

Level	Weather Forecasting and Radio Waves	
High School		
Time Required	Lesson Summary	
100 minutes (2 – 50 minute class period)	Students will learn about how weather satellites work and then analyze some of the pictures created from the data. Students will also learn how Doppler radar works. The lesson concludes with students writing a paper about the role of radio waves in weather forecasting.	
Standards		
NGSS PS4.C Information Technologies and Instrumentation Multiple technologies based on the understanding of waves and their interactions with matter are part of everyday experiences in the modern world and in scientific research. They are essential tools for producing, transmitting, and capturing signals and interpreting information.		
Vocabulary	Objectives	
Doppler radar	Students will be able to describe how weather satellites and Doppler radar devices use radio waves to provide weather data.	
Materials		
- RTL-SDR dongle and antenna - Internet access - Student computers		



Pre-Requisites	
Students must be familiar with the electromagnetic spectrum, particularly radio waves.	
Safety Considerations	
None	
Pacing Notes	
This lesson will probably last 2 -50 min class periods. Day 1 – Explanation of how weather satellites work, analyzing weather satellite data, and a class discussion. The article should be assigned as homework. Day 2 – Small group discussion, explanation of doppler radar, doppler radar videos, reading about the interference of 5G. The final paper should be assigned as homework. Be aware that if you choose to do the optional activity where you receive the signal from a weather satellite, it will add time to this lesson.	
Before the Lesson	
Follow the instructions in chapter 4 of the Windows-based technical guide to set up your RTL-SDR to receive transmissions from the NOAA satellites. (optional) Print out student handouts.	
Assessments	Classroom Instructions
Pre-Activity Assessments	Introduction
	As students come in, have them discuss the following question (quietly) with the person that sits beside them. How do people forecast the weather?
Activity Embedded Assessments	Activities
While students are sharing their ideas, listen for four correct ideas that describe	I. Discuss student conceptions of weather forecasting. Ask: How do people forecast the weather? Allow several groups to share their ideas. If students don't back up their ideas with



how the weather is forecasted. First, satellites and radar are used to detect the environment. Second, observations are made by both professional and amateur observers. Third, this information is put into a computer that uses the data to predict the weather.

If a student mentions one of the above, acknowledge it. If students are close to one of these ideas but not entirely correct, ask a series of questions to guide the conversation in the right direction.

If students do not reach these points, mention them before moving on to the next activity.

evidence, ask them how they reached that conclusion.

Say: Before the invention of radar and satellites, weather forecasting was done through local observations, which were shared with other locations through the telegraph or the telephone. Where communications were impossible, there were no advanced warnings of approaching storms. Current technologies have significantly increased the reliability of weather forecasting and have saved many lives.

1. Scan for weather satellites (optional)

At this point, it would be great if you could take your class outside and scan for one of the NOAA weather satellites. However, this is not required because it could be difficult due to your location.

You must be outside to receive the signal and have a clear line of sight to the spot where the satellite should be on the horizon. If there are obstructions, such as buildings or a forest between you and where the satellite is, you will not be able to receive the signal. This web page provides the information about the location of the satellite from your location, <https://www.n2yo.com>. (last accessed 6/24/23) Select a specific satellite, and as long as you have entered your current location,



the program will tell you when it will be passing your area and where it will be located on the horizon. If you have a good location follow the instructions in chapter 4 to receive and image the signal. You can save the map created by the Wxtolmg software and share that with your students later.

Since you can save the weather map created from the signal, you could do this activity outside the school day if you are inclined.

A word needs to be said about the antenna included in the kit and weather satellites. While the monopole antenna can receive the signal, it is not the best antenna for the job. You will find the weather map made using the data from this antenna is of lower quality. If you wish, you can construct a better antenna by following the instructions in the Educator Resources section of this document.

2. Explanation of how weather satellites work

Explain how weather satellites work to your students. You may use any instruction you choose, but please include the following information.

- Large rockets take satellites into outer space and release them
- The satellites have thrusters that allow people on Earth to direct a satellite into the correct orbit
- The satellites send collected data to Earth as radio waves, antennas on Earth receive the radio waves and visualize the data
- There are polar-orbiting satellites and geostationary satellites
- Polar-orbiting satellites collect data from the entire planet twice daily
- Geostationary satellites stay in the same place and provide data from the same location on Earth every 5-30 minutes
- A geostationary satellite can take pictures more often but of a smaller area. This is done in the case of storms that need close monitoring.
- There is a list of links with more information in the Educator Resource section of this document.

3. Analyzing weather satellite data

Say: Now, you will have the opportunity to analyze some of the data collected by weather satellites.

Hand out the activity sheet and give students time to read the directions.

Ask: Are there any questions about what you are going to do?

Allow students time to complete the activity in pairs or small groups.

As you are explaining how satellites work, pay attention to your students. Are they engaged?

If not, ask a question that requires them to explain something you just said.

If your explanation is long, consider giving students a brain break somewhere in the middle.

While students are working, walk around and observe their work.

Ask: What did you just do? What do you need to do next?



Ask: Do you think that image is useful?
Support your answer with reasoning.

Ask: Why did you label your picture this way? Share your reasons with me.

Ask: Is there something I can help you with?

Observe students; are they all engaged in the discussion?

If you see a student that is not engaged, direct the following question to them.

Walk around during small group discussions.

Ask students to explain the answers they

4. Class discussion

At the end of the activity, conduct a short whole-class discussion about what they discovered.

Ask: What was the most surprising thing you learned from this activity? Why were you surprised?

Ask: How important do you think these images are to weather forecasting? Why?

