Methods for RTK Point Collection and ArcGIS Methods for Topographic Elevation Modeling in an Area of Interest

Date Prepared: 04/30/2015 (v1 by JM)
Revised: 07/07/2016 (v2 by JM, KaC)
Revised: 09/08/2017 (v3 by JM)

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Partnership for the Delaware Estuary (PDE) Method
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Description

This method describes the procedure for field-based surveys to collect geospatial point-data using and RTK-GPS, and subsequent ArcGIS methods for building Digital Elevation Models (DEMs) of the survey areas and to compare multi-year DEMs to calculate elevational changes through time. The method has been organized into the following sections:

1. Field-based RTK-GPS data collection methodologies for:
   1.1. Topographic grid survey of an area of interest (AOI)
   1.2. Feature of interest survey within an AOI
2. Subsequent desktop-based ArcGIS methodologies for:
   2.1. Building a topographic Digital Elevation Model (DEM) of the AOI
   2.2. Comparison of multi-year datasets to measure elevational changes within an AOI

Summary of Approach

Field-based RTK-GPS surveys of an AOI are collected using two approaches: a platform grid survey; and a feature-based survey. A platform grid survey describes methods in which RTK-GPS survey points are collected at equal interval along transects separated by the same distance, to create a uniform grid of survey points (e.g. 10m x 10m). After an AOI has been delineated (i.e. marginal boundaries have been establish), a resolution for the grid survey is determined. Grid resolution can be of any extent, but is typically between 2m² and 10m², and is determined by the balance between resolutitional needs (i.e. topographic complexity) of the AOI and temporal and budgetary constraints that may limit the time available to survey. Areas of interest that are topographically uniform or where elevation changes in a singular fashion with distance (e.g. linear, exponential, etc...) will have a lower resolutional need than AOIs with a high degree of topographic complexity, and high resolution surveys require more resources (e.g. time, budget, staff, etc...).

Once a grid resolution has been established (in this method a 10m² is used), the grid survey can be undertaken. Transects are spaced across the AOI at intervals that match the resolution of the survey and demarcated at each end using 5’ PVC posts. Measuring tapes are used to ensure that the resolution between transects is maintained by checking distances at each end and in the center. RTK-GPS survey points are collected at each end and at the distances equal to the resolution along the length of each transect. Based on the goals of the survey and unique characteristics of each AOI, in addition to latitude, longitude, and elevation, data regarding the vegetation type, substrate, or other characteristic of interest should be collected at each point. The grid survey can be considered a single feature and will be modeled as a continuous surface using a GIS.
Feature-based surveys describe a method in which specific features (vegetation communities, creeks, infrastructure, etc...) are delineated and survey points are collected along their boundaries and within their perimeters. Survey points for each feature are collected within the boundary of that feature to ensure that any elevation measurement are representative of elevation found within the feature boundaries. For example, boundary points of a feature slightly elevated from the surrounding area (e.g. a tuft of vegetation isolated in an intertidal mudflat) must be taken on the elevated surface of the feature, not at the lower elevation representative of the surrounding area. The number of points collected for each feature is not static, and will be dependent on the complexity of the feature. It is important to collect enough survey points to be able to accurately define the geometry of the feature as well as the topographic variability within its boundaries. Each feature is to be given a unique identifier to facilitate isolation and independent topographic modeling within a GIS.

After RTK-GPS field-based survey points have been collected, they are imported into a GIS (this document references ArcGIS) to insure proper projection. The grid survey data is then isolated to create a digital elevation model (DEM) using the Empirical Bayesian Kriging (EBK) tool Geostatistical Analyst extension. To account for potential non-linear degeneration of the surface of the AOI across its extent, maximum overlap of points (5) is allowed and an empirical transformation using a K-Bessel (or detrended K-Bessel) semivariogram model is recommended. The DEM is subsequently exported as a Raster shapfile to be used in conjunction with individual DEMs created for each feature that was surveyed as per described above. Using the Mosaic to New Raster tool (Raster->Raster Dataset->Mosaic) add each DEM beginning with the DEM produced from the grid-based survey (foundational surface upon which features will be layered) so that the features sit on top of the grid surface (32-bit Float, Bands=1, Operator=LAST). This is now a comprehensive DEM of the topography of the AOI for the period of time when the survey was conducted.

