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A comparison study of the application of data assimilation in the short-term prediction of radiation and precipitation

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Abstract. Based on the meteorological observation of the DG plants in East China, the assimilation effect of the WRF in the summer of 2016 was studied. The results show that, in the case of using data assimilation, the model correctly predicted the occurrence time of precipitation, as well as the variation of the precipitation along with the time were well consistent with the observations, which gives more accurate downward shortwave radiation. The application of data assimilation techniques can provide reliable information to adapt to the high resolution of meso-scale meteorological model. Therefore, it provides the necessary technical support for the development of the distributed power generation.

1. Introduction

Numerical weather prediction (NWP) is playing an increasingly important role in improving the accuracy of daily meteorological service [1]. It is essentially an initial value problem about the NWP. Therefore, data assimilation is always a key problem in NWP [2]. In the PV power forecasting, the most important issue will be the accuracy and the time horizon of the global normal irradiance(GNI) forecasting, which is currently provided by NWP [3],[4]. Weather situation and cloud-free/rainfall prediction play the high value on the PV power forecasting using statistical methods, the accuracy of the weather pattern has a great impact on the statistical forecasting model [5]-[7]. On hydrological forecasting and hydropower dispatching, the precipitation is also key matter of great concern to the analysis of water regimen and flood [8],[9]. Scholars usually use NWP to improve the effect of flood forecasting. For NWP, how to improve the model accuracy through various data assimilation methods has been studied a lot [10]-[13], such as the using of satellite data, radar data and ground automatic weather stations, etc, to reduce initial field errors in the meso-scale meteorological model and improve the performance. These works have laid a good foundation for the application of NWP. This paper compares the data assimilation effects of short-term forecasts of wind and precipitation, relate and analyze the positive role of data assimilation technology and the feasibility of application in clean energy utilization.

2. Methods and data

In this case, the NWP scheme uses meso-scale model WRF(Weather Research and Forecast), which is supported by the National Center for Atmospheric Research and other departments. The WRF system established a new generation of meso-scale forecasting and data assimilation model. The WRF system studied in the meso-scale model MM5 based on meso-scale weather system and real-time prediction



for the purpose of the development of a new generation of non energy meso-scale model, structure and evolution can reveal the small-scale system [14],[15].

Background field data for WRF system are obtained using the GFS(globe forecast system) data from the National Center of Environment Prediction, 0.5 degree resolution.

In this paper, the numerical experiment scheme is to compare the objectivity of WRF system outputs before and after data assimilation.

Data assimilation scheme adopts WRFDA(Data Assimilation system for the Weather Research and Forecasting model) . As a module of WRF model system, the main frame of WRFDA is consistent with WRF mode, and can be seamlessly connected with WRF mode, which provides users with a convenient and effective data assimilation scheme [16]. The flow chart of WRFDA module is shown in Figure 1, including OB/SPROC, gen_be, UPDATE_BC, and WRFDA units.

