Applications of GPS

Up until now, we've looked at how you can use GPS receivers to tell you where you are, to navigate between points and to make digital maps of various features. But GPS isn't just used by civilians; it's also used by pilots, boat captains, farmers, surveyors, scientists and the military (just to name a few!).

While typical civilian handheld GPS receivers are usually accurate to about 5 metres, there are also very expensive, highly advanced GPS receivers that are capable of providing positions accurate to within a *centimetre*! These receivers have revolutionsed lots of industries, where highly accurate positioning is used for so many different tasks. The following sections provide a quick summary of how GPS is used in some industries.

FAST FACTS

1. **Typical civilian GPS receivers give positions accurate to around 5 metres, but advanced GPS receivers can be accurate to within a centimetre!**
2. **High accuracy GPS tells us that on average, Australia is moving 7.3 cm/year in a north-easterly direction.**
3. **Commercial jets use GPS to show passengers where the aircraft is on a map at any given time.**
4. **GPS provides tracking and guidance to soldiers, vehicles and artillery (including missiles).**
5. **Other countries have also developed satellite navigation networks similar to the American GPS system (e.g. GLONASS and GALILEO).**

Aviation

Almost all modern aircraft are fitted with multiple GPS receivers. This provides pilots (and sometimes passengers) with a real-time aircraft position and map of each flight's progress. GPS also allows airline operators to pre-select the safest, fastest and most fuel-efficient routes to each destination, and ensure that each route is followed as closely as possible when the flight is underway.

Marine

When high accuracy GPS is fitted to boats and ships, it allows captains to navigate through unfamiliar harbours, shipping channels and waterways without running aground or hitting known obstacles. GPS is also used to position and map dredging operations in rivers, wharfs and sandbars, so other boats know precisely where it is deep enough for them to operate.

Farming

Farmers rely on repeat planting season after season to maximise their crop productions. By putting GPS receivers on tractors and other agricultural equipment, farmers can map their plantations and ensure that they return to exactly the same areas when sewing their seeds in future. This strategy also allows farmers to continue working in low-visibility conditions such as fog and darkness, as each piece of machinery is guided by its GPS position instead of visual references. High accuracy GPS is also used to map soil sample locations, allowing farmers to see where the soil is most fertile across individual fields or even entire farms!

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Science

Scientists use GPS technology to conduct a wide range of experiments and research, ranging from biology to physics to earth sciences. Traditionally, when scientists wanted to understand where and how far animals roam, they had to tag animals with metal or plastic bands and then follow them to various locations to monitor their movement. Today, scientists can fit animals with GPS collars or tags that automatically log the animal's movement and transmit the information via satellite back to the researchers. This provides them with more detailed information about the animal's movements without having to relocate specific animals.

Earth scientists also use GPS technology to conduct a wide range of research. By installing high accuracy GPS receivers on physical features such as glaciers or landslips, scientists can observe and study both the speed and direction of movement, helping them to understand how landscapes change over time. Similarly, GPS receivers can be installed on solid bedrock to help understand very small and very slow changes in tectonic plate motion across the world.

Surveying

Surveyors are responsible for mapping and measuring features on the earth's surface and under water with high accuracy. This includes things like determining land boundaries, monitoring changes in the shape of structures or mapping the sea floor. Surveyors have historically required line-of-sight between their instruments in order to undertake such work, but the availability of high accuracy GPS receivers has reduced the need for this. GPS can either be setup over a single point to establish a reference marker, or it can be used in a moving configuration to map out the boundaries of various features. This data can then be transferred into mapping software to create very quick and detailed maps for customers.

Military

The GPS system was originally developed by the United States Department of Defence for use by the US military, but was later made available for public use. Since then, GPS navigation has been adopted by many different military forces around the world, including the Australian Defence Force. Some countries have even decided to develop their own satellite navigation networks for use during wartimes. Today, GPS is used to map the location of vehicles and other assets on various battlefields in real time, which helps to manage resources and protect soldiers on the ground. GPS technology is also fitted to military vehicles and other hardware such as missiles, providing them with tracking and guidance to various targets at all times of the day and in all weather conditions.

