Marine Ecological Modelling
Global Climate Change

Marine Data Science

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2020, Centre of Marine Sciences, University of Algarve

Marine data science

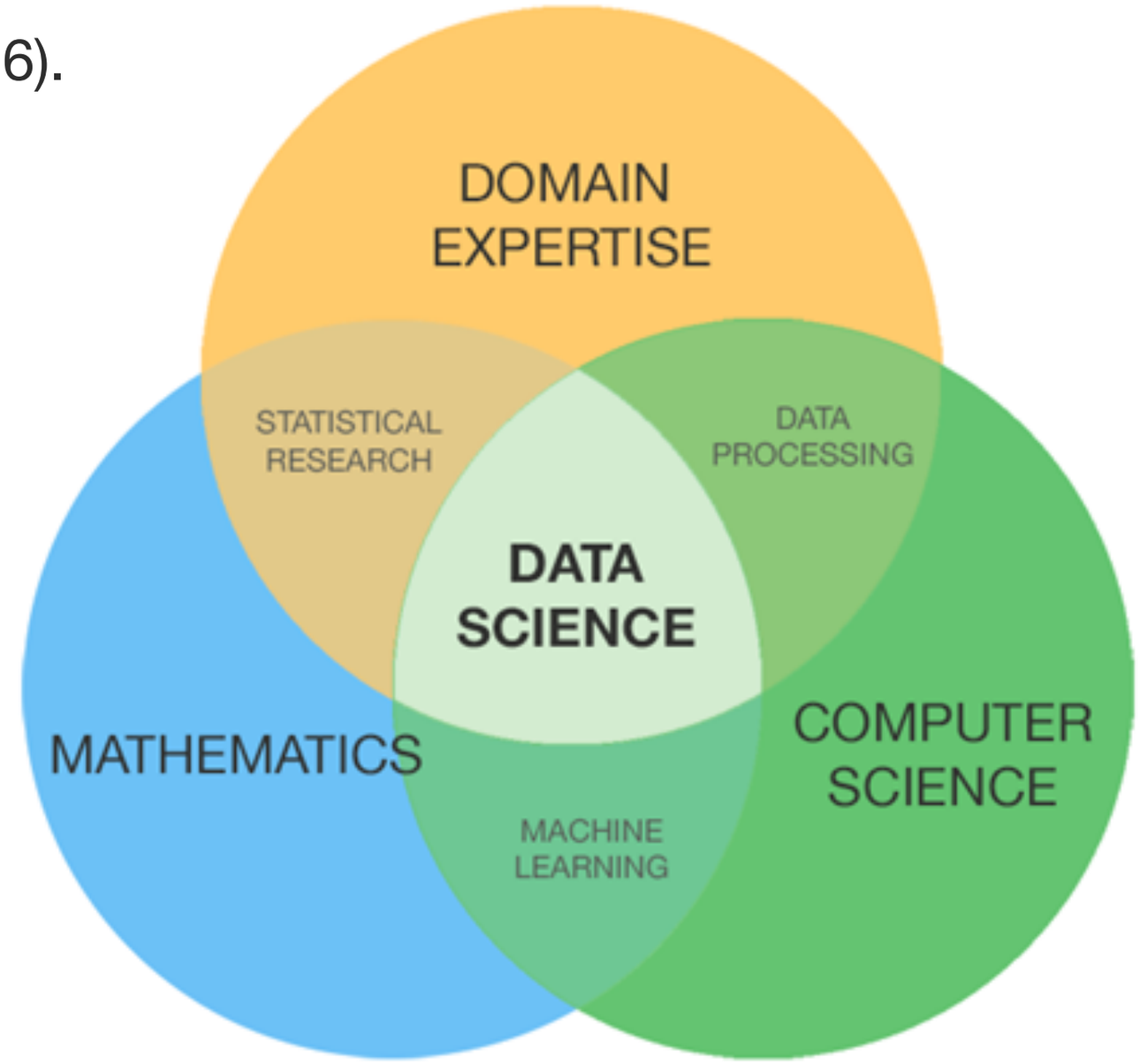
"an exciting new discipline that **turns raw data** into **understanding**, **insight**, and **knowledge**”.

(Grolemund & Wickham 2016).

Biology of species

Statistical modelling

Handling (big) data
Data processing
Data visualization
Descriptive analyses
Machine learning
Simulation scenarios



Open science tools

"allows **transparency at all stages of the research process**, coupled with **free and open access to data**, **code**, and papers".

(Hampton et al. 2014)

Coding language [**R language**]

Coding environment, editor, visualization and support [**R Studio**]

Organization, collaboration and version control [git; **GitHub**]

this talk: https://github.com/jorgeassis/

written in RStudio's RMarkdown

versioned with Git

shared with GitHub

Reproducibility and optimization

“According to interviews and expert estimates, **researchers spend up to 50 percent** of their time mired in the mundane labor of **organizing and preparing data**”. NYTimes (2014)

Transforming, rescaling, gap-filling, formatting, renaming, etc.

Underpins the scientific process.

Before

Manually (without coding);
Large Excel processes;
Internal documents and emails.

