OZONE DATA ASSIMILATION AT THE MET OFFICE

D.R Jackson and R.W Saunders

Met Office, London Road, Bracknell RG12 2SZ, U.K.
email: david.jackson@metoffice.com

Introduction

It is claimed that ozone assimilation may benefit numerical weather prediction (NWP) via: impact on wind fields through correlations between ozone and potential vorticity (and other dynamic variables); improved assimilation of satellite radiances; improved radiative heating; improved predictions of UV radiation. The impact of including ozone in operational NWP assimilation schemes is currently being investigated at other forecasting centres (see eg Holm et al, 1999; Peuch et al, 2000; Stajner et al, 2001). Here, we describe developments to include ozone within the Met Office's three-dimensional variational assimilation (3D-Var) scheme (Lorenc et al, 2000). Initially, ozone will be analysed using observations from the High Resolution Infrared Radiation Sounder (HIRS) and the Solar Backscatter Ultraviolet spectrometer (SBUV), but it is possible that data from future satellite missions will be incorporated later.

Ozone Assimilation in 3D-Var

Ozone will be assimilated using the Met Office's operational stratosphere - troposphere data assimilation system, which is based on a 40 level version of the Unified Model (UM), with a top level near 0.1 hPa and a horizontal resolution of 2.5^o latitude x 3.75^o longitude. The ozone field is advected by the model forecast winds, but no parametrization of chemical production or loss is included.

The 3D-Var code has been modified to include ozone as a control variable. An important feature of the scheme is the transforms of the control variables that are made in order to eliminate the unwieldy background error covariance from the calculation of the cost function, and to make this calculation much more computationally efficient (Lorenc et al, 2000). To this end, the ozone covariance matrix has been filtered, to allow for different scales in the horizontal, and has been transformed into empirical modes in the vertical, using zonal and seasonal average statistics. For other control variables, a further, physical, transform has been made which eliminates, or greatly reduces, correlations between the variables (see Lorenc et al, 2000). However, for simplicity at this stage it is assumed that ozone is uncorrelated with any of the other analysis variables and thus no physical transform is performed.

To begin with, only ozone data from HIRS (chiefly HIRS channel 9) shall be assimilated. The deep weighting functions of the HIRS channels mean that little information about the vertical ozone structure can be obtained. However, the forward model for HIRS is already in use at the Met Office, and this makes it relatively quick and easy to modify the code to analyse ozone and to test the assimilation system in this basic form, prior to going on to the more sophisticated system detailed below. Furthermore, it has been possible to run tests with ozone added to a 1D-Var version of the HIRS radiance assimilation, in order to assess the most appropriate representation of the ozone background error covariance matrix. Three candidates were tested: 1) background errors provided by ECMWF and calculated using the so-called 'NMC Method' (Parrish and Derber, 1992); 2) a simplified model with no vertical correlations and a variance that is the square of 10 % of the background ozone mixing ratio; 3) a hybrid solution that uses the vertical correlations from 1) and variances from 2). We examined the ozone increments for these three matrices that resulted when the HIRS channel 9 brightness temperature was reduced by 1 K. The Jacobian indicates the sensitivity of channel 9 to changes in ozone and, encouragingly, all three matrices gave rise to ozone changes near the peak of Jacobian. However, matrices 2) and 3) also produced ozone changes far away from this peak, between 10 and 1 hPa, which is not desirable. For this reason, our initial trials shall use matrix 1). These trials will start shortly.

Future Developments

After completion of the initial trials, the following further refinements to the assimilation system will be added.

- Change the ozone background error covariances to include correlations with other analysis variables. This may lead to improved analyses of both ozone and wind, particularly in the upper troposphere and lower stratosphere.

- Add ozone observations from the SBUV instrument to the assimilation. These observations will provide much more information about the vertical structure of the stratospheric ozone field than HIRS observations can.

The system may eventually be used operationally if it can be demonstrated that it has a positive impact on numerical weather forecasts. Other planned work includes assimilating data from future satellite missions (such as the Atmospheric Infrared Sounder (AIRS) and Envisat) and assessing their impact.

References

Holm, E.V, Untch, A, Simmons, A, Saunders, R, Bouttier, F and Andersson, E (1999) Multivariate ozone assimilation in four-dimensional data assimilation. *SODA Workshop on chemical data assimilation proceedings*, De Bilt, 9-10 Dec. 1998, pp 89-94.

Lorenc, A.C, Ballard, S.P, Bell, R.S, Ingleby, N.B, Andrews, P.L.F, Barker, D.M, Bray, J.R, Clayton, A.M, Dalby, T.D, Li, D, Payne, T.J and Saunders, F.W (2000) The Met. Office global three-dimensional variational data assimilation scheme. *Quart. J. Roy. Meteor. Soc.* **126** 2991-3012.

Parrish, D.F and Derber, J.C (1992) The National Meteorological Center's spectral statistical-interpolation analysis system. *Mon. Weather Rev.* **120** 1747-1763

Peuch, A, Thepaut, J-N and Pailleux, J (2000) Dynamical impact of total ozone observations in a four-dimensional variational assimilation. *Quart. J. Roy. Meteor. Soc.* **126** 1641-1659

Stajner, I, Riishojgaard, L.P and Rood, R.B (2001) The GEOS ozone data assimilation system: Specification of error statistics. *Quart. J. Roy. Meteor. Soc.* **127** 1069-1094