Prediction of hydrometeorological hazardous events in Armenia through implementing WRF-ARW physics sensitivity experiments: a case study for a persistent surface inversion event in Armenia as simulated by WRF model

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Background/Motivation (2/2)

- Armenia due to its complex mountainous terrain and geographical location is exposed to various types of hydrometeorological hazardous events, among those it is worth noting heat and cold waves, heavy rainfall, strong winds, hailstorm, snowfall, frosts, etc.
- These hazards often lead to disasters, causing big economic and human loss.
- In order to be prepared to mentioned hazards and prevent population from disasters it is vitally important to produce accurate forecasts and issue warning with sufficient lead time.
- Armenian State Hydrometeorological and Monitoring Service, Ministry of Emergency Situations uses hydrometeorological products, e.g. synoptic maps, forecasts produced by various sophisticated global models operated by Global Producing Centres (GPC) to prepare weather forecasts for Armenia

WRF deployment

- Within the framework of the state program a joint team of leading specialists from ASHMMS (MES) and the IIAP (NAS) started the deployment of the Weather Research and Forecasting (WRF) numerical weather prediction model for the territory of Armenia, which is a next-generation mesoscale forecast model and assimilation system
- Since this system requires huge number of parallel computations, it uses the available computational resources of Armenian National GRID Infrastructure (ArmNGI), which consists of primarily computational (about 500 cores) and storage resources, located in the leading scientific research and educational organizations of Armenia

WRF deployment

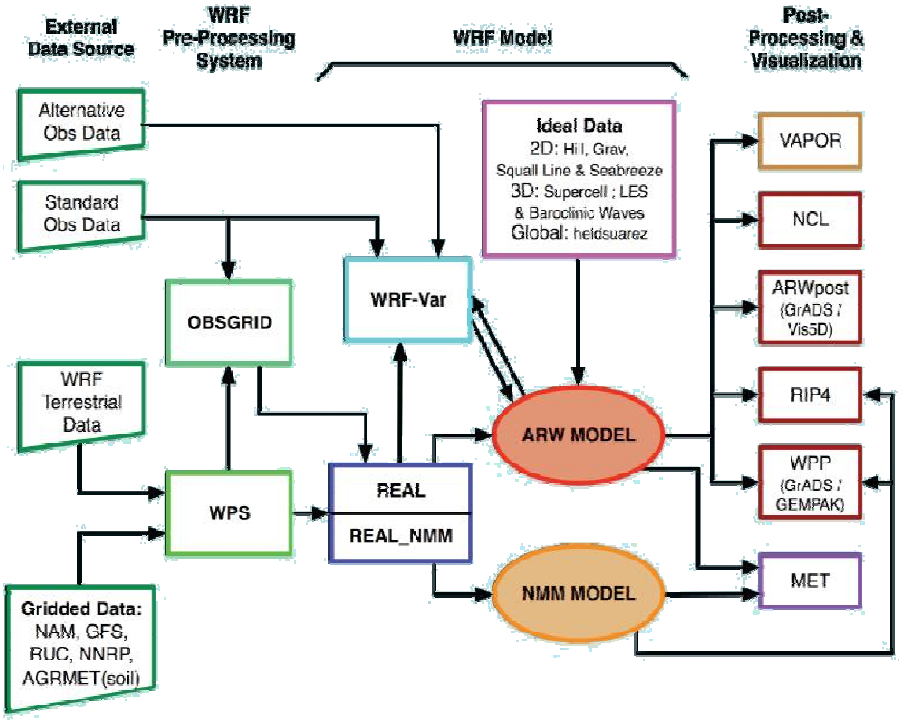
The WRF Modeling System consists of three major parts

- The WRF Preprocessing System (WPS)
- WRF with Advanced Research WRF (ARW), and/or Non-hydrostatic Mesoscale Model (NMM) core
- Post-processing and Visualization tools

