COMPARISON OF THE SRTM VER.4.1 AND ETOPO1 DIGITAL ELEVATION MODELS OVER TASHKENT GEODYNAMICAL POLYGON

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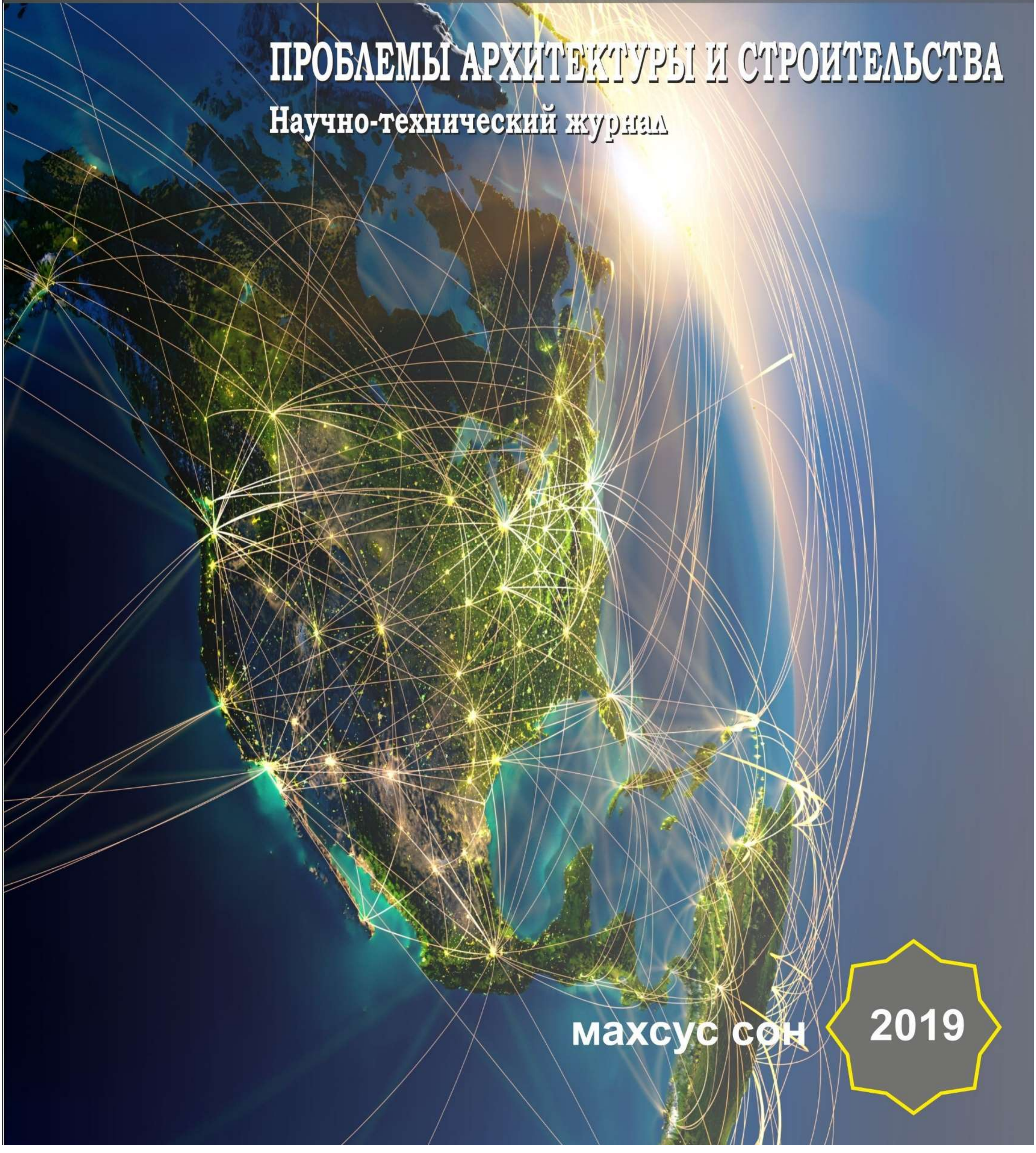

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иваются значения точек данных и отслеживается то, как они влияют на наши результаты.

