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# Re-animating Climate Change: Abstract Temporalities in Augmented Reality

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## AUTHOR BIO

Anna Madeleine Raupach is an artist and a Lecturer at Australian National University, School of Art and Design, with a PhD in Media Arts from the University of New South Wales Art (2014). By re-interpreting scientific data and information systems that underpin contemporary culture, her work explores how technology and personal expression recursively evolve.

## ABSTRACT

This article explores how animation and augmented reality (AR) can create compression and re-distribution of moving image to convey the temporal scales at play in climate change. Animation inherently fosters experimentation with the expression and understanding of time. AR combines the temporal quality of animation with the physical environment, creating a hybrid space of moving image, technology and physical objects that operate on different time scales. This presents an opportunity to engage imaginatively with aspects of climate change that science communication research has identified as problematic to comprehend, such as the immense timescale on which it occurs. My practice-based research explores techniques, including limited animation, AR image targets and layering of two-dimensional moving image in physical space, to demonstrate how these ideas can be implemented both in a gallery and in the natural environment.

## KEYWORDS

animation; augmented reality (AR); climate change; temporality

Digital technology has allowed the moving image to become integrated into real-life in unprecedented ways. The implications of this are complex and far-reaching. This article focuses on my practice-based research to demonstrate how experiencing experimental animation through augmented reality (AR) allows multiple temporalities to exist within one space. I propose that this creates new opportunities for people to conceptualise abstract notions of time and space relevant to climate change.

This article is structured in three parts. The first part builds a framework to explore experimental animation as a key medium through which to express and reflect on the co-evolution of technology and our experience of temporality. In a contemporary context, I identify AR as an emerging space in which animation and the physical world are experienced together to create a dynamic hybrid of natural, technological and human components. The second part identifies areas of climate change communication that could benefit from artistic expression. In this section, I argue that the affordances of time-based media and digital technology respond to the call from researchers for new forms of communication that engage with audiences through affect and emotion. The third part applies these theories to my own practice-based research that uses AR to re-distribute moving image across spatial boundaries. I refer to two examples: the first uses AR in response to printed materials in a gallery space, and the second extends this model into the natural environment. Throughout this article, I argue that the convergence of experimental animation and AR blends the normal experience of everyday life with that of an alternative, re-animated experience of time. This layering of temporalities can introduce inventive ways to consider how humans operate within the temporal dimensions of environmental change.

## Temporality in Animation and Augmented Reality

This section will build a framework for the idea that the abstract temporalities of experimental animation can contribute to innovative ways of conceptualising time in relation to environmental change. I will first look at the evolution of moving image aesthetics and technologies that demonstrate how the production and consumption of moving image is interlinked with our understanding of the passing of time. I will introduce the form of experimental animation known as "limited animation" that is particularly relevant to the rationale of this article, and my own art practice. I will contextualise limited animation in relation to contemporary culture and media, leading to a discussion of how AR presents new methods of integrating moving image into the physical environment.

### *Understanding the Passing of Time through Moving Image*

The forms through which we encounter animation are constantly changing in response to the technologies that shape society. While modes of production and consumption have constantly changed, the essence of animation – formed by the result of an accumulation of still images made frame-by-frame and viewed in quick succession to give the illusion of motion – remains the same.

This fundamental property makes animation a key medium through which to explore, express and reflect on the notion of change and the passing of time.

The original process of breaking down and recombining images was pioneered as a method to study motion by scientists and inventors such as Eadweard Muybridge. For artists, the process allows creative interventions into temporal experience. Animation, in this sense, provides a form through which to articulate, experiment with, and express this recursive relationship between technology and time. Several examples highlight the implications of evolving technology on the expression of temporal experience through animation. Mechanical inventions led to analogue optical toys; early photography and stop-motion allowed the ability to deconstruct how motion plays out through time; cheap production-line processes were established to make cartoons for television; and computer-generated imagery (CGI) gave way to blockbusters that drove the commercial cinematic animation industry.

Parallel to mainstream animation produced for cartoons and TV, artists were using experimental forms of animation to comment on and manipulate temporality in more abstract ways. For example, Oskar Fischinger's abstract animations translated sound into "visual music," digital animations by Charles Csuri responded to the speed of electronic technology, and William Kentridge's multi-channel installations brought animation into the art gallery. Today, immersive and mobile communication devices are instigating a pivotal point in this evolution. Animation is infiltrating into other modes including data visualisation, personal communication, social networks, VR, AR and mobile phone applications.

