

Changing the Game in Spectral:

A Spectral Detection Use Case – from Desktop to Enterprise

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Outline

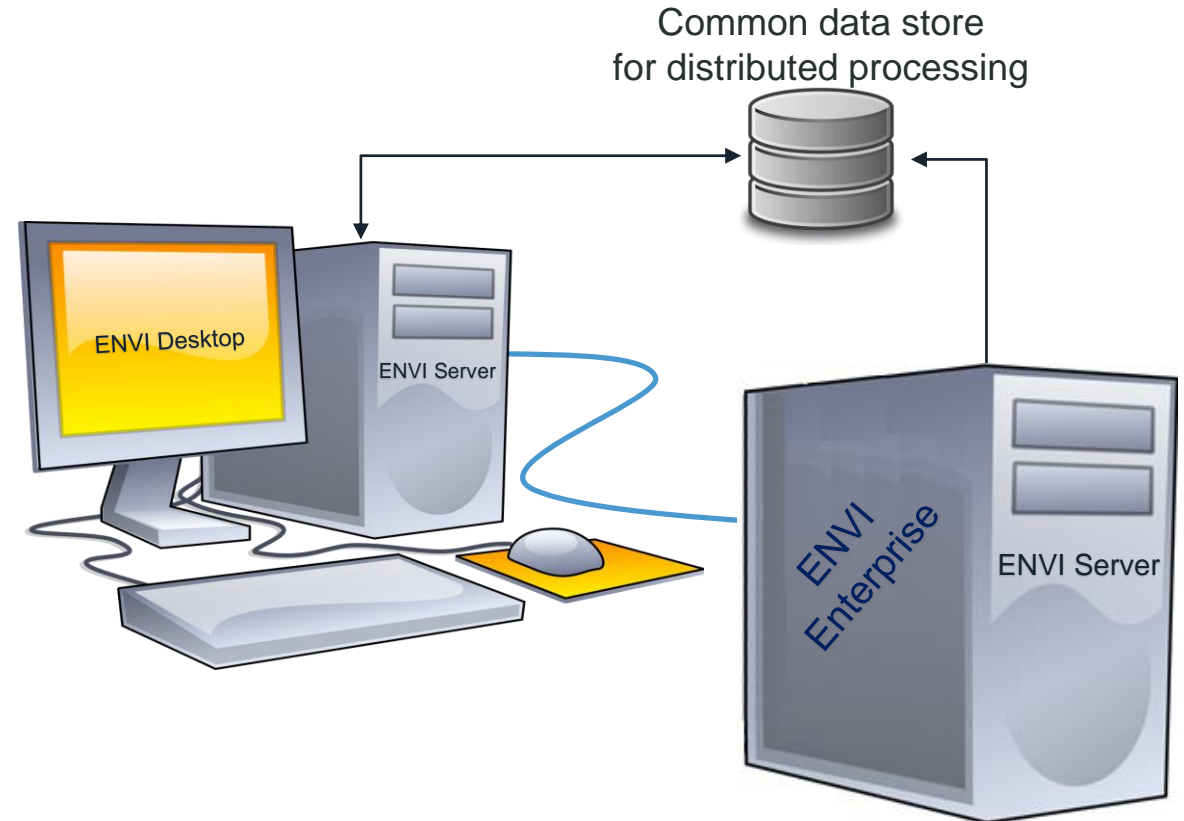


- Creating workflows that work with
 - ENVI Desktop
 - ENVI Server
 - ENVI Enterprise
- Use Case: Using hyperspectral detection algorithms with multispectral data
 - Use Case Overview
 - ENVI Processing Steps
- As a Desktop Extension
- Running on an ENVI Server
- Running in the Enterprise
- Conclusions

Write Once -- Use Multiple Ways



- Leveraging the ENVI + IDL API enables users to **develop a processing algorithm once and use it in multiple ways** within the ENVI/IDL ecosystem
- ENVI Desktop
 - Custom extension
 - ENVI Modeler
- Run on an ENVI Server
 - Can be initiated from ENVI Desktop if Desktop and Server have shared storage
- Deploy as a service via ENVI Enterprise
 - Usually accessed via a web client



ENVI is a client for ENVI Server, meaning we can connect to machines used for dedicated processing

