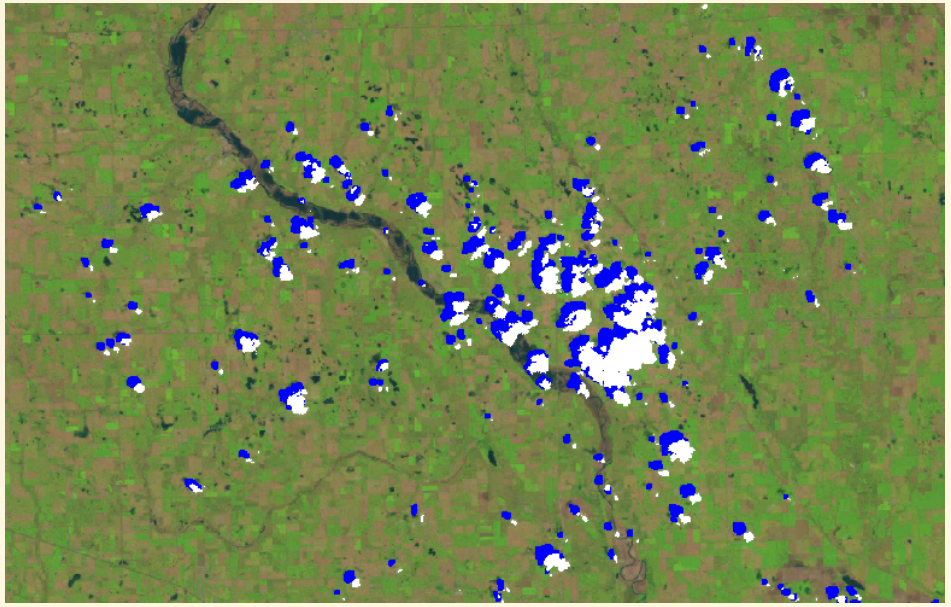
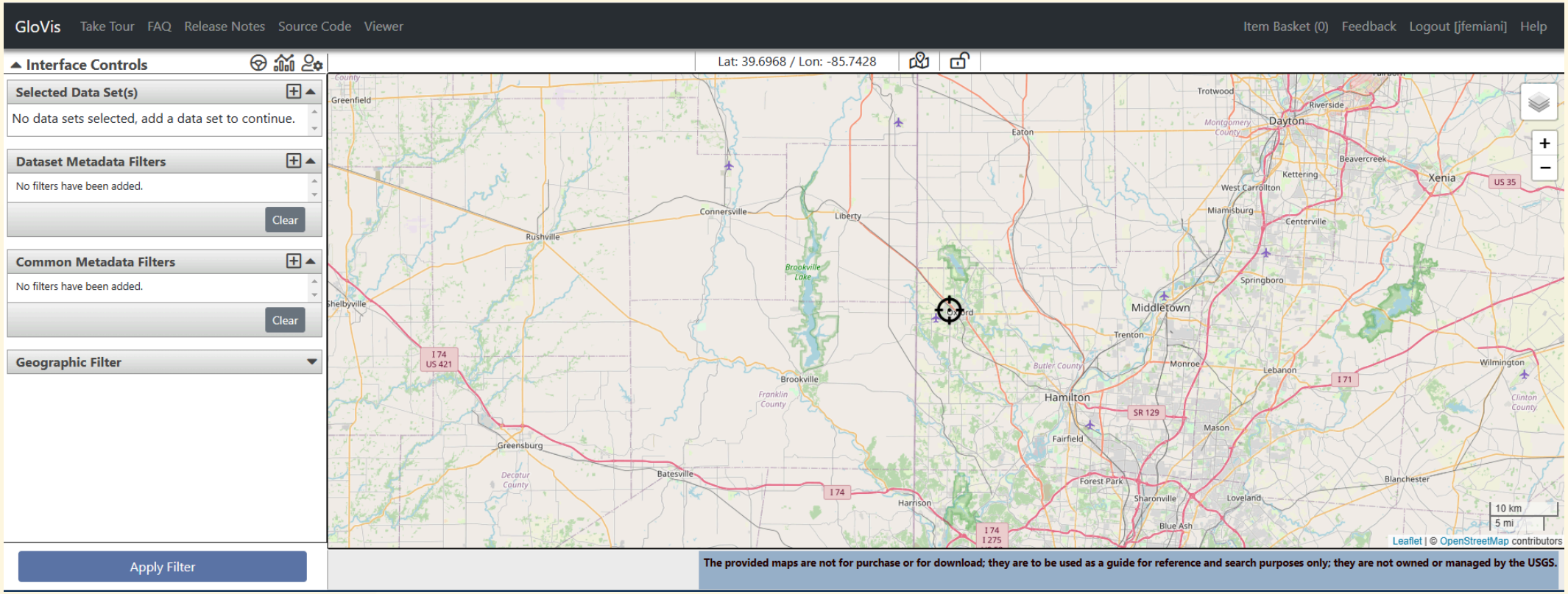
Cloud Detection in Landsat Imagery

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.



