Development of an Advanced WRF NWP System for Arabian Peninsula

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1. Introduction
Arabian Peninsula, sandwiched between vast continental land masses of Africa and Asia and bordered by the Red Sea to the west, the Persian Gulf to the east, and the Indian Ocean to the south, is one of hottest and sunniest region in the world largely because of the unique landscape and the dominance of the subtropical high atmospheric pressure system. Extreme temperature and precipitation can sometimes pose serious risks to regional life, infrastructure, and the economy. Hazards like the 2010 heat wave, the November 2009 flood in Jeddah, and frequent sand-dust storms (SDS) are of societal concern. Advancing accuracy of routine and various high-impact weather and climate prediction has been a pressing issue and of great regional interest. RAL/NCAR is developing an integrated weather and SDS forecasting system centered at the Weather Research and Forecasting (WRF) model aiming for Arabian Peninsula weather, flash flooding and SDS forecasting, and early warning.

2. WRF NWP System
The WRF model is a community model for mesoscale and microscale weather and climate forecasting developed at the National Center for Atmospheric Research (NCAR) in collaboration with federal agencies and universities. The Research Applications Laboratory (RAL) of NCAR has extended the WRF model to an end-to-end forecasting system specially for real-time operates. Besides the WRF model, the end-to-end real-time forecasting system features:
- Conventional and remote sensing observational data collection, processing, quality control
- Hybrid data assimilation with 4-dimensional observational nudging (RTFDDA) and 3dVar
- Ensemble real-time four-dimensional data assimilation (E-RTFDDA) and forecasting
- GUI-based post-processing, bias correction, graphics and visualization
- Customized model configuration and forecast products

3. Configuration for Arabian Peninsula and Forecast Snapshots
- Three nested domains at 21.6, 7.2 and 2.4 km grid spacing, 40 vertical levels
- NCEP 0.5DEG GFS4 for Initial and lateral boundary conditions
- Conventional and remote sensing data for data assimilation
- WRF physics: WSM6, MYJ, RRTMG, Grell 3D, Noah land model
- Four forecasts per day up to 72 hours

4. Simulating Extreme Rainfall Events
On the 25th of November 2009, heavy rain poured in Jeddah, Saudi Arabia’s major city on the red sea beach. The reported four-hour precipitation was about 100 mm, and resulted in the worst flood in 30 years.

5. Summary
A WRF-based operational NWP system has been developed for the subtropical Arabian Peninsula. The unique geography and desert climate with high-impact intermittent precipitation, and sparse observational network, and high-frequent erratic observations bring large challenges for data quality control and data assimilation. Numerical experiments have been conducted for the regional prevailing weather regimes and extreme events to aid the forecasting system development and configuration optimization. Evaluation of both day-to-day forecasts and extreme event simulations demonstrate the high skills and robustness of the forecasting system. Further evaluation and optimization are ongoing.

For the capability of sand and dust prediction please see Zhang et. al (P15 in chemistry session of this WRF Users’ Workshop).