Volume 3, Issue 1, 2020 ISSN: 2664-0848
DOI: https://doi.org/10.31058/j.water.2020.31002

The New Approach to Worldwide Electronic Meteorological Database Usage for Mass Hydrological Computations

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Received: 15 January 2020**;** **Accepted:** 22 March 2020**;** **Published:** 29 August 2020

Abstract:

In Eurasia, Africa, and both Americas, millions of unexplored hydrometric rivers operate. At the beginning of the XXI century, thanks to the publication of electronic databases, the development of a computer system for mass calculations of current water balances and calculations of evaporation and runoff over thousands of subsequent daily intervals, valuable and reliable hydrological information was discovered in the national meteorological databases. Until now, hydrologists all over the world could construct runoff hydrographs only from hydrometric data of daily measurements of water levels in a river. Now we get multi-year runoff hydrograph chains with daily resolution solely on the basis of weather station data. The World Meteorological Organization could lead the Global Project "Study of the water resources of unexplored rivers of all continents according to weather stations", the result of which should be the "Atlas of World Water Resources of Local Flow".

Keywords:

Weather Station Database, Heat Balance Equation, Water Balance Equation, Elementary Local Runoff, Total Evaporation

1. Introduction

When developing new territories, designing settlements, irrigation systems, in hydraulic engineering and industrial construction, prospectors and designers are always faced with the need to carry out calculations of the hydrological characteristics of unexplored river basins.

Almost everywhere in the world there are hundreds of thousands of small rivers in which there have never been measurements. In order to carry out the project and construction on an unexplored river, you need to have a quantitative assessment of the water resources of the catchment, as well as have hydrographs of runoff in years of different water content. For hydrological calculation of the annual and maximum runoff, as well as the intra-annual course of the inflow, hydrological maps are used, obtained on the basis of the study of large rivers, with various adjustment coefficients, which leads to large errors. Existing regulatory methods for calculating runoff and total evaporation are far from perfect.

In Omsk during the second half of the 20th century, a group of researchers led by Professor V.S. Mezentsev, was involved in the calculation of the elements of the water balance of certain regions of the Soviet Union in line with the solution of major water management problems, such as, for example, the project of transferring part of the flow of Siberian rivers to Kazakhstan and Central Asia. At the same time, a new theoretical concept was developed for the heat resources of the process of moisture exchange on the surface of catchments in cold countries, which made it possible to substantially refine the results of calculations of soil moisture, runoff, and evaporation. This concept is based on a generalization of facts published in special literature obtained as a result of actinometric, glaciological and cryological measurements, especially in the Arctic and Antarctic.

Although vast territories on all continents have not been studied with regard to hydrometry, networks of meteorological stations have been formed in these territories, on which standard temperature and precipitation measurements are taken daily.

The creation and publication of electronic databases at the beginning of the 3rd millennium made it possible to develop a system of mass daily runoff and evaporation calculations. Solving a system of equations linking the characteristics of heat and water resources with the elements of the water balance of the land area, it was possible to obtain long chains of local runoff, evaporation and soil moisture for each meteorological station over successive daily intervals of many years, and then generate fields of the obtained results in the form of contour maps.

2. Materials and Methods

The research materials were numerous data on measurements of air temperature and precipitation published in the Climate Handbooks, hydrometric data published in the Hydrological Yearbooks, as well as the domestic meteo.ru database.

The main method is the method of hydrological and climatic calculations of Professor Mezentsev - a system of equations: water balance, heat energy resources and the so-called equation of the relationship between the elements of heat and water balances. To compile and analyze the fields of design characteristics, the cartographic method, GIS, was widely used. The reliability of the calculated results was controlled by the correlation method - by comparing them with the measurement data and quantifying the tightness of the links.

The main purpose of this article is to notify the scientific community about the discovery of purely hydrological information previously unknown in national meteorology databases and to state the theoretical foundations and technology for introducing a new direction in hydrology - mass calculations of elements of the water balance of the land according to meteorological data. The described method can be used in conditions of unexplored land areas both by researchers and engineers.

2.1. A brief Overview of the Original Interpretation of the Concept of "Energy Resources of the Evaporation Process"

Soil scientists and hydrologists have traditionally studied the process of evaporation from the active layer of the earth's surface in the interests of irrigation. In this case, the radiation balance of the surface R was used as the climate's heat resources. In cold countries, where the daily and annual amounts of the radiation balance during the long winter period are expressed by zero and negative values, the radiation balance cannot be used as climatic energy resources and, especially, in the quality of energy resources of evaporation [1,2,3]. The temperature of the earth's surface does not depend on the radiation balance R, but on the climatic heat and energy resources Tc, that is, on the sum of the positive component of the radiation balance R+ and the vertical component of the turbulent advective heat transfer A+ directed to the earth's surface [4,5]:

$$Tc = R^{+} + A^{+} \quad (1)$$

For practical calculations of thermal resources of the climate, the empirical expression is used:

$$Tc = 1.33 \cdot th\,(t_s / 20) + 1.88 \quad (2)$$

t_s is the average annual temperature of the active surface, ^0C, this the sign of the hyperbolic tangent.

