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# The Affective mesh: Air components 3D Visualizations as a Research and Communication tool

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**KEYWORDS** *3D mapping, Air quality, ambient, environment monitoring, innovation and design, sentient, ubiquitous*

**ABSTRACT** The analysis, management, and interaction with air pollution data has been generally relegated to experts based at scientific or government institutions. There is an increasing need to make such air-related data public; where air-related data has been obtained visualizations have emerged all over the world dealing with air quality representation. The aim of this paper is to make a historical review of air quality cartographies and then to analyze these visualizations from different perspectives. Our objective is to deploy this review and analysis to cover the following topics: To whom is the information addressed and toward what purpose? Which kind of graphic and physical interfaces are being used? What are their properties, opportunities, and shortcomings in terms of communication effectiveness?

We believe that the objective of these visualizations is to produce not only information, but behavioral change in citizens; thus, a shift in visualization strategy needs to be taken. Within this context our paper presents the project *In the Air,* developed by a multidisciplinary team through collaborative workshops. The aim is to test some of these new strategies, e.g., 3D maps as interactive interfaces. The digital application of *In the Air* captures Madrid City Council's monitoring stations data, allowing not only the capability to see the density of pollutants (PM10, NO2, SO2, CO, O3) at a certain time and place, but also the analysis of historical data, to see their evolution in time, and to recognize the urban fabric. The goal of the project is to explore the 3D visualization as a tool for research that permits the intensifying of communication between scientists, institutions, and citizens, while opening up their capacity of interaction and decision making with the information exposed.

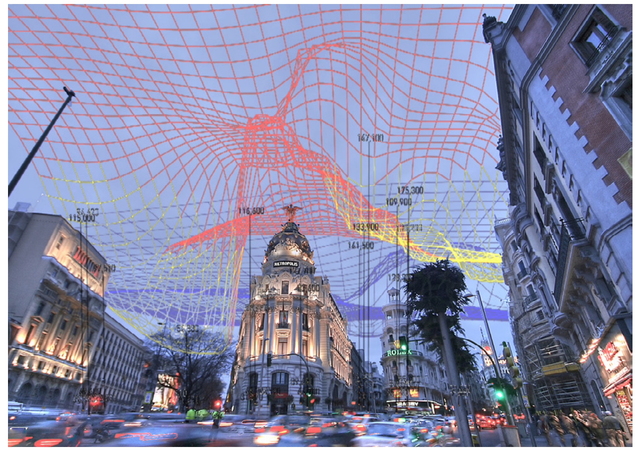

FIGURE 1: *La Gran Via of Madrid with its particle's data cloud.*

## INTRODUCTION

Air has been mapped in many fields, predominately over the course of the 20th century. It has been divided and depicted worldwide by the aviation discipline, which applied maritime cartography knowledge to the conquest of air routs and space, initially for military purposes and then for commercial ones. It has also been partially described through the migration of birds and, with great precision, through the development of meteorology. In the field of physics gases have been modeled at a microscopic level in order to ascertain how they flow and evolve, at an intermediate level these modelings are being developed to visualize air's movement and quality, for example, within the interior of buildings.

This study is centered on outdoor air, focusing on its microscopic components. These components describe a "natural-artificial" system: where pollen particles live together with heavy metal particles, sensors live with vegetation, and public institutions coexist with independent collectives. This kind of air is monitored, analyzed, and managed by what is usually called "air quality" studies. However, since air quality implies a hygienic, scientific, and/or medical analysis, we focus on the "composition" of air in order to better understand it as an ecosystem.

We are interested in getting to know the behavior and functioning of these natural-artificial entities in order to understand their relations with the city, particularly in the case of the channels between the human, the natural, and the artificial: windows and ventilation. Windows are portals of communication between human and non-human agents which permit their participation in the system. Depending on their accessibility and usability, these windows will be more or less open to civil society, and will allow the decisions concerning the air to be more or less participatory.

Even though there are many types of windows or air visualizations, in this text we shall focus on maps, since they are, for the moment, the most extended practice and they hold enough points of agreement to enable a transnational comparative of strategies and formats.

How can the mapping of this system have the effect of consolidating precise relations between nature and society, demarcating spaces and (in)appropriate relations for the interactions between humans and non-humans, even though these effects may not be predetermined or permanent? It is clear that some of the air compositions produce territories within themselves, as has occurred with the radioactive particles in Chernobyl and, more recently, in Fukushima. What kind of territoriality do these air maps create—what kind of temporality emerges?