Now (reproducible)

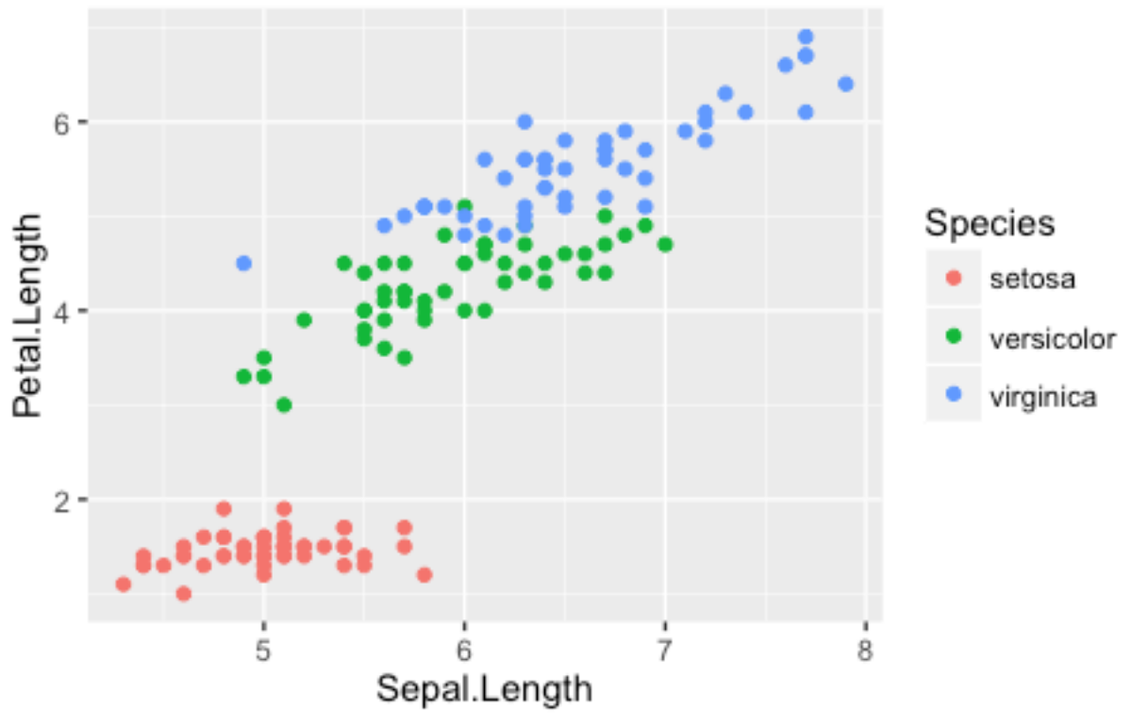
Full coded process;
Digital notebooks (e.g., RMarkdown) to document code and results.

RStudio Source Editor

notebook-demo.Rmd

Preview | Insert | Run

```
8  Try executing this chunk by clicking the *Run* button within the
   chunk or by placing your cursor inside it and pressing
   *Cmd+Shift+Enter*.
9
10 ```{r}
11 library(ggplot2)
12 ggplot(iris, aes(Sepal.Length, Petal.Length)) +
13   geom_point(aes(colour = Species))
14 ```
```



Collaboration and communication

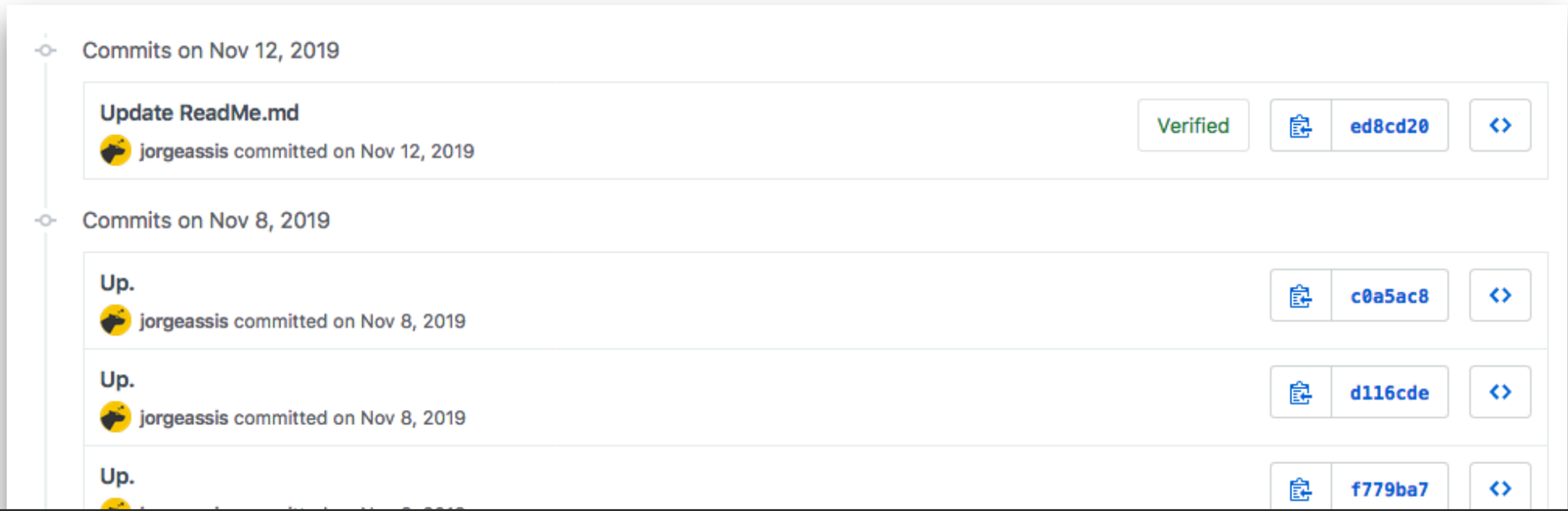
“For scientists, [Git] works like an interactive notebook for scientific computing… it keeps a lasting record of events”. Nature 2016

Before

Filenames suffixed with dates, initials (e.g., final_JL-2016-08-05.csv);
Email chains (often forwarded).

