LIFE11 ENV GR 975
FLIRE: Floods and fIre Risk assessment and management

Weather forecasting report

28/1/2013

Project location	Greece – Attiki region
Project starting date:	01/10/2012
Project ending date:	30/09/2015
Coordinating Beneficiary	National Technical University of Athens

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Name of the Action: Short-term weather forecasting

Starting date of the Action: 01/10/2012

Ending date of the Action: 30/9/2015

Extended Summary

Action B5 focuses on the provision of short-term weather forecasting data as well as of dense meteorological observations for the study area. Both weather forecasts and observations will serve as an input in the Weather Information Management Tool (WIMT) of the Decision Support System.

The present report is devoted to the detailed description of the adopted strategy for setting-up an operational weather forecasting chain that will provide the necessary input to other actions of FLIRE project. More precisely the state-of-the-art non-hydrostatic NWP model MM5 will be used to drastically increase the spatio-temporal resolution and accuracy of forecasts over the area of interest for flood but also for fire risk assessment and management. This modelling system offers a great flexibility of choice of physical parameterization schemes and it is used worldwide for a great variety of applications. In the frame of FLIRE, MM5 model is run operationally, once per day, following a three- nest strategy with 24-km, 8-km and 2-km horizontal grid increment. The model is initialized at 0000 UTC each day. Grid 1 simulation lasts 72 hours, Grid 2 starts at t+6 with a total simulation time of 66 h and finally Grid 3 starts at t+6, with a total simulation time of 42 h. Grid 3 provides every day detailed weather forecasts for the same day and the following day, at 1-h interval. The high spatial and temporal resolution of Grid 3 data will permit to provide rainfall and wind forecasts for the other Actions of the FLIRE project, namely Actions B.3, B.4 and B.6.

Introduction

The aim of Action B5 is the provision of short-term weather forecasting data as well as of observed data that will serve as an input in the Weather Information Management Tool (WIMT) of the Decision Support System. This report describes in detail the strategy adopted in order to set-up an operational weather forecasting chain that will provide the necessary input to other actions of FLIRE project.

Currently, operational Numerical Weather Prediction (NWP) systems consist of global atmospheric models which run typically at horizontal resolution ranging from 20 to 50 km and of mesoscale limited area models with horizontal resolution ranging from 5 to10 km. A significant evolution in NWP systems is planned for this decade. It is envisaged to replace or complement the current operational models by a new generation of non-hydrostatic atmospheric models that will be run with a horizontal resolution of 1-3 km. In the frame of FLIRE project the state-of-the-art non-hydrostatic NWP model MM5 will be used to drastically increase the spatio-temporal resolution and accuracy of forecasts over the area of interest for flood but also for fire risk assessment and management.

For that purpose, NOA implemented the MM5 modeling system that offers a great flexibility of choice of physical parameterization schemes and it is used worldwide for a great variety of applications. Indeed, MM5 model is run operationally, once per day, following a three- nest strategy with 24-km, 8-km and 2-km horizontal grid increment (details on the model setup are given in the following section). This modeling effort follows the worldwide trend to use increasingly higher resolutions with NWP models at operational basis, following the significant improvement of computing capabilities at prices that are continuously decreasing.

Many recent studies, found in literature, deal with the use of very-high resolution modeling. Doyle (1997) and Colle and Mass (2000), among others, have shown that increasing horizontal resolution could be very advantageous, especially in cases of circulations forced by topography and surface contrasts, as the Attiki area. Bernadet et al. (2000) argued that a grid spacing of 2 km should be used in order to explicitly reproduce convective activity. Benoit et al. (2000) also verified the results of simulations with a grid spacing varying from 35 down to 3 km in order to reproduce the flow produced by a midlatitude cyclone and found a considerable improvement in the results by increasing the grid spacing.

Description of the area

The Attiki area includes the cities of Athens and Piraeus and is characterized by a relatively complex terrain (Fig. 1b). It is surrounded by mountains on the three sides, while on the fourth side there is a major opening to the sea in the southwest (the Saronic Gulf). The three main mountains are Hymettus (1050 m) to the East, Penteli (1100 m) to the North and Parnitha (1400 m) to the Northwest. These mountains with only small gaps between them along with numerous hills located downtown Athens play an important role on the modification of the flow in the area. The Korinthian Gulf (to the west of Athens basin) is surrounded by high mountains both to the north and to the south, which under specific conditions can result in a channeling of the flow towards the Saronic Gulf.