Резюмируя применение Big Data в гидрогеологических исследованиях можно сказать, что оно содержит большие данные, улучшает процесс, научно-исследовательских работ, технический отчет, где в полной мере отражены данные о структуре территории, расчеты и выводы, полученные в ходе гидрогеологических работ. Таким образом, можно добиться максимального сбора данных и максимальной точности прогнозирования изменения гидрогеологического состояния окружающей среды и ее влияния на объект, как на этапе строительства, так и в перспективе долгосрочной эксплуатации уже готового объекта.

Литературы

1. Джуманов Ж.Х. Геоинформационные технологии в гидрогеологии. -Т.: ГП «Институт ГИДРОИНГЕО», 2016. -258 с.

2. Мавлонов А.А., Джуманов Ж.Х. Гидрогеоинформационная модель подземных вод в геоинформационных системах//Геология и минеральные ресурсы. –Т. 2006. № 2. С.55-59.

3. Хабибуллаев И., Джуманов Ж.Х. Об информационно-коммуникационной технологии в гидрогеологии. Геология и минеральные ресурсы. –Т.: 2014. № 1. С.48-54.

4. Веретенников А.В. Big Data: анализ больших данных сегодня. -М.: Молодой ученый, 2017. - № 32. С. 9-12.

5. Джуманов Ж.Х. Особенности компьютерной технологии при создании и использовании гидроинформационных моделей подземных вод// Гидрогеологические исследования в Узбекистане. Тр. посвящ. 50-летию гидрогеологической службы Узбекистана. –Т.: 2007. С.134-138.

6. Иванов П.Д., Вампилов В.Ж. Технологии Big Data и их применение на современном промышленном предприятии// Инженерный журнал: наука и инновации. 2014, Вып. 8.

7. Тиндал Сьюзен. Большие данные: все, что вам необходимо знать. PCWeek/RE, 2012. -№ 25 (810).

8. Мавлонов А.А., Джуманов Ж.Х., Мирахмедов Т.Д. К вопросу организации гидрогеоинформационной модели подземных вод (на примере г.Ташкента и Хорезмской области)// Вестник НУУз. –Т.: Университет. 2009. -№ 4/1. С.80-86.

9. Djumanov J.X. Mathematical modeling of geofiltrational of processes of the regional hydrogeological systems //Vienna, Austria. European Science Review. -2016. -№ 11-12. P 28-33.

10. Rakhmatullayev Sh., Frederic H., Kazbekov J., Philippe C., Djumanov J. Groundwater resources of Uzbekistan: an environmental and operational overview// Central European Journal of Geosciences//SPRINGER-Versita. Germany. -2012. -№4 (1) -P. 67-80.

COMPARISON OF THE SRTM VER.4.1 AND ETOPO1 DIGITAL ELEVATION MODELS OVER TASHKENT GEODYNAMICAL POLYGON

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Abstract. This study compares and evaluates the DEMs based on the Shuttle Radar Topography Mission (SRTM) as released by the by the Consortium for Spatial Information (SRTM CGIAR-CSI version 4.1), the 1 arc-minute global relief model (ETOPO1) over the Tashkent geodynamical polygon in Uzbekistan. Determining the accuracy of the elevation values of the products (absolute accuracy) was used to compare and validate the elevation products against the GNSS results.

Keywords: geoinformation technologies, remote sensing, GNSS

Абстракт: Мақолада Ўзбекистон худудида жойлашган Тошкент геодинамик полигони учун Shuttle Radar Topography Mission (SRTM CGIAR-CSI 4.1 версияси) ва ETOPO1 глобал рақамли рельеф моделларини баландликларини таққослаштириш ва танлаш натижалари келтирилган. Моделларнинг баландлик қийматларини ҳатолигини баҳолаш учун (абсолют аниқлик) GNSS ўлчовлари натижаларидан фойдаланилди.

