Bringing Space into Your Classroom

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Space borne technology affects many things in our daily lives from telephone and television communications, to national security, to scientific research, to weather forecasting, to protection and husbandry of the environment and natural resources, to providing the location of your car when you have a flat tire and need help. It is important for our students to study space and space borne technology so that they can use this technology more effectively to enrich their lives. Also, if you are looking for something that cuts across curricular lines, something that connects multiple content areas from geography and geology, from physics and environmental studies, from the science of radio to the science of space … bringing space into your student's learning experience just might be for you. I suspect that you think that bringing space into the classroom has to be expensive and requires advanced and sophisticated equipment, but you would be wrong. My purpose in this article is to illustrate a four-step approach that will allow you to bring space into your student's learning experience incrementally, at a level of rigor that is appropriate for your student, and at cost that is certainly affordable.

The four incremental building blocks that you can use to bring space into the classroom include:

1. A computer and satellite orbit prediction software
2. Adding a receiver to receive signals sent by satellites
3. Adding display software that will display imagery sent by certain satellites
4. Adding a dedicated satellite receiver and antenna for a quality satellite ground station

Step 1

Bringing space into your classroom begins with obtaining a computer and installing satellite orbit prediction software so that satellite positions and tracking are displayed in the classroom. The computer does have to be the latest and newest, high-powered computer. Many older models that have been retired will do just fine. Satellite position prediction is fundamental to using space borne technology and provides many learning experiences for students. Predicting satellite locations used to be done with tedious mathematic calculations, but for years, computers have been used to do the chore. Some of the more capable prediction software packages can be purchased for modest costs but many free computer programs are available from web resources are for various computer platforms. [1]

When you have the computer with the satellite prediction software loaded just follow these steps to get started:

Update the computer's internal clock to the correct time. Though not absolutely necessary, the correct time is required for accurate position predications. [2]

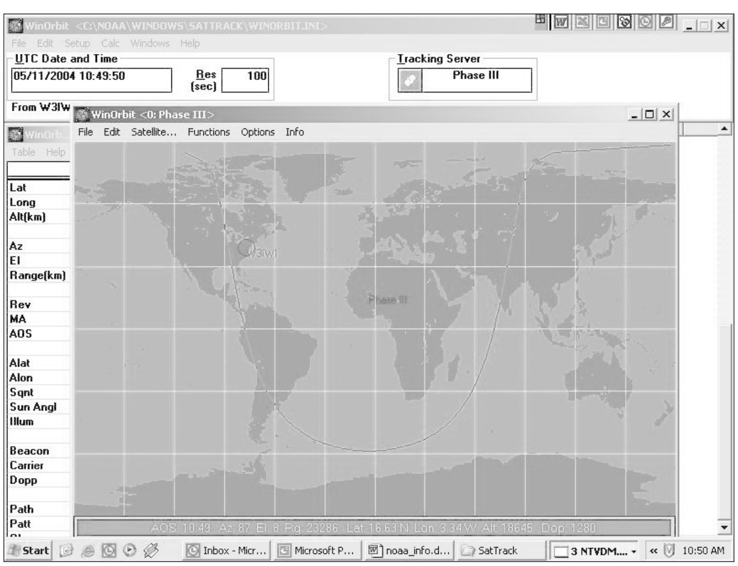


Figure 1: The typical display of orbital predication software. This is a freeware software package showing the orbit and position of a satellite.

Update the Keplerian elements. The Keplerian elements are the mathematical parameters used by the formulas in the predication software to calculate the satellite position. Up to date Keplerian elements are available from Web sites. [3]

Select the satellites you would like to track. The international space station (ISS) and Hubble space telescope are interesting to students, but also there are NOAA low orbiting weather satellites, ham radio satellites, Global Positioning Satellites and others that will interest students. You might have the students select a satellite as "their" satellite and have them research and write a report on their satellite. You might consider choosing satellites in different kinds of orbits so that the students can learn why various orbits are used to accomplished different tasks or satellite missions.

