The Status of the Statistical State: Satellites and the Diffusion of Epistemic Sovereignty[1]

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The burgeoning literature on sovereignty has generated a new appreciation in recent years for how sovereignty is constituted by a mixture of historically and geographically variable practices.[2] The role of knowledge and information in shaping and modifying those practices, however, has received little attention. This gap is particularly noteworthy in the present era of proliferating information technologies. Although sovereignty can be conceptualised usefully in terms of three dimensions—control, autonomy, and authority—generally attributed to the state,[3] the predominant materialistic reading of international relations situates the operation of each of these three elements within the tangible domain of territory, resting upon the physical foundations of military power and/or economic wealth. While social constructivists have shed light on the "knowledgeable practices" which constitute sovereignty as a mutable institution,[4] they too have largely overlooked the informational dimension of sovereignty. This article investigates the impact of one set of technologies—earth-sensing satellites—on the state's ability to control information about processes and resources within its own territory, which I call "epistemic sovereignty".

Knowledge and sovereignty are conceptual kin; both sorts of claims are fundamentally about delineating the bounds of authority. The Baconian adage equating knowledge with power points to another conjunction: both are concerned with the exercise of control in the world, whether of social actors or

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2. See J. Samuel Barkin and Bruce Cronin, "The State and the Nation: Changing Norms and Rules of Sovereignty in International Relations", *International Organization*, Vol. 48, No. 1 (Winter 1994), pp. 107–130; Thomas J. Biersteckcr and Cynthia Weber (eds.), *State Sovereignty as Social Construct* (Oxford: Cambridge University Press, 1996); R.B.J. Walker and Saul H. Mendlovitz (eds.), *Contending Sovereignties: Redefining Political Community* (Boulder: Lynne Rienner, 1990).

3. For a formulation along these lines, see Janice E. Thomson, "State Sovereignty and International Relations: Bridging the Gap between Theory and Empirical Research", *International Studies Quarterly*, Vol. 39 (Summer 1995); and Karen T. Litfin, "Sovereignty in World Ecopolitics", *Mershon International Studies Review* (November 1997).

4. Alexander Wendt, "Anarchy is What States Make of It", *International Organization*, Vol. 46 (1992), pp. 391–425; see also Bierstecker and Weber, *op cit.*, in note 2.

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natural phenomena. The two institutions which express and represent these interconnections, science (particularly as manifest in technology) and the state, are emblematic of modernity. Indeed, modernity can be characterised in terms of two central dynamics: the political encircling of the globe by the state, and the epistemological and practical encircling of the globe by science and technology. We should therefore anticipate developments at the intersection of these two tendencies, which I will term the epistemic dimension of sovereignty, to be of particular interest for students of world politics in the late modern period. The neglected epistemic dimension of sovereignty focuses upon the control over and access to the production and diffusion of information and knowledge. The basic argument is that epistemic sovereignty is often a precursor to what we normally think of as sovereignty: the state's autonomy, control, and authority within a territorial jurisdiction. The argument has been made elsewhere that information technologies increasingly are compromising state sovereignty.[5] Here I argue that recent developments in earth remote sensing, a technology whose historical roots are solidly statist, seem to be undercutting the ability of states to control information about processes and resources within their own territories.

Surveillance technologies have been the basis for the state's administrative power throughout the modern era, as Anthony Giddens and Michel Foucault have argued, albeit in different ways and reaching different conclusions.[6] Indeed, "statistics" and "state" are derived from the same root (Latin, "to stand"); not coincidentally, the large-scale collection of statistics began with the emergence of the modern state.[7] As Giddens notes, the importance of surveillance as a medium of power has not been grasped by either the liberal or the socialist traditions in political and economic theory.[8] Nor has it been grasped by any of the dominant approaches within international relations theory.

Susan Strange has made a significant contribution, however, in her depiction of the international knowledge structure. She identifies four intersecting structures in the world's political economy: security, production, finance, and knowledge. While most international relations theorists focus on relational power, or the ability of one agent to influence another's behaviour, Strange is more interested in the structural power which "confers the power to decide how things shall be done".[9] Of the four structures of power, the knowledge structure is the least understood and, in today's world, the most rapidly changing. Strange traces the shift from the medieval knowledge structure revolving around the Roman Catholic Church to the modern knowledge structure associated with the "scientific state".[10] While she observes that the contemporary revolution in information technology is generating some significant power shifts, she is

5. James N. Rosenau, *Turbulence in World Politics: A Theory of Change and Continuity* (Princeton: Princeton University Press, 1990).

6. Anthony Giddens, *The Nation-state and Violence* (Berkeley and Los Angeles: University of California Press, 1987); Michel Foucault, *Discipline and Punish: The Birth of the Prison* (New York: Vintage, 1979).

7. Peter J. Taylor and Ronald J. Johnston, "Geographical Information Systems and Geography", in John Pickles (ed.), *Ground Truth: The Social Implications of Geographic Information Systems* (New York: The Guildford Press, 1995).

8. Anthony Giddens, *op. cit.* in note 6, p. 308.

9. Susan Strange, *States and Markets* (New York: Basil Blackwell, 1988), p. 25.

10. *Ibid.*, pp. 115–123.

uncertain as to whether these shifts are merely technological and economic or whether they are perhaps indicative of a larger shift in the global knowledge structure. In her most recent book, Strange highlights the role of information technologies in the diffusion of state power.[11]

To expand upon Strange's work, the epistemic dimension of sovereignty is crucial to the way in which the scientific state constitutes itself and configures the global flow of information and knowledge. Epistemic sovereignty is distinctive, at least in part, because knowledge is inherently unlike other sources of control, autonomy, and authority. It is communicable and storable, particularly given recent technological innovations, in ways that military force and economic wealth are not. It has certain public goods properties, since the cost of its production does not increase when it is made widely available. Yet it does not always function as a public good since proprietary access to knowledge sometimes enhances its value. And, finally, while knowledge, like other kinds of power, is increasingly dependent upon technology, the structures of technology themselves reflect—and, in fact, are part and parcel with—the global knowledge structure.

Satellite technology, representing both a primary mechanism for surveillance and a central factor in the information revolution, offers an excellent arena for exploring the global knowledge structure and the epistemic dimension of sovereignty. While other information technologies, especially personal computing and telecommunications technologies, are widely believed to challenge states' control and authority, these are in some sense easy cases because of their widespread diffusion among non-state actors. Satellite technologies, particularly those relating to earth observation, offer, if not a least likely case, then a not-so-obvious case for testing the thesis that information technologies are modifying the global knowledge structure. To a greater extent than other information technologies, the roots of earth remote sensing (ERS) satellites are solidly in the domain of national security and Big Science. Looking only at the technology's early roots in the superpowers' military reconnaissance programmes, one might hypothesise that satellites place science at the service of traditional national security objectives, thereby reinforcing the scientific state. A superficial look at state-based ERS programmes, particularly the US Landsat in its early years, would reinforce that hypothesis. Indeed, no project involving the large-scale collection of statistics approaches in magnitude or scope today's state-based ERS programmes. Yet other remote sensing developments suggest that, although the technology originally emerged from and bolstered the scientific state, it is now facilitating the diffusion of epistemic sovereignty beyond the scientific state.

