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#Load key packages: `terra`, `tidyverse`, `sf`, and `ncdf4`
#Create a `data` folder for downloads using `dir.create("data", showWarnings = FALSE)`
#Download the `.nc` files from the provided GitHub URLs
#Store them in a `data/` folder and, if you are keeping your code in a git repository, add `*data*` to
your ` `.gitignore` file so git doesn't track them.

#install.packages("rasterVis")
#install.packages("ncdf4")
#install.packages("tidyterra")
library(terra)
library(tidyverse)
library(sf)
library(knitr)
library(kableExtra)
library(rasterVis)
library(ncdf4)
library(lubridate)
library(tidyterra)

dir.create("data", showWarnings = FALSE)

lulc_url <-
"https://github.com/adammwilson/DataScienceData/blob/master/inst/extdata/appears/MCD12Q1.051_aid0001.nc?
raw=true"
lst_url <-
"https://github.com/adammwilson/DataScienceData/blob/master/inst/extdata/appears/MOD11A2.006_aid0001.nc?
raw=true"

download.file(lulc_url, destfile = "data/MCD12Q1.051_aid0001.nc", mode = "wb")
download.file(lst_url, destfile = "data/MOD11A2.006_aid0001.nc", mode = "wb")

#Load and Explore the Data
#Hints:

#Use nc_open() to print the file metadata and learn the names of the subdataset
#Use rast() to read the NetCDF file and specify which subdatasets. (sbds) you want to select.
#Check layer names with names().
#Use plot() or gplot() to visualize the rasters.

#Given in starter scripts
MCD12Q1 <- nc_open("data/MCD12Q1.051_aid0001.nc")
MOD11A2 <- nc_open("data/MOD11A2.006_aid0001.nc")

lulc <- rast("data/MCD12Q1.051_aid0001.nc", subds = "Land_Cover_Type_1")
names(lulc)

plot(lulc$Land_Cover_Type_1_13, main = "MODIS Land Cover (Year 13)")

lst <- rast("data/MOD11A2.006_aid0001.nc", subds = "LST_Day_1km")
names(lst)

#Convert and Label Land Cover

#Given in starter script
Land_Cover_Type_1 <- c(
  "Water" = 0, "Evergreen Needleleaf forest" = 1, "Evergreen Broadleaf forest" = 2,
  "Deciduous Needleleaf forest" = 3, "Deciduous Broadleaf forest" = 4, "Mixed forest" = 5,
  "Closed shrublands" = 6, "Open shrublands" = 7, "Woody savannas" = 8, "Savannas" = 9,
  "Grasslands" = 10, "Permanent wetlands" = 11, "Croplands" = 12, "Urban & built-up" = 13,
  "Cropland/Natural vegetation mosaic" = 14, "Snow & ice" = 15, "Barren/Sparsely vegetated" = 16
)

lcd <- data.frame(
  ID = Land_Cover_Type_1,
  landcover = names(Land_Cover_Type_1),
  stringsAsFactors = FALSE
)

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)

lulc <- as.factor(lulc)

scoff(lst) = cbind(0.02, -273.15)

plot(lst, main = "Surface Temperature (C)")

#Part 1: Extract Time Series for a Point
#Hint
#Use extract() to get the average LST for a location in Buffalo, NY.

# Hints:

#Create a point with st_as_sf() to create a point at lon = -78.79, lat = 43.00 in wgs84 (geographic)
coordinates (crs = 4326)
#Transform to the raster's CRS with st_transform().
#Use terra::extract() to extract LST values within a 1 km buffer.
#Combine with the corresponding time(lst) values into a tidy data frame.
#Plot the result with ggplot().
#`geom_smooth()` using method = 'loess' and formula = 'y ~ x'

#Created point to find data around
buff_point <- data.frame(lon = -78.79, lat = 43.00)

#Converted point to sf
buff_point_sf <- st_as_sf(buff_point, coords = c("lon", "lat"), crs = 4326)

#Put sf and raster in the same crs
buff_point_sf <- st_transform(buff_point_sf, st_crs(lst))

