		REF:CYCLOPS-WP03-D9-EMA-DDSC Issue : 01 Rev : 01 Date : 31/08/2007

Proposal/Contract: 031874

CYCLOPS

CYber-Infrastructure for CiviL protection Operative ProcedureS

Use-cases document

(Deliverable D9)

Reference : CYCLOPS-WP03-D9-EMA-DDSC

Due date of deliverable: June 2007

Actual submission date: August 31st 2007

Start date of the project: **JUNE 1st 2006** Duration: **24 months**

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Project co-funded by the European Commission within the Sixth Framework Programme (2002-2006)		
Deliverable Dissemination Level		
PU	Public	
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	**X**
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DOCUMENT HISTORY

Issue.revision	Date	Description of change	Author	Affiliation

DISTRIBUTION LIST

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I. INTRODUCTION

The purpose of this report aims at giving a description of the chosen use-cases of Italian and French Civil Protection agencies in the perspective of Grid technology adoption. The final objective of this deliverable is to identify and to describe two use-cases that could be ported, improved or even made possible by using Grid technologies. One important point of these use-cases is that they should be representative of typical scenarios of Civil Protection, in this case this study focus on forecasting and warning operations of Civil Protection for natural hazards (forest fires and flash floods). The final objective of this deliverable is to describe precisely existing infrastructure and operations of these use-cases. This high-level knowledge of existing state will permit to redefine infrastructure and/or improve forecasting operations, to finally highlight needs and requirements of these Civil Protection services in the next deliverable "System requirements document" (D11).

The document is structure as follows:

The first part (section II) describes the general administrative and organisational context for each use-case management. For this, the French flood forecasting and emergency management, and the Italian forest fires management are described.
The next part (section III) describes systems specifications in following a technical approach. It focuses on models and applications workflows and operations. The main objective of this section is to elaborate an accurate knowledge of models and applications operations to detect possible improvements made by Grid technology adoption.
The last part (section IV) begins to envisage the future bridging of the gap between Civil Protection and Grid technology community, one of the main objective of following deliverable "System requirements document" (D11).

II. TWO USE-CASES IDENTIFIED: CONTEXT

So as to study the potentialities of GRID Technology, two cases-studies has been identified has the framework of CYCLOPS project. The first case study, French, is related to the Flood Warning Service Grand-Delta (SPC G-D[1]), the second case, Italian, concerns the *RISICO* System built up by CIMA for the Italian Civil Protection at a National (DPC[2]) and Regional scale (CF[3]). The objective of *RISICO* is to propose a decision making system about Forest Fires. The presentation of the context of these two used-cases is the object of this development.

1 FLOOD MANAGEMENT IN FRANCE

The current device, described in detail in the deliverable D06 of CYCLOPS project (Sauvagnargues-Lesage *et al…* 2007b), can be subdivided in two large parts: the forecasting part which includes elements relating to the phenomena observation, the forecast of their consequences and the devices of vigilance and alarm; and the operational part which includes the existing organizations to face up the crisis management. After a reminder of this organization, a more complete presentation of the floods forecasting will be proposed before the use-case study "Flood Warning Service Grand Delta" (SPC-GD).

1.1 Few summaries about flood management in France

The following figure (Figure 1) synthesizes the link between weather forecasting, hydrological forecast and civil protection.

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[1] SPC-GD: Service de Prévision des Crues Grand Delta

[2] DCP: Dipartimento di Proteczione Civile

[3] CF: Centri Funzionali

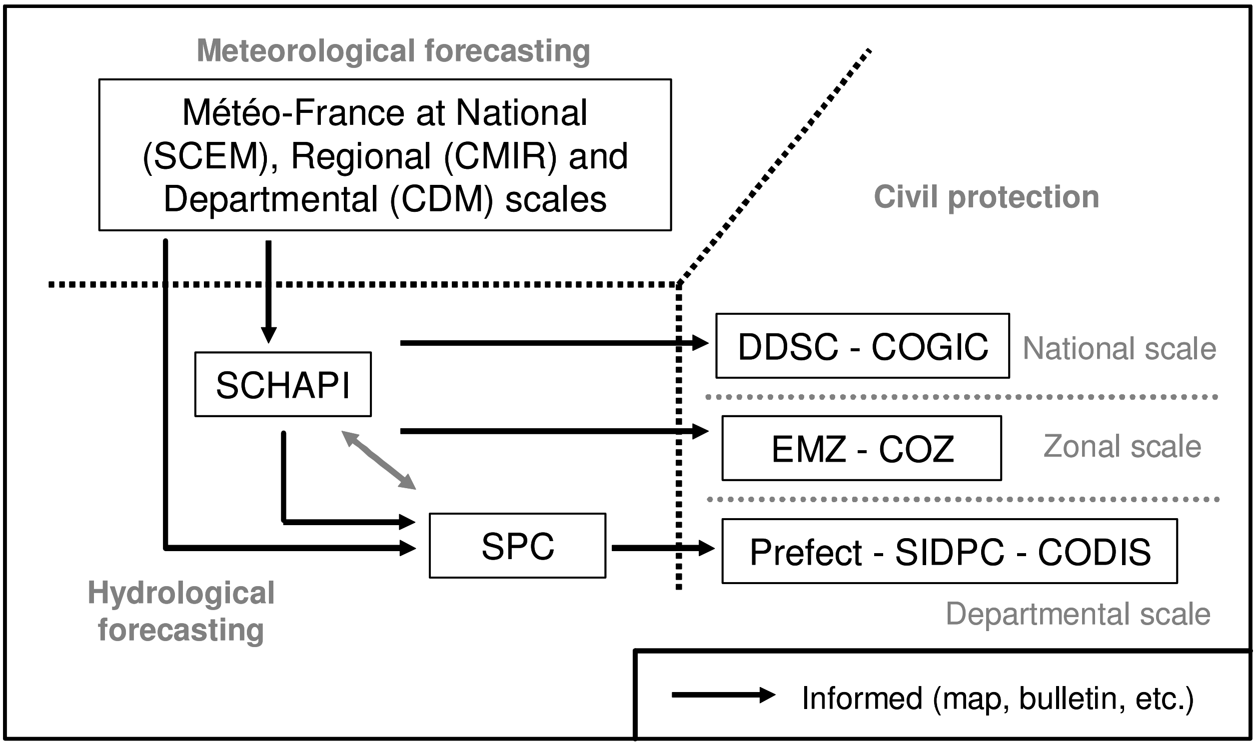

Figure 1 : Links between meteorological and hydrological forecasting and civil protection

Weather forecasting, implemented by Météo-France, is carried out through 3 organizations on the national scale (SCEM[4]), Regional (CMIR[5]) and departmental (CDM[6]). These various services propose weather forecasting on various competence scales, the departmental service thus proposing the more accurate departmental forecasts at crisis management actors.

In parallel, Météo-France carries out a vigilance map for dangerous weather events. Often used in an abusive way, the term "vigilance" doesn't correspond to a prediction or a forecast.

[4] Central service of Exploitation of Meteorology
[5] Interregional Weather centers
[6] Departmental center of Meteorology

It only represents a warning on the potentiality occurrence of a dangerous event, without ensuring its occurring. This cartography is used to the stormy events subjected to generate floods (see Figure 2).

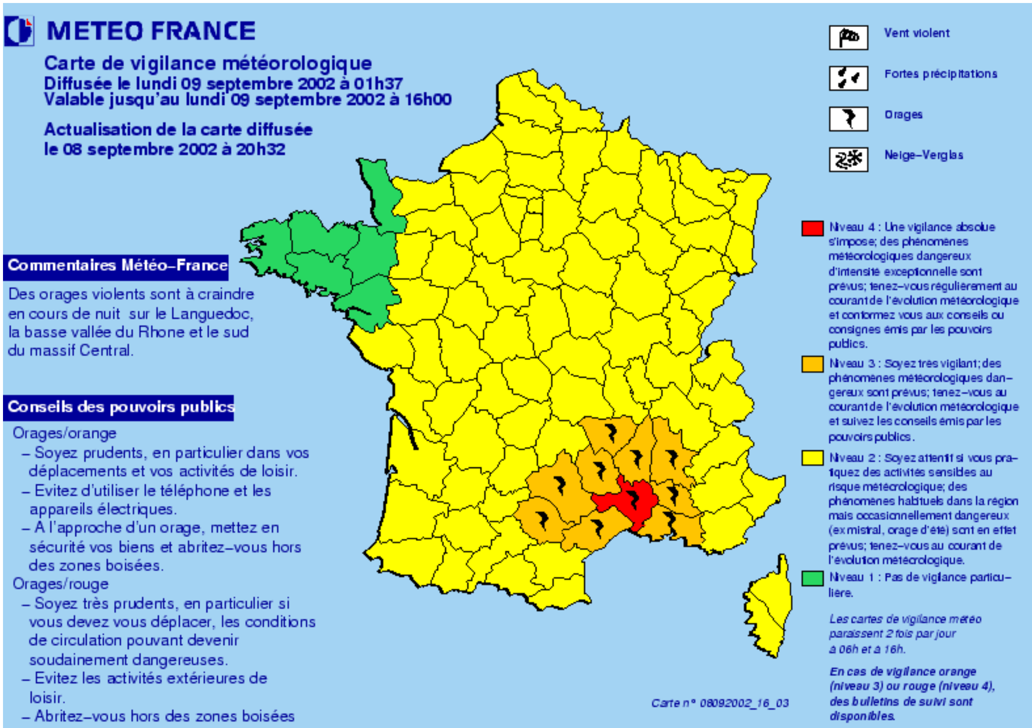

Figure 2 : Meteorological vigilance map

This cartography is composed of 4 levels (green, yellow, orange and red). For orange and red level events, a special information report is set up. It is transmitted to the actors of the crisis management (see Figure 1).

A similar system is organized for hydrological vigilance by the SCHAPI and the SPC (see Figure 3). This cartography, also including 4 levels of vigilance is also completed by a report (see Figure 4) of the event and hydrographic data (discharges and water level at the measuring station).

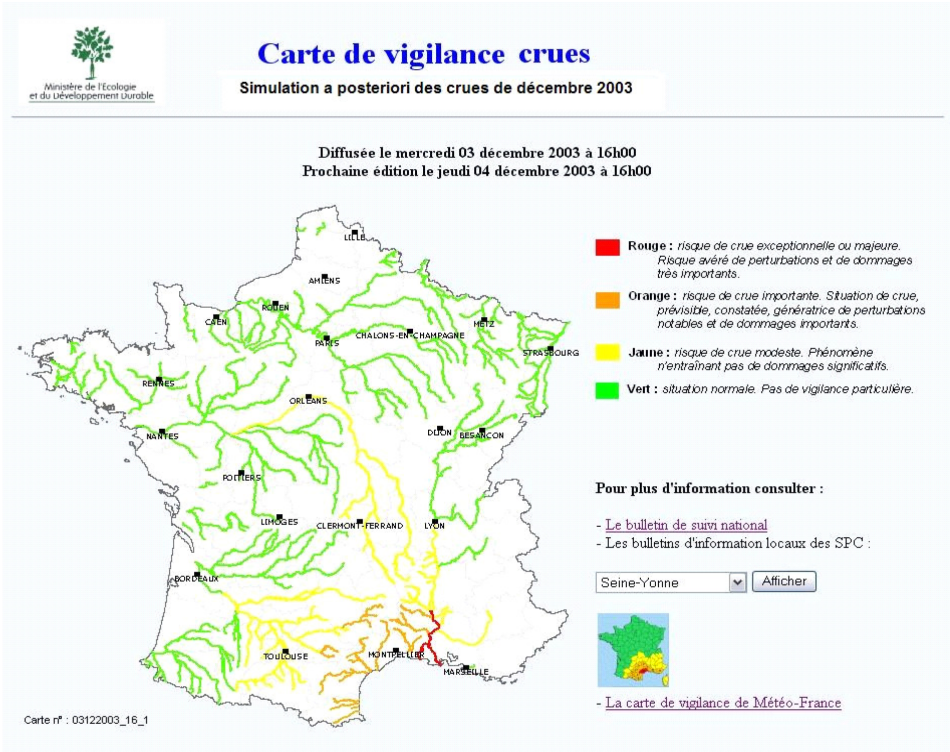

Figure 3 : Hydrological Vigilance map

BULLETIN DE SUIVI DES INONDATIONS DU SPC GRAND DELTA

Date : vendredi 30 janvier 2004 à 15h00
Bulletin valable : du vendredi 30 janvier 2004 à 15h00 locales au lundi 2 février à la mi-journée

Début d'événement : jeudi 29 janvier 2004 à 9h00
Fin d'événement : événement en cours

1) Liste des sous-bassins concernés par l'événement

- le Nil amont
- le Danube

2) Contexte météo (source Météo France)

Vigilance météo orange en cours sur les départements Aragon et Castille pour les critères fortes précipitations ou orages.
Pas de BAP en cours.
Situation générale : voir annexe.

3) Situation actuelle et appréciation des risques hydrologiques

Situation générale actuelle et évolution prévue

Bassin du Nil amont : tous les tronçons du Nil amont sont en vigilance inondations ORANGE. Tendance à la baisse lente. Cote d'alerte toujours atteinte sur Trifouilly-les-Oies ainsi que sur Toul-les-Poules.
Bassin du Danube : tous tronçons en vigilance inondations ROUGE. Cote d'alerte atteinte en aval de Saucisse-de-Morteau. Niveaux en hausse, crue centennale prévue à Budapest.

Observations le 30 janvier vers 15h00 locales

STATION	Heure locale	Cote (m)	Débit (m3/s)	Cote d'alerte (m)	Débit d'alerte (m)	Cote crue centennale (m)	Débit crue centennale (m3/s)
Station X :							
…							

Prévisions

STATION	Cote à 18h (m)	Débit à 18h (m3/s)	Cote à 21h (m)	Débit à 21h (m3/s)	…	
Station X :						
…						

Graphiques

Carte de vigilance inondations sur le territoire du SPC avec stations d'observations et de prévisions

4- Conséquences possibles (pour l'instant, celles de la vigilance météo en l'état)**:**

Des inondations importantes sont possibles dans les zones habituellement inondables, sur l'ensemble des bassins hydrologiques des départements concernés.
Des cumuls importants de précipitation sur de courtes durées, peuvent, localement, provoquer des crues inhabituelles de ruisseaux et fossés.
Risque de débordement des réseaux d'assainissement.

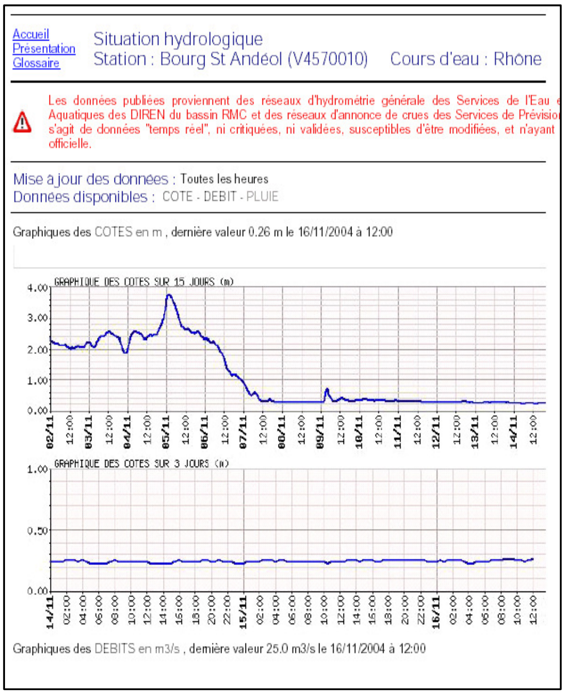

Figure 4 : Hydrological information of Vigilance map

The information produced relates to the main supervised rivers. For the other rivers, vigilance is under the competence of the concerned local authorities. As previously, this information is broadcasted to the actors of the emergency management for orange and red vigilance.

It should be noted that the broadcasted vigilance maps are available on Internet[7].

From civil protection point of view, the structure is similar to the one described in D6 (Sauvagnargues-Lesage *et al.*. , 2007b) and shows a pyramidal organization (see Figure 5).

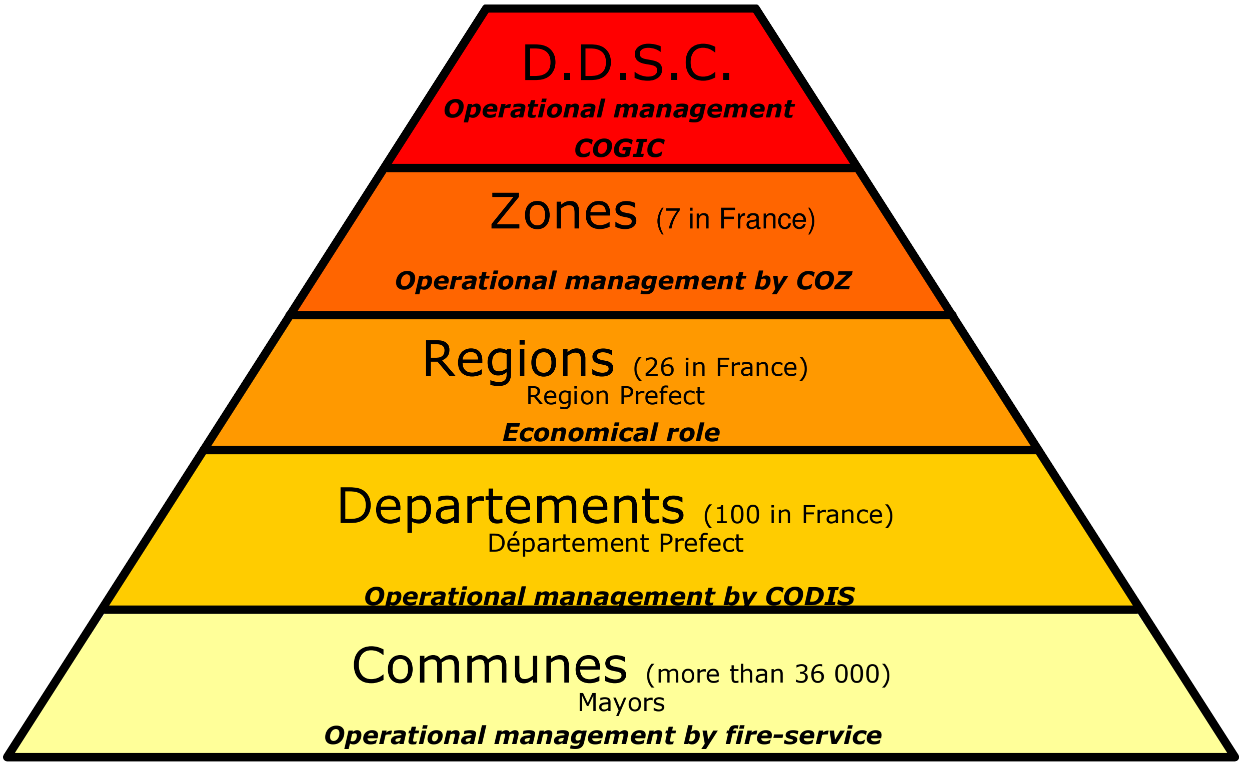

Figure 5 : Civil protection organisation

[7] Meteorological vigilance: http://www.meteofrance.com/vigilance/index.html
Hydrological vigilance: http://www.vigicrues.ecologie.gouv.fr/

Many administrations and services are involved in civil protection. Responsibilities are shared between Ministries, Zones, Departments and Communes. Civil Protection is based both on actions undertaken by State structures as well as on facilities set up for relief throughout the country. In addition they are supported by decentralized authorities.

