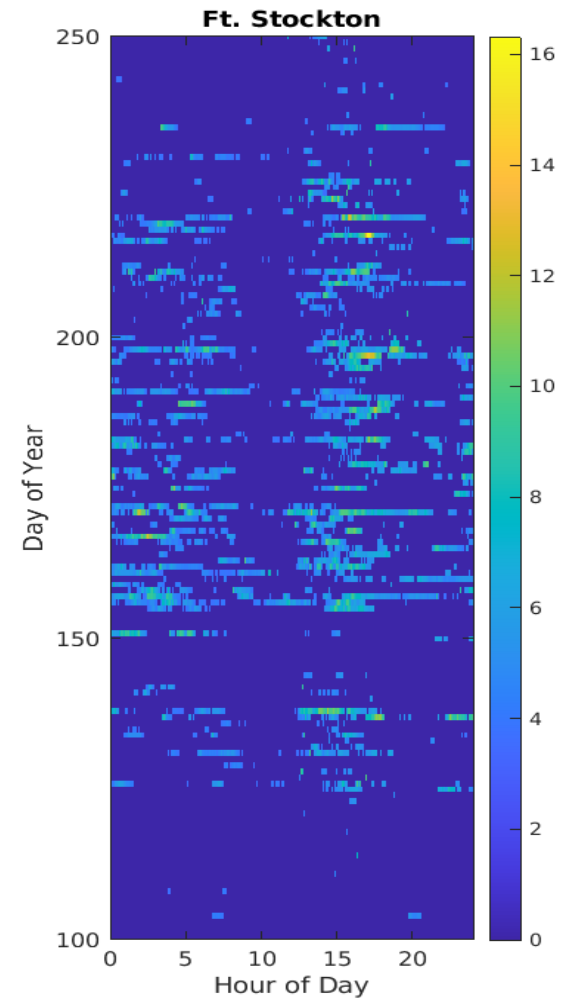
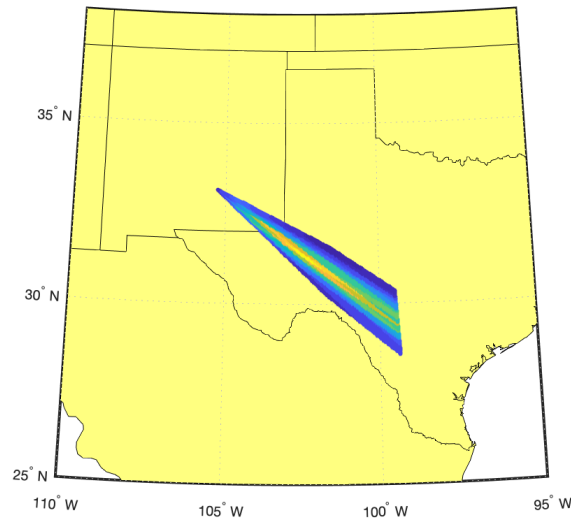
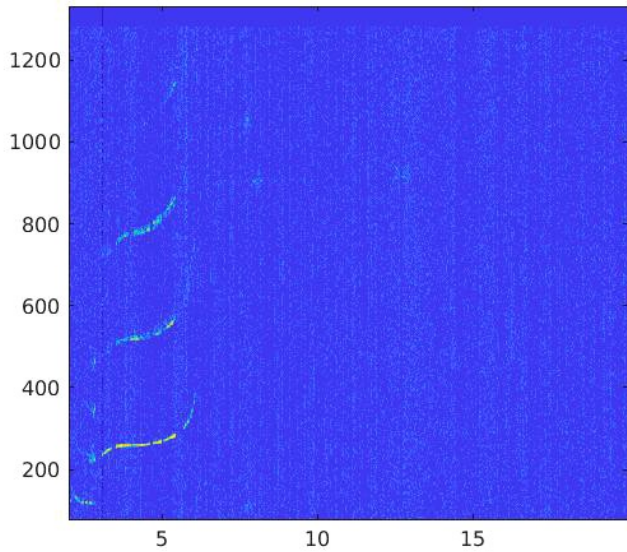
## Summer 2022 Digisonde deployment to Ft Stockton TX



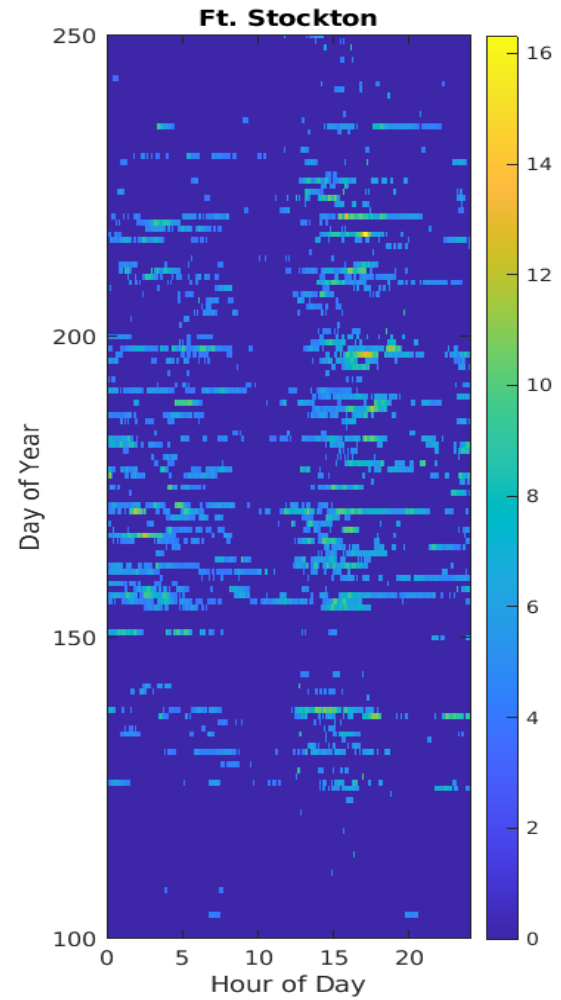
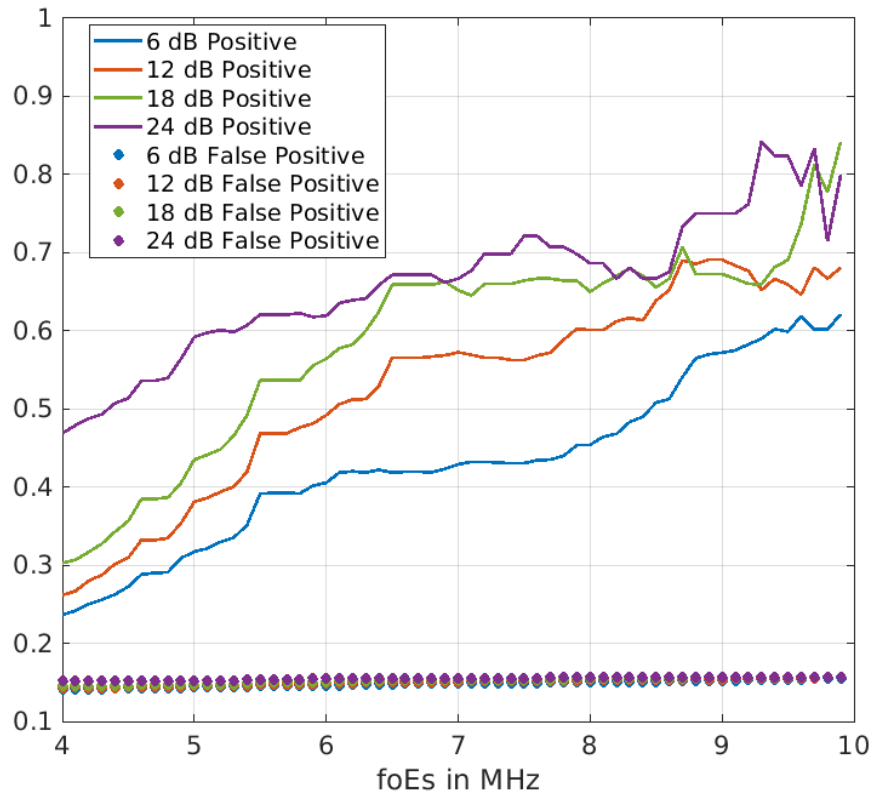
Digisonde Tower in Ft. Stockton TX  
Photo by Jeff Holmes



