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DATA POLIS

Exploring the Footprint of Data on Our Planet and Beyond

Paul Cournet
Negar Sanaan Bensi

TU Delft OPEN

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‘HERE BE DR

‘HERE BE DRAGONS’: THE LIMINAL TOPOGRAPHIES OF STATISTICAL IMAGING

Gökçe Önal

A world does not predate its images. It is shaped by them.

Hashim Sarkis, Roi Salgueiro Barrio and Gabriel Kozlowski, *The World as an Architectural Project*[1]

Nineteenth-century cartographic imagination saw dragons, sea serpents, ‘men without heads with their faces in their chests’ and many other intimidating beasts of the lands unknown, *terre incognite*, abandon their corners of the Earth—permanently.[2] Popularized by the phrase ‘here be dragons’, the mapmakers’ exotic creatures occupied uncharted territories for centuries until the colonial expansion took hold, ousting the ambiguities and risks associated with venturing unknown lands. Today, the accuracy and detail of digital Earth Engines allow for little surface for such cartographic fiction to take hold, feeding a longstanding rhetoric of omniscience through the seamless ‘Google Earth’ interface. Yet, as this paper argues, the unknown, the unseen and the liminal continue to thrive within and across the infrastructures of environmental monitoring, without necessarily disturbing the cartographic surface. Resorting to Gayatri Chakravorty Spivak’s invocation of ‘planetarity’ alongside the ‘globe’, this paper asks: What remains unseen in the regime of ubiquitous surveillance? A media-material reading is engaged for responding to this question on the two operational levels of remote imaging: data gathering and data processing. The resulting framework of spectral and statistical (in)visibilities are further discussed in relation to the production of spatial knowledge.

Introduction: Technoecologies of Images

In the midst of our serene new world of images, a descriptive revaluation of the conditions of imaging—its technical basis, and the gestures that divide it off from all previous forms of visuality—is a prerequisite for architecture to pose the question, to itself and to culture ... How can we learn to live differently? So differently that we might soon—very soon—become nonmodern?[3]

Exactly three decades ago, William J.T. Mitchell warns his reader of the tendency to (mis)take the electronic image as ‘simply a new, nonchemical form of photograph or as a single-frame video, just as the automobile was initially seen as a horseless carriage and radio as wireless telegraphy’.[4] Mitchell’s grip remains among the earliest problematizations of electronic surfaces with a ‘physical’ focus. To date, on the media studies front, scholarship on computational artefacts has gradually arrived at an elemental analysis of media infrastructures[5]—opening up an ecological field whereby questions of the *visual* extends from the screen into the 'deeper material processes' of imaging, or vice versa.[6] Elemental research as such conforms to a 'denaturalized, technologized … and thereby generalized' concept of ecology—a technoecological present, to follow Erich Hörl—that no longer sustains an exhausted nature/culture divide or an alleged 'immateriality' of the digital.[7] It offers here relational ways for attending to our electronic surfaces as a growing-together of intensities, processes, and human and more-than-human agents—'settled temporarily into what passes for a stable state'.[8]

In the case of digital images, the emphasis on emergence and relationality brings into focus a motile *environment* of image objects—broadly the sites of production, dissemination and display through which 'computation is made [visible and] meaningful to us'.[9] In problematizing architecture's cartographic surfaces, I align with Jacob Gaboury's premise that elements of 'visibility, memory, simulation, relation, and history are each inscribed into the technical infrastructure of the medium of computer graphics itself'.[10] An environmentally-attentive reading here reveals digital graphic surfaces to be laden with extractive, reductive and distortive practices that today sustain the most prominent claim to the whole Earth and continually shape the visual economies of technoscientific narratives.

Imaging Infrastructures and Architecture's Informational Surfaces

'We need to flip the figure and the background, and recognise infrastructures as one of the major planetary agencies we have at our disposal.'[11]

Today, one can't rigorously tackle questions of electronic media without engaging in a geographically distributed assemblage of resources, hardware, sensing and computing platforms, interfaces and human labour. Scholarly attempts to capture the growing complexity of computing infrastructures, of which imaging remains a part, have culminated in the many diagrams of 'sociotechnical' and 'planetary' stacks, and more recently, 'anatomical maps' of automated labour.[12] Varying in scale and focus, all investigations reveal interoperability to be a central requirement of technical systems, to the extent that 'prioritising any of these layers, at the expense of the rest of the stack, places a constraint on developing an accurate understanding of how a digital technology is conceived and works in practice'.[13] All of the layers of the imaging infrastructure—the remote sensing platform and the operating system employed for data acquisition, the type and the volume of gathered data, the algorithms and the statistical models used for processing data, the software application language, and at the outset, the interface and user interaction—perpetually co-constitute one another in the production of spatial knowledge.