At temperate and low latitudes, the energy resources of evaporation of Te are less than Tc due to the seasonal expenditure of thermal energy for compensating for the cryogenic effects of Tcr:

$$Te = Tc - T_{cr} \quad (3)$$

Only in warm countries Te = Tc. In mass calculations, the annual amounts of Te were calculated according to the empirical formula (4):

$$Te = 17.6 \cdot \sum t + 400 \quad (4)$$

Here

Those are the heat resources of evaporation, MJ / (m^2 · year),

$\sum t$ is the sum of the positive average monthly air temperatures for the year.

Water equivalent of heat resources of evaporation - the maximum possible evaporation Em, mm / year is calculated by the formula [4]:

$$Em = Te / L = 7 \cdot \sum t + 160 \quad (5)$$

Here L = 2, 512 MJ / (m^2 · mm) specific heat of water evaporation, D. Dalton constant,

$\sum t$ is the sum of the positive average monthly air temperatures for the year.

2.2. The System of Equations of Mezentsev

Equations of prof. Mezentsev [6] are based on the fundamental laws of conservation of matter and energy and describe the dynamics of the processes of gravitational and thermal drainage of the active soil layer. The system of equations was successfully used during the second half of the 20th century to calculate soil moisture, runoff, and evaporation. The author of the equations emphasized that the moisture resources for the evaporation and runoff processes, as a rule, are not precipitation P, but general moisture H:

$$H = X + W_1 - W_2 = E + R \quad (6)$$

H - total moisture equal to atmospheric moisture X in total with a change in soil moisture over the interval. This concept had to be introduced due to the fact that, for example, in periods without rains (at X = 0), the expenditure of moisture on evaporation and runoff occurs due to a decrease in moisture reserves in the soil.

In the 1960s, the USSR carried out a large program for studying the errors of precipitation measurement with a standard instrument and compiled tables of correction coefficients k for all weather stations for each month in the average year.

Atmospheric humidification X takes into account not only the corrections for the under-account of water by the device, but also a part of the winter snow reserves s melted in this spring interval [7]:

$$X = kP + s \tag{7}$$

P - precipitation, measured over the interval, k - correction factor to compensate for wind underestimation; s is the contribution of snow melting,

W1 and W2 - moisture reserves in the active layer at the beginning and at the end of the calculation interval, E - total evaporation,

R - elementary runoff in the area of the weather station. All members of the equation are expressed in millimeters.

The second equation of the system is the equation of the relationship between the elements of energy and water balance:

$$E = (Te / L) \cdot [1 + (LH / Te)^{-n}]^{-(1/n)} \tag{8}$$

Here, Te / L = Em - water equivalent of heat resources of evaporation in mm, LH / Te = H / Em– humidification coefficient equal to the ratio of moisture resources to heat resources (in units of water equivalent), n is a parameter whose value depends on runoff conditions: n = 3.0 - for plains in warm countries and countries with a temperate climate, n < 3.0 - for conditions of increased runoff in the permafrost zone and in mountainous areas.

In the Mezentsev equations, it is necessary to use only Em, and not the potential total evaporation E used by irrigators in warm countries.

The interpretation of the analytical relationship between evaporation and heat and moisture resources is fundamentally different from the rigid schemes of the coupling equations presented by other authors and suitable only for the annual interval. It is distinguished by its versatility with respect to the estimated interval (from year to day and hours) and the flexibility of the exponent (8) - taking into account the flow conditions.

The third equation of the Mezentsev system is the dependence of the average soil moisture on the moisture coefficient:

$$V_a^r = H / Em \tag{9}$$

$V_a = W_a / W_f$ - average relative soil moisture,

W_a - average soil moisture, mm, W_f - effective field moisture capacity, mm, r is a parameter characterizing the ability of soils to conduct moisture to the evaporation surface.

The fourth equation represents the dependence of average humidity from the beginning to the end of the current interval:

$$V_a = 0.5\ (V_1 + V_2) \tag{10}$$

The system of four simple equations (6), (8), (9), (10) with four unknowns (V_2, V_a, E, R) can be used to calculate runoff and evaporation over hundreds of consecutive time intervals by transmitting the result of calculating the final moisture content W_2 the previous interval to the subsequent interval in the role of the initial humidity W_1. The calculation constants are the quantities n and r, as well as W_f.

In 1960 - 1990, water balance elements were calculated for many regions of North-East Eurasia only for annual and monthly intervals. The fact is that in the pre-computer era, data preparation was carried out manually and took a lot of time. Therefore, there was no way to make a daily calculation. But at the beginning of the XXI century, when electronic databases were created and published, it became possible to try to calculate the runoff and evaporation at daily intervals. The first calculations of runoff and evaporation for thousands of consecutive intervals in 2011 showed that it is possible to extract previously unknown valuable hydrological information from a meteorological database [8].

Using the developed computer system, it is possible to obtain not only the values of the elements of current water balances, but also such characteristics as the transfer of moisture from one interval to the next, the value of the initial and average soil moisture, lack of moisture compared to the optimal value (to obtain the highest yield).

2.3. Software and Data Preparation for Calculations

In 2006, the data of daily measurements of air temperature and precipitation of 220 weather stations of the USSR in the amount of about 30 million numbers were downloaded from an open source [9] from files in text format to the built-in SQL database. The calculation results were also placed in a special built-in database. for constructing chains of hydrographs and contour maps of the entire territory in daily, ten-year, monthly, and annual resolutions [10,11].

