

MultiSpec Tutorial: Visualizing Growing Degree Day (GDD) Images

Background:

This tutorial illustrates how MultiSpec can be used for handling and analysis of general geospatial images. The image data used in this example is not multispectral data collected by a satellite or aircraft or the results of analysis of those data. Rather it is a geospatial image derived from gridded data obtained from the Applied Climate Information System (ACIS); the data is derived from measurements collected by many weather stations. More information about how this image data file was generated can be found at:

https://mygeohub.org/groups/u2u/File:Growing_Degree_Days_Details_Behind_Data.pdf

Requirements:

- *MultiSpec© software application*
(MultiSpec for Macintosh or Windows can be downloaded at: <https://engineering.purdue.edu/~biehl/MultiSpec>. Or one can use the Online version at: <https://mygeohub.org/resources/multispec>.)
- *“gdd_2012_accumulated.tif” image and “STATES.SHP” shape file are included in a zip file associated with tutorial 10 from the MultiSpec tutorial site at:*
<https://engineering.purdue.edu/~biehl/MultiSpec/tutorials.html>
Note that this zip file is about 80 MB. It will expand to 150 MB.

In this tutorial, the MultiSpec© image processing software will be used to:

- *Display a GDD geotiff file and familiarize yourself with the content of the GDD image data*
- *Overlay a shape file on the GDD image for a spatial reference of a site location*
- *Plot accumulated GDDs data per day for a selected year (Year 2012 will be used in this tutorial as an example)*
- *Create a new image representing the accumulated GDDs from a specific (planting) date.*
- *“Animate” the single channels representing accumulated GDDs for each day of the year.*

1. Growing Degree Day (GDD) Data

Growing Degree Days (GDD), also called **Growing Degree Units** (GDUs), are a heuristic tool in phenology. GDD are a measure of heat accumulation used by horticulturists, gardeners, and farmers to predict plant and pest development rates such as the date that a flower will bloom or a crop reach maturity. Growing degree days take aspects of local weather into account and allow farmers to predict the plants' pace toward maturity [online at: https://en.wikipedia.org/wiki/Growing-degree_day].

The general formula for GDD is given in equation 1. GDDs are calculated by taking the average of the daily maximum and minimum temperatures compared to a base temperature.

$$GDD = \frac{T_{\max} + T_{\min}}{2} - T_{\text{base}}.$$

Equation 1

In equation 1, T_{\max} is the highest temperature for the day, T_{\min} is the lowest temperature for the day, and T_{base} is the minimum developmental threshold temperature. If the average temperature is less than or equal to T_{base} , then GDD is equal to zero. Normally, any temperature below T_{base} is set to T_{base} before calculating the average. Also any temperature may be set to an upper threshold value before calculating the average depending on the plant. T_{base} for corn is 50 degrees Fahrenheit and a max is 86 degrees.

The GDDs in the example file for this tutorial are calculated using the **Modified Growing Degree Day** method often used for corn. T_{base} is 50 degrees and the upper threshold for the temperature is 86 degrees. The units are degrees Fahrenheit.

Each GDD geotiff file displayed in MultiSpec contains 365 (366 in a leap year) layers (channels) corresponding to each day during a one year period. Each layer represents the accumulated GDD's starting from day 1 (January 1). For example, GDD's for layers 1, 2 and 3 are calculated as:

Layer 1 = GDD's for day 1

Layer 2 = GDD's for day 1 + GDD's for day 2

Layer 3 = GDD's for day 1 + GDD's for day 2 + GDD's for day 3

2. Displaying and Visualizing GDD Image Files

- 2.1 Start MultiSpec using the icon on the desktop or from MultiSpec in the Startup Menu.
- 2.2 From the **File** menu choose **Open Image...** A dialog box will open to allow one to select the data file one wishes to use.
- 2.3 Select “**gdd_2012_accumulated.tif**” in the GDD MultiSpec Tutorial folder and **Open**, or simply double-click on “**gdd_2012_accumulated.tif**”.
- 2.4 A **Display Specification for:** dialog box (Figure 1) will appear to allow one to choose among various options for the image display.

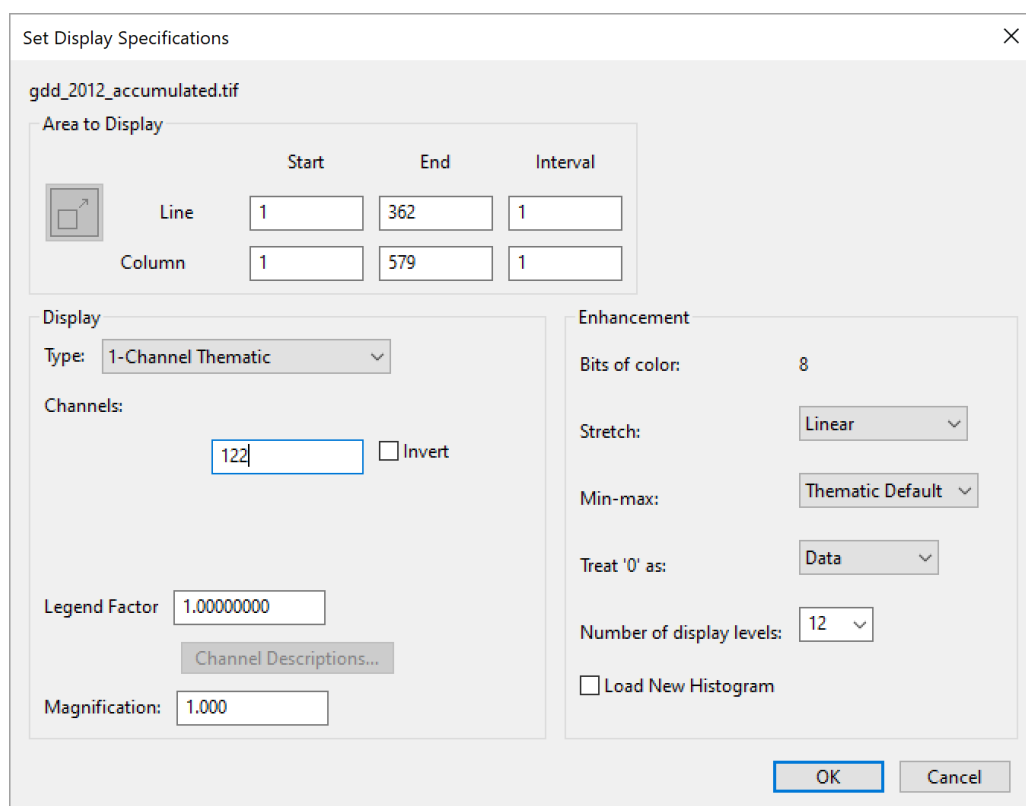


Figure 1. **Set Display Specification** dialog box for loading the “**gdd_2012_accumulated.tif**” image.

