7

Terrestrial Environmental Data Obtained from Space

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7.1 INTRODUCTION AND CLARIFICATION

This chapter is about data gathered in one commons and used to manage another commons: outer space and the Earth environment, respectively. From the commencement of space activities, space data have aided humanity in managing resources, advancing science, predicting weather, mitigating disasters, and understanding human migration, among other activities (Lyall and Larsen 2024, 333–334). As the use of the term "commons" can be controversial in space context particularly "global commons" (Hertzfeld et al. 2015; Pace 2017), it is important to note that the use of the term in this chapter does not attempt to limit how states may use the outer space environment, but rather uses the term with respect to space because space is available for use by all countries and data gathering from space affects all countries. It has been asserted that

> "[g]lobal commons" is not some talismanic term that demands every utterance invoke Elinor Ostrom … Instead, it has multiple legitimate meanings, and they can apply to outer space in different ways. Outer space is a global commons in the sense of being a domain beyond national jurisdiction and with free and open access, but it is not a global commons in the sense of being commonly owned such that nations cannot assert private property interests in space resources. (Goehring 2021, 588)

It is essential to approach the use of the term "commons" in this chapter as providing opportunities rather than restrictions. Notably, the Outer Space Treaty does not use *common heritage of mankind* language, nor does it denote a special status to the physical domain of outer space (Hertzfeld et al. 2015). Instead, in Article I, it denotes space activities as the "province of all mankind." That said, the concept of a knowledge commons is far more contextually important here. A knowledge commons can be understood as "institutionalized community governance of the sharing and, in some cases, creation of information, science, knowledge, data, and other types of intellectual and cultural resources" (Dedeurwaerdere et al. 2014, 1). The institutionalization of remote sensing data about Earth gathered from space,

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through the United Nations (UN) and other organizations, has led to the formation of a massive knowledge commons which creates new information through continued analysis of the gathered data. The variety and volume of gathered data is enormous, and applications using differing tools and accessing multiple data sources have increased, leading to additional challenges in effectively using this data (Sudmanns et al. 2020, 833).

7.2 EXISTING LEGAL/NORMATIVE FRAMEWORKS

7.2.1 *Outer Space Treaty*

When the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (hereinafter referred to as the Outer Space Treaty) came into force in 1967,[1] it created the basic legally binding framework under which actors operate in space to this day, and hopefully far beyond. Its predecessor was a nonbinding principles document, Resolution 1962: Declaration of Legal Principles Governing the Activities of States in the Exploration and Use of Outer Space (United Nations General Assembly 1963),[2] which helped to generate the consensus needed during the height of Cold War tensions to encourage and enable human endeavors in outer space. Resolution 1962 contained similar provisions to the Outer Space Treaty and helped start the process of crystallization into custom of several key principles, including freedom of access and use and nonappropriation (Lyall and Larsen 2024, 50). While it is beyond the scope of this chapter to address all Outer Space Treaty principles, the ones with particular bearing on Earth observation (hereinafter EO) data are highlighted here.

Article I sets forth the most fundamental underlying rule in the international space law regime. It establishes, first and foremost, the freedom of exploration and use. Additionally, the *benefit principle* is derived from Article I, which requires that space activities "be carried out for the benefit and in the interests of all countries." The equal right to access space without discrimination for all states is reiterated. Additionally, provision is made to facilitate and encourage cooperation in scientific investigation of space. The obligations contained in this Article are foundational for EO activities. Data obtained from satellites in space is used for weather prediction and monitoring, disaster recovery, natural resource management, agricultural management, climate modeling, tracking human migration, and numerous other purposes (Lyall and Larsen 2024). The right of all states to conduct these activities and the obligation for states to carry them out in a nondiscriminatory way while

[1] Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies, Jan. 26, 1967, 18 U.S.T. 2410, 610 U.N.T.S. 205.

[2] G.A. Res. 1962 (XVIII), Declaration of Legal Principles Governing the Activities of States in the Exploration and Use of Outer Space (Dec. 13, 1963).

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respecting the interests of all are critical when it comes to this kind of data that can be obtained from space.

It is worth noting that space is not the only jurisdiction in which freedom of access and use are mandated, while appropriation is prohibited as in Article II of the Outer Space Treaty. Both the high seas and Antarctica operate under regimes that are similar from that perspective.[3] That said, outer space does operate under a state responsibility regime that is unique in international law. This specialized regime is implemented through Article VI of the Outer Space Treaty, which mandates that states take legal responsibility for their national actors, including private entities, and conduct authorization and supervision for their activities (Cheng 1972). Notwithstanding the distinct nature of this attribution rule for outer space, the application of the law of state responsibility to space activities remains, in accordance with Article III of the Outer Space Treaty that otherwise incorporates general international law.