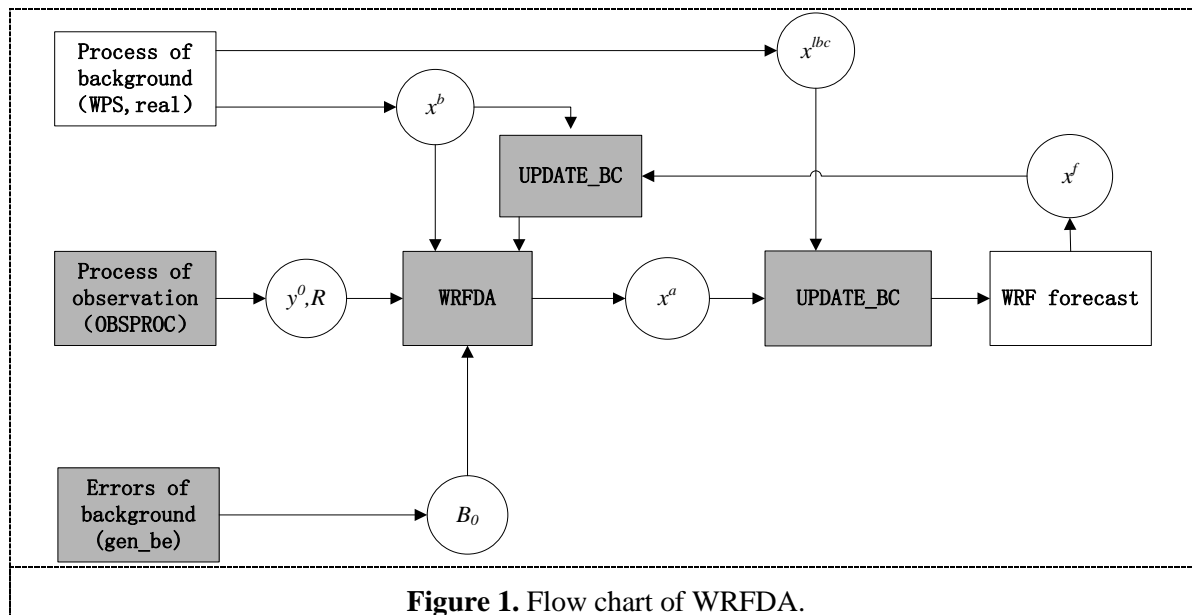


Figure 1. Flow chart of WRFDA.

Measured data were recorded by 70 meteorological stations in Jiangsu province, including 24h accumulated precipitation, atmospheric pressure, surface temperature, relative humidity, etc. This paper mainly used the precipitation data, the reason is that the accuracy of precipitation is regularly regarded as the most important item to evaluate the reliability of meso-scale numerical weather prediction model [17],[18].

3. Numerical experiment

In order to evaluate the effect of data assimilation on model prediction accuracy, we designed a set of experiments. First, using the GFS data to provide the boundary and initial conditions to run WRF model with three nested domains method(GFS-WRF). Second, using the meteorological observation of the DG plants and WRFDA module to modify the initial conditions, and run WRF model with nested domains, too. The forecast scope of the two is China, the three nested resolutions are 27km, 9km, 3km, and forecast prescription are all 24h. The time of this experiments is from June 21, 2016 to 23, during which there was a significant precipitation in Jiangsu Province.

3.1. Description of the weather process

During June 21, 2016 to 23, the 24h accumulated precipitation of Jiangsu Province which were reached the extreme rain magnitude as shown in Figure 2. As shown in Table 1, the highest daily rainfall record reached 168.6mm. Fifteen point seven percent of the meteorological stations precipitation reached the storm magnitude in June 21, and thirty percent in June 22, twenty four point three percent in June 23. Significant precipitation processes are bound to affect flood prevention and DG utilization. Therefore, in this experiments, we tried to compare the differences in prediction

performance before and after data assimilation, by analyzing the spatial and temporal distribution differences of precipitation and radiation.

