ITU A|Z • Vol 22 No 1 • March 2025 • 19-37

# Architecture as an open field of interactions: Climatic singularities in the work of Philippe Rahm

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*Received: September 2023 • Final Acceptance: February 2025*

**Abstract**
This paper proposes viewing scale as a mediating surface that bridges micro-subatomic dimensions and planetary scales, stimulating creative architectural thinking through transitions across these domains. By redefining scale as both an operation of thought and a navigable plane, the research explores its potential to inspire alternative approaches to architectural design. Drawing from thermodynamic principles and viewing the world as an interconnected whole, the study advocates for architectural practices that transcend traditional boundaries, fostering inter-scale jumps and connections. Using the concept of verticality, the paper emphasizes the continuity of design processes to address yet-to-emerge effects, encompassing multiple temporalities and speeds simultaneously. Verticality positions architecture as an interface sensitive to overlapping cycles and dynamics across disciplines and scales, suggesting that the significance of design lies not in its scale but in its capacity to engage with heterogeneous flows and intelligences operating at varying speeds. This perspective reframes spatial construction practices by integrating non-cartographic scales and micro-subatomic configurations, influencing contemporary architectural practices. The works of Philippe Rahm serve as a case study to examine these ideas. Rahm's architecture, rooted in micro-scale considerations and thermodynamic principles, provides a framework for exploring scalar jumps. By re-reading his projects through defined analytical frames, the study reveals the limitations of theory in bridging discourse and practice while highlighting practice as a mode of research. This theoretical and practical exploration seeks to uncover innovative methods of architectural thinking and making, fostering a transdisciplinary architecture that reconstructs new contiguities and expands boundaries of architecture.

**Keywords**
Architectural design, Interscalar, Micro-macro, Scale, Verticality.

*doi: 10.58278/0.2025.82*

## 1. Introduction

> *"Everything is a matter of relationships between different scales: "Individuation occurs because there is a change between the microphysical and macrophysical dimensions" (Simondon, The Individual and Its Physico-Biological Genesis, 1995).*

In the 1960s, the modernist belief in the complete knowability of the world began to give way to perspectives that embraced complexity, inconsistency, and uncertainty. Emerging theories proposed "rethinking the world not in terms of fixed laws and regularities, but as disturbances and turbulences, revealing diverse forms, uneven structures, and fluctuating organizations" (Serres et al.,1983). From this perspective, stable systems or structures do not exist, and things neither behave predictably nor repeat functions in the same way. Architecture rooted in static descriptions and the idea that form directly corresponds to functional rationalism becomes unconvincing in this context. The pursuit of idealist architecture—whether to fit an ideal reality or driven by the genius of the architect—is now outdated. This signals a theoretical deadlock, where traditional justifications for architectural form lose validity. Alternative architectural practices emerging in the 1960s, such as Archigram, Hans Hollein, Ant Farm, Buckminster Fuller, and Coop Himmelb(l)au, challenged this deadlock. By idealizing technology and claiming ethical positivism and aesthetic neutrality, these attempts revealed that form and function are shaped not only by aesthetics but also by social, philosophical, technological, and cultural contexts. For Eisenman (1976), this "functionality deadlock" and the accompanying sense of displaced positivism mark the final phases of humanism, suggesting that humans may no longer be at the center of the world, neither are they the *originating agent* of architecture. His ideas are significant for two reasons for this article. First, they align with Negarestani's (2014a) notion that "the world can be constructed independently of the human scale." Second, they highlight that architecture cannot operate within a closed, internal system. Instead, it must expand its boundaries and engage with the *broader world*.

The idea that architecture cannot be produced within a closed system has expanded the traditional focus on function to include networks, infrastructures, and flows, emphasizing relationality, interaction, and interconnectedness. While this perspective helps architecture establish relationships beyond its immediate scale and align more closely with the flows in the world, it also risks reducing architecture to a simplistic system of inputs and outputs, potentially dissolving architectural design into these networks.

For example, "Banham and Dallegret's *Environment Bubble* reimagines the house as a baroque community of household gadgets illustrating the complexity of life, integrating mechanical, electrical, and structural systems" (Sprecher, 2010). This merging of climatic, wireless, and grid-based energy systems illustrates the dissolution of architectural form, representation, and the object itself (Moon, n.d.). Similarly, "Superstudio's *Microevent/Microenvironment* warns of design's disappearance, envisioning life without objects and presenting a model where design processes and environments interact symbolically. This pursuit of flawless rationality ultimately leads to self-reflection, causing design to withdraw from circulation" (Braham & Hale, 2006).

In these examples, architecture is instrumentalized by reducing it to the behavior and capacities of mechanical systems. However, recognizing the chemical and ecological connections between climate, materials, soil, and geology frees architecture from the domain of the visible—dominated by symbols and narratives—and shifts it toward the invisible. This shift encourages architects to explore interventions in environmental, biological, and physiological layers. Such an architecture, which fosters continuous interaction with the challenges of an interconnected world, suggests that design thinking and processes must evolve. This evolution would allow the integration of the parallel development of diverse, heterogeneous elements into architecture itself. Buckminster Fuller's work across various scales, guided by his concept of "total thinking," serves as a compelling example in this context.

Buckminster Fuller represented his geodesic domes as embodiments of "comprehensive, anticipatory design science," aiming to advance toward an ideal of well-managed resources by challenging conventional artistic and architectural forms (Díaz, 2014b). He believed that these forms could address global issues if approached differently, viewing design as a dynamic process and action rather than a singular object. Fuller had the unique ability "to see our world as an interconnected whole," a perspective described as "total thinking" (Díaz, 2014a). Architect Lindy Roy supports this view, stating, "in Fuller's technique, form can no longer, even in design disciplines, be said to be a thing but, at the very least, a set of variable relations held in dynamic equilibrium." Fuller argued that design processes, by focusing on the structural constitution of form rather than its surface appearance, could uncover universal truths within patterns and networks. This perspective linked architectural form to the redistribution of resources and consumption patterns. By extending architecture beyond its conventional scale, Fuller emphasized its relationship with the broader world. His concern for the environment and resource scarcity is evident across all scales of his work, from the personal to the cosmic. This consistent focus influenced both architectural and non-architectural fields, highlighting the transformative potential of his approach (Figure 1).

Fuller does not merely discuss design thinking at every scale or advocate for *interscalarity*[1] in architecture. Instead, he asserts that architecture has the capacity to create interactions that connect different scales, making the relationship between the microscopic and the planetary understandable. What sets Fuller apart from the conventional idea of interscalarity is the *jump* he encourages to take. This jump goes beyond merely establishing relationships between adjacent scales; it is not a smooth zooming in and out. Instead, in a world that acknowledges discontinuities, it represents a shift into an entirely different scale.

Fuller's approach foreshadows an architecture capable of establishing relationships across various scales while disconnecting the concept of scale from human agency. For Rawes (2013), this novel approach redefines architecture as "a generator of relational ecologies of transformative practices," envisioning it within an expanded field[2]. This perspective not only redefines the boundaries of architecture but also enhances its capacity to engage with other disciplines, fostering a transdisciplinary approach to design.

