Insure the Volume?

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Author(s):
Eriksen, Christine; Turnbull, Jonathon

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Sensing air, atmospheres, and radiation in the Chornobyl Exclusion Zone

Christine Eriksen and Jonathon Turnbull

Introduction

This chapter examines a novel and intriguing occurrence concerning recent wildfires in the Chornobyl[1] Exclusion Zone (CEZ) in Ukraine, which rerelease radioisotopes originally deposited into local ecosystems during the Chornobyl nuclear accident of 1986. In particular, we focus on the wildfires that burned in the CEZ and elsewhere in Ukraine in April 2020, blanketing the capital, Kyiv, in smoke. The chapter considers what this kind of uncontainable, airborne, and hazardous phenomenon potentially means for insurance, as well as insurance and disaster research.

Examining this phenomenon in the context of insurance is somewhat paradoxical. Traditionally, to make an event insurable there has to be a clear causal event. Yet, how do you calculate insurance, let alone determine liability, for a harmful event (the Chornobyl disaster) that occurred decades ago by an actor (the Soviet Union) that no longer exists and can no longer be held accountable? As we demonstrate in this chapter, the original volume of damage in 1986 has expanded over time with the leakage and seepage of radioisotopes into the ground, out into waterways, and up into the air via natural processes. This creates a problematic dilemma for governance and insurance. It points to a spatiotemporal problem inherent to insurance studies. We attempt to address this problem with the help of a theoretical framework that draws on recent scholarly work in the social sciences, particularly in human geography, to foreground affective atmospheres, sensing assemblages, and volumetric sovereignty. Rather than pointing specifically to what might be insured in this context, we aim to problematise the very notion of insuring against disasters in the techno-natures of the Anthropocene.

In this chapter, we argue that affective atmospheres – not insurance frameworks – governed how people reacted to and managed the wildfires and smoke in 2020. The tangible and intangible risks of the rerelease of radioisotopes by wildfire in the CEZ are an example of the long-term consequences of 'high-tech risks':

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> In the afflictions [high-tech risks] produce they are no longer tied to their place of origin – the industrial plant. By their nature they endanger *all* forms of life on this planet. The normative bases of their calculation – the concept of accident and insurance, medical precautions, and so on – do not fit the basic dimensions of these modern threats. Atomic plants are accident no more (in the limited sense of the word 'accident'). They outlast generations… This means that the calculations of risk as it has been established so far by science and legal institutions collapses. Dealing with these consequences of modern productive and destructive forces in the normal terms of risk is a false but nevertheless very effective way of legitimizing them.
>
> (Beck 1992, p. 22)

The insurance industry plays an intrinsic role in the modern-day risk society described in Beck's seminal work, which was originally published the same year as the Chornobyl disaster. Here, 'insurance operates a security technology that, while ascribing value to life, capitalises livelihoods, and promotes [certain] lifestyles' (Lobo-Guerrero 2011, p. xi). Yet, due to the difficulty of calculating the likelihood and magnitude of environmental hazards, especially those with effects at a global scale, certain events escape the logic of insurance and are rendered 'catastrophic' anomalies. Since the 1990s, innovative insurance technologies have changed this through two manoeuvres: parametric insurance and the securitisation of catastrophic risks in global markets by means of financial derivatives (Lobo-Guerrero 2011; Grove 2012; Collier 2013). Insurance products, such as 'catastrophe bonds' still rely on the design of predictable variables that are difficult, if not impossible, to meet in the context of radioisotopes rereleased by wildfires: 'observable and easily measurable, objective, transparent, independently verifiable, reportable in a timely manner and stable and sustainable over time' (Lobo-Guerrero 2011, pp. 83–84). Politically and economically, no one wants to insure the leaky and ungovernable radioactive particles in the CEZ.

As Lobo-Guerrero (2011, p. 78) highlights, the 'crossbreeding of insurance and capital markets … [is] related to a wider process of governing through assemblages of risk.' This resonates with Beck's (1992, p. 21) understanding of risk as the 'systematic way of dealing with hazards and insecurities induced and introduced by modernisation itself.' Our case study, however, highlights the importance of a different set of assemblages in managing risk, namely sensing assemblages. The diverse and sometime overlapping forms of sensing used for detecting radiation, such as the technologies used in Kyiv and the bodies of firefighters, highlight the importance of thinking with volume to understand affective atmospheres. These affective atmospheres, together with the Anthropocene's proliferating techno-natural ecosystems, fundamentally challenge some of the legal terms traditionally used to define liability, such as labelling a natural hazard outside of human control, for which no person can be held responsible, an 'Act of God.'

