BALTIMORE INTERNATIONAL POLAR WEEKEND

POLAR WEEKEND

NORWAY-U.S. TRAVERSE OF EAST ANTARCTICA

Lamont-Doherty Earth Observatory
COLUMBIA UNIVERSITY | EARTH INSTITUTE

TOPIC: Norway-U.S. Scientific Traverse of East Antarctica

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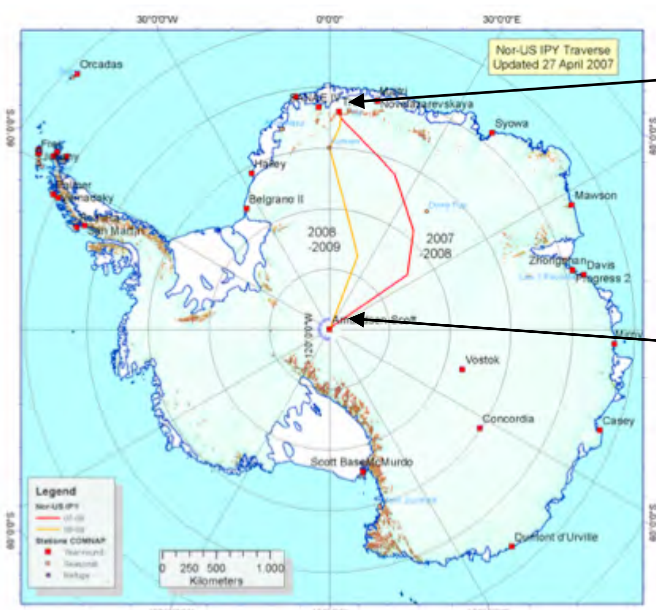


WHERE ON THE MAP ARE WE?

This field program was a collaboration between two nations, Norway and the United States traveling across East Antarctica between two permanent year round field stations: Norway's Troll Station in Queen Maud Land the outer perimeter of Antarctica, and the U.S. Amundsen-Scott station located at the South Pole. This was a two year project during the International Polar Year (IPY) covering a different route each year between the two stations.

GENERAL BACKGROUND INFORMATION ON THE SUBJECT:

The US-Norwegian traverse is crossing the high polar plateau, an area that few have ever visited and where little data have been collected. Our focus is on climate, ice sheets and sea level. There has been a lot of discussion about sea level in the last few decades. Global sea level is affected by the behavior of ice sheets in the polar regions – but it is important to know that this is a very long term process. Ice sheets can either **increase** in size by increased rates of precipitation falling as snow that lasts through the year and accumulates as part of an ice sheet, or **decrease** in size by increased melting, iceberg calving or accelerated ice flow moving water back into the ocean from the ice sheet. Scientists call this the ice sheet "mass balance" meaning the amount of snow added (accumulation) less the amount of snow lost (ablation) creates the total mass of snow. You can make a formula out of this:

Accumulation – ablation = mass balance

If more snow is added than is lost each year the ice sheet grows. If more snow is lost then the ice sheet shrinks, and in shrinking it moves snow off the land and contributes to global sea level rise (SLR).

East Antarctica is a vast, unexplored area, even more so than other parts of Antarctica. Little is known about the area's current and past climate history, as ground expeditions through the area have been nonexistant since the 1960s' International Geophysical Year crossings (traverses) of the area. Our science expedition is seeking to answer questions about the area:

1. How much does it snow in the area we traveled, and has the amount changed in recent decades?
2. What has the climate been like here the last 1000 years?
3. Is there any evidence of man-made pollution here?

WHAT ARE SOME OF THE WAYS THAT WE STUDY THESE THINGS?

We collected different pieces of information while we were in the field:

1. The team will collect snow samples from the surface and ice cores down to 90 meters (about 300 feet) along the way. The ice at 90 meters is over 1000 years old, and examining them will help us determine what the climate was like that long ago. We will also collect shallow firn cores (~30 m deep).
2. We analyzed the snow near the surface to look for contaminants

3. We dug snow pits to look at the layers in the snow
4. Between the areas where we collected cores the team is using radar to track the layers of snow all along the traverse. This tells them how much snow has fallen along the way in different years (the thickness of layers corresponds to snow fall). We are using an umanned aerial vehicle (uav), which is basically a remote controlled plane, to take radar images of the snow along the way as well as pictures.
5. We installed several Automatic Weather Stations which beam temperature, wind speed, wind direction, and pressure data to researchers in the US via a satellite link so that we could continue to collect weather information from these remote areas after the traverse is over.