The contemporary momentum of image production and screen labour have rendered computer-processable imagery a currency in design cultures. Architectural thought, reflexes and practice today are increasingly embedded in the graphic surfaces of this 'statistical-electronic' topography—a categorical term that will be adopted here, after John May, for referring to digital images.[14] To date, scholarship on the (in)visibilities of statistical-electronic display has extensively focused on pixilated censorship and blanked-out satellite imagery, no-fly-zones, aerial camouflage,

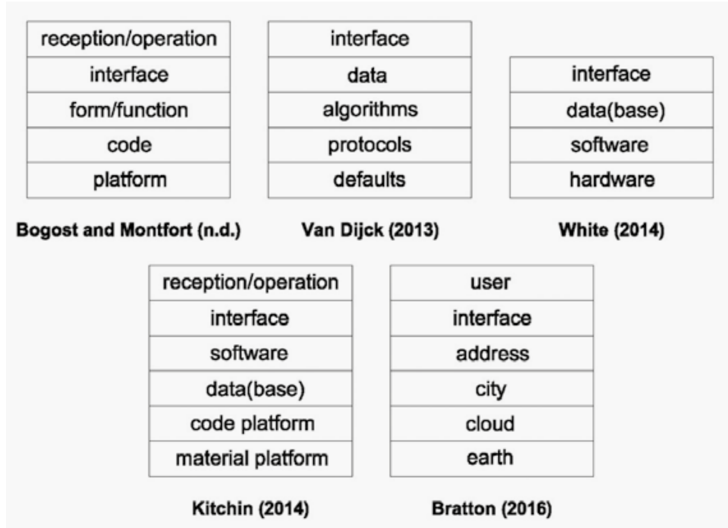

Fig. 1 Examples of 'digital technology stack' concepts from literature. Diagram adapted from Rob Kitchin, 'From a Single Line of Code to an Entire City: Reframing the Conceptual Terrain of Code/Space', in: Rob Kitchin and Sung-Yueh Perng (eds.), *Code and the City* (Abingdon, Oxon: Routledge, 2016), 20.

counter-surveillance practices and adversarial attacks—which, with the exception of the latter, conforms to a problematization of interface irregularities.[15] Of interest here, however, is not so much the censorship or curated misinformation, but rather the infrastructural layers into which the physical world is reduced, averaged, filtered and distorted before it is rendered as visual information. What gets lost—or cannot be transferred—in the act of sensing, processing and modelling Earthly energies into statistical-electronic objects? Setting out on this question, two lines of inquiry are defined: spectral (in)visibilities of sensing platforms, and statistical (in)visibilities of algorithmic modelling. The following response is structured around Spivak's invocation of 'planetarity' alongside the 'globe', which offers here a productive ground for attending to the gaps between the represented and the lived.

The Globe and the Planetarity

'Globalization is the imposition of the same system of exchange everywhere … The globe is on our computers. No one lives there.'[16]

Spivak's invocation of the planet doesn't posit an 'on the other hand' relation to the globe. The distinction, however, is growing increasingly integral to postcolonial studies, particularly for attending to the more-than-human timescales of climate histories. Against a scholarly habit of using the two words interchangeably, Dipesh Chakrabarty recounts the global as 'a singularly human story' and the planetary 'as a perspective to which humans are incidental'[17]—where the latter sustains the former. The globe, in Spivak's words, 'allows us to think that we can aim to control it'; it conforms to universals and standards, to master narratives, to an overarching geopolitical order. 'The planet,' she continues, 'is in the species of alterity'; it captures the globe as well as all things irregular, non-binary or ambiguous that escape its seamless surface, as did the mapmakers' beasts—'and yet we inhabit it'.[18] It is by paying attention to the alterity of the statistical-electronic globe that I problematize here the accelerating regime of electronic visual display—or screen—in architecture.

The Excess of Globalization

The globe is an inherently human construct. The making of its figure is grounded in histories of colonial expansion and trade, as extensively discussed to date—systematically shaped by the instruments of (circum) navigation, mobility and cartography.[19] It is a statistical artefact sustained in 'the gridwork of electronic capital', as Spivak suggests, 'an abstract ball [of] latitudes and longitudes' representing the Earth as a homogenized surface of capital and material exchange. If we then take the globe as 'an integral pictorial metaphor of modernity', following Lukas Likavcan, and its contemporary image as the Google Earth Engine, the distinction between the global and planetary imaginations becomes an infrastructural question—one that brings into focus technics of Earth observation as 'one among many of modernity's optical apparatuses'.[20]

Digital Earth Engines today comprise the visible, screen end of this anthropocentric representation practice—sustaining the state-of-the-art claim to a longstanding European endeavour of imaging the whole Earth. Cultural histories of cosmic views argue that an airminded chronicle of seeing-as-knowing underlies, in the disclosed figure of the globe, this appeal to 'total information awareness'.[21] The epistemological 'authority' of globes and geographical maps rests on this model of absolute visibility.[22] Sloterdijk rightfully defines this condition as a state of 'shadowless[ness]' with no more timeouts.[23] Adorno and Horkheimer call it a 'fully enlightened earth'.[24] For Spivak, it is the logo of the World Bank where no one lives.[25] In either instance, the globe of globalization is a human artefact, illuminated to the degree of 'overexposure' in the process of its making—from the surface of which, as I'll argue, the trivial, non-profitable and non-extractable remain eliminated.[26] This paper locates the cartographic unseen in this overexposure act, attending to the realm of the technically eliminated through Spivak's invocation of planetarity vis-à-vis the globe.