Users of ERS data are increasingly non-state actors, including a wide variety of industries, scientists, the media, and citizens' groups. High-resolution satellite imagery, until recently monopolised by the national security agencies of the superpowers, is now freely available on the market—to *every* state's military as well as to groups like Greenpeace. The multi-billion dollar industries of satellite communications and geographical information services (GIS) have dwarfed the military uses of satellites. The loosely co-ordinated international global change research programme, which relies primarily on satellite observations for its data, is likely to become the largest research project in human history, even with the

11. Susan Strange, *The Retreat of the State* (Cambridge: Cambridge University Press, 1995).

current budget-cutting mood of many governments.[12] Thus, the global transparency afforded by ERS technologies presents a tremendous challenge to states interested in controlling access to information about resources and events within their territorial jurisdiction.

As a key information technology, satellite-based sensors highlight the epistemic dimension of sovereignty; their multifarious applications elucidate how this particular aspect of sovereignty interacts with the material dimensions of sovereignty: control, autonomy, and authority over territory and citizenry. Exploring this interaction allows us to at once demonstrate the importance of the neglected informational dimension of sovereignty, and to analyse the impact of ERS technologies on the practices of sovereignty. This exploration can shed some light on, though not conclusively answer, the important question implicit in Susan Strange's work: Do information technologies pose any fundamental challenge to the modern knowledge structure, with its locus in the scientific state?

After describing the nature of ERS and related technologies, I examine the impact of transparency on the principle of territorial exclusivity, after which I look at how developments in ERS compromise the epistemic sovereignty of both developing countries and the US. I then turn to the diffusion of epistemic sovereignty both by international co-operative endeavours among states and by the increased availability of satellite images to non-state actors.

ERS and Related Technologies

Before exploring the political dimensions of ERS technologies, we should have some understanding of their history, workings, and capabilities. The space age and, more specifically, the satellite age began dramatically with the Soviet Union's launch of Sputnik in October 1957.[13] In response to Sputnik, the US established two space programmes in 1958: a secret military one and an open civilian one, the latter under the auspices of the newly created NASA. During much of the Cold War, the US had a greater interest than the Soviets in pursuing photo reconnaissance. M.J. Peterson explains:

> The Americans were interested in all forms of aerial and space reconnaissance because of the large gap between what they could find out about Soviet activity and what the Soviets could find out about US activity. A tightly closed political system allowed the Soviets to keep more things secret—even the existence of entire cities devoted to military-related research and development. Photo-reconnaissance would reduce the gap, and American leaders did little to hide their interest in it.[14]

12. "A Problem as Big as a Planet", *The Economist* (5 November 1994), pp. 83–85.

13. Although the Soviets were the first to launch a satellite, the US Air Force had a Strategic Satellite System programme underway as early as 1955. See Stephen Hall, *Mapping the Next Millennium: The Discovery of New Geographies* (New York: Random House, 1992). On the launch of Sputnik, see James Oberg, *Red Star in Orbit* (New York: Random House, 1981).

14. M.J. Peterson, "The Use of Analogies in Developing Outer Space Law", *International Organization*, Vol. 51, No. 2 (Spring 1997).

In space historian Walter McDougall's words, "First, and foremost, space was about spying, not because the US was aggressive but because the USSR was secretive."[15] Not surprisingly, the US took the lead in developing spectral sensors and other satellite technologies.

The issues of sovereignty and overflight were raised as early as 1961, when President Kennedy went to the United Nations to announce the benefits to the world from open data distribution of meteorological data.[16] Although it was, in some regards, a political ploy designed to show the contrast between the open, democratic West and the closed, totalitarian Eastern bloc, the practical effect was to differentiate satellite orbits in outer space from territorial airspace, with the principle of sovereignty applicable for the latter but not the former. With Kennedy's "technological anti-communism", weather data were also constructed as a US-supplied public good.

While the first meteorological satellites used simple television cameras to observe cloud movements, the prior use of infrared detectors in World War II had opened up the possibility of using remote sensing to detect different spectral signatures from the same terrain. In other words, because the visible spectrum represents only a tiny range of possible observation, information could also be gathered through the use of spectrometers in the infrared, microwave, X-ray, and gamma ray ranges. The dizzying amount of potential information made these technologies desirable not just to the military, but to a host of agricultural and forestry experts, geologists, hydrologists, land-use planners, and cartographers. But, from the beginning, the military jealously guarded its privileged access to ERS technologies, even though earlier weather satellites had used these same technologies, only with a lower resolution, since 1960. Indeed, it was only through the efforts of a few tenacious individuals that the first civilian satellite, Earth Resources Technology Satellite (later renamed Landsat), became a reality in 1972.

Since 1972, civilian ERS technologies have become ever more sophisticated and ever more widespread. The first Landsat acquired low-resolution images (80 metre GSD); Landsat-4 and -5 each generated moderate-resolution images of 30 metre GSD.[17] In 1985, the French SPOT (Systeme Probatoire d'Observation de la Terre) became Landsat's first competitor. The original SPOT returned colour images with 20-metre resolution and black-and-white images with 10-metre resolution, nearly crossing the line between the resolutions characteristic of military satellites and those which had characterised civilian systems. While both SPOT and Landsat images are retrievable in real time, a Russian system using conventional camera film that must be transported to Earth for processing began making images available on the commercial market with the end of the Cold War. Those images, with a resolution between 2 and 5 metres, substantially

15. Walter A. McDougall, ... *The Heavens and the Earth: A Political History of the Space Age* (New York: Basic Books, 1985), p. 194.

16. I am grateful to Lisa Shaffer for clarifying the point for me.

17. The resolution of an image is the size at which objects become recognisable. Images from military reconnaissance satellites generally have resolutions of less then 10 metres. A digital image is made up of many tiny squares or "pixels". The size of the pixel is expressed in terms of GSD (ground sample distance) in metres. See Vipin Gupta, "New Satellite Images for Sale", *International Security*, Vol. 20, No. 1 (Summer 1995), p. 94.

lowered the threshold between military and civilian ERS technologies.[18] Now, however, the line is being crossed in earnest by civilian systems which are marketing images with 1-metre resolution (equivalent to a photograph taken from an aircraft at 3,000 feet).[19]

Simultaneously, environmental science is providing the impetus for a new generation of earth-sensing satellites. During the 1990s, approximately 50 earth observation satellites will be launched by the space-faring nations of the world, at a cost of $12–15 billion.[20] Many of these satellites will contribute to the international study of global environmental change, with NASA's Mission to Planet Earth Programme leading the way. Earth observing satellites generate data on an enormous range of issues, including forest cover, the health of crops, atmospheric concentrations of many pollutants, drought conditions, crisis monitoring, resettlement of refugees, storm warnings, and the location of many resources, from drinking water to petroleum and mineral deposits, to endangered species.[21]

A rapidly expanding "value-added" industry has sprung up to produce marketable interpretations of satellite data. The most popular of these applications are Geographic Information System (GIS) technologies, which range from relatively simple PC-based software packages for image manipulation and map production to advanced analytical technologies capable of correlating and manipulating many "layers" of spatial information. The diverse and rapidly proliferating users of GIS include oil, mining and other extractive industries, researchers in governments and universities, and local communities. The fastest growing segment of the GIS industry, however, is geo-demographics, a powerful marketing tool which helps businesses to "know everything about their consumers".[22]

Because ERS and its related technologies are new and perhaps revolutionary, their long-term implications for science and the global control and distribution of information cannot be predicted with any degree of confidence. None the less, certain motifs are already evident. The global perspective and the transparency furnished by civilian ERS technologies, even if they emanate from state-based programmes, seem to pose a serious challenge to the state's ability to control information about events and processes within its own borders. One way of

18. Leonard S. Spector, "Keep the Skies Open", *Bulletin of the Atomic Scientists* (September 1989), p. 16. A 1988 image of an air base in Nevada which the Pentagon does not admit exists, apparently generated by the Russian consortium, has turned up in instructions for a Testor model aircraft and on the cover of *Popular Science*. See "Get Satellite Imagery Policy in Focus", *Aviation Week and Space Technology* (21 February 1994), p. 124.

