INSTITUTE OF GEOGRAPHY
Russian Academy of Sciences

Founded in 1918

The 2018 IGU Thematic Conference dedicated to the centennial of the Institute of Geography of Russian Academy of Science

PRACTICAL GEOGRAPHY AND XXI CENTURY CHALLENGES

CONFERENCE BOOK

PART 2

JUNE 2018, MOSCOW

Organizers

IGU UGI

Russian Academy of Sciences

Official Sponsors

rosuchebnik.ru

RFBR

IGU MOSCOW 2018

EXPERIENCE IN STUDYING CLIMATE CHANGE'S IMPACT ON DESERTIFICATION / DEGRADATION, DROUGHTS IN DIFFERENT ARID REGIONS

A.N. Zolotokrylin, T.B. Titkova, E.A. Cherenkova, V.V. Vinogradova

Institute of Geography, RAS, Moscow, Russia

The concept of modern desertification's climatic component in arid key regions in Eurasia and North Africa is proved in the monograph 'Climate Desertification' (Zolotokrylin, 2003). This concept explains the nature of climatic desertification and identifies its main peculiarities. Desertification means interaction between aridization and drylands degradation, with feedbacks in 'arid territory-atmosphere' system. Climatic aridization means refers not only to degraded territory's atmospheric humidification reduce, but meso-scale processes of heat exchange between this territory and atmosphere boundary layers as well. In case of such heat exchange, aridization sustained by positive 'albedo-precipitation' feedback. This positive feedback based on negative correlation between degraded surface's albedo and the temperature.

The concept is based on the ability to quickly restore degraded dryland ecosystems with favorable climate effects. Later, it independently became the basis of a new paradigm of desertification, developed in the work "Dryland Opportunities. A new paradigm for people, ecosystems and development "(Mortimore, 2009), instead of the supported UNCCD degradation paradigm.

The concept generalizes the experience of using satellite data (spectral properties of the surface of arid territories) for global assessments of desertification. The result showed positive trends NDVI, which contradicts the views on their progressive degradation.

The concept stimulated the development of approaches to studying the spread and dynamics of desertification / degradation, including droughts (desertification, land degradation and drought, DLDD) in different arid regions in a changing climate, which are set out below.

The position of the boundaries of bioclimatic zones (subhumid, dry subhumid, and semiarid) on the plains of Russia was determined by the aridity index (the mean annual precipitations to potential evapotranspiration ratio estimated according to the approach by Penman). The index was calculated for the period 1981–2010 (Zolotokrylin et al.2018). Steppe, some forest steppe, and broadleaf forest landscapes are located in the subhumid zone on the East European Plain. Steppe, forest steppe, and some subtaiga landscapes represent the subhumid zone on the West Siberian Plain (Fig.1) Some regions in the subhumid zone are characterized by increased frequency of atmospheric and soil atmospheric droughts and may be considered episodically arid.

The satellite indicator of land degradation shows a considerable positive trend in the dry subhumid and semiarid zones and a positive but unstable trend in the subhumid zone. The evaluation of droughts and desertification/degradation of slightly and regularly arid subhumid lands is reasonable.