The Ministry of the Interior pilots French Civil Protection operations and controls the main part of national rescue means. The Management of Defence and Civil Safety (DDSC[8]) is the central structure and is in charge of prevention and operations - through several operation centres. The Director of Civil Protection and Security is a high-rank official (Prefect), appointed by the Ministry of Interior.

At the national level, an Inter-ministerial Operational Crisis Management Centre (C.O.G.I.C.[9]) collects all information regarding a serious event that may harm the population, material goods or the environment. This is a tool that is permanently on the watch to assist the Government in its decisions.

At the intermediary level, civil protection is organised with 7 Civil Safety Zone Staff (EMZ) which analyses all the risks the zone is likely to encounter and elaborates the guidelines for the training of firemen. It also establishes a general plan for the organization of relief in the zone. Each zone is directed by a prefect of region who becomes the chief of rescue operations when a zonal disaster occurs.

Under the authority of the chief of the EMZ, the operational zone centres (C.O.Z[10]) coordinates relief operations regarding several departments or that need national reinforcement.

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[8] Direction de la défense et de la sécurité civiles

[9] Centre opérationnel de gestion interministérielle des crises

[10] Centre opérationnel zonal

At the local level, the authorities in charge of hazard prevention and emergency organization are: the mayor within the limits of his powers of keeping order, and the prefect of the department who has the main role on the decisions making for a local disaster.

- The prefect has, at his disposal, the inter-ministerial service for defence and civil defence (SIDPC[11]).

- Mayors responsible for the safety of citizens on their territory of their communes rely mainly on the fire-brigade (CS[12]). In each department belong to the departmental fire and emergency service (SDIS[13]), a departmental public establishment with an administrative commission presided by a local elected member. The Director General of the SDIS, under the authority of the prefect and the interested mayors, is responsible for the operational use of resources and the fire-brigade serving in the department. Finally, the CODIS[14] under the authority of director of SDIS manage all tactical means, and corresponds to the departmental operational of fire and rescues centre.

The following diagram (Figure 6) summarize this information showing a ratio between level of civil protection implication and importance of the event.

[11] Service Interministériel de Défense et de Protection Civile

[12] Centre de Secours

[13] Service Départemental d'Incendie et de Secours

[14] Centre Opérationnel Départemental d'Incendie et de Secours

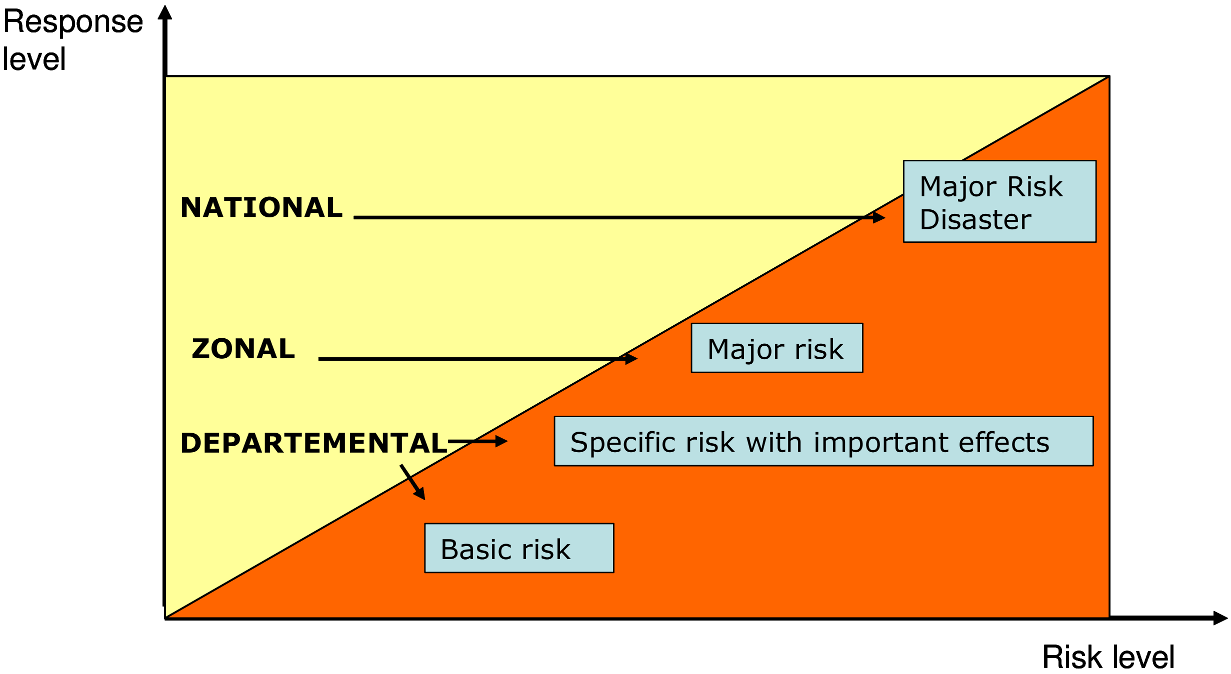

Figure 6 : Risk level and civil protection response

1.2 Flood forecasting in France

The last reformation, after the catastrophes of the Aude in 1999 (Lefrou *et al..* , 2000) and the Gard in September 2002 (Huet *et al..* , 2003) allowed to set up, in application of the law of the July 30th, 2003 on the floods warning services. 22 floods warning services have been created on the French territory since 2006 (see Figure 7). These services replaced the 56 floods announcing services.

Figure 7 : Flood warning services distribution

The SCHAPI (floods warning and monitoring hydro-meteorological national service) created by decree of June 2nd, 2003 is a service with national competence attached to the direction of the water of the Ministry for Ecology and the Durable Development. This service is in charge of a flood warning services support mission.

For this reason, it exerts a mission of animation, assistance, advisor and training for the services and establishments intervening in the field of the flood forecast and, more generally, hydrology.

The service also ensures at the national level scientific and technical coordination in this field in connection with the scientific and technical organizations of the State.

For SPC located in zones concerned by torrential floods, the service has also to ensure a continuous mission of advice and expertise in period of risk of torrential floods. The list of these services is defined by decree of the minister in charge of the environment. The service keeps informed the direction of water and the regional directions of the environment concerned by the evolution of the hydro-meteorological situation.

The following diagram (see Figure 8) presents the role of the SPC.

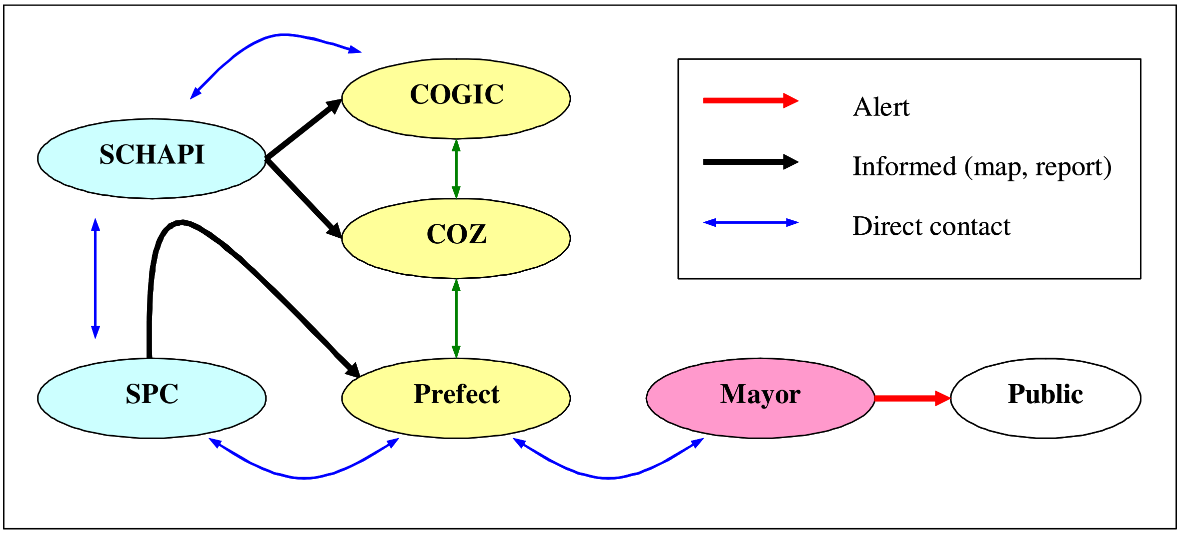

Figure 8 : Role of flood warning service

The SPC has to develop flood forecast and broadcast information on this subject. In the information transmission (see Figure 8), and according to the forecasted event, the authorities of police force (Prefect) intervene for transmitting alert to mayors and population and carry out evacuation operations, if necessary.

Flood monitoring and forecasting use two major local tools: flood forecasting planning (SDPC[15]) and flood forecasting policy (RIC[16]).

[15] SDPC: Schéma Directeur de Prévision des Crues

[16] RIC: Règlement d'Information sur les Crues

1.2.1. *Flood forecasting planning (SDPC)*

According the decree of January 12th, 2005 and decree of February 15th, 2005, the basin prefect coordinator (coordinator of the actions of the prefects for a hydrographical unit including several prefectures) have to prepare the floods forecasting planning. This diagram is intended to define the following principles and the objectives to be reached:

- the rivers sections delimitation for which, the State ensures the transmission of information floods and their forecast if it is technically possible;
- the organization of the monitoring technical operations necessary to the development of information on the floods and their forecasts;
- the choice of the public services and establishments of the State ensuring the inter-departmental mission of monitoring, of forecast and transmission of information on the floods;
- the definition of the respective roles of the various implied services ;
- the coherence betweens operations set up by the various implied services;
- the estimated calendar of the principal objectives to be reached.

The SDPC must in particular make it possible to identify the local authorities or their groupings having set up, under their responsibility and for their own needs, operations of monitoring and possibly of forecast of floods of certain zones.

The SDPC is published in the Official Journal. It must be diffused as broader as possible to the population: consultation of paper document in all concerned prefectures, numerical transmission (on CD-ROM support for example), consultation and downloading on the Internet sites.

1.2.2. Flood forecasting policy (RIC)

The prefect under the authority of which the SPC is placed, works on the RIC elaboration, after consultation of interested organizations and authorities (basin prefect coordinator, prefects of Zone, presidents of the departmental councils). In the respect of the orientations defined by the SDPC, the RIC inventories:

- the list of the cities concerned by information produced by the SPC;
- the list of the sections of river for which the levels of vigilance are allocated and, for each one of these sections, criteria allowing to define a yellow, orange or red of flood vigilance level (see Figure 3) ;
- the nature of information diffused to the public and the authorities, transmitted information to the authorities, frequency of actualization of this information;
- the nature of the collected data and forecasts worked out,
- Equipments and industries that justify the SPC to produce specific information transmission

The information in the regulation on monitoring, the forecast and the transmission of information have to be updated as needed by the prefect. The SPC produce an annual report validating the implementation of the RIC.

The creation of the SPC is recent (2006). Old floods announcing services acquired new missions which involve an important change of the practices and requirements (Sauvagnargues-Lesage et *al..,* 2007a). The actual transitional period and link which must be organized among these services and civil protection constituted the main element in the choice the French use-case of this project.

1.3 The flood warning service of the Gard : use-case interests

Within the framework of the Cyclops European project, two use-cases were selected to show the utility of Grid technology for the services of civil protection. The French case concerns one flood warning services located in the South of France (department of Gard). The choice of this service within the framework of this European project comes from several predominant criteria.

First, the "flood" risk and more particularly “flash floods” constitutes one of the natural risks the least forecasting but also the most complex from the emergency management point of view. Since the beginning of 2000, many events of variable intensity were listed in Gard and its bordering departments. The major event is the flash flood of September 2002, during which the victims were numerous and services of civil protection completely disorganized. The dynamic and the "flash" character of this natural event limit the reactivity of the services of civil protection. Moreover, during the event of September 2002, the SPC-GD and its decision support system (Ahltaïr) had technical failures which justify today a particular interest for new technologies. This new stake contributes to improve the reactivity in a context of crisis management where the reliability and the precision of the modelled data in real-time become a guarantee of success in the follow-up of the event and the anticipation of rescue operations.

In addition, SPC-GD works since many years in collaboration with research laboratories specialized in hydrology and crisis management in the objective to improve its effectiveness for the allocated mission. This cooperation, with for example the Ecole des Mines d'Alès, explains for a part the fact that SPC-GD is open for technical innovation. Moreover, SPC-GD does not have all tools necessary to the achievement of its objectives. Thus, research project are developed in collaboration with the SCHAPI, to improve its efficiency and to answer as well as possible the objectives. This improvement will pass in particular by the set up of a modelling platform available for all the French SPC and the use of global and standardized geospatial tools as well as possible to facilitate a collaborative decision-making in period of crisis.

SPC-GD has tools which appear to be interesting to test Grid technology. The functional units of the computing architecture of this service are almost well specified.

The present report describes in a next section the organisation of the SPC-GD computing architecture. It is interesting to note that the SPC-GD is composed by units managing the "in situ" data, effective rainfall and finally hydrological modelling of watersheds. Each unit constitutes a tool of decision-making for the forecasters. It is possible to consider them individually to improve their efficiency by using the technical advantages of Grid technology.

Deliverables D6 "Businesses Process Analysis Document" and D8 "Existing Analysis document" presented the organisational variations between the French and Italian civil protection in term of forecasting of natural risks. For the French case, it has been highlighted by an externalisation of competences in term of forecast. However, if SPC-GD is not included in the organization of civil protection, in period of crisis, it is in close relation with the actors of the crisis management and progressively became a main actor of the crisis management.

Finally, the question of flash floods is a subject already integrated in several projects or European initiatives. Within the framework of GMES initiative and RISK-EOS project, the case of flash floods was developed in the objective to improve crisis management of these events with the creation of special service "Flash Flood awareness".

2 FOREST FIRE MANAGEMENT IN ITALY

As for the flood management in France, the management of forest fires in Italy is described in this part. In addition the forecast part will be particularly detailed and the reasons of the choice of RISICO as use-case will be specified.

2.1 Few summaries about the forest fire management in Italy

Elements presented here are mainly extracted from the deliverable 9 of the European project EUFIRELAB[17] (Sauvagnargues-Lesage *et al..* , 2006) and from the deliverable 6 of the European project CYCLOPS (Sauvagnargues-Lesage *et al..* , 2007b).

In most of European countries, civil protection actions are assigned to particular organisations or to small public structures. In Italy, each State organisation is involved in this function: from the Presidency of the Council of the Minsters to the smallest communes, all of the civil society is represented through the **National Service of Civil Protection** founded by the ***Law n°225/1992 of 24 February 1992 of organisation of Civil Protection***. Under this scheme, the responsibilities are divided between the services of the Civil Protection on all administrative levels:

- **State** (responsible: the President of the Council) ;
- **Region** (responsible: the President of the Region) ;
- **Province** (responsible: the President of the provincial Administration) ;
- **Commune** (responsible: the Syndic).

The forest fire management system is based on a multi-partnership organisation (see following figure):

[17] HAVE FIRELAB: Euro-mediterranean Wildland Fire Laboratory, has "wall-less" Laboratory for Wildland Fire Sciences and Technologies in the Euro-mediterranean Evr1-ct-2002-40028 – Area – http://eufirelab.org

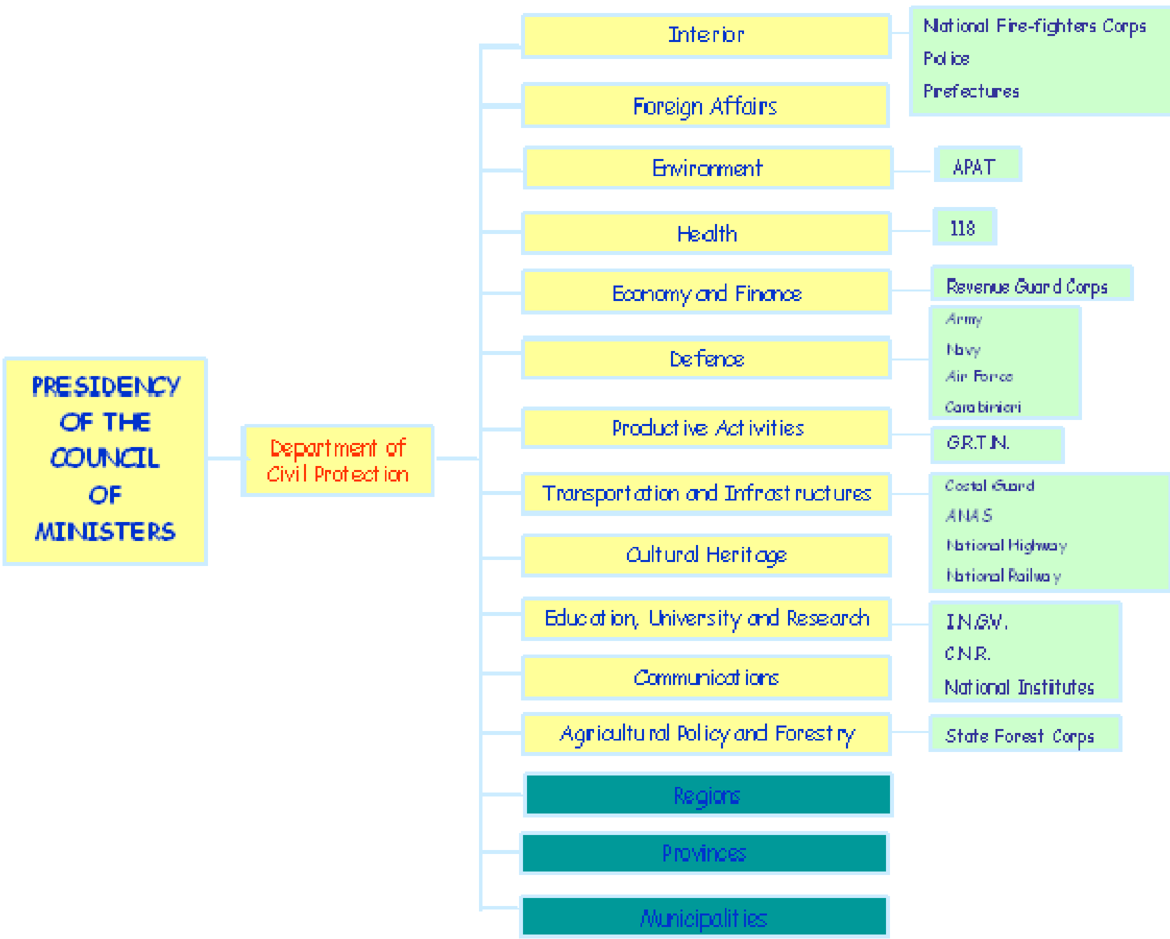

Figure 9 : Synthesis on the Italian organization

- The Department of Civil Protection (DPC) co-ordinates the activities of Civil Protection under the authority of the Prime Minister. The system depends on all the corps which constitutes the State, the National Fire Corps (CNVF[18]), involved in fire prevention and in charge of fire fighting operations.
- Fire prevention activities are carried out through the State Forest Corps (CFS[19]).