Калит сўзлар. гео-аҳборот технологиялар, ерни масофадан зондлаш, GNSS

Абстракт: В работе выполнена оценка и выбор цифровой модели рельефа для Ташкентского геодинамического полигона с использованием глобальных цифровых моделей рельефа SRTM CGIAR-CSI версии 4.1 и ETOPO1. Оценка точности и выбор моделей базировался на сравнении с значениями высотам, полученными с помощью GNSS.

Ключевые слова: геоинформационные технологии, дистанционное зондирование, GNSS.

1. Introduction

Accurate models of the topography are important from a scientific (hydrology, gravity field modelling, geology, land use, landslide monitoring) as well as from a socio-economic point of view (precise flood prediction, local-scale weather forecasts) [1]. Description of the relief in the form of a digital model is the basis of the being created Uzbek spatial data infrastructure [2]. Currently, the topography may be extracted from Digital elevation models (DEM) based on remotely sensed observations, such as SRTM (Shuttle Radar Topography Mission), which offer nearly global coverage in areas with insufficient observational data and difficult to access for observation [3]. However, the accuracy of DEMs usually is not uniform because they use various data sources in their construction. Before using it, users must first be aware of the impact of errors (such as incomplete density of observations, positional inaccuracy, data entry faults, processing errors, classification and generalization problems) of the DEM in the area of interest [4]. It is necessary to select an appropriate model for different kind of applications in the given region. Due to its accuracy and cost-effectiveness the Global Positioning System (GPS) provides new opportunities for producing and validation of DEM's especially for developing countries. The error can be directly estimated by comparing the heights extracted from a DEM and their values interpolated from GPS/levelling data [5].

The goals of this work were to quantify and compare vertical accuracy, assess dependence between vertical accuracy DEMs based on the SRTM mission as released by the by the Consortium for Spatial Information (SRTM CGIAR-CSI version 4.1) and the 1 arc-minute global relief model (ETOPO1) [6,7]. Tashkent geodynamical polygon in Uzbekistan was chosen for verification of the models.

2. Data and methods

Tashkent geodynamical polygon (TGP) operates since 1977 in order to search for precursors of earthquakes and for studying local geodynamic phenomena [8]. The region is located in the Middle Tien-Shan zone at the boundary the Tien-Shan orogenic territory and the Turan plate and it is closely related to the activity of the Karjantau depression. The mountain ranges (Karzhantau, Chatkal and Kurami), covered by young structures in some arears, surround this field and decrease in southwest direction. Note that high mountainous regions are located in the south-east and north near Charvak water reservoir and the maximum heights reaches up to 3000 m. Fig.1 shows the topography of TGP constructed from the SRTM (Shuttle Radar Topography Mission) DEM and GNSS network distribution.

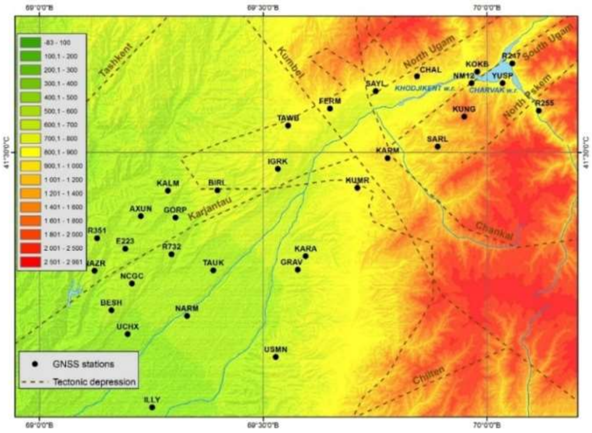


Fig. 1. SRTM topography and GNSS points used to verify the DEMs at TGP

The SRTM, undertaken by the National Geospatial-Intelligence Agency (NGA) and the National Aeronautics and Space Administration (NASA), collected data of dual spaceborne imaging radar (SIR-C) and dual X-band synthetic aperture radar (X-SAR). One of the important distinguishing features of the SRTM mission is that the data set is intrinsically three-dimensional and self-consistent geometrically over the globe. The final product (SRTM v4) released in August 2008 and is freely available on the USGS website was chosen for this study [9]. The absolute vertical error estimated using the available ground truth is better than 9 m in Eurasia, indicating that SRTM improved on its design goal of 16 m absolute by almost a factor of 2 [10].

