IdahoView Imagery Services: LISA[1] Technical Report no. 2
Setup and Use Tutorial

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Introduction

The use of satellite imagery is becoming increasingly common today. This may be because Landsat and other remote sensing data can be acquired free of charge, however a much broader reason suggests the proliferated use of satellite imagery is due to an increased need for the type of information satellite imagery can uniquely provide. No other technology offers a spatially continuous dataset with the frequent temporal periodicity and multi-decadal historical archive as does Landsat. This rich dataset represents a significant asset to the scientific community to aid research focusing on land cover change, energy balance, and global climate change.

Concurrent with the increased use and need for satellite imagery is the development of web services. Following the vision of Jack Dangermond (esri), numerous organizations and institutions have begun offering geospatial data as a web service and as a result the Geoweb was developed. To date, the great majority of data available via the Geoweb represents framework data commonly used by the GIS community (e.g., seamless roads layers, aerial imagery, state and political boundaries). These services, while widely used and broadly applicable, do not fully leverage the potential of web services. A tremendous advantage of web services are their ability to further improve access to high-quality, value-added satellite imagery that has been consistently processed (i.e., atmospherically corrected using the same techniques), co-registered, and prepared for scientific inquiry (e.g., NDVI). Developing services like these allows researchers to quickly and effectively analyze imagery by eliminating download, extraction, correction, and georectification tasks from the analysis workflow. These services, coupled with detailed pre-processing documentation, will also better allow comparison of results as input data was uniformly produced and documented.

This white paper is a tutorial in the setup and use of the LISA and is written in an easy-to-follow step-by-step fashion. The following tutorials are provided in this document:

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[1] The LISA project was funded by a grant from AmericaView (http://americaview.org/)

TUTORIAL: LOCATING AND ACQUIRING LANDSAT IMAGERY

Overview: This portion of the tutorial is intended to allow you to acquaint yourself with the EROS Data Center's website (one of the primary sources of free Landsat imagery).

Steps:

1. Let's begin by visiting the EROS Data Center's website as it is a primary source of free Landsat imagery.
   a. Launch your web browser (Internet Explorer) and navigate to http://edcsns17.cr.usgs.gov/EarthExplorer/
   b. This is the new Earth Explorer website hosted by the USGS's EROS Data Center in Sioux Falls, South Dakota.
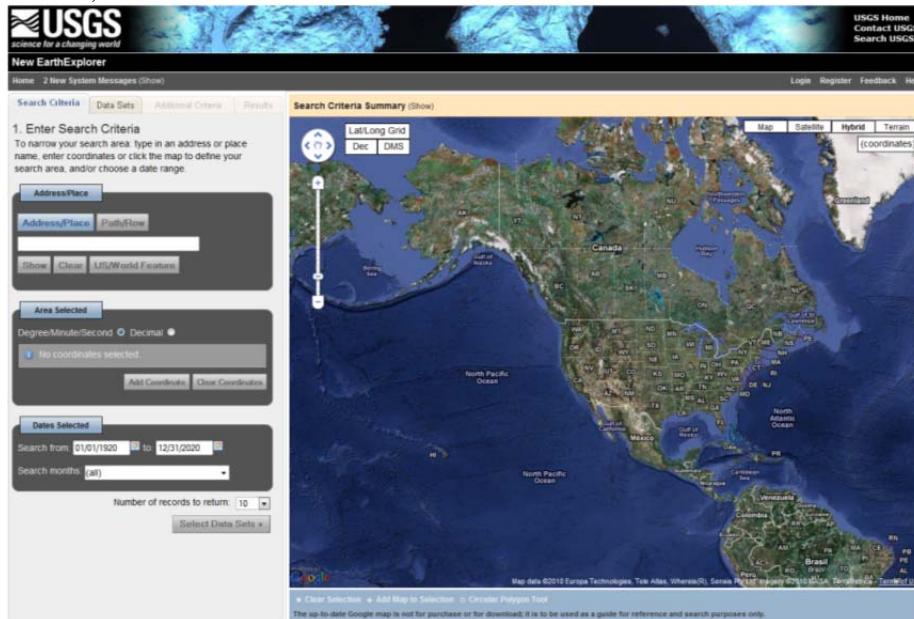

