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Remote Sensing with terra

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Associate Scientist



Bioversity International and the International Center for Tropical Agriculture (CIAT) are CGIAR Research Centers.
CGIAR is a global research partnership for a food-secure future.

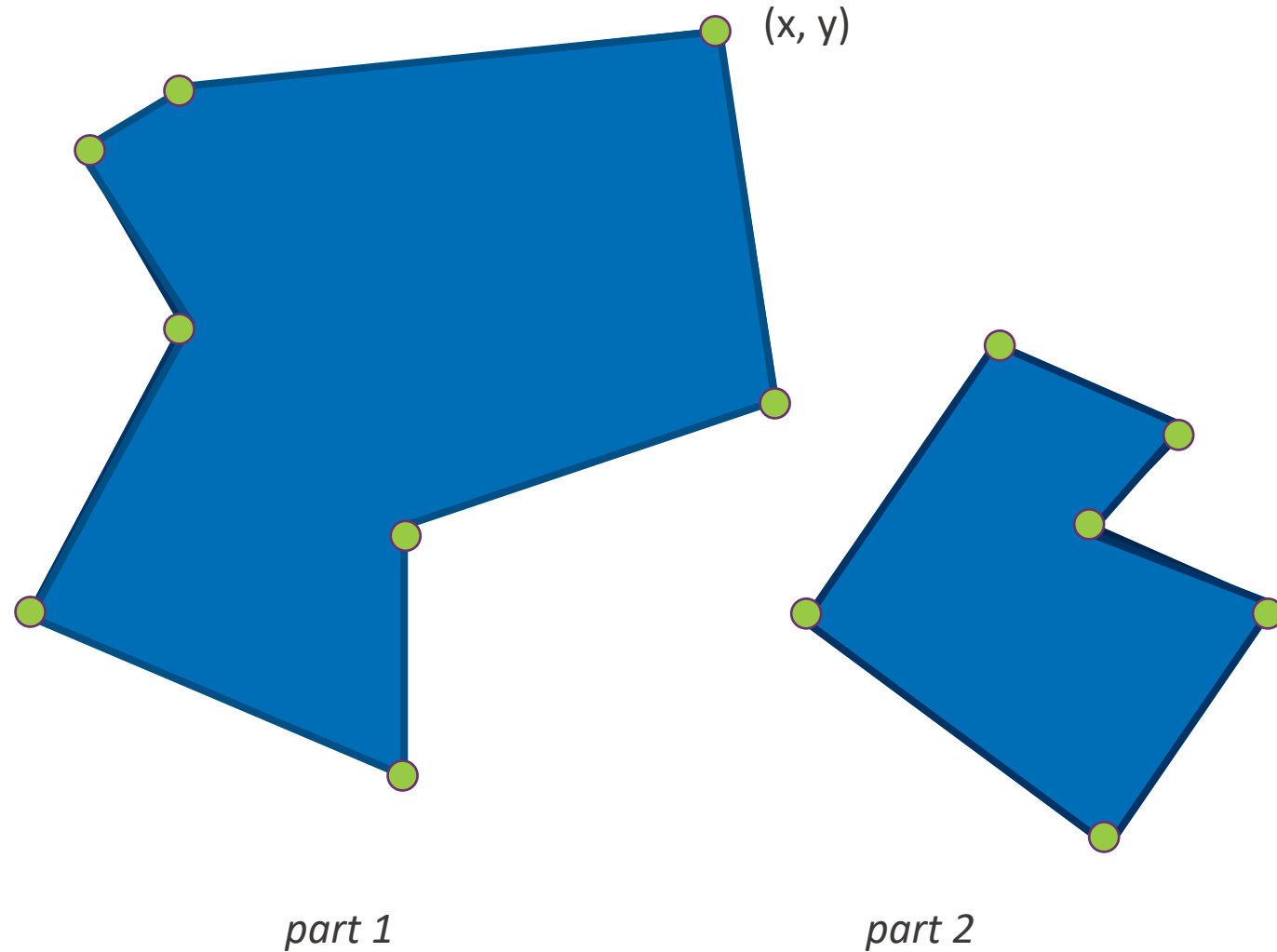
New to spatial data?

