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Progress Report: Network Routing for Offshore CCS from the Houston Area

The goal of this work is to develop a methodology for CCS source-sink network cost optimization that can be applied to selecting and aggregating sources for sequestration in the Houston to Port Arthur region. To date the following work has been completed:

- Obtain CO_2 source data
- Get waterbody, road, railroad, - NHDPlus[1], DEM[2], state park[3], pipeline[4] datasets
- Restrict data to the area of interest
- Add buffers around line datasets
- Trial cost-path analysis on a test source-sink

The CO_2 emissions data was obtained from multiple sources such as the EPA[5] and FERC[6]. Many facilities in the region already have 'capture technology' for removing CO_2 from the outlet stream. Reviewing permits issued by the TCEQ highlighted those facilities currently using capture technology[7]. By selecting these facilities, the capital cost of CCS is reduced. The figure below shows some of the initially selected sources:

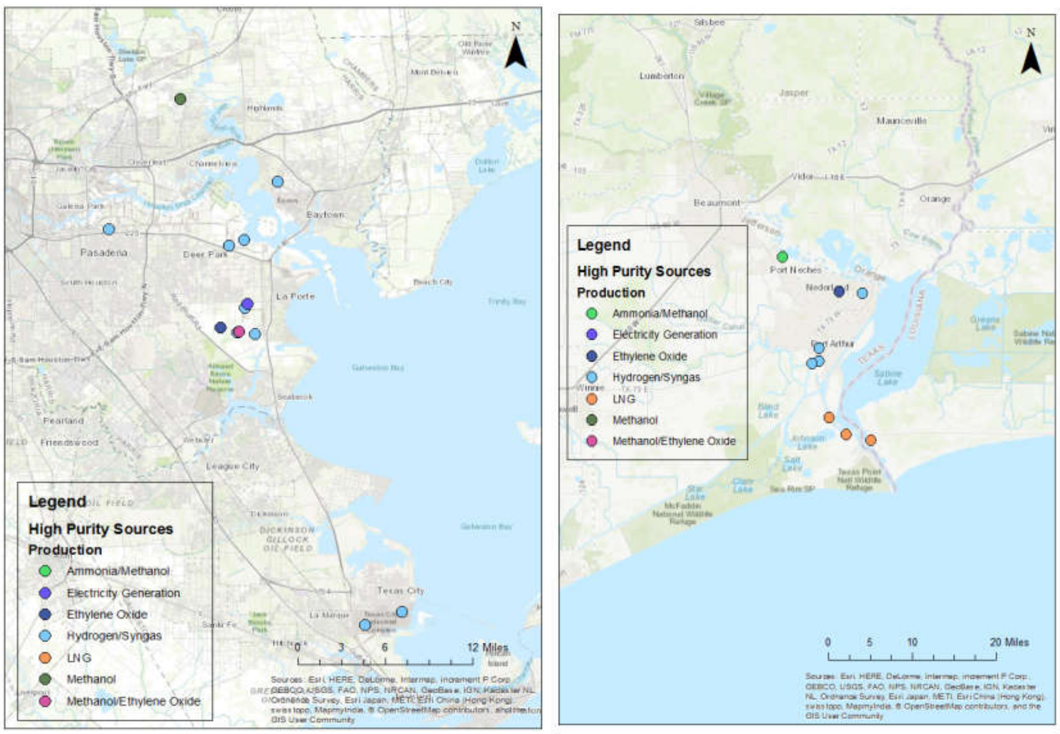

Figure 1, Maps showing facilities with existing CO_2 capture facilities in Houston (left) and Port Arthur (right)

The relevant datasets have been downloaded and the cost-layer has started to be built[8]. Each of these layers was restricted to the area of interest by using the 'Extract by Mask' tool, in which a rectangular shapefile was used for the mask. For line feature classes, the 'Buffer' tool was used to create an area for which the cost factor will be adjusted. For example, a buffer 5m either side of pipelines was created. Here the cost factor will be negative due to the right of way from the existing pipeline reducing the cost for any future pipelines built in the vicinity.