Now (reproducible)

Version control with git;
Short messages accompany committed changes.



Sharing data

Before

Published manuscripts;

Data on personal FTP server (online?) and in supplementary information.

Now (reproducible)

Published manuscripts

Data open on GitHub, Figshare, etc.

jorgeassis / marineforestsDB

Unwatch 1 | Star 0 | Fork 0

Code | Issues 0 | Pull requests 0 | Actions | Projects 0 | Wiki | Security | Insights | Settings

A fine-tuned global distribution dataset of marine forests

Edit

r | dataset | marine | records | Manage topics

233 commits | 1 branch | 0 packages | 0 releases | 1 contributor

Branch: master | New pull request | Create new file | Upload files | Find file | Clone or download

jorgeassis Update ReadMe.md — Latest commit ed8cd20 on Nov 12, 2019

Data	Up.	3 months ago
Functions	Up.	3 months ago
.DS_Store	Up.	11 months ago
.gitignore	Up.	3 months ago
Git.Rproj	Up.	3 months ago
ReadMe.md	Update ReadMe.md	3 months ago
sourceMe.R	Up.	3 months ago

ReadMe.md

A fine-tuned global distribution dataset of marine forests

J. Assis, E. Fragkopoulou, D. Frade, J. Neiva, A. Oliveira, D. Abecasis, S. Faugeron, E.A. Serrão

Abstract

Species distribution records are a prerequisite to follow climate-induced range shifts across space and time. However, synthesizing information from various sources such as peer-reviewed literature, herbaria, digital repositories and citizen science initiatives is not only costly and time consuming, but also challenging, as data may contain thematic and taxonomic errors and generally lack standardized formats. We address this gap for important marine ecosystem-

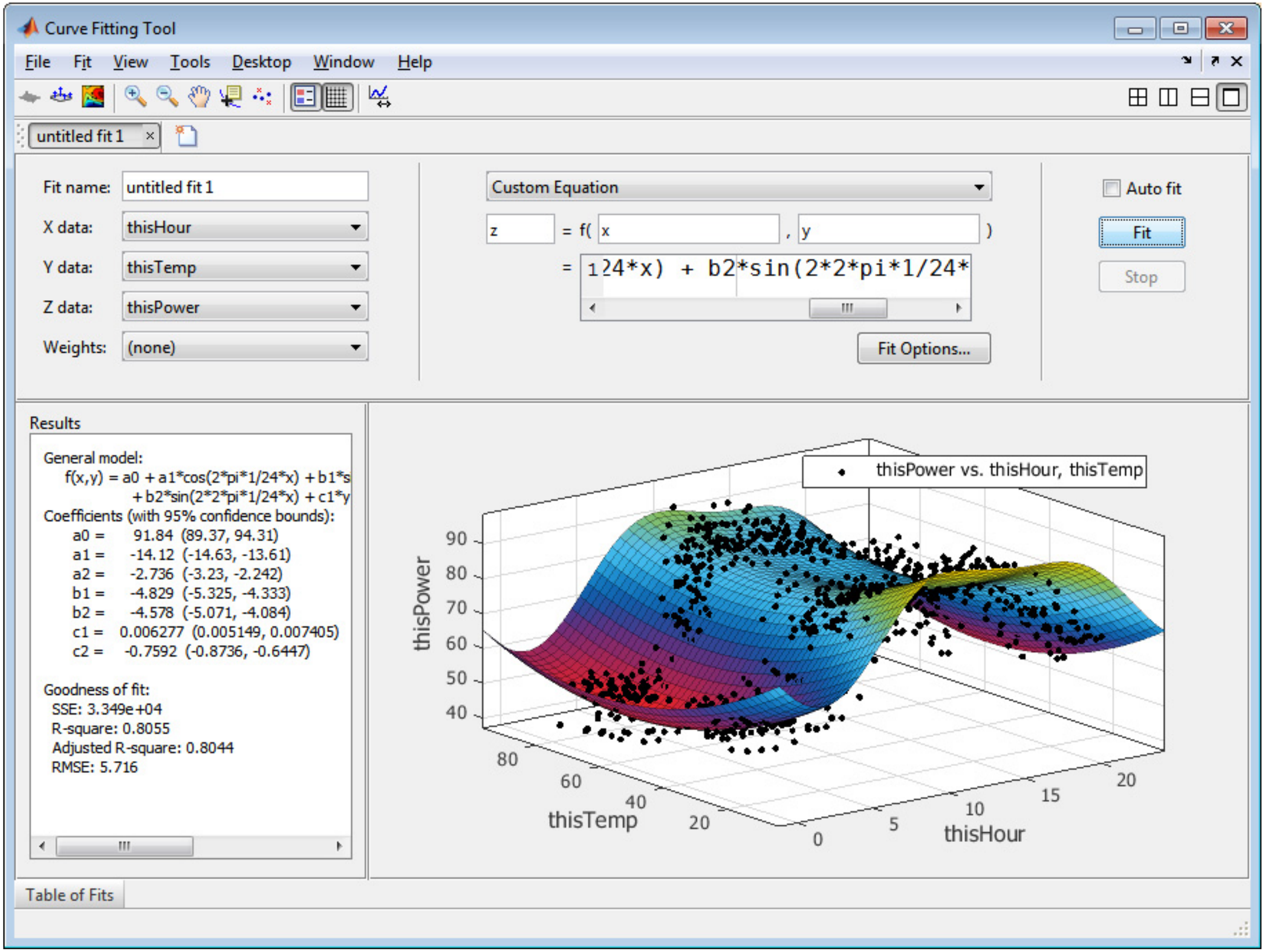
My programming origin

Being curious about how things were made.

