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## Climate Change Management in the Space Age

Paul B. Larsen

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# CLIMATE CHANGE MANAGEMENT IN THE SPACE AGE

PAUL B. LARSEN\*

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## INTRODUCTION

This Article is about how we can use space technology and regulation to help overcome adverse effects of climate change on Earth.<sup>1</sup> It describes the growing use and importance of outer space technology for monitoring, understanding, and resolving the problems of climate change.<sup>2</sup> It describes precedents for the current climate crisis, discusses relevant international space laws, and explains how they fit into the existing international laws on climate change.<sup>3</sup> It emphasizes the oversight role of the United Nations (“U.N.”).<sup>4</sup> It describes the heavy duties placed by current climate laws on the developed countries compared with the developing countries.<sup>5</sup> It explains the situation and options of the United States, China, and the developing countries.<sup>6</sup> Finally, it makes 11 recommendations toward resolution of the current stalemate.<sup>7</sup>

Defining climate change is a necessary first step. Virtually all states, including the United States, are parties to the 1992 U.N. Framework Convention on Climate Change (“UNFCCC”),<sup>8</sup> which establishes the legal definition of climate change.<sup>9</sup> The UNFCCC Article 1(2) definition of climate change is: “a change of climate which is attributed directly or indirectly to *human* activity that alters the composition of the global atmosphere and which is in addition to *natural* climate variability observed over comparable time periods.”<sup>10</sup> The same definition of climate change applies to the 2015 Paris Agreement,<sup>11</sup> which seeks to implement the UNFCCC.<sup>12</sup> Climate change attributable to human activity thus is the subject of this Article.<sup>13</sup>

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<sup>1</sup> For an examination of climate change from an outer space prospective, see Francis Lyall, *Climate Change in Space Law*, in INTERNATIONAL LAW IN THE ERA OF CLIMATE CHANGE, 175, 189 (Rosemary Rayfuse & Shirley V. Scott eds., 2012). It has now become possible to modify the Earth’s environment from outer space. Peter H. Sand, *Space Programmes and International Environmental Protection*, 21 INT’L & COMPAR. L.Q. 43 (1972).

<sup>2</sup> See *infra* Section I.D.

<sup>3</sup> See *infra* Section II.F.5.

<sup>4</sup> See *id.*

<sup>5</sup> See *infra* Section II.F.8.

<sup>6</sup> See *infra* Conclusion.

<sup>7</sup> See *id.*

<sup>8</sup> See United Nations Framework Convention on Climate Change, May 9, 1992, 1771 U.N.T.S. 107 [hereinafter Convention on Climate Change].

<sup>9</sup> *Id.* at art. 1(2).

<sup>10</sup> *Id.* (emphasis added).

<sup>11</sup> Paris Agreement art. 1, Dec. 12, 2015, T.I.A.S. No. 16-1104.

<sup>12</sup> *Id.* at art. 2.

<sup>13</sup> Recent Greenland ice excavation illustrates the distinction between climate change

Climate change is one of the most complex legal issues ever to occur, because it affects life on the entire planet Earth.<sup>14</sup> It is similar to another current problem, COVID-19, in having a paralyzing effect on all life on Earth.<sup>15</sup> It differs from COVID-19 in that climate change effects have a longer time frame.<sup>16</sup> Climate change involves many aspects of the laws of land, sea, and air as well as outer space.<sup>17</sup> Climate change mitigation,

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caused by natural and human causes. Hiroko Tabuchi, *Oil and Gas May Be a Far Bigger Threat Than We Knew*, N.Y. TIMES (Feb. 19, 2020), <https://www.nytimes.com/2020/02/19/climate/methane-flaring-oil-emissions.html?searchResultPosition=1> [<https://perma.cc/B8GX-LYZP>]. Study of Greenland ice from the 1750s (prior to the Industrial Revolution) indicates that methane emissions from *natural* causes “were far smaller than estimates used to evaluate global emissions.” *Id.* In addition, the study of Greenland ice is particularly important to oil companies that are seeking to reduce methane emissions from their operations. *Id.* Studies recommend more monitoring from space. Hiroko Tabuchi, *A Methane Leak, Seen From Space, Proves to Be Far Larger Than Thought*, N.Y. TIMES (Dec. 16, 2019), <https://www.nytimes.com/2019/12/16/climate/methane-leak-satellite.html?searchResultPosition=1> [<https://perma.cc/B8GX-LYZP>] (Methane is a particularly potent greenhouse gas: it has more than 80 times the climate-warming effect of carbon dioxide).

<sup>14</sup> See Cristian Román-Palacios & John J. Weins, *Recent Responses to Climate Change Reveal the Drivers of Species Extinction and Survival*, 117 PROC. NAT'L ACAD. SCI. U.S. No. 8, at 4211 (One-third of all animal and plant species on the planet could face extinction by 2070: the adverse effect on plant life is particularly worrisome because plants and trees are a major way of removal of emissions from the Earth).

<sup>15</sup> COVID-19 has a counter-effect on climate change by causing significant reduction in industrial production of greenhouse gas. Recent satellite monitoring of Chinese greenhouse emissions shows substantial drop in CO<sub>2</sub> emissions in early 2020. See Rafi Letzter, *Dramatic Effect of Coronavirus Lockdowns Seen From Space*, SPACE.COM (Sept. 9, 2020), <https://www.space.com/coronavirus-changes-pollution-over-china.html> [<https://perma.cc/MBV9-MD8S>]; Brad Plumer, *Emissions Declines Will Set Records This Year. But It's Not Good News*, N.Y. TIMES (Apr. 30, 2020), <https://www.nytimes.com/2020/04/30/climate/global-emissions-decline.html?searchResultPosition=1> [<https://perma.cc/2FWV-H3Z8>]; Brad Plumer & Nadja Popovich, *Traffic and Pollution Plummet as U.S. Cities Shut Down for Coronavirus*, N.Y. TIMES (Mar. 22, 2020), <https://www.nytimes.com/interactive/2020/03/22/climate/coronavirus-usa-traffic.html> [<https://perma.cc/2Z4V-AWNA>]; Debra Werner, *Satellites Reveal Striking Impact of COVID-19 on People and Air Quality*, SPACE NEWS (Apr. 26, 2020), <https://spacenews.com/satellites-reveal-striking-impact-of-covid-19-on-people-and-air-quality/> [<https://perma.cc/G7S5-UASM>]. However, the drop in emissions appears to be temporary. See Brad Plumer & Nadja Popovich, *Emissions Are Surging Back as Countries and States Reopen*, N.Y. TIMES (June 17, 2020), <https://www.nytimes.com/interactive/2020/06/17/climate/virus-emissions-reopening.html?searchResultPosition=1> [<https://perma.cc/5P4L-4C88>].

<sup>16</sup> See Convention on Climate Change, *supra* note 8, at art. 1(2)–(3); Lyall, *supra* note 1, at 176–78.

<sup>17</sup> See generally Press Release, Department of Global Communications, *U.N. Mobilizes Global Cooperation in Science-Based COVID-19 Responses* (Apr. 7, 2020) (example of importance of international cooperation on major global issue); Dustin Tingley & Michael Tomz, *Conditional Cooperation and Climate Change*, 47 COMPAR. POL. STUD. No. 3, at 344 (Nov. 2013) (discussing difficulty and importance of international action on climate change).

similar to COVID-19 elimination, can only be resolved if all countries cooperate.<sup>18</sup> Climate change may affect the current generation moderately, but it can make life unbearable for the next generations unless the current generation assumes responsibility for resolving the problems before they become permanent.<sup>19</sup>

Climate change is inherently an outer space problem because it involves the Sun and its effect on planet Earth.<sup>20</sup> We have seen results of similar climate conditions on other celestial bodies, for example on the planet Mars.<sup>21</sup> Experience with the 1987 Montreal Protocol on Substances that Deplete the Ozone Layer,<sup>22</sup> which established global restrictions on harmful aerosols, shows that international climate change problems can be resolved.<sup>23</sup> Today global warming and the related greenhouse effect<sup>24</sup> is a much greater problem than the ozone hole addressed in the Montreal Protocol; but current earthly climate change contains global aspects similar to those referenced in the Montreal Protocol.<sup>25</sup> The Montreal Protocol shows that nations can successfully agree to resolve this kind of problem and actually do it.<sup>26</sup>

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<sup>18</sup> See discussion of intergenerational responsibility, *infra* at notes 495–501.

<sup>19</sup> *Greenhouse effect*, ENCYCLOPEDIA BRITANNICA (Sept. 9, 2020), <https://www.britannica.com/science/greenhouse-effect> [<https://perma.cc/TC4P-QQZB>].

<sup>20</sup> See Mars Fact Sheet, NASA, <https://nssdc.gsfc.nasa.gov/planetary/factsheet/marsfact.html> [<https://perma.cc/S7AE-VZL5>] (last visited Oct. 13, 2020) (the atmosphere of the planet Mars is 95.1% carbon dioxide).

<sup>21</sup> Protocol to the 1979 Convention on Long-Range Transboundary Air Pollution on Further Reduction of Sulphur Emissions, art. 2, June 14, 1994, 33 I.L.M. 1542, 1543 [hereinafter Montreal Protocol].

<sup>22</sup> See generally Stephan Leahy, *Without the Ozone Treaty You'd Get Sunburned in 5 Minutes*, NAT'L GEOGRAPHIC (Sept. 9, 2020), <https://www.nationalgeographic.com/news/2017/09/montreal-protocol-ozone-treaty-30-climate-change-hcfs-hfcs/> [<https://perma.cc/QYT8-3QYJ>] (example of international cooperation that stopped ozone layer from collapsing).

<sup>23</sup> See Emissions Gap Report 2019, U.N. ENV'T PROGRAMME, <https://wedocs.unep.org/bitstream/handle/20.500.11822/30797/EGR2019.pdf?sequence=1&isAllowed=y> [<https://perma.cc/3CF8-M3A2>] (last visited Oct. 13, 2020) (U.N. Environment Gap Report 2019 definition of greenhouse gas: “The major greenhouse gases [responsible for causing global warming and climate change] are carbon dioxide(CO<sub>2</sub>), methane (CH<sub>4</sub>) and nitrous oxide (N<sub>2</sub>O). Less prevalent, but very powerful, GHGs are hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF<sub>6</sub>)”).

<sup>24</sup> Montreal Protocol, *supra* note 21, at 29.

<sup>25</sup> See Leahy, *supra* note 22.

<sup>26</sup> See generally Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies, Jan. 27, 1967, 18 U.S.T. 2410, 610 U.N.T.S. 205 [hereinafter Outer Space Treaty]; Convention on International Liability for Damage Caused by Space Objects, 29 Mar. 1972, 24 U.S.T. 2389, 961 U.N.T.S. 187 [hereinafter Liability Convention]; Registration of objects launched into outer space, Jan. 14, 1975, 28 U.S.T. 695, 1023 U.N.T.S. 15 [hereinafter Registration Convention].

The Sun is a cause of global warming on Earth. The 1967 Outer Space Treaty (“OST”)<sup>27</sup> subjects the sun to international space law in that it is included within the definition of celestial bodies.<sup>28</sup> The Sun is inherently an immense source of energy produced by continuous interior thermonuclear explosions.<sup>29</sup> Part of that energy radiates through solar gas and magnetic storms to the surface of the Earth.<sup>30</sup> It is important to keep in mind that current global warming is related to the Sun and that solar radiation is naturally changeable as it goes through phases like solar storms.<sup>31</sup>

Climate change is one of the most important problems facing life on Earth. Unless we manage to control climate change, human beings on Earth will be so adversely affected by the end of the twenty-first century that it will be extremely difficult to maintain human life.<sup>32</sup>

Space technology is an important tool for the control of climate change. Use of satellite technology to observe and control climate change on Earth is illustrated as follows<sup>33</sup>: In 2018 a European Space Agency (“ESA”) satellite observed 120 metric tons of methane gas per hour streaming out of a natural gas well, part of a fracking enterprise in Ohio.<sup>34</sup> The methane gas continued to stream out uninterrupted for twenty days.<sup>35</sup> The total emission was twice the size of previously detected emissions.<sup>36</sup> Only a satellite could observe the magnitude of this methane

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<sup>27</sup> *Definition of Celestial Body*, MERRIAM-WEBSTER, <https://www.merriam-webster.com/dictionary/celestial%20body> [<https://perma.cc/R5X9-UFKE>] (last visited Oct. 13, 2020).

<sup>28</sup> Fraser Cain, *How does the Sun Produce Energy?*, PHYS.ORG (Dec. 14, 2015), <https://phys.org/news/2015-12-sun-energy.html> [<https://perma.cc/N83L-NASA>].

<sup>29</sup> Dennis Overbye, *Telescope on Ancient Volcano Snaps Most Detailed Image Yet of the Sun*, N.Y. TIMES, Jan. 30, 2020, at A23.

<sup>30</sup> *What Is a Solar Radiation Storm?*, SPACEWEATHERLIVE.COM, <https://www.spaceweatherlive.com/en/help/what-is-a-solar-radiation-storm> [<https://perma.cc/D3M8-CL75>] (last visited Oct. 13, 2020).

<sup>31</sup> Tabuchi, *supra* note 13 (Methane causes 20% to 30% of Earth’s temperature increase). See Radboud Univ. Nijmegen, *Methane Bubbles Are Effect and Cause of Rise in Temperature*, PHYS.ORG (Nov. 22, 2017), <https://phys.org/news/2017-11-methane-effect-temperature.html#:~:text=The%20biologists%20predict%20that%20a,to%20an%20additional%20temperature%20increase> [<https://perma.cc/4WDB-JXU3>].

<sup>32</sup> Tabuchi, *supra* note 13.

<sup>33</sup> *Id.*

<sup>34</sup> *Id.*

<sup>35</sup> *Id.* (Exxon operated the well but was unable to measure the magnitude of the methane emission from Earth).

<sup>36</sup> *Id.* (only satellites can detect the nature of this kind of emissions). See generally FRANCIS LYALL & PAUL B. LARSEN, *SPACE LAW: A TREATISE* 359–86 (Routledge Taylor & Francis Group eds., 2d ed. 2018).

gas emission.<sup>37</sup> Once the ability of the satellite to observe and measure the emission was discovered, it was employed to detect other large leaks of similar nature.<sup>38</sup> Methane is natural gas which burns twice as clean as coal when burned to produce electricity.<sup>39</sup> But when it escapes into the atmosphere, it may warm the planet Earth eighty times more than similar amounts of carbon dioxide (CO<sub>2</sub>).<sup>40</sup> Subsequently, the leak in the Ohio well was fixed and the well is now back in operation.<sup>41</sup>

Orbiting satellites, like the ESA satellite described, are able to monitor similar hot spots on Earth by repeated overflights.<sup>42</sup> “Studies of oil fields in the United States have shown that a small number of sites with high emissions are responsible for the bulk of methane releases.”<sup>43</sup>

One aspect of Earth’s uniqueness is the abundant life forms which it hosts. So far we have not found life elsewhere in the universe.<sup>44</sup> Plans are now made on planet Earth to send human beings to the Moon and Mars and outer planets.<sup>45</sup> Astronomers have located other planets that appear to be sufficiently like planet Earth, where human beings may be able to exist.<sup>46</sup> But the unique requirements for sustaining human beings in outer space are a barrier which has not yet been overcome. The search to find other habitable planets like the Earth is becoming urgent.<sup>47</sup> Melting ice causes the oceans to rise, thus reducing significantly the land

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<sup>37</sup> Mark Bittman, *Is Natural Gas ‘Clean’?*, N.Y. TIMES (Sept. 24, 2013), <https://opinionator.blogs.nytimes.com/2013/09/24/is-natural-gas-clean/> [<https://perma.cc/A4BK-PUB2>].

<sup>38</sup> Tabuchi, *supra* note 13.

<sup>39</sup> *Id.*

<sup>40</sup> John Fialka, *Meet the Satellites That Can Pinpoint Methane and Carbon Dioxide Leaks*, E&ENews (Mar. 9, 2018), <https://www.scientificamerican.com/article/meet-the-satellites-that-can-pinpoint-methane-and-carbon-dioxide-leaks/> [<https://perma.cc/UQT5-QP8M>].

<sup>41</sup> Tabuchi, *supra* note 13.

<sup>42</sup> LYALL & LARSEN, *supra* note 36, at 484.

<sup>43</sup> Mike Wall, *SpaceX’s Mars Colony Plan: How Elon Musk Plans to Build a Million-Person Martian City*, SPACE.COM (June 14, 2017), <https://www.space.com/37200-read-elon-musk-spacex-mars-colony-plan.html> [<https://perma.cc/A2U8-GEKX>].

<sup>44</sup> See Morgan McFall-Johnson & Dave Mosher, *Elon Musk Says He Plans to Send 1 Million People to Mars by 2050 by Launching 3 Starship Rockets Every Day and Creating ‘A Lot of Jobs’ on the Red Planet*, BUS. INSIDER (Jan. 17, 2020), <https://www.businessinsider.com/elon-musk-plans-1-million-people-to-mars-by-2050-2020-1> [<https://perma.cc/59T9-QVEB>].

<sup>45</sup> *Id.* See also MARTIN REES, *ON THE FUTURE* (Princeton Univ. Press ed., 6th ed. 2006).

<sup>46</sup> Eric Roston, *Record Ice Loss in Greenland Is a Threat to Coastal Cities Worldwide*, BLOOMBERG (Aug. 21, 2020), <https://www.bloomberg.com/news/articles/2020-08-21/global-warming-is-melting-greenland-s-ice-sheet-causing-sea-rise> [<https://perma.cc/UP7M-NPPJ>].

<sup>47</sup> See Kate Kelland, *Climate Change Exposes Future Generations to Life-Long Harm*, REUTERS (Nov. 13, 2019), <https://news.trust.org/item/20191113230113-imehu/> [<https://perma.cc/N32X-JRRY>].

areas on which humans can live.<sup>48</sup> The increase in heat on Earth due to climate change, as well as the reduction in resources necessary for life on Earth, will restrict humans' ability to thrive.<sup>49</sup> This prospect makes it absolutely necessary to:

- (1) Prevent further climate change by removing and mitigating its causes;
- (2) Make human life on Earth possible in the different climate that is produced by climate change; and
- (3) Expedite current efforts to escape from planet Earth to other planets thought to be able to sustain life forms currently found on Earth.<sup>50</sup>

#### I. SPACE TECHNOLOGY THAT CAN CHANGE EFFECTS OF CLIMATE CHANGE

The abilities of outer space technology to measure, monitor, mitigate, and report on the consequences of climate change continue to increase at a tremendous rate. There are now approximately 2,000 functional satellites orbiting in outer space.<sup>51</sup> More than 20,000 satellites are expected to orbit in outer space in the near future.<sup>52</sup> Most of these satellites will be in Low Earth Orbit ("LEO").<sup>53</sup> Almost all of them are focused on the Earth, whether for civilian or for military purposes.<sup>54</sup> Most satellites in orbit are now civilian.<sup>55</sup> These satellites represent advanced technology

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<sup>48</sup> See McFall-Johnson & Mosher, *supra* note 44.

<sup>49</sup> Tate Ryan-Mosley et al., *The Number of Satellites Orbiting Earth Could Quintuple in the Next Decade*, MASS. INST. TECH. REV. (June 26, 2019), <https://www.technologyreview.com/2019/06/26/755/satellite-constellations-orbiting-earth-quintuple/> [<https://perma.cc/53YR-MKRF>].

<sup>50</sup> John P. Thomas, *5G From Space: 20,000 Satellites to Blanket the Earth*, TECHNOCRACY (Jan. 8, 2019), <https://www.technocracy.news/5g-from-space-20000-satellites-to-blanket-the-earth/> [<https://perma.cc/7ES5-JZ7X>].

<sup>51</sup> M. Bruno, *Rocket Lab, Wallops Island Spaceport Expect Big U.S. Launch Growth*, AVIATION WK. (Dec. 18, 2019), <https://aviationweek.com/defense-space/rocket-lab-wallops-island-spaceport-expect-big-us-launch-growth> [<https://perma.cc/4ZKF-XZ52>]. Paul Larsen, *Minimum International Norms for Managing Space Traffic, Space Debris and Near Earth Objects Impacts*, 83 J. AIR L. & COM. 739, 751 (2018).

<sup>52</sup> Kestutis Paulauskas, *Space: NATO's Latest Frontier*, NATO REV. (Mar. 13, 2020), <https://www.nato.int/docu/review/articles/2020/03/13/space-natos-latest-frontier/index.html> [<https://perma.cc/GEX5-9WGJ>].

<sup>53</sup> *Id.*

<sup>54</sup> Paris Agreement, *supra* note 11, at 1.

<sup>55</sup> Aditya Chaturvedi, *How Satellite Imagery is Crucial for Monitoring Climate Change*,

capable of providing an “effective and progressive response to the urgent threat of climate change.”<sup>56</sup> Space powers like the United States, Russia, China, India, and ESA possess the space technology necessary to measure and monitor the earthly effects of climate change.<sup>57</sup> However, climate change is a global phenomenon affecting all states.<sup>58</sup> Cooperation by all countries is crucial to counter the effects of climate change.

A. *Remote Sensing Satellites*<sup>59</sup>

Earth observation by remote sensing satellites is the most effective tool available for individual states to observe their own territory, as well as to verify that other states perform their commitments under international laws, such as the UNFCCC<sup>60</sup> and the Paris Agreement.<sup>61</sup> Satellite images are particularly valuable because: (1) they provide a bird’s eye view of everything that moves that one does not get from the ground; (2) they provide a continuous view that moves from the scale of individual buildings all the way up to the entire Earth; and (3) they make it possible to “see” things beyond the electromagnetic spectrum that would otherwise limit human sight.<sup>62</sup> Satellite images allow views of the entire landscape, including infrared and long wave-length, so as to provide, for example, a complete view of surface vegetation.<sup>63</sup>

Earth observation from outer space is particularly useful because outer space is not constrained by territorial sovereignty, which limits movements on the earth and in territorial airspace.<sup>64</sup> States are free to perform the crucial tasks of remote sensing the earth, sea temperatures, and the consistency of the atmosphere.<sup>65</sup> This basic outer space legal principle was established early in the space age by the 1967 Outer Space

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GEOSPATIAL WORLD (Jan. 30, 2020), <https://www.geospatialworld.net/blogs/satellites-for-monitoring-climate-change/> [<https://perma.cc/2UV2-ZTKA>].

<sup>56</sup> Paris Agreement, *supra* note 11.

<sup>57</sup> See LYALL & LARSEN, *supra* note 36, at 359–86.

<sup>58</sup> See Convention on Climate Change, *supra* note 8.

<sup>59</sup> See Paris Agreement, *supra* note 11.

<sup>60</sup> *Introduction to Satellite Imagery*, POLAR GEOSPATIAL CTR. UNIV. MINN. (Jan. 30, 2017), <https://www.pgc.umn.edu/guides/commercial-imagery/intro-satellite-imagery/> [<https://perma.cc/X7G3-6WJ6>].

<sup>61</sup> Karen Seto, *The Big Picture*, YALE ALUMNAE MAG. Jan.–Feb. 2020, at 55.

<sup>62</sup> Outer Space Treaty, *supra* note 26, at art. II.

