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**Interpretation---“Appropriation of outer space” by private entities refers to the exercise of exclusive control of space.**

TIMOTHY JUSTIN **TRAPP**, JD Candidate @ UIUC Law, **’13**, TAKING UP SPACE BY ANY OTHER MEANS: COMING TO TERMS WITH THE NONAPPROPRIATION ARTICLE OF THE OUTER SPACE TREATY UNIVERSITY OF ILLINOIS LAW REVIEW [Vol. 2013 No. 4]

The issues presented in relation to the nonappropriation article of the Outer Space Treaty should be clear.214 The ITU has, quite blatantly, created something akin to “property interests in outer space.”215 It allows nations to exclude others from their orbital slots, even when the nation is not currently using that slot.216 This is directly in line with at least one definition of outer-space appropriation.217 [\*\*Start Footnote 217\*\*Id. at 236 (“**Appropriation of outer space**, **therefore, is ‘the exercise of exclusive control or exclusive use’ with a sense of permanence, which limits other nations’ access to i**t.”) (quoting Milton L. Smith, The Role of the ITU in the Development of Space Law, 17 ANNALS AIR & SPACE L. 157, 165 (1992)). \*\*End Footnote 217\*\*]The ITU even allows nations with unused slots to devise them to other entities, creating a market for the property rights set up by this regulation.218 In some aspects, this seems to effect exactly what those signatory nations of the Bogotá Declaration were trying to accomplish, albeit through different means.219

**Private appropriation for temporary usage or perusal is distinct from appropriation “of” outer space. Sovereign claims are still universally prohibited.**

Abigail D. **Pershing**, J.D. Candidate @ Yale, B.A. UChicago,**’19**, "Interpreting the Outer Space Treaty's Non-Appropriation Principle: Customary International Law from 1967 to Today," Yale Journal of International Law 44, no. 1

II. THE FIRST SHIFT IN CUSTOMARY INTERNATIONAL LAW’S INTERPRETATION OF THE NON-APPROPRIATION PRINCIPLE Since the drafting of the Outer Space Treaty, several States have chosen to reinterpret the non-appropriation principle as narrower in scope than its drafters originally intended. This reinterpretation has gone largely unchallenged and has in fact been widely adopted by space-faring nations. In turn, this has had the effect of changing customary international law relating to the non-appropriation principle. Shifting away from its **original blanket application** in 1967, States have carved out an exception to the non-appropriation principle, allowing appropriation of extracted space resources.53 This Part examines this shift in the context of the two branches of the United Nation’s customary international law standard: State practice and opinio juris. **A. State Practice** The earliest hint of a change in customary international law relating to the interpretation of the non-appropriation clause came in 1969, when the United States first sent astronauts to the moon. As part of his historic journey, astronaut Neil Armstrong collected moonrocks that he brought back with him to Earth and promptly handed off to the National Aeronautics and Space Administration (NASA) as U.S. property.54 Later, the USSR similarly claimed lunar material as government property, some of which was eventually sold to private citizens. 55 These first instances of space resource appropriation did not draw much attention, but they presented a distinct shift marking the beginning of a new period in State practice. Having previously been limited by their technological capabilities, States could now establish new practices with respect to celestial bodies. This was the beginning of a pattern of appropriation that slowly unfolded over the next few decades and has since solidified into the general and consistent State practice necessary to establish the existence of customary international law. Currently, the U.S. government owns 842 pounds of lunar material.56 There is little question that NASA and the U.S. government consider this material, as well as other space materials collected by American astronauts, to be government property.57 In fact, NASA explicitly endorses U.S. property rights over these moon rocks, stating that “[l]unar material retrieved from the Moon during the Apollo Program is U.S. government property.”5 The U.S. delegation’s reaction to the language of the 1979 Moon Agreement further cemented this interpretation that appropriation of extracted resources is a **permissible exception** to the non-appropriation clause of Article II. Although the United States is not a party to the Moon Agreement, it did participate in the negotiations.59 The Moon Agreement states in relevant part: Neither the surface nor the subsurface of the moon, nor any part thereof or natural resources in place, shall become property of any State, international intergovernmental or nongovernmental organization, national organization or nongovernmental entity or of any natural person.60 In response to this language, the U.S. delegation made a statement laying out the American view that the words “in place” imply that private property rights apply to extracted resources61—a comment that went **completely unchallenged**. That **all States seemed to accept this point**, even those bound by the Moon Agreement, is further evidence of a shift in customary international law.62 B. **Opinio Juris:** Domestic Legislation Domestic law, both in the United States and abroad, provides further evidence of the shift in customary international law surrounding the issue of nonappropriation as it relates to extracted space resources. Domestic U.S. space law is codified at Section 51 of the U.S. Code and has been regularly modified to expand private actors’ rights in space.63 Beginning in 1984, the Commercial Space Launch Act provided that “the United States should encourage private sector launches and associated services.”64 The goal of the 1984 Act was to support commercial space launches by private companies and individuals.65 It did not, however, specifically discuss commercial exploitation of space. The first such mention of commercial use of space appeared in 2004, with the Commercial Space Launch Amendments Act.66 This Act specifically aimed at regulating space tourism but did not explicitly guarantee any private rights in space.67 The most significant change in U.S. space law came with the passage of the Spurring Private Aerospace Competitiveness and Entrepreneurship (SPACE) Act in 2015. As incorporated into Section 51 of the Code, this Act provides: A United States citizen engaged in commercial recovery of an asteroid resource or a space resource under this chapter shall be entitled to any asteroid resource or space resource obtained, including to possess, own, transport, use, and sell the asteroid resource or space resource obtained in accordance with applicable law, including the international obligations of the United States.68 Whereas the idea that private corporations might go into space may have seemed far-fetched to the drafters of the Outer Space Treaty, the SPACE Act of 2015 was the first instance of a government recognizing such a trend and officially supporting private companies’ commercial rights to space resources under law. With the new 2015 amendment to Section 51 in place, U.S. companies can now rest assured that any profits they reap from space mining are firmly legal—at least within U.S. jurisdictions. Although the United States was the first country to officially reinterpret the non-appropriation principle, other countries are **following suit**. On July 20, 2017, Luxembourg passed a law entitled On the Exploration and Utilization of Space Resources with a vote of fifty-five to two.69 The law took effect on August 1, 2017.70 Article 1 of the new law states simply that “[s]pace resources can be appropriated,” and Article 3 expressly grants private companies permission to explore and use space resources for commercial purposes.71 Official commentary on the law establishes that its goal is to provide companies with legal certainty regarding ownership over space materials—a goal that the commentators regard as legal under the Outer Space Treaty despite the non-appropriation principle.72 The next country to enact similar legislation may be the United Arab Emirates (UAE). According to the UAE Space Agency director general, Mohammed Al Ahbabi, the **UAE** is currently in the process of drafting a space law covering both human space exploration and commercial activities such as mining.73 To further this goal, in 2017 the UAE set up the Space Agency Working Group on Space Policy and Law to specify the procedures, mechanisms, and other standards of the space sector, including an appropriate legal framework.74 C. Opinio Juris: Legal Scholarship Other major space powers are also considering similar laws in the future, including Japan, China, and Australia. 75 Senior officials within China’s space program have explicitly stated that the country’s goal is to explore outer space and to take advantage of outer space resources.76 The general international trend clearly points in this direction in anticipation of a potential “**space gold rush**.” 7 Mirroring the shift in State practice and domestic laws, the legal community has also changed its approach to the interpretation of the nonappropriation principle. Whereas at the time of the ratification of the Outer Space Treaty the majority of legal scholars tended to apply the non-appropriation principle broadly, most legal scholars now view appropriation of extracted materials as permissible.78 Brandon Gruner underscores that this new view is historically distinct from prior legal interpretation, noting that modern interpretations of the Outer Space Treaty’s non-appropriation principle differ from those of the Treaty’s authors.79 In contrast to earlier legal theory that denied the possibility of appropriation of any space resources, scholars now widely accept that extracting space resources from celestial bodies is a “use” permitted by the Outer Space Treaty and that extracted materials become the property of the entity that performed the extraction.80 Stressing the fact that the Treaty does not explicitly prohibit appropriating resources from outer space, other authors conclude that the use of extracted space resources is permitted, meaning that the new SPACE Act is a plausible interpretation of the Outer Space Treaty.81 However, scholars have been careful to cabin the extent to which they accept the legality of **appropriation**. For instance, although Thomas Gangale and Marilyn Dudley-Rowley acknowledge the legality of private appropriation of extracted space resources, they nonetheless emphasize that “[o]wnership of and the right to use extraterrestrial resources is distinct from ownership of real property” and that any such **claim to real property** is illegal.82 Lawrence Cooper is also careful to point out this distinction: “[t]he [Outer Space] Treaties recognize sovereignty over property placed into space, property produced in space, and resources removed from their place in space, **but ban sovereignty claims by states; international law extends this ban to individuals**.”83 Although there remain some scholars who still insist on the illegality of the 2015 U.S. law and State appropriation of space resources generally,84 their dominance has waned since the 1960s. These scholars are now a minority in the face of general acceptance among the legal community that minerals and other space resources, once extracted, may be legally claimed as property. 85 Taken together, the elements described above—statements made in the international arena, de facto appropriation of space resources in the form of **moon rocks**, the adoption of new national policies permitting appropriation of extracted space resources, and the weight of the international legal community’s opinion— indicate a fundamental shift in customary international law. The Outer Space Treaty’s non-appropriation clause has been redefined via customary international law norms from its broad application to now include a carve-out allowing appropriation of space resources once such resources have been extracted.

