SEVERE CONVECTIVE PRECIPITATION AT PULA ON 25TH SEPTEMBER 2010 - NWP MODEL SIMULATIONS

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I. 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. Several rain-gauges in the area measured more than 150mm/24hr (Fig 1). For more details on the synoptic conditions, please refer to the corresponding poster in the session 6.

The operational forecast underestimated (Fig 3a) 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).

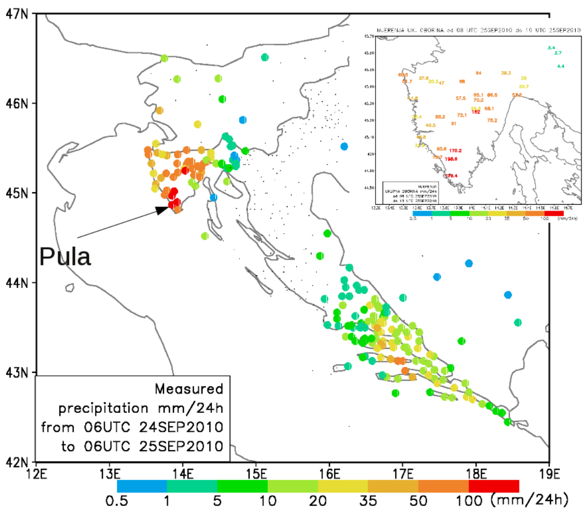

FIG. 1: The 24 hr measured precipitaition on rain-gauges.

II. 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 at ECMWF.

Local data assimilation system for a LAM ALADIN HR (Fig 2) consists of the surface assimilation which is used to change the state of the model surface variables and the upper air assimilation which changes upper air model fields using measurements in Tab 1. Surface assimilation is done by the optimal interpolation (OI) while upper air assimilation is done using the 3D variational technique (3Dvar). The background error covariance matrix used in 3Dvar was computed with the standard NMC method.

Figures 3 and 6 show accumulated 18 hour forecast precipitation, and measured 24 hour precipitation, but there was no rain in Pula in the period not covered by the forecast. The wind field is shown for 00 UTC 25th September 2010 that is close to the period of the maximum rain intensity. Forecasts obtained from operational (Fig 3a) and parallel suite (Fig 3b) 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 (Fig 4a). 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 (compare Fig 4a and Fig 4b). 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.

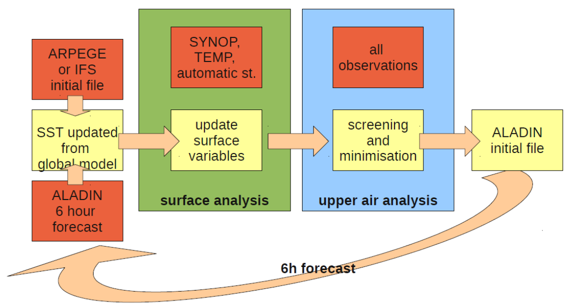

FIG. 2: The data assimilation cycle.

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	(AMSU-A,AMSU-B,SEVIRI) radiance

TAB. 1: Observation type and variables assimilated at the CMHS.

Different options for obtaining the initial and boundary conditions that are operationally available are tested. The first set for LBC comes from ARPEGE (Action de Recherche Petite Echelle Grande Echelle) from Meteo-France and the second set is obtained from the IFS (Integrated Forecast System) from ECMWF (European Center for Medium-Range Weather Forecast). Surface description used in IFS and ALADIN model is different. Therefore, in order to use the IFS initial and boundary conditions, the assimilation cycle with only surface assimilation was used. After 15 days of “worm-up” time it provided the land surface that was combined with the upper air IFS fields in order to get the initial state for ALADIN forecast (DA_IFS). The resulting precipitaiton forecast is in Fig 3c. Additionally, experiment was made where also 3dvar assimilation was applied at the time of initialization (DA+3dvar_IFS) and the precipitation is in Fig 3d.

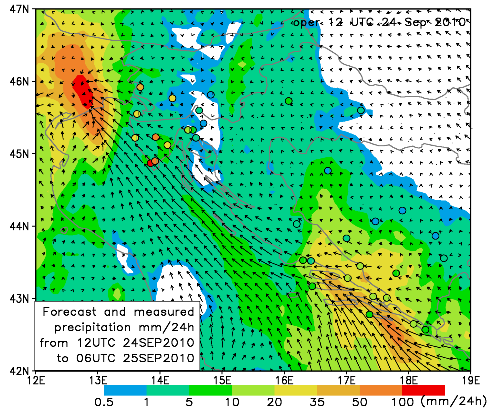

FIG. 3a: The operational (LBC from ARPEGE, DFI) precipitation forecast (shaded) and several rain-gauge measurements (circles).

