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ARTICLE

Critical Climate Histories of Eurasia

The Yenisei Makes the Weather: The Microclimate of the Krasnoyarsk Dam and Its Research, 1960s–1990s

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Abstract

When Soviet authorities began building the Krasnoyarsk Dam in 1956, the Yenisei River had an ice-free period of only 112 days a year. The thick and long-lasting ice impeded dam building and navigation. However, as the dam rose, it produced an environmental anomaly; for more than 200 kilometers downstream, the Yenisei became ice-free year-round. This led to a change of microclimate in the Yenisei basin. This article adds nuance to our conceptualization of melting glaciers and icecaps, and thawing permafrost, as harbingers of imminent global climate change. The unfreezing of the Siberian river induced an anthropogenic climate change that could, in theory, benefit the local population. But this unintended consequence of large dam building led the Soviet scientific community to take a skeptical attitude toward purposeful modification of climate to make it more favorable. Like with the global climate crisis, Soviet and post-Soviet scientists sought ways to mitigate human impact. “Is it possible,” they asked, “to freeze the Yenisei?” Today, the effects of the dam-related climate change endure and exacerbate the air pollution in the Krasnoyarsk region. But a technological solution to curtail it has not been found.

Soviet economists sought to harvest the energy of their country’s mighty Eurasian rivers, considering electricity to be the primary harbinger of progress and socialism’s lodestar in the remotest parts of the nation. Over the course of the twentieth century the Volga, the longest river in Europe and Russia’s mother-river, was virtually turned into a staircase of dams.[1] Their construction came at a cost: settlements and swaths of cultivated lands in fertile floodplains were submerged under water, and thousands of people were displaced. The image of the inundated Kalyazin Belfry rising out from the middle of the reservoir created by the 1939 construction of the Uglich Dam became a symbol of these sacrifices. Yet these massive changes to the landscape did not bring the post-Stalinist hydroelectric

[1] The dozens of dams built as part of the “Great Volga” scheme almost stopped the river’s flow. See Bernd Stevens Richter, “Nature Mastered by Man: Ideology and Water in the Soviet Union,” *Environment and History* 3 (February 1, 1997): 72. Janet Hartley, *The Volga: A History of Russia’s Greatest River* (New Haven, 2021), explores how the Volga acquired a prominent place in the Russian culture and self-identity in the nineteenth century.

construction boom to a halt. The mega-dam projects of the Khrushchev and Brezhnev periods, at least on paper, compared favorably to their predecessors: these dams exploited Siberian rivers, some of the most voluminous on earth, expanding Soviet extractive economy and industry further east. Thanks to the semi-mountainous relief of the riverbeds, they did not flood as much land and produced electricity more efficiently.

Such was the rationale of building the first dam on the Yenisei River in 1956–72, the Krasnoyarsk Dam. Its reservoir flooded farmland and villages, but the scale of loss was considered miniscule compared to the impact of the dams on the Volga. Yet the new lake contained more water, despite insignificant surface area. Filling a deep gorge with a prolific biome, it reminded of Lake Baikal. Its creation in 1967 had an unexpected immediate outcome: the Yenisei stopped freezing in winter in Krasnoyarsk. Local and federal newspapers reported that the Yenisei, for the first time, was not "sleeping" and was "naked," covering itself in a thick fog as if in shame while the temperature dropped to −56.2°F.[2] Before that, every winter it had been ever-encased in thick ice. Now, a gaping *polynya*, an unfrozen window, spreads up to 150 miles through the metropolis of Krasnoyarsk and further.

The environmental effects of the Krasnoyarsk Dam construction were not confined to the ice-free Yenisei. However, this was the most glaring and immediate consequence thereof, leading to a change of microclimate beyond Divnogorsk, the dam's hometown, and Krasnoyarsk and to a mixed reaction from participants and witnesses of this industrial feat. The Yenisei, the most distinct natural phenomenon in the region by scale and by cultural and economic significance, had "made" and continued to "make the weather," moderating the temperatures even when controlled by the dam. In an age informed and alarmed by the heating atmosphere, melting of ice sheets, and thawing of permafrost, stories like the one of the Yenisei are often obscured and misunderstood. This cluster's article "Growing Deserts and Shrinking Glaciers: The Desiccation Debates and Climate Change in the Late Nineteenth Century" tells the story of how Russian scientists came to envisage glaciers as indicators of climate change. This article deals with disappearance of seasonal ice as a driver of climate change, rather than as an indicator. Yet, importantly, the global climate change of the Anthropocene epoch and the transformation of the Siberian river—leading to microclimate change intermediately—have been concurrent and human-induced.

The permanent discontinuation of seasonal ice formation on the Yenisei galvanized critical assessment of large dam building and of both deliberate and unintentional redesign of Siberian climate. This was still happening in and against the context of climatic and technological optimism—the belief in the feasibility and practicality of anthropogenic climate change and in the applicability of a technological fix thereto.[3] At the turn of the century, human intervention into the environment came to the foreground in debates over the changing climate and over the prospects of its further control and readjustment. Compelled to defy human dependence on natural elements, Soviet and post-Soviet scientists and engineers proposed to extend the management of nature to an effort to undo the change that the dam and its reservoir had inflicted, and to freeze the Yenisei once again. This article argues that the absence of ice on the Yenisei during the winter, which altered the microclimate of Krasnoyarsk, was the most visible and inescapable evidence of anthropogenic climate change in Eastern Siberia. Yet it overshadowed such underlying and related environmental problems as the overall change in the Yenisei's hydrology, as well as the industrial pollution of water and air in its basin, and thereby prevented the adoption of measures that could resolve them.

Looking at the history of a change in microclimate detached from global climate change, this article contributes to critical climate history that circumvents climate reductionism.[4] First, climate history is

[2] "Ne spit Enisei," *Ogni Eniseia*, December 9, 1967, 2; "Kanikuly pod kryshei," *Izvestiia*, January 9, 1968, 4.

[3] Jonathan D. Oldfield, "Imagining Climates Past, Present and Future: Soviet Contributions to the Science of Anthropogenic Climate Change, 1953–1991," *Journal of Historical Geography* 60 (April 2018): 41–51.

[4] Mike Hulme, "Reducing the Future to Climate: A Story of Climate Determinism and Reductionism," *Osiris* 26:1 (2011): 245–66, quoted in George C. D. Adamson et al., "Re-Thinking the Present: The Role of a Historical Focus in Climate Change Adaptation Research," *Global Environmental Change* 48 (January 2018): 195–205.

not circumscribed by the scholarship of global warming and greenhouse gases. Preoccupation with carbon emissions and an outdated belief in hydro energy as an alternative "green" energy, let alone produced amid a vast and "pure" taiga purportedly capable of enduring the most daring industrial experiments, sidelined other forms of anthropogenic climate change. Moreover, large dams had promoted state-led development globally, which has made them somewhat immune to criticism. Second, the relationship between humanity and the natural world is not determined solely by climate processes. The focus here is on a change in microclimate that was a manifestation of a more profound environmental change. Third, common projections and models of climate processes and adaptations can flatten the specificities of local spaces, cultures, and human agency. This paper overcomes climate reductionism and determinism by looking at the intertwined microclimate and water history of the Yenisei and putting the river's transition between the three states—solid, liquid, and gas—into historical context.[5] It allows for a more nuanced interpretation of complex Soviet perceptions of climate and nature alterations in the circumstances of Siberian industrialization and urbanization.

Using a "weather archive"—the elusive evidence of once-seasonal river ice—I explain the current state of the Yenisei through the history of its damming in the 1960s and focus primarily on the responses of scientists and some public figures to this change.[6] A new body of water was created together with the Krasnoyarsk Dam, which evened up seasonal temperatures and generated new experiences of living in changing climatic conditions. As Russians settled eastern Siberia they were forced to make certain adaptations to an extreme continental climate that the indigenous people they displaced had long become accustomed to and who had geared their whole lifestyle toward it. The Soviet redesign of the local climate was informed by this history, as well as the efforts since the nineteenth century to moderate the "extremes" and make a comfortable and abiding life in Siberia. With cold winters and hot summers, ticks and mosquitos, seasonal ice and floods, Siberia had to be changed to accommodate modern human living and industrial production.