   c. To download data you will need a username and password.
   d. From the New Earth Explorer web interface, locate the pan and zoom tools in the upper left corner of the map window.
   e. Use these tools to zoom into your area of interest.
   f. Near the bottom of the map window, you should see a blue-colored bar and within this bar, you should see the option to "Add map to selection".
   g. Click this link.
   h. Notice how the bounding coordinates described by the map window have been added to the Area Selected section of your search criteria.
   i. Another way to complete the first page of this search is to enter the known path and row of the Landsat Imagery we are interested in. If you do not know this however, it is best to use the map window instead.

   j. This takes care of the spatial parameters for our search.

   k. Next, we may wish to narrow our search temporally. To do this, use the Dates Selected section (*note: you can do this if you wish, but do not need to do it for this exercise*).

   l. Click the Select Data Sets button near the bottom of the Search Criteria page.

m. The next page of the Earth Explorer wizard allows us to define the type(s) of imagery we are looking for. Expand the Landsat Archive selection and place a check in the box to the left of "L4-5 TM" (*note: this is Landsat 4 or 5, thematic mapper*).
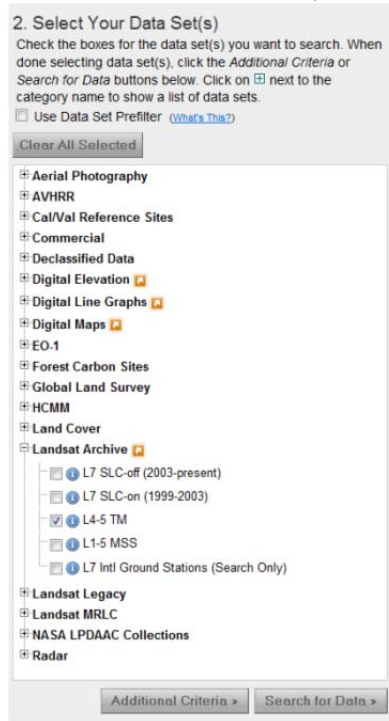
n. Next, click the Additional Criteria box.
o. There are a number of additional criteria we can use to further refine our search. Notice the section to specify WRS path and WRS row. This is the same path and row information that we could have specified on the first page of the wizard. Also, notice the Browse Exists section.

p. We will use this criterion to ensure the imagery shown to us is available through the EROS Data Center. To do this, simply set the Browse Exists to "Yes".
q. Click the Search for Data button.
r. The results shown to you will be similar to that shown below.
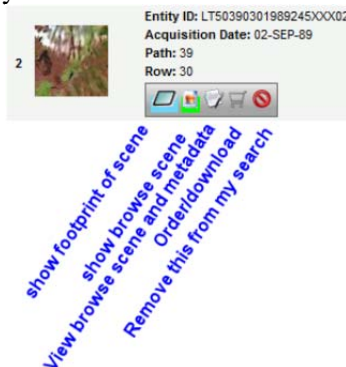
s. Let's explore these results.
t. Begin by clicking the show footprint button and look at the map window to see the result.
u. Next click the show browse scene/overlay button.
v. Lastly, view the browse scene and metadata.

w. There is a great deal of important data in the metadata. Specifically, the date and time of image acquisition as well as the sun elevation. These parameters are required to properly correct the imagery for atmospheric effects. To learn how to correct imagery for atmospheric effects find and double-click the URL link called "Atmospheric Correction" in your exercise folder.

x. The next icon will resemble either a shopping cart (as shown in our example above) or a computer hard drive. The shopping cart indicates the imagery is available at EROS but is not ready for immediate download. It's still free, but will require you to place an order and wait a few days to get your imagery. The computer hard drive icon indicates the imagery is ready for immediate download.

y. The last icon/button on the results toolbar will remove this scene from your current search. This can be useful if you are planning to order or download everything you can find save for a few.

z. Explore this website as much as you would like before leaving it.

Once you have located and downloaded the desired Landsat imagery we can begin working with it. Let's begin by viewing out new data within ArcGIS.

