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Using Free/Libre and Open Source Software in the Geological Sciences

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Abstract

In the Geological Sciences, as in any other academic field, computers and software aided work are essential tools. Although Free and Open Source software is largely used in academic institutions for several purposes it is not yet state-of-the-art for the every-day usage. The usage of free and open source software is, besides the freedom of its ease of use, distribution, and modification, also recommended due to the increasing financial burden. There are many suited and effective alternative free software applications to the most common used proprietary commercial ones. Many common work steps can even be done entirely with the free operating system Linux. A selection of free software applications is compiled which are useful for geoscientific data evaluation and presentation. The provided information aims to lower the threshold of reservations against a potential migration and gives an overview about currently available alternative software useful in the Geological Sciences.

In den geologischen Wissenschaften, wie auch in allen anderen Disziplinen, sind Computer, sowie softwareunterstützte Tätigkeiten, längst unverzichtbare Werkzeuge. Obgleich Freie und Open Source Software in vielen speziellen Einsatzgebieten verbreitet ist, wird diese noch nicht umfassend für den täglichen Gebrauch benutzt. Die Verwendung von Freier und Open Source Software ist, neben der Freiheit sie uneingeschränkt nutzen, verteilen und modifizieren zu können, auch wegen zunehmender budgetärer Einschränkungen zu empfehlen. Mit diesem Artikel möchten wir die geologische Gemeinschaft auf die vielen geeigneten Programme hinweisen, die als Alternativen zu den üblicherweise häufig benutzten proprietären, kommerziellen Programmen existieren. Viele alltägliche computergestützte Aufgaben können auch zur Gänze mit dem freien Betriebsystem Linux durchgeführt werden, ohne Einbußen in Funktionalität oder Professionalität befürchten zu müssen. Eine ausgewählte Liste geowissenschaftlich interessanter freier Anwendungen wird durch Referenzen ergänzt. Dieser Artikel soll über die Möglichkeiten freier alternativer Software informieren, die Zurückhaltung vor einer eventuellen Migration mindern, sowie einen Überblick über die aktuell verfügbare freie geowissenschaftliche Software geben.

1. Introduction

Scientific computing and therefore software applications for data processing and visualization and the preparation of manuscripts or presentations are essential workflows in geoscientific institutions and companies. Nearly every task needs computer and software aided facilities. Although free and open source software may be accepted for some special analytical tasks, it seems not widely recognized or accepted yet as an effective and productive tool for every-day work. Commonly, proprietary commercial software is preferred for most purposes.

For closed source software there is no access to the source code, but it needs not to be commercial. A lot of free proprietary software exists under the term "freeware" or "shareware". Open source software means open source code, but not necessarily free of costs. The differences between Free Software and Open Source Software are discussed in Stallman (2009). In this article the combined term "Free/Libre and Open Source Software" (FLOSS, see, e.g., Stallman, 2013) is used. FLOSS is not necessarily license-free, but commonly released under the GNU General Public License (GPL) and similar ones.

A lot of reviews exist about FLOSS in general (e.g., Fuggetta, 2003; Joode et al., 2006; Henley and Kemp, 2008; Wheeler, 2015). Several public administrations or municipalities worldwide are planning to migrate or have already migrated to FLOSS or prefer open standards (e.g., Simon, 2005; Joode et al., 2006; Cassell, 2008; Ghosh et al., 2010; Karjalainen, 2010; Comino et al., 2011; Oram, 2011; Rojas and Polzer, 2011; Rossi et al., 2012; Hillenius, 2013; Bouras et al., 2014; van Loon and Toshkov, 2015; Silic and Back, 2015). Well known examples are the municipality of Munich, the Italian military, or the French Interior Ministry (URL 1).

In education FLOSS is increasingly implemented and recommended (e.g., Lin and Zini, 2008). Several free software packages, mainly in combination with open educational resources, exist for schools. One Austrian example is the platform "desktop4education" (URL 2). An increasing amount of publications show the rising importance of FLOSS in academic institutions (e.g., Kneitschel and Geisemeyer, 2010; Gröschel, 2012; Wilson and Tchantchaleishvili, 2013; Mellor, 2014; Hudson, 2015a). Even producers of commercial software are providing Open Source software for academic research (URL 3). The usage of FLOSS is discussed in many disciplines (e.g., Feigelson and Murtagh, 1992; Tufto and Cavallini, 2005; Field et al., 2006; Faccioli et al., 2009; Weiner et al., 2009; O'Boyle et al., 2011; Ducke, 2012). For a couple of years now the European Geosciences Union (EGU) is taking attention to this topic with an own session at the annual general assembly. Mainly geoinformatics and specific geospatial software applications are concerned so far.

Scientists, students and technical staff at Geological Science institutes, as well as geotechnical staff, need to use a variety of software applications to do their tasks efficiently. Although specific FLOSS is used, or even developed at universities, only a few people are generally working with FLOSS in their daily basic work flow. The common every-day desktop tasks for administrative work, for teaching and publishing by text processing, presentation and spreadsheet usage, and graphical manipulation is still mainly done with the most popular commercial software applications. However, it is getting more and more complicated to finance all the necessary software applications.

Several articles or special issues (e.g. Butler, 1999; Grunsky, 2002a) consider some particular software applications but there is no general overview about FLOSS and its possibilities for the Geological Sciences. This article is not a software evaluation, but it is intended to show an overview of free alternatives to commercial software which are currently available for doing all necessary tasks without losing usability or effectiveness. Its scope is to demonstrate that there exist more than the common used software for professional work and that they are increasingly successfully applied. Here is not enough space to explain or compare all listed software programs in detail. Only a few essential programs for every-day work and common problems are shortly discussed. The small selection of cited references provides more detailed information about the applications.

2. FLOSS as alternative software applications

Many people do not have any problem to use different applications for one task (e.g., different browsers, multimedia players or image viewers). The usage of alternative office or image processing software, however, is a quite different story, due to year-long habits or popular beliefs. Alternatives for some most needed or used software applications are indicated in Table 1. Due to the still preferred offline usage, we do not include web applications. All listed programs are desktop applications. We are aware that scientists increasingly use mobile devices such as tablets or smartphones for their research and that a lot of applications are progressively available for that (e.g., Takeuchi and Kennelly, 2010; Weng et al., 2012; Ferster and Coops, 2013, Lee et al., 2013, 2015; Wolniewicz, 2014; Bui et al. 2015; Muir, 2015; Hansen et al. 2016), but this is beyond the scope of this article. Most of the software applications listed in Table 1 are platform independent and can be used on every common operating system. Not all programs in the tables are free software, some are proprietary freeware, but even so an alternative to commercial software. A small selection of the listed programs are shortly mentioned in the following paragraphs.