The application of the Article I benefit principle is widely debated among space law scholars (Matte 1987, 319). Some argue that the requirement to act for the benefit of all countries has been broadly met by the improvements in daily life planetwide that have flowed from space activities, including not only the EO benefits mentioned above but also importantly precision navigation and timing, communications access, provision of telemedicine, as well as other services and spin-off technologies (Gorove 1971, 101). Others, however, argue that the often incidental benefit that has accrued does not meet the legal requirement, as the benefit principle has not been implemented with the appropriate level of intentionality.[4] Either interpretation has a reasonable basis (Lee 2012, 157–159).

Likewise, the language in Article I addressing cooperative scientific endeavors is framed for facilitating and encouraging such endeavors, rather than using language of a more binding character. That said, in the view of this author, other clear obligations exist in Article I that protect key rights for states in terms of EO and its relevant data. First, there is an unambiguous requirement to permit use of a space on a nondiscriminatory basis, regardless of technological or economic development. Second, while the benefit principle may not expressly require active engagement to provide benefit to all for each individual activity conducted, it is obvious that a state cannot act knowingly against the interests of other states while complying with their *pacta sunt servanda* obligations to undertake treaties in good faith.[5] Thus, Article I

[3] *See* Convention on the Law of the Sea, Dec. 10, 1982, 1833 U.N.T.S. 397; Antarctic Treaty Dec. 1, 1959, 12 U.S.T. 794, 402 U.N.T.S. 71.

[4] "While opinion may differ on what constitutes 'the interests of all countries' and compliance with this part of the obligation might have to rely largely on the good faith of the contracting States, the rest of the sentence is much more concrete in meaning. It strongly suggests that 'all States' have a legal right to the fruits of space exploration and use" (Cheng 1997, 15).

[5] For the codification of the customary international law principle of *pacta sunt servanda*, see Vienna Convention on the Law of Treaties, art 26, 22 May 1969, 1155 U.N.T.S. 331 [Vienna Convention].

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provides a framework for nondiscriminatory use of EO data that does not knowingly contravene the interests of other states.

Article IX of the Outer Space Treaty mandates that states "shall conduct all their activities in outer space […] with due regard to the corresponding interests of all other States Parties to the Treaty." Thus, the Treaty implements a balancing mechanism to maximize overall use of space. States' free use of space is limited to the extent that such use takes into account the corresponding interests of other states (Harrington 2023). A useful formulation of the due regard principle was provided, though in a maritime context, by the tribunal in the *Chagos* arbitration: "'due regard' calls for the [State party] to have such regard for the rights of [another state party] as is called for by the circumstances and by the nature of those rights."[6] Here, it is important to note that the consideration due is to those interests, rather than just the space activities of other states. Thus, a state carrying out an EO activity must provide reasonable regard for the interests of states that may be affected by the data collected.

Finally, Outer Space Treaty Article XI creates a legal environment that facilitates the importance of sharing of space data. The Article reads:

> In order to promote international co-operation in the peaceful exploration and use of outer space, States Parties to the Treaty conducting activities in outer space, including the moon and other celestial bodies, agree to inform the Secretary-General of the United Nations as well as the public and the international scientific community, to the greatest extent feasible and practicable, of the nature, conduct, locations and results of such activities. On receiving the said information, the Secretary-General of the United Nations should be prepared to disseminate it immediately and effectively.

While this requirement is clearly tempered by the feasibility and practicability language contained within (Keefe 1995, 351), the types of data collected by civil space agencies, at least, fall within this purview of required sharing, which has been generally respected. That said, it may not be feasible or practicable for private companies to freely share the data obtained from their space activities, and likewise with regard to sharing data that have particular pertinence to national security.

7.2.2 *Remote Sensing Principles*

The 1986 UNGA resolution *Principles Relating to Remote Sensing of the Earth from Outer Space*[7] (hereinafter Remote Sensing Principles) took fifteen years to negotiate and set the stage for enhanced data sharing within the scope of activities addressed (United Nations General Assembly 1986; Ito 2011). Part of the reason for the long

[6] Chagos Marine Protected Area Arbitration (Mau. v. U.K.) ¶519 (Perm. Ct. Arb. 2015).

[7] G.A. Res. 41/64, Principles Relating to Remote Sensing of the Earth from Outer Space (December 1986) [Remote Sensing Principles].

