哨兵二号（Sentinel-2）卫星数据处理

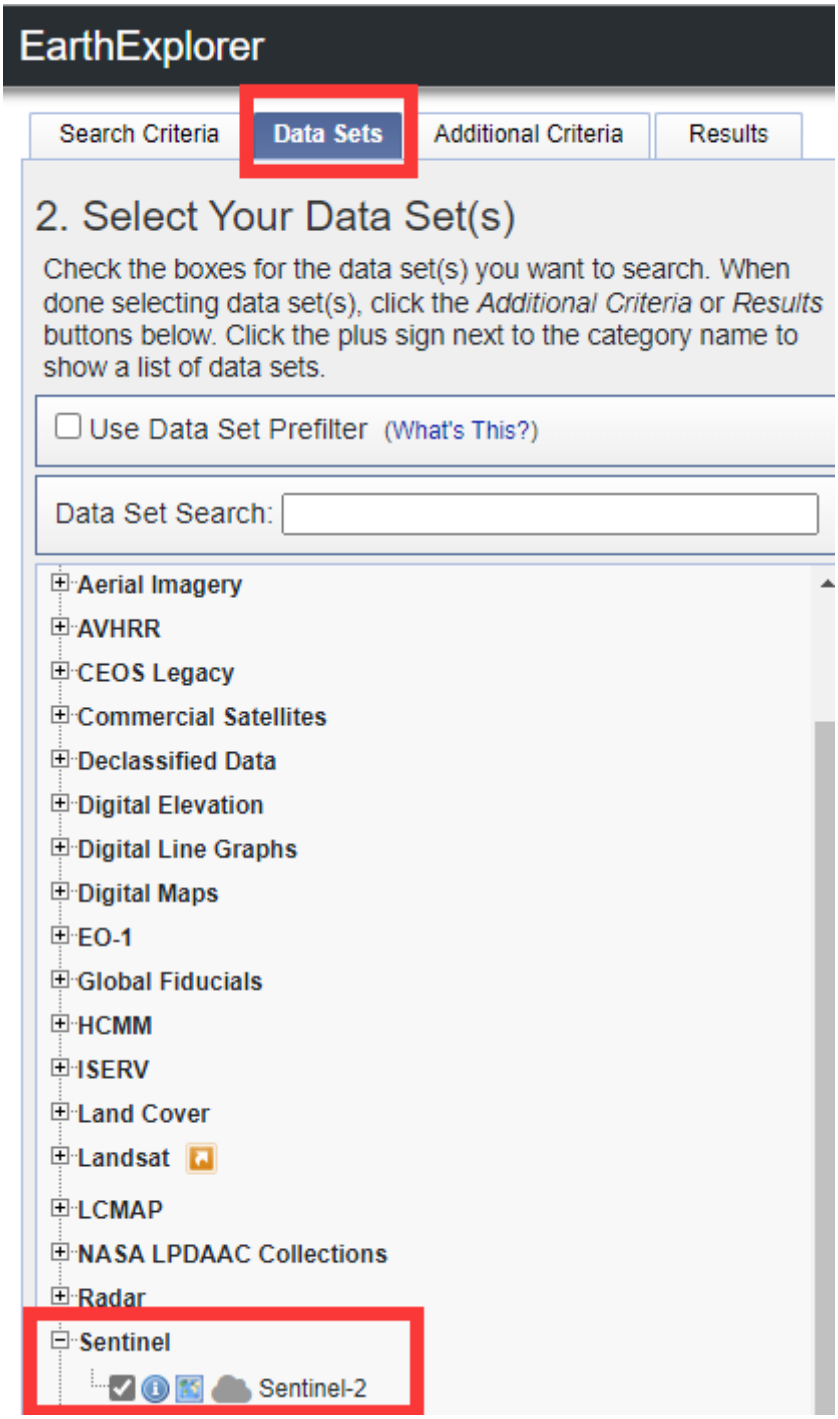
特别提醒：本文所有操作所需时间都很长，因此在自己电脑上操作的朋友记得将睡眠模式关闭。

一、数据下载

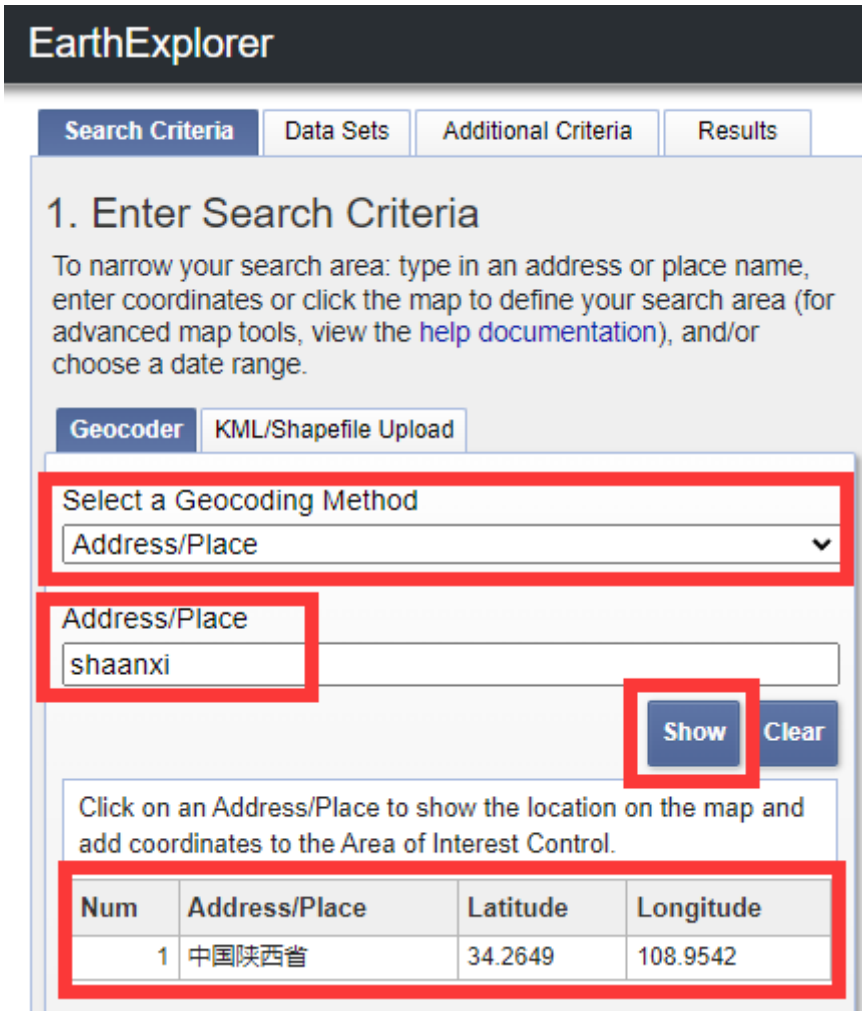
1. 打开网址：

- USGS；

2. 选择数据集：

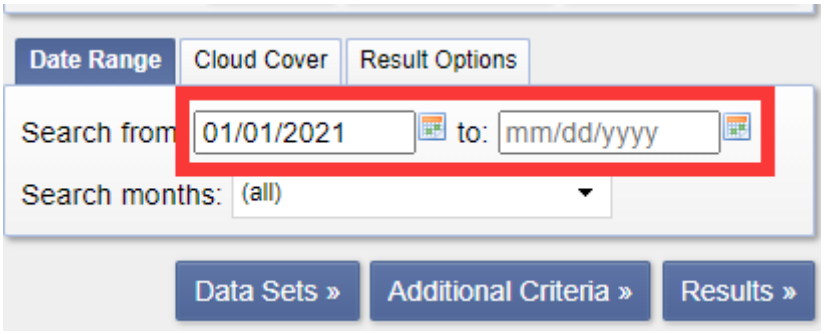


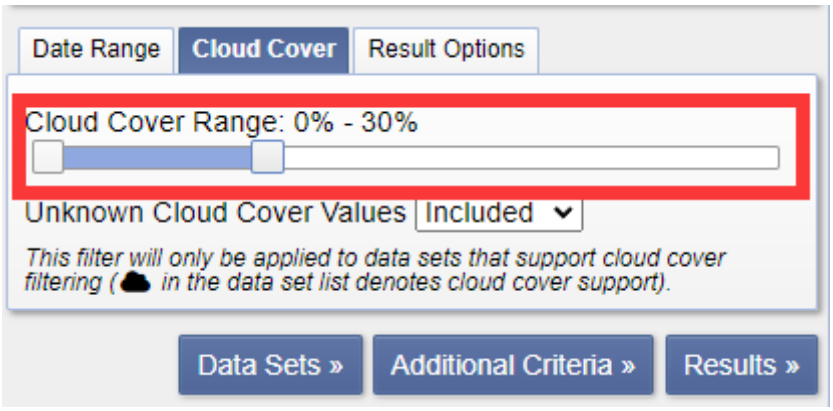
3. 选择地区：



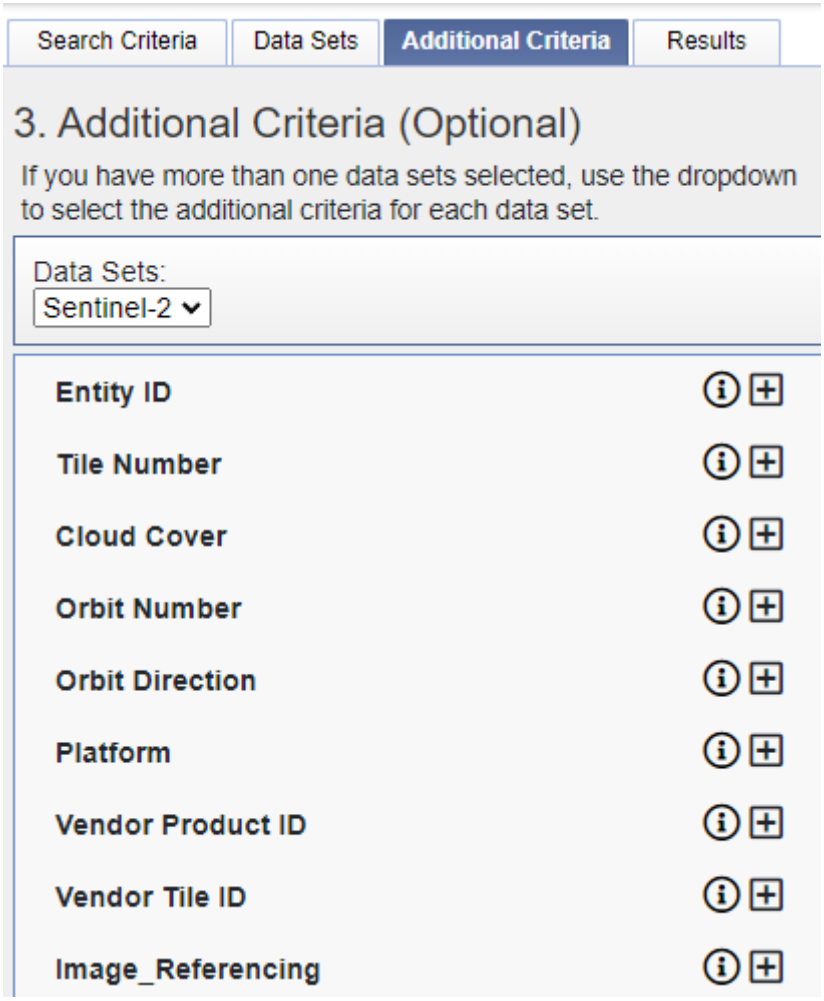
- 点击最下方红框中的陕西省即可选择；
- 该步骤如果搜索不到国内的省份，要么是省份的英文写错了，要么是需要科学上网。

