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ASSIMILATION OF GOES SOUNDER CLOUD TOP PRESSURE IN NCEP'S 48KM ETA MESOSCALE MODEL

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1. INTRODUCTION

As numerical models move to higher resolution and become more sophisticated a greater emphasis will be put on cloud prediction schemes. In the past modelers have used a wide spectrum of cloud prediction algorithms. Zivkovic and Louis (1992) and Arakawa and Schubert (1974) used diagnostic relationships of model dependent moisture variables. Lin et al. (1983) used bulk parameterizations of condensation and precipitation. Cotton et al. (1982) used comprehensive physical cloud algorithms that incorporated predictive equations for numerous particle shapes, size distributions and growth rates.

More mesoscale models are incorporating cloud prediction schemes that represent cloud water explicitly. Zhao and Carr (1997) developed the cloud prediction scheme for the Eta Model (Rogers et al. 1996), Brown et al. (1998) developed the cloud prediction scheme presently used in the Rapid Update Cycle (Benjamin et al. 1998). These cloud schemes are playing an ever increasing role in the models through their interactions with radiation, moisture transport and precipitation forecasts.

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Attempts have been made to initialize moisture and clouds in models using various types of satellite observations. Various degrees of success, using different methods, have been obtained by Wright and Hand (1994), Aune (2000), Kim and Benjamin (2000), and Bayler et al. (2000). In this paper we describe our initial attempt to modify or nudge the Eta cloud water mass field toward current satellite cloud observations. Our goal is to produce an improved cloud and moisture field for the analysis and subsequent forecast.

2. CLOUD OBSERVATIONS

The cloud top pressure product used is derived from the Geostationary Operational Environmental Satellites (GOES) infrared sounder (Menzel et al. 1998). The sounder covers about half of the operational Eta domain (using both GOES-east and GOES-west) with a pixel resolution of about 10km. The cloud top pressure is determined by the CO_2 absorption and a "split window" technique (Menzel et al. 1992). These data are produced hourly by NOAA/NESDIS and are available to NCEP.

3. MODEL BACKGROUND

For this experiment we used the November 1999 version of NCEP's operational Eta Data Assimilation/ Forecast

System (EDAS) (Black 1994; Rogers et al. 1996). Our experiment was conducted at 48km resolution with 45 vertical layers and is the same size as the operational Eta. The observations, including radiances, used during the 12-hour data assimilation cycle were obtained from NCEP and are equivalent to the operational Eta.

4. TECHNIQUE DESCRIPTION

The latitude/longitude of each cloud observation is mapped onto the corresponding Eta line/element. In the case of the 48km Eta, it is possible to have more than one observation at a grid point. Where more than one cloud observation is present the lowest pressure (highest cloud) observation is used. The cloud top pressure is then converted to the corresponding model layer. In an attempt to reduce some of the temporal variability, the relative humidity is checked one layer above and below the observation and is adjusted to that layer with the highest relative humidity.

Starting from the top of the model downward, cloud water mass is set to the minimum model threshold down to the cloud layer. If the cloud water mass is greater than the model's minimum threshold at the cloud layer, the cloud water mass is not changed. If the cloud water mass is equal to the model's minimum threshold, cloud water mass is added. The amount of cloud water mass added varies with respect to the model's threshold to initiate precipitation. Presently one-fourth of the precipitation threshold is added. Cloud water mass is not adjusted below this point. If no cloud is detected in the model grid box, cloud water mass is set to the minimum threshold down to the surface of the model.

The cloud water mass is adjusted after each cloud physics timestep (every 4th model timestep or 480 seconds) with the cloud top pressure data valid during that hour. The cloud nudging technique is done during the entire 12 hour data assimilation cycle with the T-0 analysis being used for the forecast and the next data assimilation cycle.

5. RESULTS

The impact of initializing the cloud water field is determined by comparing forecasts with the initialized clouds to a parallel control forecast which is as close as possible to the operational Eta model. The control forecast typically has an excess of high cirrus clouds. Most of the adjustment the cloud nudging does during the 12 hour EDAS is to remove cirrus. A comparison of a cloud-adjusted analysis with the control analysis is shown in Fig.1. Once the forecast cycle starts the Eta model begins to generate excess cirrus. There is generally good agreement out to about 6 hours at which time the cirrus becomes excessive as shown in Fig. 2.

