

## Time Series Analysis with SAR & Optical Satellite Data

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**Changes in land surface characteristics mirror a multitude of processes induced by human alteration of the Earth system.**

**Remote sensing can be used to detect and monitor these changes.**

**Optical and SAR satellite data is suitable for time series approaches.**

- Landsat data continuity mission since 1972 (MSS, TM, ETM+, OLI)
- ESA missions since 1991 (ERS-1/2, ENVISAT-ASAR, Sentinel-1A)

**Free and open access to higher resolution imagery.**

- USGS Landsat archive
- Copernicus Sentinel-1: SAR imaging constellation for land and ocean services
- Copernicus Sentinel-2: Optical imaging mission for land services

**Advances in information technology for data processing allow operational time series analysis.**

- ENVI standardized preprocessing tools, e. g. for automated atmospheric correction
- ENVI spatio-temporal analysis
- ENVI – Arc GIS Integration

## Motivation

### Spatio-Temporal Analysis with ENVI 5.3

- Overview
- **Live presentation** “Understanding the Century Drought”  
Spatio-temporal analysis of historic and recent Landsat acquisitions

### Time Series Analysis with SARscape 5.2

- Overview
- **Live presentation** “If the Crop Fails”  
Time series analysis with Sentinel-1A data in the service of food security

## Summary

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## Summary

## Ability to construct a stack of time-enabled raster images.

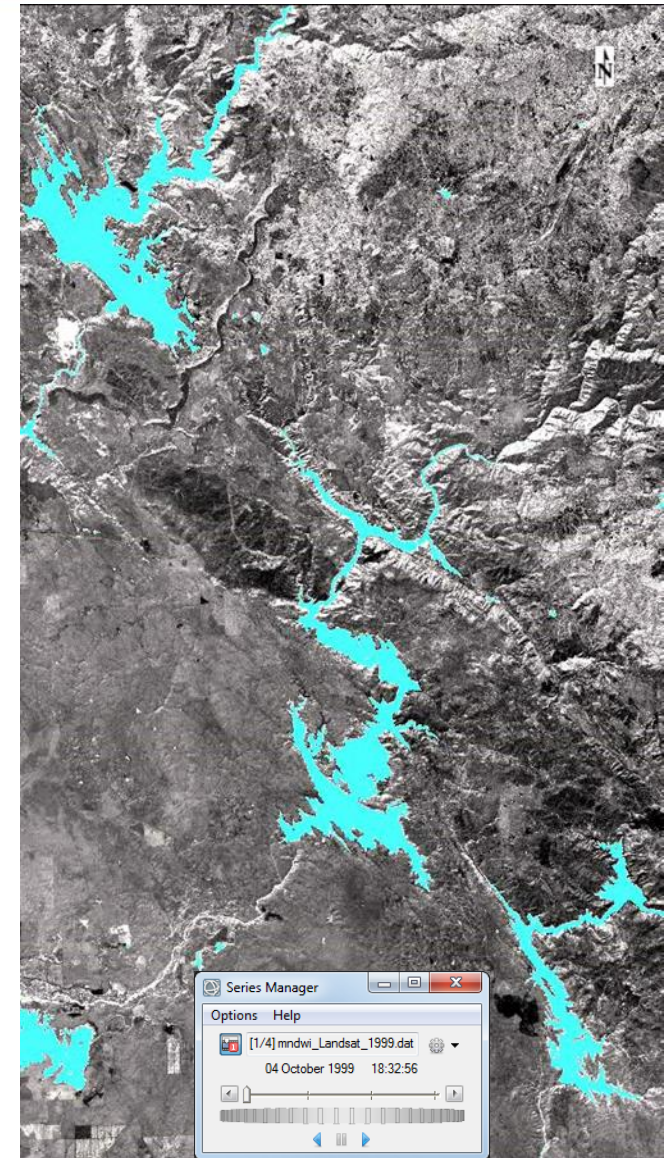
- Normalize a stack of rasters to a common spatial grid with automatic reprojection & resampling.
- Option to order the raster series sequentially according to time metadata from a wide variety of sensor data sources.

## View and animate a spatio-temporal series.

Define a custom spatial grid then re-grid a raster series to this new grid.

Plot the pixels values from different raster datasets through time.

Animation export to common video formats (.avi, .flv, .mp4, .webm, etc.).



## ENVITask System

- Modern object-oriented programming interface for processing.
- Helping you bridge the gap from Desktop applications to Enterprise solutions.

AutoChangeThresholdClassification  
BuildBandStack  
BuildRasterSeries  
BuildTimeSeries  
ChangeThresholdClassification  
ClassificationAggregation  
ClassificationSmoothing  
ClassificationToShapefile  
ColorSliceClassification  
DarkSubtractionCorrection  
DimensionsResampleRaster  
EqualizationStretchRaster  
FXSegmentation  
ForwardICATransform  
ForwardMNFTTransform  
ForwardPCATransform  
GaussianStretchRaster  
GramSchmidtPanSharpening  
ISODATAClassification

ImageBandDifference  
ImageIntersection  
ImageThresholdToROI  
LinearPercentStretchRaster  
LinearRangeStretchRaster  
LogStretchRaster  
MahalanobisDistanceClassification  
MappingResampleRaster  
MaximumLikelihoodClassification  
MinimumDistanceClassification  
NNDiffusePanSharpening  
OptimizedLinearStretchRaster  
PCPanSharpening  
PercentThresholdClassification  
PixelScaleResampleRaster  
QUAC  
QuerySpectralIndices  
ROItoClassification  
RPCOrthorectification