4. 选择日期和云度：

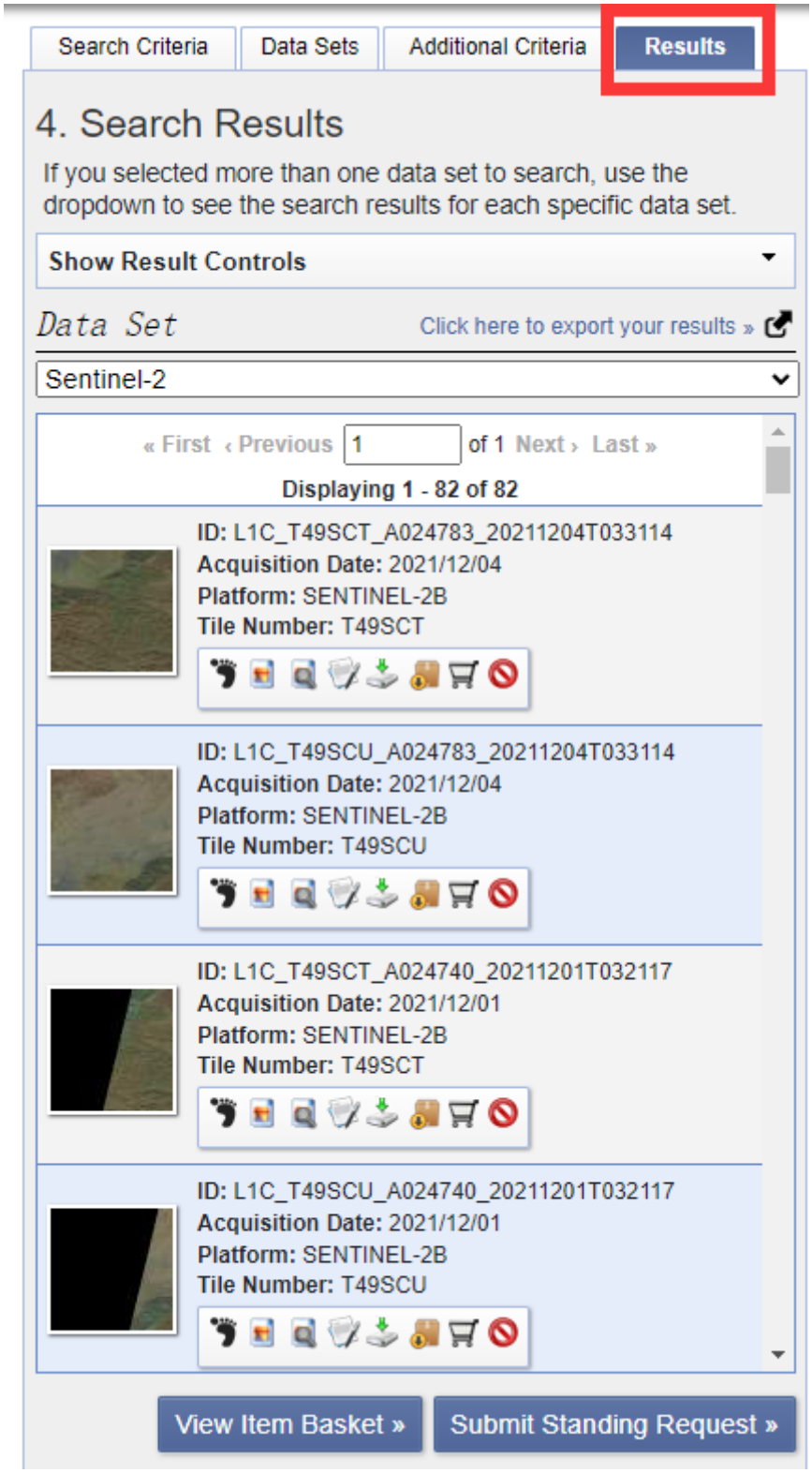




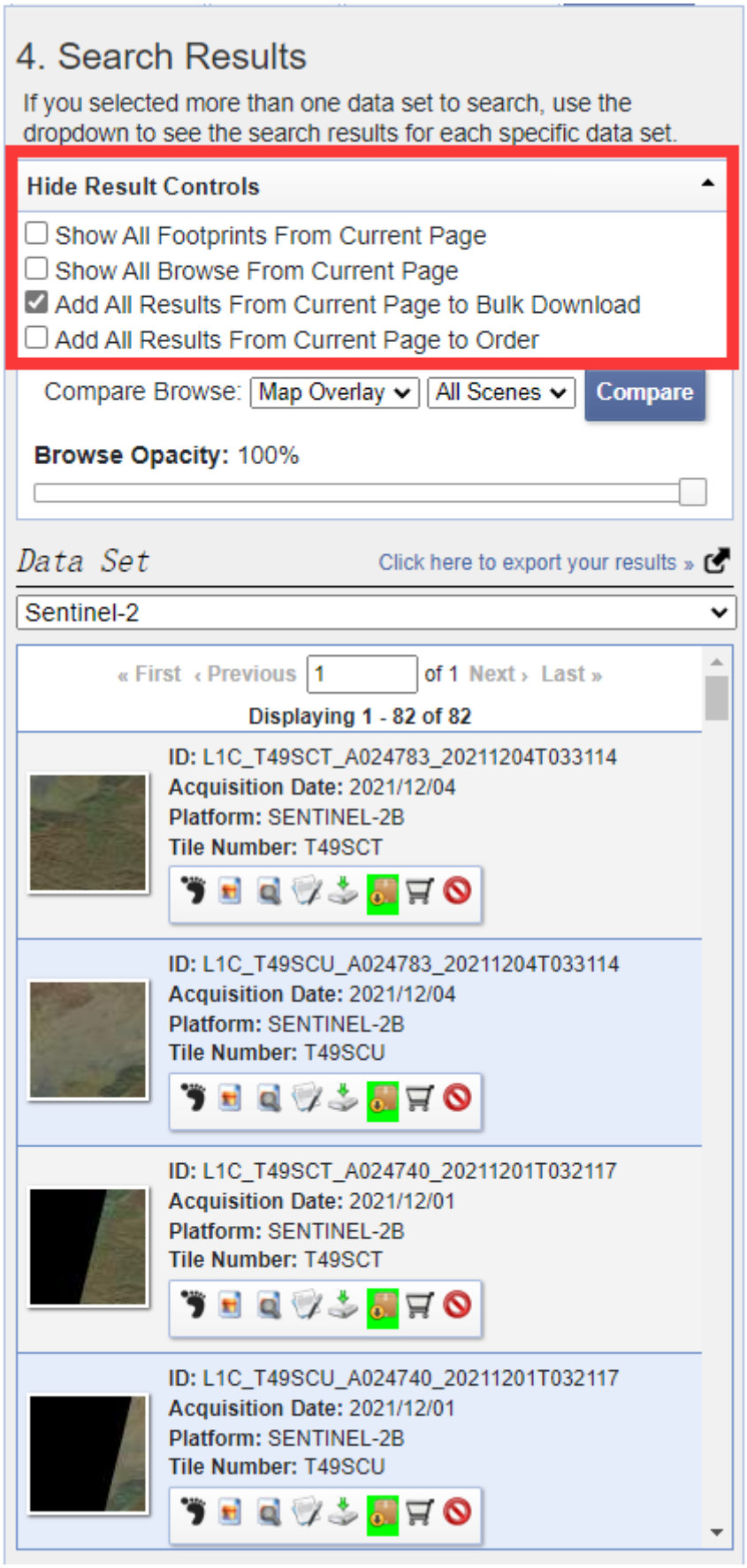
5. 选择其他参数（可选）：



6. 生成结果：

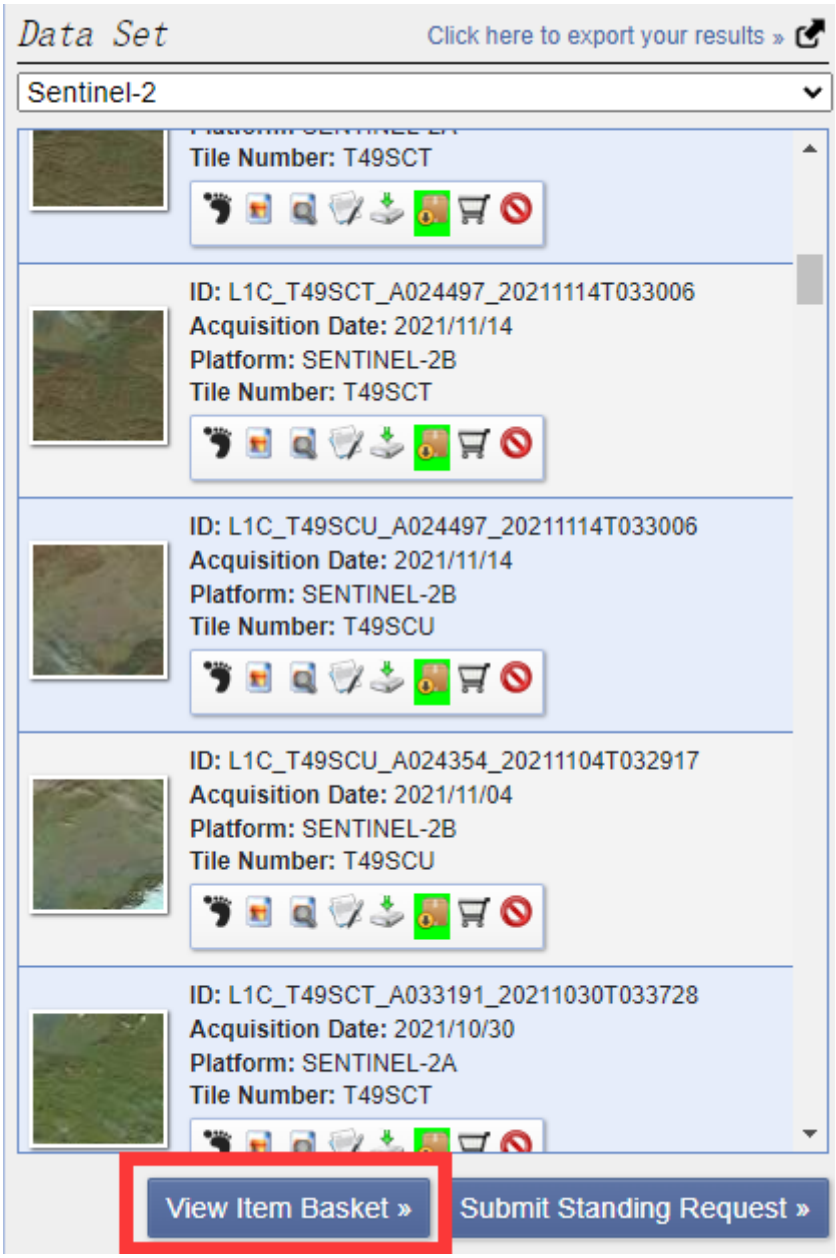

Search Criteria
Data Sets
Additional Criteria
Results
4. Search Results
If you selected more than one data set to search, use the dropdown to see the search results for each specific data set.
Show Result Controls
Data Set
Click here to export your results »
Sentinel-2
« First ‹ Previous 1 of 1 Next › Last »
Displaying 1 - 82 of 82
ID: L1C_T49SCT_A024783_20211204T033114
Acquisition Date: 2021/12/04
Platform: SENTINEL-2B
Tile Number: T49SCT
ID: L1C_T49SCU_A024783_20211204T033114
Acquisition Date: 2021/12/04
Platform: SENTINEL-2B
Tile Number: T49SCU
ID: L1C_T49SCT_A024740_20211201T032117
Acquisition Date: 2021/12/01
Platform: SENTINEL-2B
Tile Number: T49SCT
ID: L1C_T49SCU_A024740_20211201T032117
