NaviFlow Analysis Script

This notebook analyzes NaviFlow simulation results from HDF5 files.

Imports

```
import h5py
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import scienceplots
from matplotlib.cm import coolwarm
import os

# Set up scienceplots style
plt.style.use(['science', 'ieee'])
```

Helper functions

```
# Function to extract metadata from H5 files
def extract_metadata(file_path):
    with h5py.File(file_path, 'r') as f:
        metadata = {}

        # Get algorithm information
        if 'algorithm' in f:
            for key in f['algorithm'].attrs.keys():
                metadata[f'algorithm_{key}'] = f['algorithm'].attrs[key]

        # Get simulation information
        if 'simulation' in f:
            for key in f['simulation'].attrs.keys():
                metadata[f'simulation_{key}'] = f['simulation'].attrs[key]
            if 'mesh_size' in f['simulation']:
                for key in f['simulation']['mesh_size'].attrs.keys():
              metadata[f'mesh_{key}'] = f['simulation']['mesh_size'].attrs[key]

        # Get solver information
        if 'momentum_solver' in f:
            for key in f['momentum_solver'].attrs.keys():
           metadata[f'momentum_solver_{key}'] = f['momentum_solver'].attrs[key]

        if 'pressure_solver' in f:
            for key in f['pressure_solver'].attrs.keys():
           metadata[f'pressure_solver_{key}'] = f['pressure_solver'].attrs[key]
```

```
        # Get performance information
        if 'performance' in f:
            for key in f['performance'].attrs.keys():
                metadata[f'performance_{key}'] = f['performance'].attrs[key]

        # Add solver type based on file path
        if 'pyamg' in file_path:
            metadata['solver_type'] = 'PyAMG'
        elif 'preconditioned_cg' in file_path:
            metadata['solver_type'] = 'Preconditioned CG'

        # Add file path
        metadata['file_path'] = file_path

        return metadata

# Function to plot convergence metrics
def plot_convergence_metric(files, metric, title, ylabel):
    plt.figure(figsize=(10, 6))

    # Get colors from coolwarm colormap
    colors = [coolwarm(i) for i in np.linspace(0, 1, len(files))]

    for idx, (file_path, color) in enumerate(zip(files, colors)):
        with h5py.File(file_path, 'r') as f:
            if 'residual_history' in f:
                hist_group = f['residual_history']
                iterations = hist_group['iteration'][:]

                # Get solver type from file path
                if 'pyamg' in file_path:
                    solver = 'PyAMG'
                elif 'preconditioned_cg' in file_path:
                    solver = 'Preconditioned CG'
                else:
                    solver = 'Unknown'

                # Plot the metric with error checking
                if metric in hist_group:
                    data = hist_group[metric][:]
                    print(f"Plotting {metric} for {solver}:")
                    print(f"  First value: {data[0]}")
                    print(f"  Last value: {data[-1]}")
                    print(f"  Min value: {np.min(data)}")
                    print(f"  Max value: {np.max(data)}")

                    # Ensure data is not empty or all zeros
```

```
                    if len(data) > 0 and not np.all(data == 0):
                        plt.loglog(iterations, data, label=solver, color=color,
marker='o', markersize=4, markevery=5)
                    else:
                        print(f"Warning: {metric} data is empty or all zeros for
{solver}")
                else:
                    print(f"Warning: {metric} not found in {file_path}")

    plt.title(title)
    plt.xlabel('Iteration')
    plt.ylabel(ylabel)
    plt.grid(True, which='both', ls='-', alpha=0.2)
    plt.legend(bbox_to_anchor=(1.05, 1), loc='upper left')
    plt.tight_layout()

    # Set y-axis limits if needed
    plt.ylim(bottom=1e-10)  # Adjust this value based on your data

