MARBLE:

How to make an open science global magnetosphere code?

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DASH Conference October 11, 2023

MARBLE under construction

Kinetic MHD Magnetosphere
Leads: Dorelli, Bard

AGATE:
Finite-Volume Solver
Lead: Bard

*DISCO:
Guiding-Center Particle Pusher
Lead: da Silva

*STEELIE:
Ionospheric Conductances
Leads: Khazanov, Sur

Funded by LWS Grant thru 2026

*Disclaimer: All logos, names, and backronyms subject to change

2023: Year of Open Science

White House:
Office of Science and Technology

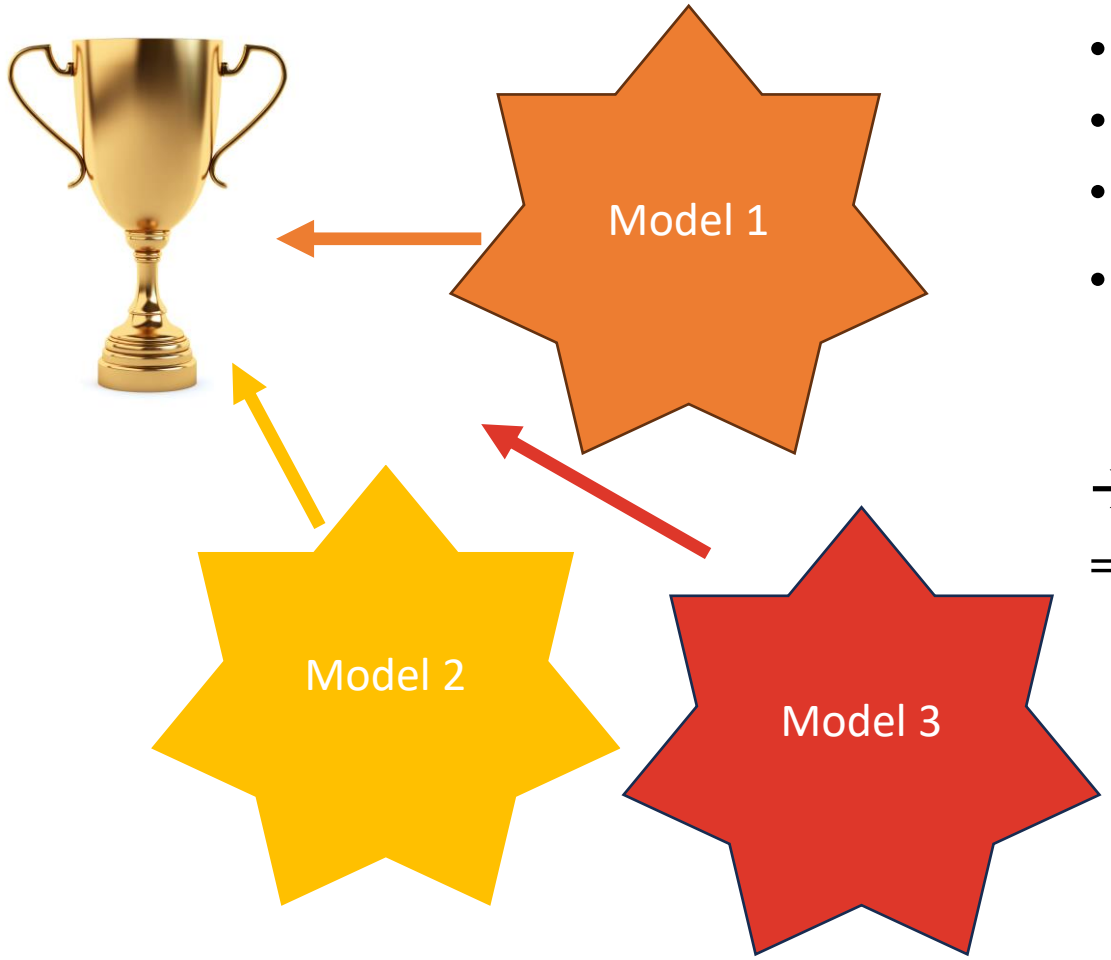
NASA:
Transform to Open Science

From *NASA SPD-41a*:

VII.
C. : "To achieve reproducibility, scientific software developed using SMD funding and used in support of a scientific, peer-reviewed publication **shall be released as open source software** no later than the publication date.

