FUTURE DIRECTIONS IN SH PHYSICS

N. A. Schwadron and LWS Steering Committee

LIVING WITH A STAR – STEERING COMMITTEE 2013-2014

LWS Steering Committee Members:

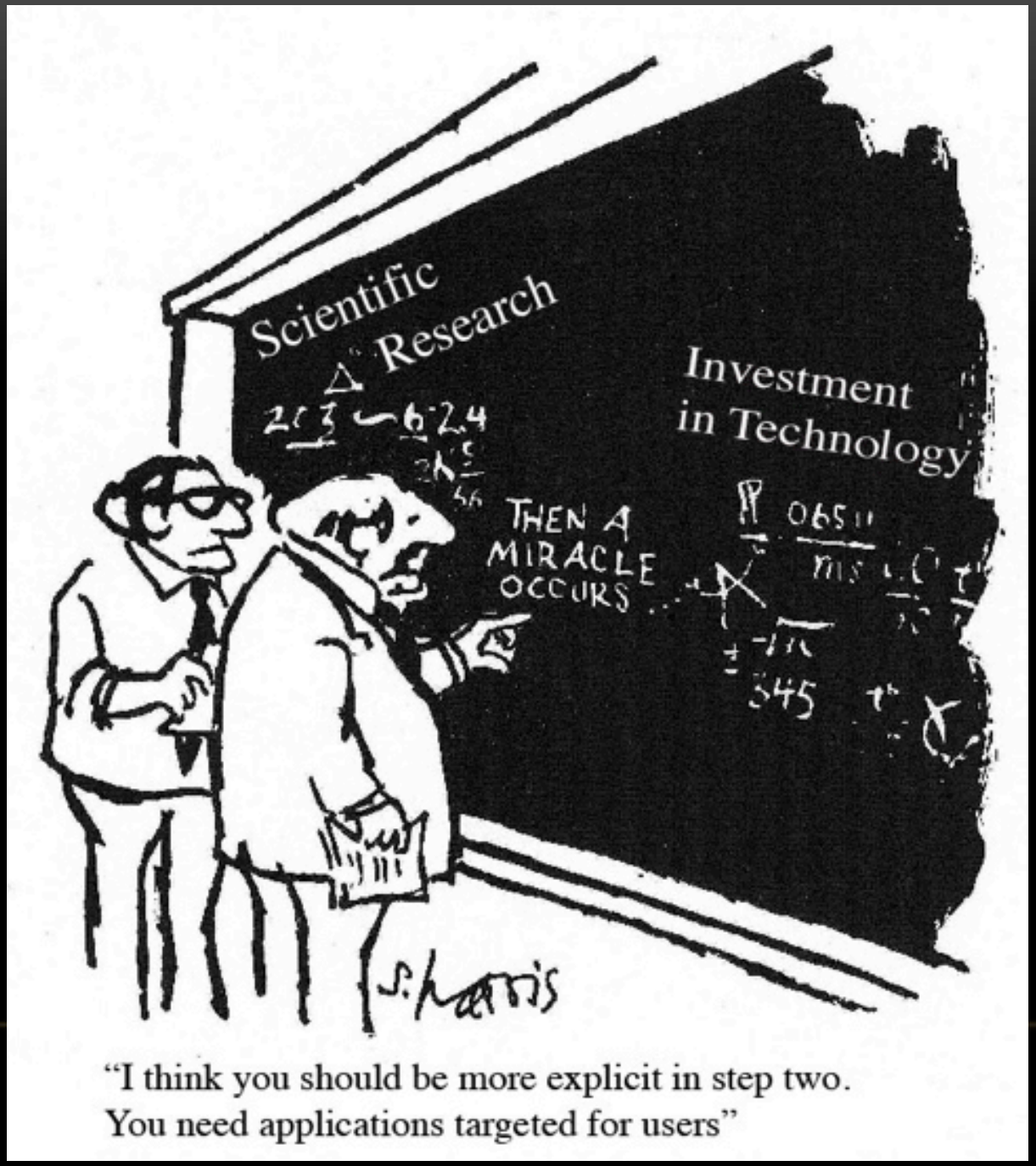
- Nathan Schwadron, UNH (Chair)
- Tony Mannucci, JPL (Co-Chair)
- Spiro Antiochus, GSFC
- Amitava Bhattacharjee, Princeton
- Tamas Gombosi, UMichigan
- Nat Gopalswamy, NASA/GSFC
- Farzad Kamalabadi, UIllinois
- Jon Linker, PSI
- Peter Pilewiske, U. Colorado
- Antti Pulkkinen, NASA/GSFC
- Harlan Spence, UNH
- Kent Tobiska, Utah State University/SET
- Daniel Weimer, Virgina Tech
- Paul Withers, BU