In this context, my interest lies in viewing scale as a mediating surface between disciplines, capable of stimulating creative production and generating new architectural thinking that emerg-

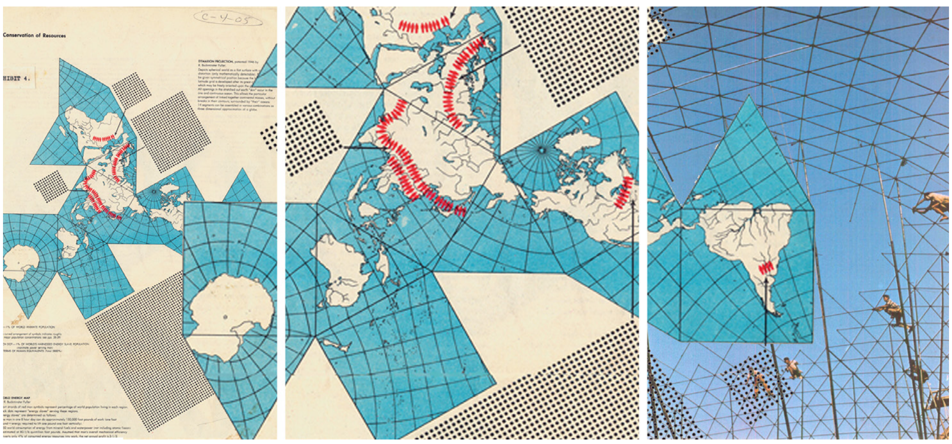

***Figure 1.*** *Fuller's conservation of resources map and geodesic domes (Collage Eda Yeyman, 2024b). Retrieved from: https://www.e-flux.com/architecture/structural-instability/208706/insecure-predictions/ and Díaz, E. (2014b).*

es from transitions between subatomic dimensions and planetary scales. By redefining scale as both an operation of thought and a navigable plane, I aim to explore how scale mechanisms can inspire alternative approaches to architectural thinking and making. Hecht's (2018) observation that "scale is messy because it is both a category of analysis and a category of practice" highlights the dual nature of scale. This insight suggests that our examination of scale often operates within established frameworks, without questioning their underlying assumptions. As both Hecht (2018) and Horton (2021) note, when applied to the humanities, scale can move beyond a field of analysis or criticism and become a new horizon for thought. Building on Horton's approach in *Cosmic Zoom* (2021), I propose understanding scale as a sequence of *relational dynamics*, emphasizing its role as a *process* that operates along a spectrum, before fixed identities are established. The scalar mediation process occurs in two stages. The first is framing, which involves gaining access to other scales through knowledge and technological means. This framing corresponds to the stabilization of scale, giving rise to certain *milieus*[3] (Horton, 2021). The second stage is differentiation, where ongoing distinctions among elements lead to the formation of entities at new scales. In a *metastable*[4] milieu, the stabilization process is temporary and serves to create a framework that defines the scale. This perspective suggests that predefined boundaries are not permanent and that our perception of the world can shift, enabling us to relate to other domains or fields through scale. In other words, each discipline manages scale differently. As Horton (2021) explains, each trans-scalar entity has its own navigation system, allowing it to focus on specific details while remaining unaware of others, thus highlighting the selective nature of perception. For Horton, this selectivity corresponds to *resolution*—disciplines are constrained by the resolution of scales, meaning each discipline selects a scale as its resolution of choice. This understanding of scale blurs the boundaries between disciplines, serving as a *surface of mediation* between encounters.

If disciplines divide the world into scales and produce knowledge at those boundaries, any transition between disciplines—whether it corresponds to different dimensions of scale—inevitably involves a shift in scale and the discontinuities and jumps mentioned earlier. This highlights why a new understanding of scale presents opportunities for architecture: by enabling the creation of new relations each time, it brings together various fields of knowledge, disciplines, and scales to *reconstitute their contiguities*.

Therefore, I propose viewing scale as a *mediating surface* and suggest that exploring the jumps and interconnections between scales can stimulate creative production, fostering new architectural thinking that emerges from transitions between subatomic dimensions and planetary scales. To make these scalar jumps visible, I use the concept of *verticality*, which encourages an architecture that can involve different speeds and temporalities simultaneously, and therefore suggests the continuity of the design process to encompass effects that have not yet emerged but could arise over time. This approach examines how spatial construction practices—shaped by a non-cartographic scale and starting from micro-subatomic configurations—can influence contemporary architectural practice.

As a case study to explore verticality, I propose re-reading the works of Philippe Rahm, who investigates transitions between micro and macro scales—from entropy to architecture—and navigates across these scales by holding together distinct levels of organization through translation. Moreover, by employing the concept of the 'dynamic whole,' Rahm integrates the evolving characteristics of environments over time, aligning precise interventions with the unique properties of each scale. I suggest that the significance of design lies not in its scale but in its ability to engage with heterogeneous flows and intelligences, positioning architecture as an interface that fosters immediate contiguities across disciplines and scales. By re-reading Philippe Rahm's built projects, I aim to investigate what discourse alone cannot achieve and expose the gaps between theory and practice, thereby highlighting the limitations of discourse's creative capacity within architecture. Treating practice as a mode of research, this exploration seeks to uncover new possibilities in the interplay between theory and practice. A critical component of this endeavor is defining the frames for this re-reading, as these frames are designed to catalyze new approaches to architectural thinking and making. The following section will first outline the theoretical background underpinning these frames, followed by an analysis of Philippe Rahm's work.

## 2. Reconstituting the contiguities

The functioning of scale as a mediating surface between different domains is only possible through the establishment of new forms of communication between them. For Serres et al. (1983), this communication entails "traveling, translating, and exchanging"—in other words, passing into the site of the Other. What Serres ultimately seeks is the universal possibility of translating any thematic into another. The key question, then, is: how does one enter into communication through architecture itself? I believe this can be achieved through a more holistic approach to architecture and by incorporating "other forms of making" that consider how to translate diverse voices in the design process. These "other forms of making" necessitate stabilization processes—like scalar mediation does—which I will refer to as *frames* in this article to establish immediate contiguities.

In this context, I propose that thermodynamic theories offer a valuable framework for addressing contiguities between *disciplines (Frame 1)* and *scales (Frame 2)*, enabling interscalar jumps like Fuller's approach. Within the realm of complexity theories, thermodynamics has gained prominence in architecture due to a shift from reductionist analyses toward systems operating "at the edge of chaos within an order" (Fraser et al., 2005). These theories emphasize the significance of systems capable of generating far-from-equilibrium states and producing multiple outcomes over time, which have profound implications for architecture.

Kugler and Shaw (1990) argue that examining a system at the moment of individuation reveals impacts across various scales, not just one. Similarly, Prigogine and Stengers (1984) demonstrate that while microscopic elements function independently under equilibrium, they collaborate under non-equilibrium conditions at the macroscopic level. Although this coordination is not uniformly coherent across scales, it suggests that changes at the subatomic level can influence broader configurations. This implies that understanding and intervening in a system requires consideration of multiple scales. Changes occurring at a single scale are insufficient to grasp the full complexity of the system.

Thermodynamic principles, therefore, provide not only a richer understanding of scale but also openness to multiple futures, unforeseen time-space outcomes, and non-linear cause-effect relationships. These principles appear to have the potential to connect and extend beyond their immediate scale, suggesting their relevance for architecture, which often operates on the edge of instability.

For some architects, the principles of thermodynamics and the behaviors observed at the subatomic level "signify the emergence of an architecture capable of integrating the microscopic and atmospheric, the biological and meteorological" (Daniell, 2013). Thermodynamics not only facilitate connections between disciplines like architecture, physics, and biology but also enable communication across scales. However, when we discuss scale across disciplines, the dialogue often becomes fragmented, contradictory, and confused. Expanding architecture's interactions with other disciplines should not merely aim to establish mutual understanding but should instead foster relationships that reconstitute contiguities in response to current architectural challenges. Much like scale, architecture itself could serve as a *surface of mediation* or an *interface* between encounters, as Fuller suggests.