RXAnomalyDetection  
RadiometricCalibration  
RadiometricNormalization  
RasterStatistics  
RasterViewshed  
RegridRaster  
RegridRasterSeriesByIndex  
RegridRasterSeriesByIntersection  
RegridRasterSeriesByUnion  
ReprojectGLT  
RootStretchRaster  
SpectralAngleMapperClassification  
SpectralIndex  
SpectralIndices  
ThematicChange  
TrainingClassificationStatistics  
VectorAttributeToROIs  
VectorRecordsToROI  
VegetationSuppression  
VideoToRasterSeries

138 Tasks in ENVI 5.3

- File search

- ENVITask Radiometric Calibration

- ENVITask QUAC  
(Atmospheric correction)

- ENVITask Spectral Index (NDVI)

```
PRO Pleiades_RadCal_Quac_NDVI_Batch
COMPILE_OPT IDL2
```

```
; Start the application
e= envi(/CURRENT)
IF e EQ !NULL THEN e = ENVI()
```

```
; Create a list of files to perform processing
filelist = File_Search()
```

```
; Get the Radiometric Calibration task from the catalog of ENVITasks
Task1 = ENVITask('RadiometricCalibration')
```

```
; Get the QUAC task from the catalog of ENVITasks
Task2 = ENVITask('QUAC')
```

```
; Get the Spectral Indices task from the catalog of ENVITasks
Task3 = ENVITask('SpectralIndices')
Task3.INDEX = ['Normalized Difference Vegetation Index']
```

```
; Define output raster directory
out_dir = 'C:\EsriEUC\enviout\'
```

```
; Open the rasters and execute the tasks
FOREACH file, filelist DO BEGIN
```

```
    ; Open an image from the filelist
    raster = e.OpenRaster(file)
```

```
    ; Run Radiometric Calibration
    out_file_cal = out_dir + PATH_SEP() + 'RadCal_' + FILE_BASENAME(file, '.XML') + '.dat'
    Task1.Input_Raster = raster
    Task1.Output_Raster_URI = out_file_radcal
    Task1.Execute
```

```
    ; Run QUAC
    out_file_quac = out_dir + PATH_SEP() + 'Quac_' + FILE_BASENAME(file, '.XML') + '.dat'
    Task2.Input_Raster = Task1.Output_Raster
    Task2.Output_Raster_URI = out_file_quac
    Task2.Execute
```

```
    ; Run Spectral Indices
    out_file_ndvi = out_dir + PATH_SEP() + 'NDVI_' + FILE_BASENAME(file, '.XML') + '.dat'
    Task3.Input_Raster = Task2.Output_Raster
    Task3.Output_Raster_URI = out_file_ndvi
    Task3.Execute
```

```
ENDFOREACH
```

```
END
```

**ENVI is integrated in all aspects of ArcGIS raster analysis.**

**ENVI is the advanced raster analysis solution for ArcGIS users.**

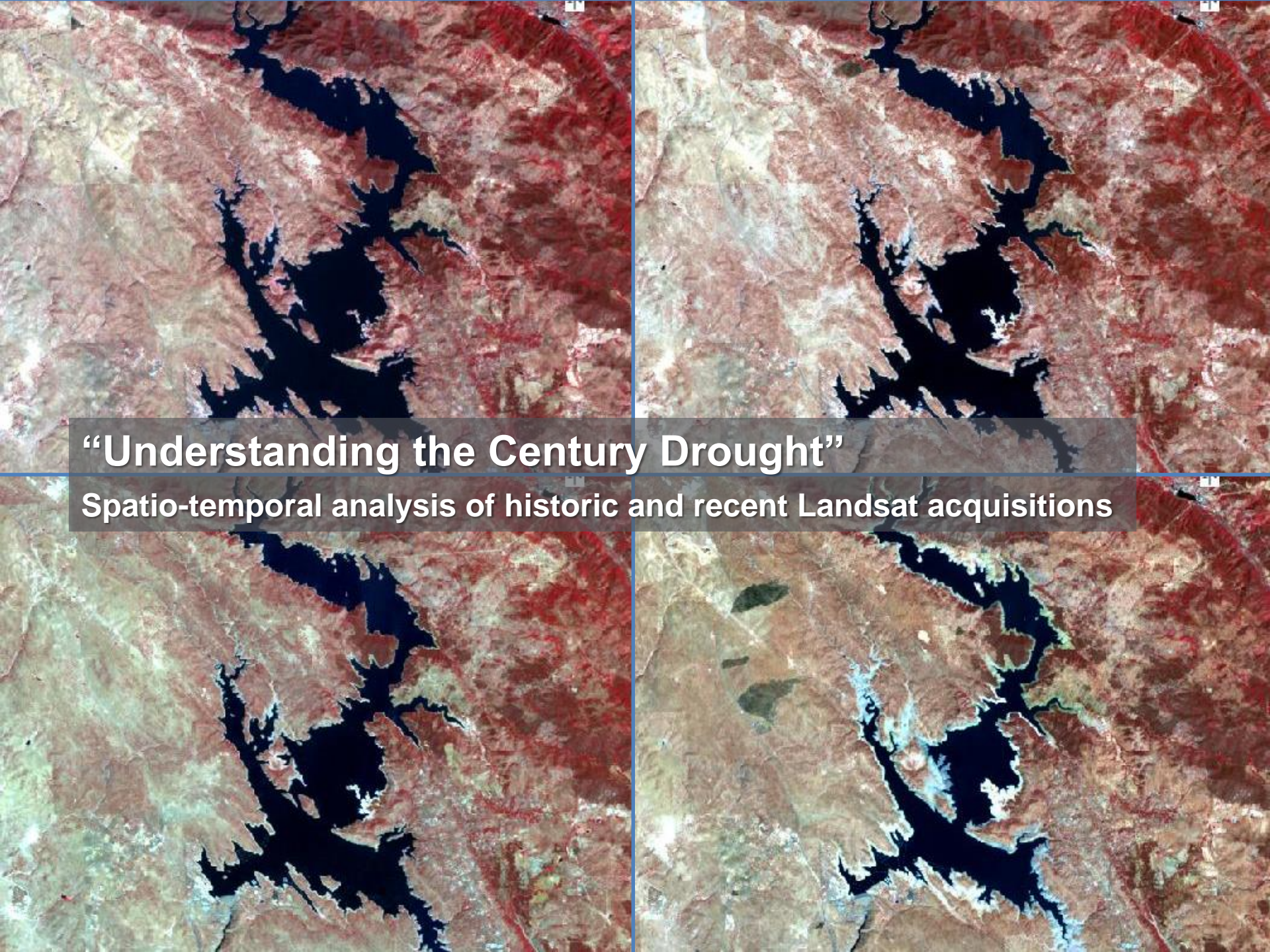
**Integration allows users to analyze imagery  
and easily share data between ENVI and ArcGIS.**