#Extracted lst points found around the buff_point_sf
extracted_lst <- terra::extract(lst, buff_point_sf)

#Got times of lst
time_lst <- time(lst)

#Added times to the extracted lst with rbind
combined_lst <- extracted_lst %>%
  rbind(time_lst)

#Found function t to convert rows to columns
fixed_combined <- t(combined_lst)

#Converted data with time to dataframe
fixed_combined <- as.data.frame(fixed_combined)

#Renamed automatic column names given
fixed_combined <- fixed_combined %>%
  rename(year = V2) %>%
  rename(temp = V1)

#Converted dates to years
fixed_combined <- fixed_combined %>%
  mutate(year = as.Date(year))

#Used "span" to fit the trend better with loess method
ggplot(fixed_combined, aes(x = year, y = temp)) + geom_point() + geom_smooth(method = "loess", formula = "y ~ x", span = 0.01) + labs(title = "Time Series of LST Near Buffalo. NY", x = "Date", y = "Land Surface Temperature (Degrees C)")

#Part 2: Monthly Climatology
#Hint
#Summarize the weekly data into monthly means using tapp().

# Hints:

#Use index = "months" and fun = mean in tapp().

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#Rename layers to month names. You could use month.name[...] or find another way to do it.
#Visualize with a ggplot using tidyterra::geom_spatraster and facet_wrap(~lyr) to compare months.
#Used tapp to sort lst by month, had to include na.rm =TRUE to include all data
monthly_lst <- tapp(lst, fun=mean, index="months", na.rm=TRUE)

names(monthly_lst)

#Renamed layers to month names
names(monthly_lst) <- c(month.name)

summary(monthly_lst)

#Checked to make sure data carried through
terra::values(monthly_lst)

ggplot(monthly_lst) + geom_spatraster(data = monthly_lst) + stat_spatraster(data = monthly_lst) +
facet_wrap(~lyr) + scale_fill_gradientn(colors = c("blue", "gray", "red"))

#Part 3: Compare LST by Land Cover Type

#Explore how LST differs between Urban & built-up and Deciduous Broadleaf Forest areas.

#Hints:

#Resample the land cover raster to match LST resolution with resample(method = "near").
#Extract values from both rasters into a combined data frame. You could use bind_cols() or other methods.
#Join land cover names from the MODIS legend table.
#Filter to the two land cover types of interest (c("Urban & built-up", "Deciduous Broadleaf forest"))
and plot monthly distributions.

#I only chose data for one year as I was having trouble doing this for all year and monthly averages; I also used the monthly_lst rather than the general lst

lulc13 <- resample(lulc$Land_Cover_Type_1_13, monthly_lst, method = "near")

#Combined rasters
lulc_lst <- c(lulc13, monthly_lst)

#Converted combined rasters to dataset
lulc_lst <- as.data.frame(lulc_lst)

#Changed name to combine with lcd
lulc_lst <- lulc_lst %>%
  rename(ID = Land_Cover_Type_1_13)

#Formatted as.character to ensure proper joining
lulc_lst_filtered <- lulc_lst %>%
  mutate(ID = as.character(ID))

lulc_lst_filtered <- lulc_lst_filtered %>%
  filter(ID == c("4", "13"))

#Formatted as.character to ensure proper joining
lcd <- lcd %>%
  mutate(ID = as.character(ID))

lulc_lst_filtered <- lulc_lst_filtered %>% left_join(lcd, by = "ID")

#Changed individual month columns to one column
lulc_lst_filtered <- lulc_lst_filtered %>%
  pivot_longer(cols = "January":"December", names_to = "month", values_to = "temperature")

#Formatted month column so it would go in month order on graph
lulc_lst_filtered$month <- factor(lulc_lst_filtered$month, levels = c("January", "February", "March",
"April", "May", "June", "July", "August", "September", "October", "November", "December"))

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ggplot(data = lulc_lst_filtered, aes(x = month, y = temperature, fill = landcover)) + geom_violin() +  
  labs(title = "Monthly LST For Landcover Type", x = "Month", y = "LST (Degrees C)", fill = "Landcover")
```