These examples show that moving image, in many cases, links the dual evolution of technology and our experience of temporality, and that animation plays a key role in the expression of this co-evolution. Throughout the advancement of mechanisms and media, animation has provided a way to model our experience of temporality and, therefore, animation itself chronicles and reflects on changing understandings of time (Johnston 227).

Within the practice of animation, my focus in this article is on experimental techniques that evoke temporal qualities outside of our usual perception of cinematic or everyday experiences. Limited animation, according to Thomas Lamarre, uses a limited frame rate in comparison to the full frame rate of twenty-four frames per second used in most live-action film (19). While Lamarre explores limited animation in reference to Japanese anime, I have found the idea relevant to hand-drawn modes of animation created through techniques including painting on glass, charcoal drawing, paper cut-outs, and the process of transferring video to still images through alternative photographic techniques, which are re-compiled as a sequence with fewer frames.

Working in this way presents the opportunity to use animation to disrupt the expectation of moving image to flow seamlessly from frame to frame and scene to scene. It creates an idiosyncratic sense of movement that engages with a different or alternative basis for the passing of time than what we expect from narrative-based moving image or everyday experience. As our perception

of time is so fundamental to how we experience the world, limited animation creates a powerful space in which other forms of representation can be encountered.

*Animation in a Contemporary Context*

Examining the role of animation in contemporary culture can allow us to explore current perceptions of temporality in the context of new technologies. Due to the recent rise of ubiquitous computing – where computational processes are built into everyday objects and devices – we now experience animation in expanded forms, including on mobile devices, in AR and VR, and on multiple screens in public space. GIFs shared on social media, or applications structured around time-sensitive moving image, such as Instagram stories or Snapchat, are based on endless or ephemeral cycles of moving image that are reminiscent of the loops of animation first created by pre-cinematic optical toys. This return of the format of short loops and small-scale animation is suggested by media theorist Lev Manovich's theory that moving image media has come "full circle," from animation to cinema and back into the realm of animation (*Language of New Media* 297–302). However, this small-scale personalised version of animation has returned in a way that is expanded and integrated further into our lives than ever before (Buchan; Leslie and McKim 207). It appears in ways that are increasingly merged with other media, for example, embedded into written articles, as icons in software interfaces and as visualisations of real-time weather data. In these forms, moving image is endless and networked, and reflects a sense of fractured and disjointed experience of time that experimental forms of animation are well-equipped to express.

Through its expansion into a dominant hybrid of contemporary media, animation presents a fertile opportunity for cross-disciplinary collaboration. Leslie and McKim highlight the role of animation in contemporary culture as a mode capable of mediating between digital and human senses. For example, animation has become a tool employed by scientists to make perceivable phenomena and temporal processes that are otherwise difficult to understand, such as climate simulations of complex variables and extended time scales (Leslie and McKim 211). They suggest that animation makes possible forms of temporality that introduce alternative histories and futures. By both envisioning future worlds and re-animating the past, it presents a way to conceptualise time scales that extend beyond human lifespans (Leslie and McKim 211). While their focus is on digital animation, I propose that techniques, such has hand-drawn animation, bring an alternative, nuanced approach that draws on personal expression rather than concrete representation. These qualities and techniques facilitate an engagement with affect and emotion, which, as I describe in the second part of this article, are important in helping viewers perceive abstract ideas surrounding the long-scale transformations evident in climate change.

*AR and Limited Animation: Merging Temporalities*

Augmented reality allows artists to superimpose virtual imagery onto the users' view of the real world, so both can be experienced at the same time and in relationship to each other (Azuma 356; Gould 26). Several media studies (Engberg and Bolter; Gould; Manovich "The Poetics of Augmented Space;" Tinnell) have begun to unpack the affordances and implications of augmented reality in a broad range of contexts including art, gaming, simulation, education, public space and ethics. These studies theorise that AR is contributing to a pivotal point in the evolution of not only moving image but the ways in which our perception of the world is merged with technology and information visualisation. The vast and complex applications of AR imply that it is more than a simple technological advancement, but potentially a new cultural movement. In this emerging cultural arena, artists are able to work within multidimensional space and combine physical experience with virtual information. Gould proposes that in this multidimensional space, the human body, technological device and physical location form an ecology that provides not only a new way of seeing, but of "sensing" the world (30).