- Geodatabase create/read/write capabilities
- ArcGIS map projection engine
- Esri layer support
- Esri basemaps
- ArcGIS map layout view

- ENVI to ArcMap link
- ENVI file format read/write
- ENVI ModelBuilder Integration
- IDL-Python Bridge bi-directional
- ENVI tools for ArcGIS / ArcGIS Server

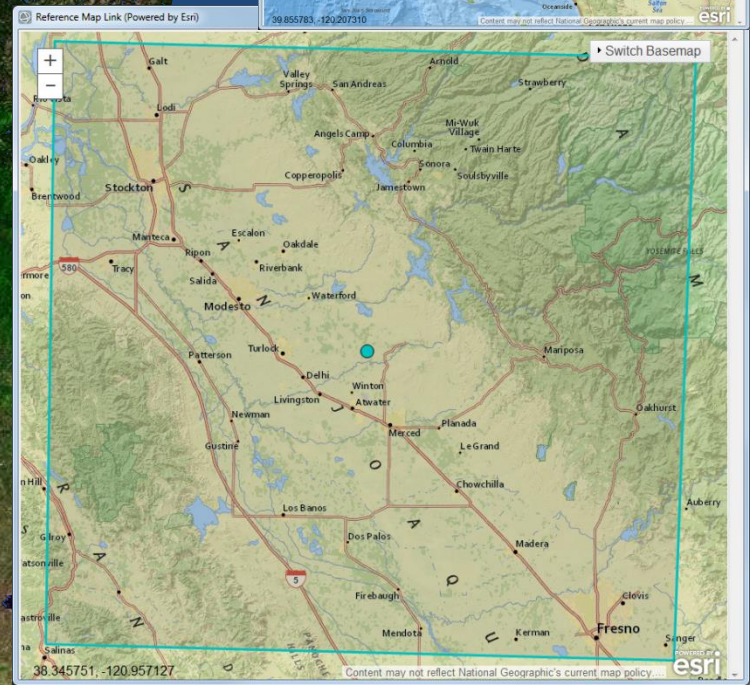
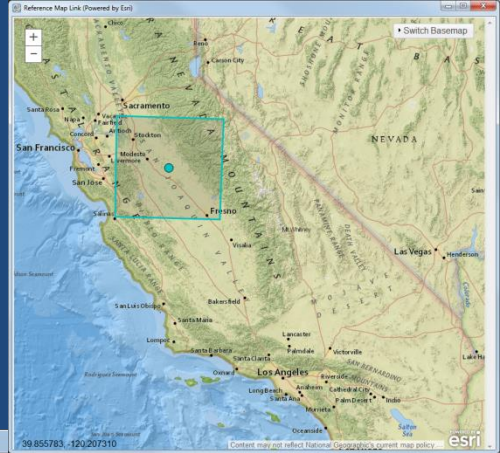
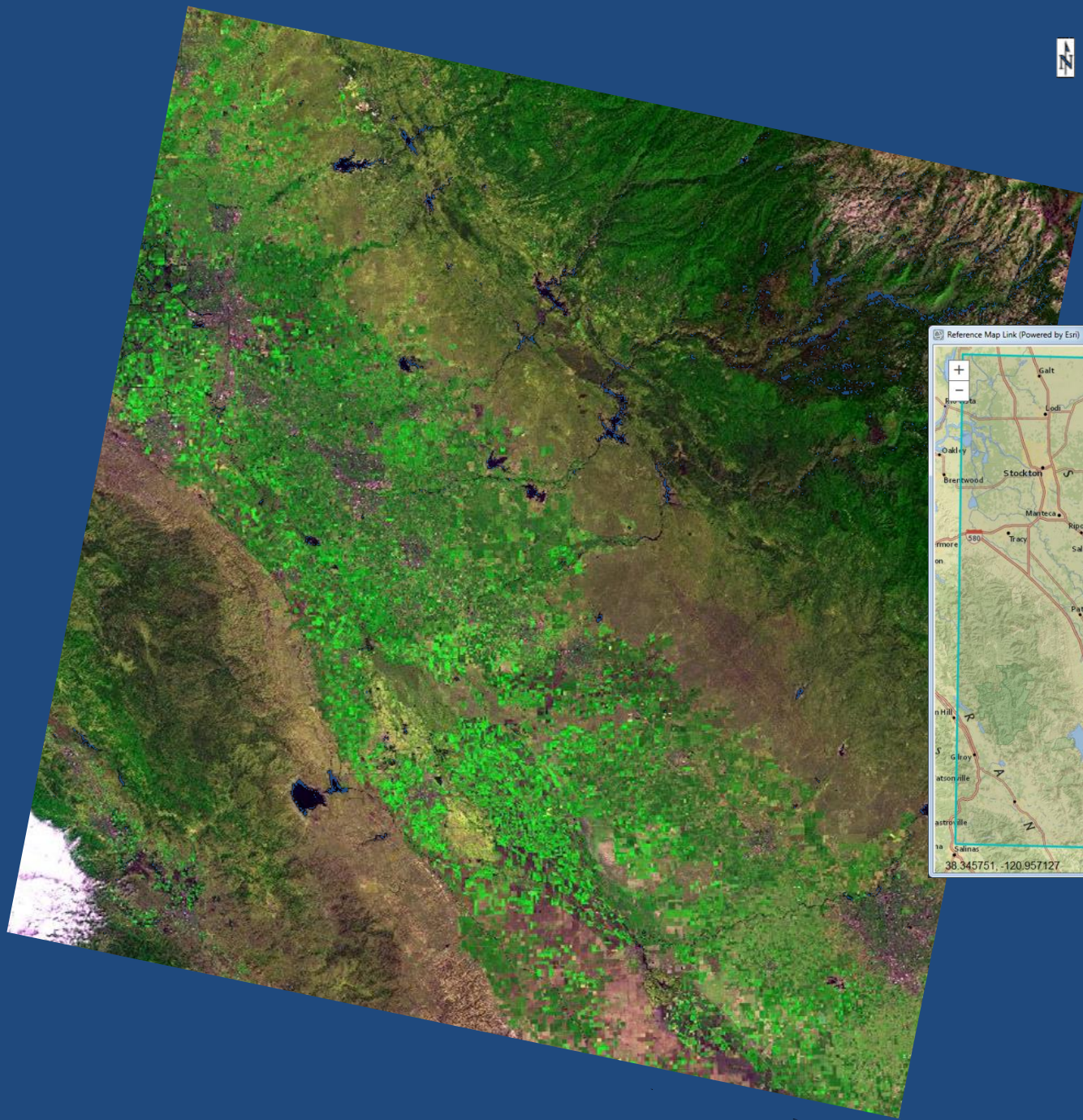






