Downloading and compiling MPAS-Atmosphere

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MPAS
Model for Prediction Across Scales

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

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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*

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Software requirements

Generally, a UNIX-like OS is needed

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

A POSIX shell and the usual programs.

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

Libraries

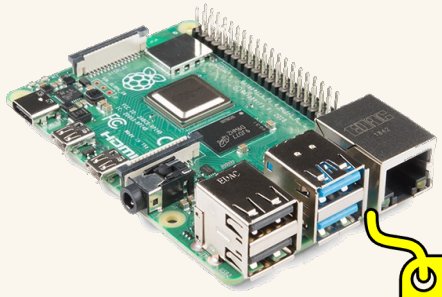
- MPI (OpenMPI, MPICH, etc.)
- Parallel-NetCDF

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

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.

Example systems that run MPAS-A



Obtaining MPAS-Atmosphere source code

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?

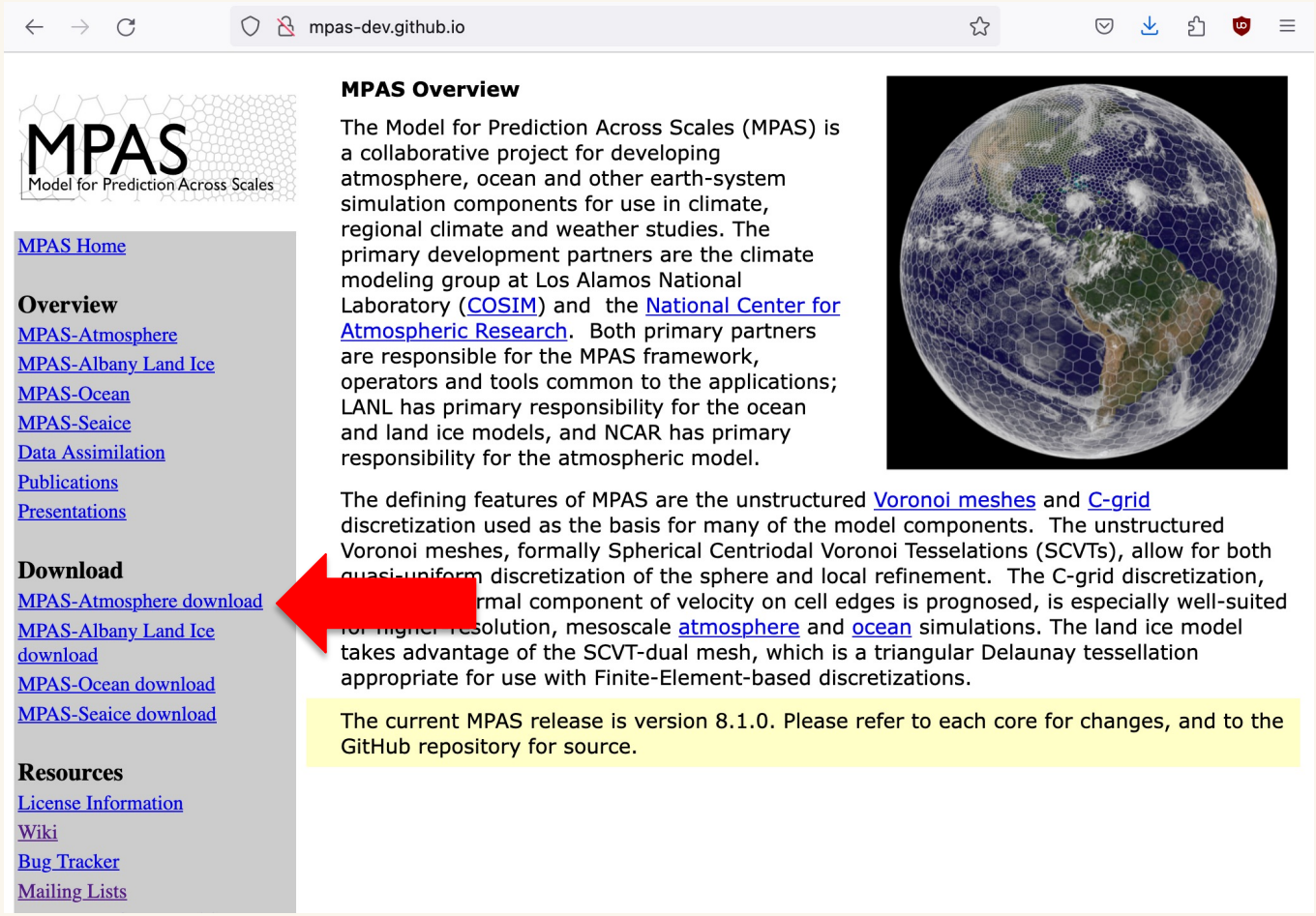
There are essentially two options:

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

The ”less preferred” method of obtaining code

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



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MPAS Atmosphere Public Releases

MPAS Home

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MPAS Developers Guide
MPAS Mesh Specification Document

MPAS Atmosphere 8.1.0 was released on 18 April 2024.

For information on the GPU-enabled MPAS-Atmosphere model, please refer to this documentation

MPAS Atmosphere 8.1.0 release notes

Source code downloads:

- MPAS v8.1.0
- GPU-enabled MPAS-Atmosphere v6.x

MPAS-Atmosphere Users' Guide

MPAS-Atmosphere tutorial

MPAS-Atmosphere meshes

Static geographical datasets

Configurations for idealized test cases

Sample input files for real-data simulations

Visualization and analysis tools

A variable resolution MPAS Voronoi mesh

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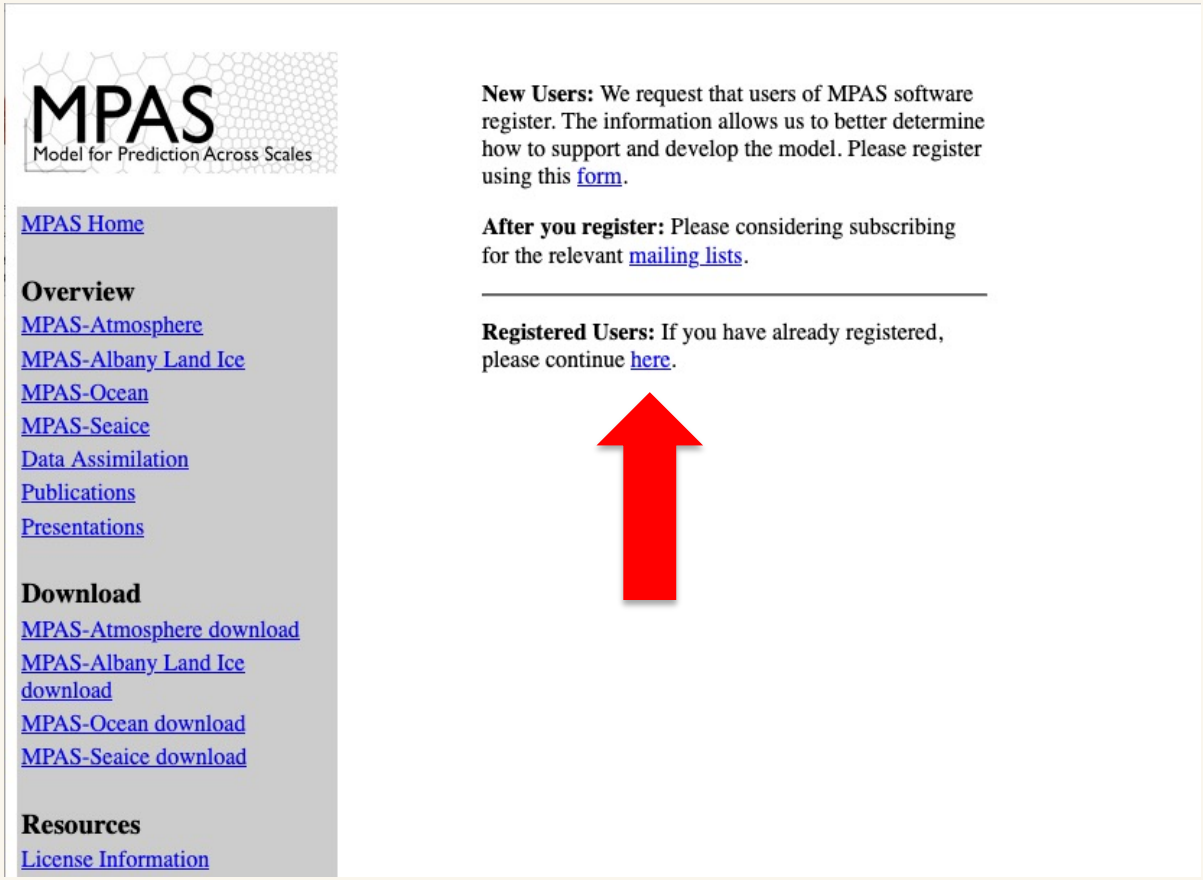