Fuller proposes that we design spatialities that act "at once as interfaces and placeholders for very different kinds of intelligence" (De la Cadena & Blaser, 2018). By this, Fuller does not mean that each architectural project should form a microcosm within itself. Instead, he advocates for spatial practices that better connect with the world's flows, striving to view the world as an interconnected whole. For Fuller, architectural thinking itself becomes an interface, where the significance lies not in the scale of design but in its capacity to engage with heterogeneous flows and intelligences operating at different speeds.

Building on this, the third frame of analysis is *temporality*, which emphasizes the continuity of relationships with a metastable world—whether these connections occur as one-time events or repeatedly *(Frame 3)*. This distinction significantly impacts architectural design across various scales. To explore this difference, I will examine Philippe Rahm's architectural and landscape projects, particularly focusing on how landscape projects, with their ability to engage more temporal layers, may produce more active interventions than architectural ones. Rosalind Krauss' essay *Sculpture in the Expanded Field* (1979) will serve as a framework for expanding the boundaries of architectural design. This approach shifts the focus from predefined categories, encouraging architecture to exist "*on the periphery*" and embrace new possibilities.

Krauss (1979) diagrams the relationships among the various disciplines in the newly expanded field of architecture, contextualizing 1960s sculpture with landscape and architecture for the first time. Similarly, combinations of architecture with landscape, biology, and program can create new forms that, while not exactly architecture, provide a productive way to engage with these external fields (Vidler, 2004). By the 1950s, this avant-garde nomadism had become exhausted, leading sculpture to explore domains outside of itself. This exploration resulted in forms that were neither sculpture, landscape, nor architecture. Examples include combinations of "*landscape*" and "*not-landscape*", such as Robert Smithson's 'Spiral Jetty' (1970) and Michael Heizer's 'Double Negative' (1969–70), as well as "architecture" and "not-architecture," exemplified by the works of Richard Serra and Robert Irwin, among others. As Krauss (1979) argues, each instance of these axiomatic structures involves some form of intervention into the actual space of architecture. Instead of choosing one side in these diagram structures that operate as opposites of each other, Krauss (1979) aims to expand the field of architecture by making it possible to be on the peripheries of this diagram; in this context, sculpture and landscape emerge as terms that can be on these peripheries, among other differently structured possibilities. Another significant aspect addressed in the article is that Krauss (1979), in expanding the field of sculpture or landscape, benefits from the examples involving *'other forms of making'*, which could be seen as a reason for this expansion.

From this perspective, the architect bears the responsibility of employing "other forms of making" to establish contiguities that address contemporary architectural challenges and better connect with the flows of the world, regardless of the design's scale. In other words, while architectural and landscape architecture projects may differ in their capacity to engage with various speeds and intelligences, the role of the designer/architect remains consistent.

The architect acts as a *translator* of the diverse voices of disorder in the world, navigating across different vocabularies to foster communication between disciplines. An architecture capable of translating these voices can encompass multiple scales, from subatomic particles to galaxies, reshaping spatial construction practices and functioning as an interface between the world's multiplicities. The central question, then, is: how can architecture infiltrate and engage with this complex, blurry domain of multiplicities? The following section will explore the architect's role in addressing this critical challenge.

## 3. Unfolding the vertical

Architectural practices that incorporate complexity theories or thermodynamic principles—grounded in the micro-subatomic layer, quantum physics, and entropy—redefine architecture as a form of action that emerges when the world shifts away from equilibrium. For architecture to effectively intervene at any scale, it must first reconstruct the "given" by establishing a new plane of operation. According to Debaise (2012), this plane arises from individuation processes within ongoing experiences through practices and cuts. The ability to abstract a segment of these experiences allows for the creation of a temporal and spatial plane that fosters further development. This plane is essential for architecture to act as an interface, enabling inter-scalar interventions and jumps—the core focus of this article. While Barad (2007), Horton (2021), and Ruyer (2016) conceptualize this plane differently—*as agential cut, resolving cut, and verticalism,* respectively—they all assign a similar role to architects in navigating and shaping these processes.

For Barad (2007), making the cut -*agential cut*- is essential for navigating our relationship with the multiplicity of the world. In her framework of agential realism, the agential cut does not mark a fixed boundary between subject and object. Instead, it refers to the active and contingent processes through which distinctions between subject, object, and the agencies of observation are enacted. For Barad (2007) these boundaries are not pre-existing but are created through specific material-discursive practices. Therefore, agential cuts are momentary stabilizations that define what is included or excluded within a phenomenon in a single action. According to Barad (2012), these cuts do not represent an absolute separation but rather a simultaneous "cutting together/apart," holding together disparate elements while distinguishing them. Barad questions how knowledge is produced and how reality is perceived through these cuts, describing them as spatiotemporal dissolutions. This perspective fundamentally shifts our understanding of how boundaries, distinctions, and entities emerge. It emphasizes the inseparability of observation, matter, and meaning, advocating for a more integrated and entangled view of the world.

This holistic approach and the process of the agential cut closely resemble the scale mechanisms discussed earlier. Building on Barad's (2012) concept, Horton (2021) introduces the idea of the "*resolving cut*," which stabilizes scale domains through a process of negotiation, isolating a specific scale by anchoring a segment of the scalar spectrum. It accomplishes this by using a medial apparatus to determine which features become readable or legible for the assembly being cut. A resolving cut not only differentiates time and space within the spectrum but also establishes a connection between two distinct parts of it, creating fundamental ontological differences by resolving the separation between the surface of observation and the surface where trans-scalar details emerge. Horton (2021) explains this process using the metaphor of a *scalar lens*. For Horton (2021), each discipline acts as a scalar lens, shaping how certain objects are resolved and understood. While knowledge producers can observe and measure the scale of objects, this capacity depends on a prior disciplinary resolving cut that defines the boundaries of inquiry. This cut delineates the scale, isolating specific assemblages or components as distinct, individuated objects. Horton's (2021) framework suggests a move away from rigid disciplinary boundaries that traditionally shape resolving cuts, emphasizing the interconnectedness of all assemblages. For Horton (2021), although all disciplines engage in the process of making resolving cuts, the posthumanities play a unique role. They critically challenge these resolutions and weave the cuts into dynamic and transformative constellations, fostering a more holistic approach to understanding scale as both an ontological difference and a construct of knowledge.

Both Barad's (2012) and Horton's (2021) ideas align with Ruyer's (2016, 2018) concept of verticalism by addressing the construction of knowledge, including momentary stabilizations, visibility, and the establishment of connections between two distinct parts by holding them together. However, unlike Barad (2012) and Horton (2021), Ruyer's verticalism (2016, 2018) describes this 'holding together' by referencing the developmental stages of organisms, which are intrinsically tied to time, and how they sustain themselves as wholes, offering a new approach to the design of systems that embody these properties.