TUTORIAL: VIEWING IMAGERY WITHIN ARCGIS

1. Launch ArcCatalog
2. Navigate to the folder where you placed your Landsat imagery.
3. Locate the Blue band of the Landsat imagery ([band 1, which happens to be the blue band when working with Landsat]).
4. Preview this imagery.
5. When prompted about "pyramids", click NO for the time being.
6. Before we can view this imagery in ArcCatalog we need to perform two simple steps. These are build pyramids and calculate statistics.
7. Click the contents tab in ArcCatalog.

Building Pyramids for raster data

8. You should see the contents of your folder.
9. Select all bands (1-7) from the contents window.
10. Right-click this selection and choose Build Pyramids...
11. From the batch build pyramids window, click OK
12. When this process finishes, preview band 1 (B1) again.
13. Does it display?

Calculating Statistics for raster data

14. The gray box you are seeing simply shows us the footprint of the raster layer. To view meaningful satellite data we also need to calculate statistics.
15. Typically we build pyramids first and then calculate statistics.
16. Return to the Contents tab for your folder.
17. Select all bands (1-7) from the contents window.
18. Right-click this selection and choose Calculate statistics...
19. From the batch calculate statistics window, click OK
20. When this process finishes, preview band 1 (B1) yet again.
21. Does it display?

22. Preview each band in turn.

View satellite imagery in ArcMap

23. Close ArcCatalog
24. Launch ArcMap
25. Now let's add some of our Landsat imagery.
26. Click the Add Data button, and add bands 1-4 from your folder.
27. You will notice that each of these displays as a separate layer in ArcMap. In reality, these bands represent the same scene of Landsat data (acquired at the same time, by the same thematic mapper sensor) and could be displayed as one layer with multiple bands.

TUTORIAL: ATMOSPHERICALLY CORRECTING SATELLITE IMAGERY

Overview: Now that we have found and previewed out Landsat imagery and determined it to be good (viewing the data is a great preliminary quality assurance step), we are ready to perform an atmospheric correction on these data. To aid end-users and students in this process we have developed a step-by-step tutorial and flash video. To better understand atmospheric correction you may wish to read the following paper available on the GIS Center's website:

<div align="center">http://giscenter.isu.edu/research/techpg/nasa_postfire/To_PDF/Ch12.pdf</div>

1. Import the imagery into Idrisi. View a flash demo at
   http://giscenter.isu.edu/help/faq_htm/1031.htm
      a. This is typically done using a GeoTIFF file supplied by the vendor .
      b. Use the Idrisi import tool, found under File---Import---Desktop Publishing…---GeoTIFF/TIFF.
      c. View the imported data. It is normal for numerous Idrisi raster layers to be created from one GeoTIFF file. Each of these raster files represents a different band of the satellite imagery.

2. Complete the Atmospheric Correction worksheet. The file is available from
   http://giscenter.isu.edu/help/faq_htm/atmosworksheet.zip .
   View a flash demo at http://giscenter.isu.edu/help/faq_htm/1032.htm
      a. Use information found in the Metadata.dim file for SPOT 4 or 5 imagery. Similar input data can be found for Landsat 5 or 7 imagery.
      b. Print the worksheet for permanent record of the correction process. Complete the bottom of the worksheet (date processed etc.) after you complete actual correction.

3. Return to Idrisi and use the ATMOSC module to complete the atmospheric correction. View a flash demo at http://giscenter.isu.edu/help/faq_htm/1033.htm
      a. Open the ATMOSC module (Image Processing—Restoration – ATMOSC)
      b. Using the worksheet completed in step 2 (above), fill in the form. *Note: you will run the correction once for each band*.

TUTORIAL: RECTIFICATION AND IMAGE-TO-IMAGE CO-REGISTRATION

<u>Overview:</u> Once the imagery has been atmospherically corrected it is then ready for final rectification or at least testing of rectification and image-to-image co-registration. It is not recommended that you proceed with this processing until the above steps have been completed. To perform final rectification of the satellite imagery follow these steps using the flash demos as needed.

BEFORE YOU BEGIN
> You will need to locate reference data for this rectification process. We have had good success using NAIP aerial imagery (1m resolution) but other data can be used as well. The reference does not need to be raster as a well positioned set of vector points, lines, or polygons can work equally as well. You may also use more than one reference for your final rectification. The reference data is often considered the "gold" data against which everything else is registered and compared to.