'If globalization is characterized by excessive visibility,' Elizabeth DeLoughrey suggests, 'planetarity provides a means to think through—but not necessarily to represent—that which is rendered invisible.'[27] DeLuoghrey invokes Adorno's and Horkheimer's cautionary take on the 'fully enlightened earth' as an imperative for the visual economy of colonialism—the exploration, observation, mapping and ultimately distribution of all life 'peripheral to modernity', including its people, resources, fauna and flora.[28] Excessive illumination understood as such is deeply embedded in (a Western mode of) knowledge production—for surveying practices remain at the forefront of imperial growth and land exhaustion, as postcolonial scholarship has extensively shown. To reiterate a well-travelled but equally important point here, the image of the globe conforms to the mechanisms, technics and standards that have been historically instrumental in making the modern world, which today fundamentally informs the prominent technologies of visualizing the planet.

The problem resides not so much in the fact that the globe is an abstraction of the planet, but that it is a 'very poor' one. It conforms to a *uni*versal claim incapable of engaging a planetary profusion, for 'the planetary ... cannot be grasped by recourse to any ideal form'.[29] Spivak's genius in coupling planetarity with the globe lies in defining this gap, through which, as Auritro Majumder argues, she 'invokes a relationship between the human and the natural worlds that is in "excess" of capitalist globalization'.[30]

In what will follow, I'll engage this 'excess' by addressing the—chronic—limitations of the (statistical-electronic) globe in sustaining planetary diversities, and discuss the implications of this gap for the production of spatial knowledge.

Spectral (In)visibilities: Reducing Life to Numerical Means

'A planetary thinking is primarily an imperative for diversities.'[31]

Contemporary planetary imagination is fundamentally shaped by a distributed and diverse operation of remote, or increasingly so, geo-sensing. Geo-sensing today has become a hypernym for the many practices of Earth observation. By design, (geo-)sensors always operate as part of a data acquisition system, either spaceborne, airborne, UAS or terrestrial. The sensing platforms involved in the task abide by different operational parameters for receiving and measuring environmental stimuli, comprising systems of 'detectors, signal conditioners, processors, memory devices, data recorders, and actuators'.[32] Regardless of the platform, all electronic sensors work by 'receiving a stimulus and responding with an electrical signal'—stimulus here implying (radiated) energy, be it optical, acoustic, mechanical or thermal, among others.[33] This practice of 'converting all of lived experience into discrete, measurable, calculable electrical charges (signals)', namely signalization, is examined here as an act of spectral elimination, which brings into focus a multi-layered operation of waves, signals and data conditioning.[34]

The processing sequence involved in remote imaging extends from the acquisition of image data to its calibration, analysis, modelling and integration, which exceeds the scope of any single article. The following discussion focuses on the initial stages of this sequence—namely on aspects of sensor design, data collection and pre-processing—as the site of a dynamic rift between the planetary and its digital abstractions. This rift, understood here as an adjustment and channelling of energies, grows together with a technoecology of signalization, where the incoming stimulus is filtered, divided, converted (into an electrical signal) and is ultimately sampled in digits. The energetic gaps that occur in the process, however, do not simply retreat from sight but simultaneously become part of a continuous subsurface equation—multiplying as approximations, illiteracies and errors along the many sequences of image processing.

Selective Sensibility: Calibrations in Sensor Design and Data Acquisition

Sensor sensitivity (to stimuli) is necessarily a selective constant. By design, any sensor is a partial aperture that only gathers stimuli (that is, radiated energy) from a predefined—and narrow—spectral band, known as its dynamic range. All such calibration involves prioritizing one form of information by physically discarding the others' radiation at the outset, the range of which depends on customer demands. The majority of optical and thermal sensors used in Earth observation include components for further channelling and separating the received radiation into spectral subregions, namely by splitting the signal into narrower wavelength bands through prisms, filters, diffraction grating or spectroscopes before the signal is converted into electric current.[35] In the following stages of processing, the physical segmentation facilitates different channels to be treated individually, which broadly involves operations of correction, feature selection, standardization and dimensionality reduction.

Spectral calibrations are imperative to sensor efficiency, given the wide range of remote sensing applications from climate studies to smart urbanization. Of interest here is not so much the component of feasibility, but a latent practice of 'selective blindness' that has historically shaped the imperial project of resource mapping.[36] Geo-sensing implicitly accommodates technics of resource extraction through the processes of sensing, quantifying, classifying and mobilizing bodies in isolation, deeming certain information redundant in the process.[37] As a practice of elimination, this may broadly involve 'removing pixels unrelated to a particular study … channelling ratios to highlight specific ground feature characteristics … and reducing [data] dimensionality of the image by Principal Component Analysis'.[38] A politics of (in)visibility underlies this process of removal, or the erasure of 'all that doesn't belong to [modernity's] parameters of legibility and certainty', Rolando Vazquez suggests, as much as a disregard of all things unprofitable and in-exchangeable.[39]

Datafication can't occur without making some forms of information more valuable than others; collecting all of the data all of the time doesn't automatically open out new potentialities for knowledge creation; rather, it solidifies the interests of the actors who are most able to take advantage of it.[40]

The increasing refinement of the sensors' stimulus range today not only multiplies this selective blindness, but simultaneously renders it more precise and processable by systematically eliminating the 'undesired' planetary energy with increasing efficiency. It echoes, following Louise Amoore and Alexandra Hall, an Enlightenment compulsion with a 'stripping away of excess by decomposition and fragmentation for the purposes of control'.[41] Today, technics of spectral and statistical separation, elimination and processing continually intensify a regime of information control by intermediaries.[42] This marks our entry point for attending to the gap between the global (here, the cartographic visible) and the planetarity (here, the unseen).