Objects

Discrete entities, defined by coordinates

points, lines, areas

typically represented as *vector*



Slide credit Robert Hijmans

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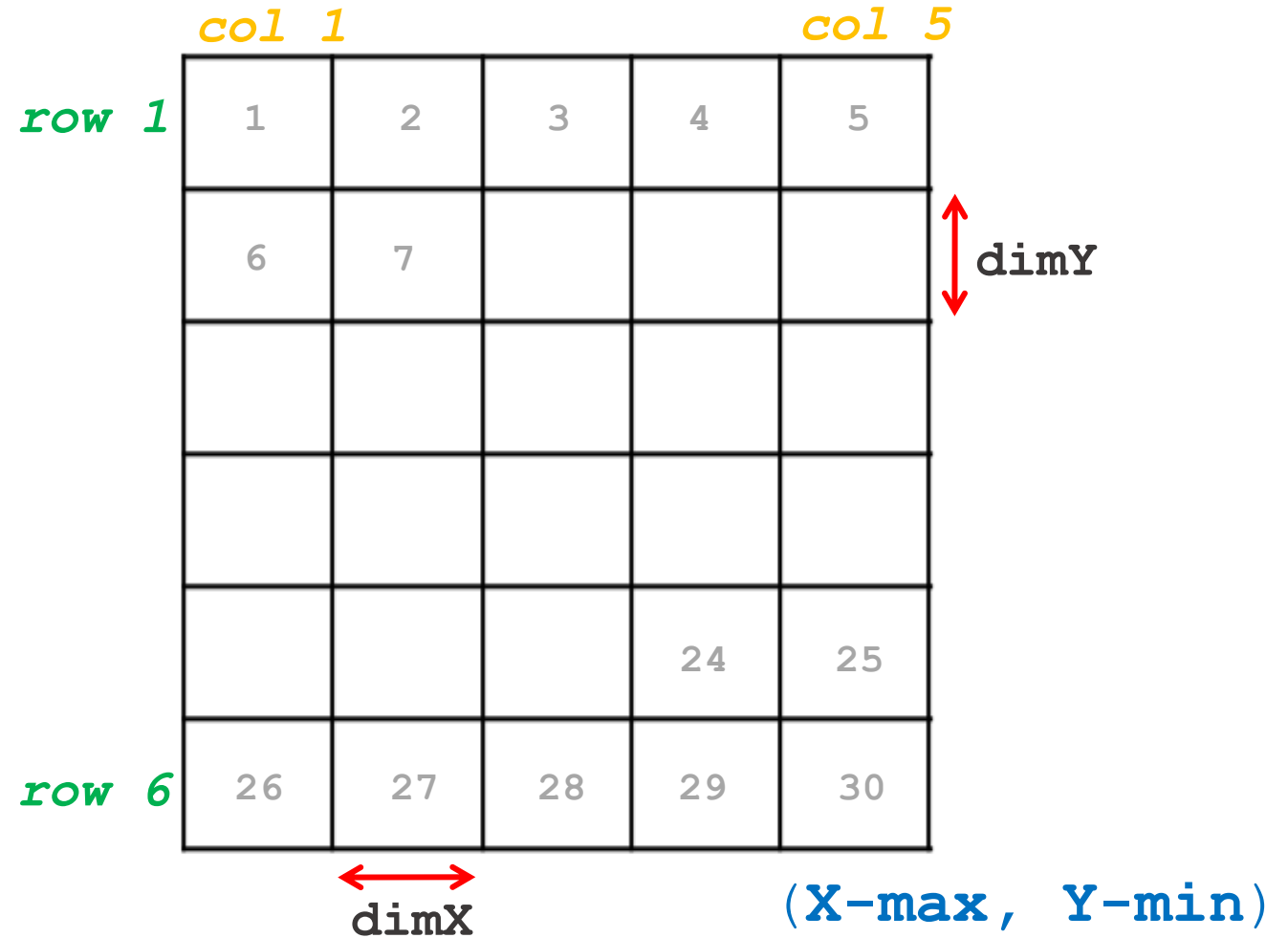


New to spatial data?

Fields

Continuously varying properties
typically represented as *raster*

(X-min, Y-max)



Slide credit Robert Hijmans

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Spatial data packages in R

```
library(rgdal)
```

```
library(sp)
```

```
library(raster)
```



```
library(rgdal)
```

```
library(sf)
```

```
library(terra)
```

Slide credit Robert Hijmans

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raster package

The good

- No file size restrictions
- 200 functions to manipulate raster and vector data
- Simple to use
- Easy integration with machine learning
- Mature and large user community

Slide credit Robert Hijmans

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raster package

The bad

- 200 functions to manipulate raster and vector data
- Unnecessarily complex (`RasterLayer`, `RasterStack`, `RasterBrick`)
- Cannot repurpose code (R only)

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raster package

The ugly

- Too slow *(it's complicated to know why it is slow!)*
- Cannot read HDF5 files *(have you processed MODIS data with raster?)*

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Like raster, but

- faster
- simpler
- more capable
- read HDF5, read COG (*what's that*)

terra: Spatial Data Analysis

Methods for spatial data analysis, especially raster data. Methods allow for low-level data manipulation as well as high-level global, local, zonal, and for regression type (interpolation, machine learning) models for spatial prediction. Processing of very large files is supported. See the manual and tutorials package; but 'terra' is simpler, better, and faster.

