Introduction and Motivation

IDL, short for Interactive Data Language, is a powerful programming language used to process large amounts of data and/or digital images. First developed in the 1970s at the Laboratory for Atmospheric and Space Physics (LASP) at the University of Colorado at Boulder, IDL has been widely applied in industries that require high-speed digital image processing and real-time data analysis. Some of the more prominent industries that use IDL are atmospheric physics, space sciences, and medical imaging.

kSA 400 Application Customization is an individually-licensed feature that gives users the flexibility to write their own analysis routines in the IDL programming language, and then have those routines compiled and executed within the kSA 400 measurement loop. We made this capability available for two types of data analysis: Simple two column data (x,y), and images. In either case, as long as the procedure is written properly and placed in the correct folder location, it will be compiled immediately upon launch of the kSA4 00 software and will then appear as a custom analysis filter in the analysis menus.

This application note gives an overview of how to use this feature within the kSA 400 software.

Sample IDL Procedure

The Application Customization feature must first be enabled before it can be used. This feature is sentinel-key enabled. Once enabled, it can be accessed by selecting **Options** from the main menu.

The kSA software provides a simple, dialog-based setup of the customized processing routines. The following procedure will demonstrate how to create a custom data filter that will invert your data (change peaks to valleys, etc.).

Note: This is a very elementary example of how to create a custom filter using IDL. You will need to be familiar with the IDL language and syntax before attempting more complex programming.

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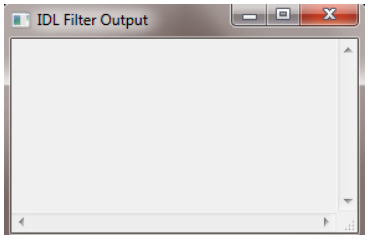
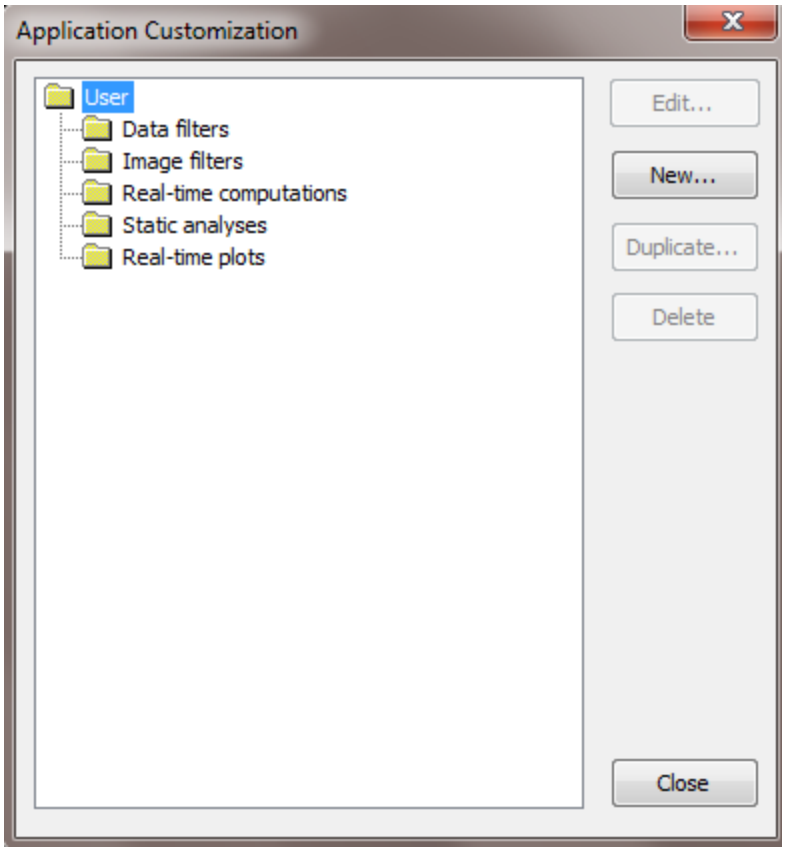
1. Click the **View** option from the main menu bar, followed by the **IDL Filter Output** option. This will bring up a blank IDL Filter Output dialog that will allow you to compile your procedure once you've finished. This step must be performed before creating a new procedure.



IDL Filter Output dialog

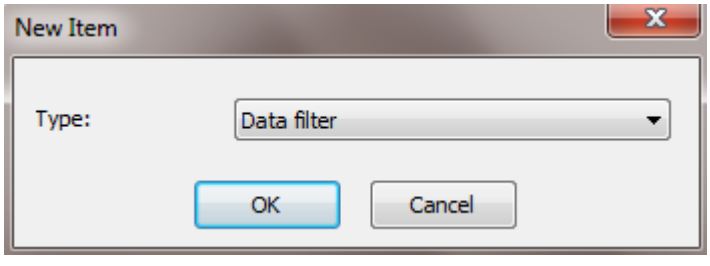
2. Select **Options** from the main menu bar, followed by **Application Customization**. The following dialog will be displayed:



Application Customization dialog

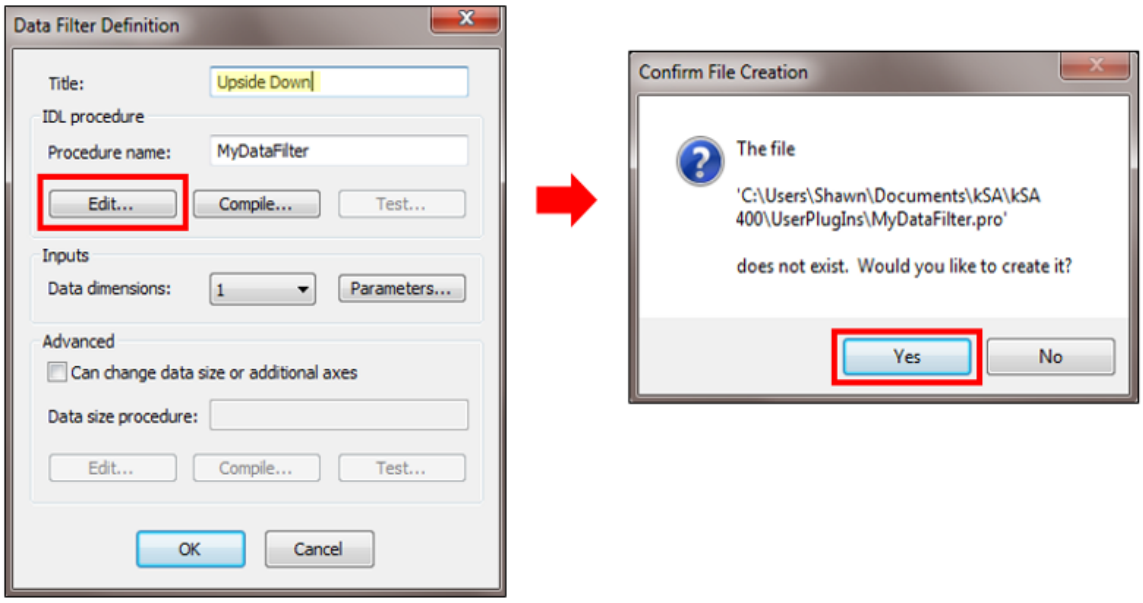
Note: You can generate IDL procedures to operate on any of the five data types shown in the image above.

3. Click the **New** button in the Application Customization window and then select the **Data Filter** type. Click **OK**.



4. In the Data Filter Definition dialog, type the name “Upside Down” in the **Title** field.

5. Under the **IDL procedure** header, click the **Edit** button. When you are prompted to create the *.pro* (procedure) file, click **Yes**.

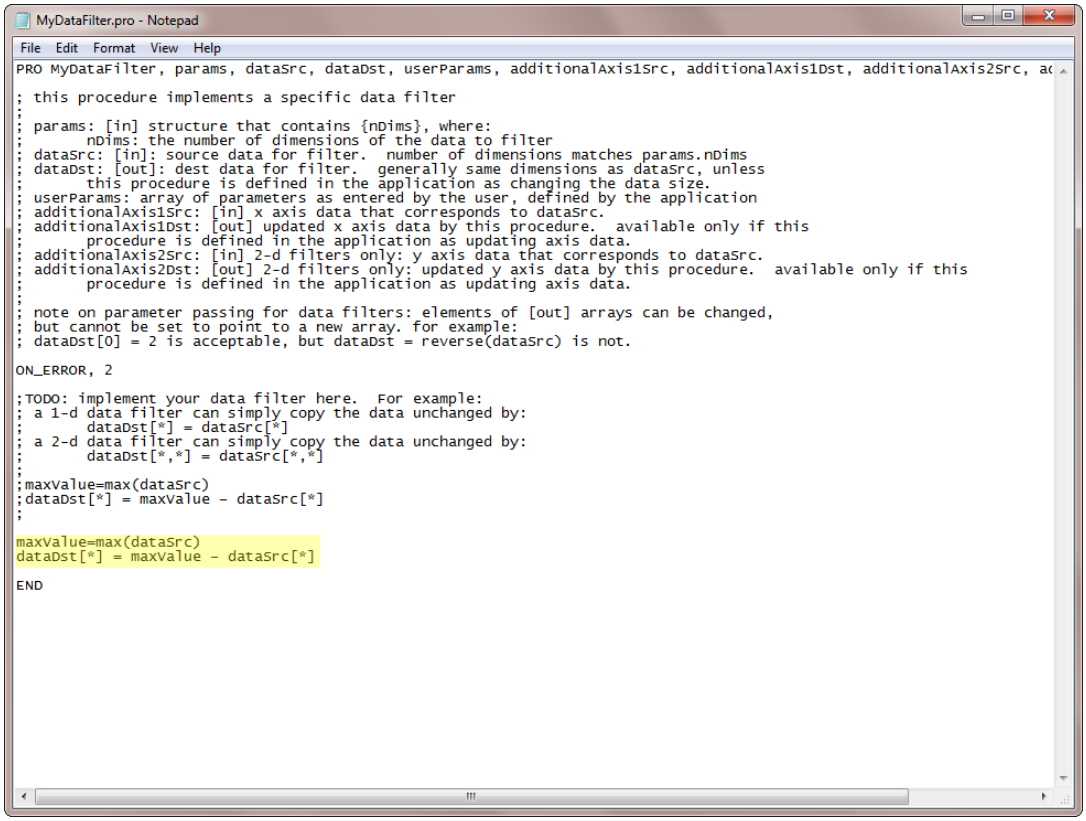


Data Filter Definition dialog

6. Scroll down to the bottom of the generated *.pro* file and add the following two lines before the END statement:

   maxValue=max(dataSrc)

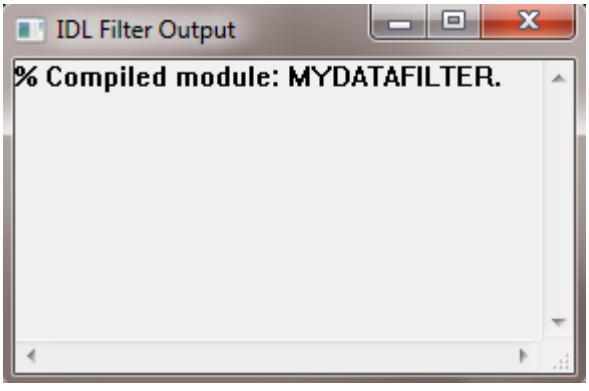
   dataDst[*] = maxValue - dataSrc[*]



