Tutorial: Extraction and use of air pollution data in the CHAP database: from. The nc to the variable

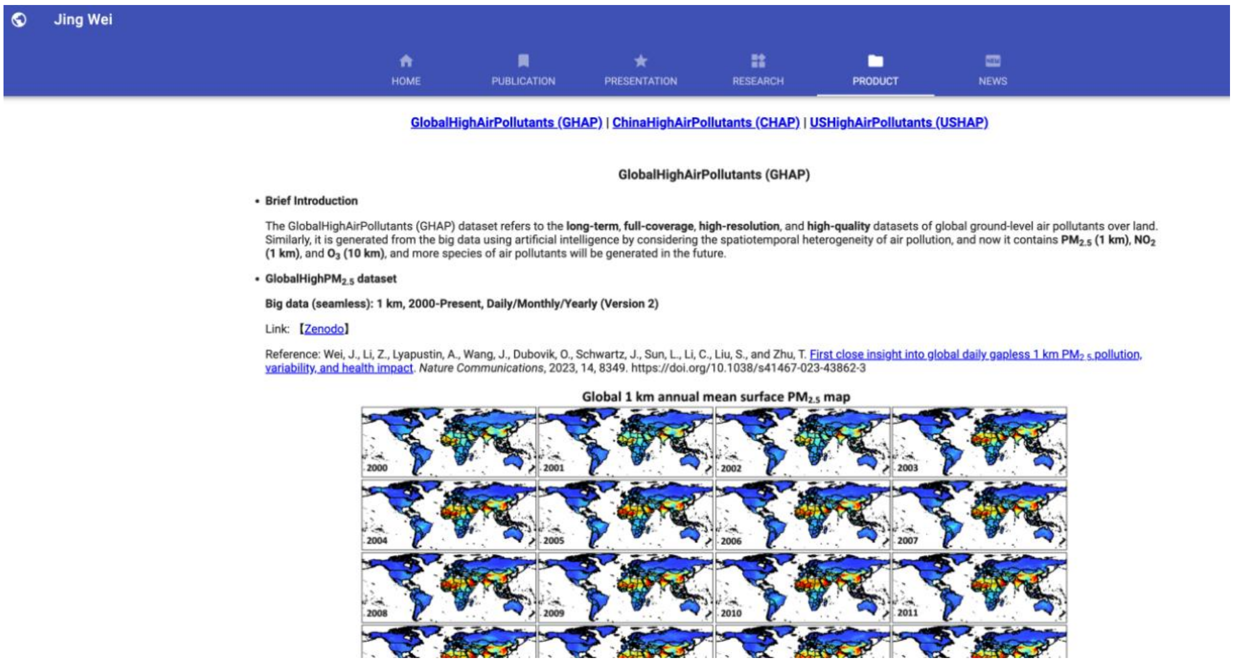
Overview of ideas

1. Downloaded from the CHAP database. nc formatted data
2. Data be treated with Python. The nc format data is batch converted to. tif form
3. The .tif format files are batch clipped with ENVI software
4. Python Call ArcGIS batch transform raster data to dbf table
5. R merges the data + dynamically extracts the variables that construct a specific time window exposure variables.

1. Data was downloaded from the CHAP database. nc formatted data

① Access the CHAP database from the following address

https://weijing-rs.github.io/product.html



GlobalHighAirPollutants (GHAP) | ChinaHighAirPollutants (CHAP) | USHighAirPollutants (USHAP)

GlobalHighAirPollutants (GHAP)

- **Brief Introduction**

  The GlobalHighAirPollutants (GHAP) dataset refers to the **long-term**, **full-coverage**, **high-resolution**, and **high-quality** datasets of global ground-level air pollutants over land. Similarly, it is generated from the big data using artificial intelligence by considering the spatiotemporal heterogeneity of air pollution, and now it contains **$PM_{2.5}$ (1 km)**, **NO_2 (1 km)**, and **O_3 (10 km)**, and more species of air pollutants will be generated in the future.

- **GlobalHigh$PM_{2.5}$ dataset**

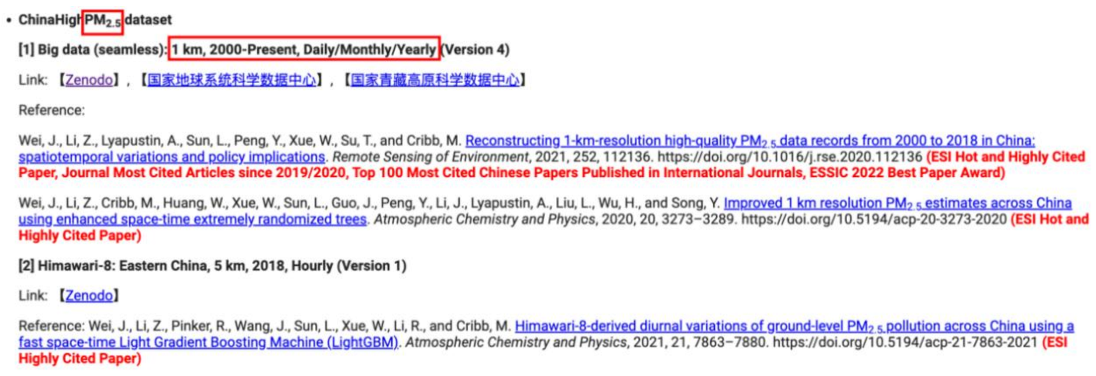
  Big data (seamless): 1 km, 2000-Present, Daily/Monthly/Yearly (Version 2)

  Link: 【Zenodo】

  Reference: Wei, J., Li, Z., Lyapustin, A., Wang, J., Dubovik, O., Schwartz, J., Sun, L., Li, C., Liu, S., and Zhu, T. First close insight into global daily gapless 1 km $PM_{2.5}$ pollution, variability, and health impact. *Nature Communications*, 2023, 14, 8349. https://doi.org/10.1038/s41467-023-43862-3

Global 1 km annual mean surface $PM_{2.5}$ map

② Select the target air pollutants: space granularity, time granularity, time range, click the database storage link



- **ChinaHighPM$_{2.5}$ dataset**

[1] Big data (seamless): 1 km, 2000-Present, Daily/Monthly/Yearly (Version 4)

Link: 【Zenodo】，【国家地球系统科学数据中心】，【国家青藏高原科学数据中心】

Reference:

Wei, J., Li, Z., Lyapustin, A., Sun, L., Peng, Y., Xue, W., Su, T., and Cribb, M. Reconstructing 1-km-resolution high-quality PM$_{2.5}$ data records from 2000 to 2018 in China: spatiotemporal variations and policy implications. *Remote Sensing of Environment*, 2021, 252, 112136. https://doi.org/10.1016/j.rse.2020.112136 **(ESI Hot and Highly Cited Paper, Journal Most Cited Articles since 2019/2020, Top 100 Most Cited Chinese Papers Published in International Journals, ESSIC 2022 Best Paper Award)**

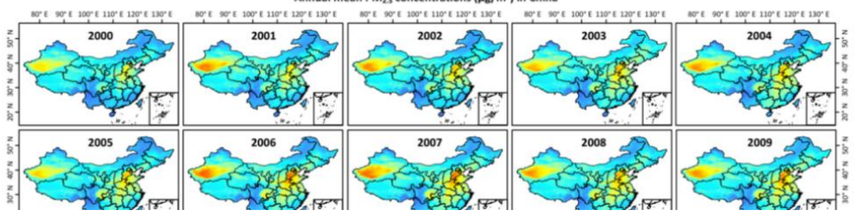
Wei, J., Li, Z., Cribb, M., Huang, W., Xue, W., Sun, L., Guo, J., Peng, Y., Li, J., Lyapustin, A., Liu, L., Wu, H., and Song, Y. Improved 1 km resolution PM$_{2.5}$ estimates across China using enhanced space-time extremely randomized trees. *Atmospheric Chemistry and Physics*, 2020, 20, 3273–3289. https://doi.org/10.5194/acp-20-3273-2020 **(ESI Hot and Highly Cited Paper)**

[2] Himawari-8: Eastern China, 5 km, 2018, Hourly (Version 1)

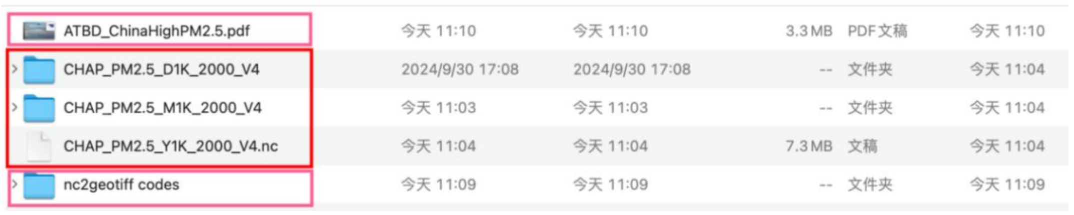
Link: 【Zenodo】

Reference: Wei, J., Li, Z., Pinker, R., Wang, J., Sun, L., Xue, W., Li, R., and Cribb, M. Himawari-8-derived diurnal variations of ground-level PM$_{2.5}$ pollution across China using a fast space-time Light Gradient Boosting Machine (LightGBM). *Atmospheric Chemistry and Physics*, 2021, 21, 7863–7880. https://doi.org/10.5194/acp-21-7863-2021 **(ESI Highly Cited Paper)**

Annual mean PM$_{2.5}$ concentrations (μg/m^3) in China



③ data specification:



ATBD_ChinaHighPM2.5.pdf	今天 11:10	今天 11:10	3.3 MB	PDF文稿	今天 11:10
CHAP_PM2.5_D1K_2000_V4	2024/9/30 17:08	2024/9/30 17:08	--	文件夹	今天 11:04
CHAP_PM2.5_M1K_2000_V4	今天 11:03	今天 11:03	--	文件夹	今天 11:04
CHAP_PM2.5_Y1K_2000_V4.nc	今天 11:04	今天 11:04	7.3 MB	文稿	今天 11:04
nc2geotiff codes	今天 11:09	今天 11:09	--	文件夹	今天 11:09

D1K: Day _ 1 Km: 1km per day

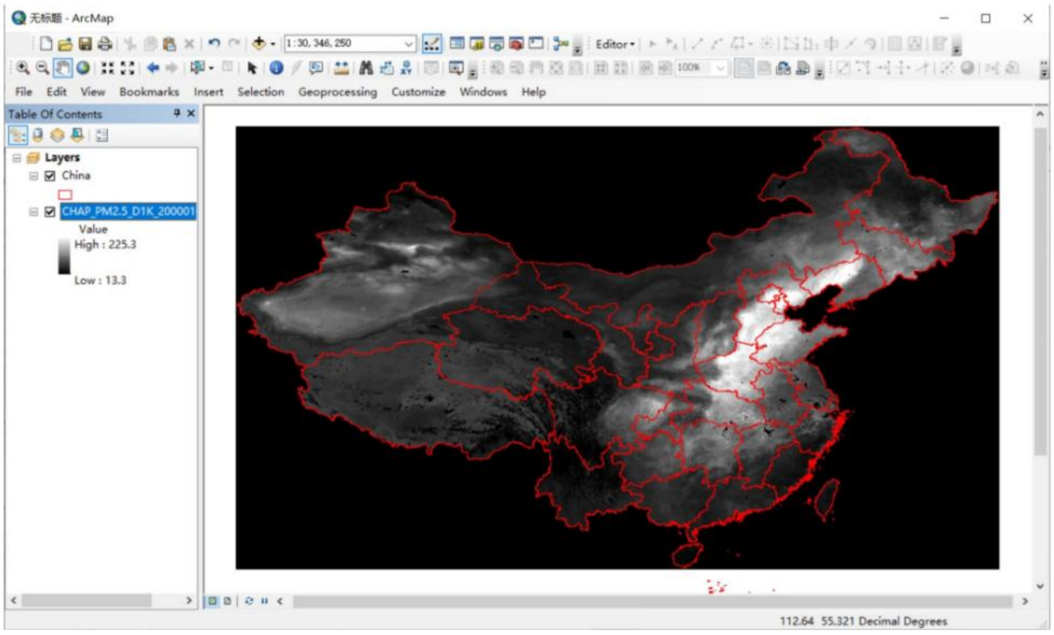
M1K: Month _ 1 Km: 1km per month

Y1K: Year _ 1 Km: 1km annually

In the ATBD_ChinaHighPM2.5.pdf is the database description, which mentions how to convert .nc into . tif:

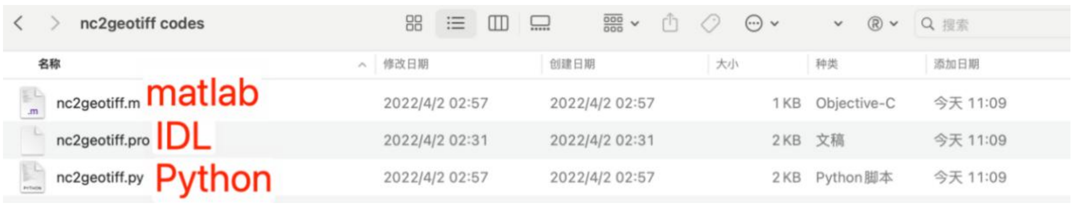
How to read?

Use Python, Matlab, and IDL codes (nc2geotiff codes.rar) to batch convert NetCDF (.nc) to GeoTIFF (.tif).