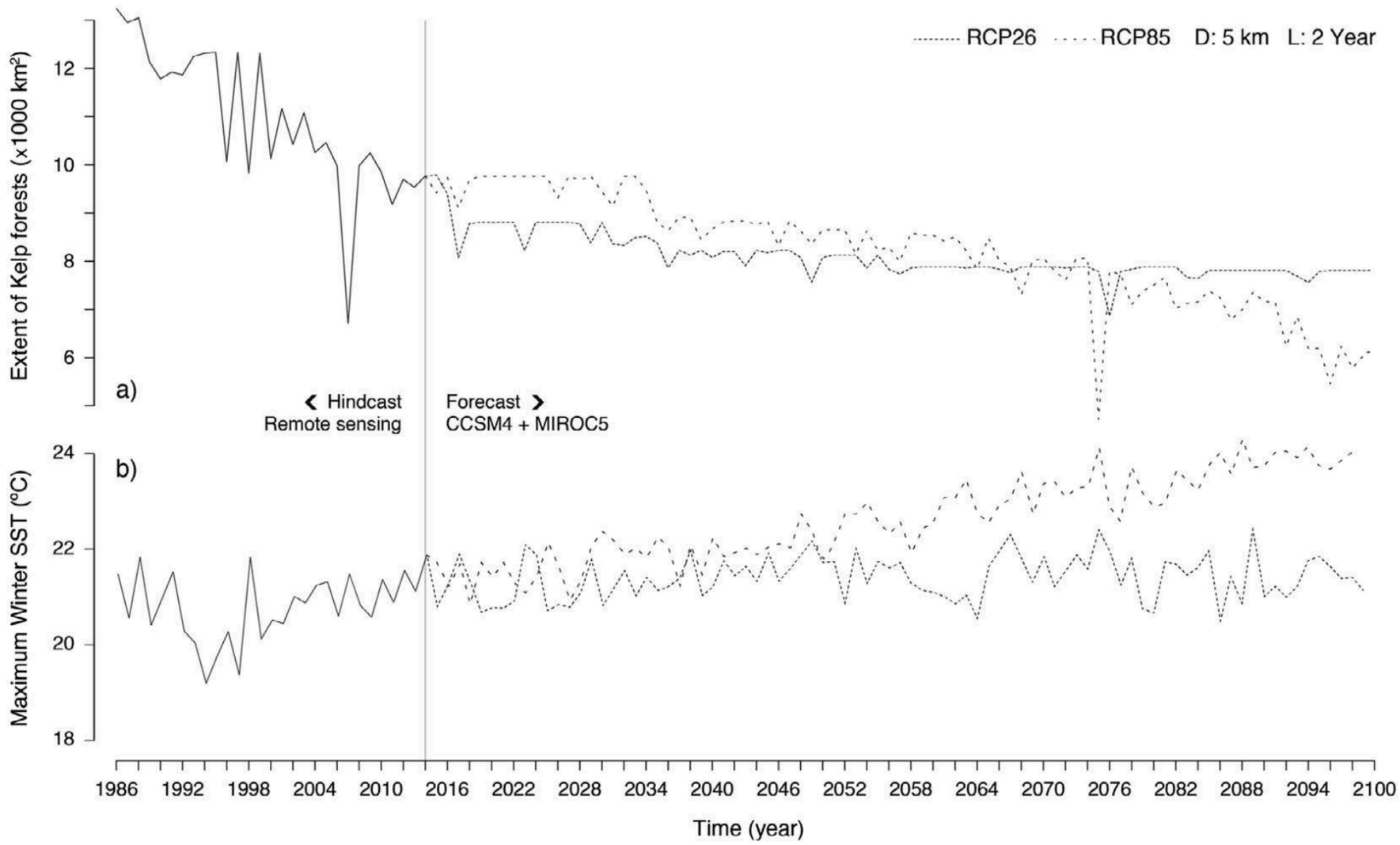
Changing stuff and see what happens.

Trial and error, error, error, error, …

1983


Curve Fitting Tool
File Fit View Tools Desktop Window Help
untitled fit 1
Fit name: untitled fit 1
X data: thisHour
Y data: thisTemp
Z data: thisPower
Weights: (none)
Custom Equation
z = f(x , y)
= 1?24*x) + b2*sin(2*2*pi*1/24*
Fit Options...
Auto fit
Fit
Stop
Results
General model:
f(x,y) = a0 + a1*cos(2*pi*1/24*x) + b1*s
+ b2*sin(2*2*pi*1/24*x) + c1*y
Coefficients (with 95% confidence bounds):
a0 = 91.84 (89.37, 94.31)
a1 = -14.12 (-14.63, -13.61)
a2 = -2.736 (-3.23, -2.242)
b1 = -4.829 (-5.325, -4.333)
b2 = -4.578 (-5.071, -4.084)
c1 = 0.006277 (0.005149, 0.007405)
c2 = -0.7592 (-0.8736, -0.6447)
Goodness of fit:
SSE: 3.349e+04
R-square: 0.8055
Adjusted R-square: 0.8044
RMSE: 5.716
thisPower vs. thisHour, thisTemp
thisPower
90
80
70
60
50
40
thisTemp
80
60
40
20
thisHour
0
5
10
15
20
Table of Fits