(photo from Ice Stories © Exploratorium, www.exploratoium.edu, by Zoe Courville)

WHAT ARE SNOW PITS?

The photograph is a snow pit I dug in Antarctica. We dig these pits so that we can study the top several meters of the snow that have accumulated in an area. This top section of snow is generally too fragile to transport as cores so we study it "in situ" (see vocabulary). We can get an idea of how much snow has fallen in a season by looking at the different layers (stratigraphy). We also look at how densely packed the snow is, snow grain size, how easily the air flows in the snow (air permeability) and how easily heat moves in the snow (thermal conductivity). "We can also tell about the temperature when the snow fell by looking at isotopes of hydrogen and oxygen from the snow samples – lighter isotopes mean that temperatures were colder when the snow fell than heavier isotopes." We can also see different processes that are affecting the area like wind scouring. It is hard work to dig the pits that are about 2 meters deep, 2 meters long and 1 meter wide!

TERMS YOU SHOULD KNOW (VOCABULARY):

Traverse is the movement of people or things from one location to another. This project was an overland scientific traverse – which means traveling over the land across sections of East Antarctica collecting scientific data as we traveled. Sometimes we collected measurements in the field and other times we collected samples to analyze back in a laboratory.

Firn which is a term for old snow which snow older than one year found in polar regions where it rarely gets above the melting temperature of ice.

In Situ means to study something where it exists in the field rather than collecting it or removing it from its environment to study it.

Proxy is a method used to figure out past climate patterns, before humans started recording climate data. Ice cores are one example of a proxy, other examples of proxies include, tree rings, boreholes, corals, and lake and ocean sediments.

WHY ARE WE STUDYING THIS IN THE POLAR REGIONS?

Snow and firn in polar regions builds up and builds up over thousands of years because temperatures are very rarely above freezing. These built-up layers of snow preserve evidence of past climates, from gases contained in bubbles in the ice, to chemicals (dust, polluntants, radiation, sea salts) found in the snow, to variations in light and heavy isotopes which allow scientists to determine temperature changes in the past. The traverse is going through East Antarctica because very few of these measurements have been made here in the past, and the East Antarctic ice sheet is the biggest ice sheet in the world! Understanding the climate history of this area is an important piece in our understanding of long term climate change, and understanding the current processes is important in determining if snow accumulation amounts are growing or shrinking due to climate changes, and how this growing or shrinking might effect sea level changes.

Zoe with student at the Polar Fair

HOW DOES THIS AFFECT US HERE IN THE UNITED STATES?

The climate record contained in the snow and ice in Antarctica reflects things that we in the U.S. have done, and how that impacts the entire planet. For instance, there is a very distinct radioactive layer in the firn that was caused by atmomic bomb testing in the 1960's.

The disappearance of lead in antarctic firn marks the switch to unleaded gasoline in the 1970's. The longest climate records from ice cores are found in this area of Antarctica, where cores drilled to bedrock contain climate information that goes back 800,000 years.

TO LEARN MORE ABOUT THIS TOPIC:
Websites: traverse.npolar.no AND icestories.exploratorium.edu
Book: Two mile time machine, by Richard Alley
Student Activities: http://traverse.npolar.no/education-outreach/become-a-student-polar-researcher

ACTIVITIES YOU CAN TRY:
1. Dig a snow pit (seasonal) in your backyard (if you don't have snow in your yard, try digging a pit in the dirt). Your snow pit doesn't have to be very deep, maybe a foot or less. Choose a wall of the pit, and make that wall as smooth and as flat as you can. Look for different layers in the snow (or dirt)…maybe there are ice layers caused by rain, or very large crystals if the bottom of your pit is near the ground.

How thick are some of the layers?

What could the thickness of the layers mean?

