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Why is the sky blue? A new question for political science

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Abstract
The future of political science in this crucial century requires that it (i) adopt the contemporary scientific paradigm, (ii) open itself to pluri-, inter- and transdisciplinarity, and (iii) redefine the main political actor, ourselves, in light of post-anthropocentric and relational turns. A theoretical revolution to a post-normal and eco-political science is needed and, through the influence of new fields such as sustainability science, is probably already in motion. In the Anthropocene, it implies paying attention to biological links that once seemed extemporaneous. And this is when we realize that the sky has become co-vulnerable. We may actually be at risk of losing blue sky through anthropogenic actions, including global warming or solar geoengineering. Politics will be crucial in determining whether or not to preserve its blue, and everything that goes with it. The article explores, through the answer to the blue question, this new super-wicked problem to illustrate the stated objectives for political science and the need to apply them. The proposals that have emerged from this also provide a new framework for Clean Air strategies for blue skies that are being developed at international and national levels.

Keywords Post-normal political science · Interdisciplinarity · Transdisciplinarity · Post-anthropocentrism · Solar geoengineering · Clean air for blue skies

Introduction

I have lived more than 40 years without knowing why the sky was blue. I have a Ph.D. in political theory. I teach political science at a university. I coordinated a political party in the parliament of a European country and I have participated in all kinds of political actions. Despite all this, I had no idea why the sky I see every morning is *that* color. Now that I do know, I am convinced that anyone studying or engaged in politics must learn the answer because it encompasses much of what we need to guide political studies in the Anthropocene. Otherwise, it will be difficult to deeply understand the current threat that solar geoengineering or climate change itself poses to the preservation of blue skies.

One virtue of this question is that to answer it properly, we must address the three objectives that I consider pending for political science. First, it requires us to fully adopt the contemporary paradigm of science. Second, it would inevitably deploy an inter- and transdisciplinary approach. And third, in the process we redefine the human in post-anthropocentric and relational terms (Braidotti 2013; West et al. 2020). Now more than ever, pursuing these goals will help us understand the complexities of the Earth system and our role as political scientists in it.

Asking *why the sky is blue* has another central virtue in relation to political science: it highlights that although we are discussing a non-human entity, this is ultimately a highly political issue. It is no longer possible to think about the environment as something separate from humans, and this has important implications for what we understand as political. With the eco-social approach cutting across each policy (Biermann 2021), understanding the hybrid relationships among distinct social–ecological systems (SES) will enable us to rethink our Holocene institutions and policies to improve our grasp of the transformative role politics might play in them (Dryzek and Pickering 2019, pp. 20–57, 87–94, 155–161).

My intent here is to explore these major issues for political science from a problem-driven approach (Nagatsu et al. 2020, pp. 1809–1810) that inserts this more-than-human object of study into politics. The sky above us has been

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denatured and made vulnerable by human actions in recent times. Polluted air often leaves us with a black sky. It could permanently lose its blue hue due to anthropogenic activities such as solar aerosol injection (SAI) or intensified global warming. The effects of this would be terrible for humans. The decisions we make – or do not make– in coming years to avoid these scenarios will be mainly political. We will have to change the habitual frameworks if we want to succeed. Meanwhile, things seem to be speeding up. In recent years, the United Nations has launched its *Clean Air for Blue Skies* strategy (UNGA 2019) and the Chinese government its *Three-year Action Plan to Win the Blue Sky Defense War* (MEE 2018; Winter et al. 2021). However, as the average global temperature soars, both the US government and the European Commission have just opened the door to research in SAI (OSTP 2023; EC 2023).

Reflection on these three general objectives of political science—one theoretical, one disciplinary, and one ontological—constitutes the basis of this text, which also aims to raise awareness about the co-vulnerability of our blue sky and the centrality of politics to this crucial new issue. Some proposals in this regard will be presented in the final discussion. I will begin by outlining what we can understand as a theoretical revolution in political science and ask whether it is already underway, given the influence of new fields such as sustainability science.

The theoretical revolution

From its academic origins in the late nineteenth century, political science adopted the central assumptions of the classical scientific paradigm, mainly because there was no other. Pioneers of the discipline used the empirical natural sciences and the epistemology of the time as reference points in their quest to become true scientists capable of achieving certainty. Consequently, a positivist political science grew in that soil (Farr 2003, pp. 306–307; Ross 2007, pp. 18, 31). When the classical model of physics collapsed in the early twentieth century, it brought us the full answer to the blue sky question. William B. Munro, in his presidential address to the American Political Science Association (APSA), observed that “a revolution so astonishing in our ideas concerning the physical world must inevitably carry its echoes into other fields of human knowledge” (1928, p. 2).

However, this scientific revolution was not reflected in political science until the mid-1970s (Toulmin 1992, pp. 145–167), and then only faintly. It has been difficult to let go of the classical metaphysical assumption of an *objective* scientific world based on universal laws, a logical–mathematical language, neutral observation, and facts free from values (Wendt 2015, pp. 12–13). Significantly, however, the twenty-first-century *Perestroika* movement in North American political science has argued that while methodological positivism is still the dominant paradigm, other ways of doing science are possible (Yanow 2005, p. 201).