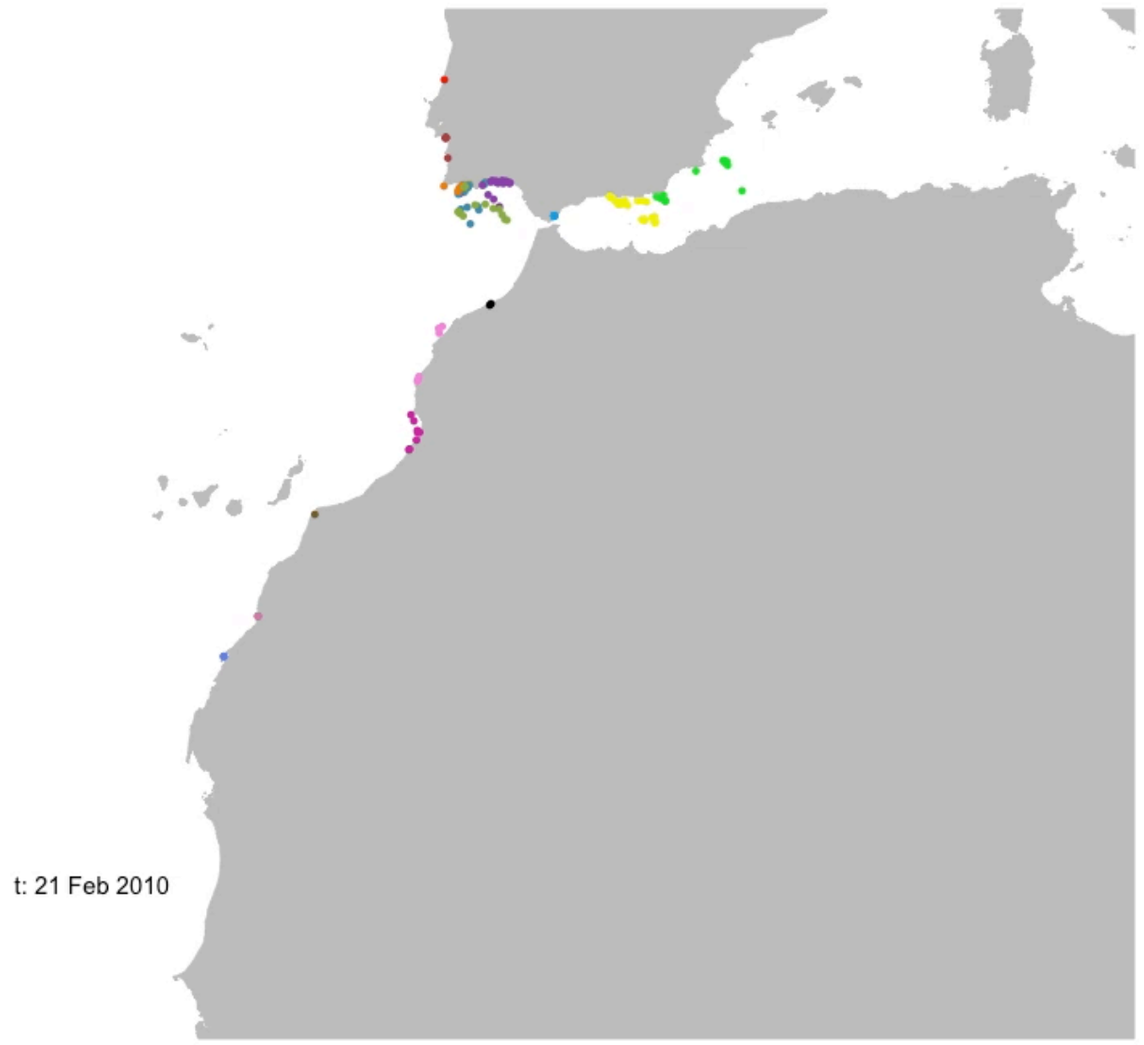
2011



Modelling the potential distribution of species.

[different climate scenarios producing shifts in distributions]

