

Warming Trend: Soviet Climate Science and State Policy  
by  
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## Introduction

Soviet climate scientist Mikhail Budyko (1920-2001) informed Alan Hecht in November 1986 that he was reluctant to assume the position of Soviet co-chairman to Working Group VIII of the 1972 US-USSR bilateral environmental agreement.<sup>1</sup> According to Hecht, the co-chairman for the American side, Budyko was “in poor health (sickly ever since childhood), easily tired, and overburdened by preparation of several books.”<sup>2</sup> Budyko’s wife died three days prior to the arrival of the US delegation in Moscow, exacerbating his fatigue.

In addition to personal health issues Budyko, the leading proponent of anthropogenic (human-caused) global warming in the Soviet Union and a popular science writer, also faced scientific opposition. He accepted the post of co-chairman to Working Group VIII, the wing of the bilateral environmental agreement on climate change, at the expense of a competing candidate, Yevgeny Borisenkov. Borisenkov led the scientific opposition to anthropogenic global warming in the Soviet Union, telling Hecht that same November he was “preparing a paper to counter Budyko’s claims that evidence for greenhouse warming has occurred.”<sup>3</sup> Budyko accepted co-chairmanship because of a promise by his politically savvy bureaucratic superior Yuri Izrael that “the issues of greenhouse gases and global climate change would be given highest priority” in the Working Group.<sup>4</sup>

This subtle victory for anthropogenic global warming was one along a lifetime of investigations that led Budyko to formulate a uniquely Soviet environmentalism. Like other industrial societies the Soviet Union suffered major environmental problems from air and water

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<sup>1</sup> Officially the “Agreement on Cooperation in the Field of Environmental Protection,” hereafter referred to as the bilateral environmental agreement.

<sup>2</sup> Alan Hecht, travel report, 15 November 1986, Box 11, Folder 105, Summary Report of the Eleventh Meeting of Working Group VIII, Lawrence Livermore Nuclear Winter Study Papers, Environmental Science and Public Policy Archives, Cambridge, United States.

<sup>3</sup> Ibid.

<sup>4</sup> Ibid.

pollution to issues of land management and ecological destruction. Unlike other industrial societies the Soviet Union was run by a Communist Party dominated by engineers and anchored to the idiosyncrasies of Marxism-Leninism. The Soviet government exerted significant pressure on scientists and used almost total censorship to blockade bad news from the public, including environmental degradation, making scientists the only interest group capable of any form of activism on nature's behalf.

In the case of climate change as an area of environmental activism, Mikhail Budyko was nearly an interest group of one. Budyko had "tight control" over climate science in the Soviet Union and although he had many colleagues over the years, their work is not known in the west, and none of them had comparable authority in the field.<sup>5</sup> Budyko's beliefs and environmental advocacy are therefore the defining test of the kind of environmentalism that developed on the issue of climate change in the Cold War Soviet Union.

Budyko grew ever more environmentally conscious over the course of his career and tried to use his (admittedly limited) influence to increase the clout of global warming and climate change as issues in the Soviet Union. This environmentalism bore the technocratic mark of the Soviet Union because it included, among other characteristics, an insistence that limits on economic growth were not necessary or desirable, that geoengineering was a viable solution to climate change and that global warming would have beneficial outcomes. Although these attributes seem strange bedfellows to environmentalism they were nonetheless held by Budyko alongside a deep conviction that climate change was the foremost contemporary issue. Budyko's technocratic environmentalism came from the confluence of aforementioned factors, as well as the institutional incentives and pressures unique to Soviet science. These factors made

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<sup>5</sup> R.G. Ellingson, F. Baer, H.W. Ellsaesser, Harshvardhan, Martin I. Hoffert, "Climate Research in the Former Soviet Union" (*FASAC Technical Assessment Report*, 1993): I-4.

environmentalism familiar in the west impossible, but nonetheless abetted technocratic sensibilities toward nature. To obtain government recognition and awareness of global warming and climate change Budyko strategically played into the sensitivities and interests of the Soviet government in his publications and used the bilateral environmental agreement to marginalize the scientific opposition to anthropogenic global warming and establish his control over the field of climate science. He was ultimately successful in maintaining remarkable control over the direction of Soviet climate research but had more limited success in getting his predictions about climate change into state planning and ultimately increasing his research budget.

Budyko, the Soviet Union's premier climate scientist, operated within the political framework determined by the institutional incentives of the Hydrometeorological Service which represented the country in international environmental cooperation and the bilateral environmental agreement.<sup>6</sup> The Hydromet had full authority to appoint co-chairmen, project leaders and include participants to all the agreement's activities. Led by Izrael from 1974 until the breakup of the Soviet Union, the Hydromet was primarily tasked with environmental data collection (precipitation, temperature, air pollution, etc.) from thousands of monitoring stations across the northern hemisphere. Though largely a weather service, in 1972 the Hydromet was the closest thing to an environmental protection agency the Soviet Union had and was assigned the role of reconciling the apparent paradoxes of Marxism-Leninism and the environment.<sup>7</sup>

One of these apparent paradoxes was the Soviet Union's "single-minded concern with industrialization" which implied environmental degradation was an acceptable price of

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<sup>6</sup> Later elevated to State Committee for Hydrometeorology and Control of the Natural Environment in 1978, hereafter referred to as the Hydromet.

<sup>7</sup> Charles E. Ziegler, *Environmental Policy in the USSR* (Amherst: University of Massachusetts Press, 1987): xxii.

“outproducing” capitalism.<sup>8</sup> Scientific challenges to domestic industrial development were sidelined by the government throughout the Cold War period. When challenges were strongest, such as scientific and local voices against the pollution of Lake Baikal or the “revolt of experts” who spoke out against the Siberian river diversion plan in 1981, successfully discontinuing government projects took years of opposition and were exceptions that prove the rule.<sup>9</sup> The obsessed pursuit of industrialization was in tension with recognition of severe environmental damage, as well as the theory of global warming that implied economic growth through fossil fuel combustion would lead to disaster.

Another ideological trait of the Soviet Union was an immense faith in the ability of humans to manipulate nature for their own benefit exemplified in the Stalinist slogan that humankind should “fix nature’s mistakes.”<sup>10</sup> Throughout the Cold War period Soviet leaders entertained enormous transformation of nature projects such as those that drained the Aral Sea, redirected the current of continent-spanning rivers or envisioned the reclamation of the steppes for farming. Joseph Stalin, Nikita Khrushchev and Leonid Brezhnev each in turn promoted their own enormous agricultural reclamation projects – from Stalin’s Great Plan for the Transformation of Nature to Khrushchev’s Virgin Lands Project to Brezhnev’s Food Program.<sup>11</sup> This was the second paradox: if the Soviet government was unintentionally ruining the environment the Soviet Union had not mastered nature.

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<sup>8</sup> Until the 1960s the environment as a conceptual category hardly existed. Nature as a whole was not seen as a fragile ecosystem the preservation of which was a widely accepted good, but a bastion of raw materials which humans were to exploit.

Douglas R. Weiner, *A Little Corner of Freedom: Russian Nature Protection from Stalin to Gorbachëv* (Berkeley: University of California Press, 1999) 289.

<sup>9</sup> *Ibid.* 361, 419.

<sup>10</sup> Brian Bonhomme, “Writing the Environmental History of the World’s Largest State: Four Decades of Scholarship on Russia and the USSR,” *Global Environment* 12 (2013): 17.

<sup>11</sup> Stalin was General Secretary until his death in 1953, Khrushchev from 1953 until his ouster in 1964, Brezhnev from 1964 until his death in late 1982.

Yet despite these prominent ideological positions the Soviet government in the view of scholars such as Robert G. Darst enthusiastically embraced international environmental cooperation. According to Darst “Brezhnev himself launched the initiative that ultimately led to the conclusion of the LRTAP [Long Range Transboundary Air Pollution] Convention and subsequently agreed to reduce Soviet sulphur dioxide emissions which crossed national borders (transboundary) by 30 percent.”<sup>12</sup> Corroborating this attitude Donald R. Kelley claims “U.S.-Soviet cooperation in the field of environmental protection” through the 1972 agreement, signed in Stockholm during a burst of international environmental agreements, was “one of the most durable areas of scientific exchange.”<sup>13</sup> Under the environmental bilateral agreement Budyko’s Working Group VIII made the most confident international statements on the inevitability of global warming and climate change in the 1980s. The bilateral environmental agreement also spurred a flurry of scientific exchanges which had by 1979 (the last year before deteriorating relations disrupted scientific exchanges) included over a thousand participants among several dozen projects.<sup>14</sup> This environmental cooperation resumed when Mikhail Gorbachev became leader in 1985 and began “an ambitious effort to fundamentally reform the USSR’s domestic and foreign policies” which resulted in the removal or circumvention of many “long-standing obstacles to scientific, diplomatic, and regulatory progress.”<sup>15</sup> Under Gorbachev’s administration the Soviet Union sent delegates to the first few negotiations of what would become the United

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<sup>12</sup> Robert G. Darst, *Smokestack Diplomacy: Cooperation and Conflict in East-West Environmental Politics* (Cambridge: MIT Press, 2001): 6.

<sup>13</sup> Donald R. Kelley, “Environmental Protection and Conservation.” *U.S.-Soviet Cooperation: A New Future*, edited by Nish Jamgotch, Jr. (New York: Praeger, 1989):83.

<sup>14</sup> *Ibid.* 87.

<sup>15</sup> Vassily Sokolov, Jill Jager, Vladimir Pisarev, Elena Nikitina, Alexandre Ginzburg, Elena Goncharova, Jeannine Cavender-Bares, and Edward A. Parson, “Turning Points: The Management of Global Environmental Risks in the Former Soviet Union,” in *Learning to Manage Global Environmental Risks Volume 1* (Cambridge: MIT Press, 2001): 139.

Nations Framework Convention on Climate Change that explicitly called for limits on carbon emissions, signed in Rio de Janeiro Brazil in 1992.

Why was the Soviet Union so engaged in international environmental cooperation? In the 1990s Robert Darst first articulated the still generally accepted explanation, corroborated by interviews of Hydromet officials and scientists published in the most directly relevant work on my subject, “Turning Points: The Management of Global Environmental Risks in the Former Soviet Union” in the MIT Press published book *Learning to Manage Environmental Risks*. Darst’s theory is that “Soviet leaders used East-West environmental cooperation as a way to project an image of ‘cooperativeness,’ and thus elicit Western cooperation in nonenvironmental areas of greater interest to the USSR.”<sup>16</sup> He argued that particular acts of environmental cooperation were only undertaken if they were low cost. For example Darst identified the 30% sulphur dioxide reduction commitment as a clear instance of political expediency because the government agreed only after realizing they were already going to achieve the emission reductions under existing economic plans.<sup>17</sup> In *Learning to Manage Environmental Risks* (2001), a semi-historical review of the Soviet environmental action, several Academy of Sciences affiliated specialists and western scholars substantiated the cooperativeness theory.<sup>18</sup> Hydromet officials, Ministry of Foreign Affairs officials, professors, scientists and others including participants to the LRTAP negotiations confirmed in many cases Soviet environmental cooperation was intended “to bolster détente.”<sup>19</sup>

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<sup>16</sup> Darst, 6.

<sup>17</sup> Darst 6, 4

Interestingly Kelley also believed at an earlier date with less supporting evidence that the bilateral environmental agreement was “meant to remind Soviet audiences that détente brought not only a reduction of bilateral tensions but also a more open door for the acquisition of advanced U.S. technology and increased trade,” from Kelley 87.

<sup>18</sup> A large number of scholars contributed to this chapter, including Vassily Sokolov, Jill Jäger, Vladimir Pisarev, Elena Nikitina, Alexandre Ginzberg, Elena Goncharova, Jeannine Cavender-Bares, and Edward A. Parson as main contributors, and acknowledgements to Ivan Tugarinov, Jane Prokop and of course Robert Darst.

<sup>19</sup> Sokolov et al., 144.

Gorbachev's glasnost (opening of Soviet society) and the collapse of the Soviet Union in 1991 liberated a huge swath of rich primaries, from interviews to archives, which significantly changed the course of Russia environmental historiography. In the decades prior to the collapse with the writing of mostly non-historians – “geographers, political scientists, economists, and others” – Russian environmental history was held back by the difficulty of collecting sufficiently quality sources.<sup>20</sup> While the pre-collapse and pre-glasnost period of scholarship argued that the Soviet Union's environmental problems were at least as bad as those in the west, 1991 “gave way to a slew of first-draft post-mortems of a failed state.”<sup>21</sup> The immediate post-collapse historiographical fashion was most famously exemplified in Murray Feshbach and Alfred Friendly, Jr.'s famous *Ecocide in the USSR*. Not only was the Soviet Union facing the normal environmental banes of industrialization *Ecocide* argued the Soviets were catastrophically mismanaging their environment in a way unprecedented in human history.

Recent catalogues of the field of Russian environmental history since then have pointed to more nuanced takes on this evolving field, including Brian Bonhomme's *Writing the Environmental History of the World's Largest State* in 2013 and *Conceptualizing and Utilizing the Natural Environment: Critical Reflections from Imperial and Soviet Russia* by Jonathan Oldfield, Julia Lajus and Denis J.B. Shaw in 2015.<sup>22</sup> These authors note a pushback against the ecocidal narrative since the 1990s, in particular the enormous influence of Douglas R. Weiner

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<sup>20</sup> Bonhomme, 14.

Also for early Russian environmental history: P.R. Pryde's *Conservation in the Soviet Union*, Joan DeBardeleben's *The Environment and Marxism-Leninism: The Soviet and East German Experience*, J. Bellamy Foster's “Marx's Ecology in Historical Perspective,” Charles E. Ziegler's *Environmental Policy in the USSR*, Donald R. Kelly's *The Economic Superpowers and the Environment: The United State, the Soviet Union, and Japan*, and the most recent major work Paul R. Josephson et al. *An Environmental History of Russia*.

<sup>21</sup> Bonhomme, 17.

<sup>22</sup> Other critical reviews include Randal Dills' “Forest and Grassland: Recent Trends in Russian Environmental History: Directions and Potentials,” (2013) and Andy Bruno's “Russian Environmental History: Directions and Potentials” (2007).

who, “undermined... the notion that the USSR’s environmental history was relatively simple, involving a defective and destructive ideology single-mindedly pursued by a monolithic system.”<sup>23</sup>

Weiner demonstrated the complexity of Soviet environmental history and showed that there were “overlapping and contesting bureaucracies, dissenting voices, and promising developments.”<sup>24</sup> In the latter of those works Weiner famously argued, contrary to the perception of the Soviet state as totalitarian and deeply intrusive in every aspect of daily life, conservationists and to a lesser degree scientists in fields related to the environment had relatively impressive freedom. He argued this by examining the role of Soviet activists, scientific experts, the academic bureaucracy and the policy elite in cultivating a surprisingly robust Soviet conservationist movement. In response to government mismanagement of the environment emerged an “environmental rhetoric” used by figures within the establishment that helped confirm “environmental issues as one of the few zones of relatively free speech in the Soviet Union.”<sup>25</sup>

Weiner’s argument is however quite reserved, including in the area of my interest, the power of Soviet climate scientists over government policy. Weiner’s view is that although “environmentalists” in the USSR had some degree of freedom, “economists, philosophers, jurists, and other social scientists must be viewed chiefly as a component of the regime’s propaganda apparatus. From Stockholm (1972) to Rio de Janeiro (1992), Soviet rhetoricians made the circuit.”<sup>26</sup> These rhetoricians were part of a state effort to project cooperativeness and

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<sup>23</sup> Bonhomme, 21.

<sup>24</sup> Ibid. 21.

