

Digital Soil Mapping

(3D modeling, spatial sampling, uncertainty quantification, feature selection)

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Content

☐ Part 1

- 3D modelling
- Spatial sampling
- Uncertainty quantification
- Feature selection

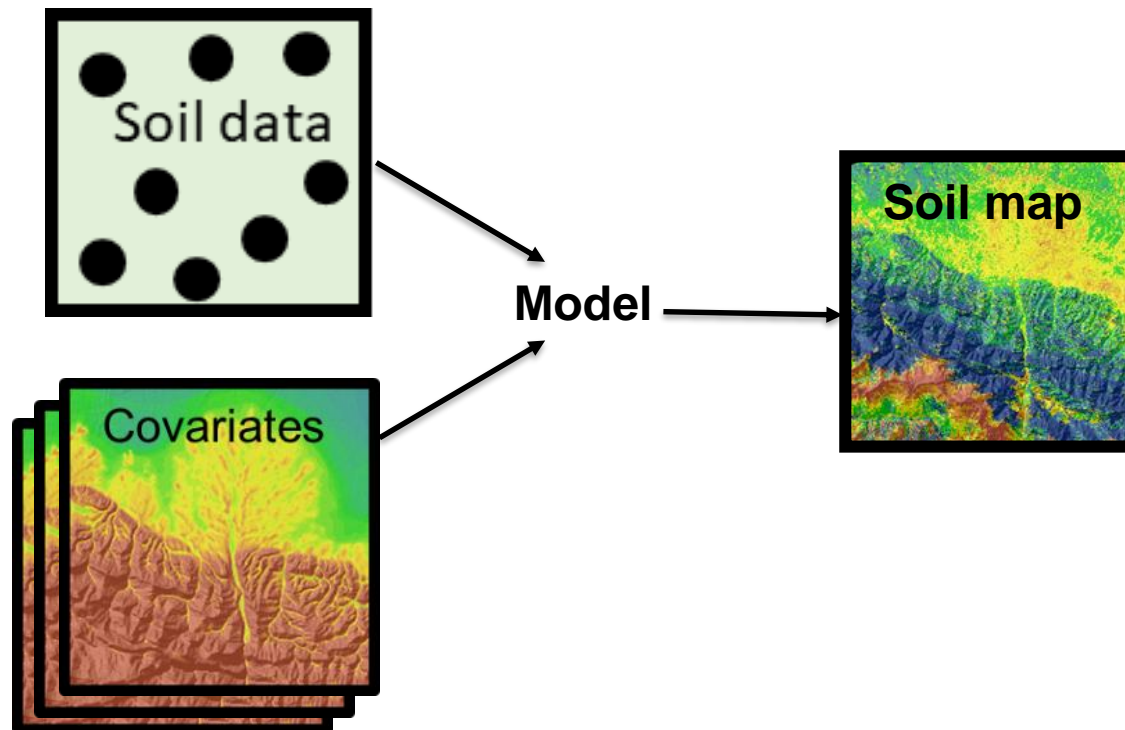
☐ Part 2

- Lets practice!

