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В.А.СТАТОВ, П.Р.РЕЙМОВ, Н.К. МАМУТОВ,
Я.Г. ХУДАЙБЕРГЕНОВ, М.Р.РЕЙМОВ

UDK 551.435+556.5+528.8

V.A.STATOV, P.R. REYMOV, N.K. MAMUTOV,
YA.G. KHUDAYBERGENOV, M.P. REYMOV
E.mail. ksucta@elcat.kg

ЧИСЛЕННЫЕ И ГЕОЭКОЛОГИЧЕСКИЕ АСПЕКТЫ МОДЕЛИРОВАНИЯ ПОВЕРХНОСТНОГО СТОКА ДЛЯ ПЛАТО УСТЮРТ

SURFACE DISCHARGE MODELLING TOOL FOR USTURT PLATEAU: NUMERICAL AND GEOECOLOGICAL ASPECTS

Эмгек Устюрт такырынын үстүңкү агымын моделдөөгө арналган. Агент ориентирленген модель ой-чуңкурлуу, кургак арык-чөнөктүү такыр тегиздикти гидрологиялык анализдөөгө ыңгайлуу метод болот. NDVI маалыматтар менен салыштырууда ПРО моделдөөнүн натыйжалары менен дал келди.

Ачкыч сөздөр: *кургактыктын гидрологиясы, агент-ориентирленген моделдер, арид аймактарынын геоморфологиясы.*

Работа посвящена моделированию поверхностного стока для плато Устюрт. Показано, что агент-ориентированная модель является адекватным методом для гидрологического анализа засушливых равнин с цепями локальных впадин и сетями мелких высохших русел. Сравнение с данными NDVI показывает приемлемое согласие с результатами моделирования ПРО.

Ключевые слова: *гидрология суши, агент-ориентированные модели, геоморфология аридных территорий.*

The paper concerns surface runoff modeling for the Usturt Plateau. It is shown that agent-based model is an adequate method for hydrological analysis of the arid plains with chains of local depressions and networks of shallow nullahs. Comparison with NDVI data shows acceptable agreement with results of ABM simulation.

Keywords*: surface hydrology, agent-oriented models, arid geomorphology.*

Surface hydrology of the arid lands is important factor for landscape formation. Usturt Plateau is based in the Central Asia. It is a big elevated plain with grey-brown desert soils (yermosols), solonchaks, sand-covered areas and takyric depressions. Usturt plateau has extensive plains, hummocks Karabaur and extensive depressions with salt deposits in a bottom. Salinity of the flat plains are varies depending from the micro-relief, vegetation and porosity of the calcic horizons. Salt balance is determined by the surface runoff, soil diffusion and wind transfer.

Regnant plant species are *Salsola arbuscula, Artemisia terrae-albae, Anabasis salsa, Salsola arbuscula, Convolvulus fruticosus, Haloxylon aphyllum, Tamarix hispida, Halocnemum strobilaceum, Kallidium caspicum, Halirnocnernis villosa, Climacoptera lanata, Anabasis aphylla, Anabasis tukestanica, Ammodendron conollyi, Carex physodes, Poa bulbosa, Rheum tatarcum, Eremopyron orientale, Agropyron fragile*. Plant diversity and vegetation density are governed with surface runoff because precipitation is a single source of a water. Condition of the Usturt pastures is vital for a cattle breeding and rare species protection in the State complex landscape preserve “Saigachiy” in the west part of the plateau.

Despite arid climatic conditions there are short but intense rains in a spring season, which cause considerable surface run-off. These short-time but intensive streams shape topography, determine vegetation density and floristic diversity, form groundwater deposits and make a great influence onto the salt transport.