## “Understanding the Century Drought”

Spatio-temporal analysis of historic and recent Landsat acquisitions



## Preprocessing

File search (batch)

- ENVITask **Radiometric Calibration**
- ENVITask **QUAC**  
(Atmospheric correction)

ENVITask **Build Time Series**

Animation of spatiotemporal series (view 1)

## Analysis

File selection (interactive)

- ENVITask **Spectral Index** (MNDWI)
- ENVITask **Color Slice Classification**
- ENVITask **Classification Aggregation**
- ENVITask **Classification to Shapefile**
- ENVIDoit **Stretch Doit**
- ENVIDoit **Classification Overlay**

Display shape files (view 1)

ENVITask **Build Time Series**

Animation of spatiotemporal series (view 2)

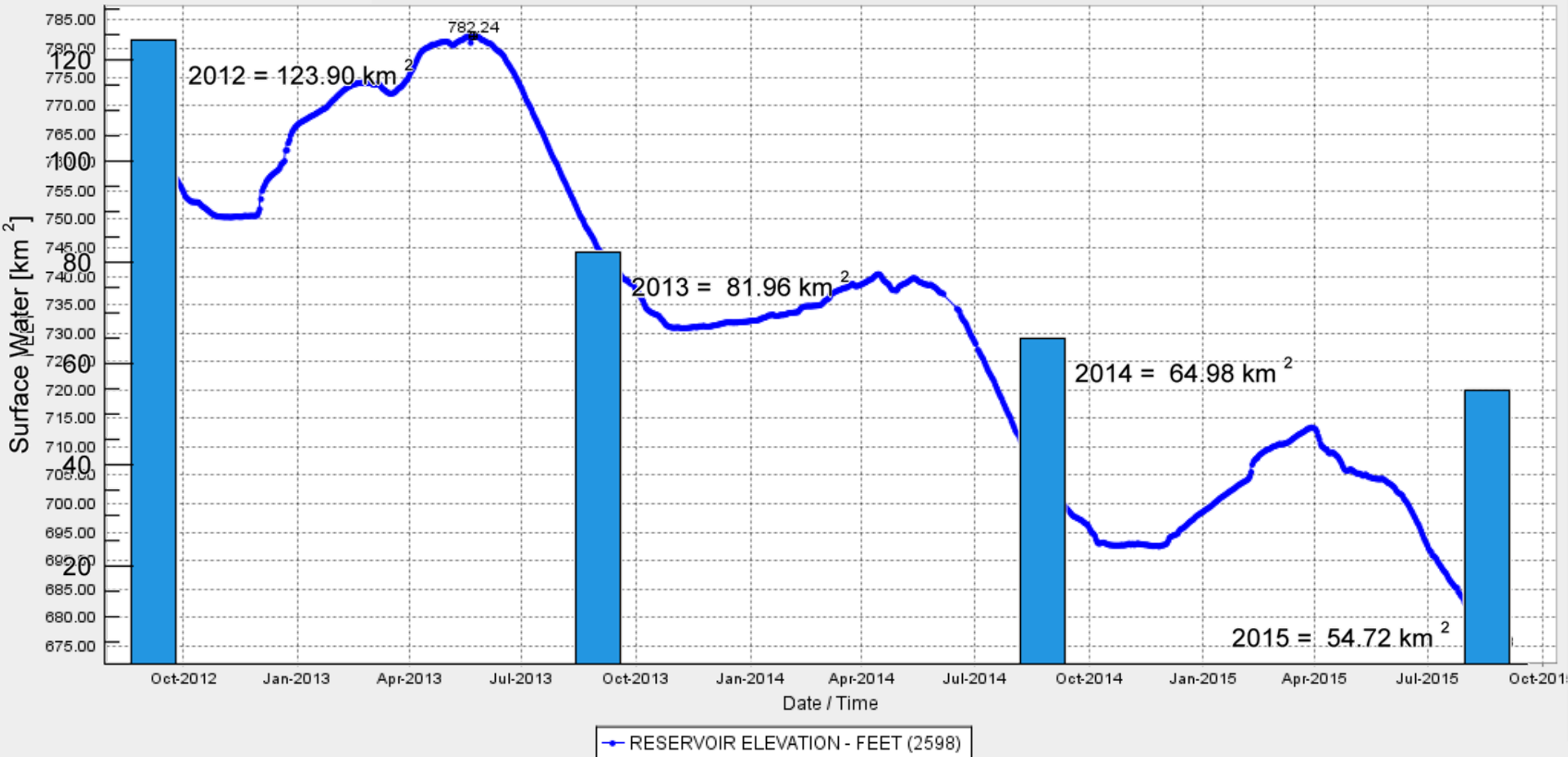