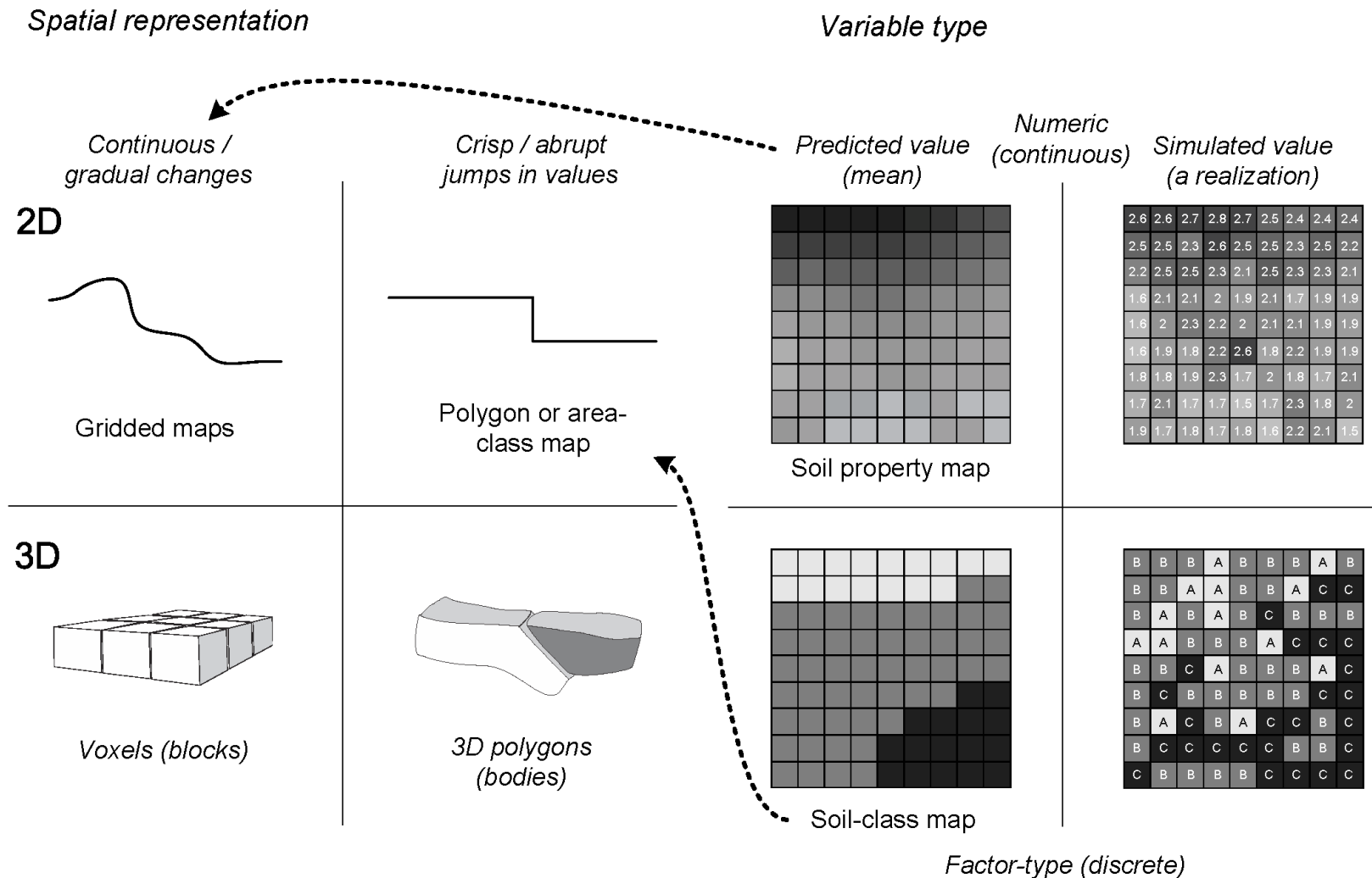
SCORPAN model

$$\boxed{S} = \boxed{f}(\boxed{s, c, o, r, p, a, n}) + \varepsilon$$

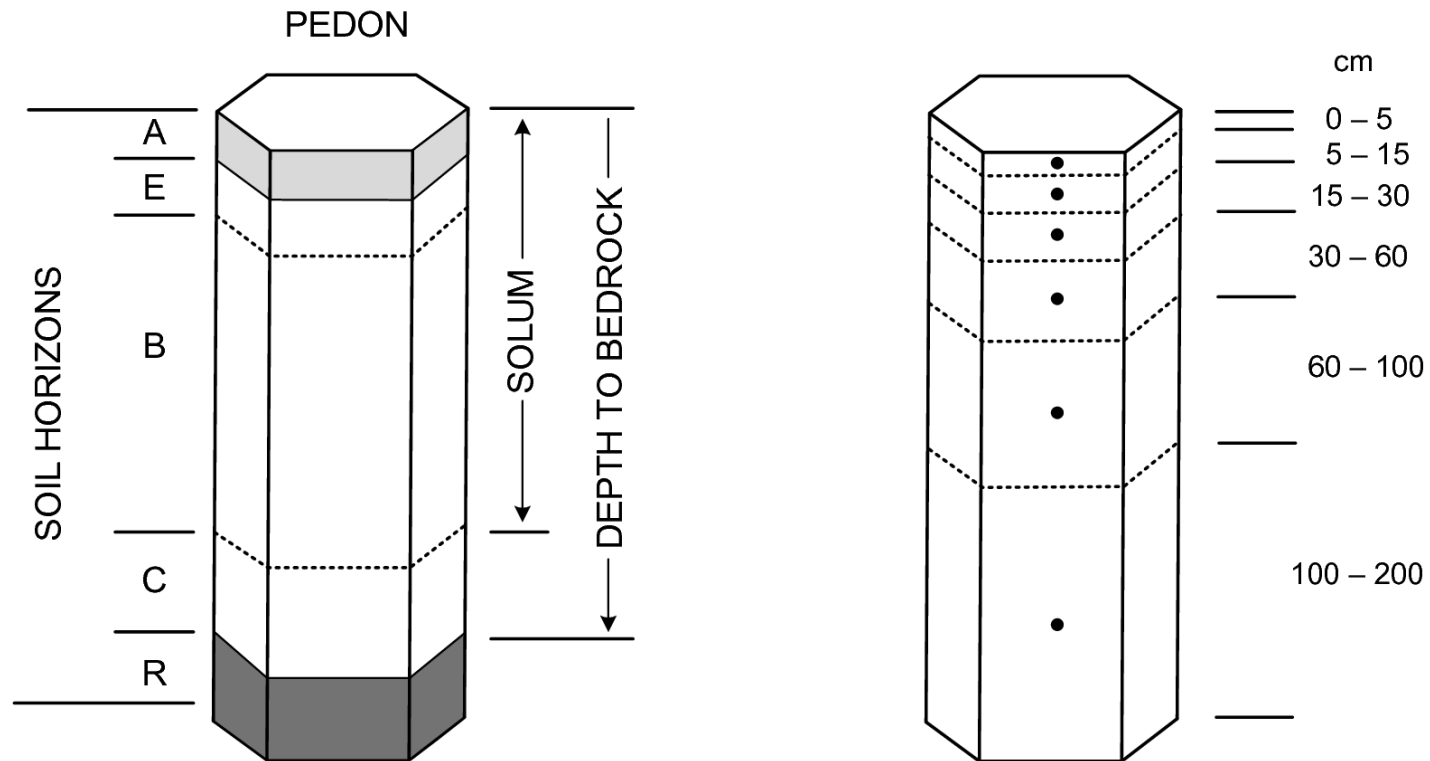
Soil data Model Covariates ε spatially dependent residuals