> 2013

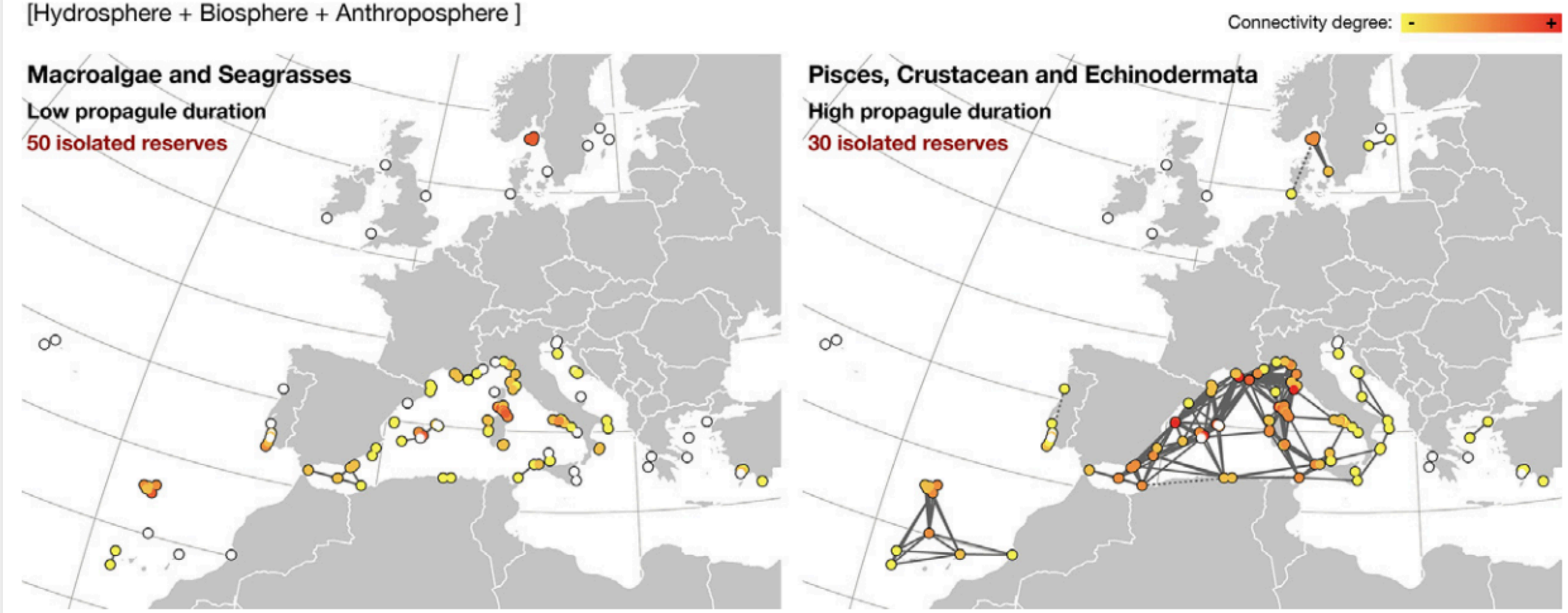


Generating virtual oceans to address marine connectivity.

[ocean currents mediating population connectivity]

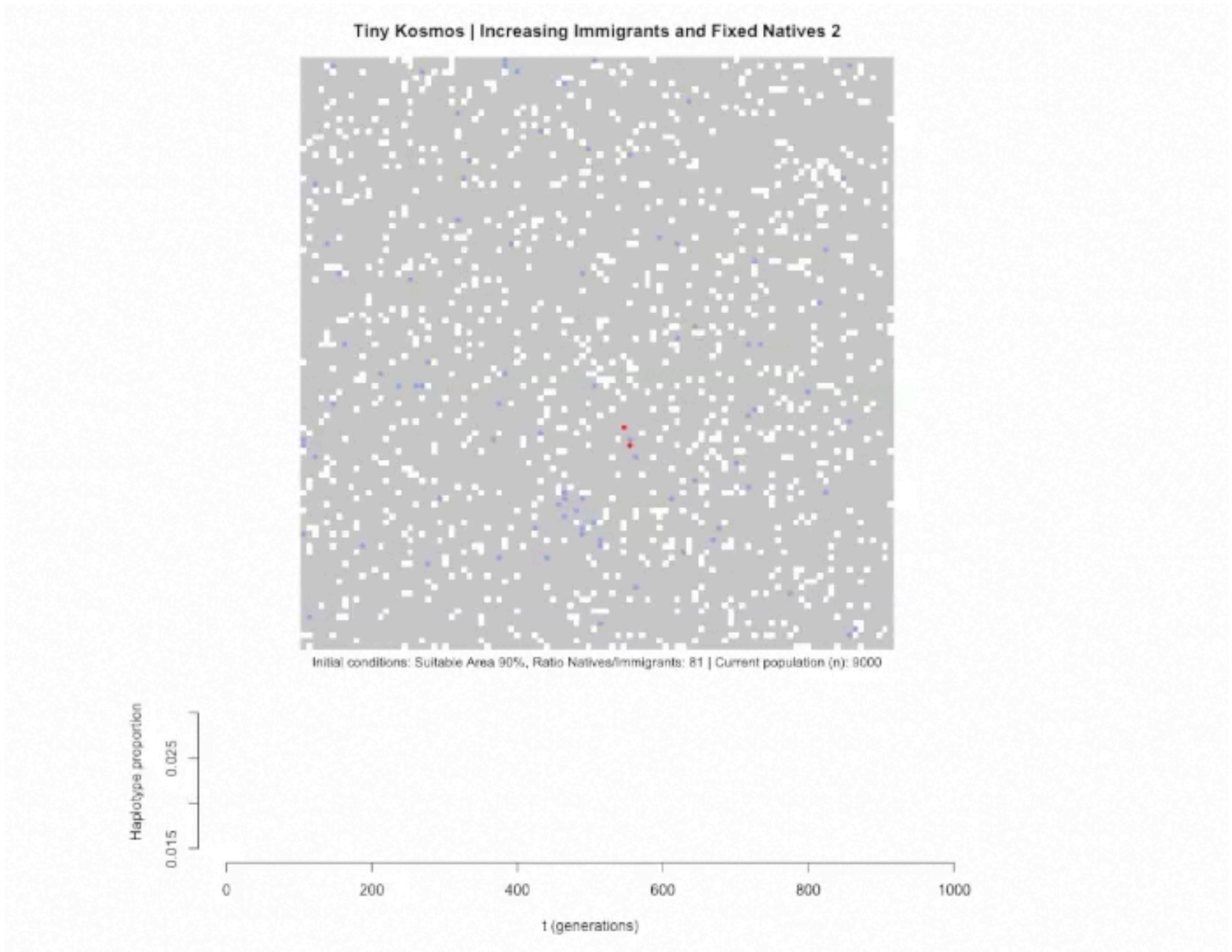
Weak biodiversity connectivity in the European network of no-take marine protected areas

[Hydrosphere + Biosphere + Anthroposphere]



Generating virtual oceans to address marine connectivity.

[ocean currents mediating population connectivity]



Generating tiny cosmos for immigrant populations.

[test assumptions like the winner takes it all]

Errors are friendly

Computer errors are just like someone saying 'I didn’t understand what you mean’. Google it (copy-and-paste!) or use Stack Overflow.