This recent opening up of political science contrasts with the development of political theory, which has been alien to and even hostile toward positivism from the very beginning (Steinmetz 2005, p. 19; see also: Agger 1991; Harding 2009; Saxonhouse 2006, p. 853; Wullweber 2014). Political theory will have to be the gateway to adapting political science to the scientific revolution, and not only because of its post-positivist spirit. Hannah Arendt and Sheldon S. Wolin, who laid much of the groundwork for contemporary political theory in the mid-twentieth century, warned us how much we would need it in times of great crisis.

Arendt taught us the importance of conceptualizing the decisive events of our time. She found that the traditional tools of thought and patterns of judgment were insufficient to understand what she called *totalitarianism*. Such an unprecedented phenomenon upended almost everything: “how can we measure length if we do not have a yardstick, how could we count things without the notion of numbers?” (Arendt 2005a, p. 313). Arendt thought that positivism hindered the possibility of assimilating such novelties from the heart of the discipline. To her mind, the insolvency of imagination rendered political science bankrupt when it came to understanding the great crises of her time (ibid., p. 314).

To escape this scientific disorientation, Arendt turned her theoretical gaze to our innate capacity for starting something new, for summoning the unexpected. She went back to a geological time not usually visited in political theory and spoke of the infinite improbability of life appearing on Earth as an example of what she understood as radical novelty (Arendt 1998, pp. 177–178). Arendt’s teaching encourages us to cultivate theoretical imagination, especially when the categories that help us to think about the world fall apart.

The American political theorist Sheldon S. Wolin continued along this path. In his landmark work *Politics and Vision*, the first part of which was published in 1960, he observed that the classical model, still in force from the seventeenth century, “errs by underestimating the role that imagination plays in the construction of scientific theories” (Wolin 2004, p. 18). What had been systematically discarded in its wake, the main victim in the triumph of what Wolin intentionally called *methodism,* was a kind of tacit, reflexive, narrative knowledge that creatively helps us judge and confront the perplexities of the political (Wolin 1969, p. 1077).

Wolin also found a fundamental oversight in what was known as the behavioral *revolution*: “A revolution without an initiating theory cannot qualify as a revolution by Kuhn’s criterion” (Wolin 1969, p. 1063).[1] Indeed, Wolin found the

[1] David Truman and Gabriel Almond tried in the 1960s to frame behavioralism as a Kuhnian-style revolution. For Wolin, behavioralism undoubtedly improved techniques for collecting and analyzing

concepts of *paradigm* and *scientific revolution* put forward by Thomas S. Kuhn (1962) useful in pointing out how we can speak of *normal* and *extraordinary* political theories in the same way as conventional scientific theories (Wolin 1968, pp. 132–139, 143). An extraordinary theory was one in which "by an act of thought, the theorist seeks to reassemble the whole political world" (Wolin 1969, p. 1078). Launching this radically new look at what is familiar to us stemmed from the need to articulate a response to the *anomalies* that occur when central phenomena no longer fit within our usual institutions and concepts (Wolin 1968, pp. 136, 148). The priority for political theorists, then, is to study the major changes and the profound imbalances of their time and adapt the theories accordingly.

Only decades after the contributions of Arendt and Wolin, we face a colossal challenge in our era, which we have conceptualized as the Anthropocene (Crutzen 2002).[2] Some thirty years ago, Silvio Funtowicz and Jerome Ravetz also built on the work of Kuhn to demand a post-normal science (PNS). Using this *revolutionary* term, they called for "a systemic, synthetic and humanistic approach" and different ways of knowing in an age marked by "risk and the environment … where facts are uncertain, values in dispute, stakes high and decisions urgent" (1993, pp. 739, 744).

We are facing extreme risk associated with surpassing most of the safe and just Earth system boundaries, as defined today from an integration of social and natural sciences (Rockström et al. 2023; see also: Persson et al. 2022; Steffen et al. 2015).[3] The intense heat waves and massive fires sweeping the globe, the great floods, droughts and storms from a warming polar vortex, the new pandemics, are manifestations of this crisis in our lives today. They have become foundational to a new understanding of the world. So, something fundamental escapes us if we interpret these events as exceptional or isolated "anomalies" that are alien to the political world.

Indeed, the foundations of political science stand in need of profound post-normal revision. Recent theoretical approaches, influenced in part by the epistemological, conceptual, and ethical framework of sustainability science (Kates et al. 2001; Nagatsu et al. 2020), have developed this post-positivist and pluralist commitment around the core concern of what we understand as *science*.

Scientific and sustainability questions are ineludible in environmental political theory (EPT), a body of theoretical work concerned with the political actions involved in the anthropogenic transformation of the planet (Gabrielson et al. 2016). Similarly, the Earth System Governance Project is harnessing the best and latest science in the quest to generate a flexible, diverse, and innovative theoretical framework from political science and other disciplines, to study governance in the Anthropocene (Burch et al. 2019). A related science–democracy relationship runs through discussions in science and technological studies (STS) about new ideas, such as including non-human actors in political analyses (Jasanoff 2017) or even in political representation (Donoso 2017). Finally, as a case in point, the theory of modernity/coloniality/decoloniality denounces the limited, situated and colonial European concept of science (Castro-Gómez 2005; Harding 2019; Mignolo and Walsh 2018).

Four decades ago, Glendon Schubert (1983, pp. 98–99) asked which of the three great scientific paradigms—Greek, Newtonian or contemporary—would provide the general framework for political science. In this impasse between the Sixth Extinction and the Fourth Industrial Revolution (Braidotti 2019, p. 37), everything seems to indicate increasing pressure to adopt and extend the last of these across the discipline.