Ruyer, a philosopher influenced by Simondon and deeply engaged with science, biology, and informatics, perceives matter as an activity, thus making matter and time inseparable. This perspective raises critical questions about the processes of individuation that constitute the cosmos—processes inherently marked by varying developmental paces and the challenge of distinguishing forms along lines of continuity. Ruyer (2016) explores these processes of individuation through the morphological analysis of organisms. However, rather than treating an organism as a complex machine with pre-formed parts operating within fixed circuits of interaction, he envisions it as a self-building entity with intrinsic unity. Ruyer (2018) emphasizes that without incorporating a vertical dimension—a layer that allows for the observation of coexisting developmental stages—the processes of morphogenesis in living organisms cannot be fully understood. According to Ruyer (2018), an organism can function even during stages where it lacks the necessary parts for the functioning of the completed machine. He illustrates this with the example of a human embryo developing its brain, heart, and lungs simultaneously, which also manages to survive while 'building' the brain, heart, and lungs—organs without which it cannot live once it is born. He argues that this is possible because the process is a goal-directed activity along a continuous line of development and more importantly, he describes wholeness as a dynamic concept.

To illustrate this, he uses the metaphor of a melody, arguing that a melody cannot be fully understood by isolating and analyzing individual notes. Its unity emerges from the temporal interplay and relational coherence of those notes, with each note gaining meaning within the context of the melody's overarching structure. This structure unfolds over time yet is experienced as a complete, meaningful whole. This idea underscores that even in temporal processes, unity can persist throughout their duration. More importantly, it highlights that wholeness is an experienced phenomenon that resists reduction to mechanistic parts, fundamentally altering the part-whole relationship.

This paper employs Ruyer's (2016, 2018) concept of *verticalism* not only because it introduces the notion of a *dynamic whole* but also for its implications for systems exhibiting such properties. First, by resisting reduction, verticalism acknowledges the discontinuity among coexisting developmental stages within a system and proposes different interventions for different scales. Second, due to its intrinsic unity, it facilitates translation between distinct organizational levels across the vertical cut.

This dynamic whole is non-reducible to its parts because each part participates in the whole directly and fully, contributing to and being shaped by its internal coherence. Consequently, the frontiers of intervention in systems spanning multiple scales also become non-reducible. Negarestani (2014b) suggests that instead of extending the constructive potentials of upper levels directly to lower ones, designers should identify equivalent manipulation conditions from macroscopic levels at the microscopic scale. In other words, the rules of manipulation and function cannot be overextended from one level to another due to the discontinuity between organizational levels. This discontinuity necessitates precise interventions aligned with the unique properties of each scale. Negarestani (2014b) therefore argues for the simultaneous deployment of top-down and bottom-up approaches, along with the *realignment of various models of intervention* in relation to one another. This realignment entails not only addressing individual scales but also navigating across them. In this context, a vertical layer plays a crucial role by revealing each 'note' (in the metaphor of melody), fostering communication that maintains coherence over time and holds together distinct levels of organization within a system. For Serres et al. (1983), this communication occurs through "translations," where each synchronic cross-section carries its own conditions of translatability. Importantly, the process of translating one system into another does not collapse the entire vertical cut into a single unified system. Instead, it unveils the distinct 'notes' within the broader system, preserving their individuality while sustaining overall coherence.

These implications of verticality provide new approaches to architecture by fostering designs that can accommodate different speeds and temporalities. The

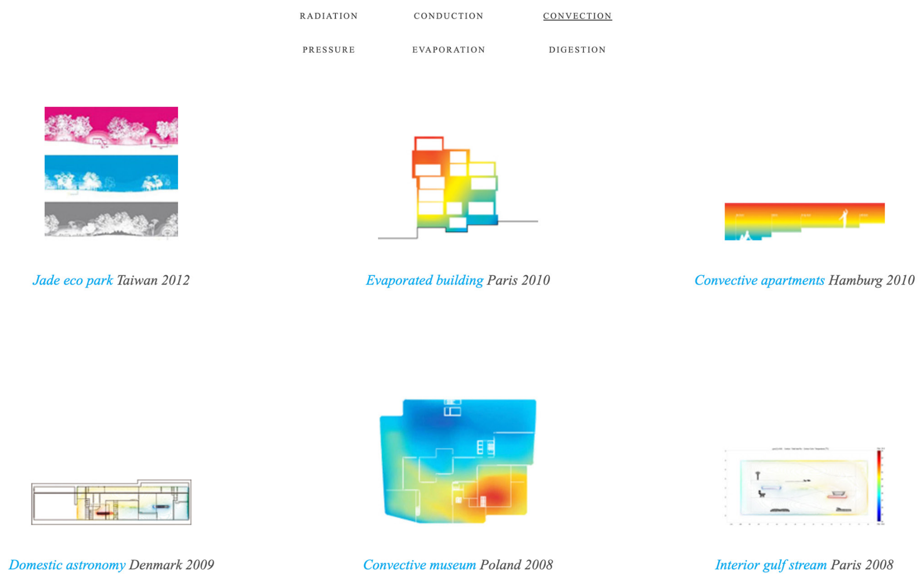


***Figure 2.*** *Phillippe Rahm's categorization system. (Rahm, P. (n.d.). Retrieved from http://www.philipperahm.com/data/convection.html).*

translation of different 'notes' enables architecture to integrate the dynamic characteristics of environments over time, while the realignment of interventions across scales creates an architecture that serves as a mediating surface between various scales and disciplines, enhancing its inclusiveness. This understanding transforms the design process by broadening it to include effects that have not yet emerged but may develop over time, as suggested by Ruyer's (2016, 2018) concept of the vertical. The design process must remain open to heterogeneous flows that influence it at various moments and, crucially, be capable of translating these encounters. In this context, Negarestani (2014a) uses the term '*re-cut the world*' to highlight the continuity of the design process: '*re-cut the world to allow for the constitution of new events, new materials, new construction methods, and new scales.*' This re-cut entails re-engagement and reinvention whenever a difference arises in the 'dynamic whole,' a challenge that is far from straightforward in practice. Its implications for landscapes and architectural projects will be explored in the next section.

## 4. Re-reading climatic singularities: Philippe Rahm

In this section, two works of Philippe Rahm; IBA Hamburg-Convective apartments (2010) as an architectural project and Jade Eco Park (2018) as a landscape project; will be explored as an analysis model where the interscalar conditions of architecture are made more evident, highlighting those who dare to make these jumps and connect the configuration of the subatomic level with architectural design methods. These two works were chosen for their ability to establish relationships with diverse data by translating multiple voices across different ranges and for the distinct approaches they offer to the question of how to enter into communication through design.

Rahm (2009) uses thermodynamics to create architecture that is open to multiple futures, with non-linear relationships across different scales. His designs are based on climatic data—an invisible, metastable parameter—and navigate between sensation and phenomenon, as well as between neurological, meteorological, physiological, and atmospheric factors. Rahm (2009) advocates for a shift from conventional design thinking based on composition to one that embraces thermal, structural, and climatic considerations, moving from narrative to meteorological fields. He integrates air currents, air quality, temperature variations, and human physiological responses, creating spaces that interact with measurable human characteristics such as melatonin and erythropoietin. This approach forms an interscalar architecture that functions as an interface between the human body and space.

Rahm (2009) asserts that air, light, and humidity are the core elements of his meteorological architecture, with principles like convection, conduction, and diffusion guiding his design. His works deviate from mainstream architectural programs, scales, or typologies, resulting in air-conditioned spaces that serve as a second meteorology, triggering sensory exchanges between body and space. (Figure 2).

Rahm (2015) designs microclimates to differentiate spaces and maintain human homeostasis. For example, users can move between temperatures ranging from 12°C to 28°C, with variations based on movement, clothing, nutrition, or social context. According to Rahm (2015), all solutions ensuring homeostasis are architectural, with space differentiation guided by corresponding tectonics.