After a brief overview of the history of air mapping, four typologies of maps will be revealed. We will take a deeper look into tridimensional maps and then, more specifically, into *In the Air project.* Finally, we shall outline the new space-time relations that these maps pose in order to understand how these maps serve as organizing tools, analysis instruments, and powerful images with rhetorical power that build the territory.

## HISTORY OF MAPPING MICROSCOPIC COMPONENTS OF THE AIR (AIR QUALITY MAPS)

In 1914, we find the first geo-localized map demarcating the detection stations of London.[1] Considering that the processing and comparison of data could take over a year, the measuring instruments are the first things to be mapped out for the institution's organizing purposes. A later map, from 1930, describes the institutions involved in the fight against pollution in the United Kingdom.[2] This institutional map is groundbreaking in the sense that it identifies the close relation between humans and non-humans, as well as the relevance of the institutions involved in the fight.

The technological expansion of the 1970s enabled the development of basic technological instruments for geospatial measuring. Aerial photography, deployed during the First World War and perfected during the Second World War, made it possible to have a "complete" register of the land territory. The first satellite was placed in orbit in 1966, and from that moment on they have been key instruments for the systematization and automation of land observation and, more recently, for the analysis of air.

By the 1970s, from the social point of view, the concern for the quality of air in cities increased. In this context we see the creation of the Clear Air Act,[3] a pioneering law that defined the responsibility of the Environmental Protection Agency (EPA) to protect and improve the air quality in the United States. In Europe, the concern for air measuring is regulated in 1978, requiring all the cities with poor indicators of contamination to measure systematically.

In the mid 1980s, Graphical User Interfaces (GUI) first appear, although it took them ten years to have an impact in the digital world through the Geospatial Information Systems (GIS). This technological development and the emergence of the internet resulted in the cross-over between the categories of producer and user of cartographies, giving rise to the era of what has been called the "democratization of technology,"[4] this also fractures the relation between display and impression; and the emergence of animated maps that introduce time as a fundamental and necessary dimension in territorial descriptions.

Digitalization has allowed real time governance over the atmosphere. This technological change has also involved, as Mark Whitehead suggests, a change in air management—whereby manual networks, once dependent upon scientists and technicians to gather and analyze the samples through physical processes gave way to automation. This delegated the responsibility to the government (and, more recently, to the public) who are now primarily in charge of constantly monitoring and automatically analyzing the data. There has also been a shift in the function of monitoring, for there is not only a need to analyze and, perhaps, manage the air quality knowledge, but there is also a need to prevent the worst possible consequences that air contamination might produce.

In 1989, the Aarhus Convention, proposed by the UN's Commission for Europe, intended to "grant the citizen's rights to access environmental information and guaranty a broader public participation in the sustainable development of cities."[5] Information was proposed as a tool to achieve behavioral changes and political implication. In 1992 a European regulation established the requirement for public administrations to make public the data obtained by measuring stations.

In the 1990s the technological development of automatic networks of detection, together with the "open data" policies of the institutions gave way to a new era in the access to environmental information. In the first decade of the 21st century those data have been public and they have produced a change in the social relations with the citizens. It is at this point when many windows open wider. The medium is more social, more ubiquitous and mobile, personal maps emerge, and the neutrality of the image is put into question.

From this moment on, a massive emergence of institutional map production takes place. The intention is to communicate the air quality to the citizen and, in some cases, educate and complete that data with information from the emitters, the health implications, etc, resulting in a process of citizen information-education that has not appeared previously with other urban systems.

In 2008, the European Union recommended the modeling of contaminants, which lead to the multiplication of centers for research and enterprises dedicated to the design of different models of geographical distribution and prediction. Simultaneously, the digital analysis of satellite images has evolved and complements the information obtained by direct measuring and simulations.

Since approximately 2006, there has been a proliferation of companies, research groups, and artistic projects, whose common aim is to measure, represent, and communicate air independent of public institutions. These entities "fill-in" all the gaps that the latter have neglected in order to build a more complex maps of the "air business".

As maps may be understood as assemblages of agents which include people, discourses, and material elements, different assemblage typologies have been considered in order to better understand what these maps really are—what one can see through them, who is communicating, who they belong to, etc.