“Plotting a map using ggplot”

1

You can apply the same code logic you used to generate the single `inset_map`, before passing the results to `grid.arrange()`:

```
plot.list <- list(p1, p2, p3, p4)

plot.list %>%

  # add inset map to each plot in the list
  lapply(function(p) ggdraw() +
           draw_plot(p, 0, 0, 1, 1) +
           draw_plot(p.shp, 0.5, 0.52, 0.5, 0.4)) %>%

  # convert each plot in the list to grob
  lapply(ggplotGrob) %>%

  # arrange in grid, as before
  grid.arrange(grobs = ., ncol = 2)
```

Important research questions

How past climate changes mediated genetic diversity levels?

How future climate will structure the distribution of marine biodiversity?

What is the potential effect of wave disturbance in the global distribution of seagrasses?

lead to,

Important technical questions

How can I work with data too big for Excel?

How can I subset big data files (e.g., time periods or other attributes)?

How can I visualize my data?

How can I model the effect of ecological drivers on my response variable?

Innovative research questions have no pre-made packages or software environments

Recommendations

Get to your own scientific questions sooner;

Learn to code [in R with RStudio];

Code in every new project;

Use version control [git with GitHub].

Learn to program in an intentional way

~~in a panic~~ feeling empowered

~~for a single purpose~~ thinking ahead

~~in isolation~~ with a community

Why learn it with R and RStudio

R is free! (“Free as in free speech”);

Optimized for research (self-documenting, repeatable);

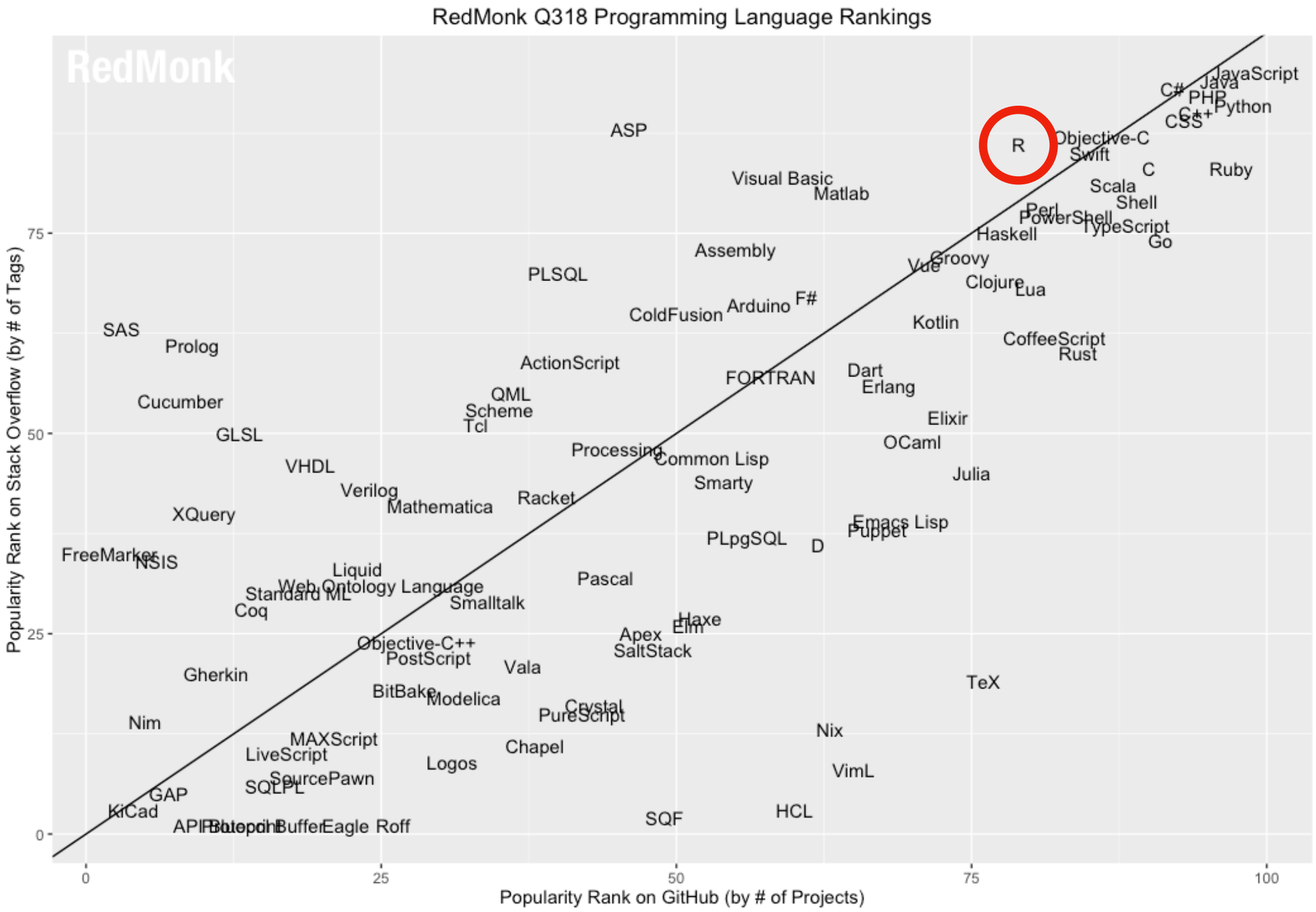
- Easier the next time
- Numerous Excel horror stories of scientific studies (TED Talk)

Scalable from small to large problems;

Many learning resources and communities;

- Stack Overflow
- Multiple R books (Free online)

R is ‘becoming’ one of the new norms (paradigm shift).