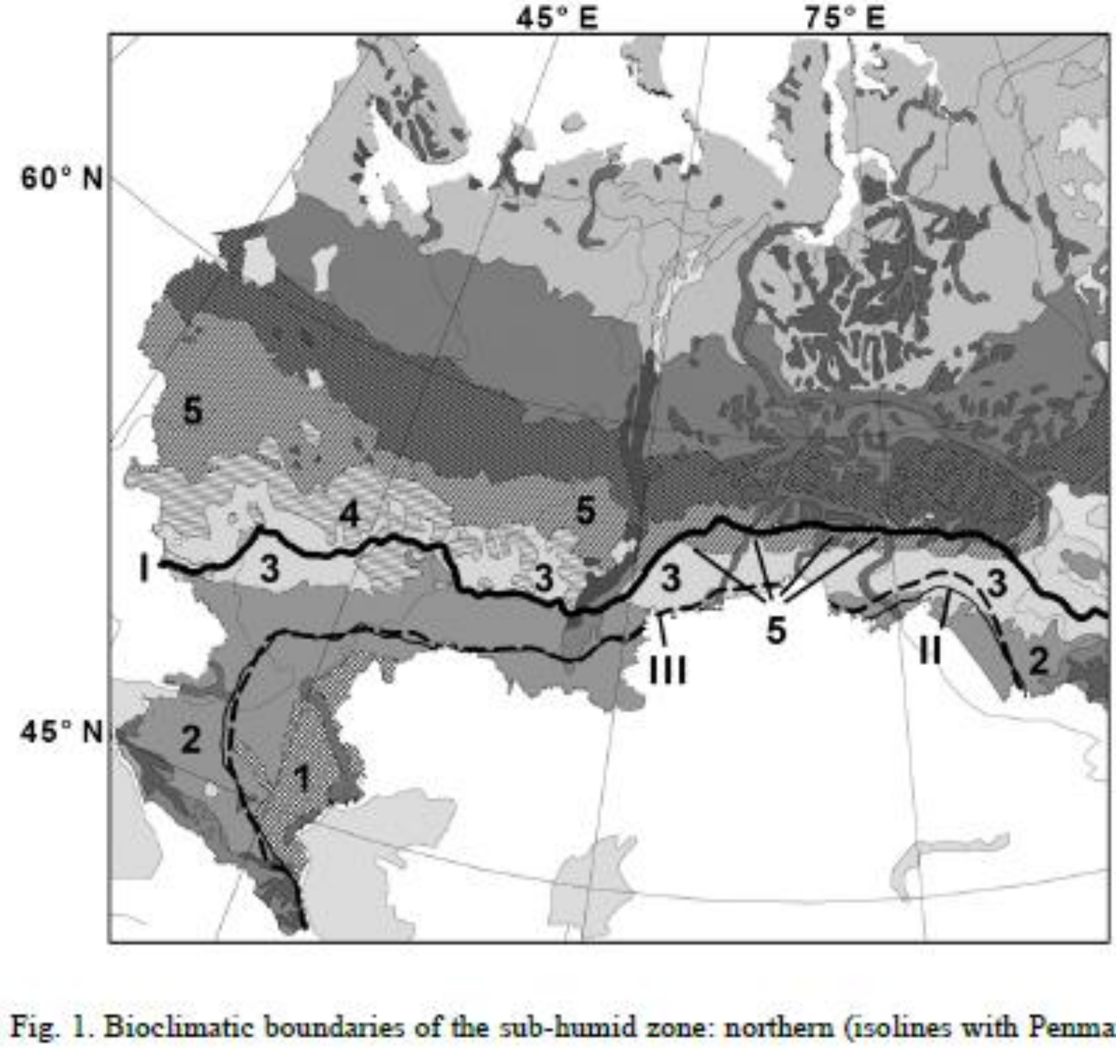

Fig. 1. Bioclimatic boundaries of the sub-humid zone: northern (isolines with Penman aridity index value, AIP equal to 0.75 - (I)) and southern (isolines with AIP value equal to 0.5 - (II)). The boundary of the semi-arid zone (an isoline with an AIP value of 0.35) - (III). The

northern boundary of the dry subhumid zone (an isoline with the value of the arthritis index for the Torntveit, AIT, 0.65 - (IV)). Landscapes: 1 - semidesert and desert, 2 - steppe typical and dry steppe, 3 - forest-steppe, 4 - broadleaf forest, 5 -Subtaiga.

The impact of El Nino-Southern Oscillation (ENSO) events on generating wet and dry conditions in the Sonoran Desert is examined (Zolotokrylin et al. 2016). Wet and dry conditions were identified from data of the Satellite Climate Extremes Index (SCEI), using MODIS satellite imagery for May–September 2000-2015. Additionally, MOD16 evapotranspiration products were considered as supplementary criteria. Negative SCEI values (dry conditions) correspond to radiation mechanism of regulation of prevailing surface temperature, while positive values (wet conditions) correspond to evapotranspiration. Five types of SCEI seasonal dynamics were identified in the Sonoran Desert. The link between these five types and ENSO events are discussed. Extreme moisture occurred in 2005 during four months, 2010 only in May, and 2012 in May, then decreased in June–July, and transitions to wet condition in September. These events occurred in years when El Niño and La Niña were active. In summer 2005, an abrupt shift from El Niño to La Niña occurred, while in summer 2010, La Niña conditions were established after May. In August 2012, El Niño was interrupted and shifted to a La Niña-like episode for a month. Our results indicate that the likelihood of wet conditions during May–September increased in shifts from El Niño to La Niña or establishment of La Niña conditions.