For this reason we have reviewed the international scene and analyzed in detail the city of Madrid as a case study. Four different types of assemblages have been identified, whose main difference is the geo-referenced object: the points of detection,[6] statistics,[7] image,[8] and experience. They do not follow a lineal order through time or an evolutionary perspective; we can find all of them working simultaneously nowadays. In this occasion we will focus on the last group: maps that geo-reference experience.

## TRIDIMENSIONAL MAPS OR GEO-REFERENTIAL MAPS OF EXPERIENCE

Maps that reference points of detection, statistics, or image have, in general, a scientific strand, in the sense that they solely show information provided by sensors and models. Further, their design is generally orientated to enhance clarity in the representation of that information. However, certain proposals that experiment with the communicative capacity of these maps seek to obtain deeper implications or more intense participation on behalf of the users emerging.

One of the strategies explored in these kind of maps is the use of tridimensional models, these models allow the identification of maximum values not only by their color, but also by the height of their points of detection.

In 2008, londonair.org.uk was the first initiative to

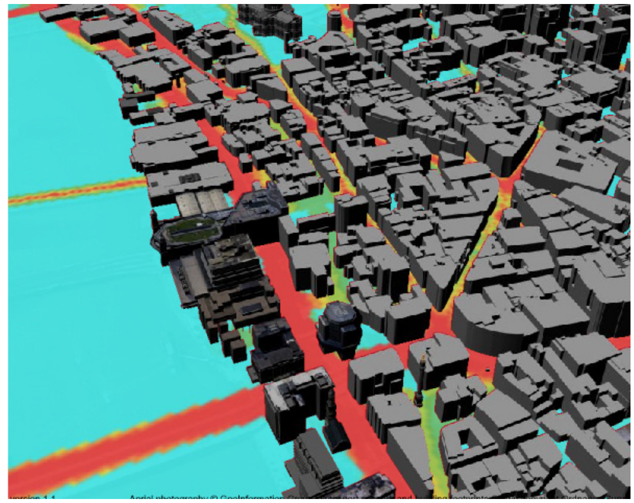

FIGURE 2: 3D *image of particle's density in London*

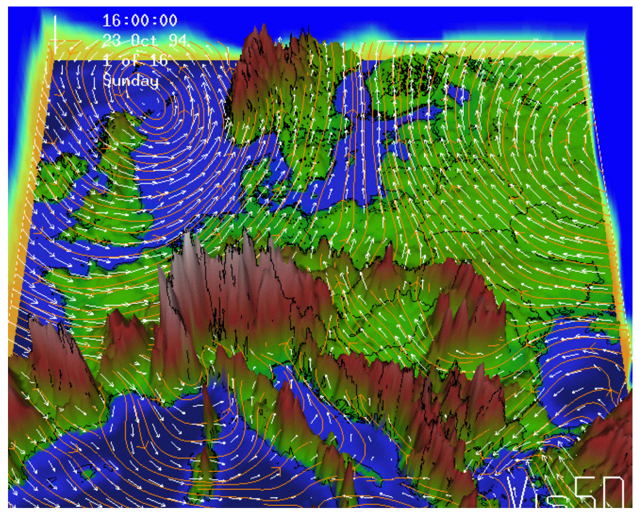


FIGURE 3: *The* DREAM *(the Danish Rimpuff and Eulerian Accidental release Model) is a comprehensive, high-resolution three-dimensional tracer model, which has been developed for studying short and large scale atmospheric transport, dispersion, and deposition (wet and dry) of radioactive air pollution caused by a single but strong source, as e.g., the Chernobyl accident.*