In this context, Rahm, through his successes and limitations in these two projects, addresses the question of what happens when architecture is considered on a micro scale and how it affects architectural thinking and practice. He aims to incorporate the dynamic characteristics of the environment into his design decisions, as changes in comfort conditions will also alter the atmosphere he creates.

After this brief introduction to Rahm's design approach, the table below provides descriptions and images of the selected projects for this article: Jade Eco Park and IBA Hamburg, before I establish the frames for re-reading. (Table 1).

In this context, I suggest looking at the projects through the frames mentioned in the previous section and re-reading them accordingly: frame 1: *contiguities of discipline,* frame 2: *contiguities of scale,* frame 3: *temporal dynamics.*

### 4.1. Frame 1: Contiguities of Discipline

Philippe Rahm establishes transitions between thermodynamic principles and architecture. His approach involves designing spaces by focusing on micro, invisible, sensory, and physiologically reactive details, achieved through passive systems and emerging technologies. The conditioned interior spaces Rahm creates largely stem from their ability to facilitate new interdisciplinary relationships. Although the data he utilizes primarily belongs to fields like engineering—encompassing electrical, mechanical, plumbing, ventilation, and wireless communication—Rahm filters and translate this information through his unique perspective to construct the space itself by using gradient maps and by reversing the conventional process for architectural design.

In each project, Rahm develops a new topography to connect thermodynamics and architecture. While the specific variables and programs of this "thermal topography" differ from project to project, the underlying concept of topography remains consistent. Rahm (n.d.) focuses on crafting microclimates using gradients and elaborates on the idea of "gradual changes in microclimatic conditions", stating that "there are multiple colors between blue (cold) and red (heat) in the environment, allowing functions to distribute spontaneously across this thermal topography without requiring designer intervention." Therefore, by using "thermal topography" Rahm (n.d.) dissolves conventional structures and programs in architectural design and re-consider the existing boundaries between functions. The production method and the layers comprising this thermal topography are shaped by spatial organization decisions. For example, in the IBA Hamburg project, a single-layer thermal topography is applied in a sectional plane to distribute various functions, while the Jade Eco Park project utilizes a three-layer overlapping topography on the plan to distribute densities rather than specific functions. (Figure 3). The difference between these two projects arises from the simultaneous microclimates intended to be created. In the IBA Hamburg project, the functions have distinct microclimates occurring simultaneously, while in the Jade Eco Park project, it is the people who experience different microclimates at the same time.

What Rahm actually does is inter-

***Table 1.*** *Comparison of IBA Hamburg and Jade Eco Park. (Eda Yeyman, 2024a).*

| IBA Hamburg Apartments | Jade Eco Park |
| --- | --- |
|  |  |
| IBA Hamburg apartments exemplify Rahm's exploration of thermal topography, emphasizing air movement based on the Archimedes principle where warm air ascends and cool air descends. Rahm suggests there could be a difference of up to 10°C between the ceiling and floor in homes, with different programmatic correspondence. Rahm (2015) argues that each room does not necessarily need to adhere to Swiss standards of 20-22°C, instead determining temperatures based on activities and clothing layers. For instance, corridors, where little time is spent, may be maintained at 15°C, while living rooms, where occupants are stationary and clothed, are set at 20°C, and wet areas, typically frequented barefoot, might reach 22°C. Rahm conceptualizes house sections based on these varying needs, adjusting floor and ceiling heights accordingly; sleeping areas might be lower in section, while bathrooms higher, creating a thermal topography where occupants can freely select preferred temperatures throughout the year.<br><br>According to De Rycke and Gengnagel (2017), to achieve this, Rahm manipulates floor horizontality to accommodate diverse spatial requirements, utilizing level differences to guide air flow from lower to upper floors, thus establishing a vertical heat gradient. The circulation system facilitating this vertical heat distribution also functions as an air reservoir, employing a double-flow air renewal system with a heat exchanger. Constructed from eco-cement that absorbs CO2 and pollutants, this system purifies air before entering apartments. Thermal sensors strategically placed outside and within the building monitor air temperature in real-time, adjusting air intake locations seasonally—drawing air from southern, sun-exposed facades in winter and northern facades in summer (Rahm, 2015). Additionally, from landscape to furniture design in the project, choices are made that do not obstruct and degrade the air flow; the heat retention and transport capacities of the materials used are also considered - up to a certain extent. For instance, curtains are installed to prevent excessive heating of the external facade, which is made of triple-glazed glass with a high thermal coefficient. This applies to the furniture used inside the house as well; furniture is selected to not obstruct air flow and is hollow and portable, foldable beds are made of natural wood to absorb excess moisture, and contribute to regulating humidity within the apartment. Landscape elements are also chosen with this context in mind. The building initially takes in air from the outdoor environment with the main wind blowing from the southwest, and before the air enters the building, it is met with feathery-leaved trees placed on the southwest side that can absorb the dust and dirt of the air. "In order to heat the soil and absorb maximum light in the south, almost black, very dark grass is replaced by white-green grass in the north to reflect maximum light and not heat the soil" (Rahm, 2015). Therefore, although artificial climate control elements are used in the project, it can be said that the priority is to reconstruct passive climate control conditions from elsewhere. Thus, Rahm creates a homogeneous space separated only by level differences between circulation and the outer shell. | The Jade Eco Park project is situated in Taichung, Taiwan, developed on the site of a former airport and integrated into a new neighborhood (Rahm, 2015). According to Bullivant (2007), it aims to establish comfortable conditions in an urban environment without relying on enclosed spaces and air conditioning The park's objective is to mitigate Taichung's extreme subtropical climate, ensuring a refreshing experience for residents and visitors. 'The park's climate has been adjusted to be cooler (shaded areas), less humid (by reducing airborne moisture and safeguarding against rain and flooding), and less polluted (incorporating filtered air free from gases and particulate matter)'(Garcia, 2014).<br>While Rahm's goal of atmospheric modification aligns with his other projects, implementing such changes across a large area is impractical. Therefore, Rahm initially identifies and enhances naturally cleaner (far from traffic), cooler (exposed to northward cold winds), and drier (protected from southwest humidity) areas. To achieve this, Rahm models existing climate conditions and uses fluid dynamics simulations to establish a three-tiered climate map. Each map primarily features variables like temperature fluctuations, humidity levels, and air quality. According to De Rycke and Gengnagel (2017), by overlaying these maps, Rahm identifies the park's coldest, driest, and cleanest zones. Here, specially designed artificial 'Climate Devices' and broad-leaved trees are strategically placed to cool, dry, and purify the air according to specific climatic profiles. The artificial Climate Devices represent the most controversial structures in the project; they can simulate rain, provide warmth via infrared light, function as fountains to cool surroundings, or act like clouds to cool and cleanse the area with water vapor (Rahm, 2015). Additionally, guided by these simulation models, the park is segmented into 11 zones, each tailored with programs suited to its unique climatic conditions. These three maps are continuously updated in real-time throughout the day and year, without reliance on static simulation models. Users access these maps through an application to select their preferred climatic conditions in the park at any given time.<br>Furthermore, the park strives to minimize energy consumption by adhering to passive climate control principles. For instance, electricity is solely used for fans to circulate air, and the park has the capacity to generate its own electricity. |

pret and transform heat maps; in other words, the act of transforming a map into a space is, in essence, a process of translation. In the IBA Hamburg project, he approaches this task by examining the relationship between heat and height, determining the placement of both heat sources—such as radiators—and functions based on the principle that warm air rises. Rahm achieves this by dividing the floors into distinct zones and adjusting their proximity in vertical sections, thereby creating different microclimates within the same floor. Apart from fixed functions like toilets or bathrooms, decisions about how the house is used are left to the occupants, who interact with the space by moving furniture to different levels according to their preferred temperature range. Rahm designs these floor slabs in relation to radiators positioned at various heights throughout the house. In this context, the height, spacing, and power of the radiators are primary considerations in his design process. Thus, Rahm prioritizes climate-related details—ventilation, radiator placement, humidity con-