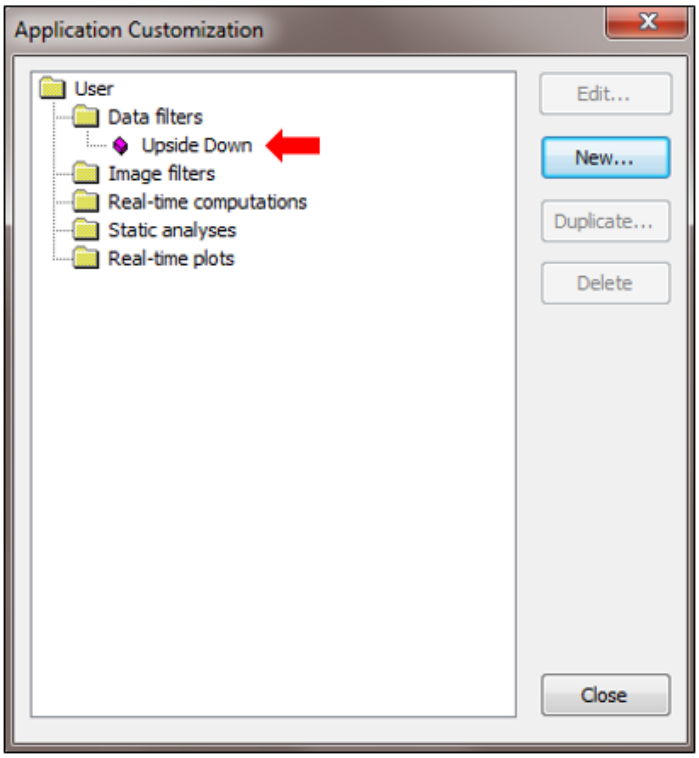
7. Click **File/Save** but leave the *.pro* file open.

8. Click the **Compile** button in the Data Filter Definition dialog (next to the **Edit** button). This dialog may be hidden behind other windows.

   At this point the software will perform a quick check of your procedure to make sure it doesn't contain errors that would prevent it from executing. Any errors that it finds will be displayed in the IDL Filter Output dialog. Fix any errors, **Save** the file, and then click the **Compile** button again until all errors have been corrected. If there are no errors in your procedure, the following message will appear in the IDL Filter Output dialog:



9. Once you've successfully compiled your procedure and any/all errors have been resolved, click **OK** in the Data Filter Definition dialog box to close it. Your new "Upside Down" data filter will appear in the folder tree of the Application Customization dialog.



Newly-created "Upside Down" data filter

10. Click **Close** on the Application Customization dialog to save your new configuration and update the application.

Note: The simple act of opening and closing the Application Customization dialog results in the reload and configuration of all programming items. **This is the main mechanism for updating the processing whenever an IDL procedure has been modified.**

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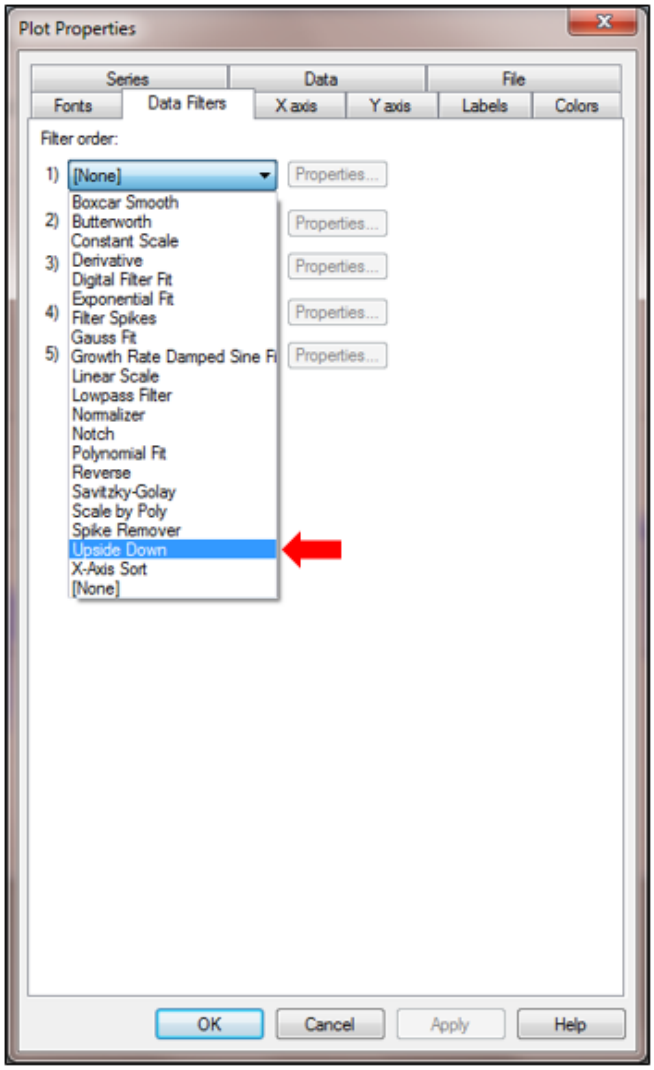
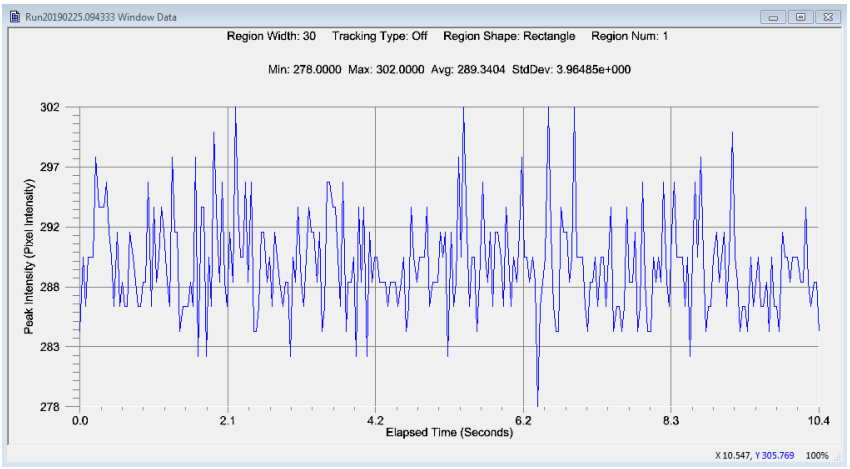
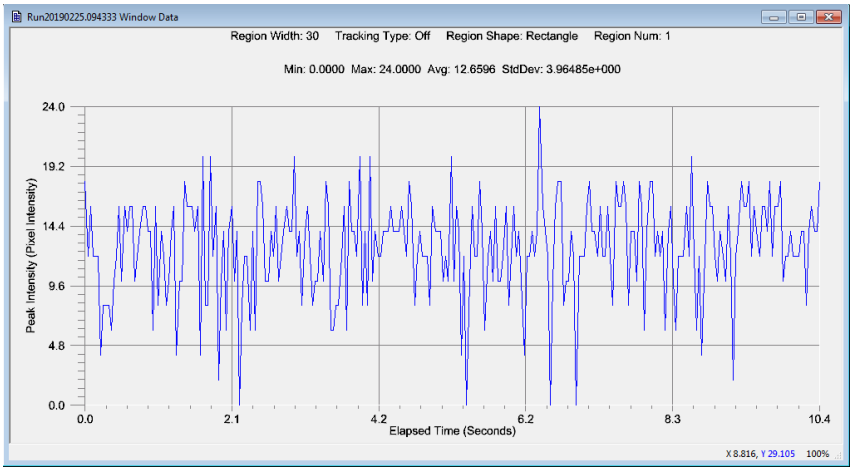
11. To test the new filter, use a line plot from any acquired image. Right click inside the plot and click **Properties**, then click on the **Data Filters** tab. Select the **Upside Down** filter and then click **OK**. Note that the plot peaks will flip and now become valleys.



