What does ‘mapping risks‘ mean in a risk society?

Que signifie “ cartographier les risques ” dans une société du risque ?

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ABSTRACT. Governments use mapping of natural and industrial risks as a regulatory tool for managing risks and anticipating their consequences in terms of land use planning. However, it often fails to take into account the spatial and temporal dynamics specific to each risk situation. In *Risk Society*, Ulrich Beck shows that it is not just a question of *juxtaposing* heterogeneous dimensions but also of showing the links between the spatialities and temporalities of risks. Moreover, mapping in a *risk society* means developing new risk metrics and revealing the many translations the latter entail. The article thus proposes taking a navigational approach to overcome the limits of traditional risk mapping.
KEYWORDS. mapping, visualization, risks, navigational approach, spatiality, territories.

Introduction

Mapping natural and technological risks has been mandatory in France since 1995 and in Switzerland since 1991. In France, regulatory mapping began in 1984 with flood risk exposure plans (*plans d’expositions aux risques, PER*), which were replaced by the natural and technological risk prevention Plans (*Plans de prévention des risques naturels et technologiques*, *PPRNT*), in 1995, enacted by law 95-101 of February 2, 1995, and improved by the Bachelot Law of July 30, 2003 (book 5, title VI of the Environmental Code). Title VI includes, among other things, laws and regulations on risk prevention plans and safeguard measures, which are essential tools of State action for preventing natural and technological risks. The PPRNT’s function is to delimit areas that are subject to natural and technological risks via government departments and to define the planning, building and management restrictions or requirements to apply to existing and future buildings.

In Switzerland, in accordance with the federal law on water management and the federal law on forests, cantons are obliged to produce hazard maps. These maps, which must be taken into account in all land use regional planning operations, were to have been completed by 2011. With 93% complete in late 2014, the Federal Office of the Environment deemed the mapping of “at risk” areas in Switzerland complete. These maps were produced most notably for regions where the potential damage was greatest. At the European level, the 2007/60/EC Directive (in effect since November 26, 2007) reinforced this obligation: member States were to integrate the maps into their spatial planning tools, disseminate information on flood zones and encourage citizen participation.

However, not only is putting risks on a map more difficult than it may appear (November, Camacho-Hübner, Latour, 2010), but the mapping device itself struggles to take into account the true nature of risks. The goals of this article are twofold: the first, to understand why mapping tools are so ineffective in accounting for risks; the second, to question the spatial nature of risks. Part 1 will propose a short state of the art about mapping risks, part 2 will draw on 3 examples of tensions in the mapping process and part 3 will consider a proposition to overcome these tensions, through a navigational perspective in mapping and visualizing risks.

1. How to consider the mapping tool? a short state of the art

Many authors have analyzed the fundamental nature and purpose of maps. The literature on maps' roles in society - their power and their history - is abundant. These analyses stress that maps in general are underpinned by the greater goal of knowledge, often pragmatic and ideological. Pierre Lascoumes, among others, underlines this in his article *Gouverner par les cartes* (2007). Moreover, as Christian Jacob brilliantly analyzed in *l'Empire des cartes* (1992), and *Brian Harley* (Bailly and Gould 1995) upheld, maps are a form of knowledge, and thus power. More than simple techniques or tools, maps can be considered a veritable socio-technical system as now it is widely understood (Campton 2009; Kitchin & Dodge 2007).

Risk mapping underwent major changes in both France and in Switzerland starting in the 1990s. Initially designed by engineers as a technical tool for the supposed and accepted goal of eliminating risks, the map has gradually become a support - even a mediation tool - for reconciling socio-economic interests and environmental issues (Laganier and Franchomme 2007). Risk mapping has gradually been incorporated into other *interessments* (Le Bourhis 2007; Callon 1986) and has even become the key of governance in the establishment of zoning regulations and the dialogue between public and private actors involved in public action (Whatmore 2009; Landström et al. 2001).