Unrecoverable Energies: Gaps and Binaries

At the outset of any remote sensing operation, once the Earthly radiation is received by the sensor, the process of electrical conversion allows it to be quantified as a numerical value, relying on the two possible states of electricity moving through a (computer's) circuit: flow or no flow, that is, 'on' or 'off', hence the binary system of 'ones' and 'zeros'. Fed into the base-2 numeral system of computing devices, the received ones and zeros are recorded as patterns of binary digits, more commonly known as 'bits'. A binary code is thus the smallest unit of the—complex—computational language. 'This language is electrical in its nature,' as Jacob Fraden suggests, and 'sensors intended for the artificial

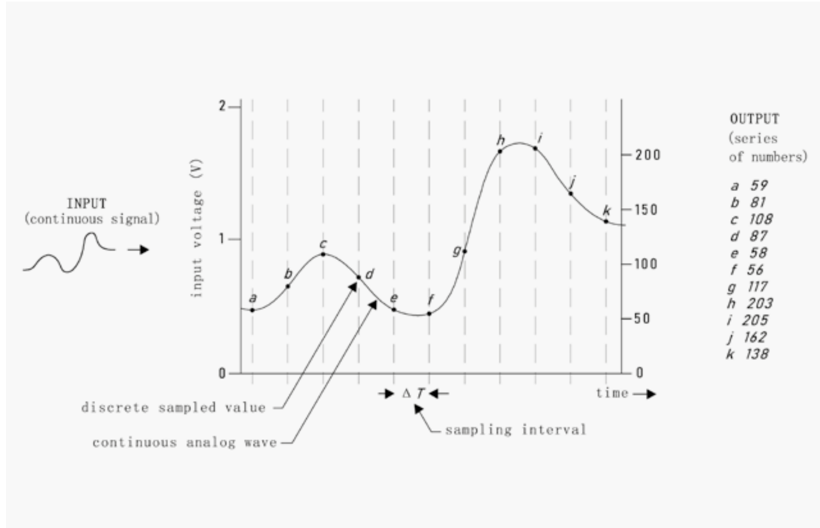

Fig. 2 Analogue-to-digital conversion process. Image drawn by the author based on Thomas M. Lillesand, Ralph W. Kiefer and Jonathan W. Chipman, Remote Sensing and Image Interpretation (New Jersey: Wiley, 2015), 26.

systems must speak the same language as the systems "speak" … responding with the output signals where information is carried by displacement of electrons.'[43] The figure below represents the process by which the (continuous) electronic signal received from the sensor is sampled in evenly fixed time intervals and recorded at each sample point as the corresponding (discrete) number.

The conversion of radiated energy here is twofold: first, into an electric current (input voltage), and secondly, into a numerical value (output). The statistical-electrical transfer depicted above marks a critical threshold between what Lucía Jalón Oyarzun describes as 'cartographic overexposure' and its 'remainders'.[44] The diagram renders tangible a physical process of leaving out (the ΔT), as well as the technique of numerical sampling involved in the act. As this conversion always conforms to an 'energy transfer between the object of measurement [and] the sensor', the overexposed—or eliminated—here is understood as planetary life itself, and only secondarily, its visibility.[45] This energetic gap is irreducible and multiplies further into the stages of image processing. May defines the technics of this signalization act as a particular form of memory and storage that is always already quantified, inscribed in the 'gestural-mental routines' of our (cultural) being.[46] However small, the gap—technically—remains intrinsic to the statistical-electronic surfaces of contemporary architecture cultures, to follow May, and ultimately to our ways of thinking and doing (through images).

In her discussion of civic activism within the 'big data optimized [smart] city,' Alison Powell points to this limitation by illustrating how the 'world-making potential of techno-systemic thinking winds its way even into the definitions and potential for civic action'—despite the sensors' technical agency in bringing to light new and multiple ways of knowing. Even in their most dissident, DIY and bottom-up form, sensing practices ultimately support the urban platform model, Powell observes, 'because [they] contribute to the same extractive and calculative dynamics of the big data optimized city'.[47] Processes of electrical conversion, sampling and datafication are technically limited in capturing the breadth of planetary life, energies and spectra. To acknowledge this partiality, I argue, is to renounce the globe-as-a-claim-to-the-whole.

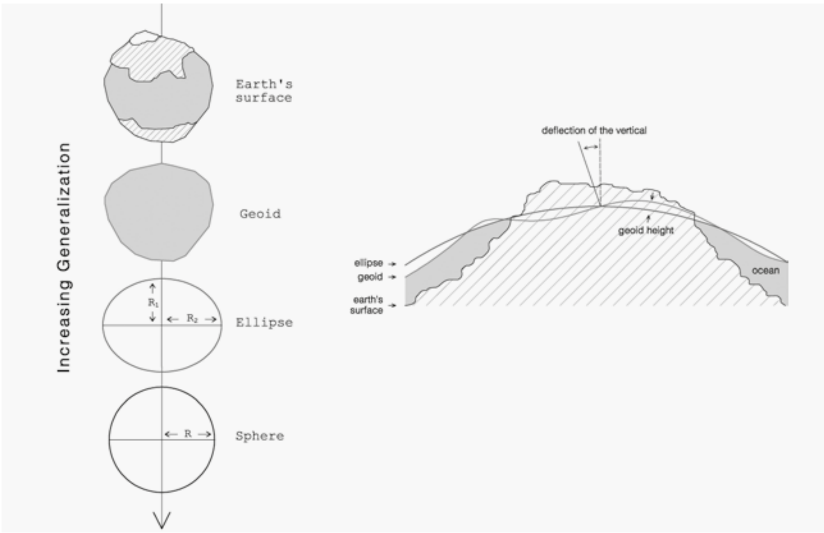

Fig. 3 [left] Modelling the shape of the Earth. Image drawn by the author based on Harrison et. al, *Earth Observation*., Vol. 1A, 56. [right] Deflection of the vertical from the geoid to the spheroid. Image drawn by the author based on *Encyclopædia Britannica, Inc.*, s.v. 'geoid', 17 March 2021, https://www.britannica.com/science/geoid, accessed 16 June 2022.