Further Information

If you're interested in finding out more about the many different ways GPS technology is used in today's world, take a look at the following resources:

Recommended Books

- 'GPS for Dummies' by Joel McNamara (2008). ISBN: 0470156236
- 'Understanding GPS – Principles and Applications' by Elliott Kaplan and Christopher Hegarty (2005). ISBN: 1580538940

Recommended URL's

- 'Applications of GPS' - http://www.gps.gov/applications/
- 'Civilian Applications of GPS' - http://www.locata.com/applications-of-gps/civilian-applications/
- 'GPS World' - http://www.gpsworld.com/
- 'A Guide to GLONASS' - http://glonass-iac.ru/en/guide/
- 'Official GALILEO Homepage' - http://www.gsa.europa.eu/galileo-0
- 'Ice Shelf Tidal Animations' - http://goo.gl/NgprIn

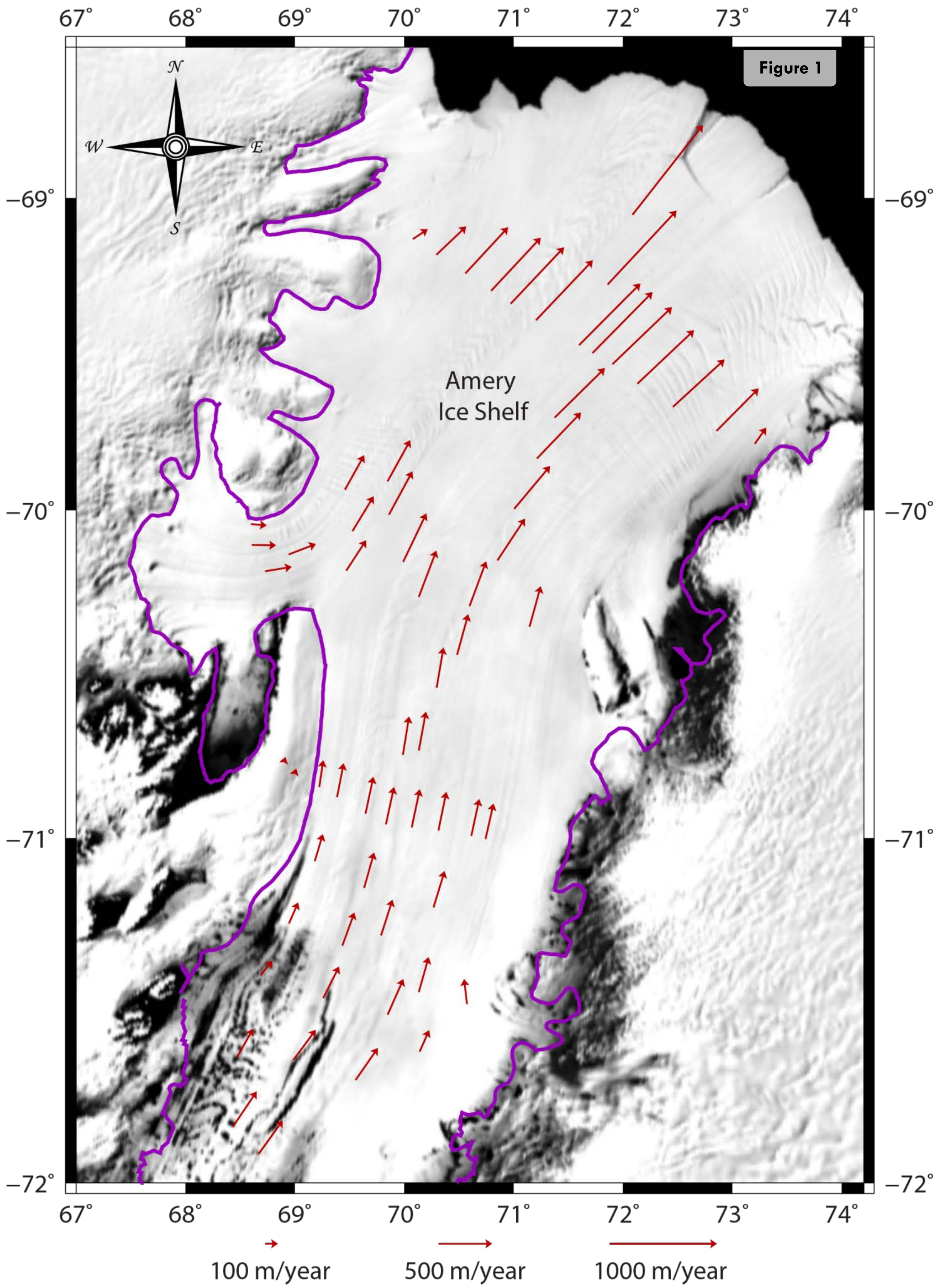
Australian Curriculum Content Descriptors: ACMNA178, ACSHE223, ACSIS124, ACSIS129, ACHGS050, ACSHE227, ACSIS145, ACSIS146, ACHGS058, ACHGS059