<sup>63</sup> *Id.* at art. I.

<sup>64</sup> *Id.*

<sup>65</sup> *Id.*

Treaty (“OST”), Article I.<sup>66</sup> “Outer space, including the Moon and celestial bodies shall be free for exploration and use by all States.”<sup>67</sup> Remote sensing from outer space of the earth, sea temperature, and atmospheric consistency are absolutely crucial for climate change mitigation. Unhindered by sovereign borders, satellites in outer space may freely observe climate change effects not only in their own national countries, but also in foreign countries and the oceans.<sup>68</sup> However, satellites in outer space are subject to international space law, in particular the OST.<sup>69</sup> This includes Earth observation from outer space orbit. Being subject to the OST, outer space is not subject to national claims of sovereignty, hence it is free for use.<sup>70</sup> Therefore, the major space powers<sup>71</sup> have asserted that they have legal rights to engage in remote sensing of Earth by satellite from outer space.<sup>72</sup> However, the OST, Article VI, requires satellites, including remote sensing satellites, to be duly licensed by a national state.<sup>73</sup>

Earth observation, using remote sensing satellites, is an effective tool available to monitor and regulate climate change effects globally. For example, the United States National Aeronautics and Space Administration (“NASA”) and ESA pollution measuring satellites showed that Chinese and Italian industrial production of nitrogen dioxide (“NO<sub>2</sub>”) emissions declined sharply from January 2020 to March 2020 when industrial output was curtailed because of government imposed quarantine due to COVID-19.<sup>74</sup>

Detailed accuracy (high-resolution) of remotely sensed images enables an observer to appreciate the intensity of climate change. New

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<sup>66</sup> Nola T. Redd, *Two New Satellites Will Launch This Year to Track Earth’s Rising Oceans*, SPACE.COM (Jan. 12, 2020), <https://www.space.com/nasa-satellite-to-track-rising-oceans-on-earth.html> [<https://perma.cc/8KVV-E4VV>].

<sup>67</sup> LYALL & LARSEN, *supra* note 36. See discussion of U.N. principles relating to the Remote Sensing of the Earth from Outer Space G.A. Res. 41/65, Principle III (Dec. 3, 1986).

<sup>68</sup> See Outer Space Treaty, *supra* note 26.

<sup>69</sup> LYALL & LARSEN, *supra* note 36. See discussion of U.N. principles relating to the Remote Sensing of the Earth from Outer Space G.A. Res. 41/65, Principle III (Dec. 3, 1986).

<sup>70</sup> See Outer Space Treaty, *supra* note 26.

<sup>71</sup> LYALL & LARSEN, *supra* note 36, at 458 (The United States, Russia, China, ESA and India are considered the major space powers).

<sup>72</sup> *Id.* at 367.

<sup>73</sup> See Outer Space Treaty, *supra* note 26, at art. VI.

<sup>74</sup> Caroline Davies, *Dramatic Fall in China Pollution Levels ‘Partly Related’ to Coronavirus*, GUARDIAN (Mar. 1, 2020), <https://www.theguardian.com/environment/2020/mar/01/dramatic-fall-in-china-pollution-levels-partly-related-to-coronavirus> [<https://perma.cc/FAT3-5LPA>]; *Coronavirus: Nitrogen Dioxide Emissions Drop Over Italy*, EUR. SPACE AGENCY (Mar. 13, 2020), [https://www.esa.int/ESA\\_Multimedia/Videos/2020/03/Coronavirus\\_nitrogen\\_dioxide\\_emissions\\_drop\\_over\\_Italy](https://www.esa.int/ESA_Multimedia/Videos/2020/03/Coronavirus_nitrogen_dioxide_emissions_drop_over_Italy) [<https://perma.cc/6ED6-G4EE>].

high-resolution remote sensing technology is increasingly able to observe detailed highly valuable images enabling governments to warn people and repair consequences of climate change disasters.<sup>75</sup> The degree of image resolution is crucial to revealing more detailed information about the earth's surface.<sup>76</sup> Much of the new remote sensing technology is privately owned and is only available at a steep price which many developing countries cannot afford to pay.<sup>77</sup> A recent report by the U.N. Committee for the Peaceful Uses of Outer Space ("COPUOS") recommended that satellite collected climate change observations about the most vulnerable parts of the Earth should be made freely available.<sup>78</sup>

The high price of high-resolution remote sensing is a continuing obstacle to its use for deterrence of climate change disasters.<sup>79</sup> In 2019, COPUOS took favorable notice of the 2017 declaration proposing establishment of a space climate observatory for the purpose of collecting and freely distributing data about climate change.<sup>80</sup> Such data can also be used for drawing models of possible consequences of such information.<sup>81</sup>

### B. *Communication Satellites*

Communication satellites are used to transmit information about climate change. Communication satellites serve as an alternate communication resource when land lines are not available. For example, during a recent earthquake disaster in Chile, the communication landlines became inoperable.<sup>82</sup> Satellite communication became the only available means of communication.<sup>83</sup> Climate change often involves disasters such as flooding or storms that make satellite communication necessary. Recently,

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<sup>75</sup> See *Earth Science Missions*, NASA, [https://climate.nasa.gov/nasa\\_science/missions?page0&per\\_page=40&order=title+asc&search=](https://climate.nasa.gov/nasa_science/missions?page0&per_page=40&order=title+asc&search=) [https://perma.cc/R26P-TZWR] (last updated Sept. 9, 2020).

<sup>76</sup> LYALL & LARSEN, *supra* note 36, at 429.

<sup>77</sup> See G.A. Res. 41/65, annex (Dec. 3, 1986).

<sup>78</sup> See *id.*; see generally Rep. of the Comm. on the Peaceful Uses of Outer Space, U.N. Doc. A/74/20, at 16 (June 2019) [hereinafter Report on Peaceful Uses of Outer Space].

<sup>79</sup> See CHRISTINA SECADES ET AL., SECRETARIAT OF THE CONVENTION ON BIOLOGICAL DIVERSITY, EARTH OBSERVATION FOR BIODIVERSITY MONITORING: A REVIEW OF CURRENT APPROACHES AND FUTURE OPPORTUNITIES FOR TRACKING PROGRESS TOWARDS THE AICHI BIODIVERSITY TARGETS 10 (2014).

<sup>80</sup> See Report on Peaceful Uses of Outer Space, *supra* note 78, at 38.

<sup>81</sup> See *id.*

<sup>82</sup> See Paul B. Larsen, *The Oslo Landslide: Disaster Management Law in the Space Age*, 40 WM. & MARY ENV'T L. & POL'Y REV. 335, 351 (2016).

<sup>83</sup> See *id.* at 363.

access to the Internet via satellite has become possible.<sup>84</sup> Small satellites are now orbiting in LEO for use as links to the internet.<sup>85</sup> They are highly valued because they are the sole means of communication for most people in developing countries.<sup>86</sup> Space-X obtained United States government authority to orbit more than 12,000 small satellites for internet access.<sup>87</sup> Several hundred communication satellites have already been launched.<sup>88</sup> Another private communication operator, One Web, is also launching hundreds of small satellites for global internet access.<sup>89</sup> These satellites will provide communication links for people who are isolated.<sup>90</sup>

Communication satellites are regulated by the International Telecommunication Union (“ITU”),<sup>91</sup> a U.N. specialized agency, which ensures unhindered navigation and communication with all satellites.<sup>92</sup> Communication satellites are essential during disasters. Parties to the Tampere Convention on Communication by Satellite During Disasters<sup>93</sup> agreed to share communications services during emergencies.<sup>94</sup> Tampere implements Article 46 of the ITU Constitution, in which ITU member states agree to accept and communicate emergency distress signals, giving such signals priority.<sup>95</sup> The U.N. Disaster Charter<sup>96</sup> established the U.N. Platform for Space-Based Information for Disaster Management and Emergency Response (“UN-SPIDER”)<sup>97</sup> as the central point of contact for use

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<sup>84</sup> See Jacqueline Feldscher, *A New Way to Provide Internet to the Masses from Space*, POLITICO (Mar. 13, 2020), <https://www.politico.com/news/2020/03/13/a-new-way-to-provide-internet-for-the-masses-from-space-127314> [<https://perma.cc/R6MC-98Y6>].

<sup>85</sup> See *id.*

<sup>86</sup> See *id.*

<sup>87</sup> Michael Sheetz & Magdalena Petrova, *Why in the Next Decade Companies Will Launch Thousands More Satellites Than in All of History*, CNBC (Dec. 15, 2019), <https://www.cnbc.com/2019/12/14/spacex-oneweb-and-amazon-to-launch-thousands-more-satellites-in-2020s.html> [<https://perma.cc/7MHM-U5G7>].

<sup>88</sup> See *id.*

<sup>89</sup> *Id.*

<sup>90</sup> See *id.*

<sup>91</sup> COLLECTION OF THE BASIC TEXTS OF THE INTERNATIONAL TELECOMMUNICATION UNION ADOPTED BY THE PLENIPOTENTIARY CONFERENCE, at 3–5 (2015) [hereinafter 2015 ITU TEXTS].

<sup>92</sup> See INTERNATIONAL LAW IN THE ERA OF CLIMATE CHANGE, *supra* note 1, at 176, 185. See also LYALL & LARSEN, *supra* note 36, at 211–14.

<sup>93</sup> Convention on the Provision of Telecommunication Resources for Disaster Mitigation and Relief Operations, June 18, 2020, 2296 U.N.T.S. [hereinafter Tampere Convention].

<sup>94</sup> *Id.* at art. III.

<sup>95</sup> See 2015 ITU TEXTS, *supra* note 91, at art. XLVI.

<sup>96</sup> G.A. Res. 61/110, ¶ 6 (Dec. 14, 2006).

<sup>97</sup> *Id.* ¶¶ 15–16.

by states during disasters.<sup>98</sup> The U.N. Emergency Coordinator<sup>99</sup> acts as the contact person for all requests for assistance under the Tampere Convention.<sup>100</sup> Only the Convention's state parties have access to its services.<sup>101</sup> Assistance without the agreement of the affected states is outside the scope of the Convention.<sup>102</sup>

### C. *Weather Satellites*

The Paris Agreement, Article 9, warns that extreme weather is associated with climate change.<sup>103</sup> Weather satellites provide specialized information regarding temperature changes and weather disasters caused by global warming.<sup>104</sup> A consequence of weather satellite technology is that governmental and non-governmental international relief can be deployed in advance of weather disasters.<sup>105</sup> Advance warning of extreme weather is provided by weather satellites. Weather information is reported to the World Meteorological Organization ("WMO"), which is a U.N. specialized agency.<sup>106</sup> Virtually all countries are members of the WMO.<sup>107</sup> It coordinates the use of weather satellites by individual national governments and provides guidelines for the most effective satellite deployment, use and distribution of information.<sup>108</sup>

The Global Climate Observation System ("GCOS") receives climate reports from more than one thousand stations around the Earth.<sup>109</sup> GCOS was organized by the Second World Climate Conference in 1992 to provide fair and even distribution of climate information to states regardless of

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<sup>98</sup> *See id.* ¶ 6.

<sup>99</sup> Tampere Convention, *supra* note 93, at art. II.

<sup>100</sup> *Id.*

<sup>101</sup> *Id.*

<sup>102</sup> *See* Larsen, *supra* note 82, at 364.

<sup>103</sup> Paris Agreement, *supra* note 11, at art. VIII.

<sup>104</sup> *See* Robin McKie, *5G Signals Could Jam Satellites that Help with Weather Forecasting*, GUARDIAN (May 4, 2019), <https://www.theguardian.com/world/2019/may/04/5g-mobile-networks-threat-to-world-weather-forecasting> [<https://perma.cc/VM5P-PUEL>] (a related issue is that the use of 5G signals could disrupt transmission of information from weather satellites).

<sup>105</sup> Jane Lubchenco & Jack Hayes, *New Technology Allows Better Extreme Weather Forecasts*, SCI.AM. (May 1, 2012), <https://www.scientificamerican.com/article/a-better-eye-on-the-storm/> [<https://perma.cc/L3RE-ZTHP>].

<sup>106</sup> Convention of the World Meteorological Organisation, Oct. 11, 1947, U.N.T.S. 142.

<sup>107</sup> *Id.*

<sup>108</sup> *See id.*

<sup>109</sup> Larsen, *supra* note 82, at 343.

their economic development.<sup>110</sup> GCOS is cosponsored by WMO, the Intergovernmental Oceanographic Commission, the U.N. Environmental Program,<sup>111</sup> and the International Science Council.<sup>112</sup>

The European Organisation for the Exploitation of Meteorological Satellites (“EUMETSAT”) was specially created to manage weather information for European countries.<sup>113</sup> Article 2 of the Convention for the Establishment of a European Organization for the Exploitation of Meteorological Satellites establishes EUMETSAT’s special focus to detect global warming temperature changes.<sup>114</sup>

#### D. Global Navigation Satellite Systems<sup>115</sup>

Global Navigation Satellite Systems (“GNSS”) have multiple functions. They are important tools for avoidance of disasters. They are used to detect the heights of oceans and warn states of approaching tsunamis.<sup>116</sup> There are now four global GNSS systems: the United States Global Positioning System (“GPS”), the European Galileo, the Russian Glonass and the Chinese BeiDou.<sup>117</sup> The four systems are increasingly designed to be interoperable, that is, the users do not necessarily know which of the four systems are presently delivering information.<sup>118</sup>

The GNSS satellites are able to detect Earth and sea movements everywhere; thus, from communication buoys in the ocean they can identify high waters.<sup>119</sup> The GNSS satellites measure time and movements precisely.<sup>120</sup> GNSS receivers track the satellites; they compare timing

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<sup>110</sup> See *The GCOS Story*, GLOB. CLIMATE OBSERVATION SYS., <https://gcos.wmo.int/en/about/gcos-story> [<https://perma.cc/N6JU-YSNC>] (last visited Oct. 13, 2020).

<sup>111</sup> See *id.*

<sup>112</sup> See *id.*

<sup>113</sup> Convention for the Establishment of a European Organization for the Exploitation of Meteorological Satellites (EUMETSAT), May 24, 1983, 1434 U.N.T.S. 3, 18–20.

<sup>114</sup> See *id.* at art. II.

<sup>115</sup> LYALL & LARSEN, *supra* note 36, at 337.

<sup>116</sup> C. Falck et al., *Near Real-Time GPS Applications for Tsunami Early Warning Systems*, 10 NAT. HAZARDS EARTH SYS. SCIS. 181 (2010).

<sup>117</sup> LYALL & LARSEN, *supra* note 36, at 349.

<sup>118</sup> Paul B. Larsen, *International Regulation of Global Navigation Satellite Systems*, 80 J. AIR L. & COM. 365, 374–75 (2015).

<sup>119</sup> Yen-Pin Lin et al., *Development of a GNSS Buoy for Monitoring Water Surface Elevations in Estuaries and Coastal Areas*, 17 SENSORS 172 (2017).

<sup>120</sup> LYALL & LARSEN, *supra* note 36, at 349.

signals from several satellites.<sup>121</sup> Thus, they are able to determine and transmit the precise location and direction of the activities being tracked. Assistance can be directed, people can be warned, and obstacles can be avoided. Furthermore, data about movements of the oceans can be collected and sent to aid research of climate change effects.<sup>122</sup>

*E. Shielding the Earth from Solar Heat by Geospatial Engineering*<sup>123</sup>

The idea of shielding the Earth from the Sun by geospatial engineering and thereby reducing global warming has been actively studied.<sup>124</sup> That might be accomplished by placing a reflective shield between the Earth and the Sun. Placing a shield in the atmosphere would have to be authorized by a state in accordance with OST Article VI, which would have the effect of making the shield the responsibility of the authorizing state.<sup>125</sup> One approach would be to place the shield far away at Lagrange Point One (1.5 million kilometers from the Earth).<sup>126</sup> Another idea is to spread a reflective band of dust around the Earth in LEO.<sup>127</sup> However, such a band would in effect be the same as space debris and could interfere with navigation.<sup>128</sup> Both approaches would require international consultation required by OST, Article IX,<sup>129</sup> because such shields or bands might interfere with outer space navigation by some countries.<sup>130</sup> It might also violate the Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques (“ENMOD”).<sup>131</sup> Articles I and II prohibit interference with the atmosphere of the earth for hostile purposes.<sup>132</sup> Furthermore, the state placing a shield or reflective

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<sup>121</sup> *Id.*

<sup>122</sup> See F. Geremia-Nievinski et al., *SNR-Based GNSS Reflectometry for Coastal Sea-Level Altimetry: Results from the First IAG Inter-Comparison Campaign*, 94 J. GEODESY 70 (2020).

<sup>123</sup> See Lyall, *supra* note 1, at 185; see also LYALL & LARSEN, *supra* note 36, at 258–59.

<sup>124</sup> See LYALL & LARSEN, *supra* note 36, at 258–59.

<sup>125</sup> See Lyall, *supra* note 1, at 188.

<sup>126</sup> LYALL & LARSEN, *supra* note 36, at 259.

<sup>127</sup> *Id.*

<sup>128</sup> See Lyall, *supra* note 1, at 186–87.

<sup>129</sup> Outer Space Treaty, *supra* note 26, at 2416–17.

<sup>130</sup> See Lyall, *supra* note 1, at 186–87.

<sup>131</sup> See Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques, Dec. 10, 1976, 1108 U.N.T.S. 151, 153.

<sup>132</sup> *Id.*

dust in outer space might become liable for damages caused, pursuant to Article VI of the Convention on International Liability for Damage Caused by Space Objects.<sup>133</sup> Placing a protective shield in outer space would also interfere with astronomy and might cause harmful interference with satellite communication. It would be difficult to remove such a shield after launch.<sup>134</sup> In view of these obstacles, it appears that shielding the Earth from the Sun is possible, but it is not recommended because of its likely adverse effects. It would trigger the precautionary principle, which cautions against conduct of unsafe experiments in outer space.<sup>135</sup>

## II. INTERNATIONAL LAWS AND REGULATIONS AFFECTING CLIMATE CHANGE

### A. *Definition of Outer Space*

Because outer space is non-sovereign territory, it is widely governed by international law, regulations, guidelines, and recommended practices.<sup>136</sup> The OST<sup>137</sup> is the primary source of international space law; however, various environmental international laws also apply.<sup>138</sup> Under OST, Articles VI and VIII, states can only exercise jurisdiction over their own satellites and satellites on their registry.<sup>139</sup> The limited application of state jurisdiction in outer space is further limited by the relationship of state-authorized satellites with satellites of other countries in non-sovereign outer space.

However, national jurisdiction and control over airspace extends to airspace above individual countries.<sup>140</sup> The airspace over the high seas

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<sup>133</sup> See Liability Convention, *supra* note 26, at 2394–95.

<sup>134</sup> Lyall, *supra* note 1, at 186.

<sup>135</sup> Paul B. Larsen, *Application of the Precautionary Principle to the Moon*, 71 J. AIR L. & COM. 296 (2006). The parties to the 1992 Convention on Biological Diversity (CBD), 1769 U.N.T.S. 79, decided in 2020 there should be no geo-engineering regarding climate in the absence of scientific basis justifying such actions. See Conf. of the Parties to the Convention on Biological Diversity, Decision Adopted by the Conference of the Parties to the Convention on Biological Diversity at Its Tenth Meeting, U.N. Doc. UNEP/CBD/COP/DEC/X/33 5 (Oct. 29, 2010).

<sup>136</sup> Outer Space Treaty, *supra* note 26, at 2413.

<sup>137</sup> *Id.* (Article III of the Outer Space Treaty provides for application of other international laws in outer space).

<sup>138</sup> Lyall, *supra* note 1, at 176–79.

<sup>139</sup> Outer Space Treaty, *supra* note 26, at 2415–16.

<sup>140</sup> Convention on International Civil Aviation, art. 1, Dec. 7, 1944, 15 U.N.T.S. 295.

is non-sovereign as defined by the U.N. Convention on the Law of the Sea.<sup>141</sup> The limited exercise of individual national jurisdiction on space activities causes the question to arise: where does sovereign air space end and non-sovereign outer space begin? A number of states (for example, Australia)<sup>142</sup> have cut the puzzle short by enacting national law claiming territoriality in their airspace up to the height of 100 kilometers altitude above sea level.<sup>143</sup> But the fact is that some international space powers, such as the United States, have not joined this trend. The United States refuses to establish and to recognize such unilateral borders between airspace and outer space.<sup>144</sup> Nevertheless, the 100 kilometer rule is beginning to receive recognition and application in the absence of intentionally agreed delimitation.<sup>145</sup> One reason is that the 100 kilometer altitude is approximately the minimum altitude at which satellites can remain in orbit.<sup>146</sup> There is no definite international agreement on the altitude at which outer space begins.<sup>147</sup> The OST addresses this issue indirectly by specifically applying to satellites in orbit.<sup>148</sup> Thus, satellites in orbit are subject to international space law.

### B. *Common Interests in a Sustainable Earth*

Outer space, like the deep seabed, can be viewed legally as a global commons.<sup>149</sup> International climate regulations are for the protection of

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<sup>141</sup> United Nations Convention on the Law of the Sea, n.d., 1833 U.N.T.S. 3, 400, 433; see Rosemary Rayfuse, *Climate Change and the Law of the Sea*, in INTERNATIONAL LAW IN THE ERA OF CLIMATE CHANGE, *supra* note 1, at 147, 149.

<sup>142</sup> LYALL & LARSEN, *supra* note 36, at 444.

<sup>143</sup> Comm. on the Peaceful Uses of Outer Space, Legal Subcomm. on Its Fifty-Sixth Session, Matters Relating to the Definition and Delimitation of Outer Space: Replies of the International Institute of Space Law (IISL), U.N. Doc. A/AC.105/C.2/2017/CRP.29 (Apr. 3, 2017); LYALL & LARSEN, *supra* note 36, at 149.

<sup>144</sup> U.S. Dep't of State, Statement by the Delegation of the United States of America, <https://2009-2017.state.gov/s/l/22718.htm> [<https://perma.cc/N7PU-JNZ7>] (last visited Oct. 13, 2020).

<sup>145</sup> LYALL & LARSEN, *supra* note 36, at 149.

<sup>146</sup> *Id.* at 148.

<sup>147</sup> *Id.* at 135.

<sup>148</sup> See Outer Space Treaty, *supra* note 26, at 2413 ("Parties to the Treaty undertake not to place in orbit around the Earth any objects carrying nuclear weapons or any other kinds of weapons of mass destruction.").

