



Navigating Around Antarctica!

Overview

This lesson allows students to consider navigation around Antarctica, where longitudinal lines converge at South Pole. Through this study, students should learn about polar stereographic projection, satellites, navigation using various instruments, Antarctic geography, and NASA's Operation IceBridge airborne mission. In the first part of this 55-80 minute lesson, students will be faced with a dilemma. Their task will be to navigate from an unknown location on the ice in Antarctica, to a field camp, using coordinates and various instruments. Added challenge arrives when they pass the 88th parallel, beyond the reach of many satellites. Students will build a plan that includes grappling with latitude / longitude. In the second part of this lesson, students learn how planes navigate near the Pole, beyond the path of many satellites. Students will also examine how time zones change as we circle the Pole.

Objectives

Long-term Learning Target: I can navigate near the Poles of the Earth using various geographic skills and instruments

Supporting Targets: I can use longitude and latitude to find a location and plan a route I can use different instruments to establish heading with or without satellite coverage I can navigate between and discuss time zones near the poles I can navigate beyond limitations in instruments near the poles

Lesson Preparation

Details

- Lesson
- Antarctic
- About 1 period
- Download and Share
- Middle School and Up

Materials

Student notecatcher
Image sets from Operation IceBridge
3 maps
Laptop computers
GPS device (optional but recommended)
Compasses (optional but recommended)

Standards

NGSS Standards

- Make copies of attached materials in **Navigating Around Antarctica Resources**.

This PDF includes:

- Student note catcher
- Color copies of image set from OIB (also provided as slides)
- Copies of 2 maps of Antarctica
- Copies of 1 polar stereographic projection - Summative Assessment Questions - Lesson Scoring Rubric

- Laptop computers with internet
- GPS device (optional but recommended - could be on a smartphone)
- Compass (optional but recommended - could be on a smartphone)
- Purchase a detailed map for the class (optional but recommended)
(suggestion: <http://www.natgeomaps.com/antarctica-map-8644>)

MS-ESS3-2 Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects.

MS-ESS1-3 Analyze and interpret data to determine scale properties of objects in the solar system.

HS-ESS3-6 Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.

Procedure

ENGAGE (5 min. or less) DO NOW: What are some ways to navigate? Think about navigation on the Earth using the position of the sun or the stars, and also with modern instruments. Write your thoughts on the note catcher. Discuss your ideas with your tablemates.

GRAPPLE (15-20 min.) Scenario: You wake up someplace in Antarctica in the southern spring. You are lying on the ice dressed warmly, with a small leather satchel next to you. The satchel contains a GPS with good batteries, a map of Antarctica, a compass, a watch, a dozen stakes, a length of rope, some nutrition bars and a note from your friend with coordinates of her camp on the ice ($89^{\circ}15'31''S$ $170^{\circ}25'10''W$). The visibility is fairly good, the sun is up and it is spring. There are a pair of skis, poles and boots next to you.

Your task: Find and travel to your Friend's camp! Make a plan to determine where you are and where you need to go. Draw your plan on the maps provided (Antarctic Map #1 and Polar Stratigraphic Map #3) including labels for all lines of latitude, longitude and your route

What you know: You know how to read a map, a watch, a GPS and a compass.

During the spring, the sun rises and sets You have heard that satellites do not cover the area close to the South Pole, beyond 85° . (Teachers: if the above information is not understood by your students,

please see Extension 1 and 2 for linked lesson suggestions)

What you learn: 1. Once you turn on your GPS, you learn you are located at $84^{\circ}22'50''\text{S}$, $160^{\circ}38'28''\text{W}$. 2. Your watch reads 11:00 AM and the sun is up fairly high in the sky.

What you need to do: Work with your tablemates to figure out your present location on a map and come up with a plan to reach your friends camp using anything in your satchel.

Take any clarifying questions. All this information is on the student note catcher. As they work, encourage students to use the right column of the note catcher to take notes, write questions and answer the prompts.

SHARE OUT TO THE CLASS as a group (5-10 min.) After 15 minutes or so, tables will share out their plan. This can be a simple swap between two tables, or a full class discussion depending on time.

Some possible plans may include:

- a. Heading north to the 88th parallel using your GPS, then use your GPS to get to 88°S , $170^{\circ}25'10''\text{W}$ longitudinal line, then use your compass to lead you from the 88th parallel to your friend's camp, traveling along the $170^{\circ}25'10''\text{W}$ parallel.
- b. Set a bearing on your compass to your friend's camp and head there.
- c. Use the GPS to set a bearing directly from your starting point to your friends camp. Set stakes in the ice in a straight line using the rope to guide your placement. "leap-frog" your stakes and continue placing them in a straight line along the bearing. Once you have passed the 85th parallel, you will not have GPS to guide you, but continue with the stakes and rope to the camp.
- d. Use the time of day from your watch, the location of the sun in the sky and stakes (to cast a shadow) to build a simple compass or gnomon. Spend a day marking the angle of the sun at each hour on the gnomon and map to give yourself a good bearing.

(While this scenario is not overly challenging due to the wealth of instruments in your satchel, it will engage them in thinking how to use what they have)

FOCUS (10 min.) Show images of flying to the South Pole from NASA Operation IceBridge (OIB) (Images sets and all resources are attached). Why do the maps look this way? Provide individual think time.

Discuss as a class that flight navigation to South Pole is a bit different from navigation in populated areas. While satellites work fine anywhere, there are few that cover the polar regions. IceSat-2, NASA's new satellite will be launched in 2018 and will capture data along the 88th parallel, so traveling along that parallel while airborne, OIB can cross-collaborate data points. Hence, flights

travel around the 88th parallel where they can receive a satellite signal and travel the upcoming satellite data gathering area, then turn to cross the pole in a straight line, setting a course due South to the pole. As soon as the pole is crossed, the compass direction switches to due North.

