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

Antonio Stanešić, Stjepan Ivatek-Šahdan, Martina Tudor and Dunja Mazzocco Drvar
Meteorological and Hydrological Service of Croatia

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).

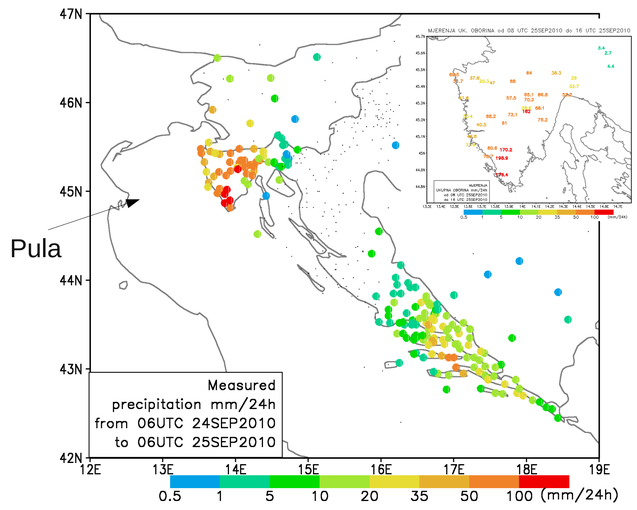


Figure: Measured precipitation on the rain gauges during the 24 hour period starting from 06 UTC 24 September 2010.

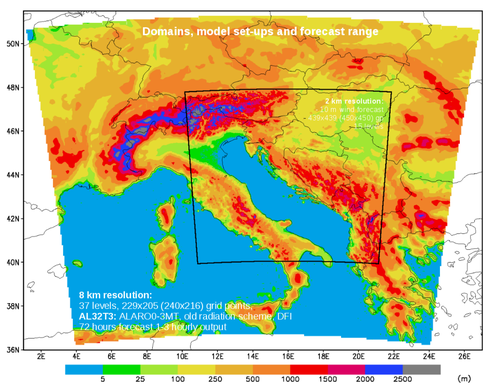


Figure: The 8km and 2km resolution domains used operationally. The high resolution runs presented here are run on 37 levels.

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.

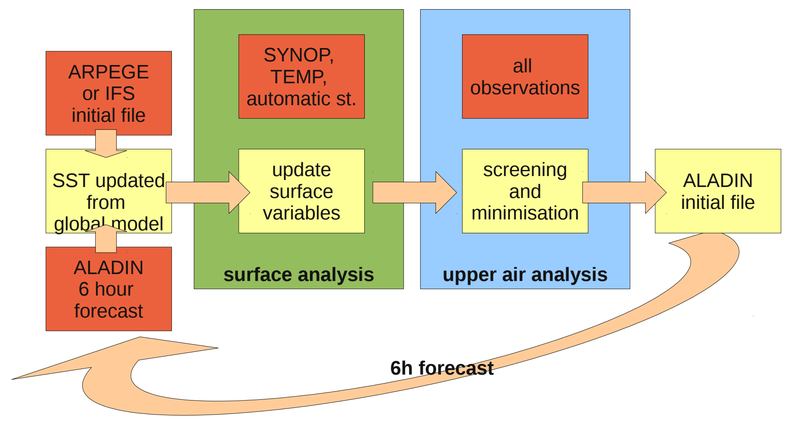


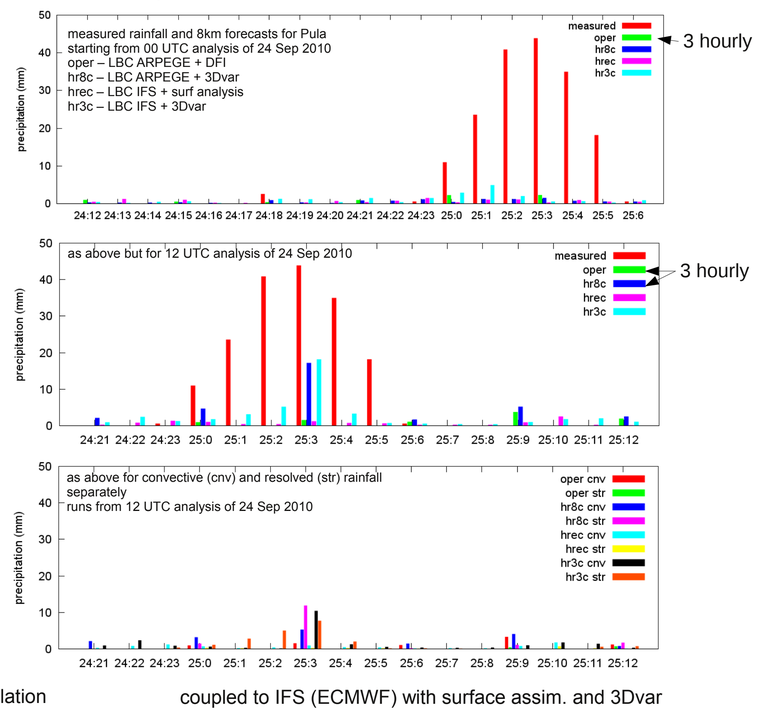
Figure: The data assimilation cycle. Local data assimilation system for a LAM ALADIN HR consists of the surface assimilation which is used to change the state of the model land surface variables and the upper air assimilation which changes upper air model fields. Surface assimilation is done by the optimal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