Once the system is set up, just let it run. It does not require on-line access, the software and computer operate stand-alone and the computer continuously calculates the selected satellite positions and updates the computer display. Figure 1 is an example of the type of display that you can expect from free satellite prediction software. The software that I recommend is called NOVA, but it costs around $50. The graphic display is more detailed and there are other valuable tracking features. Figure 2 is an example of the type of display using NOVA.

Many students have the impression that satellites orbit the earth in a wavy or sine wave motion because this is how satellite orbits are typically displayed. However, the satellites actually orbit in an elliptical orbit (almost circular) and the earth turns underneath the satellite as it orbits. On a flat map display, this results in the apparent sine-wave track. One feature I like about the NOVA software is that you can select a view of the earth from space, which gives a more 3-D view of satellite orbits (see Figure 3). In this view the students can see a more realistic orbital track, and the fast forward button advance the satellites in quick time to better illustrate the orbital track.

There are a number of learning topics that can be addressed by this first step in bring space into your classroom (see Table 1).

Step 2

Many of the satellites send out signals on frequencies that can be received on a standard police scanner receiver. In particular, the NOAA low orbiting satellites send out very strong and distinctive signals on frequencies 137.50, 137.62, 137.10 MHz. In this step, simply place a police scanner

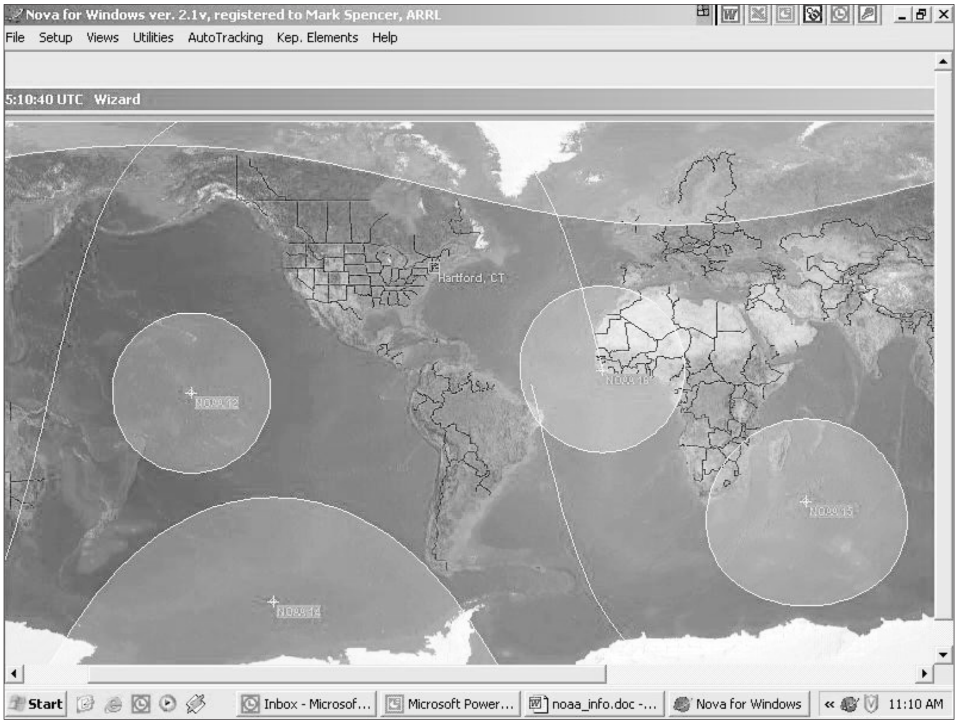


Figure 2: The display of satellite positions and orbits using a program called NOVA (approximately $50).

that is tuned to the appropriate frequencies next to the computer. An outside receiving antenna helps, but it is not necessary for this step. When the NOAA weather satellite comes within range of your classroom, the students will hear the bing-bing-bing of the satellite come up out the receiver background noise, and as the satellite goes beyond the horizon, the bing-bing-bi…. will stop. The satellite sends a weather picture using the varying audio tone that sounds like bing-bing-bing.

