Numerical simulations of the severe rainfall in Pula, Croatia, on 25th September 2010

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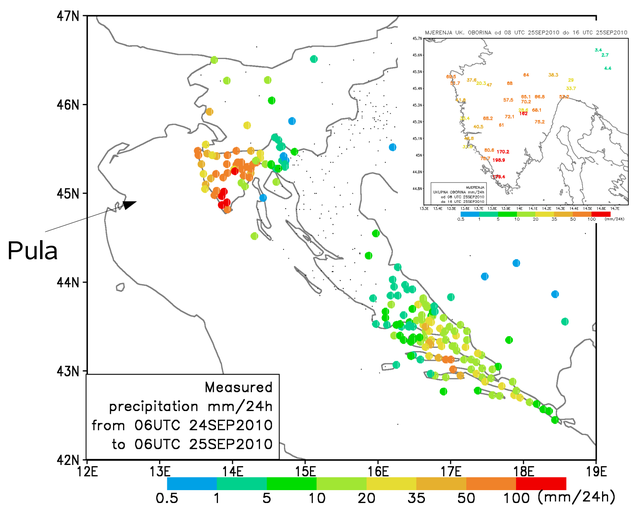
Introduction

On 25th September 2010, just after midnight intensive rain hit Pula city on the southern part of Istria Peninsula, Croatia. The rain was intensive for several hours and the rainfall rate measured at ombrograph reached 43.9 mm per hour.
For more details on the synoptic conditions, please refer to the poster 2.28.
The operational forecast underestimated the precipitation intensity and put the rainfall maximum above the sea. Therefore this case is used as a testbed for the numerical weather prediction model ALADIN (Aire Limiteé Adaptation Dynamique dévelopement InterNational).

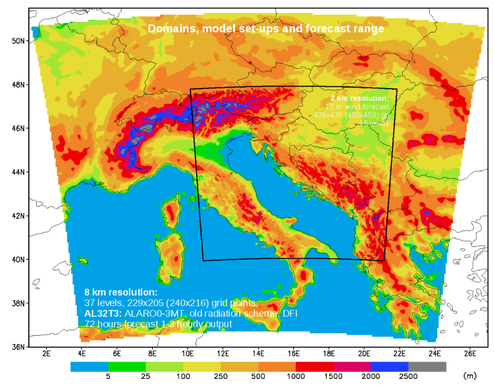


Observation type	Variable
SYNOP	surface pressure, 2m temperature and relative humidity
Aircraft	wind components
Atmospheric Motion Winds	wind components
TEMP	pressure, wind components, temperature and humidity
Wind profiler	wind components
Satellite radiances	radiance

Table: Observation type and model variables in data assimilation suite at CMHS.

Methods

The operational ALADIN forecast (OPER) at CMHS is run with 8 km horizontal resolution, it uses ARPEGE initial and boundary conditions and digital filter initialization (DFI). The parallel suite of ALADIN has similar characteristics but it uses initial conditions obtained from data assimilation (DA) cycle.



Alternative set of initial and LBC files comes from the IFS run in ECMWF. These data are used in combination with surface analysis and 3Dvar. The background error covariance matrix was computed with standard NMC method.

Figure: The 8km and 2km resolution domains used operationally. The high resolution runs presented here will be on 37 levels.

