Volume 3, Issue 1, 2020 ISSN: 2664-0848
DOI: https://doi.org/10.31058/j.water.2020.31004

The Project “Atlas of World Water Resources of Local Elemental Runoff”

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Received: 22 March 2020**; Accepted:** 31 May 2020**; Published:** 22 September 2020

Abstract:

The article presents the draft World Atlas of local water resources, which is based on water-balance calculations on meteorological data. The advantages of maps of isolines of local runoff are described, and the methodology for calculating the initial data is presented. The structure, content, and presentation templates of Atlas information are proposed. The stages of creating the Atlas are analyzed and the work distribution of map production is proposed.

Keywords:

Atlas, Water Resources, Unexplored Catchments, Runoff Rate, Local Runoff, Water-Balance Calculations.

1. Introduction

When developing new territories, designing settlements, irrigation systems, and industrial construction, problems arise in assessing the water resources of unexplored catchments and calculating the hydrological characteristics of unexplored watercourses. Existing methods for calculating runoff approved for use are far from perfect, based on introducing into the calculation formulas the set of correction factor factors [1,2]. The maps of the isolines of the runoff norms are based on materials of large and medium-sized catchments, and therefore, in principle, cannot and should not be used to determine the water resources of small rivers.

2. Materials and Methods

The works [3,4] describe the basics of the latest direction in the development of the theory and technique of water-balance calculations based not on hydrometric, but on meteorological observations. In 2010, a significant discovery was made in the gigantic meteorological databases of all countries [5] of the most valuable information not known to meteorologists or hydrologists before, which, as it turned out, allows calculating the hydrographs of runoff from elementary land sections in the vicinity of the weather station based on only two meteorological elements - temperature and precipitation. It was shown [3,6,7,8] that the data of standard regime observations of precipitation and air temperatures make it possible to calculate daily values of local elementary runoff with an accuracy sufficient for many purposes. This means that for vast land areas unexplored with respect to hydrometry on all continents, the use of weather data will not only establish the rate of runoff from small catchments, but also quantitatively describe the annual course of runoff for specific years, evaluate the parameters of the statistical distribution of phase-homogeneous runoff characteristics, and in addition, to quickly create using GIS contour maps of runoff, evaporation, soil moisture for any day, decade, month, year of the period of meteorological observations. The most important advantage of the Siberian method of solving the problem of determining the local water resources of small catchments according to meteorological data is the field representation of the elements of the water balance, which became possible only thanks to the creation of GIS and computerization of calculations. Maps guarantee the absence of local errors inherent in the method of fitting characteristics obtained on the basis of hydrometry of large rivers to small streams. But an even more attractive advantage is a clear visual genetic description of the processes of changes in the humidity of the active layer and the formation of runoff and evaporation during the transformation of precipitation falling from heaven to earth.

In order to substantially clarify the idea of the geographical distribution of local water resources in the territories of all countries where there is a network of weather stations, today we should start using the developed computer system for calculating the hydrological characteristics of local runoff and evaporation in order to replace the existing system for adjusting to small catchments information obtained by hydrometry on large rivers.

The theoretical foundations of the developed computer system are summarized in [3]; its practical application to the territories of Siberia and the Far East is described in [7].

Let us show on the example of the territories of Siberia and the Far East the results of using a computer system developed and successfully used for engineering calculations.

Organizational work on the implementation of the Project can be carried out under the auspices and methodological guidance of the World Meteorological Organization of Geneva (WMO), which includes and which is financed by all the largest states of the world. It is necessary to convert the national daily meteorological databases of observations of precipitation and average daily air temperatures in all countries from paper to electronic format and verify the results by graphical visualization of vectors and analysis of tails of ranked variation series. In addition, it is desirable to have for each country a summary of the values of the correction factors to the monthly precipitation.

In order to carry out mass control of the correctness of the results of calculation of runoff and evaporation, exhaustive information should be collected on measurements of soil moisture and evaporation from the soil surface, as well as to make available the base of hydrometric observations of runoff of small and medium-sized drainage streams - daily water discharge for specific years.