无标题 - ArcMap
File Edit View Bookmarks Insert Selection Geoprocessing Customize Windows Help
Table Of Contents
Layers
China
CHAP_PM2.5_D1K_200001
Value
High : 225.3
Low : 13.3
112.64 55.321 Decimal Degrees

nc2geotiff codes The folder is the matching will. The nc file is batch converted to. Three formats for a tif file:



名称	修改日期	创建日期	大小	种类	添加日期
nc2geotiff.m	2022/4/2 02:57	2022/4/2 02:57	1 KB	Objective-C	今天 11:09
nc2geotiff.pro	2022/4/2 02:31	2022/4/2 02:31	2 KB	文稿	今天 11:09
nc2geotiff.py	2022/4/2 02:57	2022/4/2 02:57	2 KB	Python脚本	今天 11:09

Choose your familiar software code, eg: IDL and Python I prefer.

2. Data be treated with Python: The .nc format data is batch converted to. tif form
Python Code are as follows:

```python
# 导入所需库

import os  # 用于文件路径操作

import netCDF4 as nc  # 用于处理 NetCDF 格式的数据

import numpy as np  # 用于处理数值计算和数组操作

from glob import glob  # 用于匹配文件路径模式

from osgeo import osr  # 用于设置投影信息

from osgeo import gdal # gdal 的正确导入
```

```
# 定义工作路径和输出路径
# 这里原始用的 F 盘
WorkPath = r'D:\2024.10.07 Convert nc to
tif\CHAP_PM2.5_1KM\YEAR_2000_2021_nc'  # 工作路径，存储 .nc 文件

OutPath = r'D:\2024.10.07 Convert nc to tif\CHAP_PM2.5_1KM\YEAR_2000_2021_tif'
# 输出路径，存储 .tif 文件

# 定义空气污染物类型（例如 PM1, PM2.5, PM10, O3, NO2, SO2, 和 CO 等）
AP = 'PM2.5'  # 在 NetCDF 文件中提取 PM2.5 数据

# 定义空间分辨率（例如，1 km ≈ 0.01 度）
SP = 0.01  # 定义空间分辨率，单位为度（Degree）

# 如果输出路径不存在，则创建该目录
if not os.path.exists(OutPath):
    os.makedirs(OutPath)

# 搜索工作路径下所有 .nc 文件（NetCDF 文件）
path = glob(os.path.join(WorkPath, '*.nc'))

# 遍历每个 .nc 文件进行处理
for file in path:
    f = nc.Dataset(file)  # 打开 NetCDF 文件
    # 读取指定污染物（AP，PM2.5）的数据，并转换为 NumPy 数组
    data = np.array(f[AP][:])
    # 将数据中的无效值（65535）替换为 NaN
    data[data == 65535] = np.nan

    # 读取经度和纬度信息
    lon = np.array(f['lon'][:])
    lat = np.array(f['lat'][:])
    # 获取经度和纬度的最小和最大值
    LonMin, LatMax, LonMax, LatMin = lon.min(), lat.max(), lon.max(), lat.min()
    # 获取纬度和经度的数量
    N_Lat = len(lat)
    N_Lon = len(lon)
    # 定义经度和纬度的分辨率
    Lon_Res = SP
    Lat_Res = SP

    # 定义输出文件名，去掉 .nc 扩展名，添加 .tif 扩展名
    fname = os.path.basename(file).split('.nc')[0]
    outfile = OutPath + '/{}.tif'.format(fname)

    # 创建 GeoTIFF 文件，用来存储处理后的栅格数据
    driver = gdal.GetDriverByName('GTiff')
    outRaster = driver.Create(outfile, N_Lon, N_Lat, 1, gdal.GDT_Float32) # 创建一个浮
点数 32 位的单波段图像
    # 设置 GeoTIFF 的地理变换参数：左上角坐标、分辨率等
    outRaster.SetGeoTransform([LonMin - Lon_Res / 2, Lon_Res, 0, LatMax + Lat_Res / 2,
0, -Lat_Res])
    # 定义投影为 WGS84
    sr = osr.SpatialReference()
    sr.SetWellKnownGeogCS('WGS84')
    outRaster.SetProjection(sr.ExportToWkt())
    # 将数据写入 GeoTIFF 文件
    outRaster.GetRasterBand(1).WriteArray(data)
    print(fname + '.tif', ' Finished')
```

```
# 释放内存，关闭文件
del outRaster
f.close()
```
Python

3. The .tif format files are batch clipped with ENVI software

3.1 Download the target region shp file

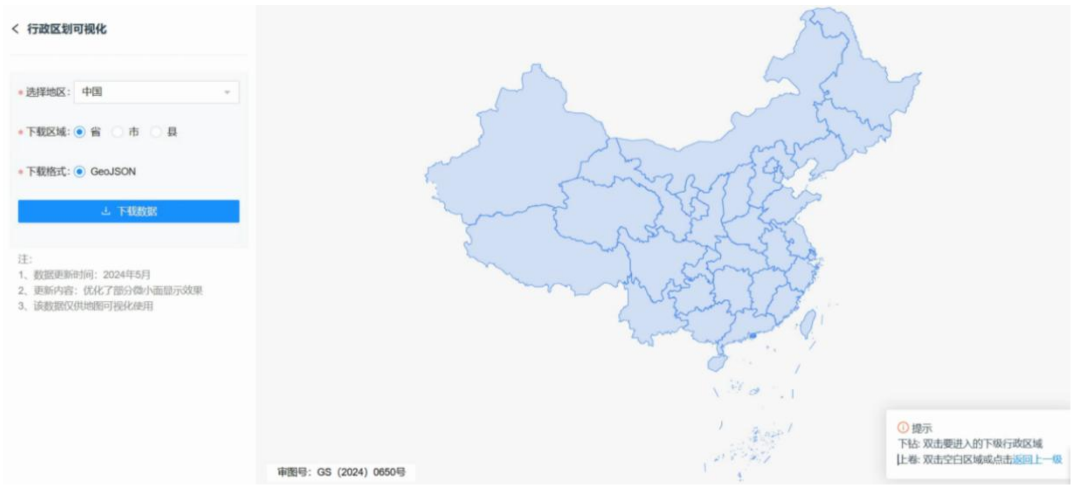
Off-the-shelf shp file is downloaded from this CSDN:

https://blog.csdn.net/weixin_61129400/article/details/142142844

Specific principles:

① Download the GeoJSON document of administrative divisions in China from the service center of Tiandi Net website-the visualization section of administrative region:

https://cloudcenter.tianditu.gov.cn/administrativeDivision


< 行政区划可视化

* 选择地区：中国
* 下载区域：[✓ 省] 市 县
* 下载格式：[✓ GeoJSON]

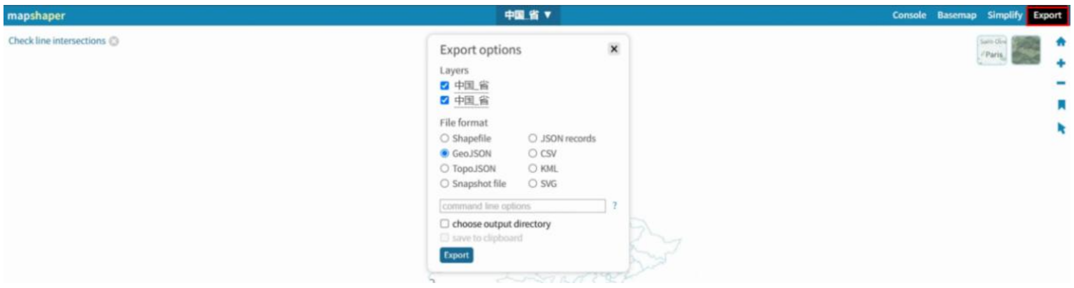
注：
1、数据更新时间：2024年5月
2、更新内容：优化了部分微小面显示效果
3、该数据仅供地图可视化使用

审图号：GS（2024）0650号

提示
下钻：双击要进入的下级行政区域
上卷：双击空白区域或点击返回上一级

② Turn the GeoJSON file to a shp file using the GeoJSON file to shp tool:

https://mapshaper.org/


Export options

Layers
[✓ 中国_省]
[✓ 中国_省]

File format
Shapefile
[✓ GeoJSON]
TopoJSON
Snapshot file
JSON records
CSV
KML
SVG

command line options

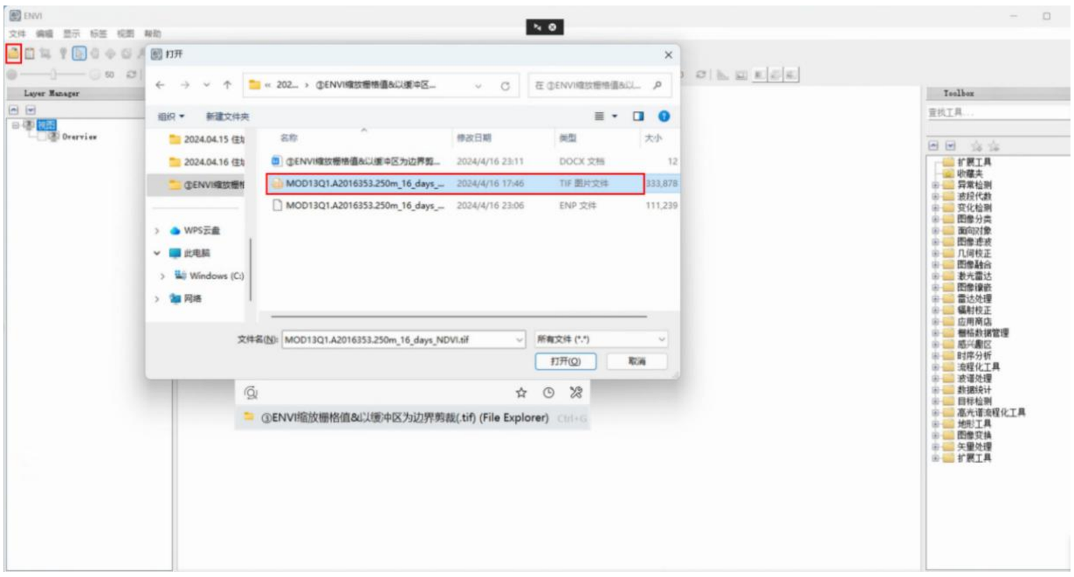
choose output directory
save to clipboard

3.2 ENVI Scale grid value & cut with buffer (. dat)

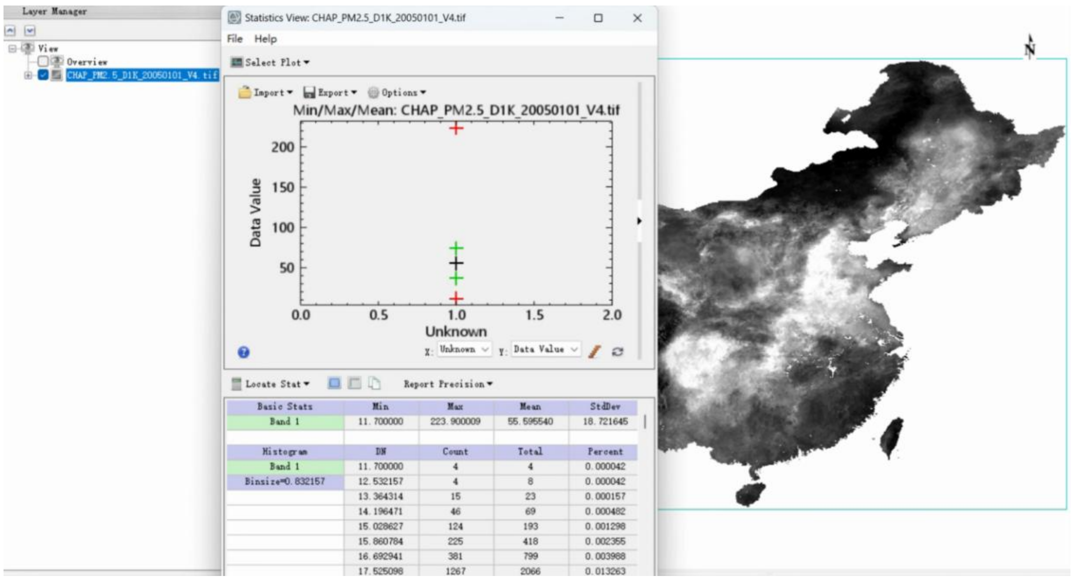
3.2.1 Single treatment method

① Initiating ENVI 5.3 (64-bit)

② Click the folder in the upper left corner to select the spliced TIF file for import



③ Select the layer right button and Quick Stats to view the distribution of grid data values

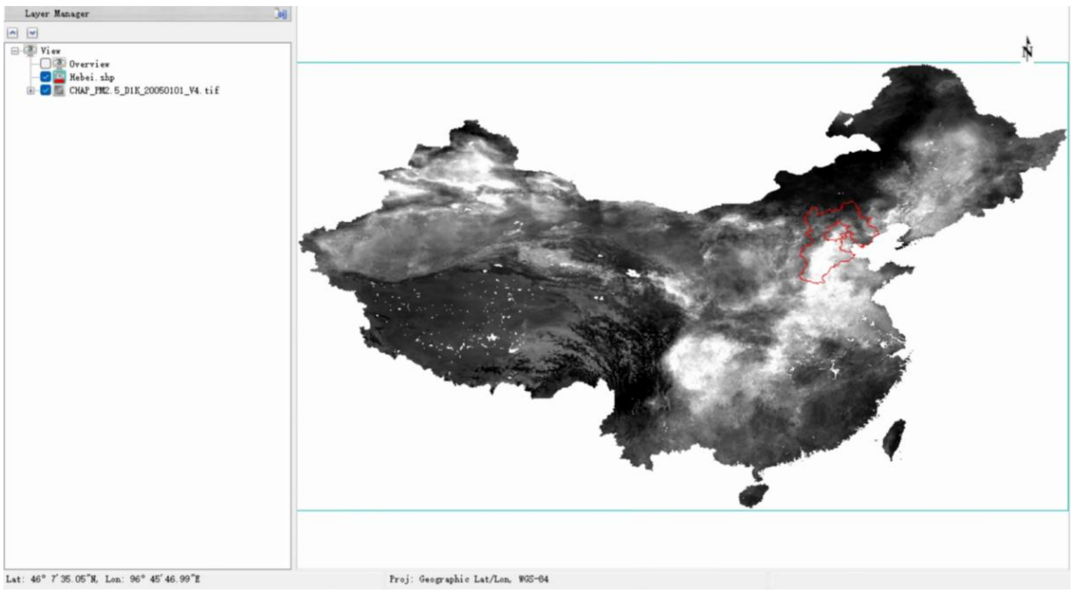


Basic Stats	Min	Max	Mean	StdDev
Band 1	11.700000	223.900009	55.595540	18.721645
Histogram	DN	Count	Total	Percent
Band 1	11.700000	4	4	0.000042
Binsize=0.832157	12.532157	4	8	0.000042
	13.364314	15	23	0.000157
	14.196471	46	69	0.000482
	15.028627	124	193	0.001298
	15.860784	225	418	0.002355
	16.692941	381	799	0.003988
	17.525098	1267	2066	0.013263

Correct value, without scaling. Cut it out directly.