With satellite signals as a backdrop, the students can now learn about satellite hardware and sensors, how they are powered, what information they collect, how is that information sent down to earth, where are these satellites looking and why, and more. Table 2 illustrates just a small sample of the instructional concepts that can be covered with listening to signals from space.

Step 3

Now this is where bringing space into your classroom starts to really get exciting. In this step you add some display software that will take the bing-bing-bing and turn it into pictures of earth that are transmitted by the satellites in space. Sure, there are lots of weather images available from the Web, but there is nothing more exciting, nor satisfying, than receiving the pictures directly from the satellites as they pass overhead! And I can't believe that the imaging software is free!

To display satellite imagery you will need a computer with more capability than required in Step 1, but the computer needed is becoming the standard computer now days and you may already have the computer in your classroom. Download a program called WXTOIMG (which stands for weather to imagery) from the site on the Web site. [4] You can purchase an upgrade for the WXTOIMG software if you desire, but the free version provides ample capabilities for your students. Once the software is installed and set up (with your location and updated Kepler data), connect the receiver audio to the computer sound card. Now when the satellite is within range, the bing-bing-bing will be translated into a weather picture, line-by-line. Figure 4 shows an example of a weather image received this way.

For various reasons, which could be discussed with your student and are excellent learning opportunities, the police scanner is not optimized to receive signals transmitted from space and the resulting imagery is degraded. However, the imagery is very useful to show the student what is actually being collected by the satellite and transmitted. An image using the visual spectrum is sent side-by-side with the image using the infra-red spectrum. The WXTOIMG software adds the map display that provides excellent reference points for the imagery. Your location would be displayed with an "X".

Now with this imagery in your student's hands, they can explore the environmental sciences along with the physical sciences and physics of space borne technology. Table 3 lists just a few of the instructional concepts that can be added in this step.

Step 4

Because of the science of radio signals that originate in space from transmitters moving at high speeds, the signal characteristics