> During this processing, keep in mind that the goal of any rectification is to geospatially locate the imagery as closely as possible to its true location relative to the other data sets used in the study/analysis. As a rule of thumb, final RMS should be <0.50 the size of a pixel. In other words, when using SPOT 5 imagery the final RMS should be 5.0 or less (SPOT 5 has 10m pixels). To better understand the importance of georegistration read the following journal papers available on the GIS Center's website:
>> http://giscenter.isu.edu/research/techpg/nasa_weeds/pdf/challenges.pdf
>> http://giscenter.isu.edu/research/techpg/nasa_oneal/to_pdf/coreg.pdf

RECTIFICATION
> View a flash demo at http://giscenter.isu.edu/help/faq_htm/1034.htm while following the steps outlined below.

> Load one band of your satellite imagery (I like to use either the RED or NIR bands as they tend to be clear and crisp) and your "gold" reference data into ArcMap. The reference data must be very well rectified/registered data as all locational errors will propagate through subsequent analysis.

> We like to use USDA NAIP imagery which has been registered very well, and verified by numerous sources.

1. Open the "Georeferencing" tool bar.
2. Open the links table
3. <u>Make sure the target layer is the satellite imagery and not the gold reference layer.</u>
4. The following sequence of steps will be performed iteratively
   a. Zoom into the geospatial data and locate common features that are clearly visible in both the satellite imagery and gold reference data.
   b. Add a control point (from the Georeferencing toolbar) by first clicking the "from" location and then clicking once again on the "to" location. For instance, you may have found a clearly visible road intersection feature in both data sets. You would begin by clicking on center of the feature in satellite imagery and then click on the center of the exact same feature within the gold reference.
   c. The coordinates for the "from-to XY coordinate pairs" will be added to the links table.
   d. Continue adding control points until you have a minimum of four points loaded into the links table.
   e. Is the RMS error 50% or less the size of a pixel?
      i. If you answered yes, then ask yourself if the geometry of the control points is good? (In other words, do you have a good distribution of points around your

area of interest (AOI)?) *Note: you may perform a rectification for only part of a full scene. The AOI may be windowed at a later time*.
1. If you answered yes again, proceed to step 6.

ii. If you answered no, then return to step 5a above and add additional control points.
1. You may wish to delete or remove "bad" control points (those with an abnormally high residual error)
2. Just make sure you always maintain at least 4 points to perform the rectify process.
3. You will need more control points if you perform a 2nd order rectification or rubber sheeting process.   In most cases a 1st order affine transformation will be adequate and indeed the best choice as it will have the least effect on the value stored by each pixel. Note: an affine transformation approximates a lateral shift whereas other methods will shift, and rotate, and squish, and squeeze the imagery (so to speak).
5. Once you have created a set of good control points, save these control points to the hard drive.

6. Rectify the imagery.

USE EXISTING CONTROL POINTS TO RECTIFY ADDITIONAL BANDS
7. To apply the same control points to another band of imagery follow the steps shown in the flash demo at http://giscenter.isu.edu/help/faq_htm/1030.htm The RMSE will be identical to that reported above.
8. The final rectification improves georegistration within the AOI. However, it may make the registration worse outside the AOI.

TUTORIAL: CREATING NDVI LAYERS

To create NDVI layers from Landsat imagery you may use any number of GIS software. The following tutorial demonstrates the development of an NDVI layer using ArcGIS.

http://giscenter.isu.edu/help/FAQ_htm/NDVI_ArcMap.htm

TUTORIAL: CREATING A COMPOSITE-NDVI (cNDVI) LAYER

The image layer produced in the previous step is a floating point TIFF file. To use this dataset in Idrisi requires it to be converted to a float file (FLT). Here is how!
http://giscenter.isu.edu/help/FAQ_htm/FloatFiles.htm

After converting the NDVI layer to a FLT file, it is ready for use within Idrisi.

