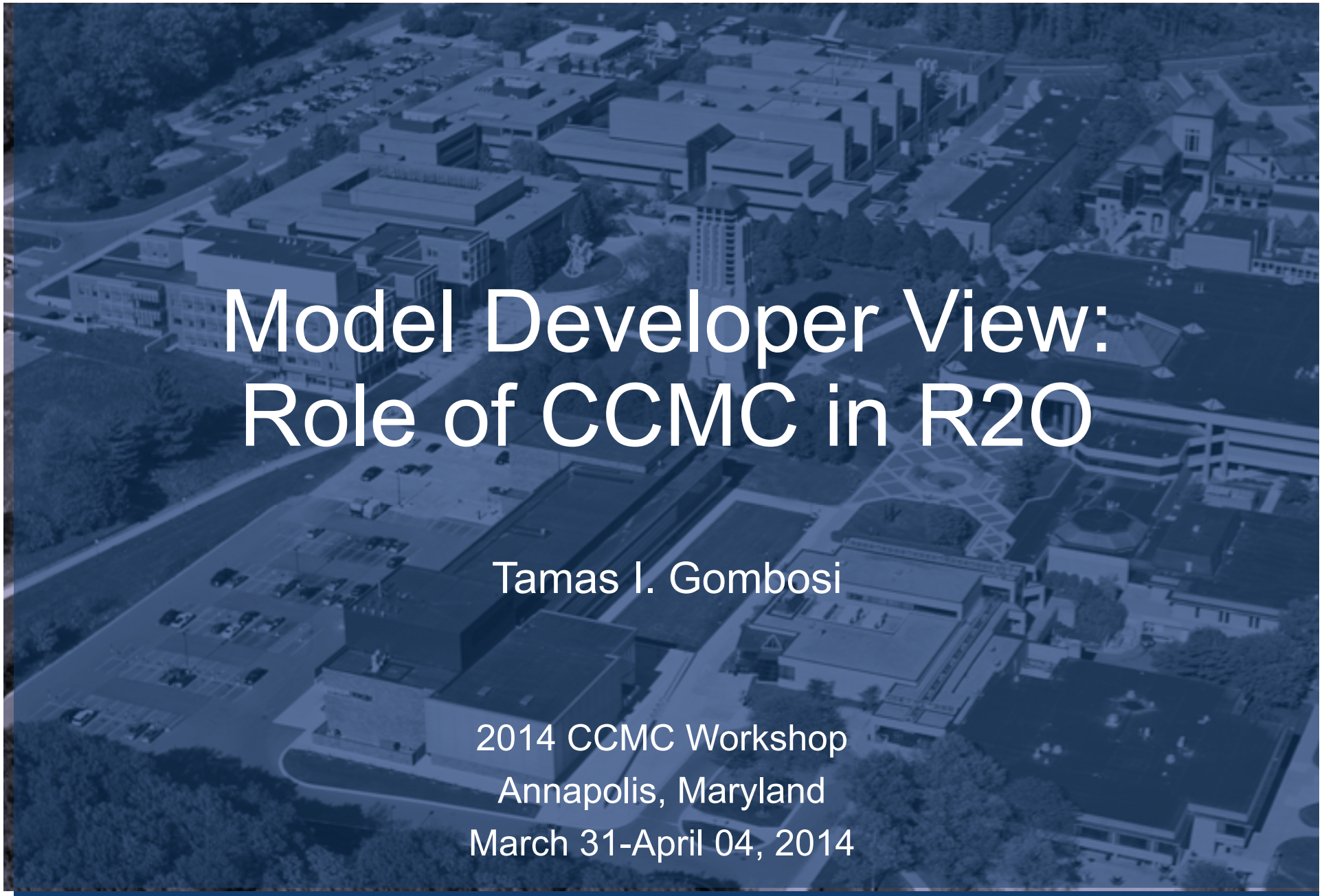

Model Developer View: Role of CCMC in R2O

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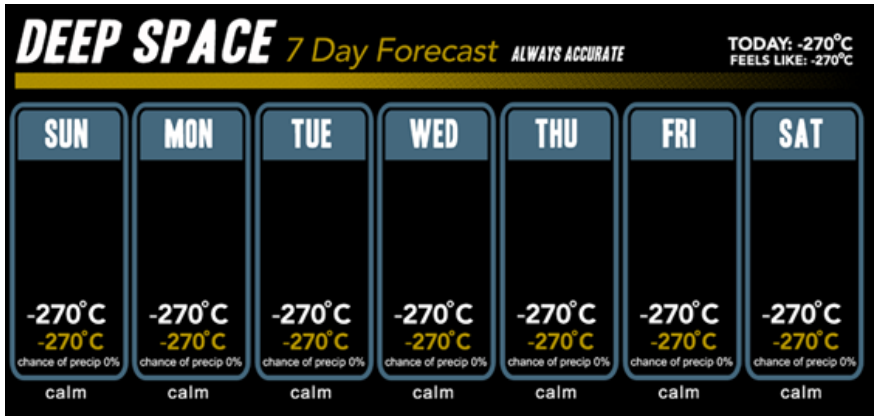