In an attempt to collaborate with this theoretical revolution, we will allow ourselves to be guided by what we could define as our *super-wicked problem*. How to preserve the current color of the sky uncovers a great problem that is also a symptom of related, equally serious problems for which there is no easy solution. We clearly cannot, must not, fail. If we add the pressure of the time factor or the absence of effective coordination in solving it, the features coincide with an entire constellation of problems related to global warming. These *super-wicked* Anthropocene problems "do not fit comfortably into the customary linear-rational model of science, (…) with reference to specific assumed logical–positivist laws". Indeed, linear models of science and technology "have contributed to the formation of wicked problems" (Sun and Yang 2016, p. 4). Because of their multi-faceted and interconnected nature, it is generally recommended that they be tackled in an inter- and transdisciplinary way, from a paradigm that assumes the complexity,

Footnote 1 (continued)

data, and establishing a *methodical path* with far-reaching consequences, but the theories that accompanied it were neither *political* nor *extraordinary*. They conformed to dominant science and ideology (Wolin 1969, pp. 1062–1064; see also Brown 2000; Gunnell 2004, p. 47).

[2] Anthropocene is a concept now in dispute throughout the social sciences, including political science, with Capitalocene as an alternative (Malm and Hornborg 2014) that could well be complementary (Chakrabarty 2017). In March 2024 the term Anthropocene was rejected as an official new epoch for the Earth by the International Union of Geological Sciences Subcommission on Quaternary Stratigraphy (Zhong 2024).

[3] The Earth system boundaries being exceeded today include global warming, the loss of intact natural ecosystems and the functional integrity of all ecosystems, and the alteration of nutrient cycles, surface water flows and groundwater levels. Trespassing them will leave us humans with less and less room to maneuver, exposing us, other species, and future generations to multiple significant harms (Rockström et al. 2023).

uncertainty, and dynamism of the Earth system (Brondízio et al. 2016; Lawrence et al. 2022; Toivanen et al. 2017).

And this is where we begin to wonder directly about the color of the sky.

The blue hour

When the sun is not visible but can be sensed because it is about to rise or has just dropped below the horizon, those moments of transition between a blackened sky dotted with small stars and the daytime celestial hues place us in *the blue hour*. This expression has sparked the imagination of musicians, artists, and scientists through the ages. In that liminal space, when only a few rays penetrate our visible atmosphere from the rising or setting sun, the sky turns a bright but dark blue. In 1881, James Chappui hypothesized that it had to do with the absorption of ultraviolet and mostly orange rays due to the decomposition and recomposition of ozone at high altitudes (Hoeppe 2007, p. 237 ff.).[4]

A decade earlier, John William Strutt began publishing a series of scientific papers reflecting his search to unravel the main mysteries about the sky and the reason for its clear blue tone during most of the day. He finished the quest in 1899, shortly before Max Planck and Albert Einstein began to turn accepted physics on its head, and all of science with it. In the *blue hour* of that revolution, Strutt (who by then signed his works as Lord Rayleigh) got it right, and his theses survived the paradigm shift.

Therefore, to explain the color of the sky, we must start with physics, but the most common and direct answer to our main question involves a bit of history:

> The sky is blue because of what's called *Rayleigh scattering*.

If this is our first approach to the subject, that answer will reveal little and elicit the essential second question: what is *Rayleigh scattering*? Then, a second answer is needed to inform us that the dispersion of light that tinges the sky of our planet to what we perceive as blue owes its name to Strutt because his research explained correctly that when the sun's white rays hit our atmosphere, blue spreads more in the sky than other colors (Strutt 1871). In what is known today as *Rayleigh's equation*, Strutt demonstrated a direct and inverse relationship between the intensity of the light scattered by air particles and the wavelength that they had previously received. Each particle acted as a "tiny antenna" that redirected shortwave, high-frequency light *better*, in greater proportion and intensity (Phipps 2016, p. 133).

From this, it follows that "all lights are present in the color of the sky" (Bohren and Fraser 1985, pp. 267–272), but in the complex synthesis of waves that are dispersed over our heads during most of the day, blue lights dominate. However, by looking up on a sunny day, we can easily see variations in tone and brightness. Strutt's mathematical function for these proportions calculated that shortwave, high-frequency violet lights scatter 9.4 times more than longwave red lights (Strutt 1871, pp. 107–110, 114). Our retina is not fully equipped to see violet, which is scarcer in the visible range of sunlight. We now know also that violet photons have long been scattered in the regions furthest away from us, so what we observe of the chromatic variety dispersed over our heads is the "sky blue" that we consider the planet's trademark (Walker 1989).

Spurred on by James Clerk Maxwell, who encouraged him to continue his research to find the particles actually involved, Strutt did not complete his theory of the sky until 1899 (Pesic 2005, pp. 118–123). After ruling out salt as the number one suspect, he found that the components of air itself – mainly the diatomic nitrogen and oxygen molecules that make up about 78% and 21% of the air, respectively – created the blue effect without the need for other particles in suspension. Advantageously, neither of these atmospheric components disappeared in the wind or rain. Without the Earth's atmosphere, we would always see the sky as black, like on the moon.