<sup>149</sup> See Paul B. Larsen, *Outer Space: How Shall the World's Governments Establish Order Among Competing Interests?*, 29 WASH. INT'L L.J. 1, 22–26 (2019) (discussing the Potential Order Based on Global Commons Principle).

life on Earth.<sup>150</sup> Both the UNFCCC and the Paris Agreement are based on the principle that the earth's environment is fragile and needs joint international management, reflecting the interests of all stakeholders.<sup>151</sup> As countries organize their climate responses by participating in the UNFCCC and the Paris Agreement, they will find analogous efforts in other space laws; for example, the entire radio frequency spectrum is managed through the ITU,<sup>152</sup> and the OST<sup>153</sup> supports global community interests, such as climate change, on Earth. It provides that outer space activities by communication, earth observation, and weather satellites "shall be carried out for the benefit and in the interests of all countries irrespective of their degree of economic or scientific development."<sup>154</sup> Outer space cannot be appropriated by individual nations.<sup>155</sup> It belongs to everybody and can be used by national space satellites to protect Earth from the disastrous consequences of global warming. Space resources must be used in accordance with international law. Outer space activities, including remote sensing and weather satellites, must comply with the OST.<sup>156</sup>

In outer space, there is a blend of governmental and non-governmental activities.<sup>157</sup> States are required to authorize and supervise both governmental and non-governmental outer space activities.<sup>158</sup> Individual governments exercise jurisdiction and control over their satellites in outer space.<sup>159</sup> Failure to do so may result in international responsibility of individual governments.<sup>160</sup> National outer space activities shall be conducted "with due regard to the corresponding interests of all other State Parties to the Treaty."<sup>161</sup> Concerned state parties "may request consultations concerning the activity or experiment."<sup>162</sup> Finally, state parties are

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<sup>150</sup> See Jutta Brunnée, *Climate Change and Compliance and Enforcement Processes*, in INTERNATIONAL LAW IN THE ERA OF CLIMATE CHANGE, *supra* note 1, at 290, 290–96.

<sup>151</sup> Paris Agreement, *supra* note 11; Convention on Climate Change, *supra* note 8.

<sup>152</sup> 2015 ITU TEXTS, *supra* note 91, at art. 44; Larsen, *supra* note 149, at 24, 26.

<sup>153</sup> Outer Space Treaty, *supra* note 26.

<sup>154</sup> *Id.* at art. I.

<sup>155</sup> *Id.* at art. II.

<sup>156</sup> *Cf. id.* at art. VII (generally stating terms for objects launched into space, applicable to concrete examples given here).

<sup>157</sup> *See id.* at art. VI.

<sup>158</sup> *See id.*

<sup>159</sup> *See* Outer Space Treaty, *supra* note 26, at arts. VI–IX.

<sup>160</sup> *See id.* at art. VII; Liability Convention, *supra* note 26.

<sup>161</sup> Outer Space Treaty, *supra* note 26, at art. IX.

<sup>162</sup> *Id.*

required to keep the public<sup>163</sup> and the U.N. Secretary General<sup>164</sup> informed about their outer space activities. Consequently, the OST, being almost universally adopted by all states having an interest in outer space, including all the space powers, may be viewed as the Constitution for outer space activities.<sup>165</sup> These crucial parts of the Treaty are accepted by all as customary international law.<sup>166</sup>

C. *Use of Other Planets for Resettlement of Life from Earth to Escape Climate Change Consequences*

The OST governs “exploration and use of outer space, including the Moon and other celestial bodies.”<sup>167</sup> National appropriation of celestial bodies is not permitted,<sup>168</sup> and non-governmental uses require governmental authorization and continuing national supervision to ensure compliance with the OST.<sup>169</sup> States retain jurisdiction and control of their own satellites landed on other celestial bodies, and ownership remains governed by national laws.<sup>170</sup> Furthermore, individual states must respect the interests of other states while on celestial bodies.<sup>171</sup> Thus, those who would avoid the climate change crisis on Earth by escaping to other planets would still be subject to earthly regulations.<sup>172</sup>

D. *The 1987 Montreal Protocol to the Convention for the Protection of the Ozone Layer*<sup>173</sup>

The Montreal Protocol banning the chemicals that destroy the earth's ozone layer is a model for climate change mitigation. The Protocol was adopted in 1987.<sup>174</sup> It quickly went into force in 1989, because the

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<sup>163</sup> See *id.* at art. XI.

<sup>164</sup> See *id.* at arts. V–XI.

<sup>165</sup> See LYALL & LARSEN, *supra* note 36, at 49.

<sup>166</sup> See *id.* at 64.

<sup>167</sup> Outer Space Treaty, *supra* note 26, at art. I.

<sup>168</sup> *Id.* at art. II.

<sup>169</sup> See *id.* at art. VI.

<sup>170</sup> See *id.* at art. VIII.

<sup>171</sup> See *id.* at art. IX.

<sup>172</sup> See *id.*

<sup>173</sup> Montreal Protocol, *supra* note 21.

<sup>174</sup> *Id.*

stratospheric ozone hole in Antarctica was growing alarmingly.<sup>175</sup> The Montreal Protocol and its subsequent additions regulate aerosols and other substances that deplete the layer of ozone surrounding the earth.<sup>176</sup> The objective is to bring the level of ozone back to its 1980 level.<sup>177</sup> The Montreal Protocol establishes a global regulatory structure for elimination of aerosols.<sup>178</sup> It has been updated several times, as necessary, due to new discoveries of dangers to the ozone layer.<sup>179</sup> The Montreal Protocol's regulatory framework establishes time frames for reducing emissions.<sup>180</sup> It establishes termination dates for different substances in order to reach the goal of reducing banned substances.<sup>181</sup> The termination dates for developing countries are longer than for developed countries.<sup>182</sup>

Adoption and national enforcement of the Montreal Protocol succeeded in reducing the ozone hole over the Antarctic; but, as a result of increases in emissions and resulting climate change, it remains necessary to continue monitoring the problem.<sup>183</sup> Towards that objective, ESA has decided to launch new satellites carrying instruments that measure stratospheric ozone and other atmospheric trace gases such as nitrogen dioxide and aerosols affecting air quality.<sup>184</sup>

The Montreal Protocol is the most important precedent for later international agreements to alleviate climate change, such as the UNFCCC and the Paris Agreement. The ozone depletion addressed by the Montreal Protocol is similar to our current climate problems.<sup>185</sup> The Montreal

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<sup>175</sup> *Id.*; *World of Change: Antarctic Ozone Hole*, NASA, <https://earthobservatory.nasa.gov/world-of-change/Ozone> [<https://perma.cc/7CQR-QAAT>] (last visited Oct. 13, 2020).

<sup>176</sup> *About Montreal Protocol*, U.N. ENV'T PROGRAMME, <https://www.unenvironment.org/ozonaction/who-we-are/about-montreal-protocol> [<https://perma.cc/MMR5-GZNP>] (last visited Oct. 13, 2020).

<sup>177</sup> *Is the Ozone Layer on the Mend? Highlights From the Most Recent WMO/UNEP Ozone Assessment*, WORLD METEOROLOGICAL ORG., <https://public.wmo.int/en/resources/bulletin/ozone-layer-mend-0> [<https://perma.cc/9Z7R-UKHR>] (last visited Oct. 13, 2020).

<sup>178</sup> Montreal Protocol, *supra* note 21, at arts. I–III.

<sup>179</sup> *See, e.g., Recent International Developments under the Montreal Protocol*, EPA, <https://www.epa.gov/ozone-layer-protection/recent-international-developments-under-montreal-protocol> [<https://perma.cc/3SUF-AUK4>] (last visited Oct. 13, 2020).

<sup>180</sup> Montreal Protocol, *supra* note 21, at arts. II–V.

<sup>181</sup> *Id.* at arts. II–V, annex A.

<sup>182</sup> *Id.* at art. V.

<sup>183</sup> *Contract Secures Build of Ozone-Monitoring Altius Satellite*, EUR. SPACE AGENCY, [http://www.esa.int/Applications/Observing\\_the\\_Earth/Contract\\_secures\\_build\\_of\\_ozone-monitoring\\_Altius\\_satellite](http://www.esa.int/Applications/Observing_the_Earth/Contract_secures_build_of_ozone-monitoring_Altius_satellite) [<https://perma.cc/76T5-6CY7>] (last visited Oct. 13, 2020).

<sup>184</sup> *Id.*

<sup>185</sup> *The World Solved the Ozone Problem. It Can Solve Climate Change*, N.Y. TIMES

Protocol proves that states can successfully agree on a common, although diversified, solution and carry it out.<sup>186</sup> It constitutes a model for dealing with climate change.

*E. The 1992 United Nations Framework Convention on Climate Change*<sup>187</sup>

The UNFCCC<sup>188</sup> is virtually universally adopted by states.<sup>189</sup> The long-term objective of the UNFCCC is to stabilize the concentration of greenhouse gas.<sup>190</sup> The UNFCCC was strongly supported by the U.N. in its 2015 Declaration on Sustainable Development.<sup>191</sup> The United States remains a party to the UNFCCC.<sup>192</sup> The Convention is the authorizing legal authority for the Paris Agreement, which is considered to be an executive agreement by the United States, meaning that Paris implements and executes the UNFCCC.<sup>193</sup> Thus, the Paris Agreement does not require Senate approval.<sup>194</sup> All the definitions listed in Article 1 of the UNFCCC apply to the Paris Agreement.<sup>195</sup> Most importantly, UNFCCC Article 1(2) defines climate change as “a change of climate which is attributed directly or indirectly to *human* activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods.”<sup>196</sup> It defines climate change as being caused by human beings.<sup>197</sup> It does not concern

(Dec. 7, 2019), <https://www.nytimes.com/2019/12/07/opinion/sunday/ozone-climate-change.html> [<https://perma.cc/F59F-L6CC>].

<sup>186</sup> Montreal Protocol, *supra* note 21.

<sup>187</sup> Convention on Climate Change, *supra* note 8, at Art. 1(2) defines climate change as “a change of climate which is activated directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods.” *Id.*

<sup>188</sup> *Id.* at 165.

<sup>189</sup> See *Status of Ratification of the Convention*, UNFCCC, <https://unfccc.int/process-and-meetings/the-convention/status-of-ratification/status-of-ratification-of-the-convention> [<https://perma.cc/Y46A-8PNC>] (last visited Oct. 13, 2020).

<sup>190</sup> See Emissions Gap Report 2019, *supra* note 23 and accompanying text.

<sup>191</sup> See G.A. Res. 70/1, ¶¶ 31–32 (Sept. 25, 2015).

<sup>192</sup> See Convention on Climate Change, *supra* note 8, at art. 12, annex 1–2.

<sup>193</sup> See Paris Agreement, *supra* note 11, at art. II.

<sup>194</sup> See ERWIN CHEMERINSKY, CONSTITUTIONAL LAW PRINCIPLES AND POLICIES 271–73 (Aspen Law & Business 1997) (explaining why the Paris Agreement did not need U.S. Senate consent to go into effect).

<sup>195</sup> Paris Agreement, *supra* note 11, at art. 1.

<sup>196</sup> Convention on Climate Change, *supra* note 8, at art. 1(2).

<sup>197</sup> See *id.*

climate changes caused by “*natural* variables,” like variations in solar heat.<sup>198</sup> The use of space technology and application of space law discussed in this Article is similarly limited to climate change caused by human intervention.

Each of the UNFCCC parties have committed to making regular inventories of their production of emissions as well as to remove emissions through oceanic and other sinks.<sup>199</sup> They commit to engage in sustainable management of all facilities producing emissions.<sup>200</sup> They also commit to promote relevant technology and law,<sup>201</sup> which would include space technology and law.<sup>202</sup> Developed countries commit to extend and also to transfer to developing countries technological resources, such as remote sensing satellite technology used to modify climate emissions.<sup>203</sup> Parties also agree to share and coordinate information freely in order to minimize duplication. Annexes to the UNFCCC<sup>204</sup> assign to developed countries special economic and technological tasks in assisting and training developing countries. The UNFCCC authorizes<sup>205</sup> reduction of global climate change effects, whereas the Paris Agreement serves as an implementing agreement.<sup>206</sup>

#### F. *The 2015 Paris Agreement on Climate Change*<sup>207</sup>

To reach the objective of the UNFCCC, the parties realized that further negotiations would be necessary.<sup>208</sup> The UNFCCC needed stronger and firmer commitments by the parties, in particular the developed countries, to accomplish the objective of stabilizing the concentration of

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<sup>198</sup> See discussion, *supra* note 30.

<sup>199</sup> See Convention on Climate Change, *supra* note 8, at art. 4.

<sup>200</sup> See Report on Peaceful Uses of Outer Space, *supra* note 78, ¶¶ 292–301.

<sup>201</sup> See Convention on Climate Change, *supra* note 8, at art. 4.

<sup>202</sup> See *id.*

<sup>203</sup> See *id.*

<sup>204</sup> See *id.* at art. 4, annexes I–II.

<sup>205</sup> Compare Outer Space Treaty, *supra* note 26, at art. VI (government authorization of nongovernmental satellite operators) with Convention on Climate Change, *supra* note 8, at art. 2.

<sup>206</sup> See Laurence Boisson de Chazournes, United Nations Framework Convention on Climate Change, U.N. AUDIOVISUAL LIBR. INT’LL. 1–2 (2008), [https://legal.un.org/avl/pdf/ha/ccc/ccc\\_e.pdf](https://legal.un.org/avl/pdf/ha/ccc/ccc_e.pdf) [<https://perma.cc/RSP3-56D8>]; INTERNATIONAL LAW IN THE ERA OF CLIMATE CHANGE, *supra* note 1, at 300–01.

<sup>207</sup> See Paris Agreement, *supra* note 11, at art. 2.

<sup>208</sup> See *id.*

greenhouse gas.<sup>209</sup> Recognition of this need first led the parties to the UNFCCC to conclude the 1997 Kyoto Protocol to the Framework Convention.<sup>210</sup> The Kyoto Protocol was also insufficient and led to the agreement to convene the conference that concluded the Paris Agreement in 2015.<sup>211</sup>

### 1. Objectives of the Paris Agreement

The Paris Agreement details the urgency of climate change on planet Earth.<sup>212</sup> It recognizes that all aspects of living on Earth will change drastically unless remedial measures are taken.<sup>213</sup> Climate change affects everybody so everybody is in the same boat. The objective of the Agreement is to provide a unified reaction to climate change on behalf of all living beings on the earth.<sup>214</sup> Thus, states agreed to<sup>215</sup>: “[H]olding the increase in the global average temperature to well below 2 degrees Celsius above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5 degrees Celsius above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change.”<sup>216</sup>

It can be questioned whether the stated goal of limiting global warming to 1.5 degrees Celsius above pre-industrial levels will be sufficient. The 2019 U.N. Intergovernmental Panel on Climate Change Special Report on Global Warming of 1.5 degrees<sup>217</sup> concluded that achievement of this goal would require “deep emission reduction” towards net zero

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<sup>209</sup> See Convention on Climate Change, *supra* note 8, at art. 1(2) (defining climate change as “a change of climate which is activated directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods.”).

<sup>210</sup> See *id.* at 1–2.

<sup>211</sup> See Paris Agreement, *supra* note 11, at 1.

<sup>212</sup> *Id.*

<sup>213</sup> See *id.*

<sup>214</sup> See *id.*

<sup>215</sup> *Id.* at art. 2(a), 4(1) (this goal is varied by Article 4(1) which adds the additional goal of achieving a balance between anthropogenic emissions and removals of greenhouse gases by sinks). See also Gerd Winter, *Armando Carvalho and Others v. EU: Invoking Human Rights and the Paris Agreement for Better Climate Protection Legislation*, 9 TRANS-NAT'L ENV'T L. 137, 144 (2020) (describing the flexibility in the upper temperature limit within the Paris Agreement).

<sup>216</sup> See discussion of Greenland ice excavations and pre-industrial emissions *supra* note 13.

<sup>217</sup> See *Headline Statements*, INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, <https://www.ipcc.ch/sr15/resources/headline-statements/> [<https://perma.cc/2UFG-HLJL>] (last visited Oct. 13, 2020).

emissions by 2050.<sup>218</sup> It would also require large reduction of other emissions, besides CO<sub>2</sub>, such as methane and nitrous oxide.<sup>219</sup> However, even achieving global warming below 1.5 degrees would still result in significant droughts, famines, stress from heat, species die-off, loss of ecosystems, loss of land, and movement of a large number of people into poverty.<sup>220</sup> The urgency of resolving the climate change crisis is thus evident. A huge amount of work and sacrifice is required.

## 2. Nationally Determined Inventories of Emissions

The Paris Agreement is founded on the basic premise that the burdens of the common work to cope with the problems of climate change must be distributed among the states in accordance with the ability of the peoples to contribute.<sup>221</sup> Thus, the developed space powers must contribute their wealth and technology while the developing states that are without space technology need only contribute what few resources they have. The developed space powers, in order to save themselves, must extend their wealth and technology not only to teach the developing countries to engage but also must actually perform on behalf of the have-not countries, because climate change is a global problem.<sup>222</sup> The Paris Agreement is organized on the principle that the extent of climate change and the remedies necessary to bring the problem to the stated objective will continuously be assessed by successive meetings of all the parties organized by the U.N.<sup>223</sup> The most recent meeting took place in Madrid, Spain, in 2019.<sup>224</sup> The conference failed to reach an agreement on assessment and carbon emissions.<sup>225</sup> They thereby increased the future burdens needed

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<sup>218</sup> *Id.*

<sup>219</sup> See *Overview of Greenhouse Gases*, EPA, <https://www.epa.gov/ghgemissions/overview-greenhouse-gases> [<https://perma.cc/V3QG-UDZV>] (last visited Oct. 13, 2020).

<sup>220</sup> See generally, *Impacts of 1.5°C global warming on natural and human systems*, INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, <https://www.ipcc.ch/sr15/chapter/chapter3/> [<https://perma.cc/9ACQ-8FSM>] (last visited Oct. 13, 2020).

<sup>221</sup> Paris Agreement, *supra* note 11, at 1 (“Taking full account of the specific needs and special situations of the least developed countries with regard to funding and transfer of technology”).

<sup>222</sup> See *id.* at 1, art. 2.

<sup>223</sup> See *id.* at art. 4.

<sup>224</sup> See Brady Dennis & Chico Harlan, *U.N. Climate Talks End With Hard Feelings, Few Results and New Doubts About Global Unity*, WASH. POST (Dec. 15, 2019), [https://washingtonpost.com/climate-environment/un-climate-talks-end-with-hard-feelings-few-results-and-new-doubts-about-global-unity/2019/12/15/38918278-1ec7-11ea-b4c1-fd0d91b60d9e\\_story.html](https://washingtonpost.com/climate-environment/un-climate-talks-end-with-hard-feelings-few-results-and-new-doubts-about-global-unity/2019/12/15/38918278-1ec7-11ea-b4c1-fd0d91b60d9e_story.html) [<https://perma.cc/H5TY-6ESL>].

<sup>225</sup> See *id.*

to be accomplished in order to reach the goal of the Paris Agreement. Some of the reasons are discussed in this Article.<sup>226</sup>

The UNFCCC commits parties to make national inventory of emissions.<sup>227</sup> Consequently the Paris Agreement Article 4(2), provides that “Each Party shall prepare, communicate and maintain successive nationally determined contributions that it intends to achieve. Parties shall pursue domestic mitigation measures, with the aim of achieving the objectives of such contributions.”<sup>228</sup> Approximate global greenhouse gas emissions as of 2015 at the time of negotiation were: China 30%, United States 15%, European Union 9%, India 7%, Russia 5%, Japan 4%, and other 30%.<sup>229</sup> This distribution has already changed.<sup>230</sup> The total United States emissions have increased, Europe’s emissions have decreased, and China’s emissions have increased.<sup>231</sup> This distribution also indicates the size of the developing countries’ burden of emission, which under the Paris Agreement require huge assistance from the developed countries such as the United States and Europe.<sup>232</sup> China is not considered a developed country under the Paris Agreement, so it is not subject to the burdens assumed by developed countries.<sup>233</sup> Both the United States and Europe possess significant satellite technology capable of deployment to

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<sup>226</sup> *Id.*

<sup>227</sup> Convention on Climate Change, *supra* note 8, at art. 4(1)(a).

<sup>228</sup> Paris Agreement, *supra* note 11, at art. 4(2).

<sup>229</sup> *Global Greenhouse Gas Emissions Data*, EPA, <https://www.epa.gov/ghgemissions/global-greenhouse-gas-emissions-data#Country> [<https://perma.cc/U2FV-RM84>] (last visited Oct. 13, 2020).

<sup>230</sup> Emissions Gap Report 2019, *supra* note 23, at 5.

<sup>231</sup> *Id.* However, subsequently the emissions of these states declined because of COVID-19. Plumer, *supra* note 15.

<sup>232</sup> See Paris Agreement, *supra* note 11, at art. 4(2) (“Each Party shall prepare, communicate and maintain successive nationally determined contributions that it intends to achieve. Parties shall pursue domestic mitigation measures, with the aim of achieving the objectives of such contributions.”). Approximate global greenhouse gas emissions as of 2015 were: China 30 %, United States 15%, European Union 9%, India 7%, Russia 5%, Japan 4%, and other 30%. *Global Greenhouse Gas Emissions Data*, *supra* note 229. However, these are not considered fixed by international law. This distribution indicates the greenhouse gas contributions of the developing countries and their great needs for assistance from the developed countries.

<sup>233</sup> See Robinson Meyer, *A Reader’s Guide to the Paris Agreement*, ATLANTIC (Dec. 16, 2015), <https://www.theatlantic.com/science/archive/2015/12/a-readers-guide-to-the-paris-agreement/420345/> [<https://perma.cc/26KH-GB9T>]; see Convention on Climate Change, *supra* note 8 (depicting China’s status as a Non-Annex 1 country); Izzet Ari & Ramazan Sari, *Differentiation of Developed and Developing Countries for the Paris Agreement*, 18 ENERGY STRATEGY REV. 175, 179 (2017).

reduce their own emissions and reduce emissions of the developing countries that lack such technology.<sup>234</sup> All the parties must report to the central registry the reductions that they intend to achieve.<sup>235</sup>

The Paris Agreement is administered by the individual states, which are required to report their nationally determined contributions of emissions to a central climate change “mechanism”.<sup>236</sup> That places unusual burdens on countries that have insufficient technology to carry out inventories. It places unusual burdens on space powers to use their remote sensing satellites to inventory non-space powers. It also places unusual burdens on space powers to check the inventories of each other to verify accuracy of reported inventories. The Paris Agreement does not have strong international policing of the contributions of individual states.<sup>237</sup> All activities are based on self-administration.<sup>238</sup>

Like the Montreal Protocol,<sup>239</sup> the Paris Agreement is designed to be continuously updated as new developments and analysis show what is required to meet its stated goal of reducing temperature increases to 1.5 degrees Celsius above pre-industrial levels.<sup>240</sup> The global total emissions have changed substantially since the initial determination when the Paris Agreement was negotiated.<sup>241</sup> The 2019 Emissions Gap Report of the U.N. Environmental Program states that the global total of emissions is much greater than previously determined.<sup>242</sup> The report concluded that “dramatic strengthening of the nationally determined contributions is needed in 2020. Countries must now increase their nationally determined contributions efforts threefold to achieve the well below 2 degrees Celsius goal and more than fivefold to achieve the 1.5 degrees Celsius goal.”<sup>243</sup> Consequently, Paris Agreement Article 4(3) now requires the

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<sup>234</sup> Debra Werner, *International Focus on Greenhouse Gas Monitoring Satellites, Sensors*, SPACE NEWS (Jan. 11, 2019), <https://spacenews.com/greenhouse-gas-satellites-ams/> [<https://perma.cc/298N-4M78>].

<sup>235</sup> Paris Agreement, *supra* note 11, at art. 4(12).

<sup>236</sup> *Id.* at art. 6(4)–(7).

