1. Introduction

One of the greatest deficiencies of numerical weather prediction models is their lack of skill in predicting clouds and precipitation in the early portions of their forecast period because of the "spin-up" problem. Even today, most mesoscale model initialize forecasts with zero cloudiness, and accept the "spin-up" time between initial time and the first reasonable cloud distributions and precipitation rates. So inclusion of clouds in an initial condition has been a long-term goal of many numerical weather prediction systems.

In this study, KLAPS (Korea Local Analysis and Prediction System; Kim et al., 2002) is used to improve the initial values of liquid water species (cloud water, cloud ice, rain water, snow, and graupel) in the MM5 (5th generation of Mesoscale Model). For retrieving liquid water species, three dimensional cloud analysis is carried out using KLAPS based on satellite data, radar data, and surface observation data. The retrieved variables are assimilated into an initial condition for MM5 with a dynamic balance constraint in order to eliminate a problem of underestimating rainfall amount of MM5 run.

We introduce the diabatic initialization algorithm including cloud analysis and the impact study to using as the initial data of numerical model is also explained.

2. KLAPS (Korea Local Analysis and Prediction System)

KLAPS was designed to provide a computationally efficient method of combining all available sources of meteorological information into three dimensional depiction of the atmospheric state, with an emphasis on nowcasting. In recent years, KLAPS has been increasingly used as a means to initialize numerical weather prediction models because of its data ingest and quality control capabilities. In this study we used the KLAPS as a basis of data assimilation system.

3. The 3-Dimensional Cloud Analysis Algorithm

The cloud analysis utilizes a variety of observation data, including GOES satellite imagery, aircraft observation, surface observation (METAR), and radar reflectivity data. Fig. 1 shows the flow diagram of KLAPS 3 dimensional cloud analysis (Albers et al., 1996). The 3-dimensional clouds are analyzed by adding the observation step by step. After producing the 3-dimensional cloud distribution, it diagnoses the mixing ratios of each hydrometeor species (Fig. 2), performs cloud typing based on stability and temperature information, and assigns appropriate vertical motion profiles to each cloud analysis field.

4. The Data Assimilation using Quasi Geostrophic Equation including Cloud Amount

The balance procedure uses a 3-dimensional var-

* Corresponding author address: Yong-Sang Kim Information Management Division, Korea Meteorological Administration, 460-18 Shindaebang-dong, Dongjak-gu, Seoul 156-720 Korea; e-mail: yskim@kma.go.kr

Fig. 1. Flow diagram of KLAPS 3-dimensional cloud analysis (after Albers et al., 1996).
Fig. 2. The final 3-dimensional cloud analysis of the 5 phases of cloud and precipitation. Each color is explained at the figures.

ational formulation to combine the background fields with the initial KLAPS univariate analyses of the mass and momentum fields (temperature, wind) while considering the cloud vertical motions. A strong constraint of mass continuity is applied as part of the 3DVAR cost function, such that the horizontal wind field, is slightly adjusted to produce divergence fields consistent with cloud vertical motion fields. In addition, to prevent the introduction of excessive gravity waves during the initial few time steps of model integration, the cost function also minimizes the time tendencies of the horizontal wind fields.

5. Results

Fig. 3 shows that the performance of precipitation forecast is improved by assimilating these variables (HOT experiment), compared to COLD experiment (i.e. an experiment without assimilating the retrieved variables). Considering the statistical verification of POD (Probability of Detection) from several rainfall case studies, the HOT experiment showed significant improvement during the first 6 hour forecasts compared to the COLD experiment (Fig. 4).

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7. Reference


Fig. 3. The 1-hourly accumulated precipitation of 2 hour forecast (1st figure is the result of COLD experiment, 2nd figure is a radar retrieved precipitation image, and 3rd is the result of HOT experiment).