

#geog370



# Free and Open Source Geographic Information Systems

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*Faculty of Health and Medicine,  
Lancaster University*



So this is the special lecture for Geog370.  
I'm a researcher in Health and Medicine and I do a  
lot of disease mapping and spatial statistics and I've  
been doing GIS at Lancaster for 20 something years.

# ArcGIS



Products

## ArcGIS for Desktop

Main Features Extensions System Requirements Pricing Free Trial



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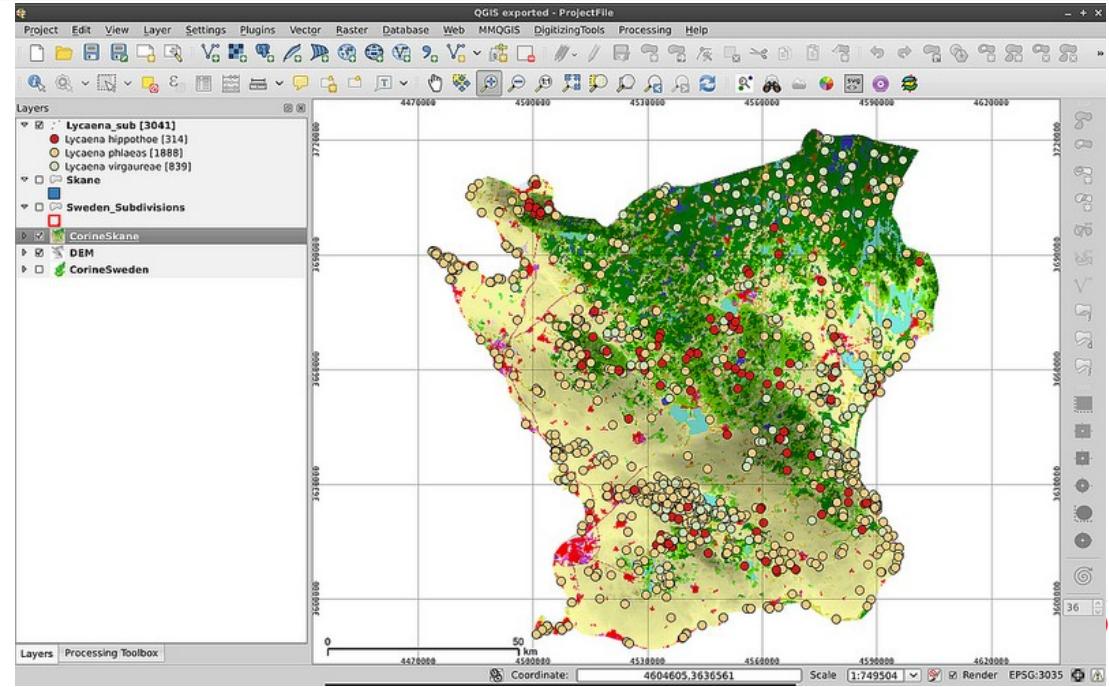
[Free Trial](#)



ArcGIS has been used in this course for a number of reasons – the University has a site license, the staff are experienced with it and so on.

But in the same way that there are alternatives to Microsoft Word for writing documents, there are other GIS packages.

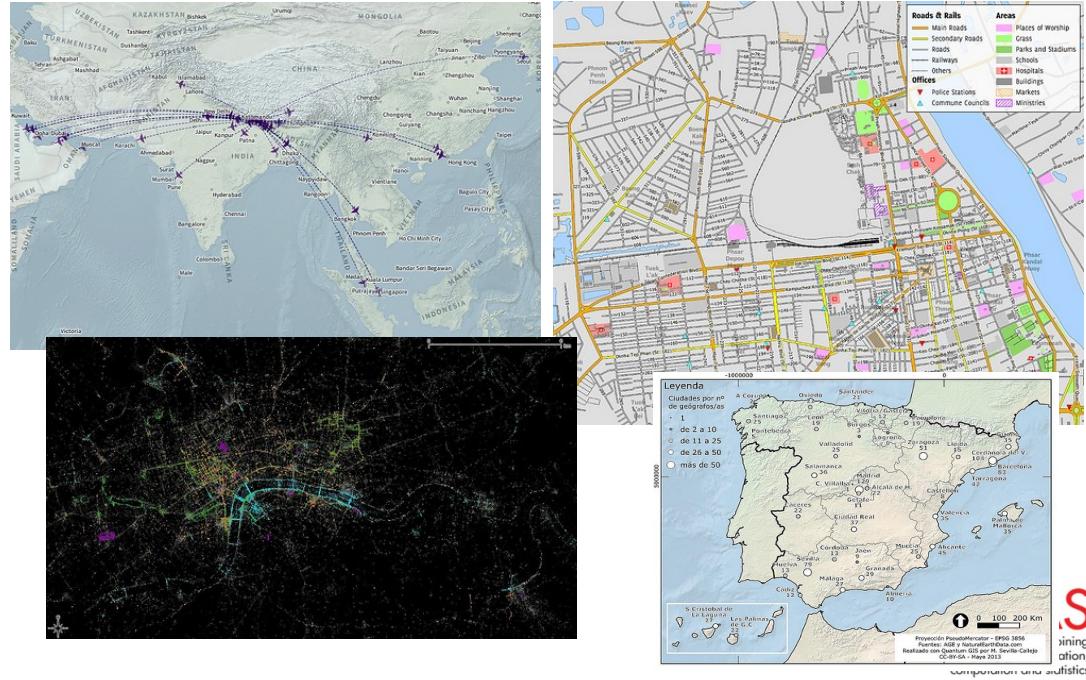
# QGIS



QGIS (until recently Quantum GIS, but now officially QGIS) is a desktop GIS program.

