Assimilating MIPAS humidity data into the Met Office stratospheric model

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Introduction

Stratospheric water vapour plays an important role in both atmospheric chemistry and dynamics. Little is known about the day to day variability of the stratospheric water vapour field, predominantly due to a lack of observational data. ENVISAT was launched in March 2002 carrying MIPAS, a Michelson Interferometer, giving many retrieved species including profiles of stratospheric water vapour. The Met Office has taken part in an EU funded project called ASSET (Assimilation of ENVISAT data) and has assimilated MIPAS data into the Met Office stratospheric model. This poster describes the humidity assimilation work undertaken at the Met Office and introduces the ASSET humidity intercomparison.

The problem

Currently within the operational Met Office assimilation scheme the specific humidity field above 100hPa is limited between 1-3 ppmm and relative humidity is kept below 10%. This is necessary because otherwise the upper stratospheric specific humidity field quickly becomes unrealistically wet. To improve the assimilation of stratospheric water vapour observations, it is necessary to understand which part of the data assimilation scheme is causing the problem.

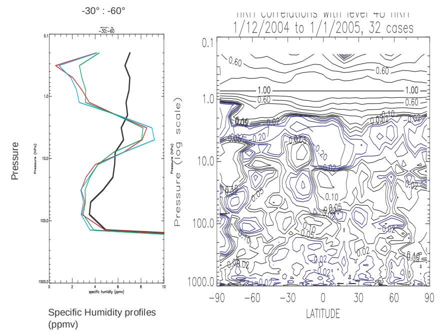
Approaches taken

We have investigated both the impact of the error covariance matrix and the form of the humidity control variable on the assimilation of MIPAS data.

Error covariance matrix
The error covariance matrix tells the assimilation scheme how to spread the observational data in the horizontal and vertical. This is especially important in data sparse areas. This matrix is exceptionally large and is therefore simplified in the data assimilation scheme. The global covariance matrix is firstly broken down into vertical eigen vectors and then followed by a horizontal transform to express the latitudinal variability. At the Met Office the model error covariance is calculated using the 'NMC' method (Parrish and Derber, 1992). Model error is represented by taking the difference between a 24 and 48 hour forecast that are valid for the same time. The assumption is that the later forecast is more accurate due to the shorter forecast length and the extra inclusion of observations.

Humidity control variable
The exact form of the humidity control variable can determine how humidity and temperature observations effect the specific humidity increments. The Met Office's current operational model has relative humidity as the humidity control variable. This is problematic in the stratosphere because there are many more temperature observations than humidity observations. Dee and Da Silva (2003) described how spurious stratospheric specific humidity increments are generated because the assimilation scheme tries to keep the relative humidity field constant in the presence of temperature observations. Their solution was to make the humidity control variable pseudo relative humidity, where the saturated specific humidity is determined by the background temperature. Holm et al (2002) have found that the atmospheric humidity field could be improved by having a normalised humidity control variable. Where the variable is normalised by an appropriate error standard deviation.

Figure 1 LHS: Analysis vs. MIPAS observations for different control variables
RHS: Vertical error correlations with ~1hPa.



Specific Humidity profiles (ppmv)

- MIPAS profile
- RH
- Normalised RH
- Normalised pseudo RH

Vertical error correlations with model level 48 = 0.7hPa (Normalised pseudo RH)

blue =negative, black = positive

To improve the assimilation of humidity data the Met Office has combined the ideas of Dee and Da Silva (2003) and Holm et al (2002). Figure 1 shows that the assimilation of MIPAS data is little improved by changing the control variable. This is because the benefits are covered up by the negative impacts of a poor error covariance matrix. The NMC method is known for generating excessively deep error correlations. We have therefore developed a scaling tool which cuts down the vertical correlations as a function of distance from each model level.

Figure 2: Specific Humidity increments for model levels 30-50 when a humidity observation is put in at level 5. LHS: Mild vertical correlation scaling, RHS: severe vertical correlation scaling

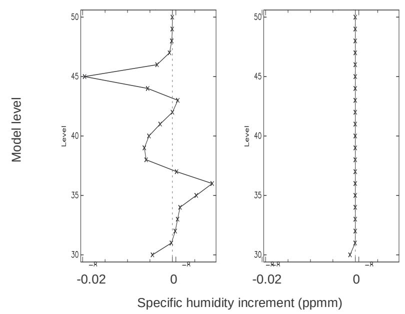
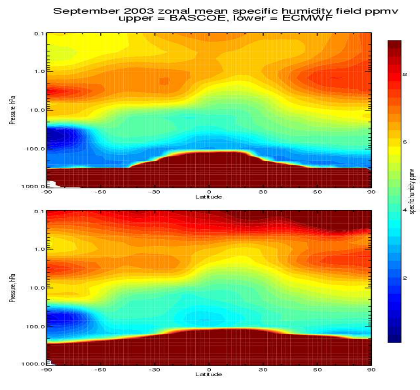


Figure 2 shows how the impact of an observation in the lower troposphere can be limited in the stratosphere by using the scaling tool. The correlation scaling is applied prior to decomposition into the vertical modes. This has the disadvantage that the scaling of the correlations is effected by this decomposition. We are currently investigating post decomposition scaling.

ASSET Humidity Intercomparison

Three ASSET partners have assimilated MIPAS water vapour profiles for September 2003 into their respective models, ECMWF (GCM), BASCOE (CTM) and the Met Office (GCM). Due to the poor results for the Met Office, their analyses are not shown below. The analyses are also in the process of being compared with independent data such as HALOE and POAM3.



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