Open vs Closed for Heliophysics Modeling

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Background: NASA Heliophysics Code development:

- 1980s: NASA Theory Program
  - Response to NAS Colgate Report
    - Need large-scale attack to solve big problems
  - Encouraged development of new multi-D codes
  - Genesis of many of present-day Heliophysics codes
  - All closed source codes, none delivered to NASA and/or community
  - Program did not request code development, only science
  - Encouraged proprietary code, evolved to discourage open code development

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Background: NASA Heliophysics Code development:

- 1990s: NASA HPCC Program
  - Response to presidential initiative for parallel processing
  - Involved multiple Agencies, with hardware as primary goal
  - NASA HPCC-ESS dedicated to development and parallelization of new codes
    - Goals were optimization and scalability
  - No requirements for code delivery
    - NASA program ended with presidential initiative
  - DoD HPCMP program did request source code delivery
    - Program continues and grows

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Background: NASA Heliophysics Code development:

- 2000s: Rise of Space Weather
  - NASA/NSF/NOAA/DoD and communities focus changed to add “enabling” research
  - Overarching goal of achieving useful first-principles models for Sun-Earth space weather
  - Work changed from developing physics codes to space weather models
  - Model coupling/interoperability now became desirable goal
  - Possible commercial application of models also became important consideration

Open vs Closed for Heliophysics Modeling

2000s: Rise of Space Weather

- Resulted in NASA Living With a Star (LWS) Program
- Supports model (not general-purpose code) development through Tools and Methods and NASA/NSF Strategic Capabilities
- Develop models that enable research and can serve as prototypes for eventual space weather operations, generally pre-specified
  - e.g., SWMF+RCM, CORHEL
- Models range from empirical to first-principles physics
- No requirement for open source, but model must be delivered to some community access site such as CCMC for use beyond developer team

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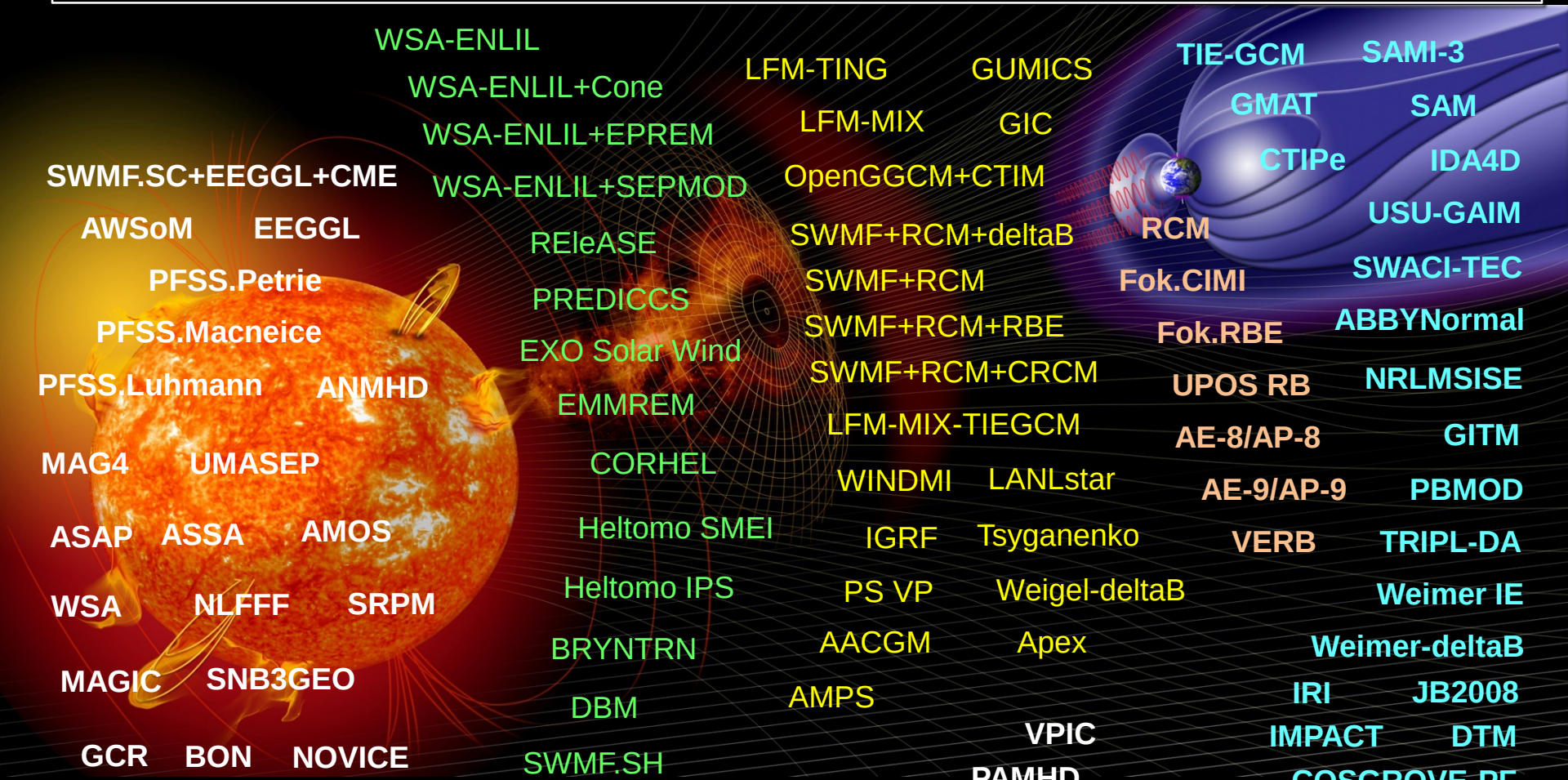
2000s: Rise of Space Weather