Three positions are apparent with regard to mapping. The first and most common concerns the production of the maps themselves, which generally aims to develop comprehensive, objective documents (Saint-Gérand and Propeck-Zimmermann 2010) and *improve the proposed representations* (Elwood 2009; Elwood 2010). Some works therefore try to circumvent the difficulties associated with the uncertainty of data that is inherent to all geographical information, especially in risk contexts, and also to propose new ways of considering the latter in terms of mapping (for example Arnaud and Davoine 2009 on natural risks, Bostrom 2008 on seismic risks). Other research aims to fill in the gaps in current territorial risk management maps and, in particular, considers how GIS (Geographic Information Systems) can facilitate the dialogue between actors (Propeck-Zimmermann et al. 2009 for industrial risks), and/or more location-specific ways of calculating risks (Propeck-Zimmermann *et al*. 2002; 2007). Others still propose new maps (territorial vulnerability maps, for instance) not through hazards or dangers, but based on territorial issues and vulnerability (D'Ercole and Metzger 2009, vonHedemann et al. 2015).

The second way is to *observe the conditions in which maps are made and what is done based on them, as a performance object*. As the development of natural risk zoning policies draws on knowledge from several fields (science, law and politics), the works of Bayet (2000) and Le Bourhis (2007) analyze the way governments organize the relationships between these practices to help legitimize the decisions taken in this area based on the administrative implementation methods. Through this, they show how risk mapping (flood here) has become a key tool for governing collectivities in France in recent decades. To use this objectivized geographical knowledge, public authorities had to impose and negotiate the map as the 'official' representation of danger, thus increasing the map's authority in both the public space and the technical and administrative sphere.

Some research also describes the exchanges between federal and local governments surrounding the mapping devices implemented by analyzing the State's institutional prevention (inevitably more normative) and the management by local authorities, where the risk is more in line with actual local experiences of rivers (Tricot 2008; Martin *et al.* 2010). Similar observations have been made for technological and industrial risks. Martinais (2007) shows not only how risk maps are used as official

evidence by governments, but also how they are a tool that allows the population to "speak of the unspeakable." (Landström et al. 2011; Beck & Kropp 2010). Finally, other works show that it is negotiations regarding the safety perimeter following the identification of natural and technological risks (notably Gralepois 2011).

The third approach diverges from the others in that, before reflecting on mapping itself, it considers *the very nature of the spaces to be mapped*. This position embraces the teachings of Ulrich Beck in *Risk Society*, which, already in 1986, reflected on changes in the spatial and temporal dynamics of risks. On one hand, he notes that risks often provoke irreversible damage. On the other hand, he argues that accidents no longer have spatial or temporal boundaries. In other words, we can know when and how a disaster begins (once it has begun), but cannot know when or how it will end. There is therefore a disruption in the spatio-temporal boundaries of risks, whose consequences are no longer localized and, above all, are impossible to predict or anticipate.

In 1986 Beck insisted on the fact that the risks linked to modernization now also affect those who produce or benefit from them (boomerang effect), but also stressed that risks continue to reinforce social inequalities as the distribution of the wealth produced by risk taking remains in the same hands. Finally, he noted that repair mechanisms (insurance and prevention) run on empty, as accidents often far exceed possible compensations.

In 2009 he added that relocation and incalculability phenomena combined with interdependency between different types of risks had become key issues, and that the temporalities of risks had also changed: as periods of latency had become measurably longer, the question of what is really affected remains open and controversial. Finally, as risks result from complex processes that involve long chains of effects, the causes and effects are often indiscernible.

The approach we propose here consists of *analyzing of the spatiality of risks* (November, 2008) and drawing its conclusions from this analysis in the form of mapping. If we follow the analyses of Ulrich Beck, we can hypothesize that risk mapping (like all insurance mechanisms) was done in a mindset that dominated between the 19th and 20th century, but that no longer corresponds to the spatiality of risks today. Effectively, considerable tensions, largely indicative of this gap in thinking, can be observed when it comes to mapping risks.

2. Mapping tensions (with the help of three case studies)

Three types of tensions can be identified, all linked to the spatial dynamics of divergent risks.

The first concerns what might be called reasoning in terms of sources of risks. Maps center around risk objects and based on them, using probabilistic calculations, concentric areas are plotted according to their potential gravity[1]. The areas show that gravity decreases gradually as we move away from the source of risk. Such is the case, for instance, for hydrocarbon storage in Geneva. As it is surrounded by intense commercial activity (a new store sporting the colors of the Swedish flag opened next to it 2010!) as well as an airport, a highway junction and a dense residential area, the site is subject to the *Ordonnance fédérale pour la protection contre les accidents majeurs* (OPAM, equivalent to the European Seveso Directive).