19. John Morrocco, "Lawmakers Warn Clinton on Satellite Imagery Sales", *Aviation Week and Space Technology* (22 November 1993), p. 38. See also Mark Clayton, "Got an Earthly Cause? New Satellites to Help", *Christian Science Monitor* (Toronto edition).

20. John H. McElroy, "INTELSAT, INMARSAT, and CEOS: Is ENVIROSAT Next?", in Gordon MacDonald (ed.), *Proceedings of the Conference on Space-based Monitoring of the Global Environment* (La Jolla: Institute on Global Conflict and Cooperation, 1992).

21. Committee on Earth Observation Satellites (CEOS), "The Relevance of Satellite Missions to the Study of the Global Environment", produced for the UNCED conference at Rio de Janeiro (Washington, DC: CEOS, 1992). On the multitude of uses for ERS, see Doug Stewart, "Eyes in Orbit Keep Tabs on the World in Unexpected Ways", *Smithsonian*, No. 19 (December 1988), pp. 70–76.

22. Jon Goss, "Marketing the New Marketing: The Strategic Discourse of Geodemographic Systems", in John Pickles (ed.), *Ground Truth: The Social Implications of Geographic Information Systems* (New York: The Guilford Press, 1995), pp. 130–132.

uncovering the nature of that challenge is to examine the impact of ERS upon a key norm of sovereignty, the principle of territorial exclusivity.

Territoriality and Transparency

The principle of territorial exclusivity, as John Ruggie argues, was an epochal development marking the end of the medieval era and has been the defining feature of the modern system of states. The recent globalisation of human activities, he claims, is precipitating the "unbundling of territoriality" and the "rearticulation of political space".[23] There is perhaps no form of technology better suited to exemplify these trends than ERS, which inherently erases territorial boundaries by virtue of the global scope of both its observations and its diffusion of information. However, while the transparency afforded by ERS no doubt undercuts the principle of territorial exclusivity, which may be its most significant effect, ERS technology can also reinforce conventional practices of territorial sovereignty in some surprising ways.

Even in the technology's original association with the superpowers' security apparatus, it displayed an intrinsic tendency to complicate the norm of territorial exclusivity. The early space age, which gave birth to ERS technologies, was characterised by fierce competition. For the superpowers, and to a lesser extent for the latecomers to space technology, large-scale space programmes were symbols of national prestige that must necessarily come under autonomous state control. Particularly for the US, military reconnaissance was intended to function as a staple in the exercise of territorial sovereignty; knowing the adversary's military and industrial capabilities was seen as essential to preventing foreign intervention. Paradoxically, just as the mutual acquisition of nuclear weapons by the superpowers rendered those weapons effectively unusable, the mutual acquisition of satellite reconnaissance technology rendered their territorial space utterly transparent. While satellites may have offered some protection against military intervention, they simultaneously opened the door to visual intervention. The mutual pursuit of territorial sovereignty through surveillance technologies necessarily undercut both sides' epistemic sovereignty; their ability to control access to information about themselves was compromised by the global gaze of the adversary's satellite systems.

The principle of territorial exclusivity is problematised in a world rendered transparent by satellite technology, in large part because the non-territorial nature of outer space is incongruous with a world of sovereign states. While the air space above a state's territory lies within that state's jurisdiction, the space above the earth's atmosphere (outer space) was declared in the 1966 Outer Space Treaty to be a *res communis*, or the common province of humanity.[24]

Even before Sputnik, the US, because of its perceived need for spy satellites, saw the necessity of establishing "freedom of space". For this reason, the US decided to launch an innocuous earth satellite for the International Geophysical

23. John Gerard Ruggie, "Territoriality and Beyond: Problematizing Modernity in International Relations", *International Organization*, Vol. 47, No. 1 (Winter 1993), p. 171.

24. "Legislating the 'Last Frontier'", *UN Chronicle*, Vol. 29 (December 1992), p. 54. M.J. Peterson argues that the US, with a greater interest in satellite reconnaissance, successfully pushed forward a high seas analogy in the development of outer space law. See M.J. Peterson, "Extending International Law to New Fields of Endeavor: Developing Outer Space Law", *op. cit.*

Year (1957), rather than a spy satellite, in order to establish the principle of open skies.[25] The prohibition of territorial claims in outer space stands in a tense relationship with the efforts of states to enhance their own security through the use of satellites stationed in non-territorial space. Given the military's leadership role and the resources required to conduct space activities, space issues would seem to reinforce the nation-state model of international relations. Yet the non-territorial nature of the arena of space activities may serve as a harbinger for challenging traditional notions of state sovereignty.[26] Interestingly, both the US and developing countries have worried that increased access to satellite imagery would undercut their ability to control information about events and resources within their own borders.

Developing Countries and Epistemic Sovereignty

In the 1970s, countries without access to satellite technology feared that an "open skies" policy with respect to civilian ERS would violate their territorial sovereignty. Although they may have harboured such fears earlier regarding military reconnaissance satellites, the fact that superpower images were not available on the commercial market was some source of comfort. In this case, military secrecy was an apparent blessing for the Third World. Thus, when NASA espoused an open skies policy with its first launch of Landsat, some Latin American countries countered that their sovereignty over natural resources extended to the dissemination of information about them. Mexico, for instance, announced that "no data would be collected over Mexican territory from air or space without prior permission".[27] In other words, the developing countries understood states' epistemic sovereignty to be implicit in the norm of territorial exclusivity; the ability to control information about one's country, which was seen as threatened by Landsat, is a crucial component of territorial sovereignty.

NASA's response was threefold. First, it argued from international law that there were no legal restrictions on the use of ERS for peaceful purposes. Second, it labelled Landsat an "experimental", rather than an "operational", project until the 1980s. Third, and most effectively, it held out the enticing promise to developing countries that the open dissemination of satellite data would extend, not reduce, their ability to control the development of their resources. To add credence to that promise, NASA established an educational programme to train scientists from developing countries to use Landsat data.[28]

Within the first decade of Landsat, many countries apparently reached the counter-intuitive conclusion that transparency and the global diffusion of data actually reinforced their territorial sovereignty. By 1980, 10 countries had built ground stations and were committed to paying NASA an annual fee of $200,000 for data transmission; dozens more were purchasing Landsat images and data tapes. Brazil, for instance, reported that the first Landsat images resulted in the

25. Walter A. McDougall, *op. cit.*, pp. 119–120.

26. [David Green, "The Reassertion of Social Aspects of Science and Technology", *Space Policy*, Vol. 10, No. 3 (August 1994), p. 242.

