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Kite Sensorship: Regulating China's Airways

By Abi Barnes

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Photo credit: Elizabeth Phung

In the eyes of a Beijinger, the view is a familiar one: an old man flying his kite in the late afternoon breeze. As the sun sets, however, the kite's colored lights flare and the traditional kite acquires a modern aspect. Make no mistake: these lights are not decorative. They indicate the presence of certain air pollutants.

Launched in July 2012, FLOAT Beijing—a community art project that utilizes citizen science—offers a simple, innovative, and non-confrontational approach to air quality monitoring: kites. Pioneered by two U.S. graduate students, the project tracks air pollutants using air sensor modules attached to kites. In recent years, China has seen an upswing in civic environmental activism, from pollution victims bringing class action lawsuits to Chinese protesters and nongovernmental organizations (NGOs) exposing the polluting practices of domestic and foreign industries. While the Chinese government has improved outlets for citizens to channel environmental grievances, many of these pathways remain either heavily congested with bureaucratic rigmarole or blocked. For this reason, bottom-up initiatives that are able to bypass these channels, like citizen science and do-it-yourself (DIY) technologies, may prove vital to mitigating China's environmental problems.

DIY technology and citizen science stand for the idea that non-experts can participate and contribute to the realm of science. Citizen science is "a field that harnesses the wisdom of crowds, a do-it-yourself approach to technology and a radical approach to knowledge that blurs the traditional boundaries between local understanding and scientific expertise," explains *chinadialogue* environmental journalist Sam Geall.[1]

Around the world, and increasingly in China, environmental NGOs act as watchdogs, exposing pollution violations and

environmental degradation. Such transparency can help strengthen environmental regulations and empower citizens to demand better environmental governance.

In China, transparency on environmental issues is still lacking. This reality makes citizen science and DIY organizations like FLOAT Beijing increasingly relevant.

Photo Credit: Elizabeth Phung

FLOAT Beijing: Letting Stifled Data Soar

In 2011, when graduate student Xiaowei Wang from Harvard first conceived of a kite sensor to monitor air quality, environmental ingenuity took to the skies. Her idea was simple: provide basic air monitoring technology and kite-making materials to Beijing residents and offer instruction on how to collect air quality data. Deren Guler, a graduate student at Carnegie Mellon, later joined the project to help design the modules. Guler drew inspiration from her classmates who had demonstrated this technology with balloons at an air quality workshop series in Pennsylvania.[2]

Guler and Wang decided to apply a similar design using kites and took their idea to China. Once in flight, the kites use GPS tracking devices to publish real-time air quality data online to open source databases and social media networks like Weibo (China's version of Twitter). Air quality sensors embedded into each kite detect volatile organic compounds (VOCs); sulfur oxides (SOx); nitrogen oxides (NOx); carbon monoxide; and particulates. On some of the kites, if the sensors detect the presence of any of these pollutants, an LED light displays the compound's corresponding color. Other FLOAT Beijing kites simply show a series of colors to reflect the overall quality of the air. The sensor chips are detachable, allowing individuals to manually upload the data post-collection.

Assembly is fairly basic, allowing Beijing residents to design and assemble their own kites. FLOAT Beijing facilitated this process through a series of kite-building workshops scattered throughout the city. With the help of small seed grants from foundations, Guler and Wang have been able to provide the tools and materials at their workshops for free—each sensor-equipped kite costing approximately 130-260 Yuan ($20-40). Because of the relatively low budget for supplies, Guler and Wang hope that these workshops can be self-sustaining if FLOAT Beijing is unable to host kite workshops in the future.[3] Materials for the air sensors can be purchased at local hardware stores, and Guler and Wang plan to provide a tutorial pamphlet on their website that includes information on how to make the air sensor modules.[4]

At the first kite workshop in July 2012, a small group of fifteen residents met at Di'anmen, a spot just north of the Forbidden City. Seasoned kite flyers, many with some seventy or so years of experience, mixed with younger generations in an activity that merged the traditional art of kite-making with modern technology. The response from the community was overwhelmingly positive, according to Guler. One retired engineer, Guler recounted, "immediately started testing out all the electronics to make sure we hadn't been cheated at the electronics market; there was genuine interest in what we were doing." The level of environmental awareness was encouraging, Wang added: "One man even made his kites with old plastic bags."