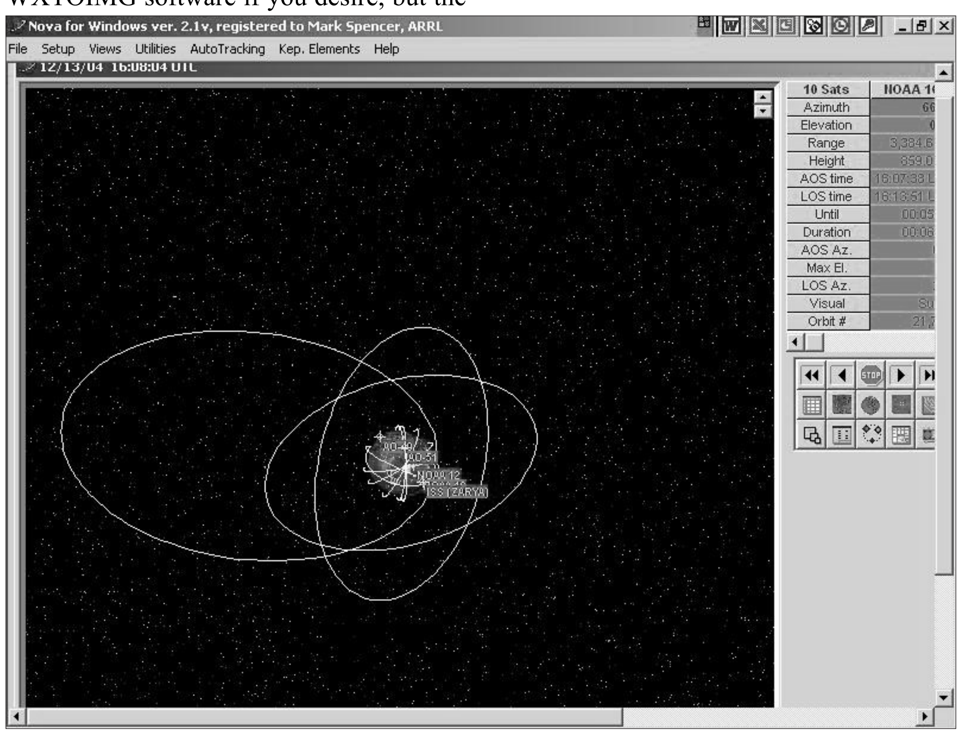


Figure 3: Three-dimensional view of orbits using NOVA software. This gives the student a different, and more realistic, perspective of satellite orbits.

Table 1: Instruction Concepts for Step 1	
Geography	Kinds of Orbits
Geopolitical Boundaries	Argument of Perigee
Periodicity	Argument of Apogee
Map Projections	Descending/Ascending Nodes
Line of Sight	Elevation
Acquisition of Signal	Inclination
Loss of Signal	Increment
Location of Satellite	Etc., etc., etc. …
Satellite Track	

Table 2: Instructional Concepts for Step 2	
Frequency and amplitude modulation	Signal acquisition
Amplitude versus gray scale	Signal strength
Video synchronization	Signal fading
Digital encoding	Signal polarization
Timing pulses	Path loss
Doppler shift	Etc., etc., etc., …

require receiving equipment designed for the purpose. Though you can hear the satellite signals with a simple police scanner, Doppler shift and signal bandwidth requirements degrade the quality of the signal received with a police scanner (understanding both of these concepts are good learning opportunities for students). With a little investment in a receiver designed to receive satellite signals there is dramatic improvement in the quality of the signals received and the real power of the WXTOIMG software and satellite pictures really comes into focus. A satellite receiver isn't as expensive as you might think. The typical receiver (an example is depicted in Figure 5) costs approximately $250. An outside antenna designed to receive signals from space also helps improve signal quality. I built a very good antenna from parts available from the local hardware store (shown in Figure 6). [5] A local ham radio operator could be a valuable resource to help with antenna construction and station set-up.

With quality signals, the imagery displayed by WXTOIMG is top notch. There is a ton of information now at the student's fingertips (or mouse pointer) to be explored. There are readouts of latitude, longitude and temperature at the location beneath the mouse pointer. The imagery can be enhanced to emphasized different phenomena such as sea-surface temperature, precipitation, vegetation, visual or infrared spectrum, etc. Additionally, the imagery can be displayed with different map projections or sequential images can be combined to create a composite mosaic of images covering a greater geographic area. The potential for study and learning with this tool is without limit. The accompanying Figures 7 through 13 illustrate some of the potential learning opportunities available to you if you bring space into your classroom. Let your student's imagination dictate what they can do with the images they get from space through their satellite station.

Available Resources

There are some very good resources available to help you bring space into your classroom. An excellent on-line (and free) curriculum resource is located at: http://octopus.gma.org/surfing/space.html. There is a very good on-line course that can be used in your classroom that is located at: http://rammb.cira.colostate.edu/visit/topic_sat.html and http://cimss.ssec.wisc.edu/satmet/CourseInfo/about.html.