27. Pamela Mack, *Viewing the Earth: The Social Construction of the Landsat Satellite System* (Cambridge, MA: The MIT Press, 1990), *op. cit.*, p. 187.

28. David T. Lindgren, "Commercial Satellites Open Skies", *Bulletin of the Atomic Scientists* (April 1988), p. 34.

discovery of several large islands within its territory and a major rectification of Amazon tributaries on its maps. The US Embassy in Mali reported that "the US government has gained a million dollars worth of Malian political mileage" from Landsat.[29]

Satellite data, then, may actually enhance states' epistemic sovereignty by helping to prepare a given territory for the exercise of sovereignty. As Thom Kuehls argues, nature is not inherently constituted to become subject to state sovereignty, but is rather socially constructed as "territory".[30] Mapping is a crucial element in this social construction. Nature has no intrinsic lines of latitude and longitude, but overlying the globe with this symbolic organisation imposes an artificial order which serves specific human purposes. Thus, the utility of ERS data for mapping and locating resources suggests that the logic of satellites does not always run contrary to the principle of territorial exclusivity.

None the less, developing countries exercise little control over the deployment of satellite technology and dissemination of satellite data, and thus have not always been satisfied with their role in the emerging ERS regime. By the early 1980s, developing countries were concerned with preserving open and non-discriminatory distribution of Landsat data, which they felt was threatened by the Reagan administration's proposal to privatise Landsat.[31] Many observers believed that Landsat data should remain a public service, analogous to census, cartographic, and meteorological data, and several studies concluded that Landsat could not successfully be commercialised. Despite these objections, the Land Remote Sensing Commercialization Act of 1984 transferred control over Landsat's data to EOSAT, a joint venture of Hughes Aircraft and General Electric, which was later acquired by Lockheed and recently transferred to Space Imaging Corporation.[32] One of EOSAT's first acts, which was greatly resented by scientists as well as developing countries, was to quadruple the price of each Landsat image.[33]

Developing countries have apparently embraced ERS, but not without some reservations about the technology's impact on their territorial sovereignty. One feature of ERS is its dual role in providing an information base and as a technology for monitoring. Sovereignty has traditionally been invoked to shield states from external intrusion, yet satellites render territory effectively naked. This fact has been abundantly clear since the first images from ERTS were returned to earth in 1972. One of those images revealed a streak of white acid off the coast of New York, indicating that an industrial barge had dumped illegally thousands of gallons of acid iron wastes into the Atlantic Ocean only days before.[34] While this incident essentially involves the US spying on itself, it demonstrates dramatically the potential for applying ERS data to environmental monitoring.

29. Pamela E. Mack, *op. cit.*, pp. 189–192.

30. Thom Kuehls, "Between Sovereignty and Environment: An Exploration of the Discourse of Government", in Karen T. Litfin (ed.), *The Greening of Sovereignty in World Politics* (Cambridge, MA: MIT Press, 1998).

31. Pamela Mack, *op. cit.*, p. 188.

32. "Report Criticizes Landsat Commercialization", *Aviation Week and Space Technology*, No. 118 (9 May 1983), p. 18; Pamela Mack, *ibid.*, p. 206.

33. Eliot Marshall, "Landsat: Drifting toward Oblivion?", *Science*, No. 243 (24 February 1989), p. 24.

34. Stephen Hall, *op. cit.*, pp. 52–53.

Indeed, given the recent proliferation of international environmental treaties, this is what makes certain countries uncomfortable—particularly those with limited access to ERS technologies. Compliance with international environmental agreements has tended to be voluntary, with non-governmental organisations frequently functioning in a watchdog capacity. When mandated, verification of compliance generally has proceeded through self-reporting. Thus, certain developing countries have expressed the concern that ERS could foster "green conditionality" and other types of "eco-imperialism". In addition, some fear that the use of satellites to monitor treaty compliance could spill over into industrial espionage. It is quite possible that "in the future, commercial remote sensors will not only be able to detect pollutants leaving a factory, but determine what a factory is producing".[35] Consequently, developing countries insisted that the 1992 Earth Summit documents contain no references to the use of ERS for "monitoring", but only for "observation".

The US, High-resolution Imagery, and Epistemic Sovereignty

Ironically, it was primarily the US, not the developing countries, which sought to place restrictions on ERS data and technology in the name of territorial sovereignty, although considerations of economic competitiveness eventually compelled the US to shift its policy. The American restrictions hark back to ERS's roots in military reconnaissance. In 1978, President Carter upheld the Pentagon's interest over NASA's by signing a presidential directive that set 10 metres as the resolution limit for non-military remote sensing.[36] But the entry into the market of SPOT images, with a resolution of 10 metres, and the Soviet satellite photographs of roughly 5 metres, soon rendered this rule obsolete. The Reagan administration deleted the rule in 1988 after being persuaded that it put American satellite operators, especially the now-privatised Landsat data marketing firm, at a disadvantage. In an effort to uphold traditional national security interests, the new directive granted veto power to the Secretaries of Defense and State over the licensing of US commercial remote sensing satellites.[37] But US officials were at a loss to describe how they would enforce a ban on the dissemination of pictures from space, since the US no longer enjoyed a monopoly on earth-scanning satellites even among industrialised countries. More importantly, the most likely beneficiaries of American regulations would be foreign satellite operators. As a SPOT spokesperson observed, "Open skies, open access is a precondition of commercial success in the remote-sensing industry."[38]

35. James Asker, "High Resolution Imagery seen as Threat, Opportunity," *Aviation Week and Space Technology*, (23 May 1994).

36. Peter D. Zimmerman, "Photos from Space: Why Restrictions Won't Work", *Technology Review*, No. 91 (May/June 1988), p. 48. The resolution of Landsat images at the time was 30 metres, while military reconnaissance satellites had a resolution of less than half a metre. See Nicholas Daniloff, "How We Spy on the Russians", *World Politics Magazine* (9 December 1979), pp. 24–34.

37. Theresa M. Foley, "Pentagon, State Department Granted Veto Over US Remote Sensing Satellites", *Aviation Week and Space Technology* (20 July 1987), pp. 20–21. In an interesting twist, the Pentagon became a paying customer of SPOT for images of Soviet military installations; while it had millions of its own images, these were classified and so could not be published in its reports. See William M. Arkin, "Long on Data, Short on Intelligence", *Bulletin of the Atomic Scientists*, Vol. 43, No. 5 (June 1987), p. 5.

38. Daniel Charles, "US Draws a Veil Over 'Open Skies'", *New Scientist*, No. 116, 1585 (5 November

Consequently, the Clinton administration amended the Reagan rule so that licensing applications for ERS systems whose capabilities are already available or are in the planning stages would be considered favourably.[39]

While the commercial availability of high-resolution data has reduced the ability of every state to control information about its own territory, its impact is particularly significant for the US, which formerly enjoyed a near monopoly on the technology. With 1-metre data being peddled on the open market by American companies like Orbimage and Space Imaging, both state and non-state actors now have access to data—including on the US—previously available only to the superpowers' military establishments. The emergence of high-resolution satellite imagery on the world market thus provides an interesting example of how the practices of sovereignty can be driven by technological developments and globalisation. A technology that cannot be controlled by a single government is impossible to contain; satellite images can be suppressed only if the data are sent to a ground station under control of the censoring government. It makes little sense to place domestic restrictions on information which is easily obtained through foreign suppliers. In a significant reconfiguration of epistemic sovereignty, the US has been compelled to revise its conceptions of national security and territoriality in order to promote its own industrial competitiveness.