Statistical (In)visibilities: Fitting Life to Standards

As much as the electrical conversion constitutes a gateway to platform interoperability, the integration of the electrical signal into the computer infrastructure hardly remains smooth. By design, a sensor may produce output signals in the form of a voltage, a current or a charge, and these may be further registered as amplitude, polarity, frequency, phase or digital code.[48] The incompatibility of different types of sensors, measurements and platforms grows exponentially into image processing—as 'variability in formats, spatiotemporal granularity, access methods, and differing semantic definitions hinder attempts to … compare, and combine data sets'.[49] The task is further complicated by a range of (spectral, spatial, temporal or radiometric) errors that are innately present in all remotely-sensed raw data—which may be either platform, sensor and/or acquisition-related, or caused by the Earth's curvature and rotation. Addressing operational interruptions as such requires the observation data to be calibrated at all stages of remote imaging.

In the base-2 numeral system of computing devices, the recorded patterns of binary digits (bits) allow the registered phenomena to be further transmitted, stored and processed in numerical sets. Algorithms and statistical models are designed to convert these datasets into quantifiable outputs with respect to the object space in question. Calibration here involves the application of several correction and standardization models for establishing platform consistency and minimum levels of differentiation between datasets. This is also referred to as homogenization. The task of homogenization—as an attempt at interoperability—brings into focus the infrastructural logic that today, on a planetary scale, 'standardise tendencies and regimes of engagement between bodies in space: postal address systems, languages and scripts, railways, transoceanic cables, time zones, international business standards, cloud platforms, and distributed ledgers'.[50] Remotely sensed datasets are similarly calibrated to pre-defined standards and measurement models for further processing.[51] Regardless of their intended use—agriculture, resource mining, climate monitoring, urban planning, etcetera—all processed image data are registered in present-day infrastructures of data analysis, interpretation and display. The globe is an outgrowth of this standardized, corrected and homogenized infrastructure space (of exchange)—resting on mathematical models of what signals, bands and surfaces, as well as errors and deviations should ideally look like.

Earth to Globe: Approximating Life

Standardization of the Earth's surface as a statistical-electronic ground (for all cartographic and positioning tasks) requires the construction of a global coordinate system—the precondition of which is the accurate measurement of the Earth's size and shape. The operations involved in modelling the shape of the Earth, however, points to a mathematical process of (surface) homogenization, namely a technique of standardization-by-approximation that yields the 'idealized' figure of the globe. Unlike the widespread, spherical imagery of the Earth Engines, Earth's shape is most accurately represented as a *geoid*. The geoid model corresponds to the Earth's gravitational forces, which vary in magnitude and direction due to the planet's irregularly distributed mass—hence the geoid's irregular shape.[52] The following section recounts the algorithmic gestures of modelling Earth by addressing the reductive-distortive instruments of surface fitting (over and under), approximating (by interpolating or extrapolating) and filling (in the blanks).[53]

The geodetic exercise of Earth modelling should be recalled here in the context of post-war Earth sciences and the research programmes initiated during and after the Cold War. Geodesy in the past century came into focus as part of an interdisciplinary endeavour to build planetary models, fuelled by 'the [post-war] availability of instruments and programs that could provide a truly global data set'.[54] This project of 'global model-building' was an imperative for the mid-twentieth century rhetoric of the whole Earth, as Robert Poole suggest, for it not only contributed to the establishment of the planet as a set of integrated systems, reconciling the growing fields of geosciences, but also yielded an interdisciplinary ground for establishing 'the interaction of science and technology with politics, society, economy, and the environment, and … an integrated mode of thinking about global developments'.[55] Decades-long efforts of accurately reconstructing the shape of the planet thus contributed to 'a new vision of the globe as an integrated political, technological and environmental space'.[56] Here, the military-scientific nexus of the geoid model brings into focus the underlying rhetoric of globalization.

