

Downloading and compiling MPAS-Atmosphere

Michael G. Duda
NCAR/MMM



Basic system requirements

Before getting in to the details of how to download and compile the code, let's first answer the question:

On which systems can MPAS-Atmosphere be run?

There are essentially two considerations:

- Hardware
- Software

Hardware requirements

Generally speaking, no requirement regarding number of CPUs or type of CPU

- But you must have relatively modern Fortran and C/C++ compilers that target your CPU architecture

However, the amount of memory (RAM) dictates the maximum domain size

- Roughly 0.175 MB/memory per grid column (assuming 55 vertical levels and 'mesoscale_reference' physics suite)

As long as you're patient enough, and as long as your simulation fits in memory, a single processor is all you need!

- *On the upper end of CPU count, model generally scales well to around 100 grid columns per MPI task*

Software requirements

Generally, a UNIX-like OS is needed

- Linux, *BSD, macOS, AIX, etc.
- Untested: Windows Subsystem for Linux

If using MPAS v8.0+, the Simple MPAS I/O Layer (SMIOL) requires just the

If using MPAS v7.3 and earlier, or if using the PIO library.

A POSIX shell and the usual programs.

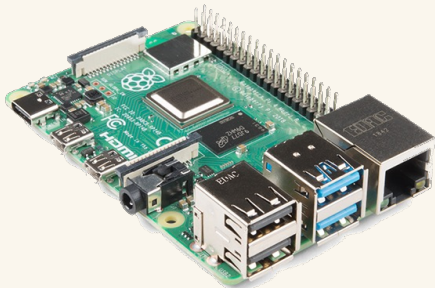
- GNU Make, grep, awk, sed, cat, ranlib/libtool, etc.

Libraries

- MPI (OpenMPI, MPICH, etc.)
- Parallel-NetCDF

- zlib
- HDF5
- NetCDF4 (C + Fortran)
- PIO

Example systems that run MPAS-A



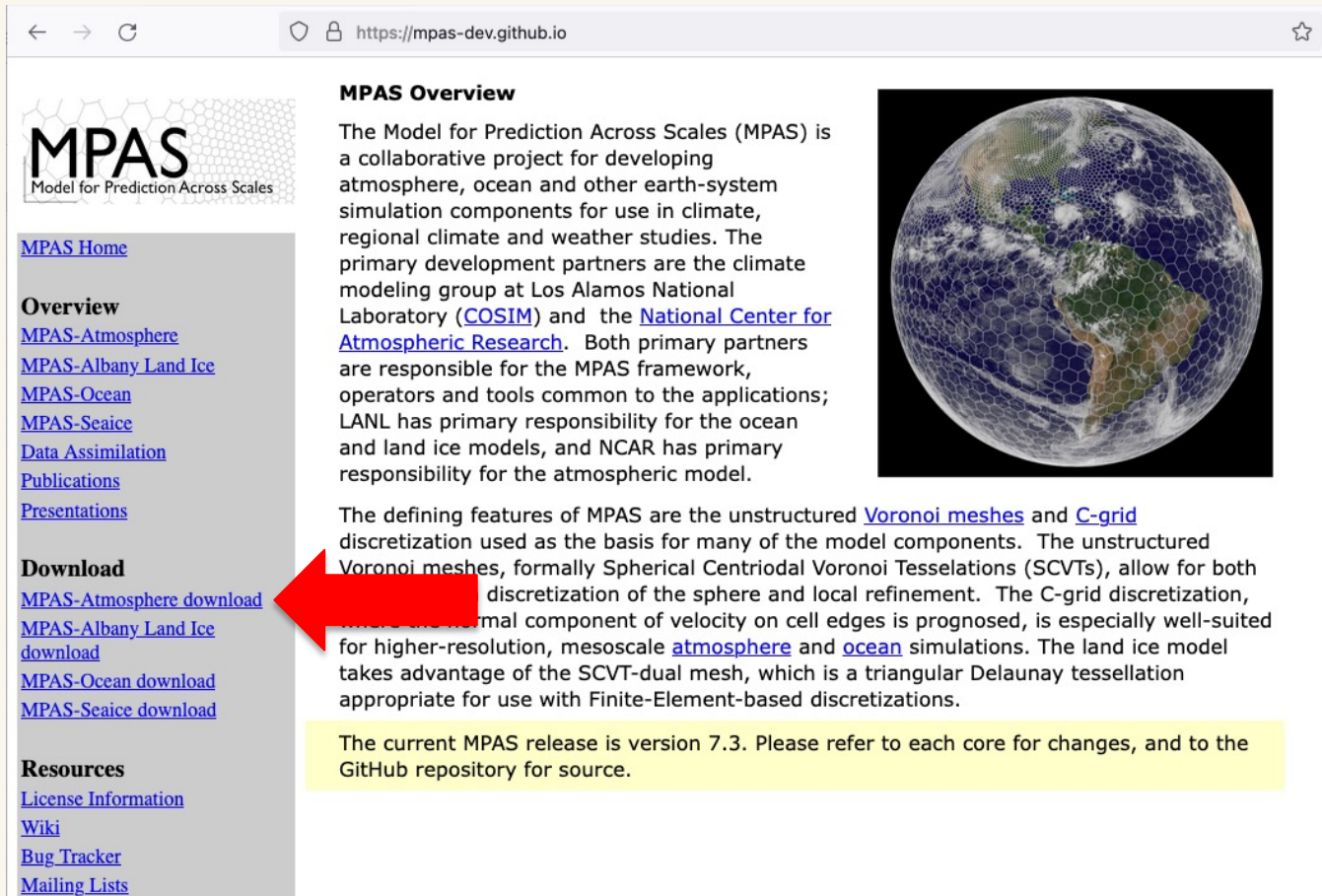
Working under the assumption that we have a system that meets the basic requirements, we can then ask:

How do I get a copy of the source code?

There are essentially two options:

- 1) The “traditional”, but not necessarily encouraged, method
 - Download a `.tar.gz` or `.zip` file
- 2) The preferred method
 - Make a *clone* of the MPAS-Model repository

One can navigate to a download link from the MPAS homepage at <https://mpas-dev.github.io/>



The screenshot shows the MPAS homepage. On the left is a navigation sidebar with links for Overview, Download, and Resources. A red arrow points to the 'MPAS-Atmosphere download' link in the Download section. The main content area features an 'MPAS Overview' section with a description of the project, a list of primary development partners (LANL and NCAR), and details about the model's defining features: unstructured Voronoi meshes and C-grid discretization. To the right of the text is an image of Earth with a hexagonal grid overlay. At the bottom of the main content area, a yellow box states the current release is version 7.3 and directs users to the GitHub repository for source code.


MPAS Overview

The Model for Prediction Across Scales (MPAS) is a collaborative project for developing atmosphere, ocean and other earth-system simulation components for use in climate, regional climate and weather studies. The primary development partners are the climate modeling group at Los Alamos National Laboratory ([COSIM](#)) and the [National Center for Atmospheric Research](#). Both primary partners are responsible for the MPAS framework, operators and tools common to the applications; LANL has primary responsibility for the ocean and land ice models, and NCAR has primary responsibility for the atmospheric model.

The defining features of MPAS are the unstructured [Voronoi meshes](#) and [C-grid](#) discretization used as the basis for many of the model components. The unstructured Voronoi meshes, formally Spherical Centriodal Voronoi Tessellations (SCVTs), allow for both discretization of the sphere and local refinement. The C-grid discretization, where the normal component of velocity on cell edges is prognosed, is especially well-suited for higher-resolution, mesoscale [atmosphere](#) and [ocean](#) simulations. The land ice model takes advantage of the SCVT-dual mesh, which is a triangular Delaunay tessellation appropriate for use with Finite-Element-based discretizations.

The current MPAS release is version 7.3. Please refer to each core for changes, and to the GitHub repository for source.

One can navigate to a download link from the MPAS homepage at <https://mpas-dev.github.io/>



MPAS
Model for Prediction Across Scales

[MPAS Home](#)

Overview

- [MPAS-Atmosphere](#)
- [MPAS-Albany Land Ice](#)
- [MPAS-Ocean](#)
- [MPAS-Seaice](#)
- [Data Assimilation](#)
- [Publications](#)
- [Presentations](#)

Download

- [MPAS-Atmosphere download](#)
- [MPAS-Albany Land Ice download](#)
- [MPAS-Ocean download](#)
- [MPAS-Seaice download](#)

Resources

- [License Information](#)
- [Wiki](#)
- [Bug Tracker](#)
- [Mailing Lists](#)
- [MPAS Developers Guide](#)
- [MPAS Mesh Specification Document](#)

MPAS Atmosphere Public Releases

MPAS Atmosphere 8.0.1 was released on 6 July 2023.

For information on the GPU-enabled MPAS-Atmosphere model, please refer to [this documentation](#)

As of September 2018, official support for MPAS-Atmosphere has migrated from the Google Groups forum to a web forum hosted by NCAR's Mesoscale and Microscale Meteorology. Users are encouraged to post any questions related to building and running MPAS-Atmosphere to the appropriate sub-topic in the MPAS-Atmosphere forum at <https://forum.mmm.ucar.edu/>. Posting to the forum requires the creation of an account, but no account is needed to browse the forum.