1. Launch Idrisi
2. To import an ArcGIS FLT file, click FILE---IMPORT---SOFTWARE SPECIFIC FORMATS---ESRI FORMATS---ARCRASTER.
3. Make sure the radio button of the import window is set to "ArcInfo raster binary format to Idrisi".
4. To set the input file use the Pick list box just like you did earlier and choose raWV02_blue.
5. Notice that with this tool, the output file name is not automatically populated for you. Type in raWV02_blue.

6. Also notice the "Convert output file from real to integer" checkbox. Do NOT check this.

   There are other cases where you could check this box and as a result make the output files much smaller in size and much faster to process. How much smaller will a file storing integers be compared to the same file storing real (floating point) data?

   Well, floating point data requires 4 bytes per data value while short integer data requires only 2 bytes per data value. So integer data is half the size of float data… of course integer data must fall within the range of -35768 to +32767 and cannot carry any decimal places! That's your trade-off.

7. Next, notice the "Output reference information" button. Click it as we need to complete this setting before the OK button will enable.

8. A Reference Parameters window will open. The default generic settings of Plane (meaning these data have been projected and are not lat-long) and meters will work perfect for us (*note: Idrisi does not perform any project on the fly or defined projection work so there is little reason to specify the exact projection used for your data*).

9. Click OK to accept the default reference parameters.

10. Now the OK button will be enabled. Click it (*note: if you are asked to overwrite the file, click YES in this case*).
11. Repeat this process for each NDVI layer.

12. To create a composite NDVI (cNDVI) layer, it is recommended that you have several NDVI layers prepared for each growing season. In the semiarid regions of the west, three NDVI layers are recommended.
13. To composite these layers together we will use the Idrisi composite tool. View a video demonstration by clicking here: http://giscenter.isu.edu/help/FAQ_htm/cNDVI.htm
14. The cNDVI data are now ready to be used in either Idrisi or ArcGIS software. To enable the layer for use as a web service, we will need to create and populate a file Geodatabase (fGDB).

TUTORIAL: USING A FILE GEODATABASE AND RASTER MOSAIC DATASETS

In ArcGIS 10, the optimal way to store TIFF imagery for subsequent use as a web service is through a fGDB and raster mosaic datasets. The LISA project leveraged this functionality and created a fGDB (LISA) containing 27 raster mosaic datasets, one for each year in the archive (1984-2010). Here is how we did it:

http://giscenter.isu.edu/help/FAQ_htm/fGDB_mosaicDataset.htm

These data were then time-enabled using a master mosaic dataset and just a little bit of database work. View the following video demonstrations to learn how.

http://giscenter.isu.edu/help/FAQ_htm/MasterMosaicDataset.htm

http://giscenter.isu.edu/help/FAQ_htm/EnableTime.htm

TUTORIAL: CREATING ARCGIS IMAGE SERVICES AND MAP SERVICES

Once the data has been created that you would like to offer as a web service and ArcGIS server software has been correctly installed on a server, it is relatively easy to create an image service. Follow this flash video to learn how:

http://giscenter.isu.edu/help/FAQ_htm/createImageService.htm

Similarly, the map document containing the time-enabled LISA archive can be served as a map service. Here is how to do it:

http://giscenter.isu.edu/help/FAQ_htm/createMapService.htm

TUTORIAL: CONNECTING TO AND USING ARCGIS WEB SERVICES

1. Launch ArcCatalog
2. Find GIS Servers in the Table of Contents
3. Expand this selection
4. Find and double-click Add ArcGIS Server
   a. In the Add ArcGIS Server wizard, choose to Use GIS Services
   b. Click Next
   c. In the next step of the wizard, enter http://ags.giscenter.isu.edu/arcgis/services to connect to the ArcGIS Server (*note: you must make this connection from within ArcCatalog. Pointing your web browser to this URL will cause an error on your computer*).
   d. Click Finish

5. A connection will be made for you and shown under the GIS Servers list
6. Double-click your new connection to actually connect to it
7. You will notice a "+" to the left of the connection title and the contents of the server will be shown in the CPD (Contents, Preview, Description) window to the right.

8. You should now be able to see all the image and map services available on this ArcGIS Server
9. LISA project data is located within the LISA folder.
10. You can navigate into this folder, preview and use these data in the same way as using Landsat imagery stored on your local hard drive.