The geoid, as stated above, is considered to be the most accurate representation of the planet's shape and indicates its gravitational potential at any given point. Integral to gravity field calculations is the method of interpolation, namely the statistical estimation of 'unknown values between known values of irregularly spaced control points'.[57] The geoid is hence an interpolated model, bearing an approximated yet highly 'complex undulating surface [that is] impossible to define in simple mathematical terms', proving too irregular for map projections.[58] Earth sciences employ (versions of) the *ellipsoid* model for computational simplicity, which is 'fitted' onto the geoid to substitute the Earth's actual size and shape either locally or globally, and to construct a precise coordinate system to support all cartographic and geodetic calculations.[59] The (approximated) reference surface thus constitutes an elemental precondition of platform interoperability in remote (Earth) imaging. What is ultimately established in the ellipsoid is a standardized, mathematically definable surface that only comes close to the shape of the Earth, presenting a smoother yet more distorted approximation of the planet than the geoid.[60]

The above diagram of 'increasing generalization' begins to render tangible the figure of the globe as problematized throughout this essay: a homogenized surface of 'overexposure', an 'abstract ball', a computerized artefact. Here, the process of refinement is coupled with a distortive dimension—that of approximation-by-interpolation and surface fitting. What gradually appears is not merely the globe-as-an-idealized-model-of-the-planet, but more fundamentally a cultural technique that abstracts the Earth by separating, converting, reducing, approximating and distorting its (gravitational) forces. The alterity moves through these energetic gaps, residues and models as they multiply into the algorithmic construction of planetary images

Civic Life to Statistical Model: Latent Complexities

'The problem of bias has mostly originated from the fact that machine learning algorithms are among the most efficient for information compression, which engenders issues of information resolution, diffraction and loss.'[61]

As monitoring tasks become more specific and multi-layered—and datasets exponentially larger—algorithmic calculations involved in processing and modelling observation data are attributed further dimensions. Broadly, algorithms are finite sets of instructions to be followed in calculations. They are also generative agents that function in tandem, sustaining the building blocks of Artificial Intelligence (AI).

AI is most commonly defined as a pattern recognition mechanism comprising neural and machine learning networks, deep learning, robotics and computer vision. The product of algorithmic computation is a statistical model, namely a cluster of probability distributions. Statistical models today remain at the forefront of big data optimization, including urban innovation platforms. Yet, as existing scholarship has extensively shown, AI is technically limited by (historical, dataset-related or algorithmic) biases, assumptions and weights, which affect city planning and management at various levels of decision making.[62]

'The cybernetic systems that underpin the framework of the data-optimized smart city are intended to reduce complexity in various aspects of city life,' Powell suggests.[63] Optimization in data-driven systems implies a 'capacity to generate an actionable output from a set of attributes', reducing probabilities to one single—optimal—conclusion.[64] And while the 'condensed output' is put forward from a set of 'rejected alternatives', as Amoore argues, 'the branching pathways continue to run beneath the surface'. However singular, the algorithmic output is a fragile and contingent value: shift the weights in the 'hidden layers' and it is modified.[65] At the city scale, this may involve rather mundane instances such as the 'shortest' routes proposed by your navigation software, or dining suggestions made by search-and-discovery apps that align with your previously-visited restaurants or consumer habits—suppressing the non-optimal or less relevant in the process. It may, however, entail sharper consequences such as reproducing the racialized practices of municipal redlining in data-driven planning, as Sara Safransky illustrates. Her work on proprietary market value assessment reveals bias in urban governance to be largely shaped by the categorical choices of algorithm designers—more specifically, by their understanding of social problems, risks, census track analysis, value estimations and investment opportunities, among other things.[66] On various levels of decision making, the statistical reductions, approximations and assumptions multiply into the everyday information infrastructures, comprising today the visual economy of Earth Engines and digital twins.

Conclusion: Emergent Relations

Sensors are capable of making environments 'present and interpretable' across spatial, spectral and temporal scales, to recall Jennifer Gabrys, bringing human and more-than-human subjects and processes into (emergent) material relations.[67] This bringing together, however, is a numerical operation growing on 'unrecoverable gaps'.[68] As this paper illustrated, outside of the planet's statistical-electronic topography lies an excess that is unextractable, non-binary and unprofitable.

The statistical-electronic technics of engaging life bring certain objects into focus and eliminate others by moving earthly intensities such as waves, signals, digits, algorithms and statistical models: comprising a technoecology of images. An elemental reading of (the extents and limits to) electronic sensing here begins to reveal a growing-integral of the seen and the unseen in quantifiable terms. The statistical-electronic unseen—namely the ecology of gaps, residues, approximations and rejected paths—does not imply an absence of surface visibility alone, but itself becomes part of a continuous subsurface equation. The invisible today grows alongside the visible in increasing precision, multiplying into the sequences of image processing and ultimately into our knowledge infrastructures.

Cartographic imagination infiltrates the surface via infrastructural rifts, I argue here, as did the dragons and the beasts. What is left out (of the image) then becomes the function of an accelerating quantification of subsurface invisibilities. The unseen invades the margins of planetary speculation with deepening precision, leaving little room for alternative registers of knowledge production to prosper. The statistical-electronic visible here remains a 'threshold of inscription', rendering the surface a function of numerical weights.[69] It is on these thresholds of the (in)visible that I locate Spivak's planetarity as a means to attend to the 'excess'—understood here as all forms of engagement that have been marginalized from the statistical-electronic regimes of architecture's surfaces, much like the beasts, sea serpents and dragons of other registers.