[18] CNVF: Corpo Nazionale dei Vigili del Fuoco

[19] CFS: Corpo Forestale dello Stato

- The Region ensures the implementation of forest fire protection plans and deals with the co-ordination of the Voluntary Corps of Forest Fire protection of Civil Protection. E.g. the Region of Piemonte that counts approximately 6200 volunteers is subdivided in 51 basic sectors.

The ministerial Corps possesses centres commanding operations for which they are responsible for:

- The Unified Permanent Operational Room (SOUP[20]) of the CNVF supervises all operations of Civil Safety for the Department of Civil Protection.
- The Operational Centre of the CFS co-ordinates prevention missions and emergency management for the environment, as well as assistance actions for Civil Protection. These national centres are in permanent alert and in co-ordination with the Regional Centres of Controls (COR[21]), the Provincial Operational Centres (COP[22]) and Local Operational Centres (COL[23]).

Defence activities regarding forest fires are implemented at the regional level under the authority of the DPC and by the regional plan for the programming of forecast, prevention and active forest fire-fighting activities[24] articulated around four sections: territory presentation, fire hazard analysis and forecast, implementation of prevention and fighting activities.

In Italy, prevention is a responsibility shared by the Ministry of Agriculture (CFS) and the Ministry of Interior (CNVF). Theirs missions concern:

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[20] SOUP: Sale Operative Unificate Permanenti

[21] COR: Centri de Controllo Regionale

[22] COP: Centri Operativi Provinviale

[23] COL: Centri Operativi Locali

[24] Piano regionale per la programmazione delle attività di previsione, prevenzione e lotta attiva contre gli incendi boschivi

- Fuel reduction and its foreseeable consequences: forestry, forest police, maintenance of access in forests, etc…
- Reduction of fire-hazard origins: reinforcement of territory monitoring, information programs for the public concerning fire hazard and individual protection measures against forest fires.

Concerning fire fighting, it is under the responsibility of the DPC and CNVF. Interventions are directed by the Operational Centres of the territories concerned by the fire. The fire fighting system is based on complementary actions:

- identification and monitoring of the sectors where fire risk is important ;
- setting off of the alert from the Regional Operational Room ;
- Fire suppression on the basis of territorial organisation defined by the Regional Plan.

2.2 Forest fire forecasting in Italy

The DPC competences within forest fire risk management are carried out in:

- Delay time, throughout the Forest Fire Risk Service.
- Real-time, with the Centro Funzionale Centrale (CFC) through the continuous monitoring of the meteorological and vegetation parameters involved in the ignition and propagation of fires also with Joint Air Operation Centre (COAU).

The CFC provides with a Decision Support System (RISICO[25]) for the Forest Fires management during the summer period. A system capable of providing useful indications for the pre-operational allocation and the operational phases of the aircrafts coordinated by the Joint Air Operation Centre of the Italian Civil Protection (COAU) and the helicopters coordinated by the Region.

[25] RISICO: Rischio Incendi e Coordnamento

The activities carried out by the Forest Fire Risk Service are:

Forecasting	- Event location - Risk assessment
Prevention	- Events' monitoring - Activity Regions monitoring - Support the regions in the risk mitigation work - Education - Information - Training - Analysis of the occurred events
Active fire fighting	- COAU

The Fire Risk Service of the DPC, in collaboration with the Meteorological National Service, since 2003 has adopted RISICO, developed by CIMA (Centro di Ricerca Interuniversitario in Monitoraggio Ambientale, see figure 10), for forest fires.

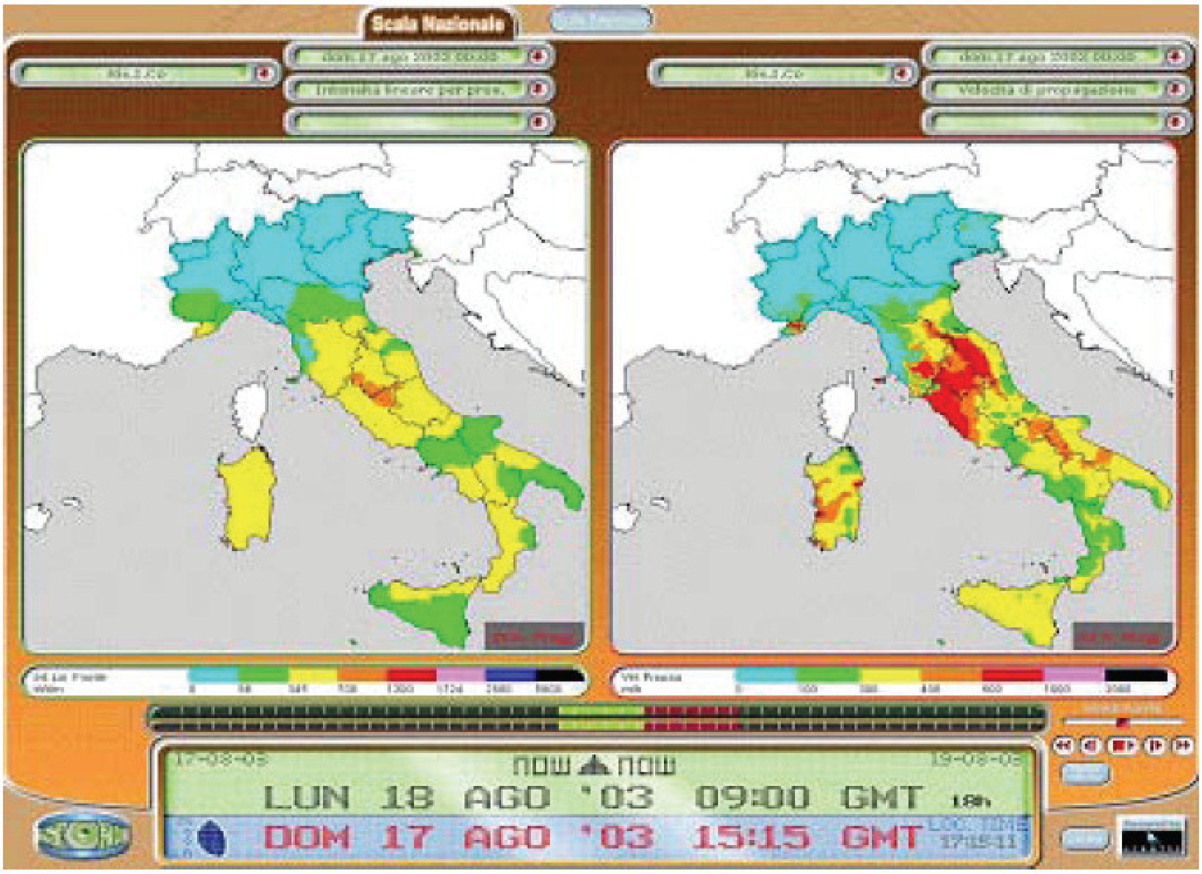

Figure 10 : Forecasting model RISICO
(Sauvagnargues-Lesage *et al.*, 2006)

It provides - every day - data for fire risk forecasting and management at National and Regional scale. The forecasting model RISICO is based on three documents:

- the dynamics of danger planned for the day ;
- a graphic document with fire intensity and spread maps determined for the main hours of the day, based on local climatic characteristics ;
- forecasts for the successive days defined starting from localised important meteorological parameters leading to forest fires.

This system will be described in details in the next part.

2.3 Choice of the use-case

During the Project Management Board Meeting on Thursday 30th November 2006, Cyclops project partners have chosen to study two specific use-cases concerning natural hazards. As presented previously, the first one concerns the French flash floods topic and initially the second one was on the Mediterranean simultaneous fires. Unfortunately, some organisational difficulties don't permit to develop seriously this thematic. After many information exchanges between Italian and French partners, a fire use-case has been chosen and validated by all partners. Different arguments can be presented in support of this choice.

The fire use-case is precisely compatible with criteria for use-cases choices presented by DDSC and EMA partners on last November:

- Added value of GRID to the process
- Relationship with GMES service
- Usage of sensor networks
- Suitability of process to prototyping

In particular, RISICO is a recent system developed in 2003 which could eventually be improved by new technologies as Grid technology. It is totally included in the European projects approach, as it has been included in the Work Package 4240 of Preview project. The Preview project is totally included in the GMES initiative. Main objective of new specification of this service was to improve it by upgrading this tool in adding some important input data.

Moreover, main contributors of RISICO development, CIMA[26] in connection with DPC and IMAA[27] are presently included in Cyclops project, it was logical to carry on the RISICO improvements in Cyclops project.

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[26] Interuniversitary Consortium for environmental monitoring

[27] Istituto di Metodologie per l'Analisi Ambientale

One technical argument concerns the providers which deliver remote geospatial data input and organisms which are involved in RISICO administrative operation for the effective operation of this tool. It will be showed that RISICO needs contribution of many different services:

- DPC
- Meteorological Network of Regione Lombardia
- Regione Lombardia Servizio Informativo Territoriale
- CIMA
- IMAA-CNR
- RL-SOUP

This heterogeneous geospatial data sources management seems to be a major argument to carry out the bringing of RISICO on Grid technology infrastructure in choosing this use-case in Cyclops project.

Finally, first tests on porting of OWS[28] on Grid technology infrastructure seem to confirm the interest of its using. Indeed, the cell resolution improvement have been estimated with a factor of ten or more by porting these geospatial web services on Grid technology.

3 SYNTHESIS

As specified in the Annex I – « Description of Work » of Cyclops project, the interest of use-case approach is to highlight the Civil Protection requirements to adopt Grid technology. These use-cases, flash floods and winter fires warning, are significant in terms of usage scenario, involvement of multi-organizations and interaction of human and technological resources. It represents existing and presently functional scenario that using and crisis management experiences have brought to light needs of enhancements by the use of advanced technologies. If this deliverable (D9) basically

[28] Open geospatial consortium Web Services

describes existing operations and infrastructures for these use-cases, the next one will give envisaged technical and organisational improvements, existing status enhancements and new organisational scenarios made possible by Grid technology adoption.

Concerning the Italian use-case, the Grid technology could eventually improve the accuracy of forest fires forecasting and the sharing of remote geospatial data sources. It could be the same advantages for the French use-case, with a special focus on the computational power benefit to manage parallel and simultaneous hydrologic modelling to enlarge models inter-comparison and modelized results validation.

III. USE-CASES TECHNOLOGICAL SPECIFICATION

1 FLOOD WARNING SERVICE SPECIFICATION

In France the dangerous natural phenomena forecasting is carry out by external organizations. For floods, the floods warning services (SPC) are performing this forecast.

After a general presentation of this service, this development will be organized around a presentation of tools developed to perform an hydrological forecast and an UML approach of this organization.

1.1 THE SPC-GD ORGANISATION

The area under monitoring for the flood warning service SPC-Grand Delta (as shown in Figure 11) covers the whole tributaries in right and left bank of the third downstream of the Rhône river (SPC-GD, 2006). The competence area of this service thus covers 5 departments (Drôme [26], Ardeche [07], Vaucluse [86], Gard [30] and the Bouches-du-Rhône [13]). The following table (

Table 1) shows the principal characteristics of these rivers.

River / Outlet	Catchment area	Historical maximum flood
Le Rhône	98 000 km²	13 000 m^3/s at *Beaucaire*
La Cance	380 km²	255 m^3/s *at Annonay*
Le Doux	630 km²	1 124 m^3/s at *Tournon*
L'Eyrieux	860 km²	> 4 000 m^3/s at *Ollières*
L'Ouvèze	124 km²	1 330 m^3/s at *Rhone river*
L'Ardèche	2 380 km²	8 000 m^3/s at *Vallon*
L'Aygues	1 100 km²	1 050 m^3/s at *Orange*
L'Ouvèze	800 km²	1 300 m^3/s at *Vaison*

La Durance	14 000 km²	6 000 m³/s at *Mirabeau*
La Cèze	1 360 km²	3 100 m³/s at *Bagnols*
Les Gardons	2 100 km²	6 700 m³/s at *Remoulins*
Le Vidourle	790 km²	2 550 m³/s at *Sommières*

Table 1 : SPC-GD rivers under supervision

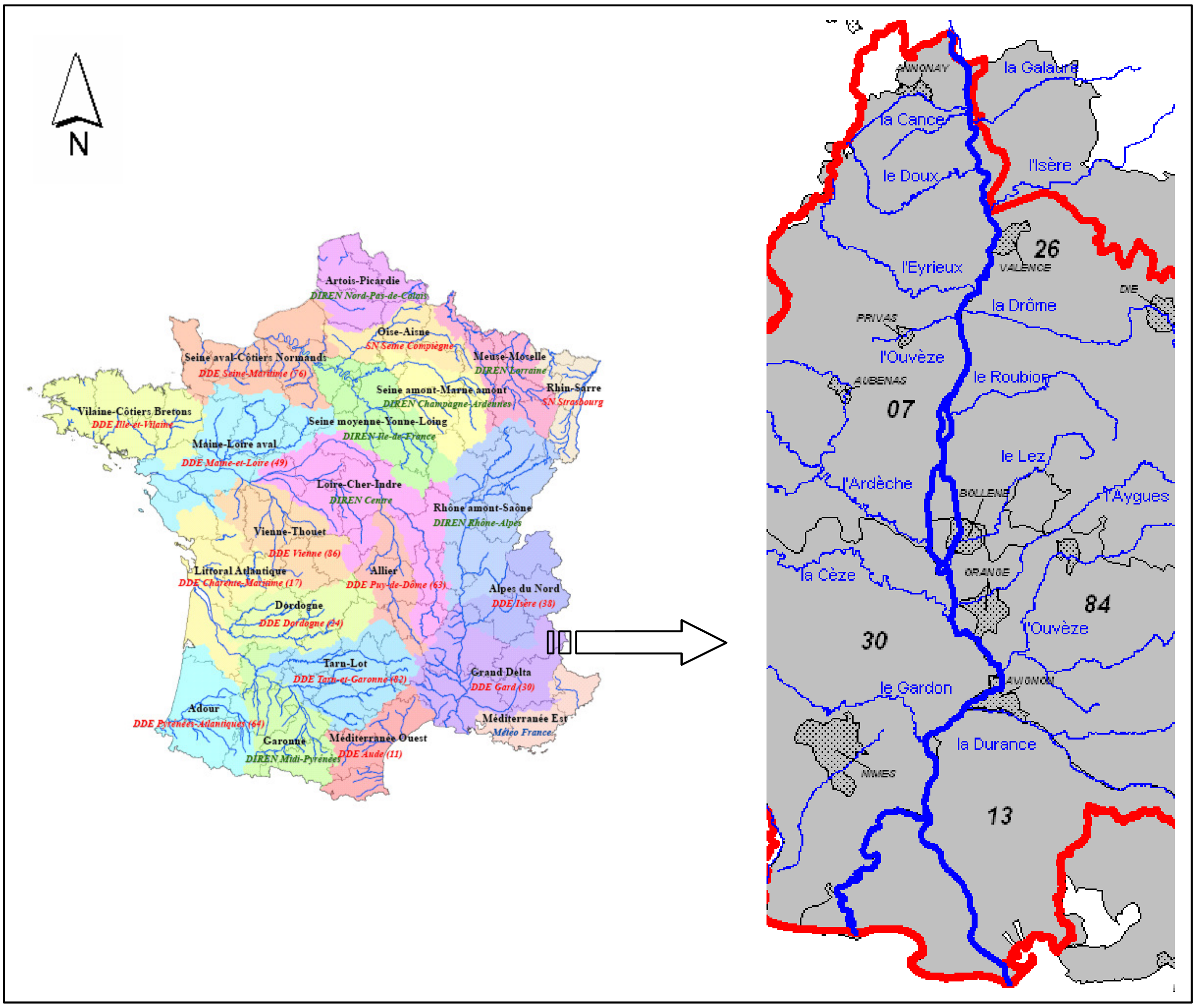

Figure 11 : SPC-GD supervision area
(Adapted from SPC-GD, 2006)

To monitor this area, SPC-GD includes several tools. These tools intend to make a good diagnosis on the event in progress for the forecaster:

- A network of telemetry (recording rain-gauges and water level stations)
- Tools of information and weather forecasting
- Tools of modelling

SPC-GD has a network of automatic transmission for measured sites including water level stations and rain-gauges. This network is supplemented by observers charged to complete information on these stations.

For meteorological data, SPC-GD has tools allowing an optimum comprehension of the phenomenon and its monitoring, with the service Météo +® of Meteo-France, as well as a real-time vision of the event with CALAMAR®[29] tool (Rainfall calculation using the Radar). CALAMAR® allows pre-processing and calibration operations of radar image according to the recording rain-gauges. A georeferenced image is produced every 5 minutes.

Modelling tools have also been self-developed by this service. These are hydraulic models (like ALHTAÏR flash floods forecasting system) allowing to estimate the discharge propagation between two sites. These models are also decision support systems for forecasters.

Finally, a GIS (Geographical Information System) platform allows a complete vision of the area under supervision. This GIS, call “SIG-SAC” still remains in a development phase.

All these tools will be detailed in the following parts of this deliverable.

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[29] Calcul de LAMes d’eau à l’Aide du Radar

Concerning communication aspects, the following figure (Figure 12) schematically presents the relations between SPC-GD and other actors of the emergency management.