[MPAS Atmosphere 8.0.1 release notes](#)

Source code downloads:

- [MPAS v8.0.1](#)
- [GPU-enabled MPAS-Atmosphere v0.x](#)

[MPAS-Atmosphere Users' Guide](#)


[MPAS-Atmosphere tutorial](#)

[MPAS-Atmosphere meshes](#)

[Configurations for idealized test cases](#)

[Sample input files for real-data simulations](#)

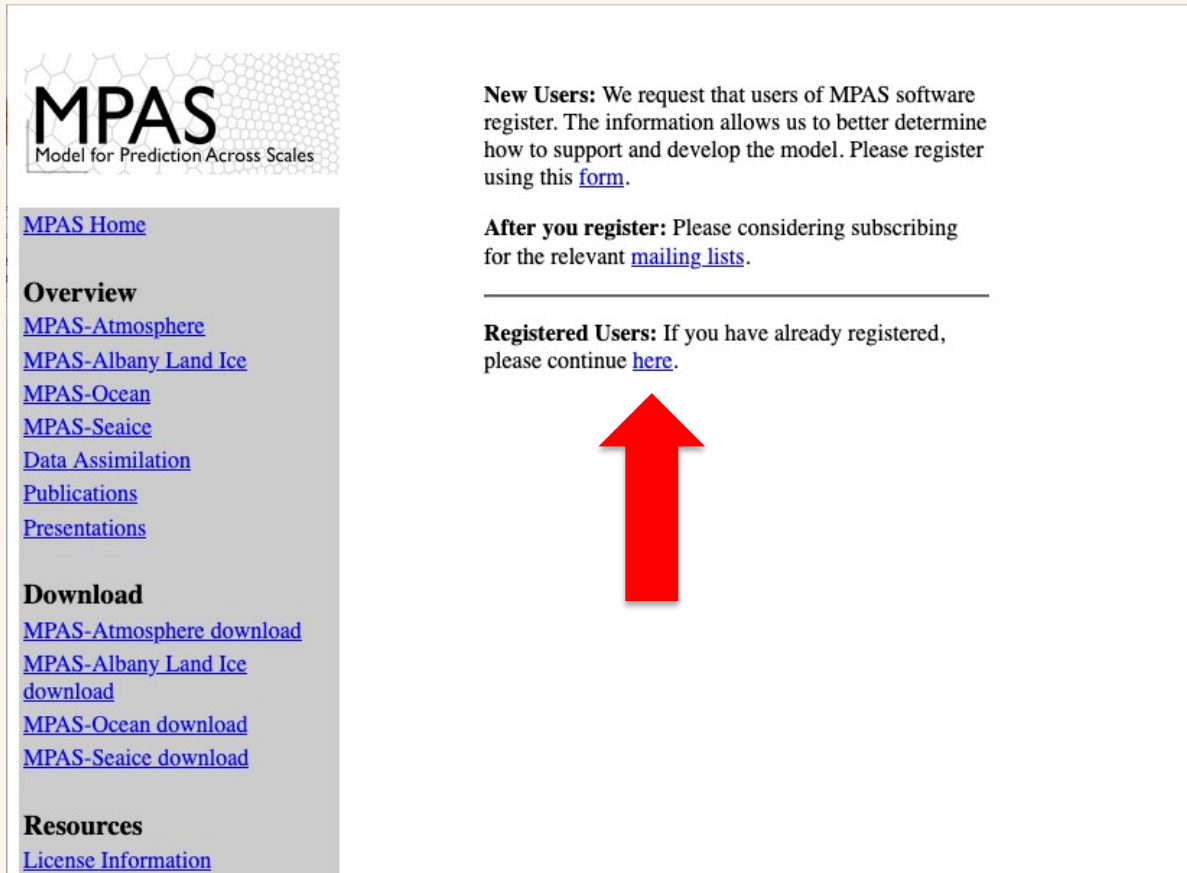
[Visualization and analysis tools](#)



A variable resolution MPAS Voronoi mesh

The "less preferred" method of obtaining code

One can navigate to a download link from the MPAS homepage at <https://mpas-dev.github.io/>



The screenshot shows the MPAS homepage. On the left is a navigation menu with sections: 'MPAS Home', 'Overview' (with links to MPAS-Atmosphere, MPAS-Albany Land Ice, MPAS-Ocean, MPAS-Seaice, Data Assimilation, Publications, and Presentations), 'Download' (with links to MPAS-Atmosphere download, MPAS-Albany Land Ice download, MPAS-Ocean download, and MPAS-Seaice download), and 'Resources' (with a link to License Information). The main content area has three sections: 'New Users' (requesting registration with a 'form' link), 'After you register' (suggesting mailing lists), and 'Registered Users' (with a 'here' link). A large red arrow points to the 'here' link in the 'Registered Users' section.

