Grounds for Comparison

Investigating Before-and-after Satellite Images

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Abstract *Whether being confronted with war crimes, natural disasters or catastrophic climate change, a type of image or image comparison frequently makes its appearance in addressing and visualizing these conflicts, crises, crimes or catastrophes: before-and-after satellite images. They have become an integral part of our media ecosystem and visual culture, especially with regard to the visualization of change and the presentation of evidence of change. With special emphasis on visual investigations dealing with the war crimes in Bucha, Ukraine, this article traces discourses and practices working with satellite images and examines the technical and medial preconditions for before-and-after image comparisons.*

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On April 4 2022 (updated April 6) The New York Times published a story about the killings of civilians in the Ukrainian town of Bucha, on the western outskirts of Kiev, under the headline (on the Times website) "Satellite images show bodies lay in Bucha for weeks, despite Russian claims."[1] After a short lead, above the byline and the written article, the website shows a satellite image with annotations and markings, identifying bodies on a street. A play button and a time code feature prominently as well, indicating that the image serves as a placeholder for a clip, running for 1:07 minutes. The clip is arranged in a split screen: moving images shot from a car, presumably with a mobile phone, on the left, satellite images on the right. The two sides, featuring the two different types or orders of images, are synchronized and annotated. Whenever the car and camera on the left move past a body on the street the footage is

1 Malachy Browne/David Botti/Haley Willis, Dead Lay Out in Bucha for Weeks, Refuting Russian Claim, Satellite Images Show, The New York Times online, 4.4.2022, [https://www.nytimes.com/2022/04/04/world/europe/bucha-ukraine-bodies.html, last accessed: May 14, 2023]. Cf. also a similar analysis at the BBC: Art. Reality Check and BBC Monitoring, BBC News, Bucha killings: Satellite image of bodies site contradicts Russian claims, bbc.com, 5.4.2022, [https://www.bbc.com/news/60981238, last accessed: May 14, 2023].

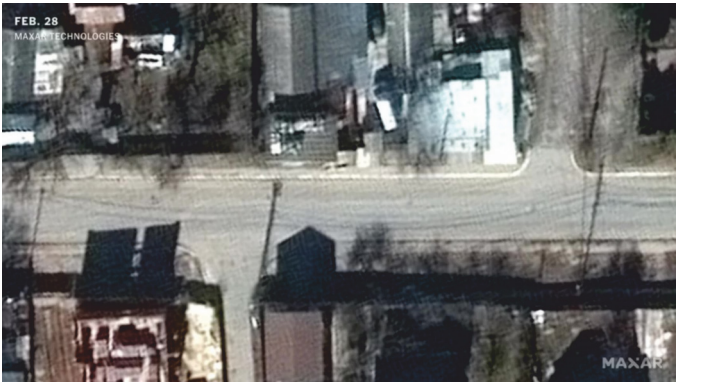
halted, the bodies are simultaneously highlighted with white squares on both sides, and the right-hand side of screen zooms in on the (otherwise static) satellite image, utilizing the image as a map showing where the car (or the camera and its operator) as well as the bodies shot in passing can be located.

In the course of the short article, which mainly serves as an extended annotation or interpretation of the images shown, three other instances of image presentation involving three other types of image constellations are utilized: one is an extract from a map of Bucha (not commissioned by or attributed to any commercial map provider), relating it to Kiev, placing it in the whole of Ukraine and highlighting, with red marks, the site of a mass grave and the short stretch of Yablonska Street where twelve bodies can be seen in the footage referenced above. The other two again contain satellite images, the second of which is another split-screen presentation of the aforementioned ground-level cell-phone footage (attributed to "Kievskiy Dvizh via Instagram", shot by a local council member on April 1) with a satellite image (attributed to Maxar Technologies) (Fig. 1). The first is a short clip or GIF, formatted as an mp4-video file (Fig. 2 & 3). It features a loop of two satellite images of the same stretch of street, from the same angle, morphing one image taken on February 28 2022 and one on March 19 2022 into one another with a digital fade. At first, on February 28, the street is empty. Then, on March 19, seven white squares mark bodies on the street, in the same image that served as quasi-thumbnail for the opening clip of the article, albeit not being featured in it.

Fig. 1: Synchronization of mobile-phone camera and satellite footage

Source: nytimes.com

Fig. 2: "Before" image



Source: nytimes.com

Fig. 3: "After" image

Source: nytimes.com

What the short clip or animation presents is thus a condensed comparison of two moments in time, separated by almost three weeks. First there was nothing—at least nothing worthy of annotations and analysis. Then there were bodies. The article presents this juxtaposition, this simple comparison of two images of the same street in order to investigate and ultimately refute or disprove claims by Russian officials at the Ministry of Defense as well as media outlets that denied Russian responsibility for the killing of civilians by stating that the bodies only appeared on the streets after the Russian troops had retreated at the end of March 2022.

As the article points out, and as the second of the two images as well as the synchronization with the video footage from April 1 show, the bodies can be made out in the satellite footage from March 19, when Russian troops still were occupying the town.