Studying microclimate change is a significant aspect of climate history, but it is done with a "shallow time depth" approach, as opposed to explorations of a distant, "deep" history that pushes the advent of the Anthropocene, and the starting point of significant anthropogenic climate change, further back in time.[7] We can define microclimate as a set of atmospheric conditions specific to a certain area, often containing bodies of water. The unfreezing Yenisei was the primary cause of a rapid microclimate change, although not the only cause, considering the intensifying global climate shifts. This phenomenon is not unique by nature, yet it *is* unique by intensity. The Kama River in the Urals, and the Angara River in eastern Siberia, also ceased freezing once they were harnessed. The transformation of the rivers' natural flow has been most noticeable near large cities (Irkutsk and Perm, respectively) where industrial and household waste make the water content even more resistant to seasonal ice formation.[8]

The Yenisei devoid of ice was a dramatic sight to those witnessing such a radical change in nature for the first time, one which fit within a human lifespan. Outside of academia, humans have difficulty conceiving of long-term, gradual planetary climatic changes that occur independent of human activity: our lives are too short compared to the pace of these changes over geological time. Or, at least, they *were*. The change on the Yenisei took place during the life of a single generation, which led to the development of an awareness of accelerated anthropogenic environmental and climatic change. In sum, this study critically discusses Soviet reflections on microclimate changes that took place before the climate change consensus of the current period, the hope being to illuminate some of the

[5] Ruth A. Morgan, "Climate, Weather, and Water in History," *WIREs Climate Change* 10:1 (January 2019): 8.

[6] Ice comes and goes, constantly transforms, but always continues to govern natural rhythms and energy exchanges. See Bathsheba Demuth, *Floating Coast: An Environmental History of the Bering Strait* (New York, 2020), 73–137.

[7] William F. Ruddiman, "The Anthropogenic Greenhouse Era Began Thousands of Years Ago," *Climatic Change* 61 (December 1, 2003): 261–93.

[8] "Pochemu ne zamerzaet Kama v Permi?" *Priroda*, 1961, no. 12: 111–12; V. A. Krotov, *Vostochnaia Sibir': Ekonomiko-geograficheskaia kharakteristika* (Moscow, 1963), 67.

probable reactions to future effects of climate change on the environment and livelihoods, and vice versa.

THE TIMELESS ICE

The Yenisei is the world's fifth longest river, and the largest to drain into the Kara Sea on the Arctic Ocean (See Map). Flowing from the south to the north, it is a natural border between western and eastern Siberia. The contours of its vast basin give shape to the Krasnoyarsk Krai administrative unit. The river has facilitated habitation, trade, and colonial conquest, and given rise to cities in eastern Siberia. Even after the Trans-Siberian Railway reached Krasnoyarsk in 1897, the Yenisei remained the most important meridional thoroughfare of the region. In the twentieth century, it facilitated industrialization and determined the placement of technology.

The Yenisei River Basin, Kmusser, Wikimedia Commons, CC BY-SA 3.0.

The climate of the Yenisei basin has ranged from Arctic in the north to continental in the south. Near Krasnoyarsk, it is extreme continental; in the late 1950s, the average annual temperature there was 32°F, dropping as low as −65°F in winter and rising as high as 98°F in summer.[9] According to some Soviet dam builders, this astounding difference of about 100°C hindered work, but it also hardened a person's body and tested their character, not dissimilar to ways the "frontier" experience

[9] Gosudarstvennyi arkhiv Rossiiskoi Federatsii (GARF), f. P5446, op. 91, d. 232, l. 2.

has been conceptualized in the United States.[10] But in general the cold was an enemy of those Soviet workers whose jobs had to be performed largely outside and were therefore at serious risk of frostbite and illness. The ice-free period on the Yenisei had been only 112 days on average near Krasnoyarsk, and the depth of the ice could exceed five feet.[11] The ice would first begin to break in the southern reaches of the river in April, the chunks lasting for several months as the river carried them north to the ocean. At the end of the ice-drift in early summer, temperatures in the Yenisei delta, in the permafrost zone, were still below freezing.[12] The direction of the river's flow—from a warming south to a still frozen north—made the movement of ice more forcible yet more prolonged, since the floes rushing downstream would crash into unfrozen ice in the north, producing massive jams. To emphasize the length and toilsomeness of the process, Ivan Nazarov, head of the Yenisei Shipping Company from 1939 to 1970 and also something of a writer, described it in anthropomorphic and gendered terms as the "hard, torturous labor pains of the river."[13]

The Yenisei's yearly ice drift had been a powerful sight and a valuable shared experience for coastal communities.[14] And it has been an important milestone both naturally and socially, for Russian and non-Russian people alike, as the article "Sea Ice, Maps, and Critical Climate History in Early Modern Northern Eurasia" shows elsewhere in this cluster with examples of other Arctic rivers. The deafening noise of crashing ice floes would repeat from season to season calling people to the banks to marvel the awakening mighty river.[15] Some years, witnesses reported two-story high floes pushed ashore.[16] In his autobiographical stories, the local village-prose writer Viktor Astafyev wrote about the entanglement of Orthodox and pagan beliefs in a procession timed to Easter, when the protagonist's grandmother and other village women walked with icons to the bursting water.[17] They imagined the process to be an end-of-the-world event (*svetoprestavlenie*), praying to both the river and the Mother of God.

It could be indeed apocalyptic: in 1961, hydrologist, climatologist, and Yenisei "biographer" Nikolai Bakhtin estimated that the spring floods and ice jams threatened around two hundred settlements, including Krasnoyarsk, every year.[18] The long period of freeze with the addition of ice drifts impeded hydraulic engineering on the Yenisei, therefore large-scale projects could be implemented only with emergence of advanced technology during the Cold War era. In the late 1960s, construction sites in Siberia became a viral topic in Soviet cultural production. The climax of Aleksandr Zarkhi's drama *People on the Bridge* (1959), filmed on the Yenisei, portrayed an ice drift challenging a semi-complete bridge and taking the life of the protagonist, but not before the heroine blows up a floe and saves the bridge and a worker on it.[19]

Mikhail Kirillov, a geographer, member of the All-Russian Society for the Protection of Nature, and chair of the Russian Geographic Society in Krasnoyarsk, noted that people have been living on the Yenisei and closely interacting with it for more than thirty-five thousand years.[20] The Yenisei always

[10] V. Ginkul, "Rasskazy o prirode," *Ogni Eniseia*, July 8, 1967, 2.

[11] P. S. Neporozhny, *Gidroenergetika Sibiri i Dal'nego Vostoka* (Moscow, 1979), 55.

[12] Nikolay Bakhtin, *Reka Enisei* (Moscow, 1961), 80.

[13] I. Nazarov, *Byli Velikoi Reki* (Krasnoiarsk, 1996), 10.

[14] Local weather experiences at Soviet military ports in the north were similarly an important source of social capital for the local community. See Ekaterina Emeliantseva Koller, "Negotiating 'Coldness': The Natural Environment and Community Cohesion in Cold War Molotovsk-Severodvinsk," in *Ice and Snow in the Cold War: Histories of Extreme Climatic Environments*, ed. Julia Herzberg et al. (New York, 2019), 255.

[15] Boris Gorizontov and Anatolii Zubkov, *V kraiu bol'shogo budushchego* (Moscow, 1961), 12.

[16] Bakhtin, *Reka Enisei*, 81.

[17] Viktor Astaf'ev, "Predchuvstvie ledokhoda. glava iz povesti Poslednyi poklon," *Nash sovremennik*, 1988, no. 6:3–26. Village writers were the "guardians" of Russian culture against Soviet modernity and urbanization. In the same story, Astafyev calls the dam a "filthy jaw" (*griaznaia cheliust'*). See Kathleen Parthé, "Village Prose: Chauvinism, Nationalism or Nostalgia?," in *New Directions in Soviet Literature: Selected Papers from the Fourth World Congress for Soviet and East European Studies, Harrogate 1990*, ed. Sheelagh Duffin Graham (London, 1992), 106–21.

[18] Bakhtin, *Reka Enisei*, 87.

[19] Aleksandr Zarkhi, "Tak sozdavalsia fil'm," *Gudok*, January 9, 1960, 4.