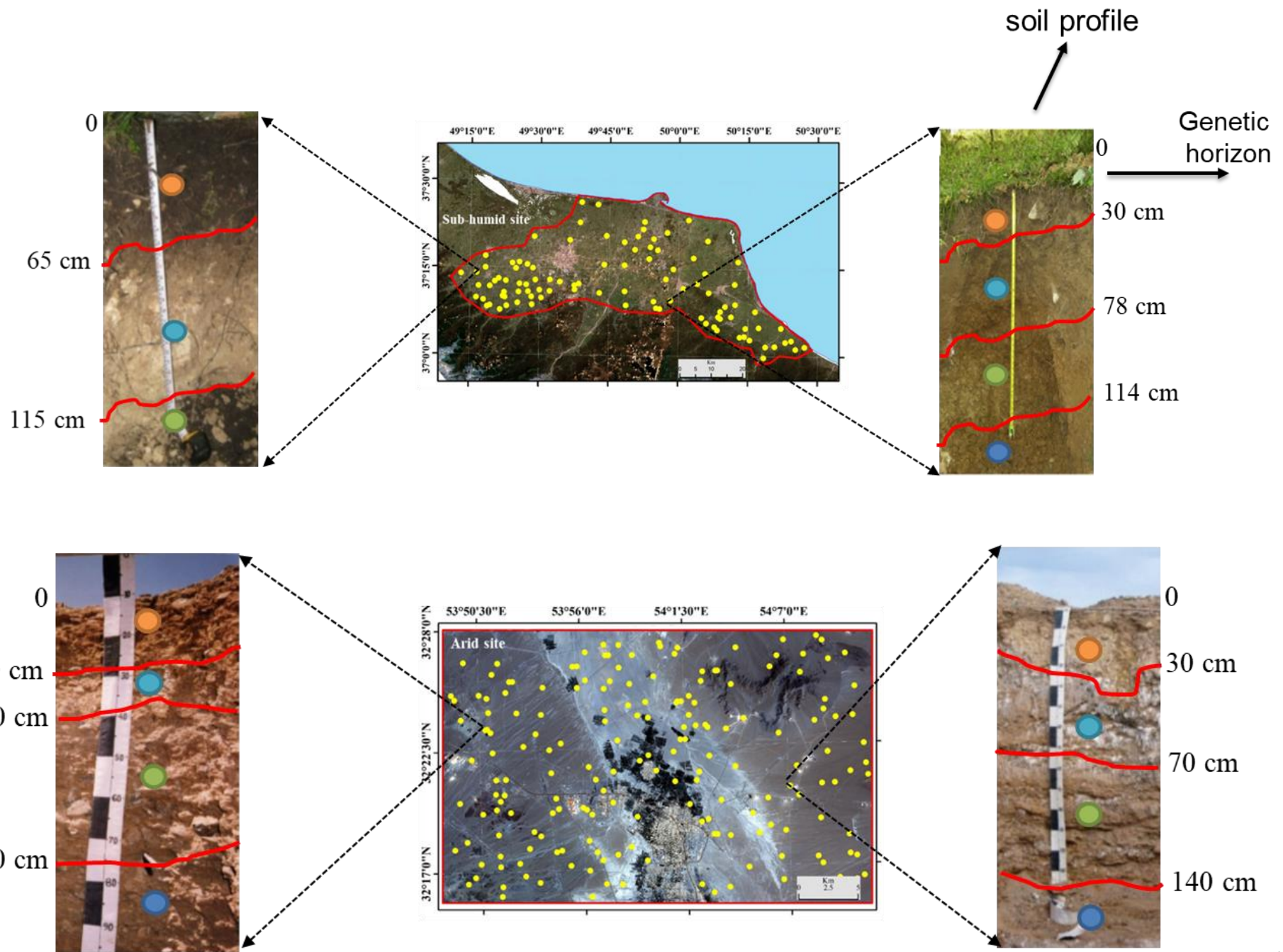


2D vs 3D Soil Mapping

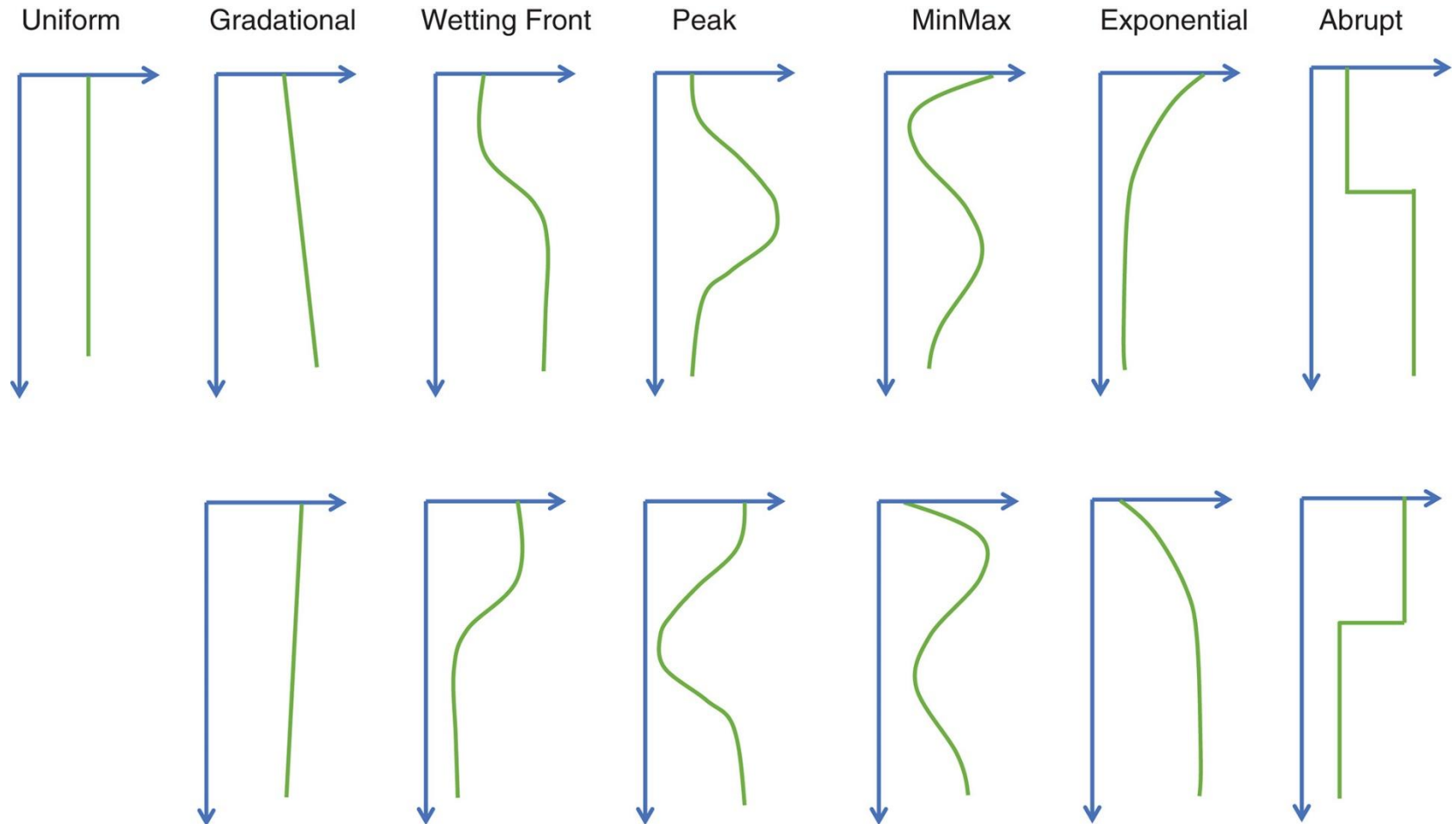


Global Soil Mapping

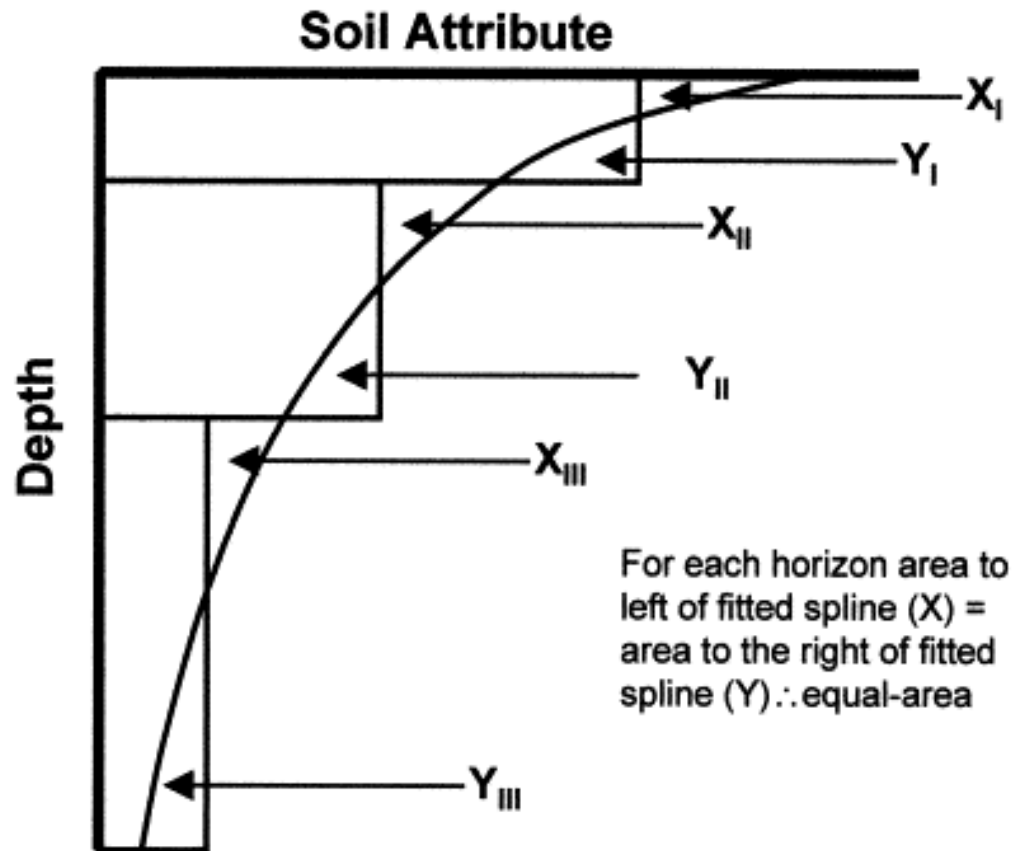


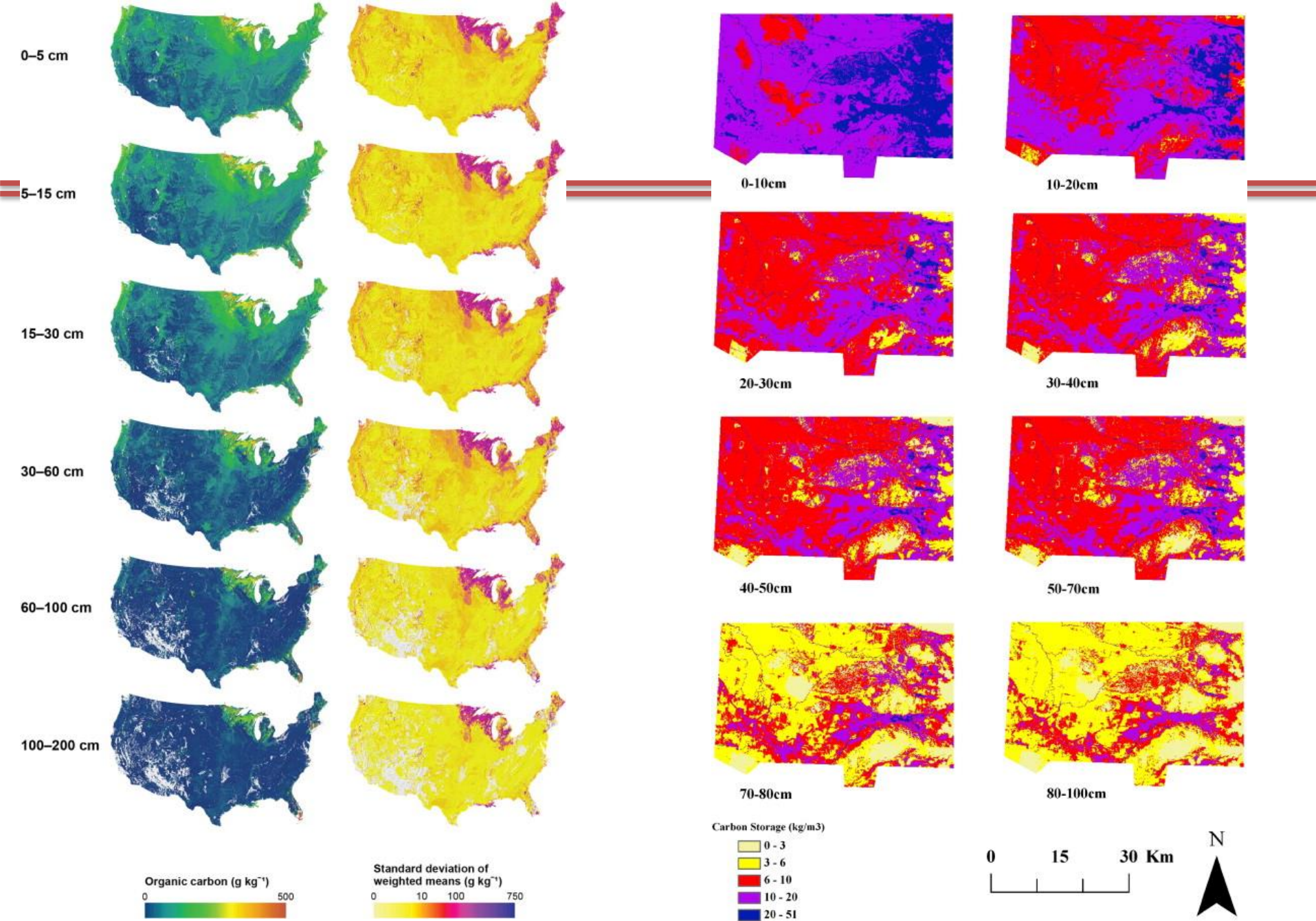


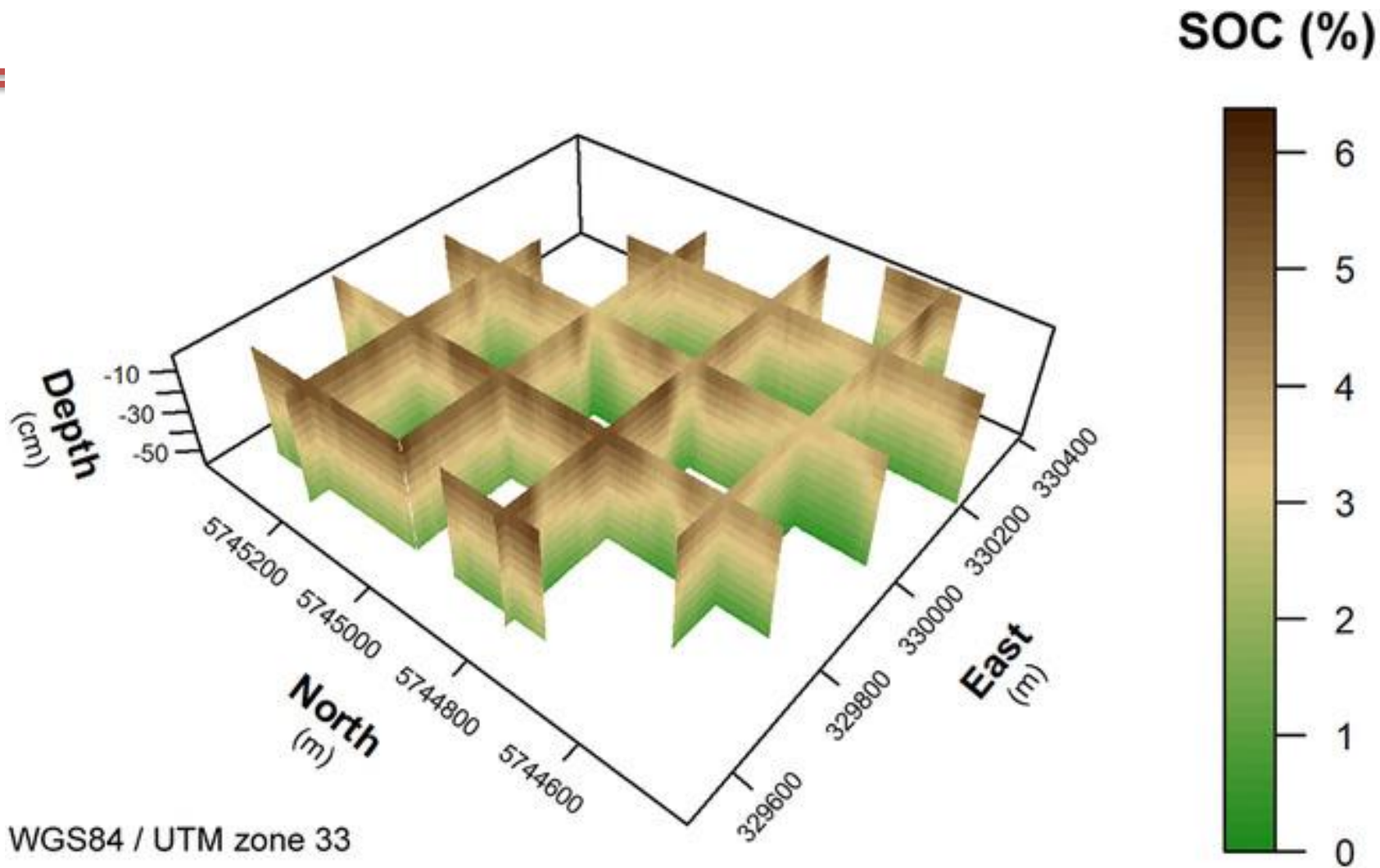
Soil Depth Functions



Equal-area quadratic smoothing splines

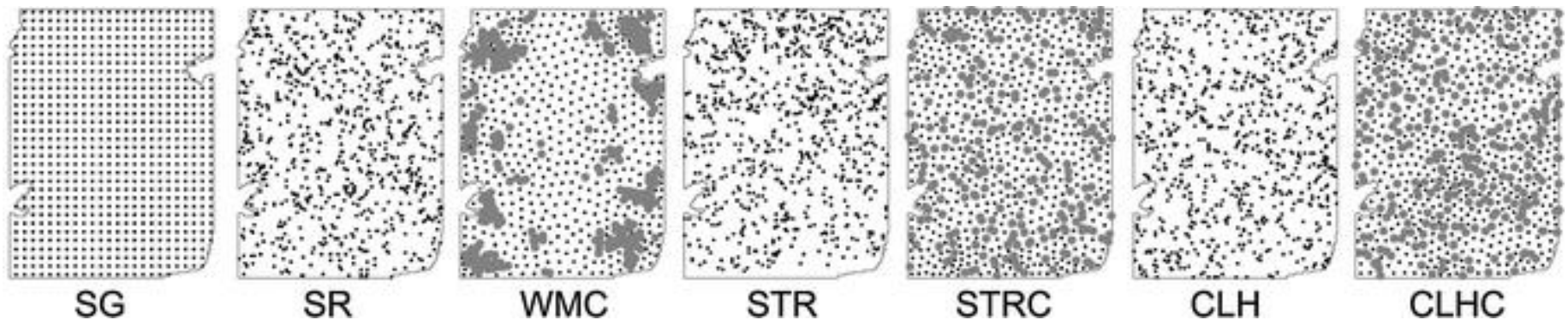






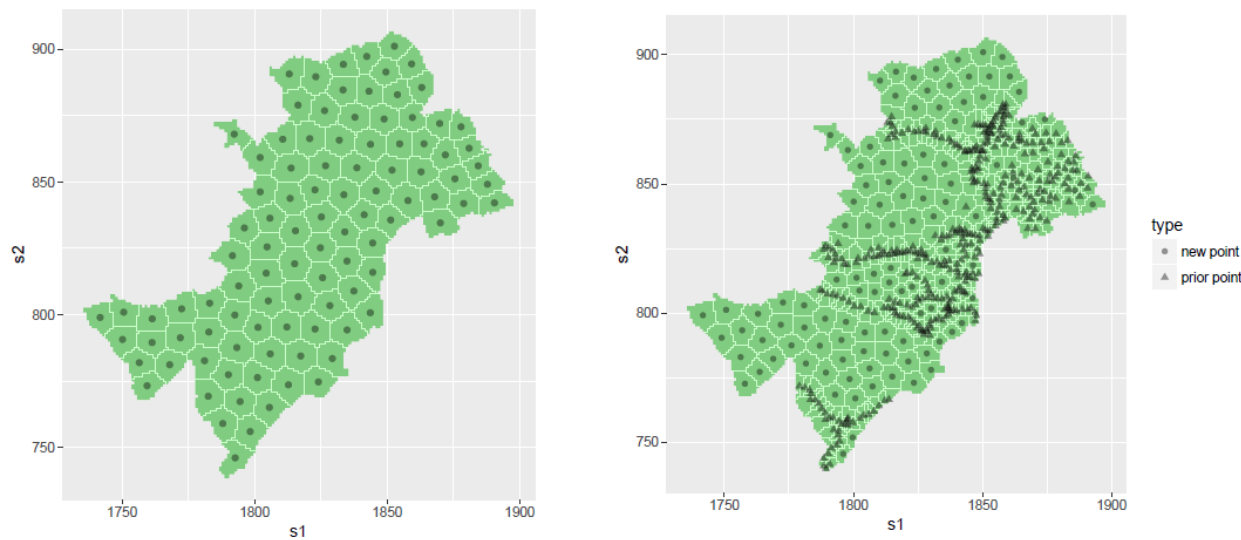
Spatial Sampling

