Track : Information Science

Title : FireCaster Project

Jean-Baptiste FILIPPI, YolandaPEREZ-FINIDORI
UMR CNRS 6134 SPE, University of Corsica, Corte, France

Résumé en Français:

Le développement de services opérationnels dédiés aux risques naturels est l'un des objectifs de cet appel à projets ANR. Dans le cadre d'un précédent projet déjà porté par le SPE, IDEA (2010-2013) Incendies De forêts, des Émissions au transfert Atmosphérique, jugé « phare » par l'ANR, plusieurs démonstrateurs dédiés au risque incendie ont été développés (méthodes, codes, services) en s'appuyant sur les avancées technologiques récentes dans le domaine de la météorologie, l'assimilation de données, la modélisation incendie et le calcul intensif. Ces outils n'ont toutefois été testés et partiellement validés que sur des cas d'étude ponctuels pour des périodes de temps limitées. Le but du projet FireCaster est le passage à l'échelle nationale de ces outils par la réalisation d'une plate-forme web permettant d'estimer le risque incendie à venir (h+24, h+48) et (2) la simulation en cas de crise, disponible partout, tout le temps, pour prévoir position des flammes et pollution si un incendie se déclare. Le projet nécessite pour cela des actions de recherche fondamentales portant sur la généralisation et le passage à l'échelle des méthodes.

Le principal défi est ici de pouvoir disposer de ces diagnostics immédiatement sur un territoire et à une date donnée. Il nécessite de lever un verrou conséquent : l'accès à des données et modèles de combustible à haute résolution. Afin de caractériser ces combustibles et la pollution potentielle, il est prévu l'utilisation de nouveaux atlas de végétation mais aussi la pollution résultante de la combustion (LA, SPE). Ces modèles seront ensuite généralisés sur le territoire, non par le développement de codes spécifiques, mais, pour la première fois, par intégration avec les modèles de surface, qui régissent les échanges d'énergie et le cycle de l'eau et dont résolution et précision ont été récemment grandement améliorées (modèle opérationnel SURFEX, développé par le CNRM).

L'approche probabiliste, basée sur des ensembles de simulations perturbées déjà a bordées avec INRIA afin de déterminer la taille potentielle des incendies, est privilégiée pour l'évaluation du risque. Elle permettra le développement d'un type de diagnostic (taille du feu) en rupture avec l'existant (potentiel d'allumage).

Les outils de lutte, développés en licence libre, permettront d'estimer les bénéfices et risques de chaque scénario d'intervention imaginé par les centres de commandement de crise ainsi que l'impact des panaches incendies sur l'exposition des pompiers et des populations. Des cartes de probabilité d'impact montrant les zones de forte présomption de passage du feu seront calculées par simulation d'ensemble tout en prenant en compte de manière interactive l'action de lutte. Un modèle de crise déterministe, plus complet, utilisera les prises de vues aériennes et les images infra-rouge satellitaires, diminuant ainsi les incertitudes sur les prévisions de surface brûlée et d'intensité du feu par assimilation de données (CECI). Ces simulations couplées au modèle météorologique Méso-NH prédiront la pollution induite par les panaches et la

micro-météorologie locale. Enfin, afin de relier risques et modèles de crise à des indicateurs innovants, les simulations seront éclairées par des indices économiques, humains et environnementaux développés par le laboratoire LISA (économie) .

Au niveau national, cette mission de service public est déléguée à Météo-France qui supervise le projet et s'ent engagé à évaluer les produits au sein d'un comité de pilotage aussi composé de l'European Forest Fire Information System (JRC), des services incendies de Corse et du service Risques du CNES. Si le succès du projet requiert une application d'abord nationale, il existe un potentiel européen et à l'export par des PME françaises qui ont déjà fait part de leur intérêt sur l'approche "simulation à la demande" et à l'accompagnement proposé par SafeCluster (anciennement pôle risque).

Summary :

The development of operational services dedicated to mitigate natural and anthropogenic risks is one of the objectives of this ANR call. In the frame of a previous project already led by SPE lab, IDEA (2010-2013 Forest-Fires, from combustion Emissions to Atmospheric transport), considered as a highlighted project by the ANR, several demonstrators dedicated to wildfire risk were developed (codes, approaches, services), aiming at proposing a new generation fire decision support system. Available thanks to recent technological advances in the field of meteorology, data assimilation, fire modeling and supercomputing these tools have only been tested and partially validated on a limited amount of case studies and over limited time periods. The goal of the FireCaster project is to extent the approaches at the national scale by prototyping a platform that allows to estimate upcoming fire risk (H+24 to H+48) and in case of crisis, to predict fire front position and local pollution (H+1 to H+12).

The main challenge is here to deliver these new diagnostics immediately for any given territory and at any given forecast date. It requires to overcome a key issue: access to high resolution (50m) fuel models and data. In order to characterize these fuels and potential pollution products, it is planned to use new vegetation atlas and study smoke emissions for various fuel types and states of fuel.