Until recently, China did not measure particulate matter less than 2.5 micrometers in diameter ($PM_{2.5}$) or ozone in its Air Pollution Index (API) reports. [5] The only three atmospheric pollutants that were measured include: PM_{10}—which does not pose as great a health risk—NO_2, and SO_2. [6] Although unable to distinguish between particulate matter sizes, the kites gauge air quality based on more stringent and comprehensive standards than China's previous guidelines, ultimately bringing to light what otherwise may have been concealed. Using the more stringent U.S. air quality standards, Guler reported that the overall air data results from the kite flying workshops registered Beijing air as "moderately unhealthy to unhealthy." Guler also noted that while these low-quality readings were unsurprisingly concentrated in heavy industry areas, rural air quality numbers were not significantly better because of the prevalence of trash burning. The air data collected from the kite workshops in the summer of 2012 contradicted Chinese reports. Specifically, the two weeks of intensive air quality measurements by FLOAT kites recorded seven unhealthy and eight severely unhealthy days, while the corresponding official statistics cited air quality for those days as healthy and moderately unhealthy.[7]

The Kite's Symbolic Subtleties

The ingenuity of the kite sensor is twofold: FLOAT Beijing neatly bypasses institutional bureaucratic channels by operating with minimal (figurative) strings attached—paperwork, conditions, or formalities—and utilizes China's strong cultural connection to kites. This combination makes for an ideal starting point for civic engagement. According to Guler, the pair chose kites because of its long tradition in China, and the large number of kite flyers, makers, and hobbyists in Beijing. Guler and Wang hoped the project would spark greater dialogue on air quality in China, and engage citizens who otherwise would have little interest in DIY electronics or air quality monitoring.

The project's symbolic appeal is perhaps less obvious. The architects of the idea represent an interesting blend of cross-national collaboration: Wang is of Chinese descent and brings fluency in Mandarin and familiarity of the culture; Guler is a Boston native who built and designed the electronics for the kites. Further, the cachet of elite education gives the project undeniable appeal and leverage throughout China—you will be hard-pressed to find many Chinese who do not recognize and glamorize the word "Ha fo" (Chinese for Harvard).

Like fireworks and gunpowder, kites are Chinese descendants. The first kite model is believed to have emerged in China around 1,000 BCE. [8] The Chinese philosopher Liu Ngan, who lived in the second century BCE, describes a man named Mih Tih who flew a wooden kite "for three days without allowing it to take rest," confirming that kite-like structures were indeed known in China during the early Han Dynasty.[9]

Kites enliven China's grey skyline. They can be found hanging over the water along Shanghai's Bund or gazing down on a group of senior citizens doing Tai Chi in one of Beijing's city parks. Unlike the diamond design that soars across Western skies, Chinese kites often take on a bird-like appearance or sport intricate designs. Kite flying remains a popular hobby, if not a refined art, among the older generations. Following a recent kite-building workshop, Guler and Wang remarked on the great number of old-generation kite masters who brought a wealth of knowledge on the art of kite-flying and design to the workshops.

Another element to the project's presumed success is what Guler's peers at Carnegie Mellon have labeled "spectacle computing."[10] The idea behind spectacle computing is to create citizen science initiatives that are exciting and accessible to citizens.[11] Attaching sensors to kites or balloons encapsulates this concept, advancing a "playful and powerful" approach to citizen science and environmental data that invites "open participation from everyone."[12]

FLOAT Beijing's kite design elegantly threads culture into citizen science techniques. The

educational and ethnic background of FLOAT Beijing's architects, fitted alongside China's kite history and local bent, give the project unique social and political appeal in China.