**Violation---they defend banning the appropriation of outer space for space debris only, which is not exclusive control.**

**Standards---**

**1] Limits—their interp means that affs about any outer space activity are topical: tourism, photography, sending rovers, collecting ice cores, launching satellites, deflecting debris, can’t sell rocks on EBAY, etc. This explodes neg prep burdens since affs are pushed to the fringes of the topic where no neg lit exists**

**2] Ground—they shift the controversy from sovereign domination to minute activity. The topic literature is grounded in a debate over sovereign control over space, which means core neg generics are space ownership bad, space democracy bad, not temporary resource extraction or expeditions. Their interp minimizes link uniqueness because our impacts will never be overcome the advantage.**

**Fairness and education are voters – debate’s a game that needs rules to evaluate it and education gives us portable skills like research, its why schools fund debate**

**Use competing interps – reasonability invites arbitrary britelines and judge intervention. CI is a prerequisite to reasonability because you have to use offense to determine if their interp is reasonable.**

### 2

#### The US is locked in a race for space dominance against Russia and China. Revisionist powers take advantage of fissures in the international economic order.

**Lambakis 18** [(Lambakis, PhD, Director of Space Studies at the National Institute for Public Policy, Editor-in-Chief of Comparative Strategy, author of several books and articles on space policy), Foreign space capabilities: Implications for U.S. national security, Comparative Strategy, Volume 37, No. 2, 87-154)] TDI

Addressing U.S. vulnerabilities: Arms control

Other nations may use diplomacy to manipulate arms developments in other countries, as Russia and China are currently attempting to do with the United States. The danger of declaring or negotiating agreements for peacetime moratoriums on direct-ascent ASATs, for example, is that it would limit the development, testing, and potentially the operation of ballistic missile defenses, especially the more capable regional Standard Missile-3 interceptors deployed by Aegis BMD ships and Aegis Ashore sites in Europe. As noted, the United States used a modified Standard Missile-3 to reach into low earth orbit to destroy an errant and toxic U.S. government satellite in 2008. This was a unique and unanticipated use of a weapon system in an emergency situation. Moreover, there are very serious definitional and verification problems associated with an ASAT agreement. ASAT weapons can be tested without the target vehicle actually being in orbit.

Russia and China continue to push treaties to constrict the deployment of U.S. defenses to protect its space activities. Both nations have long promoted the Prevention of the Placement of Weapons in Outer Space Treaty (PPWT), which the United States continues to argue is unverifiable and does not deal with the threats posed by terrestrially-based anti-satellite weapons (electronic jammers and direct-ascent ASATs)—weapon systems currently under development by Russia and China. Russia is also promoting a “No first placement of weapons in outer space” initiative, which the United States argues will not reduce mishaps, misunderstandings, and miscalculations.277 The United States has consistently avoided such legally binding commitments while arguing for voluntary commitments to agreed-upon transparency and confidence-building measures, such as the 2013 United Nations Group of Government Experts on Transparency and Confidence-Building Measures in Outer Space Activities.

The PPWT has been pushed by Russia and China and opposed by the Obama and, presumably, Trump Administrations. This is the right position as the treaty in question is designed to unduly constrain U.S. actions to defend itself in space and could affect its current and future missile defense plans. The compromise agreement by the European Union, Code of Conduct, has since been replaced by the International Code of Conduct (ICoC) for Outer Space Activities. As with any arms control arrangement or code of conduct, they are only as good as their participants—the United States lives up to the letter and spirit of its international agreements; but the same cannot be said of other key participants, particularly Russia.

Also, to what extent will adherence to the ICoC hinder steps that the United States must take to protect its space assets and deploy defenses? It is important to ask what the real benefits of signing such an accord will reap—what does the ICoC provide that the United States does not already practice in space? Commercial satellite operations already abide by norms to avoid collisions and spectrum interference. Ultimately, however, U.S. leaders must ask themselves whether they believe the ICoC will constrain these countries of greatest concern.

In response to the relative strategic restraint demonstrated by the United States, both Russia and China continue to build up and modernize their ballistic missile and counter-space capabilities. Iran and North Korea, in defiance of international sanctions, have developed ballistic missiles and have leveraged their respective space programs to improve missile programs. North Korea, also in defiance of several UN Security Council resolutions and the international community, to date has conducted five underground nuclear tests. These activities not only demonstrate the desire by these states to modernize and improve weapon systems to exploit U.S. and allied vulnerabilities, but also highlight the limited nature, if not futility, of arms control as it has often been practiced. U.S. officials should not get locked into the illusion that the United States can cause or prevent an “arms race” in space. As we have witnessed over the past decade, the United States does not have to be involved in an arms race in space for other nations to focus their investment into the development of counter-space weapon technologies.