In some senses, the US still retains its special status. By virtue of its technological edge and its ability to license satellite companies and control the dissemination of data during times of crisis, the US maintains its position of global leadership and perhaps protects its own epistemic sovereignty to a greater degree than other states. None the less, the fact remains that the US defence and intelligence establishment resisted strongly the move to commercialise high-resolution imagery because of the fear that it would compromise US national security interests. Consider, for instance, the acquisition by the US news media of moderate-resolution images just prior to Operation Desert Storm which showed clearly that Iraqi troops were not amassed at the Saudi border.[40] While the military momentum was perhaps too great for those photos to have any meaningful impact at that late date, the event highlighted the real possibility that the commercial availability of satellite images could undercut a state's ability to carry out a military operation.

It might be an overstatement to declare, as some have, that satellites have "abolished the concept of distance",[41] but it is certainly the case that the transparency afforded by ERS has undercut traditional practices of territorial sovereignty. Certainly the technology still bears the imprint of its origins in

footnote continued

1987), p. 29. Many space experts have argued that commercial ERS can promote peace by lessening military secrets and by promoting the independent verification of arms control treaties. See William J. Broad, "Private Cameras in Space Stir US Security Fears", *New York Times* (25 August 1987), p. C-12; Michael Krepon (ed.), *Commercial Observation Satellites and International Security* (New York: St. Martin's, 1990).

39. Office of the Press Secretary, The White House, "Foreign Access to Remote Sensing Capabilities", *Space Policy*, Vol. 10, No. 3 (August 1994), pp. 243–244.

40. "Where are the Troops?", *Newsweek* (3 December 1990), p. 6. For a more detailed consideration of these issues, see Richard Davis, "Spying on the Government: The Media, Remote-sensing Satellites, and US National Security Policy", *Political Communication*, No. 9 (1992), pp. 191–206.

41. Kiran Karnik, "Remote Sensing: The Indian Experience", *UNESCO Courier*, No. 46 (January 1993), p. 17.

military reconnaissance, the ultimate purpose of which was to protect the superpowers' territorial integrity, but soon the equivalent of spy data will be available to anyone—state and non-state actors alike—who has access to a credit card. The emergence of ERS data on the world market has eroded dramatically the ability of states to maintain control over information about processes and resources within their borders. The almost universal availability of ERS data has rendered much of the world transparent, and the higher the resolution, the greater the transparency. By virtue of its globality and its transparency, ERS challenges the spatial order of the modern world system; territorial exclusivity is undercut by the diffusion of epistemic sovereignty.

International Co-operation and Sovereignty Bargains

International co-operation does not subvert axiomatically state sovereignty; in an interdependent world, co-operation may actually help to sustain the institution of sovereignty, albeit in a reconfigured form. Because international co-operation typically involves a trade-off among autonomy, control, and legitimacy, it may be more accurate to say that states engage in "sovereignty bargains" rather than cede some monolithic principle of sovereignty.[42] Sovereignty bargains are struck, with autonomy, control, or authority in one area being traded for greater autonomy, control, or authority in another area.

The global proliferation of ERS technology and data has engendered some interesting trade-offs along these lines. The multiple-use character of ERS data has compelled states to try to strike a balance among cross-cutting military, economic, and environmental interests. Consequently, sovereignty bargains at the international level manifest domestically as bureaucratic competition among state agencies. Moreover, the huge economies of scale to be gained through pooling ERS resources have encouraged states to sacrifice some autonomy and control in exchange for better access to information. Simultaneously, the end of the Cold War has made certain sovereignty bargains feasible that might not have been so earlier. The effect on epistemic sovereignty is ambiguous. States, for instance, may relinquish their role as sole or primary providers of information in order to enjoy the benefits of greater collective problem-solving capacity.

A good example, mentioned above, is the incremental relaxation of restrictions on ERS technology by the US government since the late 1970s. The apparent conflict between US industrial competitiveness and perceived military interests is being resolved gradually in favour of the former. This uneasy settlement is being driven by the globalisation of technological change; whereas resolutions finer than 10 metres were once deemed a serious security risk, even domestically, the US is now licensing commercial ERS systems with a resolution of only 1 metre. In this case, the state maintains formal control through its licensing authority, but only in a greatly constrained universe of practical options.

42. I have borrowed the notion of sovereignty bargains from Bruce Byers, "Ecoregions, State Sovereignty and Conflict", *Bulletin of Peace Proposals*, Vol. 22, No. 1 (1991), pp. 68–72. For a more detailed discussion of the kinds of sovereignty bargains which typify international environmental co-operation, see Karen T. Litfin, "Sovereignty in World Ecopolitics", *Mershon International Studies Review*, Vol. 41, No. 2 (1997), pp. 167–204.

The relationship of military agencies to commercial and scientific ERS always has been a tense one.[43] The military does a good deal of inadvertent earth science, but is reluctant to share it with civilian users. Because military and civilian ERS systems often duplicate each other's work, a merger of some programmes would be more efficient; perceived national security issues, however, may pose a critical obstacle.[44] Although US military and intelligence agencies in their search for post-Cold War missions have been promoting actively access to formerly classified data and facilities, cultural barriers often prevent researchers from obtaining useable data. Again, global technological change provides the impetus for alternative sovereignty bargains which challenge the state's epistemic sovereignty. For instance, once Europe's Earth Resources Satellite-1 began returning gravity data equivalent to that generated by the US Navy's Geosat system, the US military became more responsive to civilian researchers.[45] The state remains a primary supplier of ERS data, but seems increasingly compelled to respond to the needs of non-state actors.

Before the end of the Cold War, there was a political consensus on both sides of the Iron Curtain linking space to national security objectives—not only for projects with an obvious military value, but also for civilian prestige projects. With the end of the Cold War, the alliance of space with the "national interest" has deteriorated. That development, combined with a general mood of fiscal conservatism, has sparked a major increase in the number and scope of co-operative space programmes. In the words of one observer, "Now that the Cold War is over, we can afford to be efficient."[46] That new-found interest in efficiency, it can be argued, is promoting the diffusion of epistemic sovereignty across international lines. On a purely instrumental level, the efficiency gained through co-operative programmes provides a powerful incentive for states to collaborate on a wide range of space programmes, including ERS.[47]

Besides efficiency, a second factor contributing to this diffusion of epistemic sovereignty through international ERS programmes is the broad-based requirements of global environmental change research. A patchwork of transnational scientific research programmes has sprung up in the last decade, including: the Man and the Biosphere Programme, the International Biosphere–Geosphere Programme, and the World Climate Research Programme. To a great extent, these programmes, spearheaded by international organisations and non-governmental scientific organisations, rely upon satellite data provided through

43. Interestingly, the political roots of NASA's earth science programmes lie partly in the Reagan Administration's desire to dispel the popular impression that it was only interested in space research for its military applications. "NASA Floats a Global Plan", *Science*, No. 217 (3 September 1982), p. 916. On the tension between military and civilian ERS users, see Stephen Hall, *Mapping the Next Millennium*, *op. cit.*, pp. 58–61.