At the end of the nineteenth century, only months before the wheels of quantum mechanics officially began to turn, the theory was complete. We understood the reason for the sky's color in the *blue hour* preceding the dawn of a new scientific era and all its revolutionary ideas, one of which would soon identify the corpuscular quality of light waves.

From pluridisciplinary opening to interdisciplinary exchange

After its encounter with atmospheric matter at high altitude, light is scattered, and we receive it through a series of photoreceptors in the retina. These immediately send signals to the brain to be interpreted. Thanks to language, we can name it: *blue*.

The scientific account of the interaction between light and matter at the quantum level explains the color of the sky (Nassau 1980, pp. 124–129; Tilley 2011, pp. 247–251). Central to this encounter is Werner Heisenberg's uncertainty principle, a foundational element of the new paradigm which asserts that merely observing something modifies what is observed. Like a billiard ball, the minimum photon required for observation hits what we want to know and instantly

[4] In 1953, Edward Hulburt required quantum theory to demonstrate that at least 2/3 of the blue color of the zenith at twilight is due to ozone absorption (Pesic 2005, pp. 173–174): something that has recently been confirmed (Lange et al. 2023).

changes the scenario. When an elementary particle such as an electron is detected, physicists say that its probabilistic wave function collapses, i.e., the nebula of possibilities we had to find it dissolves. This implies that if we look back and inquire into its immediate past, there is no way of knowing where it was, we can only be guided by genuine probability based on superposition of its previous states. When we detect a particle, we can pinpoint its current position, but we still do not know its other basic attribute, velocity, and vice versa. As Heisenberg wrote in 1927, “we cannot know, as a matter of principle, the present in all its details” (quoted in Gribbin 2013, p. 141).

This evasion of the present is not limited to the world of the extremely small. The light that reaches us from the Sun takes eight minutes and twenty seconds to travel the 150 million km that separate it from us. If in a hypothetical case our star were to explode, from Earth we would not perceive it instantly: for a few minutes at least, we would continue to see the same Sun as always (Galfard 2015, pp. 92–93). In other words, indeterminacy applies to the past, the present, and—it goes without saying—to the future. This pluridisciplinary opening thus leads us to a rich interdisciplinary exchange around uncertainty.

Heisenberg was also concerned with how language always mediates the task of knowledge (1958, pp. 167–186). It provides framework and expectation for what is observed because, as Friedrich Nietzsche had already written (1995, p. 83), “nature is acquainted with no forms and no concepts”. An explanation of why we see the sky as blue is therefore incomplete if we fail to study the human work of translating the visible spectrum. Here, we step away from physics to study what is happening in neurobiology (Conway 2009; Falcinelli 2017, p. 193; Siuda-Krzywicka and Bartolomeo 2020).

Research on the invaluable photoreceptor cells that have developed in the human retina through evolution, which we have named rods and cones due to their shape under the microscope, has led us to confirm our distinct way of seeing the world. The blue sky that dichromats without tritanomaly see on a sunny day is quite similar to what trichromats see, but a “red” sunrise or “green” grass is mostly perceived as a dull, grayish yellow. From this we have concluded that grass lacks a universal, *objective* color. Instead, the specificities of an individual’s retina determine how its color is perceived (Bryson 2019, pp. 114–120; Falcinelli 2017, pp. 193–197, 418–421; Tilley 2011, pp. 24–28). Not coincidentally, the notion of situated knowledge was proposed by Donna Haraway on the basis of an embodied vision that she acknowledged came to her when she reflected on the retinal cells of her dogs (1988, p. 583).

When the colorless light photons scattered by air molecules reach the retina, the cones immediately send chemical-electrical signals to the optic nerve, up to a hundred billion every second. To interpret *blue*, these signals trigger a series of operations in the human brain that we are only beginning to understand. Only 10% of what we see corresponds to information from the optic nerve. The rest is the brain’s creative work of constantly predicting what we see, since the brain requires a fifth of a second to receive and process visual stimulus (Bryson 2019, pp. 80–81). Once again, the present escapes us, but this time on our own human scale.

Another relevant finding informs us that, strictly speaking, there are no isolated colors, because they always exist in interaction with other colors and their environment (Conway 2009, p. 276). Moreover, if we have always seen the sky blue on a clear day, and at a given moment we look up without trying to register the nuances that may be in it, the visual cortex automatically incorporates the *stored* information about what we expect to see. This memory facilitates the *constancy of color* that we apply to certain objects to make them relatively independent of environmental changes. Therefore, if we only paid attention to physics, the identity of an object would vary in something as fundamental as its color throughout the day (Eagleman 2011, pp. 96–99; Falcinelli 2017, pp. 198–199, 352–354; Siuda-Krzywicka and Bartolomeo 2020). Other disciplines such as anthropology and linguistics can also help us to reflect on the path that has taken us from the first human languages to today’s *blue*. We know, for example, that the naming of warm colors, which from an evolutionary perspective were more useful for survival, preceded that of colder colors such as green and blue (Biggam 2014, pp. 12–20).

