Overview of Standards in France for Hazard Monitoring, Databases, Metadata and Analysis techniques to support Risk Assessment

FOREWORD

This paper describes France's activities and practices in hazard monitoring, detecting, database and metadata development, and mapping of hazard.

The first part gives an overview of the French policy to reduce risks from disasters, its main goals, the stakeholders involved in the policy and their roles. The purpose is to show the framework in which risk assessment is developed and how information is made available to the public. The second part defines how a damaging event is classified and characterized in France. The following parts will focus on the natural weather-related hazards that constitute major risks in France: flooding, avalanche, fire forest, cyclone, storm, shrinkage-swelling of clay soils and other meteorological phenomena.

Heat wave/cold wave and drought are particular, they are not officially included in the major hazard list and they impact the society on a longer timescale but can be costly and/or make a lot of victims. Thus these hazards will also be described.

It will be provided the following information for each hazard: usual definition in France, description of the observation network used to monitor the hazard, characteristics (notably the parameters involved) of the data base archiving the events, types of hazard analysis and mapping from the past events. The last part addresses shortly the impact of climate change into hazard analysis.

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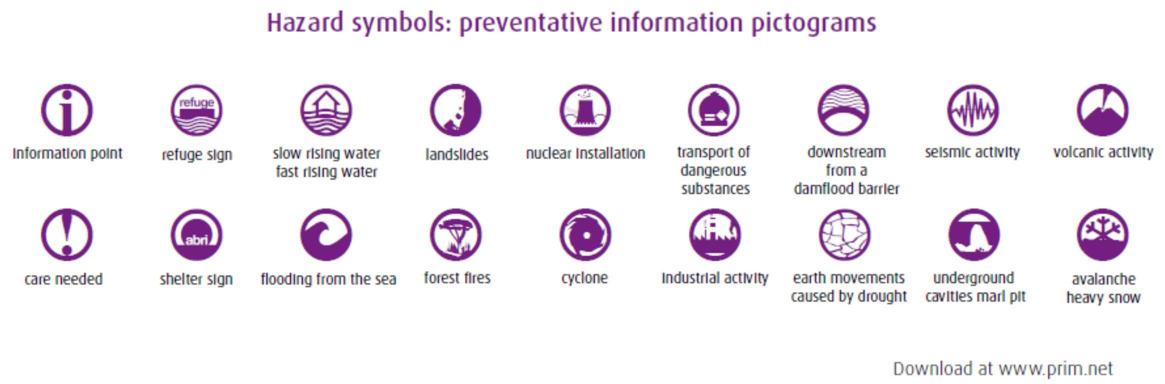
1. THE FRENCH POLICY TO REDUCE THE RISK FROM DISASTERS

1.1. Introduction

Natural disasters (earthquakes, cyclones, etc.) regularly cause large numbers of casualties throughout the world. Their strength and consequences are happily not so severe in France, however, those events that have taken place recently (the Xynthia storm of February 2010, that of Christmas 1999, flooding in the Somme, Languedoc Roussillon and Var regions, forest fires in the South and the explosion at the AZF factory in Toulouse) show that in these sorts of situations human and material damage can be considerable. Two thirds of the 36000 towns and villages in France are at risk from at least one natural disaster and 15,000 of them are at risk of flooding, the main hazard in France. French policy on managing major hazards aims to make persons and property less exposed and less vulnerable and has three main goals:

- to prevent damage, reduce its impact;
- to inform citizens in order for them to play a part in this management;
- to manage crises and disasters effectively when they occur.

Planning taking account of hazards is necessary at all levels of government and local authority decision making. France's experience in the areas of understanding and preventing hazards and in the management of disasters has allowed it, for a number of years now, to consider a number of ways in which it can cooperate internationally in order to respond to requests for support and help from foreign partners.



An event that is potentially a dangerous event is only a major risk if it occurs in an area where human, economic, environmental or cultural stakes are present.

Major risks have two main criteria:

- infrequency: because they do not happen very often society is more inclined to ignore them;
- serious consequences: large numbers of victims, large-scale damage to property and the environment.

In a general way, a major risk is characterised by large numbers of victims, a high cost in terms of material damage and impact on the environment - it is vulnerability that measures its consequences. A major risk is therefore the combination of an unexpected event and a major stake. For example, an earthquake in the middle of the desert is not a risk, but an earthquake in San Francisco is a major risk. Society as well as the individual needs to organise to cope. A scale showing the seriousness of damage has been drawn up by the Ministry of Sustainable Development. The table below classifies natural events into 6 main categories, from an incident to a major disaster.

Levels of seriousness of damage

Category		Human damage	Material damage
0	Incident	No injuries	Less than €0.3M
1	Accident	1 or more injured	Between €0.3 and €3M
2	Serious accident	1 to 9 deaths	Between €3 and €30M
3	Very serious accident	10 to 99 deaths	Between €30 and €300M
4	Disaster	100 to 999 deaths	Between €300 and €3,000M
5	Major disaster	1000 dead or more	€3,000M or more

Source : Special environmental inspection mission (mai 1999)

Eight major natural hazards are identified in France: floods, earthquakes, volcanic eruptions, landslides, avalanches, forest fires, hurricanes and storms. Four major technological risks from human activities are considered: the nuclear risk, the industrial risk, the risk of transportation of dangerous substances and the risk of dam failure.

1.2. The seven pillars of French prevention policy

1.2.1. Knowledge of phenomena, hazards and risks

Greater knowledge of hazards posed leads to a better understanding of the consequences of phenomena and an appropriate response can therefore be made, one that takes account of the level of vulnerability of the area under consideration:

- understanding past events, using historical research and the drawing up of data bases of events and of sites, such as, for example the data base of subterranean cavities, the list of floods, the atlas of areas liable to flood, the standing enquiry into avalanches, the map of avalanche phenomena or the forest fire data base;
- the various arms of the State, the French meteorological service, large numbers of French and European laboratories undertaking research that tries to understand the way these phenomena operate and to anticipate their behaviour whether it is earthquakes, forest fires, hazards involving water or technological hazards;
- using technical studies to enable the preparation of maps to show the extent and intensity of these phenomena. Studies that will sometimes enable certain phenomena to be foreseen, hours or even minutes before they occur. It is vital that these areas of research are developed and that all of this knowledge is made available to the greatest number, in particular using the Internet, or in cooperation with other bodies.

1.2.2. Monitoring

Monitoring means people can be alerted to a danger using efficient methods that suit each type of phenomenon. Meteorological monitoring, for example, is one essential part of the measures for forecasting storms, avalanches or forest fires. Geophysical monitoring is also very useful in certain geographical areas. Water monitoring is essential for forecasting flooding. Large-scale earth movements, volcanic phenomena are, also, monitored round the clock.

1.2.3. Safety information and public education

The **law of 22 July 1987** established the right of citizens to be informed of the major risks to which they are subjected to all or part of the territory, as well as safeguards that concern. This part of the law was included in **Article L125.2 of the Environmental Code**.The citizen needs to be the main actor in his own safety and that of his family. In France, there are a number of easily accessible ways available to make this happen.

Established under the authority of the prefect, the Departmental File for Major Risks (DDRM) identifies at for a department all major risks by *commune*. It explains the phenomena and presents the safeguard measures. From the DDRM, the prefect shall inform the mayor of the risks in his *commune*, using maps at 1: 25 000 and describes the nature of risks, historical events and implemented state measures. The mayor develops a Communal Informative Document on Major Risks (DICRIM). This document presents prevention measure and specific measures taken pursuant to the police authority of mayor. The DICRIM may be accompanied by communication and a poster campaign. In municipalities affected by a structure subject to an Emergency Plan (PPI), an information campaign must be performed. Its goal is to promote the risks and safety precautions. These campaigns must be renewed at least once every 5 years.

Information on major risks and their consequences for people, their property and the environment are available at council offices in every town and village and, often, on the internet. These documents also give information on safety measures that have been put in place to limit the effects of an event.

- The Ministry of Sustainable Development website for the prevention of major hazards can be viewed on www.prim.net. It makes available to everyone complete files on hazards, the information available, the state of the major hazards in each French local authority area, the list of declarations of natural disasters and, on the Cartorisques Interface, a map of events and plans for the prevention of natural disasters (PPRn).
- Information for citizens also includes keeping alive memories of past events. Since 2003, to remind people of how high floods can reach, the implementation of standardised markers showing the height of floods and the maintenance of those already in place has been mandatory for all authorities where floods have occurred.
- Since 2006, the law requires information on a purchaser or tenant of any property, whether built or not, situated in an unsafe area and/or within the perimeter of a plan for the prevention of natural or technological hazards, to be made available.
- Specific information on technological hazards is also made available to citizens.

Under **Article 13 of the European Directive Seveso II**, owners of upper tier sites classified Seveso with constraints are obliged to provide information for the local population. Although coordinated by the State the production of this information is entirely financed by the generator of the hazard and should be re-issued every five years.

The **Law of 30 July 2003** strengthened the provision of safety information and created different local, departmental and national coordinating bodies. At national level, the Advisory Board on the Prevention of Major Natural Hazards (COPRNM) is in charge of giving advice and making suggestions for the prevention of natural hazards. It includes elected representatives, State services, experts, etc. Since 2004, making schoolchildren aware of major hazards is officially part of the Education code. It is part of the curriculum in both primary and secondary schools and is tested. As part of the measures agreed in the International Strategy for Disaster Reduction (SIPC-ISDR), a body created by the UN in 2000, each second Wednesday in October is devoted to various local awareness initiatives.

1.2.4. Taking into account risks in spatial planning and city development

In order to reduce damage from natural disasters there is a need to control the planning of the natural habitat and rural spaces and to safeguard the development of fragile urban environments. The plans for the prevention of foreseeable natural hazards (PPRn) aim to avoid an increase of challenges faced in areas at risk and to reduce vulnerability in those areas that are already urban environments.

After a public enquiry and approval from the Prefect, the PPRn is declared to be of public utility and is annexed to the Local Development Framework (PLU) which has to adapt to it. From then on, planning decisions have to take into account these documents whose provisions rank above all other considerations. The same measures apply to technological and mining hazards (PPRt).

1.2.5. Mitigation

The goal of mitigation is to reduce damage by reducing either intensity of certain events - flooding, mudslides, avalanches etc. or vulnerability to the hazard - homes, commercial and industrial buildings, historic monuments, tourist sites, telecommunications networks, water, electricity and communication systems etc.

Above all, mitigation requires all persons concerned to be trained - architects, civil engineers, entrepreneurs etc. in the areas of design and planning for climate and geological phenomena as well as the building regulations. Insurance cover for disasters is included in Damage to Homes and is guaranteed by the State.

1.2.6. Preparing for crisis

Public bodies have a duty to organise all necessary safety measures. Organising this requires a balanced sharing of competences between the State and local authorities. When a rescue organisation is of a certain size or is of a certain type, in each *département*, defence or maritime area, it becomes a part of the Civil Defence Response (**Law on the modernisation of Civil Defence of 13 August 2004**).

The organisation of a Civil Defence Response (ORSEC)
This response, on the orders of the Prefect, determines, given the hazards that exist in the *département*, the general organisation of any rescue and draws up a list of all the public and private bodies able to be deployed. It will include all general measures applicable in all circumstances and others that are roper to specific identifiable hazards. The measures in the ORSEC plans also anticipate those measures that need to be taken and the rescue plans to be implemented to counter threats from particular hazards or that are linked to the existence and operation of specific installations and works. Special Intervention Plans (PPI) particularly for those sites classified as Seveso, hydroelectric dams and nuclear sites might also be drawn up.

Local Disaster Plan (PCS)
Within his area the Mayor is responsible for providing a first response. A Local Disaster Plan (PCS) is mandatory in local authority areas where there is a Plan for the Prevention of Foreseeable Natural Disasters (PPRn) that has been approved, or where it falls within an area where there is a particular intervention plan. If there is a disaster it will list the means available to a local authority for use alongside other bodies intervening, rescue services, charities etc.

Particular Safeguarding Plan (PPMS)
In educational institutions that might be exposed to one or more major hazard, the head of the establishment is obliged to draw up, in the name of (and in cooperation with) the local mayor and the rescue services a Particular Safeguarding Plan (PPMS). This plan should take into account each of the major hazards to which the establishment might be exposed. Regular simulation exercises should then take place.

1.2.7. Feedback

Insurance
In spite of all the means of prevention and intervention that exist, the damage and injury caused by a natural or technological disaster, or even a hail storm can be very important. It is therefore advisable, and often required, to anticipate the economical risk by using insurance. France has organized a pooling of insurance that covers damage caused by natural disasters: compensation for victims of natural disasters is based on the principle of sharing between all insured citizens and the establishment of a State guarantee (**Law No. 82-600 of 13 July 1982**, as amended, relating to compensation for victims of natural disasters, **Article L 125-1 of the Insurance Code**). The CAT-NAT compensation fund is financed by a surcharge of 12% on policies applicable to homes and 6% of those vehicles.

The state of CAT-NAT, giving right to compensation, must be evidenced by a ministerial decree of the Ministries of Interior and Economy that determines the date and location of the disaster and the nature of the resulting damage covered by the State guarantee.

Public goods are not covered by insurance. State and local governments must finance the reconstruction or repair of infrastructure (roads, bridges, utilities) damaged or destroyed by a natural disaster.

After crisis analysis
After the crisis is the time for analysis. Every natural disaster and each technological accident means looking again at practices and certainties. At national level in France, the Department of Ecology, Sustainable development, Transport and Housing has the staff and organizational structure to analyze this feedback, to examine what went wrong and to find out how to create the conditions necessary for the lessening the risk in the

future .

Some post disaster review reports are accessible at: http://portail.documentation.developpement-durable.gouv.fr

1.3. The main stakeholders involved in French prevention

The prevention of major risks is an activity that involves several ministries, local authorities and various agencies. The table below outlines the main stakeholders.

The French public system of major natural and technological risk management covers different levels of decision and intervention.

1.3.1. At the national level

Three ministries are involved mainly:

- Ministry of Sustainable Development for the public risk prevention and safety information;
- Ministry of Interior for planning and crisis management;
- Ministry of Economy supervises the insurance sector in charge of compensation in case of disaster.

Beyond these three key ministries, the Ministries of Research, Food, Health, Foreign Affairs and National Education contribute in their areas of expertise to the prevention of disaster risks. The General Directorate for Risk Prevention (DGPR) of the Ministry of Sustainable Development, headed by the Chief of major risks includes four services:

- the Service of technological risks;
- the Service of the prevention of nuisances and quality environment;
- the Service of natural and water hazards;
- the Office of General Affairs and Information Systems.

The Ministry of Sustainable Development implements actions in the legislative, regulatory, technical and organizational domains to improve on the one hand, prevention and risk reduction at source, on the other hand, information and protection for the citizens. It is a complex program with technical, economic and regulatory stakes that are crucial for the State, the local authorities, the industry and the public. The directorate of the Civil Protection Department of the Interior prepares and implements emergency measures that are necessary to population safeguard at the national level. Its director is a member of the executive committee of the National Council of Civil Security. The need for a coherent and transverse approach combining administrations with different organizations has led the State to implement the Interministerial Crisis Centre within the Ministry of the Interior. This center is responsible for organizing major disaster relief and supporting the operational system under the authority of the Prefect in each department. This center replaces, since February 2010, the Operational Centre of Interministerial Crisis Management (COGIC). In addition, the Advisory Board for the prevention of major natural hazards (COPRNM), created on 30 August 2003, gather parliamentarians, local elected representatives and qualified experts to enrich the thinking of policy makers.

1.3.2. At the defense area level

The zonal operational center (COZ) has the same features as the interministerial crisis center in each of the defense areas of the national territory.

1.3.3. At the local level

Risk management is the responsibility of the mayor and the prefect of the department, but the local authorities play a greater role in prevention.

What ?	Who ?	How ?
Hazard knowledge	Ministry of Sustainable Development Ministry of Agriculture (Forestry)	Funding of scientific and technical studies
Monitoring	Ministry of Sustainable Development Ministry of Agriculture Ministry of the Interior Ministry of Research	Area equipment with means for monitoring flooding, volcanism, large ground movements, earthquakes, tsunamis
Information	Ministry of Sustainable Development Ministry of the Interior mayor	The prefect established the DDRM with funding from the Ministry of Sustainable Development, the DDRM. The Mayor establishes the DICRIM. The Ministry of Sustainable Development disseminates information at the national level via the internet.
Education	Ministry of Education Ministry of Sustainable Development Ministry of Research	Inscription in secondary and high school programs
Taking into account risk when planning	Ministry of Sustainable Development	Establishment of risk prevention plans (PPR) Compliance with national regulations on seismic risk prevention (seismic zoning, resistant construction rules) monitoring compliance with the rules
Mitigation	Ministry of Sustainable Development	Training of professionals (architects, engineers, artisans)
Preparing for crisis	Ministry of the Interior mayor	According to the scale, the civil protection services or the mayor prepare for the crisis
Feedback	Participants in the preparation of disaster plans	Post disaster review
Crisis management	Ministry of the Interior (prefect) mayor General Council (firefighters)	Mobilization of resources (staff, utilities, possibly armed forces)
Compensation	Commission of natural disaster (Ministry of Economy, Ministry of Sustainable Development, Caisse Centrale de Réassurance)	For CAT-NAT events, Insurances implement a special procedure for compensation

1.4. The National Observatory of Natural Hazards (ONRN)

The National Observatory for Natural Hazards (ONRN) project was born from the shared vision of insurers, the Central Reinsurance Company (CCR) and the State after 2010 Xynthia storm. It took shape with the invitation for proposals held by the Advisory Board for the Prevention of Major Natural Hazards (COPRNM).

On the 3rd of May 2012, the Ministry of Sustainable Development (MEDDE), the CCR and the Association of French Insurance Undertakings for Natural Risk Knowledge and Reduction (Mission des sociétés d'assurances pour la connaissance et la prévention des Risques Naturels - MRN, an association created by the FFSA and GEMA), signed a partnership agreement founding the National Observatory for Natural Hazards (ONRN).

The ONRN shall progressively provide access to and share key information useful to the activities and decision making processes of stakeholders involved in risk prevention in the following fields:

- hazards and associated zoning maps,
- assets at risk, vulnerability and resilience at a local level,
- loss records and lessons learnt,
- stakeholders and their projects,
- public risk prevention programmes and procedures.

The ONRN website (www.onrn.fr) provides access to the following three services:

- A directory of stakeholders with specialist knowledge of natural hazards and their management and prevention.
- A list of existing public risk map and tabular databases generated by data producers
- ONRN indicators that provide new knowledge on natural hazards.

The ONRN indicators, accessible through a cartographic tool for consulting, downloading and/or reusing, cover:

- damages to goods subject to compensation between 1995-2010,
- the economic or human assets involved in flooding,
- the progress made in the implementation of prevention measures.

There are presently 16 socio economic indicators available. (http://www.onrn.fr/technique/indicateurs-onrn) . The scope covered by these indicators shall be progressively extended, and in particular to all hazards.

The website also proposes:

- Documentation for consulting ONRN publications or for performing a search within one of the document bases of the Ministry of Sustainable Development (approximately 6,000 documents on the topic of natural hazards).
- A toolbox comprised of documents available for download, providing general information on risk prevention, regulations and insurance.
- A glossary of the most frequently used terms.

