Sensitive experiments of a radiation fog case inland based on the deterministic and ensemble forecasts of the WRF hybrid ETKF-3DVAR system

SHENG Chunyan[1], SHI Yuguang[2], LIU Shijun[1]

1. Shandong Provincial Meteorological Institute, Jinan 250031, Shandong province, P.R.China

2. Shandong Provincial Meteorological Bureau, Jinan 250031 , Shandong province, P.R.China

Abstract In order to study the key factors of fog numerical forecast, sensitive experiments of a typical radiation fog inland on 8 November 2016 in Shandong province are conducted based on the operational ensemble forecast system in Shandong Provincial Meteorological Bureau.

Results show that good initial field is the most important for the fog numerical forecast. The hybrid-3DVAR cycle data assimilation can give better initial field for the model, as a result, the fog is improved. In this condition, the effect of the different parameterization schemes of the WRF model is negligible. Relatively the cold start from once hybrid-3DVAR data assimilation can worsen the fog forecast due to the lack of the cloud water information in the initial field. The lateral boundary conditions have less effect on the fog numerical forecast within 12 hours. Suitable parameterization schemes are important for fog numerical forecast when the initial fields are not good enough. According to the experiments in this paper, the suitable boundary-layer scheme for the radiation fog inland is different with that of the sea fog.

Key words WRF hybrid ETKF-3DVAR data assimilation, Radiation fog, Sensitive experiments

The model system:

This system is built on the WRF (Weather Research and Forecasting) model and hybrid ETKF-3DVAR system, which includes 12 and 4 km one-way nested deterministic forecast and 24-member ensemble forecasts of 12 km.

The sensitive experiments are conducted on the 12 km deterministic forecast and the first 4 ensemble members, including the effect of the assimilation initial fields, lateral boundary conditions and different parameterization schemes on of the fog numerical forecast.

Table 1 Physics parameterization schemes of deterministic forecast and the 4 ensemble forecasts

forecasts	microphysics	cumulus	boundary-layer	shortwave radiation	longwave radiation	land-surface
DET	Thompson	BMJ	YSU	Goddard	rrtm	Noah
e001	Thompson	BMJ	YSU	Goddard	rrtm	Noah
e002	Morrison	BMJ	ACM2 (Pleim)	Dudhia	rrtm	Noah
e003	Ferrier	Kain-Fritsch	MYJ	Goddard	rrtm	Noah
e004	Ferrier	BMJ	YSU	Dudhia	rrtm	Noah

Experiments design:

Exp-A: Control experiment is conducted based on the operational system scheme and starts from 20 BJT 7 November 2016 with 12 hours hybrid ETKF-3dvar data assimilation cycle;

Exp-B: Sensitive experiment, forecasts of the four ensemble members with the same initial fields and lateral conditon of control forecast;

Exp-C: Sensitive experiment, same with Exp-B but using the last time lateral boundary condition of 08 BJT 7 November 2016 ;

Exp-D: Sensitive experiment, similar with Exp-B but with cold start of hybrid-3dvar without data assimilation cycle.