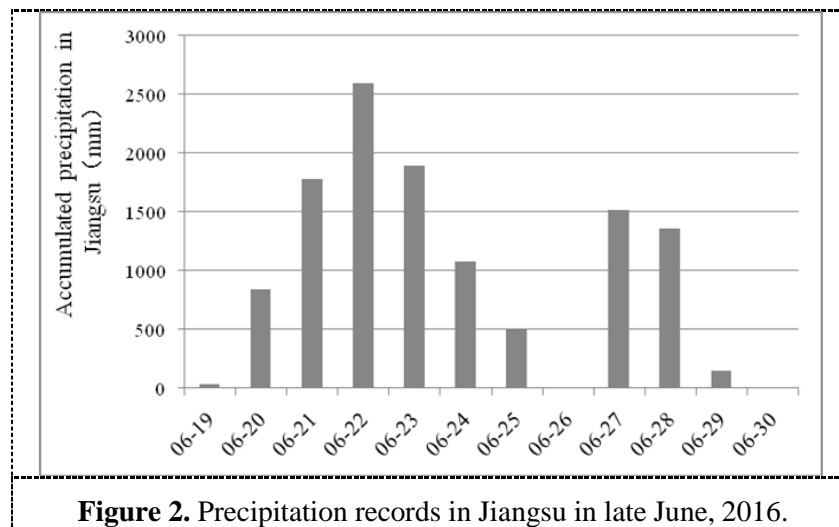


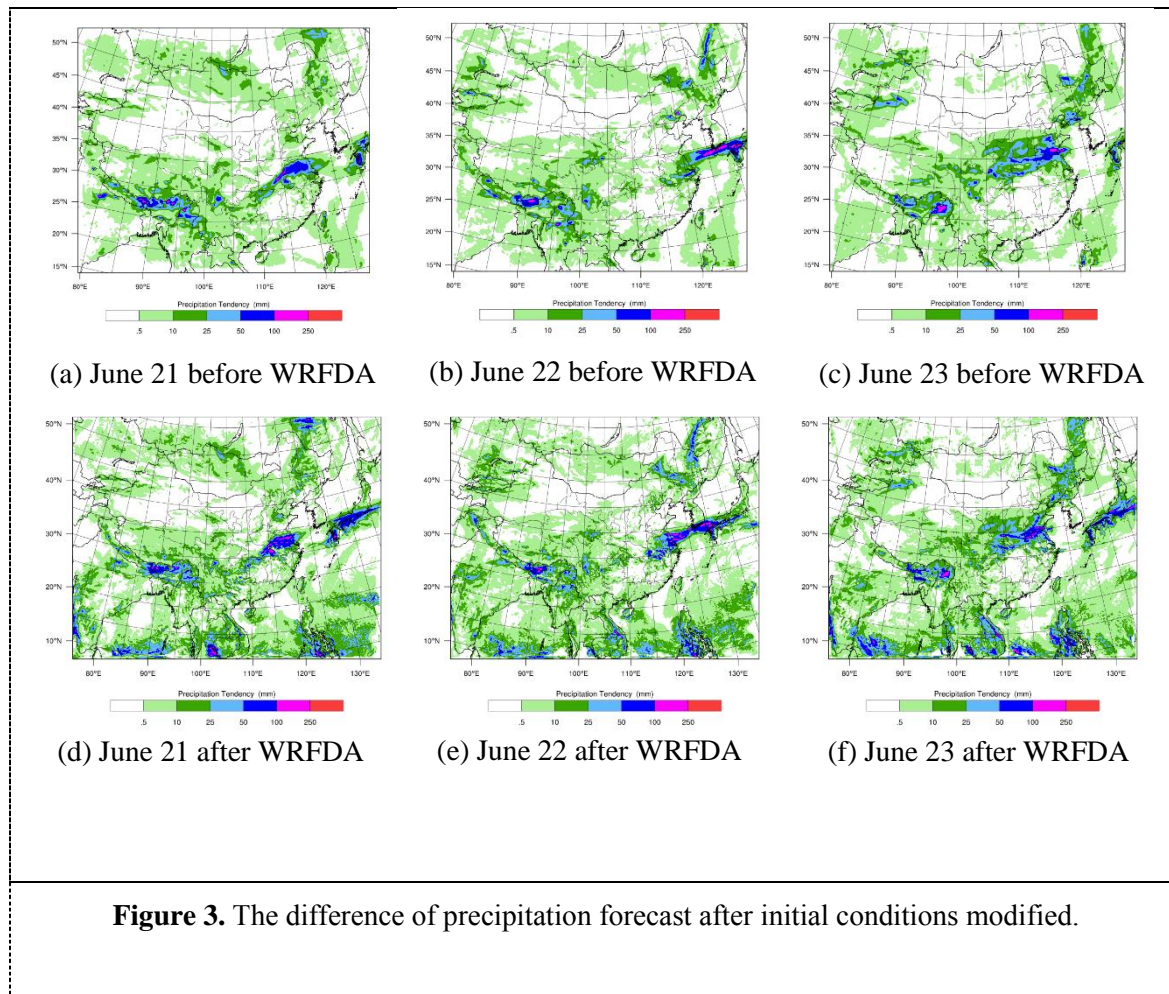
Figure 2. Precipitation records in Jiangsu in late June, 2016.