44. Committee on Earth Studies, Space Studies Board, *op. cit.*, pp. IX, 9–10; "Spy Satellites for Environmental Monitoring", *Environmental Policy and Law*, No. 26 (May 1996), p. 107.

45. Richard Kerr, "The Defense Department Declassifies the Earth—Slowly", *Science*, No. 263 (4 February 1994), pp. 625–626.

46. Joseph Pelton, *op. cit.*, p. 244.

47. Besides budgetary considerations, market forces also contribute to the internationalisation of the satellite industry. The market for launching satellites, for example, is a global one for the simple reason that demand in any one country is insufficient to support that country's launch capacity. See Jack Scarborough, "Free Trade and the Commercial Launch Industry", *Space Policy*, Vol. 8, No. 2 (May 1992), p. 109.

national space agencies. These alliances, seeking to achieve a "worldwide synergy of local research", bring together the financial and organisational capabilities of governments with the intellectual capacity of the world's scientific community.[48]

Though NASA is undoubtedly the major player in these programmes, virtually every ERS project has an international component. Most of the satellites launched under NASA's Mission to Planet Earth programme have carried instruments from other countries and have transmitted data abroad. Likewise, Japan's recently launched Advanced Earth Observing Satellite (ADEOS) carries two US and one French instruments.[49] The principle international co-ordinating body for earth observations is the Committee on Earth Observations Satellites (CEOS), which was created in 1984 in connection with the annual G-7 Economic Summit, and whose membership includes all national and supranational space agencies. A smaller body, the Earth Observations International Coordination Working Group (EO-ICWG) provides a more restricted forum for Canada, Europe, Japan, and the US to plan the International Earth Observing System (IEOS) for the 1990s and beyond.[50]

The voluntary co-operative arrangements represented by CEOS and EO-ICWG are emblematic of a particular kind of sovereignty bargain whereby states sacrifice some degree of autonomy and control over technological and informational resources in exchange for the benefits of collaboration, which include cost savings and an intellectual synergy. But this diffusion of epistemic sovereignty comes with a price. Once states become dependent on a continued supply of Earth observation data which they do not themselves control, their access to that data is perpetually at the mercy of other states' budget processes. For instance, while the ESA, having been once burned by NASA in the Spacelab project, insisted upon effective sovereignty over the elements it contributed to the Space Station, it none the less remains hostage to NASA's budgetary roller coaster. According to the 1988 ESA–NASA agreement, which typifies the language of international space agreements, states' obligations are "subject to availability of funds".[51] Given that NASA's Earth Observation System (EOS) programme has already been scaled back twice, there is a strong likelihood that budgetary politics could interfere with other co-operative ERS endeavours.

Seeking to promote the efficient and systematic use of ERS technologies, various proposals have been introduced for an international ERS regime. One proposal, initiated by the Society of Japanese Aerospace Companies, is for a World Environment and Disaster Satellite Observation System (WEDOS) that would monitor natural and man-made disasters on all time scales.[52] A more comprehensive proposal, under discussion since the mid-1980s, is for ENVI-

48. Rene Lefort, "A Worldwide Synergy", *UNESCO Courier*, No. 45 (July/August 1992), p. 42; Eugene Bierly, "The World Climate Programme: Collaboration and Communication on a Global Scale", *Annals of the American Academy of Political and Social Science*, No. 495 (January 1988), p. 110.

49. Hatoyama-Machi, "Japanese Earth Satellites Spawn Multiple User Groups", *Aviation Week and Space Technology*, No. 133 (13 August 1990), pp. 70–72.

50. Committee on Earth Studies, Space Studies Board, National Research Council, *op. cit.*, ch. IX, pp. 27–31.

51. George van Reeth and Kevin Madders, *op. cit.*, p. 226.

52. Joan Johnson-Freese, "Development of a Global EDOS: Political Support and Constraints", *Space Policy*, Vol. 10, No. 1 (February 1994), pp. 45–55. One of the strongest opponents of the Japanese proposal has been NASA, which views EDOS as a potential competitor with its own EOS programme.

ROSAT, a regime analogous to INTELSAT and INMARSAT to provide climate, meteorological, ocean, and land observations. Regime members would contribute to the capital expenses of the system by paying in proportion to use, and users would pay commercial fees for services.[53] This sort of sovereignty bargain would simultaneously increase states' mutual dependence on ERS technology and data, while making it more difficult for states to renege on prior commitments for budgetary reasons. An international ERS regime, however, whose users would include government agencies, academic researchers, multinational corporations, local communities, and non-governmental organisations, would probably be far more difficult to negotiate than a regime like INTELSAT, which serves only the communications industry. At stake would be critical questions about the ownership of knowledge among diverse user communities.

In sum, for reasons of scientific synergy and scales of economy, states are increasingly finding themselves involved in international networks and co-operative ERS programmes. These arrangements do not necessarily entail an "erosion" of sovereignty, but they do represent sovereignty bargains in which some degree of state autonomy is sacrificed in exchange for greater problem-solving capacity. But these sovereignty bargains have a clear impact on the epistemic dimension of sovereignty; co-operative ERS endeavours entail a shift in the global knowledge structure away from the scientific state described by Susan Strange. Even NASA, the undisputed world leader in civilian ERS, is deeply involved in advancing global (rather than national) science and must increasingly justify its programmes according to the needs of the international community.

While the international reconfiguration of sovereignty among states as a result of the transparency and co-operative endeavours associated with ERS technologies has been significant, perhaps even more important in the long run is the technology's diffusion beyond the state. The following section examines the impact of the dramatic expansion of ERS technologies beyond the state on epistemic sovereignty.

Diffusion of Epistemic Sovereignty Beyond the State

The three principle dynamics driving the technology's diffusion are:

(1) increased opportunities for commodification;
(2) the tremendous expansion in satellite-based science; and
(3) the growing availability of satellite imagery (along with complementary GIS and GPS technologies) among popular citizens' groups.

Thus, the diffusion of ERS technology has moved in three directions, involving three sets of non-state actors: the commercial sector, scientists, and NGOs. Because information has inherent public-goods attributes, particularly when its production requires such capital-intensive means as satellite imagery, states are

53. John L. McLucas and Paul M. Maughan, "The Case for ENVIROSAT", *Space Policy*, Vol. 4, No. 3 (August 1988), pp. 229–239; Stephen Day, "Is the Next Step, InRemSat?", *Satellite Communications*, Vol. 15, No. 4 (April 1991), p. 22; Adigun Ade Abiodun, "An International Remote Sensing System: A Possibility", *Space Policy*, Vol. 9, No. 3 (August 1993), pp. 179–184.

likely to continue to play a central role in ERS funding and applications.[54] But the staggering proliferation of ERS users is already kindling conflicts over control and access to ERS data, even as it alters conventional practices and understandings of epistemic sovereignty. The question, then, is whether ERS, along with its companion technologies, is most likely to promote the centralisation of informational power in the scientific state (or the new information hegemons), a corporate monopoly of information, or an "electronic global village".[55] Although a case can be made for any of these, the preponderance of the evidence points to a modified knowledge structure in which non-state actors gradually displace the scientific state as the locus of informational control and authority.

