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River network and watershed morphology analysis with potential implications towards basin classification

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Generally, the investigation of river network composition and watersheds morphology (fluvial geomorphology), constituting one of the key patterns of land surface, is a fundamental question of Earth Sciences. Recent ideas in this research field are the equilibrium and optimal, in the sense of minimum energy expenditure, river network evolution under constant or slowly varying conditions (Rodriguez-Iturbe, Rinaldo, 1997). It follows to such network behavior as self-similarity, self-affinity and self-organization. That is to say, under relatively stable conditions the river systems tend to some "good composed" form and vice-versa.

Lately appearing global free available detailed DEM covers involve new possibilities in this research field. We develop new methodology and program package for river network structure and watershed morphology detailed analysis on the base of ArcMap tools. Different characteristics of river network (e.g. ordering, coefficients of Horton's laws, Shannon entropy, fractal dimension) and basin morphology (e.g. diagrams of average elevation, slope, width and energy index against distance to outlet along streams) could be calculated to find a good indicators of intensity and non-equilibrium of watershed evolution.

Watersheds are non-conservative systems in which energy is dissipated by transporting water and sediment in geomorphic adjustment of the slopes and channels. The problem of estimating the amount of energy expenditure associated with overcoming surface and system resistance is extremely complicated to solve. A simplification on a river network scale is to consider energy expenditure to be primarily associated with friction of the fluid. We propose a new technique to analyze the catchment landforms based on so-called "energy function" that is a distribution of total energy index against distance from outlet.

As potential energy of water on the hillslopes is transformed into kinetic energy of the flowing fluid-sediment mixture in the runoff process, the energy is dissipated from the system. The rate of energy dissipation is defined as the work that a fluid element needs to perform to overcome friction at the unit area. Appling the product of local slope and watershed area, i.e. calculating the total energy index at the different distance from outlet, one gets the watershed "energy function" E(x). Application results indicate that the proposed method could be used for watersheds classification, regionalization and paleoreconstructions.

NASA-SRTM DEM of 3" resolution has been employed to analyze the 24 watersheds within Amur River Basin with area 20-70 thousand km2 (7-8 order). The study was carried out, in particular, to assess the limitation of SRTM DEM data, especially in flat terrains. The study also revealed that some of regularities investigated are described satisfactorily by well-known simplest model of drainage networks, so-called Peano's basin.