<sup>237</sup> *Id.* at art. 4(2)–(4).

<sup>238</sup> *Id.* at art. (2)–(11).

<sup>239</sup> Montreal Protocol, *supra* note 21.

<sup>240</sup> *Paris Climate Agreement Q&A*, CTR. FOR CLIMATE & ENERGY SOLS., <https://www.c2es.org/content/paris-climate-agreement-qa/> [<https://perma.cc/WCM9-V36T>] (last visited Oct. 13, 2020).

<sup>241</sup> Emissions Gap Report 2019, *supra* note 23, at 3–4.

<sup>242</sup> *Id.*

<sup>243</sup> *Id.* at XX. See John Knox & Christine Voigt, *Introduction to the Symposium on Transnational Climate Litigation: The Contributions of the Global South*, 114 AM. J. INT’L L. 35–36 (2020).

participating parties to increase their reductions of emissions substantially.<sup>244</sup> Unfortunately, the 2019 Madrid Environmental Conference failed to agree on emissions reductions.<sup>245</sup> States were not ready to assume greater responsibility for emissions. As a result, future climate conferences will have to adopt much higher emission reductions.

On a positive note, the identification and accomplishment of the required inventories will be facilitated by use of space technology, which continues to improve and will become most important in dealing with the greater emissions reduction demands on participating states.

### 3. Ocean and Forest Emission Sinks<sup>246</sup>

#### a. The Oceans Are Emission Sinks

The oceans are inherently international.<sup>247</sup> Most of the earth's surface, more than 70%, is water. Furthermore, 90% of emissions are thought to be deposited and recycled through the oceans.<sup>248</sup> The high seas, similar to outer space, are not subject to national sovereignty.<sup>249</sup> They are uniquely accessible to and by Earth observation satellites.<sup>250</sup> The ease of access from above is important because the oceans must be watched very carefully for the effects of global warming. One reason the amount of water in the oceans is increasing is because solar heat causes water to expand.<sup>251</sup> Another reason is that solar heat causes the ice of the Arctic, Antarctic,

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<sup>244</sup> Paris Agreement, *supra* note 11, at art. 3, 4(3).

<sup>245</sup> Fiona Harvey, *U.N. Climate Talks End With Limited Progress on Emissions Targets*, GUARDIAN (Dec. 15, 2019), <https://www.theguardian.com/environment/2019/dec/14/un-climate-talks-drag-on-as-rifts-scupper-hopes-of-breakthrough> [<https://perma.cc/5GQQ-JW4Z>].

<sup>246</sup> Convention on Climate Change, *supra* note 8, at art. 1(8) (defining a sink as "any process or activity which removes a greenhouse gas, an aerosol or a precursor of a greenhouse gas into the atmosphere").

<sup>247</sup> Lyall, *supra* note 1, at 149.

<sup>248</sup> *Id.* at 149.

<sup>249</sup> U.N. Convention on the Law of the Sea, *U.N. Preamble to the Convention on the Law of the Sea*, art. 89 (Dec. 10, 1982), [https://www.un.org/Depts/los/convention\\_agreements/texts/unclos/closindx.htm](https://www.un.org/Depts/los/convention_agreements/texts/unclos/closindx.htm) [<https://perma.cc/CUL9-BEEY>].

<sup>250</sup> *Sea-Level Monitoring Satellite on Show*, EUR. SPACE AGENCY (Nov. 15, 2019), [http://www.esa.int/Applications/Observing\\_the\\_Earth/Copernicus/Sea-level\\_monitoring\\_satellite\\_on\\_show](http://www.esa.int/Applications/Observing_the_Earth/Copernicus/Sea-level_monitoring_satellite_on_show) [<https://perma.cc/3JM6-E4FK>] (Ocean rise is also measured by coastal tide gauge stations).

<sup>251</sup> LuAnn Dahlman & Rebecca Lindsey, *Climate Change: Ocean Heat Content*, NOAA (Feb. 13, 2020), <https://www.climate.gov/news-features/understanding-climate/climate-change-ocean-heat-content> [<https://perma.cc/V4GY-X62B>].

and Greenland glaciers to melt; the melted ice flows into the oceans and causes them to rise.<sup>252</sup> Recent Earth observation by ESA's Cryosat mission indicate that ice melting from the large Pine Island glacier in the Antarctic region will occur at a more moderate pace than previously expected.<sup>253</sup> However, most recent observations observe Greenland and Antarctica losing ice six times faster than expected.<sup>254</sup> They now estimate "an extra 17 centimeters of sea level rise by the end of the century."<sup>255</sup> This would expose 400 million people to annual flooding by 2100.<sup>256</sup>

Rising waters will significantly limit the living space for human beings. The gradual rise of the water level has been measured by earth observation satellites since 1993.<sup>257</sup> The mean level of water increased 8 inches between 1980 and 2020.<sup>258</sup> The United States National Oceanic and Atmospheric Administration ("NOAA") estimates that the water level will increase at least one foot (0.3 meters) between 2000 and 2100.<sup>259</sup> Others estimate the sea to rise 2.4–3.4 feet by 2100.<sup>260</sup> The increase in

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<sup>252</sup> World Glacier Monitoring Service estimates that loss of ice quintupled during 1980–2010. See Rebecca Lindsey, *Climate Change: Global Sea Level*, NOAA (Aug. 14, 2020),

<sup>253</sup> *CryoSat Sheds New Light on Antarctica's Biggest Glacier*, *supra* note 252.

<sup>254</sup> *Greenland and Antarctica Losing Ice Six Times Faster Than Expected*, EUR. SPACE AGENCY (Mar. 11, 2020), [<sup>255</sup> \*Id.\*](https://www.esa.int/Applications/Observing_the_Earth/Space_for_our_climate/Greenland_and_Antarctica_losing_ice_six_times_faster_than_expected#:~:text=According%20to%20a%20new%20report,worst%2Dcase%20climate%20warming%20scenario.&text=This%20means%20that%20polar%20ice,of%20all%20sea%20level%20rise [https://perma.cc/WDX4-NTD5].</a></p></div><div data-bbox=)

<sup>256</sup> *Id.* NASA and the ESA are currently launching satellites that measure the extent to which polar ice melting causes the oceans to increase in height. *Sea Level Rise*, NASA (Mar. 10, 2020), [<sup>257</sup> Satellites use radar altimeters to measure the height of oceans. Lindsey, \*supra\* note 252.](http://imbie.org/about-the-project/sea-level-rise/ [https://perma.cc/7555-AAHZ].</a></p></div><div data-bbox=)

<sup>258</sup> *Climate Change Indicators: Sea Level*, EPA (Dec. 17, 2016), [<sup>259</sup> Lindsey, \*supra\* note 252.](https://www.epa.gov/climate-indicators/climate-change-indicators-sea-level#:~:text=rising%20or%20falling.-,About%20the%20Indicator,nearly%20the%20entire%20ocean%20surface [https://perma.cc/7EMY-QZBB].</a></p></div><div data-bbox=)

<sup>260</sup> Somini Sengupta & Chang Lee, *A Crisis Right Now: San Francisco and Manila Face Rising Seas*, N.Y. TIMES (Feb. 15, 2020),

water level varies in various locations on the globe due to natural differences in prevailing currents and winds.<sup>261</sup> The extent of increase will also depend on local geology, such as natural settling of sea bottom lands.<sup>262</sup> In some areas, the sea levels are falling but greenhouse emissions may reverse that trend.<sup>263</sup>

Rising seas will reduce the ability to produce food for human consumption.<sup>264</sup> Global warming of the oceans may cause migration of fish from warmer to cooler climates, thus affecting access to food sources.<sup>265</sup> Satellites observe the increase in size of the oceans and consequent reduction of land caused by rising waters. The ability to react to the oceanic consequences of climate change will depend on satellite observations. Many lowlands will be covered by water and some island states will no longer be habitable.<sup>266</sup> They will disappear totally under water.<sup>267</sup> Rising seas may thus cause submerged lowlands to change from sovereign territory to non-sovereign territories.<sup>268</sup> Determination of such fundamental legal changes necessitates minute satellite observations.<sup>269</sup> Consequently, the use of oceans as heat sinks is an important asset in mitigation of climate change effects because oceans can absorb emissions.<sup>270</sup> The question

*Rise*, *supra* note 256; *Six-Fold Increase in Polar Ice Losses Since the 1990s*, UNIV. LEEDS (Mar. 11, 2020), [https://www.leeds.ac.uk/news/article/4561/six-fold\\_increase\\_in\\_polar\\_ice\\_losses\\_since\\_the\\_1990s](https://www.leeds.ac.uk/news/article/4561/six-fold_increase_in_polar_ice_losses_since_the_1990s) [<https://perma.cc/UEX9-GGS2>].

<sup>261</sup> Lindsey, *supra* note 252.

<sup>262</sup> *Id.*

<sup>263</sup> *Id.* Ultimately the increase in sea levels will become accurately known when it actually happens.

<sup>264</sup> Renee Cho, *How Climate Change Will Alter Our Food*, STATE PLANET (Jul. 25, 2018), <https://blogs.ei.columbia.edu/2018/07/25/climate-change-food-agriculture/> [<https://perma.cc/H5WH-C63J>].

<sup>265</sup> Lyall, *supra* note 1, at 158–62.

<sup>266</sup> Michael Oppenheimer & Bruce Glavovic, *Sea Level Rise and Implications for Low-Lying Islands, Coasts and Communities*, in SPECIAL REPORT ON THE OCEAN & CRYOSPHERE CHANGING PLANET, 321, 328 (2019), [https://www.ipcc.ch/site/assets/uploads/sites/3/2019/11/08\\_SROCC\\_Ch04\\_FINAL.pdf](https://www.ipcc.ch/site/assets/uploads/sites/3/2019/11/08_SROCC_Ch04_FINAL.pdf) [<https://perma.cc/24PZ-6955>].

<sup>267</sup> *Id.*

<sup>268</sup> Lyall, *supra* note 1, at 149–62. The 71st session of the U.N. International Law Commission (2018) placed the consequences of the increasing sea levels caused by climate change on its active agenda, *see* Sean D. Murphy, *Peremptory Norms of International Law (Jus Cogens) and Other Topics: The Seventy-First Session of the International Law Commission*, 114 AM. J. INT'L L. 84 (2020). United Nations Convention on the Law of the Sea, *supra* note 141, at art. 7, 121.

<sup>269</sup> ESA's Sentinel-2 is a two-satellite mission to supply the coverage and data delivery needed for Europe's Copernicus program. The mission's frequent revisits over the same area and high spatial resolution allow changes in inland water bodies to be closely monitored.

<sup>270</sup> *Global Ocean Absorbing More Carbon*, NAT'L CTR. FOR ENV'T INFO. (Mar. 15, 2019),

is how can the oceans best be deployed to absorb the global temperature increases? The Paris Agreement Article 4(1) and Article 5 require member states to effect “removals by sinks of greenhouse gases.”<sup>271</sup> The ability of water to store heat depends on ocean depths as well as on winds and currents.<sup>272</sup> Oceans are also changing because of ice melting. Satellites can best and most comprehensively observe climate development on the water. Satellites will be able to measure the temperatures of waters and observe changes in height of the oceans.

b. Forests and Vegetation as Heat Sinks

Forests and dense vegetation territory also act as emission sinks.<sup>273</sup> They function like sponges absorbing emissions and dense vegetation keeps the soil moist.<sup>274</sup> The Japan Aerospace Exploration Agency (JAXA is Japan’s NASA) entered into a 25-year agreement with the U.N. Food and Agriculture Organization (“FAO”) to monitor by satellite the forests and dense vegetation areas around the world for greenhouse gases.<sup>275</sup> FAO Deputy Secretary General Daniel Gustafson stated, “As deforestation and land-use changes are one of the leading sources of global carbon emissions, satellite-based information has a critical role to play in supporting countries to achieve their commitments on climate change[.]”<sup>276</sup>

JAXA uses powerful l-band synthetic aperture radar for Earth observation. These satellites are able to see through clouds.<sup>277</sup>

International concerns have arisen because of conversion of large dense lowland into farming lands. Recent examples are the controversies

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<https://www.ncei.noaa.gov/news/global-ocean-absorbing-more-carbon> [<https://perma.cc/GH67-8RJS>].

<sup>271</sup> Paris Agreement, *supra* note 11, at art. 4.

<sup>272</sup> Lindsey, *supra* note 252.

<sup>273</sup> Melanie Friedel, *Forests as Carbon Sinks*, LOOSE LEAF (July 18, 2017), <https://www.americanforests.org/blog/forests-carbon-sinks/> [<https://perma.cc/22AA-KMY6>].

<sup>274</sup> *Soils are the Foundation for Vegetation*, U.N. FOOD & AGRIC. ORG. (2015), <http://www.fao.org/3/a-i4666e.pdf> [<https://perma.cc/TV3E-Q7A8>].

<sup>275</sup> *JAXA and U.N. Join Hands on Global Monitoring of Forests*, JAPAN TIMES (Feb. 15, 2020), <https://www.japantimes.co.jp/news/2020/02/15/national/science-health/jaxa-u-n-food-agency-join-hands-global-monitoring-forests/#.XksK8iMXCUl> [<https://perma.cc/83Q2-XNJJ>].

<sup>276</sup> *Id.* ESA satellites monitor all vegetation on the Earth every day and record a complete image of all growth every 10 days. See *Ending Global Plant Tracking, Proba-V Assigned New Focus*, EUR. SPACE AGENCY (Apr. 20, 2020), [https://www.esa.int/Enabling\\_Support/Space\\_Engineering\\_Technology/Proba\\_Missions/Ending\\_global\\_plant\\_tracking\\_Proba-V\\_assigned\\_new\\_focus](https://www.esa.int/Enabling_Support/Space_Engineering_Technology/Proba_Missions/Ending_global_plant_tracking_Proba-V_assigned_new_focus) [<https://perma.cc/6Y8V-2GJN>].

<sup>277</sup> *Id.*

over conversion of lands on the Amazon River from forests into agriculture.<sup>278</sup> Efforts are made to preserve these large forests as carbon dioxide sinks. Remote sensing satellites watched the 2019 Amazon fires resulting in deforestation and forest degradation.<sup>279</sup> It compared the 2019 fires with fires of previous years (2001–2018).<sup>280</sup> The comparison found a significant increase in fire activity in Bolivia, Paraguay, and Venezuela; however, satellites showed that fire activity in Brazil was about the same as in previous years.<sup>281</sup>

There are recent initiatives to plant large forests as counterweight to activities that deplete oxygen; for example, British Petrol (“BP”) recently announced such an initiative.<sup>282</sup> Interestingly, United States President Trump in his 2020 State of the Union Message to the Congress proposed planting one million trees in order to establish forests as emission sinks.<sup>283</sup>

#### 4. Reduction of Emissions from Carbon

Carbon dioxide emissions are particularly damaging to the climate.<sup>284</sup> States are required by the Paris Agreement Article 6, to reach an agreement on mitigation of carbon emissions.<sup>285</sup> However, carbon dioxide emissions from coal remain to be considered.<sup>286</sup> The 2019 U.N. Framework Convention on Climate Change (“COP 25”) met in Madrid, Spain to establish emission standards for the carbon market.<sup>287</sup> One related

<sup>278</sup> *Id.*

<sup>279</sup> *Id.*

<sup>280</sup> *Id.*

<sup>281</sup> Lizundia-Loiola et al., *Temporal Anomalies in Burned Area Trends: Satellite Estimations of the Amazonian 2019 Fire Crisis*, REMOTE SENSING J. (2020), <https://www.mdpi.com/2072-4292/12/1/151> [<https://perma.cc/HXD7-LSKE>].

<sup>282</sup> *BP Invests \$5mn in Forest Carbon Offsets Leader Finite Resources*, WORLD OF CHEMICALS, <https://www.worldofchemicals.com/media/bp-invests-5-mn-in-forest-carbon-offsets-leader-finite-resources/13591.html> [<https://perma.cc/H22F-5BEM>] (last visited Oct. 13, 2020).

<sup>283</sup> Nicole Narea & Catherine Kim, *Read the Full Text of Trump’s State of the Union Speech*, VOX (Feb. 5, 2020), <https://www.vox.com/2020/2/4/21123394/state-of-the-union-full-transcript-trump> [<https://perma.cc/FGC3-CQ6W>].

<sup>284</sup> *Why Does CO<sub>2</sub> Get Most of the Attention When There Are So Many Other Heat-Trapping Gases*, UNION CONCERNED SCIENTISTS, <https://www.ucsusa.org/resources/why-does-co2-get-more-attention-other-gases> [<https://perma.cc/252X-XY2>] (last visited Oct. 13, 2020).

<sup>285</sup> Paris Agreement, *supra* note 11, at art. 6.

<sup>286</sup> Luke Kemp, *The Paris Agreement Won’t Stop Coal, But Future Climate Talks Might*, CONVERSATION (Dec. 12, 2015), <https://theconversation.com/the-paris-agreement-wont-stop-coal-but-future-climate-talks-might-51241> [<https://perma.cc/47H3-XPEP>].

<sup>287</sup> *COP 25: Key Outcomes Agreed at U.N. Climate Talk in Madrid*, CARBON BRIEF,

issue to be considered was a provision in the Kyoto Protocol,<sup>288</sup> which preceded the Paris Agreement. Kyoto had created a system whereby states could trade past emissions to satisfy their future emission obligations towards developing countries.<sup>289</sup> However, the states failed at COP 25 to reach an essential agreement on guidelines for carbon and on other aspects of the Paris Agreement.<sup>290</sup> These issues were to be considered at the next yearly meeting of state parties to be held in Glasgow, Scotland.<sup>291</sup> That meeting has now been postponed until 2021 due to COVID-19.<sup>292</sup>

##### 5. Central Mechanism for Administration, Promotion and Guidance Regarding Climate Change Measures

Paris Agreement Article 8, establishes a so-called climate change “mechanism” to guide its members.<sup>293</sup> The mechanism would include a permanent secretariat to administer the mechanism, as well as the entire Paris Agreement.<sup>294</sup> The use of the mechanism by the members will be voluntary, although it is clear that most of the members will need technical

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<https://www.carbonbrief.org/cop25-key-outcomes-agreed-at-the-un-climate-talks-in-madrid> [<https://perma.cc/KYR4-XTNX>] (last visited Oct. 13, 2020).

<sup>288</sup> An important element of the Kyoto Protocol was to establish flexible market mechanisms, based on trade of emissions permits. Kyoto Protocol to the United Nations Framework Convention on Climate Change, Dec. 10, 1997, 2303 U.N.T.S. 162. Under this mechanism, countries must meet their targets primarily through national measures. *Id.* However, the Protocol also offers countries an additional way to meet their targets by use of market-based mechanisms. *Id.*

<sup>289</sup> *Id.* at art. 17.

<sup>290</sup> *COP 25 Talks End With No Deal On Carbon Markets*, EURONEWS, <https://www.euronews.com/2019/12/14/cop25-climate-conference-extended-after-failure-to-reach-agreement> [<https://perma.cc/K9DA-TFM4>] (last visited Oct. 13, 2020).

<sup>291</sup> *Id.*; Steven Lee Myers, *China’s Pledge to Be Carbon Neutral by 2060: What It Means*, N.Y. TIMES (Sept. 23, 2020), <https://www.nytimes.com/2020/09/23/world/asia/china-climate-change.html?searchResultPosition=10> [<https://perma.cc/897D-XQ2Z>].

<sup>292</sup> *Statement by the Executive Secretary of the U.N. Climate Change Conference, Patricia Espinosa, on the Outcome of COP 25*, U.N. CLIMATE CHANGE, <https://unfccc.int/news/state-ment-by-the-executive-secretary-of-un-climate-change-patricia-espinosa-on-the-outcome-of-cop25> [<https://perma.cc/PG4M-HZVW>] (last visited Oct. 13, 2020). See Somini Sengupta, *Coronavirus Delays Key Climate Talks*, N.Y. TIMES (Apr. 1, 2020), <https://www.nytimes.com/2020/04/01/climate/cop-climate-glasgow-coronavirus.html> [<https://perma.cc/GV67-HPGH>]. Furthermore, the Trump administration has sought to revive the U.S. coal industry by loosening the restriction on carbon dioxide emissions. Lisa Friedman & Coral Davenport, *EPA Weakens Controls on Mercury*, N.Y. TIMES (Apr. 16, 2020), <https://www.nytimes.com/2020/04/16/climate/epa-mercury-coal.html> [<https://perma.cc/B776-R3LR>].

<sup>293</sup> Paris Agreement, *supra* note 11, at art. 8.

<sup>294</sup> *Id.* at art. 17.

assistance through the mechanism to make their promised commitments.<sup>295</sup> Paris Agreement Article 6 specifically intends the mechanism to (a) mitigate all greenhouse emissions; (b) facilitate participation of governments and of private parties; (c) contribute to reduction of the host party's commitment share by reducing emissions of other states; and (d) reduce global emissions overall.<sup>296</sup> The mechanism will also be available to guide members towards the use of advanced technology such as remote sensing by satellites.<sup>297</sup> In some cases, developed states, in measuring their own contributions, will incidentally measure the emissions of other states and will share such measurements with other states within the mechanism.<sup>298</sup> The mechanism established by the Paris Agreement is based on a non-market approach;<sup>299</sup> for example, the mechanism may be administered based on the legal assumption that resolution of climate change emissions is legally in the nature of global commons.<sup>300</sup>

#### 6. Adaptation to New Situations Caused by Climate Change: Dislocation of People

Paris Agreement Article 7, seeks to lay the groundwork for major life changes.<sup>301</sup> It recognizes that climate change is not merely a matter of resolving local climate problems.<sup>302</sup> The Paris Agreement acknowledges the danger that climate change may lead to dislocation of inhabitants, for example, that rising waters will lead to inundation of islands in the Pacific Ocean and that inhabitants will have to migrate to higher land that is

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<sup>295</sup> Axel Michaelowa et al., *Negotiating Cooperation Under Article 6 of the Paris Agreement*, EUR. CAPACITY BLDG. INITIATIVE (Nov. 2019), [https://www.perspectives.cc/fileadmin/Publications/Michealowa\\_et\\_al\\_2019\\_-\\_Negotiating\\_cooperation\\_under\\_Article\\_6\\_of\\_the\\_PA.pdf](https://www.perspectives.cc/fileadmin/Publications/Michealowa_et_al_2019_-_Negotiating_cooperation_under_Article_6_of_the_PA.pdf) [https://perma.cc/D4UC-YKQK].

<sup>296</sup> Paris Agreement, *supra* note 11, at art. 6.

<sup>297</sup> *What is Technology Development and Transfer?*, U.N. CLIMATE CHANGE, <https://unfccc.int/topics/climate-technology/the-big-picture/what-is-technology-development-and-transfer> [https://perma.cc/BT5G-LKQY] (last visited Oct. 13, 2020).

<sup>298</sup> Timiebi Aganaba-Jeanty & Anna Huggins, *Satellite Measurement of GHG Emissions: Prospects for Enhancing Transparency and Answerability Under International Law*, TRANSNAT'L ENV'T L. (Mar. 25, 2019), <https://search-proquest-com.proxy.wm.edu/docview/2259297326/fulltextPDF/67BA13D4EADB4CA3PQ/1?accountid=15053> [https://perma.cc/LX93-MYWY].