There are, of course, numerous documented pitfalls to arms control—verification difficulties and noncompliance are chief among them. Russia has a history of violating key arms agreements, to include the Intermediate Nuclear Forces treaty.278 There was the supreme failure of the 1972 Anti-Ballistic Missile Treaty, which held the United States back from developing technologies and systems to defend the country against Soviet missile threats, while doing nothing to prevent the expansion of the growing Soviet missile force—with the consequent increase in the vulnerability of U.S. deterrent forces to Russian nuclear forces. There is also overwhelming evidence of the failure of the New START treaty to lead Russia to join the United States in lowering the salience and numbers of nuclear forces. **Unverifiable arms control agreements on space would likely be as subject to violation by Russia (and perhaps China)** as the numerous other arms control agreements with which it is in noncompliance. Though history is replete with examples of nations that develop weapons to counter the weapons of other nations to depict the cause of arms development as an “action-reaction” cycle instigated by the United States is often overly simplistic and factually mistaken. Strategic national aims drive weapons development for all nations. The development of a Space Based Interceptor, for example, might fulfill an urgent need to provide effective defenses against ballistic missiles and direct-ascent ASATs, so much so that it justifies the United States being the first to deploy space-based weapons. The deployment of SBI would not necessarily drive other states to deploy such a system if they were not otherwise going to do so, simply because they may not have the technical expertise, capabilities, or the money to do so, or may not have the same requirement to defend against ballistic missile attack or defend space systems. Indeed, it should not surprise us that other nations deploy defenses, potentially including space-based defenses; other states will deploy weapons that are tailored to their strategic aims whether or not we move in a similar manner before or after.

The United States has a significant stake in promoting a space environment that is secure and free to operate in since it deploys significant space assets to support national security, but this does not mean that by refraining from steps to defend its interests through force that space will not somehow become more armed. Other nations will follow their security interests regardless of what the United States does (China and Russia seem to understand there may be a significant strategic payoff in having capabilities to deny other nations the use of space). The United States, as a powerful actor in that environment, does not have the only voice. Idealism must be balanced by the practical. We might have a vision for space that is completely free of conflict and weapons deployments, but we should not be deceived into believing that our vision will not be overcome by the visions of others.

#### The plan’s treaty ratification cedes governance of the commons to China – political positioning proves

Weeden 19 [(Dr. Brian, Director of Program Planning for Secure World Foundation and has nearly two decades of professional experience in space operations and policy, PhD Science and Technology Policy @ GWU, “Testimony before the U.S.-China Economic and Security Review Commission” 4/25/19, USCC Testimony] TDI

Chinese statements in COPUOS on sovereignty and utilization of space resources have generally been in line with the G77 voting bloc of developing countries. Specific statements were made by the G77 since 2017 emphasize equitable access and space as the province of all humankind and reinforce the need for an international coordinated framework for governance of space resource utilization to avoid gaps or contradictions from domestic regimes.25,26,27 Thus, China has positioned itself firmly in the camp of most developing countries who are concerned about “rich” States being able to access space resources to the exclusion of less advanced states.

#### China supports Bogota declaration’s claim of rightful access to highly sought-after orbits

Schneider and Faulkender 18 [(Stephan, Figueroa-Conteras Law Group, B.A. Polisci @ FAU, and Garett Faulkender, FAU) “The Final Frontier: Evolution of Space Law in a Global Society,” FAU Law Journal, Spring 2018] TDI

Claimed ownership of the Geosynchynous orbit has been a point of contention since the Space Treaty. The orbit is extremely desirable due to its location around the Earth’s equator, as it is the ideal location for telecommunications satellites to maintain a constant link with their contact point on Earth.198 As an essential component of intelligence-gathering, communications, entertainment, and enterprise, a spot on this orbit is in high demand. Recognizing its importance, some nations have fought for the territorial claim over the geosynchronous orbit by classifying it as airspace. Most notable is the Bogotá 8. Created and led by Colombia in 1976, eight equatorial countries sought to secure the rights to the geostationary orbits directly above their territories.199 They argued that they could do this by extending their sovereignty to Outer Space.200 These nations attempted to do this with the 1976 Bogotá Declaration. 201

With this declaration, the Bogotá 8 argued that the GSO arises directly from the Earth’s gravity, thus implying that everything that lies in Earth’s gravitational field is airspace.202 This would allow the GSO to fall under air law instead of space law.203 They requested a special exemption for the GSO so that they could claim sovereignty without conflicting with the Outer Space Treaty and breaking international law under the established legal regime.204 They further claimed that the current system and solutions used and created by the International Telecommunications Union was “at present impracticable and unfair and would considerably increase the exploitation costs of this resource especially for developing countries that do not have equal technological and financial resources as compared to industrialized countries, who enjoy an apparent monopoly in the exploitation and use of its geostationary synchronous orbit.”205 In the end, the representative of the Soviet Union overwhelmingly rebutted the Bogotá 8’s argument.206 The subcommittee agreed that claims of sovereignty over the GSO or any other part of outer space are incompatible with the spirit of the Outer Space Treaty and should be dismissed.207 On top of this, none of the Bogotá 8 were space-capable.208 This is significant because their actions could have potentially led to another space-capable nation to do the same and claim the GSO over their territory.209

Even though the Bogotá 8 was defeated, the battle over the GSO still continued. Colombia, who signed the Outer Space Treaty but did not ratify it, went so far as to claim sovereignty over the GSO directly over their land in the 1991 Colombian Constitution. Article 101, Paragraph 4 states:

Also part of Colombia is the subsoil, the territorial sea, the contiguous zone, the continental shelf, the exclusive economic zone, the airspace, the segment of the geostationary orbit, the electromagnetic spectrum and the space in which it operates, in accordance with international law or the laws of Colombia in the absence of international regulations. 210

Article 102, Paragraph 1 then follows up by saying, “The territory with the public resources that are part of it, belong to the nation.”211 Colombia’s actions, even though it can be argued that they are in direct violation of international law, shows that it still believes it can lay claim over the GSO directly above it and that it believes that the current legal regime is unfair to developing nations.212 Colombia is not alone in this conflict. China has also played around with the idea of claiming sovereignty in outer space. They are doing this by exploring the differences between res nullius, (areas which may be appropriated as national territory), and res extra commercium (areas which may not be appropriated as national territory).213

As the common heritage and global commons adds another dimension to these legal principles,214 countries like China are realizing that the status-quo has been altered in a way that could lead to a change in the international legal structure in regard to space. The enactment of domestic Space law (e.g.; the U.S. Space Act) combined with the emergence of non-state Spacefaring actors will likely create Westphalian boundary disputes and property right conflicts with nations whose laws clash. Affording United States citizens with the right to claim Space resources will be seen as a direct blow to customary international law making. This has already encouraged Luxembourg to enact its own domestic Space law and is likely to influence other Spacefaring nations to create similar legislation that benefits their own citizens. It is expected that not all nations would have the same values and beliefs. Without international discussion, this inevitable free-for-all of domestic law making will most likely produce laws that oppose each other. If this domino effect creates opposing laws then there will be conflict in Space, which consequently creates conflict on Earth. China and Russia will likely be the next candidates to implement domestic policy for space, which could lead to major legal and political issues.