The historical premise of our analysis is the tangible lack of insurable relationships in the Soviet Union at the time of the disaster in 1986. Today, operators of nuclear power plants are liable for any damage caused by them, regardless of fault. This was not the case in 1986. The Soviet Union, moreover, was not a signatory of the conventions that addressed international liability issues: The Paris Convention on Third Party Liability in the Field of Nuclear Energy of 1960, the Vienna Convention on Civil Liability for Nuclear Damage of 1963, and the Brussels Supplementary Convention of 1963 (IAEA 2020). Thus, aside from the estimated 300,000 evacuees that had lived within what became the parameters of the CEZ (who were relocated and partly compensated by the state), compensation was difficult to claim for people affected by the disaster in the acute aftermath and the ensuing years. People were required to prove the link between radiation-related exposure and the health impairments they were experiencing. This continues to pose a major challenge for many people affected by the Chornobyl disaster. The effects of radiation are often subtle, manifesting stochastically, long after the exposure event. The intergenerational effects of exposure are also a contentious issue. The lack of quality health care in the economically and politically unstable post-Soviet states compounded these issues by making it difficult, especially for poor people, to receive compensation. Petryna (2016) outlines how this led to a new form of 'biological citizenship' in which Chornobyl suffers mobilised assaults on their health to stake claims for biomedical resources, social equity, and human rights. As Davies (2015, p. 230) writes, people felt abandoned or exposed twice, 'once to the hidden threat of radiation, and once more to a state that has abandoned them.'

There have been significant improvements to national laws and international conventions since then, first in response to the Chornobyl disaster, and subsequently after the Fukushima disaster in 2011 (World Nuclear Association 2018). However, in 1986, people in the Soviet Union were at the mercy of political will for any form of compensation, while the consequences felt overseas fell back on national principles of common or civil law as well as political will (Schwartz 2006). The strict liability of the nuclear operator, which is one of the key principles of most conventions and laws regarding nuclear third-party liability today, is significant because an insurance claimant does not have to prove how an accident occurred (i.e. prove fault) (World Nuclear Association 2018). However, even with the extension of the prescription/extinction period of insurable damage to 30 years post-event in the revised international conventions, many impairments to the environment or personal health are not covered retroactively because of the difficulty of proving causality years or decades after a disaster (Schwartz 2006). Complicating matters further in the context of wildfires in the CEZ, is the lack of an international legal agreement on the vertical extent of sovereign airspace (Billé 2017).

In what follows, we begin with a description of our theoretical framework before introducing our case study. We then build on the growing body of scholarly work on affective atmospheres, sensing assemblages, and volumetric sovereignty, which underpin our theoretical framing, to examine the ungovernable atmosphere and the uncontrollable flow of air and radioactive particles in the CEZ. We conclude by suggesting the implications of such thinking for critical disaster and insurance studies more broadly.

Atmospheric frameworks

Atmosphere as an affective phenomenon has become a critical concept in the last decade, allowing scholars in the social sciences 'to grasp the affective materiality of spacetimes that are diffuse and excessive of bodies yet also palpable through the sensory capacities of those bodies' (Engelmann & McCormack 2018, p. 187). Affect concerns the precognitive, felt, impulsive, ebbs and flows of lived experience. On these terms, atmosphere does not only refer to the envelope of gases that surrounds the Earth, but also to a field of affective experience. This mode of thinking helps us make sense of the 2020 wildfires in the CEZ, their representation, and sensed embodiment. Following Choy (2018, p. 56), it is not 'the actuality of atmospheric objects or worlds, but rather how people adjust relations and relational capacities when motivated by an atmospheric question,' which determines how affective atmospheres are sensed, embodied, and only later expressed in emotional terms (see also, Anderson 2009; Anderson & Ash 2015). The qualities of physical atmospheres, such as temperature, pressure, and humidity, vary over space and time. Human bodies can often sense these variations. Yet, this is not always the case. For example, the invisibility of radiation, and the human body's inability to detect low doses, means atmospheric radiation (and other atmospheric pollutants) gain some of their affective capacities through participating in sensing assemblages. Here, 'non-human bodies and devices of various kinds,' with the capacity to be 'affected or perturbed,' come together to render them present to human senses (Engelmann & McCormack 2018, p. 188). Recent work on environmental sensing has probed the expansive scope of sensing technologies that challenge human conceptions of agency, experience, and the boundaries of the body (e.g. Gabrys 2020). These forms of sensing, observing, and marking pertain to the wildfires in the CEZ.

