SENSITIVITY OF WRF DATA ASSIMILATION FOR HEAVY RAINFALL EVENT OVER THE TERRITORY OF ARMENIA

H. Astsatryan[1], V. Sahakyan[1], Yu. Shoukourian[1], A. Sachnazaryan[1]
Z. Petrosyan[2] , R.Abrahamyan[2], H Melkonyan[2], L. Vardanyan[2]

1 - Institute for Informatics and Automation Problems; Yerevan, Armenia
2 - State Hydrometeorology and Monitoring Service of Armenia

I. INTRODUCTION

The intensity and frequency of hazardous hydro-meteorological phenomena, especially strong winds and heavy rainfall, are expected to increase in Armenia further harming e.g. agriculture and infrastructure (Second Report, 2010). In the mean time the accuracy of severe weather prediction, e.g. thunderstorms, stormy winds and flash floods is difficult to predict for the territory of Armenia due to its complex geography and diverse terrain. At present Armenian State Hydrometeorological and Monitoring Service[1], responsible for the operational forecasting for the territory of Armenia, operates 48 meteorological stations, and only 3 meteorological station synoptic data are involved in global exchange through World Meteorological Organization Global Telecommunication System as well as historical data and monthly updates to the Global Climate Observing System Surface Network. The implementation of a numerical weather prediction regional model allows to resolve mesoscale phenomena with involving additional local specific data. This is crucial for Armenia, because the number of stations involved in the global data exchange is limited. The aim of this article is to present the results of the data assimilation impact on heavy rainfall within the Weather Research and Forecasting (WRF) model (Michalakes, 1998) based on the heavy rainfall event for the period 15-18 April 2013. The will be important step towards to the operational usage of the model, which will allow to investigate the potential impact of station`s data on short-range forecasts.

II. PRESENTATION OF RESEARCH

During 16 to 22 April 2013 continuously precipitation was observed in different regions of Armenia. For instance in Lori, Tavush and Sjuniq regions it was snow, which is not common for this period of time. During this intense synoptic event, heavy rainfall totaling more than 42-44mm in Yerevan and Artashat cities, and 38-41mm in Artik, Hrazdan, Jermuk, Fantan, Sisian, Qajaran, Gavar.

Deep convective activities at 16 of April 2013 caused heavy rainfall along the mentioned regions. Specially deep convective activities at 16 of April 2013 caused heavy rainfall at Tavush, Lori: 20-26mm/3h Suniq: 21-23mm/3h regions and Ararat valley: 18-19mm/3h.

In the mean time, the territory of Armenia during this period was under the impact of Southern Cyclone, which was blocked from east and west by the Anticyclone with the pressure in the centre 1030Mb. It is conducted penetration of cold air from North-west and North-east, and warm air from South initiating terms for big convection. FIG. 1 (a) and (b) respectively show the surface analyses and convective clouds from satellite images for the April 16 case.

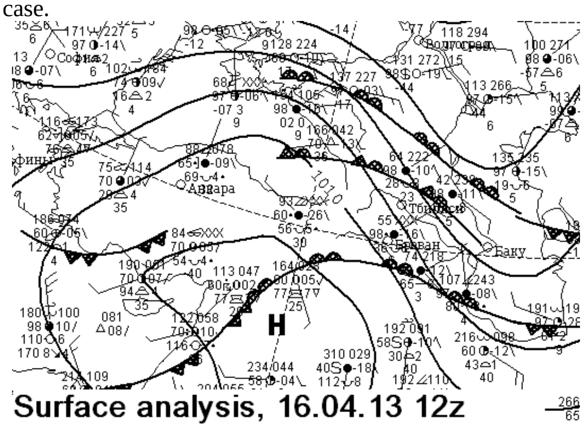


FIG 1 (a): The surface weather system and convective clouds at 12:00 UTC of 16 April 2013.

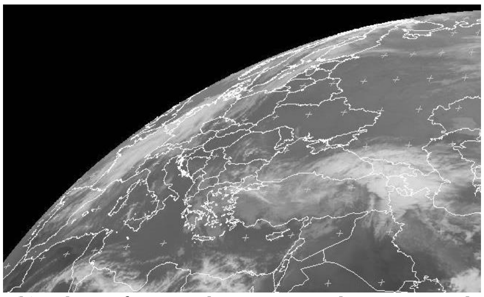


FIG 1 (b): The surface weather system and convective clouds at 12:00 UTC of 16 April 2013.

Based on preliminary investigations, the following parameterizations have been implemented in the present study:

- WRF Double Moment 6 class scheme (Morrison, 2009) enabling the investigation of the precipitation processes with the prognostic variables of cloud condensation nuclei, cloud water and rain number concentrations.
- Kain Fritsch (Kain-Fritsch, 1993) parameterization of convection, which is one of the most sophisticated convective schemes today and can reasonably forecast heavy precipitation event peak.
- Noah Land Surface Model (Hong, 2009), which becomes an important way of enhancing the capability of the regional climate models by predicting soil moisture and temperature at 4 layers with thicknesses, as well as canopy moisture and water-equivalent snow depth.
- The shortwave and longwave atmospheric radiation physics schemes (Lacis, 1974), which include cloud effects and surface fluxes.
- The Mellor-Yamada-Janjic boundary layer

1 Armenian State Hydrometeorological and Monitoring Service, http://www.meteo.am

parameterization scheme to represent effects of small-scale turbulent transport.

- The Monin-Obukhov (Janjic Eta) surface layer scheme, which includes the parameterizations of a viscous sub-layer.

The experiments have been carried out with and without the obsgrid assimilation. All experiments were conducted with nested domain; outer domain (longitude 44.7, latitude 40.0) consisting of 202×202 grid points with 6 km horizontal grid resolution and inner domain contains 151×151 grid points with 2 km horizontal grid resolution.