[1] Note that calculation methods vary according to the country (Propeck-Zimmermann *et al.* 2007).

An initial map produced by the State authorities in 2006 indicated the concentric areas in color, leaving everything else gray. Four years later, in 2010, an updated version highlighted other relevant information, including gas and oil pipelines that pass through the area (see Figure 1). This new information indicates the tension between two spatial dynamics: the first is risk sites, where, traditionally, risk originates from a source, e.g. a factory or storage of flammable material, as was long the case in the 19th century; the second is risk networks, e.g. an oil pipeline that starts in Marseille and ends in Geneva. Risk potential is present along the entire delivery route and therefore requires other forms of management.

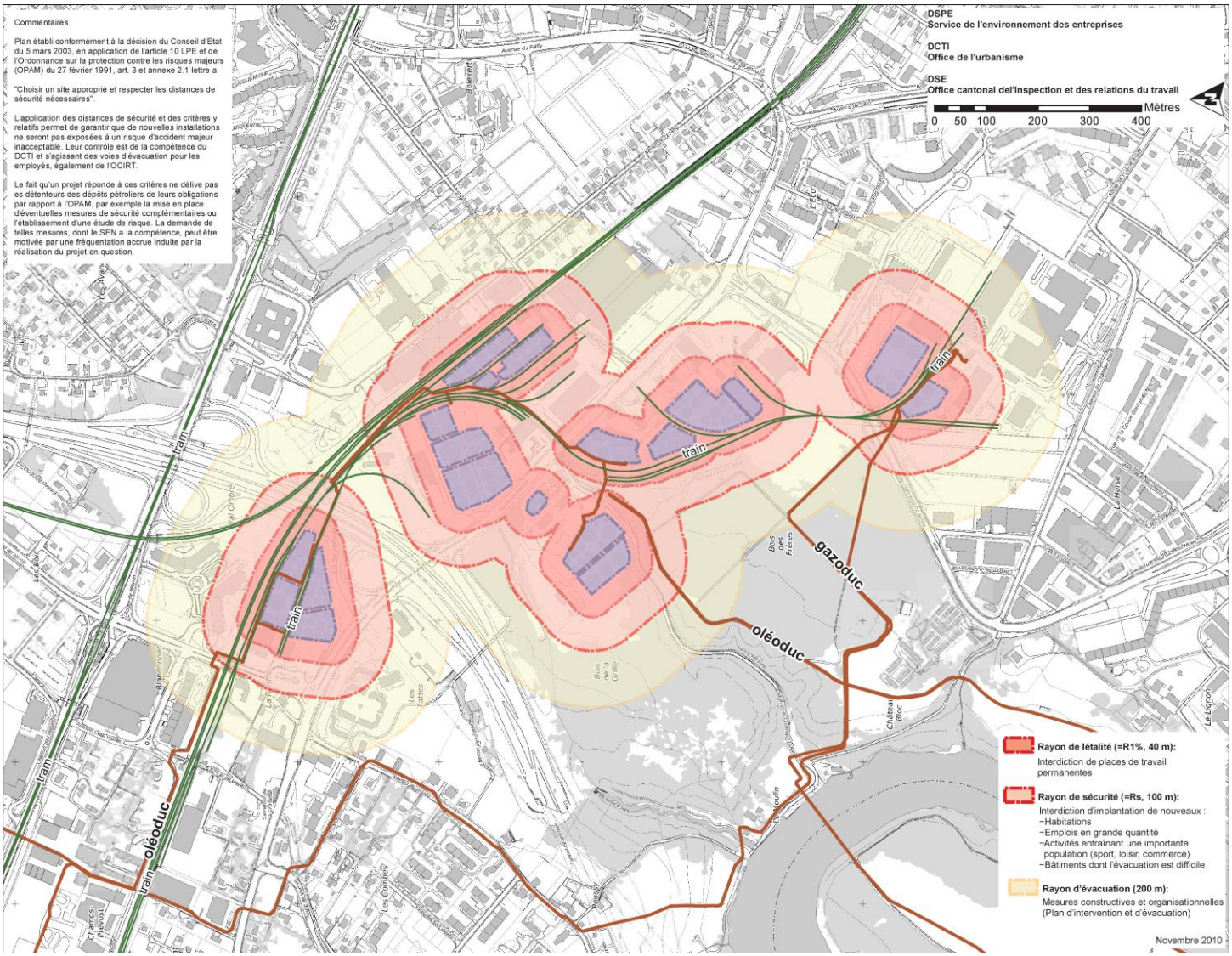

Figure 1. *Map of hydrocarbon storage in Geneva. State of Geneva, 2010.*

Map legend:

Purple: Hydrocarbon storage buildings

Dark red: Lethal radius (40 m)

Red: Security radius (100 m)

Yellow: Evacuation radius (200 m)

Lifelines in green (train) and braun (gaz and oil pipeline) added in the 2010 version.

A second example of tension in risk dynamics can be found in the field of the GMO risks. In 2001, a scientist wanted to study modified wheat's resistance to bunt thanks to a new protein. He produced a map representing the area of his field test to submit to the competent authority, the Federal Office for the Environment (FOEN) in 2001, along with his request, entitled "Risk zonation of cross-pollination with KP4 around the test site." The FOEN's refusal – the third in row – brings the controversy into the political and institutional arenas (Audétat *et al*. 2005). The initial map, which showed only the $8m^2$ concentric circles on which the KP4 experiments were to take place, was enriched with the respective requirements of different experts over the course of the procedure, to include neighboring wheat fields (solid lines, see Figure 2) in the final version. The applicant was obliged to add information to the original map to indicate the risks of cross-pollination, thus offering a more complex vision of the territory (Figure 2). The initial conception of biosafety based on the confined conditions of the molecular biology laboratory thus evolved into a more heterogeneous conception of the territory that included different actors and socio-economic issues.

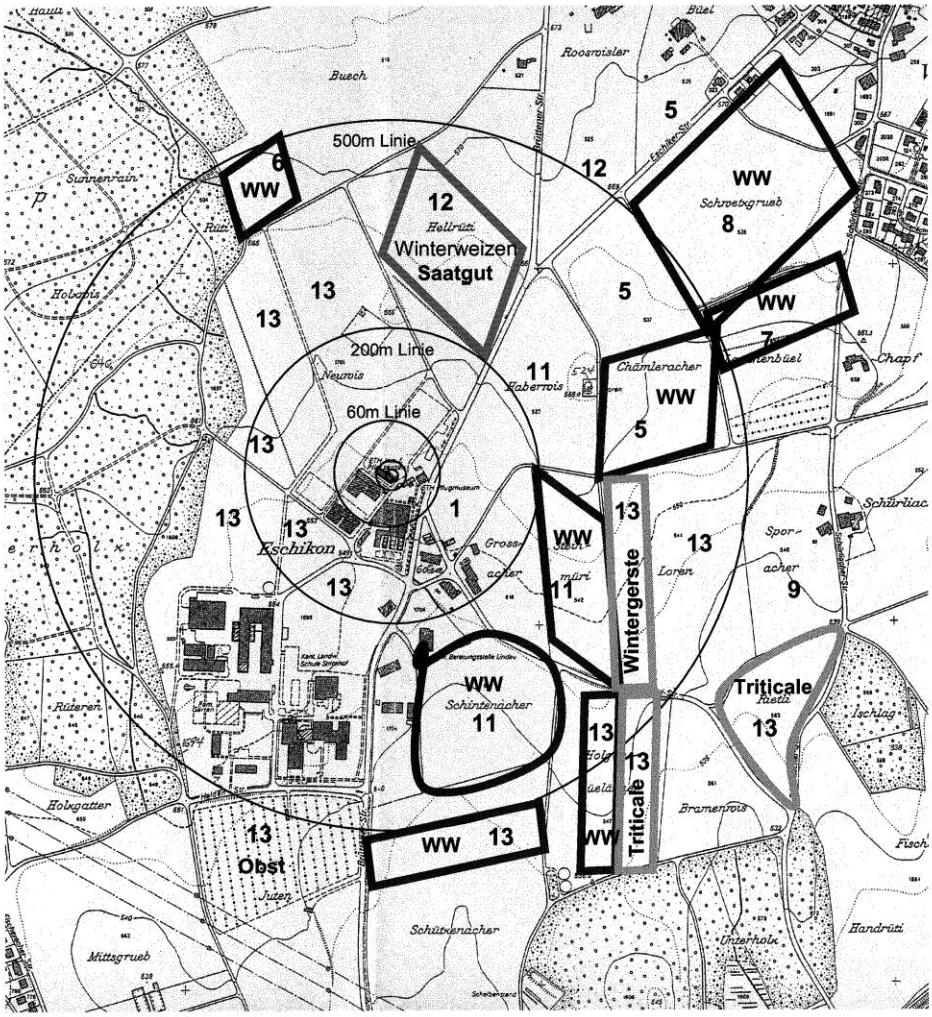

Figure 2. *Zonation map of the risk of pollen dissemination and of hybridization of transgenic wheat. Source: Map of Ch. Sautter, Institute of Plant Science, EPFZ, 2004, in Üregen G. (2004).*

Map legend:

Radius circle: 8 m; 60 m; 200 m ; 500 m. (risk of pollen dissemination)

Forms in grey and black: Field crops with risk of hybridization of transgenic wheat added in the last version of the request

In both examples mapping-related tensions were resolved - at least temporarily - through the addition and juxtaposing of different spatialities of risk, but in no way changed the foundation of the maps.

The third example considers the natural hazard mapping process in the Vaud Canton in Switzerland, and more specifically the complexity of translating this information into land-use plans. The cantons began producing risk maps in the late 1990s with the support of the Confederation. The program ended in 1994 when the FOEN, which was responsible for collecting the documents, declared the mission accomplished with 93% of the maps complete.

The risk maps indicate the habitat areas threatened by natural risks such as avalanches, landslides and floods; the cantons, and later the communes were then responsible for incorporating the information highlighted in the risk maps into their regional planning tools (communal zoning plan and building regulation) to more effectively prevent risks.

This mapping indicates the existence of dangers and is also a way for individuals to get information regarding personal prevention measures. The hazard maps of many cantons can be consulted online, as is also the case in France.