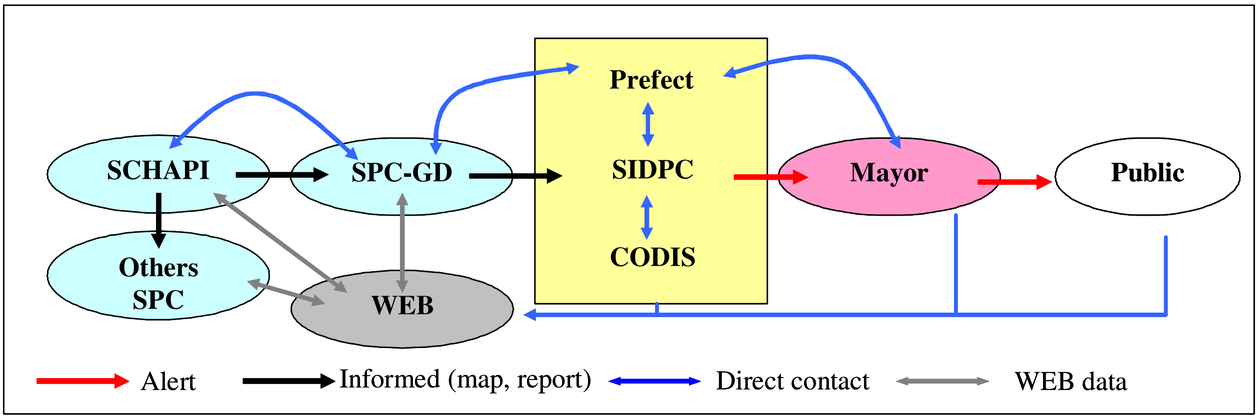

Figure 12 : SPC-GD integrated in the flood emergency management

Currently, SPC-GD develops an hydrological forecast in collaboration with the SCHAPI, and put these data on a Web platform. In parallel SPC-GD informs the local actors of emergency management (the Prefect, the SIDPC and the CODIS). The Prefect alerts to the mayors who relay this information with the population. During a crisis, SPC-GD is directly in communication with the SCHAPI but also with actors of civil protection.

This organization, illustrated on Figure 12, is interesting because it is not currently integrated into the tools of the SPC. It is thus possible to imagine services dedicated to this communication, services which could be based on Grid technology.

1.2 THE TOOLS OF SPC-GD

SPC-GD has many tools to perform hydrological forecasts on the supervised rivers. As specified previously, these tools correspond to individualized functional units which sequentially run to answer to one of the final objectives of floods monitoring in real-time. For each stage of the modelling of the hydrological conditions, the forecaster has raw or modelled data and is able to provide to the services of civil protection and local authorities the hydrological state of the territory to be supervised. The description of these tools is presented in this report.

1.2.1. An hydrometric network

The network of hydrometric stations (recording rain-gauges and water level stations) is composed of 116 stations distributed on the whole of the territory.

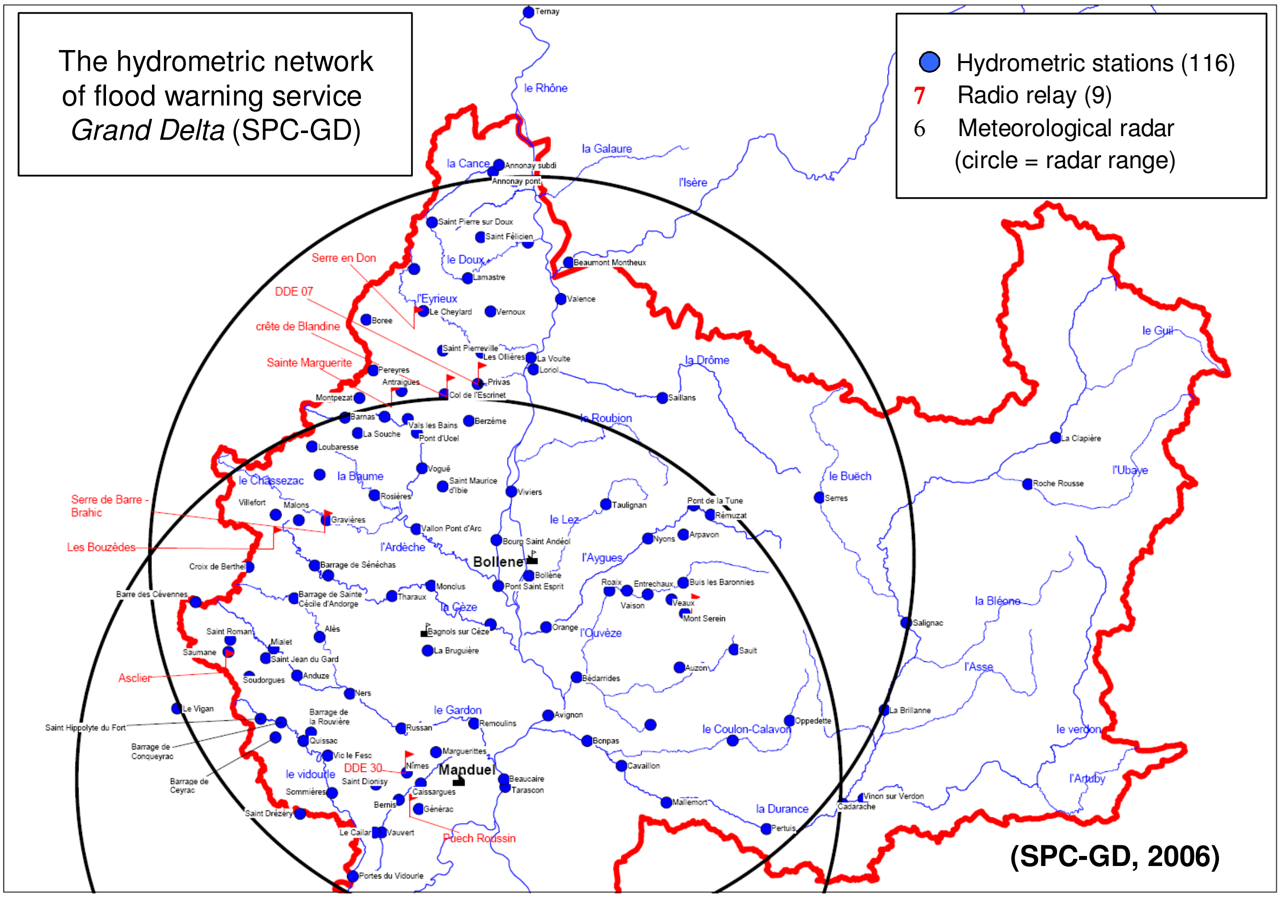

Figure 13 : SPC-GD hydrometric network

Eventually, it is expected that this service is equipped with 174 stations. These radio-transmission stations (9 radio relay, see Figure 13) are centralized by 2 concentrators then transmitted to SPC-GD (Nimes – see Figure 13). It is the platform SIGMA 2000 which allows the collection and the processing of these data. It also ensures the visualization and the management of alerts. The step of time is 5 minutes for the recovery of the data on precipitations and the water levels.

1.2.2. Meteorological tools

The SPC-GD forecasters have two types of tools to monitor the weather event: tools allowing monitoring on a large scale and returned observation of weather radar whose range is indicated on the Figure 13.

1.2.2.1. Météo-France: Tools and assistance

Meteo-France has a network of rainfall observations (network RADOME + complementary network of automatic stations). Currently these data are only partially accessible through Météo+ software of Meteo-France. In connection with the concerned interregional directions of Meteo-France, the SPC will be able to specify the stations, interesting in the field of the hydrology, for which the data could be placed at the disposal within the framework of FTP exchanges.

The satellital imagery produced by Meteo-France (infra red image, visible image…) like various meteorological observations (temperatures, wind, impacts of the lightning…) are accessible by SPC-GD through Météo+ software.

Whatever the situation and weather forecasting, Meteo-France establishes twice a day, of the reports of precipitations (BP), before 9h for the morning and before 16h for afternoon.

These documents specify the average, localized, observed, and forecasted water levels, to 24 and 48h by geographical sector.

These precipitation reports are transmitted to the electronic address of SPC-GD. It indicates, if necessary, if one of these territories is the subject of a warning precipitation (AP). On this assumption or in case of worsening of vigilance level (passage from the yellow to orange or orange to the red) the diffusion of these reports is systematically accompanied by telephone messages addressed to the 2 constraint persons.

In addition, the territory of SPC-GD is partly covered by 2 radars of ARAMIS network of Meteo-France (see Figure 13), the radar of Manduel (proximity of Nimes) and that of Bollène (northern Vaucluse). National conventions framed the providing of radar data to the private companies exploiting these data for the account of floods warning services and in particular of SPC-GD.

1.2.2.2. Radar image

To use radar imagery, SPC-GD has the tool CALAMAR, developed by the Rhéa Company which allows treating and diffusing the radar images produced by Meteo-France.

Developed by Rhéa® Company, the CALAMAR tool allows to know precipitations falling on each square kilometre of the study area, every five minutes. These images are georeferenced, in real time (every five minutes), by the rain recorders which are implanted on SPC-GD supervision area (Rhéa, 1998). The CALAMAR result (show on the Figure 14) is a georeferenced grid with the rainfall intensity value each pixel ($1km^2$).

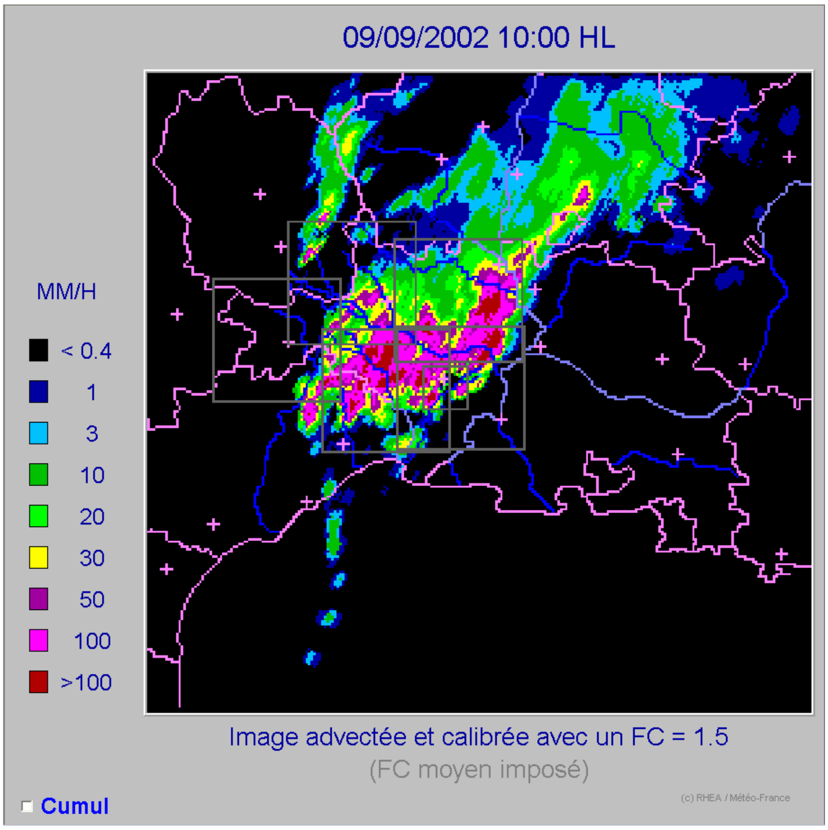

Figure 14 : CALAMAR radar image

Some statistical tests were made to compare rainfall values obtained by radar images and by rain recorders. For 80 % of the results, the difference between the two rainfall values is less than 30 %. The comparison was made for rainfall greater than 40 mm. So and subject to be corrected in real time with the rainfall recorder network, this data is considered as operational for the flood-warning service (Bressand, 2002).

These radar images make it possible to the forecaster to refine his analysis of the situation in real-time. These images are also used as data input of the flash floods forecasting model ALHTAÏR.

1.2.3. Modelling tools

Les prévisionnistes du SPC-GD s'appuient actuellement sur 2 modèles: *Prévicèze* et ALHTAÏR. Toutefois une politique forte en matière pour le développement d'une plateforme de modélisation a été mise en place depuis 2006 avec le SCHAPI (SPC-GD, 2006).

1.2.3.1. Prévicèze

Prévicèze is a propagation model integrating the developed rain specifically for the downstream part of the watershed of Cèze (see Figure 11).

From the water level data of a station located at the upstream of the watershed and collected precipitations on the 3 pluviometric stations of the watershed, the model makes it possible to make a flood forecast in Bagnols (outlet) with 7 hours in advance and a forecast of more or less 20 cm in 80 % of the cases (SPC-GD, 2006).

1.2.3.2. ALHTAÏR

The ALHTAÏR model includes three specific tools for producing floods hydrographs:

- The first tool, CALAMAR gives the rainfall data to the flash flood forecasting model (see previously).
- The second tool produces information about the watershed studied.
- Finally, ALHTAÏR software produces floods hydrographs in real time.

HYDROKIT is developed with the Geographic Information System (GIS) software ArcGis® 8.2 by Strategis® Company. It includes all watersheds and sub watersheds for the area under supervision of the SPC-GD. With a Digital Elevation Model (DEM), HYDROKIT generates automatically the hydrographical parameters (hydrographical distance, slope,...) necessary to calculate the time of concentration. The Figure 15 shows the HYDROKIT interface.

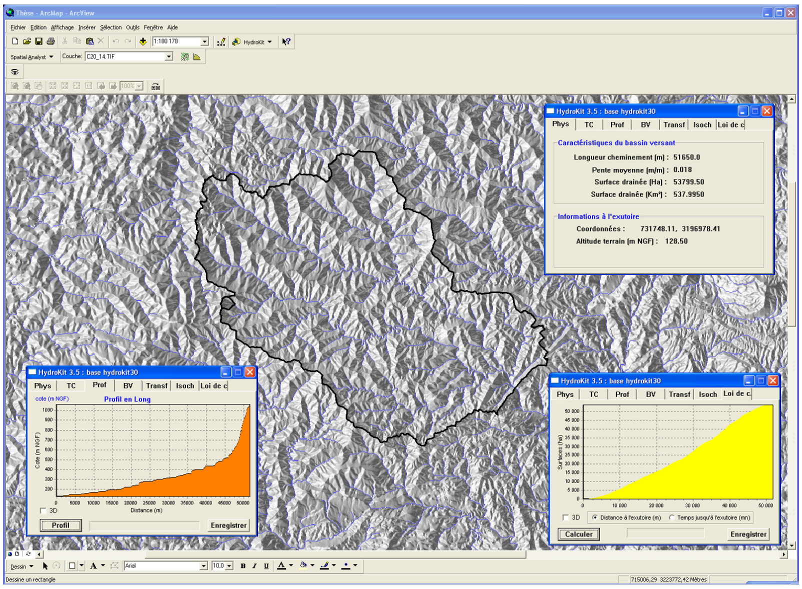

Figure 15 : Interface of HYDROKIT with ArcGIS 8.2

As CALAMAR, HYDROKIT generates a georeferenced grid with one square kilometre pixel.

The ALHTAÏR software is a hydrological flash flood forecasting model. The ALHTAÏR software interface is shown in the Figure 16.

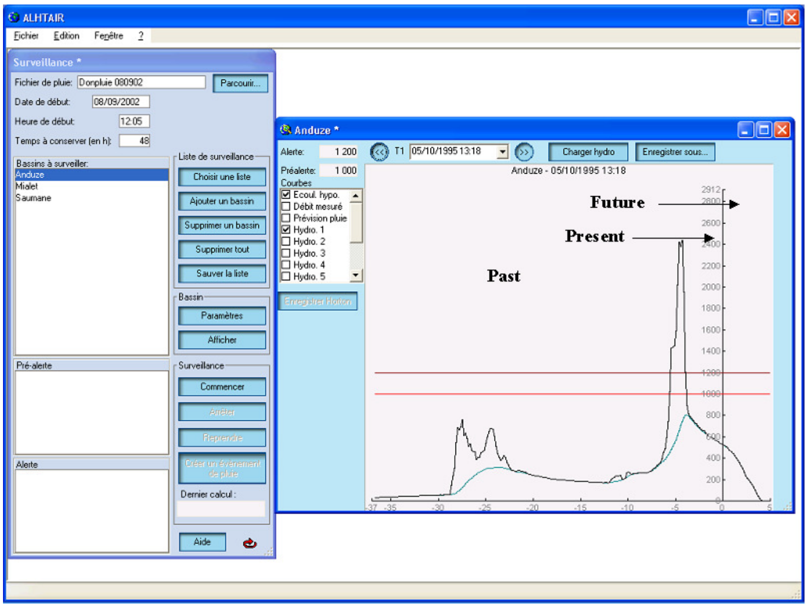

Figure 16 : ALHTAÏR Interface

This model works in real time and it includes:

- A production module (calculation of the effective rainfall), derived from the Horton principle (Horton, 1933). It allows to determine runoff according to the infiltration capacity.
- A propagation module (calculation of concentration time) that transfers the surface runoff at the outlet of the catchments provided by the HYDROKIT data.

The propagation module is given by a law which transferring the surface runoff at the outlet. This law has been calibrated for the area under supervision of the SPC-GD (Bressand, 2002).

$$V=\left(1+\frac{(p-1)}{9}\right).L^{0,25}$$

Where V is the celerity (m/s), p is the slope (%) and L is the hydraulic distance (km).

The quantity of runoff, which is calculated for a pixel, is propagated directly at the outlet each five minutes.

The production module of this flash flood forecasting model derives from the Horton principle, which explains the surface runoff by the excess of rainfall intensity in comparison to infiltration capacity. The infiltration capacity according to Horton is given by the following equation (Horton, 1933):

$$f(t)=f_c+(f_0-f_c).e^{-kt}$$

Where f is the infiltration capacity (mm/h), f_0 is the initial infiltration capacity (mm/h), fc is the final infiltration capacity (mm/h) and k (a constant) is an exponential decreasing coefficient until saturation.

When the rainfall intensity is greater than infiltration capacity, surface runoff occurs. But, this cannot alone explain the generation of all the flash floods in the Gard Region. Therefore the production module was modified (Bressand, 2002; Ayral and Sauvagnargues, 2004). The process of this module is shown in the following figure (Figure 17):

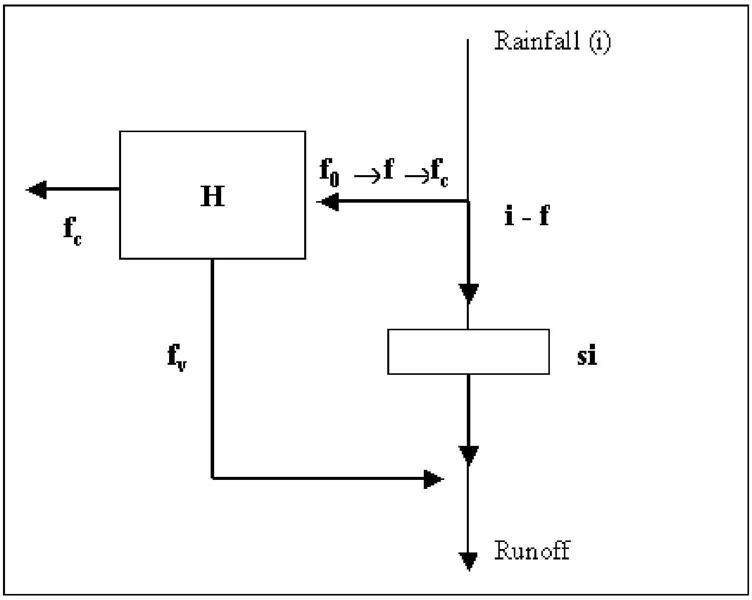

Figure 17: ALHTAÏR production module working (Ayral *et al.*, 2006)

The rainfall intensity (i) is subtracted from the initial infiltration capacity (f_0) at the beginning of the rainfall event and then the infiltration capacity (f) is downgraded. Indeed, the initial infiltration capacity reduces according to time for tending to ground infiltration (f_c). The effective rainfall (i-f) must fill a volume (si), which represents a soaking rainfall. When this volume is full, all the effective rainfall contributes to the surface runoff. The subsurface flow (f_v) is generated by the "hortonian volume" (H) emptying, which contributes to the surface runoff. At the end of the rainfall event, the soaking rainfall volume empties. This calculation is made for each pixel, every five minutes.