Liaisons to TR&T SC:

- Mario Bisi, Rutherford Appleton Laboratory
- Masha Kuznetsova, CCMC
- Kent Miller, AFOSR
- Terese Morretto, NSF
- Terry Onsager, NOAA
- Ilia Roussev, NSF
- Rodney Vierick, NOAA

LWS Program Ex Officio:

- Madhulika Guhathakurta, NASA/HQ
- Bob Leamon, NASA/HQ



"I think you should be more explicit in step two.
You need applications targeted for users"

LWS COMMUNITY PRIORITIES

Enabling discovery (Chapter 1) & Addressing Societal Needs (Chapter 3)

- LWS central to the decadal survey's strategy is the intent to achieve scientific results that will be useful to society

"Given adequate resources, the research community should be able to leverage advances in computing capability to develop the predictive models required to specify the extended space environment in order to protect society and advance growing aspirations for the use of space."

"Solar and Space Physics: A Science *for* a Technological Society"

WHAT ARE WE TRYING TO ACHIEVE?

Examples of Long-term Strategic Science Areas

- **Physics-based Geomagnetic Forecasting Capability**

  Enable1-3 day (long lead-time) and 15-30 min (short lead-time) predictions of pending extreme fluctuations in geomagnetic field

- **Physics-based Satellite Drag Forecasting Capability**

  Enable specification of the global neutral density in the thermosphere and its variations over time

- **Physics-based Solar Energetic Particle Forecasting Capability**

  Probabilistic prediction of the intensity of SEP events, and increased time periods for all-clear forecasting capability with higher confidence level

- **Physics-based TEC Forecasting Capability**

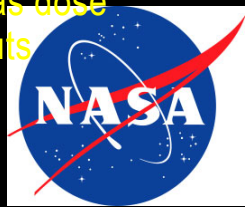
  Enable specification of the global ion density in the topside ionosphere and plasmasphere and its variations over time under varying geomagnetic conditions

- **Physics-based Scintillation Forecasting Capability**

  Enable prediction of scintillation occurrence utilizing limited sources of available data and ascertain how radio signals are degraded by ionospheric irregularities

- **Physics-based Radiation Environment Forecasting Capability**

  Enable predictive capability for the radiation environment and its effective dose as well as dose rates based on GCR, SEP, cutoff rigidity, atmosphere density, and gamma-ray/X-ray inputs



WHERE IS THE MISSING PHYSICS (1/3)

- Interdisciplinary areas with varying levels of model & physics development

  Solar Energetic Particles

  - Incorporation of Plasma Environment
    - Realistic Corona
    - CMEs
    - Solar Wind
  - Seed populations
  - Ambient Waves and Self-Generated Waves

  - Solar Probe and Solar Orbiter Discover Genesis of Solar Wind and SEPs
    - Source Populations
    - Wave Heating
    - Solar Wind Acceleration
    - Energetic Particle Acceleration

→ *CCMC Realization of global models with physical couplings and predictive capability*

WHERE IS THE MISSING PHYSICS (2/3)

- Thermosphere & Ionosphere
  - X-scale coupling
    - Coupling across scales
      - Magnetosphere
      - Lower atmosphere (small scale gravity waves * planetary waves)
  - Ion-neutral Coupling between ionosphere and thermosphere
  - Magnetosphere-Ionosphere coupling
  - Ability to predict disturbances in solar wind
    - Solar Probe and Solar Orbiter discover how Solar Wind is accelerated