While being part of the larger focus of the NYT on the war in Ukraine, the article does not belong to the section with regular reporting also featured in the print edition, with the war coverage conducted mainly or traditionally on the ground. It was published by a special branch or group of NYT reporting, launched in 2017, The New York Times Visual Investigations team. The Visual Investigations team conducts its reporting mostly on the basis of data and media, often gathered via publicly available sources, and publishes the results as hybrids of text, video, maps, graphics, and images. With both the mixed-media source material and the mixed-media output, the work of the Visual Investigations unit could be considered to exemplify a shift in investigative reporting of human-rights violations and state-sanctioned violence, and in war reporting in general, which can observed in publications and media organizations around the world.[2] The visual investigations at the NYT have their predecessors perhaps less in the methods of traditional investigative journalism and more in the investigative departments or crisis-monitoring units of the non-governmental organizations and agencies they sometimes cooperate with—human-rights NGOs like Amnesty International, for which some of their contributors have also worked previously.

"To confirm when the bodies appeared, and when the civilians were likely killed, the Visual Investigations team at The Times conducted a before-and-after analysis of satellite imagery," the article states. My article aims to examine this specific practice of visual investigations, and especially of "before-and-after analysis of satellite imagery"; this dispositive[3] of before-and-after satellite images that has become a visual trope of change and disaster in itself, with images that become metonymies for catastrophic events—albeit usually without depicting the events themselves. Whether examining the atrocities of Bucha, the attacks on Mariupol,[4]

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2 Starting with investigations into chemical attacks in the Syrian war, other main areas of interest ofthe New York Times Visual Investigations team were state-sanctioned and especially police violence, and also mass shootings, the riots at the Capitol, and the Beirut port explosion. Cf. [https://www.nytimes.com/spotlight/visual-investigations, last accessed: May 14, 2023].

3 I am treating this "tool" as a *dispositive*—a set of practices, discourses and technologies that implies specific modes of spectatorship, structures of gazes and arrangements of power and knowledge. Cf. Michel Foucault, The Confession of the Flesh. A conversation with Alain Grosrichard et al., in: Michel Foucault, *Power/Knowledge. Selected Interviews and Other Writings 1972–1977*, ed. by Colin Gordon, New York 1980, 194–228.

4 Various stages and events of the shelling of Mariupol have been reconstructed and investigated by multiple investigative reporting teams and non-governmental agencies, often using

or the destruction of cultural sites in Ukraine[5] or mosques in Xinjiang, to name but a few examples, or covering wild fires, floods or other disasters around the globe, similar types of images or image comparisons are frequently employed in addressing these conflicts, crises, crimes, and catastrophes. They have become an integral part of our contemporary media ecosystem, especially with regard to the representation and visualization of (evidence of) drastic, often violent change.[6]

This essay aims to trace discourses and practices dealing with—or even relying on—before-and-after-images as, in the words on the United States Geological Survey website, a "powerful tool"[7] for rendering change and transformations visible, as well as for providing evidence of human-rights violations. First, this essay will present a short phenomenology of *before-and-after* satellite images. In a second step it will discuss a few key technical traits and terms that are consequential for the discussion of before-and-after *satellite* images—remote sensing and ground truth—concluding with a few remarks about their implications for, and possible links between, practices of investigation and comparison that might be or become part of a broader theory of triangulation.

Working on and with satellite images raises significant questions that affect theories of media and theories and practices of comparison alike: aesthetic questions of perception, since change or transformations are visualized in the case of before-and-after images on the basis of sensing operations that go beyond human perception and need to be remediated, realigned, and recalibrated (a problem which is reflected in current theoretical discourses on an aesthetics beyond perception that in-

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before-and-after satellite images. Cf. Kai Biermann et al., Die Schlacht um Mariupol, in: *ZEIT ONLINE*, 28.4.2022, URL: https://www.zeit.de/politik/ausland/2022-04/krieg-ukraine-mariupol-schlacht-rekonstruktion [last accessed: May 14, 2023].

5 Cf. Art. Agence France-Presse, Before-and-after satellite imagery will track Ukraine cultural damage, UN says, in: The Guardian, 27.10.2022, [https://www.theguardian.com/world/2022/oct/27/before-and-after-satellite-imagery-will-track-ukraine-cultural-damage-un-says, last accessed: May 14, 2023].

6 As condensed micro-narratives and visual metonymies, before-and-after satellite images could also be discussed in the context of other visual practices where similar types of temporal image comparisons or comparative image designs feature prominently: medical diagnostic and monitoring practices for example on the one hand, or advertisements for dietary supplements, workout routines, home- and self-makeovers and other viral clickbait on the other.