Acquisition Date: 2021/12/01
Platform: SENTINEL-2B
Tile Number: T49SCU
View Item Basket »
Submit Standing Request »

7. 选择图像：

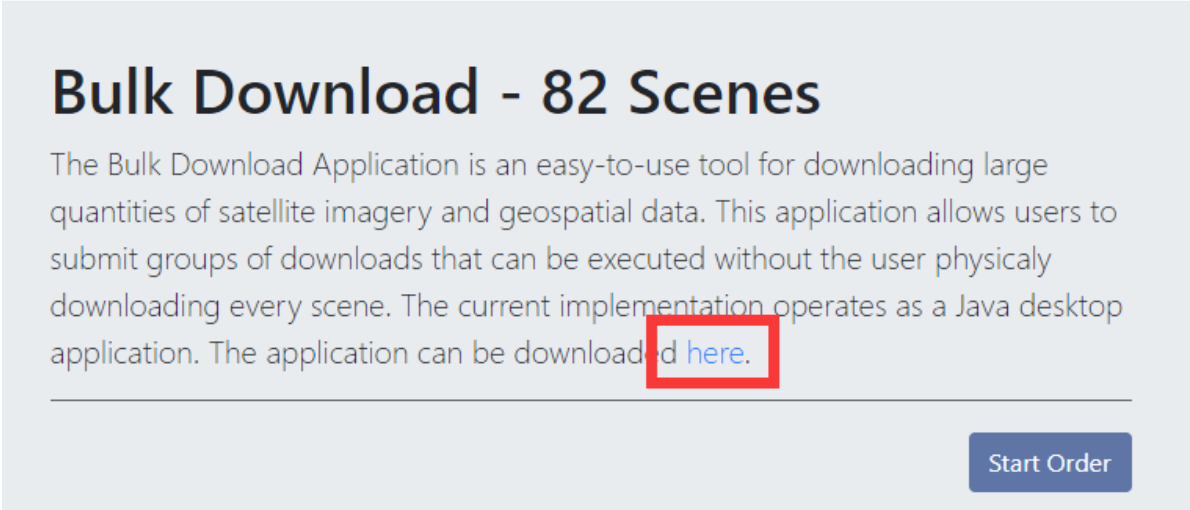


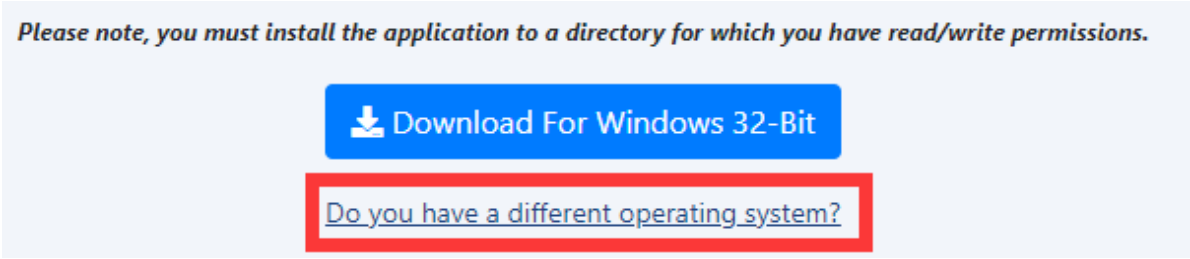
- 对每一页都做相同操作，可以看到图中的纸箱子 icon 变成了绿色，表示选定；

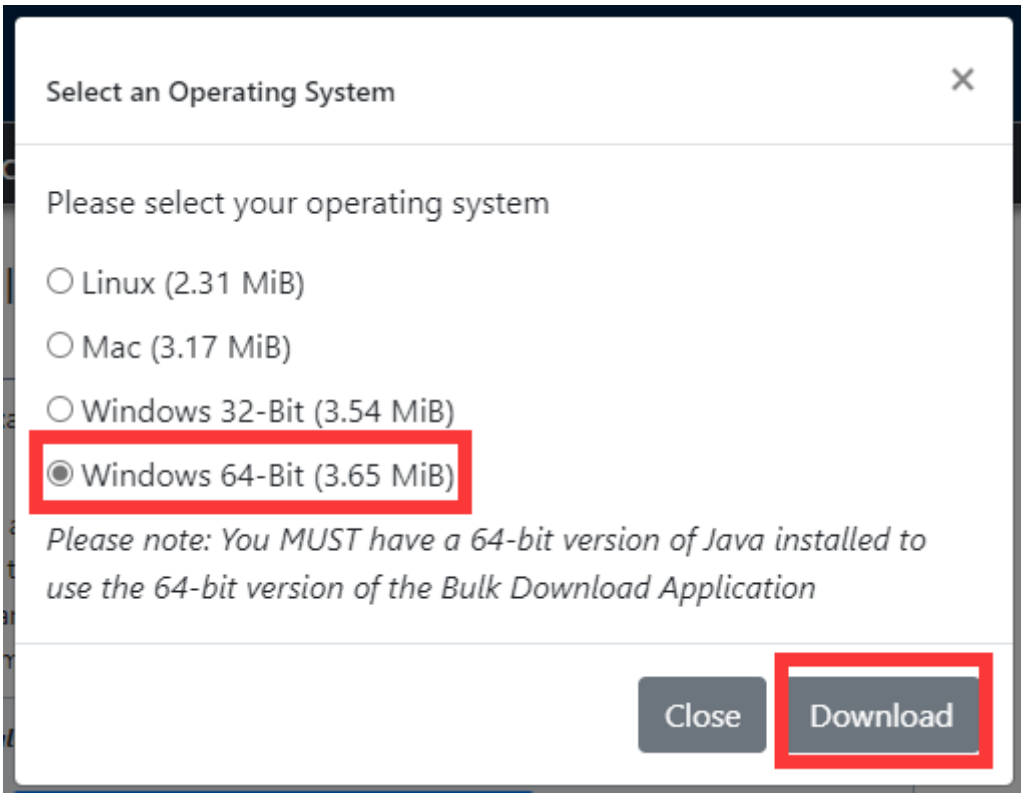
8. 生成下载链接：



9. 安装下载器：

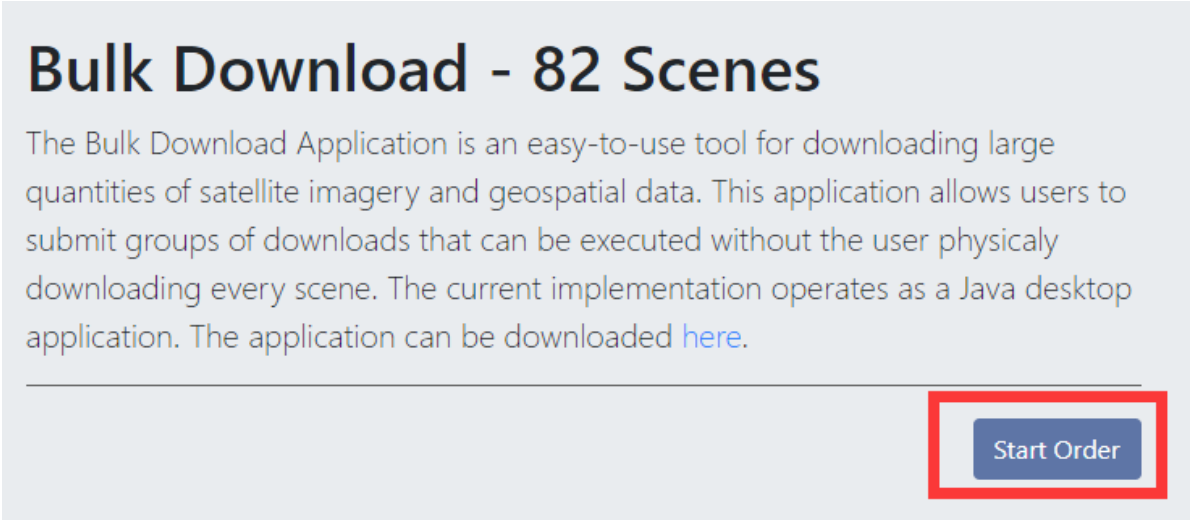






- 要安装该软件，还需要安装 java 10 64bit ， 安装方法请自行百度；
- 配好 java 的环境变量后，就可以安装该软件了；

10. 提交下载链接：



Bulk Download - 82 Scenes

The Bulk Download Application is an easy-to-use tool for downloading large quantities of satellite imagery and geospatial data. This application allows users to submit groups of downloads that can be executed without the user physicaly downloading every scene. The current implementation operates as a Java desktop application. The application can be downloaded here.