Situation: Have 4-Band Data with Many Endmembers >> 10

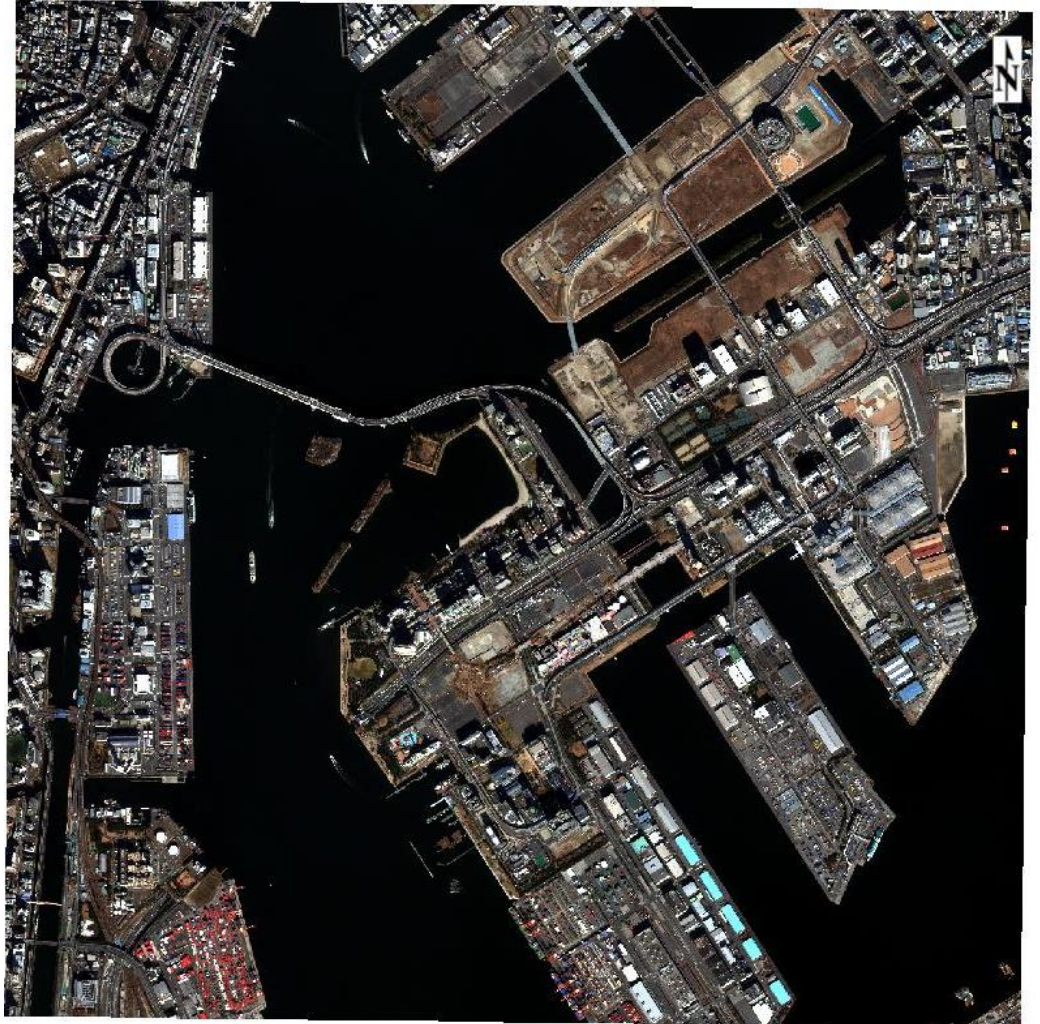


Some endmembers:

- Shadow
- Trees
- Vegetation
- Bare Earth
- Parking / Roads
- Purple / Pink Buildings
- Bright Buildings
- Blue Shipping Containers
- Red Shipping Containers
- White Shipping Containers
- Green Shipping Containers
- Water
- Etc.

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*WorldView-2
true-color RGB composite
of Port of Tokyo*



Problem: Similar to the Pigeonhole Principle Problem



Pigeons in holes.

- Here there are $n = 10$ pigeons in $m = 9$ holes
- Since 10 is greater than 9, the pigeonhole principle says that at least one hole has more than one pigeon

We can equate

- pigeons to endmembers and
- holes to bands



By Pigeons-in-holes.jpg by en:User:BenFrantzDale; this image by en:User:McKay –
Transferred from en.wikipedia to Commons.;
Original text : Edited from Image:Pigeons-in-holes.jpg, CC BY-SA 3.0,
<https://commons.wikimedia.org/w/index.php?curid=4658682>

Problem: So Our Problem Becomes ...



... We have more than 10 endmembers (pigeons) and only four bands (holes)

Pigeons with similar features in same hole



Solution: Increase the Number of Bands (Holes)



- Simple mathematical trick – **Dimensionality Expansion (DE)**
- New bands can be added by conducting Nonlinear transforms on the original bands
- First-order band:
 - $\{\mathbf{B}_i\}_{i=1}^l$ → set of original bands
- Second-order correlated bands:
 - (i) $\{\mathbf{B}_i^2\}_{i=1}^l$ → set of auto-correlated bands
 - (ii) $\{\mathbf{B}_i\mathbf{B}_j\}_{i,j=1,i \neq j,j > i}^l$ → set of cross-correlated bands
- Other nonlinear correlated bands:
 - (i) $\{\sqrt{\mathbf{B}_i}\}_{i=1}^l$ → set of square-rooted bands
 - (ii) $\{\log \mathbf{B}_i\}_{i=1}^l$ → set of logarithmic functions

Any Nonlinear transform will work

Data Experiments: ENVI DE Tool Generated Bands



**After DE
we have
22 Bands**

Band #	Bandname	Wavelength [nm]	FWHM [nm]
B1	Coastal Blue	477.9	60.8
B2	Green	546.2	69.8
B3	Red	658.8	59.3
B4	NIR1	832.5	117.8
B5 – B8	Sqrt(B1, B2, B3, B4)		
B9 – B12	Alog(B1, B2, B3, B4)		
B13 – B16	(B1, B2, B3, B4) ²		
B17 – B22	B1*B2, B1*B3, B1*B4 B2*B3, B2*B4, B3*B4		