These models will then be generalized to the whole French territory, not by developing specific codes, but for the first time by linking them to surface models, which simulate energy exchanges and water cycle in meteorological models. Surface models recently had a strong increase in resolution and accuracy that makes this link possible (SURFEX model -CNRM- operational).

In terms of risk, we propose a probabilistic approach, based on large sets of perturbed multi-model simulations (INRIA), to determine the distribution of potential fire sizes. This approach will provide a new diagnostic (fire burnt area) very different from the current indicator (risk of fire ignition with no indication on the potential size).

Fire fighting tools should help to estimate the benefits and risks of each intervention scenario as planned by crisis management centres. They should also evaluate the impact of fires on air pollution and smoke for fire-fighters and population alert.

Probability impact maps for each fire fighting scenario, showing areas where the passage of fire is highly expectable, will be obtained by ensemble simulations, taking into account interactively fire-fighting actions. Another, deterministic and more detailed

coupled Fire/Meso-NH atmospheric crisis model will determine front position, smoke pollution and local micro-meteorology with data assimilation of aerial/spaceborne observation of fire contours; it will be implemented (CECI) to reduce the uncertainty of these deterministic predictions. Eventually, in order to link the resulting computations to innovative indicators, economic, human and environmental costs will be evaluated (LISA).

At the national French level, Météo-France, responsible for this public service mission, will supervise and test the project and evaluate the products within a steering committee also composed of the European Forest Fire Information System (JRC), the National Forestry Services (ONF), the French government space agency (CNES) and Corsican fire brigades (to test crisis tools). While the project success first requires a successful application at national scale, there exists a strong potential of development at the European level. All codes will be Open-Science with French SMEs interested in selling the knowledge required to apply the platform to other countries or areas in the frame of SAFE Cluster (former Pôle Risques).

Project Goals

The goal of the FireCaster project is to develop a prototype of Wildfire Decision Support System based on state-of-the-art methods and computing resources, which will provide new ways to forecast fire danger and estimate fire impact of an ongoing crisis for operational agencies.

Although this goal is ambitious, the feasibility of FireCaster project is high, with partners and code demonstrations partly available from the previous project IDEA: Large wildfire simulation, from the flames to the atmosphere. The IDEA project focused on developing methods on specific cases. FireCaster aims to run and validate these approaches anytime, anywhere. Developing such a decision support system strongly requires further research to be generalized and scaled at a national level. In particular, the current developments of data assimilation, high resolution fuel models, combustion products and ensemble simulations are only available on complex case-by-case analysis. Such platfoms requires two parts, risk prediction and disaster management:

Risk prediction will be performed by developing innovative next-day risk assessment, using high resolution coupled surface-fuel model, Monte Carlo mass ensemble simulation of fire size and associated economic impact.

Risk assessment based on fire size is a highly innovative approach compared to the current burn probability which is not a direct indicator of fire consequence. The contribution of economists partners, in an interdisciplinary framework, is essential to translate the simulations into understandable products for risk assessment. This kind of approach, based on Monte Carlo simulations, is only available since the recent availability of supercomputers. The approach will be ready by year two and evaluated by the operational services of Météo-France (south-east and south-west fire weather forecasters).

The crisis, disaster management integrated platform will enable, in case of a declared fire, to forecast H+1 to H+12 fire-front position (with observation assimilation), burn probabilities (ensemble forecast), high resolution plume composition, fire meteorological effects and to calculate the efficiency of fighting scenarios with the cost of the wildfire.

These crisis models will perform on-demand simulation in case of verified alert (ignition reported) with initial data av ailable for anytime, anywhere on the national/European territory.

The main challenge is here to deliver these new diagnostics immediately on a given territory and at a given forecast date. It requires to overcome a major issue: access to high-resolution (50 m) fuel models and data. In order to characterize these fuels and the potential pollution products, Better knowledge on hazardous air pollutants from open vegetation fires is mandatory and requires field observations of gas and aerosols in the vicinity of the fire. The models will then have to be generalized to the whole French territory, not by developing specific codes, but for the first time by linking them to a surface models, which simulate energy exchanges and water cycle in meteorological models. Surface models recently benefited from a strong increase in resolution and precision, which makes this link possible (SURFEX operational model, CNRM) but is yet to be made.

FireCaster must also propose innovative indicators in order to link simulations to economic, human and environmental costing, which is a critical transdisciplinary research not performed at this scale before.

It is important to note that both aspects must be developed in the same project as it will ensure that shared components (fuel model, cost functions, ensembles) are designed (parameters, software) for both applications with no subsequent needs to develop complex transformation components.

Program

The project is decomposed in four tasks: three scientific tasks and one devoted to coordination, valorization and integration. Coordination/Valorisation (task 0) will be handled by SPE with the support of all partners and the steering committee.

Tasks 1 (Fuel) corresponds to the research that must be developed in order to have consistent and relevant input data and models. Tasks 2 (Crisis) and 3 (Risk) correspond to the research efforts that are required to deliver the methods for the two objectives of the project.