Table 1. Analysis of daily accumulated precipitation in late June, 2016.

Date	Station numbers (Accumulated Precipitation > 100mm)	Station numbers (Accumulated Precipitation > 50mm)	Accumulated Precipitation record (mm)
06-19	0	0	16
06-20	0	7	83.3
06-21	7	11	168.6
06-22	7	21	161.4
06-23	5	17	166.5
06-24	0	1	57.5
06-25	0	0	35.6
06-26	0	0	0.3
06-27	0	8	69.2
06-28	2	17	128.6
06-29	0	0	24.5
06-30	0	0	0.1

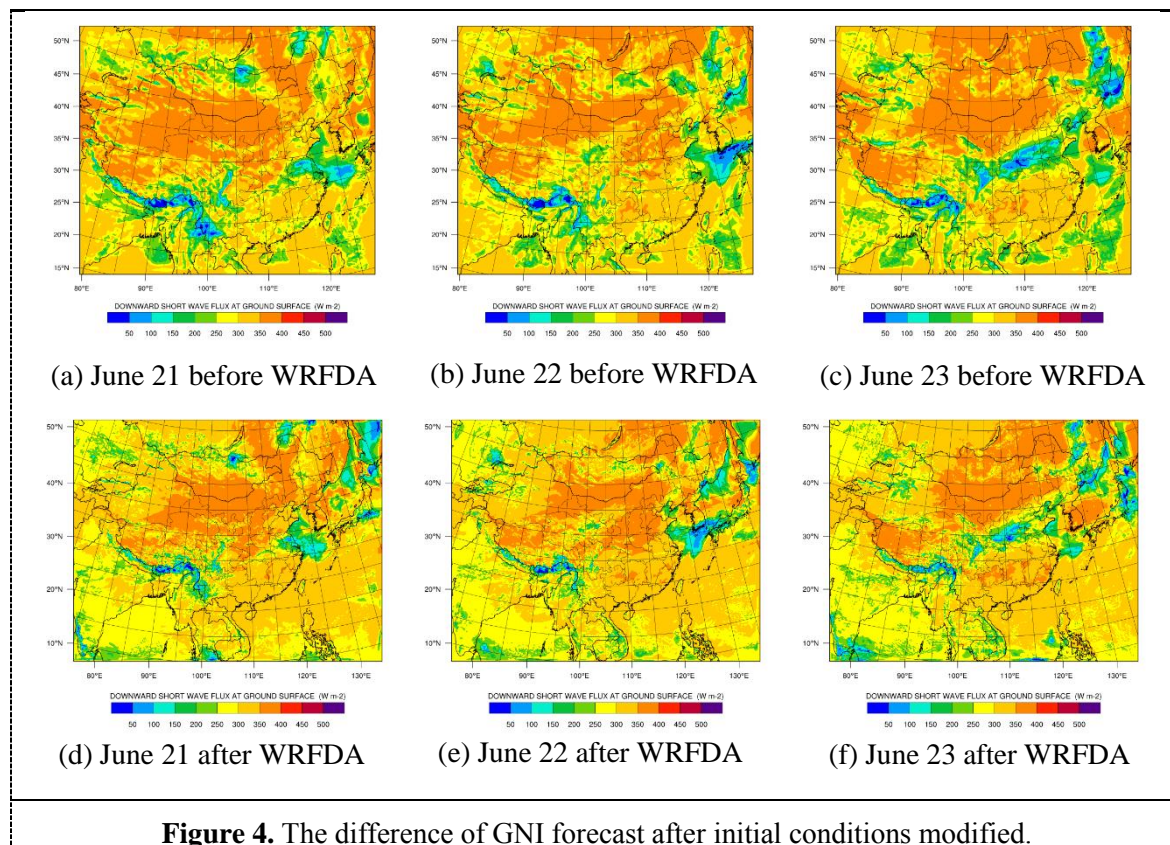
3.2. The improvement of the 24h precipitation forecasting