Create video animation

Visualization of results as  
IDL-Barplot and export as PDF

# Correlation with Reservoir Elevations

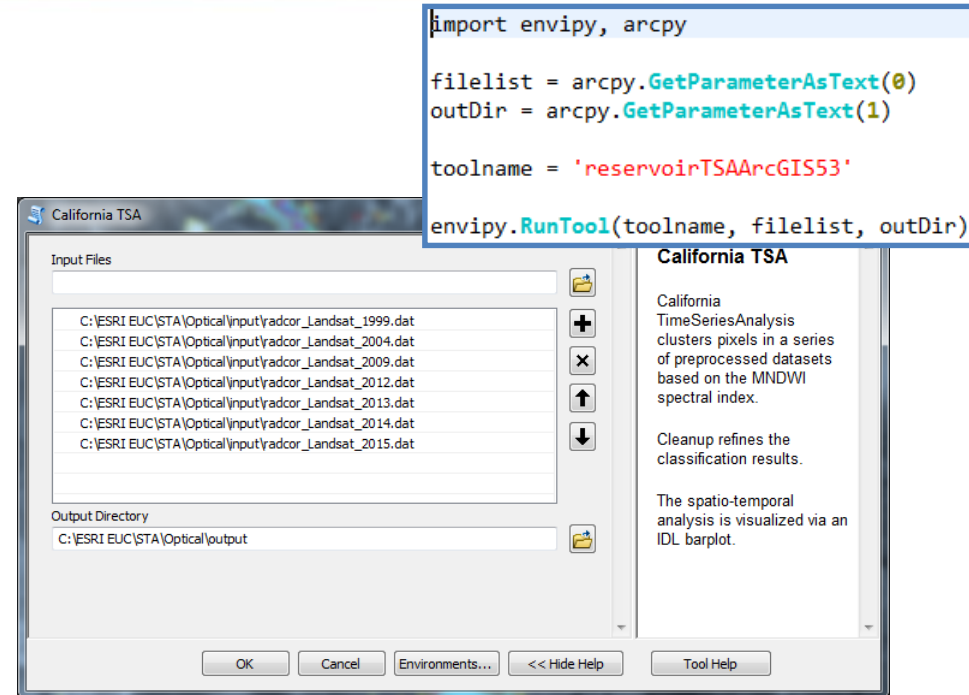


## Reservoir Surface Water - Eastern Sierra Nevada, California



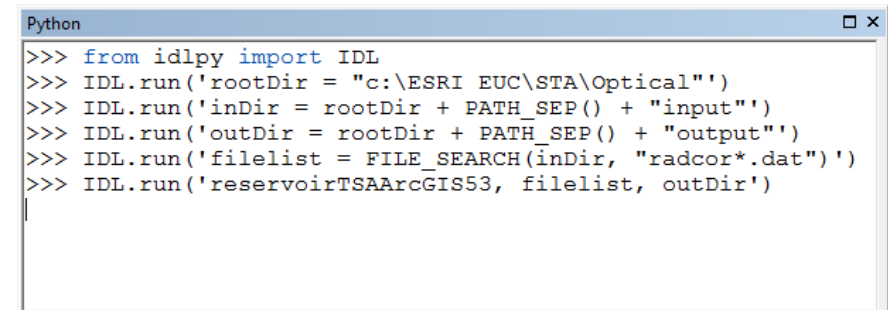
## Execute spatio-temporal analysis using a customized script tool.

- Python script file retrieves the parameters from the user interface and runs the precompiled IDL code.
- IDL code is used to interface between the Python script and the ENVITasks.



## Execute spatio-temporal analysis using the Python to IDL bridge.

- Mechanism for calling IDL code from the Python window within ArcGIS.
- IDL code is used to interface between Python and the ENVITasks.