In the current system ARW core is used

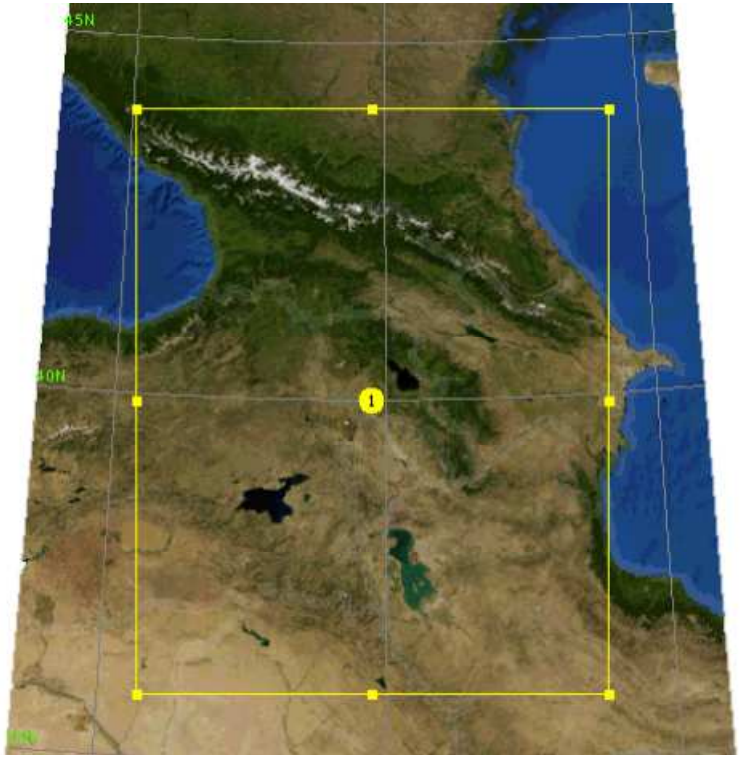
The system automatically downloads the required input data from NCEP (USA) and using ArmNGI resources does the calculations required for weather prediction

The system takes under consideration the local meteorological data and produces prediction



WRF deployment

- An ARW simulation involves one outer grid and may contain multiple inner nested grids. Each nested region is entirely contained within a single coarser grid (the parent grid).
- The spatial resolution of parent domain is 6km, nested domain is 2 km, with 27 vertical levels
- Model is run twice per day producing forecast for the next 72 hours.
- These results are quite promising, and ...is supposed to further improve the outputs, through
  - implementing physics sensitivity experiments and
  - applying data assimilation technique using 3D-VAR package