2.1 Office suites (texts, spreadsheets, presentations)

Microsoft Office is the indisputable most used office suite also in academic institutions. The most popular alternatives to *MS Office* are *Apache OpenOffice* and *LibreOffice*. In this article we call these suites by the combined term *Open/LibreOffice*. These office suites have all applications that *MS Office* offers (in parentheses), and even some more: *Writer (Word)*, *Calc (Excel)*, *Impress (Powerpoint)*, *Base (Access)*, the vector drawing application *Draw* and the formula editor *Math*. During common productive work *Open/LibreOffice* is a proper alternative to *MS Office*. Only in a few specialized workflows there might be drawbacks, but this is also true vice versa (URL 4). One strong limitation is the usage of complex *Excel*-macros within *Open/LibreOffice*. And for extensive *Powerpoint* users who need a lot of animations or exotic fonts *Impress* might not be satisfactory. Just for making simple slides without complex dynamic actions it is, however, very appropriate. Furthermore, many users prefer *Latex Beamer* (URL 5) or online tools such as *Prezi* (URL 6) or *impress.js* (URL 7) for impressive presentations. A huge amount of extensions enriches the possible functions and possibilities of those office suites (URLs 8, 9). Experiences with a large-scaled migration to *OpenOffice.org* are discussed by, e.g., Rossi et al. (2006); Karjalainen (2010).

Another common free office suite is *SoftMaker FreeOffice* which has less functionality than the commercial *SoftMaker Office* version, or compared to *Open/LibreOffice*. Contrary to the latter its compatibility with the *MS Office* formats is currently better. Schools and universities can get the version *SoftMaker Office* 2016 for free (URL 10). If the hardware is too old for using the latest version of such large office suites, or if there is no need for all their functions, the text processing program *AbiWord* and the spreadsheet program *Gnumeric* are recommended. Generally, word processing software is not recommended for writing large documents. For larger manuscripts or books in technical and natural sciences *Latex* is very efficient, but very complex and learn-intensive for many users. It should be noted, however, that after learning the basics much time for manuscript preparation can be saved. The application *LyX* (e.g., Xu, 2000; Wendl and Dooling, 2003, von Hagen, 2013; Hudson, 2015b) provides a common familiar word processing window with the strength of *Latex*. Apart from this possibility to use *Latex* without much markup language programming skills it also provides the function of "track changes". A similar solution is *TeXmacs* (van der Hoeven et al. 2013, Gubinelli et al. 2014).

2.2 Images and illustrations

Adobe Photoshop is a widely used editor for professional raster graphic and image processing. Non-professional graphic users do not need all of its plenty and complex functions. A great many work steps can be done partly or totally with free alternatives (Table 1). A popular free alternative to *Photoshop* is the *GNU image manipulation program (GIMP)*. Its usefulness for scientific publishing and a comparison to *Photoshop* is documented by Solomon (2009). A detailed feature comparison

Office Suite: MS Office ...		W	M	L
Calligra	https://www.calligra.org/	x	x	x
LibreOffice	http://www.libreoffice.org/	x	x	x
OnlyOffice	https://www.onlyoffice.com/apps.aspx	x	x	x
OpenOffice	http://www.openoffice.org/	x	x	x
Softmaker FreeOffice	http://www.freeoffice.com/	x		x
WPS Office	http://www.wps.com/	x		x
Email; Project management: MS Outlook; MS Project ...		W	M	L
Claws Mail	http://www.claws-mail.org/	x	x	x
EssentialPIM	http://www.essentialpim.com/	x		
Evolution	https://wiki.gnome.org/Apps/Evolution			x
GanttProject	http://www.ganttproject.biz/	x	x	x
Lightning Calendar	https://www.mozilla.org/en-US/projects/calendar/	x	x	x
Opera Mail	http://www.opera.com/computer/mail	x	x	x
ProjectLibre	http://www.projectlibre.org/	x	x	x
SeaMonkey	http://www.seamonkey-project.org/	x	x	x
Thunderbird	https://www.mozilla.org/en-US/thunderbird/	x	x	x
Portable Document Format: Adobe Acrobat ...		W	M	L
Adobe Reader	http://get.adobe.com/de/reader/otherversions/	x	x	
Foxit Reader	http://www.foxitsoftware.com/Secure_PDF_Reader	x		x
Master PDF Editor	https://code-industry.net/free-pdf-editor/			x
PDFCreator	http://www.pdfforge.org/pdfcreator	x		
PDFsam	http://www.pdfsam.org/	x	x	x
PDF Shaper	http://www.glorylogic.com/pdf-shaper.html	x		
PDF-Xchange Editor	https://www.tracker-software.com/product/pdf-xchange-editor	x		
PDF-Xchange Viewer (discontinued)	http://www.tracker-software.com/product/pdf-xchange-viewer	x		
Sumatra	http://www.sumatrapdfreader.org/	x		
Raster graphics: Adobe Photoshop, Corel Photopaint ...		W	M	L
Artweaver	http://www.artweaver.de/en	x		
Darktable	http://www.darktable.org/		x	x
Fiji	http://fiji.sc/	x	x	x
GIMP	http://www.gimp.org/	x	x	x
ImageJ	http://imagej.net/	x	x	x
ImageMagick	http://www.imagemagick.org/	x	x	x
IrfanView	http://irfanview.tuwien.ac.at/	x		
Krita	https://krita.org	x	x	x
Paint.NET	http://www.getpaint.net/index.html	x		
Photivo	http://photivo.org/	x	x	x
PhotofiltreLX	http://www.photofiltre-lx.org/	x	x	x
Pinta	http://pinta-project.com/	x	x	x
ScanTailor	http://scantailor.sourceforge.net/	x		x
Seashore	http://seashore.sourceforge.net/		x	
XnViewMP	http://www.xnview.com/en/xnviewmp/	x	x	x
Vector graphics: Adobe Illustrator, Corel Draw ...		W	M	L
Dia	https://wiki.gnome.org/Apps/Dia	x	x	x
(Open/LibreOffice) Draw	see link above (Office)	x	x	x
Inkscape	http://www.inkscape.org/	x	x	x
(Calligra) Karbon	see link above (Office)	x	x	x
sK1	http://sk1project.net/	x		x
yEd Graph Editor	http://www.yworks.com/products/yed	x	x	x
Computer Aided Design: AutoCAD ...		W	M	L
BRL-CAD	http://brlcad.org/	x	x	x
FreeCAD	http://www.freecadweb.org/	x	x	x
LibreCAD	http://librecad.org/cms/home.html	x	x	x
Salome	http://www.salome-platform.org/	x		x
Teigha File Converter	https://www.opendesign.com/guestfiles/TeighaFileConverter	x	x	x
Database systems: Oracle Database, MSSQL Server, MS Access ...		W	M	L
Apache Derby	https://db.apache.org/derby/	x	x	x
Firebird	http://www.firebirdsql.org/	x	x	x
(Open/LibreOffice) Base	see link above (Office)	x	x	x
MariaDB	https://mariadb.org/	x		x
MS SQL Server Express	https://www.microsoft.com/en-au/sql-server/sql-server-editions-express	x		
MySQL Community Edition	https://www.mysql.de/	x	x	x
PostgreSQL	https://www.postgresql.org/	x	x	x
SQLite	https://sqlite.org/	x	x	x

Table 1: A selection of alternative software of the mostly used software programs (also free proprietary closed software included; some of that freeware might only be used for non-commercial or academic purposes). W = Windows, M = Mac, L = Linux.