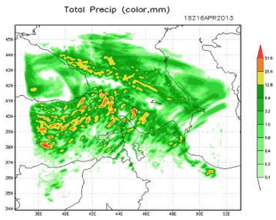
Modules have been developed for converting the requested observed data from the meteorological data repository into LITTLE_R suitable format. In Armenia, the hydrometeorological information is collected every 3 hours (00,03,06,09,12,15,18 UTC) from 48 ground stations distributed over the territory of Armenia (the distribution shown in FIG. 2).

FIG. 2: Distribution of ground stations over the territory of Armenia

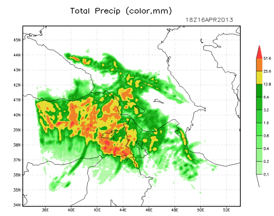
The information received from the ground stations includes real-time data on air temperature, relative humidity, wind speed and direction, pressure and precipitation. Information transmitted from many weather stations has a high quality, which makes crucial the experimental usage of the data. Most of the vertical zones in Armenia are quite well represented by the stations and the number of stations is proportional to the area of each zone. Nevertheless there is a gap in the vertical distribution of the stations, since the zone 2500-3000m above sea level, which occupies about 13% of the entire territory, is not represented by any station. These synoptic data are being used in the gridded analysis data set, which serves as an input for the global atmospheric models to produce weather forecasts at the global scale.

III. RESULTS

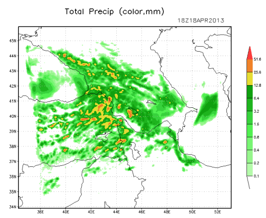
Series of numerical experiments were carried out to examine the impact of data assimilation for the heavy rainfall event. Fig. 3 shows the experimental results of the WRF model with and without data assimilation for 16 and 18 of April, 2013.



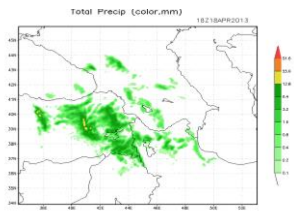
a) 16 April, 2013



b) 16 April, 2013



c) 18 April, 2013



d) 18 April, 2013

FIG. 3: b) ,d) the experimental results of the WRF model with and a),c) without data assimilation.

As it was mentioned, on 16-18 April convective nature of precipitation was observed on the territory of Armenia, particularly during 15-18 GMT of 16 April it was very strong in Lori and Tavush (20- 26 mm), Ararat valley and the foothills (18-19 mm) and Syunik (21-23 mm) regions.

The output of the model without data assimilation for 16 of April shows that maximum amount of precipitation is expected in Gegharkunik 25-30 mm and Vajoc Dzor region 12-25мм. Meanwhile data assimilation had an important impact on forecasting accuracy showing the maximum value in Tavush, Lori regions and Ararat Valley which is more close to the actual data. The result is not satisfied for the Sjuniq Region, which can be explained by the complicity of terrain orography.

On April 18, the output of the model shows abundant precipitation in Tavush and Shirak (25-50 mm) and relatively low precipitation in other regions (3 - 13 mm). In the mean time the model output with the data assimilation shows low precipitation (4 mm) in the Gegharkunik, Syunik and Lori regions, and the rest of the regions without any precipitation. In such a case the forecast is very close to the actual data (see table 1).

Name of the Region	16 15-18z	18 15-18z
Dilijan	20	0.8
Bagratashen	25	0
Stepanavan	20	4
Ananun lernancq	8	2
Shorja	5	0
Sisian	20	0.5
Jermuk	13	5
Ashotsk	2	0
Masrik	4	0
Jermuk	13	0.4
Sisian	20	2
Yerevan	17	0
Aparan	2	0

Table 1: Actual precipitation data

IV. CONCLUSIONS

The simulation results without the obsgrid assimilation for April 18 over the Geghama and Aragats mountains show more precipitation forecasts, which is explained by the mechanical orography calculations. The studies show that data assimilations significantly improves the forecasting of convective processes by decreasing the mechanical impact of orography. The impact of satellite data assimilation has been started to carry out.

V. ACKNOWLEDGMENTS

This work was supported by the Armenian Government through the project ArmGrid ("Deployment of a National e-Infrastructure for Disaster Risk Management").

VI. REFERENCES

Second National Communication of the Republic of Armenia under the United Nations Framework Convention on Climate Change. 2010. Ministry of Nature Protection of the Republic of Armenia. 132 p.

Michalakes, J., J. Dudhia, D. Gill, J. Klemp and W. Skamarock: Design of a next-generation regional weather research and forecast model: Towards Teracomputing, World Scientific, River Edge, New Jersey, 1998, pp. 117-124.

Kain, J. S., Fritsch, J. M., Convective parameterization for mesoscale models: The Kain–Fritsch scheme. The Representation of Cumulus Convection in Numerical Models, Meteor. Monogr., No. 24, Amer. Meteor. Soc., 165–170, 1993.

H. Morrison, G. Thompson, and V. Tatarskii, Impact of cloud microphysics on the development of trailing stratiform precipitation in a simulated squall line: comparison of one- and two-moment schemes, Monthly Weather Review, vol. 137, no. 3, pp. 991–1007, 2009.

S. Hong, V. Lakshmi, E. Small, et al. Effects of vegetation and soil moisture on the simulated land surface processes from the coupled WRF/Noah model, J. Geophys. Res., 2009, 114(D18): D18118.

A. Lacis, J. Hansen, A parameterization for the absorption of solar radiation in the earth's atmosphere. J. Atmos. Sci., 31, 118-133, 1974.