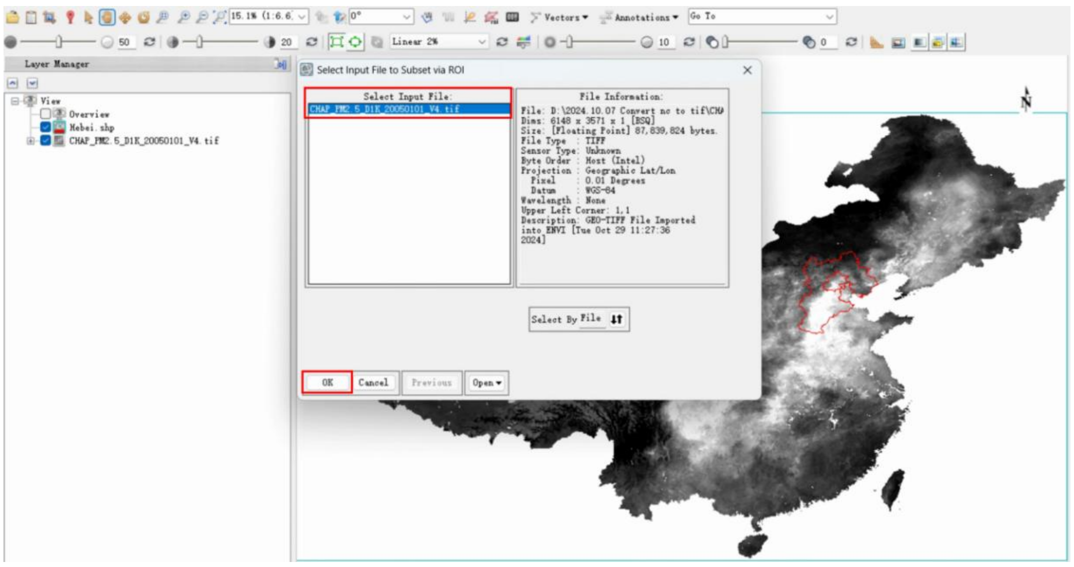
④ Use ENVI to open the buffer for the target region. The shp [buffer zone this step can be saved, because there is no edge value! So just that POI.shp cut

Importing the target area with the file. shp document


Layer Manager
View
Overview
Hebei.shp
CHAP_PM2.5_D1K_20050101_V4.tif
Lat: 46° 7' 35.05"N, Lon: 96° 45' 46.99"E
Proj: Geographic Lat/Lon, WGS-84

⑤ The tif images were trimmed using the Subset Data from ROIs (take a subset of data) tool

Click on the target data and click: OK



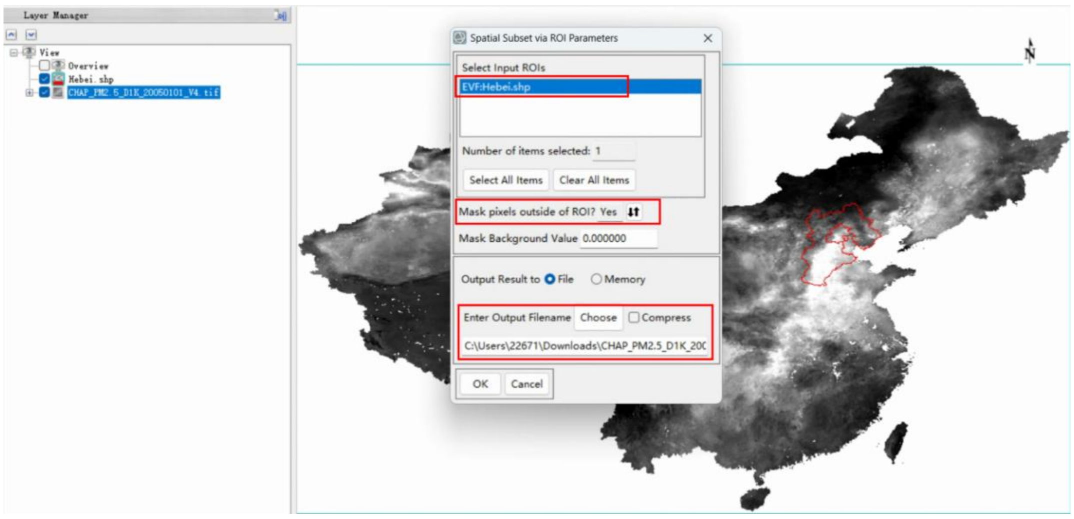
```
File: D:\2024.10.07 Convert nc to tif\CHA
Dims: 6148 x 3571 x 1 [BSQ]
Size: [Floating Point] 87,839,824 bytes.
File Type   : TIFF
Sensor Type: Unknown
Byte Order  : Host (Intel)
Projection  : Geographic Lat/Lon
  Pixel     : 0.01 Degrees
  Datum     : WGS-84
Wavelength  : None
Upper Left Corner: 1,1
Description: GEO-TIFF File Imported
into ENVI [Tue Oct 29 11:27:36
2024]
```

Select the buffer for the target region. The shp, as a cut range,

Notes: Be sure to check the Mask pixels outside of ROI (mask pixel outside the ROI) as Yes,

Select the storage location

ROI: Region of Interest Region of interest / study area



Spatial Subset via ROI Parameters

Select Input ROIs: EVF:Hebei.shp

Number of items selected: 1

Select All Items | Clear All Items

Mask pixels outside of ROI? Yes

Mask Background Value 0.000000

Output Result to [✓ File] Memory

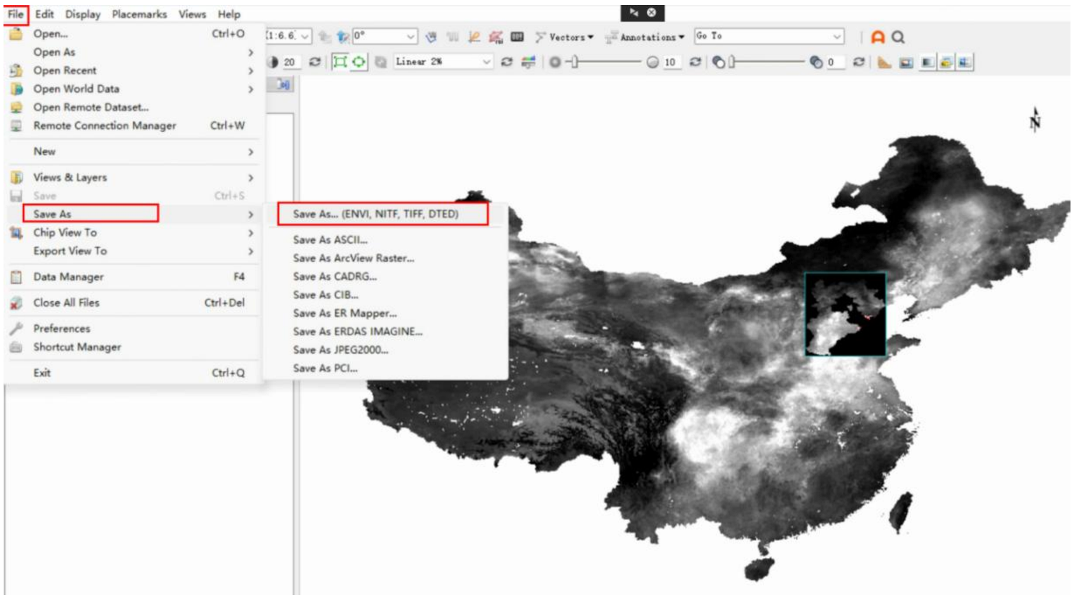
Enter Output Filename | Choose | Compress

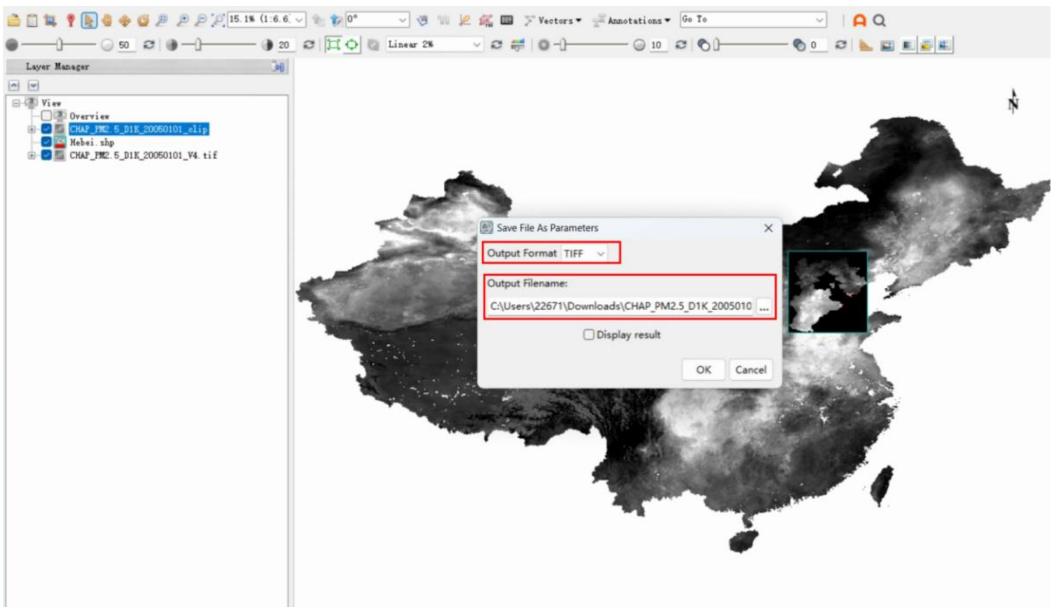
C:\Users\22671\Downloads\CHAP_PM2.5_D1K_20C

OK | Cancel

The resulting NDVI _ ROI was exported to tif format for analysis in ArcGIS (The MOD1301.A2016353.250m_16_days_ NDVI _ 1 _ ROI in the left column is not exported, and its format is ENVIs own data format. ENP),

Notes: this step need to pay special attention to is that the metadata storage path for English, otherwise error: SaveRasterFile failed: IDLnaMetadata Error. when exported to raster data, ENVI need to read input file metadata (metadata), if the path in Chinese, can lead to read to report the error, you can change the storage path.




