2D Transport Tutorial Part 6: Refined Grid with FD and MOC for Dirac Source

1. Introduction

In this tutorial, we continue working with the Dirac point source model, introducing a refined computational grid to better capture near-source transport dynamics. We will focus on increasing grid resolution in the inlet and observation zone, and then compare the results from two advection schemes: Standard Finite Difference (FD) and the Method of Characteristics (MOC). Finally, we compare both numerical results with the analytical solution.

2. Saving and Preparing the Model

1. Save the existing model into a new folder named `Dirac_refined`.
2. Use `File > Save As` to ensure a clean copy is stored with this new name.

3. Refining the Grid in ModelMuse

Steps

1. Click on the `Subdivide Grid Cells` icon in the toolbar.
2. Using your cursor, select the area of the model where the plume is expected to spread—this corresponds to **rows 17 to 21** and **columns 22 to 36**.
3. A dialog box will appear with the following fields:
   - `"From Row": 17`
`"Through Row": 21`
`"Subdivide each row into": 1` (change this to 5)
   - `"From Column": 22`
`"Through Column": 36`
`"Subdivide each column into": 1` (change this to 5)
4. Click `"OK"` to apply the refinement.

This operation reduces the cell size in that region from `10 m` to `2 m`.

4. Defining the Source and Observation Points

Using Exact Coordinates in the Vertices Tab

To precisely place the source and observation points within the refined grid, we recommend using the `Vertices` tab to enter coordinates directly.

Source Placement

1. Select the source object.
2. Go to the `Vertices` tab.
3. Enter a single point: `(400, -550)`

Observation Points

Repeat the following steps for each observation point:

- **Obs30:** `(430, -550)`
- **Obs50:** `(450, -550)`
- **Obs100:** `(500, -550)`

1. Click the observation point object.
2. Go to the `Vertices` tab.
3. Enter the corresponding coordinates.

Note: Since you are entering the positions directly, there is no need to visually reposition the objects in the model interface.

5. Simulation Using Finite Difference (FD) Scheme

Solver Configuration

- Go to `Model > MODFLOW Packages and Programs > Groundwater Transport`.
- Open the `Advection` sub-tab and choose `Standard Finite Difference`.

Run MODFLOW

- Save the model in a new folder: `dirac_refined_fd`.
- Click the green triangle to run the flow model.

Run MT3DMS

- Use the dropdown beside the green triangle.
- Select `Export MT3D Input Files`.
- Monitor the simulation and note the runtime. (Approx. 24 seconds)
- When done, check the MT3DMS listing file for mass balance discrepancy. It should be very small.

6. Simulation Using MOC Scheme

Solver Configuration

- Navigate to the same Advection tab.
- Change the scheme to `Method of Characteristics (MOC)`.

Run MODFLOW

- Save the model in a new folder: `dirac_refined_moc`.
- Run the MODFLOW simulation.

Run MT3DMS

- Export MT3D input files again.
- Run the transport model and check:
  - Runtime (approx. 18 seconds)
  - Mass balance discrepancy in the listing file (approx. 0.86%)

7. Post-Processing and Result Comparison

Importing UCN File

- Use the `Import and Display Results` tool.
- Load the UCN file from each respective folder.
- Select the final time step to visualize the plume.

Excel Analysis

- Open the `.MTO` file from each simulation.
- Copy the content into the Excel spreadsheet under the appropriate sheet (e.g., `Dirac_refined`).
- Make sure to verify the observation locations in the data columns.

8. Comparison with Analytical Solution

1. Launch the Streamlit app for the 2D Dirac model.
2. Compute the breakthrough curve for the 30-meter observation distance.
3. Download the resulting CSV.
4. Open the CSV and paste the data into the appropriate worksheet in the Excel file.
5. Compare the FD and MOC results against the analytical curve.

You should observe:

- A nearly perfect fit for the MOC result, with minor oscillations.
- A reasonable but slightly less accurate match for the FD result.