1.5. The Aided Management of Administrative Procedures related to natural and technological hazards (GASPAR)

The Gaspar application (http://macommune.prim.net/gaspar/) of the Directorate General for Risk Prevention is the backbone of its information system on natural hazards.

The Gaspar base, updated directly by departemental services, collects information on the documents for preventive information or with regulatory scope for each *commune*:

- natural PPR and technological PPR
- Procedures like " recognition of the state of natural disaster (CAT-NAT)"
- Preventive information documents:
    - TIM: Information Transmission file to the Mayor
    - DICRIM: Communal background document for populations on major hazards
    - PCS: Communal Safeguard Plan
    - AZI: Atlas of floodplains

The data from the GASPAR base are disseminated in several ways:

- Direct download of the base in the Microsoft Access 2000 format. This database is updated daily from the internal system in the Ministry.
- Direct view of database information, classified by department. This database is updated monthly or after each period of recognition of the state of natural disaster.
- Download of information from the database in text format, classified by region. This database is updated monthly or after each period of recognition of the state of natural disaster.

2. METHODOLOGY OF CLASSIFICATION OF DAMAGING EVENTS

Every year, the Ministry of Sustainable Development publishes a report on main damaging events in France and in the world. The purpose of this document is to inform the greatest number of institutional services and operators on the one hand, and the general public on the other hand, about the nature, impact and brief observations that can be made of these events.

2.1. Definition of a natural event

Damaging natural phenomena are natural events that cause damage to people, property and natural areas. A natural event can be associated with one or more phenomena. Its identification is based on three guidelines of decreasing importance: the type of associated phenomenon (or phenomena), the period when the event occurred, the event's spatial extent. The detailed typology of phenomenon is given in annex 1.

2.2. The type of phenomenon

Two separate phenomena (earthquake and flood, for example) lead us to identify two separate events, even if some criteria, such as the date and place, are the same. However, when the "separate" damaging phenomena (cyclone, landslide, flooding, for example) are connected, that is, when they occur in the same geographical area and during the same period, and one can be considered the consequence of the other, a single natural event is identified and put in the category of **natural phenomenon that generates a typology:** cyclone/hurricane, storm, etc. Possible examples include the storms on December 26, 1999, December 27 and 28, 1999 and November 6 to 11, 1982, Hurricane *Lenny* from November 17 to 19, 1999 and Cyclone *Dina* from January 22 to 23, 2002. When phenomena are "separate" but belong to the same category (flooding due to a rise in the water level and run-off flooding and mudslide, for example), the codification will focus only on the initial phenomenon category (here: 1.1) **when they occur at the same time and in the same place** (same period and consistent spatial extent compared with the climatic context observed). The floods of December 16 to 19, 1997 are thus considered to be related to a rise in the water level, run-off and mudslide.

2.3. The period of the event's occurrence

If the types are the same, the next thing to look at is the occurrence "envelope period". If the envelopes are separate, they are separate events. However, when the envelopes are close together (one to two days apart), and if – and only if - phenomena of the same nature affect large, **weakly scattered** areas (at least 10 towns or 100 km^2)**,** they are considered a single event.

2.4. The spatial extent of the event

This involves floods, earthquakes, differential settlement and atmospheric phenomena. When the same kind of damaging phenomena occur at the same time or almost simultaneously (the same or almost the same envelope) but over **widely scattered** areas, they are considered separate events. An exception is flooding caused by widespread storms, regardless of whether they are organized (squall lines),that sometimes affect very widely scattered areas during the same period (24 hours).

3. FLOODING HAZARD

3.1. Definition

Flooding is a fast or slow flood of an area usually out of the water. The flooding hazard is the result of two components:

- Water can come out of its usual flow bed;
- Man has built in the path of water (establishment of buildings, facilities and activities in the alluvial space).

3 main types of flooding are defined in France since 1992.

The slow rise of water in lowland regions

a) Flooding of plains
The flood occurs when the river comes slowly out of its riverbed and floods the lowland for a relatively long period. The river occupies the average bed and sometimes the major bed.

b) Flooding by rising natural water tables
When the land is saturated with water, sometimes the water comes to the surface and a spontaneous flood occurs. This phenomenon concerns particularly low or poorly drained lands. Because of its slow dynamics, the flood may last several weeks.

The rapid formation of torrential flow
When heavy rainfalls, such as strong showers, occur on a whole watershed, the water runs quickly and concentrates in the river, causing flash floods. The river carries large amounts of sediment and floating objects (dead wood, etc..), which leads to strong bed erosion and deposition of transported material. These can form log jams, which, if they come to break, release a huge deadly wave.

Stormwater runoff
The soil sealing by facilities (buildings, parking, etc..) and cultural practices limit the infiltration of rainfall, so the runoff increases. This often causes congestion and discharge of rainwater drainage network. It causes important and rapid water flows in the streets.

Flooding also include coastal flooding which is specific and will be developed in the next chapter.

3.2. Monitoring and Observation Data Archival

Observation from rivers in France can be retrieved in the data base HYDRO (http://www.hydro.eaufrance.fr/).

HYDRO stores the measurements of water level (at variable time steps) from 3500 measuring stations (of which 2,400 are currently in service) located on French rivers and allows access to station meta data (purpose, precise location, measure quality, history, available data). HYDRO calculated for a given station the instantaneous, daily, monthly flow rate from the values of water depth and calibration curves (relationship between the water height and flow rate). HYDRO provides at any time flow rates as accurate as possible based on the latest updated information.

Data are mainly provided by state offices, regional offices of Environment, flood forecasting services (SPC), departmental directorates of agriculture and forestry, water agencies, but also Electricité de France (EDF) or research organization (IRSTEA, universities, ...), as well as regional planning companies (la Compagnie nationale du Rhône or la Société du canal de Provence for example). These data producers install monitoring stations in the river, ensure maintenance, collect and validate and possibly correct data, and fuel the data base. They also establish for their station the calibration curves that are included in the database.

The Central Hydrometeorological Service and Support to Flood Forecasting (SCHAPI) located in Toulouse, is the HYDRO data base administrator and manages the services associated with HYDRO. It also provides developments. SCHAPI is also responsible for river flooding forecast by using meteorological data inputs from Météo-France. Warnings are disseminated through a Vigilance flood system covering waterways.

3.3. Hazard Analysis

3.3.1. The Atlas of Floodplains (AZI)

The State conducts technical studies that, without having opposable value to third parties, are data bases necessary for the consideration of risks in planning and development. The AZI is under no regulatory text, but is one of the main types of comprehensive study conducted by the State in a basin at risks. It aims to identify all the available knowledge on floods and flood zones.

The **Circular of the Ministry of Ecology and Sustainable Development, dated November 4, 2003** oversees the process of establishing Atlas of floodplains (AZI), recalling that the principles set out in the **circular of 24 January 1994 and 22 March 1995** shall be applied:

- Knowledge of flood risk is a prerequisite for any action;
- The establishment of a flood mapping is a priority;
- The most comprehensive information possible to the citizens of the existence of departmental atlas floodplains (Adzi) is to be taken.

The AZI also take into account other factors:

- Flood risk areas by the accumulation of runoff (urban, agricultural or natural);
- Natural or anthropogenic factors likely to influence the operation of the hydraulic rivers (dams, embankments, thresholds, vegetated areas ...)
- Some issues in a flood zone (buildings, campgrounds, ...).

The Ministry of Infrastructure and the Ministry of Environment and Sustainable Development have chosen the hydrogeomorphological method as the reference method to develop the floodplain atlas. The reliability of this approach has been validated during extreme floods (Aude,1999, Gard 2002). This methodology allows to define the limits of flood zones by combining a geomorphological approach (photo interpretation, field investigations ...) and the analysis of historical floods.

That method does not require a mathematical model. The boundaries of floodplains given by this method are not related to a specific return period flood. However, they provide the natural physical limits of the field of flood storage. This method considers the following definitions:
- Minor bed: fully inundated by an annual or biennial flood;
- Average bed: inundated during floods with a return period from 2 to 10 years;
- Major and exceptional bed: flooded by the most rare or exceptional floods;
- floodplain limit: maximum flood envelope (= flood zone as geomorphologically defined). It may be either precise and placed with great accuracy (steep banks) or inaccurate (low-slope banks).

This method allows to map uniformly over a whole watershed the floodplain limits and also all natural or artificial elements that can play a role in the river flow during a flood. It also included the limits reached by the major historical known floods.

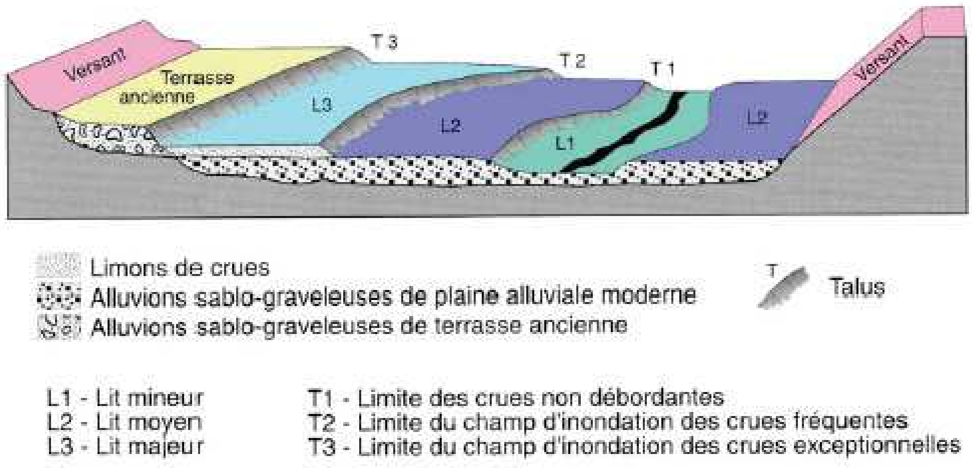


Figure 1 Scheme of the different river bed limits

AZIs contributes to the right of citizens to be informed of the major risks established by the **L125.2 article of the Environmental Code.**
2 types of mapping are produced:

- Mapping of floodability at 1:25 000 covering the whole linear of studied streams and intended to inform the general public;

- Mapping of floodability at 1:10 000 covering specific sectors with high stakes and intended to an audience of professionals and expert technicians flood risk;

All map information are organized in a Geographic Information System (GIS) and permanently updated.

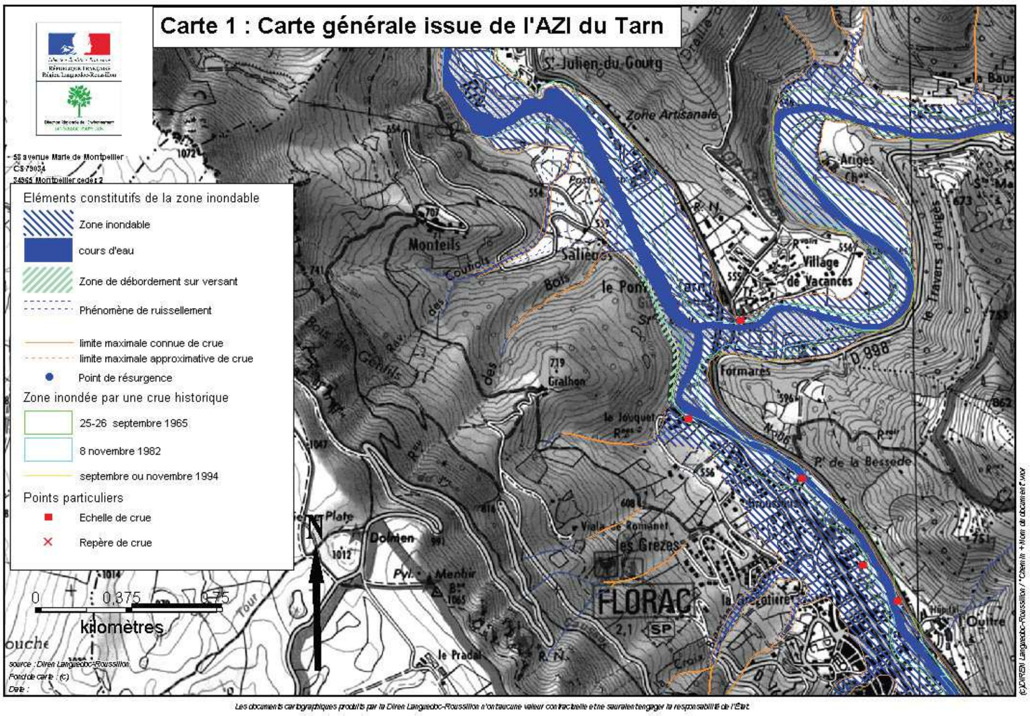


Figure 2 Floodability map example at 1:25 000 extracted from the AZI of the *département* of Tarn

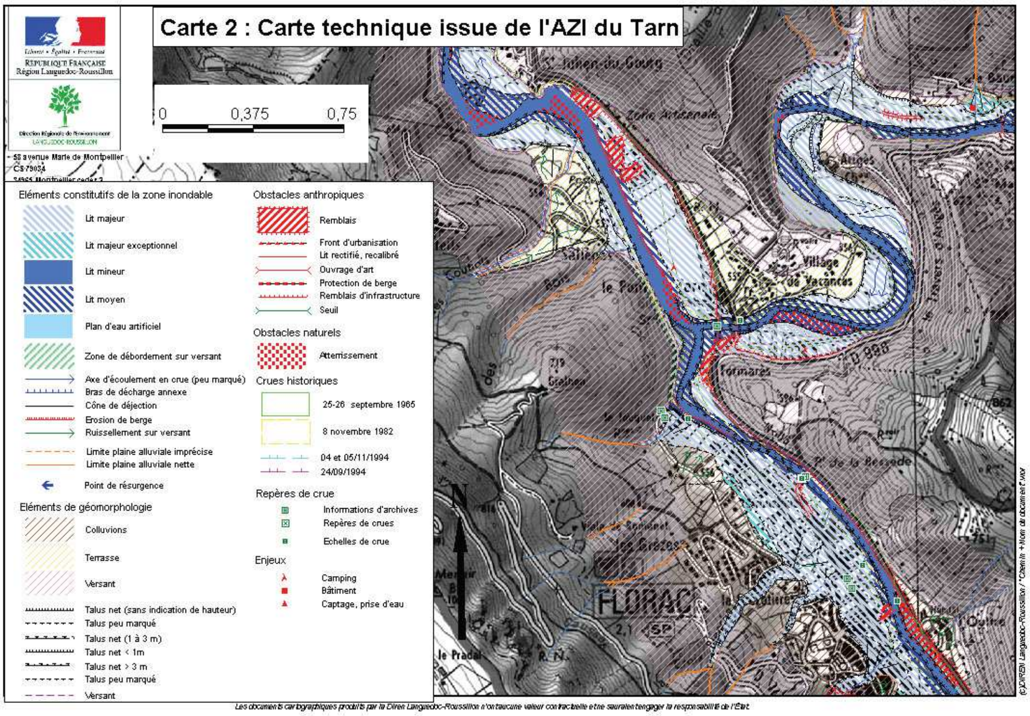


Figure 3 Floodability map example at 1:10 000 extracted from the AZI of the département of Tarn

3.3.2. The extreme rainfall website

The extreme rainfall website (pluiesextremes.meteo.fr) identifies the most significant 24 hour and 48 hour rainfall episodes having occurred in France. The goal is to know the frequency of extreme rainfall events for approaching flood risks. The database covers the period 1958-2012. It is updated annually.

The site was developed with the support from the Ministry of Sustainable Development / General Directorate for Risk Prevention.

The analysis of extreme rainfall episodes is based on daily precipitation values extracted from the climatological data base of Météo France (BDCLIM). Only precipitation values over 60 mmm/1 day or 80 mm/2days are considered.

2 techniques may allow to reach the main goal:

- the assessment of return periods
- the chronological inventory

Even if the site describes the different methods used at Météo-France to assess return periods (http://pluiesextremes.meteo.fr/phenomenes-extremes-et-durees-de-retour_r23.html), it shows only a few maps of return period. The chronological inventory was preferred to support the goal of assessing risks due to heavy rainfall.

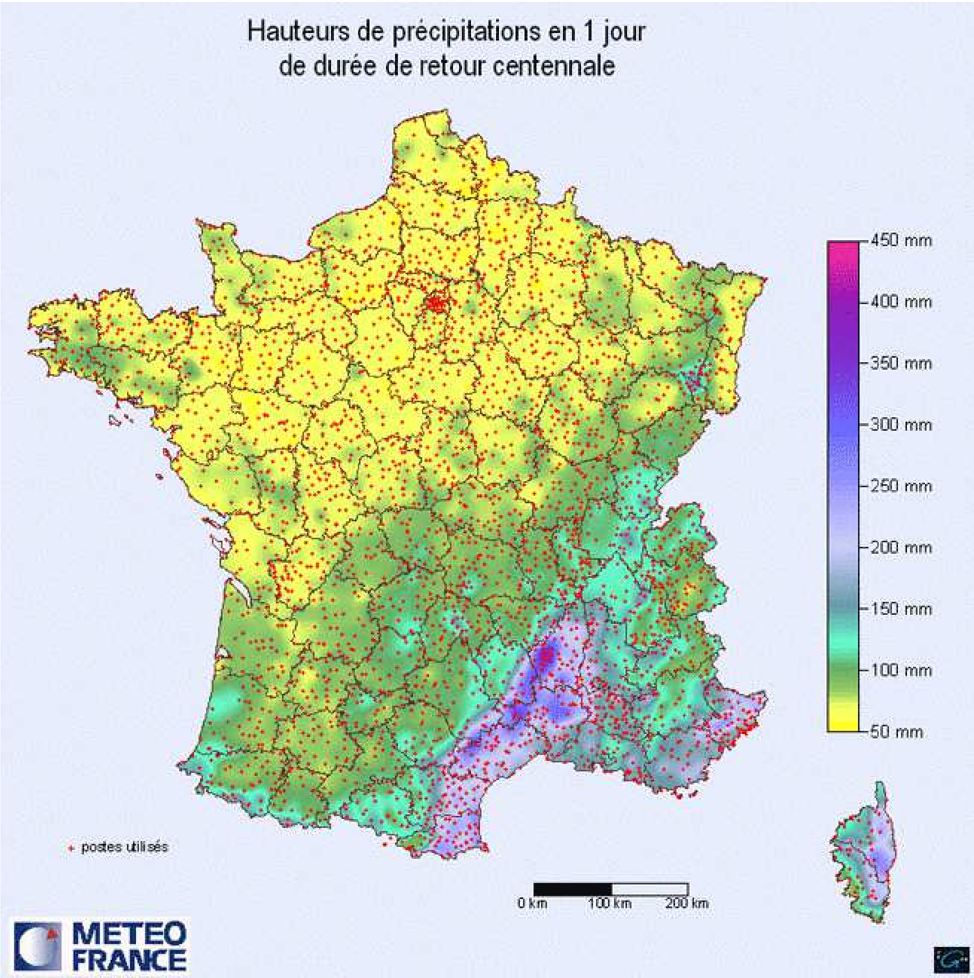


Figure 4 Centennial return period 1-day rainfall height map for France mainland. Red spots are the rainfall gauges used to calculate these heights.

The site gives access to the following information through search engines.