See Weiner’s 1999 and 2000 books, *Models of Nature: Ecology, Conservation, and Cultural Revolution in Soviet Russia* and *A Little Corner of Freedom: Russian Nature Protection from Stalin to Gorbachëv* respectively.

<sup>25</sup> Weiner, *A Little Corner of Freedom: Russian Nature Protection from Stalin to Gorbachëv* (Berkeley: University of California Press, 1999): 374-375.

<sup>26</sup> Ibid. 401.

further détente and though they have been covered thoroughly, scholars have not studied the role of scientists in their attempts to influence policy nearly as much.

In the field of Soviet science history there are many scholars who have painted the trajectory of Russian conceptions of ecology, nature, the global climate over time and the parameters of Soviet scientific debate. Loren R. Graham has published numerous works on Soviet science and the boundaries within which scientists could play politics or were influenced by politics.<sup>27</sup> Lawrence Badash has thoroughly documented, primarily from the American perspective, the Soviet-American interactions during the development of the nuclear winter theory that postulates the use of nuclear weapons would result in a global winter.<sup>28</sup> Making specific reference to Budyko's contributions to Soviet science, Jonathan Oldfield and Julia Lajus have contributed most directly to the main actors that feature in my thesis. They have both also written on Soviet science debates in general and the development of specific scientific conceptions in Russian environmental history, such as the Russian equivalent of the English concept of ecological system, known as biogeocoenose.<sup>29</sup>

My thesis strives to fill the gap in our understanding of the relationship between climate scientists in the Soviet Union and their state by recognizing one “promising development” among climate scientists involved in Working Group VIII of the US-USSR bilateral environmental agreement. The bilateral offered the Hydromet and climate scientists like Budyko

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<sup>27</sup> See Loren R. Graham, *Science and the Soviet Social Order, Science in Russia and the Soviet Union: A Short History, Science, Philosophy, and Human Behavior in the Soviet Union, and The Soviet Academy of Sciences and the Communist Party, 1927-1932*.

<sup>28</sup> See: Lawrence Badash, *A Nuclear Winter's Tale: Science and Politics in the 1980s* (Cambridge: MIT Press, 2009).

<sup>29</sup> See: Jonathan D. Oldfield, Julia Lajus, Denis J.B. Shaw, “Natural Environment: Critical Reflections from Imperial and Soviet Russia,” *The Slavonic and East European Review* 93 (2015): 1-15; also Oldfield, Jonathan D. *Russian Nature: Exploring the Environmental Consequences of Societal Change* and “Climate modification and climate change debates among Soviet physical geographers, 1940s–1960s,” *Wiley Interdisciplinary Reviews: Climate Change*; and Julia Lajus, Sverker Sörlin, “Melting the Glacial Curtain: the Politics of Scandinavian-Soviet Networks in the Geophysical Field Sciences Between Two Polar Years, 1932/33-1957/58,” *Journal of Historical Geography* 44 (2014): 44-59.

opportunities to expand their funding and promote their ideas. What were Budyko's ideas? What were the constraints within which he operated? How did Budyko use Working Group VIII to advance his agenda? These three questions correspond to my three chapters, and their answers delineate a technocratic environmentalism the limits of which defined the kind of activism that was possible for climate change in the Soviet Union.

To prove my thesis I will be relying on primary sources that unfortunately skew closer to pre-collapse period rather than the richer archival and oral material made available after the end of the Soviet Union. This is because I am neither fluent in Russian nor do I have the resources to visit Russian archives. My pre-collapse sources therefore include popular science books written by Budyko and Izrael, Soviet scientific articles and excerpts from the Soviet press, all of which are translations. I also had the good fortune of being able to access the reports of American scientists involved in Working Group VIII who provide my richest unpublished sources of Budyko and his colleagues.

These American documents are held in Harvard University's archives. They mainly include a collection from the Lawrence Livermore Laboratory, one of the institutions in continuous contact with Soviet scientist through the bilateral environmental agreement in the 1980s. Scientists from any country have incentives to overemphasize progress to guarantee continued support for their activities abroad (activities that are, besides scientifically enlightening, valuable personal experiences). These documents, which include travel reports, personal notes and correspondence written by American scientists, are subject to these normal exaggerations. This is mitigated by the fact that some the private notes of these scientists can be

directly compared to their travel reports and the fact that reporting on the perceived status of internal Soviet scientific fissures was not politically sensitive to American scientific institutions.

Among the Soviet primary sources I have a decent breadth of scientific publications which were widely translated into English because the American government expended great effort to stay up-to-date on the latest Soviet science. These publications were republished in English-language journals such as *Soviet Sociology*, *Soviet Geography* or translated wholesale such as the Soviet journal *Meteorology and Hydrology*. Sometimes these translated volumes do not cover all of the relevant years, such as in the case of *Meteorology and Hydrology* where I am missing articles published in the 1960s. I rely on writers who referenced these inaccessible articles in more recent, accessible publications, to retrieve the original contents. This is a noteworthy problem only because of Soviet scientific publications generally overemphasized the progress of Soviet science, and Budyko in particular lost some credibility for exaggerating his own accomplishments in Soviet literature reviews.<sup>30</sup>

Though relying on translators of varying quality would normally be a significant impediment, this issue is somewhat less problematic in the case of this thesis because of the relatively dry, straightforward language of science publications and even science news writing. Moreover government censorship, even if not directly applied, did have a chilling effect on what scholars would feel confident publishing, writing or even speaking privately to Americans. In the case of potential reservation on the part of Soviet scientists when speaking to American colleagues, insightful information might be lost to scholars without Russian archival materials or candid post-collapse interviews. My thesis therefore portrays the real positions and events as best

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<sup>30</sup> Ellingson et al., I-4.

I can by triangulating private correspondence, popular science writing, academic publications, US travel reports, obituaries and published interviews.

My thesis is organized into three “warming trends” argued in slightly overlapping chronological order. The first warming trend is the literal realization of anthropogenic global warming by Budyko. In chapter 1 I argue that Budyko’s environmentalist beliefs were informed by the results and scientific limitations of his research, in particular his discovery of the snowball earth and his paleoclimatic forecasts of improved agricultural productivity after global warming. The second chapter features the warming of the Soviet state towards environmental issues. The Hydromet under Yuri Izrael had institutional incentives that manifested in a particular government rhetoric around the environment that set the political boundaries of safe environmentalist advocacy.

During the twilight years of the Soviet Union, General Secretary Mikhail Gorbachev’s administration permitted open recognition of the threat of carbon emissions and anthropogenic global warming, engaging in the greening of Soviet politics. The Soviet Union and the United States worked together to found the Intergovernmental Panel on Climate Change (IPCC), on which Budyko and Izrael were key participants during the early drafts of what would be the first general consensus on climate change’s impacts. The end of the Cold War under Gorbachev ushered in the warming trend in Soviet-American relations, revealing significant shifts in the internal scientific politics of global warming among Soviet scientists. I will argue that environmentally conscious Soviet scientists like Budyko overcame domestic opposition to the carbon dioxide theory of global warming and moreover played politics to both expand their clout and achieve what they believed to be desirable environmental goals.

The particular actors who came to dominate Soviet climate science had immense influence over the initial years of global warming's debut as a major public policy issue. The scientific opinions and political disposition of Mikhail Budyko and Yuri Izrael reveal the limits of environmentalist activism and advocacy among the expert elites on the issue of climate change, and also inform our understanding of the early years of international climate negotiation leading to the IPCC and the UN Framework Convention on Climate Change (UNFCCC). This history would set the tone for future agreements such as the Kyoto Protocol (1997) and eventually the Paris Agreement signed in 2015, which occurred during the 21st session of signatories to the UNFCCC.

## Chapter 1 Budyko and Climate Change

### Mikhail Budyko and Climate Modification

Mikhail Ivanovich Budyko was born in the small town of Gomel, Belarus in 1920 during the Russian Civil War. He moved to Leningrad, where his parents were originally from, before the Second World War to pursue higher education and received a Master of Science degree in Hydro-Aero-Dynamics from the Leningrad Polytechnic Institute in 1942, during the German siege that starved the city.<sup>31</sup> Budyko began working for the Main Geophysical Observatory (MGO) in his last year of studies and was evacuated with his family as part of the temporary relocation of the MGO to avoid the Leningrad siege.<sup>32</sup> He earned his Candidate Degree in 1943 and in 1944 Budyko returned to Leningrad, the German siege having been lifted that spring. Budyko obtained his Doctoral Degree in 1951 and ascended quickly in the MGO, becoming Director in 1954 – the youngest head (34 years old) of the Observatory since its foundation in 1849.<sup>33</sup> He stayed for 21 years until his transfer to the Hydrological Institute in 1975, also in Leningrad.<sup>34</sup> Budyko spent the rest of his life in the city.

Budyko's childhood and adolescence coincided with the most tumultuous period of Soviet history. He was a member of Joseph Stalin's new Soviet scientific and technical elite, the generation of well-educated Soviet citizens who Stalin expected to rebuild the country after the Second World War. Budyko's personal research in the late 1940s on the hydrometeorological

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<sup>31</sup> William A. Dando, *Encyclopedia of World Climatology*, ed. John E. Oliver, "Budyko, Mikhail Ivanovich," (Dordrecht: Springer, 2005): 179.

Natalia Andronova, *Encyclopedia of Global Warming and Climate Change*, second edition, ed. S. George Philander, "Budyko, Mikhail," Thousand Oaks: SAGE Publications, 2012. doi: 10.4135/9781452218564.n86.

<sup>32</sup> World Meteorological Organization, "Prof. Mikhail Ivanovitch Budyko," *Bulletin* 52 (2003): 217.

<sup>33</sup> Spencer Weart, *Oral Histories: Mikhail Budyko*, web, accessed March 25 2016, <https://www.aip.org/history-programs/niels-bohr-library/oral-histories/31675>.

World Meteorological Organization, 218.

<sup>34</sup> *Ibid.* 221.

aspects of shelterbelts was immediately connected with reconstructing the economy under Stalin.<sup>35</sup>

For scientists in fields related to environmental manipulation the late Stalin period presented opportunities and risks. In 1948 Joseph Stalin proposed the Great Plan for the Transformation of Nature, a massive climate engineering program intended to improve agricultural output by constructing artificial water bodies, shelterbelts and irrigation systems – a thorough ecological redesign of a large part of the surface of the earth. The Great Plan brought together, as Denis Shaw has noted, scientists and professionals from fields as diverse as “geography... forestry, soil science, oceanology, geocryology, botany, geology, hydrology, meteorology, limnology, agricultural science and several others” who scrambled to provide knowledge the state could use to rationalize nature.<sup>36</sup> During this reshuffling of bureaucracies and scientific institutions, groups and individuals working on the Great Plan jockeyed for power and consolidated hold on their disciplines.

Budyko personally witnessed one case of reshuffling when his “mentor” Andrei A. Grigor’ev fell as head of the Institute of Geography (then a main vehicle for executing Stalin’s Plan for the Transformation of Nature).<sup>37</sup> Grigor’ev was attacked in an article published in 1950 which, according to historian Jonathan Oldfield, accused his theoretical work “and more broadly, the work of the Institute of Geography” of being too abstract and irrelevant to the Soviet economy.<sup>38</sup> Subsequent this critique Grigor’ev was removed “as head of the Institute of Geography to be replaced by I.P. Gerasimov” and this “gave rise to a series of articles in the

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<sup>35</sup> Jonathan Oldfield, “Climate modification and climate change debates among Soviet physical geographers, 1940s–1960s,” *Wiley Interdisciplinary Reviews: Climate Change* 4 (2013): 519.

<sup>36</sup> Denis J.B. Shaw, “Mastering Nature through Science: Soviet Geographers and the Great Stalin Plan for the Transformation of Nature, 1948–53,” *The Slavonic and East European Review* 93 (2015): 141.

<sup>37</sup> Andrei Lapenis, “Mikhail Ivanovich Budyko (1920–2001),” *EOS* 83 (2002): 233.

<sup>38</sup> Oldfield, 519.

leading geographical journals which reflected on the conceptual weaknesses of Grigor'ev's work."<sup>39</sup>

One of Grigor'ev's scientific contributions was toward the issue of "geographic zonality" which was the idea that there were distinct natural geographic zones formed by the combined effect of natural processes. As Oldfield has covered, in the 1950s this delimited view of natural climates was disintegrating as the interdisciplinary and global nature of climate-related sciences was becoming apparent to the scientific community in the Soviet Union.<sup>40</sup> For example in 1954 (incidentally the year after Stalin's death) the Academy of Sciences publicly identified the planetary heat and water balance "as a key focal point for Soviet physical geography" to study in the immediate future.<sup>41</sup> Budyko was interested in solving the problem of geographic zonality and began a study of the global forces that contributed to local climatic conditions.

This research into the earth's heat and water balance "formed a central part of the efforts to modify and transform regional climate... within the framework of the Great Stalin Plan" according to Oldfield, but Budyko's interest was shifting toward an interdisciplinary, global approach.<sup>42</sup> In 1956 Budyko published the foundational text of physical climatology *The Heat Balance of the Earth's Surface* which tackled the problem of geographic zonality using data collected by the MGO to produce heat maps of the northern hemisphere. In this work Budyko stressed the globally interconnected systems that contributed to geographic zonality. Later, Budyko and Innokenti P. Gerasimov (Grigor'ev's successor), who was a friend and colleague of

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<sup>39</sup> Ibid.

<sup>40</sup> Ibid. 517.

<sup>41</sup> Ibid.

<sup>42</sup> Ibid. 516.

Budyko, implored a higher degree of interdisciplinary work at the Third Geographic Union conference of 1961 for this among other reasons.<sup>43</sup>

1961 was a significant year for Soviet ambitions to transform nature: the first conference devoted to the *problems* of transforming nature gathered representative Soviet scientists including Budyko.<sup>44</sup> By that time, Stalin's Great Plan for the Transformation of Nature had been abandoned. Upon Khrushchev's ascension many of its projects were discontinued. State interest in deliberate climate modification (though not specifically the Great Plan) was however unchanged, leaving scientists and rhetoricians the job of reconciling the government's insistence on engineering nature and the probable environmental damage project failure (or project success) produced.

At the 1961 climate modification conference Budyko presented more than merely local, geographically limited problems of transforming nature. Budyko argued that at the present rate of increasing human energy output the global average surface temperature would rise to such a degree that the new climatic conditions would make life "impossible."<sup>45</sup> He published *Climate Change and the Means of Its Transformation* the following year which reiterated his tentative claim that human energy output could cause a warming of the earth.

Over the next 8 years Budyko's MGO collected data that he would use to formulate his famous 1969 climate model, which was so sensitive that a minor global cooling resulted in a global ice age. He realized that even minor perturbations in the global intake of solar radiation had apocalyptic implications for the climate, however his chief concern at the time was the

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<sup>43</sup> Mikhail I. Budyko, I.P. Gerasimov, "The Heat and Water Balance of the Earth's Surface, the General Theory of Physical Geography and the Problem of the Transformation of Nature," *Soviet Geography* 2 (1961): 11.

<sup>44</sup> A 2003 obituary claims that the conference happened because of Budyko's initiative. This is entirely possible though I do not have corroborating evidence.

<sup>45</sup> James R. Fleming, *Fixing the Sky: The Checkered History of Weather and Climate Control* (New York: Columbia University Press, 2010): 236.

possibility of global glaciation wiping out life on earth. This particular apocalyptic scenario weighed on Budyko's later writings long after he became confident the future temperature trend was one of global warming. He sounded out his conviction in the certainty of global warming at an international Leningrad climatology conference 1971 where he was in the minority. By 1990 he would, according to the Director of the Hydrological Institute, be called "the 'father' of global warming" by "eminent foreign climatologists."<sup>46</sup>

To understand Budyko's environmentalist priorities requires understanding the science of climate change from his perspective. A scholarly review of Budyko's popular and scientific works reveals he held many views on the scenarios of climate changes global warming would cause and his tone and focus changed noticeably between 1971 and the end of the Cold War. I will argue in this chapter firstly that Budyko's became permanently more fearful of global cooling than global warming because of his early work in the 1960s and secondly that as a consequence of Budyko's research into paleoclimatology he became confident that global warming might be good for agricultural output and the health of the climate.