This finally leads me to consider *qualia*, “the transformation of an objective cerebral computation to a subjective experience” from which the indefinable properties of what we see, smell, taste, or feel arise (Sacks 2017, p. 147). We know very well what seeing “sky blue” means to us, but how can we describe it? Can we be absolutely sure that the person next to us is seeing it the same way? Here, our cognitive abilities make use of language to give a name to something so perceptually elusive that it exponentially increases the difficulty of the issue. When it comes to agreeing on the common human world, as Hannah Arendt observed from political theory, an ongoing egalitarian dialog even beyond the scientific arena must inevitably be maintained (1998, pp. 50, 57, 175–176; 2005b, p. 128).

Thus, pluridisciplinary opening can facilitate a rich interdisciplinary exchange that helps us reflect on our situated, constructed and interdependent perception of political realities.

Caelicustodians

The components of our atmosphere that make the sky blue also reveal original biological connections that redefine us and our place in this Earth system. Attending to these interwoven geological histories from a political perspective may prove vital for our species.

I will start here with the fact that in other worlds, the sky is not blue. The Earth itself has had several previous atmospheres, implying previous colors of sky. About 2.3 billion years ago, the Great Oxidation ushered in the age of oxygen on the planet, largely due to the evolution of cyanobacteria and their capacity for oxygenic photosynthesis. Terrestrial skies probably first appeared as blue when atmospheric oxygen eliminated aerosols and formed the protective ozone layer, helping plants move to land roughly 400 million years ago (Hoeppe 2007, p. 273). This blue was lost in the deadliest mass extinction of the past, and it took hundreds of thousands of years to recover it. In the global warming caused by the colossal eruptions of the Late Permian Era (252 million years ago), Earth's waters became so deoxygenated that anoxic sulfur bacteria returned to the ocean surface. The resulting hydrogen sulfide emissions into the atmosphere poisoned nearly all aerobic life on the planet, severely damaged the ozone layer (Canfield 2014; Grégoire et al. 2023; Kump et al. 2005; Mann 2023; Ward and Kirschvink 2015) and turned the sky green (Ward 2008, p. 140; see also: Kolbert 2014, p. 143).

In our current scenario, the oceans have lost more than 2% of their oxygen since 1960. Eutrophication combined with global warming has multiplied oxygen minimum zones, and more than 700 hypoxic areas have been identified around the world. Hydrogen sulfide production has already been detected in many of them (Laffoley and Baxter 2019). Although a Permian-style total ocean collapse is not an immediate concern, as it would take at least a thousand years to arrive at that point, the rate of ocean warming, sea level rise, acidification, and deoxygenation is outstripping predictive models (Watson 2016; Mann 2023). The tipping point of greatest concern now is for warm-water coral reefs and for the Atlantic meridional overturning circulation, while ocean hypoxia has recently been included among tipping systems that require research and control (Lenton et al. 2023, pp. 105–108, 119–120; Ripple et al. 2023, pp. 844–845). Meanwhile, Elizabeth Kolbert warns us that the sky could lose its blue again much sooner than expected, and by our own design: if solar geoengineering is used to spread reflective particles into the stratosphere in the coming decades, "white would become the new blue" (Kolbert 2021, p. 225; see also: Hulme 2014, p. 97; Vettese and Pendergrass 2022, p. 3).

It is difficult to understand the present atmospheric or ocean compositions and the color of our sky without considering global homeostasis among air, water, and soil cycles—and their components—as contemplated in the Gaia hypothesis (Lovelock and Margulis 1974). We can relate this to the endosymbiosis famously proposed by Lynn Margulis. Accordingly, during the full eukaryotic diversification that facilitated the formation of the plant cell, cyanobacteria were phagocytosed to become chloroplasts: the tiny components of the plant cell that absorb solar energy and perform photosynthesis (Quammen 2018, pp. 173–230). This relationship provided us with the common biological origin of plants and of the color of our sky.

But, as in the notorious case of the tree that falls in an uninhabited forest, there is no blue if no one sees it. All animals have a group of proteins in our eyes, known as opsins, which are essential for capturing light and making chromatic distinctions. This fundamental element of the visual pigments in our photoreceptor cells is responsible for capturing light waves and sending them to the brain as chemical–electrical signals. Opsin is also present in cyanobacteria. It gives them a biological rhythm attuned to solar patterns and facilitates their movement toward the light (*phototaxis*) to assist photosynthesis. Curiously, the photoreceptors found in some unicellular eukaryotic dinoflagellates were originally algal chloroplasts. Once inserted into these protists, they retained their ability to capture light, which is suggestive of a prototype eye structure. Research about the complex evolution of sight is attempting to identify a common line that would link it to subsequent evolution and the various types of eyes observed in the animal kingdom (Gehring 2005, 2014; Schwab 2018).

Therefore, we can contemplate the blue of the sky thanks to the cyanobacteria that continue to supply our atmosphere with the oxygen that runs through us and builds us… and built it. The unexpected connections that accompany the answer to why the sky is blue bring us to this vista of our origins. Such a panorama can provide effective antidotes for human omnipotence and to our supposed separation from *nature*. These are crucial when thinking about politics, especially in light of our now obvious *composite* condition. Our ideas of human individuality and exceptionalism have thus been overturned as the best biology of the twenty-first century challenges former concepts of being human (Haraway 2016, p. 30). From the primordial endosymbiosis between an archaeon phagocytosing an aerobic bacterium, which became our mitochondria (Eme et al. 2017; Imachi et al. 2020; Williams et al. 2020), to our current symbiotic alliance with trillions of bacteria in our bodies (Sender et al. 2016), it no longer seems possible to seriously think of ourselves as independent or separate beings.

