AUTOMATISIERTE ZEITREIHENANALYSE VON FERNERKUNDUNGSDATEN FÜR DAS MONITORING VON OBERFLÄCHENGEWÄSSERN

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23. Workshop Arbeitskreis Umweltinformationssysteme

2.-3. Juni 2016, Leipzig

HARRIS®

Outline

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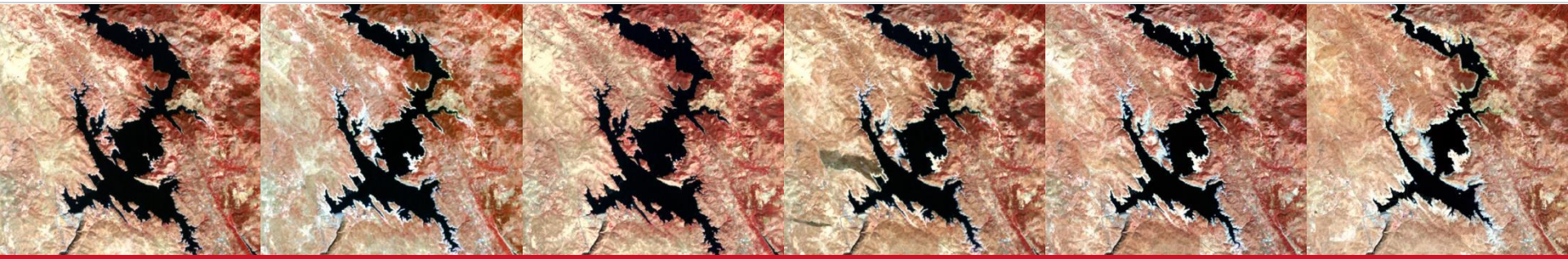
Pre-processing & Classification

Automation & Implementation in Operational Environments

Live-Demonstration

Summary



MOTIVATION

Motivation

Changes in land surface characteristics mirror a multitude of processes induced by human

Optical and

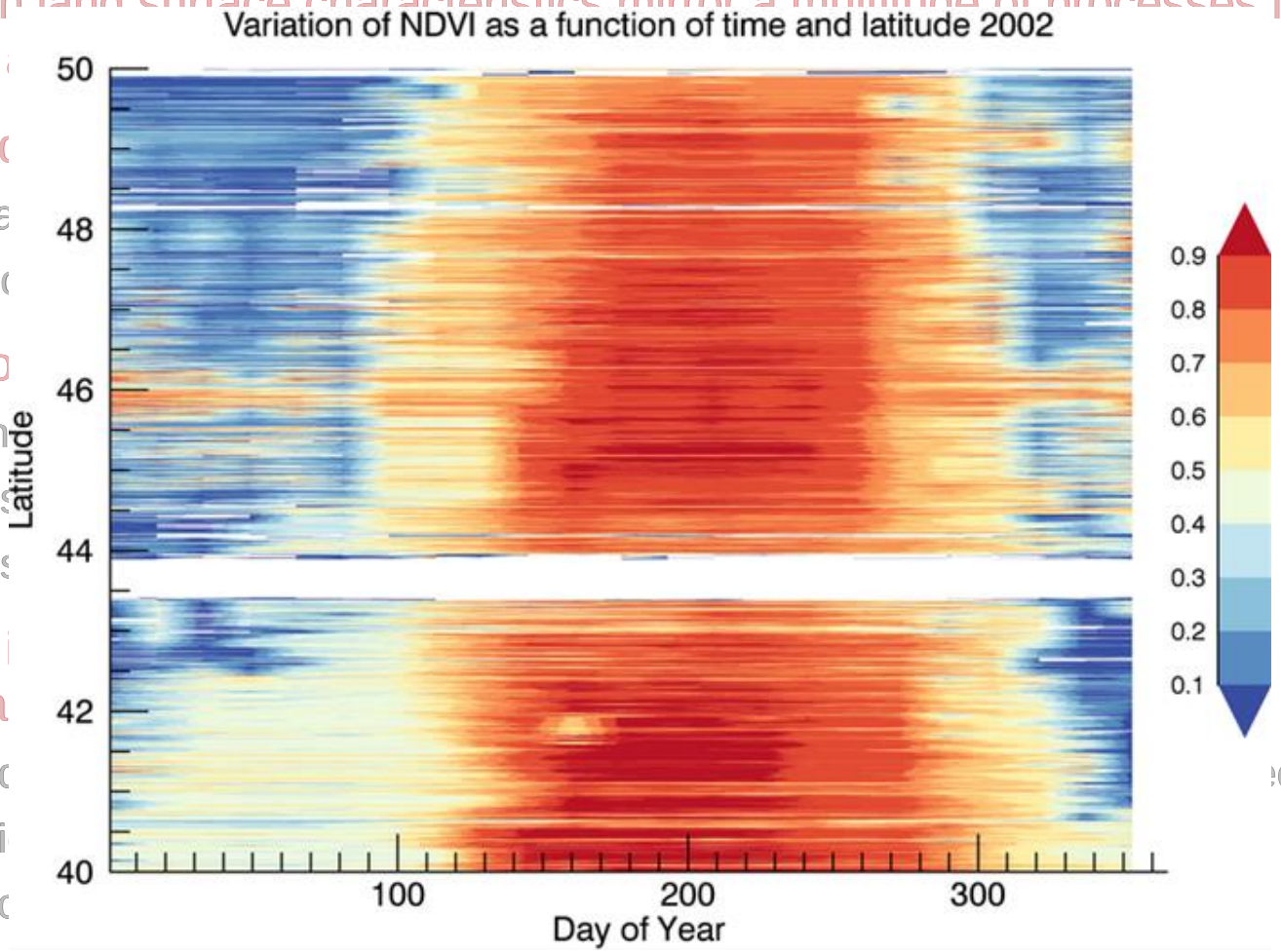
- Landsat da
- ESA missi

Free and o

- USGS Lan
- Copernicus
- Copernicus

Advances operationa

- ENVI stand
- ENVI spati
- ENVI – Arc



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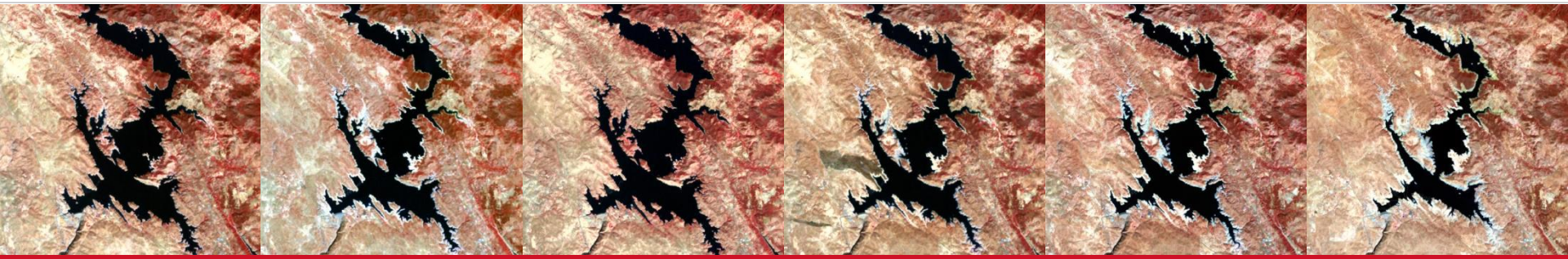


INTRODUCTION

Useful for deriving statistics from data or visualizing changes in the data over time