The production module of ALHTAÏR has six parameters. Four of them can be calibrated (f_0, f_c, f_v, and *si*), and two parameters are fixed (*k* and α).

It is possible to make a model calibration according to the studied watershed ("watershed mode") or a spatial calibration ("Spatialised mode"): the model parameters are determined by a characteristic of watersheds, pedology, geology, land use for example (Ayral, 2005, Ayral et al., 2006). In this case, parameter cartography is produced for all the SPC-GD supervision area with same characteristics (a grid with one square kilometre pixel) than CALAMAR or HYDROKIT cartographies.

The following figure (Figure 18) summarizes the ALHTAÏR operation.

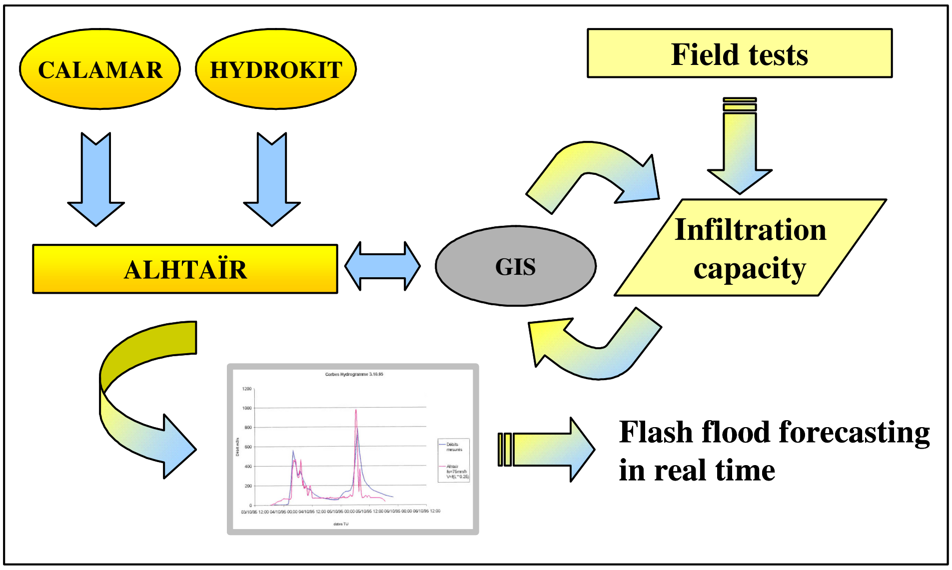

Figure 18: A flash flood forecasting model in real time: ALHTAÏR (Sauvagnargues-Lesage and Ayral, 2007)

Many watersheds are supervised in real-time with ALHTAÏR in watershed mode. The spatialized version of this model is still in phase of research, but is operational on the watershed of Gardon d'Anduze (Ayral, 2005). The development of this modelling platform, with ALHTAÏR, but also with other models is an important objective of SPC-GD.

1.2.4. A GIS tool in development: SIG-SAC

The objective of the platform SIG-SAC is, in the long term, to support forecaster decision-making process of SPC-GD. SIG-SAC, set up under the environment of ArcGis®, integrates a great number of layers of information necessary to the forecasters (see Table 2):

GIS Layers (Source)	Remarks
BD Carto® - Product of French Geographical Institute (IGN[30])	Visualization of data vectors including: administrative units, rail, road and drainage networks, the equipment, toponymy, land use.
Scan100® and Scan25® Product of IGN	Map raster of the supervision area. It allows a better localization on the SPC-GD territory.
Floodable zone atlas (SPC-GD)	
Digital Elevation Model (DEM) - Product of IGN	The MNT associated with HYDROKIT makes it possible to generate the watersheds and it also used in hydrological modelling (slope, lag time,…)
Hydrometric network cartography (SPC-GD)	All the hydrometric stations (rain recorder and gauging station) are georeferenced and their values are updating in real time.
Radar Image (Rhéa®)	The integration of the radar mages in the GIS and their updating (5 minutes) is in the process of building. It will allow to the forecasters a global vision during the flood event.

Table 2 : SIG-SAC structure

[30] IGN: Institut Géographique National

This platform is still in phase of development (Ayral, 2005). It is in particular in terms of real-time and interoperability that researchers have to make an effort.

To summarize, this SPC-GD organisation (see Figure 19) is based on three main units SIGMA2000, CALAMAR and ALHTAÏR which interact to produce different thematic results. The first one, except its role of job scheduling, permits to forecasters to provide a basic weather and hydrologic report by using raw data and their watersheds knowledge. Results of the second one, independently or calibrated with raw pluviometric data, provides pluviometric data as input parameters of ALHTAÏR or as basic elements of forecasting. Finally, the last one, using results of two others softwares, provide a real-time state of rivers discharges to precise already produced hydrologic reports.

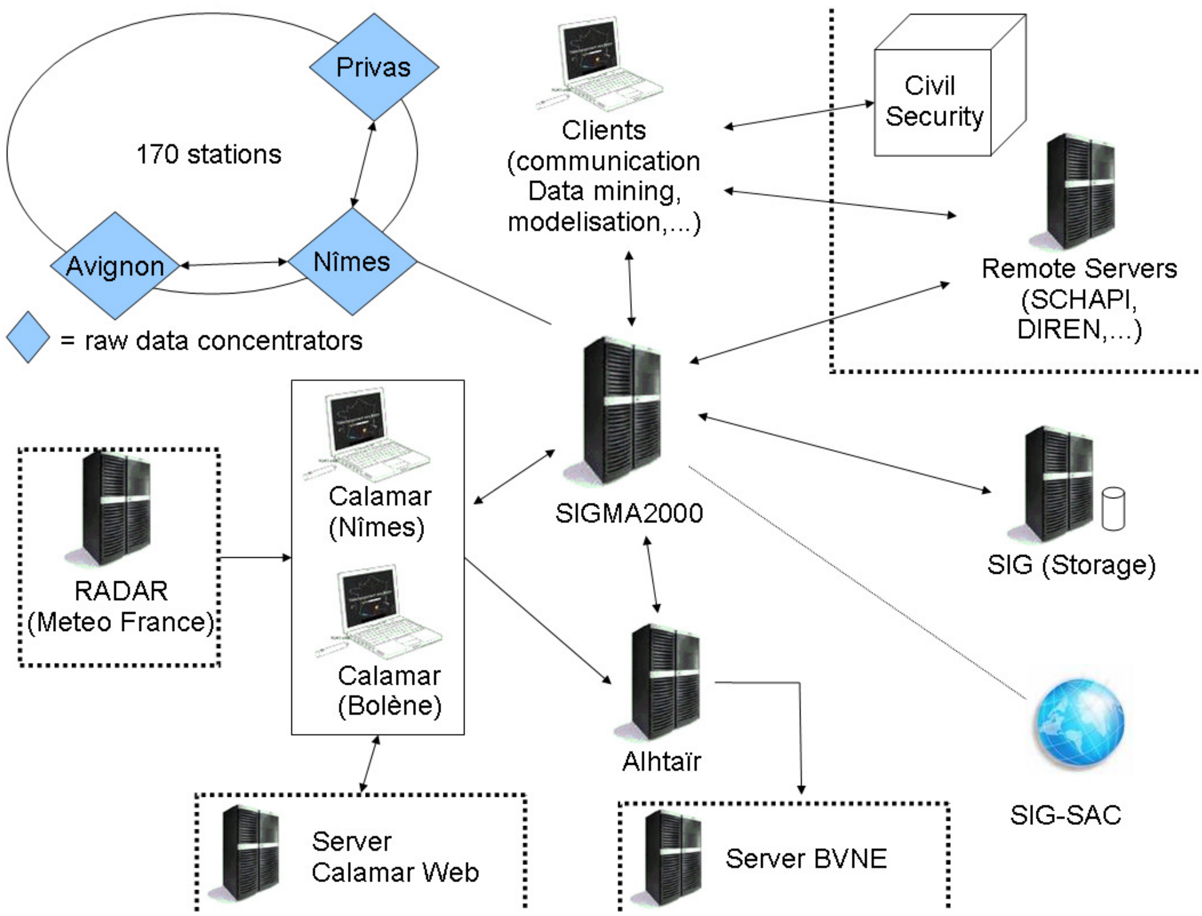

Figure 19 : SPC-GD global organisation

This global description aims at giving an overview of existing service for flash floods warning. From a computing point of view, this analyse have to be completed by an UML approach to understand in details the existing workflow among all SPC-GD units. UML method seems to be interesting to understand and to illustrate information and data exchanges between computing system and external actors and on a second hand to analyse specific workflow by main operation units.

1.3 UML ANALYSIS OF SPC-GD

1.3.1. Use-cases analyse

This diagram aims at describing the general behaviour of SPCGD system in a real-time flash floods warning context. The main actor is the forecaster who interacts with every subsystem to elaborate the more accurate as possible hydrologic report. This service is an information-oriented system based on raw and modelized data provided by automatic and independent programs. This description focuses on a real-time context corresponding to a crisis management period. All calibration and administrative tasks are considered as already made.

In the following use-cases diagram describing the SPCGD operations, three main use-cases are represented and are linked to the three main units of SPCGD system:

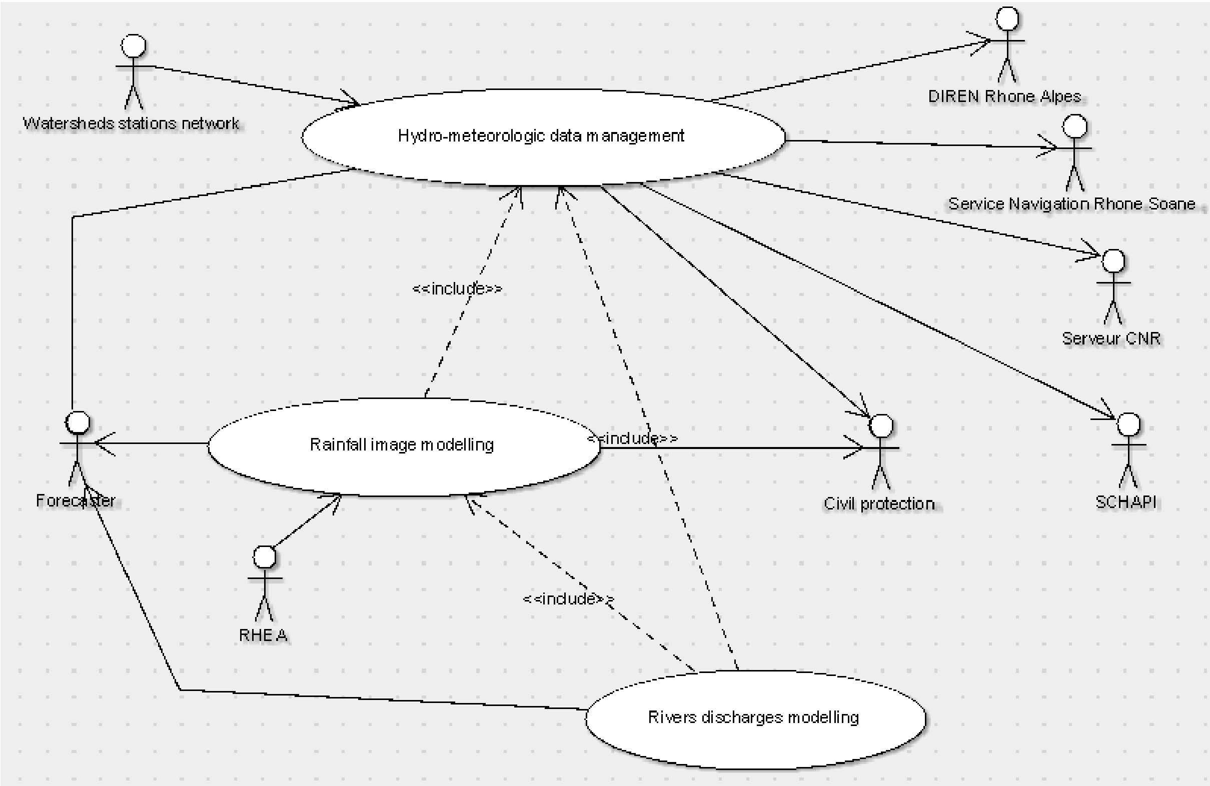

Figure 20 : Use-cases diagram of SPC-GD

The “hydro-meteorological data management” use-case is provided by SIGMA2000 which constitutes the manager of the data and information exchanges among the various modules of the service. It has a central role equivalent to job scheduling unit.

SIGMA 2000 is in “streamless” (non-stop) communication with the meteorological stations to gather the pluviometric and hydrological data (water level) and to define and adapt their stations parameters.

Moreover, it manages exports/imports towards the external servers and/or internal modules implied in the forecast and the crisis management.

- Internal exchanges in the SPCGD

- It provides to the Module CALAMAR ("Rainfall image modelling" use-case) the rainfall records in a XML file (radar image processing)
- It provides to the Ahltaïr Module ("Rivers discharges modelling" use-case) the discharges in a XML file.

- External exchanges
  - Server Vigicrues (Schapi) under format XML and .PRE (this last format having however vocation to disappear)
  - Server Hydro-Réel (DIREN Rhone Alpes) under format .PRE
  - Server ftp of the national Company of the Rhone (CNR)
  - Server ftp of the Service Service Navigation Rhone Saone

For this use-case, special and private communication exist between the departmental service of Civil Protection (CODIS) and the flash flood warning service (SPCGD) by fax to complete public forecast report.

1.3.2. Activities analyse

In addition, for a better analyse of existing system, UML activity diagrams have been produced and complete the literal description. These diagrams are useful to understand the intra-system operations. All external exchanges between actors and system are not taken in account at this analyse level.

For the "hydro-meteorological data management" use-case, the following activity diagram has been produced. It gives the workflow for 5 minutes sequence corresponding to each raw data reception event.

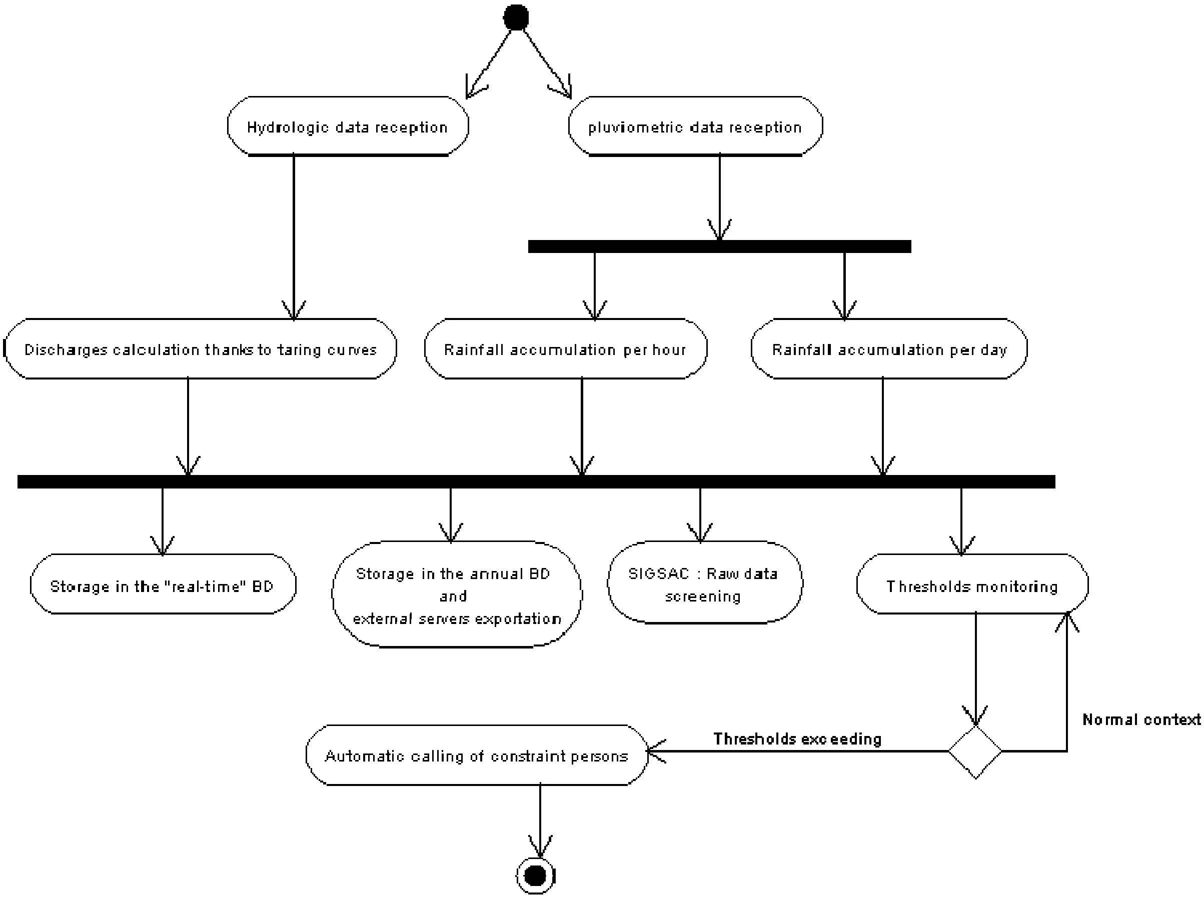

Figure 21 : « hydro-meteorological data management » Activity diagram

After raw data reception, its principal functionalities are as follows:

- The collection part software receives the radio information, decodes them, and generates a XML file that the supervision part software reads. Then thanks to pre-defined tarring curves (water level / river discharge ratio), it calculates discharges at stations locations for the hydrological data as well as the hourly and daily rainfall accumulation for the pluviometric data,
- The system has two databases, one for the real-time part with 7 days of data storage, and a database of permanent storage with an annual filing. This storage functionality permits to the forecasters to launch future batch mode calculations in order to calibration and lessons learnt operations.
- A basic integrated module for rivers behaviours visualization permits to the forecasters to have an overview of real-time context.

- Automatic thresholds exceeding monitoring and automatic call of the constraint worker to take in charge potential dangerous situation.