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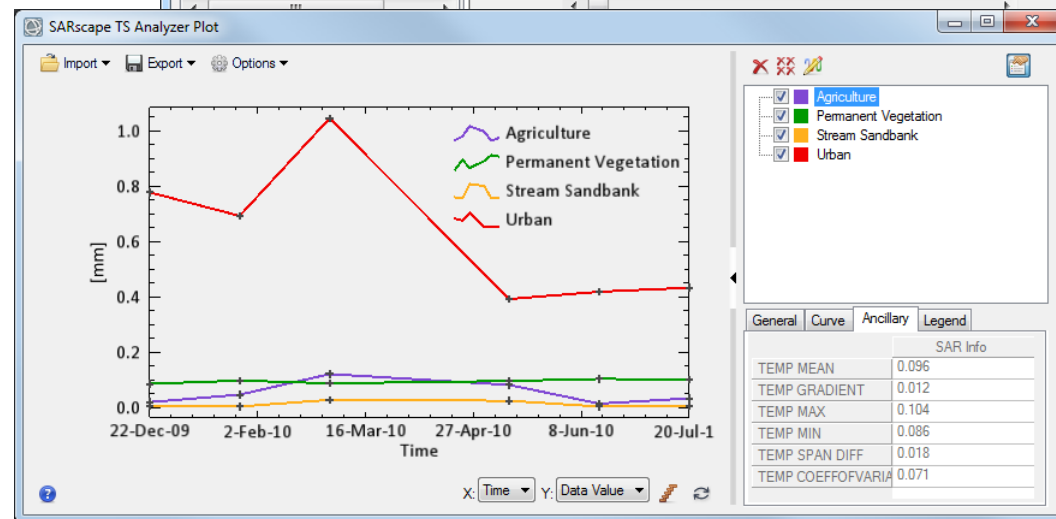
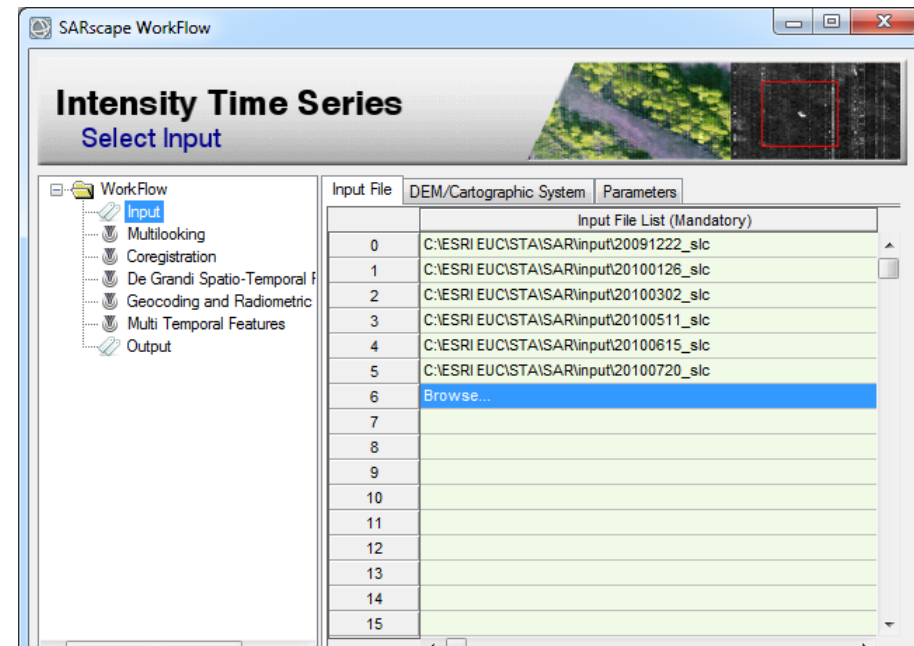
## Summary

Ability to execute a processing sequence on a multi-temporal stack of SAR images in a single iteration.

Multi-temporal features, based on first order statistics, are derived from the SAR intensity data.

These features enable to detect and extract spatio-temporal changes.

TS analyzer plot for a graphic representation of the temporal trend/signature.