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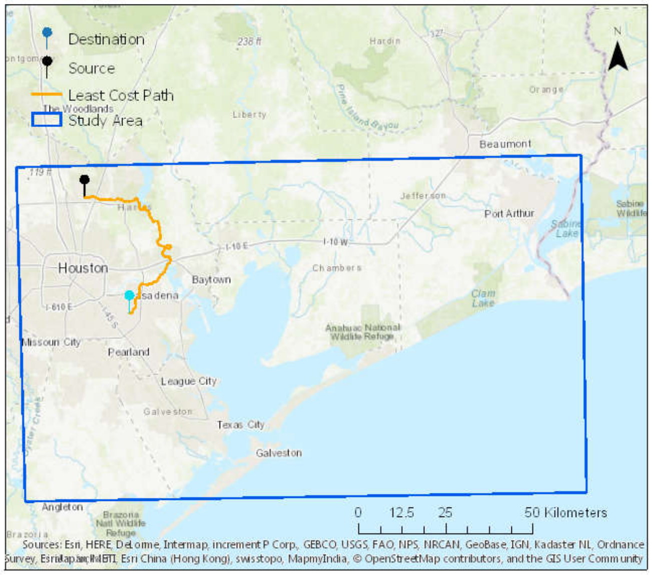
1 http://landscape1.arcgis.com/arcgis - ArcGIS NHDPlus Server. Accessed October 2017
2 http://elevation.arcgis.com/arcgis - ArcGIS Elevation Server. Accessed October 2017
3 http://tpwd.texas.gov/gis/ - Texas State Park GIS Dataset. Accessed October 2017
4 https://www.eia.gov/maps/layer_info-m.php – EIA Pipeline Dataset. Accessed October 2017
5 https://ghgdata.epa.gov/ghgp/main.do - EPA GHG Emissions from Large Facilities. Accessed September 2017
6 https://elibrary.ferc.gov/idmws/search/fercgensearch.asp - FERC library. Accessed September 2017
7 https://webmail.tceq.texas.gov/gw/webpub - TCEQ Document Search. Accessed October 2017
8 MIT, 2006, Carbon Management GIS: CO2 Pipeline Transport Cost Estimation, Carbon Capture and Sequestration Technologies Program - NETL

Two random points were created, a source and a sink. The Cost-Distance and Cost-Backlink rasters were then generated (using only the slope layer) and fed into the Cost-Path tool to generate the least cost path between the two points. This path was then analysed to ensure the answer was logical and the tools were implemented correctly. This path ended up following waterways, which is expected as they have no slope.

A Map of the Study Area Showing a Trial Least Cost Path Analysis
and Layer Decomposition



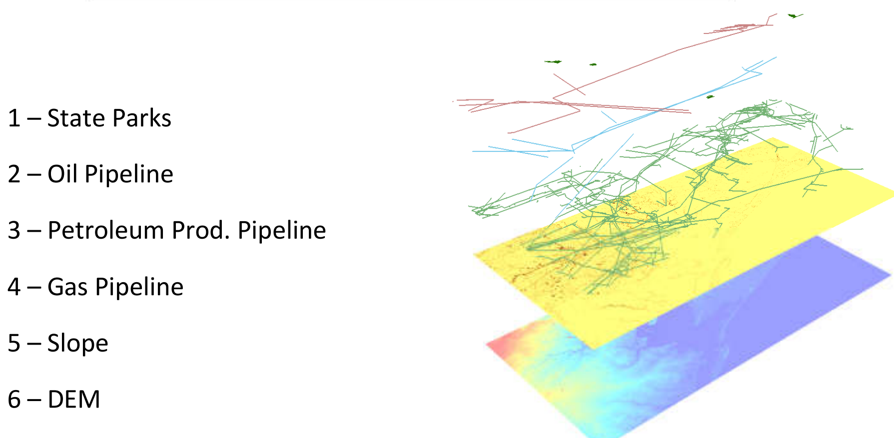


Figure 2, Showing the trial least cost path and the layer decomposition for the initial cost layer build

The next step is to finish building the cost raster. Once this is done, the least cost path can be generated from each source to each sink. The rasters from this analysis will be added and the data will be dealt with like 'stream order' in ArcPro. Where the rasters overlay (the number of overlaying routes is analagous to the stream order), the section will be denoted as a trunkline/aggregation of CO_2[9]. Where they don't overlay, equivalent to a stream order of 1, the route will be treated as a branch. The raster may have to be converted to a polyline feature class and then the vertices converted to points, to determine the node at which a branch transitions to a trunkline. The lengths, cost factors and node locations of these trunklines and branches are the output of the GIS analysis. They can subsequently be used in a standard transportation problem setup, utilizing otptimization techniques such as mixed integer and linear programming to determine the optimal source-sink pairing for a desired volume of stored CO_2.

[9] Middleton, R. S., Bielicki, J. M., 2009, A scalable infrastructure model for carbon capture and storage: SimCCS. Energy Policy, Volume 37, pp. 1052-1060