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GLOBAL CAPABILITY FOR AFWA'S DIAGNOSTIC CLOUD FORECAST SYSTEM

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1. INTRODUCTION

The Air Force Weather Agency (AFWA) supports Air Force mission planning by generating real-time forecasts of basic cloud properties, such as cloud base, top and type. For the customer-driven forecast lengths on the order of 48-96 h, simple extrapolation of diagnosed clouds exhibit no skill, so NWP-based forecast fields must be considered. However, the presence, and characteristics, of clouds derived solely from NWP moisture fields also are of insufficient quality to meet the customers' requirements. Thus, statistical post-processing techniques applied to NWP forecasts have been in use at AFWA for many years. One such cloud prediction method, the Diagnostic Cloud Forecast (DCF) system, is a variant of the model output statistics (MOS) technique in that the statistical relationships between sets of predictors and predictants is developed on pre-existing data and then applied to an independent set of predictors. For DCF during the training stage, recent NWP forecasts are the predictors while cloud analyses are the predictands; the statistical relationships are then applied to current NWP forecasts to produce a cloud forecast. In this paper we introduce recent upgrades to DCF (made operational at AFWA in late 2008) to generate global cloud forecasts. The performance of this new DCF-Global product will be demonstrated through initial verification.

2. OVERVIEW OF THE DCF TECHNIQUE

A brief overview of the DCF data preparation and statistical techniques is now presented. DCF has been described in detail by Norquist (2000); this prototype version has evolved into the baseline DCF of our current work. The first processing step in DCF involves collocating NWP forecasts with cloud analyses to facilitate development of the relationships in the training stage. Until recently DCF at AFWA processed only regional Penn State/National Center for Atmospheric Research (NCAR) Mesoscale Model Version 5 (MM5) or NCAR's Weather Research and Forecasting Model (WRF-ARW). A subjectively-chosen pool of 102 NWP-based predictors is generated for every forecast length (typically every 3 h out to 72 h) from a variety of NWP fields and derived quantities. The choice of predictors includes not only expected fields like model moisture, but also variables related to moisture (re)distribution, sub-grid scale processes and model geography, such as vorticity, temperature, wind shear, heat fluxes, and moisture and temperature advection. Model-based predictors are collocated in space (both horizontally and vertically) and time on the diagnosis grid with the World-Wide Merged Cloud Analysis (WWMCA) from AFWA's Cloud Depiction and Forecast System II (CDFSII). These predictor/predictand pairs are collected for the most recent 6-10 day period and then subjected - separately for each foreast length - to both multiple discriminant analysis, which requires the data be binned into categories, and linear regression. The coefficient files output from these techniques are then applied to a current GFS forecast in order to produce DCF forecast products that include total cloud amount and the amount, type, base altitude and thickness of up to five vertical cloud layers.

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3. CHANGES FOR GLOBAL COVERAGE

This paper highlights the changes, introduced by AER, Inc. into DCF during 2008, which became operational on 21 November 2008. The main project goal was to upgrade the DCF algorithms to process global 1/2-degree National Center for Environmental Prediction Global Forecast System (GFS) NWP fields, thereby allowing DCF to build and apply global statistical relationships, and ultimately produce global cloud forecasts. Code development was complicated by the introduction of pressure-level GFS fields since DCF defines vertical cloud layers using existing native MM5 and WRF-ARW vertical coordinates. As well, the GFS data are available on a regular latitude-longitude grid, which required changes to the horizontal derivative code used when computing derived moisture and dynamical fields, such as mixing ratios, vorticity and divergence. The new set of available GFS fields had to be matched with those expected by DCF and any missing fields computed (if possible). A number of multi-phase moisture fields generated by the MM5 and WRF explicit microphysics schemes could not be computed.

Since the nature of the production of clouds by both dynamical and thermodynamical processes varies widely within a global domain, the option was added to develop and apply the statistical relationships over subregions of the globe. Preliminary techniques involving simple spatial averaging attempt to remove any seams between adjacent regions that may appear in the various end-product cloud forecasts.

4. INITIAL RESULTS

We now present initial results of the performance of the GFS-based global DCF compared to existing regional domains based upon WRF-ARW input fields for the period 1-20 December 2008. The grid spacing of the WRF grids is 45 km. For this comparison, DCF-Global was run with only one region, thus, the statistical relationships between observed clouds and NWP fields is the same for the entire globe. Despite this simplification, RMSE and bias statistics of forecasts of fractional cloud cover (Fig. 1) indicate that DCF-Global outperforms the regional DCF applications for Europe and other regions, such as Africa, Southwest Asia and Southeast Asia (not shown). That DCF-Global is comparable in performance for CONUS suggests that DCF, in general, has been fine tuned for verification purposes for that region.

5. FUTURE UPGRADES

We anticipate further upgrades to DCF in the near future that are based on both new model inputs as well as improved finer-resolution cloud analyses. DCF has already been modified to process WRF-NMM fields from NCEP. Improved cloud analyses will also permit prediction of cloud optical properties in addition to the current cloud top/base and type information.

6. CONCLUSIONS

In late 2008 upgrades to AFWA's DCF cloud forecast product became operational. In this paper we focus on the DCF-Global product which processes NCEP 0.5-degree GFS forecast files in order to provide global coverage out to 84 h. The option to compute the predictor/predictand relationships for separate geographical subregions of the global GFS domain is now also available. This improves the quality of the resulting cloud forecasts. Future upgrades to the current system include use of an enhanced high-resolution satellite analysis that includes cloud optical properties in addition to the existing traditional cloud parameters.

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References

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Figure 1: RMSE (solid) and bias (dashed) for DCF-Global (green) and WRF (red) forecasts of fractional cloud cover for 1-20 December 2008 for region Europe (top) and CONUS (bottom). Horizontal axis denotes forecast periods 1 through 12 representing forecast hours 6 through 72 at 6-h increments.