If AR is helping create a different way of understanding the world, it is a powerful medium through which to reconceptualise climate change. Inserting animated imagery into a natural environment can present viewers with a transforming and evolving landscape right in front of them, creating stimulating opportunities to merge present-day reality with alternative imaginings. As I discuss in the second part, the ability to retain the users' visual frame of reference makes AR a persuasive and powerful channel for science communication at this time. Several science and art projects have already begun to use AR to visualise future scenarios of climate change. Examples include New York based artist Justin Brice Guarglia's work *After Ice* that visualises sea level rise using data from NASA; *SitSim*, a project led by Gunnar Liestøl at the University of Oslo to create climate visualisation for locations across Norway; and *Unmoored* by Mel Chin that allows viewers to experience a futuristic, submerged version of Times Square, New York.

Works like these often allow the user to experience an alternative version of a real-life scene through a mobile phone application. In *After Ice*, for example, the scene is overlayed with the predicted water level for the year 2080, illustrating how much of the world at that location will be underwater by that time. Visualisations such as these are often based on compositing, the process of combining virtual elements into the physical environment, in ways that mimic normal qualities of three-dimensional objects. My practice, however, uses AR to integrate the temporal and aesthetic qualities of two-dimensional limited animation with the physical environment. I suggest that this allows the two-dimensionality of screen-based moving image to merge with three-dimensional physical space, and this opens up opportunities for compositing temporal scales across different planes.

To consider the specific qualities of compositing animation in an AR space, I refer to Paul Roquet's theories of the similarities between animation and AR (230). He offers a breakdown of multiple correlations between the two art forms that is pertinent to the style of limited animation discussed previously

in this article. Roquet states that animation can be understood as a predecessor of mixed reality environments, as both are concerned with compositing different types of visual material (228–229). In AR, animation extends outside of the normal screen space to which it has been historically contained, and gains the ability to interact with real life scenarios. By doing this, animation as encountered through AR asks viewers to navigate a world made up of multiple layers of imagery, and to "understand themselves as one layer within this composited world" (Roquet 229).

Roquet's rationale links qualities of limited animation to the theory of "seamful interfaces" in ubiquitous computing (229). Seamful interfaces are interfaces of mixed reality environments where the separate layers and components do not come together seamlessly, but rather leave slight gaps and mismatches between what exists physically and what is fabricated (Chalmers; Dourish and Bell 110). Dourish and Bell write that, in ubiquitous computing, seamful interfaces are important in enabling negotiation between different layers and boundaries of space (110). Roquet notes that the style of compositing found in both limited animation and seamful interfaces draws attention to, rather than conceals, the layers of their own construction (230). Highlighting the mix of multi-platform media at work emphasises an environment constituted of multiple dynamic elements of natural, technological and human origins (Roquet 230). By exaggerating this fusion rather than attempting to hide it, artists can use AR to let viewers not only move between different visual layers but also to negotiate various rhythms and temporal scales. Roquet writes that this blending of experience of the virtual and actual can lead to forming a different way to navigate the world, and, therefore, a new means of forming identities and a sense of self – one that is composited into this multilayered environment (231).

This process of compositing animation into the environment through AR then becomes an investigation into how these different layers of visual and temporal elements come together in dynamic relationships with physical space. If, as Roquet suggests, AR instigates the formation of a new sense of self, then human identity and emotion are also key factors in experiencing augmented space (240). That human emotion is an important part of this composition of natural and media components ties into the call from science communicators for more effective strategies for engaging audiences in meaningful ways to take action against climate change. In the next section, I identify areas of climate change communication that would particularly benefit from this type of artistic practice.

## Artistic Methods of Climate Change Communication

Climate change is now known to be a significant problem by the majority of the Australians (Climate Institute; Leviston, Greenhill and Walker). However there is a disparity between people's attitudes and their actions regarding environmental issues (Leviston, Greenhill and Walker 17). There are many contributing factors to this gap between knowledge and action. Several studies (Moser and Dilling; Sheppard; Sheppard et al.) show that new forms of communication are required to effectively convey the reality of climate change in a way that successfully engages people to understand it as an immediate and

localised problem. Research has shown that purely scientific models of communication are not easily understood by lay audiences, and that more creative narratives such as stories or visual art are more capable of expressing the abstract qualities of time and space that are difficult to perceive but crucial in meaningful understanding (Leiserowitz; O'Neill and Smith; Sheppard; Sheppard et al.). As I discuss in the third part of this article in relation to my own practice-based research, the specific qualities of temporality unique to experimental animation provide a particularly valuable addition to this field, and AR can further explore this aspect by layering animation into users' immediate environment.