The authors explore a new approach to monitoring enclosed areas on the continent with accentuated desert conditions, here called "islands of desertification", resulting from the relation between albedo, surface temperature, and NDVI values. The territory of the El Pinacate y Gran Desierto de Altar Biosphere Reserve in northwestern Sonora, Mexico serves as the example to substantiate the procedure. The region is located in the Sonoran Desert and is a UNESCO World Heritage Site, a feature that guarantees minimum anthropogenic impact in the reserve. The results indicate that the approach was successful in identifying only one island of desertification in the study area (Fig.2). The island appears annually, though it varies in extent and intensity, when NDVI falls below the values 0.095–0.10 in the spring dry periods (April–June) of 2000–2017. This occurs when the radiation mechanism of surface temperature regulation begins to dominate in relation to the evapotranspiration mechanism. Its localization is practically constant year after year, indicating that it is climatically conditioned, i.e., is not caused by anthropogenic pressure. The intensity of desertification in the "desertification island" has a significant upward trend: the growth rate of the negative correlation coefficient is significant. Two types of a seasonal course of intensity are established, depending on the change of the SOI sign in the spring.

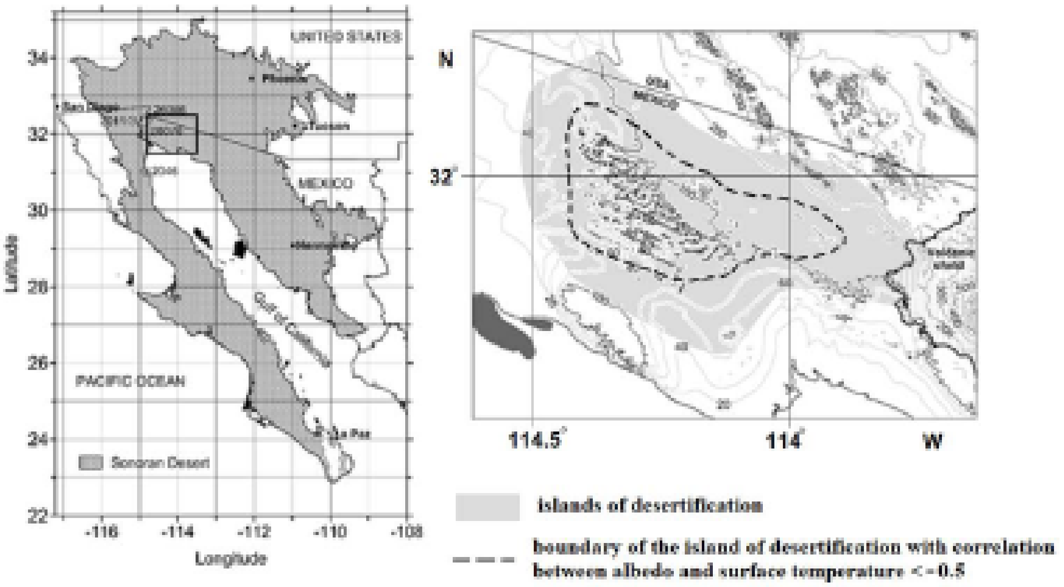

Fig. 2 The Sonoran Desert (left map). The rectangle show the study area (enlarged to the right); the circles display the location of weather stations near the area. The right map displays the elevation curves every 20 m (from 0 to 100 m), and every 100 m (from 100 to 1000 m).