0) Coordination task is under the responsibility of the coordinator and SPE lab. During the duration of the project, these tasks will ensure that all codes are compatible and well integrated in a platform/server. SPE is also in charge of the web and software developments and of the administration of the server. The communication actions (essentially with web products) are also planned in this task. In addition to the programming work, task 0 is also responsible for organizing general meetings with the steering committee and delivering reports. The end of each coordination task corresponds to the four project milestones, year 1: Set-up and complete technical specifications; year 2: First platform put to test ; year 3: Platform with all features available ; year 4: Platform validated and released.

1) Fuel: The provision of up-to-date high resolution data of fuel distribution, characterization and state (water content, load,...) is crucial. The work is decomposed in three actions: firstly (CNRM), matching parameters and developing a supersampling method; and secondly (CNRM/SPE), performing a reanalysis of fire/weather conditions to validate the approach at the national scale. 18 months of PostDoc are required in this task.

The third action (LA/SPE) consists in verifying and scaling the models to the field by performing gas sampling on experimental burns.

2) Crisis. Fire-fighting tools must help to predict fire future behaviour (deterministic) and perform estimates for probabilities/benefits balance of fighting scenarios. The work is decomposed in three actions. The first action (Inria) will focus on developing ensemble methods to compute fire burn probabilities (3 year of PhD). The second action (CECI/SPE/CNRM) is devoted to incorporate data assimilation methods to reduce uncertainties and use aerial and spaceborne fire front observations. Action 3 (LA/SPE) is devoted to the implementation of the smoke emission models and the application of the coupled fire/smoke/atmosphere code in an "on-demand" toolchain.
3) Risk. This task is devoted to develop fire risk forecast. Mass simulation approaches based on large ensembles of perturbed forecasts will be developed by INRIA/SPE (Action 1) with 2 years of PhD devoted. Action 2 coordinated by LISA/SPE/INRIA will provide a sensible meaning to those results by associating a potential economical cost to each of these fire simulations.

The consortium of the FireCaster project originates from the ANR project IDEA. The specificity of this multi-disciplinary group was to bring together scientists interested in different scales of the phenomenon to build fundamental research approaches that can work at regional scale. Most of the funding requirement here is person-power, as most of the developments will be numerical. Lab equipments are already existing in LA and SPE laboratories. GENCI resources have been requested for all intensive computations that cannot be performed in labs, SPE will provide the supercomputing resource for the daily model runs.

Expected Outcomes

The targeted challenge is "efficient resource management and climate change" with development of operational tools and methods dedicated to alert and forecast natural disaster, which is one of the topics of the challenge.

Wildfire is important because it is a major actor of environmental change, with an increase in anthropogenic pressure leading to deforestation, soil erosion, pollution and global warming by emitting large quantities of

greenhouse gases. Efficient management also means being able to apply European directives; for example, the 2008 "clean air in Europe" has strong implications in wildfire practices (limiting the use of fire to reduce biomass), and forecasting smoke pollution becomes of a prime importance. Such approaches may also find applications in climate science to enhance global emission real-time models that are used in seasonal and long term forecasts. Moreover sharing fighting resources means that it is now required to define priorities on the most destructive events. Current tools are too limited for such prioritization.

This is why FireCaster proposes new insights on more appropriate cost estimates and scenario evaluation. As suggested by the call, actors from the civil society are associated to the project, firefighters being here testers of the platform, and Météo-France, in charge of the official fire-weather assessment, is involved in the steering committee, in accordance with the National Civil Security.

Future potential valorisation of the platform is expected as follow: 1) National french services tests the system and successfully implements within the fire forecasting system. 2) Simulation web-services may be used to derive product market (education, public awareness, insurance). 3) Web and data services are expanded at the European level (enlarging the data sources). 4) Full deployment of similar platform to other area / countries will be marketed by local small companies. 5) Uniformisation of data formats and and simulation interfaces will help basic science and research to scale new approaches and pass them to an operational level.

Open community source codes and science, as well as limited dataset for verification will be provided so that most of the project tools may be enhanced with the help of the community. Up-to-now, there exists no « scientific oriented » standard open source fire front solver available for a researcher to test sub/models or parameterisations.

Finally private sector showed interest to export the technologies, and there are already contacts with some French small/medium companies. For further use outside of France, products may be developed as a simulation service, or API. These may also grow the range of products that may be sold by forecasting agencies with "on-demand simulation", a totally new product of prime interest to the insurance sector and a way to generate profit from the availability of supercomputing power.

The whole platform can also serve as a prototype for other crisis models, MesoNH/ForeFire having already been tested for eruption and lava flow, with FireCaster also planning a study on the adaptation of the platform to this phenomena with experts of the field. It is important to note that public sector assumes the consequences of natural disaster and is responsible for land management and crisis planning. FireCaster is a fundamental research project with direct application and the ambitious goal to deliver an up-to-date operational platform for national agencies.