**Space dominance solves nuclear war. Hegemony de-escalates all conflict scenarios.**

**Yoo 18** [(Emanuel S. Heller Professor of Law at the University of California, Berkeley, and a visiting scholar at AEI since 2003. He served as a deputy assistant attorney general in the Office of the Legal Counsel of the U.S. Department of Justice from 2001 to 2003, where he worked on constitutional and national security matters, as General Counsel of the U.S. Senate Committee on the Judiciary from 1995-96, and as a law clerk to Justice Clarence Thomas of the U.S. Supreme Court (John, Winning the Space Race, October 15th, <http://www.aei.org/publication/winning-the-space-race/>)] \*edited for offensive language

President Donald Trump’s National Security Strategy set a new course by focusing on rebuilding the domestic economy as central to national security and aiming at “rival powers, Russia and China, that seek to challenge American influence, values, and wealth.” Critics observed that the White House seemed to reverse past presidents’ emphasis on advancing democracy and liberal values and elevating American sovereignty over international cooperation.1

Less noticed but perhaps equally revisionist, the Trump administration reversed its predecessor’s course on outer space. Even as American military and civilian networks increased their dependence on satellites, the Obama White House had deferred to European efforts to develop a space “Code of Conduct.” The Trump administration instead relies on unilateralism: “any harmful interference with or an attack upon critical components of our space architecture that directly affects this vital US interest will be met with a deliberate response at a time, place, manner, and domain of our choosing.” On June 18, 2018, President Trump announced a new branch of the military: the United States Space Force.

Control of space already underlies the United States’ predominance in nuclear and conventional warfare. Intercontinental and submarine launched ballistic missiles, the heart of the US nuclear deterrent, pass through space to reach their targets. Reconnaissance satellites monitor rival nations for missile launches, strategic deployments, and major troop movements. Communications satellites provide the high-speed data transfer that stitches the US Armed Forces together, from generals issuing commands to pilots controlling drones. With economic rivals such as China and India, and rogue states like Iran and North Korea developing space programs that pursue similar missions, the importance of space technology to US interests and international peace will only increase.

Space not only enhances military operations, but also exposes new vulnerabilities. Anti-satellite missiles can make an opponent’s space-based communication networks easier to disable than purely ground-based systems. Losing reconnaissance satellites could blind gut the US’s strategic monitoring and disabling the GPS system would degrade its operational and tactical abilities. Space invites asymmetric warfare because anti-satellite attacks could even the technological odds against western powers that have become dependent on information-enhanced operations. As the nation most dependent on space-based networks, **the United States may have the most to lose.**

Strategists divide competition in this emerging arena into four categories. First is space support, which refers to the launching and management of satellites in orbit. The second is force enhancement, which seeks to improve the effectiveness of terrestrial military operations. The importance of these basic missions is well-established. Indeed, the very first satellites performed a critical surveillance role in the strategic competition between the United States and the Soviet Union. Spy satellites replaced dangerous aerial reconnaissance flights in providing intelligence on rival nuclear missile arsenals. Later space-based systems provided the superpowers with early warnings of ballistic missile launches. These programs bolstered stability and aided progress in nuclear arms reduction talks. Satellites created “national technical means” of verification: the capability to detect compliance with arms control treaties without the need to intrude on territorial sovereignty. They reduced the chances of human miscalculation by increasing the information available to decision makers about the intentions of other nations.

The US has made the most progress in the second mission, force enhancement, by using space to boost conventional military abilities. GPS enables the exact deployment of units, the synchronization of combat maneuvers, clearer identification of friend and foe, and precision targeting. In its recent wars, the US has used satellite information to find the enemy, even to the level of individual leaders, deploy on-station air or ground forces, and fire precision-guided munitions to destroy targets with decreased risk of collateral damage. American military leaders have argued that continued integration of space and conventional strike capabilities will allow the US to handle the twenty-first century threats—**terrorism, rogue nations, asymmetric warfare, and regional challengers**—more effectively with less resources.

The third and fourth space missions focus on space itself. Space control involves freely using space to one’s benefit while denying access to opponents. Conceptually akin to air superiority, space control begins with defense: hardening command, control, communications and reconnaissance facilities to prevent enemy interference. It includes shielding satellite components, giving them the ability to avoid collisions, disguising their location, and arming satellites to destroy attackers.2

Such forms of active defense can blend into the fourth mission: space force. Space force envisions weapons systems based in orbit that can strike targets on the ground, in the air, or in space. In an important respect, **space control and force application demand a greater exercise of power than air or naval superiority**. While air and naval superiority can be achieved through rapid deployment of assets for the duration of a conflict, dominance in space requires a broader geographic scope and longer-term duration—a constellation of space weapons would circle the globe for years.3It is in this realm that new weapons technologies are emerging, prompting questions of whether space-faring nations like the United States should treat space as another area for great power competition. “The reality of confrontation in space politics pervades the reality of the ideal of true cooperation and political unity in space, which has never been genuine, and in the near term seems unlikely,” argues Everett Dolman.4 The US certainly has taken such concerns to heart. In the decade ending in 2008, for example, the US increased its space budget from $33.7 billion to $43 billion in constant dollars. The entirety of this spending increase went to the Defense Department.

These weapons systems take several forms. Already operational, the US national missile defense system relies upon satellites to track ballistic missile launches and help guide ground-launched kill vehicles. Space-based lasers, like those in development by the US today, remain the only viable method to destroy ballistic missiles in their initial boost phase, when they are easiest to destroy.

American reliance on space-based intelligence and communication for its startling conventional military advantages has made its satellites a **target of potential rivals**. In 2007, for example, China tested a ground-launched missile to destroy a weather satellite in low earth orbit—the same region inhabited by commercial satellites. “For countries that can never win a war with the United States by using the methods of tanks and planes, attacking an American space system may be an irresistible and most tempting choice,” Chinese analyst Wang Hucheng has written, in a much-noticed comment.5

Though the 2007 ASAT (Anti-satellite weapon) test sparked international controversy, China had only followed the footsteps of the superpowers. The United States had carried out a primitive anti-satellite weapon test as early as 1959. During the Eisenhower, Kennedy, and Johnson administrations, the US continued to test anti-ballistic missile systems in an anti-satellite role. The Soviet Union followed suit. The superpowers temporarily dropped these programs with the signing of the Anti-Ballistic Missile Treaty of 1972, only to restart them in the 1990s. As rivals and rogue nations begin to mimic American development of force enhancement and space control abilities, the US will naturally develop anti-satellite weapons to restore its advantage and deter attacks. Such anti-satellite weapons may become even more common due to the vulnerability of satellites and the spread of ballistic missile technology.

Critics question whether the benefits of space weapons are worth the possibility of strategic instability. They argue that only arms control agreements and international institutions can head off a disastrous military race in space. But space will become an arena for pre-emptive deterrence. Every environment—land, air, water, and now space—has become an arena for combat. The US could deter destabilizing space threats from rivals by advancing its defensive capabilities. Some realist strategists argue not just in favor of protecting US space assets, but seeking US space supremacy. Because great power competition has already spread to space, the United States should capitalize on its early lead to control the ultimate high ground, that of outer space.

Criticisms of space weapons overlook the place of force in international politics. Advances in space technology can have greater humanitarian outcomes that outweigh concerns with space weapons themselves. Rather than increase the likelihood of war, space-based systems reduce the probability of destructive conflicts and limit both combatant and civilian casualties. Reconnaissance satellites reduce the chances that war will break out due to misunderstanding of a rival’s deployments or misperception of another nation’s intentions. Space-based communications support the location of targets for smart weapons on the battlefield, which lower harm to combatants and civilians. Space-based weapons may bring unparalleled speed and precision to the strategic use of force that could reduce the need for more harmful, less discriminate conventional weapons that spread greater destruction across a broader area. New weapons might bring war to a timely conclusion or even help nations **avoid armed conflict in the first place**. We do not argue that one nation’s overwhelming superiority in arms will prevent war from breaking out, though deterrence can have this effect. At the very least, space weapons, like other advanced military technologies, could help nations settle their disputes without resort to wider armed conflict, and hence bolster, rather than undermine, international security.