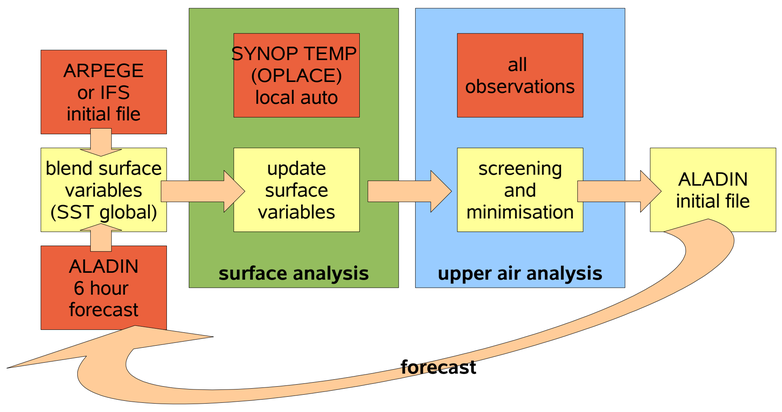
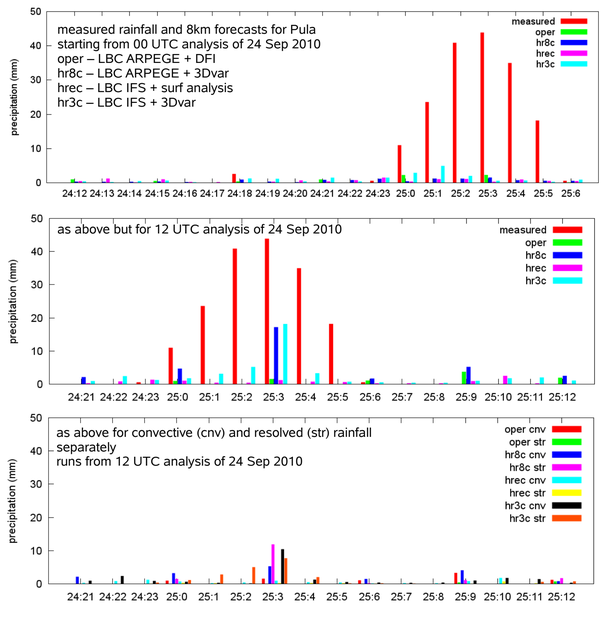


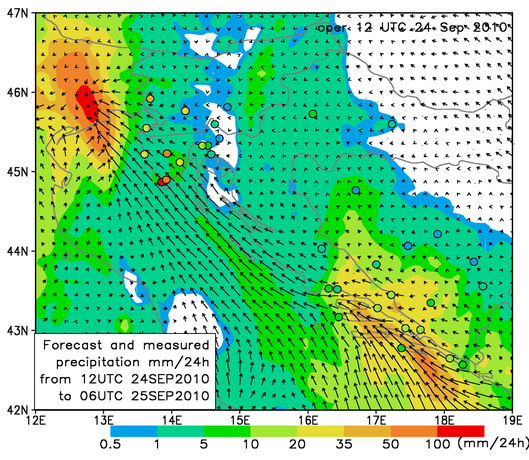
Figure: The data assimilation cycle. Local data assimilation system for a LAM ALADIN HR consists of the surface assimilation which is used to change the state of the model land surface variables and the upper air assimilation which changes upper air model fields. Surface assimilation is done by the optimal interpolation (OI) while upper air assimilation is done using the 3D variational technique (3DVAR).

Conclusions

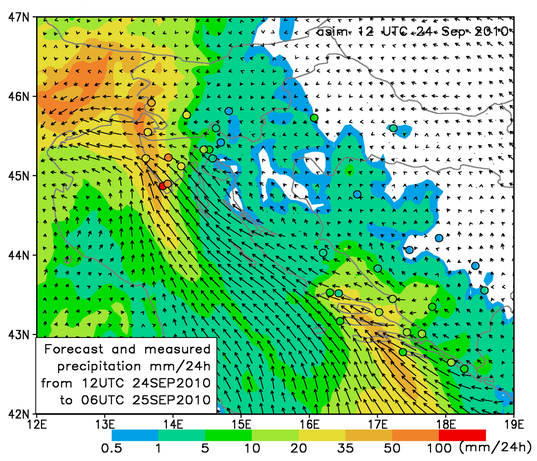
The operational ALADIN forecast severely underestimated the rainfall over Istria peninsula during the night from 24th to 25th September 2010. The parallel suite rainfall forecast was slightly better, but the predicted rainfall was far below the measured one. This encouraged testing the initial and boundary conditions coming from the IFS operational suite in ECMWF. These require at least the surface data assimilation so this run is most similar to the operational one. The rainfall in Istria was underestimated and it improved slightly when 3Dvar was used. The results are qualitatively the same for runs starting from 00 and 12 UTC analyses on 24th September 2010. The 3dvar runs from 12 UTC were better than the 00 UTC runs. Almost all precipitation for Pula in runs without 3Dvar is generated by convection scheme. In 3Dvar runs, convective and resolved precipitation schemes contribute equally.
The high resolution runs were performed with 2km resolution non-hydrostatic Aladin using 8 km resolution runs for initial and LBC data. The precipitation forecast for Pula did not improve in the high resolution runs, except in the run without the convection parametrization. However, there are features in the forecast fields from that run that make the result doubtful. The hi-res runs have generated a band of intensive precipitation over Cres island, east of Pula, but very little rainfall was measured there. This result suggests that the model has misplaced the intensive rainfall band.