Note: Since the map will record this path along the 88th parallel as a straight line, it will look as such on the flight-tracking map. Use note catcher to collect thoughts and ideas.

Use board drawing, globe or other visual aids to help explain this interesting phenomenon.

APPLY (15-25 min.) Now lets think about TIME ZONES! Take a look at these links to get your thinking going.

<https://www.timeanddate.com/worldclock/antarctica>

<http://www.worldtimezone.com/time-antarctica24.php>

Help students think about how the timezones all come together at the pole, making the time change rapidly as your cross them.

Practice Example: If it is Noon when you hit the 88th parallel after traveling South down along Greenwich Mean Time (0° Longitude), what time is it on the other side of the Pole, at 180° from where you start your circumpolar circle? Is it still “today” or is it a different day? (Answer: It is 12 hours later, so midnight)

SYNTHESIZE (5-10 min.) For each 90° that you travel around the pole on this parallel, how many time zones (hours) do you cross? (Answer: 6) For each 45° that you travel around the pole on this parallel, how many time zones (hours) do you cross? (Answer: 3) Which direction would you need to travel to go back in time? (Answer: West) To go into the future? (Answer: East)

Extension

1. General Navigation Pre-lesson - Lesson 1 from Institute of Navigation. This lesson is also attached as a pdf in Resources. <https://www.ion.org/outreach/lesson-plans.cfm>
2. Daylight Hours lesson - This lesson will help students understand how the sun angle causes different daylight hours around the world throughout the year. <http://www.npenn.org/cms/lib/PA09000087/Centricity/Domain/426/SeasonsLab...>
3. Watch this short video on the history of timezones and take notes <http://www.history.com/topics/industrial-revolution/videos/setting-time-...> Suppose we used a ball to mark time in Antarctica. How would the ball’s position change on the summer or winter solstice? What about at the equinox? Describe this in detail.
4. What is “declination” and how does it relate to navigation? Go to https://maps.ngdc.noaa.gov/viewers/historical_declination/ and explore - you will see that the magnetic South Pole is way west of the geographic South Pole. Explain how this can be!
5. IceSat-2 information can be found at <https://icesat-2.gsfc.nasa.gov/>

Resources

Image set of NASA navigation to South Pole

Student Note Catcher

Antarctic Map 1 for students to draw on

Antarctic Map 2 to use as a resource

Polar Stratigraphic Map 3 NSIDC OIB Portal Map <https://nsidc.org/icebridge/portal/map>

NASA's IceSat-2 <https://icesat-2.gsfc.nasa.gov/>

Navigation lesson plan <https://www.ion.org/outreach/lesson-plans.cfm>

Daylight Hours lesson plan

<http://www.npenn.org/cms/lib/PA09000087/Centricity/Domain/426/SeasonsLab...>

Assessment

Exit ticket (at the bottom of Student Note Catcher) should be used as a quick assessment of student ability to use Longitude, Latitude. Summative assessment could include the following questions:

- Why do planes circle along the 88th parallel when flying across the South Pole
- What tools might you use to navigate near the pole?
- How many time zones do you pass through if you travel 180° around the Pole? 360°?
- Identify various Long/Lat of locations on a map

Summative Assessment (Attached)

Lesson Scoring Rubric (Attached)

Author/Credits

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Screen Shots from NASA Operation IceBridge navigation display - courtesy John Sonntag

Map 1 from Col, Jeananda. Enchanted Learning. <http://www.EnchantedLearning.com>

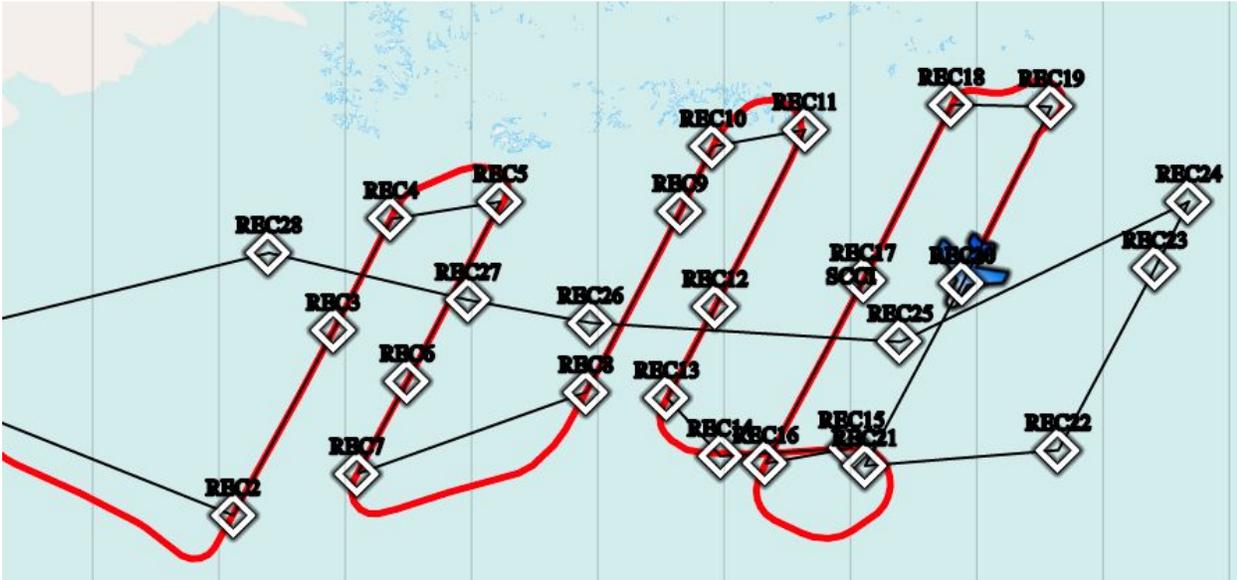
Map 2 from Geology.com <http://geology.com/world/antarctica-map.jpg>