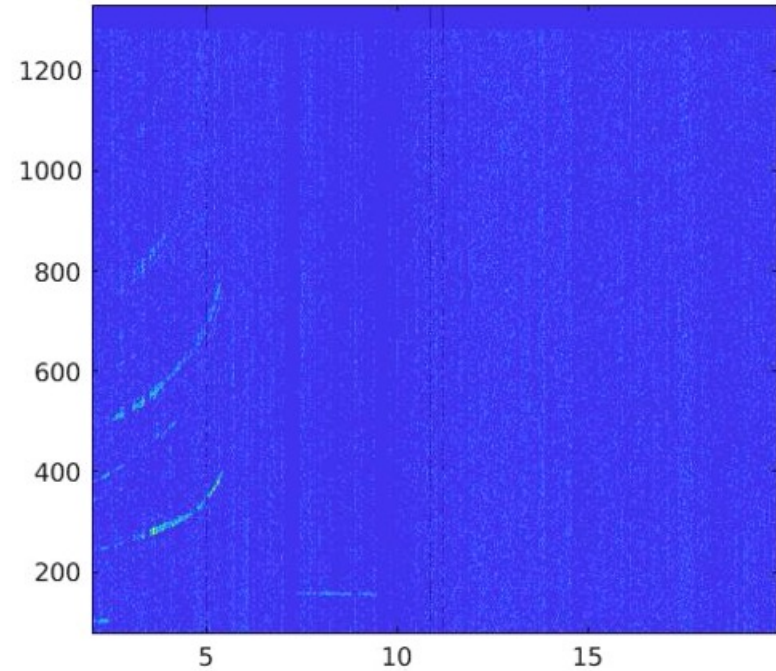
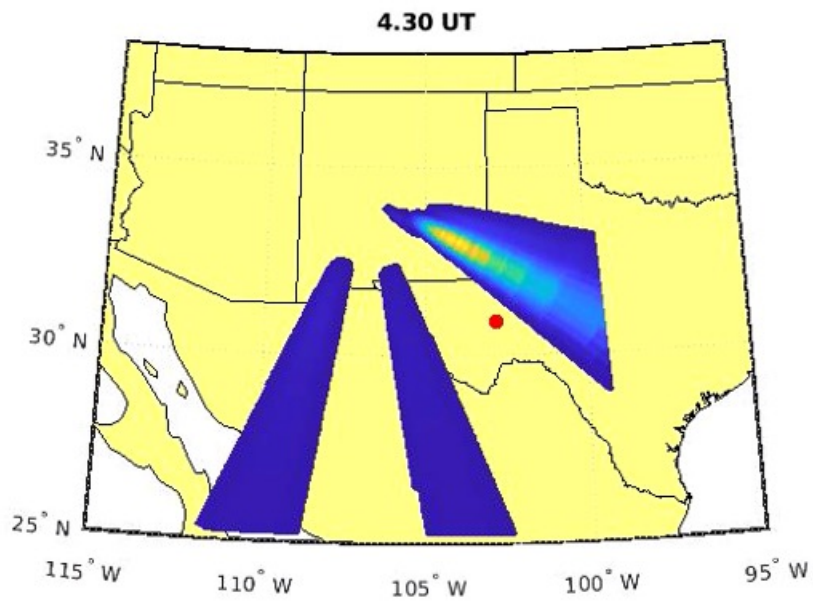
# LWA-SV success rate



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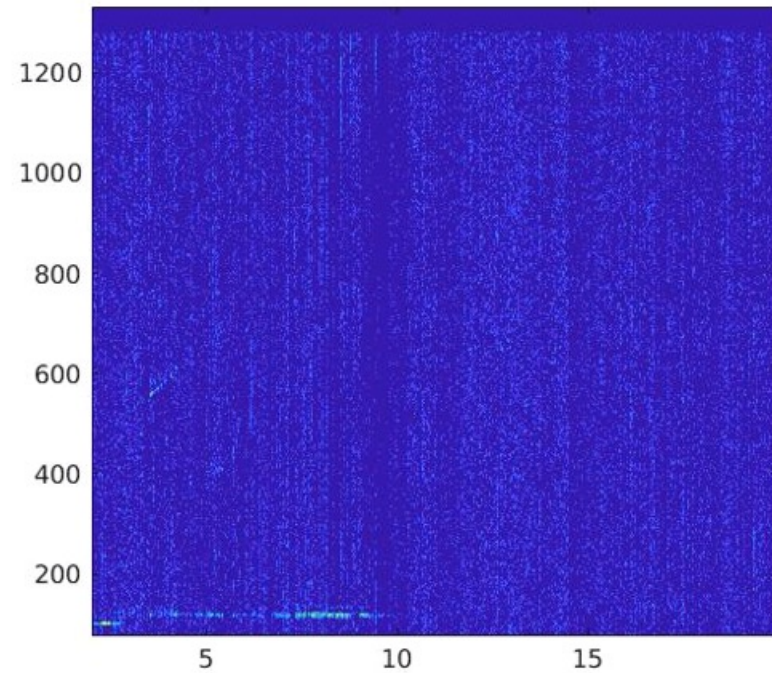
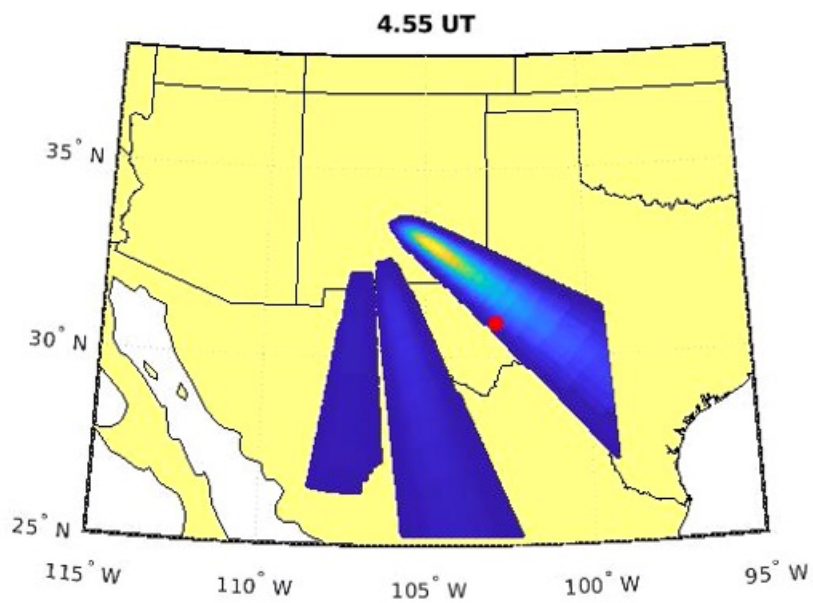