[20] M. V. Kirillov, *Priroda Krasnoiarskogo kraia i ee okhrana* (Krasnoiarsk, 1983), 5-6.

froze: the ecosystems "sharpened" for the seasonal cycles of the river, its regular transitions between the liquid and frozen states. James Scott has eloquently compared the overflow of a river in the spring to deep breathing and a sign of the vitality of its basin.[21] For the coastal soil, Yenisei spring floods, which humans view negatively, were a blessing. Both people and animals used ice crossings. The first workers at the Krasnoyarsk Dam called the road across the frozen Yenisei the "road of life" (*doroga zhizni*) after the path laid across the frozen Lake Ladoga during the siege of Leningrad (1941–44).[22] It was their only connection to basic supplies during the initial period of construction, when roads were absent and line of communication non-existent. People ice fished. In spring, the residents of Krasnoyarsk disposed of their domestic waste on the ice of the Kacha River, Yenisei's tributary, so that it would eventually float away, out of sight.[23]

SIBERIAN DEVELOPMENT

Humans have been altering the Yenisei basin for millennia, and the scale of change was amplified during the period of Russian colonization. Traditionally, the Russian state was interested in the three key gifts of Siberian nature, often relying on indigenous peoples for their extraction: furs, wood, and gold. In the 1930s the NKVD's labor camp system (Gulag), which at this time was responsible for most of the economic development in the region, continued to exploit these same resources. But it wasn't until the late 1950s that Siberia began to industrialize on the same scale as European Russia.

The USSR's Seven-Year Economic Plan of 1959–65, which in part aimed to develop the country's resource-rich eastern regions, was to a large extent a continuation of the Russian colonial mission in Siberia.[24] This time, however, the government devised a public relations campaign to change the popular imagination of Siberia from "hell"—a miserable, cold, and deserted place of tsarist exile—into "heaven"—a place of socialist abundance, power, and opportunity.[25] Both visions rendered the land and native peoples of Siberia as Russia's Asiatic backward and unenlightened "others." Making a break with the exploitation of forced labor in the frigid region under Stalin, the Soviet state under Khrushchev incentivized its people to come to Siberia and participate in the new construction projects voluntarily. Consequently, the region witnessed the effects of the global Great Acceleration—population growth, urbanization, and increased use of natural resources. With them came a sweeping environmental change.

At the height of the Cold War, the Yenisei became the engine of the Central Krasnoyarsk Territorial-Production Complex (TPK) and the third-largest metallurgical base of the USSR. TPKs were clusters of industrial enterprises sited with specific economic and geographical factors in mind that allowed them to make the most of the resources available in a given territory while avoiding transportation difficulties. The tight concentration of industrial facilities in TPKs accordingly engendered extreme environmental degradation. The extraction and processing of previously untapped coal, oil, iron ore, and bauxites near Krasnoyarsk foreshadowed a large energy demand, as did the growing population, which from 1956 to 1974 doubled to 728,000 predominantly Slavic souls.[26] A grandiose aluminum plant built in 1964 eventually consumed the largest share of energy produced by the Krasnoyarsk

[21] James Scott, "How to Write like a River," recorded on February 24, 2021, by the York University Graduate History Student Association in Zoom, video, 14.00, https://www.youtube.com/watch?v=SCIPBcBGadk&t=1611s.

[22] O. Grek et al., *Ispolin na Enisee* (Moscow, 1966), 20.

[23] Tat'iana Kiskidosova, "Sanitarnoe sostoianie gorodov Eniseiskoi gubernii v kontse XIX–nachale XX v," *Vestnik Tomskogo gosudarstvennogo universiteta*, no. 403 (2016): 49–53.

[24] "Kontrol'nye tsifry razvitiia narodnogo khoziaistva SSSR na 1959–1965 gody: tezisy doklada N. S. Khrushcheva na XXI s"ezde KPSS," *Znamia*, November 14, 1958, 1–4.

[25] Galya Diment and Yuri Slezkine, *Between Heaven and Hell: The Myth of Siberia in Russian Culture* (New York, 2014), 9.

[26] *Narodnoe khoziaistvo SSSR v 1956 g. (Statisticheskii sbornik)* (Moscow, 1956), 24; *Narodnoe khoziaistvo SSSR v 1956 g. (Statisticheskii ezhegodnik)* (Moscow, 1974), 26.

Dam.[27] Left unused, the "hidden" energy of the river would be "wasted," and since there was eighteen times more river water per resident of Krasnoyarsk than the USSR average, this water clearly was not being put to good use.[28] And with an absence of industrial demand in "the periphery," Soviet officials concluded that the excess should be diverted elsewhere, for the benefit of national development.

Plans to construct large hydroelectric power plants on the Yenisei and its tributaries had existed since the 1930s, but thanks to the lack of funding, and then the outbreak of World War II, they remained on paper until the Khrushchev era. Each new dam would of course supply electricity to local producers and communities, but every power station in the Yenisei-Angara cascade would also be linked into a Unified Siberian Energy System.[29] This centralized operation of dams was a distinguishing feature of Soviet socialist industry. It sought to ensure that the unpredictable forces of nature—seasonal river flow fluctuations—would not undermine the reliable and stable production and distribution of energy at all locations at once. The first contributors into the system were the Irkutsk Dam (built in 1950–58) and the Bratsk Dam on the Angara (built in 1954–66). The energy of the Angara's dams for the system was especially valuable: as the only river flowing out of Lake Baikal, which was fed by 330 rivers, it has a consistently strong and full current. Yet the hydroelectric dams on the Yenisei far surpassed the capacity of the rest.

The Krasnoyarsk Dam: Finger on the pulse

The Krasnoyarsk Dam was built under the guidance of a celebrated hydroengineering veteran, Andrei Bochkin, who previously had supervised the building of the Irkutsk Dam near the source of the Angara. The construction site was located near the new town of Divnogorsk, twenty-five miles southwest of Krasnoyarsk and upstream on the Yenisei. For some time, the Krasnoyarsk Dam's 6000 MW capacity was the most powerful in the world, and a point of pride for postwar Soviet industrialists.[30] The Soviets even offered copies of its turbines to the United States in 1967 to help expand the generating capacity of the Grand Cooley Dam, but they were turned down.[31] Promethean rhetoric about the conquest and proletarianization of harsh Siberian nature accompanied the damming of the Yenisei.

The Krasnoyarsk Dam's paramount benefit was its low-cost electricity, which was a fraction of a kopek per kW/h.[32] Soviet engineers were also attracted by the idea of hydropower as a renewable energy source. Lewis Mumford, a philosopher and historian writing during this global hydroelectric construction boom, assured his readers that, in the "neotechnic" era of advanced scientific and technological development, extracting electricity from the water left it "just as pure," and was therefore an ideal substitute for archaic carbon-emitting smokestacks.[33] Supposedly, Siberian nature had itself created the ideal conditions for construction with minimal cost and interference. The slope of the Yenisei, its speed and volume, and the firm shoulders of its granite canyon all offered advantages over rivers like the Volga, which flowed through steppes or plains. The Krasnoyarsk Dam's reservoir filled a narrow, deep stone gorge without flooding vast territories. In fact, the consequences *could have been* worse: the dam would have had an even greater generating capacity had it been located closer to Krasnoyarsk, but that would have entailed a larger reservoir, and the inundation of the cities of Minusinsk in

[27] As Patrick McCully explains in his *Silenced Rivers: The Ecology and Politics of Large Dams*, rev. ed. (London, 2001), 254, aluminum production requires more hydroelectric energy than any other industry.

[28] Anatolii Makarov, *Krasnoiarskoe more: zachem nuzhny Krasnoiarskoe i drugie novye moria!* (Krasnoiarsk, 1969), 20.

[29] P. S. Neporozhnyi and A. N. Semenov, *Energetika strany glazami ministra: dnevniki, 1935–1985 gg* (Moscow, 2000), 3.

[30] GARF, f. P5446, op. 91, d. 232, l. 8; Gosudarstvennyi arkhiv Krasnoiarskogo kraia (GAKK), f. 2385, op. 1, d. 64, l. 4.

[31] D. L. Edwin, "Soviet Would Bid on U.S. Dam Work. Special to The New York Times." *New York Times*, March 31, 1967, 1.

[32] GARF, f. P5446, op. 91, d. 232, l. 14. A kopek was worth only a fraction of an American cent at the time.

[33] Lewis Mumford, *Technics and Civilization* (London, 1955), 255–56.

Krasnoyarsk Krai, and Abakan, Ust-Abakan, and Chernogorsk in Khakassia.[34] In 1957, therefore, the committee of engineers opted for a safer design and location that would yield less generating capacity.

Inevitably the dam builders synchronized their activities with the natural regime of the river, taming and changing it but at the same time adjusting to its seasonal cycles. Beginning in 1959 the dam had its own newspaper, *Ogni Eniseia*, a regular rubric of which was "The Pulse of the Yenisei." Here, the hydrometeorologists assigned to the project—usually the director of the observational Divnogorsk Station, M. Teptsov—published data on the changing state of the river: water level, temperature, speed, spillway discharge, as well as predictions concerning the start, duration, and conclusion of the yearly freeze-up. Forecasts were most frequent and detailed in the late spring and early summer, when the river, which workers compared to a hibernating bear, was waking up.