Selecting the new filter in the Plot Properties dialog



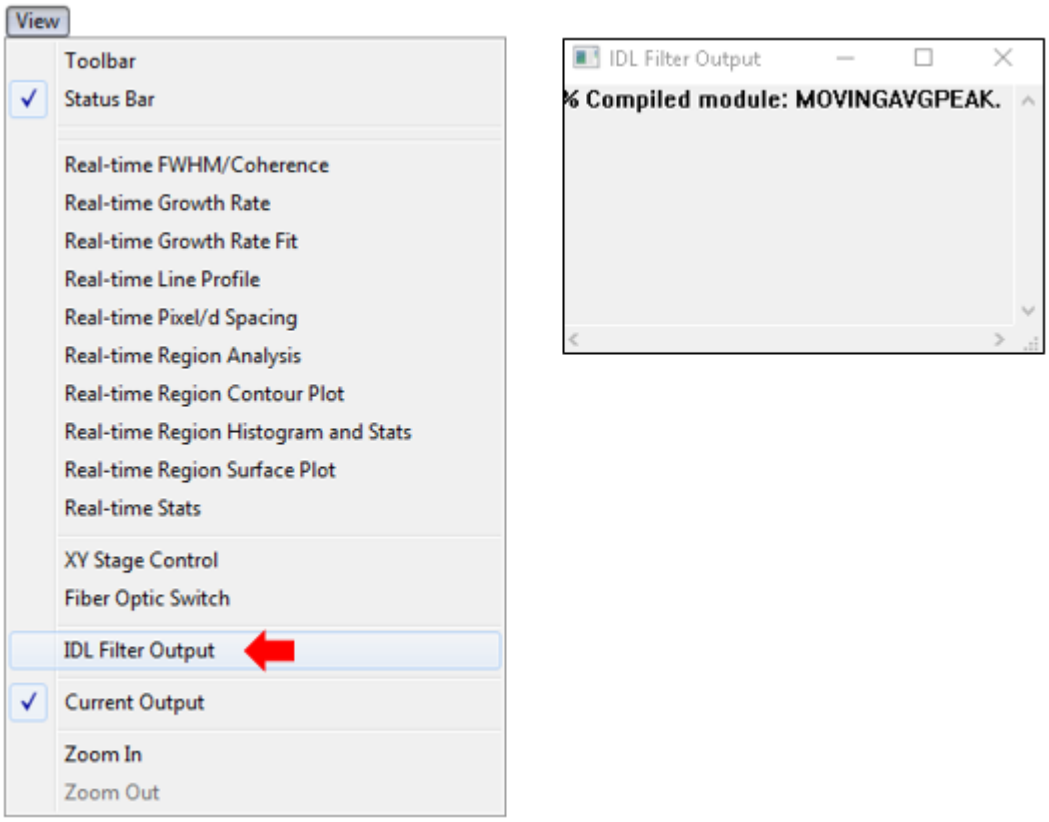
Plot before filter applied



Plot after filter applied

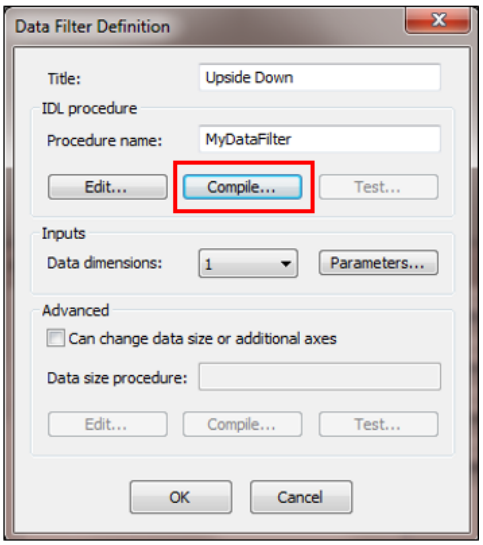
Monitoring IDL

By selecting the **View** menu and then the **IDL Filter Output** option, you can monitor the IDL print output window to aid in debugging your custom procedure/filter.



IDL Filter Output option

To compile a procedure, click **Options** from the main menu, followed by **Application Customization**. Choose a filter to compile and then click the **Edit** button (make sure the IDL Filter Output dialog is opened). Click the **Compile** button.