Monitoring of desertification islands was made in the territory of the North-Western Caspian region for the periods 1985-1991 and 2011-2017 according to the methodology (Zolotokrylin and Titkova 2011). In Fig. 3. Described islands of desertification of different intensities of predominantly anthropogenic origin in comparative periods. Comparison of the islands of desertification of their localization and intensity of desertification revealed their multidirectional changes. In the first period there was a large Chernozemelsky island of desertification of anthropogenic origin, which disappeared in the second period as a result of increased precipitation, reduction of overgrazing and anti-desert measures. New islands of desertification of anthropogenic origin arose on the territory in 2011-2017 not only in the northern desert, but also in the southern steppe.

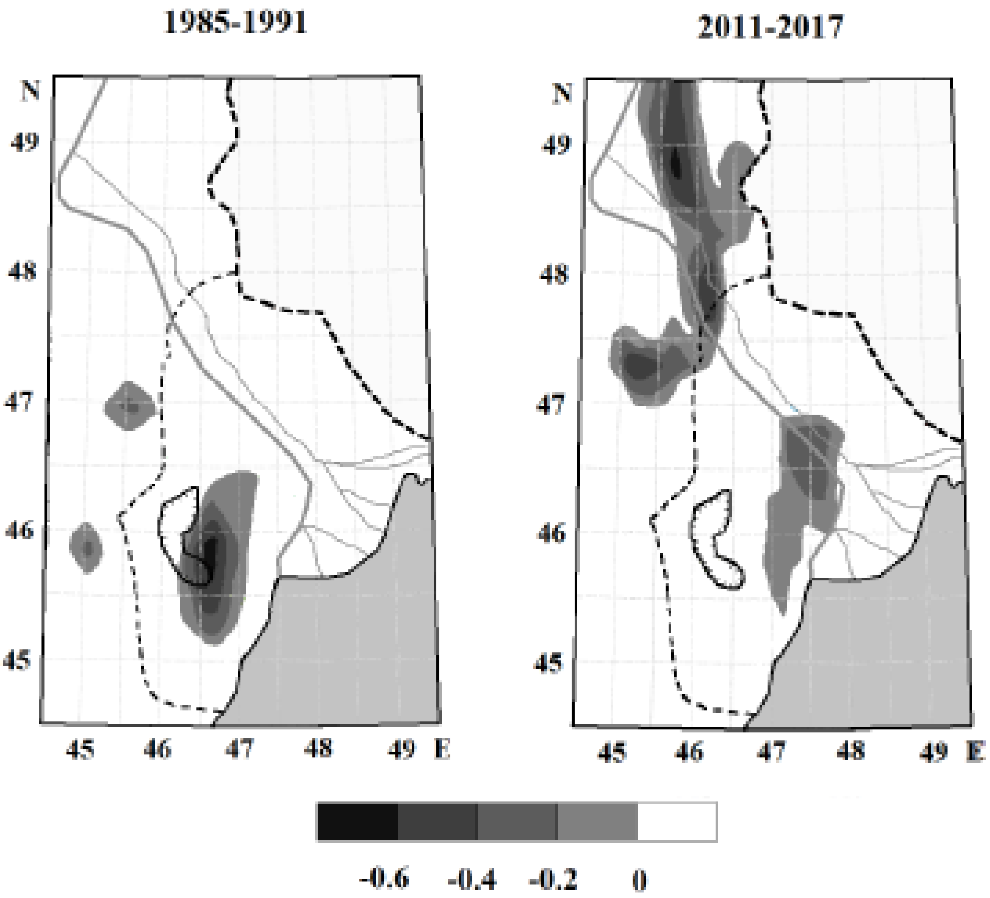

Fig. 3. Desertification islands of different intensity in the North-Western Caspian region. Desertification Intensity: 0 - -0.4 – low; -0.4 - -0.6 – moderate; < - 0.6 - high. The boundaries of the Biosphere Reserve "Black Lands" are marked, dotted - - - border of the northern desert, --- state border of the Russian Federation

Changes in the state of Mongolian arid ecosystems revealed in long-term field studies have been analyzed in accordance with the developed concept of island-type desertification. Trends have been revealed in the development of climate aridity, drought frequency, and the anthropogenic load on pastures. Indicators of area moistening, anthropogenic desertification islands, and the overgrazing degree of arid pastures have been developed on the basis of satellite MODIS data. It has been shown that the effects of a sharp reduction in the number of livestock because of natural hazards (dzut, drought) are reliably manifested by a decrease in the surface albedo and an increase in the vegetation index. The dynamics of the islands of anthropogenic desertification has been analyzed. The degree of degradation of dry-steppe, desert-steppe, and desert ecosystems has been estimated snowstorms.