Values for **Lines** and **Columns** in the **Area to Display** group provide the image dimensions that can be edited by the user if needed. For this tutorial the default values will be used which corresponds to the entire scene. These choices will display a layer with 362 lines by 579 columns of pixels. In the **Display** group, select **1-Channel Thematic** for **Display Type** and enter the value **122**

associated with the **Channel**. These choices will display a single-channel image of GDD's corresponding to May 1, 2012 (channel 122). Select **OK**.

A thematic image (Figure 2) will be displayed associated with the accumulated GDD's (Blue = fewer GDDs, Red = more GDDs) for May 1, 2012. Change the palette to Blue-Green-Red if needed. The data values are grouped into the default number of levels (12) and a legend is displayed to the left of the image indicating which palette colors are associated with each range of data. A factor can be entered to multiply the data values displayed in the legend to reflect the actual measurement unit. Sometimes the data value may be the measurement value times 100 or 1000. (Note: The 1-Channel Thematic display feature can be considered as a supervised 1-channel levels classifier.)

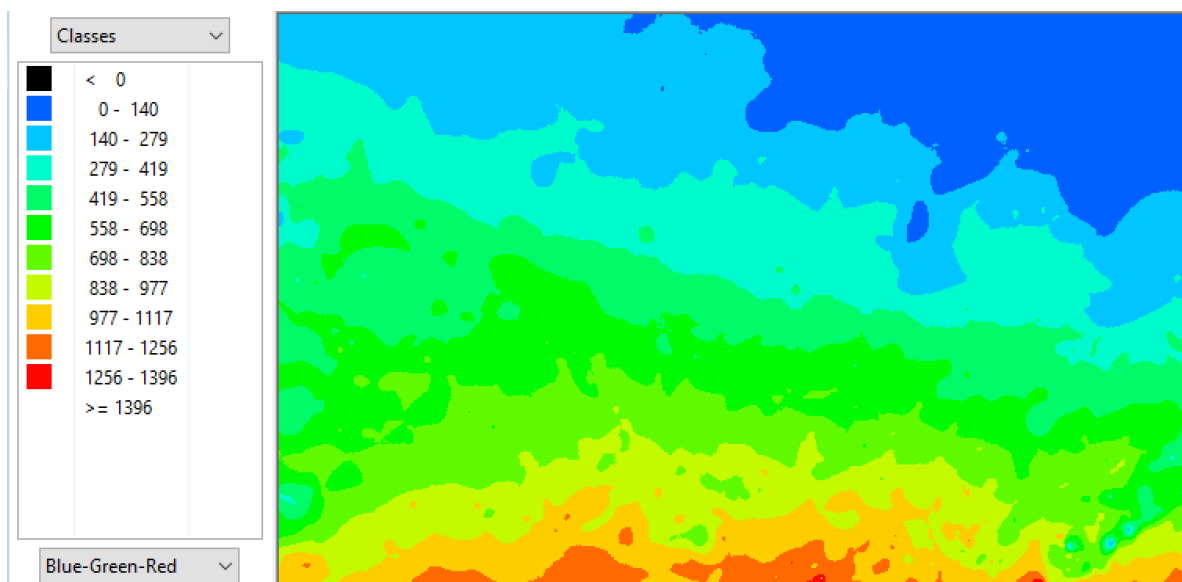



Figure 2. Thematic image representing accumulated GDDs from January 1 to May 1, 2012.

The number of classes in the legend can be changed by the user in the **Number of display levels** from the **Enhancement** group (12 group classes is the default value). One can use the **Min/Max** User Specified... option to set the min and max values for the range of data to be displayed. Black color corresponds to the default color for data values less than the minimum and white color corresponds to the default color for values greater than the maximum. Tables 1 and 2 in the Appendix

show the channel number with corresponding dates for a common year and a leap year, respectively.

- 2.5 MultiSpec's toolbar located above the displayed image has a small button for zooming in (magnifying glass with a '+') and one for zooming out (magnifying glass with a '-'). Just to the left of the image zooming buttons is a reset button () which allows one to restore the image to a zoom display of 1. The current zoom magnification is displayed to the right of the zoom-out button. Some other options are to hold the 'Option' key down while zooming to change the zoom step factor to 0.1 instead of 1 (e.g. from 1.0 to 1.1 to 1.2 etc.), providing more control when zooming into the image. (Note: 'Command' key on the Online version will do this.)
- 2.6 The user can set different values for **Channels** to display different dates. In the MultiSpec main menu select **Processor->Display Image...** The **Display Specification for:** dialog box will appear to allow the user to choose the date to be displayed (value in **Channels** within the **Display** group). The number of classes that will be displayed in the thematic map can be changed in the **Number of display levels** option. A gray scale image (Figure 3) can be displayed in MultiSpec when changing the **Type** in the **Display** group option to **1-Channel Grayscale**.

