

Chapter 5. Automation of Spatial Map with Temporal Data from DSM2-QAL Output using ArcGIS

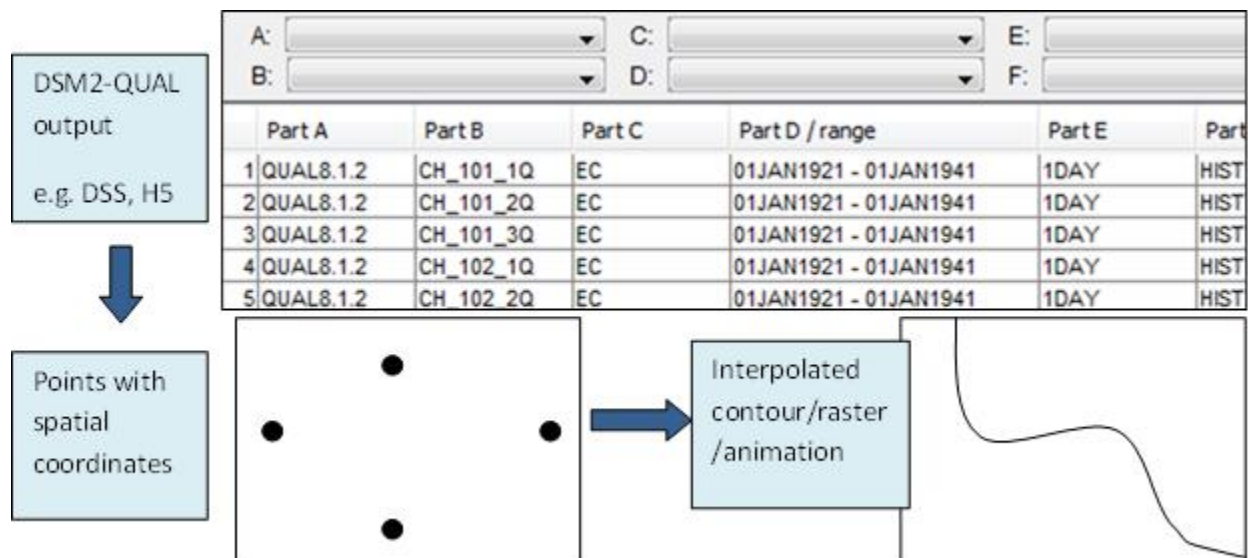
5.1 Introduction

This chapter presents a new post-processing tool for DSM2-QUAL output which enables generation of ArcGIS geo-referenced contour maps and time-varying animations to visualize water quality distributions in the Sacramento-San Joaquin Delta area.

5.2 Methodology

DSM2-QUAL output includes a DSS⁶ time series for specified locations in the Delta. The new tool extracts simulated water quality data throughout the Delta, couples with geo-referenced coordinates, and interpolates the data to create continuous contour maps. The tool then generates animations or user-specified sets of static contours for comparing simulated scenarios. This process is shown in Figure 5-1.

Figure 5-1 Flow Chart of Methodology



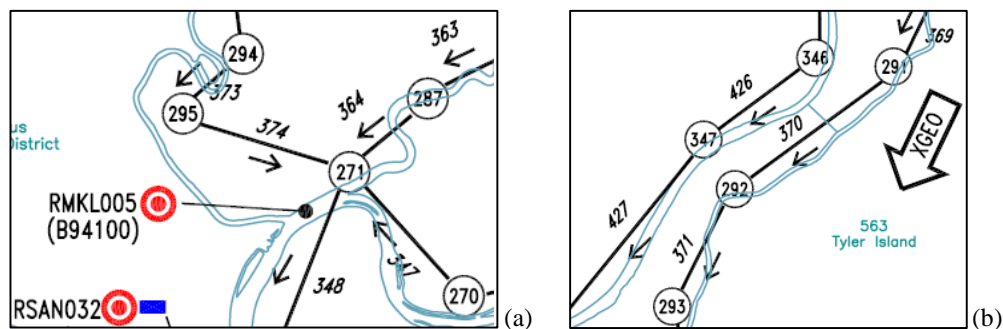
⁶ U.S. Army Corps of Engineers Hydrologic Engineering Center Data Storage System (HEC-DSS) is a file type/database that stores scientific information.

5.2.1 Spatial Network of the Delta

In order to generate a meaningful continuous surface map, a geo-referenced fine grid network of DSM2-QUAL output locations was developed based on the standard DSM2 Delta grid. This network uses locations in DSM2 channels rather than nodes to avoid situations in which multiple channels converge at one node. Figure 5-2 (a) shows an example of where Channels 374, 364, 347, 348 could have different water quality values approaching node 271.