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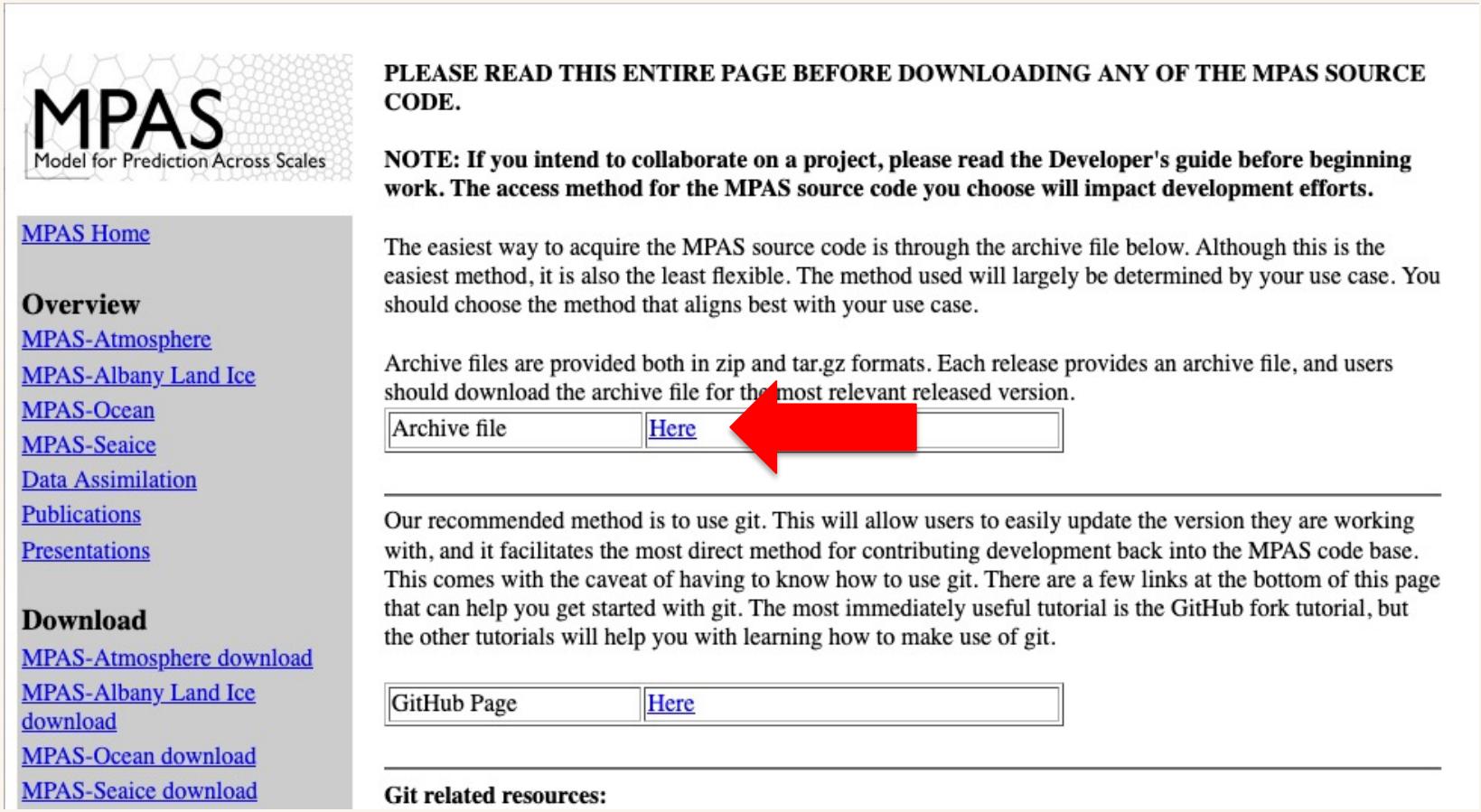