Sentinel-2 (82 scenes pending selection)

Bulk Download | Order Name - Optional | Submit Product Selections

Bulk Download - 82 Scenes

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Sentinel-2 (82 scenes pending selection)

Options: Remove Dataset | Product Selection

Displaying 1 - 82 of 82 Results Per Page: 100

< First | < Previous | 1 | Next > | Last >

Select All Products

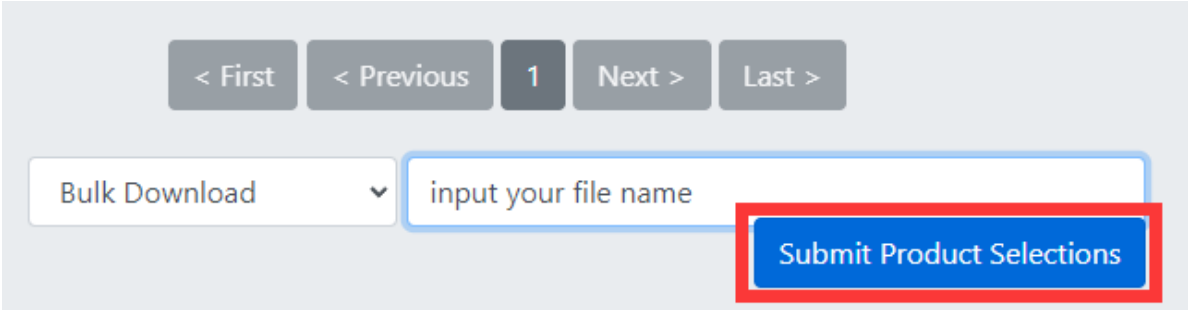
Product List

L1C Tile in JPEG2000 format

Full Resolution Browse in GeoTIFF format

Selections will be applied to all scenes within this dataset - this does not remove other selections

Select Products | Close



11. 通过软件下载：

- 打开 bda 软件；
- 登录账号；
- 在打开的 Open Order 窗口选择你的下载申请，若该窗口关闭，可在 File 菜单栏打开；
- 选择你的目标 order ；
- 点击 Begin Download 进行下载；
- 所下载的文件在 bda 软件的安装目录下；
- 一般晚上 1 点下载速度较快且连接稳定；
- 如果下载失败，出现了 error ，不要点击 Redownload ，该操作会删除下载失败的文件。此时应先下载完其他文件，最后重启 bda ， Select 错误的部分点击 Begin Download 即可继续下载；
- 当 error 发生后还有一种可行的方法就是不去管它，有时候 bda 软件会自动重新接续下载；
- 重启 bda 不成功，可能是因为它在后台运行，需要先打开资源管理器关闭它的进程。

二、数据介绍

1. 文件介绍

以 S2AMSIL1C20190122T025021N0208_R132T50RNV_20190122T065329.zip 为例：

1. S2A：表示 Sentinel-2A 卫星；
2. MSL：表示多光谱数据；
3. L1C：表示产品等级为 L1C 级别，该级别只经过了几何校正，L2A 级别产品还经过了辐射校正，但该级别需要用户自己处理；
4. 20190122T025021：表示数据获取时间，即 2019 年 1 月 22 日凌晨 2 点 50 分 21 秒，该时间为格林威治时间，比北京时间提前 8 个小时；
5. N0208_R132：处理基线编号与相对轨道编号；
6. T50RNV：拼接域编号；
7. 20190122T065329：估计是产品生成的时间；

2. 卫星介绍

		S2A	S2A	S2B	S2B	
Band Number	Band name	Central wavelength (nm)	Bandwidth (nm)	Central wavelength (nm)	Bandwidth (nm)	Spatial resolution (m)
1	Coastal aerosol	443.9	27	442.3	45	60
2	Blue	496.6	98	492.1	98	10
3	Green	560.0	45	559	46	10
4	Red	664.5	38	665	39	10
5	Vegetation Red Edge	703.9	19	703.8	20	20
6	Vegetation Red Edge	740.2	18	739.1	18	20
7	Vegetation Red Edge	782.5	28	779.7	28	20
8	NIR	835.1	145	833	133	10
8A	Narrow NIR	864.8	33	864	32	20
9	Water vapour	945.0	26	943.2	27	60
10	SWIR – Cirrus	1373.5	75	1376.9	76	60
11	SWIR	1613.7	143	1610.4	141	20
12	SWIR	2202.4	242	2185.7	238	20

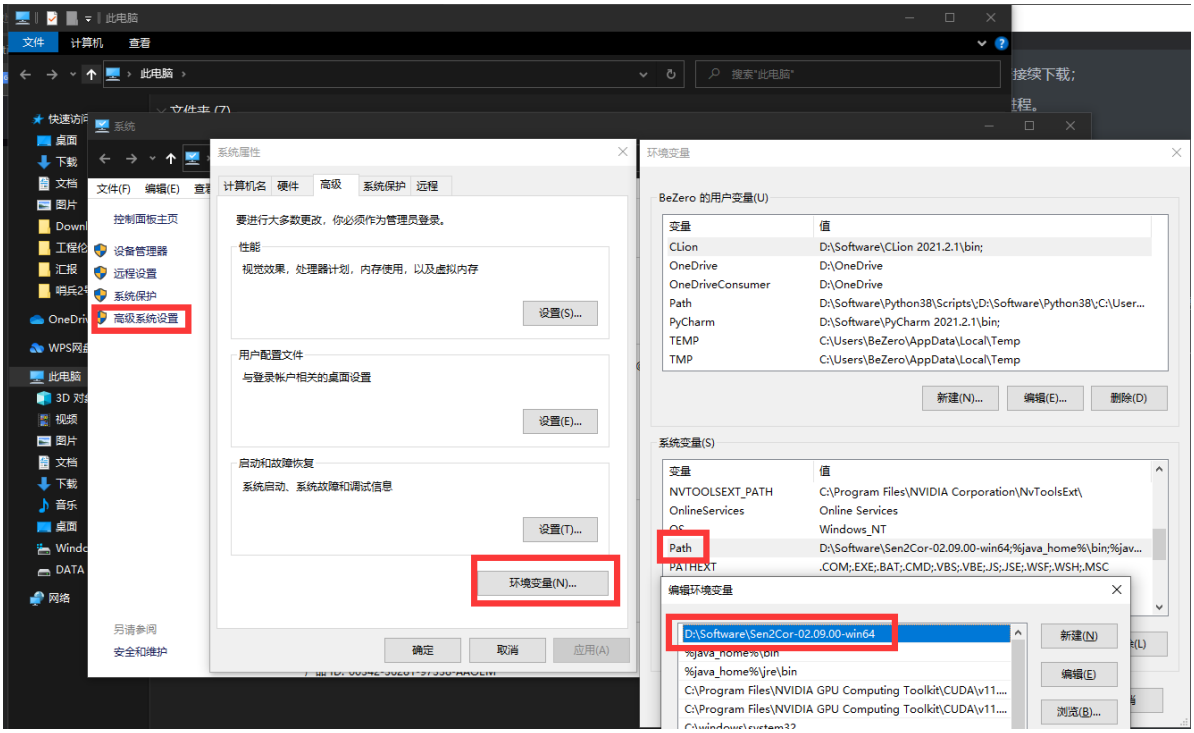
三、数据显示与处理

1. 软件下载：

- 打开网址下载图像处理工具：SNAP；
- 还需下载大气校正工具：Sen2Cor；

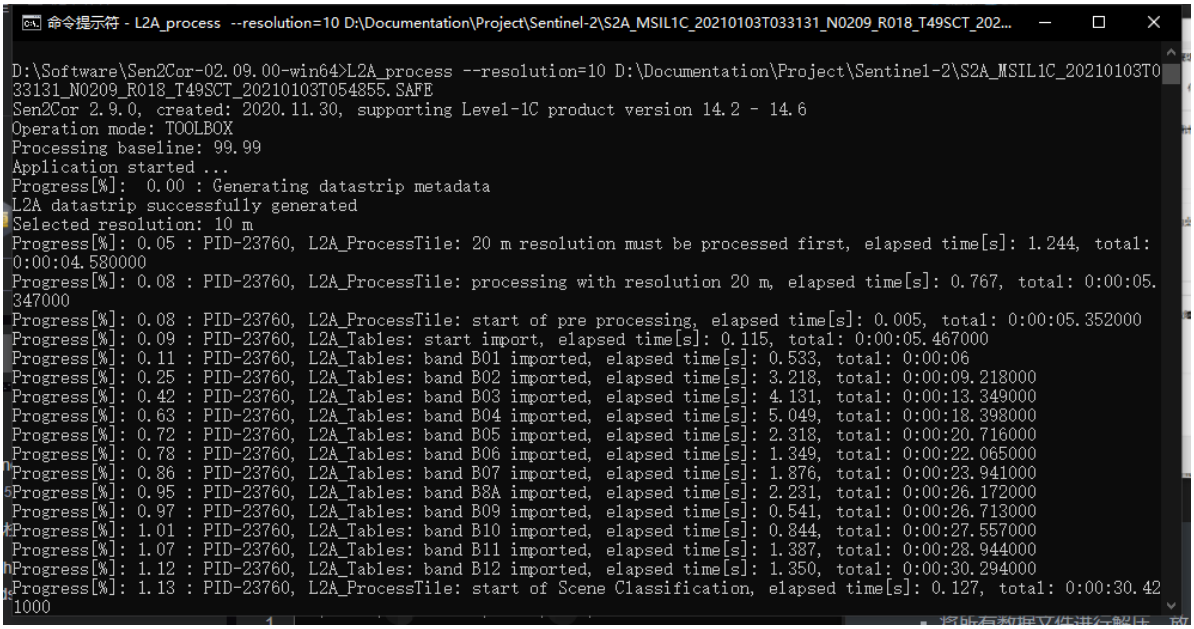
2. 软件安装：

- SNAP 无脑下一步，需要 Python 环境的用户请注意软件支持的版本；
- Sen2Cor 加压即可，如果想要在任意文件夹下使用该工具，需要将其添加入系统环境变量；



3. 大气校正：

- 将所有数据文件进行解压，放入一个单独的文件夹 Sentinel-2 中；
- 打开 cmd；
- 进入 Sen2Cor 文件夹（如果添加了环境变量可跳过该步骤）；
- 输入命令：`for /D %s in (D:\Documentation\Project\Sentinel-2\S2A_MSIL1C*) do L2A_process --resolution=10 %s`，其中 `--resolution=10` 表示处理分辨率为 10 的图像；`D:\Documentation\Project\Sentinel-2\S2A_MSIL1C*` 表示所下载的数据集的位置；
- 如果需要处理 S2B 星的数据，仅需要将上述操作中的 S2A_MSIL1C* 改为 S2B_MSIL1C* 即可。
- 等待系统处理即可；



4. 导出 TIFF：

- 创建一个 Python 环境；
- 下载 gdal (注意版本须与 python 版本匹配)；
- 将其放入你的 python 环境中的 Scripts 文件夹中（推荐使用虚拟环境）；

