Terrain Analysis Using Digital Elevation Models (TauDEM)
Synopsis of Class 10, GIS in Water Resources

This lecture continues our study of hydrologic terrain analysis using digital elevation models (DEM). It builds on the capacity introduced previously to compute flow accumulation and map channels and watersheds in a DEM based on a flow accumulation threshold. Once a raster channel network is mapped stream segments are identified and converted to vector stream segments. Catchments are delineated as the area draining separately to each stream segment. For every stream segment there is a corresponding catchment and a relational model is used to connect area represented by catchments to the corresponding stream segment and upstream and downstream stream segments providing a powerful construct in support of quantifying the hydrology at any point on the land surface.

Catchments, Watersheds and Subwatersheds. As used here catchments are the area draining separately to each stream segment. Catchments provide a tessellation of the landscape based on the D8 flow direction rules. A watershed is defined as the entire area upstream of an arbitrary point (e.g. gage) on the channel network and may include other watersheds. A subwatershed is defined as the area draining directly to a gage point on the stream network without first flowing through any other gaged point. Thus subwatersheds are non-overlapping, while watersheds may overlap.

While it is possible to delineate stream networks entirely from a DEM, mapped information in the form of stream network hydrography may often complement and in some cases be better than DEM information. In these cases techniques such as burning in the stream network and reconditioning the DEM to be consistent with the vector stream representation are used. Burning in involves lowering grid cells along the streams, or equivalently raising the off stream DEM cells by an arbitrary increment. This imposes the stream network into the DEM flow model. AGREE DEM reconditioning superimposes on the burned in stream network a taper away from streams to smooth the transition from burned in streams to the original DEM. Burning and reconditioning should be used cautiously and only when the vector stream information is deemed more reliable than the DEM.

Pit filling is the standard approach for removing sinks in a DEM. However pit filling can have undesirable effects and alternative methods such as carving or optimal pit removal have been advanced. While these are attractive, there is at present no standard implementation of them available in ArcGIS.

In delineating streams from DEMs the threshold used to delineate streams dictates the drainage density. Drainage density is defined as the length of streams divided by area and quantifies how the extent to which the land surface is dissected by streams. However when using a contributing area threshold to delineate streams there is an inverse relationship between drainage density and the threshold selected. Hydrologic processes are different on hillslopes and in channels. It is important to recognize this and account for this in the delineation of streams. The constant drop method provides an approach to objectively identify a stream delineation threshold that produces the highest resolution stream network consistent with accepted properties of stream networks.

There are multiple software tools for hydrologic terrain analysis and watershed delineation. This class will primarily use the ArcGIS Hydrology Tools that are part of spatial analyst. These will be introduced in the next exercise. However we do also introduce ArcGIS Online Hydro tools that provide cloud based simple watershed delineation and TauDEM tools which are available as an open source toolbox extension to ArcGIS as well as software as a service through CyberGIS.