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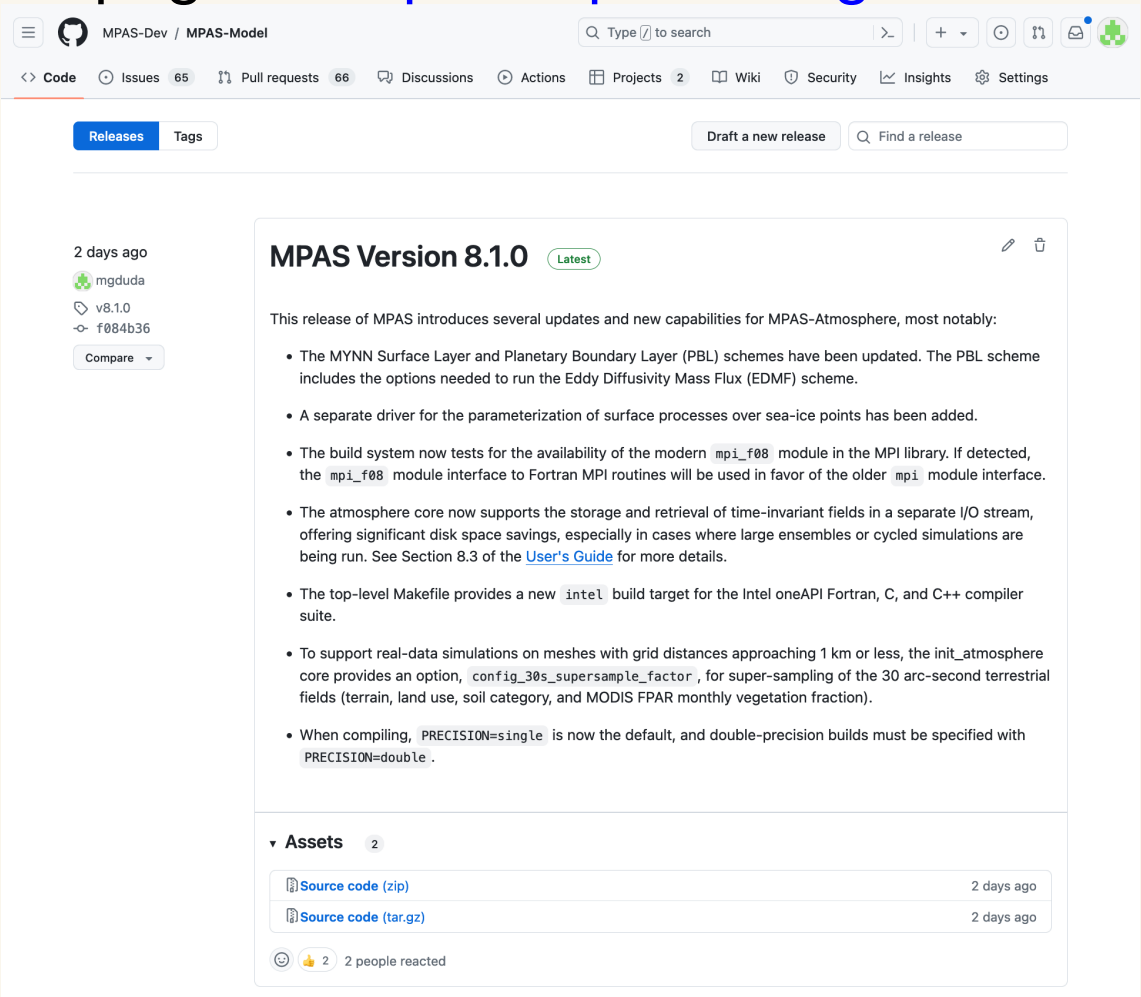