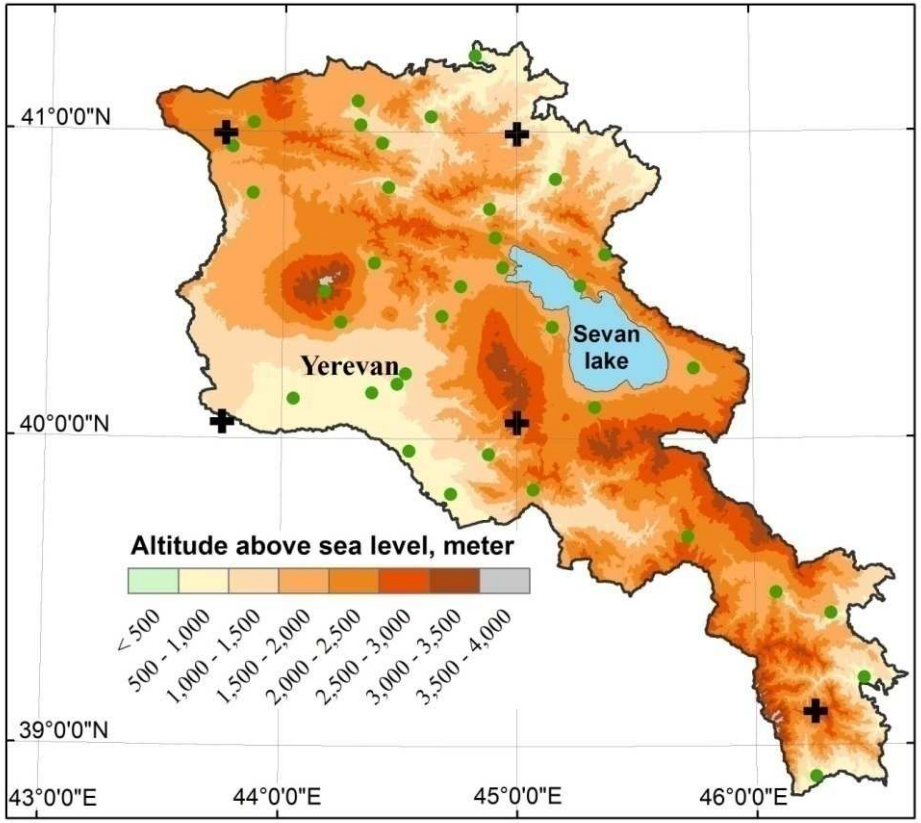


WRF physics parameterization

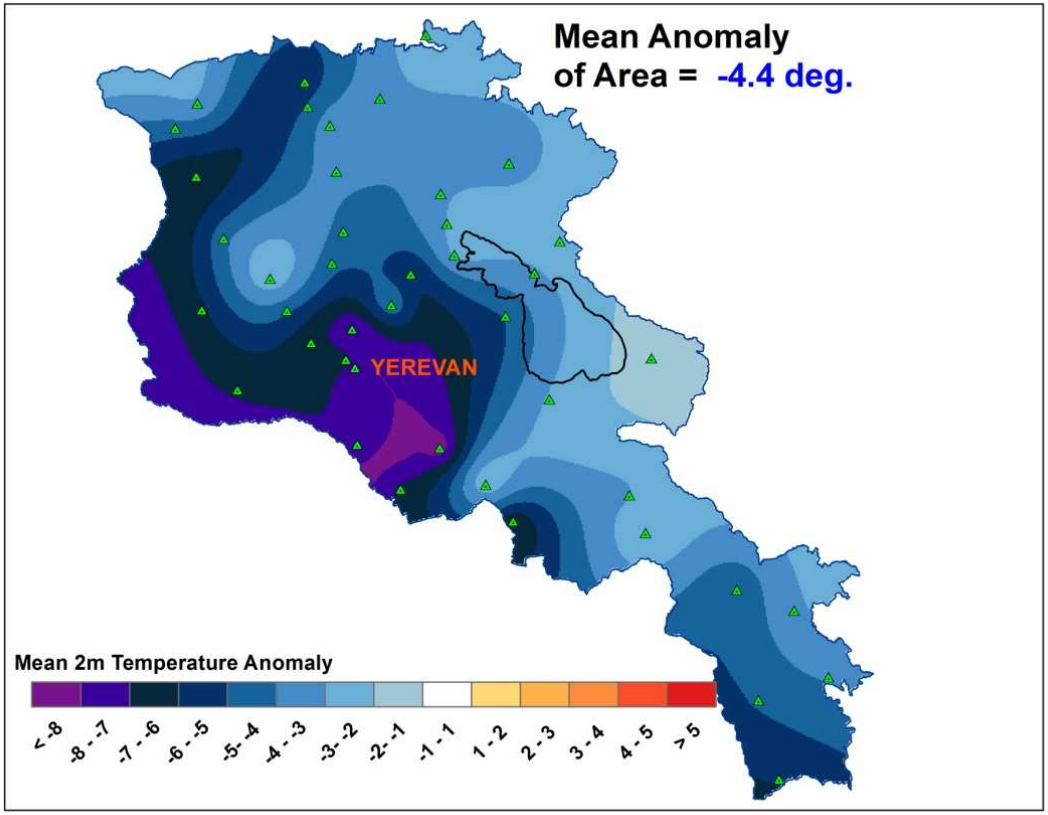
- Microphysics
  - water vapor, clouds, precipitation
- Cumulus parameterizations;
- Surface physics;
- Planetary boundary layer physics
  - turbulences in boundary layer and in free atmosphere
- Atmospheric radiation physics
  - long wave radiation physics
  - short wave radiation physics

