13.4 HIGH-RESOLUTION WEATHER FORECAST FOR AN ALERTING SYSTEM IN THE ALPS AREA

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1. INTRODUCTION

In many developed countries projects about alerting system for weather and other event have been set up. For example, in the case of flood, European action NAHA (Natural Hazard) action has the specific objectives of develop and test in real time a pre-operational pan-European Flood Alert System (EFAS) based on the LISFLOOD model with 1-10 day lead-time, focusing on the Elbe and Danube river basins; evaluate of flood defense and mitigation plans for the Elbe and Danube catchments through scenario modeling of engineering, land-use change including urban expansion and climate change effects on flood risk in view of regional sustainability and environmental preventive measures; development of a framework on Sustainable Urban Development and Integrated Management of extreme events, including concepts and methods for integrated territorial management at EU, river basin and regional level, consisting in a definition of a framework for the collection of data on the urban environment and risk factors for weather driven natural hazards, and in the development of reference methods for the simulation of current and future trends in urban and regional development and their effects on weather-driven natural hazards; give a scientific and technical support towards a European approach related to droughts; map the risk an consider the effects of climate change on floods and droughts in Europe.

Motivations for that are strictly connected to the changing weather and climate. When river banks are over-topped through rising water levels, the results can be devastating. In the last decade Europe has experienced a number of unusually long-lasting rainfall events that produced severe floods, for example in the Netherlands, Belgium, France and Germany (1993, 1995), the Czech Republic, Poland and Germany (1997), in North Italy (1994, 2000), in the UK (e.g. 1998, 2000), Tisza (2000 & 2001), in the Elbe and Danube in August 2002, in summer 2005 in Romania and the northern Alpine region, and, in 2010 again in central Europe.

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The trend seems to be continuing: according to the WMO statement on the status of the global climate in 2001 (WMO, 2002) , in England and Wales the 24-months period ending in March 2001 was the wettest in the 236-year time series of precipitation. October 2000 to March 2001 precipitation was also exceptional in the Bretagne (France), where the normal annual rainfall was exceeded by 20 % to 40 % in parts of the region. A third consecutive year of severe flooding occurred in Hungary and parts of Eastern Europe in March, when the Tisza river reached its highest level in more than 100 years, the previous record was set in 1888. The worst flooding in Poland since the 1997 floods occurred in July after two weeks of heavy rain caused flooding in the Vistula river. In August 2002 devastating and costly floods in the Elbe and the Danube rivers were observed, and further extreme precipitation and flooding in southern France, where almost half of the normal annual rainfall fell in just one day.

This summary of events seems to support projections of future climate indicating that further increase in severe floods in North and Northwest Europe may be likely.

Opposite to excess of water, the summer drought of 2003 in large parts of Europe and the drought situation on the Iberian Peninsula from winter 2005 and eastern Europe in summer 2010 onwards clearly show the growing problem of droughts in Europe. There is strong scientific evidence that an increase in mean precipitation and extreme precipitation events on the one hand and water shortages for certain regions on the other hand are two sides of the same medal, implying an increased variability of climate in Europe with probably more frequent weather driven natural hazards in the future.

The necessity to develop methodologies and information systems for the prevention and prediction of weather-driven natural hazards is evidently a necessity. Together to natural hazards, human-driven risk have to be considered. In fact, in case of any chemical hazards, it is very important to forecast the pollutants paths eventually due to accidents. Also this kind of problems are clearly weather-driven.

Chemical incidents that cause fatalities, injuries, and property damage occur all too frequently. Fortunately, catastrophic incidents such as the 1984 methyl-iso-cyanate release in

Bhopal, India, are extremely rare. But the potential for disaster is always present. For example (US EPA), according to the Chemical Safety and Accident Investigation Board (CSB), for the years 1987 through 1996, an average of 60,000 chemical releases, spills, and fires occurred annually, with the 42 percent of the incidents occurred at fixed facilities. The CSB estimates that during this 10-year period, 2,565 people were killed or injured by chemical incidents.

Hazardous substances in the community present both reporting opportunities and challenges. Chemical names, quantities, locations, and health effects, as well as populations vulnerable to a release, are key story elements. Understanding the distinction between hazard and risk is also central. A hazard is something that is capable of causing harm. The bigger the hazard, the greater the capacity to cause harm (DiNardi 1997). The hazard is based on properties intrinsic to the material and the level and duration of exposure. For example, hydrofluoric acid is toxic, propane is flammable. Little can be done to change these characteristics. The severity of the hazard often depends on exposure. The extent of exposure can be influenced by the quantity of the substance released, the circumstances of the release. All this is weather dependent and a correct forecast may have a vital importance in term of mitigation and save of life.

Another aspect concerns the fire events. For example NOAA's National Weather Service provides daily fire weather forecasts, fire weather warning products, and forecasts designed to assist wildland Fire Agencies' assessment of fire danger every day of the year. NWS Weather Forecast Offices provide fire forecasts twice a day and provide warnings in close partnership with local, state and Federal fire control agencies.

Incidents of any type, along with high impact events, point toward a future of critical weather information support for the entire emergency management community. To prepare for this critical emergency support, it is important to have methodologies, tools and information systems for the prevention and prediction of weather-driven hazards and it is evidently a necessity being supported with new capability to respond not only to incidents, but to high impact environmental all-hazard events.

