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Automated Spatio-Temporal Analysis of Remotely Sensed Imagery for Water Resources Management

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Since 2012, the state of California faces an extreme drought, which impacts water supply in many ways. Advanced remote sensing is an important technology to better assess water resources, monitor drought conditions and water supplies, plan for drought response and mitigation, and measure drought impacts. In the present case study latest time series analysis capabilities are used to examine surface water in reservoirs located along the western flank of the Sierra Nevada region of California.

This case study was performed using the COTS software package ENVI 5.3. Integration of custom processes and automation is supported by IDL (Interactive Data Language). Thus, ENVI analytics is running via the object-oriented and IDL-based ENVITask API.

A time series from Landsat images (L-5 TM, L-7 ETM+, L-8 OLI) of the AOI was obtained for 1999 to 2015 (October acquisitions). Downloaded from the USGS EarthExplorer web site, they already were georeferenced to a UTM Zone 10N (WGS-84) coordinate system.

ENVITasks were used to pre-process the Landsat images as follows:
• Triangulation based gap-filling for the SLC-off Landsat-7 ETM+ images.
• Spatial subsetting to the same geographic extent.
• Radiometric correction to top-of-atmosphere (TOA) reflectance.
• Atmospheric correction using QUAC®, which determines atmospheric correction parameters directly from the observed pixel spectra in a scene, without ancillary information.

Spatio-temporal analysis was executed with the following tasks:
• 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.
• Threshold based classification of the water index images to extract the water features.
• Classification aggregation as a post-classification cleanup process.
• Export of the respective water classes to vector layers for further evaluation in a GIS.
• Animation of the classification series and export to a common video format.
• Plotting the time series of water surface area in square kilometers.

The automated spatio-temporal analysis introduced here can be embedded in virtually any existing geospatial workflow for operational applications. Three integration options were implemented in this case study:
• Integration within any ArcGIS environment whether deployed on the desktop, in the cloud, or online. Execution uses a customized ArcGIS script tool. A Python script file retrieves the parameters from the user interface and runs the precompiled IDL code. That IDL code is used to interface between the Python script and the relevant ENVITasks.
• Publishing the spatio-temporal analysis tasks as services via the ENVI Services Engine (ESE). ESE is a cloud-based image analysis solution to publish and deploy advanced ENVI image and data analytics to existing enterprise infrastructures. For this purpose the entire IDL code can be capsuled in a single ENVITask.
• Integration in an existing geospatial workflow using the Python-to-IDL Bridge. This mechanism allows calling IDL code within Python on a user-defined platform.

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. Accordingly, the time series analysis was correlated successfully with the daily reservoir elevations of the Don Pedro reservoir (station DNP, operated by

CDEC).