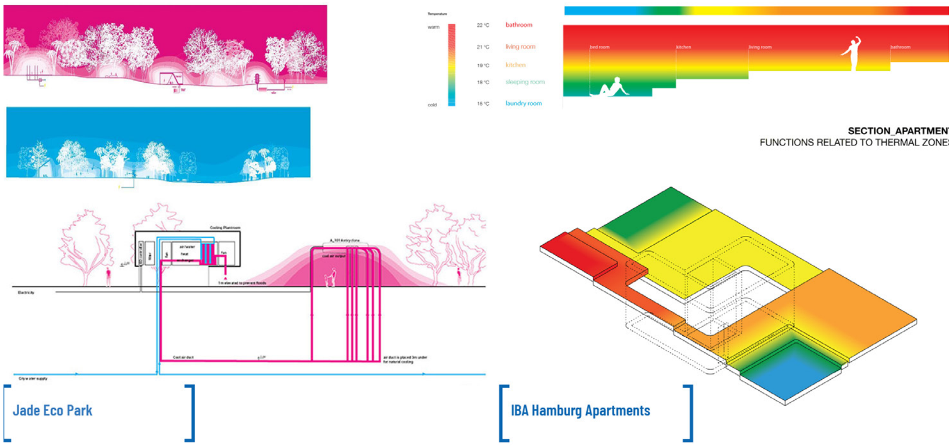


***Figure 3.*** Phillippe Rahm's thermal topographies (Rahm, P. (2010-2012). Retrieved from http://www.philipperahm.com/data/index.html).

trol, and meteorological factors—early in the design process, effectively reversing the conventional design sequence. This reversed approach has become a core design principle for Rahm, evident in nearly all of his projects.

Different than single layer of variable-heat- in Jade Eco Park Rahm focuses on individual variables: the first tracks temperature changes, the second monitors humidity, and the third measures air pollution. These maps depict the intensity of each atmospheric factor across the park. According to De Rycke et al. (2017), Rahm overlays these maps to identify the coldest, driest, and cleanest areas, forming a gradient that delineates maximum atmospheric conditions (pollution, humidity, and heat) while highlighting more comfortable areas where these factors are reduced by various methods. The spacing of the radiators transforms into the distribution of climatic devices in this project. Using these devices, Rahm designs simultaneous microclimates within the park to accommodate different comfort conditions. He argues (2009) that there is no single optimal condition that defines a perfect city or place. Instead, multiple configurations coexist, offering diverse possibilities. This coexistence of varying configurations across time and duration suggests verticality and, more importantly, introduces a new architectural practice based on instantaneous atmospheres. In this approach, spaces are defined solely by comfort conditions—microclimates—while the conventional boundaries of function and program dissolve. (Figure 4).

### 4.2. Frame 2: Contiguities of Scale

When designing contiguities of scales, Rahm consistently revisits the thermodynamic and air conditioning variables specific to each project. These variables are translated through gradient maps, which provide navigation across individual scales—starting from the micro level, such as entropy ($10^{-10}$), and extending to the macro level, including architecture ($10^{2}$) and landscape architecture ($10^{3}$).[5] By serving as a mediating surface between entropy and architecture, and due to the dynamic whole embodied by each project, it fosters distinct bodily interactions at the *meso* scale (such as $10^{-1}$) too. However, Rahm employs a single gradient map for each project, using it as a substrate for decision-making across interior, architectural, and landscape scales. This means there is no secondary mapping focused on different data, suggesting that Rahm may miss the overlapping information between two distinct thermal maps in his design process. For example, in the IBA Hamburg project, since there is no secondary mapping that includes materials' heat retention and transportation capacities, material choices do not vary significantly throughout the project. As a result, spaces with low heat retention are rendered as plain, white surfaces. Additionally, furniture is selected for its open bottoms and portability to avoid obstructing airflow. While this approach emphasizes functional furniture forms, it neglects material

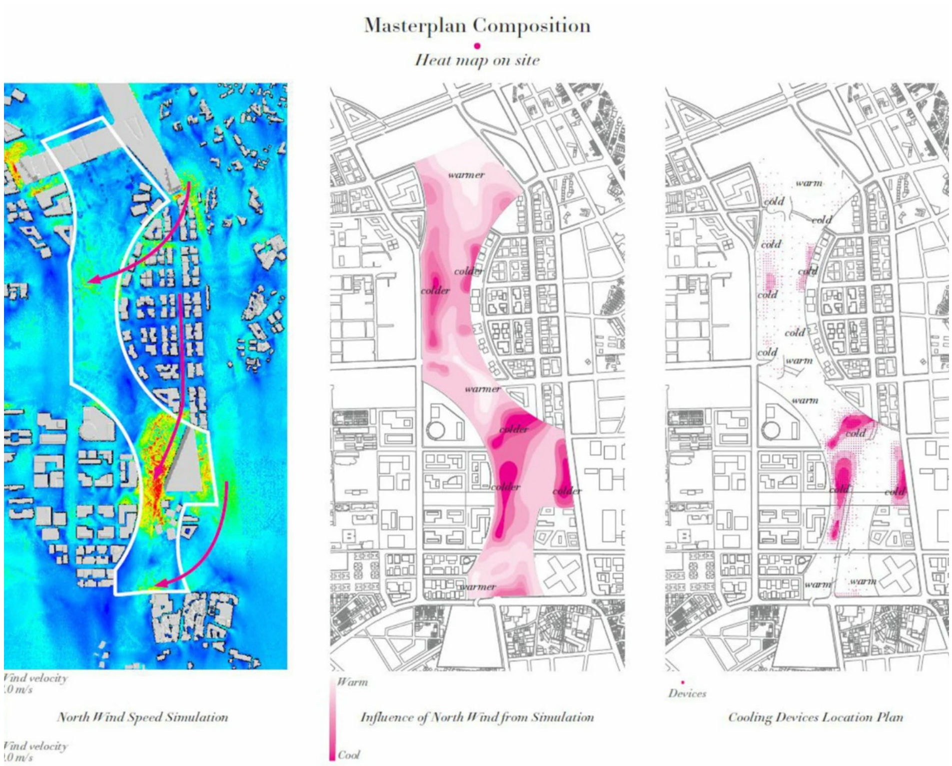


***Figure 4.*** Jade Eco Park's simulation model and Climatic Zones (Rahm, 2012. Retrieved from: https://www.baunetzwissen.de/sonnenschutz/objekte/freizeit---sport/jade-eco-park-in-taichung-8324637/gallery-5/24).