Errors were detected and corrected in an electronic database using several filters. Calculations of current water balances were performed for 120 weather stations in Siberia, the Far East, as well as for some stations in the nearest territories of the Urals and Kazakhstan. In addition, calculations were made for dozens of stations in the European territory of the USSR and Central Asia (Moscow, Sochi, St. Petersburg, Riga, Tashkent, etc.). The Sochi Weather Station is the only one in the USSR where there is no cold period and calculations were made for each day of each year, including the winter months. Table 1 contains a list of names of weather stations, the data of which were used to calculate the elements of the water balance. And building a series of contour maps. Figure 1 shows the location of all 220 weather stations.

The values of the parameter n in the communication equation (7) can vary depending on the type of landscape and the territory of distribution of frozen soils - from n = 1,0 in the extreme northeast of Eurasia, where the thickness of frozen soil reaches hundreds of meters, to n = 3.0 - outside the frozen zone.

2.4. Weather App Software Package

The package includes several modules for automating preparatory work, for real computing, saving results in tables of the embedded SQL database, for visualizing tables, and for creating contour maps. In addition, the package has a module for creating maps of the coefficient of variation of any uniform values, as well as a module for analyzing rain floods. For mass calculations of water balance elements, it is necessary to conduct a preliminary study of the vector of average daily air temperatures of a given weather station for the absence of gaps in the observation data and set the first and last dates of the vector for calculation. A special module is used to calculate current water balances in warm countries. The absence of snow cover, frozen soils and the processes of redistribution of winter precipitation during the snowmelt period simplifies and refines the calculations.

Table 1. *List of 120 weather stations in Siberia and the Far East.*

A -D	E - Ku	Ky - Pro	Ru - Z
Adamovka	Ekaterinburg	Kyra	Rubzovsk
Ajan	Ekaterinburg	Leushi	Semipalatinsk
Aktubinsk	Ekaterino-Nikolskoe	Magadan	Seymchan
Aldan	Ekimchan	Markovo	Skovorodino
Alexandrovsk (Sachalin)	Eniseisk	Minusinsk	Sretensk
Alexandrovskoe	Erbogachen	Mogocha	Suntar
Anadyr	Habarovsk	Mys Kamenny	Surgut
Aralskoe More	Hantymansyisk	Mys Shmidta	Syktyvkar
Archara	Hatanga	Mys Zolotoi	Tara
Atbasar	Hoseda-Hardt	Narjan-Mar	Terney
Baikit	Icha	Nikolaevsk-na-Amure	Tobolsk
Balchash	Irgiz	Nishneudinsk	Tomsk
Barabinsk	Irkutsk	Njaksimvol	Troizko-Pechorskoe
Barguzin	Irtyshsk	Norsk	Troizky Priisk
Barnaul	Isit	Ochotsk	Tura
Berezovo	Ivdel	Oimjakon	Turgay
Biser	Izevsk	Oktjabrskaja	Turuchansk
Blagoveshensk	Kamenskoe	Olekminsk	Ulan-Ude
Bodaibo	Karaganda	Olenec	Ushno-Kurilsk
Boguchany	Karsakpai	Omsk	Ust-Maja
Bomnak	Kirensk	Pechora	Vanavara
Borzja	Kjachta	Perm	Verchoiansk
Celinograd	Kluchi	Petropavlovsk - Kamchatsky	Viluisk
Chara	Kolpashevo	Petropavlovsk	Vitym
Chita	Korf	Podkamennaja Tunguska	Vladivostok
Chokurdach	Krasnojarsk	Pogranichny	Vrangelja
Chulman	Krasnoufimsk	Poliny Osipenko	Yakutsk
Dalnerechensk	Kurgan	Poronaisk	Zaisan
Dikson	Kustanai	Providenia	Zhigalovo

Every winter for five months in Russia, precipitation is snow, which accumulates until the end of March. During this season, the soil freezes, there is no elementary runoff, evaporation in the north is 10 mm, in the south of the territory - 40 mm. [12,13]. Therefore, the entire winter season for the computational algorithm is

Volume 3, Issue 1, 2020 ISSN: 2664-0848
DOI: https://doi.org/10.31058/j.water.2020.31002

considered as one interval. In one of the program modules, the correction of the measured amounts of liquid precipitation was made according to [14]. Correction of measured solid precipitation for each winter is much more difficult.

Figure 1. *Weather stations database meteo.ru. 2006.*

2.5. The study of the parameter n in equation (8)

The parameter n in equation (8) takes different values under different conditions of runoff formation. To determine the local value of the parameter n, it is necessary to perform several options for calculating the runoff and compare the results with the measured runoff. The highest correlation coefficient corresponds to the true value of n. Numerical experiments made it possible to obtain a map of the parameter n of the study area (Figure 2).

Figure 2. *The values of the parameter "n" from equation (7).*

The values of the parameter n in the communication equation (7) can vary depending on the type of landscape and the territory of distribution of frozen soils - from n = 1,0 in the extreme northeast of Eurasia, where the thickness of frozen soil reaches hundreds of meters, to n = 3.0 - outside the frozen zone.

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3. The Results of Mass Calculations of Soil Moisture, Elemental Runoff and Actual Evaporation

As a result of the calculations based on temperature and precipitation measurements, until 2006 a large volume of calculated runoff and evaporation values was obtained. A rough estimate of the amount of hydrological information obtained can be made if we multiply the number of weather stations (120) by the number of years of observation (45 years on average), by the number of intervals (200) and increase by 2 (the number of variables is R and E). Thus, we obtained more than 2,000,000 daily values of runoff and evaporation. Below is only a very small part of the results. To print the results of the calculation of water balance elements for all 120 stations, it is necessary to prepare more than 30 thousand pages of text. These are almost 80 A4 volumes of 400 pages each. The calculation results are presented in the form of tables, diagrams and contour maps. Fragments of the calculation results are shown in Table 2 - Table 4, as well as in Figure 3 - Figure 9.