Budyko's belief in a technocratic environmentalism by the 1980s influenced his actions to marginalize his scientific opposition through the bilateral environmental agreement and improve the standing of climate science in the eyes of the government, as we will see in chapter 3. The technocratic aspects of his environmentalism also characterized the way he persuaded Soviet officials of the importance of climate change, described in chapter 2. The first step on this process was recognizing in 1969 the incredible sensitivity of the earth to minor perturbations in incoming radiation from the sun.

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<sup>46</sup> World Meteorological Organization, 216.

## **Global Sensitivity to Incoming Radiation**

Between 1961 and 1969 Budyko moved from the belief that there were merely major obstacles to transforming nature to the position that the earth was so sensitive to minor changes in average surface temperature that there may be doomsday scenarios on the horizon for humankind. This shift in Budyko's thinking occurred because in the process of describing the heat balance of the northern hemisphere he realized the dramatic relationship between arctic ice cover and average temperature.

Soviet scientific interest in the arctic had existed since the 1930s and the later head of the Hydromet E.K. Fedorov, himself an arctic explorer, was Budyko's superior until 1974 when Fedorov moved on from the Hydromet. Budyko knew that the arctic played a significant role in the global climate and decided to study its albedo – a long understood scientific concept that describes the fraction of sunlight a patch of earth reflected back into space.

Budyko's work during the 1960s focused on accurately describing different global processes like the appropriate albedo of different areas of the earth, the general equations of heat circulation between the atmosphere, hydrosphere and lithosphere, and estimations of surface temperature change caused by radiation retention. The MGO created extensive radiation atlases and Budyko, having recognized the global nature of climate, used these to devise the first one-dimensional model of global climate in 1969 published in his article *The effect of solar radiation variations on the climate of the Earth*.

This was the culmination of research Budyko had been publishing on throughout the 1960s including as early as 1962 when he first noted the significance of the arctic in his article titled *Polar Ice and Climate*. He also said in the Bulletin of the Academy of Sciences that same year "One should have in mind that following the destruction of ice there would be a significant

change in the regime of atmospheric circulation.”<sup>47</sup> By 1966 Budyko had a distinct global lead on the modelling of global climate, according to Mott T. Greene who points to the proceedings of the international 1966 Los Angeles Symposium of the Arctic Heat Budget where Budyko presented his findings.<sup>48</sup>

The 1969 innovation Budyko pioneered was the ice-albedo feedback loop. The idea rests on two premises, that ice reflects more temperature-raising radiation back into space and that ice cover expands during cooling periods. Consequently, a cooling period will cause ice expansion, and then the ice expansion will cause further reductions in surface temperature by reflecting more radiation back into cosmic space. This meant that even minor fluctuations in the radiation absorbed by the earth could cause significant expansion or contraction of ice cover.

If the feedback loop ran without interruption, a minor global cooling could have serious ramifications. He argued in 1969 that after extending beyond a certain “critical latitude” due to a decrease in global temperature “ice will move to the equator.”<sup>49</sup> Budyko was so concerned about this prospect he described the apocalyptic scenario that should a minor decrease in the total retained radiation occur it “follows from the calculations” that there would be a “complete glaciation of the Earth.”<sup>50</sup> This snowball earth scenario would be catastrophic for life on earth and Budyko issued a warning that if ice cover ever exceeded this critical latitude “the existence of higher forms of organic life on our planet may be exterminated.”<sup>51</sup>

This apocalyptic scenario is significant for Budyko’s later environmentalism for two reasons. The ice-albedo feedback system was important firstly because Budyko would never

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<sup>47</sup> Oldfield, 521.

<sup>48</sup> Reference taken from Mott T. Greene’s “Arctic Sea Ice, Oceanography, and Climate Models” bibliography: Budyko, M. I. “Polar Ice and Climate.” In Proceedings of the Symposium on the Arctic Heat Budget and the Atmospheric Circulation, edited by J.O. Fletcher. Santa Monica, CA: Rand Corporation, 1966.

<sup>49</sup> Mikhail I. Budyko, “The effect of solar radiation variations on the climate of the earth,” *Tellus* 21 (1969): 616.

<sup>50</sup> *Ibid.*

<sup>51</sup> Budyko, “The effect of solar radiation,” 618.

subsequently underestimate the sensitivity of the planet to surface temperature. He spent the rest of his life trying to accurately depict the consequences of between 1 to 4 degrees of temperature change. Secondly this realization was important because Budyko did not imagine there was a comparable apocalyptic scenario for an equivalent amount of global warming; i.e. a certain degree of cooling could cause the planet to become *permanently encased in ice* but the same degree of warming would not cause comparable climate change. This did not mean global warming was necessarily desirable but that warming was unambiguously preferable to cooling. Every degree the planet was warmer was a degree further from the annihilation of all life.

As occasionally happens in science there was another paper published that described near identical results using a similar model published by an American scientist William D. Sellers within a month of Budyko's article.<sup>52</sup> During the 1950s and 1960s there were multiple teams of American scientists working in the same area as Budyko and the MGO, including many scientists Budyko was in continuous communication with. Greene argues that Sellers "was following Budyko's 1966 lead" from the symposium on the arctic.<sup>53</sup>

While Budyko had a predilection for simplicity American teams were producing more complicated models of climate using computers that were becoming far more advanced than anything in the Soviet Union. Greene has done an excellent short history of the Sellers-Budyko models noticing that Sellers' model was "perhaps three times as complicated as Budyko's" which highlights both Budyko's predilection for simplicity as well as US reliance on computer

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<sup>52</sup> Mott T. Greene, "Arctic Sea Ice, Oceanography, and Climate Models." Editors Keith R. Benson and Helen M. Rozwadowski, *Extremes: Oceanography's Adventures at the Poles* (Sagamore Beach: Science History Publications, 2007): 311.

<sup>53</sup> Greene, 309.

modelling.<sup>54</sup> While Budyko may have preferred simplicity, the dearth of computer technology in the Soviet Union narrowed Budyko's research options. By the 1980s these constraints led Budyko to hold the unique position among climate scientists as somewhere between a (usually) cautious apologist of global warming and an uncertain detractor.

## Global Warming

In 1971 Budyko was certain global warming would be the predominant trend of the future. He confirmed that year to a stunned audience of international climatologists in Leningrad that he thought global warming was inevitable. He maintained this claim in scientific and popular publications in the years immediately following as well. He also testified to a team of international scientists sponsored by MIT who published *Inadvertent Climate Modification* that year; however it is unclear whether Budyko believed specifically in a carbon emissions theory of global warming until at least 1972.

Until *Inadvertent Climate Modification* was published Budyko probably believed global warming was certain to occur for reasons completely unrelated to carbon emissions. His 1961 hypothesis about human energy output was not about the fact that human energy is largely derived from fossil fuels, which as a by-product, produce carbon dioxide. Budyko was arguing that human energy production released pure heat and this pure heat release functioned as heat pollution that tended to increase average surface temperature. Because most energy production occurred in cities this meant that urban climates would be the first to experience a general increase in average temperature, but if output continued at the 1961 rate Budyko believed there would be a generalized temperature increase. This mechanism for global warming interestingly

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<sup>54</sup> Greene, 308.

meant not only fossil fuels but “nuclear, and other sources” also contributed to a warmer planetary climate.<sup>55</sup>

Unfortunately the exact series of events is obfuscated by a lack of sources but sometime in 1971 Budyko not only realized global warming was inevitable but also agreed on the preponderant role of carbon dioxide. In his subsequent works he accepted the theory wholesale and even sidelined the influence of the pure heat release idea he had developed (though never failing to at least mention it in passing).<sup>56</sup> He frequently cited *Inadvertent Climate Modifications* in his own works published in the 1970s as well.

Although Budyko’s conclusions were confirmed his heat release mechanism was not, and this fact has been forgotten by writers, historians and scientists in their public accounts of scientific meetings and climate negotiations. Budyko later in life described the Leningrad conference where he announced the inevitability of global warming:

... in 1971 there was a very big scientific meeting of climatologists in Leningrad. The largest in all the history of our science. I was head of the committee for organization. The only time when almost all leading scientists from the United States, from Western Europe were present. It was a funny story... the custom is, when a big conference is finished, the organizer before the closing of conference says something — usually just saying very general words for the future problems or something. After this few general words, one of the oldest guests would take the floor and express gratitude for the hospitality, and after this the conference is closed everybody goes to official dinner. You understand. Instead of general words, I presented in short form an idea which proved to be absolutely unacceptable to everybody: the idea that global warming is unavoidable. I presented some quantitative data and expressed hope that everybody will try to do something in this field because it is very important. The result was a sensation...<sup>57</sup>

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<sup>55</sup> Budyko, in 1976, was quoting his own article from 1962 titled “Certain ways to modify climate”: M.I. Budyko and K.Y. Vinnikov, “The global warming,” *Meteorology and Hydrology* issue 7 (1976): 12.

<sup>56</sup> See for example *Climatic Changes* from 1974, page 194 where Budyko notes that besides carbon dioxide and aerosols other anthropogenic influences on climate change are “comparatively small.” He then reminds the reader “one of these factors involves the production of energy,” highlighting his own work in a rather characteristic fashion.

<sup>57</sup> Weart, *Oral Histories*.

Climatologists at the time were still mostly uncommitted, and global cooling was often considered at least as likely as a global warming trend. This recollection however carefully obfuscates the origin of the global warming – I do not know whether in Leningrad Budyko declared carbon emissions or heat release the reason global warming was inevitable. It is quite possible Budyko did not believe carbon dioxide predominated climate at this conference, as he had in fact written a book the Russian version of which was published in 1971 (later republished in English in 1974, titled *Climate and Life*) where he cited a 1966 study by Soviet scientist Kirill Y. Kondratyev who was skeptical of the influence of carbon on temperature. Kondratyev and a colleague, H.I. Niilisk, concluded in 1960 that “CO<sup>2</sup> concentration for the last 100 years... is supposed to have increased approximately by 10 per cent. As one can see from the above data, the upper limit of the possible temperature increase in this case is less than 0.1°.”<sup>58</sup> Kondratyev’s later 1966 study did not change this appraisal of the role of carbon dioxide because according to Budyko the study suggested that “the observed change in carbon-dioxide concentrations might change the temperature by a comparatively small amount.”<sup>59</sup>

Budyko was also in communication with western scientists, frequently citing the calculations and theoretical insights of scientists such as Syukuro Manabe (who Budyko greatly admired) and Richard T. Wetherald, both also concerned with human activities changing the global climate at the same time as Budyko. When writing his 1969 article Budyko cited Manabe and his colleagues, who analyzed temperature rises as a consequence of changes in atmospheric composition, and employed their calculations.<sup>60</sup> Budyko moreover reached the same conclusions as Manabe that increasing carbon dioxide content of the atmosphere increased surface

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<sup>58</sup> K.Y. Kondratyev and H.I. Niilisk, “On the question of carbon dioxide heat radiation in the atmosphere,” *Pure and Applied Geophysics* 46 (1960): 226.

<sup>59</sup> Mikhail I. Budyko, *Climatic Changes* (Washington: American Geophysical Union, 1977): 481.

<sup>60</sup> Budyko, “The effect of solar radiation,” 613.

temperature, however the Manabe model that Budyko agreed with “does not have extreme sensitivity of atmospheric temperature to CO<sup>2</sup> content” as compared with models of other scientists at the time.<sup>61</sup> Budyko was clearly aware of carbon dioxide’s warming effect but relied on Manabe and Konratyev for guidance as to the sensitivity of climate to carbon, neither of whom gave strong indications prior to 1971 that minor changes in atmospheric carbon dioxide substantially changed average surface temperature.

Regardless Budyko certainly believed in carbon dioxide’s dominant role in global warming *after* 1971. He identified carbon emissions as either the most, or one of the most important variables in every subsequent work he wrote on climate change and global warming.<sup>62</sup> In his very next major work, *Climatic Changes*, Budyko juxtaposes Konratyev’s 1966 carbon dioxide research in an unflattering way compared to more recent work, legitimizing American scientists Manabe and Wetherald who were confident at this point that carbon was a significant influence on surface temperature.<sup>63</sup>

The next stage of Budyko’s research was clear to him: a warming trend was imminent, but what would its impacts be? In 1974 he moved out of the MGO and became head of the Hydrological Institute’s climate department, where he began the project of predicting future climates that would make him controversial in the west, motivate Budyko’s political choices during the intensified Working Group VIII activities of the 1980s, and pose an obstacle in the early IPCC discussions in 1989-1991.

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<sup>61</sup> S. Manabe and R.T. Wetherald, “Thermal Equilibrium of the Atmosphere with a Given Distribution of Relative Humidity,” *Journal of Atmospheric Sciences* 24 (1967): 249.

<sup>62</sup> See his major works in English, *Climatic Changes* (1974), *Global Ecology* (1977), *The Evolution of the Biosphere* (1984), or any of his scientific articles such as *On present-day climate changes* (1976).

<sup>63</sup> Mikhail I. Budyko, *Climatic Changes* (Washington: American Geophysical Union, 1977):19.

## **Paleoclimatology versus General Circulation Models**

In 1993 a group of American scientists surveyed Soviet climate studies and drew fascinating conclusions about the divergent scientific trends of the US and the USSR. The Soviet Union's scientists had been "among the leaders" in models of complex systems that determined global climate – known as General Circulation Models (GCMs) – when "such climate studies were beginning in the west."<sup>64</sup> However 1969 was perhaps the last year the Soviets retained the scientific initiative as the US eclipsed Soviet research in the field.

The report identified the main factor that contributed to this displacement was the lower "availability of electronic computing facilities" in the Soviet Union.<sup>65</sup> This lag in computer technology placed a hard ceiling on Soviet GCM research. Whereas at an earlier stage of the science Budyko's one-dimensional model was an elegant descriptive tools, the field of GCMs matured in the US into two and eventually three-dimensional models that accounted for significantly more variables and gave American scientists more rigorous predictive power. Without sufficient computing power developing sophisticated GCMs in the Soviet Union was impossibly difficult. The array of factors and their interrelationships were enormous, including air circulation (both between regions and different altitudes of the air; e.g. the temperature at the troposphere and the stratosphere are not the same under the same climatic conditions), the hydrologic cycle, and the effect of cloud cover (itself affected by other cycles) to name a few.

Documentary evidence supports this reason for why Soviet climate science, largely directed by Budyko, shifted toward areas where computers were less necessary – reconstructing past climates through empirical data collected through field work. This became "the preferred Soviet technique for projecting future climate" even in the years immediately after the collapse

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<sup>64</sup> Ellingson, I-4.

<sup>65</sup> Ibid. I-5.

of the Soviet Union. Budyko admitted in 1990 that paleoclimatology was “the only way to do something with practically very little expense” and that “competition” between the US and the Soviet Union in GCMs was “impossible.”<sup>66</sup> Budyko persistently advocated this approach not only among Soviet scientists but also within Working Group VIII. He convinced the US delegation in 1980 to make paleoclimatology a “high priority” for the Working Group and persistently argued for the superiority of empirical (paleoclimatic) predictions of the future climate over GCMs during scientific exchanges.<sup>67</sup>

Budyko’s studies in prehistoric climate gave him and his colleagues a truly unique position on the future climate. According to Soviet paleoclimatic data, past climates that were warmer (and corresponded to higher carbon dioxide concentrations) saw more rainfall in the centre of continents, more vegetation across the earth’s surface and most importantly to Budyko were generally more stable. Budyko believed in 1988 that the “Pliocene climate optimum” was the most instructive analog for the future global climate of 2050, and under these warmer conditions “vast territories of the northern and eastern USSR” would be opened to agriculture.<sup>68</sup> However before Budyko came to this controversial conclusions in the late 1980s he held conflicting views on the potential threats and opportunities of global warming.