I begin this section by highlighting the importance of a multi-disciplinary approach to the communication of scientific information, before focusing on three areas of climate science that are problematic to communicate across this field. Second, I emphasise how artistic expression that draws on imagination can benefit deeper public engagement with these ideas. Third, I contextualise my earlier ideas related to temporality, animation and AR within this framework.

*Problematic Communication Areas*

José van Dijck's proposal for a "multi-cultural practice of science communication" offers a framework for navigating how different sets of knowledge co-exist in the context of science communication. She builds her argument on C. P. Snow's influential lecture "The Two Cultures" that argued against the divide between science and humanities, and Mike Michael's response suggesting that in postmodern society there is no hierarchy between expert and layperson (van Dijck). Expanding these two paradigms, van Dijck unpacks how cultural shifts have occurred due to new technologies, the changed role of media, and the subsequent more active role of the audience as participants (182). She suggests that, in contemporary culture, the communication of scientific information has evolved into a cultural practice that involves humans from all professions and disciplines as well as non-human agents, such as computers and software, and cultural narratives in the form of artworks, storytelling, film and TV (van Dijck 180). Rather than a rigid dichotomy between art and science, this suggests that many separate entities participate together to negotiate and make sense of scientific knowledge (van Dijck 185–86).

Within this field, Susanne Moser's breakdown of the science communication process identifies key traits of climate change that are challenging for the public to perceive ("Communicating Climate Change: History"). I focus on three of these ideas that the temporal mutability of animation and augmented reality are particularly suited to expressing.

The first refers to the invisible causes of climate change. While it is widely understood that greenhouse gas emitted from fossil-fuel use is the direct cause of climate change, this process is something that cannot be visually observed (Moser "Communicating Climate Change: History" 33). For the general public, scientific data and visualisations are often difficult to read or

comprehend. Visualising the cause of climate change requires people to imagine what the results of climate change look like, rather than referring to images of the physical process. Second, there is the geographic distance between cause and effect. Climate change is a truly global phenomenon, and it is the global accumulation of emissions that is impacting the environment, meaning that individual or even collective actions do not affect one specific place (Moser "Communicating Climate Change: History" 33). The areas most immediately affected by climate change, such as low-lying Pacific Islands or melting ice in Antarctica, are not the places producing the most carbon emissions, but are affected by climate change through an entire earth system. When conceptualising climate change, it is difficult to connect local living conditions to a global context, on both spatial and temporal scales. This leads to the third trait, which is the immense timescale according to which climate change is unfolding. It requires complicated scientific modelling to show that climate change is occurring on a timescale of decades and centuries, rather than the day-to-day or season-to-season changes that people can perceive through direct experience (Moser "Communicating Climate Change: History" 33). Again, this trait of climate change requires imagination, rather than direct observation, to comprehend.

Moser proposes potential solutions to these problems that include dialogic and interactive forms of communication that draw on emotions, narrative and place attachment, and provide the opportunity for positive contributions from audiences to instigate a sense of empowerment ("Communicating Adaptation to Climate Change: The Art;" "Reflections on Climate Change Communication"). There are several ways in which the arts can contribute to these suggested future directions.

### *Artistic Expression for Public Engagement*

Within the arena of cultural practices of science communication, I suggest that visual art – and particularly time-based media – can contribute affective means of imagining abstract perceptions of time and space that can help in conceptualising the unobservable aspects of environmental change. Kathryn Yusoff and Jennifer Gabrys write that imagination plays an important role in constructing our perception of the world (520). They suggest that imagination is crucial in conceptualising possible futures and setting them into motion, and is therefore important in how people formulate narratives and ideas about their role in relation to the climate. Yusoff and Gabrys argue that art is a way of giving form to these generative aspects of imagination (519). An example is the work of media artist Tamiko Thiel, whose uses AR to go beyond realistic simulations to create imaginative scenarios of surreal dystopian futures. Thiel's work *Gardens of the Anthropocene* (2016–17) imagines the mutations of native plants as they adapt to increasing temperatures. In *The Unexpected Growth* (2018), she depicts lifeforms made of coral merged with plastic, that slowly become bleached according to the number of human viewers over the course of a day. These works, while based on climate science research, go beyond the didactic potential of AR to simulate future landscapes as they are predicted, by provoking imaginative thought around scientific data.