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The Omsk group of researchers could undertake the production of calculations for several thousand weather stations, as well as generate contour maps of the source data: moisture, heat resources and calculation results: runoff, evaporation and, possibly, soil moisture. However, the calculation results can be compiled and prepared for publication only by the hydrometeorologists of each country to which WMO will have to transfer the results. The structure of the projected Atlas of World Water Resources of Local Runoff is described below.

3. Structure of the Atlas of World Water Resources of Local Runoff

Atlas Table of Contents

Text part

a. Introduction

b. Observation materials

c. The theoretical basis

d. Technology of calculations

e. Analysis of the results.

Applications - 5 volumes:

a. Maps of monthly and annual norms of elements of all continents - 24 cards

b. Tables (fragments) of daily values for 2 months at 10 weather stations of each continent

c. Graphs of hydrograph chains of local runoff

d. Correlation graphs of runoff and evaporation comparisons at 10 stations on each continent.

e. Maps of stations and lists of stations on each continent.

For each of several hundred key weather stations in the world, the main results should be shown, which will occupy approximately 20 pages of Appendices b and c. The template below shows fragments of tables and graphs obtained as a result of daily calculations based on materials from the Omsk weather station.

4. Atlas Table and Graph Templates

Template for publishing TBB calculation results for each of the weather stations
Weather station…..

A brief description of the location of the station, its height above sea level

Brief physical and geographical characteristics

Soil freezing depth

Years of observation (according to the site All-Russian Research Institute of Hydrometeorological Information - World Data Center [5])

Years for which the calculation of the daily elements of the water balance

Thermal energy resources (TER) of the climate Tk = ... MJ / sq

TER of evaporation Tz = ... MJ / sq. m

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The annual norm of the measured precipitation is X = ... mm / year (according to [10])

The annual runoff rate (according to [2,11]): M = ... l / (s • km2) = ... mm / year.

Table 1. *Annual amounts of elements of current water balances (CWB) calculated by meteorological data (mm / year).*

Year	KX	Zm	Z	Y
1937	363	703	279	11
1938	568	705	377	38
1939	391	704	283	9
1940	330	727	244	6
1941	421	662	295	18

Explanation. Y is the local runoff, Z is the evaporation, KX is the total moisture, Zm is the maximum possible evaporation. All values are in mm / day.