Table 2. *Daily elements of the water balance, calculated according to the materials of the Petropavlovsk-Kamchatskaya meteorological station, mm / day.*

Date	X	Em	E	R
01.10.1983	0	2,8	1,3	0,4
02.10.1983	0	3,1	1,5	0,5
03.10.1983	1,1	2,4	1,2	0,4
04.10.1983	7,6	2,4	1,2	0,4
05.10.1983	0	2,1	1	0,3
06.10.1983	47,5	2,4	1,3	0,5
07.10.1983	20,5	2,8	1,7	0,9
08.10.1983	2,2	2,4	1,5	0,9
09.10.1983	0	2,4	1,5	0,9
10.10.1983	0	1,7	1,1	0,6
11.10.1983	0	1,4	0,8	0,5
12.10.1983	62,6	2,1	1,4	1
13.10.1983	32,4	1,7	1,3	1,2
14.10.1983	0	1,7	1,3	1,3
15.10.1983	0	1,7	1,3	1,3
16.10.1983	0	1,4	1	1
17.10.1983	2,2	1,7	1,3	1,2
18.10.1983	30,2	2,1	1,6	1,6
19.10.1983	10,8	1	0,8	0,9
20.10.1983	3,2	1,7	1,3	1,6
21.10.1983	0	1,4	1,1	1,3

22.10.1983	0	1,4	1,1	1,2
23.10.1983	0	1	0,8	0,9
24.10.1983	6,5	0,7	0,5	0,6
25.10.1983	16,2	1,4	1,1	1,3
26.10.1983	0	1,4	1,1	1,3

The calculation Table 2 was made for 4,856 daily intervals of 1960 – 1984.

Table 3. *Monthly amounts of water balance elements calculated according to the weather station Sochi, mm / month.*

Month / Year	X	Em	E	R
01.2001	62,2	56,6	42,0	8,2
02.2001	243,1	49,5	40,1	17,5
03.2001	163,2	85,2	81,6	83,7
04.2001	179,5	94,3	90,3	92,5
05.2001	191,8	117,3	108,7	76,7
06.2001	118,2	145,0	125,5	59,9
07.2001	61,6	192,5	133,8	24,4
08.2001	131,3	199,8	73,3	1,7
09.2001	149,9	154,5	107,7	16,9
10.2001	295,8	110,9	86,3	29,8
11.2001	215,3	83,3	78,3	71,5
12.2001	305,3	62,9	61,3	94,4
01.2002	256,4	37,6	37,5	120,7
02.2002	135,4	54,8	54,4	145,5
03.2002	98,8	75,6	74,3	131,1
04.2002	140,8	82,3	80,0	107,0
05.2002	47,9	126,2	111,3	63,4
06.2002	245,4	151,5	133,0	67,2
07.2002	103,0	192,8	130,0	21,6
08.2002	213,1	179,3	145,4	48,2
09.2002	109,1	158,9	112,0	18,3
10.2002	381,5	132,1	103,4	31,5
11.2002	78,8	99,7	93,8	80,6
12.2002	193,1	45,2	41,4	30,5

Table 4 presents a fragment of the results of the annual summation of the daily values of the elements calculated for the Sochi station for 1945 - 2003.

Table 4. *The annual amounts of the elements of the daily water balance, mm / month, calculated at daily intervals. Meteorological station Sochi.*

Year	KX	Zm	Z	Y
1988	2390	1248	1085	993
1989	2080	1253	1029	996
1990	1659	1268	970	655
1991	2041	1277	1067	688
1992	1969	1186	946	885

1993	1396	1195	808	601
1994	1673	1296	824	378
1995	2382	1300	1165	1112
1996	1820	1311	1048	595
1997	1964	1242	1057	837
1998	1282	1357	751	458
1999	1889	1354	1014	593
2000	1542	1318	967	596
2001	2117	1352	1029	577
2002	2003	1336	1117	866

Figure 3, Figure 4 show fragments of long chains of runoff and evaporation hydrographs calculated for the first time without any hydrometric and lysimetric measurements.

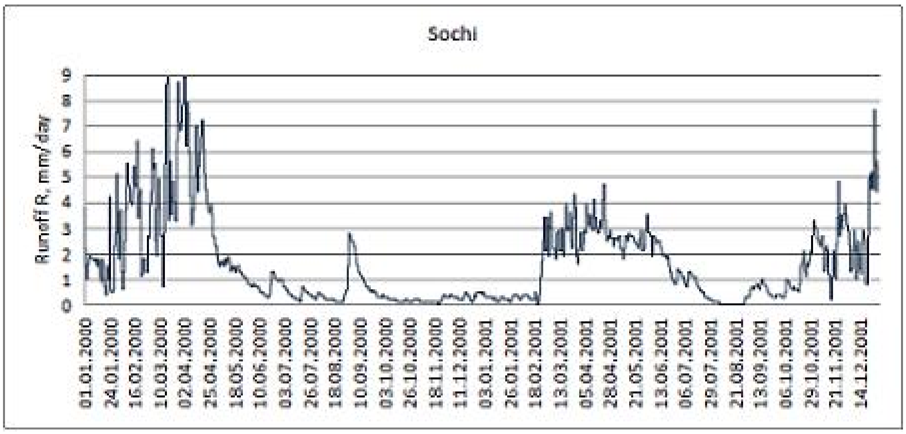

Figure 3. *Daily runoff calculated according to the data of the Sochi weather station, mm / day.*

