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P3.14 ONE DIMENSIONAL VARIATIONAL ASSIMILATION EXPERIMENTS COMBINING GOES SOUNDER AND IMAGER RADIANCE DATA

Dongsoo Kim and Dezso Devenyi

Cooperative Institute for Research in Environmental Sciences (CIRES)

University of Colorado/NOAA Research-Forecast Systems Laboratory, Boulder, Colorado

1. INTRODUCTION

Sounder and imager data from the GOES platform offer an opportunity to enhance the quality of the initial conditions for numerical weather prediction, as is done in the Rapid Update Cycle (RUC, Benjamin et al., 2001). The most important strength of sounder data over imager data is that their multichannels are designed for retrieving vertical distribution of temperature and moisture. The relative advantages of GOES imager data over sounder data includes better spatial coverage in the RUC domain, higher ingest frequency (15 min vs 1 hour), and higher resolution (4 km vs 10 km). The higher ingest frequency helps in reducing temporal sampling error, and higher spatial resolution refines the spatial variability of clouds. Therefore, imager data are used to enhance the subgrid variation of clouds, namely, multilevel fractional clouds. We formulate the fractional cloud coverage derived by imager data as a weak contraint in one dimensional variational formulation to generalize current cloud analysis employed in the 20-km RUC.

2. 20-KM RUC CLOUD ANALYSIS

The 20-km version of RUC uses the bulk mixed-phase cloud microphysics scheme from the NCAR/Penn State MM5 model, with five hydrometeor types explicitly forecast. The RUC 1-h predicted hydrometeor mixing ratios provide background fields to be modified using the single field-of-view (FOV) GOES sounder-based cloud-top pressure data. A threshold value (10^{-5} g Kg^{-1}) of the hydrometeor mixing ratio determines predicted cloud-top pressures at each grid point. Then, the GOES cloud-top data are used to determine whether hydrometeors have to be added or cleared. Since the cloud-top pressure does not include cloud thickness, a conservative cloud thickness of 50 hPa is used for cloud building. For cloud clearing, hydrometeor mixing ratios are set to zero, and the water vapor profile is adjusted such that it does not exceed 50% in relative humidity in the cleared part of the column. Detailed description is given in Kim and Benjamin (2001). Figure 1 shows the single FOV GOES sounder-based cloud-top pressure data used in a RUC cloud analysis. Figure 2 shows GOES imager data based on cloud-top pressure processed on the same domain. While the GOES imager-based cloud uses the window channel method with 1-h forecast profiles as background, a strong resemblance is seen between the two products, providing justification for the combined use of the products for initializing clouds in the RUC model.

Corresponding author address: Dongsoo Kim, NOAA/FSL R/FS1, 325 Broadway, Boulder, CO 80305, dkim@fsl.noaa.gov

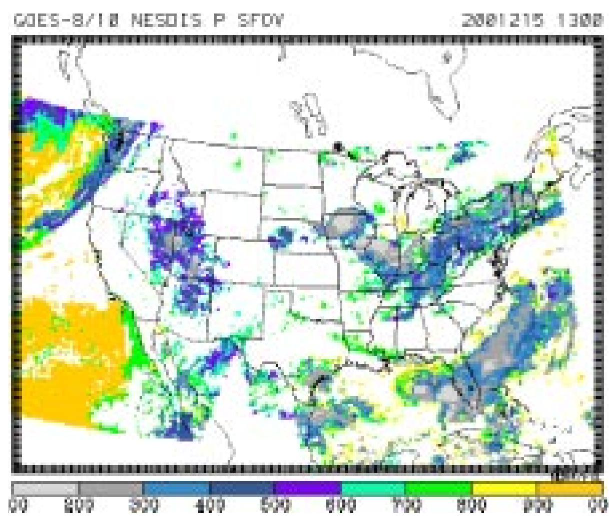

Figure 1. NESDIS single field-of-view cloud-top pressure data valid at 1300 UTC 3 August 2001. The median values of the samples in 20-km RUC are selected.

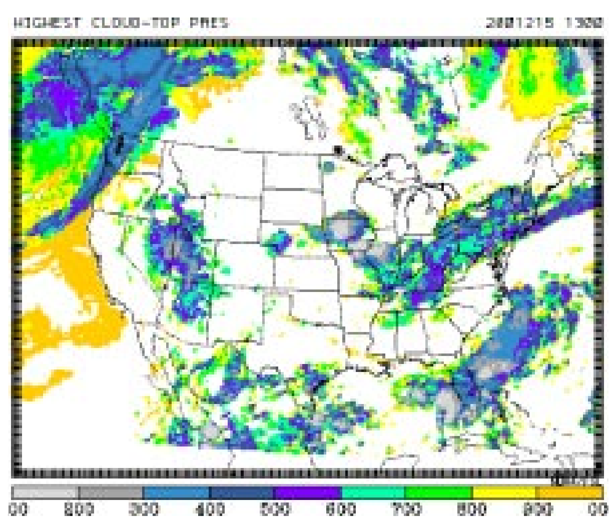

Figure 2. Hourly cloud product GOES imager data using a 20-km RUC 1-h forecast as background. The highest cloud-top pressure is plotted in the case of multilevel clouds.

3. DESIGN OF 1DVAR

In an earlier experiment, we have shown an example combining TIROS HIRS radiances with AVHRR radiances using the constrained least squares method, and results were compared with cloud profiling radar (Kim et al., 1997). In a new design of one-dimensional (1DVAR) assimilation of GOES sounder radiance data, we start with the familiar functional (for example Eyre et al., 1993)

$$2J(x) = (x - x_b)^T B^{-1} (x - x_b) + (y_o - H(x))^T R^{-1} (y_o - H(x)) + J_c + J_{op}$$

where B and R represent background error and the sum of observation and representativeness error covariances, respectively. In the first version of 1DVAR both of them are approximated by continuous functions. In a later version digital filters will be used according to the present RUC 3DVAR scheme (Devenyi et al., 2001). The nonlinear operator H is for the radiance forward model. The state vector x represents the vertical profile of temperature, water vapor, and cloud water mixing ratios. The first constraint term (J_c) is a restriction of the moisture profile to stay below saturation. The second term (J_{op}) constrains the cloud water profile by multilevel fractional cloud coverage information derived from the GOES imager. A quasi-Newton minimization method will be used in finding the optimal value of x.

4. RESULTS

We are currently evaluating two community forward/adjoint radiative transfer models, RTTOV (Saunders et al., 1999) and OPTRAN(McMillin and Kleespies, 2000) using identical background profiles and surface information (temperature, water vapor, skin temperature) at the Atmospheric Radiation Measurement (ARM) Cloud and Radiation Testbed (CART) site in Oklahoma in order to characterize bias and covariance errors in the forward model. The background profiles are 1-, 3-, 6-, 9-, and 12-h forecasts of height, temperature, water vapor, and winds as well as five hydrometeors (cloud water, rain water, ice, snow, graupel mixing ratios) from the RUC. Also, surface information is from the RUC forecasts. Both models are being used for GOES-8/10 sounder and imager radiance data, which are sampled hourly within an approximately 40-km x 40-km grid box. The sounder radiances are selected as a nearest neighborhood to the grid point, and all imager radiances are adaptively classified to obtain fractional coverages and their respective cloud-top heights. The results will be shown at the conference.

5. ACKNOWLEDGMENTS

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