The Canton of Vaud faced major issues when it began the natural hazards mapping process in 2007, notably with regard to how to translate and disseminate the information on hazard maps into concrete zoning and development plans to ensure coherent risk management for the entire canton. The Canton fell behind, vacillating between several methodologies that ultimately satisfied no one. The Confederation had effectively left the cantons to choose the approach that best suited them, which, for Vaud, was more of an obstacle than an advantage. Finally, for certain cantons, going from “danger” maps (Swiss terminology) to “risk” maps sometimes raised important issues. The process - literally one of translation - is far from simple, as we shall see.

Moreover, during this process, certain cantons changed the colors associated with the risk matrix (intensity/probability) to calculate their areas of risk. Others chose different implementation models. For its part, Vaud ordered a comparative assessment of the practices of cantons that were further along in the risk map/land-use planning transposition process (Luzern, Soleure, Nidwald and Bern) (Penelas *et al.* 2010). The report provides details about their choices in terms of legal and coordination provisions, transposition techniques and zoning procedures. Two main models were highlighted. The first, the Risk Area Model, transposes risk areas onto land use plans. The second, the Risk Indication Model, is an indicative transposition of risk areas on land use plans. The second, less comprehensive than the first, merely indicates areas potentially concerned by risks but does not propose a detailed transposition on the land use plan maps.

What makes decision making regarding the transposing of these maps in the planning tools is that, as long as risk maps do not run up against dynamics other than those for which they were conceived, there are no problems per se. However, when it comes to creating a dialogue between the classification of natural risks (which affect territories, sometimes with high use value added), administrations fear an avalanche of claims and being faulted either for their risk calculations or for not being consistent in its recommendations regarding future land uses. Suddenly burning questions arise: a house classified in a red zone should be secured and under no circumstances extended. However, when the line passes through the middle of a house, which way should the balance swing? That is why in certain cantons

insurers are demanding to have a say in the development of transposition techniques that will also include their security imperatives.

3. Towards new metrics and mapping experiments in the field of risks

These three examples of tensions show that numerous spatialities and temporalities are at work in each risk situation. Making these dynamics visible on a map, however, is a real challenge for institutional risk mapping, as it is not simply a matter of *juxtaposing* and *combining* heterogeneous dimensions, but of showing *how* they are *linked*. To go beyond the sole integration of these dimensions, we must fundamentally rethink two key elements.