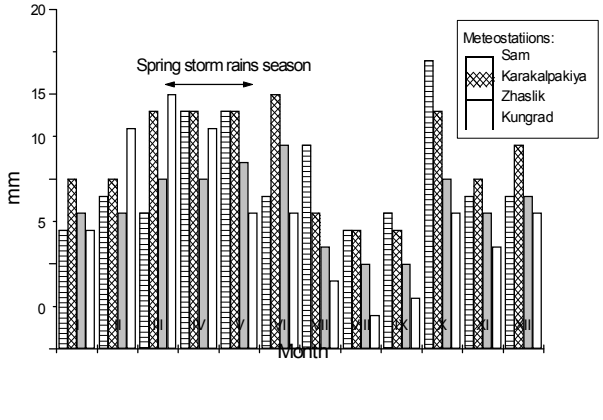

Figure 1. Averaged month precipitation for Usturt meteostations (Matmuratov 1989) /1/

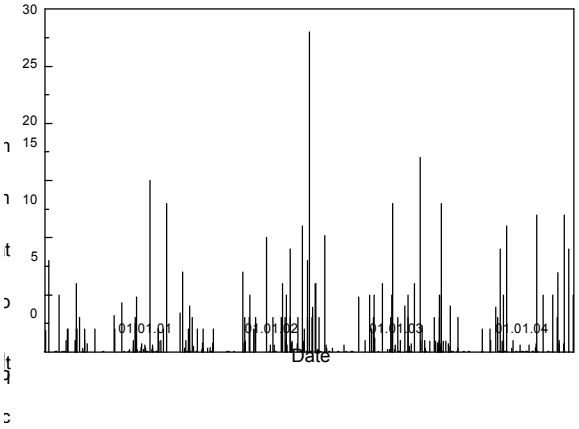

Figure 2. Daily precipitation for Zhaslik meteostation, 2000-2005

Surface water play important role in the pedogenesis and landscape formation as a main source of clay particles to form gleyic sites (takyrs), leading geomorphological factor of the water erosion, and ground water accumulation.

For example, there are small span-like depression with clay bottom named "khara" near southwest abrupt falls of the plateau. There depressions accumulate surface runoff and catenate vegetation covering with rich phitocenotical diversity.

Precipitation intensity for the studied area is shown on the Fig 1. and 2.

There are many tools for hydrological analysis. After transformation and preparation of input file we use open-source GIS Whitebox Geospatial Analysis Tools, TopModel, Grass GIS and SAGA. Also LISEM and PCRCalc software were used. As a source of raw data we use standard open database, converted and georeferenced. /2,3/

As Usturt Plateau has specific takyr-like shallow depressions and other internal sinks we should preliminary prepare DEM with filling procedure. For this purpose we used the Planchon and Darboux algorithm as well as Wang and Liu filling algorithm, which are appropriate for local areas of DEM. Further this operation of depression removal will be one of the sources of the topological error in stream network graph for plain relief, see Fig.3.

So, despite tremendous importance of the surface discharge, there is a lack of adequate modelling tool for such complicated topography and desert soils as sands and calcic yermosols.

Agent-based models are broadly used to simulate surface water discharge /4,5/. The Usturt plateau has a flat relief strongly affected with both water erosion human-induced changes. Also a shape of the Usturt plateau has some features as internal sinks, varying filtration characteristics of soil, seasonal precipitation characteristics which make difficult classical hydrological analysis using traditional numerical processing of DEM (digital elevation model) with well-known algorithms. Purpose of the study is to demonstrate advantages of the ABM waterflow simulation for dry clay and gypsum plains with vulnerable soil surface. Also the model is important for vegetation analysis and landscape transformation prognosis.

In a framework of this study we compare results of traditional methods for stream network extraction from DEM and results of agent-based hydrology model. It's shown that results for non-stationary ABM simulation differs from calculated streams topology (see Fig.4), but there are only slightly differences for stationary conditions and smoothed DEM, when trace field was converted into vector stream network.