The diversion of the Yenisei in 1963 was the turning point. It was executed with a "pioneering" method—in winter, when the river was frozen, and its level was at its lowest. From then on, keeping a finger on the Yenisei's pulse was vital. To honor the 50th anniversary of the October Revolution, the industrial bosses scheduled the launch of the first generator in 1967. During the two years prior to then a giant barge had been making several painstaking trips from Leningrad through the Arctic and upstream the Yenisei to bring six 240-ton rotors—the hearts of a turbine.[35] In April 1966, in an article titled "The Yenisei Makes the Weather," the hydrometeorological observation station warned that a developing, forceful once-in-a-century flood could well undermine the construction schedule.[36] The design engineers had played up the dam's side benefit of shielding riverside cities and villages from spring floods, but now gigantic ice floes were threatening to demolish the unfinished structure and carry its broken remains downstream to wipe out those villages and the city of Krasnoyarsk, which straddled the river. The many residents of Krasnoyarsk who had flocked to the region to find employment at the dam's construction site, or in the many industrial facilities it would eventually support, now condemned Bochkin for hanging a sword of Damocles over the city and putting their lives in danger with the unstable structure.[37]

The flood was devastating. Houses, stores, and concrete plants were flooded, ships were stranded, and loose wood choked the Yenisei and its tributaries.[38] Only "shock work" efforts on the part of workers allowed them to maintain the stronghold of the dam throughout the state of emergency, which lasted through all of May, June, and most of July 1966. The "defeat" of the river, as it was allegedly attempting to break free of the human grip for the last time, became one of the most significant achievements in the history of the dam's construction.

In February 1967 the dam's concrete base was completed, and the reservoir started to fill with the volume of water needed to create the pressure that would allow the turbines to work. Like other new man-made reservoirs in the USSR, it was referred to as a "sea," a title that glorified Soviet society's ability to subdue, transform, and create nature. The extent of land that was flooded was impressive, although the authorities downplayed it: nine of Krasnoyarsk Krai's districts (three of them in today's Khakassia), including 124 villages with more than 50,000 inhabitants, were submerged.[39] The Ministry of Agriculture's special land survey expedition had deemed the technical level of local farming in those areas as "backward," and promised the displaced farmers new lands and modern homes in new villages.[40] These new settlements were in fact created nearby, but they often lacked essential

[34] Grek et al., *Ispolin na Enisee*, 21.

[35] G. N. Stepanov et al., *Podvig na Enisee: iz istorii stroitel'stva Krasnoiarskoi GES* (Moscow, 1972), 248, 253; O. Grek and V. Belkin, *Enisei – reka elektricheskaia* (Moscow, 2005), 82.

[36] N. Vikhrov, "Enisei delaet pogodu," *Ogni Eniseia*, April 26, 1966, 3; A. I. Kuznetsov et al., "The 1966 Flood on the Yenisei River at the Krasnoyarsk Hydroelectric Project Site," *Hydrotechnical Construction*, no. 2 (February 1967): 24–26.

[37] Andrei Bochkin and I. U. Kapusto, *S vodoi, kak s ognem: rasskaz gidrostroitelia* (Moscow, 1978), 163.

[38] I. Kaziurin, "Liudi, vesna, Enisei," *Ogni Eniseia*, May 15, 1966, 3; K. Noskov, "My pavodku ne ustupili," *Ogni Eniseia*, June 23, 1966, 2; Grek and Belkin, *Enisei – reka elektricheskaia*, 77–78.

[39] A. A. Korobenkov, *Krasnoiarskoe more (populiarnyi ocherk)* (Krasnoiarsk, 1961), 14–22.

[40] GARF, f. A 262, op. 8, d. 6821, l. 42.

infrastructure, and sometimes even a water supply, and the lands that the farmers received in compensation required significant improvement before they could be put to use. There had been some predictions about how the reservoir would affect the local climate and environment, but in order to maintain progress on the project in the face of budget cuts in 1959, management reduced the funds that otherwise would have gone toward reservoir preparation and research.[41] The result was that experts calculated that the Yenisei would be free of ice *only* upstream from Krasnoyarsk.[42]

THE MICROCLIMATE CHANGE

Embracing the change

One of the most sought-after perks that a Soviet worker could obtain were travel vouchers (*putevki*) to Black Sea resorts, a coveted vacation destination.[43] Now, with the first unit of the Krasnoyarsk Dam completed and the reservoir filled, the "sea," *Ogni Eniseia* declared, was closer than ever to Siberians.[44] Anyone could take a day trip to the sea shore and enjoy sunbathing, swimming, fishing, and even sailing. And indeed, the possibilities were unlimited, since officials promised to continue making improvements to local recreational and athletic facilities.[45] By 1967 they had stocked the reservoir with thousands of fish, the hope being that they would acclimatize, and that the process could be studied.[46] Access to a large body of fresh water was a welcome feature of the transformed Yenisei basin, as was the overall change to a milder microclimate downstream of the dam. At first, this sudden change, which made Siberia less of a Siberia, and which eliminated the fall-to-spring ice cover on the Yenisei for a hundred miles, was embraced.

What exactly happened to the Yenisei, and how did its transformation induce the change of microclimate? The surface of the Krasnoyarsk Reservoir is not particularly large—approximately 810 square miles—and it has an elongated shape.[47] Its width rarely reaches 50 feet. Yet it is deep, averaging 121 feet, with a maximum depth at the foot of the dam of 345 feet. Its volume was comparable to that of the vanishing Aral Sea at the time.[48] As explained by Bakhtin, in the summer, the water going through the dam is cooler than it previously used to be, as it is taken from the deeper layers of the reservoir, at around 131 feet, where it does not start to warm up before the end of the summer.[49] The opposite happens in winter: the water below is still too warm to freeze, as it cools much later at this depth and does not drop below 37°F. Warmer water passes through the dam, and, depending on the weather conditions and spillway discharge, it prevents the Yenisei from freezing for up to two hundred miles. The overall result was that the Yenisei's average temperature moderated, rising in the winter and falling in summer, by several degrees, and this changed the local air temperature accordingly. Water and air pollution generated in the city and its environs only exacerbated these tendencies. Enterprises downstream from the dam discharged unfiltered effluvia, and the construction of wastewater

[41] GAKK, f. 2279, op. 1, d. 114, ll. 36–37.

[42] Bakhtin, *Reka Enisei*, 115.

[43] State-distributed vacations helped sustain Soviet society's belief in the socialist "good life." See Diane Koenker, *Club Red: Vacation Travel and the Soviet Dream* (Ithaca, 2013), 29. For nature's role in Soviet leisure see Johanna Conterio Geisler, "The Soviet Sanatorium: Medicine, Nature, and Mass Culture in Sochi, 1917–1991" (Ph.D. diss., Harvard University, 2014).

[44] "More stalo blizhe," *Ogni Eniseia*, June 11, 1967, 3.

[45] A. B. Abakyan et al., "Importance of Reservoirs for Rest and Sport," *Hydrotechnical Construction*, no. 7 (July 1971): 27–30.

[46] Evgenii Molochnyi, "Novosely Krasnoiarskogo moria," *Ogni Eniseia*, October 25, 1967, 3.

[47] Korobenkov, *Krasnoiarskoe more*, 37.

[48] Iu. Luganskii, "More i ego kaprisy," *Ogni Eniseia*, July 23, 1970, 4.

[49] N. P. Bakhtin, "Prognoz gidrologicheskikh uslovy Krasnoiarskogo vodokhranilishcha," (Krasnoiarsk, 1967), 387–409, quoted in N. D. Gaidenok et al., "Izmnenie gidrologicheskikh svoistv Angary i Eniseia v rezul'tate vozvedeniia kaskada GES," *Mestnoe ustoichivoe razvitie*, vol. 3 (2010), http://fsdejournal.ru/node/130.

treatment facilities was often delayed until the 1970s. In 1963, in Krasnoyarsk alone more than three hundred thousand gallons of industrial waste and sewage was released into the Yenisei daily.[50] But while industrialization made the problem worse, the dam and its reservoir were the sole reason why the Yenisei stopped freezing between Divnogorsk and Krasnoyarsk.