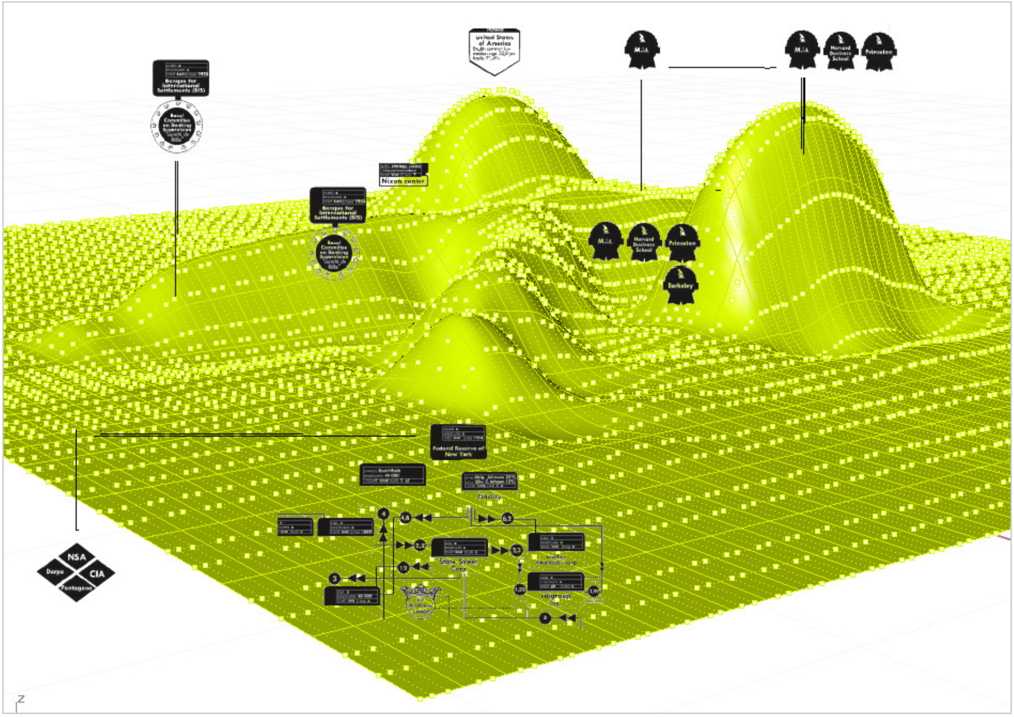


FIGURE 4: *Conceptual topographical mesh as the representational model selected.*

make this kind of tridimensional images of pollution, as a compliment to station's location maps. These images used a model of the city in 3D as their base, where the most voluminous buildings were represented. There was a superimposed image with graded colors that allowed an easy identification of the existing relation between pollution levels and the circulation system.

The Denmark National Environmental Research Institute's web page shows an animated gif where it is possible to identify, at a territorial scale, the evolution in time of contaminants related to meteorological conditions (essentially to winds).

In this context *In the Air* has the intention of meeting the challenge of exploring strategies that enhance the user's interaction with the information and turn it into experience, knowledge, and decision making capability. In other words, the aim is to shift the emphasis from the lived data to the lived-experience of the information.

*In the Air* is built collaboratively and as not-for-profit effort by temporal associations of multidisciplinary groups. Its aim is not so much the visualization, per se, of data, but the construction of a platform that enhances, through the visualization of public data, sufficient interaction with citizens so as to stimulate decision making and political action. This permits the understanding of maps not solely as representations or constructions of the world, but as a co-constitutive production by inscriptions, individuals, and collectives, using low-tech and open source resources.[9]

The challenges mentioned above are tested by the introduction of certain aspects to the visualization, aspects that are opening the door to experiences in order to facilitate the sensorial integration of spectator aspects of space into the system. This builds toward what has been called an "interactive immersive system."[10]

For this reason, the objective is to build a virtual space, where games and affects specifically regulate the relations between the user, the interface, the data, and the context. Concerning the integration of games and maps, Chris Perkins suggests a definition in which the game is an "open ended process of investigation in which new worlds are constructed in overlapping worlds of the imagination, cyberspace and reality."[11] In this manner the game is a connecting vehicle that activates the virtual space of the map with the user's body and his or her subjectivity through the imagination.

Affects may be understood as what emerges between bodies (human and non-human) that intensifies their respective capacities to be affected (that is, the map affects the body and the body affects the map). Here we are especially interested in Mark Hansen's theory,[12] which sustains that our body is built as an interface with the virtual world, therefore it is not solely a psychological reaction, but also inevitably a corporeal one. Not only this: the body is the agent that filters the information to create the digital image. In sum, the virtual experience is necessarily mediated by the body.

*In the Air* uses a topographic geo-referential mesh as the tool that organizes all the data obtained according to time and station, in order to enable the user to locate his or her position in the space and learn the density of every component, as well as his or her relative position with respect to other points in the city. This topography is distanced from the appearance of a gas and does not move according to the behaviors of a liquid, since its intention is that people take part (mentally or physically) in the model. This strategy is termed, according to artificial life research, "simulation," in contrast with the notion of "mimesis." Whereas mimesis is focused on the appearance, simulation is about identification. In mimesis there is a conscious emphasis on fiction, whereas simulation searches for the artificial doppelgänger and the transformation of the fiction into a possible reality.[13] This position confirms that design does not operate exclusively on the basis of similitude, but also on the basis of abstract codes and a complex instrumentality.