MPAS
Model for Prediction Across Scales

[MPAS Home](#)

Overview
[MPAS-Atmosphere](#)
[MPAS-Albany Land Ice](#)
[MPAS-Ocean](#)
[MPAS-Seaice](#)
[Data Assimilation](#)
[Publications](#)
[Presentations](#)

Download
[MPAS-Atmosphere download](#)
[MPAS-Albany Land Ice download](#)
[MPAS-Ocean download](#)
[MPAS-Seaice download](#)

Resources
[License Information](#)


New Users: We request that users of MPAS software register. The information allows us to better determine how to support and develop the model. Please register using this [form](#).

After you register: Please considering subscribing for the relevant [mailing lists](#).

Registered Users: If you have already registered, please continue [here](#).

The "less preferred" method of obtaining code

One can navigate to a download link from the MPAS homepage at <https://mpas-dev.github.io/>



MPAS
Model for Prediction Across Scales

[MPAS Home](#)

Overview

- [MPAS-Atmosphere](#)
- [MPAS-Albany Land Ice](#)
- [MPAS-Ocean](#)
- [MPAS-Seaiice](#)
- [Data Assimilation](#)
- [Publications](#)
- [Presentations](#)

Download

- [MPAS-Atmosphere download](#)
- [MPAS-Albany Land Ice download](#)
- [MPAS-Ocean download](#)
- [MPAS-Seaiice download](#)

PLEASE READ THIS ENTIRE PAGE BEFORE DOWNLOADING ANY OF THE MPAS SOURCE CODE.

NOTE: If you intend to collaborate on a project, please read the Developer's guide before beginning work. The access method for the MPAS source code you choose will impact development efforts.

The easiest way to acquire the MPAS source code is through the archive file below. Although this is the easiest method, it is also the least flexible. The method used will largely be determined by your use case. You should choose the method that aligns best with your use case.

Archive files are provided both in zip and tar.gz formats. Each release provides an archive file, and users should download the archive file for the most relevant released version.

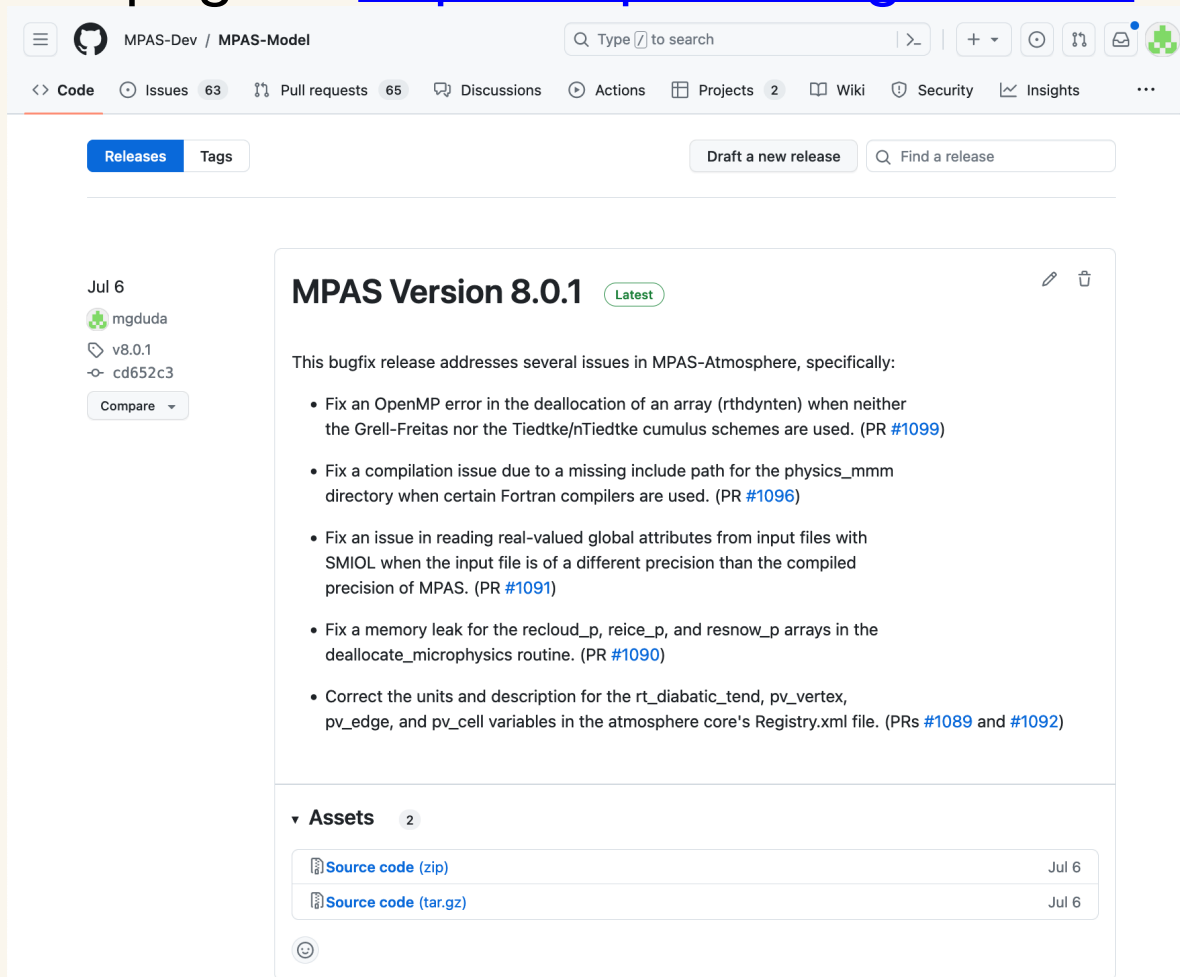
Archive file	Here
--------------	----------------------