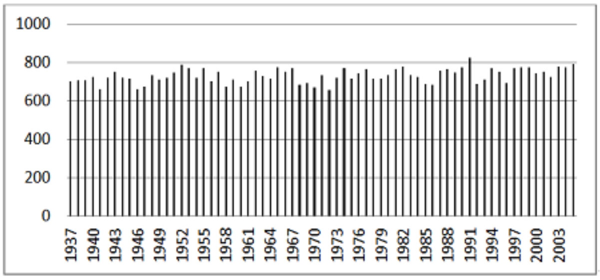

Figure 1. *Maximum possible evaporation Zm, mm / year.*

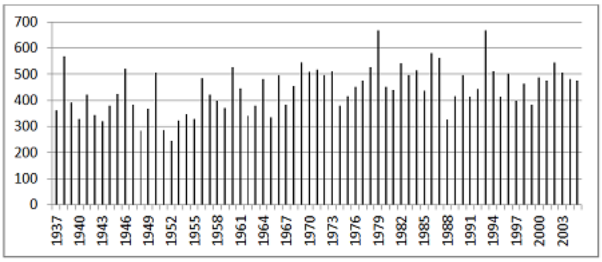

Figure 2. *Total moisture content of KX, mm / year.*

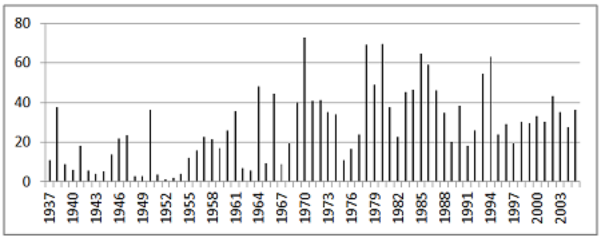

Figure 3. *Local runoff Y, mm / year.*

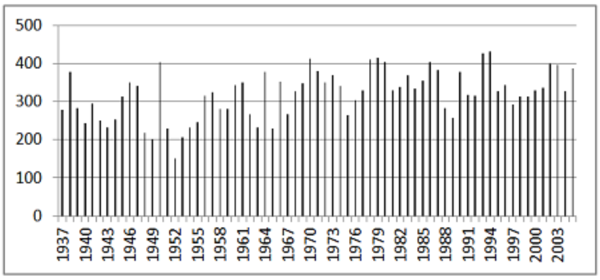

Figure 4. *Total evaporation Z, mm / year.*

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Table 2. *Elements of the water balance – monthly amounts, mm / month.*

Month	KX	Zm	Z	Y	Month	KX	Zm	Z	Y
05.1967	11	105	48	1,8	05.1972	5	89	66	14
06.1967	31	149	47	0,6	06.1972	87	137	82	7
07.1967	74	181	37	0,1	07.1972	56	148	71	3
08.1967	71	127	45	0,7	08.1972	65	131	55	1,5
09.1967	29	70	24	0,3	09.1972	36	60	23	0,5
10.1967	36	47	18	0,3	10.1972	27	29	10	0,2
05.1968	26	120	76	8,6	05.1973	23	105	74	12,9

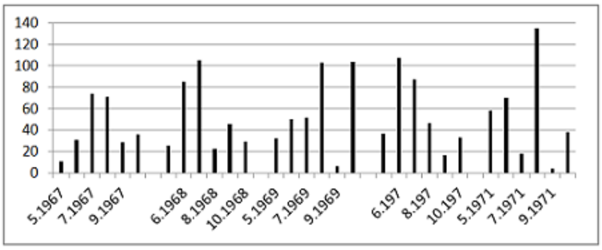

Figure 5. *Total moisturizing KX, mm / month.*

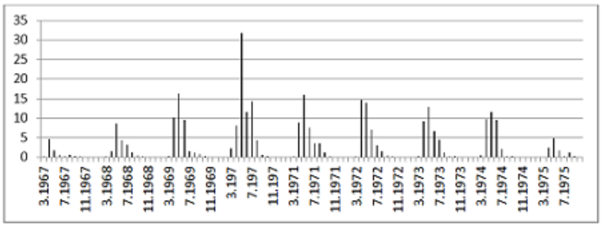

Figure 6. *Layer of local runoff Y, mm / month.*

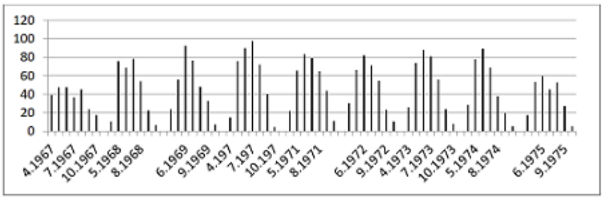

Figure 7. *Evaporation layer Z, mm / month.*

Table 3. *The daily values of the elements.*

Date	KX, mm /day	Zm, mm / day	Humidity V1	Z, mm / day	Y, mm / day
25.06.1947	1,1	4	0,54	1,5	0
26.06.1947	6,4	3,7	0,53	1,4	0
27.06.1947	0	4,3	0,55	1,7	0
28.06.1947	0	5,4	0,54	2,1	0
29.06.1947	3,2	4,9	0,53	1,8	0
30.06.1947	0	2,9	0,53	1,1	0
01.07.1947	0	3,7	0,53	1,4	0

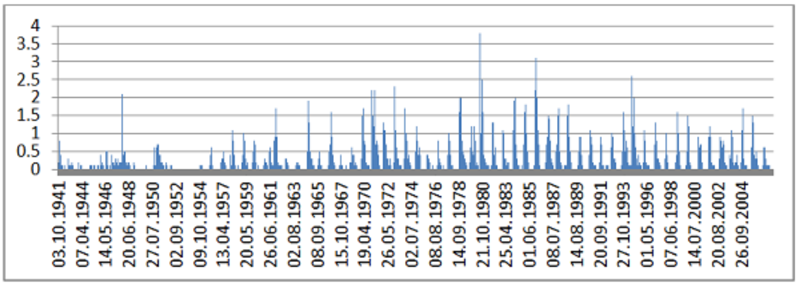

Figure 8. *The daily runoff layer in Omsk, calculated in 15118 days from April 16 to October 30, in mm / day. 1941 – 2005 (55 years).*

