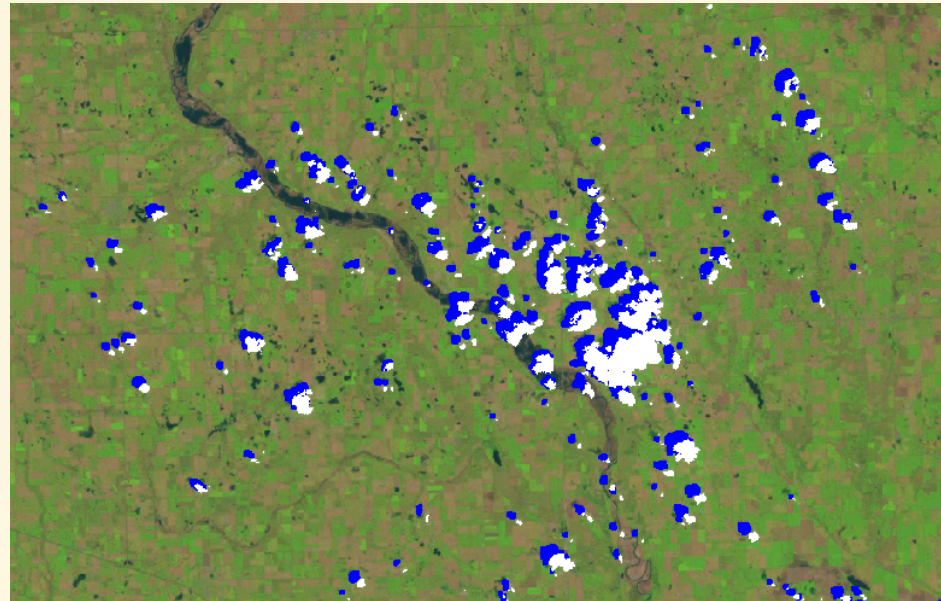


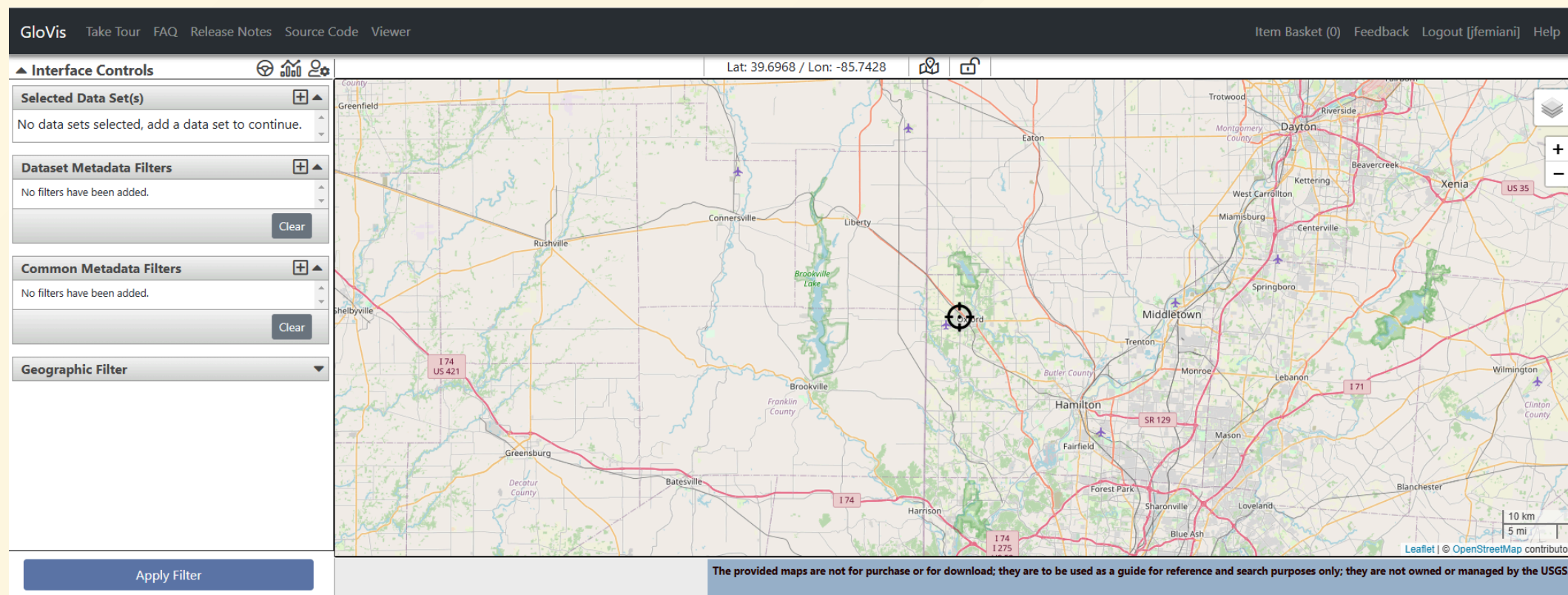
# Cloud Detection in Landsat Imagery

An overview of cloud detection techniques in Landsat data, starting with GloVIS for data access, followed by quality assessment (QA) bands and cloud detection methods.



# Accessing Landsat Imagery Using GloVIS

1. **Go to GloVIS:** Visit [glovis.usgs.gov](https://glovis.usgs.gov), a tool by the USGS for browsing and downloading satellite imagery, including Landsat.



2. **Select Area of Interest:** Use the map to navigate to your area of interest.



### 3. Choose a Dataset:

- Select the **Landsat archive** (e.g., Landsat 8 Collection 2).
- Other collections, like Sentinel or MODIS, are also available.

Selected Data Set(s)

No data sets selected, add a data set to continue.

Add Data Set

Data Set Catalog

GloVis

Data Set Filter

Filter by data set name an

Global Land Survey

IRS AWiFS

ISRO Resourcesat R1/R2 AWiFS Level 1 Systematic Orthorectified

IRS LISS-3

ISRO Resourcesat R1/R2 LISS-3 Level 1 Systematic Orthorectified

Landsat 8-9 OLI/TIRS C2 L1

Landsat 8-9 Operational Land Imager and Thermal Infrared Sensor Collection 2 Level-1