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<sup>66</sup> Weart, *Oral Histories*.

<sup>67</sup> Eugene W. Bierly and John A. Mirabitu, environmental cooperation summary, January 1982, Box 9, Folder 92, The U.S.-U.S.S.R. Agreement on Protection of the Environment and its Relationship to U.S. National Climate Program, Lawrence Livermore Nuclear Winter Study Papers, Environmental Science and Public Policy Archives, Cambridge, United States.

<sup>68</sup> Mikhail I. Budyko, “Climate of the End of the 20<sup>th</sup> Century,” *Soviet Meteorology and Hydrology* issue 10 (1988): 11.

## Global Warming Good?

Budyko has been characterized by western press, western scientists and western historians as aggressively supportive of global warming. A 1989 *New Scientist* article titled “Soviet climatologist predicts greenhouse ‘paradise’” has been cited by scholars as one piece of evidence. According to that article Budyko “envisages cattle grazing in what is now the Sahara desert” and is quoted as saying “global warming is a good thing” and “it [global warming] will increase harvests everywhere.”<sup>69</sup> The *New Scientist* also claimed that Budyko was “the man who first predicted that the greenhouse effect could warm our planet” which is demonstrably false (Budyko believed in this mechanism at the earliest in 1971, as discussed earlier).<sup>70</sup> On the basis of this particular article several books concluded that Budyko’s position, and sometimes by extension, the general Soviet scientific position, was completely irreconcilable with the position of most western scientists by the late 1980s.

It is important to decouple the concepts of climate change, global warming and climatic catastrophe from one another to understand Budyko’s indecisive and shifting opinions on the nature of future climate changes. In 1990 Budyko worried that a misinformed view of climate change was taking shape among “some people who are not specialists” including “some persons in high position[s],” who believed “climate change will be a catastrophe.”<sup>71</sup> Unlike this western environmentalism which in Budyko’s view was supported by “people who are interested in sensations,” Budyko was a member of the old guard of Soviet scientists trained in the Stalin era. Budyko believed deliberate environmental manipulation was possible, but urged caution and thorough studies before committing to transformation of nature projects.<sup>72</sup> Budyko recognized

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<sup>69</sup> Jack Miller and Fred Pearce, “Soviet climatologist predicts greenhouse ‘paradise,’” *New Scientist* 123 (1989): 24.

<sup>70</sup> *Ibid.*

<sup>71</sup> Weart, *Oral Histories*.

<sup>72</sup> *Ibid.*

that already humans were influencing the environment in unintended ways, causing climate changes, which deserved immediate scientific attention. However the effect of global warming and particular climate changes was an entirely separate question. Budyko held no default presumption that undisturbed ecosystems were preferable, and therefore held a complicated view of the different, often contrary effects on agriculture and human wellbeing that climate change could bring.

A thorough review of Budyko's shifting position on global warming reveals substantial ambivalence. In the 1970s, between *Climatic Changes* and *Global Ecology*, he highlighted the potential for more severe droughts, the expense of reorganizing economies to meet climatic needs and the threat of arctic melting. In the 1980s Soviet paleoclimatic reconstructions influenced his beliefs in the other direction; he argued in *The Evolution of the Biosphere* that plant life would thrive in a more carbon rich atmosphere and that warmer prehistoric climates were generally favourable. Throughout both decades Budyko continued to believe cooling was more dangerous than warming.

In the 1970s Budyko was cautious of climate change. In his 1974 *Climatic Changes* he repeatedly stressed the problems of adaptation to climate change, such as the “enormous capital investment” of accommodating the economy to the new climate as well as the potential “natural catastrophe” the melting of polar ice posed.<sup>73</sup> In his 1977 *Global Ecology* Budyko implies that recent droughts could have been caused by recent surface temperature changes and as Sokolov et al. have noted “according to Borisenkov... in these early years interest in the risk of climatic change was stimulated by international events, in particular the drought in the Sahel region of Africa.”<sup>74</sup>

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<sup>73</sup> Budyko, *Climatic Changes*, 205, 211.

<sup>74</sup> Sokolov et al., 148.

As Budyko's paleoclimatic data was being assembled and published around the late 1970s Budyko's perception of incoming climate changes from global warming shifted substantially. In his 1984 popular science work *The Evolution of the Biosphere*, Budyko added new elements to his projections, firstly the "physiological influence" that carbon dioxide has on productivity of plants.<sup>75</sup> Budyko secondly described the carbon output of humankind as contributing to the "'rejuvenation' of the biosphere, i.e. the restoration of natural conditions with a warm climate at all latitudes, without polar ice cover" and higher plant productivity.<sup>76</sup> This is especially good "for countries with a cold continental climate."<sup>77</sup>

These positive outcomes however were on the assumption of sufficient time for natural adaptation of the environment, i.e. "if a return [to prehistoric climate]... occurred rather slowly."<sup>78</sup> Budyko was suggesting there was a historically derivable optimal average surface temperature that would be desirable for plants and humans. However humans were recreating this optimal temperature suddenly in a short couple hundred years rather than gradually over millions of years but. Therefore Budyko hedged his predictions, such as for example by undermining the claim that there would be physiological plant productivity increases, saying these increases "could be more or less compensated for by a worsening of climatic conditions in some regions."<sup>79</sup>

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<sup>75</sup> Mikhail I. Budyko, *The Evolution of the Biosphere* (Dordrecht: D. Reidel Publishing Company, 1986): 366.

<sup>76</sup> Ibid. 368.

<sup>77</sup> Ibid.

<sup>78</sup> Ibid.

<sup>79</sup> Ibid. 367.

## Geological Time

Budyko's discovery of the possibility of a snowball earth predisposed him to fear global cooling vastly more than global warming. In *Climatic Changes* (1974) he stressed that although "man's effect on climate has been unintentional" in the case of carbon emissions, "it has nevertheless already become of great importance for preventing the further development of glaciation."<sup>80</sup> Relieved, Budyko notes that already emitted carbon will "defer planetary glaciation by thousands of years."<sup>81</sup> This anxiety recurs 10 years later in Budyko's *Biosphere* (1984) where Budyko compares future climatic catastrophes which "might lead to the partial or complete destruction of the biosphere" and cautions "almost all of these refer to the future, to millions or even billions of years distant from the present time. An exception to this is the possibility of a new glacial age, a possibility that could occur within a few thousand years."<sup>82</sup>

The reason Budyko perceived global warming as, at worst, a minor threat was that Budyko's threat perception operated on a vastly enlarged timescale. Budyko thought in geological time – his work into paleoclimatology also predisposed him to view threats through this frame of reference. Budyko pondered in *Global Ecology* how "rare statistically" it is that the continued "coincidence of factors that are favourable to the existence of life" remained for most of the earth's history such that the biosphere (i.e. life) remained intact.<sup>83</sup> Budyko continued:

The development of mankind, which took place extremely rapidly from a geological point of view, has altered fundamentally the prospects for the further existence of the Earth's biosphere. Suffice it to note that during the last several decades alone the burning of various types of fuel has increased the concentration of carbon dioxide in the atmosphere by 0.003 percent. Such an increase in the quantity of carbon dioxide compensates for a reduction that has taken place over more than 200,000 years. Thus the activity of man has altered the direction of the process of changes in concentration of carbon dioxide in the atmosphere and has

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<sup>80</sup> Budyko, *Climatic Changes*, 202

<sup>81</sup> Budyko, *Climatic Changes*, 202.

<sup>82</sup> Budyko, *Biosphere*, 393.

<sup>83</sup> Budyko, *Global Ecology*, 292.

increased the rate at which that process takes place by many thousand times. Even though in the present case man's influence on the climate was inadvertent, it has already played an important role in forestalling the further development of glaciation.<sup>84</sup>

This "reduction" in the recent geological past was a trajectory Budyko saw as frightful because, as Fedorov explained in 1979 at the First World Climate Conference in his opening remarks, "in his view there are only two inherently stable patterns: the uniformly warm climatic pattern... and a complete glaciation of the Earth."<sup>85</sup> In Budyko's vast historical timespan, during the last several hundred million years there existed a homogenous global climate where the ice caps had completely melted. Then suddenly "several million years ago this situation began to change" as temperature fell and "about two million years ago this process accelerated... a glacial period ensued, in which repeated advances of ice sometimes reached mid-latitudes... the last glacial advance ended in the northern hemisphere about ten thousand years ago."<sup>86</sup>

At the cusp of a snowball earth, human society had developed fossil fuel combustion. The geological pattern was a locomotive-speed descent towards a snowball earth and humankind was thankfully reversing the trend – anthropogenic global warming was therefore a preventative measure for the safeguarding of life on earth.

### **Environmentalism?**

Budyko believed for the rest of his life that climate change was the foremost issue for humankind to confront. Budyko feared for the fate of the biosphere in the event that ice marched as far as the equator. Budyko recognized at least in the 1970s that global warming might cause

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<sup>84</sup> Ibid.

<sup>85</sup> E.K. Fedorov, "Climatic Changes and Human Strategy," *Environment: Science and Policy for Sustainable Development* 21 (1979): 27.

<sup>86</sup> Ibid. 26.

more droughts, would certainly raise sea levels, but ultimately concluded that the sum of climate changes could be beneficial to humankind. Budyko also thought the Pliocene optimum was best for the environment, firstly insofar as a stable, Pliocene forestalled global glaciation and preserved the biosphere; secondly, because of the increased physiological productivity of plant life breathing a more carbon dense atmosphere; and thirdly because of the increased precipitation and habitable area of the earth's surface that global warming would create.

Although to a western reader the association between being an environmentalist and preventing human-induced changes in the environment (absolutely, regardless of their character) is strong, this presupposes all changes in the environment are negative changes. Environmentalists are also lauded for planting trees and preserving the biosphere – if fossil fuel combustion were creating the conditions for a healthier, more stable global ecology, then the position that global warming was beneficial is consistent with the label environmentalism. This is not western environmentalism, but technocratic environmentalism – a science-driven, paleoclimatology-influenced perception of the threats to the biosphere. The appropriate, environmentally conscious response under the conditions of Soviet science in the Cold War for a climate scientist was not to sound the alarms of apocalyptic global warming but to determine a sophisticated, comprehensive incorporation of expected climate changes into economic planning.

## Chapter 2 Incentives and Pressures of Soviet Science

### Economic Growth, the Environment and Science

In 1972 a distinguished group of concerned academics and professionals known as the Club of Rome published a fearful projection of the future. In their book *The Limits to Growth* they used computer simulations to argue that overpopulation, resource depletion and a variety of other environmental catastrophes awaited the world unless governments considered slowing down or potentially halting economic development.

*Limits* was published at the apex of a remarkable period of legal and institutional environmentalist consolidation. The burgeoning “environmentalist sensibilities” that Nicholas B. Breyfogle notes were “developing (conterminously but often independently) across the planet in the 1950s, including the USSR,” spurred the creation of new domestic and international institutions.<sup>87</sup> Western countries adopted new environmental standards and setup agencies to monitor and prevent environmental degradation. The US established the Environmental Protection Agency (EPA) in 1970 while 1972 was the year of multiple significant environmental developments stimulated by the United Nations Conference on the Human Environment in Stockholm, after which the United Nations Environmental Programme was founded.

The Soviet Union was quick to emulate western environmental protections but notwithstanding the efforts of “an influential, local-level, scientist-driven environmentalist activism” in the USSR, Soviet environmental protections were never more than half-hearted during the Brezhnev administration (1964-1982).<sup>88</sup> While admirable laws were enacted to set emissions standards and fine polluters, their enforcement was spread between numerous

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<sup>87</sup> Nicholas B. Breyfogle, “At the Watershed: 1958 and the Beginnings of Lake Baikal Environmentalism.” *Slavonic and East European Review* 93 (2015): 149-150.

<sup>88</sup> *Ibid.* 149.

government bodies, including the Hydromet, most of which were politically insignificant or had perverse incentives to undermine legislation.<sup>89</sup> Moreover these were not institutions that appeared by any accounts to be interested in using their limited political capital on scuffles with the big economic and industrial ministries.

In 1972, the year of *Limits* and the bilateral, Y.K. Fedorov was the head of the Hydromet. A distinguished arctic explorer, temporarily disgraced for his suspicious western contacts, Fedorov came back into favour in the 1960s and ascended to the top of the closest institution to an environmental protection agency the Soviet Union had. The Hydromet was both an arm of the government and the supervisory body of a number of scientific institutions including the MGO and the Hydrological Institute where Budyko would be transferred to in 1974.

As de facto voice of the government on environmental matters Fedorov personally responded to *Limits* in a thorough critique that would define the political dimensions of the Hydromet and its financially dependent scientific institutions. Fedorov, both because of his optimistic, older generation socialism and probably also under explicit instruction from his superiors, completely rejected the position that economic growth inevitably caused environmental degradation. He argued in the *Bulletin of Atomic Scientists* and his later work, *Man and Nature: The Ecological Crisis and Social Progress*, firstly that technological advances could solve environmental challenges and moreover that perhaps under a system of private ownership environmental damage was inevitable, but that under conditions of socialism negative environmental externalities were internalized and corrected for by the state.<sup>90</sup> Fedorov as

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<sup>89</sup> Sokolov et al., 141.

<sup>90</sup> *Bulletin of Atomic Scientists* article: "The Interaction of Man and the Environment: The Situation Today and Outlook for the Future," volume 28 (1972), issue 2.

representative of the Hydromet effectively set the state articulation of socialism's relationship with nature.

Although Fedorov may very well have wholeheartedly believed his critiques of *Limits* they were also the only permissible response under the institutional pressures of the 1970s Brezhnev era Soviet Union. The USSR experienced an amazing transformation from an agrarian to a modern industrial economy within the lifetime of many of its government officials. By 1986 the Soviet Union contained a huge portion of the world's engineers and the percentage of engineers on the Politburo had risen to 89% from 59% in 1956.<sup>91</sup> Loren R. Graham has argued this is strong circumstantial evidence to suggest the "management style and policy preferences" were informed by the engineering background of the leadership.<sup>92</sup> The government was committed to the idea that large-scale transformation of nature projects such as the Siberian river diversion plan, which Brezhnev supported, were practical notwithstanding the known environmental consequences. Moreover the Soviet Union was also engaged in an ideological Cold War in which economic development was an area of superpower competition.

Limits to growth, especially limits caused by environmental degradation, were in ideological opposition to the government's policy preferences. The appropriate response, that of Fedorov and the Hydromet, was to insist technological innovation could solve these problems. Fedorov thereby contributed to the formation of political boundaries of environmentalism in the Soviet Union, boundaries which this chapter will argue were channelled and refined by Izrael and Budyko's writings. This chapter will firstly explore the works of Yuri Izrael who pioneered the language that allowed the Soviet government to saddle the apparent paradox of

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<sup>91</sup> Loren R. Graham, *Science in Russia and the Soviet Union: a short history* (Cambridge: Cambridge University Press, 1993): 10-11.

<sup>92</sup> *Ibid.*

environmental degradation and nature transformation. This chapter will then secondly demonstrate how Budyko tried – with incredible caution – to place his work on climate change inside the boundaries of economic planning.