7 Quote on the website of The United States Geological Survey, URL: https://www.usgs.gov/products/multimedia-gallery/before-after-images [last accessed: May 14, 2023]. The USGS and its Earth Resources Observation and Science Center (EROS) makes ample use of this trope and tool for educational purposes, with before-and-after "Spot the Change" quizzes and a virtual remote-sensing classroom. Cf. [https://eros.usgs.gov/remote-sensing-classroom, last accessed: May 14, 2023].

volves various modes of sensing and sense-making).[8] It also involves political-epistemological questions of order, because the order of human rights (at least in the image-activist approach), if not the political global order in the 21st century, is linked to or entangled with the order of images (Lisa Parks and James Schwoch call this the "satellitization" of global security);[9] this even often relies on the tasking of satellites and the *ordering* of images (quite literally, from image databases like Maxar's "20-year, 110+-petabyte high-resolution satellite-imagery library").[10]

In many instances before-and-after satellite images may have become almost emblems of drastic global transformations and conflicts and a kind of visual trope in political, journalistic and educational contexts.[11] In the case of catastrophic climate change, before-and-after images can be considered not only as key visual aids and agents in the visualization of change but also as having been constitutive in producing it as an object of knowledge itself: as has often been pointed out, the emergence of a new formation of knowledge, like the idea of the anthropocene, can be linked closely not only to the computerization of climate data[12] but also to the monitoring and visualization of changes on the surface of the earth over time by means of remote sensing, satellite imagery and data and image juxtaposition or superimposition.[13]

Although environmental and human-rights causes, environmental violence, and violence directed at people are often interlinked, having established an emergent conception of rights and an international-relations discourse under the label "environmental security" that aims to take into account these entanglements, the following remarks will focus on the pivotal function of before-and-after image comparisons in the field of human-rights causes, state-crime investigations, and im-

8 Cf. Matthew Fuller/Eyal Weizman, *Investigative Aesthetics. Conflicts and Commons in the Politics of Truth*, London/New York 2021.

9 Lisa Parks/James Schwoch, Introduction, in: Lisa Parks/James Schwoch (eds.), *Down to Earth. Satellite Technologies, Industries, and Cultures*, New Brunswick/New Jersey/London 2012, 1–16, see 4. The architecture theorist and activist Andrew Herscher even claims, that "satellite images *produce* those objects [of Human Rights and International Relations discourse] […] as visual forms." Andrew Herscher, Surveillant Witnessing. Satellite Imagery and the Visual Politics of Human Rights, in: *Public Culture* 26 (3/2014) (74), 469–500, see 476.

10 Cf. Christina Geller, Introducing Maxar ARD: Accelerating the Pixel-To-Answer Workflow with Analysis-Ready Data, 2.2.2021, [https://blog.maxar.com/earth-intelligence/2021/introducing-maxar-ard-accelerating-the-pixel-to-answer-workflow-with-analysis-ready-data, last accessed: May 14, 2023].

11 Cf. Laura Kurgan, *Close Up at a Distance: Mapping, Technology and Politics*, New York 2013, 22–23.

12 Cf. Paul N. Edwards, *A Vast Machine: Computer Models, Climate Data, and the Politics of Global Warming*, Cambridge, Massachusetts 2010, 357–396.

13 Cf. Jennifer Gabrys, *Program Earth. Environmental Sensing Technology and the Making of a Computational Planet*, Minneapolis 2016, see especially 116.

age activism. The technical specificities involved in "sensing" and visualizing climate "events" (or rather, events over the *longue durée*) do not only affect the images produced (as translations of different wavelengths across the electromagnetic spectrum into images). The role of models and predictions in climate science, and the recursive structure of data, images and models in remote sensing, where remotely gathered data is fed into models that determine the application and calibration of remote sensors, also affect the temporality of these processes and distinguish them from forensic operations: the generating of models of a changing climate and the earth's surface is not only closely linked to remote sensing of the surface that challenges the notion of human perception; it also generates images of the projected future (of the planet) by constantly reassessing and recalibrating the images of the present through a process governed by machine learning.[14]

The visual investigations concerned with human-rights violations and state violence, on the other hand, differ somewhat in their approach, although they also rely on satellite images produced or captured by, in some cases, the same sensors, the same satellites, and the same corporations. While also relying on computer models, stitching, alignments, filters, and pattern recognition, they mostly seem to follow a model of visual evidence that is closely linked to the epistemic logic of the "evidential [in other translations: conjectural] paradigm,"[15] as Carlo Ginzburg famously called the epistemic formation emerging around 1900 and hinging on the reading of symptoms, details, tracks, and traces. Investigative practices that are—and produce knowledge that is— "indirect, based on signs and scraps of evidence, conjectural"[16] follow a specific forensic temporality and translation: the collection and analysis of remainders of past events in the present in order to turn them into evidence, to "make them speak."[17]

So before addressing some of these media specificities of satellite imagery and before-and-after images in human-rights discourses as well as contemporary non-

14 Abelardo Gil-Fournier and Jussi Parikka point out that this increasingly holds true for any sort of data gathering by means of (remote) sensors. Cf. Abelardo Gil-Fournier/Jussi Parikka, Ground Truth to Fake Geographies. Machine Vision and Learning in Visual Practices, in: *AI & Society* 36 (2021), 1253–1262, see 1259.

15 Carlo Ginzburg, Clues: Roots of an Evidential Paradigm, in: Carlo Ginzburg: Clues, Myths, and the Historical Method, Baltimore/London 1989, 96–125.

16 Carlo Ginzburg, Morelli, Freud and Sherlock Holmes. Clues and Scientific Method, in: *History Workshop* 9 (1980), 5–36, see 16.