Landsat 7 ETM+ C2 L1

Landsat 7 Enhanced Thematic Mapper Plus Collection 2 Level-1

Landsat 4-5 TM C2 L1

Landsat 4-5 Thematic Mapper Collection 2 Level-1

Landsat 1-5 MSS C2 L1

Landsat 1-5 Multi-Spectral Scanner Collection 2 Level-1

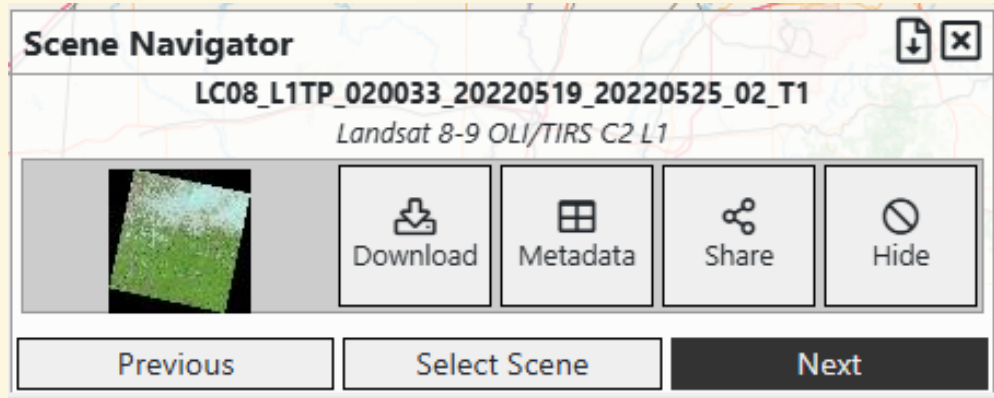
Add All Data Sets

Add Selected Data Sets

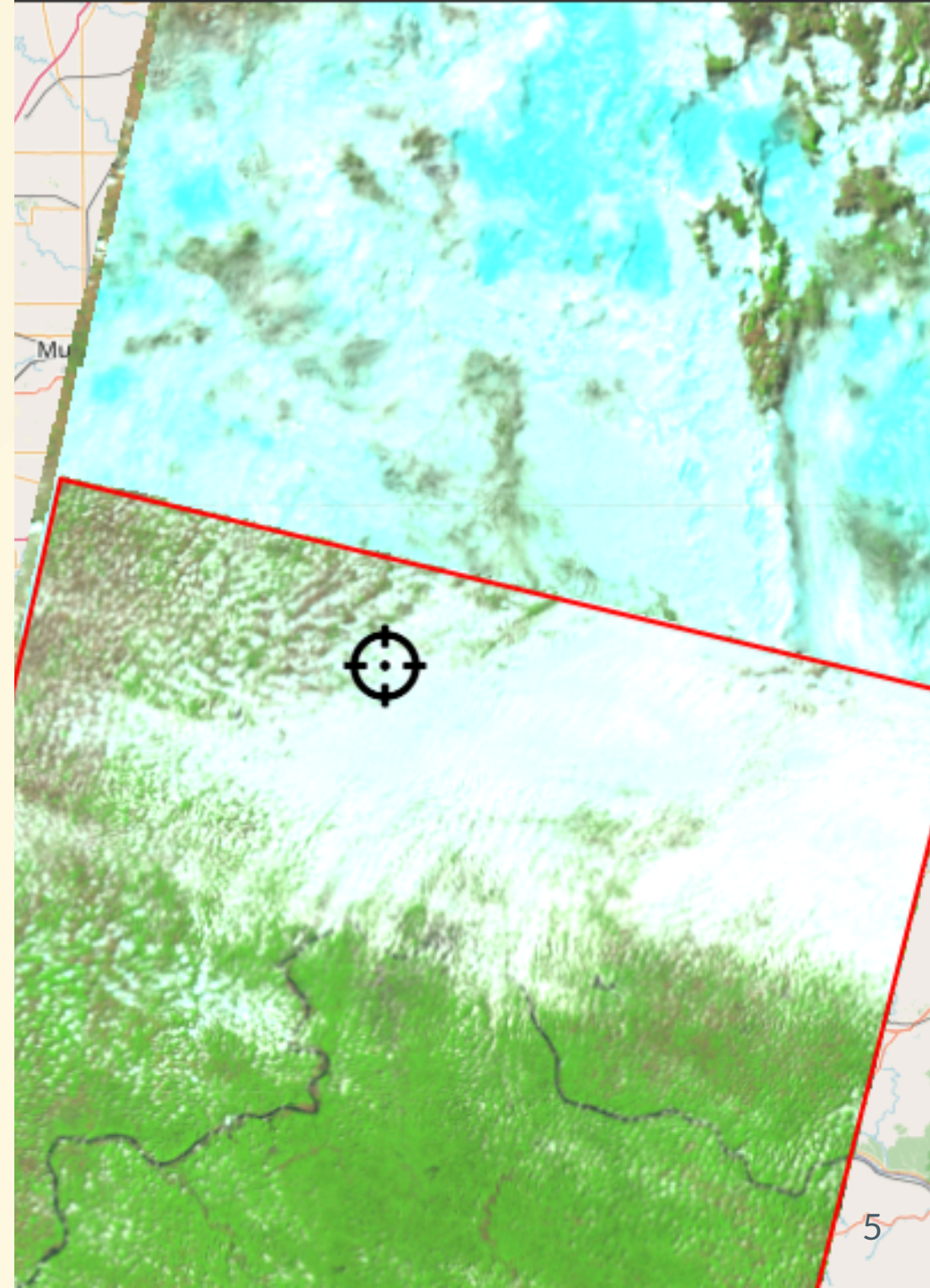
Close



# Use the scene navigator



- **Next** - Go to the next available image
- **Prev** - Duh!



**Download Options:** Choose download formats, Landsat imagery includes QA bands that provide pixel-level data on image quality, specifically cloud and shadow information.

- **QA\_PIXEL Band:**
  - Part of **Landsat Collection 2**.
  - Provides bitwise information on cloud presence, cloud shadow, snow, and water.
  - **Cloud Confidence Levels:** Indicates the probability of cloud cover per pixel.
- **QA\_RADSAT Band:**
  - Flags radiometric saturation, helpful in detecting highly reflective areas, often associated with clouds.