### **Incentives: The Government, the Hydromet, the Scientists**

The Hydromet as an institution is an interesting case of where bureaucratic and scientific incentives coexisted and overlapped. The Hydromet as an arm of the government expressed the policies and preferences of the government in the field of environment, but was also in competition with other bureaucratic interests. While the Hydromet was legally empowered to fine heavy polluters, doing so spent precious political capital, especially when carrying out environmental protection too thoroughly was perceived as a threat to economic growth. The Hydromet was both a scientific institute with ongoing research, and the administration charged with distributing funds between other scientific institutes such as the MGO and the Hydrological Institute.

In its capacity as a scientific organization the Hydromet's constraints and opportunities were similar to those of individual scientists. Discoveries that were economically valuable, or had military applications were given priority funding, however if an avenue of science was too politically interesting this could be dangerous for the scientists involved because their research independence could be compromised by a non-scientific ministry. Other risks were present if politically or economically useful discoveries were made and the government committed to a policy proposal before adequate research could determine the efficacy of a given project. This could also make accurate assessments more politically costly to scientists involved should scientific studies seemed in contradiction with the planned project. There was a careful line

scientists had to tow to remain relevant enough to justify expanded funding, but not too important to be commandeered by the economic ministries, the military or other scientists who did not mind obfuscating inconvenient facts to please their superiors.

As the 1993 research survey noted, foreign prestige often helped a Soviet scientist's clout and their chances of promotion, meaning there was a very direct advantage to being the primary intermediary of scientific exchanges or controlling the most cutting-edge work in a given field.<sup>93</sup> Budyko for example was remarkable in his near complete control of climate science in the Soviet Union partially because of respect he enjoyed among foreign scientists. This was, unfortunately for the many largely unknown climate scientists who worked with Budyko, a positive feedback loop. The more Budyko was represented in Working Group VIII the more control Budyko had over domestic climate science priorities, making him even more essential a member of the Working Group VIII team.

Although the Soviets boycotted the 1972 UN environmental conference due to East Germany's exclusion, they signed the US-USSR environmental bilateral agreement later that year in Stockholm. The US appointed the EPA the lead agency coordinating American participation, while the Hydromet was appointed by the government for the Soviet side. The bilateral was organized through the Joint Committee on which sat the head of the Hydromet and the EPA, who both worked on agendas for the various exchanges and meetings.<sup>94</sup> These exchanges were themselves organized under working groups, each with some specific role – their topics ranged from air pollution to global heat balance.<sup>95</sup>

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<sup>93</sup> Ellingson, I-4.

<sup>94</sup> Several meetings were hosted prior to 1974 to determine the structure, format etc. of regular exchanges that began in 1974.

<sup>95</sup> Working Groups according to a US summary of activities published in January 1984 (I) air pollution, (II) water pollution, (III) environmental pollution associated with agricultural production, (IV) enhancement of the urban environment, (V) preservation of nature and the organization of (nature) preserves, (VI) marine pollution, (VII)

For the Soviets, as Darst and Sokolov et al. have argued, the bilateral served Soviet foreign policy interests in several ways. As of 1969 the United States government under Richard Nixon began a policy of détente, relaxing relations with the Soviet Union. To maintain this favourable upswing in Soviet-American relations, Brezhnev's administration considered it prudent to project an image of cooperativeness. Environmental cooperation was a low-cost, politically neutral medium for furthering détente and possibly gaining valuable scientific knowledge or access to American supercomputers.

The bilateral environmental agreement was also a major opportunity for the Hydromet and Soviet climate scientists. It offered travel to the United States where Soviet scientists could gain recognition in the west, as well as impress their colleagues at home by bringing back gifts, pictures and personal experiences. The bilateral also gave the Hydromet an easy way of being important to the Soviet government's foreign policy without having to be useful in ways that risk conflicts with the economic ministries or the military. The bilateral was a brilliant solution to this problem because the desired outcome for Soviet foreign policy was independent from particular scientific findings. Soviet scientists could therefore continue, with expanded budgets, their own research interests with relative autonomy without having to justify themselves too much in economic or military terms. In fact the admitted interest of the Hydromet and Soviet climate scientists was to *bury* their significant findings in verbose, highly technical terms such that international environmental issues "would not be turned into another area of ideological interest and control."<sup>96</sup> This chapter will explore those verbose, wordy works of Yuri Izrael, uncontested head of the Hydromet, and Mikhail Budyko, uncontested leader in the field of climate science.

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biological and genetic effects of pollution, (VIII) influence of the environment on climate, (IX) earthquake prediction, (X) arctic and subarctic ecological systems, and (XI) legal and administrative measures for protecting environmental quality. See: Bierly, The U.S.-U.S.S.R. Agreement.

<sup>96</sup> Sokolov et al., 151.

Izrael and Budyko's institutional and individual incentives crafted the limits of technocratic environmentalism on climate change.

### **The Environment: A Math Problem**

The critique of *Limits* was refined by the Hydromet's new head Yuri Izrael, appointed to replace Fedorov in 1974, the first year of non-procedural matters for the Working Groups of the bilateral environmental agreement. Izrael added an innovative reconceptualization that coherently fit the environment into the ideological architecture of the Brezhnev administration's policies – a catch-phrase which betrayed Izrael mathematizing of environmental problems.

Yuri Antonovich Izrael was born in the city of Tashkent (Uzbekistan) in 1930, 10 years Budyko's junior. He obtained his Doctor of Sciences in Physics and Mathematics in 1953 from the Central Asian State University in his hometown.<sup>97</sup> Between 1953 and 1974 Izrael worked at the Geophysical Institute and later the Institute of Applied Geophysics where he became director in 1969. Izrael became head of the Hydromet in 1974, which became a State Committee in 1978, elevating Izrael to the status of a nominally high-ranking official until the collapse of 1991.

While head of the Hydromet, Izrael published academic and popular science works which reflected his institutional characterization of the problem of environmental degradation. Izrael believed that the environment was a math problem. The arrogant rhetoric of fixing nature's mistakes was wrong, as was the idea that environmental degradation was the inevitable sibling of economic development. Izrael said, incessantly, the issue of environmental degradation was

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<sup>97</sup> UNESCO, *Point Sources of Pollution: Local Effects and Their Control, Volume II*, ed. Qian Yi (EOLSS Publications, 2009): 440.

about creating an “optimal interaction between man and nature.”<sup>98</sup> At the third joint US-USSR Symposium on the Comprehensive Analysis of the Environment in Tashkent, 1977, Izrael used this exact phrase or light variations on it 8 times in the first two page of his paper (which was supposed to frame the issues of the conference).<sup>99</sup> Note that none of the other papers (Soviet or American) used this phrase, including Fedorov himself who presented at the conference. In 1979 Izrael published his first popular science work *Ecology and Control of the Natural Environment*, the second edition published in English in 1984 where he repeated this phrase almost verbatim numerous times.<sup>100</sup>

This phrase has snuck into works which Izrael was one of several contributors and even once where he was a secondary contributor. In 1982 a generously academic translation of a work Izrael coauthored included a quote about “the optimum control of anthropogenic impact on the environmental state” for example.<sup>101</sup> Even as late as 1988 Izrael, still head of the Hydromet and well into Gorbachev’s administration, said environmental problems are an issue of making sure to “optimize human society/nature interactions.”<sup>102</sup>

This phrase was a clever expansion of Fedorov’s refutation to *Limits*, which Izrael openly explained in an article in *Voprosy filosofii* (“Problems of Philosophy”). Ecological crisis would not be solved by *limiting* but *optimizing* growth.

“...man should not take the functions of the biosphere upon himself [i.e. fixing nature’s mistakes]; he should facilitate its work. Combination of efforts of man and

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<sup>98</sup> Yuri A. Izrael, “The role of Comprehensive Analysis of the Environment in Organizing the Optimal Interaction Between Man and Nature,” in *Third Joint U.S./USSR Symposium on the Comprehensive Analysis of the Environment, Taskkent USSR October 10-14, 1977* (Washington DC: Environmental Protection Agency, 1980): 7.

<sup>99</sup> *Ibid.* 7-8.

<sup>100</sup> Yuri A. Izrael, *Ecology and Control of the Natural Environment* (Dordrecht: Springer, 1992): 20, 47, 195, 383.

<sup>101</sup> L.M. Filippova, Yu. A. Anokhin, A. H. Ostromoguisky, Yuri A. Izrael, “Lake Baikal Integrated Background Monitoring: Objectives, Goals, History and Prospects,” *Environmental Monitoring and Assessment* 2 (1982): 405.

<sup>102</sup> Yuri A. Izrael, “The role of monitoring in economic management, ecological standardization,” *Environmental Monitoring and Assessment* 11 (1988): 197, 199.

nature could facilitate [stable ecosystems]... under conditions modified by man: this is the task of all who are interested in ‘environmental protection.’”<sup>103</sup>

This slogan was a clever innovation because as the quote above indicates, deliberate, theoretically large-scale transformations of nature were not precluded, and instances of environmental degradation could be explained without putting economic growth and the environment in contradiction. Environmental damage was “due to mistakes in technological policy” (Fedorov’s original answer to *Limits*) but also “an insufficiently comprehensive accounting of ecological and economic damage.” (Izrael’s own addition).<sup>104</sup> Izrael mobilized this conceptualization of the environment to attack *Limits* and at the same time push forward his institutional agenda – there will not be environmental degradation *if* we have sufficient studies, which means more funding for the Hydromet, MGO and Hydrological Institute.

This phrase was also characteristic of Izrael, a mathematician by education, because he meant optimize in a mathematical sense. Throughout his writing Izrael described environmental problems in mathematical equations which he claimed could incorporate not only measurable but even intangible goods like the “esthetic” value of the environment.<sup>105</sup> Both at Tashkent in 1977 and in *Voprosy filosofii* Izrael spoke of the “esthetic” value of nature, and boldly claimed that, with sufficient studies, scientists could “settle the question of the ratio between the satisfaction of people’s need for material things and their need for a pure and undisturbed environment (and one of high esthetic quality).”<sup>106</sup>

Izrael also put at the forefront of his domestic policy advocacy the need for more monitoring and environmental measurement, arguing that with sufficient data already existing

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<sup>103</sup> Izrael, Yuri A. “Toward a Strategy for Protection of the Environment and Rational Use of Nature in the USSR.” *Soviet Sociology* 18 (1979): 74.

<sup>104</sup> Ibid.

<sup>105</sup> Ibid. 73.

<sup>106</sup> Ibid. 75.

equations could solve environmental questions. Izrael explained the concept of maximum permissible emissions, an innovative mathematical way of determining the degree of acceptable negative health effects from pollution, and suggested a general formula could apply to almost any environmental problem. If you know the life-span of a given pollutant and the endurable maximum at a given point in time you can determine the maximum allowable emissions per year. Izrael noted that “theoretically this approach can also be applied to substances effecting the global climate, e.g. carbon dioxide” but that “there are no approved concepts as to what changes in global climate should be considered tolerable.”<sup>107</sup>

### **Climate Change and Central Planning**

Budyko replied to a question about his research independence as a scientist in an interview in 1990 that whether at the MGO or the Hydrological Institute “Everything was decided by me. My heads gave me money. What to do with money was my problem. (laughter). I could do almost anything... For a long time I had very good understanding with the heads of our State committee.”<sup>108</sup> These heads were Fedorov and Izrael, and though they provided a large degree of scientific freedom, Budyko was genuinely interested in influencing the policies of the political leadership. Convincing Izrael of the importance of climate change was one task, which as we will see in the next chapter Budyko succeeded in by 1986, but convincing the political leadership was another matter.

The same pressures of the Hydromet applied to Budyko as well. If he catastrophized the problem of the future climate he risked the economic ministries taking too much interest and

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<sup>107</sup> Yuri A. Izrael, I.M. Nazarov, A.G. Ryaboshapko, “Approaches to Standardization of Atmospheric Pollution Undergoing Long-Range and Transboundary Transport,” *Environmental Monitoring and Assessment* 2 (1982): 419.

<sup>108</sup> Weart, *Oral Histories*.

threatening Budyko's personal leadership on the issue – jeopardizing the integrity of his research. Furthermore overemphasizing the policy implications, especially if they implied costly investments, threatened to allow non-scientists to politicize the issue. As Sokolov et al. has noted the social sciences in the Soviet Union were permeated by Marxist-Leninist philosophy, and Budyko knew their unwarranted commentary could put obstructive political constraints on his hitherto completely free hand in research priorities and scientific findings.

Budyko's position that global warming caused both positive and negative climate changes was therefore a convenient vehicle for modest, low-risk political advocacy. While in a western context scientists who made bold apocalyptic anxiety-mongering statements gained traction, in the context of a planned economy Budyko's scientific and political positions merged neatly into a coherent position he advocated in his major works and on occasion in the press and scientific publications.

Because there would be desirable and undesirable climate changes caused by global warming, if the state was to best adapt to the *particular* climate changes, the state would need to incorporate anticipated climate changes into future economic plans. Budyko argued new economic plans needed to incorporate anticipated climate change so as to firstly exploit the new (better) climate with the greatest efficiency and secondly mitigate the negative economic impacts of where climate change *shifted* rather than *increased* resources.

Budyko emphasized state planning could only benefit from knowing about positive climate changes. In 1972 Budyko wrote two articles on global warming in *Izvestia* and *Pravda* which failed to note potential harms from carbon dioxide-based warming. The *Pravda* article even ended with the claim that “The possibility of climate change in the relatively near future... constitutes new evidence of the unbounded opportunities opening up before mankind in the

humbling of nature's forces."<sup>109</sup> In 1978 Budyko argued in *Literaturnaya gazeta* (a paper that often published on environmental issues) that the Soviet Union could expect "to have rich vegetation on the shore of the Arctic Ocean and grow tropical plants in central regions" while "polar navigation would improve and it would be easier to develop the vast territories of Siberia."<sup>110</sup> These climate changes were occurring within "the next several decades, i.e., for the period that should be considered in the long-term economic development plans now being drawn up."<sup>111</sup> As early as Budyko's 1974 *Climatic Changes* he argued that buildings were being made whose lifespan would overlap with incoming climate changes and therefore climate forecasts should play "some degree in planning these buildings."<sup>112</sup>

Climate change would also rearrange some natural resources (mainly rain and plant productivity) without changing the sum. For example Budyko pointed to changes in precipitation as a consequence of global warming; some climate changes would shift rain from areas where current investments in agriculture were intensive to places where agriculture was less developed. All else being equal, this would decrease agricultural output, unless of course steps were taken to calibrate the economy to the climate. If the government were inconsiderate of these changes in planning they could both see losses all else being equal or incur an opportunity cost should the climate change (assuming proper economic calibration) have resulted in a net increase in resource output.

These arguments, made in popular science books whose audience would probably be more technically inclined, were an indication of Budyko's interest in affecting government

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<sup>109</sup> Sokolov et al., 161.

<sup>110</sup> Mikhail I. Budyko, "Forecast for the Future: Global Warming Trend?" *The Current Digest of the Russian Press* 29 (1978): 17.

<sup>111</sup> Budyko, *Global Ecology*, 293.

<sup>112</sup> Budyko, *Climatic Changes*, 206.

policy, specifically agricultural planning. Budyko's activism was not pronounced or dramatic but his writing express sincere concern for feeding a growing world population and Budyko therefore carefully pushed his science into the realm of economic and political planning.