    return plt.gcf()
```

Data loading and Processing

```
# Define file paths
file_paths = [
   '/Users/philipnickel/Documents/GitHub/NaviFlow/main_scripts/04 gauss_seidel/
results/SIMPLE_Re100_mesh31x31_profile.h5',
        '/Users/philipnickel/Documents/GitHub/NaviFlow/main_scripts/03 jacobi/
results/SIMPLE_Re100_mesh31x31_profile.h5',
    '/Users/philipnickel/Documents/GitHub/NaviFlow/main_scripts/06 AMG/results/
SIMPLE_Re100_mesh31x31_profile.h5',
        '/Users/philipnickel/Documents/GitHub/NaviFlow/main_scripts/07 AMG_CG/
results/SIMPLE_Re100_mesh31x31_profile.h5',
      '/Users/philipnickel/Documents/GitHub/NaviFlow/main_scripts/02 Conjugate
Gradient/results/SIMPLE_Re100_mesh31x31_profile.h5',
                 '/Users/philipnickel/Documents/GitHub/NaviFlow/main_scripts/05
geo_multigrid/results/SIMPLE_Re100_mesh31x31_profile.h5',
     '/Users/philipnickel/Documents/GitHub/NaviFlow/main_scripts/08 CG Matrix/
results/SIMPLE_Re100_mesh31x31_profile.h5'
]

# Extract metadata from all files
metadata_list = []
for file_path in file_paths:
    metadata = extract_metadata(file_path)
    metadata_list.append(metadata)

# Create DataFrame
```

```python
df = pd.DataFrame(metadata_list)

# Display DataFrame
print("\nMetadata DataFrame:")
print(df)
```

```
Metadata DataFrame:
   algorithm_alpha_p  algorithm_alpha_u simulation_algorithm  \
0                0.3                0.7         SimpleSolver
1                0.3                0.7         SimpleSolver
2                0.3                0.7         SimpleSolver
3                0.3                0.7         SimpleSolver
4                0.3                0.7         SimpleSolver
5                0.3                0.7         SimpleSolver
6                0.3                0.7         SimpleSolver

   simulation_reynolds_number simulation_timestamp  mesh_x  mesh_y  \
0                         100  2025-04-09 17:15:50      31      31
1                         100  2025-04-09 17:11:20      31      31
2                         100  2025-04-09 17:23:21      31      31
3                         100  2025-04-09 17:23:56      31      31
4                         100  2025-04-09 17:10:50      31      31
5                         100  2025-04-09 17:26:29      31      31
6                         100  2025-04-09 17:24:25      31      31

     momentum_solver_type  pressure_solver_max_iterations  \
0  StandardMomentumSolver                         5000000
1  StandardMomentumSolver                          500000
2  StandardMomentumSolver                          100000
3  StandardMomentumSolver                          100000
4  StandardMomentumSolver                         1000000
5  StandardMomentumSolver                             100
6  StandardMomentumSolver                          100000

   pressure_solver_tolerance     pressure_solver_type  \
0               1.000000e-07       GaussSeidelSolver
1               1.000000e-07            JacobiSolver
2               1.000000e-07             PyAMGSolver
3               1.000000e-07   PreconditionedCGSolver
4               1.000000e-07       MatrixFreeCGSolver
5               1.000000e-08          MultiGridSolver
6               1.000000e-07  ConjugateGradientSolver

   performance_avg_time_per_iteration  performance_cpu_time  \
0                            0.579333            201.515469
1                            0.598274            211.602508
```

```
2                            0.007798             2.540865
3                            0.010383             3.392012
4                            0.012597             4.124768
5                            0.314297           109.199628
6                            0.004966             1.616455

   performance_iterations  performance_total_time  \
0                     350              202.766532
1                     356              212.985567
2                     333                2.596847
3                     333                3.457596