Like with atmosphere, a growing body of scholarly work concerning volumetric and voluminous conceptualisations of space and sovereignty is helpful for our analysis of the spatiotemporal problem inherent to insurance studies. Largely inspired by Sloterdijk's (2009) notion of 'spheres' and Weizman's (2002) 'politics of verticality,' these recently developed approaches enable three-dimensional (3D) understandings of space, which challenge the often disembodied two-dimensional (2D) understandings of elemental relationships (Adey 2015; Billé 2017; Billé 2019). Elden's (2009; 2013; 2017) work has been particularly influential, initially emphasising the economic, strategic, legal, and technical dimensions of vertical politics, and later acknowledging the equal importance of materiality and embodiment in thinking with volumetric spaces (Elden 2020). The title of this chapter is a play on Elden's (2013) term 'secure the volume.'

Thinking space volumetrically involves thinking through 'height and depth instead of surface, [and thinking in] three dimensions instead of areas' (Elden 2013, p. 35). Volumetric approaches have largely been concerned with metrics and measurement, whilst voluminous approaches emphasise embodied understandings of material entities (e.g. dust) within dynamic assemblages (e.g. air, oceans), which are never static and cannot be contained (Steinberg & Peters 2015). This distinction is important when considering the issues of governance and liability intrinsic to volumetric sovereignty, as it helps us unravel why a 2D conceptualisation of space is inadequate for mapping the leaky materialities of the CEZ. As Steinberg and Peters' (2015, pp. 258–259) highlight,

> …legal institutions will always attempt to delimit volumes into strata just as they will always attempt to delimit horizontal spaces into areas […] But the nature of territory as a political technology means this process will always be met with a resistance that reflects underlying dynamics that are both social and geophysical. [… In turning] our attention to the volumes within which politics is practised and territory is produced we must continually rethink the borders that we apply to various materialities and their physical states.

In bringing together these bodies of work, we aim to show how volumetric space and the movement of (contaminated) air are bound up with ideas and information as well as sensing and feeling (Mitchell 2011). These concepts are pertinent to insurance studies, as they speak to the difficulties posed by complex configurations of causation, harm, and responsibility that characterise disasters in the techno-natures of the Anthropocene. They attune scholars to the muddled spatialities and temporalities that come with accelerating environmental change. In what follows, we foreground the relationships between affective atmospheres, sensing assemblages, and volumetric sovereignty to illustrate why the volume of radioactive particles rereleased by wildfires in the CEZ is difficult to manage and even harder to insure.

Wildfires in the CEZ

On 26 April 1986, the explosion and subsequent open-air graphite fire at Reactor No. 4 of the Chornobyl Nuclear Power Plant (ChNPP) contaminated the soil, water, and atmosphere alike with radioactive material at a rate equivalent to twenty times that released during the 1945 atomic bombing of Hiroshima (Higginbotham 2019). For nine days, the fire produced updrafts that lifted deadly plumes of radioactive material into the atmosphere, which wind and rain distributed over (what was then) the western parts of the Soviet Union, particularly Belarus, Ukraine, and Russia, as well as many European countries.

The area most heavily contaminated is known as the Red Forest – a 10-km^2 area surrounding the ChNPP, named after the pine trees that turned a ginger-brown colour after absorbing high levels of radiation. The ensuing clean-up operations bulldozed the majority of the pine trees and buried them, together with other contaminated materials, in newly dug trenches (WHO 2006). These unlined and leaky trenches were then covered with a thick carpet of sand, and pine plantations were replanted in an attempt to soak up radiation and prevent its spread into the groundwater. Up to 85 percent of the radioactivity in the Red Forest is concentrated in the soil, with the remainder deposited in the bark, needles, timber, and branches of the remaining trees and other forms of vegetation (Hao et al. 2009). The gradual and indefinite evacuation of over 300,000 people and the abandonment of agriculture within the CEZ has, with time, facilitated the presence of a diverse range of flora and fauna, despite the radioactive fallout they absorb, eat, or inhale (Mycio 2004). Nevertheless, the area remains one of the most contaminated regions in the world today (Brown 2019).