→ View the images incrementally

Build Raster Series

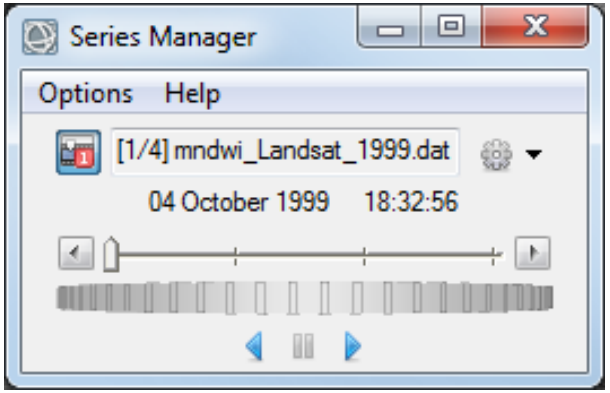
→ Construct a stack of raster images

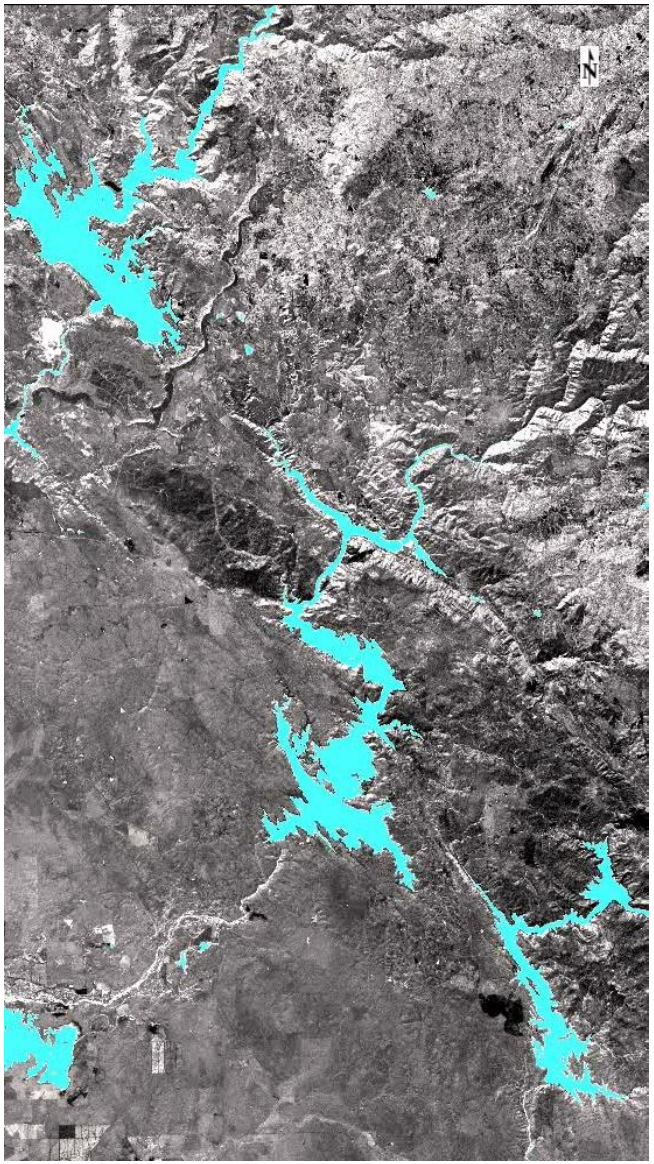
- .series-file in JSON format (→ reference to raster files)
- Order by time (optional)

Series / Animation Manager

→ View and animate series sequentially

- Text annotations
- Series time profile
- Export to video formats

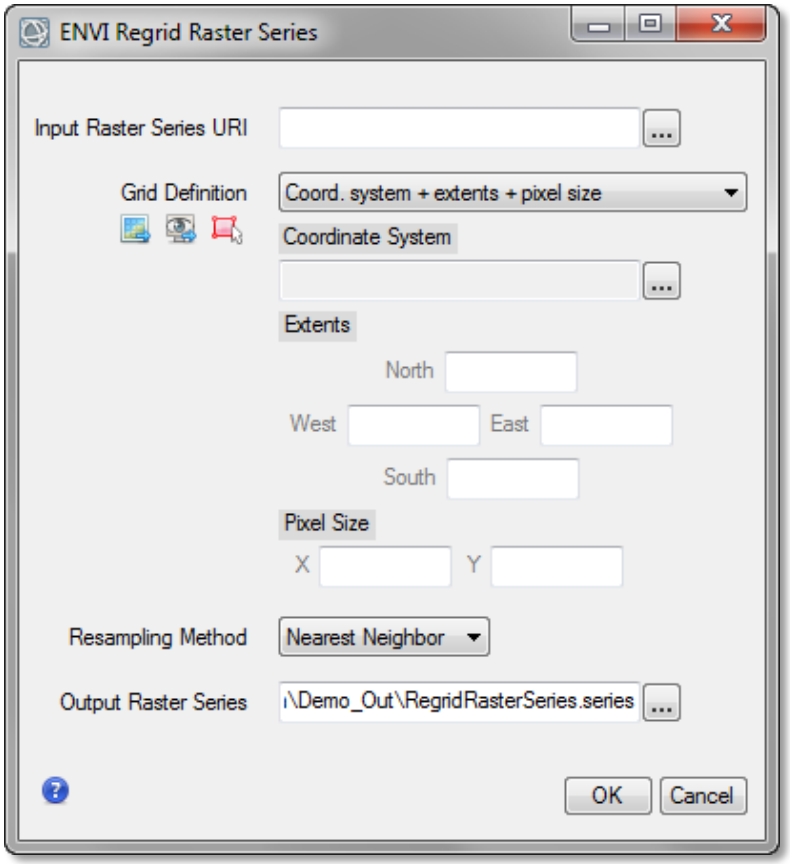


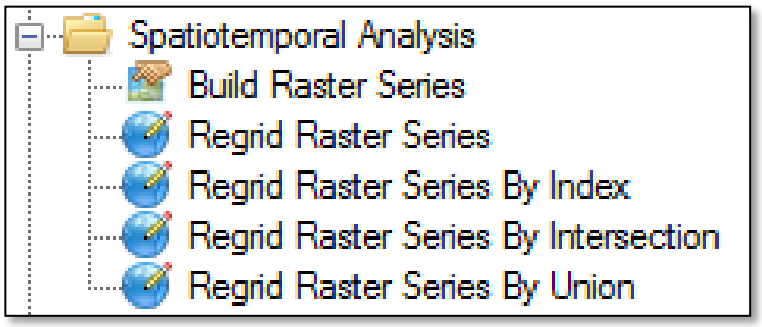


Regrid Raster Series

→ Normalize raster stack to common spatial grid with automatic reprojection & resampling

- Regrids the source rasters by either
  - Raster series (custom grid)
  - Index (selected image)
  - Intersection
  - Union
- Creates new .series-file to regrided rasters