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tail of time in reaching agreement on the Remote Sensing Principles is that it took that time to build consensus on the *opinio juris* that freedom to sense other states' territories from space without authorization is legally permissible (Ito 2011; Lyall and Larsen 2024, 340–342). The scope of remote sensing activities addressed by the Remote Sensing Principles is limited to "sensing of the Earth's surface from space by making use of the properties of electromagnetic waves emitted, reflected or diffracted by the sensed objects, for the purpose of improving natural resources management, land use and the protection of the environment," thereby staying away from discussion of remote sensing data obtained for other purposes, including national security.[8] For the purposes of this chapter, the remote sensing activities discussed here are also limited to those conducted to sense Earth (excluding data gathered by the remote sensing of outer space, except for those data relevant to the Earth environment), but does not necessarily limit itself to data for the specific uses articulated in the Remote Sensing Principles.

While the Remote Sensing Principles are not a treaty and are thus not legally binding in and of themselves,[9] they have contributed to both the development of customary international law and states' practice under the Outer Space Treaty (Aust 2010). While the status of each principle as customary international law and/or an interpretive tool for the Outer Space Treaty in accordance with the custom articulated in Article 31(3) of the Vienna Convention on the law of treaties is not essential to this chapter (Harrington 2017; Zannoni 2019, 155–157; Lyall and Larsen 2024, 344–345),[10] it is worth noting their status as "soft law," though the distinction between hard and soft law is actually not decisive in determining legal character.[11] Soft law is generally viewed as a method to focus consensus, legitimize desired conduct, and create a positive environment for consistency in the relevant state practice (Cheng 1997). Many of the UN Remote Sensing Principles are "merely re-affirmations of existing rules of international law or provisions of existing treaties" (International Law Commission 2004, para. 9).

At the end of the negotiating process, the only (new) substantial benefit for sensed or non-sensing states derived from the UN Remote Sensing Principles is contained in Principle XII, which grants the sensed state data access rights on a nondiscriminatory basis (Cheng 1997), in addition to such reaffirmed rights as nondiscriminatory access to space and full sovereignty over the natural resources of a state, in Principles III and IV, respectively. These are clearer formulations of requirements embedded in Article I of the Outer Space Treaty and discussed earlier. Disclosure of remote sensing programs under the Principles and a specific call to disclose matters that

[8] Remote Sensing Principles, see note 7, at Principle I(a).

[9] They do not fall into any of the three categories of binding international law articulated in Article 38(1) of the International Court of Justice statute. Statute of the International Court of Justice art 38(1), June 26, 1945, 15 U.S.T. 2494, 33 U.N.T.S. 993.

[10] Vienna Convention, see note 5.

[11] North Sea Continental Shelf (Ger/Neth;Ger/Den), Judgment, 1969 I.C.J. 3. (February 20).

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may be detrimental to the Earth environment and natural disaster information are also useful to all states. Principle XIII requires consultations with a sensed state, but only upon request of the sensed state; this proposition could be tricky in cases where a state is unaware that it is being sensed. In such a case, the state would not know to make such a request (Harrington 2017). The Remote Sensing Principles and subsequent initiatives enabled by them further indicate very widespread support of data sharing for the purposes enshrined therein (Harrington 2017). In particular, Principle XI expressly sets out the protection of mankind from natural disasters as a purpose of remote sensing, and calls upon sensing states to release processed data and analyzed information to states affected by natural disasters or likely to be impacted by impending natural disasters.

One of the most important clarifications, however, found in the Remote Sensing Principles regards the status of data. Principle I(e) provides a definition of the term "remote sensing activities" as "the operation of remote sensing space systems, primary data collection and storage stations, and activities in processing, interpreting and disseminating the processed data." While the Principles themselves are nonbinding, this definition provides clear evidence that they believe activities relating to collection, use, and storage of data fall within the scope of remote sensing activities, a covered space activity under the Outer Space Treaty. It may thus be argued that these data management activities are included as part of the national space activities of the state, and thus fall within states' responsibility in accordance with Article VI of the Outer Space Treaty. These activities would also likewise be captured in other relevant sections of the Outer Space Treaty, including the Article I principles as well as the obligation to act with due regard in Article IX. Of course, however, this interpretation would only hold to the extent that its results are not absurd or manifestly unreasonable.[12]

Additional definitions contained in the Remote Sensing Principles are helpful to understanding the nature of EO data in its many forms. Principle I provides definitions for each type of data within the scope of the Principles. These are primary data, processed data, and analyzed information. Primary data is the raw data collected, and though the Principles contemplate film and magnetic tape in addition to digital data transmitted through the radiofrequency spectrum, it is that digital data which is the almost exclusive form in the current day.[13] Processed data results "from the processing of the primary data, needed to make such data usable."[14] And finally analyzed information includes the interpreted data that takes into account other sources of knowledge and information, which can include information produced by human manipulation and analysis of data, information produced by running

[12] For the codification of the relevant customary international law interpretation rule, see Vienna Convention, note 5, at Art. 32(b).