Armenia experienced the second coldest December in 2013 since 1961

Topography map of Armenia

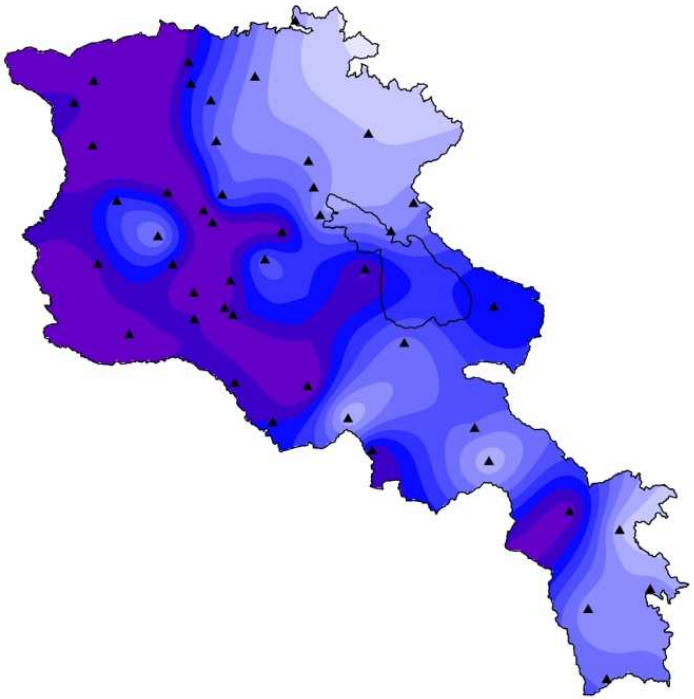


Observed monthly temperature anomaly in Armenia in December

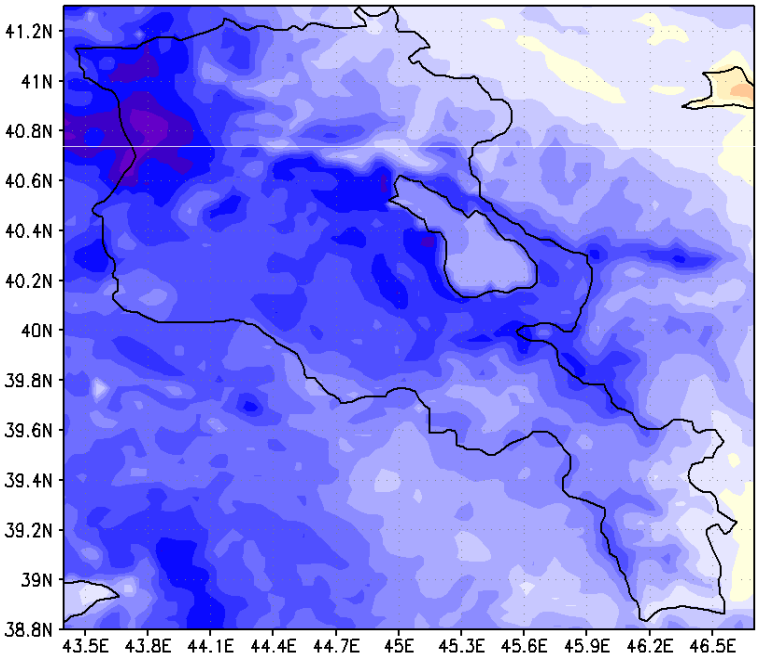


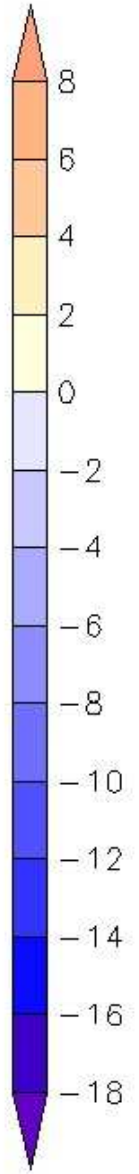
2 metre temperature distribution in Armenia at 0300 UTC averaged for 29-31 of December, 2013 observed data (a), 3-hour forecasts from WRF model (b)

(a)



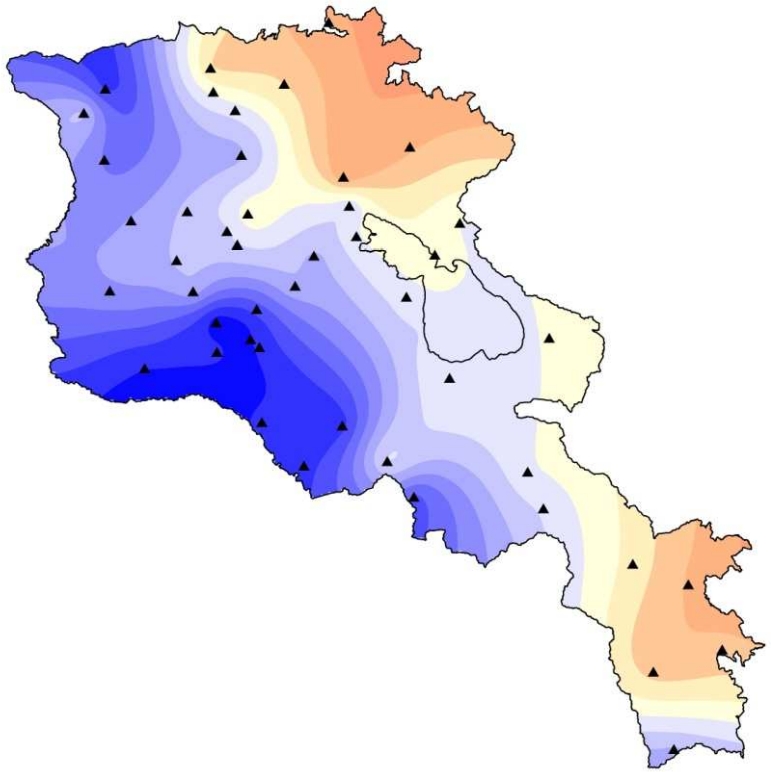
(b)