The experimental results show that the precipitation forecast of GFS-WRF is generally small from June 21 to 23. As shown in Figure 3 (a), (b) and (c), precipitation in Jiangsu Province was only large to rainstorm magnitude during these days, significantly lower than the actual precipitation record. After data assimilation, it can be clearly found in Figure 3 (d), (e) and (f) that the position and intensity of precipitation is more in line with reality. The modification of the WRF initial condition makes the more accuracy intensity of precipitation, especially in June 21. In June 22, GFS-WRF outputs shown the rain belt location has obvious eastward deviation, and northward deviation in June 23.



3.3. The improvement of the 24h GNI forecasting

Downward short wave solar radiation at ground surface is the main source of the earth's energy. It is crucial to the surface radiation balance, energy exchange, hydrological cycle, vegetation photosynthesis, and the formation of weather and climate [19],[20]. GNI is the main form of Downward short wave solar radiation, and it's the most important influential factor of PV power generation [21]. During this precipitation process, the occurrence of the rainstorm caused a low value center of irradiance in northern part of Jiangsu Province, and the daily average GNI was at a quit lower level in the whole area which was influenced by this heavy rain event. As showed in Figure 4 (a),(b),(d),(e), we can find very obvious consistency, either before or after data assimilation in June 21 and 22. This shows that although the data assimilation module implements the revision of WRF initial conditions, it is not significant in the field of GNI prediction. In June 23, the modification of WRF initial conditions is very obvious, which is shown in Figure 4 (c),(f). The difference is before the data assimilation, the low value center of irradiance is quit wide coverage, and the value of daily average DNI in northern Jiangsu is generally at 200-250 W/m². After data assimilation, the spatial distribution of daily average DNI in June 23 became more sophisticated, only a fraction of the northern Jiangsu appears minimum value which is below 250 W/m².



4. Conclusion

This paper used the meteorological observation of the DG plants in East China as data assimilation data, discussed the assimilation effect of the WRF in the summer of 2016, and compared the objectivity of WRF system outputs before and after data assimilation. The performance of the WRFDA outputs shows that the improvements of data assimilation is quite obvious, especially in the rain forecast. WRF model correctly predicted the occurrence time of precipitation, the variation of the precipitation along with the time were well consistent with the observations, the performance of downward shortwave radiation by using data assimilation. After WRF data assimilation, rain storm and heavy rain was better predicted in parts of late June 2016. The influence of the modification of WRF initial conditions in irradiance forecast is not as obvious as rain forecast, and the irradiance measurement station is quit few, the effect of the data assimilation experiment may need further study. The application of data assimilation techniques can provide reliable information to adapt to the high resolution of meso-scale meteorological model. If there have more data assimilation data, we could get the better forecasting results. Therefore, it provides the necessary technical support for the development of the distributed power generation.

5. References

- [1] Li Chongyin, Huang Hongyan, Chen Chaohui, Gui Fayin 2013 *The Theory and Research Progress of Hybrid Data Assimilation. Transactions of Atmospheric Sciences (in Chinese)*. **30**(4) 343-384.
- [2] Cheng Xinghong, Liu Ruixia, Shen Yanbo, et al. 2014 *Improved method of solar radiation simulation under cloudy days with LAPS-WRF model system based on satellite data assimilation. Chinese Journal of Atmospheric Sciences (in Chinese)*. **38**(3) 577-689.
- [3] Marseille G J, Barkmeijer J, Haan S D, Verkley W 2016 *Assessment and Tuning of Data Assimilation Systems Using Passive Observations. Quarterly Journal of the Royal Meteorological Society*. **142** 3001-3014.