Data Experiments: ENVI Processing Steps

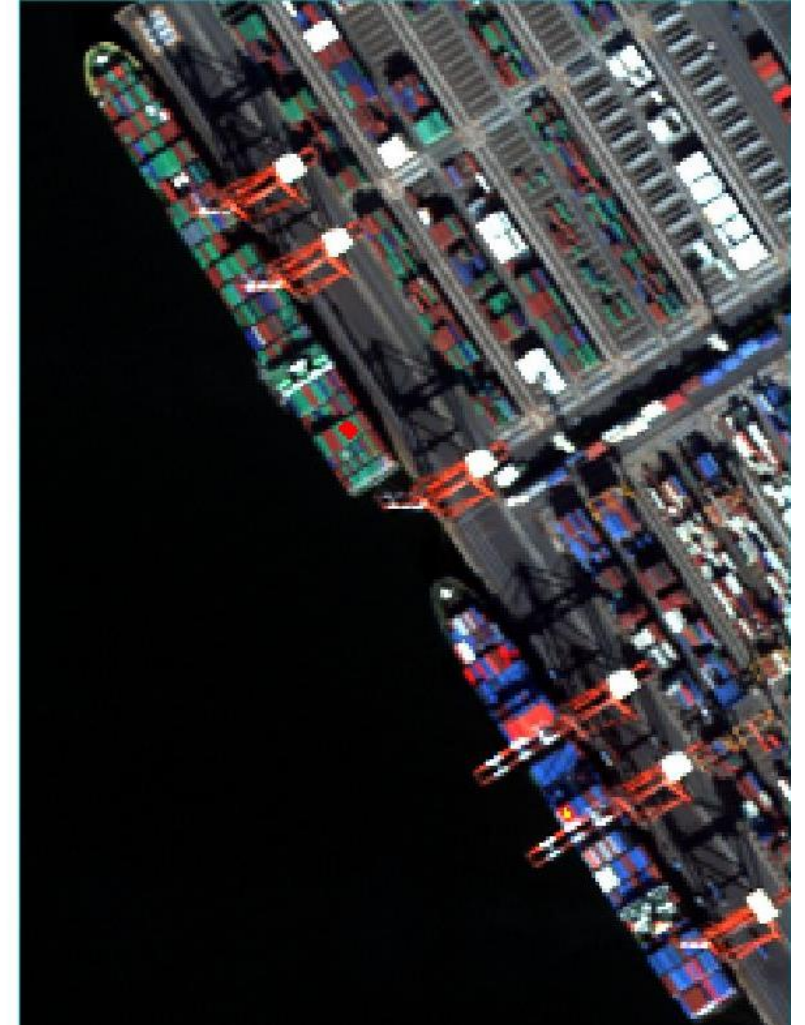


1. Selection of a subset of data for processing
2. Scaled the original data values from 1 to 11
3. Applying the DE tool
4. Using the ROI tool to select two target endmembers from the image scene:
Bright Red Container and **Green Container**
5. Selecting compute statistics from ROI tool and using the mean target spectra as the target for the ACE classification tool
6. Using the ACE classification tool

Data Experiments: ENVI ROI Tool Used to Subset Data

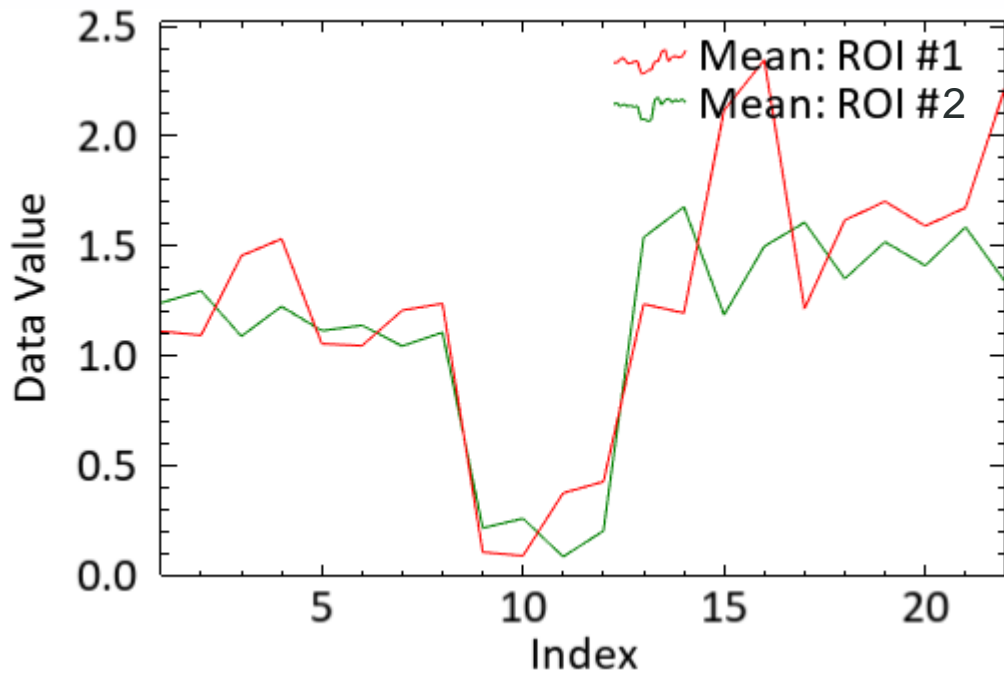


- Want to determine location of different colored shipping containers
- Shipping containers make for a good target when ground truth data is unavailable