Map 3 from AIPS https://casa.nrao.edu/aips2_docs/memos/107/node2.html

NSIDC OIB Portal map <https://nsidc.org/icebridge/portal/map>

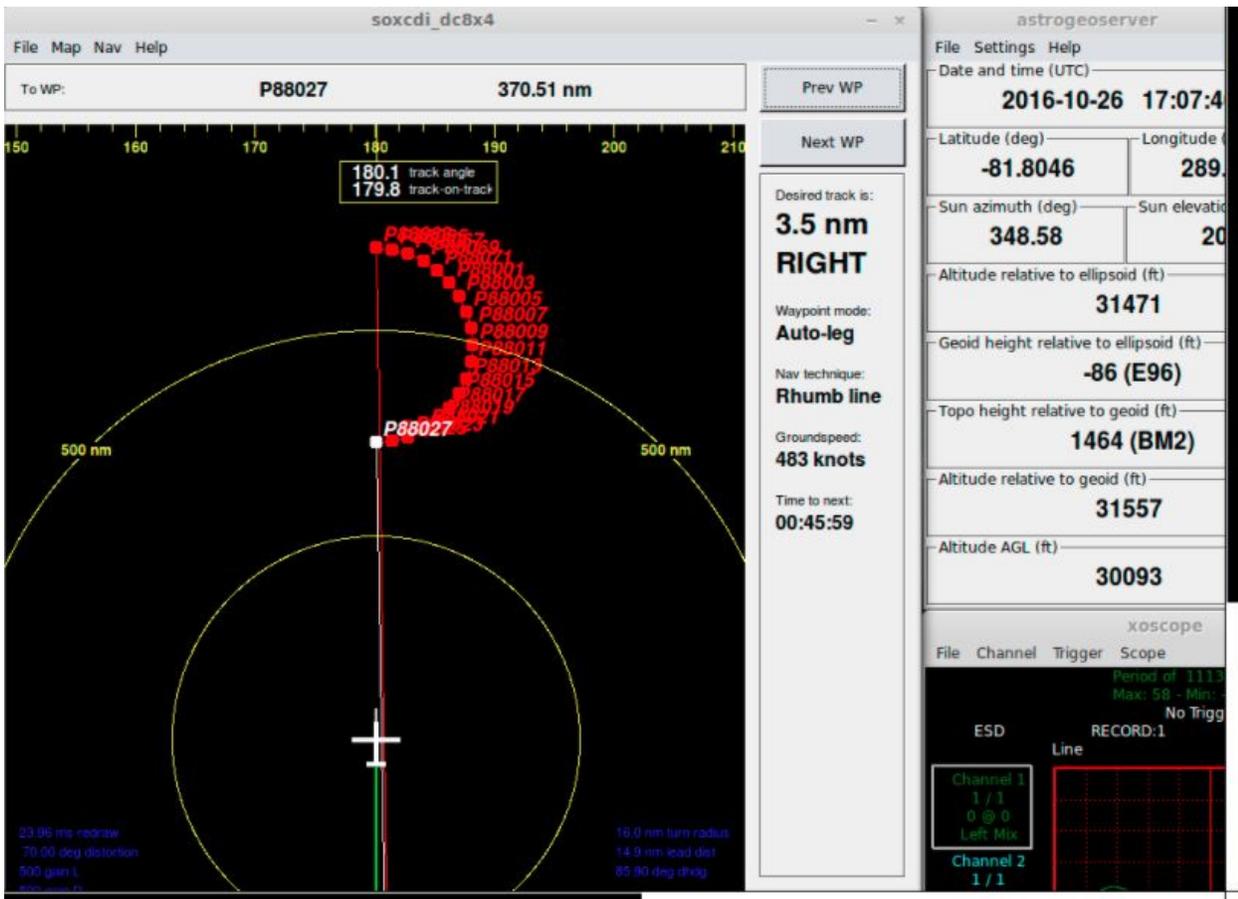
Special thanks to Amy Fitzgerald (NSIDC), John Woods and John Sonntag (NASA)

Images of Navigation and Student Note Catcher Operation IceBridge Antarctica 2016