The need for high-resolution accurate weather forecasts over the area of Athens has been stressed also in Kotroni et al. (2004) and Lagouvardos et al. (2003). These authors have evaluated one-year weather forecasts over Greece and the area of Athens with the aim, among others, to contribute to the pending question if increasing horizontal resolution produces better forecasts.

Model Setup

MM5 model (Version 3) is a non-hydrostatic, primitive equation model using terrain-following coordinates (Dudhia, 1993). Several physical parameterization schemes are available in the model for the boundary layer, the radiative transfer, the microphysics and the cumulus convection. In order to select a combination of microphysical and convective parameterization schemes that better reproduce wet processes, Kotroni and Lagouvardos (2001) performed a comparison of various combinations of schemes for cases with important precipitation amounts over E. Mediterranean. This comparison showed that the combination of Kain-Fritsch (Kain and Fritsch, 1993) parameterization scheme with the highly efficient and simplified microphysical scheme proposed by Schultz (1995) provides the most skilful forecasts of accumulate precipitation for a grid spacing of 24 km. For that reason, the operational chain of MM5 at NOA uses the combination of these two schemes. Concerning the choice of the boundary layer scheme, the current operational chain at NOA uses the MRF scheme proposed by Hong and Pan (1996).

The planetary boundary layer (PBL) scheme implemented in a model plays a decisive role on the accuracy of forecasted state and flow within the PBL. Akylas et al. (2007) have statistically evaluated three widely used PBL schemes, as implemented in MM5 model, for their skill to forecast near surface temperature and wind speed in the area of Attiki. The evaluated schemes are Blackadar and MRF (nonlocal schemes) and ETA (local scheme). The verification has been based on high-resolution forecasts at grid spacing of 8-km (for all three schemes) but also of 2-km (for MRF and ETA schemes) for a 5-month period. The analysis showed that the forecasts are improved in general when increasing the horizontal resolution. The improvement is more significant for the temperature field, where increase in resolution results in a decrease of the model cold bias. Overall the MRF showed the most consistently good behaviour, that is why this scheme is selected for the operational model forecast chain that will be run in the frame of FLIRE project.

Three one-way nested grids are defined and used at an operational basis for the needs of FLIRE project (Fig. 1a). Grid 1 has 24-km horizontal grid increment, covering the major part of Europe, the Mediterranean and the northern African coast. Grid 2 has 8-km horizontal grid increment, covering the Greek territory and all the Greek islands. Finally, Grid 3 has a 2-km horizontal grid increment, covering the entire Athens area and the adjacent water bodies (Fig. 1b), including the study area of FLIRE. The horizontal extension of the defined operational grids is shown in Fig.1a. In the vertical twenty-three unevenly spaced full sigma levels are selected (σ = 1., 0.99, 0.98, 0.96, 0.93, 0.89, 0.85, 0.80, 0.75, 0.70, 0.65, 0.60, 0.55, 0.50, 0.45, 0.40, 0.35, 0.30, 0.25, 0.20, 0.15, 0.10, 0.05, 0.00).

MM5 model is run once daily, initialized at 0000 UTC. Grid 1 simulation lasts 72 hours, Grid 2 starts at t+6 with a total simulation time of 66 h and finally Grid 3 starts at t+6, with a total simulation time of 42 h. Therefore Grid 3 provides every day detailed weather forecasts for the same day and the following day, at 1-h interval. This high spatial and temporal resolution of Grid 3 data will permit to provide rainfall and wind forecasts for the other Actions of the FLIRE project, namely Actions B.3, B.4 and B.6.