The relatively undisturbed growth of vegetation since 1986 has resulted in another problem. Over a thousand wildfires have burnt inside the CEZ since it was established, and in April 2020, fires in the area surrounding the ChNPP became a worrisome presence once again. Whilst the spectres of 1986 are alive in these wildfires, they pose different threats to the original disaster in scale and intensity. The graphite fire of 1986 released a huge amount of radioactive material high into the atmosphere that was distributed globally. The 2020 wildfires released clouds of smoke containing radioactive particles and mineral dust from radioactive pollutants absorbed and held over time by vegetation and soil. The smoke enveloped surrounding areas, including Kyiv, 100 km to the south, where one of us (Turnbull) happened to live, directly experiencing (inhaling) the smoke.

These wildfires and the drifting smoke are cause for international concern, as their likelihood increases with climate change (Amiro et al. 1996; Eriksen 2022). Whilst small increases in radioactivity were detected in the air in Kyiv in 2020, an air filter station in the north of Norway registered an increase in the presence of Caesium-137 (one of the most common radioisotopes at Chornobyl), which potentially stemmed from the CEZ (Nilsen 2020). Scientific assessments highlight that inadequate forest management 'has resulted in a high wildfire hazard in the 260,000 ha of forests and grasslands of the Ukrainian part' of the CEZ (Zibtsev et al. 2015, p. 40). Given the right wind conditions, smoke and dust can travel across not just geopolitical borders but across continents due to the indiscriminate crossing of borders by atmospheric particulates moved by uncontrollable forces, such as wind and air currents (Eriksen and Ballard 2020). This poses a health threat both to the people who eat food grown in fallout areas, and to people who inhale contaminated smoke, like firefighters and land-stewards who attempt to manage the wildfire threat. A radiological assessment of two sizeable wildfires in the CEZ in April and August 2015 found that the (effective)[2] radiation doses were above 1 millisievert (mSv) per year within the borders of the CEZ, but outside and in the rest of Europe doses were much lower, 'equivalent to a medical X-ray image at most' (Evangeliou et al. 2016, n.p.). For context, 100 mSv per year is the lowest level of exposure at which there is clear evidence of an increased risk of cancer (IAEA 2014).

In the next section, we examine the lingering consequences of the Chornobyl disaster in the context of the atmospheric challenges posed by the rerelease of radioactive fallout by wildfires that, according to local reports, were ignited by neglectful farmers and/or an arsonist. We interrogate how the relationship between atmospheric sensing, radioactive air pollution, wildfires, and volumetric sovereignty renders this ongoing socio-technical disaster uninsurable.

Sensing air, atmospheres, and radiation

Wildfires are a yearly, common occurrence in Ukraine, mostly because of farmers (sometimes illegally) burning fields, which get out of control. For this reason, the smoke that enveloped Kyiv for over a week in April 2020 was not solely from wildfires in the CEZ. The indeterminable origin of the smoke gave it an eerie quality: Was it or was it not radioactive? This concern preoccupied state agencies and others who decided to check radiation levels via spectacular acts of atmospheric sensing. These acts involved taking atmospheric measurements in public, including on Kyiv's main street Kreshchatyk, which runs through Maidan Nezalezhnosti (Independence Square). Kreshchatyk was the location of the May Day Parade in 1986 where Soviet authorities, five days after the Chornobyl disaster, knowingly exposed members of the public to high levels of radiation as the radioactive cloud enveloped them with particles carried on air currents from the ChNPP. Attempting to sense radiation today in this symbolic place is a spectacular and haunting reminder that the Chornobyl disaster continues.

We spoke with a radiation expert, Boris[3], in December 2020 to determine the purpose of the testing on Kreshchatyk earlier in the year. He suggested that the tests were a publicity stunt and that the equipment used was inappropriate for measuring the kind of exposure that might actually be a threat in this area. Boris told us that microscopic pieces of radioactive material known as 'hot particles' were a cause for concern, and although rare, may be very dangerous when ingested. The effects of hot particles are controversial in the scientific community. If ingested, some scientists suggest, these radioactive materials can settle in specific tissue in the body and deliver a concentrated dose of radiation to a small group of cells. He also suggested that the 'experiments' were carried out in places where radioisotopes were unlikely to exist *if* they had made the atmospheric journey to Kyiv. As with the initial silence and then denial by the Soviet authorities in 1986, these spectacular acts of sensing in 2020 were not useful in determining the unequal distribution and effects of the potentially radioactive air pollution. This is despite the fact that air pollution 'presses the question of how atmospheric things disperse and accumulate in unequal concentrations' (Choy 2020, p. 105).