***Figure 5.*** Interior of IBA Hamburg Apartments. (Rahm, P. (2010). Retrieved from http://www.philipperahm.com/data/projects/convectiveapartments/index.html).

considerations, often leading to generic selections. (Figure 5)

However, this is a deliberate choice by Rahm. Instead of extending the potentials of the thermal map to the furniture scale, he chooses a neutral approach that doesn't alter the thermal conditions of the interior. This creates a discontinuity, allowing for precise interventions that align with the unique properties of each scale. Thus, the thermal map applies to the spatial organization, bypasses furniture and material choices in the interior, and shifts to the body scale, triggering sensory interactions with the human body. Consequently, Rahm's methodology does not aim for seamless transitions between scales. This discontinuity is particularly evident in the Jade Eco Park project, a landscape endeavor that creates its atmosphere through artificial and natural air conditioning, effectively establishing a "second meteorology." In an interview with Rahm, Garcia (2014) notes that in Jade Eco Park, Rahm selects plants like Acer serrulatum Hayata for its dense shading properties to reduce heat, Calocedrus formosana for pollution control, and Ficus microcarpa with aerial roots to capture airborne particles for moisture control. These density-driven decisions, informed by thermal maps, aim to balance natural and artificial air conditioning. This approach enables comprehensive adjustments in temperature,

***Figure 6.*** Natural and artificial devices of Jade Eco Park (Rahm, P. (2012). Retrieved from https://www.baunetzwissen.de/sonnenschutz/objekte/freizeit---sport/jade-eco-park-in-taichung-8324637).

humidity, and air pollution across 11 ‘Climatic Zones’ in Jade Eco Park, using a mix of natural methods (like plant and tree selection) and advanced artificial climatic devices. (Figure 6) The density and distribution of climatic devices create spaces that vary in comfort and enjoyment. Climatic properties overlap, diverge, regroup, intensify, or disperse, resulting in diverse atmospheres and microclimates that users can explore and adapt to according to their preferences (Rahm, n.d.).

As in Ruyer’s (2018) melody analogy, the individual function of a single climatic device holds little significance on its own—once removed from the whole, a single device becomes meaningless. What matters is that the climatic devices within the park highlight different features—such as humidity, temperature, or clean air—throughout the process, creating instantaneous atmospheres. These temporal atmospheres then merge into the overall park design, forming a “second meteorology” for the city. The dynamic whole that Rahm achieves here is established through the interplay of artificial and natural elements with differing rates of development. To achieve the intended total effect, Rahm simultaneously realigns various models of intervention and employs both top-down and bottom-up design processes. For example, the overall placement and density of the climatic devices across the landscape are informed by measurable environmental data. Meanwhile, the landscape Rahm designs will only fully manifest in five to ten years, working in conjunction with the climatic devices to enhance or mitigate specific environmental effects. Rahm also designs these climatic devices to interact directly with the human body, creating localized microclimates in real time. Parameters such as pipe thickness and flow distances are meticulously planned to achieve this interaction. In this context, Rahm’s approach exemplifies how the manipulation equivalents of upper-level interventions can be identified or developed at lower levels.

On the other hand, the thermal map and simulation model interact with human comfort indirectly. They rely on general physiological and climatic principles rather than measuring real-time body heat or humidity. The focus remains on monitoring and manipulating environmental factors such as wind, heat, humidity, and atmospheric conditions. Leveraging these variables, the design creates a range of microclimates that allow visitors to choose spaces based on their comfort preferences. Despite this, interaction depends on user decisions, leaving bodily relationships largely unaddressed. Thus, the dynamic whole here primarily consists of pre-defined boundaries established by Rahm at the outset of the design process. Rahm achieves this through both spatial organization and climatic devices. However, better results are achieved when the heat gradient is not confined within spatial boundaries -like in the IBA Hamburg project- but instead transitions from spatial organization to the instantaneous formation of thermal topography through atmospheres, as exemplified in the Jade Eco Park project (Figure 7).

This is essentially analogous to Ruyer’s (2016, 2018) addition of a vertical layer to a fully functioning system, which makes the system’s heterogeneous components visible. This diagrammatic approach renders the measurable data of the space *visible*, thereby opening up pathways for intervention. Initially, this interface was an inaccessible concept in early projects like IBA Hamburg. However, in Jade Eco Park, fluid dynamics simulations make the gradient accessible, enabling users to transition from passive participants to active deci-

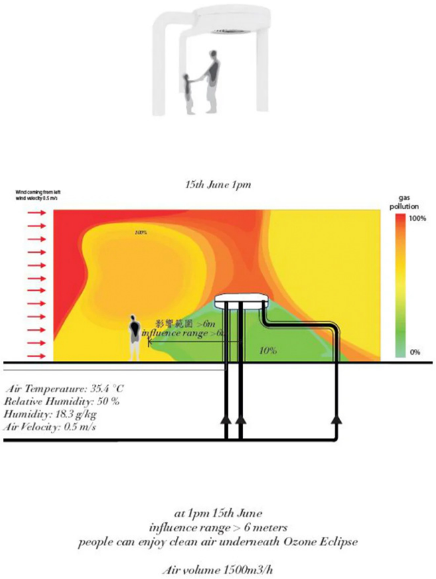


***Figure 7.*** Diagram showing the interaction of human body and Climatic Devices. (Rahm, P. (2012). Retrieved from https://www.baunetzwissen.de/sonnenschutz/objekte/freizeit---sport/jade-eco-park-in-taichung-8324637).

sion-makers. The gradient maps are continuously updated with no fixed simulation model. Users can access the maps via an application, select their desired climatic conditions, and shape their own microclimates. The drawing technique of the gradient map also plays an important role. Rahm's drawings, which incorporate air, light, humidity, and wind as foundational elements, diverge from conventional architectural drawings and are more schematic. Rahm's (2009) exploration of a technical drawing method that aligns with meteorology and physical laws—integrating air movements, speed, water vaporization, pressure, and metabolism—emerged as a byproduct of the design process and establishes a new way of representing materiality. Through these schematic drawings that encompass various variables, Rahm effectively undertakes the translation task mentioned earlier, using drawing as a tool to represent and facilitate communication between diverse data pools. These drawings function as 'communication corridors,' as described by Serres et al. (1983), bridging different disciplines on a unified plane. While the interface effectively visualizes flows, it also has another significant outcome: it homogenizes them, enabling all elements to be viewed through similar values and treated as equivalent. This process blurs distinctions between human and non-human, living and non-living, fostering a more holistic approach to understanding scale—one that is indifferent to the project's size but focuses instead on "holding together" two distinct parts according to the chosen resolution.

### 4.3. Frame 3: Temporal dynamics

Philippe Rahm's approach to time and temporality varies significantly between IBA Hamburg and Jade Eco Park project. In the IBA Hamburg project, the relatively less advanced integration of technology results in a static relationship between biological knowledge and climate standards. As long as the passive climate control systems function as intended, their operation remains unchanged over time. Moreover, these systems do not incorporate user feedback, meaning there is no mechanism to adapt or evolve based on temporal changes. Designed to accommodate seasonal variations, these buildings define how mechanical systems respond to summer and winter temperatures, allowing for limited variation within the constraints of a preconfigured system. To allow for the previously mentioned new configurations, the "re-cutting" process is carried out by users as the seasons change, enabling different levels to be used for various functions based on heat gradients. The homogeneity and neutrality of the interior, along with the mobility of the furniture, become meaningful through seasonal changes.