Particulate Suppression

In the early years of Communist China, government information was shrouded in secrecy. In stark contrast, over the past decade policymakers have pushed a growing number of initiatives promoting information transparency and citizen participation. These efforts are particularly prominent in the environmental arena. Ironically, the Chinese government is now threatening to silence independent air quality data, which could effectively shut down projects like FLOAT Beijing. A regulation drafted in 2009, referred to as Rule 81, threatens to ban independent environmental monitoring outright.[13] This ban would effectively derail environmental data by barring citizens and NGOs from independent environmental data collection and further undermine the integrity of the government's environmental data—numbers that are already subject to scrutiny.

A softer tone on independent monitoring was taken by the Ministry of Environmental Protection (MEP) Vice Minister, Wu Xiaoqing, who stated in March that accurate monitoring requires measures to guarantee the integrity of the data and that citizen monitoring can be used as a reference. [14] While the draft bill is now over two years old, a July 2012 article in the Shanghai Morning Post reporting of the bill has sparked renewed interest from Chinese citizens. [15] Until a decision is made on Rule 81, the government's stance on independent monitoring remains unclear.

The concept of "independent" data is suspect, as government agencies at all levels have broad discretion to classify information as a state secret.[16] Some Chinese NGOs have used government published data to put pressure on polluting industries and lax pollution control enforcement, such as the Chinese NGO Institute for Public and Environmental Affairs (IPE), founded by former journalist and author Ma Jun. Using government data on company pollution emissions, IPE created China's first online searchable pollution maps that indicate the location and names of companies that have violated China's pollution control laws. While not gathered by citizens, this data map provides an important service by providing citizens an accessible and understandable compilation of data.

China suppresses independent air quality data at its own risk—particularly in the age of open source and Wikileaks, where censored information is known to penetrate China's Great Firewall through proxies, exposing falsities and suppressed information. Citizen science projects, like FLOAT Beijing, accelerate innovation and creativity in the environmental arena. If such projects are met with aggression or suppression, China loses an important opportunity to improve its air quality and environment. In theory, censorship policies suppress potentially inflammatory content or information contradicting the party line; in practice, these efforts are stalling environmental progress and preventing the release of important environmental and health information.

Unstable Air Quality Monitoring

The motivation for implementing Rule 81 may rest with politics. FLOAT Beijing's operation arrived in the wake of two interrelated events: the U.S. embassy air monitoring controversy, which left many Chinese citizens disillusioned with the accuracy of government's air data, and the Chinese government's decision to monitor PM2.5 data.

In late 2011, controversy over air quality monitoring rocked Beijing, sparking mudslinging between the Chinese government and its own citizens and stirring Sino-U.S. tensions.[17] The U.S. Embassy began to release daily PM2.5 readings using its own air quality monitors. On several occasions, U.S. Embassy reported hazardous or "very unhealthy" air quality (by U.S. standards) in Beijing, while China's MEP-issued readings suggested that air quality was "favorable" and air pollution minimal.[18] These discrepancies in air quality

reporting drew heat in the Chinese blogosphere, calling into question China's air measurement models and methods of reporting. Environmentalist Ma Jun and real estate tycoon Pan Shiyi regularly used Weibo to report and compare the U.S. and official Chinese $PM_{2.5}$ readings, fueling dialogue about air quality concerns.[19] The U.S. Embassy's release of data prompted China to go so far as to challenge the legality of the embassy's air monitors, citing a violation of the Vienna Convention on Diplomatic Relations.[20]

Discrepancies in air monitoring reports can be attributed to two things, according to environmental consultant Steven Andrews: first, omission—China's air quality reports failed to account for certain pollutants; and second, commission—official reports did not necessarily reflect the true severity and health risk of China's air pollution issues.[21] One example is the announcement in 2011 that Beijing had achieved 274 "blue sky" days, a figure that most people who have spent time in the city would find incredulous. A "blue sky" day means that China's MEP-issued Air Pollution Index (API) stood at or below 100 on a 500 scale.[22]