Several major art/science projects, such as David Buckland's *Cape Farewell Project* (2001) and ClimARTE's biennale Art+Climate=Change festival (2015 and 2017) have begun to take on this role in the field of climate change communication through exhibitions, installations and residencies (Abraham and Johnson; Buckland). Within the range of artforms used in contemporary art practice, time-based media and digital technology present particular qualities that are worth highlighting. Hawkins and Kanngieser argue that audio-visual media provide environmental encounters that are immersive and embody the aspects of climate change that cannot be physically sensed in everyday life (2). Digital technology that engages with new experiences of time and space can contribute a sensory and personalised encounter with issues surrounding climate change in a way that other forms of communication cannot. Linking back to the analysis of animation in the previous section of this article, it is evident that animation is often integrated into these expansive formats, whether through a large-scale audio-visual immersive installation or an interactive mobile phone game.

### *Expressing Temporality in Relation to Climate Change*

Moser shows that perception of time is one of the key aspects that people find difficult to comprehend when considering their role in relation to large-scale environmental change. Pahl et al. describe a clash between the timelines used by scientists predicting future scenarios, commonly situated in 2050–2100, and our perceptions of future timescales from a human perspective, based more around planning for personal and community events that generally range from 5–20 years (376). This produces a mismatch between two temporal scales, which works against our ability to conceive of human behaviour impacting the environment.

Writing about the vast timescale of climate change, Timothy Morton describes global warming as a "hyperobject," or something that is "massively distributed in time and space relative to humans" (1). Morton conceptualises hyperobjects as operating on a stretched temporal scale that causes them to be extremely difficult to comprehend because, as humans, we only perceive one part of them at a time (70). Furthermore, hyperobjects encompass interrelationships between multiple objects and their properties, complicating their notion of temporality even further. Hyperobjects reveal that humans are caught in intersecting phases of time, a concept Morton terms as "phasing" (67–68). For example, our human lifetime only makes visible one "slice" of global warming within the massive time scale on which it is unfolding. Thinking of global warming as a hyperobject leads to the realisation that non-human entities exist that are far more vast and powerful than us.

The abstracted temporal scales associated with how we understand our role in relation to the environment suggest that time-based media that disrupts our usual expectation of linear time is a useful format through which to engage with these ideas imaginatively. Two examples of my own practice-based research explore how using augmented reality to layer different temporalities – of animation and natural environment – fits into this framework.

## Practice-Based Research and Climate Change

In this section, I draw on techniques developed in my own practice to demonstrate how different methods of animation and AR allow me to work with multiple dimensions of temporality and different layers of virtual and physical space. The first example, *Pranatamangsa* (2017–2018), is an AR artwork based on a traditional Indonesian farming almanac based on astronomy, known as Pranatamangsa (Iskandar; Iskandar and Iskandar). The second, *Sediments* (2018), is a site-specific artwork that uses AR to augment rocks in the natural landscape. Both of these explore how re-inserting moving image into a spatial experience brings together multiple versions of temporality, and can respond to the challenges facing climate change communication.

### *Pranatamangsa*

Made during an Asialink Arts residency in Bandung, Indonesia, this work is an animated portrayal of Javanese and Sundanese farming calendars based on traditional knowledge of astronomy. Originally displayed across two screens, one animation unfolds through twelve distinct time periods, alongside a representation of the constellations that guide this almanac. The accompanying voiceover describes farming activities and natural phenomena associated with the position of stars at certain times, such as when to cultivate and harvest crops, when animals will breed, and the transitions between seasons. The stability of Pranatamangsa knowledge is under threat due to changing climate conditions, and I found the qualities of metamorphosis and compressed temporality offered in limited animation to be expressive of this uncertainty. Furthermore, I have used AR to disrupt the linear order of this work, by creating a combinatory system that superimposes printed star maps with animations portraying environmental occurrences related to flora, fauna, seasons and elements.

