Response to T. von Clarmann: Interactive comment on "Total depletion of ozone reached in the 2010–2011 Arctic winter as observed by MIPAS/ENVISAT using a 2-D tomographic approach" by E. Arnone et al.

We thanks Thomas von Clarmann for his comments to our manuscript which allowed us to clarify some relevant issues on the 2D retrieval.

1. On page 33194, line 23 the authors state that GMTR retrievals are more suitable under vortex conditions than other codes. GMTR, however, assumes that all measurements are taken in the orbit plane, while close to the poles the azimuth angle of the line of sight causes measurements being taken significantly outside of the orbit plane. Doesn't that mean that GMTR is particularly suitable for measurements near the equator where the underlying assumption is fulfilled but less suitable for polar regions where this assumption does no longer hold?
The GMTR system is particularly suited where strong horizontal gradients are present. This is the case of the polar regions in winter time, where the horizontal gradients are very pronounced. At the Equator, where the atmosphere is fairly homogeneous, 1-D retrievals are performing well. The fact that MIPAS lines of sight are not entirely contained into the orbit plane was discussed also in response to refer #2 (please the relevant comment in our response). Indeed the ideal observations for the GMTR system should be aligned along the orbital plane, and this situation is fulfilled at the Equator as commented above. The deviation of MIPAS lines of sight from the along track alignment requires the approximation of an atmosphere homogeneous in the across track direction. This is however a second order effect on the retrieved products since the adjacent lines of sight that cross a certain portion of the atmosphere (and that are assumed to be aligned) lead to a maximum latitudinal component of the deviation from a plane geometry of 2 degree latitude in the worse cases. Despite this deviation, adjacent lines of sight still cross very similar horizontal gradients which can then be modeled in the 2-D retrieval.

2. Same place: I find the way how the Kiefer et al. paper is referenced a bit misleading: One of the main conclusions of the Kiefer et al. paper is that the problem of horizontal structure is largely remedied by considering horizontal temperature gradients in the otherwise 1-dimensional radiative transfer calculations.
Indeed Kiefer et al. showed a significant improvement can be achieved when including temperature gradients in the 1-D retrieval. However, they conclude that the use of horizontal temperature gradients into the 1-D radiative transfer can reduce the problem only for some gases. For instance ozone is only partly corrected by the use of these gradients. In our opinion the reference to Kiefer et al. paper is appropriate, e.g. in the conclusions sections the paper says: "data processing should be carried out with processors capable of fully handling inhomogeneities (such as the GMTR, Carlotti et al., 2006) or at least those of the temperature field in the atmosphere (such as the gradient inclusion strategy employed in this study)". However, following the above comment, we refined the sentence so as to refer more generally to "conventional" 1-D codes.
We are currently working on a study to rigorously assess the problems linked to the approximate solution provided by including horizontal gradients in the radiative transfer calculations and the results of this study will be available shortly.

3. Same place and page 33196 line 27: Polar vortex conditions are characterized by small-scale structure. The horizontal information smearing of one-dimensional reduced spectral resolution MIPAS retrievals, evaluated by means of horizontal averaging kernels (von Clarmann et al., 2009a) is for most species and altitudes, according to Table 2 of von Clarmann et al. (2009b), less than the horizontal spacing of the limb scans which is 410 km. This implies that the horizontal resolution is limited by the horizontal sampling. In GMTR, the horizontal grid has a spacing of 5, corresponding to far more than 500 km. This means that the horizontal resolution of GMTR is actually inferior to that of 1D-retrievals. Isn't this in conflict with the statement (which is repeated on page 33196, lines 10-14) that GMTR is particularly suitable for polar vortex observation?
We indeed did not intend to state that the MIPAS2D database (and not GMTR, that can be run on any horizontal grid) has better horizontal resolution than 1-D data, but that we treat rigorously the horizontal gradients between adjacent grid points. In this exception GMTR is more suitable than 1-D codes for the analyses of polar regions since at any given geolocation the correct modeling of horizontal gradients will improve the retrieval of the observations. We checked the text to avoid any statement on improved resolution.

References:
von Clarmann et al., The horizontal resolution of MIPAS, AMT, 2, 47-54, 2009a.
von Clarmann et al., Retrieval of temperature H2O, O3, HNO3, CH4, N2O, ClONO2 and ClO from MIPAS reduced resolution nominal mode limb emission measurements, AMT, 2, 1-17, 2009b.