Reference manager: EndNote, ProCite ...		W	M	L
Bibus	http://bibus-biblio.sourceforge.net	x	x	x
Colwiz	https://www.colwiz.com	x	x	x
Docear	http://www.docear.org/	x	x	x
KbibTeX	http://home.gna.org/kbibtex/	x		x
JabRef	http://jabref.sourceforge.net/	x	x	x
MayLib	http://paleopolis.rediris.es/cg/1506/	x	x	x
Mendeley	http://www.mendeley.com/	x	x	x
Qigga	http://www.qiqqa.com/	x		
ReadCube	https://www.readcube.com/	x	x	
Zotero	https://www.zotero.org/	x	x	x
GIS and Remote Sensing: ArcGIS, IDRISI, ENVI, ERDAS Imagine ...		W	M	L
DIVA-GIS	http://www.diva-gis.org/	x		
efoto	http://www.efoto.eng.uerj.br/en	x		x
GRASS	http://grass.osgeo.org/	x	x	x
gvSIG	http://www.gvsig.com/en	x	x	x
ILWIS	http://www.ilwis.org/	x		
KOSMO	http://www.opengis.es/	x		x
Map Window	http://www.mapwindow.org/	x		
OpenEV	http://openev.sourceforge.net/	x		x
OpenJump	http://jump-pilot.sourceforge.net/	x	x	x
Opticks	https://www.opticks.org/	x		x
OSSIM	http://trac.osgeo.org/ossim/	x	x	x
PolSARpro	https://earth.esa.int/web/polsarpro	x		x
QGIS	http://qgis.org/	x	x	x
SAGA	http://www.saga-gis.org/	x		x
uDig Spatial data viewer/editor	http://udig.refractions.net/	x	x	x
Whitebox GAT	http://www.uoguelph.ca/~hydrogeo/Whitebox/	x	x	x
Numeric/symbolic computations, statistics, data analysis, data visualization: Mathematica, Matlab, SigmaPlot, Origin, SPSS ...		W	M	L
Anaconda	https://www.continuum.io/why-anaconda	x	x	x
DataExplore	http://dmnfarrell.github.io/pandastable/	x	x	x
DataMelt	http://jwork.org/dmelt/	x	x	x
Enthought Canopy Express	https://www.enthought.com/products/epd/free	x	x	x
Fityk	http://fityk.nieto.pl/	x	x	x
FreeMat	http://freemat.sourceforge.net/	x	x	x
GNU Data language (GDL)	http://gnudatalanguage.sourceforge.net/		x	x
Gnumeric	http://www.gnumeric.org/	x		x
GnuPlot	http://www.gnuplot.info/	x	x	x
GGobi	http://www.ggobi.org	x	x	x
JASP	https://jasp-stats.org/	x	x	x
Julia	http://julialang.org/	x	x	x
LabPlot	http://labplot.sourceforge.net/			x
Mathics	http://www.mathics.org/	x		x
Maxima	http://maxima.sourceforge.net/	x	x	x
Mondrian	http://www.theusrus.de/Mondrian/	x	x	x
Octave	https://www.gnu.org/software/octave	x	x	x
Orange	http://orange.biolab.si/	x	x	x
PSPP	https://www.gnu.org/software/pspp	x	x	x
PySpread	https://manns.github.io/pyspread/	x		x
Python(x,y)	http://python-xy.github.io/	x	x	x
Qtiplot (free only version < 0.9.8.9)	http://www.qtiplot.com/ (Ubuntu Software Center etc)	x	x	x
R	http://cran.r-project.org/	x	x	x
RLPlot	http://rlplot.sourceforge.net/	x		x
SageMath	http://www.sagemath.org/	x	x	x
SciDAVis	http://scidavis.sourceforge.net/	x	x	x
Scilab	http://www.scilab.org/	x	x	x
Spyder	https://github.com/spyder-ide/spyder	x	x	x
Veusz	http://home.gna.org/veusz	x	x	x
WinPython	https://winpython.github.io/	x		
Word processing: MS Word; Writer ...		W	M	L
Abiword	http://www.abiword.org/	x	x	x
LyX	http://www.lyx.org/	x	x	x
TeXMacs	http://www.texmacs.org/	x	x	x

Table 1continued

between *GIMP* and *Photoshop* is available by Czajka (2013). Only graphic professionals would miss some particular features in *GIMP*. Moreover, there are a lot of plug-ins that increase the functionality (*PSPI*, *G`MIC*, *GIMP Plugin Registry*; URLs 11, 12, 13). Additionally, for many years the software *ImageJ* is used in numerous research groups for image processing (e.g., Collins, 2007; Schneider et al., 2012; Schindelin et al., 2015; Rueden et al., 2017).

The arguments used for raster graphic editors can also be applied for vector graphic editors. Illustrations for manuscripts, posters or presentations are currently mostly drawn by *Corel Draw* and *Adobe Illustrator*. Nonetheless, most if not any simple geoscientific figure or map can also be done with *Inkscape* or even with *Open/LibreOffice Draw*. Numerous tutorials for Inkscape provide helpful tips for users in general but also for geoscientists (e.g., Dockner, 2012; Easterbrook, 2013). *Inkscape* has become very powerful and is able to import many proprietary formats. However, for better compatibility, proprietary file formats should be avoided and replaced by using open standard formats, e.g., the Open Raster format (ora) or the Scalable Vector Graphics format (svg). Finally, selected free alternatives to commercial Computer Aided Design (CAD) software are also listed in Table 1.

2.3 Portable document format

Adobe Acrobat is not the only application to create, edit, modify and save PDF-files. *Open/LibreOffice* allows the export to the PDF format and is able to create interactive PDF-forms, PDF/A-files for storage or hybrid PDF files. With the latter it is possible to open and modify simple tasks in a PDF-file (as the original ODT-file is embedded in the PDF). A less known fact is the ability of editing and modifying simple PDF-files by *Draw* (also possible with *Inkscape*). In addition, there are various free PDF creators with which any file can be exported into the PDF format. Finally, simple PDF manipulation such as making notes, using the type-writer function or text marking can be done with many free PDF tools (see a selection in Table 1).

2.4 Database systems and reference management

For small amounts of data many geoscientists commonly use spreadsheets as a kind of database. Nonetheless, the efficient work with large datasets requires a database system. In Table 1 some free alternative database systems can be found.

One important database application is the managing of references. Bibliographic database managers are an essential tool for writing. What kind of reference manager is used depends on the workflow or personal preferences (e.g., Ovadia, 2011; Vaidhyanathan et al., 2012; Zhang, 2012; Perkel, 2015a). Some useful free alternatives are listed in Table 1. Very popular and comfortable is the *Mozilla Firefox* add-on *Zotero* which allows importing a citation from online databases with just one click (e.g., Trinoskey et al., 2009; Fernandez, 2011; Murimboh and Hollingdale, 2012). It can be integrated both in *MS Word* and *Open/LibreOffice*. A plenty of common journal styles can be downloaded via the Zotero Style Repository (URL 14). *Zotero* is also available for other browsers (Chrome, Safari, Opera) and as a standalone program, too.