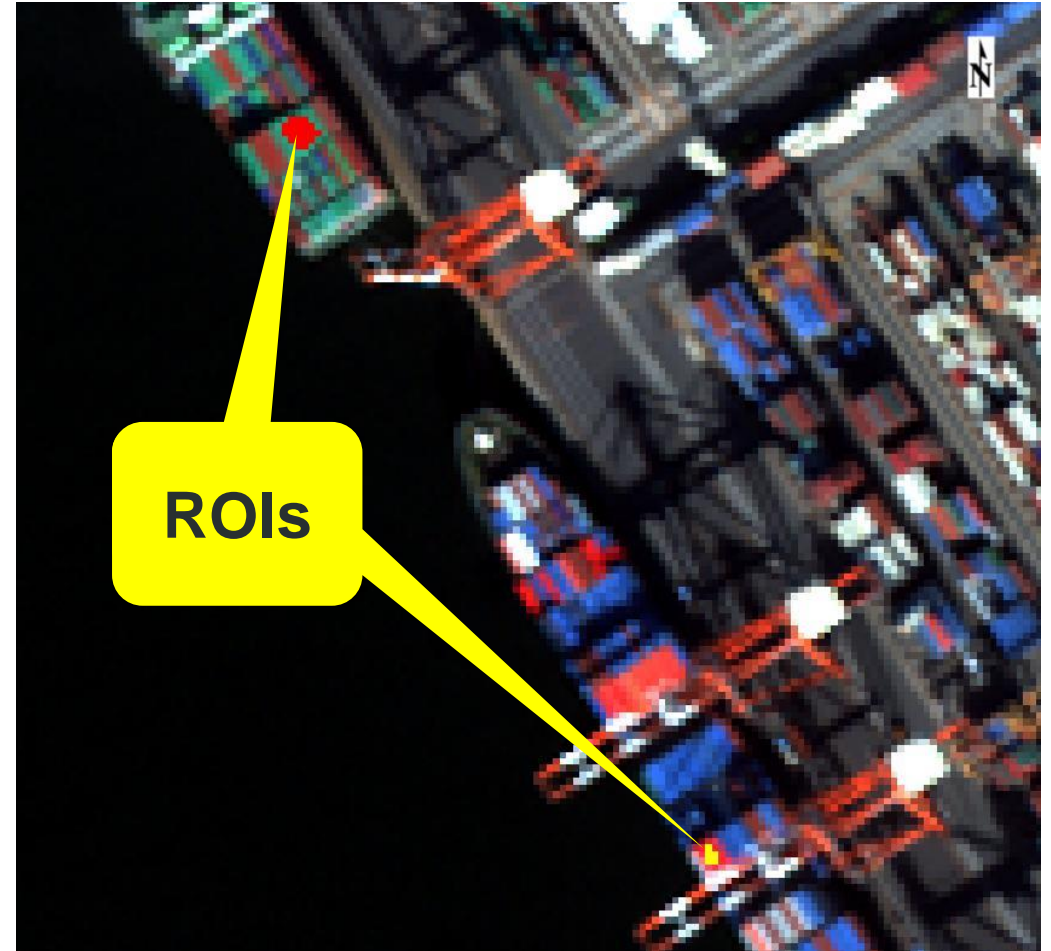




DE spectra used by ACE



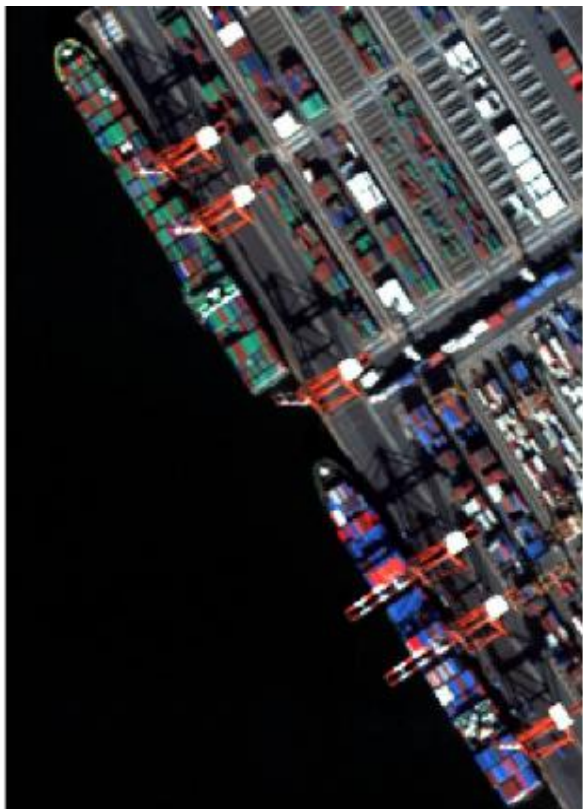
Bright Red Container and Green Container DE Spectra