<sup>299</sup> Paris Agreement, *supra* note 11, at art. 6.

<sup>300</sup> See discussion of common interests in a sustainable earth, *supra* note 149.

<sup>301</sup> Paris Agreement, *supra* note 11, at 9–11.

<sup>302</sup> *Id.* at 9.

not flooded.<sup>303</sup> That will also occur in coastal areas where entire countries may become uninhabitable.<sup>304</sup> Satellites will be able to identify territories likely to be flooded and may also identify sufficiently high ground territories fit for resettlements. The agreement expresses particular concern and need for care of people in developing countries that have fewer resources to meet such challenges.<sup>305</sup> Therefore, each state is urged to study and prepare for major changes and to communicate its adaptation information with other countries. Toward that purpose, Paris Agreement Article 7, creates a public registry administered by the Secretariat established by the Paris Agreement.<sup>306</sup> The adaptation information will include emergency preparedness, and a range of emergency responses available from UN-SPIDER.<sup>307</sup> They include short-term aid under the U.N. Disaster Charter<sup>308</sup> as well as access to many sources of assistance from the UN-SPIDER information portal.<sup>309</sup>

Climate change will alter the way people on Earth live. If there is insufficient action to respond to the coming global changes then planet Earth may become uninhabitable. Some scientists have suggested that we search for and plan to colonize other habitable planets.<sup>310</sup>

## 7. Collection and Use of Climate Change Data

Collecting, storing, and distributing climate-related information by Earth observation satellites of several nationalities are major purposes of the Paris Agreement.<sup>311</sup> Remote sensing, communication, weather, and

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<sup>303</sup> *Id.* at 1 (“Recognizing that Parties may be affected not only by climate change, but also by the impacts of the measures taken in response to it[.]”); Alice Edwards, *Climate Change and International Refugee Law*, in INTERNATIONAL LAW IN THE ERA OF CLIMATE CHANGE, *supra* note 1, at 58, 60.

<sup>304</sup> See Edwards, *supra* note 303, at 60.

<sup>305</sup> Paris Agreement, *supra* note 11, at 1.

<sup>306</sup> *Id.* at 11.

<sup>307</sup> See G.A. Res. 61/110, *supra* note 96, at 1–3.

<sup>308</sup> *Annual Report 2015*, INT’L CHARTER SPACE & MAJOR DISASTERS, <https://disasterscharter.org/documents/10180/188210/Annual-Report-15.pdf/d970c538-1921-434f-8009-136ff4443b72> [<https://perma.cc/Q69R-93LP>] (last visited Oct. 13, 2020).

<sup>309</sup> See Larsen, *supra* note 82, at 357–58 (comparing disaster management in a developed country with management in a developing country).

<sup>310</sup> See REES, *supra* note 45, at 133; see also Outer Space Treaty, *supra* note 26, at 11 (contemplating exploration and use of other celestial bodies).

<sup>311</sup> See Paris Agreement, *supra* note 11, at 15–17; *The Essential Role of European GNSS in Meteorology*, EUR. GLOB. NAVIGATION SATELLITE SYS. AGENCY, <https://www.gsc-europa.eu/news/the-essential-role-of-european-gnss-in-meteorology-2> [<https://perma.cc/7CCS-R3XH>] (last modified Sept. 9, 2020).

GNSS satellites are constantly collecting and storing data on all aspects of climate change.<sup>312</sup> The Paris Agreement requires the parties to maintain records and submit them as part of their nationally determined contributions under Article 4.<sup>313</sup> These and other data are stored and made available by the data bank of the mechanism and the registry maintained by the Secretariat pursuant to Articles 7, 8 and 17, and under Article 6(4) for the mitigation of greenhouse gas and for general support.<sup>314</sup> Transparency is at the essence of the collection. All of these data are essential for the successful administration and operation of the Paris Agreement.<sup>315</sup> They provide decisionmakers with a globally comprehensive account of greenhouse gas needing to be resolved at the present time.

The collection, administration, and availability of climate change data have the support of the U.N.<sup>316</sup> The U.N. has experience operating computer portals that act as data banks of outer space information.<sup>317</sup> UN-SPIDER serves as the portal for information about disaster management.<sup>318</sup> It also acts as the nerve center and contact point for the U.N. Disaster Charter.<sup>319</sup> Any country may contact UN-SPIDER to activate satellite communication, weather reports, and remote sensing satellites from space powers possessing such technology.<sup>320</sup> Another such central nerve center is the U.N. Office of the Emergency Relief Coordinator.<sup>321</sup> It will activate available communication satellite services of several parties to the Tampere Convention.<sup>322</sup> A task for the future would be to establish such a central office, and a data bank should exist in the machinery of the Paris Agreement.<sup>323</sup> Additionally, the Global Earth Observation System of Systems (“GEOSS”) uses satellites to monitor and collect data on all kinds of activities, including climate change.<sup>324</sup>

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<sup>312</sup> EUR. GLOB. NAVIGATION SATELLITE SYS. AGENCY, *supra* note 311.

<sup>313</sup> Paris Agreement, *supra* note 11, at 4.

<sup>314</sup> *Id.* at 7, 11–13, 21.

<sup>315</sup> *See id.* at 16.

<sup>316</sup> *See id.* at 21.

<sup>317</sup> *See What is UN-SPIDER?*, U.N. OFF. FOR OUTER SPACE AFFS., <http://www.un-spider.org/about/what-is-un-spider> [<https://perma.cc/666X-3RZR>] (last visited Oct. 13, 2020).

<sup>318</sup> *Id.*

<sup>319</sup> INT’L CHARTER SPACE & MAJOR DISASTERS, *supra* note 308, at 42. The current Earth observation images of emissions in the United States, China, and Italy as affected by COVID-19 are an important example of satellite data collection. Letzter, *supra* note 15.

<sup>320</sup> G.A. Res. 61/110, *supra* note 96, at 2.

<sup>321</sup> Tampere Convention, *supra* note 93, at 46–48.

<sup>322</sup> *Id.*

<sup>323</sup> Paris Agreement, *supra* note 11, at 7–8, 14.

<sup>324</sup> Larsen, *supra* note 82, at 366–67.

8. Cost Allocation of Climate Change Activities<sup>325</sup>

Paris Agreement Article 9, basically assigns to the developed countries (the ESA and the United States) the major share of the cost of international climate change activities.<sup>326</sup> That includes the cost of outer space activities such as remote sensing, communication satellites, weather satellites, and other outer space involvement with the consequences of climate change.<sup>327</sup> Developed countries are asked to contribute to developing countries' climate change activities and to report annually the amounts of financing they contribute.<sup>328</sup> Their financial contributions will be taken into consideration in the periodic global stock-taking to assess the effectiveness of the Paris Agreement and consider further climate activities.<sup>329</sup> Other countries are urged to contribute whatever they can.<sup>330</sup> The first session of the meeting of the parties is required to establish guidelines and procedures for developed countries to report financing for developing countries' climate change expenses.<sup>331</sup> Administration of this issue and other Paris Agreement activities is performed according to the financial mechanism established by Paris Agreement Article 6.<sup>332</sup> The driving force will be the urgency of resolving the earth's climate crisis. Both developed and developing countries will suffer if developed countries fail to contribute sufficient finances to meet the objective of the Paris Agreement: i.e., to limit the temperature increase to 1.5 degrees Celsius above pre-industrial levels.<sup>333</sup>

ESA operates the space segment for the European Union.<sup>334</sup> ESA, being a developed national entity, representing Europe, is purposely stepping up to its assigned responsibility by substantially increasing its Earth

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<sup>325</sup> Note U.N. Sustainability Goal 13(a) implements the commitment undertaken by developed-country parties to the United Nations Framework Convention on Climate Change to a goal of mobilizing jointly \$100 billion annually by 2020. *See infra* note 436. This goal is far from being reached. *See generally* G.A. Res. 71/313 (July 6, 2020).

<sup>326</sup> Paris Agreement, *supra* note 11, at 13.

<sup>327</sup> *See* EUR. GLOB. NAVIGATION SATELLITE SYS. AGENCY, *supra* note 311.

<sup>328</sup> Paris Agreement, *supra* note 11, at 13.

<sup>329</sup> *Id.* at 18–19.

<sup>330</sup> *Id.* at 13.

<sup>331</sup> *Id.* at 14.

<sup>332</sup> *See id.*

<sup>333</sup> *See* U.N., *infra* note 435, at 10.

<sup>334</sup> The purpose of Copernicus is to bring all remote sensing sources together at one location to be made available to all. ESA operates the space segment. ESA manages the distribution. LYALL & LARSEN, *supra* note 36, at 22–24, 374.

observation capacity.<sup>335</sup> The 2019 meeting of the European Ministers<sup>336</sup> significantly increased the ESA budget, in particular to aid the Copernicus Satellite Program.<sup>337</sup> The improved ESA satellite program will measure emissions more accurately than previously.<sup>338</sup> The resolution of images will be higher and the images will be wider.<sup>339</sup> A Copernicus satellite instrument, directly concerned with emissions, measures nitrogen dioxide emissions.<sup>340</sup> The director of the program explained that nitrogen dioxide “is an indicator of human activities and therefore helps distinguish [at a given location] natural from anthropogenic CO<sub>2</sub> emissions[.]”<sup>341</sup> It is important for ESA to distinguish natural from human-made emissions because only human-made emissions are subject to the climate change examination as defined and required by the UNFCCC and the Paris Agreement.<sup>342</sup> A cloud timer will ‘unmask’ (i.e., penetrate) clouds.<sup>343</sup> Previously, the program could only operate in cloud-free circumstances.<sup>344</sup> The additional funding will speed up the introduction of a new program, the Hyperspectral Imaging Mission.<sup>345</sup> It will provide data regarding accumulated storage of carbon in soils and minerals.<sup>346</sup>

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<sup>335</sup> Thierry Dubois, *ESA Gathers Record Multiyear Funding*, 181 AVIATION WK. & SPACE TECH. 22, 22 (Dec. 23, 2019).

<sup>336</sup> *Id.*

<sup>337</sup> The Copernicus program consists of four remote sensing satellites orbiting in space. They report to two EUMETSAT weather satellites which process the information. ESA and EUMETSAT coordinate the delivery of weather from 30 satellites which constitute the entire system. See *Satellites Component*, COPERNICUS, <https://www.copernicus.eu/en/about-copernicus/infrastructure/satellites-component> [<https://perma.cc/BJS8-9495>] (last visited Oct. 13, 2020). See also *Sentinel Hub Brochure*, SENTINEL HUB, [https://www.sentinel-hub.com/docs/Sentinel\\_HUB\\_Brochure\\_2019\\_NEW.pdf](https://www.sentinel-hub.com/docs/Sentinel_HUB_Brochure_2019_NEW.pdf) [<https://perma.cc/38ZQ-ZQJS>] (last visited Oct. 13, 2020).

<sup>338</sup> Dubois, *supra* note 335, at 22.

<sup>339</sup> *Id.*

<sup>340</sup> *Id.*

<sup>341</sup> *Id.*

<sup>342</sup> See Convention on Climate Change, *supra* note 8, at 170; Paris Agreement, *supra* note 11, at 4.

<sup>343</sup> See *New Earth Observation Product Will ‘See Through’ Clouds*, SCI. & TECH. FACILITIES COUNCIL (Mar. 10, 2020), <https://stfc.ukri.org/news/new-earth-observation-product-will-see-through-clouds/> [<https://perma.cc/6KHW-XNX6>].

<sup>344</sup> See Michael Otten, *An Overview of ESA’s Upcoming Missions Equipped with SLR*, EUR. SPACE AGENCY (Oct. 2008), [https://cdis.nasa.gov/lw16/docs/presentations/ops\\_8\\_Otten.pdf](https://cdis.nasa.gov/lw16/docs/presentations/ops_8_Otten.pdf) [<https://perma.cc/H54U-66JZ>].

<sup>345</sup> Stephen Clark, *Earth Observation, Deep Space Exploration Big Winners in New ESA Budget*, SPACEFLIGHT NOW (Nov. 29, 2019), <https://spaceflightnow.com/2019/11/29/earth-observation-deep-space-exploration-big-winners-in-new-esa-budget/> [<https://perma.cc/CVT9-WZXL>].

<sup>346</sup> See generally Daniel Žížala et al., *Soil Organic Carbon Mapping Using Multispectral Remote Sensing Data: Prediction Ability of Data with Different Spatial and Spectral*

ESA cooperates with NASA, which represents the other developed country categorized as such by the Paris Agreement.<sup>347</sup> NASA is not increasing either its Earth observation capacity to cope with climate change or its transfer of information and technical knowledge to developing countries.<sup>348</sup> However, NASA is continuing its regular Earth observation, which includes determination of climate change consequences.<sup>349</sup> Two new NASA Earth observation satellites are being launched in 2020 to study the increasing height of oceans.<sup>350</sup> NASA also supports other outer space Earth observation activities.<sup>351</sup> NASA operates a fleet of satellites that observe natural events on the earth's surface, collect data, and compare these current observations with past observations, noting changes.<sup>352</sup>

Also relevant is the increase in small Earth observation satellites being launched by United States non-governmental satellite operators.<sup>353</sup> The total volume of additional satellites will increase tenfold from 2,000 to 20,000 and most of the increase consists of non-governmental satellites.<sup>354</sup> Their Earth observations may therefore not be available for the United States government to transfer freely to developed countries, as directed by the Paris Agreement.<sup>355</sup>

## 9. Burden of Capacity Building

Capacity building is an important part of the Paris Agreement.<sup>356</sup> Technology transfer is mandated by Article 10 of the Paris Agreement.<sup>357</sup>

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*Resolutions*, 11 REMOTE SENSING 24 (Dec. 9, 2019), <https://www.mdpi.com/2072-4292/11/24/2947> [<https://perma.cc/66DW-8K2V>].

<sup>347</sup> Paris Agreement, *supra* note 11, at art. 4(4).

<sup>348</sup> NASA's *FY 2020 Budget*, PLANETARY SOC'Y, <https://www.planetary.org/space-policy/nasas-fy-2020-budget> [<https://perma.cc/FASQ-FCR5>] (last visited Oct. 13, 2020).

<sup>349</sup> See *What's NASA Got To Do With Climate Change?*, NASA, <https://climate.nasa.gov/faq/18/whats-nasa-got-to-do-with-climate-change/> [<https://perma.cc/SL9N-WAMV>] (last visited Oct. 13, 2020).

<sup>350</sup> *New International Ocean Satellite Completes Testing*, NASA, <https://www.nasa.gov/feature/jpl/new-international-ocean-satellite-completes-testing> [<https://perma.cc/DEK6-FBER>] (last updated July 8, 2020).

<sup>351</sup> See Larsen, *supra* note 82, at 244–350; see also LYALL & LARSEN, *supra* note 36, at ch. 13.

<sup>352</sup> See generally U.S. GOV'T ACCOUNTABILITY OFF., GAO-10-456, ENVIRONMENTAL SATELLITES: STRATEGY NEEDED TO SUSTAIN CRITICAL CLIMATE AND SPACE WEATHER MEASUREMENTS (2010).

<sup>353</sup> See Jeff Foust, *Earth Observation Companies Plan New Satellites and Seek New Customers*, SPACE NEWS (Sept. 12, 2019), <https://spacenews.com/earth-observation-companies-plan-new-satellites-and-seek-new-customers/> [<https://perma.cc/EE9A-SDAF>].

<sup>354</sup> Bruno, *supra* note 51, at 18–19.

<sup>355</sup> See *supra* text accompanying note 77.

<sup>356</sup> Paris Agreement, *supra* note 11, at art. 11.

<sup>357</sup> *Id.* at art. 10.

Technology transfers from developed to developing countries take place under the umbrella of the mechanism established under Article 6 of the Paris Agreement.<sup>358</sup> Transfer of climate change technology from developed to developing states includes satellite remote sensing, communication, GNSS, weather, and other outer space technology.<sup>359</sup> As part of technology transfer, the Paris Agreement provides developed countries assistance for educating and training developing countries in the use of new technology.<sup>360</sup>

Paris Agreement Article 13 expresses the need for climate change education.<sup>361</sup> Thus, the Paris Agreement establishes “An Enhanced Transparency Framework for Action and Support.”<sup>362</sup> This framework is intended to help developing countries understand and implement the Paris Agreement’s objective “to limit the temperature increase to 1.5 degrees Celsius above pre-industrial levels.”<sup>363</sup> In fact, the transparency framework will help developing countries to implement all aspects of the Paris Agreement. To achieve the objective of the Paris Agreement, each party is required to report to the Enhanced Transparency Framework<sup>364</sup>: (1) a national inventory of anthropogenic emissions by sources, as well as removal of sinks of greenhouse gases, including periodic updates indicating progress made; (2) progress made in adapting to the climate situation; (3) all capacity-building activities by developed countries; and (4) all capacity-building assistance they received from developed countries.<sup>365</sup> Furthermore, (5) all information will be subject to expert technical review; (6) the reviews of capacity building shall indicate needs (areas) for improvement; and (7) the conference of parties must adopt

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<sup>358</sup> See Elliot Diringer, *Technology Transfer in A New Global Climate Agreement*, PEW CTR. ON GLOB. CLIMATE CHANGE (July 9, 2016), [https://www.brookings.edu/wp-content/uploads/2016/07/09\\_climate\\_change\\_poverty\\_diringer.pdf](https://www.brookings.edu/wp-content/uploads/2016/07/09_climate_change_poverty_diringer.pdf) [<https://perma.cc/26RF-PHQ3>].

<sup>359</sup> See generally *Global Navigation Satellite Systems Workshops*, U.N. OFF. FOR OUTER SPACE AFFS., <https://www.unoosa.org/oosa/en/ourwork/psa/gnss/workshops.html> [<https://perma.cc/C5RV-D6TS>] (last visited Oct. 13, 2020).

<sup>360</sup> Paris Agreement, *supra* note 11, at art. 10.

<sup>361</sup> *Id.* at art. 13.

<sup>362</sup> See *Transparency of Support Under the Paris Agreement*, U.N. FRAMEWORK CONVENTION ON CLIMATE CHANGE SUBSIDIARY BODY FOR SCI. AND TECH. ADVICE, <https://unfccc.int/topics/climate-finance/workstreams/transparency-of-support-ex-post/transparency-of-support-under-the-paris-agreement> [<https://perma.cc/H66U-NJ4U>] (last visited Oct. 13, 2020).

<sup>363</sup> Paris Agreement, *supra* note 11, at art. 2(1)(a).

<sup>364</sup> *Id.* at art. 13; see *infra* Conclusion Section C.

<sup>365</sup> See generally *What is transparency and reporting?*, U.N. FRAMEWORK CONVENTION ON CLIMATE CHANGE (June 19, 2019), <https://unfccc.int/process-and-meetings/transparency-and-reporting/the-big-picture/what-is-transparency-and-reporting> [<https://perma.cc/7S9P-FLDS>].

procedures and guidelines for the functions of the Enhanced Transparency Framework.<sup>366</sup>

The plentitude of outer space technology in the United States and Europe, and the scarcity of this technology among developing countries, suggests prospective heavy use of the Enhanced Transparency Framework and other forms of capacity training. However, space technology also exists among other space powers such as China, Russia, and India.<sup>367</sup> During the negotiations of the Paris Agreement in 2015, China promised to transfer \$3.1 billion to assist developing countries in the South-South Climate Cooperation Fund to manage climate change.<sup>368</sup> Capacity-building plans by Russia and India under the Paris Agreement Article 13 umbrella is not known at the present time. Capacity building by these three countries and bilateral assistance agreements will be considered through the Enhanced Transparency Framework established by the Paris Agreement.<sup>369</sup>

#### 10. Periodic Global Stock-Taking of the Paris Agreement<sup>370</sup>

Climate change will cause significant problems for the countries on Earth. There will be differences depending on geographical locations. Some countries may change from developed to developing country status and *vice versa*. Decision-making under the Paris Agreement is based on consensus,<sup>371</sup> and some countries may change their minds about participation in sharing responsibilities for climate change mitigation, as happened with the United States.<sup>372</sup> Thus it will be necessary to make periodic fundamental re-evaluations of the structure and utility of the Paris Agreement. For example, the denunciation of the Paris Agreement by the United States<sup>373</sup> and the failure of COP 25 will result in global

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<sup>366</sup> *Id.*

<sup>367</sup> See Cameron Hickert, *Space Rivals: Power and Strategy in the China-India Space Race*, SCHWARZMAN SCHOLARS, <https://www.schwarzmanscholars.org/news-article/space-rivals-power-strategy-china-india-space-race/> [<https://perma.cc/87Z6-7RNX>] (last visited Oct. 13, 2020).

<sup>368</sup> See discussion of China, *infra* Conclusion Section B; see also discussion of Developing Countries, *infra* Conclusion Section C.

<sup>369</sup> See Yamide Dagnet et al., *Building Capacity for the Paris Agreement's Enhanced Transparency Framework: What Can We Learn from Countries' Experiences and UNFCCC Processes?*, WORLD RES. INST. (Mar. 2019), <https://www.wri.org/publication/capacity-building-paris-transparency> [<https://perma.cc/5F9N-GCSS>].

<sup>370</sup> Paris Agreement, *supra* note 11, at art. 14.

<sup>371</sup> *Id.* at art. 14 (5).

<sup>372</sup> See *infra* Section Conclusion.A.

<sup>373</sup> *Id.*

stock-taking of the Paris Agreement similar to the periodic stock-taking and updating of the Montreal Protocol on ozone depletion.<sup>374</sup> This stock-taking will necessarily involve evaluation of the growing availability of outer space technology to implement the Paris Agreement. Space technology and its application is growing rapidly as indicated by the increase in the number of remote sensing satellites in orbit and increasingly higher resolution of images.<sup>375</sup> Most of the additional satellites are for communication, remote sensing, and weather.<sup>376</sup> The first stock-taking is scheduled for 2023.<sup>377</sup>

#### 11. Compliance and Enforcement of Climate Change Countermeasures<sup>378</sup>

Accumulation of greenhouse gas during the industrial age can be traced mostly to developed countries.<sup>379</sup> Future increases in emissions are expected to come mostly from developing countries.<sup>380</sup> However, developed countries have the necessary technology (including space technology) and enforcement capability to reduce global emissions.

Paris Agreement Article 4(2) assigned individual responsibility to each state to define, report, and administer its control of emissions, its so-called “contribution” towards reaching the objectives of the Paris Agreement.<sup>381</sup> Developed countries are required by the Paris Agreement to assist developing countries to make their self-defined contributions.<sup>382</sup> In fact, developed countries are asked to make extra reductions beyond their self-assigned reductions in order to ease the burdens of the developing countries.<sup>383</sup> The agreement envisions eventual international economy-wide emissions reductions and mitigations.<sup>384</sup>

<sup>374</sup> See Montreal Protocol, *supra* note 21.

<sup>375</sup> See Zhen Liu et al., *Understanding the Digital Earth*, in *MANUAL OF DIGITAL EARTH* (H. Guo et al., eds., Nov. 20, 2019), [https://link.springer.com/chapter/10.1007/978-981-32-9915-3\\_1](https://link.springer.com/chapter/10.1007/978-981-32-9915-3_1) [<https://perma.cc/7QSW-LGR8>].

