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Preliminary result of monitoring hydrological cycle in the Gudjareti catchment

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Abstract

This article summarizes the existing meteorological, hydrological and snow data in , installation of the monitoring network, collection of water samples, and snow hydrology fieldwork in the Gudjareti catchment. In the frame new project was organizing additional network in the catchment Mitarbi, provided a lot of new data on snow hydrology in the studied area that was not available before. Measurements at different altitudes were useful. Although snowfall represents just about 30% of annual precipitation, snowmelt water is an important source of water for the rivers (maximum contribution about 50%). Snowmelt affects river runoff at least 2-3 months. Yet, stable water isotopes in the snowmelt water significantly differ among the sites and they are different from those in the snow cover.

Introduction

The study area is situated in the southwestern part of Georgia, in the Little Caucasus Mountains, the Adjara-Trialeti range. The altitude ranges from about 800 m a.s.l. at the Borjomi city to about 2900 m a.s.l. at the highest mountain peaks. Mean annual mean air temperature is 8.3°C in Borjomi (altitude 794 m a.s.l.), 4.4 °C in Bakuriani (altitude 1703 m). Mean air temperatures of the warmest months (July, August) in Borjomi, Bakuriani and the slopes of the study area are 19°C, 14°C and 9-10°C, respectively. Mean air temperatures in January are 2.8, -5.5 and -9°C, respectively. The mean annual precipitation amount in the area varies from 650 to 950 mm in Bakuriani (3).

The The first hydrometeorological monitoring and sampling network in the Borjom-Bakuriani area was established through the projects of the International Atomic Energy Agency (IAEA) “Using Isotope Techniques to Assess Water Resources in Georgia” (2007-2009) and “The Role of Snow in Hydrological Cycle of the Borjomula-Gudjaretis-Tskali Rivers Basin, Georgia” (2010-2013). This network is now being used in the framework of the project "Snow resources and the early prediction of hydrological drought in mountainous streams 2013 – 2016" funded by the Swiss National Science Foundation (2014-2017). This project includes monitoring in a newly equipped small experimental catchment Mitarbi since September 2014. The main goal of this project is assessment the role of snow in the generation of low flows and a better prediction of hydrological droughts in mountainous catchments.

Sampling methodology

The sampling methodology of this study focuses on data generation that describes the altitudinal evolution of the main climatic characteristics in the study area. The following sampling and monitoring concept was set up (Fig. 1):

- Monthly composite samples of precipitation (P) are collected in Hellman raingauge at four elevations- Tsagveri, Tba, Bakuriani and Mitarbi (new station). Air temperature (T) and air humidity (H) data (hourly time interval) are measured along by the HOBO sensor. Three water level gauges (WL) were installed at the Borjomula, at the Gudjareti and Mitarbi (new station) river. The gauges are equipped with the pressure transducer HOBO diver, providing hourly measurements.
- Sampling in monthly step are carried out on the three rivers, two springs Daba and Sadgeri, and the Tba borehole, for analyses of stable isotopes ^{18}O and ^{2}H.

- Snow course measurements (Snow Depth, Snow Water Equivalent) are conducted at 5 locations (elevations), along with samples for analysis of stable isotopes ^{18}O and ^{2}H.
- Snowmelt water sampling (SC) is conducted at four locations: Tba, Bakuriani, Tsagveri and Mitarbi (extended funnel gauge, plastic and tin snow lysimeters). Passive (Frisbee) samplers are placed at three locations –Tba, Tsagveri and Bakuriani.

During the first project year, monthly trips to the catchments were performed for water and snow sampling for the stable isotopes determination, sites maintenance and data acquisition of groundwater level and meteodata.

Analyses of ^{18}O and ^{2}H were performed by the Picarro Laser Water Isotope Analyzer at the Institute of Geophysics of Ivane Javakhishvili Tbilisi State University.

