Full Freezing and Drying Up of River Channel as Opposite Phenomena in High and Low Latitudes

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INTRODUCTION

Simultaneous seasonal absence of river runoff in different latitudes was investigated. The reasons of the phenomenon are full freezing and drying up of river channel. Attention is directed to coincidence in time in very distant areas and symmetric nature of the phenomena with conditional axis of symmetry in middle latitudes. The symmetry is revealed in, first, the full freezing of river channels in high latitudes is opposite to drying up of rivers in low latitudes of Northern hemisphere. The second, these phenomena are caused by opposite factors of land-surface processes and atmosphere processes. The knowledge of land-atmosphere interaction enhances our understanding of the issue in relation to climate change.

Detecting of similar natural spatio-temporal relationships has many difficulties such as:
- global scale of observations;
- necessity of simultaneous observations in different geographical regions;
- ice cover complicates to fix an absence of runoff in the river channel;
- necessity of daily observations during the long low periods;
- determination of quantiative parameters of runoff such as river discharge, volume of water;
- determination of climatic parameters such as precipitation, temperature of air, humidity, pressure, evaporation in the same periods as runoff observations.

It is possible to overcome some of the problems by remote sensing. Space satellites observations allow to detect seasonal absence of flow in river channels simultaneously on large area.

STUDIED TERRITORY AND METHODOLOGY

Investigation of hydrological variation of river runoff was conducted for the territories located in the north between 56 and 67° and in the south between 2 and 11° of northern latitude. Northern area includes middle and low stream of the Ob drainage basin (Siberia). Southern area includes catchments of the Niger (upper and middle stream), the Chary, and the rivers of Cameroon. Hydrology of all the rivers is not studied sufficiently. Total area is 3.2 million km².

Rivers with similar (zonal) type of runoff were selected for comparison of hydrological variability of runoff in different latitudes. Zonal type of runoff represents well namely climatic conditions of a region [1]. Also following conditions were taken into account:
(1) areas of river catchments have to be approximately equal to exclude influence of runoff reduction due to river length. In this research, most of hydrometric gauging points limit catchments with area from 1000 to 15000 km²;
(2) river catchments have to be of approximately equal height to exclude influence of vertical gradient of precipitation on runoff values. In this research, the catchments have mean height from 100 to 600 m;
(3) runoff values have to be measured but not estimated. Data of 225 gauging stations with total observation period of 4081 years were used in this research;
(4) only average water years have to be taken into account to exclude influence of rare events. Runoff probability used in the research was 40-60%.

RESULTS

The rivers of high northern latitudes are being covered with ice annually from November till April because of very low air temperature – Fig.1. Schuchya river is the case of such rivers. It is located in Siberia region between 67° and 68° of north latitude. Surface of catchment of the river is 1680 km² in gauge station Schuchya. Environmental zone here is forest tundra. River runoff is formed in conditions of continental climate of the type with excess humidity and insufficient warming [2]. Mean annual precipitation in this climatic zone is 350-600 mm and mean annual air temperature changes in the range of −4.0° and −9.0° C. Mean temperature of January is −22.0° C. All the rivers
are being covered with ice annually from 3 to 6 months in such climatic conditions and full freezing of rivers takes place.

Precipitation falls on a catchment surface as snow and does not effect directly on runoff value. Only groundwater provides discharge in river channels in winter period. Groundwater is located close under land surface (1.5-3.0 m) and feeds river runoff. However, the depth of soil freezing becomes 1.5-2.0 m in December. Groundwater feeding interrupts and water in river channel can freeze completely.

There is no precipitation at the same period in Africa. Groundwater is located deep under land surface and does not feed rivers. These circumstances as well as high temperature lead to drying up of river channels – Fig. 2. Gorouol river is located in the region the Niger drainage basin. Point of Dolbel in the river has coordinates 14°37′ of north latitude and 0°18′ of east longitude. Catchment area of the river in point of Dolbel is 7500 km². The environmental zone is slightly wooded savanna.

River runoff is formed by arid climate of Northern Sudan type [3]. Mean annual precipitation is in the range of 300-700 mm in this climate and mean annual air temperature is +28.6° C. Mean air temperature in January is +33.6° C. The climate of this type is characterized by two seasons those are dry season in winter and rainy season in summer. Many rivers dry up for long time in these conditions.

Another case of drying up in the south region is Mekrou river in the Niger drainage basin – Fig.3. Point of Kompongou is located in 11°24′ of north latitude and 2°11′ of east longitude. Its catchment area is 5670 km² in this point. Environmental zone is savanna.

River runoff is formed by tropical climate of Southern Sudan type here [3]. Mean annual precipitation is in the range of 700-1200 mm in this climate and mean annual air temperature is +28.5° C. Mean air temperature in January is...
The climate of Southern Sudan type is characterized by two seasons those are dry season in winter and rainy season in summer. Drying up of river channels is being observed in these conditions too.

Simultaneous absence of runoff (Fig.4.) takes place due to the same factors. However, they have opposite manifestation. They are:
(a) very low or very high air temperature;
(b) full accumulation of precipitation in form of snow on land and ice surface or complete absence of precipitation in form of rain;
(c) seasonal interruption of river runoff feeding by groundwater in the periods of soil freezing or deep location of groundwater level under land surface.

Absence of runoff in high and low latitudes has similar time characteristics:
(a) equal time period - full freezing and drying up take place during 5-6 months;
(b) similar calendar period – both phenomena takes place from December till May.

Due to analysis of hydrologic in-situ data, it was found that structure and amount of the information received through space remote sensing should provide the solution of following tasks:
• detect seasonal absence of water flow in a river channel;
• estimate frequency of these phenomena;
• detect the beginning and end of the phenomena and their duration;
• make retrospective analysis of the phenomena based on existing database of space information.

The land-surface processes are one of main point for applications to climate research and water resources management.
REFERENCES