The basis for visualization is a line drawing of the city of Madrid, what Perkins describes as a "functional navigation map."[14] In contrast to a "fantasy world map," which aims at offering a sensation of place and intensifying the sense of realism, the "functional navigation map" allows the user to place him or herself, and the territory emerges as he or she explores it. The user (or player), is simultaneously in the virtual environment and in the map, multiplying his or her spatial references. *In the Air* intensifies this self-locating capacity in the map by means of a cursor, that helps to locate with precision a point in space, offering the interpolated data of the air components in that point, obtaining unique and "customized" information.

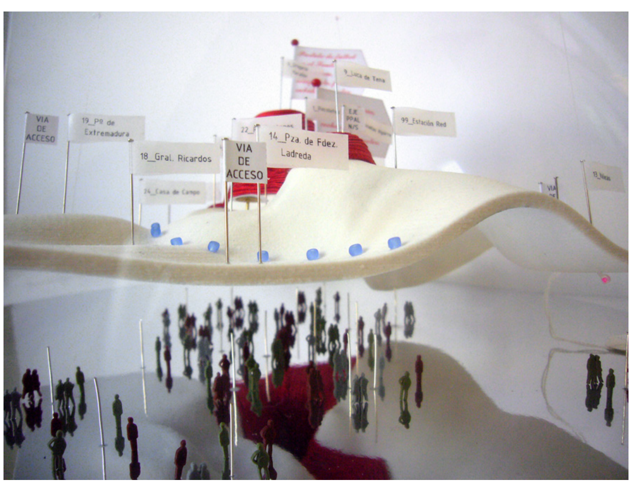


FIGURE 5: *Physical model of a particle´s mesh of Madrid, with tags reading urban events and the city. Produced with the support of Laboral Centro de Arte y Creación Industrial.*

*In the Air* also proposes the inclusion of time as a determining element for the comprehension of air behavior as it is a system in permanent change. The following question arises: what does it mean that a materiality and its territory are altered hourly, what implications does that have in its description? Maps used to be physical objects that could be stored, archived, and consulted, while these digital platforms change in real time so that the maps last for a time and then expire. In an instantaneous and ephemeral way information is produced and consumed, it has no memory—it disappears. For this reason, in addition to presenting the hourly data offered by Madrid's Council in real time, *In the Air,* with the aid of a slider, offers the possibility to go back in time, giving access to the historical data in order to observe the hourly changes of the components and their relation with urban dynamics. It becomes an instrument to re-read urban history using the air as its indicator, enabling the detection of holidays, days that the shops were on sale, football matches, weather data, etc.[15]

Using video games as reference the user's immersion in the virtual space is also explored by the possibility of navigating the map's space. This takes into account the idea that "cartographic practice inherently is learning to make projections that shape worlds in particular ways for various purposes. Each projection produces and implies specific sorts of perspective."[16] The possibility of shifting the point of view is crucial in the avoidance of one unique and hegemonic vision of the structure of the city, as well as the avoidance of having certain spots secluded by the elevation of the topography at close stations. The zoom allows the approximation to any point to observe details or offers a global vision, and the variation of the z-axis allows reading the information from both an aerial point of view and viewing the data of the entire city from an axonometric point of view. This allows a frontal perspective, or even situating oneself under the mesh. It permits us to transform the relative scale of the user and introduce him or her into the city, "feeling" the mesh from above, as if it were a mountain of data in the air.

This capability of navigating space and of positioning the spectator in an extra-linguistic scale within the virtual milieu intensifies the physical experience of data communication. According to Peter Hansen this merges human and non-human bodies on a micro scale governed by the unconscious, resulting in a perception that is not a cerebral rationalization of the impulses of our sensory organs, but a direct communication between these and the milieu. However, this capacity of navigation also allows the spectator to acquire different points of view