Historical inventory of rainfall episodes

The user can filter episodes by specifying the minimal spatial extent of the episode, the area to be concerned. He has access to cumulative rainfall maps for each episode. Those maps are created using the open source software (under GPL license) Generic Mapping Tools (G.M.T).

All days where a daily (from 6H UTC to 6 h UTC) precipitation value for at least one measurement station has been above 100 mm have been mapped (around 1650 maps). For departments located out of the Mediterranean area, episodes with a 2-day cumulative rainfall superior to 120 mm have been mapped (around 670 maps). For *départements* within the Mediterranean area, where intense and durable rainfall episodes often occur, episodes with more than 100 mm/day during 2 to 4 days on the same *département* have also been mapped (230 maps).

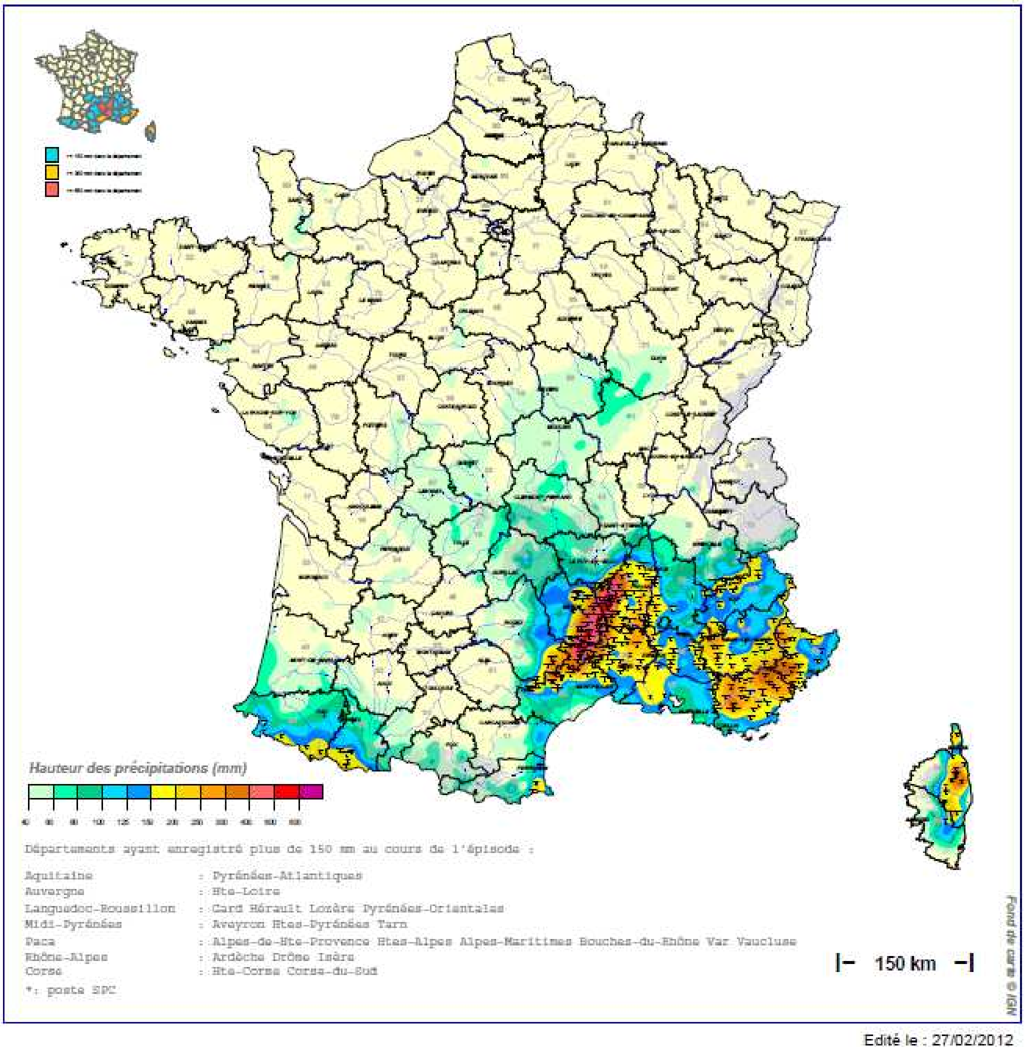


Figure 5 Map of 4-day cumulative rainfall from 2 Oct 2011 6h UTC to 6 Oct 2011 6h UTC

Memorable events

250 memorable events are mapped and documented with additional information:

- Detailed comments on the events
- Radar animation
- Cumulative rainfall animation
- Documents from media
- Post disaster review documents for exceptional events
- Hourly rainfall graphics

The memorable events include events prior to 1958, of course not as comprehensively and accurately as the most recent ones. The oldest archived event occurred in 1766.

Statistics

The user has access to numerous statistics and absolute records under map or table forms.

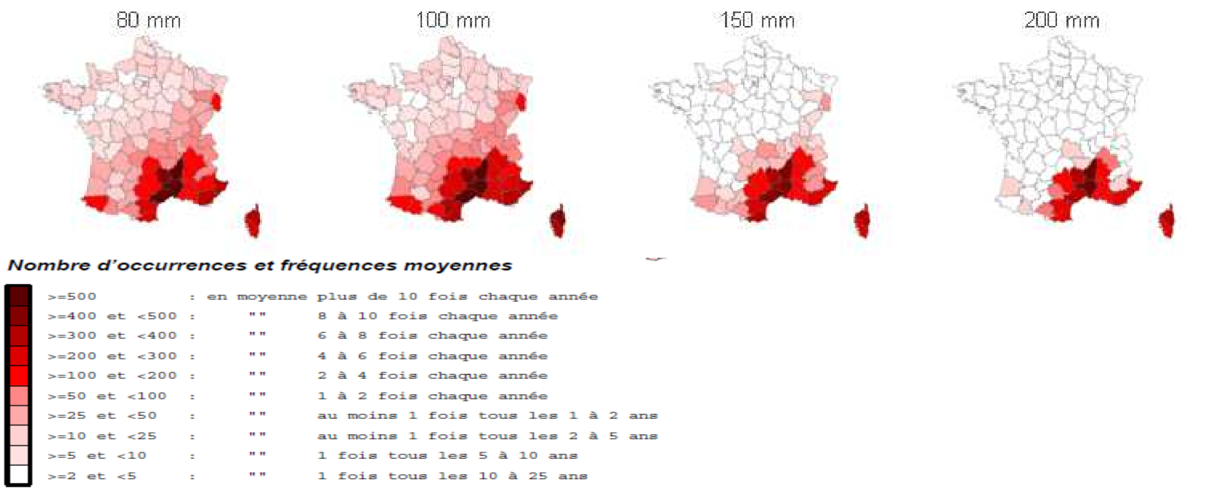


Figure 6 Map showing the number of observed episodes that have made more than 80, 100, 150 or 200 mm in a climatological day on at least one measurement point per department over the last 50 years. On France mainland, almost all but five departments have experienced at least one episode of more than 100 mm in one day.

3.3.3. Exposure maps to rising natural water tables

The BRGM is the service responsible for monitoring natural water tables. It makes available to professionnals and the general public hazard maps to rising natural water tables through the website: www.inondationsnappes.fr

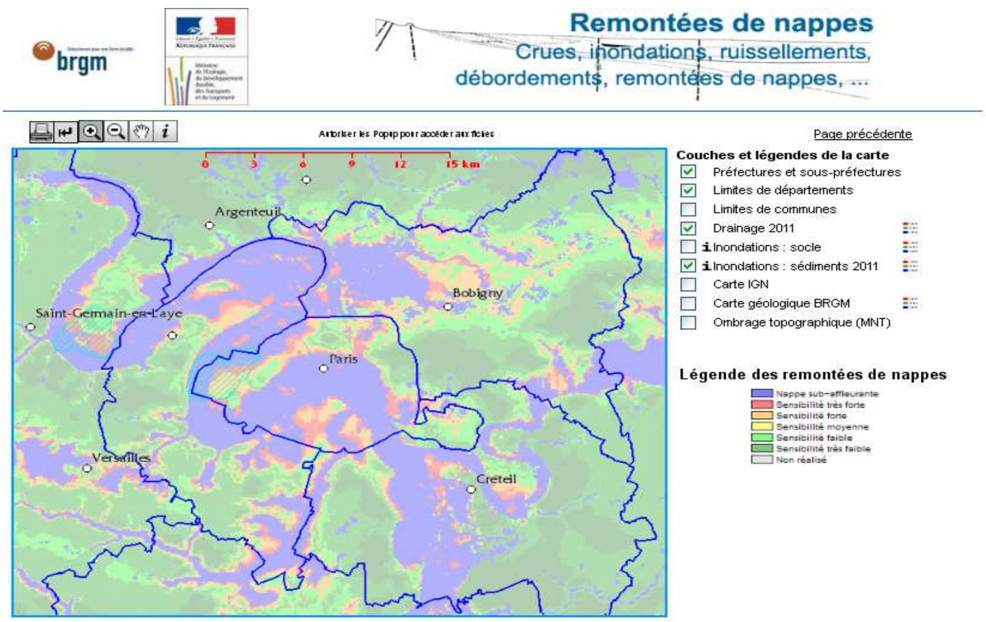


Figure 7 Hazard map to rising natural water tables for Paris and vicinity (from http://www.inondationsnappes.fr).

3.4. Preliminary Flood Risk Assessment (PFRA)

3.4.1. The national flood risk management policy

Faced with the catastrophic consequences of floods in Europe in recent decades, the European Commission responded in 2007 by adopting a directive on the assessment and management of flood risks (**Directive 2007/60/EC.**). This directive defines a working method to enable areas exposed to flood risks to reduce their impact on human health, the environment, cultural heritage and economic activity. In this context, preliminary flood risk assessments or PFRA were conducted in 2011 by government departments in each of the 14 river basin districts (District: unit of management instituted at European level for the application of the water framework directive and used for the application of the flood directive. A river basin district is the equivalent of a large river basin or group of basins).
When the European directive was transposed into French law (**National Commitment to the Environment Act (known as LENE) of 12 July 2010)**, the Government and Parliament wished to go further and define a national strategy for managing flood risks. This should contain precise, consistent guidelines for identifying priorities for action and allocating resources across the whole country. This involves first producing a national assessment of flood risks based on a synthesis of local data and focusing also on events of national importance, taking into account significant floods that have occurred in the past and are likely to recur. This preliminary assessment of flood risks at a national level provides a complete and standardized image of current exposure in France. The PFRA method includes two stages. The first stage involves defining potentially flood prone areas or Approximated Envelope for Potential Floods (EAIP)). Two kinds of areas have been defined: those subject to flooding by overflowing rivers; and those subject to coastal flood risks. Potential effects of climate change are not taken into account for flooding by overflowing rivers, because there is no clear tendency yet, but they are for coastal flooding by considering a potential rise in sea levels of a meter by 2100. The second stage involves identifying the issues at stake in these areas. This means evaluating the potential adverse consequences of a flood using indicators based on the impact on human health, housing, economic activity, the environment and cultural heritage (e.g. numbers of inhabitants, jobs, hospitals, area of built heritage etc.). For the first time, the risk of flooding is considered through the prism of what is at stake rather than just the chances of a flood occurring.

The first preliminary risk assessment on a national scale presented here should provide better knowledge to enable better action. Once shared, knowledge of the risks places responsibilities on each actor and makes it possible to focus action where the scope for progress appears greatest.

3.4.2. The Approximated Envelope for Potential Floods (EAIP)

The main goal of the EAIP is to assess the contour of extreme events by using all preexisting information (AZI, hazard maps from PPR, etc…) and by completing with additional studies (geology and topography analyses by example).

Two types of EAIP have been developed for the whole country:

- EAIPce for flooding by overflowing rivers,
- EAIPsm for coastal flooding (excluding tsunamis and retreat of the coast line)

In both cases, the effect of hydraulic structures (dams and dykes) is not taken into account, the structures are considered transparent, as they actually are for extreme events. Thus these two EAIP also include potential floods by dyke failure, but not envelopes from a flooding wave related to a dam failure.

Moreover, EAIP provide envelopes for potential flooded areas by extreme events, but they do not quantify their intensity, i.e. their destructive capacity, nor their frequency.

Taking into account these limitations, the EAIP give the most complete and homogeneous information to assess at the basin scale and nationally, the consequences of potential extreme floods. The scale of the maps is inferior to 1:100 000.

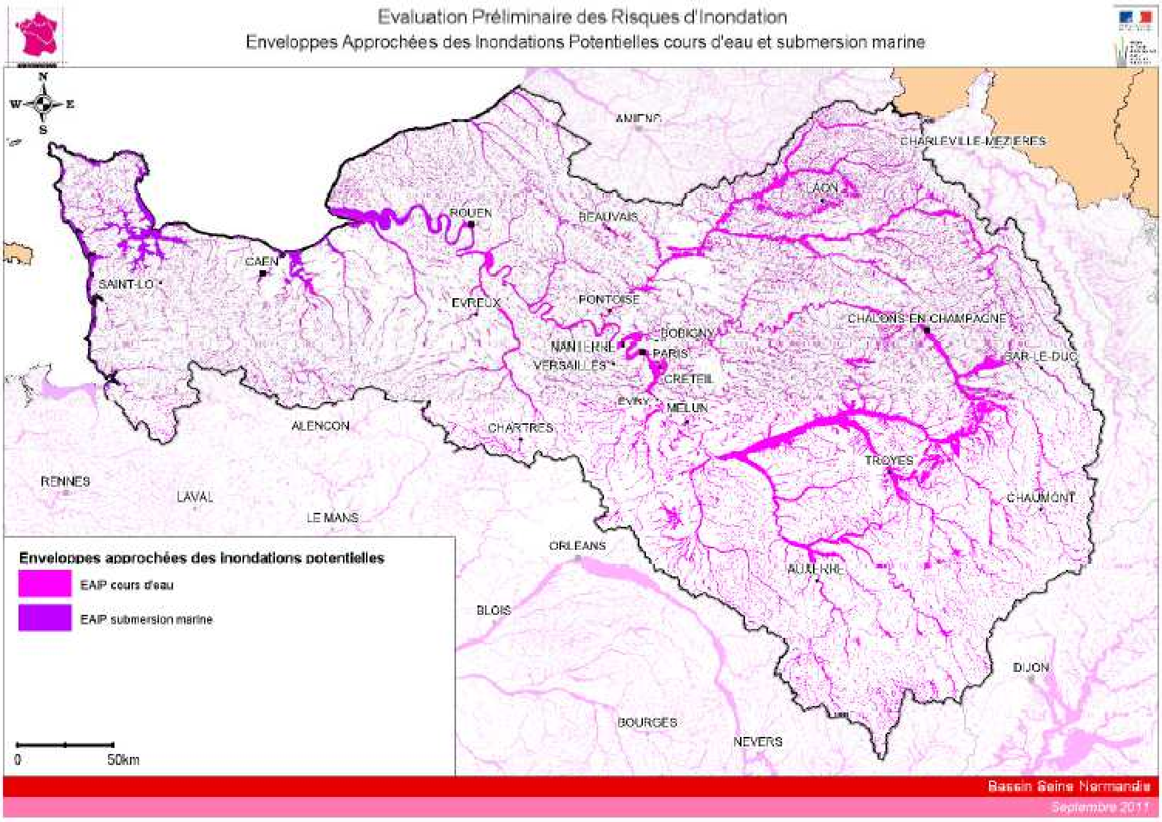


Figure 8 Approximated Envelope for Potential Floods for the Seine-Normandie basin

3.4.3. Identification of the issues at stake

Once EAIP are defined, risk assessment requires quantifying the potential negative consequences of the occurrence of flooding to human health, environment, cultural heritage and economic activity. To ensure homogeneity of the analysis, a common core of indicators at the national level has been set. The Indicators are based on the available databases at the national level (most indicators are calculated from the database BD TOPO ® from IGN).

The national PFRA evaluates the potential negative consequences of a flood using six impact indicators:
Population (permanent residents), number of hospitals, number of jobs, area of single storey housing, area of construction (and proportion of business buildings), area of notable built heritage exposed.
The "population" indicator represents the major issues at stake (economic, cultural etc.) due to the concentration of the population and thus of activity.

<u>The limits of the assessment</u>
The standardized approach of the PFRA method inevitably leads to simplifications and approximations. The presence of an issue at stake in the EAIP does not necessarily mean it is vulnerable or that it will have negative consequences if flooding occurs. Neither does the method allow the importance of these consequences, or the indirect effects of the flooding, to be evaluated. Each issue is thus dealt with in exactly the same way, and the potential seriousness of flood impacts is simply deduced from the number of issues concerned. Finally, this assessment takes no account of the effects of the policy in place up to now.

Another limit is that the population indicator is limited to permanent residents and does not take into account the population fluctuation due to tourism. In the tourist season, the population may temporary increase in coastal communities, but also in mountainous area.