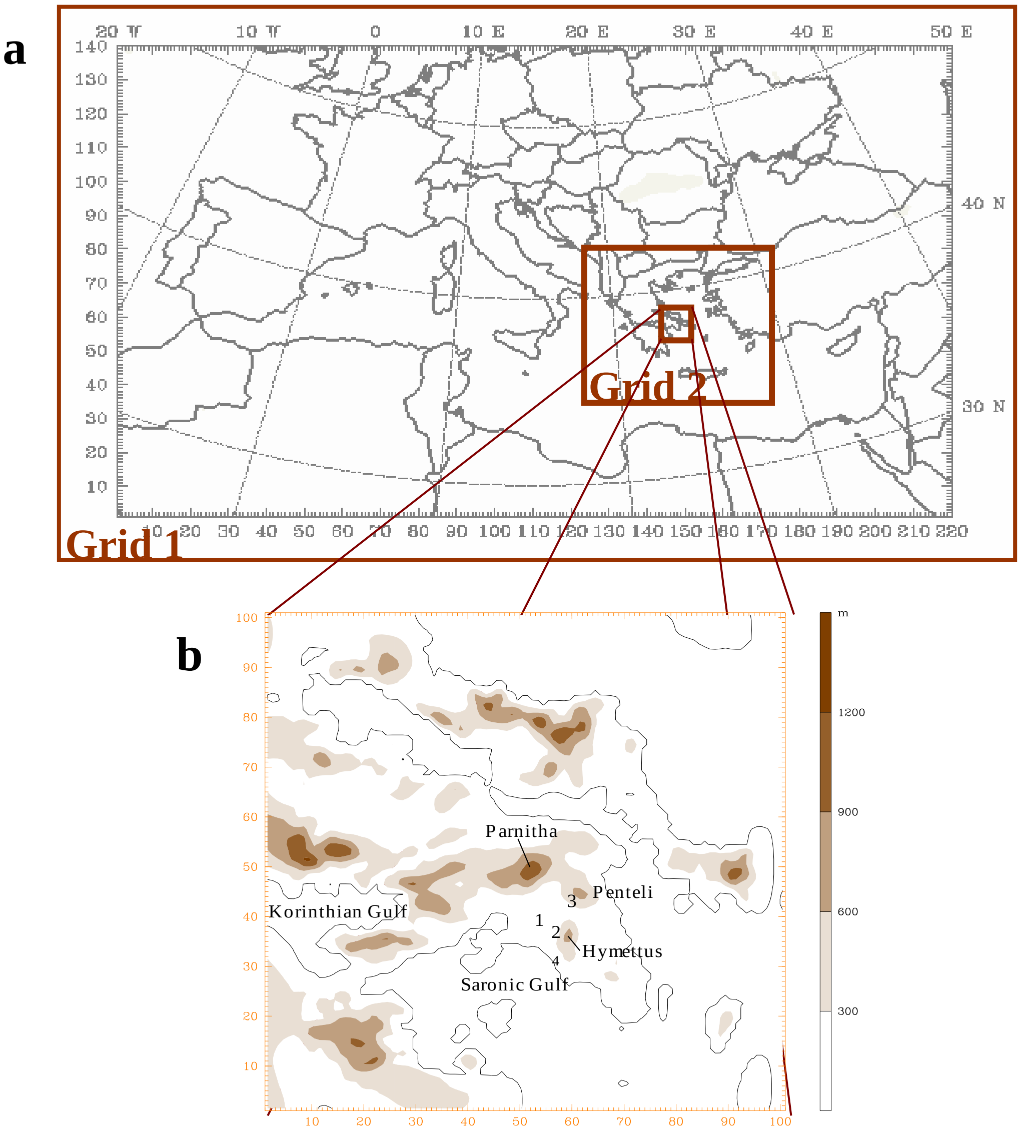
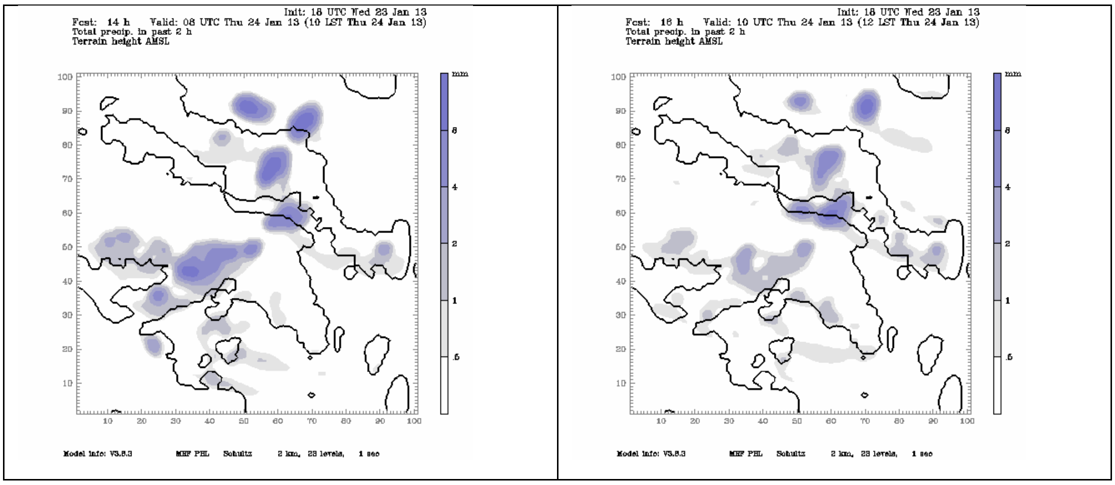


Figure 1: (a) Horizontal extension of MM5 grids. The rectangles denote the position of the intermediate and fine grid. (b) Topography of the Athens area, as resolved by MM5 Grid 3.