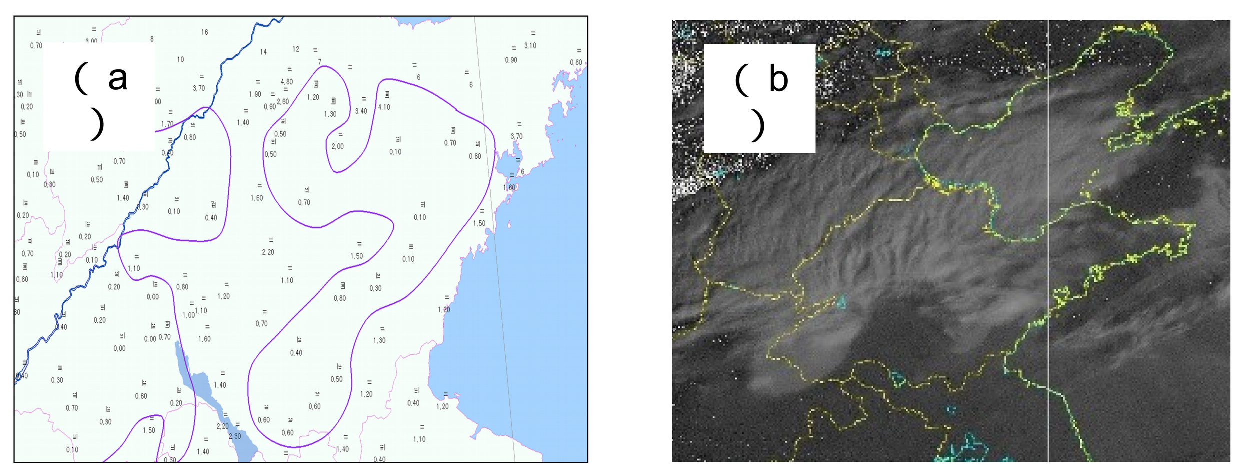

Fig.1 Observation of the surface elements and satellite cloud imagery at 8 BJT 8 November 2016 （a）Visibility observation （b）FY-2G Satellite visible imagery

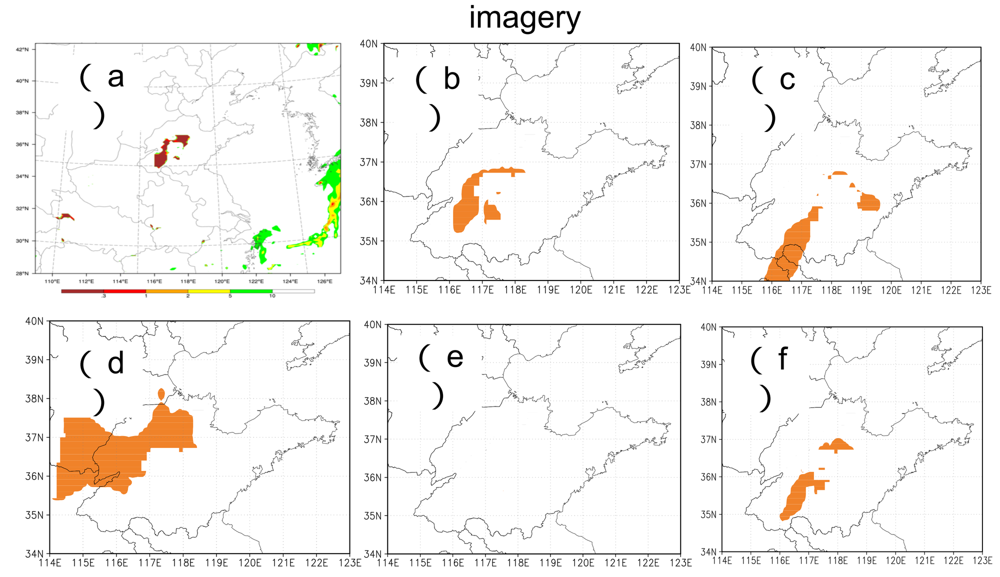

Fig.2 Exp-A experiment fog forecasts at the 8 BJT 8 November (a) visibility forecast of the DET (b) fog area forecast of the DET (c~f) fog area forecasts of e001 to e004