ENVITask system

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

AdditiveLeeAdaptiveFilter
AdditiveMultiplicativeLeeAdaptiveFilter
ApplyGainOffset
AutoChangeThresholdClassification
BinaryGTThresholdRaster
BinaryLTThresholdRaster
BitErrorAdaptiveFilter
BuildBandStack
BuildIrregularGridMetaspatialRaster
BuildMetaspatialRaster
BuildMosaicRaster
BuildRasterSeries
BuildTimeSeries
CalculateCloudMaskUsingFmask
CalculateQUACGainOffset
ChangeThresholdClassification
ClassificationAggregation
ClassificationClumping
ClassificationSieving
ClassificationSmoothing
ClassificationToShapefile
ColorSliceClassification
ConvertGeographicToMapCoordinates
ConvertMapToGeographicCoordinates
ConvertMapToPixelCoordinates
ConvertPixelToMapCoordinate
CreatePointCloudSubProject
DarkSubtractionCorrection
DataValuesMaskRaster
DimensionsResampleRaster
DirectionalFilter
DirectionalKernel
EnhancedFrostAdaptiveFilter
EnhancedLeeAdaptiveFilter
EqualizationStretchRaster
ExportColorSlices
ExportRasterToPNG
FXSegmentation
FilterTiePointsByFundamentalMatrix
FilterTiePointsByGlobalTransform
FilterTiePointsByGlobalTransformWithOrthorectification
FilterTiePointsByPushbroomModel
ForwardICATransform
ForwardMNFTransform
ForwardPCATransform
FrostAdaptiveFilter
GammaAdaptiveFilter
GaussianHighPassFilter
GaussianHighPassKernel
GaussianLowPassFilter
GaussianLowPassKernel
GaussianStretchRaster
GenerateGCPsFromReferenceImage
GenerateGCPsFromTiePoints
GeneratePointCloudsByDenseImageMatching
GenerateTiePointsByCrossCorrelation
GenerateTiePointsByCrossCorrelationWithOrthorectification
GenerateTiePointsByMutualInformation
GenerateTiePointsByMutualInformationWithOrthorectification
GeoJSONToROI
GeoPackageToShapefile
GeographicSubsetRaster
GetColorSlices
GetSpectrumFromLibrary
GramSchmidtPanSharpening
HighClipRaster
HighPassFilter
HighPassKernel
ISODATAClassification
ImageBandDifference
ImageIntersection
ImageThresholdToROI
ImageToImageRegistration
KuanAdaptiveFilter
. . .

146 tasks in ENVI 5.3.1

ENVI – ArcGIS Integration

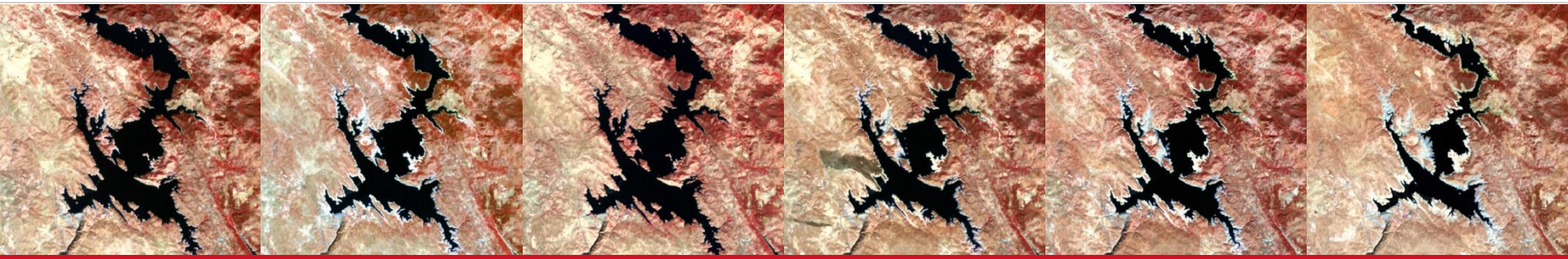
ENVI is integrated in all aspects of ArcGIS® raster analysis.

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

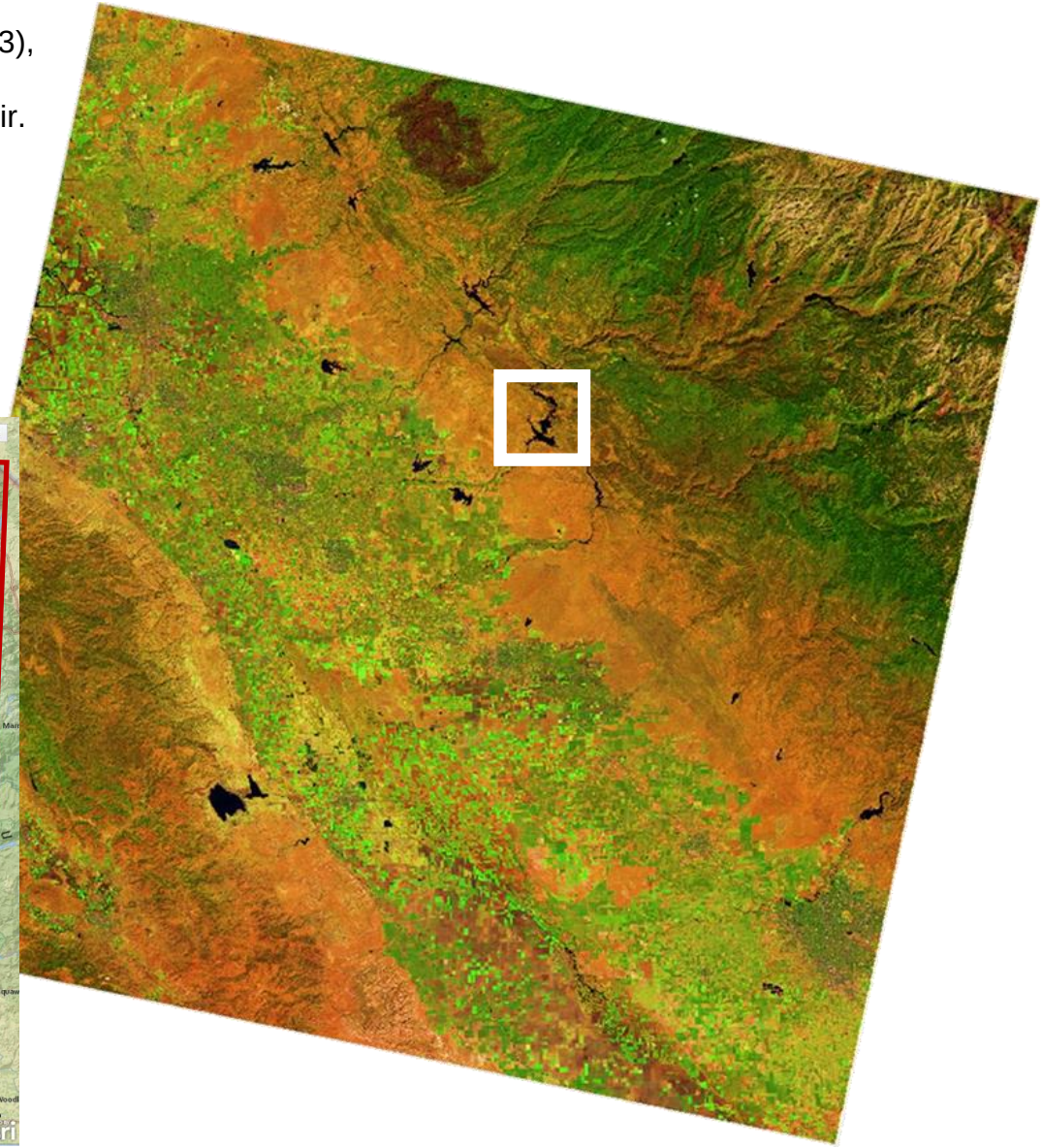
- ENVI to ArcMap® link
- ENVI file format read/write
- ENVI ModelBuilder® Integration
- IDL bi-directional Python Bridge
- ENVI tools for ArcGIS® / ArcGIS Server®