If you are working with snow try collected two samples in clear containers. Scoop one in loosely and compress the other one in tightly. These are two 'snow pit' samples. Use a flat edged spatula or dinner knife to flatten the snow away from the edge of the container so you can see the results when you do the next step. Drop a drop of food color on the top of the edge of each of the 'snow pit' samples to see how the food color moves through the snow – this is a demonstration of how permeable the snow is – i.e. how tight the space or openings between the snow flakes is allowing fluid or air to move between them.
Did the coloring move through both samples the same way or were there differences?

Describe the movement in each samples and explain what you think this means about its permeability? In an ice core, where would you expect to find the greatest permeability? Why?

Researcher Richard Alley holds a real section of a Polar ice core at our New York City Polar Fair Event

2. Make Your Own Ice Core:
Ice cores capture lots of important information. As the snow falls each year it contains information on the environment and the atmosphere included the gaseous composition, any particles from dusts or even volcanic fallout that blow into the area, and contaminants from aerosols. Each year new snow is added over the top of existing snow and this is compressed into ice. When scientists collect these cores, they look back in time to learn about the atmosphere and conditions that existed when the snow fell. Remember, in a core, the oldest information is collected from the bottom of the core and the newest information is found at the top of the core. Learn more about ice cores in the next activity "Drilling Back In Time".

Make and examine your own ice core:
There are two ways to make an ice core – select whichever one is easiest for your group.
Method #1 – Use tennis ball container, PVC pipe, clear plastic sleeving, section of copper piping etc. for an ice core. Cap with end caps. If you are able to use a container that has a large opening at either end you can warm the ice core under a warm tap and slide it out for examination by the students. (note you might need to cut off the top lip of the tube before making the sample).

Method #2 - Use a personal size water bottle for making an ice core. Examination of this type of core will be done through the bottle since you will not be able to slide the core out.

Making the core will take several days or sessions since you will add and freeze a section of ice each day. Each daily addition of ice will equate to a full season of ice in the field.

Day 1– Fill your container ~ ¼ full with carbonated sparkling water and fine grain sand if desired. Freeze.

Day 2 – Add more water to your container – this time use tap water colored with blue food color adding enough water so that you are just over ½ of the container when you return it to the freezer. The amount you added will differ from what you added yesterday.

Day 3 – Fill your container with plain tap water leaving just enough room in the bottle for it to expand as it freezes. Mix a little charcoal from the art teachers' supply or from a brickett into your water sample to add an ash quality to represent volcanic ash.

Day 4 – Take out your ice core and lets examine and describe it. If you used clear plastic sleeving, soak sample in a warm water bath long enough to unfreeze it from the edges, remove the end pieces and slide the core out. If you use water bottles you can measure and describe through the bottle.

Draw a picture of the core and record all information about the core on this picture.
Measure each layer of accumulation and record this on your picture. Label as year 1, year 2, year 3. Be careful! Where will year 1 be on your core – the top layer or the bottom layer?

Describe each layer of the ice core.

Which layer is the largest? Which is the smallest? Imagine that the core you are examining is a real polar ice core. Explain what Earth process might account for what you are seeing in each section of the ice core. Consider where in the core it is (might it be compressed); does it have sands from sediment being trapped in the ice flow; volcanic ash; does it have trapped gases – (air bubbles) etc.

3. Drilling Back in Time -
You will need a large area to complete this activity! Our team collected ice cores that are 90 meters long. Find a place where you can measure 90 meters. Mark off 90 meters placing a piece of tape and label each meter. (If you do not have an area this long you can use 1 meter to represent each 10 meters. You sacrifice some of the 'wow' factor but it is still a strongly visual activity). A 90 meter core can contain climate information covering well over 1000 years!

Consider – If 90 meters of snow accumulated in 1450 years, calculate how much snow that would be on average each year?

While we can calculate the average accumulation over the 1450 year timespan there are several things we should remember that snow compresses over time. As you move down towards the bottom of the ice core the accumulation amounts will appear smaller since the snow will be compressed. So while it is interesting to think about how much snow this would mean averaged over 1450 years we should not interpret average accumulation rates to be representative of each year's accumulation.