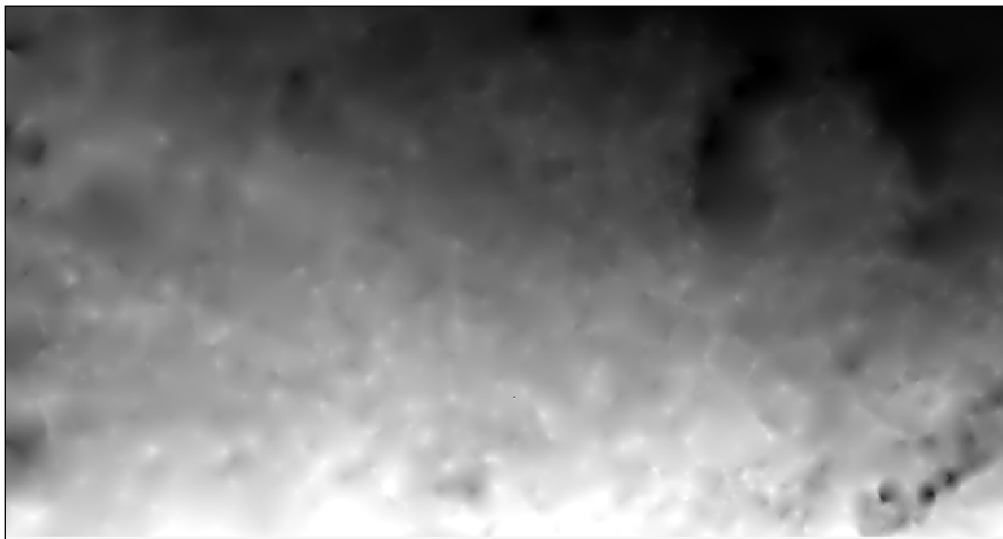


Figure 3. GDDs Grayscale image for May 1, 2012. Lighter values represent more GDDs, while darker values represent fewer GDDs.

- 2.7 To display 3 channels (dates), in the **Display** group of the **Set Display Specification for** (Figure 1): dialog box, select **3-Channel Color** option for **Display Type** and the channels values corresponding to the selected dates. (Tables 1 and 2) that will be associated with the **Red, Green** and **Blue Channels** options. These choices will display the multiple dates combined in an image composite. This resulting image illustrates how the GDD accumulate differently across the image. Figure 4 illustrates a combination of channel 300 (October 26, 2012), channel 200 (July 18, 2012) and channel 100 (April 9, 2012) for red, green, and blue. This image shows the variability of GDD through the area of interest due to differences in accumulated GDD between locations.

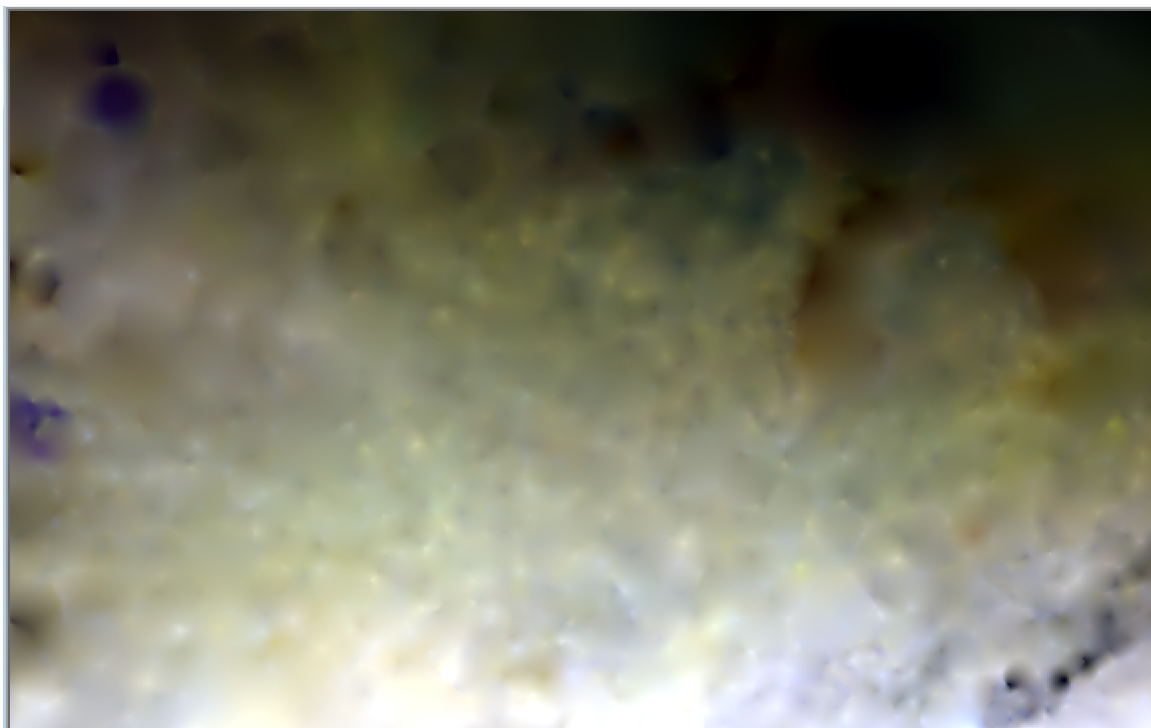


Figure 4. A combination of three channels (days): channel 300 (October 26), channel 200 (July 18) and channel 100 (April 10) during the year of 2012.

- 2.8 To display the 3 channels (days) used to create the GDDs image composite in Figure 4 in a side by side channel (days) display, from the **Processor** menu, select **Display Image...** to bring up the display dialog box. Then, select **Side-by-Side Channels** in **Type** from the **Display** group. In the **Channels** option from the **Display** group select **Subset....** The list of Channels (days) will appear. Deselect all channels by selecting **None**, then select the three channels (days) to

be display in the multichannels display. Select **OK**. A shape file can be overlaid onto the image window to spatially identify specific locations. (See section 3 for more details about shape files.) However, in a side by side channel display (multichannels) the shape file will appear in the first displayed image only. Figure 5 shows the selected channels (days) displayed side-by-side for comparison purposes with a U.S. state shape file overlaid onto the first image (image on the left side).