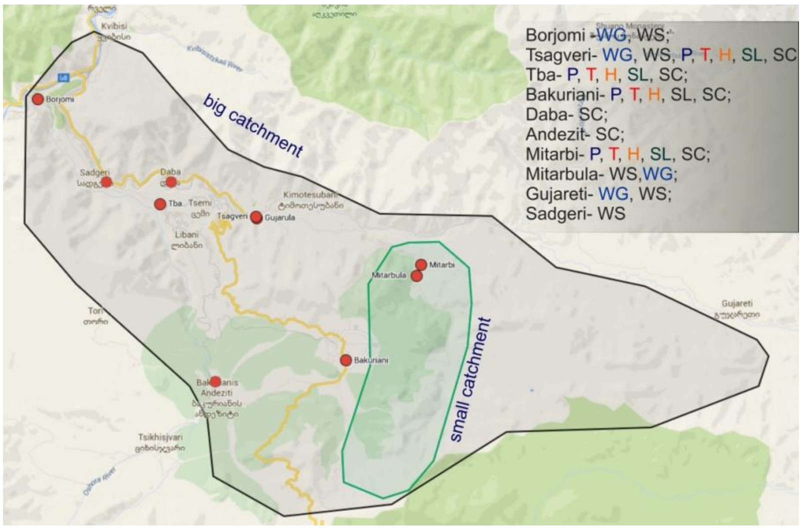

Fig. 1. Monitoring and sampling points in the studied area.

Monitoring results

During two years of monitoring, a good correlation of air temperature among three main experimental sites in the study area was observed Monitoring results show that winters of 2014 and 2015 were short.

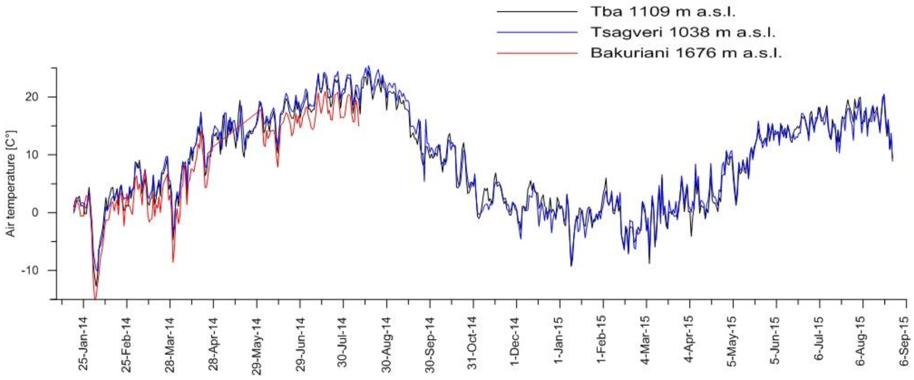

Fig.2 Air temperature monitoring data, 2014-2015.

The precipitation data for 2014 and 2015 (Fig.3) show that about 30% of annual precipitation is snow-solid.