4                     333                4.194914
5                     349              109.689749
6                     333                1.653763

                                            file_path  \
0  /Users/philipnickel/Documents/GitHub/NaviFlow/...
1  /Users/philipnickel/Documents/GitHub/NaviFlow/...
2  /Users/philipnickel/Documents/GitHub/NaviFlow/...
3  /Users/philipnickel/Documents/GitHub/NaviFlow/...
4  /Users/philipnickel/Documents/GitHub/NaviFlow/...
5  /Users/philipnickel/Documents/GitHub/NaviFlow/...
6  /Users/philipnickel/Documents/GitHub/NaviFlow/...

  pressure_solver_matrix_free
0                         NaN
1                         NaN
2                        True
3                         NaN
4                         NaN
5                         NaN
6                         NaN
```

LaTeX Table generation

```
# Create a clean DataFrame with all relevant columns
metadata_df = df[[
    'simulation_algorithm',
    'simulation_reynolds_number',
    'algorithm_alpha_p',
    'algorithm_alpha_u',
    'mesh_x',
    'mesh_y',
    'momentum_solver_type',
    'pressure_solver_type',
    'pressure_solver_tolerance',
    'performance_avg_time_per_iteration',
    'performance_cpu_time',
```

```
    'performance_iterations',
    'performance_total_time'
]].copy()

# Rename columns to be more readable
metadata_df.columns = [
    'Algorithm',
    'Re',
    'αp',
    'αu',
    'Mesh X',
    'Mesh Y',
    'Momentum Solver',
    'Pressure Solver',
    'Pressure Tolerance',
    'Time/Iter (s)',
    'CPU Time (s)',
    'Iterations',
    'Total Time (s)'
]

# Generate the LaTeX table with proper formatting
print("\\begin{table}[htbp]\n\\centering\n\\resizebox{\\textwidth}{!}{" +
      metadata_df.to_latex(index=False, float_format=lambda x: f"{x:.2e}" if x
< 0.0001 or x > 10000 else f"{x:.3f}") +
          "}\n\\caption{Solver  Comparison}\n\\label{tab:solver_comparison}\n\
\end{table}")
```

```
\begin{table}[htbp]
\centering
\resizebox{\textwidth}{!}{\begin{tabular}{lrrrrrllrrrr}
\toprule
Algorithm & Re & αp & αu & Mesh X & Mesh Y & Momentum Solver & Pressure Solver
& Pressure Tolerance & Time/Iter (s) & CPU Time (s) & Iterations & Total Time
(s) \\
\midrule
SimpleSolver & 100 & 0.300 & 0.700 & 31 & 31 & StandardMomentumSolver &
GaussSeidelSolver & 1.00e-07 & 0.579 & 201.515 & 350 & 202.767 \\
SimpleSolver & 100 & 0.300 & 0.700 & 31 & 31 & StandardMomentumSolver &
JacobiSolver & 1.00e-07 & 0.598 & 211.603 & 356 & 212.986 \\
SimpleSolver & 100 & 0.300 & 0.700 & 31 & 31 & StandardMomentumSolver & PyAMGSolver
& 1.00e-07 & 0.008 & 2.541 & 333 & 2.597 \\
SimpleSolver & 100 & 0.300 & 0.700 & 31 & 31 & StandardMomentumSolver &
PreconditionedCGSolver & 1.00e-07 & 0.010 & 3.392 & 333 & 3.458 \\
SimpleSolver & 100 & 0.300 & 0.700 & 31 & 31 & StandardMomentumSolver &
MatrixFreeCGSolver & 1.00e-07 & 0.013 & 4.125 & 333 & 4.195 \\
SimpleSolver & 100 & 0.300 & 0.700 & 31 & 31 & StandardMomentumSolver &
```

```
MultiGridSolver & 1.00e-08 & 0.314 & 109.200 & 349 & 109.690 \\
SimpleSolver & 100 & 0.300 & 0.700 & 31 & 31 & StandardMomentumSolver &
ConjugateGradientSolver & 1.00e-07 & 0.005 & 1.616 & 333 & 1.654 \\
\bottomrule
\end{tabular}
}
\caption{Solver Comparison}
\label{tab:solver_comparison}
\end{table}
```

```
metadata_df
```

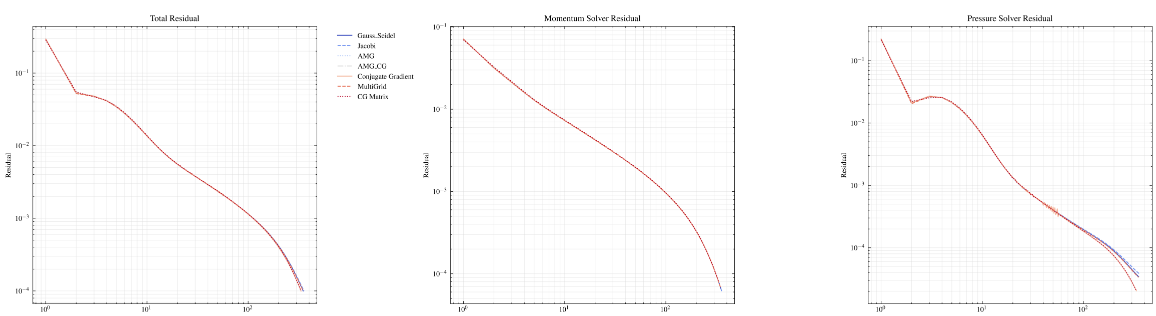
	Algorithm	Re	αp	αu	Mesh X	Mesh Y	Momentum Solver	Pressure Solver	Pressure Tolerance	Time/Iter (s)	CPU Time (s)	Iterations	Total Time (s)
0	SimpleSolver	100	0.3	0.7	31	31	StandardMomentumSolver	GaussSeidelSolver	1.000000e-07	0.577332	201.515469	351	202.766532
1	SimpleSolver	100	0.3	0.7	31	31	StandardMomentumSolver	JacobiSolver	1.000000e-07	0.598274	211.602558	356	212.985567
2	SimpleSolver	100	0.3	0.7	31	31	StandardMomentumSolver	PyAMGSolver	1.000000e-07	0.007798	2.540865	333	2.596847
3	SimpleSolver	100	0.3	0.7	31	31	StandardMomentumSolver	PreconditionedCGSolver	1.000000e-07	0.010383	3.392012	333	3.457596
