A blackbox view of incoherent scatter radar

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ISR school
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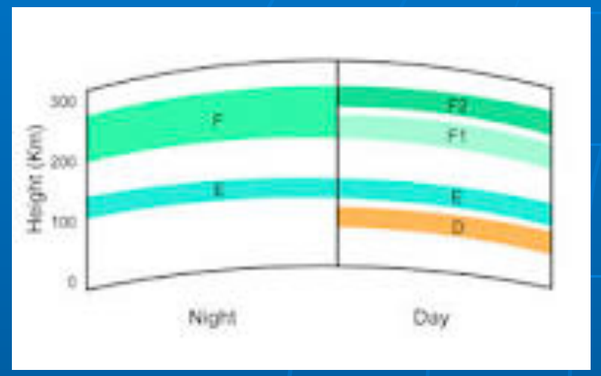
Outline

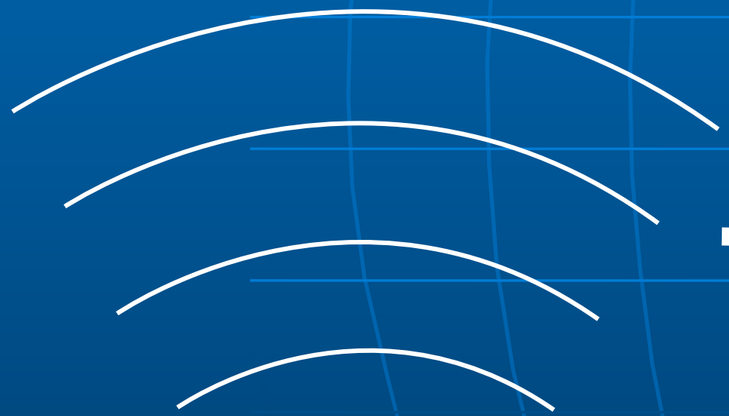
1. Brief discussion of ISR blackbox
2. Group exercises with simulator:
    1. Simulate existing ISR's
    2. Simulate creating a new ISR

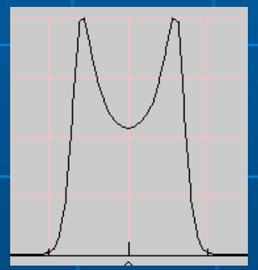
Treat ISR as a blackbox

- What are the science outputs?
- What knobs can you turn at the input?
  - For an existing ISR
  - If you got to build a new ISR
- Try it yourself with two on-line tools
  - Existing and new ISR simulators

Blackbox ISR Outputs







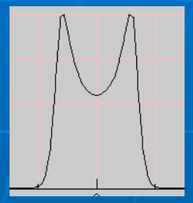
Parameters

- Electron density
- Electron temperature
- One (or more) ion temperatures
- One (or more) ion velocities

Quality of measurement

- Error bar on each parameter
- Spatial resolution
- Time resolution
- Spatial coverage

Nature of ISR measurements

 is a probability distribution, not a signal...

Imaging trying to determine if a coin is fair in a dark room...

Both the number of tries and the chance of mistaking head and tails needs to be taken into account...

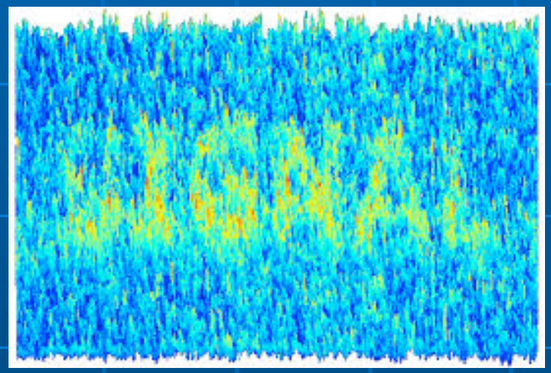
Nature of ISR measurements

What determines the error bar on a measurement?