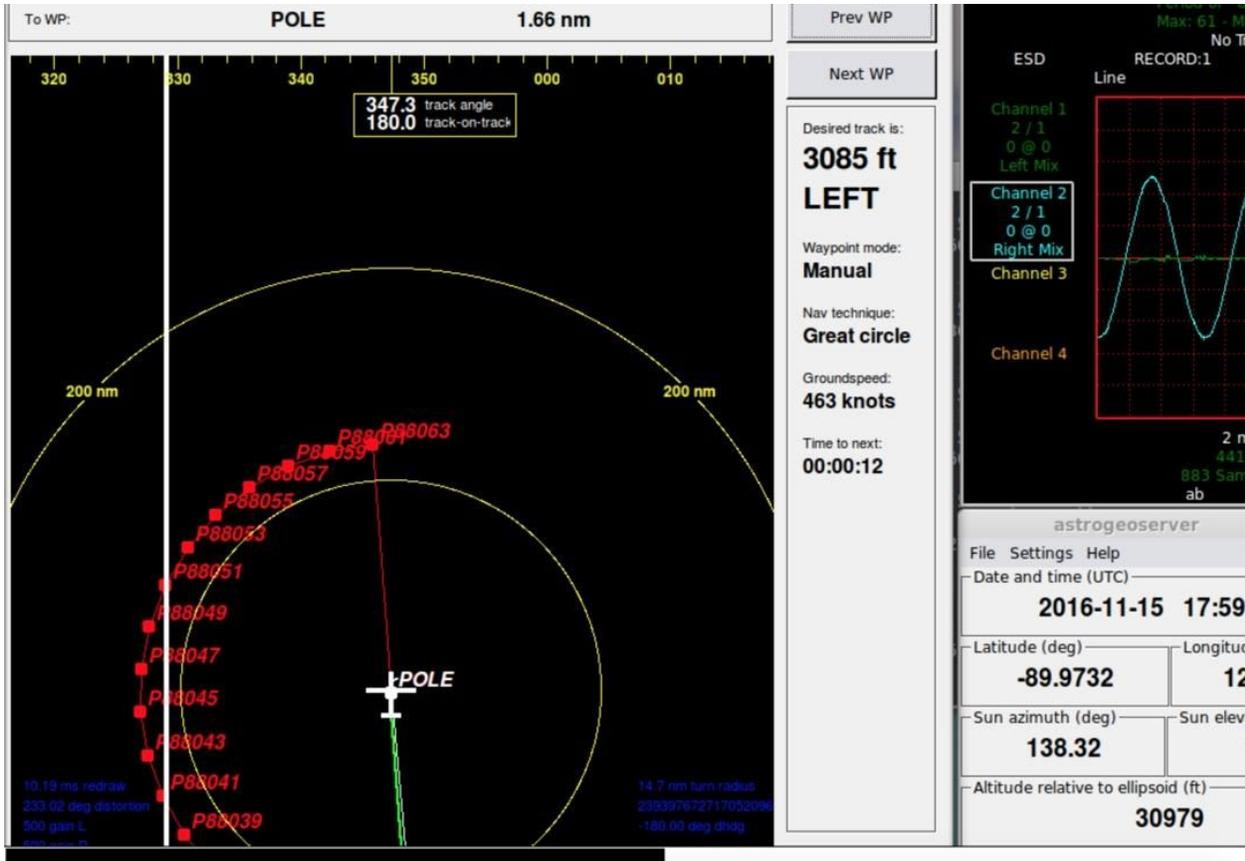
A flight path will follow a route through waypoints set up ahead of time.

(NASA image)

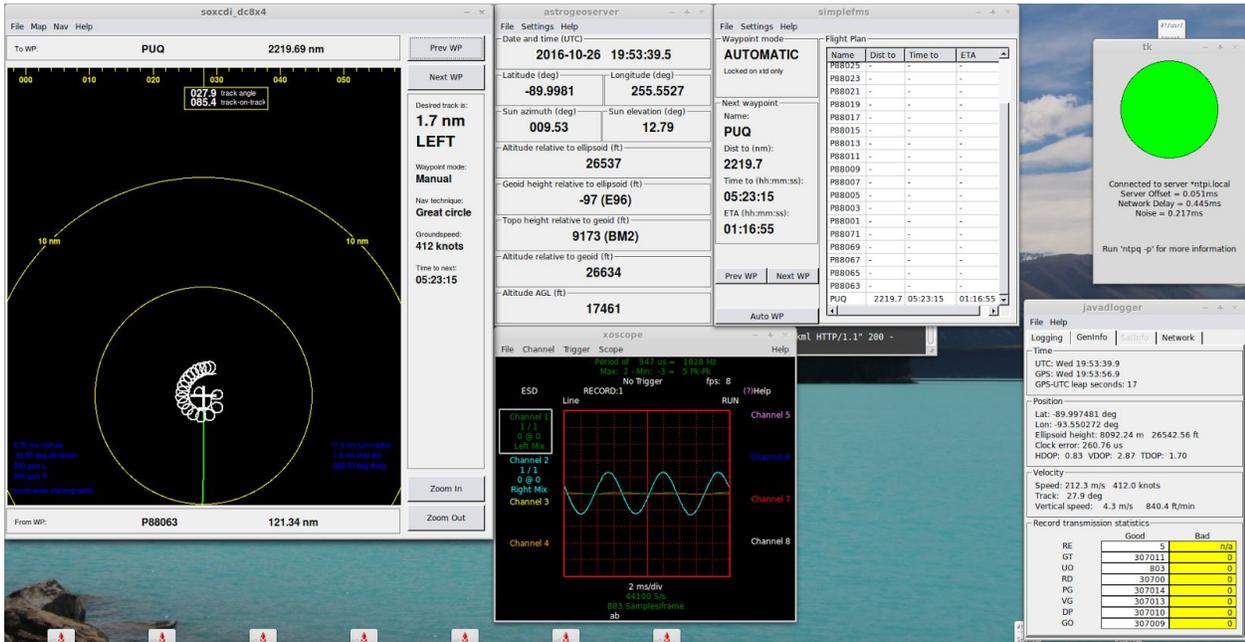


View as flight approaches 85th parallel - note the red waypoints forming a semicircle.

