Smartphone GPS use in an Introductory Statistics Course

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ABSTRACT:

In many universities today, instructors may presume that all their students have access to a smart-phone and (therefore) have access to a free GPS device!

Students enjoy collecting their own data and working on it.

This presentation reflects on some basic points of preparation for such a lab, including smart-phone software advice, information on free web tools for converting the data (from GPS data into a proper format for entry into statistical software environments), classroom exercises, and reactions given by students who have done this.

As an added bonus, each student ends up with a unique data set, ensuring that students help each other properly without sharing files.

Looking for a fun lab...

- Cell phones are ubiquitous!
- They can load GPS software onto them.
- This talk is about what I did with my students using GPS data.

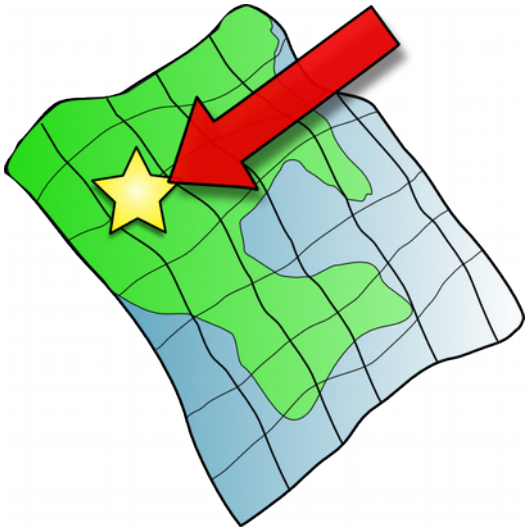
We think of this generation as being saturated in technology.

But, ironically...

They actually don't know much about the technology they use, and they are quite eager to learn!

Ken Halla (AP Government teacher) with students
http://www.nea.org/tools/56274.htm

Student Learning Objectives



- Practice simple data collection
  - ...and basic file manipulation skills
- Basic map skills / navigation
- Basic statistical manipulation
  - mean, standard deviation, scatterplots, best-fit lines
- Advanced skills - some students
  - intuitive feeling for what a standard deviation is by extrapolation along best-fit line

What does GPS mean?

These are GPS "Receivers".

and...

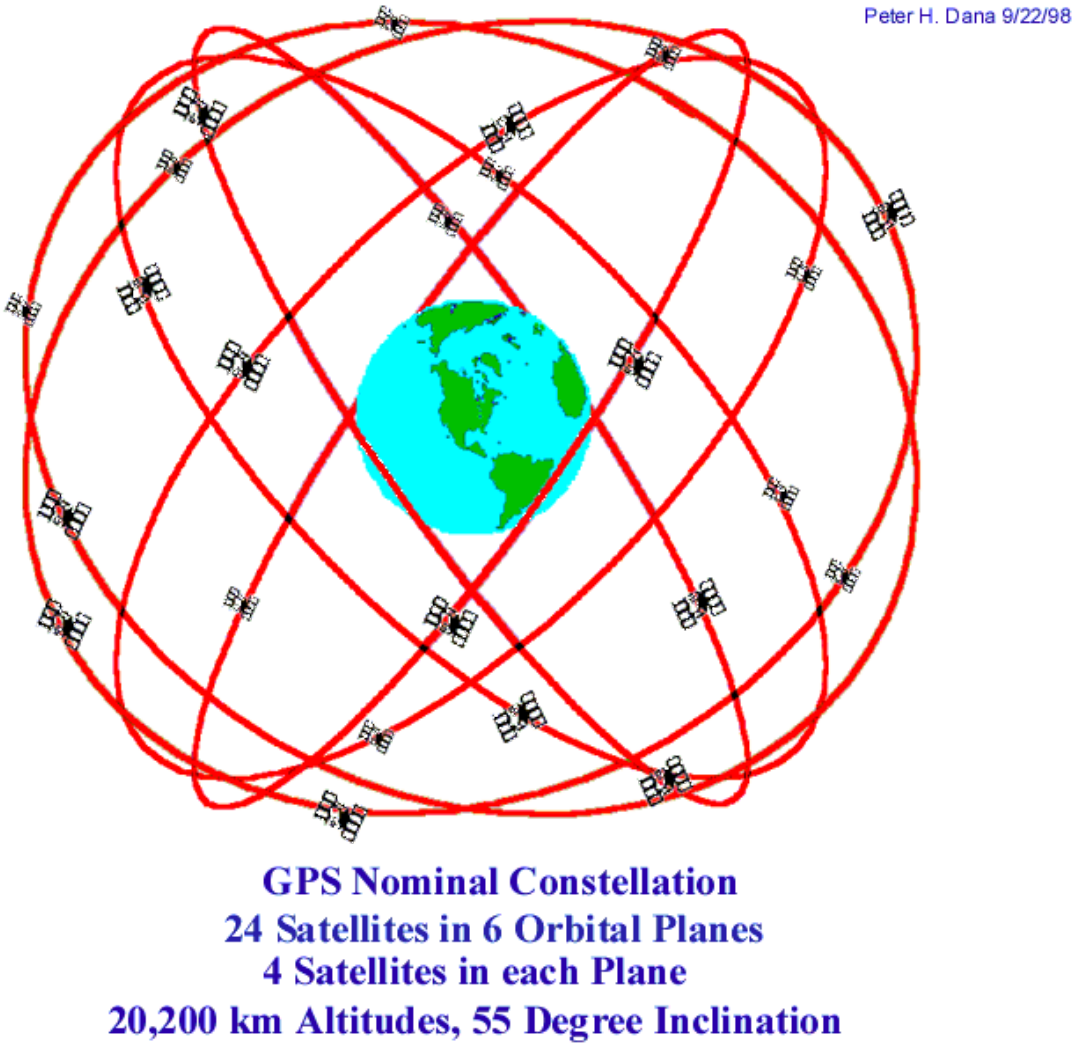
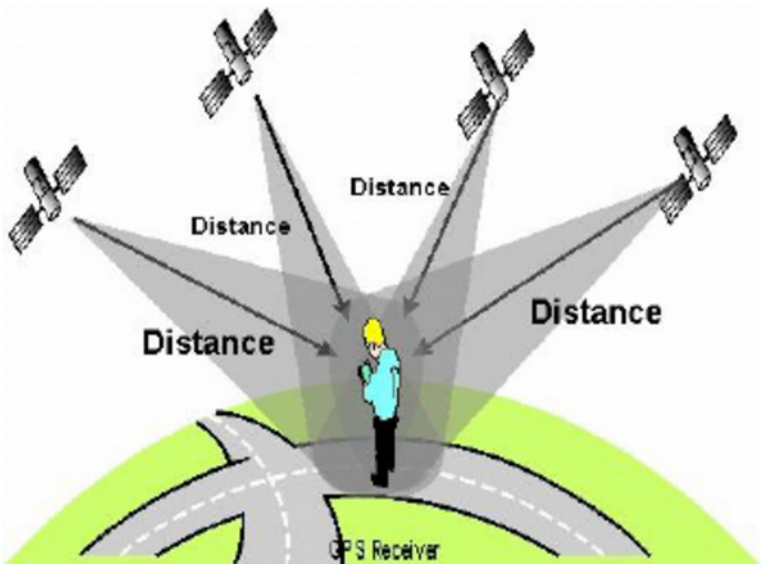