The ETOPO1 1-Arc-minute resolution (2km) model developed by the National Geophysical data Center (NGDC), an office of the National Oceanic and Atmospheric administration (NOAA) in August 2008 is based on multiple data sources. Data sets used in the ETOPO1 Global Relief Model were all originally referenced to sea level [7]. Note that ETOPO1 model also incorporate SRTM data, but it has been rarely analyzed in recently publications.

The original reference dataset used for the validation of DEMs consists of a total of about 31 GNSS points (fig. 1), collected during campaigns between 2009 and 2010 by researchers from the Institute of Seismology and the National Center of Geodesy and Cartography. The GNSS data are referenced to the ITRF2008 and provide geometric (ellipsoidal) heights with reference to the WGS84 ellipsoid. The vertical data for Uzbekistan is not connected to International Height Reference Frame (IHRF) and there is no systematic data base of geoid definition by modern methods. Therefore, the global Earth Gravitational Model 2008

(EGM2008) [11] assessment was done for Uzbekistan in our previous work [12].

The ellipsoidal height $H^{GNSS}(P)$ of a point P was transformed to a normal height (h) by using geoid undulations for EGM2008 $\zeta_{EGM2008}(P)$ at control points are received using Calculation Service of the International Center of Global Terrestrial Models (ICGEM) with equation [13,14]:

$$h(P) = H^{GNSS}(P) - \zeta_{EGM2008}(P) \qquad (1)$$

Most of the further processing took place in an ArcGIS (ESRI, Redlands, CA, USA) software. As a first step, both DEMs datasets were resampled to a STRM's 3- arcsecond grid. Homogeneous surface for investigated region TGP was created for GNSS data and DEMs using nearest neighbor interpolation [12] (fig.2).

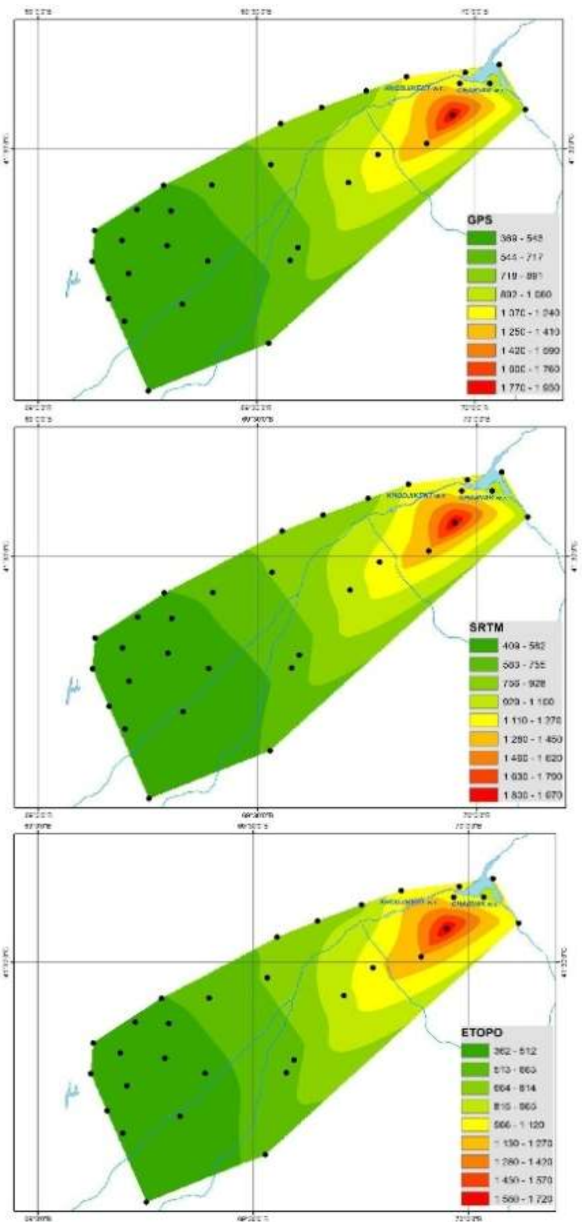


Fig.2. DEMs datasets surfaces (from left: GNSS, SRTM, ETOPO) created by using nearest neighbor interpolation