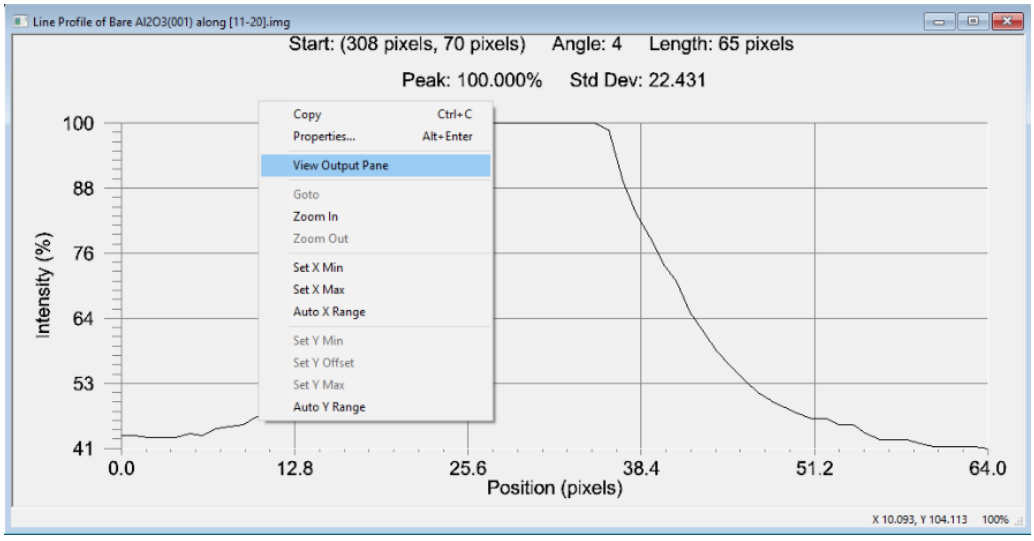


Any errors that the compiler finds will be displayed in the IDL Filter Output dialog. At this point you can make any necessary changes, save the file, and then re-compile until the procedure is clean and ready for processing.

Adding a Print Statement to an IDL Routine

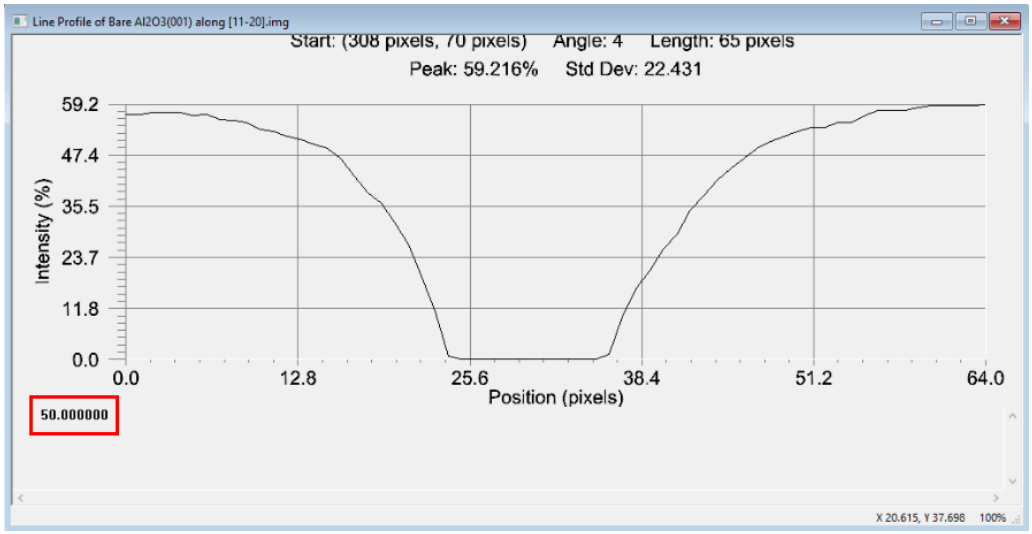
IDL also supports adding a print statement to the end of the routine/procedure in order to output a value or set of values. Where the kSA 400 software outputs this value/values will change depending on how the filter is being applied.

For example, for filters applied to static images, print statements are set to appear in the output pane under the chart that you are filtering. This is done by right clicking inside the chart and then selecting the **View Output Pane** option, as shown below.



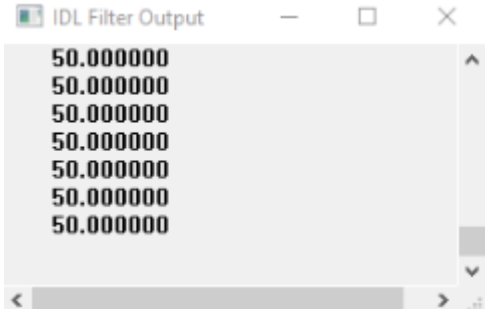
View Output Pane option in a Line Profile plot

In this case, adding the statement *print, maxValue/2* to the end of the **Upside Down** filter that you created earlier will result in your data being flipped and an output of half the max value, which is 50.



Result of print statement

If you apply a filter to a real time line profile instead of a static image, the values will output to the IDL Filter Output dialog that appears when you select **View**, followed by **IDL Filter Output**.