2.5 Statistics, data analysis and visualization

For data processing, calculations and statistics, many geoscientists use spreadsheets, and here mainly *MS Excel*. The alternative applications *Calc* or *Gnumeric* were already mentioned before. Considering the particular working tasks, the statistical reliability and preferred graphical output, also a variety of proprietary numeric and statistical programs are commonly used (e.g., *Origin*, *SigmaPlot*, *Statgraphics*, *SPSS*, *Matlab*, *Mathematica*). As in every category, a variety of free alternatives exist also here (Table 1). The increasingly popular programming language *Python* is recommended for scientific use (e.g., Bassi, 2007; Pérez et al., 2011; Ayer et al., 2014; Shen, 2014; Perkel, 2015b), and especially also in the geosciences (Lin, 2012). The language of the free software GNU *Octave* is very similar to *Matlab* (Eaton, 2012). A very modern programming language for scientific computing is *Julia* (Bezanson et al., 2012, 2014). Although already in use for several years (e.g., Tippmann 2014; Amirtha 2014) a more and more frequently used application for statistical data processing and creating plots is *R* (R Core Team, 2017). Those who do not like working in a terminal can select from a variety of graphical user interfaces (e.g., Williams, 2009; Valero-Mora and Ledesma, 2012; Racine, 2012). A lot of people are motivated for many reasons to contribute to *R* (Mair et al., 2015). Currently, more than 10500 packages for different tasks and calculations exist. The *R* statistical environment is very appropriate for the Geological Sciences (e.g., Grunsky, 2002b; Janoušek et al., 2006, 2016; Pebesma et al. 2012; Wu, 2016). Particularly mentionable is the *GeoChemical Data toolkit* (*GCDkit*, Janoušek et al., 2006, 2016). It was programmed for whole-rock data analysis of igneous rocks, but is also generally helpful for geochemical statistics and creation of publishable plots. Contrary to *R* itself the *GCDkit* package is currently running only on Windows. A selection of interesting *R* packages for the geosciences are listed in Table 2.

2.6 Specific geoscientific software

Many geoscientists develop source codes or scripts for models within their working groups but provide them not always for the whole community (see e.g. Barnes 2010; Lees 2012; Easterbrook 2014; David et al. 2016; Gil et al., 2016). Nevertheless, an enormous amount of free software exist for geoscientific research or for geotechnical engineering offices. Thus, beside the basic alternatives to common proprietary software (in Table 1), it is also necessary to present some special free tools which facilitates the handling of geoscientific data (Table 3). References to published articles of particular applications provide details about the suitability. We excluded some interesting free programs as they are dependent on proprietary environments, such as *Excel* or *Matlab*. Only such scripts or add-ins are included which run under *Open/LibreOffice* or the freely available *Matlab Compiler Runtime*. Compilations of various alternative geoscientific software can be found on several websites (see Table 4). Alternative free Geographic Information System (GIS) and remote sensing software is more popular and a lot of reviewing literature exist for that (e.g., Steiniger and Bocher 2009; Neteler et al. 2012; Moreno-Sanchez 2012; Steiniger and Hunter 2013; Leidig and

analogue: Analogue and Weighted Averaging Methods for Palaeoecology	http://CRAN.R-project.org/package=analogue (Simpson, 2007)
astrochron: A Computational Tool for Astrochronology	http://CRAN.R-project.org/package=astrochron
ClamR: Time Series Modeling for Climate Change Proxies	http://CRAN.R-project.org/package=ClamR (Wang et al., 2015)
CoinCalc	https://github.com/JonatanSiegmund/CoinCalc (Siegmund et al., 2017)
detzrcr: Compare Detrital Zircon Suites	https://CRAN.R-project.org/package=detzrcr
EMMAgeo: End-Member Modelling of Grain-Size Data	http://CRAN.R-project.org/package=EMMAgeo
forams: Foraminifera and Community Ecology Analyses	http://CRAN.R-project.org/package=forams
fossil: Palaeoecological and Palaeogeographical Analysis Tools	http://CRAN.R-project.org/package=fossil (Vavrek, 2011)
G2Sd: Grain-Size Statistics and Description of Sediment	https://CRAN.R-project.org/package=G2Sd (Fournier et al., 2014)
geologyGeometry	http://www.joshuadavis.us/software.html
geomorph: Geometric Morphometric Analyses of 2D/3D Landmark Data	https://CRAN.R-project.org/package=geomorph (Adams and Otárola-Castillo, 2013)
geoscale: Geological Time Scale Plotting	http://CRAN.R-project.org/package=geoscale
geotech: Geotechnical Engineering	https://CRAN.R-project.org/package=geotech
ggtern: An Extension to 'ggplot2', for the Creation of Ternary Diagrams	http://CRAN.R-project.org/package=ggtern
hydrogeo: Groundwater data presentation and interpretation	http://CRAN.R-project.org/package=hydrogeo
IsoplotR: Statistical Toolbox for Radiometric Geochronology	http://CRAN.R-project.org/package=IsoplotR
Isoread	https://github.com/sebkopf/isoread
LAND-SE	https://github.com/maurorossi/LAND-SE (Rossi and Reichenbach, 2016)
Luminescence: Comprehensive Luminescence Dating Data Analysis	http://CRAN.R-project.org/package=Luminescence (Kreutzer et al., 2012)
matlab: MATLAB emulation package	http://CRAN.R-project.org/package=matlab
marmap: Import, Plot and Analyze Bathymetric and Topographic Data	https://CRAN.R-project.org/package=marmap (Pante and Simon-Bouhet, 2013)
NORRRM: Geochemical Toolkit for R	http://CRAN.R-project.org/package=NORRRM (González-Guzmán, 2016)
paleoMAS: Paleoecological Analysis	https://CRAN.R-project.org/package=paleoMAS
paleotree: Paleontological and Phylogenetic Analyses of Evolution	http://CRAN.R-project.org/package=paleotree (Bapst, 2012)
paleoTS: Analyze Paleontological Time-Series	https://CRAN.R-project.org/package=paleoTS
palinsol: Insolation for palaeoclimate studies	http://CRAN.R-project.org/package=palinsol
provenance: Statistical Toolbox for Sedimentary Provenance Analysis	http://CRAN.R-project.org/package=provenance (Vermeesch et al., 2016)
R.matlab: Read and Write MAT Files and Call MATLAB from within R	https://cran.r-project.org/package=R.matlab
RockFab: Rock fabric and strain analysis tools	http://CRAN.R-project.org/package=RockFab
shapeR: Collection and Analysis of Otolith Shape Data	http://CRAN.R-project.org/package=shapeR (Libungan and Pálsson, 2015)
soilprofile: A package to consistently represent soil properties along a soil profile	https://CRAN.R-project.org/package=soilprofile
spMC: Continuous-Lag Spatial Markov Chains	http://CRAN.R-project.org/package=spMC (Sartore et al., 2016)
strap: Stratigraphic Tree Analysis for Palaeontology	http://CRAN.R-project.org/package=strap (Bell and Lloyd, 2015)
stratigraph: Toolkit for the plotting and analysis of stratigraphic and palaeontological data	http://CRAN.R-project.org/package=stratigraph
tgcd: Thermoluminescence Glow Curve Deconvolution	http://CRAN.R-project.org/package=tgcd (Peng et al., 2016)
TLdating: Tools for Thermoluminescences Dating	https://CRAN.R-project.org/package=TLdating (Strebler et al., 2017)
treeclim: Numerical Calibration of Proxy-Climate Relationships	http://CRAN.R-project.org/package=treeclim (Zang and Biondi, 2015)
XLConnect: Excel Connector for R	http://CRAN.R-project.org/package=XLConnect
CRAN Task View: Analysis of Spatial Data	https://CRAN.R-project.org/view=Spatial
CRAN Task View: Handling and Analyzing Spatio-Temporal Data	https://CRAN.R-project.org/view=SpatioTemporal

Table 2: Selected R packages useful for geological sciences.