In order to calculate changes over time, rasters created for multiple time periods will need to be compared. To do this, an attribute table for each comprehensive DEM needs to be created containing the elevation value of each pixel. The Raster Calculator is used to multiply the value field by 100, and is subsequently copied (Data Management->Raster->Raster Dataset->Copy Raster) as a 32-bit integer raster (add lowest model value in No Data field). The Build Attribute Table tool (Data Management->Raster->Raster Properties->Build Raster Attribute Table) is used to create the table, and a new field (Elev, Type=Float 8,5) is added, and subsequently back-calculated to the original elevation value (Value in comprehensive DEM = Value in 32-bit integer raster/100). Elevation models for multiple years are now able to be compared using the Raster Calculator to subtract newer models from the baseline model; pixels with negative values lost elevation, and pixels with positive values gained elevation.

**Equipment**
- Ten 5' PVC posts
- RTK GPS
- Three Survey Tapes (100 m long)
- Field Notebook/ Pens
ArcGIS 9.0 or higher
ArcGIS Geostatistical Analyst Extension

**Procedure**

**Field-Based RTK-GPS Data Collection Methodologies**

47.1  **Topographic Grid Survey of an Area of Interest (AOI)**

47.1.1  Demarcate transects

47.1.1.1  Assistant 1 stands at transect 1 edge, located at one extent of the AOI and places one 5’ PVC post in ground.

47.1.1.2  Assistant 2 attaches survey tape to the PVC post at transect 1 edge and walks across the AOI to transect end and places second PVC post in ground and attaches survey tape.

47.1.1.3  Assistants 1 and 2 measure a distance equal to the grid resolution (e.g. 10m in this example for a 10m² grid survey) from each transect 1 endpoint post into the AOI and place the transect 2 endpoint posts into the ground.

47.1.1.4  A survey tape is attached to each endpoint post on transect 2

47.1.1.5  The distance between transects 1 and 2 is checked at the mid-point to ensure distance is equal to the grid resolution

47.1.2  Collect RTK-GPS survey points along each transect

47.1.2.1  A new job is started in survey unit for the grid-based survey

47.1.2.2  Surveyor collects point at end point of transect 1

47.1.2.3  Surveyor moves distances along the survey tape stretched along transect 1 equal to the grid resolution (e.g. 10m) and collects a points until the transect is completely surveyed

47.1.2.4  Surveyor repeats steps at all subsequent transects

47.1.2.5  Job file is exported as ESRI fixed format file

47.2  **Feature of Interest Survey Within an AOI**

47.2.1  Identify features of interest

47.2.1.1  All features of interest are listed and described in field notes

47.2.2  Collect Survey Points for each feature of interest

47.2.2.1  A new job is started in survey unit for the feature survey
47.2.2.2 First feature is given unique name followed by enough "blank numbers" to cover the number of points to be collected (e.g. VegIsland0 if you expect less than 10 points to be collected; VegIsland00 if you expect less than 100 points to be collected)

47.2.2.3 Surveyor collects survey points along borders of first feature to completely capture geometry

47.2.2.4 Surveyor collects survey points within the interior of first feature at a resolution to capture its internal topographic variability

47.2.2.5 Repeat steps for each feature of interest

47.2.2.6 Job file is exported as ESRI fixed format file

Desktop-Based ArcGIS Methodologies

47.3 Building A Topographic Digital Elevation Model (DEM) of an AOI

47.3.1 Import all point data in to GIS and project in appropriate coordinate system

47.3.2 Isolate grid-based survey a single point dataset

47.3.3 Create a new shapefile outlining the boundaries of the AOI
   47.3.3.1 Right click on appropriate folder in ArcCatalog
   47.3.3.2 New\->Shapefile
   47.3.3.3 Name: Polygon; Feature Type: Polygon; Spatial Reference: Appropriate projection system; Click OK
   47.3.3.4 Right click new shapefile\->Edit Features\->Start Editing
   47.3.3.5 Outline the extent of the survey are to set boundaries and save as AOI

47.3.4 Isolate each feature from the feature-based survey as an individual point data set
   47.3.4.1 Open attribute table and highlight rows of a single feature (e.g. creek, vegetation clump, etc...)
   47.3.4.2 Right click on full point file in the table of contents (left sidebar)
   47.3.4.3 Export\->Data\->Export: Selected Features

47.3.5 Create new shapefiles outlining the boundaries of each feature from the feature-based survey (now an individual point-dataset) as with the AOI in 2.1.c