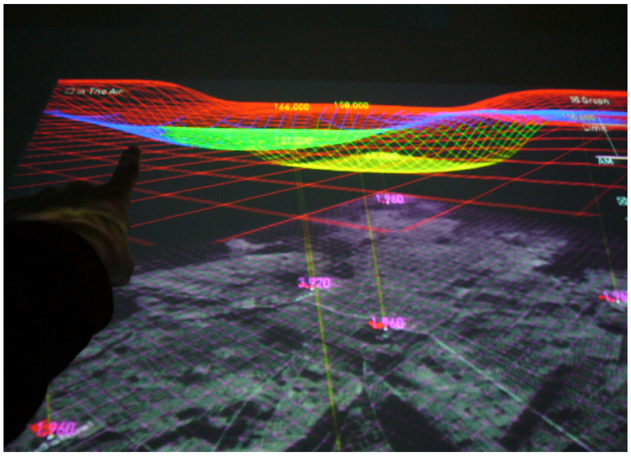

FIGURE 6: *Picture of an In the Air application's projection, with user located almost below the mesh.*

and obtain a partial perspective, for "only a partial perspective promises an objective vision." According to Amy D. Propen reading Haraway to comprehend spatial science technologies and the artifacts they produce in terms of partial perspective means understanding visualization practices in terms of their potential for producing specific ways of seeing. That is, that we not only are able to see the components of the air, but we're also able to see them from our own point of view, which may relate to our own interests, necessities, bodily experiences, and knowledge. We are enabled to generate an embodied geographical imagination, one that works toward the visualization, understanding, and affection of multiple lived worlds.

In addition to the selection of the point of view, and with the intention of having the user become immersed in the map, the application allows the control of many of the parameters of visualization. In this manner each user might construct his or her own map and version of reality, thereby offering multiple interpretations.

In order to boost the potential interactions between the map and the individual, another strategy related to games is tested: the ability of the spectator to see the effect of his or her actions in the "real world" within the virtual world. The viewer can visualize the variations that the observer can produce in the information by the manipulation of the data or of generating new virtual environments, through his or her interface. By means of a simple simulation based on the estimated ecological footprint of a citizen, it is possible to visualize the alteration of the mesh in a certain point following a hypothetical action that has been perpetrated, say, 100,000 people. Or an all-encompassing mesh as would occur within an entire city. In addition to stimulating participation, the aim of this device is to help visualize the scale of the actions that need to be addressed in order to reduce contamination levels, a primary aspect in the case of certain air compo-

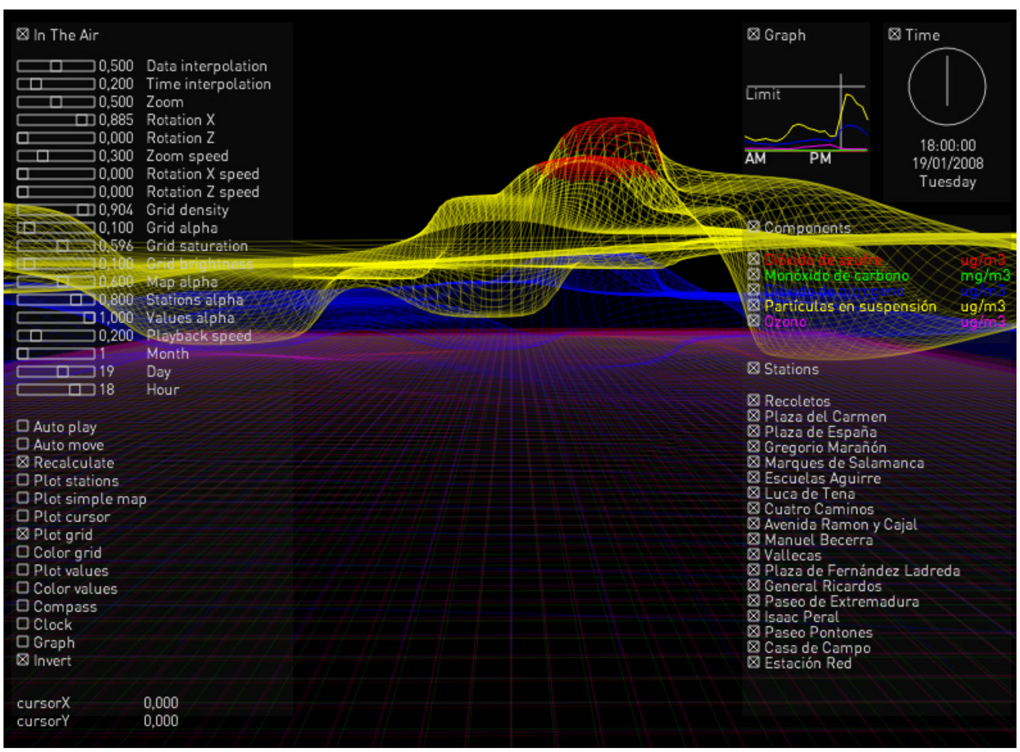


FIGURE 7: *Visualization parameters adjustable by the user: data interpolation, rotations, density of the grid, time, etc.*