For all this reasons, it is important to assess the potential risks over an area, both natural and anthropogenic. So, at the end of 2008, a project named SISTEMA (which is the Italian translation of the English word system) has started. The project has been co-funded by Regione Lombardia and it is a partnership by Epson Meteo Centre, University of Milan-Bicocca, CNR-IDPA, Arianet and Informatica Ambientale. The aim was to develop an alerting system for extreme events, depending on meteorological conditions, linked to hydro-geological events (landslides, debris flows and floods) or atmospheric emissions due to an accident in the potential-risk plants. The system can be expanded to include other potentially dangerous events, like fires.

2. SHORT DESCRIPTION OF SISTEMA PROJECT

The final aim of SISTEMA is to have a system able to forecast any potential risk over the selected areas or in that sub-areas where their characteristics make them very sensible to meteorological and local conditions. This deals with a system able to consider all relevant risks connected to both natural and anthropogenic hazards.

From the debris flow, for example, the step towards an early warning system has been the conversion of meteorological and territorial information into probabilities that a landslide is started somewhere in the region at study. The main difficulty to accomplish this lies on the need to overlap physical features of the region (exposure, slope, land use,…), the so-called static parameters, with time evolving information such as meteorological data and forecast.

Once the area has been analyzed in terms of geological features and a meteorological forecast has been conducted, a final step to be covered is to build an evaluation of the probability that landslides are triggered somewhere in the region at study. It should be clear that this is a very delicate step, since here uncertainty sums to uncertainty (a forecast is built on the basis of predicted data). But an even more difficult problem comes from the data nature itself: part of the data deal with geological features, which means that, on a short time interval, these data are time independent, while part of the data, the meteorological forecast, are strongly time dependent. Both types of data are extremely important, although juxtaposing their contributions is very complicated.

To include one more problem, the computation should be quick enough to allow the people responsible for land and population safety to start countermeasures whenever needed, with the maximum advance compatible with result reliability. The solution we devised to solve the complications mentioned above was trying at first to separate different problems, to recompose results at the end.

A first step consists of working at the static parameters by means of neural networks in regression mode, trying to single out the parts of the region where the land is frail and prone to landslides. Some results are shown in Figure 1.

The second step is performed by working at the meteorological information in Time Series mode trying to connect the landslide events recorded in the past to particular meteorological conditions. For this step to be effective, it is extremely important that a long enough meteorological record, such as a few years, be available. If the data record is too short, the neural network training is not very general and the application of the best networks found during training cannot provide reliable results. For this reason, the radar data (averaged over three-hours periods) from 2005 and over 24 hours from 2001 have been used.

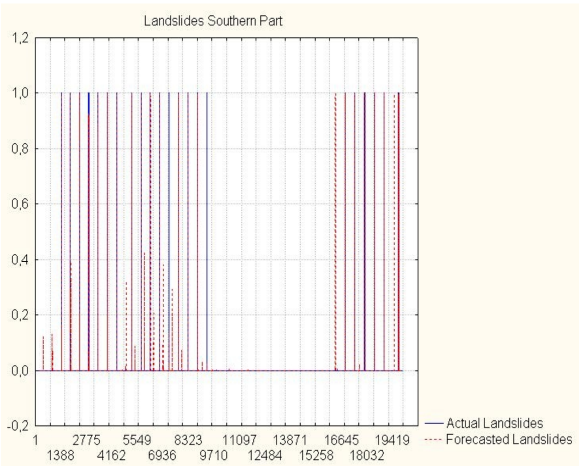

Figure 1. For a portion of the southern part of the Comunità Montana di Tirano a landslide forecast has been made on the basis of territorial parameters (exposure, curvature, lithology, slope, land use, internal relative altitude) On the horizontal axis the pixels of the portion are aligned, while on the vertical axis the probability of a landslide at that pixel is shown.

Once both types of information are dealt with, the two types of forecasting procedures should be mixed. This can be done by extracting the frail parts of the region from the land map provided by the first step and evaluating them at different time instants with the relative meteorological conditions. The data, in this case, are the juxtaposition of the historical series relative to the relevant pixels of the map of the region (typically the pixels where some landslide occurred and a small neighborhood of theirs). By neural networks in time series mode a forecast of the probability a landslide is triggered at a pixel is calculated. An example of this calculation is shown in Figure 2.

Once for each step the optimal neural network is found, its application to the new data is quick and nearly straightforward. In particular, the part dealing with geological features can be considered a given result (until some relevant change is recorded in the region); the part dealing with meteorological data can be kept running (or repeated periodically) in order for the historical series to become longer and longer; the final part locating possible landslide events on the basis of the actual meteorological conditions should be run as soon as the meteorological forecast for the day is ready.

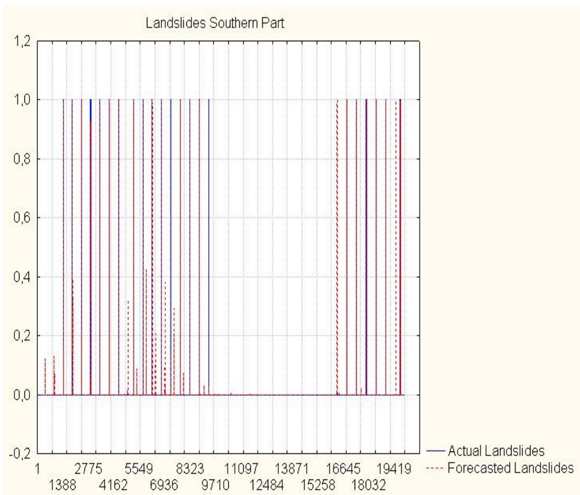

Figure 2. Eleven square areas of side 1.3 km selected from the region at study because of their frailty features. Meteorological data for those areas recorded hourly in 1983 from h.0:00, May 20 to h. 23:00, May 22.