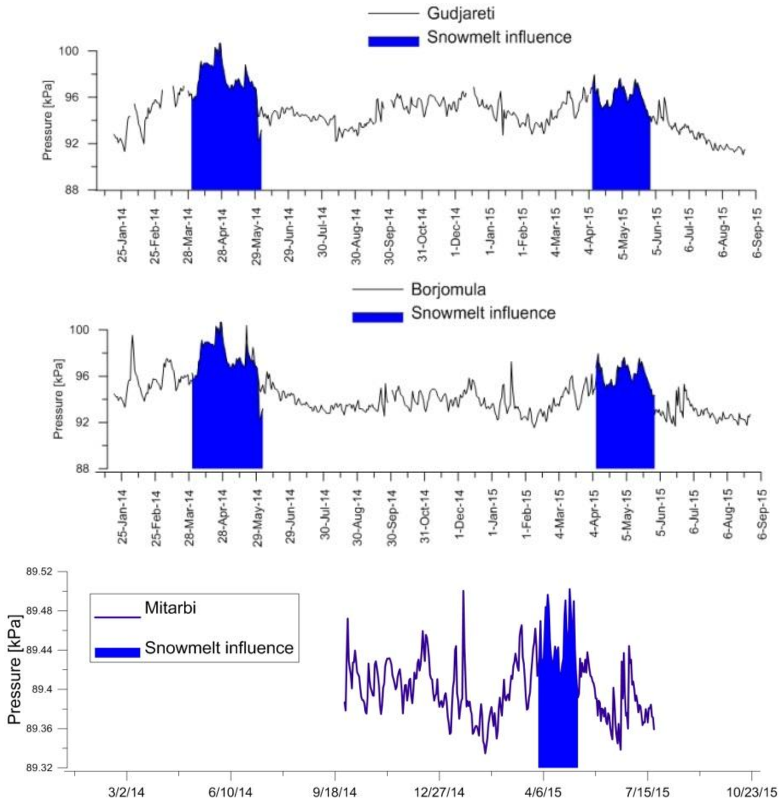

Fig. 3. River water level monitoring data 2014-2015, with indicated snowmelt periods.

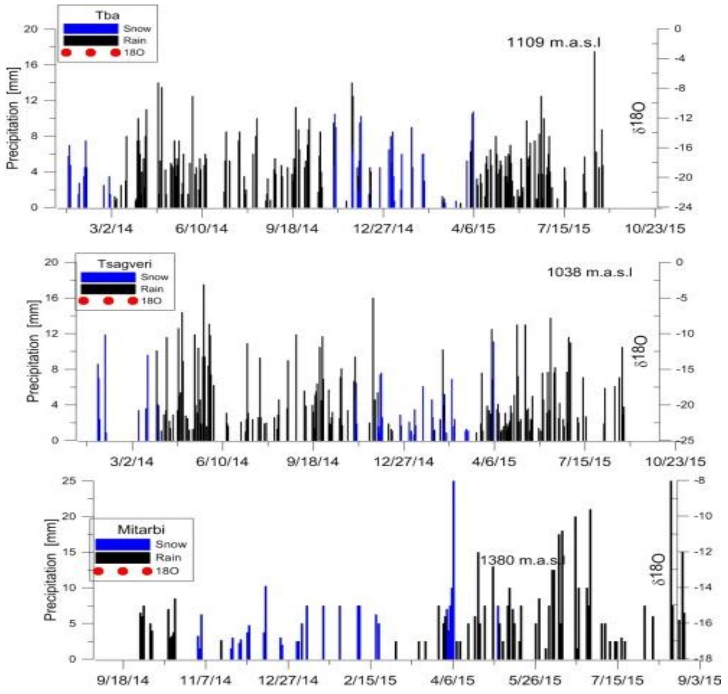

Fig. 4. Monitoring data 2014-2015, precipitation of rain and snow and its ^{18}O-content

Based on the figures 3 of river water level we can conclude that snowmelt periods for 2014 and 2015 were not long. The snowmelt period in 2014 started on February 15 and finished in the middle of March. The snowmelt period in 2015 started in the end of March and ended in April.

Fig. 4 shows that, maximum snow water equivalent (SWE) is observed in the lower part of the study area, representing about 60-80% of solid precipitation. The duration of the melting period varies between 2-3 weeks.

Fig. 5 shows the variability of ^{2}H in precipitation at different altitudes, rivers and groundwater. Groundwater does not differ isotopically from the rivers. It indicates that both the rivers and shallow groundwater come from the same source. As expected, the groundwater is generally isotopically heavier than river water. Snow cover during the snowmelt becomes isotopically enriched.