From this perspective emerges the notion of corporeal citizenship, which is closely related to feminist and intersectional situated politics. Focused on the porosity, eco-dependence and the vulnerability of bodies, it leads us to consider "the uneven and unequal exposure of human bodies to life threatening toxics, pathogens and ecological stressors" (Gabrielson and Parady 2010, p. 387). Like water or food, air is essential for life and is "enrolled in projects of social, racial, ethnic, and cultural distinction" (Choy 2011, p. 161).

Air pollution, beyond blackening the skies or brightening the reds of sunset, is now recognized as "the fourth highest risk factor for premature death globally" (Riley et al. 2021, p. 2027). From the polluted city of Baltimore, Chloe Ahmann (2020, p. 465) claims that "both in theory and in practice, people were looking to the sky for clues about how to think relationships between (and beyond) human beings". Thus, the atmosphere has created an unexpected type of political conflict and become an "object and method for a new kind of communing". New-knowledge politics allows us to be aware of such chains of contact between humans and non-humans across the *natureculture* continuum. It implies related asymmetrical vulnerability, but also "webs of care through sensorial materiality" that are fundamental to life (Puig de la Bellacasa 2017, pp. 120, 161). "What does it mean to think how, in the web of care, other than humans constantly reciprocate?", wonders Puig de la Bellacasa (ibid., p. 122).

From this post-anthropocentric vision of our role and connections in the Earth system, perhaps it is time to stop thinking of ourselves as *humanus*, those who inhabit the soil of the Earth *(humus*). Firstly, because there are other organisms that also occupy it, though we do not call them humans. If we acknowledge that we are part of a multispecies community with multiple origins—terrestrial, microbial, and aquatic—we can develop a more comprehensive explanation for our current interdependencies. The very amniotic fluid that supports our embryonic development shows us that transitions rarely end. We also owe our being, our evolution, and our vitality, to the air. We are immersed in the clear "breath of other living beings" (Coccia 2019, p. 79), though we also breathe the gray smoke and dark aerosols emitted by factories, heating, or cars. This incessant, troubled relationship runs through us and defines us.

The blue of our sky (*caelum*) reminds us every day, just by looking up, of all these relationships perpetually in process at the intersection between the biosphere and the anthroposphere, from the earliest complex life forms to everything we share today. It is difficult to determine if we can live under any other color. What seems clear is that it is unfair and disrespectful toward all life with which we share existence to behave like harmful little gods. Albeit with varying degrees of responsibility stemming predominantly from capitalist-oriented practices, in continuing to think anthropocentrically of ourselves, of humans, as exceptional, we are responsible for great ecosocial disruptions (Chakrabarty 2017). More than binding us to this or that entity, any ontological re-defining of ourselves that contributes to the needed shift must move us to act collectively in the public space, and to act quickly. So, my proposal here is that we become active protectors, caregivers, and custodians (*custodes*) of our blue skies, recognizing our reciprocal dependences and our potential alliances in the *natureculture* continuum.

We are *caelicustodians*, custodians of the heavens, and therefore of life itself.[5]

Discussion

Political studies face a significant challenge in the twenty-first century. As political scientists of this era, we must be adept at identifying and addressing the super-wicked problems of the Anthropocene, which include the risk of losing the current color of the sky. Almost ten years ago now, Robert O. Keohane set a main task for the discipline, to "creatively think about how to reframe issues of climate change in ways that make political action feasible" (2015, p. 24). And as David Schlosberg (2013) also stated, "key challenges of a climate-changed society include (…) rethinking science politics". With this in mind, this theoretical journey (Wolin 2001, pp. 34–36) that we have taken to explain the blue sky could guide the transformation of our current comprehension of the discipline while inspiring institutional and collective sustainable action.

Why is the sky blue? This new question for political science allows us to rethink the discipline as a whole: its paradigm, its limits, its general *curricula*, and even its name. Such a challenge requires experienced education and research as well as the incorporation of new *political* objects of study.

We can now acknowledge the impossibility of understanding something as fundamental as the color of the sky we see every morning without the contemporary scientific paradigm that was established in the early twentieth century. And this is not just about physics. Werner Heisenberg's famous uncertainty principle is considered the cornerstone of the post-positivist conception of science. Transferring the principles of that scientific revolution from physics to political science shows us that we cannot know the details of the past, present, or future with complete certainty. This effectively puts an end to subject/object separation in scientific research. Leaving behind nature/society dualism and accepting uncertainty while working forward from what we know are basic to the contemporary understanding of the complex Earth system and extraordinarily useful in the pursuit of sustainability (Granjou et al. 2017; West et al. 2020).

Political science can benefit from a constructivist and collaborative way of thinking and doing science. As we have seen, our approach to reality emerges from the current scientific paradigm as plural, limited and creative, dynamic and contextual, and situated and relational. Contemporary

[5] If *astronaut* denotes a "navigator of the stars", *caelicustodes,* "custodians of the sky" is proposed as the basis for the neologism *caelicustodians*.

physics enlightened our task of understanding the color of the sky, but its finding that violet lights are more present in the sky than we perceive them to be, shows us that it is also incomplete. Comprehending the colors we see above us requires a pluridisciplinary path through neurobiology, optics, linguistics or anthropology, among other fields. It takes multiple scientific disciplines to understand why dichromats see sunsets differently from trichromats, how our brains creatively anticipate the photons that hit our retina, or why we see different blues depending on the context.