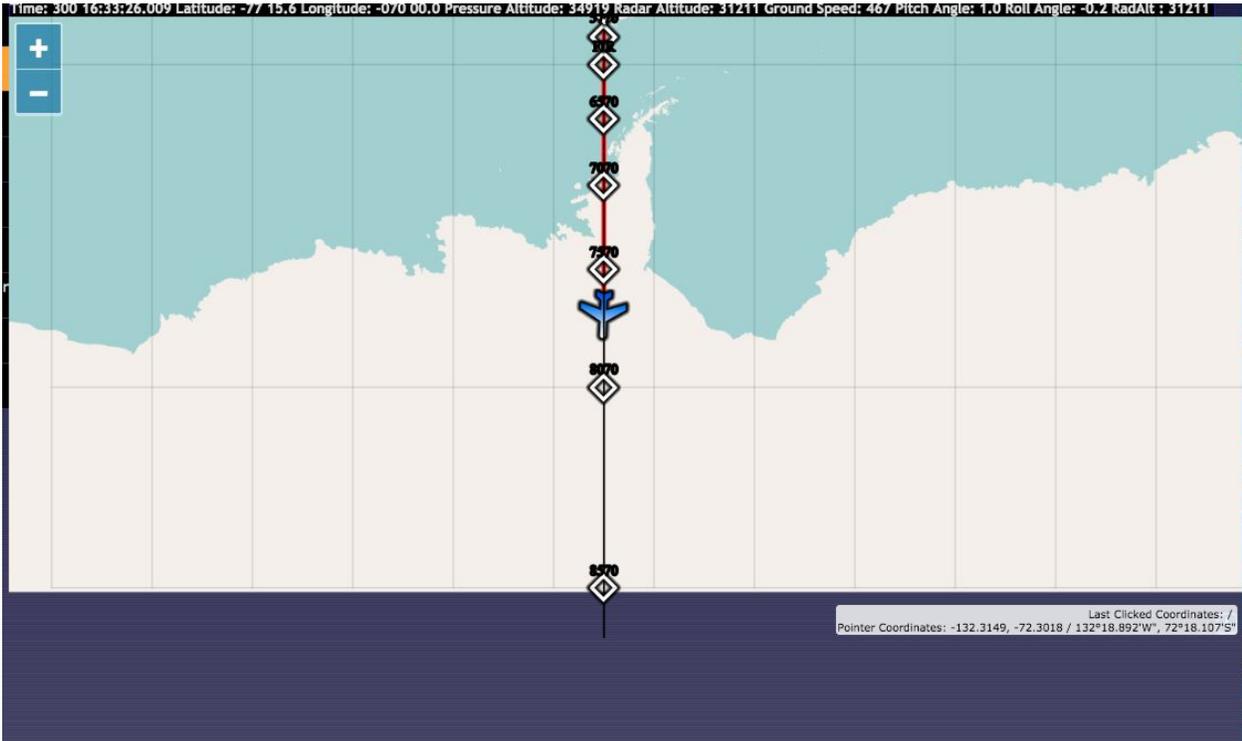
(NASA image)



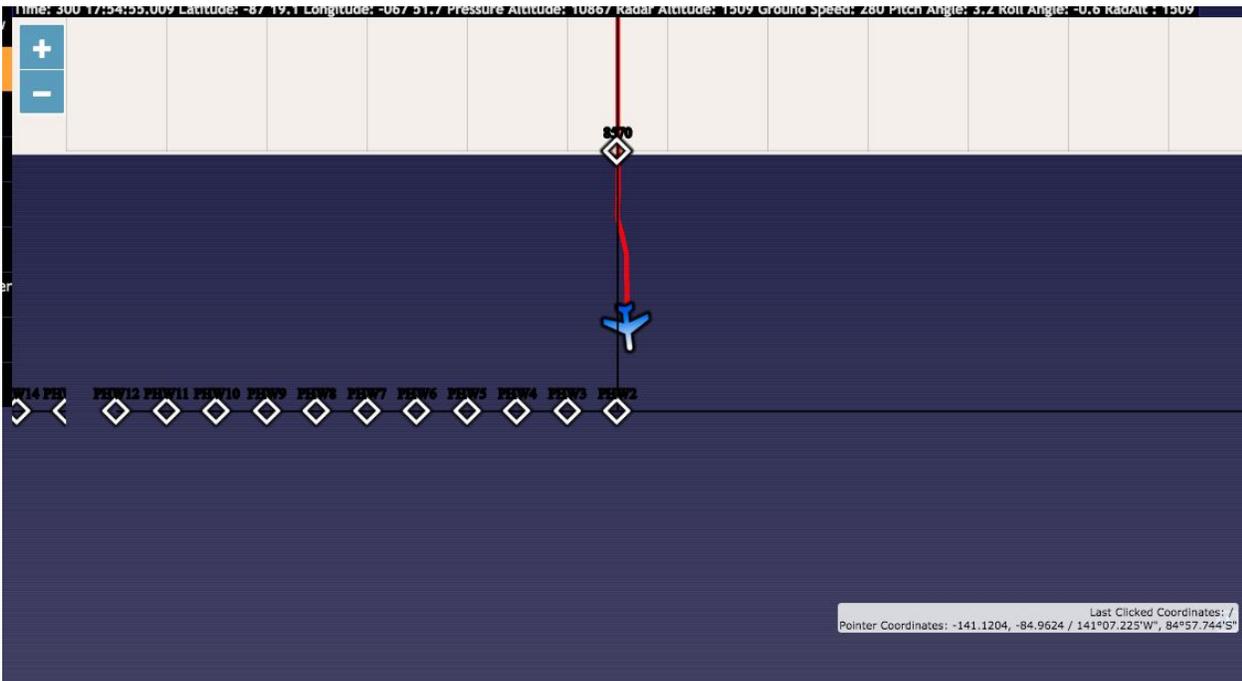
View showing location of plane at South Pole and the waypoints along the 85th parallel (NASA image)