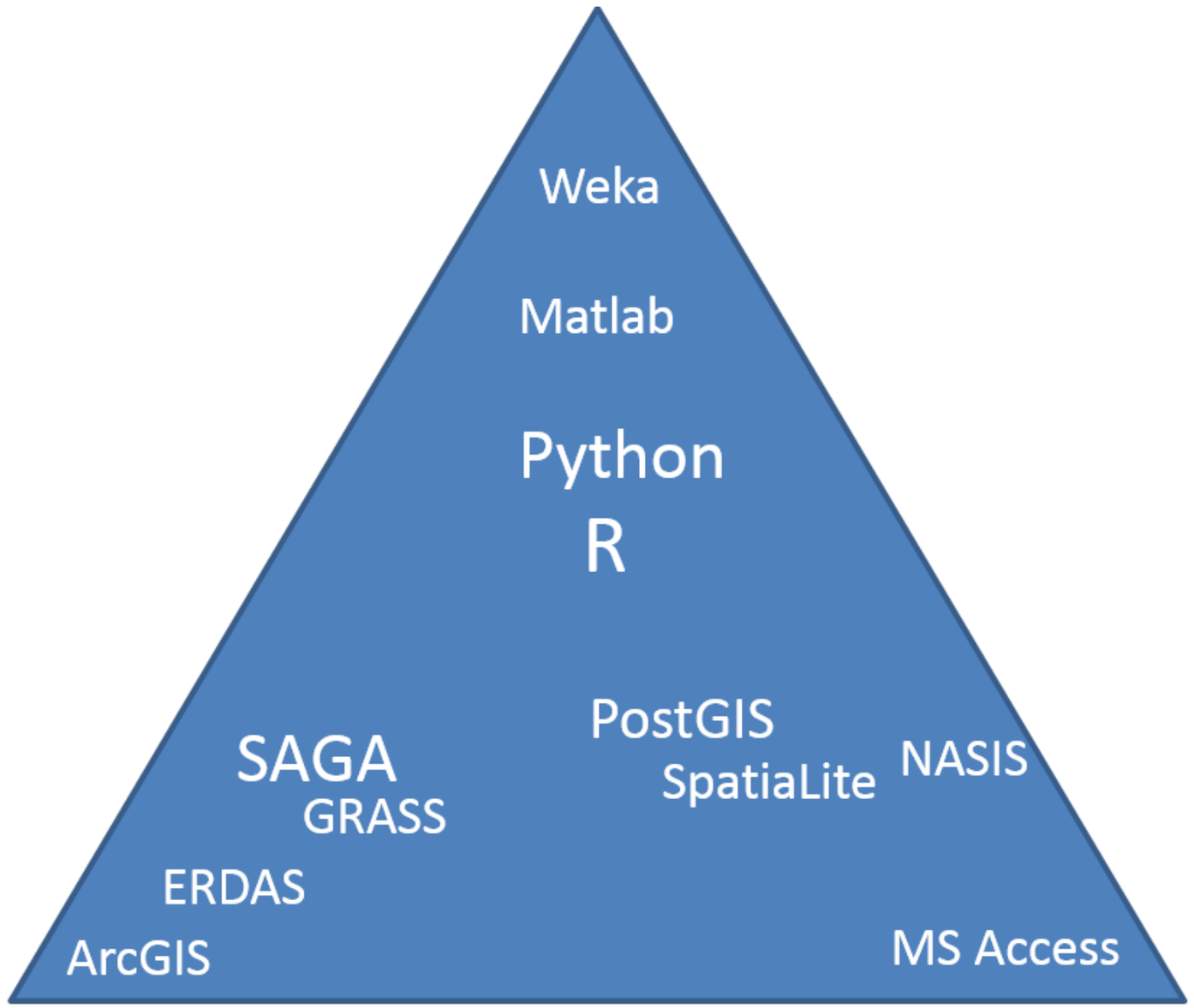

RedMonk Q318 Programming Language Rankings
RedMonk
Popularity Rank on Stack Overflow (by # of Tags)
Popularity Rank on GitHub (by # of Projects)
0
25
50
75
100
JavaScript
Java
C#
PHP
Python
C++
CSS
R
Objective-C
Swift
C
Ruby
Scala
Shell
Perl
PowerShell
TypeScript
Go
Haskell
Groovy
Vue
Clojure
Lua
Kotlin
CoffeeScript
Rust
Dart
Erlang
Elixir
OCaml
Julia
Emacs Lisp
Puppet
PLpgSQL
D
Haxe
Elm
Apex
SaltStack
TeX
Nix
VimL
HCL
SQF
ASP
Visual Basic
Matlab
Assembly
PLSQL
ColdFusion
Arduino
F#
ActionScript
FORTRAN
QML
Scheme
Tcl
Processing
Common Lisp
Smarty
Racket
Mathematica
Verilog
VHDL
XQuery
FreeMarker
NSIS
Liquid
Web Ontology Language
Standard ML
Coq
Smalltalk
Pascal
Objective-C++
PostScript
Vala
Gherkin
BitBake
Modelica
Crystal
PureScript
Nim
MAXScript
LiveScript
Chapel
Logos
SourcePawn
SQLPL
GAP
KiCad
Eagle
Roff
SAS
Prolog
Cucumber
GLSL

Advantages of writing R scripts

Reproducibility and transparency :: Not only the results, but all steps of the analysis are made available.

Flexibility :: Some analyses need only a few code tweaks, from pre-existing scripts (e.g., Github).

Exchange :: In theory other R users can understand your script.


Statistics
Weka
Matlab
Python
R
PostGIS
SpatiaLite
SAGA
GRASS
NASIS
ERDAS
ArcGIS
MS Access
Spatial analyses
Database management