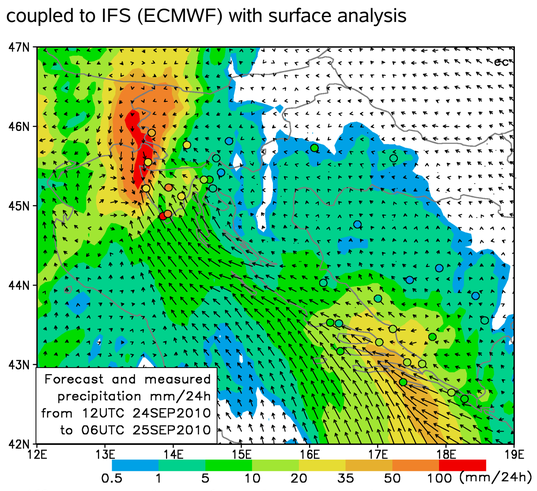
oper: coupled to ARPEGE (MF) with DFI



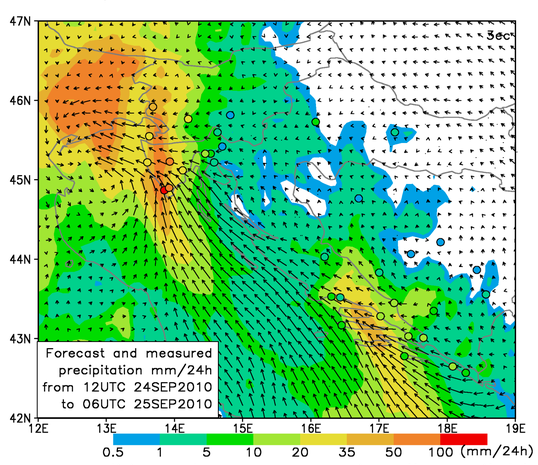
coupled to ARPEGE (MF) with 3Dvar



coupled to IFS (ECMWF) with surface analysis



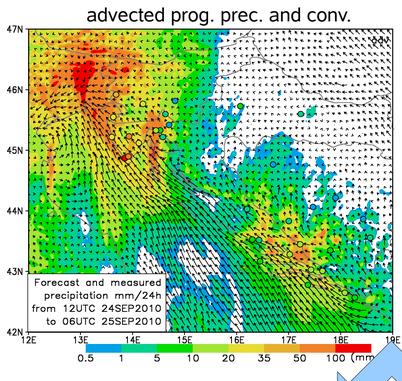
coupled to IFS (ECMWF) with 3Dvar



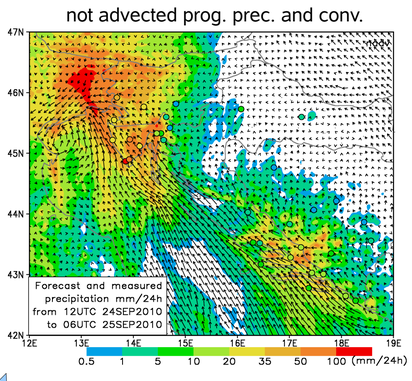
Forecasts obtained from operational and parallel suites show that the precipitation event west of Istria peninsula was forecast by both suites (OPER and DA) even several days in advance, but high precipitation maximum at southern part of the peninsula was not captured. It is assumed that observed severe precipitation was caused by convective activity supported by synoptic conditions and/or local conditions that were not represented correctly in the initial conditions or the model was not able to represent its development. In order to investigate this, different sets of experiments have been performed. These tests include the sensitivity to different initial and lateral boundary conditions, model resolution and convective parametrization scheme.