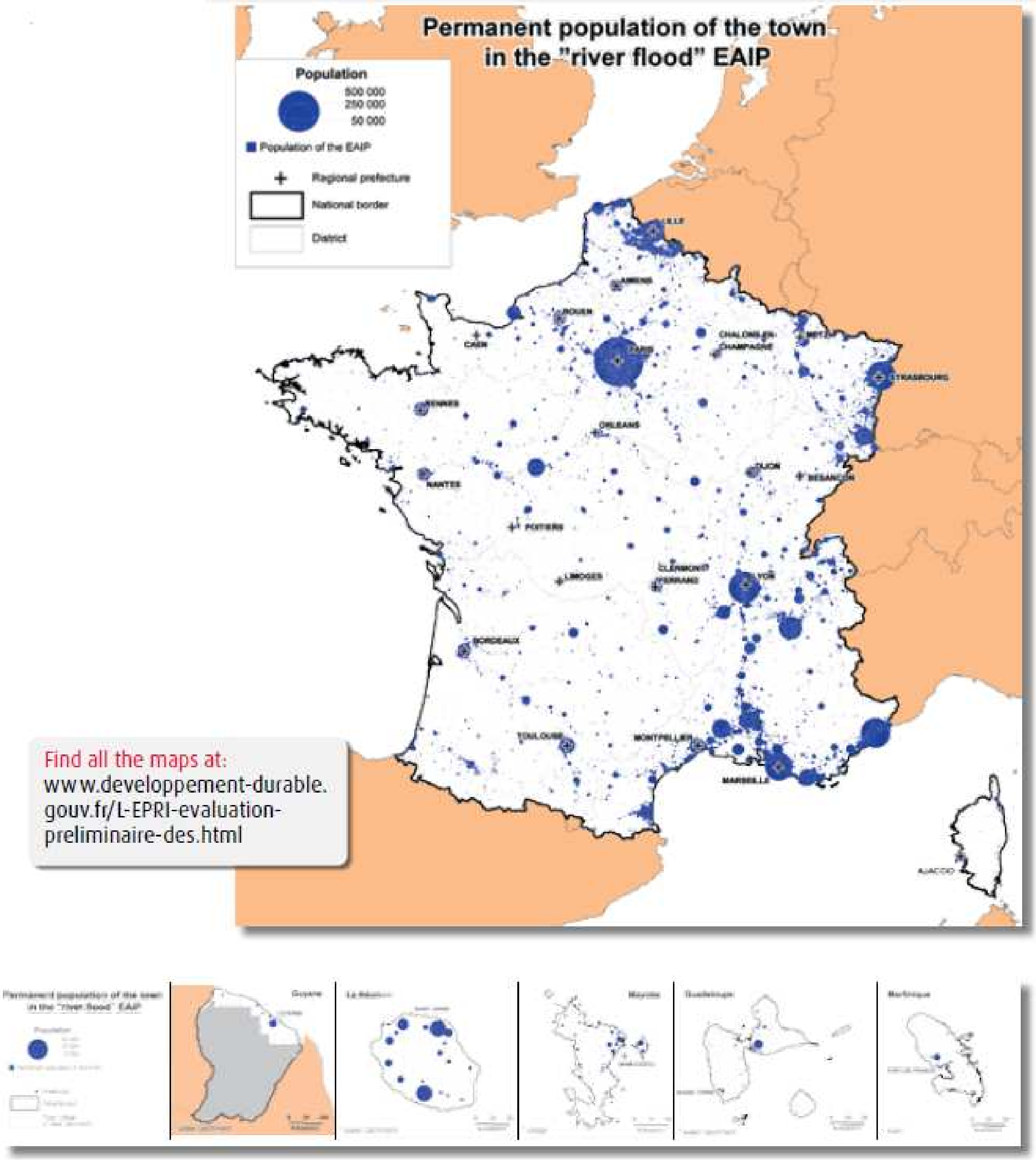


Figure 9 Map of population living permanently in the "river flood" EAIP

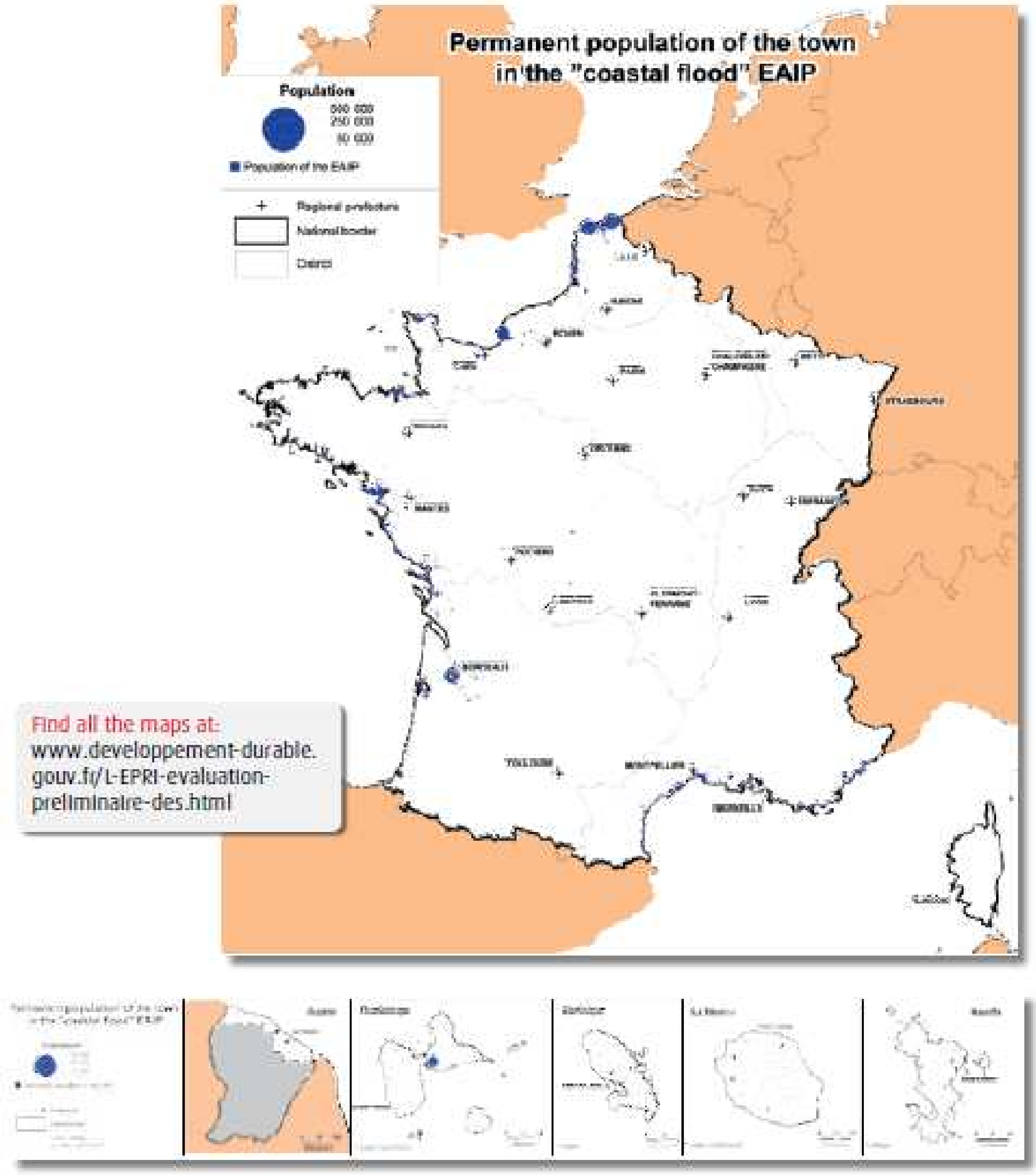


Figure 10 Map of population living permanently in the "coastal flood" EAIP

3.4.4. Implementation of a data base on historical floods

The first preliminary risk assessment has identified by the end of 2011 (end of EPRI milestone) around 2000 floods of different types including 300 remarkable events thanks to a documentary investigation on archives of State offices. Based upon this, a Data Base on Historical Floods (BDHI) (cf http://bdhi.liglab.fr/v32/web/login), covering mainland and overseas territories, is being developed by the DGPR. Documents on major floods are reviewed and synthesized so that each major flood in the BDHI is documented with at least the following information:

- Location, extension of the flooded area
- Date-duration
- Hydrometeorological genesis
- Consequences (victims, damages, socio-economic perturbations)
- Flood management

3.4.5. Future developments

The PFRA is only the first step of the new national strategy for managing flood risks. 3 others steps will be implemented:

- Based on the preliminary assessment of flood risk, the lands with a high risk of flooding (TRI) are identified.
- Based on this assessment, flood-prone areas will be mapped. The mapping must include three scenarios: a frequent flooding, average flood (return period must exceed 100 years) and extreme flooding. It must be completed by 22 December 2013.
- Based on these maps, plans of management of flood risks (PGRI) will be achieved. These plans should involve a comprehensive strategy to reduce the risk based on prevention, protection and preparedness for emergencies and be prepared for 22 December 2015 at the latest. They are developed at the district scale.

All these phases should be reviewed every six years in a cycle of continuous improvement.

4. COASTAL FLOODING HAZARD

4.1. Definition

Coastal flooding is a temporary flooding of coastal area by the sea in extreme meteorological conditions. Different factors can affect the sea level and lead to coastal flooding:

- Tide: high tide coefficients increase the probability of flooding;
- Low atmospheric pressure and wind: the conjugate action of both can lead to a rise of the sea level called storm surge;
- Swell: when it reaches the coast, it causes a rise of sea level called set-up that must be added to tide and storm surge.

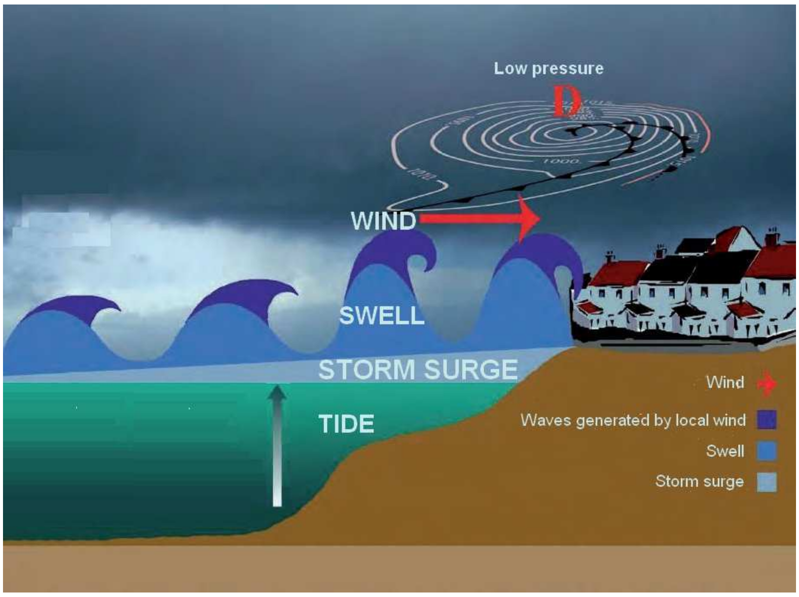


Figure 11 Scheme of different natural factors involved in coastal floods

4.2. The monitoring network of SHOM

The tide gauge network RONIM operated by the French Navy's Hydrographic and Oceanographic Department (SHOM) includes 42 permanent gauges as of 1 April 2012, including 6 in the overseas territories, one in Monaco and in the port of Toamasina (Madagascar). Data are recorded every 10 minutes, with an integration step of 2 minutes. SHOM is responsible for data quality control, processing, archival and dissemination.

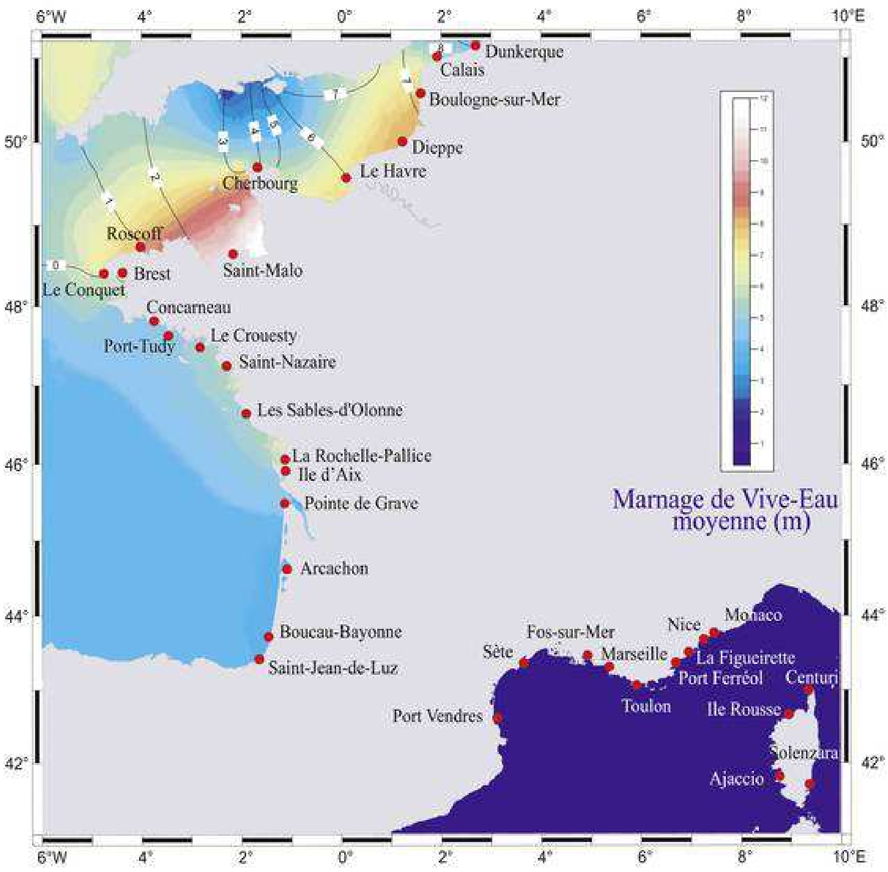


Figure 12 Map of tide gauge network RONIM in France mainland. Shades show average high tide sea level.

4.3. Statistics on extreme sea levels in France

The knowledge of extreme sea levels is of the most importance for the studies dealing with coastal hazards and all coastal and port developments. CETMEF-SHOM published in 2008 a study of extreme high tide sea levels performed by statistical analysis of tide gauge measurements at several sites and by geographic interpolation between these point, allowing the production of maps of sea levels for different return periods (10, 20, 50 and 100 years) along the French coasts of the English Channel and the Atlantic Ocean. In 2010, this study was extended to low tide levels.The maps have been updated in 2012.

For each main port / secondary site ("main" for ports with more than 10 years of measurement and called "secondary" for ports with less than 10 years of measurement), the statistical extreme levels for a given return period are evaluated from probability distribution functions derived from observations of water levels (obtained from tide gauges) and tide predictions. The method used for calculating these probability distribution functions are based, on the one hand on the statistical analysis of storm surges, on the other hand on the calculation of the probabilities of levels generated by predicted high tides. It is hypothesized that storm surge and tide are independent). Storm surges are adjusted to a Gumbel law. Finally, the return periods of extreme levels are calculated by convolution of the probability distribution of heights of high/low tide predicted and the probability distribution of storm surge.

The geographical interpolation for points between main and secondary ports is done through the *méthode de la plaque mince (Duchon, 1976).*

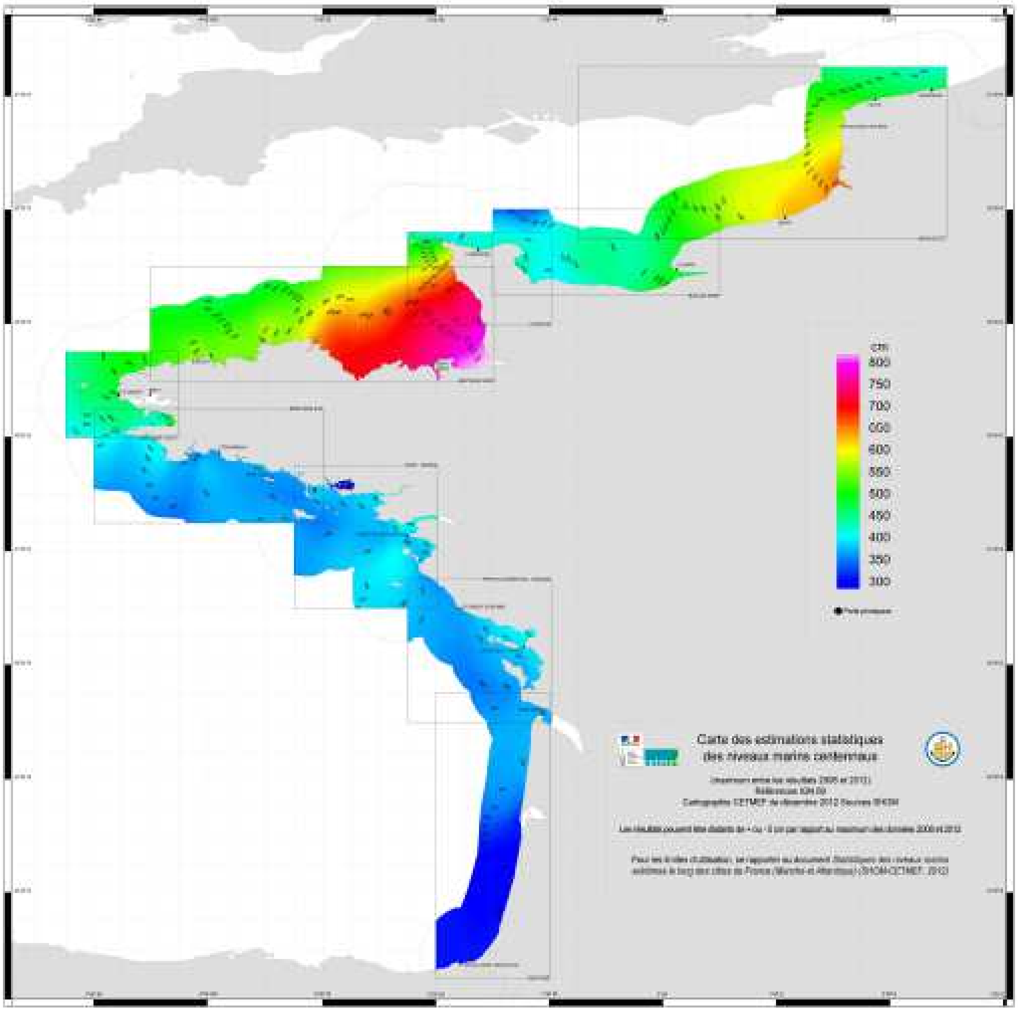


Figure 13 Composite map of maximum estimated sea levels of centennial return period. Levels are given compared to reference IGN 69.

<u>Limits of the methods</u>

Results from this method must be used carefully. The user must have in mind that:

- the results are more accurate at main ports;
- Uncertainties on the results increases with longer return periods;
- Uncertainties in the results are stronger inside bays (typically Bay of Mont St Michel) and coastal areas where there are less measurement points (Aquitaine)
- the results of the study are not valid in estuary areas and Arcachon basin (the hypothesis of independence between tide and storm surge is no more verified).

The method also considers that tide variation is predominant to storm surge, which is untrue in the Mediterranean Sea and in overseas territories. So it cannot be used in these areas. Moreover in overseas territories, cyclone events must be taken in account and processed differently.

5. AVALANCHE HAZARD

5.1. Definition

An avalanche is a rapid displacement of a mass of snow on a slope, caused by a rupture of the snowpack. Avalanche is a relatively complex physical phenomenon. The study of the stability of the snowpack on a slope uses knowledge in mechanics, snow conditions and meteorology.

Observation and recording of past phenomena are essential to better understand the avalanches. Three main programs are essential to the study and management of avalanche risk in France, particularly in a spatial planning framework:

- Location Map of Phenomena Avalanche (CLPA) describes areas where avalanches occurred in the past and are represented by their extreme limits reached,
- the Permanent Avalanche Investigation (EPA) is a historical chronicle of events observed at selected sites. The information is collected in the form of text and numbers.
- Inhabited Sites Sensitives to Avalanche (SSA) identifies the inhabited sites in winter and accessible with a secure route from avalanches, and classify them into three groups according to their sensitivity to avalanche risk.

None of these programs indicates the hazard or risk of avalanche, either in frequency or intensity or in temporality. Météo-France is responsible for forecasting the risk of avalanche for the next few days through its Vigilance map and its Snow and Avalanche Bulletins.

5.2. Observing avalanche-prone sites

Since the early twentieth century, officials from the National Forest Office (ONF) are monitoring the activity of some avalanche sites. Each avalanche is described and any potential observed damage is recorded. This monitoring continues today with the Permanent Avalanche Investigation (EPA), which is a monitoring operation carried out by agents of the ONF on about 5000 avalanche couloirs. The observations feed a computerized database that is a valuable tool for avalanche activity analysis.

Data collection is carried out by agents of the 260 observers ONF (National Forestry Office) who observe about 3900 sites across 11 departments (Corsica no longer followed). RTM (Land Restoration in Mountain) services, which are part of the ONF support the system.

Whenever an avalanche occurs on an EPA site, observers note the characteristics of the event: date, snow cover, altitudes of departure and arrival, type of avalanche, description of the deposit, etc…

All this information is reported by an online entry to the database that is managed and developed by Irstea. More than 90,000 events are now available (public data). Such a wealth of information on natural avalanches is almost unique in the world. The current funder is the Ministry of Ecology.