As seen previously, SIGMA 2000 has a central role in SPC-GD system, indeed it permits to manage input and output data among others SPC-GD units. So, all import operations are present in each activity diagrams.

Function of the SPC-GD also depends on weather radar data which are collected and stored. This function is represented by the second use-case “rainfall image modelling”. These data make it possible to evaluate the characteristics of the rainfall in real-time. From this point of view, the originality of the architecture of the SPCGD, is the use of software (CALAMAR 2) making it possible to treat the raw radar data according to pluviometric measurements of SPCGD network, in order to have an evaluation of the most reliable rainfall.

The radar images are provided by a private company RHEA which sends every 5 minutes a raw radar image. CALAMAR 2 software treats this radar image to allow forecaster to provide and precise pluviometric report.

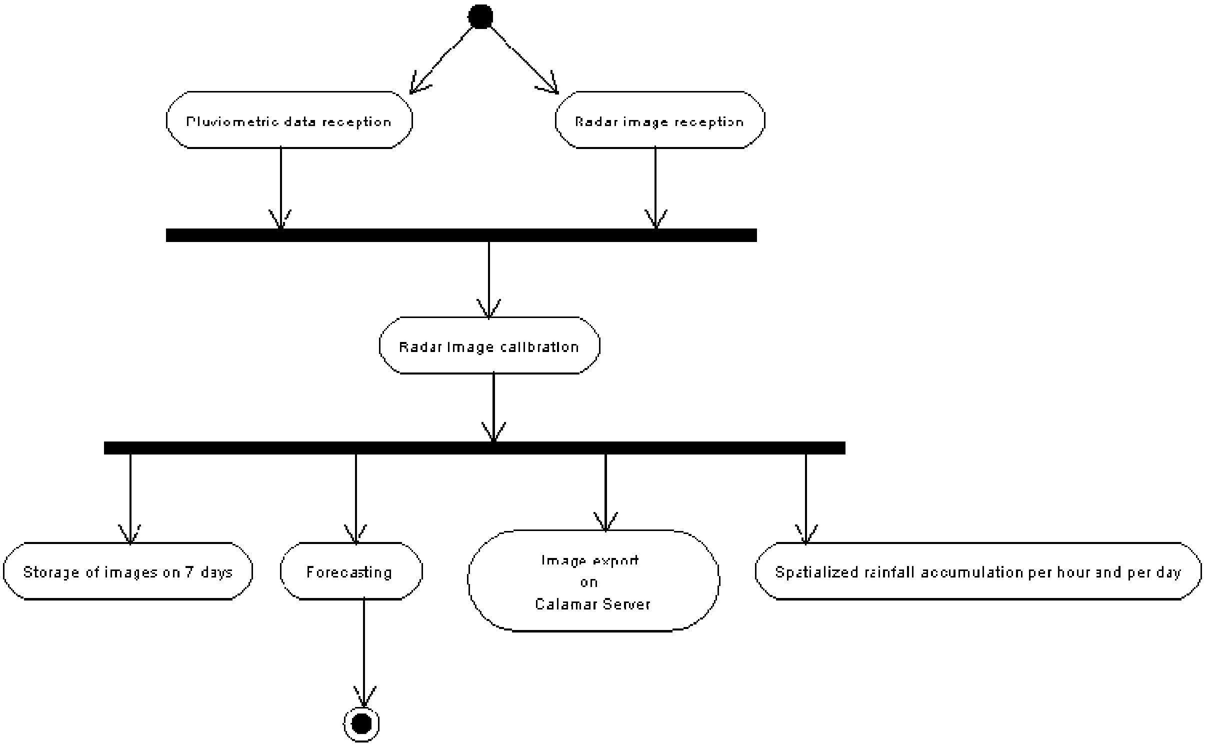

Figure 22 : « rainfall image modelling » activity diagram

This spatial analyse takes in account the raingauges values provided by SIGMA 2000 and each radar image pixel value. The same value is given for a defined zone all around the meteorological station.

Two computers are dedicated to the use of the module CALAMAR 2 (radar images of Nimes and Bolène), it is a tool allowing to georeference and to calibrate the radar data according to specific measurements coming from raingauges stations and provided by SIGMA 2000. A raster file is produced (calibrated) with for each pixel a value of actually rainfall (mm). This operation aims at generalizing the rainfall situation on all the competence territory.

From a technical point of view, the calibration operation is divided in two main geoprocessing steps:

- **Pre-processing**: the software removed all the land echoes which are not rain, corrects the effects of mask due to the relief, converts the radar reflectivity into rainfall intensity, and reconstitutes the displacement of the rainfall between two successive “instantaneous” images.

- **Calibration operation**: Software checks coherence between the pre-processed image and specific measurements of meteorological stations, thanks to the imported XML file of rainfall coming from SIGMA 2000. It consequently corrects the “pre-processed” image, which then becomes a calibrated image.

The produced data are stored on the computers carrying out calculations, on a seven days period, then possibly filed, in a manual way, by the personnel of the service.

In real-time, these data are also sent towards an external Web server (CALAMAR Web), allowing the access and the visualization of the calculated and calibrated rainfall for certain actors of Civil Protection. The principal function of this software is nevertheless to be able to visualize this rainfall, rainfall accumulation per hour and day.

The last function of CALAMAR 2 is to forecast rainfall one hour before the event with a refreshing every 5 minutes.

In addition to the visualization of the calculated rainfall, the software makes it possible to send every 5 minutes a data file in entry of the flash flood forecasting model Alhtaïr.

This software manages a private format the Rhéa© format and all the code is presently not available.

The last use-case of SPCGD is the "rivers discharges modelling" provided by Ahltaïr model. It can be considered as a Decision Support System for flash flood warning. The purpose of this model is to produce a flood hydrograph for each location of the rivers, in a real time process, for the area under supervision of the SPCGD. This forecast model is more efficient for the catchments areas smaller than 500 km^2. It is a rainfall-runoff model for flash flood forecasting. It makes it possible to produce a flood hydrograph in real-time starting from a spatialized rainfall. It has a module in batch mode to carry out simulations and the calibrations of the model itself.

For its real-time operation, it receives data from SIGMA 2000 (pluviometric raw data, water levels and discharges in format .xml) and from CALAMAR 2 (5 minutes rainfall in format .dat). The characteristic of the Alhthaïr module is to store only the entering data to allow future simulations (batch mode). No result is stored in the database, information is only analyzed and directs the SPCGD decisions-making to periodically broadcast or update a forecasting report.

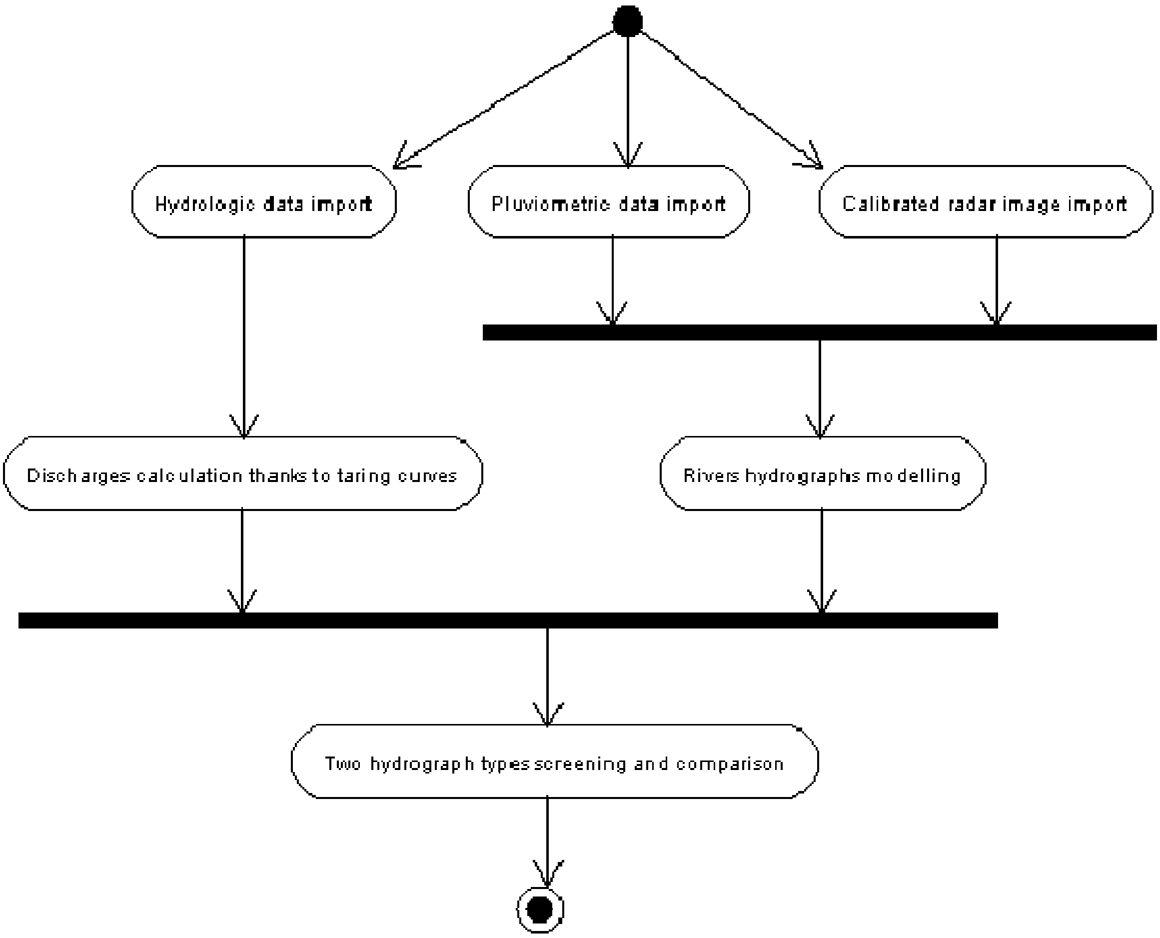

Figure 23 : « rivers discharges modelling » activity diagram

One interest of this software is to compare in real-time the modelized and stations hydrographs to evaluate the effectiveness of Ahltaïr and to produce the more accurate as possible hydrologic report to Civil protection and all services included in crisis management phase.

2 WINTER FIRES SERVICE SPECIFICATION

The proposed use-case by the Italian partners does not relate to an organization but rather a service dedicated to the forecast of winter fires.

The WINTER FIRES service, being developed within the PREVIEW project (Priolo, 2006), will provide a dynamic representation of wildland fire risk. The proposed service has been designed upon a HW/SW architecture, which fulfils all the technical requirements and the operational characteristics proper of the wildland fire emergencies.

2.1 Winter fires service overview

The WINTER FIRES service, being developed within the WP 4240 of the PREVIEW project, will provide a dynamic representation of wildland fire risk. The proposed service has been designed upon a HW/SW architecture, which fulfils all the technical requirements and the operational characteristics proper of the wildland fire emergencies. WP 4240 final product is the forecast of the *potential linear intensity* dynamics over a 72 hours time horizon discretized in 24 time intervals of 3 hours. The risk assessment carried out in WP4240 can be denoted as *dynamic*, since it is based on dynamic models able to represent, in space and time, the influence that exogenous variables and vegetal physiology have on the state variables characterizing the fuels and, therefore, on the potential behaviour of the fire. Besides, notice that, every three hours, the system receives in input new meteorological ground truth used for the re-initialisation of the state variables. Then, a new run of the system is carried out using the meteorological forecasts relevant to the remaining time intervals within the original 72-h time horizon. And so on and so forth until a new set of forecasts is available (i.e., every 24 hours).
Potential linear intensity is obtained on the basis of three main intermediate products: Fuel Load, Dynamic fuel, Moisture conditions, and Dynamic Potential Rate of Spread.

In the table below (Table 3) a synthetic description of the service being developed is presented.

DESCRIPTION	The service will provide dynamic fire risk index maps specifically suited to the Winter Fires phenomenon. The products on delivery will concern the *Fuel Characterization* products: *fuel load map* and *Dynamic maps of fuel moisture conditions;* and the *Potential Fire Behaviour* products: *Dynamic maps of potential rate of spread,* and *Dynamic maps of potential linear intensity.*
DELIVERED PRODUCTS	**Fuel load maps** This product is relevant to the average fuel load [kg m^{-2}] of each different class of fuel available for the ignition and the propagation of a wildland fire in the area of study.
	Dynamic maps of fuel moisture conditions This product is relevant to the estimated moisture conditions [%] of each different class of fuel characterizing the area of study.
	Dynamic maps of the potential rate of spread Maps relevant to the potential rate of spread [m h^{-1}], which could assume the fire front in case of successful ignition.
	Dynamic maps of the potential linear intensity Maps relevant to the potential linear intensity [kW m^{-1}], which could reach the fire front in case of successful ignition.
PERFORMANCES	The area of study is discretized over a grid of cells having 100 m of side length. The dynamic maps are relevant to a time horizon of 72 hours, and are discretized in time intervals of 3 hours. Thus, every day, a set of 3 different risk indexes (fuel moisture, rate of spread, linear intensity) for each of the 8 daily time intervals, that is 24 maps will be delivered. The fuel load

	map will be produced every time that new "fresh" information will be available. Such maps will be delivered in any case every 15 days
DELIVERY DELAY and FREQUENCY	**Fuel load map** The map will be delivered periodically, minimum frequency of 15 days.
	Dynamic maps of fuel moisture conditions A new set of maps covering the considered time horizon will be delivered every 3-hours of the day.
	Dynamic map of the potential rate of spread A new set of maps covering the considered time horizon will be delivered every 3-hours of the day.
	Dynamic map of the potential linear intensity A new set of maps covering the considered time horizon will be delivered every 3-hours of the day.
PRODUCT FORMATS	ASCII GRID files (to be displayed as bitmap files by means of suitable Graphical User Interface) and Geo Tiff.
REQUIRED INPUT	DTM, Pedological Map, Land Use thematic map, Meteorological data, and high resolution meteorological forecasts, Fuel Stick data, EO products generated by medium resolution satellite data (MODIS, SPOT Vegetation)
LOGISTIC ASPECT	Microsoft Visual Studio C++ developer. Geographical Information Systems (Mapinfo 7.5 or ESRI Arc-Gis).
USERS CONCERNED	National and Regional services in charge of fire prevention and operational fire fighting activities.

Table 3 : Service description

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2.2 Operational objectives of winter fires service

Winter fires represent a considerable source of damage for most of the European countries characterized by continental climate and mountainous topography.

Extended burned areas, and long time lasting damages characterize such a phenomenon. Usually, winter fires affect mature coniferous woodlands or mixed woodlands placed in sub-alpine areas, far from large water surfaces, and hardly accessible for fire fighting vehicles. The possible freezing of water supply facilities, and the limited daylight time available make winter fires dramatically hard to cope with. The major objective of the service is that to support decision makers in taking (hard) decisions in preventive and operative phases of wildland fire risk management during winter season. The products delivered will be useful to isolate the high-risk areas and will provide data that will be used during the preventive relocation of the fire fighting means as well as supporting the coordination of the fire fighting actions during emergency phase.

The end users of the service are the Regional Agencies in charge of fire risk management, in Italy the **Dipartimento** di **Protezione Civile** (DPC) at national scale, and, at regional scale, the regional **Centri Funzionali** (CF).

The activities for the development of this service will be performed in close cooperation with the DPC and the end user **Sala Operativa Unificata Permanente** (RL-SOUP) of Regione Lombardia, partner within the project, with the role of final user in the service pre-operational demonstration and assessment at regional level.

2.3 Precursor services and pilot project references

In Europe the projects RISK-EOS, FUEGOSAT, represent precursor services on fire Risk management, but until now the service, being developed within the WP 4240, is the first one specifically suited to the winter fires.

The starting point of the proposed activity is the upgrading of the forest fire risk forecasting system RISICO (RISchio Incendi e COordinamento) operative for the Italian Civil Protection (DPC) since august 2003. The upgrading of the present system is specifically suited for the service to regional purposes and to specific issues characterizing the winter fires phenomena with the introduction into the models of several new inputs data. The new information in use will be higher meteorological forecasts, in-situ meteorological observations, dead fuel moisture measures by in-situ sensors (fuel stick), EO products estimating vegetation condition for individuating the specific features characterizing winter fires, additionally information like EO snow cover maps will be also considered.

2.4 Targeted geographical areas and end users

COUNTRY	AREA	END USERS
Italy	Regione Lombardia	RL-SOUP, DPC

2.5 Potential geographical areas

The methodology is adaptable to other countries affected by the same phenomenon due to the use of standard meteorological and ancillary data .

COUNTRY	AREA	END USERS
Italy	Liguria, Piemonte, Trentino Alto Adige, Friuli, Veneto Val d'Aosta, and the other Italian regions affected by the phenomenon	DPC, Regional fire fighting Agencies
Germany, Spain, France, Switzerland, Portugal, Greece, Scandinavian countries, and the other European countries affected by the phenomenon	Local area affected by the phenomenon	Regional fire fighting agencies

2.6 Winter fires service/products specification

2.6.1. Information products/service overall description

The service proposed within the Work Package 4240 will provide daily dynamic wildland **fire risk index maps,** whose information-set and spatial-temporal scale are specifically suited to regional purposes and to specific issues characterizing the winter fires phenomenon.

On the basis of the dynamic wildland **fire risk index maps** the end user will be able to manage the coordination, at a regional level, of resources on the territory aiming at reducing the effect of the wildland fire over the considered territory (burned area). The objective of resource management is twofold. In the *preventive phase* means and crews are re-allocate on the basis of the forecast risk, in order to successfully fight initially spread fires, whereas in the *real-time phase* consists to determine the optimal composition of means that are sent to signalled fires. The service will be based on the implementation of specific products.

The products that will be delivered can be classified within two specific development research frameworks:

- Dynamic fuel characterization;
- Potential fire spread models.

The target of the first framework is that to characterize and simulate the dynamics of the load and the moisture conditions relevant to different kind of live and dead vegetal fuels. To this end, a fine characterization of the fuel existent in the area of study will be carried out, paying a special attention to the physiological and morphological characteristics of the fuels that are mainly involved in the ignition and propagation of winter wildland fires.

Dead fuel moisture dynamics will be modeled basing on the definition of a specific dynamic fuel moisture model. Such a model will be capable to discriminate among the different kinds of fuel present in the area of study, taking also into account the soil moisture dynamics. The information needed as input for modeling the dead fuel moisture dynamics is that related to the meteorological local variables (forecasted and observed), the fuel characteristics (kind, loading, bed depth, heath content, and moisture of extinction), and the topographical and pedological data. The validation of the model and the calibration of some parameter set will be carried out by means of some sample campaign and, overall, by using suitable dedicated sensors (moisture and temperature fuel sensors) disposed *in situ* in pre-existent meteorological stations.

As it concerns the assessment of live fuel moisture conditions, it is proposed to use data coming from different EO sources. In particular, regularly updated information coming from EO medium resolution satellites will be introduced aiming at enhances the present description of morphological/physiological parameters of vegetation (presently estimated by a quasi-static model).