Teeuw, 2015; Brovelli et al. 2017). Nevertheless, some convenient geospatial and remote sensing applications are included in Tables 1 - 3.

3. The free operating system Linux

In the previous chapter we mentioned selected alternative free software applications which can be used on the most popular operating systems. Besides the most widely used platforms like Microsoft Windows or Apple MacOS a variety of other platforms exist, such as Oracle Solaris, BSD or Linux. From those platforms Linux is the most popular one for many years. Therefore, the free Linux operating system is discussed here in detail.

Basically, Linux is not an operating system. Linux itself is only the kernel, the core of the operating system. The associated system and user applications which form the operating system are mostly an enormous amount of, generally, GNU General Public License (GPL) licensed software: GNU/Linux.

It is used in many scientific and educational institutions and organizations for particular tasks (e.g., in CERN, DESY, ESA, NASA or Fermilab). Although Linux is already the most successful operating system for mobile or embedded systems, for super computers, or servers, it is still only marginally accepted as a valuable desktop environment. The huge variety of distributions seem to be deterrent and confusing to many new Linux users. But this variety is a chance to get just that working environment which provides the best benefit. All the available distributions are mainly just variations in design, structure, or the available pre-installed software. But not only the different distributions are confusing to new users, also the various desktop environments which are available for most of the distributions seem to be a barrier. The main desktop environments are currently KDE, Gnome, Unity, Enlightenment, XFCE, Cinnamon, Mate, LXDE, and Pantheon. Some need more resources, suitable for newest hardware (e.g., KDE, Gnome, Unity), and some are adapted for older hardware (e.g., XFCE, LXDE).

Many distributions have a fast version upgrade. For stability reasons it is recommended to use Long Term Support (LTS) versions (about 3-5 years support). The regular versions of various distributions do not have a long support period (generally only 6-12 months), but on the other hand provide more recent software applications. More experienced users might prefer to install a Rolling Release version which is constantly updated and upgraded without a required re-installation. An easy way to test Linux without any risk is by using so-called Live-DVDs (or USB flash drives). The necessary ISO-files are available from any distribution (see e.g., Distrowatch; URL 15). Linux can run from within Windows, or vice versa, by virtual machines (e.g., Virtual box; URL 16). It is possible to use some Linux applications in Windows by *Cygwin* (URL 17). Contrariwise Windows programs can run on Linux by using *WINE/PlayOnLinux* (URLs 18, 19) or *Crossover Linux* (URL 20). Linux can also easily be installed parallel to Windows. So the user can decide during the starting process which operating system to use (dual boot). The usage and advantages, but also problematic issues of Linux in the academic world are pointed out in Coyle (2008), Yalta and Lucchetti (2008), Tchantchaleishvili and Schmitto (2011) and Ovadia (2013, 2014a).

4. Problems, clarifications and solutions

Beside the positive financial and efficiency aspects and the freedom of use we also have to mention some problems of migration to FLOSS. Many users are afraid of changing applications, or even the system, they are used to (see, e.g., Gallego et al., 2008, 2015; Kim et al., 2014). Not all alternatives are free of weaknesses (e.g. Mellor, 2014) or are seen as too risky in terms of user skills or costs (e.g., Goode, 2005; Lemley and Shafir, 2011; Rojas and Polzer, 2011; Silic and Back, 2015). The different unfamiliar applications might not be the main problem for a migration. Many of them (e.g., *Firefox*, *Thunderbird*, *VLC Player*, or *Moodle*) are already applied without scepticism or aversion for many years. The graphical user interface is changing also during versions upgrades of the commonly used proprietary commercial applications. Possible issues by using the uncommon environment provoke some new Linux users to stop the attempts. But there is no operating system without limitations. Even the commercial platforms had and have unquestionably some problems and they are nevertheless still used anyway.

4.1 Openness to alternative software

The huge amount of suitable alternative software applications (for any platform) or their professional abilities seem to be not well-known to many geoscientists. Even if they are known, rarely one wants to “waste time" to try those alternatives. It probably worked all perfect with the common proprietary software (pushing any previous shortcomings aside), and rarely one wants to change the routine workflows. Unfortunately, some users also quickly share the popular myth that free software can not be a stable and sufficient tool, often even though without own experience. Particularly those arguments, and the fear to lose time, hinder most people to change their applications or to try additional ones which might be even better suitable for some work steps. Considering that most users are utilising some applications successfully for several years it might be reasonable. But a try if other software might solve the tasks more effectively should always be considered. At universities proprietary software is used also with the idea that the knowledge of certain software applications is needed for the future carrier. By using such arguments it is ignored that users should not just have the skills of knowing which buttons in a certain application have to be clicked in which order, but rather to know how things can be solved in general. That means users need to understand the basics about, e.g., image or word processing and not just knowing the functions of, e.g., *Photoshop* or *Word*.

A disfavour against FLOSS is often justified by telling that if the software development is stopped the continuation of using the files is not assured. This argument is unjustified. Many