17 Eyal Weizman, *Forensic Architecture. Violence at the Threshold of Detectability*, New York 2017, 98: "Forensic speech is traditionally undertaken as a relation between three elements: an object or a building 'made to speak,' an expert who functions as the translator from the language of objects to that of people, and the forum or assembly in which such claims can be made."

governmental forensic or "counter-forensic" contexts,[18] I am going to attempt a very brief phenomenology of these types of before-and-after satellite images and how they involve and challenge practices and temporalities of comparison.

Before-and-After Satellite Images

The NYT visual investigation of the killings in Bucha features several of the key elements that transform a simple presentation of two images of the same location into a comparative configuration, a forensic device, a dispositive for the production of truth and knowledge, or even a narrative of war crimes. Apart from the scene they show, the images contain primary information like a logo with the name of the company providing them ("MAXAR"), as well as information that has been added to the images inconspicuously (the dates of their acquisition and the full name of the company, "MAXAR TECHNOLOGIES") and in order to highlight the objects of the investigation (the white squares with the annotation "BODIES"). Yet the central element or target of a criminal investigations, in this case of war crimes relating to the killings in Bucha, remains invisible in the satellite images. The spectators, operators, and investigators missed them. Or rather, the satellite operated by the US-company Maxar Technologies did. And even if it did not, we might not have been able to see the perpetrators anyway, due to the maximum resolution of commercially available satellites images (Maxar's Worldview-3 satellite has a resolution of 31cm per Pixel, which is as high as it gets in commercial applications and commercially available satellite images).[19]

What the NYT article presents instead is a short montage, a micro-movie, comprised of only two images. Although the formatting of the clip allows for a seamless and smooth transition between the two images and moments in time, the real target of the article is what happened in between—the time lapse and gap between the two instances, the two images—a gap that "might also be considered as a reservoir of imagined images and possible histories."[20] Forensic investigations and operations

18 Thomas Keenan reevaluates the use of the term by the artist and theorist Alan Sekula in order to refer to investigative and political practices that challenge government-sanctioned forensic accounts by employing similar methods and technologies. Cf. Thomas Keenan, Counter-forensics and Photography, in: *Grey Room* 55 (2014), 58–77.

19 The limited resolution of publicly available satellite images, the "threshold of detectability" (of individual humans, and also holes in roofs as the result of drone strikes, for example) is a key issue for non-governmental investigations, cf. Weizman, *Forensic Architecture*, 20–30.

20 Eyal Weizman/Ines Weizman, *Before and After. Documenting the Architecture of Disaster*, Moskow 2014, 12.

aim to close or rather fill the gap with stories and histories of traces,[21] often supplemented by other media and "material witnesses."[22]

If comparative viewing has the capacity to make the invisible visible; and if, as art historian Falk Wolf states,[23] an invisible third appears between the compared images due to the fantasy and imagination of the spectator, as occurs in a dialectic montage,[24] the forensic operation of filling the gap can be considered as closely related to or even as a specific mode of practice of comparative viewing. Fantasy and imagination, the *Einbildungskraft* of the spectator, may well be of less importance in the case of before-and-after images than detection, deduction, and synchronization, but within and from the gap, an invisible third makes its appearance nevertheless: the event, which is referenced by absences or appearances, tracks and traces. It is a structural ambiguity or openness that seems to stand in stark contrast to the discourse of evidence and self-evidence that is often associated with this type of satellite imagery and which is part of their journalistic appeal.

In their essay on before-and-after images Eyal and Ines Weizman pick up and retrace the temporal logic of this gap in before-and-after images to its earliest exponents in photography and to the latency of photochemical exposure and development:

> The history of before-and-after images is as old as the history of photography. Indeed, they emerged from the limitations of the early photographic process. The few dozen seconds required for the exposure of a mid-19th-century photograph was too long a duration to record moving figures and abrupt events. The result was that most often people were missing from the image; only buildings and other elements of the urban fabric were registered. To capture an event, two photographs were necessary. The technique was thus useful in representing the consequences of urban conflicts, revolutionary action and large-scale urban reconstructions. Because the event was registered only through changes in the environment, those studying the result of vio-

21 Cf. Simon Rothöhler, *Medien der Forensik*, Bielefeld 2021, 178. Eyal and Ines Weizman especially highlight the spatial and architectural dimension of this operation: "In before-and-after photographs, the event—whether natural, manmade or an entanglement of them both—is missing. Instead, it is captured in the transformation of space, thus calling for an architectural analysis. This spatial interpretation is called upon to fill the gap between the two images with a narrative […]." Weizman/Weizman, *Before and After*, 6.

22 In her study Susan Schuppli takes the legal term "material witness" literally and turns it in an "operative concept in its own right: material as witness." Cf. Susan Schuppli, Material Witness. Media, Forensics, Evidence, Cambridge/Massachusetts 2020, 39.

23 Falk Wolf, Demonstration: Einleitung, in: Lena Bader/Martin Gaier/Falk Wolf (eds.), *Vergleichendes Sehen*, München 2010, 263–271, see 267.