Also, political science could help explain the color of the sky. The red of the sunrise in cities around the world, the very possibility of seeing its blue during the day, depends largely on their specific policies regarding air pollution. Going forward, political science expertise in public policies, social movements, or international relations may teach us why we no longer see a gray sky in Beijing or exactly what the threat of solar geoengineering means. As David Wallace-Wells affirms, the capacity to stop deforestation or the use of fossil fuels in time "is not a question for the natural sciences but the human ones" (2019, p. 62). The fundamental discussion about the future color of the sky, be it green, white or blue, will undoubtedly be *political*.

Therefore, it seems necessary to blur the classical boundaries of political science and put an end to the old Cartesian project of disciplinary division and specialization (Alonso-Rocafort 2024). This could materialize as a new general curriculum for training students in the current paradigm. Environmental politics, philosophy of science, interdisciplinarity studies, socio-ecological transitions, sustainability science, environmental arts and humanities, or Earth system science are some of the new core subjects that should be considered for inclusion based on the broad participation of each academic community.

Moreover, impulse should be given to re-politicizing the environmental education curricula (Slimani et al. 2021). It includes the integration of political science into new bachelor's and master's programs in schools or departments offering combined degrees in sustainability. Many of these programs benefit from the organizational flexibility of international inter-university initiatives that are working together to develop new fields of study, especially in Europe (Gunn 2020; Maassen et al. 2023). Since it is no longer possible to think of human beings as separate entities, it is only a matter of time before twentieth century political science becomes twenty-first century eco-political science.

Beyond this is the need for a profound shift toward "transformative" education and research. While it is important to teach about and investigate ecological transition, and include it in academic career reward systems, teachers and learners should also experience personal and collaborative transformation of their own social and scientific assumptions that will enable them to challenge the fossil fuel status quo (Loorbach and Wittmayer 2023). This could help us to rethink our own institutions to make them sustainable and become better policy analysts, learning through collective and political actions (Slimani et al. 2021).

In this *natureculture* context, new objects of study such as the sky, forests, and oceans must be contemplated in a new, more-than-human discipline. Alien to the individual, rational, and sovereign standard of normal political science, a new relational subjectivity is gaining prominence in looking at human relationships with the self, others, and the environment (Braidotti 2019, pp. 42–54; Guattari 1989). If we understand politics as the free use of the imagination and language to decide collectively (Arendt 2005b, pp. 118, 124–126), then "only humans act politically" (Arias-Maldonado and Trachtenberg 2019, p. 4). Nonetheless, other non-human entities act with political consequences, and can be protected or represented as legal and political subjects, thereby expanding our political communities (Dryzek and Pickering 2019, p. 72; Latour 2015, pp. 82–140; Vicente 2020).

Holocene political theories, concepts, and institutions are insufficient and sometimes even inadequate to effectively tackle the complex new issues of this era. However, the extreme urgency of the existential risk we face should not cause us to overlook the importance of strengthening and deepening democratic values, most of which have long been cultivated in our discipline. Knowing how to effectively combine the best of our political studies and Earth sciences into a plural, integrative sustainability science that walks hand in hand with other social sciences and humanities is crucial to the task.

Our main question about the sky has also allowed us to introduce a potentially powerful metaphor for activating beliefs, emotions and expectations that can move the public to action. As Kate Raworth (2017) challenged the dominant images of conventional economics with a simple doughnut, offering a progressive framework for the United Nations Sustainable Development Goals (SDGs) (Warnecke 2023), the blue sky politics embedded in this narrative could offer a new framework for action on various levels. From the SDGs to the actions of national governments and civil societies to scientific resistance against solar geoengineering, the time is ripe for it.

In 2019, the United Nations General Assembly adopted by consensus a resolution designating September 7 as the *International Day of Clean Air for blue skies* (UNGA 2019). The naming of this International Day reflects a narrative that seeks mainly to establish a link between eliminating polluted air and the possibility of seeing blue sky. UN resolution highlights that air pollution "is the single greatest environmental risk to human health". It emphasizes the need to strengthen international cooperation and to raise public awareness at all levels (ibid.). This has been the United

Nations Environmental Programme communication guidance in this regard (UNEP 2022, 2023a, 2023b; see also: UNEP 2023c). As Song et al. noted:

> "the focus should not be on solving air pollution itself, but on presenting a set of visions and goals which aims to strengthen a sense of Collectivity (…) and to establish the necessary institutions and framework needed to build [this] Collective" (2020, p. 101).

Turning to the UN resolution, it acknowledged "the negative impact of air pollution on ecosystems" and "that improving air quality can enhance climate change mitigation and that climate change mitigation efforts can improve air quality" (UNGA 2019). This relational statement requires a framework that has not yet been fully explored in UNEP campaigns, which only tentatively reflect these links and have been virtually identical in recent years (UNEP 2022, p. 6; UNEP 2023a, p. 6). The alternative perspective offered in this paper, a story that tells the long history of the blue skies, the richness of its relations in Gaia and its co-vulnerability with human beings, envisions a new kind of *caelicustodian* community facing super-wicked problems in the *natureculture* continuum. If adopted by UNEP, its influence might be decisive.