LC08_L1TP_020033_20210430_20210508_02_T1_QA_PIXEL.TIF	↓
Estimated Size: 1.05 MB	
LC08_L1TP_020033_20210430_20210508_02_T1_QA_RADSAT.TIF	↓
Estimated Size: 218.39 KB	

### Scene Download Options

All Level-1 Files  
20 files

Add All Files to BulkDownload All Files NowSelect Files

Landsat Collection 2 Level-1 Product Bundle  
Estimated Size: 1.24 GB

Full-Resolution Browse (Natural Color) GeoTIFF  
Estimated Size: 14.00 MB

Full-Resolution Browse (Thermal) GeoTIFF  
Estimated Size: 14.00 MB

Full-Resolution Browse (Quality) GeoTIFF  
Estimated Size: 14.00 MB

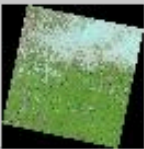
Full-Resolution Browse (Natural Color) JPEG  
Estimated Size: 6.00 MB

Full-Resolution Browse (Thermal) JPEG  
Estimated Size: 6.00 MB

Full-Resolution Browse (Quality) JPEG  
Estimated Size: 6.00 MB

### Scene Navigator

LC08\_L1TP\_020033\_20220519\_20220525\_02\_T1  
Landsat 8-9 OLI/TIRS C2 L1



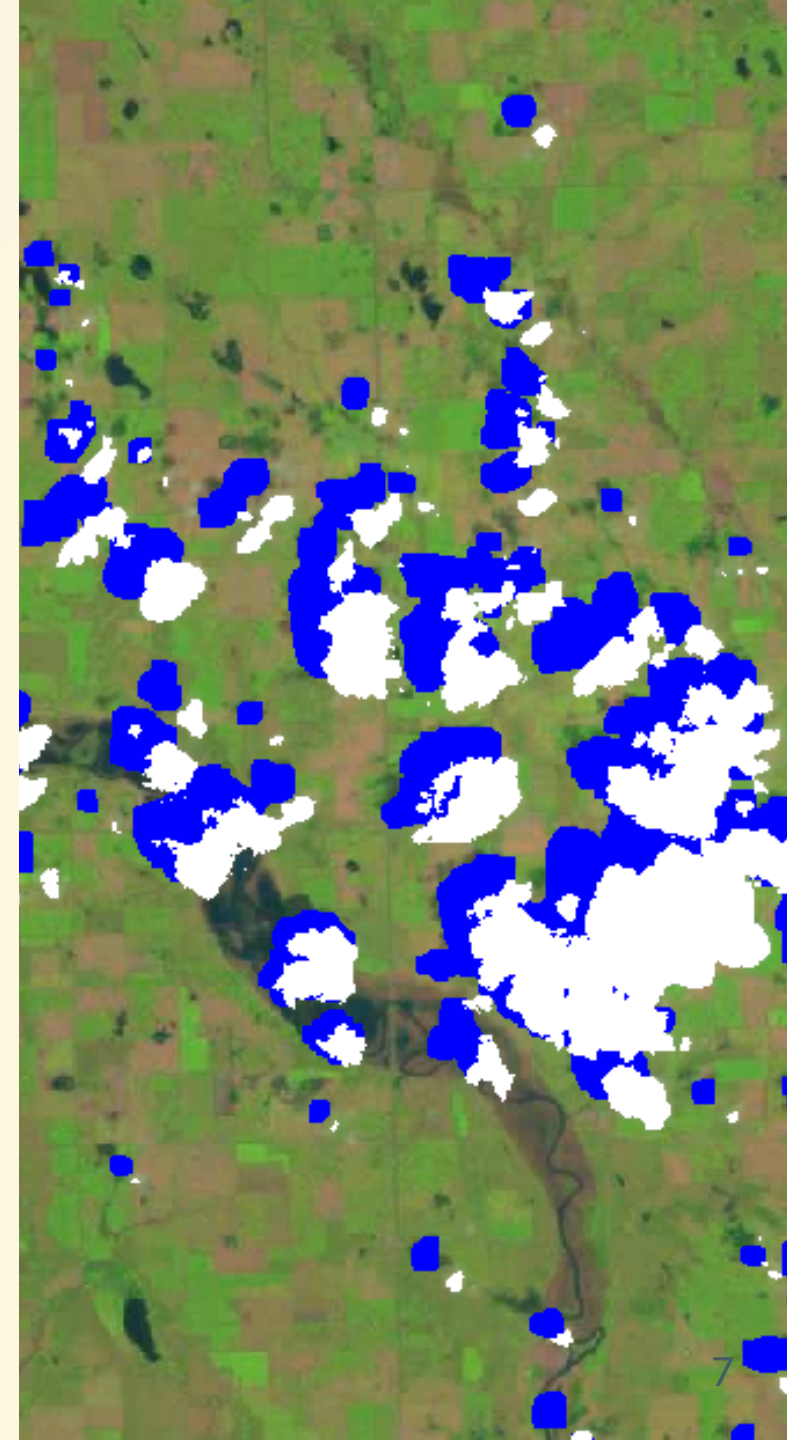
DownloadMetadataShareHide

PreviousSelect SceneNext6

# Using QA Bands for Cloud and Shadow Detection

## Decoding the QA\_PIXEL Band:

- The QA\_PIXEL band encodes multiple quality flags in a single band using bit fields.
- Each bit represents specific conditions, like **cloud confidence** or **cloud shadow**.
- Tools like **Google Earth Engine** and **QGIS** can decode these bits for masking clouds.



# Filtering by Cloud Cover

The image displays two sequential screenshots of a 'Add Filter' dialog box in a software application.

**Top Screenshot:** The dialog box is titled 'Add Filter' with a close button (X) in the top right corner. Under the 'Filter Type' section, a dropdown menu is open, showing the following options: '(Select One)', '(Select One)', 'Acquisition Date', 'Cloud Cover' (which is highlighted in blue), 'Seasonal (Month Selections)', and 'Scene Ingest Date'.

**Bottom Screenshot:** The dialog box is again titled 'Add Filter' with a close button (X) in the top right corner. The 'Filter Type' dropdown now shows 'Cloud Cover'. Below this, the 'Cloud Cover' filter is configured with a range of '0' to '8'. A slider bar is visible below the range input, with a yellow handle positioned at the '0' mark. There is an information icon (i) and a reset icon (X) to the right of the range input. At the bottom left, the checkbox 'Include Unknown' is checked. At the bottom right, there are two buttons: 'Add Filter' and 'Close'.



# Common Indices for Cloud Detection

## 1. Normalized Difference Snow Index (NDSI)

- Formula:  $\frac{\text{Green} - \text{SWIR}}{\text{Green} + \text{SWIR}}$