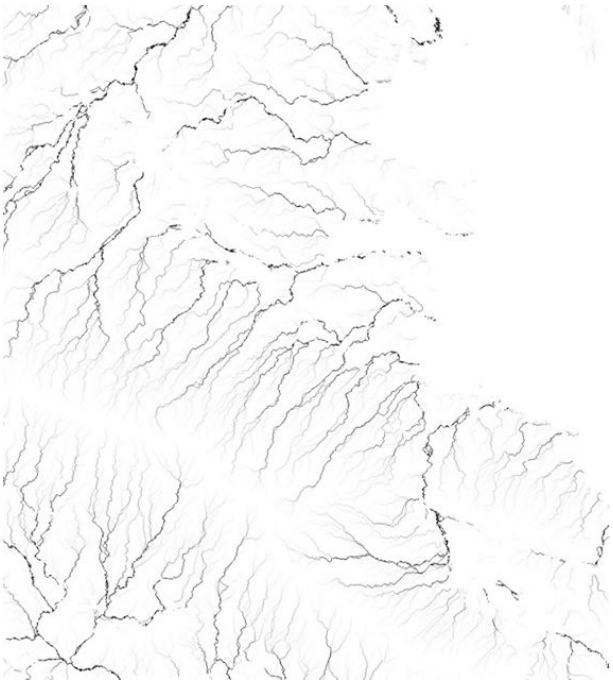

Figure 3. Stream networks for study area calculated using Dinf algorithm. Plain area between hillocks and depression

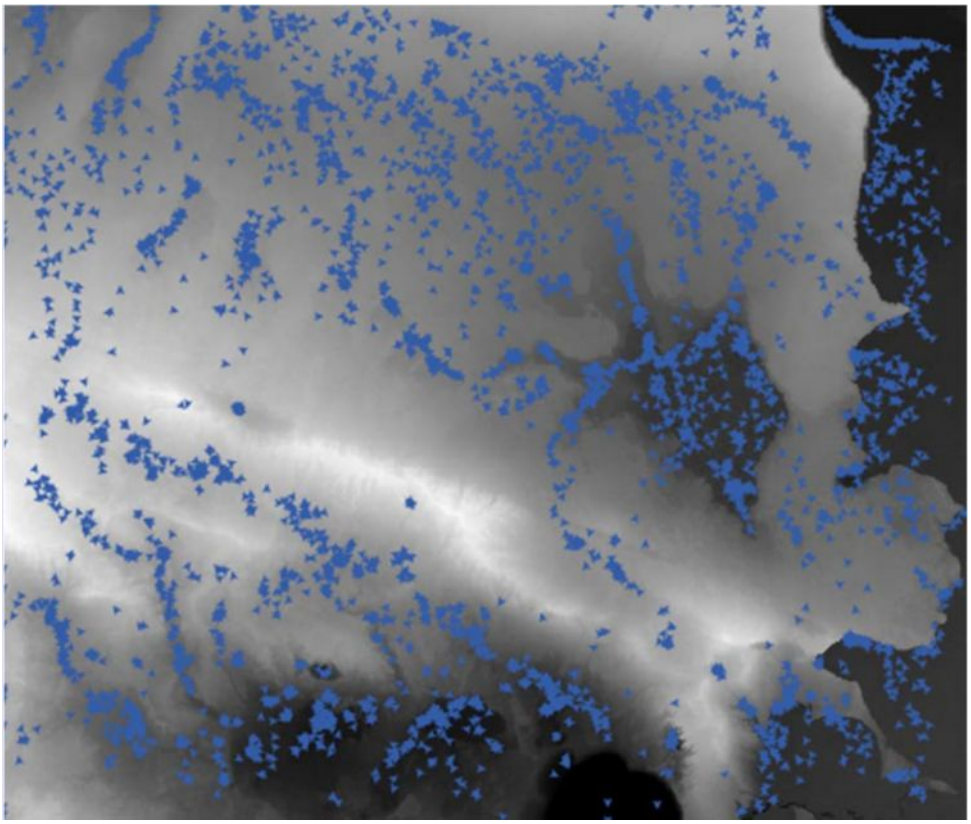

Figure 4. ABM simulation for study area

At the initial stage of the agent-based simulation we had used NetLogo software for numerical implementation of the research task. This software can work with geoinformatic data, has visual interface and widely used for many problems in spatial modeling.

Varying cell condition and other properties of the model in agent-based simulation allows solve non-stationary tasks. It is important for Usturt plateau with short rainy seasons and big precipitation level sometimes. Also we can take into account surface filtration in porous gypsum soils and sands in Usturt Plateau. Another important task for agent-based hydrology models is sediment transport, erosion and relief evolution. For Usturt plateau this part of the modeling is connected with human-induced relief changes due to roads network. Using our agent-based model we can estimate watering of the various elements of terrain and compare our results with remote data sensing and field geobotanical data. Comparison with NDVI data shows good agreement of the model result with vegetation distribution. Also there is rather good coincidence between agent- based streams and space images of the area under investigation.

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