For additional information refer to *MultiSpec Tutorial: Display and Inspection of Image data with MultiSpec (Tutorial 1)* and *MultiSpec Tutorial: Creating Vegetation Indices Images (Tutorial 8)* at the web site: <https://engineering.purdue.edu/~biehl/MultiSpec/tutorials.html>

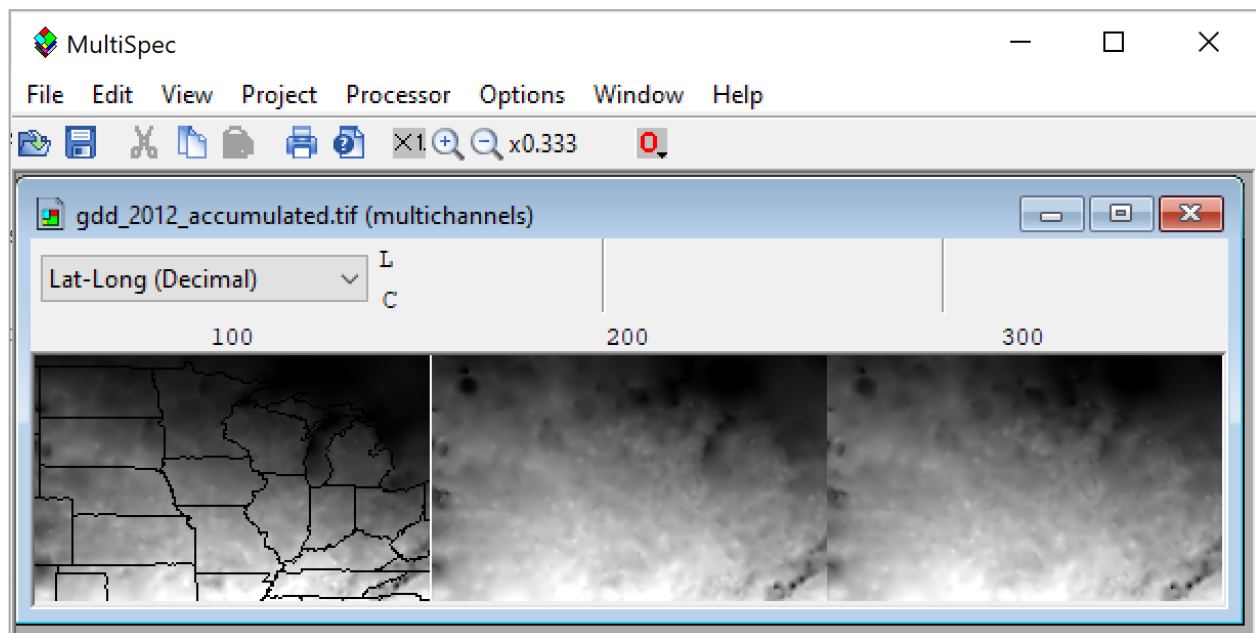


Figure 5. Three selected channels (days) displayed side-by-side: channel 300 (October 26), channel 200 (July 18) and channel 100 (April 10) from 2012.

3. Open and Overlay a Shape File

- 3.1 With the gray scale image displayed (Figure 3), select from the MultiSpec main menu **File->Open Image...** and select the STATES.shp (or other shape file) that was downloaded. You may need to change the filter (**Files of type** option) in the **Open Image...** dialog box to **Shape (*.shp)** or **All Files (*.*)**. The shape file (US states) will be overlaid onto the image window as illustrated in Figure 6.

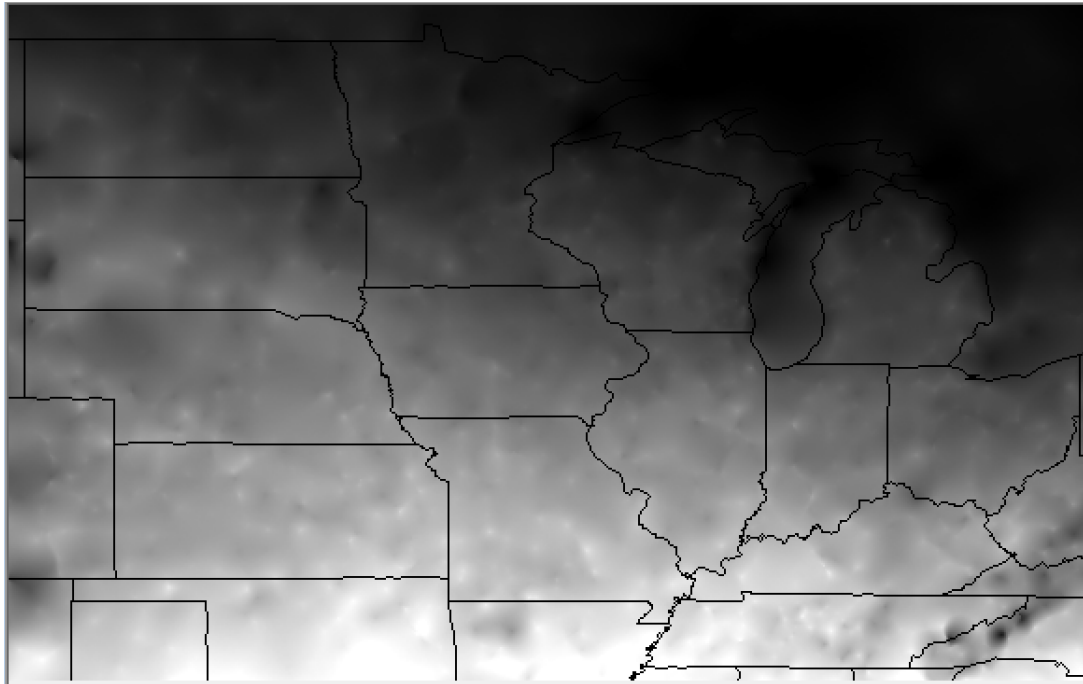


Figure 6. STATE shape file overlaid onto the GDDs Grayscale image for May 1, 2012. Lighter values represent more GDDs, while darker values represent fewer GDDs.

- 3.2 The Red 'O' popup menu button to the right of the zoom value indicator in the tool bar will become high-lighted to allow one to turn the display of the shape file overlay(s) on and off.
- 3.3 MultiSpec will automatically convert lat-long shape files to respective map coordinates for images in Albers Equal Area, Cylindrical Equal Area, Equiarectangular, Lambert Azimuthal Equal Area, Transverse Mercator, Orthographic, Sinusoidal and UTM map projections. MultiSpec first assumes the shape file is in the same units as the map projection. If there is no overlap, MultiSpec checks if the input shape file units are within the range possible for

decimal latitude-longitude degrees. If so, MultiSpec assumes the shape file is in lat-long units and converts them to map projection units. If the converted shape file values overlap with the image, then the shape file is overlaid onto the image. If a shape file has been converted, _ltom is appended to the shape file name in the overlay list for the window. (Comment: ltom stands for lat-long to meters.)