Version: 1.0-10
Depends: R ($\geq 3.5.0$)
Imports: methods, [Rcpp](#), [raster](#) ($\geq 3.3-7$)
LinkingTo: [Rcpp](#)
Suggests: parallel, [tinytest](#), [ncdf4](#)
Published: 2021-01-22
Author: Robert J. Hijmans  [cre, aut], Roger Bivand  [ctb], Karl Forner [ctb], Jeroen Ooms  [ctb], Edzer Pebesma  [ctb]
Maintainer: Robert J. Hijmans <r.hijmans at gmail.com>
BugReports: <https://github.com/rspatial/terra/issues/>
License: [GPL \(\$\geq 3\$ \)](#)
URL: <https://rspatial.org/terra>
NeedsCompilation: yes
SystemRequirements: C++11, GDAL ($\geq 3.0.4$), GEOS ($\geq 3.8.0$), PROJ ($\geq 6.3.1$)
Materials: [NEWS](#)
In views: [Spatial](#)
CRAN checks: [terra results](#)

New data classes

- SpatRaster → Replaces layer/stack/brick
 - SpatVector → Spatial vector
 - SpatExtent → Replaces extent
 - SpatRasterDataset
 - SpatRasterCollection/ SpatVectorCollection
- } New classes

New data classes

- SpatRaster → Replaces layer/stack/brick
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- } New classes

terra

New functions/names

? terra

raster package

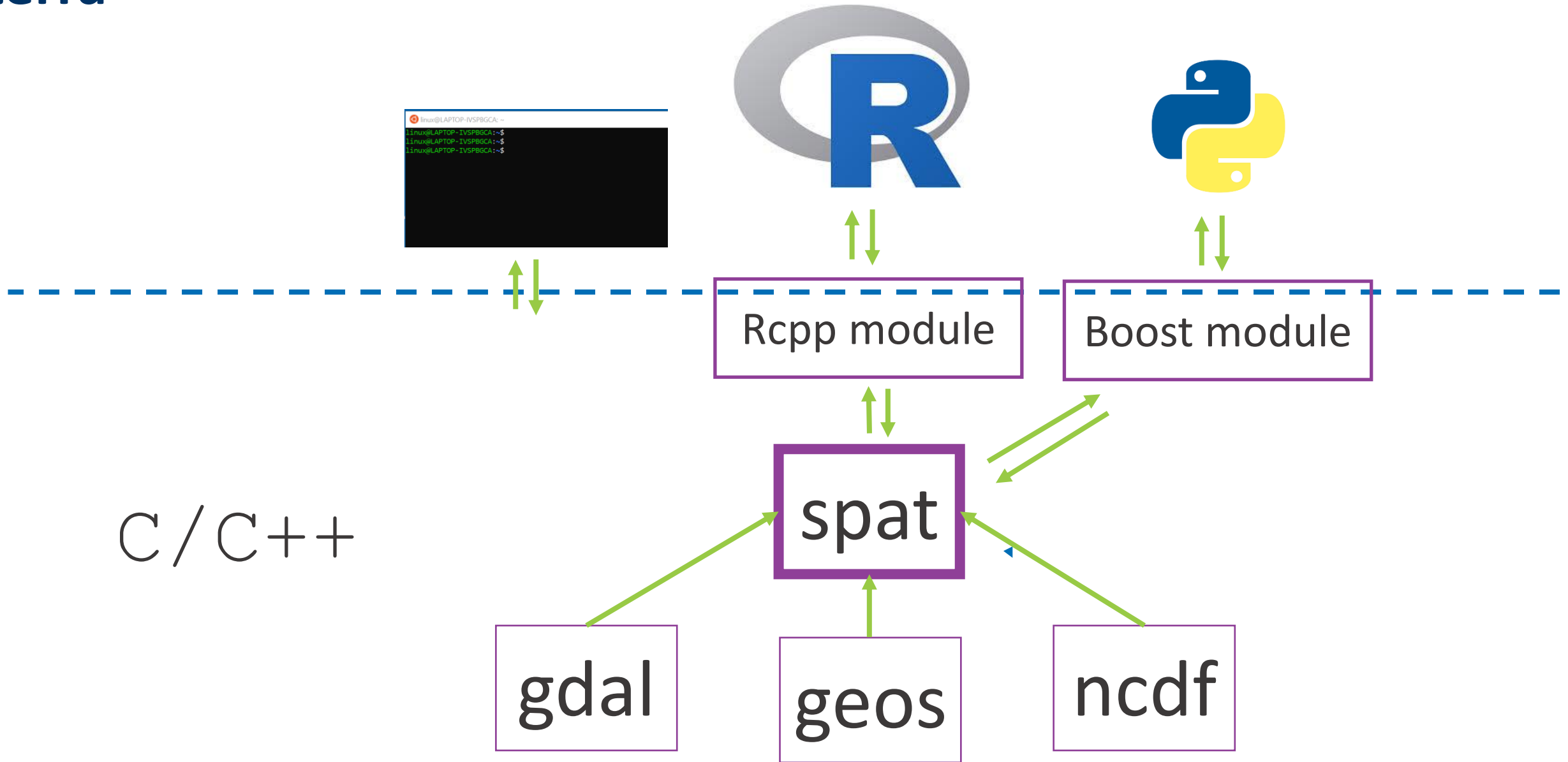
raster, brick, stack
rasterFromXYZ
stack, addLayer (combining Raster* objects or files)
addLayer
extent
calc
overlay
stackApply
extend
nlayers
NAvalue
stackSelect
reclassify, subs, cut
cellStats
projectRaster
dropLayer
isLonLat, isGlobalLonLat, couldBeLonLat
shapefile