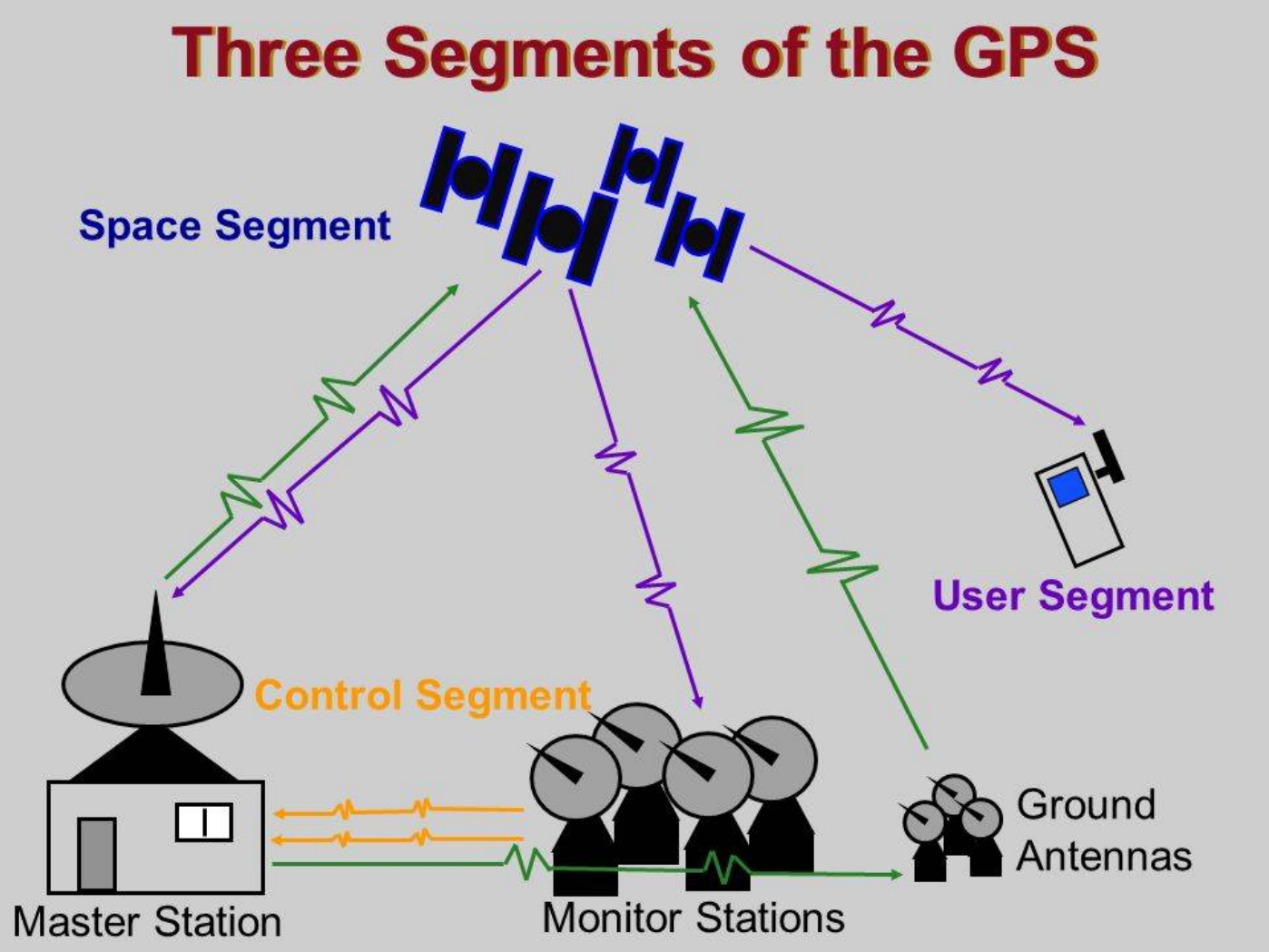
Image: Peter H. Dans

This is what GPS really means:

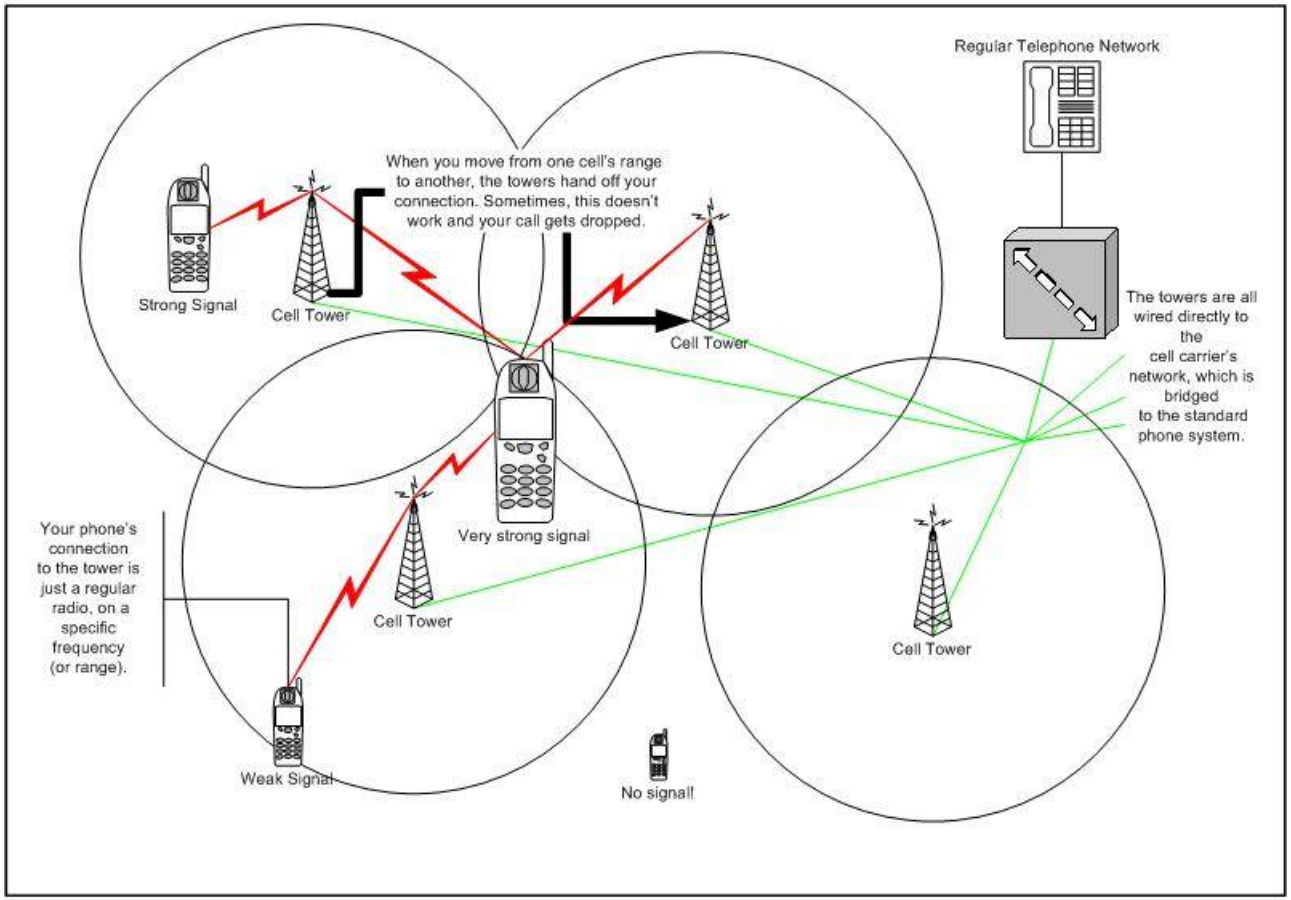


Images: Prasanna Sahu

But you knew all this...



Some phones don't have GPS receivers



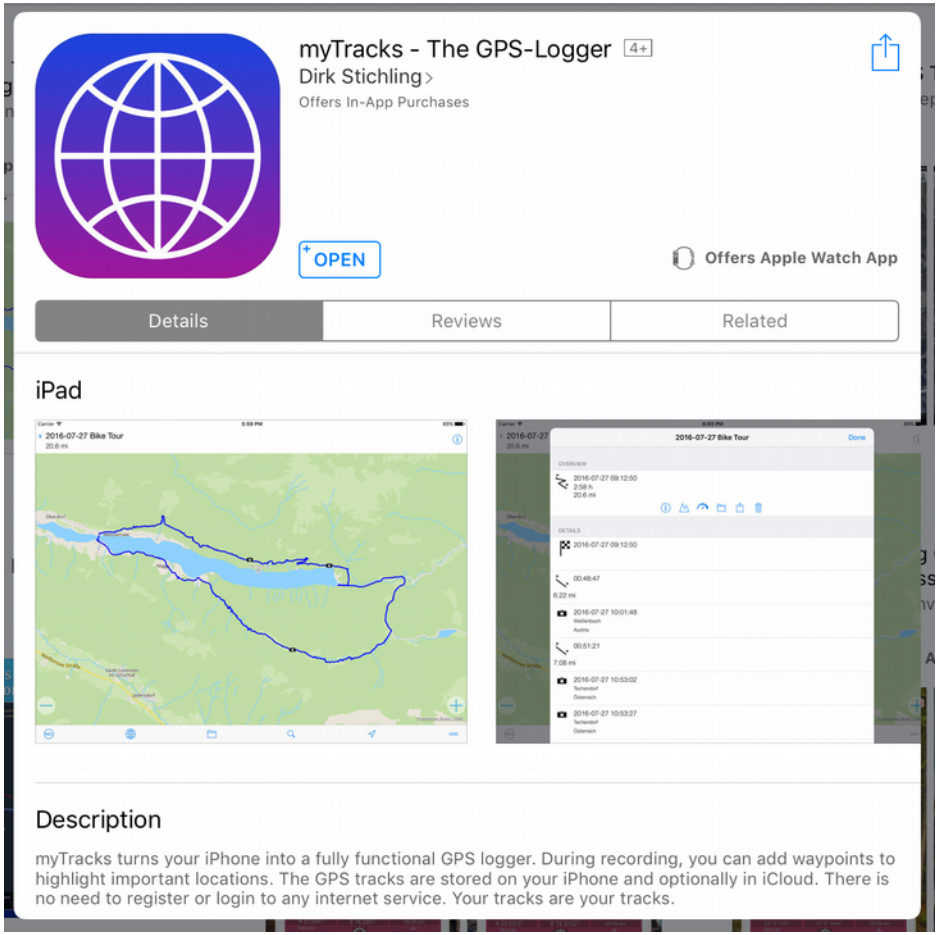
http://pursuitmag.com/locating-mobile-phones-through-pinging-and-triangulation/