Layer Manager

View
Overview
CHAP_PM2.5_D1K_20050101_clip
Hebei.shp
CHAP_PM2.5_D1K_20050101_V4.tif

Save File As Parameters

Output Format TIFF

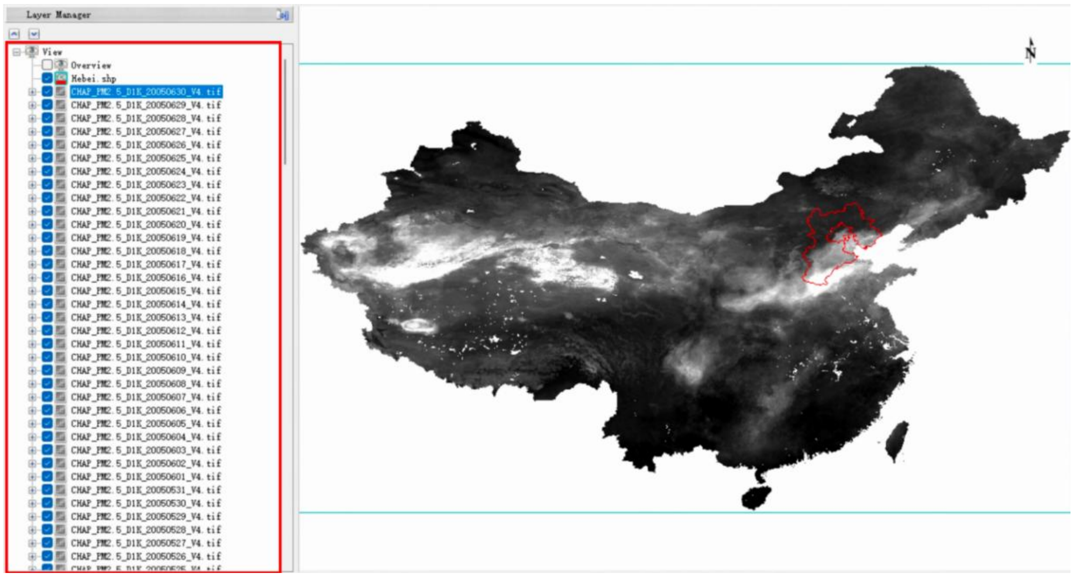
Output Filename:
C:\Users\22671\Downloads\CHAP_PM2.5_D1K_2005010

Display result

OK Cancel

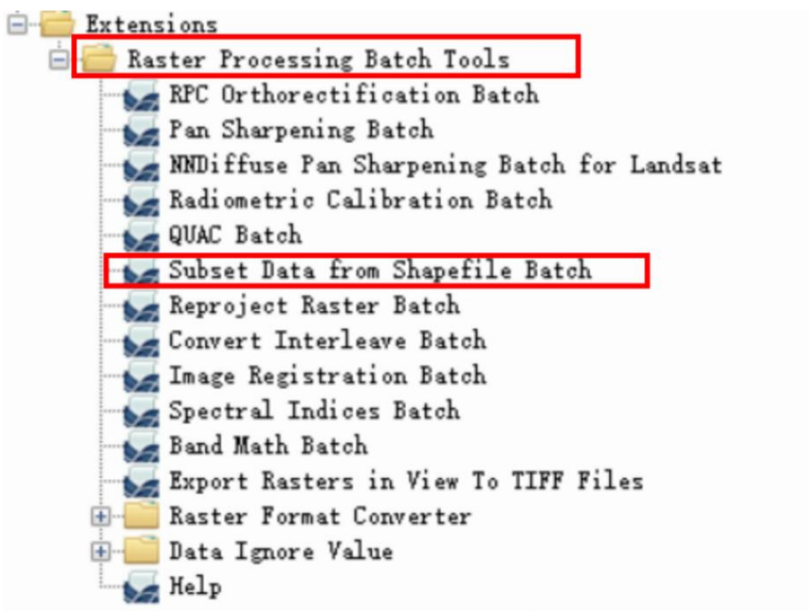
3.2.2 Batch processing method

① Import all the tif data and the target area shp data into the left column:


Layer Manager

View
Overview
Hebei.shp
CHAP_PM2.5_D1K_20050630_V4.tif
CHAP_PM2.5_D1K_20050629_V4.tif
CHAP_PM2.5_D1K_20050628_V4.tif
CHAP_PM2.5_D1K_20050627_V4.tif
CHAP_PM2.5_D1K_20050626_V4.tif
CHAP_PM2.5_D1K_20050625_V4.tif
CHAP_PM2.5_D1K_20050624_V4.tif
CHAP_PM2.5_D1K_20050623_V4.tif
CHAP_PM2.5_D1K_20050622_V4.tif
CHAP_PM2.5_D1K_20050621_V4.tif
CHAP_PM2.5_D1K_20050620_V4.tif
CHAP_PM2.5_D1K_20050619_V4.tif
CHAP_PM2.5_D1K_20050618_V4.tif
CHAP_PM2.5_D1K_20050617_V4.tif
CHAP_PM2.5_D1K_20050616_V4.tif
CHAP_PM2.5_D1K_20050615_V4.tif
CHAP_PM2.5_D1K_20050614_V4.tif
CHAP_PM2.5_D1K_20050613_V4.tif
CHAP_PM2.5_D1K_20050612_V4.tif
CHAP_PM2.5_D1K_20050611_V4.tif
CHAP_PM2.5_D1K_20050610_V4.tif
CHAP_PM2.5_D1K_20050609_V4.tif
CHAP_PM2.5_D1K_20050608_V4.tif
CHAP_PM2.5_D1K_20050607_V4.tif
CHAP_PM2.5_D1K_20050606_V4.tif
CHAP_PM2.5_D1K_20050605_V4.tif
CHAP_PM2.5_D1K_20050604_V4.tif
CHAP_PM2.5_D1K_20050603_V4.tif
CHAP_PM2.5_D1K_20050602_V4.tif
CHAP_PM2.5_D1K_20050601_V4.tif
CHAP_PM2.5_D1K_20050531_V4.tif
CHAP_PM2.5_D1K_20050530_V4.tif
CHAP_PM2.5_D1K_20050529_V4.tif
CHAP_PM2.5_D1K_20050528_V4.tif
CHAP_PM2.5_D1K_20050527_V4.tif
CHAP_PM2.5_D1K_20050526_V4.tif
CHAP_PM2.5_D1K_20050525_V4.tif

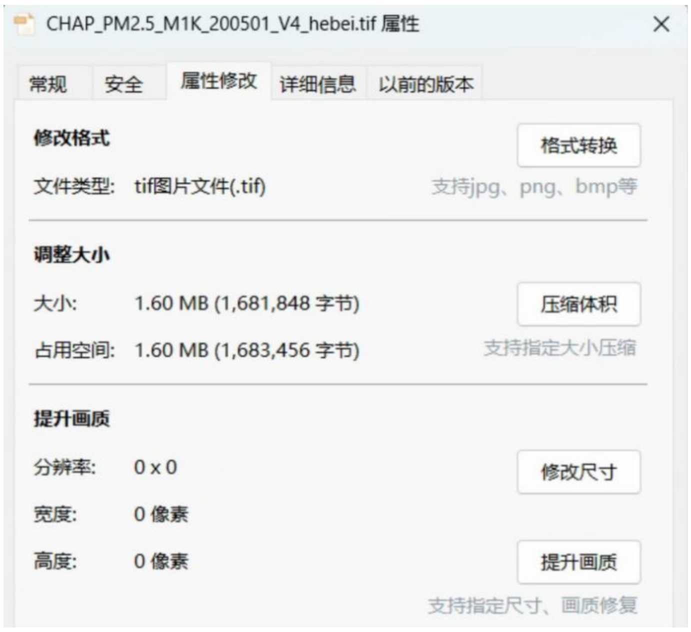
② First, you need to install the ENVI software App Store (software store), and then install the ENVI raster image batch toolkit plug-in: Raster Processing Batch Tools toolkit, used in which: Subset Data from Shapefile Batch;


Extensions
Raster Processing Batch Tools
RPC Orthorectification Batch
Pan Sharpening Batch
NNDiffuse Pan Sharpening Batch for Landsat
Radiometric Calibration Batch
QUAC Batch
Subset Data from Shapefile Batch
Reproject Raster Batch
Convert Interleave Batch
Image Registration Batch
Spectral Indices Batch
Band Math Batch
Export Rasters in View To TIFF Files
Raster Format Converter
Data Ignore Value
Help

③ Batch grid trimming using the Subset Data from Shapefile Batch (extracted data subset from Shapefile batch) plugin in the kit.

- Select all the grid data to be processed,
- Enter the Shapefile file for the target area administrative area as a cut mask,
- Set the output suffix, and the default suffix is. And dat, be sure to change it manually to.

The tif, so that by eliminating the IDL conversion. The dta is given as follows. This tif step![This step cannot move. The dat format should be generated along the line first. In dat format and then converted with IDL into. Tif; if forced to change the suffix to. The tif, will get. A tif file, but with a pixel of 0!!!!!!!!!!】


CHAP_PM2.5_M1K_200501_V4_hebei.tif 属性

修改格式

文件类型: tif图片文件(.tif)

调整大小

大小: 1.60 MB (1,681,848 字节)

占用空间: 1.60 MB (1,683,456 字节)

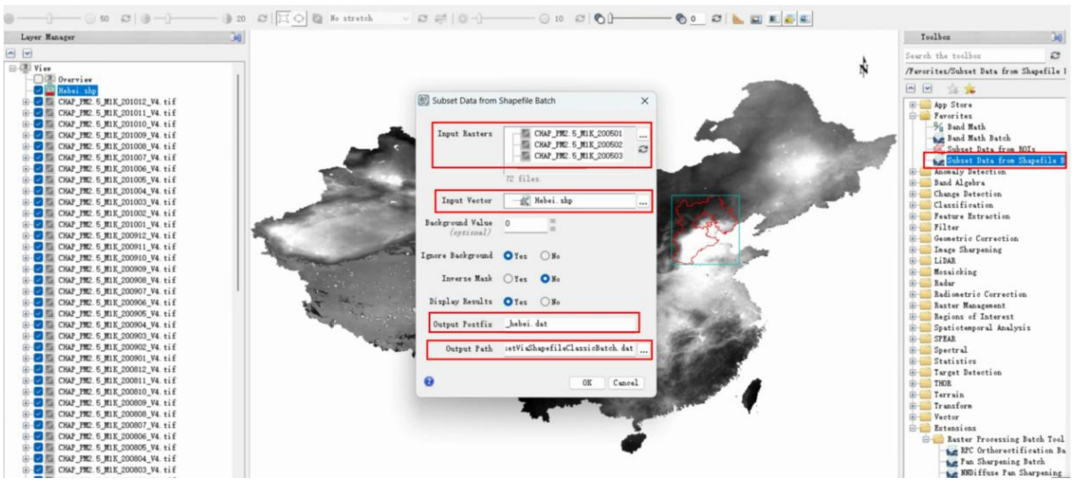
提升画质

分辨率: 0 x 0

宽度: 0 像素

高度: 0 像素

- Set up the output path.


Subset Data from Shapefile Batch

Input Rasters: CHAP_PM2.5_M1K_200501, CHAP_PM2.5_M1K_200502, CHAP_PM2.5_M1K_200503 (72 files)

Input Vector: Hebei.shp

Background Value (optional): 0

Ignore Background: [✓ Yes] No

Inverse Mask: Yes [✓ No]

Display Results: [✓ Yes] No

Output Postfix: _hebei.dat

Output Path: setViaShapefileClassicBatch.dat

Notes:

1. ENVI internal storage space is 32000M, so too large data can only be imported in batches and processed, and cannot be imported at one time. You cant do it all at once. Can only cut into small pieces, bit by bit.
2. After 6 years of DAY data, the nc status file size is about 15G, about 170G after conversion to tif format, and the tailoring will be generated. The engineering file with the enp suffix is about 20G in size; if the memory exceeds the disk memory, the ENVI software flashes back to import data. (https://wenku.csdn.net/answer/3q6b580tih)

3.3 IDL batch conversion dat to the tif file

This way is safe and does not break the tif file by making it pixel 0.

IDL code:

```
;+
; :Description:
;    Batch Convert Dat to Tif
;
; :Author: YangZeping
; :Date: 2024.05.07
;-

pro dat_to_tif
  envi = ENVI()                             ; 初始化 ENVI 对象
```

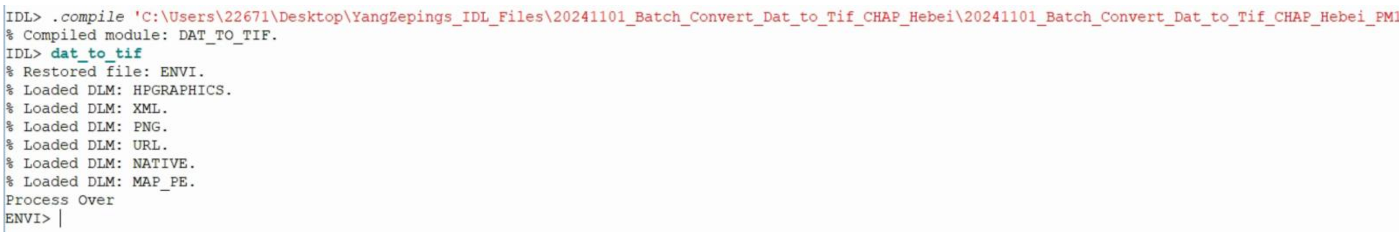
```
 dat_dir =
'C:\Users\22671\Desktop\YangZepings_IDL_Files\20241101_Batch_Convert_Dat_to_Tif_CHAP_Hebei\CHAP_PM25_1KM\MONTH_2005_2010_hebei_dat\'        ; 设置.dat 文件的目录
 tif_dir =
'C:\Users\22671\Desktop\YangZepings_IDL_Files\20241101_Batch_Convert_Dat_to_Tif_CHAP_Hebei\CHAP_PM25_1KM\MONTH_2005_2010_hebei_tif\'    ; 设置输出.tif 文件的目录
 file=file_search(dat_dir,'*dat',count = num); 在 dat_dir 中搜索所有.dat 文件，并返回文件列表及文件个数

 for i=0, num-1 do begin                ; 对于每个找到的.dat 文件执行循环
  raster = envi.OpenRaster(file[i])       ; 打开当前.dat 文件作为 raster 对象
  dat_filename = strsplit(file[i], '\' ,/EXTRACT) ; 从文件路径中提取文件名
  dat_filename = dat_filename[-1]         ; 获取文件路径中的最后一个元素 (即文件名)

  ; 改进部分: 移除文件名中的".dat"扩展名
  dat_filename = strmid(dat_filename, 0, strlen(dat_filename) - 4) ; 移除文件名最后的四个字符(".dat")

  tif_filename = dat_filename + '.tif'     ; 将文件扩展名改为.tif
  tif_path = tif_dir + tif_filename        ; 构造输出的完整.tif 文件路径
  raster.Export, tif_path, 'TIFF'          ; 导出 raster 为 TIFF 格式到指定路径
 endfor                                 ; 结束循环
 print,'Process Over'                   ; 打印处理完成的消息
end
```
IDL code

Enter the command in the command line to run the script:

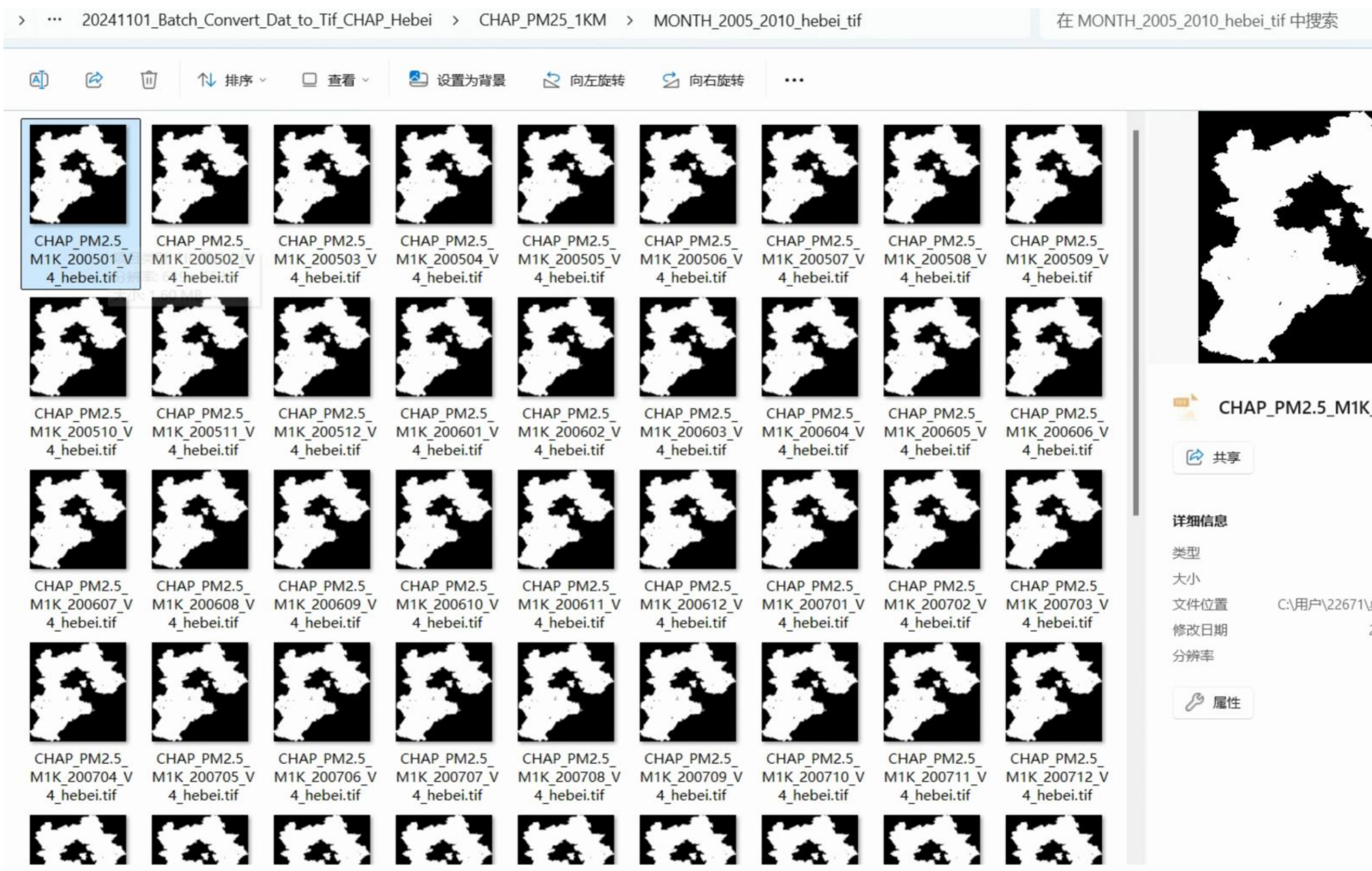
```
.compile
'C:\Users\22671\Desktop\YangZepings_IDL_Files\20241101_Batch_Convert_Dat_to_Tif_CHAP_Hebei\20241101_Batch_Convert_Dat_to_Tif_CHAP_Hebei_PM25_Month.pro'
dat_to_tif
```

Stata Ado

computational results:



```
IDL> .compile 'C:\Users\22671\Desktop\YangZepings_IDL_Files\20241101_Batch_Convert_Dat_to_Tif_CHAP_Hebei\20241101_Batch_Convert_Dat_to_Tif_CHAP_Hebei_PM
% Compiled module: DAT_TO_TIF.
IDL> dat_to_tif
% Restored file: ENVI.
% Loaded DLM: HPGRAPHICS.
% Loaded DLM: XML.
% Loaded DLM: PNG.
% Loaded DLM: URL.
% Loaded DLM: NATIVE.
% Loaded DLM: MAP_PE.
Process Over
ENVI> |
```


› ··· 20241101_Batch_Convert_Dat_to_Tif_CHAP_Hebei › CHAP_PM25_1KM › MONTH_2005_2010_hebei_tif
在 MONTH_2005_2010_hebei_tif 中搜索
排序
查看
设置为背景
向左旋转
向右旋转
CHAP_PM2.5_M1K_200501_V4_hebei.tif
CHAP_PM2.5_M1K_200502_V4_hebei.tif
CHAP_PM2.5_M1K_200503_V4_hebei.tif
CHAP_PM2.5_M1K_200504_V4_hebei.tif
CHAP_PM2.5_M1K_200505_V4_hebei.tif
CHAP_PM2.5_M1K_200506_V4_hebei.tif
CHAP_PM2.5_M1K_200507_V4_hebei.tif
CHAP_PM2.5_M1K_200508_V4_hebei.tif
CHAP_PM2.5_M1K_200509_V4_hebei.tif
CHAP_PM2.5_M1K_200510_V4_hebei.tif
CHAP_PM2.5_M1K_200511_V4_hebei.tif
CHAP_PM2.5_M1K_200512_V4_hebei.tif
CHAP_PM2.5_M1K_200601_V4_hebei.tif
CHAP_PM2.5_M1K_200602_V4_hebei.tif
CHAP_PM2.5_M1K_200603_V4_hebei.tif
CHAP_PM2.5_M1K_200604_V4_hebei.tif
CHAP_PM2.5_M1K_200605_V4_hebei.tif
CHAP_PM2.5_M1K_200606_V4_hebei.tif
CHAP_PM2.5_M1K_200607_V4_hebei.tif
CHAP_PM2.5_M1K_200608_V4_hebei.tif
CHAP_PM2.5_M1K_200609_V4_hebei.tif
CHAP_PM2.5_M1K_200610_V4_hebei.tif
CHAP_PM2.5_M1K_200611_V4_hebei.tif
CHAP_PM2.5_M1K_200612_V4_hebei.tif
CHAP_PM2.5_M1K_200701_V4_hebei.tif
CHAP_PM2.5_M1K_200702_V4_hebei.tif
CHAP_PM2.5_M1K_200703_V4_hebei.tif
CHAP_PM2.5_M1K_200704_V4_hebei.tif
CHAP_PM2.5_M1K_200705_V4_hebei.tif
CHAP_PM2.5_M1K_200706_V4_hebei.tif
CHAP_PM2.5_M1K_200707_V4_hebei.tif
CHAP_PM2.5_M1K_200708_V4_hebei.tif
CHAP_PM2.5_M1K_200709_V4_hebei.tif
CHAP_PM2.5_M1K_200710_V4_hebei.tif
CHAP_PM2.5_M1K_200711_V4_hebei.tif
CHAP_PM2.5_M1K_200712_V4_hebei.tif
CHAP_PM2.5_M1K
共享
详细信息
类型
大小
文件位置 C:\用户\22671\
修改日期
分辨率
属性

4. Python calls ArcGIS batch transform raster data to dbf table
Optional: Remove the tif file name. replace it with: _ or not.
For example, PM2.5.tif should be converted to PM25.tif; PM10 is not required.

Python Code are as follows:

```
# coding=utf-8


import os


# 设置包含 tif 文件的目录
directory = r"C:\Users\22671\Desktop\YangZepings Python Files\20241031 convert tif
to xlsx\CHAP_PM2.5_1KM\MONTH_2005_2010_hebei_tif"


# 遍历目录中的所有文件
for filename in os.listdir(directory):
    if filename.endswith(".tif"): # 确认文件是 tif 文件
        # 将文件名和扩展名分离
        name_part, extension = os.path.splitext(filename)


        # 替换文件名中的所有点为下划线，除了扩展名前的最后一个点
        new_name_part = name_part.replace('.', '')


        # 重新组合新的文件名和扩展名
        new_filename = new_name_part + extension


        # 构建完整的旧文件路径和新文件路径
        old_file = os.path.join(directory, filename)
        new_file = os.path.join(directory, new_filename)


        # 重命名文件
        os.rename(old_file, new_file)
        print("Renamed '{filename}' to '{new_filename}'")
                                                                          Python
```

4.1 Black areas were removed using the Mask function
Python Code are as follows:

```
# coding=utf-8

import arcpy  # 导入 ArcPy 库，它是与 ArcGIS Desktop 交互的 Python 库

arcpy.CheckOutExtension('spatial') # 检查并借出空间分析工具的许可证

arcpy.gp.overwriteOutput = 1  # 设置工具执行的输出可以覆盖现有文件

arcpy.env.workspace = "C:\\Users\\22671\\Desktop\YangZepings Python
Files\\20241031 convert tif to
xlsx\\CHAP_PM25_1KM\\MONTH_2005_2010_hebei_tif"  # 设置 ArcPy 环境的工作
空间，所有文件操作都在这个目录下

# 裁剪栅格
rasters = arcpy.ListRasters('*', 'tif') # 列出工作空间中所有的 tif 格式栅格文件
arcpy.AddMessage(rasters)  # 将栅格文件列表输出到 ArcGIS 的消息窗口

# 裁剪 shp
mask = "C:\\Users\\22671\\Desktop\\YangZepings Python Files\\20241031 convert tif
to xlsx\\Hebei\\Hebei.shp"  # 设置用于裁剪的形状文件（shp）的路径

for raster in rasters:  # 遍历所有栅格文件
    print(raster)  # 在控制台打印当前处理的栅格文件名
    out = "C:\\Users\\22671\\Desktop\YangZepings Python Files\\20241031 convert tif
```

```
to xlsx\\CHAP_PM25_1KM\\MONTH_2005_2010_hebei_tif_Mask\\" + raster[:-4] +
"_MASK.tif"  # 设置输出文件的路径及名称

    arcpy.gp.ExtractByMask_sa(raster, mask, out) # 使用指定的 shp 文件对栅格文件进
行裁剪, 并保存到指定的输出路径

print("OK") # 当所有栅格文件处理完成后在控制台输出"OK"

                                                                        Python
```

4.2 Turn the grid tif to a vector point shp

Python Code are as follows:

```
# coding=utf-8

import arcpy # 导入 ArcPy 库, 用于执行地理空间数据分析、数据转换等
from arcpy import env # 从 arcpy 导入 env 模块, 用于环境设置
from arcpy.sa import * # 从 arcpy 的空间分析模块导入所有功能
import os # 导入 os 模块, 用于处理文件和目录
import os.path # 导入 os.path 模块, 用于路径相关操作
import sys, string # 导入 sys 和 string 模块, sys 用于访问与 Python 解释器紧密相
关的变量和函数, string 用于常见的字符串操作

arcpy.gp.overwriteOutput = 1 # 设置工具执行的输出可以覆盖现有文件

dir = r"C:\Users\22671\Desktop\YangZepings Python Files\20241031 convert tif to
xlsx\CHAP_PM25_1KM\MONTH_2005_2010_hebei_tif_Mask/" # 设置要处理的栅格数
据所在的目录; 此处 r 是声明\保留原意而非作为转义符; 结尾正斜杠是所以系统都接
受的路径分隔符

filenames = os.listdir(dir) # 列出指定目录下的所有文件名
```

```
for filename in filenames: # 遍历文件名列表
    if os.path.splitext(filename)[1] == '.tif': # 检查文件扩展名是否为.tif, 由于文件名中自带 2 个点, 总计 3 个点, 因此后缀位于 0123 的 3
        inRaster = dir + filename # 构建完整的栅格文件路径
        Output_Workspace = r"C:\Users\22671\Desktop\YangZepings Python Files\20241031 convert tif to xlsx\CHAP_PM25_1KM\MONTH_2005_2010_hebei_tif_Mask_shp/" # 设置输出点文件的工作空间
        basename = filename[:-4] + '_Point' # 从文件名移除扩展名, 并添加'_Point'作为新的基础名
        outPoint = Output_Workspace + basename + '.shp' # 构建输出点矢量文件的完整路径
        field = "VALUE" # 设置用于点矢量数据的字段名
        print(inRaster, outPoint, field)
        arcpy.RasterToPoint_conversion(inRaster, outPoint, field) # 执行栅格到点的转换
print("ok") # 处理完成后在控制台输出"ok"
```
Python

4.3 To convert the Attribute Table batch of the shp file to a dbf table

To facilitate subsequent batch processing, this file type can be read in as dataframe by the rio package of R