24 Cf. Weizman, Forensic Architecture, 98.

> lence needed to shift their attention from the figure (the individual or action) to the ground (the urban fabric or landscape).[25]

Not only is the temporality of the gap an irreducible part or conundrum of the deployment of satellites for intelligence and image gathering, since their infrastructural condition is bound to the circumnavigation of the planet,[26] but satellite images are also affected by a different sort of latency that is nevertheless specific to their mediality: a latency that is the effect not of photochemical inscription and development but of the accessing and processing of data:

> The satellite image has an altogether different tense. […] [It] is encoded with time coordinates that index the moment of its acquisition, but since most satellite image data is simply archived in huge supercomputers, its tense is one of latency. Satellites are constantly and quietly scanning the earth, but much of what they register is never seen or known. The satellite image is not really produced, then, until it is sorted, rendered, and put into circulation, […]. Satellite image data only becomes a document of the 'real' and an index of the 'historical' if there is reason to suspect it has relevance to current affairs. Unless the satellite image is selected and displayed, it remains dormant.[27]

Satellite images gathered through remote sensing (or at least, the kind of satellite images that are later considered and turned into documents or evidence) belong, in other words, to an order of images that, paradoxically, indicate "eventness" and "the real" and are (though not only in that regard) closely aligned or a least associated with the discourses concerning other technologies and images of surveillance. Although, because of the aforementioned technical restrictions and infrastructural conditions, commercial satellites are not particularly functional for real-time surveillance, satellite images are often charged, at least in popular culture, with the "surveillant omniscience"[28] and power of a super-gaze from orbit.[29] And as seen in the claims of

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25 Weizman/Weizman, *Before and After*, 6–7.

26 Cf. Weizman/Weizman, *Before and After*, 8.

27 Lisa Parks, *Cultures in Orbit. Satellites and the Televisual*, Durham 2005, 91.

28 Thomas Y. Levin, Rhetoric of the Temporal Index. Surveillant Narration and the Cinema of "Real Time," in: Thomas Y. Levin/Ursula Frohne/Peter Weibel (eds.), *CTRL [SPACE]. Rhetorics of Surveillance from Bentham to Big Brother*, Cambridge/Massachusetts 2002, 578–593, see 590.

29 This trope not only persists in popular paranoia thrillers (like Tony Scott's *Enemy of the State* from 1998), but also makes an appearance in programmatic texts about remote sensing in human-rights causes as well. Cf. for example Lars Bromley, Eye in The Sky. Monitoring Human Rights Abuses Using Geospatial Technology, in: *Georgetown Journal of International Affairs* 10 (1/2009), 159–168. (Lars Bromley served as a project director

Maxar Technologies regarding their archive above, this trope of a synchronic omniscience indexing "the real" corresponds with a related omniscience indexing the "historical," as Parks put it:

> Archives of satellite image data thus create the potential for *diachronic omniscience*—vision through time—because they enable views of the past (and future with computer modeling) to be generated in the present that have never been known to exist at all, much less seen. Our understanding of the temporality of the satellite image should be derived through the process of its selection, display, and circulation rather than formed at the instant of its acquisition.[30]

Human-rights-related satellite imaging thus involves the emergence of what in his influential essay Andrew Herscher calls "surveillant witnessing": a "hybrid visual practice that has emerged at the intersection of satellite surveillance and human rights witnessing",[31] where human-rights concerns and military concerns become entangled (as in the discourse of "humanitarian interventions") and where, in many scholars' accounts, "distant observation, objectivity, and truth"[32] tend to be conflated.

Before-and-after satellite images as a specific way of arranging and presenting satellite images are, of course, affected, in a constitutive way, by the same latency attributed by Parks to satellite images in general. Andrew Herscher describes a common posteriority problem affecting the construction of before-and-after-satellite sequences by referring to the example of "The Eyes on Darfur" campaign, one of the first prominent human-rights investigations operating extensively, if not exclusively, with satellite images. In a study of what the American Association for the Advancement of Science referred to as an "ethnic cleansing campaign" in Darfur, South Sudan, the Geospatial Technologies and Human Rights Project, initiated by the AAAS in 2006, collected satellite images of villages in Darfur, one pair for each village, and since the aforementioned archiving of imaging satellite data makes it

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for the AAAS Geospatial Technologies and Human Rights Project and is now Head of Analysis for Humanitarian Missions at United Nations Institute for Training & Research.)

30 Parks, *Cultures in Orbit*, 91. Not only does Lisa Parks allude to the role of computer models and machine learning in remote sensing and the analysis of data gathered by satellites, here resulting in a different kind of temporal structure where the image of the present becomes the baseline for the prediction of the future (of the planet); she also points towards an ethics of working with or reading satellite images, and to the necessity of satellite literacy, where the infra-structural preconditions of the images produced and distributed are made transparent or legible.

31 Herscher, Surveillant Witnessing, 473.

32 Parks, *Cultures in Orbit*, 81.

possible to access data collected months earlier and generate images from it, the "before images" were actually accessed *after* the "after images" to provide a "baseline for comparison."[33] The baseline function indicates and guarantees that there is a clear order of the *comparata*, guiding the comparison closely. What it does not guarantee is a blue and open sky to go along with it, in order to acquire usable images—"open skies" are of course not only an atmospheric and meteorological precondition for remote viewing, but also the namesake of the treaty that enables aerial surveillance flights among the participating countries.