4	SimpleSolver	100	0.3	0.7	31	31	StandardMomentumSolver	MatrixFreeCGSolver	1.000000e-07	0.012597	4.124768	333	4.194914
5	SimpleSolver	100	0.3	0.7	31	31	Standard-	MultiGridSolver	1.000000e-08	0.314297	109.199628	349	109.689749

	Algorithm	Re	αp	αu	Mesh X	Mesh Y	Momentum Solver	Pressure Solver	Pressure Tolerance	Time/Iter (s)	CPU Time (s)	Iterations	Total Time (s)
							MomentumSolver						
6	SimpleSolver	100	0.3	0.7	31	31	StandardMomentumSolver	ConjugateGradientSolver	1.000000e-07	0.004966	1.616455	333	1.653763

Residual plots

```python
# Create a figure with three subplots side by side
fig, (ax1, ax2, ax3) = plt.subplots(1, 3, figsize=(18, 5))

# Get colors from coolwarm colormap
colors = [coolwarm(i) for i in np.linspace(0, 1, len(file_paths))]

for idx, (file_path, color) in enumerate(zip(file_paths, colors)):
    with h5py.File(file_path, 'r') as f:
         # Get algorithm information
        if 'residual_history' in f:
            hist_group = f['residual_history']
            iterations = hist_group['iteration'][:]

            # Get solver type from file path
            if '06 amg' in file_path.lower():
                solver = 'AMG'
            elif '04 gauss_seidel' in file_path.lower():
                solver = 'Gauss_Seidel'
            elif '03 jacobi' in file_path.lower():
                solver = 'Jacobi'
            elif '01 basic_cavity' in file_path.lower():
                solver = 'Basic Cavity'
            elif '07 amg_cg' in file_path.lower():
                solver = 'AMG_CG'
            elif '02 conjugate gradient' in file_path.lower():
                solver = 'Conjugate Gradient'
            elif '05 geo_multigrid' in file_path.lower():
                solver = 'MultiGrid'
            elif '08 cg matrix' in file_path.lower():
                solver = 'CG Matrix'
```

```python
            else:
                solver = 'Unknown'

            # Plot total residual
            total_residual = hist_group['total_residual'][:]
            ax1.loglog(iterations, total_residual, label=solver, color=color)

            # Plot momentum solver residual
            momentum_residual = hist_group['momentum_residual'][:]
           ax2.loglog(iterations, momentum_residual, label=solver, color=color)

            # Plot pressure solver residual
            pressure_residual = hist_group['pressure_residual'][:]
           ax3.loglog(iterations, pressure_residual, label=solver, color=color)

# Configure each subplot
for ax, title, ylabel in [(ax1, 'Total Residual', 'Residual'),
                          (ax2, 'Momentum Solver Residual', 'Residual'),
                          (ax3, 'Pressure Solver Residual', 'Residual')]:
    ax.set_title(title)
    ax.set_xlabel('Iteration')
    ax.set_ylabel(ylabel)
    ax.grid(True, which='both', ls='-', alpha=0.2)

# Add legend only to the first subplot
ax1.legend(bbox_to_anchor=(1.05, 1), loc='upper left')

plt.tight_layout()
plt.savefig('combined_residuals.pdf', bbox_inches='tight', dpi=300)
plt.show()
```



Infinity norm plot

```python
# First, let's check the data
for file_path in file_paths:
    with h5py.File(file_path, 'r') as f:
        if 'residual_history' in f:
```

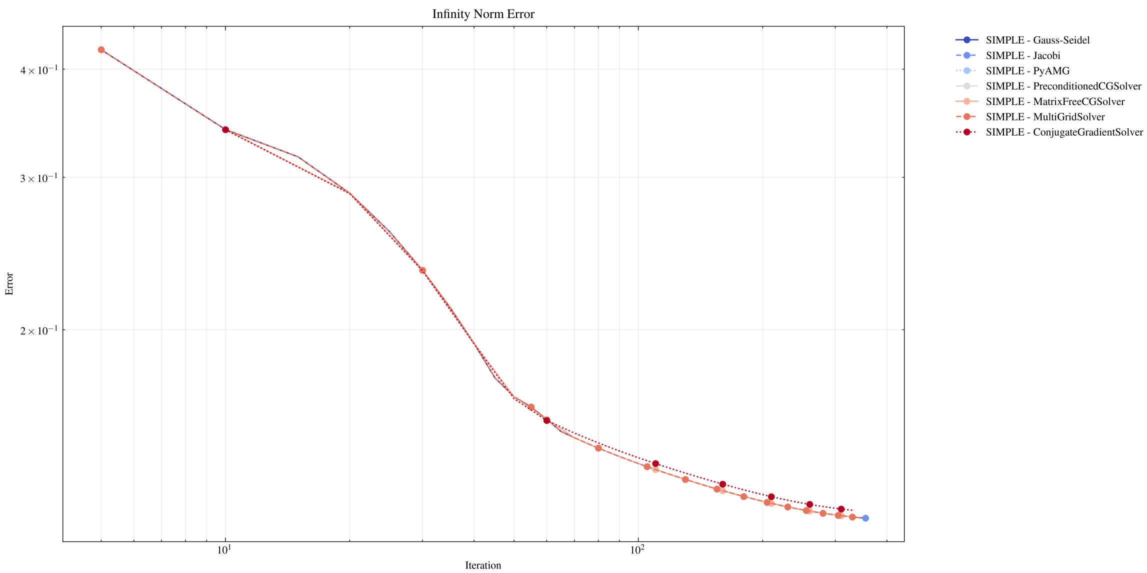
```
            hist_group = f['residual_history']
            print(f"\nChecking {file_path}:")
            print("Available metrics:", list(hist_group.keys()))
            if 'infinity_norm_error' in hist_group:
                data = hist_group['infinity_norm_error'][:]
                print(f"Infinity norm data shape: {data.shape}")
                print(f"First value: {data[0]}")
                print(f"Last value: {data[-1]}")
                print(f"Min value: {np.nanmin(data)}")  # Use nanmin instead of
min
                print(f"Max value: {np.nanmax(data)}")  # Use nanmax instead of
max
                print(f"Number of NaN values: {np.isnan(data).sum()}")
            else:
                print("No infinity norm data found!")