- [4] Diagne M, David M, Lauret P, Boland J, Schmutz N 2013 *Review of solar irradiance forecasting methods and a proposition for small-scale insular grids. Renewable and Sustainable Energy Reviews.* **27** 65-76.
- [5] Lima F J L, Martins F R, Pereira E B, Lorenz E, Heinemann D 2015 *Forecast for surface solar irradiance at the Brazilian Northeastern region using NWP model and artificial neural networks. Renewable Energy.* **87** 807-818.
- [6] Cornaro C, Pierro M, Bucci F 2015 *Master optimization process based on neural networks ensemble for 24-h solar irradiance forecast. Solar Energy.* **111** 297-312.
- [7] Mathiesen P, Collier C, Kleissl J 2013 *A high-resolution, cloud-assimilating numerical weather prediction model for solar irradiance forecasting. Solar Energy.* **92(4)** 47-61.
- [8] Cloke H L, Pappenberger F 2009 *Ensemble flood forecasting: A review. Journal of Hydrology.* **375** 613-626.
- [9] Nam D H, Mai D T, Udo K, Mano A 2014 *Short - term flood inundation prediction using hydrologic - hydraulic models forced with downscaled rainfall from global NWP. Hydrological Processes.* **28(24)** 5844-5859.
- [10] Courtier P E, Anderson W, Heckley J, et al. 2015 *Comparison of Hybrid-4D-EnVar and Hybrid-4D-Var Data Assimilation Methods for Global NWP. Monthly Weather Review.* **143** 212-229.
- [11] Bouttier F, Kelly 2001 *Observing-system experiments in the ECMWF 4D-Var data assimilation system. Quarterly Journal of the Royal Meteorological Society.* **127** 1469-1488.
- [12] Wu Shenggang, Liu Qimin, Zou Xiaolei, Wu Guoxiong 2016 *The simulation analysis of the precipitation over the southern slopes of the Tibetan Plateau based on WRF model. Acta Meteorologica Sinica (in Chinese).* **74(5)** 744-756.
- [13] Xue Chenbin, Chen Xian, Wu Yu, et al. 2017 *Application of Radar Data Assimilation in Local Severe Convective Weather Forecast. Chinese Journal of Atmospheric Sciences (in Chinese).* **41(4)** 673-690.
- [14] Powers J G, Klemp J B, Skamarock W C, et al. 2017 *The Weather Research and Forecasting (WRF) Model: Overview, System Efforts, and Future Directions.*
- [15] Z I Janjic 2004 *The NCEP WRF Core 2004 National Centers for Environmental Prediction, Camp Springs, Maryland.*
https://www.researchgate.net/publication/228600170_The_NCEP_WRF_core.
- [16] Chen Yaodeng, Chen Xiaomeng, Zeng Lamei, Wang Hongli, Wang Yuanbing 2016 *Influence of background sample error simulation on data assimilation and forecast. Plateau Meteorology (in Chinese).* **35(3)** 767-776.
- [17] B Casati, L J Wilson, D B Stephenson, et al. 2008 *Review forecast verification: Current status and future directions. Meteorological Applications.* **15(3)** 3-18.
- [18] Pan Liujie, Zhang Hongfang, Wang Jianpeng 2014 *Progress on verification methods of numerical weather prediction. Advances in Earth Science (in Chinese).* **29(3)** 372-335.
- [19] R T Pinker, B Zhang, E G Dutton 2005 *Do satellite Detect Trends in Surface Solar Radiation?. Science.* **308** 850-854.
- [20] M Wild, H Gilgen, A Roesch, et al. 2005 *From Dimming to Brightening: Decadal Changes in Solar Radiation at Earth's surface. Science.* **308** 847-850.
- [21] S Pelland, J Remund, J Kleissl, T Oozeki, KD Brabandere 2013 *Photovoltaic and solar forecasting: state of the art. IEA PVPS.*

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