The "before" image, the before-state, is implicitly invested with the notion of normality or the ordinary in order to show the differences, disturbances, destruction or death that the event in between will have caused, even though it is, naturally, often accessed "after the event" as well.[34] The image of the empty and undisturbed Yablonska Street in Bucha on February 28 2022 seemingly has no other purpose (and can therefore only be seen for half a second in the mp4 clip) than serving as a ground or baseline for the bodies to be highlighted.

While a genealogical approach like Herscher's that focuses on the determining structure of the (neo-imperial) gaze of satellites and their deploying countries and corporations highlights the power-knowledge arrangements involved in these operations, the structure of the mode of analysis and representation that governs the forensic operation tends to fade from view. While I certainly follow most of the aforementioned takes on human-rights-related remote-sensing discourses in their calls for caution, satellite literacy, and image data transparency, I would add that here literacy involves not only the genealogy of technology, the transparency about the processing of data and generating of images and the chains of operations, but also the comparative premises involved. Not only does this point towards an ethics of data gathering, processing, and presentation, which in contemporary non-governmental forensic practices are linked to terms like "open verification" or "investigative commons,"[35] but, one could argue, these concerns also align with the implications of an epistemology and ethics of comparing.

As the term indicates, before-and-after images are a necessary part of an operation of temporal comparison: not only do they invite or demand comparative viewing, they direct it and thereby direct the gaze in a different manner, also directing the comparative process through this logic of the baseline as a construction of eventlessness, a ground for comparison. According to Falk Wolf, the status of comparative viewing in general oscillates between that of a medium of knowledge and its production and that of presentation and representation.[36] This also holds true for before-

33 Herscher, Surveillant Witnessing, 488.

34 Herscher, Surveillant Witnessing, 488.

35 Cf. Fuller/Weizman, *Investigative Aesthetics*, 195–212.

36 Wolf, Einleitung, 264.

and-after images and their viewing, as a specific type of temporal comparison,[37] or rather visual spatio-temporal comparison that then needs to be verbalized, annotated, and framed. Here the act of comparing is a pretext and text alike, a function as well as a form of the image.

Remote-sensing Human-rights Violations

With the inauguration of the AAAS Geospatial Technologies and Human Rights Project in 2005, a practice came into prominent view that can be dated back only a few years and was made possible on the basis of a broader set of technological advancements, and also geopolitical and legal changes, that also affected the situation. With the passing of the Land Remote Sensing Policy Act of 1992, revitalizing the Landsat program while at the same time enabling the licensing of private remote-sensing space systems, the United States initiated a change or tweak in policy and practice that was in other parts of the world already in effect after the end of the Cold War (and even before, for example in France, with SPOT, the Satellite Pour l'Observation de la Terre, launched in 1986):[38] a privatization and commercialization of satellite companies and technologies, and, in part, declassification of satellite images from the Cold War, that pointed towards their relevance and prevalence.[39] But more specifically, these commercialization and advancements opened up the possibility of a new era of visual activism and distant witnessing, and of the remote sensing of human-rights violations, effectively turning, as the Weizmans put it hyperbolically, "the entire planet into a site of forensic investigation."[40]

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37 Regarding the structure, elements, and variations of temporal comparisons in general cf. Kirill Postoutenko/Zoltán B. Simon/Willibald Steinmetz, Temporal Comparisons: Evaluating the World Through Historical Time, in: *Time & Society* 30 (4/2021), 447–461.

38 Cf. Parks, *Cultures in Orbit*, 79–80.

39 Perhaps not coincidentally it is also precisely the era of advent of a related type of image, the era of what the German critic and filmmaker Harun Farocki famously called "operational images," to lay the emphasis on systems of machine vision and the automation of perception, which employ images as mere operative functions in broader networks of surveillance, tracking, identification, observation, and analysis. And the data-gathering apparatuses that are satellites, are, of course, very much integral parts of such networks. Cf. Harun Farocki, Phantom Images, in: *Public* 29 (2004), 12–22.

40 Weizman/Weizman, *Before and After*, 16. It needs to be added that one major aspect of early criticism of the expansion and direction of satellite witnessing was—and still is—that it is only in theory that the entire planet is witness-surveilled in that manner; in practice it is rather specific regions, often in the Middle East and Global South, that are identified as "areas of interest" (AOI) and crisis. Cf. Delf Rothe/David Shim, Sensing the Ground. On the Global Politics of Satellite-Based Activism, in: *Review of International Studies* 44 (3/2018), 414–437, see 424–425.

Early "landmark" cases where satellite imagery was quoted as evidence for the production of Weapons of Mass Destruction (Iraq 2003), human-rights violations, war crimes or even genocide (Bosnia-Herzegovina 1995,[41] Kosovo 1999)[42] still point towards a large discrepancy or asymmetries with regard to the retrieval and readability of such images.[43] However, their application beyond military intelligence and state-actor communication lead to the emergence, if not of an entirely new mode of comparing images and comparative viewing (before-and-after satellite images had their precursors in photographic military aerial reconnaissance), then of a new practice and prominence: the deployment of before-and-after satellite images as visual evidence in cases of human-rights violations and war crimes.