# Now let's create a new plot
plt.figure(figsize=(12, 6))
# Plot the data
for idx, file_path in enumerate(file_paths):
    with h5py.File(file_path, 'r') as f:
        if 'residual_history' in f:
            hist_group = f['residual_history']
            iterations = hist_group['iteration'][:]
            data = hist_group['infinity_norm_error'][:]

            # Get solver type from the DataFrame based on index
            # Since we're processing files in the same order as the DataFrame
            solver_type = df.iloc[idx]['pressure_solver_type']

            # Map solver types to display names
            solver_map = {
                'DirectPressureSolver': 'Direct',
                'GaussSeidelSolver': 'Gauss-Seidel',
                'JacobiSolver': 'Jacobi',
                'PyAMGSolver': 'PyAMG'
            }

            solver_name = solver_map.get(solver_type, solver_type)

            # Get algorithm from filename
            filename = os.path.basename(file_path)
            algorithm = filename.split('_')[0]  # e.g., 'SIMPLE'

            # Create label combining algorithm and solver
            label = f"{algorithm} - {solver_name}"

            # Remove NaN values and corresponding iterations
```

```
            mask = ~np.isnan(data)
            data = data[mask]
            iterations = iterations[mask]

            # Plot with a different color for each solver
            color = coolwarm(idx / (len(file_paths) - 1))
            plt.loglog(iterations, data, label=label, color=color, marker='o',
markersize=4, markevery=5)

# Configure the plot
plt.title('Infinity Norm Error')
plt.xlabel('Iteration')
plt.ylabel('Error')
plt.grid(True, which='both', ls='-', alpha=0.2)
plt.legend(bbox_to_anchor=(1.05, 1), loc='upper left')
plt.tight_layout()

# Set y-axis limits if needed
#plt.ylim(bottom=1e-10)  # Adjust this value based on your data

# Save and show the plot
plt.savefig('infinity_norm_error.pdf', bbox_inches='tight', dpi=300)
plt.show()
```

```
Checking          /Users/philipnickel/Documents/GitHub/NaviFlow/main_scripts/04
gauss_seidel/results/SIMPLE_Re100_mesh31x31_profile.h5:
Available    metrics:    ['cpu_time',    'infinity_norm_error',    'iteration',
'momentum_residual', 'pressure_residual', 'total_residual', 'wall_time']
Infinity norm data shape: (350,)
First value: nan
Last value: 0.1212648071886464
Min value: 0.1212648071886464
Max value: 0.42120866277455615
Number of NaN values: 280

Checking /Users/philipnickel/Documents/GitHub/NaviFlow/main_scripts/03 jacobi/
results/SIMPLE_Re100_mesh31x31_profile.h5:
Available    metrics:    ['cpu_time',    'infinity_norm_error',    'iteration',
'momentum_residual', 'pressure_residual', 'total_residual', 'wall_time']
Infinity norm data shape: (356,)
First value: nan
Last value: 0.12117951996511978
Min value: 0.12117951996511978
Max value: 0.421208641466019
Number of NaN values: 284
```

```
Checking /Users/philipnickel/Documents/GitHub/NaviFlow/main_scripts/06 AMG/
results/SIMPLE_Re100_mesh31x31_profile.h5:
Available metrics: ['cpu_time', 'infinity_norm_error', 'iteration',
'momentum_residual', 'pressure_residual', 'total_residual', 'wall_time']
Infinity norm data shape: (333,)
First value: nan
Last value: 0.12372647432534345
Min value: 0.12372647432534345
Max value: 0.340488830436078
Number of NaN values: 299

Checking /Users/philipnickel/Documents/GitHub/NaviFlow/main_scripts/07 AMG_CG/
results/SIMPLE_Re100_mesh31x31_profile.h5:
Available metrics: ['cpu_time', 'infinity_norm_error', 'iteration',
'momentum_residual', 'pressure_residual', 'total_residual', 'wall_time']
Infinity norm data shape: (333,)
First value: nan
Last value: 0.12372632240825743
Min value: 0.12372632240825743
Max value: 0.3404889874511528
Number of NaN values: 299

Checking /Users/philipnickel/Documents/GitHub/NaviFlow/main_scripts/02
Conjugate Gradient/results/SIMPLE_Re100_mesh31x31_profile.h5:
Available metrics: ['cpu_time', 'infinity_norm_error', 'iteration',
'momentum_residual', 'pressure_residual', 'total_residual', 'wall_time']
Infinity norm data shape: (333,)
First value: nan
Last value: 0.12153998235855568
Min value: 0.12153998235855568
Max value: 0.340679710527879
Number of NaN values: 299

Checking /Users/philipnickel/Documents/GitHub/NaviFlow/main_scripts/05
geo_multigrid/results/SIMPLE_Re100_mesh31x31_profile.h5:
Available metrics: ['cpu_time', 'infinity_norm_error', 'iteration',
'momentum_residual', 'pressure_residual', 'total_residual', 'wall_time']
Infinity norm data shape: (349,)
First value: nan
Last value: 0.1212796386581454
Min value: 0.1212796386581454
Max value: 0.42122010530843546
Number of NaN values: 279

Checking /Users/philipnickel/Documents/GitHub/NaviFlow/main_scripts/08 CG
Matrix/results/SIMPLE_Re100_mesh31x31_profile.h5:
Available metrics: ['cpu_time', 'infinity_norm_error', 'iteration',
'momentum_residual', 'pressure_residual', 'total_residual', 'wall_time']
```

```
Infinity norm data shape: (333,)
First value: nan
Last value: 0.12372513315521538
Min value: 0.12372513315521538
Max value: 0.3404886132057242
Number of NaN values: 299
```




```python
# First, print the DataFrame to see what's in it
print("DataFrame contents:")
print(df)

# Print the file paths we're using
print("\nFile paths:")
for file_path in file_paths:
    print(file_path)

# Plot the data
for idx, file_path in enumerate(file_paths):
    with h5py.File(file_path, 'r') as f:
        if 'residual_history' in f:
            hist_group = f['residual_history']
            iterations = hist_group['iteration'][:]
            data = hist_group['infinity_norm_error'][:]

            # Debug: Print the file path and check if it's in the DataFrame
            print(f"\nProcessing file: {file_path}")
            matching_rows = df[df['file_path'] == file_path]
            print(f"Matching rows in DataFrame: {len(matching_rows)}")
```

```
            if len(matching_rows) > 0:
                solver_name = matching_rows['solver_type'].iloc[0]
                print(f"Found solver name: {solver_name}")
            else:
                # If not found in DataFrame, extract from path
                path_parts = file_path.split('/')
              solver_type = path_parts[1] if len(path_parts) > 1 else "Unknown"

                # Map directory names to proper solver names
                solver_map = {
                    'pyamg': 'PyAMG',
                    'gauss_seidel': 'Gauss-Seidel',
                    'jacobi': 'Jacobi',
                    'basic_cavity': 'Basic Cavity',
                    'preconditioned_cg': 'Preconditioned CG'
                }

             solver_name = solver_map.get(solver_type, solver_type.replace('_',
' ').title())
                print(f"Extracted solver name from path: {solver_name}")

            # Get algorithm from filename
            filename = os.path.basename(file_path)
            algorithm = filename.split('_')[0]  # e.g., 'SIMPLE'

            # Create label combining algorithm and solver
            label = f"{algorithm} - {solver_name}"
            print(f"Final label: {label}")

            # Remove NaN values and corresponding iterations
            mask = ~np.isnan(data)
            data = data[mask]
            iterations = iterations[mask]

            # Plot with a different color for each solver
            color = coolwarm(idx / (len(file_paths) - 1))
            plt.loglog(iterations, data, label=label, color=color, marker='o',
markersize=4, markevery=5)
```

```
DataFrame contents:
   algorithm_alpha_p  algorithm_alpha_u simulation_algorithm  \
0                0.3                0.7         SimpleSolver
1                0.3                0.7         SimpleSolver
2                0.3                0.7         SimpleSolver
3                0.3                0.7         SimpleSolver
4                0.3                0.7         SimpleSolver
5                0.3                0.7         SimpleSolver
```

```
6                0.3                 0.7         SimpleSolver   

   simulation_reynolds_number simulation_timestamp  mesh_x  mesh_y  \
0                         100  2025-04-09 17:15:50      31      31   
1                         100  2025-04-09 17:11:20      31      31   
2                         100  2025-04-09 17:23:21      31      31   
3                         100  2025-04-09 17:23:56      31      31   
4                         100  2025-04-09 17:10:50      31      31   
5                         100  2025-04-09 17:26:29      31      31   
6                         100  2025-04-09 17:24:25      31      31   

     momentum_solver_type  pressure_solver_max_iterations  \
0  StandardMomentumSolver                         5000000   
1  StandardMomentumSolver                          500000   
2  StandardMomentumSolver                          100000   
3  StandardMomentumSolver                          100000   
4  StandardMomentumSolver                         1000000   
5  StandardMomentumSolver                             100   
6  StandardMomentumSolver                          100000   

   pressure_solver_tolerance     pressure_solver_type  \
0               1.000000e-07       GaussSeidelSolver   
1               1.000000e-07            JacobiSolver   
2               1.000000e-07             PyAMGSolver   
3               1.000000e-07   PreconditionedCGSolver   
4               1.000000e-07       MatrixFreeCGSolver   
5               1.000000e-08          MultiGridSolver   
6               1.000000e-07  ConjugateGradientSolver   

   performance_avg_time_per_iteration  performance_cpu_time  \
0                            0.579333            201.515469   
1                            0.598274            211.602508   
2                            0.007798              2.540865   
3                            0.010383              3.392012   
4                            0.012597              4.124768   
5                            0.314297            109.199628   
6                            0.004966              1.616455   

   performance_iterations  performance_total_time  \
0                     350              202.766532   
1                     356              212.985567   
2                     333                2.596847   
3                     333                3.457596   
4                     333                4.194914   
5                     349              109.689749   
6                     333                1.653763   

                                         file_path  \
```

```
0  /Users/philipnickel/Documents/GitHub/NaviFlow/...