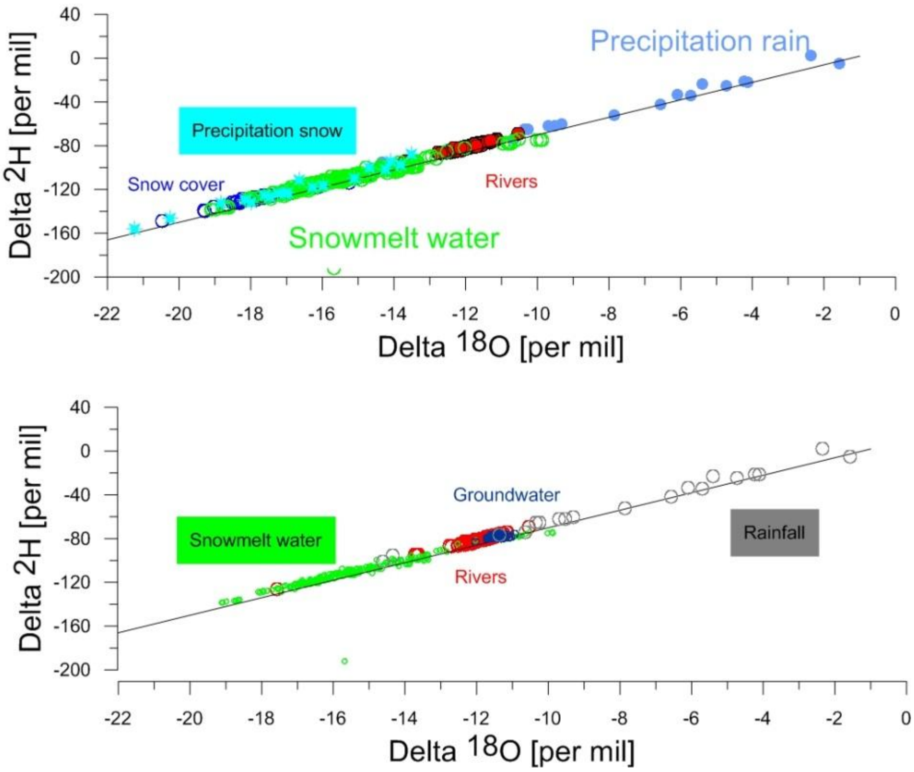

Fig 5 Isotopic composition of waters in the study area

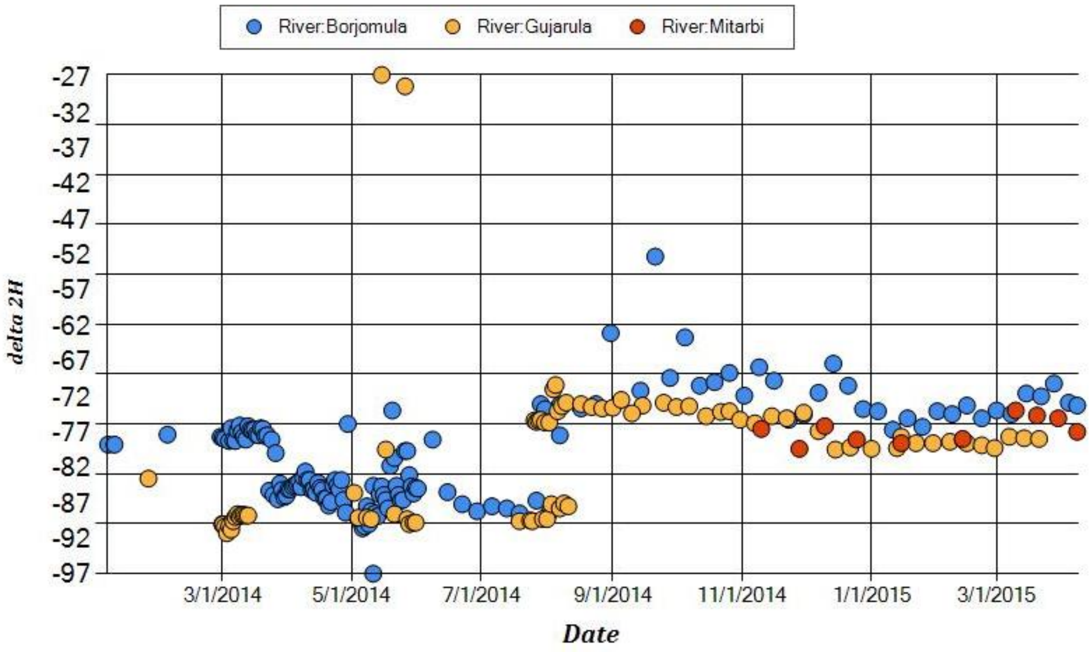

Fig. 6 Monthly ^{2}H isotopic composition of rivers in the study area, 2014-2015

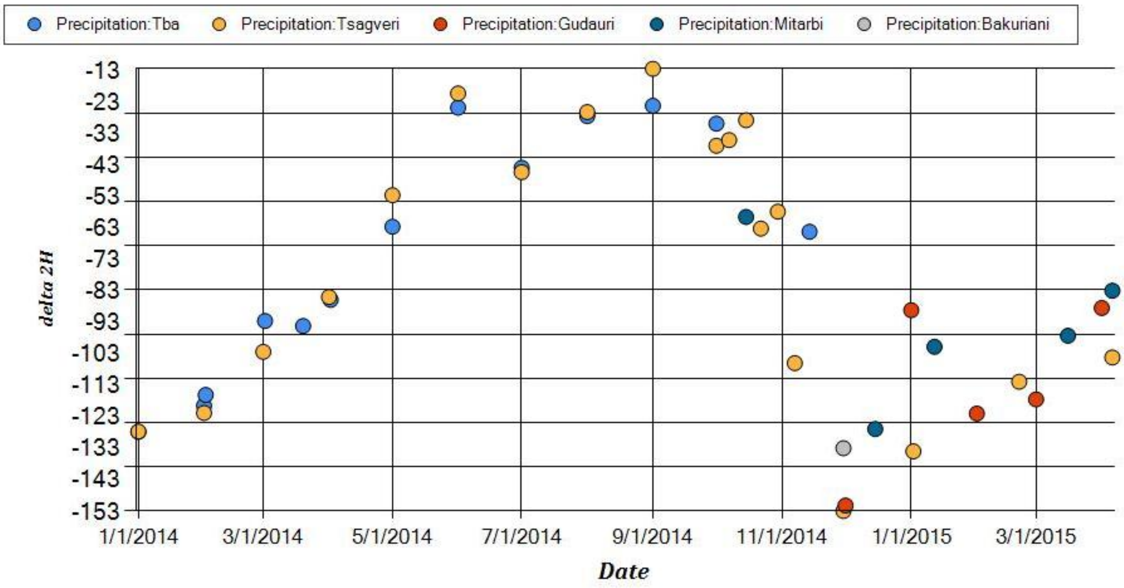