[NOTE: Be aware that MultiSpec assumes the shape file and the image data represent the same datum. In other words, no adjustments are made for matching different datums.]

- 3.4 A dialog box for editing the vector line width and color in the Windows version will appear when holding the shift key down **before** selecting the Overlay menu button with the left mouse button, and then selecting the shape file overlay to be edited. Note that '...' now follows the overlay name indicating that a dialog box will be displayed.
- 3.5 The selected shape file can be removed from memory by selecting **Edit->Clear Overlays** from the main menu. Shape files drawn in all open windows will be listed. If an open window has an image in geometric (lat-long) projection, shape files on these images will be treated as a separate shape files in the **Edit->Clear Overlay** list.

For Additional information refer to **Multispec Tutorial 6: Overlay Shape Files on Image Window** at the web site:

<https://engineering.purdue.edu/~biehl/MultiSpec/tutorials.html>.

4. Plot Accumulated GDDs Data per Day for a Selected Year

- 4.1 Select a point in the grayscale image by clicking on the desired location. Go to **Windows** option in MultiSpec main menu and select **Selection Graph**. A plot of the accumulated GDD vs. day of year (Figure 7) will be displayed showing the amount of GDD accumulated through time (days of year) for to the selected location.

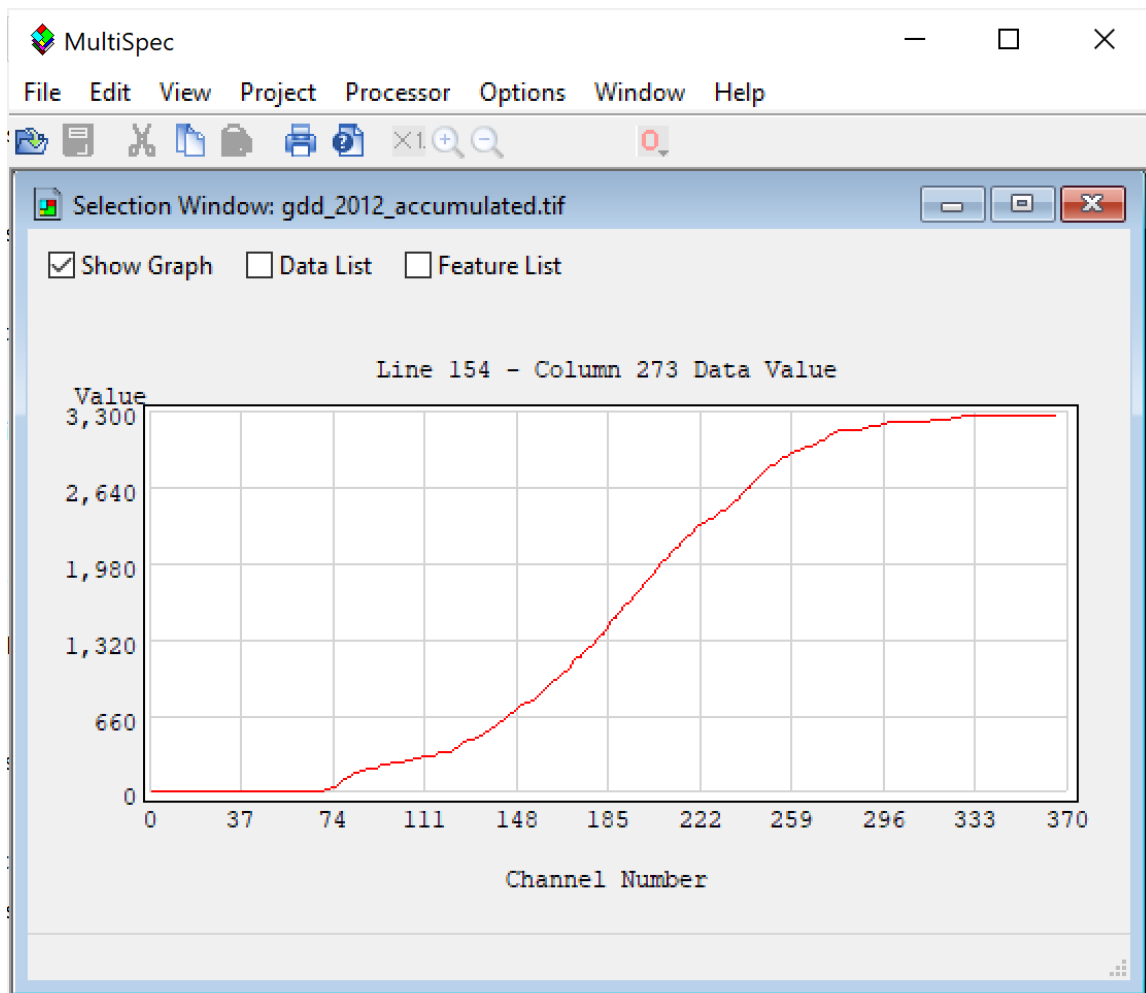


Figure 7. Plot of the accumulated Growing Degree Day vs. day of year

5. Create a New Image Representing the Accumulated GDDs from a Specific Date

- 5.1 GDD data provides the accumulated GDDs based on the start of the year. A new image can be created representing the GDD from a specific date (e.g. planting date). The steps in this section explain how to illustrate GDDs from a planting date of May 1, 2012 (Channel 122).
- 5.2 Using the image when displayed as multispectral data (not 1-channel thematic), select from the MultiSpec main menu **Processor->Reformat->Change Image File Format....** In the **Set Image File Format Change Specifications** dialog box (Figure 8) select **Transform data** In the **Set Reformat Transform Parameter** dialog box, select **Adjust Selected Channels by Selected Channels** option, and type 122 (May 1, 2012) in the **Channel** box (red circle in Figure 9). This option causes channel 122 (accumulated GDDs from January 1 to May 1, 2012) to be subtracted from all available channels, thus, providing an image which represents the accumulated GDDs starting from May 1, 2012 (planting date). Save the image in the proper folder and assign a new name. For this example the new image name is “***gdd_2012_accumulated_May_1***”. Figure 10 represents a plot of the accumulated GDDs starting on May 1. 2012 (Channel 122 – x axis).

