

Notes on processing large amounts of Earth Observation data

Alber Sánchez alber.ipia@inpe.br
Guilherme Mataveli



Research assistant - TreesLab
National Institute for Space Research - INPE
Brazil

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Overview I

- Introduction

- Computing concepts

- Linux

- Scripting

 - Bash

 - How to process data without a GUI

 - R

- Virtualization and containerization

- Platforms

 - sepal.io

 - Google Earth Engine

 - INPE

- Test case: sepal.io

Introduction.

Computing concepts.

Hardware

- ▶ Processor.
- ▶ Memory.
- ▶ Disc (InputOutput, I/O).
- ▶ Graphic User Interface (GUI).
- ▶ Console, terminal, shell, tty.
- ▶ Client, server.

Software

Map - Reduce

Resources

- ▶ [Computer Science](#) by Crash Course.



Linux.

Basic Bash commands I

Command	Explanation
whoami	What is the current user name (Who am I?).
pwd	Print working directory (Where am I?).
ls	List directory contents.
cd	Change working directory.
man	Display manual pages.
help	Display information about commands.
apropos	Search the manuals and descriptions.
rm	Remove files or directories.
cp	Copy files or directories.
mv	Move (rename) files.
mkdir	Make directories.

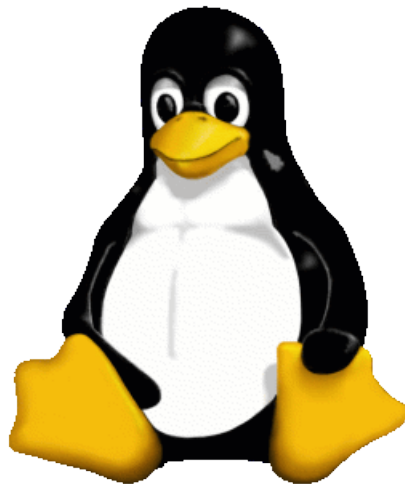
Basic Bash commands II

<code>less</code>	Open a file for reading.
<code>nano</code>	Simple text editor.
<code>vim</code>	Text editor.
<code>vimtutor</code>	The Vim tutor.
<code>wget</code>	Download data from the Internet.
<code>rsync</code>	Backup and file copying tool.
<code>ssh</code>	Remote login client.
<code>scp</code>	Secure file copy.

Basic Bash commands III

Resources

- ▶ Webpages: [Linux Journey](#).
- ▶ Books:
 - ▶ Linux basics for Hackers [6].
 - ▶ The Linux Command Line [7].
 - ▶ Unix and Linux System Administration Handbook [3].
- ▶ Courses: [Linux Foundation \(LFS101\)](#).
- ▶ Videos:
 - ▶ [Linux Commands for Beginners](#) by Learn Linux TV.
 - ▶ [Linux Crash Course](#) by Learn Linux TV.
 - ▶ [The Linux Command Line Ultimate Tutorial](#) by Average Linux User.



Bash scripting.

Resources

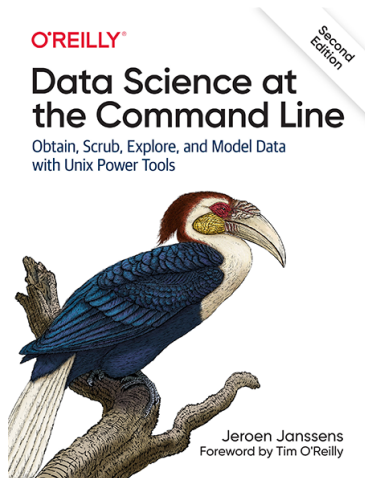
- ▶ Books: The Linux Command Line [7].
- ▶ Tutorials: [The Unix Shell](#) by Software Carpentry.
- ▶ Videos: [Bash Scripting on Linux](#) by Learn Linux TV.



How to process data without a GUI.

Data Science at the Command Line[2]

- ▶ Get data from websites, APIs, databases, and spreadsheets; scrub text, CSV, HTML, XML, JSON.
- ▶ Explore data, compute statistics, create visualizations.
- ▶ Create your own tools, re-use code.
- ▶ Parallelize and distribute data pipelines.
- ▶ Model data with dimensionality reduction, regression, and classification algorithms.
- ▶ Command line from Python, Jupyter, R, RStudio, Apache Spark.
- ▶ Read online [here](#).



