Model Developer View: Role of CCMC in R2O

Tamas I. Gombosi

2014 CCMC Workshop
Annapolis, Maryland
March 31-April 04, 2014
Outline (Issues)

☀ How are global models developed?
☀ Motivation for model developers for R2O
☀ Research codes vs. operational codes
☀ Transition process
☀ CCMC and SWPC
☀ Cost and funding of R2O
☀ Proposed funding model
☀ Model lifecycle
☀ Summary
How were US 3D Space Weather Models Originally Developed?

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
<th>Developer</th>
</tr>
</thead>
<tbody>
<tr>
<td>CTIP</td>
<td>ionosphere + thermosphere</td>
<td>NOAA SWPC</td>
</tr>
<tr>
<td>GITM</td>
<td>ionosphere + thermosphere</td>
<td>Michigan</td>
</tr>
<tr>
<td>SAMI</td>
<td>ionosphere</td>
<td>NRL</td>
</tr>
<tr>
<td>TIEGCM</td>
<td>ionosphere + thermosphere</td>
<td>NCAR HAO</td>
</tr>
<tr>
<td>USU-GAIM</td>
<td>ionosphere</td>
<td>USU</td>
</tr>
<tr>
<td>LFM</td>
<td>magnetosphere</td>
<td>Dartmouth (NRL)</td>
</tr>
<tr>
<td>OpenGGCM</td>
<td>magnetosphere</td>
<td>UNH (UCLA)</td>
</tr>
<tr>
<td>SWMF</td>
<td>corona + heliosphere + magnetosphere</td>
<td>Michigan</td>
</tr>
<tr>
<td>ENLIL</td>
<td>heliosphere</td>
<td>George Mason (NOAA SWPC)</td>
</tr>
<tr>
<td>MAS</td>
<td>corona</td>
<td>PSI</td>
</tr>
</tbody>
</table>

☀ Where and how?
- Federal/FFRDC
  - SAMI, TIEGCM, LFM
- Single developer
  - CTIP, GITM, ENLIL, OpenGGCM
- Non-federal group
  - MAS, SWMF, USU-GAIM

☉ Who paid for it?
- Federal/FFRDC
  - CTIP, SAMI, TIEGCM, LFM
- Non-space physics grant/contract
  - USU-GAIM, MAS, SWMF
- Other
  - ENLIL
- Space physics grant/contract
  - --

☉ So far space weather model development has been opportunistic, primarily relying of non-space physics funding sources.
- Is this model sustainable?
- Even if it is sustainable, progress will be determined by the needs/opportunities at other programs/agencies with little control by the primary stakeholders (NASA Heliophysics, NSF AGS, NOAA SWPC)
Why Should Model Developers Support Transition to Community Use?

☀ Benefits

☉ Community use of first-principles based codes result in wider acceptance of global modeling as the third pillar of space physics
☉ Broader community use improves competitiveness of the developer team
☉ “Societal relevance” is increasingly important as a federal funding priority
☉ Potential new funding source
☉ Good for the developers’ ego

☉ Drawbacks

☉ Potential that a code developer has to compete against his/her own code
☉ Potential exposure of physics/algorithmic/implementation weaknesses
☉ Supporting a user community is time-consuming
☉ There is no direct funding mechanism for model transition (to CCMC or SWPC)
# Research Codes vs. Operational Codes

<table>
<thead>
<tr>
<th>Research Code</th>
<th>Community Code</th>
<th>Operational Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Run and analyzed by a small group of scientists</td>
<td>Run by highly trained scientists at CCMC, analyzed by community members</td>
<td>Run and analyzed by non-scientists</td>
</tr>
<tr>
<td>Often “hacked” together with no software discipline</td>
<td>Streamlined version of research code</td>
<td>Highly controlled software product</td>
</tr>
<tr>
<td>No manual, few comments</td>
<td>Occasional manual, some comments</td>
<td>Extensive manual and detailed comments</td>
</tr>
<tr>
<td>No version tracking, bug fix history</td>
<td>Version tracking, some bug fix history</td>
<td>Version tracking, detailed bug fix history</td>
</tr>
<tr>
<td>Validation by developer</td>
<td>Independent validation</td>
<td>Continuous validation, skill score evolution</td>
</tr>
<tr>
<td>Code changes as the developer wishes</td>
<td>Occasional code updates</td>
<td>Highly controlled regular code update process</td>
</tr>
<tr>
<td>No intellectual property concern</td>
<td>CCMC “rules of the road” apply, but no contractual agreement</td>
<td>Intellectual property is major concern, lawyers involved</td>
</tr>
<tr>
<td>Developers guard source code as a trade secret</td>
<td>Source code is available only to CCMC staff</td>
<td>SWPC treats code as government property</td>
</tr>
<tr>
<td>Only limited information is published about boundary and initial conditions</td>
<td>CCMC staff does not implement new boundary/initial conditions</td>
<td>All algorithmic and model details must be clearly stated</td>
</tr>
</tbody>
</table>
Transition Process

☀ Step 1: Transition to community use (CCMC)
  ☉ CCMC
    ❁ provides access to space research models
    ❁ tests and evaluates models
    ❁ runs a real-time space weather model testbed
    ❁ supports space science education
  ☉ CCMC does not
    ❁ hardens codes
    ❁ writes code documentation
    ❁ optimizes model parameters
    ❁ fixes code bugs (features?)
  ☉ Code developers
    ❁ train CCMC staff on model use
    ❁ modify research codes to minimize the number of “knobs”
    ❁ fix code bugs (features?)