From a different point of view, accidental release of chemicals from potentially dangerous plants is considered. All data relevant to risky plant have been inserted and cataloged: in case of any accident, it is possible to compute the transport and diffusion of the pollutants in the very short-time.

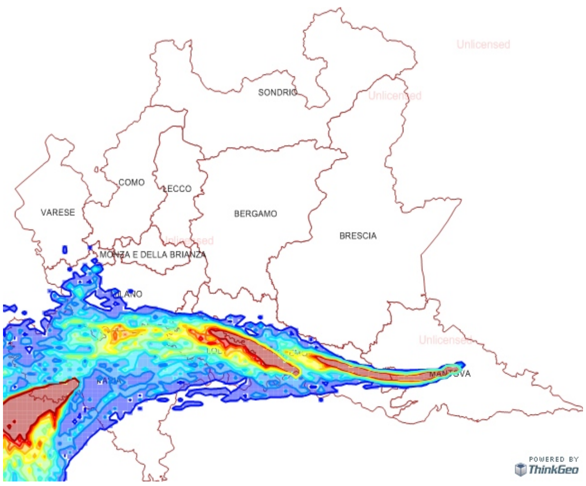

Figure 3. A simulated accidental release of chemical pollutants from three different plants in Lombardia.

At the end of the project there is the support to decision and take care of all measures for coping with disaster preparedness and response. A tool (PETer: Protection of Environment and Territory) has been targeted to the mentioned aims and it has been designed and applied within the SISTEMA project. It couples Geographical Information Systems (GIS) functions with work-flow management modules by Decision Support Systems, and communication systems by Information and Communication Technology. The final purpose is to draw up, manage, and coordinate contingency plans before, during, and after a crisis phase in an almost automatic way. That is, to define and prepare in advance people in charge to take actions, to define the activities to be performed, to be aware of available resources, to optimize the communication system among the people involved, and to exploit the transfer of knowledge. In this way, all people in decision-making roles can be efficiently linked in facing a crisis phase: crews in the field, the mobile command post and the control room, in line with enforceable regulations.
This tool meets some important requirements:

– manage the entire life-cycle of a Civil Protection Plan, in accordance with laws in force, allowing for a well-informed and organized management of data and resources, and ensuring the coordination, connectivity, and interoperability of the expected Civil Protection tasks;
– support a wide range of GIS functions, integrating alphanumeric data with cartographic data (in vector or raster format);
– provide the user with a Decision Support System, as a well-organized flow of procedures and actions (work-flows) to be sequentially executed in case of disaster, exploiting the contents of each data-set uploaded in advance (people, resources, documents, instructions, etc.);
– afford the users quick tools in the field of communication to be used by people involved in the management of an emergency situation. Technologically advanced tools are deployed in order to exploit the benefits coming from the use of mobile telephones, Personal Digital Assistants (PDA), and Tablet-PCs to share information directly in the field in the least costly and the most effective way to help save lives. The communication system allows the “actors” involved in emergency to be continuously in touch in a simple and efficient way.

The tool has been applied in a Consortium of Italian Mountain Municipalities (Valtellina di Tirano, Central Alps, Northern Italy), an area that has experienced significant losses due to natural hazards.

3. GRID DOMAINS

In the project, meteorological simulations and forecasts are made over a mesoscale domain centered on Lombardia (figure 4), which includes the central Alps region, its sub-alpine area and the Po valley. Operational forecasts are planned to be made up to 48-144 hours, depending on the domain and the resolution.

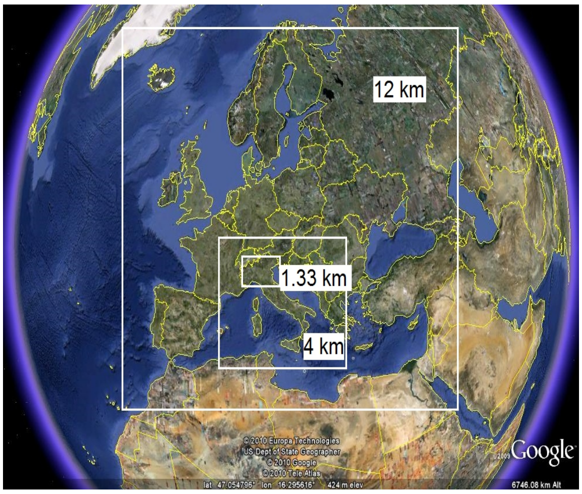

Figure 4. WRF Nested domain currently used operationally at Epson Meteo Centre.

The selected model is the WRF (Skamarock et al., 2008), which is currently used at Epson Meteo Center at different scales and resolution. Multiple-nesting have been used to simulate meteorological fields over the final domain, starting from a larger domain centered on Italy which is included in a continental-scale domain over Europe and surrounding areas. The final mesoscale domain has an horizontal resolution of 1.33 km, while the Italian domain has an horizontal grid mesh at 4 km and at the European scale domain the horizontal resolution is 12 km

Both ARW and NMM versions (the last one with greatly increased diffusion to avoid the well-known problems) have been used. In the models, explicit convection is considered at 4 and 1.33 km, KF parameterization has been used at 12 km (Kain et al., 2008). All models are run in non hydrostatic mode (Salerno, 2004).