The proposed network is three times denser than the DSM2 standard Delta grid in order to accommodate the situation when adjacent channels are close to each other in DSM2, a 1-dimensional model. Figure 5-2 (b) shows Channel 426 and 370 are very close, yet water in the channels originates from different sources. These channels' water quality values should be interpolated based on their upstream and downstream channels, not from their parallel neighbors, no matter how close they are.

Figure 5-2 Examples of DSM2 Grid



The process then established a Delta network template with 1,551 points from 517 DSM2 Delta channels, the points being located at one-fourth, one-half, and three-fourths of the channel lengths. All the network points were coupled with their longitudinal and latitude (X, Y) coordinates, in the spatial reference of NAD_1983_UTM_Zone_10N (Figure 5-3 and Figure 5-4 (a)).

5.2.2 Temporal Data Extraction and Conversion

The tool enables users to easily investigate the spatial distribution of Delta water quality at user-specified dates for multiple DSM2 simulations.

The simulated water quality data are first extracted from DSM2-QUAL output DSS file, converted to a 2-D data matrix in a text file, then imported into ArcGIS to create a point feature layer. Vtools⁷ was used in this process. Figure 5-3 shows the attribute table of an imported point group in ArcGIS.

⁷ Python library of DSS manipulation developed by DWR's Bay-Delta Office

Figure 5-3 Sample ArcGIS Point Feature Coupled with XY Coordinates, and Temporal EC Data

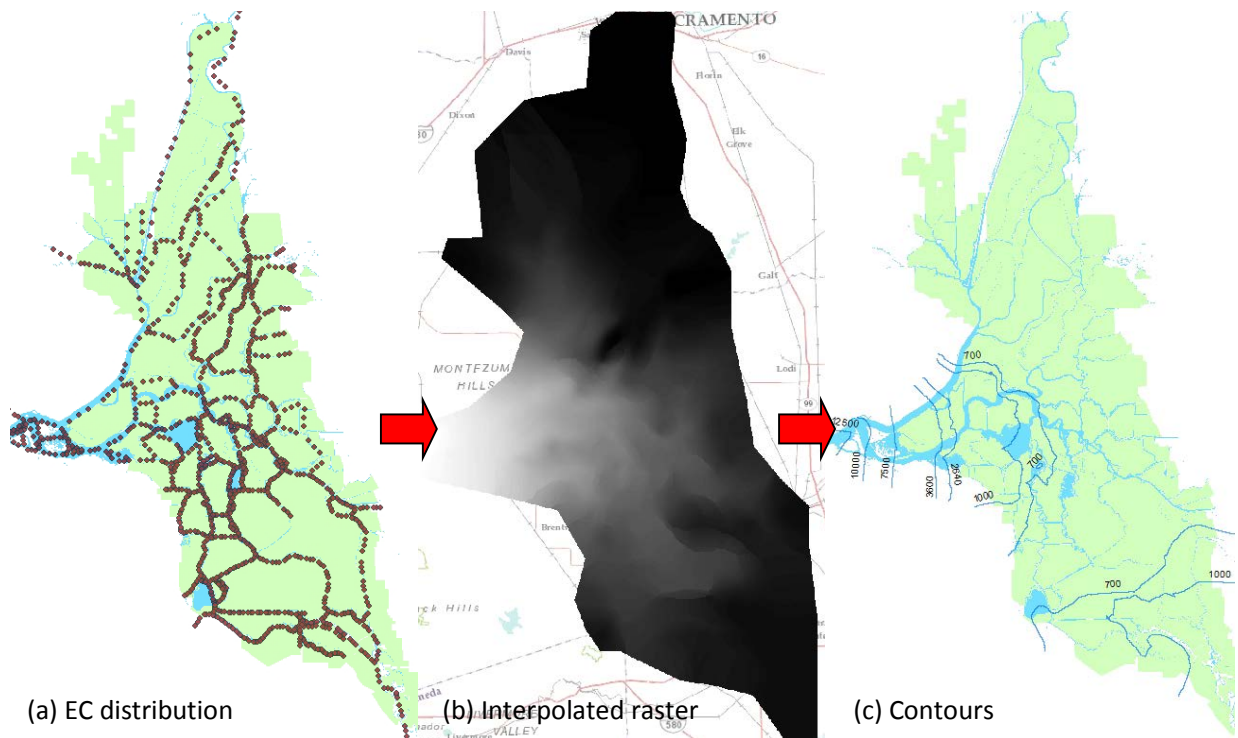
OBJECTID *	chan	pos	x_utm83	y_utm83	ec220903	ec230831	ec240828	ec250906	ec260827
1	1	ch_1_2q	652934	4172956.1	811.1	800.9	1254.5	1188.5	1264.7
2	2	ch_2_2q	652358.2	4175095.8	811.1	800.9	1251.5	1189.3	1320.6
3	3	ch_3_2q	651119.9	4176021.1	811	800	1286.3	1185.3	1338
4	4	ch_4_2q	649789.4	4177816.7	811	800	1341.9	1156.3	1335.6
5	5	ch_5_2q	649700.1	4180660.5	811	799.9	1338.1	1030.2	1324.2
6	6	ch_6_2q	649407.1	4182886.5	812	799.7	1290.3	1019.7	1302.2
7	7	ch_7_2q	648143.8	4184494.4	823.5	796.2	1297.5	1080.4	1214.4
8	8	ch_8_2q	648008.8	4186110.6	831.4	779.7	1384.2	1107.5	1101.8
9	9	ch_9_2q	648239.7	4188170	825.2	771.2	1584.5	1075.8	986.8