Notes

1 Hashim Sarkis, Roi Salgueiro Barrio and Gabriel Kozlowski, *The World as an Architectural Project* (Cambridge, MA: MIT Press, 2019), 1.
2 Chet Van Duzer, 'Bring on the Monsters and Marvels: Non-Ptolemaic Legends on Manuscript Maps of Ptolemy's Geography', *Viator* 45/2 (2014), 312.
3 John May, *Signal. Image. Architecture. (Everything Is Already an Image)* (New York: Columbia University Press, 2019), 28.
4 William J. Mitchell, *The Reconfigured Eye: Visual Truth in the Post-Photographic Era* (Cambridge, MA: MIT Press, 1992), 2.
5 Nicole Starosielski, 'The Elements of Media Studies', *Media+Environment* 1/1 (2019).
6 Jacob Gaboury, *Image Objects: An Archaeology of Computer Graphics* (Cambridge, MA: MIT Press, 2021), 11.
7 Erich Hörl, 'Introduction to General Ecology: The Ecologization of Thinking', translated by Nils F. Schott, in: Erich Hörl and James Burton (eds.), *General Ecology: The New Ecological Paradigm* (London: Bloomsbury Academic, 2017), 3.
8 Sy Taffel, *Digital Media Ecologies: Entanglements of Content, Code and Hardware* (New York: Bloomsbury Academic, 2021), 1.
9 Gaboury, *Image Objects*, op. cit. (note 6), 10.
10 Ibid., 5.
11 Lukáš Likavčan, *Introduction to Comparative Planetology* (Moscow: Strelka Press, 2019), chapter 1, Kindle.
12 For digital stacks, see: Rob Kitchin and Rob and Sung-Yueh Perng (eds.), *Code and the City* (Abingdon, Oxon: Routledge, 2016). For planetary stacks, see: Benjamin H. Bratton, *The Stack: On Software and Sovereignty* (London: MIT press, 2016). For 'anatomical maps', see: Kate Crawford and Vladan Joler, 'Anatomy of an AI System: The Amazon Echo As An Anatomical Map of Human Labor, Data and Planetary Resources', AI Now Institute and Share Lab (September 2018); https://anatomyof.ai; Matteo Pasquinelli and Vladan Joler, 'The Nooscope Manifested: Artificial Intelligence as Instrument of Knowledge Extractivism', KIM HfG Karlsruhe and Share Lab (May 2020), http://nooscope.ai.
13 Rob Kitchin, 'From a Single Line of Code to an Entire City: Reframing the Conceptual Terrain of Code/Space', in: Rob Kitchin and Sung-Yueh Perng (eds.), *Code and the City* (Abingdon, Oxon: Routledge, 2016), 8.
14 According to May's technical categorization of architecture's surfaces, an image is a statistical-electrical form of recording, storing and recovering information, commonly exemplified as (but not limited to) computer-processable digital images. Photography, as the technique of inscribing light on film, conforms to a chemical-mechanical gesture, and lastly, drawing to a hand-mechanical one.
15 For pixilated censorship and blanked-out satellite imagery, see: Trevor Paglen, *Blank Spots on the Map: The Dark Geography of the Pentagon's Secret World* (New York: Penguin, 2009); Laura Kurgan, *Close Up at a Distance: Mapping, Technology and Politics* (New York: Zone Books, 2013); Lisa Parks and Caren Kaplan (eds.), *Life in the Age of Drone Warfare* (London: Duke University Press, 2017). For no-fly-zones, see: Hagit Keysar, 'Who Owns the Sky? Aerial Resistance and the State/Corporate No-Fly Zone', *Visual Studies* 35/5 (2020), 465–477. For counter-surveillance practices and adversarial attacks, see: Adam Harvey, 'HyperFace project', 2016, https://ahprojects.com/hyperface; Eyal Weizman, *Forensic Architecture: Violence at the Threshold of Detectability* (Oxford: Princeton University Press, 2017); Kate Crawford, *The Atlas of AI* (London: Yale University Press, 2021).
16 Gayatri Chakravorty Spivak, *Death of a Discipline* (New York: Columbia University Press, 2003), 72.
17 Dipesh Chakrabarty, 'Climate and Capital: On Conjoined Histories', *Critical Inquiry* 41/1 (2014), 23.
18 Spivak, *Death of a Discipline*, op. cit. (note 16), 72.
19 Elizabeth M. DeLoughrey, 'Satellite Planetarity and the Ends of the Earth', *Public Culture* 26/2 (2014), 265; Dipesh Chakrabarty, 'The Planet: An Emergent Humanist Category', *Critical Inquiry* 46/1 (2019), 6.
20 Likavčan, *Comparative Planetology*, op. cit. (note 11), chapter 3; Lucía Jalón Oyarzun, 'Nightfaring & Invisible Maps: Of Maps Perceived, but Not Drawn', *The Funambulist* 18 (2018), 40.
21 Peter Adey, 'Aeromobilities: Geographies, Subjects and Vision', Geography Compass 2/5 (2008), 1322.
22 Denis E. Cosgrove, *Apollo's Eye: A Cartographic Genealogy of the Earth in the Western Imagination* (Baltimore: Johns Hopkins University Press, 2003), 206.
23 Peter Sloterdijk, *In the World Interior of Capital: For a Philosophical Theory of Globalization*, translated by Wieland Hoban (Cambridge: Polity Press, 2013), 141.
24 Theodor W. Adorno and Max Horkheimer, *Dialectic of Enlightenment* (London: Verso Books, 2016).