Python Code are as follows:

```
# coding=utf-8

import arcpy
import os

# 设置工作空间目录 (包含待转换的地理数据文件)
input_folder = r"C:\Users\22671\Desktop\YangZepings Python Files\20241031 convert tif to xlsx\CHAP_PM25_1KM\MONTH_2005_2010_hebei_tif_Mask_shp"
```

```python
output_folder = r"C:\Users\22671\Desktop\YangZepings Python Files\20241031
convert tif to xlsx\CHAP_PM25_1KM\MONTH_2005_2010_hebei_tif_Mask_shp_dbf"

# 创建输出文件夹（如果不存在）
if not os.path.exists(output_folder):
    os.makedirs(output_folder)

# 获取输入文件夹中的所有要素类（例如 shapefile）
arcpy.env.workspace = input_folder
feature_classes = arcpy.ListFeatureClasses()

# 遍历每个要素类并导出属性表为 .dbf 文件
for fc in feature_classes:
    # 获取要素类名称并设置输出 .dbf 文件路径
    fc_name = os.path.splitext(os.path.basename(fc))[0]
    dbf_output_path = os.path.join(output_folder, "{}.dbf".format(fc_name))

    # 将属性表导出为 .dbf 文件
    arcpy.TableToTable_conversion(fc, output_folder, "{}.dbf".format(fc_name))

    print("Exported {} to {}".format(fc, dbf_output_path))

print("属性表批量转换为 dbf 完成！")
```
Python

However, note that the resulting dbf file needs to be processed by the following R code:

```r
# import
dt <- rio::import("CHAP_PM25_M1K_200501_V4_hebei_MASK_Point.dbf")
```

```
# pointid to FID
dt3$pointid <- dt3$pointid - 1
names(dt3)[1] <- "FID"
 ## 做完这两步其实已经是 R 中的 Dataframe 格式，并且数据准确，可以直接使用！

# export
rio::export(dt, "CHAP_PM25_M1K_200501_V4_hebei_MASK_Point.xlsx")
                                                                                R
```

4.4 FID in the matching address Address and FID in the attribute table / dbf

It is convenient to match air pollution data in batches, and facilitate data merging (all time point air pollution data are merged into one file with ID)

Python Code are as follows:

```
# coding=utf-8

# 导入所需的 Python 库
import arcpy
import os

# 允许覆盖现有输出文件
arcpy.env.overwriteOutput = True

# 设置工作空间
arcpy.env.workspace = r"C:\Users\22671\Desktop\YangZepings Python
Files\20241031 convert tif to
xlsx\CHAP_PM25_1KM\MONTH_2005_2010_hebei_Match_ID_to_FID"

# 复制并重命名原始的 shp 文件以进行分析
original_shp = "Address_18369.shp"
new_shp = "Address_18369_ID_Match_CHAP_PM25_M1K_195307_FID.shp"
```

```
arcpy.CopyFeatures_management(original_shp, new_shp)

# 进行近邻分析
in_features = new_shp
near_features = "CHAP_PM25_M1K_200501_V4_hebei_MASK_Point.shp"
search_radius = "1000 Meters"

arcpy.Near_analysis(in_features, near_features, search_radius, "", "", "PLANAR")
print("Near analysis completed successfully.")

# 将近邻分析得到的结果 shp 文件导出为 xls
xls = "Address_18369_ID_Match_CHAP_PM25_M1K_195307_FID.xls"
arcpy.TableToExcel_conversion(new_shp, xls)
print("Shapefile successfully exported to Excel.")
                                                                  Python
```

5 Use the R language to merge data + dynamically extract the value and construct a specific time window

5.1 R language combined data

Merge variable data at multiple time points using the following R language:

```
# 04 合并 2005-2010 月均 PM 数据为一整体 ----
## 04-1 PM25 ----
# 加载所需的包
{
  library(rio)
  library(dplyr)
}

# 设置数据路径和结果路径
Data_dir <- "/Users/yangzeping/Desktop/YangZeping's R Files/2024.09.09 毕业设计-河
```

```r
北 RCT/Data/CHAP_PM25_1KM_MONTH_2005_2010_hebei_dbf"
Data1_dir <- "/Users/yangzeping/Desktop/YangZeping's R Files/2024.09.09 毕业设计-河
北 RCT/Data"
Results_dir <- "/Users/yangzeping/Desktop/YangZeping's R Files/2024.09.09 毕业设计-
河北 RCT/Results"

setwd(Data_dir)


# 读取主数据集
main_df <- rio::import("ID_CHAP_PM25_M1K_FID.xls")

# 定义月份列表
months <- format(seq(as.Date("2005-01-01"), as.Date("2010-12-01"), by = "month"),
"%Y%m")

# 循环处理每个月份的数据
for (ym in months) {
 dbf_filename <- sprintf("CHAP_PM25_M1K_%s_V4_hebei_MASK_Point.dbf", ym)

 # 读取 dbf 文件并进行预处理
 month_df <- import(file.path(Data_dir, dbf_filename))
 month_df$pointid <- month_df$pointid - 1
 names(month_df) <- c("FID", paste0("PM25_1km_m_", ym)) # 此处 【PM25 需要根据
变量进行修改】

 # 合并数据集, 使用 dplyr 的 left_join 进行匹配
 main_df <- main_df %>%
  left_join(month_df, by = "FID")
}
```

```r
# 剔除 FID 这列(已无用)
library(dplyr)
main_df <- main_df %>%
  select(-FID)

# 结果保存
setwd(Data1_dir)
rio::export(main_df, "PM25_200501_201012_1km_monthly.rds")

setwd(Results_dir)
rio::export(main_df, "PM25_200501_201012_1km_monthly.xlsx")
rio::export(main_df, "PM25_200501_201012_1km_monthly.rds")

## 04-2 PM10 ----
# 加载所需的包
{
  library(rio)
  library(dplyr)
}

# 设置数据路径和结果路径
Data_dir <- "/Users/yangzeping/Desktop/YangZeping's R Files/2024.09.09 毕业设计-河
北 RCT/Data/CHAP_PM10_1KM_MONTH_2005_2010_hebei_dbf"
Data1_dir <- "/Users/yangzeping/Desktop/YangZeping's R Files/2024.09.09 毕业设计-河
北 RCT/Data"
Results_dir <- "/Users/yangzeping/Desktop/YangZeping's R Files/2024.09.09 毕业设计-
河北 RCT/Results"

setwd(Data_dir)
```

```r
# 读取主数据集
main_df <- rio::import("ID_CHAP_PM10_M1K_FID.xls")

# 定义月份列表
months <- format(seq(as.Date("2005-01-01"), as.Date("2010-12-01"), by = "month"),
"%Y%m")

# 循环处理每个月份的数据
for (ym in months) {
 dbf_filename <- sprintf("CHAP_PM10_M1K_%s_V4_hebei_MASK_Point.dbf", ym)

 # 读取 dbf 文件并进行预处理
 month_df <- import(file.path(Data_dir, dbf_filename))
 month_df$pointid <- month_df$pointid - 1
 names(month_df) <- c("FID", paste0("PM10_1km_m_", ym)) # 此处 【PM10 需要根据
变量进行修改】

 # 合并数据集, 使用 dplyr 的 left_join 进行匹配
 main_df <- main_df %>%
  left_join(month_df, by = "FID")
}

# 剔除 FID 这列(已无用)
library(dplyr)
main_df <- main_df %>%
 select(-FID)

# 结果保存
```

```r
setwd(Data1_dir)
rio::export(main_df, "PM10_200501_201012_1km_monthly.rds")

setwd(Results_dir)
rio::export(main_df, "PM10_200501_201012_1km_monthly.xlsx")
rio::export(main_df, "PM10_200501_201012_1km_monthly.rds")
```