June 22, 2022

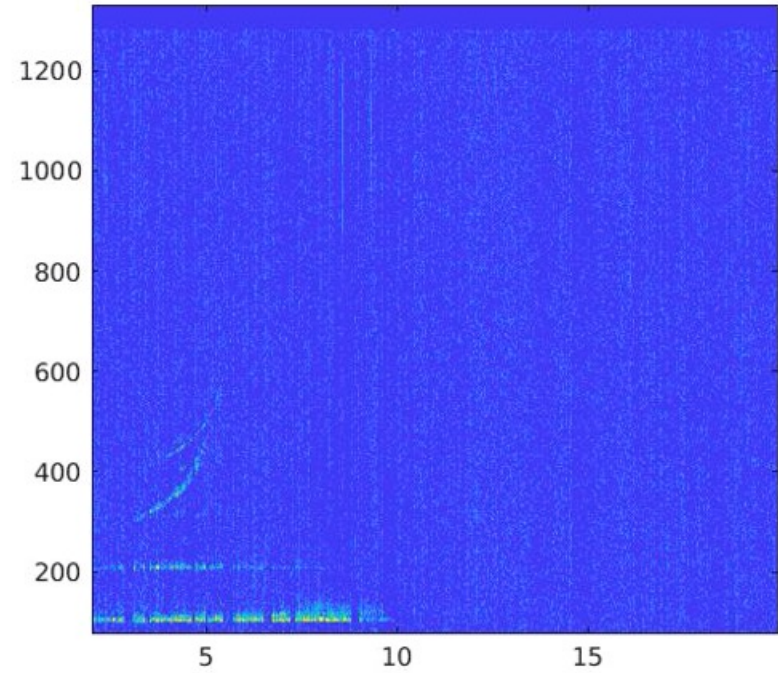
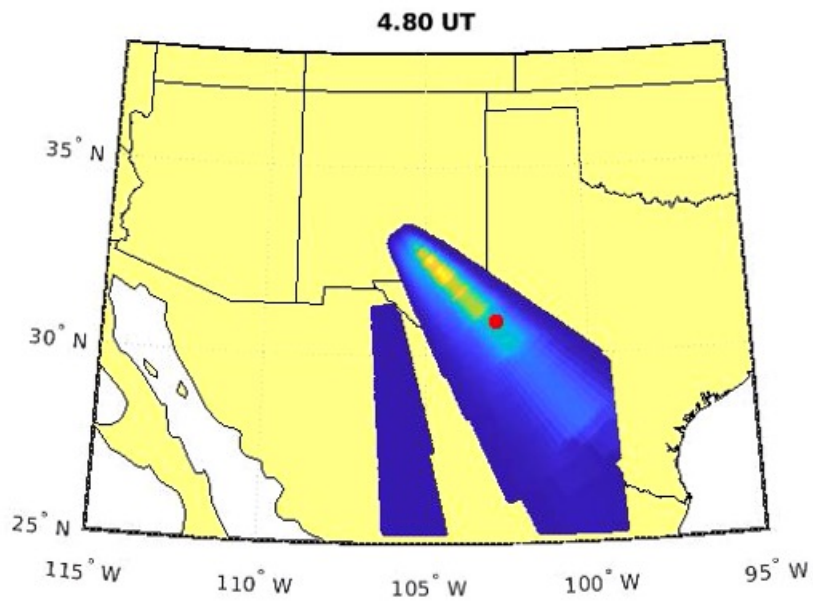




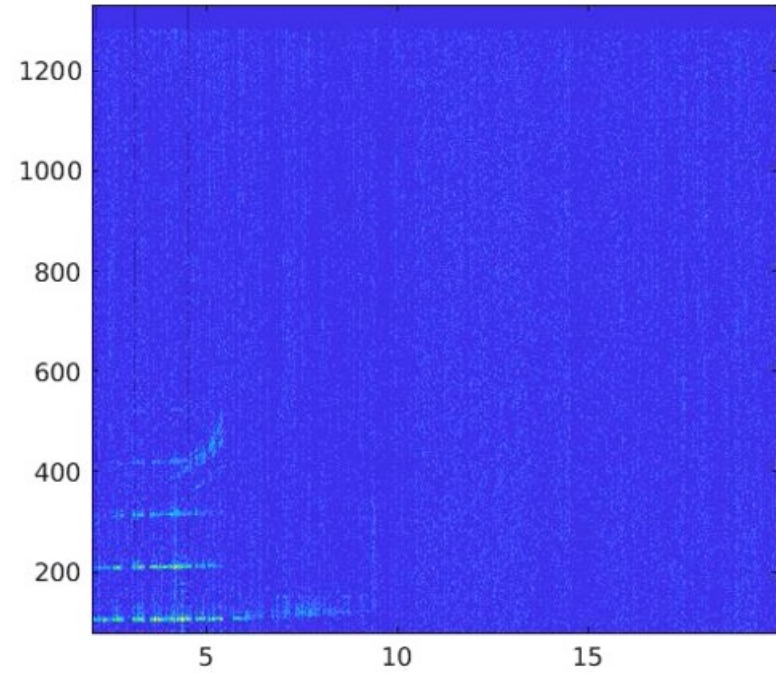
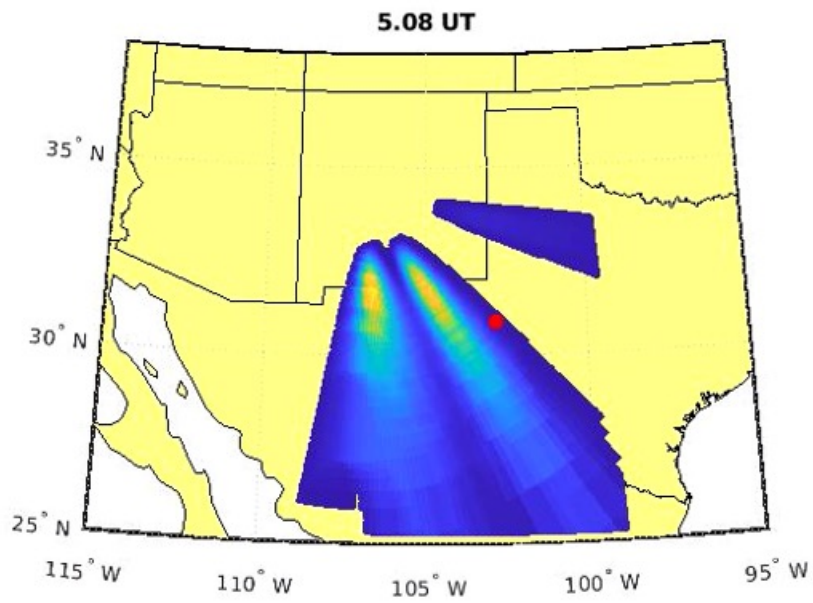
June 22, 2022



