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THE APPLICATION OF HOMEMADE FY-2 SATELLITE INFRARED DATA TO MM5

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1 INTRODUCTION

In the end of 1980's, an operational system for 3-D variation and assimilation of meteorological data was set up in the U.S.A that supplemented data assimilation, retrieval of satellite data and numerical prediction each other. NWP was thus improved. Towards the end of 1990's, satellite observations were extensively used in NWP at ECMWF to upgrade the quality of analysis and forecasting. Subsequently, Chinese meteorologists also made some studies on the analysis and assimilation of satellite data. Jiang et al. [1] were the first to apply satellite imagery in numerical simulation of typhoon-inflicted heavy rain. Shen[2] et al. and Min[3] et al. conducted variational analysis and numerical simulation of conventional soundings and unconventional cloud imagery for limited areas and found that inclusion of cloud imagery could greatly improve rainfall forecast by the model. Zhu et al. [4] suggested that the introduction of satellite-retrieved humidity field could better depict horizontal mesoscale structure of the real world. All of the studies above have achieved lots of meaningful results.

In view of the different ways in which infrared data taken from the Chinese FY-2 weather satellite are used to retrieve temperature and humidity to adjust the initial model field, MM5 numerical prediction is conducted to compare typical cases of heavy rain based on different experiment schemes. The forecasts of the schemes are objectively assessed with TS scores in the hope to explore new ways of applying satellite-retrieved data in the forecasting of heavy rains.

2 RETRIEVAL OF INFRARED DATA

For the computation of mesoscale models, multiple levels of temperature field are needed. As conventional data and infrared data from the weather satellite are two different tools that observe the same object, the atmosphere, there should be internal links between them. Temperature fields for individual levels can be retrieved from a statistical regression equation, $T_i = a_{0i} + a_{1i}C$, which is established based on conventional and FY-2 satellite data. Specifically, a_{0i} and a_{i1} are the regression coefficients, *i* is the level, *C* the grayness of cloud imagery and T_i the temperature retrieved for individual levels.

During the computation, humidity is also needed for individual levels. Generally, atmospheric humidity is small above the level of 300 hPa, attaching much importance to the study of moisture distribution in levels below it. In view of the large contribution of low-level atmospheric humidity to precipitation, humidity fields at 400, 500, 700 and 850 hPa are related by $Rh_j = b_{0j} + b_{1j}C$ with relevant grayness values of the infrared imagery of the weather satellite, following the method of linear regression. Humidity is then obtained for individual levels. Specifically, b_{0j} and b_{1j} are correlation coefficients, *j* denotes individual levels, *C* the grayness of cloud imagery and Rh_j the humidity retrieved for individual levels.

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3 DESIGN OF QUALITY CONTROL SCHEME

Following the principle of space continuity and rationality, imagery "noise" is first deleted by filtrating point grayness of the pixel. Then, simultaneous analyzed conventional data are used to correct the retrieved field, which is checked gridpoint by gridpoint for reliability against objectively analyzed gridpoints of conventional sources. It ensures consistency of the retrieved field with the analyzed conventional field.

During the observation and transportation of signals, satellites are disturbed mostly by "noises" in the form of "points". Averaging can be used for them. With temperature and humidity retrieved from grayness, corrections can be made to the retrieved field using conventional analysis for the same period. Set as base reference, objectively analyzed conventional gridpoint data are compared with corresponding gridpoint data retrieved from cloud imagery for diagnostic isolation to assess the reliability of the retrieved field. A gridpoint with errors larger than the reference is removed and replaced with the mean of the five points of the conventional field around it. For the diagnostic criterion, mesoscale information of the retrieved field must be retained while some irrational singular points are deleted.

4 ASSIMILATION OF RETRIEVED DATA

With moderate resolution, conventional observations are high in accuracy; the opposite is true of satellite observations that are marked with both accurate measurement of intensity for spatial points and observational and systematic errors. It can be used to locate an analyzed field, for which the value is close to that of the conventional field and the gradient is close to that of the unconventional field. A generalized function is then constructed.

5 CASE STUDY

To verify what effect the infrared-retrieved data would have on precipitation forecasts after it adjusts the initial field of MM5, three experiments for adjustment and assimilation and four schemes for MM5 control are designed for comparison.

For the basic model parameters in the experiments, the center of the horizontal domain is set at 115°E, 30°N with 61 × 61 horizontal gridpoints and grid intervals D = 39 km. Pressure p_t = 100 hPa at model top, vertical resolution is 11 levels with unequal thickness and semi-σ layers are, going upward, 0.95, 0.85, 0.75, 0.65, 0.55, 0.45, 0.35, 0.25, 0.15, 0.05, respectively. The model integrates for 24-h prediction with steps Δt=120.

The selected case is a precipitation that took place from 08:00 July 9 to 08:00 July 10, 2003, during which for 402 surface weather stations across China, 50 recorded moderate, 15 heavy, 15 unusually heavy and 7 exceptionally heavy, rainfall, mainly concentrating in central and eastern parts of the country. Forecast experiments are conducted of the rain with the four schemes and TS scores are evaluated for each of them.

6 CONCLUSIONS

(1) With infrared-retrieved data used to adjust initial model humidity, time validity of rainfall at heavy or above levels can be improved. The forecast accuracy can be increased to some extent for unusually and exceptionally heavy rain if the initial field is corrected for humidity enhancement and temperature assimilation using the FY-2 infrared-retrieved data. It is a potentially effective way to upgrade the forecast capabilities of numerical prediction of mesoscale systems.

(2) Due to the limitation of data, a latest case of heavy rain is studied in the experiment. The retrieval and assimilation results need more comparison and verification. It is apparent that the scheme of "adding humidity" shows that MM5 precipitation forecast is somewhat sensible to initial humidity.

(3) With the routine use of FY-2-C weather satellite, the application of assimilated domestic satellite data in numerical prediction is expected to develop with greater pace.

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