25 Gayatri Chakravorty Spivak, *An Aesthetic Education in the Era of Globalization* (Cambridge, MA: Harvard University Press, 2013), 338.
26 'Overexposure' used in Oyarzun, 'Nightfaring', op. cit. (note 20).
27 Elizabeth M. DeLoughrey, *Allegories of the Anthropocene* (Durham, NC: Duke University Press, 2019), 65–66.
28 Ibid., 67.
29 Likavčan, *Comparative Planetology,* op. cit. (note 11), chapter 3; Chakrabarty, 'The Planet', op. cit. (note 19), 25.
30 Auritro Majumder, 'Gayatri Spivak, Planetarity and the Labor of Imagining Internationalism', *Mediations* 30/2 (2017), 20.
31 Yuk Hui, 'For a Planetary Thinking', *e-flux Journal* 114 (December 2020), accessed 2 March 2022, https://www.e-flux.com/journal/114/366703/for-a-planetary-thinking/.
32 Jacob Fraden, *Handbook of Modern Sensors: Physics, Designs, and Applications* (New York: Springer, 2016), 2.
33 Ibid.
34 May, *Signal. Image. Architecture*., op. cit. (note 3), 80.
35 Barb A. Harrison et al. (eds.), *Earth Observation: Data, Processing and Applications. Volume 1A: Data—Basics and Acquisition* (Melbourne: CRCSI, 2017), 180–181.
36 Daniela Bleichmar, 'Visible Empire: Scientific Expeditions and Visual Culture in the Hispanic Enlightenment', *Postcolonial Studies* 12/4 (2009), 441.
37 Gökçe Önal, 'Media Ecologies of the "Extractive View": Image Operations of Material Exchange', *Footprint* 14/2 (2020).
38 Barb A. Harrison et al. (eds.), *Earth Observation: Data, Processing and Applications. Volume 2A: Processing—Basic Image Operations* (Melbourne: CRCSI, 2017), 147.
39 Rolando Vázquez, 'Translation as Erasure: Thoughts on Modernity's Epistemic Violence', *Journal of Historical Sociology* 24/1 (2011), 31.
40 Alison B. Powell, *Undoing Optimization: Civic Action in Smart Cities* (New Haven: Yale University Press, 2021), 154.
41 Louise Amoore and Alexandra Hall, 'Taking People Apart: Digitised Dissection and the Body at the Border', *Environment and Planning D: Society and Space* 27/3 (2009), 450.
42 Powell, *Undoing Optimization,* op. cit. (note 40), 110.
43 Fraden, *Modern Sensors*, op. cit. (note 32), 2.
44 Oyarzun, 'Nightfaring', op. cit. (note 20), 41.
45 Fraden, *Modern Sensors*, op. cit. (note 32), 3.
46 May, *Signal. Image. Architecture*., op. cit. (note 3), 39, 47–48.
47 Powell, *Undoing Optimization*, op. cit. (note 40), 8, 109, 141.
48 Fraden, *Modern Sensors*, op. cit. (note 32), 2–3.
49 Taha Selim Ustun et al., 'Data Standardization For Smart Infrastructure in First-Access Electricity Systems', *Proceedings of the IEEE* 107/9 (2019), 1793.
50 Likavčan, *Comparative Planetology,* op. cit. (note 11), Introduction.
51 Harrison et al., *Earth Observation. Vol. 1A*, op. cit. (note 35), 21.
52 George D. Garland and Urho A. Uotila, 'Geoid', *Encyclopedia Britannica*, 17 March 2021, https://www.britannica.com/science/geoid.
53 Pasquinelli and Joler, 'The Nooscope', op. cit. (note 12).
54 Soraya Boudia, 'Observing the Environmental Turn through the Global Environment Monitoring System', in: Simone Turchetti and Peder Roberts (eds.), *The Surveillance Imperative: Geosciences During the Cold War and Beyond* (New York: Palgrave Macmillan, 2014), 195.
55 Robert Poole, 'What Was Whole about the Whole Earth? Cold War and Scientific Revolution', in: Simone Turchetti and Peder Roberts (eds.), *The Surveillance Imperative: Geosciences During the Cold War and Beyond* (New York: Palgrave Macmillan, 2014), 224, 220.
56 Joseph Masco quoted in: ibid., 215.
57 Terry A. Slocum et al., *Thematic Cartography and Geovisualization* (Harlow: Pearson Education Limited, 2014), 307.
58 Ibid., 141.
59 Harrison et al., *Earth Observation. Vol. 1A,* op. cit. (note 35), 56.
60 Slocum et al., *Thematic Cartography*, op. cit. (note 57), 142.
61 Pasquinelli and Joler, 'The Nooscope', op. cit. (note 12).
62 Louise Amoore, *Cloud Ethics: Algorithms and the Attributes of Ourselves and Others* (Durham, NC: Duke University Press, 2020); see also: Pasquinelli and Joler, 'The Nooscope', op. cit. (note 12).
63 Powell, *Undoing Optimization*, op. cit. (note 40), 62.
64 Amoore, *Cloud Ethics*, op. cit. (note 62), 160.
65 Ibid., 162.
66 Sara Safransky, 'Geographies of Algorithmic Violence: Redlining the Smart City', *International Journal of Urban and Regional Research* 44/2 (2020), 213–215.
67 Jennifer Gabrys, *Program Earth: Environmental Sensing Technology and the Making of a Computational Planet* (London: Minnesota Press, 2016), 29–32.
68 Amoore and Hall, 'Taking People Apart', op. cit. (note 41), 459.
69 Brighenti Andrea Mubi, 'The Visible: Element of the Social', *Frontiers in Sociology* 2 (2017).

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