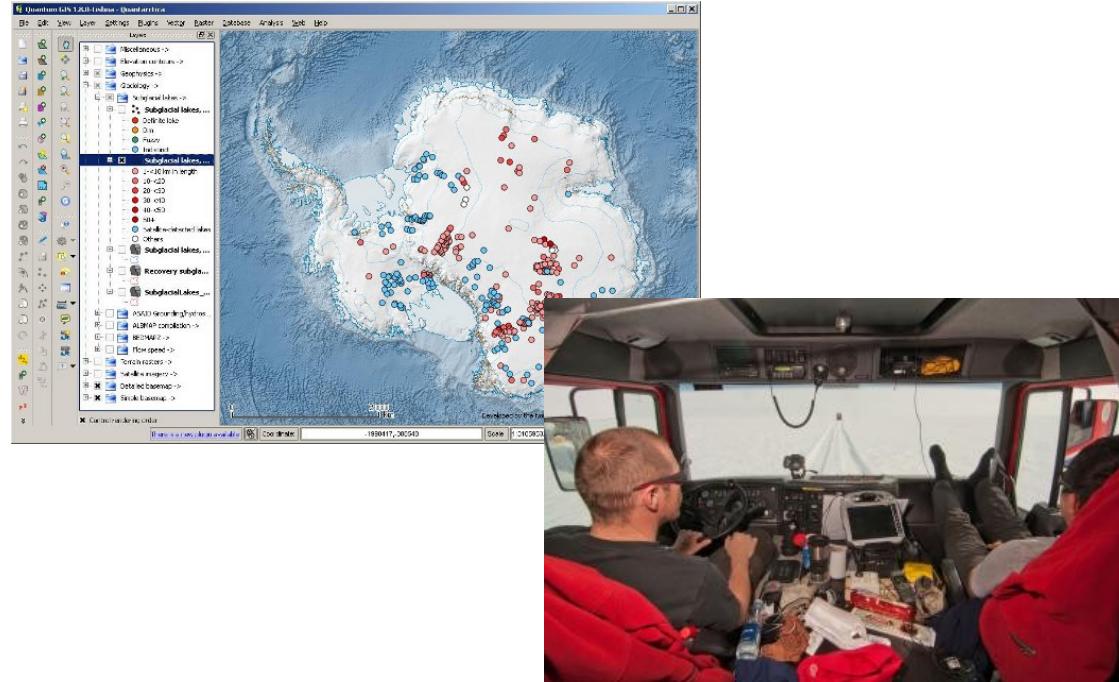
What can it do? It can load shapefiles and map them, colouring them by attribute in flexible ways. It can load raster data and draw that on a map too. It handles data in different coordinate systems, transforming them to one system for display.

# QGIS Features



- It can create and edit vector data including the geometry and attributes.
- It can produce a wide variety of maps, do raster and vector processing, and spatial analysis.
- It can connect to spatial databases, including enterprise services that operate over the internet.

# “Quantarctica”



These guys drive round Antarctica in their snow-cat vehicles and run a customised QGIS for their research.

The screenshot shows the QGIS website's 'Platforms' page. At the top right is the Lancaster University logo. Below it is a navigation bar with links: 'DISCOVER QGIS', 'FOR USERS', 'GET INVOLVED', 'DOCUMENTATION', a search bar, and a language dropdown set to 'English'. The main heading 'Platforms' is in large white text. Below it is a sub-section titled 'Download QGIS for your Platform'. It states: 'QGIS is available on Windows, MacOSX, Linux and Android. Binary packages are provided for the current version.' and 'The current version is QGIS 2.0.1 and was released in September 2013.' There are three tabs at the bottom of this section: 'INSTALLATION DOWNLOADS' (selected), 'ALL RELEASES', and 'SOURCES'. Below these tabs are five download links, each in its own box: 'Download for Windows', 'Download for Mac OS X', 'Download for Linux', 'Download for BSD', and 'Download for Android'.

QGIS runs on Windows, Apple Mac computers, Linux boxes, Android tablets and phones, and other operating systems you've probably never heard of.

But the university does not have a site license to use QGIS.

# Free and Open Source



QGIS

A Free and Open Source Geographic Information System



Create, edit, visualise, analyse and publish geospatial information on Windows, Mac, Linux, BSD (Android coming soon)

For your desktop, server, in your web browser and as developer libraries

[Download Now](#)

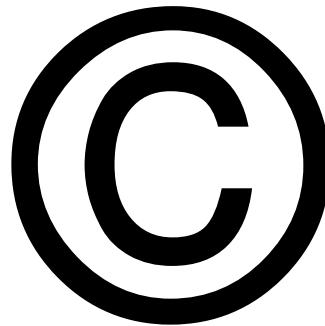
[Support QGIS](#)

Version 2.0 Dufour

Donate now!



But the university doesn't need a site license,  
because QGIS is a Free and Open Source GIS.



Computer software is considered a 'creative work', and as such is subject to the laws of copyright. Unless the author has removed their copyright by putting the program in the 'public domain', you need a license to use it. This applies to all creative works – check the small print on DVDs or music downloads to see how false is the claim of “Yours to own” that you sometimes see on ads.  
So lets look at a typical software license...

# ArcGIS Licence



The license for ArcGIS doesn't let you copy the software, or inspect it too closely. The licence may be restricted to a single computer, or a fixed number of computers, or a maximum number of simultaneous people within a site.

ESRI have a bunch of different license schemes, for example, the "ArcGIS for Home" license is a \$100 annual fee – after a year you have to pay up again, and you are not allowed to use it on anything defined as "commercial".

Apart from that, pricing is hard to come by, as is the exact license terms.

# QGIS Licence



In contrast, QGIS however is released under version 3 of the Gnu Public License, or GPL. This is classified as a “free” and “open source” licence, two concepts we will explore in more detail.

# Free Software

Free Beer



Free Speech



The phrase “Free Software” often makes people think that it refers to software obtained at zero cost, like the mythical “Free Beer”. But the word “Free” in English has a huge range of meanings.

# Free Software



Free Speech



In software terms it always fundamentally refers to “Free as in freedom”. The “Free as in beer” aspect is merely a consequence of these freedoms.



**FREE SOFTWARE  
FOUNDATION**

LANCASTER  
UNIVERSITY



- The Free Software Foundation (FSF) is a nonprofit with a worldwide mission to promote computer user freedom and to defend the rights of all free software users.



A lot of the thinking about free software has come out of a group called the Free Software Foundation

# Software Freedoms

- The freedom to run the program, for any purpose.
- The freedom to study how the program works, and change it so it does your computing as you wish.
- The freedom to redistribute copies.
- The freedom to distribute copies of your modified versions to others.



The FSF defines four software freedoms.

The first one prevents licenses restricting commercial use, or using it only on Mondays, or any other restriction like that.

The second freedom gives you the right to modify the program.

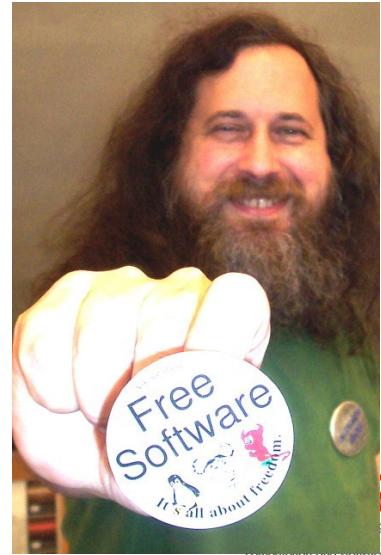
The third freedom is the “Free Beer” freedom. You can theoretically charge for distributing copies, but there's nothing to stop someone charging zero, and in these days of the internet the cost is practically zero.

The final freedom lets you distribute a modified program containing some of your code and the original.

## Free Software

- “Free software is software that respects your freedom and the social solidarity of your community. So it's free as in freedom.”

*Richard Stallman*



One of the leaders of the Free Software movement, and author of the GPL text, Richard Stallman had this to say about free software.