R

5.2 Use the R language to dynamically extract the actual value and construct the variables for a specific time window

To dynamically extract and construct variables for a specific time window using the following R code:

```r
# 06-1 构造 Monthly 1st_trimester 2nd_trimester 3rd_trimester ave_first_3_trimester PM25 PM10_规避 3rd trimester 溢出问题
  ## Author: YangZeping
  ## Date: 2024-11-09

# 01 根据 LMP 计算时间窗所需变量 ----
## 加载包 ----
{
  library(rio)
  library(tidyverse)
  library(lubridate)
}

## 设置路径 ----
Data_dir <- "/Users/yangzeping/Desktop/YangZeping's R Files/2024.09.09 毕业设计-河北 RCT/Data"
Results_dir <- "/Users/yangzeping/Desktop/YangZeping's R Files/2024.09.09 毕业设计-河北 RCT/Results"
```

```
setwd(Data_dir)

### PM25_200501_201012_1km_monthly ----
# 数据导入
dt <-
rio::import("Id_LMP_Birth_date_Gest_day_Gest_wk_Gest_mth_18089_20241107.rds")

# 空气污染数据导入
PM25 <- rio::import("PM25_200501_201012_1km_monthly.rds")
dt_PM25 <- left_join(dt, PM25, by = "ID")

# 转换日期格式并生成年份和月份变量
dt_PM25 <- dt_PM25 %>%
  mutate(
    LMP_date = ymd(LMP),
    lmp_year = year(LMP_date),
    lmp_month = month(LMP_date),

    # 孕前 9 个月的年份和月份变量
    y_pre_9m = lmp_year, y_pre_8m = lmp_year, y_pre_7m = lmp_year,
    y_pre_6m = lmp_year, y_pre_5m = lmp_year, y_pre_4m = lmp_year,
    y_pre_3m = lmp_year, y_pre_2m = lmp_year, y_pre_1m = lmp_year,

    m_pre_9m = lmp_month - 9, m_pre_8m = lmp_month - 8, m_pre_7m = lmp_month -
7,
    m_pre_6m = lmp_month - 6, m_pre_5m = lmp_month - 5, m_pre_4m = lmp_month -
4,
    m_pre_3m = lmp_month - 3, m_pre_2m = lmp_month - 2, m_pre_1m = lmp_month -
1,
    # 孕后 12 个月的年份和月份变量
    y_post_1m = Imp_year, y_post_2m = Imp_year, y_post_3m = Imp_year,
    y_post_4m = Imp_year, y_post_5m = Imp_year, y_post_6m = Imp_year,
    y_post_7m = Imp_year, y_post_8m = Imp_year, y_post_9m = Imp_year,
    y_post_10m = Imp_year, y_post_11m = Imp_year, y_post_12m = Imp_year,

    m_post_1m = Imp_month, m_post_2m = Imp_month + 1, m_post_3m = Imp_month +
2,
    m_post_4m = Imp_month + 3, m_post_5m = Imp_month + 4, m_post_6m =
Imp_month + 5,
    m_post_7m = Imp_month + 6, m_post_8m = Imp_month + 7, m_post_9m =
Imp_month + 8,
    m_post_10m = Imp_month + 9, m_post_11m = Imp_month + 10, m_post_12m =
Imp_month + 11
  )

# 处理跨年数据
dt_PM25 <- dt_PM25 %>%
  mutate(
    across(
      .cols = starts_with("y_"),
      .fns = ~ ifelse(get(sub("y_", "m_", cur_column())) <= 0, . - 1,
                      ifelse(get(sub("y_", "m_", cur_column())) > 12, . + 1, .))
    ),
    across(
      .cols = starts_with("m_"),
      .fns = ~ ifelse(. <= 0, . + 12, ifelse(. > 12, . - 12, .))
    )
  )
```

```r
# 生成动态变量名
dt_PM25 <- dt_PM25 %>%
  mutate(
    PM25_pre_9m = paste0("PM25_1km_m_", y_pre_9m, sprintf("%02d", m_pre_9m)),
    PM25_pre_8m = paste0("PM25_1km_m_", y_pre_8m, sprintf("%02d", m_pre_8m)),
    PM25_pre_7m = paste0("PM25_1km_m_", y_pre_7m, sprintf("%02d", m_pre_7m)),
    PM25_pre_6m = paste0("PM25_1km_m_", y_pre_6m, sprintf("%02d", m_pre_6m)),
    PM25_pre_5m = paste0("PM25_1km_m_", y_pre_5m, sprintf("%02d", m_pre_5m)),
    PM25_pre_4m = paste0("PM25_1km_m_", y_pre_4m, sprintf("%02d", m_pre_4m)),
    PM25_pre_3m = paste0("PM25_1km_m_", y_pre_3m, sprintf("%02d", m_pre_3m)),
    PM25_pre_2m = paste0("PM25_1km_m_", y_pre_2m, sprintf("%02d", m_pre_2m)),
    PM25_pre_1m = paste0("PM25_1km_m_", y_pre_1m, sprintf("%02d", m_pre_1m)),

    PM25_post_1m = paste0("PM25_1km_m_", y_post_1m, sprintf("%02d", m_post_1m)),
    PM25_post_2m = paste0("PM25_1km_m_", y_post_2m, sprintf("%02d", m_post_2m)),
    PM25_post_3m = paste0("PM25_1km_m_", y_post_3m, sprintf("%02d", m_post_3m)),
    PM25_post_4m = paste0("PM25_1km_m_", y_post_4m, sprintf("%02d", m_post_4m)),
    PM25_post_5m = paste0("PM25_1km_m_", y_post_5m, sprintf("%02d", m_post_5m)),
    PM25_post_6m = paste0("PM25_1km_m_", y_post_6m, sprintf("%02d", m_post_6m)),
    PM25_post_7m = paste0("PM25_1km_m_", y_post_7m, sprintf("%02d", m_post_7m)),
    PM25_post_8m = paste0("PM25_1km_m_", y_post_8m, sprintf("%02d", m_post_8m)),
    PM25_post_9m = paste0("PM25_1km_m_", y_post_9m, sprintf("%02d", m_post_9m)),
    PM25_post_10m = paste0("PM25_1km_m_", y_post_10m, sprintf("%02d",
m_post_10m)),
    PM25_post_11m = paste0("PM25_1km_m_", y_post_11m, sprintf("%02d",
m_post_11m)),
    PM25_post_12m = paste0("PM25_1km_m_", y_post_12m, sprintf("%02d",
m_post_12m))
  )
```

```
# 存储数据
rio::export(dt_PM25, "PM25_200501_201012_1km_monthly_Pre_9mth_Post_12mth.rds")
setwd(Results_dir)
rio::export(dt_PM25, "PM25_200501_201012_1km_monthly_Pre_9mth_Post_12mth.rds")

### PM10_200501_201012_1km_monthly ----
# 数据导入
setwd(Data_dir)
dt <-
rio::import("Id_LMP_Birth_date_Gest_day_Gest_wk_Gest_mth_18089_20241107.rds")

# 空气污染数据导入
PM10 <- rio::import("PM10_200501_201012_1km_monthly.rds")
dt_PM10 <- left_join(dt, PM10, by = "ID")

# 转换日期格式并生成年份和月份变量
dt_PM10 <- dt_PM10 %>%
  mutate(
    LMP_date = ymd(LMP),
    Imp_year = year(LMP_date),
    Imp_month = month(LMP_date),

    # 孕前 9 个月的年份和月份变量
    y_pre_9m = Imp_year, y_pre_8m = Imp_year, y_pre_7m = Imp_year,
    y_pre_6m = Imp_year, y_pre_5m = Imp_year, y_pre_4m = Imp_year,
    y_pre_3m = Imp_year, y_pre_2m = Imp_year, y_pre_1m = Imp_year,

    m_pre_9m = Imp_month - 9, m_pre_8m = Imp_month - 8, m_pre_7m = Imp_month -
7,
    m_pre_6m = Imp_month - 6, m_pre_5m = Imp_month - 5, m_pre_4m = Imp_month -
```

```
4,
    m_pre_3m = Imp_month - 3, m_pre_2m = Imp_month - 2, m_pre_1m = Imp_month -
1,

    # 孕后 12 个月的年份和月份变量
    y_post_1m = Imp_year, y_post_2m = Imp_year, y_post_3m = Imp_year,
    y_post_4m = Imp_year, y_post_5m = Imp_year, y_post_6m = Imp_year,
    y_post_7m = Imp_year, y_post_8m = Imp_year, y_post_9m = Imp_year,
    y_post_10m = Imp_year, y_post_11m = Imp_year, y_post_12m = Imp_year,

    m_post_1m = Imp_month, m_post_2m = Imp_month + 1, m_post_3m = Imp_month +
2,
    m_post_4m = Imp_month + 3, m_post_5m = Imp_month + 4, m_post_6m =
Imp_month + 5,
    m_post_7m = Imp_month + 6, m_post_8m = Imp_month + 7, m_post_9m =
Imp_month + 8,
    m_post_10m = Imp_month + 9, m_post_11m = Imp_month + 10, m_post_12m =
Imp_month + 11
  )

# 处理跨年数据
dt_PM10 <- dt_PM10 %>%
  mutate(
    across(
      .cols = starts_with("y_"),
      .fns = ~ ifelse(get(sub("y_", "m_", cur_column())) <= 0, . - 1,
                      ifelse(get(sub("y_", "m_", cur_column())) > 12, . + 1, .))
    ),
    across(
      .cols = starts_with("m_"),
      .fns = ~ ifelse(. <= 0, . + 12, ifelse(. > 12, . - 12, .))
    )
  )

# 生成动态变量名
dt_PM10 <- dt_PM10 %>%
  mutate(
    PM10_pre_9m = paste0("PM10_1km_m_", y_pre_9m, sprintf("%02d", m_pre_9m)),
    PM10_pre_8m = paste0("PM10_1km_m_", y_pre_8m, sprintf("%02d", m_pre_8m)),
    PM10_pre_7m = paste0("PM10_1km_m_", y_pre_7m, sprintf("%02d", m_pre_7m)),
    PM10_pre_6m = paste0("PM10_1km_m_", y_pre_6m, sprintf("%02d", m_pre_6m)),
    PM10_pre_5m = paste0("PM10_1km_m_", y_pre_5m, sprintf("%02d", m_pre_5m)),
    PM10_pre_4m = paste0("PM10_1km_m_", y_pre_4m, sprintf("%02d", m_pre_4m)),
    PM10_pre_3m = paste0("PM10_1km_m_", y_pre_3m, sprintf("%02d", m_pre_3m)),
    PM10_pre_2m = paste0("PM10_1km_m_", y_pre_2m, sprintf("%02d", m_pre_2m)),
    PM10_pre_1m = paste0("PM10_1km_m_", y_pre_1m, sprintf("%02d", m_pre_1m)),

    PM10_post_1m = paste0("PM10_1km_m_", y_post_1m, sprintf("%02d", m_post_1m)),
    PM10_post_2m = paste0("PM10_1km_m_", y_post_2m, sprintf("%02d", m_post_2m)),
    PM10_post_3m = paste0("PM10_1km_m_", y_post_3m, sprintf("%02d", m_post_3m)),
    PM10_post_4m = paste0("PM10_1km_m_", y_post_4m, sprintf("%02d", m_post_4m)),
    PM10_post_5m = paste0("PM10_1km_m_", y_post_5m, sprintf("%02d", m_post_5m)),
    PM10_post_6m = paste0("PM10_1km_m_", y_post_6m, sprintf("%02d", m_post_6m)),
    PM10_post_7m = paste0("PM10_1km_m_", y_post_7m, sprintf("%02d", m_post_7m)),
    PM10_post_8m = paste0("PM10_1km_m_", y_post_8m, sprintf("%02d", m_post_8m)),
    PM10_post_9m = paste0("PM10_1km_m_", y_post_9m, sprintf("%02d", m_post_9m)),
    PM10_post_10m = paste0("PM10_1km_m_", y_post_10m, sprintf("%02d",
m_post_10m)),
    PM10_post_11m = paste0("PM10_1km_m_", y_post_11m, sprintf("%02d",
m_post_11m)),
  PM10_post_12m = paste0("PM10_1km_m_", y_post_12m, sprintf("%02d",
m_post_12m))
 )

# 存储数据
rio::export(dt_PM10, "PM10_200501_201012_1km_monthly_Pre_9mth_Post_12mth.rds")
setwd(Results_dir)
rio::export(dt_PM10, "PM10_200501_201012_1km_monthly_Pre_9mth_Post_12mth.rds")

# 02 动态提取计算得到时间窗内环境变量浓度+计算各月浓度+各时间窗浓度 ----
## 加载包 ----
{
 library(rio)
 library(tidyverse)
}

## 设置路径 ----
setwd(Data_dir)

## 导入数据 ----
dt_PM25 <-
rio::import("PM25_200501_201012_1km_monthly__Pre_9mth_post12mth.rds")
dt_PM10 <-
rio::import("PM10_200501_201012_1km_monthly__Pre_9mth_post12mth.rds")

## 动态检索 ----
### 按行操作数据，动态计算 PM25 暴露值，过滤超出 Birth_date 的月份 ----
 # 运行时间会有点久
dt_PM25 <- dt_PM25 %>%
 rowwise() %>% # 按行进行操作，确保每一行独立处理
 mutate(
  # 使用 `if_else` 判断每个月份的暴露值是否超过分娩日期，超出则赋值为 0

  # 孕前 9 到 1 个月的暴露值
  PM25_pre_9m_value = if_else(ymd(paste0(y_pre_9m, sprintf("-%02d", m_pre_9m), "-
01")) <= ymd(Birth_date), get(PM25_pre_9m), 0),
  PM25_pre_8m_value = if_else(ymd(paste0(y_pre_8m, sprintf("-%02d", m_pre_8m), "-
01")) <= ymd(Birth_date), get(PM25_pre_8m), 0),
  PM25_pre_7m_value = if_else(ymd(paste0(y_pre_7m, sprintf("-%02d", m_pre_7m), "-
01")) <= ymd(Birth_date), get(PM25_pre_7m), 0),
  PM25_pre_6m_value = if_else(ymd(paste0(y_pre_6m, sprintf("-%02d", m_pre_6m), "-
01")) <= ymd(Birth_date), get(PM25_pre_6m), 0),
  PM25_pre_5m_value = if_else(ymd(paste0(y_pre_5m, sprintf("-%02d", m_pre_5m), "-
01")) <= ymd(Birth_date), get(PM25_pre_5m), 0),
  PM25_pre_4m_value = if_else(ymd(paste0(y_pre_4m, sprintf("-%02d", m_pre_4m), "-
01")) <= ymd(Birth_date), get(PM25_pre_4m), 0),
  PM25_pre_3m_value = if_else(ymd(paste0(y_pre_3m, sprintf("-%02d", m_pre_3m), "-
01")) <= ymd(Birth_date), get(PM25_pre_3m), 0),
  PM25_pre_2m_value = if_else(ymd(paste0(y_pre_2m, sprintf("-%02d", m_pre_2m), "-
01")) <= ymd(Birth_date), get(PM25_pre_2m), 0),
  PM25_pre_1m_value = if_else(ymd(paste0(y_pre_1m, sprintf("-%02d", m_pre_1m), "-
01")) <= ymd(Birth_date), get(PM25_pre_1m), 0),

  # 孕后 1 到 12 个月的暴露值
  PM25_post_1m_value = if_else(ymd(paste0(y_post_1m, sprintf("-%02d", m_post_1m),
"-01")) <= ymd(Birth_date), get(PM25_post_1m), 0),
  PM25_post_2m_value = if_else(ymd(paste0(y_post_2m, sprintf("-%02d", m_post_2m),
"-01")) <= ymd(Birth_date), get(PM25_post_2m), 0),
  PM25_post_3m_value = if_else(ymd(paste0(y_post_3m, sprintf("-%02d", m_post_3m),
"-01")) <= ymd(Birth_date), get(PM25_post_3m), 0),
   PM25_post_4m_value = if_else(ymd(paste0(y_post_4m, sprintf("-%02d", m_post_4m),
"-01")) <= ymd(Birth_date), get(PM25_post_4m), 0),
   PM25_post_5m_value = if_else(ymd(paste0(y_post_5m, sprintf("-%02d", m_post_5m),
"-01")) <= ymd(Birth_date), get(PM25_post_5m), 0),
   PM25_post_6m_value = if_else(ymd(paste0(y_post_6m, sprintf("-%02d", m_post_6m),
"-01")) <= ymd(Birth_date), get(PM25_post_6m), 0),