- Sampling is the process of selecting a sample from a population.
- Lack of funds for sampling and analysis is a major problem for any soil mapping project
- Soil sampling plan? Optimal?



SG square grid, SR simple random, WMC uniform distribution of point pairs for variogram estimation combined with spatial coverage, STR stratified random, STRC STR combined with spatial coverage, CLH conditional Latin hypercube, and CLHC CLH combined with spatial coverage (Zhao et al., 2015)

Spatial Sampling



Prof. Dick Brus

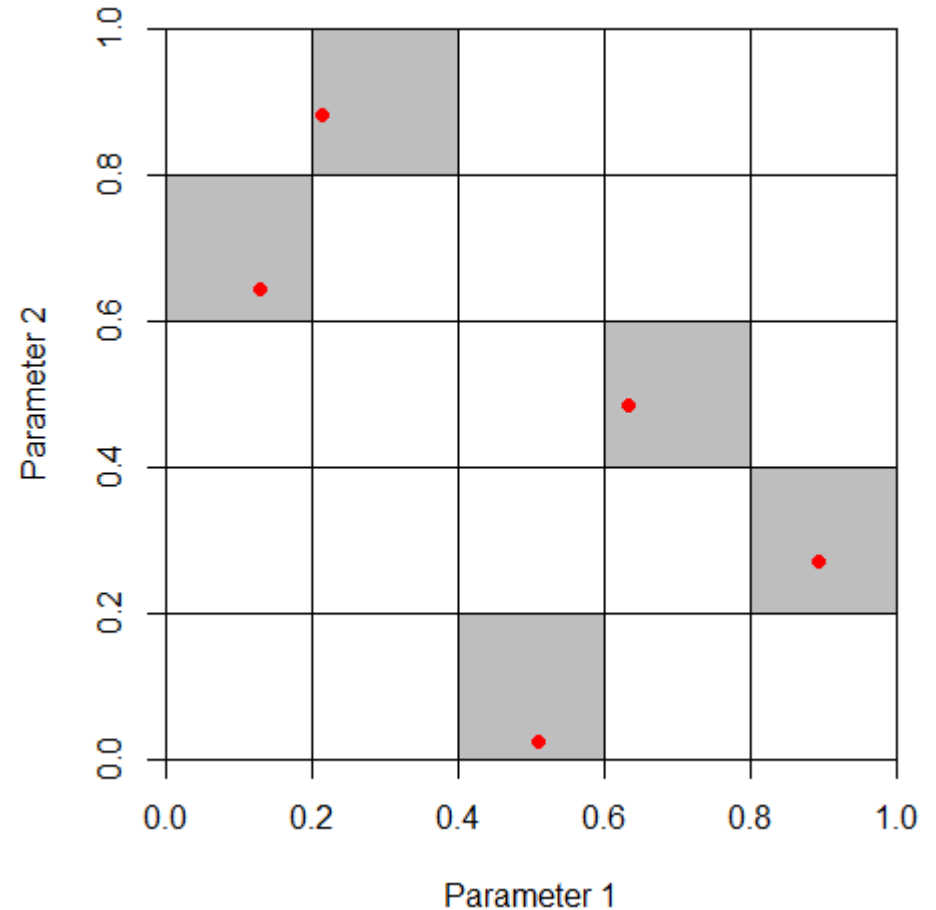
<https://www.researchgate.net/profile/Dick-Brus>

Figure 2: Spatial coverage and spatial infill sample in three woredas of Ethiopia, optimized by minimizing MSSD by k-means.

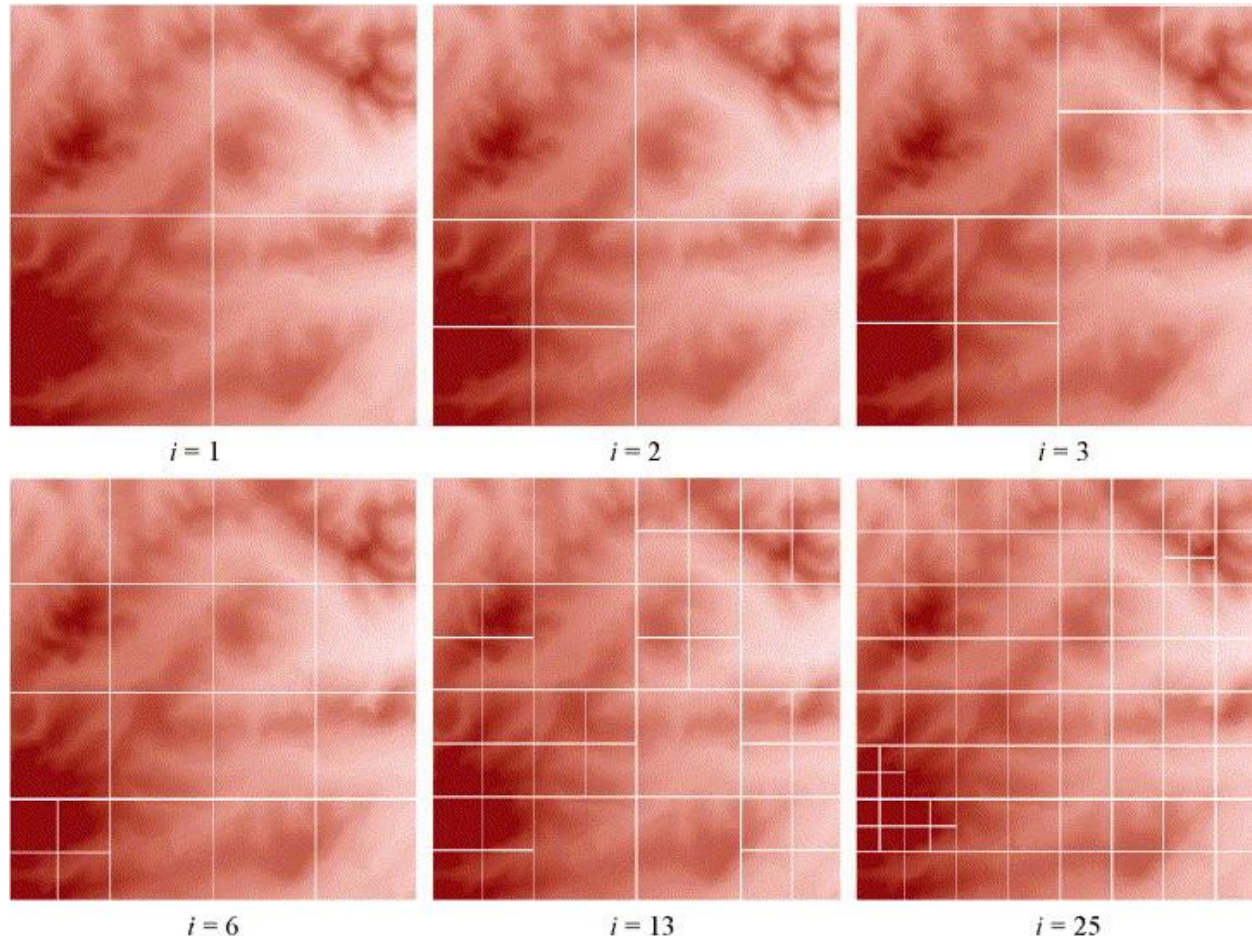
You can download the published version at:
<https://doi.org/10.1016/j.geoderma.2018.07.036>