Outline (Issues)

- 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

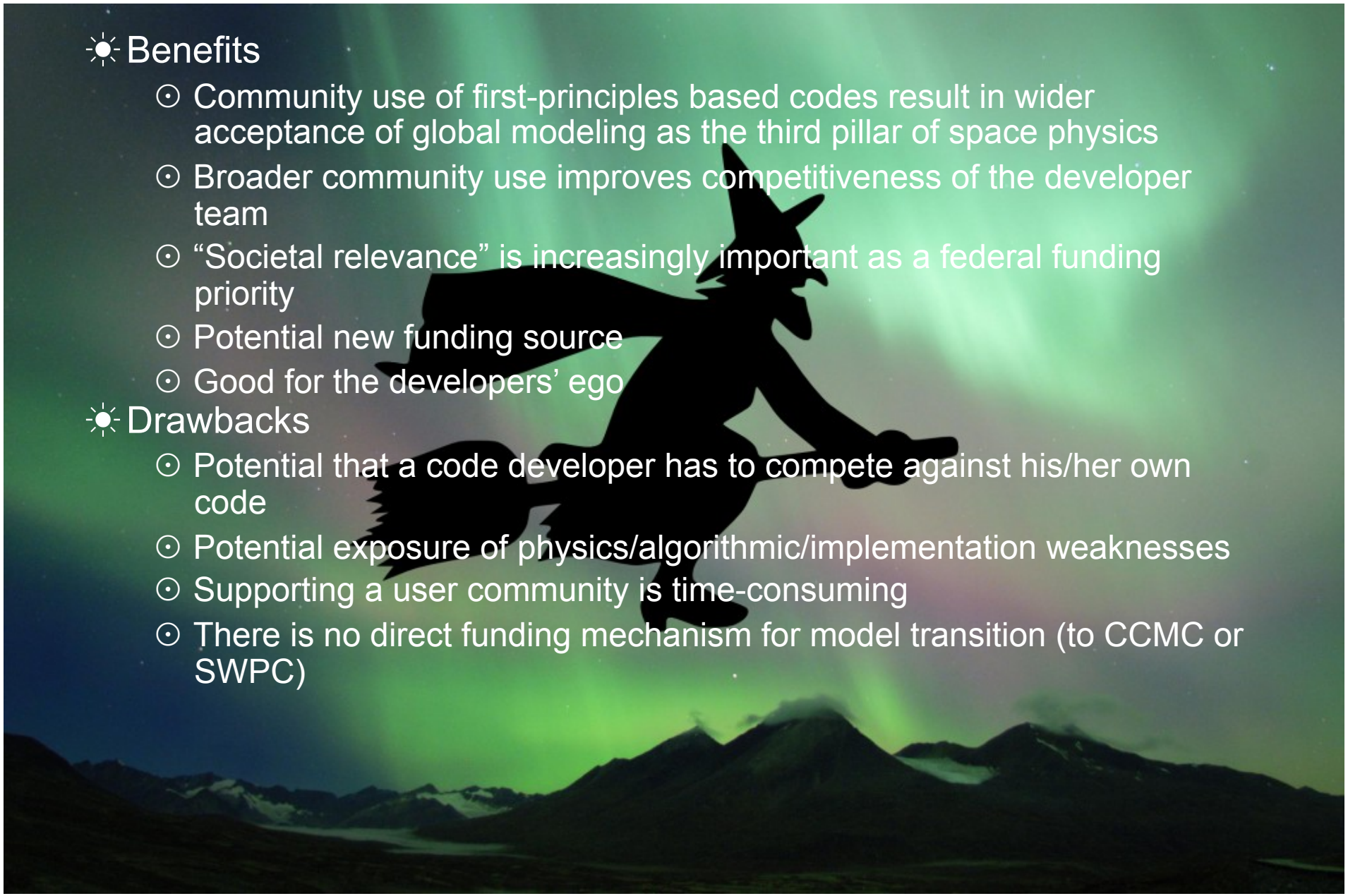


How were US 3D Space Weather Models Originally Developed?