However, scientists have used several methods to complete age calculations on ice cores:

1. The count annual layers by looking for seasonal markers.
2. Using volcanic eruptions and other known events that have impacts in the polar regions as a marker for dating.
3. Radioactive dating of gases trapped in the cores

Some of the age date information is used in completing the attached poster called 'Ice Core Time Line: How Old is the Ice'.

Using the poster information mark off on your 90 meter ice core when certain historic events occurred. (Use a separate color of tape from the markings you did previously, OR a separate color of pen to label.) Match the collection of pictures that are attached at the end of this activity sheet (from the poster) to label the timeline of events. You can add other events to the timeline from your own exploration of history.

WOW lots has happened during the time ice has been collecting in East Antarctica!!!

4. Try Being a Scientists on the Traverse:

Collect your thickest pair of ski mittens and a pair of ski goggles. Put these on and now try picking up a pencil and writing this sentence on a piece of paper:

"Location: "NUS08-7", 74º 7' S, 1º 36' E,
2700 meters above sea level
Weather: Overcast, light snowfall, -28 C, wind 14 kts
The snow pit has been dug to a depth of 2 meters"

Hard isn't it? This is what it is like to record data in the field in East Antarctica where it is too cold to take of your mittens when you work!

5. It is not how the crow flies!

Look at the attached map of the two years of the traverse. The blue line is Season 1 and the green line is season 2. Traveling from Troll station to the South Pole could have been a lot shorter! Scientists carefully selected the routes for the information they were interested in collecting as well as for the most passable route. Note that the dates are matched to stars on the map – the dates are recorded with month, day and then year. SO December 12, 2007 would be 12.12.2007.

Using the scale on the bottom of the map can you calculate:

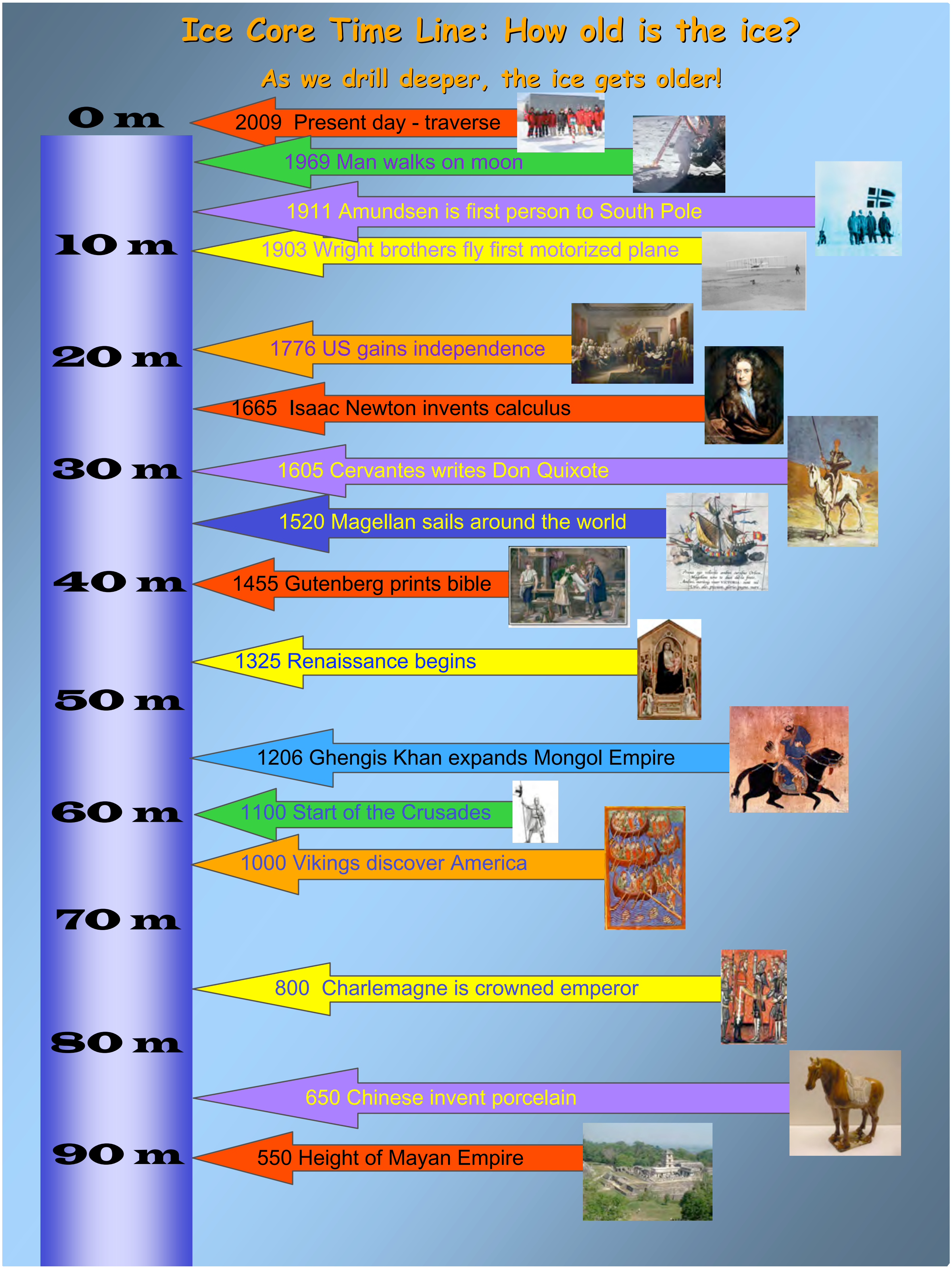
1. How many kilometers the traverse traveled in Season 1?
2. How many kilometers the traverse traveled in Season 2?
3. If the group was able to average 10 km an hour how many total hours of driving is this?
4. Some days the traverse didn't travel because they were digging snow pits and collecting information. Other days they had equipment trouble and had to stay put until they could get things repaired. Looking at the distance between the dates on Season 1 and Season 2 which season do you think went the most smoothly for the researchers? Why?
5. Look at the map where the label reads **Camp Winter**. Between Camp Winter and South Pole is a section of Antarctica that is designated a **Clean Air Sector**. This is some of the cleanest air on the Earth, so samples from this area are used to examine the Earth's atmosphere. Because of this no driving or flying is allowed in this area since the exhaust from the vehicles would contaminate the area. The red line with the stars on it shows the route the traverse took from Camp Winter to South Pole. (The blue line that crosses through this area is from the old 1964-65 traverse before there was a designated Clean Air Sector). The Clean Air Sector make the traverse travel even further from how the crow would fly! If the team had been able to continue straight to South Pole from Camp Winter how many km would that be? _______ Now calculate how many km they ended up traveling to avoid the sector? _______ At 10 km an hour how long did this take in total driving hours?