Statistics, numerical calculations, plotting		W	M	L
ArAR	http://group18software.asu.edu/ (Mercer and Hodges, 2016)	x	x	x
AvoPlot	http://code.google.com/p/avoplot/ (Peters, 2014)	x		x
CoDaPack	http://www.compositionaldata.com/ (Comas-Cufí and Thio-Henestrosa, 2011**)**	x	x	x
DensityPlotter	http://www.ucl.ac.uk/~ucfbpve/densityplotter/ (Vermeesch, 2012)	x	x	x
DisChart	http://80.251.40.59/eng.ankara.edu.tr/akiska/dischart/ (Akıska, 2015)	x		
ET_Redux	http://cirdles.org/projects/et_redux/ (McLean et al., 2016)	x	x	x
GCDkit	http://www.gcdkit.org/ (Janoušek et al., 2006, 2016)	x		
Hf-INATOR	http://link.springer.com/article/10.1007/s12145-017-0303-9 (Giovanardi and Lugli, 2017)	x	x	x
MorphoJ	http://www.flywings.org.uk/MorphoJ_page.htm (Klingenberg, 2011)	x	x	x
OpenChrom	https://www.openchrom.net/ (Wenig and Odermatt, 2010)	x	x	x
OpenGeoSys	http://www.opengeosys.org/home (Kolditz et al., 2012)	x	x	x
OpenMS	http://www.openms.de/ (Röst et al., 2016)	x	x	x
PAST	http://folk.uio.no/ohammer/past/ (Hammer et al., 2001)	x	x	
Petrograph	http://accounts.unipg.it/~maurip/SOFTWARE.htm (Petrelli et al., 2005)	x		
PHREEQC	https://wwwbrr.cr.usgs.gov/projects/GWC_coupled/phreeqc/ (Parkhurst and Appelo, 2013)	x	x	x
PmagPy	https://github.com/PmagPy/PmagPy (Tauxe et al., 2016)	x	x	
PuffinPlot	http://puffinplot.bitbucket.org/ (Lurcock and Wilson, 2012)	x	x	x
PyXRD	https://github.com/mathijs-dumon/PyXRD (Dumon & Van Ranst, 2016)	x	x	x
Rcrust	http://www.sun.ac.za/english/faculty/science/earthsciences/rcrust (Mayne et al., 2016)	x	x	x
RGeostats	http://cg.ensmp.fr/rgeostats	x	x	
SGeMS	http://sgems.sourceforge.net/ (Remy et al., 2009)	x		
SpectraFox	http://www.spectrafox.com/ (Ruby, 2016)	x		
Spekwin32	http://www.effemm2.de/spekwin	x	x	x
Theriak/Domino	http://titan.minpet.unibas.ch/minpet/theriak/theruser.html (de Capitani and Petrakakis, 2010)	x	x	x
THERIAK_D add-on	http://www.min.uni-kiel.de/~ed/theriakd/ (Duesterhoeft and de Capitani, 2013)	x	x	x
t-Igpet	https://sites.google.com/site/tsigpetteaching/ (Carr and Gazel, 2016)	x	x	
TriAngle	http://geo-consulting.warnsloh.com/triangle/ (Warnsloh, 2015)	x	x	x
uFREASI	http://www.ipgp.fr/~tharaud/uFREASI (Tharaud et al., 2015)	x	x	x
Stereographic projections, structural geological data		**W**	**M**	**L**
GarcmB	http://www.kueps.kyoto-u.ac.jp/~web-bs/tsg/software/GArcmB/ (Yamaji, 2016)	x	x	x
InnStereo	http://innstereo.github.io/	x		x
MARD	http://dx.doi.org/10.1016/j.cageo.2012.07.012 (Munro and Blenkinsop, 2012)	x	x	x
Open Plot Pj.	http://www.openplot.altervista.org/ (Tavani et al., 2011)	x	x	x
OpenStereo	http://www.igc.usp.br/index.php?id=openstereo (Grohmann and Campanha, 2012)	x	x	x
Orient	http://www.frederickvollmer.com/orient/	x	x	x
OrientXplot	http://www.rossangel.com/text_orientxplot.htm (Angel et al., 2015)	x		
SG2PS	http://www.sg2ps.eu/ (Sasvári and Baharev, 2014)	x		
Slicken	http://www.geociencias.unam.mx/~afns/Slicken_1.0.jar (Xu et al., 2016)	x	x	x
Stereonet3D	http://www.ux.uis.no/~nestor/work/programs.html (Cardozo and Allmendinger, 2013)		x	
y-gRaph	https://dl.dropboxusercontent.com/u/41688281/yR_toPaper/yRdiagram.zip (Calvin et al. 2014)	x	x	x
Image processing, data visualisation		**W**	**M**	**L**
AERYN	http://www.tcd.ie/Geology/staff/crowleyq/AERYN/ (Mouchi et al., 2016)	x		
Avogadro	http://avogadro.cc/ (Hanwell et al., 2012)	x	x	x
Binary Traverser	http://www.geo.umass.edu/climate/lewis/analysis/ (Lewis et al., 2010)	x	x	x

Table 3: Selection of Free and Open Source Software for particular geoscientific tasks (also some freeware included, see caption of Table 1). W = Windows, M = Mac, L = Linux.

FLOSS are applying international standardized file formats. Furthermore, FLOSS is, with exceptions, mainly developed collaboratively by globally distributed programmers. If some, or all, do not continue to contribute, others might and will

BoneJ	http://bonej.org/ (Doube et al., 2010)	x	x	x
EBSD-Image	http://www.ebsd-image.org/ (Pinard et al., 2011)	x	x	x
FAME	http://peternell.org/archive.html (Hammes and Peternell, 2016)	x		
GPlates	http://www.gplates.org (Williams et al., 2012)	x	x	x
Gwyddion	http://gwyddion.net/ (Nečas and Klapetek, 2011)	x	x	x
JMicroVision	http://www.jmicrovision.com (Roduit, 2015)	x	x	x
Jpor (ImageJ plug-in)	http://www.geoanalysis.org/jPOR.html (Grove and Jerram, 2011)	x	x	x
Micro-Manager	https://micro-manager.org/ (Edelstein et al., 2010, 2014)	x	x	x
ParaViewGeo	http://paraviewgeo.objectivity.ca/	x		x
surfit	http://surfit.sourceforge.net/	x		
ScatterJn	http://dx.doi.org/10.5281/zenodo.22167 (Zeitvogel and Obst, 2016)	x	x	x
xyscan	http://rhig.physics.yale.edu/~ullrich/software/xyscan/		x	x
Vespucci	https://github.com/dpfoose/Vespucci (Foose and Sizemore, 2016)	x	x	x
VESTA	http://jp-minerals.org/vesta/en/ (Momma and Izumi, 2011)	x	x	x
XCrySDen	http://www.xcrysden.org/ (Kokalj, 2003)	x	x	x
YaDiV	http://www.welfenlab.de/en/yadiv (Friese et al., 2013)	x	x	x
Stratigraphic plots		**W**	**M**	**L**
CoreWall	http://www.corewall.org/ (e.g., Conze et al., 2010)	x	x	
Polito	http://sourceforge.net/projects/polito (Stremtan and Tudor, 2010)	x	x	x
PSICAT	http://portal.chronos.org/psicat-site/ (Reed et al., 2006)	x	x	x
SedLog	http://www.sedlog.com/ (Zervas et al., 2009)	x		
TimeScale Creator	https://engineering.purdue.edu/Stratigraphy/tscreator/index/index.php	x	x	x
Spatial data		**W**	**M**	**L**
DigiFract	https://sites.google.com/site/digifract/ (Hardebol and Bertotti, 2013)	x	x	x
GMT	http://gmt.soest.hawaii.edu/ (Wessel et al., 2013)	x	x	x
GeoCube	http://www.mediafire.com/file/7dn243zkv7d3oy6/GeoCube.rar (Li et al., 2016)	x		
GeoDA	http://geodacenter.github.io/ (Anselin et al., 2006)	x	x	x
Geophysics, seismic data		**W**	**M**	**L**
APASVO	https://github.com/jemromerol/apasvo (Romero et al., 2016)	x	x	x
Madagascar	http://www.ahay.org/ (Fomel et al., 2013)	x	x	x
OpendTect	http://www.opendtect.org/	x	x	x
pynoddy	https://github.com/flohorovicic/pynoddy (Wellmann et al., 2016)	x	x	x
Seismic Toolkit	http://seismic-toolkit.sourceforge.net/	x		x
Uncategorized		**W**	**M**	**L**
ADFNE	http://alghalandis.net/products/adfne (Fadakar, 2017)	x	x	x
Dose rate calculator (DRc)	http://www.ims.demokritos.gr/download/DRcalculator.exe (Tsakalos et al., 2016)	x		
GrainSizeTools	http://marcoalopez.github.io/GrainSizeTools/ (Lopez-Sanchez and Llana-Fúnez, 2015)	x	x	x
RDSS	http://rdss.sourceforge.net/ (Apopei et al., 2015)	x	x	x
Survex	http://survex.com/	x	x	x
Therion	https://therion.speleo.sk/	x	x	x
Virtual Petrographic Microscope	http://eps.mq.edu.au/vpm/ (Tetley and Daczko, 2014)	x	x	

