Investigating hydrology of the Volga River: research by astronomer Nina Subbotina

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Abstract. The paper presents forgotten episode from the history of hydrology in Russia. It was a personal project undertaken by one of the first Russian women-astronomers Nina Subbotina (1877–1961) who was also competent and very interested in meteorological observation. Being well-known and well-respected in her day and time, Subbotina is nearly forgotten nowadays. When she was challenged with discovering of a reliable method to predict the height of floods of the Volga – one of Russia’s main rivers – she found an interesting solution. She tried comparing the heights of Volga floods with data on the solar activity and finding whether one could influence another. If it was, one would be able to prognose the height of river flood with the knowledge about current states of sunspots.

1. Introduction

History of hydrology is in a mainstream of the modern research in the history of sciences as it helps to provide some perspective to modern environmental problems. Among other aspects, historians of science are looking for different factors – anthropogenic, climatological, ecological, etc. – which were affecting hydrological regime of rivers [1–6]. It is especially important with large rivers such as the Volga River in Russia. One of those researched factors being solar activity. In the late 19th – early 20th century French astronomer and popularizer of science Camille Nicolas Flammarion (1842–1925), founder and leader of French Astronomical Society (Société Astronomique de France) entertained an idea of parallel observation of sunspots and meteorological conditions and a comparison and correlation of the two. A member of French Astronomical Society from 1899, member of the Society’s Solar Commission, Russian astronomer Nina Subbotina (Soubbotin) took this idea to heart. She maintained observations of sunspots and meteorological observations simultaneously during several decades. The results of her observations were published in professional periodicals in France, Switzerland, Germany and Russia. Then during revolutionary years in Russia in 1917–1920 and a little later she found herself living near one of great Russian rivers, the Volga, not far from Nizhniy Novgorod and surviving a large flood. She then decided to compare data about solar activity cycles and data on the heights of the Volga River floods looking for some interdependence.

2. Materials and methods

The main sources for my research were original papers published by Nina Subbotina, information about her participation in scientific conferences and also her private correspondence and office work documentation as well as information published in scientific journal of Hydrological Institute. Unpublished data were located in the State Archive of Russian Federation in Moscow.
3. Nina Subbotina’s research on the hydrology of Volga River

First of all, it is necessary to say a few words about Nina Subbotina (1877–1961) herself. She was an extraordinary person and a very talented astronomer observer. Born to the family of Russian intelligentsia, she was raised on the ideas of human equality. Her family – an old Moscow family – through 19th century comprised of interpreters, professors, clergymen, architects, her father Michail Subbotin (1850–1909) being a self-made man and professional engineer. Her aunt Dr. Olga Sokolova (1862–1916) was one of the first Russian women-medical doctors with European education and diploma. In 1895, the family moved to St.-Petersburg. Thanks to her father’s influence, young Subbotina was in love with astronomy from her early childhood.

After she arrived in St.-Petersburg she had an opportunity to visit Pulkovo observatory and to make acquaintances with professional astronomers. After that, she decided to become an astronomer herself. But it was not so easy in general and in her case in particular. In general, university education needed in order to become a professional astronomer was forbidden for women in Russian Empire. There was some equivalent of scientific education for women so-called Higher Women’s Courses (\textit{Vysshie Zhenskie Kursy}). The most respectable of those situated in Saint Petersburg and it was convenient to Subbotina. Curriculum was not quite the same as in the imperial universities but not far from it. Sadly, the Courses didn’t provide an official diploma for its graduates and as such an opportunity of professional employment. But education itself they provided. In particular, it was nearly impossible for Subbotina to enter any educational establishment. It was not due to the money or the lack thereof. Her family was well-off. She was not forbidden to study by her parents as any unwed girl in Russia needed their official permission for that and in some cases this requirement created a serious problem to future female student. It was because of her health condition. When she was seven years old, Subbotina became violently ill. She survived but was left with permanent disability. She lost the ability to hear, to speak and to move. After several surgeries and a long therapy, she regained the ability move but only with the help of crutches. It was very difficult at the place and time to acquire an intellectual profession for perfectly healthy woman more so for a woman with so serious disability. But Subbotina managed. She graduated from the Higher Women’s Courses (\textit{Vysshie Zhenskie Bestuzhevskie Kursy}) in Saint Petersburg and in time became a well-respected astronomer observer. She was the first women in Russia who published an astronomical book and won the award from Russian astronomical society [7].

There were several scientific avenues specifically interesting to Subbotina. First of all, she was interested in all kind of observations. Observations of the shooting stars, sunspots, variable stars – everything that she was able to organize in her own little private Observatory. Then observations of total solar eclipses of which she managed 6 during her life time. Three of them were a huge success: in 1905 in Burgos (Spain), in 1914 on the Karadag (Crimea), in 1936 in the Caucasus. She also successfully observed an appearance of Halley’s Comet in 1912 in Sevastopol (Crimea). The Halley’s Comet was a huge event in the astronomical community of the time. Before the actual observation of the comet, Subbotina participated in the preliminary calculations of the comet's appearance undertaken by Russian Astronomical Society. She also conducted an interesting research about the history of the Comet’s arrivals throughout the history of humankind. This research resulted in a book published in 1910 [8]. In 1913 Russian Astronomical Society awarded Subbotina a prize for this book [9, 7]. It was the first astronomical book published by a Russian woman. Also it was not so much an astronomical book as a book about history of astronomy. Nevertheless, it was highly valued. Subbotina also was very interested in the history of ancient astronomy specifically in the shape of the solar corona as it was presented in ancient pictures. For this paper, however Subbotina’s long observation of sunspots is only important [10].