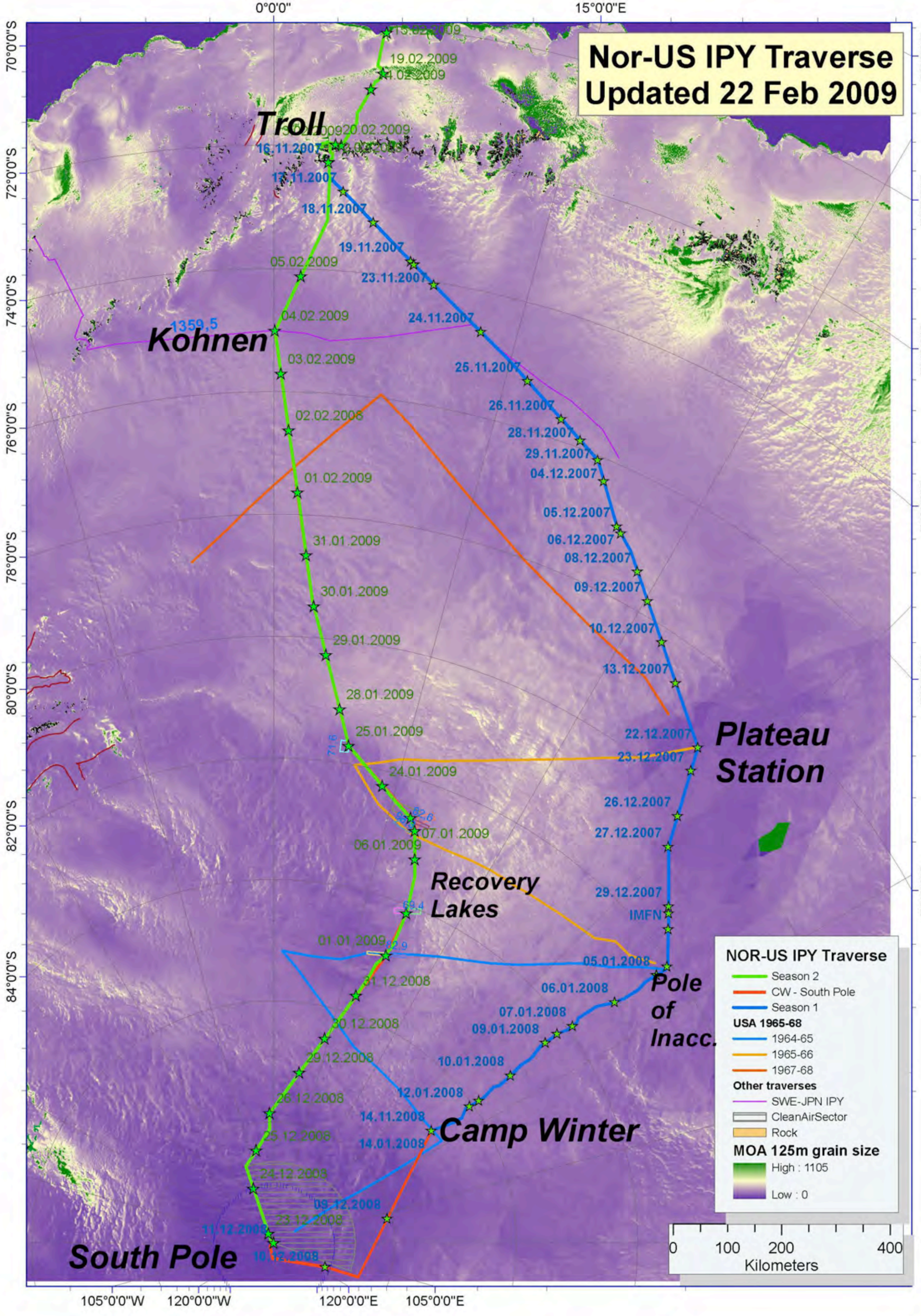
Photos from the poster to copy and add to your own timeline for Timeline Activity


Prima ego velivolis ambivi cursibus Orbem,
Magellane novo te duce ducta freto.
Ambivi, meritoq; vocor VICTORIA: sunt mi
Vela, alæ; precium, gloria; pugna, mare.




(Zoe 4th and Tom 7th from left)



Ice Core Time Line: How old is the ice?
As we drill deeper, the ice gets older!
0 m
2009 Present day - traverse
1969 Man walks on moon
1911 Amundsen is first person to South Pole
10 m
1903 Wright brothers fly first motorized plane
20 m
1776 US gains independence
1665 Isaac Newton invents calculus
30 m
1605 Cervantes writes Don Quixote
1520 Magellan sails around the world
40 m
1455 Gutenberg prints bible
1325 Renaissance begins
50 m
1206 Ghengis Khan expands Mongol Empire
60 m
1100 Start of the Crusades
1000 Vikings discover America
70 m
800 Charlemagne is crowned emperor
80 m
650 Chinese invent porcelain
90 m
550 Height of Mayan Empire


Nor-US IPY Traverse
Updated 22 Feb 2009
Troll
Kohnen
Plateau
Station
Recovery
Lakes
Pole
of
Inacc.
Camp Winter
South Pole
NOR-US IPY Traverse
Season 2
CW - South Pole
Season 1
USA 1965-68
1964-65
1965-66
1967-68
Other traverses
SWE-JPN IPY
CleanAirSector
Rock
MOA 125m grain size
High : 1105
Low : 0
0
100
200
400
Kilometers

Norway-US Scientific Traverse of East Antarctica

Meet the scientists

Dr. Tom Neumann

Expedition Leader

NASA Goddard Space Flight Center

Greenbelt, MD

Dr. Zoe Courville

Snow physical properties

Cold Regions Research and Engineering Lab

Hanover, NH

Our group gathered at the South Pole.