The dynamics relevant to fuel loads is strictly related with the seasonal meteorological conditions and with the phenological state of the vegetation that fuel can assumes. In fact, at least for the smaller classes of fuel (i.e., 1h, 10h), the state of the fuel can change from live to dead in short periods of time, modifying the fuel loads relevant to the different kind of fuel models. In order to recognize the characteristics of the fuel in the area of study and to evaluate its load in the proposed activity a specific procedure based on EO data will be implemented.

The second development research framework of WP 4240 is direct toward the assessment of the rate of spread and the potential linear intensity that a fire front could assume if ignited. To this end, specific models will be developed and implemented, whose main target is the evaluation of the wildland fire (potential) behavior in connection to the observed and forecasted meteorological and fuel moisture conditions. The information needed as input for such models is represented by the output of the previous models (dead and live fuel moisture conditions), by the meteorological local conditions provided by suitable Limited Area Model (i.e., the LAMI model), and by the topographical data of the area of study. It is worth observing that in Near-Alpine or similar regions (i.e., the Lombardy case study), very strong dry winds and long periods of absence of precipitation are quite common during winter season; such conditions represent the optimal situation for rapid spread events occurrence. In this connection, the use of very high-resolution meteorological model can improve the reliability of risk assessment. Thus, in the proposed activity it is foreseen to run a Limited Area Model at horizontal resolution of about 0.025° (2.8 km) that allows describing the near-surface motions in complex topography.

2.6.1.1. Products description (preliminary)

The system will be implemented in a MS Visual C++ procedure integrated in a pre-existing GUI in a dedicated network, and used by national civil protection services for data processing and for the visualization of information related to the other natural hazards.

The products that will be delivered within the two specific development research frameworks are respectively the following ones:

Within the Fuel characterization:

- Fuel load map

This product consists in ASCII grid files relevant to the average fuel load [kg m-2] of each different kind of fuel presents in the area of study. The map is defined over a regular grid of 100 meters side length. The map will be delivered every 15 days or less, according to the availability and the quality of information provided by EO sensors.

- Dynamic maps of fuel moisture conditions.

These products consist in ASCII grid files relevant to the moisture conditions [%] of each different kind of fuel present in the area of study. The maps will be defined over a regular grid of 100 meters side length, upon a time horizon of 72 hours discretized in 8 time intervals of 3 hours.

Within the Fire Behavior Model:

- Dynamic maps of the potential rate of spread.

This product consists in ASCII grid files relevant to the potential rate of spread [m h-1]. The map is defined over a regular grid of 100 meters side length, upon a time horizon of 72 hours discretized in 8 time intervals of 3 hours.

- Dynamic maps of the potential linear intensity.

This product consists in ASCII grid files relevant to the potential linear intensity [kW m-1]. The map is defined over a regular grid of 100 meters side cell length, upon a time horizon of 72 hours discretized in 8 time intervals of 3 hours.

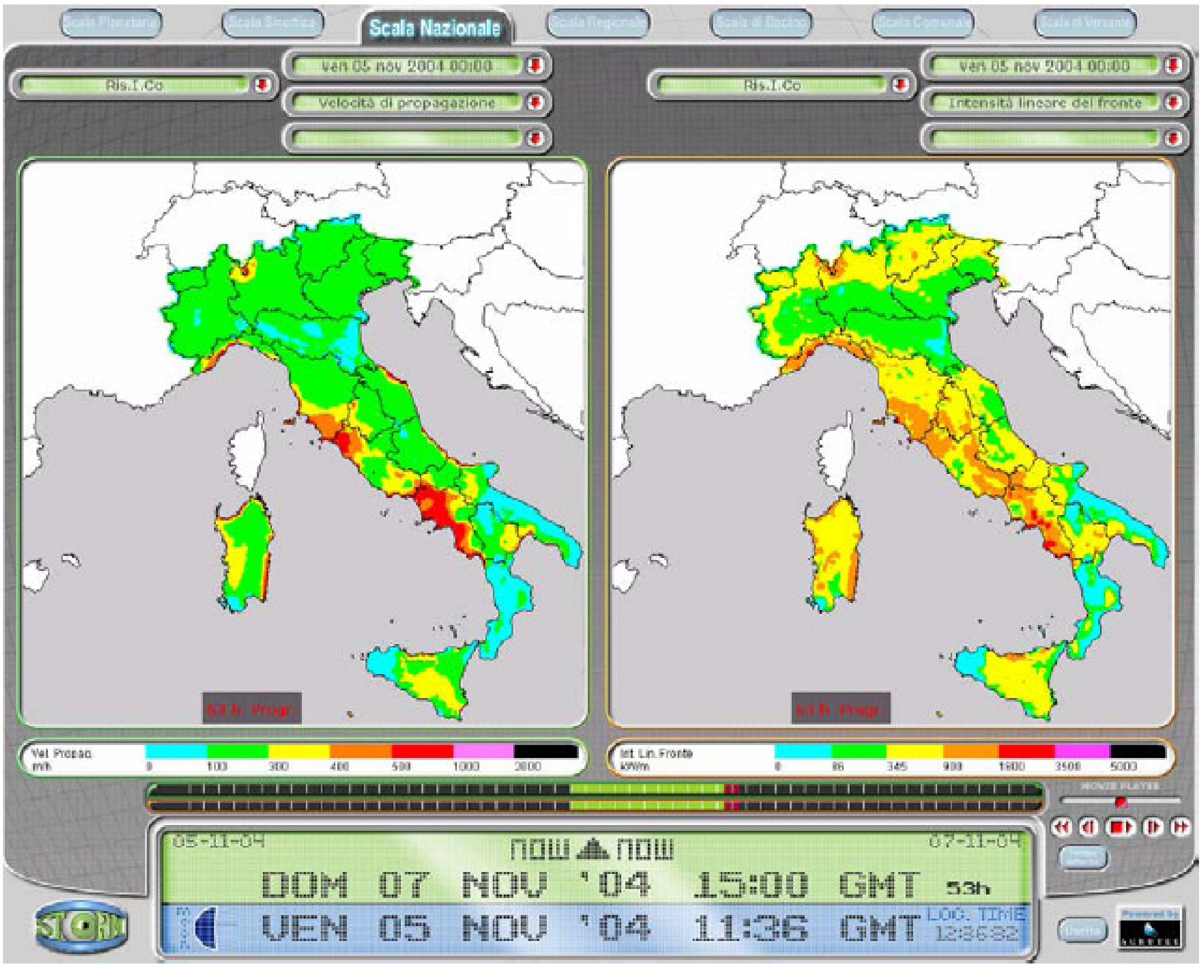


Figure 24 : Example of output of the developing Winter Fire Risk Service providing the forecast, for a certain time interval, of variables vk(t) and Ik(t). [output derived by the present RISICO System].

2.6.2. Production chain principles

The production chain will provide End User with wildland fire risk assessment, relevant to 72-hour time horizon discretized in time intervals of 3 hours, producing n=24 different fire risk index maps (see Figure 25). Daily at 6:00 AM a remote station automatically sends to the system the ASCII files elaborated by the LAM (run of 00:00 AM) and relevant to the weather forecast for the next 72 hours (3h cumulate rainfall, wind speed and direction, dew point, and air temperature). When all the data set is available the system starts its first run. Such a run uses as initial state the actual fuel moisture conditions elaborated on the basis of the last available meteorological truth data set. In fact, the local meteorological network of Regione Lombardia provides the system with a meteorological data set (3h cumulate rainfall, wind speed and direction, relative humidity, and air temperature) observed every 3 hours, and interpolated over the 100 m grid that discretized the test site area. The subsequent runs of the system are carried out using the meteorological forecasts relevant to the remaining time intervals within the original 72-h time horizon. And so on and so forth until a new set of forecasts is available (i.e., every 24 hours). The time needed for the creation of the output files is of few minutes.

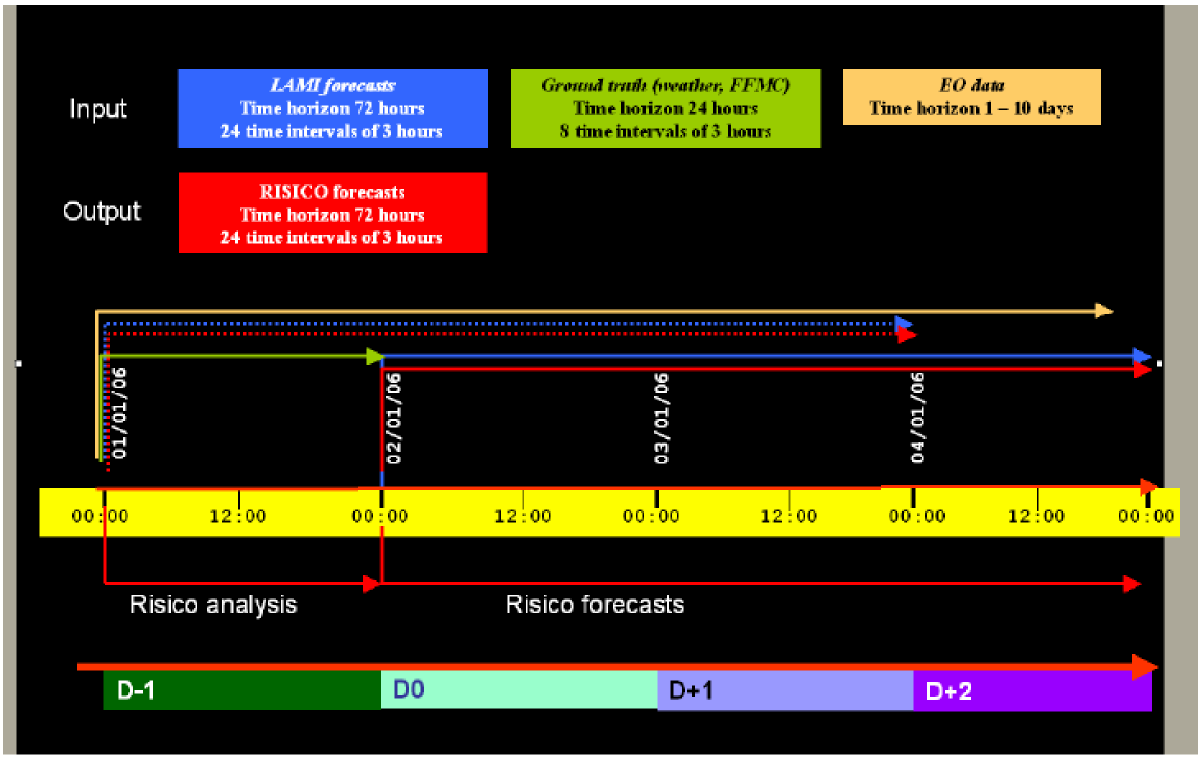


Figure 25 : Temporal production chain

A possible configuration of the Winter Fire System, described in Figure 26, envisages the software package resident and running at Provider Center, as the current system RISICO; in this case the information relevant to wildfire risk maps will be delivered by computer link from the Server to the Regional headquarters.

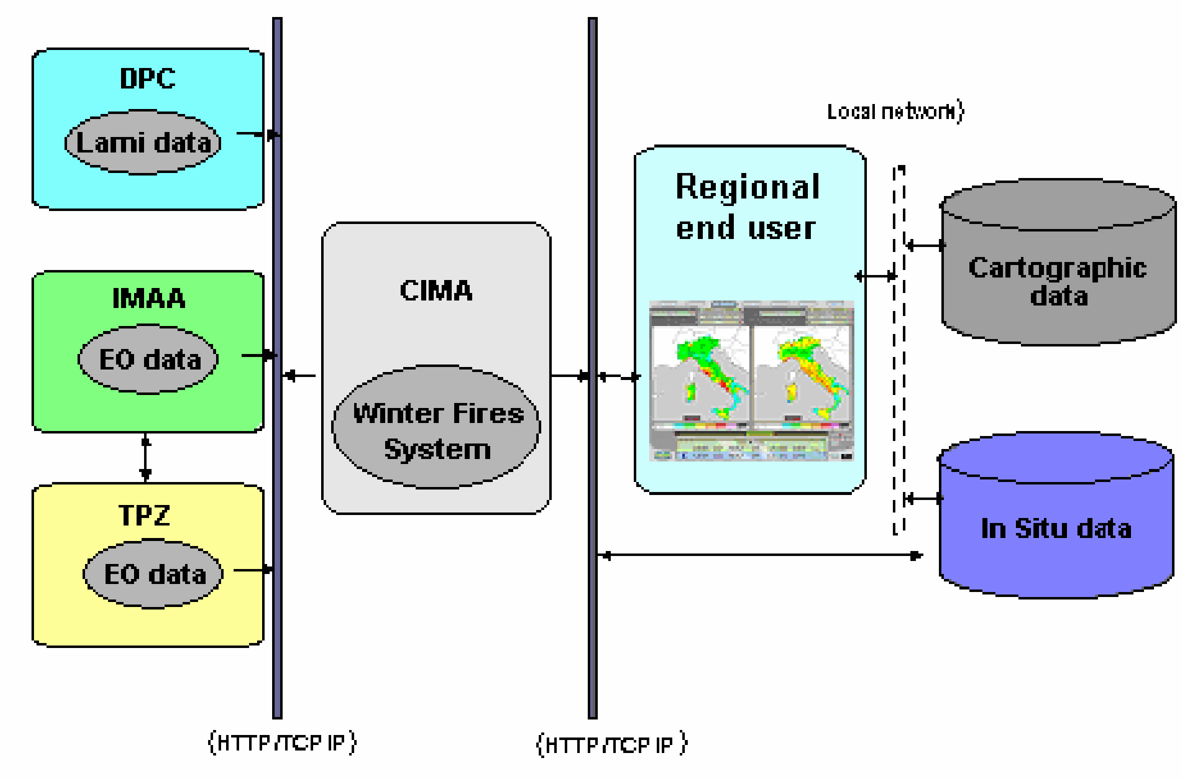


Figure 26 : Possible System Architecture.

Alternatively the System can be implemented with the Winter Fires Software package at the Client Center. This is the System Architecture required by the Italian users, as come out during the phase for the individuation of USER NEEDS. The Winter Fires System will be resident and run in a server at the RL-SOUP headquarters in Milan, and the provider CIMA, will access to the system for periodical updating and maintaining services through FTP. The Architecture being implemented is described in Figure 27.

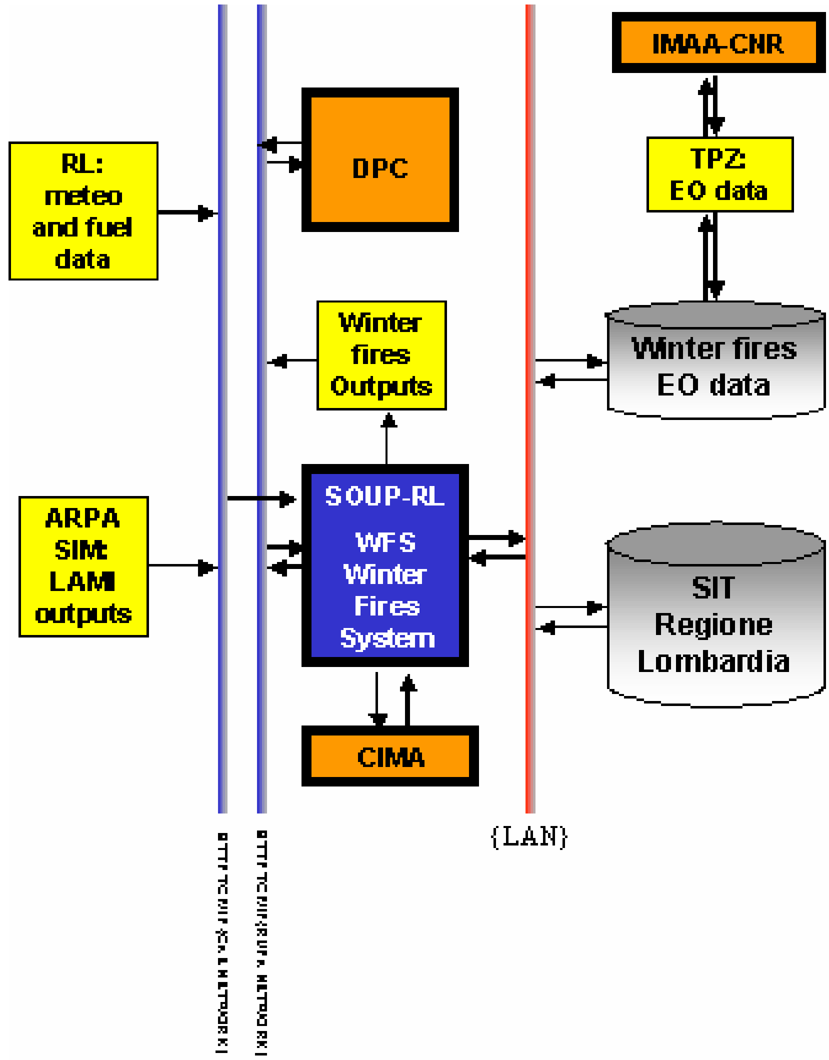


Figure 27 : The system architecture proposed by the Italian End Uses

On the basis of the information flows reported in Fig.4, and the requirements of the users the Winter Fires System will have the following configuration:

1) The software package of Winter Fires system is installed and runs on a server at **RL-SOUP** headquarters in Milan;

2) The meteorological forecasts generated by the LAMI are provided by ARPA-SIM (**DPC**) and available to download daily through dedicated HTTP TCP/IP network (CAE network);

3) The local observed meteorological data and the fuel moisture data, measured by the Meteorological Network of Regione Lombardia, are periodically (daily) downloaded into dedicated local database and, from here, reached by the system through dedicated HTTP TCP/IP network (CAE network);

4) Topography and vegetation cover data are resident into local database (**Regione Lombardia SIT Servizio Informativo Territoriale**) and available for the system through Local Area Network;

5) Earth Observation data, relevant to winter fires phenomenon, are processed by procedures defined by IMAA-CNR and TPZ, are inserted into dedicated database via FTP protocols. This database is shared and available for the system through Local Area Network;

6) CIMA can accede to the system for periodical updating and maintaining services through FTP;

7) The outputs of the Winter Fires system are available for DPC through dedicated HTTP TCP/IP network (RUPA network).

2.6.3. Deployment principles, delivery process

As described in § 2.6.2, the products will be elaborated by the system, directly at the RL-SOUP headquarter, final end user.

