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Title:	Cloverleaf Data Artifacts for ArtIMis LDRD
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Cloverleaf Data Artifacts for ArtIMis LDRD

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Abstract

This report summarizes the use of the open-source CloverLeaf/CloverLeaf3D mini-apps to generate synthetic data sets to train foundation models for the ArtIMis LDRD DI. These data artifacts are intended to be used by LANL collaborators and shared externally with our university and institutional partners. Note that CloverLeaf/CloverLeaf3D is not a LANL simulation code.

1 Introduction

CloverLeaf [1] is a compact simulation code designed to solve the compressible Euler equations on a Cartesian mesh using an explicit, second-order accurate scheme. In the discretization, each cell holds scalar quantities such as density, energy, and pressure, while the velocity components are stored at the cell corners. This mix of cell-centered and corner-based variables is known as a staggered grid layout. The primary CloverLeaf implementation is two-dimensional with an extended three-dimensional version, CloverLeaf3D [2], also available. Both 2D and 3D simulations have been generated by ArtIMis team members. Example 3D images are shown in Figure 1.

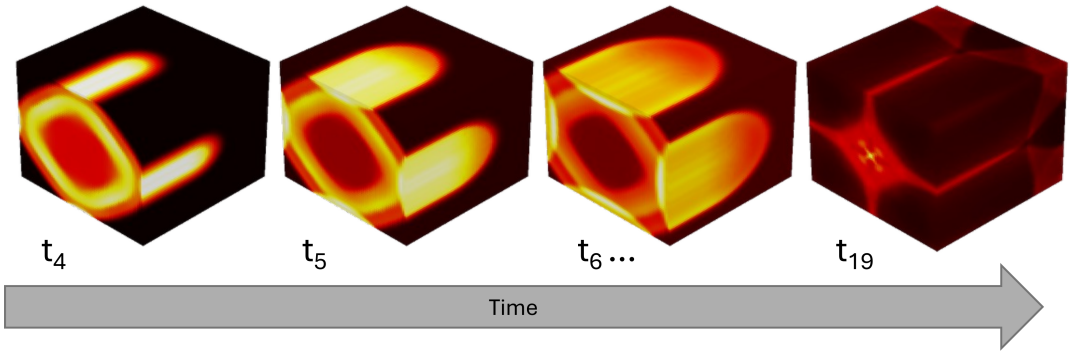

Figure 1: An example of a series of timesteps produced by CloverLeaf3D.

Cloverleaf simulations represent energy levels within the system at points in 3D space as a tensor. Each tensor represents a moment in time. Cloverleaf simulations provide a unique combination of 2D/3D data, time, and textual data (e.g., input decks) that is well-suited for multi-modal AI/ML training.

1.1 Data Sets

More recent and extensive data generation has been done using the 2D CloverLeaf version. Four data sets were each split into *train*, *test*, and *validate* subsets. The data is output originally in VTK [4] format but was converted to HDF5 [3] format for ease of AI/ML training purposes.

2 Input Deck Example

An example input deck, clover.in, is showin in Figure 2.

Table 1: Listing of data set runs.

Run	Train (# of trajectories)	Test (# of trajectories)	Validate (# of trajectories)
1	100	10	10
2	200	20	20
3	500	50	50
4	10000	100	100

```
#clover.in : cloverleaf input deck

*clover
 state 1 density=0.2 energy=1.0
 state 2 density=1.0 energy=2.5 geometry=rectangle xmin=0.0 xmax=5.0 ymin=0.0 ymax=2.0

 x_cells=960
 y_cells=960

 xmin=0.0
 ymin=0.0
 xmax=10.0
 ymax=10.0

 initial_timestep=0.04
 timestep_rise=1.5
 max_timestep=0.04

 end_step=100
 test_problem 2
*endclover
```

Figure 2: Example input deck for the CloverLeaf Simulation.

A python script was used to sample the density and energy values across the variable parameter spaces. The $log(density)$ was uniformly sampled over the range of $[0.1, 100]$ and the energy was uniformly sampled over the range of $[0.0, 1000]$. Each CloverLeaf simulation run was evolved over 100 timesteps at a resolution of $64x64$.

References

[1] CloverLeaf Github and Documentation . https://github.com/UK-MAC/CloverLeaf. Accessed December 8, 2025.

[2] CloverLeaf3D Github and Documentation . https://uk-mac.github.io/CloverLeaf3D/. Accessed December 8, 2025.

[3] The HDF Group. https://www.hdfgroup.org. Accessed December 8, 2025.

[4] W. Schroeder, K. Martin, and B. Lorensen. *The Visualization Toolkit (4th ed.)*. Kitware, 2006.