1  /Users/philipnickel/Documents/GitHub/NaviFlow/...
2  /Users/philipnickel/Documents/GitHub/NaviFlow/...
3  /Users/philipnickel/Documents/GitHub/NaviFlow/...
4  /Users/philipnickel/Documents/GitHub/NaviFlow/...
5  /Users/philipnickel/Documents/GitHub/NaviFlow/...
6  /Users/philipnickel/Documents/GitHub/NaviFlow/...

  pressure_solver_matrix_free
0                        NaN
1                        NaN
2                       True
3                        NaN
4                        NaN
5                        NaN
6                        NaN

File paths:
/Users/philipnickel/Documents/GitHub/NaviFlow/main_scripts/04    gauss_seidel/
results/SIMPLE_Re100_mesh31x31_profile.h5
/Users/philipnickel/Documents/GitHub/NaviFlow/main_scripts/03  jacobi/results/
SIMPLE_Re100_mesh31x31_profile.h5
/Users/philipnickel/Documents/GitHub/NaviFlow/main_scripts/06     AMG/results/
SIMPLE_Re100_mesh31x31_profile.h5
/Users/philipnickel/Documents/GitHub/NaviFlow/main_scripts/07  AMG_CG/results/
SIMPLE_Re100_mesh31x31_profile.h5
/Users/philipnickel/Documents/GitHub/NaviFlow/main_scripts/02        Conjugate
Gradient/results/SIMPLE_Re100_mesh31x31_profile.h5
/Users/philipnickel/Documents/GitHub/NaviFlow/main_scripts/05   geo_multigrid/
results/SIMPLE_Re100_mesh31x31_profile.h5
/Users/philipnickel/Documents/GitHub/NaviFlow/main_scripts/08    CG    Matrix/
results/SIMPLE_Re100_mesh31x31_profile.h5

Processing file: /Users/philipnickel/Documents/GitHub/NaviFlow/main_scripts/04
gauss_seidel/results/SIMPLE_Re100_mesh31x31_profile.h5
Matching rows in DataFrame: 1
```

```
KeyError: 'solver_type'
 [0;31m---------------------------------------------------------------------------
[0m
 [0;31mKeyError [0m                                Traceback (most recent call
last)
File              [0;32m/opt/homebrew/Caskroom/miniconda/base/envs/cfdeeznutz/
lib/python3.11/site-packages/pandas/core/indexes/base.py:3791 [0m,          in
 [0;36mIndex.get_loc [0;34m(self, key) [0m
 [1;32m   3790 [0m  [38;5;28;01mtry [39;00m:
 [0;32m->      3791 [0m                            [38;5;28;01mreturn [39;00m
```

```
[38;5;28;43mself [39;49m [38;5;241;43m. [39;49m [43m_engine [49m [38;5;241;43m.