Our recommended method is to use git. This will allow users to easily update the version they are working with, and it facilitates the most direct method for contributing development back into the MPAS code base. This comes with the caveat of having to know how to use git. There are a few links at the bottom of this page that can help you get started with git. The most immediately useful tutorial is the GitHub fork tutorial, but the other tutorials will help you with learning how to make use of git.

GitHub Page	Here
-------------	----------------------

Git related resources:

One can navigate to a download link from the MPAS homepage at <https://mpas-dev.github.io/>



The screenshot shows the GitHub repository page for MPAS-Dev / MPAS-Model. The 'Releases' tab is selected, displaying the latest release, 'MPAS Version 8.0.1', marked as 'Latest'. The release date is 'Jul 6' and the author is 'mgduda'. The release description states: 'This bugfix release addresses several issues in MPAS-Atmosphere, specifically:' followed by a list of five bullet points detailing fixes for OpenMP errors, compilation issues, SMIOI precision, memory leaks, and unit/description corrections. Below the description, the 'Assets' section shows two downloadable files: 'Source code (zip)' and 'Source code (tar.gz)', both dated 'Jul 6'.

The “less preferred” method of obtaining code

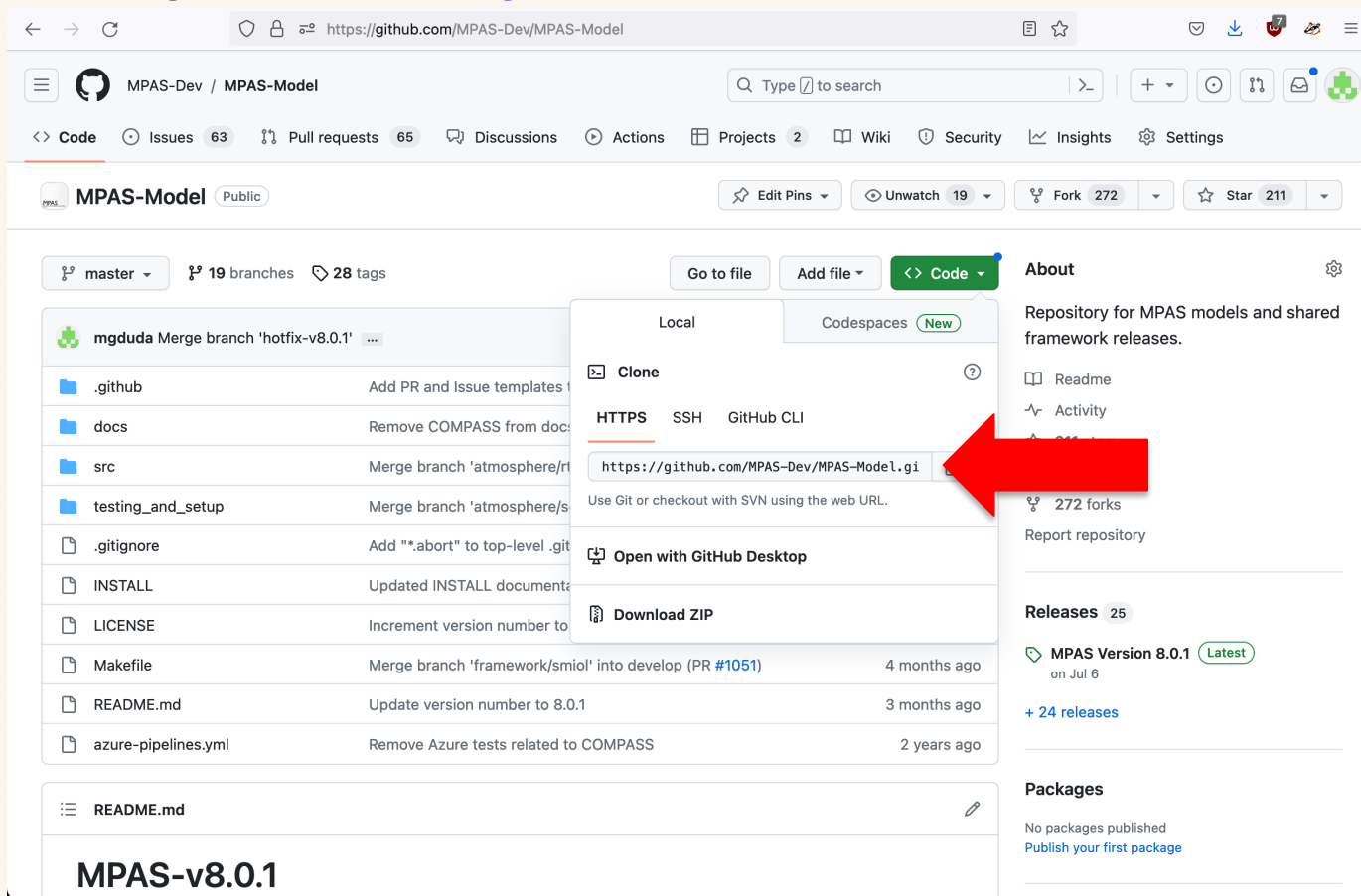
Downloading a `.tar.gz` file of a particular release of the MPAS code certainly works, but it has several disadvantages:

1. You’ll only obtain a specific release of the code
2. There’s no direct way to see the history of changes to parts of the code
3. It’s more difficult to see what local modifications have been made to the code
4. There’s no easy route to updating to a newer release while preserving your local code modifications

The preferred method of obtaining code

A much better option is to *clone* the MPAS-Model repository

- The repository URL can be found from the MPAS GitHub page at <https://github.com/MPAS-Dev/MPAS-Model>



The screenshot shows the GitHub repository page for MPAS-Model. The 'Code' button is highlighted, and the dropdown menu is open, showing the 'Clone' option. A red arrow points to the repository URL: `https://github.com/MPAS-Dev/MPAS-Model.git`. The page also shows the repository name 'MPAS-Model', the number of forks (272), stars (211), and a list of files and directories including .github, docs, src, testing_and_setup, .gitignore, INSTALL, LICENSE, Makefile, README.md, and azure-pipelines.yml. The 'About' section on the right describes the repository as 'Repository for MPAS models and shared framework releases.' and shows the latest release 'MPAS Version 8.0.1' on Jul 6.

The preferred method of obtaining code

From the command-line, the following should be sufficient:

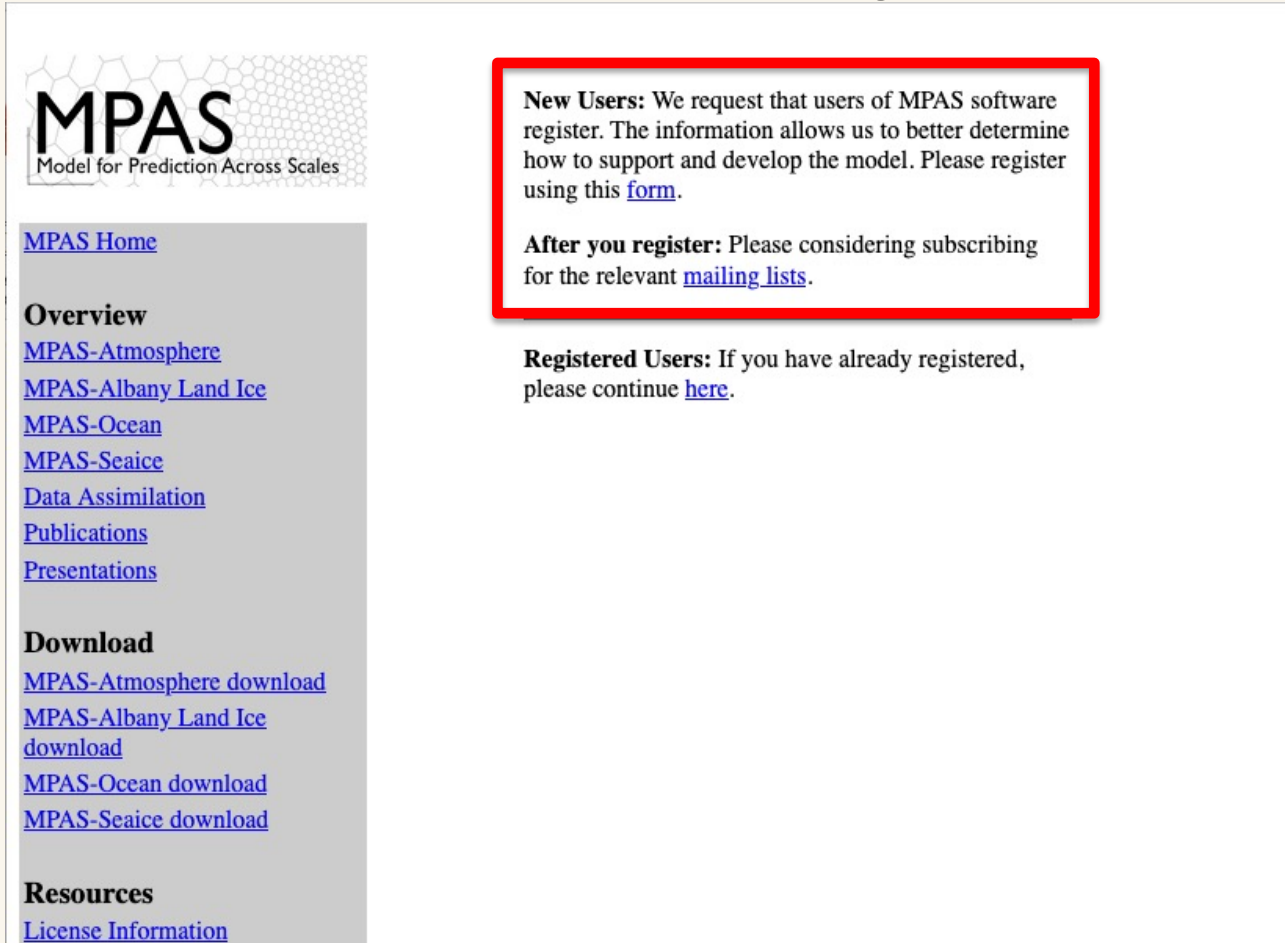
```
git clone https://github.com/MPAS-Dev/MPAS-Model.git
```