- 在 Terminal 中激活你的 python （通常是在同一目录下执行 activate.bat 文件）；
- 在 Terminal 中输入：`pip install GDAL-xxxxxx`，注意是你自己的 GDAL 版本；
- 按需配置其他环境（例如 numpy 等）；
- 使用下述代码进行批处理：

```python
from osgeo import gdal
import os
import numpy as np
from osgeo import gdal, osr, ogr
import glob
# os.environ['CPL_ZIP_ENCODING'] = 'UTF-8'

def S2tif(filename):
    # 打开栅格数据集
    print(filename)
    root_ds = gdal.Open(filename)
    # print(type(root_ds))
    # 返回结果是一个list，list中的每个元素是一个tuple，每个tuple中包含了对数据集的路径，元数据等的描述信息
    # tuple中的第一个元素描述的是数据子集的全路径
    ds_list = root_ds.GetSubDatasets()  # 获取子数据集。该数据以数据集形式存储且以子数据集形式组织
    visual_ds = gdal.Open(ds_list[0][0])  # 打开第1个数据子集的路径。ds_list有4个子集，内部前段是路径，后段是数据信息
    # print(visual_ds)
    print(f'打开数据为：{ds_list[0][1]}')
    # print(f'投影信息：{visual_ds.GetProjection()}')
    # print(f'栅格波段数：{visual_ds.RasterCount}')
    # print(f'栅格列数（宽度）：{visual_ds.RasterXSize}')
    # print(f'栅格行数（高度）：{visual_ds.RasterYSize}')
    visual_arr = visual_ds.ReadAsArray()  # 将数据集中的数据读取为ndarray

    # 创建.tif文件
    band_count = visual_ds.RasterCount  # 波段数
    xsize = visual_ds.RasterXSize
    ysize = visual_ds.RasterYSize
    out_tif_name = filename.split(".SAFE")[0] + ".tif"
    driver = gdal.GetDriverByName("GTiff")
    out_tif = driver.Create(out_tif_name, xsize, ysize, band_count, gdal.GDT_Float32)
    out_tif.SetProjection(visual_ds.GetProjection())  # 设置投影坐标
    out_tif.SetGeoTransform(visual_ds.GetGeoTransform())

    for index, band in enumerate(visual_arr):
        band = np.array([band])
        for i in range(len(band[:])):
            # 数据写出
            out_tif.GetRasterBand(index + 1).WriteArray(band[i])  # 将每个波段的数据写入内存，此时没有写入硬盘
    out_tif.FlushCache()  # 最终将数据写入硬盘
    out_tif = None  # 注意必须关闭tif文件

if __name__ == "__main__":
    from osgeo import gdal
    SAFE_Path = (r'D:\Documentation\Project\Grassland ecology\Sentinel2_pretreatment\data')
```

```
    data_list = glob.glob(SAFE_Path + "\\*.SAFE")

    for i in range(len(data_list)):
        data_path = data_list[i]
        filename = data_path + "\\MTD_MSIL2A.xml"
        S2tif(filename)
        print(data_path + "-----转tif成功")
    print("----转换结束----")
```