# Software Freedoms

- The freedom to run the program, for any purpose.
- The freedom to study how the program works, and change it so it does your computing as you wish.
- The freedom to redistribute copies.
- The freedom to distribute copies of your modified versions to others.



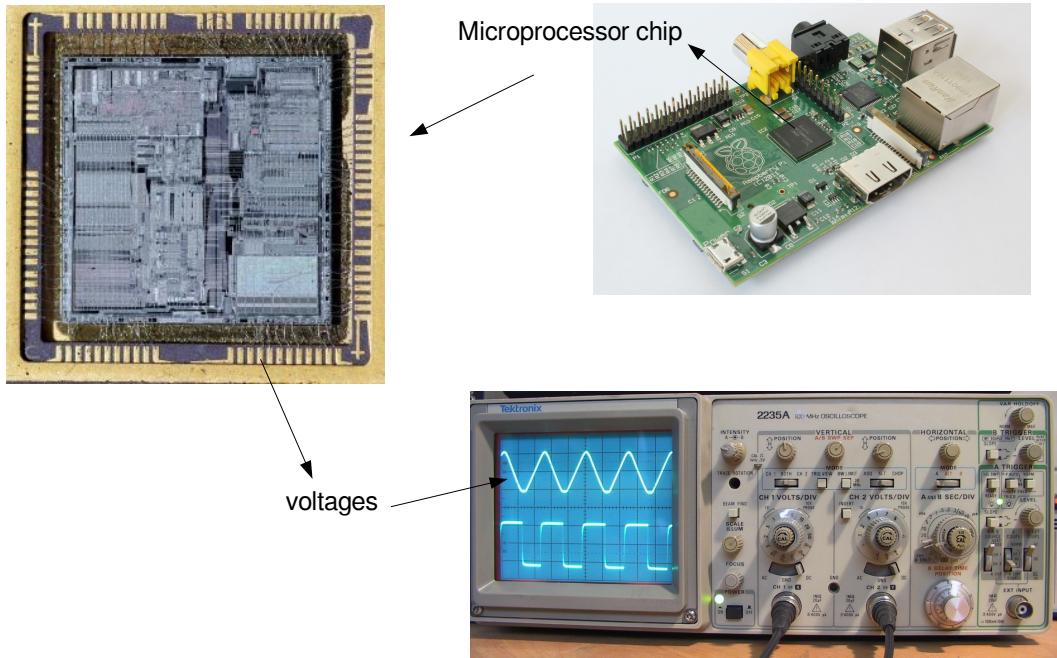
Lets look at one of the software freedoms. How do you go about studying and modifying a program?

# What is The Source Code?



We have to take a little journey down the rabbit hole of how computers work. We need to find out what “Source Code” is.

# What is The Source Code?



Everything a computer does can be traced back to electric voltages on a microprocessor chip. All your data, images, video and music have to become electrical voltages somewhere on this before heading out on the external contacts through various other circuitry to the screen or the speakers.

A computer program is a series of instructions that controls the voltages on this chip.

The program itself is just a set of stored representations of voltages, just like any other data

# What is The Source Code?



```
00002d6: 11010110 10100111 01011011 10010000 11000011 00011101 ...[...]
00002dc: 00101101 11011011 01001100 00010011 10101110 00001101 -.L...
00002e2: 11110101 00000011 01001010 11100101 11111110 00010010 ...J...
00002e8: 01010001 11101110 01101000 10110101 10001010 00110110 Q.h..6
00002ee: 00110001 11010110 00011110 11100111 00000011 11101110 1.....
00002f4: 11110011 01100110 01010101 01010010 00011111 11001001 .fUR..
00002fa: 01011101 01101111 01111010 10110100 10101111 00000111 ]oz...
0000300: 01111111 11010010 00110000 00011110 00111000 01111010 ..0.8z
0000306: 01111000 00110001 11000000 00011110 01100001 00101100 x9..a,
000030c: 00011010 00101011 11010101 00111100 10110101 01000000 .+.<.@
0000312: 10001010 00110000 11101001 11100111 11101011 01000001 .0...A
```

comparing  
health information,  
computation and statistics

To keep things simple, computers just use two levels of voltage, and call them ones and zeroes.

Each group of typically 8 or 16 ones and zeroes makes up an instruction to modify the data on the chip in some way. This pattern might mean change some other data from ones to zeroes, or it might mean take the next instruction from 23 locations back, and so on.

Alan Turing proved that a small set of very simple instructions could compute anything computable

Remembering what each of these binary codes does is not something humans do well, so...

# What is The Source Code?



```
...
insw
popaw
imul bp,[bp+0x0],word 0x5f5f
a32 insw
outsw
outsb
pop di
jnc 0x3b9
popaw
...
```

Health information  
computation and statistics

...programs can be written in higher level languages and converted into binary by other programs.

This is a short piece of a program in 'Assembly Language', which is still quite low level and works mostly with data on the chip. But it's clearly not something that is easy to write, the instructions are obscure and don't relate to real-world things that you might want to write programs about.

So computer engineers designed higher level languages, and programs that could convert them to assembly language and hence to binary codes that the processor can actually run.

# High Level Language



```
for i in [1, 3, 5, 7, 9]:  
    print i, i*2
```



Here's a simple program written in a high-level language. For the computer to run this it first has to be converted into assembly language instructions and then into binary numbers. A simple program like this could end up as several hundred assembly language instructions.

What happens when you run this?

# High Level Language



```
for i in [1, 3, 5, 7, 9]:  
    print i, i*2
```

```
1 2  
3 6  
5 10  
7 14  
9 18
```



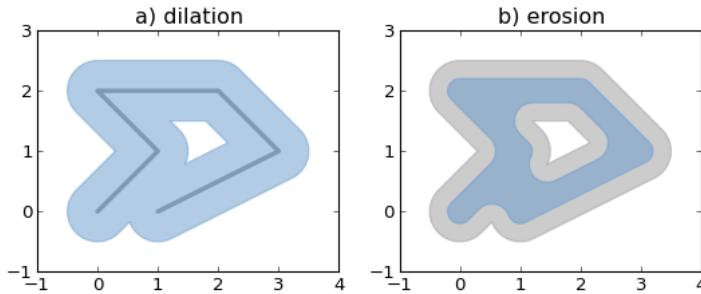
When it runs it prints out the numbers in the list and each number multiplied by two.

Two advances have happened here. Firstly, we are getting away from voltages and hardware to numbers, arithmetic, lists of things.

And secondly, making changes is easy – if you wanted to list each number multiplied by three instead of two I think the change is obvious.

# Higher Levels

```
from shapely.geometry import LineString
line = LineString([(0, 0), (1, 1), (0, 2),
                   (2, 2), (3, 1), (1, 0)])
dilated = line.buffer(0.5)
eroded = dilated.buffer(-0.3)
```



(more lines of code are needed to actually draw the plots on screen)



Programming languages can work at very high levels of abstraction. Here is an example where the language is working with geometric objects – lines and buffers.