terra package

[rast](#)
[rast](#)(, type="xyz")
[c](#)
[add<-](#)
[ext](#)
[app](#) and [arith](#)
[lapp](#)
[tapp](#)
[expand](#)
[nlyr](#)
[NAflag](#)
[selectRange](#)
[classify](#)
[global](#)
[project](#)
[subset](#)
[is.lonlat](#)
[vect](#)

Can't find what you need?

Report <https://github.com/rspatial/terra/wiki>



Remote Sensing Image Analysis Workflow

Search and Download Image

e.g. <https://earthexplorer.usgs.gov/>



Visualization and Pre-processing

Mask cloud, atmospheric correction, align



Spatial prediction

Classification & Regression



Image Enhancement

Compute Indices, transformation

Infrastructure for today

CG-Labs: <https://workshop.cgiar.scio.systems/>

Login via Globus, use CG-credential if you have one,
otherwise use Gmail, ORCID, Institutional account,...

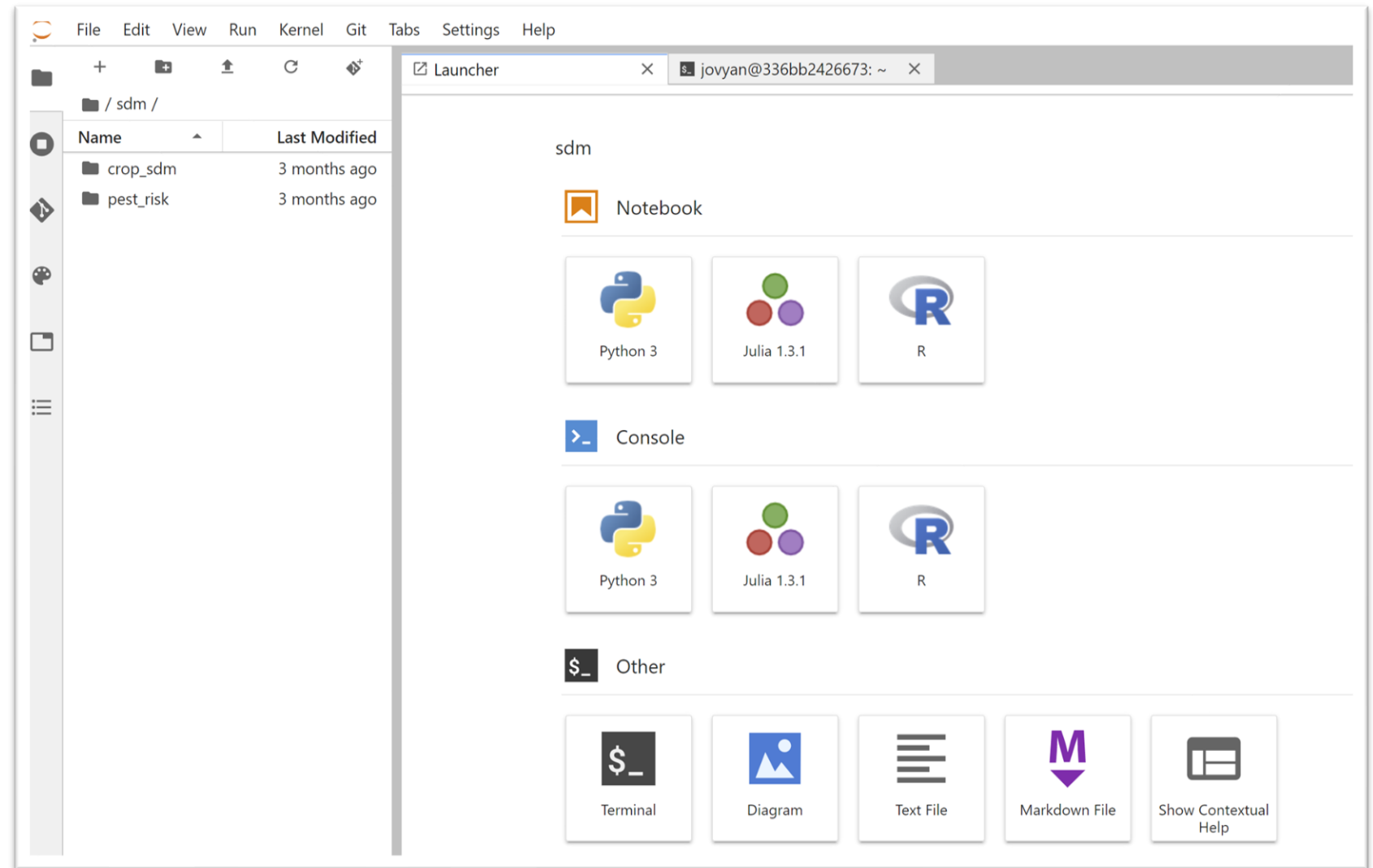
What is CGLabs?