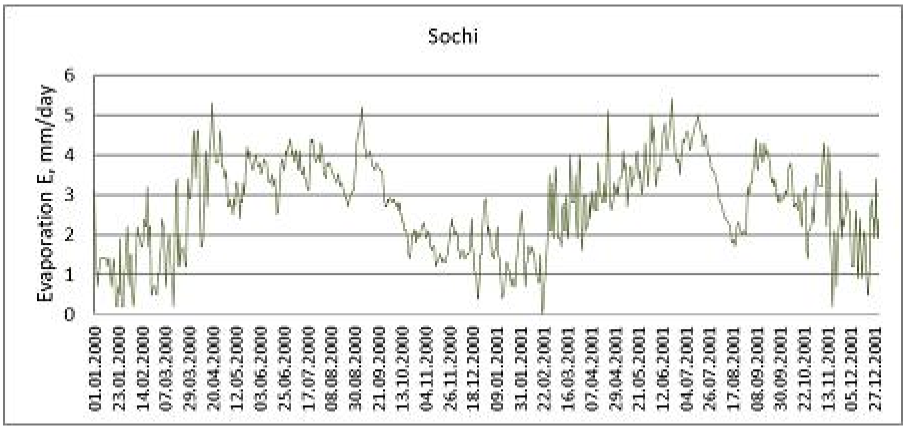

Figure 4. *Calculated daily evaporation rate in Sochi in 2000 – 2001.*

Figure 5-Figure 8 show several examples of contour maps of runoff and evaporation.

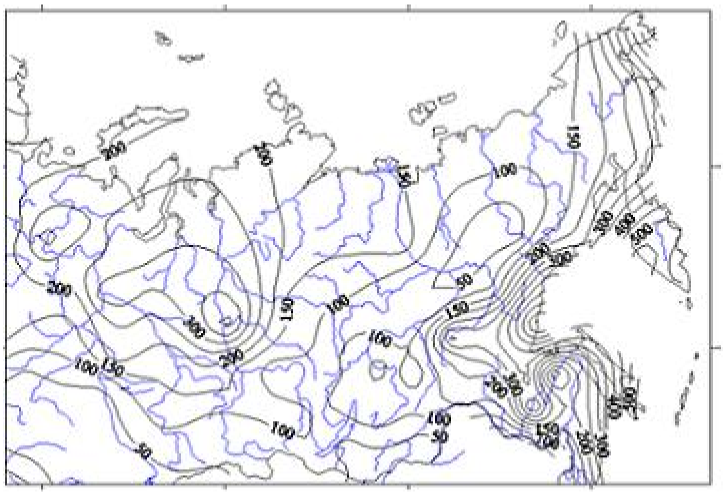

Figure 5. *Layer of annual runoff as the sum of daily values. 1970, R mm / year.*

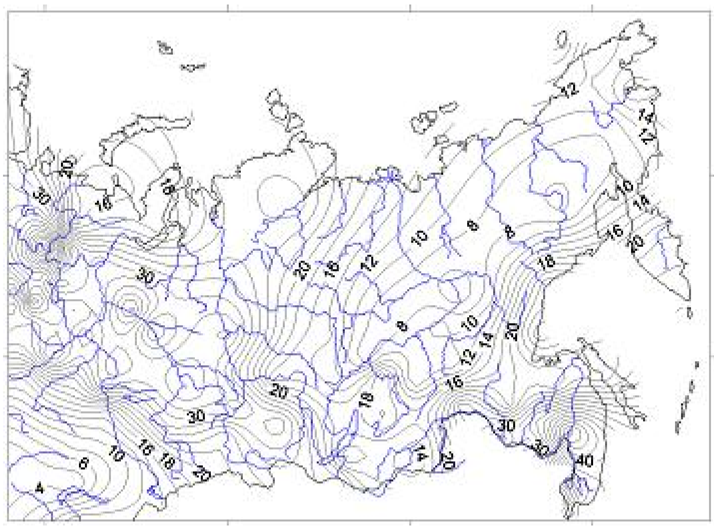

Figure 6. *Actual evaporation in the 3rd ten-day period of July 1970 E, mm / decade.*

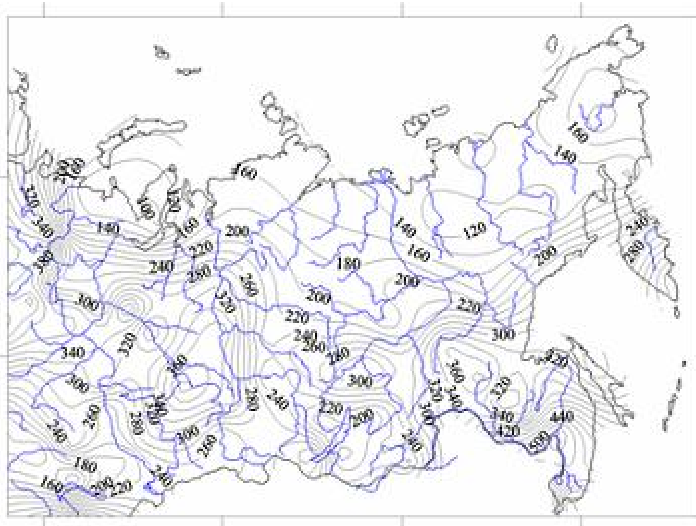

Figure 7. *The annual amount of evaporation E, mm / year.*

Volume 3, Issue 1, 2020 ISSN: 2664-0848
DOI: https://doi.org/10.31058/j.water.2020.31002