Worksheet 3

Instructions: In this worksheet we'll look at different types of data that have been collected using GPS. Start by reading the information pages provided, then look at each dataset and answer the relevant questions.

1. An ice shelf is like a large flowing 'river' of ice that floats on the ocean, often up to several hundred metres thick. As part of an Australian science program, 64 GPS receivers were setup across the Amery Ice Shelf in East Antarctica to help understand its movement over time. Scientists installed the high accuracy GPS receivers across strategic parts of the ice shelf system, and recorded data for over two years. The map in Figure 1 shows the results, where each red arrow indicates where each GPS receiver was deployed. The direction of the arrows show what direction the GPS receiver moved, and the length of each arrow indicates the speed of movement.

[see next page]



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A) Generally speaking, which direction is the ice shelf moving? Summarise how the flow direction changes slightly across different parts of the ice shelf. Be sure to note the latitude and longitude values for each area you're talking about.

B) Where is the ice shelf moving fastest, and what is the approximate speed at this location?

C) How does the speed identified in Part B (above) at the middle of the ice shelf differ from the speed at the edges of the ice shelf?

D) How does the speed of the ice shelf change as it gets closer to the coast? How much faster is the ice moving at the ocean compared to the inland regions?

E) Figure 1 shows that the two GPS receivers installed at approximately -70.8°N, 68.9°E had very little movement during the time they were deployed. Other nearby receivers directly to the east, however, are shown to be travelling at 300 to 400 m/year. Can you think what might cause these two receivers to remain stationary? What do you think the purple line on the map represents?

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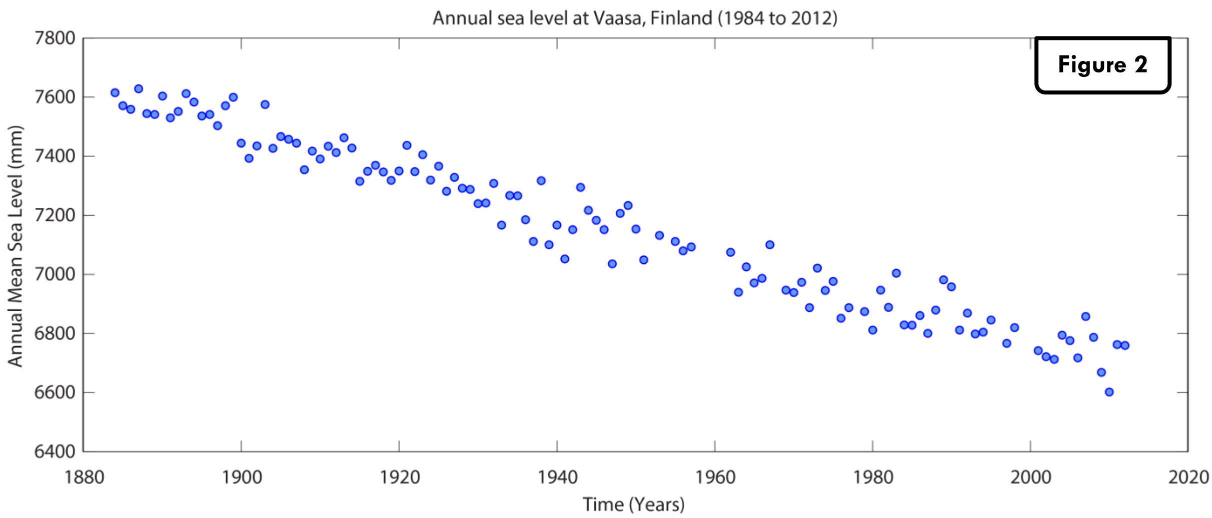
2. Scientists have been recording sea level at various locations around the world for decades. This information helps us to understand how sea level has changed in the past, and how it might change in the future. Scientists often use tide gauges to measure these changes in sea level. Tide gauges are fixed to a stable object (e.g. the end of a jetty) and repeatedly measure the distance to the surface of the water. If the distance increases, the sea level is falling (and vice versa).