Computer programs are written like this, in languages increasingly more capable of expressing real-world things. But the readable code always has to be converted to the unreadable binary format to run.

This readable – and importantly, writable – form of a computer program is the source code.

## Definition

- **Source Code**

“The preferred form for making modifications to a work”



So we get a definition from the Free Software Foundation for what source code is.

# Software Freedoms

- The freedom to run the program, for any purpose.
- The freedom to study how the program works, and change it so it does your computing as you wish.
- The freedom to redistribute copies.
- The freedom to distribute copies of your modified versions to others.



And having access to that source code, something broadly termed “Open Source” is what permits the second of the software freedoms, to study, change and hopefully improve the software.

# Some QGIS Source

```

/** 
 * \brief Horizontal move of point position
 */
int nmea_move_horz(
  const nmeaPOS *start_pos,      /**< Start position in radians */
  nmeaPOS *end_pos,             /**< Result position in radians */
  double azimuth,               /**< Azimuth (degree) [0, 359] */
  double distance               /**< Distance (km) */
)
{
  nmeaPOS p1 = *start_pos;
  int Retval = 1;

  distance /= NMEA_EARTH_RADIUS_KM; /* Angular distance covered on earth's surface */
  azimuth = nmea_degree2radian( azimuth );

  end_pos->lat = asin(
    sin( p1.lat ) * cos( distance ) + cos( p1.lat ) * sin( distance ) * cos( azimuth ) );
  end_pos->lon = p1.lon + atan2(
    sin( azimuth ) * sin( distance ) * cos( p1.lat ), cos( distance ) - sin( p1.lat ) * sin( end_pos->lat ) );

  if ( NMEA_POSIX( isnan )( end_pos->lat ) || NMEA_POSIX( isnan )( end_pos->lon ) )
  {
    end_pos->lat = 0; end_pos->lon = 0;
    Retval = 0;
  }

  return Retval;
}

```

Here's some QGIS source code that works with NMEA-format data from a GPS unit. You can see that its using trigonometry with sines and cosines to do some coordinate conversions.

Something like this must exist in ArcGIS and other proprietary GIS packages, but you aren't allowed to see it. The source code is a trade secret that the company guards closely.

# I'm not a programmer!

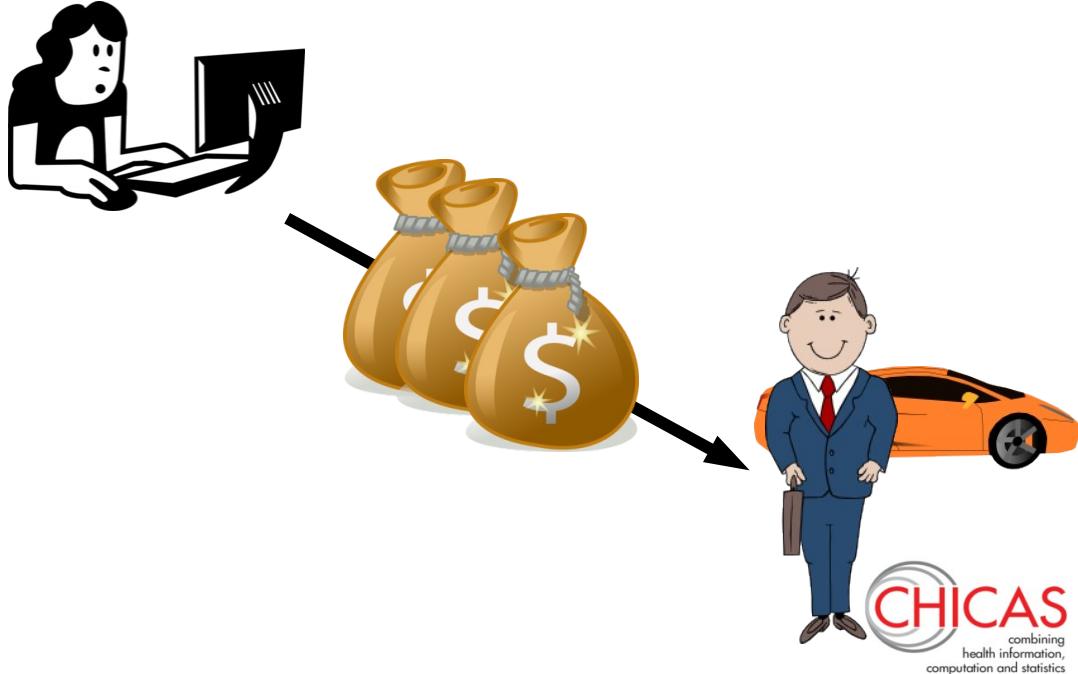


No problem, pay someone to do it!



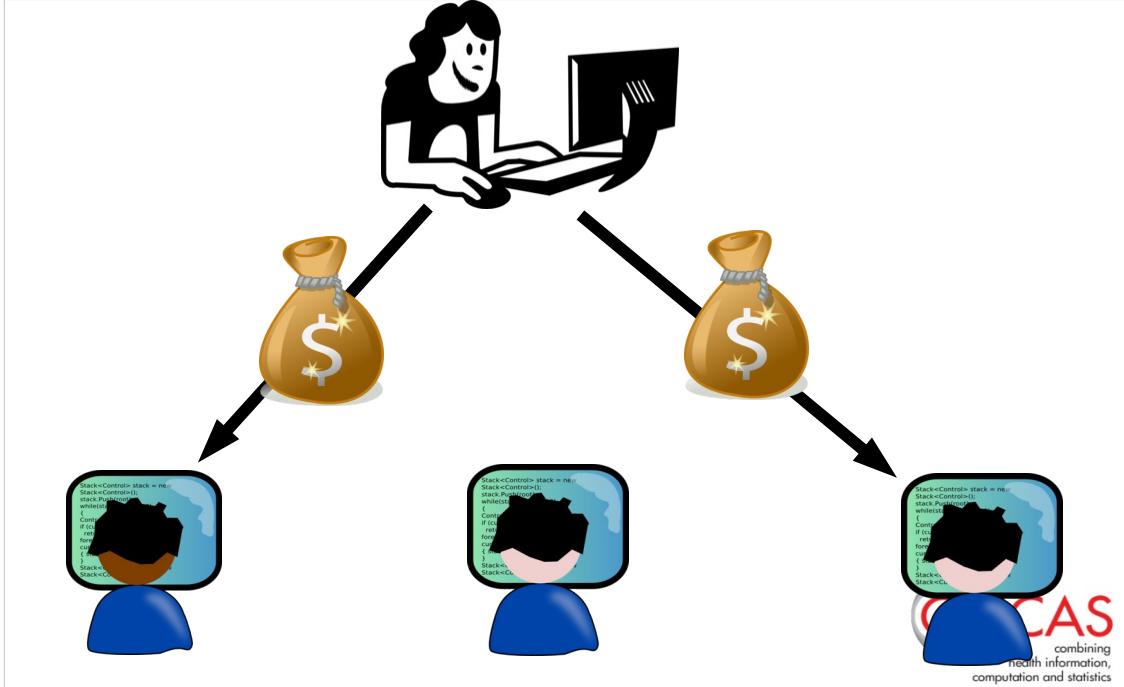
But what if you're not a programmer and you want a program to do something new?  
Now we get into economics.