The ”less preferred” method of obtaining code

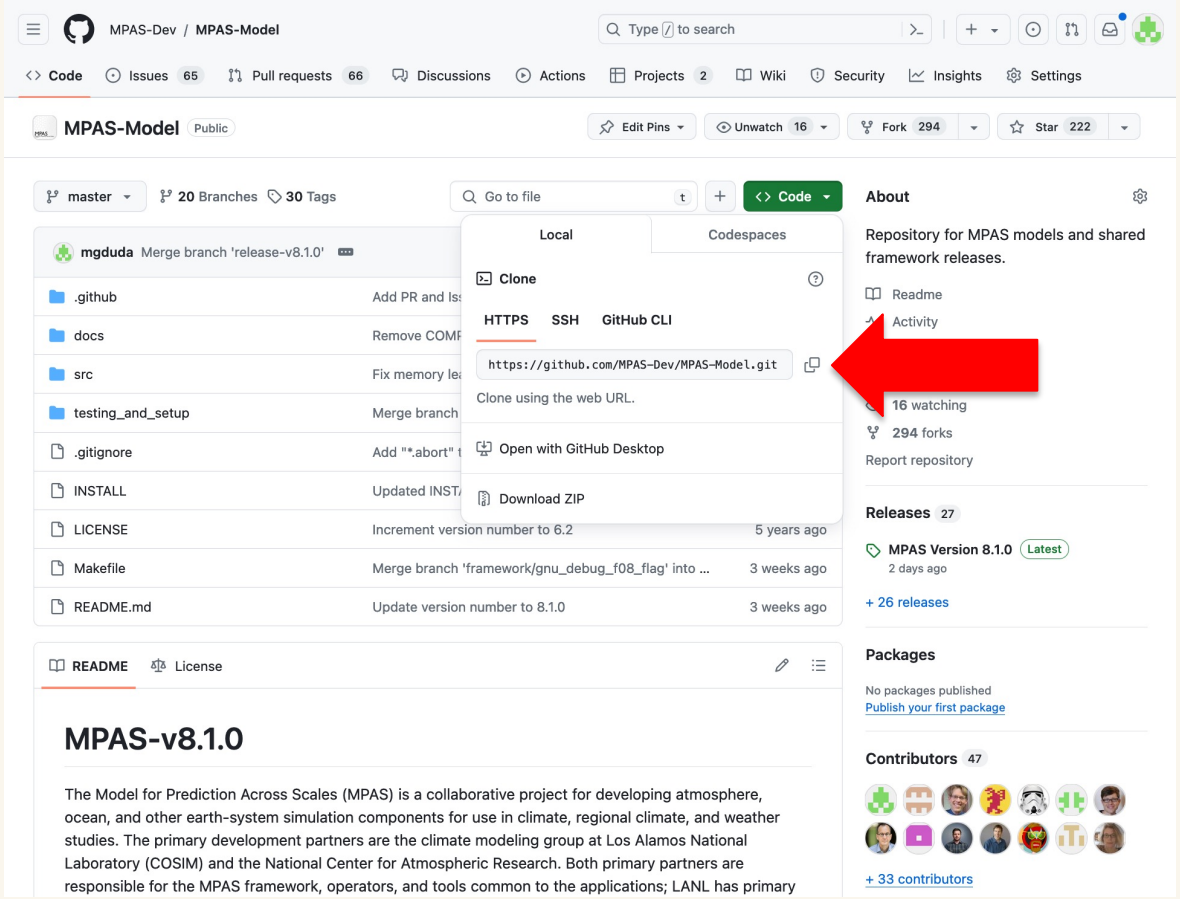
Downloading a `.tar.gz` file of a particular release of the MPAS code certainly works, but it has several disadvantages:

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 preferred method of obtaining code