For users

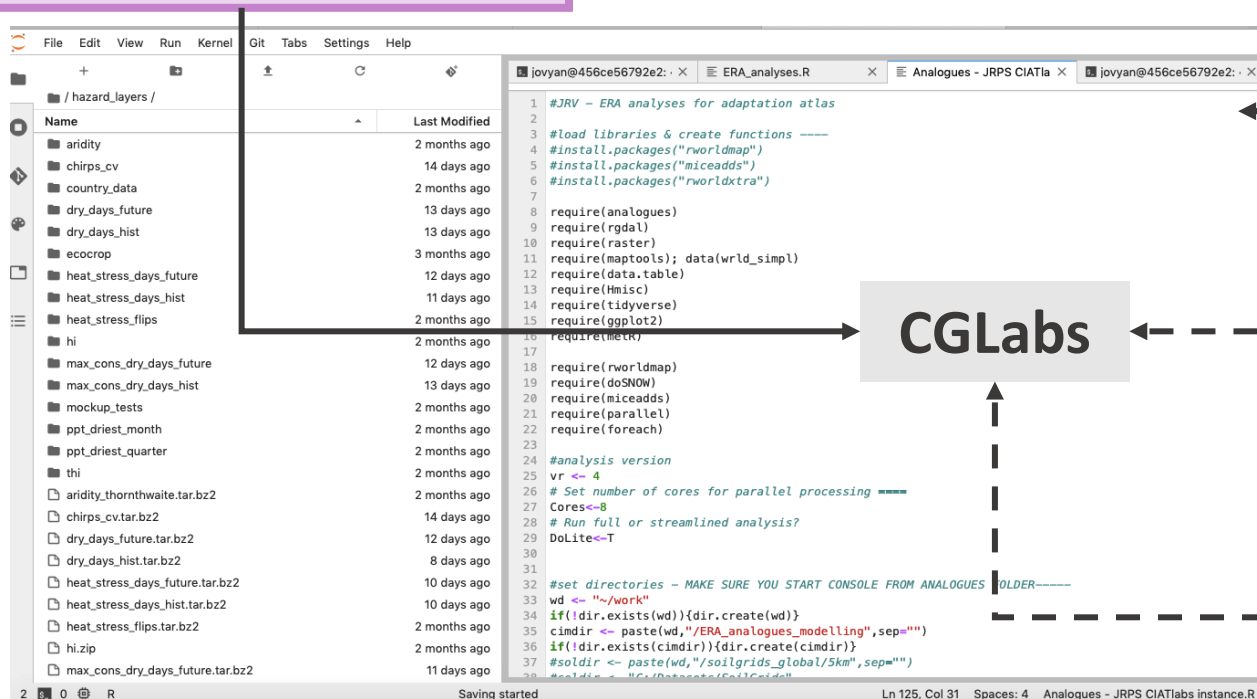
- A portable workstation
- Access to terminals or notebooks with git integrations