In contrast, the Jade Eco Park project adopts a more dynamic approach. Unlike the static system of IBA Hamburg project, the park's three maps are updated hourly throughout the year, enabling real-time adjustments based on feedback from park users. This real-time interaction creates a continuously evolving system rather than a one-time setup. Sensors positioned every 50 meters collect environmental data, capturing variations throughout the day and across seasons. By comparison to IBA Hamburg, this project focuses sole-

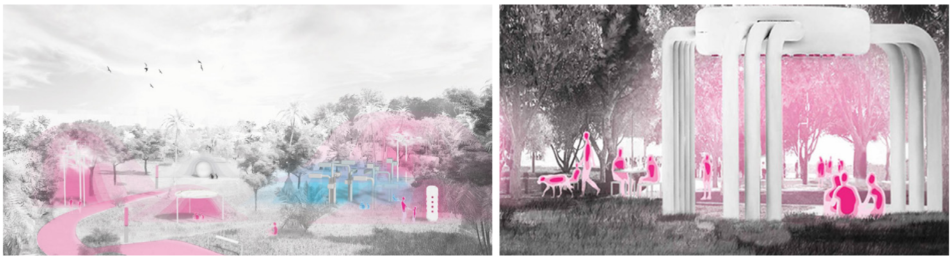

***Figure 8.*** *Instant atmospheres of Jade Eco Park (Rahm, P. (2010-2012). Retrieved from http://www.philipperahm.com/data/projects/taiwan/index.html).*

ly on temporal changes in atmospheric properties such as water vapor, temperature, and oxygen levels. However, it lacks predictive mechanisms for the site or landscape itself, such as changes in tree growth or shaded areas over time. (Figure 8) Notably, the scale of the project—being landscape architecture—introduces additional layers and heterogeneous intelligences, significantly increasing the volume of measurable data and cycles to consider compared to architectural projects. However, what enables intervention in this project is not the scale itself, but the climatic devices that create instantaneous atmospheres. Each new microclimate created is a product of this re-cut and opens the door to new experiences. Even if the dataset used remains constant, it accounts for different speeds and temporalities at the site.

## 5. Conclusion: Re-inventing the frames

At the subatomic level, the way architectural configurations relate to the molecular level challenges the boundaries between theory and practice. Relying on the idea that "the object of research and practice is architecture, and the tool is architecture itself" (Palmesino et al., 2013), seeing what discourse cannot do can only be achieved through the realization of a project.

Philippe Rahm's integration of climate systems with the biochemical dimension creates a good research area for the jumps between micro and macro scales, from entropy to architecture. His architecture becomes an interface sensitive to overlapping cycles and dynamics across disciplines and scales, suggesting that the significance of design lies not in its scale but in its ability to engage with heterogeneous flows and intelligences. This approach aligns with Fuller's concept of total thinking, which perceives architecture as part of an interconnected whole, and parallels Ruyer's (2016, 2018) verticalism, as it evaluates this whole as dynamic and operating at various speeds.

While re-reading Rahm's two works reveals new contiguities through defined analytical frames, it also highlights the limitations of his design approach and what must be sacrificed to embrace instantaneous atmospheres. Although the outcomes of the projects vary, each serves as a prototype. Rahm develops a design approach and multiple prototypes to explore the boundaries of this idea. As seen in this re-reading, Rahm's thermal topography constitutes the contiguities between disciplines and scales, acting as an interface that dissolves structures/programs and eliminates boundaries for free navigation. While this approach is theoretically liberating—shedding conventional meanings—in practice, these spaces, though seemingly open-ended due to gradient maps, must still adhere to human homeostasis requirements for specific temperatures. For instance, Rahm's design assumption of a living room at 20°C and a bedroom at 16°C reflects predicted lifestyle habits, limiting flexibility for users with different preferences. Additionally, every enclosed volume Rahm creates must function as a protected area—like a refrigerator—sealed off from external influences, as the required temperature levels are highly specific and any external interference could disrupt them. This disruption is better managed in the Jade Eco Park project, which focuses solely on generating simultaneous microclimates and atmospheres within the park.

Additionally, while these two frames reveal architecture's ability to communicate a temperature value, Rahm's methodology does not reduce architecture to the behavior and capacities of mechanical systems—reminiscent of the utopias of the 1960s. Instead, it demonstrates that innovative spatial constructs can emerge from such processes, fundamentally shifting expectations for design. In this approach, architecture is defined not by static forms but by the atmospheres it generates and the contiguities it enables through a continuous process of reinvention. However, this re-intervention or re-cut does not occur whenever there is a difference in the "dynamic whole"; it happens only when the project user decides to act. As revealed by the "contiguity of scale frame," this re-intervention is discontinuous—similar to verticality—and constrained in practice. While Rahm embraces Negarestani's (2014a) assertion that "it would be a fatal error to use and apply the same concepts interscalarly," the IBA Hamburg project fails to realign different scales, applying the same construction methods without adjustment as the scale shifts from architecture to interior spaces. In contrast, discontinuity does not disrupt spatial coherence and atmosphere in the landscape project, Jade Eco Park, since the climatic devices generate only instantaneous atmospheres rather than enclosed spaces. Thus, Rahm's success, particularly in Jade Eco Park, lies in his ability to design atmospheres that accommodate varying speeds and temporalities while employing a design process capable of integrating the dynamic characteristics of environments over time. By providing visibility into these dynamics, he presents a distinctive model for architectural practice—one where architecture acts as a mediating surface between various scales and disciplines, enhancing inclusiveness. Rahm's greatest achievement may be his resistance to reductionism and his redefinition of the part-whole relationship through the concept of verticalism. By recognizing the dynamic whole, he establishes communication networks between different systems and creates "communication corridors" through the act of translation or by producing interfaces that facilitate such exchanges.

To conclude, this re-reading suggests examining cases by initially establishing frames like scale dynamics, only to break them during the reading process. Because these frames make things visible -like different resolutions- and enable them to communicate with each other only when they are established. The aim here is to capture the slipperiness and movements that can construct contiguities to the current challenges of architecture and theory, and to construct a design process that can include this without giving up on constant re-intervention. Architecture, as the outcome of such a process, facilitates a deeper connection with the world and enables scale jumps through the creation of diverse interfaces. Here, the power of practice stems from working with theory as relays, 'practice is a set of relays from one theoretical point to another and theory is a relay from one practice to another' (Stengers, 2017). Therefore, the outcome of this research is not the reading method itself or the model for practice mentioned here, but rather critical self-reflection and a thinking tool that can be shared with others to enhance architectural knowledge. Because as Haraway (2020) posits, 'there are only a myriad of unfinished configurations of places, times, matters, meanings. Therefore, creating new conceptual frames, that encompass a world in flux—from subatomic particles to galaxies—and nurture spatial construction practices, depends on initially viewing architecture as a field that fosters interactions and then re-inventing the verticality which will bring new meaning to our relationship with the world that is at the edge of disequilibrium.

## Endnotes

[1] *Interscalarity* in architecture refers to the interaction and relationships between different scales, particularly when considering how design elements operate and relate across various levels—from the subatomic to the architectural scale and beyond. The concept emphasizes how changes at one scale can influence others and how architectural thinking must account for the dynamic interconnections between these levels (see Horton, 2021).

[2] (see Krauss, 1979). Sculpture in the expanded field. *October, 8,* 31-44.
[3] The term *milieu* refers to the environment or surrounding context in which a phenomenon or interaction occurs. It can describe the material, social, or spatial environment that influences behavior, perception, and experience (see Prominski, 2014).
[4] 'Metastability can be understood as intrinsically delayed expenditure of potential energy' (see Rosanvallon, 2012).
[5] These values are defined based on the network graph of interscalar connections in *Powers of Ten Interactive* (1999) within the *Cosmic Zoom* (see Horton, 2021).

**Acknowledgements**
This article is based on the ongoing PhD research titled "Architecture as an Open Field of Interactions," conducted under the supervision of Prof. Dr. Ayşe Şentürer in the Architectural Design PhD Program at the Graduate School of Istanbul Technical University.

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