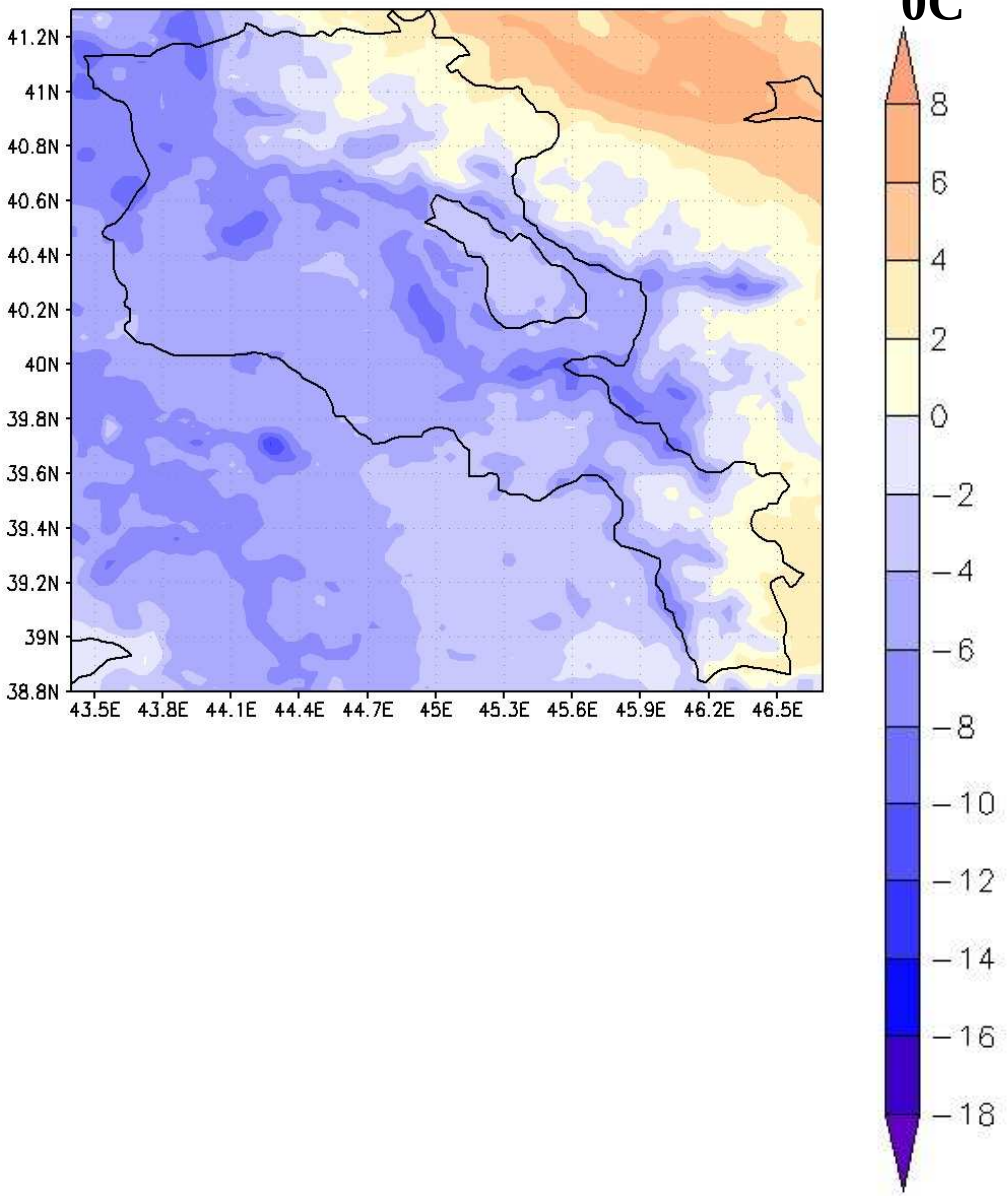


2 metre temperature distribution in Armenia at 1200 UTC averaged for 29-31 of