[13] Remote Sensing Principles, see note 7, at Principle 1(b).

[14] Remote Sensing Principles, see note 7, at Principle 1(c).

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data through existing software algorithms, and information produced by artificial intelligence analysis of data.[15] These definitions can help to conceptualize the wide variety of data that fall within the scope of this activity, some of which may involve significant human effort after the initial data collection, and some of which may be presented with the inclusion of implicit biases of human analysts and programmers.

7.2.3 *International Charter on Space and Major Disasters*

Under the *Charter on Space and Major Disasters* (hereinafter Disasters Charter), more than a dozen countries have committed space assets since 2000 to the continuing service of warning about and mitigating the effects of disasters (both natural and human-made) (The International Charter Space and Major Disasters n.d.; About the Charter n.d.). Parties to the Charter provide satellite data (processed and unprocessed) free of charge to countries (associated bodies and beneficiary bodies) affected by natural and technological disasters using a single point of contact (Lyall and Larsen 2024, 354–355). The hundreds of activations since its inception indicate a consistent state practice on the part of sensing states to deploying assets and freely share data for the stated purpose (Activation List n.d.). Though the Charter itself is not a legally binding instrument, it acts as *opinio juris*, demonstrating the obligation of states with EO capabilities (or more specifically the agencies within those states) to deploy those capabilities to manage disasters threatening humankind (Activation List n.d., Art. I; Ito 2005, 142).

7.2.4 *United Nations Platform for Space-Based Information for Disaster Management and Emergency Response (UN-SPIDER)*

Following the successful creation and implementation of the Disasters Charter, UN-SPIDER was subsequently created in January 2007, carrying out the agreement established by UN Doc. A/RES/61/110 (U.N., 2007; Lyall and Larsen 2024, 356). The mission of UN-SPIDER is to "Ensure that all countries and international and regional organizations have access to and develop the capacity to use all types of space-based information to support the full disaster management cycle" and is the first such agreement to support the full cycle of disaster management. The creation of UN-SPIDER and its continued activities provide further evidence of state practice in the area of disaster management.

7.2.5 *World Meteorological Organization Resolution 40*

With regard to meteorological data, the World Meteorological Organization (WMO), consisting of 191 member states, has established a policy of sharing of

[15] Remote Sensing Principles, see note 7, at Principle 1(d).

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space-based meteorological data since 1995. Resolution 40 (*WMO Policy and Practice for the Exchange of Meteorological and Related Data and Products including Guidelines on Relationships in Commercial Meteorological Activities*) was used to foster sharing, and the WMO has further expanded this policy in a twenty-five-page document providing for the policy, practice, guidelines, and implementation of Resolution 40 (Resolution 40, n.d.).

The practices adopted by Resolution 40 are as follows:

> 1. Members shall provide on a free and unrestricted basis essential data and products which are necessary for the provision of services in support of the protection of life and property and the well-being of all nations, particularly those basic data and products, as, at a minimum, described in Annex 1 to this resolution, required to describe and forecast accurately weather and climate, and support WMO Programmes;
>
> 2. Members should also provide the additional data and products which are required to sustain WMO Programmes at the global, regional, and national levels and, further, as agreed, to assist other Members in the provision of meteorological services in their countries. While increasing the volume of data and products available to all Members by providing these additional data and products, it is understood that WMO Members may be justified in placing conditions on their re-export for commercial purposes outside of the receiving country or group of countries forming a single economic group, for reasons such as national laws or costs of production;
>
> 3. Members should provide to the research and education communities, for their non-commercial activities, free and unrestricted access to all data and products exchanged under the auspices of WMO with the understanding that their commercial activities are subject to the same conditions identified in Adopts (2) above (WMO, n.d.).

If Practice 2 is implemented in such a way that conditions on reexport for commercial purposes do not impinge the rights of sensed states, as established under the Remote Sensing Principles, then this Resolution and subsequent documentation further indicate very widespread support of data sharing for the purposes enshrined therein. Thus, another example of effective "soft law" implementation can be seen. Given the widespread membership of states in WMO, as well as the importance of weather forecasting, Resolution 40 has played an important role in creating a shared knowledge commons for EO data from space-based sources.