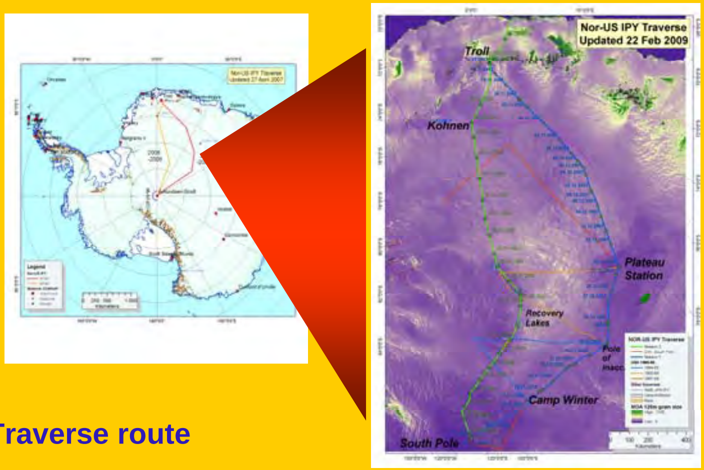
Background

The East Antarctic plateau is a massive, relatively unexplored region with little ground data available. We are trying to determine whether there is more or less snow falling in this region due to climate change, and what that could mean for sea level change.

Now the real work begins!

Workers at DRI in Reno have to wear "clean suits" to avoid contaminating the ice cores.

The ice cores are now on their way to labs at Desert Research Institute (DRI) in Reno, NV and the Norwegian Polar Institute in Norway where the chemicals frozen in the ice will be measured to look for signs of man-made pollution in East Antarctica.



Traverse route

The route this year was just over 2300 km in length, and took 3 months to complete. Along the way, we drove over some newly discovered subglacial lakes (Recovery Lakes), and will try to figure out their extent and depth.

Success!

We arrived at Troll, the Norwegian Antarctic station, on February 21, 2009. Some of us spent four months in the field.

Science on the go!

Sembla, the last vehicle in the train, pulled a moving science lab. Four different radar systems and a portable ice drill completed Sembla's load (a fifth radar system on the lead vehicle, Lasse, was used to detect crevasses).

Main science questions

→How much does it snow here, and has this amount changed in recent decades?

→What has the climate been like here the last 1000 years?

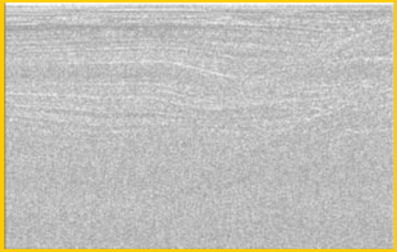
→Is there any evidence here of anthropogenic (man-made) activity abroad?

→What is the effect of climate change on the temperature here?

Ice Cores

Lou Albershardt, our driller, and Dr. Ole Teivten, MD, our doctor, with one of over 500 cores they drilled and logged during the season. The deepest core was 90 m (295 ft) in length, and will hopefully provide 1000 years of climate information, frozen in time.

Radar



GPR, or ground penetrating radar, systems were used in order to track snow layers across the plateau as a way of determining how much snow fell in different locations and to pick spots to drill ice cores. Radar systems with different frequencies can image different depths in the snow. Above, one of the higher frequency systems images the layers in the snow to about 70 m (230 ft). Right, a similar radar system was used to detect crevasses. In this image, four crevasses are shown. Can you spot them?

Temperature

Dr. Ted Scambos, from NSIDC in Boulder, CO, installed automatic weather stations (AWS) along the route to monitor weather changes in the air and 90 m down in the snow. These stations will allow us to monitor changes in temperature for up to five years in this remote region

Outreach activities

Montshire Museum of Science

Ice Stories

➡website: *icestories.exploratorium.edu*

➡website: *traverse.npolar.no*

Funding through

National Science Foundation Office of Polar Programs

Norwegian Polar Institute