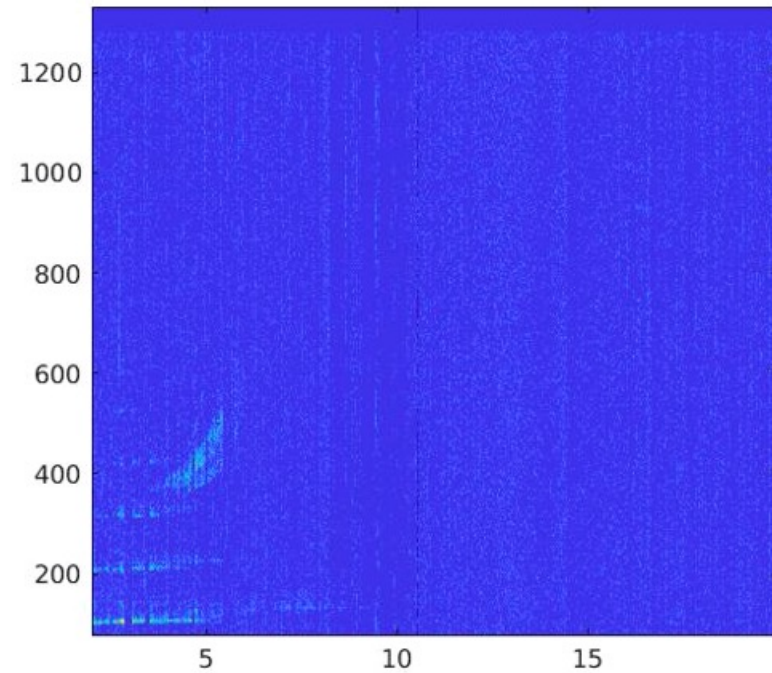
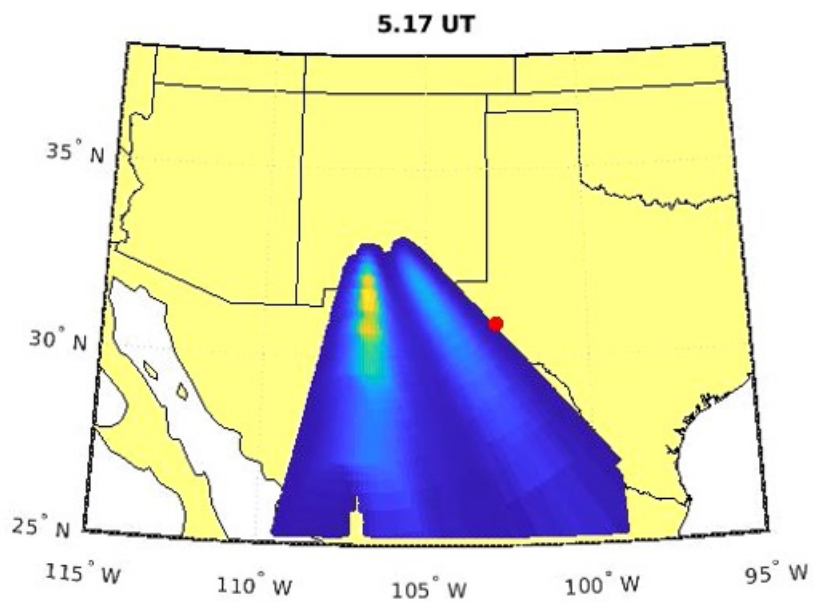
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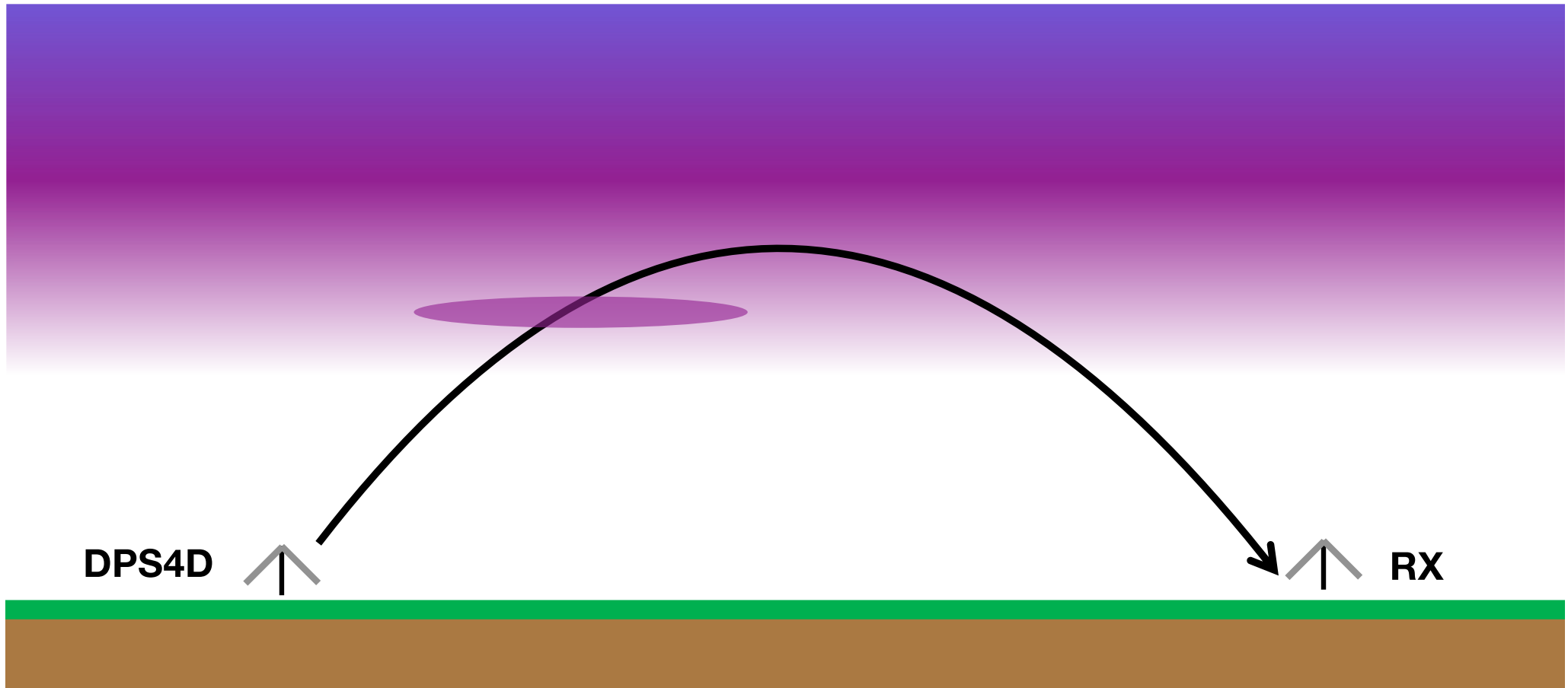
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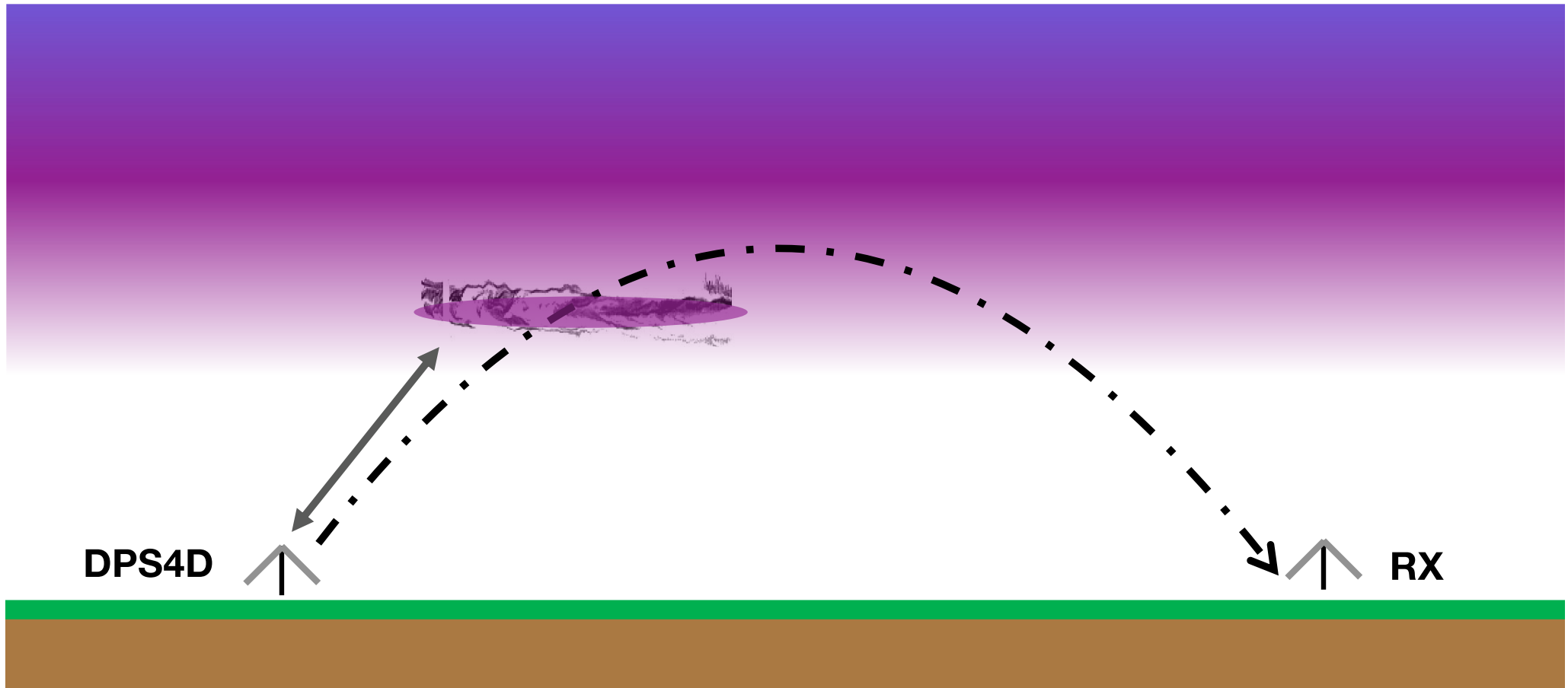
June 22, 2022