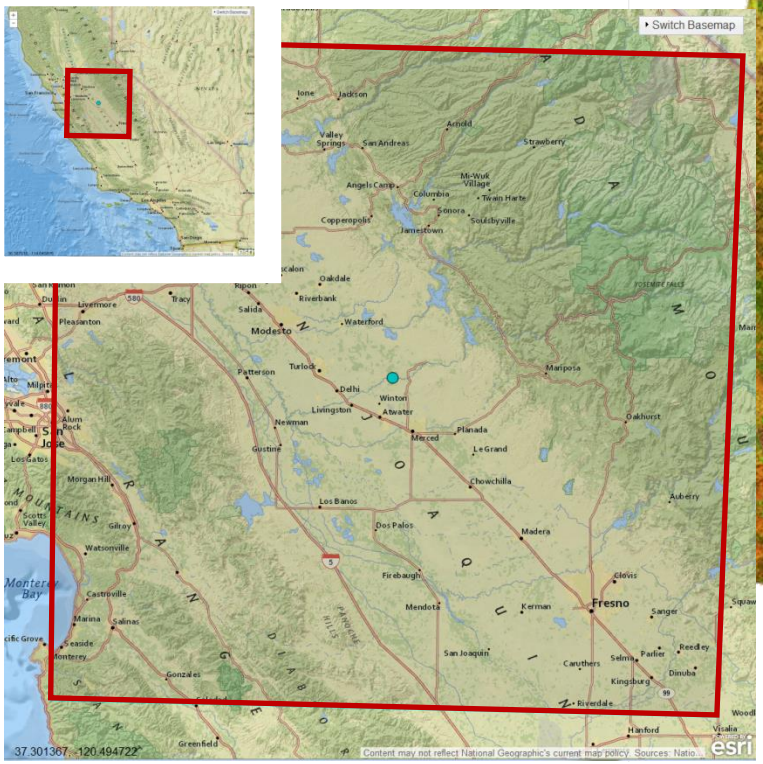
PRE-PROCESSING & CLASSIFICATION

Test site

Landsat-8 OLI color composite (RGB=753), acquired 22 Sept 2015.
The box indicates the Don Pedro reservoir.

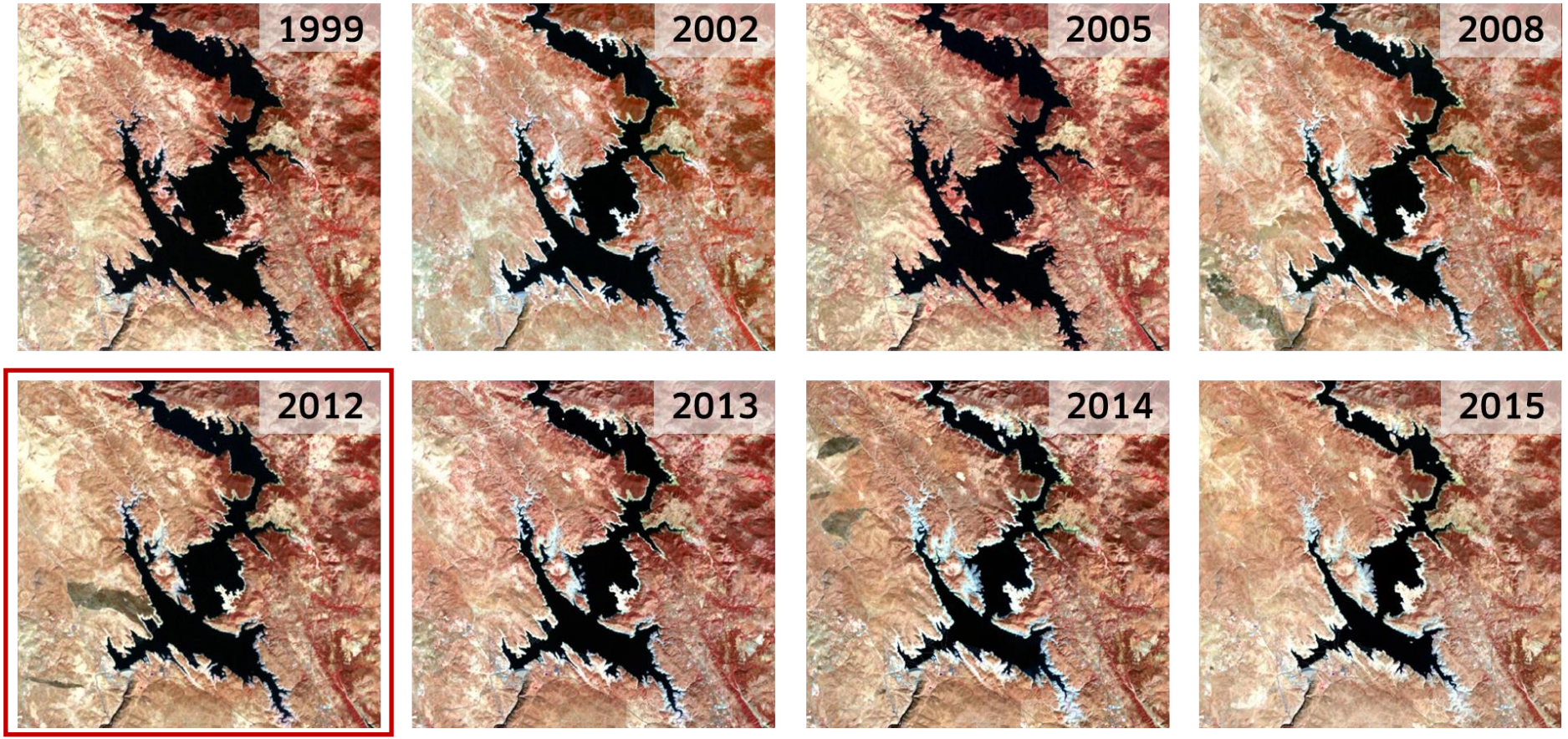


Location of the Landsat images in California.