It was expected that the Yenisei would stop freezing and continue to flow freely through the dam in the winter. However, since 1967 it has remained unfrozen at a much greater distance downstream than predicted. At first, this change was considered a good thing. Ships, with the help of the dam's ship lift (built in 1976–82), could navigate the river year-round. The risk of destructive spring floods was eliminated. The absence of ice facilitated hydraulic engineering. A new, constantly moving river in place of the one that had remained static for most of the year aligned with the propagandistic rhetoric of its "rejuvenation," its transformation from idle to productive. The river's flow even inspired the introduction of a new way to deliver concrete to the dam—through heated pipes, which were touted as "rivers of concrete."[51] The reservoir and the unfrozen river at once made winters in Krasnoyarsk a bit more comfortable for human habitation. They made flora and fauna downstream from the dam more lake-like. As the river flow slowed down, and water temperature fell in the summer, cold-loving algae took root in the Yenisei, and some species of fish—Siberian salmon and Arctic grayling—were replaced by others, bass and pike.[52] The colder summer temperatures of the Yenisei prevented people from swimming in it like they used to, but this did not seem to be an issue when there was a "sea" nearby.

The license given to this microclimate change spoke to the long-standing desire to make the Siberian environment more favorable to people accustomed to living in the center of Russia and the USSR. There had been attempts to do this on both the national and local scale. The Great Stalin Plan for the Transformation of Nature of the 1940s sought to increase agricultural yields on the Russian steppes through the creation of thousands of reservoirs.[53] Locally, Vsevolod Krutovsky, founder of Siberian horticulture and a large botanical garden in the outskirts of Krasnoyarsk, had worked on developing frost-resilient fruit trees, such as the "creeping" apple trees, in the 1920s.[54] Later, a Krasnoyarsk Dam engineer Georgy Kirpatovsky took an aesthetic approach to climate adaptation and devoted all of his free time to tending a rose garden in Divnogorsk that was heated by the electric grid linked to the dam.[55] The luscious roses would prove to astonished visitors that Siberia could be turned into a blooming garden, too.

Criticism of the change

Natalia Koptseva and Natalia Seredkina, having surveyed the most important Russian and Soviet studies on climate in Siberia, ranging from Aleksandr Voeikov's work to current research being done at the Siberian Federal University, note the increasing tendency, beginning around the turn of the twenty-first

[50] In 1961, 103 Krasnoyarsk enterprises were registered as polluters, and some were fined. See GAKK, f. P2232, op. 1, d. 4, ll. 118, 131, quoted from N. V. Gonina, *Istoricheskii opyt prirodopol'zovaniia v Angaro-Eniseiskom regione 1945–1970 gg*. (Krasnoiarsk, 2009), 80–82, 134–35.

[51] This method was used by Canadian dam builders (Grek and Belkin, *Enisei – reka elektricheskaia*, 73); Igor' Fedorov, *Sozidateli: Uchastniki stroitel'stva Krasnoiarskoi GES i goroda Divnogorska 1955–1972* (Krasnoiarsk, 2011), 46; Bochkin and Kapusto, *S vodoi, kak s ognem*, 158. Unlike a regular lock, in which the water level is changed to allow a ship's passage, in a ship lift the vessel is taken out from the water completely and delivered up- or downstream on a platform, by rail.

[52] Stepanov et al., *Podvig na Enisee*, 209; G. D. Levadnaia, "Mikrofitobentos pervykh vodokhranilishch na Obi i Enisee kak pokazatel' ikh tipologicheskikh osobennostei," in *Geograficheskie problemy pri pereraspredelenii vodnykh resursov Sibiri*, ed. V. N. Saks (Novosibirsk, 1982), 170–78.

[53] Stephen Brain, "The Great Stalin Plan for the Transformation of Nature," *Environmental History* 15:4 (2010): 670–700.

[54] "Botanicheskii sad imeni Vs. M. Krutovskogo," *Internet-entsiklopedii Krasnoiarskogo kraia*, http://my.krskstate.ru/docs/nationalparks/botanichesky-sad-imeni-vs-m-krutovskogo/.

[55] A. Sharypov, "Rozy u Divnykh gor," *Ogni Eniseia*, September 25, 1971, 4.

century, of scholars to focus on the anthropogenic influences on climate change.[56] Complementing their conclusions, this article contends that studies of the Krasnoyarsk Dam's pronounced and sudden environmental effects contributed to this shift.

Once the reservoir began to fill, Gidroproekt, the agency responsible for the dam's construction, founded a hydrometeorological observatory at the site.[57] In the 1970s, more observatories were installed in different areas of Krasnoyarsk and around the Krasnoyarsk reservoir. The hydrometeorological service conducted a microclimatic survey from 1974 to 1977 that monitored temperature, humidity, wind, precipitation, and other atmospheric indicators, all in an effort to measure the influence of the dam and its reservoir.[58] As more and more data was collected on the changes not only to the local nature and climate but also to human health, Krasnoyarsk scientists came to agree almost unanimously by the 1980s that the effects of an ice-free Yenisei were largely negative.[59] The subsequent era of glasnost augmented the public's criticism of large-scale hydroelectric construction and the industrial development that accompanied it. And this shift in attitudes peaked in the late 1980s and early 1990s with efforts to find ways to refreeze the Yenisei.

Undeniably, the greatest impact of an ice-free Yenisei during winter is fog, and the smog that results from the additional pollutants it traps. In the low temperatures, the warmer water of the river evaporates and hangs suspended in the air, instead of staying trapped in the frozen river. According to some observations, the frequency of winter fogs instantly doubled or tripled.[60] Although some fog had been anticipated, what had not been predicted was dense fogs and a toxic smog within a large city of over a million people. The low visibility hampers year-round navigation on the river, as well as vehicular transportation on the bridges that cross the river and on the roads adjacent to it. The situation is particularly acute during the persistent fogs that occur from November to January (FIGURE 1).

Research on this phenomenon was galvanized by an increase in the incidence of sickness in the city. While we cannot be certain that the higher rate of health problems was caused or exacerbated by the presence of the dam and its reservoir, rather than by the higher levels of heavy pollutants in air and water due to over-industrialization, several sources point to the connection. In 1976 the head of the Department of Social Hygiene and Healthcare Organization, Dr. A. B. Faunshmidt, established a correlation between the incidence rate of rheumatism, heart disease, and blood vessel and respiratory-tract diseases in the area and the construction of the Krasnoyarsk Dam.[61] In 1985 the Reservoir Preparation Division, which continued its operations after the completion of the dam, indicated that thanks to changes in the hydrothermal regime and the associated deterioration of sanitary conditions in coastal cities downstream from the dam, Krasnoyarsk saw sickness rates rise by 17–18 percent, respiratory issues by 20 percent, and infectious diseases by fifty percent.[62] In 1989 the division reported that the sickness rate in Krasnoyarsk was 58.5 percent higher than in the central RSFSR.[63] Some sources connected sickness to increased humidity, but *Klimat Krasnoiarska*, a 1982 book in a series on climates in different Soviet cities published by Leningrad's Gidrometizdat, showed a rather insignificant growth (only 2–5 percent) in winter humidity.[64] The risk to health, therefore, is more likely to

[56] Natalia P. Koptseva and Natalia N. Seredkina, "The History of Studying Climate Change in the Krasnoyarsk Territory," *Journal of Siberian Federal University. Humanities & Social Sciences* 10 (September 2017): 1344–55.

[57] Ia. L. Gotlib et al., *Teplovoi rezhim vodokhranilishch gidroelektrostantsii* (Leningrad, 1976), 25–26.

[58] I. D. Poliakovskaia, "K voprosu o zamorazhivanii Eniseia v raione g. Krasnoiarska," in *Mozhno li zamorozit' Enisei*, ed. V. A Koren'kov and B. A Rastoskuev (Krasnoiarsk, 1994), 41–46; "Istoriia," Federal'noe gosudarstvennoe biudzhetnoe uchrezhdenie "Srednesibirskoe upravlenie po gidrometeorologii i monitoringu okruzhaiushchei sredy," http://meteo.Krasnoyarsk.ru/FBGUSrednesibirskoeUGMS/Istoriya/tabid/182/Default.aspx.

[59] I. V. Kosmakov, "Termicheskii i ledovyi rezhim v verkhnem i nizhnem b'efakh vysokonapornykh gidroelektrostantsii: na primere Krasnoiarskoi i Saiano-Shushenskoi GES" (Cand. diss., Krasnoiarsk State University, 2001), 6.

[60] Ts. A. Shver and A. S. Gerasimova, *Klimat Krasnoiarska* (Leningrad, 1982), 142.

[61] GAKK, f. 2279, op. 1, d. 34, ll. 37–38.