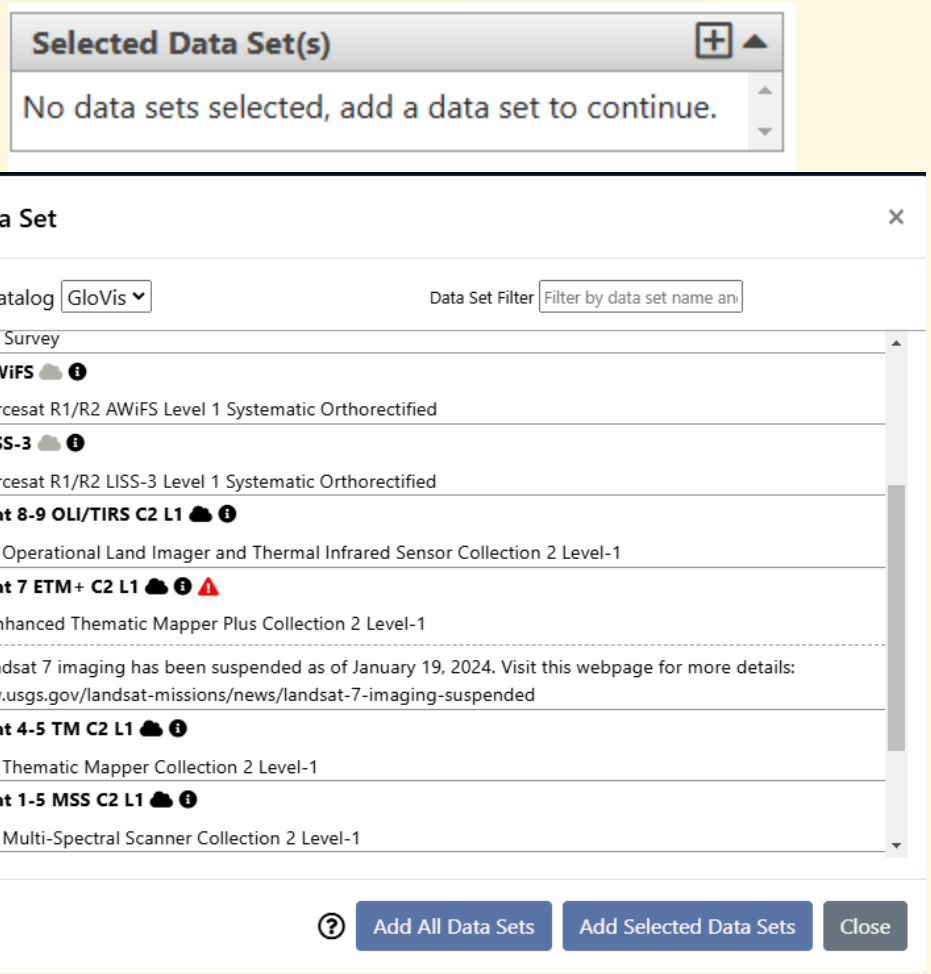
Accessing Landsat Imagery Using GloVIS

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

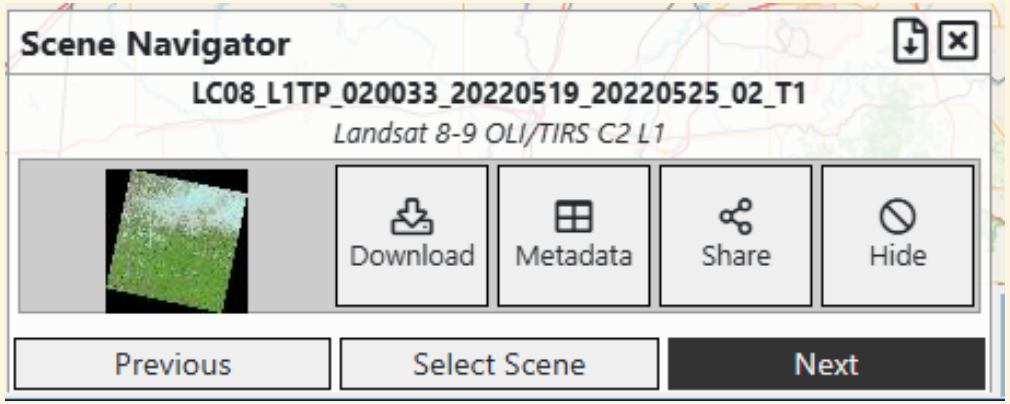


2. **Select Area of Interest**: Use the map to navigate to your area of interest.