By using 1.33 km resolution, we can completely avoid parameterization of convection that should make the simulation better. We avoided using the result of the simulation using parameterization in intermediate 4 km resolution non-hydrostatic model due to the possibility of physical inconsistency and difficulties in its justification and interpretation (Deng e Stauffer, 2006).

The same modeling chain has been used to reconstruct 57 past situations in connection with extreme events relevant to hydro-geology (debris flow, floods). These case studies cover a time period ranging from 1951 and 2009.

Initial data from all cases before 1999 have been taken by NCEP/NCAR reanalysis, while after that date the data comes from AVN-GFS initialization.

Data from the Mount Lema radar by the Swiss Meteorological Institute have being used for comparison and calibration purposes. Particularly, 3-hours accumulated radar precipitations can be used for calibration although these data have been available to us only from 2005.

4. CASE-STUDY of JULY 20th, 2008: SITUATION AND OBSERVATIONS

The analyzed case-study is an heavy precipitation event occurred on the alpine regions on the 20th of July, 2008 (figure 5).

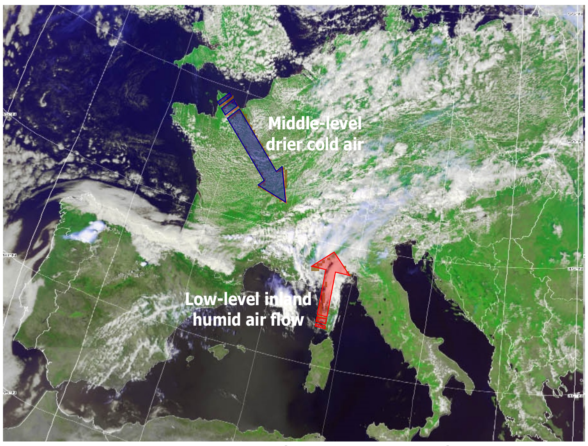

Figure 5. 20 July, 2008, from satellite. Cold, middle-level, air headed to southeast and the Alpine region. Before the crossing of cold air over the Alps, low-level humid air is pushed from the Mediterranean to North Italy. During the cold-air crossing over the Alps, low-level air entered from east in the Po Valley.

On the synoptic scale typical conditions for heavy precipitation over the north of Italy were present. A deep depression in the North Sea had formed on the 19th of July, which started to advect colder air of North Atlantic origin (Charles and Colle, 2009) southward over western Europe (fig. 6). With this structure, a cold front will move southeast reaching the northern side of the Alps, but at the same time as the cold Atlantic air will reach the Mediterranean Sea, usually in proximity of the Gulf of Biscay, a local low pressure will form in the Ligurian Sea (fig. 7).

This local depression will start to recall warmer and moist air from the Mediterranean Sea on the north-western regions of Italy (Milelli et al., 2008). The north of Italy becomes a meeting point between two air masses with different thermodynamic characteristics, which favors high instability and heavy precipitation on the Alps, on the Po Valley, on the Ligurian coasts and on the northern Apennine (Rotunno and Ferretti, 2001; Molini et al., 2009; Buzzi and Foschini, 2000). Of course every event is unique in itself.

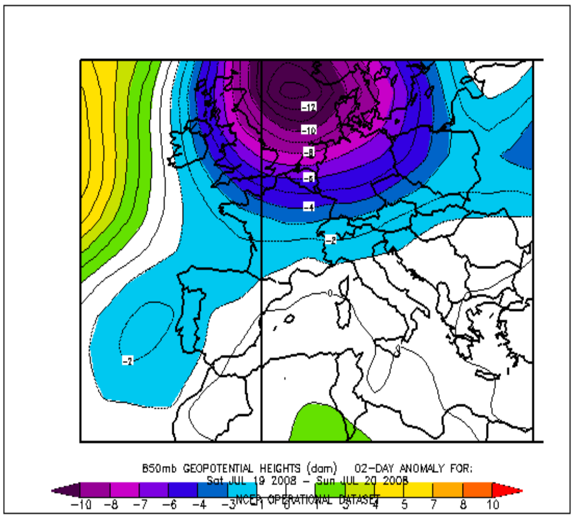

Figure 6. Geopotential anomaly two-days mean from Saturday, 19th, , 2008

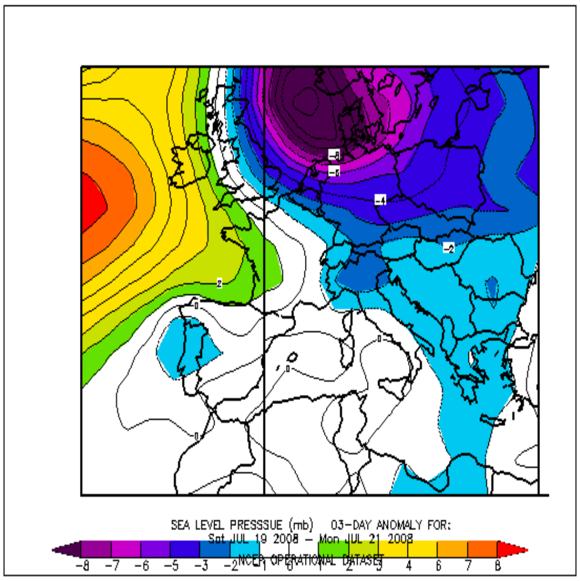

Figure 7. Sea level pressure anomaly two-days mean from 19th , 2008.