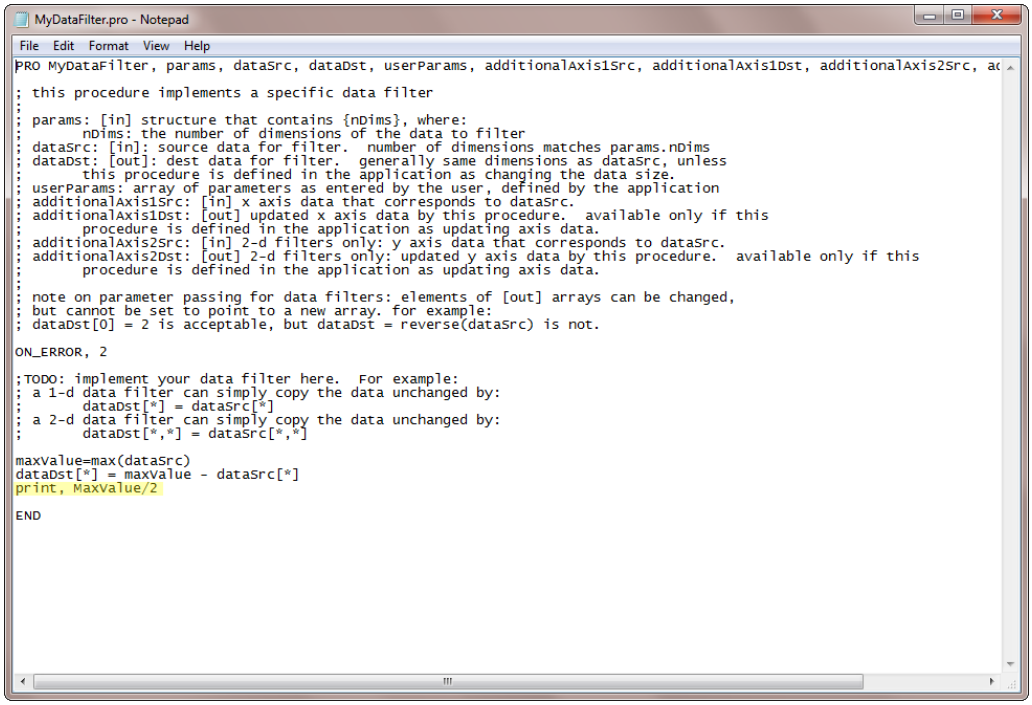


Refer to the procedures below for examples on how to add print statements for both scenarios mentioned above.

Example #1: Print Output with Static Line Scan

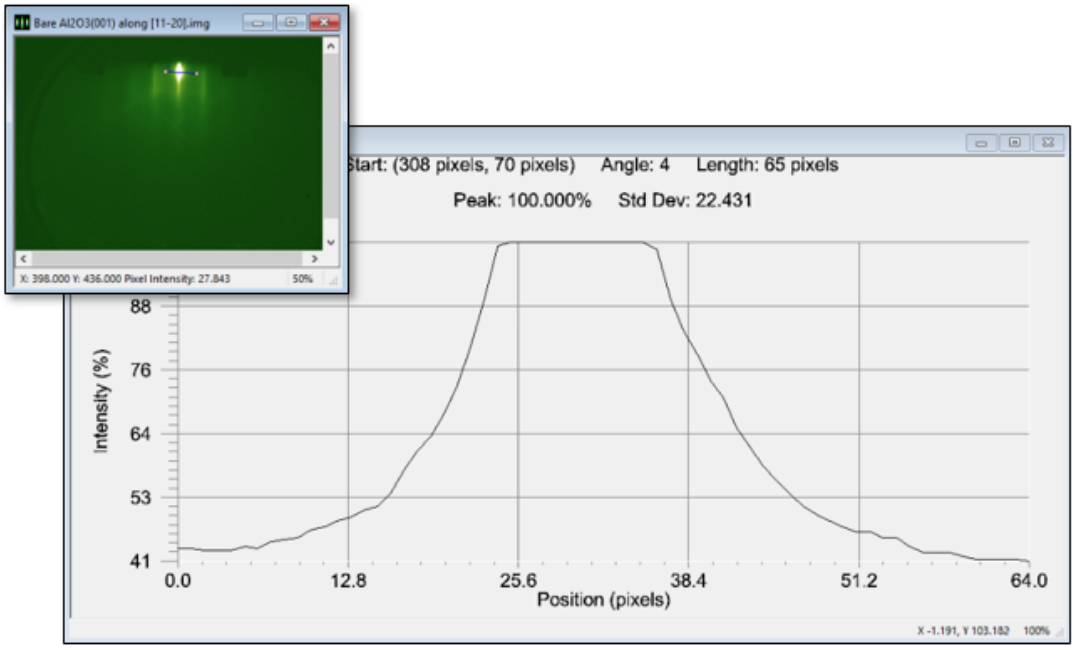
1. Click **Options**, followed by **Application Customization** and then select the **Upside Down** data filter that you created earlier in the Sample IDL Procedure section.
2. Click the **Edit** button and enter the following print statement to the end of the code:

   print, maxValue/2



Adding a print statement to the Upside Down procedure

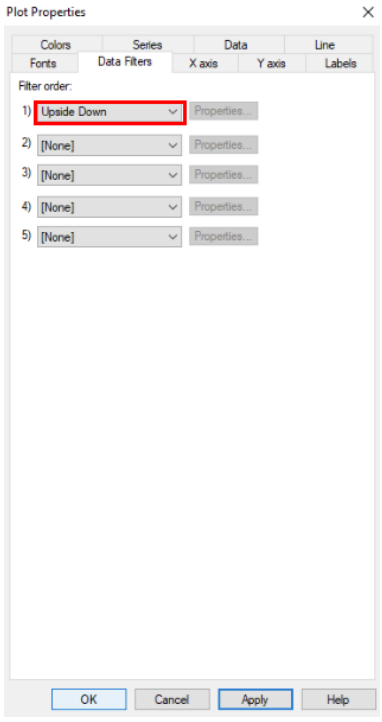
3. **Save** and **Exit** the text file, and then click the **Compile** button to make sure that everything compiles correctly.
4. Double click on an image from the RHEED image library to open it.
5. Select **Analysis** from the main menu, followed by **Line Profile**.
6. Drag the line on the image and place it across a region of interest.