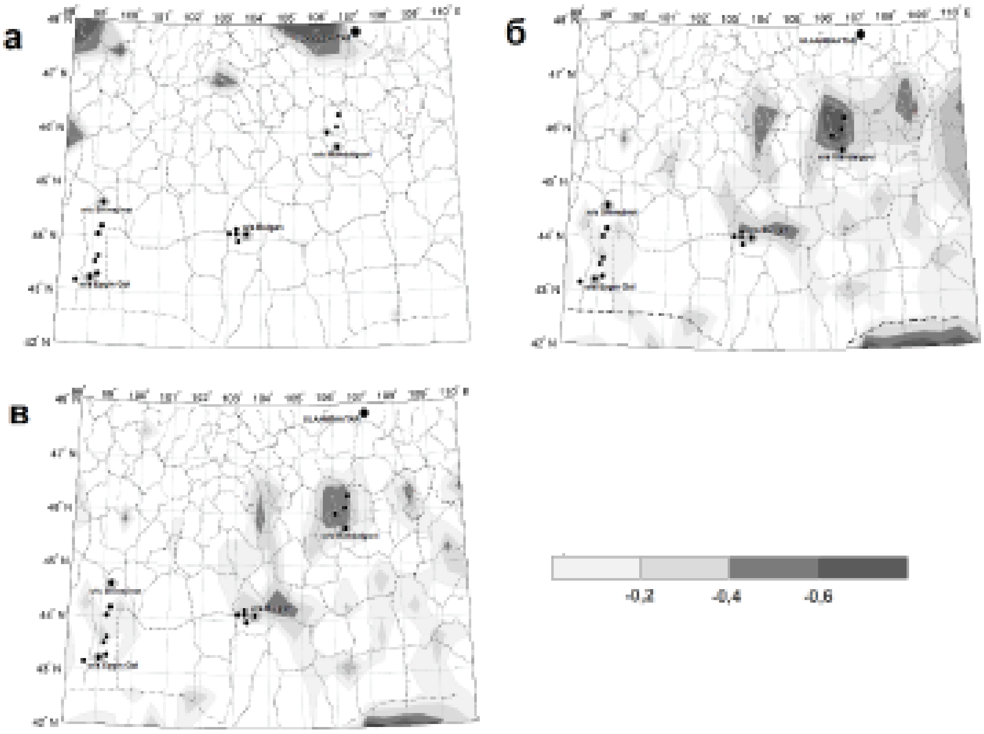

Fig. 4. Desertification islands of varying intensity in Central Mongolia: (a) 1985–1991; (b) 2005–2009; (c) 2010–2014. The locations of the key areas and weather stations are denoted with black circles and contoured black circles, respectively. Desertification Intensity: 0 - -0.4 – low; -0.4 - -0.6 – moderate; < - 0.6 - high.

The Universal Thermal Climate Index (UTCI) is used to characterize changes in climatic conditions of the population during the drought period and increase aridity (Brōde et al. 2012). UTCI aimed for a one-dimensional quantity adequately reflecting the human physiological reaction to the multidimensionally defined actual outdoor thermal environment. In the steppe area of the Saratov region (August), estimates of the degree of deterioration in the climatic conditions of life in the 2010 drought as compared to the wetter year 2004 are shown in Fig.5. Comfort and absence of thermal stress were observed in 2004. In the drought of 2010 (august), the contrast of climatic conditions increased on one of the days of the month: from weak heat stress to mild cold stress.