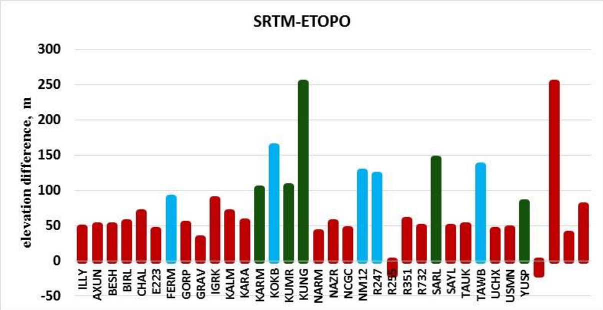
3. Results

The differences between the reference GNSS and DEMs datasets were acquired by executing the following subtractions: (SRTM-GNSS), (ETOPO1-GNSS) to determine the vertical accuracy of the TGP DEM. We obtained the error statistic shown in Table 1. The mean values of the elevation difference between SRTM, ETOPO1 and GNSS are 36.42 m and -42.07 m respectively. This comparison highlighted the difference between 26 m and 44 m for SRTM and values between -219 m and 54 m for ETOPO1. Obviously, the difference between these global assessments of DEM accuracy are that the ETOPO1 analysis indicate a consistent bias, whereas SRTM indicated a much smaller bias. RMS statistic is also higher for ETOPO1 model.

Table 1. Summary statistics of DEMs for the study area

	SRTM-GNSS, m	(ETOPO1-GNSS), m
Minimum, m	26.35	-219.31
Maximum, m	43.80	54.25
Mean, m	36.42	-42.07
RMS, m	3.34	39.34

But when considering the relief features, we can make the assumption that large bias in the heights of the ETOPO1 model are due to tectonic and water level variations in Charvak resservoir factors. The (SRTM-ETOPO) difference of the elevations at the each GNSS point was extracted for verification of the assumption (fig.3), the results confirm that the SRTM DEM elevations are overall quite close to ETOPO-DEM values (between 26 m and 88 m) for low elevation areas (AXUN, BIRL, E223, GORP, IGRK, KALM, NAZR, R351, GRAV, KARA, TAUK, R732, NARM, NCGC, BESH, UCHX, USMN, ILLY). On the contrary, major differences between DEMs were observed at mountainous part of TGP (KARM, KUMR, KUNG, SARL, YUSP). This area of the TGP is affected by the Kumbel and Chatkal depressions and significant velocity rates between 40 mm/year and 60 mm/year were found for this zone, while the flat, foothills zones show velocity rate up to 15 mm / year [15]. The total annual volume of Charvak water in the reservoir has increased almost six times since its construction in 1970 [data provided by the Hydrometeorological service of Uzbekistan]. Elevation bias for ETOPO1 model for "near water reservoir" stations (FERM, KOKB, NM12, R247, TAWB) can be explained by the seasonal water volume variations of the Charvak.



- "flat" stations
- "near water reservoir" stations
- "tectonic fault" stations

Fig.3. Elevation difference between models ETOPO1 and SRTM

4. Discussion and conclusions

The quality of two DEMs (SRTM v4 and ETOPO1) was assessed for the Tashkent geodynamical polygon in Uzbekistan. The GNSS network of TGP was used as reference data. The assessment showed a significantly bias in the ETOPO1 data of -220 m, whereas the SRTM v4 was well distributed with an RMS of 3 m. Both models better represent topography in the flat area. In contrary, the quality of models decreased for mountainous and near reservoir areas. The correcting SRTM v4 and GNSS data with global EGM2008 geoid undulation could affect the result. It can be concluded construction precise digital model of the region should be supported by local geoid information in the future.