## Vendor Lock-In



In the proprietary, closed-source system, only the manufacturer has access to the source code, and only they can change it to fix or improve it. You pay them lots of money, or they don't do it. If you've already invested lots of effort in the software you are 'locked-in' to a monopoly supplier.

# Open Source Market



With open source software you are free to purchase development from anywhere. It is an open market, which means competition for your money, more choice, and all those advantages of free markets.

Lots of developers of open source software make their living from consultancy services, providing custom features for open software which they then release under an open license. Everybody wins.

# Open Standards

- File Formats
- Data Structures
- Communication Protocols

## Facilitating

- Interoperability



There's still a chance of being locked in to a single system though, even if you have a choice of developers.

To mitigate against that, open source software has a strong record of using open standards.

If different programs can agree on the same file formats, data structures, and communications protocols, then they can all work together. If you want to change from one GIS to another and they both use open standards, then your choice is based on features, and not because you have a massive database of maps in a format only one GIS can read.

# Open Geo Standards



CAS  
combining  
health information,  
education and statistics

Many of the standards for interoperability in spatial data come from the Open Geospatial Consortium, (OGC), an organisation set up to create and ratify standards for spatial information.

# OGC Members



+hundreds of other companies, groups, universities and individuals



The OGC has a large member base, including a lot of the big names in the proprietary software world such as ESRI and Oracle. All these groups have an interest in interoperability of their software with others.

Its this kind of involvement that has lead to the increased use of open source technologies in government, and developments such as the EU INSPIRE directive to build compatible EU-wide spatial data infrastructures.

# Open Source in Govt



<https://joinup.ec.europa.eu/>



## Open source observatory

(0 )

Submitted by [Gijs Hillenius](#) on May 20, 2013

Rating: 0/5 (based on 0 votes) | 1027 reads

### 'Portugal's municipalities increasingly use open source for geoinformation'

A rising number of municipalities in Portugal are turning to open source software solutions for their Geo Information Systems, says Pedro Venâncio, a GIS engineer at the municipality of Pinhel. "When it comes to GIS, in our municipality we only use open source," he says. Venâncio is part of a team in the Covilhã-Cova da Beira region to open source GIS applications, replacing proprietary alternatives. "Training for the technicians has already started."



The EU web site has an 'open source observatory' where they track and blog about open source deployments in the EU, for example here in Portugal.

# Open Source in Govt

## UK's Geological Survey contributes to open source GIS tools



.. Infrastructure (pdf) Inspire2013 (geological survey contributes open source gis tools) (Open

 News | Created by [Gjjs Hillenius](#) | Published: 02 September 2013

## Tuscany's environmental organisation prefers open source



.. data. It is planning to combine the Geospatial Data Abstraction Library and the Quantum GIS mapserver

 News | Created by [Gjjs Hillenius](#) | Published: 09 August 2013

## Dutch provinces save millions sharing and reusing GIS tools



.. around these tools", Rutten says. "I invite GIS-experts in other countries to join us."

 News | Created by [Gjjs Hillenius](#) | Published: 16 July 2013

## Extensive open source use at France's ministry of Agriculture



.. that it develops for its geographic information systems. The ministry participates in a larger GIS software

 News | Created by [Gjjs Hillenius](#) | Published: 05 July 2013

## Italian Genoa to use open source 'wherever possible'



.. is also testing the use of Quantum GIS, Kosmo, Postgres and PostGIS for its Geographic Information Systems.

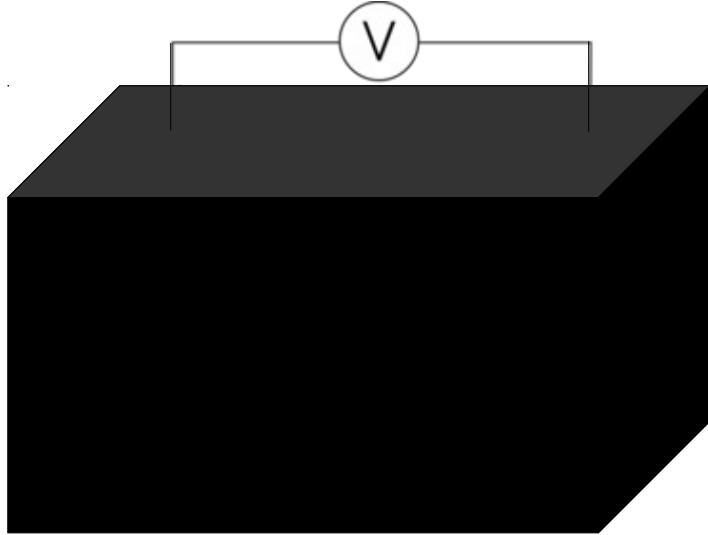
 News | Created by [Gjjs Hillenius](#) | Published: 20 June 2013



...and also in the UK, Holland, Italy, France, and most EU countries. Lots of local and regional governments and agencies are increasingly using open source, and open source geospatial computing, in their fundamental business systems.

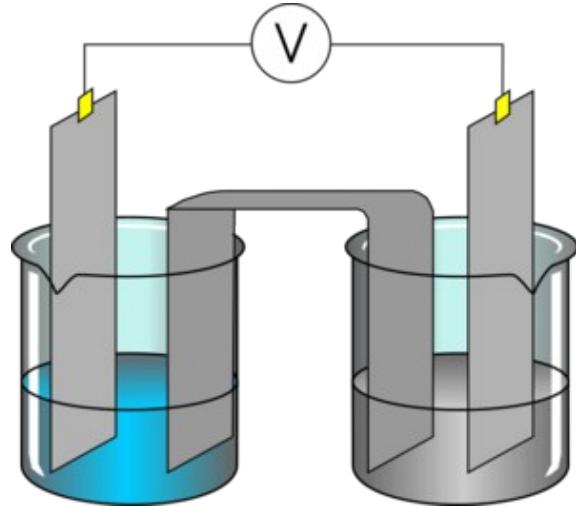
But maybe you don't want to work in government. Perhaps you want to work in science.