December, 2013. Observed data (a), 12-hour forecasts from WRF model (b)

(a)

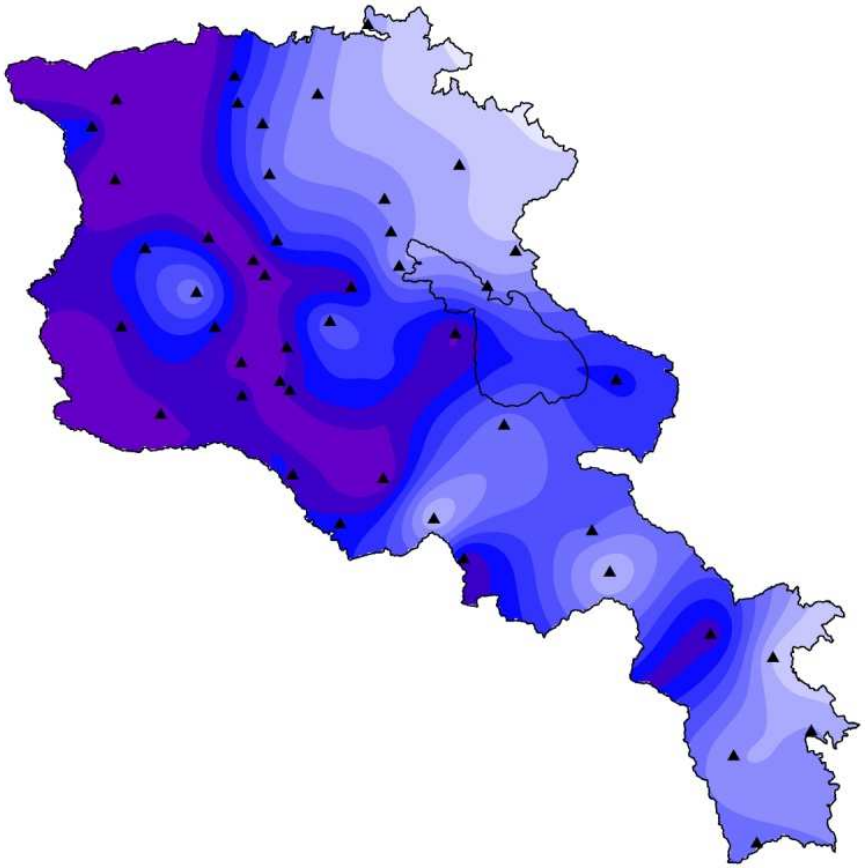


(b)