The number of measurements

and

The measurement S/N



- Flipping a coin in a bright room only one time tells you little (good S/N - small count)
- Flipping a coin a million times in a completely dark room tells you little (poor S/N, large count)

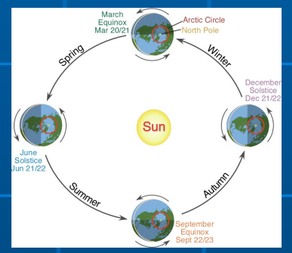
ISR blackbox inputs

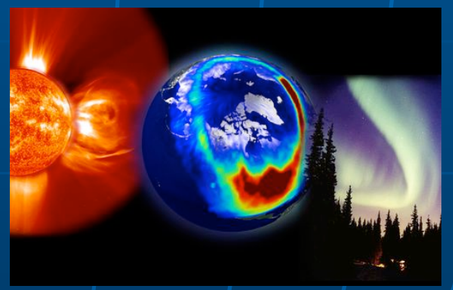
What can an ISR user typically control with an existing ISR?

Pointing direction pattern

Integration period (sets count statistics)

Radar mode (pulse length and coding, interpulse period)



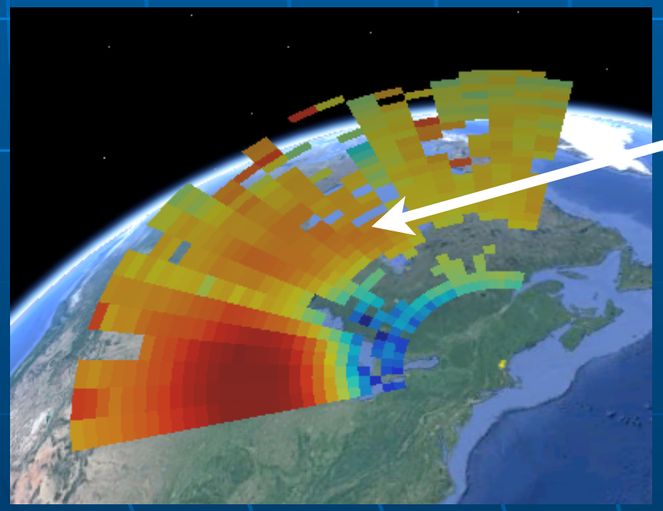


Time of year and solar activity during measurement

Pointing direction (monostatic)

Single direction gives best time resolution

Multiple directions in local area gives vector velocities

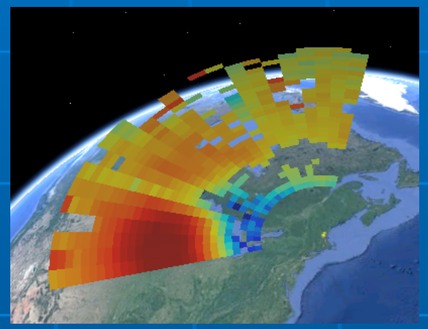


Measurements can be combined into scans

Tradeoff: number of pointing directions versus time resolution

Integration period

For dish antenna with multiple positions, integration periods must be selected beforehand.



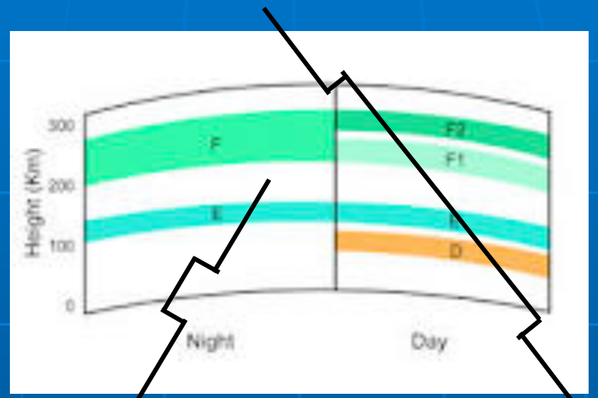
For phased array antenna or single position dish antenna, can be chosen after the experiment is run.

ISR modes - single pulse

Parameters to set:

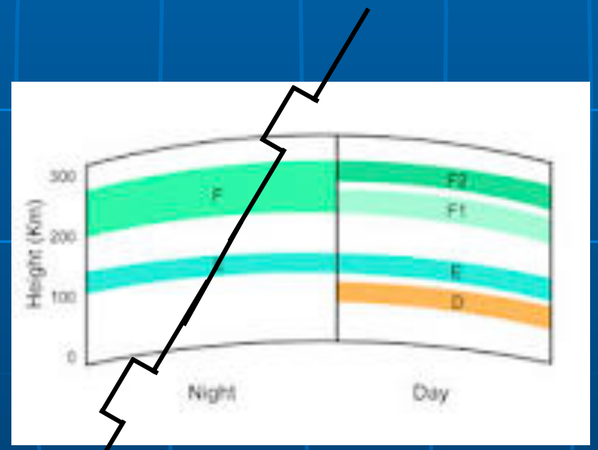
Pulse length

Shorter uncoded pulses:
Better spatial resolution,
worse S/N



Longer uncoded pulses:
Worse spatial resolution,
better S/N

Interpulse period

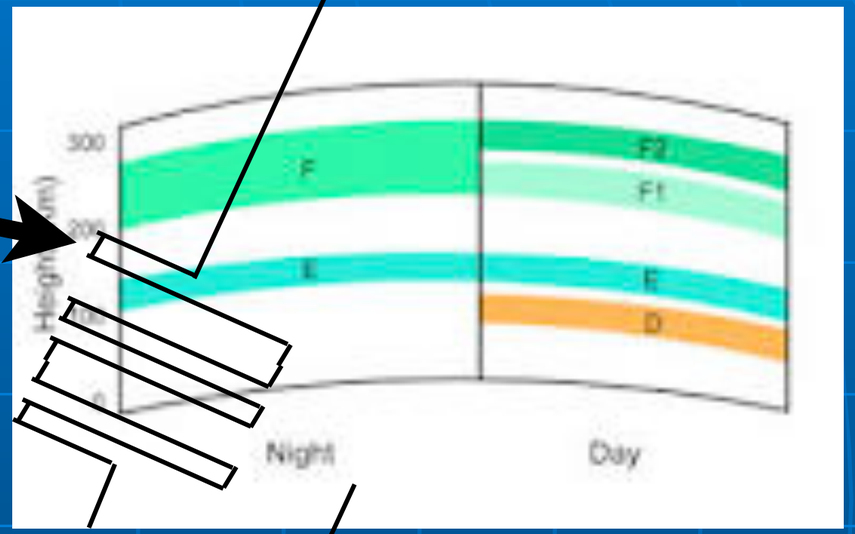


Shorter time increases counts/sec, limited by duty cycle of transmitter and need to have previous pulse not returning signal

Coded pulses - alternating code and barker code

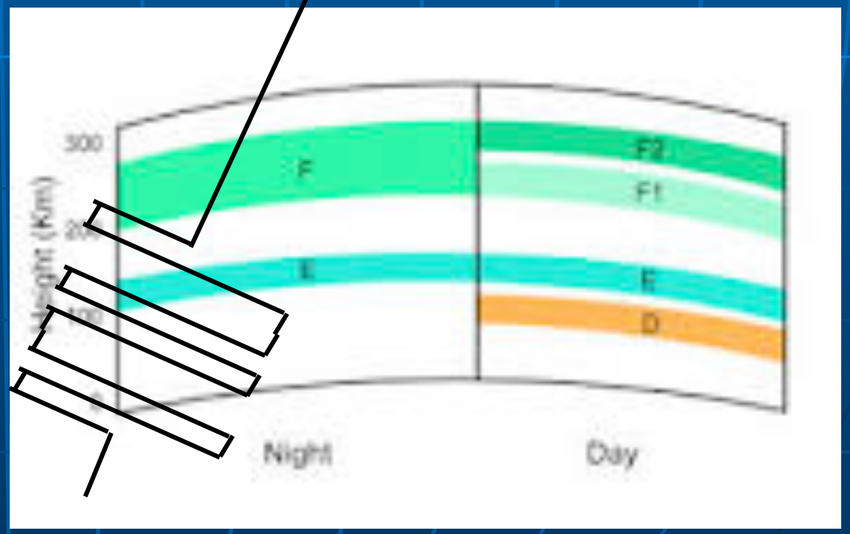
Alternating code - a combined series of phase coded pulses

- Spatial resolution set by baud length, not pulse length
- S/N set by pulse length (but not quite as good as single-pulse)



Barker code - a coded pulse that typically *only returns electron density*

- Spatial resolution set by baud length, not pulse length
- Traditionally shorter baud
- Fewer pulses than AC, but no spectrum