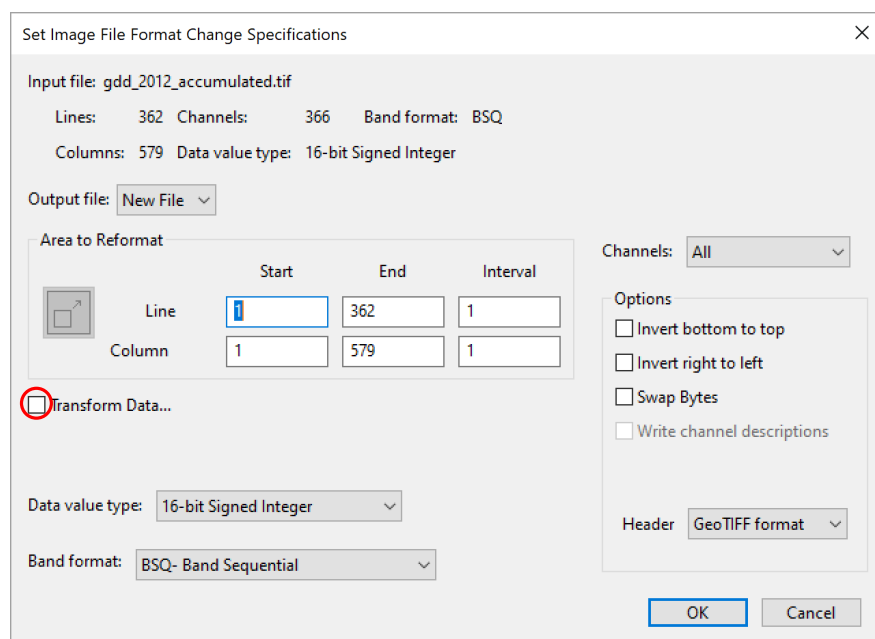


Figure 8. **Set Image File Format Change Specifications** dialog box. Red circle shows the selected **Transform Data...** option.

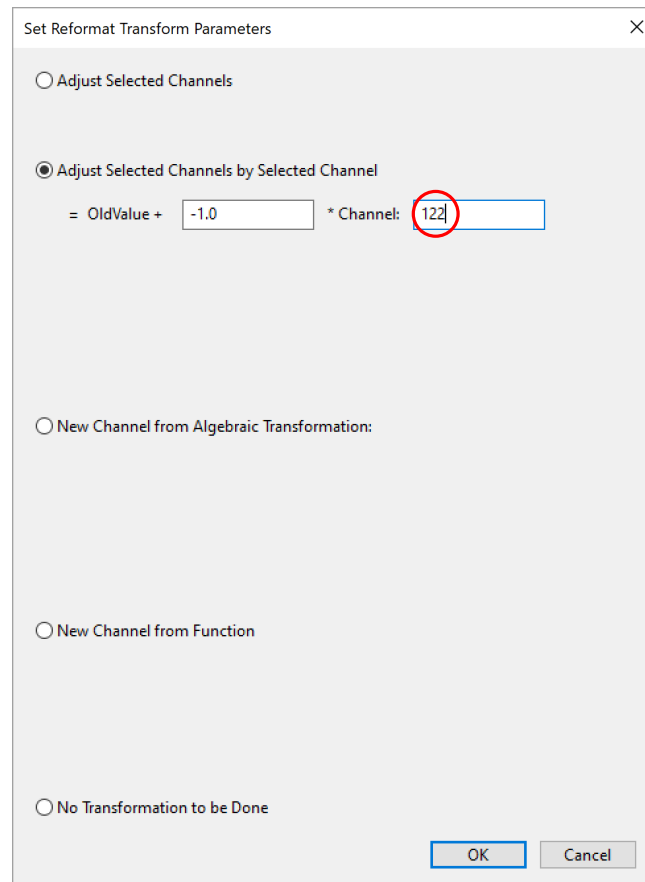


Figure 9. ***Set Reformat Transform Parameter*** dialog box with the ***Adjust Selected Channels by Selected Channels*** option selected and using channel 122.

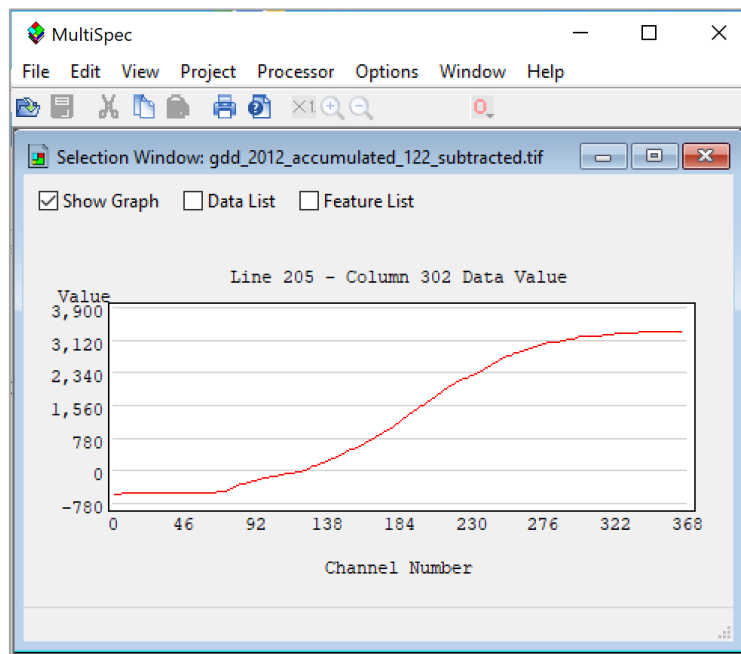


Figure 10. Illustration of the accumulated Growing Degree Days starting from channel 122 which is May 1, 2012 (planting date) vs. day of year

6. View an “Animation” of how the GDDs accumulate during the year

One can view an animation of the daily accumulations with a few fairly simple steps.