The genealogy and geopolitics of these remote-viewing or -monitoring practices are certainly worthy of scrutiny, at least from the perspective of visual-scholars among others (most of the scholarly attention devoted to satellite imagery in human-rights contexts stems from cultural studies and media studies as well as critical geography).[44] Furthermore, the way the technology works is far from self-evident, since the production of evidence relies on complex technical operations and mediatizations, as the term "remote sensing" indicates. Lisa Parks defines "remote sensing" as a "televisual practice that has been articulated with military and scientific uses of satellites to monitor, historicize, and visualize events on Earth."[45] Whereas Parks focuses on the televisuality of it, the general understanding of remote sensing is much broader and not only exclusively focused on visual practices and presentations, since it comprises any sort of "acquisition of information about an object, place, or phenomenon on the Earth's surface by means of distant observation"[46] and by employing various media and methods of data gathering through sensors. A digital camera system is but one of many different types of sensor, and signals sensed may also be acoustic, or existing in many regions of the electromagnetic spectrum beyond the optical. And the information, the data acquired, then needs to be processed before questions of legibility, of expert annotations and analysis can even arise. This processing involves techniques which, for example, naturalize the standard false color of satellite images, enhance contrast, remove distortions, perform orthogonal rectification etc.: "The satellite gathers data—we see an image."[47]

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41 Analyzed at length in Parks, *Cultures in Orbit*, 77–107.

42 Cf. Kurgan, *Close Up at a Distance*, 113–127.

43 Cf. Kurgan, *Close Up at a Distance*, 24–30.

44 Cf. Boris Michel, Forensische Blicke und Praktiken kritischer Geovisualisierung. Ein Besprechungsessay, in: *ACME. An International E-Journal for Critical Geographies* 16 (4/2017), 687–712.

45 Parks, *Cultures in Orbit*, 77.

46 Rothe/Shim, Sensing the Ground, 414.

47 Kurgan, *Close Up at a Distance*, 118. —This complex process is often part of the "service" of the image provider and satellite operator: Maxar Technologies, for example, offer and advertise "Analysis-Ready Data" (ARD), cf. Geller, Introducing Maxar ARD.

With the afore mentioned accessibility of satellite images produced out of data gathered remotely with increasingly higher resolution for the general public and for non-governmental agents, investigators, and researchers, the human rights movement transformed from an "advocacy based practice to an investigative practice,"[48] while at the same time changing the focus from human victims and perpetrators to the crime scenes, from acts to their environmental or architectural traces. Remotely sensed satellite images thus became a prime object and discourse in a practice that is today ubiquitous and far-reaching, but also often scrupulous and aware of its loaded history: the crowd sourcing of forensic methods for the investigation of state-sanctioned violence or criminal neglect as pinpointed by the NYTimes Visual Investigations team.[49]

The infrastructure and mediality of remotely sensed data translated into satellite images tend to disappear behind the images themselves, which in turn often become emblems not only of the catastrophes and events they (do not) depict, but also of the investigative endeavor. Making satellite images "legible" by annotating them and comparing them to a baseline is, of course, only one—albeit crucial—step in the investigative process. From the beginning, The New York Times Visual Investigation team, and the company Maxar and the images obtained through their WorldView3-satellite system and made commercially available through various resellers and platforms, could well have functioned as an entry point to write at length about the development, distribution, use and issues of satellite imagery, tracing the various iterations, transformations, mergers and acquisitions of a company like Maxar and the history and various stages of the NYT's work with satellite images before the launch of the Visual Investigations team, and also tracing the steps involved in investigative work with satellite images in more detail. Apart from the comparison of dates and locations and the cross-referencing and geolocation through other means and with other media which the Visual Investigations team frequently performs, this also includes details omitted from the short article: the date and platform of acquisition as well as the date of retrieval; the filters that need to be set in order to find or generate an image; the post-production and altering process to prepare the image for analysis and whether it was done by the image provider (Maxar's "Analysis-Ready Data") or data journalists, establishing the grounds for the comparative process.[50]

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48 Weizman/Weizman, *Before and After*, 19.

49 Eyal Weizman's own activist research collective, Forensic Architecture, itself an agent in the aforementioned shift, lists to date more than 90 investigations on their website, and remote sensing features more or less prominently in a quarter of them, together with related methods like geolocating and others from critical geography and archeology. Cf. [https://forensic-architecture.org/methodology/remote-sensing, last accessed: May 14, 2023].