**Fig. 1** Anna Madeleine Raupach. Video Still. *Pranatamangsa (Channel 1)* (2017). 4:35 min. vimeo.com/241999189

**Fig. 2** Anna Madeleine Raupach. Video Still. *Pranatamangsa (Channel 2)* (2017). 4:35 mins.

In the original *Pranatamangsa* animation, a reduced frame-rate draws attention to missing information. The scenes depicting the natural phenomena, such as grasshoppers laying eggs, sugar cane blooming, and wind changing direction, use limited animation to inform a sense of movement that could be perceived as accelerated (fig. 1). The adjacent channel portrays constellations moving across a painted sky, with a frame rate that is extremely reduced, creating a time-lapse (fig. 2). Based on astronomy simulations, it treats the idea of cosmic phenomena as forces that move at a far greater and more abstract temporal scale than we experience in either everyday life or in most forms of moving image. By presenting these two temporalities side-by-side, this work distinguishes the temporality of day-to-day life in contrast to that of a greater, universal scale. This allows our perception of time to be questioned and subsequently expanded.

My animations often rely on hand-drawn techniques. As Brigid Hosea describes, drawn animation encompasses the passage of time in complex ways. An animation itself is perceived as a durational piece, but each frame is also a record of the time taken in its creation (Hosea 363). The idiosyncratic expression of drawing by hand in animation emphasises that each frame represents a condensed passage of time. When multiple hand-drawn frames are compiled, the resulting animation encapsulates this compression of time as well as the sequential accumulation of these frames into a new durational form. I use these properties of drawing in animation to convey the compression and distribution of time that is also important conceptually to the themes my animations address.

Likewise, metamorphosis occurs as both technique and content. Morphing objects from one into the other requires a process that contributes to the disruption of linear temporality. Drawing the subject matter on a white background suspends it within the motion of animation rather than allowing it to become a part of a familiar narrative or as something that fits into the fabric of other experiences. This de-contextualisation challenges the manner in which the temporality of one component of the world fits together with that of another.

*Pranatamangsa* has been reproduced as an AR artwork experienced through a mobile phone application. The app is designed to be used in conjunction with a series of prints on paper that depict constellations, taken from the same astronomy simulations used to create the time-lapse animation displayed in the double-channel version of this work. These simulations, printed as star maps, convey specific times of the year when the Pranatamangsa seasons change. The app is programmed to detect these prints as image targets and, in response, play the animation scene that portrays the environmental activity associated with the night sky specific to a certain time of the year.

The AR version of the work disconnects the animations from their original sequence. The calendar system no longer plays out in a pre-designed narrative, and the agency in ordering these natural elements is transferred to the participant (fig. 4). However, presenting the prints in a horizontal line suggests an underlying linear structure. It guides the viewer to read the works in order, but detaches the moving image from its timeline (fig. 3).