GRASS GIS

- ▶ Geographic Resources Analysis Support System.
- ▶ Vector and raster geospatial data management, geoprocessing, spatial modelling, and visualization.
- ▶ Free, Libre, and Open Source Software.
- ▶ Docker container.
- ▶ Open Source GIS: A GRASS GIS Approach [4].



Orfeo ToolBox (OTB)

- ▶ OTB is a set of state-of-the-art remote sensing tools.
- ▶ It is FOSS (Free Open Source Software).
- ▶ Wide variety of applications available: from ortho-rectification or pansharpening, all the way to classification, SAR processing, and much more!
- ▶ www.orfeo-toolbox.org



GDAL programs/utilities

- ▶ GDAL is a translator FOSS library for raster and vector geospatial data.
- ▶ It presents a single raster abstract data model and single vector abstract data model to the calling application for all supported formats.
- ▶ It also comes with a variety of useful command line utilities for data translation and processing.
- ▶ Docker container.
- ▶ <https://gdal.org/programs/index.html>
- ▶ Mastering GDAL tools.



R language and environment for statistical computing.

Make script take parameters

Iteration

Recomended reading:

- ▶ Iteration, chapter 26 [11].
- ▶ Functionals, chapter 9 [10].

Parallelize code

Resources

- ▶ Tutorials: [R Tutorial](#) by w3schools.
- ▶ Books:
 - ▶ An introduction to R [8],
 - ▶ Advanced R [9].

Virtualization and containerization.

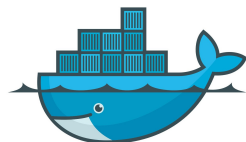
Virtualization

- ▶ A host is a piece of hardware.
- ▶ A virtual machine takes pieces of host's CPU, memory, and disc and simulates new hardware.
- ▶ A software called Hypervisor takes care of virtual machines in a host.
- ▶ VirtualBox and VMware are popular virtualization software.



Containerization

- ▶ A host is a piece of hardware.
- ▶ A virtual machine takes pieces of host's CPU, memory, and disc and simulates new hardware but it's able to share them with other host's processes.
- ▶ Reproducible, lightweight environments for processes to run.
- ▶ You're probably using them without knowing it.
- ▶ Docker and Podman are software for containerization.



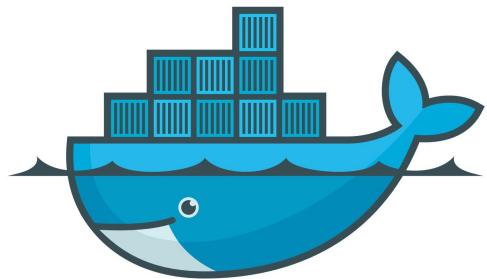
docker



podman

Docker

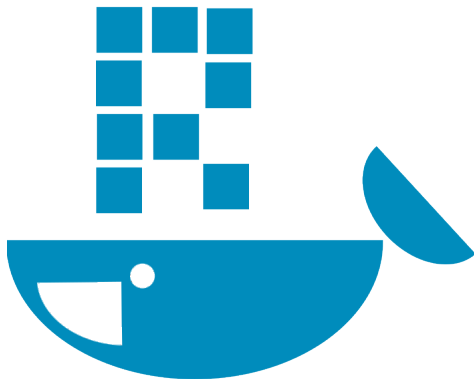
- ▶ An image is a template for creating containers.
- ▶ Images are immutable. Once created, they can't be changed.
- ▶ A container is an instance of an image.
- ▶ Docker has a repository of images called [dockerhub](#).



docker

Rocker project

- ▶ Docker containers for the R Environment.
- ▶ Docker images of r-base, rstudio, shiny, CUDA, geospatial.
- ▶ Portable, sandboxed, transparent, community optimized, versioned, extensible [1].
- ▶ Applications include data processing, share computing environments (HPC), teaching, packaging research reproducibility [5].
- ▶ Rocker project web page
<https://rocker-project.org>.



Reproducible development environments

- ▶ How do I get the same environment during developing and processing?

System for Earth Observation Data Access, Processing and Analysis for Land Monitoring - SEPAL.

SEPAL

- ▶ Cloud computing-based platform for autonomous land monitoring using remote sensing data.
- ▶ This platform allows users to access powerful cloud-computing resources to query, access and process satellite data quickly and efficiently for conducting advanced analysis.
- ▶ It is part of OpenForis.



SEPAL



openforis

Setup

Create accounts at:

- ▶ SEPAL.
- ▶ Google Earth Engine.
- ▶ Collect Earth Engine.
- ▶ NICFI-PlanetLab data.