Model	Description	Developer
CTIP	ionosphere + thermosphere	NOAA SWPC
GITM	ionosphere + thermosphere	Michigan
SAMI	ionosphere	NRL
TIEGCM	ionosphere + thermosphere	NCAR HAO
USU-GAIM	ionosphere	USU
LFM	magnetosphere	Darthmouth (NRL)
OpenGGCM	magnetosphere	UNH (UCLA)
SWMF	corona + heliosphere + magnetosphere	Michigan
ENLIL	heliosphere	George Mason (NOAA SWPC)
MAS	corona	PSI

- 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

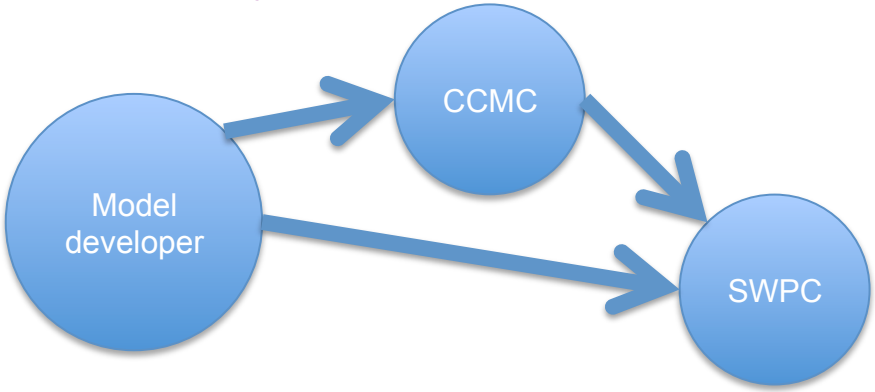
Research Code	Community Code	Operational Code
Run and analyzed by a small group of scientists	Run by highly trained scientists at CCMC, analyzed by community members	Run and analyzed by non-scientists
Often “hacked” together with no software discipline	Streamlined version of research code	Highly controlled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

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

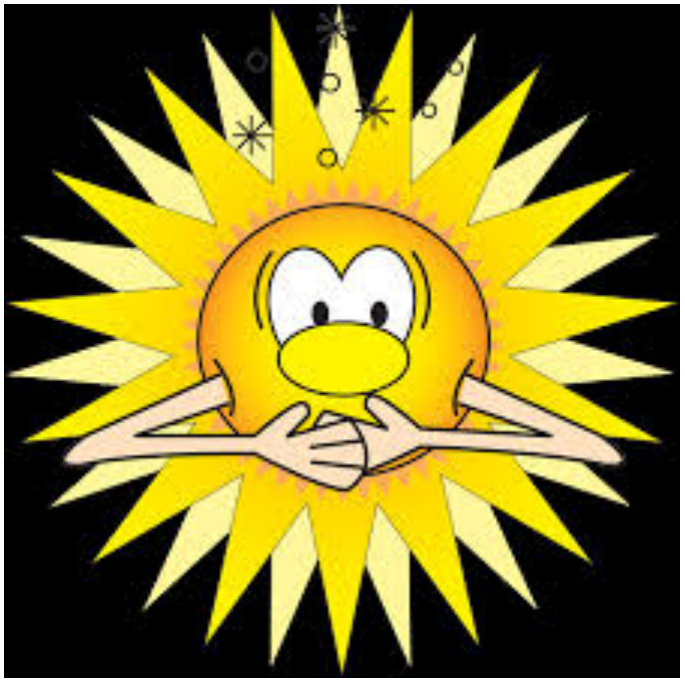


The Funding Challenge for Global Modelers

- 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 ~3years
  - 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 a scientific lifetime

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