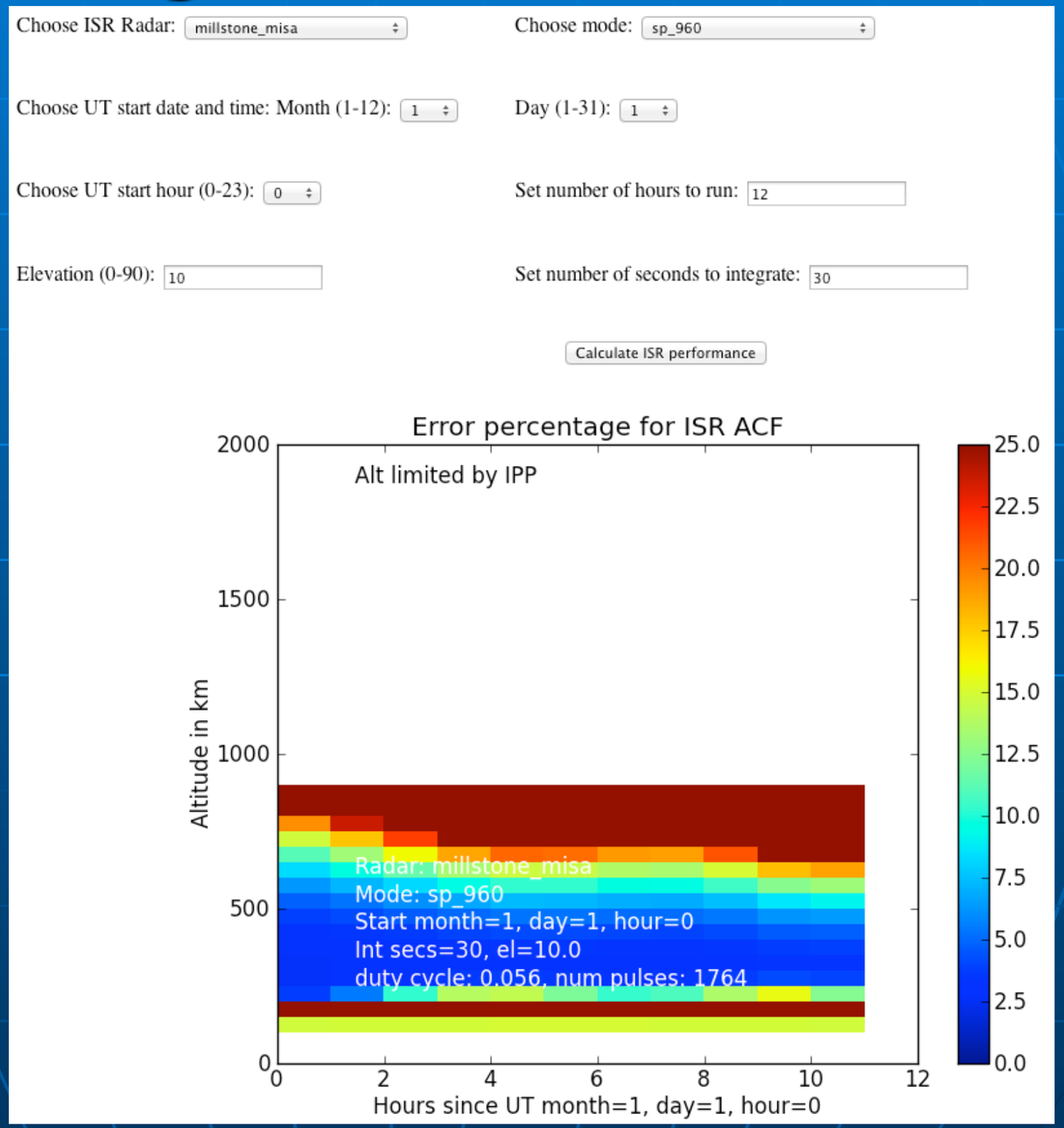
Existing ISR simulator

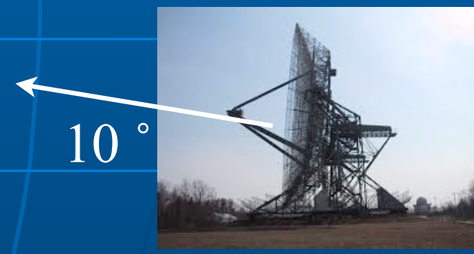
http://tinyurl/2016ISR -> ISR simulator link

Ionosphere generated by IRI model (quiet day)

Full code available (~650 lines of python)

All equations to be covered in rest of this course





ISR blackbox inputs for a new radar

What design decisions affect a new monostatic ISR?

- Radar frequency
- Aperture (m^2)
- Peak power
- Location
- Steering method and range

ISR blackbox - group exercise

Break into groups - Do exercises

http://tinyurl.com/2018ISR ->
See links under Bill Rideout's ISR blackbox talk