Get data

- ▶ Connect SEPAL to Google Earth Engine.
- ▶ Connect SEPAL to NICFI-PlanetLab (Norway's International Climate and Forest Initiative).

Recipes

- ▶ Quickly and efficiently query and process satellite data.
- ▶ A recipe is a record of steps and parameters used to make a data set (e.g. classification).
- ▶ Access GEE imagery catalog and run planetary-scale analysis without a line of code.
- ▶ Recipes include creating mosaics (optical, radar, planet), supervised classifications (of images or time series).

Modules

- ▶ GIS tools that complement SEPAL's recipes.
- ▶ Based on advanced GIS libraries.

Workflows

- ▶ Combinations of Recipes, modules, and tools to perform complex data analysis.

CLI utilities

- ▶ Command Line Interface utilities.
- ▶ GDAL, Google Drive, GEE, GuidosToolbox Workbench, Open Foris Geospatial Toolbox, Orfeo Toolbox, Python, R code.
- ▶ IDEs.

IDEs

- ▶ Integrated Development Environments.
- ▶ JupyterLab.
- ▶ Jupyter Notebook.
- ▶ RStudio.

Start a machine

Get data

Start an R-spatial container

Get root password

Google Earth Engine.

National Institute for Space Research in Brazil - INPE.
<https://data.inpe.br>

Base de Informações Georeferenciadas - BIG

- ▶ Hospedar programas e projetos que produzem dados.
- ▶ Os dados do INPE: <https://data.inpe.br/stac/browser>
- ▶ O servidor de mapas BDC : <https://data.inpe.br/big/geoserver>
- ▶ Contato: data.support@inpe.br

Base de Informações Georeferenciadas - BIG

- ▶ Ambiente operacional (24/7).
- ▶ Infraestrutura para atender projetos institucionais.
- ▶ Instancias de processamento sob demanda:
 - ▶ (2vCPUs + 8GB RAM) - (256vCPUs + 1TB RAM)
 - ▶ GPUs A100 e H100 (em preparação)
- ▶ Contato: data.support@inpe.br

Brazil Data Cubes - BDC

- ▶ Os dados do BDC: <https://data.inpe.br/bdc/explorer>
- ▶ O servidor de mapas BDC : <https://data.inpe.br/bdc/geoserver>
- ▶ O BDC Lab: <https://data.inpe.br/bdc/lab>
- ▶ Contato: data.support@inpe.br

Infraestrutura digital BIG BDC na COIDS

- ▶ <https://data.inpe.br/iam>
- ▶ <https://data.inpe.br/big/geonetwork>
- ▶ <https://data.inpe.br/big/geoserver>
- ▶ <https://data.inpe.br/big/nextcloud>
- ▶ <https://data.inpe.br/stac/browser>
- ▶ <https://data.inpe.br/bdc/stac>
- ▶ <https://data.inpe.br/bdc/wtss>
- ▶ <https://data.inpe.br/bdc/wlts>
- ▶ <https://data.inpe.br/bdc/geoserver>
- ▶ <https://data.inpe.br/bdc/explorer>
- ▶ <https://data.inpe.br/bdc/terracollect>
- ▶ <https://data.inpe.br/bdc/lab>
- ▶ <https://data.inpe.br/queimadas/bdq>
- ▶ <https://data.inpe.br/queimadas/geoserver>
- ▶ https://data.inpe.br/queimadas/situacao_atual

Infraestrutura compartilhada de pesquisa na DIOTG (experimental)

- ▶ Jupyter
- ▶ Python
- ▶ Rstudio
- ▶ *R*
- ▶ QGIS
- ▶ Nextcloud
- ▶ PostGRESQL
- ▶ Virtual machines
- ▶ Metview

- ▶ Atividades de capacitação.
 - ▶ Oficina BIG/Queimadas.
 - ▶ BIG TechTalks.
 - ▶ PG-CAP CAP-419 CAP-395
 - ▶ PG-SER SER-347 SER-350
- ▶ Pesquisas.
- ▶ Recursos disponíveis.

Test case: `sepal.io`

Script for...

- ▶ Suppose we have an R script for computing...

Take home message

References I

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References III

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- [11] Hadley Wickham, Mine Çetinkaya-Rundel, and Garrett Grolemund. *R for Data Science: Import, Tidy, Transform, Visualize, and Model Data*. Second edition. Beijing ; Sebastopol, CA: O'Reilly, 2023. ISBN: 978-1-4920-9740-2.