   In 1883, a tide gauge was installed at Vaasa in Finland to measure the local sea level. Figure 2 shows the sea level recorded by the tide gauge between 1884 and 2012. Each blue dot represents the average sea level for that year, where the sea level is given in millimeters.



A) Briefly describe the trend in sea level shown by the graph in Figure 2.

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B) What are the highest and lowest recorded sea levels at Vaasa, and in what year did these levels occur (approximately)?

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C) Use a ruler to draw a straight line through all the points in Figure 2 to indicate the average sea level trend. Using your average estimate and the formula for the slope of a line (below), estimate the rate at which the sea level is changing at Vaasa (mm per year). Be sure to show your working.

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$$Rate = Slope = \frac{Rise}{Run} = \frac{Change\ in\ height}{Change\ in\ time}$$

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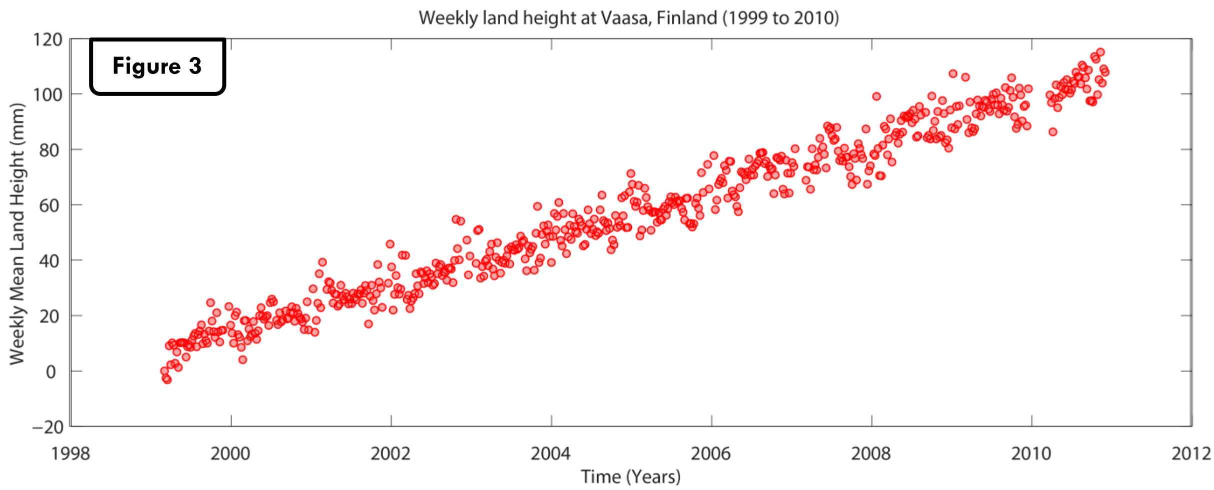
In 1999, scientists installed a permanent high accuracy GPS receiver onto some rocks near the Vaasa tide gauge. Figure 3 shows the height of the land recorded by the GPS for each week between 1999 and 2012. Each red dot represents the average land height for that week, where the land height is given in millimeters.



D) Briefly describe the trend in land height shown by the graph in Figure 3.