Fig. 7 Monthly ^{2}H-content in precipitation in the study area, 2014-2015

Fig. 7 reveals the typical seasonal variation of the isotopic composition of precipitation.

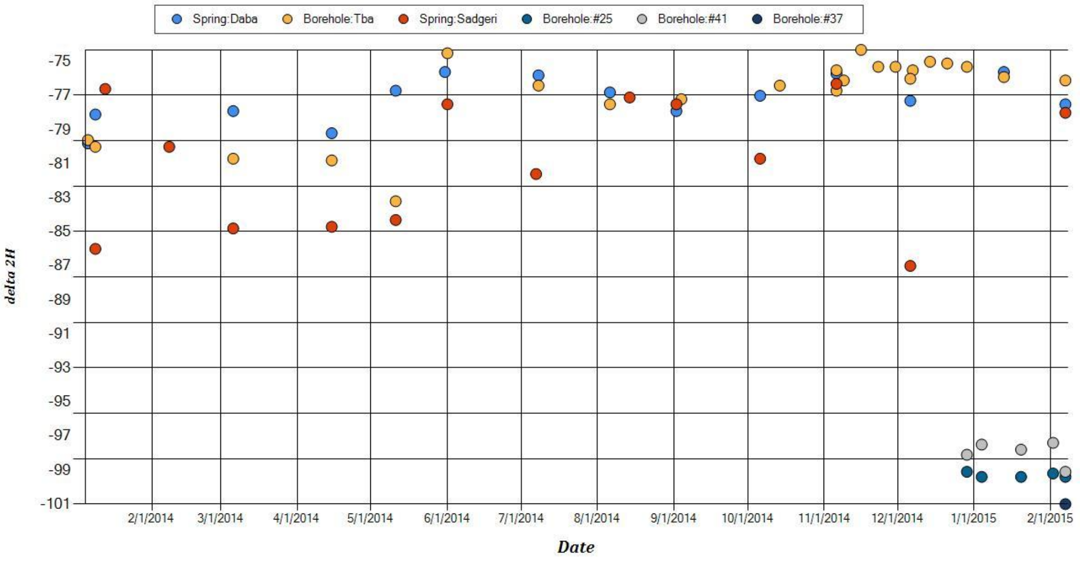

Fig.8 Monthly ^{2}H – content in groundwaterin the study area, 2014-2015.