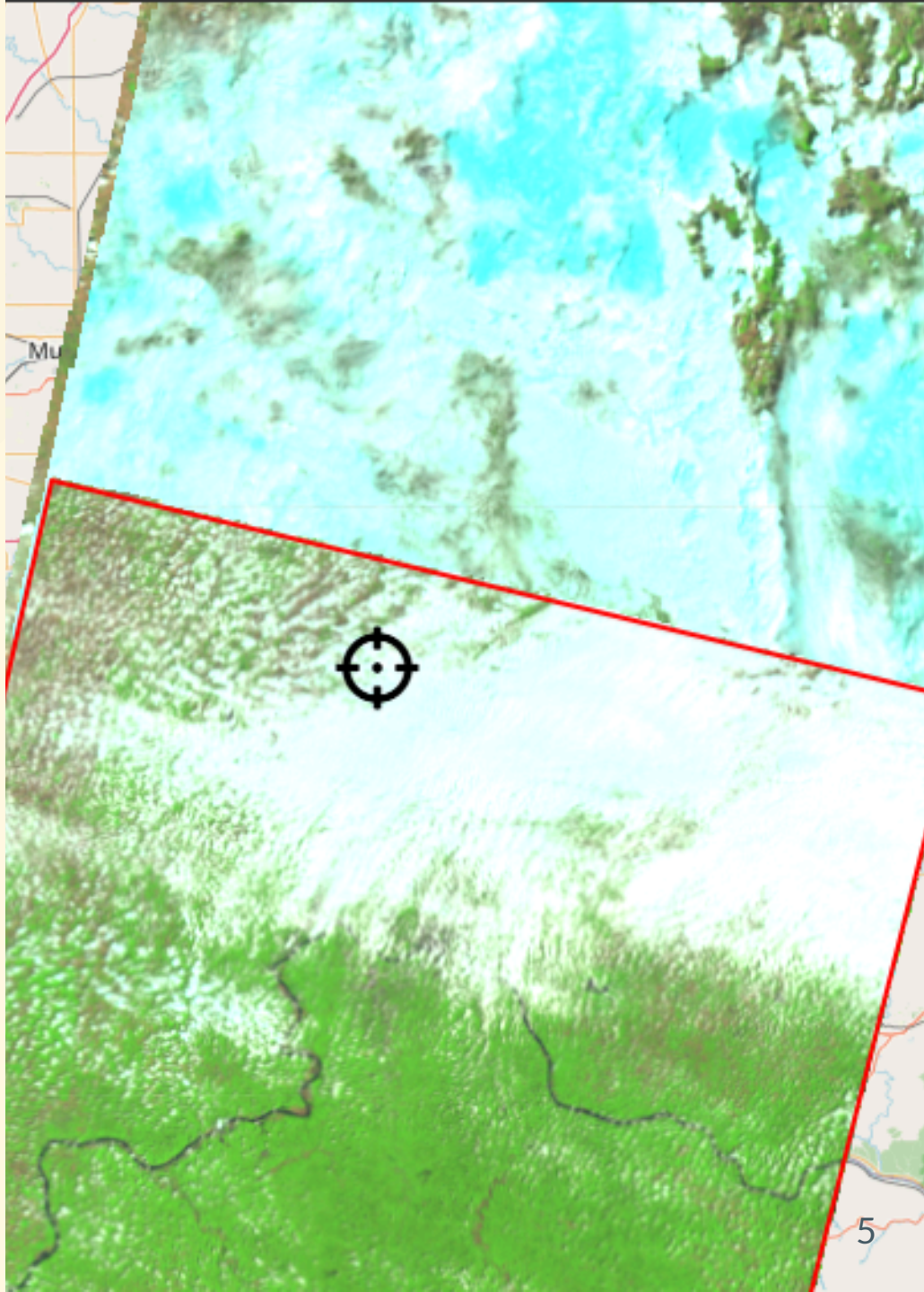
3. **Choose a Dataset**:
   - Select the **Landsat archive** (e.g., Landsat 8 Collection 2).
   - Other collections, like Sentinel or MODIS, are also available.