5.2.3 GIS Spatial Interpolation

The spatial analyst function "kriging" of ArcGIS is used to create interpolated raster images. Kriging is an advanced geostatistical procedure that generates an estimated surface from a scattered set of points with z-values. It is based on statistical models that include autocorrelation, that is, the statistical relationships among the measured points. (How Kriging works, Kriging in Geostatistical Analyst).

The spatial analyst function 'contour list' is then used to create specified contours from the interpolated raster images (How Contouring works). Users are able to specify any data ranges (e.g. EC levels of 2,640 us/cm or 75% volume water from Sacramento River).

Figure 5-4 Interpolation of ArcGIS to Generate Contours and Colored Raster from Geo-Referenced Points

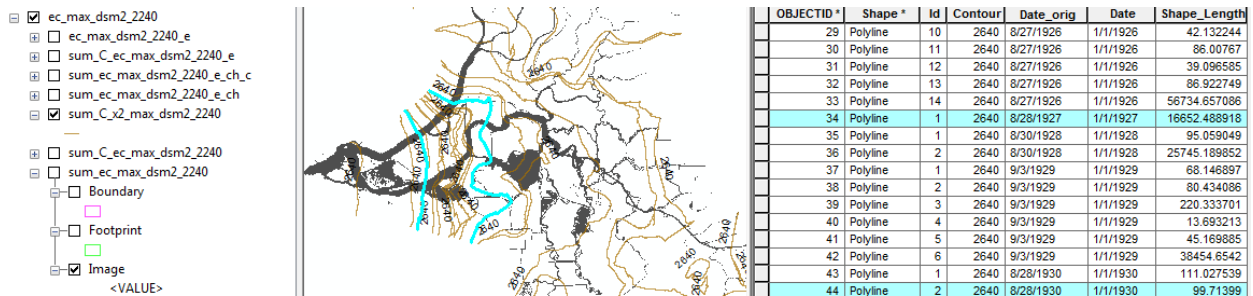


5.2.4 GIS Visualization of Temporal Data

ArcGIS 10 and higher versions have a "time-enable" feature, which can visualize data changes over time in ArcMap. For the two types of map objects, ArcGIS has different ways to process:

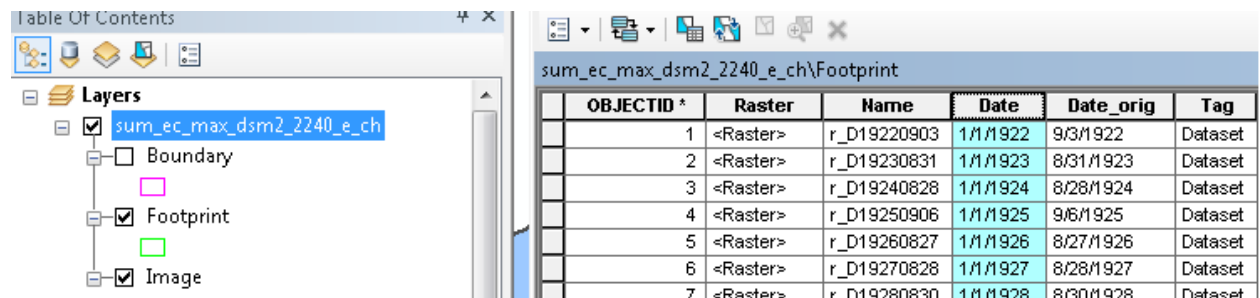
- Contours (vector maps) are combined into a summarized polylines feature (Figure 5-5)
- Raster images (color band maps) are combined into a mosaic dataset (Figure 5-6).