   PM25_post_7m_value = if_else(ymd(paste0(y_post_7m, sprintf("-%02d", m_post_7m),
"-01")) <= ymd(Birth_date), get(PM25_post_7m), 0),
   PM25_post_8m_value = if_else(ymd(paste0(y_post_8m, sprintf("-%02d", m_post_8m),
"-01")) <= ymd(Birth_date), get(PM25_post_8m), 0),
   PM25_post_9m_value = if_else(ymd(paste0(y_post_9m, sprintf("-%02d", m_post_9m),
"-01")) <= ymd(Birth_date), get(PM25_post_9m), 0),
   PM25_post_10m_value = if_else(ymd(paste0(y_post_10m, sprintf("-%02d",
m_post_10m), "-01")) <= ymd(Birth_date), get(PM25_post_10m), 0),
   PM25_post_11m_value = if_else(ymd(paste0(y_post_11m, sprintf("-%02d",
m_post_11m), "-01")) <= ymd(Birth_date), get(PM25_post_11m), 0),
   PM25_post_12m_value = if_else(ymd(paste0(y_post_12m, sprintf("-%02d",
m_post_12m), "-01")) <= ymd(Birth_date), get(PM25_post_12m), 0)
 ) %>%
 ungroup() # 取消按行分组，恢复数据框到标准列操作

### 按行操作数据，动态计算 PM10 暴露值，过滤超出 Birth_date 的月份 ----
dt_PM10 <- dt_PM10 %>%
 rowwise() %>% # 按行进行操作，确保每一行独立处理
 mutate(
   # 使用 `if_else` 判断每个月份的暴露值是否超过分娩日期，超出则赋值为 0

   # 孕前 9 到 1 个月的暴露值
   PM10_pre_9m_value = if_else(ymd(paste0(y_pre_9m, sprintf("-%02d", m_pre_9m), "-
01")) <= ymd(Birth_date), get(PM10_pre_9m), 0),
  PM10_pre_8m_value = if_else(ymd(paste0(y_pre_8m, sprintf("-%02d", m_pre_8m), "-01")) <= ymd(Birth_date), get(PM10_pre_8m), 0),
  PM10_pre_7m_value = if_else(ymd(paste0(y_pre_7m, sprintf("-%02d", m_pre_7m), "-01")) <= ymd(Birth_date), get(PM10_pre_7m), 0),
  PM10_pre_6m_value = if_else(ymd(paste0(y_pre_6m, sprintf("-%02d", m_pre_6m), "-01")) <= ymd(Birth_date), get(PM10_pre_6m), 0),
  PM10_pre_5m_value = if_else(ymd(paste0(y_pre_5m, sprintf("-%02d", m_pre_5m), "-01")) <= ymd(Birth_date), get(PM10_pre_5m), 0),
  PM10_pre_4m_value = if_else(ymd(paste0(y_pre_4m, sprintf("-%02d", m_pre_4m), "-01")) <= ymd(Birth_date), get(PM10_pre_4m), 0),
  PM10_pre_3m_value = if_else(ymd(paste0(y_pre_3m, sprintf("-%02d", m_pre_3m), "-01")) <= ymd(Birth_date), get(PM10_pre_3m), 0),
  PM10_pre_2m_value = if_else(ymd(paste0(y_pre_2m, sprintf("-%02d", m_pre_2m), "-01")) <= ymd(Birth_date), get(PM10_pre_2m), 0),
  PM10_pre_1m_value = if_else(ymd(paste0(y_pre_1m, sprintf("-%02d", m_pre_1m), "-01")) <= ymd(Birth_date), get(PM10_pre_1m), 0),

  # 孕后 1 到 12 个月的暴露值
  PM10_post_1m_value = if_else(ymd(paste0(y_post_1m, sprintf("-%02d", m_post_1m), "-01")) <= ymd(Birth_date), get(PM10_post_1m), 0),
  PM10_post_2m_value = if_else(ymd(paste0(y_post_2m, sprintf("-%02d", m_post_2m), "-01")) <= ymd(Birth_date), get(PM10_post_2m), 0),
  PM10_post_3m_value = if_else(ymd(paste0(y_post_3m, sprintf("-%02d", m_post_3m), "-01")) <= ymd(Birth_date), get(PM10_post_3m), 0),
  PM10_post_4m_value = if_else(ymd(paste0(y_post_4m, sprintf("-%02d", m_post_4m), "-01")) <= ymd(Birth_date), get(PM10_post_4m), 0),
  PM10_post_5m_value = if_else(ymd(paste0(y_post_5m, sprintf("-%02d", m_post_5m), "-01")) <= ymd(Birth_date), get(PM10_post_5m), 0),
  PM10_post_6m_value = if_else(ymd(paste0(y_post_6m, sprintf("-%02d", m_post_6m), "-01")) <= ymd(Birth_date), get(PM10_post_6m), 0),
    PM10_post_7m_value = if_else(ymd(paste0(y_post_7m, sprintf("-%02d", m_post_7m),
"-01")) <= ymd(Birth_date), get(PM10_post_7m), 0),
    PM10_post_8m_value = if_else(ymd(paste0(y_post_8m, sprintf("-%02d", m_post_8m),
"-01")) <= ymd(Birth_date), get(PM10_post_8m), 0),
    PM10_post_9m_value = if_else(ymd(paste0(y_post_9m, sprintf("-%02d", m_post_9m),
"-01")) <= ymd(Birth_date), get(PM10_post_9m), 0),
    PM10_post_10m_value = if_else(ymd(paste0(y_post_10m, sprintf("-%02d",
m_post_10m), "-01")) <= ymd(Birth_date), get(PM10_post_10m), 0),
    PM10_post_11m_value = if_else(ymd(paste0(y_post_11m, sprintf("-%02d",
m_post_11m), "-01")) <= ymd(Birth_date), get(PM10_post_11m), 0),
    PM10_post_12m_value = if_else(ymd(paste0(y_post_12m, sprintf("-%02d",
m_post_12m), "-01")) <= ymd(Birth_date), get(PM10_post_12m), 0)
  ) %>%
  ungroup() # 取消按行分组，恢复数据框到标准列操作

## 计算窗口期浓度平均值以得到最终变量 ----
### PM25 ----
#### 计算孕前和孕后的 3 个 Trimester 的平均浓度 ----
dt_PM25 <- dt_PM25 %>%
  rowwise() %>%
  mutate(
    # 孕前 Trimester 平均浓度，仅包含非零数值
    PM25_pre_3rd_trimester = mean(c(PM25_pre_9m_value, PM25_pre_8m_value,
PM25_pre_7m_value)[c(PM25_pre_9m_value, PM25_pre_8m_value,
PM25_pre_7m_value) != 0], na.rm = TRUE),
    PM25_pre_2nd_trimester = mean(c(PM25_pre_6m_value, PM25_pre_5m_value,
PM25_pre_4m_value)[c(PM25_pre_6m_value, PM25_pre_5m_value,
PM25_pre_4m_value) != 0], na.rm = TRUE),
    PM25_pre_1st_trimester = mean(c(PM25_pre_3m_value, PM25_pre_2m_value,
PM25_pre_1m_value)[c(PM25_pre_3m_value, PM25_pre_2m_value,
PM25_pre_1m_value) != 0], na.rm = TRUE),

    # 孕后 Trimester 平均浓度，仅包含非零数值
    PM25_post_1st_trimester = mean(c(PM25_post_1m_value, PM25_post_2m_value,
PM25_post_3m_value)[c(PM25_post_1m_value, PM25_post_2m_value,
PM25_post_3m_value) != 0], na.rm = TRUE),
    PM25_post_2nd_trimester = mean(c(PM25_post_4m_value, PM25_post_5m_value,
PM25_post_6m_value)[c(PM25_post_4m_value, PM25_post_5m_value,
PM25_post_6m_value) != 0], na.rm = TRUE),
    PM25_post_3rd_trimester = mean(c(PM25_post_7m_value, PM25_post_8m_value,
PM25_post_9m_value)[c(PM25_post_7m_value, PM25_post_8m_value,
PM25_post_9m_value) != 0], na.rm = TRUE)
  ) %>%
  ungroup()

#### 计算 whole pregnancy 的月均浓度 ----
dt_PM25 <- dt_PM25 %>%
  rowwise() %>% # 按行操作数据，以确保每一行的 `pregnancy_months` 列生成的值
与其所在行独立计算
  mutate(
    # 计算孕期的起始日期
    start_date = ymd(LMP), # 将末次月经日期 `LMP_date` 作为孕期的开始日期
    end_date = ymd(Birth_date), # 将出生日期 `Birth_date` 转换为日期格式并作为孕期
的结束日期

    # 创建一个日期序列，涵盖整个孕期的月份
    pregnancy_months = list(seq.Date(
      from = floor_date(start_date, "month"), # 将 `start_date` 向下取整到月份起点
      to = floor_date(end_date, "month"), # 将 `end_date` 向下取整到月份起点
      by = "month" # 生成从 `start_date` 到 `end_date` 之间每月的日期序列
    )),

    # 动态提取每个月份的浓度值，并计算平均浓度
    PM25_whole_pregnancy = mean( # 计算孕期各月份 PM2.5 浓度的平均值
      sapply(pregnancy_months, function(d) { # 使用 `sapply` 遍历每个月份的日期 `d`
        var_name <- paste0("PM25_1km_m_", year(d), sprintf("%02d", month(d)))
        # 动态构造列名 `var_name`，例如 `PM25_1km_m_2007_05`，以匹配每个月份的
数据列

        if (var_name %in% names(dt_PM25)) get(var_name) else NA
        # 检查 `var_name` 是否存在于数据框的列名中，存在则提取该列值，否则返回
`NA`
      }), na.rm = TRUE # 忽略 NA 值计算平均浓度
    )
  ) %>%
  ungroup() # 取消 `rowwise` 分组，以便后续操作按列进行

dt_PM25 <- dt_PM25 %>%
  select(
    ID,
    PM25_pre_9m_value,
    PM25_pre_8m_value,
    PM25_pre_7m_value,
    PM25_pre_6m_value,
    PM25_pre_5m_value,
    PM25_pre_4m_value,
    PM25_pre_3m_value,
    PM25_pre_2m_value,
    PM25_pre_1m_value,
    PM25_post_1m_value,
    PM25_post_2m_value,
    PM25_post_3m_value,
    PM25_post_4m_value,
    PM25_post_5m_value,
    PM25_post_6m_value,
    PM25_post_7m_value,
    PM25_post_8m_value,
    PM25_post_9m_value,
    PM25_post_10m_value,
    PM25_post_11m_value,
    PM25_post_12m_value,
    PM25_pre_3rd_trimester,
    PM25_pre_2nd_trimester,
    PM25_pre_1st_trimester,
    PM25_post_1st_trimester,
    PM25_post_2nd_trimester,
    PM25_post_3rd_trimester,
    PM25_whole_pregnancy
  )

### PM10 ----
#### 计算孕前和孕后的 3 个 Trimester 的平均浓度 ----
dt_PM10 <- dt_PM10 %>%
  rowwise() %>%
  mutate(
    # 孕前 Trimester 平均浓度，仅包含非零数值
    PM10_pre_3rd_trimester = mean(c(PM10_pre_9m_value, PM10_pre_8m_value,
PM10_pre_7m_value)[c(PM10_pre_9m_value, PM10_pre_8m_value,
PM10_pre_7m_value) != 0], na.rm = TRUE),
    PM10_pre_2nd_trimester = mean(c(PM10_pre_6m_value, PM10_pre_5m_value,
PM10_pre_4m_value)[c(PM10_pre_6m_value, PM10_pre_5m_value,
PM10_pre_4m_value) != 0], na.rm = TRUE),
    PM10_pre_1st_trimester = mean(c(PM10_pre_3m_value, PM10_pre_2m_value,
PM10_pre_1m_value)[c(PM10_pre_3m_value, PM10_pre_2m_value,
PM10_pre_1m_value) != 0], na.rm = TRUE),

    # 孕后 Trimester 平均浓度，仅包含非零数值
    PM10_post_1st_trimester = mean(c(PM10_post_1m_value, PM10_post_2m_value,
PM10_post_3m_value)[c(PM10_post_1m_value, PM10_post_2m_value,
PM10_post_3m_value) != 0], na.rm = TRUE),
    PM10_post_2nd_trimester = mean(c(PM10_post_4m_value, PM10_post_5m_value,
PM10_post_6m_value)[c(PM10_post_4m_value, PM10_post_5m_value,
PM10_post_6m_value) != 0], na.rm = TRUE),
    PM10_post_3rd_trimester = mean(c(PM10_post_7m_value, PM10_post_8m_value,
PM10_post_9m_value)[c(PM10_post_7m_value, PM10_post_8m_value,
PM10_post_9m_value) != 0], na.rm = TRUE)
  ) %>%
  ungroup()

#### 计算 whole pregnancy 的月均浓度 ----
dt_PM10 <- dt_PM10 %>%
  rowwise() %>% # 按行操作数据，以确保每一行的 `pregnancy_months` 列生成的值
与其所在行独立计算
  mutate(
    # 计算孕期的起始日期
    start_date = ymd(LMP), # 将末次月经日期 `LMP_date` 作为孕期的开始日期
    end_date = ymd(Birth_date), # 将出生日期 `Birth_date` 转换为日期格式并作为孕期
的结束日期

    # 创建一个日期序列，涵盖整个孕期的月份
```

```r
   pregnancy_months = list(seq.Date(
     from = floor_date(start_date, "month"), # 将 `start_date` 向下取整到月份起点
     to = floor_date(end_date, "month"), # 将 `end_date` 向下取整到月份起点
     by = "month" # 生成从 `start_date` 到 `end_date` 之间每月的日期序列
   )),

   # 动态提取每个月份的浓度值，并计算平均浓度
   PM10_whole_pregnancy = mean( # 计算孕期各月份 PM2.5 浓度的平均值
     sapply(pregnancy_months, function(d) { # 使用 `sapply` 遍历每个月份的日期 `d`
       var_name <- paste0("PM10_1km_m_", year(d), sprintf("%02d", month(d)))
       # 动态构造列名 `var_name`，例如 `PM10_1km_m_2007_05`，以匹配每个月份的
数据列

       if (var_name %in% names(dt_PM10)) get(var_name) else NA
       # 检查 `var_name` 是否存在于数据框的列名中，存在则提取该列值，否则返回
`NA`
     }), na.rm = TRUE # 忽略 NA 值计算平均浓度
   )
  ) %>%
  ungroup() # 取消 `rowwise` 分组，以便后续操作按列进行

dt_PM10 <- dt_PM10 %>%
  select(
   ID,
   PM10_pre_9m_value,
   PM10_pre_8m_value,
   PM10_pre_7m_value,
   PM10_pre_6m_value,
   PM10_pre_5m_value,
   PM10_pre_4m_value,
    PM10_pre_3m_value,
    PM10_pre_2m_value,
    PM10_pre_1m_value,
    PM10_post_1m_value,
    PM10_post_2m_value,
    PM10_post_3m_value,
    PM10_post_4m_value,
    PM10_post_5m_value,
    PM10_post_6m_value,
    PM10_post_7m_value,
    PM10_post_8m_value,
    PM10_post_9m_value,
    PM10_post_10m_value,
    PM10_post_11m_value,
    PM10_post_12m_value,
    PM10_pre_3rd_trimester,
    PM10_pre_2nd_trimester,
    PM10_pre_1st_trimester,
    PM10_post_1st_trimester,
    PM10_post_2nd_trimester,
    PM10_post_3rd_trimester,
    PM10_whole_pregnancy
  )

## 保存结果 ----
rio::export(dt_PM25,
"PM25_pre_post_trimesters_whole_pregnancy_18089_rev_3rd_trimester.rds")
rio::export(dt_PM10,
"PM10_pre_post_trimesters_whole_pregnancy_18089_rev_3rd_trimester.rds")
rio::export(dt_PM25,
"PM25_pre_post_trimesters_whole_pregnancy_18089_rev_3rd_trimester.xlsx")
rio::export(dt_PM10,
"PM10_pre_post_trimesters_whole_pregnancy_18089_rev_3rd_trimester.xlsx")


setwd(Results_dir)
rio::export(dt_PM25,
"PM25_pre_post_trimesters_whole_pregnancy_18089_rev_3rd_trimester.rds")
rio::export(dt_PM10,
"PM10_pre_post_trimesters_whole_pregnancy_18089_rev_3rd_trimester.rds")
rio::export(dt_PM25,
"PM25_pre_post_trimesters_whole_pregnancy_18089_rev_3rd_trimester.xlsx")
rio::export(dt_PM10,
"PM10_pre_post_trimesters_whole_pregnancy_18089_rev_3rd_trimester.xlsx")
```

R