2.6.4. Methodology, algorithms, models used

Following reasoning lines similar to those introduced by the developers of the Canadian Forest Fire Danger Rating System and United States' National Fire Danger Rating System, the general architecture of a system designed in order to assess the dynamic wildfire risk distribution could be represented as in Figure 28. Different modules compose such a system, each of which represents a specific model. First, it is necessary to represent the dynamics relevant to the state variables associated with the fuel load, over the considered territory, as well as those related to the fuel moisture. In general, such dynamics refer to different fuel typologies (at least, dead and live fuel must be distinguished). Then, the potential fire spread model has to be considered in order to quantitatively describe the potential behaviour of a wildfire front, in absence of any extinguishing action. Such a model is not used to obtain a forecast of the propagation process of a specific ignited fire, but only to evaluate the risk of spread after a possible ignition.

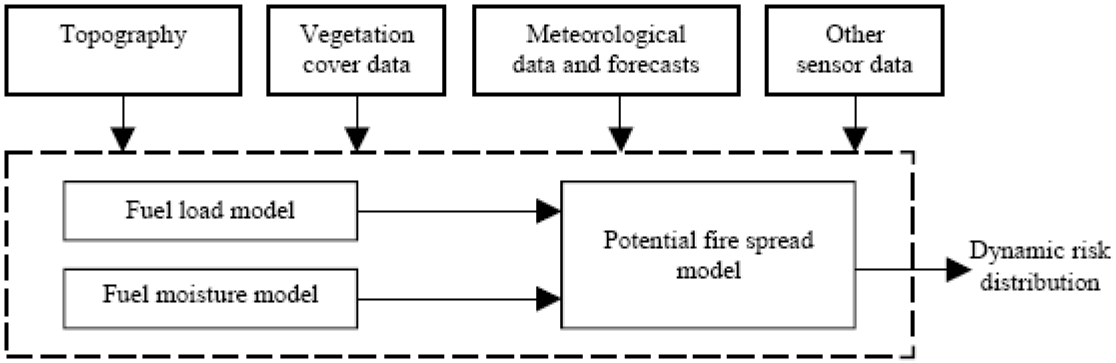


Figure 28 : A schematic representation of the structure of a system designed

The information that feeds the various modules represented in Fig.5, is partly static and partly dynamic. The first are related to topography, land use/vegetation cover data, which can be obtained from a data set stored in a Geographical Information System (GIS). As regards the dynamic information entering the system, it consists of meteorological data (provided by a network of ground sensors, such as rain gauges, anemometers, fuel sticks sensors, etc.), and of meteorological forecasts (provided by a fine scale meteorological model), over a time horizon of suitable length. Besides, data coming from other sensors (ground or satellite based) are available.

A suitable choice of the variables used to represent the wildland fire dynamic risk is that of using the rate of spread and the linear intensity that a fire could assume in case of a successful ignition of the available fuel.

The conceptual scheme depicted in Figure 28, is quite general and may constitute the basis for the development of different schemes for the assessment of wildland fire risk. What such schemes are different in may be related to the definition of fuel classes and characteristics, to the mathematical structure of the models appearing in the figure, and to the values of the parameters of such models. WP 4240 refers to the existent Italian state of the art, that is the system RISICO (RISchio Incendi e

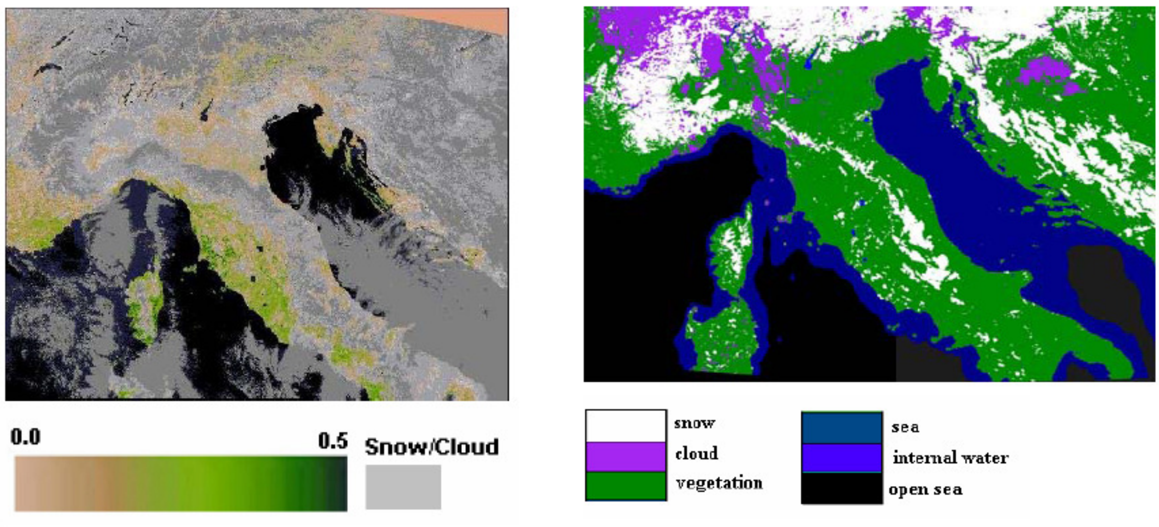
COordinamento), developed and designed by the CIMA and whose main goal is the assessment, at national level, of forest fire dynamic hazard.

In particular, the aim of WP 4240 is to upgrade the present RISICO system providing additional dynamic inputs with upgraded products derived by EO and other sensors. Such data will provide the system with more detailed and reliable information.
The use of satellite remote sensing is considered, more and more, very effective for fire susceptibility estimation given that a number of factors involved (land cover, vegetation condition) may be derived, at least partially, from satellite data. The Remote Sensing data can provide valuable information for the characterization of the state of vegetation, mapping of fuel types and vegetation properties at different temporal and spatial scales including the global, regional and landscape levels. The characterization of fuel types and status is very important for computing spatial fire hazard and risk and simulating fire growth and intensity across a landscape. Evaluations of changes occurring in moisture content and proneness of vegetation to fire will be performed using MODIS data. Concerning this purpose many vegetation indices such as NDVI (Normalized Difference Vegetation Index), NDWI (Normalized Difference Water Index), MSI (Moisture Stress Index), GVMI (Global Vegetation Moisture Index), LWCI (Leaf Water Content Index) will be analyzed.

However, due to the complex nature of fuel characteristic, a fuel map is considered to be one of the most difficult thematic layers to build up. The advent of sensors with increased spatial resolution may improve the accuracy and reduce the cost of fuels mapping. For this purpose, some High Resolution satellite data, like ASTER (*Advanced Spaceborne Thermal Emission and Reflection radiometer*) will be analyzed to ascertain how well such satellite data can provide an exhaustive classification of fuel properties.
Two different approaches will be adopted for fuel type mapping: the well-established hard classification techniques and spectral mixture analysis. Fieldwork fuel type

recognition, performed nearly simultaneous to remote sensing data acquisitions, will be used to assess the results obtained from remotely sensed data.

The following figure (Figure 29) shows some examples of the EO products that could be used in the Winter Fire Risk System.



a) NDVI map – MODIS acquired in 2005-03-02 b) SNOW COVER map - MODIS acq. in 2001-01-01

Figure 29 : Examples of EO products derived by MODIS data will integrate the Input data of the Winter Fires System: a) map of the vegetation index NDVI, b) map of SNOW Cover.

Another upgrade of the system that will be implemented is the use of the outputs of a 0.025° Lokal Modell – LAMI Limited Area Model instead of those previously used corresponding to 0.05° degrees.

2.6.5. Inputs requested and providers

The required data for the service activities are the following ones:

2.6.5.1. At Production level

- Digital Terrain Model; aspect angle [rad], slope [%], and elevation [m] files; ASCII grid format 20 meters side cell (provider Regione Lombardia);
- Pedological Map; soil characteristics and depth of each different layers; 1:50.000 scale, vectorial (shape) format (provider Regione Lombardia);

- Land use thematic map (Regione Lombardia DUSAF map) 1:10.000 scale vectorial (shape) format (provider Regione Lombardia);
- Custom Fuel Model File; kind of fuel, loading [kg m^{-2}], bed depth [m], heath content [kJ kg^{-1}], and moisture of extinction [%] files. Text format (provider CIMA).
- Meteorological fields files Limited Area Model LAMI outputs. Cumulated rainfall [m], air temperature [K], dew point temperature [K], wind speed [m s^{-1}], and wind direction [rad] files; ASCII grid format, discretized in time steps of 3 hours over a time horizon of 72 hours, and defined over a regular grid of 0.025° side cells (provider DPC).
- Local weather observed conditions. Cumulated rainfall [m], Cumulated snowfall [m], air temperature [K], relative humidity [K], wind speed [m s^{-1}], and wind direction [rad] (provider Regione Lombardia).
- Fuel stick data. Moisture conditions [%] and temperature [K] of fuel stick sensors (provider Regione Lombardia).
- EO products generated by medium resolution satellite data like MODIS, SPOT Vegetation. [such as EO maps relevant to state of vegetation, live fuel moisture conditions assessment, live and dead fuel load assessment, and EO products relevant to meteorological observations such as Snow Cover maps, etc.] The availability of good quality data in winter can be limited by the presence of clouds, in such cases the problem can be resolved using few days synthesis products.

2.6.5.2. At users level

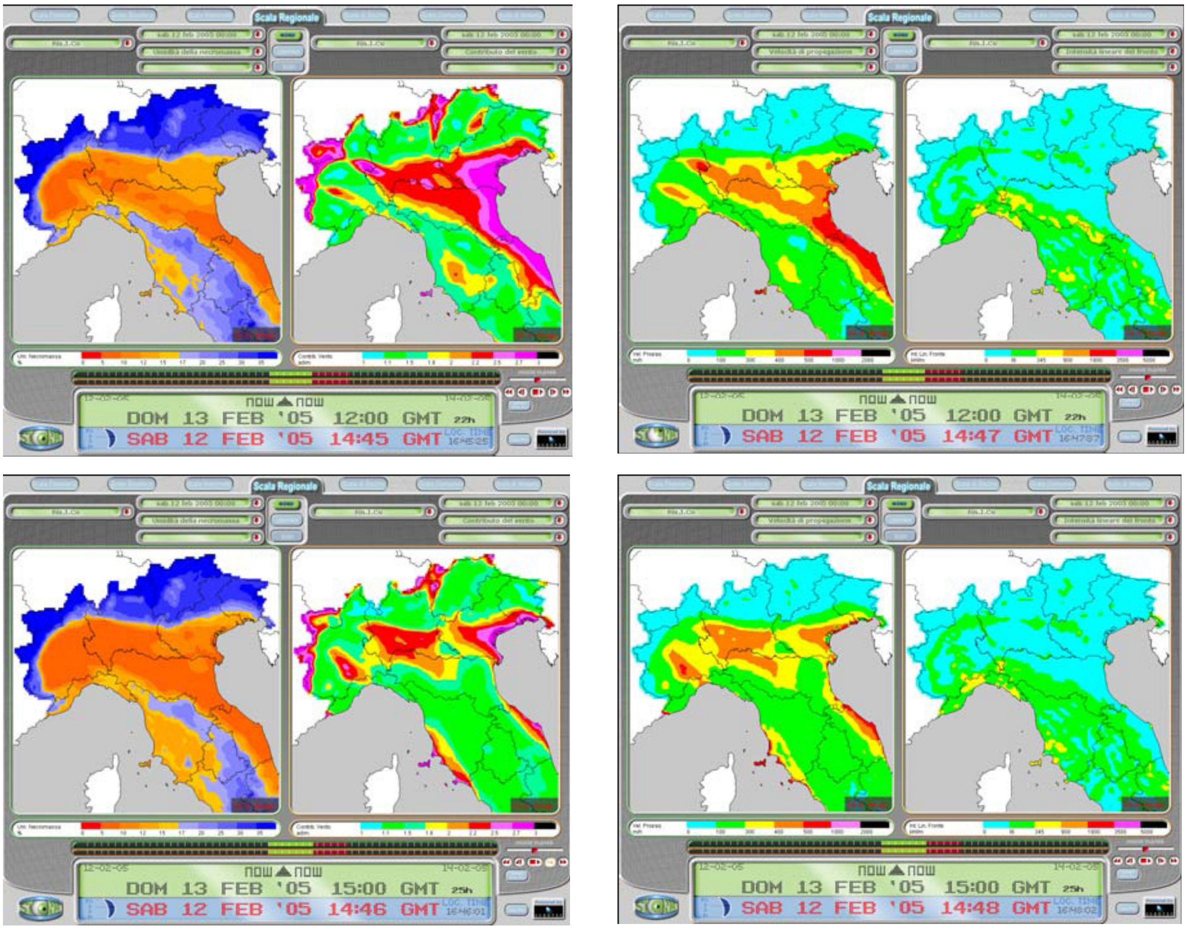
- Regional Technical Map of the area of study, vectorial (shape) format and raster format, scale 1:10.000 (provider Regione Lombardia); Digital colored ortophotography of the area of study (provider Regione Lombardia).
- Meteorological data from the meteo stations

2.6.6. Skills required to use the products/services

Capability to manage a GIS environment is required.

2.6.7. Example of illustrations

In the following figure (Figure 30) is proposed an example of the output elaborated by the present RISICO system, similar to the output deriving from the upgrading of the system for Winter Fires Service.



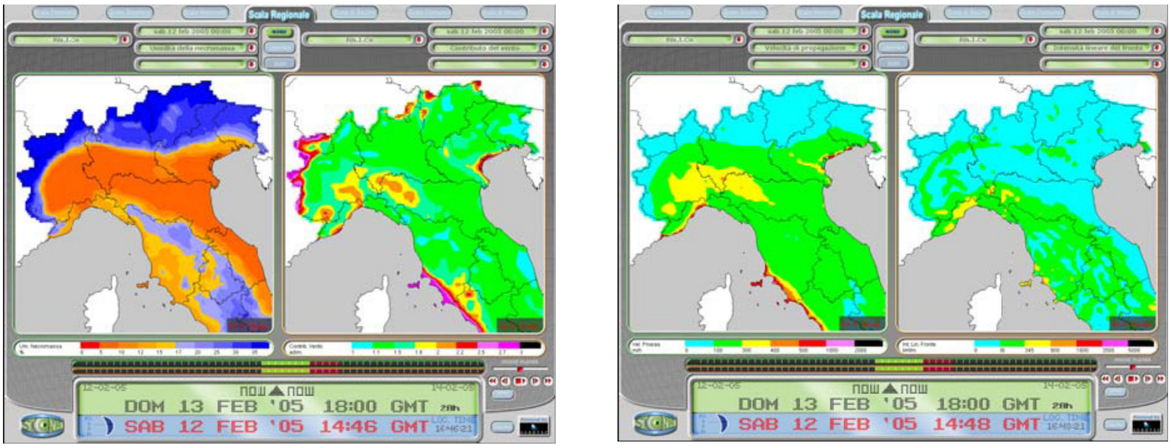


Figure 30 : Examples of outputs will be delivered by the Winter Fires Risk System. Forecasts produced on 12th February 2005 for the next day. Each column represents the dynamic from 12:00 to 18:00 of 4 different outputs. From left to right: a) dead fine fuel moisture condition, b) wind speed contribution to fire Spread, c) potential rate of spread, d) potential linear intensity. [Output derived by the present Risico system].

2.6.8. Users

The users of the proposed service are the national and regional authorities in charge of the Protection of Forests by Fires events, dealing with both the prevention activity and the emergency management.

In Italy the Users are:

- at national at national level the Dipartimento della Protezione Civile
- at local level the concerned Regional authorities

Within the Preview Project the End Users involved are the **Dipartimento di Protezione Civile** (DPC) and the **Sala Operativa Unificata Permanente** of **Regione Lombardia** (RL-SOUP).

The Dipartimento della Protezione Civile (DPC) is a division of the Italian Presidency of Ministry Council, and represents the national authority in charge of civil protection activity. Its fields of interest are planning, prevention and management of every kind of risk all over the national territory. It **plays the role of addressing and coordination** of all the forces operating on Italian territory and is in charge of

guideline issues, procedural and operational standards. The DPC has a primary political role with established rules and guidelines for risk
prevention plans, risk prediction, preparation and management of emergency plans. It therefore covers all the intervention phases of prevention, forecasting, crisis and post-crisis for natural, environmental and industrial risks (e.g. Hydrogeological risks, forest fires, industrial accidents, etc.)

*The **Sala Operativa Unificata Permanente** (SOUP) of **Regione Lombardia** (RL), participates, at regional level, in the organization and implementation of civil protection activities: prevision, prevention, relief, early rehabilitation.*

The National Warning System is provided by Department of Civil Protection and Regions's authorities through the national network of **Centri Funzionali**, which are the operative support units, in charge of collecting, elaborating and exchanging every kind of data and which provide support for decisions taken by the Department of Civil Protection. The *Centri Funzionali* are related to local authorities and to the *Centri di Competenza* involved in risk management.

2.6.9. Users benefits

The proposed activities will provide service supporting the decision-making of end users: Regione Lombardia and Department of Civil Protection, customizing the fire support product RISICO to the user working during winter fire season.

The benefits will be in the:

- *preventive phase where* means and personnel may be re-allocate on the basis of the forecast risk maps, in order to successfully fight initially spread fires
- *real-time phase* to determine the optimal composition of means that are sent to the outbreak fires.

IV. CONCLUSION

These use-cases are representative of the civil protection operations in terms of forecasting. These two use-cases show the overlap of the services dedicated to civil protection aspects. As presented here, monitoring and warning systems seem to be good candidates to consider the use of the Grid technology within civil protection, and to study requirements.

One of the interests of this study relates to the complementarities between the two use-cases, even if it would have been interesting to widen this study with other types of risks. Flash floods and forests fires reveal a need for real-time calculations, computational power and remote data sharing. The Italian use-case is interested in an application and its technical specifications, conferring a technical approach, whereas the French use-case is based on a virtual organization philosophy, with interrelationships among specialized services conferring a more conceptual approach. The whole of these ideas will be developed in detail in Deliverable D11.

The precise analysis of Italian and French existing systems shows a complex technical organization which requires strong informatics competences to consider a porting on a Grid technology.
For the French case, tools and applications used were developed mainly by private companies. These companies hold the source codes and the technical knowledge of their implementation, necessary to a recodage on a Grid infrastructure.
For the Italian application, the code being developed by a public organization in close cooperation with Italian civil protection, the portability should be “easier”.

One of the common points of these two systems is their spatial orientation and a strong requirement for remote spatial resources sharing, thematic in full rise in the field of civil protection. This technology is well controlled today with Internet and Webmapping, but its integration within a Grid infrastructure is still not defined. Within the use-cases described previously, some indicators encourage to propose future research in this direction. For the French use-case, the described service is in period of reorganization, relating to the passage from floods announcement service to floods warning service. In addition, the two presented use-cases propose significant requirements for traditional and geospatial data sharing among geographically distant organizations.

One of the significant points in the description of these use-cases is the strong requirement for improvement. The low technical and human constraints enounced by the services allow considering a phase of effective and productive prototyping.

The study of the existing systems being henceforth established, the inventory of the requirements for civil protection of the next deliverable (D11) will be drawn up by considering the desired organisational and technical improvements within these services of civil protection.

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