Corporatisation

Conflicts over the control of ERS data abound, many of them precipitated by the increasing commercialisation of ERS technology and data. Developing countries' lack of confidence in an uninterrupted supply of ERS data from the US, particularly after the privatisation of Landsat, has prompted the largest of them to build their own remote-sensing satellites.[56] Researchers have harboured similar sentiments, but they lack the option of building their own satellites. According to one scientist, the tremendous increase in the cost of Landsat data after privatisation effectively impeded a good deal of scientific research.[57] Privatisation of Landsat, it may be argued, had a profoundly anti-democratic effect on the accessibility of its images. In 1980, over 128,000 Landsat film products were sold at an average price of $15, compared with just over 4,000 sold at an average price of $150 in 1989.[58] As a result, Landsat data were far less available to researchers, educators, and less prosperous governments.

Both government agencies and scientific researchers feel that commercialisation threatens their access to data. SPOT, for instance, implemented a policy in 1989 of giving preferential service to its largest customers, the oil and mining industries, potentially placing certain government agencies at a disadvantage in obtaining urgently needed data.[59] More recently, European governments threatened to launch a "data war" by attempting to restrict commercial access to ERS data from weather satellites. Their moves inflamed researchers, who claimed that scientific and commercial data would not be easily distinguishable.[60] In a

54. Molly K. Macauley and Michael A. Toman, "Supplying Earth-observation Data from Space", *Space Policy*, Vol. 8, No. 1 (February 1992), p. 17.

55. John Pickles, "Conclusion", *Ground Truth, op. cit.*, p. 228.

56. Frederic Golden, "A Catbird's Seat on Amazon Destruction: Brazil's Space Agency is Playing an Expanded Role in Monitoring the Nation's Environment", *Science*, Vol. 246, 4927 (13 October 1989), p. 201.

57. Christopher Fotos, "Commercial Remote Sensing Satellites Generate Debate, Foreign Competition", *Aviation Week and Space Technology*, No. 129 (19 December 1988), pp. 49–50.

58. Patrick McHaffie, "Manufacturing Metaphors: Public Cartography, the Market, and Democracy", in John Pickles (ed.), *Ground Truth: The Social Implications of Geographic Information Systems* (New York: The Guildford Press, 1995), pp. 125–126.

59. Spector, *op. cit.*, p. 16; Group of Experts, UNISPACE 82 Conference, "International Remote Sensing System Proposed by Experts", *UN Chronicle*, Vol. 22, No. 2 (February 1985), p. 20.

60. Andrew Lawler, "US, Europe Clash over Plan to Set Policy on Data Access", *Science*, No. 268 (28 April 1995), p. 493.

similar vein, ensuring data consistency is a central concern for researchers, whereas commercial competitiveness entails exactly the opposite: capabilities, image size and hardware are differentiated as much as possible to prevent commercial users from switching systems.[61]

While states, particularly those lacking the ability to launch their own spy satellites, are likely to be primary consumers of the new high-resolution images, they will none the less be dependent upon the private corporations that sell those images. All of these points of contention have implications for issues of control and authority in an information age. As the commercial viability of satellite imagery grows, states can expect to see their epistemic sovereignty challenged on multiple fronts.

Global Science

The privatisation of Landsat and the entry of SPOT images and high-resolution data on the commercial market may constitute only one chapter in the ERS saga. The new satellite-based global environmental research programmes promise to grant access to vast quantities of information to a wide variety of scientists. When combined with computer technology, these images could be made available world-wide on a nearly instantaneous basis.[62] Already, a marine biologist can sit at his computer and "get information from a free-ranging whale anywhere on Earth".[63] NASA's Earth Observing System (EOS), which will soon begin returning unprecedented amounts of environmental data on a continual basis, will be complemented by a host of information storage and interpretive technologies that will make the data accessible to scientists around the world. Yet, as one user of satellite data in Africa remarks: "It's great that there is more information available, but if you still need a Ph.D. to run the GIS software and $50,000 of high-tech equipment, then it will still favour government agencies and work against community, neighbourhood, and nonprofit groups."[64] Rather than a monolithic scientific state or a corporate monopoly of information, might the new ERS technologies generate or reinforce a global technocracy?

At first glance, the logic underlying ERS appears to be profoundly technocratic. The skills required to operate satellites and sensors, and to decipher ERS data and imagery, are concentrated in an elite group of technicians and scientists in the industrialised countries.[65] At times, ERS experts exhibit an almost missionary zeal reminiscent of the Baconian technocratic ideal. One champion of ERS technology even declares that human survival depends upon it: "The great opportunity for progress in the world in the 20th century was physics, which built the world we live in. The great opportunity for creative progress in the next century will be Earth Science. It will determine if humankind is in the universe

61. Joanne Gabrynowicz, *op. cit.*, p. 174.
62. Vipin Gupta, "New Satellite Images for Sale", *op. cit.*, p. 105.
63. Doug Stewart, *op. cit.*, p. 71.
64. Geographer Trevor Harris, quoted in Mark Clayton, "Got an Earthly Cause?", *op. cit.*, p. 4.
65. David Rhind, "Geographical Information Systems and Environmental Problems", *International Social Science Journal*, No. 43 (November 1991), p. 662.

to stay."[66] As the technical capabilities of ERS technology expand, such sentiments may become even more prevalent.

However, despite the technocratic potential of ERS, other forces could compel the architects of ERS technology to become more accountable to its users. Even if many users appear to be "high priests", the very multiplicity of their voices suggests the potential for a diffusion of informational control along multiple channels. The state may be an important channel, but it is neither the only one nor is it a univocal one. As "Big Science" projects lose their appeal in a time of budgetary conservatism, and as their prestige value is diminished with the end of the Cold War, space agencies must increasingly justify ERS programmes in terms of their users' requirements. Not only does this result in sovereignty bargains in the form of international co-operative endeavours which modify the scientific state, but it also compels state programmes to be more accountable to the needs of non-state actors. One space scientist calls this a "thoroughly post-modern approach", stating that, "No longer will the development of new technology be driven by an elite of scientists and engineers, but a broader base of consultation will be required with the many user constituencies."[67]

ERS is a multifaceted technology incorporating sometimes contradictory tendencies. On the one hand, the global view afforded from the vantage point of space seems especially conducive to notions of "planetary management" and the centralisation of power. Indeed, in the discourse surrounding ERS, references to "managing the planet" and "global management" abound.[68] Yet global science is inherently decentralised, depending upon "countless loosely knit and continually shifting networks of individual researchers—most of whom resist outside intervention—in communication that crisscrosses the borders of well over a hundred sovereign nations".[69] The decentralised nature of global science is likely to have important social and political implications for efforts to cope with global ecological interdependence, the implications which are beyond the scope of this article.

While the global science based upon ERS data has many of the earmarks of a mammoth technocratic enterprise, it is not immune to public opinion; nor are its fruits available only to the elite. For instance, NASA's Mission to Planet Earth programme was conceived as a vehicle for restoring the confidence of Americans, newly concerned about the environment, in the space agency after the *Challenger* disaster.[70] Within the last couple of years, NASA has developed

66. Thomas W. Becker, "Mission to Planet Earth and Global Space Education Policy", *Space Policy*, Vol. 8, No. 2 (May 1992), p. 158. Many ERS enthusiasts advocate a crash programme in the developing countries aimed at "creating a scientific outlook". See U.R. Rao, Chairman of India's Space Commission, "Space Technology in Developing Nations: An Assessment", *Space Policy*, Vol. 9, No. 2 (May 1993), p. 169.