In order to have a picture of the event closest to reality as possible, we have used NCEP 2.5 X 2.5 reanalysis data, GFS and ECMWF model data analysis of the date in question, vertical soundings from Milan Linate airport, satellite images and, for a high resolution observational precipitation field, we used 1km x 1km radar data from the Swiss meteorological office (Joss et al., 1997). This precipitation field covers most of north-western Italy. (We remember that our main interest are heavy precipitation events over Lombardy, so our observational data covers the region we are focusing on).

As observed from radar data, on the 20th convective events started on Ossola (NE of Piedmont) around 9 UTC (fig. 8), in the next three hours convective precipitation extended to Lombardy's Alps and Prealps and the northern most plains of Piedmont and Lombardy.

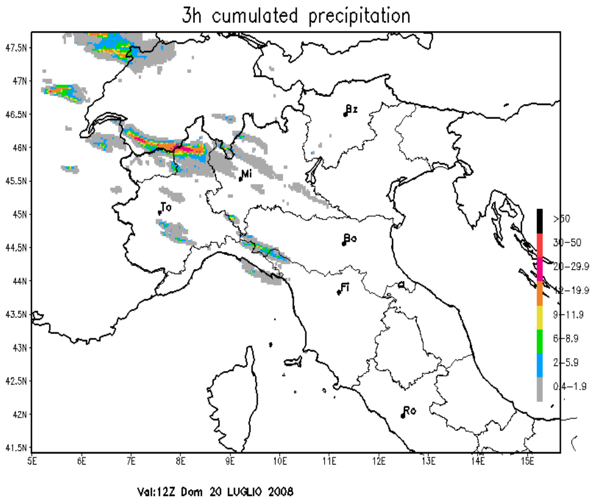

Figure 8. Accumulated precipitation from 9 to 12 UTC, July 20th , 2008, radar data.

More isolated storms also formed on the northern Apennine and surrounding coasts and plains. In the interval between 12 and 15 UTC we have the most intense precipitation over Ossola and the north of Lombardy with a mean of 40 mm/3hrs and locally spikes of 60-70 mm/3hrs (fig. 9).

In these three hours the meeting of the two air masses with different characteristics occurs, which leads to the greatest instability and the heaviest convective precipitation in the alpine and southern prealpine regions, the potential instability on the mountains was also increased by insulation, since for most of the morning hours on north-western Italy there were mostly sunny skies. In the next hours the winds pushed the precipitation westward, with some local convective events on the plains of Lombardy (fig. 10).

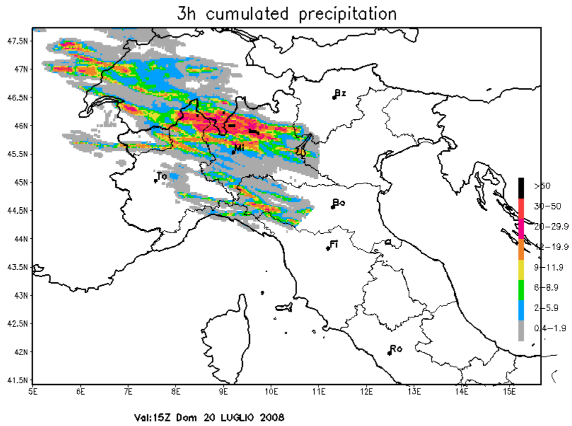

Figure 9. Accumulated precipitation from 12 to 15 UTC, July 20th , 2008, radar data

The precipitation started to decrease from 18 UTC, when only local storms occurred and widespread rain started to cease (fig. 11). The precipitation over Lombardy stopped almost everywhere by midnight.

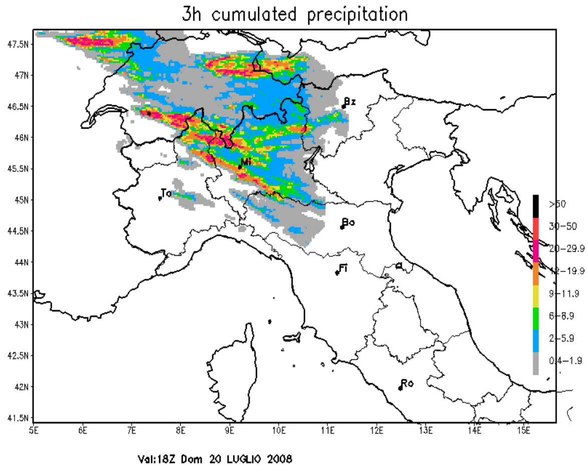

Figure 10. Accumulated precipitation from 15 to 18 UTC, July 20th , 2008, radar data

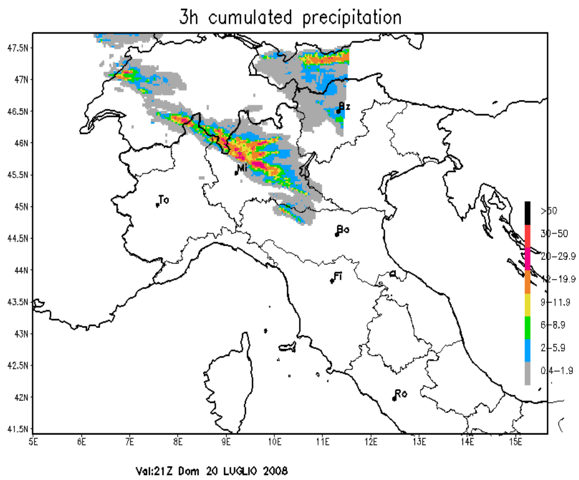

Figure 11. Accumulated precipitation from 18 to 21 UTC, July 20th , 2008, radar data

During the whole event, that lasted approximately 12 hours, several regions, from Ossola to the northwest of Lombardy, measured between 120 and 150 mm of rain.