☀ Step 2: Transition to operations (SWPC)
  ☉ Code developers
    ❁ periodic code updates
    ❁ standby software support
    ❁ code documentation
    ❁ optimize default options
  ☉ SWPC
    ❁ code hardening (nuclear war resistant)
    ❁ code documentation
    ❁ licensing agreements
    ❁ software traceability and conventions
    ❁ transition to new platforms
    ❁ periodic skill evaluation and updates
    ❁ + many other issues
CCMC and SWPC

☀ They are natural allies …
☉ … but sometimes they act as siblings
☉ … they share most friends and distractors
♀ Friends: model developers, space science community, user community, etc
♀ Detractors: intra-agency and inter-agency turf battles, budget squeeze, OMB, public ignorance about space weather, etc

☉ They need each other …
☉ … and they know it
☉ … and their friends know it
☉ … and their distractors are afraid of it
☀ We need a clearly defined model transition chain and job description
The Funding Challenge for Global Modelers

☀ There is no direct mechanism to obtain support for space weather model development and/or maintenance

☉ NOAA has no extramural program in this area

☉ AFOSR has very limited funds and they mostly support intramural activities (AFRL)

♁ NSF
△ “Intellectual Merit” is the determining factor in selections and panels evaluate proposed applications and ignore code development challenges and needs
△ AGS core programs support individuals with small (~$100K) awards
△ GEM, CEDAR and SHINE are targeted for new physics insights
△ New Space Weather program is underfunded and has little track record
△ GEO-wide FESD focuses on applications
△ Agency-wide “cyber” programs focus on computer science aspects

☉ NASA
△ The Information Technology Research Program (Joe Bredekamp) in SMD is dead
△ Heliophysics has no targeted model development program
△ ... but it has an instrument development program...
△ LWS has no model development program, panels mainly value applications

☉ NASA-NSF Partnership (Strategic Capabilities)
△ Supports some model developments
△ Cadence is very spiky (once every five years)
△ Awards support 2-3 FTEs (including applications), not big enough
What is the Cost of Transition?

☀ Estimate for SWMF

☉ Transition/support to CCMC: ~0.5 FTE/year
   † Simplify options
   † Fine-tune defaults
   † Train personnel
   † Regular consultations
   † Regular updates

☉ Transition/support to SWPC: ~ 1 FTE/year
   † Manual
   † Robustness
   † Software engineering
   † Intellectual property issues
   † Support services
   † Regular updates

☉ 1.5 FTE/year is probably a robust estimate for most large codes
Proposed Funding Model

☀️ Create R2O institutes
  ☉ Funded by NOAA
    ☉ NOAA is the operational space weather agency of the US government
    ☉ NOAA might seek partnership with AFWA
    ☉ Create an R2O institute for each global model to be transitioned
    ☉ These institutes are funded as long as the model is operational
  ☉ Institutes also serve the CCMC transition/support
    ☉ This is an integral part of the R2O process
    ☉ More work is needed if a model goes beyond CCMC
    ☉ Additional support from NASA/NSF/AFOSR

☀️ Institutes are competed through the SWPC model selection process
  ☉ Geospace model selection process is a good template
  ☉ Funding levels should be between $250K and $500K per year

☀️ Fund Step 1 transition (to CCMC) in LWS TR&T and NSF Space Weather
  ☉ Replace LWS Techniques and Methods with transition
  ☉ Include transition in the NSF Space Weather portfolio
Model Lifecycle

☀ From concept to working code
  ☉ This stage typically takes ~10 FTE-years
  ☉ In the past this was opportunistically funded

☀ From working code to CCMC
  ☉ This stage typically takes ~5 FTE-years
  ☉ This stage can be funded by space physics opportunities

☀ Community use/acceptance/validation at CCMC
  ☉ Typically ~3 years
  ☉ During this time team is funded by space physics applications

☀ Transitioning to SWPC
  ☉ Typically ~3 years
  ☉ Selection process is ~1–1.5 years
  ☉ During this time team is funded by space physics applications

☀ A new group of young smart people emerge and write a better model
  ☉ Anywhere between 10 and 25 years
  ☉ We should ban young people …

☀ Total lifetime of (good) global models from concept to obsolescence
  ☉ ~30 years
  ☉ A scientific lifetime…
Summary

☀ Present codes were developed with opportunistic approach
  ☉ Space Weather was only an afterthought and not the driver
☀ Research codes – Community codes – Operational codes
  ☉ What a difference!
☀ Funding is a challenge
  ☉ There is a need for long-term funding
  ☉ Many fathers, few parents
☀ Need for a new funding model for R2O
☀ Model lifecycle is a scientific lifetime

☀ The major agencies (NASA, NSF, NOAA, DoD) need to find a sustainable support model