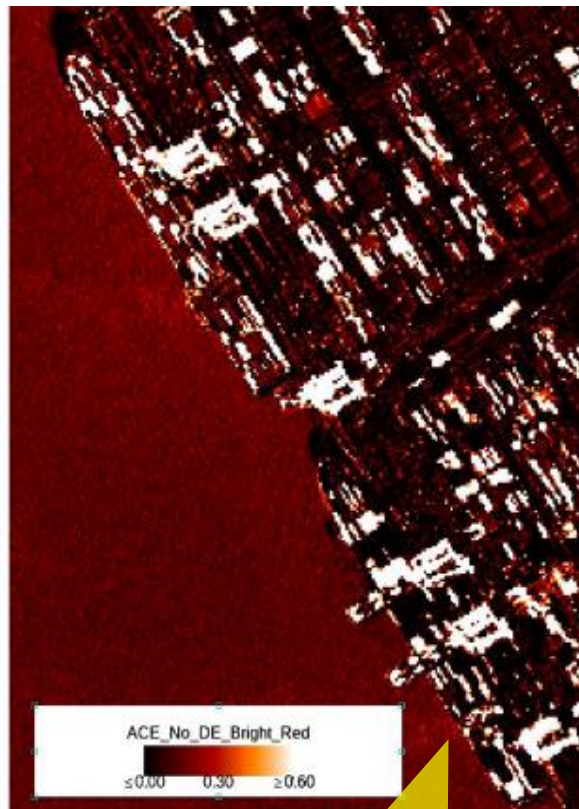
WorldView-2 Data Experiments: Bright Red Container Results



RGB Composite Image



ACE without DE



Detects all red objects

ACE with DE



Detects only bright red containers

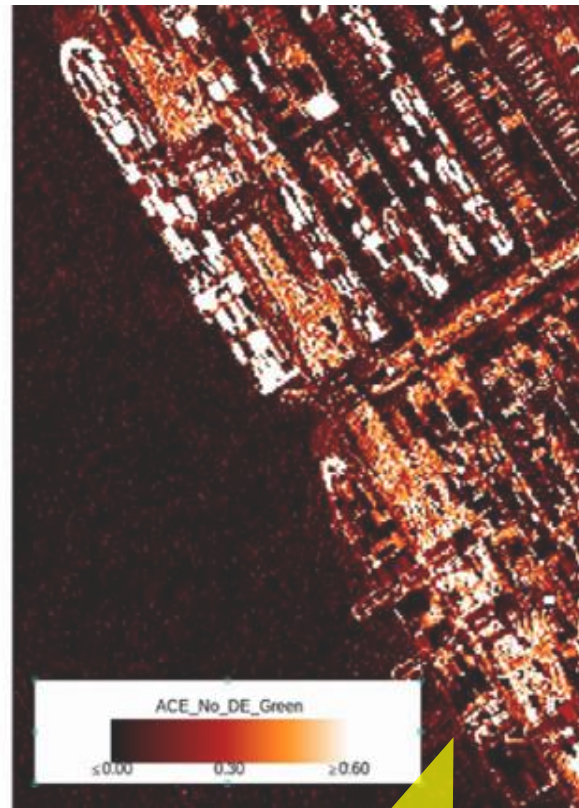
WorldView-2 Data Experiments: Green Container Results



RGB Composite Image

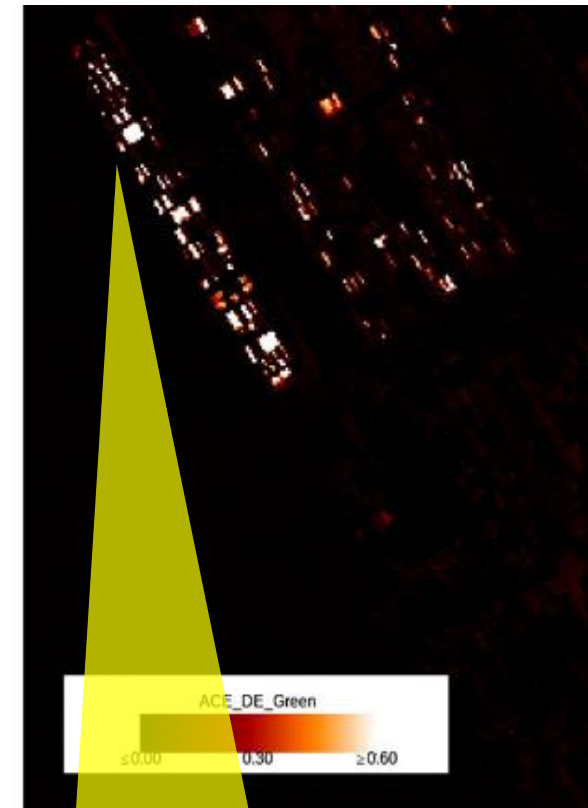


ACE without DE



Detects many objects

ACE with DE



Detects only green containers

Run as an ENVI Extension



The screenshot displays the ENVI software interface. The main window shows a satellite image of a city. On the left, the Layer Manager shows 'Tokyo_WV2b4_rad.dat' selected. The Toolbox on the right contains various processing tools, with 'DE_ACE_Containers' highlighted under the 'Extensions' category. A green arrow points from this extension to the 'DE2' dialog box. The dialog box has the following fields:

- Input Raster: Tokyo_WV2b4_rad.dat
- Input Spectral Library: TokyoData\Red_Green_Container.sli
- Directory (optional): C:\data\working\de_tokyo\

Buttons for 'OK' and 'Cancel' are visible at the bottom right of the dialog box.

