Atmos. Meas. Tech. Discuss., 7, C2892–C2895, 2014
www.atmos-meas-tech-discuss.net/7/C2892/2014/

Atmospheric Measurement Techniques
Discussions

Interactive comment on "An airborne perfluorocarbon tracer system and its first application for a Lagrangian experiment" *by* Y. Ren et al.

Anonymous Referee #2

Received and published: 25 September 2014

General Comments

This article documents a new tracer system designed to track air masses over time windows of more than a day, sufficient for deformation by advection and mixing with surrounding air. The system includes both the tracer release mechanism, an adsorption tube sampler (ATS) and a laboratory analytical system for the PFC tracers. The system was tested for the first time during the SHIVA campaing by releasing the tracer from a ship and sampling the air mass using ATS. The aircraft was also equipped with a gas chromatograph which could detect the tracer although not calibrated. This prooved very useful when comparing to simulated tracer mixing ratios and demonstrating the

traverse of the tracer plume. The utility of the tracer system is established in this paper including its capability to resolve structure in the tracer that has been released.

The scientific approach is thorough and the instrumentation is described well in the paper. The authors were very careful in their experimental approach, for example by showing that there had been no contamination of sampling tubes by using blanks.

The crossing of the plume on the first aircraft flight 5 hours after release produced an impressive quantitative correspondence between concentrations sampled and the simulated concentrations using the HYSPLIT Lagrangian model. As happens during field experiments, a sample was missed at the key time (07:10) when the flight track first crossed the tracer plume. However, the second measurement from the gas chromatograph (GHOST) sampled in this gap and provides convincing evidence that the aircraft did indeed cross the centre of the plume at this early stage. By using a coincident sample measured by both ATS and GHOST, the GHOST measurements were calibrated and show that the GHOST sample near the plume centre sampled a concentration in close accord with the maximum simulated by HYSPLIT.

However, this good fortune also highlights a potential difficulty in the utilisation of the tracer release and sampling system. High frequency sampling is required (without gaps) to resolve the tracer filaments typical of a tracer release and it is difficult to direct an aircraft across the tracer for a representative sample. The later intercepts on the first flight grazed the flanks of the plume (although the mixing ratio correspondence is still impressive) and the second flight almost missed the tracer plume altogether. A wider question not addressed in this paper (which focuses on the experimental methods) is whether the sampling strategy and frequency can be made sufficiently good to infer quantitative information about the evolution of an air mass. For example, in order to infer air mass dilution rate from the tracer data (or to refine a model estimate) it would be necessary to: (i) fly transects across the centre of the plume several times, knowing that the centre had not been missed and (ii) to resolve the shape of tracer concentration distribution on each transect. Clearly forecasting the tracer plume and executing an aircraft flight pattern are central to the potential success of the system. In the conclusions, the authors should include some discussion of how they envisage the new tracer system could be used in the quantification of atmospheric processes and the parameters involved in models. The big question is what we can learn with the new system that we could not know without it?

Overall the paper is well written and presents a tracer release system of unprecedented precision and I recommend publication subject to minor revisions.

Technical Corrections

1. abstract: "forecasted" -> "forecast" in both occurrences

2. p.6793: "parts per quadrillion" -> 10^{-15}

3. The background is very low for the PMCP released, but the analytical system has great precision. Is there a possibility that PMCP release could increase the background during a campaign with several 30kg releases? Is this an insignificant contribution to global warming impact?

4. p.6796: "flow at the ground"

5. p. 6806: "shown in panels a and b"

6. Sections 4 and 5: some high concentrations were observed outside the bounds of the modelled tracer plume and conjectures were made to the structure that might have been there in reality. In section 4 it was stated that the tracer plume was underestimated in the NE-SW direction (along the filament) and at a later time "probably dispersed more in the SE direction". In the conclusions it was stated that the "plume simulated by HYSPLIT is somewhat narrower than the one inferred from the measurements". I think here you meant to say that it was shorter in the along-filament direction (rather than narrower which would imply thinner in the across-filament direction).

However, a key aspect of the Lagrangian simulations at 5 hours is that the tracer plume is a simple ellipse which has elongated slightly but has not folded. Even by 25 hours after release the tracer distribution is elongated in one direction only and the structure is very simple. However, it should be noted that the resolution of the advecting wind field is only 1 degree and the longest axis of the tracer plume in Fig.8 is only 0.35 deg and only 2 deg by 25 hours. Although deformation in this relatively coarse windfield is felt it can only result in stretching of a tracer blob into an ellipse. Folding of tracer structures, characteristic of chaotic advection, could only occur once the tracer filament length exceeds the advecting wind field resolution. Therefore, it is likely that any variation in the wind field on scales less than 1 degree, combined with temporal variation, will result in stretching and folding of the tracer distribution on smaller scales than those seen in Figs. 8 and 9. Therefore, the main deficiency of the simulation is that the tracer plume is not sufficiently stretched or distorted, even at 5 hours. This is not the same as concluding that the tracer needs to spread further (as a result of stronger turbulent mixing).

The authors should discuss these likely deficiencies in the simulations. Given this discussion, the correspondence in concentration between observation and model is remarkably good at 5 hours.

Interactive comment on Atmos. Meas. Tech. Discuss., 7, 6791, 2014.