For Boris, the atmospheric sensing in Kyiv was not strictly a scientific act, but rather a political one. As noted by Choy (2018, p. 57) 'numbers and measures themselves are both visceral and affecting.' The chances of registering an increased dose rate outside the CEZ was unlikely, as the 2020 wildfires were not energetic enough to pick up and carry radioisotopes long distances. This is unlike the original disaster during which vast releases of energy allowed radioisotopes to travel across continents (Higginbotham 2019). This spectacular sensing, therefore, was generative of the affective atmosphere associated with the wildfire, as the readings taken on Kreshchatyk were posted on social media and circulated widely.

During the wildfires, residents of Kyiv had to close their windows to keep out the smoke as it engulfed streets and apartments. Living in Kyiv meant embodying, and sharing with neighbours, 'the specificity of experiences of being in and indeed of witnessing things becoming airborne' (McCormack 2009, p. 27). As Kyiv residents stayed indoors, a sense of 'being contained' arose, which was especially troubling for people whose movements were already restricted due to the COVID-19 lockdown. The lack of fresh air both inside and outside gave rise to a sense of envelopment by air pollution. Whilst unpleasant at the best of times, the fact that the smoke was potentially coming from the CEZ added another layer of fear. Such embodied everyday responses to the affective atmosphere of the CEZ wildfires are important to understand in the context of governing nuclear spaces. Nuclear wildfires reanimate a particular imagination associated with nuclear fallout from earlier disasters. Be it fallout from the Chornobyl disaster or nuclear weapons testing elsewhere (Masco 2006; Eriksen 2022), the affective atmosphere created by wildfires involves uncertainty and fear. Because of radiation's ambiguous status in public discourse, these atmospheres form regardless of the actual threat posed.

Much of the maintenance work to contain both the fear and threat is carried out by firefighters who, while tackling wildfires in the CEZ, simultaneously mollify public concerns about exposure. Yet, each time they do so, they are individually exposed to contaminants that persist in the landscape long-term as a result of the original disaster. Firefighters can reach the limit of what is considered a safe annual radiation dose over a 'relatively small number of days' (Zibtsev et al. 2015). While radiation levels during a wildfire are not as high as they are during a direct encounter with a radioactive source, the cumulative effect of exposure to low levels of radiation over the career of a firefighter is unknown. Dose rates are not always the most useful measure for understanding the possible consequences of such atmospheric exposures according to some. In areas where radiation spikes are recorded in proximity to the wildfires, 'hot particles' (as discussed above) are made airborne and can be inhaled. There is concern that radiation risk models derived only from external exposure, do not account for the risks associated with internally ingested hot particles. Background (or ambient) radiation levels only represent an average exposure. As such, '[t]he true evaluation of nuclear risk is tied to specific exposures rather than the background radiation count' (Masco 2006, p. 299). The effects of hot particles are difficult to measure, though, as they operate at extremely small scales. They complicate the notion of how we experience the environment in such miniscule quantities (cf. Creager 2018), pointing to how the environment is not just outside us, but also within us (Alaimo 2010).

Furthermore, radiation readings and sensors alone cannot account for the effects of exposure to radiation during wildfires. Rather, sensing radioactivity is an embodied experience for firefighters who lack adequate monitoring and safety equipment and instead feel a tingling sensation on their skin when fighting a fire in a radioactively contaminated area (Evans 2011; Eriksen & Ballard 2020; Eriksen 2022). As Shapiro (2015, p. 375) notes, '[b]odies are sensors that indicate the presence of toxicants and, in some cases, specify their atmospheric concentration with uncanny precision.' Creager (2018, p. 70) similarly suggests, 'human bodies come to serve as unconscious sensors of their environments.' A range of animals are also enrolled as sentinels for determining the effects of the Chornobyl disaster on 'nature' more broadly (Petryna 2013; Masco 2006). These vernacular accounts of radioactive landscapes contribute to the sensing of 'nuclear weather-worlds' (Alexis-Martin 2020). Human and nonhuman bodies, through microscopic atmospheric encounters, 'are often embroiled in sensing the world well before cognition catches wind of protracted chemical encounters' (Shapiro 2015, p. 375).