<sup>376</sup> See Christopher D. Johnson, *Handbook for New Actors in Space*, SECURE WORLD FOUND. (2007), [https://swfound.org/media/205710/handbook\\_for\\_new\\_actors\\_in\\_space\\_2017\\_web2.pdf](https://swfound.org/media/205710/handbook_for_new_actors_in_space_2017_web2.pdf) [<https://perma.cc/GAU9-BTSD>].

<sup>377</sup> Paris Agreement, *supra* note 11, at art. 10.

<sup>378</sup> See Brunnée, *supra* note 150, at 290.

<sup>379</sup> See Peter C. Frumhoff et al., *The Climate Responsibilities of Industrial Carbon Producers*, *CLIMATIC CHANGE* 132, 158–61 (July 23, 2015).

<sup>380</sup> See Brunnée, *supra* note 150, at 290–91.

<sup>381</sup> Paris Agreement, *supra* note 11, at 3.

<sup>382</sup> *Id.* at 13.

<sup>383</sup> *Id.* at 4.

<sup>384</sup> See discussion *supra* Section II.F.5.

While the goal of the Paris Agreement is clearly defined, the Paris Agreement does not establish mandatory compliance and enforcement standards.<sup>385</sup> It establishes only guidelines for each state to follow,<sup>386</sup> it being assumed that countries will be motivated by self-interest to implement the Paris Agreement. Nevertheless, several states in their court decisions have decided that compliance with Paris Agreement guidelines are compulsory by national regulation.<sup>387</sup> As Jutta Brunnée explains in her essay *Climate Change and Compliance and Enforcement Processes*,<sup>388</sup> international environmental modifications, such as climate change, have been most effective in the form of guidelines and non-binding standards.<sup>389</sup> It has been difficult to reach agreement among multiple states for mandatory standards.<sup>390</sup> States are increasingly accepting non-binding guidelines as domestically binding rules.<sup>391</sup> Thus, application of the Paris Agreement is basically left to the individual participating countries.

The Paris Agreement's international enforcement of its members' emission contributions functions essentially through the central public registry of contributions to be administered by the central registry (data bank) established by Article 4(12) of the Paris Agreement.<sup>392</sup> That is aimed to provide transparency for the calculation and determination of whether the objectives of the Paris Agreement are being reached or whether more stringent reductions will be necessary in order to "limit the temperature increase to 1.5 [degrees Celsius] above pre-industrial levels."<sup>393</sup>

Use of Earth observation satellite technology is crucial for determination of emissions,<sup>394</sup> rise of the seas, ability of the seas to absorb emissions, and many other factual observations.<sup>395</sup> Exact measurement

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<sup>385</sup> Paris Agreement, *supra* note 11.

<sup>386</sup> *Id.* at 18.

<sup>387</sup> See, e.g., *R. (on the application of Plan B Earth) v. Secretary of State for Transport and Heathrow Airport* [2020] EWCA Civ 214 (Eng.)

<sup>388</sup> Brunnée, *supra* note 150, at 294–300. See also Paul B. Larsen, *Space Traffic Management Standards*, 83 J. AIR L. & COM. 360–85 (2018) (discussing international standards).

<sup>389</sup> Brunnée, *supra* note 150, at 300.

<sup>390</sup> *Id.* at 290–91.

<sup>391</sup> *Id.* at 308, 311–12.

<sup>392</sup> Paris Agreement, *supra* note 11, at 5. See discussion *supra* Section II.F.7.

<sup>393</sup> Paris Agreement, *supra* note 11, at 3.

<sup>394</sup> See Letzter, *supra* note 15 (discussing United States and ESA satellite measurements of United States, Italian, and Chinese emissions).

<sup>395</sup> Guo Hua-Dong et al., *Earth Observation Big Data for Climate Change Research*, 6 ADVANCES IN CLIMATE CHANGE RSCH. 108, 115 (2015); Alessandra Potenza, *A NASA Satellite that Monitors CO2 is Revealing the Inner Workings of Our Planet*, VERGE (Oct. 12, 2017), <https://www.theverge.com/2017/10/12/16460014/nasa-oco-2-satellite-carbon-dioxide-earth-atmosphere-plants-ocean-climate-change> [<https://perma.cc/2U7J-NT82>].

of national contributions are difficult to obtain and require sophisticated technology.<sup>396</sup> To reach the objectives of the Paris Agreement, it is urgently necessary for the space powers to use their satellite technology to measure not only their own commitments but also those of other countries. The increasing number of satellites predicted for outer space will be able to more comprehensively observe and measure global warming emissions.<sup>397</sup> Individual states' reports of contributions can almost instantaneously be verified because of the wide availability of the technology.<sup>398</sup> Space technology has the unique function of providing transparency about the performance of each national state.<sup>399</sup> Thus, space technology is an important force and tool toward compliance with the non-binding guidelines of the Paris Agreement and will become more so as the technology increases in magnitude and capability. Remote sensing, communication, GNSS, and weather satellites are the most promising tools available for individual states to organize their mitigation of climate change effects and to verify that other states perform their commitments under the Paris Agreement.<sup>400</sup> Their volume is growing.<sup>401</sup> In addition, other enforcement tools provide adequate transparency and peer pressure.<sup>402</sup>

Human survival depends on compliance with basic limitations on and reductions of climate change;<sup>403</sup> however, conflicting national priorities interfere with national enforcement of international climate change guidelines.<sup>404</sup> An ultimate question is whether survival of life on Earth can be accomplished by voluntary commitments. Some governments may not be sufficiently authoritative to secure adoption of non-binding climate

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<sup>396</sup> *Measuring Progress Towards the Targets of the Paris Climate Agreement*, U.N. ECO. COMM'N FOR EUR., <https://www.unece.org/info/media/news/statistics/2016/measuring-progress-towards-the-targets-of-the-paris-climate-agreement/doc.html> [<https://perma.cc/3VFY-YA8F>] (last visited Oct. 13, 2020).

<sup>397</sup> Aditya Chaturvedi, *How Satellite Imagery is Crucial for Monitoring Climate Change*, GEOSPATIAL WORLD (Jan. 30, 2020), <https://www.geospatialworld.net/blogs/satellites-for-monitoring-climate-change/> [<https://perma.cc/9FNS-8Y6M>].

<sup>398</sup> Timiebi Aganaba-Jeanty & Anna Huggins, *Satellite Measurement of GHG Emissions: Prospects for Enhancing Transparency and Answerability Under International Law*, 8 TRANSNAT'L ENV'T L. 303, 312–13 (2019).

<sup>399</sup> *Id.* at 305.

<sup>400</sup> Ayodele Adekunle Faiyetole, *Potentialities of Space-Based Systems for Monitoring Climate Policies and Mitigation of Climate Process Drivers*, 16 ASTROPOLITICS 28, 39–40 (2018).

<sup>401</sup> Chaturvedi, *supra* note 397.

<sup>402</sup> Brunnée, *supra* note 150, at 318. See discussion *supra* Part I.

<sup>403</sup> David McCoy et al., *Climate Change and Human Survival*, 348 BRIT. MED. J. 2351 (2014).

<sup>404</sup> U.N., FRAMEWORK CONVENTION ON CLIMATE CHANGE, SYNTHESIS REPORT ON THE IMPLEMENTATION OF THE FRAMEWORK FOR CAPACITY-BUILDING IN DEVELOPING COUNTRIES 7 (2015).

change guidelines. One option for a stronger decision-making framework would be to establish a special U.N. agency for civil climate change issues like the International Civil Aviation Organization,<sup>405</sup> which serves civil air traffic, or like the ITU,<sup>406</sup> which serves civil telecommunication frequencies. Both organizations are created by special treaties for those subjects only.<sup>407</sup> They both adopt international minimum standards for civil traffic that the members are obligated to observe and follow.<sup>408</sup> One advantage of such an arrangement would be that climate change would become detached from decision-making regarding other international—primarily national security—issues. Such an arrangement would be an option if the voluntary arrangement of the participating parties fails.

## 12. Subsidiary Bodies to Consider and Implement Climate Change Countermeasures

The Paris Agreement's structure includes a Secretariat to administer the Agreement.<sup>409</sup> Furthermore, the Paris Agreement established a Scientific and Technological Committee as well as the permanent Central Mechanism for the Promotion of the Paris Agreement and Guidance of its Members.<sup>410</sup> Their purposes are constantly to consider the best possible tools for climate change mitigation.<sup>411</sup> They will assess the best uses of space technology for meeting climate change problems, including application of available space laws and regulations for possible further reduction of greenhouse gases to aid reduction of global warming.<sup>412</sup> The joint structure of the UNFCCC and the Paris Agreement also receives great support from the U.N. and all its specialized agencies as described immediately below.<sup>413</sup>

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<sup>405</sup> Convention on International Civil Aviation, Dec. 7, 1844, 15 U.N.T.S. 295 (established the International Civil Aviation Organization ("ICAO") which is a specialized agency of the U.N.).

<sup>406</sup> 2015 ITU TEXTS, *supra* note 91.

<sup>407</sup> See Larsen, *supra* note 51, at 783.

<sup>408</sup> *Id.*

<sup>409</sup> Paris Agreement, *supra* note 11, at 12–13.

<sup>410</sup> See discussion *supra* Section II.F.5.

<sup>411</sup> Paris Agreement, *supra* note 11, at 21–22. See *infra* notes 495–502 (discussing inter-generational responsibility. Courts have decided that individuals are entitled to enforcement as a matter of human right in accordance with the Paris Agreement Article 4(3)).

<sup>412</sup> *Subsidiary Body for Scientific and Technological Advice (SBSTA)*, U.N., <https://unfccc.int/process/bodies/subsidiary-bodies/sbsta> [<https://perma.cc/LHW3-9685>] (last visited Oct. 13, 2020).

<sup>413</sup> See *infra* Section II.F.13.

### 13. Supporting Role of the United Nations

The U.N. strongly supports climate change mitigation.<sup>414</sup> The U.N. acts as depositary of the UNFCCC, including the Paris Agreement.<sup>415</sup> Article 16 of the Paris Agreement provides that the U.N. bodies and specialized agencies may be represented at the conference of the parties to the Paris Agreement.<sup>416</sup> The U.N. has established a Secretariat which supports the UNFCCC and the Paris Agreement.<sup>417</sup> The supporting role of the U.N. makes available the resources of U.N. bodies such as COPUOS, including COPUOS subsidiaries such as UN-SPIDER.<sup>418</sup> It also favors the availability of the expertise and assistance of the ITU, the WMO, and similar U.N. specialized agencies, all of which administer satellite issues essential for control and mitigation of climate change effects.<sup>419</sup>

#### a. United Nations Regulation of Remote Sensing Satellites

The 1985 U.N. Principles Relating to the Use of Remote Sensing of Earth from Outer Space<sup>420</sup> regulate and support the use of remote

<sup>414</sup> *Climate Change*, U.N. DEV. PROGRAMME, <https://www.undp.org/content/undp/en/home/2030-agenda-for-sustainable-development/planet/climate-change.html> [https://perma.cc/4W33-LHB2] (last visited Oct. 13, 2020); *Goal 13: Climate Action*, U.N. DEV. PROGRAMME, <https://www.undp.org/content/undp/en/home/sustainable-development-goals/goal-13-climate-action.html> [https://perma.cc/WE87-84RE] (last visited Oct. 13, 2020).

<sup>415</sup> United Nations Framework Convention on Climate Change, Mar. 21, 1994, 1771 U.N.T.S. 30822.

<sup>416</sup> Paris Agreement, *supra* note 11, at 21 (“The United Nations and its specialized agencies and the International Atomic Energy Agency, as well as any State member thereof or observers thereto not party to the Convention, may be represented at sessions of the Conference of the Parties serving as the meeting of the Parties to this Agreement as observers. Any body or agency, whether national or international, governmental or non-governmental, which is qualified in matters covered by this Agreement and which has informed the secretariat of its wish to be represented at a session of the Conference of the Parties serving as the meeting of the Parties to this Agreement as an observer, may be so admitted unless at least one third of the Parties present object. The admission and participation of observers shall be subject to the rules of procedure referred to in paragraph 5 of this Article.”).

<sup>417</sup> *About the Secretariat*, U.N. FRAMEWORK CONVENTION ON CLIMATE CHANGE, <https://unfccc.int/about-us/about-the-secretariat> [https://perma.cc/A7U5-WZYG] (last visited Oct. 13, 2020).

<sup>418</sup> *Comm. on the Peaceful Uses of Outer Space*, U.N. OFF. FOR OUTER SPACE AFFS., <https://www.unoosa.org/oosa/en/ourwork/copuos/index.html> [https://perma.cc/8V5A-GZQL] (last visited Oct. 13, 2020); *About Us*, U.N. OFF. FOR OUTER SPACE AFFS. UN-SPIDER, <http://www.un-spider.org/about> [https://perma.cc/B5PY-NQNJ] (last visited Oct. 13, 2020).

<sup>419</sup> *About International Telecommunication Union (ITU)*, U.N. INT'L TELECOMM. UNION, <https://www.itu.int/en/about/Pages/default.aspx> [https://perma.cc/QQ9B-7QZ8] (last visited Oct. 13, 2020).

<sup>420</sup> G.A. Res. 41/65, *supra* note 77 (the remote sensing principles were drafted by the UN

sensing satellites for the welfare of life on Earth. Thus, they support global warming mitigation by use of space technology.<sup>421</sup> As a U.N. resolution, the remote sensing principles are only recommendatory.<sup>422</sup> They do not have the binding effect of a treaty obligation.<sup>423</sup> The resolution recommends that states share relevant remote sensing information with other states.<sup>424</sup> Principle X supports use of remote sensing for protection of the natural environment.<sup>425</sup> For that purpose, states shall distribute information to help vulnerable states avoid disasters.<sup>426</sup> Sensed states shall have access to sensed information “on reasonable cost terms,” with particular consideration paid to the interests of developing countries,<sup>427</sup> regarding governmental and non-governmental remote sensing activities.<sup>428</sup> Thus, developing states have received special cost terms.<sup>429</sup> An argument can be made that remote sensing to remedy climate change consequences should be free as a principle of humanitarian law, “as a norm of customary law.”<sup>430</sup>

Remote sensing to avoid harmful consequences of climate change is in the interest of all countries. Thus, the U.N. Principles are important for the protection of the environment from climate change.<sup>431</sup> However, they are only recommendatory.<sup>432</sup> National security laws of several countries restrict the sensing of their territories.<sup>433</sup> The United States, Canada, India, France, and Italy have limited the access to remote sensing of their territories.<sup>434</sup>

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Committee for the Peaceful Uses of Outer Space (“COPUOS”). See LYALL & LARSEN, *supra* note 36.

<sup>421</sup> *Id.*

<sup>422</sup> *Id.*

<sup>423</sup> *How Decisions are Made at the UN*, U.N., <https://www.un.org/en/model-united-nations/how-decisions-are-made-un> [<https://perma.cc/4H7J-9TUX>] (last visited Oct. 13, 2020).

<sup>424</sup> G.A. Res. 41/65, *supra* note 77, at Principle IX.

<sup>425</sup> *Id.* at Principle X.

<sup>426</sup> *Id.* at Principles X–XI.

<sup>427</sup> *Id.* at Principle XII.

<sup>428</sup> *Id.* at Principle XIV.

<sup>429</sup> *Id.* at Principle XII.

<sup>430</sup> LYALL & LARSEN, *supra* note 36, at 375.

<sup>431</sup> *Id.* at 371.

<sup>432</sup> U.N., *supra* note 423.

<sup>433</sup> JOANNE I. GABRYNOWICZ, NAT'L CTR. FOR REMOTE SENSING, AIR, & SPACE L., *THE LAND REMOTE SENSING LAWS AND POLICIES OF NATIONAL GOVERNMENTS: A GLOBAL SURVEY*, 7, 11–13 (2007).

<sup>434</sup> *Id.* at 11–12.

b. United Nations Guidelines for Global Development<sup>435</sup>

In 2015, the U.N. General Assembly (“UNGA”) adopted 17 long-term global development guidelines leading to a range of sustainability goals.<sup>436</sup> One of those goals, Goal 13, is for all nations to take effective action to combat climate change<sup>437</sup>:

Goal 13. Take urgent action to combat climate change and its impacts[:]

13.1 Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries[.]

13.2 Integrate climate change measures into national policies, strategies and planning[.]

13.3 Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning[.]

13.(a) Implement the commitment undertaken by developed-country parties to the United Nations Framework Convention on Climate Change to a goal of mobilizing jointly *\$100 billion annually by 2020*<sup>438</sup> from all sources to address the needs of developing countries in the context of meaningful mitigation actions and transparency on implementation and fully operationalize the Green Climate Fund through its capitalization as soon as possible[.]

13.(b) Promote mechanisms for raising capacity for effective climate change–related planning and management in least developed countries and small island developing

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<sup>435</sup> U.N., TRANSFORMING OUR WORLD: THE 2030 AGENDA FOR SUSTAINABLE DEVELOPMENT, <https://sustainabledevelopment.un.org/content/documents/21252030%20Agenda%20for%20Sustainable%20Development%20web.pdf> [<https://perma.cc/2V2A-4DW8>] (last visited Oct. 13, 2020).

<sup>436</sup> *Id.*

<sup>437</sup> *Id.* at Goal 13.

<sup>438</sup> *Id.* (emphasis added). This is an estimate of the capital needed to counter the effects of climate change. The U.N. Members have failed to raise this huge sum.

States, including focusing on women, youth and local and marginalized communities.<sup>439</sup>

All the U.N. organizational bodies are requested by the UNGA to prepare guidelines for long-term sustainability in their areas of activity.<sup>440</sup> Thus, it became subject to action by COPUOS, which is an UNGA Committee.<sup>441</sup>

c. COPUOS Guidelines for the Long-Term Sustainability of Outer Space Activities

Sustainable management is a basic climate change tool mandated not only by the UNGA but also by the UNFCCC.<sup>442</sup> COPUOS acknowledges its special responsibility for global coordination of the use of space technology to control the adverse effects of climate change.<sup>443</sup> The 2019 annual COPUOS report to the UNGA recognizes that the new satellite technology is particularly important for ascertaining and monitoring facts about climate change and in countering effects.<sup>444</sup> COPUOS concludes that remote sensing satellites are and should increasingly be used to: “[T]rack changes in sea level, carbon dioxide concentrations, sea ice depletion and terrestrial snow mass and to gather data on remote areas such as deserts, oceans, the polar caps and glaciers.”<sup>445</sup>

The COPUOS report acknowledges that climate change is now affecting terrestrial and ocean surfaces of the earth. It is important and now possible to observe changes more frequently as they happen.<sup>446</sup> Remote sensing satellites in orbit are able to provide and record such information.<sup>447</sup> Based on satellite-collected information, when added to

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<sup>439</sup> *Id.*

<sup>440</sup> *Id.*

<sup>441</sup> *Id.* at Preamble.

<sup>442</sup> U.N., *U.N. Framework Convention on Climate Change*, [https://unfccc.int/files/essential\\_background/background\\_publications\\_htmlpdf/application/pdf/conveng.pdf](https://unfccc.int/files/essential_background/background_publications_htmlpdf/application/pdf/conveng.pdf) [<https://perma.cc/NBA7-VXGG>] (last visited Oct. 13, 2020).

<sup>443</sup> *Environment and Natural Resources: Climate Change*, U.N. OFF. FOR OUTER SPACE AFFS. (Aug. 21, 2020), <https://www.unoosa.org/oosa/en/ourwork/psa/emnrm/climatechange.html> [<https://perma.cc/5ZJ5-U3Z5>]; GABRYNOWICZ, *supra* note 433, at 37.

<sup>444</sup> Report on Peaceful Uses of Outer Space, *supra* note 78, at 36–38 (COPUOS established an implementing working group).

<sup>445</sup> *Id.* at 37.

<sup>446</sup> *Id.* at 16.

<sup>447</sup> *Id.*; LYALL & LARSEN, *supra* note 36.

information collected on the surface of the earth, experts are now better able to understand the nature and extent of climate change on Earth.<sup>448</sup>

Considering that COPUOS is a U.N. committee and that the U.N. is supportive of the UNFCCC and the Paris Agreement,<sup>449</sup> COPUOS is a crucial addition to organized satellite support for climate change detection and mitigation. Furthermore, COPUOS is a deliberative body that can react independently to climate change events as they develop.<sup>450</sup>

COPUOS established a subcommittee to study sustainable development.<sup>451</sup> It prepared, and the full committee adopted, 21 guidelines for long-term sustainability of outer space resource activities.<sup>452</sup> The adverse consequences of climate change upon global resources is part of the outer space guidelines because climate change puts all economic resources at risk.<sup>453</sup> Climate change must be mitigated in order for all resources to reach full sustainable development.<sup>454</sup> Thus, COPUOS established the 21 voluntary international guidelines.<sup>455</sup> COPUOS resolved that climate change is a global problem affecting all states.<sup>456</sup> Mitigation of emissions requires international cooperation for the guidelines to become effective.<sup>457</sup> The guidelines are legally based on a COPUOS resolution asking states to conduct their activities so as “to address natural and man-made hazards that could compromise the operations of States.”<sup>458</sup>

The COPUOS guidelines on sustainability, like the UNFCCC and the Paris Agreement, place greater responsibility on developed, rather than on developing, nations.<sup>459</sup> They assume that the space powers, such as the United States, the ESA member states, Russia, and China, will use their space technology not only for themselves but also on behalf of the countries that do not possess such technology.<sup>460</sup> Developing countries are urged to seek the assistance of space powers to combat the adverse

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<sup>448</sup> U.N., *supra* note 435, at 15.

<sup>449</sup> Paris Agreement, *supra* note 11.

<sup>450</sup> U.N. OFF. FOR OUTER SPACE AFFS., *supra* note 418.

<sup>451</sup> Report on Peaceful Uses of Outer Space, *supra* note 78, at 16.

<sup>452</sup> *Id.* at 50 (contextualizing the guidelines for the long-term sustainability of outer space activities).

<sup>453</sup> *Id.* at 16, 37–38, 64.

<sup>454</sup> *Id.* at 16, 37–38.

<sup>455</sup> U.N., *supra* note 435, ¶ 39.

<sup>456</sup> Report on Peaceful Uses of Outer Space, *supra* note 78, at 37.

<sup>457</sup> G.A. Res. 1962 (XVIII) (requiring states to use outer space for their common benefit).

<sup>458</sup> Report on Peaceful Uses of Outer Space, *supra* note 78, at 51.

<sup>459</sup> *See id.* at 1, 7, 11, 15, 17–19; Convention on Climate Change, *supra* note 8, at 166, 168–70, 173–75; Paris Agreement, *supra* note 11, at 1, 3–4, 8–10.