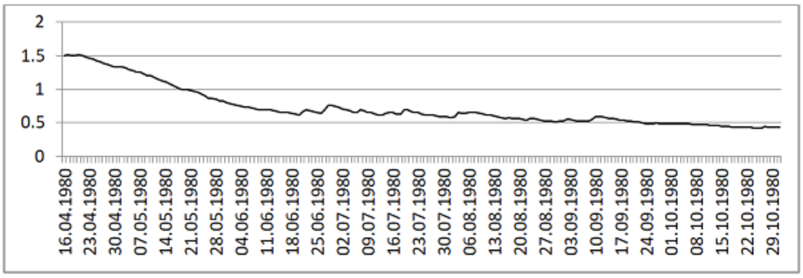

Figure 9. *Relative soil moisture (in fractions of the lowest moisture capacity) in Omsk from April to November 1980. V = 1 is the optimal humidity equal to the lowest moisture capacity.*

In Figure 10 shows weather stations for which the results of calculating runoff and evaporation are compared with measured values for specific months and years [6].

Figure 10. *Meteorological stations for which the reliability of the calculated daily values of local runoff and evaporation for specific years has been verified [6].*

5. Conclusion and Prospects

a. Local runoff maps would be several times more detailed if not 220 weather stations, but approximately 5,000 weather stations and stations operating in these territories in the 20th century would be exposed online for Russia and neighboring countries.

b. Therefore, in the near future it is necessary to convert meteorological information from paper carriers of all stations and posts on all continents and perform hydrological calculations of the daily current water balances of local runoff in order to create a World Atlas of local runoff water resources (World Atlas of Water Balance Elements).

c. The World Meteorological Organization could already today open a new project, important for a substantial refinement of the water resources of the continents, promising to complete the creation of sets of geographical fields (isoline maps) begun in Siberia.

d. Instead of organizing expensive gauging stations and stations on millions of small rivers in uninhabited territories, new key precipitation gauges equipped with thermographs should be placed, and their layout should be strictly calculated taking into account the height of the terrain and the exposure of the slope. At some posts, it is necessary to build stock sites with automatic measurement of flood parameters in order to improve the calculation method for calculating water balance elements.

Organizational work on the Project could be successfully carried out under the auspices and methodological guidance of WMO. It is necessary to convert all available daily meteorological databases of observations of precipitation and average daily air temperatures in all countries from paper to electronic format and verify the results by graphical visualization of vectors and analysis of the tails of ranked variation series. In addition, it is desirable to have for each country a summary of the values of the correction factors to the monthly precipitation.

To carry out mass control of the correctness of the results of calculation of runoff and evaporation, comprehensive information should be collected on measurements of soil moisture and evaporation from the soil surface, as well as a database of hydrometric observations of runoff of small and medium-sized drainage streams - daily water discharge for specific years.

The Omsk group of researchers can undertake the production of calculations over decades without gaps in the vector of average daily air temperatures for thousands of weather stations, as well as generating contour maps of the initial data: moisture, heat and calculation results: runoff, evaporation and, possibly, soil moisture. However, the calculation results can be compiled and prepared for publication only by the hydrometeorologists of each country to which WMO will transmit the results.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this article.

Author Contributions

Conceptualization: I.V.K.; Validation: I.V.K, N.P.V.; Formal analysis: I.V.K.; Investigation: I.V.K.; Resources: I.V.K.; Data Curation: I.V.K; Writing – original draft preparation: I.V.K; Writing – review and editing: I.V.K, N.P.V.; Visualization: N.P.V.; Supervision: N.P.V.; Project administration: N.P.V.; Funding acquisition: N.P.V.

Funding

This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.

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