Latin Hypercube

- a stratified random procedure
- follows the idea of a Latin square
- the number of strata equals the sample size



The Variance Quadtree Algorithm



Minasny et al., 2007

تعیین الگوی نمونه برداری مکانی با استفاده از روشهای مختلف

https://agrieng.scu.ac.ir/article_11663_921b9dd2b88247001e25dcc198eba661.pdf

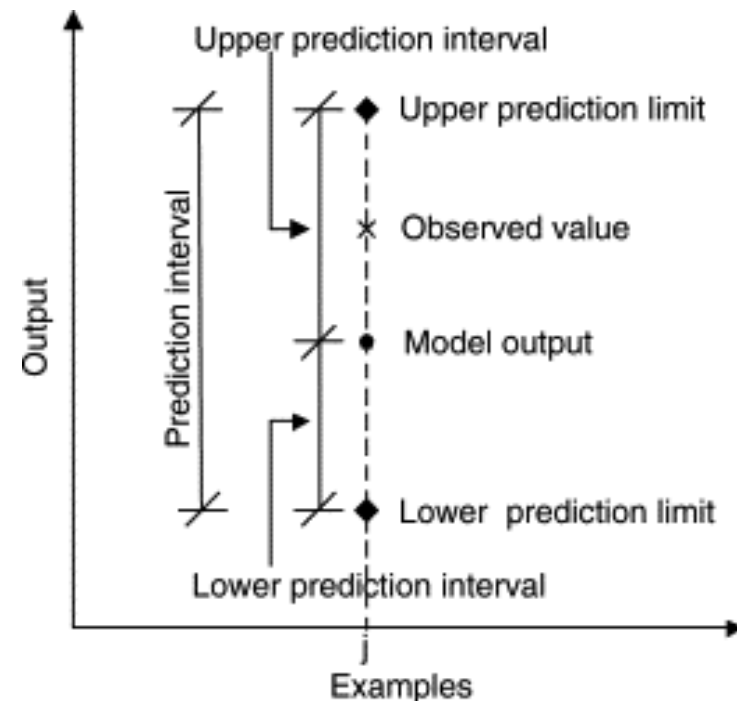
Uncertainty Quantification

Predictions (**maps**) may be subject to **error** and **uncertainty** from multiple sources:

- *insufficient training sample size*
- *model parameterization*
- *interactions amongst covariates*
- *missing covariates*
- *measurement error within the input and output data*

1. *positioning error (location accuracy);*
2. *sampling error;*
3. *measurement error (in the laboratory);*
4. *temporal sampling error;*
5. *data input error (or typing error);*

- Information related to the uncertainty of predictions is required.
- upper and lower prediction limits (prediction interval).



Uncertainty Quantification

have a built-in ability to quantify uncertainty

- *linear regression*
- *ordinary kriging*
- *universal kriging*
- *kriging with external drift*
- *cokriging*
- *sequential Gaussian simulation*
- *regression kriging*
- *quantile regression forest*
-

do not have a built-in ability to quantify uncertainty

- *Bayesian*
- *bootstrap methods*
- *postprocessor (UNEEC)*
- *analytical (mean variance methods)*
- ...



Prof. Gerard Heuvelink

<https://www.researchgate.net/profile/Gerard-Heuvelink>

Feature selection

Feature selection is the process of reducing the number of input variables when developing a predictive model.



Feature selection

- **Feature Selection**: Select a subset of input features from the dataset.
 - **Unsupervised**: Do not use the target variable (e.g. remove redundant variables).
 - Correlation
 - **Supervised**: Use the target variable (e.g. remove irrelevant variables).
 - **Wrapper**: Search for well-performing subsets of features.
 - RFE
 - **Filter**: Select subsets of features based on their relationship with the target.
 - Statistical Methods
 - **Intrinsic**: Algorithms that perform automatic feature selection during training.
 - Decision Trees
- **Dimensionality Reduction**: Project input data into a lower-dimensional feature space.



1. Open Rstudio

2. Clear Project List

The screenshot displays the RStudio application window. The top menu bar includes File, Edit, Code, View, Plots, Session, Build, Debug, Profile, Tools, and Help. The toolbar below the menu bar contains icons for creating a new file, opening a file, saving, and navigating. The main editor pane on the left shows a script titled 'Untitled1*' with the following R code:

```
1 1 + 1
2 2 + 3 + 4
3 x <- c(1:100)
4 hist(x)
5
```

The console pane at the bottom left shows the R startup message:

```
You are welcome to redistribute it under certain conditions.
Type 'license()' or 'licence()' for distribution details.

Natural language support but running in an English locale

R is a collaborative project with many contributors.
Type 'contributors()' for more information and
'citation()' on how to cite R or R packages in publications.

Type 'demo()' for some demos, 'help()' for on-line help, or
'help.start()' for an HTML browser interface to help.
Type 'q()' to quit R.

>
```

The right-hand pane shows the 'Environment' tab, which currently displays 'Global Environment'. A red arrow points from the 'Clear Project List' option in the 'Project' menu to the 'Environment' tab. The 'Project' menu is open, showing options: New Project..., Open Project..., Open Project in New Session..., Close Project, Clear Project List (highlighted), and Project Options... The status bar at the bottom of the window shows the time as 4:35 PM on 2/9/2021.

3. New Project

The screenshot displays the RStudio application window. The top menu bar includes File, Code, View, Plots, Session, Build, Debug, Profile, Tools, and Help. The toolbar below the menu bar contains icons for creating a new file, opening a file, saving, and running code. The main editor window on the left shows a script titled 'Untitled1*' with the following R code:

```
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2 2 + 3 + 4
3 x <- c(1:100)
4 hist(x)
5
```