Subbotina began her observations of sunspots in 1895 being a teenager still. From 1899 she worked closely with French Astronomical Society (\textit{Société Astronomique de France}), Belgian Astronomical Society (\textit{Société Belge d’Astronomie}), and Russian Astronomical Society (\textit{Russkoe Astronomicheskooe Obozhestvo}). She used their programs for observations and published the results in their periodicals. As an owner of a private observatory she could plan her own research. So, she
combined observations of sunspots with meteorological observations as Camille Flammarion recommended. In 1903–1905 her observatory situated in her family’s estate Sobolki in the Mozhaisk district of the Moscow province even was an officially registered station of the Nickolaev Main Physical Observatory (Nikolaevskaya Glavnaya Fizicheskaya Observatoriya).

Everything went well. However, in 1918, the new revolutionary government confiscated her observatory. Left without any means to survive Subbotina went to live with her brothers who were employed in different capacities in Sormovsky plant situated in Sormovo near Nizhniy Novgorod. Soon she found a job as an astronomer-observer in the branch of local government responsible for culture and education. As she managed to save her astronomical equipment she immediately resumed her observations. Simultaneously she worked with schoolchildren and plant workers as a popularizer of science. As an educator, she encountered a program created by Hydrological Institute (Gidrologicheskij Institut) for secondary schools. In 1920 Hydrological Institute formulated and published 70,000 questionnaires for schoolchildren and their tutors to observe the spring floods of the rivers and report back to the Institute. As a scientist in residence, Subbotina was charged with the task. Moreover, in 1921–1922 she participated in that research. The river in question was one of the larger Russian rivers, the Volga.

But it was not enough for Subbotina to simply observe. She lived through several floods of Volga and knew how devastating for people and local economy they were. She understood very well that to find a way to predict the height of the Volga flood was of utmost importance. Looking through office documentation of the Makaryevskaya fair which in reality was one of the largest and oldest trade markets in the country Subbonina found yearly data on the floods observations of Volga river beginning from 1820. She asked herself whether solar activity with which she was so well acquainted was correlated somehow with the flood height of the river. So, she took data about the heights of Volga floods from 1820 to 1922 and compared it with the known number of sunspots for the same period. She took as an average constant for floods height during the century 8.5344 meters and an average constant for sunspots 60 in Wolf numbers. Moreover, she found some parallelism which she presented as a curve.

![Figure 1. A curve of the heights of Volga floods in comparison with the number of sunspots calculated by Nina Subbotina and published in 1923 in “Volga” (“Volga”) journal](image)

In September 1922 the Third Congress of the Russian Association of physicists was held in Nizhniy Novgorod. 239 delegates were present from 22 different Russian towns and cities. Nearly a
half being residents of Nizhniy Novgorod or nearby arears, including Subbotina. The civil war ended only recently and travelling across the country usually was difficult and dangerous. However, on September 15, the participants began arriving in Nizhniy Novgorod. On September 17 the meetings have begun. But it was not only by chance of her location and her natural scientific curiosity that Subbotina attended the congress.

From her early days in Sormovo Subbotina was in contact with the Nizhniy Novgorod radio laboratory which was among the main congress organizers. During her years in Sormovo Subbotina was sending the results of her sunspots observations to said laboratory and became well acquainted with physicists working there. She could not miss such an event organized by her close associates. She became congress delegate from Sormovo Astronomical Club of which she was founder and president. So, she was speaking twice during the Congress – the first time as a representative of her Astronomical Club and the second presenting her own research. So, on September 19 Subbotina gave her paper about supposed correlation between the heights of Volga floods and the number of sunspots based on data encompassing a century of observation in the meeting of the section of Geophysics. She argued that one could see some correlation between the two. The paper was very well received by her fellow congress attendants, mostly physicists and geophysicists by their background and occupation.

In 1923 Subbotina published results of the research in the local journal “Volga” intended for those who lived and worked on the great river [11]. She argued about importance of such research, asked those interested for more data of the floods not only near Nizhniy Novgorod but also in other points. But speaking about correlation between the floods heights and the number of sunspots she was more careful then during her presentation to the Congress a year prior. She was sure and the curve she calculated showed that some interdependence was present. But it was more complicated than the direct correlation. Subbotina wanted to continue her research but had no opportunity to do so. Thanks to another administrative reform in 1923 she was let go from her position and soon returned to Saint Petersburg, which had already been renamed Leningrad.

4. Conclusion
In 1918 Nina Subbotina, an experienced astronomer-observer found herself in difficult life situation thanks to the change of government in the country and new governmental policy. Moved to the factory settlement Sormovo on Volga River, she lived through high flood which was quite devastating. Struggling to find a way to predict such events she turned to her astronomical and meteorological experience. Her idea to compare the heights of Volga floods during the one-hundred-year period with the solar activity was well received by geophysicists during the Third Congress of the Russian Association of physicists in 1922. Further research shown however it was a possibility that sought out correlation existed it was much more complex than the direct correlation. New data was needed to continue research and to make conclusions that are more accurate. But the opportunity to continue never presented itself and the project was left unfinished. Despite this fact, it was an interesting attempt of an extraordinary mind.

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