CEOS WGISS-46: TECHNOLOGY EXPLORATION FOSS Libraries and Tools to Raise EO Data and Applications

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Earth Observation in the realm of FOSS

"Earth Observation is in transition"

- Until <u>middle of 2000s</u>, the established paradigm dictated that space agencies were in charge of the data generation and responsible for the facilities and infrastructure (Ground Segment) to download the data. Users were well trained experts that they locally produced high level products. Both agencies and users were used to **proprietary** software.

- However, the OPEN DATA, OPEN ACCESS and others FREE movements rose. The US revised data sharing policies and organizations such as USGS, NASA and NOAA began to provide free access to environmental and remotely sensed data of highest quality. GNU/Linux was very valuable for this wind of change.

Status of the geospatial FOSS by middle of 2000s

- Some examples: , , and just began their development.

- Supporters: The Open Source Geospatial Foundation was formed in February 2006. QGIS became an incubator project of the OSGeo Foundation in 2007.

- Meetings: The internationally acclaimed "FOSS4G" annual conference was held in Bangkok, Thailand, for the first time in September 2004.

- Standards organizations: GRASS GIS promoted in 1994 the basis of the Open Geospatial Consortium. service interface standards and encoding standards have enabled a geospatial technology revolution.

The role of companies

- In 2005, Google launched ⬛ and offered an API that allows maps to be embedded on third-party websites.

- Google Maps debuts on Apple's first iPhone in 2007.

- A geoscientist's personal opinion:

  "... I think that all geoscientists should be thankful to the Google company for making GIS popular and accessible to everybody, and especially for giving away KML to general public..."
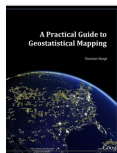

Figure 1: Tomislav Hengl: A Practical Guide to Geostatistical Mapping - 2009

A paradigm shift at the SAOCOM mission inception

- In September 2006, the **IDB** Improving lives approved a loan to Argentina to partially finance the Program for the Development of a Satellite System and Applications Based on Earth Observation (PROSAT) (AR-L1017). This was the first funding from a multilateral agency to develop an EO satellite program.

- A novel aspect of the SAOCOM project was that, in parallel to the design and construction of the satellites, a set of applications dedicated to agriculture and hydrology were developed. The **IDB** showed that the simultaneous development of these three Strategic Applications would exceed the incurred costs for the project.

- In order to fulfill requirements for **IDB**, CONAE faced the development of new interactive Web Products intended for final users, such as farmers and others decision makers, who had rarely been exposed to GIS and remote sensing.

The SAOCOM Strategic Application architecture

Proprietary GIS neither suited a client-server architecture, nor had the flexibility and reliability for the development of operational Web apps.
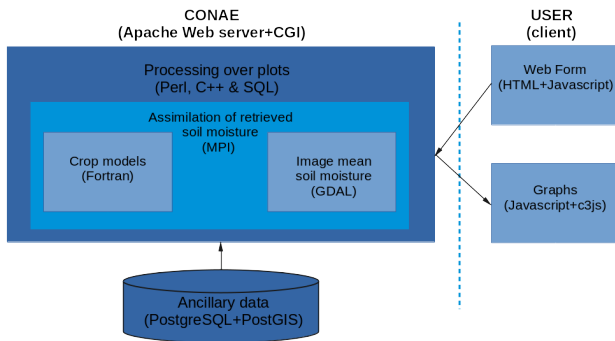

Figure 2: Expanding LAMP (Linux-Apache-MySQL-Python) servers with GIS extensions from the growing set of FOSS technologies.
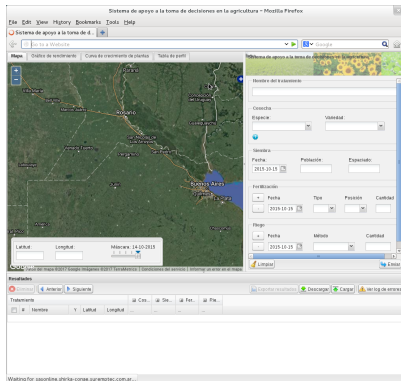
The SAOCOM Strategic Application for agriculture

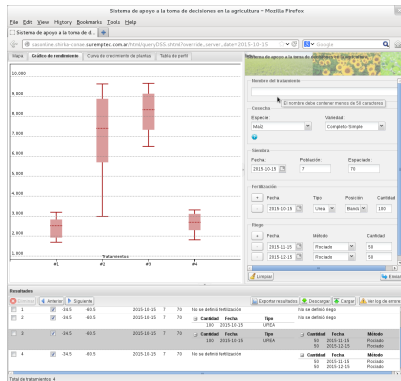Figure 3: The Web 2.0 and Web APIs are the basis of the L4 products.