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

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

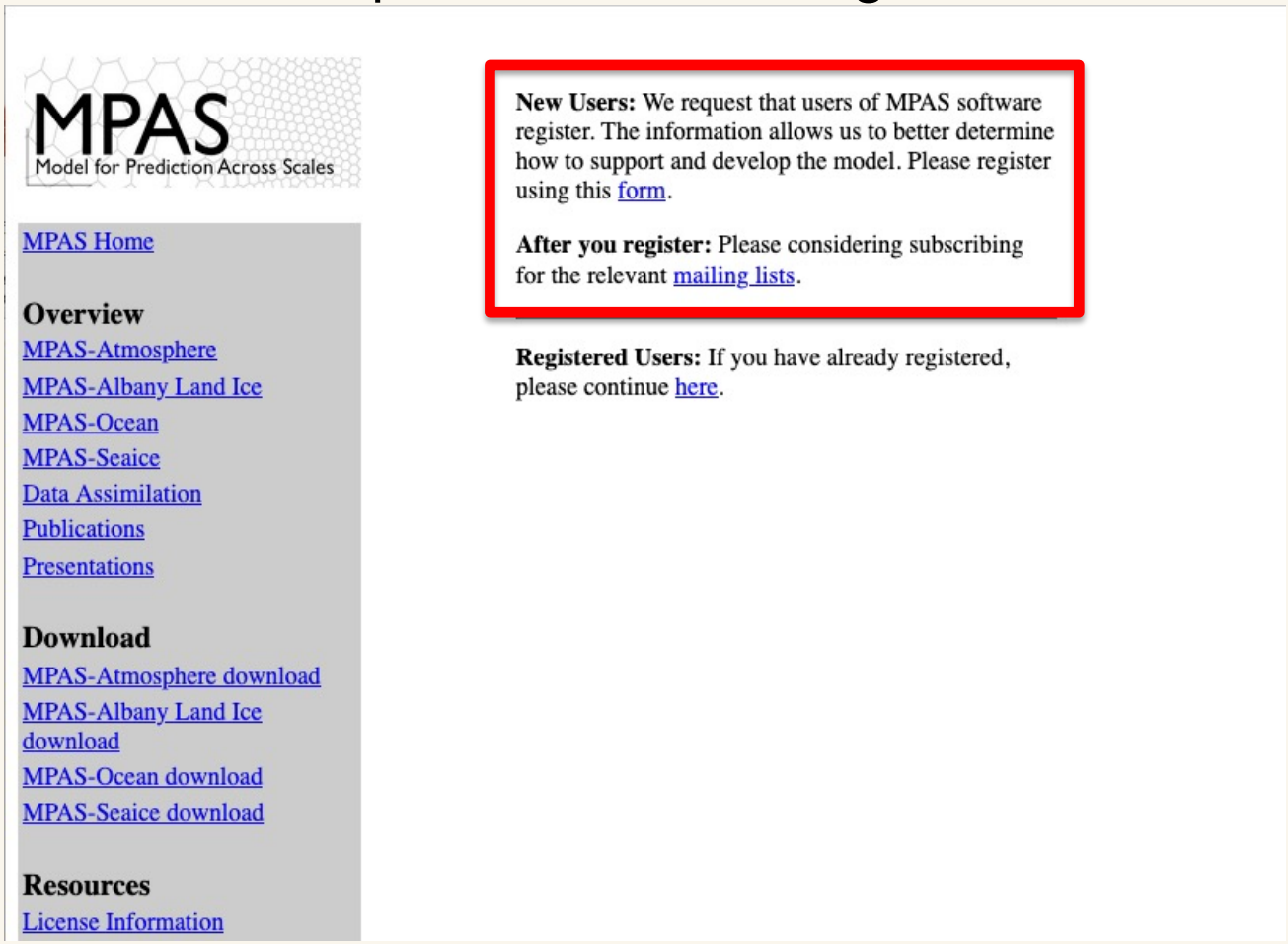
Cloning the repository should take about 10 seconds or less…

