P1.8 THE MET OFFICE 3D-VAR STRATOSPHERE-TROPOSPHERE DATA ASSIMILATION SYSTEM

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1. INTRODUCTION

The Met Office has developed a variational data assimilation system for its Unified Model forecast system. The three-dimensional variational (3D-VAR) system was first implemented in the standard operational global forecast suite in March 1999 (Lorenc et al, 2000). Versions of the 3D-VAR system were subsequently developed for other model configurations, most recently for the stratosphere-troposphere model.

Since October 1991 daily stratospheric analyses have been produced using a stratosphere-troposphere data assimilation system (Swinbank and O'Neill, 1994). Initially, the analyses were produced using a special research version of the Analysis Correction (AC) data assimilation scheme (Lorenc et al, 1991) to support the Upper Atmosphere Research Satellite project. Subsequently, the system was run as part of the operational forecast suite. On 14th November 2000 the stratospheric data assimilation system was converted to use 3D-VAR.

2. THE ASSIMILATION SYSTEM

The new stratosphere-troposphere data assimilation system is based on a 40 level version of the Unified Model with its top around 0.1 hPa, and a vertical resolution of about 2.5 km in the stratosphere. The model levels were chosen so that they are the same as the standard 30-level global forecast model in the troposphere, but extra stratospheric levels were added, with the aim of allowing improved processing of satellite temperature soundings. The horizontal resolution is 2.5° latitude by 3.75° longitude (exactly the same as for the old stratosphere-troposphere system).

As with the standard global forecast model, the background (forecast) error covariances were calculated using the so-called "NMC method", using differences between T+48 and T+24 forecast fields (see Ingleby, 2001 for details). A disadvantage of the method originally used (for the standard global assimilation model) is that the longer horizontal scales in the stratosphere were not represented. This has been addressed using localised (rotated) vertical modes in the stratosphere.

The other major development has been in the assimilation of satellite soundings. The old stratospheric assimilation system used temperature retrievals derived by NESDIS from TOVS measurements, while the new system assimilates ATOVS radiances directly. Compared to the standard global system, the stratospheric system uses extra channels at high levels, including data over high land. There have also been changes to the satellite bias correction system. Bias corrections are not applied to the uppermost channels, since there are no reference data to correct the biases against.

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3. RESULTS

Prior to implementation, trials of the assimilation system were run for two one-month periods (December 1998 and June 1999). As previously found for the standard (30-level) global model, the replacement of the AC scheme with 3D-VAR led to a major improvement in forecast skill, as judged by verification against (primarily tropospheric) observations. Figure 1 shows an example of a comparison of forecast scores for 500 hPa height. (Note that these trials were run at a higher horizontal resolution). Generally speaking, the tropospheric forecast skill of the 40-level 3D-VAR system is very similar to that of the 30-level system, but the 40-level system starts to have an advantage near and above the tropopause.

In the stratosphere it harder to judge the impact of the change objectively, but subjective assessment indicates that the new system is generally performing well; Fig. 2 shows examples of fields produced by both the new and old systems. Other comparisons show that there are some systematic changes near the stratopause; this is partly because an error was found in the ozone climatology, which has now been corrected. There are also some significant changes in low-latitude winds in the upper stratosphere; these are attributed to insufficient balance between mass- and wind-field errors in the background error covariance files. Further work is planned to correct this deficiency.

4. FUTURE PLANS

The next step in the development of the stratosphere-troposphere data assimilation system will be the adoption of the new semi-implicit dynamical core which has been developed for the Unified Model.

In the next couple of years, it is planned that the stratosphere-troposphere data assimilation and forecast system will be used to demonstrate the feasibility of extending the standard operational global forecast model to span the stratosphere. That would allow all the customer requirements for global forecasts to be met using a single model configuration.

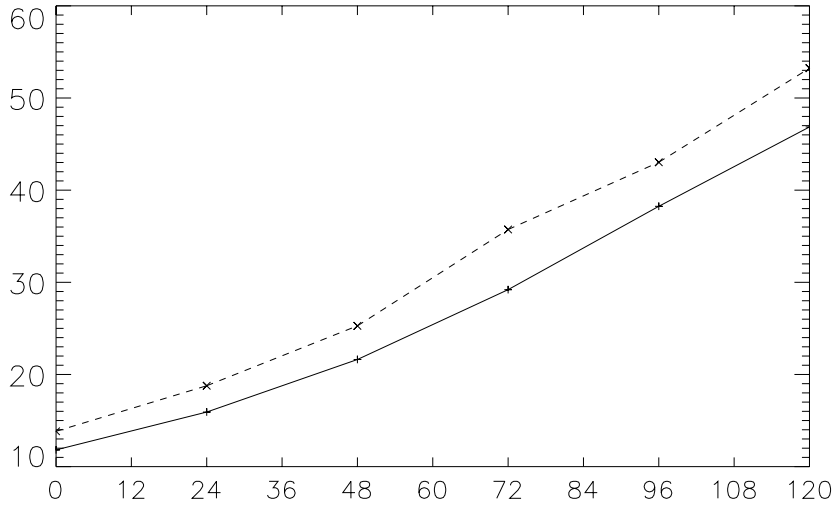

Figure 1: Comparison of 500 hPa geopotential height verification against radiosondes (RMS error in m) as a function of forecast length (hours) 20N - 90N for 40-L June 99 trials; dashed line AC, sold line 3DVAR

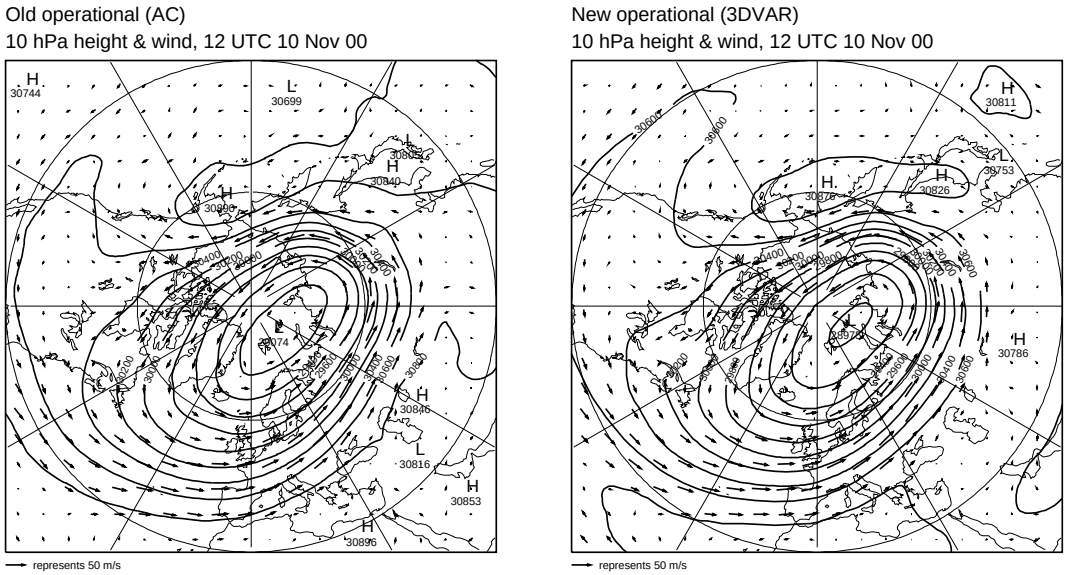

Figure 2: Comparison of mid-stratospheric geopotential height and wind fields from old and new stratospheric data assimilation systems.

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