The citizen outrage over the PM2.5 readings in Beijing sparked the Chinese government's introduction in February 2012 of new air quality standards that include both $PM_{2.5}$ and ozone.[23] Under this new regulation, thirty major cities were required to immediately begin $PM_{2.5}$ data collection, with eighty additional cities to follow suit by 2013.[24] The ultimate objective is national compliance by 2016.[25]

A major source of $PM_{2.5}$ emissions in China is coal generation, and this industry sees no signs of waning. Health studies show a strong correlation between exposure to fine particulate matter, such as $PM_{2.5}$, and heart and lung disease.[26] In some Chinese cities, $PM_{2.5}$ concentrations are reported to stand on average between six and seven times higher than the World Health Organization's most lenient standards.[27] In addition to $PM_{2.5}$ health risks, other detectable particulates, including VOCs, NO_2, and SO_2, have been linked to cardiovascular disease, respiratory ailments, and premature death.[28]

Awareness of these health problems is gaining traction in China. The president of the China Medical Association recently warned that "air pollution will become the biggest health threat in China unless the government takes greater steps to monitor and publicize the dangers of smog."[29] It is estimated that only one percent of China's 560 million urbanites breathe air considered safe by European Union standards.[30] Additionally, while the actual figure remains in dispute, China's air pollution is responsible for the premature death of approximately 400,000 Chinese each year.[31] FLOAT Beijing's arrival is therefore timely, offering citizens a direct way to confront environmental issues that impact their health.

The New Breed of Innovators

While the adoption of citizen science and DIY technologies is new to China, citizens, companies, and NGOs around the world have been using these strategies for decades to create information transparency and tackle environmental challenges. Throughout Japan during the late 1980s, morning glory flowers and acid rain test kits became the focal point of a citizen science extravaganza: the Morning Glory Acid Rain Survey. As morning glory petals are sensitive to acid, the flowers used were able to naturally detect for higher acidity levels.[32] These basic monitoring instruments raised environmental awareness about acid rain pollution in Japan during the 1990s.[33] Combining basic technology with minimal labor—and relatively low cost—DIY technologies, according to John Elkington, a corporate responsibility expert, can circumvent top-down institutional bulwarks that delay environmental progress. In a recent article on this growing trend, Elkington claims that DIY allows individuals to tackle society's problems head-on, without having to wait for business or government to intervene.[34] Today's forward-thinking fringe, Elkington proposes, is composed of DIY innovators, which he offers make up "a new, scrappy world of innovation [that] is surfacing at the margins of the current order."[35]

DIY technology and citizen science go hand in hand, with the former enabling the latter through scientific tools an average person can use without relying on professional instruction or guidance. While the general concept of citizen science is not new, advances in technology and social media are redefining the role of citizen participation in the scientific arena. This trend is putting greater emphasis on citizen involvement to take on environmental challenges directly. Mobile phones and other social media platforms are also creating new ways to disseminate and aggregate citizen-derived data and information. A recent study examined the potential uses of mobile phones as monitoring tools, including possibilities like calibrating air quality and using mobile phones as tools for measuring and monitoring one's natural surroundings.[36]

In China, a number of NGOs are using citizen science strategies:

- Beijing-based NGO Green Beagle began conducting its own $PM_{2.5}$ environmental monitoring reports following the embassy controversy, and, according to former Green Beagle staff member Chen Liwen, was the first organization of its kind to do so. The group raised money to purchase portable handheld $PM_{2.5}$ air quality devices and through social media, encouraged organizations to join in their efforts to test Beijing's air quality.[37] Chen remarked that following these calls to action, "some local NGOs began to react and perform monitoring locally," adding that the efforts of Green Beagle were instrumental in drawing greater government attention to air quality concerns and the absence of government $PM_{2.5}$ monitoring.[38]