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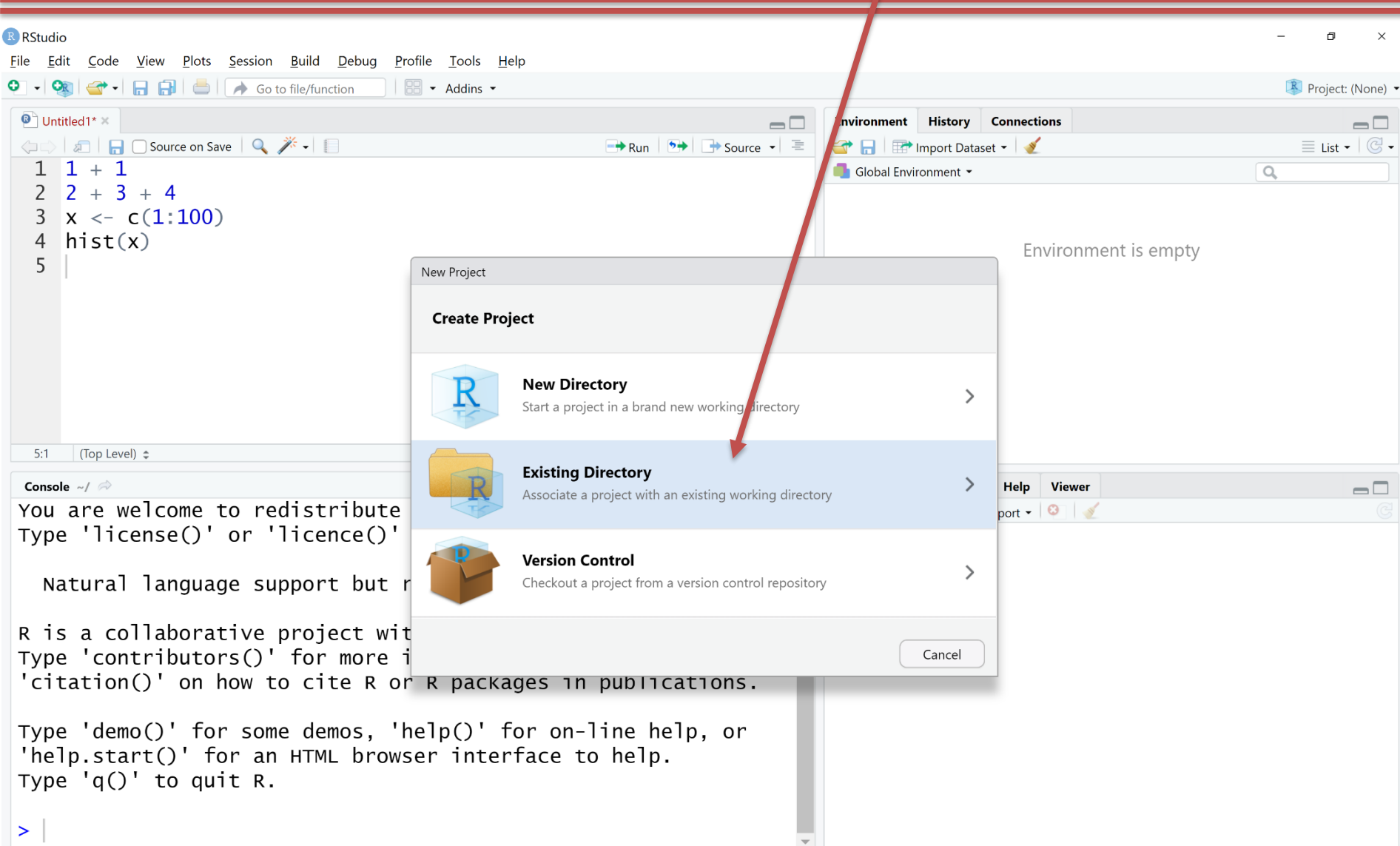
>
```

The right-hand pane shows the 'Environment' tab, which currently displays 'Global Environment'. A red arrow points to the 'New Project...' button in the top right corner of the RStudio window. The 'Project: (None)' dropdown menu is open, showing the following options:

- New Project...
- Open Project...
- Open Project in New Session...
- Close Project
- Clear Project List
- Project Options...

The bottom status bar shows the Windows taskbar with the search bar and various application icons, including RStudio and the Windows Explorer.

4. Existing Directory



The image shows the RStudio interface with a 'New Project' dialog box open. A red arrow points to the 'Existing Directory' option. The background shows the RStudio environment with a script editor, console, and environment pane.

RStudio Interface:

- Menu Bar:** File, Edit, Code, View, Plots, Session, Build, Debug, Profile, Tools, Help
- Toolbar:** Go to file/function, Addins
- Script Editor:** Untitled1*
1 1 + 1
2 2 + 3 + 4
3 x <- c(1:100)
4 hist(x)
5 |
- Environment Pane:** Project: (None), Global Environment, Environment is empty
- Console:** You are welcome to redistribute
Type 'license()' or 'licence()' for
Natural language support but r
R is a collaborative project with
Type 'contributors()' for more i
'citation()' on how to cite R or R packages in publications.
Type 'demo()' for some demos, 'help()' for on-line help, or
'help.start()' for an HTML browser interface to help.
Type 'q()' to quit R.
> |

New Project Dialog Box:

- Create Project**
- New Directory**
Start a project in a brand new working directory
- Existing Directory** (Selected)
Associate a project with an existing working directory
- Version Control**
Checkout a project from a version control repository
- Cancel**

5. Find the folder and find **Day_07_AdvancedTopic** and open

The screenshot shows the RStudio interface with two windows open. The 'Choose Directory' window is in the foreground, displaying a file explorer view of the 'Soil and Water Research' directory. The '03_Day_Covariates' folder is selected. The 'Open Existing Directory' window is also open, showing the 'Browse...' button. Two red arrows point from the text 'Find the folder' and 'find Day_07_AdvancedTopic' to the '03_Day_Covariates' folder and the 'Browse...' button, respectively.

Environment is empty

Project: (None)

Environment History Connections

Import Dataset

Global Environment

Help Viewer

Port

Folder: 03_Day_Covariates

Open Cancel

Open Existing Directory

Directory:

Browse...

Create Project Cancel

☐ Open in new session

Type 'license()' or 'licence()' for license information for this R package.

Natural language support but not for all languages.

R is a collaborative project with many contributors.

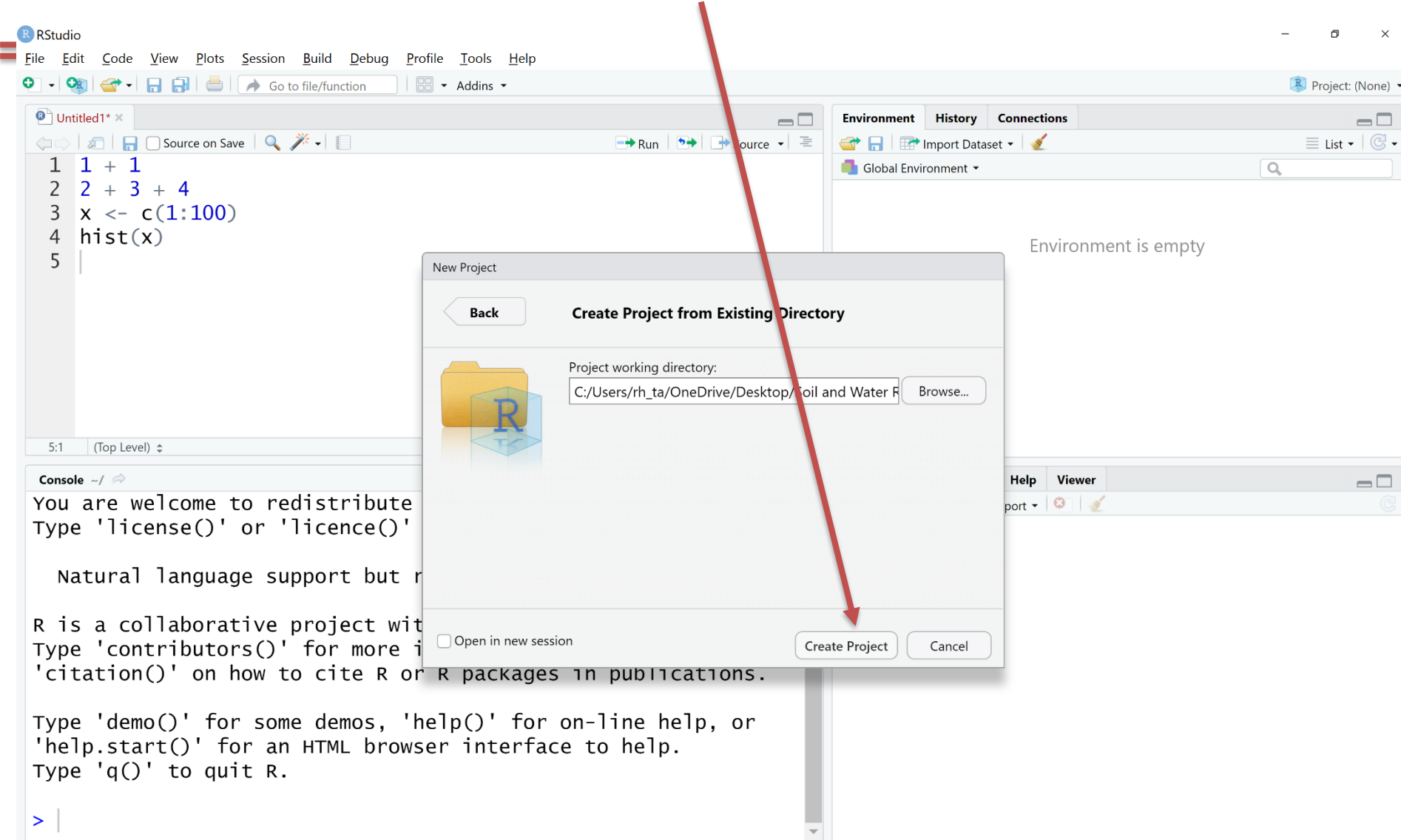
Type 'contributors()' for more information and 'citation()' on how to cite R or R packages in publications.

Type 'demo()' for some demos, 'help()' for on-line help, or 'help.start()' for an HTML browser interface to help.

Type 'q()' to quit R.

> |

6. Create project



The screenshot shows the RStudio interface with the 'New Project' dialog box open. The dialog box has a 'Back' button and a title 'Create Project from Existing Directory'. It contains a folder icon with the R logo, a text field for 'Project working directory:' with the path 'C:/Users/rh_ta/OneDrive/Desktop/Soil and Water R', and a 'Browse...' button. At the bottom, there is an unchecked checkbox 'Open in new session' and two buttons: 'Create Project' and 'Cancel'. A red arrow points from the title '6. Create project' to the 'Create Project' button. The background shows the RStudio editor with a script containing R code, the console with R startup messages, and the Environment pane showing 'Global Environment'.

RStudio

File Edit Code View Plots Session Build Debug Profile Tools Help

Go to file/function

Addins

Project: (None)

Environment History Connections

Import Dataset

Global Environment

Environment is empty

New Project

Back

Create Project from Existing Directory

Project working directory:

C:/Users/rh_ta/OneDrive/Desktop/Soil and Water R

Browse...

☐ Open in new session

Create Project Cancel