# Open Source in Science



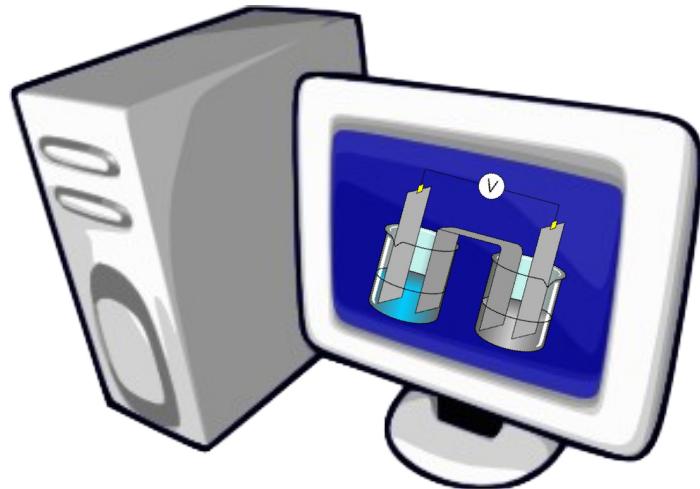
Openness is fundamental to science. If you tell me you've got this black box that creates electricity from nothing you could probably be lying. You're certainly not being a good scientist.

# Open Source in Science



Science requires you to open the box, and show your working, describe it in the minutest detail so other people can repeat your experiment and successfully reproduce your results.

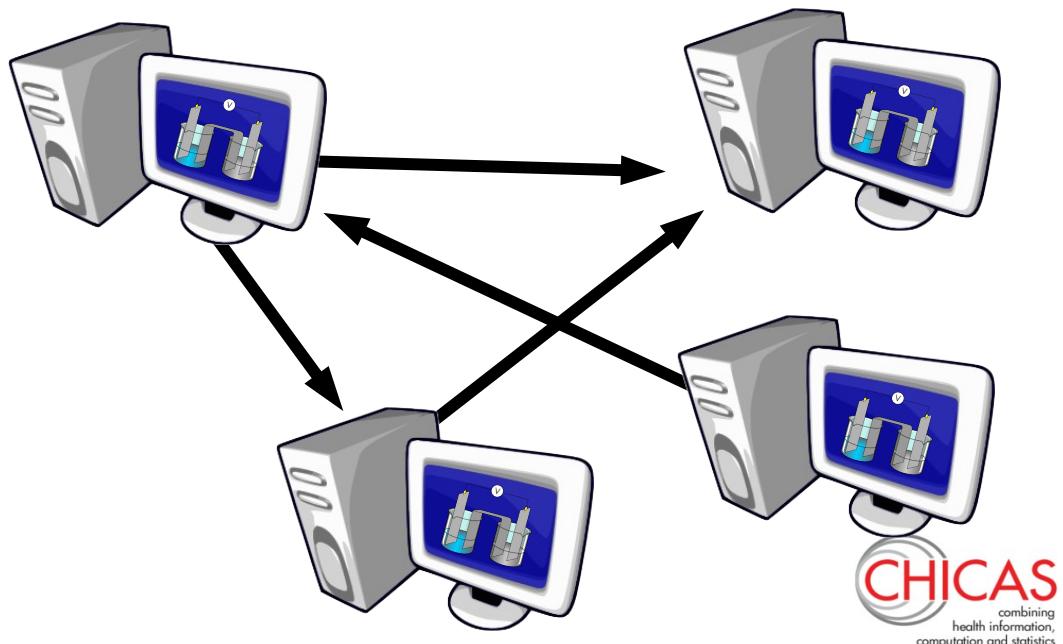
# Open Source in Science



But a vast amount of science these days is done using computers. How do you know exactly what your computer did? How can anyone else know?

You need to see the source code of everything that touched your experiment.

# Open Source in Science



And if your science is done using free software, then anyone can get the source code and repeat your science.

But also, you have to release any code you've written under a free and open license too!

With proprietary, closed-source software there is not only a financial cost and an unknown process, but also the danger of the software being withdrawn by the company, and then the science is lost.

# Developers



**DANGER  
NERD AT WORK**



So how are we going to be writing all this software?  
We need more developers, and they aren't all going  
to be nerds.



**The Open Source  
Geospatial Foundation**

<http://www.osgeo.org/>



The Open Source Geospatial Foundation is an organisation whose aim is to help in the development and use of open source geospatial software.

For example, it supports the QGIS desktop GIS by providing the web site and other systems that the QGIS developers use. It doesn't pay any of their salaries though.

# Open Development



QGIS » QGIS Application

Search

Overview Activity Roadmap Issues **New issue** Wiki Repository

## Issues

Filters Status all Add filter:

Apply Clear Save

#	Status	Subject	Created	Updated
9134	New	customization menu doesn't work	27/11/2013 09:41 am	27/11/2013 09:41 am
9132	Closed	WMTS GetCapabilities actually asks for WMS	27/11/2013 06:32 am	27/11/2013 06:54 am
9131	Closed	WMS/WMTS dialog - loses text after /	27/11/2013 06:16 am	27/11/2013 07:02 am
9129	New	Use columns aliases when doing a "save as..." of a layer/table with a join	27/11/2013 03:08 am	27/11/2013 03:08 am
9128	New	wrong perimeter value in the identify feature tool	27/11/2013 12:29 am	27/11/2013 12:29 am
9127	New	DBManager should show Postgres materialized views	26/11/2013 03:26 pm	26/11/2013 03:26 pm
9126	New	Extend layer window with toolbar	26/11/2013 03:53 am	26/11/2013 03:53 am
9125	New	Uninstalling weeklyes	26/11/2013 03:08 am	26/11/2013 03:08 am
9124	New	Heatmap in percentage	25/11/2013 11:20 pm	27/11/2013 02:02 am
9122	Closed	DYF of Italian Cadastral Map not load	25/11/2013 04:27 pm	25/11/2013 05:33 pm

OSGeo - Open Source Geospatial Foundation

And open source development is often done out in the open too – this is the current list of bugs, issues, feature requests in QGIS. You can see who submitted the issue, whether a developer has taken an interest in fixing it and so on.

Compare with proprietary systems which are not keen to tell you about bugs in their software. And bugs get fixed quicker. I've seen examples of bug reports being filed, a developer making the fix, and the end user working with the fixed version all happen in under an hour.

Now we'll go beyond the GIS Desktop to look at a couple of other geospatial software packages supported by OSGeo.