Cloning the repository should take about 10 seconds or less...

- *(I timed this at home, and it took 5.16 s)*

```
$ git clone https://github.com/MPAS-Dev/MPAS-Model.git
Cloning into 'MPAS-Model'...
remote: Enumerating objects: 71, done.
remote: Counting objects: 100% (71/71), done.
remote: Compressing objects: 100% (47/47), done.
remote: Total 46608 (delta 38), reused 42 (delta 23), pack-reused
46537
Receiving objects: 100% (46608/46608), 19.65 MiB | 2.57 MiB/s,
done.
Resolving deltas: 100% (35848/35848), done.
```

You may also like to register as an MPAS user and join the MPAS-Atmosphere Users mailing list



The screenshot shows the MPAS website. On the left is a navigation menu with links for Home, Overview, various model components (Atmosphere, Land Ice, Ocean, Seaice), Data Assimilation, Publications, Presentations, Download (with sub-links for Atmosphere, Land Ice, Ocean, and Seaice), and Resources (with a link for License Information). The main content area on the right contains a red-bordered box with the following text:

New Users: We request that users of MPAS software register. The information allows us to better determine how to support and develop the model. Please register using this [form](#).

After you register: Please considering subscribing for the relevant [mailing lists](#).

Below the red box, it says:

Registered Users: If you have already registered, please continue [here](#).

In order to compile MPAS and its required libraries, relatively modern Fortran, C, and C++ compilers are necessary

- The Fortran compiler should be recent enough to support the ISO_C_BINDING module from the Fortran 2003 standard, procedure pointer components of derived types, and a few bits of the Fortran 2008 standard
- Most versions of common compilers from the last couple of years should be fine

Building MPAS requires *at least* the following libraries:

- Any implementation of MPI-2, e.g., MPICH, MVAPICH, OpenMPI
 - Ensure that `mpif90` and `mpicc` commands are in your path
- Parallel-NetCDF (<http://trac.mcs.anl.gov/projects/parallel-netcdf/>)
 - Set `PNETCDF` environment variable to base installation directory

Preliminary requirements: the easiest route

Installing the full set of I/O libraries required by MPAS can be tedious.

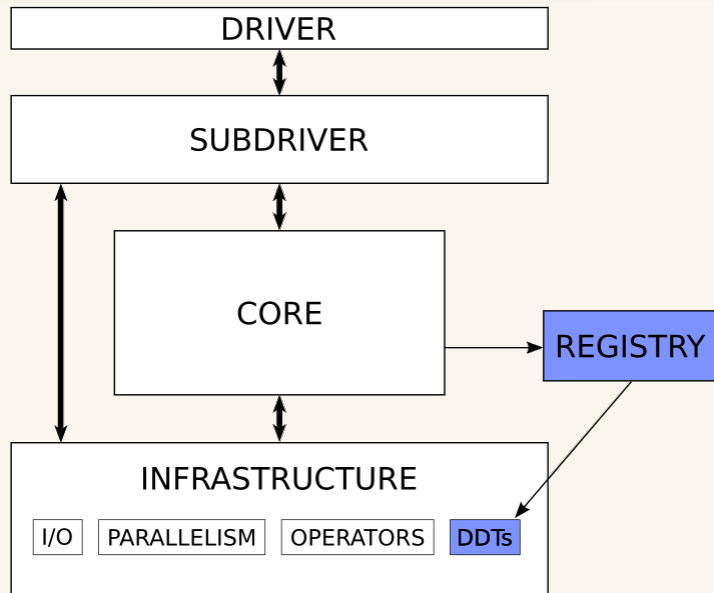
To make this easier, we've prepared a shell script that may be helpful:

```
https://www2.mmm.ucar.edu/projects/mpas/scripts/mpas\_lib\_install.sh
```