nents, since the impossibility of finding a direct cause-effect relation between citizen actions and their effects on the levels of pollution make it hard for citizen engagement. In a more complex manner (but possibly a less graphic one since it uses codes) the Urban Eco-Map project, focused on the urban production of $CO_2$, visualizes the effects of our actions through a sustainability level. The aim is to enlist different kinds of virtual control to gain the experience for real-life action as a sort of training—an informative prototype in which to test actions in the city.

The territory that this visualization builds is translocated and multi-temporal, since simulated space and time lack direct references in the real world and produce a hybrid space-time in-between that of the machine, the contamination data, and the subject. They produce a shared time where it is impossible to segregate any of the members. It is in this territory where we find the measuring stations, the mountains of contaminants, the user, and his navigation of this space. Also, the physical body, the computer's mouse, the Madrid Council and other agents are linked, inhabiting a navigable air in permanent transformation that builds a non-representational map, a performative space for the invisible agents of our air.

## CONCLUSION

We have been able to identify the close relationship that exists between the agent that measures, the measuring instrument, the kind of data obtainable, its visualization, and the territory it builds, within the map. This even extends to the territory built with, and in, the maps. Particularly in those cases where invisible elements were concerned, the map could still be understood as a platform that combines visualization, information, and participation; these factors make all elements tangible, thus enabling the possibility of working with them.

We have also seen how these maps produce other representations and other faces or visions of the territory, even though they still do not "give back" or reconfigure the physical territory: their limits are still geopolitical, they do not determine power relations or even symbolic material with the clarity that takes place in protected areas, as for conservation as an example.[20] However, they do transform the urban landscape, since these "infostructures"[21] require material infrastructures such as sensor networks to obtain data, servers to process the data, and data centers to gather them. All of them are "black box" artifacts, parasites to energy providers and continuous consumers of the energy which produce new sensing bodies and new prosthetic urban bodies.

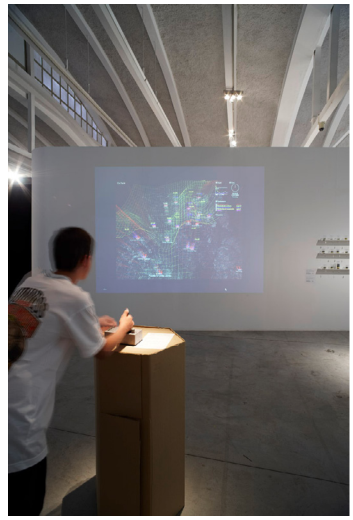

FIGURE 8: *Joystick navigation through the application's virtual space. Produced with the support of Laboral Centro de Arte y Creación Industrial.*

Also, a new kind of citizen emerges, what Whitehead has termed a "digital atmospheric self." The information that a citizen receives might condition his or her way of life and, thus, his or her decision chosen in which to live, or buy a house within; further, people who suffer certain illnesses or that are extremely sensitive to the contaminants are enabled to manage their own health. It is necessary to take into account that in Foucoultian terms the network serves as a vigilance net that has been established to guaranty the security of the citizens, not to supply complete data on the atmosphere. There is a shift from the institutional government to the self-government of the air, a type of control that turns the responsibility back to the citizen. Importantly, one must not loose sight of the fact that these are not just technological changes, but that certain socio-political conditions have been necessary for these changes in governing mentality.

What is not clear yet is how citizens receive these maps. Are they being used as tourists maps to locate certain areas? As real estate maps? As weather maps to know if one should put on a coat, wear a mask, or not leave the house? Beyond their individual use it is necessary to develop techniques for them to work as the basis for the mobilization and creation of new air policies, as a place of action that allows sharing governance with associations of local agents as a tool of air empowerment. Let us widely open the windows to permit such new realities and opportunities with air information.

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*Nerea Calvillo* is an architect, professor, researcher and curator specialised in new technologies as design tools, and interested in mapping urban invisible agents.

## NOTES

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**7** They are mostly research institute maps which show predictions of air quality. Examples: Software Models for the Environment at the Informatics Faculty of the Politecnic University of Madrid, GMSMA (Madrid), AirNow (EEUU).

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