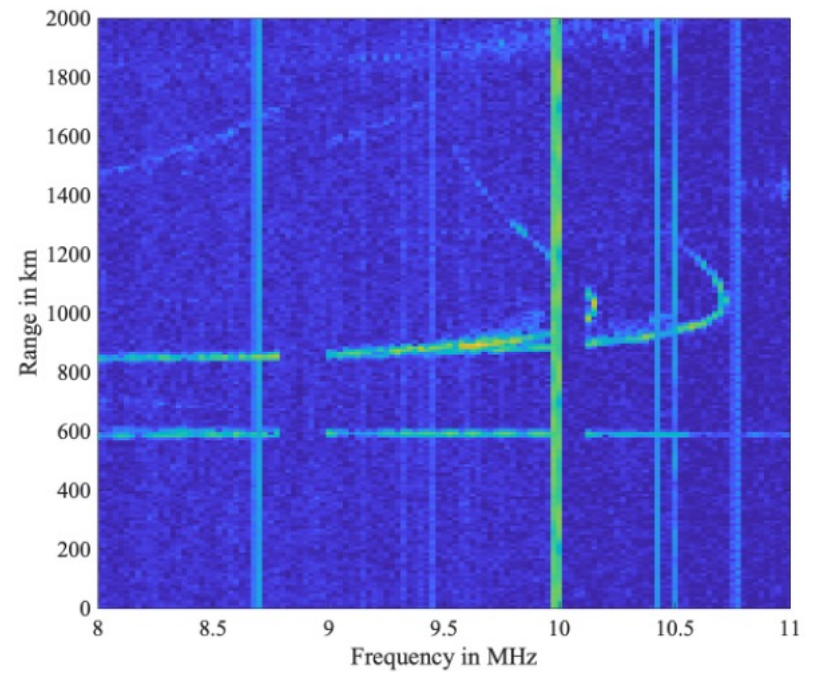
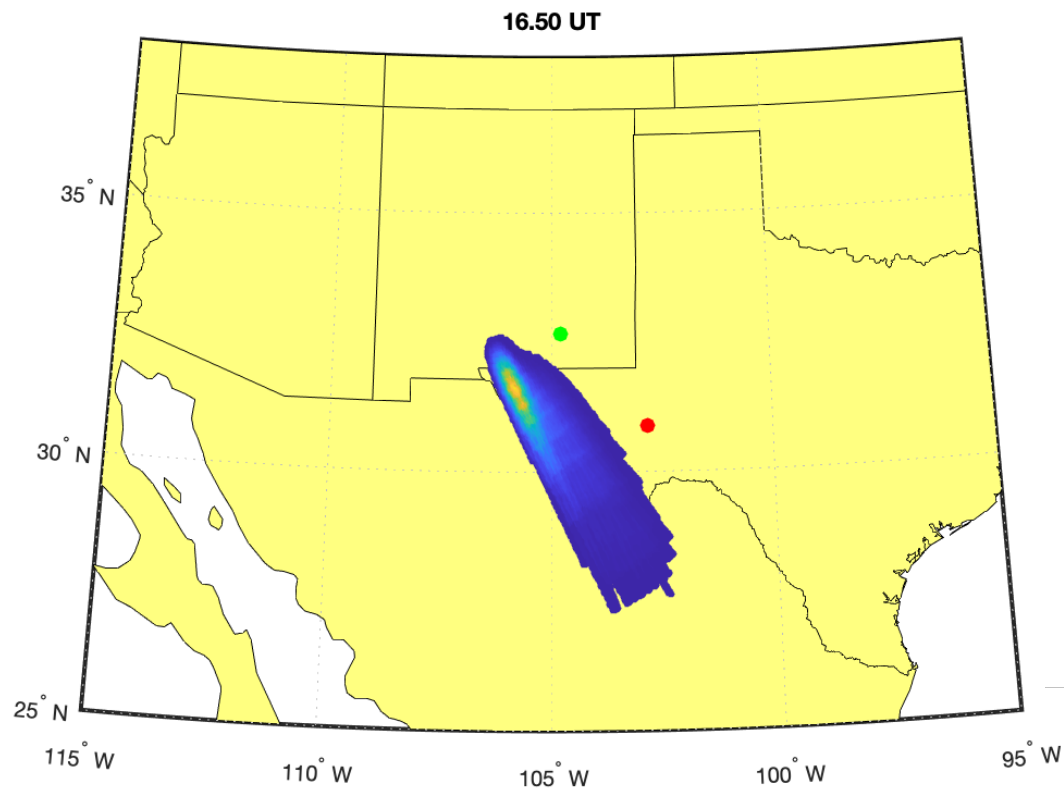
## Sporadic E Scintillation and Backscatter



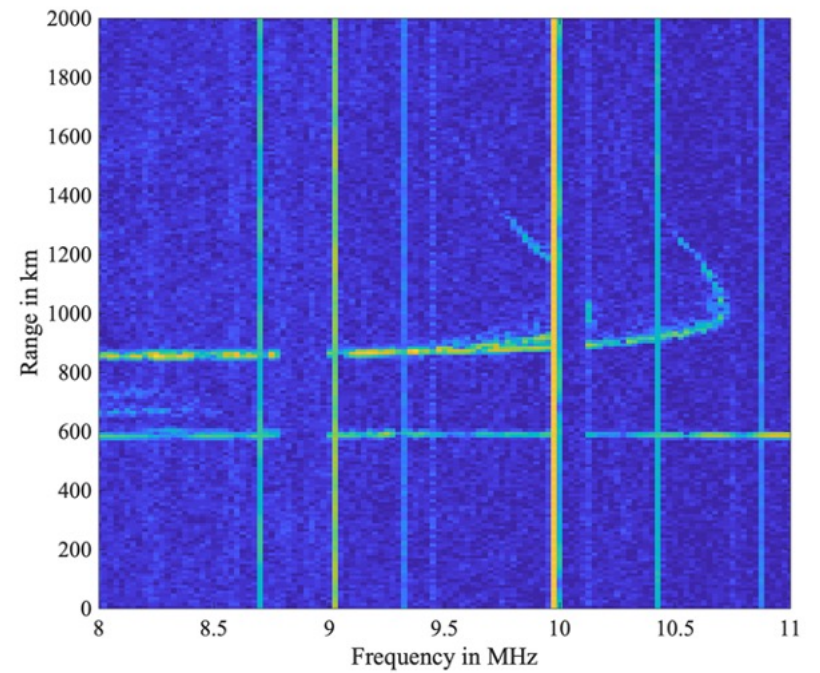
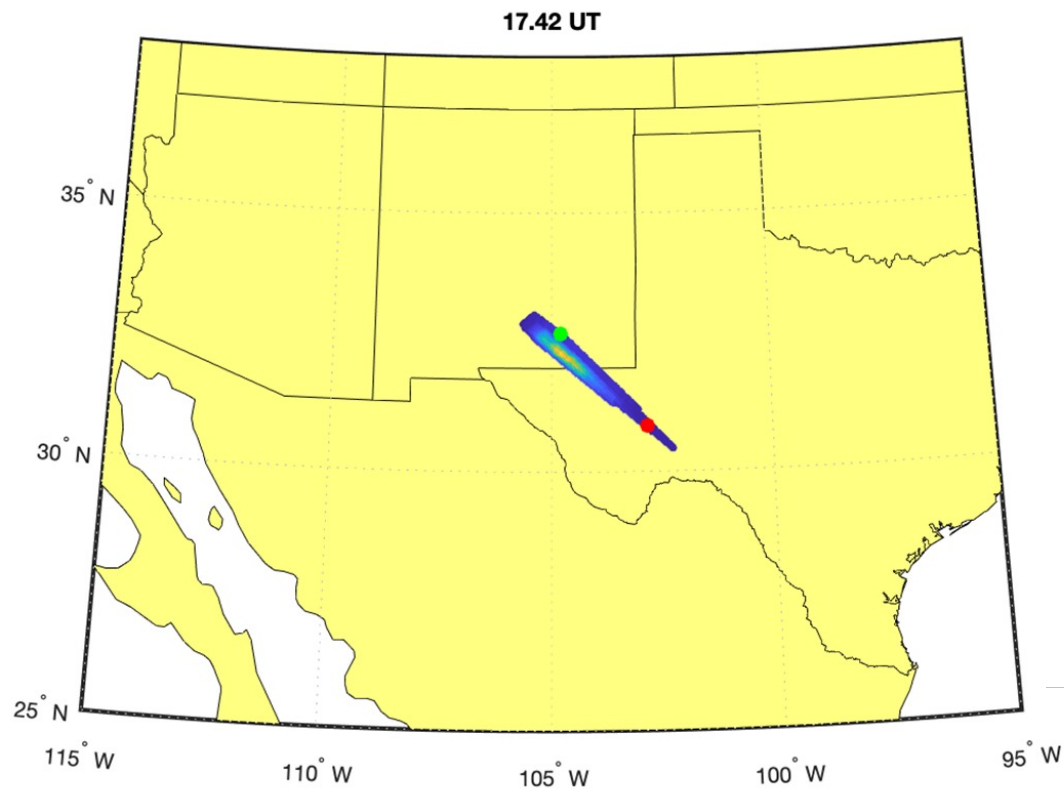
# Sporadic E Scintillation and Backscatter