Notes:

- Before running or following the above script, you will need to have downloaded the library sources from <https://www2.mmm.ucar.edu/projects/mpas/scripts>
- If you already have an MPI library, skip the MPICH installation
- After editing paths and compiler names at the top, you *may* be able to run the script, but in general the script may be best used as a guide

Model Organization



MPAS-Model/

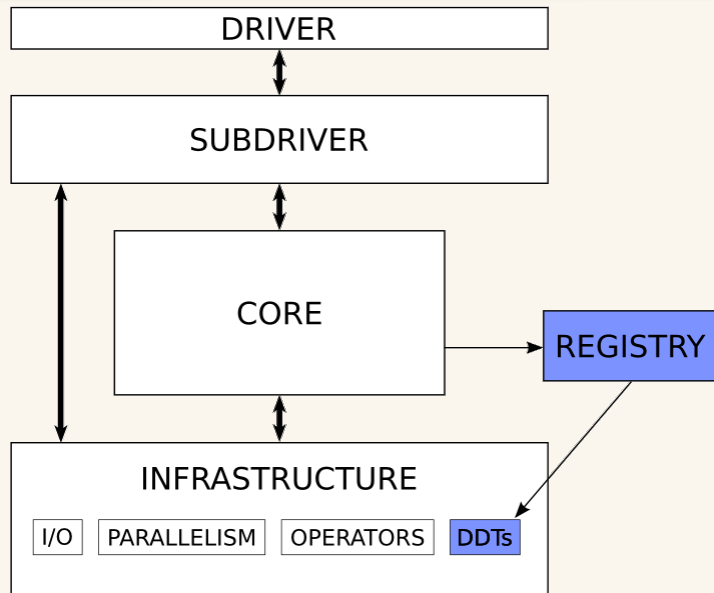
└── src/

- └── core_atmosphere/
- └── core_init_atmosphere/
- └── core_landice/
- └── core_ocean/
- └── driver/
- └── external/
- └── framework/
- └── operators/

Checking out the MPAS code provides all MPAS models, not just MPAS-Atmosphere

- All models share a common set of infrastructure modules
- Each MPAS model is implemented as a “core” that lives in its own directory
- User must select which “core” to compile
- Each “core” is associated with a source code subdirectory under src/ and has a Registry file (similar to WRF)

Model Organization



Running MPAS-Atmosphere involves two “cores”:

- The **init_atmosphere** core is responsible for
 - Interpolating static fields to the mesh
 - Generating a vertical grid
 - Horizontally and vertically interpolating meteorological data to the 3-d grid
- The **atmosphere** core is the model itself; integrates forward in time from initial state

Compiling MPAS

There is no “configuration” step for MPAS, unlike, e.g., for the WRF model

- All build flags are either set in the top-level `Makefile` or on the command-line

General MPAS build command:

```
$ make target CORE=core <options>
```

target can be either

clean

or

gfortran

ifort

nvhpc

llvm

... plus a few others...

For MPAS-Atmosphere, **core** may be

atmosphere

init_atmosphere

<options> can be zero or more of

DEBUG=true

AUTOCLEAN=true

PRECISION=single

OPENMP=true

Compiling MPAS

Typical build of both the `init_atmosphere` and `atmosphere` cores involves:

```
make gfortran CORE=init_atmosphere (build init_atmosphere_model)
```

```
make clean CORE=atmosphere (clean any infrastructure files used by both  
init_atmosphere and atmosphere)
```

```
make gfortran CORE=atmosphere (build atmosphere_model)
```

By default, MPAS cores are built with double-precision reals

MPAS-Atmosphere can be built in single precision

- Add `PRECISION=single` to build commands for single-precision executables
- execution time ~35% less compared with double-precision
- output files approximately half as large

Summary

- Ensure that you have a system running a UNIX-like operating system with the usual commands: make, awk, sed, grep, ***git***, etc.
 - Available memory dictates maximum number of grid cells
- Install supporting libraries (MPI, Parallel-NetCDF; or if you need PIO: HDF5, NetCDF4, Parallel-NetCDF, PIO)
 - Can use `mpas_lib_install.sh` script as a guide
- Obtain the MPAS-Model source code with *git clone*
- Compile the *init_atmosphere* and *atmosphere* cores