- China's oldest NGO, Friends of Nature, is reporting on $PM_{2.5}$ in Henan Province and publishing the data online.[39]

- The Mochou Environmental Association, a Chinese NGO based in Nanjing, is carrying out water quality monitoring work that engages teenagers in the community to gather water samples and collect data.[40] MEA's water research on the nearby Mochou Lake was reportedly instrumental in getting the local government to start a local water quality management program.[41]

The intersection of local and cultural elements and the international community often escapes large-scale, top-down environmental initiatives, which all too often must navigate complex institutional systems and lack strong local relationships. Research has shown that integrating locals in environmental projects can enhance a project's chance of success.[42] Many large-scale international projects fail to achieve their target objectives because of cultural disconnects and fractured communications.[43] In his paper discussing the importance of culture in international environmental policymaking, Kenneth E. Wilkening builds on the idea of integrating the local with the international, focusing on the need for culture "to be viewed as a toolkit of environmental ideas."[44] According to Wilkening, international relations scholars often fall prey to viewing culture "as a residual category used to explain what can't be explained by other 'political' factors," which he suggests can leave scholars and international aid organizations disconnected from important cultural connections.[45] Because of the role kites play in China's history and contemporary life, FLOAT Beijing necessarily bridges these cultural chasms. The project's fusion of localism and international collaboration highlights the benefit of using citizen science in international environmental projects.[46]

Older kite makers became mentors at the FLOAT Beijing workshops.

Criticisms of Citizen Science

Despite the positive contribution of citizen science, it is not without its limitations. A general criticism of citizen science is that the data is less sophisticated and comprehensive than its professional or government counterpart—and subsequently more vulnerable to scrutiny and attack. In China, government air quality monitors have been upwards of 20 times more expensive than those of their NGO counterparts.[47] However, intrinsic value lies in the data's origins. Allowing citizens to select the air quality monitoring sites and witness the data collection first-hand contributes to the data's legitimacy, arguably making the data more reliable in certain respects. Data quality concerns, however, are valid. In light of this dilemma, new methods are surfacing for improving the quality of citizen science data. One example is the use of a "knowledge gradient," which acts as an analytical tool for researchers to identify ways of improving the quality of citizen science data by "harness[ing] the benefits of local involvement."[48]

The benefits of citizen science, especially in countries where channels of civic environmental participation are already limited, arguably outweigh drawbacks in data sophistication. Citizen science not only contributes to an important pool of environmental data, but also spreads awareness and knowledge about environmental issues through civic participation and international collaboration. The formidable challenge that modern environmental problems present has invariably brought the concept of citizen science into greater focus as a tool for finding solutions to global environmental problems.

Limitations to Independent Environmental Monitoring in China

Environmental advances from NGO-government collaboration have been tempered by constraints in operational independence. Despite the Chinese government's 2008 Environmental Open Information Measures (issued by the Ministry of Environmental Protection), citizens and environmental NGOs remain limited in their ability to access information on pollution. While the Chinese news media has greatly expanded its reporting of pollution incidents over the past twenty years, there are numerous examples of the news media being censored by the government, which limits environmental journalism, undermines the legitimacy and availability of fact reporting, and can delay solutions to environmental problems.