# Es irregularities

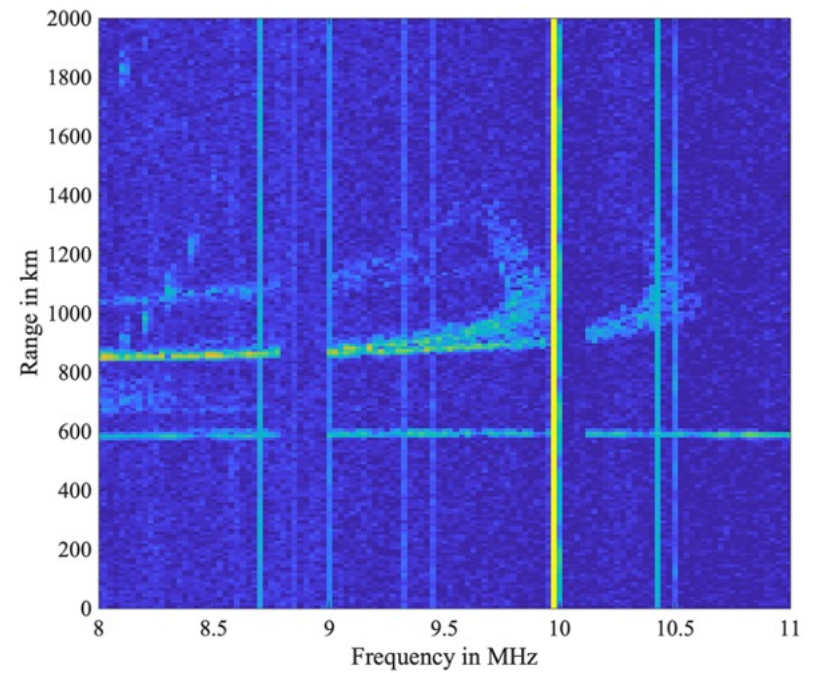
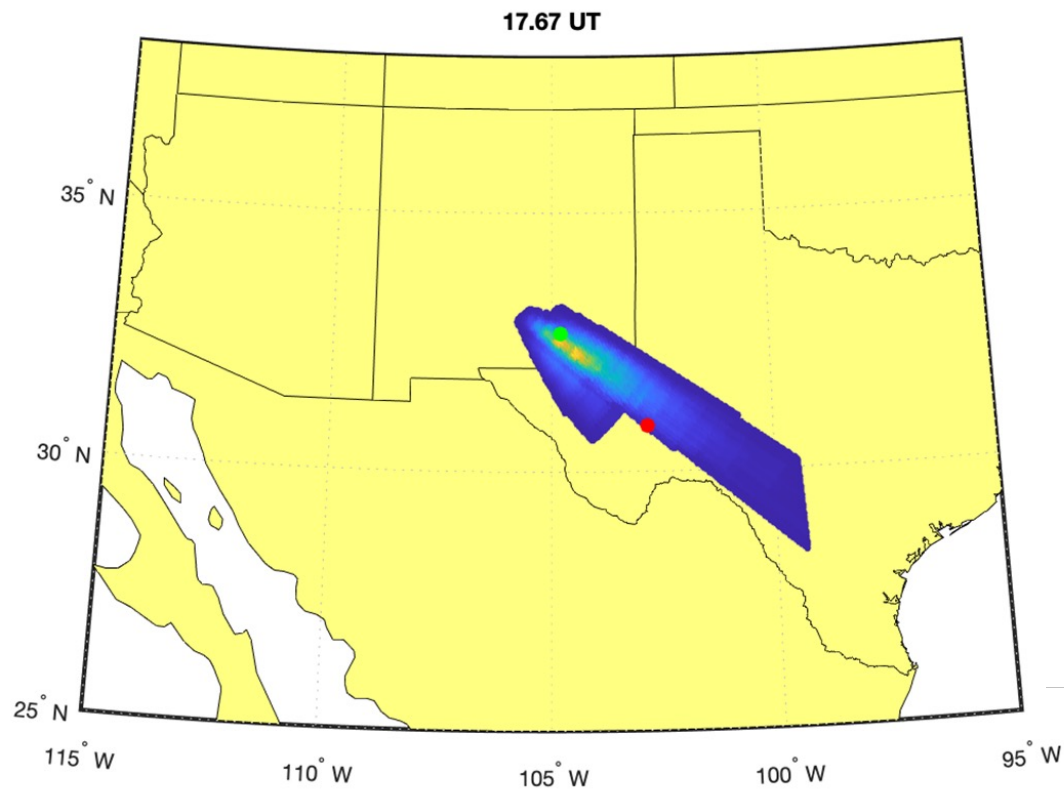


# Es irregularities

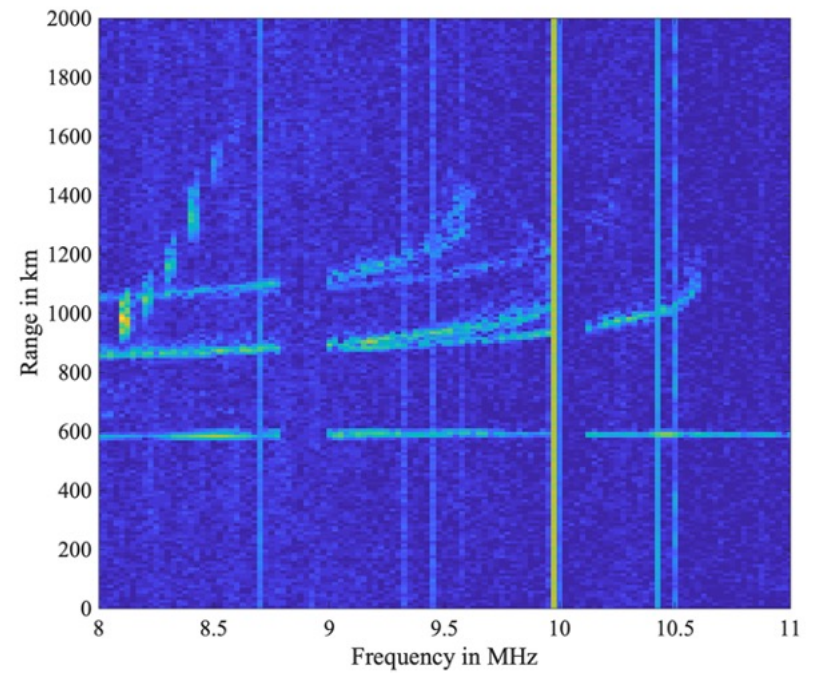
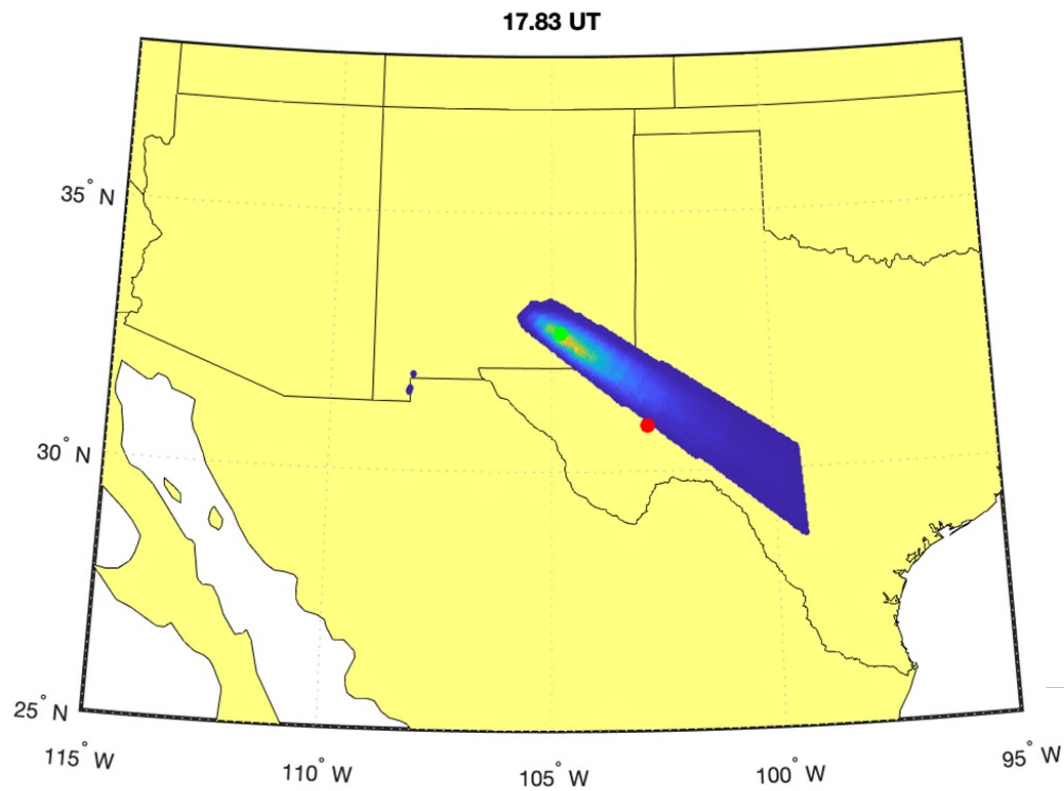