D.: "At the end of the period of performance of a research award, scientific software developed as part of the award, **to extent practicable, shall be released as open source software** if allowed under existing laws and regulation."

… conflicts with Closed Development of Models



Current grant funding system for geospace models:

- Multi-year, decade-long development process
- Closed, secretive competition
- Difficult to use codes without consulting with dev team
- Difficult to add/modify code for one's own purposes (unless you're already a developer!)

→Not entirely compatible with open science principles!
= Findable, Accessible, Interoperable, Reusable

With MARBLE, we have a unique opportunity to build in open-science and open-source from ground up!

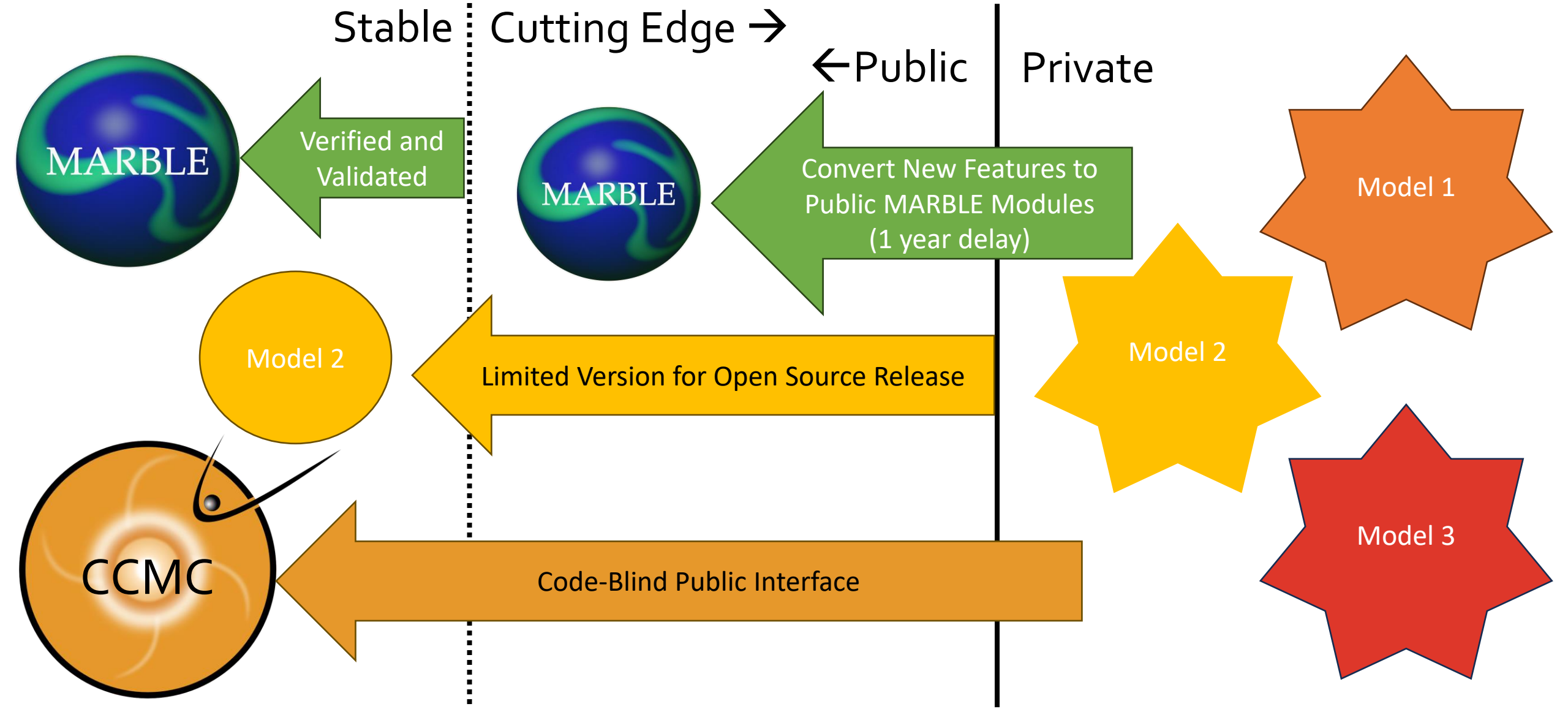
An open-science global magnetosphere code