- 代码中第 17 行是取第一个数据子集（band 2、3、4、8），要使用其他 band 须自行更改（第 18 行代码可以查看每个数据子集的信息）；
- 由于读取子数据集时，gdal 工具会将波段进行重组，导致波段的顺序与原数据集（sentinel-2 原始数据集）的波段顺序不同，因此可以通过 `gdalinfo [文件名或子数据集名]` 来获取重组后波段的顺序结构，方法如下：
  - 首先，打开并进入你所下载的 gdal 文件夹下的 `Lib\site-packages\osgeo` 目录；
  - 该目录下检查是否有一个 `gdalinfo.exe` 程序；
  - 在该目录下打开 cmd 命令行；
  - 输入 `gdalinfo xxx/xxx.xml` 查看数据信息，下面给出一个具体的例子以供参考：

```
$ gdalinfo S2A_MSIL2A_20210202T032941_N9999_R018_T49SCT_20211210T131028.SAFE/MTD_MSIL2A.xml
# 上面这行是我的输入，其中数据文件夹为 S2A_MSIL2A_20210202T032941_N9999_R018_T49SCT_20211210T131028.SAFE
# 由于 gdalinfo 不能直接读取 S2A 的文件，因此应该读取 xml 文件：/MTD_MSIL2A.xml
# 程序支持写入相对或绝对路径，此处我是将数据文件放入了该目录下进行读取
# 下面是文件信息的输出：
Driver: SENTINEL2/Sentinel 2
Files: S2A_MSIL2A_20210202T032941_N9999_R018_T49SCT_20211210T131028.SAFE/MTD_MSIL2A.xml
Size is 512, 512
Metadata:
  AOT_QUANTIFICATION_VALUE=1000.0
  AOT_QUANTIFICATION_VALUE_UNIT=none
  AOT_RETRIEVAL_ACCURACY=0.0
  BOA_QUANTIFICATION_VALUE=10000
  BOA_QUANTIFICATION_VALUE_UNIT=none
  CLOUD_COVERAGE_ASSESSMENT=1.049327
  CLOUD_SHADOW_PERCENTAGE=0.440092
  DARK_FEATURES_PERCENTAGE=30.990644
  DATATAKE_1_DATATAKE_SENSING_START=2021-02-02T03:29:41.024Z
  DATATAKE_1_DATATAKE_TYPE=INS-NOBS
  DATATAKE_1_ID=GS2A_20210202T032941_029330_N99.99
  DATATAKE_1_SENSING_ORBIT_DIRECTION=DESCENDING
  DATATAKE_1_SENSING_ORBIT_NUMBER=18
  DATATAKE_1_SPACECRAFT_NAME=Sentinel-2A
  DEGRADED_ANC_DATA_PERCENTAGE=0.0
  DEGRADED_MSI_DATA_PERCENTAGE=0
  FOOTPRINT=POLYGON((108.8262199395114 34.3223655300343,
110.01937756706981 34.3377366079947, 110.03062458149692
33.347577738129736, 108.85113286341723 33.3327671075422,
108.8262199395114 34.3223655300343))
```

```
  FORMAT_CORRECTNESS=PASSED
  GENERAL_QUALITY=PASSED
  GENERATION_TIME=2021-12-10T13:10:28.715000Z
  GEOMETRIC_QUALITY=PASSED
  HIGH_PROBA_CLOUDS_PERCENTAGE=0.061825
  MEDIUM_PROBA_CLOUDS_PERCENTAGE=0.484693
  NODATA_PIXEL_PERCENTAGE=0.000043
  NOT_VEGETATED_PERCENTAGE=47.824116
  PREVIEW_GEO_INFO=Not applicable
  PREVIEW_IMAGE_URL=Not applicable
  PROCESSING_BASELINE=99.99
  PROCESSING_LEVEL=Level-2A
  PRODUCT_START_TIME=2021-02-02T03:29:41.024Z
  PRODUCT_STOP_TIME=2021-02-02T03:29:41.024Z
  PRODUCT_TYPE=S2MSI2A
  PRODUCT_URI=S2A_MSIL2A_20210202T032941_N9999_R018_T49SCT_20211210T131028.SAFE
  RADIATIVE_TRANSFER_ACCURACY=0.0
  RADIOMETRIC_QUALITY=PASSED
  REFLECTANCE_CONVERSION_U=1.03080315559675
  SATURATED_DEFECTIVE_PIXEL_PERCENTAGE=0.000000
  SENSOR_QUALITY=PASSED
  SNOW_ICE_PERCENTAGE=0.002857
  SPECIAL_VALUE_NODATA=0
  SPECIAL_VALUE_SATURATED=65535
  THIN_CIRRUS_PERCENTAGE=0.502809
  UNCLASSIFIED_PERCENTAGE=10.570553
  VEGETATION_PERCENTAGE=6.625548
  WATER_PERCENTAGE=2.496857
  WATER_VAPOUR_RETRIEVAL_ACCURACY=0.0
  WVP_QUANTIFICATION_VALUE=1000.0
  WVP_QUANTIFICATION_VALUE_UNIT=cm
Subdatasets:
  SUBDATASET_1_NAME=SENTINEL2_L2A:S2A_MSIL2A_20210202T032941_N9999_R018_T49SCT_20211210T131028.SAFE/MTD_MSIL2A.xml:10m:EPSG_32649
  SUBDATASET_1_DESC=Bands B2, B3, B4, B8 with 10m resolution, UTM 49N
 # 上述两行，第一行是子数据的位置信息，第二行是子数据的波段信息

 SUBDATASET_2_NAME=SENTINEL2_L2A:S2A_MSIL2A_20210202T032941_N9999_R018_T49SCT_20211210T131028.SAFE/MTD_MSIL2A.xml:20m:EPSG_32649
  SUBDATASET_2_DESC=Bands B5, B6, B7, B8A, B11, B12, AOT, CLD, SCL, SNW, WVP with 20m resolution, UTM 49N
  SUBDATASET_3_NAME=SENTINEL2_L2A:S2A_MSIL2A_20210202T032941_N9999_R018_T49SCT_20211210T131028.SAFE/MTD_MSIL2A.xml:60m:EPSG_32649
  SUBDATASET_3_DESC=Bands B1, B9, AOT, CLD, SCL, SNW, WVP with 60m resolution, UTM 49N
  SUBDATASET_4_NAME=SENTINEL2_L2A:S2A_MSIL2A_20210202T032941_N9999_R018_T49SCT_20211210T131028.SAFE/MTD_MSIL2A.xml:TCI:EPSG_32649
  SUBDATASET_4_DESC=True color image, UTM 49N
Corner Coordinates:
Upper Left  (    0.0,    0.0)
Lower Left  (    0.0,  512.0)
Upper Right (  512.0,    0.0)
Lower Right (  512.0,  512.0)
Center      (  256.0,  256.0)
```

```
$ gdalinfo SENTINEL2_L2A:S2A_MSIL2A_20210202T032941_N9999_R018_T49SCT_20211210T131028.SAFE/MTD_MSIL2A.xml:10m:EPSG_32649
# 上面一行代码的作用是获取第一个子数据集的信息，子数据集的位置在上一节代码中有注释
ERROR 1: PROJ: proj_create_from_database: Cannot find proj.db
ERROR 1: PROJ: proj_create: no database context specified
ERROR 1: PROJ: proj_create: no database context specified
ERROR 1: PROJ: proj_create: no database context specified
ERROR 1: PROJ: proj_create: no database context specified
Driver: SENTINEL2/Sentinel 2
Files: S2A_MSIL2A_20210202T032941_N9999_R018_T49SCT_20211210T131028.SAFE/MTD_MSIL2A.xml

S2A_MSIL2A_20210202T032941_N9999_R018_T49SCT_20211210T131028.SAFE/GRANULE/L2A_T49SCT_A029330_20210202T032944/MTD_TL.xml

S2A_MSIL2A_20210202T032941_N9999_R018_T49SCT_20211210T131028.SAFE/GRANULE/L2A_T49SCT_A029330_20210202T032944/IMG_DATA/R10m/T49SCT_20210202T032941_B04_10m.jp2

S2A_MSIL2A_20210202T032941_N9999_R018_T49SCT_20211210T131028.SAFE/GRANULE/L2A_T49SCT_A029330_20210202T032944/IMG_DATA/R10m/T49SCT_20210202T032941_B03_10m.jp2

S2A_MSIL2A_20210202T032941_N9999_R018_T49SCT_20211210T131028.SAFE/GRANULE/L2A_T49SCT_A029330_20210202T032944/IMG_DATA/R10m/T49SCT_20210202T032941_B02_10m.jp2

S2A_MSIL2A_20210202T032941_N9999_R018_T49SCT_20211210T131028.SAFE/GRANULE/L2A_T49SCT_A029330_20210202T032944/IMG_DATA/R10m/T49SCT_20210202T032941_B08_10m.jp2
# 上面的输出结果显示了波段重组后的信息
Size is 10980, 10980
Origin = (300000.000000000000000,3800040.000000000000000)
Pixel Size = (10.000000000000000,-10.000000000000000)
Metadata:
  AOT_QUANTIFICATION_VALUE=1000.0
  AOT_QUANTIFICATION_VALUE_UNIT=none
  AOT_RETRIEVAL_ACCURACY=0.0
  BOA_QUANTIFICATION_VALUE=10000
  BOA_QUANTIFICATION_VALUE_UNIT=none
  CLOUD_COVERAGE_ASSESSMENT=1.049327
  CLOUD_SHADOW_PERCENTAGE=0.440092
  DARK_FEATURES_PERCENTAGE=30.990644
  DATATAKE_1_DATATAKE_SENSING_START=2021-02-02T03:29:41.024Z
  DATATAKE_1_DATATAKE_TYPE=INS-NOBS
  DATATAKE_1_ID=GS2A_20210202T032941_029330_N99.99
  DATATAKE_1_SENSING_ORBIT_DIRECTION=DESCENDING
  DATATAKE_1_SENSING_ORBIT_NUMBER=18
  DATATAKE_1_SPACECRAFT_NAME=Sentinel-2A
  DEGRADED_ANC_DATA_PERCENTAGE=0.0
  DEGRADED_MSI_DATA_PERCENTAGE=0
  FORMAT_CORRECTNESS=PASSED
  GENERAL_QUALITY=PASSED
  GENERATION_TIME=2021-12-10T13:10:28.715000Z
  GEOMETRIC_QUALITY=PASSED
```

```
  HIGH_PROBA_CLOUDS_PERCENTAGE=0.061825
  MEDIUM_PROBA_CLOUDS_PERCENTAGE=0.484693
  NODATA_PIXEL_PERCENTAGE=0.000043
  NOT_VEGETATED_PERCENTAGE=47.824116
  PREVIEW_GEO_INFO=Not applicable
  PREVIEW_IMAGE_URL=Not applicable
  PROCESSING_BASELINE=99.99
  PROCESSING_LEVEL=Level-2A
  PRODUCT_START_TIME=2021-02-02T03:29:41.024Z
  PRODUCT_STOP_TIME=2021-02-02T03:29:41.024Z
  PRODUCT_TYPE=S2MSI2A
  PRODUCT_URI=S2A_MSIL2A_20210202T032941_N9999_R018_T49SCT_2021121
0T131028.SAFE
  RADIATIVE_TRANSFER_ACCURACY=0.0
  RADIOMETRIC_QUALITY=PASSED
  REFLECTANCE_CONVERSION_U=1.03080315559675
  SATURATED_DEFECTIVE_PIXEL_PERCENTAGE=0.000000
  SENSOR_QUALITY=PASSED
  SNOW_ICE_PERCENTAGE=0.002857
  SPECIAL_VALUE_NODATA=0
  SPECIAL_VALUE_SATURATED=65535
  THIN_CIRRUS_PERCENTAGE=0.502809
  UNCLASSIFIED_PERCENTAGE=10.570553
  VEGETATION_PERCENTAGE=6.625548
  WATER_PERCENTAGE=2.496857
  WATER_VAPOUR_RETRIEVAL_ACCURACY=0.0
  WVP_QUANTIFICATION_VALUE=1000.0
  WVP_QUANTIFICATION_VALUE_UNIT=cm
Image Structure Metadata:
  COMPRESSION=JPEG2000
Corner Coordinates:
Upper Left  (  300000.000, 3800040.000)
Lower Left  (  300000.000, 3690240.000)
Upper Right (  409800.000, 3800040.000)
Lower Right (  409800.000, 3690240.000)
Center      (  354900.000, 3745140.000)
# 下面的代码详细介绍了波段重组后各波段的信息
Band 1 Block=128x128 Type=UInt16, ColorInterp=Red
  Description = B4, central wavelength 665 nm
  Overviews: 5490x5490, 2745x2745, 1373x1373, 687x687, 344x344
  Metadata:
    BANDNAME=B4
    BANDWIDTH=30
    BANDWIDTH_UNIT=nm
    SOLAR_IRRADIANCE=1512.06
    SOLAR_IRRADIANCE_UNIT=W/m2/um
    WAVELENGTH=665
    WAVELENGTH_UNIT=nm
Band 2 Block=128x128 Type=UInt16, ColorInterp=Green
  Description = B3, central wavelength 560 nm
  Overviews: 5490x5490, 2745x2745, 1373x1373, 687x687, 344x344
  Metadata:
    BANDNAME=B3
    BANDWIDTH=35
    BANDWIDTH_UNIT=nm
    SOLAR_IRRADIANCE=1823.24
    SOLAR_IRRADIANCE_UNIT=W/m2/um
    WAVELENGTH=560
```

```
    WAVELENGTH_UNIT=nm
Band 3 Block=128x128 Type=UInt16, ColorInterp=Blue
  Description = B2, central wavelength 490 nm
  Overviews: 5490x5490, 2745x2745, 1373x1373, 687x687, 344x344
  Metadata:
    BANDNAME=B2
    BANDWIDTH=65
    BANDWIDTH_UNIT=nm
    SOLAR_IRRADIANCE=1959.66
    SOLAR_IRRADIANCE_UNIT=W/m2/um
    WAVELENGTH=490
    WAVELENGTH_UNIT=nm
Band 4 Block=128x128 Type=UInt16, ColorInterp=Undefined
  Description = B8, central wavelength 842 nm
  Overviews: 5490x5490, 2745x2745, 1373x1373, 687x687, 344x344