- Differentiates clouds (like snow) by their high reflectance in the visible range and low reflectance in SWIR.

## 2. Normalized Difference Cloud Index (NDCI)

- Formula:  $\frac{\text{Blue} - \text{SWIR}}{\text{Blue} + \text{SWIR}}$
- Useful for separating clouds from other bright surfaces due to clouds' high reflectance in the blue band.

SWIR is band 6 on Landsat 8, Band 5 on Landsat 7 or 5

# Brightness Temperature for Cloud Detection

- **Thermal Infrared (TIR) Bands:**
  - Use Landsat's thermal bands (e.g., Bands 10 and 11 on Landsat 8) to assess brightness temperature.
  - **Clouds are generally colder** than ground surfaces, making TIR a reliable tool for detecting thick clouds.

# Advanced Cloud Detection: Fmask

- **Fmask (Function of Mask):**

- A specialized algorithm for detecting clouds, cloud shadows, and snow in Landsat data.
- Uses multiple spectral indices (prev. slides) and brightness temperature thresholds.
- Uses solar position to project shadows & verify them
- Commonly applied in preprocessing to automate cloud and shadow masking.

**Benefits:** Fmask is robust, combining spectral, thermal, and contextual information to improve cloud detection accuracy.

**Source:**

- <https://github.com/GERSL/Fmask> (matlab),
- <https://github.com/ubarsc/python-fmask> (python)

# Summary

- **GloVIS:** A powerful tool for accessing Landsat imagery, with filters for cloud cover.
- **QA Bands:** Provide pixel-level flags for clouds, shadows, and other quality issues.
- **Cloud Detection Methods:** Include indices (NDSI, NDCI), brightness temperature, and advanced tools like Fmask.
- **Dataset Selection:** Choose appropriate Landsat Collection 2 products for pre-processed cloud masks.



# Further Resources

- [GloVIS](#)
- [USGS Earth Explorer](#)
- [Google Earth Engine](#)
- [Fmask \(matlab\)](#), and a [python port](#)

Explore these resources for more on Landsat data and cloud detection tools.