Figure 5-5 Sample GIS Vector Feature with Extracted Contours from Specified Times



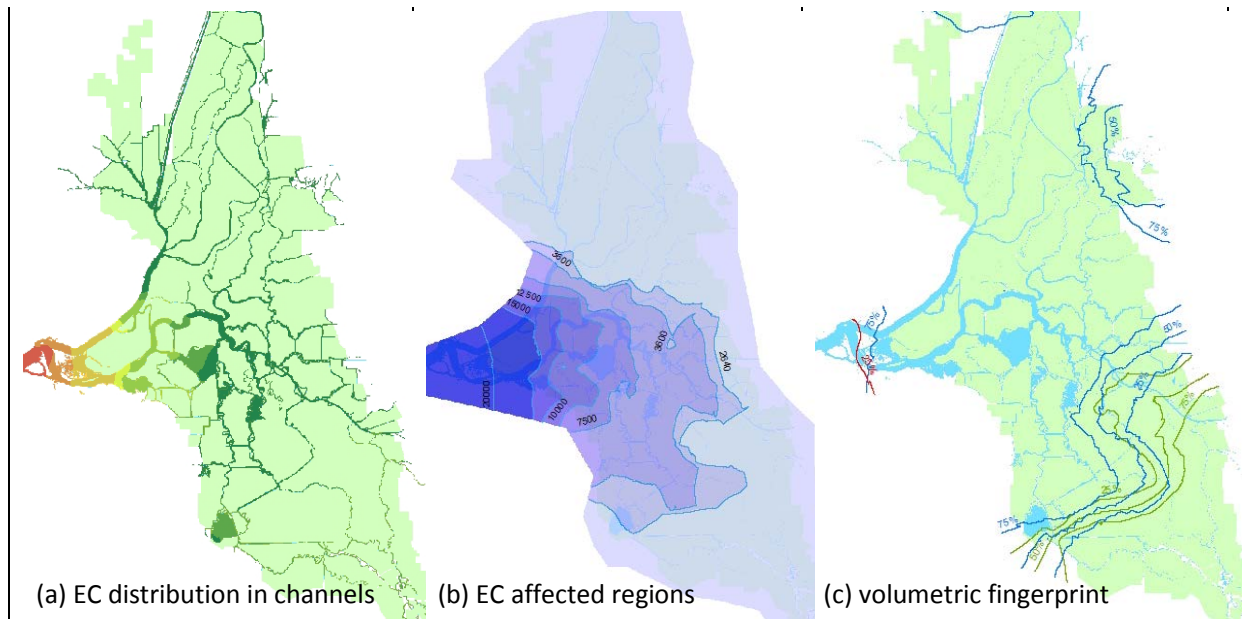
The new tool described in this chapter utilizes Python scripts to automate assignment of time features to the generated maps and combine them into user defined groups, in the format of geodatabase provided by ArcCatalog. Time Property Tab and Time Slider are used to control, display, and export the designed temporal maps.

Figure 5-6 Sample GIS Mosaic Feature with Extracted Raster Images from Specified Times



5.3 Sample Applications

The tool has been used to help analysis of possible 2014 drought scenarios. It was applied to the water quality output from simulations of various 2014 drought forecasts and historic drought events pre- and post-SWP installation and operation. In particular, the periods of 1976-2012 and 1922-1940 were studied. Detailed maps and animations of the corresponding outputs have been placed on DWR Portal online folder at: http://baydeltaoffice.water.ca.gov/downloads/DSM2_Users_Group/DSM2_QUAL_spatial/

Figure 5-7 Sample Presentations of the Areal Distribution of Water Quality in the Delta

5.3.1 Water Quality

The major application of the designed tool is to display the spatial distribution of Delta water quality. Salinity (in terms of EC) is a key parameter. Figure 5-7 (a) shows a typical way of presenting the EC distribution within Delta channels, with colors red to green, to display salinity level from high to low. Figure 5-7 (b) shows another way of presenting EC, based on the new tool.