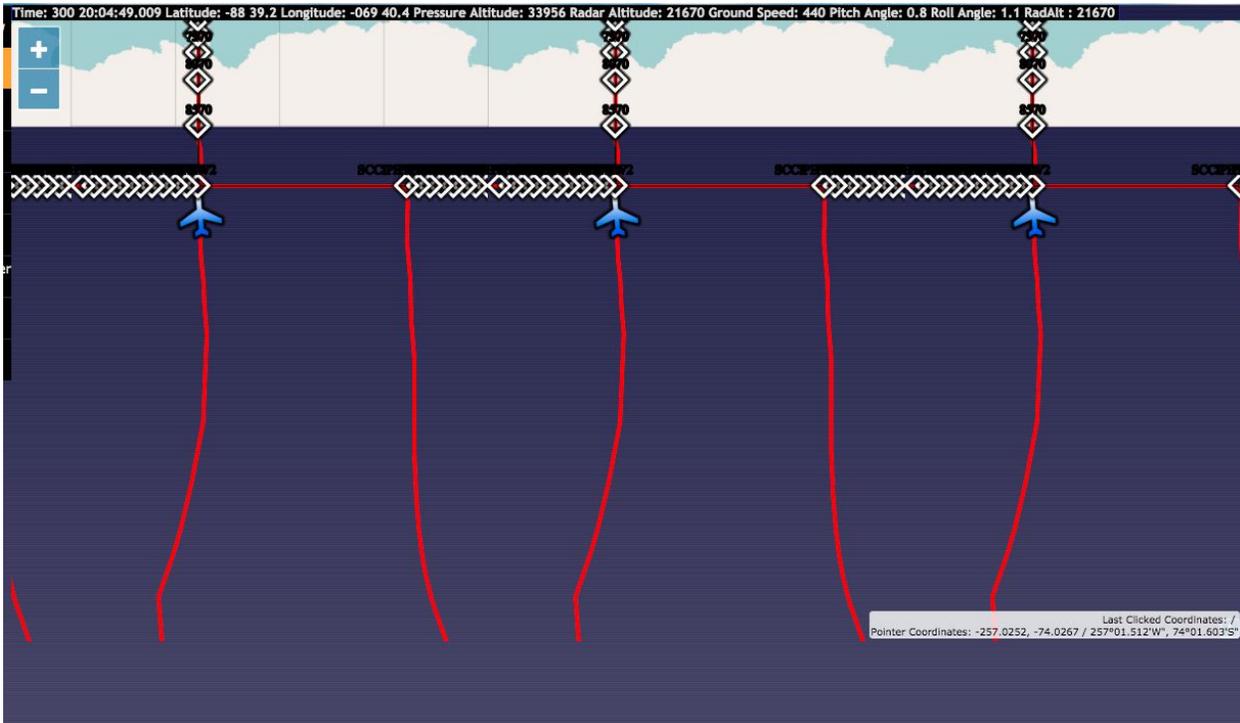
Full view readout of instrument panel while crossing the South Pole. (NASA image)



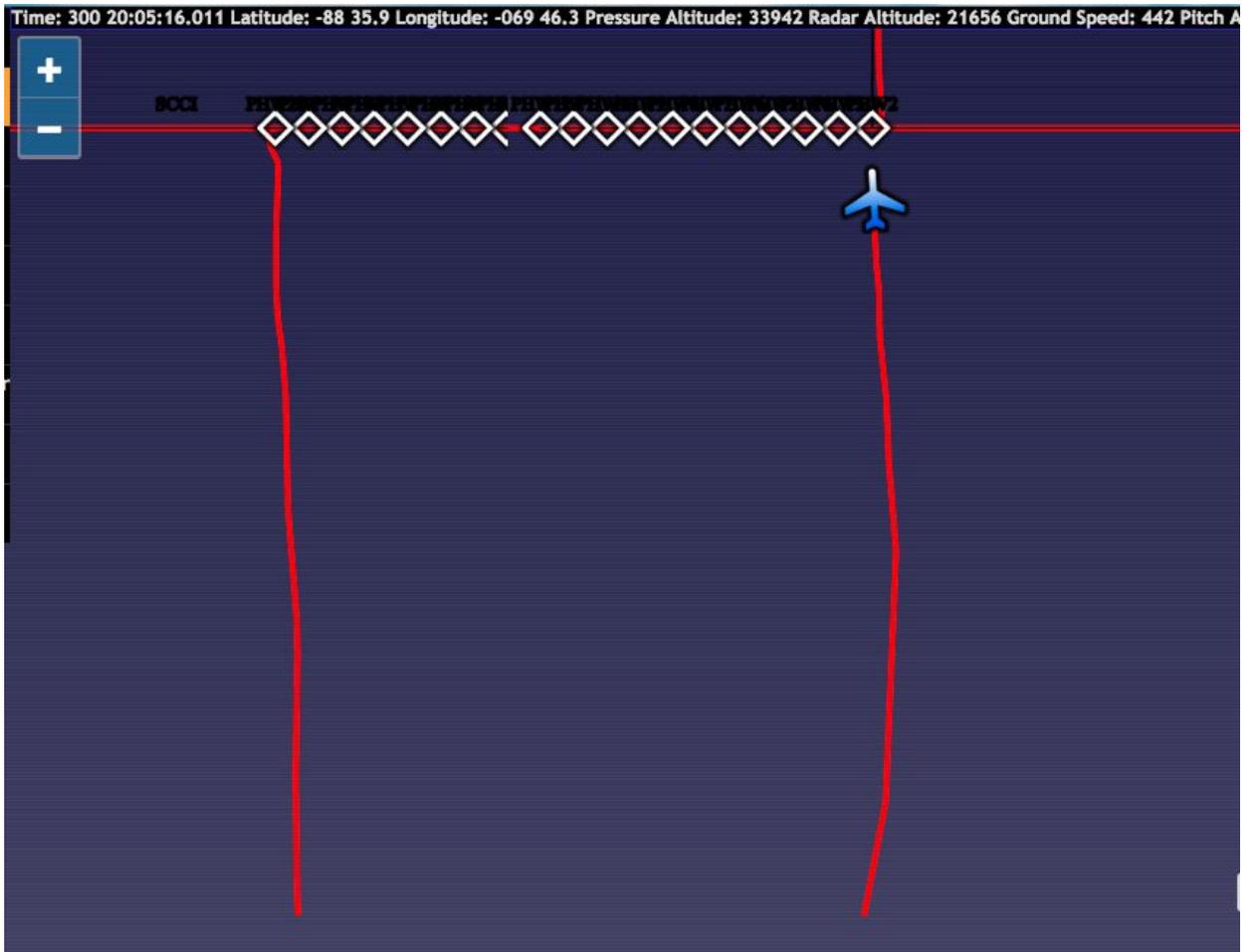
View of flight path approaching the 85th parallel. Note how we will “Fly off the map” at 85° S (NASA image)