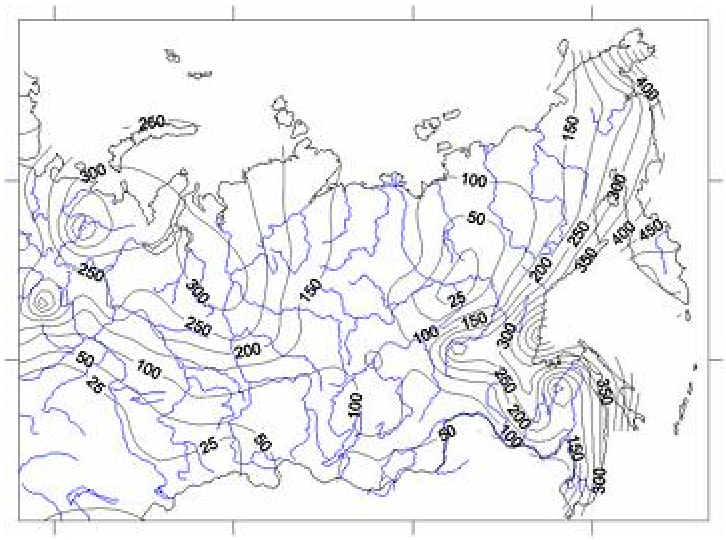

Figure 8. *The annual flow rate R, mm / year.*

3.1. Mass Control of the Reliability of the Calculation Results

In the 1960s and 1980s, it was possible to compare the estimated runoff with that measured only for the south of the taiga of Western Siberia, where the rivers have a fairly dense network of gauging stations. Here, in conditions of exceptional flatness of territories, the runoff layer does not depend on the catchment area. Then the first results of monitoring the estimated annual and monthly runoff and soil moisture values were obtained and the correctness of the calculated runoff values was established. Thus, more than 40 years ago, hydrologists and hydraulic engineers were convinced that for unexplored areas of Siberia, it is possible to use the estimated flow for practical purposes. But only thanks to the creation of electronic databases, such enormous work became possible as a mass comparison of the daily values of runoff and evaporation with the measured ones [11].

Figure 9. *Map of weather stations for which the calculated runoff and evaporation results were compared with the measured values.*

For objective and comprehensive control of the mass of the calculated values of the elements of the water balance, several sources of measurement data were used: materials of the State Water Cadastre [15,16,17,18], observations of stations of the International Hydrological Decade [19,20] and others. A detailed report on the work done is given in the monograph [11]. Figure 9 shows a map of 35 meteorological stations for which it was possible to use appropriate measurements at the nearest river catchment or lysimetric station and carry out a check for several consecutive years with monthly and even daily intervals.

Despite the fact that the catchment area exceeds the area of the receiving opening of the precipitation gauge by a trillion times, in many cases in specific years and months the flow values differ from the measured values by no more than 10–20%! This indicates a significant representativeness of meteorological data for catchments of large rivers. This fact indicates a fairly high reliability of the runoff obtained by calculation according to meteorological data. Figure 10 shows the results of comparing the runoff calculated from temperatures and precipitation in Sochi with the measured runoff in the Sochi River, near the village of Plastunka. Since the average annual rainfall in 1967 - 1972. at a meteorological station near the sea it turned out to be equal to 1500 mm, and in the mountains at the catchment basin - 2155 mm, it is impossible to compare the absolute values of runoff. Therefore, to assess the tightness of the connection, the values of the layer of the calculated runoff were normalized and expressed in fractions of the average value. The average monthly water discharge in the Sochi River is expressed in fractions of the average for all months, equal to 14.1 cubic meters per second, and the average monthly runoff layer, calculated daily, in fractions of the average for all months (44.9 mm / month).

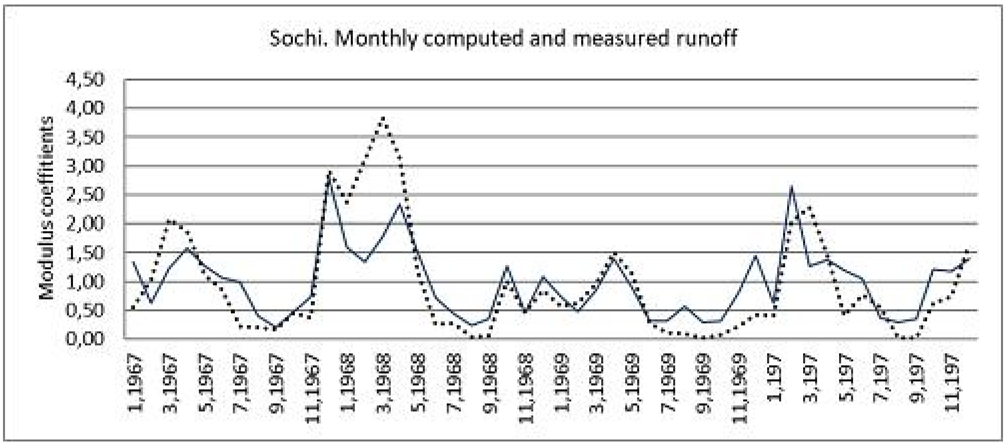

Figure 10. *The monthly amount of daily runoff calculated for the Sochi weather station and the average monthly hydrometric flow of water in the Sochi River near the village of Plastunka.*

To verify the reliability of annual runoff amounts calculated from meteorological data at daily intervals for each of the 72 weather stations in Siberia, the value of the hydrometric runoff was determined from the Atlas map [21]. In Figure 11 shows a correlation graph of the relationship between calculated and measured values.