Atmospheres, then, are something we are immersed in. They are embodied, but they are also sensed and represented. These representations contribute to the overall affective atmosphere of atmospheric things, such as potentially radioactive smoke. Thinking atmospherically draws attention to the ways in which wildfires are atmospheric from the outset. Wind and oxygen fanned the spread of the 2020 wildfires in the CEZ, while much-needed rain ultimately extinguished them. In attending to the affective and material atmospheres of these wildfires, we come to understand their representation and sensed embodiment as issues of suspension: material and affective. First, wildfires resuspended the radioisotopes originally deposited during the disaster in 1986, causing problems for the firefighters exposed to them. Second, the clouds of smoke that spread from the CEZ and enveloped surrounding areas may or may not have been radioactive, suspending exposed populations in a liminal state of uncertainty. This state of uncertainty is compounded by the stochastic nature of radioactivity's effects – especially hot particles – which are difficult to account for and measure. The atmospheric effects of the wildfires, therefore, are both material and affective.

What, then, do notions of suspension, which challenge understandings of the terrestrial and the atmospheric as separate, do to notions of sovereign power and accountability for environmental catastrophes? What are the implications for thinking about insurance in the context of disasters that unfold in uncontainable spaces?

Volumetric sovereignty and leaky materialities

Measurement and containment – or rather the lack thereof – is key to understanding the long-term and uninsurable consequences of the Chornobyl disaster. Notions of the CEZ as a contained space are complicated when we think volumetrically and voluminously. Understanding the CEZ as a vertical space that extends both upwards and downwards allows us to reframe the movement of radioisotopes beyond standard 2D cartographic representations of contamination. How radioisotopes evade borders is increasingly understood through their embodied existence in local ecologies, biologies, and ecosystems (Brown 2015; Brown 2019). Moreover, radioisotopes from Chornobyl continue to leak into consumable products that are consumed locally *and* globally (Brown 2020; Davies 2015). Radioisotopes deposited in the soil are absorbed by vegetation, becoming embodied in bark, leaves, grass, fruit, and berries, amongst other things. In turn, animals, birds, and insects ingest them, contributing to the ecological movement of radioisotopes through their own vertical and horizontal mobilities. When wildfires occur, the radioisotopes are released via combustion into the atmosphere where they circulate and, depending on the atmospheric and particulate conditions, can drift with wind and rain across geopolitical boundaries. This poses problems for determining accountability in relation to industrial accidents that are not contained spatially and temporally.

Radioisotopes also leak and seep from the soil and unlined trenches into the groundwater and waterways. As with creatures, they become embodied in people when the polluted water, vegetation, and air are consumed or inhaled. Adequately mapping the leakage that has occurred in the decades since the Chornobyl disaster is impossible, as radioisotopes are metabolised through complex socioecological systems. As Cons (2017) highlights, 'seepage is a process, not an event. It is the ooze that heralds the failures of projects aiming to produce space and territory as solid containers.' In attempting to 'secure the volume,' Elden (2013) states the need to know where the law applies (and ceases to apply), and which law is operable. Yet, this approach leaves any effort to secure or insure the volume of radioactive smoke particles released by CEZ wildfires in limbo, as there is no international legal agreement on the vertical extent of sovereign airspace (Billé 2017). This creates a problematic horizontal dilemma for governing volumetric sovereignty.

The inability to control the movement of particulates – be they laced with radiation or not – is a poignant example of the inadequacy of existing legal frameworks to address the leaky materialities of the CEZ. Reflecting on Zee's (2017) study of dust storms travelling from China to South Korea, Billé (2017) suggests, '[d]ust blurs the line between earth and liquid as it is driven downwind. As a fugitive substance, it is a voluminous entity that surrounds, embraces, confuses, and potentially kills.' In the case of the CEZ, dust particles are one of the main parameters that underpins the 25-year multinational effort that went into funding and constructing the gigantic shelter that now covers the leaking and crumbling original sarcophagus over Reactor No. 4. This effort is already (possibly inadvertently) thinking with volume as they grapple with the consequences of a potential rerelease of radioactive materials. These voluminous, leaky materialities are an issue of international concern, particularly for more affluent European countries downwind of Chornobyl who have the means to mitigate the threat. Yet, it is also the crux of the uncertainty embodied by firefighters in the CEZ; an issue, as argued in the previous section, laden with affective atmospheres as well as leaky materialities.