Use the scene navigator

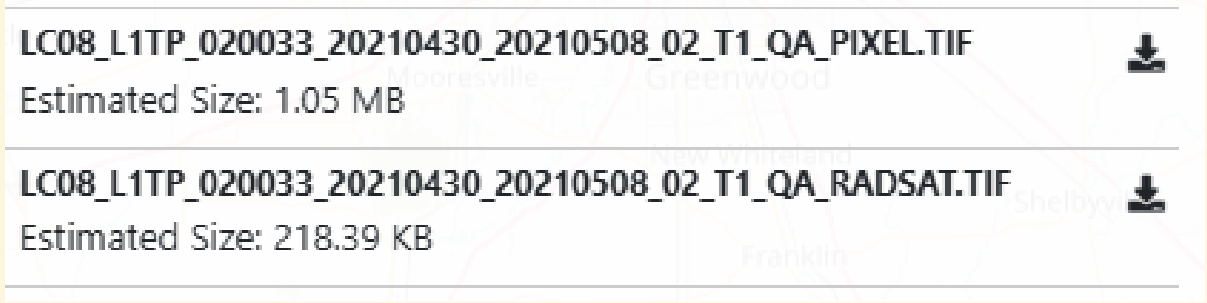


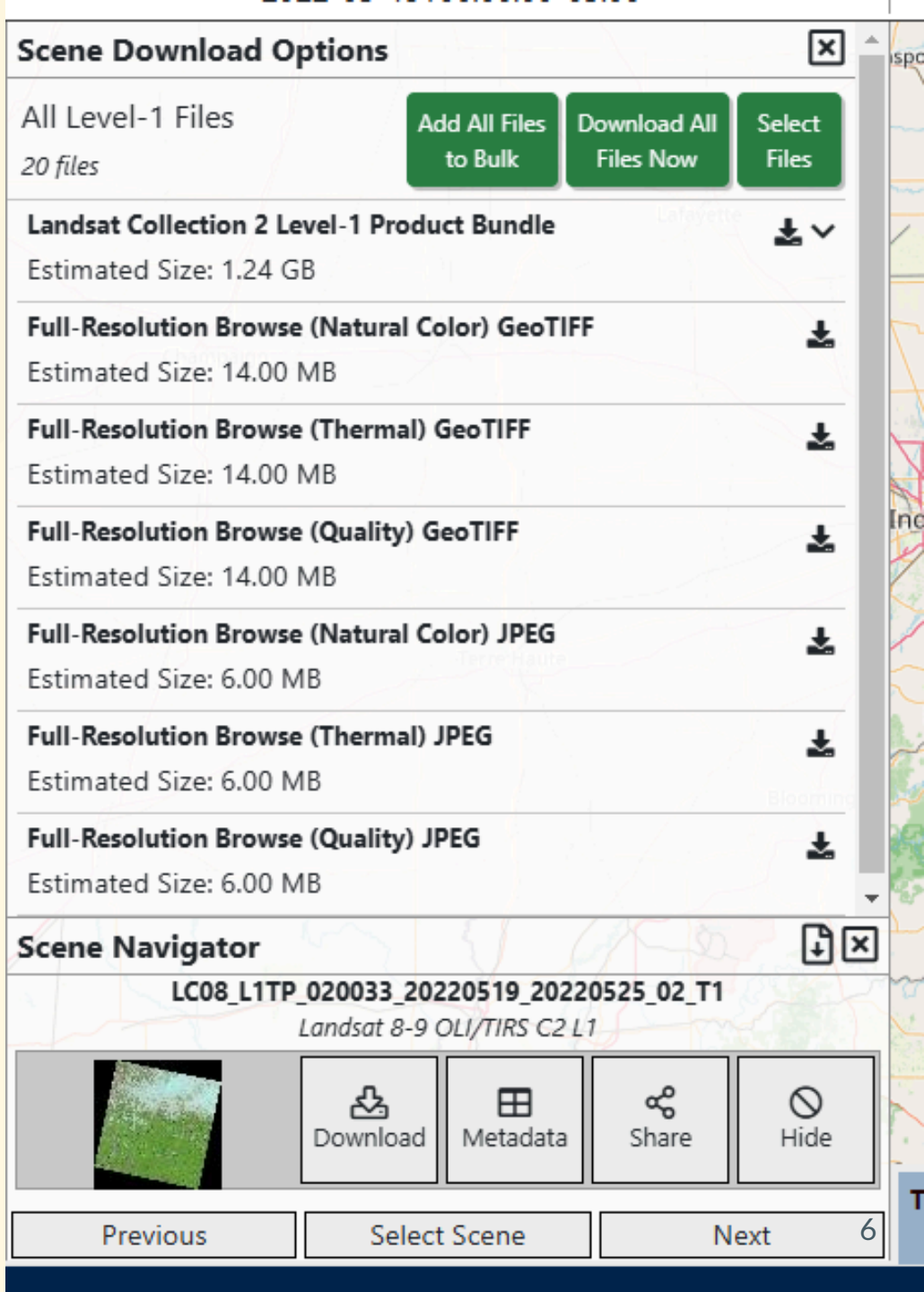
- **Next** - Go to the next available image
- **Prev** - Duh!