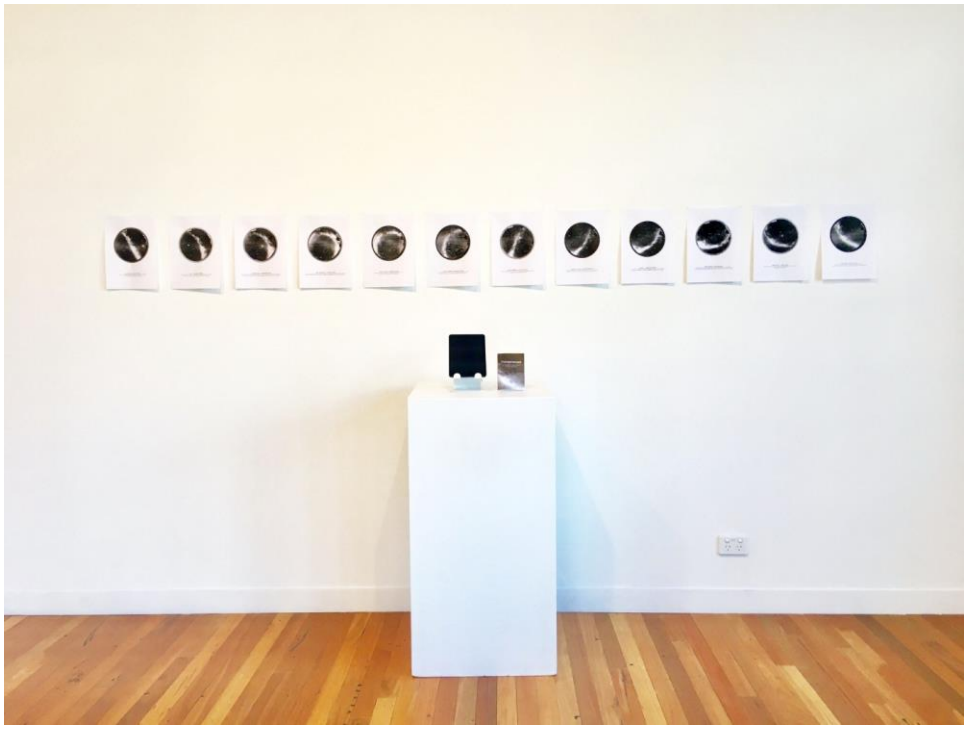


**Fig. 3** Anna Madeleine Raupach. Installation View. *Pranatamangsa AR* (2018). 12 Photocopies (29.7 x 21 cm each). Augmented Reality App. Megalo Print Studio and Gallery, Canberra. www.annamadeleine.com/pranatamangsa-ar/

The interplay between static and moving image is also important here. As printed images, the astronomy simulations are no longer treated as a time-lapse but as single snapshots taken from this expansive depiction of the universe. Layering the prints with animation merges the spatial barrier between static and moving image, blending the temporalities of a moment captured and a scene set into motion. The animations are encoded as transparent video, causing them to appear as if floating in space, to provide further integration into the viewer's own environment. However by offsetting the distance between the physical print and the animation, I have maintained the element of "seamful interfaces" described previously in this article (fig. 5).

This work demonstrates that AR can re-order and re-distribute how moving image is experienced. I have used the affordances of AR to reflect the

unpredictability surrounding Pranatamangsa knowledge due to changing climate conditions that are destabilising the transitions between seasons and impacting agricultural activity. This is achieved by superimposing the temporality of a hand-drawn animation over a static image that conveys only a snapshot of the much greater time-scale on which these natural phenomena are linked, and allows the viewer to detach and re-organise the original animation.


**Fig. 4** (left) Anna Madeleine Raupach. Users Interacting with AR App. *Pranatamangsa AR* (2018). Megalo Print Studio and Gallery, Canberra

**Fig. 5** (right) Anna Madeleine Raupach. AR App Screenshot. *Pranatamangsa AR* (2018)

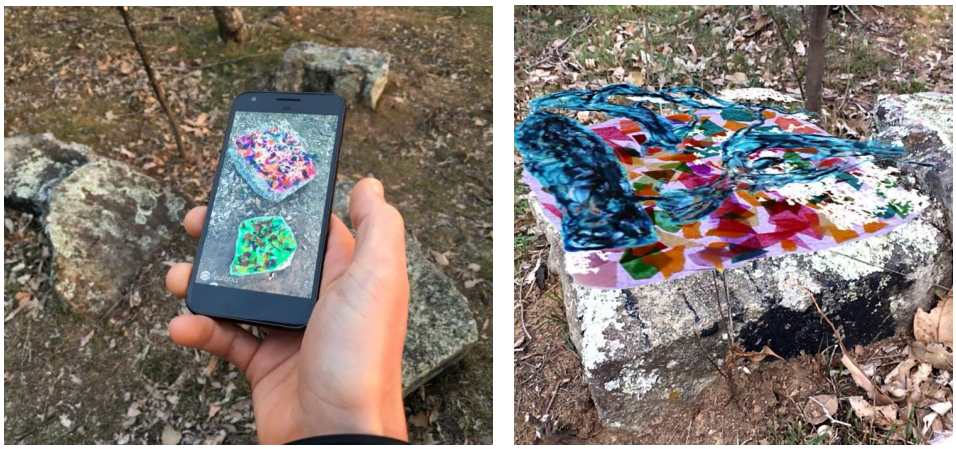
*Sediments*

*Sediments* is a site-specific AR artwork made during a residency at Bundanon Trust, New South Wales, Australia, and shown at Siteworks festival in 2018. In creating *Sediments* I moved out of a gallery space and used AR to activate the natural environment. Rather than printed images, this work uses the surfaces of a group of rocks situated in the natural landscape as AR targets (fig. 6). This process involved experimenting with using AR techniques in varying lighting conditions, and integrating multiple layers of moving image to further highlight a multiplicity of temporal scales set against the temporality inherent to the natural landscape.