Tokyo_WV2b4_rad.dat	
Dataset Name	Tokyo_WV2b4_rad.dat
Description	Calibrated Radiance from 10J
Dimensions	2,530 x 2,530 x 4 [BSQ] Float
Projection	UTM, Zone 54 North
Pixel Size	2 Meters
Datum	WGS-84
Date	24 January 2010
Data Ignore Value	0.000000

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ENVI Modeler



A visual programming tool to create custom task-based workflows in ENVI

Combines the power of the ENVI API with a simple and intuitive user interface

- Build workflows without any knowledge of ENVI programming

Batch-process data

Run tasks remotely on an ENVI Server

Generate IDL and Python programs from models

ENVI Tasks



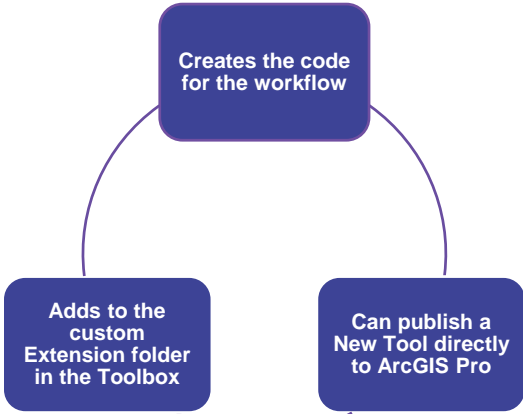
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The screenshot displays the ENVI Modeler interface with a workflow diagram in the main workspace. The workflow starts with 'Open 4 rasters for processing' and '[ROI] ROI #1', leading to an 'Iterator' node. From the iterator, the flow goes to 'Spectral Index' and 'Create Subsets from ROI', then to 'Subset Raster' and 'Aggregator'. The aggregator leads to 'Extract Elements from Array' and 'Extract Properties and...'. The 'Extract Properties and...' node leads to 'Build Band Stack' and 'View'. A separate path from 'Aggregator' goes to 'Extract the spatial reference from the first scene'. The 'Build Band Stack' node leads to 'Stack the images together and run ISODataClassification'. The 'View' node is the final step.

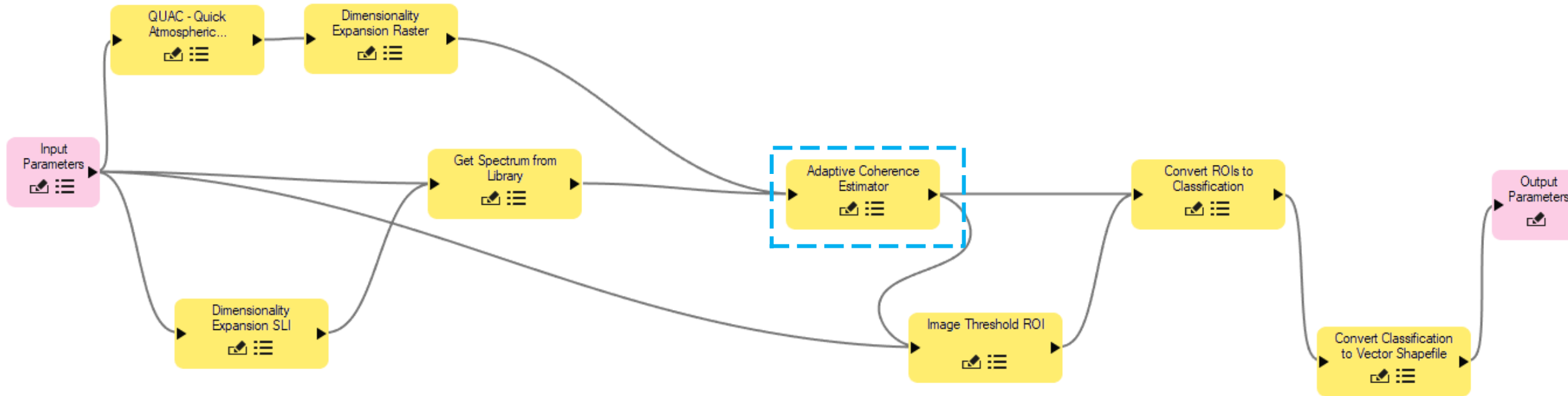
The 'Toolbox' on the left shows a tree view with categories like Favorites, Anomaly Detection, Band Algebra, Change Detection, Classification, Feature Extraction, Filter, Geometric Correction, Image Sharpening, LiDAR, Mosaicking, Precision Ag Toolkit, Radar, Radiometric Correction, Raster Management, Regions of Interest, SARscape, Spatiotemporal Analysis, SPEAR, Spectral, Statistics, Target Detection, Task Processing, ENVI Modeler, Run GSF Task, Run Task, THOR, Terrain, Transform, Vector, and Extensions.