50 Procedural transparency and literacy in this regard could allow for a more effective countering of conspiratorial narratives doubting or denying the veracity of images and investiga-

Ground Truth: Triangulations

While it may be a practice-theoretical commonplace that the grounding from which some takes on human-rights-related remote sensing may profit can be found in the practices and discourses themselves,[51] the relation between "remote" and "ground", "grounding" and "sensing" is far from uncomplicated or stable. In the environmental sciences, archeology, and geography, and also in forensic architectural analysis[52] and other fields 'ground truth' traditionally refers to information gathered *in situ*, on location, on the actual ground, thereby allowing for the aforementioned referencing and calibration of remotely sensed data: "Ground truths emerge on location; they are local, specific, and situated so as to be able to offer a grounding for the network of technologies of sense and location."[53] But as Abelardo Gil-Fournier and Jussi Parikka, highlighting the "relational dimension" of the concept,[54] also point out, it would be misleading to assume a strict dichotomy between "ground" and "remote" that might entail or suggest other powerful and problematic dichotomies like "analogue" and "digital" (in this case with the assumption: analogue ground — digital data). The authors also point out that "ground" has increasingly become a category also referring to various states of aggregation of data that often also take the form of images, and that "ground truth is read from a mass of images, instead of comparatively off the [physical] ground":[55]

> Ground truth is actually a broader term for knowledge verification and calibration that circulates in diverse contexts and practices. In other words, ground

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tions while often and increasingly working—or pretending to work—with the same open-source methods. For counter-forensic strategies dealing with "dark epistemology" cf. Eyal Weizman, *Open Verification*, in: e-flux Architecture, Becoming Digital, June 2019, [https://www.e-flux.com/architecture/becoming-digital/248062/open-verification/, last accessed: May 14, 2023]. In the case of the NYT Bucha investigation, for example, a common thread on social media or in pro-Russian media coverage was to point out that seemingly no Maxar image of that location was available for the dates referenced by the NYT, ignoring that for the image acquisition, a wider angle range than the preset (a wider off-nadir) had to be entered. Cf. the analysis and instructions of the activist group Volksverpetzer, Philip Kreißel, *So könnt Ihr die Satelliten-Bilder-Beweise zu Butscha selbst überprüfen*, 10.4.2022, [https://www.volksverpetzer.de/ukraine/satelliten-bilder-butscha/, last accessed: May 14, 2023].

51 Cf. the practice-theoretical criticism of accounts like Herscher's in James R. Walker, Remote Sensing for International Human Rights Advocacy: Critiques and Responses, in: *Journal of Human Rights* 19 (2/2020), 183–200.

52 Cf. [https://forensic-architecture.org/methodology/ground-truth, last accessed: May 14, 2023].

53 Gil-Fournier/Parikka, Ground Truth to Fake Geographies, 1254.

54 Gil-Fournier/Parikka, Ground Truth to Fake Geographies, 1257.

55 Gil-Fournier/Parikka, Ground Truth to Fake Geographies, 1254.

> truth surfaces as an operation where sets of material traces are distinguished as registers of information. If the detective recognizes and operationalizes the material arrangement of a footprint, the dust on a shoe or the ash of a cigarette as clues indicative of a potential event, in a similar way ground truth encapsulates a set of filtered objects to be mobilized as data.[56]

In that sense "ground truth" is not a practice of comparison in and of itself, but rather—again following the analogies with Ginzburg's detective and evidential paradigm—established by alignments or operations of matching. Nevertheless, ground truths become a media prerequisite for the practice of image comparison. They are an integral part of a set of practices that are involved to prepare quasi-stable or temporarily stable *comparata* that in turn allow for an image comparison or comparative viewing to take place and be staged in order to demonstrate and visualize change. In that sense the triangle of *comparata* and *tertium* has a pretext that can also described as an operation of triangulation, as the term is used in social sciences as well as investigative and data-research contexts;[57] and thinking about the proceduality of comparing certainly also involves paying attention to such pretexts.

In the NYT visual investigations of Bucha, as in many other similar investigations, producing a "stable" ground for satellite-image comparisons involves, as we have seen, an operation involving anchoring images with maps, and satellite footage with videos, hence cross-referencing and synchronizing data with data, images with other images (visible in the side-by-side or split-screen clip arrangement), "rendering data into readable, comparable forms."[58] Grounding the truth in this sense is not an operation that requires the proverbial "boots on the ground," since the ground, was never unmediated to begin with—and not only in the case of these investigations. It reveals itself as a task where data literacy, satellite literacy, and comparison literacy become one ground, one endeavor. Grounds for contemporary image comparisons are legion, and they are matters of concern and urgency. Satellite images and their before-and-after comparisons demonstrate that every act of comparing requires complex and hybrid grounding and alignment operations that sometimes almost seem to become obscured by the spectacular surface of before-and-after images (which may well hold true for all kinds of everyday comparisons or quasi-comparisons that operate on the basis of preprocessed data). But the ground is contested. And even if it appears stable, it is moving and shifting constantly. And

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56 Gil-Fournier/Parikka, Ground Truth to Fake Geographies, 1256.

57 Cf. Paulette Rothbauer, Triangulation, in: Lisa Given, The SAGE Encyclopedia of Qualitative Research Methods, Los Angeles 2008, 892–894.

58 Monica M. Brannon, Standardized Spaces. Satellite Imagery in the Age of Big Data, in: *Configurations*, 21 (3/2013), 271–299, see 272.

whether observed remotely or closely, we should be well aware of the processes that are involved in producing this appearance.

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Images

Fig. 1–3 from: browne, Malachy/botti, David/willis, Haley, Dead Lay Out in Bucha for Weeks, Refuting Russian Claim, Satellite Images Show, The New York Times online, 4.4.2022, URL: https://www.nytimes.com/2022/04/04/world/europe/bucha-ukraine-bodies.html [last accessed: May 14, 2023].

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