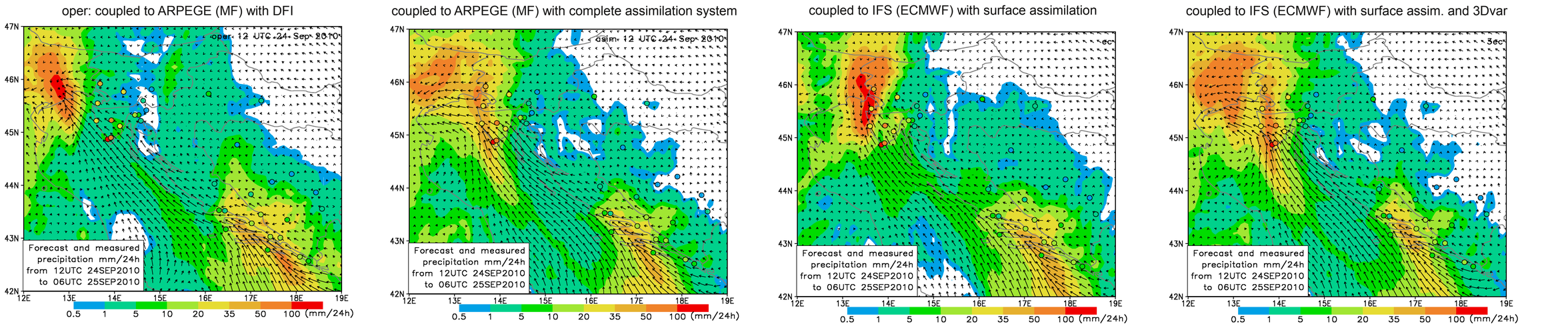
Table: Observation type and variables assimilated at the Croatian Meteorological and Hydrological Service.

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

Conclusions

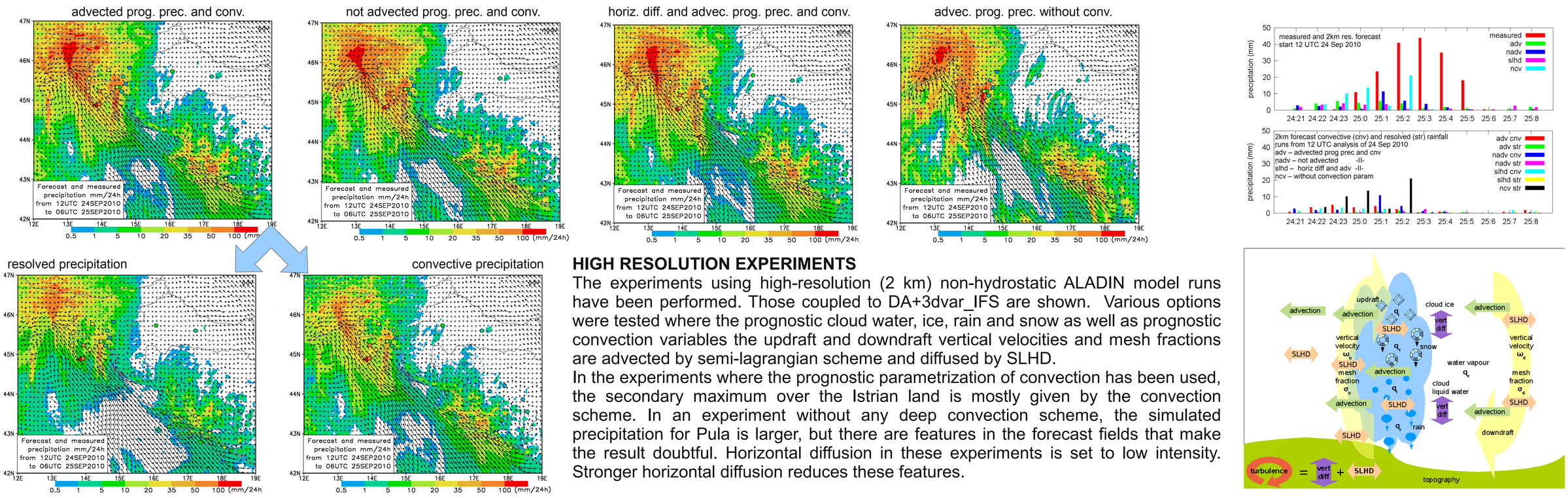
The operational ALADIN forecast severely underestimated the rainfall over Istria peninsula during the night from 24th to 25th September 2010. The parallel suite rainfall structures were slightly better, with second maximum of rainfall over Istria peninsula, but the predicted rainfall amount was far below 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 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 performed with 2km resolution non-hydrostatic Aladin using DA+3Dva_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. 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.





Figures 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 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 at Meteo-France and the second set is obtained from the IFS (Integrated Forecast System) model that is run operationally at 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). Additionally, experiment was made where also 3dvar assimilation was applied at the time of initialization (DA+3dvar_IFS).



HIGH RESOLUTION EXPERIMENTS

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 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.
In the experiments where the prognostic parametrization of convection has been used, the secondary maximum over the Istrian land is mostly given by the convection scheme. In an experiment without any deep convection scheme, the simulated precipitation for Pula is larger, 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.