  Metadata:
    BANDNAME=B8
    BANDWIDTH=115
    BANDWIDTH_UNIT=nm
    SOLAR_IRRADIANCE=1041.63
    SOLAR_IRRADIANCE_UNIT=W/m2/um
    WAVELENGTH=842
    WAVELENGTH_UNIT=nm
```

```
$ gdalinfo SENTINEL2_L2A:S2A_MSIL2A_20210202T032941_N9999_R018_T49SCT_20211210T131028.SAFE/MTD_MSIL2A.xml:20m:EPSG_32649
ERROR 1: PROJ: proj_create_from_database: Cannot find proj.db
Driver: SENTINEL2/Sentinel 2
Files: S2A_MSIL2A_20210202T032941_N9999_R018_T49SCT_20211210T131028.SAFE/MTD_MSIL2A.xml

S2A_MSIL2A_20210202T032941_N9999_R018_T49SCT_20211210T131028.SAFE/GRANULE/L2A_T49SCT_A029330_20210202T032944/MTD_TL.xml

S2A_MSIL2A_20210202T032941_N9999_R018_T49SCT_20211210T131028.SAFE/GRANULE/L2A_T49SCT_A029330_20210202T032944/IMG_DATA/R20m/T49SCT_20210202T032941_B05_20m.jp2

S2A_MSIL2A_20210202T032941_N9999_R018_T49SCT_20211210T131028.SAFE/GRANULE/L2A_T49SCT_A029330_20210202T032944/IMG_DATA/R20m/T49SCT_20210202T032941_B06_20m.jp2

S2A_MSIL2A_20210202T032941_N9999_R018_T49SCT_20211210T131028.SAFE/GRANULE/L2A_T49SCT_A029330_20210202T032944/IMG_DATA/R20m/T49SCT_20210202T032941_B07_20m.jp2

S2A_MSIL2A_20210202T032941_N9999_R018_T49SCT_20211210T131028.SAFE/GRANULE/L2A_T49SCT_A029330_20210202T032944/IMG_DATA/R20m/T49SCT_20210202T032941_B8A_20m.jp2

S2A_MSIL2A_20210202T032941_N9999_R018_T49SCT_20211210T131028.SAFE/GRANULE/L2A_T49SCT_A029330_20210202T032944/IMG_DATA/R20m/T49SCT_20210202T032941_B11_20m.jp2
```

```
S2A_MSIL2A_20210202T032941_N9999_R018_T49SCT_20211210T131028.SAFE/GRANULE/L2A_T49SCT_A029330_20210202T032944/IMG_DATA/R20m/T49SCT_20210202T032941_B12_20m.jp2

S2A_MSIL2A_20210202T032941_N9999_R018_T49SCT_20211210T131028.SAFE/GRANULE/L2A_T49SCT_A029330_20210202T032944/IMG_DATA/R20m/T49SCT_20210202T032941_AOT_20m.jp2

S2A_MSIL2A_20210202T032941_N9999_R018_T49SCT_20211210T131028.SAFE/GRANULE/L2A_T49SCT_A029330_20210202T032944/QI_DATA/MSK_CLDPRB_20m.jp2

S2A_MSIL2A_20210202T032941_N9999_R018_T49SCT_20211210T131028.SAFE/GRANULE/L2A_T49SCT_A029330_20210202T032944/IMG_DATA/R20m/T49SCT_20210202T032941_SCL_20m.jp2

S2A_MSIL2A_20210202T032941_N9999_R018_T49SCT_20211210T131028.SAFE/GRANULE/L2A_T49SCT_A029330_20210202T032944/QI_DATA/MSK_SNWPRB_20m.jp2

S2A_MSIL2A_20210202T032941_N9999_R018_T49SCT_20211210T131028.SAFE/GRANULE/L2A_T49SCT_A029330_20210202T032944/IMG_DATA/R20m/T49SCT_20210202T032941_WVP_20m.jp2
Size is 5490, 5490
Origin = (300000.000000000000000,3800040.000000000000000)
Pixel Size = (20.000000000000000,-20.000000000000000)
Metadata:
  AOT_QUANTIFICATION_VALUE=1000.0
  AOT_QUANTIFICATION_VALUE_UNIT=none
  AOT_RETRIEVAL_ACCURACY=0.0
  BOA_QUANTIFICATION_VALUE=10000
  BOA_QUANTIFICATION_VALUE_UNIT=none
  CLOUD_COVERAGE_ASSESSMENT=1.049327
  CLOUD_SHADOW_PERCENTAGE=0.440092
  DARK_FEATURES_PERCENTAGE=30.990644
  DATATAKE_1_DATATAKE_SENSING_START=2021-02-02T03:29:41.024Z
  DATATAKE_1_DATATAKE_TYPE=INS-NOBS
  DATATAKE_1_ID=GS2A_20210202T032941_029330_N99.99
  DATATAKE_1_SENSING_ORBIT_DIRECTION=DESCENDING
  DATATAKE_1_SENSING_ORBIT_NUMBER=18
  DATATAKE_1_SPACECRAFT_NAME=Sentinel-2A
  DEGRADED_ANC_DATA_PERCENTAGE=0.0
  DEGRADED_MSI_DATA_PERCENTAGE=0
  FORMAT_CORRECTNESS=PASSED
  GENERAL_QUALITY=PASSED
  GENERATION_TIME=2021-12-10T13:10:28.715000Z
  GEOMETRIC_QUALITY=PASSED
  HIGH_PROBA_CLOUDS_PERCENTAGE=0.061825
  MEDIUM_PROBA_CLOUDS_PERCENTAGE=0.484693
  NODATA_PIXEL_PERCENTAGE=0.000043
  NOT_VEGETATED_PERCENTAGE=47.824116
  PREVIEW_GEO_INFO=Not applicable
  PREVIEW_IMAGE_URL=Not applicable
  PROCESSING_BASELINE=99.99
  PROCESSING_LEVEL=Level-2A
  PRODUCT_START_TIME=2021-02-02T03:29:41.024Z
  PRODUCT_STOP_TIME=2021-02-02T03:29:41.024Z
```

```
  PRODUCT_TYPE=S2MSI2A
  PRODUCT_URI=S2A_MSIL2A_20210202T032941_N9999_R018_T49SCT_20211210T131028.SAFE
  RADIATIVE_TRANSFER_ACCURACY=0.0
  RADIOMETRIC_QUALITY=PASSED
  REFLECTANCE_CONVERSION_U=1.03080315559675
  SATURATED_DEFECTIVE_PIXEL_PERCENTAGE=0.000000
  SENSOR_QUALITY=PASSED
  SNOW_ICE_PERCENTAGE=0.002857
  SPECIAL_VALUE_NODATA=0
  SPECIAL_VALUE_SATURATED=65535
  THIN_CIRRUS_PERCENTAGE=0.502809
  UNCLASSIFIED_PERCENTAGE=10.570553
  VEGETATION_PERCENTAGE=6.625548
  WATER_PERCENTAGE=2.496857
  WATER_VAPOUR_RETRIEVAL_ACCURACY=0.0
  WVP_QUANTIFICATION_VALUE=1000.0
  WVP_QUANTIFICATION_VALUE_UNIT=cm
Image Structure Metadata:
  COMPRESSION=JPEG2000
Corner Coordinates:
Upper Left  (  300000.000, 3800040.000)
Lower Left  (  300000.000, 3690240.000)
Upper Right (  409800.000, 3800040.000)
Lower Right (  409800.0ERROR 1: PROJ: proj_create: no database context specified
ERROR 1: PROJ: proj_create: no database context specified
ERROR 1: PROJ: proj_create: no database context specified
ERROR 1: PROJ: proj_create: no database context specified
ERROR 1: PROJ: proj_create: no database context specified
ERROR 1: PROJ: proj_create: no database context specified
ERROR 1: PROJ: proj_create: no database context specified
ERROR 1: PROJ: proj_create: no database context specified
ERROR 1: PROJ: proj_create: no database context specified
ERROR 1: PROJ: proj_create: no database context specified
00, 3690240.000)
Center      (  354900.000, 3745140.000)
Band 1 Block=128x128 Type=UInt16, ColorInterp=Undefined
  Description = B5, central wavelength 705 nm
  Overviews: 2745x2745, 1373x1373, 687x687, 344x344, 172x172
  Metadata:
    BANDNAME=B5
    BANDWIDTH=15
    BANDWIDTH_UNIT=nm
    SOLAR_IRRADIANCE=1424.64
    SOLAR_IRRADIANCE_UNIT=W/m2/um
    WAVELENGTH=705
    WAVELENGTH_UNIT=nm
Band 2 Block=128x128 Type=UInt16, ColorInterp=Undefined
  Description = B6, central wavelength 740 nm
  Overviews: 2745x2745, 1373x1373, 687x687, 344x344, 172x172
  Metadata:
    BANDNAME=B6
    BANDWIDTH=15
    BANDWIDTH_UNIT=nm
    SOLAR_IRRADIANCE=1287.61
    SOLAR_IRRADIANCE_UNIT=W/m2/um
```

```
    WAVELENGTH=740
    WAVELENGTH_UNIT=nm
Band 3 Block=128x128 Type=UInt16, ColorInterp=Undefined
  Description = B7, central wavelength 783 nm
  Overviews: 2745x2745, 1373x1373, 687x687, 344x344, 172x172
  Metadata:
    BANDNAME=B7
    BANDWIDTH=20
    BANDWIDTH_UNIT=nm
    SOLAR_IRRADIANCE=1162.08
    SOLAR_IRRADIANCE_UNIT=W/m2/um
    WAVELENGTH=783
    WAVELENGTH_UNIT=nm
Band 4 Block=128x128 Type=UInt16, ColorInterp=Undefined
  Description = B8A, central wavelength 865 nm
  Overviews: 2745x2745, 1373x1373, 687x687, 344x344, 172x172
  Metadata:
    BANDNAME=B8A
    BANDWIDTH=20
    BANDWIDTH_UNIT=nm
    SOLAR_IRRADIANCE=955.32
    SOLAR_IRRADIANCE_UNIT=W/m2/um
    WAVELENGTH=865
    WAVELENGTH_UNIT=nm
Band 5 Block=128x128 Type=UInt16, ColorInterp=Undefined
  Description = B11, central wavelength 1610 nm
  Overviews: 2745x2745, 1373x1373, 687x687, 344x344, 172x172
  Metadata:
    BANDNAME=B11
    BANDWIDTH=90
    BANDWIDTH_UNIT=nm
    SOLAR_IRRADIANCE=245.59
    SOLAR_IRRADIANCE_UNIT=W/m2/um
    WAVELENGTH=1610
    WAVELENGTH_UNIT=nm
Band 6 Block=128x128 Type=UInt16, ColorInterp=Undefined
  Description = B12, central wavelength 2190 nm
  Overviews: 2745x2745, 1373x1373, 687x687, 344x344, 172x172
  Metadata:
    BANDNAME=B12
    BANDWIDTH=180
    BANDWIDTH_UNIT=nm
    SOLAR_IRRADIANCE=85.25
    SOLAR_IRRADIANCE_UNIT=W/m2/um
    WAVELENGTH=2190
    WAVELENGTH_UNIT=nm
Band 7 Block=128x128 Type=UInt16, ColorInterp=Undefined
  Description = AOT, Aerosol Optical Thickness map (at 550nm)
  Overviews: 2745x2745, 1373x1373, 687x687, 344x344, 172x172
  Metadata:
    BANDNAME=AOT
Band 8 Block=128x128 Type=UInt16, ColorInterp=Undefined
  Description = CLD, Raster mask values range from 0 for high
confidence clear sky to 100 for high confidence cloudy
  Overviews: 2745x2745, 1373x1373, 687x687, 344x344, 172x172
  Metadata:
    BANDNAME=CLD
Band 9 Block=128x128 Type=UInt16, ColorInterp=Undefined
```

```
  Description = SCL, Scene Classification
  Overviews: 2745x2745, 1373x1373, 687x687, 344x344, 172x172
  Categories:
      0: NODATA
      1: SATURATED_DEFECTIVE
      2: DARK_FEATURE_SHADOW
      3: CLOUD_SHADOW
      4: VEGETATION
      5: NOT_VEGETATED
      6: WATER
      7: UNCLASSIFIED
      8: CLOUD_MEDIUM_PROBA
      9: CLOUD_HIGH_PROBA
     10: THIN_CIRRUS
     11: SNOW_ICE
  Metadata:
    BANDNAME=SCL
Band 10 Block=128x128 Type=UInt16, ColorInterp=Undefined
  Description = SNW, Raster mask values range from 0 for high confidence NO snow/ice to 100 for high confidence snow/ice
  Overviews: 2745x2745, 1373x1373, 687x687, 344x344, 172x172
  Metadata:
    BANDNAME=SNW
Band 11 Block=128x128 Type=UInt16, ColorInterp=Undefined
  Description = WVP, Scene-average Water Vapour map
  Overviews: 2745x2745, 1373x1373, 687x687, 344x344, 172x172
  Metadata:
    BANDNAME=WVP
```