- *(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.
```

After obtaining the code for the first time

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



Preliminary requirements

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.

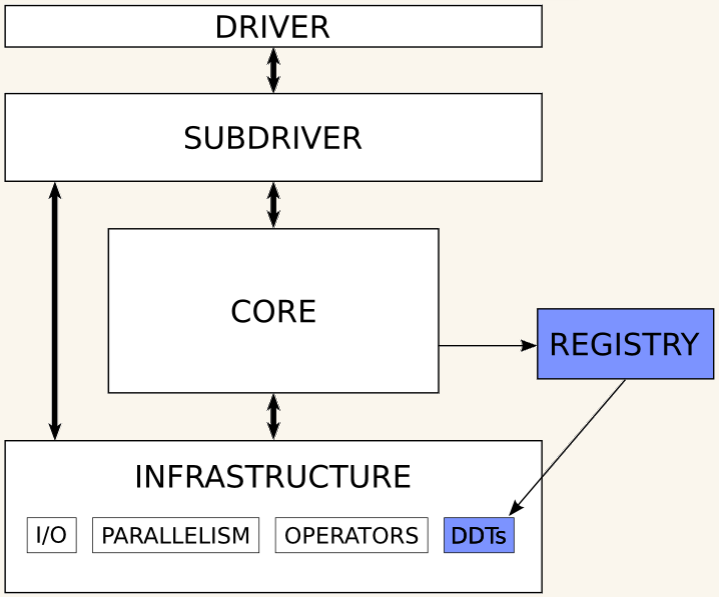
To make this easier, we've prepared a shell script that may be helpful:

`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

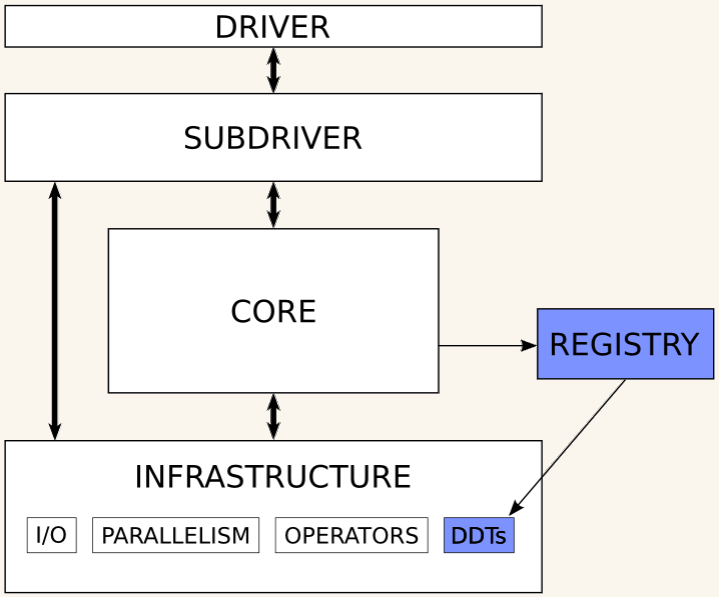


Checking out the MPAS code provides all MPAS models, not just MPAS-Atmosphere

- 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)

```
MPAS-Model/
    src/
        core_atmosphere/
        core_init_atmosphere/
        core_landice/
        core_ocean/
        driver/
        external/
        framework/
        operators/
```

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

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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

```
gnu
intel
nvhpc
llvm
... plus a few others...
```

For MPAS-Atmosphere, core may be

```
atmosphere
init_atmosphere
```

<options> can be any of

```
DEBUG=true
AUTOCLEAN=true
PRECISION=double
OPENMP=true
```

Compiling MPAS

Typical build of both the init_atmosphere and atmosphere cores involves:

`make gnu CORE=init_atmosphere` *(build* `init_atmosphere_model`*)*

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

`make gnu CORE=atmosphere` *(build* `atmosphere_model`*)*

By default, MPAS cores are built with single-precision floating-point variables

MPAS-Atmosphere can be built in double precision

- Add `PRECISION=double` to build commands for double-precisoin executables
- Execution time is slower compared with single-precision
- Output files approximately twice 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
- Ensure that you have modern Fortran, C, and C++ compilers
- 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