The monitored sites, often easily observable and reported on the observation of the EPA maps, were originally selected on the basis of damage on forests. Today, the selection is made upon human issues (roads, houses) and the scientific knowledge of avalanches.

Commune : 65017 - ARAGNOUET
N° site : 003 Pour information, nom actuel du site CIMETIERE

Nombre total d'événements : 7

Historique :

Dates				Altitudes				Dépôt			Caractéristiques						Météo 3 jours précédents					Météo 4h précédentes						Causes				Victimes			Dégâts ou lieux atteints						Constat			
date 1	date 2	heure	tranche horaire	altitude départ	altitude arrivée	versant opposé	zone plane	longueur (m)	largeur (m)	hauteur (m)	A	B	C	D	E	F	hauteur de neige	vent fort	direction vent	redoux	pluie	neige	pluie	vent fort	ciel clair	nuages	brouillard	naturelle	involontaire	artificielle	inconnue	néant	blessés	morts	néant	construction	poteaux	forêt	routes	cours d'eau	visibilité	alerte bd évènt	date	Observation
22/02/11 13:00	23/02/11 09:00			2000	1200			30	6	2.0	4	4	9	2	2	2	51-100	?		X	X	X	X	?	?	?	?	X				X							X		B	O	24/02/11	Non diffusable
12/02/09 00:00	16/02/09 00:00			2200	1500			60	8	1.0	8	3	2	5	2	2	?	?		?	?	?	?	?	?	?	?	X				X			X						B	N	16/02/09	Non diffusable
01/11/08 00:00	02/11/08 00:00			2000	1350			5	3	1.5	4	4	2	2	2	2	21-50			X	X	X						X				X			X						B	N	04/11/08	Non diffusable
04/02/84 00:00	04/02/84 00:00	00:00	Jour	2450	1320						2	5	2	5	2	2	21-50			X	X				X			X				X			X									
15/01/81 00:00	15/01/81 00:00		Soir	1700	1400						2	5	2	5	2	5	21-50				X		X					X				X			X									
Remarques: L'avalanche s'arrête au-dessus de la RN 129.																																												
19/12/80 00:00	19/12/80 00:00		Soir	1650	1260						9	9	5	9	9	9	51-100				X		X					X				X			X									Non diffusable
Remarques: L'avalanche s'est arrêtée à la Neste d'Aragnouet.																																												
01/02/78 00:00	01/02/78 00:00	00:00	Jour	1500	1300			10	4	3.0	2	4	2	2	2	2	>100	X	err				X	X		X		X				X			X									Non diffusable
Remarques: Route obstruée sur 10 m de longueur; 3-4 m de largeur; 3 m de haut.																																												

Figure 14 Extract of EPA (from ONF-IRSTEA, updated 27/11/12)

5.3. The inventory of areas prone to avalanches

A cartographic inventory of areas prone to avalanches was undertaken in 1970. This inventory covers all French Alpine massifs and Pyrenees, but deals primarily with the areas close to urbanized areas and ski areas. The specifications was proposed by IRSTEA and the methodology developed by the National Geographic Institute (IGN). These location maps of avalanche phenomena (CLPA) are set to 1: 25 000. They show the maximum envelope of identified past avalanches and avalanche zones located by the analysis of aerial photographs.

The CLPA is mainly based on the EPA for locating old avalanches. Investigation and consultation with the various stakeholder organizations in mountain areas (services land restoration in mountain (RTM), the services tracks, regional and national parks, DDE) complete the approach. The CLPA is a strictly informative document that became essential for the management of the road network, ski areas or the study of tourism development projects. More than 710 000 hectares have been mapped.

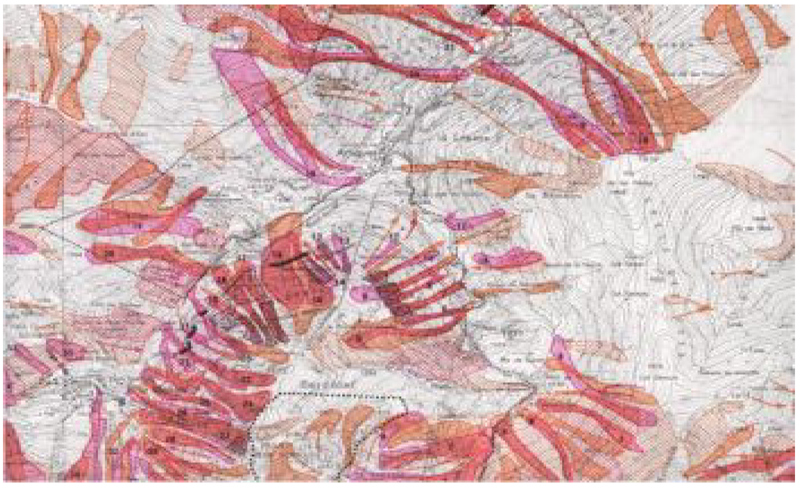


Figure 15 Extract from CLPA© IRSTEA

5.4. Climatological Study of the Natural Avalanche Activity: Project ECANA

ECANA is a project funded by the Directorate General for Risk Prevention (DGPR) of the Ministry of Environment since 2009. The work is done in collaboration between the research unit Torrential Erosion Snow and Avalanches (ETNA) of IRSTEA and the Centre of Snow study (CEN) of Météo France. Its main goal is the study of the climatology of natural avalanche activity in the French Alps. To do this, it relies mainly on the French avalanche data archived by IRSTEA in EPA, but also on snow and weather data acquired, assimilated and reanalyzed by Météo-France. The assumption usually made for risk management that the avalanche phenomenon is stationary in time is to be tested and challenged. To do this, advanced statistical methods of time series analysis, modeling, classification and selection of variable are implemented.

First results of the projects can be found here: http://www.avalanches.fr/projet-ecana/

6. Forest fire hazard

6.1. Definition

A forest fire is a fire that affected a forest area (forest, bush, garrigue) greater than 1 hectare. Forest fires combines natural factors and human factors, not only in the explanation of their origin but also in their magnitude.

6.2. Monitoring and daily forecasting

6.2.1. Météo-France's role

A framework agreement 2008-2012 between the Directorate of Civil Protection (DSC) and Météo-France was signed. In terms of forest fires, it is stated that: "Météo France provides to the DSC, key but non unique elements for assessing the risk of forest fires. The DSC is responsible for the public dissemination of information about the risks of forest fires. Météo-France participates in the dissemination of risks at the request of the DSC.

Météo France forecasters are placed within Zone Headquarters (EMZ) to assess the risk of forest fire due to meteorological conditions.

In the Southwest area (Aquitaine, Midi-Pyrénées and Poitou-Charentes), this service is based in the Zonal Operational Center (COZ) of Bordeaux. In the South (15 Mediterranean *départements*), it is based at the EMZ in Valabre (Gardanne - 13).

The forest fire watch starts in Bordeaux by the end of winter because a first drought period is often observed in March -April, creating a risk in the massif des Landes de Gascogne. The forest fire watch starts in Valabre by June. The forest fire watch ends in autumn.

6.2.2. The monitoring network in the South

The risk of forest fire is assessed on 15 *départements* for 116 elementary areas of 400 to 800 km^2. To achieve the fire assistance, Météo-France forecasters receive in addition to the traditional weather network (stations + radars) data from around 300 automatic weather stations collected in real time. Each station measures wind, temperature, humidity and precipitation.

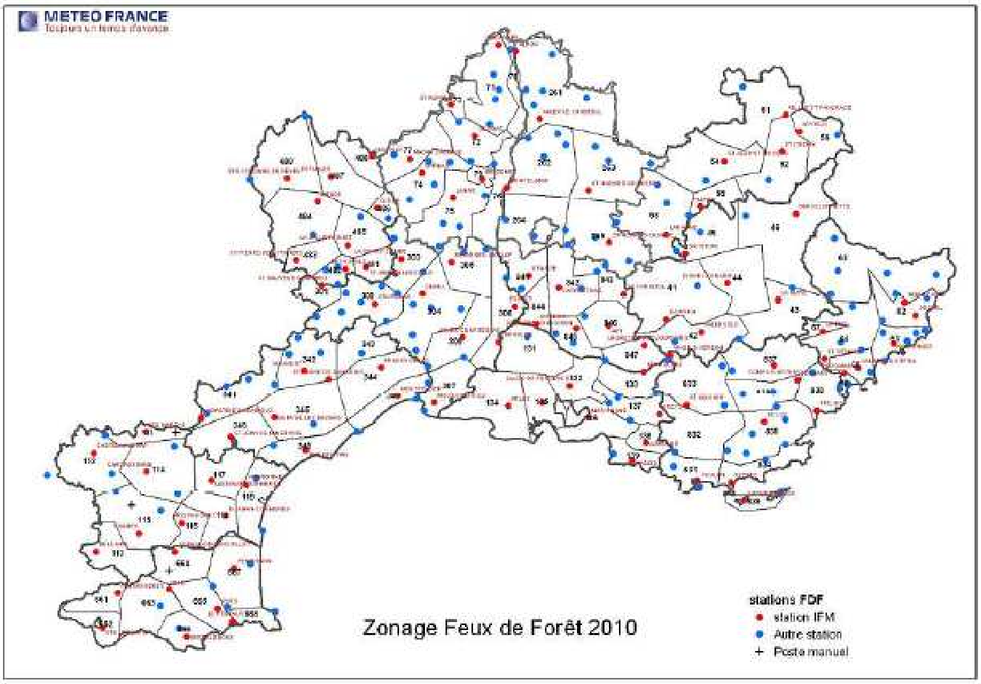


Figure 16 Map of the meteorological station network used in the South for forest fire monitoring

The Mediterranean area has in addition a network for measuring the water content of plants (2 points per *département*), operated by the ONF, with the scientific support of INRA. Measures of the flammability of Kermes oak and rosemary are also made by the Center of Testing and Research of Entente (CEREN). These measurements are made in the summer, once or twice a week depending on the level of hazard.

Meteorological conditions give only favorable conditions to fire outbreaks. Most of forest fires start because of human factors. The forest itself must be monitored to detect fire outbreak as soon as possible. Fire outbreak monitoring includes fixed terrestrial watch towers, mobile patrols, supplemented by aircrafts.

6.2.3. The method used for forecasting the forest fire hazard

The forecast is based on a daily assessment of the drought conditions and meteorological parameters such as wind, temperature, humidity and solar radiation. A danger index, the IFM (developed in Canada) taking into account the drought conditions and the meteorological parameters is calculated. The IFM calculation relies on the calculation of 3 intermediate indices: the Fine Fuel Moisture Code (ICL), the Duff Moisture Code (IH) and the Drought Code (IS). It gives better results than other hazard indices in most situations. In France, in case of recent rainfall, as well as in mountainous backcountry area, it is the only reliable index. However, The IFM is not flawless. In particular, it gives poor results in cases of severe drought, during which it significantly underestimates the level of danger in low to moderate wind condition. The heat wave of summer 2003 and its abysmal record in terms of surface area burned in South defense area showed the limits of an analysis that would confined to use IFM only. Therefore, during periods of severe drought, the analysis cannot rely on this index and other indices are used.

Two other indices are calculated:
- the outbreak threshold, an estimate of the wind speed above which a fire becomes possible. This estimate is a function of the water content in light fuel.
- the propagation index, an estimate of the theoretical propagation speed of a fire on a flat ground as a function of the wind speed, the temperature and the soil water content.

From the detailed analysis of the all the previous computed indices and his experience, the "forest fire" forecaster assigns to each zone, a level of danger for days J and J +1 on a six level scale: L (low), L (light), M (moderate), S (severe), T (very severe) or E (exceptional).

These forecasts are made available to the services of Civil Defence (Zone Headquarter, Operational Centre Of Fire and Rescue, ...) and other State services via a dedicated website with restricted access. Hazard level predicted in each zone is used for the selection of preventive systems. It is a decisive factor for optimizing mobilization and the deployment of means to fight against forest fires.

6.3. The forest fire data base in the South: Prométhée

Prometheus data base lists information on forest fires in the Mediterranean region. Designed and launched in 1973, it covers 15 departments of the southeast of France. The Data base is managed by the Delegation to the Protection of the Mediterranean Forest (DPFM) in coordination with the Ministries of the Interior and Agriculture. Accessible on the Internet (www.promethee.com), it includes data on burned surfaces, the number of forest fires, the distribution of fires by municipalities, hourly and monthly distributions of fire outbreaks.

In France many various stakeholders with different working culture and experience are involved in the problem of forest fire. The main goal of Prométhée data base is to gather and homogenize data coming from very diverse sources and disseminate the information to all the stakeholders concerned by forest fire hazards.

Fires are identified (i.e. created in the data base) every day by firefighters. Forest fires but also other fires in rural and peri-urban areas are taken into account.

The essential meta data archived for each fire are the following:
- location("*département, commune, lieu-dit*")
- date (day, month, year)
- DFCI coordinates of the outbreak (DFCI is the coordinates system used notably by DSC and firefighters)
- The time of the alert,
- The alert origin,

In the case of forest fires:
- The date and time of the first intervention
- The date and time of the end of intervention,
- The area covered and the indication (if any) of fire in progress

In the case of other fires in rural and peri-urban areas:
- The type of damage and the indication of a threat to forest

All of these variables (except the locality and the alert origin) are required. The reference of the fire is generated automatically.

In the case of forest fires, additional data will be provided by various services: firefighters, foresters, gendarmes and police.

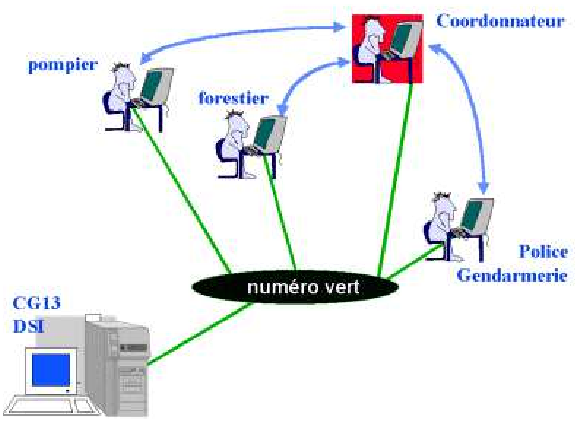


Figure 17 Organization scheme for updating the Prométhée data base

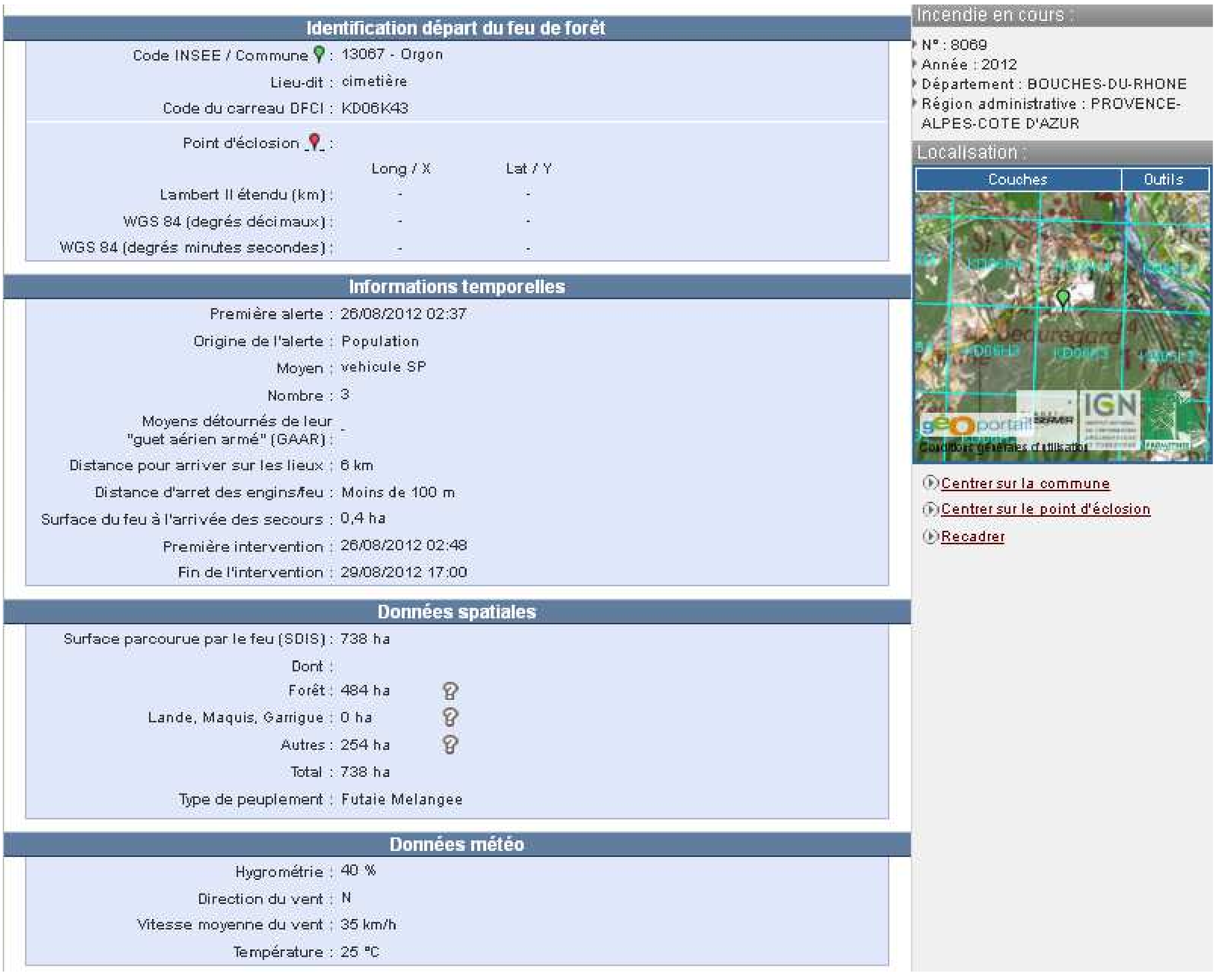
Map data
Map data are (or) the outbreak point(s) and the forest fire limits located on a map.

Additional data
Additional data are the data provided for fire greater than 10 hectares (less than 10% of forest fires). This mainly concerns the distribution of the areas covered by the fire.

Meteorological data

Meteorological data are of three types:

- data provided by firefighters and foresters who have weather suitcases: humidity, temperature, wind speed and direction,
- data retrieved automatically and once a week from METEO FRANCE files that can be linked to a fire: soil water content in the area of the fire, IFM, ICL, IH, IS indices from the closest weather station to the fire.
- data recorded three times a day by weather stations during the season of forest fires: wind, temperature, soil water content, IFM, outbreak threshold, propagation speed.. These data, systematically collected once a week, are not related to fires.