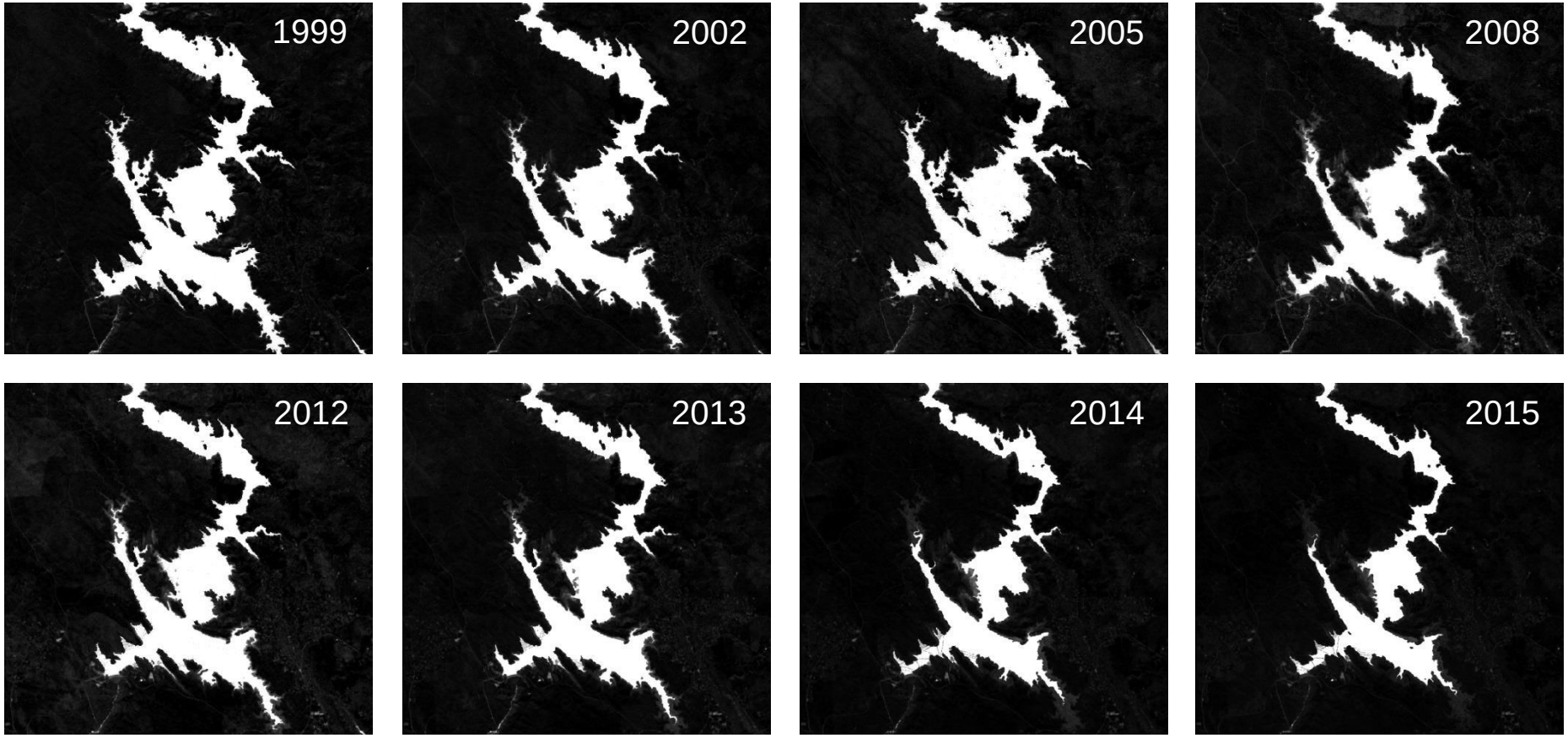
Pre-processing

- Triangulation based gap-filling for the SLC-off Landsat-7 ETM+ images.
- Radiometric correction to top-of-atmosphere (TOA) reflectance.
- Atmospheric correction using QUAC®, which determines correction parameters directly from the observed pixel spectra.



Classification

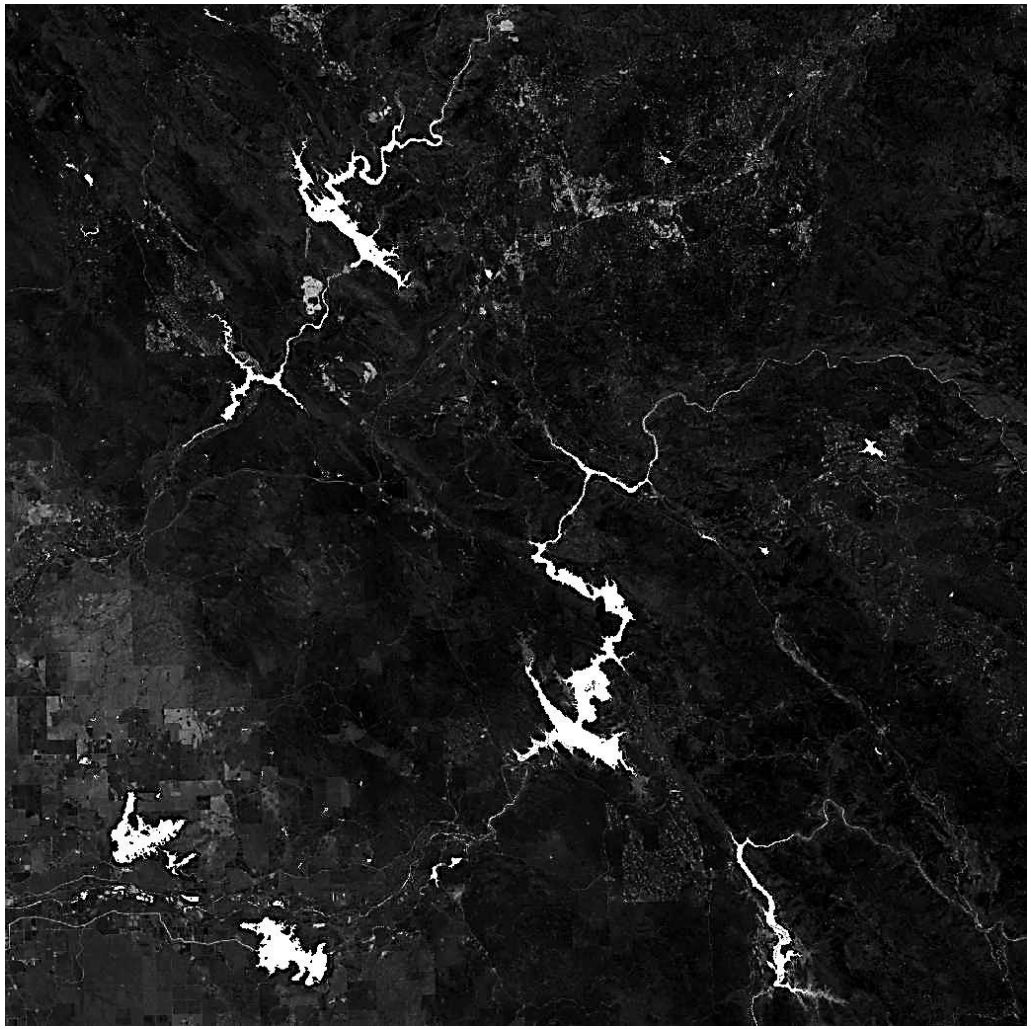
- Creation of Modified Normalized Difference Water Index images (MNDWI, Xu 2006) to enhance open water features while suppressing noise from built-up land, vegetation, and soil.