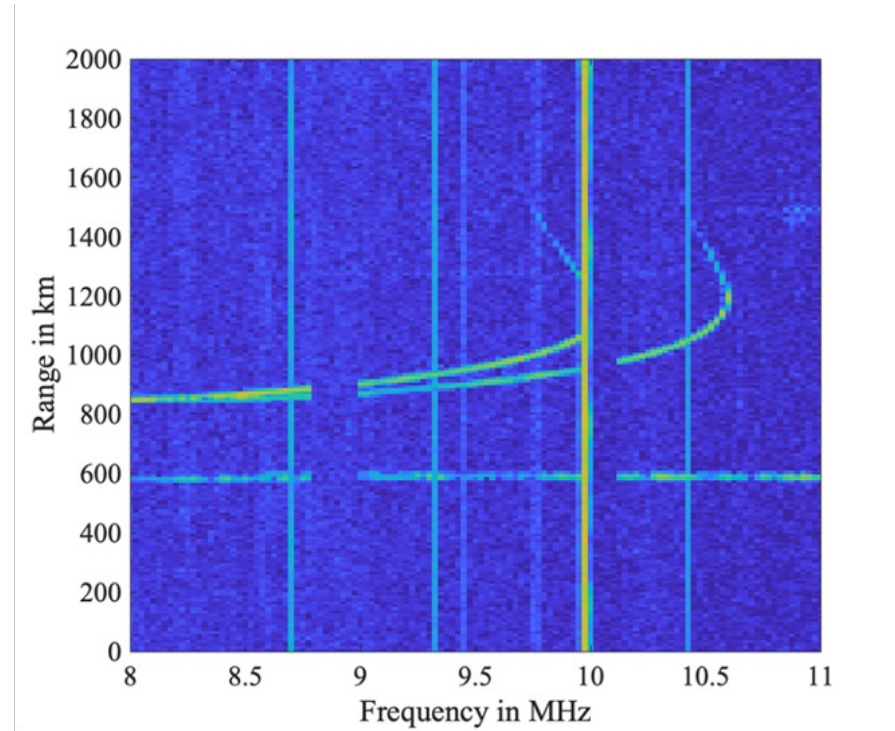
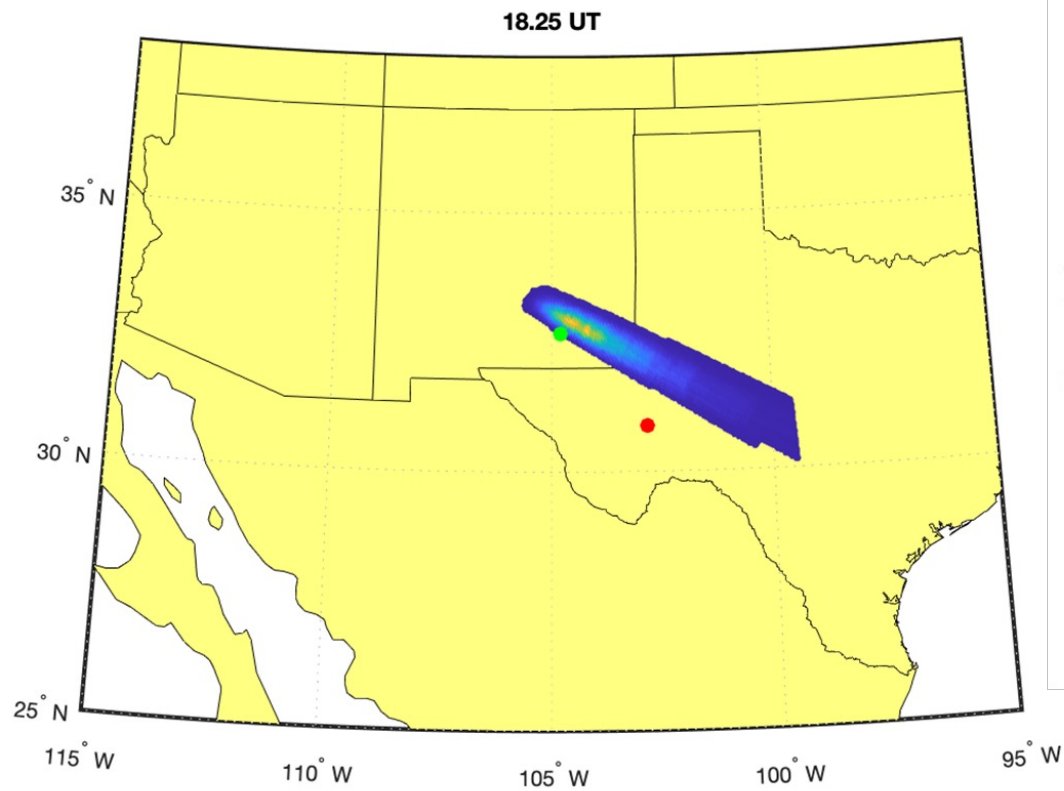
# Es irregularities



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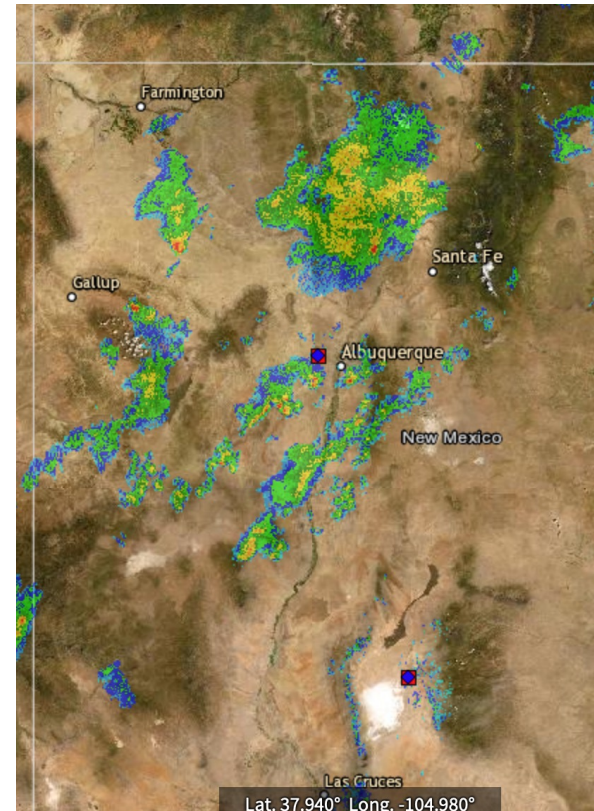
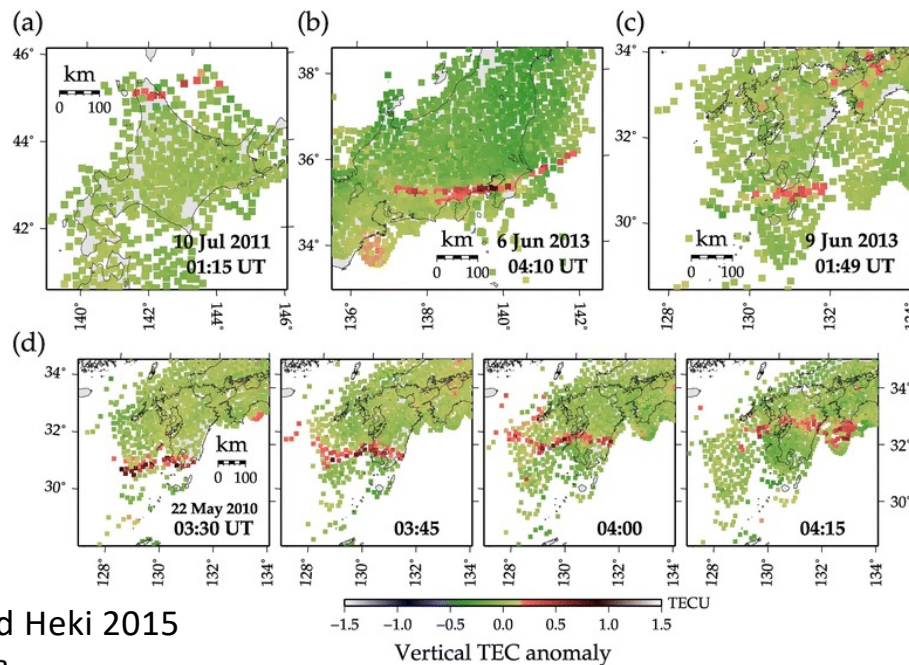


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# Questions?