UNEP communication about the *Clean Air for blue skies* strategy also highlights the importance of air pollution abatement for achieving the SDGs (2022, p. 6; 2023a, p. 6). However, "there is no headline goal or even target focusing on air pollution exclusively" (Zusman et al. 2023, p. 1513). In response, specific proposals for "A Clean Air Sustainable Development Goal" are already being put forward for SDG successors (Lelieveld 2017; Zusman et al. 2023). The initiative might gain more momentum if it were called the *Clean Air for Blue Skies SDG*. As in prior cases, it could be also complemented by a broader, post-anthropocentric narrative that calls for positive and reciprocal action.

At the national level, the *2018–2020 Three-year Action Plan to Win the Blue Sky Defense War*, implemented by the Government of China in 2018 (MEE 2018), has demonstrated the importance of public policy in explaining the color of the sky (Jiang et al. 2021). Air quality in the country has been shown to depend on "the multilevel governance framework of authoritarian environmentalism and the context of ecological civilization" that gives some "discursive space" to civil society participation (Winter et al. 2021, p. 1060; see also: Ahlers and Shen 2018). As Shen and Ahlers has pointed out, "blue sky fabrication" can be seen "as an administrative endeavor and a governance problem" (2019, p. 136). Their research on the governmental *G20 Blue Campaign* in the host city of Hangzhou in 2016, shows how natural and social scientists formed a task-force team to ensure the efficiency and legitimacy of the measures implemented (Shen and Ahlers 2019). This case study illustrates the importance of the political dimension in explaining the presence or absence of blue skies over a region.

Although the Chinese government's clean air strategy explicitly describes a "Blue Sky Defense" policy, the use of warfare language or coercive methods would run contrary to the vision described here. Other concepts and frameworks are needed, and could be introduced if unexpected discursive spaces open up.

Finally, if we evaluate stratospheric aerosol injection (SAI), a potential action against global warming that would whiten the sky, we should start by acknowledging the benefits of approaching the issue primordially from an action-oriented, pluralist, integrated and post-normal political science of sustainability (Caniglia et al. 2021).

As I mentioned above, in June 2023, both the US Government (OSTP 2023) and the European Commission (EC 2023) explicitly expressed openness to research in SAI. The US document is particularly interesting, as it begins with a section analyzing the physical aspects of solar geoengineering and ends with a look at the ecological, socio-economic, environmental justice, and geopolitical issues involved.

The potential effects of this method of solar geoengineering on climate patterns, agriculture, more extreme drought or precipitation events, ozone depletion, planetary water systems, or even its stated goal of decreasing temperatures in all regions of the globe seem dangerously uncertain. Moreover, SAI alone would be insufficient to address the overstepping of other related Earth system boundaries such as biodiversity loss, acidification of the oceans, or air pollution. There is also concern about the potential climate rebound effect of having to stop SAI abruptly for unforeseen reasons. Furthermore, it is extremely reckless to test these effects prior to implementation; our only guides should be models or natural analogs such as volcanic eruptions (Hulme 2014; Kravitz and MacMartin 2020). In fact, a small-scale outdoor experiment in Baja California has led the Mexican government (2023) to declare the first state ban on such experiments.

This journey around the blue sky issue has shown us that the sky and the planet are not machines open to linear engineering interventions. How we frame the issue is therefore fundamental, and we cannot separate its science from its politics (Schubert 2021). The worrying lack of public understanding about what is at stake (Biermann et al. 2022) has led governance scholars to launch an international campaign, calling on the United Nations to sign an *International Non-Use Agreement on Solar Geoengineering* (https://www.solargeoeng.org/). It has been signed by more than 500 academics from 67 countries and more than 1900 organizations and 3600 citizens to date. Given its concern for blue skies, UNEP might welcome this initiative.

Other motivations behind this call for an international non-use agreement—which the present work adheres to—include the possibility of using this technology for military ends, its clear incentive against decarbonization and the impossibility of fairly, democratically, and effectively governing it in the current international system (Biermann et al. 2022; Hulme 2014; Kolbert 2021). Once again, politics are at the forefront.

Conclusions

Transformation to sustainability requires stories, metaphors, and the transcending of ancient paradigms (Abson et al. 2017, pp. 32, 35; Riley et al. 2021). Answering the fundamental question of *why is the sky blue* allows us to weave a pluri-, inter-, and transdisciplinary narrative of unexpected connections. The blue of the sky is directly related to the human gaze, which originated from the same cyanobacteria that made that blue possible millions of years ago. As SAI pressures increase, and global temperatures and GHG emissions reach record highs (UNEP 2023d), the sky has become a pertinent object of political study. If political science is to collaborate in resolving one of the main dilemmas of our time, we must understand what it means to give up the blue sky.

From this problem-driven approach, a transition to eco-political science is thus proposed, featuring a renewed curriculum, cross-cutting paradigm, and experienced pedagogy capable of integrating with emerging Sustainability science programs to meet the challenges ahead.

The second proposal of this article calls for the conceptual re-definition of humans as *caelicustodians*. This vision and its implications could be incorporated into the institutional Clean Air strategies for blue skies that are being developed at international and national levels, including initiatives aimed at achieving a Clean Air SDG.

The resulting awareness of our place in a broader community that defines us as custodians of an increasingly vulnerable blue sky, and ultimately of ourselves in the great web of care and life, could trigger cascading network effects.

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