Report on UK Fluids Network Short Research Visit 'Enhancement of the Parallel Moist-Parcel-In-Cell Code', 20-24 May 2019

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The Parallel Moist Parcel-in-Cell code (PMPIC), developed in collaborations with the Edinburgh Parallel Computing Centre, is an adaptation of the original code in the component-based framework used by the Met Office NERC Cloud model (MONC). This version of the code offers increased scalability and will enable simulations run over thousands of cores, offering a greatly increased resolution when studying the development of clouds in a Lagrangian model. However, because this version of the code has been refactored to fit with the MONC framework, the first part of the SRV was primarily spent on familiarisation with PMPIC, assisted by Dr Böing.

Subsequently, the objective of the visit was to implement some of the recent changes made in the non-parallel code into this new framework, in particular we decided to prioritise fluxes of heat and moisture at the lower boundary, alongside the effects of the Earth's rotation and a mean flow through the domain. As adding all of these features would allow for a range of simple idealised test cases to be run in PMPIC initially, and are important steps towards more realistic simulations of atmospheric convection.

Surface fluxes are added from a prescribed two-dimensional profile. Currently, this is done using an analytic function of x and y, but will later be extended to read the profiles from an input file. This flux is then calculated at the value of each parcel in the lower grid layer and used to increment the buoyancy and humidity. A global correction is calculated using the ratio of the total flux on each parcel and the integrated flux across the lower layer to ensure the correct flux is added to the system. We also apply a uniform cooling of 2K/day (non-dimensionalised) to the domain.

In implementing the effects of rotation, the traditional approximation, in which the horizontal components of the Coriolis vector are neglected, was not used. These manifest as additional terms in the vorticity equation. The horizontal mean flow was added as an extra term during parcel advection and an x and y component can be prescribed. This will later be extended to incorporate vertical shear profiles.

Some issues with the parallel code were also brought to light during the development of these features. In particular, adding mean flow exposed an issue with halo-swapping (the moving of parcels between processors) at the horizontal (periodic) boundaries in which parcel positions were not adjusted correctly. This has since been resolved.

Figure 1 shows an example y-z cross-section of a cloud developed from an analytic flux profile subject to coriolis rotation and a mean flow directed along the y-axis. A dimensional version of this code is currently also in development, alongside several other refinements.

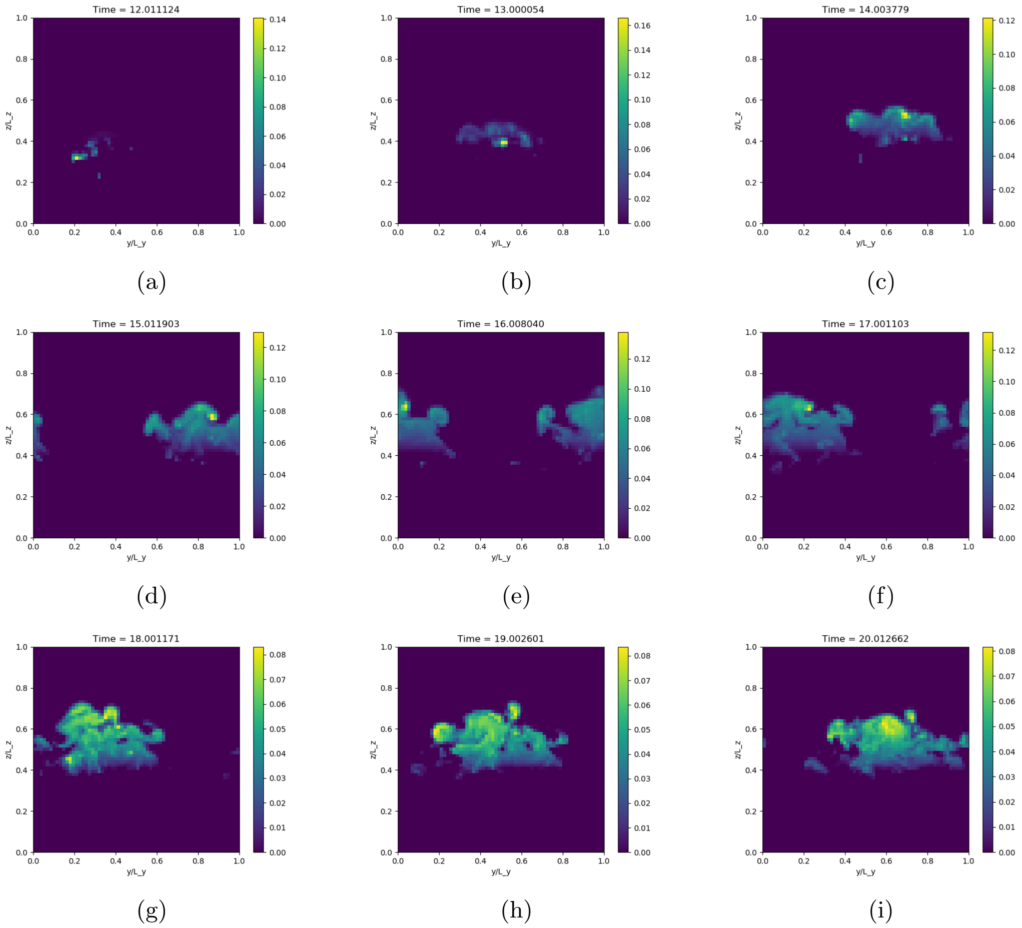

Figure 1: Y-Z cross-sections of the gridded liquid water fraction obtained from MPIC simulations with a resolution of 64^3. These show the development of a cloud from surface fluxes with a mean flow through the domain of $v = 0.1$ (in the positive y-direction, non-dimensional units). We start from $t = 12$ (non-dimensional time) as this is the first point at which condensation occurs within the simulation. Note that we do not yet have a subgrid visualisation of liquid water fraction in PMPIC, hence the use of the gridded field.