To begin we must consider the metrics of risk mapping and of risks themselves, which undoubtedly implies promoting other types of mapping. Risk cannot only be measured in terms of risk sources or network (since they are both local and global and often occur on multiple geographical scales). In other words, it is not that which is closest that is necessarily most risky. The proximity (or contiguity) rule that shaped how risk has been understood and mapped is problematic because it has obscured, or overshadowed, other spatial dynamics of risk, particularly connectivity dynamics (November 2004, 2008). Hence, in a risk society it is extremely important to think in terms of distance (between objects, situations, etc.) (Créton-Cazanave 2010). These distances do not all have the same metrics, which can of course be kilometric but can also be cognitive, etc. Examples of this approach can be cited, for instance in the field of flood management by watershed as is now done in England, France and Switzerland.

Secondly, developing means to grasp the multiple translations of risk (in the sense of Latour and Callon, i.e. as successive reconfigurations by which a collective is solidified or not) is also essential. Being attentive to the different actors' knowledge and know-how relative to risks and how they relate to one another is a first step. However, we must also acknowledge that there are other, different ways of assessing risks, though their degree of formalization may differ (see Landström et al. (2011), for a good example of the co-production of expertise based on very different formalizations). In this sense, the territorial vulnerability map produced from the issues identified by the actors involved (i.e. not based on physical phenomena) has great potential because it highlights areas of extreme sensitivity that generate vulnerability for the entire territory (D'Ercole and Metzger 2009). This means paying more attention to what are the risk translations at stake and what the risk assembles. Finally, we must consider maps not as a finished product but as a trajectory whose paper version is but one phase (for the entire argument, see November et al., 2010).

If one follows the challenge raised by these two points, 'traditional' 2D Euclidean risk mapping that identifies risk in a given territory in a mono-faceted way alone clearly cannot address them. Rather it is essential to experiment with new types of mapping. To conclude, we would like to cite some experimental work which, in its own way, seems apt to meet some of the challenges raised by an approach to mapping that takes *Risk Society* seriously.

The first experiment, led by Jacquinod and Langumier (2010), uses 3D mapping and notably animated and georeferenced 3D representations to stimulate discussion between stakeholders (local authorities, residents, etc.) and concretely assemble urban planning, land use and risk prevention issues during the development of RPPs (in this case for the prevention of flood risks). The second attempts to show the many human and non-human actors (rivers, administrations, legislations, etc.) involved in any given risk situation in the form of a dashboard and the knowledge produced and accumulated by these

actors in time and space (see Figure 3). The prototype, called 'Risk Explorer'[2] allows users to connect different pieces of information and know-how (expert and layman, e.g. from meteorologists, planners, residents, architects, farmers, etc.) produced by different actors, and to follow their evolution in time and space.

