1. Question: A price to pay in these models is that one needs to use an interparcel mixing algorithm when the density of parcels in an area becomes too large (and LASM needs a global mass fixer to map variables to a fixed grid!).

   Answer: Firstly, the interparcel mixing algorithm is not used to address the clustering or rarefying of parcels, but to reduce the aliasing error caused by the poor representation of the parcel shape. In LASM, when the linear deformation matrix cannot simulate the parcel shape accurately, the interparcel mixing is called. Fig. 1 in the manuscript shows an example, where the red ellipse (deformation matrix) does not match the green dots (skeleton points) well.

   Secondly, the global mass fixer is turned off in this study. The total mass on the parcels is exactly conserved when there is no tendency calculated by external processes, so this should be a strong constraint on the simulation. The total mass on the fixed grids cannot be conserved when remapping tracer density as:

$$\rho_{mI} = \frac{1}{\sum_{j \in S_I} \psi_j(I)} \sum_{i \in S_I} \psi_i(I) \rho_{mi}, \tag{1}$$

   where S_I is the index set of parcels which are connected with grid I, $\psi_i(.)$ is the shape function of parcel i, ρ_{mi} is the tracer density of parcel i for species m, and ρ_{mI} is the tracer density of grid I. When remapping tracer mass as:

$$m_{mI} = \frac{1}{\sum_{j \in S_I} \psi_j(I)} \sum_{i \in S_I} \psi_i(I) m_{mi}, \tag{2}$$

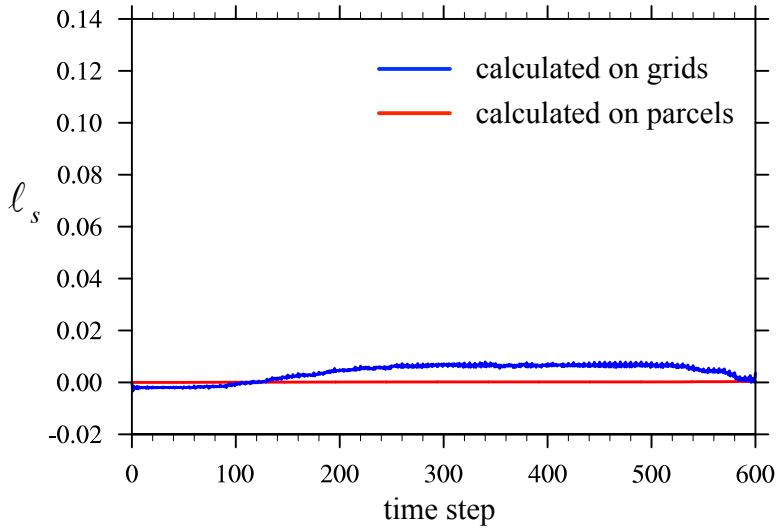
   the total mass on the grids is also conserved. Unfortunately, there may be unwanted density value on the grids near the Poles, when the mesh is lat-lon due to the convergence of grid lines. We are working on this problem, but for the time being, LASM remaps tracer density as shown in Eq. (1).

2. Question: Do these tests span flow conditions found in realistic full model simulations?

   Answer: The barotropic test case provides more realistic flow, and you can see the animations in the supplement files.

3. Question: Could one compare the mixing algorithms in established models with the mixing algorithm in this manuscript? Could one do a turbulent flow and look at energy spectra for the tracers or some other mixing diagnostic (e.g., entropy measure as proposed in Lauritzen and Thuburn, 2011, QJRMS)?

   Answer: The mixing algorithm has already been compared with the one in HEL, which may be the only Lagrangian scheme with mixing algorithm that utilized the standard tests for verification. You can refer Fig. 7 in Kaas et al. (2013) (A hybrid Eulerian-Lagrangian numerical scheme for solving prognostic equations in fluid dynamics). I calculated the entropy diagnostics ℓ_s defined in Lauritzen and Thuburn (2011) on both parcels and grids for the non-divergent



   deformation test case with slotted cylinder initial condition, see the figure above. When calculated on the parcels, ℓ_s is zero when the mixing has not been invoked in the non-divergent deformation test case, otherwise ℓ_s is nonzero, but is still very small (see the red line). When on the grids, there are even negative values, which are caused by the remapping from parcels to grids.

4. Question: The mixing algorithms have tunable parameters: what values would the authors settle on for "real-world" applications?

   Answer: The tunable parameters $\gamma_m = 5$, $\beta_1 = 1$, $\beta_2 = 1000$, $d_0 = 0.5$, $d_1 = 0.1$, $r_0 = 1$, $r_1 = 5$, $\gamma_0 = 1$, $\gamma_1 = 5$, $\alpha_0 = 1$ and $\alpha_1 = 0.5$ are fixed for the 2D applications or even 3D ones. This will be revised in the real applications.

5. Question: please provide details on the mapping from tracer grid to the static grid (Dong et al., 2014) and inform the reader how the tendencies are mapped from the static lat-lon grid to the Lagrangian grid. In particular, what variables are mapped: the product between mixing ratio and density or just mixing ratio? Is tracer mass conserved in the process?

   Answer: The mapping is shown in Eq. (1). For the tendencies mapping, the variables are density change rate of each species. The total Cly in the test case is conserved.

6. Question: Thereafter the authors are kindly asked to investigate further why doing the coupling on the static mesh leads to a noisy solution. Obviously the mapping from Lagrangian parcel space to the static mesh (and vice versa) preserves linear relations (since Cly is conserved!). Is it the mapping from parcel grid to lat-lon grid that results in noise, is it the mapping of tendencies from lat-lon to parcel grid that introduces noise, or both? Does the mass-fixer introduce noise? Could it be the large resolution difference between parcel grid (in areas of convergence) and 1 degree lat-lon grid?

   Answer: When calculating tendencies on the mesh, the noise may be caused by the fact that the significant tendencies of Cl and Cl2 are very local to the edge of the terminator. When a parcel moves away from the terminator, it may still be influenced by the grids on the terminator, and then it transfers the effects to other grids. It is believed by the authors that this is the mismatching between Eulerian representation and Lagrangian representation. In contrast, when calculating on the parcels, the tendencies are evaluated on the parcel centroid, and the solution is noise-free. Therefore, it would be better to formulate the chemical reactions (even physical parameterizations) on the parcels. Grewe et al. (2014) (On the theory of mass conserving transformations for Lagrangian methods in 3D atmosphere-chemistry models) proposed a relatively complex non-overlapping partition of parcels, but it is not applied in LASM currently, and may be incorporated in the future.