

# S U P P L E M E N T

## AN INTERACTIVE ONLINE EDUCATIONAL APPLET FOR MULTIPLE FREQUENCIES OF RADAR OBSERVATIONS

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Name: \_\_\_\_\_

Date: \_\_\_\_\_

### Problem Set 3: Rain/Multi-frequency Radars

You will use the radar simulator found at <http://ethan-nelson.me/radarlabviewer> to develop responses to this activity. The site displays maps and cross sections of reflectivities through a midlatitude cyclone at four different frequencies: S-band, Ku-band, Ka-band, and W-band. First, click the layers button in the top right corner of the map. This allows you to look at surface conditions, overlay winds and modify the layers shown. Now click “Display Horizontal Cross Sections”. This shows maps of reflectivities at various heights in the atmosphere selected using the slider, as well as liquid and ice phase mixing ratios below. Toggle between the various frequencies using the buttons to see how different radars would view the storm. To get a more detailed look at particular segments of the storm, click the “Display Vertical Cross Sections” button. You can change the latitude and longitude sliders to move the locations of the slices. Again toggle the different frequencies to see how each radar would view each slice (latitude on left and longitude on right) and compare against the liquid and ice phase mixing ratios below. Click any of the images to see a bigger version. Feel free to tinker around with the applet a bit and then answer the questions below.

1. Load Case #1. This shows a horizontal PPI cross section of the scene at 10 km above the surface. Click between the W-band and S-band. What differences do you see in reflectivity? Based on the water content plots, are these areas dominated by liquid or ice phase droplets?
  
2. Now load Case #2, which is a vertical cross section through the center of the cyclone. Focus on the right side, which is the meridional cross section. Again alternate between the W-band and S-band reflectivities.

What similarities and differences between the two frequencies do you notice in the upper areas of the cross section? What about in areas of heavy rain indicated by the mixing ratio plots (e.g. at 40° latitude)? Now alternate between Ka and S bands. How do things change if you compare Ka-band to S-band?

3. Focusing now on the left side of Case #2, choose Ku-band or S-band. What do you think is causing the sudden increase in reflectivity near 4 km in height? What do you think this level approximately signifies within the environment? Hint: use the mixing ratio plots to guide your answer.
  
4. The above questions have assumed that you are using radars with ideal sensitivities. Current satellite radars have more limited sensitivities, or minimum detectable reflectivities (MDR), in the Ku-band and Ka-band. Pick a vertical cross section and write down the latitude or longitude you selected. Toggle the radar sensitivities for Ku-band and Ka-band by clicking the "Improved mission MDR shown" button. What features might be missed by this higher MDR?
  
5. Imagine you are a scientist working for NASA and want to observe the spatial distributions of both clouds (smaller water and ice droplets) and precipitation (larger water and ice droplets) using a multiple-frequency radar. You are given a total of \$4 million to create a satellite-based radar, but engineering costs limit the number of frequencies and sensitivity of each one. Additionally, size constraints for the radar dish limit the range of sensitivities available. Using the following table, design your ideal multi-frequency radar to accomplish your goal and explain why you chose this combination.

Frequency \ Sensitivity	S-band 3 GHz	Ku-band 14 GHz	Ka-band 35 GHz	W-band 94 GHz
-30 dBZ	--	--	--	\$2
0 dBZ	\$4	\$3	\$3	\$1
12 dBZ	\$3	--	\$2	--
18 dBZ	\$3	\$1.5	--	--
All quoted prices are in millions of dollars.				

6. What advantages do you notice from using a satellite-based radar compared to the ground-based NEXRAD network? Can you think of any disadvantages?

## Feedback survey on the application

This last section should only be answered once you have completed the activity. The answers you choose will not affect your grade. Your answers will be anonymized prior to analysis.

Reflecting on your knowledge in the topic of radars at multiple frequencies, how would you rate your knowledge *prior* to completing this assignment?

- No knowledge
- Little knowledge
- Some knowledge
- Significant knowledge
- Complete knowledge

Having completed the assignment, how would you rate your knowledge *now*?

- No knowledge
- Little knowledge
- Some knowledge
- Significant knowledge
- Complete knowledge

How much did the horizontal cross sections help in understanding the differences in radars at multiple frequencies?

- No help
- A little help
- Moderate help
- Much help
- Great help

How much did the vertical cross sections help in understanding the differences in radars at multiple frequencies?

- No help
- A little help
- Moderate help
- Much help
- Great help

Overall, how much did this activity help your learning in understanding the differences in radars at multiple frequencies?

- No help
- A little help
- Moderate help
- Much help
- Great help

How easy was the tool associated with this assignment to use?

- Very easy
- Moderately easy
- A little easy
- Neutral
- A little difficult
- Moderately difficult
- Very difficult

How problematic was the tool when trying to use it?

- Very problematic
- Somewhat problematic
- Not problematic

What concept was made clearest by the applet?

What concept is still unresolved for you after completing the applet?

Do you have any feedback for making this activity more useful or interesting?