### **Hydromet and Climate Science Successes**

Budyko and Izrael's positions of advocacy were occasionally taken seriously by the government. One example was Izrael's influence on the LRTAP negotiations. While the initiative for the LRTAP treaty was originally Brezhnev's, he was still uncertain about signing the final agreement in 1979 until Hydromet got involved. After a special visit from Norway's Environment Minister the Hydromet gained details about the LRTAP issue that helped them recommend "to the Ministry of Foreign Affairs that the USSR should participate in LRTAP" which Brezhnev then signed.<sup>113</sup> According to Sokolov et al. "continued participation LRTAP, however, seemed unlikely" because of increasing Cold War tensions and a standoff at the 1982 Stockholm Acidification Conference over 30% sulphur dioxide reductions but "nevertheless, Hydromet officials, led by chair Izrael, were in favor of the 30 percent proposal" and persuaded the government to join the "Thirty Percent Club" and commit to reductions.<sup>114</sup>

The Hydromet also stood to gain from these actions. Signing LRTAP and committing to 30% sulphur dioxide reductions "led to a sharp increase in attention that Soviet scientists and officials devoted to the problem" and allowed the Hydromet "to use this issue to secure a major expansion in its resources and responsibilities."<sup>115</sup> When the US and the USSR ratified the LRTAP agreement in 1979, "a government interdepartmental commission was created to

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<sup>113</sup> Sokolov et al., 143.

<sup>114</sup> Ibid. 144.

<sup>115</sup> Ibid. 155.

regulate domestic implementation; the commission was headed by the State Committee of Hydrometeorology.”<sup>116</sup> Climate change was also given direct patronage and recognition in state planning in 1981 when it was included as a budgetary item in the 1981-1985 State Scientific and Technical Program under the title “To Develop a Methodology of Assessing Possible Climate Change and Its Impact on the National Economy.”<sup>117</sup>

Izrael was abundantly aware he could leverage the Hydromet’s role as a vehicle for détente with the United States to obtain recognition, an expanded mandate and more funding. As an official of the government it’s highly improbable he wasn’t actively coordinating the Hydromet’s activities to conform to the country’s foreign policy. Douglas Weiner identified “tight links” between the Soviet conservation movement and “Soviet foreign policy strategists” which makes the odds of a State Committee being ignorant of foreign policy issues implausible.<sup>118</sup>

In *Voprosy filosofii* and *Ecology* Izrael emphasized the value of environmental research as a tool for economic planning and fostering good relations with the west. Nicholas Robinson and Gary Waxmonsky (head of the US EPA who worked alongside Izrael in the agreement) wrote in 1988, summarizing the accomplishments of the environmental bilateral, that what was curious about Izrael’s *Ecology* was that he “relied almost exclusively on the Environmental Agreement, a bilateral forum, to develop a strong and *domestic* policy agenda.”<sup>119</sup> (emphasis theirs) The bilateral environmental agreement provided Izrael a tool for expanding his clout

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<sup>116</sup> David G. Victor, Kal Raustiala and Eugene B. Skolnikoff. *The implementation and effectiveness of international environmental commitments: theory and practice* (Cambridge: MIT Press, 1998): 526.

<sup>117</sup> Sokolov et al., 148.

<sup>118</sup> Weiner, *A Little Corner of Freedom*, 403.

<sup>119</sup> Nicholas A. Robinson and Gary R. Waxmonsky, “The U.S.-U.S.S.R Agreement to Protect the Environment: 15 Years of Cooperation,” *Environmental Law* 403 (1988): 420.

relative to other ministries while Working Group VIII provided Budyko a tool for convincing both Izrael and his superiors of the importance of climate change.

### **The Case of Nuclear Winter**

The politicization of a scientific issue actually did occur within the exchanges of Working Group VIII's activities – the issue of nuclear winter. In the early 1980s several prominent American scientists predicted that the climatic effects of nuclear war would be so devastating that even a perfectly successful first strike would cause mass starvation in the victorious country. The detonation of even a limited number of nuclear weapons would, the US team projected, cause such a massive increase in atmospheric dust and aerosols that there would be an ensuing global winter that would destroy the agriculture of both superpowers, regardless of who attacked first.<sup>120</sup>

This theory was of immediate interest to the Soviet military and so Budyko, Izrael as well as others involved in the Atmospheric Physics Institute (namely Georgy Golitsyn and A. Obukhov) were asked to carefully study the matter. Budyko, Izrael and Golitsyn produced a book *Climatic Catastrophes* on the issue, while Budyko's 1984 *Biosphere* and Izrael's 1984 revised *Ecology* both added a whole section devoted to the disaster that nuclear war would ravage because of nuclear winter. The director of the Academy of Sciences, Yevgeny Velikhov also wrote a book for an international audience *The Night After... Climatic and Biological Consequences of Nuclear War*. Golitsyn wrote on the subject continuously throughout the 1980s,

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<sup>120</sup> Lawrence Badash, *Nuclear Winter's Tale: Science and Politics in the 1980s* (Cambridge: MIT Press, 2009): 205.

which was also a discussion at the All-Union Conference Against Nuclear War Threat for Disarmament and Peace as early as May 1983.<sup>121</sup>

Other aspects of Working Group VIII's climate research were also redirected by nuclear winter. Vladimir Aleksandrov, chief of the Soviet Union's Computing Division, had enjoyed many trips to the US under the aegis of the agreement, using American supercomputers to model the atmosphere.<sup>122</sup> He visited on multiple occasions to toy with general circulation models the Soviet Union couldn't compute as easily, but these were thoroughly sidelined when nuclear winter became of interest to the government.

The Soviet government quickly incorporated nuclear winter into their foreign policy, agreeing completely and insisting on the importance of avoiding nuclear confrontation. The Soviet push for nuclear winter was so enthusiastic that American commentators and politicians suspected this was a propaganda tool to embolden forces for disarmament and undermine the US expansion of military spending under Ronald Reagan. Soviet scientists were in fact, as Lawrence Badash put it, "refreshingly open" about how the study of nuclear winter was "a logical continuation of the anti-war activities of scientists."<sup>123</sup>

The case of nuclear winter however should be viewed as a *successful* politicization of a scientific issue in the Soviet Union. The scientists involved were not displaced, with the Computing Centre, the Atmospheric Physics Institute (mostly through Golitsyn) and Izrael and Budyko through the Hydromet maintaining control of scientific studies in nuclear winter.

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<sup>121</sup> Golitsyn, G.S. and A.S. Ginsburg. "Comparative estimates of climatic consequences of Martian dust storms and of possible nuclear war." *Tellus* 37 (1985): 173.

See also: Aleksandrov, V.V. and G.L. Stenchikov. "On a numerical experiment modelling climatic consequences of nuclear war." *Journal of Computational Mathematics and Mathematical Physics* 14 (1984): 140-144. (Russian), and Golitsyn, G.S. "Possible atmospheric consequences of a nuclear conflict." *Vestnik Academy of Sciences USSR* no. 9 (1983): 57-60. (Russian, cited by Golitsyn pg. 180)

<sup>122</sup> Aleksandrov also mysteriously disappeared in 1985 during a nuclear winter conference. This is still unresolved to this day.

<sup>123</sup> Badash, 223.

Moreover the politically valuable implications of nuclear war were consistent with what was the genuine horror that Izrael, Budyko, Golitsyn and other scientists felt towards the possibility. Stephen Shenfield has even argued that in their introduction to Izrael, Budyko and Golitsyn's *Global Climatic Catastrophes* "an attempt is made to claim Soviet priority in the discovery of nuclear winter" and that this was perhaps "to enhance the legitimacy of the nuclear winter hypothesis in the eyes of readers within the Soviet power elite."<sup>124</sup> Badash who wrote a comprehensive account of nuclear winter's history was also struck by the bold claim to first discovery the Soviet authors made, though noting priority claims were "almost a staple of Soviet behavior."<sup>125</sup>

Badash also notes Soviet enthusiasm in hosting three working meetings and leading the preparation of two reports for the World Meteorological Organization on the issues of nuclear winter.<sup>126</sup> Notwithstanding this apparently noteworthy attention to nuclear winter, actual resources were not nearly as forthcoming as in the United States and although "the Kremlin may have been more interested in NW than the White House... there is no evidence of manpower and resources ever being directed massively to the study."<sup>127</sup> Mikhail Gorbachev himself endorsed the theory without naming it in January 1987 by asserting that whomever "still dares make a first nuclear strike, he will doom himself to agonizing death – not even from a retaliatory strike but from the consequences of the explosion from his own warheads."<sup>128</sup>

Notwithstanding the government's clear position on nuclear winter under Gorbachev, Soviet interest in nuclear winter exchanges and cooperation faded after the mysterious vanishing

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<sup>124</sup> Stephen Shenfield, "Nuclear Winter and The USSR: Note of Correction," *Millennium: Journal of International Studies* 15 (1986): 416.

<sup>125</sup> Badash, 226.

<sup>126</sup> Ibid.

<sup>127</sup> Ibid.

<sup>128</sup> Ibid.

of Aleksandrov in Spain in 1985. Nobody knows why Aleksandrov died that year and perhaps the answer would illuminate why nuclear winter as an area of interest faded in the Soviet Union, but notwithstanding the involvement of the KGB, the scientists involved may have considered their work done. They had clearly committed the government to the political position that corresponded to their research and put some additional weight to disarmament.

Meanwhile global climate change remained generally apolitical with the effort Izrael and Budyko to balance between contrary potential threats that might inadvertently and badly politicize the issue. Izrael was determined to keep tight control of issues under the bilateral environmental agreement while Budyko likewise tried to maintain his monopoly on climate change. Budyko's control however was not completely secure. As western scholars and American travel reports have indicated, he had many strained relations with other scientists both on scientific and personal issues.

Furthermore, between 1979 and 1985 the bilateral had fallen in to serious disrepair, there had not for example been a Joint Committee meeting of the Hydromet and the EPA over this period. The Soviet invasion of Afghanistan in 1979 had restarted animosities between the superpowers. Ronald Reagan was elected in 1981 and the year after declared the Soviet Union an "evil empire" – the Cold War was becoming confrontational again. Then Brezhnev, Chernenko and Andropov died (1982-1984) and the Communist Party of the Soviet Union elected their last leader – Mikhail Gorbachev.

### Chapter 3 Politics of Hydrometeorology

#### Renewed Hostilities, End of Détente

In 1979 the Soviet Union invaded Afghanistan, and détente abruptly ended. The US boycotted the Moscow Olympics in 1980, the favour returned by the Soviet boycott of the 1984 Los Angeles Olympics. Tensions mounted and although the bilateral environmental agreement was one of the few areas of cooperation that continued under renewed hostility, cooperation was nonetheless significantly curtailed. There were for example no Joint Committee meetings between 1979 and 1985.<sup>129</sup>

1979 ushered in a precipitous drop in exchanges under all working groups of the agreement, and both the US and USSR engaged in official and unofficial visa “freezes” disallowing scientists from entering one another’s country. Annual meetings of Working Group VIII, focusing on the issue of climate change, nonetheless continued most years under these strained conditions. During one of these meeting in August 1984, Yevgeny Borisenkov (former co-chair of the working group and then head of the MGO) commented privately to visiting American scientist Michael MacCracken on this issue, who reported that Borisenkov believed “the exchange was getting out of balance now since their (USSR) bureaucracy had disallowed some (or most) of the Soviet visits to the US in the last two years.”<sup>130</sup> Although Borisenkov also indicated he genuinely thought “that the Soviet Olympics decision was not a retaliation for 1980-Moscow but rather a genuine concern about safety.”<sup>131</sup> Borisenkov said he was unsure whether

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<sup>129</sup> Robinson, 416.

<sup>130</sup> Michael MacCracken, travel report, 26 July 1984, Box 9, Folder 93, Report of Trip to USSR under WGVIII, Lawrence Livermore Nuclear Winter Study Papers, Environmental Science and Public Policy Archives, Cambridge, United States.

<sup>131</sup> Ibid.

the government position on the safety of Los Angeles for athletes was not mirrored for scientists.<sup>132</sup>

The private notes of American scientists visiting the Soviet Union during this period paint a significantly more strained picture of the state of exchanges than their institutional travel reports. Lawrence Gates from the Livermore Laboratory wrote on his notepad in July 1984 “On WG VIII activity - they tend to repackage same old gang with little new results,” expressing frustration that the only way to learn “new science” was by talking to “new people” (emphasis his).<sup>133</sup> Gates moreover wrote that it was “easy to show them, frustrate them, embarrass them - not very satisfying.”<sup>134</sup> That said, Gates also wrote that Konstantin Vinnikov, Budyko’s protégé, was an exception as he had “some new work usually.”<sup>135</sup> When relations were warmer in 1986, MacCracken learned “there was no banquet in 1983 due to poor relations” under instruction directly from the government.<sup>136</sup>

Working Group VIII’s topic was “influence of the environment on climate” and the group oversaw several subprojects, including “three major projects,” namely project 11 on “effects of global heat balance on the atmosphere and climate,” project 12 on the “effects of pollution of the atmosphere on climate” and project 13 on the “influence of changes in solar

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<sup>132</sup> Ibid.

<sup>133</sup> Lawrence Gates, personal notes, 17 July 1984, Box 10, Folder 94, On WG VIII activity, Lawrence Livermore Nuclear Winter Study Papers, Environmental Science and Public Policy Archives, Cambridge, United States.

<sup>134</sup> Ibid.

<sup>135</sup> Ibid.

<sup>136</sup> Michael MacCracken, travel report, 4 August 1986, Box 10, Folder 101, Foreign Travel Report, Lawrence Livermore Nuclear Winter Study Papers, Environmental Science and Public Policy Archives, Cambridge, United States.

activity on climate.”<sup>137</sup> Budyko was the first Soviet project 11 leader (there were always two leaders, one from each country).<sup>138</sup>

As of December 1981, under just Working Group VIII’s mandate more than 79 separate events had taken place, including 8 symposia, 43 meetings, 8 completed cooperative projects, and 20 scientific exchanges with a duration exceeding 30 days.<sup>139</sup> Involved were a total of 190 American and 81 Soviet scientists who not only presented to one another, but also co-authored papers (such as between the Geophysical Fluid Dynamics Laboratory (GFDL) at Princeton and the MGO) and did field work collaboratively.<sup>140</sup> Specifically on anthropogenic climate change there were several symposia in Tashkent (1976), Leningrad (1977), Dushanbe (1978) and Tbilisi (1979) as well as a major workshop in Leningrad (1981) specifically on the role of carbon dioxide.

The 1981 Leningrad workshop was the site of “a great deal” of disagreement between Soviet and American scientists on “the effect of increasing CO<sup>2</sup> content in the atmosphere.”<sup>141</sup> The workshop concluded having reached “qualitative” but not “quantitative” agreement – i.e. Soviet scientists agreed carbon dioxide’s effect on the atmosphere was one of warming, but disputed the significance of carbon dioxide compared to non-anthropogenic factors.<sup>142</sup> However this report masked the disagreements among Soviet scientists which were just as strong as those with the Americans. While Budyko was quite confident in the significance of carbon dioxide in causing global warming, among his Soviet colleagues there were still disputes as to its influence. Yevgeny Borisenkov and Kirill Konratyev were among the domestic opposition to

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<sup>137</sup> Bierly, The U.S.-U.S.S.R. Agreement.

<sup>138</sup> Ibid.

<sup>139</sup> Ibid.

<sup>140</sup> Ibid.

<sup>141</sup> Ibid.

<sup>142</sup> Ibid.

anthropogenic global warming, though they believed non-anthropogenic climate change was probably occurring.

These scientific disagreements were also in practice political disagreements. Among Soviet scientists there were disagreements about the role of carbon dioxide, and between American and Soviet scientists there was a deep divide in the expected climate changes of global warming due to American use of GCMs and Soviet use of paleoclimatology. The ascension of Mikhail Gorbachev in 1985 would open up another round of opportunities and threats for Soviet scientists and officials, and though Budyko greatly benefitted in 1986 from renewed environmental cooperation, Izrael would lose out in the bureaucratic renewal that ushered in the creation of the State Committee for the Protection of Nature in 1988. Though Budyko's reputation within the Soviet Union remained strong, his international perception significantly turned for the worse between 1988 and 1991 when the Intergovernmental Panel on Climate Change (IPCC) was founded and Budyko was most forceful in advocating for the benefits of global warming. These countervailing shifts in Budyko's position demonstrate that Budyko and Izrael were right in their assessment that the government exercised disproportionate ability to undo personal consolidation of resources and influence.

