**Faculty Notes/Instructions**

**1. Overview of the module** – could be the same, or an expanded version of, the text entered as the Publication Description on QUBES. Having all the information in the downloaded files will be of great use to the future instructor. The overview should provide the conceptual context for the resource.

This module was designed and implemented in the course of R Data Science in the Program in Environmental Sciences at Northwestern University by Yingying Xie.

Course: ENVR\_SCI 390-0-03 R Data Science

Course information: two 80-minute classes per week, 17 students (undergrad and graduate students). Students work on their laptop with R and RStudio installed. Class contents usually include a short lecture (20-30 minutes) and hands-on practice (50-60 minutes).

In this module, students are introduced to concepts of remote sensing and the data logistics, and NEON remote sensing data. Students learn how to apply spatial data processing (e.g. read, write, and extract spatial data, data frame modification) and visualization (e.g. maps, histogram, scatter plot) skills using R coding program to process NEON remote sensing data to address a few simple scientific questions. Before this module, students already learned the essential R packages (e.g. ggplot2, raster and sf) required by this module. The NEON remote sensing data were introduced in this module as a case study to show students how data processing and visualization skills can be used to address questions in a real case. In this module, students practice the basic workflow of spatial data processing and visualization.

This module was implemented in two classes. Each class was 80 minutes. In the first class, a short lecture introduced the concepts of remote sensing, data logistics and structures, NEON and NEON remote sensing data. Then the instructor led students to conduct practice based on provided R script, instructions, and data of Harvard Forest (i.e. HARV) site and plot shapefiles. Detailed information of data products, processing and analysis were explained along the practice. In the practice, students need to modify example codes to address a few questions.

In the second class, data and information of two more sites (WREF and NIWO) were given. Students were divided into groups. Each group should identify a question related to the information in the data of three sites and discuss how to use processing and analysis skills to address that questions. Each student should submit a report, which is a document (pdf, word or html) rendered from Rmarkdown file including R script, results and narratives.

**2. Learning Objectives** – student centered, assessable learning objectives

Quantitative/Data Skills learning objectives:

* Visualize remote sensing data using ggplot in R
* Use basic data modification to process remote sensing data in R
* Know how to extract information and use analysis skills to address scientific questions

Concept learning objectives:

* Understand basic remote sensing data logistics and data structure
* Know the NEON framework and the airborne data products

Other learning objectives:

* Collaborate to design a case study based on a simple scientific question
* Communicate data analysis results using graphs, writing and verbal ways

**3. A description of the data and its source**

Data used in this module include NEON AOP data of three sites (HARV, WREF, NIWO). For each site, only one tile (1km\*1km) of seven data products collected 2017 were provided, including CHM (canopy height), biomass, DTM (elevation), DSM, slope, aspect, water indices and vegetation indices. All AOP data are geotiff files.

Shapefiles of all NEON plots polygons and centroids are also provided.

All data were downloaded from NEON website, reorganized, and stored in the 09\_data folder.

**4. Challenges to Address** – are there areas that your students frequently have trouble or common misconceptions that the instructor should be aware of. If you have ways you deal with them in your classroom be sure to provide these.

As this course focuses more on R coding skills, students do not get much background information to understand the biological and ecological setting of NEON data products. So the questions that students intended to address in their own case study were limited or dependent their own knowledge related to the variables (e.g. biomass, vegetation indices) in data.

To fill the knowledge gap, information of the data product and variables were introduced in the R coding practice. But it takes time for students to really digest the meaning and understand the ecological applications of these data. Thus, to overcome this challenge, it is recommended to provide background reading materials or videos for students to read or watch before classes.

Reading materials can be found at <https://www.neonscience.org/community/papers-publications>.

Videos include: <https://youtu.be/39YrzpxVRF8>, and <https://youtu.be/PRE5KV2_w3Q>.

**5. Assessment strategy** – provide suggestions (and, were appropriate, upload other documents) for assessing the learning objectives of the module content.

In the implementation, extra credits were given based on a simple rubric (in the last slide). More assessments can be done through students’ course performances in R coding practice, group discussion and the independent report.