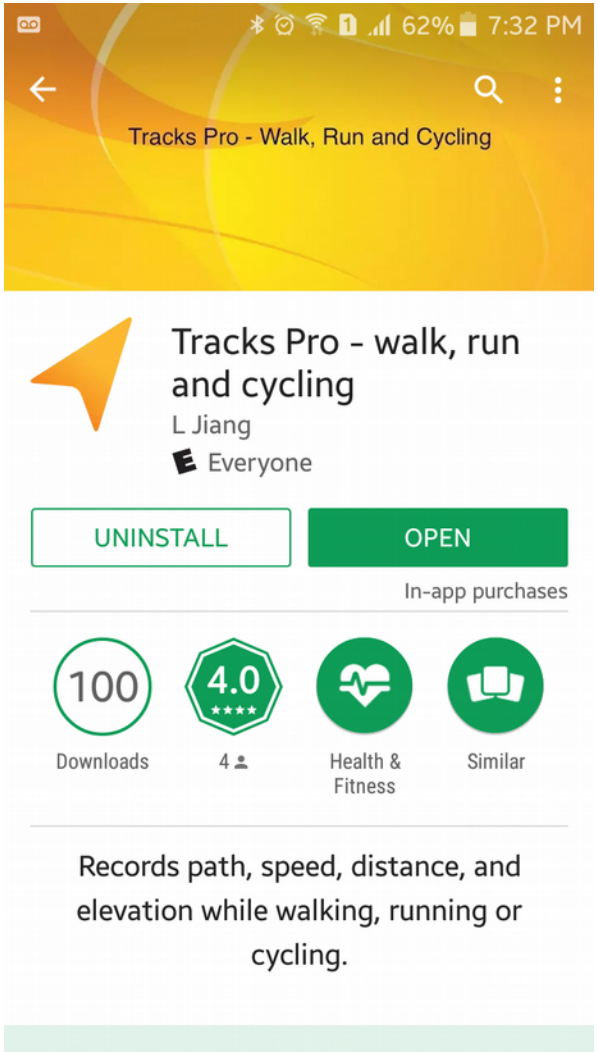
- Phones that don't have native GPS receivers do a pretty good job anyhow, but they just don't give elevation data. We can fix that issue with free on-line tools.

Before Lab Day:

- Prior to Lab Day, I give them printed instructions for both iPhone/Android users.
- I recheck the App Store and Google Play the week before, to make sure the software I like is still available, or I choose a new one and adjust the instructions.
  - The apps I suggest don't require log-ins or account creation.
  - They need to be able to easily export .gpx files.

My Favorite GPS apps:





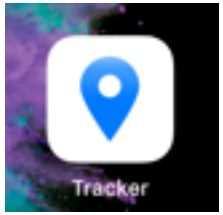
Dual-purpose slides: I'm going to fly past many of the slides, because they're intended for people who download the slides later so they'll have good instructions.

Another iPhone option:

App Store:

“Minimalist GPS Tracker” by 64 Characters

https://www.64characters.com/tracker



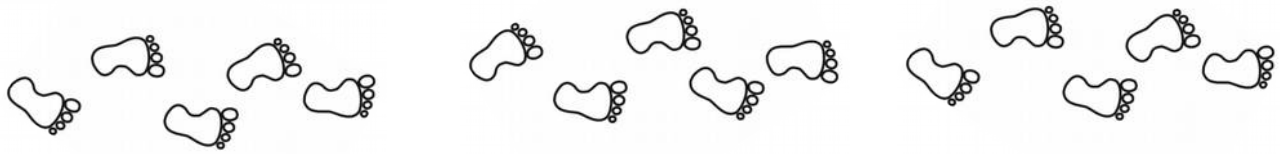
This part works smoothly

- They are usually fine to download and install apps. The apps make track recording simple.
- They need to know their Apple ID password to install apps, or Google Play password. (Most are fine.)

Record a path along a line:

-Install and Open the app.
-Go outside and wait about 20 seconds.
-Find a straight path that you can walk/run along.
  (i)Press little button in the lower left corner with
    “REC” in a circle, then confirm.
  (a)Click the big red button on the app to record

-For about 2 minutes, walk around, run, jump, etc,
  along your straight path.



Caveats

- If the students don't get enough data, the results aren't fun.
- I suggest asking them to collect “at least 50 points” or something like that.
- If they aren't moving, most GPS software will not record data. If they find that the .gpx file is small, usually they just need to try again and walk around a bit more.

record and save your track

- <u>iPhone users</u>

-When you've finished, click the “REC” button and confirm that you wish to “Stop recording”.

-It should be saved.

-Press the folder icon. Select desired track. It should display. Then hit the "i" info icon.

-Press the export icon. You don't need special options, so press the export icon again.

- <u>Android users</u>

-When you've finished, click the button with the little square to stop

-Name your track. Then save it.

-In the upper left corner, click MORE then Export, as GPX.

-Click “Share Track File”.

export to .gpx and email to self

- This is where a few students begin to have issues (maybe 3 or 4 students out of 28).
- Sometimes email software does not play well with the other apps on the phone.
- Apple users can try cloud storage.
- Android users can try Google Drive.
- Usually one student finds a hack and shares it.

Browsers/OSs hide files:

- Apple does not want users to be aware of files!
- Android is going that way as well!