6.1 Open ***gdd_2012_accumulated.tif*** as described in section 2.

- Select **1-Channel Thematic** for the Display Type.
- Select **User Specified...** for the Enhancement Min/Max.
- In the “Set Specifications for Display Enhancement” dialog box, set Min value to 0 and Max value to 5500 which is close to the maximum value in the image at the end of the year. Then close the Enhancement dialog box by selecting OK.
- Enter 24 for the number of display levels.
- Select OK to close the “Multispectral Display” dialog box.

The result for channel one will be a solid blue image illustrated in Figure 11. The image represents the accumulated growing degree days for January 1 for the Midwest U.S. There are very few growing degrees days in most years at this time.

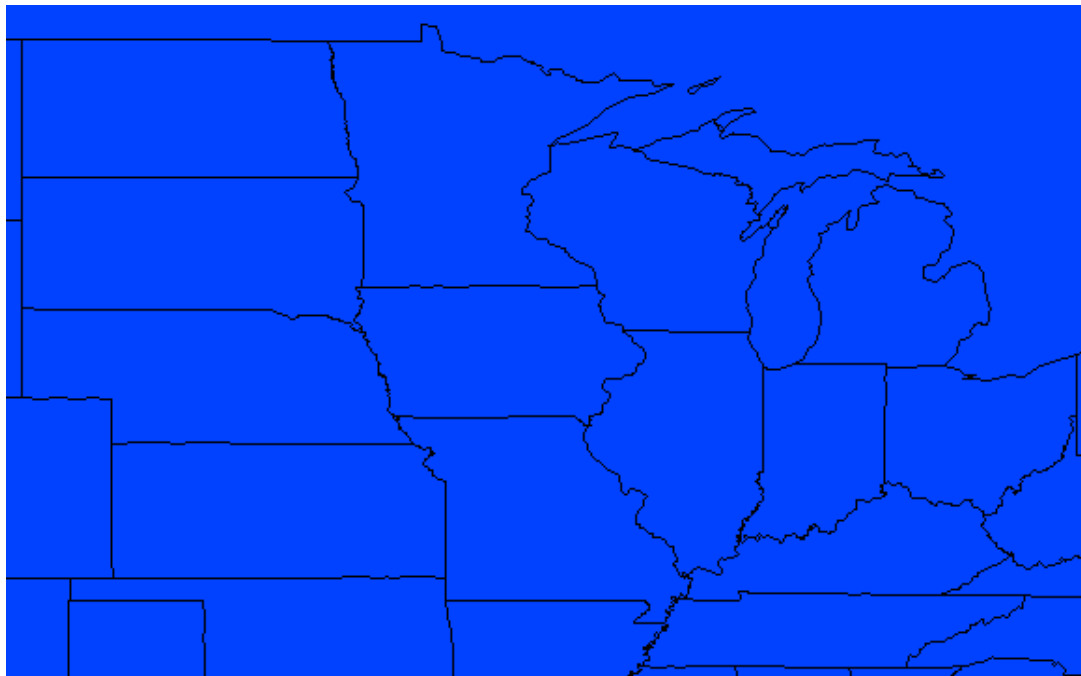


Figure 11. Illustrating 1-channel thematic display of channel one (January 1) with state boundaries overlaid on the image.

6.2 Add State Shape file overlay on the image.

- Follow steps as described in step 3.

The result will be an image as displayed in Figure 11.

6.3 Now animate the displayed image.

- One can quickly display channel 2 (day 2 or January 2) by striking the right arrow key. Each time one strikes the right arrow key, the image being displayed will advance to the next channel (or day). Striking the right arrow key has the same affect as opening the Display Dialog box and increment the channel by 1 and then selecting the OK button. If one strikes the left arrow key, one will go back to the previous channel.
- If one holds the right arrow key down, one will obtain a “poor man’s” animation as the channels are displayed in order. One can view how the growing degree days first begin accumulating in the south and then moves to the north as spring progresses.
- If one holds the shift key down and strikes the up arrow, the last channel will be displayed. If one holds the shift key down and strikes the down arrow, the first channel will be displayed.

Concluding Remarks

This tutorial illustrates how MultiSpec can be used to help visualize and study geospatial data in general.

There are many other operations that one can do with MultiSpec including several Reformatting processes. See other tutorials or the MultiSpec Introduction at the MultiSpec web site for more information. The MultiSpec web site is: <https://engineering.purdue.edu/~biehl/MultiSpec/>. Or contact Larry Biehl at biehl@purdue.edu with questions.