At first look, the synoptic conditions would of lead us to believe that more widespread precipitation was to be expected over the north of Italy, while heavy and lasting precipitation occurred only over the Alps and Prealps. The main reason for this was the passage of cold fronts on the 18th and on the 19th of July that lead to precipitation over Lombardy (fig. 12), and to a negative temperature anomaly at 850 hPa over the region. (fig. 13). This severely decreased the instability, as demonstrated by the measured instability indexes, on the Po plain, that lead to the formation of few convective cells.

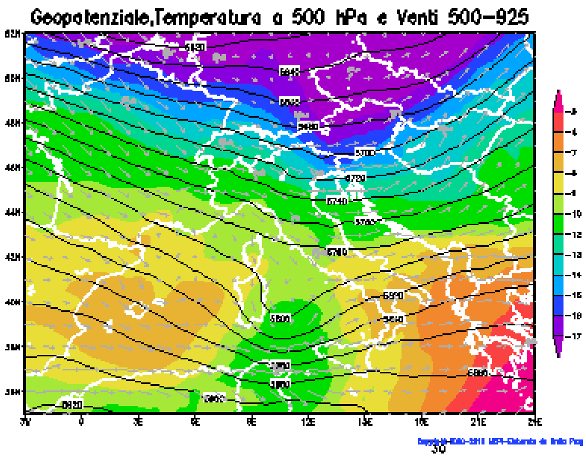

Figure 12. Geopotential and temperature field, with mean winds between 500 and 950 hPa at 12 UTC July 18th , 2008.

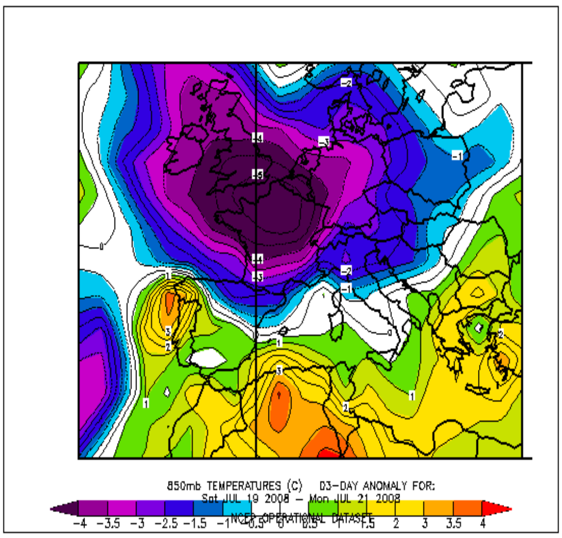

Figure 13. Three-days mean temperature anomaly at 850 hPa starting July 18th , 2008.

5. CASE-STUDY of JULY 20th, 2008: MODEL SIMULATIONS.

Several runs simulating the event were made. The models used are WRF-NMM, WRF-ARW, RSM. A detailed inter-comparison between model and observational data has been made only for WRF-NMM and WRF-ARW.

Runs are initialized at 00UTC of the 19th and of the 20th of July. Initialization and contour data is taken from the GFS model. The model is structured with a triple nesting as shown in fig. 4. The models was run with the same physical and dynamical characteristics at all three resolutions, with the exception of the cumulus scheme: for the 12km grid both the Kain-Fritsch (KF) and Betts-Miller-Janjic (BMJ) schemes have been tested, while for the 4km and 1.3 km grids convection is treated explicitly (Bryan et al., 2003; Weisman et al., 2008; Elementi et al., 2005).

One of the main aspects been investigated is the role of resolution in the forecast results, i.e. what elements of the forecasts are tied to resolution, how certain aspects of a typical scale are transmitted to a more coarse or finer grid. Another important aspect is to understand what elements of the forecast are related to the initial data.

For the run initialized on July 20th, precipitation on Piedmont and the north of Lombardy starts been generated between 9 and 12 UTC, in coherence with observation, at every scale. Bias scores (Gilleland et al., 2009; Ebert, 2009) obtained comparing model and radar data for 3 hour accumulated precipitation, from 12 to 15 UTC is shown in fig. 14.

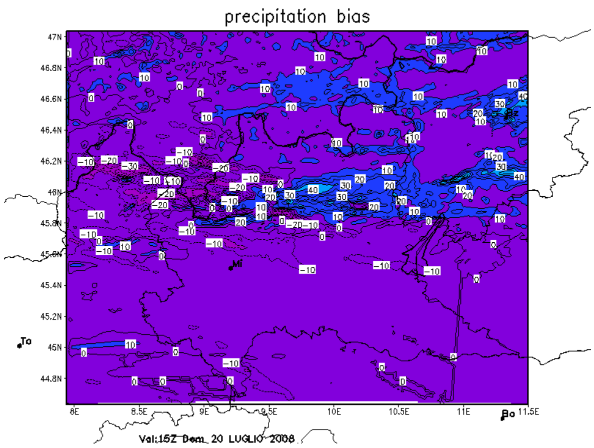

Figure 14. Precipitation bias for 3-hours accumulated precipitation starting 12 UTC July 20th, 2008.