Ask: Do you think all the images are necessary, or could there be fewer and still get the same results? Why?

5. Professional article reading

<https://eos.org/science-updates/transforming-satellite-data-into-weather-forecasts>
(last accessed 6/24/23)

Students need to read authentic science publications. The assigned reading was published in a peer-reviewed journal. That means that other academically minded people read this paper and found no major flaws in the logic presented.

Explain the above to students before assigning the reading. It would be beneficial for students to have this article printed out. This would allow a student to underline, circle, and write in the margins. Please encourage students to create a list of questions about things they don't understand as they read. Explain to students that this reading will be challenging for everyone and that it is okay to admit they didn't understand something.

6. Small group discussions

After students have completed the reading and questions, have them meet with a group of their peers to discuss what they read. Students will need to be vulnerable during this discussion by admitting what they didn't understand. Therefore, individuals must be comfortable with the students in their groups. This might be a good time to allow them to select their group.

Please encourage students to talk about the parts of the paper they didn't understand before they start talking about the questions.



provide.

If students' logic is faulty, gently guide them to the correct answers.

As the videos are playing, walk around and monitor students. If you find a student, who is not actively writing answers on their page, redirect them to the questions. If the student still doesn't answer questions, speak to them after class. Determine if there was an acceptable reason for the student not participating.

7. Explanation of doppler radar's role in weather forecasting

Now explain to students that meteorologists don't just use satellites to forecast the weather. Tell them that another technology, doppler radar, is used to supplement the information provided by the satellites. Both satellites and doppler radar use radio waves to send and receive information. While satellites supply forecasters with images from above, doppler radar provides information from a platform placed approximately 100 ft from the ground.

8. How radar works video

The following videos explain how doppler radar works. By watching these videos, students should understand how this technology helps weather forecasters.

Distribute the student sheet before you start the video. Be aware that this page contains questions on the video and questions accompanying the reading.
<https://www.youtube.com/watch?v=NZ7rNeQck2A> (last accessed 6/24/23)

This first video is only 3 minutes, but the man provides a lot of information because he talks quickly. You may need to play this video more than once.

<https://www.youtube.com/watch?v=ISwbh4F50dY> (last accessed 6/24/23)

This video gives students a tour of a National Weather Service Radar station.

<https://www.youtube.com/watch?v=GVSRY5wmEOY> (last accessed 6/24/23)

This last video is longer than the other two but provides information not included in the other two videos.

Since some students struggle to pull information out of videos, you may want to review the answers to the questions after all videos are finished. Alternatively, you could give students a chance to ask about things they missed during a large group discussion.

9. Reading about 5G's interference with satellites.

Students should read the short article which describes how the desire for 5G cell phone coverage may impact weather forecasting.

<https://www.9news.com/article/weather/weather-colorado/interference-5g-weather-forecasting/73-a0b30746-33f4-45ef-bca7-a7bf8dd9bbc4> (last accessed 6/24/23)

Grade student papers to determine if they understand how radio waves affect weather forecasting.	After students have finished the article, ask the following question and allow as many students as possible to give their opinion. Ask: Is it more important to have 5G cell phone coverage or accurate weather forecasting? Support your response with reasoning. 10. Have students write an explanation of how people forecast the weather using radio waves and the benefits, and how 5 G could affect it
Post Activity Assessments	Closure
	To end this lesson, have students write a 1-2 page paper. This paper should describe the role of radio waves in weather forecasting. In addition, students should describe how interference from other users may affect future attempts at predicting the weather. Finally, the papers should conclude with an estimation of what could occur if weather forecasting is affected by a lack of information from satellites.

Accommodations

Make any changes necessary to meet students' IEPs.

If you don't have computers, the data from the weather service can be downloaded in advance. In addition, the articles can also be obtained in advance.

Educator Resources

Information on how weather satellites

https://www.nasa.gov/directorates/heo/scan/communications/outreach/funfacts/txt_satellite_comm.html (last accessed 6/24/23)

<https://www.weather.gov/about/satellites> (last accessed 6/24/23)

<https://eos.org/science-updates/transforming-satellite-data-into-weather-forecasts> (last accessed 6/24/23)

A fantastic site that provides information about radar in written form

<https://www.weather.gov/jetstream/how> (last accessed 6/24/23)

Building an antenna

The technical guide included on this web page contains information on building an appropriate antenna.

Additional information can be found here:

<https://www.rtl-sdr.com/rtl-sdr-tutorial-receiving-noaa-weather-satellite-images/> (last accessed 6/24/23)

Optional Extension Activities

If you would like the students to know more about specific NOAA satellites, have them investigate the information on this web page. <https://www.nesdis.noaa.gov/current-satellite-missions/currently-flying> (last accessed 6/24/23)

Acknowledgments

This is the seventh lesson in a nine-lesson series intended to increase student understanding of radio frequencies. You are welcome to just use this lesson but if you are interested in this topic consider checking out the others in the series.

Lesson One: Mechanical Waves

Lesson Two: Electromagnetic Waves

Lesson Three: Electromagnetic Spectrum

Lesson Four: Argumentation and Radio Waves



Lesson Five: Investigating Spectrum Users

Lesson Six: Aircraft and Newton's Second Law of Motion

Lesson Seven: Weather Forecasting and Radio Waves

Lesson Eight: Satellites and Society

Lesson Nine: Spectrum Management

The creation of the lessons in this series was funded by a generous grant from the National Science Foundation (NSF). The lessons were created as part of the National Radio Dynamic Zone (NRDZ) project at the National Radio Astronomy Observatory (NRAO).