Fig. 8 shows that the variations of isotopic composition of groundwaters Tba, Daba and Sadgeri are similar. Groundwaters in the boreholes 25, 37 and 41 are isotopically depleted, indicating old mineral (paleo) waters. This phenomenon is shown also on Fig. 9

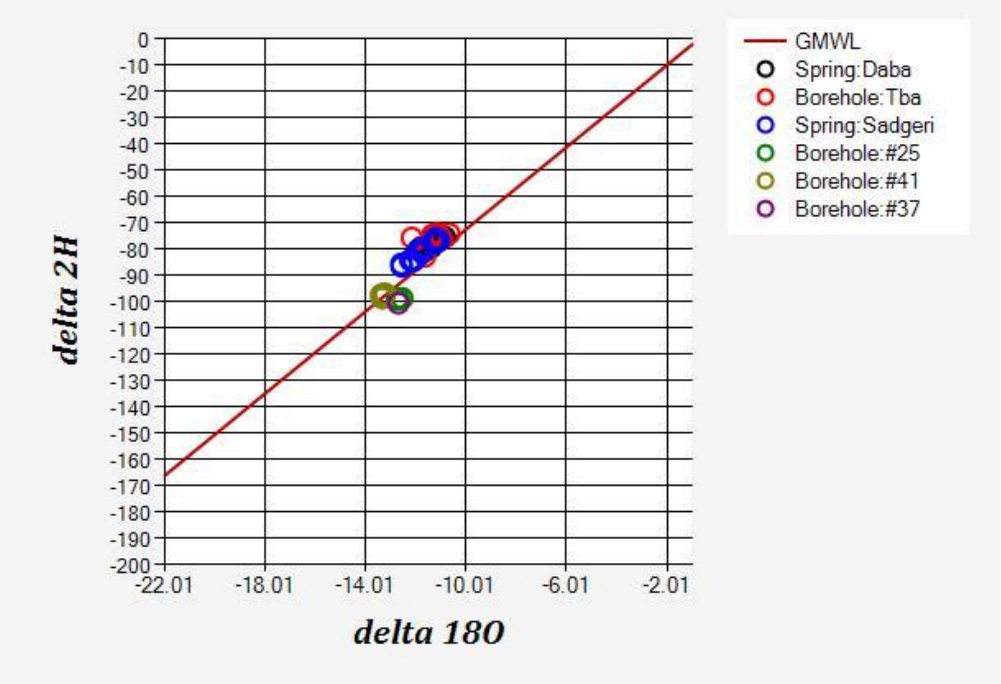

Fig. 9 Relationship ^{2}H-^{18}O in groundwaters from springs and boreholes in the study area, 2014-2015

Historical runoff data were assessed (Fig.10) in order to estimate potential evapotranspiration a better simulation of low flows and mitigation of hydrological droughts.