Environmental NGOs in China often focus on maintaining a good rapport with the government, which can mean avoiding controversial environmental issues and remaining sufficiently under the auspices of the Communist Party. This often translates into limited operational independence. For example, Friends of Nature voluntarily limited the number of its members to 10,000 in an effort to assuage government concerns that the group's popularity might pose a political threat.[49] Chinese NGOs thus operate in an environment of perceived independence under strict control. Oxford Professorial Fellow, Steven Tsang, characterizes the government-civil society relationship as follows:

"The approach Hu (Jintao)[50] has adopted is to treat civil society like a bird in a cage. The Party or the state is prepared to enlarge the cage as it sees fit but a cage is nonetheless maintained. This is to ensure that civil society can have sufficient scope to operate in the non-critical realm while its ambition to extend its scope to the critical realm is contained so that the development of civil society cannot pose a threat to the continuation of Party rule."[51]

The important contribution of NGO-government cooperation should not go overlooked. Chinese and international NGOs often work collaboratively with the Chinese government and government research institutes. This approach has helped improve China's environmental governance. For example, Ma Jun's IPE, which relies on MEP data, is helping to bring about legislative and regulatory environmental reform, says environmental consultant Vance Wagner. He

notes that these collaborative efforts have contributed to many milestones in China, like the recently revised air quality standards.[52]

Although NGO ties to government have facilitated—and in many ways strengthened—environmental progress, independent environmental data will continue to remain deficient without greater citizen-driven research and monitoring to supplement it. The idea of further restricting these channels, and ratifying a law like Rule 81, will only undermine the legitimacy and validity of Chinese data. Accordingly, citizen science is better served by those organizations farthest from government reach to ensure the data's independence. The Chinese government should encourage NGO models that operate more intimately with communities, like Green Beagle, as these groups are well-positioned to facilitate citizen-science projects.

Fostering Citizen Science

If China is serious about mitigating air pollution, greater civic engagement and citizen science are imperative. The most faithful and reliable sources for environmental information are those who have nothing to gain other than truth. Local citizens are obvious candidates, since those directly impacted by poor air quality are the ones most invested in improving it.

Drawing attention to invisible environmental threats is difficult. It requires comprehensive, unbiased, and thorough investigation. Citizen science and independent environmental assessment serve an important oversight and investigative function. Where citizen science is stifled, innovative environmental solutions will lag.

At the Rio +20 meeting this year, an articulate teenager took the stage and asked the international community to address the security and health of the planet's future. Concerned with the conference resulting in diplomatic dead ends, Brittany Trifold of New Zealand shamed the world by disparaging global inaction. During her few minutes in the spotlight, Trifold implored world leaders to think of the children, reminding them that while the youth remain voiceless in these decisions, children are the ones who ultimately inherit the outcomes of today's decisions.

While the convention was branded a failure by most, some—including the presidents of Natural Resources Defense Council and Earthjustice—saw a success story in Rio +20. They pointed out that not all meaningful environmental activism comes in the form of international agreements and top-down projects—sometimes it is the ground-up initiatives and citizen-driven projects that drive change.[53] In China, clusters of children showed up to FLOAT Beijing's workshop to assume a leadership role in their future and, standing only a few feet high, demonstrated the epitome of a "bottom-up" approach as they held their kites high and shed light on an important environmental issue.

The idea that kites could turn Beijing's veil of smog into a visible beacon of air quality monitoring is a hopeful sign for China's environment; however, the challenges loom large. Citizen-driven environmental initiatives that incorporate citizen science and DIY technology lie at the heart of effective environmental work. While the NGO model in China, which emphasizes collaboration with the government, has made headway in protecting China's environment, greater citizen empowerment and citizen science may prove indispensable to tackling environmental challenges. Greater support, both domestically and internationally, for projects like FLOAT Beijing will better prepare our world to face the fearsome environmental hurdles ahead.

Abigail Barnes is a student at Vermont Law School and a Junior Research Fellow with the U.S.-China Partnership. She has written for chinadialogue and worked at the Woodrow Wilson Center's China Environment Forum in Washington, D.C in the summer of 2012. The author wishes to thank CEF and Tara Sun Vanacore for her insightful feedback and edits on earlier versions of this paper. She can be reached at: barnes.abi@gmail.com.

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[2] *See http://www.instructables.com/id/Air-quality-balloons/*

[3] FLOAT Beijing does not currently have workshops planned after September, 2012.

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