<sup>460</sup> *Id.*

effects of climate change.<sup>461</sup> This includes the use of outer space technology such as remote sensing satellites, communication satellites, GNSS, and weather satellites as listed in the 2019 annual COPUOS report.<sup>462</sup>

The states are entrusted with implementation of the COPUOS sustainability guidelines.<sup>463</sup> Adoption of the guidelines will result in some disuniformity of implementation because each state has different national priorities.<sup>464</sup> Disuniformity is a weakness of the guidelines.<sup>465</sup> However, when implementation is linked to other international laws and regulations such as the Paris Agreement, then the implementation and enforcement will become more uniform. COPUOS will encourage member states to implement the sustainability and climate change guidelines uniformly by putting the issue on its formal agenda. COPUOS capacity-building can also contribute to uniform implementation of the guidelines.<sup>466</sup>

The 21 COPUOS Guidelines for States to Assure Long Term Sustainability of Outer Space Activities relate to climate change directly or indirectly.<sup>467</sup> Only those guidelines that directly concern conduct of outer space activities as they impact climate change on the earth are discussed here.<sup>468</sup> Those guidelines recommend as follows:

Guideline A.2 considers “a number of elements when developing, revising, or amending as necessary, national regulatory frameworks for outer space activities” and recommends that states take into consideration the long term sustainable development goals and potential impact on human activities on Earth, including activities that cause global warming, when they adopt and implement regulations for outer space.<sup>469</sup>

Guideline A.4(1) ensures “the equitable, rational and efficient use of the radio frequency spectrum and the various orbital regions used by satellites” by encouraging states to pay special attention to the long term sustainability on Earth in allocating radio frequencies for outer space activities, e.g., to avoid harmful radio interferences with climate change mitigation on Earth which requires use of radio frequencies for communication with Earth observation satellites.<sup>470</sup>

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<sup>461</sup> Report on Peaceful Uses of Outer Space, *supra* note 78, at 52–53.

<sup>462</sup> *Id.* at 16, 19, 31, 37–38.

<sup>463</sup> *See id.* at 3.

<sup>464</sup> Larsen, *supra* note 149, at 57.

<sup>465</sup> *Id.*

<sup>466</sup> Report on Peaceful Uses of Outer Space, *supra* note 78, at 28–29, 67.

<sup>467</sup> *See id.* at 6–8, 10, 13–14, 17–19.

<sup>468</sup> *Id.*

<sup>469</sup> *Id.* at 5–6.

<sup>470</sup> *Id.* at 7.

Guideline A.5(2) seeks to “[e]nhance the practice of registering space objects” by urging states in their registration of space objects to provide information about their operation and status.<sup>471</sup> In view of the multitude of private remote sensing and communication satellites, the public, in particular developing countries, will benefit from knowing the nature of the information being collected about climate change in their countries.<sup>472</sup>

Guideline B.1(1) seeks to “[p]rovide updated contact information and share information on space objects and orbital events” by telling states to share information about climate change forecasts and adoption of precautionary measures in their authorized satellite operations.<sup>473</sup>

Guideline B.6(1) encourages states to “[s]hare operational space weather data and forecasts” by encouraging states to collect, archive, share, intercalibrate and disseminate “critical space weather [information] as a means of enhancing the long-term sustainability of outer space activities.”<sup>474</sup>

Weather satellite collection and the distribution of weather information is an important way of warning people of impending violent weather caused by climate change.<sup>475</sup> Guideline B.6(4) urges states to provide common access to space weather information and establish interoperability of data portals to critical weather information.<sup>476</sup>

Guideline B.7(1) seeks to “[d]evelop space weather models and tools and collect established practices on the mitigation of space weather efforts” by urging states and international organizations to promote and support further development and research into weather forecasting.<sup>477</sup> Such research should include “the effects of the changing solar environment and the evolving terrestrial magnetic field.”<sup>478</sup> The research would consider the effect of global warming of the earth due to increasing human-caused emissions.<sup>479</sup> Such research by individual states should be coordinated with ongoing research activities within COPUOS, WMO, the International Space Environment Service and other international organizations.<sup>480</sup>

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<sup>471</sup> *Id.* at 8.

<sup>472</sup> See G.A. Res. 41/65, *supra* note 77, at 116. See also G.A. Res. 62/101 (Dec. 17, 2007) at ¶¶ 5–6 (regarding registration of space objects as well as Registration Convention).

<sup>473</sup> Report on Peaceful Uses of Outer Space, *supra* note 78, at 10.

<sup>474</sup> *Id.* at 13.

<sup>475</sup> *Early Warning Systems*, U.N., <https://www.un.org/en/climatechange/early-warning-systems.html> [<https://perma.cc/G2AX-KQCA>] (last visited Oct. 13, 2020).

<sup>476</sup> Report on Peaceful Uses of Outer Space, *supra* note 78, at 13.

<sup>477</sup> *Id.* at 14.

<sup>478</sup> *Id.*

<sup>479</sup> See *id.*

<sup>480</sup> *Id.*

Guideline B.7(2) encourages both states and international organizations to collect information about ground-based and space-based weather anomalies.<sup>481</sup> Such would include weather phenomena caused by human-caused emissions.<sup>482</sup> It would also include collection of chlorine emissions causing depletion of the ozone.<sup>483</sup> Such research could lead to additional guidelines that would further relieve problems of global warming.<sup>484</sup> This guideline recognizes that some of that information may be privately owned because it is collected by non-governmental satellite operators such as non-governmental earth observation satellites.<sup>485</sup> However, the guideline encourages adoption of international standards making publicly available such information.<sup>486</sup> Such standards could be coordinated and developed within the COPUOS Technical and Scientific Subcommittee.<sup>487</sup>

Guideline C.3(2)–(3) seeks to “[p]romote and support capacity-building” by urging states and international organizations to promote, support, and transfer space technology and economic resources to assist developing states to counter the adverse effects of climate change.<sup>488</sup> Developed countries are urged to coordinate such capacity-building activities with each other in order to avoid duplication.<sup>489</sup>

Guideline C.3(4) recommends space powers use satellites to collect weather information and transmit such information to developing states to help them avoid disasters.<sup>490</sup> States are urged to make such information freely available to developing states.<sup>491</sup>

Guideline C.4(1) seeks to “[r]aise awareness of space activities” by urging general awareness and societal benefits of space activities and their utility.<sup>492</sup> Guideline C.4(2) advises states and international organizations “to promote institutional and public awareness of space activities

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<sup>481</sup> *Id.*

<sup>482</sup> *See id.* at 14.

<sup>483</sup> *See* Montreal Protocol, *supra* note 21, at 30.

<sup>484</sup> *The Causes of Climate Change*, NASA, <https://climate.nasa.gov/causes/> [<https://perma.cc/QAY2-KDA8>] (last visited Oct. 13, 2020).

<sup>485</sup> Report on Peaceful Uses of Outer Space, *supra* note 78, at 14.

<sup>486</sup> *Id.* at 14–15.

<sup>487</sup> *Committee on the Peaceful Uses of Outer Space and its Subcommittees*, U.N. OFFICE FOR OUTER SPACE AFFS., <https://www.unoosa.org/oosa/en/ourwork/copuos/comm-subcomms.html> [<https://perma.cc/VEK4-JJDL>] (last visited Oct. 13, 2020).

<sup>488</sup> Report on Peaceful Uses of Outer Space, *supra* note 78, at 17–18.

<sup>489</sup> *Id.*

<sup>490</sup> *Id.* at 18.

<sup>491</sup> *Id.*

<sup>492</sup> *Id.*

and their application for sustainable development, environmental monitoring and assessment, disaster management and emergency response.”<sup>493</sup> Guideline C.4(2) raises the important legal issue of responsibility of the current generation for future generations.<sup>494</sup> The issue of generational legal responsibility is a particularly sensitive aspect of climate change.<sup>495</sup> A recent decision by the highest court of the Netherlands decided that the current generation is legally obliged to protect its future citizens from the adverse effects of climate change.<sup>496</sup> A similar inter-generational climate change case was recently rejected by a United States Court of Appeals.<sup>497</sup> The COPUOS guidelines on sustainability place responsibility on developed nations to “tak[e] into account the needs of current and future generations” in capacity-building and awareness.<sup>498</sup>

Guideline C.4(4) accepts that much space technology of the developed states is now non-governmental.<sup>499</sup> It stresses the need for coordination and cooperation among governmental and non-governmental satellite operators towards long term sustainability of space activities.<sup>500</sup>

Guideline D.1(3) seeks to “[p]romote and support research into and the development of ways to support sustainable exploration and use of outer space” by urging states and intergovernmental organizations to “promote the development of technologies that minimize the environmental impact of manufacturing and launching space assets and . . . maximize the use of renewable resources and the reusability or repurposing of space assets to enhance the long term sustainability of these activities.”<sup>501</sup>

These recommended activities would include mitigation of the adverse effects of climate change.<sup>502</sup>

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<sup>493</sup> *Id.*

<sup>494</sup> *Id.* at 18.

<sup>495</sup> Fabian Schuppert, *Climate Change and Intergenerational Justice*, UNICEF OFF. RSCH.-INNOCENTI, <https://www.unicef-irc.org/article/920-climate-change-and-intergenerational-justice.html> [<https://perma.cc/6KWP-FKKQ>] (last visited Oct. 13, 2020).

<sup>496</sup> HR 12 December 2019, NJ 2020, 41 m.nt. J. Spier (Neth./Stichting Urgenda) (Neth.) at 5.7.3. See Isabella Kaminski, Historic Urgenda Climate Ruling Upheld by Dutch Supreme Court, CLIMATE DOCKET (Dec. 20, 2019), <https://www.climatedocket.com/2019/12/20/urgenda-climate-ruling-netherlands-supreme-court/> [<https://perma.cc/KTW9-PCTG>].

<sup>497</sup> *Juliana v. United States*, 947 F.3d 1159, 1165 (9th Cir. 2020) (decided in a 2–1 decision to reject the case for not being justiciable).

<sup>498</sup> Report on Peaceful Uses of Outer Space, *supra* note 78, at 18.

<sup>499</sup> *Id.* at 19.

<sup>500</sup> *Id.*

<sup>501</sup> *Id.*

<sup>502</sup> See *id.* at 6–8, 10, 13–14, 16–18.

## CONCLUSION

A. *The United States and the Paris Agreement*

The United States is the second largest producer of greenhouse gases on Earth.<sup>503</sup> Climate change and its consequences, are controversial subjects in United States domestic politics because the Trump Administration does not support mitigation of climate change.<sup>504</sup> It has weakened regulation of emissions from oil, coal, and gas.<sup>505</sup> The majority of the United States population is of the view that climate change is real.<sup>506</sup> A 2019 poll by the Yale Program on Climate Change Communication showed that seventy-two percent of Americans hold the view that climate change is happening and must be acted on.<sup>507</sup>

The rest of the world clearly needs United States participation in solving the global climate crisis. Implementation of the Paris Agreement remains absolutely necessary for the whole world, including the United States. Average temperatures in the United States continue to rise.<sup>508</sup> A 2019 analysis by NASA and NOAA showed that average temperature increased 1 degree Celsius (1.8 degrees Fahrenheit) since the 1950s, and the increase is caused to a large extent by the burning of fossil fuels and to a decreasing extent by burning of coal.<sup>509</sup>

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<sup>503</sup> Pierre Friedlingstein et al., *Global Carbon Budget 2019*, 11 EARTH SYS. SCI. DATA 1783, 1810 (2019).

<sup>504</sup> Philip A. Wallach, *Where Does US Climate Policy Stand in 2019?*, BROOKINGS INST. (Mar. 22, 2019), <https://www.brookings.edu/2019/03/22/where-does-u-s-climate-policy-stand-in-2019/> [https://perma.cc/9UC3-Y3K3].

<sup>505</sup> See Friedman & Davenport, *supra* note 292. In 2015 the United States caused 14.3% of global greenhouse emissions. Furthermore, implementation of National Environmental Policy Act (“NEPA”) assessments have been less effective in containing environmental damages under the Trump administration. See Arnold W. Reitze Jr., *Dealing with Climate Change Under the National Environmental Policy Act Climate Change Regulations and Rules Environmental Impact Statements, Greenhouse Gases*, 43 WM. & MARY ENV'T L. & POL'Y REV. 173 (2018). See also Nadja Popovich et al., *The Trump Administration Is Reversing 100 Environmental Rules. Here's the Full List.*, N.Y. TIMES (July 15, 2020), <https://www.nytimes.com/interactive/2020/climate/trump-environment-rollbacks.html> [https://perma.cc/G2SC-CWDW].

<sup>506</sup> Yale Program on Climate Change Communication (@YaleClimateComm), TWITTER (Dec. 17, 2019, 10:31 AM), <http://twitter.com/YaleClimateComm/status/1206960009856405505> [https://perma.cc/9985-DCDV].

<sup>507</sup> *Id.*

<sup>508</sup> *Climate Change Indicators: U.S. and Global Temperature*, EPA (Dec. 17, 2016), <https://www.epa.gov/climate-indicators/climate-change-indicators-us-and-global-temperature> [https://perma.cc/C9CR-CQA3].

<sup>509</sup> Henry Fountain, *2019 Was Hot. The 2010s Were Even Hotter*, N.Y. TIMES, Jan. 16, 2020, at A8.

The United States is a party to the UNFCCC.<sup>510</sup> Towards its implementation, the Obama Administration promoted and managed negotiation of the Paris Agreement.<sup>511</sup> The Obama Administration signed the Paris Agreement on behalf of the United States as an executive agreement, which does not require Senate ratification.<sup>512</sup> Thus, the Paris Agreement is now the law of the land.<sup>513</sup> The Paris Agreement went into effect for the United States in early 2017 when President Obama issued an executive order adopting it.<sup>514</sup>

Under the existing structure of the Paris Agreement, major responsibility for the success of the Paris Agreement is placed on developed countries such as the United States.<sup>515</sup> Deployment of the large United States fleet of remote sensing satellites will be a most important tool for the success of the Paris Agreement. However, President Trump announced in 2017 his intention to denounce the Paris Agreement, alleging

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<sup>510</sup> Convention on Climate Change, *supra* note 8, at 165.

<sup>511</sup> OFF. OF THE PRESS SEC'Y, *Fact Sheet: U.S. Reports its 2025 Emission Target to the UNFCCC*, WHITEHOUSE (Mar. 31, 2015), <https://obamawhitehouse.archives.gov/the-press-office/2015/03/31/fact-sheet-us-reports-its-2025-emissions-target-unfccc> [<https://perma.cc/94RB-4UD4>].

<sup>512</sup> Jessica Durney, *Defining the Paris Agreement: A Study of Executive Power and Political Commitments*, 11 CARBON & CLIMATE L. REV. 234, 242 (2017).

<sup>513</sup> The United States has ratified the 1992 Framework Convention on Climate as a treaty. United Nations Framework Convention on Climate Change, United Nations Treaty Collection. Hence the Paris Agreement is considered to be authorized by the 1992 Framework Treaty thus permitting the U.S. Government to consider it an executive agreement which does not require Senate advise and consent. See Curtis A. Bradley & Jack I. Goldsmith, *Presidential Control Over International Law*, 131 HARV. L. REV. 1201, 1248–49, 1268–69. The United States has also acquiesced in COPUOS climate mitigation. See Joseph Kurt, *Triumph of the Space Commons: Addressing the Impending Space Debris Crisis Without an International Treaty*, 40 WM. & MARY ENV'T L. & POL'Y REV. 305, 312 (2015).

<sup>514</sup> Emissions Gap Report 2019, *supra* note 23, at XXI, urges the USA to:

Introduce regulations on power plants, clean energy standards and carbon pricing to achieve an electricity supply that is 100 per cent carbon-free • Implement carbon pricing on industrial emissions • Strengthen vehicle and fuel economy standards to be in line with zero emissions for new cars in 2030 • Implement clean building standards so that all new buildings are 100 per cent electrified by 2030.

*Id.*

None of these goals have been pursued by the Trump administration. Popovich et al., *supra* note 505.

<sup>515</sup> See Cinnamon P. Calarne & JD Colavecchio, *Balancing Equity and Effectiveness: The Paris Agreement & the Future of International Climate Change Law*, 27 N.Y.U. ENV'T L.J. 107, 137–40 (2019).

that it places too great a burden on the United States.<sup>516</sup> Article 28 of the Paris Agreement provides that any party to the Paris Agreement may withdraw from it “at any time after three years from the date on which this agreement has entered into force for a Party.”<sup>517</sup> Such withdrawal takes effect “on date as may be specified in the notification of withdrawal by the denouncing Party.”<sup>518</sup> Accordingly, the denunciation will take effect one day after the next United States presidential election in November of 2020.<sup>519</sup> The president elected in the 2020 election will therefore have the choice to change course so as to reenter the Paris Agreement and/or seek modification of the Paris Agreement as needed for it to reach and accomplish its goal.<sup>520</sup> Alternatively, the new president may stay the course adopted by the Trump Administration.<sup>521</sup>

United States departure from the Paris Agreement will likely lead to dysfunction of the Paris Agreement.<sup>522</sup> The decision by the Trump Administration has been met by disappointment among the other state parties to the Paris Agreement.<sup>523</sup> The absence of the major economic world power, the United States, from the Paris Agreement severely handicaps global climate change emission counter measures.<sup>524</sup> Other states may follow suit. They have not yet done so.<sup>525</sup> The United States

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<sup>516</sup> See Justine N. Stefanelli, *U.S. Submits Notification of Withdrawal from Paris Agreement*, AM. SOC'Y OF INT'L L. (Nov. 4, 2019), <https://www.asil.org/ILIB/us-submits-notification-withdrawal-paris-agreement> [<https://perma.cc/Z7SC-DYR6>]. The United States did not denounce the Framework Convention and remains a party subject to its provisions on climate change. See Carolina Arlota, *Does the United States' Withdrawal from the Paris Agreement on Climate Change Pass the Cost-Benefit Analysis Test?*, 41 U. PA. J. INT'L L. 881, 923, 926–27 (2020).

<sup>517</sup> Paris Agreement, *supra* note 11, at art. 28, § 1.

<sup>518</sup> *Id.* at art. 28, § 2.

<sup>519</sup> Kayla Clark, *The Paris Agreement: Its Role in International Law and American Jurisprudence*, 8 NOTRE DAME J. INT'L & COMP. L. 107, 122–23 (2018).

<sup>520</sup> See *id.* at 122–23. The recently expressed willingness of China to assume a greater share of the burden of climate change may become a factor in possible negotiation of U.S. reentry into the Paris Agreement. See *infra* note 593.

<sup>521</sup> *Id.*

<sup>522</sup> Knox & Voigt, *supra* note 243, at 35.

<sup>523</sup> Michael D. Shear, *Trump Will Withdraw U.S. From Paris Climate Agreement*, N.Y. TIMES (June 1, 2017), <https://www.nytimes.com/2017/06/01/climate/trump-paris-climate-agreement.html> [<https://perma.cc/3NUV-VT53>].

<sup>524</sup> Knox & Voigt, *supra* note 243, at 35–36.

<sup>525</sup> See Lisa Friedman, *Trump Serves Notice to Quit Paris Climate Agreement*, N.Y. TIMES (Nov. 4, 2019), <https://www.nytimes.com/2019/11/04/climate/trump-paris-agreement-climate.html> [<https://perma.cc/7EHR-Q9UY>].

remains subject to the Paris Agreement and its implementation until November 2020.<sup>526</sup>

The Paris Agreement needs United States leadership.<sup>527</sup> United States support for resolution of the climate change problem is crucial, but it alone does not resolve the ultimate problem which is for all the people on Earth and their political leaders to take climate change seriously. Being the most developed country, the United States is key to solving the problem. All states and all their resources need to be activated. That includes universal deployment of outer space climate change mitigation assets as provided in the UNFCCC and the Paris Agreement.<sup>528</sup>

### *B. China and the Paris Agreement*

China is the largest developing country.<sup>529</sup> It is also the third largest space power with a major arsenal of space equipment including remote sensing, communication, weather, and global navigation satellites.<sup>530</sup> Due to its recent industrial awakening, it is now by far the largest emitter of emissions and its output continues to grow,<sup>531</sup> except that the recent COVID-19 problem appears to have curtailed industrial emissions.<sup>532</sup> The curtailment is likely temporary, but that and the United States presidential election provide interesting opportunities either toward or away from international mitigation of the climate change problems.<sup>533</sup>

At the Paris Agreement conference, China promised independently that it would stop its gradual increase in emissions, and that it would increase its use of non-fossil energy by 20% by 2030.<sup>534</sup> These two goals

<sup>526</sup> Clark, *supra* note 519.

<sup>527</sup> Yale Program on Climate Change Communication, *supra* note 506.

<sup>528</sup> See Convention on Climate Change, *supra* note 8, at 170–71; see also Paris Agreement, *supra* note 11, at art. 10, § 5.

<sup>529</sup> *China's status as developing country undeniable*, GLOBAL TIMES (Dec. 11, 2019), <https://www.globaltimes.cn/content/1173184.shtml> [<https://perma.cc/99LU-V5NZ>].

<sup>530</sup> Paul B. Larsen, *Outer Space Arms Control: Can The USA, Russia and China Make This Happen?*, 23 J. CONFLICTS & SEC. L. 132–59 (2018). See also LYALL & LARSEN, *supra* note 36, at ch. 16.

<sup>531</sup> See generally *Global Greenhouse Gas Emissions Data*, *supra* note 229.

<sup>532</sup> Lauri Myllyvirta, Analysis: *China's CO2 Emissions Surged Past Pre-Coronavirus Levels in May*, CARBONBRIEF (June 29, 2020), <https://www.carbonbrief.org/analysis-china-co2-emissions-surged-past-pre-coronavirus-levels-in-may#:~:text=China's%20CO2%20emissions%20have%20surged,and%20power%20plants%20reduced%20output> [<https://perma.cc/G8YX-PRXX>].

<sup>533</sup> Paris Agreement, *supra* note 11, at art. 28, § 2.

<sup>534</sup> OFF. PRESS SEC'Y, U.S.-CHINA JOINT ANNOUNCEMENT ON CLIMATE CHANGE (2014). China is under increasing pressure to assume a greater share of the global climate change

appear to be in line with China's previous policy which is not to commit to a substantial new climate change sacrifice.<sup>535</sup> China also announced that it would create a South-South Climate Cooperation Fund to assist the developing countries in dealing with climate change and that China would contribute \$3.1 billion to the Fund in order to assist developing countries as they deal with climate change impacts.<sup>536</sup> Developing countries participating in the South-South Climate Cooperation Fund will be the main beneficiaries.<sup>537</sup> China has also entered into capacity agreements with a dozen developing countries.<sup>538</sup> China's commitment to climate change mitigation pales in comparison with the commitments of developed countries under the Paris Agreement.<sup>539</sup> Consequently it is a cause of the United States' problem with and departure from the Paris Agreement.<sup>540</sup> China is clearly a major space power like the United States, Russia, and the ESA member states.<sup>541</sup> As a major space power, it should be grouped with the United States and the ESA member states regarding use of space technology to mitigate climate change on Earth. This could become an issue in the United States rejoining the Paris Agreement structure.

### C. *The Developing Countries and Climate Change*

Recent extreme weather events in Africa have caused African countries to appreciate the exceptional ability of space technology to help developing countries manage the adverse effects of climate change.<sup>542</sup> The greatest causes of natural disasters in East Africa are droughts and

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effort. China's leader, Xi Jinping, stated in a September 2020 speech to the United Nations General Assembly: "Humankind can no longer ignore the repeated warnings of nature." See Myers, *supra* note 291. In his speech, he promised further reductions in greenhouse gas emissions and that China would achieve carbon neutrality by 2060. See *id.* He promised that China would reach peak emissions sooner than 2030. See *id.*

<sup>535</sup> Oren Cass, *The Key Charade of the Paris Agreement*, NAT'L REV. (June 6, 2017), <https://www.nationalreview.com/2017/06/paris-agreement-china-india-set-easy-emissions-goals/> [https://perma.cc/SWM3-7YR7].