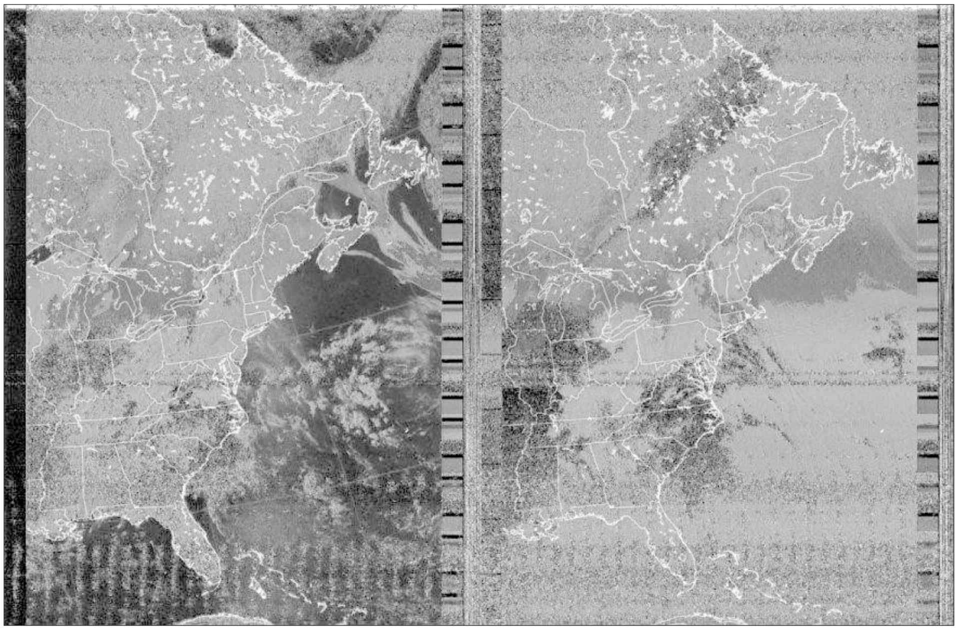


Figure 4: The imagery received using a police scanner receiver. The visual and infrared images are displayed side-by-side. Noise, static, and degraded signals prevent clear images, but the images are usable for instructional purposes.

There are free resources available to help with basic electronics, wireless technology and the science of radio at: http://www.arrl.org/FandES/tbp/ and http://www.arrl.org/FandES/tbp/Curriculum-Materials.html. You are also invited to contact the author and request a CD-ROM packed with resources that will stimulate ideas to bring space into your classroom. The author can be contacted by mail: Mark Spencer, WA8SME, ARRL Education and Technology Program Coordinator, 774 Eastside Rd., Coleville, CA 96107; by e-mail at mspencer@arrl.org; by phone (Pacific Time Zone) 530-495-9150.

References

[1] DOS Satellite Tracking Programs: http://www.amsat.org/amsat/ftpsoft.html#pc-trk Windows Satellite Tracking Program: http://www.amsat.org/amsat/ftpsoft.html#win-trk

[2] Update computer clock to correct time: http://www.boulder.nist.gov/timefreq/service/its.htm

[3] Update software with current Keplerian data: http://www.space-track.org/perl/login.pl

[4] Download display software from: http://www.wxtoimg.com/

[5] Ralph E. Taggart, *Weather Satellite Handbook*, 5th Edition, American Radio Relay League, Newington, CT, ISBN: 0-87259-448-3, pgs. 2-9 through 2-11.

Table 3: Instructional Concepts for Step 3

Geography	Resolution
Geology	Gray scale
Geo-political boundaries	Calibration curves and data
Remote sensing	Latitude/longitude
Weather phenomena	Bandwidth and data throughput
Infrared spectrum	Map projections
Visual spectrum	Etc., etc., etc., ...

Figure 5: Example of a dedicated satellite receiver.

Figure 6: A simple, but effective, satellite receiving antenna can be made from materials purchased from your local home improvement store. The antenna is unobtrusive, lightweight and easily installed on a rooftop.