Figure 4: The Decision Support System for agriculture product

The SAOCOM mission application software

Table 1: A brief summary of FOSS implemented for the SAOCOM Strategic Application

Servers	Libraries	Compilers & Interpreters
OS GNU/Linux	GDAL/OGR	C/C++: gcc/g++, FSF
Apache Web Server	HDF5	Fortran: gfortran, FSF
PostgreSQL + PostGIS	NCO	Python: python, PSF
		Perl: perl, TPF
		Bash: bash, GNU Bourne-Again SHell
		Javascript: ECMA standard

Solution to conflicting versions

Although processors units are mainly implemented over Virtual Machines (VSphere), dependencies between different versions of libraries within a VM often interfere.

docker is used to run software packages called "containers". Containers are isolated from each other and bundle their own tools, libraries and configuration files being lighter than VMs.

Cloud computing with Docker is widely supported (*Amazon EC2 Container Service, Google Compute Engine, Microsoft Azure*)

Conda is an open source, cross-platform, language-agnostic package manager and environment management system. The conda package and environment manager is included in all versions of Anaconda, Miniconda and ANACONDA.

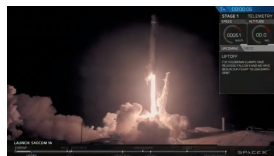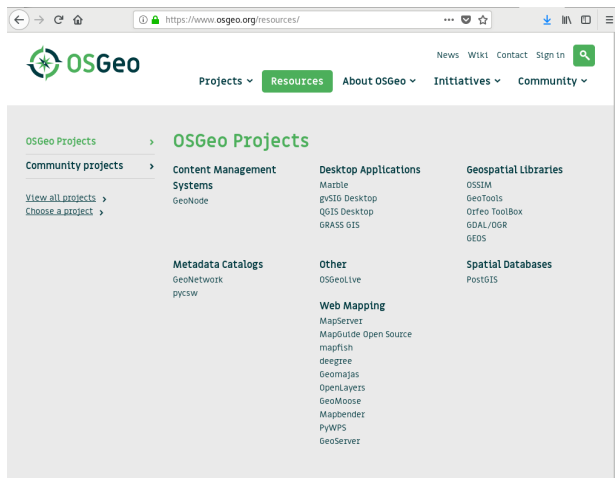Figure 5: The SAOCOM platform and its $35\mathrm{m}^2$ L-band SAR polarimetric antenna deployed.

Figure 6: On Sunday, October 7 at 7:21 p.m. PDT, SpaceX successfully launched the SAOCOM 1A satellite from Space Launch Complex 4E (SLC-4E) at Vandenberg Air Force Base in California.

Status of the geospatial FOSS

Figure 7: OSGeo supports more than 20 projects, 10 community projects, and several initiatives. FOSS4G annual conference regularly attracts over 1,000 practitioners.

The road ahead

- Open Science is a paradigm to make scientific research, data and results transparent and accessible for science and society. It consists of several tiers, including Open Access, Open Data and Open Source.

- Within geoscience, the new role model of "Open Science" or "Science 2.0" is emerging. Many desiderata for future "open scientists", including publication of both the data and software, active international networking and reach out to industry and society are already common practice.

Environments suited for the new trends

- **R** is great not only for doing statistics, but also for many other tasks, including GIS analysis and working with spatial data.

- **python** offers similar facilities. It is just a matter of taste.

- There are many useful packages (for example, the GDAL/OGR bindings for R and Python are available through CRAN and PyPI, respectively).

- Both are boosted by Data Science revolution.

- Reproducible Research is easier to achieve. The **jupyter** Notebook is an open-source web application that allows you to create and share documents that contain live code, equations, visualizations and narrative text. Uses include: data cleaning and transformation, numerical simulation, statistical modeling, data visualization, machine learning, and much more.

Conclusion

"Earth Observation is in transition"

Non expert users expect higher level EO products to support decision making processes (SAOCOM report).

FOSS foundations, standard organizations, companies, and many others boosted remote sensing and GIS, and revolutionized the way EO data is applied.

Some FOSS projects have become a *de facto* standard.

Agencies, experts and developers may need guidance to cope with the assorted options FOSS provides, and the rapid changing ITs. Best practices guides, recommendations and assistance will undoubtedly be welcomed by the community of EO.

Thank you to WGISS-46 organizers and participants