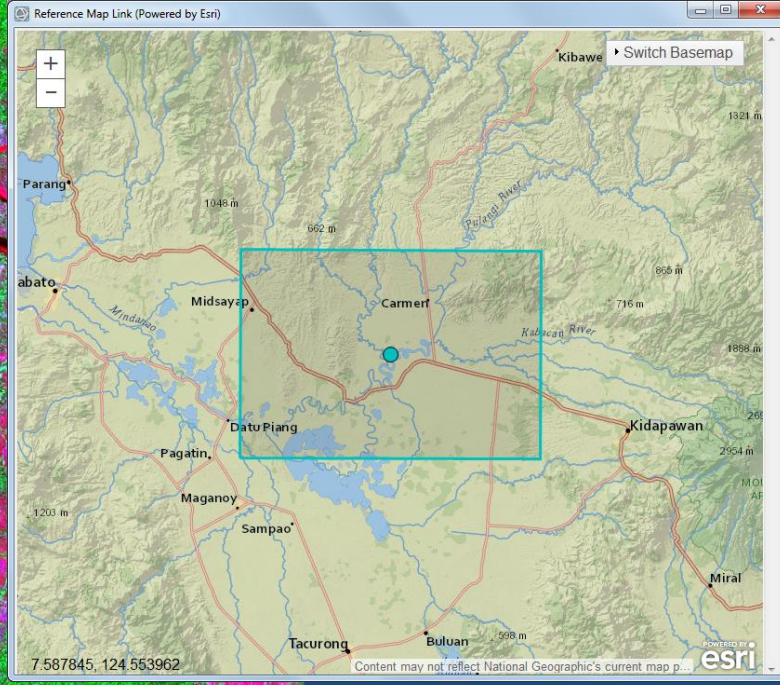
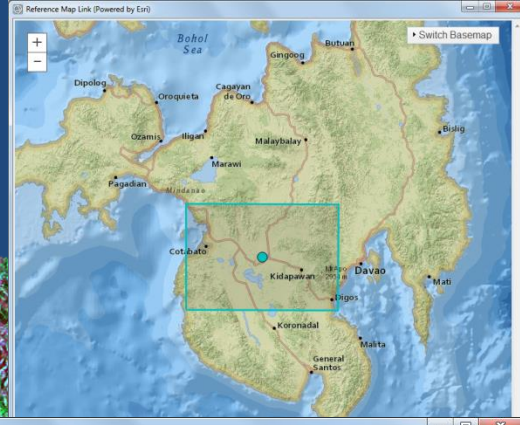
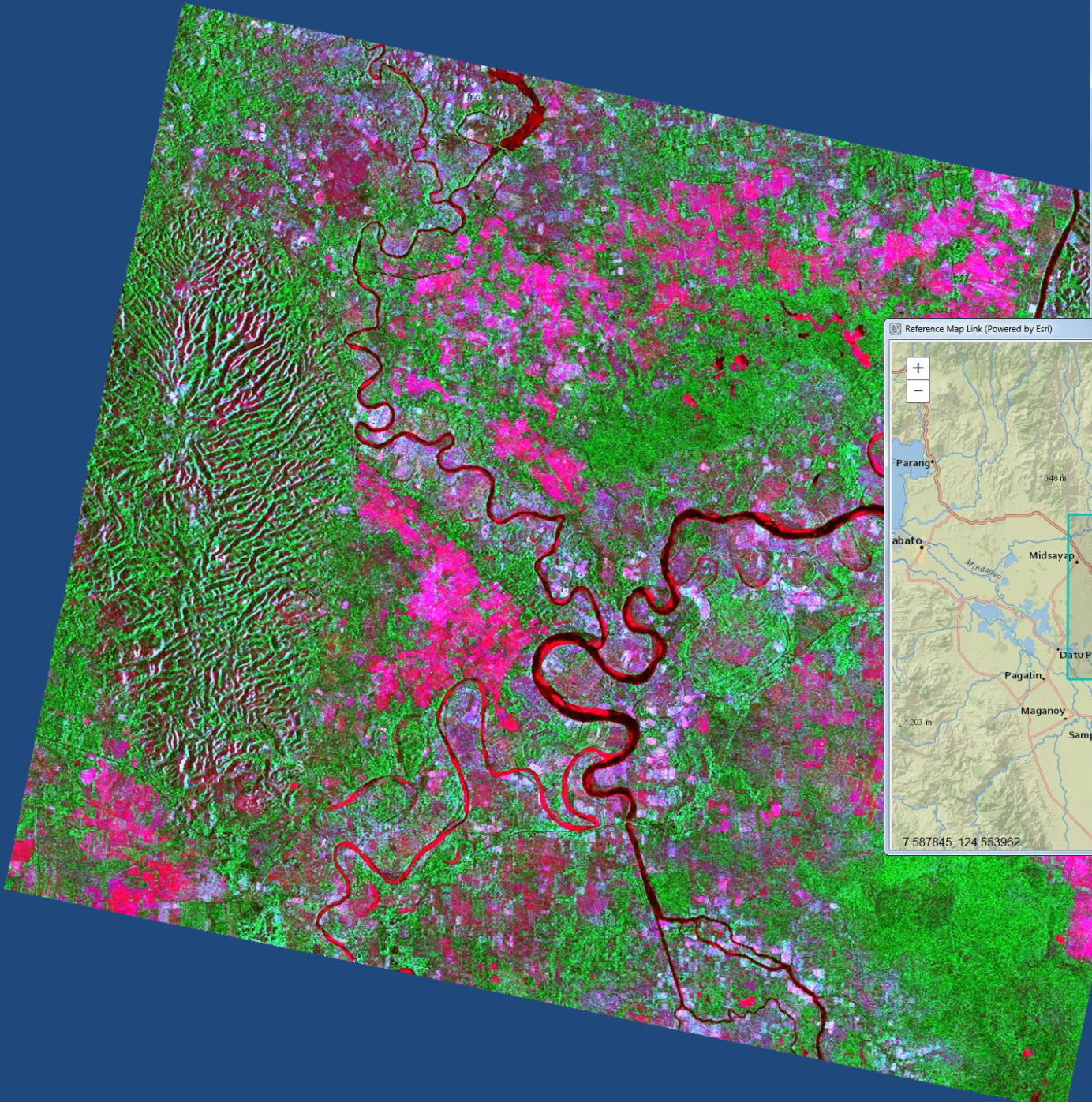


**“If the Crop Fails”**

**Time series analysis with Sentinel-1A data in the service of food security**







# Processing Sequence for SAR Intensity Time Series Analysis with SARscape 5.2



## Preprocessing

Data import (interactive)

Sample selection (optional, interactive)

## Analysis

File input (interactive)

DEM selection (interactive)

Parameters (interactive)