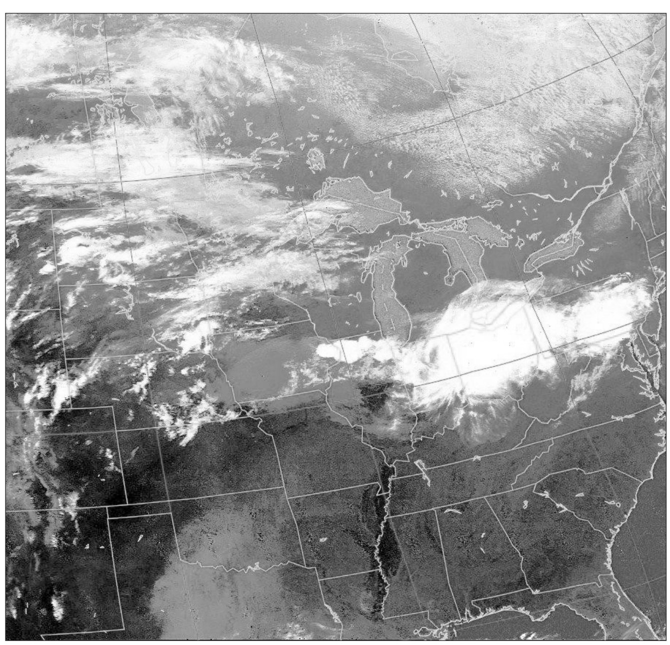


Figure 7: The imagery produced with a satellite receiver is a big improvement over the police scanner. The WXTOIMG software produces a multi-spectral display and colorizes the imagery for better interpretation. Here the oceans are blue, vegetation green, and various cloud levels shades of gray through white. Note the cloud mass over Ohio.

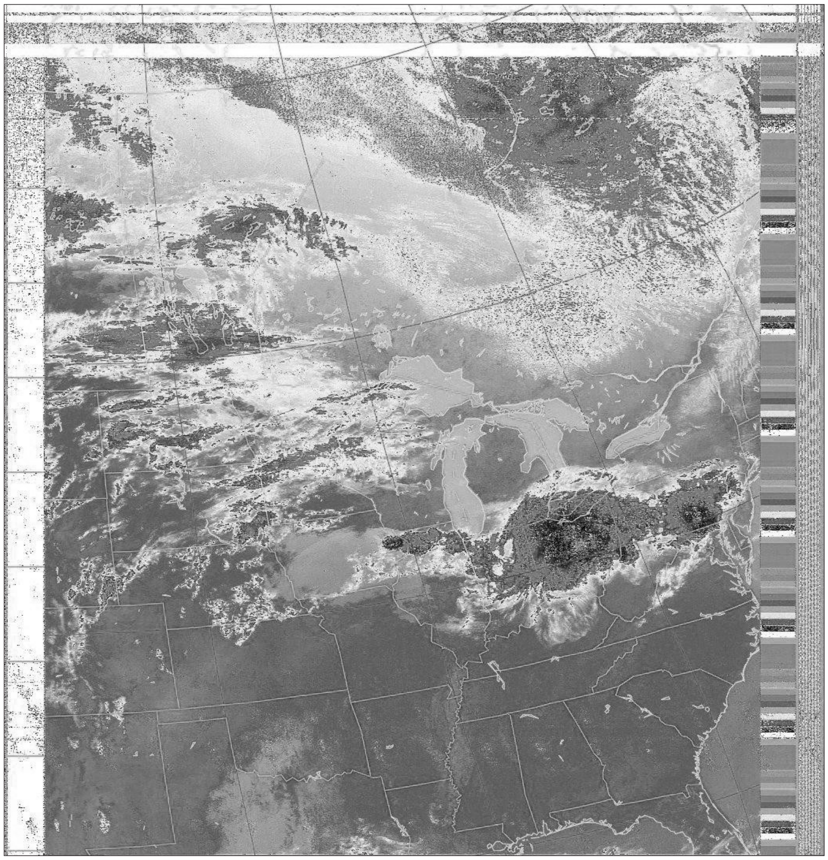
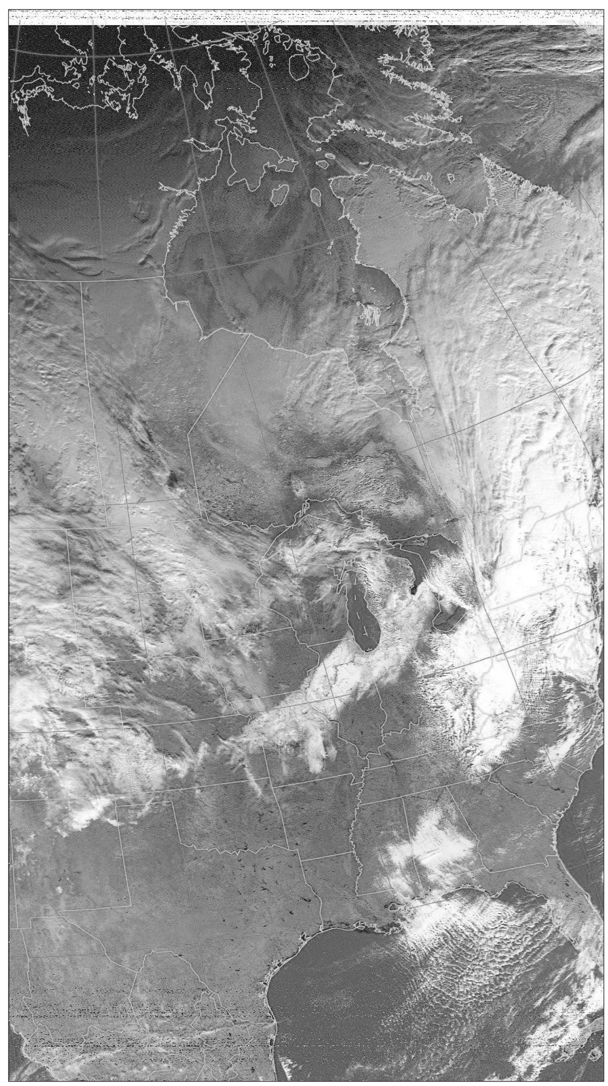