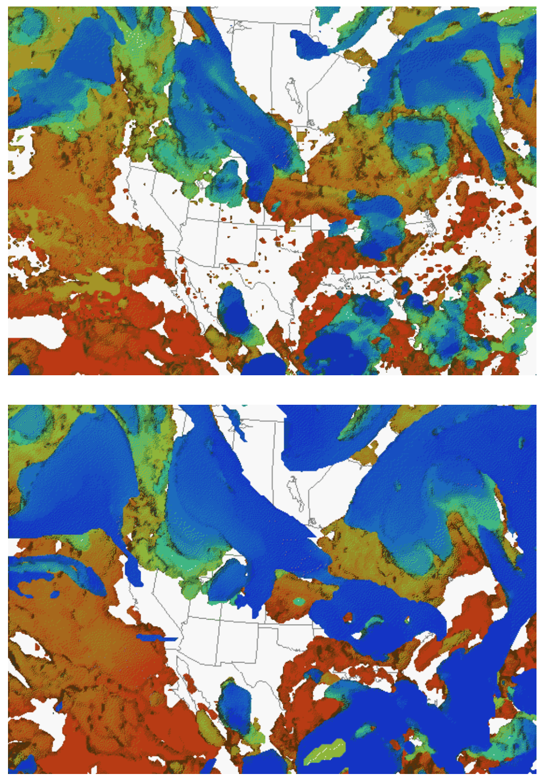

Fig. 1. Eta model analysis for 00 UTC on June 4, 2001. (top) Cloud field adjusted with GOES Sounder clouds. (bottom) Cloud field from control analysis.

The authors have looked at other statistics to determine impact of the cloud adjustment. We have presently completed winter and spring cases. The relative humidity shows a small improvement in the upper level wet bias associated with the removal of the excess cirrus. The precipitation threat scores showed small mixed results. This result was expected since the cloud adjustment only has an impact out to about 6 hours where the threat scores are for a 24-hour time period. Results that were not expected are the lack of impact on the temperature. No differences were found in the temperature comparisons between the cloud adjusted and control forecasts. It has since been found that the radiation physics do not take into account changes in the grid scale cloud water mass.

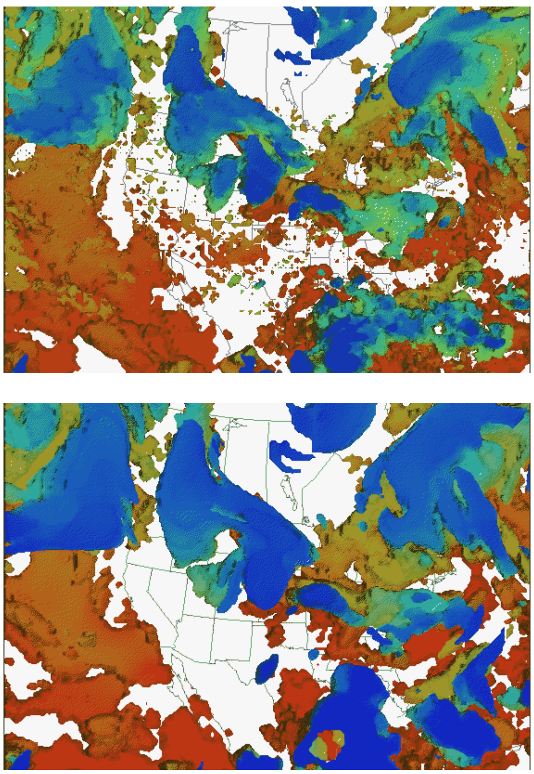

Fig. 2. Eta model output valid 06 UTC on June 4, 2001. (top) Analysis of the cloud field adjusted with GOES Sounder clouds. (bottom) Cloud field from 6 hour forecast using the 00 UTC cloud adjusted analysis.