Spatial and Geographic objects for PostgreSQL

Home

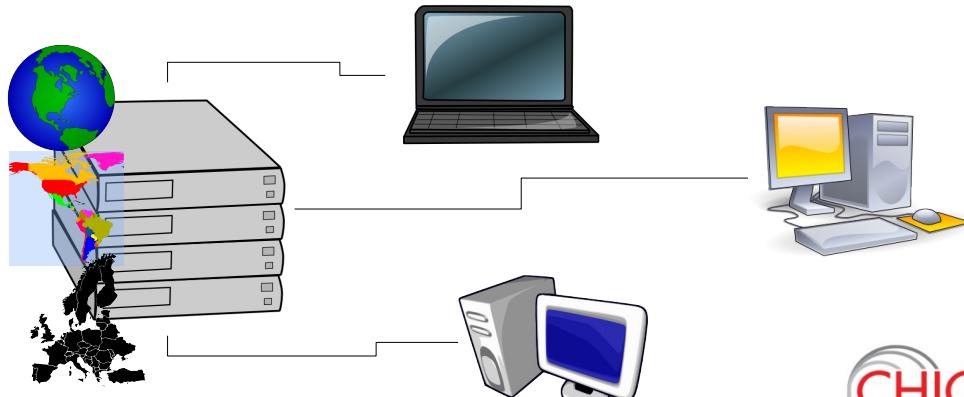
Download

Documentation

Development

Support

OSGeo



PostGIS is a spatial database that typically runs on your enterprise servers and lets people connect and share access to spatial data. It can do spatial functions such as buffering and nearest-neighbour as well as route-finding on road networks.

It has been used to replace proprietary spatial databases costing five figures and up. Proprietary software licenses multiply in cost when you scale up a database, with open source you only have the cost of new hardware.

# OpenLayers



## OpenLayers

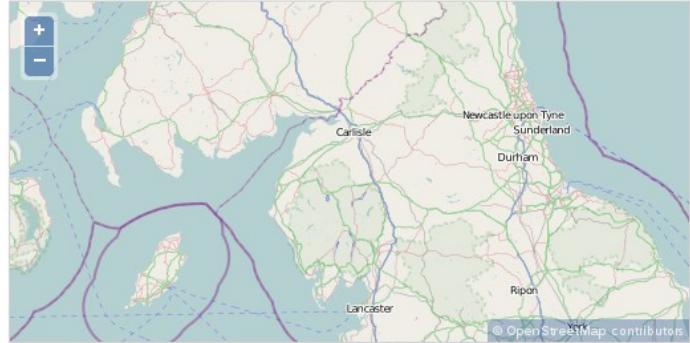
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### OpenLayers: Free Maps for the Web

#### Get OpenLayers Now!

- 2.13.1 (Stable): [.tar.gz](#) | [.zip](#)
- 2.13.1 Release Notes
- API Documentation, User documentation
- See examples of OpenLayers Usage: [Release Examples \(2.13.1\)](#), [Development Examples](#)
- Fork us on [GitHub](#)



Put an open map widget in any web page!



At the other end of the scale, OpenLayers is a Javascript program that runs on your web browser when a web site wants to display a map. It works a bit like Google Maps, giving you a zoomable draggble map that web site authors can add their data to.

# OSGeo Labs



A screenshot of the OSGeo Labs website. The header features the text "Be part of "Geo for All"" over a background image of Earth. On the left is a sidebar with links: Home, About, How to join, Locations, News, Past events, Training, Training resources, and Webinars. Below these are the logos for OSGeo, ICA, and ACI. The main content area has a heading "Mission - "Making geospatial education and opportunities accessible to all"" followed by a detailed paragraph about the mission. To the right is a map showing the locations of 56 labs worldwide, with a caption stating "56 labs worldwide as of 13th November, 2013". At the bottom right is a small "S" logo with the text "ing on, comparison and statistics".

As well as software development, OSGeo has an education and research arm which has helped establish a number of Open Source Geospatial Labs in universities across the globe.



**FOSS4G**  
NOTTINGHAM 2013

**OSGeo**  
*Your Open Source Compass*

**OSGeo's Global Conference for Open Source Geospatial Software**

The annual gathering of Open Source Geospatial Developers, Users and Leaders. At Nottingham's new East Midlands Conference Centre in the heart of the country, 17th to 21st September

**"Geo For All"**



A lot of the funding for this comes from the international FOSS4G conference which was in Nottingham this year (Portland, Oregon next year). We had 850 delegates from all over the world and from varied fields gathered together for five days discussing open geospatial issues.

# FOSS4G Sponsors



The conference had a lot of sponsors, including ESRI. Although its unlikely ArcGIS will ever be released as open source, proprietary companies are seeing the need to interoperate with open solutions, otherwise they are going to get pushed out.

A lot of this is down to the increasing push towards “open data” in business, government, and science.

# Open Data

- **Definition**

“Open data is data that can be freely used, reused and redistributed by anyone – subject only, at most, to the requirement to attribute and sharealike.”



This definition comes from the Open Knowledge Foundation.

# Open Data



Open Knowledge  
Foundation

## What Kinds of Open Data?



### Geodata

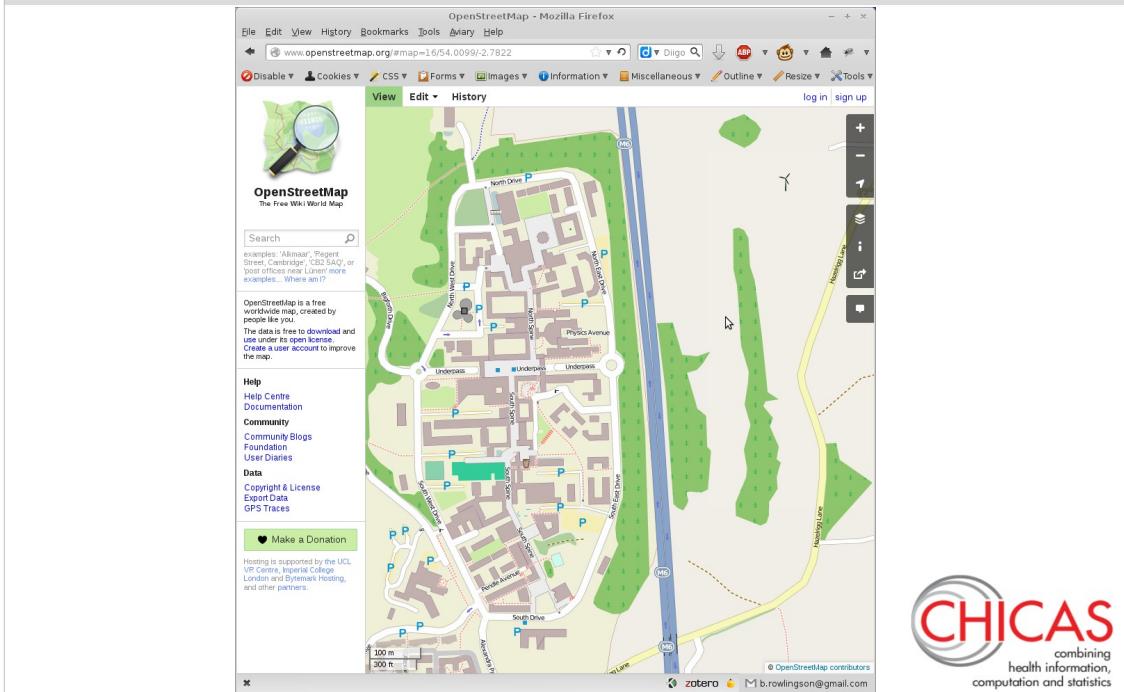
The data that is used to make maps — from the location of roads and buildings to topography and boundaries.