Identification départ du feu de forêt
Code INSEE / Commune : 13067 - Orgon
Lieu-dit : cimetière
Code du carreau DFCI : KD06K43
Point d'éclosion :

	Long / X	Lat / Y
Lambert II étendu (km) :	-	-
WGS 84 (degrés décimaux) :	-	-
WGS 84 (degrés minutes secondes) :	-	-

Informations temporelles
Première alerte : 26/08/2012 02:37
Origine de l'alerte : Population
Moyen : vehicule SP
Nombre : 3
Moyens détournés de leur "guet aérien armé" (GAAR) : -
Distance pour arriver sur les lieux : 6 km
Distance d'arret des engins/feu : Moins de 100 m
Surface du feu à l'arrivée des secours : 0,4 ha
Première intervention : 26/08/2012 02:48
Fin de l'intervention : 29/08/2012 17:00

Données spatiales
Surface parcourue par le feu (SDIS) : 738 ha
Dont :
Forêt : 484 ha
Lande, Maquis, Garrigue : 0 ha
Autres : 254 ha
Total : 738 ha
Type de peuplement : Futaie Melangee

Données météo
Hygrométrie : 40 %
Direction du vent : N
Vitesse moyenne du vent : 35 km/h
Température : 25 °C

Incendie en cours :
N° : 8069
Année : 2012
Département : BOUCHES-DU-RHONE
Région administrative : PROVENCE-ALPES-COTE D'AZUR

Localisation :
Couches | Outils
Centrer sur la commune
Centrer sur le point d'éclosion
Recadrer

Figure 18 Example of a file (data and meta data of a forest fire) in Prométhée data base (from www.promethee.com)

This data base allows the users to have access to an inventory of forest fires through a search engine and to various statistical analyses.

Statistiques des feux de forêt par département

Départements	Nbre feux 2012	Nbre feux 2013	Surface 2012 (ha)	Surface 2013 (ha)	Nbre moyen de feux par an entre 2008 et 2012 (ha)	Surface moyenne brulée par an entre 2008 et 2012 (ha)
ALPES-DE-HAUTE-PROVENCE	65	8	252	14	39	84
ALPES-MARITIMES	102	7	251	11	101	216
ARDECHE	105	10	506	31	105	365
AUDE	168	18	261	28	138	438
BOUCHES-DU-RHONE	158	1	831	54	154	729
CORSE-DU-SUD	244	6	173	0	294	1193
DROME	23	5	18	3	28	21
GARD	98	3	86	3	49	120
HAUTE-CORSE	368	7	458	6	272	522
HAUTES-ALPES	19	1	70	1	7	35
HERAULT	161	15	538	13	173	1327
LOZERE	61	8	322	7	60	280
PYRENEES-ORIENTALES	65	3	459	42	57	371
VAR	180	15	86	15	153	253
VAUCLUSE	35	1	73	0	23	28

Statistiques des feux de forêt par région

Régions	Nbre feux 2012	Nbre feux 2013	Surface 2012 (ha)	Surface 2013 (ha)	Nbre moyen de feux par an entre 2008 et 2012 (ha)	Surface moyenne brulée par an entre 2008 et 2012 (ha)
CORSE	612	13	631	6	566	1715
LANGUEDOC-ROUSSILLON	553	47	1666	93	477	2536
PROVENCE-ALPES-COTE D'AZUR	559	33	1563	95	477	1345
RHONE-ALPES	128	15	524	34	133	386

Statistiques des feux de forêt sur la zone Prométhée

	Nbre feux 2012	Nbre feux 2013	Surface 2012 (ha)	Surface 2013 (ha)	Nbre moyen de feux par an entre 2008 et 2012 (ha)	Surface moyenne brulée par an entre 2008 et 2012 (ha)
Zone méditerranéenne Prométhée	1852	108	4384	228	1653	5982

Figure 19 Example of statistics available at www.promethee.com

7. HAZARD DUE TO METEOROLOGICAL PHENOMENA

Météo-France is responsible for monitoring and forecasting the evolution of atmosphere, surface ocean and snowpack and thus ensures the safety of persons and property. It disseminates to the authorities and public through the Vigilance map, up to 24 hours before, warnings for 8 risks: high winds, rain-flooding (in cooperation with the flood prediction network), storms, snow / ice, avalanches, heat waves, cold waves and waves/coastal flooding (using data from the tide gauge network). The Vigilance system is complemented by broadcasting Special Weather Bulletins for marine hazards and in the overseas *départements*, the cyclone warning system. The French Multi-Hazards system was comprehensively described in previous WMO seminars and will not be developed here.

7.1. Definitions

7.1.1. Tropical cyclones/Hurricane (wind)

In general, a tropical cyclone vortex is defined as a tropical atmospheric perturbation, with very low central pressure (less than 980 hPa), turning clockwise in the southern hemisphere, and anticlockwise in the northern hemisphere. A cyclone enters its mature phase when the average wind speed in it reaches 118 km/h. Depending on the region, it is called cyclone, hurricane or typhoon. At this stage, the cyclone consists of large cloud masses, very strong winds and torrential rains occur and waves and storm surge are generated.

The Cyclone Watch is coordinated at an international level by the WMO that has designated in each oceanic basin a Regional Specialized Meteorological Center (RSMC) that has the duty to detect cyclones and forecast their trajectories: Those RSMC are Miami for the North Atlantic Ocean and North-East Pacific, Tokyo for the North Pacific Ocean; New Delhi for the Bay of Bengal and the Arabian Sea, Fiji for the southwest Pacific Ocean, Saint-Denis-de-la-Reunion for southwest Indian Ocean).

The SAFFIR-SIMPSON scale is used in the North Atlantic Ocean and the North-East Pacific to classify cyclones from 1 to 5, according to the mean wind speed.

Classification	Pressure at the center in hPa	Wind speed in km/h	Damages
Class 1	More than 980	118-153	Minimal
Class 2	965-980	154-177	Moderate
Class 3	945-964	178-209	Intense
Class 4	920-944	210-249	Extreme
Class 5	Less than 920	More than 249	Catastrophic

7.1.2. Mid-latitude storm (wind)

The wind is the essential element that determines a storm and its intensity is an indicator of the state of the storm. Sometimes, when it blows strong, (gusts over 100-120 km/h), serious consequences for the safety of persons and property are to be feared. Wind is frequently accompanied by precipitation and sometimes, especially in hot weather, thunderstorms. The storm presents itself as a complex meteorological entity.

Storms are directly related to the atmospheric depressions that are the backbone of their synoptic context and determine their characteristics and evolution.

A storm can therefore be defined as a violent wind, fairly long (several hours), associated with the passage of an atmospheric depression. In Beaufort scale used in marine meteorology, the term storm refers to the 10 graduation and corresponds to winds with an average speed between 89 and 102 km/h.

Tornadoes are considered a particular type of storms, characterized by a limited lifetime and affecting a small geographic area compared with conventional storms. However they can generate the strongest winds on earth surface (more than 400km/h). They are rare and unpredictable in France for now. In average, 15 tornados with an intensity of F1 or more (on the Fujita scale) and 2 tornados with an intensity of F2 or more are estimated to occur.

7.1.3. Lightning

Lightning is a massive electrostatic discharge between electrically charged regions within clouds, or between a cloud and the Earth's ground. Cloud-to-ground lightning are responsible for many losses and damage caused to the environment, buildings and people. The national network of lightning detection consists of 19 sensors distributed throughout France mainland. It is operated by Meteorage, a subsidiary of Météo-France and Vaisala.

7.1.4. Hailstorm

Hailstorms are storms leading to precipitation of ice particules of different shapes which are transparent or partially to totally opaque. The diameter of the particules varies generally between 5 mm and 50 mm.

7.1.5. Snow and freezing rain

A snowfall is a precipitation of isolated or clustered ice crystals from a cloud. Freezing rainfall are at the origin of generally transparent and smooth ice deposit, generally formed by the freezing of supercooled raindrops on objects whose surface is at a temperature below or slightly above zero degrees Celsius. Non supercooled raindrops that lead to ice deposit when impacting very negative temperature objects can also be considered freezing rain.

7.2. Hazard monitoring

Météo-France operates a complete observation network including around 550 surface stations (mainland), automated high mountain stations, radiosonde station, buoys and radars. It also collects the observations from surface stations from partners (DGPR, EDF,…).
All these observation data can accessible in real time by forecasters through Synopsis software, the visualization tool of Météo-France. In addition, satellite images, data from the national tide gauge network and the lighting detection network and outputs from different forecast models are also available on Synopsis. Hazard nowcasting and forecasting are made from there.

7.3. Météo-France climatological data base

7.3.1. Description

All data in France (mainland and overseas territories, surface, upper air and marine) coming from surveys and observations from synoptic stations, radiosonde stations, stations of the State Climatological Network (RCE), mainland automatic stations, semaphores and selected weather ships are considered climatological data. All these data are accompanied by a set of information, called metadata, describing the history of the measurement points, and any information needed to monitor homogeneity of data or knowledge of the data catalogue.

Most of these data (excluding "marine" data) are managed by the ORACLE relational Data Base Management System. The Météo-France climatological data base contains:

- Mainland "basic" data : observed and / or measured data (daily, hourly and 6 minutes parameters)
- Mainland developed data:
  - decadal and monthly data;
  - precalculated climate normals for the periods 1951-1980, 1961-1990, 1971-2000 and 1981-2010;
  - Daily and monthly records;
  - hydrometeorological information (threshold-excedeed, return period);
  - agrometeorological information;
  - long series of homogenized data
- Overseas "basic" data
- International data

Extreme values for return periods from 2 to 100 years are calculated for wind, rainfall and snowfall through different statistical laws and included in the database. Those values are associated with a 70% confidence interval.

Most of data are not free of charge and must be used under license.

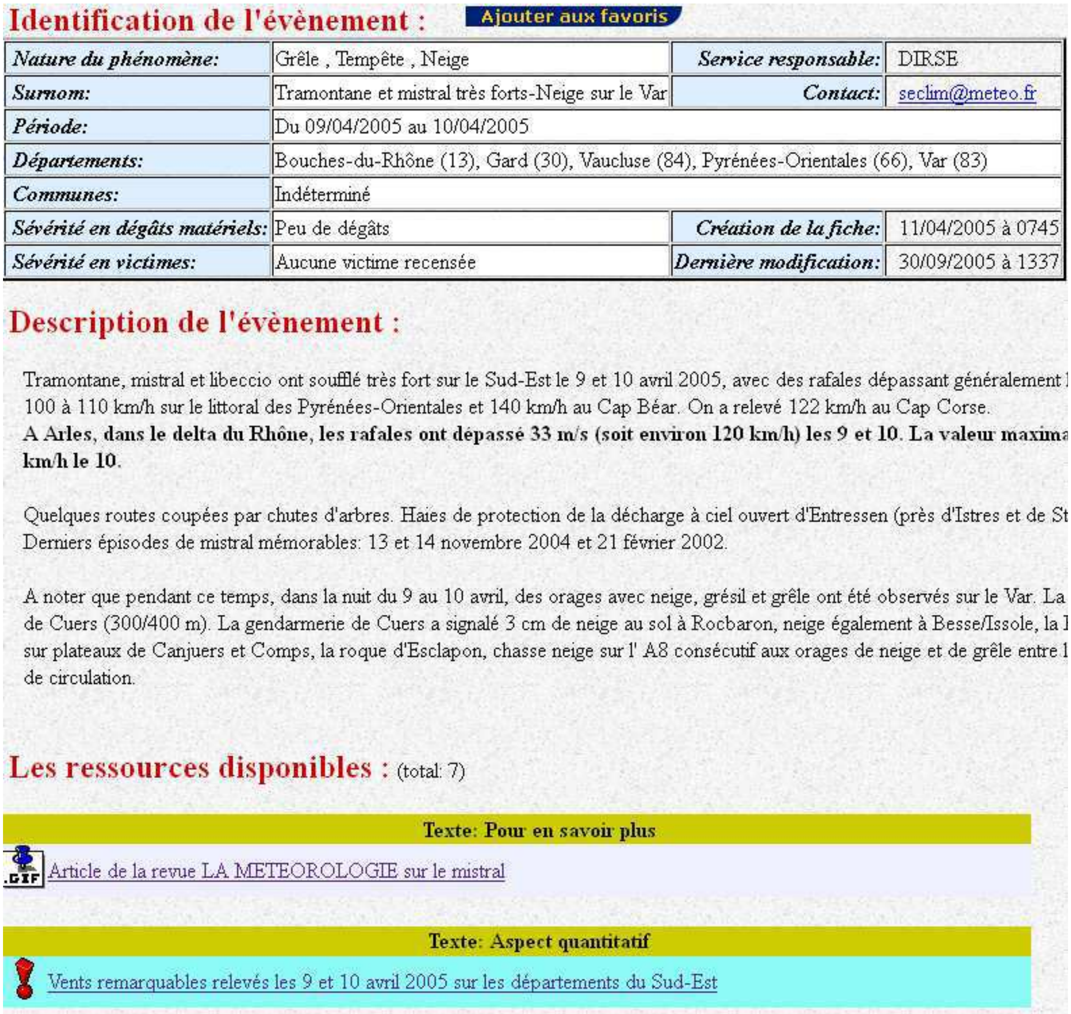
7.3.2. Data rescue activity

Climatologists work continuously to integer very old data in the data base. This data rescue action focuses on daily precipitation, daily minimal and maximal temperature and hourly pressure at sea level. In general data set are complete after 1960. The data rescue concerns data recorded before 1959 for temperature and 1949 for pressure. This work will allow having longer and denser series of homogenized data throughout the country. Meta data are also rescued following the recommendations of the technical guide of WMO WCDMP n°53.

7.4. The data base of remarkable events (BDEM)

Météo France maintains for internal needs a data base that archives remarkable events. It provides elements summarizing those events and information. It covers not only events caused by the meteorological phenomena considered in this chapter but also all weather-related phenomena including landslide/mudslide, forest fires, floods, storm surges, avalanches, highly polluted situation, etc….
Links to additional resources related to the event such as radar and satellite image, model fields, photos, newspaper articles may be available.

The events are not only chosen on meteorological criteria. The selection is partly subjective. It is based upon the common sense of the climatologist, his knowledge of the event in terms of media coverage and of course his experience. Archived events are spectacular and/or catastrophic and are triggered by a meteorological situation. By construction, the BDEM is not to be used for statistical processing because it is not comprehensive.



Identification de l'évènement : Ajouter aux favoris

Nature du phénomène:	Grêle , Tempête , Neige	*Service responsable:*	DIRSE
Surnom:	Tramontane et mistral très forts-Neige sur le Var	*Contact:*	seclim@meteo.fr
Période:	Du 09/04/2005 au 10/04/2005		
Départements:	Bouches-du-Rhône (13), Gard (30), Vaucluse (84), Pyrénées-Orientales (66), Var (83)		
Communes:	Indéterminé		
Sévérité en dégâts matériels:	Peu de dégâts	*Création de la fiche:*	11/04/2005 à 0745
Sévérité en victimes:	Aucune victime recensée	*Dernière modification:*	30/09/2005 à 1337

Description de l'évènement :

Tramontane, mistral et libeccio ont soufflé très fort sur le Sud-Est le 9 et 10 avril 2005, avec des rafales dépassant généralement l
100 à 110 km/h sur le littoral des Pyrénées-Orientales et 140 km/h au Cap Béar. On a relevé 122 km/h au Cap Corse.
A Arles, dans le delta du Rhône, les rafales ont dépassé 33 m/s (soit environ 120 km/h) les 9 et 10. La valeur maxima km/h le 10.

Quelques routes coupées par chutes d'arbres. Haies de protection de la décharge à ciel ouvert d'Entressen (près d'Istres et de St
Derniers épisodes de mistral mémorables: 13 et 14 novembre 2004 et 21 février 2002.

A noter que pendant ce temps, dans la nuit du 9 au 10 avril, des orages avec neige, grésil et grêle ont été observés sur le Var. La de Cuers (300/400 m). La gendarmerie de Cuers a signalé 3 cm de neige au sol à Rocbaron, neige également à Besse/Issole, la l sur plateaux de Canjuers et Comps, la roque d'Esclapon, chasse neige sur l' A8 consécutif aux orages de neige et de grêle entre l de circulation.

Les ressources disponibles : (total: 7)

Texte: Pour en savoir plus

Article de la revue LA METEOROLOGIE sur le mistral

Texte: Aspect quantitatif

Vents remarquables relevés les 9 et 10 avril 2005 sur les départements du Sud-Est

Figure 20 Example of information contained in BDEM for one event.

8. HEAT WAVE/ COLD WAVE HAZARD

8.1. The monitoring and warning procedure for heat waves

Heat waves are known meteorological phenomena, for which, however, there is no standard meteorological definition. In France, the heat wave of summer 2003 was the most intense recorded in France since the 1950s: a heat wave with an exceptional intensity occurred during the first half of August. This episode was accompanied of important ozone pollution both in duration and intensity.

In the immediate aftermath of the heat wave, the Institute of Health Surveillance (InVS) has produced and contributed to many epidemiological studies aiming to:

- Inform the mortality from all causes attributable to the heat wave in 2003 in the biggest French cities and at national level ;
- Identify, through two large case-control studies, the risk factors of mortality for the deceased elderly;
- Know, in the nine cities of the air and health monitoring program air, the part attributable respectively to ozone and temperature in mortality.

To better respond to heat waves, the Ministry of Health has developed a Heat wave National Plan (PNC) in 2004. The PNC defines actions to prevent the health impact of episodes of high temperatures. It includes recommendations to various stakeholders: professionals, health, social stakeholders.

The PNC includes a heat alert and health system (Sacs) identifying, in the meteorological context, what actions are to be implemented. The system was designed by InVS and Météo-France based on a framework agreement signed in early 2004 and to facilitate the development of procedures for prevention and warning against the health hazards of meteorological origin.

The Sacs is based on monitoring biometeorological indicators (IBM) forecasts and on a system of warning thresholds set at a local scale.

The indicator used is the pair (IBMn, IBMx), where IBMn is the moving average over 3 days of minimum temperatures, and IBMx the moving average over 3 days of maximum temperatures. It was implemented based on statistical studies between weather indicators and percentages of daily mortality. Alert thresholds have been selected for each city seeking to have the least possible missed alerts, and the least possible false alarms that would discredit the operational system. For example, the couple in Paris (21-31 °C) was chosen as the threshold for defining a heat wave.

Based upon the pair (IBMn, IBMx), the PNC can be scaled on 3 levels:

- the seasonal watch is the period from 1 June to 31 August. Each day of this period, InVS monitors weather and health indicators in collaboration with Météo-France.
- The level of warning and action (Miga) is triggered by the prefects of departments if the thresholds established by the Sacs are forecast to be exceeded on the same day or on the three following days. Health and social measures contained in the PNC are implemented at the local or the national level, for example, support for people at risk or opening of additional beds in hospitals.
- The maximum level of mobilization corresponds to an exceptional situation exceeding the health field. It is triggered by the Prime Minister on the recommendation of the Ministers of Health and of the Interior and involved all the stakeholders concerned by the PNC.

The Sacs is revised every year after the seasonal watch. Alert thresholds can evolve to optimize the system. Also, since 2003, the population may be less vulnerable to heat wave because it is more aware of the dangers of the heat and because of the measures implemented by the PNC.

8.2. Météo-France methodology for climatological classification

The heat wave definition based on the couple (IBMn, IBMx) is set for sanitary purpose and warning thresholds vary locally. Moreover they are to evolve as the population becomes more resilient to heat waves. No "official" definition exists for heat wave or cold wave. Météo-France has implemented its own method to define heat waves at a national level that allows establishing a climatological classification of the most severe cold or hot events.

8.2.1. Definition of indicators

The overall approach of the daily temperature in France is made through a thermal indicator (**Ind1**), mean temperature ((TN + TX)/2) averaged on 30 metropolitan stations for which data are available without loss since 1947. The indicator itself is hence available daily without missing since 1947.