The 'Program: Untitled' window shows the following code:

```
Program: Untitled
Run Create Extension
-----
; Generated by the ENVI Modeler
; ENVI 5.4.1, API 3.1.0
proc MyProgram
  compile_opt idl2, hidden
  on_error, 2
  ;-----
  ; Landsat_subset_series
  ;-----
  hInfo = $
  {
    '1' = $
    {
      'url' = "\\\\fridge\envi_data\time_series\landsat_subset\landsat_sub
      'factory' = "URLRasterSeries" + $
    }
  }
  rasterSeries_1 = (ENVIhydrate(Json_Parse(hInfo))){}
  ;-----
  ; Extract Rasters from Raster Series
  ;-----
  task_1 = ENVITask("ExtractRastersFromRasterSeries")
  task_1.input_raster_series = rasterSeries_1
  task_1.Execute
  ;-----
  ; Iterator
  ;-----
  foreach iterator_1, task_1.output_rasters do begin
    ;-----
    ; Spectral Index
    ;-----
    task_2 = ENVITask("SpectralIndex")
    task_2.input_raster = iterator_1
    task_2.index = "NDVI"
    task_2.Execute
    ;-----
    ; View
    ;-----
    view = envi.GetView()
    layer = view.CreateLayer(task_2.output_raster)
    ;-----
    ; Data Manager
    ;-----
    envi.Data.Add, task_2.output_raster
  endforeach
end
```