7.2.6 *Long-Term Sustainability Guidelines*

In 2018, the UN Committee on the Peaceful Uses of Outer Space adopted the *Guidelines for the Long-Term Sustainability of Outer Space Activities* (hereinafter LTS Guidelines) by consensus (Commission on the Peaceful Uses of Outer Space 2018). While many of these guidelines are focused on issues relating to safety of

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space operation and minimization of space debris, they do take into account the importance of space activities in achieving the UN Sustainable Development Goals more broadly (Commission on the Peaceful Uses of Outer Space 2018, 1; The 17 Goals, n.d.). Like the Remote Sensing Principles, the LTS Guidelines are nonbinding (Commission on the Peaceful Uses of Outer Space 2018, Section I para. 15). In fact, they contain extensive discussion on their voluntary nature, which was necessary to build consensus for them (Commission on the Peaceful Uses of Outer Space 2018, Section I paras. 16–20).

Two guidelines in particular contain subparts relevant to the governance of EO activities and remote sensing data. Guideline C.3.4 addresses sharing of data for disaster mitigation purposes.

> States and international intergovernmental organizations should also undertake efforts to make relevant space-based information and data accessible to countries affected by natural disasters or other catastrophes, guided by considerations of humanity, neutrality and impartiality, and to support capacity-building activities aimed at enabling the receiving countries to make optimal use of such data and information. These space-based data and information with appropriate spatial and temporal resolution should be freely, quickly and easily available for countries in crisis.

This language continues to reinforce the legally binding data-sharing obligation of Outer Space Treaty Article XI, as well as the benefit principle from Article I. It also reinforces concepts found in the non-legally binding Remote Sensing Principles and Disasters Charter. Though the LTS Guidelines contain specific language indicating that they are not intended to interpret or modify existing international law, they still have value in showing consistent state views on these important matters of data commons.

Within Guideline C.4, both paragraphs 1(a) and 2 likewise address relevant matters, though these are not so specifically focused on data. In paragraph 1(a), states are called upon to "[p]romote institutional and public awareness of space activities and their applications for sustainable development, environmental monitoring and assessment, disaster management and emergency response" (Commission on the Peaceful Uses of Outer Space 2018, Guideline C.4); while in paragraph 2, public awareness and education take the focus:

> States and international intergovernmental organizations should promote public awareness of space applications for sustainable development, environmental monitoring and assessment, disaster management and emergency response through information-sharing and joint efforts with public institutions and non-governmental entities, taking into account the needs of current and future generations. In designing space education programmes, States, international intergovernmental organizations and non-governmental entities should pay special attention to courses on enhancing knowledge and practice of the utilization of space applications to support sustainable development. States and international intergovernmental organizations

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> should initiate the voluntary collection of information on public awareness and education tools and programmes with a view to facilitating the development and implementation of other initiatives with similar objectives. (Commission on the Peaceful Uses of Outer Space 2018, Guideline C.4.2)

Though the handling of the data themselves is certainly important, when considering the EO knowledge commons, it is necessary to engage in longer term planning to ensure public support and development of a future geospatial workforce. Importantly, paragraph 2 brings intergenerational equity into account when considering information-sharing efforts. Though not expressly mentioned in the early public international space law instruments such as the Outer Space Treaty, it has become clear that intergenerational equity is taking center stage, largely as a result of the consequences of anthropogenic climate change. Building the future workforce is another tool that can be used towards satisfaction of the benefit principle, in addition to providing substantive benefits to both sustainable development and disaster management. Though they are quite general and not highly technical, the LTS Guidelines contribute to the normative framework through which EO activities and associated data are understood.

7.2.7 *Selected United Nations Efforts Regarding Climate Change*

It is helpful to briefly mention the UN Framework Convention on Climate Change of 1992 (hereinafter Framework Convention) and associated efforts.[16] It seems remarkable that climate change garnered sufficient attention more than thirty years ago to produce the Framework Convention, but yet we are still in the relatively early stages of climate change mitigation. The Framework Convention emphasizes both intergenerational equity and the importance of acting with precaution.[17] Articles 4, 6, 7, 9, 10, and especially 12 all contain elements of information sharing. Article 4 paragraph 1(g) specifically calls for the "development of data archives related to the climate system and intended to further the understanding and to reduce or eliminate the remaining uncertainties regarding the causes, effects, magnitude and timing of climate change and the economic and social consequences of various response strategies," thus creating a specific knowledge commons. Article 5, paragraphs (a) and (b) call for support to further cooperative data sharing and collection efforts. Paragraph (b) promotes "access to, and the exchange of, data and analyses thereof obtained from areas beyond national jurisdiction." Certainly, data collected from space falls expressly within the relevant purview of the Framework Convention, and thus this instrument plays an important role in our knowledge commons.