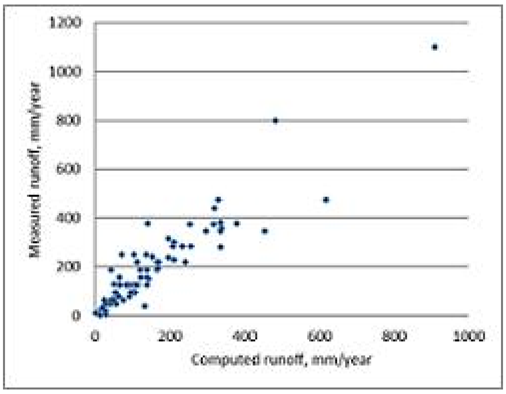

Figure 11. *Comparison of annual runoff rates calculated from daily intervals with hydrometric runoff [21], (mm / year). Correlation coefficient r = 0.933.*

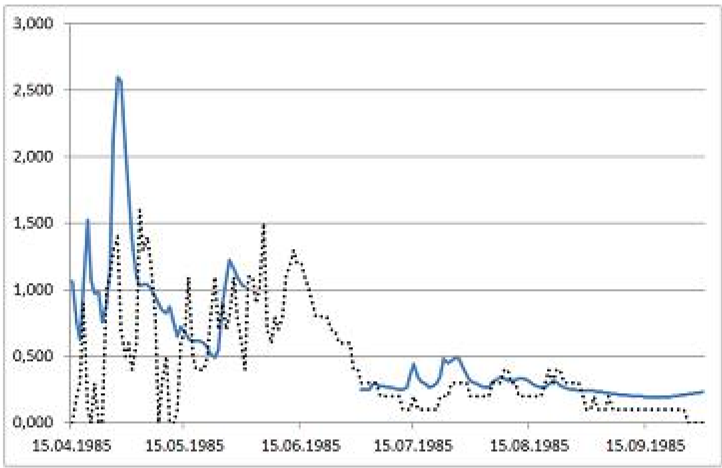

Figure 12. *Calculated daily layers of a local runoff based on the data of station Tobolsk (dashed line) and measured in the river Aremzjanka - village Chukmanka. Daily discharges are counted in units of a layer (mm / day), 1985.*

In Figure 12 shows a comparison of the calculated runoff for Tobolsk with that measured in the neighboring Aremzianka River in 1985. Within 30 days of June there were gapless omissions of measurements of the levels. However, they can be restored on the calculated runoff. Figure 13 shows the point charts of the comparison between the computed evaporation monthly sums and measured sums for the 31 summer months from April to October 1967 - 1971 in Omsk. The correlation coefficient is 0.80. Table 5 shows the correlation coefficients between the calculated and measured monthly amounts of evaporation for several weather stations in the study area.

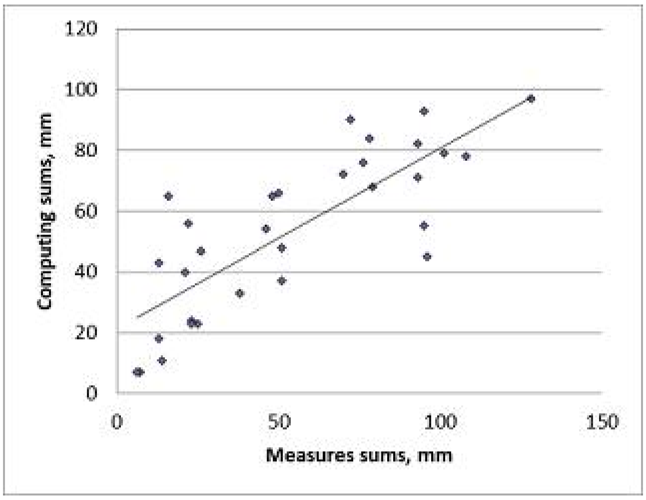

Figure 13. *The reliability control of the computed evaporation in Omsk. Coefficient of correlation of monthly sums of evaporation from the May and up to October equal 0.96 and 0.95.*

The given examples of correlations are characterized by the tightness of the connection r = 0.80 - 0.95, which indicates the reliable quality of the results of mass calculations of hydrological characteristics calculated from meteorological data. However, sometimes quite small values of the correlation coefficients appear. This can only be explained by inaccurate measurements, since the mathematical scheme is always unchanged and cannot give good results for some stations and bad for others. However, it cannot be said that our calculation system takes into account all factors of runoff and evaporation formation.