The 3 day moving average **Ind3** has also been derived from **Ind1** and assigned to the intermediate days.

8.2.2. Identification of an event

An intense cold is identified for a Day when one of the following conditions is met:
- The thermal indicator daily (Ind1) is below -3 °C;
- The average over three days of the daily thermal indicator (ind3) is less than 2 ° C.

An intense heat is identified for a Day when one of the following conditions is met:
- The thermal indicator daily (Ind1) is greater than 26 ° C;
- The average over three days of daily (ind3) thermal indicator is above 25 ° C.

Each day D that met the above criteria is included in a cold wave or a heat wave.

8.2.3. Duration of an event

The starting day and the ending day are defined through other thresholds. These thresholds were determined empirically from the beginning and the end of known events (cold wave of February 1956, August 2003 heat wave, etc ...).

A cold wave previously detected (from Ind1 or ind3) includes the periods adjacent to the D-day for which the daily thermal indicator (Ind1) does not become lastingly greater than 0 ° C. The term lastingly means three days or more.

A heat wave previously detected (from Ind1 or ind3) includes the periods adjacent to Day D for which the thermal indicator daily (Ind1) does not become lastingly less than 23 ° C. The term lastingly means three days or more.

8.2.4. Intensity of an event

The maximum intensity is very simply the minimum (respectively maximum) value of the thermal indicator (Ind1) reached within the episode of cold wave (respectively heat wave).

The overall intensity was determined for cold wave by cumulating the degrees below 0° C over the duration of the episode. For heat waves, the intensity was determined by cumulating the degrees above 23 ° C over the duration of the episode.

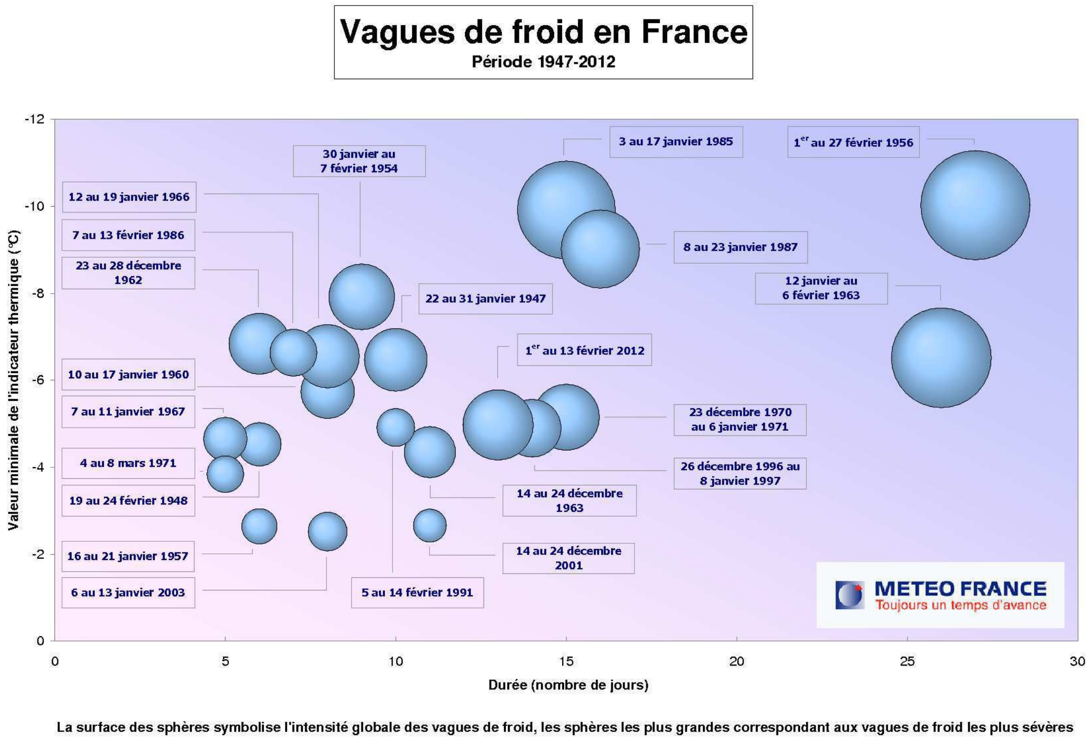


Figure 21 Inventory of past cold waves classified by duration (x-axis) and maximum intensity (y-axis). The sphere surface of each cold wave is proportional to its global intensity.

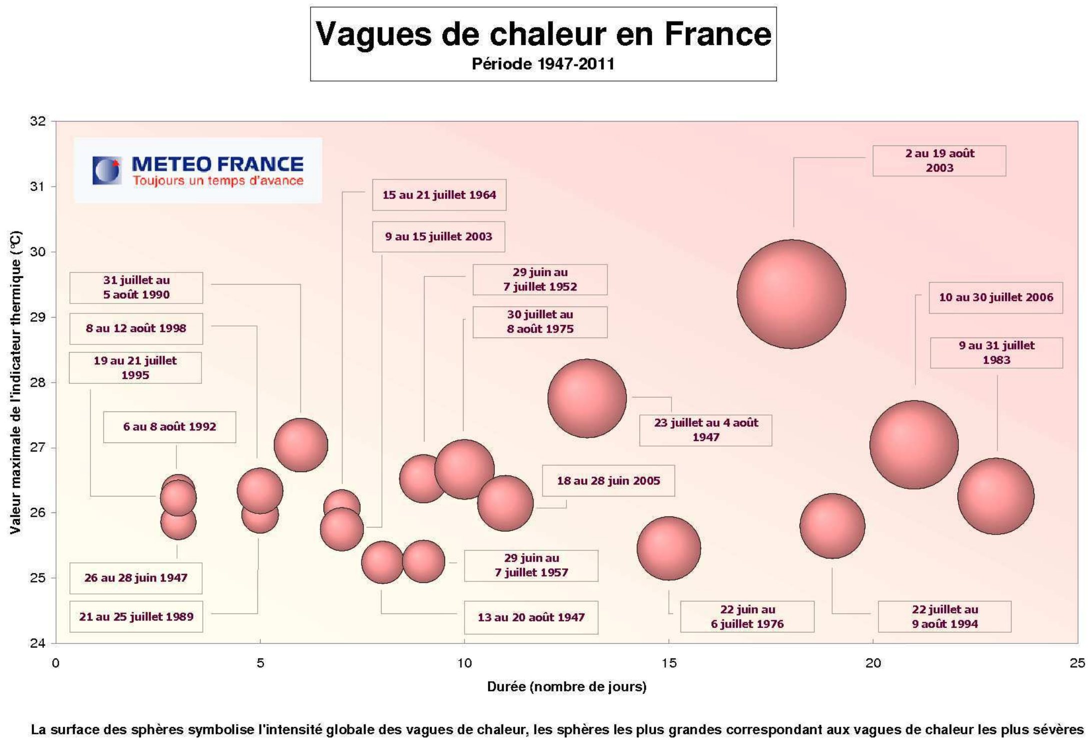


Figure 22 Inventory of past heat waves classified by duration (x-axis) and maximum intensity (y-axis). The sphere surface of each heat wave is proportional to its global intensity.

8.2.5. Limitations of the method and perspectives

The use of a global indicator fairly manages to identify major events in France. However, events with an exceptional intensity that only affect a limited part of the country can be missed. Moreover, the starting and ending dates may be considerably "smoothed": a heat /cold wave does usually not start and end at the same time on the whole country. So Météo-France is thinking of deriving the indicator at regional scale to apprehend heat/cold wave with limited extent.

9. DROUGHT HAZARD

9.1. Definition

A drought can be defined as a water deficit of (at least) one component of the hydrological cycle. Three indicators exist at Météo France to monitor three types of drought: meteorological, agricultural and hydrological.

The approach adopted to develop the drought indicators is based on the Standardized Precipitation Index (SPI), widely used internationally and recommended by WMO since December 2009. The SPI, based on the distribution of precipitation, was developed by *McKee et al* in 1993.

These indicators are constructed from Safran Isba Modcou (SIM) data available in the climatological data base of Météo-France at monthly interval on a regular mesh of 8 km. The chronological series of these data start in 1958.

SIM is a serie of three connected models:
- SAFRAN provides an analysis of meteorological forcings from surface observations soil and atmospheric profiles.
- ISBA is a surface scheme that calculates the exchange of water and energy at the soil-atmosphere interface from forcings provided by SAFRAN.
- MODCOU is a distributed hydrological model that calculates the evolution of groundwater and runoff.

In France, drought is a major issue for the water management sector. Stakeholders are informed of the evolution of water resources through bulletins of hydrological situation (BSH) published by MEDDE on a monthly basis for national and local areas. The archives of the national BSH for 2013 are available here:
http://www.eaufrance.fr/ressources/documents/documents-213/bulletin-national-de-situation/

9.2. The indices in use at Météo France for drought monitoring

9.2.1. The Standardized Precipitation Index (SPI)

The SPI is related to meteorological drought and estimates the rainfall deficit.

Total precipitation for each SIM mesh area are cumulated at a monthly time step on a moving period of n month where n can be 1, 3, 6 or 12. Then the statistical distributions of each calendar month for the period 1971-2000 (taken as the reference period), are adjusted on theoretical distributions characterized by their density function. An adjusted density function is obtained for each month (based on data from 1971 to 2000). Distributions are then projected on a standard normal distribution of mean 0 and standard deviation 1 for standardized indicator values.

The main interests of this method are:
- to ensure a spatial coherence of the indicator: we can compare the values of the indicator throughout the territory

- to make a direct correspondence between the value of the indicator and the return period of the drought on the defined time scale (1,3,6, 12 months)
- to define the different characteristics of events: start, end, severity, magnitude.

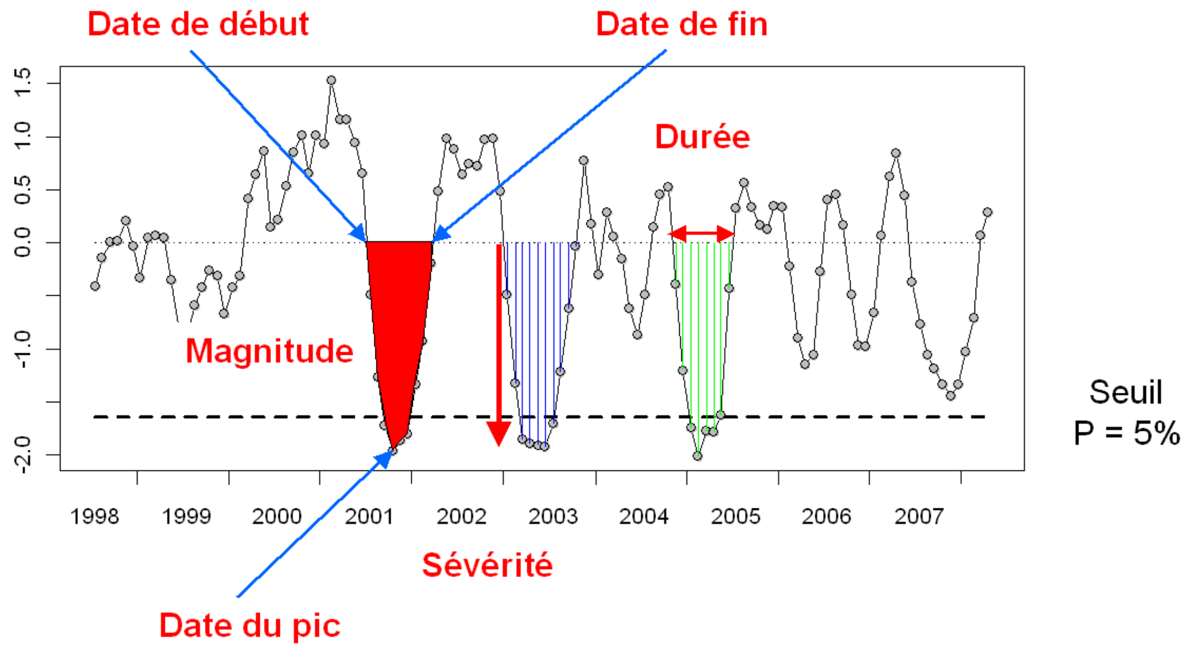


Figure 23 Different characteristics of the drought events identified on a mesh. The use of probability thresholds (within 5%) can also be used to classify the events with their intensities.

By convention, a drought begins when the index reached a negative value and ends when the SPI again reaches a positive value. The magnitude of the drought is defined as the sum of the SPI all months impacted by the drought. In this way it is possible to compare the intensity of different drought of the same duration. Direct correspondence between the value of the indicator and the return period quantile is derived from the distribution of values of a normal distribution, e.g. a value of the indicator of -1.28 corresponds to a probability threshold of 10% and thus the return period quantile 10 years.

9.2.1. The Standardized Soil Wetness Index (SSWI)

The SSWI is related to agricultural drought and estimates the soil water content deficit.

The SSWI is calculated in the same manner as the SPI, based on monthly averaged values of the Soil Wetness Index (SWI) index derived from the following calculation:

$$SWI = \frac{w - w_{wilt}}{w_{fc} - w_{wilt}}$$

where w is the integrated soil water content in soil water content, w_{wilt} the water content at wilting point and w_{fc} the soil water content at field capacity.

The SWI represents the surface soil moisture (first 2 meters), especially in the root area.

Compared to SPI, the SSWI integrates all the parameters of the water balance and especially temperature. Thus, the SSWI is shifted to the SPI: in a rainfall deficit period, the soils dries with a variable inertia, marked by the seasonal cycle (low evaporation in winter and high evaporation in summer).
The SSWI takes into account via the SWI the real soil evapotranspiration that can be limited during periods of intense soil drought.

The SPI and SSWI are calculated each month with 4 time depths: 1month, 3 months, 6 months and 12 months.

Maps are produced linking the value of index, the return period and the characterization of drought.

Value of the index	Return period	Characterization
≥ 1.75	≥ 25 years	Extremely wet
1.28 to 1.75	10 to 25 years	Very wet
0.84 to 1.28	5 to 10 years	Moderately wet
- 0.84 to 0.84	0 to 5 years	Around normal
-1.28 to -0.84	5 to 10 years	Moderately dry
-1.75 to -1.28	10 to 25 years	Very dry
≤-1.75	≥ 25 years	Extremely dry

The different indices produced can be used to characterize different hazards at different timescale. Hereafter are examples of use of some indices.

SPI 6 months characterizes relatively long droughts, which may have hydrological impacts. The cumulative rainfall of 6 months actually corresponds to periods of groundwater recharge or dam recharge. SPI 12 months characterizes long droughts which according to their intensity can be related to problems in the operation of large aquifers with annual or multi annual response time. SSWI 12 months characterizes long droughts which according to their intensity can be related problems on ecosystems (forest or land movements).

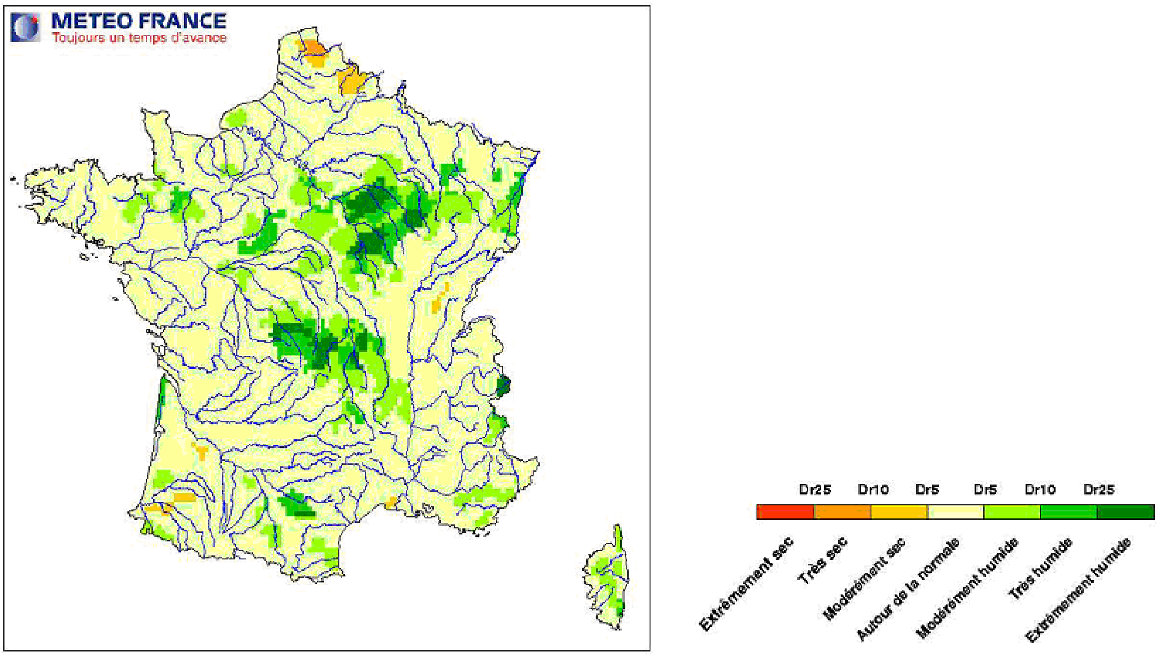


Figure 24 Map of drought situation for November 1959 to January 1959 characterized with SPI3months. The colors refer to the return period of the drought.

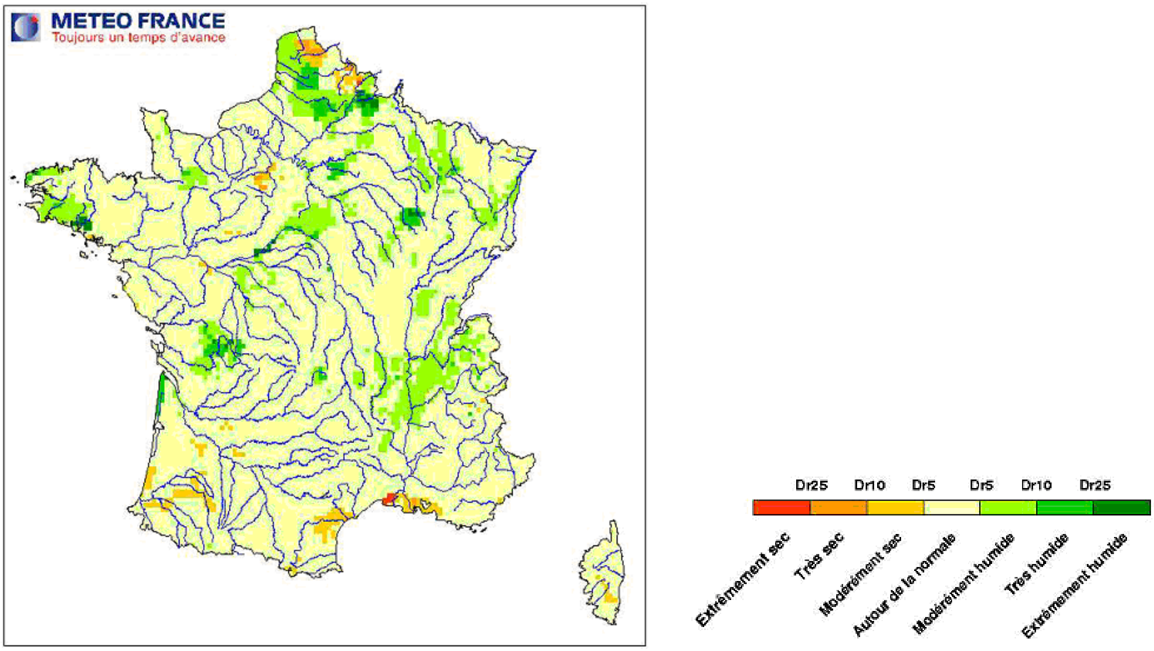


Figure 25 Map of drought situation for November 21959 to January 1959 characterized with SSWI3months. The colors refer to the return period of the drought.