[62] Ibid., d. 103, l. 22.

[63] Ibid., d. 154, l. 62.

[64] Shver and Gerasimova, *Klimat Krasnoiarska*, 139.

FIGURE 1 "Soaring" Yenisei in winter. Photograph by Sergey Tokarev.

stem from air pollution. In present-day Krasnoyarsk, industrial and automobile exhausts combine with the fog emanating from the ice-free Yenisei to create "black sky" conditions (*rezhim chernogo neba*).[65]

The change in the river's thermal regime transcended the area where the river remained unfrozen in winter. The river's summertime water temperature fell by 12.6–18°F from 1967 to 1974, compared to 1933–60, which cooled the surrounding air temperature by 1°F.[66] This effect extended over 2 miles from the banks of the river. The fall in maximum water temperature could be measured 373 miles downstream.[67] In the summer, the cooling impact of the river was felt as far as 800 miles away. The use of river water to cool nuclear reactors and its discharge back into the Yenisei at the Zheleznogorsk Mining and Chemical Combine thirty-seven miles to the northeast of Krasnoyarsk altered the hydrology of the river too; radioactive contamination spread for more than 500 miles downstream.[68] Near Yeniseisk, past the confluence of the Yenisei and the Angara, the water temperature in the summer was still 2.6–3.2°F lower than it had been, and at the Arctic port of Igarka it was 0.6–1.8°F lower. This change, according to V. P. Krivosheeva of the Krasnoyarsk meteorological services, began in 1963, when the Yenisei was diverted.[69] The Angara was also warmed and cooled in various sections either side of the dams at Irkutsk and Bratsk, its waters, like the Yenisei's, also polluted with industrial waste and decaying vegetation from its flooded banks.

The freezing and thawing of the Yenisei set the pace for natural cycles, and the existence of the reservoir altered the crucial point in time when the air temperature over the lands along the river crossed the 32°F divide. In spring, it happened nine days earlier near Krasnoyarsk. Even at a great distance, where the Yenisei did freeze, the change of the seasons shifted by days, and the ice was made thinner. This has affected organisms in and outside the river, as well as people's livelihoods. The water's biomass has increased quantitatively but decreased qualitatively; phytoplankton has increased four to

[65] "Siberian Black Skies Have Russia's Dirtiest City Begging for Gas," *Bloomberg.Com*, June 12, 2020, https://www.bloomberg.com/news/articles/2020-06-12/siberian-black-skies-have-russia-s-dirtiest-city-begging-for-gas.

[66] Shver and Gerasimova, *Klimat Krasnoiarska*, 163.

[67] G. A. Orlova, "Izmenenie termicheskogo rezhima Eniseia i Obi nizhe Krasnoiarskoi i Novosibirskoi GES," in *Puti preobrazovaniia rechnogo stoka na iuge Sibiri* (Novosibirsk, 1984), 32–49.

[68] V. I. Bulatov, *200 iadernykh poligonov SSSR* (Novosibirsk, 1993), 72, quoted in Gonina, *Istoricheskii opyt prirodopol'zovaniia*, 88.

[69] V. P. Krivosheeva, "Izmenenie ledotermicheskogo rezhima v nizhnem b'efe eniseiskikh GES," in *Tezisy dokladov Led-89* (Leningrad, 1989), 10–11.

five times, for example, but the number of aquatic species has fallen from thirty-two to twenty-one.[70] Unable to cross the frozen river to their wintering grounds, the roe deer population has decreased.[71] While putting an end to spring floods, then, the dam created a new problem: winter flooding of coastal settlements, due to the permanent liquid state of the Yenisei and its higher level in winter.[72]

Soviet environmentalists criticized other ambitious dam projects in Siberia that both preceded the construction of the Krasnoyarsk Dam and were rejected later in the 1980s and 1990s. They began to reconsider the virtue of large dams in the wake of what Philip R. Pryde called the "Baikal awakening" of the late 1960s to environmental problems.[73] The degradation of Lake Baikal was caused by industrialization—particularly the placement of a large cellulose combine on its banks—and the damming of the Angara River, which raised the lake's water level.[74] Environmental threats to Baikal and the river systems linked to it catalyzed the first Soviet mass environmental movement. Planned projects such as the Nizhneobskaia Dam on the Ob, the Evenkiiskaia (Turukhanskaia) Dam on the Lower Tunguska, and the Sredneeniseiskaia Dam on the Yenisei have not gone forward, although it could be argued that the major reason for this was the collapse of the USSR and lack of funding, rather than public pushback.

Environmentalists also began to resist some long-mooted and audacious Soviet geo-engineering plans aimed at large-scale modification of the climate. Engineers had long dreamt of finding ways to reverse the northern flow of certain great Siberian rivers, sending their waters south toward the arid lands of Central Asia rather than into the Arctic Ocean. The Yenisei was not one of them, but there was a plan to connect it with the Ob River, which was a candidate for diversion.[75] Projects designed to melt the Arctic ice also were floated, the benefits of which would be a warmer climate in the north and easier navigation along the Northern Sea route. Environmentalists warned that the repercussions of such fanciful projects would be hard to predict, and the changes impossible to undo. Hydrologists had been studying the effects of the new Siberian reservoirs on the heat balance in the north since the 1970s, given that water from the Yenisei constitutes 7 percent of the Arctic's Kara Sea and occupies 45.6 percent of its watershed.[76] They have found that the regulated Yenisei has *less* heat flux, since its mean temperature has decreased as a result of its waters sitting in a deep stone reservoir.[77]

As climate change has become one of the most pressing global issues, Russian geographers have begun to ask whether the large reservoirs on Siberia's rivers could be contributing to the greenhouse effect in the Eurasian taiga and possibly impact the climate in the mid-latitudes of Siberia, foreshadowing the approach of the rising ocean.[78] More than seventy years of data accumulated at the Stolby Nature Reserve, which was established near Krasnoyarsk in 1925 for the protection and study of the wilderness, show that the temperatures in the area have been steadily increasing, most prominently in

70 A. N. Gadinov, "Ekologicheskoe sostoianie faunisticheskogo kompleksa vodotoka r. Enisei pod vliianiem zaregulirovaniia" (Cand. diss., Russian Federal Research Institute of Fisheries and Oceanography, Novosibirsk, 2009), 154.

71 A. A. Danilkin, *Kosuli. Biologicheskie osnovy upravleniia resursamy* (Moscow, 2014), 138–39.

72 V. A. Koren'kov, "Osnovnye rezul'taty naturnykh issledovanii temperaturnogo rezhima v b'efakh Krasnoiarskoi GES i vozmozhnye puti resheniia problem v nizhnem b'efe," in *Mozhno li zamorozit' Enisei*, ed. V. A. Koren'kov and B. A. Rastoskuev (Krasnoiarsk, 1994), 8.

73 Philip R. Pryde, *Environmental Management in the Soviet Union* (Cambridge, England, 1991), 12.

74 Nicholas Breyfogle, "Sacred Waters: The Spiritual World of the Lake Baikal," in *Meanings and Values of Water in Russian Culture*, ed. Jane Costlow and Arja Rosenholm (London, 2017), 33–50. On Baikal pollution see Bryce Stewart, "New Dams, Warming Waters, Forest Fires: Lake Baikal in Peril," Arkady Kalikhman and Tatiana Kalikhman, "The Environmental History of Lake Baikal," and Elena Kochetkova, "Baikal Waters: Industrial Development and Institutional Debates, 1950s–1970s," all in *Place and Nature: Essays in Russian Environmental History*, ed. David Moon et al. (Winwick, 2021), 185–94, 231–68, and 292–313, respectively.

75 Bakhtin, *Reka Enisei*, 108. American engineers devised similar schemes for the U.S. north. See B. Forest and P. Forest, "Engineering the North American Waterscape: The High Modernist Mapping of Continental Water Transfer Projects," *Political Geography* 31 (March 1, 2012): 167–83.

76 Bakhtin, *Reka Enisei*, 88.

77 T. V. Odrova, "Izmenenie ledovotermicheskogo rezhima Eniseia v rezul'tate gidrotekhnicheskogo stroitel'stva," *Vodnye resursy*, 1977, no. 1:184–87.