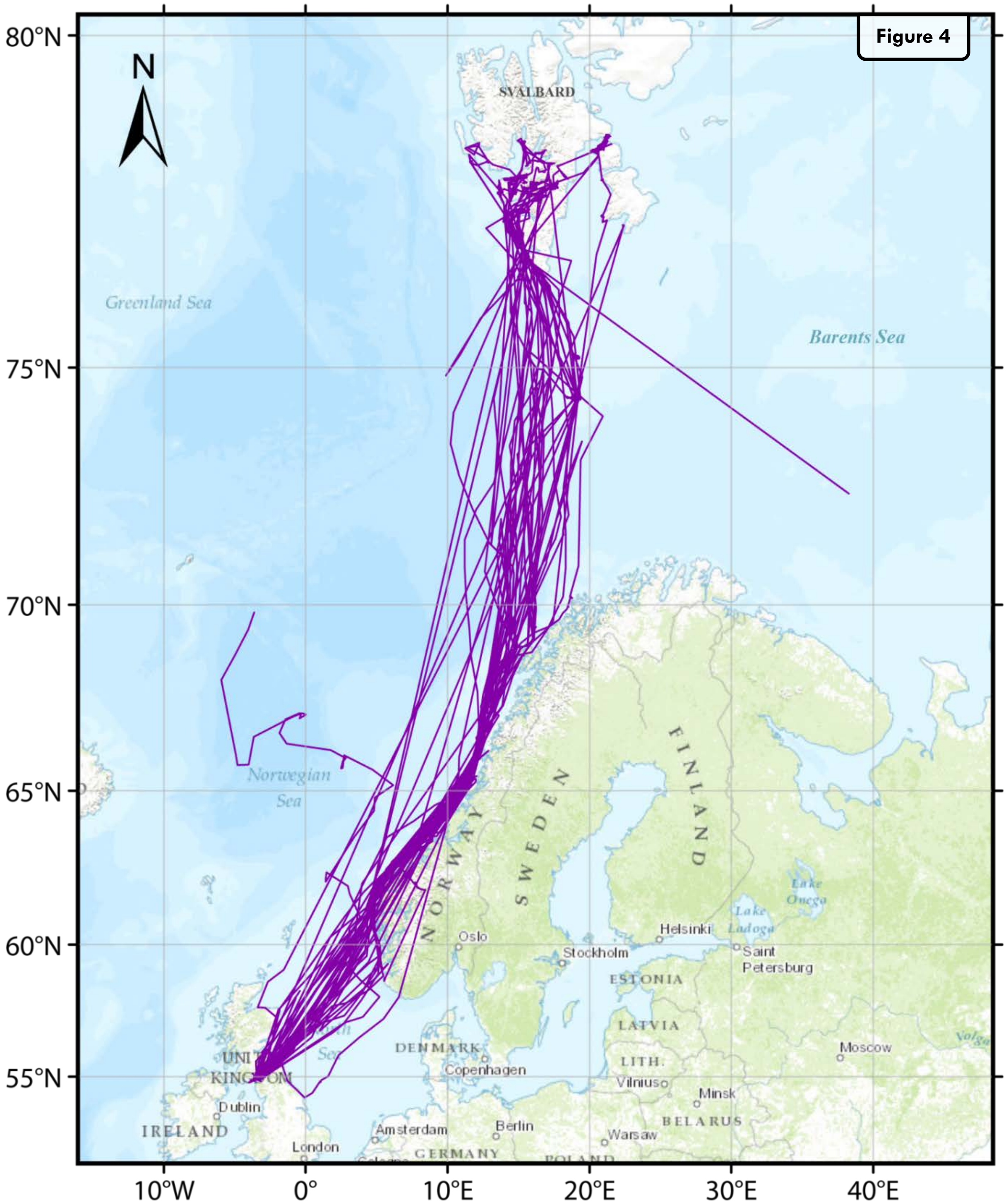
E) Use a ruler to draw a straight line through all the points in Figure 3 to indicate the average land height trend. Using your average estimate and the formula for the slope of a line (below), estimate the rate at which the land height is changing at Vaasa (mm per year). Be sure to show your working.

$$Rate = Slope = \frac{Rise}{Run} = \frac{Change\ in\ height}{Change\ in\ time}$$

F) How does the land height rate compare against the sea level rate at Vaasa?

G) What does this tell you about the sea level at Vaasa? Is the sea level actually falling (as shown in Figure 2), or is something else going on? Explain your answer.

3. GPS receivers can also be attached to animals to study various populations by tracking their movement. In 2006, scientists fitted 22 Barnacle Geese with GPS at their breeding grounds in Svalbard, to better understand their flight paths and wintering location. The map in Figure 4 shows the movements of these birds between 2006 and 2009 (marked in purple).



A) Looking at the map, describe the general migration pattern of the geese.

B) Do the geese fly directly to their destination(s), or do they tend to follow features to find their way around?

C) At what positions do the geese start and stop following the Norwegian coastline?

D) Two GPS tracks are shown to end prematurely in the Norwegian and Barents Sea. What is the most likely cause for this?

E) **Extension:** Do some research on Barnacle Geese using your own sources. How do their migration patterns and wintering sites compare with the answers you provided for Questions A, B and C? Be sure to provide references for your sources of information.