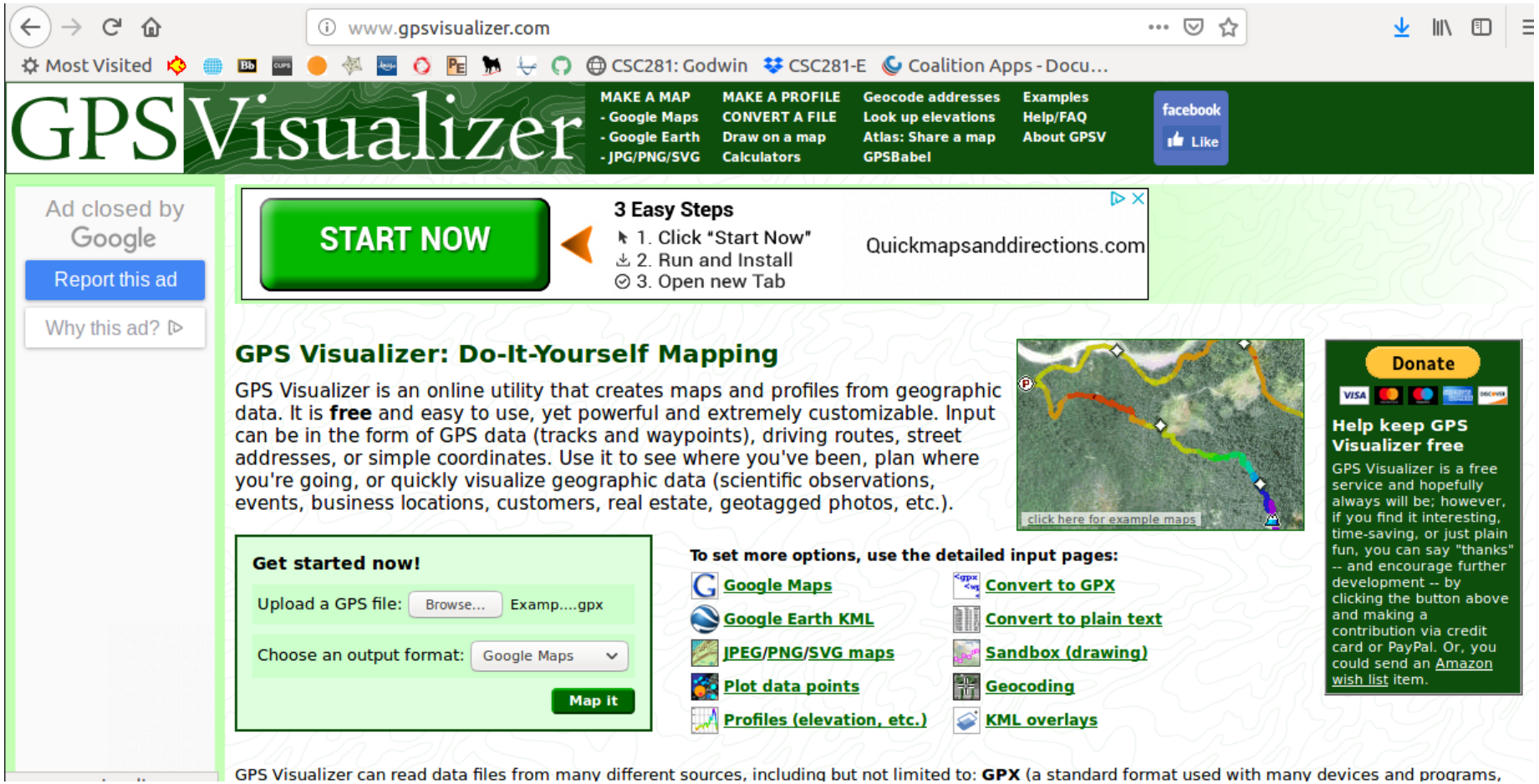
Downloading from email

- Apple users, Chrome users, may have issues downloading.
- Computer complains about the .gpx file, because there is “no application to open .gpx”
- Tell students to ignore the warning. We are not opening the file locally.
- Some computers/browsers hide the downloads. They need to know where the downloaded file went!

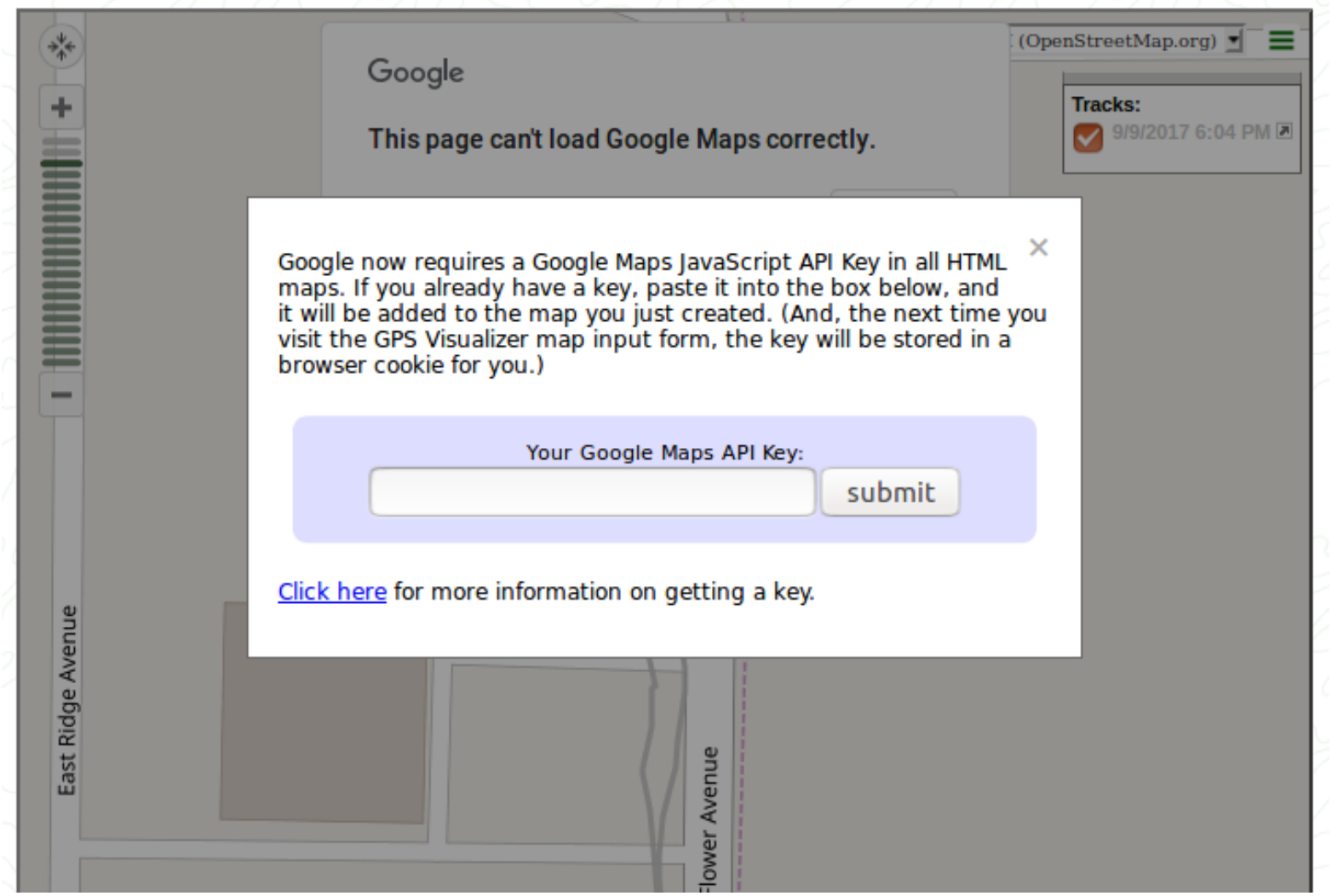
Upload the file to view on map:

Go to: http://www.gpsvisualizer.com/

Load your gpx file. Click “Map it”