Classification

$$MNDWI = \frac{Green - SWIR}{Green + SWIR}$$

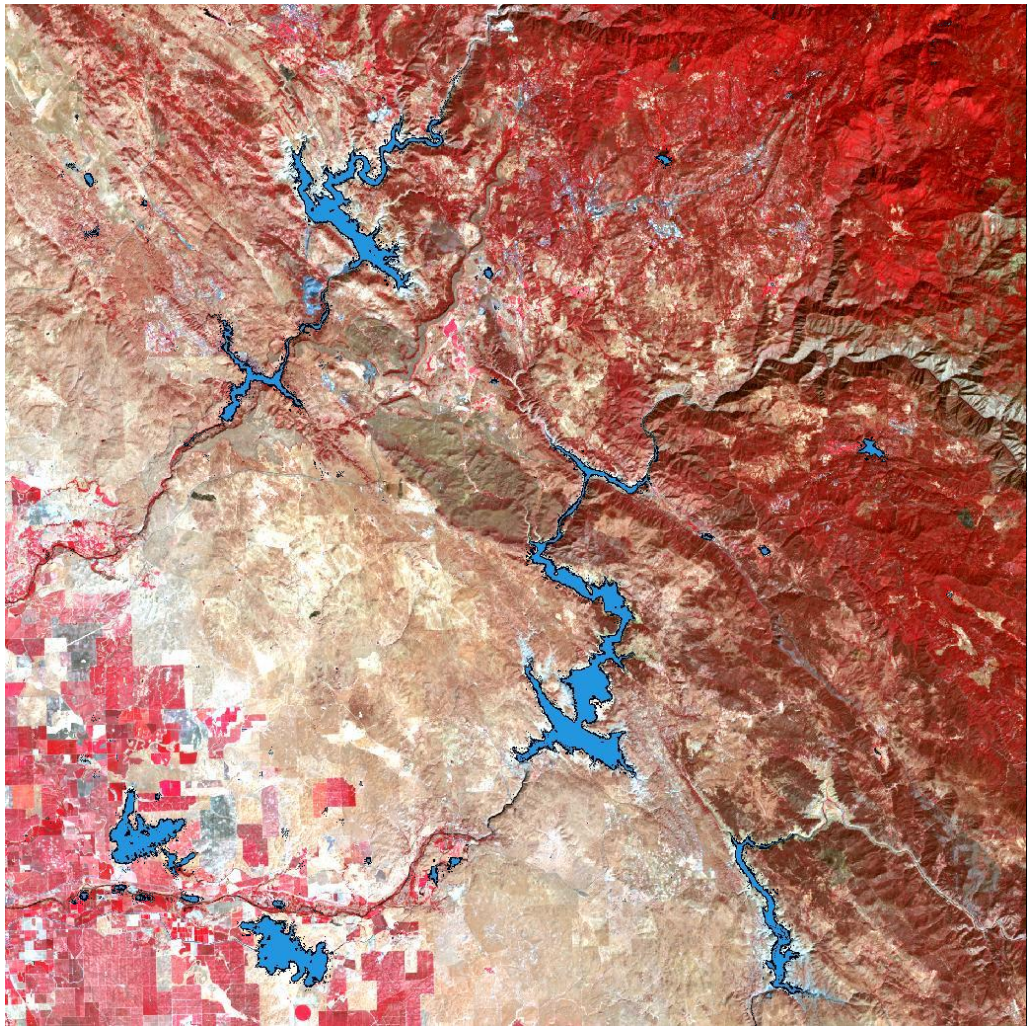
- Open water has greater positive values than NDWI, as it absorbs more SWIR than NIR wavelengths.
- Built-up features have negative values.
- Soil and vegetation have negative values, as soil reflects more SWIR than NIR wavelengths.



MNDWI image, Landsat-8 OLI, Oct. 2015.

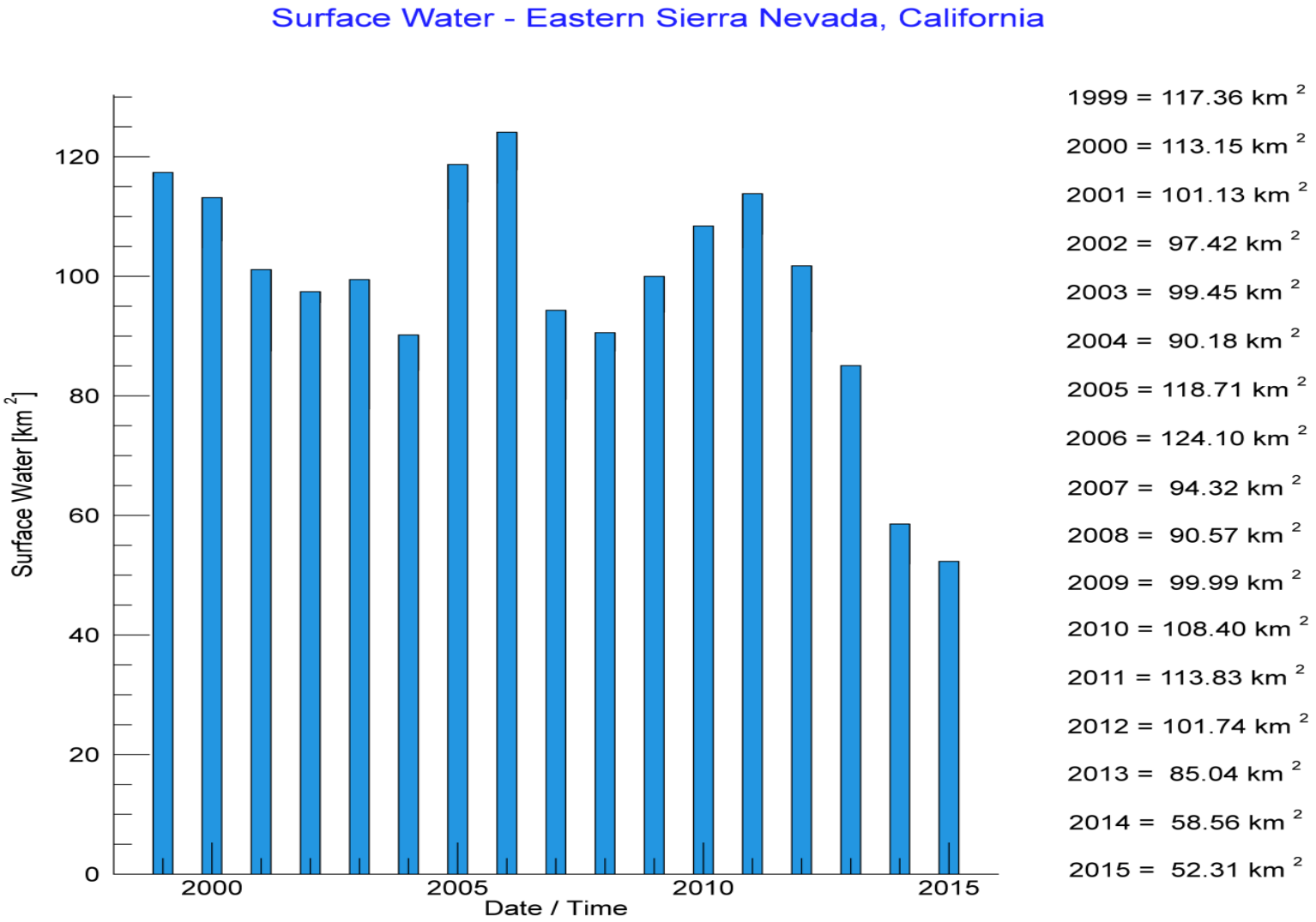
Classification

- Threshold based classification of the MNDWI images to extract water features.
- Classification aggregation as a post-classification cleanup process.