[16] United Nations Framework Convention on Climate Change, May 9, 1992, 1771 U.N.T.S. 107.
[17] See, e.g., Art. 3.

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Within this framework exists the Global Climate Observing System (GCOS) Programme, administered through the WMO (Global Climate Observing System n.d.). There are four main contributors to the satellite network of the programme, namely the Climate Change Initiative of the European Space Agency, the Copernicus Climate Change Service operated on behalf of the European Union, Climate Service EUMETSAT, and Earth Science Division of the US National Aeronautics and Space Administration (GCOS Satellite Programs n.d.). The data from these networks, along with atmospheric, terrestrial, and ocean-based sources are used to measure the Essential Climate Variables to measure climate change. Meanwhile, the Intergovernmental Panel on Climate Change is the UN body charged with assessing climate change-related science, including the data produced by the GCOS Programme (The Intergovernmental Panel on Climate Change n.d.). One only needs to glance at the UN Environment Programme (UNEP) organizational chart to obtain a sense of the scale and complexity of intergovernmental agreements, organizations, and actors within the UNEP system (United Nations n.d.).

7.3 ORGANIZATIONS WITH SPACE DATA SHARING INITIATIVES, A SAMPLING

While some organizations with space data sharing initiatives have been discussed in the context of legal and quasi-legal instruments normalizing space data commons, there are far more groups with various data sets, provided by various actors and for various purposes. This section endeavors to address some of these efforts to provide a sense for how extensive and potentially overlapping space data commons can be.

Though not entirely within the scope of the topic of this chapter, the International Asteroid Warning Network is an interesting example of a data commons using both ground-based and space-based data sources to provide information about outer space (International Asteroid Warning Network n.d.). The data in question specifically addresses naturally occurring Near Earth Objects that could pose a direct threat to Earth and Earth's environment, which is why it is mentioned here.

The UN Development Programme Geographic Information System and Satellite Imagery Team (United Nations Development Programme Pacific Office 2020) works in cooperation with the UN Satellite Centre (UNOSAT) to provide specialized applications and data to countries in need (United Nations Satellite Centre n.d.; United Nations Institute for Training and Research 2019). Within UNOSAT's primary mandate is to "support Member States with satellite imagery analysis over their respective territories and to provide training and capacity development in the use of geospatial information technologies, on the basis of voluntary contributions." Thus, UNOSAT both analyzes and provides data directly while also performing other capacity-building efforts including workforce development. UNOSAT has also partnered with NVIDIA to utilize artificial intelligence in their efforts (United Nations Institute for Training and Research 2022).

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Perhaps an unexpected addition to this list, the UN Human Settlements Programme (UN-Habitat) endeavors achieve the goal of providing sustainable and adequate shelter for all people. So where does EO data fit in here (UN-Habitat n.d.)? UN-Habitat maintains the Earth Observation Toolkit for Sustainable Cities and Human Settlements, tied to UN Sustainable Development Goal (SDG) 11 (The Earth Observations Toolkit n.d.). "The primary motivation for this toolkit is to support local communities, cities and countries in understanding the value and usefulness of Earth observations for SDG 11 and the New Urban Agenda and to provide practical guidance and examples of Earth observation data, tools, and use cases in support of sustainable urbanization and resilience" (The Earth Observations Toolkit n.d.). This organization is highlighted as it offers a demonstration that EO data is aggregated, freely shared, and analyzed for purposes beyond weather/climate monitoring and disaster mitigation.

Likewise, the UN Office on Drugs and Crime plays a role in this knowledge commons as well, incorporating data obtained from remote sensing systems into their efforts to combat crime and drug trafficking (United Nations Office on Drugs and Crime n.d.). Space-based data is essential for creating a safer human society in addition to managing the relationship of humans with our natural environment here on Earth. That said, this particular use of data can (reasonably) raise heightened concerns regarding its potential misuse by governmental entities or private bad actors. Privacy concerns are legitimate with the aggregation of any big data and must be considered with regard to human rights and data protection.

The World Health Organization (WHO) Geographic Information Systems (GIS) Centre for Health uses geospatial data to aid in effective and rapid decision-making in human health policy (WHO GIS Centre for Health n.d.). "By connecting maps, apps, data and people the WHO GIS Centre is dedicated to support countries and partners to make informed public health decisions faster and to extend the reach of geospatial information across the organization." Not all countries are currently prepared to integrate GIS data into their public health system, so the services provided by the WHO GIS Centre help to equalize the health opportunities across countries of differing levels of development, a good example of space activities leading to benefit for all humankind.