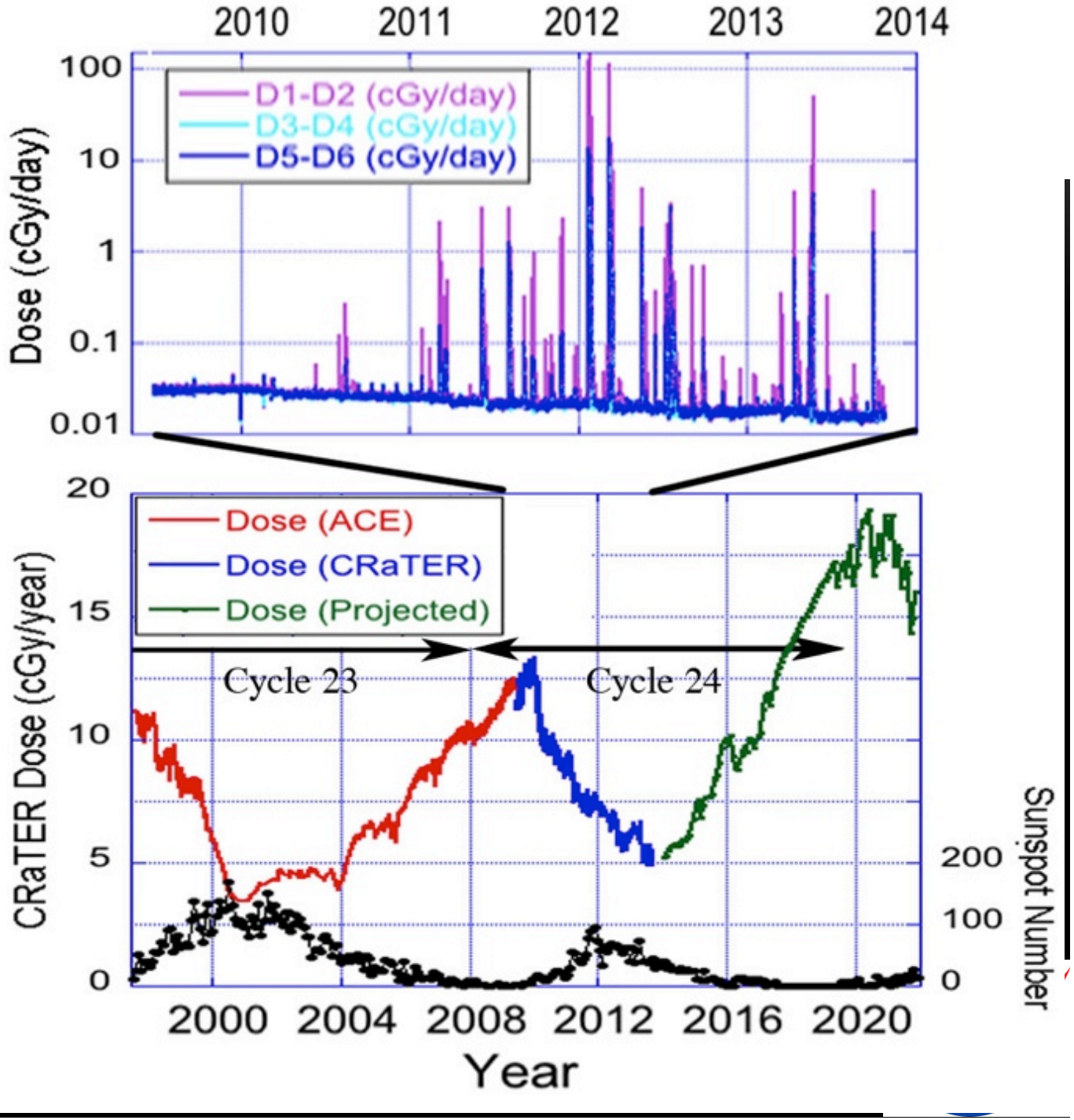
→ *CCMC Aids in realization of global models with physical couplings and predictive capability*

WHERE IS THE MISSING PHYSICS (3/3)

- CME Initiation
  - Incorporation of Realistic Physics-based Solar Wind
  - Ability to predict disturbances based on behavior
  - Relationship to Dynamo
  - Evolution during solar cycle
  - Regulation of Open Magnetic Flux and Solar Wind

→ *Realization of global models with physical couplings and predictive capability*

- Space weather in a new era of solar activity
- Basic questions about the dynamo, history and future of solar activity
- A worsening radiation environment
- Potential for large SEP events, but events in cycle 24 weaker



FUTURE DIRECTIONS & IMPLICATIONS (1/2)

- LWS 10 year Plan in work
  - Observational Requirements and New Data Sources

CCMC Flexible Data Assimilation

  - Innovative Use of Ground Measurements

CCMC provides framework for “nowcasting”?

Needed for each dataset is a collection of software utilities in common languages

  - Sun-Planet Connections

Flexible Data Assimilation from *extended* datasets

  - Forums for Data Validation

CCMC testing and validation center

FUTURE DIRECTIONS & IMPLICATIONS (2/2)

- LWS 10 year Plan in work
  - Extreme Space Weather and Habitability

Extended datasets using models in new environments

  - Applied Research and Transition to Operations

CCMC has a critcal role

  - Large-scale computing

CCMC provides more flexible access

  - Cultivating Comprehensive End-to-End Models

CCMC provides testing and validation to aid in understanding strength and limitation of modules