Figure 8: The same image with areas of precipitation enhanced. Note that those clouds over Ohio are actually some very intense thunderstorms.

Figure 9 (right): This imagery on Thanksgiving shows a band of snow cover over Illinois and Indiana from a passing cold front. Placing the mouse cursor over the snow covered area showed the surface temperature to be near zero degrees centigrade, cloud cover is typically well below zero degrees centigrade.



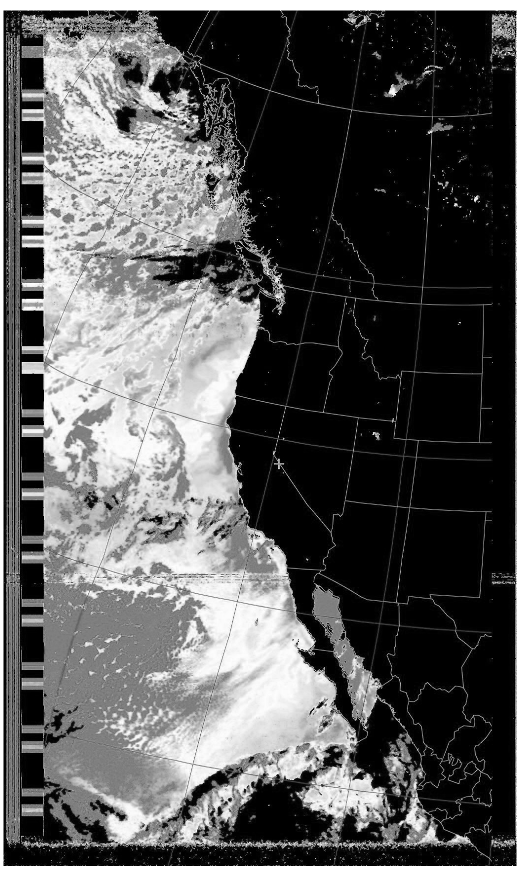


Figure 10 (left): A west coast image with sea-surface temperature enhancements. Notice the warm water in the Gulf of Baja (hard to see in black and white - Ed.). Students can plot sea currents by using the temperature measurements under the mouse cursor.