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Interactive comment on "Variability of the Lagrangian turbulent diffusivity in the lower stratosphere" *by* B. Legras et al.

B. Legras et al.

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1. We agree with Dr Konopka that it would be useful to redo our calculations using diabatic velocities and we plan do so, hopefully with his contribution, among our highest priorities for the near future. It is, however, arguable that our wind data are not only dominated by numerical noise since fairly accurate reconstructions of the observed transects are performed. Moreover, we show that using 3-hourly data, a large amount of the spurious motion due to the assimilation procedure can be filtered out.

We do not think that the comment on interpolation and numerical diffusion is relevant to fully Lagrangian trajectory calculations. We perform direct interpolation of velocities from the model levels to the level of the parcel, thus avoiding any smoothing due to intermediate interpolation on pressure or potential temperature levels. The vertical

interpolation is presently linear in log pressure, it could be done in potential temperature or in the hybrid coordinate without much difference. The vertical displacement takes into account the slope of model surfaces. If we were using vertical diabatic velocities, only the horizontal displacements should be calculated in that way.

2.It is well admitted that turbulence is related to wind shear and all parametrizations employed in atmospheric models rely upon this idea. Our goal here is not to test such a parametrization but to provide an independent estimate of the diffusion resulting from unresolved turbulent motion. Moreover, the comparison with the three-dimensional Lyapunov exponent shows in particular that a shear based parametrization would fail to predict the shape of the polar vortex sheet on 11 March 2000. In most cases, when structures cannot be well identified in both the observations and the reconstructions, we can only estimate so far a mean diffusion over a fairly large flight distance. This is clearly a limitation and we are investigating how to improve that.

Other comments:

- We have added a reference to the Batchelor regime and the work mentioned by Dr Konopka, adding also a reference to the review article of Falkovich et al.
- It is easy to make the random walk dependent on the shear but as indicated above, this was against our goal in this study.
- The mathematical problems in relating the microscopic approach to the diffusion equation have been basically solved by Einstein (1905) in his famous paper on Brownian motion and have been universally applied since then.
- The fluctuations are found proportional to $\sqrt{1/N}$ by a calculation of the variance of the difference between the true mean and a mean obtained with a finite sample of N elements. The dependence in $\sqrt{D}$ arises from the scaling of tracer dispersion with D.

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- The length scale $\ell_d = \sqrt{\gamma/D}$ results from the equilibrium of strain and diffusion as obtained, e.g., in a simple one-dimensional equation applied along the converging direction

$$\partial_t \chi - \gamma y \partial_y \chi = D \partial_{y^2} \chi$$

  which admits $\chi = \mathrm{erf}(y/\ell_d)$ as a stationary solution where erf denotes the error function. As the cloud of particles emitted form a given parcel evolves backward, it samples an increasing volume of the flow and the reconstruction performed from such backward time is fairly insensitive to the initial scales that are smoothed by the sample. The sharp variations in the reconstructions arise from the propagator of the gradient, that is from the history of the flow, ,as measured from the Lyapunov exponents, not from the initial conditions. See also the answer to Dr. Sparling.

- There is no error in Fig.(4)a. It is a known problem that CTMs like REPROBUS may currently miss a significant amount of depletion at the end of the Arctic winter.

- We have added the ER-2 observations in two panels of Fig. 3.

- The definition of the roughness function and related quantities has been improved.

- The inertial volume is defined from the inertial matrix as now indicated in the text. It is used as a measure of dispersion and this does require the cloud to remain elliptical.

- Sharp variations of diffusion may occur as a result of a transport or a mixing barrier. The vortex edge has been identified in many previous studies as a transport barrier. Comparison of Lagrangian averaged diffusion with effective diffusivity cannot be done easily. The first one is done over trajectories that may come near the edge outside the jet from a long way in the surf zone while the later is an

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average over a contour which has a minimum on the jet. See Joseph and Legras (2002) for a discussion on related matter.

- We meant aliases which is a technical word from the theory of Fourier analysis. We have, however, replaced this word as suggested by Dr. Konopka.
- The 3-hourly winds are better because the high-frequency fluctuations due to the assimilation are made less persistent in this case than with 6-hourly sampling. The difference with the added white noise lies the dependence upon sampling and also the fact that the added white noise is applied with a time-step of 9s. Since wind errors occur at mesoscale they do not average as diffusion along the flight track.
- Some errors mentioned by Dr Konopka are due to his usage of a preprint older than the submitted manuscript in which there were already corrected. His page numbers also refer to this preprint.

Reference:

Joseph, B., and Legras, B..: Relation between kinematic boundaries, stirring, and barriers for the Antarctic polar vortex, J. Atmos. Sci., 59, 1198–1212, 2002.

Interactive comment on Atmos. Chem. Phys. Discuss., 4, 8285, 2004.