Choosing an area of interest

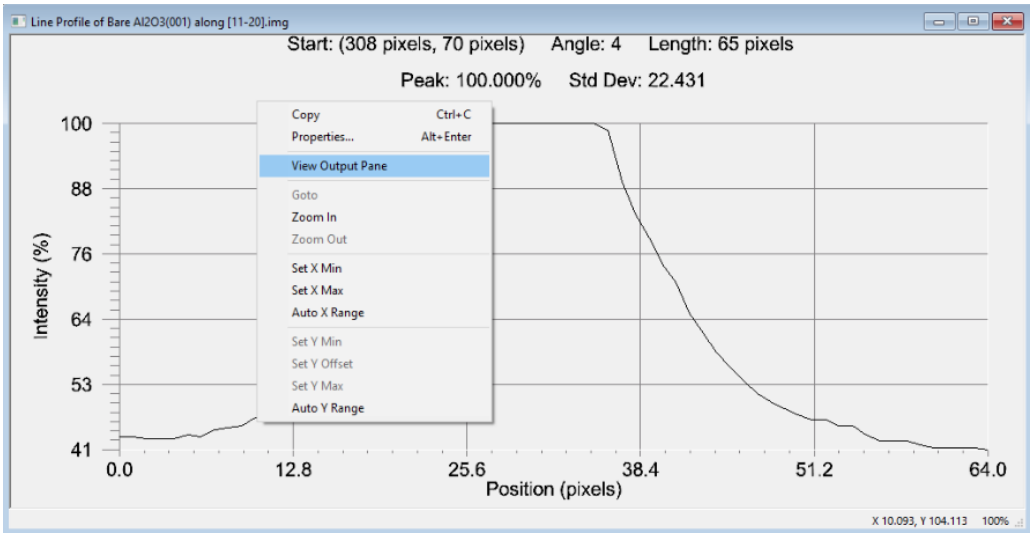
7. Right click inside the line profile plot and select **Properties**.
8. Click the **Data Filters** tab and choose the **Upside Down** filter from the first available drop-down.

9. Click **OK** and the data in your line profile plot will flip. Notice that you will <u>not</u> see the print output inside the IDL



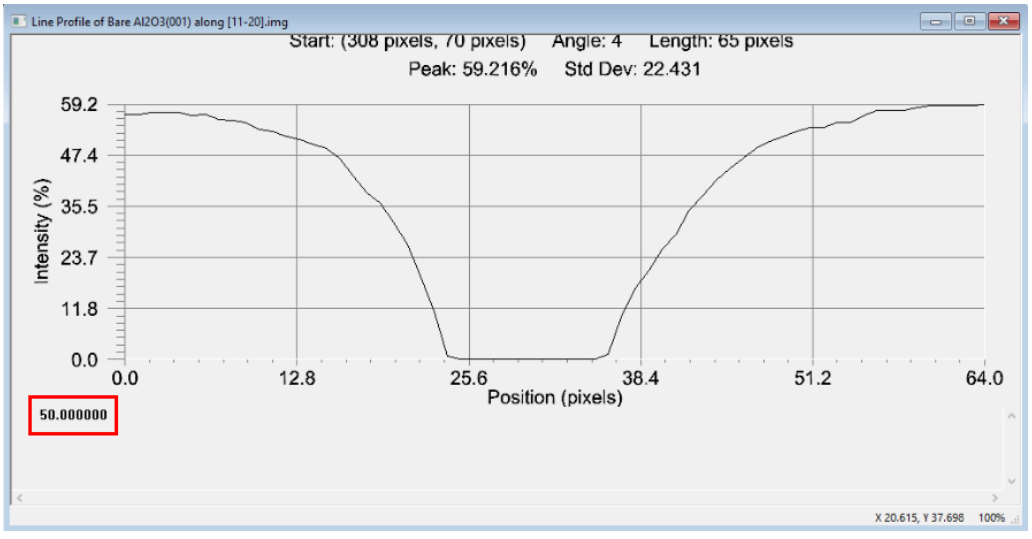
Filter Output dialog.

10. Right click again in the Line Profile dialog, this time choosing the **View Output Pane** option.



View Output Pane option

You now have a displayed output that corresponds to half the max value (100/2), or 50.

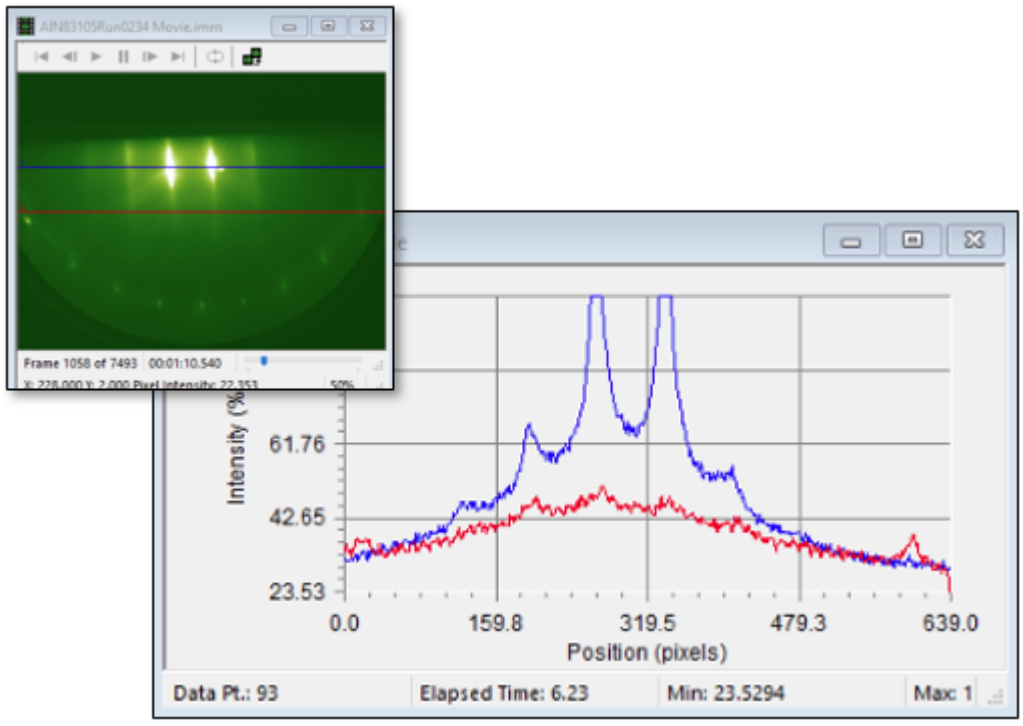


Result of print statement

Example #2: Print Output with Real-time Line Scan

Note: The following procedure assumes that the *print, maxValue/2* statement used above has already been added to the Upside Down c code**.**