```
1 1 + 1
2 2 + 3 + 4
3 x <- c(1:100)
4 hist(x)
5
```

5:1 (Top Level)

Console ~/

You are welcome to redistribute

Type 'license()' or 'licence()'

Natural language support but r

R is a collaborative project with

Type 'contributors()' for more i

'citation()' on how to cite R or R packages in publications.

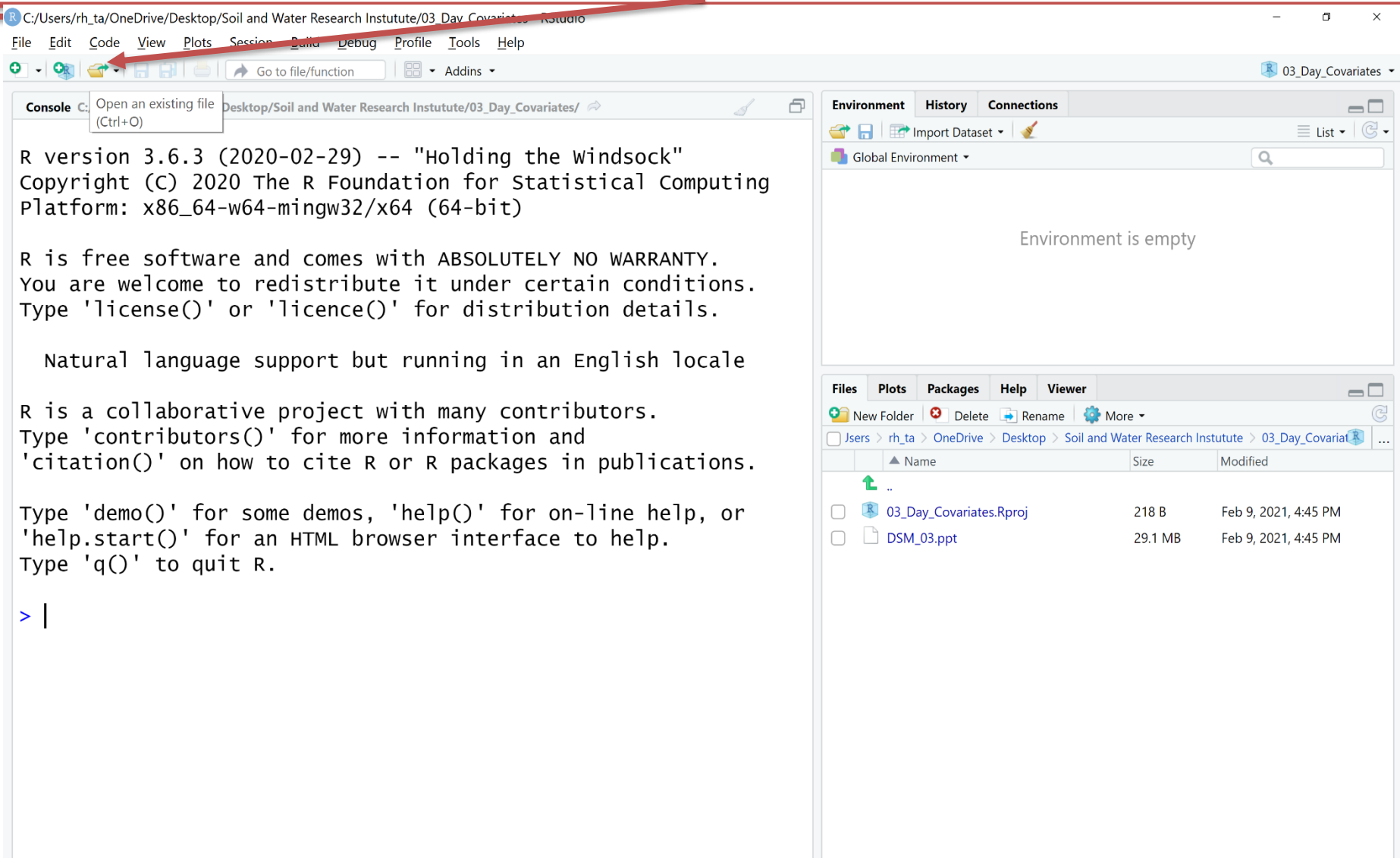
Type 'demo()' for some demos, 'help()' for on-line help, or

'help.start()' for an HTML browser interface to help.

Type 'q()' to quit R.

>

7. Open an existing file and find **07_R_AdvancedTopic.R**



The screenshot shows the RStudio interface. The top menu bar includes File, Edit, Code, View, Plots, Session, Build, Debug, Profile, Tools, and Help. The toolbar below the menu bar has icons for opening files, saving, and other functions. A red arrow points to the 'Open an existing file' button in the toolbar.

The console window on the left displays the following text:

```
R version 3.6.3 (2020-02-29) -- "Holding the windsock"
Copyright (C) 2020 The R Foundation for Statistical Computing
Platform: x86_64-w64-mingw32/x64 (64-bit)

R is free software and comes with ABSOLUTELY NO WARRANTY.
You are welcome to redistribute it under certain conditions.
Type 'license()' or 'licence()' for distribution details.

Natural language support but running in an English locale

R is a collaborative project with many contributors.
Type 'contributors()' for more information and
'citation()' on how to cite R or R packages in publications.

Type 'demo()' for some demos, 'help()' for on-line help, or
'help.start()' for an HTML browser interface to help.
Type 'q()' to quit R.

> |
```

The file explorer on the right shows the current directory structure:

- Environment: Global Environment
- History: (empty)
- Connections: (empty)
- Files: (empty)
- Plots: (empty)
- Packages: (empty)
- Help: (empty)
- Viewer: (empty)

The file explorer also shows a list of files in the current directory:

Name	Size	Modified
03_Day_Covariates.Rproj	218 B	Feb 9, 2021, 4:45 PM
DSM_03.ppt	29.1 MB	Feb 9, 2021, 4:45 PM

8. Open **07_R_AdvancedTopic.R**