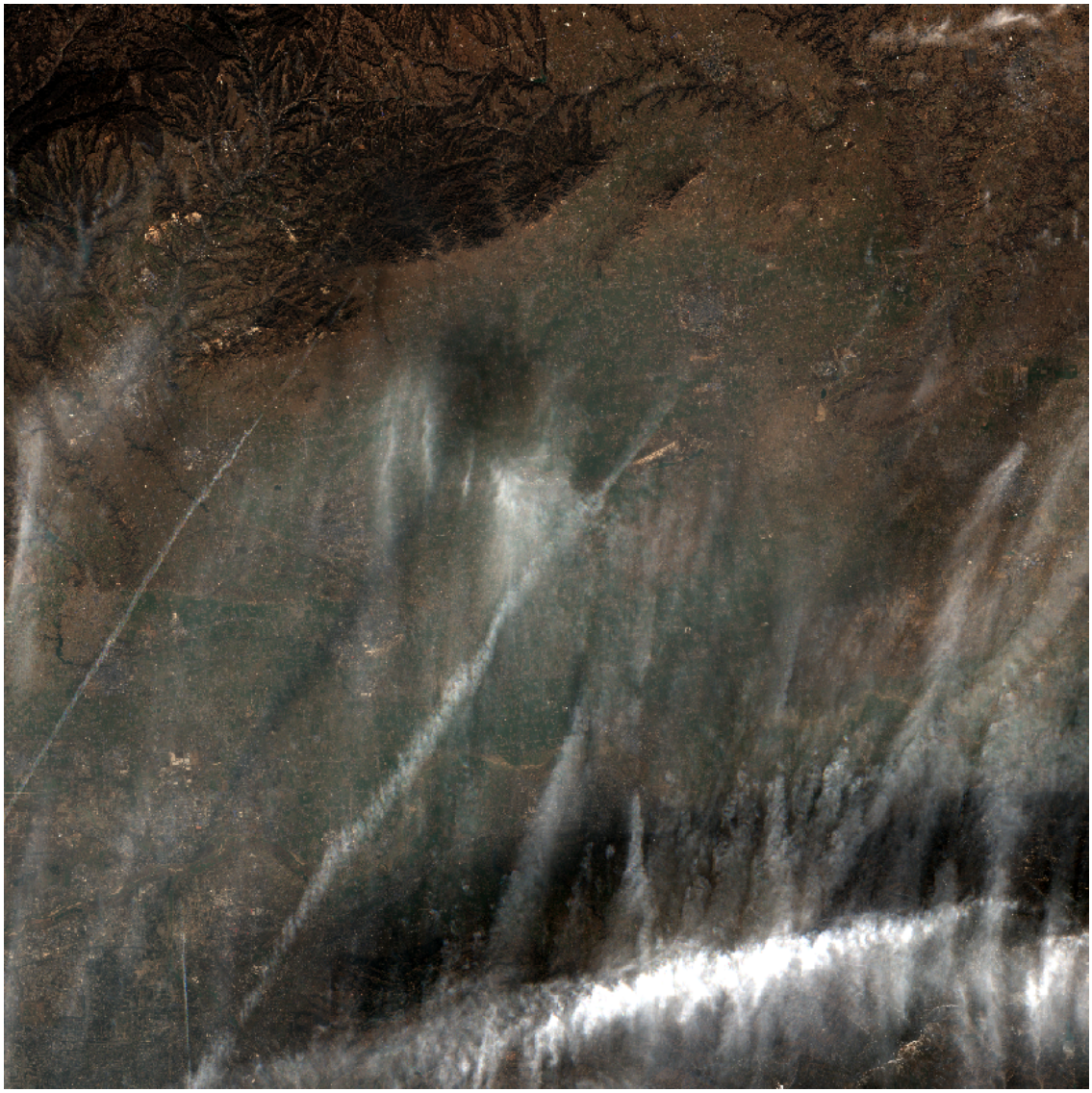
```
$ gdalinfo SENTINEL2_L2A:S2A_MSIL2A_20210202T032941_N9999_R018_T49SCT_20211210T131028.SAFE/MTD_MSIL2A.xml:60m:EPSG_32649
ERROR 1: PROJ: proj_create_from_database: Cannot find proj.db
ERROR 1: PROJ: proj_create: no database context specified
ERROR 1: PROJ: proj_create: no database context specified
ERROR 1: PROJ: proj_create: no database context specified
ERROR 1: PROJ: proj_create: no database context specified
ERROR 1: PROJ: proj_create: no database context specified
ERROR 1: PROJ: proj_create: no database context specified
ERROR 1: PROJ: proj_create: no database context specified
Driver: SENTINEL2/Sentinel 2
Files: S2A_MSIL2A_20210202T032941_N9999_R018_T49SCT_20211210T131028.SAFE/MTD_MSIL2A.xml

S2A_MSIL2A_20210202T032941_N9999_R018_T49SCT_20211210T131028.SAFE/GRANULE/L2A_T49SCT_A029330_20210202T032944/MTD_TL.xml

S2A_MSIL2A_20210202T032941_N9999_R018_T49SCT_20211210T131028.SAFE/GRANULE/L2A_T49SCT_A029330_20210202T032944/IMG_DATA/R60m/T49SCT_20210202T032941_B01_60m.jp2

S2A_MSIL2A_20210202T032941_N9999_R018_T49SCT_20211210T131028.SAFE/GRANULE/L2A_T49SCT_A029330_20210202T032944/IMG_DATA/R60m/T49SCT_20210202T032941_B09_60m.jp2
```

```
S2A_MSIL2A_20210202T032941_N9999_R018_T49SCT_20211210T131028.SAFE/GRANULE/L2A_T49SCT_A029330_20210202T032944/IMG_DATA/R60m/T49SCT_20210202T032941_AOT_60m.jp2

S2A_MSIL2A_20210202T032941_N9999_R018_T49SCT_20211210T131028.SAFE/GRANULE/L2A_T49SCT_A029330_20210202T032944/QI_DATA/MSK_CLDPRB_60m.jp2

S2A_MSIL2A_20210202T032941_N9999_R018_T49SCT_20211210T131028.SAFE/GRANULE/L2A_T49SCT_A029330_20210202T032944/IMG_DATA/R60m/T49SCT_20210202T032941_SCL_60m.jp2

S2A_MSIL2A_20210202T032941_N9999_R018_T49SCT_20211210T131028.SAFE/GRANULE/L2A_T49SCT_A029330_20210202T032944/QI_DATA/MSK_SNWPRB_60m.jp2

S2A_MSIL2A_20210202T032941_N9999_R018_T49SCT_20211210T131028.SAFE/GRANULE/L2A_T49SCT_A029330_20210202T032944/IMG_DATA/R60m/T49SCT_20210202T032941_WVP_60m.jp2
Size is 1830, 1830
Origin = (300000.000000000000000,3800040.000000000000000)
Pixel Size = (60.000000000000000,-60.000000000000000)
Metadata:
  AOT_QUANTIFICATION_VALUE=1000.0
  AOT_QUANTIFICATION_VALUE_UNIT=none
  AOT_RETRIEVAL_ACCURACY=0.0
  BOA_QUANTIFICATION_VALUE=10000
  BOA_QUANTIFICATION_VALUE_UNIT=none
  CLOUD_COVERAGE_ASSESSMENT=1.049327
  CLOUD_SHADOW_PERCENTAGE=0.440092
  DARK_FEATURES_PERCENTAGE=30.990644
  DATATAKE_1_DATATAKE_SENSING_START=2021-02-02T03:29:41.024Z
  DATATAKE_1_DATATAKE_TYPE=INS-NOBS
  DATATAKE_1_ID=GS2A_20210202T032941_029330_N99.99
  DATATAKE_1_SENSING_ORBIT_DIRECTION=DESCENDING
  DATATAKE_1_SENSING_ORBIT_NUMBER=18
  DATATAKE_1_SPACECRAFT_NAME=Sentinel-2A
  DEGRADED_ANC_DATA_PERCENTAGE=0.0
  DEGRADED_MSI_DATA_PERCENTAGE=0
  FORMAT_CORRECTNESS=PASSED
  GENERAL_QUALITY=PASSED
  GENERATION_TIME=2021-12-10T13:10:28.715000Z
  GEOMETRIC_QUALITY=PASSED
  HIGH_PROBA_CLOUDS_PERCENTAGE=0.061825
  MEDIUM_PROBA_CLOUDS_PERCENTAGE=0.484693
  NODATA_PIXEL_PERCENTAGE=0.000043
  NOT_VEGETATED_PERCENTAGE=47.824116
  PREVIEW_GEO_INFO=Not applicable
  PREVIEW_IMAGE_URL=Not applicable
  PROCESSING_BASELINE=99.99
  PROCESSING_LEVEL=Level-2A
  PRODUCT_START_TIME=2021-02-02T03:29:41.024Z
  PRODUCT_STOP_TIME=2021-02-02T03:29:41.024Z
  PRODUCT_TYPE=S2MSI2A
  PRODUCT_URI=S2A_MSIL2A_20210202T032941_N9999_R018_T49SCT_20211210T131028.SAFE
  RADIATIVE_TRANSFER_ACCURACY=0.0
```

```
  RADIOMETRIC_QUALITY=PASSED
  REFLECTANCE_CONVERSION_U=1.03080315559675
  SATURATED_DEFECTIVE_PIXEL_PERCENTAGE=0.000000
  SENSOR_QUALITY=PASSED
  SNOW_ICE_PERCENTAGE=0.002857
  SPECIAL_VALUE_NODATA=0
  SPECIAL_VALUE_SATURATED=65535
  THIN_CIRRUS_PERCENTAGE=0.502809
  UNCLASSIFIED_PERCENTAGE=10.570553
  VEGETATION_PERCENTAGE=6.625548
  WATER_PERCENTAGE=2.496857
  WATER_VAPOUR_RETRIEVAL_ACCURACY=0.0
  WVP_QUANTIFICATION_VALUE=1000.0
  WVP_QUANTIFICATION_VALUE_UNIT=cm
Image Structure Metadata:
  COMPRESSION=JPEG2000
Corner Coordinates:
Upper Left  (  300000.000, 3800040.000)
Lower Left  (  300000.000, 3690240.000)
Upper Right (  409800.000, 3800040.000)
Lower Right (  409800.000, 3690240.000)
Center      (  354900.000, 3745140.000)
Band 1 Block=128x128 Type=UInt16, ColorInterp=Undefined
  Description = B1, central wavelength 443 nm
  Overviews: 915x915, 458x458, 229x229
  Metadata:
    BANDNAME=B1
    BANDWIDTH=20
    BANDWIDTH_UNIT=nm
    SOLAR_IRRADIANCE=1884.69
    SOLAR_IRRADIANCE_UNIT=W/m2/um
    WAVELENGTH=443
    WAVELENGTH_UNIT=nm
Band 2 Block=128x128 Type=UInt16, ColorInterp=Undefined
  Description = B9, central wavelength 945 nm
  Overviews: 915x915, 458x458, 229x229
  Metadata:
    BANDNAME=B9
    BANDWIDTH=20
    BANDWIDTH_UNIT=nm
    SOLAR_IRRADIANCE=812.92
    SOLAR_IRRADIANCE_UNIT=W/m2/um
    WAVELENGTH=945
    WAVELENGTH_UNIT=nm
Band 3 Block=128x128 Type=UInt16, ColorInterp=Undefined
  Description = AOT, Aerosol Optical Thickness map (at 550nm)
  Overviews: 915x915, 458x458, 229x229
  Metadata:
    BANDNAME=AOT
Band 4 Block=128x128 Type=UInt16, ColorInterp=Undefined
  Description = CLD, Raster mask values range from 0 for high
confidence clear sky to 100 for high confidence cloudy
  Overviews: 915x915, 458x458, 229x229
  Metadata:
    BANDNAME=CLD
Band 5 Block=128x128 Type=UInt16, ColorInterp=Undefined
  Description = SCL, Scene Classification
  Overviews: 915x915, 458x458, 229x229
```

```
  Categories:
      0: NODATA
      1: SATURATED_DEFECTIVE
      2: DARK_FEATURE_SHADOW
      3: CLOUD_SHADOW
      4: VEGETATION
      5: NOT_VEGETATED
      6: WATER
      7: UNCLASSIFIED
      8: CLOUD_MEDIUM_PROBA
      9: CLOUD_HIGH_PROBA
     10: THIN_CIRRUS
     11: SNOW_ICE
  Metadata:
    BANDNAME=SCL
Band 6 Block=128x128 Type=UInt16, ColorInterp=Undefined
  Description = SNW, Raster mask values range from 0 for high confidence NO snow/ice to 100 for high confidence snow/ice
  Overviews: 915x915, 458x458, 229x229
  Metadata:
    BANDNAME=SNW
Band 7 Block=128x128 Type=UInt16, ColorInterp=Undefined
  Description = WVP, Scene-average Water Vapour map
  Overviews: 915x915, 458x458, 229x229
  Metadata:
    BANDNAME=WVP
```

- rgb 图像展示:



- 通过改变代码中的子数据集以及 gdalinfo 工具查询的信息可以获取 Sentinel-2 数据集的不同波段。

参考文献

[1] KilllerQueen. Python脚本批量读取哨兵2号（Sentinel2）影像并另存为Geotiff格式[EB/OL]. 2021-03-10[2022-01-13]. https://blog.csdn.net/KilllerQueen/article/details/114637970.