1. In the kSA 400 software, click **View** from the main menu, followed by the **IDL Filter Output** option. This is the dialog where the print output will be displayed.
2. Select **Acquire** from the main menu, followed by **Scan Mode**.
3. Open a movie file from the RHEED image library (you can also use your camera as a source).
4. Click on the **Line** button in the **Add new region** section.
5. Place the new line over any area of interest.
6. Open the real-time chart by selecting **View** from the main menu, followed by **Real-time Line Profile**.
7. Click the **Start** button in the Scan Mode dialog to ensure that you are collecting data on your real-time profile as the movie plays.



8. Right click inside the Real-time Line Profile chart (it may be hidden behind other windows) and select **Properties**.
9. Click the **Data Filters** tab and choose the **Upside Down** filter from the first available drop-down. If you'll recall, we edit-

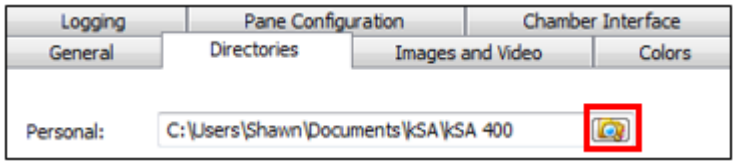
ed the Upside Down filter earlier by adding the following print statement at the end:

print, maxValue/2

10. Click **OK**.
11. Click the **Start** button again in the Scan Mode dialog. The line profiles should flip upside down and the print statement should begin populating in the IDL Filter Output dialog. This print statement should update in real-time while the scan is running.

Setting Your Personal Application Folder Location

1. Select **Options/General** from the main menu, and then click on the **Directories** tab. The path displayed in the **Personal** field is the folder where user folders are placed.
2. Click on the folder icon at the right to browse to a different folder if desired.



Location of User Programs and the Configuration File

Custom procedures/programs that are written by the user are stored in the **UserPlugIns** folder, which is a subfolder of the **Personal** folder mentioned above. The **UserPlugIns** folder contains a standard configuration file named *User.apcf* and also any user-written IDL *.pro* files.

Viewing the User Configuration File

The configuration file (*user.apcf*) describes how each custom routine will be called, and also explicitly details the associated inputs and outputs.

Note: The kSA user interface does not provide complete customization of the configuration file.

Real-Time Computations in the Configuration File

Source Columns

A source column is a named value calculated by the kSA software for every data measurement. A source file can be provided to the customization routine in order to compute a derived value.

The following section in the configuration file describes each source column:

[User_RT_ColumnComputers_List_0_Definition_SourceCols_List]

The description starts with how many total source columns are configured (Num=).

Each configured source column has its own section labeled with its number:

[User_RT_ColumnComputers_List_0_Definition_SourceCols_List_0]

The definition includes the following:

Field	Description
Description	English name of the source column.
ColumnID	The ID of the column (from the table below).
UnitsID	The units of the column (from the table below).
IndexByID	Signifies if the column is indexed (from the table below)
StatsType	an internal kSA field

[User_RT_ColumnComputers_List_0_Definition_SourceCols_List]
Num=1
[User_RT_ColumnComputers_List_0_Definition_SourceCols_List_0]
Description=Peak Intensity - Default (Pixel Intensity) Region No.
ColumnID=1
UnitsID=5
IndexByID=3

SampleStatType=16777215

Units

Unit Name	Unit ID
UnitsDefault	1
UnitsSeconds	2
UnitsVolts	4
UnitsAbsoluteIntensity	5
UnitsPercentIntensity	6

Index

Index Name	Index ID
IndexDefault	1
IndexByLine	2
IndexByWindow/Region	3

Column

Column Name	Column ID	IndexBy	Units
AbsElapsedTime	0	1	1
PeakIntensity	1	3	5
SummedIntensity	2	3	5
AverageIntensity	3	3	5
CentroidIntensity	11	3	5

The following is an example of a *User.apcf* file that was properly set up with peak intensity as a source column:

Note: UnitsID and IndexByID must be set to these values.

[User]
CustomizationLevel=2
[User_DataFilters_List]
Num=0
[User_ImageFilters_List]
Num=0
[User_RT_ColumnComputers_List]
Num=1
[User_RT_ColumnComputers_List_0_Definition]
DisplayName=MovingAvgPeak
ProcedureName=MovingAvgPeak
[User_RT_ColumnComputers_List_0_Definition_SourceCols_List]
Num=1
[User_RT_ColumnComputers_List_0_Definition_SourceCols_List_0]
Description=Peak Intensity - Default (Pixel Intensity) Region No.
ColumnID=1
UnitsID=5
IndexByID=3
SampleStatType=16777215
[User_RT_ColumnComputers_List_0_Definition_ResultCols_List]
Num=1
[User_RT_ColumnComputers_List_0_Definition_ResultCols_List_0]
Description=User-defined column 0 - Default n/a
ColumnID=36000
UnitsID=0
IndexByID=0
SampleStatType=16777215
[User_RT_ColumnComputers_List_0_Definition_UserParamDefList_ParamDefs]
Num=0
[User_RT_ColumnComputers_List_0_Definition_ResultColRanges]
Num=0
[User_RTCs_List]
Num=0
[User_StaticCharts_List]
Num=0

Conclusion

The use of IDL programming via the kSA 400 Application Customization feature allows you to customize your kSA 400 analysis capabilities. Once enabled, the kSA 400 software provides a simple, dialog-based setup of the customized processing routines to allow you to easily integrate your custom analysis routines into the kSA 400 application. For complex data processing implementations, a working knowledge of the IDL programming language is required.