APPENDIX

Table 1. Channel number and corresponding dates for a 365-day year

Jan	Ch	Feb	Ch	Mar	Ch	Apr	Ch	May	Ch	Jun	Ch	Jul	Ch	Aug	Ch	Sep	Ch	Oct	Ch	Nov	Ch	Dec	Ch
1	1	1	32	1	60	1	91	1	121	1	152	1	182	1	213	1	244	1	274	1	305	1	335
2	2	2	33	2	61	2	92	2	122	2	153	2	183	2	214	2	245	2	275	2	306	2	336
3	3	3	34	3	62	3	93	3	123	3	154	3	184	3	215	3	246	3	276	3	307	3	337
4	4	4	35	4	63	4	94	4	124	4	155	4	185	4	216	4	247	4	277	4	308	4	338
5	5	5	36	5	64	5	95	5	125	5	156	5	186	5	217	5	248	5	278	5	309	5	339
6	6	6	37	6	65	6	96	6	126	6	157	6	187	6	218	6	249	6	279	6	310	6	340
7	7	7	38	7	66	7	97	7	127	7	158	7	188	7	219	7	250	7	280	7	311	7	341
8	8	8	39	8	67	8	98	8	128	8	159	8	189	8	220	8	251	8	281	8	312	8	342
9	9	9	40	9	68	9	99	9	129	9	160	9	190	9	221	9	252	9	282	9	313	9	343
10	10	10	41	10	69	10	100	10	130	10	161	10	191	10	222	10	253	10	283	10	314	10	344
11	11	11	42	11	70	11	101	11	131	11	162	11	192	11	223	11	254	11	284	11	315	11	345
12	12	12	43	12	71	12	102	12	132	12	163	12	193	12	224	12	255	12	285	12	316	12	346
13	13	13	44	13	72	13	103	13	133	13	164	13	194	13	225	13	256	13	286	13	317	13	347
14	14	14	45	14	73	14	104	14	134	14	165	14	195	14	226	14	257	14	287	14	318	14	348
15	15	15	46	15	74	15	105	15	135	15	166	15	196	15	227	15	258	15	288	15	319	15	349
16	16	16	47	16	75	16	106	16	136	16	167	16	197	16	228	16	259	16	289	16	320	16	350
17	17	17	48	17	76	17	107	17	137	17	168	17	198	17	229	17	260	17	290	17	321	17	351
18	18	18	49	18	77	18	108	18	138	18	169	18	199	18	230	18	261	18	291	18	322	18	352
19	19	19	50	19	78	19	109	19	139	19	170	19	200	19	231	19	262	19	292	19	323	19	353
20	20	20	51	20	79	20	110	20	140	20	171	20	201	20	232	20	263	20	293	20	324	20	354
21	21	21	52	21	80	21	111	21	141	21	172	21	202	21	233	21	264	21	294	21	325	21	355
22	22	22	53	22	81	22	112	22	142	22	173	22	203	22	234	22	265	22	295	22	326	22	356
23	23	23	54	23	82	23	113	23	143	23	174	23	204	23	235	23	266	23	296	23	327	23	357
24	24	24	55	24	83	24	114	24	144	24	175	24	205	24	236	24	267	24	297	24	328	24	358
25	25	25	56	25	84	25	115	25	145	25	176	25	206	25	237	25	268	25	298	25	329	25	359
26	26	26	57	26	85	26	116	26	146	26	177	26	207	26	238	26	269	26	299	26	330	26	360
27	27	27	58	27	86	27	117	27	147	27	178	27	208	27	239	27	270	27	300	27	331	27	361
28	28	28	59	28	87	28	118	28	148	28	179	28	209	28	240	28	271	28	301	28	332	28	362
29	29			29	88	29	119	29	149	29	180	29	210	29	241	29	272	29	302	29	333	29	363
30	30			30	89	30	120	30	150	30	181	30	211	30	242	30	273	30	303	30	334	30	364
31	31			31	90			31	151			31	212	31	243			31	304			31	365

Table 2. Channel number and corresponding dates for a leap year

Jan	Ch	Feb	Ch	Mar	Ch	Apr	Ch	May	Ch	Jun	Ch	Jul	Ch	Aug	Ch	Sep	Ch	Oct	Ch	Nov	Ch	Dec	Ch
1	1	1	32	1	61	1	92	1	122	1	153	1	183	1	214	1	245	1	275	1	306	1	336
2	2	2	33	2	62	2	93	2	123	2	154	2	184	2	215	2	246	2	276	2	307	2	337
3	3	3	34	3	63	3	94	3	124	3	155	3	185	3	216	3	247	3	277	3	308	3	338
4	4	4	35	4	64	4	95	4	125	4	156	4	186	4	217	4	248	4	278	4	309	4	339
5	5	5	36	5	65	5	96	5	126	5	157	5	187	5	218	5	249	5	279	5	310	5	340
6	6	6	37	6	66	6	97	6	127	6	158	6	188	6	219	6	250	6	280	6	311	6	341
7	7	7	38	7	67	7	98	7	128	7	159	7	189	7	220	7	251	7	281	7	312	7	342
8	8	8	39	8	68	8	99	8	129	8	160	8	190	8	221	8	252	8	282	8	313	8	343
9	9	9	40	9	69	9	100	9	130	9	161	9	191	9	222	9	253	9	283	9	314	9	344
10	10	10	41	10	70	10	101	10	131	10	162	10	192	10	223	10	254	10	284	10	315	10	345
11	11	11	42	11	71	11	102	11	132	11	163	11	193	11	224	11	255	11	285	11	316	11	346
12	12	12	43	12	72	12	103	12	133	12	164	12	194	12	225	12	256	12	286	12	317	12	347
13	13	13	44	13	73	13	104	13	134	13	165	13	195	13	226	13	257	13	287	13	318	13	348
14	14	14	45	14	74	14	105	14	135	14	166	14	196	14	227	14	258	14	288	14	319	14	349
15	15	15	46	15	75	15	106	15	136	15	167	15	197	15	228	15	259	15	289	15	320	15	350
16	16	16	47	16	76	16	107	16	137	16	168	16	198	16	229	16	260	16	290	16	321	16	351
17	17	17	48	17	77	17	108	17	138	17	169	17	199	17	230	17	261	17	291	17	322	17	352
18	18	18	49	18	78	18	109	18	139	18	170	18	200	18	231	18	262	18	292	18	323	18	353
19	19	19	50	19	79	19	110	19	140	19	171	19	201	19	232	19	263	19	293	19	324	19	354
20	20	20	51	20	80	20	111	20	141	20	172	20	202	20	233	20	264	20	294	20	325	20	355
21	21	21	52	21	81	21	112	21	142	21	173	21	203	21	234	21	265	21	295	21	326	21	356
22	22	22	53	22	82	22	113	22	143	22	174	22	204	22	235	22	266	22	296	22	327	22	357
23	23	23	54	23	83	23	114	23	144	23	175	23	205	23	236	23	267	23	297	23	328	23	358
24	24	24	55	24	84	24	115	24	145	24	176	24	206	24	237	24	268	24	298	24	329	24	359
25	25	25	56	25	85	25	116	25	146	25	177	25	207	25	238	25	269	25	299	25	330	25	360
26	26	26	57	26	86	26	117	26	147	26	178	26	208	26	239	26	270	26	300	26	331	26	361
27	27	27	58	27	87	27	118	27	148	27	179	27	209	27	240	27	271	27	301	27	332	27	362
28	28	28	59	28	88	28	119	28	149	28	180	28	210	28	241	28	272	28	302	28	333	28	363
29	29	29	60	29	89	29	120	29	150	29	181	29	211	29	242	29	273	29	303	29	334	29	364
30	30			30	90	30	121	30	151	30	182	30	212	30	243	30	274	30	304	30	335	30	365
31	31			31	91			31	152			31	213	31	244			31	305			31	366