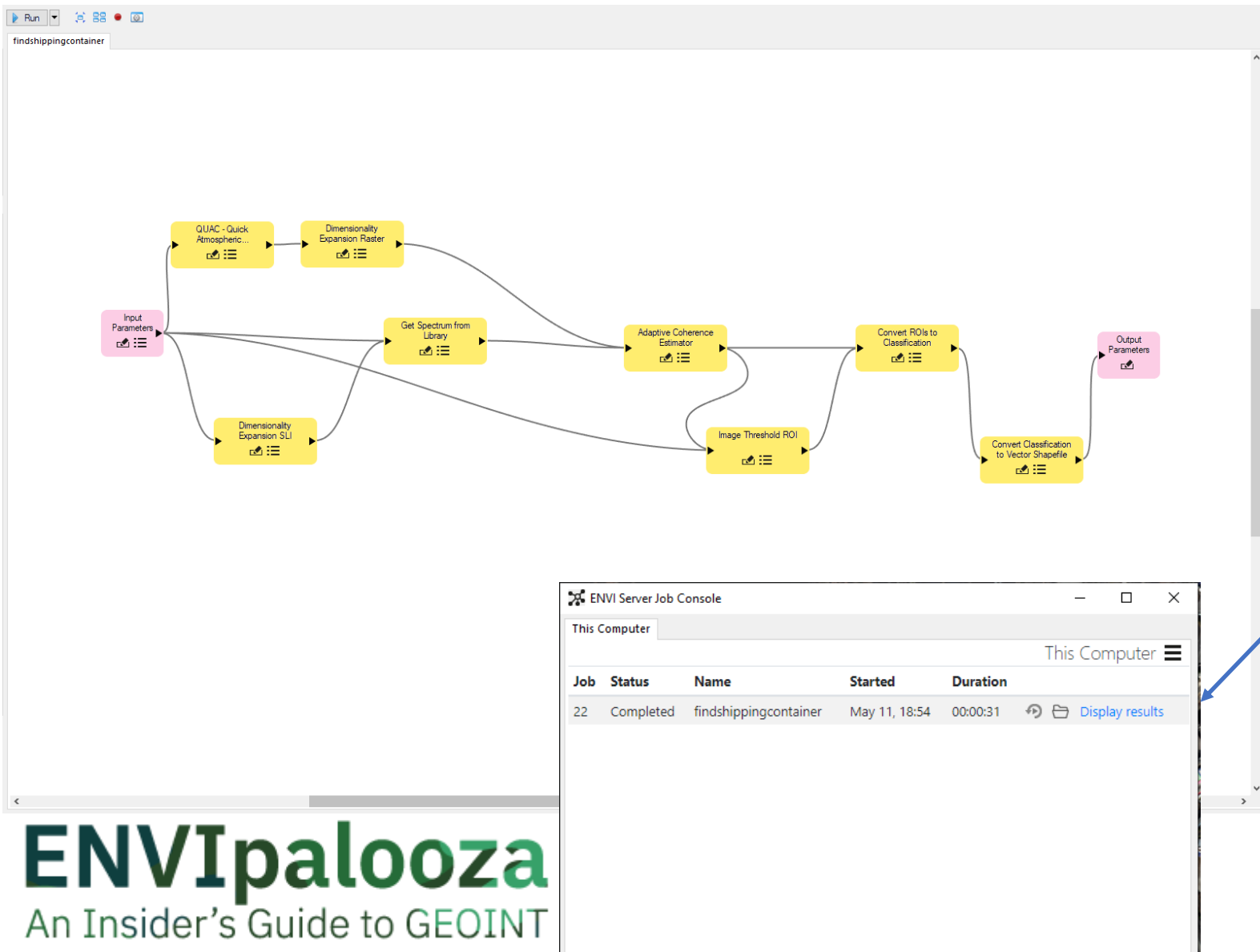
ENVI Processing Steps in Modeler



 Can be other target detection algorithms

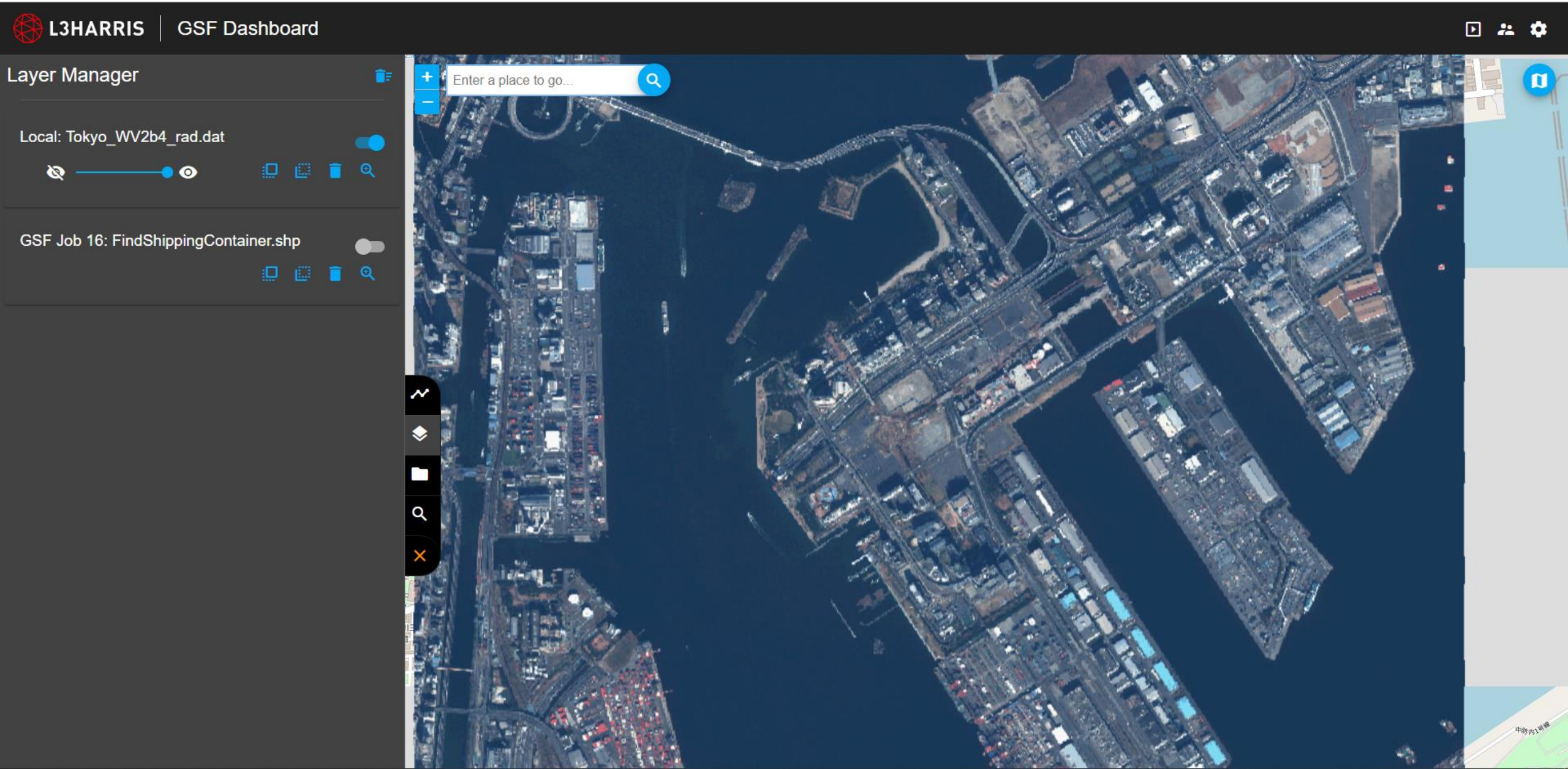
Each  represents an ENVI Task

Run on ENVI Server



- Can initiate the spectral processing from the Modeler to run on a separate Server
- For this example, we will use the same machine to act as the ENVI Server
- Note that the results can be displayed in Desktop ENVI provided that the Desktop and ENVI Server share the output directory

Run in a Web Client



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Conclusions



- ENVI / IDL Technologies allow for development of spectral analysis processing tools/workflows that can be utilized from Desktop to Enterprise including allowing for pushing processing to external Servers:
Write Once – Use Multiple Ways
- Multispectral images usually do not have sufficient dimensionality to accommodate all targets to be classified, a DE process is used to alleviate this dilemma.
- This presentation demonstrates how this DE allows the ACE hyperspectral classifier to be utilized for effective classification of targets in an urban environment using WorldView-2 multispectral imagery.
- The use of models made the process of testing the classifier and comparing the results much more efficient, compared to writing API code or invoking tools through a user interface.

**DE solves the Pigeon Hole problem
and allow hyperspectral detectors/classifiers
to work well with multispectral imagery**



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