### **Mikhail Gorbachev Comes to Power**

After his election in 1985 Gorbachev began a shocking wave of reforms in the Soviet Union to liberalize society and reshuffle the bureaucracy. Glasnost greatly relaxed censorship both in the general press and within the sciences, while the "new thinking" in foreign policy became part of "an across-the-board campaign to improve the USSR's international image"<sup>143</sup>

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<sup>143</sup> Darst, 107.

During his leadership Gorbachev and his Foreign Minister, Eduard Shevardnadze, suggested interesting though probably unserious proposals for changing the United Nations to incorporate ecology. Shevardnadze for example suggested “political ecology requires more involvement of the Security Council in solving problems and activating such tools as transparency and strict international monitoring.”<sup>144</sup> Gorbachev himself recommended the creation of a special emergency environmental council and also reforming an old UN body into an Environmental Trustee Council.<sup>145</sup>

In the sciences, as historian Paul Josephson has noted, Gorbachev was seriously committed to academic freedom to help improve the competitiveness of Soviet science. As part of his program of reforms Gorbachev tried accelerating the rate of retirement for older bureaucrats to let new people with ideas more reformist replace them.<sup>146</sup> This was especially clear in the case of the State Committee for the Protection of Nature as we will see later.

Gorbachev’s greening of Soviet foreign policy naturally extended to the bilateral environmental agreement which saw a substantial uptick in Soviet political interest in 1986. Until then American scientists remained frustrated with apparent Soviet disinterest in climate cooperation since 1979. Increasingly sophisticated GCM research was also persuading western scientists that global warming (whether anthropogenic or not) was likely to be disastrous. Writing to Alan Hecht in June 1986, MacCracken, in his capacity as a leader in Working Group VIII of the bilateral environmental agreement, was uncertain of how to encourage the Soviet government to see global warming as a threat:

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<sup>144</sup> Robin Churchill, “Controlling Emissions of Greenhouse Gases.” *International Law and Global Climate Change*, ed. Robin Churchill, David Freestone (Norwell: Kluwer Academic Publishers Group, 1991): 179.

<sup>145</sup> *Ibid.* 178.

<sup>146</sup> Paul Josephson, “Guest Comment: Science under Gorbachev – Glasnost’, Perestroika, and Physics.” *American Journal of Physics* 57 (1989): 395.

In thinking about how to get Soviet officialdom interested in the CO<sup>2</sup>/trace gas issue, I am at a bit of a loss. Warming will be a benefit... increased uv is not a problem... and their coastlines (excepting Leningrad) don't seem highly populated. So we are left with the hydrologic cycle perturbations; only the GFDL model shows summer drying in European Russia... and all precipitation results are highly uncertain. The various model estimates of soil moisture change are also quite variable... I think it will be rather hard to generate much more than U.S.S.R. interest in further studies (unless their altruism toward developing nations is particularly strong).<sup>147</sup>

MacCracken effectively described the problems of Working Group VIII since Leningrad 1981. Soviet scientists were using paleo-analogs that showed global warming was, overall, a net benefit at least in the Soviet Union. Heightened tensions had prevented trips that might have reconciled US-Soviet scientific disagreements, especially where American supercomputer access would have convinced Soviet scientists of the negative impacts of global warming even for Russia. By 1986 however Budyko and his immediate coterie were convinced of the paleo-analog approach's value.

Gorbachev's election had heralded noticeable changes to Working Group VIII. MacCracken perceived a significant change in tone and interest in the summer of 1986 – particularly in “the make-up of the Soviet delegation” which he found “very interesting.”<sup>148</sup> He optimistically noted in his report that “interest of the USSR delegation in the CO<sup>2</sup> issue was quite apparent by the participants selected.”<sup>149</sup> MacCracken along with 9 other US scientists were scheduled to visit the Soviet Union for Working Group VIII's annual meeting a month after he had complained about Soviet disinterest in “the CO<sup>2</sup>/trace gases issue” (i.e. anthropogenic global warming), as quoted above. The meeting seemed to him to prove the new Soviet government was more interested than the previous one in scientific cooperation through Working Group VIII.

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<sup>147</sup> Michael MacCracken, internal correspondence, 17 June 1986, Box 10, Folder 96, Lawrence Livermore Nuclear Winter Study Papers, Environmental Science and Public Policy Archives, Cambridge, United States.

<sup>148</sup> MacCracken, Report of Trip to USSR under WGVIII.

<sup>149</sup> Ibid.

In attendance in July was A.M. Obukhov “head of the USSR Academy of Science’s Institute of Atmospheric Physics (IAP)” which MacCracken thought was another “indication, I believe, of the importance they placed on the meeting.”<sup>150</sup> Obukhov “was extremely interested” in the discussion, including on issues he was not a specialist in.<sup>151</sup> He “proved an engaging and active participant.”<sup>152</sup> Georgy Golitsyn, Obukhov’s junior in the IAP, and lead scientist (second only to Aleksandrov, at this point missing for over a year) on the issue of nuclear winter in the Soviet Union, was also present.<sup>153</sup> Golitsyn and Obukhov were the two scientists most invested in nuclear winter, which would publicly endorse next year, and their presence implied political interest.

Also participating were Budyko, Vinnikov, and the aerosols and trace gases project leader Igor Karol from the MGO. For Budyko’s part in showing Soviet interest in the working group, MacCracken was “impressed” to learn that Budyko had “encouraged” the preparation of a report on the Chernobyl nuclear disaster, one of the authors of which was a “leader and decision maker on energy alternatives.”<sup>154</sup> Though MacCracken recognized this as leadership on Budyko’s behalf to demonstrate “Soviet interest in the CO<sup>2</sup> issue,” Budyko still maintained his insistence on the superiority of “paleoclimatic reconstructions” over GCMs throughout the exchange.<sup>155</sup>

Also revealing of Soviet government interest in expanding cooperation through Working Group VIII were the curious comments of Izrael’s new personal assistant, V. Lobanov. Lobanov spoke extensively with several members of the US delegation, including MacCracken, who

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<sup>150</sup> Ibid.

<sup>151</sup> Ibid.

<sup>152</sup> Ibid.

<sup>153</sup> Ibid.

<sup>154</sup> Ibid.

<sup>155</sup> Ibid.

learned through Lobanov that Izrael was searching for a new co-chairman of Working Group VIII.<sup>156</sup> Lobanov also confided that the future issue of flooding around Leningrad as a consequence of increased sea levels was now under serious consideration, the Hydromet having already made statements encouraging Finland to consider working with the Soviet Union on the construction of major dikes to mitigate potential damage.<sup>157</sup>

Another American scientist, Wei-Chyung Wang, in his trip report from the same exchange also observed Lobanov asserting his own (and by extension, Izrael's) direct influence over working group issues. Apparently Lobanov "claims he represents the enforcer of the new 'open-door' policy [regarding the US/USSR agreement]" and "he is trying to establish his authority over the Soviet scientists" and one example was that "he told me he should be the one to ask for CFCs' production in the U.S.S.R. as the Soviet scientists have to get his permission if being asked."<sup>158</sup> Though Lobanov's attempts to "establish his authority" were probably not indicative of a new or special pressure emanating from Izrael, his appointment indicates some shifts in the official postings of the Hydromet shortly following Gorbachev's ascension. Lobanov's comments about Leningrad sea level rises indicate the government was calibrating some plans for preventative climate measures – in this case resulting in the construction of a dam to protect Leningrad.

In November 1986, Alan Hecht visited the Soviet Union to discover that Budyko was appointed co-chairman of Working Group VIII, signifying in his opinion "a change in internal Soviet politics" that "brings emphasis by the Soviets on the problems of greenhouse gases and

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<sup>156</sup> Ibid.

<sup>157</sup> Ibid.

<sup>158</sup> Wei-Chyung Wang, travel report, August 1986, Box 10, Folder 101, Foreign Trip Report, Lawrence Livermore Nuclear Winter Study Papers, Environmental Science and Public Policy Archives, Cambridge, United States.

climate change.”<sup>159</sup> He wrote in his trip report that “the meeting marks a major turning point in the history of Working Group VIII.”<sup>160</sup> MacCracken’s and Hecht’s assessments were correct that Soviet interest in expanding cooperation through Working Group VIII had increased. The working group would begin preparing a major joint work within a couple years, *Prospects for the Future Climate*, eventually published in 1990, with the group’s activities only to diminish somewhat because of the creation of the IPCC in 1988.

### **Climate Science Politics: The Case of Borisenkov**

When MacCracken visited the Soviet Union that summer he was exposed to an unfolding internal conflict between Budyko and his scientific adversaries. Budyko tried to use the conference to delegitimize the scientific positions of Yevgeny Borisenkov, Kiril Kondratyev and their camp who opposed anthropogenic global warming at least as early as the Leningrad workshop in 1981. The tactical manoeuvre succeeded by November when Budyko, with Izrael’s help, became Soviet co-chairman of Working Group VIII, replacing the previous co-chairman at Borisenkov’s expense.

Budyko attempted to marginalize Borisenkov’s scientific position by obtaining as strong a stance on carbon dioxide’s role in causing global warming as he could from the US delegation during the July exchange. At the end of the scheduled events the scientists had to compose summaries of the scientific discussion. During these discussions the Soviet scientists, in particular Budyko, surprised MacCracken with their forcefulness in elevating the status of the issue of carbon dioxide. Budyko and his junior colleague Vinnikov pushed for “a strong

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<sup>159</sup> Hecht, Summary Report of the Eleventh Meeting.

<sup>160</sup> Ibid.

affirmative statement” that carbon dioxide had “caused the 0.5°C warming since about 1880.”<sup>161</sup> The American scientists by contrast were more cautious, preferring a double negative statement “i.e., the observed warming is not inconsistent with projected CO<sup>2</sup> effects.”<sup>162</sup> Budyko pleaded to MacCracken that “he was willing to give on anything else to avoid the double negative,” and privately stressed that “he was considering moving into other fields” unless there was “progress being made” on the issue of carbon dioxide so that he could conduct new projections – as close as a scientist gets to a veiled threat.<sup>163</sup> MacCracken “sensed health problems may be playing a role in this” but also saw a strategy by Budyko to marginalize his climate skeptical colleagues.<sup>164</sup> In the end they forged a compromise “by using the term ‘more probable’ than other causes and including the double negative in a qualifying phrase,” though apparently Vinnikov “was not very pleased with the negotiated sentence,” wishing a stronger stance.<sup>165</sup>

During the July trip MacCracken met with Borisenkov in Moscow and discovered that “he does not generally believe that the [observed global] warming is due to CO<sup>2</sup>, but that recent climate changes are due to biospheric changes.”<sup>166</sup> Borisenkov represented “an important, but minority, viewpoint in the USSR” that Budyko, Vinnikov and Izrael hoped to marginalize by extracting from the negotiated scientific summary a clear statement of Soviet-American consensus on the role of carbon dioxide in global warming.<sup>167</sup> Budyko’s scientific disagreements spilled over into personal disagreements, which meant Budyko had “strained relations” with other Soviet scientists.<sup>168</sup>

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<sup>161</sup> MacCracken, Report of Trip to USSR under WGVIII.

<sup>162</sup> Ibid.

<sup>163</sup> Ibid.

<sup>164</sup> Ibid.

<sup>165</sup> Ibid.

<sup>166</sup> Ibid.

<sup>167</sup> Ibid.

<sup>168</sup> Hecht, Summary Report of the Eleventh Meeting.

In November 1986 Izrael appointed Budyko as the Soviet-side co-chairman of Working Group VIII, the position Borisenkov, then Director of the MGO “assumed” he would be given.<sup>169</sup> According to Hecht’s report “Borisenkov was extremely upset by not being appointed by Izrael... Borisenkov and Budyko have long standing disagreements,” but more than mere disagreements “Borisenkov could not recognize Budyko as his ‘chief.’”<sup>170</sup> Besides Borisenkov, in that same report Hecht recollected that Budyko and Kiril Kondratyev also disagreed “on many things, particularly evidence of recent climate change.” The Soviet government through Yuri Izrael of the Hydromet was giving critical backing to the working group on global warming and climate change forecasting. Consequently American scientists were becoming increasingly optimistic about the future of Working Group VIII.

American scientists were so charmed by Budyko’s elevation and the implication for future exchanges that the Lawrence Livermore scientists (Hecht, Wang and MacCracken and others) penned a letter to the Senior Editor of Encyclopedia Britannica in August 1986, a month after MacCracken’s substantive visit in summer. They suggested the Encyclopedia inquire to Budyko if he might submit something on the issue of carbon dioxide and global warming. They noted he was “a much stronger proponent that the observed warming is in fact due to CO<sup>2</sup> than are most U.S. modelers.”<sup>171</sup> Budyko was “an avid reader” of the Encyclopedia “as a general reference” and so this a thoughtful compliment to Budyko by the Livermore scientists<sup>172</sup>

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<sup>169</sup> Ibid.

<sup>170</sup> Ibid.

<sup>171</sup> Lawrence Livermore Laboratory, letter to Charles Cegielski, 22 August 1986, Box 11, Folder 106, Lawrence Livermore Nuclear Winter Study Papers, Environmental Science and Public Policy Archives, Cambridge, United States.

<sup>172</sup> Ibid.

Through the window of these reports by American scientists of Working Group VIII to the bilateral environmental agreement we can take a glimpse at early Gorbachev era bureaucratic-scientific political maneuvering. Budyko's actions in July 1986 and his acceptance of the co-chairmanship in November could have been because of the general atmosphere of Gorbachev's bureaucratic reshuffling. If Budyko's control of climate change were potentially the target of job transfers or funding cuts, gaining recognition from American scientists could both eliminate potential contenders that might usurp his monopoly on the direction of climate science, and also prove Budyko's continued value as an instrument diplomacy.

To effectively maintain control of Soviet climate science Budyko navigated the Soviet system's incentive structure surrounding the bilateral to marginalize his opposition. This secured his ability to continue modest advocacy for the importance of climate change through his expert recommendations and science writing. That July he had in fact enthused to MacCracken that his climate forecast of potential increased precipitation "had played a role in stopping the [Siberian] river diversion project."<sup>173</sup> Budyko was proud to have contributed to the downfall of the project which he considered foolish, even if, as MacCracken heard from Golitsyn, there were other practical considerations that were probably more important in ending the project.<sup>174</sup> Beyond the micro-politics of which camp of Soviet scientists would lead the Soviet side of the bilateral agreement and set the agenda and tone of meetings, Izrael's Hydromet itself was also engaged in politics within the larger Soviet bureaucracy, and the Hydromet lost badly.

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<sup>173</sup> MacCracken, Report of Trip to USSR under WGVIII.

<sup>174</sup> Ibid.