5.3.2 Fingerprint of Water Volume and Constituents

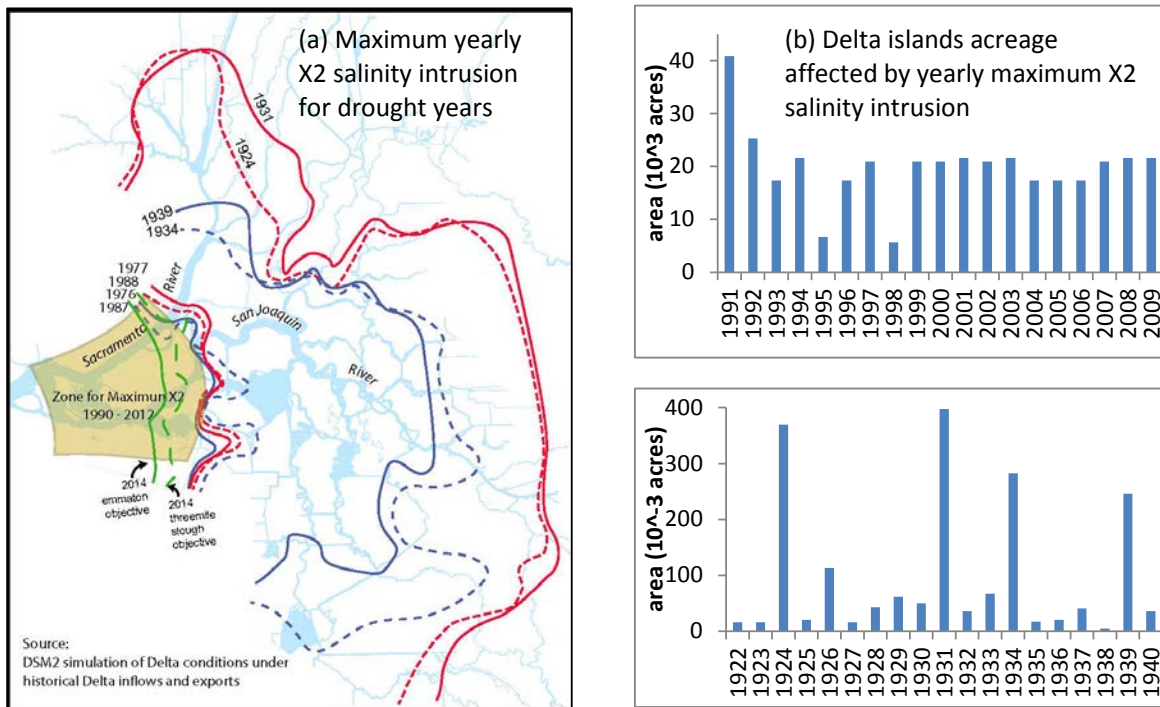
DSM2-Qual can generate constituent and volume fingerprints which show the contribution of various sources in the Delta (Anderson, 2002). The new tool can also display the distribution of different sources of water or constituent in various combinations. Figure 5-7 (c) provides a sample contour map with a volumetric fingerprint from sources of Martinez (red contours), the Sacramento River (blue contours), and the San Joaquin River (green contours), with their respective contributions of 25%, 50%, and 75%.

5.3.3 Other Functions Extensions

ArcGIS provides a powerful and well-established platform to spatially analyze DSM2-Qual output, such as comparing different scenarios, comparing to other geo-referenced data such as observed data, spatial analysis, etc.

Figure 5-8 (a) displays the comparison of maximum yearly X2 intrusion of some historical drought years, as well as the recent 20 years and 2 forecast scenarios in 2014. Figure 5-8 (b) displays the comparison of Delta islands acreage affected by yearly maximum salinity intrusion for the periods of 1991-2009 (after project) and 1922-1940 (pre-project).

Figure 5-8 Sample Map of Maximum Salinity Intrusions of Different Drought Years Using DSM2 Simulation



5.4 Summary and Future Work

A new tool uses ArcGIS, Python scripts, and DSM2-QUAL output to generate static or dynamic Delta-wide contours of DSM2-generated water quality parameters. This tool can help users:

- directly investigate the distribution of water quality in the Delta,
- better visualize model output for specified time period,
- identify the areal extent of the Delta affected by changes in water quality due to changes in hydrology, Delta geometry, or barrier installation and operation,
- compare scenarios or different years from another perspective, and
- validate the water quality model from another perspective, particularly under low Delta outflow conditions.

Future work will use geo-referenced Delta agriculture diversion locations in order to refine estimation of impact to Delta agriculture under significant salinity intrusion.

5.5 Acknowledgements

Lan Liang provided important help in the study and report revision.

5.6 Reference

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