UN Geospatial is made up of geospatial experts who use data, including EO data obtained from space, in support of all UN missions and mandates (United Nations Geospatial n.d.). Their objective is to improve the effectiveness, efficiency, and universality with which geospatial data is applied to these ends (United Nations Geospatial n.d.). UN Geospatial is embedded in the Office of Information and Communications Technology (United Nations Office of Information and Communications Technology n.d.), which is a key player in the implementation of the Secretary-General's Data Strategy (Secretary-General's Data Strategy n.d.). The Data Strategy seeks to build "a whole-of-UN ecosystem that unlocks our full data potential" (United Nations Secretary n.d.). Implicit in the data strategy is a recognition of the complexity of the UN data gathering, management, and analysis

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apparatuses, and the inherent inefficiency that can arise among such a tangled web of organizational structures. At a fundamental level, the Data Strategy can be seen as a streamlining effort. The UN Global Service Centre (UNGSC) of the Department of Operational Support also plays a significant role in GIS through the UNGSC Service for Geospatial, Information, and Telecommunications Technologies (ITT), which "provides a direct single point of contact for digital technology services and solutions" (Geospatial, Information and Telecommunications Technologies n.d.; United Nations Global Service Centre n.d.).

The Group on Earth Observations (GEO) and its Global Earth Observation System of Systems (GEOSS) play a vital role in the coordination and dissemination of the space-based environmental data commons (About GEOSS, n.d.). The participation of 152 partnering organizations, including intergovernmental, international, nongovernmental, and regional partners operating in EO and related spaces goes a long way to ensuring availability of data across these platforms and venues for sharing. The simple fact however, that there are indeed 152 of these organizations, which are inherently international groups, demonstrates the significant fragmentation of laudable efforts for sharing data. While many of the relevant groups are mentioned in this chapter for illustrative purposes, it is certainly not feasible to include description of all 152 organizations here.

UN Global Pulse, which is notably not a partner or GEOSS, identifies as itself as the innovation lab for the UN Secretary-General (United Nations Global Pulse n.d.). This office includes data and digital tools in its innovation portfolio, but its endeavors are far broader than just EO. UN Global Pulse may be an ideal place to continue to work on the problem, in cooperation with GEO, to simplify access to, tracking of, and analysis of EO data acquired from space-based sources.

7.4 OPPORTUNITIES, ISSUES, AND RECOMMENDATIONS

7.4.1 *Opportunities*

Many positive developments can be seen in the use of data obtained from space to better environmental conditions and human life on Earth. The UN SDGs, in particular, have catalyzed use of space data to achieve their goals (Commission on the Peaceful Uses of Outer Space 2018, 1; The 17 Goals n.d.). The global nature of the SDGs requires a global data collection and management strategy. There is now wide availability of commercial data, much of it offered free of charge and with additional processing or analytical services provided. While the increasing incidence of natural and human-made disasters is, of course, tragic, their escalating pace and severity has raised awareness of the importance of working together. After all, no state is isolated from the possibility of such disasters, and the state that is a provider of data and services today may be the recipient of such when it inevitably faces one or more disasters in the future. Tragedy, while unfortunate, does bring people together to work for the common good.

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Numerous efforts are aimed at capacity building, and not just providing data and analysis. While the proverb "give a man a fish, and he eats today; teach a man to fish and he eats for the rest of his life" is true, perhaps the better formulation is "give a man a fish today and then teach him how to fish, so he isn't hungry today and is ready to learn the skills he needs for the rest of his life." In terms of data from space, there has been clear effort to provide the initial fish, but also the fishing skills and equipment. Such capacity-building efforts contribute positively to data compatibility, as downstream experts and users will already be trained to produce data in a format that is more universally usable.

7.4.2 *Issues*

Despite, or perhaps because of, best efforts, the complexity of the data sharing environment is dizzying. It is possible to get lost in the array of arrangements and organizations who are standing by to provide data and/or analysis for a range of problems and under a variety of circumstances. These efforts have led to a fragmentation of data sharing, wherein dozens of organizations may be implicated in any one circumstance. The end user in need of data needs to be aware of where and how to obtain what they need. Smaller countries with lower budgets may struggle to allocate personnel who are prepared to navigate these complex systems. Technical challenges abound. "Developments of sensing observations and producing information from it need to be accompanied by suitable storage, processing and retrieval systems" (Sudmanns et al. 2020, 844). The specific technical challenges regarding both hardware- and web-based systems are broadly beyond the scope of this chapter.