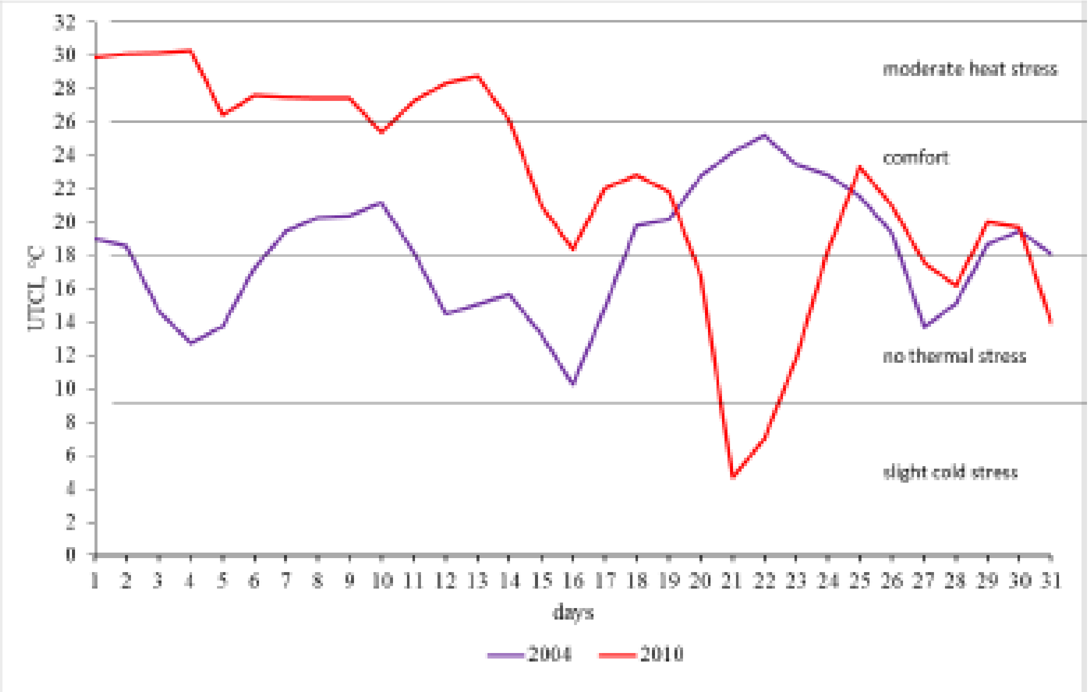

Fig. 5. Daily changes in UTCI in August 2004 (normal conditions) and 2010 (drought) in the Volga steppe (Saratov region).

Keywords: drylands, climatic desertification, desertification islands, drought.

REFERENCES

Bröde P, Fiala D, Błażejczyk K, Holmér I, Jendritzky G, Kampmann B, Tinz B und Havenith G (2012). Deriving the operational procedure for the Universal Thermal Climate Index (UTCI). Int J Biometeorol. 56, pp.481–494.

Mortimore M, Anderson S, Cotula L, Davies J, Fasser K, Hesse S, Morton J, Nyangena W, Skinner J and Wolfangel C (2009). Dryland Opportunities: A new paradigm for people, ecosystems and development. IUCN, Gland, Switzerland. IIED, London, UK and UNDP/DDC, Nairobi, Kenia. 86 p.

Zolotokrylin AN (2003). Klimaticheskoye opustynivaniye. (Climatic desertification). Moscow. Nauka Publ. 246 p.

Zolotokrylin A.N. and Titkova T.B. (2011). A new Approach to the Monitoring of Desertification Centres. Arid ecosystems. Vol.1. No.3, pp.125-130.

Zolotokrylin A, Titkova T, Brito-Castillo L (2016). Wet and dry conditions patterns in the Sonoran Desert associated with ENSO events in 2000-2015 period. J.Arid Env., 2016. 11, pp.21-32

Zolotokrylin A.N., Gunin P.D., Titkova T.B., Bazha S.N., Danzhalova E.V. and Kazantseva T.I. (2016). Diagnosis of the desertification dynamics of arid pastures in Mongolia from observation in key areas and MODIS data. Arid Ecosystems, 6(3), pp.149-157.

Zolotokrylin AN, Cherenkova EA, Titkova TB (2018). Bioclimatic Subhumid Zone of Russia Plains: Droughts, Desertification, and Land Degradation. Arid Ecosystems. Vol.8. No.1, pp.7-12.