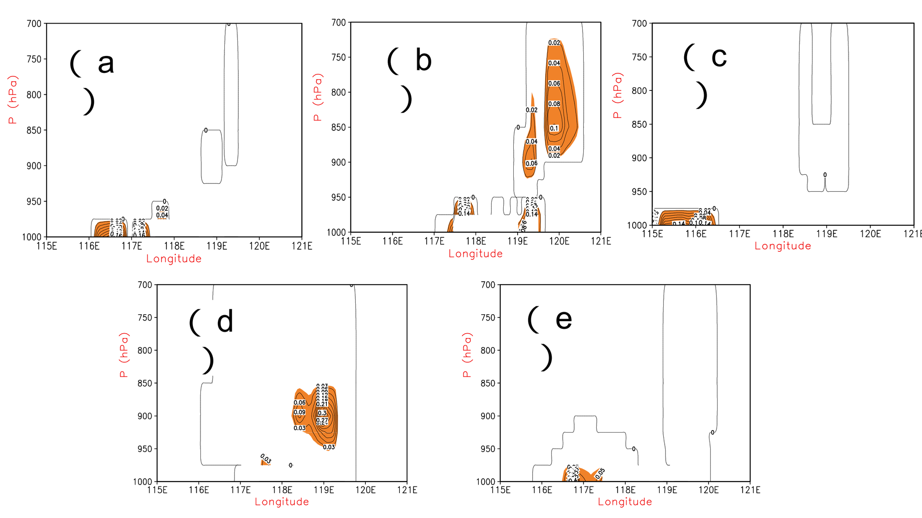

Fig.3 The cross-section along 35.8°N of the cloud water mixing ratio under 700 hPa for forecast fields at 08 BJT 8 November 2016 Exp-A (unit: g•kg^{-1}, shaded is the area of the cloud water mixing ratio exceeding 0.016 g•kg^{-1}) （a）DET （b）e001 (c) e002 (d) e003 (e) e004

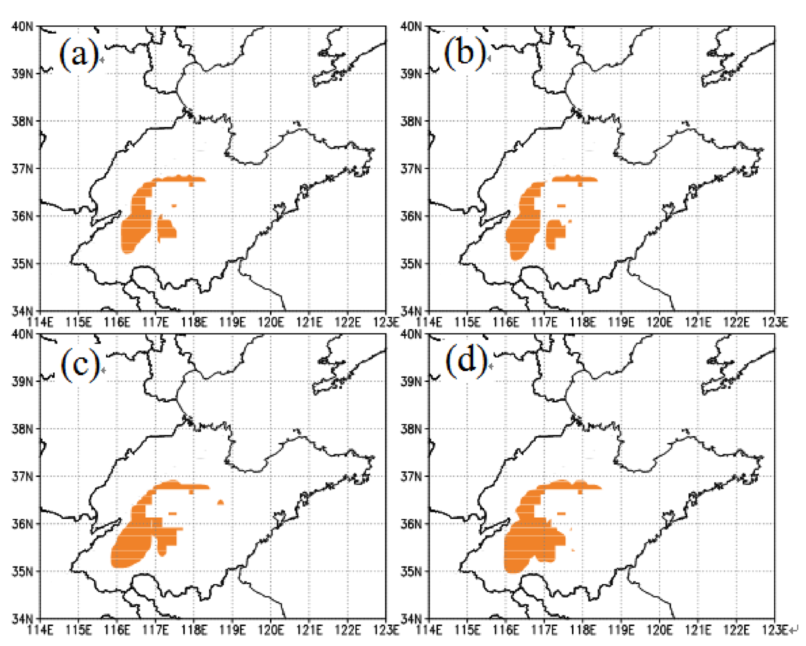

Fig.4 The fog forecasts of the 4 ensemble elements at 08 BJT 8 November 2016 in Exp-B （a）e001 （b）e002 （c）e003 （d）e004