67. Graham Harris, "Global Remote Sensing Programmes, Global Science, Global Change: An Australian Perspective", *Space Policy*, Vol. 9, No. 2 (May 1993), p. 131. A current example is the struggle that the new 1-metre systems face in winning customers who currently use aircraft for mapping or monitoring. Aerial remote-sensing involves "well ensconced relationships with a local pilot, a local customer, [and] local analytical people". See Joseph Anselmo, "High-resolution Satellite Competition Heats Up", *Aviation Week and Space Technology*, No. 140 (11 July 1994), p. 56.

68. For instance, see *Scientific American, Managing Planet Earth* (New York: W.H. Freeman, 1990).

69. James R. Beniger, "Information Society and Global Science", *Annals of the American Association of Political and Social Scientists*, No. 495 (January 1988), p. 23.

70. Daniel Clery and William Brown, "Sensing Satellites: Who Calls the Tune?", *New Scientist*, No. 130, 1767 (4 May 1991), p. 17.

ERS data can also facilitate the localisation of control in some surprising ways. Perhaps most interesting is the use of satellite data by indigenous peoples for mapping their customary land rights and documenting the role of the state and multinational corporations in environmental destruction. Environmental advocacy groups and indigenous rights groups in Indonesia, Nepal, Thailand, and the Pacific Northwest are using satellite-generated data to *reterritorialise* their political practices to an extent previously inconceivable.[77] Indigenous communities around the world, in Canada, the Caribbean, the Amazon, and the Himalayas, are attempting to integrate their traditional knowledge into conventional scientific methodologies through the use of satellite data and GIS software packages to legitimate territorial claims.[78] While ERS data may deterritorialise political practice at the level of the nation-state, when used for "counter-mapping" by indigenous peoples at the local level, it seems to have exactly the opposite effect.[79]

Similarly, environmental advocacy groups have put ERS data and imagery to work for their own purposes. The Nature Conservancy and the Natural Heritage Network, for instance, have used satellite images to evaluate biodiversity and assess the health of plant and animal communities in their efforts to monitor enforcement of the US Endangered Species Act. Environmental and development groups in post-apartheid South Africa are applying GIS in a way that incorporates local knowledge, community needs, and specific histories into plans for sustainable development.[80] Thus, ERS technologies may reconfigure epistemic sovereignty from below, a promising development for groups trying to assert local control.

The logic of ERS with respect to the scientific state operates in multiple directions. For public-goods reasons, most information production continues to emanate from the state, even in the face of trends towards commercialisation. Yet those trends have undercut the ability of states with ERS capabilities to control information flows in any coherent way. If the combination of new companies and global environmental science succeeds in making high-quality data available at low cost, the ability of citizen groups to monitor the activities of both governments and corporations, and consequently to hold them accountable, will increase exponentially.

77. Martua Sirait *et al.*, "Mapping Customary Land in East Kalimantan, Indonesia: A Tool for Forest Management", *Ambio*, Vol. 23, No. 7 (November 1994), pp. 411–417; Cultural Survival, *Geomatics: Who Needs It?*, Vol. 18, No. 4 (Spring 1995); Jefferson Fox (ed.), "Spatial Information and Ethnoecology: Case Studies from Indonesia, Nepal, and Thailand", an unpublished manuscript available from the East–West Center in Honolulu, HI. I am grateful to Judith Mayer for her insight into the reterritorialising of political practice at the grassroots level.

78. See the following articles in the special issue of *Cultural Survival Quarterly*, 'Geomatics: Who Needs It?', Vol. 18, No. 4 (Winter 1995): Beverly Bird, "The EAGLE Project: Re-mapping Canada from an Indigenous Perspective", pp. 23–24; Bernard Nietschmann, "Defending the Miskito Reefs with Maps and GPS", pp. 34–37; Bruce Wilcox and Kristin Dunn, "Indigenous Cultural and Biodiversity: Overlapping Values of Latin American Regions", pp. 49–53; Alix Flavelle, "Community-based Mapping in Southeast Asia", pp. 72–73.

79. Bruce Stein, "Putting Nature on the Map", *Nature Conservancy* (January/February 1996), pp. 24–27.

80. Harris *et al.*, "Pursuing Social Goals through Geographic Information Systems: Redressing South Africa's Political Ecology", in John Pickles (ed.), *Ground Truth, op. cit.*

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Conclusion

The ability to control the flow of information, or what I have called epistemic sovereignty, is central to the exercise of control and authority within a territorial jurisdiction. The transparency and the global perspective of ERS technologies entail multiple, and sometimes contradictory, implications for epistemic sovereignty. The primary challenges are from the private sector, global science, and popular movements. On the one hand, ERS contributes to the unbundling, but not the abolition, of territoriality, often deterritorialising state practices. The principle of non-intervention, upon which traditional norms of sovereignty have relied, is at least called into question by the global gaze and the ubiquity of ERS images. On the other hand, ERS has also strengthened the territorial sovereignty of a few developing countries in their remote regions. Yet the greatest contribution of ERS to the reconfiguration of epistemic sovereignty might very well be in its applications to the proliferation of information and political practices beyond the state—most importantly, in the decentralised networks which constitute global science and the local efforts of community, environmental and peace groups.[81]

While state-funded ERS programmes have their roots in the balance-of-power politics characteristic of the national security state, today they tend to exemplify the sorts of sovereignty bargains required by scientific and environmental co-operation. The availability of high-resolution data on the commercial market has forced states to make a trade-off between traditional security objectives and industrial competitiveness. While none of these developments entails an outright "erosion" of sovereignty, they do highlight the importance of the epistemic dimension of sovereignty. The control over the flow of information, which is essential to the modern scientific state, appears to be shifting beyond the scientific state.

If modernity is interpreted as the enclosure of the globe via the twin institutions of state sovereignty and private property, then ERS technologies at once epitomise and challenge that trend. On the one hand, by making visible the invisible, satellite imagery renders nature subject to claims of ownership and control—whether by states or by oil and mining companies. On the other hand, in light of the globality and transparency inherent in ERS technologies and the emphasis on environmental co-operation, ERS has the potential to become a tool in the revisioning of nature as a global commons. Indeed, this is the thrust of much of the discourse surrounding environmental ERS. Likewise, the commercial availability of high-resolution satellite images opens the door for a host of non-state actors, especially citizens' groups and the news media, to involve themselves in the high-stakes national security issues which were once the sole purview of states' military establishments. There is also an interesting tension between the universal, totalising perspective of the planetary gaze, and the application of ERS technologies to popular sovereignty through the decentralisation of scientific and political control.

Although these revisions of epistemic sovereignty do not entail the withering away of the scientific state, they do suggest that the information revolution, and

81. See Paul Wapner, "Politics Beyond the State: Environmental Activism and World Civic Politics", *World Politics*, Vol. 47 (April 1995), pp. 311–340.

ERS technologies in particular, can contribute to the transformation of the knowledge structure. The scientific state may no longer be the predominant player, as it once was, with respect to satellite technologies. That trend is likely to continue, but how far it will go and with what consequences for the global knowledge structure cannot be known at present.