1. Findable + Accessible
   - Open-source license on public repository
2. Interoperable
   - Needs to work with other community codes/libraries/data analysis pipelines
3. (Re)usable
   - Needs to be fast/efficient, depending on problem
   - Verification and Validation
   - Easy to set up run configurations

A Community Code can also be used for:

- Teaching
- Quick Analysis/Experimentation
- Prototype Development
- Ingestion of Advanced Features

Balancing Closed Development with Open Science



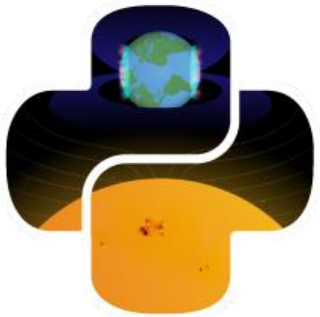
How do you make an open-science global magnetosphere code?

1. Make it easy to use
2. Make it work well
3. Make it easy to modify and append
4. ???
5. Science!

Step 1: Ease of Use

Marble will be written entirely in Python.

- Simple installation via pip and requirements.txt
  - No messing around with Makefiles/Cmake/Intel OMP etc.
- More rapid, easier development compared to C/C++/Fortran
- Cross-compatibility with PyHC ecosystem



sunpy

plasmapy

(and all other Python libraries, e.g. matplotlib)

Step 2: Speed

Although native Python is slow, there are several accelerator libraries:

CPUs/multi-threading

MPI4Py

Graphics Processing Units

PyCUDA

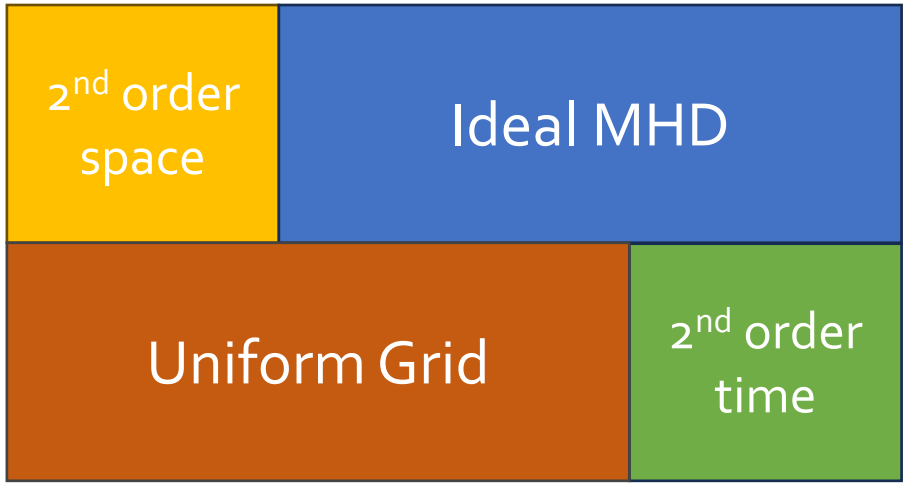
CUDA Python

Computers of the future will likely utilize “heterogeneous architectures”: run on CPUs and GPUs simultaneously!

Step 3: Modular Development

Sub-modules provide balance between:

Flexibility



Simplicity

A second-order scheme that solves the ideal MHD equations on a uniform grid

Modules also allow for ease of adding new features, e.g.:

Kinetic MHD

Adaptive Mesh Grid

Step 4: ???

Other challenges in community code model for global codes:

- How do we balance "needing to publish" with "openly sharing"?
  - Need to encourage community to value software development efforts like they do paper publications
- How will it be funded long-term?
  - E.g. MARBLE project ends in 2026; will it continue with volunteer work?
  - Infrastructure funding?

Step 5: Science!

A Python community global magnetosphere code will enhance science return!

- Teaching/Training:
  - simulation codes and algorithms
- Flexibility
  - Applications to many use cases
- Innovation/Assimilation:
  - Easier to prototype and rewrite in Python
  - Push new features back to community repo
- Ease of use/co-existing with PyHC libraries
- Reproducibility