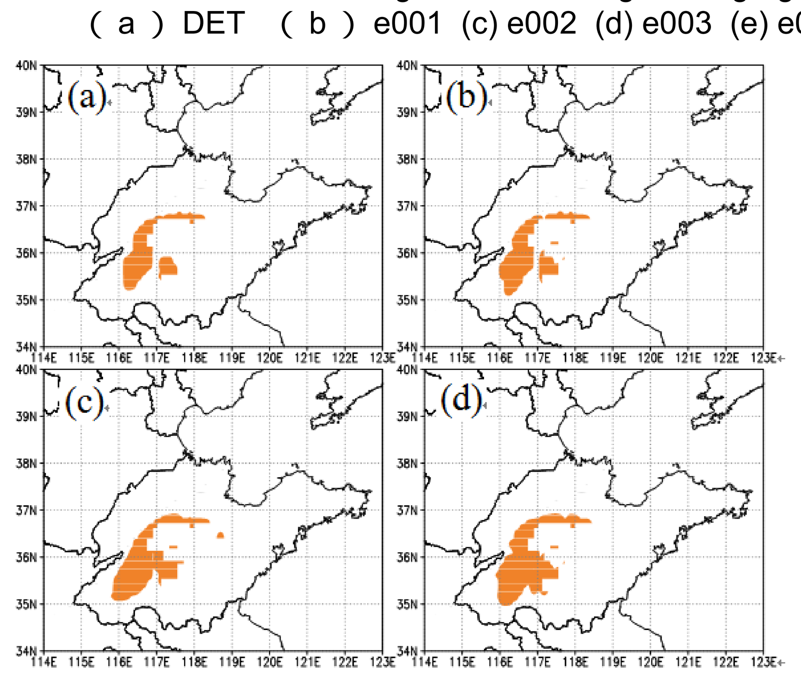

Fig.5 The fog forecasts of the 4 ensemble elements at 08 BJT 8 November 2016 in Exp-C （a）e001 （b）e002 （c）e003 （d）e004

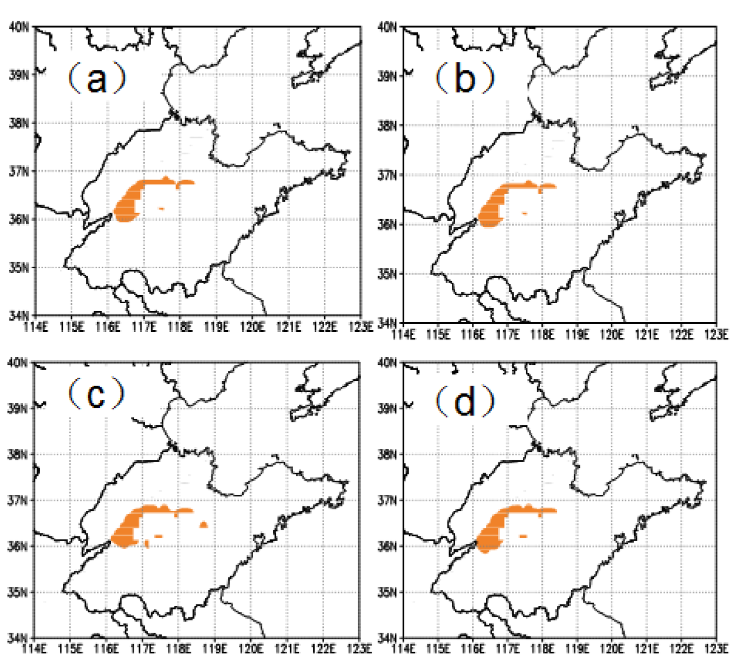

Fig.6 Fog forecasts of the 4 ensemble elements at 02 BJT in Exp-D （a）e001 （b）e002 （c）e003 （d）e004

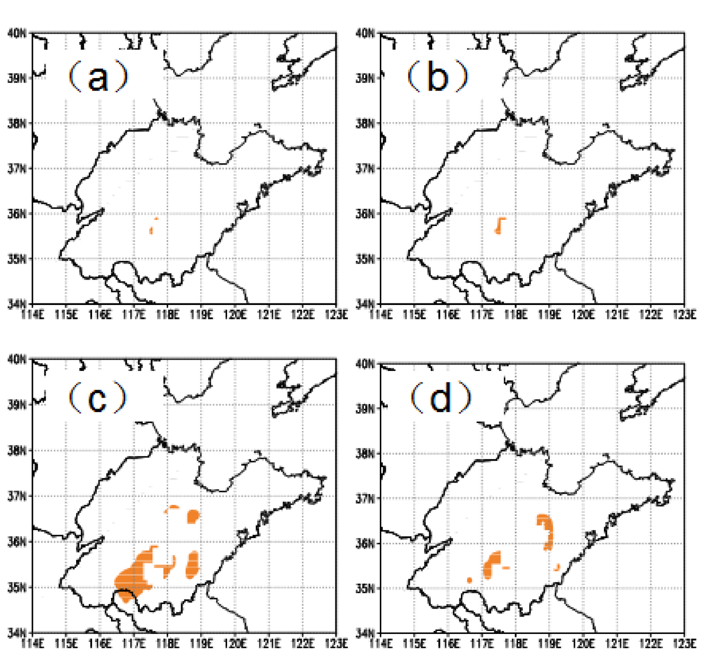

Fig.7 Fog forecasts of the 4 ensemble elements at 08 BJT in Exp-D （a）e001 （b）e002 （c）e003 （d）e004