Though there is widespread agreement that states should help each other to mitigate disasters, forecast weather, and model climate change, geopolitical tension and security implications can and do still get in the way. Export controls are applied to satellite remote sensing technologies, making technology transfer and cooperation more difficult. Countries have a patchwork of laws governing the capture of EO data from space, limiting resolution either universally or in certain geographic areas and designating sensitive security zones for which images are often not legally available. These challenges arise even when all parties enter a situation in good faith and with the best intentions. Data just might not be available. Additionally, domestic legal systems may provide personal or institutional penalties for those who share technology or data in violation of these security rules, even if they do so unknowingly.

International competition and conflict have led to the breakdown of international cooperation. Mistrust is rampant, and states have less faith in international law to mitigate risks in the international system. Thus, political will for new treaties and even (to some extent) new soft law instruments has evaporated, allowing our international normative system to stagnate. Likewise, contentious domestic politics in many states have all but precluded the possibility of new treaty ratification, and even make the prospect of new domestic legislation difficult.

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It would be unfair, however, to place all the blame on politics, governments, or intergovernmental complexity for these challenges. Proprietary commercial data can also serve as a roadblock to obtaining data that exists, but that is not available. Privatizing EO operations permits commercial control of data in general. Commercial companies do not inherently have the same incentives to share data as governments do, as owners or shareholders expect their companies to turn a profit. While making some data freely available is feasible, contributes to goodwill, and in some cases can lead to lucrative government contracts, there will always be a limit on what private companies will release for nothing, and how low their prices can be for data that is not freely given. After all, even the Remote Sensing Principles endeavor to set up a system where data are provided to sensed states on "reasonable cost terms."[18] Even weather forecasting is increasingly being carried out by private companies (Cirac-Claveras 2019).

Of course, a lack of public awareness of the role space plays in day-to-day life and the benefits space has provided, increasing quality of life around the globe. Increasingly people, especially young people, push back on the value of "space exploration" – lacking an understanding of what a domestic space budget provides (Ramani 2023). Growing governmental domestic EO capabilities, or even the capacity for budgets to purchase EO data, can become challenging when constituencies do not understand the value of funding. The problem is exacerbated when such constituencies see space as an active detractor, a contributor to climate change rather than a set of activities and technologies that can significantly improve our ability to manage climate change as a species.

7.4.3 *Recommendations*

This chapter provides three key recommendations with regard to the management of the EO environmental data commons. First, public communication strategies need to be developed and implemented specifically with a focus on the benefits of EO data provided from space. The images offered by Maxar in the news following Russia's invasion of Ukraine hinted at the usefulness of this data being available (SatNews 2022). The myriad other uses of data and imagery need to be made clear. The likelihood that the average person knows that space data can improve crop yields, map efficient routes, and contribute significantly to sustainable urban housing solutions is quite low. While maybe somewhat higher, it is likely that many people are either unaware or take for granted the extent to which weather forecasting and climate data is obtained from space. These communications campaigns can come from intergovernmental, nongovernmental, public, and private organizations, but should include a common message: Data from space are highly beneficial, especially when those data can be aggregated and shared.

[18] Remote Sensing Principles, see note 21, at Principle XII.

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Such a communications strategy would not only ease the path for space-related budget allocation, but (arguably) even more importantly, would pave the way for the next generation to prepare themselves to undertake careers in systems engineering, software development, and geographic information system applications. Without a sufficiently developed workforce of tomorrow, humanity cannot expect to continue to reap the benefits of the technologies we have developed. "The sheer amount of multi-dimensional and multi-temporal data, interdisciplinary research, and the dynamics of new developments, in general, makes sharing results, algorithms and knowledge between the experts of different fields and non-expert users essential" (Sudmanns et al. 2020, 842). Thus, actual sharing of results should factor prominently in any communications campaign.

Of course, ensuring that capacity-building efforts take interoperability into account is essential, as is the continued organization and streamlining of international efforts for data sharing, primarily facilitated at the UN level and through GEOS. Capacity building efforts must likewise recognize that not all data are equal – a workforce needs to be prepared to manage raw, processed, and analyzed data, respectively. In particular, enlisting the efforts of UN Global Pulse in achieving these objectives, in line with the existing Secretary-General's Data Strategy, is likely to prove highly beneficial. While some states may challenge the status of space as a global commons, it seems more difficult and less worthwhile to challenge the idea that data about our planet constitute a knowledge commons from which all of humanity should benefit (where feasible and practicable).

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