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.

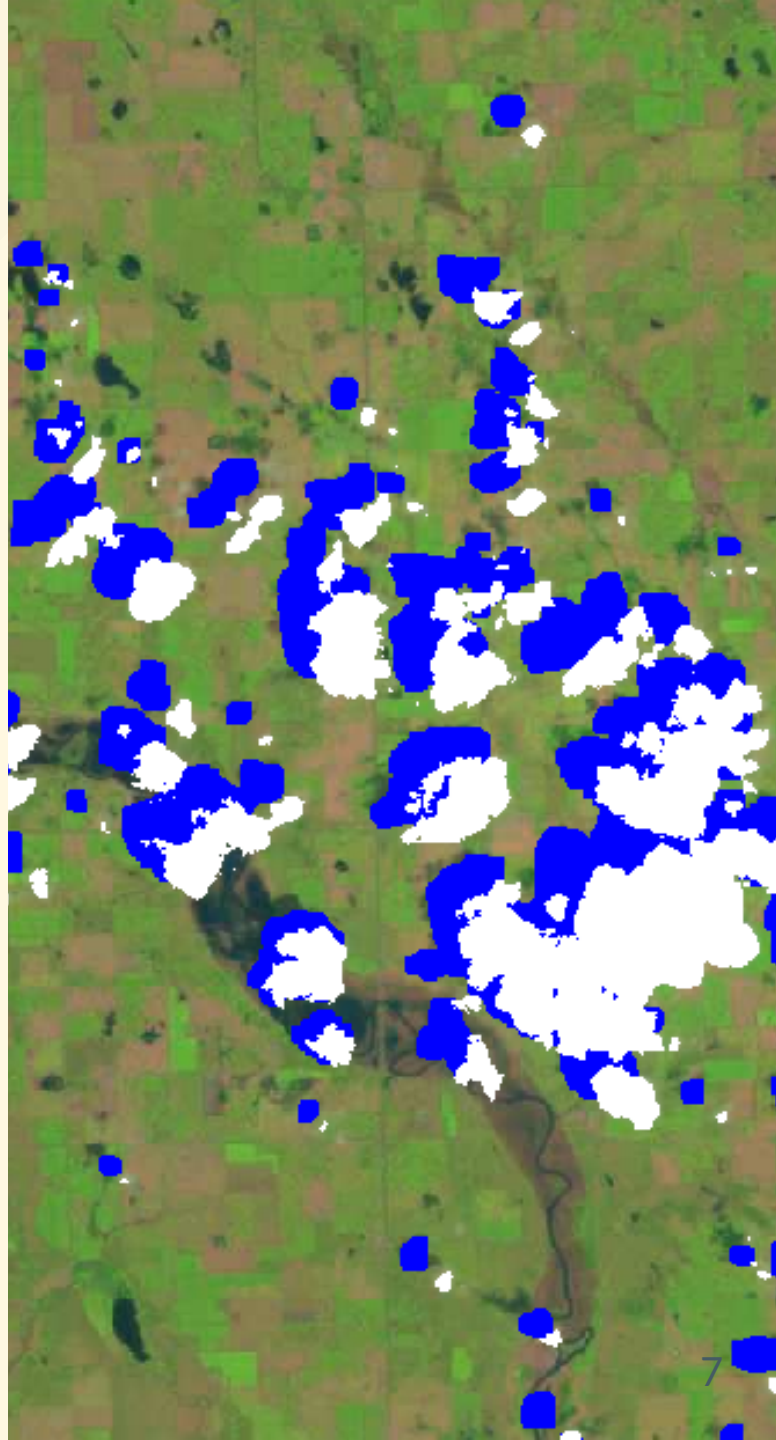




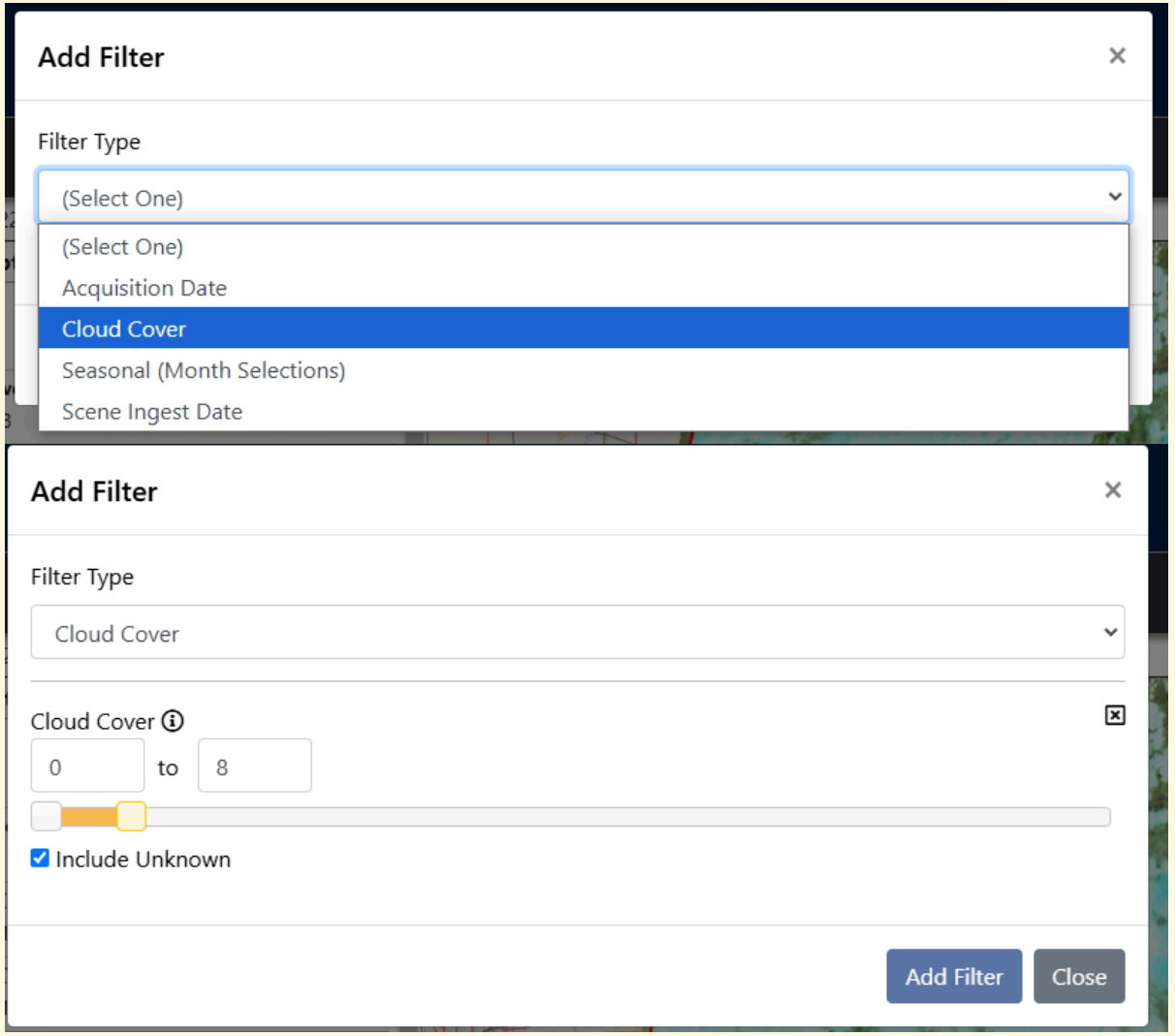
Using QA Bands for Cloud and Shadow Detection

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



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 onLandsat 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.