Different options for obtaining the initial and boundary conditions that are operationally available in the Croatian Meteorological and Hydrological Service (CMHS) are tested. The first set for LBC comes from ARPEGE (Action de Recherche Petite Echelle Grande Echelle) that is run operationally in Meteo-France and the second set will be obtained from the IFS (Integrated Forecast System) model that is run operationally at ECMWF (European Center for Medium-Range Weather Forecast). A possibility of improving the initial conditions via the data assimilation using these sets initial and boundary conditions is investigated.

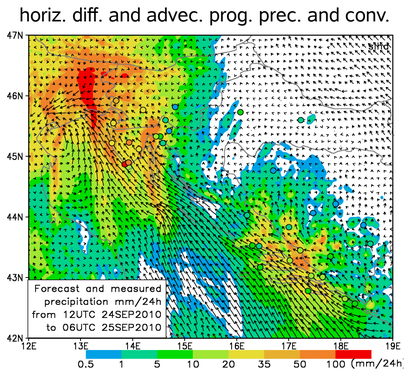
advected prog. prec. and conv.



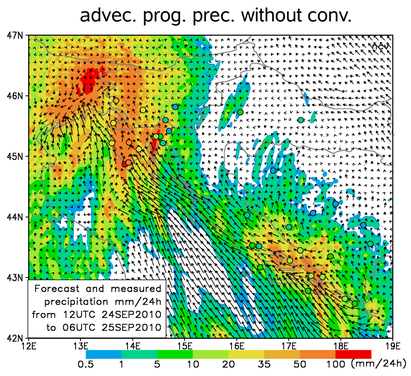
not advected prog. prec. and conv.



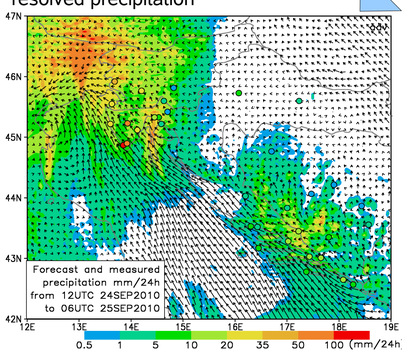
horiz. diff. and advec. prog. prec. and conv.



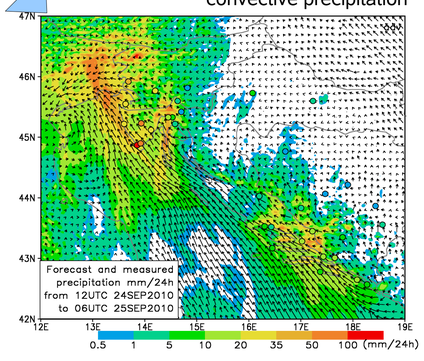
advec. prog. prec. without conv.

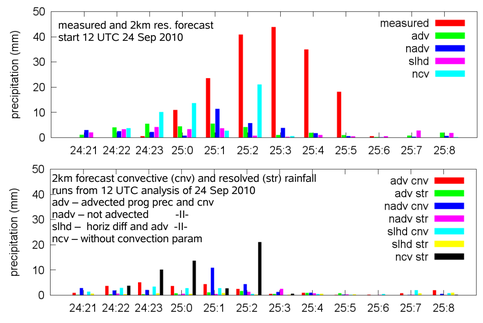


resolved precipitation



convective precipitation





HIGH RESOLUTION EXPERIMENTS

The experiments using high-resolution (2 km) non-hydrostatic ALADIN model runs have been performed. Various options were tested where the prognostic cloud water, ice, rain and snow as well as prognostic convection variables the updraft and downdraft vertical velocities and mesh fractions are advected by semi-lagrangian scheme and diffused by SLHD.
The experiments where the prognostic parametrization of convection has been used have indicated the existence of the secondary maximum over the Istrian land. Most of the precipitation was given by the convection scheme. This result suggests the importance of using the convective parametrization even in the resolutions in which it is assumed that the convection is resolved. In an experiment without any deep convection scheme, the simulated resolved precipitation is much larger than the resolved precipitation in runs with convection scheme.