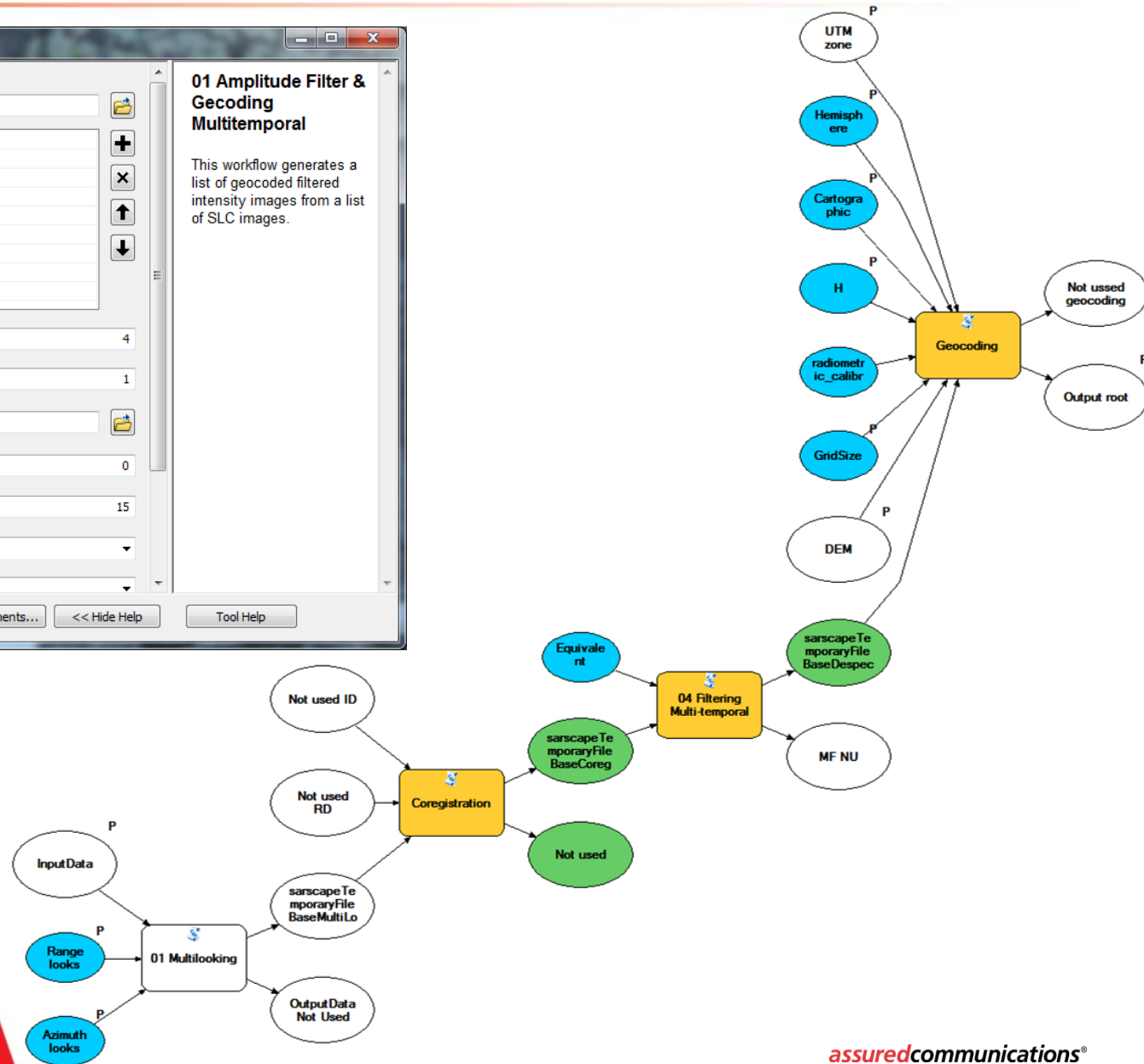
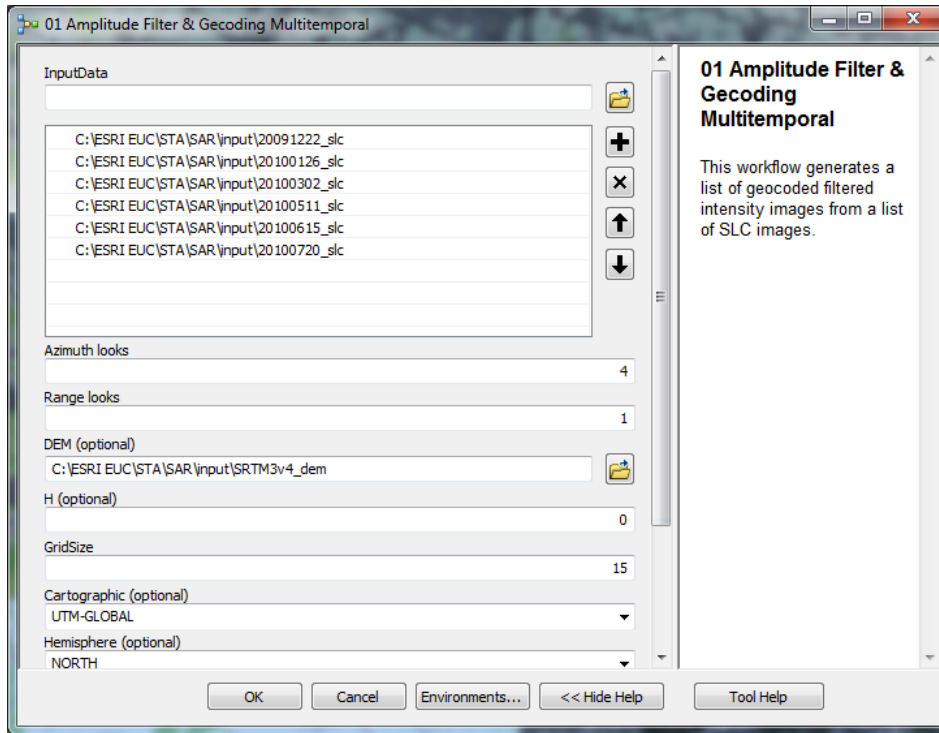
- Multilooking
- Coregistration
- De Grandi spatio-temporal filtering
- Geocoding and radiometric calibration
- Multi-temporal features

Display RGB composite of  
multi-temporal features (CovMinGrad)

Display spatio-temporal series

Perform time series analysis (interactive)

# Implementation in ArcMap



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**The software platform ENVI facilitates the processing and analysis of large image time series.**

**ENVI makes it easy to add spatio-temporal information to your GIS from virtually any image type.**

**ENVI allows integration of its operational workflows in ArcGIS.**

**ENVI allows you to analyze geospatial imagery within any ArcGIS environment – on the desktop, for mobile devices, and in the cloud.**

**Use ENVI for ArcGIS to fuse information from imagery with GIS layers to gain actionable intelligence.**



**GIS & Imagery in one World!**



# Thank You!



## Meet Us at Booth 20

[harris.com](http://harris.com)



### ENVI® ADVANCED IMAGE ANALYSIS FOR ArcGIS® USERS

From software and sensors to actionable information, Harris provides geospatial solutions that help you make informed decisions — when and where you need it.

- ENVI® for ArcGIS®
- IntelliEarth™
- Geiger-mode LiDAR