Table 3 continued

do, especially if the consumers demand and interest is high. A commercial company on the other hand, which gives up because of various reasons, rarely provide the public with all the programming codes in order to continue the development. A lot of prominent software vanished due to brand competition in the past. If the source codes of abandoned applications would not made public, many files would be not easily accessible in future. A fact which is getting important with the increasing demand for open data, data archiving and reproducibility (see e.g., Lees 2012; Davis et al., 2016; Gil et al., 2016). Vendor lock-in is one of the main reasons for keeping the common proprietary software. When data is saved in a proprietary file-format, which is not convertible loss-free, it needs very concise evaluation if it is better to keep locked-in to a particular software or to risk the migration to a new format. In many cases FLOSS is able to import most of the important proprietary file formats without any serious loss. In the case of data reproducibility open source software fulfils a more reliable check of data than closed software (e.g., Stallman 2005; Ince et al., 2012; Lees 2012; Easterbrook 2014; Gezelter 2015). FLOSS, with non-proprietary data file formats, provide the more likely ability to reuse data loss-free from old or possibly vanished applications.

4.2 Manuscript preparation and submission

To our experience, the main threshold of migration are the office suite as well as the graphic editor and their interoperability for collaborative writing and editing. By preparing a scientific manuscript with several co-authors it is usually sent via email to all collaborative partners. Every co-author must be able to open, read, modify, and save the various files, be it a text, spreadsheet or graphic file. Most scientists are accustomed to *Word* for writing their manuscripts and expect this also from their collaborative authors, because of compatibility.

Of course, many users cannot resign of *MS Office*, be it because of some complex macros or special forms. But there is no reason not to install *Open/LibreOffice* in addition. By working with proprietary software it is more or less expected that all collaborative colleagues have access to the same applications. Regarding collaborations with colleagues at institutions with lower budgets it is rather unfair to insist on expensive software instead to use the free available versions (see also e.g., Lees 2012). FLOSS can be installed several times on different PCs, it can be copied (or the link can be sent) to collaborative colleagues worldwide to have the same work flow. In some cases an alternative to an additional office installation is the usage of WebODF (URL 21). With this Mozilla Firefox-add-on it is possible to open, modify and save Open Document files.

An often overlooked compatibility problem occurs due to the usage of commercial or unusual fonts, or due to different spacing, which distorts some document layouts. Liberation is a TrueType font collection (from Red Hat) which is compatible to the largely used font types Arial, Times new Roman and Courier. The standard fonts in *MS Office* are currently the proprietary fonts Calibri or Cambria which are not available on Linux. Due to such compatibility problems Google developed similar free fonts (Carlito and Caladea; URL 22, 23) which can easily be installed on Linux. The possibility of embedding fonts into a document seems also not widely be known or used. Moreover, many users are rarely aware of the difference between the layout and just the content. It seems to be common to copy and paste between different documents without considering the taking over of possibly different formats and fonts. Many users do direct formatting in text documents instead of the recommended use of style sheets. A lot of time is consumed just by repairing and reformatting the whole document at the end.

Another main reason to defend the use of particular commercial software is the file format for manuscript submissions requested by most publishers of journals or books. For submission of text manuscripts mainly a proprietary file format like DOC/DOCX is mandatory, some publishers accept also PDF or TEX-files (see, e.g., Tchantchaleishvili and Schmitto, 2011; Krewinkel and Winkler, 2017). For archiving or scientific documentation an ISO-certified file format like Open Document Text would be much more appropriate (e.g., Weir, 2009; Park and Oh, 2012; Wilson and Tchantchaleishvili, 2013). In some European administrations it is partially already mandatory, see, for example, information on "Open Document Format (ODF): guidance for UK government" (URL 24). The final print layout is anyway done by the publishers themselves, basically they only require the correct structure of the text. In fact, word processors like *Word* or *Writer* have many disadvantages for preparing large structured text documents. Instead of using the classic word processors, or even the typesetting program *Latex*, which is limited in collaborative exchange (in its offline state), many scientists use already web-based tools for publishing multi-author-manuscripts (e.g., Perkel, 2014). Furthermore, beside compatibility issues due to different office versions of the co-authors, the constant reformatting of repeated submissions of a manuscript before acceptance in a journal is wasting time (Brischoux and Legagneux, 2009; Budd, 2017; Krewinkel and Winkler, 2017). Those authors suggest better to concentrate on the scientific content and structure, and to format the manuscript according to the journals guidelines only after acceptance. Preparing manuscripts by a lightweight markup language is one excellent solution to do this, at least for not too complex contents. Many authors already use a more lightweight markup language such as Markdown (URL 25), particularly if publishing the same content in different formats as in printed or web-based publications (see e.g., Ovadia, 2014b; Krewinkel and Winkler, 2017). Text in Markdown can be written in any text editor and with a converter such as *Pandoc* (URL 26) exported to nearly any format, mainly to HTML, ODT or PDF. The useful viable track changes feature can currently be used with *CriticMarkup* (URL 27), but there will surely be many more innovative solutions in the future. The general capability of FLOSS for preparing, submitting and publishing manuscripts is documented by several authors (e.g., Zaritski 2003; Faccioli et al., 2009; Tchantchaleishvili and Schmitto, 2011; Wilson and Tchantchaleishvili, 2013). Furthermore, thoughts on future geoscientific publishing should be considered (Gil et al., 2016).

4.3 Productive work with Linux

Many Windows users which are familiar with some free software applications are often surprised when they learn that those programs were always a part of Linux. Thus, if people have already used free alternatives on Windows they will not experience so many changes after migration. The so-called user-friendly environment of Windows is often rather due to its familiarity of long-time usage since the first encounter with computers.

One example of the usefulness of Linux is the much faster installation process compared to Windows. With a nowadays easy installation of most Linux distributions, which in many cases can be finished within half an hour, nearly all the necessary software packages for general usage are already installed. This is contrary to Windows, where after the installation of the operating system all the necessary software have to be added separately. The drivers for most of the common hardware are already implemented in the Linux kernel, thus usually no extra installation of drivers are necessary. Actually, Linux has a much broader driver support than Windows, especially when using old(er) hardware. If older hardware is not supported by Windows anymore, it would most probably still work with Linux. Only most recent or unusual exotic hardware might cause a problem.