[39;49m [43mget_loc [49m [43m( [49m [43mcasted_key [49m [43m) [49m
[1;32m      3792 [0m   [38;5;28;01mexcept [39;00m   [38;5;167;01mKeyError [39;00m
[38;5;28;01mas [39;00m err:

File                         [0;32mindex.pyx:152 [0m,                         in
[0;36mpandas._libs.index.IndexEngine.get_loc [0;34m() [0m

File                         [0;32mindex.pyx:181 [0m,                         in
[0;36mpandas._libs.index.IndexEngine.get_loc [0;34m() [0m

File          [0;32mpandas/_libs/hashtable_class_helper.pxi:7080 [0m,         in
[0;36mpandas._libs.hashtable.PyObjectHashTable.get_item [0;34m() [0m

File          [0;32mpandas/_libs/hashtable_class_helper.pxi:7088 [0m,         in
[0;36mpandas._libs.hashtable.PyObjectHashTable.get_item [0;34m() [0m

[0;31mKeyError [0m: 'solver_type'

The above exception was the direct cause of the following exception:

[0;31mKeyError [0m                                  Traceback (most recent call
last)
Cell  [0;32mIn[146], line 24 [0m
[1;32m                                                                    21 [0m
[38;5;28mprint [39m( [38;5;124mf [39m [38;5;124m" [39m [38;5;124mMatching     rows
in    DataFrame:     [39m [38;5;132;01m{ [39;00m [38;5;28mlen [39m(matching_rows)
[38;5;132;01m} [39;00m [38;5;124m" [39m)
[1;32m         23 [0m   [38;5;28;01mif [39;00m   [38;5;28mlen [39m(matching_rows)
[38;5;241m> [39m  [38;5;241m0 [39m:
[0;32m---> 24 [0m    solver_name  [38;5;241m= [39m  [43mmatching_rows [49m [43m[ [49m [38;5;124;43m' [3
[49m [38;5;241m. [39miloc[ [38;5;241m0 [39m]
[1;32m                                                                    25 [0m
[38;5;28mprint [39m( [38;5;124mf [39m [38;5;124m" [39m [38;5;124mFound
solver        name:        [39m [38;5;132;01m{ [39;00msolver_name [38;5;132;01m}
[39;00m [38;5;124m" [39m)
[1;32m     26 [0m  [38;5;28;01melse [39;00m:
[1;32m      27 [0m      [38;5;66;03m# If not found in DataFrame, extract from
path [39;00m

File              [0;32m/opt/homebrew/Caskroom/miniconda/base/envs/cfdeeznutz/
lib/python3.11/site-packages/pandas/core/frame.py:3893 [0m,                 in
[0;36mDataFrame.__getitem__ [0;34m(self, key) [0m
[1;32m        3891 [0m    [38;5;28;01mif [39;00m    [38;5;28mself [39m [38;5;241m.
[39mcolumns [38;5;241m. [39mnlevels  [38;5;241m> [39m  [38;5;241m1 [39m:
[1;32m   3892 [0m      [38;5;28;01mreturn [39;00m  [38;5;28mself [39m [38;5;241m.
[39m_getitem_multilevel(key)
[0;32m->             3893 [0m              indexer              [38;5;241m= [39m
```

```
[38;5;28;43mself [39;49m [38;5;241;43m. [39;49m [43mcolumns [49m [38;5;241;43m.
[39;49m [43mget_loc [49m [43m( [49m [43mkey [49m [43m) [49m
[1;32m   3894 [0m  [38;5;28;01mif [39;00m is_integer(indexer):
[1;32m   3895 [0m     indexer  [38;5;241m= [39m [indexer]

File                [0;32m/opt/homebrew/Caskroom/miniconda/base/envs/cfdeeznutz/
lib/python3.11/site-packages/pandas/core/indexes/base.py:3798 [0m,           in
[0;36mIndex.get_loc [0;34m(self, key) [0m
[1;32m   3793 [0m    [38;5;28;01mif [39;00m  [38;5;28misinstance [39m(casted_key,
[38;5;28mslice [39m)  [38;5;129;01mor [39;00m (
[1;32m   3794 [0m          [38;5;28misinstance [39m(casted_key, abc [38;5;241m.
[39mIterable)
[1;32m          3795 [0m                                [38;5;129;01mand [39;00m
[38;5;28many [39m( [38;5;28misinstance [39m(x,              [38;5;28mslice [39m)
[38;5;28;01mfor [39;00m x  [38;5;129;01min [39;00m casted_key)
[1;32m   3796 [0m     ):
[1;32m   3797 [0m         [38;5;28;01mraise [39;00m InvalidIndexError(key)
[0;32m->      3798 [0m                              [38;5;28;01mraise [39;00m
[38;5;167;01mKeyError [39;00m(key)          [38;5;28;01mfrom [39;00m [38;5;250m
[39m [38;5;21;01merr [39;00m
[1;32m   3799 [0m  [38;5;28;01mexcept [39;00m  [38;5;167;01mTypeError [39;00m:
[1;32m      3800 [0m          [38;5;66;03m#  If  we  have  a  listlike  key,
_check_indexing_error will raise [39;00m
[1;32m   3801 [0m    [38;5;66;03m#  InvalidIndexError. Otherwise we fall through
and re-raise [39;00m
[1;32m   3802 [0m     [38;5;66;03m#  the TypeError. [39;00m
[1;32m             3803 [0m                       [38;5;28mself [39m [38;5;241m.
[39m_check_indexing_error(key)

[0;31mKeyError [0m: 'solver_type'
```