78 L. K. Malik, "Ekologicheskie problemy krupnykh sibirskikh GES," *Energiia: ekonomika, tekhnika, ekologiia*, 2011, no. 7:24–34; G. A. Tiusov, "Otsenka nabliudaemykh i ozhidaemykh k seredine XXI veka klimaticheskikh izmenenii na vodosborakh krupnykh vodokhranilishch GES Rossii," *Vodnoe khoziaistvo Rossii: problemy, tekhnologii, upravlenie*, 2014, no. 4:60–71.

winter, which is consistent with the warming in the rest of Eurasia.[79] The latest evidence of the faster pace of warming in the north and the significance of the Yenisei basin for the Arctic, might spark new interest in the impact of large dams and reservoirs, as well as industrial pollution, on the climate in the Russian north.[80]

The negative effects that the Krasnoyarsk Dam had on the surrounding natural environment, as well as on the population of the Krasnoyarsk urban agglomeration, were not limited to changes in the microclimate. The dam disrupted the movement of sediment and deprived the Yenisei of what Soviet hydrologists called its "self-cleaning" ability.[81] It also disrupted the migration of fish to their usual spawning and feeding grounds. In a bitter commemorative account, those who remained after the inhabitants of the Daursk District had been resettled tell of a thirty-six-foot layer of rotting fish at the upstream base of the dam.[82] Finally, what its promoters called a "sea" did not belong where it was, as has been made clear by the ongoing erosion of its banks ever since the time of its creation.

All this compelled the writer Viktor Astafyev to call the Krasnoyarsk Dam a blood clot on the Yenisei.[83] He blamed the dam for negatively effecting his health citing an instance when the diurnal temperature variation—95°F during the day and 41°F at night—which he attributed to the release of water from the dam, caused his chronic pneumonia to flare up and led to his emergency hospitalization.[84] In 1986, the writer Sergei Zadereev and the director Vladimir Kuznetzov, both born in Siberia, collaborated on a controversial film called *Plotina* ("Dam").[85] It was narrated by Fatey Shipunov, a mastermind of the Kedrograd sustainable forestry experiment of the 1950s–60s, former head of the laboratory of biosphere research at the Academy of Sciences, and fervent defender of Lake Baikal and the Volga River.[86] Against scenes of villages, burning houses, and dynamite explosions, the scientist talked about large dams as anti-ecological formations that destroy floodplains—cradles of "Russian" culture—and forests, undermining agriculture and riverine ecology. Arguing that dams supported unnecessary production and did not turn a profit, he advocated for dismantling them, reexamining projects planned for the future, and utilizing alternative energy sources. Kuznetzov believes that the popular success of the film was responsible for the subsequent revision of the design for the Boguchany Dam on the Angara, and for construction of the Katun Dam in Altai being deferred.[87]

Make the Yenisei freeze again

Two conferences organized in Divnogorsk by the Siberian branch of the All-Union Institute of Hydraulic Engineering (VNIIG) and Krasnoyarsk State University solidified the consensus that,

[79] N. V. Fokina et al., "Dinamika klimata i izmenenie fenologicheskikh sezonov goda zapovednika 'Stolby,'" *Vestnik Krasnoiarskogo gosudarstvennogo pedagogicheskogo universiteta im. V. P. Astaf'eva*, 2013, no. 2: 228–31; N. V. Goncharova and A. A. Knorre, "Osnovnye tendentsii izmeneny klimata v zapovednike 'Stolby' po dannym sobstvennoi meteostantsii za nepreryvny period nabliudenii 1947–2016 gg." in *Nauchnye issledovaniia v zapovednikakh i natsional'nykh parkakh Iuzhnoi Sibiri*, vyp. 8, ed. V. V. Nepomniashchii (Novosibirsk, 2018), 15–20.

[80] Paul Voosen, "The Arctic Is Warming Four Times Faster than the Rest of the World," *Science*, December 14, 2021, https://doi.org/10.1126/science.acz9830.

[81] This belief in the "self-cleaning" capacity of rivers gave Soviet industry a license for unbridled pollution. See Donald A. Filtzer, *The Hazards of Urban Life in Late Stalinist Russia: Health, Hygiene, and Living Standards, 1943–1953* (New York, 2010), 118–19.

[82] M. I. Safonova, *Pamiati Daurskogo raiona* (Balakhta, 2017), 25.

[83] *Kinozhurnal Eniseiskii meridian no. 5 (1999)*, dir. A. Zverev (Krasnoiarskaia kinostudiia), https://www.net-film.ru/film-212/?search=qKrasnoyarsk.

[84] Astaf'ev letter to Valentin Kurbatov, August 21, 1994, in Gennady Sapronov, *Krest beskonechny: pis'ma iz glubiny Rossii, 1974–2001* (Irkutsk, 2003), 360–61.

[85] *Plotina* was translated into multiple languages. In 1987 the film received the Grand Prize at the Ecofilm festival in Czechoslovakia. It was removed from the program at the festival in Leipzig after its authors attracted the suspicion of Soviet intelligence. *Plotina*, dir. Vladimir Kuznetsov (Krasnoiarskaia kinostudiia, 1986), https://office.net-film.ru/film-45/.

[86] Douglas R. Weiner, *A Little Corner of Freedom: Russian Nature Protection from Stalin to Gorbachev* (Berkeley, 2002), 322.

[87] Vladimir Kuznetsov, email to the author, March 2019.

henceforth, hydroelectric engineering had to be held to a higher standard for the sake of the environment.[88] The first, held in 1989 and devoted to an "Investigation of the Impact of Hydroelectric Structures on the Ice Regime of Rivers and the Environment" ("Ice-89"), gathered eighty experts from twenty-nine organizations, including the Leningrad and Siberian VNIIG, Gidroproekt, and technical and hydrometeorological research institutes from Siberia, the Far East, and the national republics. The plenary speakers, A. G. Vasilevsky and I. N. Shatalina of the Leningrad VNIIG, postulated that the mere presence of water resources should no longer be the sole determinant behind decisions on the exploitation of energy potential.[89] The attendees discussed past, ongoing, and future power station projects within the context of restrictions, the risks that river and sea ice posed to hydraulic engineering projects, as well as the possibility of using ice as a construction material.[90] The Krasnoyarsk Dam was a focal point, and in the contemporary conditions of late-Soviet glasnost and perestroika, its negative consequences, such as microclimate change, were now exposed. Speakers argued that there was no need to build such colossal hydroelectric dams, with their attendant massive reservoirs, and proposed a variety of solutions that would modernize the dam and restore the Yenisei's natural hydrology.

None of the solutions advanced at the 1989 conference were implemented, apparently, and in April 1993 some of the speakers returned to Divnogorsk for a second conference, this time with the more straightforward title, "Is it Possible to Freeze the Yenisei?" under the aegis of Krasnoyarsk State University. Participants did manage to appoint a commission of local officials, engineers, scientists, meteorologists, and ecologists tasked with brainstorming ways to regulate the temperature downstream from the Krasnoyarsk Dam.[91] But even though the agenda of this conference was more specific, opinions were more polarized. Valery Manchuk, director of the Krasnoyarsk Research Institute for Medical Problems of Northern Regions, which was founded in 1976 specifically to study human adaptation to environments compromised by industrial development, asserted that the transformations of nature stemming from the construction of the Bratsk, Krasnoyarsk, and Sayano-Shushenskaia dams were unprecedented.[92] An engineer by the name of A. P. Verbitsky presented one of the schemes to refreeze the Yenisei, and then also filed suit against the Krasnoyarsk Dam and its owner and operator at the time, Krasnoiarskenergo, charging them with harming both the environment and his family (the case was dismissed for lack of evidence).[93] The majority of participants viewed new technical solutions with skepticism, concentrating instead on methods to improve the intake and flow of water. Boris Rastoskuyev, director of the Krasnoyarsk Dam from 1960 to 1986, and Anatoly Epifanov, an engineer and security expert at the Krasnoyarsk and Sayano-Shushenskaya dams, dismissed the arguments of doctors and meteorologists as unfounded and argued that re-freezing the Yenisei was not only fiscally irresponsible but in fact impossible. I. Polyakovskaya of the Krasnoyarsk Hydrometeorological Center confirmed that the river's altered regime was irreversible, and attempting to re-freeze it was impossible and even dangerous.[94]

The two conferences merely scratched the surface of the problem—the disappearance of the Yenisei's ice, and the microclimate change its absence caused—while downplaying the overarching

[88] Founded in 1921 in Leningrad, the institute played a major role in Lenin's GOELRO plan of nationwide electrification. Today, it serves RusHydro, the Russian inheritor of the Soviet hydroelectricity company. See "Stranitsy istorii VNIIG," *Rusgidro*, http://www.vniig.rushydro.ru/company/100-let-vniig-im-b-e-vedeneeva/istoriya-vniig/.