### Space Debris Brink

#### Concede util

#### Cross x proves there’s no way to solve existing space debris which should already have triggered the impact

**Probability – 0.1% chance of a collision.**

**Salter 16** [(Alexander William, Economics Professor at Texas Tech) “SPACE DEBRIS: A LAW AND ECONOMICS ANALYSIS OF THE ORBITAL COMMONS” 19 STAN. TECH. L. REV. 221 \*numbers replaced with English words] TDI

The probability of a collision is currently low. Bradley and Wein estimate that the maximum probability in LEO of a collision over the lifetime of a spacecraft remains below one in one thousand, conditional on continued compliance with NASA’s deorbiting guidelines.3 However, the possibility of a future “snowballing” effect, whereby debris collides with other objects, further congesting orbit space, remains a significant concern.4 Levin and Carroll estimate the average immediate destruction of wealth created by a collision to be approximately $30 million, with an additional $200 million in damages to all currently existing space assets from the debris created by the initial collision.5 The expected value of destroyed wealth because of collisions, currently small because of the low probability of a collision, can quickly become significant if future collisions result in runaway debris growth.

**Time frame – Kessler effect 200 years away**

**Stubbe 17** [(Peter, PhD in law @ Johann Wolfgang Goethe University Frankfurt) “State Accountability for Space Debris: A Legal Study of Responsibility for Polluting the Space Environment and Liability for Damage Caused by Space Debris,” Koninklijke Brill Publishing, ISBN 978-90-04-31407-8, p. 27-31] TDI

The prediction of possible scenarios of the future evolution of the debris p o p ulation involves many uncertainties. Long-term forecasting means the prediction of the evolution of the future debris environment in time periods of decades or even centuries. Predictions are based on models84 that work with certain assumptions, and altering these parameters significantly influences the outcomes of the predictions. Assumptions on the future space traffic and on the initial object environment are particularly critical to the results of modeling efforts.85 A well-known pattern for the evolution of the debris population is the so-called Kessler effect’, which assumes that there is a certain collision probability among space objects because many satellites operate in similar orbital regions. These collisions create fragments, and thus additional objects in the respective orbits, which in turn enhances the risk of further collisions. Consequently, the num ber of objects and collisions increases exponentially and eventually results in the formation of a self-sustaining debris belt aroundthe Earth. While it has long been assumed that such a process of collisional cascading is likely to occur only in a very long-term perspective (meaning a time 1 n of several hundred years),87 a consensus has evolved in recent years that an uncontrolled growth of the debris population in certain altitudes could become reality much sooner.88 In fact, a recent cooperative study undertaken by various space agencies in the scope of i a d c shows that the current l e o debris population is unstable, even if current mitigation measures are applied. The study concludes:

Even with a 90% implementation of the commonly-adopted mitigation measures [...] the l e o debris population is expected to increase by an average of 30% in the next 200 years. The population growth is primarily driven by catastrophic collisions between 700 and 1000 km altitudes and such collisions are likely to occur every 5 to 9 years.89

### Private sector

#### Public sector mining thumps

NASA 19 [“NASA Invests in Tech Concepts Aimed at Exploring Lunar Craters, Mining Asteroids,” NASA, June 11, 2019, <https://www.nasa.gov/press-release/nasa-invests-in-tech-concepts-aimed-at-exploring-lunar-craters-mining-asteroids>] TDI

NASA Invests in Tech Concepts Aimed at Exploring Lunar Craters, Mining Asteroids

Robotically surveying lunar craters in record time and mining resources in space could help NASA establish a sustained human presence at the Moon – part of the agency’s broader [Moon to Mars exploration](https://www.nasa.gov/specials/moon2mars/) approach. Two mission concepts to explore these capabilities have been selected as the first-ever Phase III studies within the [NASA Innovative Advanced Concepts](https://www.nasa.gov/niac) (NIAC) program.

“We are pursuing new technologies across our development portfolio that could help make deep space exploration more Earth-independent by utilizing resources on the Moon and beyond,” said Jim Reuter, associate administrator of NASA’s Space Technology Mission Directorate. “These NIAC Phase III selections are a component of that forward-looking research and we hope new insights will help us achieve more firsts in space.”

The Phase III proposals outline an aerospace architecture, including a mission concept, that is innovative and could change what’s possible in space. Each selection will receive as much as $2 million. Over the course of two years, researchers will refine the concept design and explore aspects of implementing the new technology. The inaugural Phase III selections are:

Robotic Technologies Enabling the Exploration of Lunar Pits

William Whittaker, Carnegie Mellon University, Pittsburgh

This mission concept, called Skylight, proposes technologies to rapidly survey and model lunar craters. This mission would use high-resolution images to create 3D model of craters. The data would be used to determine whether a crater can be explored by human or robotic missions. The information could also be used to characterize ice on the Moon, a crucial capability for the sustained surface operations of NASA’s Artemis program. On Earth, the technology could be used to autonomously monitor mines and quarries.

[Mini Bee Prototype to Demonstrate the Apis Mission Architecture and Optical Mining Technology](https://www.nasa.gov/directorates/spacetech/niac/2019_Phase_I_Phase_II/Mini_Bee_Prototype)

Joel Sercel, TransAstra Corporation, Lake View Terrace, California

This flight demonstration mission concept proposes a method of asteroid resource harvesting called optical mining. Optical mining is an approach for excavating an asteroid and extracting water and other volatiles into an inflatable bag. Called Mini Bee, the mission concept aims to prove optical mining, in conjunction with other innovative spacecraft systems, can be used to obtain propellant in space. The proposed architecture includes resource prospecting, extraction and delivery.

#### Asteroid mining fails

Fickling 20 [(David, Bloomberg opinion columnist, previously at Guardian and Financial Times, MA in Eng Lit from Cambridge) “We’re Never Going to Mine the Asteroid Belt,” Bloomberg Opinion, December 21, 2020, <https://www.bloomberg.com/opinion/articles/2020-12-21/space-mining-on-asteroids-is-never-going-to-happen>] TDI

It’s wonderful that people are shooting for the stars — but those who declined to fund the expansive plans of the nascent space mining industry were right about the fundamentals. Space mining won’t get off the ground in any foreseeable future — and you only have to look at the history of civilization to see why.

One factor rules out most space mining at the outset: gravity. On one hand, it guarantees that most of the solar system’s best mineral resources are to be found under our feet. Earth is the largest rocky planet orbiting the sun. As a result, the cornucopia of minerals the globe attracted as it coalesced is as rich as will be found this side of Alpha Centauri.

Gravity poses a more technical problem, too. Escaping Earth’s gravitational field makes transporting the volumes of material needed in a mining operation hugely expensive. On Falcon Heavy, the large rocket being developed by Elon Musk’s SpaceX, transporting a payload to the orbit of Mars comes to as little as [$5,357 per kilogram](https://www.spacex.com/media/Capabilities&Services.pdf) — a drastic reduction in normal launch costs. Still, at those prices just lofting a single half-ton drilling rig to the asteroid belt would use up the annual exploration budget of a small mining company.