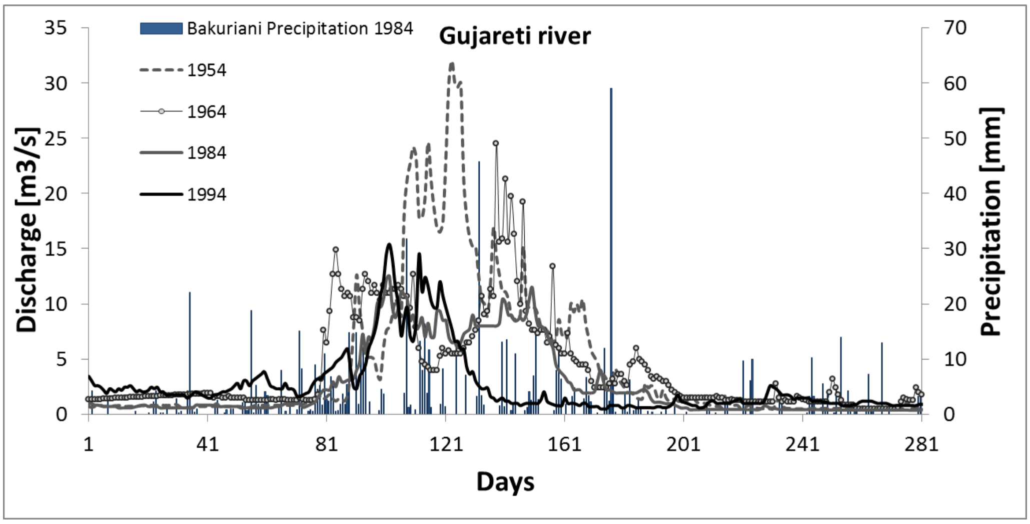

Fig. 10 Gudjareti River discharge at Tsagveri.

Peak stream flows occur in response to snowmelt and snowmelt mixed with rain. A decreasing magnitude of flow peak can be also observed on Fig.10

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Data of 2014-2015 show that air temperatures increased approximately around the middle of March, but a more intensive snowmelt started a few days later. Water levels in the rivers increased as a response to the snowmelt and later the typical snowmelt runoff regime (diurnal variability of runoff) evolved. Isotopic composition of snowmelt water sampled at Bakuriani by means of the smaller tin and the larger plastic lysimeters were mostly similar, except the beginning of the snowmelt period.

Snowmelt water at Tsagveri (lower altitude) during more intensive snowmelt was isotopically lighter than at Tba (higher altitude, but more exposed to sunshine radiation).

River water reacted to increased snowmelt input in the middle of March, following rainfall on March 19 and continuation of snowmelt since March 26 of 2015.

Conclusions

- The moitoring network established in the project has provided a high amount of new data on snow hydrology in the studied area (solid-liquid precipitation, hourly variability of water levels in the rivers, snow cover characteristics, stable water isotopes,…).
- Although snowfall represents only about 30% of annual precipitation, snowmelt water is an important source of water for the rivers (maximum contribution about 50%).
- Snowmelt affects river runoff during at least 2-3 months.
- Snowmelt is thus important also for water availability in dry summer period.
- Stable water isotopes in the snowmelt water significantly differ among the sites and they are different from those in the snow cover.

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გიორგი მელიქაძე, ნატალია ჟუკოვა, მარიამ თოდაძე, სოფიო ვეფხვაძე

აბსტრაქტი

სტატიაში გაანალიზირებულია არსებული მეტეოლოგიური, ჰიდროგეოლოგიური და თოვლის საფარის მონაცემები. ხორციელდებოდა ექსპედიციები წყლის და თოვლის საფარის სინჯების აღების მიზნით. ახალი პროექტის ფარგლებში დამატებით მიტარბის მდინარის აუზში ორგანიზება გაუკეთდა სამონიტორინგო ქსელს, რომლის მეშვეობითაც მოპოვებული იქნა უახლესი მასალა თოვლის ჰიდროლოგიაში, რომელიც არ არსებობდა მანამდე. სხვადასხვა სიმაღლეზე განხორციელებული გაზომვები გამოდგა წარმატებული. თოვლის ნალექმა შეადგინა მთლიანი ნალექების მოცულობის 30%. ის წარმოადგენს მდინარეების მკვებავი წყლის მნიშვნელოვან წილს (მაქსიმალური წილი 50%). თოვლის დნობის შედეგად მდინარეების წყალუხვობა გძელდება 2–3 თვე. დადგინდა, რომ თოვლის ნადნობი წყლის იზოტოპური შემადგენლობა განსხვავდება სხვადასხვა სიმაღლეზე და ასევე, განსხვავდება თოვლის საფარის იზოტოპური შემადგენლობისაგან.