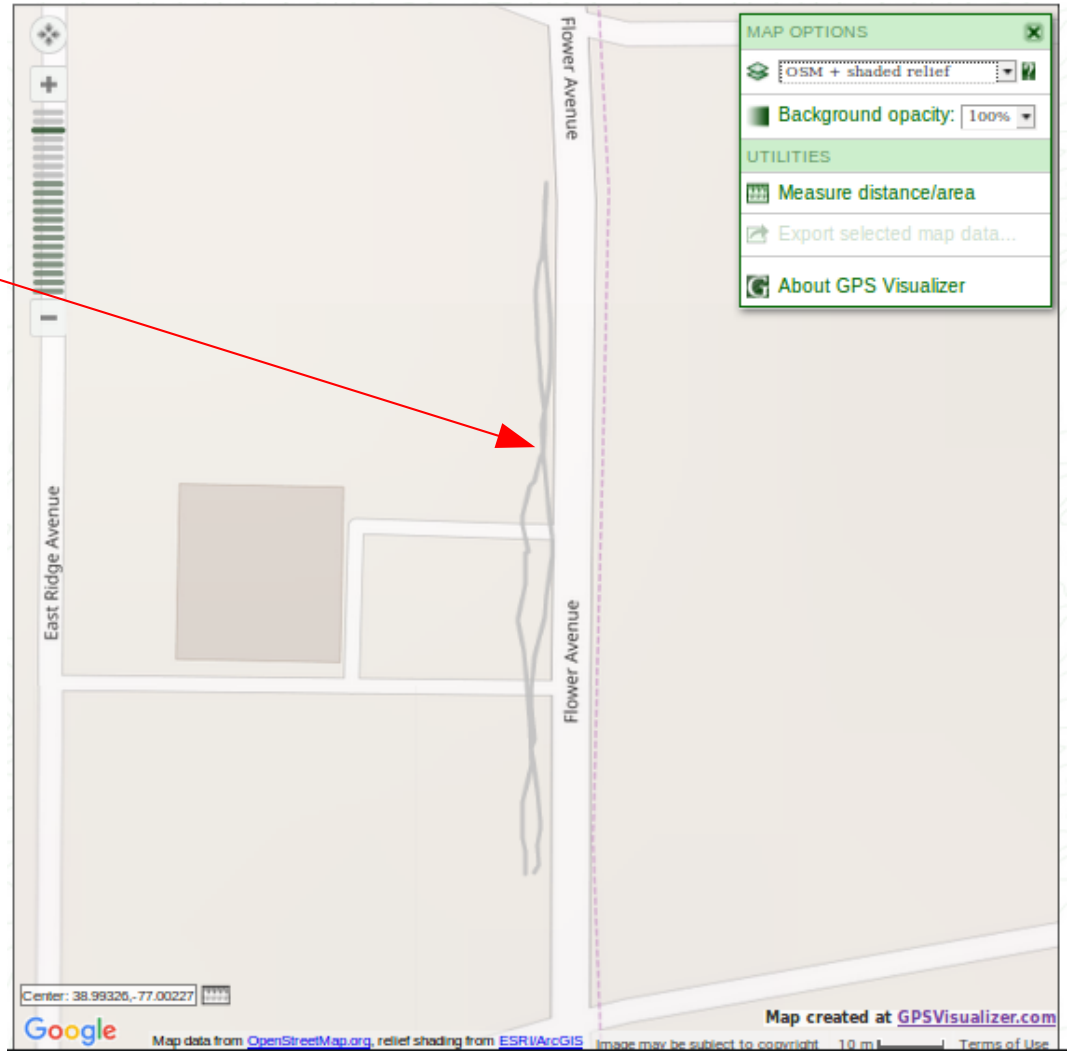


Ignore the API key warning



It will default to OSM (Open Street Maps)

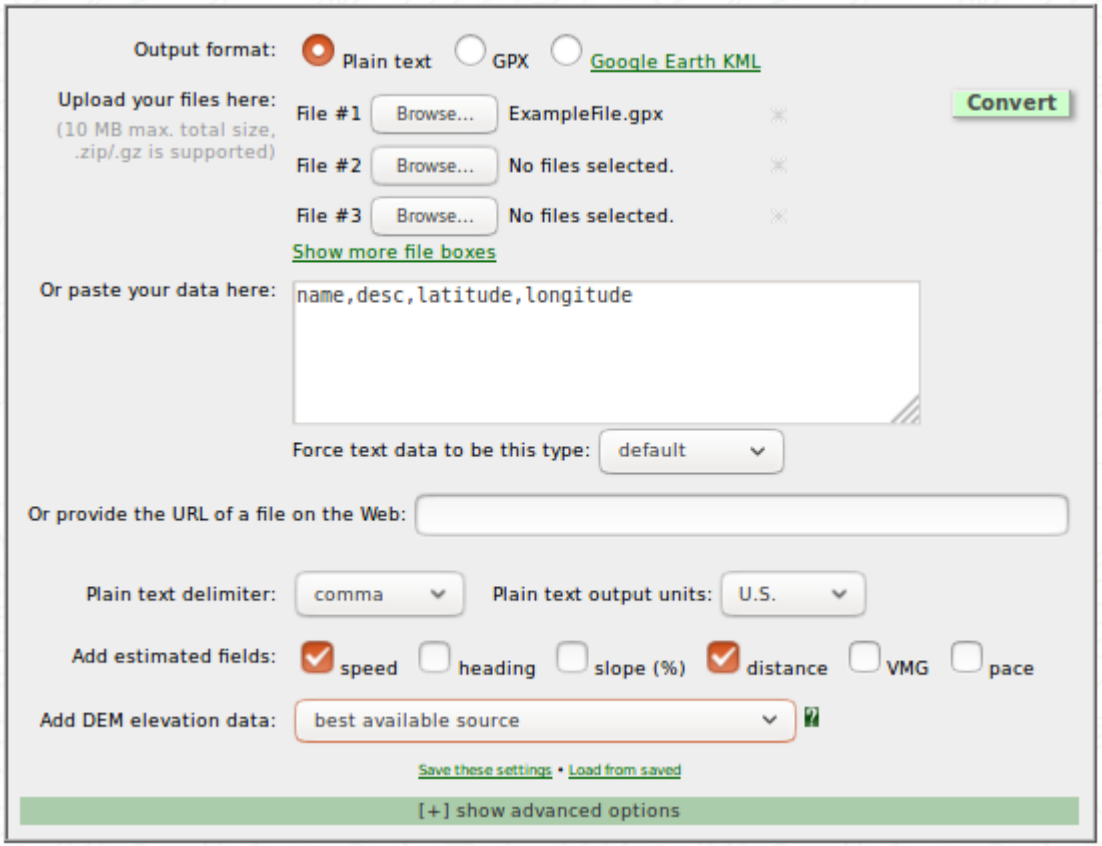
Path line color or style may differ. Might be dots.