<sup>536</sup> *Id.*; *China South-South Climate Cooperation Fund*, WORLD-ENERGY (Sept. 6, 2019), <https://www.world-energy.org/article/1632.html> [https://perma.cc/XK2H-X7ML].

<sup>537</sup> WORLD-ENERGY, *supra* note 536.

<sup>538</sup> See *id.*

<sup>539</sup> See Carlarne & Colavecchio, *supra* note 515, at 137–38, 149–51; see also Cass, *supra* note 535.

<sup>540</sup> See Cass, *supra* note 535.

<sup>541</sup> LYALL & LARSEN, *supra* note 36, at 458.

<sup>542</sup> Verenardo Meeme, *Digital Tools Help Africa Mitigate Climate Disasters*, SCIDEV.NET (Feb. 20, 2020), <https://www.scidev.net/sub-saharan-africa/climate-change/news/digital-tools-help-africa-mitigate-climate-disasters.html> [https://perma.cc/D4EE-J5VW].

floods.<sup>543</sup> The Chief of the Kenyan National Drought Management Authority recently expressed the need for early satellite monitoring of climate change to prepare for droughts.<sup>544</sup> Droughts caused \$12.1 billion in damage in Kenya during 2008 through 2011.<sup>545</sup> Floods are the second major cause of disasters in Africa.<sup>546</sup> That was dramatically shown in the 2019 floods in Mozambique, Malawi, and Zimbabwe.<sup>547</sup> The African Center for Research of the Epidemiology of Disasters reports that 446 thousand people died and 337 million people were affected in various ways in 1,143 disasters between 2000 and 2019.<sup>548</sup>

Developing countries, like those in Africa, have learned that weather satellites are now able to predict the probabilities of extreme weather phenomena and can warn governments and their people of oncoming dangers and consequences.<sup>549</sup> Earth observation satellites are able to collect and transmit digital images of disasters during and after disasters have happened.<sup>550</sup> Remote sensing images are essential for planning and executing relief to stricken people.<sup>551</sup> They are also essential for estimating and providing assistance necessary to aid affected territories to recover.<sup>552</sup> Getting acquainted with and learning how to benefit from high-tech space technology is a problem in Africa because of its technological newness.<sup>553</sup> Thus there is need for capacity-building as mandated by Article 10 of the Paris Agreement.<sup>554</sup>

Climate disasters and management of risks were the main subjects of the African Risk Capacity Conference in Nairobi in February 2019.<sup>555</sup> Effective use and technical training in space technology were major subjects of discussion.<sup>556</sup> Lack of technical knowledge and poverty are major barriers to use of high-tech information like modeling extreme

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<sup>543</sup> *Id.* The Global South is inherently apprehensive about environmental regulation from the Global North, see Jeffrey J. Minetta, *Environmental Governance and the Global South*, 42 WM. & MARY ENV'T L. & POL'Y REV. 82, 84–86 (2018).

<sup>544</sup> Meeme, *supra* note 542.

<sup>545</sup> REPUBLIC OF KENYA, KENYA POST-DISASTER NEEDS ASSESSMENT (PDNA) 2 (2012).

<sup>546</sup> Meeme, *supra* note 542.

<sup>547</sup> *Id.*

<sup>548</sup> *Id.*

<sup>549</sup> *Id.*

<sup>550</sup> McKie, *supra* note 104.

<sup>551</sup> *Id.*

<sup>552</sup> *Id.*

<sup>553</sup> Meeme, *supra* note 542.

<sup>554</sup> *See id.*

<sup>555</sup> *Id.*

<sup>556</sup> *Id.*

weather conditions.<sup>557</sup> The African Union recently established the African Risk Capacity Agency to engage in technical capacity training.<sup>558</sup> It recently provided Malawi, Mauritania, Niger, and Senegal \$36.8 million for capacity training.<sup>559</sup>

The above information shows that countries in Africa are well aware of the benefits of space technology. Other developing countries are as well.<sup>560</sup> The developing countries are ready to help themselves to mitigate the adverse consequences of climate change.<sup>561</sup> It is evident that they will need capacity training from the space powers.<sup>562</sup> The Paris Agreement seeks to fill this need,<sup>563</sup> but the Agreement is weak regarding the use of space technology to assist in mitigating climate-caused problems.<sup>564</sup> It differentiates between developed and developing states rather than between space powers and non-space powers.<sup>565</sup> It only assigns financial support and capacity burdens to developed countries.<sup>566</sup> It should assign equal space technology burdens on all the space powers (United States, China, Russia, the ESA member states and perhaps India).

Climate change is a global problem.<sup>567</sup> It affects developed and developing countries, as well as space powers and non-space powers, equally hard.<sup>568</sup> A difference is that space powers can use available space resources to counter climate change.<sup>569</sup> The developing countries do not possess such resources.<sup>570</sup> However, the developing countries may be more ready for climate change than assumed by the Paris Agreement.<sup>571</sup> Importantly, China, Russia, and India all possess valuable Earth observation space technology.<sup>572</sup> There is no longer a reason to make a distinction between their space technology and that belonging to the United States and the

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<sup>557</sup> *Id.*

<sup>558</sup> Mariam Rita Fawole Masini, *African SIDS under the International Climate Change Regime: Opportunities and Challenges for Regional Cooperation in Operationalizing the Paris Agreement*, 14 MCGILL J. SUST. DEV. L. 119, 137 (2018).

<sup>559</sup> Meeme, *supra* note 542.

<sup>560</sup> Masini, *supra* note 558, at 137.

<sup>561</sup> *See id.*

<sup>562</sup> *See* Paris Agreement, *supra* note 11, at 12.

<sup>563</sup> *See id.* at 9.

<sup>564</sup> *See id.* at 14.

<sup>565</sup> *Id.* at 13–15.

<sup>566</sup> *Id.* at 13, 15.

<sup>567</sup> Report on Peaceful Uses of Outer Space, *supra* note 78, at 20, 37.

<sup>568</sup> *Id.*

<sup>569</sup> LYALL & LARSEN, *supra* note 36, at 376–77.

<sup>570</sup> Paris Agreement, *supra* note 11, at 13–15.

<sup>571</sup> *See* LYALL & LARSEN, *supra* note 36, at 458.

<sup>572</sup> *Id.*

ESA member states. All are in possession of mature earth observation space technology.<sup>573</sup> Earth observation satellites from all five space powers are now regularly in orbit over developed as well developing countries.<sup>574</sup> Duplication of outer space activities is now a greater issue.<sup>575</sup> The five space powers should coordinate their Earth observation activities as they currently coordinate their GNSS global activities in COPUOS.<sup>576</sup> Another significant issue is the effective sharing of resources and information rather than of satellite ownership and possession.<sup>577</sup> Space powers as well as the other state parties to the Paris Agreement need to coordinate data sharing as they do when coordinating and sharing GNSS resources.<sup>578</sup>

Climate change emissions are mitigated by forests.<sup>579</sup> However, deforestation has become a major problem in several developing countries, particularly in Brazil, Bolivia, and Colombia.<sup>580</sup> Professor Cesar Rodriguez-Garavito<sup>581</sup> describes bringing a lawsuit against the government of Colombia for permitting deforestation to affect climate change adversely.<sup>582</sup> In consequence of the suit, the Columbian court ordered the Colombian government to accept legal responsibility for illegal deforestation.<sup>583</sup> The court decision was based on the legal concept that the current generation of people has a legal obligation to preserve the environment for future generations.<sup>584</sup> This legal concept has become widely accepted, particularly in developing countries.<sup>585</sup> It has also been advocated in a number of developed countries and was recently upheld by the Supreme Court of the Netherlands in the case of *Urgenda Foundation v. State of the Netherlands*.<sup>586</sup> The Dutch Court based its decision on the European

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<sup>573</sup> *Id.*

<sup>574</sup> Refer to recent COVID-19 satellite observations of the United States, China and Italy by U.S. and ESA satellites, Letzter, *supra* note 15.

<sup>575</sup> See Larsen, *supra* note 118, at 392.

<sup>576</sup> See *id.* at 404.

<sup>577</sup> *Id.* at 399, 404.

<sup>578</sup> See *id.*

<sup>579</sup> Cesar Rodriguez-Garavito, *Human Rights: The Global South's Route to Climate Litigation*, 114 AJIL UNBOUND 40, 41 (2020).

<sup>580</sup> *Id.* at 42.

<sup>581</sup> *Id.* at 40.

<sup>582</sup> *Id.* at 42.

<sup>583</sup> *Id.*

<sup>584</sup> *Id.* at 41. See Ottavio Quirico, *Climate Change, Regionalism and Universalism: Elegy for the Arctic and the Antarctic?* 35 AM. U. INT'L L. REV. 487, 525 (2020).

<sup>585</sup> See Rodriguez-Garavito, *supra* note 579, at 41.

<sup>586</sup> HR 12 December 2019, NJ 2020, 41 m.nt. J. Spier (Neth./Stichting Urgenda) (Neth.); see Andre Nollkaemper & L. Burgers, *A New Classic in Climate Change Litigation: The Dutch Supreme Court Decision in the Urgenda Case*, EJIL:TALK (Jan. 6, 2020), <https://>

Convention on Human Rights<sup>587</sup> protection of a person's right to life and home.<sup>588</sup> The decision brings into issue the recent decision of the United States Ninth Circuit Court of Appeals in *Juliana v. the United States* declining to accept the somewhat similar legal principle that no person shall be deprived of life, liberty, and property as stated in the Fifth Amendment to the United States Constitution.<sup>589</sup> However, the *Urgenda* decision appears to have influenced a recent United Kingdom decision, *Plan B. Earth v. Heathrow Airport*.<sup>590</sup> Although this case was finally founded on

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[www.ejiltalk.org/a-new-classic-in-climate-change-litigation-the-dutch-supreme-court-decision-in-the-urgenda-case/](http://www.ejiltalk.org/a-new-classic-in-climate-change-litigation-the-dutch-supreme-court-decision-in-the-urgenda-case/) [<https://perma.cc/CXE4-KFDE>]. A group of 900 Dutch citizens had sued the Dutch government to force it to reduce greenhouse gas emission by 25% by 2020 (compared with the 1990 level of emissions). The Netherlands Supreme Court decided that The European Convention on Human Rights, art. 2,8, which protects life of the family and individual rights to life, entitled the claimants to protection against the danger that climate change posed to those rights. Therefore, the Government and the Parliament were held to be obligated to reduce emissions as demanded. The Supreme Court found support for its decision in the climate goals of the Paris Agreement. This decision by the highest court in the Netherlands and its acceptance by the government of the Netherlands set a precedent for other states parties to the European Convention on Human Rights to follow. Issues relating to intergenerational responsibility for climate change consequences will tend to be decided likewise by the courts in other European countries. It is remarkable that Holland's supreme court had the temerity to dictate specific climate goals for its national government and legislature to follow. Furthermore, there is analogy between the European Convention on Human rights protection of a person's life and home and the United States Constitution, Fifth Amendment's protection life, liberty, and property and its effect on climate change issues to be considered by United States courts. *See generally* *Juliana v. United States*, 947 F.3d 1159 (9th Cir. 2020).

<sup>587</sup> Convention for the Protection of Human Rights and Fundamental Freedoms, Nov. 4, 1950, 213 U.N.T.S. 221 [hereinafter European Convention on Human Rights]. *See* Stephen Humphreys, *Climate Change and International Human Rights Law*, in INTERNATIONAL LAW IN THE ERA OF CLIMATE CHANGE, *supra* note 1, at 33–34.

<sup>588</sup> European Convention on Human Rights, *supra* note 587, at art. 2, 8.

<sup>589</sup> *Juliana*, 947 F.3d at 1159 (9th Cir. 2020) (The case brought the issue of intergenerational responsibility for climate change consequences before the U.S. federal 9th Circuit Court of Appeals. The lawsuit was brought by 21 young plaintiffs claiming that Government failure to protect them against increasing emission deprived them of life, liberty and property in violation of the Fifth Amendment to the U.S. Constitution. In contrast to the Dutch Supreme Court, the U.S. court did not have the temerity to order the U.S. Government to reduce climate change emissions. The Court dismissed the case stating that it was beyond the Constitutional power of the Federal court to grant relief because the court did not have the constitutional authority to order the U.S. government to change the law on climate emissions; only Congress could do that. The decision is now on appeal).

<sup>590</sup> *See* R. (on the application of Plan B Earth) v. Secretary of State for Transport and Heathrow Airport, [2020] EWCA (Civ) 214 (Eng.) (concerning whether expansion of London Heathrow Airport had to consider the climate change mitigation established by the Paris Agreement. The Court decided that Heathrow Airport and the UK government

enforcement of domestic law implementing the Paris Agreement, the result of the United Kingdom court decision was acceptance of the fact that governments have a legal duty to protect the lives of their people from the adverse consequences of climate change.<sup>591</sup>

#### D. Recommendations

1. *Follow the precedent of the 1987 Montreal Protocol:* The important precedent of the Montreal Protocol shows that states can successfully come to agreement on global climate change issues.<sup>592</sup>

2. *The United States should rejoin the Paris Agreement:* Reentry of the United States into the Paris Agreement would provide a singular opportunity for renegotiation of the Agreement, establishing more equality and balance among the four space powers, the United States, China, Russia, the ESA member states, and possibly India.<sup>593</sup>

3. *Revive and implement the developmental decision-making process of the Paris Agreement:* Climate change is a uniquely global dilemma that threatens all living things on Earth.<sup>594</sup> Correspondingly, outer space technology and outer space regulation are therefore uniquely global by nature, and uniquely able to control and mitigate climate change globally; the reason is that states are equally subject to international space laws and regulations.<sup>595</sup>

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had failed to consider the climate goals of the Paris Agreement (to limit emissions to an increase of 1.5 degrees Celsius because the Paris Agreement goals had been incorporated into official UK government policy, adopted into UK law. Thus, the goal of the Paris Agreement was clearly in issue before the court. The expansion and consequent increase in air traffic would tend to increase emissions. It is remarkable that the UK judiciary had the temerity to order the UK government to comply these specific emission standards).

<sup>591</sup> *Id.*

<sup>592</sup> *The Montreal Protocol on Substances That Deplete the Ozone Layer*, U.S. DEP'T OF STATE (Feb. 11, 2019), <https://www.state.gov/key-topics-office-of-environmental-quality-and-transboundary-issues/the-montreal-protocol-on-substances-that-deplete-the-ozone-layer/> [<https://perma.cc/8UXW-ZG9S>].

<sup>593</sup> Elliot Henson, *Can the Paris Deal be Renegotiated?*, CTR. FOR CLIMATE & ENERGY SOLUTIONS (June 2, 2017), <https://www.c2es.org/2017/06/can-the-paris-deal-be-renegotiated/> [<https://perma.cc/CMF6-4SA5>]; see also Myers, *supra* note 291.

<sup>594</sup> Paris Agreement, *supra* note 11, at art. 4(3) (assuming that remedies for climate change are of national character involving nationally determined contributions).

<sup>595</sup> *Space Law*, U.N. OFF. FOR OUTER SPACE AFFS. (2020), <https://www.unoosa.org/oosa/en/ourwork/spacelaw/index.html> [<https://perma.cc/U3RR-E5AJ>].

The climate change problem is inherently limited to emissions caused by *human* beings in the industrial revolution.<sup>596</sup> It does not concern *naturally* caused emissions from natural phenomena such as volcanoes or by fluctuations in solar heat.<sup>597</sup> The goal of the Paris Agreement is to reduce temperature increases to 1.5 degrees Celsius above the level that existed at the beginning of the industrial revolution.<sup>598</sup> Recent studies<sup>599</sup> show that this requires agreement and coordination of and by all the states, and it requires the developed countries that benefitted from the industrial revolution to shoulder most of the economic burden. Furthermore, as can be concluded from the failed COP 25 conference, the task of emission reduction becomes more urgent as time passes without coordinated action.<sup>600</sup> It needs to begin immediately. Delays will only increase the burden.<sup>601</sup> Failure to deal with the consequences of global warming will result in catastrophe for life on Earth.<sup>602</sup> Fortunately, space technology resources and regulation are developing rapidly and will increasingly assist in moving the states of the earth toward the goal set by the Paris Agreement.<sup>603</sup> The obvious recommendation is therefore *to revitalize the Paris Agreement* so as to mobilize all resources needed to reach its stated goal.

4. *Make climate change information freely available:* Orbiting satellites reach all countries, whether developed or developing.<sup>604</sup> The space powers should make climate change information available, without charge, to all countries for the purpose of reducing global warming and emissions.

5. *Engage more actively in capacity development of developing countries:* Climate change severely undermines the economies of all the states on Earth.<sup>605</sup> Therefore, space resources and space laws, regulations and

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<sup>596</sup> *The Causes of Climate Change*, NASA (Aug. 4, 2020), <https://climate.nasa.gov/causes/> [<https://perma.cc/3QGM-BNX5>].

<sup>597</sup> *Id.*

<sup>598</sup> Paris Agreement, *supra* note 11, at art. 2(1)(c).

<sup>599</sup> Emissions Gap Report 2019, *supra* note 23, at 5–6.

<sup>600</sup> Dave Keating, *Failure in Madrid as COP25 Climate Summit Ends in Disarray*, FORBES (Dec. 15, 2019), <https://www.forbes.com/sites/davekeating/2019/12/15/failure-in-madrid-as-cop25-climate-summit-ends-in-disarray/#11e8e2c3d1fe> [<https://perma.cc/VC4W-HZ3S>].

<sup>601</sup> Emissions Gap Report 2019, *supra* note 23, at 3.

<sup>602</sup> Knox & Voigt, *supra* note 243, at 39 (“A future of international law where we lose the battles of climate change and global biodiversity loss is one that will have to address simultaneously mass migration, battles over resources, closing orders, violence and unrest.”).

<sup>603</sup> Lyall, *supra* note 1, at 178–79.

<sup>604</sup> *Id.* at 181–82.

<sup>605</sup> *Global Economy Will be 3 Percent Smaller by 2050 Due to Lack of Climate Resilience*,

guidelines should be applied to sustain the global space economy. Developed countries have a huge interest in strengthening the sustainability of developing countries so that they can become financially and technologically strong enough to deal with their own climate-related problems.<sup>606</sup>

6. *All the space powers must actively participate in capacity development:* Not only the developed countries, but all the space powers should do capacity transfer of space technology, 'knowhow' and resources to the non-space powers. Therefore China, Russia, and India, now categorized as developing countries under the Paris Agreement, should be categorized with the United States and the ESA member states in terms of deploying space resources towards climate change, and should share and coordinate space resources to cope with climate change.<sup>607</sup>

7. *COPUOS must become more active in promoting mitigation of climate change problems:* COPUOS should adopt a guideline requiring transfer of climate-related space technology to developing countries.

8. *Adoption of uniform minimum international standards and recommended practices for mitigation of climate change problems:* States engaged in outer space traffic are currently considering adoption of international mandatory space traffic standards.<sup>608</sup> An obvious question is whether success of the Paris Agreement requires uniform mandatory international standards. It is recommended that the participating states consider adoption of standards for sources of energy that cause greenhouse gas with the provision that participating states would be bound to adopt them.<sup>609</sup>

9. *Consider all options for meeting climate change problems:* Climate change requires international agreement to resolve problems caused by climate change.<sup>610</sup> Failure to agree raises the possibility that the earth may

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ECONOMIST (Nov. 20, 2019), <https://www.eiu.com/n/global-economy-will-be-3-percent-smaller-by-2050-due-to-lack-of-climate-resilience/> [<https://perma.cc/89B5-7LDT>].

<sup>606</sup> *Id.*

<sup>607</sup> ORG. FOR ECON. CO-OPERATION & DEV., *THE SPACE ECONOMY IN FIGURES 29* (2019) (ebook).

<sup>608</sup> Larsen, *supra* note 388.

<sup>609</sup> *Clean Energy Can Meet 90% of Paris Energy-Related Goals*, U.N. FRAMEWORK CONVENTION ON CLIMATE CHANGE (July 5, 2017), <https://unfccc.int/news/clean-energy-can-meet-90-of-paris-energy-related-goals> [<https://perma.cc/3RFM-HMWW>].

<sup>610</sup> *Is It Too Late to Prevent Climate Change?*, NASA (Aug. 4, 2020), <https://climate.nasa.gov/faq/16/is-it-too-late-to-prevent-climate-change/> [<https://perma.cc/87UG-A6SW>].

become uninhabitable.<sup>611</sup> It is important to study and ascertain all possibilities, including escaping to other potentially habitable planets because our time on planet Earth may be limited by failure to mitigate climate change.<sup>612</sup>

10. *Consider all the long-term options:* Long-term sustainability of the earth is affected by climate change.<sup>613</sup> Climate change has the potential of severely disrupting life on Earth by interrupting global economic development, causing global food shortages, and dislocating many people.<sup>614</sup> If states fail to come to agreement on international action, it could lead to disaster. The long-term future of the earth is in the balance. The state parties to the Paris Agreement need to direct all the space powers to apply, share and coordinate their space resources to mitigate climate change affecting them, as well as all non-space powers. The UNGA needs to formulate sustainability guidelines more squarely directed at resolving economic problems affecting climate change. COPUOS should adopt guidelines asking states to deploy forms of all outer space technology including remote sensing, communication, weather satellites, and global navigation satellite systems directly to control dangerous warming of the Earth, and for the space powers to mitigate this danger, thus making long-term sustainability of the earth possible.

11. *Take advantage of the COVID-19 moratorium:* The economic consequences of COVID-19 may reduce greenhouse gas temporarily. However, this is a unique extension of time to resolve climate change problems. This moratorium should become a catalyst to organize and implement effective global curtailment of greenhouse gas.<sup>615</sup>

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<sup>611</sup> Robin Young & Jack Mitchell, *Humans Have 30 Years To Stave Off Climate Change, 'Uninhabitable Earth' Author Says*, WBUR (May 13, 2020), <https://www.wbur.org/hereandnow/2019/05/13/climate-change-uninhabitable-earth-david-wallace-wells> [<https://perma.cc/2LLE-528N>].

<sup>612</sup> Astronomers have identified millions of planets suitable for human habitation. See REES, *supra* note 45; see also Larsen, *supra* note 149. We need to examine them as possible environments suitable for human colonization if we needed to escape from Earth.

<sup>613</sup> GARY W. YOHE ET AL., 2007: *Perspectives on Climate Change and Sustainability*, in CLIMATE CHANGE 2007: IMPACTS, ADAPTATIONS, AND SUSTAINABILITY 811, 813, 826 (Robert Kates et al., eds., Cambridge Univ. Press).

<sup>614</sup> *Id.* at 824–25.

<sup>615</sup> Meehan Crist, *What the Pandemic Means for Climate Change*, N.Y. TIMES (Mar. 29, 2020), <https://www.nytimes.com/2020/03/27/opinion/sunday/coronavirus-climate-change.html> [<https://perma.cc/F3P5-PAJ6>].