While *Sediments* is based on the same AR image target technique used to create *Pranatamangsa*, working in the natural environment required more attention to the materiality of the image target and the outside influences that effected its detection. The rocks were effective as AR targets because of the high level of contrast, texture and detail in the lichen and stone surfaces. The rock surfaces were photographed in even shade to avoid lighting discrepancies that would interrupt detection of the image. This assisted the camera to detect the image targets successfully the majority of the time. However, shadows cast by branches and people, as well as the variation in the surface under harsh lighting conditions, could prevent the image target to be tracked. Initial experiments found that AR techniques such as ground detection could have been implemented to recognise the rocks as a horizontal surface and subsequently display an animation. Image targets, nonetheless, more effectively presented the rocks and their AR counterparts as deliberately interlinked and allowed

more control over connecting specifically designed animations to each different rock (fig. 7).

**Fig. 6** Anna Madeleine Raupach. AR App Screenshot. *Sediments* (2018). Bundanon Trust, NSW. http://www.annamadeleine.com/sediments/



**Figs. 7 and 8** Anna Madeleine Raupach. AR App. *Sediments* (2018). Bundanon Trust, NSW.

*Sediments* expands on the use of AR to portray abstract notions of temporality in two ways: by compositing multiple layers of animation stacked on top of each other, and by superimposing these layers onto a rock surface, which foregrounds them over the additional temporal scale of deep geologic time. Each rock corresponded to three layers of animations: a different section hand-painted map of the Shoalhaven River; a digital drawing that traces the patterns of lichen existing on the rocks; and collaged animation based on microscopic images of sandstone (fig. 8). Each of these layers moves at a different time scale and utilised a different sense of motion. The painted river flowed, the lichen expanded and shrunk, and the microscopic collage shifted subtlely. Once again, the idea of seamful interfaces was employed by creating space in between the image target and each layer of animation. While initially each layer was spaced out evenly, the end result required the two upper layers of animation to be merged into one due to size restrictions of incorporating individual files.

I used this method of layering to reflect different ways in which rocks – and many natural elements of the landscape in general – are shaped over centuries of natural and human impacts, referencing erosion due to river flow, the growth of plant life forms, and human intervention. Rocks encompass overwhelmingly immense time scales. Their geologic time scale is that of a hyperobject, which introduces a new perspective to interacting with them. As Morton writes, "the vastness of the hyperobject's scale makes smaller beings – people, countries, even continents – seem like an illusion" (32). In *Sediments*, the layers of moving image that appear superimposed on top of the rocks evoke the ways in which the timescale of human life intersects with that of immense natural timescales. This helps depict how natural events play out simultaneously yet at different temporal scales. It reimagines invisible forces that effect how land is formed, bringing into focus how small human timescale is in relation to geologic forces.

**Fig. 9** Anna Madeleine Raupach. Users Interacting with AR App at Siteworks Festival. *Sediments* (2018). Bundanon Trust, NSW.

Creating AR counterparts for the rocks allowed me to integrate animation in an unexpected location. The artwork transformed the rocks, which are usually a part of nature seen as solid and static, into fleeting and transient expressions of imagined life forms. The work demonstrates how AR and animation can be used to activate the natural landscape in ways that call to attention the invisible and imperceptible forces that are contributing to the environmental change over extended periods of time.

## Conclusion

This article has built a case for the use of experimental animation and AR in science communication to ignite the imagination of audiences in considering the temporal dimensions at play in climate change. Moving image that draws on abstract notions of time and space, as achieved through limited animation,

can affectively impart the unpredictable and unobservable aspects of environmental change that is spatially and temporally distant from everyday life. In addition to the ability of AR to composite moving image into a viewer's immediate surroundings, these attributes express some of the key traits of climate change that science communication researchers have identified as problematic aspects for people to perceive. The two examples discussed demonstrate initial experiments in ways for this to occur through practice-based research both in a gallery setting and in the natural landscape. This points to the potential for creating personalised, yet other-worldly, experiences that reframe the environment as being in constant transformation on many different temporal scales.

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