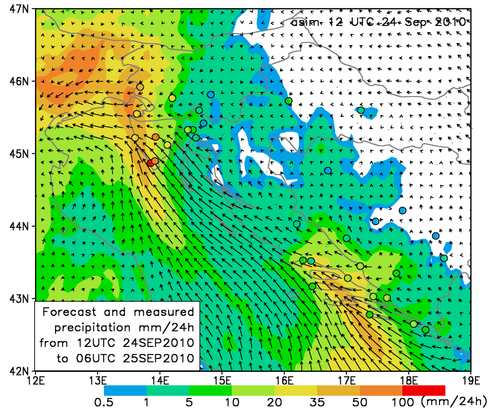

FIG 3b. As Fig 3a, but with 3Dvar.

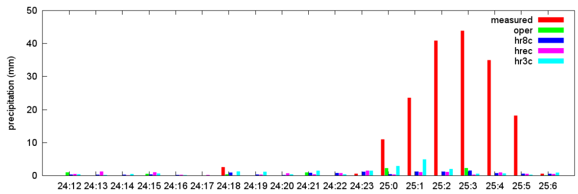

FIG. 4a: Hourly measured and model precipitation for Pula from 00 UTC 24 Sep 2010 (*oper* and *hr8c* are 3 hourly) .

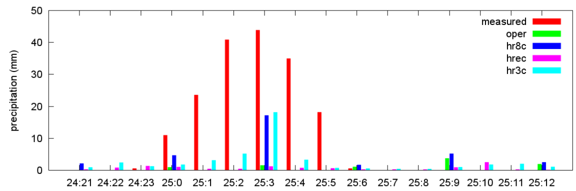

FIG. 4b: As Fig 4a, but for 12 UTC run.

The experiments using high-resolution (2 km) non-hydrostatic ALADIN model runs have been performed. Those coupled to DA+3dvar_IFS are shown. Various options were tested (Fig 5) 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 (or not) by semi-lagrangian scheme and diffused (or not) by SLHD (Semi-Lagrangian Horizontal Diffusion). SLHD on a variable requires Lagrangian advection of the variable. Additionally, an experiment without any convection scheme has been performed.

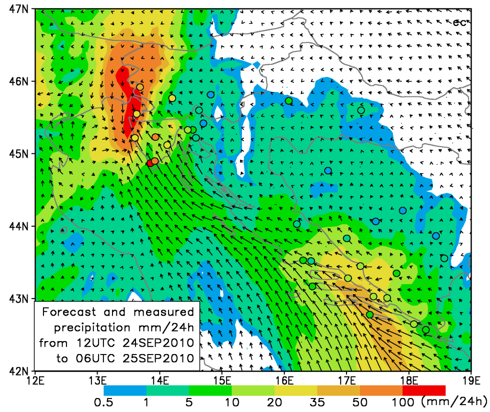

Fig 3c. As Fig 3a, but coupled to IFS with surface assimilation.

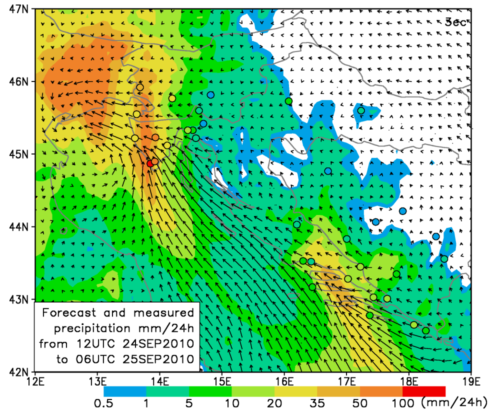

Fig 3d. As Fig 3c, but with 3Dvar.

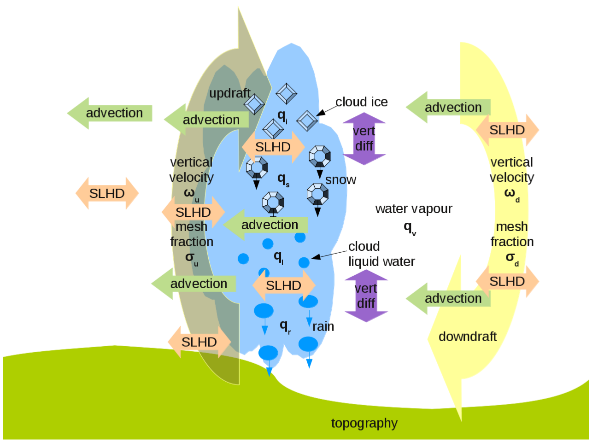

FIG. 5: An illustration of the microphysics scheme.