Thinking with volume, in conversation with human geography approaches to affective atmospheres, complicates ideas of territory, sovereignty, and property, making it difficult to insure against certain events, such as radioactive air pollution resulting from the rerelease of nuclear fallout (see also Goldstein (2020) on the Southeast Asian haze crisis). If lightning or spontaneous combustion had lit the wildfires in the CEZ (i.e. natural causes), they could be deemed an 'Act of God.' Yet does this actually apply in the techno-natural ecosystem of the CEZ? The wildfires exacerbate an existing socio-technical disaster, rereleasing radioisotopes that pollute the surrounding air. Accountability for the radioactive air pollution is complicated further, as the wildfires were a result of negligent farming practices or deliberate arson. While there may be an individual (or group of individuals) at fault for igniting a fire that got out of control, they are not to blame for the long-term consequences of the irresponsible actions of the Soviet authorities 36 years ago. Holding someone accountable (even if only by issuing a fine), or labelling a wildfire as a purely natural event, enables 'those in power' to cover up, or even justify, decisions and actions that have 'proved both environmentally unsound, and socially, if not morally, bankrupt' (Steinberg 2006, p. xiv). As with many other events particular to the Anthropocene, wildfires in the CEZ fundamentally challenge what counts as an 'Act of God.'

Conclusion

Air currents, like water currents, are carriers of change. Yet, ownership and responsibility are opaque when it comes to what these currents carry and the consequences of the change they deliver. Once radioisotopes are rereleased by wildfire, moving downwards into the soil and upwards into the atmosphere, the dimensionality implied by 'volume' and the calculability implied by 'metric' (Elden 2013) easily becomes abstract and dematerialised (a point also emphasised by Steinberg and Peters (2015) in relation to oceanic materiality). Such abstract and dematerialised forms of reimagined and reanimated disasters, which originally occurred decades ago, are incompatible with standard geographical approaches to territorial boundaries and the legalities of insurable matter. Yet, the consequences of these voluminous, leaky materialities are unequivocal (a point also demonstrated by Nading (2017) in the context of chemicals). In the CEZ, where first the graphite fire and then wildfires burned, and in the surrounding areas where radioactive smoke continues to drift, radiation has continuously reshaped local ecologies, biologies, and ecosystems in acute and subtle ways since 1986.

Thinking with atmospheres, sensing assemblages, and volume, we suggest, offers fruitful avenues for critical disaster and insurance studies to engage with events that refuse containment, and that invoke affective responses at scales unbound by geopolitical territories, sovereign states, and insurance technologies. In this chapter, we introduced such literatures to both enliven and materialise scholarly discussions of insurance, and to understand the long-term lived experiences and continuing consequences of the Chornobyl disaster. Engaging with work on atmospheres as both material and affective, we outlined how atmospheric sensing became a politicised and spectacular event in the wake of the 2020 wildfires in the CEZ. Attending to sensing assemblages, we showed how the bodies of firefighters are emblematic of the embodied and uncontainable effects of radioactive pollution. Turning to work on volumetric sovereignty, we highlighted how 2D conceptualisation of space are inadequate for mapping the leaky materiality of the CEZ, especially as the 2020 wildfires re-suspended radioisotopes atmospherically. Conceiving of space in 3D allowed us to challenge notions of insurability and sovereign space. As Elden (2009, xxii) suggests, '[r]ecognizing the vertical dimension of territory shows that territory is a volume rather than an area.' We hope that these lessons will aid how conceptual and physical borders are managed, applied, or rethought, as disasters unfold in techno-natural ecosystems in the future.

Notes

1 In Ukraine, the name Chornobyl is used, transliterated from the Ukrainian Чорнобиль, instead of Chernobyl, which is transliterated from the Russian Чернобыль.

2 'Effective dose' is a technical term used in radiological protection. It calculates the dose for whole bodies, as opposed to individual organs (the 'equivalent dose'), which receive exposure differently.

3 This is a pseudonym used for confidentiality reasons.

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