Power is another issue. The international space station, with 35,000 square feet of solar arrays, generates up to 120 kilowatts of electricity. That drill would need a [similar-sized power plant](https://www.rocktechnology.sandvik/en/products/exploration-drill-rigs-and-tools/compact-core-drill-rigs/) — and most mining companies operate multiple rigs at a time. Power demands rise drastically once you move from exploration drilling to mining and processing. Bringing material back to Earth would raise the costs even more. Japan’s Hayabusa2 satellite spent six years and 16.4 billion yen ($157 million) recovering a single gram of material from the asteroid Ryugu and returning it to Earth earlier this month.

### Devastating Impacts

#### Extinction from warming requires 12 degrees and intervening actors will solve before then

Farquhar 17 [(Sebastian, leads the Global Priorities Project (GPP) at the Centre for Effective Altruism) “Existential Risk: Diplomacy and Governance,” 2017, <https://www.fhi.ox.ac.uk/wp-content/uploads/Existential-Risks-2017-01-23.pdf>] TDI

The most likely levels of global warming are very unlikely to cause human extinction.15 The existential risks of climate change instead stem from tail risk climate change – the low probability of extreme levels of warming – and interaction with other sources of risk. It is impossible to say with confidence at what point global warming would become severe enough to pose an existential threat. Research has suggested that warming of 11-12°C would render most of the planet uninhabitable,16 and would completely devastate agriculture.17 This would pose an extreme threat to human civilisation as we know it.18 Warming of around 7°C or more could potentially produce conflict and instability on such a scale that the indirect effects could be an existential risk, although it is extremely uncertain how likely such scenarios are.19 Moreover, the timescales over which such changes might happen could mean that humanity is able to adapt enough to avoid extinction in even very extreme scenarios. The probability of these levels of warming depends on eventual greenhouse gas concentrations. According to some experts, unless strong action is taken soon by major emitters, it is likely that we will pursue a medium-high emissions pathway.20 If we do, the chance of extreme warming is highly uncertain but appears non-negligible. Current concentrations of greenhouse gases are higher than they have been for hundreds of thousands of years,21 which means that there are significant unknown unknowns about how the climate system will respond. Particularly concerning is the risk of positive feedback loops, such as the release of vast amounts of methane from melting of the arctic permafrost, which would cause rapid and disastrous warming.22 The economists Gernot Wagner and Martin Weitzman have used IPCC figures (which do not include modelling of feedback loops such as those from melting permafrost) to estimate that if we continue to pursue a medium-high emissions pathway, the probability of eventual warming of 6°C is around 10%,23 and of 10°C is around 3%.24 These estimates are of course highly uncertain. It is likely that the world will take action against climate change once it begins to impose large costs on human society, long before there is warming of 10°C. Unfortunately, there is significant inertia in the climate system: there is a 25 to 50 year lag between CO2 emissions and eventual warming,25 and it is expected that 40% of the peak concentration of CO2 will remain in the atmosphere 1,000 years after the peak is reached.26 Consequently, it is impossible to reduce temperatures quickly by reducing CO2 emissions. If the world does start to face costly warming, the international community will therefore face strong incentives to find other ways to reduce global temperatures.

#### Non UQ – squo debris thumps

Orwig 16 [(Jessica, MS in science and tech journalism from Texas A&M, BS in astronomy and physics from Ohio State) “Russia says a growing problem in space could be enough to spark a war,” Insider,’ January 26, 2016, <https://www.businessinsider.com/russia-says-space-junk-could-spark-war-2016-1>] TDI

NASA has already [warned that](https://www.businessinsider.com/space-junk-at-critical-density-2015-9) the large amount of space junk around our planet is growing beyond our control, but now a team of Russian scientists has cited another potentially unforeseen consequence of that debris: War.

Scientists estimate that anywhere from 500,000 to 600,000 pieces of human-made space debris between 0.4 and 4 inches in size are currently orbiting the Earth and traveling at speeds over [17,000 miles per hour](https://www.nasa.gov/mission_pages/station/news/orbital_debris.html).

If one of those pieces smashed into a military satellite it "may provoke political or even armed conflict between space-faring nations," Vitaly Adushkin, a researcher for the Institute of Geosphere Dynamics at the Russian Academy of Sciences, reported in a paper set to be published in the peer-reviewed journal [Acta Astronautica](https://www.sciencedirect.com/science/article/pii/S0094576515303416), which is sponsored by the International Academy of Astronautics.

#### Space debris creates existential deterrence and a taboo

Bowen 18 [(Bleddyn, lecturer in International Relations at the University of Leicester) “The Art of Space Deterrence,” European Leadership Network, February 20, 2018, <https://www.europeanleadershipnetwork.org/commentary/the-art-of-space-deterrence/>] TDI

Fourth, the ubiquity of space infrastructure and the fragility of the space environment may create a degree of existential deterrence. As space is so useful to modern economies and military forces, a large-scale disruption of space infrastructure may be so intuitively escalatory to decision-makers that there may be a natural caution against a wholesale assault on a state’s entire space capabilities because the consequences of doing so approach the mentalities of total war, or nuclear responses if a society begins tearing itself apart because of the collapse of optimised energy grids and just-in-time supply chains. In addition, the problem of space debris and the [political-legal hurdles to conducting debris clean-up](https://doi.org/10.1080/14777622.2014.890489) operations mean that even a handful of explosive events in space can render a region of Earth orbit unusable for everyone. This could caution a country like China from excessive kinetic intercept missions because its own military and economy is increasingly reliant on outer space, but perhaps not a country like North Korea which does not rely on space. The usefulness, sensitivity, and fragility of space may have some existential deterrent effect. [China’s catastrophic anti-satellite weapons test in 2007](https://defenceindepth.co/2017/01/11/chinas-space-weapons-test-ten-years-on-behemoth-pulls-the-peasants-plough/) is a valuable lesson for all on the potentially devastating effect of kinetic warfare in orbit.

#### Alliances check miscalc – too costly

MacDonald 13 [(Bruce, teaches at the United States Institute of Peace on strategic posture and space/cyber security issues, leads a study on China and Crisis Stability in Space, and is adjunct professor at the Johns Hopkins School of Advanced International Studies) “Deterrence and Crisis Stability in Space and Cyberspace,” in Anti-satellite Weapons, Deterrence and Sino-American Space Relations, September 2013, <https://apps.dtic.mil/dtic/tr/fulltext/u2/a587431.pdf>] TDI

The US alliance structure can promote deterrence and crisis stability in space, as with nuclear deterrence. China has no such alliance system. If China were to engage in large-scale offensive counter-space operations, it would face not only the United States, but also NATO, Japan, South Korea and other highly aggrieved parties. Given Beijing’s major export dependence on these markets, and its dependence upon them for key raw material and high technology imports, China would be as devastated economically if it initiated strategic attacks in space. In contrast to America’s nuclear umbrella and extended deterrence, US allies make a tangible and concrete contribution to extended space deterrence through their multilateral participation in and dependence upon space assets. Attacks on these space assets would directly damage allied interests as well as those of the United States, further strengthening deterrent effects.