The 0000 UTC Global Forecast System (GFS, provided by the National Centers for Environmental Predictions-NCEP, USA) gridded analysis fields and 6-hour interval forecasts, at 0.5-degree lat/lon horizontal grid increment, are used to initialize the model and to nudge the boundaries of Grid 1 during the simulation period. No preforecast spin up period or assimilation of additional observations is used in the operational MM5 model chain. The sea surface temperature is initialized from the same GFS dataset. For land use and topography the 30arcsec resolution files provided by USGS are used.

Example of Operational Forecasts

An example of MM5 Grid 3 forecasts for a recent event of moderate precipitation over the Attiki area is shown in Fig. 2. This four-panel figure shows the evolution of rainfall over the area covered by Grid 3 on 24 January 2013. Although this particular event did not affect the area of Anatoliki Attiki (study area of FLIRE), it is a good example of how the temporal and spatial resolution of rainfall can be predicted by a high-resolution model. Precipitation forecasts will be evaluated against measurements during the project and the results of this verification will be the subject of a future deliverable (foreseen for March 2015).



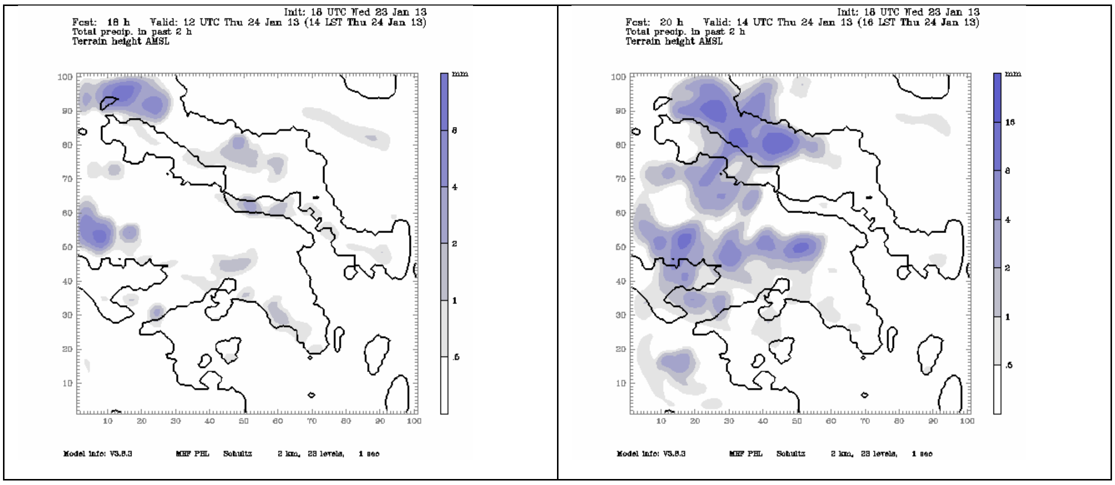


Figure 2: Precipitation forecasts provided from MM5 Grid 3 for 24 January 2013 (each panel shows 2-h accumulated precipitation).

Conclusions

In the frame of Action B.5 a numerical weather prediction strategy has been adopted with the aim to provide the necessary wind and precipitation forecasts at the spatial and temporal resolution needed for the completion of Actions B.3, B.4 and B.6. The adopted modeling strategy is based on the use of MM5 state-of-the-art non-hydrostatic model which is applied with 3 one-way nests, over the Mediterranean, Greece and Attica respectively. The model is run once daily and the forecasts are provided with 2-km horizontal grid increment and 1-h time increment for the current and the following day. The model performance will be evaluated within the project period for its skill to provide accurate precipitation forecasts.

The adopted strategy complies with the world-wide effort to provide increasingly higher resolutions with NWP models at operational basis, following the significant improvement of computing capabilities at prices that are continuously decreasing.

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