9.2.1. The Standardized Flow Index (SFI)

The SFI is a standardized indicator based on flow values modeled by the SIM chain for 900 points.

9.2.2. A specific issue of drought: the geotechnical drought

The geotechnical drought is the visible consequence on buildings of ground movement due to a volume change of the ground (mainly clay) after an unusual dewatering. The shrinkage and swelling of clay soils, although not dangerous to people, annually generates on French territory considerable and expensive damage to buildings. It is the second most costly hazard to be compensated after flooding. The Bureau of Geological and Mining Research (BRGM) is in charge of studying and mapping this hazard. The maps are available at **www.argiles.fr.** They are intended to delineate, at 1:50 000, areas prone to the phenomenon a priori, and give a hazard level on a 4 degree scale: zero, low, medium and high. They are used for public information and also as a basis for drawing up PPRs.

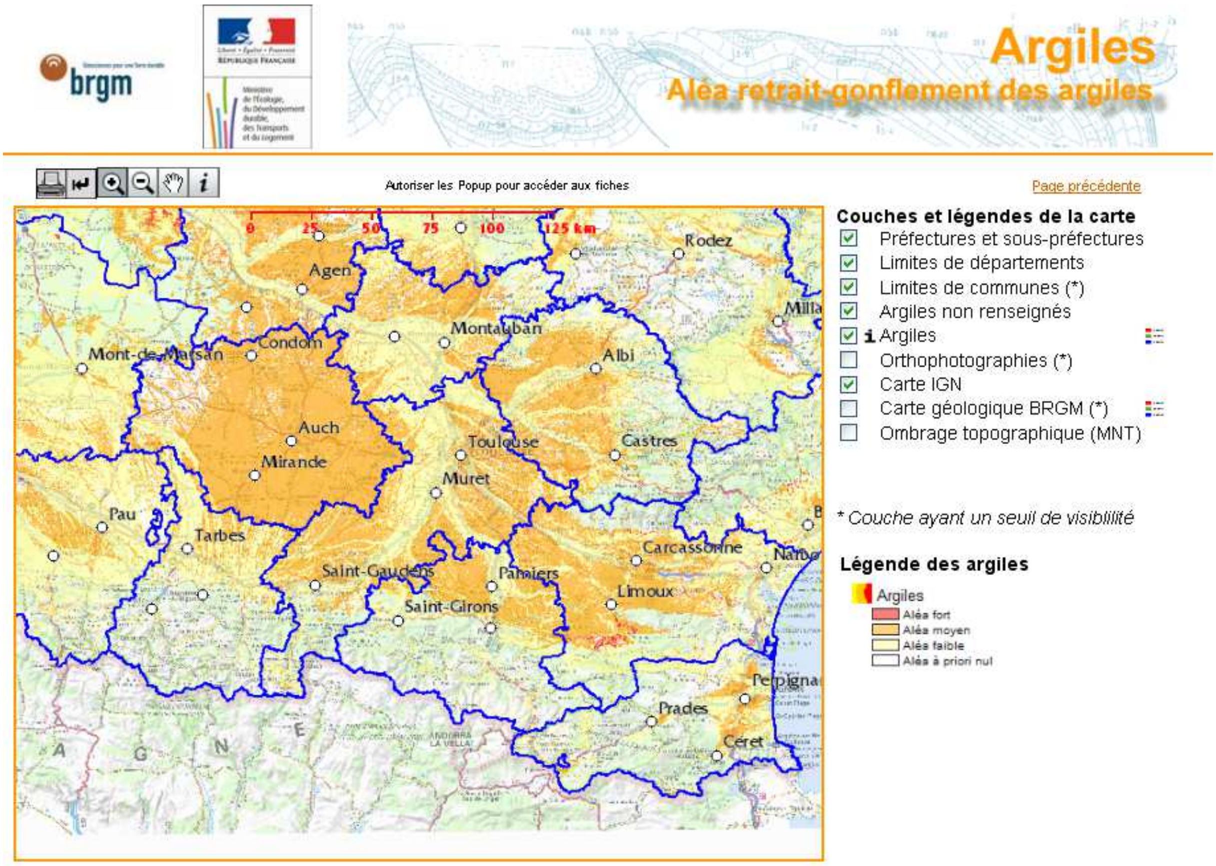


Figure 26 Map of exposure to shrinkage-swelling hazard for the Haute-Garonne *department.*

10. MULTI-HAZARD MAPPING FOR THE PUBLIC : CARTORISQUES

10.1. Goals

Cartorisques is to give access on the internet (http://cartorisque.prim.net/) to all interactive maps of major natural and technological hazards. Published information from the decentralized services of the State, under the authority of the prefects are concerned. For now, the following hazards are mapped into Cartorisques: flooding (partial), areas of seismicity, the avalanche phenomena and Natural Disaster (CAT-NAT) declarations. Three types of information are provided:

- Preventive safety information for the awareness of population (CPLA, AZI,…)
- Information related to the obligation to inform the buyer or the tenant of a property (contained in the PPR)
- Information for use in territory planning (contained in PPR)

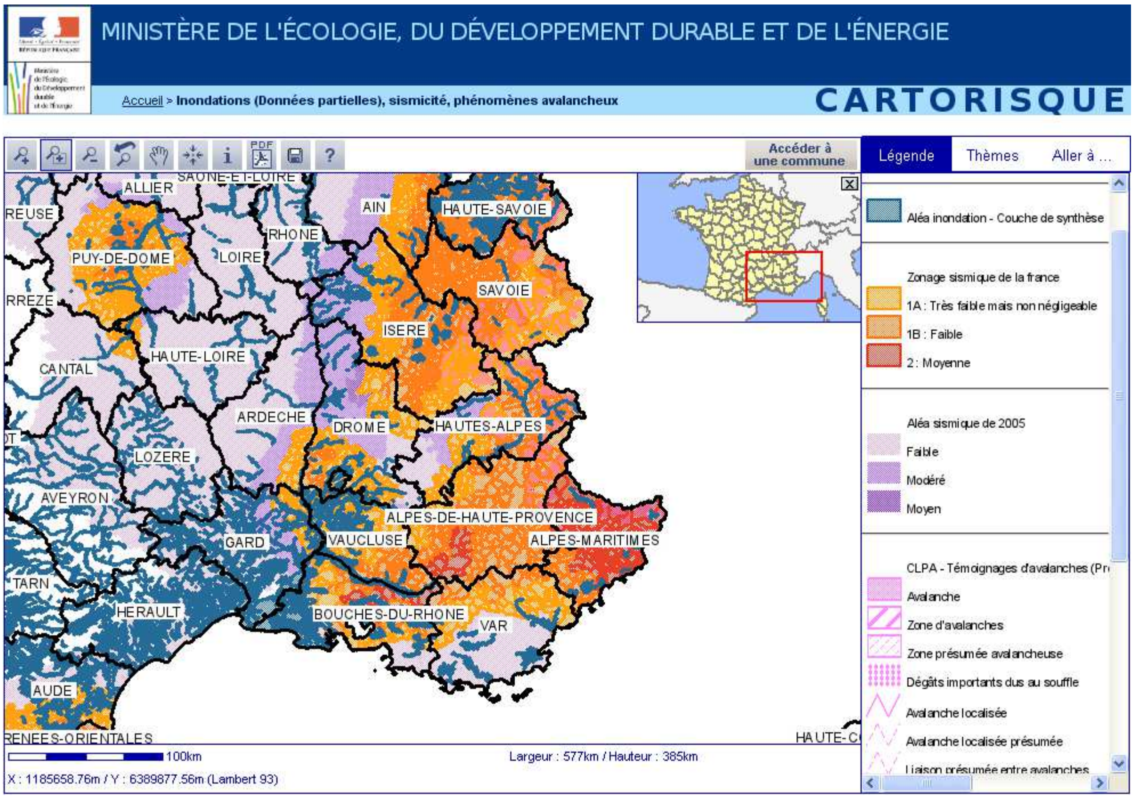


Figure 27 Example of multi-hazard maps for the Southeast of France

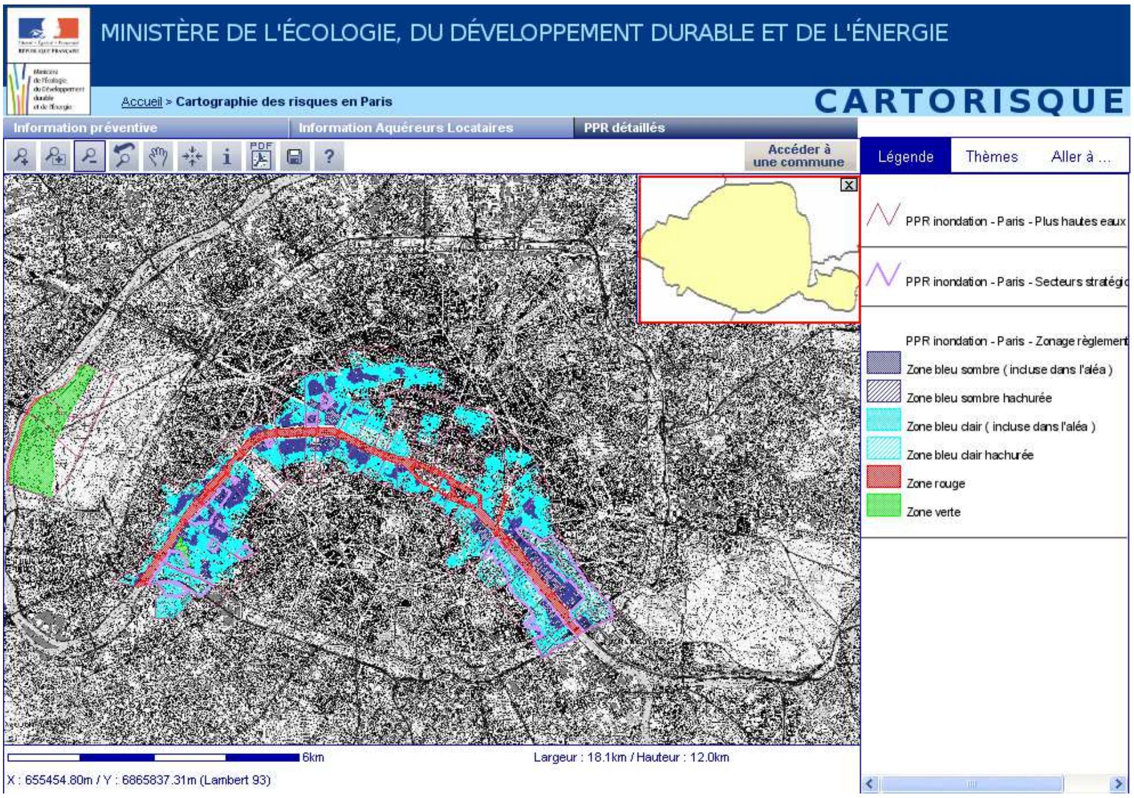


Figure 28 Multi-Hazard Map extracted from PPR -Paris

10.2. Supporting technology

Cartorisques provides the ability to access to published data as specified by Web Map Service Specification (WMS) and Web Feature Service data (WFS) developed by the Open Geospatial Consortium (OGC). The OGC was founded to define specifications to ensure interoperability between different platforms and geospatial architectures.

11. CLIMATE CHANGE AND RISK ADAPTATION

In 2010, the Ministry of Sustainable Development called upon the expertise of French climate scientists to produce a reasoned assessment of climatic conditions in France in the 21st century. Dr Jean Jouzel was appointed to lead this assessment which was carried out by scientists from CNRS/INSU/IPSL and LGGE, from Météo France, BRGM, CEA, CETMEF, and the CNES. The results are compiled in the series “Le climat de la France au XXIe siècle” which provides climatic benchmarks to inform development of measures for adapting to climate change. A first set of results were published in January 2011. They relied on two regional climatic models from French institutions: ARPEGE (CNRM-Météo-France), LMDz (IPSL: Insitut Pierre Simon Laplace), running with two different IPCC greenhouse gas emission scenarii (A2 and B2). A second set of results were published in January 2012, coming other regional climatic models: ALADIN-climat (CNRM-Météo-France), LMDz (IPSL: Institut Pierre Simon Laplace) in a different version, MAR (LGGE: Laboratoire de Glaciologie et Géophysique de l’Environnement), running with the following IPCC scenarios: A1B, A2, B1.

This tool is crucial for the many stakeholders concerned with the problem of adaptation, namely local communities, the private economic sector, associations and State run services. The production of such reference data was therefore given top priority (Action n°1) in the French National Plan for Adaptation Plan to Climate Change, which came into force on 19 July 2011. The work received financial backing from the Ministry of Sustainable Development, General Directorate for Energy and Climate (DGEC). The National Observatory on the Effects of Global Warming (Observatoire National sur les Effets du Réchauffement Climatique, ONERC) is responsible for organizing and disseminating the scientific information.

ACRONYMS

ADZI: Atlas Départemental des Zones Inondables
AZI: Atlas des Zones Inondables
BDCLIM: Base de Données Climatologiques
BDEM: Base de Données des Evénements Marquants
BDHI: Base de Données Historiques sur les Inondations
BRGM: Bureau de Recherches Géologiques et Minières
BSH: Bulletin de Situation Hydrologique
CAT-NAT: Evénement déclaré CATastrophe NATurelle
CCR: Caisse Centrale de réassurance
CEN: Centre d'Etude de la Neige
CEREN: Centre d'Etude et de Recherche de l'Entente
CETMEF: Centre d'Etudes Techniques Maritimes et Fluviales
CLPA: Carte de Localisation des Phénomènes Avalancheux.
CNRS: Centre Nationale de Recherche Scientifique
COGIC: Centre Opérationnel de Gestion Interministérielle des Crises
COPRNM: Conseil d'Orientation pour la Prévention des Risques naturels Majeurs
COZ: Centre Opérationnel de Zone
DDE: Direction Départementale de l'Équipement.
DDRM: Dossier Départemental des Risques Majeurs.
DFCI: Défense de la Forêt Contre les Incendies
DGEC: Direction Générale de l'Energie et du Climat
DGPR: Direction Générale de la Prévention des Risques
DICRIM: Document d'Information Communal sur les RIsques Majeurs.
DPFM: Délégation à la Protection de la Forêt Méditerranéenne
DSC: Direction de la Sécurité Civile
EAIP: Enveloppe Approchée des Inondations Potentielles
EAIPce: EAIP cours d'eau
EAIPsm: EAIP submersion marine
ECANA: Etude Climatologique de l'Activité Avalancheuse NAturelle
EDF: Electricité De France
EPA: Enquête Permanente sur les Avalanches
EMZ: Etat-Major de Zone
ETNA: unité de recherché Erosion Torrentielle Neige et Avalanche
FFSA: Fédération Française des Sociétés d'Assurances
GASPAR: Gestion Assistée des Procédures Administratives relatives aux Risques naturels et technologiques
GEMA: Groupement des Entreprises Mutuelles d'Assurance
GIS: Geographic Information System
G.M.T: Generic Mapping Tool
GPL: General Public License
IBM: Indicateurs bio-météorologiques
ICL: Indice de Combustible Léger
IGN: Institut national de l'information géographique et forestière
IFM: Indice Forêt Météo
IH: Indice de l'Humus
INRA: Institut National de la Recherche Agronomique
InVS: Institut national de la Veille Sanitaire
INSU: Institut National des Sciences de l'Univers
IPSL: Institut Pierre Simon Laplace
IPCC: International Panel on Climate Change
IRSTEA: Institut national de Recherche en Sciences et Technologie pour l'Environnement et l'Agriculture
IS: Indice de Sécheresse
LGGE: Laboratoire de Glaciologie et de Géophysique de l'Environnement
MEDDE: Ministère de l'Ecologie, du Développement durable et de l'Energie
MRN: Mission des sociétés d'assurances pour la connaissance et la prévention des Risques Naturels

OGC:	Open Geospatial Consortium
ONERC:	Office National sur les Effets du Réchauffement Climatique
ONF :	Office National des Forêts
ONRN:	Observatoire National des Risques Naturels
ORSEC:	Organisation de la Réponse de SEcurité Civile
PCS:	Plan Communal de Sauvegarde
PFRA:	Preliminary Flood Risk Assessment
PGRI:	Plan de Gestion du Risque Inondation
PLU:	Plan Local d'Urbanisme.
PNC:	Plan National Canicule
PPI:	Plan Particulier d'Intervention.
PPMS:	Plan Particulier de Mise en Sûreté
PPR:	Plan de Prévention des Risques.
PPRn:	Plan de Prévention des Risques naturels
PPRt:	Plan de Prévention des Risques technologiques et miniers
RCE:	Réseau Climatologiques de l'Etat
RTM:	service de Restauration des Terrains en Montagne
RSMC:	Regional Specialized Meteorological Center
SFI:	Standardized Flow Index
SHOM:	Service Hydrographique et Océanographique de la Marine
SIM:	Safran Isba-Modcou
SIPC-ISDR:	Stratégie Internationale de Prévention des Catastrophes naturelles -International Strategy for Disaster Reduction
SPC:	Service de Prévision des Crues
SPI:	Standardized Precipitation Index
SSA:	Sites habités Sensibles aux Avalanches
SSWI:	Standardized Soil Water Index
TIM:	dossier de Transmission d'Informations au Maire
TRI:	Territoires à Risque d'Inondation
UN:	United Nations
WFS:	Web Feature Service
WMO:	World Meteorological Organisation
WMS:	Web Map Service

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ANNEXE 1 : TYPOLOGY OF NATURAL MAJOR RISKS

1.1 Flooding
1.1.1 By a rise in the water level (waterway overflowing its banks)
1.1.2 By run-off and mudslide
1.1.3 By torrential flow (torrent and talweg)
1.1.4 By rising natural water tables
1.1.5 By marine submersion
1.2 Ground movement
1.2.1 Subsidence
1.2.2 Collapse
1.2.3 Rock slide, falling rocks and blocks
1.2.4 Landslide
1.2.5 Advancing dune
1.2.6 Receding cliff and coastline
1.2.7 Differential settlement
1.3 Earthquake
1.4 Avalanche
1.5 Volcanic eruption
1.5.1 Lava flow (or intrusion)
1.5.2 Pyroclastic flows
1.5.3 Aerial fallout
1.5.4 Gas
1.5.5 Lahars
1.6 Forest fires
1.7 Atmospheric phenomena
1.7.1 Cyclone/hurricane (wind)
1.7.2 Storms and squalls (wind)
1.7.3 Waterspouts (wind)
1.7.4 Lightning
1.7.5 Hail
1.7.6 Snow and freezing rain