For system admins

Complete Jupyterhub experience without the complicated setup



Code sharing GitHub



CG Labs

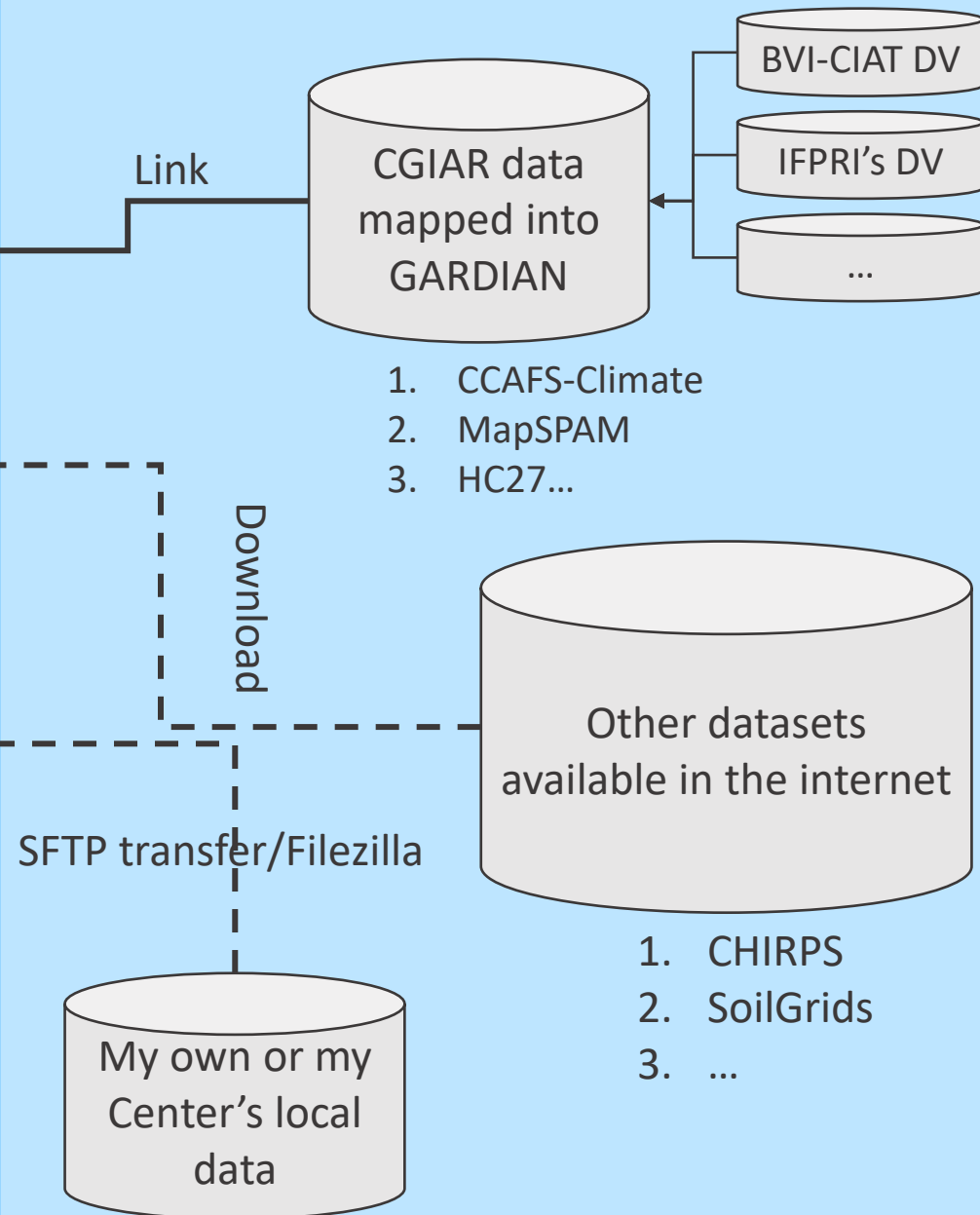
Computing resource

Cloud resource
(AWS, GCP, Azure)

Local Cluster
at my center

Slide credit Julian Ramirez

Data



Is it customizable?