The best scores are obtained for this period, which is the period of time, as described before, with the highest intensity of precipitation. To be noted how the model with a 4 km grid has a better and more realistic distribution of the precipitation field. Both the 12 km and the 4 km runs overestimate precipitation over the Piedmont plain, which is almost absent in reality, but the error in the 12 km grid is more widespread and also extended over west Lombardy. Apart from the Piedmont plain the 4 km grid has a high bias due mainly to the overestimation of the intensity of precipitation, which is by experience a systematic behavior for convective events (Bukovsky and Karoly, 2009). The 12 km grid both with the KF and BMJ schemes creates a more extended and spread out area of convective precipitation which is not similar to reality.

So explicit convection does generate more realistic structures at least during the first phase of a convective event. The difference between the 4 km run and the 1.3 km run is quite small, the exception is the generation of single cell storms in the finest grid. The distribution of the precipitation field and the intensity is almost identical. So in this case the increase of resolution between the 9 and 24 hours of the forecast, maintaining identical physical and dynamical schemes, generates almost no difference.

The predicted stream-flow is shown in fig. 15. The comparison with observations, made with station data for surface winds and the Milan sounding for upper air winds, shows a good accordance with reality. Optimistically low biases could be expected also for the next times, suspecting the movement of convective precipitation along the streamlines.

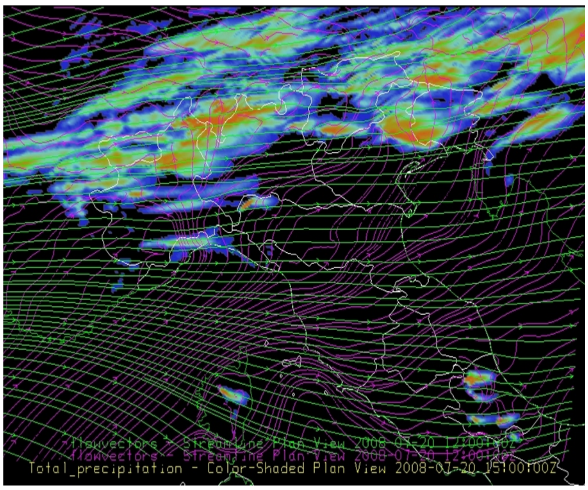

Figure 15. Predicted low and middle layer stream-flows and accumulated precipitation at 15 UTC July 20th, 2008.

However, the next time intervals, 15-18 UTC and 18-21 UTC, present a higher bias at every grid scale (Judd et al., 2008). The main region of error is the Po plain, because the model predicts the formation of intense and widespread convective precipitation, while radar data shows only local sparse storms.

To understand the reason of this behavior we can point out that the measured CAPE by the Milan Linate sounding (fig. 16), in the middle of the Po plain, is 357 J/kg. The predicted CAPE at all scales is between 1200 and 2000 J/kg. In the model forecasts the conditions for generating heavy convective precipitation on the Po plain are present, conditions that do not exist in reality.

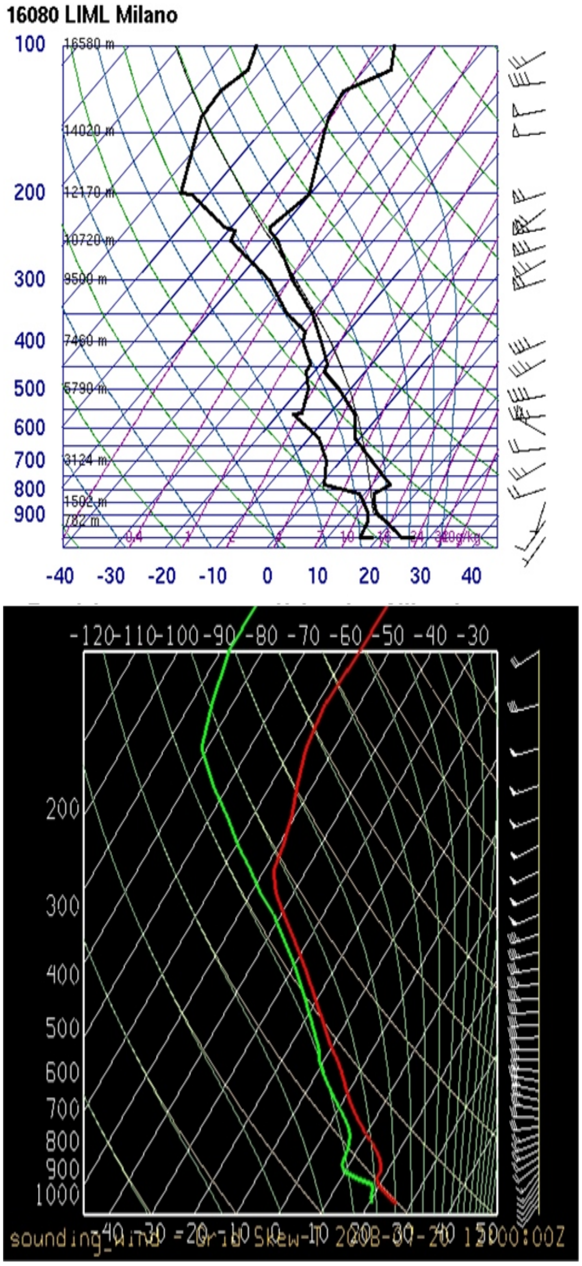

Figure 16. Measured (up) and predicted (down) soundings at Milan Linate site at 12 UTC July 20th , 2008.