The waypoints here appear as a straight line along the 85th parallel. (NASA image)



The computer has difficulty reading how the plane will head south and then north again... what would be a better way to show this? (NASA image)



Where is the South Pole on this image? (at the bottom) Why does it appear this way? (because after crossing the Pole, the plane will be heading North) (NASA image)

Student Note Catcher

Name _____

Class _____

Date _____

Lesson	Student Response Area
<p>Do Now:</p> <p>What are some ways to navigate? Think about navigation on the Earth using the sun, the stars, and also with instruments. Write your thoughts here</p> <p>Write (use the right column), then discuss your ideas with your tablemates.</p>	<p>Do Now:</p>

GRAPPLE:

Scenario: You wake up someplace in Antarctica in the southern summer. You are lying on the ice dressed warmly, with a small leather satchel. The satchel contains a GPS with good batteries, a map, a watch, a compass, some nutrition bars, a dozen short metal stakes, a coil of rope and a note from your friend with coordinates of her camp on the ice **88°27'40"S, 108°45'10"W**. The visibility is fair with gentle winds whipping up a bit of snow, but it is spring, so the sun is up for at least 9 hours of the day. There is a pair of skis, poles and boots next to you.

You need to make a plan and travel to your friend's camp. How will you do that?

Your task:

1. Find your Friend's camp!
2. Make a plan to determine where you are and where you need to go.
3. Draw your plan on the maps provided (Antarctic Map 1 and 3) including labels for all lines of latitude, longitude and your route

What you know:

1. You know how to read a map, a watch, a GPS and a compass.
2. The daylight hours in the spring near the poles include some sunlight and some darkness
3. You have heard that some satellites do not cover the area close to the South Pole, beyond 88°.
4. 1° of latitude = 60 nautical miles (approx. 100 km)

What you learn:

1. Once you turn on your GPS, you learn where you are located: **87°22'50"S, 160°38'28"W**.
2. Your watch reads 11:00 AM and the sun is up and the weather is fair.

What you need to do:

Work with your table to figure out your present location on a map and come up with a plan to reach your friends camp.

Use this space to take notes, answer questions and make a plan.

Use a detailed map of Antarctica to help you (or use the link to the National Snow and Ice Data Center (NSIDC) Operation IceBridge Portal Map to help you locate yourself [here](#). Once on this map, click S for southern hemisphere and move over the center of Antarctica. As you move your mouse across the map, you will see Longitude, Latitude on the bottom right. Zoom in and out with the + and - buttons.)

Did you find yourself? Describe your location:

Did you find your friend's camp? Detail what direction you will have to go from where you are:

Use Antarctic Map 1 to draw lines of latitude and longitude. Also, draw your route!

Use Antarctic Map 2, The NSIDC map, more detailed maps your teacher may have, and online maps for reference.

FOCUS:

Look at the colored screen captures taken as we flew to the South Pole with NASA's Operation IceBridge mission, labeled "Images of Navigation over South Pole - Operation IceBridge 2016"

Why do the images look the way they do? See the images showing the plane "flying off the map". Why does it appear this way?

APPLY:

Now lets think about TIME ZONES! Take a look at these links to get your thinking going.

<https://www.timeanddate.com/worldclock/antarctica>

<http://www.worldtimezone.com/time-antarctica24.php>

1. If it is Noon when you hit the 88th parallel along Greenwich Mean Time (0° Longitude), what time is it on the other side of the Pole, at 180°?

2. For each 45° that you travel, how many time zones (hours) do you cross?

3. Which direction would you need to travel to go back in time? To go into the future?

Extension: What is “declination” and how does it relate to navigation?

Go to

https://maps.ngdc.noaa.gov/viewers/historical_declination/ and explore - you will see that the magnetic South Pole is way west of the geographic South Pole. Explain how this can be!

Exit Ticket:

Choose one point on the map of Antarctica and ask your shoulder partner to figure out the latitude/longitude of that location.

Choose a second point and ask them to set a course between the two points.

Write the locations you picked for your partner and the heading they set to navigate between them.

Turn your note catcher face down if your partner was able to meet the Learning Target.