The OKF is an organisation devoted to promoting the creation and use of open data.

One of the greatest geospatial open data sets is probably OpenStreetMap.

# OpenStreetMap



In case you've not seen it, its a map of the world that anyone can edit.

I added the wind turbine.

Both the pretty map tiles and the underlying vector data are all licensed under an open data license encouraging re-use.

[maps.stamen.com](https://maps.stamen.com)



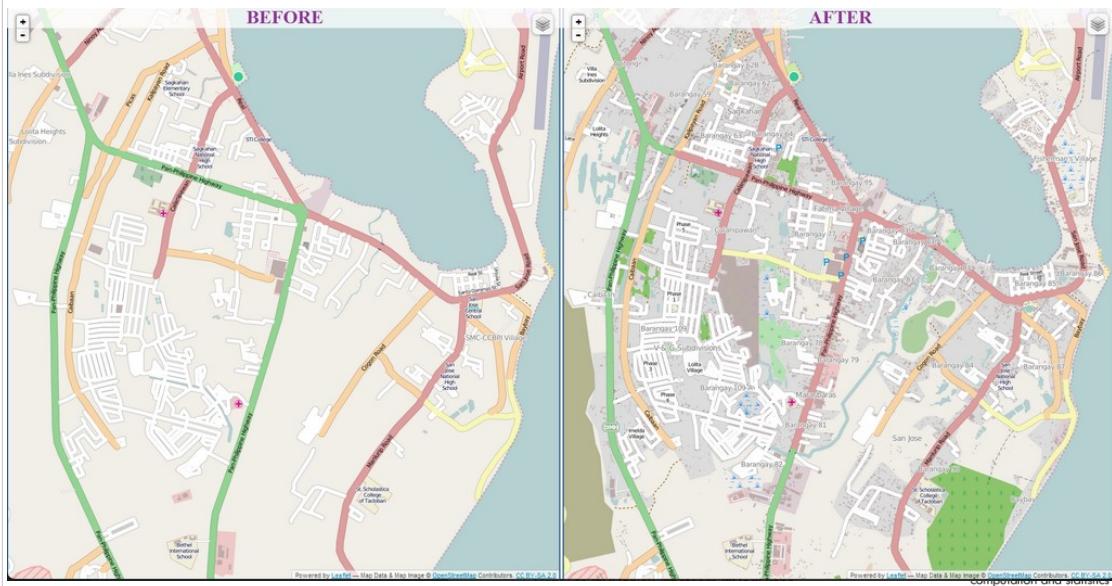
Re-used OSM data  
CC licensed



For example the “stamen maps” company have produced these pretty “watercolour” maps based on OSM data.

# OpenStreetMap

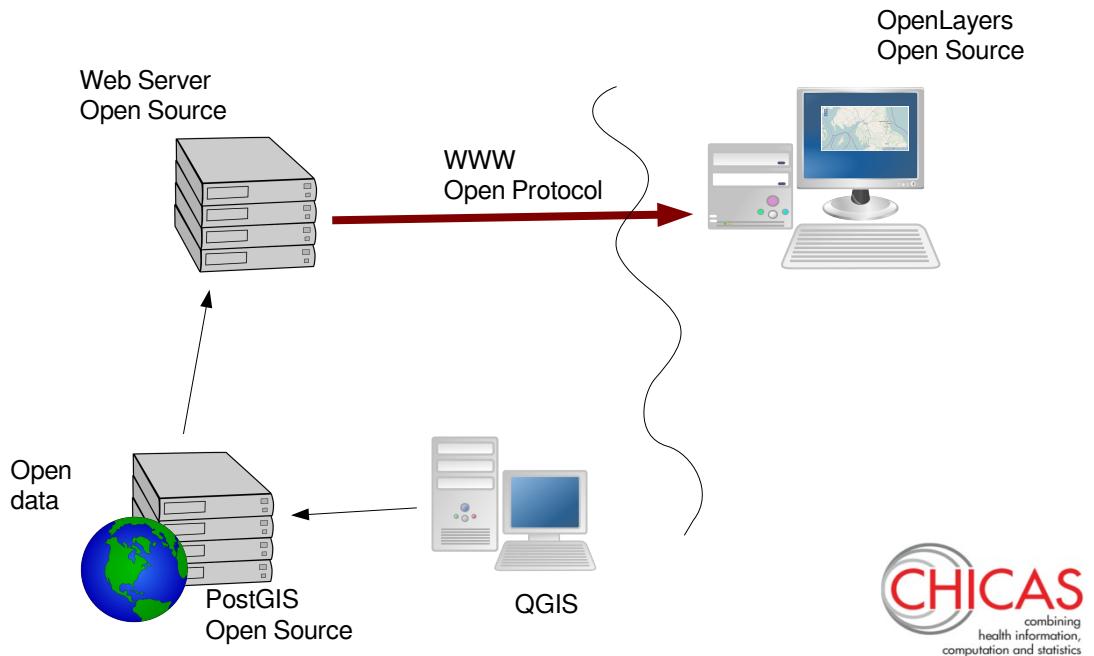
## Tacloban, Philippines



Less frivolously, OSM data is used in humanitarian situations – here you can see how mappers worked on the OSM data of typhoon-hit Tacloban to fill in detail from aerial photography and reports from emergency workers on the ground.

OSM is used by relief workers to print out hard copy maps.

# Open Applications



So what have we got?

We have the infrastructure to create fully open, and free, spatial applications, from the system storing the data, the desktop GIS editing it, the web server providing the public service, and the browser interface drawing the user's map.

Open Source licenses let us scale this up at zero cost.

Open Standards let us swap components

Open Data lets us create maps

And importantly it is in building these integrated systems that a lot of open-source development gets funded.

# Conclusions

- Software freedoms
- Free/Open vs Proprietary/Closed
- Source Code
- Open source, open standards, open data
- Open software development
- Open source geospatial applications



So in summary here's some things you should have learnt.

What software freedoms are

How free and open source software differs from proprietary and closed software

What source code is

Aspects of “Openness” in IT and in geospatial information

How Open Source software is developed

Open Source capabilities

# Links

- Further reading

QGIS: <http://www.qgis.org/>

The Open Source definition: <http://opensource.org/osd>

Free Software Foundation: <http://www.fsf.org>

The Open Source Geospatial Foundation: <http://www.osgeo.org/>

ELOGeo E-learning: <http://elogeo.nottingham.ac.uk/>

EU Open Source Observatory: <http://www.osor.eu/>

EU News Item: “Open Source 5-10 Times Cheaper”

<https://joinup.ec.europa.eu/community/osor/news/french-interior-ministry-open-source-5-10-times-cheaper>



## Links and further reading