### State Committee for the Protection of Nature

Gorbachev's administration, in response to the well-known failures of the Soviet Union's diffuse environmental regulatory structure, created a new State Committee for the Protection of Nature (Goskompriroda) in early 1988 to consolidate environmental protection under one agency. According to Gary Waxmonsky (former EPA head) and Nicholas Robinson, Izrael had been pressing "vigorously for the establishment of a national Ecology Program" and the consolidation of environmental protection for years by this time.<sup>175</sup> Izrael expected that, given his qualifications and personal advocacy, "any such centralization would take place under the aegis" of the Hydromet – however instead Izrael and the Hydromet "were the biggest losers in the bureaucratic reshuffling; the agency was stripped of all but its atmospheric monitoring functions."<sup>176</sup>

According to D.J. Peterson "a prolonged battle over management authority raged" between the two agencies, and although Goskompriroda had the power "to publish data" on the Soviet environment, the Hydromet could obstruct Goskompriroda's activities by declining to provide "unimpeded access" to such data.<sup>177</sup> Moreover Izrael, the most objectively qualified candidate for position, was probably further upset because the first new chairman appointed to Goskompriroda, Fedor Morgun, resigned soon after due to "his lack of experience in environmental protection."<sup>178</sup> The subsequent appointee, Nikolai Vorontsov, "went on to criticize" Izrael "bluntly" after Gorbachev made Vorontsov chairman in June 1989.<sup>179</sup> In October of that year the Goskompriroda published a major report, *The State of the Environment in the*

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<sup>175</sup> Robinson, 421.

<sup>176</sup> Sokolov et al., 151-152.

<sup>177</sup> D.J. Peterson, *Troubled Lands: The Legacy of Soviet Environmental Destruction* (Boulder: Westview Press, 1993): 167, 163.

<sup>178</sup> Ibid. 162.

<sup>179</sup> Ibid. 167.

*USSR*, which, besides being “the first document to provide a comprehensive” account of Soviet environmental conditions, also complained that there was “a shortage of timely and objective official ecological information.”<sup>180</sup> The agency was also tasked with drafting an Ecological Program for the next Five-Year Plan (1991-1995), the idea Izrael had been the most vocal lobbyist of prior to 1988.<sup>181</sup>

Morgun and Vortontsov’s appointments were both deliberate attempts by the Gorbachev administration to replace the officials in charge of handling environmental issues, in accordance with Gorbachev’s general reshuffling of the bureaucracy. Morgun had good ties to Gorbachev, while Vorontsov had shown a reformist streak by apparently contributing to the discontinuation of a hydroelectric dam and vocally opposing pollution of Lake Baikal.<sup>182</sup> By contrast “Izrael was one of the last remaining bureaucrats from the Brezhnev era to survive in the era of perestroika.”<sup>183</sup>

Izrael’s sudden collapse within the establishment also curtailed Budyko’s opportunities to extend his influence, as the new leaders of the Goskompriroda were not as well acquainted with Budyko as those in the Hydromet. The Goskompriroda was transferred responsibility for all international environmental cooperation and negotiation, including the bilateral with the United States – though this did not affect Budyko’s participation there. Budyko coauthored with MacCracken *Prospects for a Future Climate*, completed in 1990, which was the culmination of Working Group VIII’s activities since 1986.

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<sup>180</sup> Ibid. 161.

<sup>181</sup> Ibid.

<sup>182</sup> Ibid. 162.

<sup>183</sup> Ibid. 167.

## Intergovernmental Panel on Climate Change

In 1988 the IPCC was established by the combined efforts of the World Meteorological Organization and the United Nations Environmental Programme. Both Soviet and American scientists became prominent officials and scientific attendants within the IPCC. The IPCC is an interesting institution because its role is purely to assess scientific research produced outside the organization itself – the IPCC does not author studies itself, but reports on studies.

The IPCC intersected with Working Group VIII because of the Soviet scientists involved – Izrael and Budyko were represented in the IPCC and Working Group VIII. Tora Skodvin has written a short political science review of the case of paleo-analogs and why they were dismissed during preparations for the First IPCC Assessment Report. According to the internal correspondence of scientists involved in the early working groups under the IPCC, Budyko's paleoclimate analogs caused a conflict which ultimately ended with the discrediting of paleoclimate analogs within the IPCC.

Budyko's paleoclimatic approach was considered dangerous by other western scientists participating in the IPCC's First Assessment because its inclusion in the report would legitimize the potential viability of the “do nothing” solution to global warming.<sup>184</sup> On the basis of Budyko's bold claims about the beneficial impacts of global warming Budyko's candidacy for chairmanship of the working group tasked with specifically assessing the paleo-analog approach was rejected.<sup>185</sup> American scientists involved were in a dilemma because over-criticizing Budyko's technique could “run the risk of sabotaging the whole US-USSR cooperation” but

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<sup>184</sup> Tora Skodvin, *Structure and Agent in the Scientific Diplomacy of Climate Change: An Empirical Case Study of Science-Policy Interaction in the Intergovernmental Panel on Climate Change* (New York: Kluwer Academic Publishers, 2000): 140.

<sup>185</sup> *Ibid.* 141.

under-criticizing the paleo-analog approach risked undermining the conclusions of the IPCC working group report.<sup>186</sup>

Budyko was strongly supported by Izrael who both promoted the paleo-analog approach, complaining in one instance when it was not included in the schedule for a 1989 IPCC meeting.<sup>187</sup> This was suspicious to other scientists, and so a major figure in the IPCC, Bert Bolin, interrogated Budyko and concluded that “Budyko operated under instructions from Izrael.”<sup>188</sup> After this incident the political motivations of the paleo-analog were apparently obvious and the approach was excluded from the First Assessment Report.

Sir John Houghton in his autobiography relates another incident at an IPCC meeting that affirms this trajectory for Budyko’s work and foreign respect. The meeting took place in Bristol, November 1991 – one month before the collapse of the Soviet Union – where scientists agreed to discuss the future climate. According to Houghton the Russian scientists attending “were keen to push the Budyko line” because “Budyko was powerful and influential in Russian science” but when Budyko’s colleagues saw “other published papers” they “had their eyes opened.”<sup>189</sup> Houghton claims “poor Budyko was left out in the cold” and allegedly Budyko “insisted that” Houghton “had undermined him in setting up a meeting which, in his view, killed his reputation.”<sup>190</sup> Though there is insufficient documentary evidence to verify that Budyko was marginalized by the IPCC process and the international scientific community in the late 1980s and early 1990s, Budyko’s career was certainly slowing down in the last decade of his life.

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<sup>186</sup> Ibid. 139.

<sup>187</sup> Ibid.

<sup>188</sup> Ibid. 141-142.

<sup>189</sup> John Houghton, *In the Eye of the Storm: The autobiography of Sir John Houghton* (Oxford: Lion Books, 2013): 145.

<sup>190</sup> Ibid.

The last Soviet-American report composed by Working Group VIII and published in 1990, *Prospects for Future Climate*, did not contain dramatic predictions of greenhouse paradise, incidentally. After several pages of waffling between the positive and negative results of global warming on precipitation the report's boldest agricultural claim was that "the results showed small increased in yields of spring wheat and winter rye in more northern regions with climate warming, and lower yields of barley and potatoes in the central region of the European USSR."<sup>191</sup> Maybe Michael MacCracken had negotiated Budyko down from bolder claims, perhaps this report reflected Budyko's genuine impression at the time of the effect of global warming on agriculture, or perhaps IPCC politics had spilled over into what Budyko wanted to project through the Working Group VIII report. Whatever the case, the collapse of the Soviet Union and the discrediting of the paleo-analog approach pushed Budyko into a peripheral role in the IPCC and international climate negotiation until his death in 2001.

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<sup>191</sup> *Prospects for Future Climate: A Special US/USSR Report on Climate and Climate Change*, ed. by Michael C. MacCracken, Alan D. Hecht, Mikhail I. Budyko, Yuri A. Izrael, (1990, Chelsea, Lewis Publishers, Inc): 213.

## Conclusion

The first comprehensive international agreement to reduce global carbon emissions was the 1997 Kyoto Protocol. The agreement would not be binding unless the ratifying countries represented at least 55% of world carbon emissions.<sup>192</sup> Although 124 countries representing 44% of emissions had ratified the agreement by 2004, the United States withdrew in 2001, leaving Russia the last major emitter to commit; they represented 17.5% of world emissions.<sup>193</sup> Bryon MacWilliams and Quirin Schiermeier relayed in *Nature* a Moscow climate research summit from 2004 when hope was dashed that Russia would save Kyoto.<sup>194</sup> According to non-Russian attendants the summit was “a trap” for “unscheduled speakers” to claim “global warming was a myth.”<sup>195</sup> The previous year’s World Climate Change Conference (not to be confused with the World Climate Conference), organized by Yuri Izrael and also hosted by Russia, was criticized for similar reasons, accused of being “stage-managed” and a “pseudo-democratic enterprise.”<sup>196</sup> Izrael himself was privately called “autocratic” and some western scientists considered boycotting the conference, fearing its real purpose was “to help block ratification of the Kyoto Protocol.”<sup>197</sup> Izrael had come out in May 2003 against Kyoto, apparently questioning in a memorandum “whether the rise in temperature [over the past 100 years] was in fact due to human activity” (square brackets are the authors’).<sup>198</sup> MacWilliams and Schiermeier lamented that unlike “in communist times, when concerned members successfully opposed several government proposals they considered misguided, including a plan to re-route large northward-

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<sup>192</sup> Quirin Schlermeier and Bryon MacWilliams, “Climate change: Crunch time for Kyoto,” *Nature* 431 (2004): 12.

<sup>193</sup> *Ibid.*

<sup>194</sup> *Ibid.*

<sup>195</sup> *Ibid.*

<sup>196</sup> Quirin Schlermeier, “Researchers rattled as Kyoto Protocol hangs in the balance,” *Nature* 423 (2003): 792.

<sup>197</sup> *Ibid.*

<sup>198</sup> Schlermeier, “Climate change,” 13.

flowing Siberian rivers” then, in 2004, no one was “willing to voice their objection to Izrael’s stance on the treaty.”<sup>199</sup> This is a generous interpretation of the freedom that, other than Budyko and Izrael, climate scientists had in “communist times.”

I have not confirmed Izrael’s memorandum or examined the exact nature of his argument against Kyoto, which might have included qualifiers that resolve his apparent volte-face on anthropogenic climate change. Izrael authored *Anthropogenic Climate Change* with Budyko in 1987 where they made a compelling case for carbon dioxide’s role in global warming. The alleged new-found climate skepticism could be a misinterpretation of Izrael’s circumlocutory way of wording anything resembling a policy statement. Izrael’s apparent climate skepticism could also be consistent with the character of a man abundantly aware of the political expectations of Russia’s chief climate scientist and representative on the IPCC in the wake of a period of severe economic contraction. In any case, in November 2005 he sent a letter to President Vladimir Putin apparently urging action on climate change, “suggesting burning thousands of tons of sulfur in the stratosphere as a remedy.”<sup>200</sup> He then in 2007 claimed “I think the panic over the global warming is totally unjustified. There is no serious threat to climate.”<sup>201</sup> Izrael’s reputation as a “fossil communist fighting for fossil fuel” may or may not be justified, but the legacy of Soviet climate science lingered in his 2005 geoengineering proposal. Russia did ultimately ratify the Kyoto Protocol in 2004, which was also reminiscent of Soviet times because of speculations that Russia ratified Kyoto “in exchange for agreement by the EU on

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<sup>199</sup> Ibid.

<sup>200</sup> James R. Fleming, *Fixing the Sky: The Checkered History of Weather and Climate Control* (New York: Columbia University Press, 2010): 254.

<sup>201</sup> Paul G. Harris, *The Politics of Climate Change: Environmental Dynamics in International Affairs* (New York: Routledge, 2009): 38.

terms for Moscow's admission to the World Trade Organization."<sup>202</sup> Yuri Antonovich Izrael died in January 2014.

The fragmentary newspaper clippings that describe Izrael's last 10 years are a contradictory mess of rumours and charged accusations and I conclude from the above two paragraphs that there is so much more scholarship to be done on Soviet era climate scientists than has been done presently. My thesis presented a triangulation of different sources in an attempt to describe the limits and unique character of environmentalism in the Soviet Union expressed through Budyko's lifelong commitment to increasing the stature of climate change and guaranteeing its scientifically rigorous study.

Budyko navigated a system which put limits on environmental activism but Budyko also made conscientiously restrained choices when attempting to persuade the government of the importance of global warming and climate change. Budyko was not a closet dissident and he only cautiously implored the government to calibrate the economy to incoming climate change. Budyko could have opened any of the chapters of his books with a strong political stance but he never dared to say something like: "the next Five-Year Plans from 1981-1985 and 1986-1990 must incorporate predicted changes in agriculture among the territories of the Soviet Union derived from paleoclimatic forecasts. Unless sufficient funding is provided for climate change research the global food supply might be so seriously jeopardized in the 1990s and early 20th century that millions of people will starve in the developing world. The Soviet Union has a moral obligation to commit to serious reorganization of the national economy so as to adapt to

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<sup>202</sup> Schlermeier, "Researchers rattled," 13.

Paul Josephson, Nicolai Dronin, Ruben Mnatsakanian, Aleh Cherp, Dmitry Efremenko, Vladislav Larin. *An Environmental History of Russia* (Cambridge: Cambridge University Press, 2013): 301.

inevitable, halt preventable, and exploit beneficial climatic changes.” Budyko never said anything that bold.

My thesis made Budyko its main character in part because so little is known about anybody else who did climate science in the Soviet Union. Although Budyko was the most visible and prominent Soviet climate scientist there were many others beneath him in the Hydrological Institute, the MGO and the Hydromet. Konstantin Vinnikov, Budyko’s protégé, left Russia for Princeton in 1991, became a professor at the Department of Maryland in 1993, and coauthored studies comparing GCM predictions thereafter. Georgy Golitsyn, Yevgeny Borisenkov, Igor Karol, Kirill Konratyev – there were many climate scientists in the Soviet Union whom historians barely have basic encyclopedic knowledge.

While Izrael and Budyko operated underneath the constraints of the political leadership, these lesser known scientists operated underneath the deliberately cautious boundaries of technocratic environmentalism set up by Izrael and Budyko. Had Izrael and Budyko not been the particular scientists in charge of the Soviet position on climate change maybe another scientist in the same place would have been bolder – entirely conceivable given the tumult of the Second World War, Stalinism and the Great Plan for the Transformation of Nature on who happened to end up in high places within Soviet scientific institutions. Perhaps other scientists *were* bolder but historians have yet to uncover their failed attempts to persuade Izrael and Budyko.

Each chapter of my thesis has analyzed an aspect of Russian environmental history that has been at best treated peripherally by other scholars. Mikhail Budyko’s beliefs about global warming have been discussed occasionally by historians however the events of the IPCC and his reputation through articles like those in the *New Scientist* have eclipsed the more difficult

explanations for Budyko's position on global warming which I detail in chapter 1. However notwithstanding Budyko's earlier ambivalence, scholars should recognize that Budyko's beliefs were not inconsistent with environmentalism in the Soviet context – rather, Budyko's position was possibly the most aggressive form of advocacy he could have undertaken given the bureaucratic and political consequences of catastrophizing in Soviet science. I catalogued these pressures in chapter 2 and showed that the result was Izrael's rhetoric of optimizing the relationship between man and nature and Budyko's argument for calibrating the economy to anticipated climate changes. Finally I used documentary evidence from the American side of Working Group VIII to interrogate the fissures of Soviet climate science under the new conditions of Gorbachev's Soviet Union.

Ironically Budyko's strategy was perhaps too acclimatized to the pre-Gorbachev era. He knew how to maintain his scientific independence, he could navigate the political boundaries of post-Stalin Soviet environmental rhetoric, and he may have had a noteworthy influence on some policies related to climate. However the Gorbachev administration, even though they appear by all accounts to have adopted the "Budyko line" in climate negotiations, did not noticeably reward Budyko or his immediate allies during the bureaucratic reshuffling of the late 1980s. Maybe Budyko had truly guaranteed his dominance of the field by ousting his scientific opposition, not just in 1986 but other untold times where a fruitful climate activism would have existed. Perhaps Budyko was not obeying but instead setting the limits of a technocratic environmentalism in the Soviet Union.

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