47.3.6 Open Geostatistical Wizard in Geostatistical Analyst Toolbar

47.3.7 Create Topographic Digital Elevation Model (DEM) from grid-based survey
   47.3.7.1 Methods: Empirical Bayesian Kriging under Geostatistical methods
47.3.7.2 Import Data

47.3.7.2.1 **Source Dataset:** grid-based survey point data; **Data Field:** elevation field; **Click Next**

47.3.7.3 Set the General Properties and Run Model

47.3.7.3.1 **Subset Size:** 100; **Overlap Factor:** 5; **Number of Simulations:** 100; **Output Surface Type:** Prediction; **Transformation:** Empirical; **Semivariogram Type:** K-Bessel; **Search Neighborhood:** Default; **Predicted Value:** Default; **Click Next**

47.3.7.4 Investigate semivariogram prediction errors and QQ plot to insure model is meets the users requirements (information to assess model can be found at: [http://desktop.arcgis.com/en/arcmap/10.3/guide-books/extensions/geostatistical-analyst/what-is-empirical-bayesian-kriging-.htm](http://desktop.arcgis.com/en/arcmap/10.3/guide-books/extensions/geostatistical-analyst/what-is-empirical-bayesian-kriging-.htm)) **Hit Finish**

47.3.7.5 Right click model->Save as Layer File

47.3.7.6 Right click model->Data->Export to Raster

47.3.7.7 Data Management->Raster->Raster Processing->Clip

47.3.7.8 **Input Raster:** Raster DEM from EBK model (2.1.f.iv); **Output Extent:** AOI (2.1.c.v); Check **Used Input Features for Clipping Geometry** box; **Output Raster Dataset:** Appropriate location; **NoData Value:** the lowest elevation value noted in the DEM; Do NOT check **Maintain Clipping Extent; Click OK**

47.3.8 Follow steps in 2.1f Create Topographic Digital Elevation Model (DEM), for each feature of interest isolated as a single point file in step 2.1.d, but using the polygon of each feature as the clipping extent in the final step

47.3.9 Layer the DEMs to create a single, site-wide topographic DEM

47.3.9.1 Raster->Raster Dataset->Mosaic To New Raster

47.3.9.2 Add each DEM **BEGINNING with the grid-based DEM (***this one first***)**

47.3.9.3 Add appropriate destination, name, and spatial reference; **Pixel Type:** 32-bit Float; **Number of Bands:** 1; **Click OK**

47.3.10 Make 32-bit Signed Copy

47.3.10.1 Spatial Analyst Tool->Map Algebra->Raster Calculator

47.3.10.2 Create equation to multiply the values of each pixel by 100: **Final DEM** (step 2.1.i) * 100; set appropriate output location/name; **Click OK**

47.3.10.3 You now have an identical DEM with the value (elevation increased by two orders of magnitude)

47.3.10.4 Data Management-> Raster->Raster Dataset->Copy Raster
47.3.10.5 Add Raster created in 2.1.j.ii; set appropriate output location; **NoData Value:** lowest value in 2.1.j.ii output; **Pixel Type:** 32-bit Signed; **Click Environments...; Processing Extent:** AOI; **Click OK**

47.3.11 Build Attribute Table

47.3.11.1 Data Management->Raster->Raster Properties->Build Raster Attribute Table

47.3.11.2 Enter raster from 2.1.j

47.3.12 Back-calculate original elevation values

47.3.12.1 Open raster attribute table

47.3.12.2 Table Options->Add Field

47.3.12.3 **Name:** Elev; **Type:** Float (Precision=8; Scale=5); **Click OK**

47.3.12.4 Right click on raster->Edit Features->Start Editing

47.3.12.5 Right click on Elev field heading in attribute table->Field Calculator

47.3.12.6 Elev=Value/100

47.3.12.7 Click OK

47.4 **Comparison of Multi-Year Datasets to Measure Elevational Changes within an AOI**

47.4.1 Spatial Analyst Tool->Map Algebra->Raster Calculator

47.4.2 Create equation to subtract older (original Time 1) time-point DEMs from newer datasets; Time2 – Time 1; set appropriate output raster; **Click OK**

47.4.3 Negative values indicate the magnitude of loss of elevation at that location since the Time 1 data was collected, positive values indicate the magnitude of gain in elevation since the time 1 data was collected