- Yes! Check out <https://github.com/SCiO-systems/cgspatial-notebook>
- Need to add more R or Python packages?

folder	binder	Update Dockerfile	7 months ago
folder	extra	add maxent.jar	7 months ago
folder	hooks	cgspatial-notebook	8 months ago
folder	tests	Update conftest.py	3 months ago
file	.travis.yml	Update .travis.yml	3 months ago
file	Dockerfile	Update Dockerfile	2 months ago
file	LICENSE	cgspatial-notebook	8 months ago
file	Makefile	Update Makefile	3 months ago
file	README.md	Update README.md	2 months ago
file	guides.ipynb	cgspatial-notebook	8 months ago
file	libraries.R	Update libraries.R	2 months ago
file	requirements-test.txt	cgspatial-notebook	8 months ago

Add your r-install command here
`install.packages("terra")`

Let's find some data

- *terra + luna +cog*



Codes available in https://github.com/ani-ghosh/workshop/blob/main/cgiar_csi_jan_2021_remote_sensing_with_R/workshop_terra.ipynb

Package ecosystem around terra

Crop modeling

Rwofost, Rquefts, Recocrop, ...

Data

geodata, luna

Analysis

luna, predicts

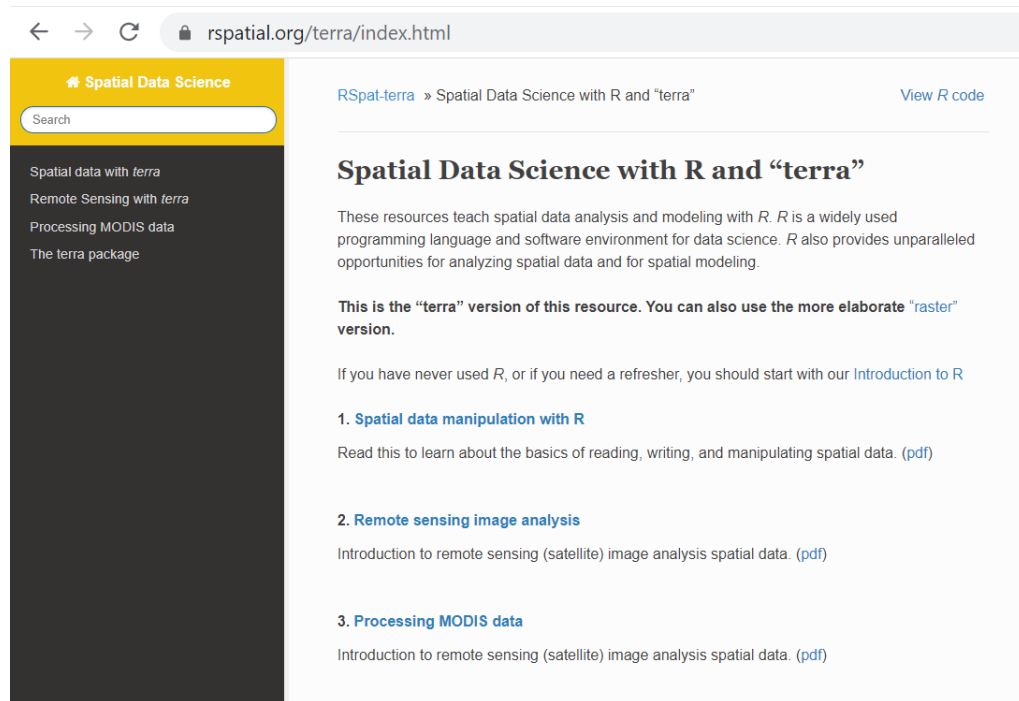
Slide credit Robert Hijmans

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Resources

rspatial.org/terra



A screenshot of the website rspatial.org/terra/index.html. The browser address bar shows the URL. The page has a yellow header with the text "Spatial Data Science" and a search bar. A dark sidebar on the left lists topics: "Spatial data with terra", "Remote Sensing with terra", "Processing MODIS data", and "The terra package". The main content area has a breadcrumb "RSPat-terra » Spatial Data Science with R and 'terra'" and a link "View R code". The title is "Spatial Data Science with R and 'terra'". The text describes resources for learning spatial data analysis with R and terra. It includes a note that this is the "terra" version of the resource, with a link to the "raster" version. It also provides a starting point for users new to R or terra, linking to an "Introduction to R" page. Three numbered sections are listed: 1. Spatial data manipulation with R, 2. Remote sensing image analysis, and 3. Processing MODIS data, each with a link to a PDF introduction.

← → ↻ rspatial.org/terra/index.html

Spatial Data Science

Search

Spatial data with *terra*
Remote Sensing with *terra*
Processing MODIS data
The terra package

RSPat-terra » Spatial Data Science with R and "terra" [View R code](#)

Spatial Data Science with R and "terra"

These resources teach spatial data analysis and modeling with *R*. *R* is a widely used programming language and software environment for data science. *R* also provides unparalleled opportunities for analyzing spatial data and for spatial modeling.