Some problems were also found in the cloud product. At times there can be considerable temporal variability in the assigned cloud top pressure. To remove some of this, the layers above and below the assigned layer are checked for the highest relative humidity. If one of these layers has a higher relative humidity, the cloud top is reassigned to that layer.

6. REMARKS

The scheme described above will be tested during the summer and fall to get a more complete picture of the cloud assimilation effects. Efforts are presently underway at NCEP and NESDIS to address some of the deficiencies identified in the cloud product and the Eta's cloud physics.

7. REFERENCES

Arakawa A., and W.H. Schubert, 1974: Interaction of a cumulus cloud ensemble with the large-scale environment. Part I, *J. Atmos. Sci*. **31**, 674-701.

Aune, Robert M., 1996: Initializing cloud predictions using the GOES-8 sounder. 8th Conf. On Satellite Meteorology and Oceanography, Atlanta, GA, Amer. Meteor. Soc., 408-412.

Bayler, G.M., R.M. Aune, and W.H. Raymond, 2000: NWP cloud initialization Using GOES sounder data and improved modeling of nonprecipiataing clouds. *Mon. Wea. Rev.*, **128**, 3911-3920.

Benjamin, S.G., J.M. Brown, K.J. Brundage, B.E. Schwartz, T.G. Smirnova, T.L. Smith, L.L. Morone, and G.J. DiMego, 1998: The operational RUC-2. 16th Conference on Weather Analysis and Forecasting, Phoenix, AZ, Amer. Meteor. Soc., 249-252.

Black, T.L., 1994: The new NMC mesoscale Eta model: Description and forecast examples. *Wea. Forecasting*, **9**, 265-278.

Brown, J.M., T.G. Smirnova, and S.G. Benjamin, 1998: Introduction to MM5 level-4 microphysics into the RUC-2. Preprints, 12th Conf. On Numerical Weather Prediction, Phoenix, AZ, Amer. Meteor. Soc., 113-115.

Cotton W. R., M.A. Stephens, and G.J. Tripoli 1982: The Colorado State University three-dimensional cloud/mesoscale model – 1981. Part II: An ice phase parameterization. *J. Rech. Atmos*., **16**, 295-320.

Kim, D., S.G. Benjamin, 2000: Assimilation of cloud-top pressure derived from GOES sounder. Preprints, 10th Conf. On Satellite Meteorology and Oceanography, Long Beach, CA. Amer. Meteor. Soc., 110-113.

Lin, Y-L., R.D. Farley, and H.D. Orville, 1983: Bulk Parameterization of the snow field in a cloud model. *J. Clim. Appl. Meteor*., **22**, 1065-1092.

Menzel, W.P., F.C. Holt, T.J. Schmit, R.M.Aune, A.J. Schreiner, G.S. Wade, and D.G. Gray, 1998: Application of GOES-8/9 soundings to weather forecasting and nowcasting. *Bull. Amer. Meteor. Soc*., **79**, 2059-2077.

Menzel, W.P. D.P. Wylie and K.I. Strabala, 1992: Seasonal and diurnal changes in cirrus clouds as seen in four years of observations with the VAS. *J. Appl. Meteor*., **31**, 370-385.

Rogers, E., T.L. Black, D.G. Deaven, G.J. DiMego, Q. Zhao, M. Baldwin, N.W. Junker, and Y. Lin, 1996: Changes to the operational "early" Eta analysis/forecast system at the National Centers for Environmental Prediction. *Wea. Forecasting*, **11**, 391-413.

Wright, B.J., and W. Hand, 1994: An operational cloud analysis for the UK Met Office mesoscale model. Preprints, 10th Conf. On Numerical Weather Prediction, Portland, Amer. Meteor. Soc., 321-323.

Zhao, Q., and F.H. Carr 1997: A prognostic cloud scheme for operational NWP models. *Mon. Wea. Rev*., **125**, 1931-1953.

Zivkovic, M. and J-F. Louis, 1992: A new method for developing cloud specification schemes in a general circulation model. *Mon. Wea. Rev*., **120**, 2928-2941.