Volume 3, Issue 1, 2020 ISSN: 2664-0848
DOI: https://doi.org/10.31058/j.water.2020.31002

Table 5. *Correlation coefficients of monthly evaporation amounts for the summer season (May to October) of each year.*

Meteorological station – Lysimeter station	1967	1968	1969	1970	1971	1972	1974
Vladivostok – Primorskaja	0.67	0.73	0.73	0.26	0.8	**0.93**	**0.92**
Chabarovsk –Chabarovskaja	**0.98**	0.83	0.82	**0.96**	0.85	0.67	**0.93**
Seymcjan - Kolimskaja	**0.96**	**0.97**	**0.99**	0.77	**0.98**	0.89	0.83
Yakutsk – Pokrovsk	**0.93**	**0.996**	**0.92**	–	0.79	–	0.79
Minusinsk – Chakasskaja	**0.993**	**0.98**	0.78	–0.07	**0.99**	**0.97**	0.67
Nishneudinsk – Tulun	0.19	0.86	**0.92**	0.83	0.85	**0.94**	**0.93**
Surgut -- Sytomino	–	0.89	0.67	**0.9**	**0.92**	**0.9**	0.64
Omsk –- Omsk	0.74	**0.96**	**0.95**	**0.91**	0.74	0.76	0.5
Kurgan – Kurgan	0.79	–	**0.97**	0.85	–	0.14	–
Uralsk – Uralsk	–	0.82	**0.96**	0.88	**0.95**	**0.94**	**0.96**
Barnaul – Barnaul	0.51	0.85	0.62	0.51	–	**0.9**	– 0.17

3.2. Reasons for the Inequality Between the Calculated Values of Runoff and Evaporation and Measurement Data

There are many reasons for the discrepancy between the calculated and measured values of the elements of the water balance. According to official data, the accuracy of measurements in the networks of national meteorological services does not exceed:

± 10% - relative to the measured water consumption,

± 10–15% - for measuring liquid precipitation,

± 50–100% - for hard winter precipitation.

Due to the fact that precipitation is measured directly at the weather station, that is, at a point, their use for calculating soil moisture and evaporation allows us to theoretically relate all the calculation results only for a small area around the weather station, but experience shows that this, fortunately, is not So. During a rainfall over a weather station, precipitation data for a nearby catchment (the area of which is several square kilometers) are absolutely not representative, and the layer of precipitation on the catchment may be 2-3 times less than in the device. It may also happen that numerous rainfall falls on the catchment area, and there has not been a single rain over the weather station located in the center of the catchment. In such cases, any correlation between the measured and calculated values of runoff, evaporation, soil moisture will be absent.

Let's consider two more reasons causing the inequality of the calculated and measured values.

a. In the correction of solid atmospheric precipitation, large errors arise in the calculations, since we use the correction factors given for the average year for specific years.

b. In formulas for recalculating the flow of water into a layer or module, a constant nominal value of the catchment area is used, but in many cases, in the conditions of a flat topography and very gentle slopes, especially in the arid zone, the effective values of the catchment area in different years can vary significantly. Therefore, the modulus and runoff layer are obtained in different years with significant errors.

c. The calculated elementary runoff does not have a time shift, while the hydrometric runoff depends on the time at which the flow should reach the hydrometric station. The larger the coverage area, the more time it takes to reach the hydraulic ram. Observer errors in measuring water levels must also be taken into account.

4. Conclusion and Prospects

The Mezentsev system of equations is the most general and universal mathematical model of the processes of moisture conversion at the level of the active surface, since it is based on two fundamental conservation laws: energy and matter. The creation and publication of electronic databases made it possible to develop a system of mass daily runoff and evaporation calculations. Valuable hydrological information unknown to anyone previously known was found in electronic meteorological databases.

All meteorological stations, the data of which were used to calculate runoff and evaporation, are located on the terrain at altitude levels from 0 to 250-300 meters, and in Transbaikalia to heights of 600-800 meters above sea level. Thus, all the calculation results according to the weather stations characterize the flat territories - lowlands and plateaus. Most of the economic activity of the world's population is carried out on lands in the range of marks from 0 to 500 m above sea level. For example, in Eurasia and North America, 73 - 80% of the total population lives on lowlands and plateaus up to 500 m high. A significant part of the network of weather stations is located in the same range of heights. Therefore, the results of hydrological calculations based on data from these weather stations are of the greatest interest. For catchments in mountainous regions where rivers are at high elevations (from 1000 m to 4000 m), water resources can be estimated using similar calculations, for which the necessary data from weather stations located in the mountains at high levels are necessary. Therefore, in the highlands for the study of water resources, it is necessary to create not hydrological stations, but weather stations with stock stations at different heights and different expositions of the slopes.

Meteorology and hydrology have always been close scientific disciplines, however, they were divided in the minds of specialists and administratively. Now they turned out to be united in a single science, hydrometeorology based on an analytical description of the processes of conversion of atmospheric moisture into runoff and evaporation. Extraction and use of huge hydrological information from world meteorological databases is an urgent problem for hydrologists of all countries. As a result of the joint efforts of the leading states, the World Atlas of Water Resources of the Local Runoff of Small Rivers will be created and published.

Conflicts of Interest

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

Author Contributions

Conceptualization: I.V.K.; Methodology: I.V.K., K.S.A.; Software: K.S.A.; Validation: I.V.K, K.S.A.; 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, K.S.A.; Visualization: I.V.K; Supervision: I.V.K; Project administration: I.V.K; Funding acquisition: I.V.K.

Funding

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

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