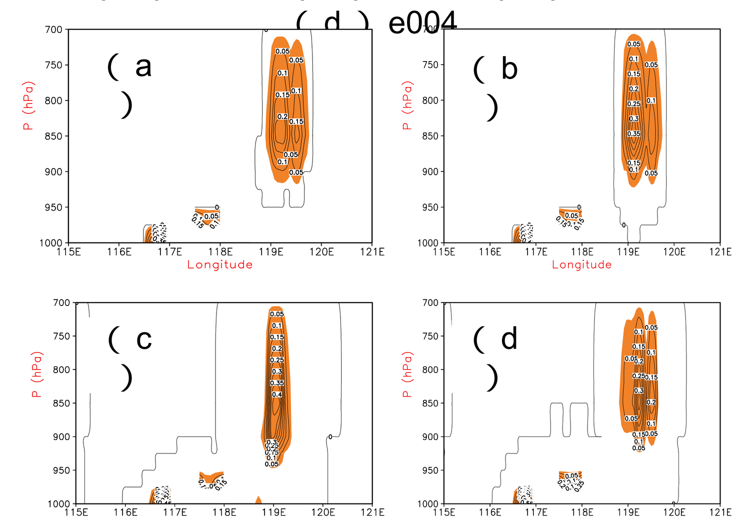

Fig.8 The cross-section along 36.5°N of the cloud water mixing ratio forecasts under 700 hPa for the 4 ensemble elements at 02 BJT 8 November 2016 in Exp-D (unit: g•kg^{-1}, shaded is the area of the cloud water mixing ratio exceeding 0.016 g•kg^{-1}) （a）e001 （b）e002 （c）e003 （d）e004

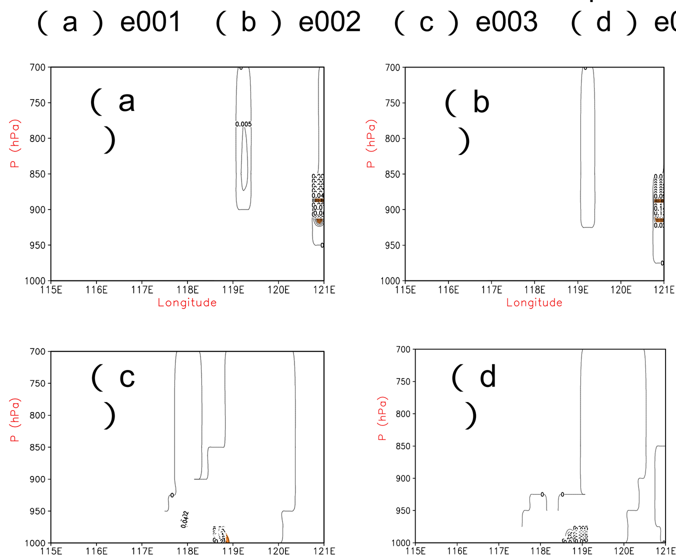

Fig.9 The cross-section along 36.5°N of the cloud water mixing ratio forecasts under 700 hPa for the 4 ensemble elements at 08 BJT 8 November 2016 in Exp-D (unit: g•kg^{-1}, shaded is the area of the cloud water mixing ratio exceeding 0.016 g•kg^{-1}) （a）e001 （b）e002 （c）e003 （d）e004

Corresponding author address: Chunyan Sheng, 12 Wuyingshan Road Tianqiao District Jinan City, 250031, Shandong province, P.R.China
E-mail: sdqxscy@126.com