Upload again to export to .csv

- Before we export it, we can add elevation.
- Most phone software will not give elevation.

http://www.gpsvisualizer.com/convert_input



http://www.gpsvisualizer.com/convert_input

Choose output format: Plain Text
Click “Browse” to attach your file

Choose plain text delimiter: comma
(Errors result when using whitespace.)

Choose “Add DEM elevation from best source”

Click the boxes next to “speed” and “distance” to add these columns

Then, click the “convert” button above.

Click to download and save your csv file
(which you can open in a spreadsheet if desired).

Now it's in .csv format

Your data has been converted to comma-separated text.

Right-click on the following link to download the file to your hard drive; you may want to give it a more sen

Click to download 20181231114958-54101-data.csv

Donate

Help keep GPS Visualizer free

If you're enjoying GPS Visualizer, please support further development by making a contribution via P

The contents of your file are also displayed in this box, if you'd rather cut and paste:

```
type,time,latitude,longitude,altitude (ft),speed (mph),distance (mi),distance_interval (ft),color,
T,2017-09-09 22:04:09.999,38.992775000,-77.002289000,268.4,,0.000,,c0c0c0,9/9/2017 6:04 PM,
T,2017-09-09 22:04:12.999,38.992806000,-77.002290000,268.7,2.6,0.002,11.29,,,
T,2017-09-09 22:04:13.999,38.992825000,-77.002293000,268.9,4.8,0.003,6.97,,,
T,2017-09-09 22:04:15.999,38.992857000,-77.002294000,269.2,4.0,0.006,11.66,,,
T,2017-09-09 22:04:16.999,38.992876000,-77.002295000,269.4,4.7,0.007,6.93,,,
T,2017-09-09 22:04:18.999,38.992910000,-77.002282000,269.6,4.4,0.009,12.92,,,
T,2017-09-09 22:04:19.999,38.992928000,-77.002279000,269.8,4.5,0.011,6.61,,,
T,2017-09-09 22:04:25.999,38.992967000,-77.002280000,270.1,1.6,0.013,14.21,,,
T,2017-09-09 22:04:26.999,38.992989000,-77.002281000,270.3,5.5,0.015,8.02,,,
T,2017-09-09 22:04:29.999,38.993031000,-77.002285000,270.7,3.5,0.018,15.34,,,
T,2017-09-09 22:04:30.999,38.993041000,-77.002286000,270.7,2.5,0.018,3.65,,,
```

Map this data: Google Maps, Google Earth, JPEG map, SVG map, or elevation profile — or go to the **map f**

Import to any software

- American University uses StatCrunch

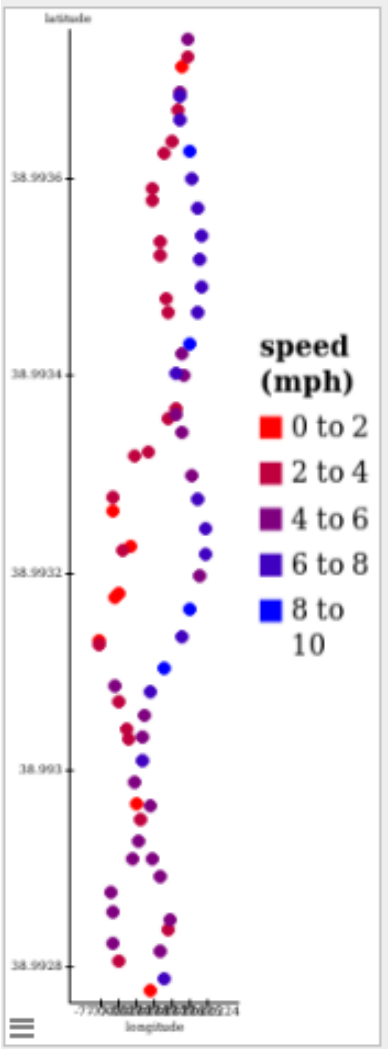
20181231114958-54101-data.csv

StatCrunch | Applets | Edit | Data | Stat | Graph | Help

Row	type	time	latitude	longitude	altitude (ft)	speed (mph)	distance (mi)	distance_inte	color	name
1	T	2017-09-09 2:	38.992775	-77.002289	268.4		0		c0c0c0	9/9/2017 6:04
2	T	2017-09-09 2:	38.992806	-77.00229	268.7	2.6	0.002	11.29		
3	T	2017-09-09 2:	38.992825	-77.002293	268.9	4.8	0.003	6.97		
4	T	2017-09-09 2:	38.992857	-77.002294	269.2	4	0.006	11.66		
5	T	2017-09-09 2:	38.992876	-77.002295	269.4	4.7	0.007	6.93		
6	T	2017-09-09 2:	38.99291	-77.002282	269.6	4.4	0.009	12.92		
7	T	2017-09-09 2:	38.992928	-77.002279	269.8	4.5	0.011	6.61		
8	T	2017-09-09 2:	38.992967	-77.00228	270.1	1.6	0.013	14.21		
9	T	2017-09-09 2:	38.992989	-77.002281	270.3	5.5	0.015	8.02		
10	T	2017-09-09 2:	38.993031	-77.002285	270.7	3.5	0.018	15.34		
11	T	2017-09-09 2:	38.993041	-77.002286	270.7	2.5	0.018	3.65		
12	T	2017-09-09 2:	38.993069	-77.00229	271	3.5	0.02	10.26		
13	T	2017-09-09 2:	38.993086	-77.002292	271.2	4.2	0.022	6.22		
14	T	2017-09-09 2:	38.993127	-77.002302	271.6	3.5	0.024	15.2		

Now you can play!