Linux is especially useful and comfortable if mainly basic tasks like writing and reading texts, viewing images or performing Internet research is done and old PCs or notebooks are wanted to be in continued use. Depending on the desktop environment only marginal changes in usage are recognizable. The home-directory is comparable with the familiar "My

General (Free Software alternative collections, manuals)
Awesomecow (http://awesomecow.com/) debianlinux - Scientific Software (http://debianlinux.net/science.html) FLOSSmanuals (http://en.flossmanuals.net/) Free Open Source Software (https://freeopensourcesoftware.org) Free Software Directory (https://directory.fsf.org) Linux Alternative Project (http://www.linuxalt.com/) Linux Equivalents to Windows Software (http://www.linuxlinks.com/article/20070701111340544/Equivalents.html) List of free statistical software (http://statistiksoftware.com/free_software.html) Open Source Alternative (http://www.opensourcealternative.org/) Opensource-DVD (http://www.opensource-dvd.de) Open Source Software & Freeware (https://informatik.univie.ac.at/studierende/info/software/opensource/) Open Source Software Directory (https://opensourcesoftwaredirectory.com/) Open Source Software List: The Ultimate List (http://www.datamation.com/open-source/open-source-software-list-ultimate-list-1.html) osalt - open source as alternative (http://www.osalt.com/) OSS Watch (http://oss-watch.ac.uk/) SourceForge (http://sourceforge.net) UbuntuScience (https://help.ubuntu.com/community/UbuntuScience/AlternativesToProprietarySoftware) Wikipedia Portal: Free and open-source software (https://en.wikipedia.org/wiki/Portal:Free_and_open-source_software)
Software Compilations and Informations for Geoscientists
All the software a geoscientist needs. For free! (http://all-geo.org/volcan01010/2011/11/all-the-software-a-geoscientists-needs-for-free/) Geochemical Plotting Programs (http://serc.carleton.edu/NAGTWorkshops/petrology/plot_programs.html) Geoforge (http://www.geoforge.org/) Geotechnical Engineering Software Database (http://www.geoengineer.org/software/home) List of free geology software (http://en.wikipedia.org/wiki/List_of_free_geology_software) OntoSoft (http://www.ontosoft.org) OpenScience (http://www.openscience.org) Open Source and Free Software and Resources for Geoscientists (https://babelflysch.wordpress.com/software/) Open Source Software related to Geoscience and Remote Sensing (http://www.grss-ieee.org/open-source-software-related-to-geoscience-and-remote-sensing) USGS Github Repositories (https://github.com/usgs)
Scientific/Educational Linux distributions
ArcheOS (http://www.archeos.eu/ | http://doc.archeos.it/) BioLinux (http://environmentalomics.org/bio-linux/) Fedora Scientific (https://labs.fedoraproject.org/de/scientific/) Mathbuntu (http://www.mathbuntu.org/) OSGeo-Live (http://live.osgeo.org/en/index.html) Uberstudent (http://uberstudent.org/) Zorin OS Educational (http://zorin-os.com/)

Table 4: Useful weblinks to alternative software.

Documents" from Windows. Data can only be saved in the home folder, which is more secure than the possible spreading over different (even system) folders commonly done in Windows. Linux users are, on default, not allowed to do anything outside of the home folder. Programs are generally not executed with administrative rights. Thus, it is not so easy to damage the system by inappropriate usage. With Linux it is not urgently necessary to install firewall and anti-virus software on desktop-PCs and notebooks. This saves a lot of memory and handling time. Also, defragmenting, which is often ignored by Windows users anyway, is, due to a different file management, less urgently needed. Many Linux distributions compiled for general educational or scientific use are available, and some distributions are even developed for particular academic disciplines (Table 4). As it is easy to quickly install any available specific software (e.g., via the software centre of the distribution repositories), any distribution which is more comfortable for the user might be preferred.

Although Linux provides an effective desktop system for general and professional usage it should not be seen just as a replacement but as an alternative to Windows or MacOS. Some task or device or some needed proprietary software better works on Windows or MacOS. Compared to MacOS many similarities with Linux can be found as both platforms are UNIX based. In many institutions or offices, but also during external collaboration, both Windows and Mac co-exist for a long time, despite some issues. Curiously, the coexistence of Linux with Windows and Mac is questioned. This might stem from one possible reason: when Windows or Mac fails or crashes it is ordinary inconvenience, the troubles are annoying but have to be taken for granted. Does the same happen with Linux this is hastily interpreted as confirmation that it is unprofessional free junk, and rarely any attempts are accepted to search for possible solutions. Unfortunately, free is often interpreted as ineffective, a speculation that confirms new users that the software is not suitable for professional usage. Our own subjective experience is that using Linux and open source software is less time consuming, with fewer issues. There is less maintenance needed, regarding, e.g., security, system cleaning, system crashes, driver problems, or individual software installations and updates.

4.4 Reasons for migration to FLOSS

According to van Loon and Toshkov (2015) a migration to FLOSS in European municipalities rarely occurs for financial reasons, this more likely happens in companies, but rather due to top-down decisions. At universities a top-down decision for a migration to FLOSS, or to any specific software products, would be counterproductive as it would hinder unhampered science workflow and creativity. Nevertheless, some hints within and between research institutions to successful usage of FLOSS would possibly lower the threshold of unease about a migration to free alternative software. More and more recent scientific articles definitely state the particular usage of FLOSS in the methodology part.

At universities geoscience graduate students need, and mostly get, access to a desktop computer during their thesis work. Most commercial software licences, however, are strictly only available for staff members. Unfortunately, that fact might undermine a legal PC installation. One strong argument for using FLOSS, at least for student PCs, is that students can use in any case the same applications at home because they are freely available. Students would not be dependent on the PCs at the universities. Not only students, also scientific, technical, and possibly administrative, staff could use free software, or even straightaway Linux.

One good reason to keep on some proprietary software for, e.g., PCs of analytical devices, is the technical support, which is in those particular cases rather more needed than for simple everyday office applications. Academic work cannot be compared with industrial production or service companies which depend on more or less the same programs and workflows. Depending what kind of research projects are currently done some programs are not used regularly in geoscience institutes. As most proprietary software applications at the universities nowadays are not bought, but rented for a certain time, paying rent for some expensive applications is not warrantable for many institutes when the application is not constantly used. As universities are public institutions, it will be irresponsible against the public to waste enormous amounts of money for software applications which are not irreplaceable for most uses in lab work, research or administration. All academic institutions should take the possibility to do their research without the obstacle of expensive proprietary commercial, even monopolistic, software (see e.g., Nature, 2000; or Lees, 2012). But also geotechnical engineering offices might benefit by avoiding vendor lock-in with their software applications.

5. Concluding remarks

Many academic institutions worldwide already use FLOSS because of the lack of sufficient commercial software for certain research tasks but also due to reasons of costs and freedom of own adjustments. It is not recommended replacing commercial software in general, many of those fit excellently for their purpose. But there is no reason to rent expensive office suites, graphic editors or calculation software when there are free alternatives which provide the same, or possibly better, efficiency and usability. This article intends to demonstrate that plenty of equivalent free alternatives to proprietary programs exist for the most used operating systems. Getting familiar with this alternatives in relatively short time is generally not a big issue, similar to relearning new upgrade versions of used proprietary software. At least, everyone can try the alternatives to check if they provide the needed functions and work steps for their productivity. As there is a huge amount of different specialized geoscientific topics there are also as many ways of computing workflows. This article is far from being a complete overview of FLOSS for the geosciences, but it should help to decrease the threshold to evaluate or use such alternatives if necessary. There is no need just to take only what is available in the commercial software sector. There is the freedom to choose what fits the best for a purpose - for one user alone or in collaboration with others.

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