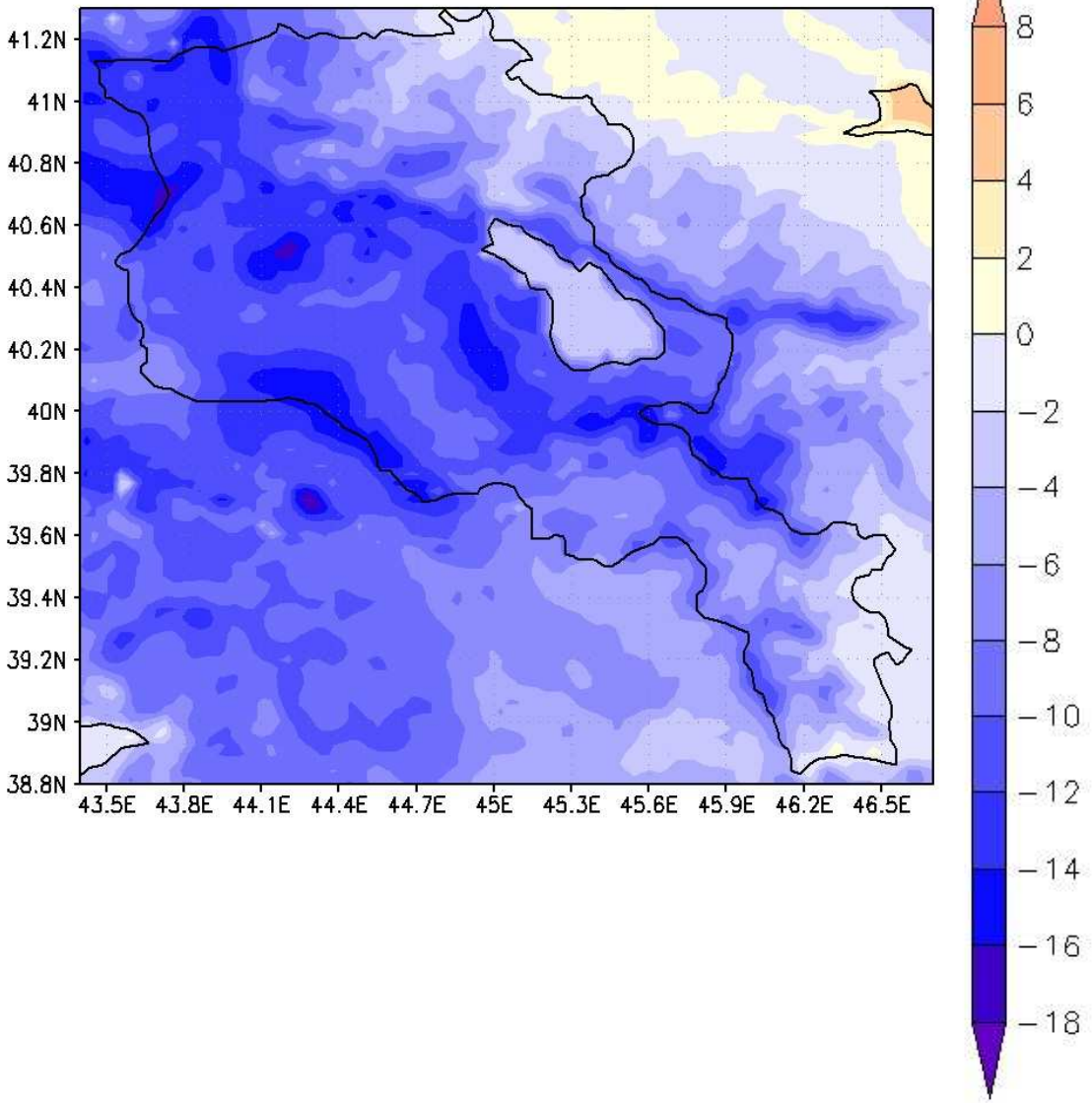


2 metre temperature distribution in Armenia at 0000 UTC averaged for 29-31 of December, 2013. Observed data (a), 24-hour forecasts from WRF model (b)

(a)



(b)



CONCLUSIONS

- Prediction of hazardous hydrometeorological phenomena for Armenia is a challenging task.
- Weather Research and Forecasting (WRF) numerical weather prediction model, which is a next-generation mesoscale forecast model and assimilation system has been implemented, which advances both the understanding and the prediction of mesoscale precipitation systems and promotes closer ties between the research and operational forecasting communities.
- The results from this case study show that high resolution WRF model has a clear advantage over ERA-Interim model in representation of spatial temperature pattern in Armenia associated with topography influence.

CONCLUSIONS

- **However, it should be noted that there are significant uncertainties and errors in WRF temperature forecasts as can be seen from the verification results. Significant RMSE values and negative correlation coefficients were obtained for the area covering inversion basin.**
- **An even finer grid is necessary to resolve the detailed topography and to correctly simulate local processes. An accurate modeling of the planetary boundary layer (PBL) over finescale orography is particularly important for the studied process. Future work should test the model sensitivity to various parameterizations such as the PBL physics and verification of other surface meteorological elements (pressure, wind, humidity) and vertical profiles of temperature, wind and humidity during this dramatic inversion event in Armenia.**

Way Forward

- This is one of the first attempts for this kind of experiments with quite promising results.
- It is planned to
  - continue the experiments changing also other physics parameterization options
  - applying data assimilation technique
- The outcomes will serve as a basis for solving various application issues (environment, agriculture, water resources, etc.)

Thank You for Attention !