This is the "terra" version of this resource. You can also use the more elaborate "raster" version.

If you have never used *R*, or if you need a refresher, you should start with our [Introduction to R](#)

1. [Spatial data manipulation with R](#)

Read this to learn about the basics of reading, writing, and manipulating spatial data. [\(pdf\)](#)

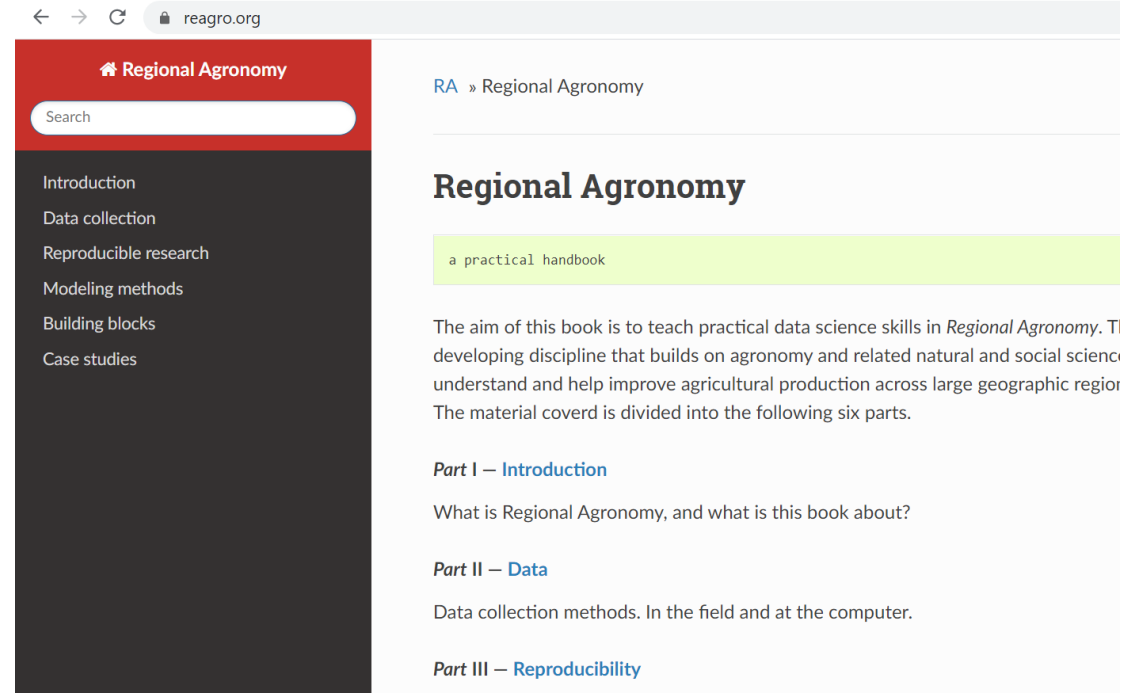
2. [Remote sensing image analysis](#)

Introduction to remote sensing (satellite) image analysis spatial data. [\(pdf\)](#)

3. [Processing MODIS data](#)

Introduction to remote sensing (satellite) image analysis spatial data. [\(pdf\)](#)

Agronomy "at scale"



A screenshot of the website reagro.org. The browser address bar shows the URL. The page has a red header with the text "Regional Agronomy" and a search bar. A dark sidebar on the left lists topics: "Introduction", "Data collection", "Reproducible research", "Modeling methods", "Building blocks", and "Case studies". The main content area has a breadcrumb "RA » Regional Agronomy". The title is "Regional Agronomy". Below the title is a green box with the text "a practical handbook". The text describes the aim of the book, which is to teach practical data science skills in Regional Agronomy. It mentions that the material is divided into six parts. Three parts are listed: Part I – Introduction, Part II – Data, and Part III – Reproducibility, each with a brief description of its content.

← → ↻ reagro.org

Regional Agronomy

Search

RA » Regional Agronomy

Regional Agronomy

a practical handbook

The aim of this book is to teach practical data science skills in *Regional Agronomy*. This developing discipline that builds on agronomy and related natural and social sciences to understand and help improve agricultural production across large geographic regions. The material covered is divided into the following six parts.

Part I – Introduction

What is Regional Agronomy, and what is this book about?

Part II – Data

Data collection methods. In the field and at the computer.

Part III – Reproducibility

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Thank you!

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