To investigate further, from the stream-flow image, dry dynamics are acceptably well forecasted, from the pseudo-sounding over Milan (fig. 16), the temperature profile is forecasted in good accordance to reality, the main difference is in the dew temperature profile. Which leads us to conclude that the instability is due to the overestimation of humidity in low to mid model levels, which seems to be somewhat of a systematic behavior.The run initialized on the 19th should give us some ideas on the role of initial data (Jankov et al., 2007), taking into account the passage of the cold front on the 18th and on the 19th.

The forecasted CAPE on 12UTC of the 20th is still between 1000 and 2000 J/kg over the Po Plain, which leads to the generation of convective precipitation during the afternoon hours on the Piedmont plains and locally on Lombardy's plain (fig. 17). At the same time the precipitation is underestimated over some alpine regions. In particular the regions between Ossola and northwestern Lombardy, that saw the greatest quantity of precipitation (Ferraris et al., 2002) in reality, have a negative bias (fig. 18).

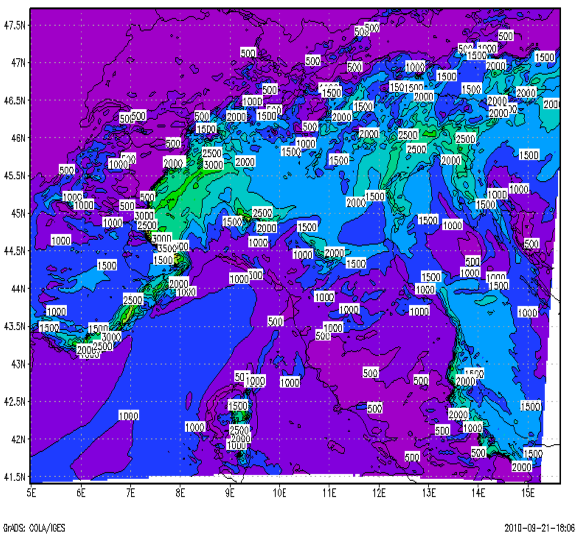

Figure 17. Predicted CAPE in the afternoon of July 20th , 2008. Too much high values are present especially in the plain areas.

The quality of the forecast is inferior for runs initialized on the 19th. First of all high instability on the Po plain is still generated. Furthermore the dry dynamics are different compared to the runs initialized on the 20th and, in particular, farther from the observation, which is of direct consequence of different initial data. The result is the generation of the convective system with the heaviest precipitation on the Piedmont plain that moves westward, which is not in accordance with reality. While for the run initialized on the 20th, the heaviest convective events are generated on Ossola and northwest of Lombardy, and only afterward the precipitation moves unrealistically towards southwest.

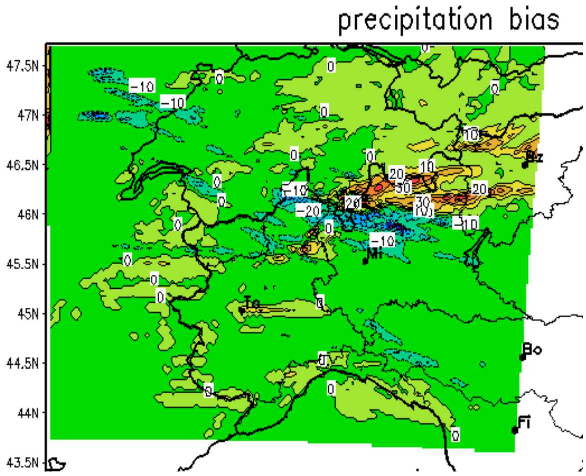

Figure 18. Precipitation biases in the afternoon of July 20th , 2008. Underestimation of rain amount is present in some alpine areas.

The variation of the cumulus scheme on the coarsest grid leads to very few differences on the precipitation patterns on the two finest grids. The BMJ scheme tends to produce weak and very distributed precipitation field, that lead to better classic skill scores even if the patterns are not realistic.

6. Conclusion

In the framework of a project named SISTEMA, which has the aim to develop an alerting system for extreme events, depending on meteorological conditions, linked to hydro-geological events (landslides, debris flows and floods) or atmospheric emissions due to an accident in the potential-risk plants, and opened to possible inclusion of other potentially dangerous events (like fires) many simulations have been performed for relevant past situations over a nested domain chain centered in the central part of the south-alpine region. Comparison among different physical schemes and resolutions have been performed, together with the analysis of the prediction errors for weather fields. Particularly, precipitation has been taken into account, considering available radar data over the target region.

Results of the performed simulations have shown that the model can reproduce several of the characteristics of the considered events in the alpine area, both from the locations of the precipitation and its distribution and intensity, as well as the timing of the examined events.

However, the comparison with the radar data have also shown that systematic over-estimations occur when the rain intensity is greater than 20 mm/3h). Some precipitations, but with generally low values, also appear in mountain areas where radar data don't show anything.

In the case-study shown here, some underestimation also occurred in different alpine areas, while unrealistic instability in the plain wrongly appear in the model; this has been due to a humidity excess mixed in the low-middle layer over the Po Valley, probably linked to the boundary layer scheme.

Unfortunately we don't have radar data for relevant cases before 2001. We do have data from rain gauges and the analysis is in progress.

Anyway, the simulations performed have also shown that when an extreme hydro-geological event occurred, model's predicted values can be used as a valid input in the hydrological models. These ones should be able to identify the threshold values for that event and the possible overcoming. In the aims of the project SISTEMA, this is the proper case when the alert procedure will start, sending information to local authorities and decision makers and activating any required mitigation of risks and effects.

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