- Resulted in founding of CCMC, Community Coordinated Modeling Center
- Serve as repository for NASA/NSF funded models
  - Generally phenomena specific
- Provide community access to model **results**
  - Generally “event” runs
- Provide model validation and inter-comparison
- Foster model coupling
- But not direct nor fund model development or maintenance

Expanding Collection Of Models at CCMC: > 80



WSA-ENLIL
WSA-ENLIL+Cone
WSA-ENLIL+EPREM
WSA-ENLIL+SEPMOD
REleASE
PREDICCS
EXO Solar Wind
EMMREM
CORHEL
Heltomo SMEI
Heltomo IPS
BRYNTRN
DBM
SWMF.SH
DIPS

LFM-TING
GUMICS
LFM-MIX
GIC
OpenGGCM+CTIM
SWMF+RCM+deltaB
SWMF+RCM
SWMF+RCM+RBE
SWMF+RCM+CRCM
LFM-MIX-TIEGCM
WINDMI
LANLstar
IGRF
Tsyganenko
PS VP
Weigel-deltaB
AACGM
Apex
AMPS
VPIC
PAMHD
PIC-Hesse

TIE-GCM
SAMI-3
GMAT
SAM
CTIPe
IDA4D
USU-GAIM
RCM
SWACI-TEC
Fok.CIMI
ABBYNormal
Fok.RBE
NRLMSISE
UPOS RB
GITM
AE-8/AP-8
PBMOD
AE-9/AP-9
TRIPL-DA
VERB
Weimer IE
Weimer-deltaB
IRI
JB2008
IMPACT
DTM
COSGROVE-PF
Ovation Prime

SWMF.SC+EEGGL+CME
AWSoM
EEGGL
PFSS.Petrie
PFSS.Macneice
PFSS.Luhmann
ANMHD
MAG4
UMASEP
ASAP
ASSA
AMOS
WSA
NLFFF
SRPM
MAGIC
SNB3GEO
GCR
BON
NOVICE
NAIRAS
CARI-7

Corona
Heliosphere
Magnetosphere
Local Physics
Inner Magnetosphere
Ionosphere/Thermosphere

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Models at CCMC:

- Range from purely statistical to general-purpose first-principle equations solvers
- Range from fully open, to open w license, to source at CCMC but run on request only, to source code not available even to CCMC
- CCMC follows wishes of developer; trusted agent
- Open source codes usually consist of general-purpose solvers and associated with some government institution to provide long-term funding, maintain, track bugs, version control, etc.
- Other large-scale codes maintained and updated mainly by developing Team and collaborators

Open vs Closed for Heliophysics Modeling

Closed:

- Developing and maintaining truly open space weather models would require long-term commitments
  - No present resources for such funding
- Locks in certain technology, so stifles competition and innovation
- Small pool of possible contributors and of “easy” contributions to space weather models
  - Waste of NASA resource to support open code
- Penalizes model developers when competing for science programs
  - Removes incentive for innovative code development
- Concerns about possible commercialization

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Open:

- Demonstrated tremendous benefit in data analysis libraries
  - SolarSoft, SunPy, Astropy, Helioviewer, …
- Given much of development effort is in data ingestion and validation, models could benefit as well
- Simulation analysis tools could greatly benefit
  - e.g., Visit, NASA-supported SimulationPy at CCMC, ??
- Maximizes *science* competition
- Preserve NASA investments in model development
- More rigorous verification and validation of models
- Promote model coupling and extension
  - Overarching goal of LWS
- **Enhance mission support**
  - **Tailor models toward mission observations**

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Conclusions:

- Would benefit NASA HSD to establish permanent programs for code development
  - **Essential for achieving space weather goals**
  - Not clear that “community model” appropriate yet for HSD
- Mixture of long-term model development and short-term innovative algorithm development
- Best to partner with other Agencies, such as NSF and DOE
- At very least, require delivery of source code to NASA …, but would also require open licensing
- Continued software opportunities would help alleviate developers concern regarding self-competition