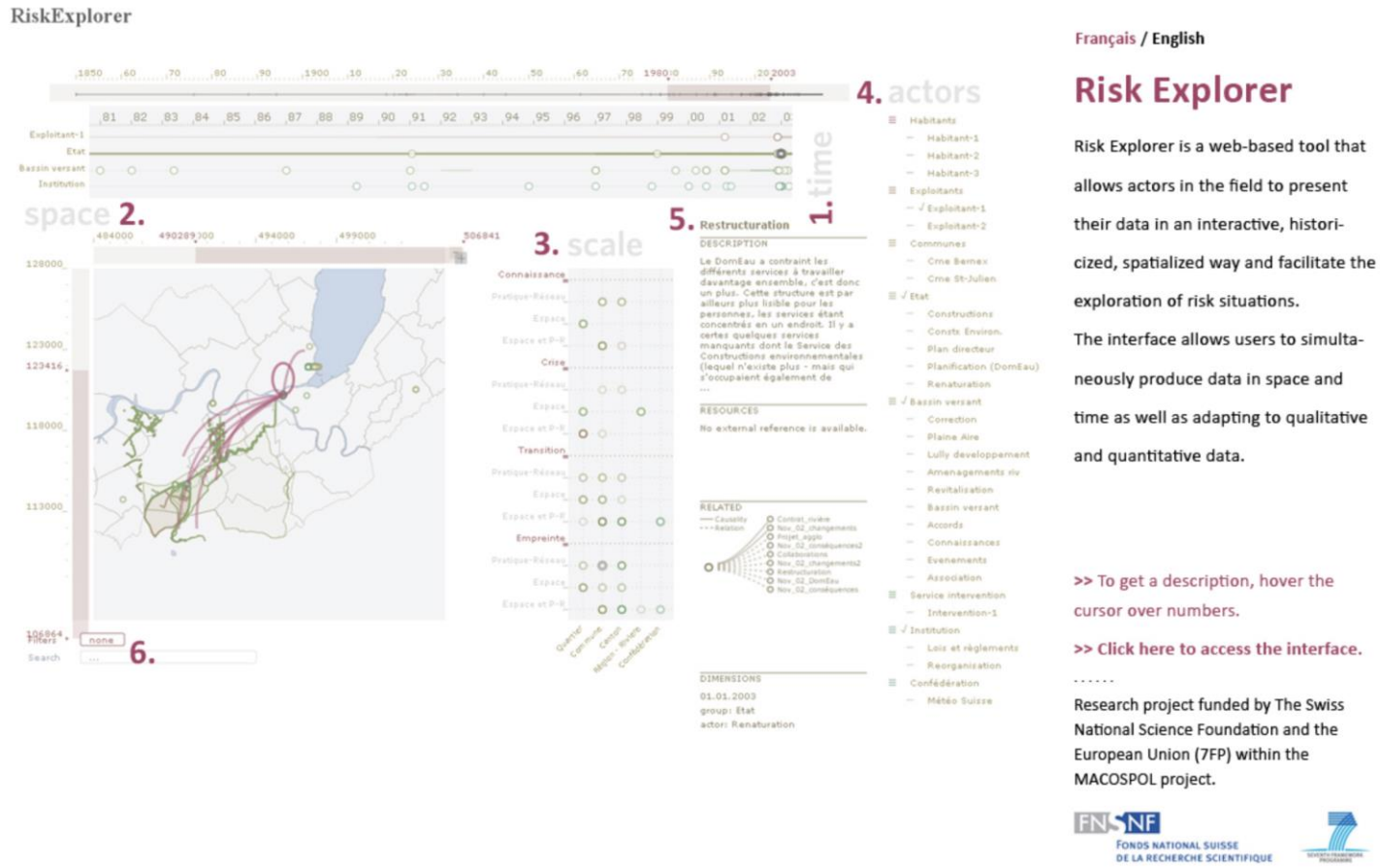

Figure 3. *Example of a 'navigational' approach: Risk Explorer (http://www.riskexplorer.org/rei/)*

In a word, this prototype helps us understand risk situations (in this case, the risk of flooding in the outskirts of Geneva), to explore them and to get a clear idea of the combined resources and knowledge in such a situation. The dashboard enables us to understand the territorial dynamics at work and to take them into account in the management of risks. The advantage of this representation is that it allows us to explore risk situations and highlight its various translations to account for the plurality of knowledge available. The challenge here is to not limit the representation and to remain free to navigate (November et al., 2010) between the different dimensions of the situation analyzed: in time (1), in space/territories (2), between scales (3), within the actors (4), and search for the related documents (maps, law articles, etc.) (5). There is a search function for key words as well (6). All the items are dynamics, sizable, and clickable.

[2] This prototype was funded by the Swiss National Science Foundation (RiskPrint project).

Conclusion

It would appear that the risk cartography used by institutions is ultimately not adapted to today's issues, as it does not incorporate the complex dynamics of the risks we can observe. This, in turn, generates a great deal of tension. As we have seen, mapping in a risk society implies developing new risk metrics and illuminating the many translations through which it traverses. The mapping experiments described above (a few among many) are not maps in the strict cartographic sense of the term. The Anglo-Saxon expression 'mapping', which has a broader connotation and refers to identifying and making a collective inventory, would be more faithful in this respect. On the one hand these tools allow us to see the distribution of power as it occurs in risk situations and, in all likelihood, to develop quality governance. One the other hand, extending the mapping of risks to different stakeholders (and not only institutional ones) seems a path to solve some of the tensions described in the paper.

The field of investigation for mapping experiments that appreciate the complexity of the spatiality and spatial representation of risks is open – a challenge that should be taken head on. Ulrich Beck was a real visionary.

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