## Sporadic E – Similar to thunderstorms

Similar to thunderstorms, Sporadic E forms in discrete patches, often propagating fronts. Impossible to predict exact location where it will occur.



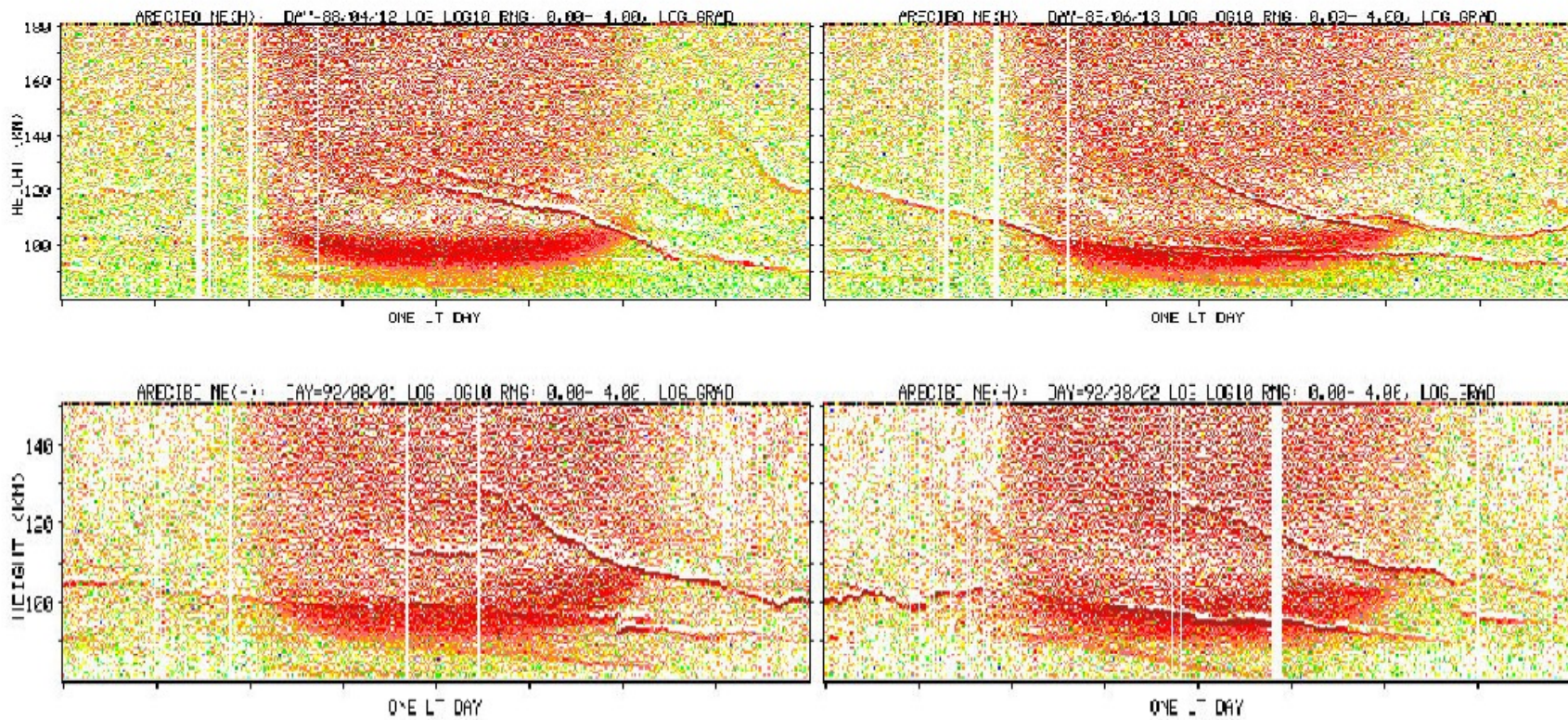
Maeda and Heki 2015

THE AIR FORCE RESEARCH LABORATORY

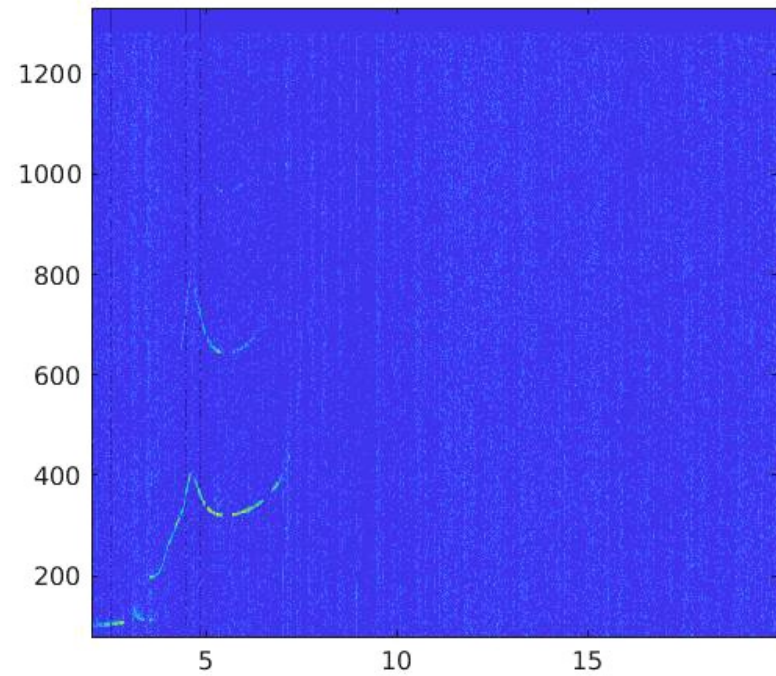
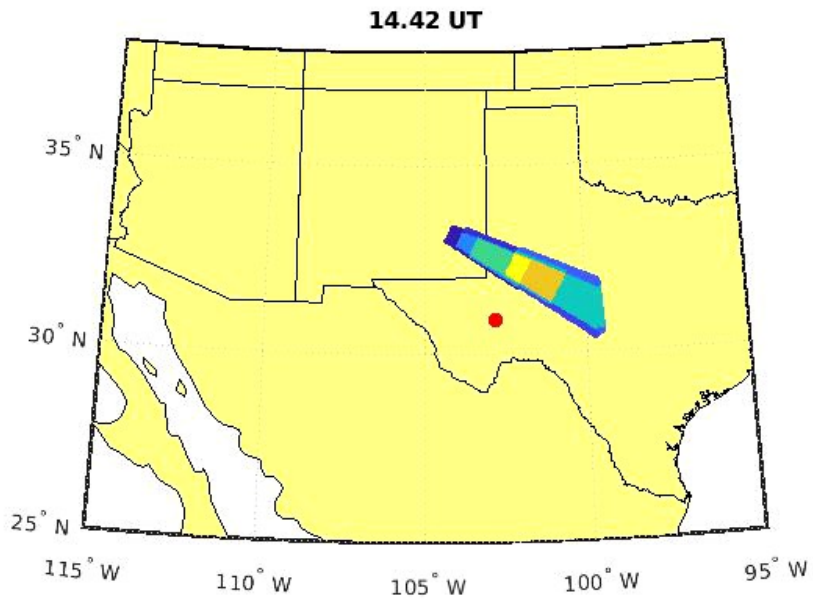
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# Sporadic E Formation

Descending Layers over Puerto Rico - Christakis et al. 2009



June 18, 2022



August 6, 2022