#### Rigorous climate simulations prove hydrophilic black carbon would cause atmospheric precipitation – results in a rainout effect that reverses nuclear cooling

Reisner et al. 18 ([Jon Reisner – Climate and atmospheric scientist at the Los Alamos National Laboratory. Gennaro D’Angelo – Climate scientist at the Los Alamos National Laboratory, Research scientist at the SETI institute, Associate specialist at the University of California, Santa Cruz, NASA Postdoctoral Fellow at the NASA Ames Research Center, UKAFF Fellow at the University of Exeter. Eunmo Koo - Scientist at Applied Terrestrial, Energy, and Atmospheric Modeling (ATEAM) Team, in Computational Earth Science Group (EES-16) in Earth and Environmental Sciences Division and Co-Lead of Parallel Computing Summer Research Internship (PCSRI) program at the Los Alamos National Laboratory, former Staff research associate at UC Berkeley. Wesley Even - Computational scientist in the Computational Physics and Methods Group at Los Alamos National Laboratory. Matthew Hecht – Atmospheric scientist at the Los Alamos National Laboratory. Elizabeth Hunke - Lead developer for the Los Alamos Sea Ice Model (CICE) at the Los Alamos National Laboratory responsible for development and incorporation of new parameterizations, model testing and validation, computational performance, documentation, and consultation with external model users on all aspects of sea ice modeling, including interfacing with global climate and earth system models. Darin Comeau – Climate scientist at the Los Alamos National Laboratory. Randy Bos - Project leader at the Los Alamos National Laboratory, former Weapons Effects program manager at Tech-Source. James Cooley – Computational scientist at the Los Alamos National Laboratory specializing in weapons physics, emergency response, and computational physics.) “Climate impact of a regional nuclear weapons exchange:An improved assessment based on detailed source calculations,” March 16, 2018, <https://agupubs.onlinelibrary.wiley.com/doi/full/10.1002/2017JD027331>] TDI