Exit Ticket:



Antarctic Map 1

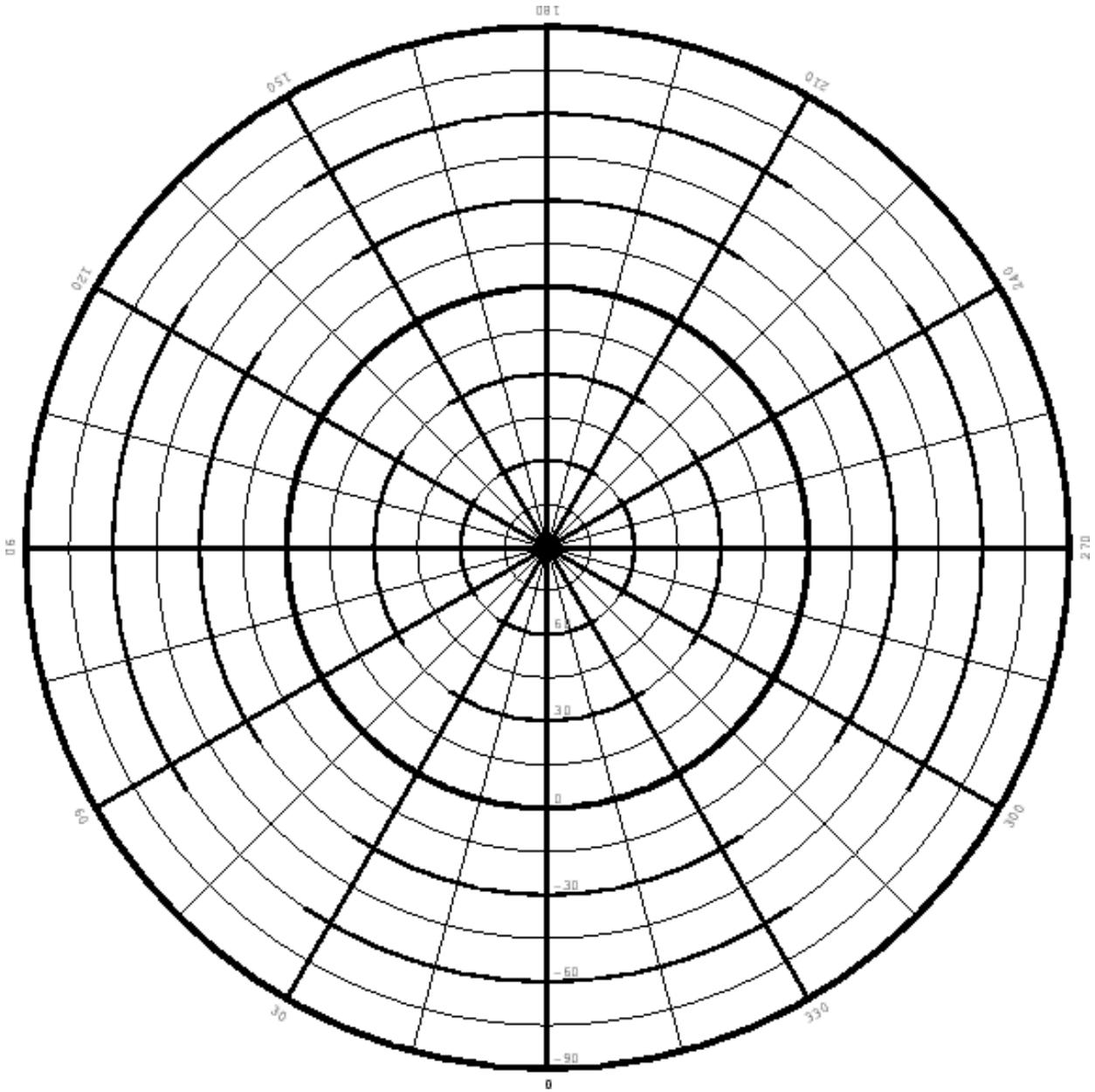


Antarctic Map 2



Taken from <http://geology.com/world/antarctica-map.jpg>

Map 3 - Polar Statigraphic Projection



Summative Assessment Questions

1. Why do planes circle along the 88th parallel when flying across the South Pole?
2. What tools might be useful to navigate near the pole?
3. How many time zones do you pass through if you travel 180° around the Pole?
4. What about if you pass through 360°?
5. Choose 3 locations in Antarctica on a map (NSIDC or other map you used in this lesson) and identify the longitude and latitude. Write them correctly here.
6. Einstein extra credit: Why are the locations of the magnetic and geographic South Pole different?

Navigation Around the Poles! Lesson Scoring Rubric

Student Name _____ Class _____ Date _____

Lesson Learning Target	3 - Meets expected level of proficiency	2 - Beginning level of proficiency	1 - Limited evidence of proficiency
I can use longitude and latitude to find a location and plan a route	Student can differentiate longitude and latitude, use coordinates to find a location, and calculate a heading in planning a route	Student shows proficiency with 2 of these 3 skills	Student shows proficiency with 1 of these 3 skills.
I can use different instruments to establish heading within and beyond satellite coverage	Student can use a compass, map and GPS to establish locations and bearings	Student shows proficiency with 2 of these 3 skills	Student shows proficiency with 1 of these 3 skills
I can navigate between and discuss time zones near the poles	Student shows an understanding of time zones, where they are located, which direction the zones progress, and how longitudinal lines come together at the pole	Student shows proficiency with 2 of these 3 skills	Student shows proficiency with 1 of these 3 skills
I can navigate beyond limitations in some instruments near the poles	Student can score 5-6 correct answers on the summative assessment	Student can score 3-4 correct answers on the summative assessment	Student can score 1-2 correct answers on the summative assessment
Extensions (optional)	Student extended their learning by engaging in the video on timezones and was able to answer the follow up question, and/or student learned about declination on how the geographic and magnetic poles can be in different places. Assign extra points as desired.		