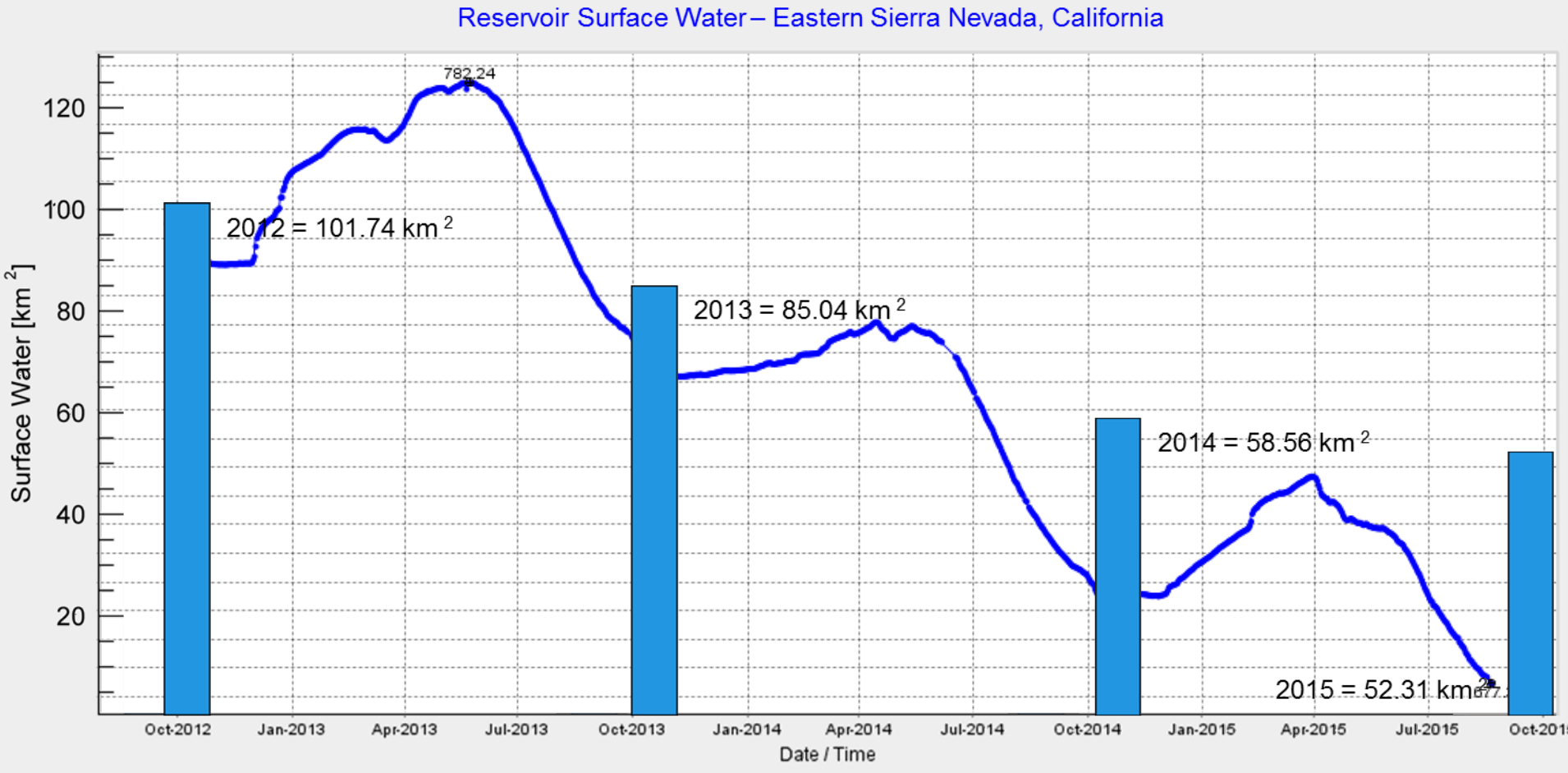


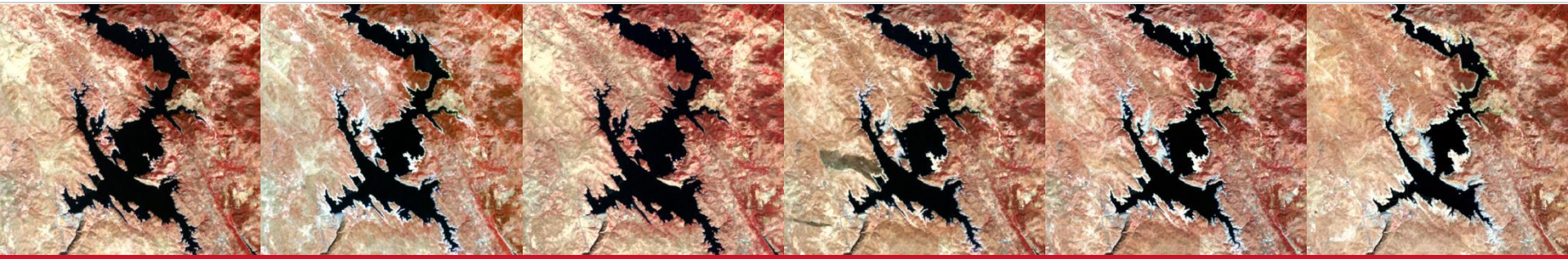
Landsat-8 Oli_tirs scene, Oct. 2015 with classified water features.

Time series of water surface area



Correlation with reservoir elevations





AUTOMATION & IMPLEMENTATION IN OPERATIONAL ENVIRONMENTS

Operational workflow using the ENVI 5 API

Pre-processing

Triangulation based gap-filling (SLC-off Landsat-7 ETM+ images)

File search (batch)

- ENVITask Radiometric Calibration
- ENVITask QUAC (Atmospheric correction)

ENVITask Build Time Series

Animation of spatiotemporal series (view 1)

Classification

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

ENVI 5 API – Operational example

Start ENVI in batch mode

ENVITask RadiometricCalibration

ENVITask QUAC
(Atmospheric correction)

```
PRO radcal_Landsat, filelist
  COMPILE_OPT IDL2

  e = ENVI(/HEADLESS)

  ; Get the radiometric calibration task
  RCTask = ENVITask('RadiometricCalibration')
  RCTask.Output_Data_Type = 'Float'
  RCTask.Calibration_Type = 'Top-of-Atmosphere Reflectance'

  ; Get the quick atmospheric correction task
  QUACTask = ENVITask('QUAC')
  QUACTask.Sensor = 'Landsat TM/ETM/OLI'

  ; Loop over every file
  FOREACH file, filelist DO BEGIN
    raster = e.OpenRaster(file)

    ; Calibrate to top-of-atmosphere reflectance
    RCTask.input_raster = raster
    RCTask.output_raster_uri = e.GetTemporaryFilename()
    RCTask.Execute

    ; Perform QUAC atmospheric correction
    QUACTask.input_raster = RCTask.output_raster
    QUACTask.output_raster_uri = e.GetTemporaryFilename()
    QUACTask.Execute
  ENDFOREACH
END
```

Implementation in operational environments

Implementation in geospatial workflows using the IDL bi-directional Python bridge.

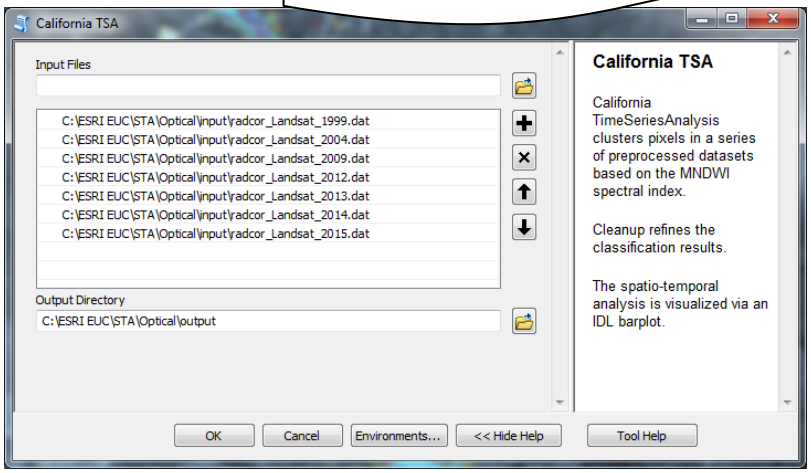
- Mechanism for calling IDL code from any Python environment (here: ArcGIS®).
- IDL code is used to interface between Python and the ENVITasks.

```
Python
>>> from idlpy import IDL
>>> IDL.run('rootDir = "c:\ESRI EUC\STA\Optical"')
>>> IDL.run('inDir = rootDir + PATH_SEP() + "input"')
>>> IDL.run('outDir = rootDir + PATH_SEP() + "output"')
>>> IDL.run('filelist = FILE_SEARCH(inDir, "radcor*.dat")')
>>> IDL.run('reservoirTSAArcGIS53, filelist, outDir')
```

Deployment within ArcGIS®
using a customized script tool.