\*BC = Black Carbon

The no-rubble simulation produces a significantly more intense fire, with more fire spread, and consequently a significantly stronger plume with larger amounts of BC reaching into the upper atmosphere than the simulation with rubble, illustrated in Figure 5. While the no-rubble simulation **represents the worst-case scenario** involving vigorous fire activity, **only a relatively small amount of carbon makes its way into the stratosphere** during the course of the simulation. But while small compared to the surface BC mass, stratospheric BC amounts from the current simulations are significantly higher than what would be expected from burning vegetation such as trees (Heilman et al., 2014), e.g., the higher energy density of the building fuels and the initial fluence from the weapon produce an intense response within HIGRAD with initial updrafts of order 100 m/s in the lower troposphere. Or, in comparison to a mass fire, wildfires will burn only a small amount of fuel in the corresponding time period (roughly 10 minutes) that a nuclear weapon fluence can effectively ignite a large area of fuel producing an impressive atmospheric response. Figure 6 shows vertical profiles of BC multiplied by 100 (number of cities involved in the exchange) from the two simulations. The total amount of BC produced is in line with previous estimates (about 3.69 Tg from no-rubble simulation); however, the majority of BC resides **below the stratosphere** (3.46 Tg below 12 km) and can be **readily impacted by scavenging from precipitation** either via pyro-cumulonimbus produced by the fire itself (not modeled) or other synoptic weather systems. While the impact on climate of these more realistic profiles will be explored in the next section, it should be mentioned that **these estimates are** still **at the high end**, considering the inherent simplifications in the combustion model that lead to **overestimating BC production**. 3.3 Climate Results Long-term climatic effects critically depend on the initial injection height of the soot, with larger quantities reaching the upper troposphere/lower stratosphere inducing a greater cooling impact because of longer residence times (Robock et al., 2007a). Absorption of solar radiation by the BC aerosol and its subsequent radiative cooling tends to heat the surrounding air, driving an initial upward diffusion of the soot plumes, an effect that depends on the initial aerosol concentrations. **Mixing and sedimentation** tend to **reduce this process**, and low altitude emissions are also significantly impacted by precipitation if aging of the BC aerosol occurs on sufficiently rapid timescales. But once at stratospheric altitudes, aerosol dilution via coagulation is hindered by low particulate concentrations (e.g., Robock et al., 2007a) and lofting to much higher altitudes is inhibited by gravitational settling in the low-density air (Stenke et al., 2013), resulting in more stable BC concentrations over long times. Of the initial BC mass released in the atmosphere, most of which is emitted below 9 km, **70% rains out within the first month** and 78%, or about 2.9 Tg, is removed within the first two months (Figure 7, solid line), with the remainder (about 0.8 Tg, dashed line) being transported above about 12 km (200 hPa) within the first week. This outcome differs from the findings of, e.g., Stenke et al. (2013, their high BC-load cases) and Mills et al. (2014), who found that most of the BC mass (between 60 and 70%) is lifted in the stratosphere within the first couple of weeks. This can also be seen in Figure 8 (red lines) and in Figure 9, which include results from our calculation with the initial BC distribution from Mills et al. (2014). In that case, only 30% of the initial BC mass rains out in the troposphere during the first two weeks after the exchange, with the remainder rising to the stratosphere. In the study of Mills et al. (2008) this percentage is somewhat smaller, about 20%, and smaller still in the experiments of Robock et al. (2007a) in which the soot is initially emitted in the upper troposphere or higher. In Figure 7, the e-folding timescale for the removal of tropospheric soot, here interpreted as the time required for an initial drop of a factor e, is about one week. This result compares favorably with the “LT” experiment of Robock et al. (2007a), considering 5 Tg of BC released in the lower troposphere, in which 50% of the aerosols are removed within two weeks. By contrast, the initial e-folding timescale for the removal of stratospheric soot in Figure 8 is about 4.2 years (blue solid line), compared to about 8.4 years for the calculation using Mills et al. (2014) initial BC emission (red solid line). The removal timescale from our forced ensemble simulations is close to those obtained by Mills et al. (2008) in their 1 Tg experiment, by Robock et al. (2007a) in their experiment “UT 1 Tg”, and © 2018 American Geophysical Union. All rights reserved. by Stenke et al. (2013) in their experiment “Exp1”, in all of which 1 Tg of soot was emitted in the atmosphere in the aftermath of the exchange. Notably, the e-folding timescale for the decline of the BC mass in Figure 8 (blue solid line) is also close to the value of about 4 years quoted by Pausata et al. (2016) for their long-term “intermediate” scenario. In that scenario, which is also based on 5 Tg of soot initially distributed as in Mills et al. (2014), the factor-of2 shorter residence time of the aerosols is caused by particle growth via coagulation of BC with organic carbon. Figure 9 shows the BC mass-mixing ratio, horizontally averaged over the globe, as a function of atmospheric pressure (height) and time. The BC distributions used in our simulations imply that the upward transport of particles is substantially less efficient compared to the case in which 5 Tg of BC is directly injected into the upper troposphere. The semiannual cycle of lofting and sinking of the aerosols is associated with atmospheric heating and cooling during the solstice in each hemisphere (Robock et al., 2007a). During the first year, the oscillation amplitude in our forced ensemble simulations is particularly large during the summer solstice, compared to that during the winter solstice (see bottom panel of Figure 9), because of the higher soot concentrations in the Northern Hemisphere, as can be seen in Figure 11 (see also left panel of Figure 12). Comparing the top and bottom panels of Figure 9, the BC reaches the highest altitudes during the first year in both cases, but the concentrations at 0.1 hPa in the top panel can be 200 times as large. Qualitatively, the difference can be understood in terms of the air temperature increase caused by BC radiation emission, which is several tens of kelvin degrees in the simulations of Robock et al. (2007a, see their Figure 4), Mills et al. (2008, see their Figure 5), Stenke et al. (2013, see high-load cases in their Figure 4), Mills et al. (2014, see their Figure 7), and Pausata et al. (2016, see one-day emission cases in their Figure 1), due to high BC concentrations, but it amounts to only about 10 K in our forced ensemble simulations, as illustrated in Figure 10. Results similar to those presented in Figure 10 were obtained from the experiment “Exp1” performed by Stenke et al. (2013, see their Figure 4). **In that scenario as well, somewhat less that 1 Tg of BC remained in the atmosphere after the initial rainout**. As mentioned before, the BC aerosol that remains in the atmosphere, lifted to stratospheric heights by the rising soot plumes, undergoes sedimentation over a timescale of several years (Figures 8 and 9). This mass represents the effective amount of BC that can force climatic changes over multi-year timescales. In the forced ensemble simulations, it is about 0.8 Tg after the initial rainout, whereas it is about 3.4 Tg in the simulation with an initial soot distribution as in Mills et al. (2014). Our more realistic source simulation involves the worstcase assumption of no-rubble (along with other assumptions) and hence serves as an upper bound for the impact on climate. As mentioned above and further discussed below, our scenario induces perturbations on the climate system similar to those found in previous studies in which the climatic response was driven by roughly 1 Tg of soot rising to stratospheric heights following the exchange. Figure 11 illustrates the vertically integrated mass-mixing ratio of BC over the globe, at various times after the exchange for the simulation using the initial BC distribution of Mills et al. (2014, upper panels) and as an average from the forced ensemble members (lower panels). All simulations predict enhanced concentrations at high latitudes during the first year after the exchange. In the cases shown in the top panels, however, these high concentrations persist for several years (see also Figure 1 of Mills et al., 2014), whereas the forced ensemble simulations indicate that the BC concentration starts to decline after the first year. In fact, in the simulation represented in the top panels, mass-mixing ratios larger than about 1 kg of BC © 2018 American Geophysical Union. All rights reserved. per Tg of air persist for well over 10 years after the exchange, whereas they only last for 3 years in our forced simulations (compare top and middle panels of Figure 9). After the first year, values drop below 3 kg BC/Tg air, whereas it takes about 8 years to reach these values in the simulation in the top panels (see also Robock et al., 2007a). Over crop-producing, midlatitude regions in the Northern Hemisphere, the BC loading is reduced from more than 0.8 kg BC/Tg air in the simulation in the top panels to 0.2-0.4 kg BC/Tg air in our forced simulations (see middle and right panels). The more rapid clearing of the atmosphere in the forced ensemble is also signaled by the soot optical depth in the visible radiation spectrum, which drops below values of 0.03 toward the second half of the first year at mid latitudes in the Northern Hemisphere, and everywhere on the globe after about 2.5 years (without never attaining this value in the Southern Hemisphere). In contrast, the soot optical depth in the calculation shown in the top panels of Figure 11 becomes smaller than 0.03 everywhere only after about 10 years. The two cases show a similar tendency, in that the BC optical depth is typically lower between latitudes 30º S-30º N than it is at other latitudes. This behavior is associated to the persistence of stratospheric soot toward high-latitudes and the Arctic/Antarctic regions, as illustrated by the zonally-averaged, column-integrated mass-mixing ratio of the BC in Figure 12 for both the forced ensemble simulations (left panel) and the simulation with an initial 5 Tg BC emission in the upper troposphere (right panel). The spread in the globally averaged (near) surface temperature of the atmosphere, from the control (left panel) and forced (right panel) ensembles, is displayed in Figure 13. For each month, the plots show the largest variations (i.e., maximum and minimum values), within each ensemble of values obtained for that month, relative to the mean value of that month. The plot also shows yearly-averaged data (thinner lines). The spread is comparable in the control and forced ensembles, with average values calculated over the 33-years run length of 0.4-0.5 K. This spread is also similar to the internal variability of the globally averaged surface temperature quoted for the NCAR Large Ensemble Community Project (Kay et al., 2015). These results imply that surface air temperature differences, between forced and control simulations, which lie within the spread may not be distinguished from effects due to internal variability of the two simulation ensembles. Figure 14 shows the difference in the globally averaged surface temperature of the atmosphere (top panel), net solar radiation flux at surface (middle panel), and precipitation rate (bottom panel), computed as the (forced minus control) difference in ensemble mean values. The sum of standard deviations from each ensemble is shaded. Differences are qualitatively significant over the first few years, when the anomalies lie near or outside the total standard deviation. Inside the shaded region, differences may not be distinguished from those arising from the internal variability of one or both ensembles. The surface solar flux (middle panel) is the quantity that appears most affected by the BC emission, with qualitatively significant differences persisting for about 5 years. The precipitation rate (bottom panel) is instead affected only at the very beginning of the simulations. The red lines in all panels show the results from the simulation applying the initial BC distribution of Mills et al. (2014), where the period of significant impact is much longer owing to the higher altitude of the initial soot distribution that results in longer residence times of the BC aerosol in the atmosphere. When yearly averages of the same quantities are performed over the IndiaPakistan region, the differences in ensemble mean values lie within the total standard deviations of the two ensembles. The results in Figure 14 can also be compared to the outcomes of other previous studies. In their experiment “UT 1 Tg”, Robock et al. (2007a) found that, when only 1 Tg of soot © 2018 American Geophysical Union. All rights reserved. remains in the atmosphere after the initial rainout, temperature and precipitation anomalies are about 20% of those obtained from their standard 5 Tg BC emission case. Therefore, the largest differences they observed, during the first few years after the exchange, were about - 0.3 K and -0.06 mm/day, respectively, comparable to the anomalies in the top and bottom panels of Figure 14. Their standard 5 Tg emission case resulted in a solar radiation flux anomaly at surface of -12 W/m2 after the second year (see their Figure 3), between 5 and 6 time as large as the corresponding anomalies from our ensembles shown in the middle panel. In their experiment “Exp1”, Stenke et al. (2013) reported global mean surface temperature anomalies not exceeding about 0.3 K in magnitude and precipitation anomalies hovering around -0.07 mm/day during the first few years, again consistent with the results of Figure 14. In a recent study, Pausata et al. (2016) considered the effects of an admixture of BC and organic carbon aerosols, both of which would be emitted in the atmosphere in the aftermath of a nuclear exchange. In particular, they concentrated on the effects of coagulation of these aerosol species and examined their climatic impacts. The initial BC distribution was as in Mills et al. (2014), although the soot burden was released in the atmosphere over time periods of various lengths. Most relevant to our and other previous work are their one-day emission scenarios. They found that, during the first year, the largest values of the atmospheric surface temperature anomalies ranged between about -0.5 and -1.3 K, those of the sea surface temperature anomalies ranged between -0.2 and -0.55 K, and those of the precipitation anomalies varied between -0.15 and -0.2 mm/day. All these ranges are compatible with our results shown in Figure 14 as red lines and with those of Mills et al. (2014, see their Figures 3 and 6). As already mentioned in Section 2.3, the net solar flux anomalies at surface are also consistent. This overall agreement suggests that the **inclusion of organic carbon aerosols, and** ensuing **coagulation** with BC, **should not dramatically alter the climatic effects** resulting from our forced ensemble simulations. Moreover, aerosol growth would likely **shorten the residence time of the BC particulate in the atmosphere** (Pausata et al., 2016), possibly **reducing the duration of these effects.**

#### No credible scenario for extinction—outdated fringe science and well-meaning threat inflation