In the experiments (eg. Fig 6a) where the prognostic parametrization of convection has been used, the secondary maximum over the Istrian land is mostly given by the convection scheme (compare Figs 6b and 6c). In an experiment without any deep convection scheme, the simulated precipitation for Pula is larger (Fig 7), but there are features in the forecast fields that make the result doubtful. Horizontal diffusion in these experiments is set to low intensity. Stronger horizontal diffusion reduces these features.

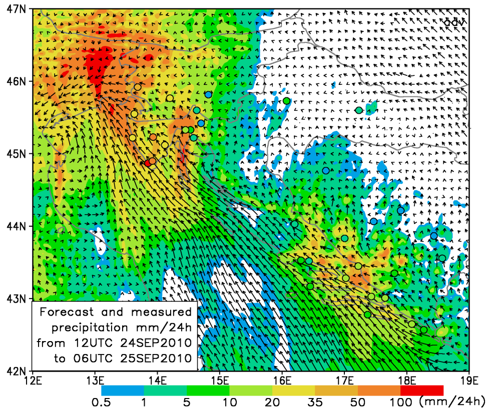

FIG. 6a: 2km resolution 18 hour precipitation forecast (shaded), 24 hr measurements on rain gauges (circles) and wind for 03 UTC 25 Sep 2010 (advected hydrometeors and convection).

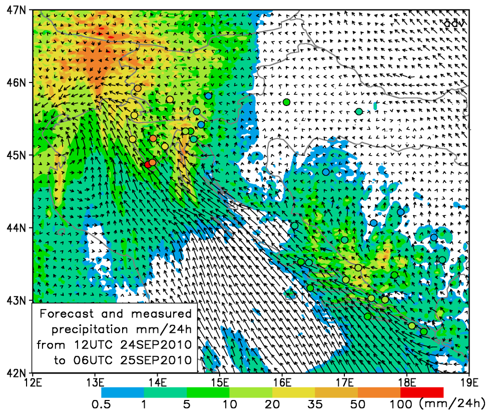

FIG 6b: As Fig 6a, but for resolved model precipitation only.

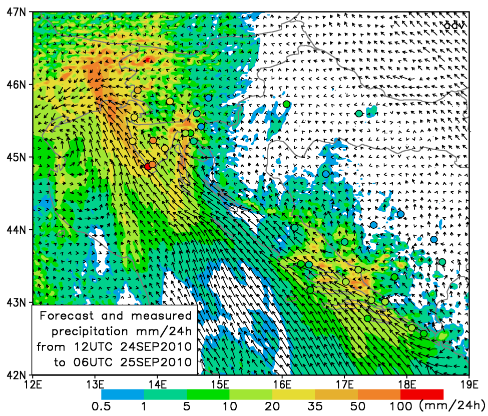

Fig 6c. As Fig 6a, but for convective precipitation only.

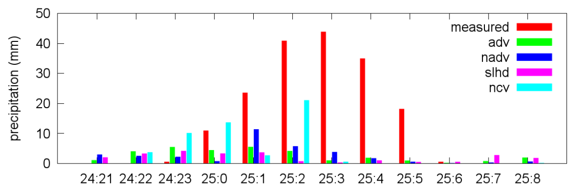

FIG. 7: Hourly measured and model precipitation for Pula.

III. RESULTS AND 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 structures were slightly better, with second maximum of rainfall over Istria peninsula, but the predicted rainfall amount was far below the measured one. This encouraged testing the initial and boundary conditions coming from the IFS operational suite at ECMWF. They were used in combination with the surface assimilation (DA_IFS) and additionally with the upper air assimilation (DA+3Dvar_IFS). Results from DA_IFS are similar to the operational run. Again, better rainfall structures were present in DA_IFS_3Dvar with slightly larger rainfall amounts compared to ASSIM.

The results of the operational 8 km model runs are qualitatively the same for runs starting from 00 and 12 UTC analyses on 24th September 2010 (Fig 4a and 4b). 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 performed with 2km resolution non-hydrostatic Aladin using DA+3Dvar_IFS 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, but this result is doubtfull due to other features in the model fields. The high resolution 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.

IV. ACKNOWLEDGMENTS

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V. REFERENCES

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