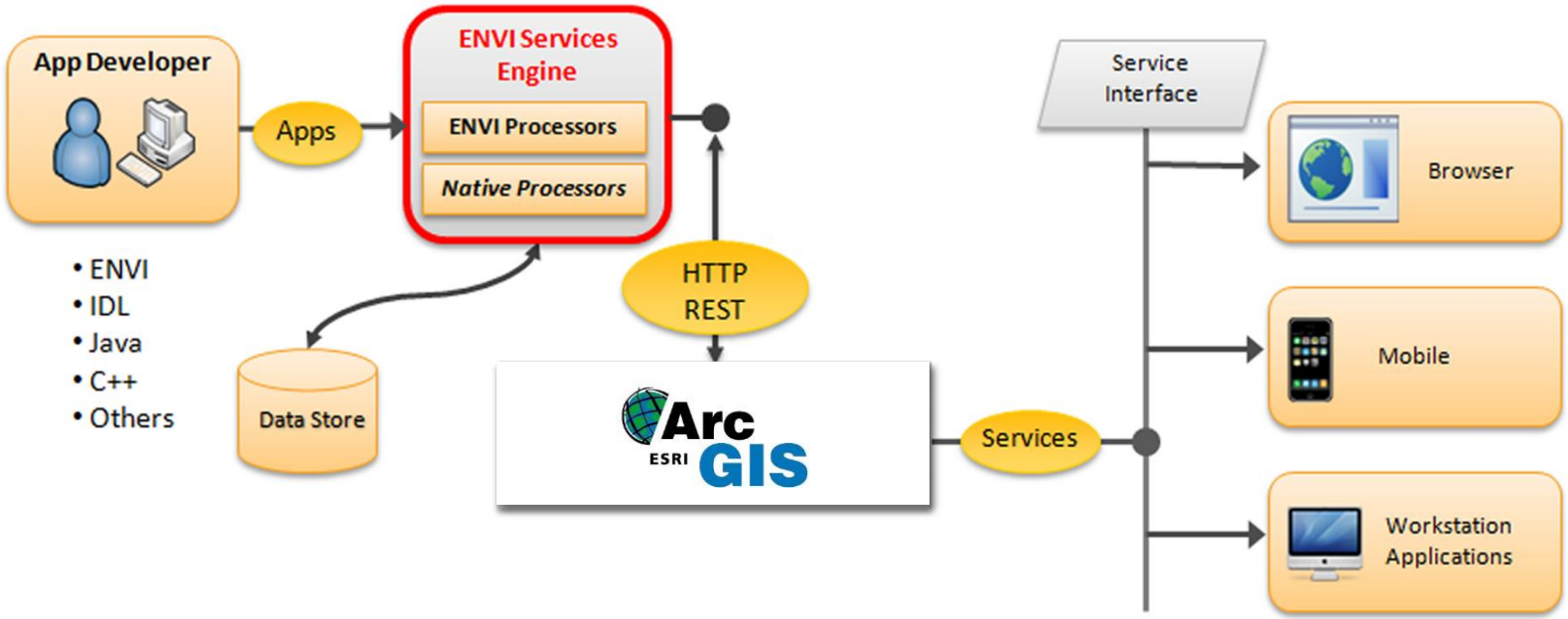
- Python script file retrieves the parameters from the user interface and runs the precompiled IDL code.
- IDL code is used to interface between the Python script and the ENVITasks.

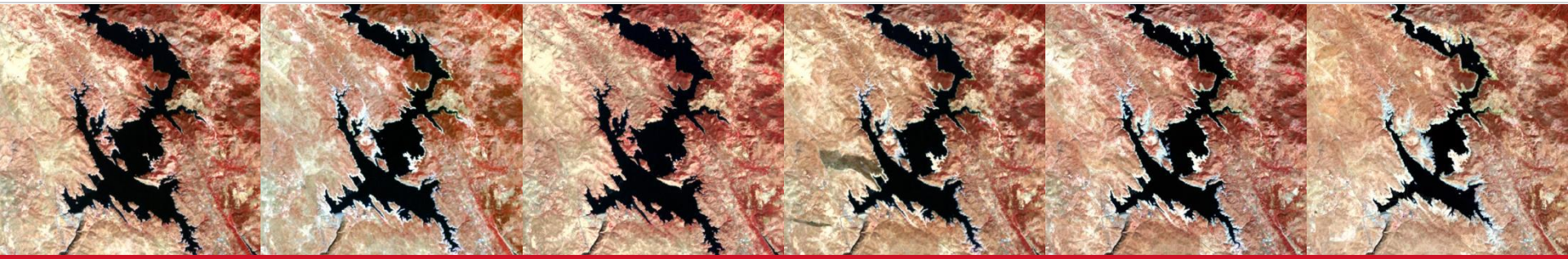
```
import envipy, arcpy

filelist   = arcpy.GetParameterAsText(0)
outDir     = arcpy.GetParameterAsText(1)

toolname = ,reservoirTSAArcGIS53,

envipy.RunTool(toolname, filelist, outDIR)
```



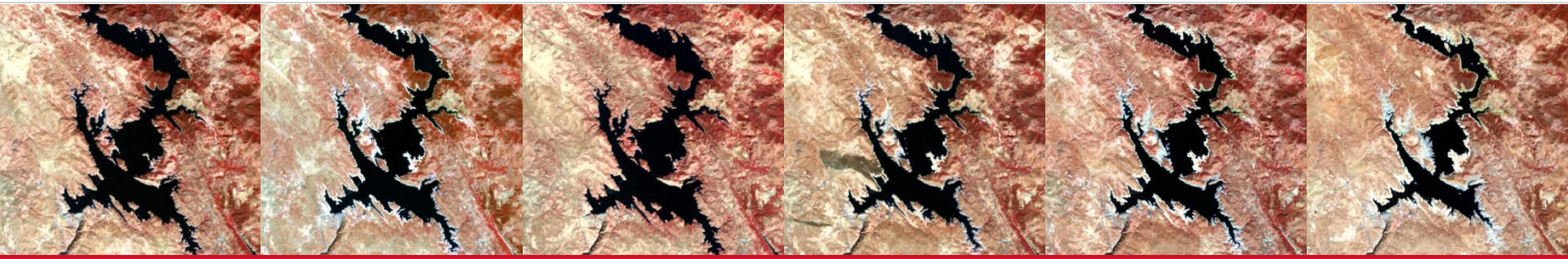
Implementation as a web-based service

Publishing the ENVITasks for spatio-temporal analysis as a REST-based web-service via the ENVI Services Engine (ESE) to existing enterprise infrastructures or cloud solutions.





LIVE-DEMONSTRATION



SUMMARY

Summary

Based on a time series of satellite imagery, the results of this case study verify the drastic decrease of the amount of surface water in the AOI, indicative of the major drought that is pervasive throughout California.

The simple implementation in online services with the technology of HARRIS and ESRI makes it possible to calculate and retrieve tailored, individual analyses for user-defined areas on-the-fly.

Vielen Dank!

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