[89] A. G. Vasilevskii and I. N. Shatalina, "Nauchnye problemy modernizatsii sushchestvuiushchikh, proektiruemykh i stroiashchikhsia gidrouzlov s tsel'iu uluchsheniia gidrotermicheskikh aspektov ekologii regiona ikh vozvedeniia," in *Materialy konferentsii i soveshchanii "Lёd-89"* (Leningrad, 1991), 4–6.

[90] For instance, engineers from the Krasnoyarsk Dam proposed using ice in the concrete mixture to cool it down, as it tended to heat up and develop cracks while solidifying. See G. Makedonskii and K. Chikvaidze, "I kholod berem v soiuzniki," *Ogni Eniseia*, December 23, 1961, 3.

[91] "Rasporiazhenie ot 1.06.93 no.229-P ob obrazovanii ekspertnoi komissii," *Administratsiia Krasnoiarskogo kraia*, https://docs.cntd.ru/document/985002538.

[92] V. T. Manchuk, "Nezamerzayushchii Enisei i nekotorye pokazateli zdorov'ia naseleniia g. Krasnoiarska," in *Mozhno li zamorozit' Enisei*, ed. V. A Koren'kov and B. A Rastoskuev (Krasnoiarsk, 1994), 49–51.

[93] A. Verbitskii, "Na ozdorovlenie reki nuzhny milliony," in *Mozhno li zamorozit' Enisei*, 103–4.

[94] I. Poliakovskaia, "Enisei ne zamerznet nikogda," in *Mozhno li zamorozit' Enisei*, 94-97.

environmental changes that were at its source, as well as its overlap with global and regional climate shifts. The plan for a technological fix that would enable water from the upper layers of the reservoir to pass through the dam gained traction. Specialists from the Central Aerological Observatory in Moscow proposed an even more ambitious and somewhat fantastic solution involving the artificial crystallization of the fog near Krasnoyarsk.[95] The goal of these schemes was to ameliorate the ecological situation in the big city, and they were predicated on the common assumption that the dam was the key factor in keeping the Yenisei ice-free, and in the change in the region's microclimate. Both meetings barely addressed the industrial waste released into the river at Krasnoyarsk, which prevented ice formation further downstream, nor the air pollution that turned the Yenisei's increasingly frequent fogs into a public health hazard. The speakers at the 1993 conference did bring up the "Clean Yenisei" Program, which was launched in the 1980s and headed by Iosif Gitelson, a Krasnoyarsk-based doctor and biophysicist and one of the authors of the BIOS experiments with closed artificial ecosystems.[96] Yet the program operated in isolation from studies of the dam's environmental consequences, and it was short-lived.

The tendency to shirk responsibility for the region's environmental degradation from one profit-focused producer to another outlived the USSR. At a recent press conference, the Krasnoyarsk Dam director from 1998 to 2018, Sergey Kaminsky, attributed Krasnoyarsk's ecological problems entirely to industrial pollution unrelated to the dam, which he argued played a net positive role in the environment.[97] Similarly, Valentin Bryzgalov, the chief engineer, rejected claims that large dams had brought negative ecological and social changes in their wake. When the Three Gorges Dam on China's Yangtze River provoked a public controversy because of its negative environmental impact and displacement of more than a million people, Bryzgalov defended the Chinese government: to his mind, the benefits of the dam, construction of which began in 2003, far outweighed such externalities.[98] To this day Russian dam builders continue to urge the state to carry on with the building of large dams, both to protect their own legacy, and to ensure that their knowledge and expertise remain in high esteem and demand.

CONCLUSION

The Krasnoyarsk Dam continues to produce electricity, now under the ownership of a large aluminum and energy-producing company, the En+ Group, and the ice-free Yenisei remains an issue.[99] The history of the complex relationships between the "organic machine" of the dam, the natural environment surrounding it, and the microclimate of the immediate vicinity goes back to the 1950s and 1960s, when Soviet engineers and workers transformed the valleys of Siberian rivers, and their unwelcoming climate, by creating monumental hydroelectric dams.[100] It was hard and dangerous work, but veterans of the Krasnoyarsk Dam's construction still cherish the sense of extraordinary achievement won by damming one of the greatest rivers on the planet. For them, the dam was a creative force, giving them an illusion of power as well as the opportunity to build a good life. On the flip side, the project, which

[95] A. A. Chernikov et al., "Metody vozdeistvii na ledotermicheskii rezhim i mikroklimat v priberezhnoi zone nizhnego b'efa gidrouzla," and G. A. Tregub and V. I. Khvorost'ianov, "Raschet elementov ledotermicheskogo rezhima nizhnego b'efa GES pri iskustvennoi kristallizatsii tumanov pareniia nad polyn'ei," both in *Tezisy dokladov "Led-89"* (Leningrad, 1989), 3–4 and 28–30, respectively.

[96] N. I. Gitel'zon, *Ekologicheskie issledovaniia vodoemov Krasnoiarskogo kraia Mezhduvedomstvennyi sbornik nauchnykh trudov AN SSSR* (Krasnoiarsk, 1983), 210.

[97] Tat'iana Riabinina, "Ges i klimat: mify i real'nost'," *Komsomol'skaia pravda*, March 30, 2016, 32–33.

[98] Petr Neporozhnyi et al., *Edinaia Energeticheskaia Sistema Rossii: Vospominaniia Stareishikh Energetikov* (Moscow, 1998), 557.

[99] The smelter produces more than a million tons of aluminum annually. En+ Group, presided over by the oligarch Oleg Deripaska, is the largest shareholder of RUSAL, the company he founded. Since Russia's full-scale invasion of Ukraine, the company has continued to sell aluminum abroad, increasing its revenue to nearly $14 billion in 2022 and more than $12 billion in 2023. See RUSAL, "Consolidated Financial Statements for the year ended 31 December 2023," March 14, 2024, 9, rusal.ru/en/investors/financial-stat/msfo/.

[100] Richard White, *The Organic Machine: The Remaking of the Columbia River* (New York, 2001).

was rooted in Russian colonialism, displaced whole villages, drowned fertile lands under a massive reservoir, and caused a host of environmental changes.

In 1967 the Yenisei ceased to freeze in the upstream approaches to Krasnoyarsk, and for a hundred miles downstream of the city. This anomaly set off an immediate change in the microclimate. The annual freeze and thaw cycle of the untamed river had acted as nature's seasonal clock, but the modern Soviet state was determined to synchronize it with the linear timeline of human progress toward socialism. Design engineers had created both miniature and large, fully functional models of the Krasnoyarsk Dam for research, educational, and demonstrative purposes, but none of these could replicate the actual features of the local environment, or accurately predict the real-life consequences of hydroelectric dam construction. For Soviet technocrats, the dam's perceived benefits outweighed its limitations. It would take decades for the complex and detrimental consequences of the Krasnoyarsk Dam, and other large dams, to become apparent and thereby shatter the lingering perception of hydropower as fairly sustainable, clean, and climate-friendly.

This history of the impact of the Krasnoyarsk Dam and its role in the reassessment of anthropogenic environmental and climate change—and whether it is possible to reconcile with or overturn it—offers a glimpse of one of the possible futures being ushered in by a transformed environment, and the new human experiences in it. It has become a rule to associate climate change with "normalization" of extreme weather due to its anticipated higher frequency. The case at hand is distinct: extremes here were in fact smoothed out, but this also has led to unintended consequences.

"That global warming is our doing should be a comfort, not a cause for despair," writes David Wallace-Wells. "That we know we are, ourselves, responsible for all of its punishing effects should be empowering," because "we remain in command. No matter how out of control the climate system seems," he avers, "we are all its authors. And still writing."[101] By the 1990s, Soviet engineers and ecologists were ready to admit the failure of *some* environmental practices, and they were determined to address them. Their thinking, perhaps, was symptomatic of Russia's overall transition into a new nation. But the desire to undo the damage inflicted upon the Eurasian environment—not to mention the changes to the planetary climate unrelated to the dams—has, just like the civil traumas experienced under the Soviet regime, proven unrealistic. In their determination to alter the Yenisei's hydrology, Soviet planners downplayed the river's role in sustaining the climate in its basin. But the river continues to "make" the weather. And this reminds us that we need to recognize the value of the natural world we have harmed, to scrutinize more closely any project that might modify the climate, and rethink and reject the harmful practices of the past. Delaying these commitments, and subverting them with technological optimism, will only accelerate the catastrophe.

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[101] David Wallace-Wells, *The Uninhabitable Earth: Life after Warming* (New York, 2019), 34.

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