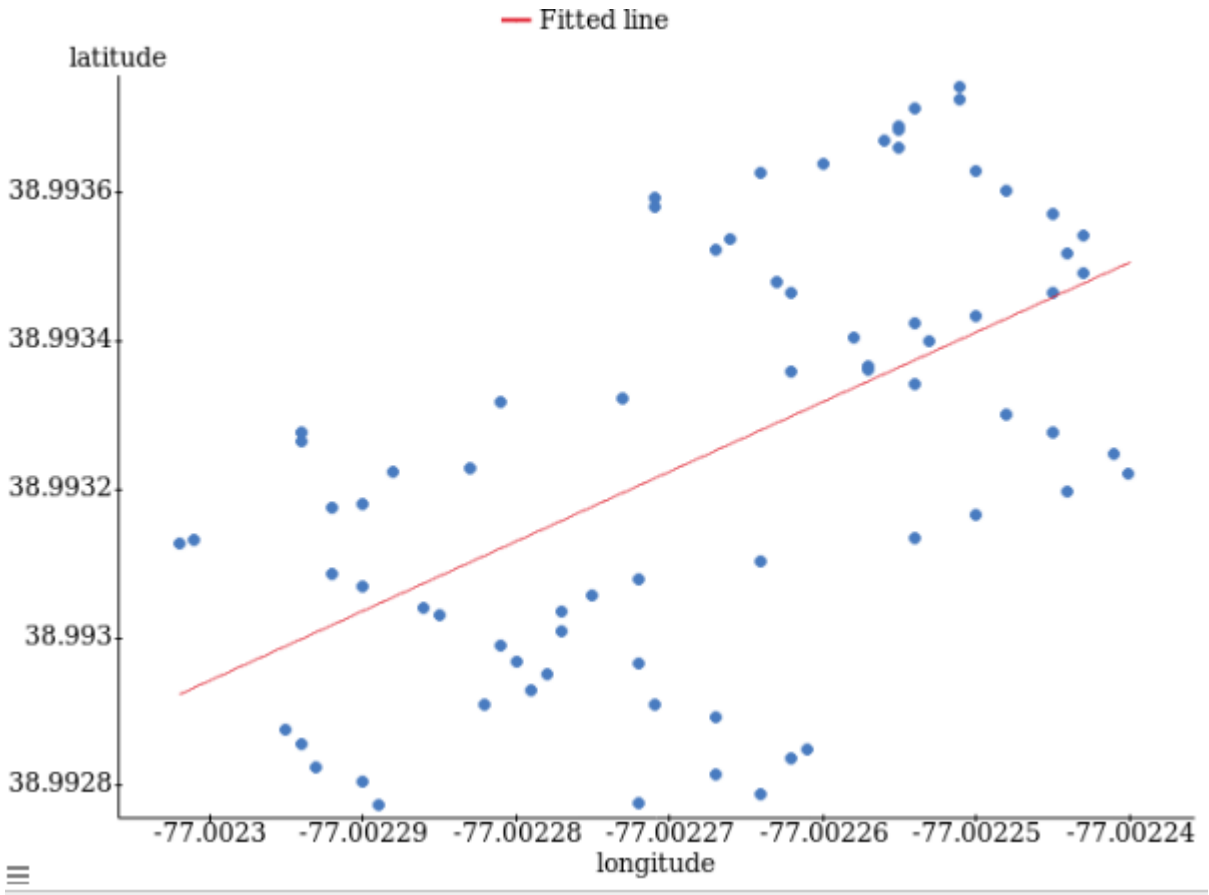
Beware:
We say “Lat/Lon” but
x=Longitude (E/W)
y=Latitude (N/S)



Regression...

Same points as before.

The path is mostly a N/S path, but the scaling makes it look otherwise.



Simple linear regression results:
Dependent Variable: latitude
Independent Variable: longitude
latitude = 761.35776 + 9.3810811 longitude
Sample size: 74
R (correlation coefficient) = 0.56133639
R-sq = 0.31509855
Estimate of error standard deviation: 0.00023920399

Parameter estimates:

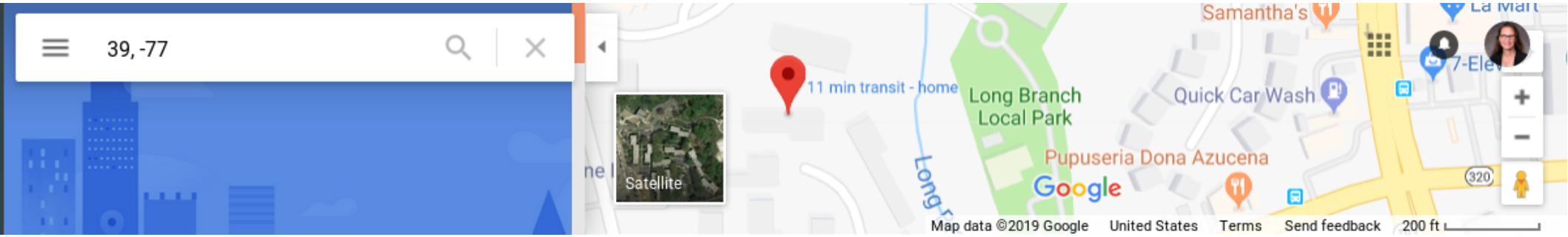
Parameter	Estimate	Std. Err.	Alternative	DF	T-Stat	P-value
Intercept	761.35776	125.51077	≠ 0	72	6.0660751	<0.0001
Slope	9.3810811	1.629962	≠ 0	72	5.7553986	<0.0001

Analysis of variance table for regression model:

Source	DF	SS	MS	F-stat	P-value
Model	1	0.0000018953423	0.0000018953423	33.124613	<0.0001
Error	72	0.0000041197355	5.7218549e-8		
Total	73	0.0000060150778			

Extrapolation

- I had my students extrapolate a point along the line of best fit which was 5 standard deviations away from the mean x-value (Longitude).
- Unless they walked a very straight N/S path, this usually resulted in a point about a block away, but it was a place they were familiar with.



Students enjoy this lab:

- “Although it makes sense, I had never thought of GPS data in this way. I enjoyed doing this lab because it wasn’t perfect data. It was data that I collected rather than something manufactured.” M.B.

- In this lab, I most enjoyed viewing the path I walked. Overall, I thought the lab was a fun activity that taught me about tracking paths and linear graphs.” A.B.

More feedback:

- “I learned, for the first time, that I am able to map coordinates on Google maps. I was impressed with the the app’s accuracy of where I was walking on campus and the speed of which I was walking or running.” L.C.
- “I enjoyed this lab because it challenged me in several ways but also taught me navigation skills. I learned the importance of latitude and longitude in addition to several key aspects of reading a map. I found the calculations fascinating and understandable.” V. C.

And more...

- “Overall, it was fun actually creating the data I would later mess around with in the analyzing part of this lab.” C.F.
- “Overall, this assignment was interesting because I was using data collected from my everyday life. This is a walk I take every day to get from campus back to where I live. I never knew you could type coordinates into Google Maps” V. F.

In Conclusion:

- GPS data is easily obtained by students
- .gpx files can be converted to .csv on-line
- Any software can load it and analyze .csv files
- Students enjoy analyzing data they collect.
- slides: https://www.donnadietz.com
- dietz@american.edu
- https://tinyurl.com/Dietz-GPS

  (Video instructions)