References:

1. Rexer, M., and C. Hirt. 2014. "Comparison of Free High-Resolution Digital Elevation Data Sets (ASTER GDEM2, SRTM v2.1/v4.1) and Validation Against Accurate Heights from the Australian National Gravity Database." Australian Journal of Earth Sciences 61 (2): 213–226. doi:10.1080/08120099.2014.884983

2. Resolution of the President of the Republic of Uzbekistan, 2013, On Measures on Implementation of Investment Project. Creation of National Geographic Information System, RP-2045.

3. Farr, T. G., P. A. Rosen, E. Caro, R. Crippen, R. Duren, S. Hensley, M. Kobrick, M. Paller., E. Rodriguez, L. Roth, D. Seal, S. Shaffer, J. Shimada, and J. Umland. 2007. "The Shuttle Radar Topography Mission." Reviews of Geophysics 45 (2): 1–43. doi:10.1029/2005RG000183.

4. Wechsler, S. P.: Perceptions of Digital Elevation Model Uncertaintyby DEM Users, URISA Journal, 15, 57-64, 2003.

5. Kiamehr, R. & Sjöberg, L.E. Effect of the SRTM global DEM on the determination of a high-resolution geoid model: a case study in Iran. J Geodesy (2005) 79: 540. https://doi.org/10.1007/s00190-005-0006-8

6. USGS (United States Geological Survey), 2004. Shuttle Radar Topography Mission, 1 Arc Second scene SRTM_u03_n008e004, Unfilled Unfinished 2.0, Global Land Cover Facility, University of Maryland, College Park, Maryland, February 2000. http://glcf.umd.edu /data/srtm/

7. Amante, C. and B. W. Eakins, ETOPO1 1 Arc-Minute Global Relief Model: Procedures, Data Sources and Analysis. NOAA Technical Memorandum NESDIS NGDC-24, 19 pp, March 2009. Go to this web site: http://www.ngdc.noaa.gov/mgg/global/global.html.

8. Yarmukhamedov, A.R., 1988. The morpho-structure of the median Tien Shan and its relationship with seismicity. Tashkent: Fan, 163 p. (In Russian). https://www.geo-fund.am/files/library/1/15247392644395.pdf

9. CGIAR. 2014. "CGIAR." http://srtm.csi.cgiar.org/

10. Rodriguez, E., C. S. Morris, J. E. Belz, E. C. Chapin, J. M. Martin, W. Daffer, and S. Hensley (2005), An assessment of the SRTM topographic products, JPL Publ., D31639, 143 pp.

11. Pavlis, N. K., Holmes, S. A., Kenyon, S. C. and Factor, J. K., 2012, The Development and Evaluation of the Earth Gravitational Model 2008 (EGM2008), J. Geophys. Res. Vol. 117, B04406.

12. Fazilova D., Magdiev H. Comparative study of interpolation methods in development of local geoid // International Journal of Geoinformatics, 2018, - V.14, №1. –pp. 29–33.

13. Barthelmes, F. and Köhler, W., 2016, International Centre for Global Earth Models (ICGEM), in: Drewes, H., Kuglitsch, F., Adám, J. et.al., The Geodesists Handbook 2016, Journal of Geodesy, Vol. 90, No.10, 907-1205

14. Hofmann-Wellenhof, B., Lichtenegger, H. and Collins, J., 2001, Global Positioning System. Theory and Practice, 3rd Edition, (New York: Springer-Verlag).

15. Hamidov H.L., 2012. Identification of morpho-kinetic indicators of modern geodynamics of western Tiang Shan // Modern geodynamics of Central Asia and dangerous natural processes: quantitative research results: Materials of the All-Russian meeting and youth school on modern geodynamics (Irkutsk, September 23–29, 2012). - In 2-ht. - Irkutsk: IZSORAN, 2012. T. 2. 211 p. www.crust.irk.ru/images/upload/new-sfond143/299.pdf

ANALYSIS OF EVAPOTRANSPIRATION RATINGS IN THE AMUDARYA RIVER BASINS OF CENTRAL ASIAN AREAS WITH APPLICATION GOOGLE EARTH ENGINE CODES

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